ASIAN UNIVERSITY FOR WOMEN

REQUEST FOR PROPOSAL (RFP)

Design, Supply, Installation, Testing, and Commissioning of Sewage Treatment Plant (STP), Water Treatment Plant (WTP), and Underground Water Reservoir (UGWR) Fire Protection System for the Academic Building **(Retender)**

Asian University for Women (AUW), Arefin Nagar Campus

Summary Sheet

Name of the company	Asian University for Women
Procurement Reference Number	Package/STP-WTP-UGWR/25_26
Date of issue of the RFP	29 July 2026
Date and Closing Time for RFP submission	18th August July 2026 (12:01 pm) (GMT +6)
Quotation submission mail address	tender175@auw.edu.bd
Address for Communication	**Asian University for Women** 20/A M. M. Ali Road Chattogram 4000, Bangladesh Tel: +880-31-285-4980 Fax: +880-31-285-4988

Bidders are invited to submit their proposals in accordance with the terms outlined in the enclosed Request for Proposal (RFP).

AUW reserves the right to reject any or all offers without providing any reason.

Confidentiality must be strictly maintained. The information provided here should only be used for its intended purpose and scope. By retaining this RFP, you agree to treat all information as confidential.

All communications regarding this Request for Proposal should be directed to AUW, with copies sent to the email addresses listed in the RFP email.

For any further queries, please contact:

- **Primary Point of Contact for RFP Process and Technical Queries:**
  Mohammed Ishrat Bin Mahbub
  Director of Supply Chain Management
  Email: mohammed.mahbub@auw.edu.bd
  Contact Number: +8801926673027; Whatsapp: +8801671470348

Proposals should be submitted only to the following email: tender175@auw.edu.bd
No other AUW email address should be used in the "To," "CC," or "BCC" fields. Any proposal that violates this instruction may be disqualified.

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RFP and Tender Notice

Asian University for Women (AUW) is committed to adhering to the highest standards of financial integrity and management best practices in all aspects of its operations, including RFPs, Tender Notices, and campus construction. We value respect for all, high standards for occupational health and safety, environmental preservation, and equality of men and women as workers and their entitlements for equal wage for equal work. We encourage all our contractors to employ at least 50% women in their workforce. Should anyone notice or otherwise come to know of any practice or incidence of malfeasance, corruption, unlawful or disrespectful treatment or unsafe living or working conditions, avoidable environmental degradation or mismanagement in any form, they may write in full confidentiality to the Secretary of the Board of Trustees. In case of receipt of any such submission with sufficient specificity, an independent agency may investigate the matter and respond to the writer and if appropriate, to the public.

boardsecretary@asian-university.org

AUW is a privately funded independent international university governed by its Board of Trustees with a public service mission. All decisions relating to its management are at the sole discretion of its Board of Trustees.

Thank you for helping AUW achieve the highest ethical and management standards.

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Proposal Summary

Executive Summary

The Asian University for Women (AUW) invites proposals from qualified and experienced firms for the design, supply, installation, testing, and commissioning of a complete **Sewage Treatment Plant (STP), Water Treatment Plant (WTP), and Underground Water Reservoir (UGWR – Fire Protection System)** for its Main Academic Building.

The project aims to deliver reliable, efficient, and fully compliant water management and fire protection infrastructure in accordance with applicable national regulations and international standards. The selected contractor will provide a turnkey solution, ensuring high-quality design, execution, testing, commissioning, and long-term operational performance.

Project Implementation Schedule

The successful bidder shall execute and complete the Works within the timeframe stipulated in the Letter of Award and Contract Agreement. The Contractor shall provide all necessary resources to ensure timely delivery of the project in accordance with the approved implementation schedule.

The indicative project milestones are as follows:

Activity	Duration
Submission and approval of detailed design, shop drawings, and technical documentation	Within 14 working days from the date of award
Procurement, supply, delivery, installation, and system integration	Within 130 working days following design approval
Testing, commissioning, performance verification, and operator training	Within 16 working days following completion of installation
Total Contract Completion Period	**160 working days from the date of Contract Signing**

The Contractor shall promptly notify AUW of any circumstances that may affect the approved schedule and shall implement appropriate mitigation measures to avoid delays. Any extension of time shall be subject to AUW's prior written approval.

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Proposal Evaluation Methodology

All proposals will be evaluated in accordance with the Asian University for Women (AUW) procurement policies and established evaluation procedures. The assessment process will be based on a combined technical and commercial evaluation to ensure the selection of the most qualified and value-driven bidder.

The evaluation criteria and corresponding weightings are as follows:

Evaluation Criteria	Weighting
Technical Compliance and Proposed Solution	70%
Financial Proposal and Commercial Competitiveness	30%
Total	**100%**

Only proposals that substantially comply with the technical requirements and performance specifications may be considered for final evaluation. AUW reserves the right to seek clarifications, verify submitted information, and conduct reference checks as part of the evaluation process.

The contract will be awarded to the bidder whose proposal is determined to be the most advantageous to AUW, offering the optimum balance of technical merit, demonstrated capability, quality, lifecycle value, and commercial competitiveness.

Warranty and Post-Installation Support

The Contractor shall provide a comprehensive warranty for a minimum period of one (1) year, in accordance with Section 4, ITA 2.7, covering all materials, equipment, components, workmanship, and system performance.

During the warranty period, the Contractor shall perform all required preventive and corrective maintenance services at no additional cost to AUW. Any defects, malfunctions, or performance deficiencies identified during this period shall be promptly rectified to ensure uninterrupted and reliable operation of the systems.

The Contractor shall also maintain adequate availability of qualified service personnel, technical support, and essential spare parts throughout the warranty period to ensure timely response and effective maintenance services.

Training and Handover

Upon completion, the contractor shall conduct a comprehensive training session for AUW's designated staff on system operation, troubleshooting, and maintenance. The contractor shall submit the following documents prior to handover:

- As-built drawings
- Operation and Maintenance (O&M) manuals
- Test reports and commissioning certificates
- Warranty certificates

Confidentiality and Compliance

The Contractor shall maintain strict confidentiality of all information, drawings, reports, and documents provided by AUW.

All design, supply, installation, testing, commissioning, and associated works related to the Sewage Treatment Plant (STP), Water Treatment Plant (WTP), Underground Water Reservoir (UGWR), and connected utility systems shall comply with the latest editions of the Bangladesh National Building Code (BNBC), Bangladesh Environment Conservation Act (BECA) and Environment Conservation Rules (ECR), Department of Environment (DoE) requirements, Bangladesh Water Act, applicable BSTI drinking water quality standards, WHO Drinking Water Quality Guidelines, NFPA standards, IEC standards, and relevant ASTM/ISO standards. Treated sewage effluent quality shall meet the discharge limits prescribed by the Department of Environment (DoE), Government of Bangladesh, and potable water produced by the WTP shall comply with BSTI and WHO drinking water quality requirements.

The design and construction of UGWRs, water supply systems, drainage systems, treatment facilities, ventilation, electrical installations, and fire protection provisions shall conform to the requirements of BNBC and applicable local authority regulations. Fire detection, fire suppression, emergency access, and life-safety provisions shall comply with BNBC and NFPA requirements.

The Contractor shall be solely responsible for obtaining all required approvals, permits, clearances, inspections, and no-objection certificates from the relevant authorities, including but not limited to the Department of Environment (DoE), Chattogram Development Authority (CDA) where applicable, Chattogram WASA, Fire Service and Civil Defence (FSCD), and other statutory agencies. The Contractor shall also ensure environmental protection, occupational health and safety, and public safety throughout the execution of the works.

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Scope of Work

The scope of work should be updated to focus on the (STP, WTP, UGWR (Fire). The CONTRACTOR shall be responsible for the complete execution design, supply, installation, testing, commissioning, and handover of the (STP, WTP, UGWR (Fire) in accordance with international codes and standards. The scope includes, but is not limited to, the following:

1. Site Assessment and Mobilization

- Conduct site visits and assessments as required.
- Mobilize resources and set up utility service connections for the site office (if required).

2. Design and Documentation

- Prepare design drawings and obtain approval from relevant authorities.
- Develop shop drawings (Civil, Structural, MEP) based on the GFC layout and obtain approval from the Client and Consultant before execution.
- Submit an execution schedule that accounts for both imported and local materials.
- Submit material samples (from the approved BOQ brand list) for approval.
- Prepare all required documentation, including as-built drawings, calculations, and handover documents, in compliance with relevant codes.

3. Supply and Installation

- Provision and installation of equipment and accessories as per drawings and specifications.
- Include any necessary electrical, mechanical, civil, or other items not explicitly covered in the supporting BOQ or technical specifications.
- Manage on-site storage of both imported and local materials, with proper records maintained by the storekeeper.
- Execute work strictly in accordance with approved shop drawings.

4. Testing, Commissioning, and Balancing

- Perform testing, commissioning, and balancing of all installed (STP, WTP, UGWR (Fire).
- Ensure quality and compliance with all relevant codes and standards.
- Provide valid calibration certificates for all testing equipment used, attached with the test report.

5. Technical Team Assignment

- Assign a dedicated technical team (Project Manager, Project Engineer, Safety Officer, etc.) to be continuously available throughout execution.

6. Reporting and Progress Monitoring

- Prepare and submit supporting documents, including:
    - Daily field reports
    - Monthly progress reports

- Material inspection reports
- Requests for inspection throughout execution

7. Post-Handover Documentation and Training

- Prepare and submit all post-handover documentation for the (STP, WTP, UGWR (Fire) including:
  - Operation & Maintenance (O&M) Manuals
  - As-built drawings
  - Warranties
  - Commissioning reports and test certificates
  - Training manuals
  - Spare parts lists
- Conduct training for client personnel on all installed systems.

8. General & Additional Scope of Works

- The Contractor shall prepare detailed shop drawings (Civil, Structural, MEP) based on the GFC drawings and actual site conditions and obtain approval from the PMC and Client prior to commencement of work at site. If the Contractor considers that any required item is missing from the GFC drawings, such items may be included in the BOQ. In such cases, a separate note shall be clearly mentioned in the remarks section.
- Submit the actual execution schedule, taking into account both imported and local materials.
- Prepare documentation works including as-built drawings and handover documents, testing, pre-commissioning, post commissioning and all types of calculation in compliance with relevant codes upon completion of execution.
- Submit material samples based on the brand list for approval by the client's technical team and consultant.
- Manage on-site storage for imported and local materials with proper record by the store keeper.
- Include any necessary items (i.e, electrical. mechanical, civil, etc.) which is not included in the supporting BOQ and technical specifications should be considered in the shop drawings before execution.
- Execution works must be carried out in accordance with the approved shop drawings & related GFC drawings.
- Assign a dedicated technical team/engineers (i.e, Project Manager, Project Engineer, Safety Officer etc.) to be continuously available during execution.
- Ensure the quality of execution meets all compliance and code requirements.
- Prepare and submit all necessary supporting documents such as daily field reports, monthly progress reports, material inspection reports, and requests for inspection throughout the execution period.
- Prepare post-handover documents for STP, WTP, UGWR (MEP & Civil) systems include Operation & Maintenance (O&M) Manuals, as-built drawings, warranties, commissioning reports, test certificates, training manuals, and spare parts lists for all installed systems.
- The contractor will perform the temporary generator installation and termination to facilitate the ant testing and commissioning of the overall working scope with their own cost.
- If any item brands are missing from the BOQ the contractor shall follow the country of origin in the technical specifications when selecting product brands.

- All foreign and local items must undergo factory inspection with necessary test either locally or abroad by the engineers, consultant, and client prior to shipment or delivery.
- The contractor shall be responsible for obtaining approval and the required inspections by DOE.
- All testing equipment's must have a valid calibration certificate.
- The attic stock should be calculated as 2% of the total quantity of materials installed, to be provided after project handover.
- During execution, if any core cutting/punches is required, the contractor shall be responsible for any leakage that occurs after the work is completed. The contractor must ensure that all core cutting is properly sealed and leak-proof.
- Any **substandard work**, use of **unapproved materials**, or **non-compliance with QC policies** will attract a **hefty penalty**, deducted from the R/A bill against the issued NCR.
- The contractor shall ensure the STP, WTP, UGWR (Fire) works for academic building is fully operational after completing all works, tests, commissioning activities, and required certifications.
- The contractor must comply with all **EHS (Environment, Health & Safety)** policies and standards.
- If any technical personnel are deemed unsuitable by the Client/Consultant, they must be replaced immediately.
- The contractor shall submit an **RFI** (Request for Information) for drawings/decisions with at least **two weeks' lead time** for consultant feedback.
- The contractor must maintain the site in a **neat and clean condition**. Debris shall be disposed of at designated areas, and a **separate team** must be deployed for curing works.
- The contractor shall submit a detailed **Work Method Statement (WMS)**.
- Any faulty & defective work will be done by contractor shall be rectified by contractor with his own cost.
- Contractor will carry out free of cost maintenance & servicing for 24 months from the date of handover.
- Contractor will submit the technical specifications & catalogue of materials.
- Contractor must take approval of material from PMC & CLIENT prior mass delivery to project
- All gradient, level, slope etc. of different element with sections/sketch should clearly mention in shop drawing Considering the GFC drawings and actual site conditions Any information or issue that could potentially hinder the progress of work must be brought to the attention of the PMC and client at least 14 days in advance.
- Require material sourcing transparency: submit certificates, delivery notes, and sample approvals
- Contractor must submit the method statement before commencing of the work
- Contractor shall take necessary precautions to protect existing buildings, utilities, and infrastructure during work execution.
- Contractor is responsible for any road cutting issues for connectivity with academic building.
- The contractor shall provide 2 sets of shop drawings (A1), 2 sets of as-built drawings (A1 and A2), and 2 sets in A3 size. All documents, calculations, operation manuals, maintenance checklists, and color images of approved samples shall be submitted in one A3 set and one A4 set.
- The Client/PMC reserves the right to instruct third-party testing at any stage. Costs shall be borne by the Contractor.
- The contractor shall be fully responsible for obtaining all approvals, clearances, and compliance with relevant authority requirements with his own cost. prior, during and after execution of work
- FAT and SAT to be conducted
- Contractor will train to client personnel for smooth operation of STP, WTP system.
- Contractor has to coordinate with respective party (if necessary) (Plumbing, electrical, fire contractor) for STP, WTP smooth installation work

- Final payment shall not be released without submission of complete as-built drawings, O&M manuals, and test certificates.
- All materials and equipment must be submitted with datasheets and samples for approval prior to procurement. Any unapproved material used shall be rejected.
- The Contractor shall not deviate from approved drawings, specifications, or materials without prior written approval from the Client/PMC. Any unauthorized work shall be rejected and rectified at the Contractor's own cost.
- The Contractor shall submit method statements for all major activities and obtain approval prior to execution.
- The Contractor shall establish a site office at his own arrangement. Electricity consumption for the site office shall be metered through a sub-meter to be installed by the Contractor. The source of power supply will be provided and indicated by the Client, and all electricity charges shall be borne by the Contractor based on actual usage.
- Contractor will maintain the all HSE requirements
- The Contractor shall arrange third-party testing of the STP and WTP as required by the PMC and the Client. All costs associated with such testing shall be borne by the Contractor.
- The Contractor shall submit the concrete mix design prepared and certified by BUET, MIST, or CUET in accordance with the specifications stated in the BOQ and obtain approval from the Client/PMC prior to commencement of concreting works. All costs associated with the mix design shall be borne by the Contractor.

  The Contractor shall obtain approval from the Client/PMC for at least two (2) reputed Ready-Mix Concrete (RMC) suppliers before procuring concrete for the Project.

- All construction materials, including but not limited to reinforcement bars (BSRM/GPH), sand, stone aggregates, and cement, shall be subject to approval by the Client/PMC prior to use.
- The Contractor shall submit all relevant material test reports to the Client/PMC at least one (1) day prior to the scheduled concrete casting.
- A qualified Contractor's representative (Engineer) shall remain present at the RMC plant throughout the concreting operation to ensure compliance with approved material specifications and concrete quality requirements.
- Any non-conformance related to the quality of materials, concrete production, transportation, placement, or workmanship identified during concreting operations shall be subject to penalties as determined by the Client/PMC.
- Concrete compressive strength testing shall be carried out as specified in the project requirements. For each casting segment, three (3) sets of concrete cylinders shall be prepared:
  - One (1) set shall be tested at BUET/MIST;
  - One (1) set shall be tested at CUET;
  - One (1) set shall remain under the custody of the Client/PMC.

  All testing costs shall be borne by the Contractor.

- The Contractor shall submit all relevant test reports along with each Interim Payment Certificate (IPC). Processing and certification of IPCs shall be subject to satisfactory submission and acceptance of the required test reports.
- During post-concreting inspections, if any construction defects or non-conformities are identified by the PMC, a Non-Conformance Report (NCR) shall be issued. The Contractor shall take all necessary corrective actions and close the NCR to the satisfaction of the PMC/client. If any major deviation noticed, contractor has to redo the work with his own cost

- The Contractor shall provide a minimum warranty period of ten (10) years for all waterproofing works executed under the Contract.
- The Contractor shall take all necessary precautions to ensure continuity of work during adverse weather conditions, including the provision of temporary rain shelters, tarpaulins, and other protective measures as required.
- The Contractor shall strictly comply with all applicable construction safety standards, regulations, and project-specific Health, Safety, and Environment (HSE) requirements.
- The Contractor shall be solely responsible for site mobilization, logistics, temporary facilities, resource deployment, and all preparatory works necessary for execution of the Contract. The Contractor shall complete the works within the stipulated contract duration.
- The Contractor shall engage Qualified engineers, supervisors, safety personnel, and skilled workforce as necessary to execute the works in accordance with the approved drawings, specifications, and quality standards.
- No claims, excuses, or requests for extension arising from inadequate site preparation, insufficient resources, safety violations, or quality deficiencies shall be accepted. The Contractor shall fully comply with all contractual obligations. Any negligence or failure to comply may result in penalties as determined by the Client/PMC.
- All utility costs, including but not limited to electricity, water, and other services required for execution of the works, shall be borne by the Contractor. The Client shall only facilitate access to the available utility sources at the project site. Any distribution, connection, consumption, maintenance, and associated costs shall remain the sole responsibility of the Contractor.
- The Contractor shall conduct all necessary material testing, including but not limited to reinforcement bars, cement, sand, stone aggregates, and other construction materials, as required by the Client/PMC. All testing shall be carried out at approved laboratories, and the associated costs shall be borne entirely by the Contractor.
- No excuse will be acceptable in terms of site preparation, site development & HSE contractor must conduct site assessment prior execution of civil work. if any negligence noticed, hefty penalty will be imposed.
- No excuses will be acceptable regards disposal of excavated material. Contractor has to dump the material as per direction of Engr. in charge of Client /PMC.
- Contractor will take all precaution so that water cannot ingress or stagnant inside foundation trench. if any negligence noticed, hefty penalty will be imposed.

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Summary of Qualification of Tenderers

The Applicant must meet the following qualification criteria:

1. A minimum of Ten (10) years of experience in STP, WTP, UGWR (Fire) Works Design, installations and operations.
2. Specific experience as a Prime Contractor in STP, WTP, UGWR (Fire) Works Design, installations and operations, with at least one (01) contract of similar nature, complexity, and construction methods/technology successfully completed within the last five (05) years, having a minimum value of Tk. 2.5 (two and half) crore.
3. Experience in completing STP, WTP, UGWR (Fire) Works Design, installations and operations for a building with a total built-up area of at least 10,000 square meters.
4. The average annual turnover shall be greater than Tk. 3 (Three) crore, calculated over the best three (3) years within the last five (5) years.
5. The minimum amount of liquid assets, i.e., working capital or credit line(s), of the Tenderer shall be Tk. 2 (Two) crore.
6. Proven reputation as a constructor in both the public and private sectors, supported by a detailed company profile, client list, and work accomplishment certificates.
7. The applicant must not have any record of contract non-performance in the **last 5 years** from the RFP publication date.
8. All pending litigation must not exceed **15% of the applicant's net worth**.
9. Applicants must demonstrate: Relevant **professional and technical qualifications, Managerial capability,** A **reliable reputation** for contract performance, Adequate and **skilled personnel.**
10. The successful Applicant, who later becomes the Tenderer, is required to perform the works and services as described in the subsequent Tender.
11. Applicants must have access to the necessary equipment and physical facilities to perform the work by either owning the equipment, having proven access through a contractual arrangement (e.g., lease or hire), or having assured access to such equipment for the required duration. All required equipment must be in full working condition.

Section 1. Instructions to Applicants

1. Interpretation 1.1 Throughout this qualification Document:

(a) the term **"in writing"** means communication written by hand or machine duly signed and includes properly authenticated messages by facsimile or electronic mail;

(b) if the context so requires, **singular** means plural and vice versa;

(c) **"day"** means calendar days unless otherwise specified as working days;

(d) **"Qualification Document"** means the Document provided by the Employer to an Applicant as a basis for preparation of the Application; and

(e) **"Application"** depending on the context, means an application submitted by an Applicant for Qualification to participate in the subsequent Tenders and to perform the Contract, in response to an Invitation for Qualification.

1.1 Corrupt, Fraudulent, Collusive or Coercive Practices

1.2 It is the Employer's policy to require that Employer's staff, as well as Applicants/Tenderers, suppliers, and contractors and their subcontractors observe the highest standard of ethics during the procurement and execution of such contracts. In pursuance of this policy, the Authority-.

(a) defines, for the purposes of this provision, the terms set forth below as follows:

(i) **"corrupt practice"** is the offering, giving, receiving or soliciting, directly or indirectly, of anything of value to influence improperly the actions of another party;

(ii) "fraudulent practice" is any act or omission, including a misrepresentation, that knowingly or recklessly misleads, or attempts to mislead, a party to obtain a financial or other benefit or to avoid an obligation;

(iii) "collusive practice" is an arrangement between two or more parties designed to achieve an improper purpose, including to influence improperly the actions of another party;

(iv) "coercive practice" is impairing or harming, or threatening to impair or harm, directly or indirectly, any party or the property of the party to influence improperly the actions of a party;

(v) "obstructive practice" is (aa) deliberately destroying, falsifying, altering or concealing of evidence material to the investigation or making false statements to investigators in order to materially impede a Bank investigation into allegations of a corrupt, fraudulent, coercive or collusive practice; and/or threatening, harassing or intimidating any party to prevent it from disclosing its knowledge of matters relevant to the investigation or from pursuing the investigation; or (bb) acts intended to materially impede the exercise of the Authority's inspection and audit rights provided.

(b) will reject a proposal for award if it determines that the Tenderer recommended for award has, directly or through an agent, engaged in corrupt, fraudulent, collusive, coercive or obstructive practices in competing for the contract in question;

(c) will sanction a firm or individual, including declaring ineligible, either indefinitely or for a stated period of time, to be awarded a contract if it at any time determines that the firm has, directly or through an agent, engaged in corrupt, fraudulent, collusive, coercive or obstructive practices in competing for, or in executing, a contract.

2. Source of Funds

The Employer will arrange fund towards the cost of the project named in the ADS. The Employer intends to apply a portion of that funds to eligible payments under the contract(s) resulting from the Tendering for which this prequalification is conducted.

3. Eligible Applicants

3.1 This Invitation for Qualification is open to all potential Applicants from all countries, except Israel. An Applicant will be eligible if it is a citizen, or is constituted, registered and operates in conformity with the provisions of the laws of that country.

3.2 Applicants may be a physical or juridical individual or body of individuals, or company, association or any combination of them in the form of a Joint Venture, Consortium or Association (JVCA) invited to take part in public procurement or seeking to be so invited or submitting an Applicant in response to an Invitation for Qualification.

3.3 Applicants shall have the legal capacity to enter into the Contract under the Applicable Law.

3.4 Applicants and all parties constituting the Applicant shall not have a Conflict of Interest. Applicants in its own name or its other names or also in the case of its Persons in different names shall not be under a declaration of ineligibility for corrupt, fraudulent, collusive or coercive practices.

3.5 Applicants with a poor performance, consistent history of litigation or arbitration awards against it shall not be eligible for Qualification.

3.6 Applicants shall not be insolvent, be in receivership, be bankrupt, be in the process of bankruptcy, be not temporarily barred from undertaking business and it shall not be the subject of legal proceedings for any of the foregoing.

3.7 Applicants shall have fulfilled its obligations to pay taxes and social security contributions under the provisions of laws and regulations of the country of its origin.

3.8 Applicants shall provide such evidence of their continued eligibility satisfactory to the Employer, as the Employer will reasonably request.

3.9 Applicants' requirements for eligibility will extend, as applicable, to each JV partner and Specialist Subcontractor proposed by the Applicant.

3.10 This Invitation for Qualification is open to all potential Applicants from all countries, except Israel. An Applicant will be eligible if it is a citizen, or is constituted, registered and operates in conformity with the provisions of the laws of that country.

3.11 Applicants may be a physical or juridical individual or body of individuals, or company, association or any combination of them in the form of a Joint Venture, Consortium or Association (JVCA) invited to take part in public procurement or seeking to be so invited or submitting an Applicant in response to an Invitation for Qualification.

3.12 Applicants shall have the legal capacity to enter into the Contract under the Applicable Law.

3.13 Applicants and all parties constituting the Applicant shall not have a Conflict of Interest. Applicants in its own name or its other names or also in the case of its Persons in different names shall not be under a declaration of ineligibility for corrupt, fraudulent, collusive or coercive practices.

3.14 Applicants with a poor performance, consistent history of litigation or arbitration awards against it shall not be eligible for Qualification.

3.15 Applicants shall not be insolvent, be in receivership, be bankrupt, be in the process of bankruptcy, be not temporarily barred from undertaking business and it shall not be the subject of legal proceedings for any of the foregoing.

3.16 Applicants shall have fulfilled its obligations to pay taxes and social security contributions under the provisions of laws and regulations of the country of its origin.

3.17 Applicants shall provide such evidence of their continued eligibility satisfactory to the Employer, as the Employer will reasonably request.

3.18 Applicants' requirements for eligibility will extend, as applicable, to each JV partner and Specialist Subcontractor proposed by the Applicant.

4. Eligible Materials, Equipment and Associated Services

4.1 All materials, equipment and associated services to be supplied under the Contract are from eligible sources, unless their origin is from Israel.
4.2 For the purposes of this Clause, **"origin"** means the place where the Materials and Equipment's are mined, grown, cultivated, produced or manufactured or processed, or through manufacturing, processing, or assembly, another commercially recognized new product results that differs substantially in its basic characteristics from its components or the place from which the associated services are supplied.

5. Site Visit

5.1 Applicants must visit and examine the Site of Works and its surroundings and obtain, at their own responsibility and expense, all information necessary for preparing the Application, submitting any subsequent Tender, and entering into a contract.

5.2 Applicants and any of its personnel or agents will be granted permission by the Employer to enter into its premises and lands for the purpose of such visit, but only upon the express condition that the Applicant, its personnel, and agents will release and indemnify the Employer and its personnel and agents from and against all liability in respect thereof, and will be responsible for death or personal injury, loss of or damage to property, and any other loss, damage, costs, and expenses incurred as a result of the inspection.

5.3 The costs of visiting the Site shall be at the Applicants' own expense.

6 Qualification: General

Qualification Document

6.1 The Sections comprising the Qualification Document are listed below, and should be read in conjunction with any Addendum issued under ITA Clause 11.

- Section 1 Instructions to Applicants (ITA)
- Section 2 Application Data Sheet (ADS)
- Section 3 Application Forms
- Section 4 Scope of Works

6.2 Applicants are expected to examine all instructions, forms, terms, and specifications in the Qualification Document as well as in Addendum to Qualification, if any.

7 Clarification of Qualification Document

7.1 Applicants requiring any clarification of the qualifications Document shall contact the Employer in writing at the Employer's address indicated in the RFP before **two-third** of the time allowed for preparation and submission of Application elapses.

7.2 Non-performance of a contract shall not occur within the last years, prior to the deadline for Application submission based on all information on fully settled disputes or litigation.

8 Litigation History

8.1 For the purpose, a fully settled dispute or litigation is one that has been resolved in accordance with the Dispute Resolution Mechanism under the respective contract and where all appeal instances have been exhausted.

8.2 For a Joint Venture under ITA Sub Clause 18.1, the precise minimum requirements of Leading Partner and other partners shall be as specified in the ADS.

9. Joint Venture, Consortium or Association (JVCA)

9.1 Applicants may participate in the qualification process and subsequent procurement proceedings by forming a Joint Venture, Consortium or Associations (JVCA) or alternately with the intent to enter into such an agreement supported by a Letter of Intent.

9.2 The JV agreement, indicating at least the parts of the Works to be executed by the respective partners, shall be legally entered into case-by-case in the Applicant's Leading Partner's country of origin, as specified in the ADS, duly signed by all legally authorized representatives of the Persons who are parties to such agreement.

9.3 Applicants, as an alternate to ITA Sub Clause 9.2, may intend to enter into a JV agreement case-by-case in the form of a Letter of Intent along with the proposed agreement, indicating at least the parts of the Works to be executed by the respective partners, duly signed by all partners of the intended JV and authenticated by an authority of the Applicant's Leading Partner's country of origin, as stated in the ADS, with the declaration that the partners will execute the Joint Venture agreement in the event the Applicant, in the first place pre-qualified and then successful in the subsequent Tender.

9.4 Applicants shall submit the Letter of Intent and the proposed JV agreement along with the Application.

9.5 For a Joint Venture under ITA Sub Clause 9.1, the precise minimum qualification requirements of Leading Partner and other partners shall be as specified in the ADS.

9.6 In cases where a JV partner's, personnel capacity, equipment capacity and financial capacity individually fulfils the precise minimum qualifying requirement of that particular component as specified, capacities of such partner(s) in the JV will be combined together for summation to determine the total precise minimum qualifying requirements criterion of that JV as stated under ITA Sub Clause 9.5.

9.7 Each partner of the JV shall be jointly and severally liable for the execution of the Contract, all liabilities and ethical and legal obligations in accordance with the Contract terms.

9.8 The JV shall nominate a Representative (partner-in-charge) who shall have the authority to conduct all business for and on behalf of any and all the partners of the JV during the tendering process and, in the event the JV is awarded the Contract, during contract execution including the receipt of payments for and on behalf of the JV.

9.9 The composition or the constitution of a JV once formed shall not be allowed to be altered prior to signing of the Contract.

9.10 Alteration of partners to the composition or constitution at a date later than the signing of the Contract during execution shall be allowed by the Employer only when any of such partners is found to be incompetent or has serious difficulties which may impact the overall implementation of the proposed Works, where the incoming partner shall require to have qualifications higher than that of the outgoing partner.

9.11 Each partner of the JV shall complete the JV Partner Information (Form F3) for submission with the Application.

10 Contents of Application

10.1 The Application prepared by the Applicants shall comprise the following:

10.1.1 Application Submission Letter (**Form F-1**);

10.1.2 Applicant Information (**Form F-2**);

10.1.3 documents demonstrating that they are enrolled in the relevant professional or trade organizations registered in their country of origin;

10.1.4 written confirmation authorizing the signatory of the Application to commit the Applicant;

10.1.5 documents confirming the legal capacity stating that there are no existing orders of any judicial court that prevents either the Applicant or employees of that Applicant subsequently entering into or signing a Contract with the Employer;

10.1.6 documents confirming that the Applicant is not insolvent, in receivership, bankrupt or in the process of bankruptcy, temporarily barred from undertaking business and shall not be the subject of legal proceedings for any of the foregoing;

10.1.7 documents confirming that all claims, arbitration or other litigation cases have been satisfactorily resolved, and if not, they shall have no serious negative impact on the financial capacity of the Applicant;

10.1.8 documents confirming that the Applicant has fulfilled its obligations to pay taxes and social security contributions under the provisions of laws and regulations of its country of origin as a proof of fulfilment of taxation obligations;

10.1.9 documents establishing the Applicant's eligibility to perform the contract;

10.1.10 documents establishing the origin of all Materials, Equipment and services to be supplied under the Contract, as stated under ITA Clause 26;

10.1.11 documents establishing the minimum qualifications of the Applicant required to be met for due performance of the Works and physical services under the contract;

10.1.12 any other document as specified in the ADS.

10.2 In addition to the requirements stated under ITA Sub Clause 9.1, Applications submitted by a JV or proposing a Specialized Subcontractor shall include:

10.2.1 Joint Venture Agreement legally entered into in the Applicant's Leading Partner's country of origin, by all partners, as stated under ITA Sub Clause 18.2;

Or,

10.2.2 Letter of Intent along with the proposed agreement duly signed by all partners of the intended JV and authenticated by an authority of the Applicant's Leading Partner's country of origin with the declaration that it will execute the Joint Venture Agreement in the event the Applicant and the Tenderer is successful in the subsequent Tender, as stated under ITA Sub Clause 18.3;

10.2.3 the JV Partner Information (**Form F-3**), as stated under ITA Sub Clause 18.11;

10.2.4 the Specialist Subcontractor Information (**Form F-4**), as stated under ITA Sub Clause 19.6.

11 Documents Establishing the Applicant's Qualification

11.1 Applicants shall complete and submit the Applicant Information (**Form F-2**) and shall include documentary evidence, as applicable to satisfy the following:

11.1.1 details on the financial standing of the Tenderer, such as profit and loss statements and corresponding auditor's report establishing the liabilities and assets;

11.1.2 details of general experience in Fire management works on case-by-case procurement proceedings performed for each of the last years along with the sums, dates and recipients;

11.1.3 details of specific experience in construction works of similar nature and size on case-by-case procurement proceedings performed for each of the last years along with the sums, dates and recipients;

11.1.4 details of average annual turnover for a period;

11.1.5 details of existing commitments and works to assess the minimum Tender Capacity;

11.1.6 details of adequacy of working capital for the subsequent Tender i.e., access to line(s) of credit and availability of other financial resources;

11.1.7 details of numbers of technical and administrative personnel along with their qualification and experience proposed for the subsequent Tender;

11.1.8 details of Applicant's technical facilities, available major construction equipment's, measures for ensuring quality such as, ISO certification and design, research and development facilities proposed to carry out the Contract;

11.1.9 details of Procuring Entities who may be contacted, if necessary, by the Employer; and authority to seek references from the Applicant's bankers or any other sources.

11.2 Applicants, if applying as an existing or intended JV, shall submit documentary evidence to establish its qualifications as stated under ITT and, in particular, it shall submit an affidavit nominating one of the JV partners as the REPRESENTATIVE (partner-in-charge) who shall have the authority to conduct all business for and on behalf of any and all the partners of the JV during the tendering process and, in the event the JV is awarded the Contract, during contract execution including the receipt of payments for and on behalf of the JV.

12 Bank Guarantees

12.1 Performance Bank Guarantee Clause

12.1.1 The successful bidder, upon receiving the Notification of Award (NoA), shall furnish an unconditional and irrevocable **Performance Bank Guarantee** in favor of *Asian University for Women (AUW)*.

12.1.2 The amount of the Performance Bank Guarantee shall be **ten percent (10%) of the total Contract Price**, issued from any scheduled bank operating in Bangladesh and acceptable to AUW.

12.1.3 The Performance Bank Guarantee shall remain **valid until twenty-eight (28) days after the completion of the Defects Liability Period** or final acceptance of the works, whichever is later.

12.1.4 Failure to submit the Performance Bank Guarantee within the stipulated time may result in the cancellation of the award and forfeiture of any right to the contract.

12.1.5 The Performance Bank Guarantee shall be returned to the Contractor upon satisfactory completion of all contractual obligations and submission of all completion documents as per AUW's satisfaction.

12.1.6 AUW reserves the right to **invoke the Performance Bank Guarantee**, in whole or in part, in the event of the Contractor's default, non-performance, or breach of any contractual terms.

12.2 Advance Payment Bank Guarantee (if applicable)

12.2.1 If the Employer provides any **advance payment** to the Contractor, the Contractor shall furnish an **unconditional and irrevocable bank guarantee** for the full amount of the advance, valid until the advance is fully recovered.

12.2.2 The Employer may encash the bank guarantee in the event the Contractor **fails to utilize the advance for the purpose of contract execution**.

12.3 Invocation of Bank Guarantee

12.3.1 The Bank Guarantee shall be **payable on demand** and **irrevocable**, and the Employer's written statement regarding Contractor's default shall be **conclusive** for the purpose of encashment.

12.3.2 The Bank Guarantee shall remain valid regardless of any disputes under the Contract, until it is **released in writing by the Employer**.

13 Insurance Requirements

13.1 General Insurance Coverage

The Contractor shall, at its own cost and expense, maintain insurance coverage throughout the duration of the Project to adequately cover risks associated with the performance of the Work. All insurance policies shall be issued by insurers acceptable to the Employer and shall remain in force until the completion of the Project.

13.2 Material Insurance

The Contractor shall insure all materials, equipment, and supplies brought to or used on the Project site against loss or damage due to fire, theft, vandalism, natural hazards, or any other risks associated with handling, storage, and transportation. The coverage shall be for the full replacement value of the materials.

13.3 **Personnel Insurance**

The Contractor shall provide adequate insurance coverage for all personnel, including employees, subcontractors, and consultants, engaged in the execution of the Project. This shall include, but is not limited to:

13.4 Workers' compensation or equivalent coverage as required by law Personal accident and injury insurance Health and medical coverage in case of work-related incidents

13.5Liability Insurance

The Contractor shall maintain public liability and third-party liability insurance to cover claims arising from bodily injury, death, or property damage caused by the Contractor's activities, equipment, or personnel during the execution of the Project.

13.6 Proof of Insurance

Prior to commencement of work, the Contractor shall submit certified copies of all insurance policies or certificates of insurance to the Employer. All insurance policies shall require that no cancellation or material modification shall be effective without at least thirty (30) days prior written notice to the Employer.

13.7Additional Requirements

The Contractor shall ensure that all subcontractors maintain similar insurance coverage. The Contractor shall be responsible for any gaps in coverage resulting from subcontractor non-compliance.

14. Liquidated Damages

14.1If the Contractor fails to complete the Works or any part thereof within the time specified in the Contract, the Contractor shall be liable to pay **liquidated damages** at the rate of **1% (one percent) of the Contract Price per week** of delay, unless otherwise specified in the Contract.

14.2The total amount of liquidated damages shall not exceed **10% (ten percent) of the Contract Price**.

14.3Liquidated damages shall be **deducted from any payments due to the Contractor**, including the Performance Security, without prejudice to any other rights of the Employer under this Contract.

15 Termination

15.1 Termination for Default

15.1.1 If the Contractor:

a. Fails to commence, continue, or complete the Works in accordance with the Contract; or

b. Fails to remedy any breach, delay, or defect within the period specified in a written notice from the Employer; the Employer may, at its sole discretion, **terminate the Contract for default**, in whole or in part.

15.1.2 Upon termination for default, the Employer shall have the right to:

a. **Cancel the Contract** immediately;

b. **Engage another Contractor** to complete the Works at the risk and cost of the defaulting Contractor;

c. **Recover from the Contractor all additional costs, losses, and damages** incurred as a result of the Contractor's
failure, including legal and administrative expenses;

d. **Forfeit any Performance Security or other guarantees** provided by the Contractor;

e. **Restrict or debar the Contractor** from future contracts with the Employer for a period as deemed appropriate.

15.1.3 Termination under this Clause shall be **without prejudice to any other remedies** available to the Employer under the Contract or applicable law, including claims for additional damages or specific performance.

15.2 **Termination for Convenience**

15.2.1 The Employer may, at any time, **terminate the Contract, in whole or in part, for convenience**, without assigning any reason.

15.2.2 In such cases, the Contractor shall be entitled to payment for:

a. Work executed up to the date of termination; and

b. Reasonable costs incurred for materials or commitments directly related to the terminated portion, but **shall not be entitled to any loss of profit or unperformed work**.

15.3 **Termination for Insolvency or Bankruptcy**

15.3.1 If the Contractor becomes **insolvent, bankrupt, or enters into receivership or liquidation**, the Employer may **terminate the Contract immediately**.

15.3.2 The Employer shall have the right to **recover costs incurred to complete the Works** from any outstanding payments or Performance Security.

15.4 **Termination for Force Majeure**

15.4.1 If a **Force Majeure event** persists for a period exceeding 90 days, the Employer or Contractor may terminate the Contract by giving written notice.

15.4.2 Upon termination due to Force Majeure:

a. Neither party shall be liable for damages resulting directly from the termination;

b. The Contractor shall be paid for all work executed up to the date of termination.

15.5**Acceleration and Material Breach**

15.5.1 In case of delays or partial non-performance, the Employer may issue a **directive for accelerated performance**.

15.5.2 Failure to comply with the acceleration directive shall constitute a **material breach**, justifying immediate termination under Clause 15.1

15.6 **Effect of Termination**

15.6.1 Termination of the Contract under any of the above clauses shall be **without prejudice to any other rights or remedies** of the Employer under the Contract or applicable law.

15.6.2 All obligations of the Contractor regarding **confidentiality, indemnity, and warranty** shall survive termination.

15.7**Acceleration of Completion**

15.7.1 In the event of any delay or failure to accomplish the task, the Employer may issue a **written directive for accelerated performance**, specifying the revised timeline and milestones.

15.7.2 Failure to comply with the acceleration directive shall be treated as a **material breach**, justifying immediate termination and enforcement of ITA 15.2.

16. Descope of Work

16.1.1 The Employer reserves the right to **descope, reduce, or modify the scope of work** under the Contract, in whole or in part, by giving written notice to the Contractor.

16.1.2 Upon receiving a descope notice, the Contractor shall:

a. Immediately **stop work on the descoped items**;

b. Submit a **revised work plan, cost estimate, and schedule** within 7 working days; and

c. **Deliver any completed work, materials, or documentation** related to the descoped items.

16.1.3 The Employer shall **adjust the Contract Price** proportionally to reflect the descoped work. Such adjustment shall include:

a. Reduction of contract payment corresponding to the value of descoped items; and

b. Recovery of any **unapproved costs incurred by the Contractor** on the descoped items.

17. Back charge

17.1.1 The Employer may **back charge the Contractor** for costs or damages incurred due to:

a. Non-performance, defective work, or delay caused by the Contractor;

b. Failure to comply with specifications, drawings, or contractual obligations; or

c. Additional work or remedial work carried out by the Employer or third parties to complete the Contractor's scope.

17.1.2 Back charge amounts shall be:

a. **Deducted from any payment due** to the Contractor, including Performance Bank Guarantee; or

b. **Payable by the Contractor directly** within 15 days of written notice.

17.1.3 The Contractor shall **not be entitled to any extension of time, additional payment, or claim** for costs related to the back charged items.

17.2 Procedure for Issuing Descope or Backcharge Notices

17.2.1 The Employer shall issue **written notice specifying**:

a. The descoped work or backcharged items;

b. The reason for descope or backcharge;

c. The monetary amount, if applicable; and

d. The time for compliance or payment.

17.2.2 The Contractor shall **acknowledge receipt of the notice** and comply with all instructions without delay.

18 Survival of Rights

All rights of the Employer to descope, backcharge, recover costs, or enforce compliance under this Clause shall **survive the termination or completion of the Contract**.

19 Employer's Entitlement to Remedy Default

If the Contractor fails to execute any part of the Works, to remedy a defect, or to complete outstanding work within a reasonable time following notice from the Employer, the Employer shall be entitled to carry out all necessary work at the Contractor's cost by employing other persons. All necessary costs so incurred shall constitute a debt due from the Contractor to the Employer, recoverable by deduction from payments due or otherwise; provided always that the Contractor's liability and obligations under the Contract shall not be affected or diminished by the exercise of this right by the Employer.

20 DISPUTES

In no event shall AUW be liable to the Contractor for payments for any extra work the Contractor performs in addition to that required under the Statement of Work above unless the Contractor performs such work by written directive of AUW and unless the contract is amended accordingly. No officer, director, employee, or agent of AUW is authorized to direct any extra work by oral order. In the event of any claims or disputes arising from or relating to this contract, the parties shall use their best efforts to settle the claims or disputes. To this effect, they shall consult and negotiate with each other in good faith and, recognizing their mutual interests, attempt to reach a just and equitable solution satisfactory to both parties. If they fail to reach such a solution within THIRTY (30) days, either Party may refer the matter to arbitration, as per the law of Bangladesh, which shall be the exclusive method of resolving such disputes. The arbitration shall be conducted in Chattogram, Bangladesh. The results of arbitration shall be final and binding on the Parties and shall be in lieu of any other remedy.

21 Engineer's Instructions

The Engineer may issue to the Contractor (at any time) instructions which may be necessary for the execution of the works, all in accordance with the Contract. The Contractor shall only take instructions from the Engineer or from the Engineer's Representative (if appointed) or an assistant to whom the appropriate authority to give instruction has been delegated (Delegation by the Engineer).

