PART 2 – Works' Requirements

Section VII - Works' Requirements

Table of Contents

TECHNICAL SPECIFICATIONS

" ARCHITECTURAL AND CIVIL WORKS"

Contents

1. PRELIMINARIES

GENERAL

PRE-CONSTRUCTION WORK

The Engineer and Contractor will carry out a joint condition-in survey using digital photographs to record the condition of the site upon handover to the Contractor. This will determine the state of the site that the Contractor must hand back upon completion of the works.
The Contractor will carry out a detailed site setting out for the works.

A pre-Construction meeting will be held between the Contract supervision Engineer and the Contractor to review the following information:

Condition-in Survey of the facility
Site Survey
Work Method Statement
Work Program
Schedule of Materials and Installed Equipment

The Contractor must mobilize on the project site within 7 calendar days of the date of issue of the Notice to commence or as otherwise stipulated in the contract.

Site restrictions
Site security limitations: The Contractor will have to comply with any restrictions on site area, access or working times advised by the Engineer.

Access: Access on to and within the site, use of the site for temporary works and constructional plant including working and storage areas, location of offices, workshops, sheds, roads and parking, is restricted to the areas shown on the drawings or as agreed with the Engineer.

Occupied areas of site or buildings
For the parts of the site designated as occupied areas in the **occupied areas schedule**:

- Allow occupants to continue using the area for the required period.
- Make available safe access for occupants.
- Arrange work to minimize nuisance to occupants and ensure their safety.

- Protect occupants against weather, dust, dirt, water or other nuisance, by such means as temporary screens.

Protection of persons and property

Temporary works: Provide and maintain required barricades, guards, fencing, shoring, temporary roadways, footpaths, signs, lighting and traffic flagging.

Access ways, services: Do not obstruct or damage roads and footpaths, drains and watercourses and other existing services in use on or adjacent to the site. Determine the location of such services. If damage occurs, immediately repair it at the Contractors cost.

Property: Do not damage property which is to remain on or adjacent to the site, including adjoining property encroaching onto the site. If damage occurs, immediately repair it at the Contractors cost.

Existing services

Attend to existing services as follows:

- If the service is to be continued, repair, divert or relocate as required.
- If the service is to be abandoned, cut and seal or disconnect, and make it safe.

Submit proposals to the Contract supervision Engineer for action for existing services before starting this work. Minimize the number and duration of interruptions.

Adjoining property

Records: For properties described in the **Adjoining properties to be recorded schedule**:

- The Contractor is to inspect the properties with the Engineer and owners and occupants of the properties, before start of work.
- Make detailed records of conditions existing within the properties, especially structural defects and other damage or defacement.
- Arrange for at least 2 copies of each record, including drawings, written descriptions, and photographs, to be endorsed by the owners and occupants, or their representatives, as evidence of conditions existing before commencement of work.

Submit one endorsed copy of each record to the Engineer. The Contractor is to keep the other endorsed copy.

CONSTRUCTION PLANT

Access
Access route and site access point will be as agreed with the Engineer.

Use of existing services
Existing services may be used as temporary services for the performance of the contract subject to conditions stated in the **Existing services schedule**.

Contractors Facilities and Work Practices
The Contractor is required to provide adequate toilet and washroom facilities for his staff. These facilities shall be kept clean and serviceable at all times.

The Contractor is required to provide adequate first aid equipment on-site, failure of the Contractor to ensure the availability of first aid equipment on-site will result in an immediate 'stop work' order being issued. All costs and time delays resulting from any such 'stop work' order is entirely the Contractors responsibility.

A site office will be established by the Contractor at the work site. The location of the site office will be identified by the Engineer to the Contractor. The office will have a complete set of the contract documents.

The Contractor is to maintain a safe, healthy and tidy worksite at all times and all work activities are to be performed with protective and safety equipment appropriate for the task. The Contractor is entirely responsible for workplace safety and unsafe work practices will be identified and recommendations made for revised work methods as appropriate.

Project signboards
Provide project-specific signboards and the following:
- Location, size and wording as directed by the Engineer.
- Maintain a good condition for the duration of the work.
- Remove on completion.

Obtain approval before display of advertisements or provision of other signboards.

BUILDING THE WORKS

Surveys
Setting out: Set out the works from the dimensioned drawings
Check surveys: Check the set out regularly on site

Final survey: Confirm final set out of roads, services and buildings on the as constructed drawings after Practical Completion

Survey marks

Definition: The term "survey mark" means a survey peg, bench mark, reference mark, signal, alignment, level mark or any other mark used or intended to be used for the purpose of setting out, checking or measuring the work.

Care of survey marks: Preserve and maintain the survey marks in their true positions. If the survey marks are damaged, immediately advise the Engineer and rectify the damage.

Contractor's representative

The contractor must employ a suitably experienced engineer as the Site Manager. This person must be on site during working hours, and fluent in English and technical terminology. The Contractor's Site Manager will have the authority to make all decisions concerning the project

Program of work

The Contractor is to provide a construction program which has the following information:

- Sequence of work.
- Allowance for holidays.
- Activity inter-relationships.
- Periods within which various stages or parts of the work are to be executed.
- Time scale: Working days.

-Update the program weekly. Identify changes since the previous version, and show the estimated percentage of completion for each item of work.

Site meetings

Hold and attend weekly site meetings throughout the contract and ensure attendance of appropriate subcontractors, the Site Manager and Engineer. The meeting schedule may be modified by the Engineer.

The meeting will consider the following items:

· Technical issues.
· Commercial issues.
· Program.
· Quality of work.

The Contractor is to keep minutes of site meetings. Within 3 working days after each meeting, submit to each party written copies of the minutes.

Items supplied by owner

Materials and other items identified in the **Items to be supplied schedule** will be supplied free of charge to the Contractor for installation in the execution of the works. Unload and take delivery of them, inspect them for defects and then take care of them. If defects are found, advise. Return unused items to the owner

COMPLETION OF THE WORKS

Final cleaning

Before Practical Completion, clean throughout, including interior and exterior surfaces exposed to view. Clean carpeted and soft surfaces. Clean debris from the site, roofs, gutters, downpipes and drainage systems. Remove waste and surplus materials.

Reinstatement

Before practical completion, clean and repair damage caused by installation or use of temporary work and restore existing facilities used during construction to original condition.

Adjoining property

At practical completion, for properties described in the **Adjoining properties to be recorded, schedule** inspect the properties with the Engineer and owners and occupants of the properties, recording any damage that has occurred since the pre-commencement inspection.

Post construction Works

The Contractor will provide the following documentation after all site construction has been completed:

· Warranty Statement
· Material Test Certificates
· As-Built Drawings

A condition-out survey will be conducted with the Contractor and Engineer at which damages caused by the Contractor will be identified. The Engineer will determine if the Contractor is to make repairs or if the damage will be deducted from the Contractor's final invoice.

Removal of plant

Within 10 working days after practical completion, remove temporary works and construction plant no longer required. Remove the balance before the end of the defect's liability period.

MISCELLANEOUS

Compliance with the law
The Contractor is responsible for compliance with all requirements of authorities. The owner, before entering into the contract, has given the notices, paid the fees, and obtained the permits, approvals and other authorizations stated in the **Prior applications and approvals schedule**.

2. GENERAL REQUIREMENTS

GENERAL

CONTRACT DOCUMENTS

Drawings
Large scale drawings take precedence over small scale drawings. Written or calculable dimensions take precedence over scaled dimensions. If there are any errors in dimensions, set out or size, immediately notify the Engineer.

Bill Of Quantities
If there are any errors in description of items or omissions in the BOQ, immediately notify the Engineer.

If there are any items which are unclear or are not available within the project program, immediately notify the Engineer.

Services diagrammatic layouts
Layouts of service lines, plant and equipment shown on the drawings are diagrammatic only, except where figured dimensions are provided or calculable.

Before commencing work:
- Obtain measurements and other necessary information.
- Coordinate the design and installation in conjunction with all trades.

Site Levels
Spot levels and identified levels on drawings take precedence over contour lines and ground profile lines.

INSPECTION

Inspection Notification Schedule

The Contractor is to notify the Engineer when the items identified in the **Inspection Notification Schedule** are ready for inspection.

Notice

Minimum notice for inspections to be made on site is 24 hours for off-site personnel, 4 hours for onsite personnel e.g., on-site: 4 hours, off-site: 2 working days. Increase if your office is remote from the site.

If notice of inspection is required in respect of parts of the works that are to be concealed, advise when the inspection can be made before concealment.

SUBMISSIONS

Samples

Submit nominated samples for approval of the Engineer.
If it is intended to incorporate samples into the works, submit proposals for approval. Only incorporate samples in the works which have been approved. Do not incorporate other samples.

Keep endorsed samples in good condition on site, until practical completion.

Shop drawings

General: If required, submit dimensioned drawings showing details of the fabrication and installation of services and equipment, including relationship to building structure and other services, cable type and size, and marking details.
Diagrammatic layouts: Coordinate work shown diagrammatically in the contract documents, and submit dimensioned set-out drawings.

TESTS

Notice

Give notice of time and place of nominated tests.

Attendance

The Contractor is to carry out and attend all tests nominated in this specification. As a minimum, the Contractor will carry out the following tests:

· Flatness of the sub-base (allowed tolerance is ±2 cm using the 4 Lm bar test), to be certified on site.
· Flatness of the base of foundations (allowed tolerance is ±2 cm using the 4 Lm bar test), to be certified on site.
· Testing the granulometric composition and strength of all aggregates to be used.
· Testing of all concrete in accordance with the regulations and methods as stated in the Concrete section of the specification.
· Bricks shall have certified crush strength of greater than 105 kg/cm2.
· The Contractor will supply all necessary appliances and labor for testing of the complete water supply system at such time and as directed by the Engineer. Such testing shall as a minimum require the pressurizing of the complete water supply system to a pressure of not less than 4.5bar. The pipework and fittings shall retain this pressure for a minimum of 1 hour following the commencement of the test.
· All drains shall be hydraulically tested to a minimum of 1500 mm head and no drains shall be covered up until such test has been made and repeated as necessary until passed to the approval of the Engineer. Access plugs and caps shall be removed, greased, refitted and made sound prior to the final testing.

MATERIALS AND COMPONENTS

Consistency

For the whole quantity of each material or product use the same manufacturer or source and provide consistent type, size, quality and appearance.

Manufacturers or suppliers' recommendations

Proprietary items: Select, if no selection is given, and transport, deliver, store, handle, protect, finish, adjust, prepare for use, and provide manufactured items in accordance with the current written recommendations and instructions of the manufacturer or supplier.
Proprietary systems/assemblies: Assemble, install or fix in accordance with the current written recommendations and instructions of the manufacturer or supplier.
Project modifications: Advise of activities that supplement, or are contrary to, manufacturers or suppliers' written recommendations and instructions.

Proprietary items

Identification of a proprietary item does not necessarily imply exclusive preference for the item so identified but indicates the necessary properties of the item.
Alternatives: If alternatives are proposed, submit proposed alternatives and include samples, available technical information, reasons for proposed substitutions and cost. If necessary, provide

an English translation. State if provision of proposed alternatives will necessitate alteration to other parts of the works and advise consequent costs.

EXECUTION

COMPLETION

Warranties

Name the owner as warrantee in conformance with the **Warranty schedule**. Register with manufacturers as necessary. Retain copies delivered with components and equipment.

Commencement: Commence warranty periods at practical completion or at acceptance of installation, if acceptance is not concurrent with practical completion.

OPERATION AND MAINTENANCE MANUALS

General

General: Submit operation and maintenance manuals for installations.

Format – hard copy

These will be A4 size loose leaf, in commercial quality files with hard covers, each indexed, divided and titled. Include the following features:

- Cover: Identify each binder with typed or printed title "OPERATION AND MAINTENANCE MANUAL", to the spine. Identify title of project and date of issue.
- Drawings: Fold drawings to A4 size and accommodate them in the files so that they may be unfolded without being detached from the rings.
- Text: Manufacturers' printed data, including associated diagrams, or typewritten, single-sided on paper, in clear concise English.

Number of copies: 3.

3. DEMOLITIONS

GENERAL

INTERPRETATION

Demolished materials classes

Salvaged for re-use: Demolished materials scheduled for re-use in the works.

Salvaged for disposal: Demolished materials scheduled for re-use elsewhere.
Demolished for re-use: Non-scheduled demolished materials proposed by contractor for re-use in the works.
Demolished for removal: Other demolished materials.

SUBMISSIONS

Execution
Submit the risk assessment method statement and equipment proposed for the demolition, including the following:
- Dewatering and groundwater control and disposal of surface water.
- Control of erosion and contamination of the site, surrounding areas and drainage systems.
- Dust control.
- Noise control.

INSPECTION

Notice
Give sufficient notice so that inspection may be made of the following:
- Adjacent structures before commencement of demolition.
- Propping of structures prior to demolition works.
- Structure after stripping and removal of roof coverings and other external cladding.
- Underground structures after demolition above them.

PRODUCTS

DEMOLISHED MATERIALS

Demolished materials
Ownership: Ownership of demolished materials is described in the **Demolished materials classes table**. Reuse: If it is proposed to reuse demolished materials in the works, submit proposals. All demolished materials by default belong to the Employer unless otherwise stipulated.

Salvage: Recover without damage materials to be salvaged, for reuse in conformance with the **Salvaged materials for reuse schedule** or for disposal in conformance with the **Salvaged materials for disposal schedule**.

Removal: Remove from the site demolished materials which are the property of the contractor. Do not burn or bury on site.
Transit: Prevent spillage of demolishing materials in transit.

EXECUTION

SUPPORT

Temporary support
If temporary support is required, certification for its design and installation is required from a professional engineer engaged by the contractor and approved by the supervising Engineer.
Until permanent support is provided, provide temporary support for sections of existing buildings which are to be altered and which normally rely for support on work to be demolished.
Support excavations for demolition of underground structures. Provide supports to adjacent structures where necessary, sufficient to prevent damage resulting from the works.

Permanent supports
If permanent supports for adjacent structures are necessary and are not described, give notice and obtain instructions.

PROTECTION

Encroachment
Prevent the encroachment of demolished materials onto adjoining property, including public places.

Weather protection
If walls or roofs are opened for alterations and additions or the surfaces of adjoining buildings are exposed, provide temporary covers to prevent water penetration. Provide covers to protect existing plants and equipment and materials intended for reuse.

Dust protection
Provide dust-proof screens, bulkheads and covers to protect existing finishes and the immediate environment from dust and debris.

Security
If a wall or roof is opened for alterations and additions, provide security against unauthorized entry to the building.

DEMOLITION

Explosives
Do not use explosives in the demolition process.

HAZARDOUS MATERIALS

General
General: Hazardous materials that have already been identified are set out in the **Identified hazardous materials schedule**.

Hazardous materials
General: Give notice immediately hazardous materials or conditions are found, including the following:
- Asbestos or material containing asbestos.
- Flammable or explosive liquids or gasses.
- Toxic, infective or contaminated materials.
- Radiation or radioactive materials.
- Noxious or explosive chemicals.
- Tanks or other containers which have been used for storage of explosive, toxic, infective or contaminated substances.

COMPLETION

Notice of completion
Give at least 3 working days' notice of completion of demolition so that adjacent structures may be inspected following completion of demolition.
Make good any damage arising out of demolition work. Obtain written acceptance from the owner of each adjoining property of completeness and standard of making good.

Temporary support
General: Clear away at completion of demolition.

4. SITE PREPARATION

GENERAL

AIMS

Responsibilities

The aim of this work section is to clear the site and put in place adequate environmental controls to allow the commencement of earthworks and/or building works.

SUBMISSIONS

Execution

Submit the methods and equipment proposed for the earthworks, including the following:
- Dewatering and groundwater control and disposal of surface water.
- Control of erosion and contamination of the site, surrounding areas and drainage systems. - Dust control.
- Noise control.

Trees

Work near trees

Keep the area within the drip line free of construction material and debris. Do not place bulk materials and harmful materials under or near trees. Do not place spoil from excavations against tree trunks. Prevent wind-blown materials such as cement from harming trees and plants.

Prevent damage to tree bark. Do not attach stays, guys and the like to trees.

If excavation is required near trees to be retained, give notice and obtain instructions.

Open up excavations under tree canopies for as short a period as possible.

Use hand methods to locate, expose and cleanly remove the roots on the line of excavation. If it is necessary to excavate within the drip line, use hand methods such that root systems are preserved intact and undamaged.

Backfill to excavations around tree roots with backfill free from weed growth and harmful materials. Place the backfill layers, each of 300 mm maximum depth, compacted to a dry density similar to that of the original or surrounding soil. Do not backfill around tree trunks to a height greater than 300 mm above the original ground surface. Immediately after backfilling, thoroughly water the root zone surrounding the tree.

Water trees as necessary, including where roots are exposed at ambient temperature > 35°C.

Existing services

Marking

Before commencing earthworks, locate and mark existing underground services in the areas which will be affected by the earthwork's operations including clearing, excavating and trenching.

Excavation
Do not excavate by machine within 1 m of existing underground services.

ENVIRONMENTAL PROTECTION

Dust protection
Provide dust-proof screens, bulkheads and covers to protect existing finishes and the immediate environment from dust and debris.

Dewatering
Keep groundworks free of water. Provide and maintain slopes and drains on excavations and embankments to ensure free drainage. Place construction, including fill, masonry, concrete and services, on ground from which free water has been removed. Prevent water flow over freshly laid work.

SITE CLEARING

Extent
Clear only the following site areas:
- Areas to be occupied by works such as buildings, paving, excavation, regrading and landscaping.
- Other areas designated to be cleared.

Contractor's site areas: If not included within the areas specified above, clear generally only to the extent necessary for the performance of the works.

Clearing and grubbing
Remove everything on or above the site surface, including rubbish, scrap, grass, vegetable matter and organic debris, scrub, trees, timber, stumps, boulders and rubble.
Remove tree stumps and roots over 75 mm diameter to a minimum depth of 500 mm below subgrade under buildings, embankments or paving, or 300 mm below finished surface in unpaved areas. Holes remaining after grubbing shall be backfilled with sand material to prevent ponding of water. The material shall be compacted to the relative density of the existing adjacent ground material.
Old works: Remove old works, including slabs, foundations, paving's, drains and manholes found on the surface unless identified on the drawings to remain intact.

Topsoil

All topsoil shall be stripped over the area on which construction or grading takes place. This topsoil shall be carefully stockpiled to be reused for landscaping on completion of the building operations or otherwise disposed of as directed.

Disposal of materials

Disposal
General: Remove cleared and grubbed material from the site.

5. EARTHWORKS

GENERAL

INTERPRETATION

Definitions
For the purposes of this work section the definitions given below apply.
- Bad ground: Ground unsuitable for the purposes of the works, including fill liable to subsidence, ground containing cavities, faults or fissures, ground contaminated by harmful substances and ground which is or becomes soft, wet or unstable.
- Line of influence: A line extending downward and outward from the bottom edge of a footing, slab or pavement and defining the extent of foundation material having influence on the stability or support of the footings, slab or pavement.

RECORDS OF MEASUREMENT

Excavation and backfilling
Do not commence backfilling or place permanent works in the excavation until the following have been agreed and recorded:

- Depths of excavations related to the datum.
- Final plan dimensions of excavations.

Method of measurement: To be jointly agreed between the Engineer and Contractors Site Manager unless otherwise agreed.

INSPECTION

Notice

Give sufficient notice so that inspection may be made of the following:
- Excavation completed to contract levels or founding material.
- Filling completed to contract levels.

TOLERANCES

Tolerances
Finish the surface to the required level, grade and shape within the following tolerances:
- Under building slabs and load bearing elements: + 0, -40 mm.
- Pavement subgrades; + 0, - 60 mm.
- Other ground surfaces: 50 mm, provided the area will drain and match adjacent construction where required.

PRODUCTS

FILL MATERIALS

Fill material generally
Fill material is to be inorganic, non-perishable material.
Excluded materials:
- Organic soils.
- Materials contaminated through past site usage.
- Silts or silt-like materials.
- Fill containing wood, metal, plastic, boulders or other deleterious material.

Classifications for structural fill are based on the intended use of the fill, and defined as follows:
Class I structural fill - used as support for shallow foundations, paved areas, and slabs each with loadings of 3660 kg/m2 or more, for storage tanks, truck turnarounds, and base course and sub-base course for roadway pavements.
Class II structural fill - used as support for shallow foundations, paved areas, and slabs each with loadings of less than 3660 kg/m2 and for parking areas, backfill around foundations, for the construction of embankments, and for roadways pavement subgrades.
Class III non-structural fill - used in areas where installation of structures or equipment is not planned and in open areas where grading is only required to reach levels noted on the drawings.

Re-use of material recovered from excavation
Re-use excavated material elsewhere on site if approved by the Engineer.

EXECUTION

REMOVAL OF TOPSOIL

General
Remove topsoil to all areas to be cut, areas to be filled, areas to be occupied by structures, pavements, embankments and the like.
Maximum depth: 100 mm.

Re-use of removed topsoil
Re-use removed topsoil elsewhere on site as directed by the Engineer.

EXCAVATION

Extent
Excavate over the site to give correct levels for construction, pavements, filling and landscaping.

Excavate for footings, pits and shafts, to the required sizes and depths. Confirm that bearing capacity is adequate.

Proof rolling
Proof roll excavations for pavements, filling and non-spanning slabs on ground to determine the extent of any bad ground.

Disposal of excess excavated material
Remove excess excavated material from the site and dispose of it legally.

BEARING SURFACES

General
Provide flat bearing surfaces for loadbearing elements including footings. Step to suit changes in levels. Make the steps to the appropriate courses if supporting masonry.

REINSTATEMENT OF EXCAVATION

General
Where excavation is deeper than the required depth, fill and consolidate to the correct depth.

SUPPORTING EXCAVATIONS

Provision of supports
Provide temporary supports to all excavations greater than 1.8m deep. Confirm the type of support and level of protection required with the Engineer.

Removal of supports
Remove temporary supports progressively as backfilling proceeds.

Adjacent structures

Temporary supports
Provide supports to adjacent structures where necessary, sufficient to prevent damage arising from the works. This applies to all structures where the line of influence is interfered with by the proposed excavation works.
Lateral supports: Provide lateral support using shoring.
Vertical supports: Provide vertical support where necessary using piling or underpinning or both.

Permanent supports
If permanent supports for adjacent structures are necessary and are not described, give notice and obtain instructions.

PREPARATION FOR FILLING

General
Prepare the ground surface before placing fill (including topsoil fill), ground slabs or load bearing elements. Shape to assist drainage. Compact the ground exposed after stripping or excavation.

Placing fill

General
Layers: Place fill in maximum 15cm horizontal layers across the fill area.

Mix: Place fill in a uniform mixture.

Protection: Protect the works from damage due to compaction operations. Where necessary, limit the size of compaction equipment or compact by hand. Commence compacting each layer at the structure and proceed away from it.

COMPACTION REQUIREMENTS FOR FILL AND SUBGRADE

Density
Compact the subgrade exposed by excavation to a minimum depth of 15cm. Compact each layer of fill to the required depth and density, as a systematic construction operation. Shape surfaces to provide drainage and prevent ponding.
Density of all layers of filling are to be approved by the Engineer before subsequent layers are placed. Maximum rock and lump size in layer after compaction: 2/3 compacted layer thickness.

Moisture content
Adjust the moisture content of fill during compaction in order to achieve the required density. Do not allow subgrade or fill layers to dry out after compaction before placing subsequent layers of fill. Do not over water filling to greater than the moisture content of adjoining undisturbed ground.

6. SERVICE TRENCHING

GENERAL

INSPECTION

Notice
Give sufficient notice so that inspection may be made at the following stages:
- Service trenches excavated before laying the service.
- Services laid in trenches and ready for backfilling.

EXECUTION

Excavating

Excavation
Excavate for underground services, to required levels and grades. Generally, make the trenches straight between inspection points and junctions, with vertical sides and uniform grades.

Trench widths
General: Keep trench widths to the minimum required for laying and bedding of the relevant service and construction of pits.

Trench depths
If excavation is necessary below the zone of influence of the underside of adjacent footings, give notice, and provide support for the footings as instructed.

Obstructions
Clear trenches of sharp projections. Cut back roots encountered in trenches to at least 600 mm clear of services. Remove other obstructions including stumps and boulders which may interfere with services or bedding.

Dewatering
Keep trenches free of water. Place bedding material, services and backfilling on firm ground free of surface water.

Excess excavation
If trench excavation exceeds the correct depth, reinstate to the correct depth and bearing value using compacted bedding material or sand stabilized with 1 part of cement to 20 parts of sand by weight.

Backfilling

General
Backfill service trenches as soon as possible after the service has been laid and bedded, if possible, on the same working day. Place the backfill in layers maximum150 mm thick and compact to the approval of the Engineer.

Backfill material
General fill with no stones greater than 25 mm occurring within 150 mm of the service, or other materials as required for particular services or locations.
Under roads and paved areas and within 4 m of building: Coarse sand, controlled low strength material or fine crushed rock.
In topsoil areas: Complete the backfilling with topsoil for at least the top 100 mm.

Reinstatement of surfaces

General
Reinstate existing surfaces removed or disturbed by trench excavations to match existing and adjacent work.

7. LANDSCAPE – WALLS AND FENCES

GENERAL

Inspection

Notice
Give sufficient notice so inspection may be made of the following:
- Setting out before commencement of construction.
- Filter fabric and subsurface drainage in place before backfilling.

PRODUCTS

Timber

Hardwood
All hardwood in timber fences is to be best quality without any rot, significant knots, twists, or other defects which may affect its strength.

Preservative treatment: Provide only timbers with preservative treatment painted on the timbers surface where the timber is in the ground, or ensure that all timber is highly resistant to rot.

Steel

Steel tubes and channels
All steel tubes and channels used for posts, rails, stays are to be painted or galvanized to ensure the maximum lifetime for the item without significant maintenance. Refer to **Finishes Schedule**.

Wire
Chain wire, cable wire, tie wire and barbed wire are to be galvanized or other suitable metallic finish for maximum lifetime.

Concrete walls

General
Concrete walls and concrete foundations are to be constructed as shown on the drawings.

Stonewalls

Walling stone

Natural stone: Stone of uniform quality, sound and free from defects liable to affect its strength, appearance or durability.
Field stone: Local weathered uncut random sized natural stones.
Quarried stone: Cut or uncut random or regular size stone.

Crib walls

GENERAL

Type: Proprietary system of interlocking precast concrete units with selected backfill placed and compacted progressively to form a retaining wall.

Gabion walls

GENERAL

Type: Proprietary system of rock filled wire baskets.

Brick walls

GENERAL

Brick walls on stone or concrete foundations are to be constructed as shown on the drawings.

Earth block walls

GENERAL

Earth block walls on stone or concrete foundations are to be constructed as shown on the drawings.

Filter fabric

GENERAL

Type: Polymeric fabric formed from a plastic yarn composed of at least 85% by weight of propylene, ethylene, amide or vinylidene chloride and containing stabilizers or inhibitors to make the filaments resistant to deterioration due to ultraviolet light.

Protection

Provide heavy duty protective covering. Store clear of the ground and out of direct sunlight. During installation do not expose the filter fabric to sunlight for more than 14 days.

EXECUTION

General

Set out

General: Set out the wall and fence lines and mark the positions of posts, gates and bracing panels.

Clearing

Extent: Except trees or shrubs to be retained, clear vegetation within 1 m of the landscape walls. Grub out stumps and roots of removed trees or shrubs and trim the grass to ground level, but do not remove the topsoil.

Excavation

Excavate for foundations and footings.

Earth footings

Backfill with earth around posts, compacting firmly by hand or machine in 150 mm deep layers.

Concrete footings

In ground: Place mass concrete around posts and finish with a weathered top falling 25 mm from the post to ground level.

On slabs: Provide welded and drilled post flanges and fix with 3 masonry anchors per post. Strip footings: Place mass concrete or reinforced concrete footings for walls. Refer to drawings for details.

Gates

Types

Gates are to be constructed with minimum 30 x 30mm steel tube frames for rigidity. Infill panels can be steel sheet, steel mesh, timber boards or other material as identified on the drawings.

Hardware

Provide the following:

- Drop bolt and ferrule to each leaf of double gates.
- Latch to one leaf of double gates.
- Provision for locking by padlock.
- Holding lugs for security bars to the inside face of double gates with vehicle access.
- Minimum of 2 hinges for gates 1.2m high. 3 hinges for gates 1.2 to 2.1m high. 4 hinges for gates greater than 2.1m high.

Hand access
General: Where required, provide hand holes to give access from outside to reach locking provision.

Chain wire barriers

Fence dimensions
Maximum post spacing: 3000 mm.

Component sizes
Intermediate posts: 42.4 mm diameter, 2.6 mm wall thickness.
End, corner and gate posts: 60.3 mm diameter, 2.9 mm wall thickness.

Chain wire: 3.15 mm diameter wire woven to form uniform mesh.
Mesh generally: 50 mm.
Tie wire: 2 mm diameter.

Post and rail barriers:
- Rails and gooseneck stay: 33.7 mm diameter, 2.6 mm wall thickness.

Railless barriers:
- Struts: 42.4 mm diameter, 2.6 mm wall thickness.
- Cable wires:
. Two strands: 3.15 mm diameter wire.
. One strand: 4 mm Heli coil wire.

Security barriers:
- Chain wire selvedge: Twisted and barbed.
- Barbed wire to security fencing post extensions: Barbs at 95 mm maximum centers.

Installation

Posts: Do not splice members except in posts when splice is embedded at least 150 mm into concrete. Fit tightly fitting steel caps to posts, except where fixed to overhead structure.
Chain wire: Lace chain wire to end and gate posts. Tie chain wire twice around members at 250 mm maximum intervals. Twist ends twice and cut off neatly.
Cable wire: Tension cable wire(s) to support chain wire after at least 24 hours curing of concrete footings.

Footing type: Concrete.
Footing size:
. Intermediate and end posts: 225 mm diameter x 600 mm depth.
. Corner posts and gate: 225 mm diameter x 900 mm depth.

Post and rail barriers:
Rails: Connect rail(s) to posts using bolted split pipe fittings and purpose-made caps and brackets with rail apertures.

Continuous rail type fences: Join the rails together in long lengths using purpose-made sleeves or socketed connections, and pass them through the apertures of caps and brackets on intermediate posts. Railless barriers:
- Struts: Provide struts at ends, corners and gates.
Security barriers:
- Security fencing: Strain barbed wire between post extensions.

Gates
Frame tubes: 33.7 mm diameter, 2 mm wall thickness.
Chain wire: Match fence.
Maximum width: 3600 mm.

Security barriers:
- Barbed wire security gate extension supports: 26.9 mm diameter, 2 mm wall thickness.
- Barbed wire: Match fence.

Stone walls

Construction
Select the stones for their locations and lay them in the wall with the minimum of stone cutting.
Footings: Select the largest, flattest and most regular stones for footings, and set them in concrete blinding in accordance with drawings.
Copings: Select stones of reasonably uniform size and finish the top of the wall to a level line or cap with precast concrete sections.

Retaining walls
Construction: Where dry stone walls act as retaining walls, construct the stonework to be free draining through the wall. Batter back the wall face 50 – 70 mm for every 300 mm in height. Cap

the top of the wall. Backfill progressively, with a layer at least 300 mm thick of porous material, such as coarse aggregate or crushed rock in the size range 20 – 40 mm. Install filter fabric to stop movement of silt into porous material. Minimum thickness: 450 mm.
Where stone walls are mortared, batter back the wall face 50 – 70 mm for every 300 mm in height. Cap the top of the wall. Backfill progressively, with a layer at least 300 mm thick of porous material, such as coarse aggregate or crushed rock in the size range 20 – 40 mm. Install filter fabric to stop movement of silt into porous material. Install a slotted pipe drain at the bottom of the wall backfill to ensure all water is drained away from the wall face.

8. LANDSCAPE – SOILS AND PLANTING

GENERAL

SUBMISSIONS

Suppliers
Obtain statements from suppliers of plant materials, giving the following:
- Particularly of the supplier's experience in the required type of work.
- Lead times for delivery of the material to the site.

INSPECTION

Notice
Give sufficient notice so that inspection may be made of the following:
- lawns prepared before seeding
- plant holes excavated and prepared for planting
- set out of gravel paths prepared for filling

PRODUCTS

TOPSOIL

Source
Import topsoil unless the topsoil type can be provided from material recovered from the site.

Additives

Use additives to raise topsoil to the required standard approved by the Engineer.

COMPOST AND FERTILIZER

Compost
Provide well-rotted vegetative material or animal manure, free from harmful chemicals, grass and weed growth.
Fertilizer
Provide proprietary fertilizers, delivered to the site in sealed bags marked to show manufacturer or vendor, weight, fertilizer type, recommended uses and application rates.

GRAVEL PATHS

Provide paths constructed with consolidated small gravel chippings and concrete edging pavers were shown on plans.

EXECUTION

PREPARATION

Vegetative spoil
Remove vegetative spoil from site. Do not burn.

ROCKWORK

Rock work
General: Place rocks while ground formation work is being carried out. Provide site rock, otherwise provide imported rock. Bury rock two thirds by volume, with weathered faces exposed. Protect the weathered faces from damage.
Site rock: Stockpile for future placement and accessibility for lifting. Dispose of other rock off site.
Imported rock: Provide rock which has been selected before delivery.

SUBSOIL

Ripping
Rip parallel to the final contours wherever possible. Do not rip when the subsoil is wet or plastic. Do not rip within the dripline of trees and shrubs to be retained.
Ripping depths: Rip the subsoil to the following typical depths:
- Compacted subsoil: 300 mm.

- Heavily compacted clay subsoil: 450 mm.

Planting beds

Excavated: Excavate to bring the subsoil to at least 300 mm below finished design levels. Shape the subsoil to fall to subsoil drains where applicable. Break up the subsoil to a further depth of 100 mm.

Unexcavated: Remove weeds, roots, builder's rubbish and other debris. Bring the planting bed to 75 mm below finished design levels.

Cultivation

Minimum depth: 100 mm.
Services and roots: Do not disturb services or tree roots; if necessary, cultivate these areas by hand.
Cultivation: Thoroughly mix in materials required to be incorporated into the subsoil. Cultivate manually within 300 mm of paths or structures. Remove stones exceeding 50 mm, and weeds, rubbish or other deleterious material brought to the surface during cultivation. Trim the surface to design levels after cultivation.

Additives

Apply additives after ripping or cultivation and incorporate into the upper 100 mm layer of the subsoil. Refer to the **Soil additives schedule.**

TOPSOIL

Placing topsoil

Spread the topsoil on the prepared subsoil and grade evenly. Ensure that grassed areas may be finished flush with adjacent hard surfaces such as kerbs, paths and mowing strips.
Contamination: Where diesel oil, cement or other toxic material has been spilt on the subsoil or topsoil, excavate the contaminated soil, dispose of it off the site, and replace it with site soil or imported topsoil.
Finishing: Feather edges into adjoining undisturbed ground.

Consolidation

Compact lightly and uniformly in 150 mm layers. Produce a finished topsoil surface which has the following characteristics:
- Smooth and free from stones or lumps of soil.
- Graded evenly into adjoining ground surfaces.
- Ready for planting.

Refer to the **Soil additives schedule**.

Topsoil depths
Spread topsoil to the following typical depths:
- Excavated planting areas: If using organic mulch, 200 mm.
- Irrigated grassed areas generally: 150 mm.
- Non-irrigated grass areas: 100 mm.

Surplus topsoil
Spread surplus topsoil on designated areas on site, if any; otherwise, dispose off-site.
Designated areas to be determined by the Engineer.

GRAVEL PATHS

Pavement
Use small size gravel in layers not exceeding 150 mm thick to form paths were shown on drawings.
Colour and type of gravel to the approval of the Engineer. Retain sides of path with either:
- Precast decorative concrete paving edge strips, color to approval of the Engineer.
- Concrete kerbs

9. PAVEMENT BASE AND SUBBASE

GENERAL

INSPECTION
Notice
Give sufficient notice so that inspection may be made of the following:
- Prepared subgrade.
- Proof rolling of base prior to sealing.

TESTS

Compaction control tests
The placement and compaction criteria of fill shall be in accordance with K20-1CS.
Frequency of compaction control tests
Not less than the following (whichever requires the most tests):
- 1 test per layer per 25 lineal meters for 2-lane roads.
- 1 test per layer per 1000 $m^2$for carparks.

- 3 tests per layer.

PRODUCTS

BASE AND SUBBASE MATERIAL

GENERAL

Base and subbase materials shall comply with the **Base and subbase compliance table**.

Base and subbase compliance table

Course	Source	Compliance requirement
Base	Crushed rock or natural gravel	
Subbase	Crushed rock or natural gravel	

EXECUTION

SUBGRADE PREPARATION

General

Subgrade preparation to be undertaken in accordance with the Earthwork work section.

SUBBASE AND BASE COMPACTION

General

Compact each layer of fill to the required depth and density, as a systematic construction operation.
Unstable areas: Any unstable areas which develop during rolling or are identified by proof rolling shall be removed for the full depth of the layer and disposed of and replaced with fresh material.

Compaction requirements

Apply uniform and sufficient compactive effort over the whole area to be compacted. Use rollers appropriate to the materials and compaction requirements.

Moisture content

During spreading and compaction, maintain materials at the optimum moisture content to permit maximum compaction of the material.
Spraying: Maintain moisture content. Use water spraying equipment capable of distributing water uniformly in controlled quantities over uniform lane widths.

PLACING BASE AND SUBBASE

General
Weak surfaces: Do not place material on a surface which has been so weakened by moisture that it will not support, without damage, the constructional plant required to perform the work.
Spreading: Spread material in uniform layers without segregation.
Moisture content: Maintain wet mixed materials at the required moisture content before and during spreading. Add water to dry mixed materials through fine sprays to the entire surface of the layer after spreading, to bring the material to the required moisture content.
Layer thickness: 150 mm maximum and 75 mm minimum (after compaction). Provide equal layers in multilayer courses.

CONCRETE PAVEMENT

GENERAL

INTERPRETATION

Definitions
For the purposes of this work section the definitions given below apply.
- Absolute level tolerance: Maximum deviation from design levels.
- Relative level tolerance: Maximum deviation from a 3 m straight edge laid on the surface.

INSPECTION

Notice
Give sufficient notice so that inspection may be made of the following:
- Concrete formwork, reinforcement and dowels in position.
- Commencement of concrete placing.

SUBMISSIONS

Products – proposals
Curing compounds: If it is proposed to use a liquid membrane-forming curing compound submit certified test results for water retention.
Curing by the covering sheet method: Submit details of the proposed covering material. Repair materials: Submit proposals for epoxy resin/grout and elastomeric sealant.

TESTS

General

Perform tests of the type and frequency necessary to adequately control the materials and processes used in the construction of the works and in conformance with the **Tests schedule**.

Compliance assessment tests

Timing: Obtain materials samples at the time of delivery to the site.

Location: Sample from selected sample sites within designated uniform test lots, consisting of an area placed, or compacted or both in one day. Test lots must be uniform in terms of material properties and density.

Specimen type: A set of compression test specimens shall consist of four 200 x 200 x 200 mm cubes, each cube being one specimen.

The specimens within each set shall be tested at the following ages in conformance with the

Test schedule.

- One at 7 days for information.
- Two in 28 days. The 28 day strength shall be taken as the average of the two specimens. If one specimen in this test shows evidence of improper sampling, molding or testing, it shall be discarded. The remaining specimen shall be considered the test result. Should both specimens show the specified defects, the entire test shall be discarded.
- The fourth shall be retained as a spare to be tested as required.

Discharge slump tests

Carry out slump tests at approximately one quarter and three-quarter points of the load during discharge. Working slump: 100mm

Maximum slump: 125 mm. Note concrete with slump greater than this value will be rejected and removed from the site at the contractor's cost.

Flexural strength assessment of concrete

Acceptance criterion: The average strength of any set of 3 consecutive project samples must not exceed the specified maximum value.

Tests schedule

Samples	ASTM C172
Curing	ASTM C31

Testing	ASTM C39
Slump Determination	ASTM C143
Air Content	ASTM C231 or C173

PRODUCTS

REINFORCEMENT

All reinforcing shall be supported and wired together to prevent displacement by construction loads, or the placing of concrete, beyond the tolerances specified in ACI 301. Any tack or spot welding of reinforcement shall not be performed without approval from the Engineer.

Reinforcement shall be free of loose rust and of any other coating which may adversely affect the bond.

Splices in bar reinforcement shall be located and lapped as shown on the design drawings. Bars in lapped splices shall be in contact unless otherwise shown on the design drawings. Additional splices, if required, shall be made only at locations, and in a manner approved by the Engineer. Welded splices shall not be used. All lap splices in bar reinforcement shall be fully in compliance with ACI 318-02.

Welded wire fabric used in concrete paving shall have lapped splices made so that the overlap between the outermost cross wires of each fabric sheet is at least 50 mm.

Unless specifically indicated on the design drawings, splicing by means of proprietary mechanical splices shall not be used.

Concrete spacers, metal or plastic bar spacers i.e. chairs, shall be used for obtaining proper spacing of reinforcement from the bottom and sides of formwork.

Dowels

Provide each dowel in one piece, straight, cut accurately to length with ends square and free from burrs. Fix in locations as shown on the design drawings.

AGGREGATE

Aggregate size:

- For fixed form placement: < 40 mm.
- For slip form placement: To be a size compatible with the paving machine.

Washing: Wash aggregate as necessary or as directed to remove significant dust or achieve requirements for soluble salt content or concrete drying shrinkage.

CEMENT

Cement shall conform to the requirements of ASTM specification C-150 Type 1 or similar approved standard for normal Portland cement.
Cement shall be free from any hardened lumps and foreign matter. It shall have a minimum of 90% of particles by weight passing the 75-micron sieve, an initial setting time in excess of 30 minutes and a final setting time of less than 7 hours.
Cement shall be stored in a waterproof shaded area. The cement stacks shall be placed at a minimum distance of 300mm from the walls. The damp proof floor shall be constructed by raising it minimum 300mm above the ground.
Curing Compounds
: Obtain approval from the Engineer for all curing compounds prior to use.
Covering sheet materials: To be opaque polyethylene film, or burlap-polyethylene sheet, or equivalent material.

Concrete
Ready-mixed concrete shall comply with M-150 (1:2:4) for non-reinforced mass concrete and M-200 (1:1.5:3) for reinforced concrete and the requirements of these standards.

On-site batch mixed concrete shall have characteristics and proportions of concrete ingredients which conform to those specified in M-150 (1:2:4) and M-200 (1:1.5:3).
Admixtures: Introduce a solution in a portion of the mixing water. Ensure a uniform distribution of the admixture in the batch within the mixing period.
Mixing time: Measure the mixing time after solid materials are in the mixer, provided that mixing water is introduced before a quarter of the mixing time has elapsed. Increase mixing time if necessary to obtain the required uniformity and consistency of concrete. Do not overmix such that additions of water are needed.
Transport: Transport and discharge the concrete without segregation.
Elapsed delivery time: Discharge truck mixed concrete within a time (t hours) determined as follows, where T is the temperature of the concrete in degrees Celsius: $t = 2 - 0.05T$.

EXECUTION

PLACING

Rate
Place at a rate of at least 25 linear meters of pavement per hour.

Tolerances
Edges abutting gutters: Within 5 mm of the level of the actual gutter edge.

Rigid pavement surface:
- Absolute tolerance: ± 10 mm.
- Relative tolerance: 5 mm.

Concrete surface course: + unspecified, - 5 mm.
Joint locations (rigid pavement): 15 mm.

Cold weather
Subbase: Ensure that the subbase surface is free of frost.

Cold weather concreting shall be in accordance with the following:

a. The guidelines of ACI 306R shall be followed when the Forecasted Mean Daily Temperature drops below 4°C for three consecutive days. The minimum concrete temperature when delivered at the site shall be in accordance with Table I.
b. If water or aggregate is heated above 38°C, the water shall be combined with the aggregate in the mixer before cement is added. Cement shall not be mixed with water or with mixtures of water and aggregate having a temperature greater than 38°C.
c. Concrete shall only be poured when the ambient temperature is rising.
d. All concrete shall be insulated from freezing for the greater of following:
   1. 3 days
   2. Until the concrete reaches an in-place compressive strength of 35 kg/cm2,
e. All materials shall be free from frost.
f. Accelerating admixtures shall not be used without approval from the Engineer.

Maintain the concrete at a temperature of at least 10°C for at least 24 hours after placing.

Admixtures
General: Do not add calcium chloride, salts, chemicals or other material to the mix to lower the freezing point of the concrete.

TABLE I - <u>MINIMUM COLD WEATHER TEMPERATURE</u>

AIR TEMPERATURE °C	**MINIMUM CONCRETE TEMPERATURE °C**	
	For Sections with Smallest Dimension Less Than 300 mm	**For Sections with Smallest Dimension 300 mm Or Greater**
-1 to 4	16	13

-18 to -1	18	16
Below -18	21	18

Hot weather

Avoid premature stiffening of the mix and reduce water absorption and evaporation losses. If the temperature of the surrounding air is higher than 32°C:

- Mix, transport, place and compact the concrete as rapidly as possible, and cover with an impervious membrane or hessian kept wet until moist curing begins.
- Hold the concrete to a temperature 32°C when placed.

Hot weather concreting shall be in accordance with the following:

a. Concrete temperatures shall be kept within desirable limits using methods recommended in ACI 305R.

b. For mass concrete, i.e., concrete sections having a minimum dimension of 750mm or greater, the maximum acceptable concrete temperature is 21°C at time of discharge.

c. For other concrete structures, the maximum acceptable concrete temperature is 32°C at time of discharge.

d. If ice is used as part of the mixing water, mixing should be continued until the ice is completely melted. e. Retempering shall not increase the water content above that in the mix design.

Placing in fixed forms

Place concrete uniformly over the width of the slab or lane and so that the face is generally vertical and normal to the direction of placing. Hand spread concrete using shovels, not rakes.

Compact concrete using internal mechanical vibration of sufficient amplitude to produce noticeable vibrations at 300 mm radius. Insert vibrators into the concrete to the depth which will provide the best compaction, but not deeper than 50 mm above the surface of the subbase, and for a duration sufficient to produce satisfactory compaction, but not longer than 30 seconds in any one location.

Slip form placing

Spreading: Place the plastic concrete in a uniform layer over the width of the slab being placed. Do not damage the existing surface and edge of previously constructed concrete.

Vibration: Use suitable internal vibrators or surface type equipment with vibrating beam or beams of adequate power to fully compact the whole depth of the concrete.

Slab edges: Use supplementary immersion type vibrators next to slab edges if necessary to ensure that the sides of slabs present a uniform dense appearance free from honeycombing or areas deficient in fines over at least 95% of the surface.

Finishing

Immediately after placement and spreading and compaction of the plastic concrete, start finishing operations to achieve finish shown on the drawings.

Curing

Protect fresh concrete from premature drying and from excessively hot or cold temperatures. Maintain the concrete at a reasonably constant temperature with minimum moisture loss for the curing period.

Temperature: Maintain the concrete at a temperature > 5°C for at least 7 days.
Curing compound method: Spray the entire surface including edges using a mechanical sprayer, at a uniform application rate of at least 0.35 L/m^2. Respray defective areas within 30 minutes. Respray within 3 hours after heavy rain. Apply as a continuous coating without visible breaks or pinholes.
Covering sheet method: Immediately after finishing operations, cover concrete using damp hessian or cotton mats overlapped at least 150 mm and anchored against displacement by wind or other interference. Keep the mats continuously damp until covered by the covering sheet material. Repair tears and the like immediately.
Joint sawing: Sheet materials may be removed for the minimum distance and period to permit joint sawing, provided the concrete is kept moist by other means.
Moist curing method: Immediately after finishing operations keep the concrete surface continuously damp by spraying constantly with water, fog, or mist, using suitable spraying equipment.
Minimum curing time: 7 days.

JOINTS

Construct expansion, contraction and construction joints straight and plumb. Make transverse joints normal to longitudinal joints. Extend transverse expansion and contraction joints continuously from edge to edge of the pavement through interconnected slabs.

Transverse construction joints: To be as follows:
- Planned location: Terminate each day's placing operation at a transverse construction joint located to coincide with a planned contraction or expansion joint.

- Unplanned joints: If placement is interrupted for 30 minutes or longer, form a tied transverse construction joint within the middle third of the distance between planned joints but no closer than 1.5 m to the nearest planned joint. If necessary, remove placed concrete back to the required location. Expansion joints: Provide formed full depth joints around structures and features which project through, into or against the pavement, and elsewhere as required.

COMPLETION

Protection
Keep traffic, including construction plants, off the pavement entirely during curing, and thereafter permit access only to necessary constructional plant vehicles until the pavement is at least 14 days old.

Traffic on pavement
General: Give notice before opening the pavement to traffic before the work is completed. Provide adequate means of protection.

10. **PAVERS – MORTAR BED**

GENERAL

INSPECTION

Notice
Give sufficient notice so that inspection may be made of the following:
- Substrate immediately before tiling.
- Trial set-outs before execution.
- Control joints before sealing.

SUBMISSIONS

Samples
Submit labeled samples of pavers, grout and sealants, illustrating the range of variation in color and finish.

TOLERANCES

Completed paving

Conform to the **Surface level tolerances table**:

Surface level tolerances table

Item	Level tolerance	
	Absolute	**Relative**
Vehicular pavements- mortar	± 5 mm	5 mm
Footpaths- mortar	± 10 mm	<10 mm

PRODUCTS

MORTAR

Materials

Cement shall conform to the requirements of ASTM specification C-150 Type 1 or similar approved standard for normal Portland cement.

- White cement: Iron salts content ≤ 1%.
- Off-white cement: Iron salts content ≤ 2.5%.

Lime: Confirm source of Lime with Engineer to ensure highest quality Lime is used in the mortar. Protect from damage on site and store minimum 300mm above ground in a waterproof storage facility.

Sand: Fine aggregate with a low clay content selected for grading, sharp and free from efflorescing salts. River or pit sand should be sharp, angular, hard, clean uncoated particles free from clay and organic impurities.

Water: Water to be used for the mixing of mortar should be clean and free from oil, acid, alkali, salts, organic materials or other substances that are harmful to the mortar mix.

Measurement of volume: Measure binders and sand by volume using buckets or boxes. Do not allow sand to bulk by absorption of water.

Bedding mortar

Proportioning: Standard and ratio of mix for all mortar shall be M-400 (1:3), M-300 (1:4), M-250 (1:5) and M 200 (1:6) Provide minimum water.

GROUT

Type

Cement based proprietary grout: Mix with water. Fine sand may be added as a filler in wider joints. Portland cement-based grout: Mix with fine sand. Provide minimum water consistent with workability.

- For joints < 3 mm: 1 cement:2 sand.
- For joints 3 mm: 1 cement:3 sand.

Pigments

Pigments for coloured grout: Provide colourfast fillers compatible with the grout material. For cement-based grouts, provide lime-proof natural or synthetic metallic oxides compatible with cement.

Water

General: To be clean and free from any deleterious matter.

PAVERS

Concrete and clay segmental paving units

Provide labeled samples of all pavers for approval of the Engineer prior to use. Ensure that the horizontal dimensions of each paver have a maximum variation of 3mm in 300mm. Any pavers outside this tolerance will be rejected and removed from the site. Ensure that all pavers are free from fault lines, cracked edges, surface flakes, mould marks or other defects before use.

Stone paving units

Provide labeled samples of all pavers for approval of the Engineer prior to use. Ensure that all stone pavers are free from fault lines, cracked edges, surface flakes or other defects before use.

EXECUTION

SUBSTRATES

Drying and shrinkage

Before paving, allow at least the following times to elapse (for initial drying out and shrinkage) for these substrates:

- Concrete slabs: 42 days.
- Toppings on slabs: A further 21 days.

PREPARATION

Trial set-out
Prepare a trial paving set-out to each area as follows to:
- Maximise the size of equal margins of cut pavers.
- Locate movement joints.
- Note minor variations in joint widths to eliminate cut tiles at margins.

Ambient temperature
General: If the ambient temperature is < 5 or > 35°C, do not lay pavers.
Substrates
Ensure substrates are as follows:
- Clean and free of any deposit or finish which may impair adhesion or location of pavers. - Excessive projections are hacked off and voids and hollows are filled with cement: sand mix not stronger than the substrate or weaker than the bedding.
Absorbent substrates: If suction is excessive, control it by dampening but avoid over-wetting and do not apply mortar bedding to substrates showing surface moisture.
Dense concrete: If not sufficiently rough to provide a mechanical key, roughen by scrabbling or the like to remove 3 mm of the surface and expose the aggregate; then apply a bonding treatment.

Fixtures
Before paving ensure that fixtures interrupting the surface are accurately positioned in their designed or optimum locations relative to the paving layout.

PAVING GENERALLY
Variations
If necessary, distribute variations in hue, colour, or pattern uniformly, by mixing pavers or paving batches before laying.

Paving joints
Joint widths: Set out pavers to give uniform joint widths of 6 < 12 mm.

Margins
Provide whole or purpose-made pavers at margins where practicable, otherwise set out to give equal margins of cut pavers. If margins less than half paver width are unavoidable, locate the cut pavers where they are least conspicuous.

Protection
Traffic: Keep pedestrian and vehicular traffic off paving until the bedding has set and attained its working strength.

Cleaning: Keep the work clean as it proceeds and protect finished work from damage.

MORTAR BEDDING

Preparation of pavers
Suction: Soak porous pavers in water for half an hour and then drain until the surface water has disappeared.

Bedding
Use bedding methods and materials which are appropriate to the paver, the substrate, the conditions of service, and which leave the paver firmly and solidly bedded in the bedding material and adhered to the substrate. Form falls integral with the substrate.

Mortar beds
Either lightly dust the screeded bed surface with dry cement and trowel level until the cement is damp, or spread a thin slurry of neat cement, or cement-based thin bed adhesive, on to the tile back.
Do not provide mortar after the initial set has occurred.
Nominal thickness of 20mm for mortar bed unless noted otherwise on drawings.

MOVEMENT JOINTS

General
Provide movement joints in the following locations:
- Location:
. Over structural (isolation, contraction, expansion) joints.
. At internal corners.
. Around the perimeter at abutments.
. At junctions between different substrates.
. To divide large paved areas into bays, maximum 5 m wide, maximum 16 m^2.
. At abutments with the building structural frame and over supporting walls or beams where flexing of the substrate is anticipated.
- Depth of joint: Right through to the substrate.
- Sealant width: 6 – 25 mm.
- Depth of elastomeric sealant: One half the joint width, or 6 mm, whichever is the greater.

Movement joint materials

Divider strip: A proprietary expansion joint consisting of a neoprene filler sandwiched between plates with lugs or ribs for mechanical keying. Set flush with the finished surface.
Proprietary slide plate divider strip: An arrangement of interlocking metal plates grouted into pockets formed in the concrete joint edges.
Sealant: Two-pack self-leveling non-hardening mold resistant, one-part silicone or polyurethane sealant applied over a backing rod. Finish flush with the tile surface.
Backing rod: Compressible closed cell polyethylene foam with a bond-breaking surface.

GROUTED AND CAULKED JOINTS

Grouted joints
Commence grouting as soon as practicable after bedding has set. Clean out joints as necessary before grouting.
Face grouting: Fill the joints solid and tool flush. Clean off surplus grout. Wash down when the grout has set. When the grout is dry, polish the surface with a clean cloth.

COMPLETION

Cleaning
Completion: Leave pavements clean on completion.

11. **PAVERS – SAND BED**

GENERAL

INSPECTION

Notice
Give sufficient notice so that inspection may be made of the following:
- Completed base preparation.
- Completed trial set-out for segmental paving.

TOLERANCES

Tolerances
Conform to the Surface level tolerances table:

Surface level tolerances table

Level tolerance		
Item	**Absolute**	**Relative**
Vehicular pavements	± 10 mm	10 mm
Footpaths	± 10 mm	5 mm

PRODUCTS

MATERIALS

Bedding sand

Grading: All sand must pass through a sieve with 2.0mm apertures.
Moisture content: Uniform in moisture content with spread.
Deleterious material: Free of deleterious material, such as soluble salts which may cause efflorescence.

Joint filling sand

Grading: All sand must pass through a sieve with 1.0mm apertures.
Moisture content: The sand shall be dry when spread.

Deleterious material: Free of deleterious material, such as soluble salts which may cause efflorescence.

COMPONENTS

Concrete and clay segmental paving units

Provide labeled samples of all pavers for approval of the Engineer prior to use. Ensure that the horizontal dimensions of each paver have a maximum variation of 3mm in 300mm. Any pavers outside this tolerance will be rejected and removed from the site. Ensure that all pavers are free from fault lines, cracked edges, surface flakes, mold marks or other defects before use.

Stone paving units

Provide labeled samples of all pavers for approval of the Engineer prior to use. Ensure that all stone pavers are free from fault lines, cracked edges, surface flakes or other defects before use.

EXECUTION

SUBGRADE PREPARATION

General

The subgrade shall be prepared in accordance with the Earthwork work section.

SUBBASE

General

The subbase shall be prepared in accordance with the Pavement base and subbase work section.

BASE

General

The base course shall be prepared in accordance with the Pavement base and subbase work section.

BEDDING SAND

General

Preparation: Remove all loose material from the prepared base.

Spreading: Screed uncompacted sand over prepared base in a uniform manner to achieve a 30 mm thick layer. Maintain sand at a uniform loose density.

LAYING PAVING

General

Pattern: Paving units are to be laid on the screeded sand bedding to the nominated pattern shown on the drawings.
Joints: Paving units are to be laid with a 2 – 3 mm gap between adjoining units.
Cut courses: Do not use cut units with a plain dimension of less than 50 mm.
Control joints: Where paving units are to be placed over control joints in an underlying concrete base, a joint is to be provided in the pavers. The joint shall be 10 mm wide and filled with approved jointing material.

COMPACTION OF BEDDING

General

After laying of the paving units the sand bedding shall be fully compacted using a vibrating plate compactor. Joint filling: All paving units are to be compacted to design levels prior to the commencement of joint filling.

JOINT FILLING

General

Spread dry sand over the paving units and fill the joints by brooming. Undertake one or more passes with the vibrating plate compactor and refill the joints with sand. Repeat the process until the joints are completely filled.

Timing: Fill joints on the same day that pavers are compacted.

PROTECTION OF THE WORK

General

Protection: All vehicular and pedestrian traffic shall be prevented from using the pavement until all compaction and joint filing is completed and all edge restraints are in place.

CLEANING

Cleaning

General: Leave pavements clean on completion.

12. PAVEMENT KERB, CHANNEL AND LINEMARKING

GENERAL

INSPECTION

Notice

Give sufficient notice so that inspection may be made of the following:

- Set out the kerbs and channels.
- Set out of line marking prior to painting.

TOLERANCES

Kerbs and channels conform to the following:

- Absolute level tolerance: 10 mm.
- Maximum deviation from design alignment: 50 mm.

- Maximum deviation from a 3 m straightedge placed on horizontal, vertical, or sloping surfaces required to be straight: 5 mm.

Line marking to conform to the following:

- The location of markings shall not vary from the locations shown on the drawings by more than 50mm.

INTERPRETATION

Definitions

General: For the purposes of this work section the definitions given below apply.

- Absolute level tolerance: Maximum deviation from design levels.
- Relative level tolerance: Maximum deviation from a 3 m straightedge laid on the surface - Channels and kerbs: Includes all forms of concrete gutters, dish drains, grated drains and mountable barrier kerbing.

PRODUCTS

MATERIALS

Concrete

Ready-mixed concrete shall comply with M-150 (1:2:4) for non-reinforced mass concrete and M-200 (1:1.5:3) for reinforced concrete and the requirements of these standards.

On-site batch mixed concrete shall have characteristics and proportions of concrete ingredients which conform to those specified in M-150 (1:2:4) and M-200 (1:1.5:3).

Pavement marking paint

Provide samples of pavement marking paint and technical specifications for approval by the Engineer prior to use on site.

EXECUTION

LINEMARKING

Setting out

Set out the work to ensure that all markings are placed in accordance with the drawings.

Surface preparation

Clean dry surface: Pavement markings shall only be applied to clean dry surfaces. Clean the surface to ensure a satisfactory bond between the markings and wearing surface of the pavement.

Wet weather: Pavement marking shall not be carried out during wet weather or if rain is likely to fall during the process.
Provision for traffic: Provide for traffic while undertaking the work and protect the pavement markings until the material has hardened sufficiently so that traffic will not cause damage.
Mixing of paint: All paint shall be thoroughly mixed in its original container before use to produce a smooth uniform product.

Application of paint
Pavement markings shall be straight or with smooth, even curves where intended. All edges shall have a clean, sharp cut off. Any marking material applied beyond the defined edge of the marking shall be removed leaving a neat and smooth marking on the wearing surface of the pavement.

Removal of pavement markings
General: Remove pavement markings, no longer required, from the wearing surface of pavements without significant damage to the surface.

CHANNELS AND KERBS

General
Before placing any kerb and/or gutter, the foundation material shall be shaped and compacted to form a firm base. Where placed on pavement courses, the foundation shall be compacted to the requirements of the Pavement base and subbase work section.

Kerb and/or gutters may be constructed in fixed forms, by extrusion or by slip forming in accordance with the drawings. The foundation, concrete quality, curing and testing details shall be in accordance with the Concrete Paving work section.

Tolerances
The level at any point on the surface of the gutters shall be within ± 10 mm of design levels. When a straight edge 3 m long is laid on top of or along the face of the kerb or on the surface of gutters, the surface shall not vary more than 5 mm from the edge of the straight edge.

Joints
Contraction joints: Formed every 3 m of gutter length for a minimum of 50% of cross-sectional area. The joint shall be tooled 20 mm in depth to form a neat groove of 5 mm minimum width.

Expansion joints: 15 mm in width for the full depth of the kerb and gutter. Joints shall be constructed at intervals not exceeding 15 m and where the gutter is attached to pits and retaining walls. Expansion joints shall consist of approved preformed jointing material.

Concrete pavement: Where kerbs and/or gutters are cast adjacent with a concrete pavement the same type of contraction, construction and expansion joints specified in the concrete base shall be continued across the kerb and/or gutter.

Backfill

Timing: After the new kerb and gutter has been constructed and not earlier than three days after placing, the spaces on both sides of the kerb and/or gutters shall be backfilled and reinstated in accordance with the drawings.

Material: Backfill material behind the kerb shall consist of granular material, free of organic material, clay and rock in excess of 50 mm diameter.

Compaction: Backfill material behind the kerb shall be compacted in layers not greater than 150 mm thick.

13. CONCRETE GENERAL

GENERAL

INSPECTION

Notice

Give sufficient notice so that inspection may be made of the following:

- Base or subgrade before covering.
- Membrane or film underlay installed on the base.
- Completed formwork, and reinforcement, cores, fixings and embedded items fixed in place. - Surfaces or elements to be concealed in the final work before covering.
- Commencement of concrete placing.

SUBMISSIONS

Products – proposals

Curing compounds: If it is proposed to use a liquid membrane-forming curing compound submit certified test results for water retention.

Curing by the covering sheet method: Submit details of the proposed covering material. Repair materials: Submit proposals for epoxy resin/grout and elastomeric sealant.

TESTS

General

Perform tests of the type and frequency necessary to adequately control the materials and processes used in the construction of the works and in conformance with the **Tests schedule**.

Compliance assessment tests

Timing: Obtain materials samples at the time of delivery to the site.

Location: Sample from selected sample sites within designated uniform test lots, consisting of an area placed, or compacted or both in one day. Test lots must be uniform in terms of material properties and density.

A set of compression test specimens shall consist of four 200 x 200 x 200 mm cubes, each cube being one specimen.

The specimens within each set shall be tested at the following ages in conformance with the **Tests schedule.** - One at 7 days for information.

- Two in 28 days. The 28-day strength shall be taken as the average of the two specimens. If one specimen in this test shows evidence of improper sampling, moulding or testing, it shall be discarded. The remaining specimen shall be considered the test result. Should both specimens show the specified defects, the entire test shall be discarded.
- The fourth shall be retained as a spare to be tested as required.

Discharge slump tests

Carry out slump tests at approximately one quarter and three-quarter points of the load during discharge. Working slump: 80mm

Maximum slump: 110 mm. Note concrete with slump greater than this value will be rejected and removed from the site at the contractor's cost.

Flexural strength assessment of concrete

Acceptance criterion: The average strength of any set of 3 consecutive project samples must not exceed the specified maximum value.

Tests schedule

Samples	ASTM C172
Curing	ASTM C31
Testing	ASTM C39
Slump Determination	ASTM C143
Air Content	ASTM C231 or C173

PRODUCTS

Reinforcement

All reinforcing shall be supported and wired together to prevent displacement by construction loads, or the placing of concrete, beyond the tolerances specified in ACI 301. Any tack or spot welding of reinforcement shall not be performed without approval from the Engineer.
Reinforcement shall be free of loose rust and of any other coating which may adversely affect the bond.

Splices in bar reinforcement shall be located and lapped as shown on the design drawings. Bars in lapped splices shall be in contact unless otherwise shown on the design drawings. Additional splices, if required shall be made only at locations, and in a manner approved by the Engineer. Welded splices shall not be used. All lap splices in bar reinforcement shall be fully in compliance with ACI 318-02.

Welded wire fabric used in concrete paving shall have lapped splices made so that the overlap between the outermost cross wires of each fabric sheet is at least 50 mm.
Unless specifically indicated on the design drawings, splicing by means of proprietary mechanical splices shall not be used.

Concrete spacers, metal or plastic bar spacers i.e. chairs, shall be used for obtaining proper spacing of reinforcement from the bottom and sides of formwork.

Dowels

Provide each dowel in one piece, straight, cut accurately to length with ends square and free from burrs. Fix in locations as shown on the design drawings.

Formwork

Construct formwork with timber or steel elements to support the concrete for the full duration of the critical curing period. Construct in a durable manner with sufficient props and fixings to ensure that the formwork remains in position at all times.

Aggregate

Aggregate size:
- For fixed form placement: < 40 mm.
- For slip form placement: To be a size compatible with the paving machine.

Washing: Wash aggregate as necessary or as directed to remove significant dust or achieve requirements for soluble salt content or concrete drying shrinkage.

Cement

Cement shall conform to the requirements of ASTM specification C-150 Type 1 or similar approved standard for normal Portland cement.

Cement shall be free from any hardened lumps and foreign matter. It shall have a minimum of 90% of particles by weight passing the 75-micron sieve, an initial setting time in excess of 30 minutes and a final setting time of less than 7 hours.

Cement shall be stored in a waterproof shaded area. The cement stacks shall be placed at a minimum distance of 300mm from the walls. The damp proof floor shall be constructed by raising it minimum 300mm above the ground.

Curing products

Curing compounds: Obtain approval from the Engineer for all curing compounds prior to use.

Covering sheet materials: To be opaque polyethylene film, or burlap-polyethylene sheet, or equivalent material.

Concrete

Ready-mixed concrete shall comply with M-150 (1:2:4) for non-reinforced mass concrete and M-200 (1:1.5:3) for reinforced concrete and the requirements of these standards.

On-site batch mixed concrete shall have characteristics and proportions of concrete ingredients which conform to those specified in M-150 (1:2:4) and M-200 (1:1.5:3).

Admixtures: Introduce a solution in a portion of the mixing water. Ensure a uniform distribution of the admixture in the batch within the mixing period.

Mixing time: Measure the mixing time after solid materials are in the mixer, provided that mixing water is introduced before a quarter of the mixing time has elapsed. Increase mixing time if necessary to obtain the required uniformity and consistency of concrete. Do not overmix such that additions of water are needed.

Transport: Transport and discharge the concrete without segregation.

Elapsed delivery time: Discharge truck mixed concrete within a time (t hours) determined as follows, where T is the temperature of the concrete in degrees Celsius: $t = 2 - 0.05T$.

POLYMERIC FILM UNDERLAY

Location
Provide a vapor barrier under slabs on ground including integral ground beams and footings.

Installation
Lay over the base, lap joints at least 200 mm and seal the laps and penetrations with waterproof adhesive tape. Face the laps away from the direction of concrete pour. Patch or seal punctures or tears before pouring concrete. Cut back as required after concrete has gained strength and forms have been removed.

Base preparation
According to base type, as follows:
- Concrete working base: Remove projections above the plane surface, and loose material. - Graded prepared subgrade: Blind with sufficient sand to create a smooth surface free from hard projections. Wet the sand just before laying the underlay.

EXECUTION

PLACING- GENERAL

Cold weather
Subbase: Ensure that the subbase surface is free of frost.
Cold weather concreting shall be in accordance with the following:

a. The guidelines of ACI 306R shall be followed when the Forecasted Mean Daily Temperature drops below 4°C for three consecutive days. The minimum concrete temperature when delivered at the site shall be in accordance with Table I.
b. If water or aggregate is heated above 38°C, the water shall be combined with the aggregate in the mixer before cement is added. Cement shall not be mixed with water or with mixtures of water and aggregate having a temperature greater than 38°C.
c. Concrete shall only be poured when the ambient temperature is rising.
d. All concrete shall be insulated from freezing for the greater of following:

1. 3 days

2. Until the concrete reaches an in-place compressive strength of 35 kg/cm2, e. All materials shall be free from frost.

f. Accelerating admixtures shall not be used without approval from the Engineer.
Maintain the concrete at a temperature of at least 10°C for at least 24 hours after placing.

Admixtures

General: Do not add calcium chloride, salts, chemicals or other material to the mix to lower the freezing point of the concrete.

TABLE I - MINIMUM COLD WEATHER TEMPERATURE

AIR TEMPERATURE °C	MINIMUM CONCRETE TEMPERATURE °C	
	For Sections with Smallest Dimension Less Than 300 mm	For Sections with Smallest Dimension 300 mm Or Greater
-1 to 4	16	13
-18 to -1	18	16
Below -18	21	18

Hot weather
Avoid premature stiffening of the mix and reduce water absorption and evaporation losses. If the temperature of the surrounding air is higher than 32°C:
- Mix, transport, place and compact the concrete as rapidly as possible, and cover with an impervious membrane or hessian kept wet until moist curing begins.
- Hold the concrete to a temperature 32°C when placed.

Hot weather concreting shall be in accordance with the following:
a. Concrete temperatures shall be kept within desirable limits using methods recommended in ACI 305R.
b. For mass concrete, i.e., concrete sections having a minimum dimension of 750mm or greater, the maximum acceptable concrete temperature is 21°C at time of discharge.
c. For other concrete structures, the maximum acceptable concrete temperature is 32°C at time of discharge.
d. If ice is used as part of the mixing water, mixing should be continued until the ice is completely melted. e. Retempering shall not increase the water content above that in the mix design.

Placing in fixed forms
Place concrete uniformly over the width of the slab and so that the face is generally vertical and normal to the direction of placing. Hand spread concrete using shovels, not rakes.

Compact concrete using internal mechanical vibration of sufficient amplitude to produce noticeable vibrations at 300 mm radius. Insert vibrators into the concrete to the depth which will provide the best compaction, but not deeper than 50 mm above the surface of the subbase, and for a duration sufficient to produce satisfactory compaction, but not longer than 30 seconds in any one location.

Elapsed delivery time

General: Ensure that the elapsed time between the wetting of the mix and the discharge of the mix at the site is in conformance with the **Elapsed delivery time table**. Do not discharge below 10°C or above 32°C.

Elapsed delivery time table

Concrete temperature at time of discharge (°C)	**Maximum elapsed time (hours)**
10 – 24	2.00
24 – 27	1.50
27 – 30	1.00
30 – 32	0.75

Finishing

Immediately after placement and spreading and compaction of the plastic concrete, start finishing operations to achieve finish shown on the drawings.

Curing

Protect fresh concrete from premature drying and from excessively hot or cold temperatures. Maintain the concrete at a reasonably constant temperature with minimum moisture loss for the curing period.

- Temperature: Maintain the concrete at a temperature > 5°C for at least 7 days.

Curing compound method: Spray the entire surface including edges using a mechanical sprayer, at a uniform application rate of at least 0.35 L/m^2. Respray defective areas within 30 minutes. Respray within 3 hours after heavy rain. Apply as a continuous coating without visible breaks or pinholes.

Covering sheet method: Immediately after finishing operations, cover concrete using damp hessian or cotton mats overlapped at least 150 mm and anchored against displacement by wind or other interference. Keep the mats continuously damp until covered by the covering sheet material. Repair tears and the like immediately.

- Joint sawing: Sheet materials may be removed for the minimum distance and period to permit joint sawing, provided the concrete is kept moist by other means.

Moist curing method: Immediately after finishing operations keep the concrete surface continuously damp by spraying constantly with water, fog, or mist, using suitable spraying equipment.
Minimum curing time: 7 days.

CORES, FIXINGS AND EMBEDDED ITEMS

Adjoining elements

For adjoining elements to be fixed to or supported on the concrete, provide for the required fixings. If required, provide for temporary support of adjoining elements during construction of the concrete.

Protection

Grease threads. Protect embedded items against damage.
Compatibility: Ensure inserts, fixings and embedded items are compatible with each other, with the reinforcement and with the concrete mix to be used.
Corrosion: If in external or exposed locations, galvanize anchor bolts and embedded fixings.

Structural integrity

Fix cores and embedded items to prevent movement during concrete placing. In locating cores, fixings and embedded items, reposition but do not cut reinforcement, and maintain cover to reinforcement.

Tolerances

Maximum deviation from correct positions:
- Cores and embedded items generally: 10 mm.
- Other fixing bolts: 3 mm.

COMPACTION

Compaction

Methods: Use immersion and screed vibrators accompanied by hand methods as appropriate to remove air bubbles and to fully compact the mix.
Vibrators: Do not allow vibrators to come into contact with partially hardened concrete, reinforcement or items including pipes and conduits embedded in concrete. Do not use vibrators to move concrete along the forms. Avoid over-vibration that may cause segregation.

Placing

Use placing methods which avoid segregation and loss of concrete, and which minimize plastic settlement. Maintain a generally vertical and plastic concrete edge at faces of a pour.
Layers: Place concrete in layers ≤ 300 mm thick, such that each succeeding layer is compacted before the previous layer has taken the initial set.

Rain
General: Do not expose concrete to rain before it has been placed and set.

Vertical elements
In vertical elements, limit the free fall of concrete to 1500 mm per 100 mm element thickness, up to a maximum free fall of 3000 mm, using enclosed vertical chutes or access hatches in forms.

CONSTRUCTION JOINTS

Location
Do not relocate or eliminate construction joints, or make construction joints not shown on the drawings. If emergency construction joints are made necessary by unforeseen interruptions to the concrete pour, submit a report on the action taken.

Joint preparation
Roughen and clean the hardened concrete joint surface. Remove loose or soft material, free water, and foreign matter. Dampen the surface just before placing the fresh concrete and coat with a neat cement slurry.

EXPANSION JOINTS

Joint filling
Joint filling: Fill with approved jointing materials. Finish visible jointing material neatly flush with adjoining surfaces. Preparation: Before filling, dry and clean the joint surfaces, and prime.
Watertightness: Apply the jointing material so that joints subject to ingress of water are made watertight.