Subject to the following provisions, the Contractor shall comply with the instructions given by the Engineer or the Engineer's Representative (if appointed) or delegated assistant, on any matter related to the Contract.

If an instruction states that it constitutes a Variation, (Variation by instruction) shall apply.

If not so stated and the Contractor considers that the instruction:

(a) Constitutes a Variation (or involves work that is already part of an existing Variation); or
(b) does not comply with applicable laws or will reduce the safety of the works or is technically impossible.

the Contractor shall immediately, and before be commencing any work related to the instruction, give a Notice to the Engineer with reasons. It the Engineer does not respond within 7 days after receiving this Notice, by giving a Notice confirming, reversing or varying the instruction, The Engineer shall be deemed to have revoked the instruction. Otherwise the Contractor shall comply with and be bound by the rems of the Engineer's response.

22 Defects and Rejection

If, as a result of an examination, inspection, measurement or testing, any plant, Materials, Contractor's design (if any) or workmanship is found to be defective or otherwise not in accordance with the Contract, the Engineer shall give a Notice to the Contractor describing the item of Plant, Materials, design or workmanship that has been found to be defective. The Contractor shall then promptly prepare and submit a proposal for necessary remedial work.

The Engineer May Review this proposal, and may give a notice to the Contractor stating the extent to which the proposed work, if carried out, would not result in the Plant, Materials, Contractor's design (if any) or workmanship complying with the Contract. After receiving such a Notice, the Contractor shall promptly submit a revised proposal to the Engineer. If the Engineer gives no such notice within 14 days after receiving the Contractor's proposal (or revised proposal), The Engineer shall be deemed to have given a notice of No-objection.

If the Contractor fails to promptly submit a proposal (or revised proposal) for remedial work, or fails to carry out the proposed remedial work to which the engineer has given (or is deemed to have given) a notice or No-objection, the Engineer may instruct:

- If any work, materials, design, goods, or services provided by the Contractor are found to be defective, non-compliant, or otherwise unsatisfactory, AUW may require the Contractor to correct, replace, or remedy such deficiencies at the Contractor's own risk and cost. Any necessary retesting, reinspection, or verification following such remedial actions shall also be carried out at the Contractor's expense.
- If such defects, deficiencies, rejection, or retesting result in additional costs, losses, or delays to AUW, the Contractor shall be liable for and reimburse AUW for all such reasonable additional costs incurred.

23 Employer's Entitlement to Remedy Default

If the Contractor fails to execute any part of the Works, to remedy a defect, or to complete outstanding work within a reasonable time following notice from the Employer, the Employer shall be entitled to carry out all necessary work at the Contractor's cost by employing other persons. All necessary costs so incurred shall constitute a debt due from the Contractor to the Employer, recoverable by deduction from payments due or otherwise; provided always that the Contractor's liability and obligations under the Contract shall not be affected or diminished by the exercise of this right by the Employer.

24 Alternatives due to failure of completion by the contractor

If the contractor fails to complete specific items of work within the time schedule, the client reserves the right to assign to the completion of works those specific items to another contractor. The cost incurred for completing those items will be deducted from the original contractor's total bill. Additionally, the Defects Liability Period (DLP) for the reassigned work will still be the responsibility of the original (general) contractor.

ASIAN UNIVERSITY FOR WOMEN

Section 2. Application Data Sheet

ITA Clause	Amendments of, and Supplements to, Clauses in the Instructions to Applicants
	RFP IDENTIFICATION NO: _____
A. General	
ITA 1.1	The Employer is ***Asian University for Women represented by Deputy Project Director, Asian University for women, 20/A, M.M Ali Road, Chattogram-4000, Bangladesh.***
	The Name of the Subsequent Tender is: ***STP, WTP, UGWR works for three storied with a semi-basement Academic Building for Asian University for women.*** Application Ref:..... Package No:..... *[if there is more than one(1) lot, individual lots are to be identified]*
ITA3.1	The source of public funds is: ***AUW own fund.***
ITA3.3	The name of the Development Partner is: ***None***
ITA6.1	Materials, Equipment's and associated services from the following countries are not eligible: ***Israel***

B. Qualification Criteria	
ITA13.1	Non-performance of a contract shall not occur within the last ***5 (five)*** years. [*years counting backward from the date of publication of RFP]*
ITA13.2	All pending litigation shall in total not represent more than ***15 (fifteen)*** percent of the Applicant's net worth.
ITA 14.1 (a)	The minimum number of years of general experience of the Applicant in public or private STP, WTP, UGWR System as Prime Contractor shall be ***10 (ten)*** years. [*years counting backward from the date of publication of RFP]*
ITA14.1 (b)	The minimum specific experience as a STP, WTP, UGWR works of at least ***1 (one)*** contract(s) of similar nature, complexity and methods/technology completed over a period of ***5 (five)*** years shall be required. *[years counting backward from the date of publication of RFP.]*
ITA 14.1(c)	A satisfactory completion of similar works of at least BDT ***2.5 (Two and half) crore*** under a single contract over a period of ***5 (Five)*** years shall be required. *[years counting backward from the date of publication of RFP.]*

ITA 15.1

The required average annual **STP, WTP, UGWR** turnover shall be greater than *BDT 3 (Three)* crore over the last *5 (five) years*.

[years counting backward from the date of publication of RFP.]

ITA 15.1(c)

The minimum amount of liquid assets or working capital or credit facilities of the Applicant shall be greater than ***BDT 2 (Two) crore*** on a day after publication of RFP.

ITA 16.1(a)

A Project Manager shall have the following qualifications and experience:

No	Position	Total Works Experience (years)	In Similar Works Experience(years)
1.	Project Manager (Civil)	8 yrs	6 yrs

ITA 16.1(b)

The minimum number of Engineers with qualifications and experience shall be as follows:

No.	Position	Total Works Experience (years)	In Similar Works Experience (years)
1.	Project Engineer, B.Sc. Engr. (Civil)	Min. 6 yrs	Min. 5 yrs
2.	Project Engineer, B.Sc. Engr. (MEP)	Min. 6 yrs	Min. 5 yrs

ITA 16.1(c)

Other key staff with qualifications and experience shall be as follows*[state requirements]*:

No.	Position	Total Works Experience (years)	In Similar Works Experience (years)
1.	Safety Supervisor	Min. 4 yrs.	Min. 4 yrs

ITA 17.1

The Applicant shall own or have proven access to hire or lease of the major equipments to accomplish the tasks, Mention the equipment lists to accomplish the tasks as below:

No	Equipment Type and Characteristics	Minimum Number Required
1.	Essential tools & equipment	
2.	Essential tools & equipment for small scale metal works	
3.		
4.		
5.		
6.		
7.		

ITA 18.2

In the case the Applicant's Leading Partner's country of origin is Bangladesh, the value of non-judicial stamp for execution of the Joint Venture agreement shall be BDT ***BDT 300 (three hundred) only***

ITA 18.3

In the case the Applicant's Leading Partner's country of origin is Bangladesh, the Letter of Intent along with the proposed agreement shall be authenticated by a Notary Public.

<table>
<tr><td>ITA 18.5</td><td>The minimum qualification requirements of Leading Partner and other Partner(s) of a JV shall be as follows:
<table>
<tr><th>ADS Clauses References</th><th>Requirements by summation</th><th>Requirements for Leading Partner</th><th>Requirements for another Partner(s</th></tr>
<tr><td>ITA-14.1(a)</td><td>Summation not applicable</td><td>Same as stated in ADS</td><td>Same as for Leading Partner</td></tr>
<tr><td>ITA-14.1(b)</td><td>100%</td><td>At least one characteristic</td><td>Not applicable</td></tr>
<tr><td>ITA-14.1(c)</td><td>100%</td><td>At least one characteristic</td><td>Not applicable</td></tr>
<tr><td>ITA-15.1(a)</td><td>100%</td><td>40%</td><td>25%</td></tr>
<tr><td>ITA-15.1(b)</td><td>100%</td><td>40%</td><td>25%</td></tr>
<tr><td>ITA-15.1(c)</td><td>100%</td><td>40%</td><td>25%</td></tr>
<tr><td>ITA-16.1(a)</td><td>Summation not applicable</td><td>To be appointed by lead partner</td><td>Not applicable</td></tr>
<tr><td>ITA-16.1(b)</td><td>100%</td><td>At least one characteristic</td><td>Not applicable</td></tr>
<tr><td>ITA-16.1(c)</td><td>100%</td><td>At least one characteristic</td><td>Not applicable</td></tr>
<tr><td>ITA-17.1</td><td>100%</td><td>At least one characteristic</td><td>Not applicable</td></tr>
</table></td></tr>
<tr><td>ITA 19.4</td><td>The Employer intends to execute the following specific components of the proposed Works by the Nominated Subcontractor(s): None</td></tr>
<tr><td>ITA 20.1</td><td>Domestic Preference shall not be applicable for eligible National Tenderers</td></tr>
<tr><td colspan="2">D. Application Preparation</td></tr>
<tr><td>ITA 23.4</td><td>Use of Qualification Document posted in the website is not permitted for preparation of Applications.</td></tr>
<tr><td>ITA 25.1</td><td>The Applicant shall provide with its Application the following additional documents: None</td></tr>
</table>

E. Application Submission	
ITA31.1	For ***Application submission purposes*** only, the Employer's address is: For ***Tender submission purposes*** only, the Procuring Entity's address is: TO AUW PROCURMENT COMMITTEE Email address: tender175@auw.edu.bd The deadline for the submission of Applications is: ***Time & Date: 12:01pm. 8 /18/2026***

ASIAN UNIVERSITY FOR WOMEN

Section 3. Application Forms

Form	Title
	Application Forms
F – 1	Application Submission Letter
F – 2	Applicant Information
F – 3	JV Partner Information (*if applicable*)
F – 4	Subcontractor Information (*if applicable*)
F – 5	Historical Contract Non-Performance
F – 6	Personnel Information

Application Submission Letter (Form F-1)

ASIAN UNIVERSITY FOR WOMEN

[This letter should be completed and signed by the Authorized Signatory preferably on the Letter-Head Pad of the Applicant]

To: Date:[dd/mm/yy]

[Contact Person]

[Name of Employer]

[Address of Employer]

Invitation for Qualification No: ***[indicate RFP No]***

Tender Package No: ***[indicate Package No]***

This Package is divided into the following Number of Lots ***[indicate number of Lot(s)]***

We, the undersigned, apply to be qualified for the referenced Works and Physical Services and declare that:

(a) We have examined and have no reservations to the Qualification Document, issued by you on *[insert date];* including [*state numbers*].

(b) We, including as applicable, any JVCA partner or Specialist Subcontractor for any part of the contract resulting from this Qualification process, have nationalities from eligible countries according to the ITA.
[insert the nationality of the Applicant, including that of all partners in case of a Joint Venture, and the nationality of each already identified subcontractor, if applicable];

(c) we are submitting this Application as a sole Applicant;
or
we are submitting this Application as the partners of a JVCA, comprising the following other partners;

Sl. No	Name of Partner	Address of Partner
1		
2		
3		

or

(e) we, including as applicable any JVCA partner, declare that we are not associated, nor have been associated in the past, directly or indirectly, with a consultant or any other entity that has prepared the design, specifications and other documents in accordance with ITA;

(f) we intend to subcontract an activity or part of the Works, to the following Specialist Subcontractor(s);

Activity or part of the Works	Name of Specialist Subcontractor with Address

(g) we, including as applicable any JVCA partner, confirm that we do not have a record of poor performance, such as abandoning the works, not properly completing contracts, inordinate delays, or financial failure as stated in ITA, and that we do not have, or have had, any litigation against us, other than that stated in the Applicant Information (**Form -2**);

(h) we, including as applicable any JVCA partner, confirm that we do not have a record of insolvency, receivership, bankrupt or being wound up, our business activities were not been suspended, and it was not been the subject of legal proceedings in accordance with ITA;

(i) we, including as applicable any JVCA partner, confirm that we have fulfilled our obligations to pay taxes and social security contributions applicable under the relevant national laws and regulations of our country(s) of origin in accordance with;

(j) we, including as applicable any JVCA partner or Specialist Subcontractor for any part of the contract resulting from this Qualification process, have not been declared ineligible by any International Development Agency or the Government of Bangladesh on charges of engaging in corrupt, fraudulent, collusive or coercive practices in accordance with ITA; orby an act of compliance with a decision of the United Nations Security Council.

(k) furthermore, we are aware of ITA concerning such practices and pledge not to indulge in such practices in competing for or in executing the Contract;

(l) we are not participating as Applicants in more than one Application in this pre-qualification process;

(m) we understand that you may cancel the prequalification process at any time and that you are neither bound to accept any Application that you may receive nor to invite the pre-qualified Applicants to tender for the contract subject of this prequalification, without incurring any liability to the Applicants.

Signature:	*[insert signature of authorised signatory of the Applicant]*
Name:	*[insert full name of signatory with National ID Number]*
In the capacity of:	*[insert capacity of signatory]*

Duly authorized to sign the Application for and on behalf of the Applicant

[If there is more than one (1) signatory, or in the case of a JVCA, add other boxes and sign accordingly]

Attachment 1:

Written confirmation authorizing the above signatory to commit the Applicant and the subsequent Tenderer
[and, if applicable]

Attachment 2:

JV Agreement / Letter of Intent to form JV with draft proposed Agreement

ASIAN UNIVERSITY FOR WOMEN

Applicant Information (Form -2)

[This Form should be completed only by the Applicant, preferably on its Letter-Head Pad]

Invitation for Qualification No: *[indicate IFP No]*

Tender Package No: *[indicate Package No]*

This Package is divided into the following Number of Lots: *[indicate number of Lot(s)]*

1.	**Eligibility Information of the Applicant [According to ITT]**	
1.1	Nationality of individual or country of registration	
1.2	Applicant's legal title	
1.3	Applicant's registered address	
1.4	Applicant's legal status *[complete the relevant box]*	
	Proprietorship	
	Partnership	
	Limited Liability Concern	
	Government-owned Enterprise	
	Others [please describe, if applicable]	
1.5	Applicant's year of registration	
1.6	Applicant's authorised representative details	
	Name	
	National ID number, if any	
	Address	
	Telephone / Fax numbers	
	e-mail address	
1.7	Litigation ITT	
	Information on non-performance of contract and pending litigation furnished in Form ***F-5***	
1.8	Applicant to attach photocopies of the original documents mentioned aside	[All documents required under ITT Clauses]
The following two information are applicable for national Applicants		

1.9	Applicant's Value Added Tax Registration (VAT) Number	
1.10	Applicant's Tax Identification Number(TIN)	

[The foreign Applicants, in accordance with ITT Clause 5, shall provide evidence by a written declaration to that effect to demonstrate that it meets the criterion]

2. Qualification Information of the Applicant [According to ITT Clause]

2.1 General Experience in HVAC Works of Applicant

Start Month Year	End Month Year	Years	Contract No and Name of Contract Name and Address of Employer Brief description of Works	Role of Applicant [Prime/Sub/Management]

2.2 Specific Experience in HVAC Works of Applicant
Completed Contracts of similar nature, complexity and methods/ technology

Contract No **Name of Contract**	[insert reference no] of [insert year] [insert name]		
Role in Contract ***[tick relevant box].***	Prime Contractor	Subcontractor	Management Contractor
Award date **Completion date** **Total Contract Value**	[insert date] [insert date] [insert amount]		
Employer's Name **Address** **Tel / Fax** **e-mail** **Brief description with justifications of the similarity compared to this Employer's requirements**	[state justification in support of its similarity compared to the proposed works]		

2.3 Average annual turnover
[total certified payments received for contracts in progress or completed for each year of works in progress or completed; using selling exchange rate quoted by the source being Bangladesh Bank on the date reported, if applicable]

Year	Amount & Currency	

<table>
<tr><td>2.4</td><td colspan="4">Existing commitments and works
[targeted to be completed by the Intended Completion Date of the proposed works]</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">Name of Contract
Contract No [reference] of [year]
Name of Employer
Contact Address
Tel/fax
e-mail</td><td rowspan="2">Target Completion Date</td><td colspan="2">Value of Existing Commitments and Works</td></tr>
<tr><td>Amount & Currency</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2.5</td><td colspan="4">Financial Resources available to meet the HVAC System cash flow</td></tr>
<tr><td rowspan="3"></td><td>No</td><td>Source of Financing</td><td colspan="2">Amount Available</td></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td>Amount & Currency</td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="5">In order to confirm the above statements the Applicant shall submit, as applicable, the documents</td></tr>
<tr><td>2.6</td><td colspan="4">Contact Details [According to ITT]</td></tr>
<tr><td></td><td colspan="4">Name, address, and other contact details of Applicant’s Bankers and other Employer(s) that may provide references, if contacted by this Employer</td></tr>
<tr><td>2.7</td><td colspan="4">Qualifications and experience of key technical and administrative personnel proposed for Contract administration and management [According to ITT]</td></tr>
<tr><td></td><td colspan="2">Position
Name
Years of General Experience</td><td colspan="2">Years of Specific Experience</td></tr>
<tr><td></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="5">[Tenderer to complete details of as many personnel as are applicable .Each personnel listed above should complete the Personnel Information (Form-6]</td></tr>
<tr><td>2.8</td><td colspan="4">Major Construction Equipment’s proposed to carry out the Contract [According to ITT]</td></tr>
<tr><td></td><td colspan="2">Item of Equipment</td><td>Condition
(new, good, average, poor)</td><td>Owned, leased or to be purchased
(state owner, lessor or seller)</td></tr>
<tr><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td colspan="5">[Applicant to list details of each item of major construction equipment, as applicable]</td></tr>
</table>

JVCA Partner Information (Form -3)

[This Form should be completed by each JVCA partner].

Invitation for Qualification No: *[indicate IFP No]*

Tender Package No *[indicate Package No]*

This Package is divided into the following Number of Lots

1.	**Eligibility Information of the JVCA Partner [*According to ITT*]**	
1.1	Nationality of Individual or country of Registration	
1.2	JVCA Partner's legal title	
1.3	JVCA Partner's registered address	
1.4	JVCA Partner's legal status *[complete the relevant box]*	
	Proprietorship	
	Partnership	
	Limited Liability Concern	
	Government-owned Enterprise	
	Other (please describe, if applicable)	
1.5	JVCA Partner's year of registration	
1.6	JVCA Partner's authorised representative details	
	Name	
	National ID number, if any	
	Address	
	Telephone / Fax numbers	
	e-mail address	
1.7	Litigation	
	Information on non-performance of contract and pending litigation furnished in ***Form-5***	
1.8	JVCA Partner to attach copies of the original documents mentioned aside	[All documents required under ITT Clauses]
The following two information are applicable for national JVCA Partners only		
1.9	JVCA Partner's Value Added Tax Registration (VAT) Number	

1.10	JVCA Partner's Tax Identification Number(TIN)					
[The foreign JVCA Partners, in accordance with ITT, shall provide evidence by a written declaration to that effect to demonstrate that it meets the criterion]						
2.	**Key Activity(ies) for which it is intended to be joint ventured [According to ITT]**					
	Elements of Activity			**Brief description of Activity**		
3.	**Qualification Information of the JVCA Partner [ITT]**					
3.1	**General Experience in Construction Works of JVCA Partner**					
	Start Month Year	**End Month Year**	**Years**	**Contract No and & Name of Contract Name and Address of Procuring Entity Brief description of Works**		**Role of JVCA Partner [Prime/Sub/Management]**
3.2	**Specific Experience in Construction Works of JVCA Partner Completed Contracts of similar nature, complexity and methods/construction technology**					
	Contract No Name of Contract	[insert reference no] of [insert year] [insert name]				
	Role in Contract [tick relevant box]	Prime Contractor		Subcontractor	Management Contractor	
	Award date Completion date Total Contract Amount	[insert date] [insert date] [insert amount]				
	If partner in a JV, specify participation of the total Contract Amount	_____%		Amount & Currency [insert amount] USD/GBP/EUR/JPY Equivalent [insert amount] delete not appropriate		
	Employer's Name Address Tel / Fax e-mail Brief description with justifications of the similarity compared to this Employer's requirements	[state justification in support of its similarity compared to the proposed works]				
3.3	**Average annual construction turnover *[total certified payments received for contracts in progress or completed for each year of works in progress or completed; using selling exchange rate quoted by the source being Bangladesh Bank on the date reported, if applicable]***					
	Year	**Amount & Currency**				

<table>
<tr><td>3.4</td><td colspan="4">Existing commitments and works
[targeted to be completed by the Intended Completion Date of the proposed works;]</td></tr>
<tr><td rowspan="3"></td><td rowspan="3">Name of Contract
Contract no [reference] of [year]
Name of Employer
Contact Address
Tel/fax
e-mail</td><td rowspan="3">Target Completion Date</td><td colspan="2">Value of Existing Commitments and Works</td></tr>
<tr><td>Amount & Currency</td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>3.5</td><td colspan="4">Financial Resources available to meet the construction cash flow</td></tr>
<tr><td rowspan="3"></td><td rowspan="2">No</td><td rowspan="2">Source of financing</td><td colspan="2">Amount Available</td></tr>
<tr><td>Amount & Currency</td><td></td></tr>
<tr><td></td><td></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="4">In order to confirm the above statements the JVCA Partner shall submit, as applicable, the documents mentioned in ITT Clause 28.</td></tr>
<tr><td>3.6</td><td colspan="4">Contact Details</td></tr>
<tr><td></td><td colspan="4">Name, address, and contact details of Tenderer’s Bankers and other Employer(s) that may provide references if contacted by this Employer</td></tr>
</table>

<table>
<tr><td>3.7</td><td colspan="3">Qualifications and experience of key technical and administrative personnel proposed for Contract administration and management</td></tr>
<tr><td></td><td>Position
Name
Years of General Experience</td><td colspan="2">Years of Specific Experience</td></tr>
<tr><td></td><td></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="3">[Tenderer to complete details of as many personnel as are applicable. Each personnel listed above should complete the Personnel Information (Form -6)]</td></tr>
<tr><td>3.8</td><td colspan="3">Major items of Construction Equipment proposed for carrying out the works [ITT Clause 28]</td></tr>
<tr><td></td><td>Item of Equipment</td><td>Condition
(new, good, average, poor)</td><td>Owned, leased or to be purchased
(state owner, leaser or seller)</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">[Tenderer to list details of each item of Major equipment, as applicable]</td></tr>
</table>

Signature
(Name of Authorized Signatory of the JVCA Partner)

ASIAN UNIVERSITY FOR WOMEN

Specialist Subcontractor Information **(Form F-4)**

[This Form should be completed by each Subcontractor, preferably on its Letter-Head Pad]

Invitation for Qualification No: *[indicate IFP No]*

Tender Package No *[indicate Package No]*

This Package is divided into the following Number of Lots

1.	**Eligibility Information of the Subcontractor [*ITT*]**	
1.1	Nationality of Individual or country of Registration	
1.2	Subcontractor's legal title	
1.3	Subcontractor's registered address	
1.4	Subcontractor's legal status *[complete the relevant box]*	
	Proprietorship	
	Partnership	
	Limited Liability Concern	
	Government-owned Enterprise	
	Other (please describe)	
1.5	Subcontractor's year of registration	
1.6	Subcontractor's authorized representative details	
	Name	
	Address	
	Telephone / Fax numbers	
	e-mail address	
1.7	Subcontractor to attach copies of the following original documents	All documents to the extent relevant to ITT Clause in support of its qualifications
The following two information are applicable for national Subcontractors		
1.8	Subcontractor's Value Added Tax Registration (VAT) Number	
1.9	Subcontractor's Tax Identification Number (TIN)	

[The foreign Subcontractors, in accordance with ITT, shall provide evidence by a written declaration to that effect to demonstrate that it meets the criterion]		
2. Key Activity(ies) for which it is intended to be Subcontracted		
2.1	**Elements of Activity**	**Brief description of Activity**
2.2	**List of Similar Contracts in which the proposed Subcontractor had been engaged**	
	Name of Contract and Year of Execution **Value of Contract** **Name of Employer** **Contact Person and Contact details** **Type of Work Performed**	

Signature (Name of Authorized Signatory of the Proposed Sub-Contractor)

ASIAN UNIVERSITY FOR WOMEN

Historical Contract Non-Performance (Form F-5)

[The following table shall be filled in for the Applicant and for each partner of a Joint Venture]

Applicant's Legal Name: *[insert full name]*
Date: *[dd/mm/yy]*
Joint Venture Party Legal Name:*[insertfull name]* IFP No. and title: *[insert RFP number and title]*
Page *[insert page number]* of *[insert total number]* pages

Non-Performing Contracts in accordance with Qualification Criteria and Requirements			
☐ Contract non-performance did not occur during the *[number]* years specified in Qualification Criteria and Requirements, ☐ Contract(s) not performed during the *[number]* years specified in Qualification Criteria and Requirements,			
Year	**Non performed portion of contract**	**Contract Identification**	**Total Contract Amount (Current value)**
[insert year]	*[insert amount and percentage]*	Contract Identification: *[indicate complete contract name/ number, and any other identification]* Name of Employer: *[insert full name]* Address of Employer: *[insert street/city/country]* Reason(s) for non performance: *[indicate main reason(s)]*	
Pending Litigation, in accordance with Qualification Criteria and Requirements			
☐ No pending litigation in accordance with Qualification Criteria and Requirements,. ☐ Pending litigation in accordance with Qualification Criteria and Requirements, as indicated below.			

Year	**Outcome as Percentage of Total Assets**	**Contract Identification**	**Total Contract Amount (current value)**
[insert year]	*[insert percentage]*	Contract Identification: [indicate complete contract name, number, and any other identification] Name of Employer: *[insert full name]* Address of Employer: *[insert street/city/country]* Matter in dispute: *[indicate main issues in dispute]*	**Total Contract Amount (current value)**

ASIAN UNIVERSITY FOR WOMEN

Personnel Information (Form -6)

[This Form should be completed for each person proposed by the Tenderer on Form PW5-2& PW5-3, where applicable]

Name of the Applicant:	*[insert Title]*
Invitation for Tender No:	*[indicate RFP No]*
Tender Package No	*[indicate Package No]*
This Package is divided into the following Number of Lots	*[indicate number of Lot(s)]*

A.	**Proposed Position** (tick the relevant box)	
☐ Electrical/Mechanical Engineer	☐ Prime Candidate	☐ Alternative Candidate
☐ Key Personnel	☐ Prime Candidate	☐ Alternative Candidate

B.	**Personal Data**
Name:	
Date of Birth:	
Years overall experience:	
National ID Number:	
Years of employment with the Tenderer:	
Professional Qualifications: 1. 2. 3. 4.	

C.	**Present Employment** *[to be completed only if not employed by the Applicant]*	
Name of the Employer:		
Address of the Employer:		
Present Job Title:		
Years with the present Employer:		
Tel No:	Fax No:	e-mail address:

Contact *[manager/personnel officer]:*

D. Professional Experience			
Summaries professional experience over the last twenty (**20**) years, in reverse chronological order. Indicate particular technical and managerial experience relevant to the project.			
	From	To	Company / Project / Position / Relevant technical and management experience.
1			
2			
3			
4			
5			

(Name and Signature of the Proposed Personnel)

ASIAN UNIVERSITY FOR WOMEN

Bill of Quantities

ASIAN UNIVERSITY FOR WOMEN

Package: Construction of Civil & MEP Works of STP, WTP & UGWR (Fire)			
Project: Asian University of Women, Permanent Campus Project, Arefin Nagar, Chattogram			
Summary Page			
Package Name	**Package No**	**Summary Description**	**Total Amount (BDT)**
General Works	Part A	General Works	
STP	Part B	Supply, Installation, Testing & Commissioing of MEP Works of STP	
	Part C	Construction of Civil Works of STP	
WTP & UGWR (Fire)	Part D	Construction of Civil Works UGWR (FIRE) & WTP	
	Part E	Supply, Installation, Testing & Commissioing of MEP Works of UGWR (FIRE) & WTP	
		Grand Total (Including VAT, AIT)	
In Words:			

Part: A:Tentative BOQ of Consturction of General Works of STP, WTP & UGWR (Fire)					
Project: Asian University of Women, Permanent Campus Project, Arefin Nagar, Chattogram					
Scope: Consturction of General Works of STP, WTP & UGWR (Fire)					
S/N	**Description of Work**	**Unit**	**Quantity**	**Unit Rate**	**Total Amount (BDT.)**
1	Erection and maintenance of site office and removal of the same after completion of work in accordance with the conditions of contract. In addition to the office required for his own use, the contractor shall provide and maintain furnished field office for the use of the Engineerin-charge and his staff. The field office is to have a concrete floor, adequate foundation, brick walls, false ceiling of hard board with seasoned Garjan wood frame and painted, and all windows are to be glazed and provided with steel grill. Outside and inside wall surface are to be painted on plaster acceptable to the Engineer in-charge. The field office shall be maintained in a secure and watertight condition by the contractor until the completion of the contract and shall be provided with electricity, running water and sewerage. All doors shall be fitted with approved locks and windows shall be provided with screen/blinds. Before construction the contractor shall submit plans and drawings showing proposed details and location for the field office, including foundations, access roads, shades, layout of electrical and water supply and hard standings thereto for the approval of the Engineer-in-charge.	Job	1		
2	Engineer's site office of minimum 10 sqm plinth area with providing necessary facilities including office furniture, consumables, stationeries etc.	Job	1		
3	Providing necessary facilities in construction site for maintaining site safety including safety helmet, safety belt , apron, gumboot, goggles	Job	1		
4	Supplying and providing of first aid box with necessary materials/medicine (hygienic gown, thermometer, adhesive dressings, antiseptic solutions, bandages, cotton balls or swaps, emergency blanket, gloves, hand sanitizer, ice pack, saline etc). All complete as per direction of Engineer-in - charge.	Job	1		
5	Providing 3 sets as-built drawings subject to Engineer's approval produced in AutoCAD software in 584.5 mm x 413.5 mm (A-2 size) standard drawing paper, and operating and maintenance manual of the equipment and plant incorporated in the works, if any, in original by the date stated in the particular conditions of contract (PCC). If the contractor does not supply	Per Tender	1		

S/N	Description of Work	Unit	Quantity	Unit Rate	Total Amount (BDT.)
	the as-built drawings and operating & maintenance manuals by the date stated in the particular conditions of contract (PCC), or they do not receive the Engineer-in-charge's approval, the Engineer-in-charge shall withhold the amount stated in the PCC from the payments due to the contractor. The as-built drawings must show the permanent works as actually constructed and reflect the revision of drawings supplied to the contractor during the Contract as well as revisions of drawings supplied to the contractor during the contract. (One set of as-built drawings shall be considered for measurement and payment)				
7	Mobilization and cleaning site before commencing actual physical work and during contract period and demobilization after completion of the Works under contract accepted by Engineer-in-Charge/Consultant. This work shall also covers clayey cleaning and clearing, and in the ground to the project can be executed an extent that all the events of works of smoothly in a working environment with a particular attention on safety and security in all respects, agreed by the Engineer / Consultant, where payments are to be based on ground area determined by the Engineer-in-Charge / Consultant. and be proportionate to the percentage progress of work under contract as a whole in all respects and approved by the	LS	1.000		
				Total Amount(Part A)	
In Words:					

Part: B:Tentative BOQ of Supply, Installation, Testing, Commissioing of MEP Works of STP					
Project: Asian University of Women, Permanent Campus Project, Arefin Nagar, Chattogram					
Scope: Supply, Installation, Testing, Commissioing of MEP Works of STP					
S/N	**Description of Work**	**Unit**	**Quantity**	**Unit Rate**	**Total Amount (BDT)**
1	Supplying, fitting and fixing the **Diffuser unit submersed type for aeration tank** ,all complete as per directions of the E-I-C. The Specifications is as follows: - Fine bubble diffuser, Disk type - Air Flow: 20 ~150 LPM - Dia: 250mm (10 inch) - Origin: Taiwan/China/India	pcs	30.000		
2	Supplying, fitting and fixing the **Air Blower** ,all complete as per directions of the E-I-C. The Specifications is as follows: - Roots Air Blower - Model: TH 75 - Capacity: 180~200 m3/hr - Motor Power: 7.5 HP - Power Supply: 380~415V, 50Hz - Origin: Taiwan/China/India	set	2		
3	Supplying, fitting and fixing the **Sludge Transfer Pump**,all complete as per directions of the E-I-C. The Specifications is as follows: - Submersible Cutter Sewage Pump Or Centrifugal type pump - Head-10 M - Capacity: 10 m3/hr - Motor Power: 2 HP - Power Supply: 1/3ph/220V/2900rpm/50hz - Origin: Taiwan/Italy/China	set	3		
4	Supplying, fitting and fixing the **Digital Flow Meter,** all complete as per directions of the E-I-C. The Specifications is as follows: - Size: 1.5 inch (Inclusing fitting materials) - Velocity Range: 0.3 – 10 m/s - LCD digital display - Ambient Temperature: −10°C to +60°C - Pressure Rating: Up to 1.6 MPa (16 bar) - Body Material: Carbon steel / Stainless steel - Origin: Taiwan/China/India	set	1		
5	Supplying, fitting and fixing the **Raw Water Feed Pump**,all complete as per directions of the E-I-C. The Specifications is as follows: - Horizontal centrifugal pump - Capacity: 10,000 liter/hr, - Motor Power: 2 HP, 1 Phase - Origin: Italy/taiwan/China	set	2		

S/N	Description of Work	Unit	Quantity	Unit Rate	Total Amount (BDT)
6	Supplying, fitting and fixing the **Multi-grade Sand Filte**r,all complete as per directions of the E-I-C. The Specifications is as follows: **Vessel** - Vessel Materials : FRP (Fiber Glass Reinforce Plastic), - Shape: Vertical cylindrical type, - Vessel Size: 24" Ø X 72" H, - Media quantity: As per required - Operation: Semi auto & backwash - Origin: Bangladesh/Taiwan/China/India **Filter Media** - Mesh Sand, Size : 1-3 mm , Per Bag : 1CFT - Course Silex : Mesh Size : 3-6mm, Per Bag : 1CFT - Graded Sand :Mesh Size 6-12 mm, Per Bag : 1CFT - Origin: Bangladesh/Taiwan/China/India	set	1		
7	Supplying, fitting and fixing the **Activated Carbon Filte**r,all complete as per directions of the E-I-C. The Specifications is as follows: **Vessel** - Vessel Materials : FRP (Fiber Glass Reinforce Plastic), - Shape: Vertical cylindrical type, - Vessel Size: 24" Ø X 72" H, - Media quantity: As per required - Operation: Semi auto & backwash - Origin: Bangladesh/Taiwan/China/India **Filter Media** - Graded Sand :Mesh Size 12-25 mm, Per Bag : 2CFT - Activated Carbon: Mesh Size : 4-6mm, Iodine No: 750mg/g, Per Bag : 1CFT - Origin: Bangladesh/Taiwan/China/India	set	1		
8	Supplying, fitting and fixing **NaOCl Dosing Unit**, all complete as per directions of the E-I-C. The Specifications is as follows: - Chemical Dosing Unit purpose uses tank, - Pump & others PVC tank - Tank capacity: 200Liter - Origin: China/Bangladesh/Taiwan	set	1		
9	Supplying, fitting and fixing the **Panel Board**, all complete as per directions of the E-I-C. The Specifications is as follows: - Electrical Panel Board with all equipment's included (100 A TPN+50 A ECC Copper Bus Bar, Outgoing-MCB 04 nos 10A SP, 04 Nos 16 A SP, 05 Nos 20 A SP. 02 Nos 20 A DP, Incoming-MCCB (50-63 A), Outgoing-MPCB (50-63 A) Circuit Breaker, Digital Meter, Push ON/OFF Switch with DOL starter, Indicating Lamp, Supply Return Cooling fan, Danger Sign & name Plate, cable Gland, SS lock, rubber gasket, transparent sheet for busbar, CT Ratio (3X63 A), Fuse, 3X4 A, etc. Socket, hardware, Cable, etc.) - Board size: 30"x24"X10" (HXWXD), Type: MS with powder coated - Mangetic Coductor: 32mpr, 220v/50hz - Overload: 32mpr, 220v/50hz - Relay, Relay Base, Timer and Channel: 6/8 Pin - Band: ABB/Schneider/Equivalent - Origin: Germany/China/Bangladesh/India required	set	1		
10	Supply, installation, testing & commissioing of FRLS PVC insulated power & domestic cables following Brands: BRB/BBS/SQ				
i	NYY=1CX10 mm2	Mtr	200		
ii	NYY=1CX6 mm2	Mtr	150		
iii	NYY=2CX4 mm2	Mtr	150		

S/N	Description of Work	Unit	Quantity	Unit Rate	Total Amount (BDT)
iv	NYY=2CX2.5 mm2	Mtr	100		
11	Supply, installation, testing & commissioing of FRLS PVC insulated earthing cables following Brands: BRB/BBS/SQ				
i	BYA=1CX10 mm2	Mtr	100		
ii	BYA=1CX6 mm2	Mtr	100		
iii	BYA=1CX4 mm2	Mtr	100		
iv	BYA=1CX2.5 mm2	Mtr	50		
12	Supply & Installation of 16-18 SWG capsule type cable tray with cover considering fixing supporters thread rod & angle in the following specification				
i	Capsule Type Cable Tray (150X75)mm	RFT	100		
10	Supply, Unloading, Storing, Safe keeping, Shifting, fitting & fixing of Extra heavy uPVC pipe shall be made uPVC as per BS4514/ISO4422/SS213 standard including injection moided uPVC fittings where required e.g Tees, Bends (90º and 45º), Back Door Bends, Side Door Bends, Offset Bends, Clean out cap, Loose socket coupler, plug bend, reducer Bush socket, Test Opener, Door Socket, coupling & screwed, socketed adaptors, flanged tail piece, saddle and jointing with solvent cement, connection compelte in all respect as required at site. Cutting, Chase/hole in floor / Wall / Slab and GI Heavy class pipe sleeves of one size larger diameter shall be provided whatever the pipe are crossing fire rated wall / floor / slab and sealing the sleeves with in between and fire sealant compound at either ends. The Item include cutting wall, floor, slab and making the same with required materials. Pipe shall be bell end socket type. Approved type of solvent sealant shall be used to install pipe and jointing the pipe with pipefittings. Joint shall be watertight. In brick wall pipe shall be surrounded by concrete in 1:3, 5: 5.5 and shall be clamped to wall wall properly at an interval of not more than 12m. Pipe laying shall have the following gradient unless otherwise specifled. Proper support should use for both riser pipe and horizontal pipe. Nominal Diameter of pipe with thickness shall be as follows. Product shall be of A1, Partex, RFL, National Polymer Ltd. Bangladesh or equivalent.				
10.1	150 mm dia, 4.5 mm thick	Rm	50.000		
10.2	100 mm dia, 3.4 mm thick	Rm	120.000		
10.3	50 mm dia,2.4 mm thick	Rm	80.000		
11	After complete installation the system shall be **tested and commissioned** as per recommendation of the manufacturer and standard. The system shall be tested with pressure in presence of the Client/Consultant. All testing of electrical system shall be done as per direction. Test certification shall be taken from the Engineer	Job	1.00		
12	Preparation of **As-built drawing** for all elements of WTP and UGWR. Doccumentation for handover and O&M manual for WTP including tagging & signage. Any other related doccuments preparation as per requirement. All completed approved and accepted by the Engineer-in-charge.	Job	1.00		

13	**Tagging, Identification & Signage Indication**	Job	1.00		
14	Miscellaneous & Others	Job	1.00		
				Total Amount (Part B)	
In Words:					

Part: C:Tentative BOQ of Consturction of Civil Works of STP					
Project: Asian University of Women, Permanent Campus Project, Arefin Nagar, Chattogram					
Scope: Supply, Installation, Testing and Commissioning of STP					
S/N	**Description of Work**	**Unit**	**Quantity**	**Unit Rate (BDT)**	**Total Amount (BDT)**
1	Providing layout and carry over PWD bench-mark (BM) at site from nearby BM pillar, property lines, existing ground level (EGL), formation ground level (FGL), highest flood levels (HFL), plinth levels (PL), mean sea level (MSL), setting and marking all pillars, marker, pegs etc. showing and maintaining reduced levels (RL"s) including locating, establishing, protecting all public utilities within the premise of work and finally all to be presented in black and white	sqm.	120		
	Mobilization and cleaning site before commencing actual physical work and during contract period and demobilization after completion of the works under contract to be accepted by the Engineer-in-charge. This work shall also cover cleaning and clearing, cutting or filling, dressing the project area on and in the ground to an extent that all the events of works of the project can be executed smoothly in a working environment with a particular attention on safety and security in all respects, and to stockpile the end outcome to a place for disposal agreed by the Engineer-in-charge, where, payments are to be based on ground area determined by the Engineer-in-charge and be proportionate to the percentage progress of work under contract as a whole in all respects and approved by the Engineer-in-charge	sqm	120		
3	Earth work in excavation in all kinds of soil for foundation trenches including layout, providing center lines, local benchmark pillars, levelling, ramming and preparing the base, fixing bamboo spikes and marking layout with chalk powder, providing necessary tools and plants, protecting and maintaining the trench dry etc., stacking, cleaning the excavated earth at a safe distance out of the area enclosed by the layout etc. all complete and accepted by the Engineerin-charge, subject to submit method statement of carrying out excavation work to the Engineer-in-charge for approval. However, engineer's approval shall not relieve the contractor of his responsibilities and obligations under the contract. Excavation depth up to 6m	cum	540		

4	Sand filling in foundation trenches and plinth with sand having min. F.M. 1.2 in 150 mm in layers including leveling, watering and compaction to achieve minimum dry density of 95% with optimum moisture content (Modified proctor test) by ramming each layer up to finished level as per design supplied by the design office only, all complete and accepted by the Engineer-in-charge.	cum	162		
6	One layer brick flat soling in foundation or in floor with first class/picked jhama bricks (BDS 208) including preparation of bed and filling the interstices with local sand, leveling etc. complete and accepted by the Engineer-in-charge.	sqm	150		
7	Mass concrete (1:2:4) in foundation or in floor with cement, sand (F.M. 1.2) and picked jhama brick chips including				

S/N	Description of Work	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
	breaking of chips, screening, mixing, laying, compacting to required level and curing for at least 7 days including the supply of water, electricity, costs of tools & plants and other charges etc. all complete and accepted by Engineer-in-charge. (Cement: CEM-II / B-M) **Mass concrete in foundation (1:2:4) with brick chips and local sand of F.M. 1.2.**	cum	14		
8	Brick works with first class bricks with cement sand (F.M. 1.2) mortar (1:4) in exterior walls including filling the interstices with mortar, raking out joints, cleaning and socking the bricks at least for 24 hours before use and washing of sand, necessary scaffolding, curing at least for 7 days etc. all complete including cost of water, electricity and other charges (measurement to given as 250 mm width for one brick length and 375 mm for one brick and a half brick length) accepted by the Engineer-in-charge. (Cement: CEM-II/B-M) In ground floor	cum	10		

9	Reinforced cement concrete works with minimum cement content relates to mix ratio 1:1:2 having minimum compressive strength f'c = 35 MPa at 28 days on standard cylinders as per standard practice of Code ACI / BNBC, Cement conforming to BDS EN-197-1-CEM-I, 52.5N, and adding approved high range water reducing admixture of complying specific type (generally be Type-G) under ASTM-C 494, best quality coarse sand [Sylhet sand or coarse sand of equivalent F.M. 2.2], 20 mm down well graded crushed stone chips conforming to ASTM C-33 (Aggregate grading as per table shown in technical specification), conducting necessary tests, making and placing shutter in position and maintaining true to plumb, making shutter water-tight properly, placing reinforcement in position; mixing with standard mixer machine with hopper and fed by standard measuring boxes, casting in forms, compacting by vibrator machine and curing at least for 28 days, removing centering-shuttering after specified time approved; including cost of water, electricity, other charges etc. all complete approved and accepted by the Engineer-in-charge. (Doses of admixture to be fixed in consultation with design office) (Rate is excluding laboratory test fees, the cost of reinforcement and its fabrication, placing, binding etc. and the cost of shuttering & centering)				
9.1	Footing and Slab	cum	125.14		
9.2	RCC Wall	cum	116.48		
11	Centering and shuttering, including strutting, propping etc. (The formwork must be rigid enough both in and out of plane, to make the concrete surface true to the designed shape and size by using necessary MS sheets of minimum 16 BWG, angles of minimum size 40 mm x 40 mm x 5 mm, flat bars etc.) and removal of form for				
11.1	For Mat	sqm	34.14		
11.2	For Vertical wall	sqm	106.19		
11.3	For Top slab	sqm	588.34		