14. **CONCRETE FINISHES**

GENERAL

TOLERANCES
General

Unformed surfaces: Confirm conformance with the **Tolerance classes table** for the class of finish nominated using a straight edge placed anywhere on the surface in any direction.

Tolerances class table

Class	Measurement	Maximum deviation (mm)
A	3 m straight edge	3
B	3 m straight edge	6
C	600 mm straight edge	6

PRODUCTS

MATERIALS

Surface hardeners, sealers and protectors
Supply: If required by the project documentation, provide proprietary products in accordance with the manufacturer's written requirements.

EXECUTION

SURFACE MODIFIERS

General
Application: Apply to clean surfaces in accordance with the manufacturer's requirements.

UNFORMED SURFACES

General
Screed and level slab surfaces to finished levels, to tolerance class C.

Finishing methods
Broom finish: After floating, draw a broom or hessian belt across the surface to produce a coarse-even textured slip-resistant transverse-scored surface.
Machine floated finish: After screeding and when the concrete has stiffened sufficiently, work the slab surface using a machine float. Hand float in locations inaccessible to the machine float. Cut and fill to tolerance class B and refloat immediately to a uniform, smooth texture.

Scored or scratch finish: After screeding, give the surface a coarse scored texture using a stiff brush or rake drawn across the surface before the final set.
Steel trowelled finish: After machine floating, use power trowels to produce a smooth surface relatively free from defects. Then, when the surface has hardened sufficiently, use steel hand trowels to produce the final finish free of trowel marks and defects, and uniform in texture and appearance, to tolerance class A.
Wood float finish: After screeding, machines produce the final finish using a wood float, to tolerance class B.

Polished finishes
Water blast: After steel trowelling, water blast the curved surface to provide texture or to form patterns without exposing the coarse aggregate using medium pressure water jets. Ensure that aggregate is not removed to a depth greater than 10mm.
Applied finish: To a steel trowel finished surface, apply a proprietary liquid or dry shake material in accordance with the manufacturer's written requirements.
Burnished finish: Continue steel trowelling until the concrete surface attains a polished or glossy appearance.

Surface finishes
General: Provide surface finishes in conformance with the **Integral finish schedule**.

FORMED SURFACES

General
Provide formed concrete finishes in conformance with the **Formed surface finishes schedule**.
Damage: Do not damage concrete works through premature removal of formwork.

Curing
General: If forms are stripped when concrete is at an age less than the minimum curing period, commence curing exposed faces as soon as the stripping is completed.

Finishing methods
If exposed formed concrete elements are to have a finish other than off the form, provide details of proposed procedures. If not identified otherwise, all formed surfaces will be off form finish.
Exposed aggregate finish: Remove the vertical face forms while the concrete is green but set. Wet the surface and scrub using stiff fiber or wire brushes, using clean water freely, until the surface film of mortar is mechanically removed, and the aggregate uniformly exposed. Do not use acid etching. Rinse the surface with clean water.

Floated finishes:
- Sand floated finish: Remove the forms while the concrete is green. Wet the surface and rub using a wood float. Rub fine sand into the surface until a uniform color and texture are produced. - Grout floated finish: Remove the forms while the concrete is green. Dampen the surface and spread a slurry, using hessian pads or sponge rubber floats. Remove surplus slurry and work until a uniform color and texture are produced.

Surface repairs
Surface repair method: Before commencing repairs, submit proposals to the Engineer for approval.

15. PRECAST CONCRETE

GENERAL

DEFINITIONS

Definitions
For the purposes of this work section the following definition applies:
- Precast units: Concrete elements manufactured in other than their final position including elements manufactured on site but excluding tilt-up panels.

INSPECTION

Notice
Give sufficient notice so that inspection may be made of the following:
- Formwork dimensions and stability.
- Panel edge details and penetrations.
- Connection materials, reinforcement and inserts in place.

SUBMISSIONS

Subcontractors
Submit name and contact details of proposed manufacturer of precast concrete units.

Design
Veneered fabrication: If veneered fabrication is proposed, submit proposals to the Engineer.

Contractor design: Provide verification by a professional engineer of compliance of the design with project documents.

Shop drawings

Submit shop drawings of precast units showing the proposed details for their design, manufacture, assembly, transport and installation, including the following:
- Project title and manufacturer's name.
- Shape or profile drawings (submit these before fabrication of molds and tooling). - Concrete mix and type of cement if special-class concrete.

- Veneer details, if applicable.
- Surface finish class and surface treatment, if applicable.
- Curing and protection methods.
- Marking plan.
- Equipment and methods for handling, transport and installation, including lifting inserts and pick-up points.
- Calculated maximum loadings on lifting and bracing inserts and attachments.
- Evidence of load capacity of lifting and bracing inserts and attachments in the form of test reports or calculations.

Lifting

Early lifting: If it is proposed to lift the units by their designated lifting points before 28-day strength has been achieved, submit evidence to demonstrate that the unit has adequate strength to carry its own weight without damage or residual cracking or deflection on removal of the lifting device.
Attachments for handling purposes: If it is proposed to locate lifting attachments, holes and other temporary fixings for handling purposes on visible faces of units, submit proposals.
Lifting units: If it is proposed to lift or support units at other than specified points, submit proposals.

PROTOTYPES

General

Provide prototypes in accordance with the Prototypes schedule.
Maintain prototypes on site, undamaged and protected from discoloration for comparison with manufactured precast units.

Test panels

Make separate test panels for surface finish, color, or both, in conformance with the **Prototypes schedule**.

PRODUCTS

PRECAST UNITS

Marking

Identification: Identify units by marks which are as follows:

- Remain legible until after the unit has been fixed in place.
- Are not visible in the completed structure.
- Show the date of casting.
- Show the correct orientation of the unit.
- On other than units manufactured as a standard product, indicate the locations within the structure in accordance with the marking plan.

Tolerances

Fixings and embedded items in precast units: To be maximum of 5mm from design location unless agreed otherwise with the Engineer.

Lifting devices

Capacity: Design each lifting device for a working load at least 1.65 times the maximum calculated static load at that point and an ultimate load 4 times the maximum static load.

Attachments

Sealing: Recess lifting attachments such as ferrules, or other types of cast-in fixings, and provide plugs for sealing.

VENEERED CONSTRUCTION

General

Use a method which ensures that delamination of the veneer will not occur. Obtain approval from the Engineer prior to construction commencing.

EXECUTION

HANDLING

Precautions
Lift or support units only at designated or other approved points. Use handling methods which do not overstress, warp or damage the units. Protect the units against staining, discolouration and other damage until they are installed in their final location.

Attachments
Remove temporary attachments after erection. Seal or otherwise make good residual recesses.

INSTALLATION

General
Fixing: Fix the units securely and accurately in their final positions.
Ancillaries: Provide components and materials, including fasteners, braces, shims, jointing strips, sealant, flashings, grout and mortar, necessary for the installation of the units.

16. EARTH BLOCK WALLING

GENERAL

INSPECTION
Notice
Give sufficient notice so that inspection may be made of the following:
- Forms for blocks prior to casting blocks.
- Completed blocks prior to use.
- Damp-proof courses, in position.
- Built-in items, in position.

TESTS

Unit sampling
Rate: For each test, sample units at the rate of 1 per 500, randomly selected.

Unit tests
Dry density: Field or laboratory test for block in the range of 1200 – 2000 kg/m^3.

Absorption:
- Application: Stabilized units for maximum absorption of 2.5% by weight.
- Sample size: 100 mm cube, cut from a sample unit.

Dimensional accuracy:
- Confirm size of block is within an acceptable range of variance not greater than 10 mm per 300mm length of block.

Robustness: Unit must remain intact, but corner chipping is permitted, consistent with the unit remaining suitable for wall construction.

Defects:
- Breakages (maximum): 50 x 50 x 50 mm broken off per unit.
- Cracks (maximum): 75 mm long, 3 mm wide, 5 mm deep.

SAMPLES

General

Color and texture: Supply sample units indicating the range of likely variation. Label, and store on site under cover when accepted.
- Number: 4.
- Size: Full size.

Face work: Provide a sample panel.
- Size (minimum): 900 mm long x 600 mm high.
- Location to be determined on site.

TOLERANCES

Tolerances

Conform to the **Tolerances table**.

Tolerances table

Property	Tolerance criteria: Permitted deviation (mm)
Horizontal position of any earth wall element specified or shown in plan at its base or at each storey level	45 mm

Deviation with a storey from a vertical line through the base of the member	35 mm per 3 m of height
Deviation from vertical in total height of building (from base)	40 mm
Relative displacement between load bearing walls in adjacent storeys intended to be in vertical alignment	40 mm
Deviation (bow) from line in plan in any length up to 10 m	Single curvature: 45 mm
Deviation from design wall thickness	- 20 mm, + 40 mm

PRODUCTS

MATERIALS

Soil particle sizes
Sand: 0.06 – 2.0 mm.
Coarse aggregate: 2.0 – 25 mm.

Soil particle size distribution
Organic content: < 2%.
Clay and silt content: 10 – 30%.
Sand and coarse aggregate content: 30 – 80%.

Water
Clean, fresh, free from impurities.

Crack-control agent
Straw:
- Length: 40 – 60 mm.
- Ratio: 5 kg to 30 kg of straw/m^3 of soil.

Stabilizing agent

Type: Cement.
Standard: Cement shall conform to the requirements of ASTM specification C-150 Type 1 or similar approved standard for normal Portland cement.

Mortar

Earthen mortar: Same mix as for the units, but with added sand, and no straw or particles over 6 mm. Thoroughly soak and mix to prevent clay-balling.

Water repellent additives may be added to improve water resistance. Provide a submission to the Engineer for approval.

COMPONENTS

Damp-proof courses

Material: Embossed Polythene sheeting. Install sheeting at the base of all walls to stop moisture rising up wall structures.

Masonry units

Formed size (h x w x l): 100 x 250 x 350 mm unless approved otherwise by the Engineer.

Nailing blocks

Solid timber, or hollow timber box filled with earthen mortar. Timber unseasoned or thoroughly pre-wetted.

Steel components, including reinforcement

All steel components to be galvanized for maximum durability after incorporation into the structure.

Window and Door lintels

Lintels: Use steel, concrete or timber lintels in accordance with the manufacturers' technical literature or conform to the **Steel angle and T-lintels table**.

Steel angle and T-lintels table

Maximum span mm)	Wall height above ≤ 600 mm			Wall height above > 600 mm, ≤ 1800 mm		
	Angle lintel size	**T-Lintel dimensions: H x W x T (mm)**	**Bearing min. (mm)**	**Angle lintel size**	**T-Lintel dimensions: H x W x T (mm)**	**Bearing min. (mm)**

1000	Two 75 x 50 x 5 Unequal angles	81 x 150 x 6	100	Two 125 x 75 x 8 Unequal angles	136 x 150 x 6	200
2000	Two 100 x 75 x 6 Unequal angles	136 x 150 x 6	150	Two 150 x 90 x 8 Unequal angles	156 x 150 x 6	200
2400	Two 125 x 75 x 8 Unequal angles	156 x 150 x 6	150	Two 150 x 90 x 10 Unequal angles	160 x 150 x 10	250
2800	Two 150 x 90 x 8 Unequal angles	158 x 150 x 8	200	Two 150 x 100 x 10 Unequal angles	210 x 200 x 10	300
3000	Two 150 x 90 x 10 Unequal angles	160 x 150 x 10	200	Two 150 x 100 x 12 Unequal angles	210 x 200 x 10	300

Timber lintels

Size: Width of the wall and in conformance with the **Timber lintels height table**.
Grade: Best quality of imported Russian timber or suitable approved local timber.
Bearing: 300 mm (minimum).

Timber lintels height table

Maximum span (mm)	Lintel height (mm)
1200	150

1800	150
2400	200
3000	250

Timber fixing plates

Size: 200 x 50 mm (minimum).

Holding-down bolts
Type: 10 mm diameter threaded rod.
Termination: Horizontal 5 x 100 x 200 mm steel plate, weld-fixed, or with nuts.
Depth of embedment:
- Length (minimum): 450 mm.

EXECUTION

FABRICATION

Mixing
General: Moisten soil to liquid limit. Leave pit-mixed mud wet overnight.
Stabilizing: Add cement at 2.5 – 15% by mass.
Crack control: Add straw at 5 – 30 kg/m^3.
Hot weather: If placement of walling is to proceed when surrounding outdoor shade temperature exceeds 32ºC, submit a proposal.

Forming
Press mix into forms on a bed of sand on the ground or on concrete. Lift forms vertically and wash. Do not move units until cured.

Curing
General: Sun-dry the units for more than 7 days in situ (under shelter in hot, dry weather) after forming. Then tip the units on one side and sun-dry in situ for another 7 days.
Cement stabilized: Cover blocks with plastic sheet for at least 24 hours after casting.

Storage

Stack cured units close to point of use on boards off the ground. Stack on edge, 2 – 3 rows high. Orient stacks for equal exposure to sun and wind on both faces. Protect the tops of stacks against the weather.

LAYING UNITS

General
Drying: Do not lay units until they are dry and at least 28 days after forming.
Unsterilized units: Sprinkle with water before laying. Relay disturbed units in fresh mortar.
Temperature: Do not lay when ambient temperature is or is expected to be < 5°C within 48 hours of placement. Do not lay on frozen materials.
Daily progress: Establish leads at corners. Step back incomplete walls, do not tooth. Cover incomplete work at the top. Lay a maximum of 500 – 700 mm height per day.
Voids at dissimilar materials: Fill with earthen mortar.
Protection: Protect tops of walls from rain until the roof is in place.

Joints
Bedding: Full flush type, with no open head joints.
Bond: Running bond. Overlap units 100 mm.
Type: Flush, 13 – 19 mm thick. Tool concave at exposed surfaces. Remove excess mortar. Control joints:
- Spacing as identified on drawings.

Protection
Unstabilised units: Do not locate unstabilised units within 100 mm of adjacent floor levels, within 225 mm of adjacent ground levels, within 100 mm of the top of unenclosed walls and parapets, around roof drains, and in other areas where there is risk of moisture.
DAMP PROOF COURSES

Location
At the base of the earth walls above footings or slab (plinth).

Walls on slabs
Finish flush with the outer face of the slab and the inner face of the wall. Upturn on inside behind skirting and downturn at outer face of slab, at least 25 mm.

Installation

General: Lay in long lengths, in a single width. Lay full width at angles and intersections and lap at least 150 mm at joints. Step as necessary.

FIXINGS AND EMBEDDED ITEMS

Nailing blocks and nailers

Installation: Build-in as the work progresses. Use nailing blocks to fix all window frames, door frames and other wall mounted fixtures.
Partitions: Nail timber framed partitions to nailing blocks.

REINFORCEMENT

Installation

Do not cut, weld or grind on site. Build-in as work progresses. Lap 450 mm at splices. Fold and bend at corners so that the longitudinal wires are continuous. Stop 200 mm short of control joints. Place in the center of the width of the wall, and in the bedding joint.

Cover (minimum):
- 75 mm for exposed surfaces.
- 25 mm for protected surfaces.

Vertical intervals (maximum): 500 mm, for full height of the wall.

STEEL LINTELS

Installation

Do not cut, weld or grind on site. Build-in as work progresses. Keep lintels 10 mm clear of heads and frames. Install T-lintels with horizontal components at the bottom, centered in the width of the wall.
Propping: Temporarily prop lintels during construction and until the wall reaches its required strength.

TIMBER LINTELS

Installation

Build-in as work progresses. Keep lintels 10 mm clear of heads and frames.

PIPES AND CONDUITS

Installation

Installation: Lay conduits and water pipes in mortar joints as far as possible. Otherwise lay in chases.
Cover (minimum): 100 mm, if built-in.
Chases: Maximum depth 50 mm. Run vertically, not horizontally. Do not chase in exposed face work. Thicken the walls for larger piping.

BOND BEAMS

Positions

Provide a continuous bond beam to bearing walls, at framed floor and at roof bearing levels. Build-in as work progresses. Anchor the floor and roof structures to the bond beams. Bond beams may be concrete, timber or steel beams as identified on the drawings.
Position: Centre on the wall.
Bedding: Mortar leveling course.

HOLDING DOWN BOLTS

General

Cover (minimum): 75 mm. Location: Refer to drawings for locations, length of holding down bolts.

Installation

Set in perpends and units split lengthwise, in alternating courses. Do not locate within 150 mm of the end of the wall. Located in the center of the wall.

FINISHES

Appearance

Marks and stains: Remove at completion.
Efflorescence: Remove before sealing or rendering.

Mud render

General: Render the exteriors of walls made of unstabilised units.
Preparation: Brush the substrate, score and moisten.
Mix: 3:1 clay: clean sand, with straw reinforcing, and enough water to make a paste.
Render: Two coats, each 5 – 7 mm thick.
Finish: Polish the coating using sheepskin or small rounded stones.

TEMPORARY WORK

Face work sample panel
If not incorporated, demolish the panel.
Refer to the **Earth Block Walling Construction Schedule,** BOQ and drawings for details of locations and built-in components.

17. BRICKWORK

GENERAL

INSPECTION

Notice
Give sufficient notice so that inspection may be made of the following:
- Set out of brickwork to lintels, arches and other architectural features.
- Damp-proof courses, in position.
- Lintels, in position.

PRODUCTS

MATERIALS

First Class Bricks
First Class Bricks shall be made from good brick earth free from saline deposits, and shall be sand molded. They shall be thoroughly burnt by coal without being vitrified, of uniform and good color shall be regular and uniform in size, shape and texture with sharp square edges and parallel faces. They must emit a clear metallic ringing sound when struck one against another. They shall be free from flaws, cracks, chips, stones, and nodules of lime or canker. A First-Class Brick shall not absorb more than 1/6th of its weight of water after being soaked for one hour.

Second Class Bricks
Second Class Bricks shall be as well burnt as First Class or may be slightly over burnt but not vitrified, and must give a clear ringing sound when struck one against another. Slight irregularities in size, shape or color are acceptable provided irregular or uneven courses do not result. Second Class Bricks may have slight chips or flaws but must be free from lime or canker nodules. They shall not absorb more than 1/4th of their weight of water after being soaked for one hour.

General

Machine made pressed bricks shall be standard commercial products. The Engineer prior to use in the Works shall approve the use of machine-made pressed bricks.
Bricks not meeting the above requirements shall not be used in brickwork.
First and Second-Class Bricks should have the following dimensions after burning: 250mm x 120mm x 70mm. The unit weight of First- and Second-Class Bricks shall not be less than 1100 kg/m^3.
The crushing strength of bricks shall be tested in a laboratory. The average crushing strength of First- and Second-Class Bricks shall not be less than 17MPa (N/mm^2).
At the start of the works samples of the bricks shall be tested for crushing strength and water absorption, and brickwork shall only commence when the Engineer has approved the bricks. The Contractor may then only change the source of supply of bricks after samples from the new supplier have similarly been tested and approved.

Mortar materials
Cement shall conform to the requirements of ASTM specification C-150 Type 1 or similar approved standard for normal Portland cement.
- White cement: Iron salts content ≤ 1%.
- Off-white cement: Iron salts content ≤ 2.5%.

Lime: Confirm source of Lime with Engineer to ensure highest quality Lime is used in the mortar. Protect from damage on site and store minimum 300mm above ground in a waterproof storage facility.
Sand: Fine aggregate with a low clay content selected for grading, sharp and free from effloresing salts. River or pit sand should be sharp, angular, hard, clean uncoated particles free from clay and organic impurities.
Water: Water to be used for the mixing of mortar should be clean and free from oil, acid, alkali, salts, organic materials or other substances that are harmful to the mortar mix.
Measurement of volume: Measure binders and sand by volume using buckets or boxes. Do not allow sand to bulk by absorption of water.

Mortar
Proportioning: Standard and ratio of mix for all mortar shall be M-400 (1:3), M-300 (1:4), M-250 (1:5) and M 200 (1:6). Provide minimum water.

COMPONENTS

Nailing blocks
Solid timber, or hollow timber box filled with earthen mortar. Timber unseasoned or thoroughly pre-wetted.

Steel components, including reinforcement
All steel components to be galvanized for maximum durability after incorporation into the structure.

Window and Door lintels
Lintels: Use steel, concrete or timber lintels in accordance with the manufacturers' technical literature or conform to the **Steel angle and T-lintels table**.

Steel angle and T-lintels table

Maximum span (mm)	Wall height above ≤ 600 mm			Wall height above > 600 mm, ≤ 1800 mm		
	Angle lintel size	**T-Lintel dimensions: H x W x T (mm)**	**Bearing min. (mm)**	**Angle lintel size**	**T-Lintel dimensions: H x W x T (mm)**	**Bearing min. (mm)**
1000	Two 75 x 50 x 5 Unequal angles	81 x 150 x 6	100	Two 125 x 75 x 8 Unequal angles	136 x 150 x 6	200
2000	Two 100 x 75 x 6 Unequal angles	136 x 150 x 6	150	Two 150 x 90 x 8 Unequal angles	156 x 150 x 6	200
2400	Two 125 x 75 x 8 Unequal angles	156 x 150 x 6	150	Two 150 x 90 x 10 Unequal angles	160 x 150 x 10	250
2800	Two 150 x 90 x 8	158 x 150 x 8	200	Two 150 x 100 x 10	210 x 200 x 10	300

	Unequa l angles			Unequal angles		
3000	Two 150 x 90 x 10 Unequa l angles	160 x 150 x 10	200	Two 150 x 100 x 12 Unequal angles	210 x 200 x 10	300

Timber lintels
Size: Width of the wall and in conformance with the **Timber lintels height table**.
Grade: Best quality of imported Russian timber or suitable approved local timber
Bearing: 300 mm (minimum).

Timber lintels height table

Maximum span (mm)	Lintel height (mm)
1200	150
1800	150
2400	200
3000	250

Timber fixing plates
Size: 200 x 50 mm (minimum).

Holding-down bolts
Type: 10 mm diameter threaded rod.
Termination: Horizontal 5 x 100 x 200 mm steel plate, weld-fixed, or with nuts.
Depth of embedment:
- Length (minimum): 450 mm.

EXECUTION

GENERAL

General

Construction of masonry brickwork shall not commence until the Engineer has accepted the footings on which it is to be placed.
Brickwork shall be built plumb, curved or battered as shown on the Drawings or as may be required, by skilled masons and properly supervised workmen. Bricks shall be clean and if necessary, they shall be scrubbed. Bricks shall be soaked in water for at least one hour before use.
Unless otherwise specified bricks shall be laid in English Bond, with frogs downward. All horizontal joints shall be parallel and level. Vertical joints in alternate courses shall come directly over one another. Joint thickness shall be 6mm and shall in no case exceed 8mm. The height of four courses including 4 bed joints shall rise 300mm. Set out brickwork with joints of uniform width and minimize cutting of masonry units.
Walls shall always be carried up regularly along their entire length unless otherwise directed by the Engineer.

Mortar mix
Mortar mixing shall be done in a mechanical mixer unless the Engineer specifically permits hand mixing. If hand-mixing is done, the operation shall be carried out on a clean watertight platform and cement & sand shall be first mixed dry in the required proportion to obtain a uniform color and then the mortar shall be mixed for at least two minutes after addition of water.
Cement Mortar shall be mixed in such quantities as can be used in the work within 30 minutes. Mortar, which has taken the initial set, shall not be used, nor shall it be re-mixed with fresh mortar.

Preparing lime putty:
- Using hydrated lime: Add lime to water in a clean container and stir to a thick creamy consistency. Leave undisturbed for at least 16 hours. Remove excess water and protect from drying out. - Using quicklime: Run to putty as soon as possible after receipt of quicklime. Partly fill a clean container with water, add lime to half the height of the water, then stir and hoe ensuring that no lime remains exposed above the water. Continue stirring and hoeing for at least 5 minutes after all reaction has ceased, then sieve into a maturing bin. Leave undisturbed for at least 14 days. Protect from drying out. Mortar proportions (cement:lime:sand):As defined on the drawings.
Sand stockpile: Ensure sand is dry and stored undercover to avoid errors in volume batching during the mixing process.

Protection from contamination
Protect masonry materials and components from ground moisture and contamination.

Building in Embedded items: Build in fixing blocks, brackets, lintels and accessories as the construction proceeds. Steel door frames: Fill the backs of jambs and heads solid with mortar as the work proceeds.

Joining to existing

If joining to existing work is required, provide a straight joint. Do not tooth new masonry into existing work.

Chasing

Chasing of brickwork shall be to the Brickwork chasing table and subject to the following limitations:

- Parallel chases on opposite faces of a wall shall not be closer than 600 mm to each other.

Brickwork chasing table

Brick thickness (mm)	Depth of chase (maximum mm)
More than 250 thick	35
250 thick	25
100 thick non load bearing walls only	20

Joint finish

Lay brickwork on a full bed of mortar. Fill perpends solid.

Finish:

- Externally: Tool to give a dense water-shedding finish for face brickwork or rake not more than 10mm to give a key for render finish.
- Internally: If the wall is to be plastered, rake not more than 10 mm to give a key.

Temporary support

If the final stability of the brickwork or blockwork is dependent on structural elements to be constructed after the brickwork, provide proposals for temporary support or bracing for the approval of the Engineer.

FACEWORK

Cleaning

General: Clean progressively as the work proceeds to remove mortar smears, stains and discolouration.

Color mixing

Evenly distribute the color range of units and prevent color concentrations and "banding" unless specifically identified as a feature of the brickwork.

DAMP-PROOF COURSES

Damp-proof courses
Material: Embossed Polythene sheeting. Install sheeting at base of all walls to stop moisture rising up wall structures.

Location
Provide damp-proof courses as follows:
- Walls built off slabs on ground: In the bottom course of the wall on top of the slab. - Walls adjoining infill floor slabs: In the course above the slab. Project 40 mm and dress down over the membrane turned up against the wall.

Installation
Lay in long lengths. Lap full width at angles and intersections and at least 150 mm at joints. Step as necessary, but not exceeding 2 courses per step. Sandwich damp-proof courses between mortar.

CONTROL OF MOVEMENT

Joints
Provide joints as follows:
- Expansion joints for brickwork:
. Maximum length of continuous wall face: 8 m.
. Closest joint location to external corner: 2.5m
. Maximum vertical spacing: 8 m.
. Width of control joint: 10 mm 20 mm.
. Width of horizontal joint: 15 mm 20 mm.
Filler material: Provide compatible sealant and bond breaking backing materials which are non-staining to masonry.
- Bond breaking materials: To be non-adhesive to sealant, or faced with a non-adhering material. - Foamed materials: To be closed-cell or impregnated, not water-absorbing.
Joint filling:
- Installation: Clean the joints thoroughly and insert an easily compressible backing material before sealing. - Sealant depth: Fill the joints with a gun-applied flexible sealant for a depth of at least two-thirds the joint width.

Refer to the **Brickwork Construction Schedule**, BOQ and drawings for details of locations, types and extent of built-in components.

18. STONEWORK

GENERAL

INSPECTION

Notice
Give sufficient notice so that inspection may be made of the following:
- The prepared stone sample range.
- Lintels in position.
- Damp proof courses in position.

TOLERANCES

Dimensions of stone units
Maximum deviation from required dimensions:
- Load Bearing stone in cut blocks: 4 mm.
- Other stone used in foundations or not exposed to view: No size requirement unless noted otherwise in this work section.

PRODUCTS

NATURAL STONE

Stone types
Sandstone defects: Minor shale laminates and minor concentrations of carbonaceous material (tea leaves) are acceptable in visible faces. Neither defect is acceptable in carved or molded work.
Granite defects: Igneous stone (e.g., granite) obtained from quarry stone extracted in blocks sufficiently large to suit the project requirements, and containing no more than a small degree of micro cracking.

Stone selection
Grading: Select stone of the designated quality grade.
Matching: Within each grade, select stone for the best match of color and pattern.

Source of stone supply
Ensure the stone quarry or supplier can provide all stone required for the project without the need to find alternative supplies.

MORTAR

Mortar materials
Cement shall conform to the requirements of ASTM specification C-150 Type 1 or similar approved standard for normal Portland cement.
- White cement: Iron salts content ≤ 1%.
- Off-white cement: Iron salts content ≤ 2.5%.

Lime: Confirm source of Lime with Engineer to ensure highest quality Lime is used in the mortar. Protect from damage on site and store minimum 300mm above ground in a waterproof storage facility.
Sand: Fine aggregate with a low clay content selected for grading, sharp and free from efflorescing salts. River or pit sand should be sharp, angular, hard, clean uncoated particles free from clay and organic impurities.
Water: Water to be used for the mixing of mortar should be clean and free from oil, acid, alkali, salts, organic materials or other substances that are harmful to the mortar mix.
Crushed stone: Fine aggregate consisting partly or wholly of crushed stone, made from material of the same type as the stone facing.
Measurement of volume: Measure binders and sand by volume using buckets or boxes. Do not allow sand to bulk by absorption of water.

Mortar
Standard and ratio of mix for all mortars shall be M-400 (1:3), M-300 (1:4), M-250 (1:5) and M-200 (1:6). Provide minimum water.

Mortar mix
Mortar mixing shall be done in a mechanical mixer unless the Engineer specifically permits hand mixing. If hand-mixing is done, the operation shall be carried out on a clean watertight platform and cement & sand shall be first mixed dry in the required proportion to obtain a uniform color and then the mortar shall be mixed for at least two minutes after addition of water.
Cement Mortar shall be mixed in such quantities as can be used in the work within 30 minutes. Mortar, which has taken the initial set, shall not be used, nor shall it be re-mixed with fresh mortar.
Preparing lime putty:
- Using hydrated lime: Add lime to water in a clean container and stir to a thick creamy consistency. Leave undisturbed for at least 16 hours. Remove excess water and protect from drying out.

- Using quicklime: Run to putty as soon as possible after receipt of quicklime. Partly fill a clean container with water, add lime to half the height of the water, then stir and hoe ensuring that no lime remains exposed above the water. Continue stirring and hoeing for at least 5 minutes after all reaction has ceased, then sieve into a maturing bin. Leave undisturbed for at least 14 days. Protect from drying out. Mortar proportions (cement:lime:sand):As defined on the drawings.
Sand stockpile: Ensure sand is dry and stored undercover to avoid errors in volume batching during the mixing process.

EXECUTION

WORKMANSHIP GENERALLY

Cutting
Perform the necessary cutting and shaping of stone to designated profiles including weathering, jointing, chasing, forming grooves. Make the bed, face and back joints of the stone square and true where dimensioned stone is required.

Carving and molding
Achieve a clean sharp finish. Carry out all work identified on the drawings to the approval of the Engineer.

LAYING UNITS

Bedding
Remove dust and foreign material from the bedding surfaces. Water the face of the stone units so that full strength joints are achieved. Where possible, bed and joint the stone in one operation. Lay each stone on a full bed of mortar. Solidly fill and grout vertical joints as the work proceeds. Point up joints around flashings as necessary.

Natural bed
Lay load bearing sedimentary stone with its natural bed at 90 degrees to the load, except for the following:
- Cladding panels: In non-loadbearing cladding panels, form each panel with its natural bed at right angles to the face.

Temporary support
Provide support as necessary to the stone while the mortar is curing, using bracing, joint spacers, or both.

Bracing and joint spacers: non-damaging and non-staining softwood wedges soaked in water. Do not allow metal pinch bars to bear directly on the stone.

Raking and toothing
Raise advanced work no more than 1.5 m above the general level, and rake back. Do not tooth stonework for subsequent additions except where toothing is shown on the drawings.

Bonding
Bond the masonry so as to provide stability and monolithic structural action to the stonework assembly.

STONE FOUNDATIONS

Stone footings
Construct the footing course entirely of through stones, and if stepping is necessary, overlap the stepped courses at least 300 mm.

Subfloor stone foundation walls
Minimum foundation wall thicknesses:
- Supporting masonry walls 100 mm thick: 300 mm.
- Supporting masonry walls 250 mm thick: 450 mm.
- Supporting masonry walls 370 mm thick: 600 mm.

Stone sizes:
- Maximum height: 350 mm.
- Minimum height: Generally 175 mm; through stones 300 mm.

Bond pattern: Provide through stones as follows:
- All stones in top and bottom courses.
- Elsewhere as header units.

Slab bearings: Provide continuous bearing at least 100 mm wide to the edge of suspended slabs.

DAMP-PROOF COURSES

Material
Material: Embossed Polyethylene sheeting. Install sheeting at the base of all walls to stop moisture rising up wall structures.

Location

Provide damp-proof courses as follows:
- Walls built off slabs on ground: In the bottom course of the wall on top of the slab.
- Walls adjoining infill floor slabs: In the course above the slab. Project 40 mm and dress down over the membrane turned up against the wall.

Installation
Lay in long lengths. Lap full width at angles and intersections and at least 150 mm at joints. Step as necessary, but not exceeding 2 courses per step. Sandwich damp-proof courses between mortar.

JOINTING AND POINTING

Joints
Size (mm): Not less than 3mm or more than 5mm for dimensioned stonework. Size may vary for non-dimensioned stonework from 10mm to 30mm. Joint size should not exceed this without approval of the Engineer.
Jointing material: Mortar with a strength less than the stonework. Lime putty were identified on drawings for special dimensioned stonework.
Pointing material: Coloured mortar or mortar as above, refer to Schedule or drawings. Lime putty were identified on drawings for special dimensioned stonework.

SEALANT JOINTING

Preparation for jointing
Immediately before joining remove loose particles from the joint, using brushes or compressed air.

Taping
Protect the stonework surface on each side of the joint using 50 mm wide masking tape or equivalent means. On completion of pointing remove the tape and remove any stains or marks from the stonework surface.

Jointing materials
Use recommended jointing and pointing materials which are compatible with each other and with the contact surfaces and non-staining to finished surfaces.
Priming: Apply the recommended primer to the surfaces in contact with sealant materials. Sealant color: Refer to Schedule or drawings.
Foamed materials (in compressible fillers and backing rods): Closed cell or impregnated types which do not absorb water.

Sealant application
Apply the sealant to dry joint surfaces. Do not apply the sealant in unsuitable weather conditions (e.g., when the ambient temperature is outside the range 5 – 50°C) or outside the recommended working time for the material or the primer.

Joint finish
General: Produce a smooth, slightly concave surface using a tool designed for the purpose.

COMPLETION

Cleaning
Cleaning: Leave the stonework clean on completion.
Refer to the **Stonework Construction Schedule**, BOQ and drawings for details of locations, types and extent of built-in components.

19. LIGHT STEELWORK

GENERAL

INSPECTION

Notice
Give notice so that inspection may be made of steel framing erected before lining or cladding.

SUBMISSIONS

Design
The Contractor is to confirm that all proposed member sizes are available for the project in accordance with the drawings and BOQ. If selected sizes are not available, seek alternatives and obtain approval from the Engineer.

EXECUTION

CONSTRUCTION GENERALLY

Fabrication
Length: Cut members accurately to length so that they fit firmly against abutting members. Service holes: Form holes by drilling or punching if needed.

- Bushes: Provide plastic bushes or grommets to site cut holes.
- Swarf: Remove swarf and other debris from cold-formed steel framing immediately. Site work: Do not fabricate on site where welded connections are required.

Fastening
Select from the following:
- Bolting.
- Self-drilling, self-tapping screws.
- Blind rivets.

Welding
Burning: Avoid procedures that result in greater than localized "burning" of the sheets or framing members. Protect other adjoining materials from damage during welding activities.
Other workers: Protect other workers on site from welding flash, sparks and other potential injuries during welding activities.

Prefabricated frames
Protect frames from damage or distortion during storage, transport and erection.

Unseasoned timber
Do not fix in contact with framing without fully painting the timber and/or the steel to avoid future rusting of the steel.

Earthing
Permanent earthing: Required.
Temporary earthing: Provide temporary earthing during erection until the permanent earthing is installed.

Protection
Coatings which have been damaged by welding or other causes shall be restored. Thoroughly clean affected areas to base metal and coat with zinc rich organic primer.

TRUSSES

Fabrication
Factories assemble trusses and transport to site where possible. Obtain approval from the Engineer if it is required to fabricate trusses on site.

Marking
Permanently mark each truss to show:
- Manufacturer.
- Tag or number.
- Location.
- Support points.

Installation
Fix to support structures, plumb to within H/200, where H is the height at the apex.

COMPLETION

Cleaning
On completion of framing remove debris from any gaps between members.

20. STEELWORK PAINTING

GENERAL

INSPECTION

Notice
Give sufficient notice so that inspection may be made of the following:
- Surfaces after preparation prior to application of first coating.
- Coating after application of final coat.

SAMPLES

Painting and coating color
Submit a sample of the finished product for each different coating system.
Size of each sample: 200 x 200 mm.

PRODUCTS

GENERAL

General

All protective coatings must be handled, stored, mixed and applied strictly in accordance with the manufacturer's instructions and Product Data Sheets.

EXECUTION

PROTECTION

Surroundings
Provide protection of the surroundings to the coating works and ensure that no abrasive, overspray or paint waste debris is released either to air, ground or to any watercourse. Repair or clean damage as appropriate.

Contamination
Ensure protection of sensitive items during surface preparation and coating works. Do not permit surface preparation debris to contaminate coated surfaces which are not yet dry, nor cause damage to any other services or equipment.

Stacking and handling
Do not stack, handle or transport coated items until the coating has sufficiently cured so as to resist handling actions.
Stack and handle all steelwork using fabric slings or padded chains, used in a manner that ensures that no damage is caused to the coating system. Adopt soft packaging, carpet strips or other deformable materials between all steel items. Do not permit steel to steel contact in any situation.
Water ponding: Stack coated items so that water ponding does not or cannot occur whilst the items are in storage, transport or "laydown".

Repair of coating damage
If damage occurs, repair so as to ensure that the full corrosion protection ability of the system is reinstated.

SURFACE PREPARATION

General
Coatings shall be applied only to properly prepared and cleaned surfaces.

Surface preparation
Ensure all surfaces are free from oil, grease, dirt, bird droppings or any other contaminants, particularly soluble contaminants.

Surface defects: Remove or correct other surface defects, including cracks, laminations, deep pitting, undercutting, weld spatter, slag, burrs, fins and sharp edges.
Remove all weld spatter by grinding or chipping.

Priming
Prime coat all surfaces with zinc rich primer on the same day as the completion of surface preparation works. In every case, the specified surface preparation standard, in both cleanliness and profile, shall be evident at the time that the primer coating is applied.

COATING APPLICATION

General
Apply the coatings in accordance with the **Paint Finishes Schedule**.

Final surface preparation for coating application
Limits: If the following climatic/substrate conditions are present do not apply coating:
- The ambient air temperature is below 5°C or above 40°C.
- The substrate temperature is below 10°C or above 35°C.
- The surface to be coated is wet or damp.

Defects: Apply materials so as to produce an even coating free from film defects.
Detail: Stripe coat all welds, bolt holes, sharp edges and difficult to spray areas by brushing in with the prime coat and intermediate coat material prior to the full coating application.

Subsequent coats
Ensure that before any subsequent coating layer is applied, the surface condition of the preceding coat is complete and correct in all respects, including its cleanliness and freedom from defects. Correct any defects before the next coating layer is applied.

21. LIGHT TIMBERWORK

GENERAL

INSPECTION
Notice
Give sufficient notice so that inspection may be made of the following:
- Timber framing after erection before lining or cladding.
- Roof framing and connection to wall and ceiling structures.

SUBMISSIONS

Design

The Contractor is to confirm that all proposed member sizes are available for the project in accordance with the drawings and BOQ. If selected sizes are not available, seek alternatives and obtain approval from the Engineer.

PRODUCTS.

TIMBER

Timber grades

Structural timbers:
- Appearance grade if exposed to view in the finished work:
Use best quality timber free from twists, knots, splits and other visual or physical defects. - Structural grade if concealed in the building:
Lower quality timber with some visual defects acceptable but with minimal physical defects.

SHEET PRODUCTS

Structural plywood panels

All structural plywood panels used for construction purposes are to be approved by the Engineer. Refer to drawings and BOQ for details of locations and sizes. All structural plywood is to be tested before use to the satisfaction of the Engineer to ensure that it will be suitable for the proposed use. Use branded or certified plywood products where possible.

Hardboard or fibreboard panels

All hardboard or fibreboard panels used for construction purposes are to be approved by the Engineer. Refer to drawings and BOQ for details of locations and sizes. All material is to be tested before use to the satisfaction of the Engineer to ensure that it will be suitable for the proposed use. Use branded or certified products where possible.

COMPONENTS

Steel **post bases**

Minimum dimensions:
- Stirrup: 75 mm wide x 6 mm thick.
- Dowel: 20 mm diameter heavy tube.

Location: To timber posts supported off concrete slabs or footings.

Finish: Galvanized after fabrication.

Fasteners
Material:
Use best quality steel bolts, washers and nuts for bolted connections. Washers to be used on both sides of timber to avoid crushing of the timber at the connection point.
Use the best quality screws to avoid damage to screw heads during the tightening process.
Use best quality bright steel nails for internal work protected from the weather and galvanized nails for external fixings exposed to the weather.
Lightweight alloy bolts and screws will not be permitted.
Installation: Pre-drill holes in hardwood timber to avoid splitting the timber.
Do not split or otherwise damage the timber or fastener by hammering bolts or screws into the timber.

EXECUTION

GENERAL

Protection from weather
General: Provide temporary protection for members until permanent covering is in place.

FLOOR FRAMING

Bearers and joists
Leveling: Level bearers and joists by packing for the full width of the member.
Joints: Locate joints only over supports:
- Minimum bearing of bearers: 50 mm.
- Minimum bearing of joists: 30 mm.

Fixing: Secure bearers and joists to support to provide restraint against lateral movement.
Joist restraint: If joist timber is unseasoned, the span 3000 mm, provide solid blocking between each joist in rows at 1800 mm centers and at the ends of the joists over the supports.
Members: Provide bearers and joists were shown on the drawings and in the BOQ.

Flooring
Providing flooring of structural plywood were shown on the drawings and in the BOQ.

ROOF AND CEILING FRAMING

Wall plates
Fix timber wall plates to top of masonry walls with either straps or bolts, or provide fixings cast into the ring beam as required.

Ceiling framing
Constructed timber framed ceilings were shown on drawings with battens fixed to underside of trusses or ceiling joists as required.

Additional support
Provide a frame member behind every joint in fiber cement sheathing or plywood lining to ensure that the lining is fully supported.

Roof cladding boards
Provide roof cladding boards minimum of 20mm thick to full extent of roof structure to support flat metal sheet roofing where shown on drawings. Securely fix the structure and ensure that the top surface is as smooth as possible to avoid damage to the roof sheeting.

TRUSSES

Installation
Support: Support trusses on bottom chord at two points only, unless designed for additional support.
Plumb: Within H/200, where H is the height.
Vertical movement: Over internal walls provide at least 10 mm vertical clearance and use bracing methods which allow for vertical movements.
Construction: Construct trusses strictly in accordance with the drawings. If variations are proposed due to construction fabrication or installation issues, obtain approval from the Engineer before changing the design.

COMPLETION

Tightening
Tighten bolts, screws and other fixings so that joints and anchorages are secure at all times.

Clean up
Remove all shavings, discarded chips and pieces of timber from the structure during construction and clean up all working areas prior to Completion.

22. WATERPROOFING

GENERAL

INTERPRETATIONS

Definitions

For the purposes of this work section the definitions given below apply.
- Substrates: The surfaces on which membrane systems are laid.
- Bitumen: A viscous material comprising complex hydrocarbons which is soluble in carbon desulfated, softens when it is heated, is waterproof and has good powers of adhesion. It is produced as a refined by-product of oil.
- Bond breakers: Layers which prevent membranes from bonding to the backgrounds. - Membranes: Impervious barriers to liquid water which may be:
. Liquid applied: Membranes applied in liquid or gel form and air cured to form a seamless film. . Sheet applied: Membranes applied in sheet form with joints lapped and bonded.
- Membrane systems: Combinations of membranes, flashings, drainage and accessories which form waterproof barriers and which may be:
. Loose-laid.
. Bonded to backgrounds fully or partially.

INSPECTION

Notice

Give sufficient notice so that inspection may be made as follows:
- Background preparation completed.
- Before membranes are finished, covered up or concealed.

PRODUCTS

MEMBRANES

Membrane systems

To be proprietary membrane systems where possible having certification from an international testing organization.

Internal roof outlets for membrane roof

Proprietary funnel shaped sump cast into the roof slab, set flush with membrane, with a flat removable grating and provision (e.g. clamp ring) for sealing the membrane into the base of the outlet.

Warranty Guarantee

All waterproofing works must be backed with a 10 year product as well as application guarantee by the Contractor or sub-contractor directly to the Employer

EXECUTION

PREPARATION

General

Prepare backgrounds as follows:

- Fill all cracks in backgrounds wider than 1.5 mm with a filler compatible with the membrane system. - Fill voids and hollows in concrete backgrounds with a concrete mix not stronger than the background. - Remove excessive projections.
- Remove deleterious and loose material.
- Leave the surface free of contaminants, clean and dust free.

Moisture content

Concrete backgrounds: Cure for > 21 days.

Falls

Verify that falls in backgrounds are > 1:100.

Joints and filets

Internal corners: Provide 45° filets.
External corners: Round or arris edges.
Movement control joints: Prepare all background joints to suit the membrane system.

Priming

If required, prime the backgrounds with compatible primers to ensure adhesion of membrane systems.

APPLICATION

Protection
Protect membrane from damage during installation.

Drains
Prevent moisture from tracking under the membranes at drainage locations.
Drains and cages: Provide grates or cages, to prevent blockage from debris.
Overflows: Turn the membranes into the overflow to prevent moisture from tracking behind the membrane.

Sheet joints
Bituminous sheet membranes:
- Side laps > 50 mm.
- End laps > 100 mm.
Synthetic rubber membranes:
- Factory–vulcanized laps > 40 mm.
- Field side laps > 50 mm for side laps.
- Field end-laps > 100 mm for end laps.

Curing of liquid applied systems
To the manufacturers' instructions.

Movement control joints
Locate over movement control joints in the substructure.
Filets and bond breakers: Provide sufficient dimension to allow the membrane to accommodate the movement.
Bonded membranes: Carry movement joints in the substrate through the surface finish.

Membrane terminations
Edge protection: Provide upturns above the maximum water level expected from the exposure conditions of rainfall intensity and wind.
- Minimum height of 200mm for all upturns above membrane level unless noted otherwise on the drawings.
- Anchoring: Secure sheet membranes along the top edge.
- Edge protection: Protect edges of the membrane.
- Waterproofing above terminations: Waterproof the structure above the termination to prevent moisture entry behind the membrane using capping, waterproof membranes or waterproof coatings.

Membrane vertical penetrations

- Pipes, ducts, and vents: Provide separate sleeves for all pipes, ducts, and vents and have them fixed to the substrate. Minimum height of 200mm for all sleeves above membrane level unless noted otherwise on the drawings.

Overlaying finishes on membranes

Compatibility: If a membrane is to be overlayed with another system such as tiles, pavers, ballast, insulation, soil, and the like, provide an overlaying system that is compatible with and not cause damage to the membrane.

Ensure that no damage is caused to the membrane during the laying of the overlay material. If any damage occurs immediately stop work and repair the damage before proceeding with the overlay process.

Bonded or partially bonded systems: If the topping or bedding mortar requires to be bonded to the membrane, provide sufficient movement joints in the topping or bedding mortar to reduce the movement over the membrane. Geotextile product of the recommended grade.

23. ROOFING

GENERAL

INSPECTION

Notice

Give sufficient notice so that inspection may be made of:

- Roof framing during construction.
- Those parts of the roofing, vapor barrier, insulation and roof plumbing installation which will be covered up or concealed.

SUBMISSIONS

Samples

Submit samples of the following showing the range of variation available:

- Corrugated and flat metal roof sheeting
- Roof capping, flashings, gutters, downpipes

PRODUCTS

MATERIALS AND COMPONENTS

Fasteners

Self-drilling screws: Corrosion resistant screws to approval of Engineer.

Nuts and bolts: Corrosion resistant fastenings to approval of Engineer.

Fastenings to timber battens or purlins: Provide fastenings just long enough to penetrate the thickness of the timber without piercing the underside.

CORRUGATED METAL ROOFING AND CLADDING

General

Provide a proprietary system of preformed corrugated sheets and all purpose-made accessories required to complete the installation to roof framing or wall framing. Refer to the Corrugated **Sheet Roofing Materials Schedule** for details.

FLAT SHEET METAL ROOFING AND CLADDING

General

Provide a system of flat metal sheets and all purpose-made accessories required to complete the installation to roof framing or wall framing. Refer to **Flat Sheet Roofing Materials Schedule** for details.

GLAZED ROOFING AND SKYLIGHTS

General

Provide a proprietary overhead glazing system fixed to glazing bars or directly to the roof framing. Provide all purpose-made accessories required to complete the installation. Refer to **Glazed Roofing Materials and Skylight Schedule** for details.

ROOF VENTILATORS

General

Provide proprietary roof mounted ventilators and all purpose-made accessories required to complete the installation where shown on the drawings to ventilate the roof space.

Provide fabricated ventilators in walls as shown on the drawings to ventilate the roof space. Refer to **Roof Ventilators Schedule** for details.

EXECUTION

INSTALLATION

Protection

Keep the roofing and rainwater system free of debris and loose material during construction, and leave them clean and unobstructed on completion. Repair damage to the roofing and rainwater system.

If it is necessary to repair minor damage to metal roofing, do so immediately after the damage has occurred. The Contractor takes care to not damage other surfaces during the repair works.

Thermal movement

Provide for thermal movement in the roof installation and the structure, including movement in joints and fastenings.

SHEET METAL ROOFING AND CLADDING

Roofing sheet installation

Fixings: Provide all fixings required to fix the roof sheeting to the framing so that the entire roof covering is waterproof and secure. All loose edges are to be fixed down to ensure that they cannot get loose in high winds.

Expansion joints: refer to drawings for locations of expansion joints in roofs and details of construction.

Ridges and eaves

Treat ends of sheets as follows:

- Project sheets 50 mm into gutters.
- Close off ribs of ribbed sheeting at bottom of sheets using mechanical means or with purpose-made end caps.
- Turn pans of ribbed sheeting up at tops and down into gutters by mechanical means. - Provide pre-cut notched eaves flashings and bird proofing wire mesh where necessary.

Ridge and eaves capping

Finish off along ridge and side eaves edges with purpose-made ridge capping and eaves capping.

End laps

Where end laps are unavoidable in roof sheeting, and the sheet profile is not suitable for interlocking or contact end laps, construct a stepped type lap. Refer to details on drawings as required.

Length of lap (mm): Laps to ends of sheets should not be less than 150mm and sealed with a continuous line of silicone sealant between the sheets of roofing.

Curved corrugated sheet
Form by rolling from material recommended for curving. Minimize crimping or creasing across the face of the sheet. Trim off crimped or creased edges and ends.
K-Span roofing where identified on the drawings is to be strictly controlled during the installation process to ensure that the completed work is of a high standard.

Cladding sheet installation
Fixings: Provide all fixings required to fix the wall cladding sheeting to the framing so that the entire wall is waterproof and secure. All loose edges are to be fixed to ensure that they cannot get loose in high winds.
Expansion joints: refer to drawings for locations of expansion joints in walls and details of construction.
Flashings: Flashings are required at the top, sides and bottom of all metal wall cladding to ensure that the wall is waterproof in all weather conditions.

Metal separation
Prevent direct contact between incompatible metals, and between green hardwood and aluminium or coated steel, by either:
- Applying an anti-corrosion, low moisture transmission coating to contact surfaces.
- Inserting a separation layer.

GLAZED ROOFING AND SKYLIGHTS

Installation
Fixing: Fix all glazed roof panels and skylights in accordance with the drawings.
Flashings: Flashings are required at the top, sides and bottom of all glazed roof panels and skylights to ensure that the roof is waterproof in all weather conditions.

ROOF VENTILATORS

Installation
Fixing: Fix roof ventilators in accordance with the manufacturer's construction details or in accordance with the drawings for fabricated ventilators.

ROOF RAINWATER GOODS

General

Provide the flashings, capping, gutters, rainwater heads, outlets and downpipes necessary to complete the roof system.

Jointing sheet metal rainwater goods

Butt joints: Make joints over a backing strip of the same material.

Soldered joints: Do not solder aluminium or aluminium/zinc-coated steel.

Sealing: Seal fasteners and mechanically fastened joints. Fill the holes of blind rivets with silicone sealant.

Jointing system: Refer to the Gutter and Downpipe Schedule for specific jointing details for each type of element.

Flashings and capping

Installation: Flash roof junctions, upstands, abutments and projections through the roof. Perform required shapes where possible. Cut, notch, bend or dress down as necessary to follow the profile of adjacent surfaces. Lap joints 150 mm in running lengths. Provide matching expansion joints at 6 m maximum intervals.

Upstands: Flash projections above or through the roof with two-part flashings, consisting of a base flashing and a cover flashing, with at least 100 mm vertical overlap. Provide for independent movement between the roof and the projection.

Wall abutments: Provide over flashings where roofs abut walls, stepped to the roof slope in brickwork.

- In masonry: Build cover flashing at least 100mm into the wall at least 250 mm above the roof level. Provide base flashing on roof and provide at least 100mm vertical overlap.
- In concrete: Turn cover flashing at least 30 mm into saw cut grooves at least 250 mm above the roof level, wedge at 200 mm centres with compatible material and render over top of flashing. Provide base flashing on roof and provide at least 100mm vertical overlap.

Fixing to pipes: Solder, or seal with neutral cured silicone rubber and either of the following:

- Secure with a clamping ring.
- Provide a proprietary flexible clamping shoe with attached metal surround flashing.

Gutters

Prefabricate gutters to the required shape where possible. Form stop ends, bends and returns. Provide overflows to prevent back-flooding.

Gutter and sump support: Provide framing and lining to support valley gutters, box gutters and sumps. Line the whole area under the gutters and sumps.

Support: Steel straps as shown on drawings or as approved by the Engineer.

Lining: Timber boards or plywood as shown on drawings or as approved by the Engineer.

Valley gutters: Profile to suit the valley boarding. Nail or screw to the valley boarding at the top end to prevent the gutter creeping downwards.
Gratings and guards: Provide removable gratings over rainwater heads and sumps:
- Type: Wire mesh cages reinforced with steel bars where required due to size and expected snow loads. Refer to drawings for details.
Expansion joints: Provide expansion joints in guttering longer than 30 m:
- Type: Refer to drawings for details.

Downpipes
Prefabricate downpipes to the required section and shape where possible. Connect heads to gutter outlets and, if applicable, connect feet to rainwater drains.
Access cover: Provide a removable watertight access cover at the foot of each downpipe stack if the downpipe is connected to rainwater drains.
Downpipe support: Provide supports and fixings for downpipes.

ROOF MOUNTED EQUIPMENT ACCESS

Walkway
Product: Provide proprietary walkway systems to locations as shown on drawings. Provide fabricated systems constructed as shown on drawings. Fabricate in accordance with the metalwork section of the specification.
Installation: Install proprietary systems in accordance with manufacturers details and as identified on drawings.

COMPLETION

Roof Inspection
The Contractor is to closely inspect the entire roof covering and metal cladding to walls at completion of the works.
Make good any defects or damage to the sheeting, capping or flashings. Remove all loose metal and other rubbish, spare nails, screws, filings and other debris.
Clean down the roof, gutters, downpipe outlets to ensure that it is in good condition ready for occupation.

24. WINDOWS AND WINDOW HARDWARE

GENERAL

INTERPRETATION

Definitions

For the purposes of this work section windows also include louvers, either vertical or horizontal, set into frames.

INSPECTION

Notice

Give sufficient notice so that inspection may be made of the following:
- Openings prepared to receive windows (where windows are to be installed in prepared openings).
- Fabricated window assemblies delivered to the site, before installation.
- Commencement of window installation.

PRODUCTS

LOUVRE ASSEMBLIES

General

Provide louver blades mounted in a surround frame and able to withstand the wind pressure for that location without failure or permanent distortion of blades, and without blade flutter.

Adjustable louvers

Provide louver blades clipped into holders which pivot, linked together in banks, each bank operated by an operating handle incorporating a latching device, or by a locking bar.

Screens

Provide metallic coated steel wire mesh screens behind louvers to prevent the entry of birds, rodents and windblown leaves and papers.

INSECT SCREENS

Aluminium/Mild steel framed screens

Provide insect screens with mesh frame channels. Provide an extended frame section where necessary to adapt to window opening gear.
- Mesh: Fix the mesh into the frame channel with a continuous resilient gasket, so that the mesh is taut and without distortion.

Fixed screens
Provide fixed screens to the window frames with a clipping device which permits removal for cleaning.

Hinged screens
Hinge at the side to give access to the opening sash.

Sliding screens
Provide a matching aluminium head guide, sill runner, and frame style sections for screens not part of the window frame.
- Hardware: Nylon slide runners and finger pull handle.

SECURITY WINDOW GRILLES

General
Provide security grilles in accordance with the drawings or proprietary metal security grille screens, fixed to the building structure with tamper resistant fastenings.

WINDOW HARDWARE

Hardware
Provide hardware of sufficient strength and quality to perform its function, appropriate to the intended conditions of use and climate and fabricated with fixed parts firmly joined.

EXECUTION

INSTALLATION

General
Install windows so that the frames:
- Are plumb, level and straight within acceptable building tolerances.
- Are fixed or anchored to the building structure to resist the wind loading.
- Will not carry any building loads, including loads caused by structural deflection.
- Allow for thermal movement.

Flashing and weathering
Install molds, sealant and cement pointing as required so that water is prevented from penetrating the building between the window frame and the building structure.

Fixing and fasteners

Materials: Use materials compatible with the item being fixed and of sufficient strength, size and quality to perform their function.

Concealed fixings: Provide a corrosion resistant finish.

Exposed fixings: Match exposed fixings to the material being fixed.

Support: Provide appropriate back support (for example blocking and backing plates) for hardware fixings. Window fastener spacing (nominal): 600 mm.

Window fasteners: Conceal fasteners where possible.

Packing: Pack behind fixing points with durable full width packing.

Prepared masonry openings: If fixing timber windows into existing prepared openings with fastenings through the frame face, make the fastener heads finish below the surface and fill the hole for a smooth surface finish.

Joints

Make accurately fitted tight joints so that neither fasteners nor fixing devices such as pins, screws, adhesives and pressure indentations are visible on exposed surfaces.

Operation

Ensure moving parts operate freely and smoothly, without binding or sticking and are lubricated.

Supply

Deliver window hardware items, ready for installation, in individual complete sets for each window.

- In a separate dust and moisture proof package labeled for the specific window.
- Including the necessary templates, fixings and fixing instructions.

Refer to the drawings and **Window Construction, Louvre Construction** and **Security Grille Construction Schedules** for details of windows. Refer to the **Window Hardware Schedule** for details of window hardware.

COMPETITION

Cleaning

The Contractor is to clean all frames, glass, hardware at completion. Any damage to frames, or broken glass is to be repaired or replaced to the satisfaction of the Engineer.

Adjustment

Leave the hardware properly adjusted with working parts in working order and lubricated where appropriate.

25. DOORS AND DOOR HARDWARE

GENERAL

INTERPRETATION

Definitions
For the purposes of this work section the definitions given below apply.
- Door frame: Includes door trims.
- Door set: An assembly comprising a door or doors and supporting frame, guides and tracks including the hardware and accessories necessary for operation.
. Fire-door set: A door set which retains its strength and limits the spread of fire.
. Smoke-door set: A door set which restricts the movement of smoke.
- Flush door: A door leaf having two flat faces which entirely cover and conceal its structure. It includes doors with cellular and particleboard cores.
- Joinery door: A door leaf having stiles and rails, framed together. A joinery door may also incorporate glazed panels.
. Louvered door: A joinery door in which the panel spaces are filled in with louver blades.

INSPECTION

Notice
Give sufficient notice so that inspection may be made of the following:
- Door frames standing in place before building in to brickwork.
- Door frames installed before fixing trim.

SUBMISSIONS

Samples
Submit samples of all hardware items for approval by the Engineer before use in the works.

Subcontractors
Automatic sliding door assemblies: Submit names and contact details of proposed supplier and installer.

Product warranties

Automatic sliding door assemblies: Submit a warranty from the supplier and installer for the system and its installation, for a period of at least twelve months from the date of completion.
Hardware: Submit the warranties offered by the manufacturer for the hardware items provided in the works.

Keys
Key codes: Submit the lock manufacturer's record of the key coding system showing each lock type, number and type of key supplied, key number for re-ordering, and name of supplier.
Keys: For locks keyed to differ and locks keyed alike, verify quantities against key records, and deliver all keys and records to the Engineer at completion.

PRODUCTS

FRAMES

Aluminium frames
To be assembled from heavy duty aluminium sections, including necessary accessories such as buffers, strike plates, fixing ties or brackets, and suitable for fixing specified hardware.

Timber frames
To be constructed with best quality timber. Obtain approval from the Engineer for the timber selection before use. Construct as shown on the drawings and ensure that all joints are securely made to avoid distortion of the frame in use.

Steel frames
To be folded from metallic-coated steel sheet sections, joints to be continuously welded, including necessary accessories such as buffers, strike plates, spreaders, fixing ties or brackets, and suitable for fixing specified hardware.
Finish: Grind the welds smooth, prepare and paint the welded joints with primer. Then prime the entire frame.
Hardware and accessories: Provide for fixing hardware including hinges and closers, using 4 mm back plates inside the frame. Screw fix the hinges into the back plates.
Base metal thickness:
- General: ≥ 1.1 mm.
- Fire rated door sets: ≥ 1.4 mm.
- Security door sets: ≥ 1.6 mm.

DOORS

Flush doors

Solid core PVC flush doors:

- 4mm Plain / Printed / Prelim PVC sheets are used on both sides of 20mm multichannel hollow PVC panel infill material to cover the panel.
- Reinforced with 19mm x 19mm MS tube welded frame with unmatched screw holding capacity, strength & dimensionally stability.
- Lightweight, & 100% environmentally friendly.

Cellular core flush doors:

- Provide a sub frame of 25 mm minimum width timber around openings for louvers and glazing. - Provide additional material to take hardware and fastenings.
- Cut outs: If openings are required in flush doors (e.g., for louvers or glazing) make the cut outs not closer than 120 mm to the edges of the doors.

Solid core flush doors:

- Core of timber strips laid edge to edge, fully glued to each other and to facings each side of no less than two sheets of timber veneer.
- Single thickness of moisture resistant general-purpose particleboard.

Refer to drawings and **Flush Doors Construction Schedule** for details.

Joinery doors

Fabricate joinery doors as shown on the drawings and in the **Joinery Doors Construction Schedule**.

Construction

Form rebates to suit standard rebated door hardware.

Louver grilles: Construct by inserting the louver blades into a louver frame, and fix the frame into the door.

Double doors

Provide rebated meeting stiles unless the doors open in both directions. Chamfer square edged doors to prevent binding between the leaves.

DOORSETS

Automatic sliding door assemblies

Provide auto sliding door assemblies in accordance with the **Automatic door schedule**.

Toughened glass door assemblies

Provide toughened glass door assemblies with matching concealed hinges and patch fittings as appropriate. Ensure that all glass edges are protected during installation and polish on completion.

Fire-resistant door sets

Provide fire resistant doors and frames as matched sets for door openings required to have a fire rating. Provide copies of test certificates from recognised authorities proving the performance of the door sets.

Smoke-resistant door sets

Provide smoke resistant doors and frames as matched sets for door openings required to have a smoke stopping capability.

Provide copies of test certificates from recognised authorities proving the performance of the door sets or seals to frames.

Security screen door sets

Provide security screen door sets in accordance with the **Security screen doors construction schedule**.

ANCILLARY MATERIALS

Nylon brush seals

To be dense nylon bristles locked into galvanized steel strips and fixed in a groove in the edge of the door or in purpose-made anodised aluminium holders fixed to the door

Pile weather strips

To be polypropylene or equivalent pile and backing, low friction silicone treated, ultra-violet stabilized.

Door Seals

To be proprietary items as identified in Schedules and to approval of Engineer.

HINGES

Butt hinge sizes

Refer to **Hinge table A** and **Hinge table B** in which length (l) is the dimension along the knuckles, and width (w) is the dimension across both hinge leaves when opened flat.

- Steel, stainless steel, brass, bronze butt hinges for timber doors in timber or steel frames: To **Hinge table A.**

- Aluminium hinges for aluminium doors, or for doors of other materials in aluminium frames: To **Hinge table B**.

Hinge materials

Aluminium hinges: High tensile aluminium with fixed stainless-steel pins in nylon bushes, and with nylon washers to each knuckle joint.
Doors fitted with closers: Provide low friction bearing hinges.

Hinge pins

Exterior or security doors opening out: Provide fixed pin hinges.

Hinge table A

Nominal hinge size **l x w x t (mm)**	Door leaves not exceeding any of the following		
	Mass (kg)	**Width (mm)**	**Thickness (mm)**
70 x 50 x 1.6	16	620	30
85 x 60 x 1.6	20	820	35
100 x 75 x 1.6	30	920	40
100 x 75 x 2.5	50	920	50
100 x 75 x 3.2	70	1020	50
125 x 100 x 3.2	80	1220	50

Hinge table B

Nominal hinge size lxwxh (mm)	Door leaf not exceeding mass (kg)	Minimum construction	
		Knuckles	**Screws/hinge leaf**
100 x 70 x 3	30	3	3
100 x 80 x 3.5	50	5	4

Number of hinges

Provide 3 hinges for doors up to 2200 mm high, and 4 for door leaves between 2200 mm and 3000 mm high.

Wide throw
If necessary, provide wide throw hinges to stop doors binding on obstacles such as nibs or deep reveals.

DOOR HANGING SYSTEMS

General
Provide sliding door tracks in conformance with the schedules.

LOCKS AND LATCHES

General Door Hardware
Provide hardware of sufficient strength and quality to perform its function, appropriate to the intended conditions of use and climate and fabricated with fixed parts firmly joined.

Bolts
Provide bolts including barrel bolts and tower bolts with associated hardware, including lock plates, ferrules or floor sockets.

Furniture
Provide lock and latch furniture suitable for use with the lock or latch to which it is installed with the corresponding level of performance.

Strike plates
Use strike plates provided with the locks or latches.

Fire rated door closers
Provide closers tested and certified for use as components of fire door assemblies.

Door Controllers Performance
Provide door controllers, including door closers, floor or head spring pivots which are suitable for the door type, size, weight and swings required and the operating conditions, including wind pressure.

EXECUTION

FRAMES

General
Install doors so that the frames:
- Are plumb, level and straight within acceptable building tolerances.
- Are fixed or anchored to the building structure to resist the wind loading.
- Will not carry any building loads, including loads caused by structural deflection.
- Allow for thermal movement.

Flashing and weathering

Install molds, sealant and cement pointing as required so that water is prevented from penetrating the building between the door frame and the building structure.

Aluminium frames
Building in to masonry: Screw galvanized steel brackets twice to jambs and build in. Fixing to masonry openings: Use proprietary expansion anchors and screw through jambs at each fixing.

Frame fixing
Brackets: Metallic-coated steel:
- Width: ≥ 25 mm.
- Thickness: ≥ 1.5 mm.

Jamb fixing centers: ≤ 600 mm.

Fixing and fasteners
Materials: Use materials compatible with the item being fixed and of sufficient strength, size and quality to perform their function.
Concealed fixings: Provide a corrosion resistant finish.
Exposed fixings: Match exposed fixings to the material being fixed.
Support: Provide appropriate back support (for example blocking and backing plates) for hardware fixings. Packing: Pack behind fixing points with durable full width packing.
Prepared masonry openings: If fixing timber door frames into existing prepared openings with fastenings through the frame face, make the fastener heads finish below the surface and fill the hole for a smooth surface finish.

Joints
Make accurately fitted tight joints so that neither fasteners nor fixing devices such as pins, screws, adhesives and pressure indentations are visible on exposed surfaces.

Operation
Ensure moving parts operate freely and smoothly, without binding or sticking and are lubricated.

Supply
Deliver door hardware items, ready for installation, in individual complete sets for each door.
- In a separate dust and moisture proof package labeled for the specific door.
- Including the necessary templates, fixings and fixing instructions.

Refer to the drawings and **Flush Doors, Joinery Doors, Security Screen Doors, Fire** and **Smoke Resistant Dorset Schedules** and **Automatic Door Construction Schedules** for details of frames and doors.

COMPLETION

Cleaning

The Contractor is to clean all frames, doors, glass, hardware at completion. Any damage to frames and doors, or broken glass is to be repaired or replaced to the satisfaction of the Engineer.

Adjustment

Leave the hardware properly adjusted with working parts in working order and lubricated where appropriate.

26. GLAZING

GENERAL

INSPECTION

Notice

Inspection: Give sufficient notice so that inspection may be made of the following:

- Glass products before they are installed.

PRODUCTS

GLASS

Glass and glazing materials

Glass and glazing materials generally: Free from defects which detract from appearance or interfere with performance under normal conditions of use.

Glazing plastics: Free from surface abrasions, and warranted by the manufacturer for 10 years against yellowing or other color change, loss of strength and impact resistance, and general deterioration.

Refer to **Annealed glass, Processed glass** and **Fabricated glass schedules** for specific details for the works.

GLAZING MATERIALS

General

Glazing materials (including putty, glazing compounds, sealants, gaskets, glazing tapes, spacers, setting blocks): Appropriate for the conditions of application and the required performance.

Single glazing
Single glazing shall be executed with glass of the various types described herein. Ordinary (non-safety) glass may be pre-cut or cut on site.

Wired glass
Wired glass shall be cut so that the wires embedded are truly vertical and horizontal (i.e., at right angles to the cut edges).

Laminated glass
Laminated glass shall be factory cut before delivery to site. Site cutting will not be permitted.

Jointing materials
Provide recommended jointing and pointing materials which are compatible with each other and with the contact surfaces and non-staining to finished surfaces. Do not provide bituminous materials on absorbent surfaces.

Pile weather strips
Materials: Polypropylene or equivalent pile and backing, low friction silicone treated, ultra violet stabilized.
Finned type: A pile weather seal with a central polypropylene fin bonded into the center of the backing rod and raised above the pile level.

Extruded gaskets and seals
Type: Non cellular (solid) seals to exclude water from glass/frame junctions.
Material:
- Rubber products to be neoprene, ethylene propylene diene monomer (EPDM) or silicone rubber. - Flexible polyvinyl chloride (PVC)

Priming
Apply the recommended primer to the surfaces in contact with sealant materials.

Movement joints
Depth of elastomeric sealant: One half the joint width, or 6 mm, whichever is the greater.
Foamed materials (in compressible fillers and backing rods): Closed-cell or impregnated types which do not absorb water.

Bond breaking: Provide backing rods, and other back-up materials for sealants, which do not adhere to the sealant.

MIRRORS

Reflective surface
Type: Silver layer deposited on the glass or glazing plastic.

EXECUTION

GLASS PROCESSING

General
Perform required processes on glass, including cutting, obscuring, silvering and bending. Form necessary holes, including for fixings, equipment, access holes and speaking holes. Process exposed glass edges to a finish that will reduce the risk of injury.

INSTALLATION

General
Install the glass so that:
- Each piece is held firmly in place by permanent means which enable it to withstand the normal loadings and ambient conditions at its location without distortion or damage to glass and glazing materials. - Building movements are not transferred to the glass.
- External glazing is watertight and airtight.
Toughened glass: Do not cut, work, or permanently mark after toughening. Use installation methods which prevent the glass making direct contact with metals or other non-resilient materials.
Frameless installations: Join the vertical edges of adjacent glass panels with silicone jointing compound. External timber framed glazing: Glaze with putty. Do not dry bead into timber frames.

FIXING MIRRORS

Screw fixing
Direct to wall plugs with dome-headed chromium-plated screws in each corner and at 900 mm maximum centers around perimeter. Provide polyethylene sleeves and washers to prevent contact between screw and glass. Do not over-tension the screws.

Frame fixing

Proprietary aluminium frames to mirror perimeter, corners mitred. Attach the frame to the wall with concealed screw fixings. Frames and finish to approval of the Engineer.

Bead fixing
Rebated timber beads to mirror perimeter, corners mitred. Screw fix the beads to the substrate.

GLAZED SHOWER SCREENS

Type
Proprietary system comprising frames of extruded aluminium, stainless steel, or PVC, assembled around safety glass to form fixed panels and sliding, hinged or pivoted doors.

Water shedding
Provide an assembly which sheds water to the inside without retaining it on the frame surfaces. Seal the edge of the frame to adjoining surfaces with a resilient strip.

Sliding assemblies
Hanging: Hang the sliding sash on stainless steel or nylon sheaves on overhead channel track formed in the frame head, and fit nylon or equivalent bottom guides.
Hardware: Pull handles on both sides of sash, or of leading sash in multiple sash arrangements.

COMPLETION

Cleaning
Replace damaged glass and leave the work clean, polished, free from defects, and in good condition.

27. GLASS BLOCKWORK

GENERAL

INSPECTION

Notice
Give sufficient notice so that inspection may be made of the following:
- Frame and expansion jointing installed, before reinforcing.
- Perimeter and vertical reinforcing installed, before placing mortar and blocks.

SUBMISSIONS

Samples

Glass blocks: Submit 2 blocks of each type showing size, color, design and pattern of faces. Accessories: Submit samples of reinforcing, fasteners, expansion materials and sealant.

PRODUCTS

MORTAR-JOINTED PANELS

Perimeter

Frames:

- Size: 100 x 50 x 6 mm.
- Material: Aluminium channel.
- Fixing: 10 mm masonry anchors with galvanized washers.
- Drainage: Drill holes in the web of the sill channel.

Expansion jointing and sill channel lining: 10 mm (minimum) x width of the channel rebate.

Glass blocks

Refer to **Glass block schedule** for block types.

Mortar

Cement: Slow setting Portland cement with low shrinkage.

Hydrated lime: calcium, or pressure-hydrated dolomitic lime if > 92% of active ingredients are hydrated. Sand: Clean sharp river mineral sand, salt free, no admixtures, no iron compounds.

Water: Clean, potable.

Mortar and pointing mix by volume (cement:lime:sand): 1:0.25:3. As dry as practicable. Pigments: Powder oxides.

- Colour: Refer to **Glass Block schedule**

Reinforcement: 4.5 – 6 mm diameter, in lengths to suit full width or height of panel, as appropriate.

FIRE-RATED PANELS

Perimeter

Frames:

- Size: 150 x 75 x 9 mm.
- Material: Mild steel channel.
- Fixing: 10 mm masonry anchors with heavy galvanized washers.
- Drainage: Drill holes in the web of the sill channel.

Expansion jointing:
- Type: Ceramic fiber blanket, 38 mm (minimum) x width of channel rebate.
Sill channel lining: Ceramic fiber board, 12 mm (minimum) x width of channel rebate.

Glass blocks
Refer to **Glass block schedule** for block types.