S/N	Description of Work	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT
10	Supplying, fabrication and fixing to detail as per design : ribbed or deformed bar reinforcement (excluding laboratory test fees) for Reinforced concrete, produced and marked in accordance with BDS ISO 6935-2:2016 (or standard subsequently released from BSTI) including straightening and cleaning rust, if any, bending and binding in position with supply of G.I. wires, conducting necessary laboratory tests etc. (excluding splices or laps) complete in all respect and accepted by the Engineer-in-charge (Measurement shall be recorded only on standard mass per unit length of bars, while dia of bars exceeds its standard)				

10.1	Grade 500 (B500DWR: complying BDS ISO 6935-2:2016 / ASTM A615) ribbed or deformed bar produced and marked according to Bangladesh standard, with minimum yield strength, fy (ReH)= 500 MPa and whatever is the yield strength within allowable limit as per BNBC/ ACI 318, the ratio of ultimate tensile strength fu to actual yield strength fy, shall be at least 1.25 and minimum elongation after fracture and minimum total elongation at maximum force is 17% and 8% respectively	kg	34560.79		
11	Minimum 6 mm thick cement sand (F.M. 1.2) plaster (1:4) with fresh cement to slab, R.C.C. columns, beams, Walls, and finishing the corners and edges including washing of sand, cleaning the surface, curing at least for 7 days, cost of water, electricity, scaffolding and other charges etc. all complete in all respect as per drawing and accepted by the Engineer-in-charge. (Cement: CEM-II/B-M)	sqm.	1092.50		
12	Road cutting & debris removal for connectivity	Job	1.00		
13	Shore protection with Sheet Pile & Bracing work with I joist (if necessary as per site condition) contractor will submit the design & method statement prior execution of work (contractor is solely responisble for design)	Job	1.00		
14	Minimum 12 mm thick cement sand (F.M. 1.2) plaster with neat cement finishing to plinth wall with cement (1:4) up to 150 mm below ground level including washing of sand, finishing the edges and corners and curing at least for 7 days, cost of water, electricity, scaffolding and other charges etc. all complete in all respect as per drawing and accepted by the Engineer-in-charge. (Cement: CEM-II/B-M)	sqm.	95.10		
15	Miscellaneous & Others	Job	1.00		
				Total Amount (Part B)	
In Words:					

Part: D:Tentative BOQ of Consturction of Civil Works of UGWR (FIRE) & WTP					
Project: Asian University of Women, Permanent Campus Project, Arefin Nagar, Chattogram					
Scope: Construction of Civil Works UGWR (FIRE) & WTP					
S/N	**Description of Work**	**Unit**	**Quantity**	**Unit Rate**	**Total Amount (BDT)**
1	Providing layout and carry over PWD bench-mark (BM) at site from nearby BM pillar, property lines, existing ground level (EGL), formation ground level (FGL), highest flood levels (HFL), plinth levels (PL), mean sea level (MSL), setting and marking all pillars, marker, pegs etc. showing and maintaining reduced levels (RL‟s) including locating, establishing, protecting all public utilities within the premise of work and finally all to be presented in black and white	sqm.	213.12		
2	Mobilization and cleaning site before commencing actual physical work and during contract period and demobilization after completion of the works under contract to be accepted by the Engineer-in-charge. This work shall also cover cleaning and clearing, cutting or filling, dressing the project area on and in the ground to an extent that all the events of works of the project can be executed smoothly in a working environment with a particular attention on safety and security in all respects, and to stockpile the end outcome to a place for disposal agreed by the Engineer-in-charge, where, payments are to be based on ground area determined by the Engineer-in-charge and be proportionate to the percentage progress of work under contract as a whole in all respects and approved by the Engineer-in-charge.	sqm	213.12		
3	Earth work in excavation in all kinds of soil for foundation trenches including layout, providing center lines, local benchmark pillars, levelling, ramming and preparing the base, fixing bamboo spikes and marking layout with chalk powder, providing necessary tools and plants, protecting and maintaining the trench dry etc., stacking, cleaning the excavated earth at a safe distance out of the area enclosed by the layout etc. all complete and accepted by the Engineerin-charge, subject to submit method statement of carrying out excavation work to the Engineer-in-charge for approval. However, engineer’s approval shall not relieve the contractor of his responsibilities and obligations under the contract. Earthwork in excavation in foundation trenches up to 8.5m depth Contractor will take all HSE precaution during excavation phase & soley reposnible for any unwanted occurance .Contratcor will dispose the excavated material as per direction E-I-C	cum	1,491.00		
4	Prepare rainshed with tarpulin & bamboo to execute the civil work at site as per direction E-I-C . Note that contractor will take all prepration water won't stagnanat inside foundation trenches .He will use mud pump /shallow pump etc to remove the water & to make the site ready for work	sqm	312.5		
5	Sand filling in foundation trenches and plinth with sand having min. F.M. 1.2 in 150 mm in layers including leveling, watering and compaction to achieve minimum dry density of 95% with optimum moisture content (Modified proctor test) by ramming each layer up to finished level as per design supplied by the design office only, all complete and accepted by the Engineer-in-charge.	cum	447.30		

6	One layer brick flat soling in foundation or in floor with first class/picked jhama bricks (BDS 208) including preparation of bed and filling the interstices with local sand, leveling etc. complete and accepted by the Engineer-in-charge	sqm	266.40		
	Supplying and laying of single layer polythene sheet	sqm	266.40		

S/N	Description of Work	Unit	Quantity	Unit Rate	Total Amount (BDT)
7	weighing one kilogram per 6.5 square meter in floor or anywhere below cement concrete complete in all respect and accepted by Engineer-in-charge.				
8	Mass concrete (1:2:4) in foundation or in floor with cement, sand (F.M. 1.2) and picked jhama brick chips including breaking of chips, screening, mixing, laying, compacting to required level and curing for at least 7 days including the supply of water, electricity, costs of tools & plants and other charges etc. all complete and accepted by Engineer-in-charge. (Cement: CEM-II / B-M) **Mass concrete in foundation (1:2:4) with brick chips and local sand of F.M. 1.2.**	cum	24.26		
9	Brick works with first class bricks with cement sand (F.M. 1.2) mortar (1:4) in exterior walls including filling the interstices with mortar, raking out joints, cleaning and socking the bricks at least for 24 hours before use and washing of sand, necessary scaffolding, curing at least for 7 days etc. all complete including cost of water, electricity and other charges (measurement to given as 250 mm width for one brick length and 375 mm for one brick and a half brick length) accepted by the Engineer-in-charge. (Cement: CEM-II/B-M) In ground floor	cum	32.76		
10	Reinforced cement concrete works with minimum cement content relates to mix ratio 1:1:2 having minimum compressive strength f'c = 35 MPa at 28 days on standard cylinders as per standard practice of Code ACI / BNBC, Cement conforming to BDS EN-197-1-CEM-I, 52.5N, and adding approved high range water reducing admixture of complying specific type (generally be Type-G) under ASTM-C 494, best quality coarse sand [Sylhet sand or coarse sand of equivalent F.M. 2.2], 20 mm down well graded crushed stone chips conforming to ASTM C-33 (Aggregate grading as per table shown in technical specification), conducting necessary tests, making and placing shutter in position and maintaining true to plumb, making shutter water-tight properly, placing reinforcement in position; mixing with standard mixer machine with hopper and fed by standard measuring boxes, casting in forms, compacting by vibrator machine and curing at least for 28 days, removing centering-shuttering after specified time approved; including cost of water, electricity, other charges etc. all complete approved and accepted by the Engineer-in-charge. (Doses of admixture to be fixed in consultation with design office) (Rate is excluding laboratory test fees, the cost of reinforcement and its fabrication, placing, binding etc. and the cost of shuttering & centering)				
11	Footing and Slab	cum	252.83		
12	RCC Wall	cum	161.85		

13	Supply ,fabrication & fixing Grade 500 (B500DWR: complying BDS ISO 6935-2:2016 / ASTM A615) ribbed or deformed bar produced and marked according to Bangladesh standard, with minimum yield strength, fy (ReH)= 500 MPa and whatever is the yield strength within allowable limit as per BNBC/ ACI 318, the ratio of ultimate tensile strength fu to actual yield strength fy, shall be at least 1.25 and minimum elongation after fracture and minimum total elongation at maximum force is 17% and 8% respectively (Rate including Lap,splices ,chair bar etc)	kg	68,875.92		

S/N	Description of Work	Unit	Quantity	Unit Rate	Total Amount (BDT)
14	Centering and shuttering, including strutting, propping etc. (The formwork must be rigid enough both in and out of plane, to make the concrete surface true to the designed shape and size by using necessary MS sheets of minimum 16 BWG, angles of minimum size 40 mm x 40 mm x 5 mm, flat bars etc.) and removal of form for				
14.1	For Mat	sqm	33.60		
14.2	For Vertical wall	sqm	1,250.76		
14.3	For Top slab	sqm	464.40		
15	Supply and application of waterproofing treatment to slabs and walls using three coats of acrylic based fiber reinforced elastomeric liquid water proofing membrane conforming to relevant ASTM standards product available in market. Surface preparation shall include cleaning, drying, making free from dirt, grease, wax, removing all chalked and scaled materials, fungus , mending the surface defects using sandpaper, filling cracks using suitable Crack Seal as necessary. First coat shall be diluted by 30% water and used as self-priming coat for the following two coats, achieving force coverage of 10sft/ltr. Incase of greater surface area, fiber mesh can be used in between the priming coat and second coat, followed by two more coats for better durability.All shall be completed as per manufacturer's specifications & recommendations and accepted by the Engineer-incharge	sqm.	899.10		
16	Minimum 6 mm thick cement sand (F.M. 1.2) plaster (1:4) with fresh cement to slab, R.C.C. columns, beams, Walls, and finishing the corners and edges including washing of sand, cleaning the surface, curing at least for 7 days, cost of water, electricity, scaffolding and other charges etc. all complete in all respect as per drawing and accepted by the Engineerin-charge. (Cement: CEM-II/B-M)	sqm.	899.10		
17	Supplying, fitting and fixing SS **Ladder** of 3000 mm x 600 mm size in which outer frame of 2 mm thick 50 mm dia SS pipe and horizontal bar for lower part (approximately 1800 mm) of 2 mm thick 40 mm dia SS pipe @ 200 mm c/c and fitting and fixing the whole with 100 mm x 100 mm x 6 mm SS base plate on both side and fitting base plate on RCC or Brick wall by Rowel Bolt including welding, bending, fabricating, all complete as per drawing, design and specification etc. all complete in all respect and accepted by Engineerin-charge	sqm.	5.10		

18	Interior standard acrylic emulsion paint (plastic or matt finish) of approved best quality and colour delivered from authorized local agent of the manufacturer in a sealed container; applying to interior wall and ceiling with surface preparation including cleaning drying, making free from dirt, grease, wax, removing all chalked and scaled materials, fungus, mending good the surface defects using sand paper and necessary scaffolding; applying necessary interior sealer of specified brand on prepared surface; then applying necessary interior putty of specified brand for levelling, spot filling, crack filling and cutting by sand paper/zero water paper; finally applying 2 coats of interior emulsion paint spreading by brush/roller/spray& necessary scaffolding etc. up to desired finishing, elapsing specified time for drying or recoating; all complete in all floors and accepted by the Engineer-in-charge.	sqm.	475.98		

S/N	Description of Work	Unit	Quantity	Unit Rate	Total Amount (BDT)
19	Water-proofing membrane on external surface of primed vertical or inclined wall /on plastered and primed back-wall and concrete cast against membrane & foundation	sqm	551.59		
20	Shore protection with Sheet Pile & Bracing work with I joist (if necessary as per site condition) contractor will submit the design & method statement prior execution of work (contractor is solely responisble for design)	Job	1.00		
22	Supply and installation of 0.457 mm thick corrugated galvanized iron sheet (Bangladesh made) having min weight 63-65 kg per bundle (2'-6" width, 70 – 72 rft long) fitted and fixed on M.S. sections with 'J' hook or wooden purlin with screws, limpet washers and putty etc. (up to level-4) all complete and accepted by the Engineer-in-charge	sqm.	13.69		
23	Miscellaneous & Others	Job	1.00		
				Total Amount (Part D)	
In Words:					

Part: E:Tentative BOQ of Supply, Installation, Testing & Commissioing of MEP Works of UGWR (FIRE) & WTP					
Project: Asian University of Women, Permanent Campus Project, Arefin Nagar, Chattogram					
Scope: Supply, Installation, Testing & Commissioing of MEP Works of UGWR (FIRE) & WTP					
S/N	**Description of Work**	**Unit**	**Quantity**	**Unit Rate (BDT)**	**Total Amount (BDT)**
1	Supplying, fitting and fixing the **Cetrifugal Pump for Feed Water** ,all complete as per directions of the E-I-C. The Specifications is as follows: - Power: 4hp, - Head meter: 50-60, - Capacity : 10m3/hr, - Type of Pump : Multi Stage Vertical - Origin: ItalyTaiwan/China	Set	2.00		
2	Supplying, fitting and fixing the **Cetrifugal Pump for Feed Water**,all complete as per directions of the E-I-C. The Specifications is as follows: - Power: 1.5hp, - Head meter: 30-40, - Capacity : 1-2m3/hr, - Type of Pump : Centrifugal Function - Origin: ItalyTaiwan/China	Set	2.00		
3	Supplying, fitting and fixing the **Dosing Pump** ,all complete as per directions of the E-I-C. The Specifications is as follows: - Power : 0.5hp - Head meter: 10m, - Capacity : 2-6 LPH - Origin: ItalyTaiwan/China	Set	2.00		
4	Supplying, fitting and fixing the **Dosing Checmial Tank** ,all complete as per directions of the E-I-C. The Specifications is as follows: -Type of Tank : HDPE, - Capacity : 100 Liter - Origin: Bagladesh/China/India	pcs	2.00		
5	Supplying, fitting and fixing the **Water Flow Meter,** all complete as per directions of the E-I-C. The Specifications is as follows: - Type: Rota, - Capacity : 50GPM, - In out -2 inch (Inclusing fitting materials) - Origin: Bagladesh/China/India	Set	2.00		
6	Supplying, fitting and fixing the **Multi-grade Sand Filte**r,all complete as per directions of the E-I-C. The Specifications is as follows: **Vessel** - Type : MS, - Model : 900X1800 (HXD), - Body Thickness: 5mm, - End Dish : 6mm, - Hand Whole Size : 300mm, - Manhole : 450, - Origin: Bangladesh/Taiwan/China/India **Filter Media** - Mesh Sand, Size : 1-3 mm , Per Bag : 1CFT - Course Silex : Mesh Size : 3-6mm, Per Bag : 1CFT - Graded Sand :Mesh Size 6-12 mm, Per Bag : 1CFT - Origin: Bangladesh/Taiwan/China/India	Set	1.00		

7	Supplying, fitting and fixing the Activated Carbon Filter,all complete as per directions of the E-I-C. The Specifications is as follows: Vessel - Type : MS, - Model : 900X1800 (HXD), - Body Thickness: 5mm, - End Dish : 6mm, - Hand Whole Size : 300mm, - Manhole : 450, - Origin: Bangladesh/Taiwan/China/India Filter Media - Graded Sand :Mesh Size 12-25 mm, Per Bag : 2CFT - Activated Carbon: Mesh Size : 4-6mm, Iodine No: 750mg/g, Per Bag : 1CFT - Origin: Bangladesh/Taiwan/China/India	Set	1.00		

8	Supplying, fitting and fixing the **Softener (Resin) Filte**r,all complete as per directions of the E-I-C. The Specifications is as follows: **Vessel** - Type : FRP, - Dimention : 400X1625 (DXH), - Operation Type : Top mounted Head and Manual - Origin: China/USA/Taiwan **Filter Media** - Support Sand: Mesh Size : 6-12mm, Per Bag : 1CFT - Cation Exchange Resin: Mesh Size : 0.5-1mm, - Regenration Solution : NaCl- 10-15%. Per Bag : 25 Liter - Origin: China/USA/Taiwan	Set	1.00		
9	Supplying, fitting and fixing the Panel Board, all complete as per directions of the E-I-C. The Specifications is as follows: - Electrical Panel Board with all equipment's included (200 A TPN+100 A ECC Copper Bus Bar, Outgoing-MCB 05 Nos-10A, 05 Nos 16 A SP, 04 Nos 20 A SP, 03 Nos 20 A DP, 02 Nos 32 A DP Incoming-MCCB (100-125 A), Outgoing-MPCB (63-100 A) Circuit Breaker, Digital Meter, Push ON/OFF Switch with DOL starter, Indicating Lamp, Supply Return Cooling fan, Danger Sign & name Plate, cable Gland, SS lock, rubber gasket, transparent sheet for busbar, CT Ratio (3X125 A), Fuse, 3X4 A, etc. Socket, hardware, Cable, etc.) - Board size: 42"x30"X10" (HXWXD), Type: MS with powder coated - Mangetic Coductor: 63mpr, 440v/50hz - Overload: 63mpr, 440v/50hz - Relay, Relay Base, Timer and Channel: 6/8 Pin - Band: ABB/Schneider/Equivalent - Origin: Germany/China/Bangladesh/Indiarequired	Set	1.00		
10	**Supply, installation, testing & commissioing of FRLS PVC insulated power & domestic cables following Brands: BRB/BBS/SQ**				
i	NYY=1CX25 mm2 (19-W)	Mtr	165		
ii	NYY=1CX6 mm2	Mtr	130		
iii	NYY=2CX4 mm2	Mtr	120		
iv	NYY=2CX2.5 mm2	Mtr	100		
v	BYA=1CX1.5 mm2 (RED)	Mtr	200		
vi	BYA=1CX1.5 mm2 (BLACK)	Mtr	200		

vii	BYA=1CX2.5 mm2 (RED)	Mtr	200		
viii	BYA=1CX2.5 mm2 (BLACK)	Mtr	200		
11	Supply, installation, testing & commissioing of FRLS PVC insulated earthing cables following Brands: BRB/BBS/SQ				
i	BYA=1CX16 mm2	Mtr	50		
ii	BYA=1CX6 mm2	Mtr	70		
iii	BYA=1CX4 mm2	Mtr	60		
iv	BYA=1CX2.5 mm2 (GREEN)	Mtr	60		

S/N	Description of Work	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
12	Supply & Installation of 16-18 SWG capsule type cable tray with cover considering fixing supporters thread rod & angle in the following				
i	Capsule Type Cable Tray (200X100)mm	RFT	150		
13	**Supply, Installation, testing & Commissioing of Internal Electrification Works**				
i	24" industrial exhaust fan galvanized with shutter type, rated power 0.55-0.75 kW, 440 V AC (foreign made accepted / approved by the Engineer). Including vertical ducting connectivity along with fresh air duct with luber of Fire Pump room & WTP Room. Country of Origin: China/Equivalent	Set	2		
	Light Fittings				
	Ceiling recessed /surface mounted imported 2'-0" tube light fixture of 20w and all other necessary accessories as per drawing and direction of Engineer in charge. Brand: Energy+/Unifix/Ledvance/Osram	Nos	12		
iii	Switch Board				
	Imported grey color gang switches & socket from Legrand(France) /M.K(singapore)/Schneider and wall boxes complete with all other necessary accessories & connections everything complete as per drawing and instruction of the Engineer-in-charge. The wall boxes may be PVC MK including earthing block.Brand:Legrand(France) /M.K(singapore)/Schneider				
	2 Gang (10A)	Sets	2		
	3 Gang (10A)	Sets	4		
iv	SOCKET OUTLET				
	Imported 5A 2/3-pin, 250V, combined switched universal socket outlet from Legrand(France/UK) /M.K(UK) / Crabtree (UK) /Schneider suitable for 2/3 pin plug including the box, cover plate with necessary galvanized machine screws, earthing block complete with necessary connections and direction of the Engineer-in-charge. The box may be locally made of 18 SWG galvanized sheet steel as per drawing and direction of Engineer in charge. Brand:Legrand(France) /M.K(singapore)/Schneider	Sets	6		
v	Electrical related others goods & accessories (PVC Pipe, Sockets, shadlle, screw, lux, cable tie, PVC tape etc.). Brand: RFL/Npoly/Sajan	Lot	1		
14	Earthing System				

	Earthing the electrical installation with 12.7 mm Cu wire (Earth electrode) with its protection by 40 mm (1.5") dia G.I. pipe (Top 10' & bottom 10') having 6.35 mm. dia hole across the pipe at 305 mm. interval up-to GL to be earthed including necessary connecting copper sockets, bolts, nuts, etc. complete for maintaining earth resistance within 1 ohm as per accepted / approved by the Engineer. Depth of earth boring at 36576 mm. (120 ft) to 45720 mm (150ft) (from GL & length of electrode 38100 mm. (125 ft) to 47244 mm (155ft), Construction of earthing inspection pit inside measurement 600 mm x 600 mm x 600mm with 250 mm thick brick in cement mortar (1:4) with 100mm thick RCC top slab (1:2:4) with 1% re-enforcement 450 mm dia water sealed CI man-hole cover with locking arrangement including necessary earth works, site filling and one brick flat soling 75 mm thick (1:3:6) base concrete for making inlet channel & 12mm thick (1:2) cement plaster with neat finishing etc. all complete up to a depth of .75 meter. Earth pit bus bar (150mm X 10mm X 300mm) with all other facilities for cable connection.Brand of Copper: Cooper tech	Sets	1		

S/N	Description of Work	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
15	**Supply, Installation, Testing and commissioning of Fire Management System for Fire Pump Room & WTP Room. Brand: Honeywell**				
i	Microprocessor based addressable Fixed temperature heat detector. It shall have electronic dual thermistor and a fixed alarm temperature of 68 deg C. The unit shall have LED indicator. Detector sensitivity must be programmed in the control panel software. Listed: UL/ULC/EN/VDS/JIS	Nos	2		
ii	Microprocessor based addressable Smoke Detector. Detector sensitivity must be programmed in the control panel software. sensitivity must be continuously monitored and reported to the panel. Listed: UL/ULC/EN/VDS/JIS	Nos	2		
iii	Intelligent dual-action Manual Pull Station including an addressable interface mounted inside, Key/lock reset, double action pull station complete with back box with all other accessories and consumables. Built-in multi color LED complete as required. Listed: UL/ULC/EN/VDS/JIS	Nos	2		
iv	Conventional type Horn with Strobe for Audible & Visible application, combination of Audible & Visible (A/V) Notification Appliances. The strobe light shall consist of a xenon flash tube and associated lens / reflector system. Provide a label inside the strobe lens to indicate the listed candela rating of the specific strobe. 1.FM Approved, UL 464, UL 1971& BFP Listed 2.Nominal voltage 24VDC 3.Units have feld selectable candela options of 15, 30, 60, 75, and 110 candela 4.Switch selection for high or low dBA 5.Switch for chime, whoop, mechanical and 2400Hztone.Listed: UL/ULC/EN/VDS/JIS	Nos	2		
v	Fire Alarm Repeater Panel	Nos	1		
vi	Supply and installation of "Exitlight" complete with rechargeable battery and charge light and other necessary accessories suitable for AC / DC power supply (220V single phase)	Nos	3		

vii	Supply and installation of "Emergency light" complete with rechargeable battery and charge light and other necessary accessories suitable for AC / DC power supply (220V single phase)	Nos	2		
viii	Supply and installation of "Emergency fog light" complete with rechargeable battery and charge light and other necessary accessories suitable for AC / DC power supply (220V single phase)	Nos	2.00		
ix	Supply & fixing the following capacities multi purpose ABC dry chemical powder stored pressure type with manometer system fire extinguisher suitable for repeated use complete with wall bracket etc. as per sample accepted & approved by the Engineer. Mono Ammonium Phosphate based 40% ABC dry chemical agent & has a moisture-proof, anti-caking properties. Working pressure : 12 BAR minimum & Test pressure : 25 BAR minimum. Proper fire rating (as per NFPA 10) according to the capacity of the extinguisher. Manufacturer certificate shall have to be submitted if needed. Also sample of the dry chemical powder will be tested by the proper authority in Bangladesh if needed.Country of origin : MALAYSIA / UAE or equivalent product. Capacity: 5 KG	Nos	4.00		
x	Supply & fixing the following capacities Carbon dioxide (CO2) fire extinguisher suitable for repeated use complete with wall bracket, discharge nozzle etc. as per sample accepted & approved by the Engineer.Country of origin : UAE / MALAYSIA or equivalent product.	Nos	4.00		
xi	2C×1.5mm2 Fire Resistant Cable Core Diameter1.5 sq.mm with PVC Conduit, Maximum allowable Resistance 12.1 Ohms/km/Core Maximum loop length: 1850 m.Listed: UL Listed	Mtr	300.00		
xii	2C×2.5mm2 Fire Resistant Cable Core Diameter 2.5 sq.mm with PVC Conduit, Maximum allowable Resistance 7.41 Ohms/km/Core Maximum loop length: 3000 m. Listed: UL Listed	Mtr	300.00		

S/N	Description of Work	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
xiii	Fire related others accessories	Job	1.00		
xiv	Testing Commissioing & Integration between academic building & WTP & Fire Pump Room of Fire System	Job	1.00		
16	**Tagging, Identification & Signage Indication**	Job	1.00		
17	**ICT (Information and Communication Technology) CCTV (Night vision), PABX, PA, Networking & WIFI , 9U Server rack, accessories including required cables like cat 6 cable, OM4 fibre optic cable etc. Country of origin: EU/Germany/USA. N.B: All of ICT device must be approved & verify by the AUW, IT department.**	Job	1.00		
18	Supplying different inside dia best quality **CPVC pressure pipe** for water supply having specific gravity 1.35 - 1.45, and other physical, chemical, thermal, fire resistivity properties etc. as per BSTI approved manufacturer standards or ASTM, BS/ISO/IS standards fitting and fixing in position with sockets, bends, with all accessories such as round grating/ domed roof grating, bends, sockets etc. approved and accepted by the Engineer-in-charge. Brand: Sajan/Npoly/RFL				
i	50 mm dia wall thickness 3.9 mm - 4.5 mm	Rm	250		
19	After complete installation the system shall be **tested and commissioned** as per recommendation of the manufacturer and standard. The system shall be tested with pressure in presence of the Client/Consultant. All testing of electrical system shall be done as per direction. Test certification shall be taken from the Engineer	Job	1.00		

20	Preparation of **As-built drawing** for all elements of WTP and UGWR. Doccumentation for handover and O&M manual for WTP including tagging & signage. Any other related doccuments preparation as per requirement. All completed approved and accepted by the Engineer-in-charge.	Job	1.00		

S/N	Description of Work	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
21	Supply & installation of **fire rated door** complete & accepted by the Engineer-in-charge with the following specification: Standard(s) for safety: UL Certified, FM Approved & NFPA 80 standard. ANSI / UL 10C: Positive pressure of fire tests of door assemblies. ANSI / UL 10B: Fire tests of door assemblies. UL Subject 63: Outline of investigation for fire frames. Shutter materials: Mild steel. Fire resistivity (Door & frame): Two hours. Fire resistivity (accessories): Three hours (panic bar, pul handle, ceramic fibre tape for sealing smoke, hinge, bolt and screw, mortice lock, door closer. Door frame: 2 vertical fire resisting jamb and 1 fire resisting horizontal jamb made with single rabbet hollow steel channel frame made of 2.3 mm imported cold rolled mild steel sheet. Four SS hinges (size: 112 mm x 100 mm x 3.4 mm) are used on each leaf screwed with frame. Door leaf: Door leaf faces consists of 1.6 mm thick imported cold rolled MS sheet attached together using interlocking mechanism and tack welding which is filled with imported 100 kg/m3 rock wool cake. Stiffeners should be used inside to strengthen structure. Vision Panel: Made of UL certified 5 mm glass. It has clear vision area of 150 mm x 100 mm. Its frame is made of 1.6 mm imported cold rolled MS sheet and SS pop rivet used for fixing. Ceramic fibre tape is used for sealing smoke. Internal insulation: Rock wool. Surface treatment: All MS sheets are chemically treated coated with zinc phosphate before assembly in highly equipped chemical treatment plant. All chemicals are imported. Paint Finish: Epoxy powder coated paint finish and curing in temperature controlled gas oven.	Nos	2.00		
22	Miscellaneous & Others and Tangging with Signage	Job	1.00		
				Total Amount(Part E)	
In Words:					

Design Brief Report for Civil & MEP Works of Water Treatment Plant (WTP), Sewage Treatment Plant (STP) & Underground Water Reservoir (UGWR) for Asian University for Women

Location: Bayezid Link Road, Chattogram.

ASIAN UNIVERSITY FOR WOMEN

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1 Introduction

The Asian University for Women is developing a new campus near Bayezid Link Road in Chattogram. To meet the campus water demand, groundwater will be sourced through a deep tubewell system. However, to ensure compliance with standard drinking water quality requirements, a dedicated Water Treatment Plant (WTP) is being established.

In addition, an Underground Water Reservoir (UGWR) is proposed to store the treated water and ensure a reliable and continuous supply across the campus. To address wastewater management and environmental sustainability, a Sewerage Treatment Plant (STP) is also being constructed to treat the generated sewage prior to safe discharge or reuse.

1.1 Background

In this preliminary design, a Water Treatment Plant (WTP) is proposed for the premises of Asian University for Women, located at Bayezid Link Road, Chattogram. The university campus is planned as a large institutional complex comprising multiple buildings. The main academic building will primarily serve educational functions, while several additional residential and institutional buildings are proposed for future expansion phases.

Considering the overall campus development plan, a reliable and sustainable water supply system is required to meet domestic and operational water demands. The proposed WTP will be designed to supply treated water for general consumption purposes, including drinking, sanitation, and other utility requirements within the campus facilities.

The source of raw water for the proposed treatment plant will be a deep tube-well located near the designated WTP site. The proximity of the source to the treatment facility will facilitate efficient pumping and operational management. In addition to domestic water storage, provisions will be made for firefighting water storage and chiller water storage within the same vicinity to ensure integrated infrastructure planning and optimized land utilization.

Furthermore, wastewater generated from the campus facilities will be collected and conveyed to a proposed Sewage Treatment Plant (STP) for appropriate treatment prior to disposal or reuse. This integrated approach ensures environmental compliance, sustainable water management, and long-term operational efficiency of the campus utility systems.

2 Design Basis

2.1 Water Treatment Plant

Following design parameters were considered for design purpose:

Source of Water: Deep Tube well
Plant Capacity : 15m³ per Hour
Plant Operation Time: 13 Hours Per day
Plant Operation: Semi-Auto
Plant Backwash and Regeneration and wash time: 1 Hour per day

2.2 Raw Water Quality

Test report of raw water from the source deep tube well was provided by the client. The test result is mentioned in the table below:

Table 2-1: Raw Water Quality

S/N	Water Quality Parameters	Unit	Concentration Present	Bangladesh Standard (ECR' 23)	WHO Guideline Values
1	pH	-	7.6	6.5-8.5	6.5-8.5
2	Color	Hazen	22	15	-
3	Total Hardness	mg/l	60	500	500
4	Chloride	mg/l	0.3	250	250
5	TDS	mg/l	143	1000	-
6	Manganese (Mn)	mg/l	0.01	0.4	0.4
7	Arsenic (As)	mg/l	0.0	0.05	0.01
8	Fecal Coliform	CFU/100ml	0	0	0
9	Total Coliform	CFU/100ml	0	0	0
10	Iron (Fe)	mg/l	0.1	0.3-1	0.3

2.3 Characteristics of Treated Water

Characteristics of the treated water is shown in the table below. The design is done considering the requirements of the client and standard general practice.

Table 2-2: Characteristics of treated water

S/N	Water Quality Parameters	Unit	Concentration Value
1	pH	-	
2	Total Hardness	mg/l	7.0-8.0
3	Chloride	mg/l	>250
4	Color	TCU	>10
5	TDS	mg/l	>1000
6	Iron (Fe)	mg/l	>0.30
7	Manganese (Mn)	mg/l	0.08
8	Arsenic (As)	mg/l	0.01-0.05
9	Fecal Coliform	CFU/100 ml	0
10	Total Coliform	CFU/100 ml	0

2.4 Water Demand Calculation

Water demand of the facility was calculated on the basis of data provided by the concerned officials and standard parameters as suggested by BNBC. The calculation chart is shown below:

Table 2-3: Water Demand Calculation

S/N	Parameter	Data
1	Total Population of the Campus	1800
2	Daily water demand in liter per capita	100[1]
3	Estimated water demand per day	180 m^3
4	Water required for HVAC air cooled chiller	7 m^3
5	Total Water required	187 m^3
6	**Required Flow rate (considering 13 hours operation per day)**	**14.38 m^3/hour**

Note: 1. The Daily demand for Education Institution is 100 lpcd (liter per capita per day) as per BNBC 2020.

2.4.1 Under-Ground Water Reservoir

The proposed Underground Water Reservoir (UGWR) is designed as a reinforced concrete structure with a total internal footprint of 23.0 m x 9.0 m. The reservoir adopts a separate tank storage strategy to optimize the building's footprint while meeting the stringent requirements of the Bangladesh National Building Code (BNBC) 2020.

Storage Capacity and BNBC Compliance

In accordance with BNBC 2020, the UGWR is sized to provide a storage capacity equivalent to the total daily water demand, plus the mandatory reserve for firefighting.

- **Domestic & Raw Water:** Based on an estimated daily demand of 187m^3 the main chamber has a capacity of 256m^3.
- **Fire Water Reserve:** A dedicated fire water reserve of 372m^3 is maintained within the lower portion of the main reservoir.
- **Chiller Water:** A separate, dedicated chamber of 1.5mx 9.0m is provided specifically for the cooling system requirements.

2.4.2 Sewerage Treatment Plant

Following design parameters were considered for design purpose:

Type of Effluent : Sewage
Total Manpower : 1800 persons
Use of Water per person/day: 1,08,000 liter/day
Treatment Hours: 24 hrs./day

Table 2-4: Waste Water Demand Calculation

S/N	Parameter	Data
1	Total Population of the Campus	1800
2	Daily water demand in liter per capita	60 liter/day
3	Estimated waste water demand	108 KLD

2.5 Design capacity

2.5.1 Water Treatment Plant (WTP)

In this preliminary design, a water treatment plant with a capacity of 15 m^3/hr is proposed to meet the projected water demand of the Asian University for Women campus. The design capacity has been determined based on data provided by the concerned officials and engineers involved in the project, along with standard water consumption rates from BNBC 2020. Detailed design calculations and assumptions are presented in the subsequent sections of this report.

2.5.2 Underground Water Reservoir (UGWR)

An underground water reservoir (UGWR) is proposed to ensure a reliable and continuous water supply for the facility. The main storage structure has dimensions of 11.0 m x 9.0 m, with a total depth of 7 m. The existing raw water tank in the building has not been utilized, as the deep tube well is located very close to the WTP, while the tank is situated at a considerable distance. Transferring water to and from the tank through additional piping would unnecessarily complicate the system design.

To optimize space and operational efficiency, the reservoir is designed with the following key features:

- **Raw Water & Fire Water Reservoir**: The primary compartments are divided into two sections.
    - The first section consists of the raw water tank, which has dimensions of 9.5 m × 9.0 m and a water depth of 3.0 m. Based on these dimensions, the raw water tank provides a storage capacity of approximately 256.5 m^3.
    - The second section is designated as the fire water reservoir, which is separated from the raw water tank. This reservoir has dimensions of 11.0 m × 9.0 m and a water depth of 4.0 m, providing a total storage capacity of approximately 346.5 m^3.

- **Chiller Water Compartment:** The dedicated Chiller Water Compartment (1.5m x 9.0m) is supplied by treating the water sourced from the main Water Treatment Plant (WTP). This system ensures that the cooling water meets the necessary hardness parameters to prevent scaling and operational inefficiencies in the chiller units.

2.5.3 Sewage Treatment Plant (STP)

A sewage treatment plant (STP) with an approximate footprint of 18.5 m × 6 m is proposed to treat wastewater generated from the campus. The design is based on projected wastewater generation rates derived from the provided project data and standard per capita wastewater production values. The STP will ensure that treated effluent meets relevant discharge standards prior to disposal or reuse, as applicable.

3 Proposed Locations for WTP, STP & UGWR

The proposed locations for the WTP, STP & UGWR are shown in the figure below:

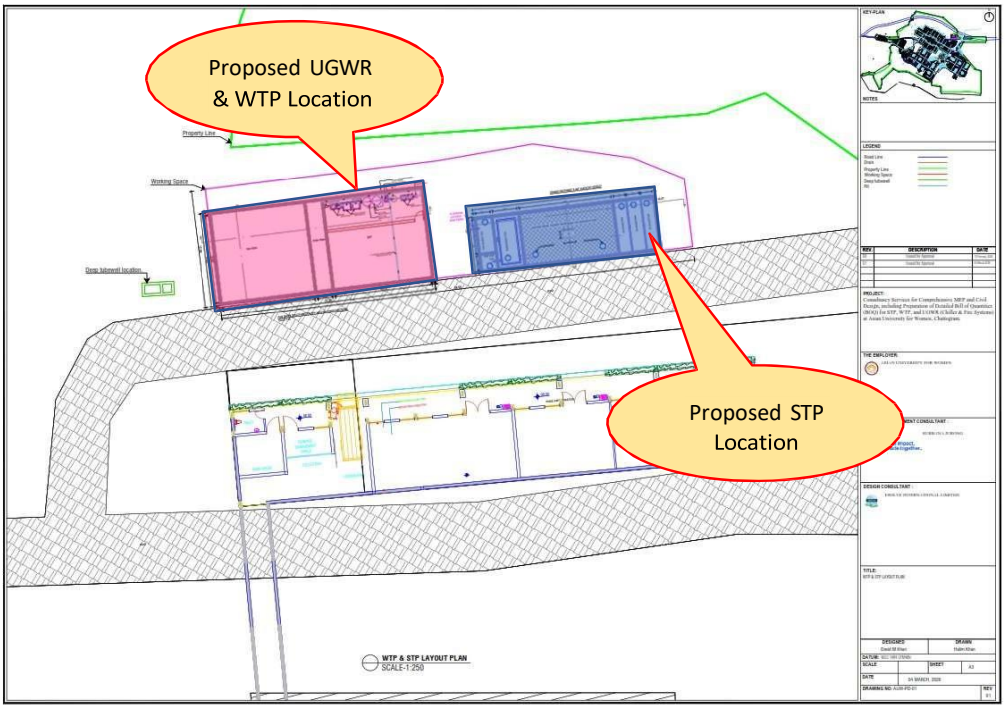


Figure 3-1: Proposed locations for setting up the WTP, STP & UGWR

4 Process Description

The key objective of the treatment plant is to improve the quality of raw water and to make the water eligible for usage purpose. This section describes the technical description of the water treatment plant.

4.1 Process Flow Diagram of WTP

The process flow diagram is shown below:

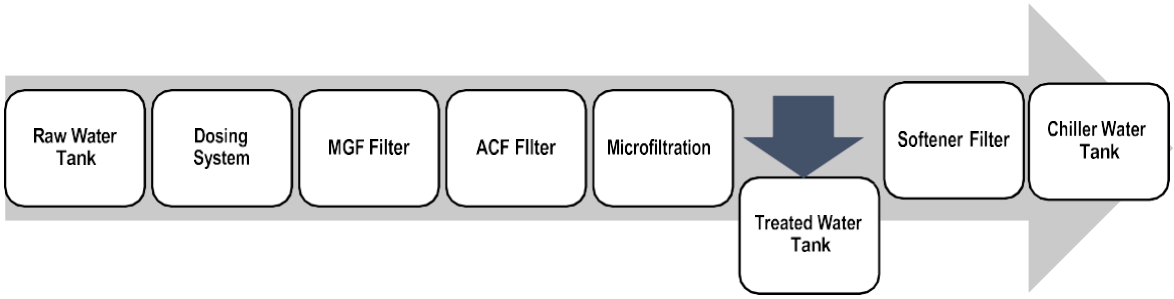


Figure 4-1: Process flow diagram of the proposed WTP

4.2 Detailed Description of the Process

Each step of the process is described in the following sections:

Dosing System

The dosing system will ensure effective disinfection of raw water through controlled chemical addition to eliminate pathogenic microorganisms and maintain residual protection.

Multi Grade Filter -MGF

The water will then feed to the Multi Grade Sand filter and activated carbon filter through a feed pump for the removal of suspended solids and turbidity, iron if present into water.

Activated Carbon Filter -ACF

The filtered water will then be passed through Activated carbon filter for the removal of any residual chlorine and removal of any organics, color, and odor present if any.

Microfiltration

The microfiltration unit will remove fine suspended particles, algae, impurities, and associated contaminants, including trace heavy metals attached to particulates, as a pre-treatment step.

Treated Water Tank

Finally, there will be a treated water tank for reserve tank as output of the treated water. This treated water will be as drinkable, health and safety.

Softener Filter

The treated water from the microfiltration unit will then be passed through a softener filter for the removal of hardness causing minerals such as calcium and magnesium through the ion exchange process, preventing scale formation in pipelines and improving overall water quality.

Chiller Water Tank

This treated water will be conveyed to the chiller water tank for use in the cooling system. The tank will provide a continuous and stable water supply, ensuring efficient and reliable chiller operation.

4.3 Process Flow Diagram of STP

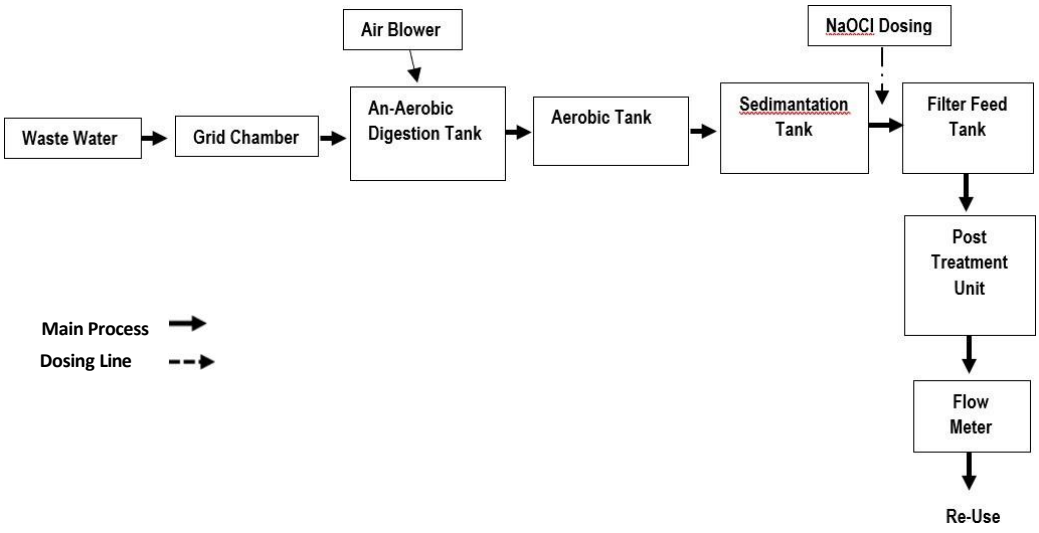


Figure 4-2: Process flow diagram of the proposed STP

4.4 Detailed Description of the Process

Grid Chamber

The screened wastewater flows into the grid chamber from the building master pit, where additional solids and grit are settled out.

Anaerobic Digestion Tank

After the grid chamber, the wastewater enters the anaerobic digestion tank. This tank is a sealed vessel that is devoid of oxygen and contains anaerobic bacteria. These bacteria break down the organic matter in the wastewater, producing biogas and sludge. A hydraulic retention time of 8 hours has been considered in the design criteria.

Aerobic Tank

The wastewater then flows into the aerobic tank, which is an open tank containing aerobic bacteria that require oxygen to thrive. In the aerobic tank, these bacteria consume the remaining organic matter in the wastewater, producing CO_2, water, and new bacterial cells. The treatment unit operates with a designed hydraulic retention time of 20 hours.

Sedimentation Tank

After the wastewater has been treated in the aerobic tank, it is sent to the sedimentation tank, where the activated sludge settles to the bottom and is recycled back to the aerobic tank. The clarified effluent is then sent to the NaOCl dosing unit for disinfection. This treatment unit operates with a designed hydraulic retention time of 4.5 hours.

NaOCl Dosing

The clarified effluent is disinfected by dosing it with sodium hypochlorite (NaOCl). This kills any remaining bacteria and disinfects the effluent.

Filter Feed Tank

From the sedimentation tank the wastewater will enter the filter tanks though sodium hypochlorite dosing. In the filter unit the wastewater will treat using Multi Grade Filter (MGF) and Activated Carbon Filter (ACF). The outlet water from the filter unit will be eligible for using **Gardening and Vehicle wash purpose**.

Post Treatment Unit

The treated water from filter unit will enter the post treatment unit and will store in the tank. The storage capacity of the post treatment will for 2hrs. the overflow water will discharge in the drainage system. The water of the post treatment unit will use for **Gardening and Vehicle wash** purpose.