Mortar
Cement: Slow setting Portland cement with low shrinkage.
Sand: Clean sharp river mineral sand, salt free, no admixtures, no iron compounds. Water: Clean, potable.
Mortar and pointing mix by volume (cement:sand): 1:3. As dry as practicable.
- Compressive strength (minimum): 10 MPa at 2 days, 35 MPa at 28 days.
Pigments: Powder oxides.
- Colour: Refer to **Glass Block schedule**
Reinforcement: 6 mm diameter, in lengths to suit full width or height of panel, as appropriate.

Finish
Sealant: Fire resistant non-setting non-staining waterproof elastomeric sealant, hardening only at the surface.

SEALANT-JOINTED PANELS

Perimeter
Frames: Proprietary extruded aluminium frame.
- Fixing: 12-gauge 40 mm long stainless-steel pan head screws, with nylon masonry plugs where appropriate.

Glass blocks
Refer to **Glass block schedule** for block types.

Panels
Reinforcement: 50 x 3 mm flat bars.
Block-locating clips: Proprietary plastic clips designed to clip on the reinforcement and fit the glass block edges.

Finish

Grouting sealant: Silicone.
- Colour: Refer to **Glass Block schedule**

EXECUTION

Ambient conditions
General: Do not install below 5°C. Maintain panels above 5°C for the first 48 hours after construction.

Perimeter
Frames: Erect 4-sided frame mitred at corners, spaced 5 mm clear of the structure on packing. Fixing: 400 mm centers. Center hole on each side circular, other holes slotted longitudinally 50 mm.
- Packing: 75 x 75 x 2 mm zinc-plated steel.
- Sill channel: Lay sill channel lining in rebate.
- Jamb and head channels: Adhesive-fix expansion joining in rebates.

Panels
Laying blocks: By hand, may be knocked into position using a rubber or soft nylon hammer. Align block patterns consistently. Prevent mortar extrusion under load while setting.
Bond: Stack bond.
Reinforcement:
- Frame: Two rods all round, hooked and connected with wire at the corners. Horizontal rods to be a tie rod assembly, with 6 mm diameter tie rods at 200 mm centers, spacing the main rods 40 – 45 mm apart. - Joint: Two rods in at least every second horizontal joint, and every tenth vertical joint. Overlap 230 mm (minimum) at corners. Do not tie vertical rods to horizontal rods. Do not impinge on expansion joints. Tie joint reinforcement to frame reinforcement.
- Cover (minimum): 15 mm to outside face, 10 mm to inside face, 5 mm to blocks. Joints:
- Widths (clear): 10 – 15 mm. For curved walls, 5 – 20 mm for vertical joints.
- Width tolerance: ± 3 mm.
- Placing mortar: Do not retemper mortar. Do not furrow joints. Fill channel frame and panel joints.
- Pointing: Point before mortar has hardened. Neatly tool to a smooth, dense concave joint. Remove excess mortar from glass surfaces using a damp cloth before mortar set occurs, without damaging the glass. Protect against premature drying, but do not moisten.

SEALANT-JOINTED PANELS

Perimeter

Frames:
- Assembly: Mitre frame at corners. Assemble with connection angles and cleats, drill, and fix frames to angles with blind rivets.
- Fixing jamb frames: Position screws to clear the ends of the reinforcing bars. Fix screws with neoprene washers and through the packing, at 400 mm (maximum) centers, and pairs 100 mm from ends. - Fixing sill frame: Fix screws with neoprene washers and through the packing, at 800 mm (maximum) centers, and 100 mm from ends.
- Packing: Locate to square the frame, maximum 10 mm, to sill and jamb frames only. **Panels**
Laying blocks: Select and orient glass blocks to ensure consistent coursing dimensions. Lightly clean edges with steel wool.
Block-locating clips: Locate onto sill frame profile 20 mm from each corner and centered at every perpend, ribbed side up. Insert in perpends, including at jamb frames, centered at course center line. Clip onto reinforcing bars 20 mm from the ends and centered at every perpend, ribbed side up. Insert above top course 20 mm from each corner and centered at every perpend.

Bond: Stack bond.
Joint reinforcement: Joint: Run reinforcement horizontally, and slot into the jamb frame channels on top of the glass block courses, except the top course, finishing 3 mm short of the jamb frame rebate faces.

Joints:
- Widths: 3 – 4 mm.

Finish
Jointing: Clean and dry substrates. Execute work neatly, without gaps and holes. Inject structural sealant into blockwork joints to a depth of 5 – 8 mm.
Grouting: Clean and dry substrates. Execute work neatly, without gaps and holes. Apply grouting sealant to mitred frame corner joints, and apply to blockwork joints, including at the perimeter frame, to both panel faces. Remove excess sealant from glass at completion, without damaging the glass.

MAINTENANCE

Mortar-jointed and fire-rated panels
Final clean: Wash using clean water. Remove dry powder using a clean soft dry cloth.

28. INSULATION AND VAPOR BARRIERS

GENERAL

INTERPRETATION

Definitions
General: For the purposes of this work section the definitions given below apply.
- Sarking-type material: Flexible reflective foil membrane material normally used for waterproofing, vapor proofing or thermal reflectance.
- Mineral wool (including glass wool and Rockwool): Entangled mat of fibrous non-crystalline material derived from inorganic oxides or minerals, rock, slag or glass, processed at high temperatures from a molten state.
- Vapour barrier: A material or system that adequately impedes the transmission of water vapor. -

INSPECTION.

Notice
Give sufficient notice so that inspection may be made of the insulation to roof space in areas which will be covered up or concealed.

PRODUCTS

MATERIALS AND COMPONENTS

Bulk insulation
Mineral wool blankets and cut pieces: Provided in bulk rolls for laying over roof structures or on roof slabs and batts to suit ceiling member spacing.
Polystyrene (extruded rigid cellular sheets): Provided in modular panels for fixing to walls and roof slabs.
Reflective insulation: Provided in bulk foil rolls for laying over roof structures and foil batts to suit ceiling member spacing.

Sarking-type material
Sarking: Reflective foil fixed as a membrane to reduce liquid water transfer in walls or roof structures but allow water vapor to move through the building envelope.
Vapor barrier: Reflective foil sealed as a membrane to stop all liquid water and water vapour transfer.

Fasteners and supports

Metallic-coated steel.

EXECUTION

GENERAL

Bulk insulation
Batts: Fit tightly between framing members. If support is not otherwise provided, fix over wire mesh stapled to the framing and stretch tight.

Reflective foil laminate
To timber: Metallic-coated flat head nails or staples at 300 mm maximum centers.
To steel or aluminium: Double sided pressure sensitive tape.
Overlap (minimum): 150 mm and adhesive fix.

Roof sarking locations
Location: Provide sarking under metal sheet roofs. Fix over timber supports and run rolls across the roof plane. Overlap each layer of foil so that any water will run down the slope and discharge into the gutter without dripping into the roof space.

ROOF INSULATION

General
Location: The whole of the ceiling area, except the following:
- Eaves, overhangs, roof lights, vents and openings.
- Roofs to outbuildings, garages, and semi-enclosed spaces such as verandas, porches.

Installation
Refer to the drawings and **Insulation Schedule** for details of insulation requirements for the works.

29. **LINING**

GENERAL

INSPECTION
Notice
Inspection: Give sufficient notice so that inspection may be made of the wall face or framing before installation of linings.

29.1.2. SUBMISSIONS

Samples

Plasterboard: Submit two 300x300mm samples of each type.
Fiber cement sheet: Submit two 300x300mm samples of each type.
Accessories: Submit samples of accessories, fasteners, trims and cornices.

TOLERANCES

Surface

Flatness, twist and bow: ≤ 3.0 mm deviation from a 1.5 m straightedge placed in any position.

PRODUCTS

MATERIALS AND COMPONENTS

Plasterboard

Plasterboard sheet lining to be the best quality imported sheet material, size, type and thickness in accordance with the Project Schedule, to the approval of the Engineer.

Fiber cement

Fiber cement sheet lining to be the best quality imported sheet material, size, type and thickness in accordance with the Project Schedule, to the approval of the Engineer.

Fasteners

Steel nails: Hot dip galvanized.
Screws: Coated steel cross head screws.

Adhesives

For plasterboard: Epoxy grout adhesive as supplied by the plasterboard sheet manufacturers. For cement sheet: Mastic adhesive.

Sealants

Fire rated sealant: non-hardening sealant compatible with the materials to be sealed and having a fire rating equal to that of the partition it seals.
Acoustic sealant: non-hardening sealant compatible with the materials to be sealed and having a specific gravity of not less than 1.5 gm/cubic centimeter and of 100% polyurethane mastic.

EXECUTION

CONSTRUCTION GENERALLY

Conditions

Do not commence lining work until such time as the building or zone in question is enclosed and weathertight and all wet trades have been completed.

Substrates or framing

Before fixing linings check and, if necessary, adjust the alignment of wall faces or framing. Make good any damaged areas that may affect the fixing of the lining. Ensure that there are no projections from the face of the wall structure that may affect the installation of the lining material.

Ceiling linings

Do not install ceilings until at least 14 days after the timber roof structure is fully loaded where this is used for support of the ceiling.

Accessories and trim

Provide accessories and trim necessary to complete the installation.

Adhesives

Provide adhesives of types appropriate to their purpose, and apply them so that they transmit the loads imposed, without causing discolouration of finished surfaces.

PLASTERBOARD LINING

Supports

Install timber battens or galvanized steel channels as follows:

- Where framing member spacing exceeds the recommended spacing.
- Where direct fixing of the plasterboard is not possible due to the arrangement or alignment of the framing or wall face.

Installation

Gypsum plasterboard: Install strictly in accordance with manufacturers recommendations. Framed construction: Screw or nail or combine with adhesive.

Masonry construction: Fix using adhesive direct to masonry.

Suspended ceilings: Fix using screw or screw and adhesive to ceiling members.

To steel channels: Fix using screw or screw and adhesive.

Multiple sheet layers
Application: Fire rated and acoustic rated walls.
Joints: Fill and flush up all joints and fixings in each layer and caulk up perimeters and penetrations before commencing succeeding layers. Stagger all sheet joints by minimum 200 mm.

Joints
Flush joints: Provide recessed edge sheets and finish flush using perforated paper reinforcing tape.
Butt joints: Make joints over framing members or otherwise provide back blocking.
External corner joints: Make joints over metallic-coated steel corner beads.
Control joints: Install purpose-made metallic-coated control joint beads at not more than 12 m centers in walls and ceilings and to coincide with structural movement joints.

FIBER CEMENT LINING

Supports
Install timber battens or galvanized steel channels as follows:
- Where framing member spacing exceeds the recommended spacing.
- Where direct fixing of the fiber cement is not possible due to the arrangement or alignment of the framing or substrate.

Installation
Run sheets across the framing members. In flush jointed applications, stagger end joints in a brick pattern and locate them on framing members, away from the corners of large openings. Provide supports at edges and joints.
Timber framed construction: Nail only or combined with adhesive.
Steel framed construction: Screw only or combined with adhesive.
Masonry construction: Fix using adhesive direct to masonry.
Suspended flush ceilings: Fix using screw or screw and adhesive to ceiling members or support frame. Ceilings and soffits: Provide battens where fixing to underside of rafters, roof trusses and purlins.

Multiple sheet layers
Application: Fire rated and acoustic rated walls.
Joints: Fill and flush up all joints and fixings in each layer and caulk up perimeters and penetrations before commencing succeeding layers. Stagger all sheet joints by minimum 200 mm.

Joints

Flush joints: Provide recessed edge sheets and finish flush using perforated paper reinforcing tape.
- Movement joints in walls: Position a stud parallel to the joint on each side.
- Movement joints in ceilings and soffits: Provide movement joints to divide ceilings into bays not larger than 10.8 x 7.2 m and soffit linings into bays not larger than 4.2 x 4.2 m or 5.4 x 3.6 m. Provide framing parallel to the joint on each side. Do not fix the lining to abutting building surfaces.

External corner joints: Make joints over metallic-coated steel corner beads.
Control joints: Provide purpose-made metallic-coated control joint beads at ≤ 7.2 m centers in walls and ceilings and to coincide with structural movement joints

CEILING ACCESS

General
Location: Provide personnel access ways to each separate ceiling space.
Size (mm): Minimum of 600 x 600 mm
Material: Match adjacent ceiling lining.
Type: Plain cover supported on all sides by timber trim fixed to the underside of the ceiling.

CORNICES

General
Plasterboard cornice: Install plasterboard trims to the junctions between wall surfaces and ceilings as shown on the drawings.
Timber cornices: Install timber trims to the junctions between wall surfaces and ceilings as shown on the drawings.

COMPLETION

General
Ensure that all surfaces are protected, dry and free from damage until paint finishes are to be applied. All plasterboard and fiber cement surfaces must dry for at least 7 days before painting is to commence.

30. **PARTITIONS – SYSTEMS**

GENERAL

INTERPRETATION

Definitions

For the purposes of this work section the definitions given below apply.

- Partition – fully demountable: A partition system in which any component may be demounted without damage, using only small hand tools, and subsequently reassembled without cutting, trimming or refinishing.
- Partition – semi demountable: A partition system in which the major components are designed to be removed and reused but panels or linings, which are likely to be damaged during removal, are not. - Partition – non demountable: A partition system in which major components, such as panels or linings, are likely to be damaged during removal and may require cutting, trimming or structural repair before reuse. - Cool room panel system: A partition system fabricated to suit specific thermal conditions in which the insulated panels are designed to be removed and reused but panels or trims are likely to be damaged during removal.

INSPECTION

Notice

Give sufficient notice so that inspection may be made of the following stages:

- Installation of framing / fixings before they are enclosed.

SUBMISSIONS

Samples

Submit samples as follows:

- A sample, at least 300 x 300mm, of each panel type.
- Floor and ceiling fixings and adjustments.
- Samples at least 100 mm long of each structural section, including posts, sills, transoms, door frames, ceiling channels and metal channel headrails, and each molding, cover strip and bead. - Skirting, skirting duct, skirting duct stop ends, returns and removable covers.

TOLERANCES

General

Deviation (from true grid lines and planes): up to 3 mm maximum in a 1500mm length. Misalignment (of adjoining surfaces at grid junctions): 3 mm maximum.

Flatness, twist and bow: Maximum 3 mm deviation from a 1500mm straightedge placed in any position.

PRODUCTS

PARTITIONS

General

Provide proprietary non-load-bearing partition wall framing and lining comprising cold formed steel or extruded aluminium members, or both, in conformance with the **Partition construction schedule**.

Building movements

Provide clearances or movement joints so that partitions are not damaged by structural building movements such as long-term slab deflection. Where fire resistance or acoustic properties are specified provide a resilient foam or mastic seal having properties equal to those required for the partition.

Control joints

General: Provide for control joints in sheet finishes where required by the structural frame.

EXECUTION

PREPARATION

General

Prepare the base to receive the partitions. Ensure that all surfaces are flat without bumps or hollows that could affect the performance of the partition system.

Set out

Set out the partitions so that the partition grid, as expressed in panel joints and center lines of frame members, coincides with the ceiling grid and the building grid, if applicable.

ERECTION

Partition erection

Install the partitions so they:

- Are plumb, level, on their correct alignments, and firmly fixed.
- Have adequate top support by fixing the top plate to the ceiling structure or slab soffit, or are stabilized by lapping and fastening intersecting or butting plates together.
- Have bottom plates fixed at 600 mm maximum centers generally, and 100 mm maximum from ends. Install cool room panel systems to manufacturer's recommendations and standard details

where feasible. Ensure that all seal strips, cover strips, accessories, fixings needed to satisfactorily carry out the installation are provided and installed to the approval of the Engineer.

Fixing

Concealed fixings. The demountable items provide fixings capable of being repeatedly removed and replaced without damage to finishes.

Fixing to masonry: Provide masonry anchors of expansion or chemical grout type. Do not provide explosive driven fastenings.

Fixing to suspended ceilings: Provide adequate top support to the partition without damage to the ceiling components.

Protection

Protect existing work from damage during the installation and make good any damage. Provide temporary coverings if necessary.

Sound properties

Preserve the sound reduction properties of partitions by sealing flanking sound transmission paths during installation, including junctions between partitions and other building surfaces, air gaps around door sets, recesses, such as pelmets and blind boxes and cut-outs for services. Avoid cut-outs next to or back-to-back with each other.

Sealing methods: Use appropriate sealing methods, such as durable resilient gaskets or closed cell foam strips. Provide solid resilient materials in preference to foamed materials whenever possible.

Support

Provide additional support in the form of framing for fixing hardware, fixtures and fittings.

SERVICES

Services access

Conceal associated building services, either within cavities in the partition structure, or within ducted skirtings supplied as part of the partition system, or both. Provide removable or demountable components of the partition system, for access to services concealed within partition cavities.

31. ROOM DIVIDERS

GENERAL

INSPECTION

Notice
Give sufficient notice so that inspection may be made of the following:
- Overhead tracks installed before dividers/door panels are hung and ceiling installed.

SUBMISSIONS

Samples
Submit 2 samples of each of the following where applicable:
- Sections proposed to be used for frames, louvers and slats.
- Colour range samples of facings and prefinished production material.
- Manufacturer's standard door furniture items.

TOLERANCES

Tolerances
Deviation (from true grid lines and planes): up to 3 mm maximum in a 1500mm length. Misalignment (of adjoining surfaces at grid junctions): 3 mm maximum.
Flatness, twist and bow: Maximum 3 mm deviation from a 1500mm straightedge placed in any position.

EXECUTION

COMPLETION

Maintenance manual
Submit manufacturer's published recommendations for service use.

Cleaning
Temporary coating: On or before completion of the works, or before joining up to other surfaces, remove all traces of temporary coatings used as a means of protection.

SELECTIONS
Refer to the **Folding Doors, accordion doors and operable walls Schedules** for details of room dividers for the works.

32. SUSPENDED CEILINGS

GENERAL

INSPECTION

Notice

Give sufficient notice so that inspection may be made of the framing preparation and stout of suspended ceilings before installation of panels.

SUBMISSIONS

Samples

Submit samples as follows:

- Ceiling material: Sheet, panel, tile, with insulation
- Methods: Methods of jointing, fixing, height adjustment.
- Suspension: Sections proposed for suspension system, including wall angles and trim.

PRODUCTS

LININGS

Fibrous plaster tiles

Best quality imported fibrous plaster tiles with hard cast plaster face for decorative ceiling sections.

Plasterboard panels

Best quality imported glass fiber reinforced gypsum plasterboard panels or tiles. Refer to the **Suspended ceiling construction schedule**.

Suspension system

Refer to the **Suspended ceiling construction schedule**.

EXECUTION

INSTALLATION

Ceiling grid

Set out the ceiling grid so that panel joints and center lines of visible suspension members coincide with grid lines shown on the drawings. If not otherwise shown, set out so that opposite margins are equal.

Pattern and texture: Set out patterned or heavily textured materials to give consistency in direction of pattern or texture.
Special sized panels: Provide special sized purpose-made panels to fill non-standard margins, openings and penetrations.

Cut tile edges
General: Conceal, or finish to match prefinished edges.

Lighting
Fit lights within the ceiling grid system to ensure that distortion, overloading or excessive vertical deflection is prevented. Support lights on the ceiling primary grid members.

Proprietary systems
Provide suspended ceilings as complete proprietary systems, each fabricated by one manufacturer and installed by a specialist installer of demonstrated capacity.

Protection
Protect existing work from damage during the installation.

Stability
Install the ceiling level; and fix so that under normal conditions there is no looseness or rattling of ceiling components.

SUPPORTS

Bracing
General: Provide bracing to prevent lateral movement and to resist any imposed horizontal seismic force.

External suspended ceilings
Support external suspended ceilings on rigid members capable of carrying the imposed loads. Install members to minimize any eccentricity, and ensure that the upward and downward wind loads are carried through to the supporting structure.

Movement joints
Install the ceiling with control joints to correspond in location and direction to those in the structural frame.

Finishes
Repair damaged finishes by replacement or refinishing of the item. All repairs are to be completed so no sign of the damage is visible in the completed work.

Support members
Grid members: If required, notch grid members at the junction with the perimeter trim to ensure the panels lie flat on the perimeter trim.
Services: Do not suspend from services (e.g., pipework or ductwork) unless the service has been designed to accept the ceiling load. In locations where services obstruct the ceiling supports, provide bridging and suspension on each side of the services.
Spacing: Space the support members as required by the loads on the system and the type of ceiling, and allow for the installation of services and accessories, including ductwork, light fittings and diffusers. Provide additional support or suspension members for the fixing of such items.

Suspension system
Height adjustment: Provide height adjustment by means of a length adjustment device at each suspension point, permitting length variation of at least 50 mm.

PANELS

General
Fitting: Fit panels accurately and neatly, free from air leakage and staining.
Panel lock clips: If panels are exposed to wind loads or if required for security, insert locking clips at the junction of rails and panels.

Accessories and trim
Provide accessories and trim necessary to complete the installation.
Plasterboard trim: Provide purpose-made corner beads, casing beads and stop beads.
Metal Trim: Provide trims at junctions with other building elements and surfaces, such as walls, beams and penetrations, consistent with the style, materials and finishes of the ceiling system generally.

Service penetrations
Provide openings for, and fit the ceiling system up to, all services elements such as light fittings, ventilation outlets, detectors, sprinklers and loudspeakers.

ACCESS PANELS

Finish
Match the ceiling panels in appearance and performance and mark the panel for easy identification.

COMPLETION

Spares
Supply spare matching tiles and accessories of each type for future replacement purposes. Store the spare materials on site where directed.

33. **JOINERY**

GENERAL

TOLERANCES
Responsibilities
Fabricate and install joinery items. Items to be undamaged, plumb, level, straight and free of distortion and to the **Tolerances table**.

Tolerances table

Property	Tolerance criteria
Plumb and level	2 mm in 800 mm
Offsets in flush adjoining surfaces	< 1 mm
Alignment of adjoining doors	< 1.5 mm

INSPECTION

Notice
Give sufficient notice so that inspection may be made of the following:
- Shop fabricated or assembled items ready for delivery to the site.
- Site erected assemblies on completion of erection.

SUBMISSIONS

Samples
Submit samples to the **Sample table** for approval by the Engineer.

Sample table

Description	No. of samples
Each type of board to be used complete with finish and edge stripping	2

Description	No. of samples
Typical item of hardware indicating each finish	2
Stone benchtop indicating range of colors	2
Timber balustrade section	1
The finish to all stainless-steel items	2
Complete timber bench cupboard door, including hardware	1
Complete drawer front, including hardware	1

PRODUCTS

JOINERY MATERIALS AND COMPONENTS

Joinery timber
Best quality Russian joinery timber to approval of the Engineer.

Plywood
Best quality imported plywood to the approval of the Engineer.

Decorative overlays
Timber veneer or laminate to approval of the Engineer.
Thickness (minimum):
- For horizontal surfaces fixed to a continuous background: 1.2 mm minimum. - For vertical surfaces fixed to a continuous background: 0.8 mm.
- For edge strips: 0.8 mm.

Stone facings
Provide stone slabs to benchtops within the visual range of the approved samples.

Timber veneers

Provide veneers falling within the visual range of the approved samples.

JOINERY ITEMS

General

Provide materials noted on drawings as follows:
- Joinery components and their location, indicative construction details, trims, materials, dimensions and thicknesses, and finishes shall be as detailed.
- All dimensions noted on drawings shall be confirmed on site before construction of the joinery. - Finished selections and hardware are noted in the **Joinery Fixtures schedule**.

KITCHEN ASSEMBLIES

Plinths

Material: Construct from exterior grade general purpose plywood unless already in place as a concrete plinth.
Thickness: 16 mm.
Fabrication: Form up with front and back members and full height cross members at not more than 900 mm centers.
Finish: Decorative laminated sheet or ceramic/ stone tile finish.
Installation: Fix to floor and secure to wall to provide level platform for carcasses.

Carcasses

Material: Select from the following:
- Melamine overlaid a high moisture resistant particleboard.
- Approved solid timber sections.

Thickness: 16 mm minimum.
Joints: Select from the following:
- Proprietary mechanical connections.
- Screws and glue.

Shelves: Support on battens or fix directly into grooves inside walls of joinery units.
Finish: Decorative laminated sheet or solid timber finish.
Fasteners: Conceal with finish.
Installation: Secure to walls at not more than 600 mm centers.

Drawer fronts and doors

Material: Refer to the drawings for specific details of joinery or select from the following:
- Melamine overlaid a high moisture resistant particleboard.

- Approved solid timber sections with or without inset glass panels.
- Metal grille or sheet metal panels fixed over timber frames

Thickness: 16 mm minimum.
Maximum door size: 2400 mm high, 900 mm wide, 1.5 m2 on face.
Finish: Decorative laminated sheet, solid timber finish or paint.

Drawer backs, sides and bottoms
Material: Select from the following:
- Melamine overlaid a high moisture resistant particleboard.
- Approved solid timber sections.

Thickness: 12 mm minimum.
Finish: Decorative laminated sheet or solid timber finish.

Laminated benchtops
Material: High moisture resistant particleboard.
Benchtop thickness: 33 mm.
Finish: Decorative laminated sheet.
Exposed edges: Extend laminate over shaped nosing, finishing > 50 mm back on underside or provide solid timber edge trim.
Installation: Fix to carcass at least twice per 600 mm length of benchtop.
Joint sealing: Clamp with proprietary mechanical connectors to ensure high quality connection between benchtop sections. Ensure joints in benchtops are clear of sinks to avoid water damage to joints.

Stone or concrete benchtops
Material:
- Thickness is to be minimum of 40mm unless noted otherwise on the drawings.
- Concrete benchtops may have a polished finish or be covered with ceramic tiles.

Splashback:
Material is identical to benchtop unless noted otherwise in the Fixtures **Schedule**.
- Thickness is to be 16mm for high moisture resistant particleboard with laminate finish. - Thickness is to be 20mm minimum for stone.
- Thickness is to be 40mm minimum for concrete. Alternatively use ceramic tile splashback for concrete benchtops.
- Waterproof silicone sealant is to be used as a continuous seal between the benchtop and splashback.

Drawer and door hardware

Hinges, drawer runners, door handles and locks are to be to the approval of the Engineer.

TIMBER BALUSTRADES
Provide materials for the approval of the Engineer before installation. Ensure all dimensions are checked on site before construction starts. Refer to BOQ and drawings for the extent of work.

EXECUTION

JOINERY

General
Joints: Provide materials in single lengths whenever possible. If joints are necessarily making them over supports.
Framing: Frame and trim where necessary for openings, including those required by other trades.

Accessories and trim
Provide accessories and trim necessary to complete the installation.

Fasteners
Visibility: Do not provide visible fixings except in the following locations:
- Inside cupboards and drawer units.
- Inside open units.

Visible fixings: Where fastenings are unavoidable on visible joinery faces, sink the heads below the surface and fill the sinking flush with a material compatible with the surface finish. In surfaces which are to have clear or tinted timber finish provide matching wood plugs showing face (not end) grain. In surfaces which are to have laminate finish provide proprietary screws and caps finished to match.
Fixings: Screws with washers into timber or steel framing, or masonry anchors to brickwork.

Adhesives
Provide adhesives to transmit the loads imposed and to ensure the rigidity of the assembly, without causing discolouration of finished surfaces.

Finishing
Edge strips: Finish exposed edges of sheets with edge strips which match sheet faces or use solid timber trims as noted on the drawings.
Matching: For surfaces which are to have clear or tinted finish, arrange adjacent timber pieces to match the grain and color.

Hygiene requirements: To all food handling areas and voids at the backs of units to all areas, seal all carcass junctions with walls and floors, and to cable entries, with silicone sealant for vermin proofing. Apply water resistant sealants around all plumbing fixtures and ensure the sealants are fit for purpose.

DELIVERY AND STORAGE

General
Deliver joinery units to site in unbroken wrapping or containers so that its moisture content is not adversely affected. Do not store in areas of wet plaster. Keep storage to a minimum by delivering items only when required for installation.
Examine joinery units for completeness and repair defects before installing in place.

Background
Clean all background surfaces that will be permanently concealed behind joinery before installing in place.

TIMBER BALUSTRADES

General
Provide a balustrade to the stair and landing, consisting of posts, handrail, infill panels, and associated moldings as noted in the BOQ and drawings.

COMPLETION

Cleaning
Temporary coatings: On or before completion of the works, or before joining up to other surfaces, remove all traces of temporary coatings used as a means of protection.
General: Remove all dust, marks and rubbish from all surfaces and internal spaces. Clean and polish all surfaces such as solid timber, anodised or painted metals, glass, stone, concrete, ceramic tiles and laminates.
Refer to the **Joinery Fixtures Schedule** for locations, type and finishes of joinery items.

34. **METALWORK**

GENERAL

INSPECTION

Notice

Give sufficient notice so that inspection may be made of the following:

- Shop fabricated or assembled items ready for delivery to the site.
- Site erected assemblies on completion of erection.

SUBMISSIONS

Samples

Submit samples to the **Sample table** for approval by the Engineer.

Sample table

Description	No. of samples
Each type of metal item to be purchased	2
Typical joints of welded or fabricated items	2
Finished sample of each type of painted or anodised metal work indicating range within color specified and finish	2
The finish to all stainless-steel items	2

Manufacturer's data: Submit manufacturer's published product data and details for purchased items.
Stainless steel: For each batch of stainless steel supplied to the works, submit the certificate of compliance specified for the applicable standard.

PRODUCTS

MATERIALS AND COMPONENTS

Metals

Performance: Provide metals suited to their required function, finish and method of fabrication, in sections of strength and stiffness adequate for their purpose.

Rivets

Use blind rivets where available in the required metal.

Masonry anchors
Proprietary types comprising screws or bolts in self-expanding sockets.

Masonry plugs
Screws in purpose-made resilient plastic sockets or fixed to timber plugs built into the wall surface.

EXECUTION

CONSTRUCTION GENERALLY

Metals
Provide metals so that they transmit the loads imposed and ensure the rigidity of the assembly without causing deflection or distortion of finished surfaces.

Fasteners
Materials: Provide fasteners in materials of mechanical strength and corrosion resistance at least equal to that of the lowest resistant metal joined.
To copper and copper alloys: Provide copper or copper-alloy fixing devices only.
To aluminium and aluminium alloys: Provide aluminium alloy or stainless-steel fixing devices only.
To stainless steel: Provide appropriate stainless-steel materials only.

Fabrication
Workshop: Fabricate and pre-assemble items in the workshop wherever practicable.
Edges and surfaces: Keep clean, neat and free from burrs and indentations. Remove sharp edges without excessive radiusing.
Tube bends: Form bends in tube without visibly deforming the cross section.
Colour finished work: Match colors of sheets, extrusions and heads of fasteners.
Thermal movement: Accommodate thermal movement in joints and fastenings.

Fabrication tolerances
Structural work generally: 2 mm from design dimensions.

Joints
Fit joints to an accuracy appropriate to the class of work. Finish visible joints made by welding, brazing or soldering using grinding, buffing or other methods appropriate to the class of work, before further treatment.
Self-finished metals: Free of surface color variations, after jointing.
Joints: Fit accurately to a hairline where feasible.

Marking
Provide suitable and sufficient marks or other means for identifying each member of site-erected assemblies, and for their correct setting out, location, erection and connection.

Splicing
Provide structural members in single lengths where possible. Obtain approval of the Engineer for locations of joints where splices in metalwork cannot be avoided.

WELDING AND BRAZING

General
Quality: Provide finished welds which are free of surface and internal cracks, slag inclusion, and porosity.

Brazing
General: Ensure brazed joints have sufficient lap to provide a mechanically sound joint. Do not use butt joints relying on the filler metal filet only.

STAINLESS STEEL FABRICATION

Welding stainless steel
All tube, angle or thick plate material is to be welded unless noted otherwise on the drawings. Ensure that welds do not discolor the final surface finish in the welding process.

Riveting
Riveting may be used only to join stainless steel sheets or strips less than 1 mm thick. Drill (not punch) the rivet hole, and drive the rivet cold. On completion, clean and passivate the riveted assembly.

Soldering
Do not solder stainless steel.

METAL FIXTURES

General
Provide metal fixtures where noted on drawings and in the **Metal Fixtures Schedule** as follows:

- Components such as toilet roll holders, towel rails, soap dishes and their location, indicative construction details, trims, materials, dimensions and thicknesses, and finishes shall be as detailed or described in the schedule.
- All dimensions noted on drawings shall be confirmed on site.

PIPE HANDRAILS, STAIRS, LADDERS AND BALUSTRADES

Assembly
Material: Refer to drawings and BOQ for details of member sizes and assembly of components.

Fabrication
Method: Welding.
Joints: Produce smooth unbroken surfaces at joints. Make end-to-end joints over an internal sleeve.
Bends: Make changes of direction in rails by evenly curved pipe bends.
Free ends: Seal the free ends of pipes with fabricated or purpose-made end caps.

Fixing to structure
Provide fabricated pre drilled or purpose-made brackets or post bases, and attach the pipework to the building structure with fixings, including bolts into masonry anchors, and coach screws or bolts into timber, of metal compatible with the pipework.

Galvanizing
If possible, complete fabrication before galvanizing; otherwise apply a zinc-rich primer to affected joint surfaces.

Painting
If possible, complete fabrication before painting; otherwise apply paint to affected joint surfaces after fixing on site. Make good all damaged painted surfaces before completion of the building works.

CORNER GUARDS AND VEHICLE GUARDS

Corner Guards
Where corners of the structure are required to be protected from mechanical damage, provide metal corner guards as follows and as identified on the drawings or in the BOQ:
- Consisting of angle sections or sections fabricated from metal sheet bent to the radius or angle of the corner.

- Fitting close to adjoining surface finishes.
- Solidly grouted up at the back to eliminate voids.
- Securely fixed by a method which does not cause distortion in the guard surface, and consists of either concealed built in lugs, or flush countersunk head fixings into masonry anchors.
- Paint finish in accordance with the **Finishes Schedule**.

Vehicle Guards

Where external features such as lamp posts, fire hose reels or pedestrian walkways are required to be protected from vehicle damage, provide metal guards as follows and as identified on the drawings and in the BOQ:
- Consisting of steel pipe posts set in deep concrete pads with welded end caps or bent to form a rail and two posts.
- Steel barrier rails securely bolted to the posts.
- Heavy duty protection posts will be large diameter steel pipe posts filled with concrete. - Paint finish in accordance with the **Finishes Schedule**.

WATER STORAGE TANKS AND STANDS

Water Tanks

Fabricate metal water storage tanks to sizes shown on drawings and as identified in the BOQ. Allow for all reinforcement of tank walls, floors, and around fixtures projecting from the tank.
Bolt together prefabricated plastic or metal water storage tanks to sizes shown on drawings and as identified in the BOQ.
Fabricate metal tank stands for the water storage tanks as identified on the drawings and in the BOQ. Refer to the **Metal Fixtures Schedule** for details.

COMPLETION

Maintenance manual

General: Submit manufacturer's published recommendations for service use.

Cleaning

Temporary coatings: On or before completion of the works, or before joining up to other surfaces, remove all traces of temporary coatings used as a means of protection.

35. STAINLESS STEEL BENCHING

GENERAL

INSPECTION

Notice

Give sufficient notice so that inspection may be made of the units when fabrication is complete, before delivery.

SUBMISSIONS

Samples

Submit samples to the **Sample table** for approval by the Engineer.

Sample table

Description	No. of samples
Typical joints of welded or fabricated items	2
The finish to all stainless-steel items	2

Stainless steel: For each batch of stainless steel supplied to the works, submit the certificate of compliance specified for the applicable standard.

Site welding

General: If site welding is proposed, submit details indicating location and process.

PRODUCTS

MATERIALS

Stainless steel

Plate, sheet, strip, bar and pipe: To ASTM standards.
Type: 304.

Stainless steel sheet

Surface finish: Fine brushed finish not including underside of shelves, and door backs and drawer backs. Thickness: 1.2 mm minimum.

Particleboard

Use moisture resistant particleboard minimum thickness 12mm to splashback and 25mm to benchtop as substrate for support of flat sheet.

Plywood
Use external grade structural plywood minimum thickness 12mm to splashback and 25mm to benchtop as substrate for support of flat sheet.

COMPONENTS

Fasteners
Material: Stainless steel.
Dimensional system: Metric.
Bolt and screw heads: Polished, pan type or countersunk.

Hardware
Material: Stainless steel.
Handles: Stainless steel unless noted otherwise.

Sealants
Type: Neutral cure one-part silicone.
Performance: Flexible. Resistant to growth of mold, bacteria and fungi. Colourfast.

Adhesive
Type: Spray contact adhesive.

EXECUTION

FABRICATION GENERALLY

Stainless steel welding
Process: Gas tungsten arc welding.
Weld type: Butt.
Surface finish: Grade I, 120 grit.
Welding materials: Compatible with metal being welded.
Weld quality: Free from imperfections such as cracks and pits. Grind and polish to give required surface finish. Continuous exposed welds.
Joints: Strength at least that of parent metal. Free from crevices and folds.
Joint position: At corners and edges as far as possible. Minimize joints in flat panels.

Protection
Provide temporary self-adhesive plastic film to stainless steel surfaces.

Hardware fixing
Drill and tap, or weld fix.

Linishing grain direction
Benches and shelves: Lengthwise.
Bowls: Horizontal to sides, parallel to bench grain to bottom. Mitre at bottom corners. Abutting surfaces: Parallel where possible.

BENCH TOPS FABRICATION

Bench tops
Material: Stainless steel sheet.
Thickness: 2 mm.
Refer to drawings for details of bench construction and nominal overall sizes. Confirm all dimensions on site before fabricating bench units.
Exposed corners: Radius exposed corners at least 5 mm, including back vertical corners of upstands.
Internal back vertical corners: Fuse only from behind.
Wet bench perimeter: Except at wall flashing, provide a raised bead, with a fascia.
Dry bench perimeter: Except at wall flashing, provide a fascia.

Fascia
Fascia height: 30mm unless noted otherwise.
Fascia return: Full depth of bench top unless noted otherwise.

Drainer
Drainer falls to sinks: 1:50, 450 mm long.
Drainer surface: Plain.

Wall splashback
Type: Integral.
Height above bench: 300mm unless noted otherwise.
Ends: Return for full width of bench top.

Fixing to support frame

Type: Screw fix benchtop to support frame through welded lugs on front and back frames at 600mm centers into plywood or particle board substrate. Provide star washers under screw heads.
If no substrate is used, weld benchtop to frame on welded lugs on front and back frames at maximum 300mm centers.

BOWL FABRICATION

Bowls
Type: Deep drawn stainless steel.
Thickness:
- Capacity < 75 L: 1.6 mm.
- Capacity 75 L: 2 mm.
Internal radii: 25 mm minimum.
Minimum depth: 250 mm.
Wastes:
- Size (minimum): 50mm diameter.
- Position: Centered in single bowls, adjacent in double bowls.
- Plug: Heavy-duty commercial.
Fall to waste (minimum):
- Capacity < 75 L: 10 mm.
- Capacity 75 L: 25 mm.

FRAME FABRICATION

Bench top support frame
Support: Provide sufficient support so that no load is placed on the waste pipe or water connections.
- Design deflection (maximum): 3 mm.
Members: 31.8 x 31.8 x 1.6 mm stainless steel pipe. Seal ends.
Extent: Perimeter and at sides of bowls, with additional members spaced as follows:
- 1.6 mm sheet: 350 mm maximum centers.
- 2 mm sheet: 500 mm maximum centers.
Maximum unsupported area: 0.3 m2.
If 25mm plywood or particle board substrate is used, the benchtop can be supported on front and back rails only, with additional members at 1200mm maximum centers.
Connections: Welded.

Bench legs
Members: 31.8 x 31.8 x 1.6 mm stainless steel pipe. Seal ends.

Fixing to bench top support frame: Weld all around at junctions.
Spacing: 1200 mm maximum.
Fixing to walls: Predrilled 100 x 50 x 2 mm stainless steel plate welded to legs at 600 mm high.
Feet: Nylon or chrome-plated aluminium, adjustable vertically ± 25 mm. Threaded section must not protrude from the leg.

SHELVING FABRICATION

Under bench shelving

Material: Stainless steel.
Thickness: 1.6 mm.
Shelf support: 30 x 30 x 5 mm stainless steel angles.
- Extent: Perimeter, with additional angles spaced to give a maximum unsupported area of 0.3 m2.
Connections: Welded.
Fixing of support to legs: Welded.
If 25mm plywood or particle board substrate is used, the shelf can be supported on front and back rails only, with additional members at 1200mm maximum centers.
Fixing of shelf to support: as for benchtop support.

Over bench shelving

Material: Stainless steel.
Thickness: 1.6 mm.
Shelf support: 25.4 x 25.4 x 1.6 mm stainless steel pipe brackets minimum 300mm high above the shelf level. Seal ends.
- Spacing: 900 mm maximum with 25mm substrate or shelf fabricated with 30 x 30 x 5 mm stainless steel angles, 600mm with 12mm substrate.
- Fixing to wall: Two 50 x 50 x 5 mm stainless steel plates, fixed with at least two M8 bolts. Weld to top and bottom of the support brackets.
Fixing of shelf to support: Screw fix minimum of 3 times through tube into side of shelf or shelf angles. Seal between shelf and support.

DRAWERS FABRICATIONS

Drawers

Material: Stainless steel.
Thickness: 1.2 mm.
Construction: Welded.

Frames: Removable, and interchangeable with other drawer frames. Provide extension-type drawer slide mechanism and front panel. Provide rubber stops at rear.
Front panel: 20 mm thick double pan construction.
Housing: Back and 2 sides of a neat external appearance.
Runners: Incline to rear so drawers roll closed. Provide a stop so the drawer cannot be pulled out accidentally. Locks: Chrome-plated brass.

INSTALLATION GENERALLY

Welding
Preference should be given to any other fixing method other than site welding. Obtain approval from the Engineer for any proposed site welding.

Sealing
Gaps < 5 mm wide: Apply sealant at the following locations:
- Butt joints between benches.
- Between benches, including flashings, and walls.
- Spaces and gaps under benches.

Gaps 5 mm wide: Close with stainless steel infill panels.

Floor fixing
8 mm diameter stainless steel dowels, sealed to floor with silicone sealant.

COMPLETION

Protection
General: Temporary self-adhesive plastic film: Remove from stainless steel surfaces.

36. FIRE EXTINGUISHERS AND BLANKETS

GENERAL

SAMPLES

General
Provide samples of all fire extinguishers proposed for use in the project for approval of the Engineer.

AUTHORIZED PRODUCTS

General
Provide equipment from Certified manufacturers only. Provide copies of the test certificates if requested by the Engineer.

PRODUCTS

EXTINGUISHERS

Extinguisher type and location
Provide portable fire extinguisher types and matching signs to the locations identified in the **Fire Extinguisher Schedule**.

BLANKETS

Fire blanket type and location
Provide fire blanket types and matching signs to the locations identified in the **Fire Blanket Schedule**.

37. **WINDOW COVERINGS**

GENERAL

INSPECTION

Notice
Give sufficient notice so that inspection may be made of the building locations and surfaces prepared to receive window coverings before installation.

SUBMISSIONS

Samples
Submit 2 samples of each of the following where applicable, for approval by the Engineer:
- Sections proposed to be used for frames, louvers and slats.
- Finish prepared surfaces with trims.
- Colour range samples of fabrics, facings and production material.
- Manufacturer's standard control system furniture items.

PRODUCTS

MATERIALS

Fire hazard

Do not provide materials which, when subject to fire conditions, will emit excessive smoke or dangerous fumes.

INTERNAL

Curtains and fabric shades

Install curtains or shades to locations identified on drawings or in BOQ. Check all dimensions on site before fabricating the track and making curtains. Refer to the Curtain **Schedule**.

Aluminium Venetian blinds

Install aluminium blinds to locations identified on drawings or in BOQ. Check all dimensions on site before fabricating tracks and making blinds. Refer to **Aluminium Venetian Blind Schedule**.
Slat material: High tensile aluminium alloy.
Thickness: 0.175 mm.
Cord: 1.5 mm thick polyester with braided jacket and safety tassel, and ladders for location and control. Top and bottom rails: 0.5 mm aluminium zinc coated steel powder coat finish.

Plastic Venetian blinds

Install plastic blinds to locations identified on drawings or in BOQ. Check all dimensions on site before fabricating tracks and making blinds. Refer to **Plastic Venetian Blind Schedule**.
Slat material: Extruded polystyrene.
Thickness: 3 mm nominal.
Slat width: 50 mm nominal.
Cord: Internal 2.3 mm thick polyester.
Tape: To allow a 42 mm pitch between ladders and a 8 mm slat overlap.
Top and bottom rails: 0.5 mm aluminium zinc coated steel powder coat finish.

Timber Venetian blinds

Install timber blinds to locations identified on drawings or in BOQ. Check all dimensions on site before fabricating tracks and making blinds. Refer to **Timber Venetian Blind Schedule**.
Slat material: Approved timber
Thickness: 5 mm nominal.
Slat width: 50 mm nominal.

Cord: Internal 2.3 mm thick polyester.
Tape: To allow a 42 mm pitch between ladders and a 8 mm slat overlap.
Top and bottom rails: 0.5 mm aluminium zinc coated steel powder coat finish.

Vertical louver blinds
Install vertical blinds to locations identified on drawings or in BOQ. Check all dimensions on site before fabricating tracks and making blinds. Refer to **Vertical Louvre Blind Schedule**.
Type: Louvers supported by a carrier system which traverses on wheels and operates with a friction spring loaded clutch mechanism.
Louver blades: Heavy duty fabric or vinyl coated fabric blades in single, straight lengths finishing 10 mm above floor or sill level, without twists, warp, bows, edge ripples or fraying. Fix a weight into a pocket formed in the bottom of each blade.
Spacing: Space the blades evenly with plastic spacers which lock into the carrier rail to provide a continuous linkage, and fix with sealed plastic slat holders carried by plastic rotation pivots. Connect the bottoms of the blades by a plastic link chain with reversers.
Tracks: Fabricated to suit size of blades for width of window or within a pelmet extending past the face of the window.
Operation: Dual continuous loop chains controlling the functions of tilting and drawing.

EXECUTION

INSTALLATION

General
Fixing: Secure the tracks with ceiling clamps or wall mounted brackets so that there are no fixings through the track.

COMPLETION

Maintenance manual
Submit the manufacturers' data as follows:
- Recommendations for service use, care and maintenance.
- List of manufacturers and suppliers of replacement parts. Tile type: e.g., Stone type or product identifier. Rely on approved samples for general quality compliance.

38. PLASTERING

GENERAL

INTERPRETATION

Abbreviations

For the purpose of this work section the abbreviations given below apply.
- CRF: Cement render – finish.
- CRM: Cement render – medium.
- CRS: Cement render – stronger.
- CRW: Cement render – weaker.
- LF: Lime felting render- weaker.
- GPF: Gypsum plaster – finish.

INSPECTION

Notice

Give sufficient notice so inspection may be made of the following:
- Backgrounds immediately before applying base coats.
- Finish treatments before decoration.

PRODUCTS

MATERIALS AND COMPONENTS

Accessories

Beads: To be metal proprietary sections manufactured to be fixed to backgrounds and/or embedded in the plaster to form and protect plaster edges and junctions.

Aggregates

Sand: To be fine, sharp, well-graded sand with a low clay content and free from efflorescing salts.

Bonding products

To be proprietary products manufactured for bonding cement-based plaster to solid backgrounds.

Cement

Cement shall conform to the requirements of ASTM specification C-150 Type 1 or similar approved standard for normal Portland cement.

Coloring products

To be proprietary products manufactured for coloring cement plaster.

Integral pigment proportion: 5% by mass of cement.

Curing products
To be proprietary products manufactured for use with the plaster system.

Gypsum plaster
To be a proprietary product containing calcium sulfate hemihydrate with additives to modify setting.

Lime
Confirm the source of Lime with the Engineer to ensure the highest quality Lime is used in the mortar. Protect from damage on site and store minimum 300mm above ground in a waterproof storage facility.

Preparing lime putty:
- Using hydrated lime: Add lime to water in a clean container and stir to a thick creamy consistency. Leave undisturbed for at least 16 hours. Remove excess water and protect from drying out. - Using quicklime: Run to putty as soon as possible after receipt of quicklime. Partly fill clean container with water, add lime to half the height of the water, then stir and hoe ensuring that no lime remains exposed above the water. Continue stirring and hoeing for at least 5 minutes after all reaction has ceased, then sieve into a maturing bin. Leave undisturbed for at least 14 days. Protect from drying out.

Mixes
Select a mix ratio to suit the application in conformity to the

Mixes table.
Measurement: Measure binders and sand by volume using buckets or boxes. Do not allow sand to bulk by absorption of water.
Plaster mixing: Machine mix for greater than 3 minutes and less than 6 minutes.
Strength of successive coats: Ensure successive coats are no richer in binder than the coat to which they are applied.

Mixes table

Mix type	Application	Upper and lower limits of proportions by volume			
		Gypsum	Cement	Lime	Sand

Cement render coats in: -Single or multi-coat systems with integral finishing treatments -Base coats in multi coat systems with cement or gypsum finishes	CRS	Dense and smooth concrete and masonry Thrown finishing treatments Tiled finishes Gypsum finishes Cement finishes	- -	1 1	0 0.5	3 4.5
	CRM	Clay or concrete masonry	- -	1 1	0.5	4.5 6
	CRW	Lightweight concrete masonry and other weak backgrounds	- -	1 1		6 9
Cement finish coats	CRF	Cement renders base coats	- -	1 1	1	1.5 2
Lime felting finish coats	LF	Cement renders base coats			1	3
Gypsum finish coats	GPF	Cement render base coats	3 1	- -	1 1	- 1

Movement control joint products

To be proprietary products manufactured for use with the plastering system and to accommodate the anticipated movement of the backgrounds and/or the plaster.

Water
To be clean and free from any deleterious matter.
Refer to the **Plastering Construction Schedule** for details of plastering and locations.

EXECUTION

PREPARATION
Substrates
Ensure substrates have:
- Any deposit or finish which may impair adhesion of plaster cleaned off.
- If solid or continuous, excessive projections hacked off and voids and hollows filled with plaster stronger than the first coat and not weaker than the background.

Absorbent substrates: If suction is excessive, control it by dampening but avoid over-wetting and do not plaster backgrounds showing surface moisture.
Dense concrete: If not sufficiently rough to provide a mechanical key, roughen by scratching or hacking to remove 2 mm of the surface and expose the aggregate then apply a bonding treatment.
Painted surfaces: Remove paint and hack the surface at close intervals.
Untrue substrates: If the substrate is not sufficiently true to ensure conformity with the thickness limits for the plaster system or has excessively uneven suction resulting from variations in the composition of the background, apply additional coats.

Beads
Location: Fix beads as follows:
- Angle beads: At all external corners.
- Drip beads: At all lower terminations of external plaster.
- Mechanical fixing to background: at 300 mm centers.
- Movement control beads: At all movement control joints.
- Stop beads: At all terminations of plaster and junctions with other materials or plaster systems.

Bonding treatment
If bonding treatment is required, throw a wet mix onto the background as follows:
- Cement plaster: 1 part cement to 2 parts sand.
- Gypsum plaster: 1 part gypsum to 2 parts sand.

Curing: Keep continuously moist for 5 days and allow to dry before applying plaster coats.
Thickness: From greater than 3mm but less than 6 mm.

Embedded items

If there are water pipes and other embedded items, sheath them to permit thermal movement. Ensure embedded items will have a suitable level of corrosion resistance prior to embedment.

APPLICATION

Plastering
General: Provide plaster finishes as follows:
- Resistant to impacts expected in use.
- Free of irregularities.
- Consistent in texture and finish.
- Firmly bonded to substrates for the expected life of the application.
- As a suitable substrate for the nominated final finish.

Base coats: Scratch-comb each base coat in two directions when it has stiffened.

Finishing treatments
Plain:
- Bag: To be a finish mainly free from sand by rubbing the finish coat with a Hessian pad when it has set firm.
- Carborundum stone: To be a smooth finish free from sand, rubbing the finish coat with a fine carborundum stone when it has set hard.
- Steel trowel: To be a smooth dense surface by steel trowelling which is not glass-like and is free from shrinkage cracks and crazing.
- Wood or plastic float: To be an even surface by wood or plastic floating the finish coat on application. Incidental work

Return plaster into reveals, beads, sills, recesses and niches. Plaster faces, ends, and soffits of projections in the background, such as string courses, sills, and other wall features. Trim around openings. Plaster exposed inside of built-in cupboards.

Joining up
If joining up is required, ensure joints will not be visible in the finished work after decoration.

Movement control joints
Provide movement control joints in the finish to coincide with movement joints in the background. Ensure that the joint in the background is not bridged during plastering.
- Depth: Extend the joint right through the plaster and reinforcement to the background. - Width: 3 mm, or the same width as the background joint, whichever is greater.

Damp-proof courses: Do not continue plaster across damp-proof courses.
V-joints: Provide V-joints, cut right through the plaster to the background, at the following locations:

- Abutments with metal door frames.
- Abutments with other finishes.
- Junctions between different backgrounds.

Plaster thickness

Conform to the **Plaster thickness table**.

Plaster thickness table

Plaster	Application	Upper limit of thickness (mm)			
		Single coat systems	**Multi-coat systems**		
			Base coat(s)	**Finish coat**	**System**
Cement render base coat sand cement or gypsum finish coats	On smooth dense concrete	12	10	4	13
	On clay and concrete brickwork and other backgrounds	15	13	4	16

Temperature

If the ambient temperature is less than 10ºC or more than 30ºC ensure that the temperature of mixes, backgrounds and reinforcement are, at the time of application, greater than 5ºC or less than 35ºC.

TOLERANCES

General

Conform to the **Tolerances table**.

Tolerances table

Property	Tolerance criteria: Permitted deviation (mm)
Features[1]: Verticality in 2000 mm	3
Features: Horizontality in 2000 mm	3
Soffits: Horizontality in 2000 mm	5

Walls: Verticality in 2000 mm	5
Walls: Flatness[2] in 2000 mm	4
[1 Features]: Conspicuous horizontal or vertical lines including external corners, parapets, reveals, heads, sills, movement control joints and moldings.	
[2 Flatness]: Measured under a straightedge laid in any direction on a plane surface.	

COMPLETION

Curing
General: Prevent premature or uneven drying out and protect from the sun and wind.
Keeping moist: If a proprietary curing agent is not used, keep the plaster moist as follows:
- Base coats and single coat systems: Keep continuously moist for 2 days and allow to dry for 5 days before applying further plaster coats.
- Finish coats: Keep continuously moist for 2 days.

39. CEMENTITIOUS TOPPINGS

GENERAL

INTERPRETATIONS

Abbreviations
For the purposes of this work section the abbreviations given below apply.
- BCS: Bonded – cement and sand.
- BFC: Bonded – fine concrete.
- FFC: Floating – fine concrete.
- MGR: Monolithic – granolithic.
- SFC: Separated – fine concrete.

TOLERANCES

General
Thickness:
- Thickness < 15 mm: ± 2 mm.
- Thickness ≥ 15 < 30 mm: ± 5 mm
- Thickness ≥ 30 mm: ± 10 mm
Flatness: Measured under a 3000 mm straightedge laid in any direction on a plane surface:
- Grade A: < 3 mm.

- Grade B: ≥ 3 < 5 mm
- Grade C: ≥ 5 < 10 mm

PRODUCTS

Admixtures
Introduce a solution in a portion of the mixing water. Ensure a uniform distribution of the admixture in the batch within the mixing period.

Aggregates
Coarse aggregate: To be nominal single size.
Fine aggregate: To be fine, sharp, well-graded sand with a low clay content and free from efflorescing salts.

Bonding products
To be proprietary products manufactured for bonding cement-based toppings to concrete backgrounds.

Cement
Cement shall conform to the requirements of ASTM specification C-150 Type 1 or similar approved standard for normal Portland cement.

Coloring products
To be proprietary products manufactured for coloring cement toppings.
Integral pigment proportion: 5% by mass of cement.

Coloured chips
To be marble chips of selected color or proprietary products manufactured for distribution in cement toppings.

Concrete
On-site batch mixed concrete shall have characteristics and proportions of concrete ingredients which conform to those specified in M-150 (1:2:4).

Curing products
To be proprietary products manufactured for use with cement-based toppings and with the floor finish to be laid on the toppings.

Mixes

Provide concrete as follows or select mix proportions to the Mixes table.

-Air entrainment: ≤ 3%

-Nominal coarse aggregate size: ≤ 0.3 x topping thickness

- Slump: 80 mm.

Water quantity: Use the minimum necessary to achieve full compaction and prevent excessive water being brought to the surface during compaction.

Mixes table

Mix type		Thickness (mm)	Upper and lower limits of proportion by mass (mm)		
			Cement	Fine aggregate	Coarse aggregate
Bonded – cement and sand	BCS	35	1 1	3 4.5	0 0
Bonded – fine concrete	BFC	40	1 1	3 3	1 2
Floating – fine concrete	FFC	100	1 1	3 3	1 2
Monolithic – granolithic	MGR	Floors and treads: 25 Risers and skirtings: 13	1	2	1
Separated – fine concrete	SFC	70	1 1	3 3	1 2

Movement control joint products

Provide products manufactured for use with cement-based toppings and accommodate the anticipated movement of the backgrounds and/or the toppings.

Sealing products

Provide proprietary products manufactured for the sealing of movement joints in cement-based toppings.

Slip-resistance products

Provide proprietary products manufactured to improve the wet-slip resistance of toppings.
- Silicon carbide granules:
-Granule size: $\geq 300 < 600$ µm
. Color: Black.

Surface treatment products

Provide proprietary products manufactured for use with cement- based toppings to change the characteristics of the surface of the finished topping.

Reinforcement

All reinforcing shall be supported and wired together to prevent displacement by construction loads, or the placing of concrete, beyond the tolerances specified in ACI 301. Any tack or spot welding of reinforcement shall not be performed without approval from the Engineer.
Reinforcement shall be free of loose rust and of any other coating which may adversely affect the bond.

Water

General: To be clean and free from any deleterious matter.
Refer to the **Cementitious Toppings Construction Schedule** for details of toppings and locations.

EXECUTION

PREPARATION

Backgrounds

Ensure backgrounds have:
- Any deposit which may impair adhesion of monolithic or bonded toppings cleaned off. - Excessive projections hacked off and voids and hollows filled with a mix not stronger than the background nor weaker than the topping.
- Hardened concrete roughened by scratching or hacking to remove 2 mm of the surface and expose the aggregate.

Bonded toppings

Before laying topping wash the subfloor with water and use a bonding product or treat as follows:

- Keep wet for ≥ 2 hours.
- Remove surplus water and brush on neat cement or a clean slurry of cement and water. - Place the topping while the slurry is wet.

APPLICATION

Laying
Spread the mix and compact and level the surface to finished levels.
Monolithic toppings: Lay while concrete subfloor is plastic and surface water is no longer visible.
Toppings over 50 mm thick:
- Lay in two layers of equal thickness.
- Place a layer of reinforcement between the layers of toppings. Lap reinforcement 100 mm and tie. Do not create four-way laps.

Floating and trowelling
Machine float finish:
- After leveling, consolidate the surface using a machine float.
- Cut and fill and refloat immediately to a uniform, smooth, granular texture.
- Hand float in locations inaccessible to the machine float.

Flatness: Grade B.
Steel trowel finish: After machine floating finish as follows:
- When the surface has hardened sufficiently, use steel hand trowels to produce the final consolidated finish free of trowel marks and uniform in texture and appearance.

Flatness: Grade A.
Wood float finish: After machine floating finish as follows:
- Use wood or plastic hand floats to produce the final consolidated finish free of float marks and uniform in texture and appearance.

Flatness: Grade A.

Floor finish dividers
Finish cementitious toppings at junctions with differing floor finishes with a corrosion resistant metal dividing strip suitable fixed to the background, with top edge flush to the finished floor. If changes of floor finish occur at doorways make the junction directly below the closed door.

Monolithic toppings
Coved skirtings: Form coves in the topping material, and finish the top to a neatly struck line. Mitre internal and external angles.10 mm radius to top of skirting. 25mm radius to junction between floor and skirting.

Movement control joints
Provide movement control joints to divide toppings into bays as follows
- Form in situ using square edge steel forms and trowelling a 3 mm radius to edges. - Form a groove, extending at least one quarter the depth of the section, either by using a grooving tool, by sawing, or by inserting a pre-moulded strip.
- Install a movement control joint product.
Bay sizes:
- Area: ≤ 15 m2.
- Length to width ratio: ≤ 1:1.5.
Joints in background: Provide movement control joints in toppings to coincide with joints in the background.

Slip-resistance treatment
Stair treads: Form two grooves and fill with a silicon carbide two-part resin.
- Dimensions: 10 mm deep, 15 mm wide, length ≥ width of tread less 100 mm.
- Position:
. First groove: Centre 35 mm from tread nose.
. Second groove: Centre 60 mm from step nose.
Plane surfaces: Apply silicon carbide granules after floating and before the topping surface has set, and trowel into the surface so that the granules remain exposed.
- Application rate: 1 kg/m^2 evenly distributed.

Surface coloring
Apply the coloring product or coloured marble chips after floating and before the topping surface has set and trowel into the surface so that it is even in color distribution.

Temperature
If the ambient temperature is less than 10ºC or more than 30ºC ensure that the temperature of mixes, backgrounds and reinforcement are, at the time of application, greater than 5ºC or less than 35ºC.

COMPLETION
Curing
General: Prevent premature or uneven drying out and protect from the sun and wind.
Curing: Use a curing product or, as soon as it has set sufficiently, keep the toppings moist by covering with polyethylene film for seven days.

40. **TILING**

GENERAL

INSPECTION

Notice

Give sufficient notice so that inspection may be made of the following:
- Floor preparation and set out of the floor tiles before fixing.
- Wall preparation and set out of the wall tiles before fixing.
- Control joints before sealing and grouting.

SUBMISSIONS

Samples

Submit labeled samples of tiles, including fittings, accessories, grout and sealants, illustrating the range of variation in color and finish.

INTERPRETATIONS

Definitions

For the purposes of this work section the definitions given below apply.
- Substrates: The surfaces on which tiles are bedded.
- Bedding: Mixtures of materials which are applied to substrates in a plastic state and dry and cure to adhere tiles to substrates.
. Adhesive bedding: Tiling adhered by adhesives.
. Mortar bedding: Tiling adhered in a cementitious mortar bed.
- Pavers: Slabs made from clays, stone, precast concrete and/or other inorganic raw materials generally over 20 mm thick used as coverings for floors and supported over continuous substrates. - Tiles: Thin slabs made from clays and/or other inorganic raw materials used generally as coverings for floors and walls and adhered to continuous supporting substrates.
. Natural stone: Tiles cut from natural stone.
. Industrial cast: Tile products of reconstituted stone. Also known as manufactured stone. . Cementitious: Manufactured cement based pre-finished tiles.
. Terrazzo – cementitious: Manufactured cementitious terrazzo tiles formed in a suitable machine to give sufficient compaction and density to the finished surface, and moisture cured before grinding and honed at the place of manufacture. Thickness is usually 35 mm.
- Wet areas: Areas within buildings with water supply and drainage systems.

TOLERANCES

Completed tiling
Conform to the **Tolerances table**.

Tolerances table

Property	Tolerance criteria
Alignment: Deviation of the finished tiles from a 3 m straight edge laid against any joints	< 4 mm
Flatness: Deviation of any plane surface under a 3 m straight edge laid in any direction on an area of uniform grade	< 4 mm

PRODUCTS

TILES AND ACCESSORIES

Tiles
Coves, nosing's and skirtings: To be matching stop-end and internal and external angle tiles moulded for that purpose.
Exposed edges: To be purpose-made border tiles with the exposed edge glazed to match the tile face. If such tiles are not available, round edge with grout.

ADHESIVES

Type
General: Provide adhesives to the **Wall tiling schedule** and to the **Floor tiling schedule** and compatible with the materials and surfaces to be adhered.
Prohibited uses: Do not provide the following combinations:
- Cement-based adhesives on wood, metal, painted or glazed surfaces, gypsum-based plaster.
- Organic solvent-based adhesives on painted surfaces.
- Organic PVC-based adhesives and organic natural rubber latex adhesives in damp or wet conditions. - PVA (polyvinyl acetate) based adhesives in wet areas or externally.

MORTAR

Materials

Cement: Cement shall conform to the requirements of ASTM specification C-150 Type 1 or similar approved standard for normal Portland cement.
- White cement: Iron salts content ≤ 1%.
- Off-white cement: Iron salts content ≤ 2.5%.

Lime: Confirm source of Lime with Engineer to ensure highest quality Lime is used in the mortar. Protect from damage on site and store minimum 300mm above ground in a waterproof storage facility.

Sand: Fine aggregate with a low clay content selected for grading, sharp and free from efflorescing salts.

Measurement of volume: Measure binders and sand by volume using buckets or boxes. Do not allow sand to bulk by absorption of water.

Bedding mortar

Proportioning: Select proportions from the range 1:3 – 1:4 cement: sand to obtain satisfactory adhesion. Provide minimum water.

Terra cotta tiles: Use proprietary polymer modified mortar.

Water

General: To be clean and free from any deleterious matter.

GROUT

Type

Cement based proprietary grout: Mix with water. Fine sand may be added as a filler in wider joints.

Terra cotta tiles: Use proprietary polymer modified grout.

Portland cement-based grout: Mix with fine sand. Provide minimum water consistent with workability. - For joints < 3 mm: 1 cement:2 sand.
- For joints 3 mm: 1 cement:3 sand.

Pigments

Pigments for coloured grout: Provide colourfast fillers compatible with the grout material. For cement-based grouts, provide lime-proof natural or synthetic metallic oxides compatible with cement.

EXECUTION

Provide tiling systems to walls, floors and other substrates as follows:
- Consistent in color and finish.
- Firmly bonded to substrates for the expected life of the installation.

- Resistant to expected impacts in use.
- Set out with joints accurately aligned in both directions and wall tiling joints level and plumb. - To direct all water flowing from supply points to drainage outlets without leakage to the substrate or adjacent areas.

SUBSTRATES

Drying and shrinkage

Before tiling, allow at least the following times to elapse (for initial drying out and shrinkage) for these substrates:
- Concrete slabs: 42 days.
- Concrete blockwork: 28 days.
- Toppings on slabs and rendering on blockwork: A further 21 days.

PREPARATION

Ambient temperature

If the ambient temperature is less than 5 or more than 35°C, do not lay tiles.

Substrates

Ensure substrates are as follows:
- Clean and free of any deposit or finish which may impair adhesion or location of tiles. - If solid or continuous, excessive projections are hacked off and voids and hollows are filled with cement: sand mix not stronger than the substrate or weaker than the bedding.

Absorbent substrates: If suction is excessive, control it by dampening but avoid over-wetting and do not apply mortar bedding to substrates showing surface moisture.

Dense concrete: If not sufficiently rough to provide a mechanical key, roughen by scratching or hacking to remove 3 mm of the surface and expose the aggregate; then apply a bonding treatment.

TILING GENERALLY

Sequence

General: Fix wall tiles before floor tiles.

Cutting and laying

Cutting: Cut tiles neatly to fit around fixtures and fittings, and at margins where necessary. Drill holes without damaging tile faces. Rub edges smooth without chipping.

Laying: Return tiles into sills and openings. Butt up to returns, frames, fittings, and other finishes.

Variations
Distribute variations in hue, color, or pattern uniformly, by mixing tiles or tile batches before laying.

Protection
Floor tiles: Keep traffic off floor tiles until the bedding has set and attained its working strength. Cleaning: Keep the work clean as it proceeds and protect finished work from damage.

SETTING OUT
Tile joints - Set out tiles to give uniform joint widths within the following limits:
- Ceramic floor tiles: 4 to 6 mm.
- Quarry floor tiles: 6 to 12 mm.
- Terrazzo and stone pavers to floor: 2 to 3 mm.
- Large and/or irregular floor tiles: 6 to 12 mm.
- Mounted mosaics: To match mounting pattern.
- Ceramic wall tiles: 3 to 5 mm.
- Terrazzo and stone wall panels: 2 to 3 mm.

Margins
Provide whole or purpose-made tiles at margins where practicable, otherwise set out to give equal margins of cut tiles. If margins less than half tile width are unavoidable, locate the cut tiles where they are least conspicuous.

Fixtures
If possible, position tiles so that holes for fixtures and other penetrations occur at the intersection of horizontal and vertical joints or on the center lines of tiles. Continue tiling fully behind fixtures which are not built into the tiling surface. Before tiling ensure that fixtures interrupting the tile surfaces are accurately positioned in their designed or optimum locations relative to the tile layout.

FALLS AND LEVELS

Grading
Grade floor tiling to even and correct falls to floor wastes and elsewhere as required. Make level junctions with walls. Where falls are not required lay level.
Fall, general: 1:100 minimum.
Fall, in shower areas: 1:60 minimum.

BEDDING

Preparation of tiles
Adhesive bedding: Fix tiles dry; do not soak.
Mortar bedding: Soak porous tiles in water for half an hour and then drain until the surface water has disappeared.
Terra cotta tiles: Use pre sealed tiles or apply a breathable sealer and lay dry. If a final sealed finish is selected, use a compatible laying sealer.

Bedding
Use bedding methods and materials which are appropriate to the tile, the substrate, the conditions of service, and which leave the tile firmly and solidly bedded in the bedding material and adhered to the substrate. Form falls integral with the substrate.

Thin adhesive beds
Provide only if the substrate deviation is less than 3 mm when tested with a 3 m straight edge. Cover the entire tile back with adhesive when the tile is bedded.
Thickness: 1.5 – 3 mm.

Thick adhesive beds
Provide on substrates with deviations up to 6 mm when tested with a 3 m straight edge, and with tiles having deep keys.
Nominal thickness: 6 mm.

Adhesive bedding application
Apply adhesive by notched trowel to walls and floors and direct to tiles if required, to provide evenly distributed coverage after laying.
Wall tile spacers: Do not use spacer types that inhibit the distribution of adhesive.
Curing: Allow the adhesive to cure for the period nominated by the manufacturer prior to grouting or allowing foot traffic.

Mortar beds
For floor tiles: Either lightly dust the screeded bed surface with dry cement and trowel level until the cement is damp, or spread a thin slurry of neat cement, or cement-based thin bed adhesive, on to the tile back. Do not provide mortar after the initial set has occurred.
- Nominal thickness: 20 to 40 mm.

MOVEMENT JOINTS

General

Provide movement joints to the **Movement joints schedule** and as follows:

- Location:

. Over structural (isolation, contraction, expansion) joints.

. Close to external corners in large tiled areas.

. Around the perimeter of the floor.

. At junctions between different substrates.

. To divide large tiled areas into bays, maximum 5 m wide, maximum 16 m2.

. At abutments with the building structural frame and over supporting walls or beams where flexing of the substrate is anticipated.

- Depth of joint: Right through to the substrate.
- Sealant width: 6 – 10 mm.
- Depth of elastomeric sealant: One half the joint width, or 6 mm, whichever is the greater.

Movement joint materials

Divider strip: A proprietary expansion joint consisting of a neoprene filler sandwiched between plates with lugs or ribs for mechanical keying. Set flush with the finished surface.

Sealant: Two-pack self-leveling non-hardening mold resistant, one-part silicone or polyurethane sealant applied over a backing rod. Finish flush with the tile surface.

Backing rod: Compressible closed cell polyethylene foam with a bond-breaking surface.

GROUTED AND CAULKED JOINTS

Grouted joints

Commence grouting as soon as practicable after bedding has set. Clean out joints as necessary before grouting.

Face grouting: Fill the joints solid and tool flush. Clean off surplus grout. Wash down when the grout has set. When the grout is dry, polish the surface with a clean cloth.

Edges of tiles: Grout exposed edge joints.

Mosaic tiles

Grouting mosaics: If paper faced mosaics are to be bedded in cement mortar, pre-grout the sheeted mosaics from the back before fixing. After fixing, rub grout into the surface of the joints to fill any voids left from pre grouting. Clean off surplus grout. When grout has set, wash down. If necessary, use a proprietary cement remover.

Sealant joints

Provide joints filled with sealant and finished flush with the tile surface as follows:

- Where tiling is cut around sanitary fixtures.
- Around fixtures interrupting the tile surface, for example pipes, brackets, bolts and nibs. - At junctions with elements such as window and door frames and built-in cupboards. Width: 5 mm.
Depth: Equal to the tile thickness.

JOINT ACCESSORIES

Floor finish dividers
Finish tiled floors at junctions with differing floor finishes with a corrosion resistant metal dividing strip suitably fixed to the substrate, with top edge flush with the finished floor. Where changes of floor finish occur at doorways make the junction directly below the closed door.

COMPLETION

Cementitious terrazzo tiled surfaces
In situ grind and polish the completed installation with equipment nominated by the tile supplier.

Spare tiles
Supply spare matching tiles and accessories of each type for future replacement purposes. Store the spare materials on site where directed by the Engineer.
Quantity: At least 1% of the quantity installed.

Cleaning
Clean tiled surfaces using an appropriate tile cleaning agent, and polish.

41. **VINYL FINISHES**

GENERAL

INSPECTION

Notice
Give sufficient notice so that inspection may be made of the substrate immediately before fixing vinyl finishes.

SUBMISSIONS

Samples

Range: Submit labeled samples of vinyl finishes illustrating the range of colour, pattern or texture as seen in the finished work.
Minimum size per sample:
- Sheet: 450 x 450 mm.
- Linear accessories (coving, skirting, stair nosing, protection strips, and the like): A piece 300 mm long. Welded joints: Submit a sample joint 300 mm long.

Identification
Labeling: Label each sample, giving brand, product name, and manufacturer's code reference

PRODUCTS

MARKING

Identification
Deliver materials to the site in the manufacturer's containers legibly marked to show the following:
- Manufacturer's identification.
- Product brand name.
- Product type.
- Dimensions and quantity.
- Handling and installation instructions.

SHEETS AND TILES

Edges of sheets and tiles
Ensure edges are firm, unchipped, machine-cut accurately to size and square to the face, and that tile edges are square to each other.

Polyvinyl chloride (PVC)
Resilient floor covering, jute or polyester felt backing: To BS EN 650.
Resilient floor covering, with foam layer: To BS EN 651.

EXECUTION

PREPARATION

Substrates
Ensure substrates conform to the **Substrate tolerance table** and are as follows:

- Clean and free of any deposit or finish which may impair adhesion or location and functioning of movement joints.

Substrate tolerance table

Property	Length of straight edge laid in any direction	Max. deviation under the straight edge
Flatness	3000 mm	4 mm
Projections	100 mm	1 mm

Cleaning concrete surfaces: Mechanically remove the following surface treatments:
- Sealers and hardeners.
- Curing compounds.

Concrete substrate correction: Remove projections and fill voids and hollows with a leveling compound compatible with the adhesive.
Moisture content: Do not commence installation unless the following periods have elapsed: - Concrete slabs: 42 days.
Toppings on slabs: A further 21 days.