Flow Meter

Throughout the treatment process, the flow rate of the wastewater is monitored using a flow meter. This helps to ensure that the treatment process operates efficiently and effectively.

5 UGWR, WTP & STP Layout Plan

Water Treatment Plant (WTP) & Underground Water Reservoir (UGWR)

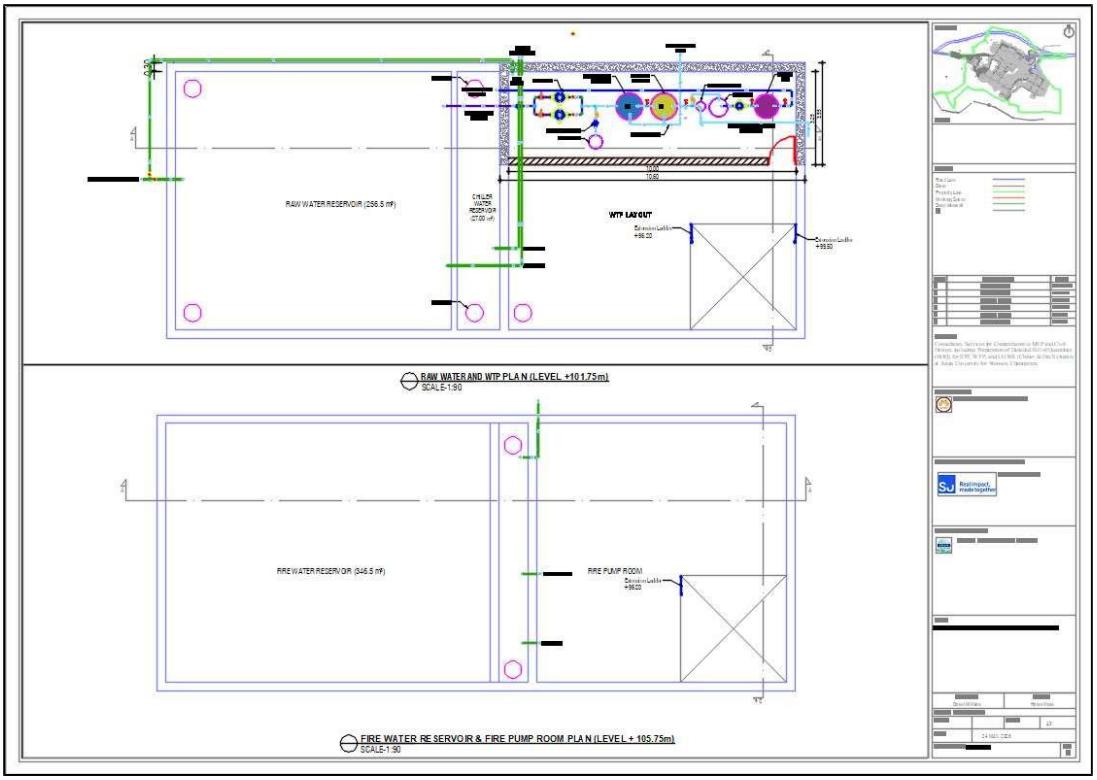


Figure 5-1: Plan view of WTP & UGWR

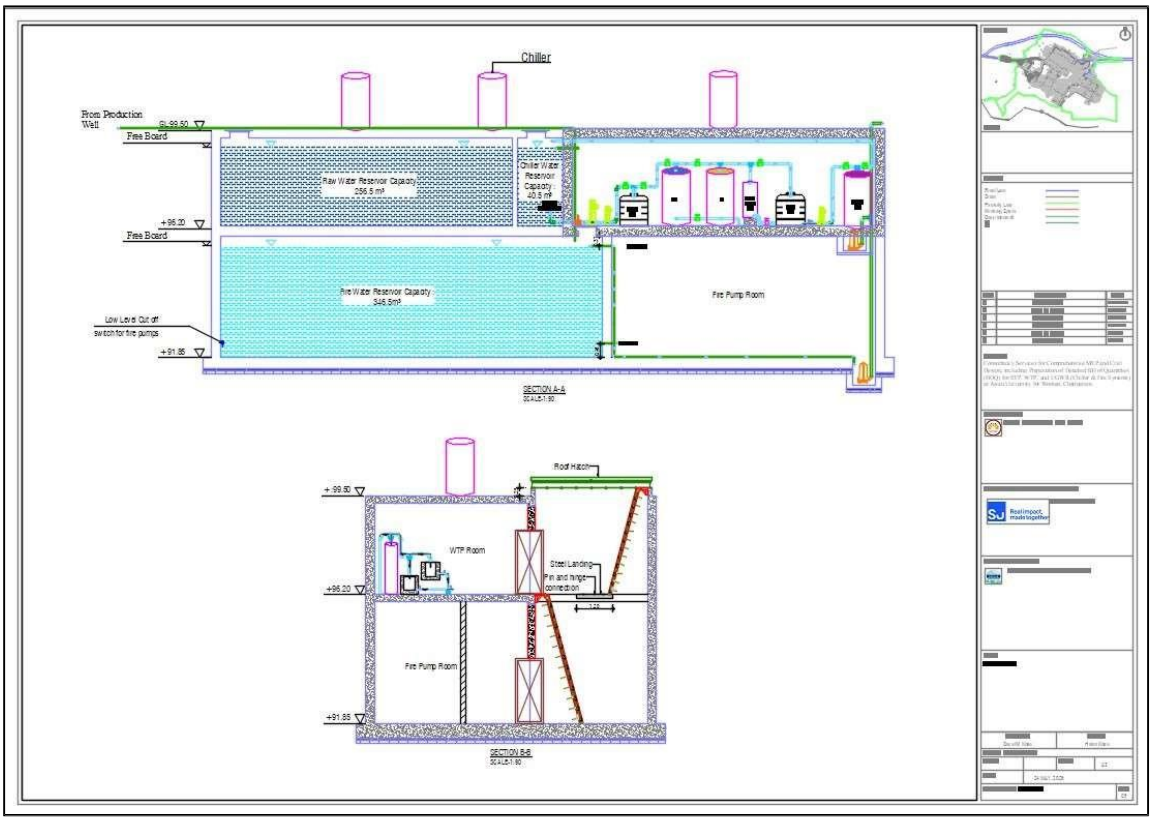


Figure 5-2: Section view of WTP & UGWR

Sewerage Treatment Plant (STP)

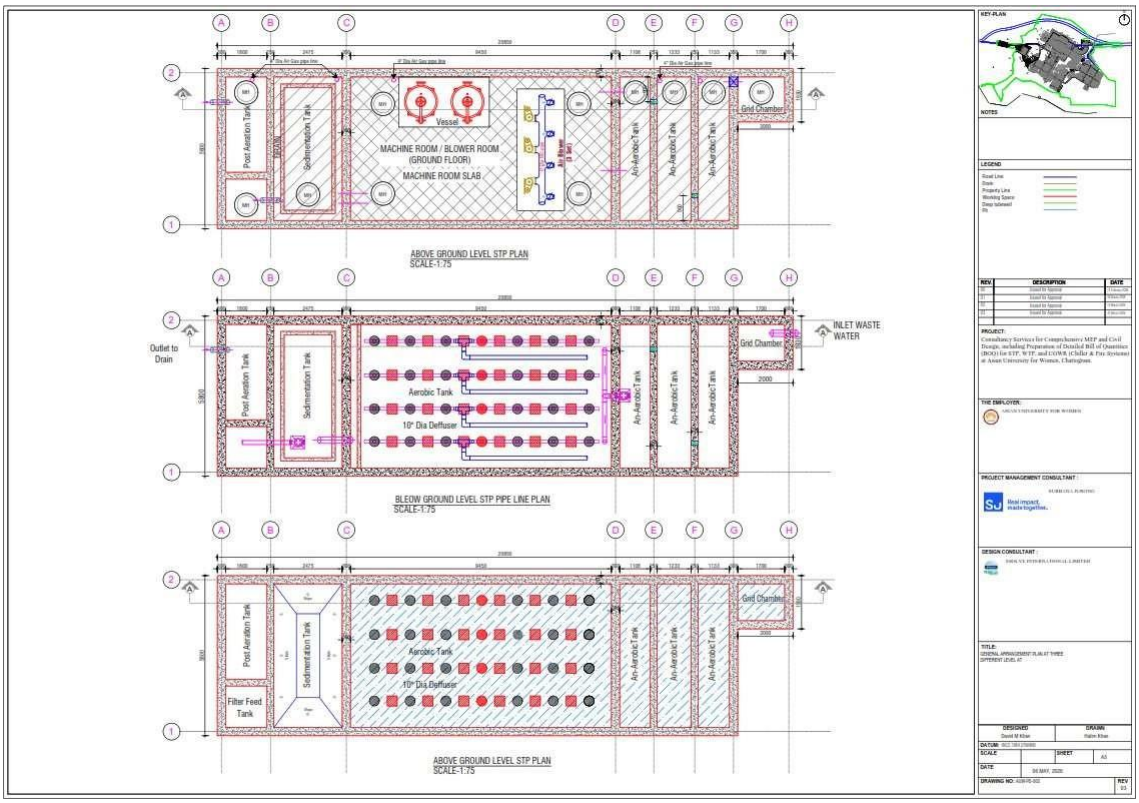


Figure 5-3: Plan View of STP

6 Civil design

6.1 Structural Design (Water Treatment Plant & UGWR)

To analyze the proposed "Water Treatment Plant (WTP)", 3D finite element model has been developed to represent the superstructure using **ETABS V22**. The substructure was analyzed using **ETABS V22**. Geometry, loading, and design codes are followed as per Bangladesh National Building Code (BNBC-2020) and other relevant codes and standards. Based on the architectural and MEP drawing, analysis and design of superstructure and substructure has been performed. Separate hand calculations are also conducted for verification where necessary.

6.1.1 Design Information and Criteria

6.1.1.1 Design *Codes, Standards & References*

The structures are designed in accordance with the following codes, standards and technical literatures:

- BNBC 2020; Bangladesh National Building Code
- ACI 318-08; Building Coder Standard of American Concrete Institute
- ACI 350; Code Requirements for Environmental Engineering Concrete Structures
- ASCE 7-05; Minimum Design Loads for Buildings by American Society of Civil Engineers

6.1.1.2 Material Properties

Steel: Steel reinforcement strength for RCC members is **500 MPa**

Concrete: The concrete compressive strength for RCC members is **35 MPa**

6.1.1.3 Soil Parameter

Based on the *Report on Sub-Soil Investigation in Connection with the Construction of Proposed Academic Building WTP, STP & UGWR Area, Baizid, Chattogram* a total of three boreholes (BH-01, BH-02, and BH-03) were carried out at the proposed site. Among these, BH-03 is located closes to the proposed WTP site and has therefore been considered as the governing case for the present structural design analysis. According to the investigation findings, the allowable bearing capacity of the soil at a depth of 7.5 m below RL is **696 kN/m²** and **SPT** value at that depth **38**. The soil ϕ value for this borehole is found to be **27.46°**. The Ground Water Table depth is at **RL 66 m** below the existing GL (may vary with season).

6.1.1.4 *Loading Considerations*

6.1.1.4.1 Dead Load (DL)

As per **BNBC 2020**, the dead load has been assessed based on the forces due to:

- Weight of the member itself.
- Weight of all materials of construction incorporated into the building to be supported permanently by the members.
- Weight of permanent partitions.
- Weight of fixed service equipment.
- Water Tank load of 1000 L capacity.
- Floor finish of 1.5 kN/m^2
- Ceiling/plaster of 1.0 kN/m^2

6.1.1.4.2 Live Load

According to the Table 6.2.3: Minimum Uniformly Distributed and Concentrated Live Loads (BNBC 2020, Part 6, Chapter 2), the following live load has been considered for the analysis of this structure:

- Uniformly distributed load for floor is 4.0 kN/m^2
- Uniformly distributed load for roof is 2.0 kN/m^2

6.1.1.4.3 Equipment's Weight

The following table shows the weight of the equipment that will exist in the structure.

Table 6-1: Operating Weight of the Equipment

Equipment Name	***Quantity***	***Unit***	***Operating Weight***	***Unit Weight (kN)***
WTP				
Centrifugal Pump for Feed Water	2	Pcs	80 kg	0.80
Dosing Pump	2	Pcs	3 kg	0.03
Dosing Chemical Tank	2	Pcs	100 kg	1.00
Water Flow Meter	1	set	1 kg	0.01
Pressure Vessel for MGF and ACF	2	Set	2400 kg	24.00
Mesh Sand for MGF Filter	20	Bag	600 kg	6.00
Course Silex for MGF	6	Bag	300 kg	3.00

Equipment Name	*Quantity*	*Unit*	*Operating Weight*	*Unit Weight (kN)*
Graded Sand for MGF	6	Bag	300 kg	3.00
Graded Sand for MGF & ACF	20	Bag	600 kg	6.00
Graded Sand for MGF & ACF	20	Bag	600 kg	6.00
Iron Removal Media	8	Bag	600 kg	6.00
Activated Carbon	6	Bag	300 kg	3.00
Sediment Filter - MF	1	set	100 kg	1.00
Connecting Pipe Fittings	1	Lot	100 kg	1.00
Pump Connecting Fittings	1	lot	20 kg	0.20
Electric Control Panel Box	1	Set	20 kg	0.20
Chiller Water Reservoir				
Centrifugal Pump for Feed Water	2	Pcs	20 kg	0.20
Pressure Vessel for MGF and ACF	2	Set	500 kg	5.00
Support Sand for Resin	1	Bag	100 kg	1.00
Cation Exchange Resin	5	Bag	150 kg	1.50
Sediment Filter - MF	1	set	10 kg	0.10
Connecting Pipe Fittings	1	Lot	100 kg	1.00
Electric Control Panel Box	1	Set	5 kg	0.05
Fire Panel Room				
Fire Pump Skids	1	Set	778 kg	0.78
Pump system controller	1	EA	116 kg	0.12
Fire Pump Skids	1	Set	1306 kg	1.30
Pump system controller	1	EA	45 kg	0.045
Diesel Tanks	1	EA	176 kg	0.18
Pump vertical multistage jockey	1	Set	125 kg	0.13
Pump system controller	1	EA	8 kg	0.008
HVAC				
Chiller	3~4	Pcs	75 Ton	750

6.1.1.4.4 Earth Pressure Coefficient

The lateral earth pressure coefficients for this design were determined using two distinct analytical approaches, one is using Jaky's Formula, and another is Mononobe-Okabe formula, to account for different loading conditions.

Upon comparing the results of both methodologies, it was observed that both the methods yielded the same active earth pressure coefficient value. To ensure a conservative and robust structural response, this value was adopted as the governing parameter for the final design and reinforcement detailing.

The sample calculation for both approaches is provided below.

Static Conditions (Jaky's Formula)

Jaky's formula was employed to calculate the coefficient of earth pressure at rest (K_o), representing the pressure exerted by the soil when it is in an equilibrium state with zero lateral strain.

$$\text{Soil pressure coefficient at rest, } K_o = 1 - \sin\theta$$

Here,

Angle of internal friction, $\phi = 27.46$ degrees **[As per Soil Report (BH 03)]**

Therefore, Soil pressure coefficient at rest, $K_o = (1 - \sin 27.46) = 0.54$

Seismic Conditions (Mononobe-Okabe)

The Mononobe-Okabe method was utilized to determine the dynamic active earth pressure coefficient (Kae), accounting for additional lateral forces generated during a seismic event. [https://eurocodeapplied.com/design/en1998/mononobe-okabe]

Input

Design value of the angle of shearing resistance of soil	ϕ'_d	27.46	°	**[As per Soil Report (BH 03)]**
Design value of the friction angle between the soil and the wall	δ_d	18.31	°	**[As per B.M Das "Principles of Foundation Engineering, 9ed, 16.7", $\delta_d = 2/3\ \phi'_d$]**
Inclination angle of the wall back surface	ψ	90	°	
Inclination angle of the backfill top surface	β	0	°	
Horizontal seismic coefficient	k_h	0.21		**[In accordance with EN1998-5 7.3.2.2(4)P and BNBC 2020 Sec. 2.5.4; $k_h = 2/3.Z.S$ where Z = 0.28 & S = 1.15 for SC soil type]**
Vertical seismic coefficient	k_v	-0.11		**[In accordance with EN1998-5 7.3.2.2(4)P and BNBC 2020 Sec. 2.5.13; $k_v = 0.5\ k_h$]**

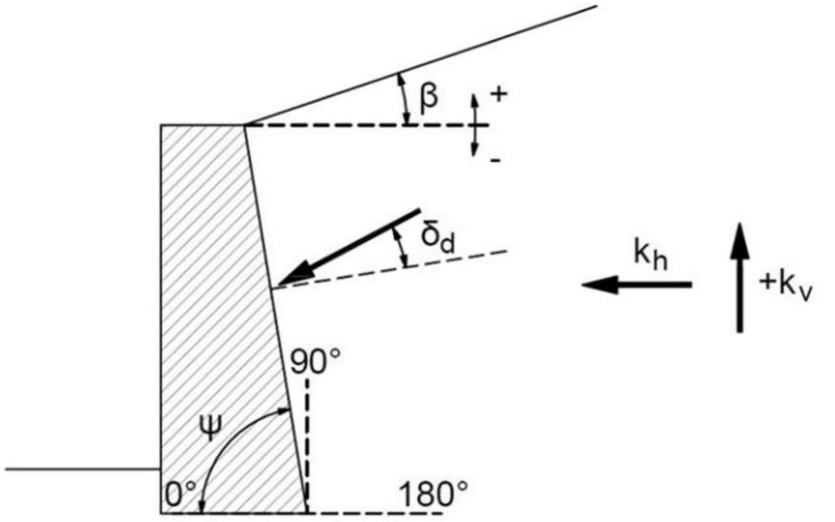


Figure 6-1 Convention of angles for calculating the earth pressure coefficients (see also EN1998-5 Figure E.1)

Results

Mononobe-okabe dynamic earth pressure coefficient for active state	$K_{AE} = 0.4834$
Mononobe-okabe dynamic earth pressure coefficient for active state including factor $(1-k_v)$	$(1-k_v)\cdot K_{AE} = 0.5365$

The auxiliary angle θ is calculated for the case of water table below the retaining wall in accordance with *EN1998-5 equation (E.6)* as follows:

$\tan\theta = k_h / (1 - k_v) = 0.210 / [1 - (-0.110)] = 0.189$

This tangent value corresponds to angle $\theta = 10.713$ °.

Mononobe-Okabe earth pressure coefficient for active state

For active states *EN1998-5 equations (E.2) and (E.3)* are applicable. The following intermediate factors are calculated:

$a_1 = \sin(\psi + \varphi'_d - \theta) = 0.9576$

$a_2 = \cos\theta\cdot\sin^2\psi\cdot\sin(\psi - \theta - \delta_d) = 0.8592$

$a_3 = 1 + [\sin(\varphi'_d + \delta_d)\cdot\sin(\varphi'_d - \beta - \theta) / \sin(\psi - \theta - \delta_d) / \sin(\psi + \beta)]^{0.5} = 1.4859$

For the case where $\beta \le \varphi'_d - \theta$ *EN1998-5 equation (E.2)* applies:

$K_{AE} = a_1^2 / (a_2\cdot a_3^2) = 0.9576^2 / (0.8592\cdot 1.4859^2) = 0.483$

Therefore the dynamic earth pressure coefficient for active states according to Mononobe-Okabe method is calculated as $K_{AE} = 0.483$

6.1.1.4.5 Lateral Earth Pressure

Based on the Rankine earth pressure theory, the lateral earth pressure that the underground wall will experience has been calculated below:

Lateral Earth Pressure (with surcharge), $\sigma_h = Ko\ \gamma.H$

Here,

Outside soil depth, H = 7.5 m

Unit weight of saturated soil, $\gamma_s = 20$ kN/m^3

Angle of internal friction, $\theta = 27.46$ degrees **[As per Soil Report (BH03)]**

Soil pressure coefficient at rest, $K_o = 0.54$ **[From Previous Section]**

Therefore, active earth pressure at bottom, $\sigma_h = 0.54 \times 20 \times 7.5 = 81$ kN/m^2

6.1.1.4.6 Vertical Earth Pressure

The calculation of vertical earth pressure is shown below,

$$\text{Vertical Earth Pressure, } \sigma_v = \gamma \times H$$

Outside soil depth, H = 7.5 m

Unit weight of saturated soil, $\gamma = 20$ kN/m^3

Therefore, earth pressure at the base projection, $\sigma_v = 20 \times 7.5 = 150$ kN/m^2

6.1.1.4.7 Fluid Pressure

The black water, that will be present in the structure, will exert pressure on the base along the Gravity and that on the RCC walls non-uniformly in the Local 3 axis. The following criteria has been considered for its calculation:

For Fire Water Reservoir

$$\text{Hydrostatic Pressure, } P = \gamma.H$$

Where,

Fluid depth, H = 3.70 m [TWL]

Unit weight of water, $\gamma_w = 10$ kN/m^3

Therefore, hydrostatic pressure at bottom, $P = 10 \times 3.70 = 37$ kN/m^2

For Raw Water Reservoir

$$\text{Hydrostatic Pressure, } P = \gamma.H$$

Where,

Fluid depth, H = 2.70 m [TWL]

Unit weight of water, $\gamma_w = 10$ kN/m^3

Therefore, hydrostatic pressure at bottom, $P = 10 \times 2.70 = 27$ kN/m^2

6.1.1.4.8 Seismic Load Calculation (EQ)

Earthquake load calculation of the structure has been performed based on **Part 6, Chapter 2** of **BNBC 2020** and **ASCE 7-05**. The factors considered for the earthquake loading are provided in the following table:

Table 6-2: Static Earthquake Pattern Parameters (BNBC 2020)

Parameters	***Value***	***Remarks***
Structure type	CMRF	
Seismic force resisting system	Special reinforced concrete shear walls	Table 6.2.19
Soil Type	SC	Table 6.2.13
Town	Chittagong	
Zone, Z	0.28	Figure 6.2.24
Occupancy Category	III	Table 6.2.17
Importance Factor, I	1.25	Table 6.2.17
Time Period, T (sec)	0.267	
Reduction Factor, R	6	Table 6.2.19
Cd	5	Table 6.2.19
Ss	0.7	Table 6.C.1
S1	0.28	Table 6.C.1
Fa	1.15	Table 6.C.2
Fv	1.725	Table 6.C.3
Long Period Transition	2	
Ω	2.5	Table 6.2.19
Damping Ratio	0.05	

6.1.1.4.9 Wind Load Calculation (W)

The following table illustrates the parameters used for wind load definition which are as per **BNBC 2020** and **ASCE 7-05**.

Table 6-3: Wind Load Parameters (BNBC 2020, ASCE 7-05)

Parameters	***Value***	***Remarks***
Location	Chittagong	Sec-2.4.4 & Table 6.2.8
Occupancy Category	III	Sec-1.2.3 & Table 6.1.1
Basic Wind Speed (mph)	179	Table 6.2.8
Structure Frame Type	CMRF	Sec 2.4.7 & Figure 6.2.4
Importance Factor (I)	1.15	Table 1.2.1
Directionality Factor (Kd)	0.85	Table 6.2.12
Exposure type	B	Sec 2.4.6

Parameters	Value	Remarks
Topographical Factor (Kzt)	1.00	Figure 6.2.4
Gust Factor	0.85	Sec-2.4.8.1
e1	0.052	
e2	0.686	
Windward- (Cp)	0.80	Figure 6.2.6
LeeWard- (Cp)	0.348	Figure 6.2.6

6.1.1.4.10 Subgrade Modulus of Soil (Ks)

The subgrade modulus (Ks) represents the stiffness of the supporting soil and defines the relationship between the pressure applied to the soil and the resulting settlement. It is an important parameter for analyzing soil–structure interaction, particularly for foundations, slabs, and underground structures.

The bearing capacity at the proposed depth is found to be 696 kN/m^2 as mentioned in the previous section. As per ***Bowles- Foundation Analysis & Design | Section 9.6***; the modulus of subgrade reaction as per the following equation for 25 mm settlement and F.S of 2.5,

$$\text{SI: } k_s = 40(\text{SF})q_a \quad \text{kN/m}^3$$
$$\text{Fps: } k_s = 12(\text{SF})q_a \quad \text{k/ft}^3$$

Ref: Foundation Analysis & Design-Bowles (5th Edidtion)Page:526

Ks = 40 x 2.5 x 696 = 69,600 kN/m^3 = 69.6 MN/m^3

Thus, the subgrade modulus for the proposed structure at the foundation is 69.6 MN/m^3. The ACI manual of Concrete indicates that uniform loading will cause greater deflection towards the center of slabs. To model this effect, 50 percent increment of the modulus of subgrade reaction has been assumed at the edges (periphery).

6.1.2 Pre-Processing in ETABS

6.1.2.1 Load Patterns Defined

The following load patterns are applied for the analysis of this structure as per **BNBC 2020** and **ASCE 7-05**:

Table 6-4: Applied Load Patterns

Load	Type	Self-Weight Multiplier	Auto Lateral Load
DL	Dead	1	-
LL	Live	0	-
H (Soil)	Other	0	-
F (Water)	Other	0	-
EQX	Seismic	0	ASCE 7-05
EQY	Seismic	0	ASCE 7-05

Load	*Type*	*Self-Weight Multiplier*	*Auto Lateral Load*
WX	Wind	0	ASCE 7-05
WY	Wind	0	ASCE 7-05
FF + Plaster	Super Dead	0	-
Chiller	Dead	0	-
Machinery	Dead	0	-

6.1.2.2 Load Combinations

According to **BNBC-2020,** the following **Allowable Strength Design (ASD)** load combinations and Ultimate **Strength Design (USD)** load combinations are defined in the analysis for serviceability checks and design respectively. These unfactored load combinations are enveloped under the name '**Envelope (Serviceability)**'. And the factored load combinations are enveloped under the name '**Envelope (Design)**'.

Allowable Strength Design (ASD)

a. D + F

b. D + L + F + H

c. D + 0.75 L + F + H

d. D + F + H + WX-

e. D + F + H + WX+

f. D + F + H + WY-

g. D + F + H + 0.75 WX+ + 0.75 L

h. D + F + H + 0.75 WX- + 0.75 L

i. D + F + H + WY+

j. D + F + H + 0.75 WY- + 0.75 L

k. D + F + H + 0.75 WY+ + 0.75L

l. 0.6 D + H + WX-

m. 0.6 D + H + WX+

n. 0.6 D + H + WY-

o. 0.6 D + H + WY+

p. 0.6 D + H + 0.7EQX+

q. 0.6 D + H + 0.7EQX-

r. 0.6 D + H + 0.7EQY+

s. 0.6 D + H + 0.7EQY-

Ultimate Strength Design (USD)

(1) 1.4 D + 1.4 F

(2) 1.2 D + 1.2 F + 1.6 L + 1.6 H

(3) 1.2 D + 1.2 F + 1.6 H +1.6 L

(4) 1.2 D + 1.6 L + 0.8 Wx+

(5) 1.2 D + 1.6 L + 0.8 Wx-

(6) 1.2 D + 1.6 L + 0.8 Wy+

(7) 1.2 D + 1.6 L + 0.8 Wy-

(8) 1.2 D + 1.6 Wx+ + 1 L

(9) 1.2 D + 1.6 Wx- + 1 L

(10) 1.2 D + 1.6 Wy+ + 1 L

(11) 1.2 D + 1.6 Wy- + 1 L

(12) 0.9 D + 1.6 Wx+

(13) 0.9 D + 1.6 Wx-

(14) 0.9 D + 1.6 Wy+

(15) 0.9 D + 1.6 Wy-

(16) 1.307 D +1 EX+ + 0.3 EY+ +1 L

(17) 1.307 D +1 EX+ + 0.3 EY- +1 L

(18) 1.307 D +1 EX- + 0.3 EY+ +1 L

(19) 1.307 D +1 EX- + 0.3 EY- +1 L

(20) 1.307 D +0.3 EX+ + 1 EY+ +1 L

(21) 1.307 D +0.3 EX+ + 1 EY- +1 L

(22) 1.307 D +0.3 EX- + 1 EY+ +1L

(23) 1.307 D +0.3 EX- + 1 EY- +1 L

(24) 0.793 D + 1 EX+ + 0.3 EY+ +1.6 H

(25) 0.793 D + 1 EX+ + 0.3 EY- +1.6 H

(26) 0.793 D + 1 EX- + 0.3 EY+ +1.6 H

(27) 0.793 D + 1 EX- + 0.3 EY- +1.6 H

(28) 0.793 D + 0.3 EX+ + 1 EY+ +1.6 H

(29) 0.793 D + 0.3 EX+ + 1 EY- +1.6 H

(30) 0.793 D + 0.3 EX- + 1 EY+ +1.6 H

(31) 0.793 D + 0.3 EX- + 1 EY- +1.6 H

Here,

D = Dead Load

L = Live Load

H = Soil Load

F = Fluid/water Load

EQX = Seismic Load in x-direction

EQY = Seismic Load in y-direction

WX = Wind Load in x-direction

WY = Wind Load in y-direction

Serviceability limit states of buildings and structures shall be checked for the load combinations set forth in this Section as well as mentioned elsewhere in this Code. For serviceability limit states involving visually objectionable deformations, repairable cracking or other damage to interior finishes, and other short-term effects, the suggested load combinations for checking vertical deflection due to gravity load is,

D + L

For serviceability limit states involving creep, settlement, or similar long-term or permanent effects, the suggested load combination is:

D + 0.5L

For serviceability limit state against lateral deflection of buildings and structures due to wind effect, the following combination shall be used:

D + 0.5L + 0.7W

6.1.2.3 Applied Chiller Load

Total chiller load = 75 Ton = 750 kN

Roof slab area = (22.2 x 9.6) – (3.7 x 3.7) m^2 = 199.4 m^2

Applied UDL on slab = 750/199.4 kN/m^2 = 3.8 kN/m^2

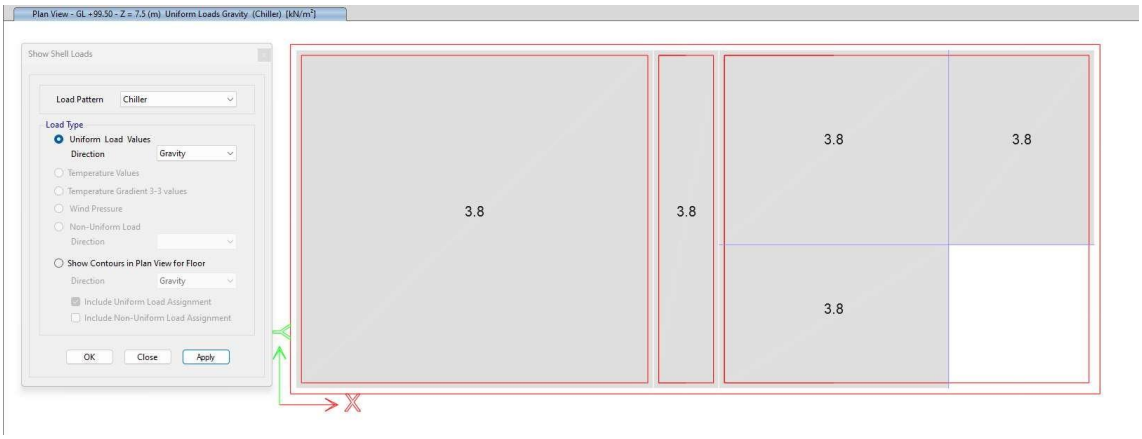


Figure 6-2 Applied Chiller Load (UDL)

6.1.2.4 Applied Earth Pressure

6.1.2.4.1 Lateral Earth Pressure

In ETABS, non-uniform loads may be assigned to shell elements using the command path **Assign → Shell Loads → Non-Uniform** as seen in Figure 6-3. This feature enables the application of loads that vary in magnitude with respect to the global coordinate system.

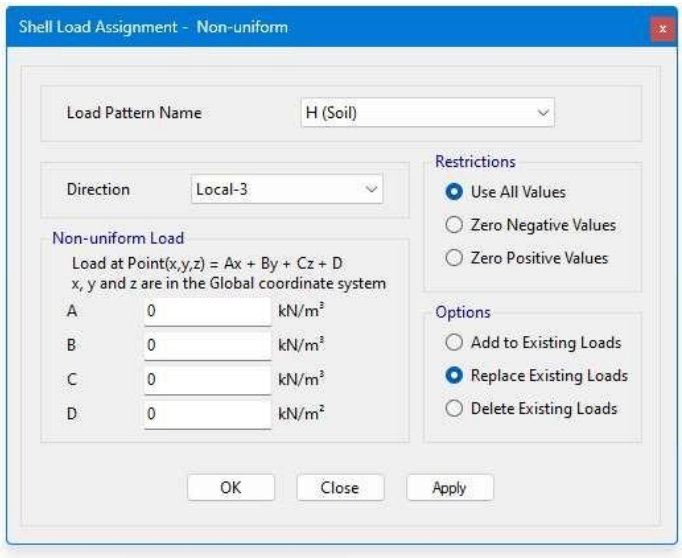


Figure 6-3 Shell Load Assignment -Non-Uniform

For the RCC wall, the lateral earth pressure acts in a triangular distribution, where the pressure increases linearly with depth. Based on the previously calculated values, the maximum lateral earth pressure at the base of the wall is **81 kN/m²**, reducing to **0 kN/m²** at the ground surface.

For modelling purposes, the structure is assumed to lie in the **X–Z plane**, where the **Z-axis** represents the vertical direction. Since the pressure variation occurs only with respect to depth (Z-direction), there is no variation in the **X** or **Y** directions; therefore, the corresponding coefficients **A** and **B** are taken as zero.

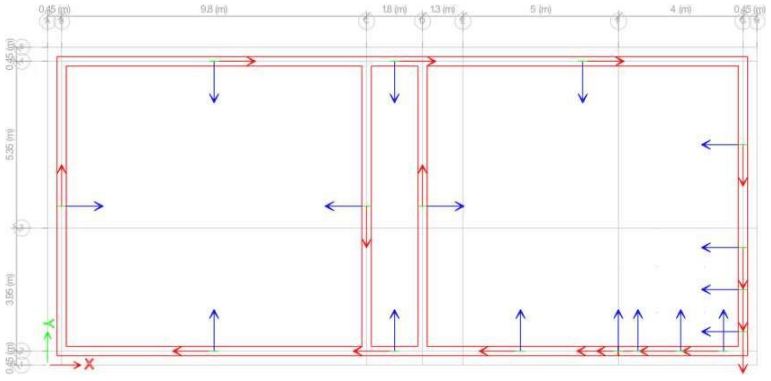


Figure 6-4 Local 3 Axis Illustration of Wall- Plan View (Blue Arrow indicates Local-3)

The non-uniform pressure distribution is defined in ETABS using a linear expression of the form:

$$Load = Cz + D$$

The coefficients **C** and **D** are determined using the known boundary conditions **(Along Local 3 axis)**:

- At the base of the wall (**z = 0 m**), the lateral pressure is **81 kN/m²**:

  $$C \times 0 + D = 81$$

  Hence,

  $$D = 81$$

- At the top of the wall (**z = 7.5 m**), the lateral pressure is **0 kN/m²**:

  $$C \times 7.5 + 81 = 0$$

  Solving for **C**:

  $$C = -10.8 \text{ kN/m}^3$$

Accordingly, the pressure decreases linearly from **81 kN/m²** at the bottom to **0 kN/m²** at the top, representing the expected triangular earth pressure distribution acting on the wall.

Figure 6-5 Applied Lateral Soil Load on RCC Wall (Along Local 3)

6.1.2.4.2 Vertical Earth Pressure

The vertical earth pressure, as calculated above, has been applied as uniformly distributed pressure on the extended portion of the mat foundation as seen in the following in Figure 6-6.

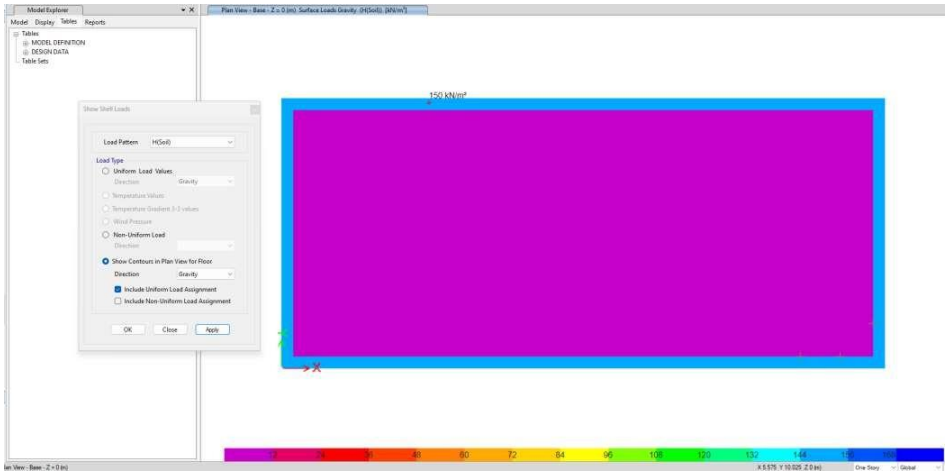


Figure 6-6 Vertical Soil Pressure on base extension (kN/m²)

6.1.2.5 Applied Fluid Pressure

6.1.2.5.1 Fluid Pressure on Wall

Similar to lateral earth pressure, the fluid pressure is also applied on the wall. The fluid will exert triangular load on the wall. In ETABS, this load is applied as non-uniformly distributed shell load as seen in Figure 6-7.

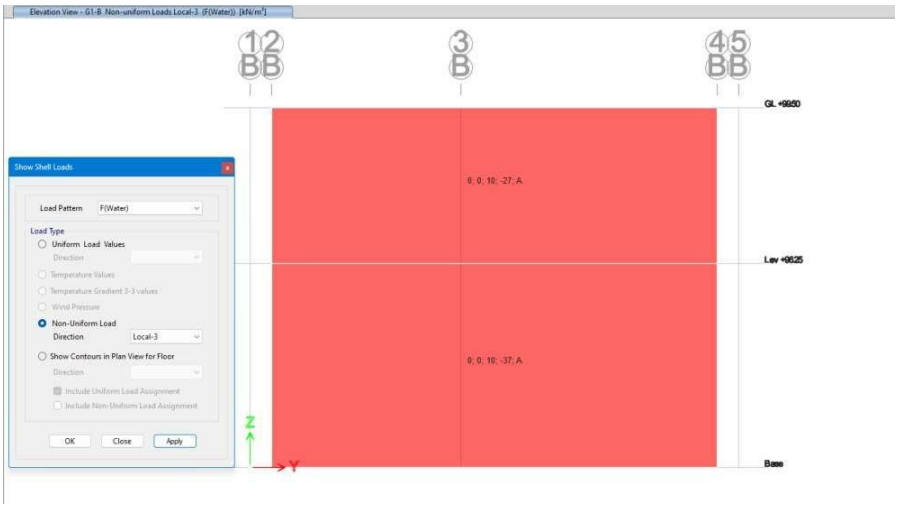


Figure 6-7 Applied Fluid Pressure on RCC Wall

6.1.2.5.2 Fluid Pressure on Slab

The fluid will exert uniformly distributed pressure on the slab as shown in Figure 6-8.

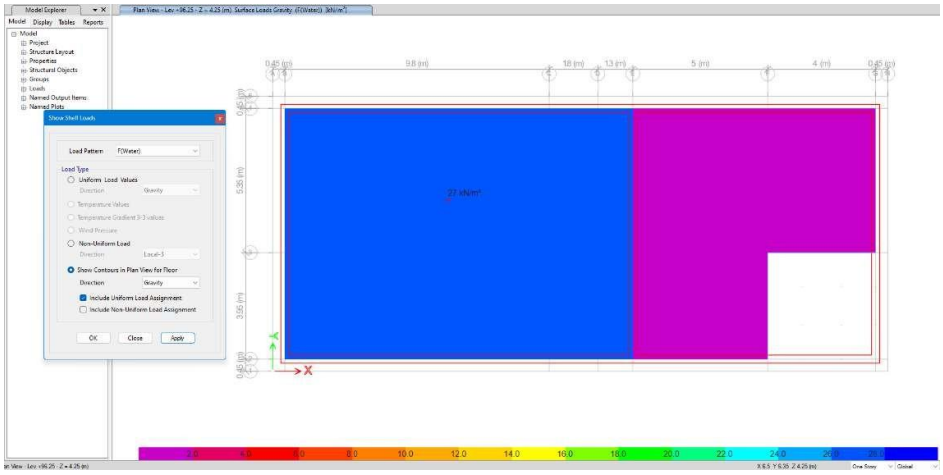


Figure 6-8 Applied Fluid Load on First Floor Slab

6.1.2.6 *Applied Subgrade Modulus of Soil (Ks)*

The subgrade modulus of soil, as per soil investigation report mentioned above, has been applied as area spring at the mat foundation of the structure as seen in the Figure 6-9

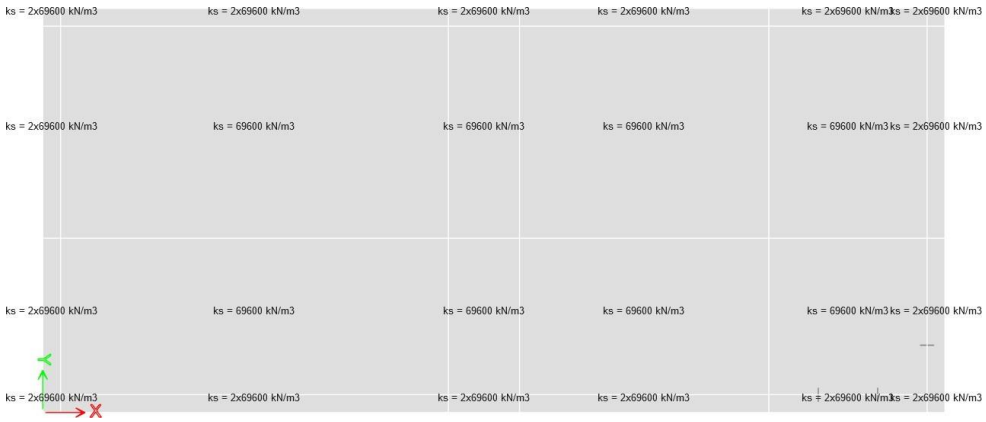


Figure 6-9 Subgrade Modulus of Soil (Area Spring)

6.1.3 Model Overview

6.1.3.1 Structural System Description

The overall structural system comprises reinforced concrete beams, slabs, and shear walls that collectively provide strength, stiffness, and stability to the structure.

The finite element method (FEM) has been adopted for analysis, with appropriate meshing applied to capture realistic load distribution and deformation characteristics. A mesh size of 0.5 m has been used for the shear walls, while a mesh size of 0.5 m has been adopted for the floor slabs. These meshing parameters ensure a balance between computational efficiency and analytical accuracy.

The dimensions and reinforcement details of all structural components, including beams, slabs, and walls, are provided in the accompanying structural drawings for reference.

6.1.3.2 3D Model of the Structure

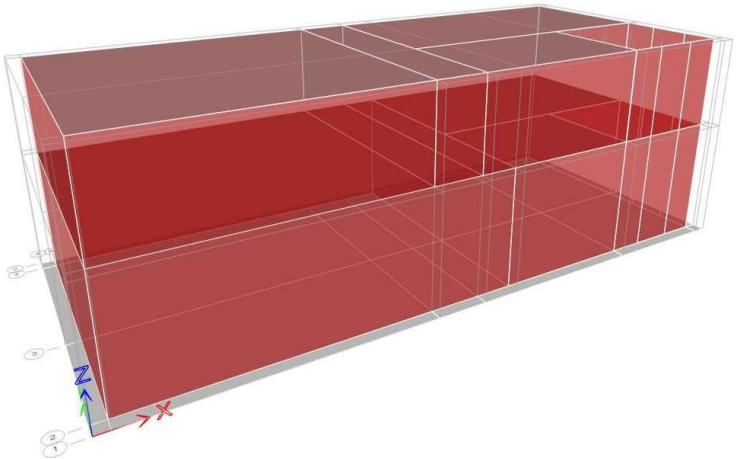


Figure 9: 3D Model of the Structure (ETABS)

6.1.4 Serviceability and Stability Checks

6.1.4.1 Post-Processing

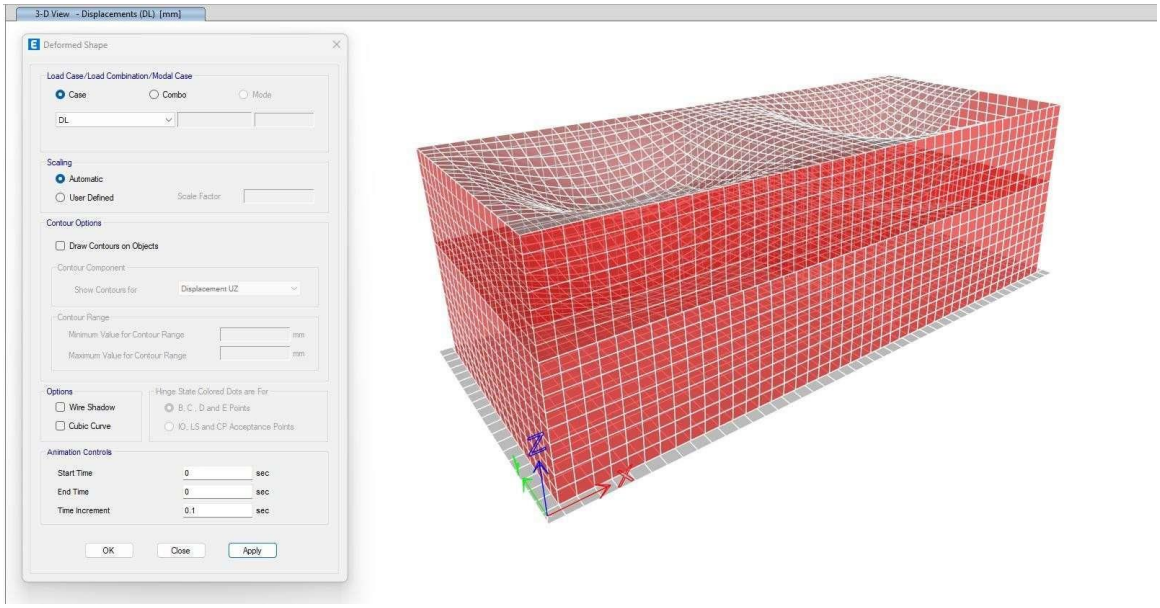


Figure 10: Deformed Shape of the Structure

6.1.4.2 Model Check

All the concrete members have passed the design as seen in the following figures.

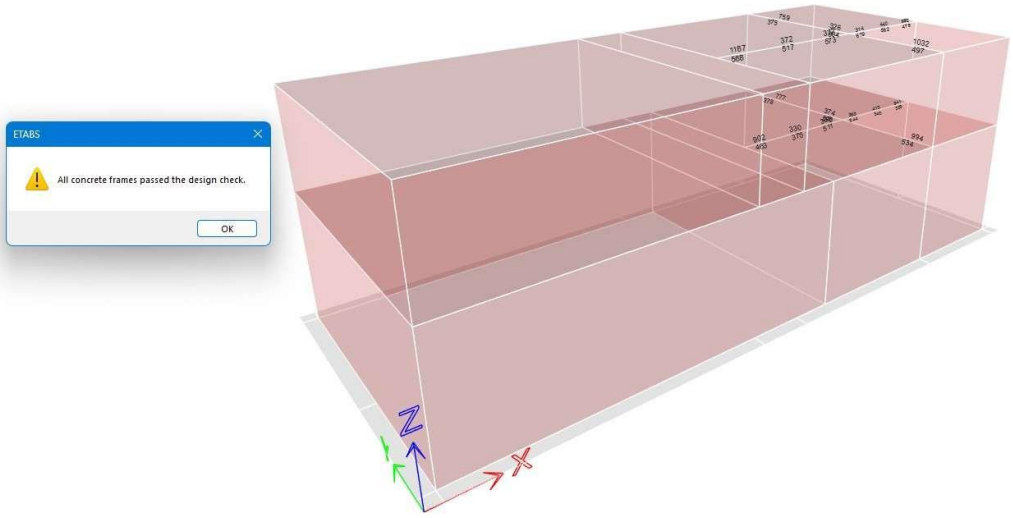


Figure 6-10 Concrete Frame Failure Check (ETABS)

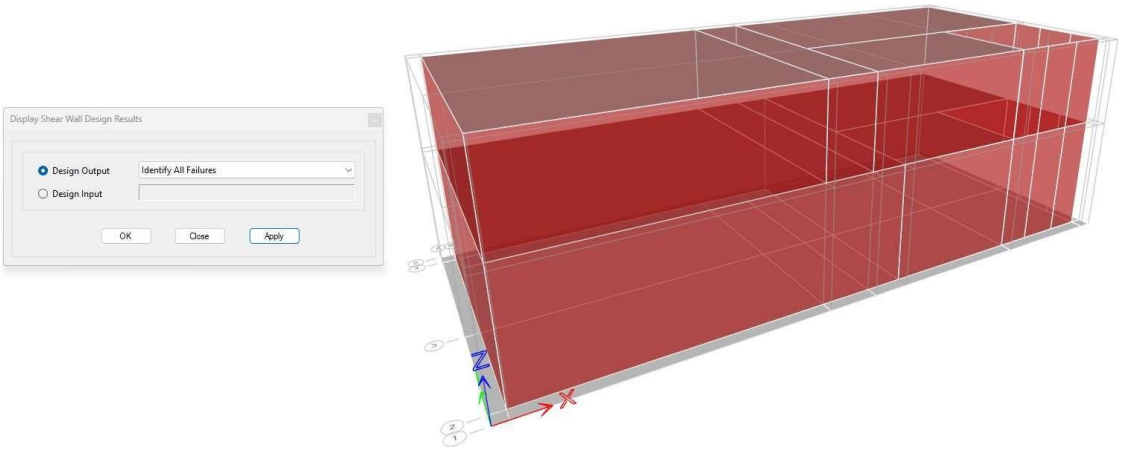


Figure 6-11 RCC Wall Failure Check (ETABS)

6.1.4.3 Beam Deflection Check (Iterative with Design)

According to Nilson | Design of Concrete Structures 14th Ed | Chapter 6 | Section 6.7, the Short-Term deflection obtained from ETABS analysis due to Dead Load and Live Load is converted into Long-Term deflection by multiplying it with a factor (Equation 6.12) as mentioned below;

d. Long-Term Deflection Multipliers

On the basis of empirical studies (Refs. 6.7, 6.9, and 6.11), ACI Code 9.5.2 specifies that *additional* long-term deflections Δ_l due to the combined effects of creep and shrinkage be calculated by multiplying the immediate deflection Δ_i by the factor

$$\lambda_\Delta = \frac{\xi}{1 + 50\rho'} \tag{6.11}$$

where $\rho' = A_s'/bd$ and ξ is a time-dependent coefficient that varies as shown in Fig. 6.9. In Eq. (6.11), the quantity $1/(1 + 50\rho')$ is a reduction factor that is essentially a section property, reflecting the beneficial effect of compression reinforcement A_s' in reducing long-term deflections, whereas ξ is a material property depending on creep and shrinkage characteristics. For simple and continuous spans, the value of ρ' used in Eq. (6.11) should be that at the midspan section, according to the ACI Code, or that at the support for cantilevers. Equation (6.11) and the values of ξ given by Fig. 6.9 apply to both normalweight and lightweight concrete beams. The additional, time-dependent deflections are thus found using values of λ_Δ from Eq. (6.11) in Eq. (6.6).

Values of ξ given in the ACI Code and Commentary are satisfactory for ordinary beams and one-way slabs, but may result in underestimation of time-dependent deflections of two-way slabs, for which Branson has suggested a 5-year value of $\xi = 3.0$ (Ref. 6.7).

Research by Paulson, Nilson, and Hover indicates that Eq. (6.11) does not properly reflect the reduced creep that is characteristic of higher-strength concretes (Ref. 6.13). As indicated in Table 2.2, the creep coefficient for high-strength concrete may be as low as one-half the value for normal concrete. Clearly, the long-term deflection of high-strength concrete beams under sustained load, expressed as a ratio of immediate elastic deflection, correspondingly will be less. This suggests a lower value of the material modifier ξ in Eq. (6.11) and Fig. 6.9. On the other hand, in high-strength concrete beams, the influence of compression

steel in reducing creep deflections is less pronounced, requiring an adjustment in the section modifier $1/(1 + 50\rho')$ in that equation.

Based on long-term tests involving six experimental programs, the following modified form of Eq. (6.11) is recommended (Ref. 6.13):

$$\lambda_\Delta = \frac{\mu\xi}{1 + 50\,\mu\rho'} \tag{6.12}$$

in which

$$\mu = 1.4 - f_c'/10{,}000$$
$$0.4 \le \mu \le 1.0 \tag{6.13}$$

The proposed equation gives results identical to Eq. (6.11) for concrete strengths of 4000 psi and below, and much improved predictions for concrete strengths between 4000 and 12,000 psi.

TABLE 6.2
Maximum allowable computed deflections

Type of Member	Deflection to Be Considered	Deflection Limitation
Flat roofs not supporting or attached to nonstructural elements likely to be damaged by large deflections	Immediate deflection due to the live load L	$\frac{l}{180}$
Floors not supporting or attached to nonstructural elements likely to be damaged by large deflections	Immediate deflection due to the live load L	$\frac{l}{360}$
Roof or floor construction supporting or attached to nonstructural elements likely to be damaged by large deflections	That part of the total deflection occurring after attachment of the nonstructural elements (sum of the long-time deflection due to all sustained loads and the immediate deflection due to any additional live load)	$\frac{l}{480}$
Roof or floor construction supporting or attached to nonstructural elements not likely to be damaged by large deflections		$\frac{l}{240}$

Table 6-5 Inputs for Deflection Check of Beam

Inputs											
Beam	Grid	Length L	Width b	Depth h	Concrete strength f'c	Compression Rebar Dia ϕ_bar	Number of compression bar	ϕ_stirrup	Concrete clear cover cc	Creep co-efficient ξ	Immediate Deflection due to DL + LL from ETABS
		in	*in*	*in*	*psi*	*mm*	*Nos*	*mm*	*in*		*in*
RB01	1~2	354.3	12	20	5000	20	4	10	1.5	3	0.83
RB02	C~E	236.2	12	20	5000	16	3	10	1.5	3	0.26
RB02	E~F	145.6	12	20	5000	16	3	10	1.5	3	0.06
FB01	1~2	354.3	12	20	5000	20	3	10	1.5	3	0.47

Inputs											
Beam	Grid	Length L	Width b	Depth h	Concrete strength f'_c	Compression Rebar Dia Φ_bar	Number of compression bar	Φ_stirrup	Concrete clear cover cc	Creep co-efficient ξ	Immediate Deflection due to DL + LL from ETABS
		in	*in*	*in*	*psi*	*mm*	*Nos*	*mm*	*in*		*in*
FB02	D~E	185	12	20	5000	16	3	10	1.5	3	0.08
FB02	E~F	155.5	12	20	5000	16	3	10	1.5	3	0.06

Table 6-6 Deflection Check of Beam

Deflection Check						
Effective depth d	Compression reinforcement ratio ρ'	μ	Long term deflection multiplier λ_Δ	Long Term Deflection	Allowable Limit l/240	Status
in				*in*	*in*	
17.7	0.0148	0.9	1.62	1.34	1.48	OK
17.8	0.0088	0.9	1.93	0.5	0.98	OK
17.8	0.0088	0.9	1.93	0.12	0.61	OK
17.7	0.0111	0.9	1.8	0.85	1.48	OK
17.8	0.0088	0.9	1.93	0.15	0.77	OK
17.8	0.0088	0.9	1.93	0.12	0.65	OK

6.1.5 Design of Element

The design of all structural elements is done using the "Limit State Method". All relevant Limit State is considered in design to ensure adequate safety and serviceability. The design includes design for durability, construction and use in service should be considered. The realization of design objectives requires compliance with clearly defined standards for materials, production, workmanship, and maintenance and use of structure in service.

This section includes all the design processes for a single element such as beam, wall, slab, and foundation.

6.1.5.1 Beam Design

Design of beams requires determination of the cross-sectional dimensions and reinforcement details to satisfy both serviceability and strength requirements. The serviceability requirement for deflection is controlled by effective span to effective depth ratio. Generally, depth of the beam is large and governed by the strength requirement. The spacing of reinforcement controls the serviceability requirement for crack. The detailing of longitudinal and transverse bars should satisfy the bending, shear and bond requirements. The bending moment and shear are determined from the analysis generally based on the elastic theory.

Beams are designed for the worst condition. So, the maximum values from the combination have been used for the design.

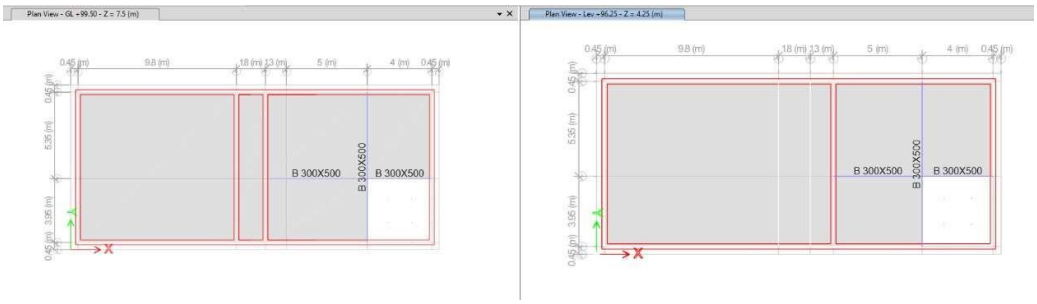


Figure 6-12 Beam Section Properties (Roof Slab & First Floor Slab)

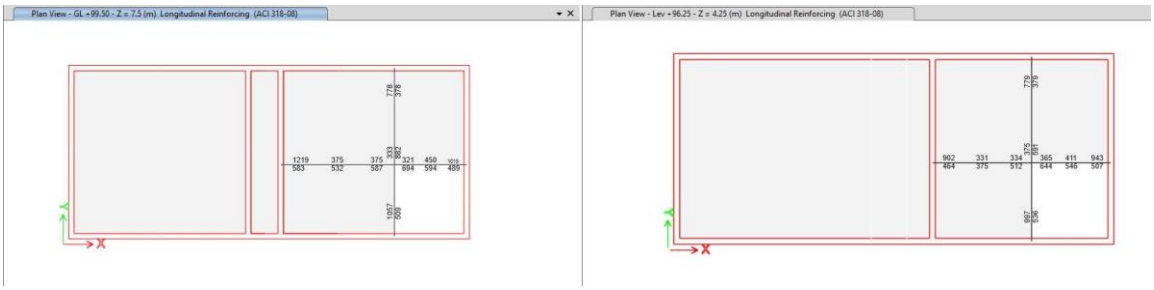


Figure 6-13 Longitudinal Reinforcing Detail (mm²)

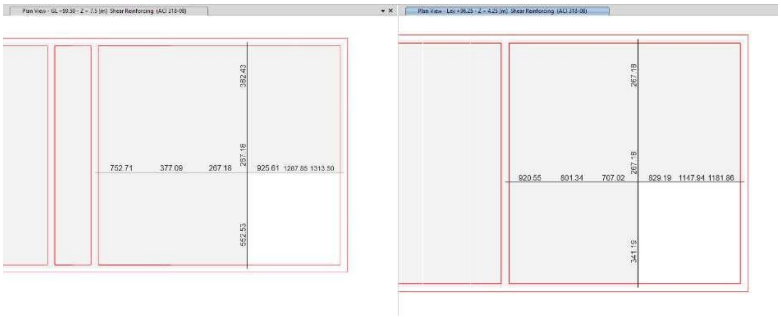


Figure 6-14 Shear Reinforcing Detail (mm²/m)

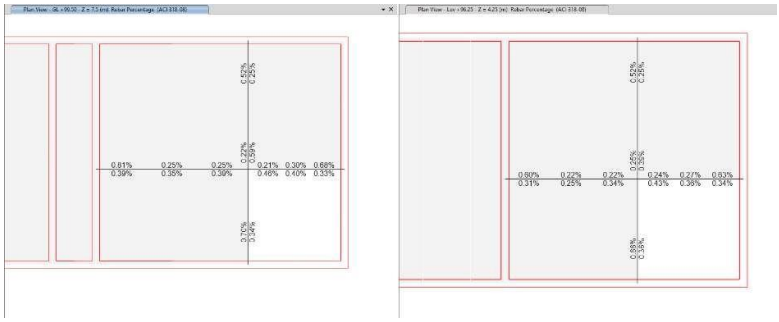


Figure 6-15 Total Rebar Percentage (%)

6.1.5.1.1 Sample Design of Beam

The sample design of **Beam RB1**, obtained from analysis using **ETABS,** according to ACI 318-08 and BNBC 2020 is shown below. The design summary for the remaining beams has been provided in the later part of the design report.

ETABS Concrete Frame Design

ACI 318-08 Beam Section Design (Summary)

Beam Element Details

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF	Type
GL +99.50	B3	1	B 300X500	(1) 1.4 D + 1.4 F	9300	9300	1	Sway Special

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
300	500	300	0	76.2	76.2

Material Properties

E_c (MPa)	f'_c (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
27805.57	35	1	500	500

Design Code Parameters

φ_T	φ_{CTied}	$\varphi_{CSpiral}$	φ_{Vns}	φ_{Vs}	φ_{Vjoint}
0.9	0.65	0.75	0.75	0.65	0.85

Design Moment and Flexural Reinforcement for Moment, Mu3

	Design Moment kN-m	Design P_u kN	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	-218.9363	0	1252	0	375	1252
Bottom (-2 Axis)	109.4682	0	0	598	375	598

Shear Force and Reinforcement for Shear, Vu2

Shear V_{u2} kN	Shear φV_c kN	Shear φV_s kN	Shear V_p kN	Rebar A_v/s mm²/m
129.6241	93.6843	35.9398	45.403	273.33

Torsion Force and Torsion Reinforcement for Torsion, Tu (Part 1 of 2)

T_u kN-m	$\varphi T_{cr}/4$ kN-m	Rebar A_t/s mm²/m	Rebar A_l mm²	Cover mm	Area A_{cp} cm²	Area A_{oh} cm²	Area A_o cm²	Perimeter, p_{cp} mm
0.0201	5.181	0	0	44.5	1500	867.8	737.7	1600

Torsion Force and Torsion Reinforcement for Torsion, Tu (Part 2 of 2)

Perimeter, p_h mm
1244.4

6.1.5.2 RCC Wall Design

A nominal thickness of 300 mm is maintained throughout the internal and external walls of the WTP. This section provides the design calculations for the exterior wall at its maximum height, representing the most critical structural condition.

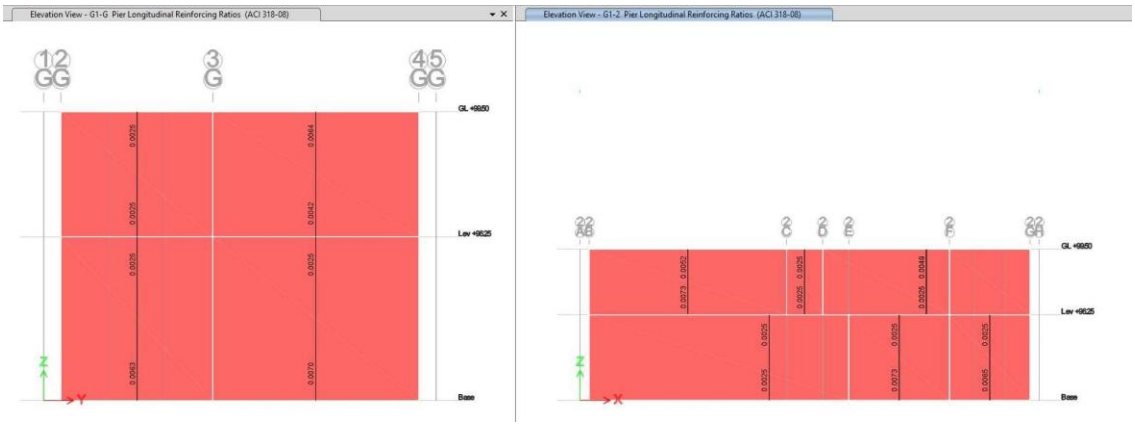


Figure 6-16 Pier Reinforcing Ratio of Exterior Wall

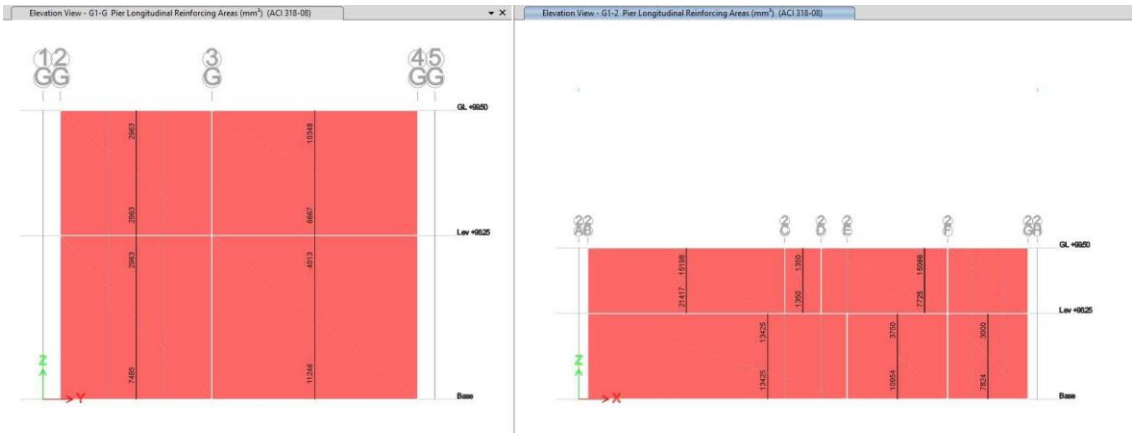


Figure 6-17 Pier Longitudinal Reinforcing Detail of Exterior Wall (mm^2)

6.1.5.2.1 Sample Design of RCC Wall

The sample design for the **300 mm thick perimeter wall**, obtained from analysis using **ETABS,** according to **ACI 350** and **BNBC 2020** is shown below. The design summary for remaining RCC wall has been provided in the later part of the design report

ETABS Shear Wall Design

ACI 318-08 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
GL +99.50	PW1	5350	450	9800	300	0.808

Material Properties

E_c (MPa)	f'_c (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
27805.57	35	1	500	500

Design Code Parameters

φ_T	φ_C	φ_v	φ_v (Seismic)	IP_{MAX}	IP_{MIN}	P_{MAX}
0.9	0.65	0.75	0.6	0.04	0.0025	0.8

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	450	450	10250	450	9800	300
Bottom	Leg 1	450	450	10250	450	9800	300

Flexural Design for Pu, Mu2 and Mu3

Station Location	Required Rebar Area (mm^2)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm^2
Top	15198	0.0052	0.0021	(1) 1.4 D + 1.4 F	988.8952	1002.7055	653.6123	2940000
Bottom	21417	0.0073	0.0021	(1) 1.4 D + 1.4 F	2677.2862	-1433.5925	1499.705	2940000

Shear Design

Station Location	ID	Rebar mm^2/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	φV_c kN	φV_n kN
Top	Leg 1	750	(1) 1.4 D + 1.4 F	988.8952	653.6123	1337.5093	3007.9393	4832.2923
Bottom	Leg 1	750	(1) 1.4 D + 1.4 F	2677.2862	1499.705	1283.0604	3261.198	5085.5509

Boundary Element Check (ACI 21.9.6.3, 21.9.6.4) (Part 1 of 2)

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa
Top–Left	Leg 1	Not Required	(23) 1.307 D +0.3 EX- + 1 EY- +1 L	979.4684	373.8327	0.26
Top–Right	Leg 1	Not Required	(23) 1.307 D +0.3 EX- + 1 EY- +1 L	979.4684	373.8327	0.41
Bottom–Left	Leg 1	Not Required	(23) 1.307 D +0.3 EX- + 1 EY- +1 L	2482.3624	1351.2802	0.56
Botttom–Right	Leg 1	Not Required	(23) 1.307 D +0.3 EX- + 1 EY- +1 L	2482.3624	1351.2802	1.13

Boundary Element Check (ACI 21.9.6.3, 21.9.6.4) (Part 2 of 2)

Stress Limit MPa	C Depth mm	C Limit mm
7		
7		
7		
7		

Here,

Wall Thickness, h = 300 mm

Required Rebar Area = 21417 mm^2 **[As per ETABS Analysis]**

Pier Length = 9800 mm = 9.8 m

Required Rebar Area per length = 21417/9.8 = 2185 mm^2/m

According to ACI 350,

$$A_{s,min} = 0.003bh$$

Here,

Width, b = 1000 mm **[Per meter strip]**

Thickness, h = 300 mm

Therefore, $A_{s,min}$ = 0.003 x 1000 x 300 = 900 mm^2/m

Thus, governing rebar area, As = 2185 mm^2/m

Required vertical reinforcement area per face, $A_{s,face}$ = 2185/2 mm^2/m = 1093 mm^2/m each face

Table 6-7 Design Summary of RCC Wall (Exterior)

Reinforcement Type	Required As (mm^2/m)	Provided Rebar Dia (mm)	Required Spacing (mm c/c)	Provided Spacing (mm c/c)	Provided As (mm^2/m)
Top Vertical	1093	16ϕ	184	125	1609
Top Horizontal	375	12ϕ	151	125	905
Bottom Vertical	1093	16ϕ	184	125	1609
Bottom Horizontal	375	12ϕ	151	125	905

6.1.5.2.2 Crack Width Check of Wall

Maximum Ultimate Moment	(ETABS)	M	=	1434	kN-m
Width of the section		b	=	1000	mm
Thickness of section		h	=	300	mm
Concrete Strength		f'c	=	35	MPa
Distance from neutral axis	C=(h/2)	C	=	150	mm
Moment of inertia	I= (bh^3)/12	I	=	2250000000	mm^4
Tensile stress of concrete	σ=(MC)/I	σ	=	9.6E-05	MPa
Modulus of Rupture	fr=0.62λv(f'c)	fr	=	3.6680	MPa

Here λ = 1 for nominal weight concrete

Modulus of Rupture (fr) is more than Maximum bending stress, so there will be no crack on the concrete surface.

As per **ACI-350 Table 4.1**, for Humid, moist air, and soil, the maximum allowable crack width is **0.3 mm**. Again, according to **ACI 224.R-01 | Equation 4-15,**

1. KNOWN DATA / INPUT PARAMETERS					
Parameter	**Notes**	**SI Value**	**SI Unit**	**Imperial**	**Imp. Unit**
Yield Strength of Steel fy		**500.0**	MPa	72.5	ksi
Allowable Steel Stress fs	40% of fy	200.0	MPa	29.0	ksi
Rebar Dia d_{b1}		**16.000**	mm	0.63	inch
Concrete Clear Cover c_1	From tensile face of concrete to nearest edge of rebar	**75.000**	mm	2.95	inch

2. PROVIDED REINFORCEMENT					
Parameter	**Notes**	**SI Value**	**SI Unit**	**Imperial**	**Imp. Unit**
Provided Rebar Dia d_b		**16.000**	mm	0.630	inch
Rebar Spacing s_2	*Centre-to-centre*	**125.000**	mm	5.000	inch
Rebar Area per Unit As	*SI: $\pi/4 \cdot db^2 / (s_2/1000)$* *Imperial: $\pi/4 \cdot db^2 / (s_2/12)$*	1608.495	mm^2/m	0.748	in^2/ft

3. CRACK WIDTH CALCULATION					
Parameter	**Formula**	**Value**	**Unit**	**SI Value**	**SI Unit**

Fracture Coefficient k	*ACI 224R-01 | $k = 2.8 \times 10^{-5}$*	0.00003	—		
β	*Range: 1.2 – 1.35*	1.25	—		
Active Steel Ratio p_{t1}	*$As / (12 \cdot d_{b1} + 2.c_1)$*	0.05555	—		
Grid Index I	*$(d_{b1} \times s_2) / p_{t1}$*	56.69895	—		
Crack Width W	*ACI 224R-01 | Eqn 4-15 | $k \cdot \beta \cdot fs \cdot \sqrt{I}$*	0.00764	in	0.194	mm

4. RESULT					
Calculated Crack Width:	**0.194**	**mm**	**Allowable Width:**	**0.300**	**mm**
SATISFACTORY — Calculated width (0.194 mm) < Allowable width (0.3 mm)					

6.1.5.3 Slab Design

The reinforced concrete slabs were designed using an **integrated Finite Element Method (FEM)** approach within ETABS, ensuring a precise distribution of internal forces across the floor system. By modeling the slabs as thin-shell elements, the analysis accounts for both in-plane (diaphragm) and out-of-plane (flexural) stiffness, providing a comprehensive view of the slab's structural response under gravity and lateral loading.

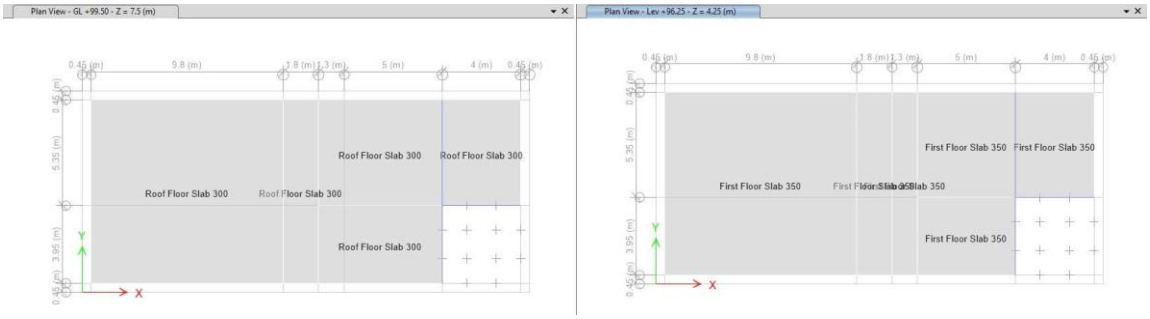


Figure 6-18 Slab Section Properties (mm)

6.1.5.3.1 Slab Thickness Check

The sample calculation of ***Roof slab*** has been shown in this section of the design report.

According to Nilson – Design of Concrete Structures, 14th Ed, Section 13.8,

b. Slabs with Beams on All Sides

The parameter used to define the relative stiffness of the beam and slab spanning in either direction is α_f, calculated from Eq. (13.4) of Section 13.6c. Then α_{fm} is defined as the average value of α_f for all beams on the edges of a given panel. According to ACI Code 9.5.3.3, for α_{fm} equal to or less than 0.2, the minimum thicknesses of Table 13.5 shall apply.

For α_{fm} greater than 0.2 but not greater than 2.0, the slab thickness must not be less than

$$h = \frac{l_n(0.8 + f_y/200{,}000)}{36 + 5\beta(\alpha_{fm} - 0.2)} \qquad (13.8a)$$

and not less than 5.0 in.

For α_{fm} greater than 2.0, the thickness must not be less than

$$h = \frac{l_n(0.8 + f_y/200{,}000)}{36 + 9\beta} \qquad (13.8b)$$

and not less than 3.5 in.,

where l_n = clear span in long direction, in.
α_{fm} = average value of α_f for all beams on edges of a panel [see Eq. (13.4)]
β = ratio of clear span in long direction to clear span in short direction

Here,

Steel Strength, fy = 500 MPa = 72,500 psi

Total Dimension = 10 m x 9.0 m **[Large Panel]**

Clear Spans:

ln,long = 10.0 m

ln,short = 9.0 m

Aspect Ratio, β = (ln,long)/(ln,short) = 1.1

Given the beam size is quite substantial relative to typical slab thickness, thus $\alpha_{fm} > 2$.

Using equation 13.8b,

h = 252 mm

Thus, provided slab thickness for roof slab is 300 mm.

6.1.5.3.2 Flexural Design of Slab

The flexural design of the **roof slab**, obtained from ETABS analysis, has been shown in this section.

Table 6-8 Reinforcement summary table for Roof Slab as per ETABS

Reinforcement Type	As,min (mm²/m)	Provided Rebar Dia (mm)	Provided Spacing (mm c/c)	Provided As (mm²/m)	Remarks
Top (x-direction)	450	16ϕ	200	1006	1-20ϕ extra
Top (y-direction)	450	16ϕ	200	1006	1-20ϕ extra

Reinforcement Type	As,min (mm^2/m)	Provided Rebar Dia (mm)	Provided Spacing (mm c/c)	Provided As (mm^2/m)	Remarks
Bottom (x-direction)	450	16ϕ	125	1609	-
Bottom (y-direction)	450	16ϕ	125	1609	-

According to ACI 350,

$$As,min = 0.003bh$$

Here,

Width, b = 1000 mm **[Per meter strip]**

Thickness, h = 300 mm

Therefore, As,min = 0.003 x 1000 x 300 = 900 mm^2/m

Minimum reinforcement area per layer, $A_{s,face}$ = 900/2 mm^2/m = 450 mm^2/m each layer, each way.

From ETABS analysis the following rebar intensity has been obtained;

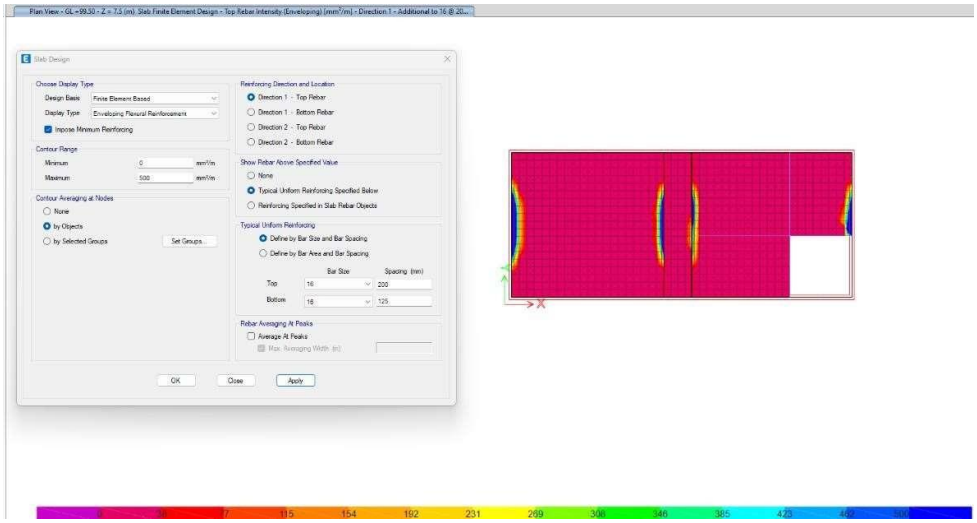


Figure 6-19 Top rebar intensity mm^2/mm (Direction-1)

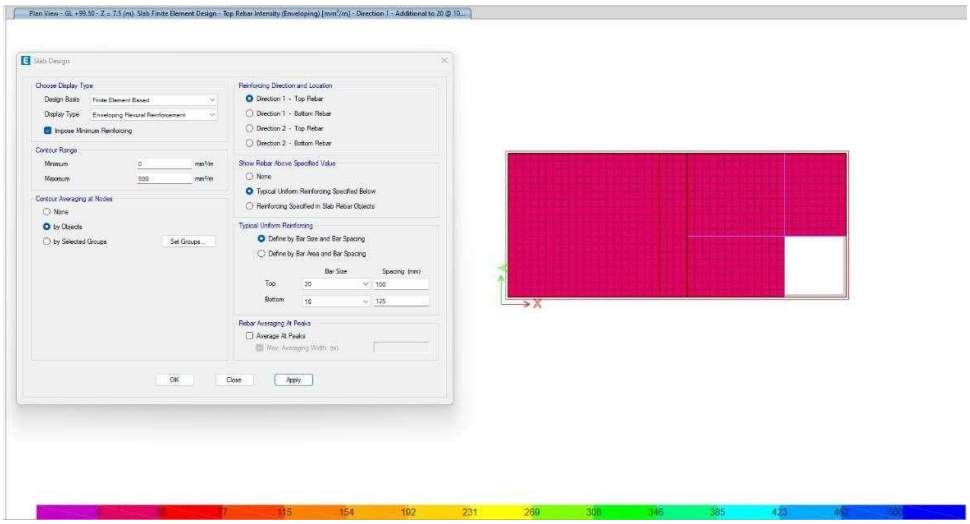


Figure 6-20 Top rebar intensity mm²/mm (Direction-1)

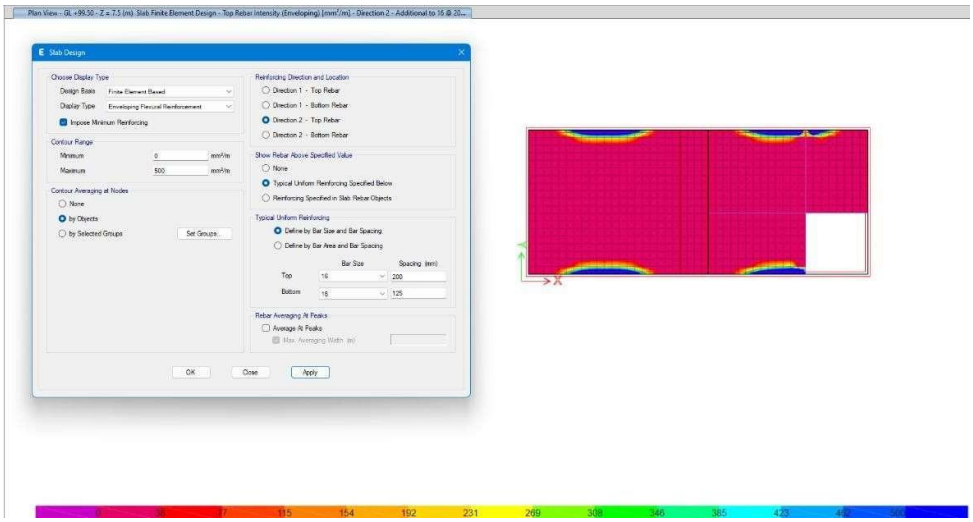


Figure 6-21 Top rebar intensity mm²/mm (Direction-2)

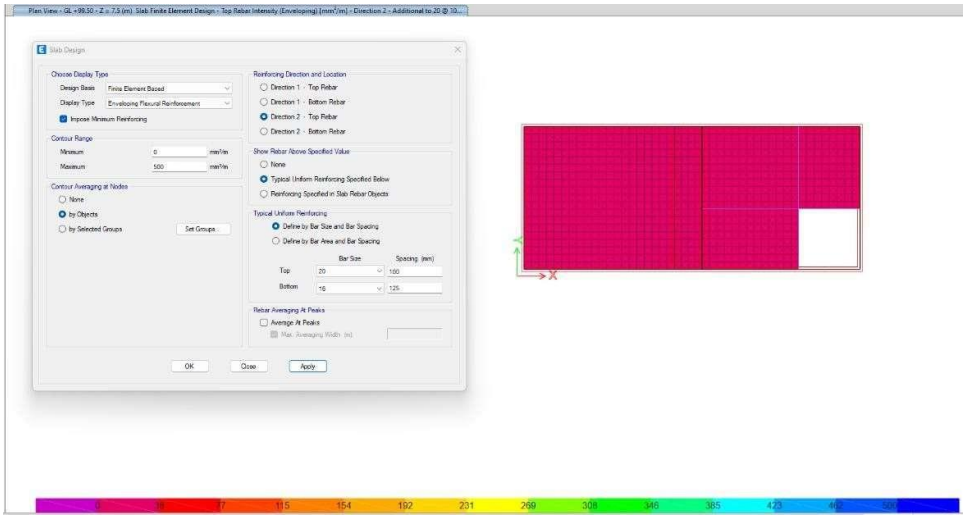


Figure 6-22 Top rebar intensity mm²/mm (Direction-2)

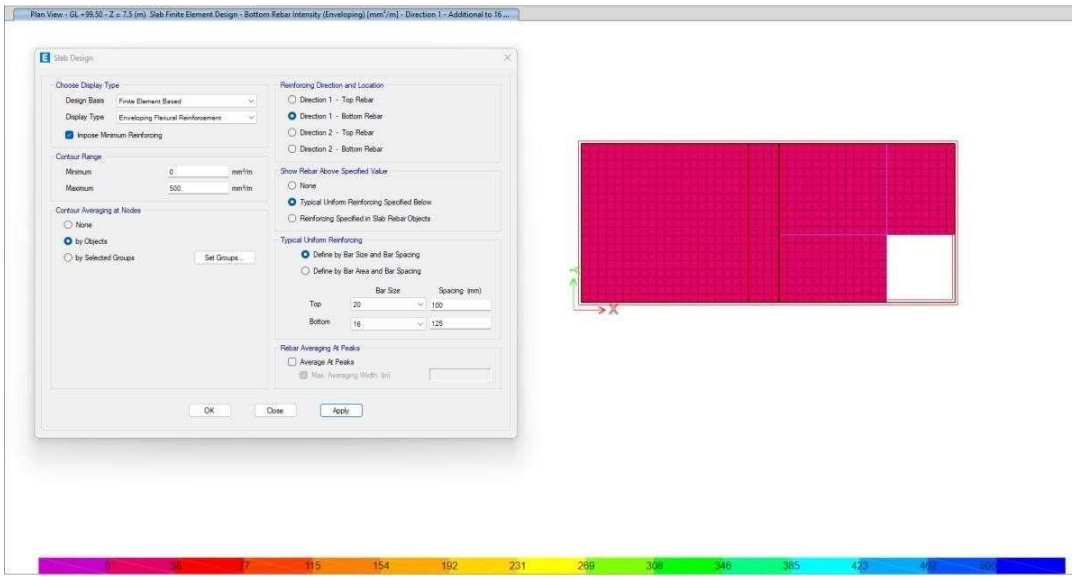


Figure 6-23 Bottom rebar intensity mm²/mm (Direction-1)

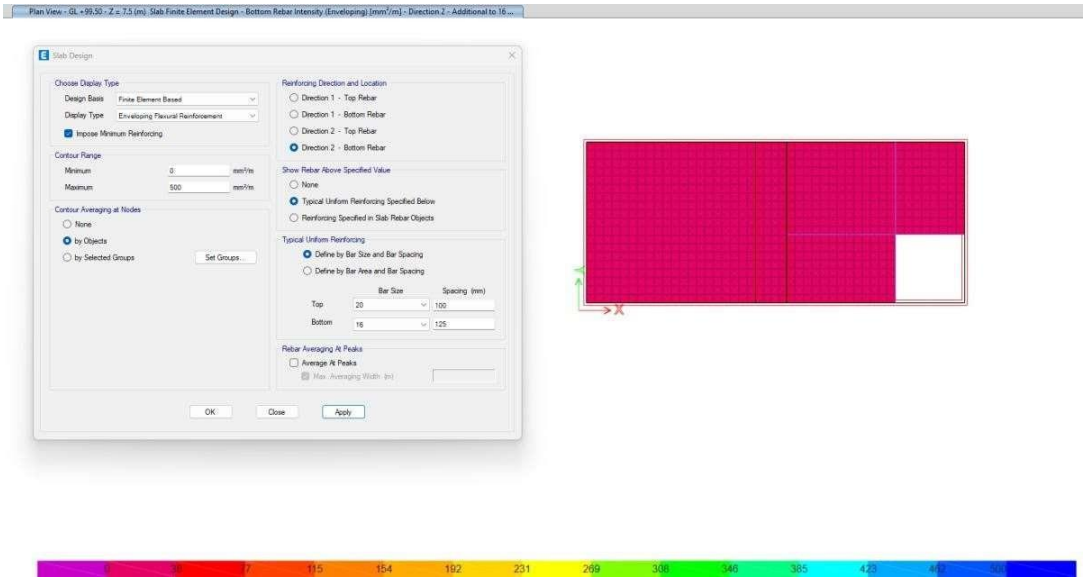


Figure 6-24 Bottom rebar intensity mm²/mm (Direction-2)

6.1.5.3.3 Crack Width Check of Slab

As per **ACI-350 Table 4.1**, for Humid, moist air, and soil, the maximum allowable crack width is **0.3 mm**. Again, according to **ACI 224.R-01 | Equation 4-15,**

1. KNOWN DATA / INPUT PARAMETERS					
Parameter	**Notes**	**SI Value**	**SI Unit**	**Imperial**	**Imp. Unit**
Yield Strength of Steel fy		**500.0**	MPa	72.5	ksi
Allowable Steel Stress fs	40% of fy	200.0	MPa	29.0	ksi
Rebar Dia d_{b1}		**16.000**	mm	0.63	inch
Concrete Clear Cover c_1	From tensile face of concrete to nearest edge of rebar	**50.000**	mm	1.97	inch

2. PROVIDED REINFORCEMENT

Parameter	Notes	SI Value	SI Unit	Imperial	Imp. Unit
Provided Rebar Dia d_b		**20.000**	mm	0.630	inch
Rebar Spacing s_2	*Centre-to-centre*	**200.000**	mm	8.000	inch
Rebar Area per Unit As	*SI: $\pi/4 \cdot db^2 / (s_2/1000)$* *Imperial: $\pi/4 \cdot db^2 / (s_2/12)$*	1005.310	mm^2/m	0.467	in^2/ft

3. CRACK WIDTH CALCULATION					
Parameter	**Formula**	**Value**	**Unit**	**SI Value**	**SI Unit**
Fracture Coefficient k	*ACI 224R-01 | $k = 2.8 \times 10^{-5}$*	0.00003	—		
β	*Range: 1.2 – 1.35*	1.25	—		
Active Steel Ratio p_{t1}	*$As / (12 \cdot d_{b1} + 2.c_1)$*	0.04066	—		
Grid Index I	*$(d_{b1} \times s_2) / p_{t1}$*	123.92865	—		
Crack Width W	*ACI 224R-01 | Eqn 4-15 | k·β·fs·√I*	0.01130	in	0.287	mm

4. RESULT					
Calculated Crack Width:	**0.287**	**mm**	**Allowable Width:**	**0.300**	**mm**
SATISFACTORY — Calculated width (0.287 mm) < Allowable width (0.3 mm)					

From ETABS model as seen in Figure 6-33, the maximum crack width is 0 mm which is less than maximum allowable crack width.