Working environment
Do not start work before the building is enclosed, wet work is complete and dry, and good lighting is available. Protect adjoining surfaces.

SHEET AND TILE INSTALLATION

Sheet set out
Set out sheets to give the minimum number of joints. Run sheet joints parallel with the long sides of floor areas, vertically on walls.

Tile set out
Set out tiles from the center of the area. Wherever possible cut tiles at margins only, to give a cut dimension of at least 100 mm x full tile width. Match edges and align patterns. Arrange the material so that variation in appearance is minimized.

Joints
Non-welded: Butt edges together to form tight neat joints showing no visible open seam.

Junctions
Scribe neatly up to returns, edges, fixtures and fittings. Finish flush with adjoining surfaces.

Rolling
Where rolling is required, roll the finish in 2 directions before the adhesive sets, using a 70 kg multi-wheeled roller.

Cleaning
Keep the surface clean as the work proceeds.

VINYL SHEETING

Welded joints
Heat welding: After fixing, groove the seams using a grooving tool and weld the joints with matching filler rod and using a hot air welding gun. When the weld rod has cooled, trim off flush.
Cold welding: Apply seaming compound 100 mm wide to the substrate centrally under the seam. Roll the seam until the compound is forced up into the joint. Clean off flush using a damp cloth.
Epoxy jointing: Join seams with epoxy adhesive.

STAIRS

Vinyl
Preformed: Provide purpose-made **vinyl** stair finish combining riser, nosing and tread in the one element. Lay each step consecutively with the joint at the bottom of each riser.
Formed in situ: Fit the sheet **vinyl** to each tread, and to the riser above, in one piece, coved in the angle. Accurately scribe, cut and fit to stair nosing and perimeters.

Stair nosing
Aluminium: Purpose-made extruded anti-slip aluminium nosing.
Vinyl: Purpose-made molded anti-slip section, matching the stair finish. Refer to the **Stair Finishes Schedule**.

JOINTS AND ACCESSORIES

Junctions
Finish junctions flush with adjoining surfaces. Where changes of floor finish occur at doorways locate the joint on the centreline of the closed-door leaf.

Cover strips

Provide edge cover strips at junctions with different floor finishes and to exposed edges.
Metal cover strip: Extruded tapered strip 25 mm wide, of the same thickness as the sheet or tile. Fix with masonry anchors at 200 mm maximum centers.
UPVC cover strip: Feather-edge strip matching the floor finish, fixed with contact adhesive.

Movement joints

Location: Provide movement joints as follows:
- Over structural (isolation, contraction, expansion) joints.
- At junctions between different substrates.

Depth of joint: Right through to the substrate.
Sealant width: 6 – 10 mm.
Depth of elastomeric sealant: One half the joint width, or 6 mm, whichever is the greater.

Vinyl skirting

Feather edge: Moulded PVC skirting section.
Flat skirting: Flat PVC skirting section.
Fixing: Fix to walls with contact adhesive.
Minimum height: 100 mm.

Coves and nosing's

Coved skirtings: Carry the flooring material up over a profiled coving section to form skirting, weld all joints. Minimum radius of 20mm to curving.

COMPLETION

Protection

Keep traffic off floors until bonding has set or for 24 hours after laying, whichever period is the longer. Do not allow water in contact with the finish for 7 days.
Reinstatement: Repair or replace faulty or damaged work. If the work cannot be repaired satisfactorily, replace the whole area affected.

Spare materials

General: Supply spare matching covering materials and accessories of each type for future replacement purposes. Store the spare materials on site where directed.
Quantity: At least 1% of the quantity installed.

Cleaning

Clean the finished surface. Buff and polish. Before handover, mop and leave the finished surface clean and undamaged on completion.
Refer to the **Sheet and Tile Schedule** for details and locations of vinyl finishes.

42. CARPETS

GENERAL

INSPECTION

Notice
Give sufficient notice so that inspection may be made of the following:
- Subfloor prepared to receive the carpet installation.
- Fixings, edge strips, and underlay installed ready to lay carpet.

SUBMISSIONS

Samples
General: Submit labeled production run samples illustrating the range of color and pattern available in the required carpet types.
Sample size:
- Carpet: 1 m long x roll width or 1 m wide, whichever is less.

Edge strip: Submit a 300 mm length of each type.
Accessories: Submit one sample of each of the following:
- Carpet gripper.
- Heat-bonding tape.
- Bonding adhesive.

PRODUCTS

CARPET

Batching
Carpet laid in a single area and of a single specified type, quality, color and design, must come from one manufacturing batch and dye lot.

Insect resistance

Insecticide: Provide carpets and underlays composed entirely of materials either inherently resistant to insect attack, or treated against insect attack, including by moth and carpet beetle.

MATS

Coir mats
Provide a mat made to fit each designated mat recess to the **Mats schedule**.

ADHESIVE AND TAPES

Adhesives
Compatible with the floor covering material, and suitable for bonding it to the subfloor. Friction compound: Suitable for holding tiles in position without permanent sticking.

Hot-melt adhesive tapes
Commercial grade glass fiber and cotton thermoplastic adhesive coated tape 60 mm wide on a 90 mm wide metal foil base and backed with silicone-coated release paper.

STRIPS

Preformed gripper strips
Commercial grade plywood carpet gripper strip with 3 rows of rust-resistant angled pins of length appropriate to the carpet type.
Size (minimum): 33 mm wide x 7 mm thick.
Location: At edges, except where edge strips are used. Provide double gripper strips to edges where recommended.

Edge strips
Type: Heavy duty edge strip appropriate to the floor covering type (tackles or adhesive fixed), capable where necessary of accommodating different levels of adjacent floor finishes.
Form: Metal moulding or extrusion, with vinyl inserts.
Location: At exposed edges of the carpet, and at junctions with differing floor finishes or finishes of a different thickness. Where edge strips occur at doorways, locate the junctions directly below the closed door.
EXECUTION

SUBSTRATE

Substrates
General: Ensure substrates conform to the **Substrate tolerance table** and are as follows:
- Clean and free of any deposit or finish which may impair adhesion or location and functioning of movement joints.

Substrate tolerance table

Property	Length of straight edge laid in any direction	Max. deviation under the straight edge
Flatness	3000 mm	8 mm
Smoothness	200 mm	2 mm

Concrete substrate correction: Remove projections and fill voids and hollows with a leveling compound compatible with the adhesive.
Moisture content: Do not commence installation unless the following periods have elapsed:
- Concrete slabs: 42 days.
- Toppings on slabs: A further 21 days.
Fixtures: Remove door stops and other fixtures, and refix in position undamaged on completion of the installation.

LAYING CARPET

Setting out
Lay the carpet in continuous lengths without cross joins in the body of the area. Where unavoidable cross joins occur at doorways, locate the joins directly below the closed doors.
Partition layout: Confirm that permanent partitions have been installed before starting carpet laying.

Fixing underfelt
Glue continuously to concrete at edges and joints with a 100 mm wide strip to each piece, and at 600 mm centers both ways with 150 mm diameter patches.

Seaming methods
Woven carpet: Machine or hand sew. Do not provide glued taped seams.
Tufted carpet: Seam with hot-melt adhesive tape.

Fixing

Permanent stick method: Immediately after laying, and again one hour later, roll the carpet from the center diagonally towards each edge using a 65 kg multi-wheeled roller. Do not roll foam-backed carpet.
Dual bonded underlay: Fix with adhesive between carpet and underlay, and between underlay and subfloor. Gripping system: Performed gripper strip and tackles edge strip. Space fixings at 150 mm maximum centers.

Cutting laid carpet
Method: Where penetrations through laid carpet are necessary for electrical, telephone or other outlets, cut the carpet either by cross cutting or by cutting rectangular or circular openings.

LAYING ON STAIRS

Fixing method
To concrete stairs: Adhesive fixing.

Laying method
Closed rise types: Apply the floor covering continuously to the treads and risers.

COMPLETION

Cleaning
Progressively clean the work. Remove waste, excess materials and adhesive.
Final cleaning: When the installation is complete, clean the carpet as necessary to remove extraneous matter, marks and soiling and to lift the pile where appropriate.
Protection: provide fabric drop sheets. Do not use plastic sheeting. If wheeled traffic is to follow carpet installation protect with hardboard sheets butted and fixed with adhesive tape. Refer to the **Carpet and Laying Schedule** for types and locations of carpets.

43. **PAINTING**

GENERAL

INSPECTION

Notice
Give sufficient notice so that inspection may be made of the substrate immediately before application of paint finishes.

SUBMISSIONS

Clear finish coated samples
Submit pieces of timber or timber veneer matching the timber to be used in the works, prepared and coated in accordance with the paint system.

Opaque coated samples
Provide approx. 600x600mm samples on representative substrates of each paint system showing surface preparation, color, gloss level and texture.

PRODUCTS

PAINTS

Combinations
Do not combine paints from different manufacturers in a paint system.
Clear timber finish systems: Provide only the combinations of putty, stain and sealer recommended by the manufacturer of the top coats.

Delivery
Deliver paints to the site in the manufacturer's labeled and unopened containers.

Tinting
Provide only products which are colour tinted by the manufacturer or supplier.

Putty
Non-timber substrates: Oil-based or polymeric based.
Timber finishes: Lacquer or water based only.

EXECUTION

PREPARATION

Order of work
Other trades: Before painting, complete the work of other trades as far as practicable within the area to be painted, except for installation of fittings and laying flooring materials.

Clear finishes: Complete clear timber finishes before commencing opaque paint finishes in the same area.

Protection

Fixtures: Remove door furniture, switch plates, light fittings and other fixtures before starting to paint, and refix in position undamaged on completion of the installation.

Adjacent surfaces: Protect adjacent finished surfaces liable to damage from painting operations.

"Wet paint" warning

Place notices conspicuously and do not remove them until paint is dry.

Restoration

Clean off marks, paint spots and stains progressively and restore damaged surfaces to their original condition. Touch up damaged decorative paintwork or misses only with the paint batch used in the original application.

Substrate preparation

Prepare substrates to receive the painting systems.

Cleaning: Clean down the substrate surface. Do not cause undue damage to the substrate or damage to, or contamination of, the surroundings.

Filling: Fill cracks and holes with fillers, sealants, putties or grouting cements as appropriate for the finishing system and substrate, and sand smooth.

Clear finish: Provide filler tinted to match the substrate.

Clear timber finish systems: Prepare the surface so that its attributes will show through the clear finish without blemishes, by methods which may involve the following:

- Removal of discolorations, including staining by oil, grease and nailheads.
- Puttying.

PAINTING

Provide coating systems to substrates as follows and as scheduled:

- Consistent in color, gloss level, texture and thickness.
- Free of runs, sags, blisters, or other discontinuities.
- Fully adhered to.
- Resistant to expected impacts in use.
- Resistant to environmental degradation within the manufacturer's stated life span.

Drying

Ensure that the moisture content of the substrate is at or below the recommended maximum level for the type of paint and the substrate material.

Paint application
Apply the first coat immediately after substrate preparation and before contamination of the substrate can occur. Apply subsequent coats after the manufacturer's recommended drying period has elapsed.

Priming before fixing
Apply one coat of wood primer (2 coats to end grain) to the back of the following before fixing in position:
- Timber door and window frames.
- Bottoms of external doors.
- Associated trims and glazing beads.

Spraying
If the paint application is by spraying, use conventional or airless equipment which does the following:
- Satisfactorily atomises the paint being applied.
- Does not require the paint to be thinned beyond the maximum amount recommended by the manufacturer.
- Does not introduce oil, water or other contaminants into the applied paint.

Sanding
Clear finishes: Sand the sealer using the finest possible abrasive and avoid cutting through the color. Take special care with round surfaces and edges.

Repair of galvanizing
For galvanized surfaces which have been subsequently welded, prime the affected area.

SELECTIONS-PAINT SYSTEMS

Paint system description
Choose from the following paint systems and substrates and paint in accordance with manufacturers recommendations and **Painting Schedules**:

Paint Systems:
Flat water based: Interior
Low gloss water based: Interior
Flat or low gloss water based: Exterior
Semi-gloss water based: Interior

Semi-gloss water based: Exterior
Gloss water based: Interior
Gloss water based: Exterior
Semi-gloss, oil based: Interior
Full gloss, oil based: Interior
Full gloss, oil based: Exterior
Texture finish, water based: Interior
Texture finish, water based: Exterior
Varnish clear: Interior
Varnish tinted: Interior
Opaque timber finish, water based: Exterior Paving paint - Semi gloss oil-based Roofing paint, oil based
Low flame spread specialized coating

Substrate Types:
Existing paintwork (oil based)
Existing paintwork (water based)
Concrete
Cement render
Fiber cement
Brickwork
Set plaster
Glass reinforced gypsum plaster
Plasterboard (paper faced)
Iron and steel
Aluminium
Metallic-coated steel
Oil-based air-drying primed metal Organic or inorganic zinc primed metal
Timber Particleboard
UPVC

Number of coats
Unless specified as one coat or two coat systems, each paint system consists of at least 2 coats.

Color selection
As nominated in the **Painting schedules**.

TECHNICAL SPECIFICATIONS

"MECHANICAL AND SANITARY WORKS"

1. GENERAL

1.1. Authoritative Standards and Codes of Practice

The authoritative standards referred to in this Specification are the British Standards, IPC and Codes of Practice in Conjunction with the Ethiopian Building Code of Practice.

Should the contractor wish to substitute any other Authoritative Standards or Codes of Practice for any referred to in the Specification, he must submit details of any such standard or Code of Practice with two copies of the document for approval of the Engineer. Approval will only be given to use an alternative Standard or Code of Practice if the Engineer considers the proposed Standard or Code of Practice will produce work of a standard equal or better than that of the specified Standard or Code of Practice.

The whole of the plumbing works is to be executed by a registered plumber and drain layer in strict accordance with the Regulations of the Local Authorities and to the satisfaction of the Engineer.

1.2. Working Drawings

For all work within building the Contractor shall produce drawings showing details of his proposals. The drawings shall be submitted to the Engineer for his approval and no work shall commence until the drawings have been approved.

1.3. As Built Drawings

On completion of the works, when required by the Contract, the Contractor shall prepare drawings showing the work as built. The drawings shall be submitted to the Engineer for his approval. When the drawings have been approved, copy negatives shall be provided by the Contractor to the Client for his retention.

2. Domestic cold and hot water

2.1. Pumps

a- Lift and booster Pumps

1- Centrifugal pumps with electric motors shall be used.
2- The pumps to be vertical type and shall be directly coupled to their electric motors.
3- Pumps shall be low speed and quiet in operation.
4- Pumps shall be firmly mounted. Measures to prevent vibration shall be taken where necessary.
5- Constant speed pump is to be considered with Hydro-Pneumatic Pressure Tank

6- Impellers: Fully enclosed, bronze; key to the shaft.
7- Shaft: Type 316 stainless steel, ground smooth.
8- Shaft Seals: Mechanical, hardened ceramic and carbon segment faces.
9- Bearings: Oil lubricated, external cups.
10- Couplings: Self-aligning, flexible type

.

Hydro-Pneumatic Pressure Tank:

Tank shall be cylindrical or spherical, closed type, constructed in compliance with ASME code or equivalent for unfired pressure vessels.

2.2. Pipework Connections

a- Flexible connections shall be used so as to prevent the transmission of pump and motor noise via pipework.
b- All pipework connections to and from the pump shall be adequately supported and anchored against thrust
c- Inlet and outlet pipework connections to pumps shall be fitted with gate valves complying with the relevant provisions

2.3. Pipes

Materials shall follow BS specifications

a) Cold water distribution pipes

Underground pipes (site)

a- HDPE: for site underground pipes from water meter to main tanks, from main tanks to daily tanks and from daily tanks to distribution closet.
b- All fittings shall be installed using butt-fused fittings, thermo-fused fittings/couplings, or flanged adapters and must be approved by the Engineer
c- JOINING METHOD
d- The pipe shall be joined with butt, heat fusion joints as outlined in ASTM D2657 and conform to the Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe, Technical Report TR-33/2005, published by the Plastic Pipe Institute (PPI). All joints shall be made in strict compliance with the manufacturer's recommendations. A factory qualified joining technician as designated by pipe manufacturer or experienced, trained technician shall perform all heat fusion joints in the presence of the ASPA inspector
e- Pipes working temperature from -5oC to 70oC

Above ground and within building distribution pipes

POLYPROPYLENE PIPE AND FITTINGS

a- Polypropylene Piping: NSF listed type 1, flame retardant polypropylene conforming to ASTM D4104, with a maximum average flame spread of zero seconds and a maximum extent of burning of 13mm, in accordance with ASTM D635.

b- Polypropylene Drainage Fittings: NSF listed and have integral heavy gauge, nickel/chrome electrical resistance wire molded in place in the fitting body. Copper wire elements, loose wire or other loose joint components are prohibited.

c- Joints: Connection between polypropylene pipe and fittings shall be made using an electric fusion joint. All joints shall have a fusion cycle controlled by a microprocessor operated, waterproof control unit equipped with input and output voltage sensors, ambient temperature sensors to automatically adjust fusion time and audible alarms to indicate cycle interruptions and completion of the joining process. The unit shall be capable of fusing multiple joints and with a minimum capability of eight 50mm joints with the same fusion time as a single joint.

d- Connections between polypropylene and other piping materials shall be made using approved adapters according to manufacturer's recommendations. All electro fusion machines shall be third party certified by UL and CSA.

e- PN 10 (SDR 11)

f- To be used for all pipes from water meter to main tanks, from main tanks to daily tanks and from daily tanks to fixtures through walls and ceiling high level as per drawings

g- Temperature from -5oC to 60oC

b) Hot water distribution pipes

POLYPROPYLENE PIPE AND FITTINGS

a- Polypropylene Piping: NSF listed type 1, flame retardant polypropylene conforming to ASTM D4104, with a maximum average flame spread of zero seconds and a maximum extent of burning of 13mm, in accordance with ASTM D635.

b- Polypropylene Drainage Fittings: NSF listed and have integral heavy gauge, nickel/chrome electrical resistance wire molded in place in the fitting body. Copper wire elements, loose wire or other loose joint components are prohibited.

c- Joints: Connection between polypropylene pipe and fittings shall be made using an electric fusion joint. All joints shall have a fusion cycle controlled by a microprocessor operated, waterproof control unit equipped with input and output voltage sensors, ambient temperature sensors to automatically adjust fusion time and audible alarms to indicate cycle interruptions and completion of the joining process. The unit shall be capable of fusing multiple joints and with a minimum capability of eight 50mm joints with the same fusion time as a single joint.

d- Connections between polypropylene and other piping materials shall be made using approved adapters according to manufacturer's recommendations. All electro fusion machines shall be third party certified by UL and CSA.
e- PN 16 (SDR 7.4)
f- To be used for all pipes from water meter to main tanks, from main tanks to daily tanks and from daily tanks to fixtures through walls and ceiling high level as per drawings
g- Temperature from -5oC to 80oC

c) Hot water pipes insulation

a- Exposed at roof pipes:
Supply & installation mineral fiber pipe insulation - 25mm with aluminium cladding
b- Within building pipes
Supply & installation mineral fiber pipe insulation - 25mm

2.4. Plumbing fixtures

Final count and combination of all sanitary fittings, fixtures and accessories shall be as per interior designer / architectural details plans and documents.

Installation to include the supply and installation of plumbing fixtures, drain traps, angle valves, chrome plated copper tubes, escutcheon plates and all required accessories needed for the proper operation of the related plumbing fixtures.

2.5. Lavatories

TYPE LAV-1: white vitreous china, or approved equal; complete with the following trim and accessories or approved equal:

Mixer and bottle trap with adjustable inlet pipe, wall tube and wall flange.

16 mm angle valve with 300 mm long chrome plated copper tube, blue index.

16 mm angle valve with 300 mm long chrome plated copper tube, red index

TYPE LAV-2: scrubbing type compatible with healthcare requirement and ID dimensions and plans.

TYPE LAV-3: delivery room scrubbing type compatible with healthcare requirement and ID dimensions and plans.

2.6. SHOWER

TYPE SH, 50 mm drain opening complete with all accessories chrome plated bath mixer with ceramic head parts, automatic rocker switch: bath/shower, 20 mm shower outlet, integrated non-return valve, with handles and fastening set

chrome plated shower rail, 600 mm with wall brackets, sliding piece and swivel holder.
chrome plated hand shower.
shower hose 1700 mm.
soap tray.
chrome plated basket sponge holder
chrome plated robe hook.
Shower shall be complete with all accessories

2.7. SINK

SINK- TYPEs
SK-1 stainless steel type 304, inset type for fixing into counter top, single bowl, single drainer, 18-gauge thickness, with 2 faucet holes. Sink to be self-rim complete with the ALL accessories.
And as specified in the architectural details where:

SK-2 KITCHEN SINK stainless steel type 304, inset type for fixing into counter top, single bowl, single drainer, 18-gauge thickness, with 2 faucet holes. Sink to be self-rim complete with the ALL accessories and as per the architectural details

SK-3 LABORATORIES SINK Washing module completely manufactured polypropylene for laboratory applications. interior plan with 26mm thickness and raised edge all around with 37mm thickness. Washing modules with 1 or 2 sinks and 1 or 2 Rehabilitation/Construction and Equipment and as specified in the architectural details

2.8. HOSE BIB

HOSE BIBB - TYPE HB-1: to consist of chrome plated metal bibcock, 15 mm male back inlet connection and 15 mm male, hose thread outlet, with 15 mm chrome plated metal hose union female threaded similar to Grohe or approved equal.

2.9. WATER TAP

WATER TAP - TYPE WT-1 15 mm, chrome plated brass, back inlet connection, similar to Grohe, or approved equal

2.10. Connection of Tubing to Cold Storage Tanks, Hot Water Cylinders and Sanitary Fittings.

Each connection of tubing to cold water storage tanks shall be made by drilling a hole in the tank side and using a long screw, union and two back nuts all well screwed up in non- toxic approved jointing compound (red-lead shall not be used). Joints of tubing to flanged and bossed connections of hot water cylinders shall be made with boiler screw, union and back nut screwed up in jointing compound.

Connections to sanitary fittings shall be made with 450 mm length copper tubing bent to shape as required with copper to iron couplings at each end, and joint to union of fittings and tubing.

2.11. Fixing Sanitary-ware and Fittings

All sanitary-ware and fittings shall be left in a clean and good condition to the satisfaction of the Engineer. All fittings shall be fixed in accordance with the manufacturer's instructions.
Lavatory basin brackets shall be cut and pinned to walls in cement mortar including making good, rendering, tiling or plastering, etc.

2.12. Testing of Pipelines –General

The contractor shall provide all water, fittings, pipe stoppers, test pumps, pressure gauges and the necessary labour and tools for the hydraulic testing of pressure pipelines and air testing of drains and sewers.

The equipment must be maintained in good order and the gauges shall be tested to the satisfaction of the Engineer.

The cost of providing all equipment and labour required shall be included in the price quoted by the Contractor for pipe laying.

Trenches must be kept dry until the pipes have been passed by the Engineer. Water for all testing must be obtained from an approved source.
The Contractor shall give the Engineer not less than 24 hours' notice of his intention to test a section of pipeline.

2.13. Testing Pressure Pipelines

Pipelines shall be tested hydraulically in sections during the course of construction.

Testing shall be applied to prove the structural soundness of the various units in the line, including pipes, valves and anchorages, and to prove the water tightness of the line.

Tests shall be applied to sections of pipelines not exceeding 1000 metres in lengths or such lesser length as may be required, and pipe joints shall be left uncovered.

The Contractor shall provide for transmitting the unsupported end thrusts to solid ground at the ends or into the sides of the trenches.

Before testing, the Contractor shall ensure that the anchorage of bends is complete and that all branch outlets taking end thrusts are properly stayed. All anchor blocks must be fully cured before testing the pipeline.

The test pressure unless otherwise directed in the Contract will be 1.5 times the working pressure with a minimum of 50 metres head.
The specified test pressure must be achieved at all points along the section of pipeline under test.

The ends of the section to be tested must be blanked off by means of end pieces, blank flanges or discs provided and temporarily fitted by the Contractor at his own expense together with any anchorage that may be required. Valves shall not be used to isolate test sections forming the pipeline.

The pipeline or pipework shall be filled with water in such a manner as to prevent any shock or water hammer and allow for the complete evacuation of air, and kept under observation for leakage at static head for twenty-four hours. If there are no leakages the pressure shall be raised slowly to the required test pressure for that pipeline and maintained at that pressure for a period long enough for the Engineer to examine the whole section under test, or not less than 4 hours whichever is the longer period. Thereafter, for a period of 2 hours the leakage of water, as measured by the amount drawn into the pump to maintain the pressure must not exceed a rate of 0.1 litre per mm nominal internal diameter per kilometre length of main per 30 metres head for each 24 hours.

All pipes or joints which are proved to be in any way defective shall be cut out, remade and retested as often as may be necessary until a satisfactory test in obtained and any work which fails or is proved by test to be unsatisfactory in any way shall be cut out and re-done by the Contactor at his own expense.

In addition to the tests in separate sections, on completion the main shall be tested in whole or in parts to the same pressure and by the same procedure as that outline for individual sections.

During pipe laying the gauge shall remain in the pipeline and shall be pulled by a stout rope or chain which shall be threaded through each successive pipe or tube so that the gauge is never more than one pipe length behind laying. Any debris collected in front of the gauge shall be regularly cleaned out before the next pipe is placed in position.

2.14. Sterilization of Water mains

The pipelines after testing shall be thoroughly flushed out and cleaned.

After the Engineer has approved the cleaning, the Contractor shall completely fill the pipelines with water to which he shall have added chloride of lime or other approved chemical to give concentration of free chlorine of 50 mg. per litre.

Chorine gas must not be injected direct into the main from a cylinder otherwise than through an approved chlorinator and care must be taken to ensure that there is no flow back into the preceding sections of main.

The method used for sterilization shall be approved by the Engineer and solution allowed to remain in the pipelines for not less than 6 hours, nor more than 24 hours. Chlorine residual tests shall then be taken at the end of the main furthest from the dosing point. The sterilization process shall be repeated until the free chlorine residual test shall be carried out on site in order to obtain an accurate reading of the free chloride present.

2.15. Electric Water Heaters

HEATER: thermal storage, high pressure, wall mounted, cylindrical type with bottom inlet and outlet connections and comprising inner water container, outer casing, end covers, thermal insulation, two electric immersion heaters, two thermostats, safety unit and wall mounting brackets.

WATER CONTAINER: heavy gauge submerged-arc electric welded steel, designed for working pressure of 600 kPa, hydrostatically tested to 1200 kPa at factory and lined on all surfaces in contact with water with copper lining 14.6 kg/m2.

OUTER CASING AND END COVERS: heavy gauge sheet steel, treated to combat rust and finished with baked-on hard wearing white stove enamel. Space between water container and outer casing and end covers to be filled with polyurethane foam insulation. Outer casing to have entry for 25 mm electric conduit.

HEATING ELEMENTS: to have Titanium sheaths and to be removable without draining water container. Each element to have separate contactor and high limit temperature control. Elements to be to BS EN 60335-2-73.

THERMOSTAT: each heating element to be controlled by separate and adjustable thermostat of immersion type with temperature adjustment range not less than 32 to 88 deg. C. and current rating not less than 20 Amp. Thermostats to be to BS EN 60730-2-10.

SAFETY UNIT: to comprise expansion relief valve pre-set at 700 kPa, non-return valve, stopcock and drain.
LOCAL CERTIFICATION: Heaters should be certified by local authorities as applicable.

2.16. UV Water Filters

The UV disinfection unit is used to minimize the growth of organisms within the cold-water supply.
UV filter shall be able to destroy more than 99.99% of all pathogens within seconds without using chemicals.
UV filter shall be equipped with electronic controls to operate and monitor UV lamps for optimum performance.

Two Filters shall be considered as acting and standby units.
The output water quality shall be tested by vendor to be potable water quality.

2.17. Water hammer arrestors

1. Standard: ASSE 1010 or PDI-WH 201.
2. Type: Metal bellows or Copper tube with piston
3. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

Locate water hammer arrestor as per below procedures:
1- Determine the length of the branch
2-If it is less than 20 ft then select a water hammer arrester that has same number of fixture units as the pipe, it should be located between the last two fixtures.
3- If it is more than 20 ft put a water hammer arrester for each 20 ft with a total capacity more than the whole branch, and then distribute it between fixtures not based on length.
4-Depending on the manufacturer there will be a pressure limit (65 psi example) if you exceed it you will need to select the larger size.
5- When placing on very long runs serving one appliance, follow the manufacturer catalogue, it usually depends on two factors the length of the pipe and the size of the pipe.

2.18. Solar water heating system

Supply, deliver, install, test and commission SOLAR WATER HEATING SYSTEM to engineer's approval including all necessary accessories to produce a complete and working unit.

Reference to particular manufacturer's goods is given as a guide to the standard / quality expected and equal and approved alternatives may be used. However, alternative systems must be accompanied with manufacturer's brochures,

The solar hot water storage cylinder and panel shall be located on the roof (approximately 6 meters above ground level) and the contractor is deemed to have factored for hoisting and all necessary supports in his unit rates.

Closed circuit thermosiphon solar water heating unit complete with:1000 liters low carbon steel, polyurethane foam insulated solar hot water cylinder with cold and hot water connections

3No. titanium coated collector with an aperture area of 2 square meters. Collector is to be manufactured from treated pressed steel with multifold risers, phosphate and powder-coated. Collector tray shall be 0.7mm marine grade

The system shall be as 'MEGASUN 300' complete with over-temperature and over-pressure relief valve as well as a monitoring device to constantly monitor closed circuit fluid level.

- Solar collector specifications:

1. Collector frame of aluminium profile (Al Mg Si 05).
2. Rear cover of galvanized steel 0.5mm thick, tightly fitted with elastic EPDM seal.
3. Water frame of suitable gauge and thickness: Headers are punched with upper expansion, for perfect manifolds fitting, thus avoiding pressure drop in the collectors. Tube pitch = 107mm (EN 1652)
4. Copper water frame: Ø22 headers: solar collector feed and feed-back. Ø8 manifolds: solar collector Thermal absorption.
   Aluminium water frame: Ø22 headers: solar collector feed and feed-back. Ø10 manifolds: solar collector Thermal absorption.
5. Complete area absorber made of black painted aluminium 0.3mm thick, or selective aluminium 0.4mm thick, covers the complete window area as well as the headers, thus increasing the collector's absorbency, Laser Welded to the water frame.
6. High density, eco-friendly thermal insulation achieved with a 50mm and 20mm (back and lateral) thick layer of prepressed glass wool for the minimization of thermal losses. Glass wool insulation thermal conductivity: λ=0.032 W/m grd (DIN 56612, measured at 0°C)
7. Tempered solar glass, with a stable coefficient of expansion and high light transmittance, can withstand adverse weather conditions (e.g., hail storm, extreme temperature changes, etc.). BS 6206

2.19. Chorination Unit

A. Description: Chlorination unit suitable to serve main domestic water system.

B. The unit shall contain tank and pump with control module to ensure limit of dosing is not exceeds 0.8ml/L

C. Tank shall be polyethylene tank with minimum of 15Gal (56.8L) capacity, or sized to provide required performance for a week, choose the greater.

D. The concentration of chlorine in tank shall be 1%

E. The pump(s) on the unit features are as follow:

Pump Features

Varied pump sizes to suit different flow rates and chlorine residual requirements.

3-point roller design assists in anti-siphon protection

Self-priming against maximum working pressure

F. The unit shall include a polyethylene tank with spill containment, a four float level control system with high/ low level controls, and chemical metering pumps.

G. Chlorine dioxide dosing shall not exceed 0.8 mg/l.

H. System shall be completed with the following features:

1. Chemical level alarm.
2. Post pressure alarm.

3. Low pressure alarm.
4. Leak detection alarm.
5. Timer alarm.

3. DRAINAGE

3.1. STANDARD AND CODES OF PRACTICE

The requirements of the following British Standards and Codes of Practice shall be observed.

British Standards

a) B.S. 556 Part 1+2 Concrete cylindrical pipes and fittings (including manholes, inspection chambers and street gullies)
b) B.S. 401 Concrete un-reinforced tubes and fittings (with ogee joints for surface water drainage)
c) B.S. 437 Part 1 Cast iron spigot and socket drain pipes and fittings.
d) B.S. 1247 Manhole step irons (in malleable cast iron)
e) B.S 2760 Pitch-impregnated fibre drainage pipes and fittings.
f) B.S. 1211 Centrifugally cast (spun) iron pressure pipes for water, gas and sewage.
g) B.S. 1130 Cast iron drain fittings.

Codes of Practice

a)	C.P	301	Building drainage
b)	C.P.	2005	Sewerage
c)	C.P.	2010	Pipelines

3.2. UPVC Pipes

The pipe work and fittings for use underground shall be u PVC to B.S. 5255

3.3. W.C. Pans and Washbasins

Shall be of vitreous China to B.S 3402. Unless otherwise specified the colour shall be white.

3.4. W.C. Seats

White

3.5. Cisterns

Polythene or polypropylene cisterns shall comply with the requirements of B.S. 4213.

Galvanised cisterns shall comply with the requirements of B.S. 417 grade 'A'. Vitreous China cisterns shall comply with the requirements of B.S. 3402.

3.6. Floor Drains

Floor drains shall be rust-resistant and provided with removable strainers or gratings
TYPE FD-1: to have 150 mm round flat strainer with 58 sq.cm. minimum open free area.

3.7. ROOF DRAIN

TYPE RD-1: uPVC, elevated dome type, suitable for flat roof finish; and supplied complete with removable dome grid, screws and washers, with perforated extension with flat clamp collar for gravel drain. Drain to be smooth and screw fixed to roof slab

3.8. Cleanouts

Metal Floor Cleanouts; Type FCO-1

(a) Size: Same as connected branch.
(b) Type: Heavy-duty, adjustable housing.
(c) Body or Ferrule: Cast iron.
(d) Clamping Device: Required.
(e) Outlet Connection: Spigot.
(f) Closure: Brass plug with straight threads and gasket.
(g) Adjustable Housing Material: Cast iron with set-screws or other device.
(h) Frame and Cover Material and Finish: Stainless Steel.

3.9. Grease interceptor

1. Standard: ASME A112.14.3 and PDI-G101, for intercepting and retaining fats, oils, and greases from food preparation.
2. Body Material: Cast iron.
3. Interior Lining: Corrosion-resistant enamel.
4. Exterior Coating: Corrosion-resistant enamel.
5. Inlet and Outlet Size: 110mm
6. Cleanout: Integral.
7. Mounting: Recessed, flush with floor.
8. Operation: Automatic recovery.

3.10. Septic Tanks

Septic tanks shall be constructed to the dimensions and general arrangement detailed on the drawings and in the Contract. Tanks with blockwork shall be constructed as for manholes.

3.11. Testing of Septic Tanks

Septic tanks and other chambers shall be tested by filling with water after completion of backfilling.

The first one metre of depth may be filled as quickly as the supply permits. Between this and top water level the rate of filling must not exceed one metre in 24 hours. After filling to top water level no further water shall be introduced for 2 days. At the end of this period the tanks shall be topped up to water level and allowed to stand. The tank shall be considered satisfactory if the fall in water level in 24 hours does not exceed 15 mm.

In the event of a fall exceeding the above the tank will be emptied and any defects made good prior to re-test as before, all at the Contractor's expense.

3.12. Ventilating Pipes and Stack Vents

Ventilating pipes and stack vents shall terminate with a domical cage or other cover that does not restrict air flow. They shall be positioned so that foul air does not cause a nuisance or health hazard.

3.13. VALVES

a- CHECK OR NON-RETURN VALVES

All check or non-return valves up to and including 65mm. Nominal bore shall be of the swing check of bronze construction in accordance with B.S. 1953.

All check or non-return valves 80mm. Nominal bore and above shall be of the swing check type of cast iron construction in accordance with the requirements of B.S. 4090.

The pressure classification of all check-non-return valves shall depend on the pressure conditions pertaining to the Site of the Works.

3.14. WASTE FITMENT TRAPS

a- STANDARD AND DEEP SEAL P AND S TRAPS

Where standard or deep seal traps are specified, they shall be manufactured in suitable non-ferrous materials in accordance with the full requirements of B.S.1184.

In certain circumstances, cast iron traps may be required for cast iron baths and in these instances bath traps shall be provided which are manufactured in accordance with the full requirements of B.S. 1291.

b- ANTI-SYPHON TRAPS

Where anti-syphon traps are specified, these shall be similar or equal to the range of traps manufactured by Greenwood and Hughes Ltd., Deacon Works, Little Hampton, Sussex, England.

3.15. TESTING AND INSPECTION

Site Tests – Pipework System

a- UNDERGROUND DRAINAGE SYSTEM

A Site test shall be carried out on all drainage pipes before concrete haunchings or surrounds are applied. These tests shall be carried out preferably from manhole to manhole.

Short drains connected to a main drain between manholes shall be tested as one system with the main drain. In long branches a testing junction shall be inserted next to the junction with the main drain and the branch tested separately. After the test has been passed, the testing junction shall be effectively sealed.

All tests on underground drains shall be water tests. Smoke tests shall not be permitted.

In certain circumstances air tests may be permitted on cast iron drains at the discretion and to the approval of the Architect.

Water tests shall be carried out in accordance with the methods described under B.S. Code of Practice 301. Clauses 601 (b) and (c) and the test pressure shall be not less than 1.520mm head at the highest point in the pipe section and not more than 10.360m head at any point in the section.

The test pressure shall be maintained for a period of one hour during which time the pipes and joints shall be inspected for sweating and leakage. Any leaks discovered during the tests shall be made good by the Sub-Contractor and the section re-tested.

In addition to pressure tests, drain pipe runs shall also be tested for straightness where applicable. This test shall be carried out in accordance with one of the two methods described in B.S. Code of Practice 301, Clause 601 (C).

b- ABOVE GROUND SOIL WASTE AND VENTILATION PIPE SYSTEMS

All soil, waste and ventilation pipe system forming part of the above ground installation, shall be given a smoke test to a pressure of 38mm of water gauge and this pressure shall remain constant for a period of not less than three minutes.

All soil, waste and ventilation pipe system forming part of the above ground installation, shall be given a smoke test to a pressure of 38mm of water gauge and this pressure shall remain constant for a period of not les than three minutes. Water tests on above ground soil, waste and ventilating pipe systems shall not be permitted. Pressure tests shall be carried out before any work which is to be concealed is finally enclosed.

Any defects revealed by the tests shall be made good by the Sub-Contractor and the test repeated to the approval of the Architect.

In all other respects, tests shall comply with the requirements of B.S. Codes of Practice 304.

c- SITE TEST – PERFORMANCE

Following satisfactory pressure tests on the pipework systems, operational tests shall be carried out in accordance with the relevant B.S. Codes of Practice on the system as a whole to establish that special valves, gauges, controls, fittings, equipment and plant are functioning correctly to the satisfaction of the Architect.

4. VENTILATION

4.1. FANS

a- Propeller Fan

1- FAN: wall mounting, supplied complete with electric motor, pressed steel ring mounting plate, anti-vibration mounts, mounting arms, galvanized steel wire guard on motor side, discharge louvre shutters with aluminium frame, and capacitor within wall-mounting box for connecting to fan on Site. Fan blades to be steel, statically and dynamically balanced and directly connected to motor.

b- Ceiling Fan

1- FAN: Ceiling mounted, motor mounts directly to ceiling.
2- Low noise models with vibration free operation.
3- Efficiency: fans shall be available with minimum of 3 speeds.
4- Provide controller mount to wall in an accessible location for users.
5- Blades: shall be epoxy paint steel.

4.2. DUCTS AND INSULATION

a- SHEET METAL MATERIALS

1- General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2- Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G90 (Z275).
   2. Finishes for Surfaces Exposed to View: Mill phosphatized.

3- Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B.

b- SINGLE-WALL DUCTS AND FITTINGS – STANDARD

4- General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".
5- Manufacturers of Round Ductwork: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work
6- Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Transverse joints in duct 1500 mm diameter and larger shall be flanged.
7- Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
8- 1. Fabricate round ducts larger than in diameter with butt-welded longitudinal seams.
9- 2. Fabricate flat-oval ducts larger than in width (major dimension) with butt-welded longitudinal seams.
10- Elbows, Transitions, Offsets, Branch Connections and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," Figure 3-4, "90-Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

c- HANGERS AND SUPPORTS

1- Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
2- Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
3- Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
4- Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

5- Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
6- Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
7- Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

d- **INSULATION MATERIALS**

1- Products shall not contain asbestos, lead, mercury, or mercury compounds.
2- Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
3- Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
4- Mineral-Fiber Board Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IB, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film.
1. Thermal Conductivity: 0.038W/mK at 20 deg. C (68 deg. F).
2. Density : 48kg/m3.

4.3. SPLIT UNITS

a- **INDOOR UNITS**
1- Wall-Mounted, Decorative type unit
2- Inverter compressor with high efficiency
3- Units to be provided with control allow for switching between duty and stand-by every maximum of 6 hours of operation
4- Controller shall switch to other unit in case of failure detection
5- Room temperature shall be maintained at 16oC
6- Condensate to be provided and directed to outdoor at low level
7- Unit noise level shall not exceed 35NC at medium speed operation

b- **OUTDOOR UNITS**
1- Air-Cooled, Compressor-Condenser Components
1. *Casing*: Steel, finished with baked enamel in color selected by Engineer, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. *Compressor:* Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
a. Compressor Type: Scroll.
b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.

c. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with AHRI 210/240, and with liquid subcooler. d. Refrigerant Charge: R-407C or R-410A.

2- Fan: Aluminum-propeller type, directly connected to motor.
3- Motor: Permanently lubricated, with integral thermal-overload protection. Comply with requirements of section "Common Motor Requirements for HVAC Equipment."
4- Low Ambient Kit: Permits operation down to 7 deg C .
5- Mounting Base: Polyethylene.
6- Provide protection cage around outdoor unit to avoid falling

4.4. HEPA Filters

1- Description: Factory-fabricated HEPA filters with holding casing.
2- Media: UL 586, fibrous glass, constructed of continuous sheets with closely spaced pleats with aluminum separators.
3- Media: UL 586, fibrous glass, constructed of continuous sheets with closely spaced pleats with vinyl-coated aluminum separators.
4- Media: UL 586, fibrous glass, constructed of continuous sheets with closely spaced pleats with separators of ribbons of filter media.
5- Frame Material: Stainless steel.
6- Frame Material: Aluminum.
7- Media to Frame Side Bond: Polyurethane foam.
8- Media to Frame Side Bond: Silicone.
9- Media to Frame Side Bond: Neoprene adhesive.
10- Media to Frame Side Bond: Fiberglass-mat packing.
11- Media to Frame Side Bond: Thermosetting sealant. O. Face Gasket: Neoprene expanded rubber.
12- Face Gasket: Ceramic fiber.
13- Face Gasket: Silicone.
14- Duct-Mounting Frames: Construct downstream corners of holding device with cushion pads to protect media. Provide bolted filter-sealing mechanism to mount and continuously seal each individual filter.
15- High Efficiency Particulate Air (HEPA) filters shall be individually tested and certified to be 99.97 percent minimum efficient when handling [0.3] micron particles in accordance with DOP test method. Filters shall be factory scanned. The DOP efficiency and MERV value along with filter serial number and name of manufacturer shall be marked on the filter. HEPA filter shall have maximum pressure drop of 250 Pa (1" WG) when clean at rated flow with a final pressure drop of 500 Pa (2" WG).

4.5. PORTABLE GAS DETECTOR

Portable gas detector, for all the combustible gas leakage detection, LPG, methane, natural gas and ethane, propane, benzene, ethylene, propane, acetyl propane, the corners of alkanes, gas, oil, toluene), halocarbon (methyl chloride, methyl chloride, acetone, ethylene), alcohol (methanol, ethanol) sewage gas, etc.

Gas leak detector shall be with ultra-high sensitivity combustible gas leakage detector. Electrochemistry sensor is more suitable for locating and detecting leakage gas.

Detector shall be
a. compact,
b. easy to operate
c. Easy to carry
d. And can also be attached with a flexible probe
e. Comfortable handle.

Performance requirements:

1. Range LPG/LNG/methane/propane/LEL natural gas: 100% lel
2. Resolution: 1% lel
3. Detection method: Diffusion
4. Detection principle: catalysis
5. Display: color LCD display
6. Power supply method: Lithium ion rechargeable battery
7. Alarm: Three-level alarm of sound and light vibration
8. Response time:<20s
9. Working environment: Temperature: (-20-60) ℃; Humidity (15% ~ 95%) RH
10. Detection instrument Built-in pump suction detection method, double buzzer prompt and its growing light indication

4.6. LPG SYSTEM

a. PIPES:

1. Copper Tube: Comply with ASTM B 88, Type L (ASTM B 88M, Type B).
2. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.
3. Bronze Flanges and Flanged Fittings: ASME B16.24, Class 150.
   a. Gasket Material: ASME B16.20, metallic, flat, asbestos free, aluminium o-rings, and spiral-wound metal gaskets.
   b. Bolts and Nuts: ASME B18.2.1, carbon steel or stainless steel.
4. Protective Coating: Factory-applied, extruded PE a minimum of 0.022 inch (0.56 mm) thick.

b. FLEXIBLE HOSE:

* Hose, hose connections, and flexible connectors shall be fabricated of materials that are resistant to the action of LP Gas as both liquid and vapor.

* Hose shall be designed for a working pressure of 350 psig (2.4 MPag) with a safety factor of 5 to 1 and shall be continuously marked with the manufacturer's name or trademark.

* The hose shall be securely connected to the appliance. The use of rubber slip ends without hose clips shall not be permitted for domestic cylinders.

c. GAS PRESSURE REGULATORS:

* Single stage regulators shall have a maximum outlet pressure settings of 1 psig (7 kPag) and shall be equipped with integral overpressure shutoff device and additionally can be equipped integral pressure relief valve, if applicable, that shuts off the flow of LP Gas vapour when the outlet pressure of the regulator reaches the overpressure limits as per test standards.

5. FIRE PROTECTION

5.1. PORTABLE FIRE EXTINGUISHERS

a) Multipurpose dry-chemical (FE-01):

Extinguishers shall be UL-rated 4-A:60-B:C, 4.5-kg nominal capacity, in enameled-steel container.

b) CO2 Fire extinguishers (FE-02):

4.5 kg carbon dioxide type, with steel body and red enamel finish, pull-pin, squeeze-handle, double braided hose and non-conducting discharge horn.

c) Class K type (FE-03):

Stored Pressure Design, wet chemical, UL Rating 2-A: K, capacity 1.6 gallon (6 l), all stainless-steel cylinder and valve construction, exclusive crevice free, but welded cylinder, tested on commercial deep fat fryers to ANSI / UL, 711 test protocol and safe to use on class C fires, class 2A rated to meet fire code occupancy hazard requirements, temperature range +40°F to 120°F, and meets NFPA-10, class K standard. In addition, the following characteristics need to be included;

I. Clear instruction label using graphics to show steps required to operate extinguisher
II. Easy-to-pull safety pin
III. Tough impact resistant metal valve, handle & lever
IV. UL approved wall hanger
V. Corrosion resistant cylinder & valve assembly

d) Foam type (FE-04):

Pressurized, AFFF-Foam Type: UL-rated 3-A:20B, 9.5-L (2-1/2-gal.) nominal capacity, in stainless-steel container with pressure-indicating gage.

i. Automatic fire extinguisher - Foam type (AFE-01):

Foam AFFF: 6-kg nominal capacity, in manufacturer's standard enameled-metal container, ceiling mounted. Supplied complete with pressure dial gauge, spring operated safety relief valve, and a recharge port. Standard glass bulb operating temperature is 68 ºC. Coverage radius at 3m height shall not be less than 1.5m. Include mild steel ceiling bracket.

ii. Wheeled fire extinguisher (WFE-01):

Wheeled Fire Extinguishers Type (WFE-1): Multipurpose Dry-Chemical Type: UL rated 30-A:160-B:C,
23 kg (50-lb) nominal capacity, in enameled steel container.

iii. Wheeled fire extinguisher (WFE-02):

Pressurized, FFFP-Foam Type: UL-rated 20-A:160-B, 125- L (33-gal.) nominal capacity, in stainless-steel container with pressure-indicating gage and resistance to outdoor conditions.

5.2. ACCESSORIES

A. Mounting Brackets: Manufacturer's standard steel, designed to secure extinguisher, of sizes required for types and capacities of extinguishers indicated, with plated or baked-enamel finish.
   1. Provide brackets for extinguishers not located in cabinets.

B. Identification: Provide lettering to comply with authorities having jurisdiction for letter style, color, size, spacing, and location. Locate as indicated by Engineer.

TECHNICAL SPECIFICATIONS

"ELECTRICAL WORKS"

Section 1: General Specifications for Electrical Services

1.1 Introduction

A Stand-alone Battery based Solar Roof top mounted Photovoltaic (SPV) Power System consists of SPV array, Module Mounting Structure, Power Conditioning Unit (PCU) consisting of Maximum Power Point Tracker (MPPT), and Controls & Protections, interconnect cables, Junction boxes, Distribution boxes and switches. PV Array is mounted on a suitable structure.

Components and parts used in the SPV power plants including the PV modules, metallic structures, cables, junction box, switches, PCUs etc., should conform to the BIS or IEC or international specifications listed below, wherever such specifications are available and applicable. Solar PV system shall consist of following equipment/components. Solar PV modules consisting of required number of Crystalline PV cells, mounting structures Junction Boxes, Earthing and lightening protections, IR/UV protected PVC Cables, pipes and accessories.

This section of the Specification deals with the general standards of materials and workmanship and approved methods in connection with the design, manufacture and installation of the electrical services. This section must be read in conjunction with other sections of the Specifications and Drawings and schedules issued herewith. In the instance of reference to more than one standard the stringent of all shall govern.

The Battery based SPV system shall support essential electric equipment and its indicative electrical power requirements and categorizes the following:

i. Room and service lightings/LED lamps with switches;
ii. Medical equipment's, Oxygen concentrators, @ Pharmacy Refrigerator;
iii. USB Phone charger. etc

The recommended power system configuration (system voltage) is 220V ac electricity supply through inverter.

Except for materials or items or equipment which are specified as being supplied and/or fixed for the works by others, these works shall include the supply, testing and delivery to site, loading, unloading, storage in safe custody, erection, connection, finishing, carrying out preliminary tests at site, commissioning, performance testing and operation for at least one month and putting into service of the whole of the materials, fittings and all cables and conduits necessary for the electrical installation works as specified and scheduled herein and/or indicated on the drawings issued herewith.

Materials and products shall comply with the following:

i. This Specification

ii. Balance of Solar PV Systems (BOS): IEC 61215 Crystalline Silicon Terrestrial PV modules poly/mono. IEC 61730 Solar PV module safety qualification requirements. IEC 61701 PV modules to be used in a highly corrosive atmosphere (Coastal area etc,) must qualify Salt Mist corrosion Testing.

iii. Appropriate British Standard (BS) Specifications and Codes of Practice (CP). Particular mention is made to BS7671: 1992 "Requirements for Electrical Installations" (IEE Wiring Regulations Sixteenth Edition) including all current amendments and the Standards of the International Electro technical Commission (IEC) Publication 364 "Electrical Installations in buildings". EN 12464, IEC 906-1 Socket outlets, IEC 669-1 Switches.

iv. Appropriate Australian/New Zealand Standards (AS/NZS)

AS/NZS 3000	Wiring Rules
AS/NZS 5033	Installation and Safety requirements for photovoltaic (PV) arrays
AS/NZS 4509.2	Stand-alone Power Systems-Design
AS/NZS 1170.2	Structural design actions-Wind actions
AS/NZS 1768	Lightning Protection
AS/NZS 3008	Electrical Installations-Selection of cables

v. Government Rules

vi. Local Authority's Bye-laws and Regulations

vii. Electricity Supply Authority's requirements

viii. Fire Prevention Officer's requirements

ix. Health and Safety at Work regulations

Accredited installers shall comply with the above listed standards where applicable.

The Contractor shall notify the Engineer of any revisions or additions to the foregoing as they are published during the installation of the Works for the Engineer's decision and instructions.

The Contractor shall pay all charges necessary for any Authority's approval of any part of the works.

(a) Prequalification requirement

- The bidder shall fulfill relevant trade license for the assignment to the national by-law and decrees,
- The bidders should submit, with their offer, manufacture authorization, recent test certificates of each items from authorized institution (accredited laboratory),
- The bidders have to provide at least 3 years past experience in similar assignment,
- Subcontracts shall be properly and lawfully signed, and
- Each pages of the relevant offer document shall properly sign and stamped.

(b) Suitability of Materials

Materials and products shall be supplied to suit the temperature and other conditions of use normally expected to apply after the installation is completed, and also to withstand any test specified herein or in any document referred to herein.

(c) Definitions

For this document uses the same terminology as outlined in AS/NZS 5033. Two important definitions are:

a) Where the word “shall” is used, this indicates that a statement is mandatory

b) Where the word “should” is used, this indicates that a statement is a recommendation

For the purpose of this Specification:

i. The definitions given in BS 7671:1992 Requirements for Electrical Installations (IEE Wiring Regulations 16th Edition) referred to hereinafter interchangeably as the IEE Wiring Regulations or BS 7671 shall apply.

ii. The words "weatherproof" and "dust protected" shall have the meanings ascribed to them in BS 2817, definitions 13 and 178 respectively.

iii. As applied to steel conduits and fittings, the words "protection against corrosion according to class 2" (or to class 4) shall have the following meaning:

Class 2 - Medium protection both inside and outside (e.g. stoving enamel, air drying paint).

Class 4 - Heavy protection both inside and outside (e.g. hot dip zinc coating, sherardizing).

iv. As applied in cable trunking (steel surface) the words "protection against corrosion according to class 3" shall have the meaning:

Class 3 - Heavy protection both inside and outside (e.g. galvanized steel complying with BS 2989, Class 2A or 2B).

(d) Standardization

For the purpose of this Specification:

The following equipment shall be standardized throughout the installation:

i. SPV modules
ii. Solar PV module mounting structure
iii. Array Junction Box
iv. Batteries
v. LV distribution and sub-distribution cabling.
vi. Distribution boards.
vii. Wall mounted switch fuses and isolators.
viii. Socket outlets, spur units, lighting switches etc.

Every item of equipment shall in each of the above groups be of the same make and type unless otherwise specified.

(e) Methods of Fixing

General

The size of bolt or screw used must be the nearest permitted by the diameter of the hole in the equipment to be used.

All bolt or screw holes provided in equipment shall be used and in each, fixing must be secure. All screws and bolts shall be sherardized.

For fixing in block, brick or concrete, holes of the correct size for screws or bolts shall be neatly drilled with tungsten carbide tipped twist drill to a depth (excluding plaster thickness) equal to the length of plug to be used. The plug length must be correct for the screw. Fixings shall not be made between joints in blockwork or brickwork.

All fixings required to pre-cast concrete wall planks shall be drilled and plugged. Under no circumstances shall "shot fired fixings" be used.

Conduit boxes shall be fixed by two roundhead screws.

Countersunk screws shall only be used where countersunk holes are provided, otherwise the wood screws shall be roundhead and setscrews shall be cheese head.

Where holes have to be drilled for fixing, No.10 wood screws shall be the minimum size used. Fixing screws used in conjunction with Class 3 and 4 conduit and trunking shall be stainless steel.

(f) Lightweight Accessories

Fixing to hollow partitions etc. where the hole is bottomless shall be by means of rawl plug screw anchors.

Fixing to supporting metalwork shall be made where possible, by means of setscrews or bolts and nuts of appropriate size for the equipment, holes being drilled to correct size. Each bolt and setscrew shall be fitted with a plain washer and shake proof washer under the nut. Where it is not possible to fit a nut, a tapped hole shall be provided.

Fixings to structural steelwork shall be to the approval of the Engineer.

(g) Workmanship

All extra low voltage wiring should be performed by a 'competent' person, which is defined by the Australian Standard AS/NZS 4509.1 stand-alone power systems as: "a person who has acquired through training, qualifications, experience or a combination of these, knowledge and skill enabling that person to correctly perform the task required.

All work shall be performed by a licensed electrician.

(h) Training

Providing training to at least two engineers and/or site staff for Operation, Maintenance and Trouble shooting skills.

1.2 Certificates, Applicable Standards and Packing

Products shall be certified or compliant with the offered Specification. Test Certificates shall be submitted from acceptable organization. Organizations accredited to ISO 17025 or equivalent standards shall be acceptable for issuing the component certifications. A maximum measurement of 3% is permitted on all test of compliance.

The supplier provides the most appropriate system integration, components, assembly and packaging that meet the entire system component specifications and the best practices recommendations.

The solar PV system is packed and pre-wired to provide convenient installations at site by a qualified technician. The system is constructed such that users can perform routine maintenance such as replace and repair, also technician can easily perform system diagnostics.

Supply materials must have a type-test certificate from an accredited testing and certification organization and meets or exceeds the technical specifications. Organizations accredited according to ISO 25 or equivalent is acceptable for issuing the component certifications. Accredited testing institute has to put its currently valid approval mark or seal for complying of the standards and shall consist of their relevant information on traceability of solar cells and module as per ISO 9000 standard.

PV Module

The applicable international standard for PV modules is IEC 61215 crystalline silicon terrestrial modules-design qualification and type approval.

Batteries

The applicable international standard for battery is IEC 61427 IEC 2001 Ed.2, secondary cells and batteries for solar photovoltaic Energy systems (PVES)-General requirements and method of test.

Charge Controller

The applicable international standard for Charge Controller and interconnection system equipment for use with distributed energy resources is IEC 62509.

Stand-alone Photovoltaic (PV) systems

The applicable international standard for characteristic parameter of stand-alone photovoltaic (PV) system is IEC61194 (ed.1) Reference by IEC 61215.

Roofing materials

The applicable international standard for roofing material is UL 790 (fire test) of safety.

Panel Board

The applicable international standard for Panel Board or combiner box is UL 1741 Safety.

Fuses

The applicable international standard for Fuses is UL 248 of safety.

1.3 Technical Details of the equipment to supply

Bidders shall strictly follow to comply with the bid technical requirement details of the equipment to be offered.

1.3.1 Balance of System Components

Bidders shall include all required balance system components in their offer, PV module, Battery, Charge Controller, Fittings, Wiring and Cables, Connections, lightning Arrestor and Earthing, etc., that are required to complete the electrical power use from solar system installation. A complete supply shall be included in the offer.

1.3.2 Solar PV Modules Array

The PV module shall be capable of fully charging batteries, to power daily loads as indicated in the design. The net output of supplying power shall achieve after all losses incurred in cabling, panels, controllers and the battery bank. Based on a net daily energy to the system the minimum array size of watt peak can be determined. Bidders have to verify this value and present their offer.

The photovoltaic modules shall be warranted to provide their rated output at standard conditions with ±15% for a minimum of 15 years under tropical conditions. Photovoltaic modules of the model offered have to be tested at the ESTI (European Solar Test Installation) or an equivalently qualified institution (such as TUV Rhineland and ASU-PTL) certified according to the international standard IEC-61215.

Cells shall be made of crystalline silicon. Modules have to be framed with marine grade Aluminium with appropriate seals to prevent water and corrosion damage to the active components. The backing of the panel may be glass or other material impermeable to water that is accepted under the applicable international standards.

The modules shall have a separate connection box on its back-side that meets protection class IP65. The terminals must be clearly marked with "+" and +-+ for the corresponding connections. Connections shall be of a screw type with a capacity sufficient to accommodate the recommended size of stranded copper interconnection wire. Connections shall be of the direct wire type; wiring using crimped or soldered connection shall not be used. Connection screws shall include lock washers or other means to prevent loosening due to thermal cycling of the panels.

For the panel model proposed, the bidder shall have to include as a part of the tender response the following information:

- Voc, Isc, Impp, Vmpp, and Wp at standard conditions,
- The relationship between temperature and module output,
- The I-V (current-voltage) curves for 1000 W/m2 solar inputs,
- Physical size and weight,
- Details of the materials used in construction, including the frame, the connection boxes., the backing material and the encapsulation material,
- Number of cells per panel,

- A statement of warranties in effect for the proposed module type shall be provided,

Type: Crystalline silicon – Poly or Mono Module Efficiency: >=75%

Warranty (Product and Performance): 5 years warranty.

Module frame: Anodized aluminium. Non-corrosive and electrolytically compatible mounting structure.

Mounting structure: Metallic mounting structure. Hot dip Galvanized with 70 microns thickness. Module minimum rated power: The nominal power of a single PV module shall be >=175Wp.

RF Identification tag for each solar module: must be able to withstand environmental conditions and last the life of solar module and shall be kept inside the module laminate.

RF Identification tag data shall consist of:

a) Name of the manufacturer of PV module
b) Name of the manufacturer of Solar cells
c) Month and year of the manufacture (separately for solar cells and module)
d) Country of origin (separately for solar cells and module)
e) I-V curve for the module
f) Wp, Im, Vm and FF for the module
g) Voc, Isc,
h) Unique serial No and Model No of the module
i) Date and year of obtaining IEC PV module qualification certificate
j) Name of the test lab issuing IEC certificate
k) Other relevant information on traceability of solar cells and module as per ISO 9000 standard.

Power output rating: to be given for standard test conditions (STC). I-V curve of the sample module should be submitted.

The contractor is expected to remove trees if any that could cause shade over the PV panel at any time of the year.

The Panels shall be mounted East-West with a tilt towards the equator (South) equal to the latitude (approximately) twelve degrees (120) facing towards the south.

1.3.3 Batteries:

The batteries to be supplied shall be sealed solar battery, maintenance free and deep cycle.

The battery banks shall be able to effectively provide as per the designed daily load requirement when fully charged. The basic requirements for the battery five years or longer rated service life when the average depth of discharge (DoD) is 20%. Minimum battery terminal voltage is 2 Volts dc. The battery will also be IEC-896-1 compliant. Self-discharge shall not exceed 3% per month.

At an average daily duty cycle of 20% depth of discharge at C10 rate, the battery shall achieve a minimum of 5,000 cycles of operation. Maximum allowable DoD in service shall be 80%. The battery delivered in a dry charged condition. Its shelf life at 300C much be 2 years or more if store in its original packing.

The battery case must be mechanically strong enough to allow being transported and carried by hand over flat land. As a part of the documentation, the conditions required for transport of the cells shall be provided and will include information as to any requirement for maintaining of a specific cell orientation during transport.

Inter-connection cables with the proper connection lugs shall be provided with the batteries. It shall be of the correct type and size.

The following information shall be included with the offer for the battery proposed:

- Columbic and energy efficiency,
- Ampere Hour (AH) capacity at C10 and C100 discharge rate conditions,
- Specific gravity vs cell voltage curves,
- Curves or table for cycle life vs average DoD,
- Physical characteristics including weight dry and wet, height, width, length, connection post dimensions, case material and cell cap type,
- Complete English language manuals for handling, initial charging, installation, operation and inspection,
- Warranty terms and procedures for making warranty claims.

Battery mounting shall be in accordance with applicable internationally recognized practices and adequate electrical safety. Battery mounting shall be in accordance with acceptable international standards.

1.3.4. Charge Controllers

Battery charging will be managed by Maximum Power Point Tracking (MPPT) Charge Controllers. The controller's characteristics and the array configuration shall be matched as to provide the maximum energy delivery to the battery. Due to the harsh environmental conditions at the site and the need for high system reliability, it is required that the rated controller capacity exceed the maximum required capacity in the design by at least 20%. Switching of charge currents have to be controlled from the main switchboard located in the battery house.

Signal indicator shall be included in the controller to show energy flow from the array to the battery charge and discharge level. The device shall have variable speed cooling fans that vary output according to the need for component cooling. Charge controllers shall be supplied with charge and discharge voltage set, which match the battery requirements to ensure adequate protection and cycling. The battery should be protected from deep discharge.

The charge controller shall be able to protect battery over charge, battery undercharge and excessive deep discharge, against reverse polarity of module or battery and reverse polarity of dc load. The controller shall have an indication to users the following:

- The battery is in the charging mode.
- A battery state of charge indicator included on or near the controller of load.
- When the battery condition is:
- Suitable to operate loads
- Energy conservation required
- The controller appropriately labeled such that the user does not have to refer to a manual to understand the existing condition.

Full technical specification for the controller shall be provided in English with offer for each controller model proposed. Complete English language manuals for handling, initial charging, installation, operation and inspection. A statement of warranties in effect must be provided for each controller model proposed.

1.3.5 Solar PV Module Mounting Structure

All array supports, brackets, screws and other metal parts shall be of suitable low-corrosion materials suitable for the lifetime and duty of the system, that do not increase their rates of corrosion when mounted together in an array, and when mounted on the surface of the underlying structure.

This may include techniques to minimize corrosion rates appropriate to the local environment, including but not restricted to methods such as: non-reactive separators between metal surfaces and under screw and bolt heads; and selection of materials with appropriate type and thickness of anti-corrosive coating.

Refer to the manufacturer's guidelines to ensure that the materials introduced are compatible with the roofing.

Any roof penetrations shall be suitably sealed and waterproofed for the expected life of the system.

It is important to allow sufficient clearance to facilitate self-cleaning of the roof to prevent the build-up of leaves and other debris (Refer to roofing manufacturers guidelines.)

If fauna (such as birds, vermin, etc) are a problem in the vicinity of the installation then consideration should be given to how to prevent them gaining access under the array.

Where monocrystalline or polycrystalline modules are used, at least 100mm clearance shall be allowed below the array for cooling by natural ventilation. Insufficient ventilation will result in high operating temperatures for the modules.

The installer shall follow the array frame supplier/manufacturer's recommendations when mounting the array to the roof support structure, to ensure that the array structure still meets AS1170.2 certification.

The PV modules shall be mounted on fixed metallic structures of adequate strength and appropriate design, which can withstand the load of the modules and high wind velocities up to 150 km per hour.

a. The module mounting structure will be designed in such a way that it will occupy minimum space without forfeiting the output from SPV panels & shall be designed to allow easy replacement of any module.

b. The System integrator must ensure proper water proofing in case of any modifications to the roof.

c. Where the PV array cable and conduit passes through steel roof an appropriate collar flashing or dectite shall be installed.

d. Detailed specifications for the mounting structure are given below:

Wind velocity withstanding capacity	150 km / hour
Structure material	Structural materials shall be corrosion resistant and electrolytically compatible with the materials used in the module frame, its fasteners, nuts and bolts. Hot dip galvanized steel with galvanization thickness of min 70 micron or aluminium alloy.
Bolts, nuts, fasteners, panel mounting clamps	Stainless steel SS304
Mounting arrangement for Gable Roofs	Single Shed Roof type
Installation	The structures shall be designed for simple mechanical on-site installation.
Minimum distance between roof edge and mounting structure (Horizontal clearance)	Greater than or equal to 60cm.

Minimum clearance between lowest part of panel and mounting structure (Vertical Clearance)	Shall not be less than 10cm.
Access for panel cleaning and maintenance	All solar panels must be accessible from the top for cleaning and from the bottom for access to the junction box
Panel tilt angle	North-south orientation with a fixed tilt 12 degrees angle (south facing)
Warranty	The structure must have a free replacement warranty for 10 years.

The prospective installer shall specify installation details of the solar PV modules and the support structures with lay-out drawings and array connection diagrams. The work shall be carried out as per the designs approved by concerned authority.

The successful bidder shall provide full design, drawings and technical specifications of the proposed physical design and get prior approval before starting the installation. The details of frame structure construction and physical size, assembly of the rack, solar panel array attachment onto the supporting structure and connection detail on roof structure shall be provided.

1.3.6 Power Control Box Unit

Floor mounted Control Box shall consist of Charge Controller, Bus Bar to and from the battery bank, SPD, relay, LED display, power line from PV array to charge control, dc circuit breaker, power line from charge control to battery bank via dc circuit breaker, power line from charge control to load, dc fuses as per ratings and all the necessary accessories. The Control box is free of dust, vermin, and waterproof and made of cast Aluminium alloy or Powder coated Aluminium. The box shall have lockable door and with door handle. The terminals will be connected to copper bus-bar arrangement of proper sizes. The Control box shall have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables. Protection shall be IP 65 enclosure and IEC 62208 Hinged door with EPDM rubber gasket to prevent water entry with transparent covers with Surge Protection Device (SPD) class – I/II, DC fuse with holder and string disconnector. It should be placed at 5 feet height or above for ease of accessibility. All fuses shall have DIN rail mountable fuse holders and shall be housed in thermoplastic IP65 enclosure with transparent covers. Suitable markings shall be provided on the bus bar for easy identification and the cable ferrules must be fitted at the cable termination points for identification.

The box shall have two pieces of solid earthing points on either side with an arrangement for sufficient ventilation.

LCD display with light shall be provided with functional bush button to display the following characteristics:

- Total Load [kW]
- Load current A
- Battery capacity [Ahr]
- Battery voltage [V]
- Battery charging current [A]
- Battery temperature
- Input/Output Voltage
- PV Panel Voltage
- Battery Charging coefficient (adjustable)

1.3.7 Array Junction Box

The array junction box is free of dust, vermin, and waterproof and made of Fiber Reinforced Thermo Plastic or cast Aluminium alloy or Powder coated Aluminium. The box shall be out door type. The terminals shall be connected to copper bus-bar arrangement of proper sizes. The array junction boxes will have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables. Protection shall be IP 65 enclosure and IEC 62208 Hinged door with EPDM rubber gasket to prevent water entry with transparent covers. It should be placed at a place for ease of accessibility. Suitable markings shall be provided on the bus bar for easy identification and the cable ferrules must be fitted at the cable termination points for identification.

1.3.8 DC Distribution Board

- DC Distribution panel to receive the DC output from the array field.
- Shall be surface mounted steel sheet.
- DC DPBs shall have sheet from enclosure of dust and vermin proof conform to IP 65 protection. The bus bars are made of copper of desired size. Suitable capacity MCBs/MCCB shall be provided for controlling the DC power output to the loads along with necessary surge arrestors.

1.3.9 Fuse and Breaker for Protection

Fuse and Circuit breakers shall include to safe users and protect system components from the following:

- Protection against short circuit on installed electric lines and on user's load,
- Protection against internal shorts in charge controller or other devices,

- Circuit protection against damage by the high PV open circuit voltage when it is connected to the controller without battery,
- Protection for maintenance and repair technicians

1.3.10 Luminaries

Lighting shall be screw mounted E27 concentrated Light emitting diodes (LED) providing the proper lumens as shown in the drawing. All lights are to be individually wall mounted switch control, mounting height of the lamp is at 250cm above ground level on pendant fittings with reflector to bring the light brighter to the point of use or work plane.

Floor mounted type light fittings for examination rooms shall be movable type, adjustable height and adjustable lighting level switch. The lamp shall be LED type, The fitting shall come with socket outlet plug.

Flood lights shall be LED type wall mounted

At the Practical Completion of the Contract the Contractor shall allow for replacing all defective and burnt-out lamps and shall supply 5% of each internal lamps type and rating of lamp installed.

1.3.11 Wiring and Cabling

Stranded and flexible insulated copper wire shall be used. All wiring shall be according to the drawing and should be sized to keep line voltage losses less than 5% and allow the circuit to operate with the rating capacity in safe.

The wiring consists of the electric line installation from:

- PV module to charge controller through circuit protection in distribution box.
- Charge controller to battery.
- Distribution board to house installation.

All exposed wiring shall be in separate and appropriate diameter conduits. No wire joints shall be allowed between distribution board end connections. All connections should be laid in junction boxes and all wiring shall be color coded and labeled.

Polyvinyl Chloride (PVC) or Cross-Linked Polyethylene (XLPE) Insulated, Single Wire Armored and PVC Sheathed Cables

This section of the Specification deals with all main, sub-main and sub- circuit wiring specified to be carried out in PVC or XLPE insulated PVC bedded, single wire armored and PVC sheathed overall cable with copper conductors.

(a) **British Standard**

The cables and associated materials shall comply with the following British Standard Specifications, unless otherwise stated:

BS 1442 -	Galvanized mild steel wire for armoring cables.
BS 5467 -	Specification for cables with thermosetting insulation for electricity supply.
BS 6346 -	Specification for PVC Insulated cables for electricity supply.
BS 6360 -	Specification for copper conductors in insulated cables and cords. BS 6746 - Specification for PVC Insulation and sheath of electric cables.

(b) **Cable Type**

PVC or XLPE insulated power cables shall have copper conductors, PVC sheath, single steel wire armor and PVC sheath overall.

Cable Support System

The cable support system shall be constructed from galvanized cold rolled steel sections. No section shall be smaller than 41mm x 41mm or manufactured in a material of thickness less than 2.7 mm. The support system shall be capable of accepting the cable cleat fixing bolts or studs.

Unless stated otherwise, racks shall be designed to accommodate additional cables to the extent of 20% of those to be installed under this Contract.

The spacing of the racks shall not be greater than that set out in the IEE Wiring Regulations or specified elsewhere in the contract documents.

1.3.11.1 **Method of Installation - General**

Except where special structures such as cable bridges are required, the whole of the supporting steelwork, racks, trays, cleats, clips etc. shall be supplied by the Contractor.

All cables shall be run with particular regard to neatness of appearance, multiple runs shall be marshalled so that cables entering or leaving the crossover shall be kept to a minimum.

(a) **Cable Glands**

All cable glands shall be of the correct type and size for the specific application and location.

Cable glands for PVC or XLPE insulated cables shall be of the two-stage type, which grip both the cable sheath and the armouring independently and incorporate an external earthing lug. A PVC shroud shall be used with all cable glands.

(b) Straight Through Joints

Each cable shall be run in one continuous length. No joints will be permitted unless otherwise agreed by the Engineer.

(c) Bending Radii of Cables

Bends in cables shall be as large as possible and in no case shall the bending radii of any cable be such that the cable may suffer damage.

(d) Cleats and Saddles

Cable cleats shall be manufactured in pressure die cast silicon aluminium grade LM6 to BS 1490. Cable cleats shall be manufactured in two identical halves and secured to the support system by two studs or bolts suitable for fixing to the support system.

These shall be provided in vertical and horizontal runs of cables at intervals of not more than 1.2 meters.

Single core cables carrying alternating current for three phase working shall, as far as possible, be arranged in trefoil formation with the cables touching and where departures from the trefoil arrangement cannot be avoided; approved arrangements shall be employed to minimize sheath currents or other undesirable effects.

The cleating arrangements for single core cables shall be of sufficient strength to withstand the forces setup during short circuit conditions.

Where installed on trays, cables not provided with cleats shall be secured by heavy gauge copper or plastic-coated clips or saddles at intervals of not more than 1.2m, not more than six cables shall be embraced by one clip, and not more than two layers of cables shall be run on one way.

Where installed on flat surfaces, cables shall be secured by cable cleats at intervals of not more than 1.2 meters.

Every cable shall be securely supported throughout its length and at a point not more than one meter from its termination, and on vertical routes passing through a floor, immediately above the floor.

(e) Cable Identification

Each end of cable shall be provided with an identification label, which shall be lettered to the Engineer's instruction.