So, the design is safe **(OK)**

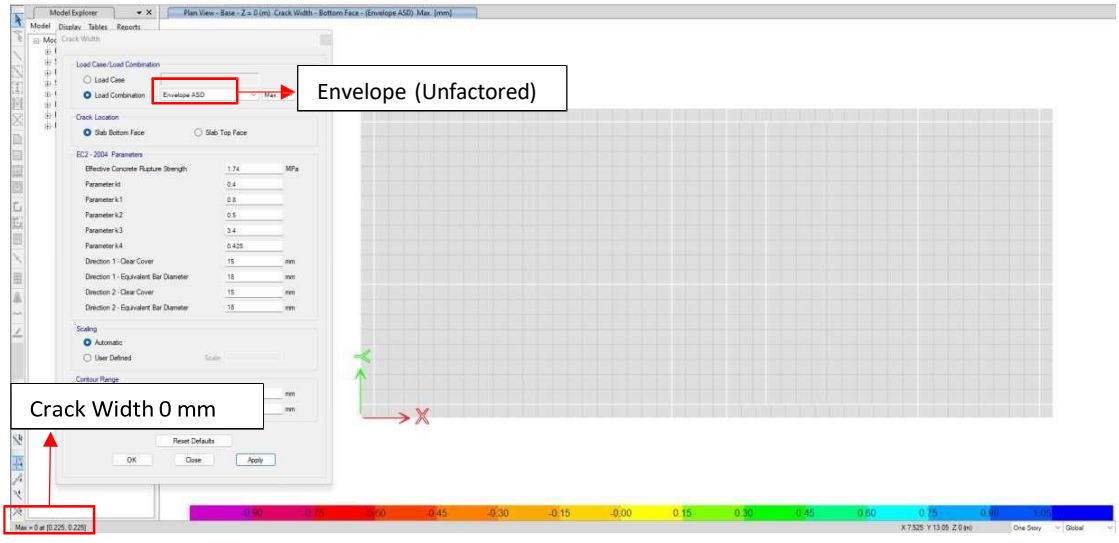


Figure 6-25 Crack Width in ETABS (Un-factored Load Combinations)

6.1.5.4 Substructure Design

The design of the mat foundation was performed using **ETABS**, utilizing the **Finite Element Method (FEM)** to accurately model the complex interaction between the superstructure, the raft, and the underlying soil. By discretizing the slab into a mesh of quadrilateral shell elements, the software captures localized stress concentrations and varying stiffness parameters that traditional rigid methods might overlook.

The design accounts for the two-way bending action of the mat, with reinforcement requirements determined based on the computed nodal moments and shear forces. To ensure a realistic distribution of flexural stresses, the soil was modeled as an elastic area spring, allowing the FEM analysis to account for differential settlements and their subsequent impact on the design moments.

For the proposed structure, ***Mat foundation*** has been designed at two different depths below FGL. The design for the Mat footing with necessary calculations and checks has been provided below.

6.1.5.4.1 Foundation Type and Layout

The initial thickness of the mat foundation has been considered 500 mm. The foundation layout plan is shown in the following figure;

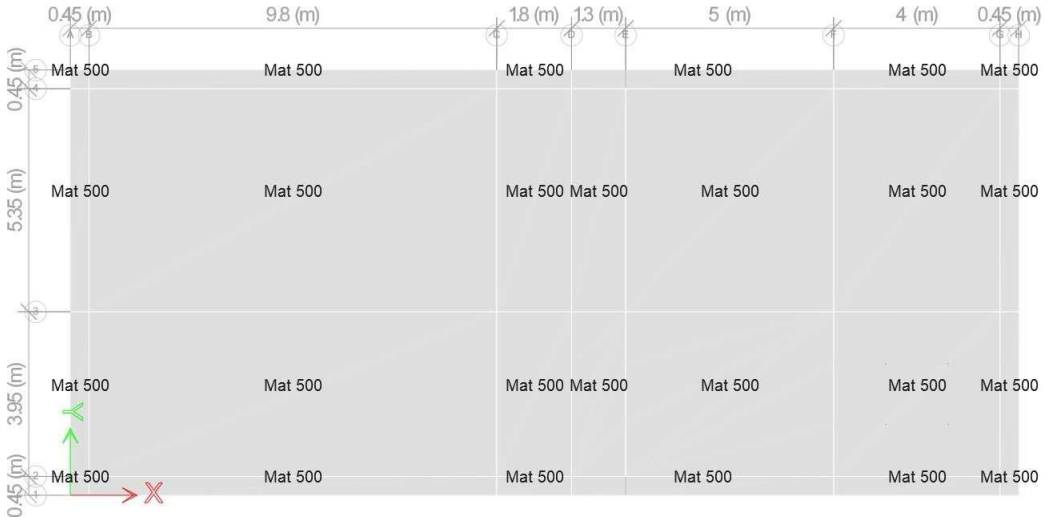


Figure 6-26 Mat Foundation (Plan View)

6.1.5.4.2 Uplift Check

The mat foundation is found to be safe against uplift as seen in the following table. The check is done using the results obtained from ETABS analysis based on **ACI 318-08**. Allowable Factors have been used to check uplift. "**If soil bearing pressures in all load cases show negative values, that means there is no uplift on the foundation."**

Table 6-9 Uplift Check for Mat Foundation

Load Case Name	***Load Combination***	***Bearing Pressures***	***Unit***	***Remarks***
Uplift 1	DL+LL	-5.771	kN/m^2	***No Uplift***
Uplift 2	DL+0.7Ex	-6.504	kN/m^2	***No Uplift***
Uplift 3	DL-0.7Ex	-5.964	kN/m^2	***No Uplift***
Uplift 4	DL+0.7Ey	-6.201	kN/m^2	***No Uplift***
Uplift 5	DL-0.7Ey	-6.267	kN/m^2	***No Uplift***
Uplift 6	DL+0.7LL+0.525Ex	-6.112	kN/m^2	***No Uplift***
Uplift 7	DL+0.7LL-0.525Ex	-5.707	kN/m^2	***No Uplift***

Load Case Name	*Load Combination*	*Bearing Pressures*	*Unit*	*Remarks*
Uplift 8	DL+0.7LL+0.525Ey	-5.885	kN/m^2	***No Uplift***
Uplift 9	DL+0.7LL-0.525Ey	-5.934	kN/m^2	***No Uplift***
Uplift 10	0.6DL+0.7Ex	-4.011	kN/m^2	***No Uplift***
Uplift 11	0.6DL-0.7Ex	-3.470	kN/m^2	***No Uplift***
Uplift 12	0.6DL+0.7Ey	-3.707	kN/m^2	***No Uplift***
Uplift 13	0.6DL-0.7Ey	-3.744	kN/m^2	***No Uplift***

6.1.5.4.3 Settlement Check

According to **BNBC 2020 | Table 6.3.8**, the maximum allowable settlement for mat foundation is **75 mm**.

The maximum settlement, found from the analysis in ETABS for ***Allowable Strength Design load combinations (ASD)***, is within the limit.

Thus, the structure is safe in settlement.

Table 6.3.8: Permissible Total Settlement, Differential Settlement and Angular Distortion (Tilt) for Shallow Foundations in Soils (in mm) (Adapted from NBCI, 2005)

Type of Structure	Isolated Foundations						Raft Foundation					
	Sand and Hard Clay			Plastic Clay			Sand and Hard Clay			Plastic Clay		
	Maximum Settlement	Differential Settlement	Angular Distortion	Maximum Settlement	Differential Settlement	Angular Distortion	Maximum Settlement	Differential Settlement	Angular Distortion	Maximum Settlement	Differential Settlement	Angular Distortion
Steel Structure	50	0.0033 L	1/300	50	0.0033 L	1/300	75	0.0033 L	1/300	100	0.0033 L	1/300
RCC Structures	50	0.0015 L	1/666	75	0.0015 L	1/666	75	0.0021 L	1/500	100	0.002 L	1/500
Multistoried Building												
(a) RCC or steel framed building with panel walls	60	0.002 L	1/500	75	0.002 L	1/500	75	0.0025 L	1/400	125	0.0033 L	1/300
(b) Load bearing walls												
(i) L/H = 2 *	60	0.0002 L	1/5000	60	0.0002 L	1/5000	Not likely to be encountered					
(ii) L/H = 7 *	60	0.0004 L	1/2500	60	0.0004 L	1/2500	Not likely to be encountered					
Silos	50	0.0015 L	1/666	75	0.0015 L	1/666	100	0.0025 L	1/400	125	0.0025 L	1/400
Water Tank	50	0.0015 L	1/666	75	0.0015 L	1/666	100	0.0025 L	1/400	125	0.0025 L	1/400

Notes: The values given in the Table may be taken only as a guide and the permissible total settlement, differential settlement and tilt (angular distortion) in each case should be decided as per requirements of the designer.

L denotes the length of deflected part of wall/ raft or centre to centre distance between columns.

H denotes the height of wall from foundation footing.

* For intermediate ratios of L/H, the values can be interpolated.

Table 6-10 Settlement Check for Mat (ASD Load Combination)

Description	***Value***	***Unit***
Allowable Settlement	75.00	mm
Obtained Settlement (Uz Min)	4.35	mm
Settlement Check is	**OK**	

File Edit Format-Filter-Sort Select Options

Units: As Noted Hidden Columns: Yes Sort: Uz ASC

Filter: ([Story] = 'Base') AND ([Output Case] = 'Envelope ASD')

	Story	Output Case	Case Type	Step Type	Ux mm	Uy mm	Uz mm
▶	Base	Envelope ASD	Combination	Min	-0.206	-0.345	-4.345
	Base	Envelope ASD	Combination	Min	-0.208	-0.35	-4.344
	Base	Envelope ASD	Combination	Min	-0.205	-0.34	-4.338
	Base	Envelope ASD	Combination	Min	-0.211	-0.355	-4.336
	Base	Envelope ASD	Combination	Min	-0.206	-0.335	-4.324
	Base	Envelope ASD	Combination	Min	-0.214	-0.36	-4.322
	Base	Envelope ASD	Combination	Min	-0.265	-0.343	-4.313

Figure 6-27 Settlement in the Uz direction (mm) (ASD Load Combination)

6.1.5.4.4 Soil Bearing Pressure Check

The soil capacity check has been conducted for both mat footings. The maximum soil pressure for the load combination **DL + LL**, obtained from the ETABS model, has been found to be within the range of bearing capacity of soil that is found in the provided soil test report.

The soil capacity check that has been conducted for the Mat is provided below. Thus, the area provided for this mat is sufficient as the soil capacity is within range.

Table 6-11 Soil Capacity Check for Mat (DL + LL)

Description	***Value***	***Unit***
Bearing capacity of soil (Soil report)	696	kN/m^2
Maximum soil pressure (ETABS)	146	kN/m^2
Soil Capacity Check is	**OK**	

	Story	Output Case	Case Type	Step Type	Soil Pressure kN/m^2
▶	Base	Uplift (1) DL + LL	NonStatic	Max	-145.901
	Base	Uplift (1) DL + LL	NonStatic	Max	-145.901
	Base	Uplift (1) DL + LL	NonStatic	Max	-145.837
	Base	Uplift (1) DL + LL	NonStatic	Max	-145.837
	Base	Uplift (1) DL + LL	NonStatic	Max	-145.766
	Base	Uplift (1) DL + LL	NonStatic	Max	-145.766
	Base	Uplift (1) DL + LL	NonStatic	Max	-145.554

Figure 6-28 Soil pressure obtained for Mat Foundation for (DL + LL)

6.1.5.4.5 Flexural Design

All necessary design checks for the mat foundation confirm that the provided thickness and mat area are adequate to safely resist the applied structural loads. The flexural behavior and design of the mat have been carried out using ETABS software, following standard design codes and criteria.

This section presents the sample results of the flexural analysis and design for the mat.

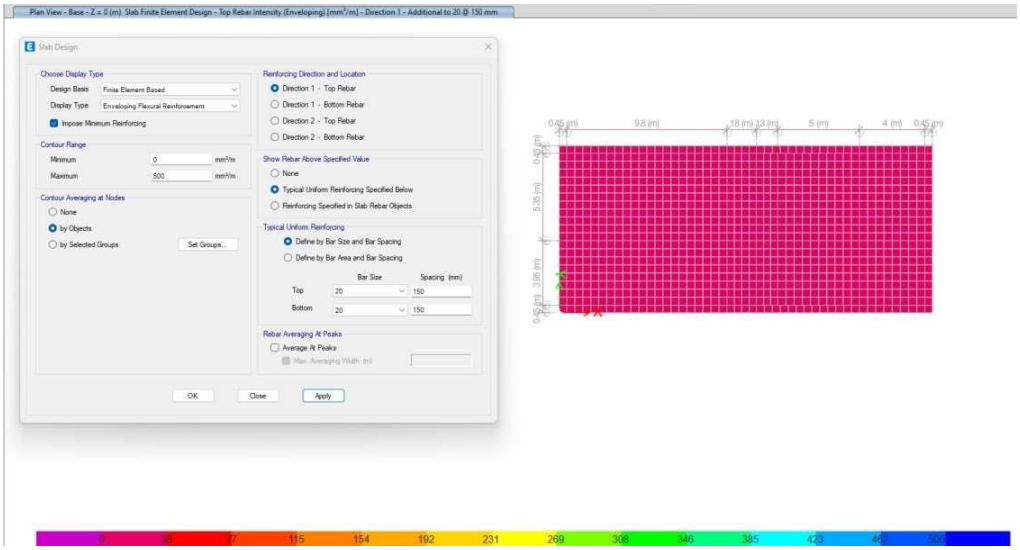


Figure 6-29 Top rebar intensity mm²/mm (Direction-1)

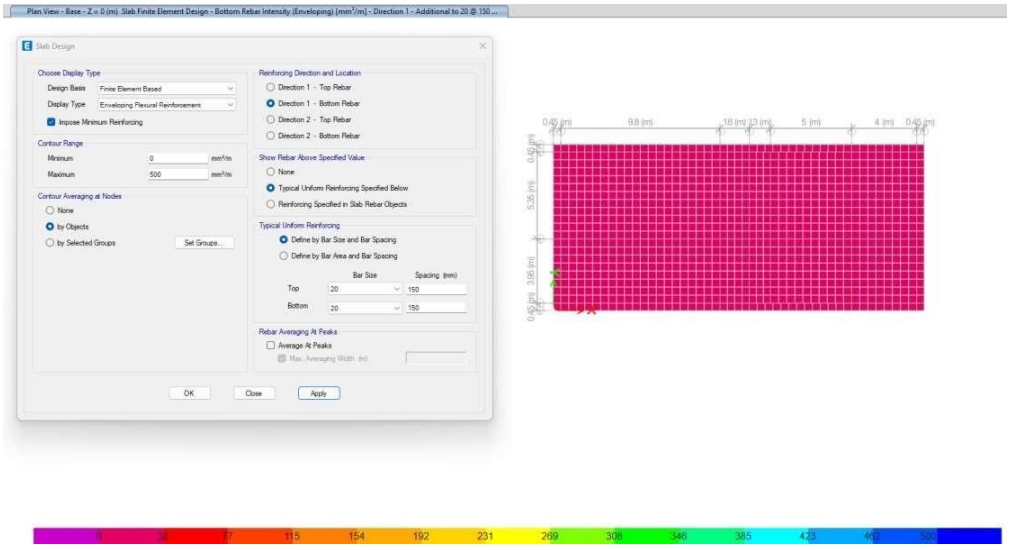


Figure 6-30 Bottom rebar intensity mm²/mm (Direction-1)

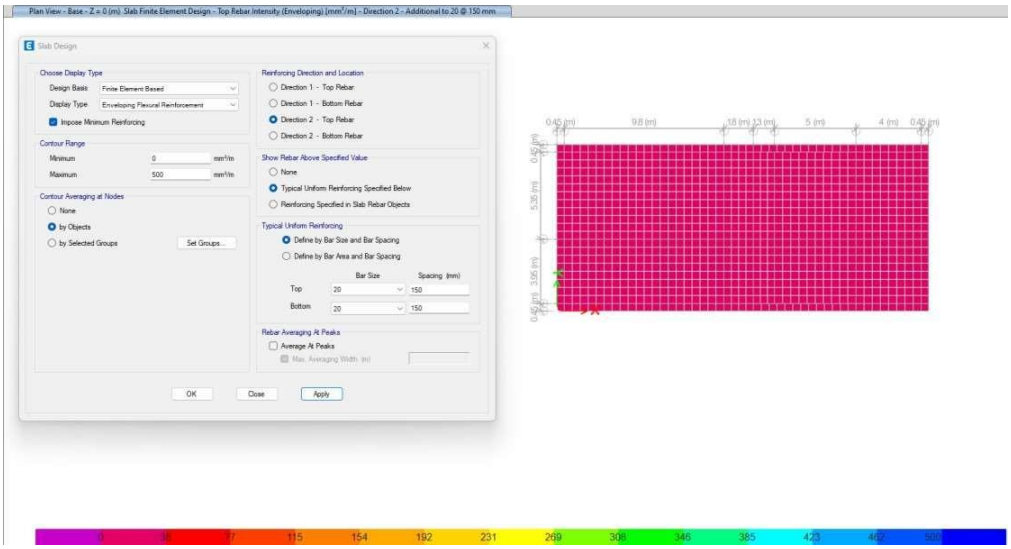


Figure 6-31 Top rebar intensity mm²/mm (Direction-2)

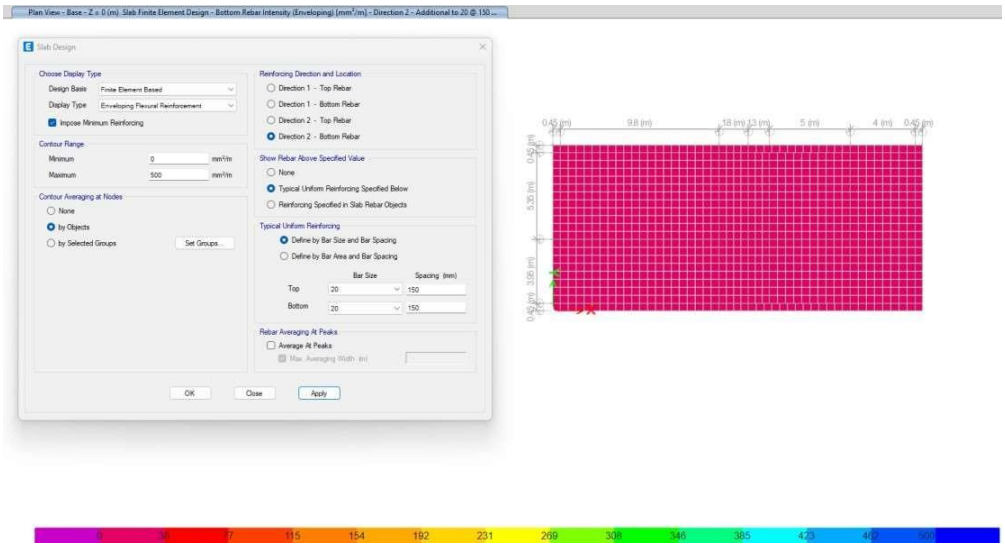


Figure 6-32 Bottom rebar intensity mm²/mm (Direction-2)

According to ACI 350,

$$A_{s,min} = 0.003bh$$

Here,

Width, b = 1000 mm **[Per meter strip]**

Thickness, h = 500 mm

Therefore, $A_{s,min} = 0.003 \times 1000 \times 500 = 1500$ mm²/m

Minimum reinforcement area per layer, $A_{s,face} = 1500/2$ mm²/m = 750 mm²/m each layer, each way

Table 6-12 Reinforcement summary table for Mat Foundation as per ETABS

Reinforcement Type	As,min (mm^2/m)	Provided Rebar Dia (mm)	Provided Spacing (mm c/c)	Provided As (mm^2/m)
Top (x-direction)	750	20ϕ	150	2095
Top (y-direction)	750	20ϕ	150	2095
Bottom (x-direction)	750	20ϕ	150	2095
Bottom (y-direction)	750	20ϕ	150	2095

6.1.5.4.6 Crack Width Check of Mat Foundation

As per **ACI-350 Table 4.1**, for Humid, moist air, and soil, the maximum allowable crack width is **0.3 mm**. Again, according to **ACI 224.R-01 | Equation 4-15,**

1. KNOWN DATA / INPUT PARAMETERS					
Parameter	**Notes**	**SI Value**	**SI Unit**	**Imperial**	**Imp. Unit**
Yield Strength of Steel fy		**500.0**	MPa	72.5	ksi
Allowable Steel Stress fs	40% of fy	200.0	MPa	29.0	ksi
Rebar Dia d_{b1}		**20.000**	mm	0.79	inch
Concrete Clear Cover c_1	From tensile face of concrete to nearest edge of rebar	**75.000**	mm	2.95	inch

2. PROVIDED REINFORCEMENT					
Parameter	**Notes**	**SI Value**	**SI Unit**	**Imperial**	**Imp. Unit**
Provided Rebar Dia d_b		**20.000**	mm	0.787	inch
Rebar Spacing s_2	*Centre-to-centre*	**150.000**	mm	6.000	inch
Rebar Area per Unit As	*SI: $\pi/4 \cdot db^2 / (s_2/1000)$ Imperial: $\pi/4 \cdot db^2 / (s_2/12)$*	2094.395	mm^2/m	0.974	in^2/ft

3. CRACK WIDTH CALCULATION					
Parameter	**Formula**	**Value**	**Unit**	**SI Value**	**SI Unit**
Fracture Coefficient k	*ACI 224R-01 | $k = 2.8 \times 10^{-5}$*	0.00003	—		
β	*Range: 1.2 – 1.35*	1.25	—		
Active Steel Ratio p_{t1}	*$As / (12 \cdot d_{b1} + 2.c_1)$*	0.06343	—		
Grid Index I	*$(d_{b1} \times s_2) / p_{t1}$*	74.48451	—		
Crack Width W	*ACI 224R-01 | Eqn 4-15 | $k \cdot \beta \cdot fs \cdot \sqrt{I}$*	0.00876	in	0.223	mm

4. RESULT					
Calculated Crack Width:	**0.223**	**mm**	**Allowable Width:**	**0.300**	**mm**
SATISFACTORY — Calculated width (0.223 mm) < Allowable width (0.3 mm)					

From ETABS model as seen in Figure 6-33, the maximum crack width is 0 mm which is less than maximum allowable crack width.

So, the design is safe **(OK)**

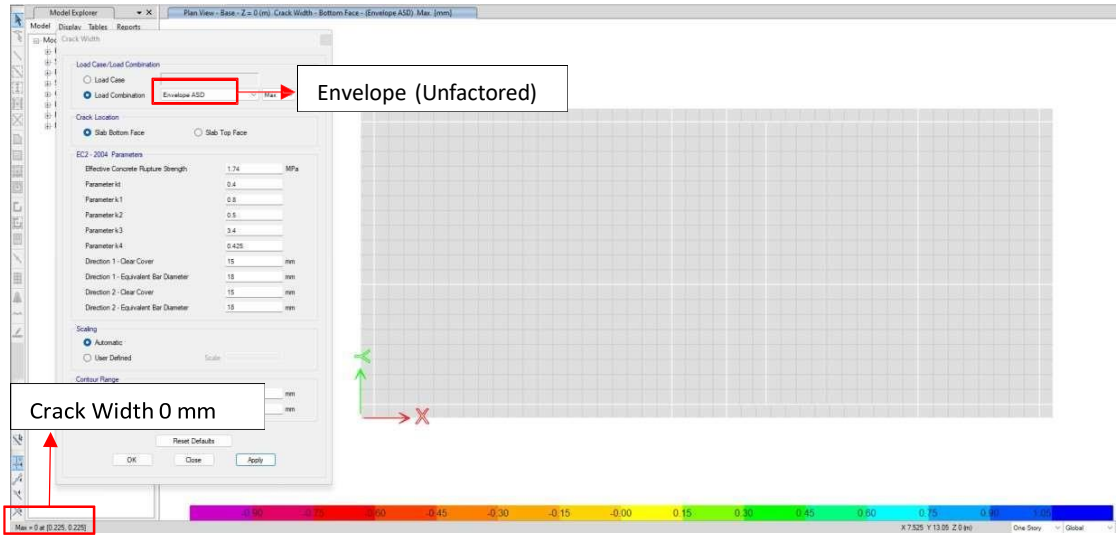


Figure 6-33 Crack Width in ETABS (Un-factored Load Combinations)

6.2 Structural Design (Sewage Treatment Plant)

To analyze the "Sewage Treatment Plant", 3D finite element model has been developed to represent the superstructure using **ETABS V22**. The substructure was analyzed using **ETABS V22** Geometry, loading, and design codes are followed as per Bangladesh National Building Code (BNBC-2020). Based on the architectural drawing, analysis and design of superstructure has been performed. Separate hand calculations are also conducted for verification where necessary.

6.2.1 Design Information and Criteria

6.2.1.1 Design Codes, Standards & References

The structures are designed in accordance with the following codes, standards and technical literatures:

- BNBC 2020; Bangladesh National Building Code
- ACI 318-08; Building Coder Standard of American Concrete Institute
- ACI 350; Code Requirements for Environmental Engineering Concrete Structures
- ASCE 7-05; Minimum Design Loads for Buildings by American Society of Civil Engineers

6.2.1.2 Material Properties

- ***Steel:*** Steel reinforcement strength for RCC members is **500 MPa**
- ***Concrete:*** The concrete compressive strength for RCC members is 35 MPa

6.2.1.3 Soil Parameter

Based on the *Report on Sub-Soil Investigation in Connection with the Construction of Proposed Academic Building WTP, STP & UGWR Area, Baizid, Chattogram* a total of three boreholes (BH-01, BH-02, and BH-03) were carried out at the proposed site. Among these, BH-01 is located closes to the proposed WTP site and has therefore been considered as the governing case for the present structural design analysis. According to the investigation findings, the allowable bearing capacity of

the soil at a depth of 4 m below RL is **196 kN/m²** and **SPT** value at that depth **14**. The soil ϕ value for this borehole is found to be **35.73°**. The Ground Water Table depth is at **RL 66 m** below the existing GL (may vary with season).

6.2.1.4 Loading Considerations

6.2.1.4.1 Dead Load (DL)

As per **BNBC 2020**, the dead load has been assessed based on the forces due to:

- Weight of the member itself.
- Weight of all materials of construction incorporated into the building to be supported permanently by the members.
- Weight of permanent partitions.
- Weight of fixed service equipment.
- Water Tank load of 0.4 kN/m^2
- Floor finish of 1.5 kN/m^2
- Ceiling/plaster of 1.0 kN/m^2

6.2.1.4.2 Live Load

According to the Table 6.2.3: Minimum Uniformly Distributed and Concentrated Live Loads (BNBC 2020, Part 6, Chapter 2) and Employer's Requirement (Section 1.4.2), the following live load has been considered for the analysis of this structure:

- Uniformly distributed load for common floor is 2.0 kN/m^2
- Uniformly distributed load for ordinary flat roof is 2.0 kN/m^2
- Uniformly distributed load for office room is 3.0~5.0 kN/m^2
- Uniformly distributed load for stair is 4.8 kN/m^2

6.2.1.4.3 Equipment's Weight

The following table shows the weight of the equipment that will exist in the structure.

Table 6-13: Weight of the Equipment

Equipment Name	*Quantity*	*Unit*	*Unit Weight*	*Total Weight (kN)*
Pump	6	set	30 kg	1.8
Blower	3	set	300 kg	9.0
ACF	1	set	1200 kg	12.0
MGF	1	set	1200 kg	12.0

6.2.1.4.4 Earth Pressure Coefficient

The lateral earth pressure coefficients for this design were determined using two distinct analytical approaches, one is using Jaky's Formula, and another is Mononobe-Okabe formula, to account for different loading conditions.

Upon comparing the results of both methodologies, it was observed that Jaky's formula yielded the maximum coefficient value. To ensure a conservative and robust structural response, this higher value was adopted as the governing parameter for the final design and reinforcement detailing.

The sample calculation for both approaches is provided below.

Static Conditions (Jaky's Formula)

Jaky's formula was employed to calculate the coefficient of earth pressure at rest (Ko), representing the pressure exerted by the soil when it is in an equilibrium state with zero lateral strain.

$$\text{Soil pressure coefficient at rest, } K_o = 1 - \sin\theta$$

Here,

Angle of internal friction, $\phi = 35.73$ degrees **[As per Soil Report (BH 01)]**

Therefore, Soil pressure coefficient at rest, $K_o = (1 - \sin 35.73) = 0.42$

Seismic Conditions (Mononobe-Okabe)

The Mononobe-Okabe method was utilized to determine the dynamic active earth pressure coefficient (Kae), accounting for additional lateral forces generated during a seismic event. [https://eurocodeapplied.com/design/en1998/mononobe-okabe]

Input

Design value of the angle of shearing resistance of soil	ϕ'_d	35.73	°	**[As per Soil Report (BH 01)]**
Design value of the friction angle between the soil and the wall	δ_d	23.82	°	**[As per B.M Das "Principles of Foundation Engineering, 9ed, 16.7", $\delta_d = 2/3\ \phi'_d$]**
Inclination angle of the wall back surface	ψ	90	°	
Inclination angle of the backfill top surface	β	0	°	
Horizontal seismic coefficient	k_h	0.21		**[In accordance with EN1998-5 7.3.2.2(4)P and BNBC 2020 Sec. 2.5.4; $k_h = 2/3.Z.S$ where Z = 0.28 & S = 1.15 for SC soil type]**
Vertical seismic coefficient	k_v	-0.11		**[In accordance with EN1998-5 7.3.2.2(4)P and BNBC 2020 Sec. 2.5.13; $k_v = 0.5\ k_h$]**

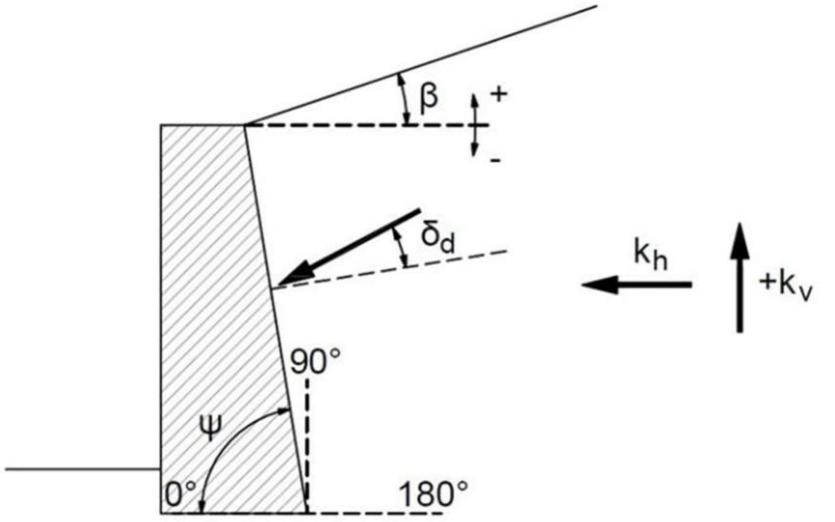


Figure 6-34 Convention of angles for calculating the earth pressure coefficients (see also EN1998-5 Figure E.1)

Results

Mononobe-okabe dynamic earth pressure coefficient for active state	$K_{AE} = 0.3658$
Mononobe-okabe dynamic earth pressure coefficient for active state including factor $(1-k_v)$	$(1-k_v)\cdot K_{AE} = 0.4061$

The auxiliary angle θ is calculated for the case of water table below the retaining wall in accordance with *EN1998-5 equation (E.6)* as follows:

$\tan\theta = k_h / (1 - k_v) = 0.210 / [1 - (-0.110)] = 0.189$

This tangent value corresponds to angle $\theta = 10.713$ °.

Mononobe-Okabe earth pressure coefficient for active state

For active states *EN1998-5 equations (E.2) and (E.3)* are applicable. The following intermediate factors are calculated:

$a_1 = \sin(\psi + \varphi'_d - \theta) = 0.9062$

$a_2 = \cos\theta \cdot \sin^2\psi \cdot \sin(\psi - \theta - \delta_d) = 0.8094$

$a_3 = 1 + [\sin(\varphi'_d + \delta_d) \cdot \sin(\varphi'_d - \beta - \theta) / \sin(\psi - \theta - \delta_d) / \sin(\psi + \beta)]^{0.5} = 1.6652$

For the case where $\beta \le \varphi'_d - \theta$ *EN1998-5 equation (E.2)* applies:

$K_{AE} = a_1^2 / (a_2 \cdot a_3^2) = 0.9062^2 / (0.8094 \cdot 1.6652^2) = 0.366$

Therefore the dynamic earth pressure coefficient for active states according to Mononobe-Okabe method is calculated as $K_{AE} = 0.366$

6.2.1.4.5 Lateral Earth Pressure

Based on the Rankine earth pressure theory, the lateral earth pressure that the underground wall will experience has been calculated below:

Lateral Earth Pressure (with surcharge), $\sigma_h = Ko\ \gamma.H$

Here,

Outside soil depth, H = 3.95 m

Unit weight of saturated soil, $\gamma_s = 20$ kN/m^3

Angle of internal friction, $\phi = 35.73$ degrees **[As per Soil Report (BH 01)]**

Soil pressure coefficient at rest, $K_o = (1 - \sin 35.73) = 0.42$

Therefore, active earth pressure at bottom, $\sigma_h = 0.42 \times 20 \times 3.95 = 33.18$ kN/m^2

6.2.1.4.6 Fluid Pressure

The black water, that will be present in the structure, will exert pressure on the base along the Gravity and that on the RCC walls non-uniformly in the Local 3 axis. The following criteria has been considered for its calculation:

$$\text{Hydrostatic Pressure, } P = \gamma.H$$

Where,

Fluid depth, H = 4.727 m [TWL]

Unit weight of water, $\gamma_w = 10$ kN/m^3

Therefore, hydrostatic pressure at bottom, $P = 10 \times 4.727 = 47.27$ kN/m^2

6.2.1.4.7 Seismic Load Calculation (EQ)

Earthquake load calculation of the structure has been performed based on **Part 6, Chapter 2** of **BNBC 2020**. The factors considered for the earthquake loading are provided in the following table:

Table 6-14: Static Earthquake Pattern Parameters (BNBC 2020)

Parameters	***Value***	***Remarks***
Structure type	CMRF	
Seismic force resisting system	Special reinforced concrete shear walls	Table 6.2.19
Soil Type	SC	Table 6.2.13
Town	Chittagong	
Zone, Z	0.28	Figure 6.2.24
Occupancy Category	III	Table 6.2.17
Importance Factor, I	1.25	Table 6.2.17
Time Period, T (sec)	0.267	
Reduction Factor, R	6	Table 6.2.19
Cd	5	Table 6.2.19
Ss	0.7	Table 6.C.1
S1	0.28	Table 6.C.1
Fa	1.15	Table 6.C.2
Fv	1.725	Table 6.C.3
Long Period Transition	2	
Ω	2.5	Table 6.2.19
Damping Ratio	0.05	

6.2.1.4.8 Wind Load Calculation (W)

The following table illustrates the parameters used for wind load definition which are as per **BNBC 2020** and **ASCE 7-05**.

Table 6-15: Wind Load Parameters (BNBC 2020, ASCE 7-05)

Parameters	***Value***	***Remarks***
Location	Chittagong	Sec-2.4.4 & Table 6.2.8
Occupancy Category	III	Sec-1.2.3 & Table 6.1.1
Basic Wind Speed (mph)	179	Table 6.2.8
Structure Frame Type	CMRF	Sec 2.4.7 & Figure 6.2.4
Importance Factor (I)	1.15	Table 1.2.1
Directionality Factor (Kd)	0.85	Table 6.2.12
Exposure type	B	Sec 2.4.6
Topographical Factor (Kzt)	1.00	Figure 6.2.4
Gust Factor	0.85	Sec-2.4.8.1
e1	0.052	
e2	0.686	
Windward- (Cp)	0.80	Figure 6.2.6
LeeWard- (Cp)	0.348	Figure 6.2.6

6.2.1.4.9 Subgrade Modulus of Soil

The subgrade modulus (Ks) represents the stiffness of the supporting soil and defines the relationship between the pressure applied to the soil and the resulting settlement. It is an important parameter for analyzing soil–structure interaction, particularly for foundations, slabs, and underground structures.

The bearing capacity at the proposed depth is found to be 196 kN/m^2 as mentioned in the previous section. As per ***Bowles- Foundation Analysis & Design | Section 9.6***; the modulus of subgrade reaction as per the following equation for 25 mm settlement and F.S of 2.5,

$$\text{SI: } k_s = 40(\text{SF})q_a \quad \text{kN/m}^3$$
$$\text{Fps: } k_s = 12(\text{SF})q_a \quad \text{k/ft}^3$$

Ref: Foundation Analysis & Design-Bowles (5th Edidtion)Page:526

Ks = 40 x 2.5 x 196 = 19,600 kN/m^3 = 19.6 MN/m^3

Thus, the subgrade modulus for the proposed structure at the foundation is 19.6 MN/m^3. The ACI manual of Concrete indicates that uniform loading will cause greater deflection towards the center of slabs. To model this effect, 50 percent increment of the modulus of subgrade reaction has been assumed at the edges (periphery).

6.2.2 Pre-Processing in ETABS

6.2.2.1 Load Patterns Defined

The following load patterns are applied for the analysis of this structure as per **BNBC 2020** and **ASCE 7-05**:

Table 6-16: Applied Load Patterns

Load	*Type*	*Self-Weight Multiplier*	*Auto Lateral Load*
DL	Dead	1	-
LL	Live	0	-
H (Soil)	Other	0	-
F (Water)	Other	0	-
EQX	Seismic	0	ASCE 7-05
EQY	Seismic	0	ASCE 7-05
WX	Wind	0	ASCE 7-05
WY	Wind	0	ASCE 7-05
FF + Plaster	Super Dead	0	-

6.2.2.2 *Load Combinations*

According to **BNBC-2020,** the following **Allowable Strength Design (ASD)** load combinations and Ultimate **Strength Design (USD)** load combinations are defined in the analysis for serviceability checks and design respectively. These unfactored load combinations are enveloped under the name '**Envelope (Serviceability)**'. And the factored load combinations are enveloped under the name '**Envelope (Design)**'.

Allowable Strength Design (ASD)

a. D + F

b. D + L + F + H

c. D + 0.75 L + F + H

d. D + F + H + WX-

e. D + F + H + WX+

f. D + F + H + WY-

g. D + F + H + 0.75 WX+ + 0.75 L

h. D + F + H + 0.75 WX- + 0.75 L

i. D + F + H + WY+

j. D + F + H + 0.75 WY- + 0.75 L

k. D + F + H + 0.75 WY+ + 0.75L

l. 0.6 D + H + WX-

m. 0.6 D + H + WX+

n. 0.6 D + H + WY-

o. 0.6 D + H + WY+

p. 0.6 D + H + 0.7EQX+

q. 0.6 D + H + 0.7EQX-

r. 0.6 D + H + 0.7EQY+

s. 0.6 D + H + 0.7EQY-

Ultimate Strength Design (USD)

(1) 1.4 D + 1.4 F

(2) 1.2 D + 1.2 F + 1.6 L + 1.6 H

(3) 1.2 D + 1.2 F + 1.6 H +1.6 L

(4) 1.2 D + 1.6 L + 0.8 Wx+

(5) 1.2 D + 1.6 L + 0.8 Wx-

(6) 1.2 D + 1.6 L + 0.8 Wy+

(7) 1.2 D + 1.6 L + 0.8 Wy-

(8) 1.2 D + 1.6 Wx+ + 1 L

(9) 1.2 D + 1.6 Wx- + 1 L

(10) 1.2 D + 1.6 Wy+ + 1 L

(11) 1.2 D + 1.6 Wy- + 1 L

(12) 0.9 D + 1.6 Wx+

(13) 0.9 D + 1.6 Wx-

(14) 0.9 D + 1.6 Wy+

(15) 0.9 D + 1.6 Wy-

(16) 1.307 D + 1 Ex + 0.3 Ey + 1 L

(17) 1.307 D + 1 Ex + 0.3 Ey + 1 L

(18) 1.307 D + 1 Ex + 0.3 Ey + 1 L

(19) 1.307 D + 1 Ex + 0.3 Ey + 1 L

(20) 1.307 D + 0.3 Ex + 1 Ey + 1 L

(21) 1.307 D + 0.3 Ex + 1 Ey + 1 L

(22) 1.307 D + 0.3 Ex + 1 Ey + 1 L

(23) 1.307 D + 0.3 Ex + 1 Ey + 1 L

(24) 0.793 D + 1 Ex + 0.3 Ey

(25) 0.793 D + 1 Ex + 0.3 Ey

(26) 0.793 D + 1 Ex + 0.3 Ey

(27) 0.793 D + 1 Ex + 0.3 Ey

(28) 0.793 D + 0.3 Ex + 1 Ey

(29) 0.793 D + 0.3 Ex + 1 Ey

(30) 0.793 D + 0.3 Ex + 1 Ey

(31) 0.793 D + 0.3 Ex + 1 Ey

Here,

D = Dead Load

L = Live Load

H = Soil Load

F = Fluid/water Load

EQX = Seismic Load in x-direction

EQY = Seismic Load in y-direction

WX = Wind Load in x-direction

WY = Wind Load in y-direction

Serviceability limit states of buildings and structures shall be checked for the load combinations set forth in this Section as well as mentioned elsewhere in this Code. For serviceability limit states involving visually objectionable deformations, repairable cracking or other damage to interior finishes, and other short-term effects, the suggested load combinations for checking vertical deflection due to gravity load is,

- D + L

For serviceability limit states involving creep, settlement, or similar long-term or permanent effects, the suggested load combination is:

- D + 0.5L

For serviceability limit state against lateral deflection of buildings and structures due to wind effect, the following combination shall be used:

- D + 0.5L + 0.7W

6.2.2.3 Applied Lateral Earth Pressure

In ETABS, non-uniform loads may be assigned to shell elements using the command path Assign → Shell Loads → Non-Uniform as seen in Figure 6-3. This feature enables the application of loads that vary in magnitude with respect to the global coordinate system.

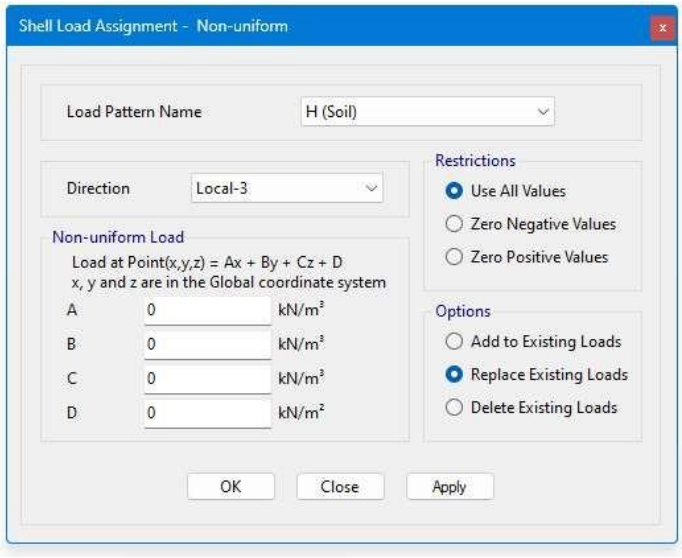


Figure 6-35 Shell Load Assignment -Non-Uniform

For the RCC wall, the lateral earth pressure acts in a triangular distribution, where the pressure increases linearly with depth. Based on the previously calculated values, the maximum lateral earth pressure at the base of the wall is **33.18 kN/m²**, reducing to **0 kN/m²** at the ground surface.