Labels shall be permanently attached to the cables in an approved manner, loose tags will not be accepted.

The materials of the labels and fastenings shall be such as to avoid corrosion due to incompatibility of materials and to ensure permanent legibility.

(f) <u>Cables Installed in Service Ducts. Cable Tunnels and Fire Ducts</u>

Where installed in service ducts, cables shall be installed at least 25mm clear of walls and ceilings on cable cleats.

Cable cleats shall be fixed to the galvanized rolled steel cable support system at distances in accordance with IEE Wiring Regulation.

Where cables emerge from a service duct and rise up a wall, a length of suitable sized galvanized steel pipe, bushed at each end shall be threaded over the cable to 450mm above floor level and so positioned as to protect the cable from mechanical damage.

Where cables are detailed to be drawn into ducts, cable pulling eyes shall be used and the cable shall be supported on rollers without sharp edges during drawing operation. All cable ducts shall first be cleared and proved by drawing mandrel of slightly less diameter than the duct immediately before pulling in the cables. Any lubricant used shall have no deleterious effect on the cables.

Where draw-in pits are inserted in the route, they will be of such size that no undue strain caused by bending radii is placed upon the cables. Minimum bending shall be as specified.

Cable rollers shall be used when drawing cables into a pit to ensure that no undue strain is placed on the cables.

After the cable is taken off the drum and flaked, the bending radii shall not be less than those stated for the installation.

After the cable is installed in a duct, the Contractor shall supply and install a suitable purpose made sealing gland assembly within each duct to prevent the ingress of water and to ensure that a complete watertight seal is provided.

(g) <u>Termination of PVC and XLPE Insulated Cables</u>

The method of stripping the sheath, filler and insulation, shall be as recommended by the cable manufacturer, and shall be such that no damage is caused to the insulation or conductor.

Each cable gland shall be fitted in accordance with the manufacturer's recommendations.

1.3.11.2 **<u>Elastomer and Polyvinyl Chloride Insulated Cables enclosed in Heavy Gauge Conduit and Metal Trunking</u>**

1) General

This section of the Specification deals with main, sub-main and sub-circuit wiring specified to be carried out in VR, EPR, BR, SR and PVC insulated cables drawn into heavy gauge conduit or installed in cable trunking.

Recognized good engineering practice shall be adopted for all conduit runs and no conduit shall be run in such a way as to provide a trap for moisture condensation.

Precautions shall be taken to prevent the ingress of moisture, silt, brick and concrete chippings etc. into the conduit system during and after the installation of same. Hexagonal headed stopping plugs shall be fitted to the ends of all conduit not connected to fixing and outlet boxes. Where condensation has occurred, the conduits shall be thoroughly dried by drawing swabs through it. The inside of all conduits shall be free from burrs or other obstructions.

Where conduits enter the building from outside or in other positions and where in the opinion of the Engineer there may be substantial difference in temperature between different parts of the conduit system, junction boxes shall be inserted into the conduit system and filled with plastic compound to impede the free movement of air in the conduits.

2) Cables

Cables shall be single core, insulated but non-sheathed and shall comply with the following:

BS 6004: Specification for PVC Insulated Cables (Non-Armoured) for Electric Power and Lighting.

BS 6007: Specification for Rubber -Insulated Cables for Electric Power and Lighting. The rated voltage of all cables shall be 600/1000 volts.

Cable joints shall only be made at main switches, distribution boards, ceiling boxes and fixed accessories. No joints shall be made in joint boxes unless the special permission of the Engineer is first obtained.

All phase cables shall be red, yellow or blue, neutral cables black and circuit protective conductors yellow and green. All single pole switches shall be connected in phase cable.

Conduit and cable trunking capacity as set out in the IEE Wiring Regulations shall not be exceeded.

3) Conduits and Fittings

(i) Steel Conduits and Fittings

Steel conduits shall be new, heavy gauge, welded and screwed, enameled or galvanized as specified and shall comply with BS 4568: Part 1. Each length of conduit shall bear a stamp guaranteeing it to be to this standard. The use of conduit less than 20mm diameter shall not be permitted.

All conduit fittings and accessories, including couplers, ordinary clips, saddles, pipe hooks, screwed reducers, stopping plugs, nuts and male and female bushes shall comply with BS 4568 Parts 1 and 2 where applicable.

All screwed couplers, reducers, unions and lock nuts shall be made of malleable iron and all stopping plugs, male and female bushes made of brass. Round locknuts only shall be used on surface work.

(ii) PVC Conduits and Fittings

PVC conduits shall be new, heavy gauge, super high impact as specified and shall comply with BS 4607 and BS 6099. Each length of conduit shall bear a stamp guaranteeing it to be to this standard. The use of conduit less than 20mm diameter shall not be permitted.

All conduit fittings and accessories, including couplers, ordinary clips, saddles, reducers, stopping plugs, male and female bushes, etc. shall comply with BS 4607 and BS 6099 where applicable.

All couplers, reducers, unions, lock nuts, stopping plugs, male and female bushes shall be made of uPVC. Round lock nuts shall be used on surface work.

Solid or Inspection Elbow, Bends, Tee and Inspection Couplings shall not be used.

For wiring purposes all draw-in and inspection boxes must be installed in readily accessible positions as agreed with the Engineer.

Where cables under 6mm2 are being drawn-in, through boxes shall be used to minimize bending of cables. The heavy-duty type fitted with neoprene gaskets shall be used for external work. The inside surface of erected conduit and fittings shall be smooth and free from burrs and other defects.

Where boxes are flush with the ceilings or wall surfaces approved break joint rings shall be provided where necessary to hide the joint.

Underground buried conduits shall have a minimum of 700mm depth from natural ground level.

Excavation for pipe laying shall be carried out only after a full supply of pipes has been made readily available for that section. The bottoms of excavations shall be trimmed and consolidated to the correct levels. Any excavation in excess of the required depth shall be material of the same composition as pipe beds. If the bottom of excavations is not firm, excavation shall be carried to firm level and to approval by the Engineer and filled with material of the same composition as pipe bed. Rock projections, boulders and any hard spots shall be removed and excavations made to true level.

The minimum width of excavations for pipes shall be 600mm for pipes up to 200mm diameter and not less than 600mm greater than the external diameter of the pipe for pipe sizes over 200mm.

The bottom of excavations shall be approved prior to bedding.

Pipes and fittings shall be inspected for damages and defects prior to laying. Any pipes found to be damaged or defective shall be rejected and removed off the site if determined unsuitable for any purpose.

Pipes shall be joined in accordance with the appropriate practice for each type of pipe and strictly following the manufacturers' instructions. Solvent cement to be used for UPVC, PVC, Polyethylene pipe and fitting jointing shall be as recommended by the pipe and fitting manufacturer.

Granular beds and surround shall be graded gravel approved by the Engineer with a maximum size of 20mm free from dust and organic material. The bed shall be placed to the width of the trench, 50mm below pipe and up to 150mm above the crown of pipe or as indicated in drawings.

4) Conduit Joints

Joints in steel conduits shall be made tight by painting the threads just before jointing with an approved aluminium paint to help prevent corrosion and to ensure a high conductivity joint.

Joints in PVC conduits shall be made with specially prepared waterproof adhesives of appropriate types for the joint.

Running joints shall be used only where absolutely necessary; they shall be painted with two coats of the above aluminium paint as soon as they have been tightened.

Conduits crossing expansion joints in the concrete shall be jointed by means of an expansion coupler. The coupler shall be wrapped with waterproof building paper for a distance of 300mm on either side. An inspection box shall be fitted as close as possible on each side of the expansion coupler and a copper protective conductor complying with the IEE Wiring Regulations installed in the conduit between the boxes. The protective conductor shall terminate at each box by means of a M4 brass roundhead tapped onto the bottom of the box and 2 No. flat brass washers.

5) Inspection Boxes

Small standard circular conduit boxes shall be provided and fixed at all junctions and the necessary angles and bends of the conduits.

For surface work boxes of the raised back pattern shall be used.

Conduit boxes mounted outside a building shall have external fixing lugs. Boxes shall be fitted with light steel covers when used internally, overlapping type on flush work, and recessed covers when used externally and in damp situations.

To ensure adequate earth continuity and fitting it is essential that the correct size hole is cut. Holes shall be formed using a hole cutter of approved design. A ring saw cutter must not be used.

No more than two right angle bends or equivalent sets must be made in conduit runs between inspection boxes. On straight runs inspection boxes must be fitted after each second conduit length.

Corners shall be turned by easy bends or sets made cold without altering the section or opening the seams of the conduit. No bend shall have an outside radius of less than three times the external diameter of the conduit. All bends must be machine made.

Where conduits are installed side by side, all off-sets shall be similar and where off-sets are necessary at switch boxes, distribution boards etc. they shall be as short as possible.

Where bending of the conduit causes damage to the paint finish, it shall be made good immediately with high quality matching paint.

Sheet steel adaptable inspection boxes shall be provided and fixed in inspection positions where more than two conduits cross. These boxes shall be 150mm x 150mm x 50mm deep. Where the boxes are fully recessed, they shall be provided with 2mm mild steel lids overlapping the boxes 5mm all round.

In damp and external situations, malleable cast iron adaptable boxes shall be used. The boxes shall be provided with neoprene gaskets and malleable cast iron lids secured by four M4 brass roundhead screws. The boxes shall have external fixing lugs.

Boxes shall be fixed with a minimum number of two No.10 round brass screws in plastic wall plugs.

No more than three conduits up to 25mm diameter will be allowed per side on the above adaptable boxes. Where more than three conduits per side occur, proportionally larger boxes shall be used. Deeper boxes shall be provided for conduits larger than 25mm diameter.

Conduits shall be terminated to adaptable boxes, distribution boards, consumer units, switches etc. by means of smooth bore male brass bushes and couplers.

Spanner or purpose made tools shall be used to tighten all conduit fittings. Pliers or toothed wrenches shall not be used.

Where boxes are flush with the ceiling or wall surface approved break joint rings shall be provided where necessary to hide the joint.

6) Flexible Conduit

Where specified, final connection to machines and other items of apparatus shall be with flexible conduit.

The flexible conduit shall consist of a single layer of leaded steel, sheathed with PVC. The flexible conduit shall terminate in couplings with threaded internal sleeve and plastic male bush.

The interconnection between the solid and flexible conduit shall be via a small circular conduit box.

A separate copper protective conductor complying with IEE Wiring Regulations must be included within the conduit and be connected to a brass earthing terminal at each end. Brass washers must be placed above and below the earth wire on the terminals. On no account must a screw securing box lids be used for earthing purposes.

7) Painting Conduits

Conduit and fittings installed behind plaster shall be given one coat of red lead primer immediately after erection.

On concealed installations, in concrete floors and screed where the finish of the conduit fittings is damaged during erection, it shall be made good in the same colour.

Where installed in roof spaces, specified to be in a damp situation, the conduit and fittings shall be given one coat of red primer immediately after fixing.

Galvanized conduit and fittings shall be given one coat of aluminium paint after the installed runs have been inspected by the Engineer.

8) Installation of Conduits

All conduits must be run vertically or horizontally; diagonal runs will not be permitted on walls. Conduits, conduit fittings and equipment shall be fixed by heavy distance saddles fixed not more than 1000mm apart secured by means of 1.75" x No.8 brass countersunk screws, in a plastic wall plug of the correct size.

Conduit installed in concealed positions such as ceiling or floor spaces, shall be fixed by spacer bar saddles, fixed not more than 1000mm apart to the fabric of the building as specified above.

Conduit buried in concrete shall have 40mm depth of cover over its entire length. Conduit buried in plaster shall have 6mm depth of cover over its entire length.

Conduits which are to be cast in concrete slab shall be laid directly on the upper surface of the shuttering before the concrete is poured. Fixing holes shall not be drilled or otherwise made in the back of the conduit boxes.

A space of 75mm shall be left between adjacent and the like conduits where they are to be covered with concrete.

Conduits installed in chases shall be fixed with corrugated steel clips secured with hardened steel pins at 1200mm centers.

Conduits laid on concrete floor slab or floor and roof beams shall be fixed by means of corrugated steel saddles secured by hardened steel pins at 1200mm centers.

On pre-stressed beams fixings must be into the joints between the beams unless instructed otherwise by the Engineer.

Where conduits, boxes or other fittings are fitted to girders, wrought iron girder clips of approved pattern shall be employed and in no circumstances shall holes be drilled in girders without written instructions from the Engineer.

All conduit outlets installed in concrete or other in-situ construction must be plugged with extreme care to prevent the ingress of foreign matter and the conduit system from becoming blocked during building construction. The Contractor will be held entirely responsible for any additional cost resulting from blockage of conduits due to neglect or lack of attendance.

Female brass bushes shall be screwed on to all free ends of conduit.

Conduit systems shall be electrically and mechanically continuous and watertight after installation. All conduit systems shall be arranged wherever possible to be self-drained to conduit boxes and outlet points. Where necessary, provision shall be made to counteract condensation as directed by the Engineer.

Immediately before wiring, all conduit systems shall be thoroughly swabbed out until dry and clean.

All spare ways in junction boxes etc. left for possible future extensions shall be fitted with brass stopping plugs.

At connection between trunking and apparatus a 4mm paxolin fillet shall be fixed between the two to prevent chafing of cables on metalwork. The cables slot cut in the fillet shall be 5mm smaller all round than the slot cut in the metalwork. As an alternative a standard flanged adaptor or flanged assembly shall be used. Direct attachment of trunking to apparatus will only be permitted if cable entries are provided with smooth bore bushes or grommets and the return edge of the trunking lid is left intact.

Where trunking is used to enclose cables leaving a distribution board the trunking shall be sized to accommodate all cables connected to the board and to leave room for cables that may be connected to spare ways at a future date.

Holes in trunking shall be drilled, cut or punched and all cut edges painted.

Individual pieces of trunking shall be independently supported. On straight runs, fixing shall be at regular intervals not exceeding 1200mm and shall consist of 1.75" X No.10 roundhead black japanned steel screws. Where weatherproof trunking is used, fixing screws shall be brass.

Trunking systems erected outside shall be weatherproof. When installed in damp situations the trunking must be spaced from the wall by means of short tube collars.

Cable supports shall be provided at 900mm intervals in vertical runs. Where a fire barrier is required between floors, a cable support shall be provided at floor level and fibre-glass insulation packed between the pins.

Where extra low voltage circuits are contained in the same trunking as mains voltage circuits, cable insulation shall be to mains voltage standards. The cables for each different system shall be laced together to denote the different service and voltage ranges and shall be installed on cable separators fixed at 900mm intervals.

Cable separators shall also be provided when it is specified on the plan that circuits are to be separated and when the space factor exceeds 20%. Cable retaining straps shall be provided above each cover fixing button on a horizontal run of trunking when the cover is on the underside.

The trunking shall be adequately bonded throughout its entire length to comply with IEE Wiring Regulations.

1.4 Switchgear and Distribution Boards

1.4.1 General

This section of the Specification deals with switch gear and distribution boards to be supplied and installed throughout the installation.

British Standard Specification

All fuse switch gear, circuit breakers and contactors etc. shall be of the types outlined, suitable for the fault currents of the system and in accordance with the following British Standard Specifications, unless otherwise specified.

BS 89	Direct acting electrical indicating instruments.
BS 142	Electrical protective relays.
BS 158	Markings and arrangement of switchgear busbars, main connections and small wiring.
BS 159	Bus-bars and Bus-bar connections.
BS 162	Electric Power Switchgear.
BS 1598	Ceramic insulating material for electrical purposes.
BS 1858	Bitumen based filling compounds for electrical purposes.
BS 3858	Binding and identification sleeves for use on electric cables and wires.
BS 3871	Miniature air-break circuit breakers for AC circuits.
BS 3938	Current transformers.
BS 3941	Voltage transformers.
BS 4800	Paint colors for building purposes.
BS 5559	Identification of apparatus terminals and general rules for a uniform system of marking using an alphanumeric notation.
BS 6004	PVC-insulated cables (non-armored) for electric power and lighting.
BS 6321	PVC-insulated cables for switch gear and control gear wiring.

1.4.2 Fault Levels

The switchboards and switchgear shall be designed for the system fault levels to be checked and confirmed by the Contractor throughout the main and sub- distribution networks.

Circuit breakers, switch gear, isolators, contactors, busbars and cable connections shall be suitable for operating at the calculated fault levels.

1.4.3 Fuses

All fuses shall be rated in accordance with BS 88 and shall be to BS rating.

1.4.4 Cable Glands

All cable boxes and glands for the termination of all cabling shall be supplied as necessary by the Contractor.

All cable glands shall be in accordance with this Specification and be suitable for the cables specified.

All cable glands shall be complete with locknut, earth tag and shroud. Terminals shall be marked in a clear and permanent manner.

Entry holes, suitable for the reception of XLPE or PVC/SWA and MICC cables shall be provided in the gland plates.

1.4.5 Labelling

Each outgoing and incoming circuit shall be clearly labelled to indicate the circuit controlled.

Labels shall include black lettering, minimum height 5mm on a white background for general use, and 5mm red letters on a white background for warning labels.

All labels shall be screwed, not glued or fixed by the use of rivets.

Any labelling required inside the panel shall not be by the use of self-adhesive PVC strip.

1.5 Fuses and Miniature Circuit Breakers

1.5.1 Fuses Generally

All fuses shall comply with the requirements of BS88 and shall be supplied to suit the rating of the circuits protected in accordance with the requirements of the IEE Wiring Regulations.

1.5.2 Power Fuses

All fuses in distribution switch and fuse gear and fused distribution boards shall be HRC Cartridge Fuses type and category 414AC80 and DC4, arranged vertically and barriers shall be provided between phases. Unless protected by interlocked covers, all live parts shall be fully shrouded.

Type test certificate shall be provided, if required by the Engineer. All cartridge fuses shall be fitted with a device to indicate a blown element. Fuses shall be of the make and type specified and only one make and type shall be used through the installation to ensure discrimination between fuses.

For contactor control gear, the main circuit fuses shall be connected between the isolator and contactor. Each fuse switch and contactor unit shall be supplied with a spare set of fuses and the design of the equipment shall be such that means shall be provided for retaining the spare set of fuses within the fused switch or contactor cubicle compartment.

1.5.3 Control Fuses

Where a control circuit is supplied directly from main power conductors, it shall be protected by HRC power fuses as in power fuses above.

In general, control fuse bases and carriers, of the fully shrouded type having cartridge fuses will be accepted subject to the approval of the Engineer.

The fuse bases and carriers shall be colored as follows, in accordance with clause 42 of BS 162:-

5 amp	Black
15 amp	Light Green
Link	White

Fuses of ratings other than 5 or 15 amp, shall have the rating inscribed on the fuse carrier or label. Such fuses shall be distinguished by approved colorings. Thermo setting self-adhesive labels shall be fitted adjacent to all control fuses and links.

1.5.4 Fuses for Plugs and Spur Units

Fuses for plugs and spur units shall be of the rating of the equipment they protect and shall be to BS 1362 for the 13 amp and ring final circuit accessories or to BS 196 for fuses for industrial ring final circuit accessories.

1.5.5 Miniature Circuit Breakers

All miniature circuit breakers shall be rated to withstand the prospective short circuit currents of the circuits they protect without causing any interference in any other protective devices associated with the distribution system.

At the same time, the design of the circuit breaker shall be such that it will protect the circuit for which it is intended and not cause or allow other protective devices to operate when overload current conditions apply.

Miniature circuit breakers shall be in accordance with BS 3871: Part 1 and comply with the IEE Wiring Regulations. They shall be capable of interrupting 415 volts, three phase symmetrical faults.

Miniature circuit breakers shall be type C unless otherwise stated.

1.6 Distribution Boards

All distribution boards shall be of the sizes and types specified and shall be in accordance with BS 5486 Part 12 and shall be fitted with miniature circuit breakers. Miniature circuit breakers shall be in accordance with BS 3871 Part 1 except where modified by this Specification. Where distribution boards are specified to be complete with an isolator or switch, the isolator or switch shall be double pole for SP&N distribution boards and four pole for TP&N distribution boards. The isolator or switch shall be integral with the distribution board enclosure.

The enclosure shall comprise a case and door(s) of sheet metal. The type of construction shall be damp and dust protected as specified to BS 5420 classification IP31 as a minimum standard.

Surface mounting shall be office pattern, fitted with cylinder lock. Doors shall be provided with quick release hinges.

Sheet steel used in the construction of the distribution boards shall have a quality of surface finish equal to that of sheet steel to BS 1440 Part 1A HRP or BS 1449 Part 28 GR4/GP.

Sheet steel shall be electro-zinc coated to minimum thickness of 0.009mm and chromate washed. All door furniture, e.g., locks handles, fasteners etc. shall be chromium plated.

Painted finishes for all steel for use indoors shall have two coats of rust proof primer, then filled as necessary to a smooth finish, then two undercoats applied and the final finish being two coats of epoxy resin paint, the final coat drying to a hard semi-gloss surface.

All bright machined parts shall have a protective treatment applied by the manufacturer before dispatch and this treatment is to be kept intact up to the time of handover unless it has to be removed for installation. If the surface is then exposed after installation, the Contractor shall apply a further protective coating in accordance with the manufacturer's requirements.

Bus-bars shall be rigidly mounted in the same position on all poles relative to their banks of fuses or MCB's and fully shrouded to enable spare ways to be wired whilst the board is live. Busbars shall be copper to BS159.

All incoming terminals shall be fully shrouded and of the pressure clamp or socket type.

Renewable labels in the form of cards in a transparent envelope shall be provided within the enclosure for recording the following information of each circuit: -

- Circuit designation and location served
- Cable size
- Circuit rating

The sequence of identification shall be stated on the label card. The make and type of fuse that discriminates and/or protects the miniature circuit breakers shall be indicated.

If installation of fuses other than the manufacturer stated would not discriminate or protect the miniature circuit breakers, then a label to this effect shall be installed in the distribution board.

External labels shall be fitted in accordance with "nameplates and labels" and shall be brass plates with engraved black letters.

Neutral terminals shall be provided, one for each outgoing phase way, i.e. three neutral terminals for each TP way in positions respective to their phase terminals.

1.7 Lighting Installation

1.7.1 General

The lighting installation shall comply with the previous sections of this Specification in so far as they are applicable.

1.7.2 Wiring for Lighting Circuits

Wiring for lighting circuits shall be carried out on the "loop-in" principle. The "feed" and "neutral" shall be looped at the lighting point using the "three plate" system.

The wiring shall be in cable of the appropriate rating, type and grade in accordance with the IEE Wiring Regulations. The sub-circuits shall be installed and numbered as shown on the design drawings.

The conduit box at each lighting and ceiling switch point shall be provided with an earthing terminal consisting of a 12mm M4 roundhead brass screw and two flat washers fitted to a tapped hole in the box.

To facilitate the connection of the protective conductors a length of 2.5mm2 yellow/green PVC flexible cord fitted to a 5 amp porcelain shrouded brass connector shall be secured to the earthing terminal.

1.7.3 Concealed Conduit Installation

Small circular metal conduit boxes or equivalent "loop-in" boxes shall be provided at each lighting point in which to terminate hard wiring.

Such boxes shall be securely fixed to the structure of the buildings in order to support the weight of the luminaire. Two boxes shall be used for supporting fluorescent luminaires.

Where boxes finish behind surface level the correct size extension ring shall be used to finish level with the ceiling finish.

1.7.4 Surface Conduit Installation

Small circular raised back metal boxes shall be provided and securely fixed at all lighting points. The hard wiring shall be terminated in fixed based porcelain connectors. Heat resisting cables shall be used or heat resisting sleeving applied to PVC sheathed cables and taken into the luminaire from the hard wiring.

1.7.5 Trunking Installation

Where fluorescent luminaires are fixed to channel or trunking they shall be fixed direct on using the trunking manufacturer's fittings/attachments. Hard wiring shall be taken into the luminaires. PVC sheathed cables shall be sheathed with heat resistant sleeving where they are installed within the luminaires.

Runs of trunking shall be supported at equally spaced intervals of not more than 300 mm apart. The two outer suspension points shall be not more than 450mrn from the ends to the run.

Where more than one length of trunking is required to make up a run splice plates shall be used at the joint. Joints shall not be made in the center half portion of a span between suspension points.

An earthing terminal shall be provided in each run of trunking comprising an M4 screw, with two brass flat washers, screwed into a tapped hole in the trunking.

1.7.6 Cleaning of Luminaires

At completion of the Contract the Contractor shall thoroughly clean all luminaires to ensure all dust, grit, building rubbish, etc. is removed from each luminaire.

1.7.7 Switches

Switch boxes shall comply with BS 4662 and shall be fixed by means of two No. 8 round head screws in plastic wall plugs. In external and damp situations brass screws shall be used.

1.8 General Power Installation

1.8.1 General

The general power installation shall comply with other sections of this Specification in so far as they are applicable.

1.8.2 Makes of Accessories and Equipment

The make and finish of accessories and equipment, shall be as indicated in the detailed schedule of equipment.

1.8.3 . 16 amp Outlets and Spur Units

The socket outlets are generally to be wired in ring circuits. Where radial circuits are to be installed, these shall be indicated on the drawings.

1.8.4 Fixed Equipment

Items of equipment that essentially stand in one position but are moved for cleaning may be specified to be supplied from flush fitting controls. Where this is the case, the control shall be fitted at the height specified and a flush fitting box shall be fixed below the control to allow the flexible cables to be taken to the equipment.

The accessories to be used to enable flexible cables to be taken to these boxes shall either be flex outlet plates or a fixed connector block in a conduit box fitted with a strain relief grip.

1.9 Luminaires

1.9.1 British Standards

Components used in the construction of luminaires and the luminaires themselves shall conform to the following British Standards: -

BS 52: 1963: Bayonet lamp caps, lamp holders and BC adapters

BS 2782: 1975: Methods of testing plastics

BS 4533: Electric luminaries (lighting fittings) BS 4800: 1972: Paint colours for building purposes

1.10 Earth System (grounding)

1.10.1 General

System earth connection shall be made to:

System ground shall be connected: PV array structure, the chassis and any conductive surfaces.

Negative terminal of DC line at which of the shortest route.

The installed lightning protection required protecting level A – common lightning risk and the installation of the mast's height lay at least 250cm at the two top edge of an array with copper rod ground cable, earth mat, bentonite powder etc. and shall be installed in accordance with international acceptable installation standard for lighting and earth connection. A proper interconnection shall be done between the mast and earth system.

Earth connection shall be:

- By a purpose-made fitting providing earthing or bonding connections for dissimilar metals and fitted to the manufacturer's instructions, or
- by purpose-made washers with serrations or teeth for the connection between the PV module and mounting frame fitted to the manufacturer's instructions, and
- be arranged so that the removal of a single module earth connection will not affect the continuity of the earthing or bonding connections to any other module.
- Self-tapping screws shall not be used. Particular attention shall be paid to mechanical protection and support. Earth cable cannot pass through a steel roof without additional mechanical protection (conduit) and an appropriate collar flashing (e.g. dectite). The same conduit that is used for the PV array cable can also be used for the earth cable. Installation is not subject to lightning.

Main Equipotential Earthing and Bonding

1.10.2 Materials General

All materials used in the earthing network shall be of high conductivity annealed copper of type size and with protective covering manufactured to the appropriate British Standard.

1.10.3 Method of Installation

Non-current-carrying metalwork shall be bonded to extraneous fixed metalwork and the whole of the non-current-carrying metalwork shall be bonded together in accordance with the 16th Edition of the IEE Wiring Regulations.

1.10.4 Bonding of Protective Conductors

All metal pipes or conduits in which the cables have been installed shall be bonded to the main earth point. The joints, metal sheath and armour, if any, of the cable shall not increase the resistance of the protective conductor. Where cables are more than 365 meters in length, the metal sheaths and armour of such cables shall be bonded to earth at intervals of 350 meters.

1.10.5 Earth Tapes

All connections to earth tapes shall be made by means of tinning, sweating and bolting. All connection to fixings of earth tapes to the building shall be by means of 3.5mm thick phosphor bronze or gunmetal saddles and brass screws.

1.10.6 Bonding to Extraneous Metalwork

Metal sinks waste pipes, hot and cold pipes shall be bonded to the nearest socket outlet and/or spur unit by means of a 2.5 sq.mm PVC insulated cable, colored green/yellow, enclosed within heavy gauge conduit terminating at a low level in a BS 1363 box fitted with a flex outlet plate complete with a solidly mounted earth stud.

From the flex outlet plate a 4 sq.mm FVC insulated cable, coloured green and yellow shall be installed in a neat and tidy manner and be securely bonded to the extraneous metalwork.

1.10.7 Protective Conductors Associated with Flexible Conduits

Where flexible conduits are installed, each shall be provided with a separate earth conductor of 4.0 sq.mm minimum size and shall be connected to the nearest conduit box and the apparatus served by means of tinned copper lugs, brass screws and washers. The protective conductor shall not be installed within the flexible conduit unless otherwise specifically agreed in writing by the Engineer.

1.11 Lightning Protection

1.11.1 General

The lightning protection system shall comply with BS 6651.

1.11.2 Aluminium Tape

Aluminium tape used for roof termination networks and down conductors shall be bare to BS 2898-1350 and shall have a minimum cross-sectional area of 50mm^2.

1.11.3 Copper Tape

Copper tape used for earthing shall be bare and made from high conductivity copper to BS 1432 C101/C103 and shall have a minimum cross-sectional area of $50mm^2$.

1.11.4 **Fixing of Tape Conductors**

Conductor tapes shall be fixed to the background using metallic tape clips of the spacer bar type using 1" x no.10 countersunk wood screws and wall plug.

When straight through, cross or tee joints are formed in the tape, square tape clamps shall be used and these shall be fixed to the background as described above for tape conductor clips.

Copper conductor fixing accessories shall be made from high quality copper alloys and aluminium accessories shall be made from high quality aluminium alloys.

No accessory meant for copper conductors shall be used on aluminium conductor and vice-versa.

When aluminium fittings are installed, an approved oxide inhibiting compound shall be applied to the connection after it has been made.

At the junction between aluminium down conductors and copper earthing conductors, a bimetallic connector shall be used. The connector shall be firmly fixed to the background using 1" x no.10 countersunk wood screw and wall plug.

1.11.5 **Air Termination Network**

Their termination network shall be arranged so that no part of the roof is more than 5 meters from an air termination conductor.

1.11.6 **Down Conductors**

There shall be one down conductor for every 10 meters of the building perimeter at ground level.

Down conductors shall be as evenly spaced, and shall be routed as directly from the air termination network to the earth termination, as the building contour will permit.

The existence of re-entrant loops in the down conductors shall not be permitted, except as allowed by BS 6651.

1.11.7 **Earth Termination Network**

The earth termination network shall be executed in copper tape and copper clad earth electrodes only.

The connection between tape and earth rod shall be made with a proprietary rod to tape clamp of high strength copper alloy body and screw. Commercial brass shall not be used for this purpose. This connection shall be made at least 150mm above the immediate surrounding ground and enclosed in an earth inspection chamber.

The inspection pit and cover shall be made of concrete of internal dimensions 160 x 160mm and minimum depth of 210mm. The top of the pit shall not be below the general surrounding ground.

1.11.8 Earth Resistance

The resistance to earth of the complete lightning protection system measured at any point, shall not exceed 10 ohms.

The resistance of each individual earth shall not exceed ten times the number of down conductors in the complete system.

1.11.9 Environmental Conditions

The system shall be able to reliably provide full and continuous power under the following conditions:

Ambient Temperature range: 10oC to 55oC

High levels of solar ultraviolet radiation,

High presents of dust,

Presence of insects.

The offered equipment to work reliably in the indicated environmental conditions shall be supported with test evidence document, by the bidder/manufacturer to show its successful operation under similar conditions.

1.12 Protection, Safety and Work Hazards

The installation features of the equipment shall ensure, there is no significant electrical or physical danger to users due to the design and placement of the system.

Environmental Management

Successful bidder shall be required to minimize the environmental impact of the work by adopting respectful waste management behavior and fulfilling environmental norms. Among others, shall be required to:

- Avoid cutting trees except those that create shading of PV panel array.
- Optimize and reduce wire cut and other waste production,
- Clean wastes after completion of the installation area that arise due to installation.

1.13 Warranty

At the time of contract execution, the contractor must provide warranties and guarantees for the PV installation. Bid respondent shall fully define in its proposal the warranty offered. Bidders must meet warranty requirements with the following:

System Warranty: should any faults arise; this warranty shall be covered for the necessary maintenance or component replacement free of charge for full functionality to be restored within seven working days.

Product Warranty: in addition to the three years warranty, the contractor shall guarantee for the system products based on usual practices as per hereunder:

Components shall be warranted as per hereunder:

- A minimum fifteen years on PV modules
- A minimum five years on Batteries
- A minimum 4000 hours life time on luminaries
- A minimum three years on charge controller
- A minimum ten years on PV mounting structures
- A minimum ten years on battery bed or box and
- A minimum ten years warranty on lightning system and system grounding are required.

Annual energy performance warranty: the bidder shall provide the warranty for the performance of the energy for one year.

1.14 Documentation and Training

Successful bidder shall provide manufacturer's documents of technical specifications, maintenance and operation and users manuals of each component installed.

List of installed components and including spare parts, tools, associated manufacturers literature and warranty claim shall be handover to users of each installed components.

The supplier shall have to prepare and provide user's manual intended for the users. The user's manual should be in local language, if possible, otherwise in English and French and has to be simple and easy to understand.

The user manual shall consist at least the following:

- Briefing of signal indication on charge control: battery charging, battery low voltage and battery overcharge. The relationship between energy available on a daily basis and sunlight conditions clearly and easily shall be explained.
- Description of disconnect breakers and routine attendance.

- Proper system operation including load limitation; suggested operation, weather condition load management during periods of inclement weather.
- Briefing shutdown procedures in cases of fault.
- User level trouble shooting guide.
- Contact information for warranty claim, maintenance and access to spare parts.

1.15 O & M Manual

The supplier shall provide for components, an operation and maintenance manual to be used by the service technicians. The manual shall be in a language understandable by the technician. The manual includes the specific details of installation, operation and maintenance.

A detailed technical description of the component.

- Instructions and routine maintenance recommendation.
- Trouble shooting guide shall include repairs and diagnostic procedures to be done by a qualified technician.
- A functional block diagram and electrical line diagram showing the connection and ratings of component.
- A set of blank log sheets for record.
- Contact information for queries and breakdown maintenance service.

The training shall be split into three major components: system installation, system operation and maintenance and demand side management.

The training shall include operating hours, battery discharge, number of appliances operated simultaneously, response to extended periods of cloudy weather etc., explained in detail together with the maintenance requirements for the unit. The bidders shall provide training methodology together with their offer.

1.16 After Sales Services

After sale service shall apply to the solar photovoltaic energy system, including light fittings and main components supplied under this contract. The bidder shall prove and demonstrate that it has the capacity to provide after sales service with capable staff in its bid document with company profile.

1.17 Testing and Commissioning

1.17.1 General

The following inspections and commissioning tests shall be performed:

- Inspection of the supply sets of materials, transportation and delivery condition shall be conducted by Client's or Consultant's technical officers prior to arrival and transportation to the final destination as appropriate carried at the supplier's premises, in Djibouti or beneficiary site.
- Test for proper installation for the main apparatus and the complementary stands, as well as, product commissioning shall be conducted by authorized and responsible parties.
- Inspect all sets of goods and materials incorporated are new, unused, and of the most recent or current models, and check for recent improvements and amendments whether incorporate in design of the supply.

1.17.2 Inspection and Commissioning Tests

As the installation proceeds and on completion of the installation and at the expiration of the maintenance period, the Contractor shall carry out tests in the presence of the Engineer on all sections of the Electrical Services Installation and shall submit six signed copies of the results of the tests to the Engineer, together with six copies of a Completion and Inspection Certificate as required by the IEE Wiring Regulations Part 7.

Site testing of all systems and components comprising the Contract works shall be carried out in the presence of and to the complete satisfaction of the Engineer, AFTER the Contractor has first satisfied himself that the systems are operating correctly.

The Contractor shall prepare and submit for approval comprehensive commissioning documents prior to commencement of testing.

No section of the installation shall be energized until these tests have been completed.

The Contractor shall provide all certified instruments, equipment, plant, labour and materials necessary for conducting specified site tests and shall be responsible for and prepared to demonstrate the accuracy of all test instruments supplied by him.

All installations, plant and tests must satisfy the requirements of the Factories Act and the requirements of all other interested Authorities and the Contractor shall include for all safety devices, etc. required by such Act or Authority.

Observations shall be made of the operation and performance of the installations and subsequent readjustments made as necessary.

Accurate records of all commissioning and testing shall be kept and results comprehensively reported to the Engineer when the installed system(s) are functioning correctly.

Where it is not possible at the particular time of commissioning and/or demonstration of the plant for full load conditions to be obtained or assimilated, the Contractor shall repeat the requisite operations of the commissioning and demonstrations under such full load conditions (or the reasonable approximation or simulation of such conditions acceptable to the Engineer) at the first opportunity.

The Contractor shall ensure that all equipment and plant under his supply shall be tested at the makers works before dispatch and six copies of test certificates in respect of each test shall be forwarded to the Engineer.

All works tests shall comply with the relevant British Standard Specification or IEC Standard Specification and shall be sufficient to show that equipment will function correctly when installed as part of the Sub-Contract works.

Each item of electrical plant or equipment so tested shall be fitted with a plate giving at least the following information:

- Date of Test
- Individual equipment serial number
- BSS number if any
- Test Voltage
- Operating voltage (if different from test voltage)
- Test current
- Full load current (if different from test current)
- Loading (expressed in kVA) and power factor Phase
- Frequency (expressed in Hz)

The above information shall be included on the test certificate for each item of plant or equipment. This shall also include a description of any particular method of wiring and/or connection with the location of the test and signature of the witness.

The following test results shall be submitted:

a) Continuity of ring final circuit conductors

b) Continuity of protective conductors, including main and supplementary equipotential bonding

c) Earth electrode resistance

d) Insulation resistance

e) Insulation of site-built assemblies

f) Protection by electrical separation

g) Protection by barriers or enclosures during erection

h) Polarity

i) Earth fault loop impedance

j) Operation of residual current devices and fault voltage operated protective devices

Each circuit breaker shall be operated manually or electrically 50 times to the satisfaction of the Engineer. Where the circuit breaker is designed for electrical operation at least 10 of these operations shall be made with 80% normal voltage applied to the trip coil in accordance with BS 116: 1952. During this test the trip free feature shall be demonstrated.

1.18 Mounting Heights

Except where otherwise detailed in the drawings or stated in the Bill of Quantities all accessories and fittings shall be fixed at the following heights above finished floor level:

- Distribution boards 1700mm to centerline of board.
- Lighting switches and push buttons 1400mm.
- Sockets (general) 400mm.

Section 2: Particular Specifications for Electrical Services

2.1 General

The electrical materials and works will be selected, erected, inspected and tested in accordance with the following: -

i. This Specification

ii. Appropriate British Standard (BS) Specifications and Codes of Practice (CP). (IEE Wiring Regulations Sixteenth Edition) including all current amendments and the standards of International Electro-technical Commission (IEC) Publication 364 "Electrical Installations in buildings".

iii. Government Rules

iv. Local Authority's Bye-laws and Regulations

v. Electricity Supply Authority's requirements

vi. Fire Prevention Officer's requirements

vii. Health and Safety at work regulations

The Contractor shall notify the Engineer of any revisions or additions to the foregoing as they are published during the installation of the Works for the Engineer's decision and instructions.

The Contractor shall pay all charges necessary for any Authority's approval of any part of the Works.

The Contractor shall include everything required for the completion of the Works within the installation to ensure continuous operation of all equipment and plant.

The Contractor shall ensure that the installation is compatible with Architectural and Structural details.

The Contractor shall note the requirement for detailed coordinated working drawings showing the location or layout of wiring accessories or particular method of installation.

2.2 Suitability of Materials and Products

Materials and products shall be supplied to suit all conditions of use normally expected to apply after completion of the installation. They should also withstand any tests specified in this Specification or any other documents referred to herein.

Unless otherwise explicitly stated in the contract documents, all materials and equipment incorporated in the Works shall be new and for the purpose intended.

2.3 Lighting Installation

2.3.1 General

The Contractor shall supply, install and connect the complete lighting installation as described herein and indicated on the drawings. All recessed luminaries within suspended ceiling tiles may be supported independently by the ceilings. However, the Contractor must ensure that the arrangements for fixing of the luminaries to be ordered are completely compatible with the ceiling grid type.

Final connection to all luminaries shall be carried out using 2.5mm2 heat resisting flexible plug-in lighting Luminaries Support Coupler (LSC) system. In the case of luminaries within the suspended ceiling areas, ample lengths of flexible cable shall be provided so that the luminaries can be moved horizontally a distance of 600mm in any direction from the position shown on the drawing without straining the cable.

The lighting installation shall be carried out using PVC insulated, stranded copper conductor cables, drawn within heavy gauge, high impact PVC conduit.

Separate circuit protective conductors of the same cross-sectional area as the phase conductors shall be provided.

Lighting circuits shall be wired in 1.5mm2 or 2.5 mm2 cables as indicated on the drawings. No cable size smaller than 1.5mm2 shall be used for the lighting installation.

The lighting installation shall be flush/concealed with conduits concealed within suspended ceiling voids or buried as necessary within walls, floors and other building finishes.

The Contractor shall ensure that all conduits, cables etc. installed are clear of any thermal or other insulation which may be provided within ceiling voids, etc.

Wiring shall be carried out in loop-in system and no cable junctions or terminations will be permitted in inaccessible locations.

Lighting cables shall be drawn within conduits specifically provided for the purpose and sha1l not be drawn within conduits provided for other services or vice versa.

The Contractor shall prepare detailed working drawings of the installation indicating the exact positioning and routing of all conduits, trunkings, luminaires etc. and submitted to the Architect for approval prior to commencement of installation.

Low voltage luminaires installed within the bar area of the restaurant on the first floor are to be supplied via a remote wire wound transformer of the multi-outlet type rated at 225VA enabling a maximum of four 50-watt luminaires to be connected to it. The transformer shall be measured as one luminaire point and the short connections to the luminaires measured separately.

The Contractor shall ensure that the transformer and associated cabling are installed to the manufacturer's specifications.

The modular luminaires in the meeting room on the first floor shall be suspended at 500mm below ceiling level by methods recommended by the manufacturer.

The spherical pendant luminaires mounted in the void shall be mounted to form a spiral with the first numerically identified luminaire suspended with the lower side of the sphere at 500 mm below the mounting ceiling level. The subsequent luminaires shall be mounted with their lower side progressively 500 mm below the one above it.

2.3.4 Lighting Switches

Lighting switches for the control of luminaires shall be suitable for flush mounting with overlapping white plastic front plates, single or multi-gang as indicated on the drawings

.

2.4 16 Amp Socket Outlets

General purpose socket outlets, unless otherwise specified, shall be of 16 ampere capacity, single pole and of rectangular pin type to BS 1363/1947 with a white plastic front plate and integral switches. They shall be mounted in rectangular galvanised steel boxes single or multi-gang as necessary with at least one adjustable lug.

Socket outlets for mounting onto the skirting trunking shall be of a type suitable for that purpose and shall be provided with all necessary proprietary accessories. No local improvising shall be accepted.

2.4.1 Wiring

The installation shall be carried out using PVC insulated single core cables having stranded copper conductors enclosed in heavy gauge high impact PVC conduit and steel cable trunking. Separate circuit protective conductors (c.p.c.) of the same cross sectional area as phase conductors shall also be provided and installed for each circuit. Where the phase conductors are wired in a ring, the c.p.c. conductors shall also be wired in a ring.

All 16 amp socket circuits shall be wired using 2.5mm2 cables or other size as indicated on the drawings.

No cable size smaller than 2.5mm2 shall be used for any power installation.

The power circuits shall be a flush or concealed installation with conduits concealed within suspended ceiling voids or buried as necessary within walls, floors and other building finishes. On the second to the tenth-floor open space areas the cables shall be laid in the skirting trunking fixed on the surface of the walls at skirting level and in under floor threshold units where the trunking crosses an opening such as a door.

The Contractor shall ensure that all cabling, conduits, trunking etc. installed are clear of any thermal or other insulation which may be provided within the ceiling and floor voids, risers etc.

Power circuits shall be contained within the conduits or trunking compartment specifically provided for the purpose and shall not be installed within conduits or trunking compartments provided for other services or vice versa.

Detailed working installation drawings shall be prepared by the Contractor indicating the exact positioning and routing of all conduits, trunking etc.

These drawings shall be submitted by the Contractor to the Architect for approval prior to commencement of the installation.

2.5 Earthing and Bonding

The entire cable, trunking, conduit and cable tray installation, together with the sheathed and earthing conductors of cables shall be electrically bonded to earth.

All main, sub-main and final distribution boards, plant and equipment shall be bonded to earth in an approved manner by solid copper conductors secured by means of substantial bonding clamps.

The Contractor shall bond, in all locations, all extraneous conductive parts of the installation including sinks, basins, waste pipes, hot and cold water pipes and all general items of mechanical services plant. The bonding shall be carried out using green/yellow PVC insulated single core conductors.

All steel accessories boxes for light switches, socket outlets etc. shall be bonded to earth by connecting the brass earth terminal at the back of the box solidly to the circuit protective conductor.

All bonding installations shall be carried out in a neat and unobtrusive manner to the satisfaction of the Engineer.

2.6 Lightning Protection

The lightning protection system shall consist of an air terminal network, down conductors, earth termination network and bonding to prevent side flashing.

2.6.1 **Air Termination Network**

The air termination network shall consist of bare aluminium conductor tape which forms a network mesh of not more than 20m by 10m as shown on the drawing. The tape shall be 30mm x 3mm thick.

All tape intersections or connections shall be carried out with connectors which are compatible with the tape material. All fixings of tapes to the building shall be by means of tape clips of cast gun metal upper and lower sections with countersunk brass screws.

2.6.2 **Down Conductors**

Down conductors shall be installed to provide a low impedance path from the air termination network to the earth termination network, to allow the lightning current to be safely conducted to earth.

The down conductors shall be of bare aluminium conductor tape of dimensions 30mm x 3mm and shall be fixed in like manner as the air termination network conductors. The aluminium conductor tapes shall terminate onto a test clamp at a height of 1.5m from ground level from where a copper tape will lead into the ground termination.

Down conductors systems shall take the most direct route from the air termination network to the earth termination network. The routes chosen shall be such as to avoid side-flashing.

Re-entrant lops shall not be permitted in the conductor except where the length of the conductor forming the loop does not exceed eight times the width of the open side of the loop as recommended in BS 6651. The routing of conductors inside the structure shall not be permitted.

2.6.3 **Earth Termination Network**

The earth termination network shall consist of high conductivity annealed bare copper conductor tape of dimensions 30mm x 3mm from the test clamps installed at 1.5m above ground level and terminating onto earth rods driven into the ground.

The copper tape to earth rod connection shall be via a rod to tape clamp of cast gun metal body and phosphor bronze bolt. The connection shall be made above the surrounding soil in the inspection chamber to facilitate visual inspection.

The earth rods shall be of the extensible type made from pure electrolytic copper of minimum thickness 0.25m, molecularly bonded onto low carbon steel cores with high tensile strength. The threads shall be rolled onto the rod with a uniform layer of copper. The coupling shall be of silicon and aluminium bronze, counter-bored and shall completely cover the threads on the rods. The rods shall be 1500mm x 16mm diameter and driven to a depth of 4.5m.

The whole earthing assembly shall be enclosed in a concrete earth inspection chamber of 300mm x 300mm external dimensions complete with a concrete cover.

2.6.4 Bonding

The Contractor shall bond all exposed metal work on or around the structure to the lightning protection system to avoid side-flashing. All such bonding shall be carried out using factory made accessories.

2.7 Data points comprises:

a) 25mm diameter rigid and heavy gauge conduits, with PVC socket box 7x7 cm, PVC conduit fittings, pull boxes as needed. Note that more than one cable can pass through one conduit Ø 25mm (see drawings).

b) four pair UTP CAT 6 data cable. Data point starts from floor data box up to the data socket without cut/joints, even in draw boxes.

c) Data outlet socket (RJ45), one or two gang as shown on drawings and mentioned in B.O.Q.

d) All data socket outlets shall be tough, impact resistant construction together with innovative design and high performance and safety.

e) Data outlet sockets shall be of moulded type.

PoE Switch:

- Management Type : Unmanaged
- Gigabit ports : 12
- PoE+ ports : 12
- PoE budget : >=250W
- Form Factor : Rack-mount
- Auto-balance : Yes
- Power Supply : Internal

Patch panel:

- ID stripes for identifying port allocations
- IDC: suitable for 22-26 AWG stranded and solid wire
- Compatible with both 110& Krone punch down tools
- Cable Management with optional cable management bar
- Operating temperature: -10oC to 60oC
- Life (mating cycles): Jack: 750 cycle's min (ISO/IEC 11801, IEC 60603-7-4).

2.8 SOLAR POWERED LED STREET LIGHTS:

A Solar LED Lighting System is a solar Photovoltaic System designed for outdoor application especially for remote areas where conventional electricity is not available.

A typical Solar Lighting System consists of the following system components:

- Solar PV Module
- Storage Battery
- LED Light Unit
- Microprocessor based Solar Charge Controller
- GI Pole with silver paint.
- Bracket for panel mounting.
- Weatherproof Battery box
- Connecting Cable, hardware and other accessories.

Working Principle

Solar PV Module converts the Sunlight in to electricity during daytime. The electricity is stored in storage battery for use in the night to operate the light unit. The storage battery is connected to the solar PV Module through a solar charge controller to avoid overcharging and to prevent short circuit of the battery. A light unit is connected to the battery through the solar charge controller & it automatically switches ON the light unit at dusk and switches OFF at dawn.

PV Module [150Wp] A solar PV module of required size is used. The size of the module (Wp) is determined by the following parameters:

- Numbers of hours of operation of light per day.
- Total wattage of the light.
- Autonomy of the lights. Manufactured & IEC Standard

- High efficiency crystalline silicone Solar cells, laminated between glass and back sheet using EVA as an encapsulation for improved power tolerance.
- Low iron textured toughened glass for high transmittance, better output and safety.
- Weather proof junction box with easy interconnection arrangement.
- Designed for system voltage of up to 1000V DC.
- Nominal Power Pmax (W) : 150
- Max-Power Voltage Vmp (V) : 17
- Max-Power Current mp (A) : 7.06
- Open Circuit Voltage Voc (V) : 21
- Short Circuit Current Isc (A) : 7.62
- Dimensions (Lx W x H) : 1490 x 675 x 35mm
- W
eight: 11.75 Kg each

Other Charactersistics:

- Type of cell: Mono/Multi Crystalline Silicon
- Front Face: Tempered Glass (Low Iron)
- Encapsulate: Wthylene Vinyl Acetate
- Frame: Anodised Aluminium
- Junction Box: Weather proof Nylon 6
- Tem Coefficients: Voltage -0.123V/K, Current +4.4mA/K, Power: -0.47%/K
- NOCT: 47+/-2 C
- LED Luminary [30W]
- The light unit operates during the night. High power LED with 120 lumens/watt output with life of more than 50,000 hours is used. LED lights give 90% more light output than any CFL lamps.

The light unit has the following features and technical specifications.

Input Voltage 11 – 15 V DC

Power Factor = > 0.95

Index of Protection Level IP 65

Life expectancy of Product Above 50,000 hrs with 70% Lumens maintenance

Color Temperature (Minimum 5500 to 6500K (Suitable for white light)

Color Rendering >70

Make LED High power LED: CREE or Nichia.

LED viewing angle LED viewing angle

LED Housing(body) High quality housing such as Pressure Die cast aluminium with smooth finish

power coated.

Efficiency Efficiency of driver is > =85%

Operating Temp. -5 to 60 Deg C. Ambient

Humidity. 90%

Efficiency of bare LED >= 120 lumens / Watt.

LED Operating Current (Driver output current)

350ma to 700ma(as per manufacturers specification)

Output Luminous Flux of fixture >75%

Isolation 1.7KV AC between Input and Output for 1.5Mins.

Tubular Battery [120 Ah/ 12V]

Battery is used for storing electricity generated by the solar PV module for use in the night. Preferably SMF or tubular batteries are used.

Technical details:

C20 capacity: 120Ah

Nominal Voltage: 12V

Battery weight: 28Kg

Dimensions (l x w x h): 518x275x250 mm

Features:

- Batteries are designed to withstand frequent and long power cuts.
- Assembled in polypropylene containers with plate holding cradles.
- Extra thick tubular plates as per Hi- Power design.
- Thick tubular plates are of low antimony alloy and cast in
- HADO/SUVEMA machines at above 100 bas pressure for super fine
- grain structure and minimized grid corrosion at high temperature.
- Negative plates are of low antimony alloy with lattice structures.
- Micro porous ceramic vent cum sealsed float plugs to reduce topping up frequency.
- Resistance to corrosion and high ambient temperature.

- Abuse resistant.
- Low self discharge.
- Deep cycle design.

Microprocessor based Solar Charge Controller [10A]

Solar charge Controller is used for protecting the battery from over charging and deep discharging. As the Solar Charge Controller is programmable the Dusk to Dawn and time Control can be adjusted for automatic operation of the light. In addition to this the solar charge controller has a advantage for setting the light for peak hours and non peak hours. The solar charge controller has the required temperature sensor for preventing the battery from overheating due to load.

Electrical Parameters:

- Rated charge current: 10Amps
- Maximum Load current: 12 Amps
- Nominal Battery voltage: 12V
- Battery Floating Voltage: 13.6 V
- Battery Voltage Range: 10.5V - 14.5V
- Battery Low Voltage Cut-Off:10.8V(Re connect 12.5)
- Battery over Voltage Cut-off: 14.5V
- Maximum PV open circuit Voltage: 20V
- Maximum PV Panel Input: 150Wp
- Self Consumption (Loss of Empty Load): < 20Ma

General:

- Efficiency: > 90% at full load
- Humidity: 95% non-condensing
- Size (L X B X H): 110x76x40 mm
- Construction: Open Frame
- Terminations: Connectors
- Operating Temperature: 0 to 50 oC Storage
- Temperature: 0 to 70 oC

Protections:

Reverse current protection from battery to PV is available. Indications:

- Load Cut-off: Red
- Battery Fully Charged: Yellow
- Battery Charging: Green
- PV voltage: White

Cautions:

- No short circuit protections for output load, PV input & battery
- terminations are available.
- No PV input polarity & output overload protection.
- No in-built reverse polarity protection for load hence LED driver
- should have reverse polarity protection.
- Rated Battery & Rated PV Panel should be used.
- Battery Box

  Battery box is used to house the battery securely. Metallic powder coated & vented boxes are used.

  Features:

  - IP 65 grade metal box.
  - Weather proof powder coated.
  - Theft proof locking system.
  - Ventilated body.
  - Pole [5 m]
  - Galvanized Iron (GI) pole.
  - B-class.
  - 150mm diameter.
  - Primer with silver coating is done after fabrication.
  - Pole height 8 m.
  - Built in Battery mounting stand.
  - T

  -section and brackets for Solar panel mounting.

  Accessories:

  - 2 core cable from luminay to battery.

- 2 core cable from Panel to battery.
- 10sq mm wire for battery connections.
- Big U clamps for battery box mounting.
- Small U clamps for Solar panel mounting.
- Assorted nuts and bolts for panel fixing.
- Lugs for wires.

2. 9 Fire Alarm System: (Conventional System)

General

The Contractor shall supply and install the Fire Alarm system as shown on drawings and as herein specified. The system shall include fire alarm control panel, fire alarm sounders, double action manual fire alarm break glass units, chimes, charger and battery, heat detectors, smoke detectors, fire alarm annunciators, conduits, wiring and all necessary parts to install a complete fire alarm system. The installation shall be in accordance with BS 5839: Part 1:1980 with all relevant amendments and shall be approved by the local fire authorities.

Features

The system shall be a general alarm non-coded, supervised type.

Activation of a manual fire alarm station or any of the automatic alarm initiating device, shall sound the alarm on pre-signals chimes if any, relating to the zone in which his station is energized and shall give indication on the control panel and annunciators. The signal shall be continuous until the station from which it originates is restored to normal and a reset button on the control unit is operated.

The sounder circuit shall be electrically supervised against open circuits, high resistance faults, short circuits and shunt faults. Such faults shall cause a trouble bell to ring at the fire alarm control panel and a trouble lamp to lit. It shall be possible to silence the bell but the lamp shall remain lit until the fault is eliminated.

The system shall be capable of expansion without obsoleting any of the original equipment.

All equipment shall be accessible for maintenance and not interfere with maintenance of other nearby equipment.

Finishes shall be as herein specified or as selected by the Engineer.

In case of power failure the system shall automatically change over to the battery standby.

If a fire pump is included in the project, a zone shall be allocated in the fire alarm control panel to give a visual and audible alarm when the fire pump operates.

Control Panel

Control panel shall be constructed of sheet steel and shall fully comply with the European Standard EN54 Parts 2 & 4 and provided with windows for the alarm and trouble lights. All components shall be of the plug-in type, for simple replacement and extension in the future.

Control panel shall be provided with all necessary relays, resistors, fuses, transformers, rectifiers and all other components to assure full and proper functioning of the system.

Control panel shall include: power on lamps, system trouble lamp, audible trouble signal, trouble silence switch with ring back, alarm silence pushbutton with repeat alarm capability, low battery indicator with rest, ground detection indicator, alarm reset, supervised alarm lamps, zone disconnect switches, zone disconnected lamps, zone "Open" test pushbuttons, zone alarm test pushbuttons, end of line resistors pre-signal alarm chime, etc.

If the system is such that the removal of a trigger device (fire alarm initiating device) from the circuit could affect the operation of the trigger devices a fault signal shall be generated at the control panel.

The standard modules shall be modified as necessary to suit the number of detectors connected to them.

Indicator lamps shall be of the LED type for long working life.

Each zone shall be equipped with an auxiliary contact for control of a remote annunciator.

Control panel shall include a power supply module to provide a filtered and regulated source of power to provide additional power wherever supplementary power is required within the system. It shall include sealed batteries, a non-interchangeable output fuse, key reset automatic transfer to standby on power failure.

Control panel shall in addition have an audible signal and lamp to indicate AC failure of the charger.

All identifications shall be both in English and in local language.

Control panel shall be equipped to send fire messages to at least three telephone no. incase of fire via auto dialer thru telephone lines.

Smoke Detectors – Optical

Smoke detectors shall be of the photoelectric type and shall operate on the light scatter principle. Detectors shall be factory set to detect smoke at a normal 2 percent light obscuration per foot.

All smoke detectors shall be equipped with a dual photocell circuit to provide maximum stability against the effects of aging, dust, and film accumulation. Controlled porosity filters shall be incorporated in the smoke chamber to prevent false alarms from dust and insects.

For maximum maintenance free service and low power requirement, the light source for the detection chamber shall be a solid state light emitting diode.

Smoke detectors shall comply with BS 5446 Part 1.

Heat Detectors

Fixed temperature heat detectors shall be activated at a fixed pre-determined temperature and shall comprise a phosphor bronze spring, held under tension by standard sprinkler fusible solder, silver contacts, etc. They shall be rated at 58C operation except in high ambient temperature rooms such as boiler room, rooms if any, where they shall be rated at 93C operation.

Combined fixed temperature and Rate-of-rise detectors shall, in addition, be activated when increase in temperature has a rate higher than a predetermined value and shall comprise in addition to the elements mentioned above, an air chamber, a vent and a flexible metal diaphragms, a set of silver contacts, etc.

Heat detectors shall comply with BS 5445: Part-5 and those used for higher ambient temperature rooms shall comply with BS 5445: Part-8.

Manual Fire Alarm Stations (Call Points)

Unit shall be double action smash glass type with pull lever.

Stations shall have the operating characteristics specified under "Features".

Stations shall be constructed of tough, high impact, red lexan. Finish shall be high gloss and smooth. They shall not have painted finish that can be chipped and leave raw metal exposed. Station shall be bi-lingual English/Arabic silk screened white on glass.

The alarm switch shall be totally enclosed to seal it from contaminants and assure positive action.

No broken glass shall get into the switch to prevent immediate or subsequent action.

Stations shall be surface mounting type unless otherwise indicated.

Unit shall comply with BS 5839: Part-2.

Alarm Bells , sirens , and sounders

1-indoor bells shall be red. It shall produce a 75 db(A) as required by BS 5839.

2- outdoor sirens with flashing lamp shall be weatherproof red color, it shall have a sound output of 96 db(A) at 1m to fulfill the minimum requirement of 65db or 5db(A) above any other noise likely to persist for a period longer than 30 seconds as required by BS5839.

Sirens with Battery/Charger Console

Battery/Charger console shall be an integral part of the control panel ie. Both sealed lead acid batteries and automatic battery charger for DC power being housed within the FACP.

The charger shall be a two-rate constant potential unit maintaining the batteries fully charged under all service conditions. After an AC power failure longer than 10 seconds, a timer shall automatically switch the charger to its high-rate mode. Following the predetermined high-rate charge period, the timer shall automatically return the batteries to float charge. A remote initiation of the timed high rate charge mode shall be possible.

The front of the cabinet shall be provided with hinged doors.

The unit shall be ventilated through louvers.

Conduits

Conduits shall be used where MICC cables are not specified or when an MICC cable is entering into a building. Conduits shall be rigid steel type where used exposed and nonmetallic rigid PVC type where used embedded, or above false ceiling to the approval of Local Fire Authorities.

Cables

As determined on the fire riser diagram.

Batch Pad Footing Report

Symbols and Abbreviations

N : **Axial Load Of Combination**
$\sum N$: Total Axial Load
TW : Total Weight of Footing
h : Footing Depth
h_{taper} : Taper Height
Ecc_1 : Column Eccentricity in X Direction
Ecc_2 : Column Eccentricity in Y Direction
$\sum M_x$: Total Moment in X Direction
$\sum M_y$: Total Moment in Y Direction

V_{pd} : **Punching Demand**
V_{pc} : Punching Capacity
V_{pd-cf} : Punching Demand(On Column Face)
V_{pc-cf} : Punching Capacity(On Column Face)
V_{pd-ep} : Punching Demand(On Effective Perimeter)
V_{pc-ep} : Punching Capacity(On Effective Perimeter)
σ_{soil} : Soil Stress
u_p : Effective Perimeter
B_{EPx} : Width of effective perimeter in X direction
B_{EPy} : Width of effective perimeter in X direction
d_{sect} : Distance from column face to effective perimeter edge
d : Effective Depth

V_{dx-cf} : **Shear Force On Column Face, X-Direction**
V_{dy-cf} : Shear Force On Column Face, Y-Direction
V_{dx-d} : Shear Force On Location d Away From Column Face, X-Direction
V_{dy-d} : Shear Force On Location d Away From Column Face, Y-Direction
d_{v1} : Distance from Column Face to Footing Edge
d_{v2} : Distance from Location d Away From Column Face to Footing Edge
σ_{cf} : Soil stress on column face
σ_c : Soil stress at nearest corner
σ_{max} : Max. corner stress

F-1C2 Design Summary

Geometric Properties and Materials

Footing Materials

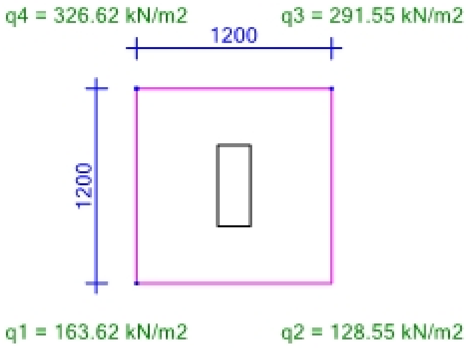
Concrete Material	C20/25
Rebar Material	Grade 460 (Type 2)

Geometric Properties

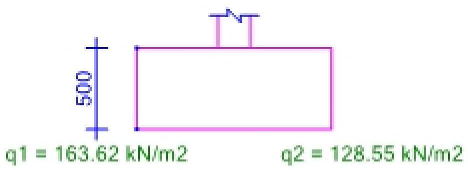
B_X	1200.00 mm
B_Y	1200.00 mm
Height	500.00 mm
Taper Height	0.00 mm

Corner Stresses

Lower-Left Corner	163.62 kN/m2
Lower-Right Corner	128.55 kN/m2
Upper-Right Corner	291.55 kN/m2
Upper-Left Corner	326.62 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	236.6 kN	3.6 kN	-3.3 kN	-5.8 kN.m	6.1 kN.m
Comb #2	340.9 kN	5.1 kN	-4.7 kN	-8.3 kN.m	8.7 kN.m
Comb #3	346.9 kN	5.3 kN	-4.7 kN	-8.6 kN.m	8.0 kN.m
Comb #4	190.1 kN	3.1 kN	-3.2 kN	-5.0 kN.m	6.5 kN.m
Comb #5	281.0 kN	2.6 kN	-4.8 kN	-2.5 kN.m	9.4 kN.m
Comb #6	286.7 kN	6.1 kN	-3.2 kN	-11.5 kN.m	5.4 kN.m
Comb #7	292.3 kN	4.4 kN	-11.2 kN	-7.3 kN.m	29.1 kN.m
Comb #8	275.5 kN	4.2 kN	3.3 kN	-6.7 kN.m	-14.3 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	0.72	24	17.28
Soil	:	1.008	18	18.144
Total	:			35.424

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	271.99	-4.02	4.48	187.28	159.37	190.49	218.39
Comb #2	376.36	-5.70	6.32	259.20	219.61	263.52	303.10
Comb #3	382.36	-5.95	5.63	266.64	225.31	264.41	305.74
Comb #4	225.53	-3.40	4.92	151.32	127.73	161.92	185.51
Comb #5	316.47	-1.22	6.98	199.79	191.29	239.75	248.25
Comb #6	322.14	-8.42	3.78	239.83	181.35	207.58	266.06
Comb #7	327.72	-5.05	23.47	163.62	128.55	291.55	326.62
Comb #8	310.88	-4.59	-12.72	276.00	244.09	155.78	187.69

Demand	Capacity	Status
Maximum Soil Stress: 326.62 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	-4.02	271.99	14.78 mm	200 mm	✓
	Y	4.48	271.99	16.47 mm	200 mm	✓
Comb #2	X	-5.7	376.36	15.15 mm	200 mm	✓
	Y	6.32	376.36	16.8 mm	200 mm	✓
Comb #3	X	-5.95	382.36	15.57 mm	200 mm	✓
	Y	5.63	382.36	14.73 mm	200 mm	✓
Comb #4	X	-3.4	225.53	15.06 mm	200 mm	✓
	Y	4.92	225.53	21.83 mm	200 mm	✓
Comb #5	X	-1.22	316.47	3.87 mm	200 mm	✓
	Y	6.98	316.47	22.05 mm	200 mm	✓
Comb #6	X	-8.42	322.14	26.14 mm	200 mm	✓
	Y	3.78	322.14	11.72 mm	200 mm	✓
Comb #7	X	-5.05	327.72	15.41 mm	200 mm	✓
	Y	23.47	327.72	71.62 mm	200 mm	✓
Comb #8	X	-4.59	310.88	14.78 mm	200 mm	✓
	Y	-12.72	310.88	40.91 mm	200 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.182$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})$^(1/3) + $k_1\ \sigma_{cp}$

k = 1 + (200/d)^(1/2)

k = 1.68,

$\rho_l = (\rho_{lx}\ \rho_{ly})$^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.0027, ρ_{ly} = 0.0027, ρ_f = 1,

ρ_l = 0.0027,

$\sigma_{cp} = \Sigma N / L_x L_y$ = 0.22 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.4 N/mm²

$v_{min} = 0.035\ k$^(3/2) f_{ck}^(1/2) + $k_1\ \sigma_{cp}$

v_{min} = 0.4 N/mm²

$v_{Rd,c} = Max(v_{Rd,c1}, v_{min})$ = 0.4 N/mm²

$v_{Rdmax} = 0.5\ (0.6\ (1 - (f_{ck} / 250)))\ f_{cd}$

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy})$ = 8344

$B_{EPx} = B_x + 2d_{sect}$ = 1936

$B_{EPy} = B_y + 2d_{sect}$ = 2236

$d_{sect} = 2d_{eff}$ = 868

$V_{pc\text{-}cf}$ = 2734 kN

$V_{pc\text{-}ep}$ = 1678 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	271.99	188.88	2734.20	299.22	0.11	1666.97	645.09	0.39
Comb #2	376.36	261.36	2734.20	414.04	0.15	1666.97	892.62	0.54
Comb #3	382.36	265.53	2734.20	420.64	0.15	1666.97	906.85	0.54
Comb #4	225.53	156.62	2734.20	248.11	0.09	1666.97	534.90	0.32
Comb #5	316.47	219.77	2734.20	348.15	0.13	1666.97	750.58	0.45
Comb #6	322.14	223.71	2734.20	354.39	0.13	1666.97	764.02	0.46
Comb #7	327.72	227.59	2734.20	360.53	0.13	1666.97	777.27	0.47
Comb #8	310.88	215.89	2734.20	342.01	0.13	1666.97	737.33	0.44

Comparison at	Demand / Capacity	Status
Effective Perimeter	906.8 kN / 1667.0 kN	√
Column Face	420.6 kN / 2734.2 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	127.15	322.50	√	90.02	322.50	√
Comb #2	176.37	322.50	√	124.88	322.50	√
Comb #3	178.56	322.50	√	125.88	322.50	√
Comb #4	107.03	322.50	√	76.47	322.50	√
Comb #5	142.89	322.50	√	103.74	322.50	√
Comb #6	156.36	322.50	√	108.16	322.50	√
Comb #7	175.60	322.50	√	135.03	322.50	√
Comb #8	154.56	322.50	√	113.97	322.50	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	71.91	322.50	√	35.64	322.50	√
Comb #2	99.77	322.50	√	49.46	322.50	√
Comb #3	100.84	322.50	√	49.88	322.50	√
Comb #4	60.78	322.50	√	30.28	322.50	√
Comb #5	81.23	322.50	√	40.73	322.50	√
Comb #6	88.06	322.50	√	43.19	322.50	√
Comb #7	103.01	322.50	√	53.37	322.50	√
Comb #8	88.97	322.50	√	45.08	322.50	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	178.6 kN / 322.5 kN	√
Column Face in Y-Direction	135.0 kN / 322.5 kN	√
Effective Perimeter in X-Direction	103.0 kN / 322.5 kN	√
Effective Perimeter in Y-Direction	53.4 kN / 322.5 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	321.11	702.00	158.53	702.00
Comb #2	445.51	702.00	219.95	702.00
Comb #3	450.47	702.00	221.77	702.00
Comb #4	271.14	702.00	134.66	702.00
Comb #5	362.28	702.00	181.85	702.00
Comb #6	393.62	702.00	191.37	702.00
Comb #7	455.97	702.00	237.56	702.00
Comb #8	395.60	702.00	200.58	702.00

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	23.8 kN.m	9ϕ16 / 150.0 mm	702.00 mm2/1608.50 mm2	√
Reinforcement Area in Y-Direction	45.6 kN.m	9ϕ16 / 150.0 mm	702.00 mm2/1608.50 mm2	√

F-1C3 Design Summary

Geometric Properties and Materials

Footing Materials

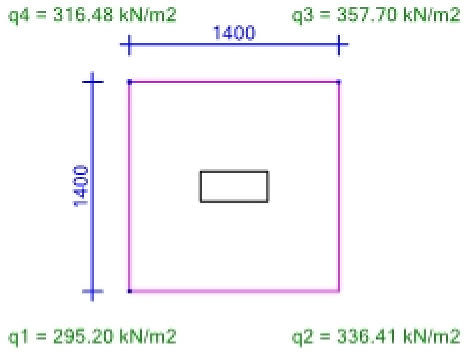
Concrete Material	C20/25
Rebar Material	Grade 460 (Type 2)

Geometric Properties

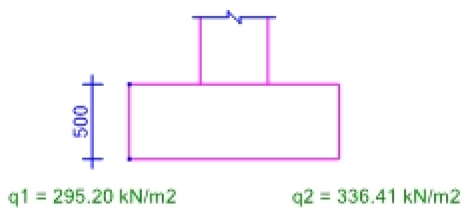
B_X	1400.00 mm
B_Y	1400.00 mm
Height	500.00 mm
Taper Height	0.00 mm

Corner Stresses

Lower-Left Corner	295.20 kN/m2
Lower-Right Corner	336.41 kN/m2
Upper-Right Corner	357.70 kN/m2
Upper-Left Corner	316.48 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	409.5 kN	-5.1 kN	-2.8 kN	9.2 kN.m	4.8 kN.m
Comb #2	591.6 kN	-7.2 kN	-4.0 kN	13.0 kN.m	6.9 kN.m
Comb #3	551.6 kN	-8.2 kN	-4.5 kN	14.2 kN.m	7.5 kN.m
Comb #4	365.7 kN	-3.6 kN	-2.0 kN	7.1 kN.m	3.6 kN.m
Comb #5	486.7 kN	-13.0 kN	-3.4 kN	29.7 kN.m	5.9 kN.m
Comb #6	496.2 kN	0.8 kN	-3.4 kN	-7.7 kN.m	5.7 kN.m
Comb #7	494.6 kN	-5.6 kN	-4.9 kN	9.7 kN.m	9.8 kN.m
Comb #8	488.3 kN	-6.6 kN	-1.9 kN	12.3 kN.m	1.8 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	0.98	24	23.52
Soil	:	1.372	18	24.696
Total	:			48.216

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	457.76	6.64	3.41	211.57	240.60	255.53	226.50
Comb #2	639.84	9.42	4.87	295.20	336.41	357.70	316.48
Comb #3	599.85	10.14	5.27	272.35	316.70	339.74	295.39
Comb #4	413.91	5.27	2.57	194.03	217.06	228.32	205.29
Comb #5	534.94	23.17	4.19	213.10	314.43	332.75	231.43
Comb #6	544.40	-7.24	4.00	284.83	253.18	270.68	302.34
Comb #7	542.85	6.89	7.36	245.81	275.95	308.12	277.98
Comb #8	536.50	9.04	0.84	252.12	291.66	295.32	255.78

Demand	Capacity	Status
Maximum Soil Stress: 357.70 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	6.64	457.76	14.5 mm	233.33 mm	✓
	Y	3.41	457.76	7.46 mm	233.33 mm	✓
Comb #2	X	9.42	639.84	14.73 mm	233.33 mm	✓
	Y	4.87	639.84	7.61 mm	233.33 mm	✓
Comb #3	X	10.14	599.85	16.91 mm	233.33 mm	✓
	Y	5.27	599.85	8.78 mm	233.33 mm	✓
Comb #4	X	5.27	413.91	12.72 mm	233.33 mm	✓
	Y	2.57	413.91	6.22 mm	233.33 mm	✓
Comb #5	X	23.17	534.94	43.31 mm	233.33 mm	✓
	Y	4.19	534.94	7.83 mm	233.33 mm	✓
Comb #6	X	-7.24	544.4	13.3 mm	233.33 mm	✓
	Y	4	544.4	7.35 mm	233.33 mm	✓
Comb #7	X	6.89	542.85	12.69 mm	233.33 mm	✓
	Y	7.36	542.85	13.55 mm	233.33 mm	✓
Comb #8	X	9.04	536.5	16.85 mm	233.33 mm	✓
	Y	0.84	536.5	1.56 mm	233.33 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.171$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})^{\wedge}(1/3) + k_1\ \sigma_{cp}$

k = 1 + (200/d)^(1/2)

k = 1.68,

$\rho_l = (\rho_{lx}\ \rho_{ly})^{\wedge}(1/2) * \rho_f$, $\rho_{lmin} = 0.02$

$\rho_{lx} = 0.0027$, $\rho_{ly} = 0.0027$, $\rho_f = 1$,

$\rho_l = 0.0027$,

$\sigma_{cp} = \Sigma N / L_xL_y = 0.27$ N/mm²

$C_{Rd,c} = 0.12$, $k_1 = 0.10$

$v_{Rd,c1} = 0.41$ N/mm²

$v_{min} = 0.035\ k^{\wedge}(3/2)\ f_{ck}^{\wedge}(1/2) + k_1\ \sigma_{cp}$

$v_{min} = 0.41$ N/mm²

$v_{Rd,c} = Max(v_{Rd,c1}, v_{min}) = 0.41$ N/mm²

$v_{Rdmax} = 0.5\ (0.6\ (1 - (f_{ck} / 250)))\ f_{cd}$

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy}) = 8244$

$B_{EPx} = B_x + 2d_{sect} = 2186$

$B_{EPy} = B_y + 2d_{sect} = 1936$

$d_{sect} = 2d_{eff} = 868$

$V_{pc\text{-}cf} = 2539$ kN

$V_{pc\text{-}ep} = 1682$ kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	457.76	233.55	2538.90	511.62	0.20	1665.41	621.63	0.37
Comb #2	639.84	326.45	2538.90	715.11	0.28	1665.41	868.87	0.52
Comb #3	599.85	306.04	2538.90	670.41	0.26	1665.41	814.57	0.49
Comb #4	413.91	211.18	2538.90	462.60	0.18	1665.41	562.07	0.34
Comb #5	534.94	272.93	2538.90	597.87	0.24	1665.41	726.43	0.44
Comb #6	544.40	277.76	2538.90	608.45	0.24	1665.41	739.28	0.44
Comb #7	542.85	276.96	2538.90	606.71	0.24	1665.41	737.17	0.44
Comb #8	536.50	273.72	2538.90	599.61	0.24	1665.41	728.54	0.44

Comparison at	Demand / Capacity	Status
Effective Perimeter	868.9 kN / 1665.4 kN	√
Column Face	715.1 kN / 2538.9 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	168.24	376.25	√	209.42	376.25	√
Comb #2	235.47	376.25	√	293.05	376.25	√
Comb #3	223.33	376.25	√	277.40	376.25	√
Comb #4	150.56	376.25	√	187.64	376.25	√
Comb #5	219.21	376.25	√	261.28	376.25	√
Comb #6	199.08	376.25	√	248.27	376.25	√
Comb #7	201.27	376.25	√	253.39	376.25	√
Comb #8	195.98	376.25	√	240.95	376.25	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	90.39	376.25	√	136.27	376.25	√
Comb #2	126.51	376.25	√	190.71	376.25	√
Comb #3	120.07	376.25	√	180.75	376.25	√
Comb #4	80.83	376.25	√	121.98	376.25	√
Comb #5	117.74	376.25	√	172.70	376.25	√
Comb #6	106.95	376.25	√	161.44	376.25	√
Comb #7	108.53	376.25	√	164.68	376.25	√
Comb #8	104.90	376.25	√	157.04	376.25	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	235.5 kN / 376.3 kN	√
Column Face in Y-Direction	293.0 kN / 376.3 kN	√
Effective Perimeter in X-Direction	126.5 kN / 376.3 kN	√
Effective Perimeter in Y-Direction	190.7 kN / 376.3 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	400.91	819.00	633.49	819.00
Comb #2	561.14	819.00	886.56	819.00
Comb #3	532.46	819.00	840.18	819.00
Comb #4	358.59	819.00	567.08	819.00
Comb #5	522.27	819.00	802.06	819.00
Comb #6	474.38	819.00	750.50	819.00
Comb #7	480.88	819.00	765.60	819.00
Comb #8	465.77	819.00	729.98	819.00

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	88.7 kN.m	10ϕ16 / 150.0 mm	819.00 mm2/1876.58 mm2	√
Reinforcement Area in Y-Direction	56.1 kN.m	10ϕ16 / 150.0 mm	819.00 mm2/1876.58 mm2	√

F-1C4 Design Summary

Geometric Properties and Materials

Footing Materials

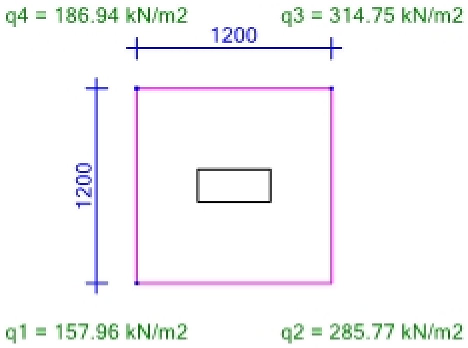
Concrete Material	C20/25
Rebar Material	Grade 460 (Type 2)

Geometric Properties

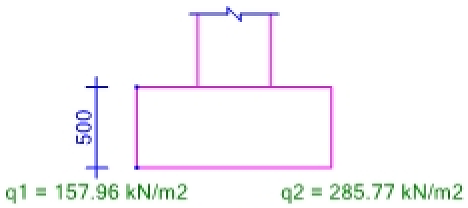
B_X	1200.00 mm
B_Y	1200.00 mm
Height	500.00 mm
Taper Height	0.00 mm

Corner Stresses

Lower-Left Corner	157.96 kN/m2
Lower-Right Corner	285.77 kN/m2
Upper-Right Corner	314.75 kN/m2
Upper-Left Corner	186.94 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	253.4 kN	-1.4 kN	-2.9 kN	3.1 kN.m	4.9 kN.m
Comb #2	363.5 kN	-2.0 kN	-4.1 kN	4.4 kN.m	7.0 kN.m
Comb #3	238.7 kN	0.1 kN	-1.8 kN	0.6 kN.m	3.1 kN.m
Comb #4	341.9 kN	-3.2 kN	-4.7 kN	6.4 kN.m	8.1 kN.m
Comb #5	304.9 kN	-8.9 kN	-3.5 kN	22.8 kN.m	5.9 kN.m
Comb #6	303.2 kN	5.6 kN	-3.5 kN	-15.5 kN.m	5.9 kN.m
Comb #7	306.8 kN	-1.1 kN	-5.0 kN	2.3 kN.m	10.0 kN.m
Comb #8	301.3 kN	-2.2 kN	-1.9 kN	5.1 kN.m	1.8 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	0.72	24	17.28
Soil	:	1.008	18	18.144
Total	:			35.424

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	288.79	2.39	3.48	180.18	196.76	220.92	204.34
Comb #2	398.88	3.41	4.97	247.90	271.59	306.10	282.41
Comb #3	274.11	0.65	2.21	180.44	184.93	200.26	195.77
Comb #4	377.30	4.80	5.75	225.39	258.74	298.64	265.29
Comb #5	340.35	18.40	4.17	157.96	285.77	314.75	186.94
Comb #6	338.58	-12.68	4.18	264.65	176.61	205.61	293.64
Comb #7	342.25	1.76	7.53	205.45	217.64	269.90	257.71
Comb #8	336.68	3.97	0.82	217.15	244.74	250.46	222.87

Demand	Capacity	Status
Maximum Soil Stress: 314.75 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	2.39	288.79	8.26 mm	200 mm	✓
	Y	3.48	288.79	12.05 mm	200 mm	✓
Comb #2	X	3.41	398.88	8.55 mm	200 mm	✓
	Y	4.97	398.88	12.46 mm	200 mm	✓
Comb #3	X	0.65	274.11	2.36 mm	200 mm	✓
	Y	2.21	274.11	8.06 mm	200 mm	✓
Comb #4	X	4.8	377.3	12.73 mm	200 mm	✓
	Y	5.75	377.3	15.23 mm	200 mm	✓
Comb #5	X	18.4	340.35	54.08 mm	200 mm	✓
	Y	4.17	340.35	12.26 mm	200 mm	✓
Comb #6	X	-12.68	338.58	37.44 mm	200 mm	✓
	Y	4.18	338.58	12.33 mm	200 mm	✓
Comb #7	X	1.76	342.25	5.13 mm	200 mm	✓
	Y	7.53	342.25	21.99 mm	200 mm	✓
Comb #8	X	3.97	336.68	11.8 mm	200 mm	✓
	Y	0.82	336.68	2.45 mm	200 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.171$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})$^(1/3) + $k_1\ \sigma_{cp}$

k = 1 + (200/d)^(1/2)

k = 1.68,

$\rho_l = (\rho_{lx}\ \rho_{ly})$^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.0027, ρ_{ly} = 0.0027, ρ_f = 1,

ρ_l = 0.0027,

$\sigma_{cp} = \Sigma N / L_x L_y$ = 0.23 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.4 N/mm²

v_{min} = 0.035 k^(3/2) f_{ck}^(1/2) + $k_1\ \sigma_{cp}$

v_{min} = 0.4 N/mm²

$v_{Rd,c} = Max(v_{Rd,c1}, v_{min})$ = 0.4 N/mm²

$v_{Rdmax} = 0.5\ (0.6\ (1 - (f_{ck} / 250)))\ f_{cd}$

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy})$ = 8244

$B_{EPx} = B_x + 2d_{sect}$ = 2186

$B_{EPy} = B_y + 2d_{sect}$ = 1936

$d_{sect} = 2d_{eff}$ = 868

$V_{pc\text{-}cf}$ = 2539 kN

$V_{pc\text{-}ep}$ = 1666 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	288.79	200.55	2538.90	317.16	0.12	1651.81	655.95	0.40
Comb #2	398.88	277.00	2538.90	438.06	0.17	1651.81	906.00	0.55
Comb #3	274.11	190.35	2538.90	301.03	0.12	1651.81	622.59	0.38
Comb #4	377.30	262.01	2538.90	414.36	0.16	1651.81	856.98	0.52
Comb #5	340.35	236.36	2538.90	373.78	0.15	1651.81	773.06	0.47
Comb #6	338.58	235.13	2538.90	371.84	0.15	1651.81	769.04	0.47
Comb #7	342.25	237.68	2538.90	375.87	0.15	1651.81	777.38	0.47
Comb #8	336.68	233.81	2538.90	369.75	0.15	1651.81	764.72	0.46

Comparison at	Demand / Capacity	Status
Effective Perimeter	906.0 kN / 1651.8 kN	√
Column Face	438.1 kN / 2538.9 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	97.71	322.50	√	130.48	322.50	√
Comb #2	135.32	322.50	√	180.70	322.50	√
Comb #3	89.04	322.50	√	119.60	322.50	√
Comb #4	131.58	322.50	√	175.01	322.50	√
Comb #5	139.60	322.50	√	172.88	322.50	√
Comb #6	130.10	322.50	√	165.18	322.50	√
Comb #7	117.78	322.50	√	160.42	322.50	√
Comb #8	112.30	322.50	√	146.83	322.50	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	40.54	322.50	√	75.40	322.50	√
Comb #2	56.16	322.50	√	104.45	322.50	√
Comb #3	36.83	322.50	√	68.79	322.50	√
Comb #4	54.72	322.50	√	101.48	322.50	√
Comb #5	57.82	322.50	√	103.14	322.50	√
Comb #6	53.92	322.50	√	97.50	322.50	√
Comb #7	49.26	322.50	√	92.45	322.50	√
Comb #8	46.22	322.50	√	85.12	322.50	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	139.6 kN / 322.5 kN	√
Column Face in Y-Direction	180.7 kN / 322.5 kN	√
Effective Perimeter in X-Direction	57.8 kN / 322.5 kN	√
Effective Perimeter in Y-Direction	104.4 kN / 322.5 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	184.28	702.00	327.92	702.00
Comb #2	255.24	702.00	454.21	702.00
Comb #3	167.62	702.00	299.46	702.00
Comb #4	248.47	702.00	441.01	702.00
Comb #5	263.03	702.00	445.50	702.00
Comb #6	245.21	702.00	422.12	702.00
Comb #7	223.14	702.00	402.32	702.00
Comb #8	210.82	702.00	369.94	702.00

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	45.4 kN.m	9ϕ16 / 150.0 mm	702.00 mm2/1608.50 mm2	√
Reinforcement Area in Y-Direction	26.3 kN.m	9ϕ16 / 150.0 mm	702.00 mm2/1608.50 mm2	√

F-1C5 Design Summary

Geometric Properties and Materials

Footing Materials

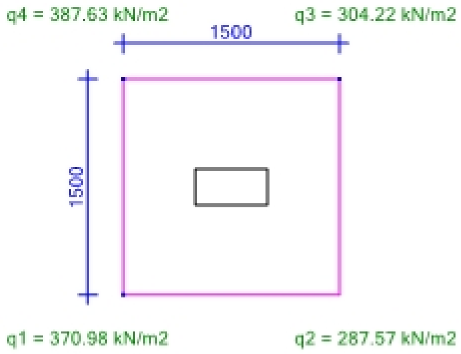
Concrete Material	C20/25
Rebar Material	Grade 460 (Type 2)

Geometric Properties

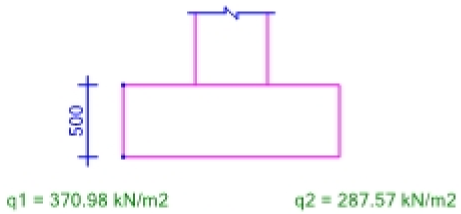
B_X	1500.00 mm
B_Y	1500.00 mm
Height	500.00 mm
Taper Height	0.00 mm

Corner Stresses

Lower-Left Corner	370.98 kN/m2
Lower-Right Corner	287.57 kN/m2
Upper-Right Corner	304.22 kN/m2
Upper-Left Corner	387.63 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	493.4 kN	15.1 kN	-2.7 kN	-24.1 kN.m	4.6 kN.m
Comb #2	704.3 kN	21.5 kN	-3.8 kN	-34.2 kN.m	6.6 kN.m
Comb #3	462.6 kN	12.2 kN	-1.6 kN	-19.4 kN.m	2.7 kN.m
Comb #4	675.0 kN	23.0 kN	-4.5 kN	-36.8 kN.m	7.8 kN.m
Comb #5	597.1 kN	11.4 kN	-3.2 kN	-10.5 kN.m	5.4 kN.m
Comb #6	587.1 kN	24.9 kN	-3.3 kN	-47.3 kN.m	5.7 kN.m
Comb #7	595.7 kN	18.7 kN	-4.9 kN	-30.4 kN.m	9.8 kN.m
Comb #8	588.4 kN	17.6 kN	-1.6 kN	-27.5 kN.m	1.3 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	1.125	24	27
Soil	:	1.575	18	28.35
Total	:			55.35

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	548.75	-16.55	3.27	267.49	208.65	220.28	279.12
Comb #2	759.60	-23.46	4.68	370.98	287.57	304.22	387.63
Comb #3	517.97	-13.26	1.90	250.41	203.27	210.01	257.15
Comb #4	730.31	-25.30	5.54	359.71	269.77	289.46	379.40
Comb #5	652.41	-4.84	3.81	291.79	274.57	288.13	305.34
Comb #6	642.44	-34.87	4.04	340.35	216.36	230.71	354.70
Comb #7	651.08	-21.01	7.39	313.59	238.88	265.15	339.86
Comb #8	643.77	-18.70	0.46	318.55	252.05	253.69	320.19

Demand	Capacity	Status
Maximum Soil Stress: 387.63 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	-16.55	548.75	30.16 mm	250 mm	√
	Y	3.27	548.75	5.96 mm	250 mm	√
Comb #2	X	-23.46	759.6	30.88 mm	250 mm	√
	Y	4.68	759.6	6.16 mm	250 mm	√
Comb #3	X	-13.26	517.97	25.59 mm	250 mm	√
	Y	1.9	517.97	3.66 mm	250 mm	√
Comb #4	X	-25.3	730.31	34.64 mm	250 mm	√
	Y	5.54	730.31	7.58 mm	250 mm	√
Comb #5	X	-4.84	652.41	7.42 mm	250 mm	√
	Y	3.81	652.41	5.84 mm	250 mm	√
Comb #6	X	-34.87	642.44	54.28 mm	250 mm	√
	Y	4.04	642.44	6.28 mm	250 mm	√
Comb #7	X	-21.01	651.08	32.27 mm	250 mm	√
	Y	7.39	651.08	11.35 mm	250 mm	√
Comb #8	X	-18.7	643.77	29.05 mm	250 mm	√
	Y	0.46	643.77	0.72 mm	250 mm	√

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.193$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})$^(1/3) + $k_1\ \sigma_{cp}$

k = 1 + (200/d)^(1/2)

k = 1.68,

$\rho_l = (\rho_{lx}\ \rho_{ly})$^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.0027, ρ_{ly} = 0.0027, ρ_f = 1,

ρ_l = 0.0027,

$\sigma_{cp} = \Sigma N / L_xL_y$ = 0.29 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.41 N/mm²

v_{min} = 0.035 k^(3/2) f_{ck}^(1/2) + $k_1\ \sigma_{cp}$

v_{min} = 0.41 N/mm²

$v_{Rd,c} = Max(v_{Rd,c1}, v_{min})$ = 0.41 N/mm²

$v_{Rdmax} = 0.5\ (0.6\ (1 - (f_{ck} / 250)))\ f_{cd}$

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy})$ = 8444

$B_{EPx} = B_x + 2d_{sect}$ = 2236

$B_{EPy} = B_y + 2d_{sect}$ = 1986

$d_{sect} = 2d_{eff}$ = 868

$V_{pc\text{-}cf}$ = 2930 kN

$V_{pc\text{-}ep}$ = 1728 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	548.75	243.89	2929.50	618.14	0.21	1710.18	637.25	0.37
Comb #2	759.60	337.60	2929.50	855.66	0.29	1710.18	882.12	0.52
Comb #3	517.97	230.21	2929.50	583.48	0.20	1710.18	601.52	0.35
Comb #4	730.31	324.58	2929.50	822.67	0.28	1710.18	848.10	0.50
Comb #5	652.41	289.96	2929.50	734.91	0.25	1710.18	757.63	0.44
Comb #6	642.44	285.53	2929.50	723.69	0.25	1710.18	746.06	0.44
Comb #7	651.08	289.37	2929.50	733.42	0.25	1710.18	756.09	0.44
Comb #8	643.77	286.12	2929.50	725.18	0.25	1710.18	747.60	0.44

Comparison at	Demand / Capacity	Status
Effective Perimeter	882.1 kN / 1710.2 kN	√
Column Face	855.7 kN / 2929.5 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	207.89	403.13	✓	250.18	403.13	✓
Comb #2	288.64	403.13	✓	347.11	403.13	✓
Comb #3	192.02	403.13	✓	231.87	403.13	✓
Comb #4	282.09	403.13	✓	338.12	403.13	✓
Comb #5	227.31	403.13	✓	282.90	403.13	✓
Comb #6	264.23	403.13	✓	308.32	403.13	✓
Comb #7	251.61	403.13	✓	304.03	403.13	✓
Comb #8	239.94	403.13	✓	287.19	403.13	✓

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	116.36	403.13	✓	167.50	403.13	✓
Comb #2	161.57	403.13	✓	232.48	403.13	✓
Comb #3	107.35	403.13	✓	154.92	403.13	✓
Comb #4	158.01	403.13	✓	226.84	403.13	✓
Comb #5	127.26	403.13	✓	187.24	403.13	✓
Comb #6	147.89	403.13	✓	208.68	403.13	✓
Comb #7	141.21	403.13	✓	203.69	403.13	✓
Comb #8	133.94	403.13	✓	192.23	403.13	✓

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	288.6 kN / 403.1 kN	√
Column Face in Y-Direction	347.1 kN / 403.1 kN	√
Effective Perimeter in X-Direction	161.6 kN / 403.1 kN	√
Effective Perimeter in Y-Direction	232.5 kN / 403.1 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	520.93	877.50	793.79	877.50
Comb #2	723.34	877.50	1101.69	877.50
Comb #3	480.75	877.50	734.18	877.50
Comb #4	707.27	877.50	1074.93	877.50
Comb #5	569.70	877.50	887.56	877.50
Comb #6	662.08	877.50	988.72	877.50
Comb #7	631.76	877.50	965.28	877.50
Comb #8	600.01	877.50	911.00	877.50

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	110.2 kN.m	11ϕ16 / 150.0 mm	877.50 mm2/2010.62 mm2	√
Reinforcement Area in Y-Direction	72.3 kN.m	11ϕ16 / 150.0 mm	877.50 mm2/2010.62 mm2	√

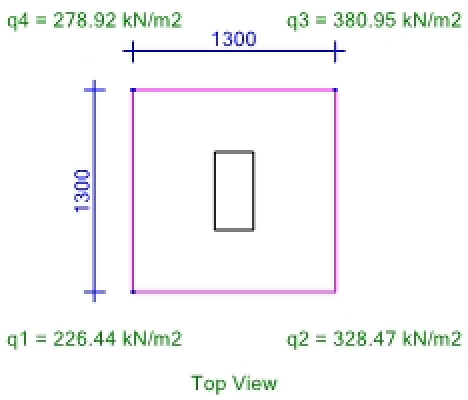
F-1C6 Design Summary

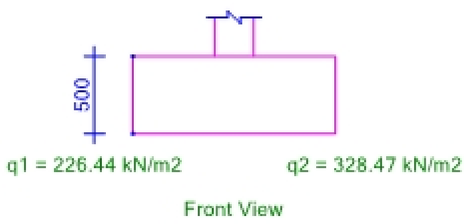
Geometric Properties and Materials

Footing Materials
Concrete Material C20/25
Rebar Material Grade 460 (Type 2)

Geometric Properties
B_X 1300.00 mm
B_Y 1300.00 mm
Height 500.00 mm
Taper Height 0.00 mm

Corner Stresses
Lower-Left Corner 226.44 kN/m2
Lower-Right Corner 328.47 kN/m2
Upper-Right Corner 380.95 kN/m2
Upper-Left Corner 278.92 kN/m2





Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	329.7 kN	-11.1 kN	-4.5 kN	18.7 kN.m	8.3 kN.m
Comb #2	469.3 kN	-15.8 kN	-6.4 kN	26.5 kN.m	11.8 kN.m
Comb #3	296.1 kN	-9.9 kN	-3.4 kN	16.7 kN.m	5.9 kN.m
Comb #4	471.7 kN	-15.9 kN	-7.1 kN	26.6 kN.m	13.1 kN.m
Comb #5	397.6 kN	-14.9 kN	-4.7 kN	26.3 kN.m	8.1 kN.m
Comb #6	393.7 kN	-11.8 kN	-6.1 kN	18.4 kN.m	11.8 kN.m
Comb #7	404.2 kN	-13.3 kN	-12.3 kN	22.2 kN.m	29.6 kN.m
Comb #8	387.1 kN	-13.4 kN	1.5 kN	22.6 kN.m	-9.8 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	0.845	24	20.28
Soil	:	1.183	18	21.294
Total	:			41.574

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	371.27	13.10	6.02	167.47	239.01	271.91	200.37
Comb #2	510.87	18.60	8.58	228.08	329.66	376.51	274.93
Comb #3	337.72	11.71	4.26	156.21	220.17	243.45	179.50
Comb #4	513.24	18.68	9.61	226.44	328.47	380.95	278.92
Comb #5	439.12	18.91	5.76	192.47	295.76	327.21	223.91
Comb #6	435.30	12.52	8.70	199.62	268.02	315.53	247.13
Comb #7	445.73	15.52	23.48	157.23	242.00	370.26	285.49
Comb #8	428.69	15.91	-9.03	234.85	321.78	272.47	185.55

Demand	Capacity	Status
Maximum Soil Stress: 380.95 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	13.1	371.27	35.28 mm	216.67 mm	✓
	Y	6.02	371.27	16.22 mm	216.67 mm	✓
Comb #2	X	18.6	510.87	36.4 mm	216.67 mm	✓
	Y	8.58	510.87	16.79 mm	216.67 mm	✓
Comb #3	X	11.71	337.72	34.67 mm	216.67 mm	✓
	Y	4.26	337.72	12.62 mm	216.67 mm	✓
Comb #4	X	18.68	513.24	36.4 mm	216.67 mm	✓
	Y	9.61	513.24	18.72 mm	216.67 mm	✓
Comb #5	X	18.91	439.12	43.07 mm	216.67 mm	✓
	Y	5.76	439.12	13.11 mm	216.67 mm	✓
Comb #6	X	12.52	435.3	28.77 mm	216.67 mm	✓
	Y	8.7	435.3	19.98 mm	216.67 mm	✓
Comb #7	X	15.52	445.73	34.82 mm	216.67 mm	✓
	Y	23.48	445.73	52.68 mm	216.67 mm	✓
Comb #8	X	15.91	428.69	37.12 mm	216.67 mm	✓
	Y	-9.03	428.69	21.06 mm	216.67 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.193$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})$^(1/3) + $k_1\ \sigma_{cp}$

k = 1 + (200/d)^(1/2)

k = 1.68,

$\rho_l = (\rho_{lx}\ \rho_{ly})$^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.0027, ρ_{ly} = 0.0027, ρ_f = 1,

ρ_l = 0.0027,

$\sigma_{cp} = \Sigma N / L_xL_y$ = 0.25 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.41 N/mm²

$v_{min} = 0.035\ k$^(3/2) f_{ck}^(1/2) + $k_1\ \sigma_{cp}$

v_{min} = 0.41 N/mm²

$v_{Rd,c} = Max(v_{Rd,c1}, v_{min})$ = 0.41 N/mm²

$v_{Rdmax} = 0.5\ (0.6\ (1 - (f_{ck} / 250)))\ f_{cd}$

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy})$ = 8444

$B_{EPx} = B_x + 2d_{sect}$ = 1986

$B_{EPy} = B_y + 2d_{sect}$ = 2236

$d_{sect} = 2d_{eff}$ = 868

$V_{pc\text{-}cf}$ = 2930 kN

$V_{pc\text{-}ep}$ = 1714 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	371.27	219.69	2929.50	410.07	0.14	1699.96	720.75	0.42
Comb #2	510.87	302.29	2929.50	564.26	0.19	1699.96	991.77	0.58
Comb #3	337.72	199.83	2929.50	373.01	0.13	1699.96	655.61	0.39
Comb #4	513.24	303.69	2929.50	566.88	0.19	1699.96	996.37	0.59
Comb #5	439.12	259.84	2929.50	485.01	0.17	1699.96	852.48	0.50
Comb #6	435.30	257.57	2929.50	480.79	0.16	1699.96	845.05	0.50
Comb #7	445.73	263.75	2929.50	492.31	0.17	1699.96	865.30	0.51
Comb #8	428.69	253.66	2929.50	473.49	0.16	1699.96	832.22	0.49

Comparison at	Demand / Capacity	Status
Effective Perimeter	996.4 kN / 1700.0 kN	√
Column Face	566.9 kN / 2929.5 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	181.04	349.38	✓	135.67	349.38	✓
Comb #2	250.51	349.38	✓	187.66	349.38	✓
Comb #3	162.95	349.38	✓	121.48	349.38	✓
Comb #4	252.77	349.38	✓	189.93	349.38	✓
Comb #5	218.98	349.38	✓	161.88	349.38	✓
Comb #6	208.80	349.38	✓	158.60	349.38	✓
Comb #7	235.03	349.38	✓	185.75	349.38	✓
Comb #8	212.82	349.38	✓	160.37	349.38	✓

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	105.94	349.38	✓	64.85	349.38	✓
Comb #2	146.63	349.38	✓	89.75	349.38	✓
Comb #3	95.14	349.38	✓	58.07	349.38	✓
Comb #4	148.13	349.38	✓	90.83	349.38	✓
Comb #5	127.86	349.38	✓	77.74	349.38	✓
Comb #6	122.50	349.38	✓	75.51	349.38	✓
Comb #7	140.40	349.38	✓	88.53	349.38	✓
Comb #8	124.89	349.38	✓	76.70	349.38	✓

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	252.8 kN / 349.4 kN	√
Column Face in Y-Direction	189.9 kN / 349.4 kN	√
Effective Perimeter in X-Direction	148.1 kN / 349.4 kN	√
Effective Perimeter in Y-Direction	90.8 kN / 349.4 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	479.20	760.50	275.15	760.50
Comb #2	663.24	760.50	380.73	760.50
Comb #3	430.55	760.50	246.37	760.50
Comb #4	669.84	760.50	385.31	760.50
Comb #5	578.63	760.50	329.28	760.50
Comb #6	553.83	760.50	320.85	760.50
Comb #7	632.41	760.50	376.03	760.50
Comb #8	564.59	760.50	325.38	760.50

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	38.5 kN.m	10ϕ16 / 150.0 mm	760.50 mm2/1742.54 mm2	√
Reinforcement Area in Y-Direction	67.0 kN.m	10ϕ16 / 150.0 mm	760.50 mm2/1742.54 mm2	√

F-1C27 Design Summary

Geometric Properties and Materials

Footing Materials

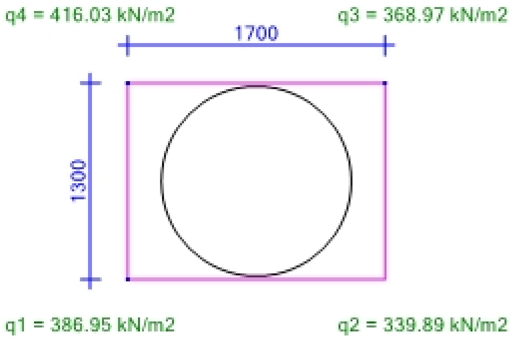
Concrete Material	C20/25
Rebar Material	Grade 460 (Type 2)

Geometric Properties

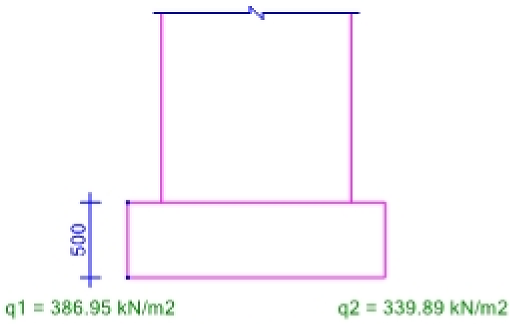
B_X	1700.00 mm
B_Y	1300.00 mm
Height	500.00 mm
Taper Height	0.00 mm

Corner Stresses

Lower-Left Corner	386.95 kN/m2
Lower-Right Corner	339.89 kN/m2
Upper-Right Corner	368.97 kN/m2
Upper-Left Corner	416.03 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	543.8 kN	7.9 kN	-4.5 kN	-11.8 kN.m	8.6 kN.m
Comb #2	780.9 kN	11.4 kN	-6.5 kN	-17.0 kN.m	12.3 kN.m
Comb #3	547.8 kN	6.9 kN	-1.5 kN	-10.2 kN.m	3.0 kN.m
Comb #4	699.5 kN	10.8 kN	-8.6 kN	-15.9 kN.m	16.3 kN.m
Comb #5	649.1 kN	-0.3 kN	-6.7 kN	12.7 kN.m	13.6 kN.m
Comb #6	656.0 kN	19.3 kN	-4.1 kN	-41.0 kN.m	7.0 kN.m
Comb #7	648.9 kN	9.9 kN	-17.3 kN	-15.0 kN.m	46.5 kN.m
Comb #8	656.2 kN	9.2 kN	6.4 kN	-13.2 kN.m	-25.9 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	1.105	24	26.52
Soil	:	1.547	18	27.846
Total	:			54.366

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_xL_y - 6 \Sigma M_x / (L_xL_y^2) - 6 \Sigma M_y / (L_x^2L_y)$

$\sigma_2 = \Sigma N / L_xL_y + 6 \Sigma M_x / (L_xL_y^2) - 6 \Sigma M_y / (L_x^2L_y)$

$\sigma_3 = \Sigma N / L_xL_y + 6 \Sigma M_x / (L_xL_y^2) + 6 \Sigma M_y / (L_x^2L_y)$

$\sigma_4 = \Sigma N / L_xL_y - 6 \Sigma M_x / (L_xL_y^2) + 6 \Sigma M_y / (L_x^2L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	598.16	-7.80	6.33	276.83	244.26	264.49	297.07
Comb #2	835.29	-11.27	9.10	386.95	339.89	368.97	416.03
Comb #3	602.14	-6.77	2.27	282.99	254.69	261.93	290.23
Comb #4	753.85	-10.55	11.99	343.99	299.92	338.22	382.30
Comb #5	703.44	12.60	10.31	275.51	328.14	361.09	308.45
Comb #6	710.40	-31.32	4.89	379.05	248.23	263.85	394.67
Comb #7	703.23	-10.10	37.83	278.87	236.70	357.54	399.71
Comb #8	710.61	-8.62	-22.63	375.69	339.68	267.39	303.41

Demand	Capacity	Status
Maximum Soil Stress: 416.03 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	-7.8	598.16	13.04 mm	283.33 mm	✓
	Y	6.33	598.16	10.59 mm	216.67 mm	✓
Comb #2	X	-11.27	835.29	13.49 mm	283.33 mm	✓
	Y	9.1	835.29	10.9 mm	216.67 mm	✓
Comb #3	X	-6.77	602.14	11.25 mm	283.33 mm	✓
	Y	2.27	602.14	3.76 mm	216.67 mm	✓
Comb #4	X	-10.55	753.85	14 mm	283.33 mm	✓
	Y	11.99	753.85	15.91 mm	216.67 mm	✓
Comb #5	X	12.6	703.44	17.91 mm	283.33 mm	✓
	Y	10.31	703.44	14.66 mm	216.67 mm	✓
Comb #6	X	-31.32	710.4	44.09 mm	283.33 mm	✓
	Y	4.89	710.4	6.88 mm	216.67 mm	✓
Comb #7	X	-10.1	703.23	14.36 mm	283.33 mm	✓
	Y	37.83	703.23	53.8 mm	216.67 mm	✓
Comb #8	X	-8.62	710.61	12.13 mm	283.33 mm	✓
	Y	-22.63	710.61	31.85 mm	216.67 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_xL_y - B_xB_y$

$\beta = 1.171$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})$^(1/3) + $k_1\ \sigma_{cp}$

k = 1 + (200/d)^(1/2)

k = 1.68,

$\rho_l = (\rho_{lx}\ \rho_{ly})$^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.0021, ρ_{ly} = 0.0035, ρ_f = 1,

ρ_l = 0.0027,

$\sigma_{cp} = \Sigma N / L_xL_y$ = 0.32 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.41 N/mm²

v_{min} = 0.035 k^(3/2) f_{ck}^(1/2) + $k_1\ \sigma_{cp}$

v_{min} = 0.41 N/mm²

$v_{Rd,c} = Max(v_{Rd,c1}, v_{min})$ = 0.41 N/mm²

v_{Rdmax} = 0.5 (0.6 (1 - (f_{ck} / 250))) f_{cd}

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy})$ = 8244

$B_{EPx} = B_x + 2d_{sect}$ = 1936

$B_{EPy} = B_y + 2d_{sect}$ = 2186

$d_{sect} = 2d_{eff}$ = 868

$V_{pc\text{-}cf}$ = 2539 kN

$V_{pc\text{-}ep}$ = 1702 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	598.16	270.66	3515.40	664.35	0.19	1782.64	850.03	0.48
Comb #2	835.29	377.96	3515.40	927.72	0.26	1782.64	1187.01	0.67
Comb #3	602.14	272.46	3515.40	668.77	0.19	1782.64	855.69	0.48
Comb #4	753.85	341.11	3515.40	837.26	0.24	1782.64	1071.28	0.60
Comb #5	703.44	318.30	3515.40	781.27	0.22	1782.64	999.64	0.56
Comb #6	710.40	321.45	3515.40	789.01	0.22	1782.64	1009.54	0.57
Comb #7	703.23	318.20	3515.40	781.05	0.22	1782.64	999.35	0.56
Comb #8	710.61	321.54	3515.40	789.24	0.22	1782.64	1009.83	0.57

Comparison at	Demand / Capacity	Status
Effective Perimeter	1187.0 kN / 1782.6 kN	√
Column Face	927.7 kN / 3515.4 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	85.58	456.88	√	210.78	349.38	√
Comb #2	119.83	456.88	√	295.02	349.38	√
Comb #3	83.84	456.88	√	206.35	349.38	√
Comb #4	109.90	456.88	√	271.00	349.38	√
Comb #5	103.86	456.88	√	254.67	349.38	√
Comb #6	113.91	456.88	√	269.70	349.38	√
Comb #7	113.37	456.88	√	283.81	349.38	√
Comb #8	107.34	456.88	√	267.18	349.38	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	0.61	456.88	√	106.11	349.38	√
Comb #2	0.86	456.88	√	148.55	349.38	√
Comb #3	0.60	456.88	√	103.77	349.38	√
Comb #4	0.79	456.88	√	136.48	349.38	√
Comb #5	0.74	456.88	√	128.59	349.38	√
Comb #6	0.81	456.88	√	138.39	349.38	√
Comb #7	0.82	456.88	√	142.82	349.38	√
Comb #8	0.77	456.88	√	134.34	349.38	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	119.8 kN / 456.9 kN	√
Column Face in Y-Direction	295.0 kN / 349.4 kN	√
Effective Perimeter in X-Direction	0.9 kN / 456.9 kN	√
Effective Perimeter in Y-Direction	148.6 kN / 349.4 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	95.38	760.50	450.64	994.50
Comb #2	133.57	760.50	630.86	994.50
Comb #3	93.36	760.50	440.86	994.50
Comb #4	122.57	760.50	579.57	994.50
Comb #5	115.82	760.50	545.58	994.50
Comb #6	126.88	760.50	584.05	994.50
Comb #7	127.02	760.50	606.63	994.50
Comb #8	119.97	760.50	570.78	994.50

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	63.1 kN.m	10ϕ16 / 150.0 mm	760.50 mm2/1742.54 mm2	√
Reinforcement Area in Y-Direction	13.4 kN.m	13ϕ16 / 150.0 mm	994.50 mm2/2278.70 mm2	√

F-1C8 Design Summary

Geometric Properties and Materials

Footing Materials

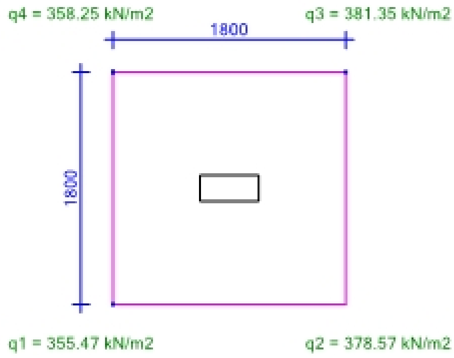
Concrete Material	C20/25
Rebar Material	Grade 460 (Type 2)

Geometric Properties

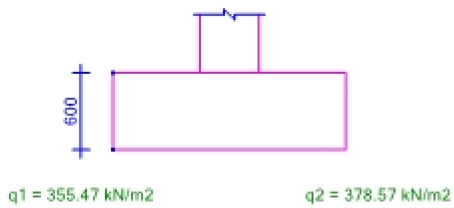
B_X	1800.00 mm
B_Y	1800.00 mm
Height	600.00 mm
Taper Height	0.00 mm

Corner Stresses

Lower-Left Corner	355.47 kN/m2
Lower-Right Corner	378.57 kN/m2
Upper-Right Corner	381.35 kN/m2
Upper-Left Corner	358.25 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	770.0 kN	-6.6 kN	-0.8 kN	11.8 kN.m	1.4 kN.m
Comb #2	1112.0 kN	-9.5 kN	-1.1 kN	16.9 kN.m	2.0 kN.m
Comb #3	821.1 kN	-4.1 kN	1.2 kN	7.5 kN.m	-1.9 kN.m
Comb #4	898.1 kN	-11.0 kN	-2.9 kN	19.3 kN.m	5.0 kN.m
Comb #5	919.5 kN	-14.6 kN	-1.0 kN	32.1 kN.m	1.8 kN.m
Comb #6	928.4 kN	-1.3 kN	-0.9 kN	-3.7 kN.m	1.5 kN.m
Comb #7	922.2 kN	-7.7 kN	-2.6 kN	13.5 kN.m	5.9 kN.m
Comb #8	925.7 kN	-8.2 kN	0.8 kN	14.8 kN.m	-2.6 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	1.944	24	46.656
Soil	:	1.944	18	34.992
Total	:			81.648

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_xL_y - 6 \Sigma M_x / (L_xL_y^2) - 6 \Sigma M_y / (L_x^2L_y)$

$\sigma_2 = \Sigma N / L_xL_y + 6 \Sigma M_x / (L_xL_y^2) - 6 \Sigma M_y / (L_x^2L_y)$

$\sigma_3 = \Sigma N / L_xL_y + 6 \Sigma M_x / (L_xL_y^2) + 6 \Sigma M_y / (L_x^2L_y)$

$\sigma_4 = \Sigma N / L_xL_y - 6 \Sigma M_x / (L_xL_y^2) + 6 \Sigma M_y / (L_x^2L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	851.62	7.84	0.93	253.82	269.95	271.87	255.74
Comb #2	1193.65	11.22	1.35	355.47	378.57	381.35	358.25
Comb #3	902.77	5.08	-1.20	274.64	285.09	282.63	272.17
Comb #4	979.76	12.74	3.25	285.95	312.16	318.84	292.63
Comb #5	1001.18	23.33	1.21	283.76	331.76	334.25	286.25
Comb #6	1010.05	-4.51	1.02	315.33	306.05	308.16	317.44
Comb #7	1003.89	8.92	4.37	296.17	314.53	323.52	305.16
Comb #8	1007.34	9.89	-2.13	302.92	323.28	318.89	298.53

Demand	Capacity	Status
Maximum Soil Stress: 381.35 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	7.84	851.62	9.21 mm	300 mm	✓
	Y	0.93	851.62	1.09 mm	300 mm	✓
Comb #2	X	11.22	1193.65	9.4 mm	300 mm	✓
	Y	1.35	1193.65	1.13 mm	300 mm	✓
Comb #3	X	5.08	902.77	5.63 mm	300 mm	✓
	Y	-1.2	902.77	1.33 mm	300 mm	✓
Comb #4	X	12.74	979.76	13 mm	300 mm	✓
	Y	3.25	979.76	3.31 mm	300 mm	✓
Comb #5	X	23.33	1001.18	23.3 mm	300 mm	✓
	Y	1.21	1001.18	1.21 mm	300 mm	✓
Comb #6	X	-4.51	1010.05	4.47 mm	300 mm	✓
	Y	1.02	1010.05	1.01 mm	300 mm	✓
Comb #7	X	8.92	1003.89	8.89 mm	300 mm	✓
	Y	4.37	1003.89	4.35 mm	300 mm	✓
Comb #8	X	9.89	1007.34	9.82 mm	300 mm	✓
	Y	-2.13	1007.34	2.12 mm	300 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_xL_y - B_xB_y$

$\beta = 1.147$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}$ k (100 ρ_l f_{ck})^(1/3) + k_1 σ_{cp}

k = 1 + (200/d)^(1/2)

k = 1.61,

ρ_l = (ρ_{lx} ρ_{ly})^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.0022, ρ_{ly} = 0.0022, ρ_f = 1,

ρ_l = 0.0022,

σ_{cp} = ΣN / $L_x L_y$ = 0.31 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.37 N/mm²

v_{min} = 0.035 k^(3/2) f_{ck}^(1/2) + k_1 σ_{cp}

v_{min} = 0.39 N/mm²

$v_{Rd,c}$ = Max($v_{Rd,c1}$, v_{min}) = 0.39 N/mm²

v_{Rdmax} = 0.5 (0.6 (1 - (f_{ck} / 250))) f_{cd}

$V_{pc\text{-}cf}$ = v_{Rdmax} u_p d,

$V_{pc\text{-}ep}$ = $v_{Rd,c}$ u_p d,

u_p = 2(B_{EPx} + B_{EPy}) = 9844

B_{EPx} = B_x + 2d_{sect} = 2586

B_{EPy} = B_y + 2d_{sect} = 2336

d_{sect} = 2d_{eff} = 1068

$V_{pc\text{-}cf}$ = 3124 kN

$V_{pc\text{-}ep}$ = 2299 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	851.62	262.85	3123.90	949.73	0.30	2270.71	844.47	0.37
Comb #2	1193.65	368.41	3123.90	1331.15	0.43	2270.71	1183.62	0.52
Comb #3	902.77	278.63	3123.90	1006.77	0.32	2270.71	895.20	0.39
Comb #4	979.76	302.39	3123.90	1092.62	0.35	2270.71	971.53	0.43
Comb #5	1001.18	309.01	3123.90	1116.51	0.36	2270.71	992.77	0.44
Comb #6	1010.05	311.74	3123.90	1126.41	0.36	2270.71	1001.57	0.44
Comb #7	1003.89	309.84	3123.90	1119.54	0.36	2270.71	995.47	0.44
Comb #8	1007.34	310.91	3123.90	1123.39	0.36	2270.71	998.88	0.44

Comparison at	Demand / Capacity	Status
Effective Perimeter	1183.6 kN / 2270.7 kN	√
Column Face	1331.2 kN / 3123.9 kN	√

Shear Check

$V_{dx\text{-}cf}$ = σ_{cf} d_{vx1} L_y + ((σ_{max} - σ_{cf}) d_{vx1} L_y / 2)

$V_{dy\text{-}cf}$ = σ_{cf} d_{vy1} L_x + ((σ_{max} - σ_{cf}) d_{vy1} L_x / 2)

$V_{dx\text{-}d}$ = σ_{cf} d_{vx2} L_y + ((σ_{max} - σ_{cf}) d_{vx2} L_y / 2)

$V_{dy\text{-}d}$ = σ_{cf} d_{vy2} L_x + ((σ_{max} - σ_{cf}) d_{vy2} L_x / 2)

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	329.89	565.15	√	386.33	565.15	√
Comb #2	462.70	565.15	√	541.75	565.15	√
Comb #3	345.83	565.15	√	407.19	565.15	√
Comb #4	385.87	565.15	√	450.74	565.15	√
Comb #5	405.55	565.15	√	465.96	565.15	√
Comb #6	385.21	565.15	√	454.14	565.15	√
Comb #7	391.03	565.15	√	459.99	565.15	√
Comb #8	391.79	565.15	√	459.01	565.15	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	197.55	565.15	√	260.46	565.15	√
Comb #2	277.09	565.15	√	365.28	565.15	√
Comb #3	207.12	565.15	√	274.06	565.15	√
Comb #4	231.32	565.15	√	304.41	565.15	√
Comb #5	242.86	565.15	√	316.17	565.15	√
Comb #6	230.67	565.15	√	305.50	565.15	√
Comb #7	234.53	565.15	√	310.06	565.15	√
Comb #8	234.73	565.15	√	309.55	565.15	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	462.7 kN / 565.1 kN	√
Column Face in Y-Direction	541.7 kN / 565.1 kN	√
Effective Perimeter in X-Direction	277.1 kN / 565.1 kN	√
Effective Perimeter in Y-Direction	365.3 kN / 565.1 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	1113.85	1287.00	1552.20	1287.00
Comb #2	1562.33	1287.00	2176.84	1287.00
Comb #3	1167.80	1287.00	1633.22	1287.00
Comb #4	1304.02	1287.00	1814.16	1287.00
Comb #5	1369.36	1287.00	1884.32	1287.00
Comb #6	1300.61	1287.00	1820.52	1287.00
Comb #7	1322.01	1287.00	1847.79	1287.00
Comb #8	1323.40	1287.00	1844.73	1287.00

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	217.7 kN.m	13ϕ16 / 150.0 mm	1287.00 mm2/2412.74 mm2	√
Reinforcement Area in Y-Direction	156.2 kN.m	13ϕ16 / 150.0 mm	1287.00 mm2/2412.74 mm2	√

F-1C9 Design Summary

Geometric Properties and Materials

Footing Materials

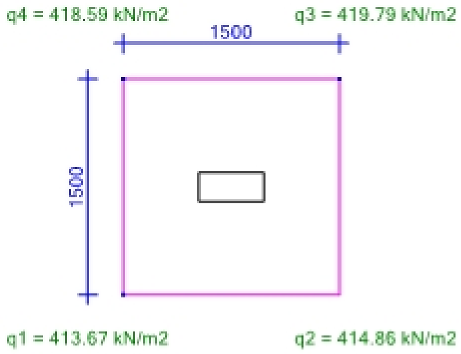
Concrete Material	C20/25
Rebar Material	Grade 460 (Type 2)

Geometric Properties

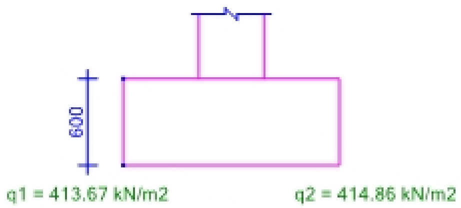
B_X	1500.00 mm
B_Y	1500.00 mm
Height	600.00 mm
Taper Height	0.00 mm

Corner Stresses

Lower-Left Corner	413.67 kN/m2
Lower-Right Corner	414.86 kN/m2
Upper-Right Corner	419.79 kN/m2
Upper-Left Corner	418.59 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	612.6 kN	0.6 kN	-0.8 kN	-0.2 kN.m	1.4 kN.m
Comb #2	880.9 kN	0.9 kN	-1.1 kN	-0.2 kN.m	2.1 kN.m
Comb #3	705.9 kN	-1.1 kN	-2.7 kN	2.5 kN.m	4.5 kN.m
Comb #4	678.8 kN	2.6 kN	0.9 kN	-3.0 kN.m	-1.3 kN.m
Comb #5	736.6 kN	-6.1 kN	-0.9 kN	18.1 kN.m	1.7 kN.m
Comb #6	733.7 kN	7.7 kN	-0.9 kN	-18.5 kN.m	1.7 kN.m
Comb #7	733.6 kN	1.0 kN	-2.7 kN	-0.8 kN.m	6.1 kN.m
Comb #8	736.8 kN	0.5 kN	0.8 kN	0.4 kN.m	-2.7 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	1.35	24	32.4
Soil	:	1.35	18	24.3
Total	:			56.7

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	669.33	0.23	0.96	295.37	296.18	299.59	298.79
Comb #2	937.64	0.34	1.39	413.67	414.86	419.79	418.59
Comb #3	762.63	1.90	2.91	330.41	337.15	347.49	340.75
Comb #4	735.51	-1.43	-0.77	330.81	325.71	322.98	328.07
Comb #5	793.27	14.46	1.15	324.81	376.23	380.32	328.90
Comb #6	790.45	-13.92	1.15	374.00	324.51	328.62	378.10
Comb #7	790.25	-0.21	4.50	343.60	342.84	358.85	359.60
Comb #8	793.47	0.76	-2.20	355.21	357.90	350.09	347.40

Demand	Capacity	Status
Maximum Soil Stress: 419.79 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	0.23	669.33	0.34 mm	250 mm	✓
	Y	0.96	669.33	1.43 mm	250 mm	✓
Comb #2	X	0.34	937.64	0.36 mm	250 mm	✓
	Y	1.39	937.64	1.48 mm	250 mm	✓
Comb #3	X	1.9	762.63	2.49 mm	250 mm	✓
	Y	2.91	762.63	3.81 mm	250 mm	✓
Comb #4	X	-1.43	735.51	1.95 mm	250 mm	✓
	Y	-0.77	735.51	1.05 mm	250 mm	✓
Comb #5	X	14.46	793.27	18.23 mm	250 mm	✓
	Y	1.15	793.27	1.45 mm	250 mm	✓
Comb #6	X	-13.92	790.45	17.61 mm	250 mm	✓
	Y	1.15	790.45	1.46 mm	250 mm	✓
Comb #7	X	-0.21	790.25	0.27 mm	250 mm	✓
	Y	4.5	790.25	5.7 mm	250 mm	✓
Comb #8	X	0.76	793.47	0.95 mm	250 mm	✓
	Y	-2.2	793.47	2.77 mm	250 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.147$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})$^(1/3) + $k_1\ \sigma_{cp}$

k = 1 + (200/d)^(1/2)

k = 1.61,

$\rho_l = (\rho_{lx}\ \rho_{ly})$^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.0022, ρ_{ly} = 0.0022, ρ_f = 1,

ρ_l = 0.0022,

$\sigma_{cp} = \Sigma N / L_x L_y$ = 0.35 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.38 N/mm²

v_{min} = 0.035 k^(3/2) f_{ck}^(1/2) + $k_1\ \sigma_{cp}$

v_{min} = 0.39 N/mm²

$v_{Rd,c}$ = Max($v_{Rd,c1}$, v_{min}) = 0.39 N/mm²

v_{Rdmax} = 0.5 (0.6 (1 - (f_{ck} / 250))) f_{cd}

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy})$ = 9844

$B_{EPx} = B_x + 2d_{sect}$ = 2586

$B_{EPy} = B_y + 2d_{sect}$ = 2336

$d_{sect} = 2d_{eff}$ = 1068

$V_{pc\text{-}cf}$ = 3124 kN

$V_{pc\text{-}ep}$ = 2324 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	669.33	297.48	3123.90	737.06	0.24	2291.16	1293.57	0.56
Comb #2	937.64	416.73	3123.90	1032.51	0.33	2291.16	1812.10	0.79
Comb #3	762.63	338.95	3123.90	839.80	0.27	2291.16	1473.88	0.64
Comb #4	735.51	326.89	3123.90	809.93	0.26	2291.16	1421.46	0.62
Comb #5	793.27	352.57	3123.90	873.54	0.28	2291.16	1533.10	0.67
Comb #6	790.45	351.31	3123.90	870.42	0.28	2291.16	1527.63	0.67
Comb #7	790.25	351.22	3123.90	870.21	0.28	2291.16	1527.26	0.67
Comb #8	793.47	352.65	3123.90	873.75	0.28	2291.16	1533.47	0.67

Comparison at	Demand / Capacity	Status
Effective Perimeter	1812.1 kN / 2291.2 kN	√
Column Face	1032.5 kN / 3123.9 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	235.46	470.95	√	291.93	470.95	√
Comb #2	329.90	470.95	√	409.04	470.95	√
Comb #3	272.22	470.95	√	337.38	470.95	√
Comb #4	260.13	470.95	√	321.46	470.95	√
Comb #5	298.94	470.95	√	359.95	470.95	√
Comb #6	297.19	470.95	√	358.20	470.95	√
Comb #7	280.98	470.95	√	350.45	470.95	√
Comb #8	280.77	470.95	√	348.38	470.95	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	114.03	470.95	√	173.85	470.95	√
Comb #2	159.78	470.95	√	243.60	470.95	√
Comb #3	132.06	470.95	√	201.21	470.95	√
Comb #4	125.95	470.95	√	191.65	470.95	√
Comb #5	144.77	470.95	√	216.92	470.95	√
Comb #6	143.93	470.95	√	215.78	470.95	√
Comb #7	136.49	470.95	√	208.69	470.95	√
Comb #8	136.11	470.95	√	207.56	470.95	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	329.9 kN / 471.0 kN	√
Column Face in Y-Direction	409.0 kN / 471.0 kN	√
Effective Perimeter in X-Direction	159.8 kN / 471.0 kN	√
Effective Perimeter in Y-Direction	243.6 kN / 471.0 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	618.49	1072.50	948.96	1072.50
Comb #2	866.59	1072.50	1329.66	1072.50
Comb #3	715.83	1072.50	1098.02	1072.50
Comb #4	683.18	1072.50	1045.91	1072.50
Comb #5	785.20	1072.50	1181.60	1072.50
Comb #6	780.62	1072.50	1175.47	1072.50
Comb #7	739.51	1072.50	1139.15	1072.50
Comb #8	737.96	1072.50	1132.87	1072.50

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	133.0 kN.m	11ϕ16 / 150.0 mm	1072.50 mm2/2010.62 mm2	√
Reinforcement Area in Y-Direction	86.7 kN.m	11ϕ16 / 150.0 mm	1072.50 mm2/2010.62 mm2	√

F-1C10 Design Summary

Geometric Properties and Materials

Footing Materials

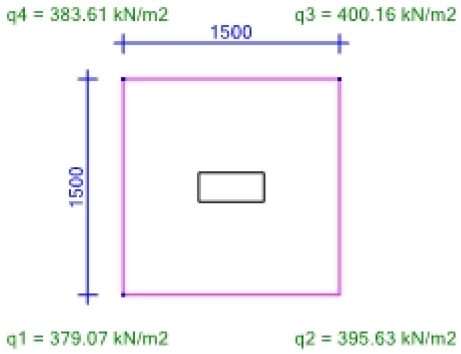
Concrete Material	C20/25
Rebar Material	Grade 460 (Type 2)

Geometric Properties

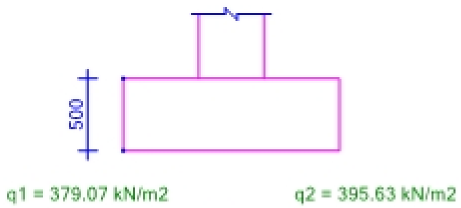
B_X	1500.00 mm
B_Y	1500.00 mm
Height	500.00 mm
Taper Height	0.00 mm

Corner Stresses

Lower-Left Corner	379.07 kN/m2
Lower-Right Corner	395.63 kN/m2
Upper-Right Corner	400.16 kN/m2
Upper-Left Corner	383.61 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	572.5 kN	-2.0 kN	-0.6 kN	4.3 kN.m	1.2 kN.m
Comb #2	821.3 kN	-2.9 kN	-0.9 kN	6.1 kN.m	1.7 kN.m
Comb #3	656.2 kN	-0.4 kN	-2.5 kN	1.5 kN.m	4.3 kN.m
Comb #4	645.7 kN	-4.2 kN	1.1 kN	8.3 kN.m	-1.6 kN.m
Comb #5	684.6 kN	-9.4 kN	-0.7 kN	23.5 kN.m	1.3 kN.m
Comb #6	689.2 kN	4.4 kN	-0.8 kN	-13.2 kN.m	1.6 kN.m
Comb #7	684.9 kN	-2.2 kN	-2.5 kN	4.5 kN.m	5.9 kN.m
Comb #8	689.0 kN	-2.7 kN	1.0 kN	5.8 kN.m	-3.0 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	1.125	24	27
Soil	:	1.575	18	28.35
Total	:			55.35

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	627.80	3.25	0.89	271.67	283.23	286.38	274.81
Comb #2	876.64	4.66	1.27	379.07	395.63	400.16	383.61
Comb #3	711.54	1.27	3.03	308.60	313.10	323.88	319.38
Comb #4	701.02	6.13	-1.05	302.53	324.33	320.59	298.80
Comb #5	740.00	18.80	0.95	293.76	360.63	364.01	297.15
Comb #6	744.58	-11.00	1.17	348.39	309.29	313.46	352.56
Comb #7	740.27	3.39	4.66	314.70	326.74	343.31	331.27
Comb #8	744.31	4.42	-2.54	327.46	343.17	334.16	318.44

Demand	Capacity	Status
Maximum Soil Stress: 400.16 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	3.25	627.8	5.18 mm	250 mm	✓
	Y	0.89	627.8	1.41 mm	250 mm	✓
Comb #2	X	4.66	876.64	5.31 mm	250 mm	✓
	Y	1.27	876.64	1.45 mm	250 mm	✓
Comb #3	X	1.27	711.54	1.78 mm	250 mm	✓
	Y	3.03	711.54	4.26 mm	250 mm	✓
Comb #4	X	6.13	701.02	8.74 mm	250 mm	✓
	Y	-1.05	701.02	1.5 mm	250 mm	✓
Comb #5	X	18.8	740	25.41 mm	250 mm	✓
	Y	0.95	740	1.29 mm	250 mm	✓
Comb #6	X	-11	744.58	14.77 mm	250 mm	✓
	Y	1.17	744.58	1.57 mm	250 mm	✓
Comb #7	X	3.39	740.27	4.57 mm	250 mm	✓
	Y	4.66	740.27	6.3 mm	250 mm	✓
Comb #8	X	4.42	744.31	5.94 mm	250 mm	✓
	Y	-2.54	744.31	3.41 mm	250 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.171$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})^{(1/3)} + k_1\ \sigma_{cp}$

$k = 1 + (200/d)^{(1/2)}$

$k = 1.68,$

$\rho_l = (\rho_{lx}\ \rho_{ly})^{(1/2)} * \rho_f\ ,\ \rho_{lmin} = 0.02$

$\rho_{lx} = 0.0027,\ \rho_{ly} = 0.0027,\ \rho_f = 1,$

$\rho_l = 0.0027,$

$\sigma_{cp} = \Sigma N / L_x L_y = 0.33$ N/mm²

$C_{Rd,c} = 0.12,\ k_1 = 0.10$

$v_{Rd,c1} = 0.41$ N/mm²

$v_{min} = 0.035\ k^{(3/2)}\ f_{ck}^{(1/2)} + k_1\ \sigma_{cp}$

$v_{min} = 0.41$ N/mm²

$v_{Rd,c} = Max(v_{Rd,c1},\ v_{min}) = 0.41$ N/mm²

$v_{Rdmax} = 0.5\ (0.6\ (1 - (f_{ck} / 250)))\ f_{cd}$

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d,$

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d,$

$u_p = 2(B_{EPx} + B_{EPy}) = 8244$

$B_{EPx} = B_x + 2d_{sect} = 2186$

$B_{EPy} = B_y + 2d_{sect} = 1936$

$d_{sect} = 2d_{eff} = 868$

$V_{pc\text{-}cf} = 2539$ kN

$V_{pc\text{-}ep} = 1705$ kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	627.80	279.02	2538.90	706.01	0.28	1684.15	647.86	0.38
Comb #2	876.64	389.62	2538.90	985.85	0.39	1684.15	904.65	0.54
Comb #3	711.54	316.24	2538.90	800.18	0.32	1684.15	734.27	0.44
Comb #4	701.02	311.56	2538.90	788.35	0.31	1684.15	723.42	0.43
Comb #5	740.00	328.89	2538.90	832.18	0.33	1684.15	763.64	0.45
Comb #6	744.58	330.93	2538.90	837.34	0.33	1684.15	768.37	0.46
Comb #7	740.27	329.01	2538.90	832.49	0.33	1684.15	763.92	0.45
Comb #8	744.31	330.81	2538.90	837.04	0.33	1684.15	768.10	0.46

Comparison at	Demand / Capacity	Status
Effective Perimeter	904.7 kN / 1684.2 kN	√
Column Face	985.9 kN / 2538.9 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	225.09	403.13	√	276.78	403.13	√
Comb #2	314.51	403.13	√	386.66	403.13	√
Comb #3	253.57	403.13	√	314.83	403.13	√
Comb #4	254.89	403.13	√	311.62	403.13	√
Comb #5	286.19	403.13	√	340.79	403.13	√
Comb #6	277.07	403.13	√	335.49	403.13	√
Comb #7	268.07	403.13	√	332.19	403.13	√
Comb #8	269.01	403.13	√	331.27	403.13	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	130.44	403.13	√	186.62	403.13	√
Comb #2	182.27	403.13	√	260.73	403.13	√
Comb #3	147.19	403.13	√	211.87	403.13	√
Comb #4	147.72	403.13	√	210.52	403.13	√
Comb #5	165.83	403.13	√	232.23	403.13	√
Comb #6	160.58	403.13	√	227.37	403.13	√
Comb #7	155.78	403.13	√	223.89	403.13	√
Comb #8	156.07	403.13	√	223.45	403.13	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	314.5 kN / 403.1 kN	√
Column Face in Y-Direction	386.7 kN / 403.1 kN	√
Effective Perimeter in X-Direction	182.3 kN / 403.1 kN	√
Effective Perimeter in Y-Direction	260.7 kN / 403.1 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	591.24	877.50	902.17	877.50
Comb #2	826.12	877.50	1260.44	877.50
Comb #3	666.92	877.50	1024.24	877.50
Comb #4	669.55	877.50	1017.74	877.50
Comb #5	751.67	877.50	1122.86	877.50
Comb #6	727.81	877.50	1099.28	877.50
Comb #7	705.70	877.50	1082.36	877.50
Comb #8	707.23	877.50	1080.24	877.50

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	126.0 kN.m	11ϕ16 / 150.0 mm	877.50 mm2/2010.62 mm2	√
Reinforcement Area in Y-Direction	82.6 kN.m	11ϕ16 / 150.0 mm	877.50 mm2/2010.62 mm2	√

F-1C11 Design Summary

Geometric Properties and Materials

Footing Materials

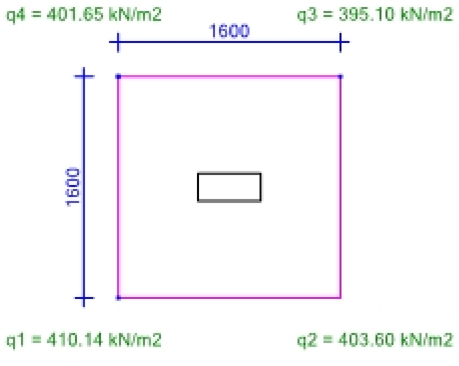
Concrete Material	C20/25
Rebar Material	Grade 460 (Type 2)

Geometric Properties

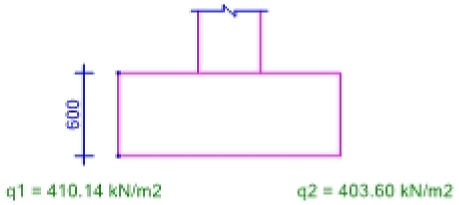
B_X	1600.00 mm
B_Y	1600.00 mm
Height	600.00 mm
Taper Height	0.00 mm

Corner Stresses

Lower-Left Corner	410.14 kN/m2
Lower-Right Corner	403.60 kN/m2
Upper-Right Corner	395.10 kN/m2
Upper-Left Corner	401.65 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	673.9 kN	2.4 kN	2.1 kN	-3.0 kN.m	-3.3 kN.m
Comb #2	966.2 kN	3.4 kN	2.9 kN	-4.3 kN.m	-4.7 kN.m
Comb #3	746.2 kN	0.6 kN	-0.3 kN	-0.3 kN.m	0.5 kN.m
Comb #4	787.7 kN	4.7 kN	5.1 kN	-6.5 kN.m	-8.3 kN.m
Comb #5	813.4 kN	-3.9 kN	2.6 kN	14.5 kN.m	-4.2 kN.m
Comb #6	803.9 kN	9.6 kN	2.4 kN	-21.7 kN.m	-3.7 kN.m
Comb #7	809.0 kN	3.1 kN	0.8 kN	-4.2 kN.m	0.5 kN.m
Comb #8	808.4 kN	2.6 kN	4.2 kN	-2.9 kN.m	-8.4 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	1.536	24	36.864
Soil	:	1.536	18	27.648
Total	:			64.512

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	738.42	-1.56	-2.05	293.74	289.16	283.15	287.73
Comb #2	1030.71	-2.23	-2.90	410.14	403.60	395.10	401.65
Comb #3	810.72	0.13	0.36	315.96	316.34	317.41	317.03
Comb #4	852.20	-3.70	-5.18	345.91	335.06	319.87	330.72
Comb #5	877.94	12.17	-2.67	329.03	364.68	356.86	321.21
Comb #6	868.46	-15.92	-2.26	365.87	319.22	312.61	359.26
Comb #7	873.51	-2.36	0.96	343.27	336.35	339.16	346.08
Comb #8	872.89	-1.39	-5.88	351.63	347.55	330.31	334.39

Demand	Capacity	Status
Maximum Soil Stress: 410.14 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	-1.56	738.42	2.12 mm	266.67 mm	✓
	Y	-2.05	738.42	2.78 mm	266.67 mm	✓
Comb #2	X	-2.23	1030.71	2.17 mm	266.67 mm	✓
	Y	-2.9	1030.71	2.81 mm	266.67 mm	✓
Comb #3	X	0.13	810.72	0.16 mm	266.67 mm	✓
	Y	0.36	810.72	0.45 mm	266.67 mm	✓
Comb #4	X	-3.7	852.2	4.34 mm	266.67 mm	✓
	Y	-5.18	852.2	6.08 mm	266.67 mm	✓
Comb #5	X	12.17	877.94	13.86 mm	266.67 mm	✓
	Y	-2.67	877.94	3.04 mm	266.67 mm	✓
Comb #6	X	-15.92	868.46	18.34 mm	266.67 mm	✓
	Y	-2.26	868.46	2.6 mm	266.67 mm	✓
Comb #7	X	-2.36	873.51	2.7 mm	266.67 mm	✓
	Y	0.96	873.51	1.1 mm	266.67 mm	✓
Comb #8	X	-1.39	872.89	1.6 mm	266.67 mm	✓
	Y	-5.88	872.89	6.74 mm	266.67 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.147$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}$ k (100 ρ_l f_{ck})^(1/3) + k_1 σ_{cp}

k = 1 + (200/d)^(1/2)

k = 1.61,

ρ_l = (ρ_{lx} ρ_{ly})^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.0022, ρ_{ly} = 0.0022, ρ_f = 1,

ρ_l = 0.0022,

σ_{cp} = ΣN / L_xL_y = 0.34 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.38 N/mm²

v_{min} = 0.035 k^(3/2) f_{ck}^(1/2) + k_1 σ_{cp}

v_{min} = 0.39 N/mm²

$v_{Rd,c}$ = Max($v_{Rd,c1}$, v_{min}) = 0.39 N/mm²

v_{Rdmax} = 0.5 (0.6 (1 - (f_{ck} / 250))) f_{cd}

$V_{pc\text{-}cf}$ = v_{Rdmax} u_p d,

$V_{pc\text{-}ep}$ = $v_{Rd,c}$ u_p d,

u_p = 2(B_{EPx} + B_{EPy}) = 9844

B_{EPx} = B_x + 2d_{sect} = 2586

B_{EPy} = B_y + 2d_{sect} = 2336

d_{sect} = 2d_{eff} = 1068

$V_{pc\text{-}cf}$ = 3124 kN

$V_{pc\text{-}ep}$ = 2317 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	738.42	288.44	3123.90	817.23	0.26	2285.83	1151.70	0.50
Comb #2	1030.71	402.62	3123.90	1140.73	0.37	2285.83	1607.59	0.70
Comb #3	810.72	316.69	3123.90	897.25	0.29	2285.83	1264.46	0.55
Comb #4	852.20	332.89	3123.90	943.16	0.30	2285.83	1329.16	0.58
Comb #5	877.94	342.95	3123.90	971.65	0.31	2285.83	1369.32	0.60
Comb #6	868.46	339.24	3123.90	961.15	0.31	2285.83	1354.52	0.59
Comb #7	873.51	341.22	3123.90	966.75	0.31	2285.83	1362.41	0.60
Comb #8	872.89	340.97	3123.90	966.06	0.31	2285.83	1361.43	0.60

Comparison at	Demand / Capacity	Status
Effective Perimeter	1607.6 kN / 2285.8 kN	√
Column Face	1140.7 kN / 3123.9 kN	√

Shear Check

$V_{dx\text{-}cf}$ = σ_{cf} d_{vx1} L_y + ((σ_{max} - σ_{cf}) d_{vx1} L_y / 2)

$V_{dy\text{-}cf}$ = σ_{cf} d_{vy1} L_x + ((σ_{max} - σ_{cf}) d_{vy1} L_x / 2)

$V_{dx\text{-}d}$ = σ_{cf} d_{vx2} L_y + ((σ_{max} - σ_{cf}) d_{vx2} L_y / 2)

$V_{dy\text{-}d}$ = σ_{cf} d_{vy2} L_x + ((σ_{max} - σ_{cf}) d_{vy2} L_x / 2)

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	269.25	502.35	√	327.87	502.35	√
Comb #2	375.93	502.35	√	457.76	502.35	√
Comb #3	291.84	502.35	√	355.40	502.35	√
Comb #4	315.72	502.35	√	384.76	502.35	√
Comb #5	334.21	502.35	√	399.71	502.35	√
Comb #6	335.51	502.35	√	398.35	502.35	√
Comb #7	317.93	502.35	√	385.91	502.35	√
Comb #8	320.65	502.35	√	392.83	502.35	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	142.60	502.35	√	204.95	502.35	√
Comb #2	199.10	502.35	√	286.15	502.35	√
Comb #3	154.34	502.35	√	221.90	502.35	√
Comb #4	167.55	502.35	√	240.82	502.35	√
Comb #5	177.02	502.35	√	251.58	502.35	√
Comb #6	177.66	502.35	√	251.37	502.35	√
Comb #7	168.20	502.35	√	241.32	502.35	√
Comb #8	170.24	502.35	√	245.47	502.35	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	375.9 kN / 502.4 kN	√
Column Face in Y-Direction	457.8 kN / 502.4 kN	√
Effective Perimeter in X-Direction	199.1 kN / 502.4 kN	√
Effective Perimeter in Y-Direction	286.1 kN / 502.4 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	775.05	1144.00	1148.85	1144.00
Comb #2	1082.14	1144.00	1604.02	1144.00
Comb #3	839.20	1144.00	1244.02	1144.00
Comb #4	910.11	1144.00	1349.75	1144.00
Comb #5	962.10	1144.00	1409.17	1144.00
Comb #6	965.64	1144.00	1407.56	1144.00
Comb #7	914.49	1144.00	1352.67	1144.00
Comb #8	924.61	1144.00	1376.07	1144.00

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	160.4 kN.m	12ϕ16 / 150.0 mm	1144.00 mm2/2144.66 mm2	√
Reinforcement Area in Y-Direction	108.2 kN.m	12ϕ16 / 150.0 mm	1144.00 mm2/2144.66 mm2	√

F-1C12 Design Summary

Geometric Properties and Materials

Footing Materials

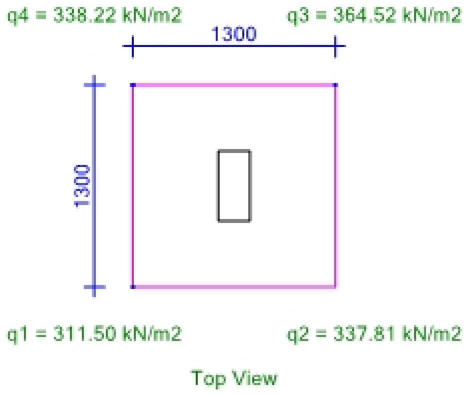
Concrete Material	C20/25
Rebar Material	Grade 460 (Type 2)