For modelling purposes, the structure is assumed to lie in the **X–Z plane**, where the **Z-axis** represents the vertical direction. Since the pressure variation occurs only with respect to depth (Z-direction), there is no variation in the **X** or **Y** directions; therefore, the corresponding coefficients **A** and **B** are taken as zero.

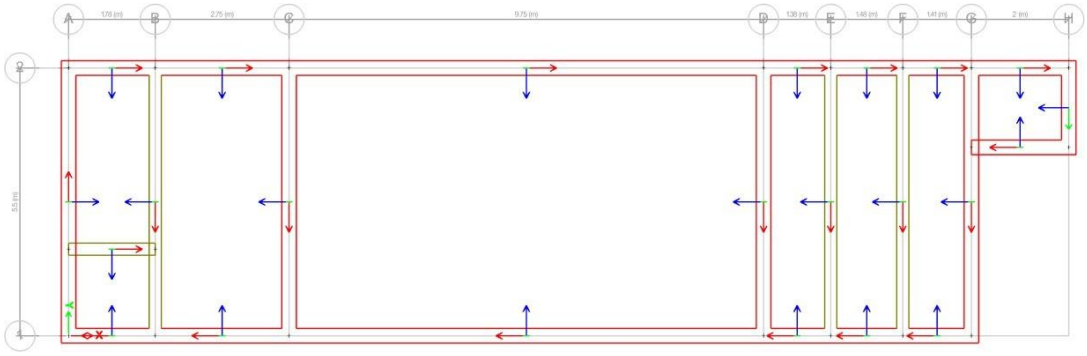


Figure 6-36 Local 3 Axis Illustration of Wall (Blue Arrow indicates Local-3)

The non-uniform pressure distribution is defined in ETABS using a linear expression of the form:

$$Load = Cz + D$$

The coefficients **C** and **D** are determined using the known boundary conditions **(Along Local 3 axis)**:

- At the base of the wall (**z = 0 m**), the lateral pressure is **33.18 kN/m²**:

$$C \times 0 + D = 33.18$$

Hence,

$$D = 33.18$$

- At the top of the wall (**z = 3.95 m**), the lateral pressure is **0 kN/m²**:

$$C \times 3.95 + 33.18 = 0$$

Solving for **C**:

$$C = -8.4 \text{ kN/m}^3$$

Accordingly, the pressure decreases linearly from **33.18 kN/m²** at the bottom to **0 kN/m²** at the top, representing the expected triangular earth pressure distribution acting on the wall.

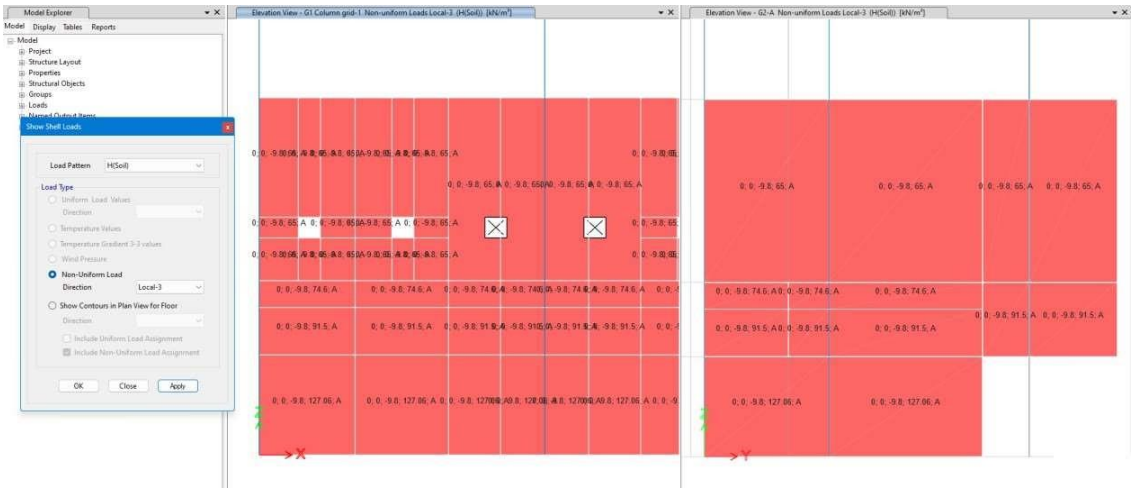


Figure 6-37 Applied Soil Load on RCC Wall

6.2.2.4 Applied Fluid Pressure

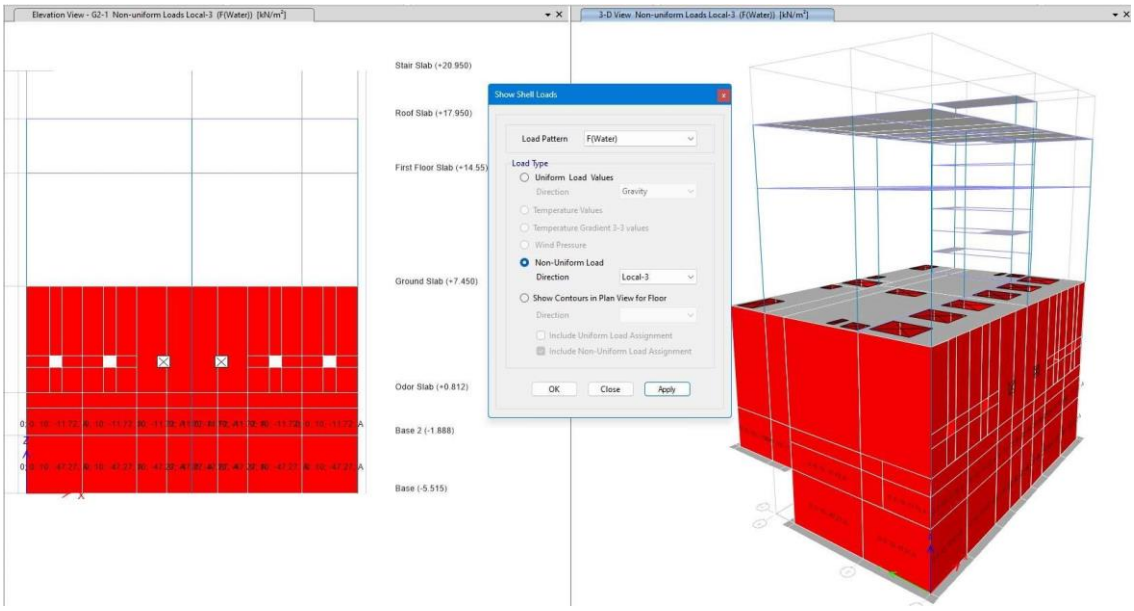


Figure 6-38 Applied Fluid Pressure on RCC Wall

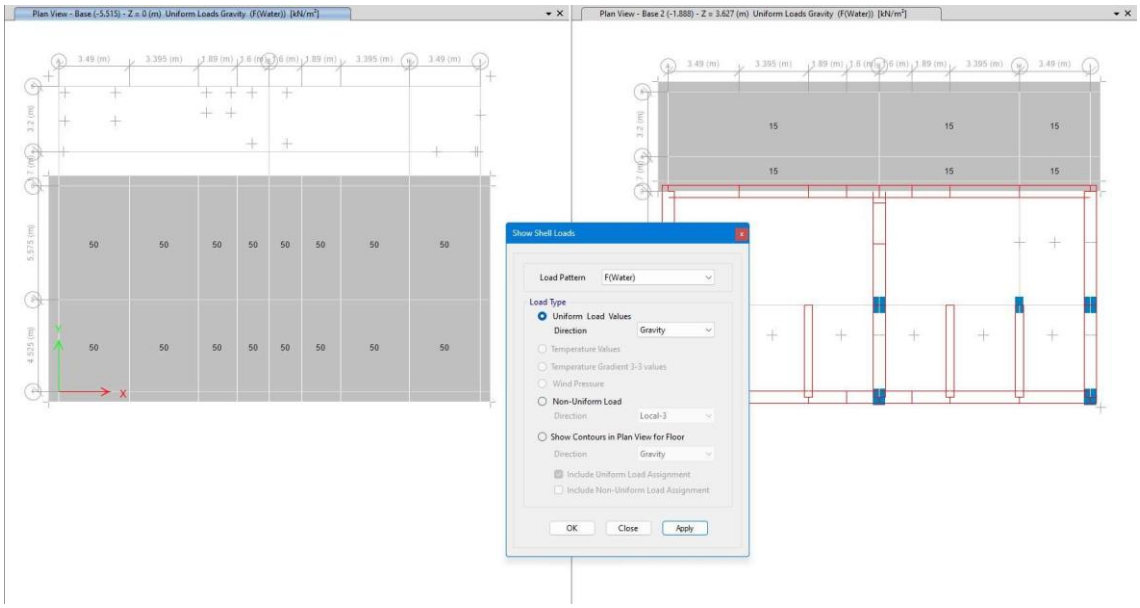


Figure 6-39 Applied Fluid Load on Bottom Mat

6.2.2.5 Applied Subgrade Modulus of Soil (Ks)

The subgrade modulus of soil, as per soil investigation report mentioned above, has been applied as area spring at the mat foundation of the structure as seen in the following figures.

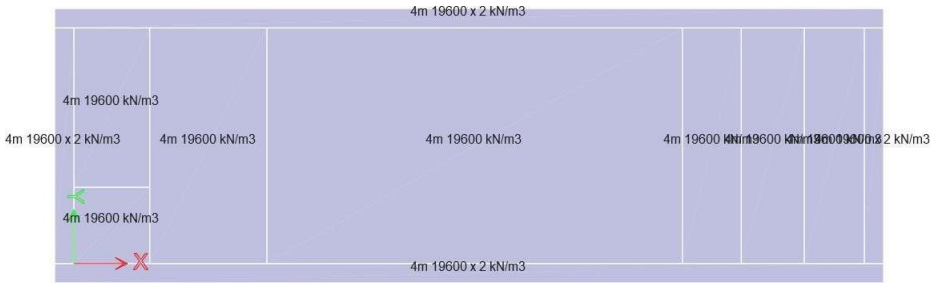


Figure 6-40 Subgrade Modulus of Soil (Area Spring)

6.2.3 Model Overview

6.2.3.1 Structural System Description

The overall structural system comprises **reinforced concrete beams, slabs, and shear walls** that collectively provide strength, stiffness, and stability to the structure. Both the slabs and shear walls contain various **openings** to accommodate functional and service requirements, all of which have been explicitly modeled in **ETABS** to ensure accurate representation of structural behavior.

The **finite element method (FEM)** has been adopted for analysis, with appropriate meshing applied to capture realistic load distribution and deformation characteristics. A **mesh size of 0.3 m** has been used for the shear walls, while a **mesh size of 0.3 m** has been adopted for the floor slabs. These meshing parameters ensure a balance between computational efficiency and analytical accuracy.

The **dimensions and reinforcement details** of all structural components, including beams, slabs, and walls, are provided in the accompanying **structural drawings** for reference.

6.2.3.2 3D Model of the Structure

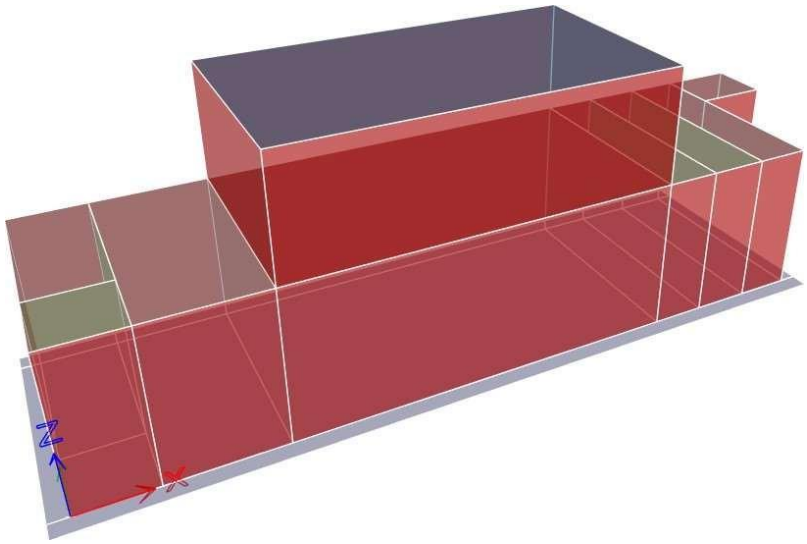


Figure 6-41 3D Model of the proposed structure (ETABS)

6.2.4 Serviceability and Stability Checks

6.2.4.1 Post-Processing

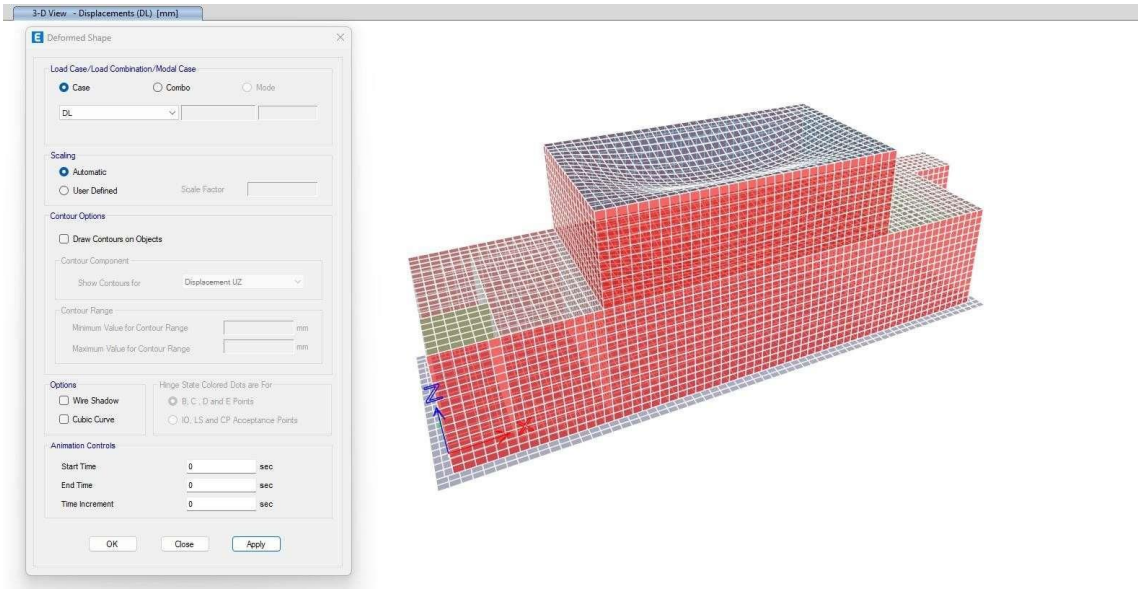


Figure 6-42 Deformed Shape of the Structure for Case: DL

6.2.4.2 *Model Check*

All the concrete members have passed the design as seen in the following figure.

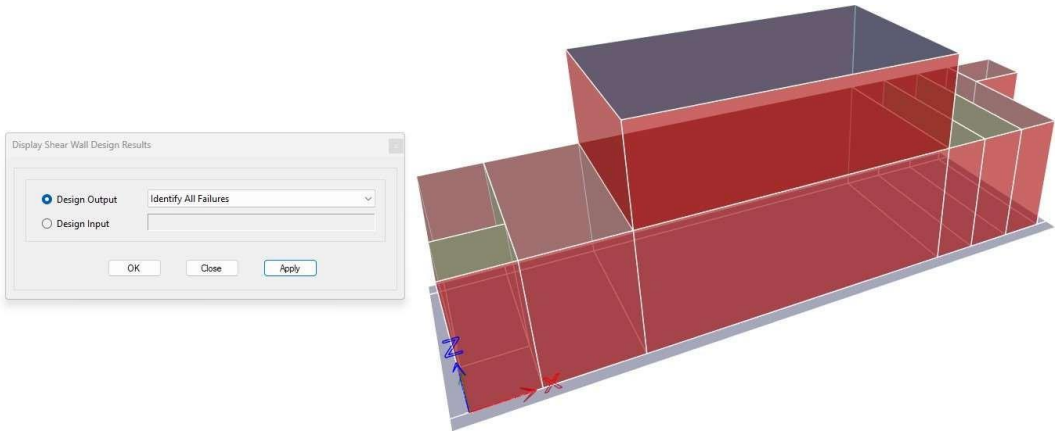


Figure 6-43 RCC Wall Failure Check (ETABS)

6.2.5 Design of Element

The design of all structural elements is done using the **"Limit State Method**". All relevant Limit State is considered in design to ensure adequate safety and serviceability. The design includes design for durability, construction and use in service should be considered. The realization of design objectives requires compliance with clearly defined standards for materials, production, workmanship, and maintenance and use of structure in service.

This section includes all the design processes for a single element such as wall, slab, and footing.

6.2.5.1 RCC Wall Design

The proposed has two types of wall of thickness 300 mm perimeter wall and 250 mm internal wall. The sample design of the perimeter wall has been provided in this section.

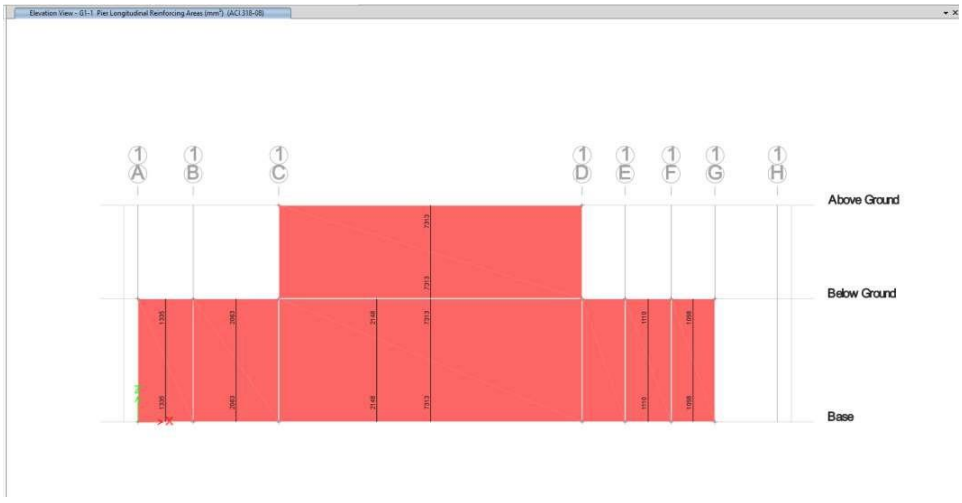


Figure 6-44 Pier Longitudinal Reinforcing Detail (mm^2)

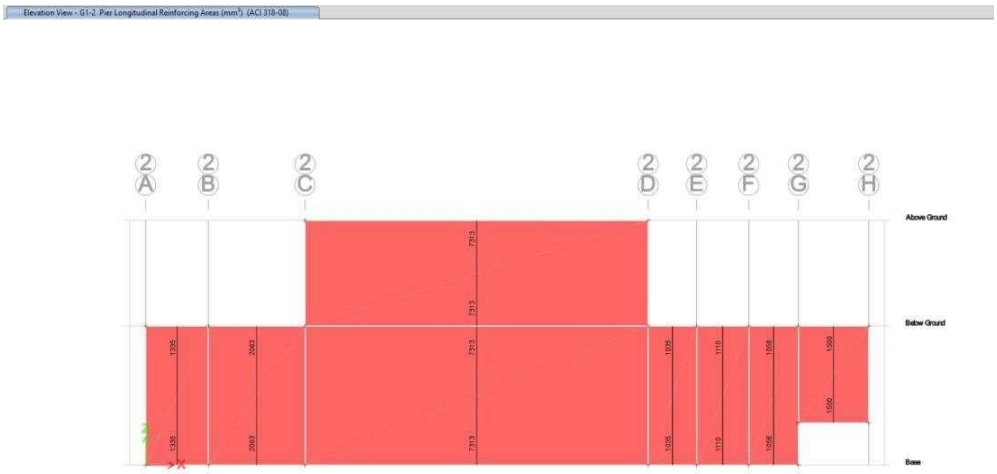


Figure 6-45 Pier Longitudinal Reinforcing Detail (mm²)

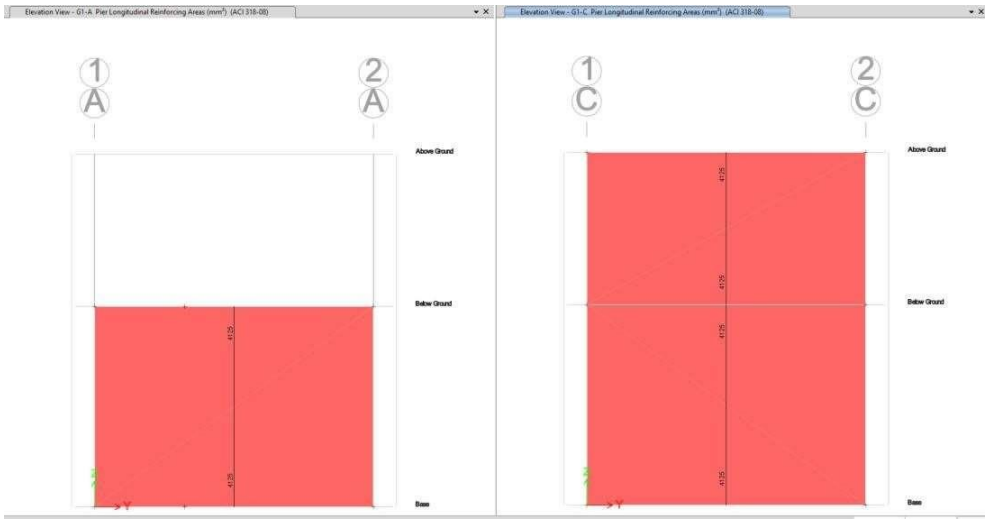


Figure 6-46 Pier Longitudinal Reinforcing Detail (mm²)

6.2.5.1.1 Sample Design of RCC Wall

The sample design for the **300 mm thick perimeter wall**, obtained from analysis using **ETABS,** according to **ACI 350** and **BNBC 2020** is shown below. The design summary for remaining RCC wall has been provided in the later part of the design report

ETABS Shear Wall Design

ACI 318-08 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
Below Ground	P3	9405	0	9750	300	0.88

Material Properties

E_c (MPa)	f'_c (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
27805.57	35	1	517.11	517.11

Design Code Parameters

φ_T	φ_C	φ_v	φ_v (Seismic)	IP_{MAX}	IP_{MIN}	P_{MAX}
0.9	0.65	0.75	0.6	0.04	0.0025	0.8

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	4530	0	14280	0	9750	300
Bottom	Leg 1	4530	0	14280	0	9750	300

Flexural Design for Pu, Mu2 and Mu3 (Part 1 of 2)

Station Location	Required Rebar Area (mm^2)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m
Top	7313	0.0025	0.0021	(31) 0.793 D + 0.3 EX- + 1 EY- +1.6 H	508.5914	50.8316	30.1403
Bottom	7313	0.0025	0.0021	(31) 0.793 D + 0.3 EX- + 1 EY- +1.6 H	755.8785	486.4251	140.6398

Flexural Design for Pu, Mu2 and Mu3 (Part 2 of 2)

Pier A_g mm^2
2925000
2925000

Shear Design

Station Location	ID	Rebar mm^2/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	φV_c kN	φV_n kN
Top	Leg 1	750	(25) 0.793 D + 1 EX+ + 0.3 EY- +1.6 H	465.7721	92.9488	211.7712	2914.881	4729.926
Bottom	Leg 1	750	(25) 0.793 D + 1 EX+ + 0.3 EY- +1.6 H	668.9276	215.0361	199.4582	2945.3544	4760.3994

Boundary Element Check (ACI 21.9.6.3, 21.9.6.4) (Part 1 of 2)

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	Not Required	(23) 1.307 D +0.3 EX- + 1 EY- +1 L	890.8694	36.4464	0.3	7
Top–Right	Leg 1	Not Required	(23) 1.307 D +0.3 EX- + 1 EY- +1 L	890.8694	36.4464	0.31	7
Bottom–Left	Leg 1	Not Required	(23) 1.307 D +0.3 EX- + 1 EY- +1 L	1208.3769	100.1947	0.39	7
Botttom–Right	Leg 1	Not Required	(23) 1.307 D +0.3 EX- + 1 EY- +1 L	1208.3769	100.1947	0.43	7

Here,

Wall Thickness, h = 300 mm

Required Rebar Area = 7313 mm^2 **[As per ETABS Analysis]**

Pier Length = 9750 mm = 9.75 m

Required Rebar Area per length = 7313/9.75 = 750 mm^2/m

According to ACI 350,

$$A_{s,min} = 0.003bh$$

Here,

Width, b = 1000 mm **[Per meter strip]**

Thickness, h = 300 mm

Therefore, $A_{s,min} = 0.003 \times 1000 \times 300 = 900\ mm^2/m$

Thus, governing rebar area, $A_s = 900\ mm^2/m$

Required vertical reinforcement area per face, $A_{s,face} = 900/2\ mm^2/m = 450\ mm^2/m$ each face

Table 6-17 Design Summary of RCC Wall (Exterior)

Reinforcement Type	Required As (mm^2/m)	Provided Rebar Dia (mm)	Required Spacing (mm c/c)	Provided Spacing (mm c/c)	Provided As (mm^2/m)
Top Vertical	450	16ϕ	447	125	1609
Top Horizontal	375	12ϕ	151	125	905
Bottom Vertical	450	16ϕ	447	125	1609
Bottom Horizontal	375	12ϕ	151	125	905

6.2.5.2 Slab Design

The reinforced concrete slabs were designed using an **integrated Finite Element Method (FEM)** approach within ETABS, ensuring a precise distribution of internal forces across the floor system. By modeling the slabs as thin-shell elements, the analysis accounts for both in-plane (diaphragm) and out-of-plane (flexural) stiffness, providing a comprehensive view of the slab's structural response under gravity and lateral loading.

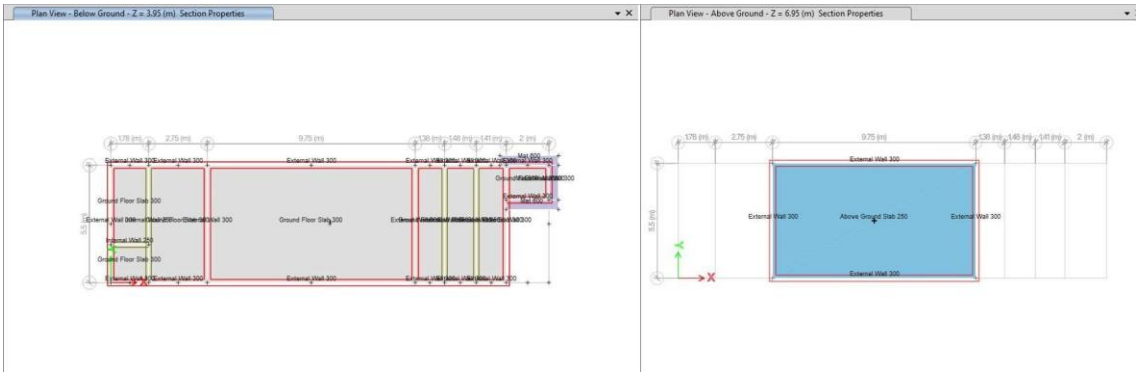


Figure 6-47 Slab Section Properties (mm)

6.2.5.2.1 Slab Thickness Calculation

The sample calculation of first floor slab has been shown in this section of the design report.

According to Nilson – Design of Concrete Structures, 14th Ed, Section 13.8,

b. Slabs with Beams on All Sides

The parameter used to define the relative stiffness of the beam and slab spanning in either direction is α_f, calculated from Eq. (13.4) of Section 13.6c. Then α_{fm} is defined as the average value of α_f for all beams on the edges of a given panel. According to ACI Code 9.5.3.3, for α_{fm} equal to or less than 0.2, the minimum thicknesses of Table 13.5 shall apply.

For α_{fm} greater than 0.2 but not greater than 2.0, the slab thickness must not be less than

$$h = \frac{l_n(0.8 + f_y/200{,}000)}{36 + 5\beta(\alpha_{fm} - 0.2)} \qquad (13.8a)$$

and not less than 5.0 in.

For α_{fm} greater than 2.0, the thickness must not be less than

$$h = \frac{l_n(0.8 + f_y/200{,}000)}{36 + 9\beta} \qquad (13.8b)$$

and not less than 3.5 in.,

where l_n = clear span in long direction, in.
α_{fm} = average value of α_f for all beams on edges of a panel [see Eq. (13.4)]
β = ratio of clear span in long direction to clear span in short direction

Here,

Steel Strength, fy = 500 MPa = 72,500 psi

Total Dimension = 9.450 m x 5.200 m **[Large Panel]**

Clear Spans:

ln,long = 9.45 m

ln,short = 5.20 m

Aspect Ratio, β = (ln,long)/(ln,short) = 1.81

Given the beam size is quite substantial relative to typical slab thickness, thus $\alpha_{fm} > 2$

Using equation 13.8b,

h = 228.6 mm

Thus, provided slab thickness for large span is 250 mm.

6.2.5.2.2 Flexural Design

The rebar intensity of the first-floor slab, obtained from ETABS analysis, has been shown in the following figures.

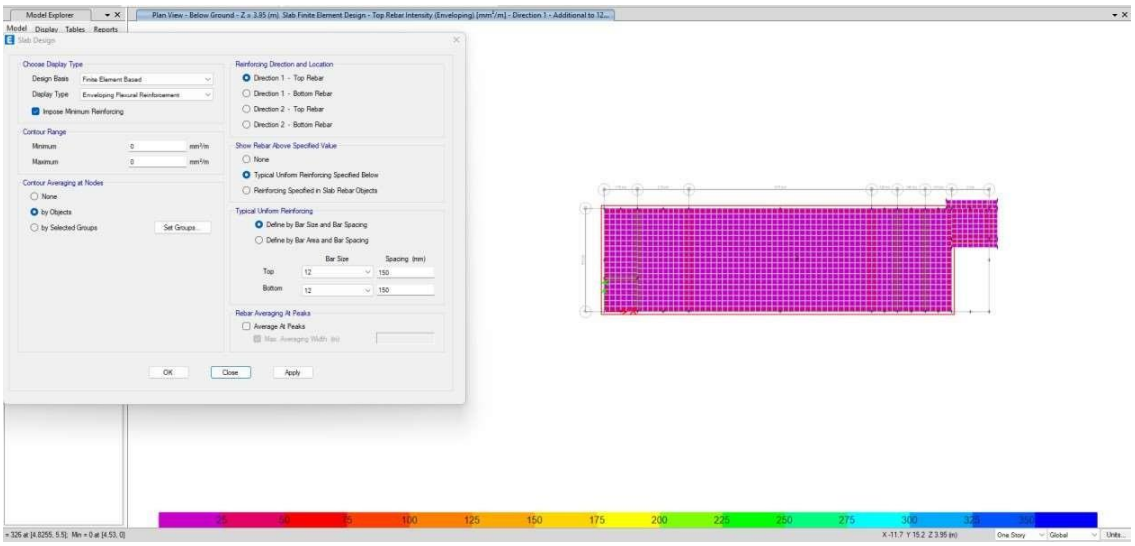


Figure 6-48 Top rebar intensity mm²/mm (Direction-1)

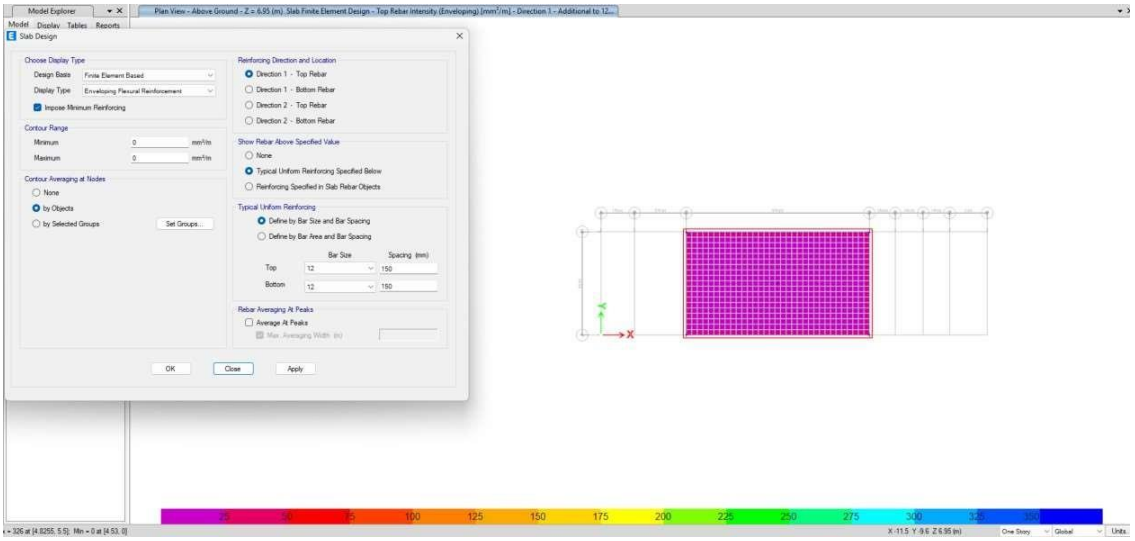


Figure 6-49 Top rebar intensity mm²/mm (Direction-1)

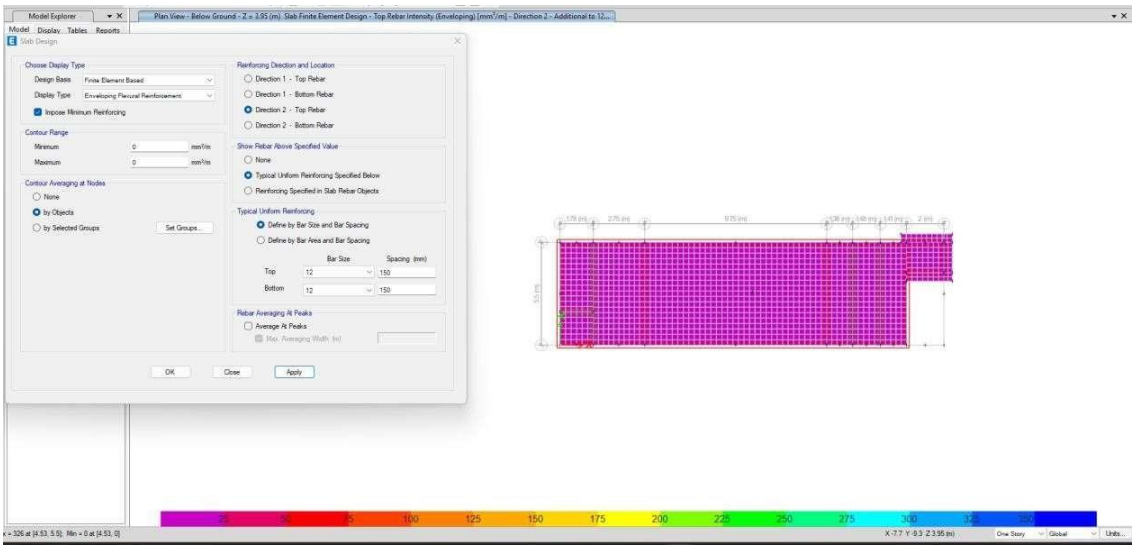


Figure 6-50 Top rebar intensity mm²/mm (Direction-2)

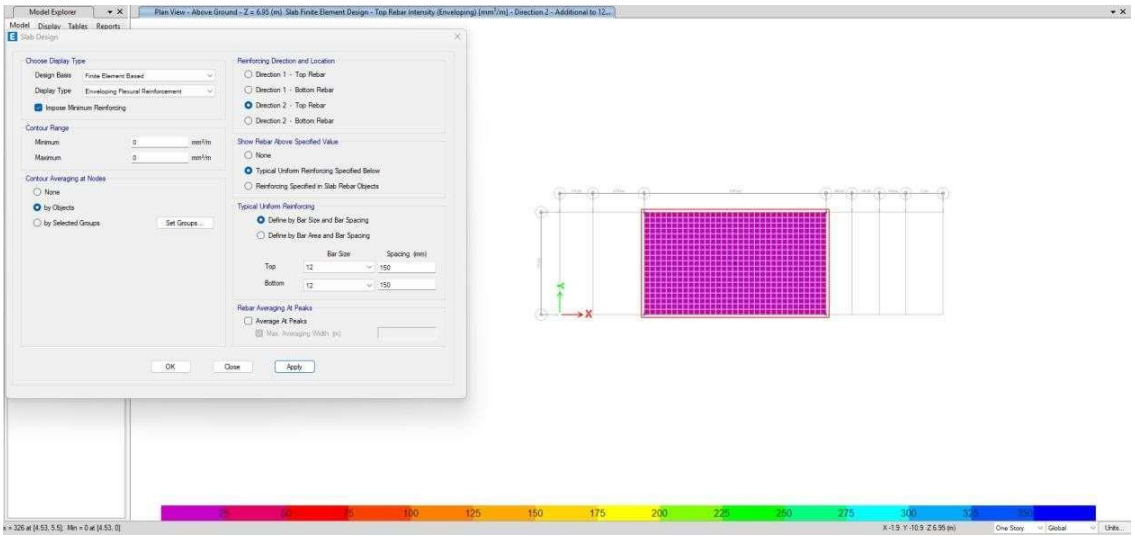


Figure 6-51 Top rebar intensity mm²/mm (Direction-2)

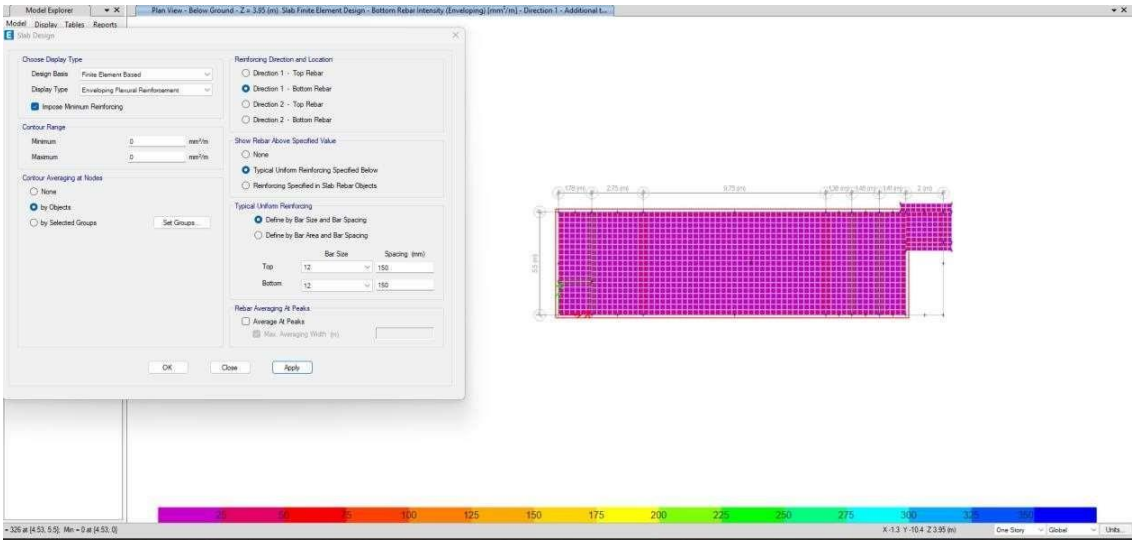


Figure 6-52 Bottom rebar intensity mm^2/mm (Direction-1)

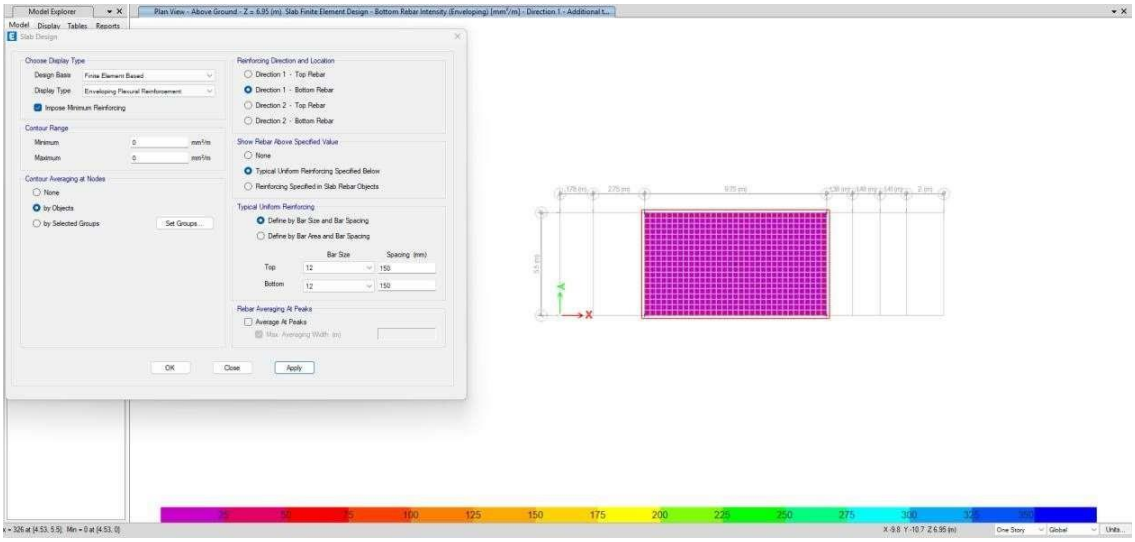


Figure 6-53 Bottom rebar intensity mm^2/mm (Direction-2)

According to ACI 350,

$$A_{s,min} = 0.003bh$$

Here,

Width, b = 1000 mm **[Per meter strip]**

Thickness, h = 250 mm

Therefore, As,min = 0.003 x 1000 x 250 = 750 mm^2/m

Minimum reinforcement area per layer, $A_{S,face}$ = 750/2 mm^2/m = 375 mm^2/m each layer, each way.

Table 6-18 Reinforcement summary table for First Floor Slab as per ETABS

Reinforcement Type	As,min (mm²/m)	Provided Rebar Dia (mm)	Provided Spacing (mm c/c)	Provided As (mm²/m)	Remarks
Top (x-direction)	375	12ϕ	125	905	-
Top (y-direction)	375	12ϕ	125	905	-
Bottom (x-direction)	375	12ϕ	125	905	-
Bottom (y-direction)	375	12ϕ	125	90	-

6.2.5.2.3 Crack Width Check of Slab

As per **ACI-350 Table 4.1**, for Humid, moist air, and soil, the maximum allowable crack width is **0.3 mm**. Again, according to **ACI 224.R-01 | Equation 4-15,**

1. KNOWN DATA / INPUT PARAMETERS					
Parameter	**Notes**	**SI Value**	**SI Unit**	**Imperial**	**Imp. Unit**
Yield Strength of Steel fy		**500.0**	MPa	72.5	ksi
Allowable Steel Stress fs	40% of fy	200.0	MPa	29.0	ksi
Rebar Dia d_{b1}		**12.000**	mm	0.47	inch
Concrete Clear Cover c_1	From tensile face of concrete to nearest edge of rebar	**75.000**	mm	2.95	inch

2. PROVIDED REINFORCEMENT					
Parameter	**Notes**	**SI Value**	**SI Unit**	**Imperial**	**Imp. Unit**
Provided Rebar Dia d_b		**12.000**	mm	0.472	inch
Rebar Spacing s_2	*Centre-to-centre*	**125.000**	mm	5.000	inch
Rebar Area per Unit As	*SI: $\pi/4 \cdot db^2 / (s_2/1000)$ Imperial: $\pi/4 \cdot db^2 / (s_2/12)$*	904.779	mm²/m	0.421	in²/ft

3. CRACK WIDTH CALCULATION					
Parameter	**Formula**	**Value**	**Unit**	**SI Value**	**SI Unit**
Fracture Coefficient k	*ACI 224R-01 | $k = 2.8 \times 10^{-5}$*	0.00003	—		
β	*Range: 1.2 – 1.35*	1.25	—		
Active Steel Ratio p_{t1}	*$As / (12 \cdot d_{b1} + 2.c_1)$*	0.03635	—		
Grid Index I	*$(d_{b1} \times s_2) / p_{t1}$*	64.98827	—		
Crack Width W	*ACI 224R-01 | Eqn 4-15 | $k \cdot \beta \cdot fs \cdot \sqrt{I}$*	0.00818	in	0.208	mm

4. RESULT					
Calculated Crack Width:	**0.208**	**mm**	**Allowable Width:**	**0.300**	**mm**
SATISFACTORY — Calculated width (0.208 mm) < Allowable width (0.3 mm)					

From ETABS model as seen in Figure 6-33, the maximum crack width is 0 mm which is less than maximum allowable crack width.