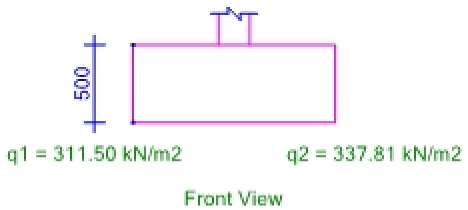
Geometric Properties

B_X	1300.00 mm
B_Y	1300.00 mm
Height	500.00 mm
Taper Height	0.00 mm

Corner Stresses

Lower-Left Corner	311.50 kN/m2
Lower-Right Corner	337.81 kN/m2
Upper-Right Corner	364.52 kN/m2
Upper-Left Corner	338.22 kN/m2





Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	370.9 kN	-2.7 kN	-2.2 kN	4.7 kN.m	4.5 kN.m
Comb #2	529.7 kN	-3.9 kN	-3.2 kN	6.8 kN.m	6.5 kN.m
Comb #3	403.7 kN	-2.3 kN	-5.1 kN	4.0 kN.m	8.9 kN.m
Comb #4	451.9 kN	-3.9 kN	0.0 kN	6.8 kN.m	1.4 kN.m
Comb #5	449.0 kN	-4.8 kN	-1.9 kN	9.6 kN.m	3.6 kN.m
Comb #6	441.1 kN	-1.7 kN	-3.4 kN	1.7 kN.m	7.3 kN.m
Comb #7	441.6 kN	-3.2 kN	-10.5 kN	5.6 kN.m	26.7 kN.m
Comb #8	448.4 kN	-3.3 kN	5.2 kN	5.8 kN.m	-15.9 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	0.845	24	20.28
Soil	:	1.183	18	21.294
Total	:			41.574

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	412.43	3.37	3.42	225.52	243.90	262.57	244.18
Comb #2	571.24	4.82	4.89	311.50	337.81	364.52	338.22
Comb #3	445.30	2.84	6.31	238.50	254.01	288.49	272.97
Comb #4	493.48	4.82	1.46	274.83	301.18	309.17	282.82
Comb #5	490.58	7.22	2.59	263.48	302.93	317.08	277.63
Comb #6	482.64	0.86	5.61	267.92	272.60	303.25	298.57
Comb #7	483.20	3.94	21.47	216.53	238.04	355.30	333.79
Comb #8	490.01	4.14	-13.27	314.87	337.49	265.02	242.41

Demand	Capacity	Status
Maximum Soil Stress: 364.52 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	3.37	412.43	8.16 mm	216.67 mm	✓
	Y	3.42	412.43	8.29 mm	216.67 mm	✓
Comb #2	X	4.82	571.24	8.43 mm	216.67 mm	✓
	Y	4.89	571.24	8.56 mm	216.67 mm	✓
Comb #3	X	2.84	445.3	6.38 mm	216.67 mm	✓
	Y	6.31	445.3	14.17 mm	216.67 mm	✓
Comb #4	X	4.82	493.48	9.78 mm	216.67 mm	✓
	Y	1.46	493.48	2.96 mm	216.67 mm	✓
Comb #5	X	7.22	490.58	14.72 mm	216.67 mm	✓
	Y	2.59	490.58	5.28 mm	216.67 mm	✓
Comb #6	X	0.86	482.64	1.78 mm	216.67 mm	✓
	Y	5.61	482.64	11.63 mm	216.67 mm	✓
Comb #7	X	3.94	483.2	8.15 mm	216.67 mm	✓
	Y	21.47	483.2	44.43 mm	216.67 mm	✓
Comb #8	X	4.14	490.01	8.45 mm	216.67 mm	✓
	Y	-13.27	490.01	27.07 mm	216.67 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.171$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})$^(1/3) + $k_1\ \sigma_{cp}$

k = 1 + (200/d)^(1/2)

k = 1.68,

$\rho_l = (\rho_{lx}\ \rho_{ly})$^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.0027, ρ_{ly} = 0.0027, ρ_f = 1,

ρ_l = 0.0027,

$\sigma_{cp} = \Sigma N / L_xL_y$ = 0.29 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.41 N/mm²

v_{min} = 0.035 k^(3/2) f_{ck}^(1/2) + $k_1\ \sigma_{cp}$

v_{min} = 0.41 N/mm²

$v_{Rd,c} = Max(v_{Rd,c1}, v_{min})$ = 0.41 N/mm²

$v_{Rdmax} = 0.5\ (0.6\ (1 - (f_{ck} / 250)))\ f_{cd}$

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy})$ = 8244

$B_{EPx} = B_x + 2d_{sect}$ = 1936

$B_{EPy} = B_y + 2d_{sect}$ = 2186

$d_{sect} = 2d_{eff}$ = 868

$V_{pc\text{-}cf}$ = 2539 kN

$V_{pc\text{-}ep}$ = 1689 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	412.43	244.04	2538.90	457.41	0.18	1669.73	726.74	0.44
Comb #2	571.24	338.01	2538.90	633.54	0.25	1669.73	1006.57	0.60
Comb #3	445.30	263.49	2538.90	493.86	0.19	1669.73	784.65	0.47
Comb #4	493.48	292.00	2538.90	547.29	0.22	1669.73	869.54	0.52
Comb #5	490.58	290.28	2538.90	544.07	0.21	1669.73	864.43	0.52
Comb #6	482.64	285.58	2538.90	535.27	0.21	1669.73	850.44	0.51
Comb #7	483.20	285.92	2538.90	535.89	0.21	1669.73	851.43	0.51
Comb #8	490.01	289.95	2538.90	543.45	0.21	1669.73	863.43	0.52

Comparison at	Demand / Capacity	Status
Effective Perimeter	1006.6 kN / 1669.7 kN	√
Column Face	633.5 kN / 2538.9 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	184.91	349.38	√	143.41	349.38	√
Comb #2	256.59	349.38	√	199.02	349.38	√
Comb #3	201.06	349.38	√	157.99	349.38	√
Comb #4	219.85	349.38	√	168.44	349.38	√
Comb #5	224.57	349.38	√	171.62	349.38	√
Comb #6	212.19	349.38	√	167.12	349.38	√
Comb #7	236.31	349.38	√	194.36	349.38	√
Comb #8	230.34	349.38	√	184.42	349.38	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	111.29	349.38	√	71.95	349.38	√
Comb #2	154.46	349.38	√	99.87	349.38	√
Comb #3	121.52	349.38	√	79.16	349.38	√
Comb #4	131.80	349.38	√	84.62	349.38	√
Comb #5	134.85	349.38	√	86.50	349.38	√
Comb #6	128.04	349.38	√	83.47	349.38	√
Comb #7	145.62	349.38	√	97.44	349.38	√
Comb #8	140.42	349.38	√	92.50	349.38	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	256.6 kN / 349.4 kN	√
Column Face in Y-Direction	199.0 kN / 349.4 kN	√
Effective Perimeter in X-Direction	154.5 kN / 349.4 kN	√
Effective Perimeter in Y-Direction	99.9 kN / 349.4 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	511.10	760.50	305.92	760.50
Comb #2	709.34	760.50	424.61	760.50
Comb #3	557.68	760.50	336.72	760.50
Comb #4	605.69	760.50	359.61	760.50
Comb #5	619.53	760.50	367.22	760.50
Comb #6	587.77	760.50	355.43	760.50
Comb #7	666.10	760.50	414.40	760.50
Comb #8	643.49	760.50	393.34	760.50

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	42.5 kN.m	10ϕ16 / 150.0 mm	760.50 mm2/1742.54 mm2	√
Reinforcement Area in Y-Direction	70.9 kN.m	10ϕ16 / 150.0 mm	760.50 mm2/1742.54 mm2	√

F-1C28 Design Summary

Geometric Properties and Materials

Footing Materials

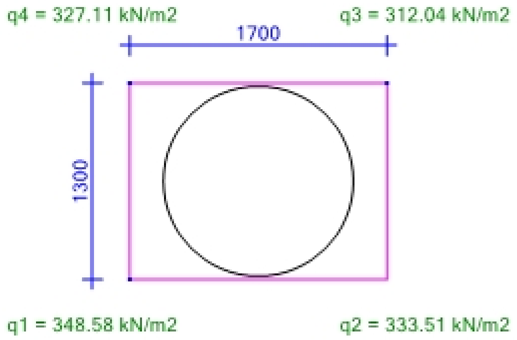
Concrete Material	C20/25
Rebar Material	Grade 460 (Type 2)

Geometric Properties

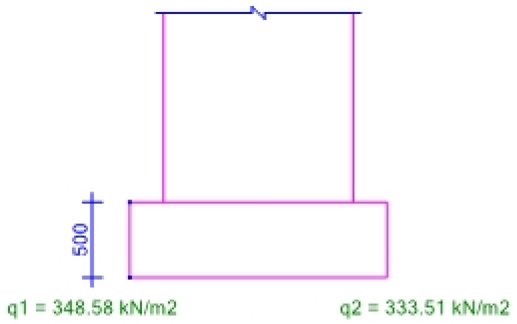
B_X	1700.00 mm
B_Y	1300.00 mm
Height	500.00 mm
Taper Height	0.00 mm

Corner Stresses

Lower-Left Corner	348.58 kN/m2
Lower-Right Corner	333.51 kN/m2
Upper-Right Corner	312.04 kN/m2
Upper-Left Corner	327.11 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	474.7 kN	3.5 kN	5.1 kN	-4.3 kN.m	-7.3 kN.m
Comb #2	675.6 kN	5.0 kN	7.3 kN	-6.1 kN.m	-10.4 kN.m
Comb #3	517.8 kN	3.7 kN	2.9 kN	-4.8 kN.m	-4.3 kN.m
Comb #4	600.7 kN	4.4 kN	8.8 kN	-5.1 kN.m	-12.3 kN.m
Comb #5	563.5 kN	-5.1 kN	4.9 kN	20.4 kN.m	-5.5 kN.m
Comb #6	575.7 kN	13.5 kN	7.3 kN	-30.7 kN.m	-12.0 kN.m
Comb #7	576.8 kN	4.2 kN	-5.8 kN	-4.9 kN.m	27.6 kN.m
Comb #8	562.4 kN	4.3 kN	18.1 kN	-5.4 kN.m	-45.0 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	1.105	24	26.52
Soil	:	1.547	18	27.846
Total	:			54.366

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	529.03	-2.54	-4.71	252.20	241.60	226.57	237.17
Comb #2	729.99	-3.61	-6.72	348.58	333.51	312.04	327.11
Comb #3	572.14	-2.99	-2.81	269.63	257.13	248.15	260.65
Comb #4	655.09	-2.91	-7.95	315.19	303.04	277.65	289.80
Comb #5	617.90	17.82	-3.01	247.19	321.60	312.00	237.58
Comb #6	630.04	-23.91	-8.29	348.25	248.39	221.92	321.78
Comb #7	631.19	-2.86	24.66	252.19	240.26	319.03	330.96
Comb #8	616.74	-3.24	-35.96	343.25	329.73	214.89	228.40

Demand	Capacity	Status
Maximum Soil Stress: 348.58 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	-2.54	529.03	4.8 mm	283.33 mm	✓
	Y	-4.71	529.03	8.89 mm	216.67 mm	✓
Comb #2	X	-3.61	729.99	4.94 mm	283.33 mm	✓
	Y	-6.72	729.99	9.21 mm	216.67 mm	✓
Comb #3	X	-2.99	572.14	5.23 mm	283.33 mm	✓
	Y	-2.81	572.14	4.91 mm	216.67 mm	✓
Comb #4	X	-2.91	655.09	4.44 mm	283.33 mm	✓
	Y	-7.95	655.09	12.14 mm	216.67 mm	✓
Comb #5	X	17.82	617.9	28.84 mm	283.33 mm	✓
	Y	-3.01	617.9	4.87 mm	216.67 mm	✓
Comb #6	X	-23.91	630.04	37.95 mm	283.33 mm	✓
	Y	-8.29	630.04	13.15 mm	216.67 mm	✓
Comb #7	X	-2.86	631.19	4.52 mm	283.33 mm	✓
	Y	24.66	631.19	39.07 mm	216.67 mm	✓
Comb #8	X	-3.24	616.74	5.25 mm	283.33 mm	✓
	Y	-35.96	616.74	58.3 mm	216.67 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.171$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})^{\wedge}(1/3) + k_1\ \sigma_{cp}$

$k = 1 + (200/d)^{\wedge}(1/2)$

$k = 1.68$,

$\rho_l = (\rho_{lx}\ \rho_{ly})^{\wedge}(1/2) * \rho_f$, $\rho_{lmin} = 0.02$

$\rho_{lx} = 0.0021$, $\rho_{ly} = 0.0035$, $\rho_f = 1$,

$\rho_l = 0.0027$,

$\sigma_{cp} = \Sigma N / L_x L_y = 0.28$ N/mm²

$C_{Rd,c} = 0.12$, $k_1 = 0.10$

$v_{Rd,c1} = 0.41$ N/mm²

$v_{min} = 0.035\ k^{\wedge}(3/2)\ f_{ck}^{\wedge}(1/2) + k_1\ \sigma_{cp}$

$v_{min} = 0.41$ N/mm²

$v_{Rd,c} = \mathrm{Max}(v_{Rd,c1}, v_{min}) = 0.41$ N/mm²

$v_{Rdmax} = 0.5\ (0.6\ (1 - (f_{ck} / 250)))\ f_{cd}$

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy}) = 8244$

$B_{EPx} = B_x + 2d_{sect} = 1936$

$B_{EPy} = B_y + 2d_{sect} = 2186$

$d_{sect} = 2d_{eff} = 868$

$V_{pc\text{-}cf} = 2539$ kN

$V_{pc\text{-}ep} = 1684$ kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	529.03	239.38	3515.40	587.57	0.17	1768.97	751.80	0.42
Comb #2	729.99	330.31	3515.40	810.76	0.23	1768.97	1037.37	0.59
Comb #3	572.14	258.89	3515.40	635.45	0.18	1768.97	813.06	0.46
Comb #4	655.09	296.42	3515.40	727.58	0.21	1768.97	930.93	0.53
Comb #5	617.90	279.59	3515.40	686.27	0.20	1768.97	878.08	0.50
Comb #6	630.04	285.09	3515.40	699.75	0.20	1768.97	895.33	0.51
Comb #7	631.19	285.61	3515.40	701.04	0.20	1768.97	896.98	0.51
Comb #8	616.74	279.07	3515.40	684.98	0.19	1768.97	876.44	0.50

Comparison at	Demand / Capacity	Status
Effective Perimeter	1037.4 kN / 1769.0 kN	√
Column Face	810.8 kN / 3515.4 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	72.69	456.88	√	180.96	349.38	√
Comb #2	100.46	456.88	√	250.07	349.38	√
Comb #3	77.85	456.88	√	193.33	349.38	√
Comb #4	90.72	456.88	√	226.29	349.38	√
Comb #5	92.88	456.88	√	223.57	349.38	√
Comb #6	100.27	456.88	√	239.81	349.38	√
Comb #7	94.27	456.88	√	237.71	349.38	√
Comb #8	97.15	456.88	√	246.40	349.38	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	0.52	456.88	√	90.58	349.38	√
Comb #2	0.72	456.88	√	125.18	349.38	√
Comb #3	0.56	456.88	√	96.81	349.38	√
Comb #4	0.65	456.88	√	113.24	349.38	√
Comb #5	0.66	456.88	√	113.72	349.38	√
Comb #6	0.72	456.88	√	122.57	349.38	√
Comb #7	0.68	456.88	√	118.93	349.38	√
Comb #8	0.71	456.88	√	123.31	349.38	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	100.5 kN / 456.9 kN	√
Column Face in Y-Direction	250.1 kN / 349.4 kN	√
Effective Perimeter in X-Direction	0.7 kN / 456.9 kN	√
Effective Perimeter in Y-Direction	125.2 kN / 349.4 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	81.00	760.50	385.43	994.50
Comb #2	111.95	760.50	532.65	994.50
Comb #3	86.70	760.50	411.87	994.50
Comb #4	101.15	760.50	481.89	994.50
Comb #5	103.43	760.50	481.31	994.50
Comb #6	111.78	760.50	517.96	994.50
Comb #7	105.47	760.50	506.13	994.50
Comb #8	108.92	760.50	524.73	994.50

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	53.3 kN.m	10ϕ16 / 150.0 mm	760.50 mm2/1742.54 mm2	√
Reinforcement Area in Y-Direction	11.2 kN.m	12ϕ16 / 150.0 mm	994.50 mm2/2278.70 mm2	√

F-1C14 Design Summary

Geometric Properties and Materials

Footing Materials

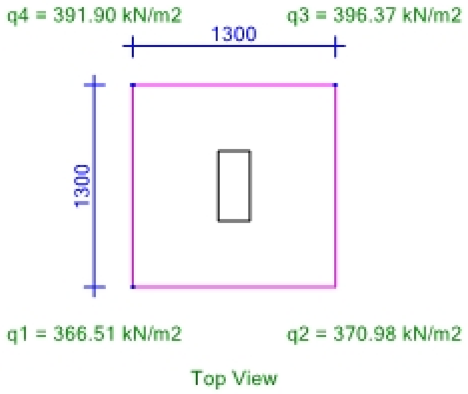
Concrete Material	C20/25
Rebar Material	Grade 460 (Type 2)

Geometric Properties

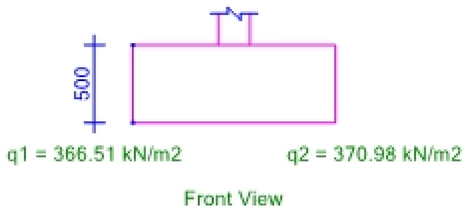
B_X	1300.00 mm
B_Y	1300.00 mm
Height	500.00 mm
Taper Height	0.00 mm

Corner Stresses

Lower-Left Corner	366.51 kN/m2
Lower-Right Corner	370.98 kN/m2
Upper-Right Corner	396.37 kN/m2
Upper-Left Corner	391.90 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	421.8 kN	-0.3 kN	-2.3 kN	0.7 kN.m	4.4 kN.m
Comb #2	603.1 kN	-0.5 kN	-3.4 kN	1.0 kN.m	6.3 kN.m
Comb #3	516.9 kN	0.0 kN	-3.6 kN	0.2 kN.m	6.2 kN.m
Comb #4	455.5 kN	-0.7 kN	-1.7 kN	1.5 kN.m	3.9 kN.m
Comb #5	505.4 kN	-2.0 kN	-3.2 kN	4.8 kN.m	6.4 kN.m
Comb #6	506.9 kN	1.2 kN	-2.4 kN	-3.1 kN.m	4.3 kN.m
Comb #7	516.1 kN	-0.4 kN	-8.8 kN	0.9 kN.m	22.5 kN.m
Comb #8	496.2 kN	-0.4 kN	3.2 kN	0.8 kN.m	-11.9 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	0.845	24	20.28
Soil	:	1.183	18	21.294
Total	:			41.574

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	463.35	0.57	3.25	263.73	266.87	284.62	281.48
Comb #2	644.63	0.82	4.65	366.51	370.98	396.37	391.90
Comb #3	558.50	0.21	4.39	317.90	319.05	343.05	341.90
Comb #4	497.03	1.11	3.00	282.86	288.95	305.34	299.26
Comb #5	546.93	3.85	4.74	300.19	321.20	347.07	326.06
Comb #6	548.49	-2.47	3.06	322.93	309.45	326.17	339.65
Comb #7	557.64	0.74	18.12	278.45	282.50	381.48	377.43
Comb #8	537.78	0.64	-10.32	344.67	348.15	291.76	288.28

Demand	Capacity	Status
Maximum Soil Stress: 396.37 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	0.57	463.35	1.24 mm	216.67 mm	✓
	Y	3.25	463.35	7.01 mm	216.67 mm	✓
Comb #2	X	0.82	644.63	1.27 mm	216.67 mm	✓
	Y	4.65	644.63	7.21 mm	216.67 mm	✓
Comb #3	X	0.21	558.5	0.38 mm	216.67 mm	✓
	Y	4.39	558.5	7.87 mm	216.67 mm	✓
Comb #4	X	1.11	497.03	2.24 mm	216.67 mm	✓
	Y	3	497.03	6.04 mm	216.67 mm	✓
Comb #5	X	3.85	546.93	7.03 mm	216.67 mm	✓
	Y	4.74	546.93	8.66 mm	216.67 mm	✓
Comb #6	X	-2.47	548.49	4.5 mm	216.67 mm	✓
	Y	3.06	548.49	5.58 mm	216.67 mm	✓
Comb #7	X	0.74	557.64	1.33 mm	216.67 mm	✓
	Y	18.12	557.64	32.5 mm	216.67 mm	✓
Comb #8	X	0.64	537.78	1.19 mm	216.67 mm	✓
	Y	-10.32	537.78	19.2 mm	216.67 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.171$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})$^(1/3) + $k_1\ \sigma_{cp}$

k = 1 + (200/d)^(1/2)

k = 1.68,

$\rho_l = (\rho_{lx}\ \rho_{ly})$^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.0027, ρ_{ly} = 0.0027, ρ_f = 1,

ρ_l = 0.0027,

$\sigma_{cp} = \Sigma N / L_x L_y$ = 0.32 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.41 N/mm²

v_{min} = 0.035 k^(3/2) f_{ck}^(1/2) + $k_1\ \sigma_{cp}$

v_{min} = 0.41 N/mm²

$v_{Rd,c}$ = Max($v_{Rd,c1}$, v_{min}) = 0.41 N/mm²

v_{Rdmax} = 0.5 (0.6 (1 - (f_{ck} / 250))) f_{cd}

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy})$ = 8244

$B_{EPx} = B_x + 2d_{sect}$ = 1936

$B_{EPy} = B_y + 2d_{sect}$ = 2186

$d_{sect} = 2d_{eff}$ = 868

$V_{pc\text{-}cf}$ = 2539 kN

$V_{pc\text{-}ep}$ = 1700 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	463.35	274.17	2538.90	513.88	0.20	1682.15	816.46	0.49
Comb #2	644.63	381.44	2538.90	714.93	0.28	1682.15	1135.89	0.68
Comb #3	558.50	330.47	2538.90	619.40	0.24	1682.15	984.11	0.59
Comb #4	497.03	294.10	2538.90	551.23	0.22	1682.15	875.80	0.52
Comb #5	546.93	323.63	2538.90	606.57	0.24	1682.15	963.73	0.57
Comb #6	548.49	324.55	2538.90	608.30	0.24	1682.15	966.47	0.57
Comb #7	557.64	329.96	2538.90	618.44	0.24	1682.15	982.59	0.58
Comb #8	537.78	318.21	2538.90	596.43	0.23	1682.15	947.61	0.56

Comparison at	Demand / Capacity	Status
Effective Perimeter	1135.9 kN / 1682.2 kN	√
Column Face	714.9 kN / 2538.9 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	200.82	349.38	√	156.97	349.38	√
Comb #2	279.57	349.38	√	218.59	349.38	√
Comb #3	241.65	349.38	√	189.43	349.38	√
Comb #4	215.84	349.38	√	168.15	349.38	√
Comb #5	244.24	349.38	√	189.86	349.38	√
Comb #6	240.32	349.38	√	186.44	349.38	√
Comb #7	257.78	349.38	√	210.40	349.38	√
Comb #8	240.40	349.38	√	192.04	349.38	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	120.77	349.38	√	78.37	349.38	√
Comb #2	168.15	349.38	√	109.14	349.38	√
Comb #3	145.42	349.38	√	94.52	349.38	√
Comb #4	129.71	349.38	√	84.01	349.38	√
Comb #5	147.04	349.38	√	95.18	349.38	√
Comb #6	144.36	349.38	√	93.30	349.38	√
Comb #7	157.80	349.38	√	105.04	349.38	√
Comb #8	145.85	349.38	√	95.87	349.38	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	279.6 kN / 349.4 kN	√
Column Face in Y-Direction	218.6 kN / 349.4 kN	√
Effective Perimeter in X-Direction	168.2 kN / 349.4 kN	√
Effective Perimeter in Y-Direction	109.1 kN / 349.4 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	554.70	760.50	333.75	760.50
Comb #2	772.32	760.50	464.79	760.50
Comb #3	667.87	760.50	402.62	760.50
Comb #4	595.83	760.50	357.71	760.50
Comb #5	675.25	760.50	404.79	760.50
Comb #6	663.19	760.50	397.04	760.50
Comb #7	722.63	760.50	447.36	760.50
Comb #8	668.92	760.50	408.31	760.50

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	46.5 kN.m	10ϕ16 / 150.0 mm	760.50 mm2/1742.54 mm2	√
Reinforcement Area in Y-Direction	77.2 kN.m	10ϕ16 / 150.0 mm	760.50 mm2/1742.54 mm2	√

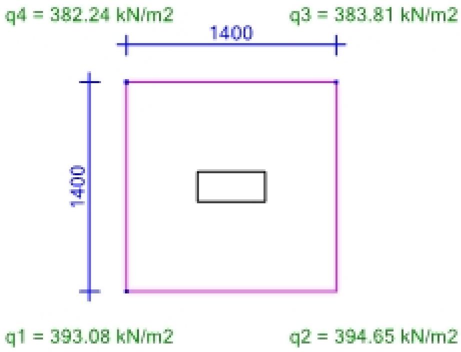
F-1C15 Design Summary

Geometric Properties and Materials

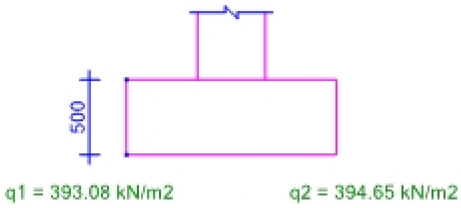
Footing Materials
Concrete Material   C20/25
Rebar Material   Grade 460 (Type 2)

Geometric Properties
B_X 1400.00 mm
B_Y 1400.00 mm
Height   500.00 mm
Taper Height   0.00 mm

Corner Stresses
Lower-Left Corner   393.08 kN/m2
Lower-Right Corner   394.65 kN/m2
Upper-Right Corner   383.81 kN/m2
Upper-Left Corner   382.24 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	497.7 kN	0.6 kN	1.6 kN	-0.1 kN.m	-2.5 kN.m
Comb #2	713.1 kN	0.9 kN	2.3 kN	-0.1 kN.m	-3.6 kN.m
Comb #3	528.6 kN	-0.4 kN	0.2 kN	1.5 kN.m	-0.3 kN.m
Comb #4	608.4 kN	1.9 kN	3.4 kN	-1.7 kN.m	-5.4 kN.m
Comb #5	596.0 kN	-5.7 kN	1.8 kN	17.2 kN.m	-2.9 kN.m
Comb #6	598.6 kN	7.2 kN	1.9 kN	-17.4 kN.m	-3.1 kN.m
Comb #7	601.0 kN	0.6 kN	0.2 kN	0.3 kN.m	1.2 kN.m
Comb #8	593.6 kN	1.0 kN	3.6 kN	-0.5 kN.m	-7.3 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	0.98	24	23.52
Soil	:	1.372	18	24.696
Total	:			48.216

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	545.96	0.25	-1.72	281.76	282.86	275.34	274.24
Comb #2	761.35	0.36	-2.48	393.08	394.65	383.81	382.24
Comb #3	576.81	1.32	-0.16	291.75	297.52	296.83	291.06
Comb #4	656.63	-0.73	-3.69	344.67	341.48	325.36	328.55
Comb #5	644.22	14.38	-1.97	301.53	364.44	355.84	292.93
Comb #6	646.79	-13.78	-2.16	364.85	304.59	295.14	355.40
Comb #7	649.21	0.60	1.36	326.94	329.57	335.52	332.88
Comb #8	641.80	0.00	-5.49	339.44	339.46	315.46	315.44

Demand	Capacity	Status
Maximum Soil Stress: 394.65 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	0.25	545.96	0.46 mm	233.33 mm	✓
	Y	-1.72	545.96	3.15 mm	233.33 mm	✓
Comb #2	X	0.36	761.35	0.47 mm	233.33 mm	✓
	Y	-2.48	761.35	3.26 mm	233.33 mm	✓
Comb #3	X	1.32	576.81	2.29 mm	233.33 mm	✓
	Y	-0.16	576.81	0.28 mm	233.33 mm	✓
Comb #4	X	-0.73	656.63	1.11 mm	233.33 mm	✓
	Y	-3.69	656.63	5.61 mm	233.33 mm	✓
Comb #5	X	14.38	644.22	22.33 mm	233.33 mm	✓
	Y	-1.97	644.22	3.05 mm	233.33 mm	✓
Comb #6	X	-13.78	646.79	21.3 mm	233.33 mm	✓
	Y	-2.16	646.79	3.34 mm	233.33 mm	✓
Comb #7	X	0.6	649.21	0.93 mm	233.33 mm	✓
	Y	1.36	649.21	2.09 mm	233.33 mm	✓
Comb #8	X	0	641.8	0.01 mm	233.33 mm	✓
	Y	-5.49	641.8	8.55 mm	233.33 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.171$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})^\wedge(1/3) + k_1\ \sigma_{cp}$

$k = 1 + (200/d)^\wedge(1/2)$

$k = 1.68$,

$\rho_l = (\rho_{lx}\ \rho_{ly})^\wedge(1/2) * \rho_f$, $\rho_{lmin} = 0.02$

$\rho_{lx} = 0.0027$, $\rho_{ly} = 0.0027$, $\rho_f = 1$,

$\rho_l = 0.0027$,

$\sigma_{cp} = \Sigma N / L_xL_y = 0.33$ N/mm²

$C_{Rd,c} = 0.12$, $k_1 = 0.10$

$v_{Rd,c1} = 0.41$ N/mm²

$v_{min} = 0.035\ k^\wedge(3/2)\ f_{ck}^\wedge(1/2) + k_1\ \sigma_{cp}$

$v_{min} = 0.41$ N/mm²

$v_{Rd,c} = Max(v_{Rd,c1}, v_{min}) = 0.41$ N/mm²

$v_{Rdmax} = 0.5\ (0.6\ (1 - (f_{ck} / 250)))\ f_{cd}$

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy}) = 8244$

$B_{EPx} = B_x + 2d_{sect} = 2186$

$B_{EPy} = B_y + 2d_{sect} = 1936$

$d_{sect} = 2d_{eff} = 868$

$V_{pc\text{-}cf} = 2539$ kN

$V_{pc\text{-}ep} = 1704$ kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	545.96	278.55	2538.90	610.19	0.24	1683.96	741.39	0.44
Comb #2	761.35	388.45	2538.90	850.92	0.34	1683.96	1033.89	0.61
Comb #3	576.81	294.29	2538.90	644.66	0.25	1683.96	783.28	0.47
Comb #4	656.63	335.01	2538.90	733.88	0.29	1683.96	891.68	0.53
Comb #5	644.22	328.68	2538.90	720.01	0.28	1683.96	874.83	0.52
Comb #6	646.79	330.00	2538.90	722.88	0.28	1683.96	878.32	0.52
Comb #7	649.21	331.23	2538.90	725.58	0.29	1683.96	881.60	0.52
Comb #8	641.80	327.45	2538.90	717.31	0.28	1683.96	871.55	0.52

Comparison at	Demand / Capacity	Status
Effective Perimeter	1033.9 kN / 1684.0 kN	√
Column Face	850.9 kN / 2538.9 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	187.26	376.25	✓	237.41	376.25	✓
Comb #2	261.22	376.25	✓	331.23	376.25	✓
Comb #3	197.77	376.25	✓	248.88	376.25	✓
Comb #4	227.39	376.25	✓	288.95	376.25	✓
Comb #5	241.38	376.25	✓	294.81	376.25	✓
Comb #6	241.56	376.25	✓	295.63	376.25	✓
Comb #7	222.45	376.25	✓	281.36	376.25	✓
Comb #8	223.03	376.25	✓	285.14	376.25	✓

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	100.34	376.25	✓	153.17	376.25	✓
Comb #2	139.99	376.25	✓	213.71	376.25	✓
Comb #3	105.78	376.25	✓	160.77	376.25	✓
Comb #4	122.04	376.25	✓	186.50	376.25	✓
Comb #5	129.32	376.25	✓	192.74	376.25	✓
Comb #6	129.43	376.25	✓	193.16	376.25	✓
Comb #7	119.12	376.25	✓	181.59	376.25	✓
Comb #8	119.94	376.25	✓	183.92	376.25	✓

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	261.2 kN / 376.3 kN	√
Column Face in Y-Direction	331.2 kN / 376.3 kN	√
Effective Perimeter in X-Direction	140.0 kN / 376.3 kN	√
Effective Perimeter in Y-Direction	213.7 kN / 376.3 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	445.40	819.00	712.42	819.00
Comb #2	621.37	819.00	993.96	819.00
Comb #3	469.78	819.00	747.68	819.00
Comb #4	541.48	819.00	867.42	819.00
Comb #5	574.05	819.00	895.74	819.00
Comb #6	574.54	819.00	897.72	819.00
Comb #7	528.84	819.00	844.55	819.00
Comb #8	531.85	819.00	855.43	819.00

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	99.4 kN.m	11ϕ16 / 150.0 mm	819.00 mm2/1876.58 mm2	√
Reinforcement Area in Y-Direction	62.1 kN.m	11ϕ16 / 150.0 mm	819.00 mm2/1876.58 mm2	√

F-1C16 Design Summary

Geometric Properties and Materials

Footing Materials

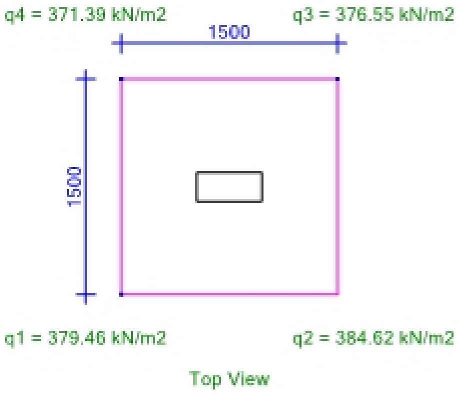
Concrete Material	C20/25
Rebar Material	Grade 460 (Type 2)

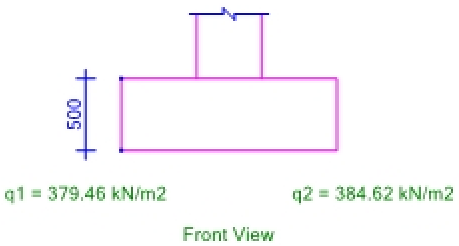
Geometric Properties

B_X	1500.00 mm
B_Y	1500.00 mm
Height	500.00 mm
Taper Height	0.00 mm

Corner Stresses

Lower-Left Corner	379.46 kN/m2
Lower-Right Corner	384.62 kN/m2
Upper-Right Corner	376.55 kN/m2
Upper-Left Corner	371.39 kN/m2





Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	554.6 kN	0.0 kN	1.5 kN	1.0 kN.m	-2.3 kN.m
Comb #2	795.2 kN	0.0 kN	2.1 kN	1.5 kN.m	-3.3 kN.m
Comb #3	673.1 kN	2.2 kN	3.3 kN	-2.8 kN.m	-5.5 kN.m
Comb #4	590.3 kN	-2.3 kN	0.0 kN	5.2 kN.m	0.2 kN.m
Comb #5	666.9 kN	-6.5 kN	1.8 kN	18.6 kN.m	-2.8 kN.m
Comb #6	664.1 kN	6.5 kN	1.8 kN	-16.1 kN.m	-2.8 kN.m
Comb #7	666.5 kN	-0.1 kN	0.1 kN	1.5 kN.m	1.5 kN.m
Comb #8	664.5 kN	0.1 kN	3.5 kN	1.0 kN.m	-7.1 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	1.125	24	27
Soil	:	1.575	18	28.35
Total	:			55.35

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x\,(h - h_{taper}) + Ecc_1\,N$

$\Sigma M_y = M_y + V_y\,(h - h_{taper}) + Ecc_2\,N$

Corner stresses,

$\sigma_1 = \Sigma N / L_xL_y - 6\,\Sigma M_x / (L_xL_y^2) - 6\,\Sigma M_y / (L_x^2L_y)$

$\sigma_2 = \Sigma N / L_xL_y + 6\,\Sigma M_x / (L_xL_y^2) - 6\,\Sigma M_y / (L_x^2L_y)$

$\sigma_3 = \Sigma N / L_xL_y + 6\,\Sigma M_x / (L_xL_y^2) + 6\,\Sigma M_y / (L_x^2L_y)$

$\sigma_4 = \Sigma N / L_xL_y - 6\,\Sigma M_x / (L_xL_y^2) + 6\,\Sigma M_y / (L_x^2L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	609.94	1.01	-1.58	272.09	275.69	270.08	266.47
Comb #2	850.51	1.45	-2.27	379.46	384.62	376.55	371.39
Comb #3	728.47	-1.72	-3.80	333.58	327.46	313.95	320.06
Comb #4	645.67	4.03	0.24	279.36	293.71	294.57	280.23
Comb #5	722.22	15.33	-1.89	297.09	351.61	344.88	290.36
Comb #6	719.49	-12.90	-1.90	346.08	300.21	293.47	339.33
Comb #7	721.86	1.41	1.58	315.51	320.51	326.14	321.14
Comb #8	719.85	1.03	-5.37	327.66	331.32	312.21	308.55

Demand	Capacity	Status
Maximum Soil Stress: 384.62 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	1.01	609.94	1.66 mm	250 mm	✓
	Y	-1.58	609.94	2.59 mm	250 mm	✓
Comb #2	X	1.45	850.51	1.71 mm	250 mm	✓
	Y	-2.27	850.51	2.67 mm	250 mm	✓
Comb #3	X	-1.72	728.47	2.36 mm	250 mm	✓
	Y	-3.8	728.47	5.22 mm	250 mm	✓
Comb #4	X	4.03	645.67	6.25 mm	250 mm	✓
	Y	0.24	645.67	0.38 mm	250 mm	✓
Comb #5	X	15.33	722.22	21.23 mm	250 mm	✓
	Y	-1.89	722.22	2.62 mm	250 mm	✓
Comb #6	X	-12.9	719.49	17.93 mm	250 mm	✓
	Y	-1.9	719.49	2.64 mm	250 mm	✓
Comb #7	X	1.41	721.86	1.95 mm	250 mm	✓
	Y	1.58	721.86	2.19 mm	250 mm	✓
Comb #8	X	1.03	719.85	1.43 mm	250 mm	✓
	Y	-5.37	719.85	7.47 mm	250 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x\,L_y$

$A_{eff} = L_xL_y - B_xB_y$

$\beta = 1.171$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})$^(1/3) + $k_1\ \sigma_{cp}$

k = 1 + (200/d)^(1/2)

k = 1.68,

$\rho_l = (\rho_{lx}\ \rho_{ly})$^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.0027, ρ_{ly} = 0.0027, ρ_f = 1,

ρ_l = 0.0027,

$\sigma_{cp} = \Sigma N / L_x L_y$ = 0.32 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.41 N/mm²

v_{min} = 0.035 k^(3/2) f_{ck}^(1/2) + $k_1\ \sigma_{cp}$

v_{min} = 0.41 N/mm²

$v_{Rd,c} = Max(v_{Rd,c1}, v_{min})$ = 0.41 N/mm²

v_{Rdmax} = 0.5 (0.6 (1 - (f_{ck} / 250))) f_{cd}

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy})$ = 8244

$B_{EPx} = B_x + 2d_{sect}$ = 2186

$B_{EPy} = B_y + 2d_{sect}$ = 1936

$d_{sect} = 2d_{eff}$ = 868

$V_{pc\text{-}cf}$ = 2539 kN

$V_{pc\text{-}ep}$ = 1701 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	609.94	271.08	2538.90	685.92	0.27	1680.88	629.43	0.37
Comb #2	850.51	378.01	2538.90	956.47	0.38	1680.88	877.69	0.52
Comb #3	728.47	323.76	2538.90	819.22	0.32	1680.88	751.74	0.45
Comb #4	645.67	286.97	2538.90	726.11	0.29	1680.88	666.30	0.40
Comb #5	722.22	320.99	2538.90	812.19	0.32	1680.88	745.30	0.44
Comb #6	719.49	319.77	2538.90	809.12	0.32	1680.88	742.48	0.44
Comb #7	721.86	320.83	2538.90	811.78	0.32	1680.88	744.92	0.44
Comb #8	719.85	319.94	2538.90	809.53	0.32	1680.88	742.85	0.44

Comparison at	Demand / Capacity	Status
Effective Perimeter	877.7 kN / 1680.9 kN	√
Column Face	956.5 kN / 2538.9 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	216.34	403.13	√	268.04	403.13	√
Comb #2	301.78	403.13	√	373.91	403.13	√
Comb #3	260.83	403.13	√	323.95	403.13	√
Comb #4	231.85	403.13	√	284.17	403.13	√
Comb #5	275.97	403.13	√	331.31	403.13	√
Comb #6	271.61	403.13	√	327.74	403.13	√
Comb #7	256.06	403.13	√	316.93	403.13	√
Comb #8	258.28	403.13	√	322.26	403.13	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	125.46	403.13	√	180.37	403.13	√
Comb #2	175.01	403.13	√	251.63	403.13	√
Comb #3	151.49	403.13	√	218.08	403.13	√
Comb #4	134.28	403.13	√	191.72	403.13	√
Comb #5	160.03	403.13	√	225.28	403.13	√
Comb #6	157.50	403.13	√	222.47	403.13	√
Comb #7	148.46	403.13	√	213.31	403.13	√
Comb #8	150.20	403.13	√	216.83	403.13	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	301.8 kN / 403.1 kN	√
Column Face in Y-Direction	373.9 kN / 403.1 kN	√
Effective Perimeter in X-Direction	175.0 kN / 403.1 kN	√
Effective Perimeter in Y-Direction	251.6 kN / 403.1 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	568.56	877.50	871.96	877.50
Comb #2	793.13	877.50	1216.40	877.50
Comb #3	686.31	877.50	1054.24	877.50
Comb #4	608.72	877.50	926.85	877.50
Comb #5	725.23	877.50	1089.23	877.50
Comb #6	713.78	877.50	1075.64	877.50
Comb #7	672.84	877.50	1031.17	877.50
Comb #8	680.28	877.50	1048.18	877.50

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	121.6 kN.m	11ϕ16 / 150.0 mm	877.50 mm2/2010.62 mm2	√
Reinforcement Area in Y-Direction	79.3 kN.m	11ϕ16 / 150.0 mm	877.50 mm2/2010.62 mm2	√

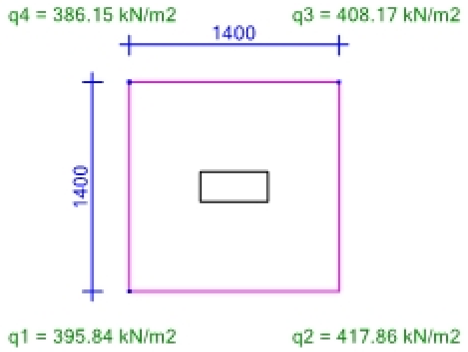
F-1C17 Design Summary

Geometric Properties and Materials

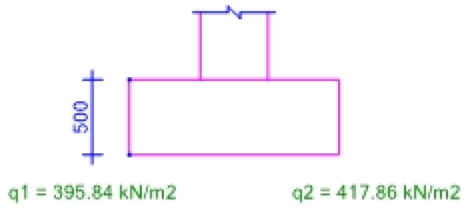
Footing Materials
Concrete Material C20/25
Rebar Material Grade 460 (Type 2)

Geometric Properties
B_X 1400.00 mm
B_Y 1400.00 mm
Height 500.00 mm
Taper Height 0.00 mm

Corner Stresses
Lower-Left Corner 395.84 kN/m2
Lower-Right Corner 417.86 kN/m2
Upper-Right Corner 408.17 kN/m2
Upper-Left Corner 386.15 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	515.7 kN	-2.2 kN	1.5 kN	4.6 kN.m	-2.3 kN.m
Comb #2	739.7 kN	-3.1 kN	2.1 kN	6.6 kN.m	-3.3 kN.m
Comb #3	634.1 kN	-4.1 kN	3.3 kN	7.6 kN.m	-5.4 kN.m
Comb #4	540.4 kN	-0.9 kN	0.0 kN	2.9 kN.m	0.3 kN.m
Comb #5	616.7 kN	-9.2 kN	1.8 kN	23.0 kN.m	-2.9 kN.m
Comb #6	621.1 kN	3.9 kN	1.7 kN	-11.9 kN.m	-2.6 kN.m
Comb #7	624.8 kN	-2.7 kN	-0.1 kN	5.8 kN.m	1.9 kN.m
Comb #8	613.0 kN	-2.5 kN	3.6 kN	5.3 kN.m	-7.4 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	0.98	24	23.52
Soil	:	1.372	18	24.696
Total	:			48.216

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	563.96	3.52	-1.54	283.42	298.81	292.05	276.66
Comb #2	787.93	5.04	-2.22	395.84	417.86	408.17	386.15
Comb #3	682.34	5.55	-3.77	344.23	368.50	352.03	327.77
Comb #4	588.64	2.46	0.27	294.35	305.12	306.30	295.54
Comb #5	664.88	18.40	-1.96	303.28	383.73	375.17	294.72
Comb #6	669.35	-9.95	-1.75	367.09	323.57	315.92	359.44
Comb #7	673.01	4.42	1.88	329.60	348.95	357.15	337.80
Comb #8	661.21	4.02	-5.58	340.77	358.36	333.94	316.35

Demand	Capacity	Status
Maximum Soil Stress: 417.86 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	3.52	563.96	6.24 mm	233.33 mm	✓
	Y	-1.54	563.96	2.74 mm	233.33 mm	✓
Comb #2	X	5.04	787.93	6.39 mm	233.33 mm	✓
	Y	-2.22	787.93	2.81 mm	233.33 mm	✓
Comb #3	X	5.55	682.34	8.13 mm	233.33 mm	✓
	Y	-3.77	682.34	5.52 mm	233.33 mm	✓
Comb #4	X	2.46	588.64	4.18 mm	233.33 mm	✓
	Y	0.27	588.64	0.46 mm	233.33 mm	✓
Comb #5	X	18.4	664.88	27.67 mm	233.33 mm	✓
	Y	-1.96	664.88	2.95 mm	233.33 mm	✓
Comb #6	X	-9.95	669.35	14.87 mm	233.33 mm	✓
	Y	-1.75	669.35	2.61 mm	233.33 mm	✓
Comb #7	X	4.42	673.01	6.57 mm	233.33 mm	✓
	Y	1.88	673.01	2.79 mm	233.33 mm	✓
Comb #8	X	4.02	661.21	6.08 mm	233.33 mm	✓
	Y	-5.58	661.21	8.44 mm	233.33 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.171$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})$^(1/3) + $k_1\ \sigma_{cp}$

k = 1 + (200/d)^(1/2)

k = 1.68,

$\rho_l = (\rho_{lx}\ \rho_{ly})$^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.0027, ρ_{ly} = 0.0027, ρ_f = 1,

ρ_l = 0.0027,

$\sigma_{cp} = \Sigma N / L_xL_y$ = 0.34 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.41 N/mm²

v_{min} = 0.035 k^(3/2) f_{ck}^(1/2) + $k_1\ \sigma_{cp}$

v_{min} = 0.41 N/mm²

$v_{Rd,c} = Max(v_{Rd,c1}, v_{min})$ = 0.41 N/mm²

v_{Rdmax} = 0.5 (0.6 (1 - (f_{ck} / 250))) f_{cd}

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy})$ = 8244

$B_{EPx} = B_x + 2d_{sect}$ = 2186

$B_{EPy} = B_y + 2d_{sect}$ = 1936

$d_{sect} = 2d_{eff}$ = 868

$V_{pc\text{-}cf}$ = 2539 kN

$V_{pc\text{-}ep}$ = 1708 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	563.96	287.74	2538.90	630.31	0.25	1687.75	765.84	0.45
Comb #2	787.93	402.01	2538.90	880.63	0.35	1687.75	1069.98	0.63
Comb #3	682.34	348.13	2538.90	762.61	0.30	1687.75	926.59	0.55
Comb #4	588.64	300.33	2538.90	657.89	0.26	1687.75	799.35	0.47
Comb #5	664.88	339.22	2538.90	743.10	0.29	1687.75	902.88	0.53
Comb #6	669.35	341.50	2538.90	748.09	0.29	1687.75	908.95	0.54
Comb #7	673.01	343.37	2538.90	752.19	0.30	1687.75	913.93	0.54
Comb #8	661.21	337.35	2538.90	739.00	0.29	1687.75	897.90	0.53

Comparison at	Demand / Capacity	Status
Effective Perimeter	1070.0 kN / 1687.7 kN	√
Column Face	880.6 kN / 2538.9 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	197.95	376.25	✓	248.23	376.25	✓
Comb #2	276.79	376.25	✓	347.04	376.25	✓
Comb #3	243.19	376.25	✓	305.17	376.25	✓
Comb #4	203.56	376.25	✓	255.36	376.25	✓
Comb #5	254.22	376.25	✓	307.85	376.25	✓
Comb #6	243.25	376.25	✓	300.52	376.25	✓
Comb #7	236.58	376.25	✓	296.52	376.25	✓
Comb #8	235.55	376.25	✓	297.85	376.25	✓

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	106.04	376.25	✓	160.74	376.25	✓
Comb #2	148.28	376.25	✓	224.75	376.25	✓
Comb #3	130.51	376.25	✓	197.84	376.25	✓
Comb #4	108.88	376.25	✓	165.15	376.25	✓
Comb #5	136.18	376.25	✓	201.88	376.25	✓
Comb #6	130.29	376.25	✓	195.63	376.25	✓
Comb #7	126.74	376.25	✓	192.05	376.25	✓
Comb #8	126.64	376.25	✓	192.84	376.25	✓

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	276.8 kN / 376.3 kN	√
Column Face in Y-Direction	347.0 kN / 376.3 kN	√
Effective Perimeter in X-Direction	148.3 kN / 376.3 kN	√
Effective Perimeter in Y-Direction	224.7 kN / 376.3 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	470.73	819.00	747.46	819.00
Comb #2	658.23	819.00	1045.09	819.00
Comb #3	579.06	819.00	919.88	819.00
Comb #4	483.56	819.00	768.01	819.00
Comb #5	604.53	819.00	938.04	819.00
Comb #6	578.40	819.00	909.39	819.00
Comb #7	562.60	819.00	893.05	819.00
Comb #8	561.62	819.00	896.73	819.00

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	104.5 kN.m	10ϕ16 / 150.0 mm	819.00 mm2/1876.58 mm2	√
Reinforcement Area in Y-Direction	65.8 kN.m	10ϕ16 / 150.0 mm	819.00 mm2/1876.58 mm2	√

F-1C18 Design Summary

Geometric Properties and Materials

Footing Materials

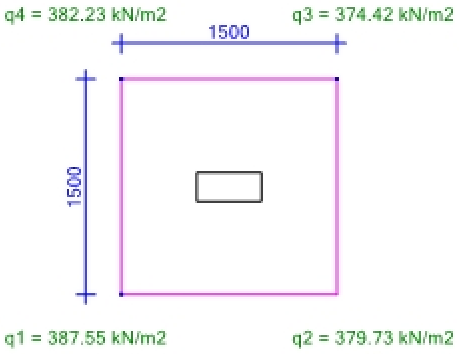
Concrete Material	C20/25
Rebar Material	Grade 460 (Type 2)

Geometric Properties

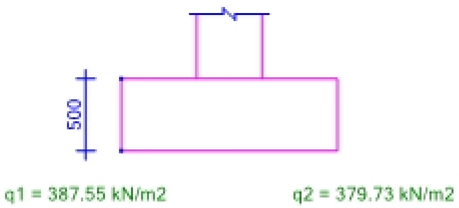
B_X	1500.00 mm
B_Y	1500.00 mm
Height	500.00 mm
Taper Height	0.00 mm

Corner Stresses

Lower-Left Corner	387.55 kN/m2
Lower-Right Corner	379.73 kN/m2
Upper-Right Corner	374.42 kN/m2
Upper-Left Corner	382.23 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	559.3 kN	2.2 kN	1.0 kN	-2.6 kN.m	-1.5 kN.m
Comb #2	801.9 kN	3.2 kN	1.5 kN	-3.8 kN.m	-2.2 kN.m
Comb #3	701.3 kN	4.9 kN	3.0 kN	-7.2 kN.m	-4.9 kN.m
Comb #4	572.7 kN	0.2 kN	-0.7 kN	1.2 kN.m	1.4 kN.m
Comb #5	675.6 kN	-3.7 kN	1.3 kN	14.0 kN.m	-2.1 kN.m
Comb #6	666.6 kN	9.0 kN	1.1 kN	-20.4 kN.m	-1.6 kN.m
Comb #7	676.7 kN	2.6 kN	-0.7 kN	-2.9 kN.m	2.9 kN.m
Comb #8	665.5 kN	2.7 kN	3.2 kN	-3.4 kN.m	-6.7 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	1.125	24	27
Soil	:	1.575	18	28.35
Total	:			55.35

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	614.60	-1.54	-1.04	277.74	272.26	268.58	274.05
Comb #2	857.21	-2.20	-1.49	387.55	379.73	374.42	382.23
Comb #3	756.65	-4.77	-3.37	350.76	333.82	321.82	338.76
Comb #4	628.09	1.25	1.06	275.04	279.48	283.26	278.83
Comb #5	730.92	12.14	-1.44	305.83	349.01	343.87	300.70
Comb #6	721.99	-15.84	-1.04	350.89	294.58	290.88	347.19
Comb #7	732.06	-1.64	2.59	323.67	317.83	327.05	332.89
Comb #8	720.85	-2.05	-5.08	333.05	325.76	307.70	315.00

Demand	Capacity	Status
Maximum Soil Stress: 387.55 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	-1.54	614.6	2.5 mm	250 mm	✓
	Y	-1.04	614.6	1.69 mm	250 mm	✓
Comb #2	X	-2.2	857.21	2.56 mm	250 mm	✓
	Y	-1.49	857.21	1.74 mm	250 mm	✓
Comb #3	X	-4.77	756.65	6.3 mm	250 mm	✓
	Y	-3.37	756.65	4.46 mm	250 mm	✓
Comb #4	X	1.25	628.09	1.98 mm	250 mm	✓
	Y	1.06	628.09	1.69 mm	250 mm	✓
Comb #5	X	12.14	730.92	16.61 mm	250 mm	✓
	Y	-1.44	730.92	1.98 mm	250 mm	✓
Comb #6	X	-15.84	721.99	21.94 mm	250 mm	✓
	Y	-1.04	721.99	1.44 mm	250 mm	✓
Comb #7	X	-1.64	732.06	2.24 mm	250 mm	✓
	Y	2.59	732.06	3.54 mm	250 mm	✓
Comb #8	X	-2.05	720.85	2.85 mm	250 mm	✓
	Y	-5.08	720.85	7.04 mm	250 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$V_{pd} = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.171$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})^{\wedge}(1/3) + k_1\ \sigma_{cp}$

$k = 1 + (200/d)^{\wedge}(1/2)$

$k = 1.68,$

$\rho_l = (\rho_{lx}\ \rho_{ly})^{\wedge}(1/2) * \rho_f\ ,\ \rho_{lmin} = 0.02$

$\rho_{lx} = 0.0027,\ \rho_{ly} = 0.0027,\ \rho_f = 1,$

$\rho_l = 0.0027,$

$\sigma_{cp} = \Sigma N / L_x L_y = 0.32$ N/mm²

$C_{Rd,c} = 0.12,\ k_1 = 0.10$

$v_{Rd,c1} = 0.41$ N/mm²

$v_{min} = 0.035\ k^{\wedge}(3/2)\ f_{ck}{}^{\wedge}(1/2) + k_1\ \sigma_{cp}$

$v_{min} = 0.41$ N/mm²

$v_{Rd,c} = Max(v_{Rd,c1},\ v_{min}) = 0.41$ N/mm²

$v_{Rdmax} = 0.5\ (0.6\ (1 - (f_{ck} / 250)))\ f_{cd}$

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d,$

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d,$

$u_p = 2(B_{EPx} + B_{EPy}) = 8244$

$B_{EPx} = B_x + 2d_{sect} = 2186$

$B_{EPy} = B_y + 2d_{sect} = 1936$

$d_{sect} = 2d_{eff} = 868$

$V_{pc\text{-}cf} = 2539$ kN

$V_{pc\text{-}ep} = 1701$ kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	614.60	273.16	2538.90	691.17	0.27	1681.74	634.24	0.38
Comb #2	857.21	380.98	2538.90	963.99	0.38	1681.74	884.60	0.53
Comb #3	756.65	336.29	2538.90	850.91	0.34	1681.74	780.82	0.46
Comb #4	628.09	279.15	2538.90	706.34	0.28	1681.74	648.16	0.39
Comb #5	730.92	324.85	2538.90	821.98	0.32	1681.74	754.27	0.45
Comb #6	721.99	320.88	2538.90	811.93	0.32	1681.74	745.06	0.44
Comb #7	732.06	325.36	2538.90	823.25	0.32	1681.74	755.45	0.45
Comb #8	720.85	320.38	2538.90	810.65	0.32	1681.74	743.88	0.44

Comparison at	Demand / Capacity	Status
Effective Perimeter	884.6 kN / 1681.7 kN	√
Column Face	964.0 kN / 2538.9 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	218.21	403.13	√	269.64	403.13	√
Comb #2	304.46	403.13	√	376.21	403.13	√
Comb #3	274.57	403.13	√	338.41	403.13	√
Comb #4	222.55	403.13	√	275.24	403.13	√
Comb #5	274.14	403.13	√	331.16	403.13	√
Comb #6	275.82	403.13	√	330.22	403.13	√
Comb #7	260.88	403.13	√	323.33	403.13	√
Comb #8	259.79	403.13	√	323.19	403.13	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	126.48	403.13	√	181.53	403.13	√
Comb #2	176.48	403.13	√	253.29	403.13	√
Comb #3	159.39	403.13	√	228.30	403.13	√
Comb #4	128.99	403.13	√	185.25	403.13	√
Comb #5	158.91	403.13	√	224.65	403.13	√
Comb #6	159.84	403.13	√	224.63	403.13	√
Comb #7	151.37	403.13	√	217.65	403.13	√
Comb #8	151.04	403.13	√	217.62	403.13	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	304.5 kN / 403.1 kN	√
Column Face in Y-Direction	376.2 kN / 403.1 kN	√
Effective Perimeter in X-Direction	176.5 kN / 403.1 kN	√
Effective Perimeter in Y-Direction	253.3 kN / 403.1 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	573.24	877.50	877.57	877.50
Comb #2	799.85	877.50	1224.46	877.50
Comb #3	722.19	877.50	1103.71	877.50
Comb #4	584.64	877.50	895.55	877.50
Comb #5	720.23	877.50	1086.17	877.50
Comb #6	724.47	877.50	1086.12	877.50
Comb #7	685.92	877.50	1052.16	877.50
Comb #8	684.13	877.50	1052.02	877.50

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	122.4 kN.m	11ϕ16 / 150.0 mm	877.50 mm2/2010.62 mm2	√
Reinforcement Area in Y-Direction	80.0 kN.m	11ϕ16 / 150.0 mm	877.50 mm2/2010.62 mm2	√

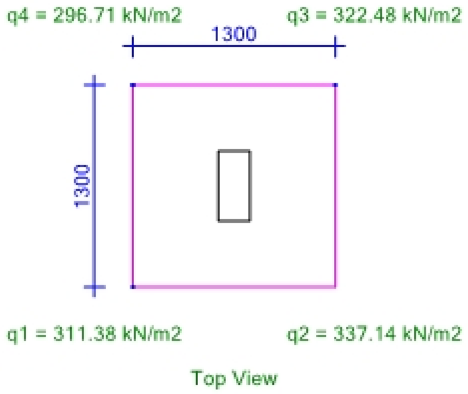
F-1C19 Design Summary

Geometric Properties and Materials

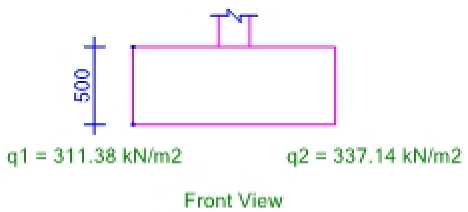
Footing Materials
Concrete Material C20/25
Rebar Material Grade 460 (Type 2)

Geometric Properties
B_X 1300.00 mm
B_Y 1300.00 mm
Height 500.00 mm
Taper Height 0.00 mm

Corner Stresses
Lower-Left Corner 311.38 kN/m2
Lower-Right Corner 337.14 kN/m2
Upper-Right Corner 322.48 kN/m2
Upper-Left Corner 296.71 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	346.0 kN	-2.7 kN	2.4 kN	4.6 kN.m	-3.1 kN.m
Comb #2	494.0 kN	-3.8 kN	3.4 kN	6.6 kN.m	-4.4 kN.m
Comb #3	449.6 kN	-3.8 kN	5.7 kN	6.4 kN.m	-9.0 kN.m
Comb #4	349.4 kN	-2.3 kN	-0.2 kN	4.1 kN.m	1.8 kN.m
Comb #5	419.3 kN	-4.7 kN	3.6 kN	9.3 kN.m	-5.6 kN.m
Comb #6	411.0 kN	-1.7 kN	2.1 kN	1.8 kN.m	-1.8 kN.m
Comb #7	420.8 kN	-3.2 kN	-5.1 kN	5.6 kN.m	17.8 kN.m
Comb #8	409.5 kN	-3.2 kN	10.8 kN	5.5 kN.m	-25.2 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	0.845	24	20.28
Soil	:	1.183	18	21.294
Total	:			41.574

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6\ \Sigma M_x / (L_x L_y^2) - 6\ \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6\ \Sigma M_x / (L_x L_y^2) - 6\ \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6\ \Sigma M_x / (L_x L_y^2) + 6\ \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6\ \Sigma M_x / (L_x L_y^2) + 6\ \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	387.53	3.30	-1.89	225.47	243.48	233.15	215.14
Comb #2	535.61	4.72	-2.68	311.38	337.14	322.48	296.71
Comb #3	491.15	4.53	-6.13	294.98	319.72	286.26	261.52
Comb #4	390.96	2.98	1.74	218.46	234.72	244.22	227.96
Comb #5	460.89	6.99	-3.79	263.98	302.15	281.45	243.29
Comb #6	452.55	0.92	-0.75	267.30	272.35	268.26	263.21
Comb #7	462.37	4.00	15.22	221.10	242.94	326.09	304.25
Comb #8	451.08	3.91	-19.76	310.19	331.57	223.63	202.25

Demand	Capacity	Status
Maximum Soil Stress: 337.14 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	3.3	387.53	8.51 mm	216.67 mm	✓
	Y	-1.89	387.53	4.88 mm	216.67 mm	✓
Comb #2	X	4.72	535.61	8.81 mm	216.67 mm	✓
	Y	-2.68	535.61	5.01 mm	216.67 mm	✓
Comb #3	X	4.53	491.15	9.22 mm	216.67 mm	✓
	Y	-6.13	491.15	12.47 mm	216.67 mm	✓
Comb #4	X	2.98	390.96	7.62 mm	216.67 mm	✓
	Y	1.74	390.96	4.45 mm	216.67 mm	✓
Comb #5	X	6.99	460.89	15.16 mm	216.67 mm	✓
	Y	-3.79	460.89	8.22 mm	216.67 mm	✓
Comb #6	X	0.92	452.55	2.04 mm	216.67 mm	✓
	Y	-0.75	452.55	1.66 mm	216.67 mm	✓
Comb #7	X	4	462.37	8.65 mm	216.67 mm	✓
	Y	15.22	462.37	32.92 mm	216.67 mm	✓
Comb #8	X	3.91	451.08	8.68 mm	216.67 mm	✓
	Y	-19.76	451.08	43.81 mm	216.67 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x\ L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.171$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})$^(1/3) + $k_1\ \sigma_{cp}$

k = 1 + (200/d)^(1/2)

k = 1.68,

$\rho_l = (\rho_{lx}\ \rho_{ly})$^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.0027, ρ_{ly} = 0.0027, ρ_f = 1,

ρ_l = 0.0027,

$\sigma_{cp} = \Sigma N / L_xL_y$ = 0.27 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.41 N/mm²

v_{min} = 0.035 k^(3/2) f_{ck}^(1/2) + $k_1\ \sigma_{cp}$

v_{min} = 0.41 N/mm²

$v_{Rd,c} = Max(v_{Rd,c1}, v_{min})$ = 0.41 N/mm²

$v_{Rdmax} = 0.5\ (0.6\ (1 - (f_{ck} / 250)))\ f_{cd}$

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy})$ = 8244

$B_{EPx} = B_x + 2d_{sect}$ = 1936

$B_{EPy} = B_y + 2d_{sect}$ = 2186

$d_{sect} = 2d_{eff}$ = 868

$V_{pc\text{-}cf}$ = 2539 kN

$V_{pc\text{-}ep}$ = 1679 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	387.53	229.31	2538.90	429.79	0.17	1663.66	682.86	0.41
Comb #2	535.61	316.93	2538.90	594.01	0.23	1663.66	943.78	0.57
Comb #3	491.15	290.62	2538.90	544.71	0.21	1663.66	865.44	0.52
Comb #4	390.96	231.34	2538.90	433.60	0.17	1663.66	688.90	0.41
Comb #5	460.89	272.72	2538.90	511.15	0.20	1663.66	812.13	0.49
Comb #6	452.55	267.78	2538.90	501.90	0.20	1663.66	797.43	0.48
Comb #7	462.37	273.59	2538.90	512.79	0.20	1663.66	814.73	0.49
Comb #8	451.08	266.91	2538.90	500.27	0.20	1663.66	794.83	0.48

Comparison at	Demand / Capacity	Status
Effective Perimeter	943.8 kN / 1663.7 kN	√
Column Face	594.0 kN / 2538.9 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	172.52	349.38	√	132.89	349.38	√
Comb #2	238.84	349.38	√	183.94	349.38	√
Comb #3	223.54	349.38	√	174.41	349.38	√
Comb #4	173.18	349.38	√	133.46	349.38	√
Comb #5	212.91	349.38	√	163.49	349.38	√
Comb #6	194.11	349.38	√	150.02	349.38	√
Comb #7	220.57	349.38	√	178.19	349.38	√
Comb #8	220.74	349.38	√	181.26	349.38	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	103.58	349.38	√	66.70	349.38	√
Comb #2	143.40	349.38	√	92.34	349.38	√
Comb #3	134.93	349.38	√	87.56	349.38	√
Comb #4	103.94	349.38	√	66.94	349.38	√
Comb #5	128.11	349.38	√	82.41	349.38	√
Comb #6	116.26	349.38	√	74.95	349.38	√
Comb #7	134.97	349.38	√	89.38	349.38	√
Comb #8	135.97	349.38	√	90.90	349.38	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	238.8 kN / 349.4 kN	√
Column Face in Y-Direction	183.9 kN / 349.4 kN	√
Effective Perimeter in X-Direction	143.4 kN / 349.4 kN	√
Effective Perimeter in Y-Direction	92.3 kN / 349.4 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	475.87	760.50	283.55	760.50
Comb #2	658.84	760.50	392.53	760.50
Comb #3	619.37	760.50	372.21	760.50
Comb #4	477.56	760.50	284.65	760.50
Comb #5	588.36	760.50	349.86	760.50
Comb #6	534.38	760.50	319.12	760.50
Comb #7	618.11	760.50	380.05	760.50
Comb #8	622.01	760.50	386.54	760.50

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	39.3 kN.m	10ϕ16 / 150.0 mm	760.50 mm2/1742.54 mm2	√
Reinforcement Area in Y-Direction	65.9 kN.m	10ϕ16 / 150.0 mm	760.50 mm2/1742.54 mm2	√

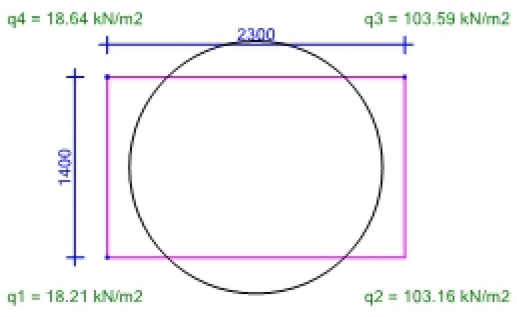
F-1C30 Design Summary

Geometric Properties and Materials

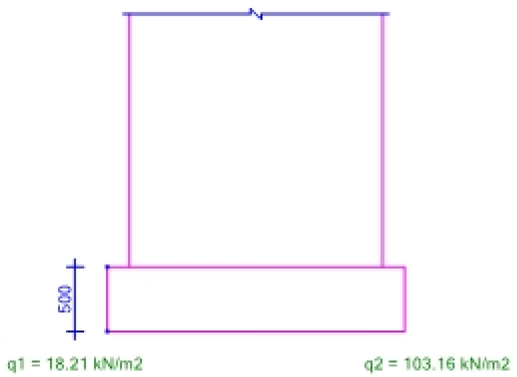
Footing Materials
Concrete Material C20/25
Rebar Material Grade 460 (Type 2)

Geometric Properties
B_X 2300.00 mm
B_Y 1400.00 mm
Height 500.00 mm
Taper Height 0.00 mm

Corner Stresses
Lower-Left Corner 18.21 kN/m2
Lower-Right Corner 103.16 kN/m2
Upper-Right Corner 103.59 kN/m2
Upper-Left Corner 18.64 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	97.0 kN	-0.2 kN	1.2 kN	3.2 kN.m	-0.2 kN.m
Comb #2	136.2 kN	-0.3 kN	1.7 kN	4.6 kN.m	-0.2 kN.m
Comb #3	149.6 kN	-0.1 kN	1.7 kN	2.6 kN.m	-1.9 kN.m
Comb #4	107.6 kN	-0.3 kN	1.1 kN	4.7 kN.m	1.5 kN.m
Comb #5	116.9 kN	-10.1 kN	1.5 kN	37.0 kN.m	-0.5 kN.m
Comb #6	115.8 kN	9.6 kN	1.3 kN	-29.3 kN.m	0.1 kN.m
Comb #7	92.7 kN	-1.1 kN	-13.1 kN	6.3 kN.m	44.3 kN.m
Comb #8	140.0 kN	0.6 kN	15.9 kN	1.4 kN.m	-44.7 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	1.61	24	38.64
Soil	:	2.254	18	40.572
Total	:			79.212

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x\,(h - h_{taper}) + Ecc_1\,N$

$\Sigma M_y = M_y + V_y\,(h - h_{taper}) + Ecc_2\,N$

Corner stresses,

$\sigma_1 = \Sigma N / L_xL_y - 6\,\Sigma M_x / (L_xL_y^2) - 6\,\Sigma M_y / (L_x^2L_y)$

$\sigma_2 = \Sigma N / L_xL_y + 6\,\Sigma M_x / (L_xL_y^2) - 6\,\Sigma M_y / (L_x^2L_y)$

$\sigma_3 = \Sigma N / L_xL_y + 6\,\Sigma M_x / (L_xL_y^2) + 6\,\Sigma M_y / (L_x^2L_y)$

$\sigma_4 = \Sigma N / L_xL_y - 6\,\Sigma M_x / (L_xL_y^2) + 6\,\Sigma M_y / (L_x^2L_y)$

Comb	**ΣN (kN)**	**ΣMx (kN.m)**	**ΣMy (kN.m)**	**σ1 (kN/m2)**	**σ2 (kN/m2)**	**σ3 (kN/m2)**	**σ4 (kN/m2)**
Comb #1	176.18	3.11	0.43	50.23	58.50	59.20	50.93
Comb #2	215.42	4.45	0.64	60.46	72.30	73.34	61.50
Comb #3	228.78	2.50	-1.09	68.60	75.26	73.50	66.84
Comb #4	186.83	4.57	1.98	50.33	62.50	65.71	53.54
Comb #5	196.09	31.91	0.26	18.21	103.16	103.59	18.64
Comb #6	195.05	-24.46	0.78	92.49	27.39	28.66	93.75
Comb #7	171.94	5.78	37.74	15.13	30.52	91.66	76.27
Comb #8	219.21	1.68	-36.69	95.57	100.04	40.58	36.12

Demand	**Capacity**	**Status**
Maximum Soil Stress: 103.59 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	**Direction**	**Moment (kN.m)**	**Axial Load (kN)**	**Eccentricity (M/N)**	**Limit (L/6)**	**Status**
Comb #1	X	3.11	176.18	17.64 mm	383.33 mm	✓
	Y	0.43	176.18	2.47 mm	233.33 mm	✓
Comb #2	X	4.45	215.42	20.64 mm	383.33 mm	✓
	Y	0.64	215.42	2.99 mm	233.33 mm	✓
Comb #3	X	2.5	228.78	10.95 mm	383.33 mm	✓
	Y	-1.09	228.78	4.75 mm	233.33 mm	✓
Comb #4	X	4.57	186.83	24.47 mm	383.33 mm	✓
	Y	1.98	186.83	10.62 mm	233.33 mm	✓
Comb #5	X	31.91	196.09	162.74 mm	383.33 mm	✓
	Y	0.26	196.09	1.35 mm	233.33 mm	✓
Comb #6	X	-24.46	195.05	125.38 mm	383.33 mm	✓
	Y	0.78	195.05	3.99 mm	233.33 mm	✓
Comb #7	X	5.78	171.94	33.62 mm	383.33 mm	✓
	Y	37.74	171.94	219.47 mm	233.33 mm	✓
Comb #8	X	1.68	219.21	7.65 mm	383.33 mm	✓
	Y	-36.69	219.21	167.38 mm	233.33 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x\,L_y$

$A_{eff} = L_xL_y - B_xB_y$

$\beta = 1.111$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})$^(1/3) + $k_1\ \sigma_{cp}$

k = 1 + (200/d)^(1/2)

k = 1.68,

$\rho_l = (\rho_{lx}\ \rho_{ly})$^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.0016, ρ_{ly} = 0.0044, ρ_f = 1,

ρ_l = 0.0027,

$\sigma_{cp} = \Sigma N / L_xL_y$ = 0.07 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.39 N/mm²

v_{min} = 0.035 k^(3/2) f_{ck}^(1/2) + $k_1\ \sigma_{cp}$

v_{min} = 0.39 N/mm²

$v_{Rd,c}$ = Max($v_{Rd,c1}$, v_{min}) = 0.39 N/mm²

v_{Rdmax} = 0.5 (0.6 (1 - (f_{ck} / 250))) f_{cd}

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy})$ = 8744

$B_{EPx} = B_x + 2d_{sect}$ = 2186

$B_{EPy} = B_y + 2d_{sect}$ = 2186

$d_{sect} = 2d_{eff}$ = 868

$V_{pc\text{-}cf}$ = 3515 kN

$V_{pc\text{-}ep}$ = 1694 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	176.18	54.71	3515.40	183.48	0.05	1688.23	94.77	0.06
Comb #2	215.42	66.90	3515.40	224.35	0.06	1688.23	115.88	0.07
Comb #3	228.78	71.05	3515.40	238.27	0.07	1688.23	123.07	0.07
Comb #4	186.83	58.02	3515.40	194.57	0.06	1688.23	100.50	0.06
Comb #5	196.09	60.90	3515.40	204.22	0.06	1688.23	105.49	0.06
Comb #6	195.05	60.57	3515.40	203.14	0.06	1688.23	104.92	0.06
Comb #7	171.94	53.40	3515.40	179.06	0.05	1688.23	92.49	0.05
Comb #8	219.21	68.08	3515.40	228.30	0.06	1688.23	117.92	0.07

Comparison at	Demand / Capacity	Status
Effective Perimeter	123.1 kN / 1688.2 kN	√
Column Face	238.3 kN / 3515.4 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	14.29	618.13	✓	63.15	376.25	✓
Comb #2	17.70	618.13	✓	77.93	376.25	✓
Comb #3	18.16	618.13	✓	80.99	376.25	✓
Comb #4	15.84	618.13	✓	69.53	376.25	✓
Comb #5	25.01	618.13	✓	97.43	376.25	✓
Comb #6	22.62	618.13	✓	90.36	376.25	✓
Comb #7	21.58	618.13	✓	97.29	376.25	✓
Comb #8	23.61	618.13	✓	108.46	376.25	✓

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	0.00	618.13	✓	35.21	376.25	✓
Comb #2	0.00	618.13	✓	43.53	376.25	✓
Comb #3	0.00	618.13	✓	44.98	376.25	✓
Comb #4	0.00	618.13	✓	38.91	376.25	✓
Comb #5	0.00	618.13	✓	57.63	376.25	✓
Comb #6	0.00	618.13	✓	52.83	376.25	✓
Comb #7	0.00	618.13	✓	54.37	376.25	✓
Comb #8	0.00	618.13	✓	60.03	376.25	✓

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	25.0 kN / 618.1 kN	√
Column Face in Y-Direction	108.5 kN / 376.3 kN	√
Effective Perimeter in X-Direction	0.0 kN / 618.1 kN	√
Effective Perimeter in Y-Direction	60.0 kN / 376.3 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	12.32	819.00	151.18	1345.50
Comb #2	15.26	819.00	186.82	1345.50
Comb #3	15.66	819.00	193.33	1345.50
Comb #4	13.66	819.00	166.93	1345.50
Comb #5	21.56	819.00	243.85	1345.50
Comb #6	19.51	819.00	224.16	1345.50
Comb #7	18.76	819.00	233.32	1345.50
Comb #8	20.52	819.00	258.25	1345.50

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	25.8 kN.m	11ϕ16 / 150.0 mm	819.00 mm2/1876.58 mm2	√
Reinforcement Area in Y-Direction	2.2 kN.m	17ϕ16 / 150.0 mm	1345.50 mm2/3082.95 mm2	√

F-1C31 Design Summary

Geometric Properties and Materials

Footing Materials

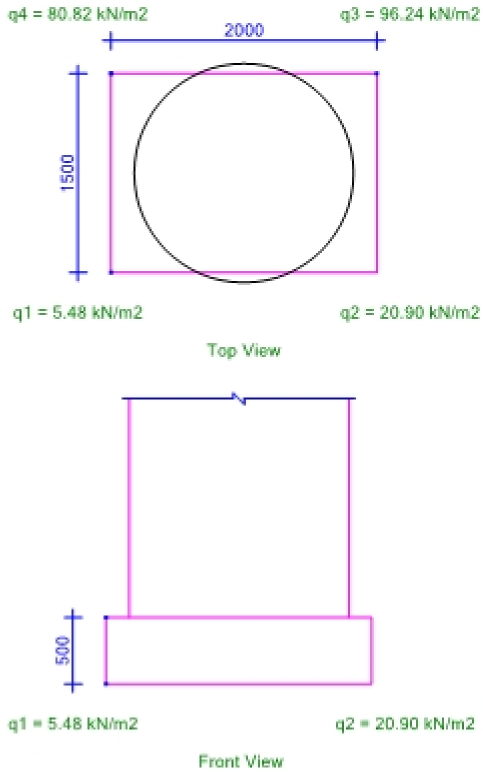
Concrete Material	C20/25
Rebar Material	Grade 460 (Type 2)

Geometric Properties

B_X	2000.00 mm
B_Y	1500.00 mm
Height	500.00 mm
Taper Height	0.00 mm

Corner Stresses

Lower-Left Corner	5.48 kN/m2
Lower-Right Corner	20.90 kN/m2
Upper-Right Corner	96.24 kN/m2
Upper-Left Corner	80.82 kN/m2



Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	65.7 kN	-0.2 kN	-0.3 kN	3.2 kN.m	2.4 kN.m
Comb #2	91.9 kN	-0.3 kN	-0.4 kN	4.6 kN.m	3.4 kN.m
Comb #3	91.9 kN	-0.1 kN	-0.1 kN	2.6 kN.m	1.1 kN.m
Comb #4	91.9 kN	-0.3 kN	-0.4 kN	4.7 kN.m	4.2 kN.m
Comb #5	78.8 kN	-10.1 kN	0.3 kN	37.0 kN.m	1.2 kN.m
Comb #6	78.8 kN	9.6 kN	-0.9 kN	-29.3 kN.m	4.4 kN.m
Comb #7	78.8 kN	-1.1 kN	-12.4 kN	6.3 kN.m	43.9 kN.m
Comb #8	78.8 kN	0.6 kN	11.8 kN	1.4 kN.m	-38.2 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	1.5	24	36
Soil	:	2.1	18	37.8
Total	:			73.8

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	139.45	3.11	2.23	40.11	48.39	52.86	44.57
Comb #2	165.71	4.45	3.21	46.10	57.96	64.37	52.51
Comb #3	165.71	2.50	1.06	50.84	57.52	59.63	52.96
Comb #4	165.71	4.57	3.99	45.15	57.35	65.32	53.13
Comb #5	152.58	31.91	1.37	6.94	92.04	94.78	9.68
Comb #6	152.58	-24.45	3.99	79.47	14.27	22.25	87.45
Comb #7	152.58	5.78	37.67	5.48	20.90	96.24	80.82
Comb #8	152.58	1.68	-32.31	80.93	85.41	20.79	16.31

Demand	Capacity	Status
Maximum Soil Stress: 96.24 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	3.11	139.45	22.29 mm	333.33 mm	✓
	Y	2.23	139.45	16.02 mm	250 mm	✓
Comb #2	X	4.45	165.71	26.84 mm	333.33 mm	✓
	Y	3.21	165.71	19.35 mm	250 mm	✓
Comb #3	X	2.5	165.71	15.11 mm	333.33 mm	✓
	Y	1.06	165.71	6.38 mm	250 mm	✓
Comb #4	X	4.57	165.71	27.6 mm	333.33 mm	✓
	Y	3.99	165.71	24.07 mm	250 mm	✓
Comb #5	X	31.91	152.58	209.14 mm	333.33 mm	✓
	Y	1.37	152.58	8.99 mm	250 mm	✓
Comb #6	X	-24.45	152.58	160.25 mm	333.33 mm	✓
	Y	3.99	152.58	26.15 mm	250 mm	✓
Comb #7	X	5.78	152.58	37.89 mm	333.33 mm	✓
	Y	37.67	152.58	246.89 mm	250 mm	✓
Comb #8	X	1.68	152.58	11 mm	333.33 mm	✓
	Y	-32.31	152.58	211.75 mm	250 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.223$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})$^(1/3) + $k_1\ \sigma_{cp}$

k = 1 + (200/d)^(1/2)

k = 1.68,

$\rho_l = (\rho_{lx}\ \rho_{ly})$^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.002, ρ_{ly} = 0.0036, ρ_f = 1,

ρ_l = 0.0027,

$\sigma_{cp} = \Sigma N / L_x L_y$ = 0.05 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.38 N/mm²

$v_{min} = 0.035\ k$^(3/2) f_{ck}^(1/2) + $k_1\ \sigma_{cp}$

v_{min} = 0.39 N/mm²

$v_{Rd,c}$ = Max($v_{Rd,c1}$, v_{min}) = 0.39 N/mm²

v_{Rdmax} = 0.5 (0.6 (1 - (f_{ck} / 250))) f_{cd}

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy})$ = 8744

$B_{EPx} = B_x + 2d_{sect}$ = 2186

$B_{EPy} = B_y + 2d_{sect}$ = 2186

$d_{sect} = 2d_{eff}$ = 868

$V_{pc\text{-}cf}$ = 3515 kN

$V_{pc\text{-}ep}$ = 1687 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	139.45	46.48	3515.40	159.00	0.05	1684.63	101.09	0.06
Comb #2	165.71	55.24	3515.40	188.94	0.05	1684.63	120.12	0.07
Comb #3	165.71	55.24	3515.40	188.94	0.05	1684.63	120.12	0.07
Comb #4	165.71	55.24	3515.40	188.94	0.05	1684.63	120.12	0.07
Comb #5	152.58	50.86	3515.40	173.97	0.05	1684.63	110.61	0.07
Comb #6	152.58	50.86	3515.40	173.97	0.05	1684.63	110.61	0.07
Comb #7	152.58	50.86	3515.40	173.97	0.05	1684.63	110.61	0.07
Comb #8	152.58	50.86	3515.40	173.97	0.05	1684.63	110.61	0.07

Comparison at	Demand / Capacity	Status
Effective Perimeter	120.1 kN / 1684.6 kN	√
Column Face	188.9 kN / 3515.4 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	13.81	537.50	✓	53.98	403.13	✓
Comb #2	16.81	537.50	✓	65.41	403.13	✓
Comb #3	15.62	537.50	✓	61.39	403.13	✓
Comb #4	17.04	537.50	✓	66.35	403.13	✓
Comb #5	24.83	537.50	✓	83.88	403.13	✓
Comb #6	22.85	537.50	✓	79.85	403.13	✓
Comb #7	24.38	537.50	✓	98.22	403.13	✓
Comb #8	21.66	537.50	✓	88.86	403.13	✓

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	0.00	537.50	✓	32.45	403.13	✓
Comb #2	0.00	537.50	✓	39.40	403.13	✓
Comb #3	0.00	537.50	✓	36.78	403.13	✓
Comb #4	0.00	537.50	✓	39.97	403.13	✓
Comb #5	0.00	537.50	✓	53.62	403.13	✓
Comb #6	0.00	537.50	✓	50.34	403.13	✓
Comb #7	0.00	537.50	✓	59.05	403.13	✓
Comb #8	0.00	537.50	✓	53.00	403.13	✓

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	24.8 kN / 537.5 kN	√
Column Face in Y-Direction	98.2 kN / 403.1 kN	√
Effective Perimeter in X-Direction	0.0 kN / 537.5 kN	√
Effective Perimeter in Y-Direction	59.1 kN / 403.1 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	12.09	877.50	143.04	1170.00
Comb #2	14.72	877.50	173.62	1170.00
Comb #3	13.66	877.50	162.22	1170.00
Comb #4	14.93	877.50	176.13	1170.00
Comb #5	21.72	877.50	233.88	1170.00
Comb #6	20.00	877.50	220.08	1170.00
Comb #7	21.57	877.50	260.31	1170.00
Comb #8	19.15	877.50	233.97	1170.00

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	26.0 kN.m	11ϕ16 / 150.0 mm	877.50 mm2/2010.62 mm2	√
Reinforcement Area in Y-Direction	2.2 kN.m	15ϕ16 / 150.0 mm	1170.00 mm2/2680.83 mm2	√

F-1C20 Design Summary

Geometric Properties and Materials

Footing Materials

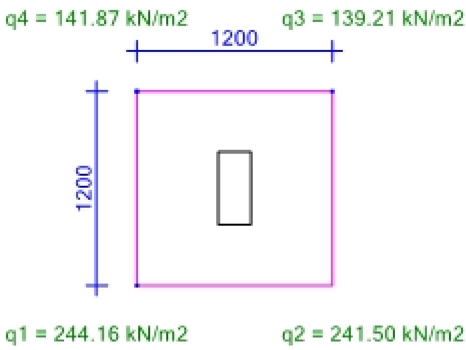
Concrete Material	C20/25
Rebar Material	Grade 460 (Type 2)

Geometric Properties

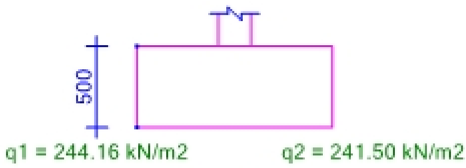
B_X	1200.00 mm
B_Y	1200.00 mm
Height	500.00 mm
Taper Height	0.00 mm

Corner Stresses

Lower-Left Corner	244.16 kN/m2
Lower-Right Corner	241.50 kN/m2
Upper-Right Corner	139.21 kN/m2
Upper-Left Corner	141.87 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	191.0 kN	0.3 kN	1.1 kN	-0.4 kN.m	-1.4 kN.m
Comb #2	270.7 kN	0.5 kN	1.6 kN	-0.5 kN.m	-1.9 kN.m
Comb #3	284.3 kN	0.6 kN	2.4 kN	-0.9 kN.m	-3.7 kN.m
Comb #4	171.5 kN	0.2 kN	0.3 kN	0.0 kN.m	0.5 kN.m
Comb #5	225.2 kN	-1.0 kN	0.9 kN	3.1 kN.m	-0.3 kN.m
Comb #6	233.1 kN	1.8 kN	1.8 kN	-4.0 kN.m	-2.9 kN.m
Comb #7	217.7 kN	0.3 kN	-4.4 kN	-0.3 kN.m	15.0 kN.m
Comb #8	240.6 kN	0.5 kN	7.1 kN	-0.6 kN.m	-18.3 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	0.72	24	17.28
Soil	:	1.008	18	18.144
Total	:			35.424

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_xL_y - 6 \Sigma M_x / (L_xL_y^2) - 6 \Sigma M_y / (L_x^2L_y)$

$\sigma_2 = \Sigma N / L_xL_y + 6 \Sigma M_x / (L_xL_y^2) - 6 \Sigma M_y / (L_x^2L_y)$

$\sigma_3 = \Sigma N / L_xL_y + 6 \Sigma M_x / (L_xL_y^2) + 6 \Sigma M_y / (L_x^2L_y)$

$\sigma_4 = \Sigma N / L_xL_y - 6 \Sigma M_x / (L_xL_y^2) + 6 \Sigma M_y / (L_x^2L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	226.40	-0.19	-0.80	160.66	159.31	153.78	155.13
Comb #2	306.07	-0.27	-1.11	217.35	215.48	207.75	209.62
Comb #3	319.69	-0.54	-2.54	232.71	228.94	211.31	215.08
Comb #4	206.90	0.07	0.62	141.28	141.78	146.08	145.58
Comb #5	260.63	2.63	0.11	171.45	189.75	190.53	172.23
Comb #6	268.56	-3.10	-2.02	204.29	182.76	168.71	190.23
Comb #7	253.16	-0.08	12.82	131.58	131.01	220.03	220.60
Comb #8	276.02	-0.38	-14.73	244.16	241.50	139.21	141.87

Demand	Capacity	Status
Maximum Soil Stress: 244.16 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	-0.19	226.4	0.86 mm	200 mm	✓
	Y	-0.8	226.4	3.52 mm	200 mm	✓
Comb #2	X	-0.27	306.07	0.88 mm	200 mm	✓
	Y	-1.11	306.07	3.64 mm	200 mm	✓
Comb #3	X	-0.54	319.69	1.7 mm	200 mm	✓
	Y	-2.54	319.69	7.94 mm	200 mm	✓
Comb #4	X	0.07	206.9	0.35 mm	200 mm	✓
	Y	0.62	206.9	2.99 mm	200 mm	✓
Comb #5	X	2.63	260.63	10.11 mm	200 mm	✓
	Y	0.11	260.63	0.43 mm	200 mm	✓
Comb #6	X	-3.1	268.56	11.54 mm	200 mm	✓
	Y	-2.02	268.56	7.54 mm	200 mm	✓
Comb #7	X	-0.08	253.16	0.32 mm	200 mm	✓
	Y	12.82	253.16	50.63 mm	200 mm	✓
Comb #8	X	-0.38	276.02	1.39 mm	200 mm	✓
	Y	-14.73	276.02	53.36 mm	200 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_xL_y - B_xB_y$

$\beta = 1.171$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}$ k (100 ρ_l f_{ck})^(1/3) + k_1 σ_{cp}

k = 1 + (200/d)^(1/2)

k = 1.68,

ρ_l = (ρ_{lx} ρ_{ly})^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.0027, ρ_{ly} = 0.0027, ρ_f = 1,

ρ_l = 0.0027,

σ_{cp} = ΣN / L_xL_y = 0.19 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.4 N/mm²

v_{min} = 0.035 k^(3/2) f_{ck}^(1/2) + k_1 σ_{cp}

v_{min} = 0.4 N/mm²

$v_{Rd,c}$ = Max($v_{Rd,c1}$, v_{min}) = 0.4 N/mm²

v_{Rdmax} = 0.5 (0.6 (1 - (f_{ck} / 250))) f_{cd}

V_{pc-cf} = v_{Rdmax} u_p d,

V_{pc-ep} = $v_{Rd,c}$ u_p d,

u_p = 2(B_{EPx} + B_{EPy}) = 8244

B_{EPx} = B_x + 2d_{sect} = 1936

B_{EPy} = B_y + 2d_{sect} = 2186

d_{sect} = 2d_{eff} = 868

V_{pc-cf} = 2539 kN

V_{pc-ep} = 1648 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	226.40	157.22	2538.90	248.63	0.10	1633.95	514.23	0.31
Comb #2	306.07	212.55	2538.90	336.14	0.13	1633.95	695.20	0.43
Comb #3	319.69	222.01	2538.90	351.09	0.14	1633.95	726.14	0.44
Comb #4	206.90	143.68	2538.90	227.22	0.09	1633.95	469.95	0.29
Comb #5	260.63	180.99	2538.90	286.22	0.11	1633.95	591.97	0.36
Comb #6	268.56	186.50	2538.90	294.93	0.12	1633.95	609.99	0.37
Comb #7	253.16	175.80	2538.90	278.02	0.11	1633.95	575.01	0.35
Comb #8	276.02	191.68	2538.90	303.14	0.12	1633.95	626.95	0.38

Comparison at	Demand / Capacity	Status
Effective Perimeter	726.1 kN / 1633.9 kN	√
Column Face	351.1 kN / 2538.9 kN	√

Shear Check

V_{dx-cf} = σ_{cf} d_{vx1} L_y + ((σ_{max} - σ_{cf}) d_{vx1} L_y / 2)

V_{dy-cf} = σ_{cf} d_{vy1} L_x + ((σ_{max} - σ_{cf}) d_{vy1} L_x / 2)

V_{dx-d} = σ_{cf} d_{vx2} L_y + ((σ_{max} - σ_{cf}) d_{vx2} L_y / 2)

V_{dy-d} = σ_{cf} d_{vy2} L_x + ((σ_{max} - σ_{cf}) d_{vy2} L_x / 2)

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	95.70	322.50	√	72.20	322.50	√
Comb #2	129.44	322.50	√	97.68	322.50	√
Comb #3	137.42	322.50	√	104.46	322.50	√
Comb #4	87.11	322.50	√	65.70	322.50	√
Comb #5	114.22	322.50	√	84.45	322.50	√
Comb #6	120.82	322.50	√	90.42	322.50	√
Comb #7	121.23	322.50	√	99.23	322.50	√
Comb #8	133.71	322.50	√	109.68	322.50	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	53.57	322.50	√	31.21	322.50	√
Comb #2	72.47	322.50	√	42.23	322.50	√
Comb #3	77.23	322.50	√	45.19	322.50	√
Comb #4	48.74	322.50	√	28.39	322.50	√
Comb #5	63.76	322.50	√	36.80	322.50	√
Comb #6	67.85	322.50	√	39.43	322.50	√
Comb #7	70.39	322.50	√	42.88	322.50	√
Comb #8	77.76	322.50	√	47.43	322.50	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	137.4 kN / 322.5 kN	√
Column Face in Y-Direction	109.7 kN / 322.5 kN	√
Effective Perimeter in X-Direction	77.8 kN / 322.5 kN	√
Effective Perimeter in Y-Direction	47.4 kN / 322.5 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	239.83	702.00	135.44	702.00
Comb #2	324.42	702.00	183.23	702.00
Comb #3	345.40	702.00	196.02	702.00
Comb #4	218.23	702.00	123.21	702.00
Comb #5	285.63	702.00	159.15	702.00
Comb #6	303.50	702.00	170.48	702.00
Comb #7	312.35	702.00	186.08	702.00
Comb #8	344.93	702.00	205.77	702.00

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	20.6 kN.m	9ϕ16 / 150.0 mm	702.00 mm2/1608.50 mm2	√
Reinforcement Area in Y-Direction	34.5 kN.m	9ϕ16 / 150.0 mm	702.00 mm2/1608.50 mm2	√

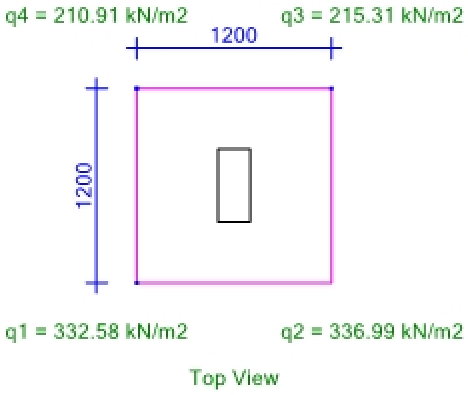
F-1C21 Design Summary

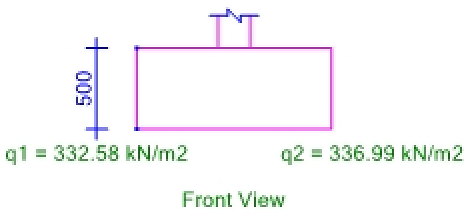
Geometric Properties and Materials

Footing Materials
Concrete Material C20/25
Rebar Material Grade 460 (Type 2)

Geometric Properties
B_X 1200.00 mm
B_Y 1200.00 mm
Height 500.00 mm
Taper Height 0.00 mm

Corner Stresses
Lower-Left Corner 332.58 kN/m2
Lower-Right Corner 336.99 kN/m2
Upper-Right Corner 215.31 kN/m2
Upper-Left Corner 210.91 kN/m2





Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	289.9 kN	-0.4 kN	2.9 kN	0.8 kN.m	-4.2 kN.m
Comb #2	412.2 kN	-0.5 kN	4.1 kN	1.2 kN.m	-6.0 kN.m
Comb #3	394.7 kN	-0.5 kN	4.5 kN	1.0 kN.m	-7.2 kN.m
Comb #4	285.7 kN	-0.3 kN	2.0 kN	0.9 kN.m	-2.3 kN.m
Comb #5	345.7 kN	-2.0 kN	3.1 kN	4.8 kN.m	-4.1 kN.m
Comb #6	350.0 kN	1.1 kN	3.8 kN	-2.8 kN.m	-6.0 kN.m
Comb #7	336.6 kN	-0.5 kN	-2.6 kN	1.1 kN.m	12.2 kN.m
Comb #8	359.1 kN	-0.4 kN	9.5 kN	0.8 kN.m	-22.3 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	0.72	24	17.28
Soil	:	1.008	18	18.144
Total	:			35.424

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	325.28	0.63	-2.75	233.21	237.62	218.56	214.15
Comb #2	447.63	0.91	-3.93	321.36	327.66	300.34	294.05
Comb #3	430.09	0.77	-4.92	313.08	318.44	284.27	278.91
Comb #4	321.10	0.69	-1.31	225.16	229.92	220.81	216.04
Comb #5	381.11	3.81	-2.52	260.20	286.64	269.11	242.67
Comb #6	385.38	-2.28	-4.07	289.67	273.82	245.58	261.44
Comb #7	372.00	0.89	10.93	217.29	223.46	299.38	293.21
Comb #8	394.49	0.63	-17.52	332.58	336.99	215.31	210.91

Demand	Capacity	Status
Maximum Soil Stress: 336.99 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	0.63	325.28	1.95 mm	200 mm	✓
	Y	-2.75	325.28	8.44 mm	200 mm	✓
Comb #2	X	0.91	447.63	2.02 mm	200 mm	✓
	Y	-3.93	447.63	8.79 mm	200 mm	✓
Comb #3	X	0.77	430.09	1.8 mm	200 mm	✓
	Y	-4.92	430.09	11.44 mm	200 mm	✓
Comb #4	X	0.69	321.1	2.14 mm	200 mm	✓
	Y	-1.31	321.1	4.09 mm	200 mm	✓
Comb #5	X	3.81	381.11	9.99 mm	200 mm	✓
	Y	-2.52	381.11	6.62 mm	200 mm	✓
Comb #6	X	-2.28	385.38	5.92 mm	200 mm	✓
	Y	-4.07	385.38	10.55 mm	200 mm	✓
Comb #7	X	0.89	372	2.39 mm	200 mm	✓
	Y	10.93	372	29.39 mm	200 mm	✓
Comb #8	X	0.63	394.49	1.61 mm	200 mm	✓
	Y	-17.52	394.49	44.42 mm	200 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.171$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})$^(1/3) + $k_1\ \sigma_{cp}$

k = 1 + (200/d)^(1/2)

k = 1.68,

$\rho_l = (\rho_{lx}\ \rho_{ly})$^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.0027, ρ_{ly} = 0.0027, ρ_f = 1,

ρ_l = 0.0027,

$\sigma_{cp} = \Sigma N / L_x L_y$ = 0.27 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.41 N/mm²

v_{min} = 0.035 k^(3/2) f_{ck}^(1/2) + $k_1\ \sigma_{cp}$

v_{min} = 0.41 N/mm²

$v_{Rd,c} = \mathrm{Max}(v_{Rd,c1}, v_{min})$ = 0.41 N/mm²

v_{Rdmax} = 0.5 (0.6 (1 - (f_{ck} / 250))) f_{cd}

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy})$ = 8244

$B_{EPx} = B_x + 2d_{sect}$ = 1936

$B_{EPy} = B_y + 2d_{sect}$ = 2186

$d_{sect} = 2d_{eff}$ = 868

$V_{pc\text{-}cf}$ = 2539 kN

$V_{pc\text{-}ep}$ = 1682 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	325.28	225.89	2538.90	357.22	0.14	1662.25	738.82	0.44
Comb #2	447.63	310.85	2538.90	491.59	0.19	1662.25	1016.72	0.61
Comb #3	430.09	298.68	2538.90	472.34	0.19	1662.25	976.89	0.59
Comb #4	321.10	222.98	2538.90	352.64	0.14	1662.25	729.33	0.44
Comb #5	381.11	264.66	2538.90	418.54	0.16	1662.25	865.63	0.52
Comb #6	385.38	267.63	2538.90	423.24	0.17	1662.25	875.35	0.53
Comb #7	372.00	258.34	2538.90	408.54	0.16	1662.25	844.95	0.51
Comb #8	394.49	273.95	2538.90	433.23	0.17	1662.25	896.02	0.54

Comparison at	Demand / Capacity	Status
Effective Perimeter	1016.7 kN / 1662.2 kN	√
Column Face	491.6 kN / 2538.9 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	140.19	322.50	√	106.62	322.50	√
Comb #2	193.18	322.50	√	147.00	322.50	√
Comb #3	186.79	322.50	√	142.92	322.50	√
Comb #4	136.81	322.50	√	103.13	322.50	√
Comb #5	169.79	322.50	√	127.13	322.50	√
Comb #6	170.27	322.50	√	129.24	322.50	√
Comb #7	170.14	322.50	√	134.29	322.50	√
Comb #8	186.99	322.50	√	151.34	322.50	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	78.81	322.50	√	46.14	322.50	√
Comb #2	108.64	322.50	√	63.61	322.50	√
Comb #3	105.28	322.50	√	61.83	322.50	√
Comb #4	76.62	322.50	√	44.63	322.50	√
Comb #5	95.28	322.50	√	55.38	322.50	√
Comb #6	95.88	322.50	√	56.10	322.50	√
Comb #7	97.28	322.50	√	58.12	322.50	√
Comb #8	108.09	322.50	√	65.45	322.50	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	193.2 kN / 322.5 kN	√
Column Face in Y-Direction	151.3 kN / 322.5 kN	√
Effective Perimeter in X-Direction	108.6 kN / 322.5 kN	√
Effective Perimeter in Y-Direction	65.5 kN / 322.5 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	352.46	702.00	200.11	702.00
Comb #2	485.79	702.00	275.91	702.00
Comb #3	470.54	702.00	268.21	702.00
Comb #4	342.99	702.00	193.58	702.00
Comb #5	426.31	702.00	239.53	702.00
Comb #6	428.63	702.00	243.02	702.00
Comb #7	433.26	702.00	252.06	702.00
Comb #8	480.14	702.00	283.95	702.00

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	28.4 kN.m	9ϕ16 / 150.0 mm	702.00 mm2/1608.50 mm2	√
Reinforcement Area in Y-Direction	48.6 kN.m	9ϕ16 / 150.0 mm	702.00 mm2/1608.50 mm2	√

F-1C22 Design Summary

Geometric Properties and Materials

Footing Materials

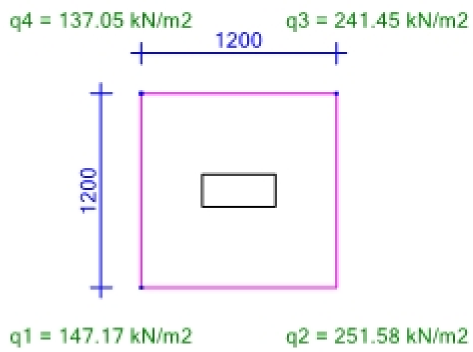
Concrete Material	C20/25
Rebar Material	Grade 460 (Type 2)

Geometric Properties

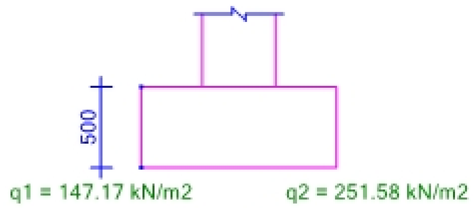
B_X	1200.00 mm
B_Y	1200.00 mm
Height	500.00 mm
Taper Height	0.00 mm

Corner Stresses

Lower-Left Corner	147.17 kN/m2
Lower-Right Corner	251.58 kN/m2
Upper-Right Corner	241.45 kN/m2
Upper-Left Corner	137.05 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	204.7 kN	-0.1 kN	1.2 kN	1.3 kN.m	-1.9 kN.m
Comb #2	291.5 kN	-0.2 kN	1.7 kN	1.8 kN.m	-2.7 kN.m
Comb #3	288.8 kN	0.8 kN	2.4 kN	-0.5 kN.m	-4.0 kN.m
Comb #4	190.5 kN	-1.1 kN	0.4 kN	3.4 kN.m	-0.4 kN.m
Comb #5	244.4 kN	-6.4 kN	1.4 kN	18.2 kN.m	-2.2 kN.m
Comb #6	246.9 kN	6.1 kN	1.5 kN	-15.2 kN.m	-2.4 kN.m
Comb #7	242.0 kN	-0.4 kN	-0.1 kN	2.2 kN.m	1.8 kN.m
Comb #8	249.2 kN	0.1 kN	3.0 kN	0.8 kN.m	-6.3 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	0.72	24	17.28
Soil	:	1.008	18	18.144
Total	:			35.424

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	240.11	1.21	-1.29	167.02	175.44	166.46	158.04
Comb #2	326.88	1.74	-1.84	227.35	239.44	226.65	214.56
Comb #3	324.23	-0.06	-2.77	234.97	234.56	215.34	215.75
Comb #4	225.88	2.80	-0.22	147.88	167.35	165.84	146.37
Comb #5	279.81	15.03	-1.46	147.17	251.58	241.45	137.05
Comb #6	282.28	-12.12	-1.65	243.85	159.65	148.21	232.41
Comb #7	277.42	2.05	1.73	179.52	193.75	205.78	191.55
Comb #8	284.67	0.86	-4.84	211.50	217.48	183.88	177.90

Demand	Capacity	Status
Maximum Soil Stress: 251.58 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	1.21	240.11	5.05 mm	200 mm	✓
	Y	-1.29	240.11	5.39 mm	200 mm	✓
Comb #2	X	1.74	326.88	5.33 mm	200 mm	✓
	Y	-1.84	326.88	5.63 mm	200 mm	✓
Comb #3	X	-0.06	324.23	0.18 mm	200 mm	✓
	Y	-2.77	324.23	8.54 mm	200 mm	✓
Comb #4	X	2.8	225.88	12.41 mm	200 mm	✓
	Y	-0.22	225.88	0.96 mm	200 mm	✓
Comb #5	X	15.03	279.81	53.73 mm	200 mm	✓
	Y	-1.46	279.81	5.21 mm	200 mm	✓
Comb #6	X	-12.12	282.28	42.95 mm	200 mm	✓
	Y	-1.65	282.28	5.84 mm	200 mm	✓
Comb #7	X	2.05	277.42	7.38 mm	200 mm	✓
	Y	1.73	277.42	6.25 mm	200 mm	✓
Comb #8	X	0.86	284.67	3.03 mm	200 mm	✓
	Y	-4.84	284.67	17 mm	200 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.171$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})$^(1/3) + $k_1\ \sigma_{cp}$

k = 1 + (200/d)^(1/2)

k = 1.68,

$\rho_l = (\rho_{lx}\ \rho_{ly})$^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.0027, ρ_{ly} = 0.0027, ρ_f = 1,

ρ_l = 0.0027,

$\sigma_{cp} = \Sigma N / L_x L_y$ = 0.2 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.4 N/mm²

$v_{min} = 0.035\ k$^(3/2) f_{ck}^(1/2) + $k_1\ \sigma_{cp}$

v_{min} = 0.4 N/mm²

$v_{Rd,c} = Max(v_{Rd,c1}, v_{min})$ = 0.4 N/mm²

$v_{Rdmax} = 0.5\ (0.6\ (1 - (f_{ck} / 250)))\ f_{cd}$

$V_{pc-cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc-ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy})$ = 8244

$B_{EPx} = B_x + 2d_{sect}$ = 2186

$B_{EPy} = B_y + 2d_{sect}$ = 1936

$d_{sect} = 2d_{eff}$ = 868

V_{pc-cf} = 2539 kN

V_{pc-ep} = 1651 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	240.11	166.74	2538.90	263.69	0.10	1637.87	545.37	0.33
Comb #2	326.88	227.00	2538.90	358.99	0.14	1637.87	742.47	0.45
Comb #3	324.23	225.16	2538.90	356.07	0.14	1637.87	736.43	0.45
Comb #4	225.88	156.86	2538.90	248.06	0.10	1637.87	513.04	0.31
Comb #5	279.81	194.31	2538.90	307.29	0.12	1637.87	635.55	0.39
Comb #6	282.28	196.03	2538.90	310.00	0.12	1637.87	641.15	0.39
Comb #7	277.42	192.65	2538.90	304.67	0.12	1637.87	630.12	0.38
Comb #8	284.67	197.69	2538.90	312.63	0.12	1637.87	646.58	0.39

Comparison at	Demand / Capacity	Status
Effective Perimeter	742.5 kN / 1637.9 kN	√
Column Face	359.0 kN / 2538.9 kN	√

Shear Check

$V_{dx-cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy-cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx-d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy-d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	78.32	322.50	√	104.21	322.50	√
Comb #2	106.85	322.50	√	142.15	322.50	√
Comb #3	104.39	322.50	√	140.93	322.50	√
Comb #4	75.20	322.50	√	97.98	322.50	√
Comb #5	112.50	322.50	√	137.90	322.50	√
Comb #6	108.93	322.50	√	135.78	322.50	√
Comb #7	91.76	322.50	√	121.69	322.50	√
Comb #8	95.50	322.50	√	129.74	322.50	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	32.32	322.50	√	60.08	322.50	√
Comb #2	44.10	322.50	√	81.97	322.50	√
Comb #3	43.20	322.50	√	80.91	322.50	√
Comb #4	30.91	322.50	√	56.83	322.50	√
Comb #5	46.37	322.50	√	82.34	322.50	√
Comb #6	44.93	322.50	√	80.51	322.50	√
Comb #7	37.89	322.50	√	70.28	322.50	√
Comb #8	39.79	322.50	√	74.65	322.50	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	112.5 kN / 322.5 kN	√
Column Face in Y-Direction	142.2 kN / 322.5 kN	√
Effective Perimeter in X-Direction	46.4 kN / 322.5 kN	√
Effective Perimeter in Y-Direction	82.3 kN / 322.5 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	147.24	702.00	261.41	702.00
Comb #2	200.91	702.00	356.65	702.00
Comb #3	196.57	702.00	352.38	702.00
Comb #4	141.07	702.00	246.97	702.00
Comb #5	211.38	702.00	355.62	702.00
Comb #6	204.74	702.00	348.23	702.00
Comb #7	172.57	702.00	305.71	702.00
Comb #8	180.54	702.00	324.97	702.00

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	35.7 kN.m	9ϕ16 / 150.0 mm	702.00 mm2/1608.50 mm2	√
Reinforcement Area in Y-Direction	21.1 kN.m	9ϕ16 / 150.0 mm	702.00 mm2/1608.50 mm2	√

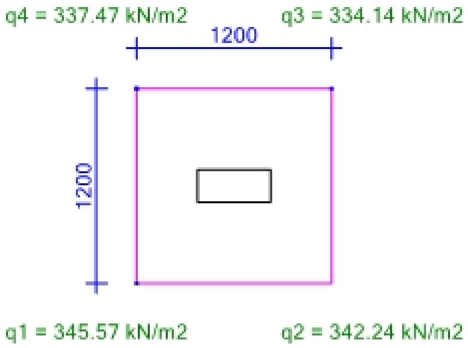
F-1C23 Design Summary

Geometric Properties and Materials

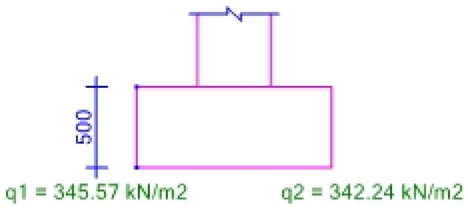
Footing Materials
Concrete Material C20/25
Rebar Material Grade 460 (Type 2)

Geometric Properties
B_X 1200.00 mm
B_Y 1200.00 mm
Height 500.00 mm
Taper Height 0.00 mm

Corner Stresses
Lower-Left Corner 345.57 kN/m2
Lower-Right Corner 342.24 kN/m2
Upper-Right Corner 334.14 kN/m2
Upper-Left Corner 337.47 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	318.1 kN	1.2 kN	0.8 kN	-0.9 kN.m	-1.2 kN.m
Comb #2	454.0 kN	1.7 kN	1.2 kN	-1.4 kN.m	-1.7 kN.m
Comb #3	292.5 kN	-0.3 kN	0.5 kN	1.4 kN.m	-0.8 kN.m
Comb #4	444.0 kN	3.1 kN	1.4 kN	-3.6 kN.m	-2.0 kN.m
Comb #5	385.1 kN	-4.6 kN	1.0 kN	15.3 kN.m	-1.5 kN.m
Comb #6	378.4 kN	7.6 kN	1.0 kN	-17.6 kN.m	-1.5 kN.m
Comb #7	401.8 kN	1.1 kN	-0.8 kN	-0.3 kN.m	3.1 kN.m
Comb #8	361.7 kN	1.8 kN	2.8 kN	-2.0 kN.m	-6.0 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	0.72	24	17.28
Soil	:	1.008	18	18.144
Total	:			35.424

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_xL_y - 6\ \Sigma M_x / (L_xL_y^2) - 6\ \Sigma M_y / (L_x^2L_y)$

$\sigma_2 = \Sigma N / L_xL_y + 6\ \Sigma M_x / (L_xL_y^2) - 6\ \Sigma M_y / (L_x^2L_y)$

$\sigma_3 = \Sigma N / L_xL_y + 6\ \Sigma M_x / (L_xL_y^2) + 6\ \Sigma M_y / (L_x^2L_y)$

$\sigma_4 = \Sigma N / L_xL_y - 6\ \Sigma M_x / (L_xL_y^2) + 6\ \Sigma M_y / (L_x^2L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	353.55	-0.34	-0.82	249.52	247.19	241.52	243.85
Comb #2	489.39	-0.48	-1.17	345.57	342.24	334.14	337.47
Comb #3	327.94	1.25	-0.52	225.22	233.89	230.26	221.59
Comb #4	479.47	-2.02	-1.34	344.62	330.63	321.31	335.30
Comb #5	420.53	13.02	-0.99	250.26	340.66	333.81	243.41
Comb #6	413.83	-13.82	-0.97	338.76	242.75	236.00	332.00
Comb #7	437.24	0.30	2.64	293.40	295.51	313.87	311.76
Comb #8	397.12	-1.11	-4.60	295.61	287.90	255.94	263.65

Demand	Capacity	Status
Maximum Soil Stress: 345.57 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	-0.34	353.55	0.95 mm	200 mm	✓
	Y	-0.82	353.55	2.31 mm	200 mm	✓
Comb #2	X	-0.48	489.39	0.98 mm	200 mm	✓
	Y	-1.17	489.39	2.38 mm	200 mm	✓
Comb #3	X	1.25	327.94	3.81 mm	200 mm	✓
	Y	-0.52	327.94	1.59 mm	200 mm	✓
Comb #4	X	-2.02	479.47	4.2 mm	200 mm	✓
	Y	-1.34	479.47	2.8 mm	200 mm	✓
Comb #5	X	13.02	420.53	30.96 mm	200 mm	✓
	Y	-0.99	420.53	2.35 mm	200 mm	✓
Comb #6	X	-13.82	413.83	33.41 mm	200 mm	✓
	Y	-0.97	413.83	2.35 mm	200 mm	✓
Comb #7	X	0.3	437.24	0.7 mm	200 mm	✓
	Y	2.64	437.24	6.05 mm	200 mm	✓
Comb #8	X	-1.11	397.12	2.79 mm	200 mm	✓
	Y	-4.6	397.12	11.59 mm	200 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x\ L_y$

$A_{eff} = L_xL_y - B_xB_y$

$\beta = 1.171$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})^{(1/3)} + k_1\ \sigma_{cp}$

$k = 1 + (200/d)^{(1/2)}$

$k = 1.68$,

$\rho_l = (\rho_{lx}\ \rho_{ly})^{(1/2)} * \rho_f$, $\rho_{lmin} = 0.02$

$\rho_{lx} = 0.0027$, $\rho_{ly} = 0.0027$, $\rho_f = 1$,

$\rho_l = 0.0027$,

$\sigma_{cp} = \Sigma N / L_x L_y = 0.28$ N/mm²

$C_{Rd,c} = 0.12$, $k_1 = 0.10$

$v_{Rd,c1} = 0.41$ N/mm²

$v_{min} = 0.035\ k^{(3/2)}\ f_{ck}^{(1/2)} + k_1\ \sigma_{cp}$

$v_{min} = 0.41$ N/mm²

$v_{Rd,c} = Max(v_{Rd,c1}, v_{min}) = 0.41$ N/mm²

$v_{Rdmax} = 0.5\ (0.6\ (1 - (f_{ck} / 250)))\ f_{cd}$

$V_{pc-cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc-ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy}) = 8244$

$B_{EPx} = B_x + 2d_{sect} = 2186$

$B_{EPy} = B_y + 2d_{sect} = 1936$

$d_{sect} = 2d_{eff} = 868$

$V_{pc-cf} = 2539$ kN

$V_{pc-ep} = 1683$ kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	353.55	245.52	2538.90	388.28	0.15	1670.34	803.04	0.48
Comb #2	489.39	339.85	2538.90	537.46	0.21	1670.34	1111.58	0.67
Comb #3	327.94	227.74	2538.90	360.15	0.14	1670.34	744.88	0.45
Comb #4	479.47	332.96	2538.90	526.56	0.21	1670.34	1089.04	0.65
Comb #5	420.53	292.03	2538.90	461.83	0.18	1670.34	955.17	0.57
Comb #6	413.83	287.38	2538.90	454.47	0.18	1670.34	939.94	0.56
Comb #7	437.24	303.64	2538.90	480.18	0.19	1670.34	993.12	0.59
Comb #8	397.12	275.78	2538.90	436.12	0.17	1670.34	901.99	0.54

Comparison at	Demand / Capacity	Status
Effective Perimeter	1111.6 kN / 1670.3 kN	√
Column Face	537.5 kN / 2538.9 kN	√

Shear Check

$V_{dx-cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy-cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx-d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy-d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	111.89	322.50	√	149.42	322.50	√
Comb #2	154.94	322.50	√	206.93	322.50	√
Comb #3	104.99	322.50	√	139.25	322.50	√
Comb #4	154.42	322.50	√	205.02	322.50	√
Comb #5	152.82	322.50	√	193.10	322.50	√
Comb #6	151.97	322.50	√	191.25	322.50	√
Comb #7	139.95	322.50	√	188.06	322.50	√
Comb #8	130.78	322.50	√	176.40	322.50	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	46.04	322.50	√	85.84	322.50	√
Comb #2	63.77	322.50	√	118.88	322.50	√
Comb #3	43.18	322.50	√	80.19	322.50	√
Comb #4	63.58	322.50	√	118.11	322.50	√
Comb #5	62.87	322.50	√	113.60	322.50	√
Comb #6	62.52	322.50	√	112.71	322.50	√
Comb #7	57.79	322.50	√	108.01	322.50	√
Comb #8	54.25	322.50	√	101.49	322.50	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	154.9 kN / 322.5 kN	√
Column Face in Y-Direction	206.9 kN / 322.5 kN	√
Effective Perimeter in X-Direction	63.8 kN / 322.5 kN	√
Effective Perimeter in Y-Direction	118.9 kN / 322.5 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	210.04	702.00	373.80	702.00
Comb #2	290.86	702.00	517.66	702.00
Comb #3	197.02	702.00	349.02	702.00
Comb #4	289.96	702.00	514.02	702.00
Comb #5	286.83	702.00	492.16	702.00
Comb #6	285.23	702.00	488.14	702.00
Comb #7	263.22	702.00	470.37	702.00
Comb #8	246.61	702.00	441.81	702.00

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	51.8 kN.m	9ϕ16 / 150.0 mm	702.00 mm2/1608.50 mm2	√
Reinforcement Area in Y-Direction	29.1 kN.m	9ϕ16 / 150.0 mm	702.00 mm2/1608.50 mm2	√

F-1C24 Design Summary

Geometric Properties and Materials

Footing Materials

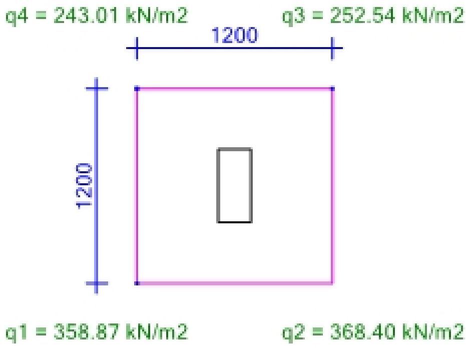
Concrete Material	C20/25
Rebar Material	Grade 460 (Type 2)

Geometric Properties

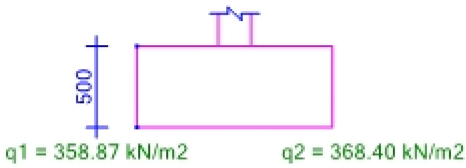
B_X	1200.00 mm
B_Y	1200.00 mm
Height	500.00 mm
Taper Height	0.00 mm

Corner Stresses

Lower-Left Corner	358.87 kN/m2
Lower-Right Corner	368.40 kN/m2
Upper-Right Corner	252.54 kN/m2
Upper-Left Corner	243.01 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	332.3 kN	-0.9 kN	1.7 kN	1.7 kN.m	-2.2 kN.m
Comb #2	474.2 kN	-1.3 kN	2.5 kN	2.5 kN.m	-3.1 kN.m
Comb #3	338.7 kN	-0.3 kN	-0.2 kN	0.8 kN.m	0.7 kN.m
Comb #4	430.3 kN	-1.8 kN	4.2 kN	3.2 kN.m	-5.6 kN.m
Comb #5	400.9 kN	-2.6 kN	2.3 kN	5.8 kN.m	-3.2 kN.m
Comb #6	396.6 kN	0.4 kN	1.9 kN	-1.7 kN.m	-2.0 kN.m
Comb #7	392.7 kN	-1.2 kN	-4.2 kN	2.3 kN.m	15.7 kN.m
Comb #8	404.8 kN	-1.0 kN	8.4 kN	1.9 kN.m	-20.9 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	0.72	24	17.28
Soil	:	1.008	18	18.144
Total	:			35.424

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	367.72	1.28	-1.28	255.34	264.25	255.38	246.48
Comb #2	509.63	1.83	-1.83	353.89	366.62	353.93	341.20
Comb #3	374.09	0.58	0.61	255.65	259.69	263.92	259.88
Comb #4	465.76	2.34	-3.52	327.52	343.80	319.38	303.09
Comb #5	436.30	4.54	-2.03	294.28	325.83	311.70	280.15
Comb #6	432.06	-1.47	-1.03	308.71	298.53	291.38	301.56
Comb #7	428.15	1.71	13.62	244.11	255.96	350.54	338.70
Comb #8	440.21	1.37	-16.68	358.87	368.40	252.54	243.01

Demand	Capacity	Status
Maximum Soil Stress: 368.40 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	1.28	367.72	3.49 mm	200 mm	✓
	Y	-1.28	367.72	3.47 mm	200 mm	✓
Comb #2	X	1.83	509.63	3.6 mm	200 mm	✓
	Y	-1.83	509.63	3.58 mm	200 mm	✓
Comb #3	X	0.58	374.09	1.55 mm	200 mm	✓
	Y	0.61	374.09	1.63 mm	200 mm	✓
Comb #4	X	2.34	465.76	5.03 mm	200 mm	✓
	Y	-3.52	465.76	7.55 mm	200 mm	✓
Comb #5	X	4.54	436.3	10.41 mm	200 mm	✓
	Y	-2.03	436.3	4.66 mm	200 mm	✓
Comb #6	X	-1.47	432.06	3.39 mm	200 mm	✓
	Y	-1.03	432.06	2.38 mm	200 mm	✓
Comb #7	X	1.71	428.15	3.98 mm	200 mm	✓
	Y	13.62	428.15	31.81 mm	200 mm	✓
Comb #8	X	1.37	440.21	3.12 mm	200 mm	✓
	Y	-16.68	440.21	37.9 mm	200 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.171$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}$ k (100 ρ_l f_{ck})^(1/3) + k_1 σ_{cp}

k = 1 + (200/d)^(1/2)

k = 1.68,

ρ_l = (ρ_{lx} ρ_{ly})^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.0027, ρ_{ly} = 0.0027, ρ_f = 1,

ρ_l = 0.0027,

σ_{cp} = ΣN / L_xL_y = 0.31 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.41 N/mm²

v_{min} = 0.035 k^(3/2) f_{ck}^(1/2) + k_1 σ_{cp}

v_{min} = 0.41 N/mm²

$v_{Rd,c}$ = Max($v_{Rd,c1}$, v_{min}) = 0.41 N/mm²

v_{Rdmax} = 0.5 (0.6 (1 - (f_{ck} / 250))) f_{cd}

V_{pc-cf} = v_{Rdmax} u_p d,

V_{pc-ep} = $v_{Rd,c}$ u_p d,

u_p = 2(B_{EPx} + B_{EPy}) = 8244

B_{EPx} = B_x + 2d_{sect} = 1936

B_{EPy} = B_y + 2d_{sect} = 2186

d_{sect} = 2d_{eff} = 868

V_{pc-cf} = 2539 kN

V_{pc-ep} = 1695 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	367.72	255.36	2538.90	403.84	0.16	1674.40	835.23	0.50
Comb #2	509.63	353.91	2538.90	559.68	0.22	1674.40	1157.55	0.69
Comb #3	374.09	259.78	2538.90	410.83	0.16	1674.40	849.69	0.51
Comb #4	465.76	323.45	2538.90	511.51	0.20	1674.40	1057.91	0.63
Comb #5	436.30	302.99	2538.90	479.16	0.19	1674.40	991.00	0.59
Comb #6	432.06	300.04	2538.90	474.50	0.19	1674.40	981.37	0.59
Comb #7	428.15	297.33	2538.90	470.20	0.19	1674.40	972.48	0.58
Comb #8	440.21	305.70	2538.90	483.45	0.19	1674.40	999.88	0.60

Comparison at	Demand / Capacity	Status
Effective Perimeter	1157.6 kN / 1674.4 kN	√
Column Face	559.7 kN / 2538.9 kN	√

Shear Check

V_{dx-cf} = σ_{cf} d_{vx1} L_y + ((σ_{max} - σ_{cf}) d_{vx1} L_y / 2)

V_{dy-cf} = σ_{cf} d_{vy1} L_x + ((σ_{max} - σ_{cf}) d_{vy1} L_x / 2)

V_{dx-d} = σ_{cf} d_{vx2} L_y + ((σ_{max} - σ_{cf}) d_{vx2} L_y / 2)

V_{dy-d} = σ_{cf} d_{vy2} L_x + ((σ_{max} - σ_{cf}) d_{vy2} L_x / 2)

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	157.44	322.50	√	118.29	322.50	√
Comb #2	218.38	322.50	√	164.08	322.50	√
Comb #3	157.82	322.50	√	118.48	322.50	√
Comb #4	203.23	322.50	√	153.57	322.50	√
Comb #5	193.73	322.50	√	144.40	322.50	√
Comb #6	184.33	322.50	√	138.20	322.50	√
Comb #7	198.50	322.50	√	156.91	322.50	√
Comb #8	206.56	322.50	√	165.11	322.50	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	88.13	322.50	√	51.25	322.50	√
Comb #2	122.25	322.50	√	71.10	322.50	√
Comb #3	88.19	322.50	√	51.25	322.50	√
Comb #4	114.15	322.50	√	66.62	322.50	√
Comb #5	108.54	322.50	√	62.93	322.50	√
Comb #6	103.08	322.50	√	59.88	322.50	√
Comb #7	113.68	322.50	√	67.99	322.50	√
Comb #8	118.83	322.50	√	71.49	322.50	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	218.4 kN / 322.5 kN	√
Column Face in Y-Direction	165.1 kN / 322.5 kN	√
Effective Perimeter in X-Direction	122.2 kN / 322.5 kN	√
Effective Perimeter in Y-Direction	71.5 kN / 322.5 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	394.53	702.00	222.18	702.00
Comb #2	547.28	702.00	308.21	702.00
Comb #3	394.99	702.00	222.32	702.00
Comb #4	510.62	702.00	288.65	702.00
Comb #5	485.80	702.00	272.15	702.00
Comb #6	461.57	702.00	259.58	702.00
Comb #7	506.11	702.00	294.73	702.00
Comb #8	528.46	702.00	310.00	702.00

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	31.0 kN.m	9ϕ16 / 150.0 mm	702.00 mm2/1608.50 mm2	√
Reinforcement Area in Y-Direction	54.7 kN.m	9ϕ16 / 150.0 mm	702.00 mm2/1608.50 mm2	√

F-1C25 Design Summary

Geometric Properties and Materials

Footing Materials

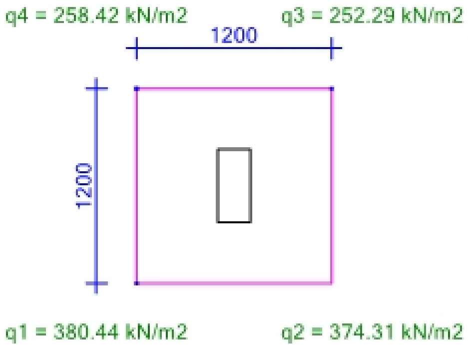
Concrete Material	C20/25
Rebar Material	Grade 460 (Type 2)

Geometric Properties

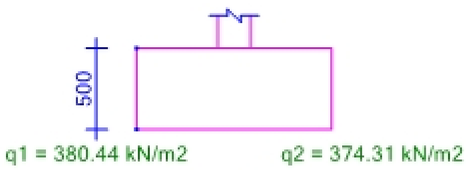
B_X	1200.00 mm
B_Y	1200.00 mm
Height	500.00 mm
Taper Height	0.00 mm

Corner Stresses

Lower-Left Corner	380.44 kN/m2
Lower-Right Corner	374.31 kN/m2
Upper-Right Corner	252.29 kN/m2
Upper-Left Corner	258.42 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	344.1 kN	0.7 kN	2.2 kN	-1.0 kN.m	-2.8 kN.m
Comb #2	490.7 kN	1.0 kN	3.1 kN	-1.4 kN.m	-4.0 kN.m
Comb #3	347.4 kN	0.2 kN	0.2 kN	-0.2 kN.m	0.0 kN.m
Comb #4	450.4 kN	1.4 kN	4.7 kN	-2.0 kN.m	-6.4 kN.m
Comb #5	412.2 kN	-0.6 kN	3.0 kN	2.5 kN.m	-4.5 kN.m
Comb #6	413.8 kN	2.3 kN	2.1 kN	-4.9 kN.m	-2.2 kN.m
Comb #7	405.8 kN	0.8 kN	-3.9 kN	-1.0 kN.m	15.5 kN.m
Comb #8	420.1 kN	0.9 kN	9.1 kN	-1.3 kN.m	-22.1 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	0.72	24	17.28
Soil	:	1.008	18	18.144
Total	:			35.424

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) - 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6 \Sigma M_x / (L_x L_y^2) + 6 \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	379.56	-0.61	-1.69	271.58	267.33	255.59	259.84
Comb #2	526.11	-0.87	-2.41	376.76	370.72	353.95	359.99
Comb #3	382.84	-0.09	0.13	265.71	265.10	266.01	266.62
Comb #4	485.81	-1.34	-4.00	355.89	346.61	318.84	328.13
Comb #5	447.58	2.23	-2.97	313.40	328.87	308.24	292.77
Comb #6	449.21	-3.70	-1.09	328.56	302.88	295.33	321.02
Comb #7	441.21	-0.59	13.51	261.52	257.43	351.28	355.36
Comb #8	455.57	-0.88	-17.57	380.44	374.31	252.29	258.42

Demand	Capacity	Status
Maximum Soil Stress: 380.44 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	-0.61	379.56	1.61 mm	200 mm	✓
	Y	-1.69	379.56	4.45 mm	200 mm	✓
Comb #2	X	-0.87	526.11	1.65 mm	200 mm	✓
	Y	-2.41	526.11	4.59 mm	200 mm	✓
Comb #3	X	-0.09	382.84	0.23 mm	200 mm	✓
	Y	0.13	382.84	0.34 mm	200 mm	✓
Comb #4	X	-1.34	485.81	2.75 mm	200 mm	✓
	Y	-4	485.81	8.23 mm	200 mm	✓
Comb #5	X	2.23	447.58	4.98 mm	200 mm	✓
	Y	-2.97	447.58	6.64 mm	200 mm	✓
Comb #6	X	-3.7	449.21	8.23 mm	200 mm	✓
	Y	-1.09	449.21	2.42 mm	200 mm	✓
Comb #7	X	-0.59	441.21	1.33 mm	200 mm	✓
	Y	13.51	441.21	30.63 mm	200 mm	✓
Comb #8	X	-0.88	455.57	1.94 mm	200 mm	✓
	Y	-17.57	455.57	38.57 mm	200 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.171$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})$^(1/3) + $k_1\ \sigma_{cp}$

k = 1 + (200/d)^(1/2)

k = 1.68,

$\rho_l = (\rho_{lx}\ \rho_{ly})$^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.0027, ρ_{ly} = 0.0027, ρ_f = 1,

ρ_l = 0.0027,

$\sigma_{cp} = \Sigma N / L_x L_y$ = 0.32 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.41 N/mm²

$v_{min} = 0.035\ k$^(3/2) f_{ck}^(1/2) + $k_1\ \sigma_{cp}$

v_{min} = 0.41 N/mm²

$v_{Rd,c} = Max(v_{Rd,c1}, v_{min})$ = 0.41 N/mm²

$v_{Rdmax} = 0.5\ (0.6\ (1 - (f_{ck} / 250)))\ f_{cd}$

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy})$ = 8244

$B_{EPx} = B_x + 2d_{sect}$ = 1936

$B_{EPy} = B_y + 2d_{sect}$ = 2186

$d_{sect} = 2d_{eff}$ = 868

$V_{pc\text{-}cf}$ = 2539 kN

$V_{pc\text{-}ep}$ = 1700 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	379.56	263.59	2538.90	416.84	0.16	1677.79	862.12	0.51
Comb #2	526.11	365.35	2538.90	577.78	0.23	1677.79	1194.98	0.71
Comb #3	382.84	265.86	2538.90	420.44	0.17	1677.79	869.57	0.52
Comb #4	485.81	337.37	2538.90	533.52	0.21	1677.79	1103.44	0.66
Comb #5	447.58	310.82	2538.90	491.54	0.19	1677.79	1016.61	0.61
Comb #6	449.21	311.95	2538.90	493.33	0.19	1677.79	1020.30	0.61
Comb #7	441.21	306.40	2538.90	484.55	0.19	1677.79	1002.15	0.60
Comb #8	455.57	316.37	2538.90	500.31	0.20	1677.79	1034.76	0.62

Comparison at	Demand / Capacity	Status
Effective Perimeter	1195.0 kN / 1677.8 kN	√
Column Face	577.8 kN / 2538.9 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	161.48	322.50	√	121.91	322.50	√
Comb #2	223.96	322.50	√	169.12	322.50	√
Comb #3	159.86	322.50	√	119.94	322.50	√
Comb #4	210.06	322.50	√	159.50	322.50	√
Comb #5	194.74	322.50	√	146.90	322.50	√
Comb #6	196.19	322.50	√	146.05	322.50	√
Comb #7	201.49	322.50	√	159.63	322.50	√
Comb #8	213.01	322.50	√	170.77	322.50	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**	**Demand (kN)**	**Capacity (kN)**	**Status (kN)**
Comb #1	90.47	322.50	√	52.74	322.50	√
Comb #2	125.49	322.50	√	73.16	322.50	√
Comb #3	89.23	322.50	√	51.82	322.50	√
Comb #4	118.07	322.50	√	69.06	322.50	√
Comb #5	109.30	322.50	√	63.73	322.50	√
Comb #6	109.71	322.50	√	63.54	322.50	√
Comb #7	115.32	322.50	√	69.03	322.50	√
Comb #8	122.62	322.50	√	73.88	322.50	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	224.0 kN / 322.5 kN	√
Column Face in Y-Direction	170.8 kN / 322.5 kN	√
Effective Perimeter in X-Direction	125.5 kN / 322.5 kN	√
Effective Perimeter in Y-Direction	73.9 kN / 322.5 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	404.93	702.00	228.77	702.00
Comb #2	561.64	702.00	317.36	702.00
Comb #3	399.75	702.00	224.91	702.00
Comb #4	528.05	702.00	299.47	702.00
Comb #5	489.00	702.00	276.12	702.00
Comb #6	491.27	702.00	274.97	702.00
Comb #7	513.49	702.00	299.48	702.00
Comb #8	545.24	702.00	320.46	702.00

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	32.0 kN.m	9ϕ16 / 150.0 mm	702.00 mm2/1608.50 mm2	√
Reinforcement Area in Y-Direction	56.2 kN.m	9ϕ16 / 150.0 mm	702.00 mm2/1608.50 mm2	√

F-1C26 Design Summary

Geometric Properties and Materials

Footing Materials

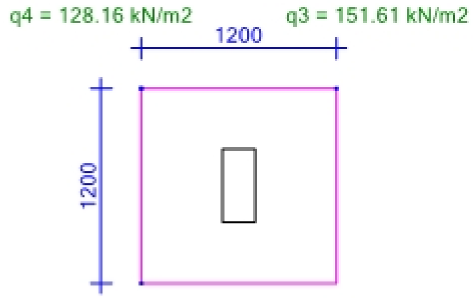
Concrete Material	C20/25
Rebar Material	Grade 460 (Type 2)

Geometric Properties

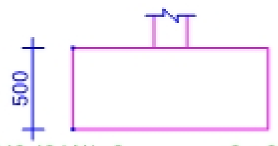
B_X	1200.00 mm
B_Y	1200.00 mm
Height	500.00 mm
Taper Height	0.00 mm

Corner Stresses

Lower-Left Corner	249.43 kN/m2
Lower-Right Corner	272.88 kN/m2
Upper-Right Corner	151.61 kN/m2
Upper-Left Corner	128.16 kN/m2



Top View



Front View

Loading Info

Combinations	N	Vx	Vy	Mx	My
Comb #1	202.5 kN	-2.3 kN	1.5 kN	4.1 kN.m	-1.6 kN.m
Comb #2	287.8 kN	-3.3 kN	2.1 kN	5.9 kN.m	-2.3 kN.m
Comb #3	196.1 kN	-2.0 kN	0.8 kN	3.4 kN.m	-0.9 kN.m
Comb #4	279.9 kN	-3.5 kN	2.6 kN	6.0 kN.m	-2.8 kN.m
Comb #5	245.4 kN	-4.2 kN	2.5 kN	8.4 kN.m	-3.8 kN.m
Comb #6	240.6 kN	-1.5 kN	1.1 kN	1.4 kN.m	-0.1 kN.m
Comb #7	232.6 kN	-2.9 kN	-5.3 kN	5.1 kN.m	18.0 kN.m
Comb #8	253.3 kN	-2.7 kN	8.8 kN	4.7 kN.m	-21.9 kN.m

Soil Stress Check

Total footing, soil and pedestal weight is calculated.

Member		Volume (m3)	Unit Weight (kN/m3)	Weight (kN)
Pad Footing	:	0.72	24	17.28
Soil	:	1.008	18	18.144
Total	:			35.424

In order to calculate total axial load, weights are added to axial loads,

$\Sigma N = N + TW$

Total moments are calculated using the equation below,

$\Sigma M_x = M_x + V_x (h - h_{taper}) + Ecc_1 N$

$\Sigma M_y = M_y + V_y (h - h_{taper}) + Ecc_2 N$

Corner stresses,

$\sigma_1 = \Sigma N / L_x L_y - 6\ \Sigma M_x / (L_x L_y^2) - 6\ \Sigma M_y / (L_x^2 L_y)$

$\sigma_2 = \Sigma N / L_x L_y + 6\ \Sigma M_x / (L_x L_y^2) - 6\ \Sigma M_y / (L_x^2 L_y)$

$\sigma_3 = \Sigma N / L_x L_y + 6\ \Sigma M_x / (L_x L_y^2) + 6\ \Sigma M_y / (L_x^2 L_y)$

$\sigma_4 = \Sigma N / L_x L_y - 6\ \Sigma M_x / (L_x L_y^2) + 6\ \Sigma M_y / (L_x^2 L_y)$

Comb	ΣN (kN)	ΣMx (kN.m)	ΣMy (kN.m)	σ1 (kN/m2)	σ2 (kN/m2)	σ3 (kN/m2)	σ4 (kN/m2)
Comb #1	237.91	2.94	-0.85	157.98	178.38	172.45	152.05
Comb #2	323.25	4.18	-1.20	214.12	243.17	234.84	205.78
Comb #3	231.50	2.45	-0.52	154.09	171.08	167.44	150.45
Comb #4	315.34	4.32	-1.50	209.20	239.21	228.77	198.76
Comb #5	280.80	6.35	-2.51	181.65	225.77	208.35	164.22
Comb #6	276.01	0.70	0.46	187.66	192.49	195.69	190.85
Comb #7	268.05	3.67	15.41	119.87	145.39	252.43	226.91
Comb #8	288.75	3.38	-17.46	249.43	272.88	151.61	128.16

Demand	Capacity	Status
Maximum Soil Stress: 272.88 kN/m2	Allowable Maximum Soil Stress: 420.00 kN/m2	√

Eccentricity Check

Comb	Direction	Moment (kN.m)	Axial Load (kN)	Eccentricity (M/N)	Limit (L/6)	Status
Comb #1	X	2.94	237.91	12.35 mm	200 mm	✓
	Y	-0.85	237.91	3.59 mm	200 mm	✓
Comb #2	X	4.18	323.25	12.94 mm	200 mm	✓
	Y	-1.2	323.25	3.71 mm	200 mm	✓
Comb #3	X	2.45	231.5	10.57 mm	200 mm	✓
	Y	-0.52	231.5	2.27 mm	200 mm	✓
Comb #4	X	4.32	315.34	13.7 mm	200 mm	✓
	Y	-1.5	315.34	4.77 mm	200 mm	✓
Comb #5	X	6.35	280.8	22.63 mm	200 mm	✓
	Y	-2.51	280.8	8.94 mm	200 mm	✓
Comb #6	X	0.7	276.01	2.52 mm	200 mm	✓
	Y	0.46	276.01	1.67 mm	200 mm	✓
Comb #7	X	3.67	268.05	13.71 mm	200 mm	✓
	Y	15.41	268.05	57.5 mm	200 mm	✓
Comb #8	X	3.38	288.75	11.69 mm	200 mm	✓
	Y	-17.46	288.75	60.48 mm	200 mm	✓

Punching Check

Punching force will be calculated according to EN 1992-1-1:2004 (6.4.3)

$Vpd = \sigma_{soil} * A_{eff} * \beta$

$\sigma_{soil} = \Sigma N / L_x L_y$

$A_{eff} = L_x L_y - B_x B_y$

$\beta = 1.171$

Punching capacity will be calculated according to EN 1992-1-1:2004 (6.4.4)

(6.47) $v_{Rd,c1} = C_{Rd,c}\ k\ (100\ \rho_l\ f_{ck})$^(1/3) + $k_1\ \sigma_{cp}$

k = 1 + (200/d)^(1/2)

k = 1.68,

$\rho_l = (\rho_{lx}\ \rho_{ly})$^(1/2) * ρ_f , ρ_{lmin} = 0.02

ρ_{lx} = 0.0027, ρ_{ly} = 0.0027, ρ_f = 1,

ρ_l = 0.0027,

$\sigma_{cp} = \Sigma N / L_xL_y$ = 0.2 N/mm²

$C_{Rd,c}$ = 0.12, k_1 = 0.10

$v_{Rd,c1}$ = 0.4 N/mm²

v_{min} = 0.035 k^(3/2) f_{ck}^(1/2) + $k_1\ \sigma_{cp}$

v_{min} = 0.4 N/mm²

$v_{Rd,c} = Max(v_{Rd,c1}, v_{min})$ = 0.4 N/mm²

$v_{Rdmax} = 0.5\ (0.6\ (1 - (f_{ck} / 250)))\ f_{cd}$

$V_{pc\text{-}cf} = v_{Rdmax}\ u_p\ d$,

$V_{pc\text{-}ep} = v_{Rd,c}\ u_p\ d$,

$u_p = 2(B_{EPx} + B_{EPy})$ = 8244

$B_{EPx} = B_x + 2d_{sect}$ = 1936

$B_{EPy} = B_y + 2d_{sect}$ = 2186

$d_{sect} = 2d_{eff}$ = 868

$V_{pc\text{-}cf}$ = 2539 kN

$V_{pc\text{-}ep}$ = 1652 kN

Comb	ΣN (kN)	σ_{Soil}(kN/m2)	Vpc-cf (kN)	Vpd-cf (kN)	D/C-cf	Vpc-ep (kN)	Vpd-ep (kN)	D/C-ep
Comb #1	237.91	165.21	2538.90	261.27	0.10	1637.24	540.37	0.33
Comb #2	323.25	224.48	2538.90	354.99	0.14	1637.24	734.21	0.45
Comb #3	231.50	160.77	2538.90	254.24	0.10	1637.24	525.83	0.32
Comb #4	315.34	218.98	2538.90	346.31	0.14	1637.24	716.24	0.44
Comb #5	280.80	195.00	2538.90	308.37	0.12	1637.24	637.78	0.39
Comb #6	276.01	191.67	2538.90	303.12	0.12	1637.24	626.91	0.38
Comb #7	268.05	186.15	2538.90	294.38	0.12	1637.24	608.85	0.37
Comb #8	288.75	200.52	2538.90	317.11	0.12	1637.24	655.85	0.40

Comparison at	Demand / Capacity	Status
Effective Perimeter	734.2 kN / 1637.2 kN	√
Column Face	355.0 kN / 2538.9 kN	√

Shear Check

$V_{dx\text{-}cf} = \sigma_{cf}\ d_{vx1}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx1}\ L_y / 2)$

$V_{dy\text{-}cf} = \sigma_{cf}\ d_{vy1}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy1}\ L_x / 2)$

$V_{dx\text{-}d} = \sigma_{cf}\ d_{vx2}\ L_y + ((\sigma_{max} - \sigma_{cf})\ d_{vx2}\ L_y / 2)$

$V_{dy\text{-}d} = \sigma_{cf}\ d_{vy2}\ L_x + ((\sigma_{max} - \sigma_{cf})\ d_{vy2}\ L_x / 2)$

On Column Face,

X-Direction **Y-Direction**

Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	106.29	322.50	√	78.84	322.50	√
Comb #2	144.86	322.50	√	107.39	322.50	√
Comb #3	102.19	322.50	√	75.79	322.50	√
Comb #4	142.22	322.50	√	105.53	322.50	√
Comb #5	133.29	322.50	√	98.50	322.50	√
Comb #6	117.01	322.50	√	87.72	322.50	√
Comb #7	138.08	322.50	√	111.80	322.50	√
Comb #8	148.57	322.50	√	121.15	322.50	√

On "d" Distance Away From Column Face,

		X-Direction			Y-Direction	
Comb	Demand (kN)	Capacity (kN)	Status (kN)	Demand (kN)	Capacity (kN)	Status (kN)
Comb #1	59.49	322.50	√	34.41	322.50	√
Comb #2	81.09	322.50	√	46.89	322.50	√
Comb #3	57.14	322.50	√	33.04	322.50	√
Comb #4	79.68	322.50	√	46.11	322.50	√
Comb #5	74.91	322.50	√	43.31	322.50	√
Comb #6	65.39	322.50	√	37.98	322.50	√
Comb #7	80.35	322.50	√	48.74	322.50	√
Comb #8	86.64	322.50	√	52.74	322.50	√

Comparison at	Demand / Capacity	Status
Column Face in X-Direction	148.6 kN / 322.5 kN	√
Column Face in Y-Direction	121.1 kN / 322.5 kN	√
Effective Perimeter in X-Direction	86.6 kN / 322.5 kN	√
Effective Perimeter in Y-Direction	52.7 kN / 322.5 kN	√

Bending Reinforcement Check

Comb	Md_x (kN.m)	Required As_x (mm2)	Md_y (kN.m)	Required As_y (mm2)
Comb #1	266.33	702.00	148.71	702.00
Comb #2	363.02	702.00	202.62	702.00
Comb #3	255.86	702.00	142.86	702.00
Comb #4	356.64	702.00	199.20	702.00
Comb #5	335.03	702.00	186.62	702.00
Comb #6	292.87	702.00	164.69	702.00
Comb #7	356.34	702.00	210.74	702.00
Comb #8	384.05	702.00	228.18	702.00

Comparison of	Design Moment	Selected Rebar	Required / Provided	Status
Reinforcement Area in X-Direction	22.8 kN.m	9ϕ16 / 150.0 mm	702.00 mm2/1608.50 mm2	√
Reinforcement Area in Y-Direction	38.4 kN.m	9ϕ16 / 150.0 mm	702.00 mm2/1608.50 mm2	√