So, the design is safe **(OK)**

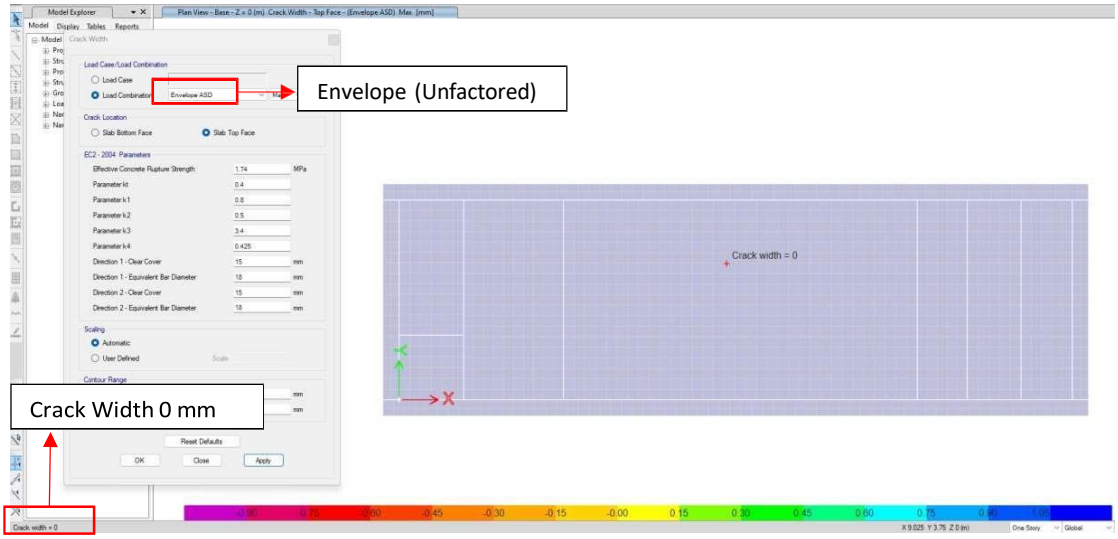


Figure 6-54 Crack Width in ETABS (Un-factored Load Combinations)

6.2.5.3 Substructure Design

The design of the mat foundation was performed using **ETABS**, utilizing the **Finite Element Method (FEM)** to accurately model the complex interaction between the superstructure, the raft, and the underlying soil. By discretizing the slab into a mesh of quadrilateral shell elements, the software captures localized stress concentrations and varying stiffness parameters that traditional rigid methods might overlook.

The design accounts for the two-way bending action of the mat, with reinforcement requirements determined based on the computed nodal moments and shear forces. To ensure a realistic distribution of flexural stresses, the soil was modeled as an elastic area spring, allowing the FEM analysis to account for differential settlements and their subsequent impact on the design moments.

For the proposed structure, ***Mat foundation*** has been designed at two different depths below FGL. The design for the Mat footing with necessary calculations and checks has been provided below.

6.2.5.3.1 Foundation Type and Layout

The initial thickness of the mat foundation has been considered 600 mm. The foundation layout plan is shown in the following figure;

Figure 6-55 Mat Foundation (Plan View)

6.2.5.3.2 Uplift Check

The mat foundation is found to be safe against uplift as seen in the following table. The check is done using the results obtained from ETABS analysis based on **ACI 318-08**. Allowable Factors have been used to check uplift. "**If soil bearing pressures in all load cases show negative values, that means there is no uplift on the foundation."**

Table 6-19 Uplift Check for Mat

Load Case Name	*Load Combination*	*Bearing Pressures*	*Unit*	*Remarks*
Uplift 1	DL+LL	-11.21	kN/m^2	***No Uplift***
Uplift 2	DL+0.7Ex	-9.347	kN/m^2	***No Uplift***
Uplift 3	DL-0.7Ex	-10.704	kN/m^2	***No Uplift***
Uplift 4	DL+0.7Ey	-7.769	kN/m^2	***No Uplift***
Uplift 5	DL-0.7Ey	-8.061	kN/m^2	***No Uplift***
Uplift 6	DL+0.7LL+0.525Ex	-10.372	kN/m^2	***No Uplift***
Uplift 7	DL+0.7LL-0.525Ex	-11.341	kN/m^2	***No Uplift***
Uplift 8	DL+0.7LL+0.525Ey	-9.245	kN/m^2	***No Uplift***
Uplift 9	DL+0.7LL-0.525Ey	-9.483	kN/m^2	***No Uplift***
Uplift 10	0.6DL+0.7Ex	-9.347	kN/m^2	***No Uplift***
Uplift 11	0.6DL-0.7Ex	-10.704	kN/m^2	***No Uplift***
Uplift 12	0.6DL+0.7Ey	-7.769	kN/m^2	***No Uplift***
Uplift 13	0.6DL-0.7Ey	-8.061	kN/m^2	***No Uplift***

6.2.5.3.3 Settlement Check

According to JE Bowles, the maximum allowable settlement is 25 mm. According to **BNBC 2020 | Table 6.3.8**, the maximum allowable settlement for mat foundation is **75 mm**.

The maximum settlement, found from the analysis in ETABS for ***Allowable Strength Design load combinations (ASD)***, is within the limit.

Thus, the structure is safe in settlement.

Table 6.3.8: Permissible Total Settlement, Differential Settlement and Angular Distortion (Tilt) for Shallow Foundations in Soils (in mm) (Adapted from NBCI, 2005)

Type of Structure	Isolated Foundations						Raft Foundation					
	Sand and Hard Clay			Plastic Clay			Sand and Hard Clay			Plastic Clay		
	Maximum Settlement	Differential Settlement	Angular Distortion	Maximum Settlement	Differential Settlement	Angular Distortion	Maximum Settlement	Differential Settlement	Angular Distortion	Maximum Settlement	Differential Settlement	Angular Distortion
Steel Structure	50	0.0033 L	1/300	50	0.0033 L	1/300	75	0.0033 L	1/300	100	0.0033 L	1/300
RCC Structures	50	0.0015 L	1/666	75	0.0015 L	1/666	75	0.0021 L	1/500	100	0.002 L	1/500
Multistoried Building												
(a) RCC or steel framed building with panel walls	60	0.002 L	1/500	75	0.002 L	1/500	75	0.0025 L	1/400	125	0.0033 L	1/300
(b) Load bearing walls												
(i) L/H = 2 *	60	0.0002 L	1/5000	60	0.0002 L	1/5000	Not likely to be encountered					
(ii) L/H = 7 *	60	0.0004 L	1/2500	60	0.0004 L	1/2500	Not likely to be encountered					
Silos	50	0.0015 L	1/666	75	0.0015 L	1/666	100	0.0025 L	1/400	125	0.0025 L	1/400
Water Tank	50	0.0015 L	1/666	75	0.0015 L	1/666	100	0.0025 L	1/400	125	0.0025 L	1/400

Notes: The values given in the Table may be taken only as a guide and the permissible total settlement, differential settlement and tilt (angular distortion) in each case should be decided as per requirements of the designer.

L denotes the length of deflected part of wall/ raft or centre to centre distance between columns.

H denotes the height of wall from foundation footing.

* For intermediate ratios of L/H, the values can be interpolated.

Table 6-20 Settlement Check for Mat (ASD Load Combination)

	Value	***Unit***
Allowable Settlement	50	mm
Obtained Settlement (Uz Min)	37.222	mm
Settlement Check is	**OK**	

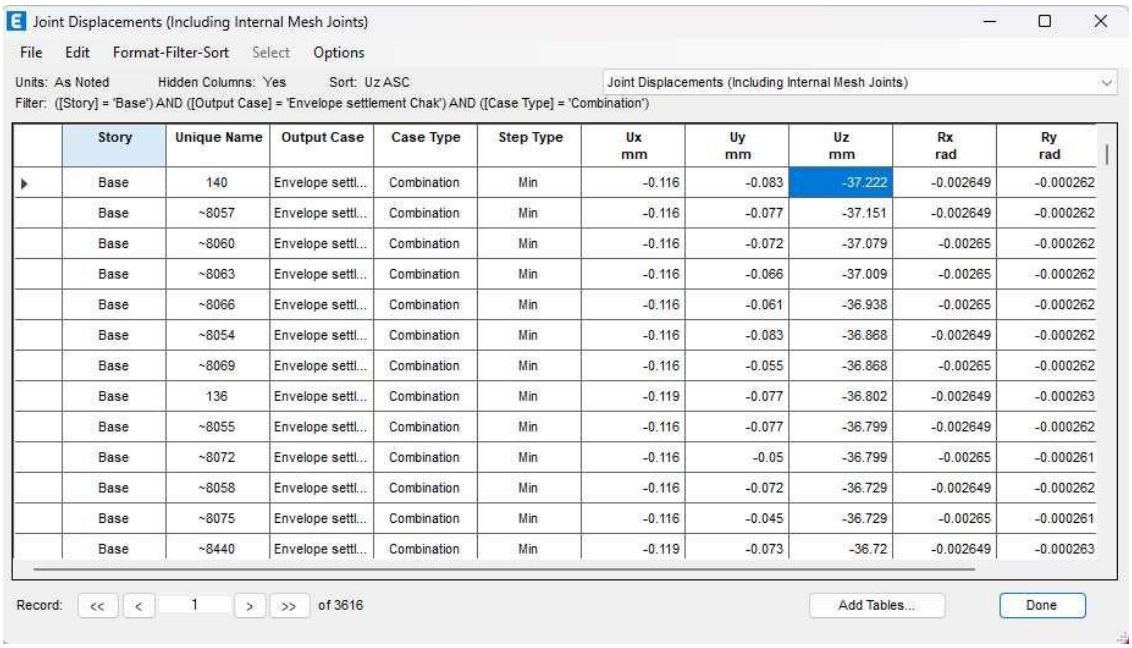


Figure 6-56 Settlement in the Uz direction (mm)

6.2.5.3.4 Soil Bearing Pressure Check

The soil capacity check has been conducted for both mat footings. The maximum soil pressure for the load combination DL + LL, obtained from the ETABS model, has been found to be within the range of bearing capacity of soil that is found in the provided soil test report.

The soil capacity check that has been conducted for the Mat is provided below. Thus, the area provided for this mat is sufficient as the soil capacity is within range.

Table 6-21 Soil Capacity Check for Mat (DL + LL)

	Value	***Unit***
Bearing capacity of soil (Soil report)	196.13	kN/m^2
Maximum soil pressure (Model)	64.722	kN/m^2
Soil Capacity Check is	**OK**	

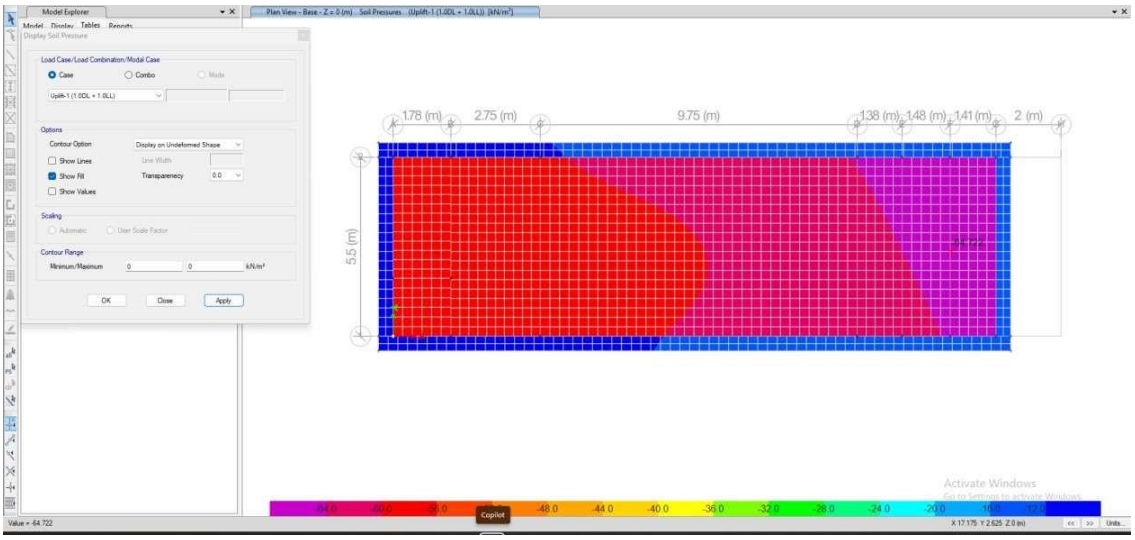


Figure 6-57 Soil pressure obtained for Mat

6.2.5.3.5 Flexural Design

All necessary design checks for the mat foundation confirm that the provided thickness and mat area are adequate to safely resist the applied structural loads. The flexural behaviour and design of the mat have been carried out using ETABS software, following standard design codes and criteria.

This section presents the sample results of the flexural analysis and design for the mat.

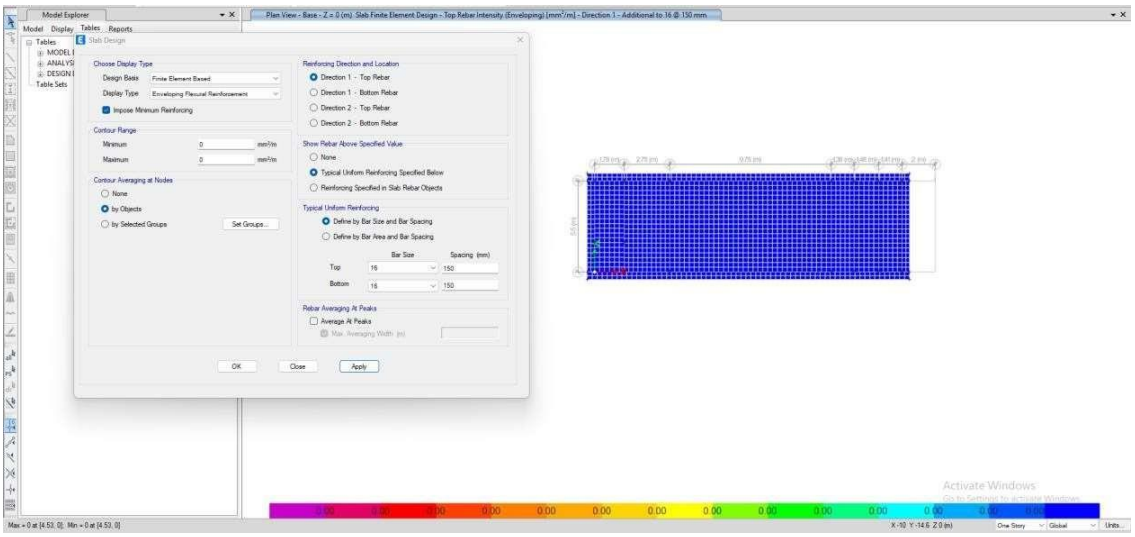


Figure 6-58 Top rebar intensity mm²/mm (Direction-1)

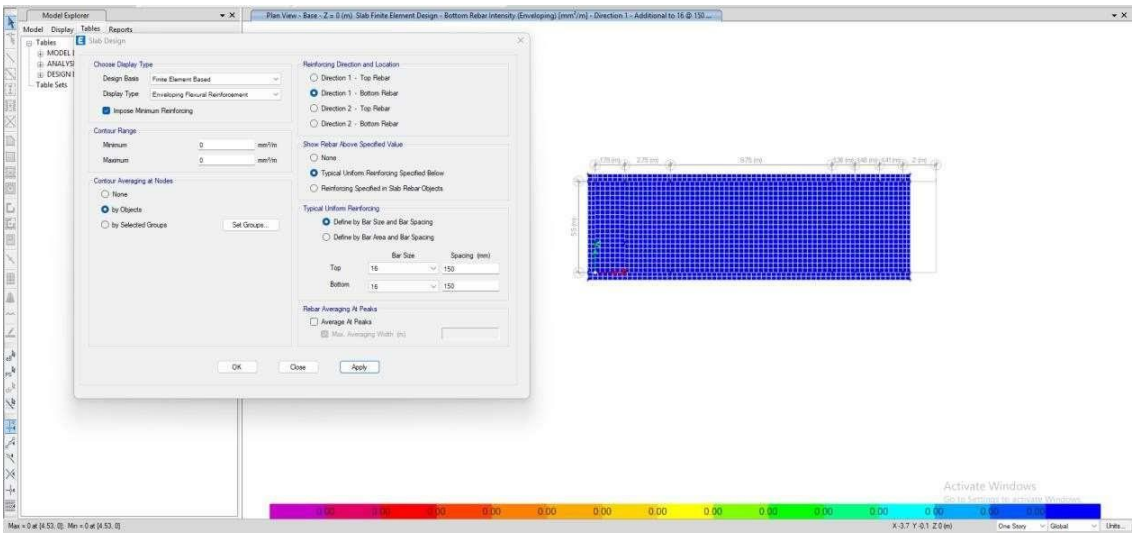


Figure 6-59 Bottom rebar intensity mm²/mm (Direction-1)

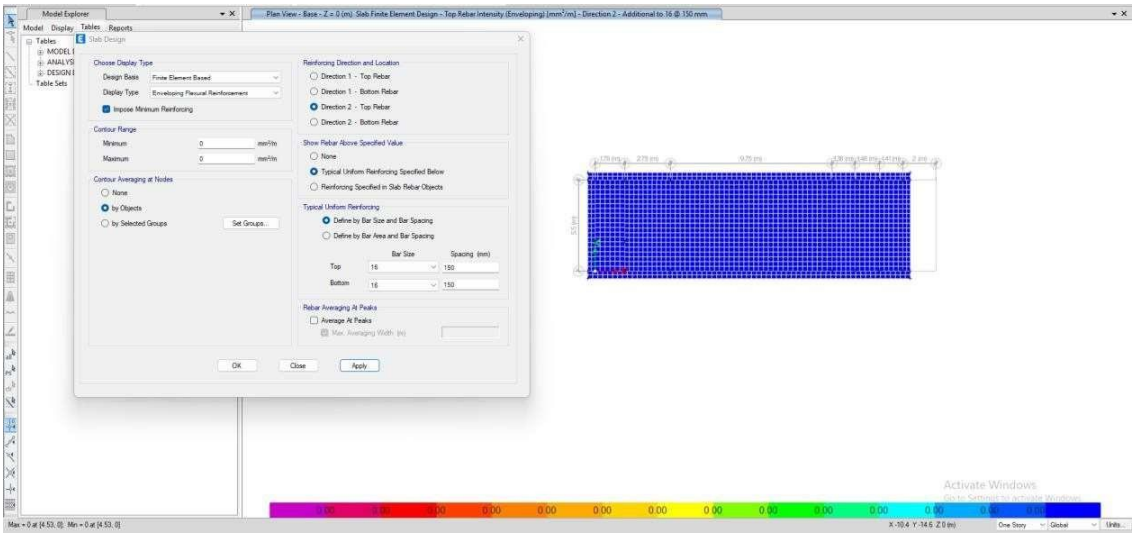


Figure 6-60 Top rebar intensity mm²/mm (Direction-2)

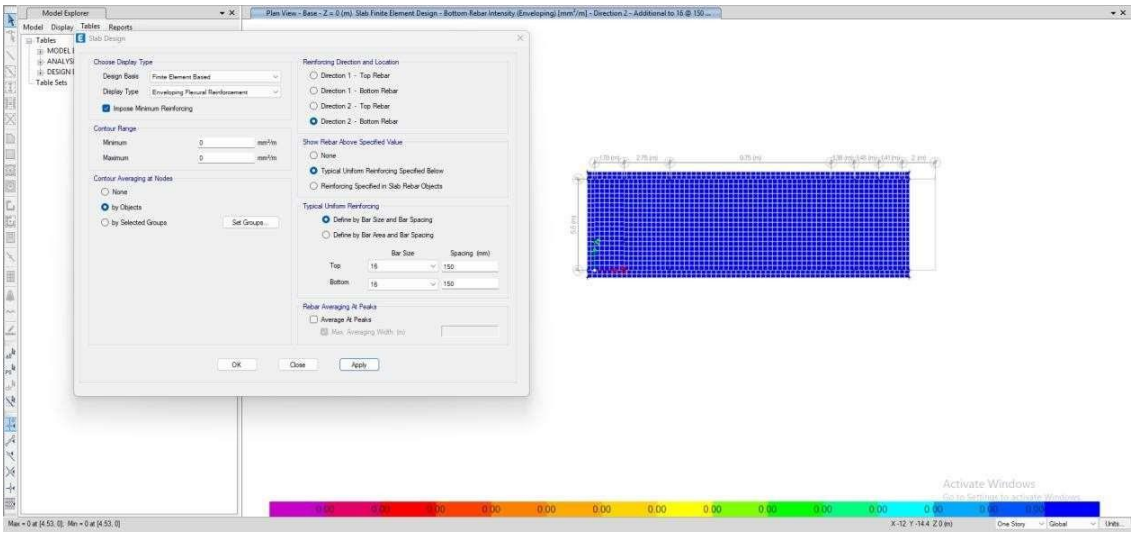


Figure 6-61 Bottom rebar intensity mm²/mm (Direction-2)

According to ACI 350,

$$A_{s,min} = 0.003bh$$

Here,

Width, b = 1000 mm **[Per meter strip]**

Thickness, h = 600 mm

Therefore, $A_{s,min}$ = 0.003 x 1000 x 600 = 1800 mm²/m

Minimum reinforcement area per layer, $A_{s,face}$ = 1800/2 mm²/m = 900 mm²/m each layer, each way

Table 6-22 Reinforcement summary table for Mat Foundation as per ETABS

Reinforcement Type	As,min (mm²/m)	Provided Rebar Dia (mm)	Provided Spacing (mm c/c)	Provided As (mm²/m)
Top (x-direction)	900	16ϕ	125	1609
Top (y-direction)	900	16ϕ	125	1609
Bottom (x-direction)	900	16ϕ	125	1609
Bottom (y-direction)	900	16ϕ	125	1609

Annexure: Detail Design Drawings

QA Plan for Civil & MEP Works of Water Treatment Plant (WTP), Sewage Treatment Plant (STP) & Underground Water Reservoir (UGWR) for Asian University for Women

Location: Bayezid Link Road, Chattogram.

ASIAN UNIVERSITY FOR WOMEN

Table of Contents

Project Title	Comprehensive MEP and Civil Design including Preparation of Detailed Bill of Quantities (BOQ) for STP, WTP, and UGWR (Chiller & Fire Systems)
Project Location	Asian University for Women, Chattogram, Bangladesh
Client	Asian University for Women (AUW)
Project Management Consultant (PMC)	Surbana Jurong
Design Consultant	Esolve International Limited
Document Number	AUW-QAP-001
Document Date	04 June 2026
Revision	REV 01
Applicable Standards	BNBC 2020, ACI 318-08, ASCE 7-05, BDS 1313:1991, ASTM A615M, ISO 9001:2015, BS EN ISO 10931, ASME B31.3

Purpose And Scope

This Quality Assurance (QA) Plan establishes the quality management framework for the design, construction, testing, and commissioning of the Sewage Treatment Plant (STP), Water Treatment Plant (WTP), and Underground Water Reservoir (UGWR) including Chiller and Fire Systems at the Asian University for Women (AUW), Chattogram, Bangladesh.

1.1 Purpose

- Ensure all construction works are carried out in conformance with the approved design drawings, specifications, and applicable Bangladesh and international standards.
- Define the roles, responsibilities, inspection checkpoints, and documentation requirements for all quality-related activities.
- Establish a systematic approach to identifying and resolving non-conformances.
- Provide comprehensive equipment testing protocols from factory acceptance through to site commissioning.
- Provide an auditable record of quality activities from construction through to handover.

1.2 Scope

This plan covers the following works as per design drawings:

- WTP Structural Works: RCC bottom slab (Level +91.85m), RCC walls, roof beams (FB-1/FB-2), and roof slabs (Levels +96.20m, +99.50m, +101.75m) – Drawing Nos. AUW-PDR-01 to AUW-PDR-14.
- STP Structural Works: Bottom slabs (Levels +95.55m and +96.70m), ground slab (Level +99.50m), walls with manhole openings, and top roof slab (Level +102.75m).
- WTP MEP Works: Raw water reservoir (256.5 m^3), chiller water reservoir (40.5 m^3), ACF/MF filters, micro-filtration unit, softener, dosing system, fire water reservoir (346.5 m^3), fire pump room, associated pipework.
- STP MEP Works: Aerobic/Anaerobic tanks, aeration diffuser system (30 No. × 250mm disk diffusers), Roots air blowers (3 × 7.5HP), ACF/MGF filters, grit chamber, sedimentation tank, post-aeration tank, pipeline network.
- Electro-Mechanical Equipment: Raw water feed pumps, sludge transfer pumps, digital flow meter, multi-grade sand filter, activated carbon filter, NaOCl dosing unit, electrical panel board, uPVC pipework.
- Civil Ancillary Works: Cable trays, manholes, pipe trenches, portable steel stairs, stainless steel covers.

Applicable Standards and References

2.1 Design and Structural Standards

- Bangladesh National Building Code (BNBC 2020) – Primary code for structural design and loads.
- ACI 318-08 – Building Code Requirements for Structural Concrete.
- ACI 350 – Code Requirements for Environmental Engineering Concrete Structures (liquid-containing).
- ASCE 7-05 – Minimum Design Loads for Buildings and Other Structures.
- BDS 1313:1991 – Bangladesh Standard for Deformed Steel Bars (fy = 500 MPa).
- ASTM A615M – Deformed and Plain Steel Bars for Concrete Reinforcement.
- ASTM A36/A36M – Carbon Structural Steel (for structural steel members).

2.2 MEP, Process and Equipment Standards

- BS EN ISO 10931 / BS 4514 / ISO 4422 – uPVC piping systems.
- ASTM A53 / BS 1387 – Steel pipe (GI/MS) for fire and air lines.
- ISO 9906 Grade 2 – Rotodynamic pumps: hydraulic performance acceptance tests.
- ISO 1217 / ISO 10816 – Displacement compressors and mechanical vibration evaluation.
- ISO 4064 / OIML R 49 – Water meters and flow measurement accuracy.
- ASME Section X – Fibre-Reinforced Plastic Pressure Vessels.
- IEC 61439-1/-2 – Low-voltage switchgear and controlgear assemblies.
- IEC 60364-6 – Low-voltage electrical installations: verification.
- IEC 60947-4 – Low-voltage switchgear: contactors and motor starters.
- NFPA 20 – Standard for the Installation of Stationary Pumps for Fire Protection.
- NFPA 22 / BS EN 12845 – Water tanks and fire suppression systems.
- Bangladesh Environment Conservation Rules (DoE) – STP effluent quality limits.
- WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater (Vol. 2).
- ISO 9001:2015 – Quality Management Systems requirements.

Inspection Level Definitions

Symbol	Type	Description
H	Hold Point	Work SHALL NOT proceed until inspection is witnessed and approved by PMC/Consultant
W	Witness Point	PMC/Consultant to be notified and should witness; work may proceed if they do not attend after notice period
R	Review Point	Documents submitted for review and comment before proceeding
I	Inspection Point	Contractor inspects and records; PMC may audit records at any time
T	Test Point	Formal test to be witnessed, results recorded and accepted before next activity proceeds

All Hold Points (H) must be formally notified to the PMC at least 24 hours in advance. Work at a Hold Point SHALL NOT commence without written clearance from the PMC/Design Consultant. Test Points (T) require the Contractor to submit a test plan (method statement) at least 5 working days prior to the test date.

Inspection and Test Plan (ITP) Summary

Activity	Contractor	PMC	Design Consultant
Excavation & levelling	I	W	R
Brick flat soling & CC blinding	I	W	R
Bottom slab rebar placement	I	H	R
Formwork inspection (pre-pour)	I	W	R
Concrete pour – bottom slab	I	H	W
Concrete cube/cylinder sampling	I	W	R
Wall rebar placement	I	H	R
Water stopper installation	I	H	R
Roof beam rebar placement	I	H	R
Roof slab rebar placement	I	H	R
Concrete pour – roof slab/beam	I	H	W
28-day concrete strength result	I	R	R
Pump installation & alignment	I	H	W
Pump pressure & performance test	T	H	W
Pressure vessel inspection (pre-install)	I	H	H
Pressure vessel hydrostatic test	T	H	H
Pipe installation & supports	I	W	R
Pipeline pressure test (uPVC & GI)	T	H	W
Diffuser installation (STP aeration tank)	I	H	W
Diffuser bubble uniformity test	T	H	W
Air blower run test	T	H	W
Panel board wiring & PAT test	T	H	W
Flow meter calibration check	T	W	R
WTP MEP equipment installation	I	W	H
STP aeration system function test	T	H	W
WTP filter commissioning	T	H	H
Effluent quality test (STP)	T	H	H
Final inspection & handover	I	H	H

5.1 General Requirements

All materials shall conform to the specifications listed in the approved construction documents. No materials shall be incorporated into the permanent works without prior approval from the PMC. The Contractor shall maintain a Material Approval Register (MAR).

5.2 Concrete

- Minimum 28-day compressive strength: f'c = 35 MPa for all structural elements.
- Cylinder specimens: Diameter D = 100mm, Height H = 150mm (As per general notes in structural drawing).
- Curing: Minimum 21 days. Horizontal surfaces by water ponding; vertical surfaces by wrapping moist jute fabric.
- Trial mix design to be submitted and approved before any concrete is cast.

5.3 Steel Reinforcement

- Grade: 500 MPa High Strength Deformed Bar (HSDB) for all elements.
- Standards: BDS 1313:1991 and/or ASTM A615M.
- Testing: Tensile strength, percentage elongation, and bend/rebend tests at BUET, CUET, or approved institute.
- Structural steel members (stairs, fixings): ASTM A36/A36M.

5.4 Material Quality Control Register

Material / Item	Standard / Spec	Test Required	Frequency	Acceptance Criteria
Deformed Rebar (500 MPa)	BDS 1313:1991, ASTM A615M	Tensile, elongation, bend/rebend	Each delivery / batch	$f_y \geq 500$ MPa per BDS 1313
Concrete (Ready Mix / Site Mix)	ACI 318-08, BNBC 2020	Cube/cylinder strength, slump	Per 50m³ each pour	$f'_c \geq 35$ MPa at 28 days
PVC Water Stopper	Manufacturer spec	Dimensional check, joint integrity	Each roll delivered	225mm width, no defects
uPVC Pipe (WTP/STP)	BS EN ISO 10931, BS 4514	Pressure test, dimensional check	Each batch	Rated pressure, correct dia.
Dosing Chemicals (WTP)	Manufacturer MSDS	Certificate of Conformity	Each delivery	Correct grade and concentration
Diffuser (250mm disk, STP)	Manufacturer Specification, Taiwan/China/India	Visual, bubble function test	Each unit installed	Uniform diffusion, no blockage
FRP Filter Vessels (MGF/ACF)	ASME Section X / Manufacturer Specification	Dimensional, hydrostatic test	Each vessel	No leakage at 1.5x rated pressure

Material / Item	Standard / Spec	Test Required	Frequency	Acceptance Criteria
Submersible/Centrifugal Pump	ISO 9906, Manufacturer Specification	Performance, vibration, insulation	Each pump	Flow/head per duty point, IR > 1MΩ
Roots Air Blower (7.5 HP)	ISO 1217, Manufacturer Specification	Run test, vibration, sound level	Each unit	Flow 180-200 m^3/hr, vibration ≤ 4.5mm/s
Digital Flow Meter (1.5”)	ISO 4064 / OIML R 49	Calibration, zero-flow check	Each unit	±2% of reading accuracy
NaOCl Dosing Unit (200L tank)	Manufacturer Specification	Leak test, dose-rate verification	Each unit	No leaks, dose within ±5% of setpoint
SS Covers (WTP Room)	Manufacturer Specification	Dimensional, load rating	Each cover	Correct size and load class

Equipment Test Requirements

This section establishes comprehensive test requirements for all electro-mechanical. Tests shall be performed at two stages: (a) Factory Acceptance Test (FAT) prior to delivery and (b) Site Acceptance Test (SAT) following installation. All test records shall be submitted to the PMC and Design Consultant prior to commissioning.

6.1 Pump Testing Requirements

The following tests apply to all pumps. Testing shall follow ISO 9906 Grade 2 acceptance criteria unless manufacturer specifications are more stringent.

Pump Tag / Type	Standard / Reference	Tests Required	Acceptance Criteria	Record Required
Raw Water Feed Pump (10,000 L/hr., 2HP)	ISO 9906 Gr.2	Shop test: flow-head curve, efficiency Site: run test, vibration, current draw	Flow ≥ 10,000 L/hr @ rated head, vibration ≤ 4.5mm/s	Factory test cert, site commissioning record
Sludge Transfer Pump (Submersible, 10m³/hr., 2HP)	ISO 9906 Gr.2, IEC 60034	Megger insulation test (IR>1MΩ @ 500V), run & performance test, seal integrity test	Flow ≥ 10 m³/hr @ 10m head, no casing leakage	IR test certificate, site run record
Sludge Transfer Pump	ISO 9906 Gr.2	Same as above; duty/standby changeover test	Duty/standby auto-changeover within 5 sec	Commissioning sheet, switchover test record
NaOCl Dosing Pump	ISO 9906, Manufacturer Specification	Dose-rate calibration, stroke-frequency test, chemical resistance inspection	Dose accuracy ±5%, no chemical leaks	Calibration record

6.2 Pressure Vessel and Filter Testing Requirements

All pressure vessels (FRP filter vessels – MGF and ACF), in-ground concrete tanks (STP aerobic/anaerobic, sedimentation), and storage reservoirs (WTP raw water, fire water, chiller water) shall be subject to the following tests before being placed into service:

Vessel / Equipment	Size / Spec	Standard	Tests Required	Acceptance Criteria	Record Required
Multi-grade Sand Filter (MGF)	24" Ø x 72" H, FRP vessel	ASME Sec X, Manufacturer Specification	Pre-install visual & dimensional Hydrostatic: 1.5x working pressure for 1hr Media layer verification	No leakage, correct media depths, ΔP within spec, backwash flow per design	Hydrostatic test cert, media check sheet, commissioning record

Vessel / Equipment	Size / Spec	Standard	Tests Required	Acceptance Criteria	Record Required
			Backwash flow test Flow rate & pressure drop test		
Activated Carbon Filter (ACF)	24" Ø x 72" H, FRP vessel	ASME Sec X, Manufacturer Specification	Pre-install visual & dimensional Hydrostatic: 1.5x working pressure for 1hr Carbon bed depth verification Service flow & backwash cycle test Chlorine removal efficiency (effluent sample)	No leakage, media depth OK, Cl2 residual < 0.2 mg/L downstream	Hydrostatic cert, chlorine test report, commissioning record
NaOCl Dosing Tank (200L)	200L PVC / PE tank	Manufacturer Specification, COSHH	Visual inspection Leak test (fill to 110% capacity, hold 1hr) Venting / overflow inspection Secondary containment check	No leaks, overflow functional, bunded area confirmed	Inspection checklist, leak test record

6.5 Electrical Panel and Control Equipment Testing

All electrical panels, motor controls, contactors, overloads, and associated cabling shall be tested in accordance with IEC 61439 and IEC 60364-6 before energizing any connected equipment. A qualified electrical engineer shall carry out and certify all electrical tests.

Equipment / System	Standard / Reference	Tests Required	Acceptance Criteria	Record Required
Electrical Panel Board (ABB/Schneider, 300x300, 32A)	IEC 61439-1/-2 IEC 60364-6	1. Visual & mechanical inspection 2. Insulation Resistance (IR) test 3. Continuity test 4. Polarity check 5. Functional test (MCB, MCCB, overloads) 6. Earth fault loop impedance	IR > 1MΩ at 500V DC (IEC 60364-6) All conductors continuous Correct polarity confirmed All protective devices operate correctly Zs within prescribed limits	IR test certificate Electrical inspection certificate (EIC) Test schedule per IEC 60364-6 Part 6
Motor Control (Pump & Blower)	IEC 60947-4 IEC 60034	1. Motor winding IR test 2. No-load current test 3. Direction of rotation check 4. Overload relay setting verification 5. Thermal protection function test	IR > 1MΩ @ 500V DC No-load current within 10% of nameplate Correct rotation Overload set to ≤ 115% FLA Trip at 125% FLA within time	Motor test cert Commissioning record per motor
Magnetic Conductor / Contactor (32A, 220V/50Hz)	IEC 60947-4-1	1. Mechanical operation test 2. Coil voltage test 3. Contact resistance measurement	Correct make/break action Coil picks up at ≥85% Un, drops off at ≤75% Un Contact resistance < 0.1 mΩ	Contactor test sheet
Overload Relay (32A, 220V/50Hz)	IEC 60947-4-1	1. Trip current calibration test 2. Manual reset test 3. Phase-loss protection function test	Trip within specified time/current curve Manual reset functional	Relay calibration record

Equipment / System	Standard / Reference	Tests Required	Acceptance Criteria	Record Required
			Phase-loss trip ≤ 5 sec	
Cabling (3mm² Cu PVC) Panel to equipment	IEC 60502-1 BS 7671	1. Continuity test 2. IR test (each core to earth) 3. Correct gland and termination check	Continuity confirmed each core IR > 1MΩ at 500V DC All glands watertight (IP rating)	Cable test record Gland inspection checklist

6.6 Flow Meter Calibration and Testing

The digital flow meter (1.5-inch, 1 No.) shall be calibrated by an accredited laboratory (NABL or equivalent) prior to installation, and an in-situ check performed after installation as follows:

Equipment	Specification	Tests Required	Test Method	Acceptance Criteria & Record
Digital Flow Meter (1.5-inch, 1 No.)	Velocity: 0.3-10 m/s Pressure: up to 1.6 MPa LCD display Carbon/SS body	1. Pre-installation dimensional & material check 2. Zero-flow check 3. In-situ calibration check (flow comparison) 4. Pressure integrity test 5. Display & output signal test	1. Verify pipe size, facing, gasket condition 2. Energise with no flow; verify zero reading 3. Compare meter reading against reference standard at ≥20% and ≥80% of max flow 4. Apply rated working pressure; inspect connections 5. Verify 4-20mA (or pulse) output matches display	Zero error < 0.05% FS Flow reading accuracy ±2% of reading (ISO 4064 Class B) No leakage at connections Signal output within ±0.5% Record: calibration certificate (NABL/accredited lab), site commissioning record

6.7 NaOCl Dosing Unit Testing

- Chemical Resistance Inspection: Verify tank and pump materials are compatible with sodium hypochlorite solution (NaOCl).
- Leak Test: Fill tank to 110% of rated capacity (220L); hold for 1 hour; inspect all joints, fittings, and connections for leaks.
- Overflow / Vent Test: Verify overflow and vent pathways are unobstructed.
- Dose Rate Calibration: Set dosing pump to target dose; measure actual volume delivered over 10 minutes; verify within ±5% of setpoint.
- Secondary Containment Check: Confirm bunded area can contain 110% of tank volume.

6.8 Equipment Handover Test Sequence (STP)

The following sequence shall be followed for the final integrated commissioning of the STP electro-mechanical systems:

- Step 1: Pre-commissioning checks: All equipment installed per approved drawings; electrical connections verified; instrumentation calibrated.
- Step 2: Air system test: Blower run test (individual units); pipe pressure test; diffuser bubble uniformity test with clean water fill.
- Step 3: Pump test: Run test for each feed pump and sludge transfer pump; verify flow and head against duty curve.
- Step 4: Filter system test: Flow through MGF and ACF at design rate; verify ΔP within specification; backwash cycle test.
- Step 5: Dosing system test: Dose calibration for NaOCl; verify chlorine residual in effluent stream.
- Step 6: Integrated run: Introduce diluted wastewater; run all systems for minimum 7 days; collect effluent samples daily.
- Step 7: Effluent quality test: Submit samples to approved laboratory; results to be within Bangladesh DoE and WHO limits (see Section 7.9).

6.9 Effluent Quality Acceptance Criteria (STP)

Upon completion of the STP process trial (Step 6 above), treated effluent shall be sampled and tested. Results shall comply with the Bangladesh Department of Environment (DoE) standards and WHO guidelines:

Parameter	Unit	Raw Inlet (Typical)	Bangladesh DoE Std.	WHO Guideline	Test Method
pH	-	6.5 - 8.5	6.0 - 9.0	6.5 - 8.5	pH meter (calibrated)
BOD_5	mg/L	150 - 300	≤ 50	≤ 10	APHA 5210-B
COD	mg/L	300 - 600	≤ 200	≤ 50	APHA 5220-C
TSS	mg/L	100 - 300	≤ 100	≤ 30	APHA 2540-D
TDS	mg/L	500 - 1500	≤ 2100	≤ 1000	APHA 2540-C
Faecal Coliform	MPN/100mL	10^6 - 10^8	≤ 1000	≤ 200	APHA 9221-E
Total Nitrogen	mg/L	30 - 50	≤ 100 (as N)	≤ 10	APHA 4500-N
DO (Effluent)	mg/L	< 1	≥ 4.5	≥ 5	DO meter
Chlorine Residual	mg/L	0	0.2 - 1.0	< 0.2 (after treatment)	DPD colorimetric
Oil & Grease	mg/L	30 - 100	≤ 10	≤ 5	APHA 5520-B

Note: Samples to be taken from the final effluent outlet (post ACF/MGF treatment). Minimum 3 composite samples on separate days during the 7-day trial. Testing to be carried out by a DoE-approved or NABL-equivalent accredited laboratory.

Structural QC Checkpoints: WTP / UGWR

The following checkpoints apply to WTP and UGWR structural works based on design drawings.

Activity	Insp. Point	Acceptance Criteria	Frequency	Responsible	Record
Bottom Slab Formwork	Pre-concrete	Level ±5mm, dimensions per AUW-PDR-04/05	100%	Site Engineer	Form check sheet
Bottom Slab Rebar (+91.85m)	Pre-concrete	Ø20@150 C/C T&B, 500mm thick, 75mm cover	100%	Site Engineer	Rebar inspection report
RCC Wall Rebar	Pre-concrete	12Ø@125c/c & 16Ø@125c/c per AUW-PDR-06	100%	Site Engineer	Rebar inspection report
Concrete – Bottom Slab	During pour	f'c=35MPa min, slump per spec, no cold joints	Each pour	QC Inspector	Concrete pour record
Concrete Cube Sampling	During pour	6 cubes per 50m³, test at 7 & 28 days	Per 50m³	Lab Technician	Cube test report
Roof Beam FB-1/FB-2 (+96.20m)	Pre-concrete	300x500mm, stirrups Ø10@100-150 C/C	100%	Site Engineer	Rebar inspection report
Roof Slab (+96.20m)	Pre-concrete	350mm thick, Ø16@125 C/C btm, Ø16@200 C/C top	100%	Site Engineer	Rebar inspection report
Roof Slab (+99.50m)	Pre-concrete	300mm thick, Ø16@125 C/C btm, Ø16@200 C/C top	100%	Site Engineer	Rebar inspection report
Water Stopper Installation	Pre-concrete	225mm PVC at all construction joints below ground	100%	Site Engineer	Installation check
Concrete Curing	Post-pour	Min. 21 days, ponding on horiz., jute wrap on vert.	Daily	Site Foreman	Curing log
Reservoir Hydrostatic Test	Post-construction	Fill to design level; hold 72hr; water level drop ≤10mm/24hr	100%	QC Inspector	Hydrostatic test record

7.1 Key Structural Parameters – WTP/UGWR

- Bottom Slab: 500mm thick at Level +91.85m; Ø20@150 C/C both ways; clear cover 75mm to mat bottom.
- RCC Walls: 12Ø@125c/c horizontal and 16Ø@125c/c vertical (inner layer); corner zones with increased reinforcement per AUW-PDR-06.
- Roof Beams (FB-1 & FB-2): 300×500mm; main bars 3-Ø20 (top/bottom); stirrups Ø10@100 C/C at ends, @150 C/C at mid-span.
- Roof Slab at +96.20m: 350mm thick; Ø16@125 C/C bottom, Ø16@200 C/C top.
- Seismic Zone: Zone 3 per BNBC 2020; Wind Speed: 80 m/s.
- Foundation Type: Footing foundation per General Note AUW-PDR-01.

Structural QC Checkpoints: STP

The following checkpoints apply to STP structural works based on design drawings.

Activity	Insp. Point	Acceptance Criteria	Frequency	Responsible	Record
Bottom Slab (+95.55m)	Pre-concrete	600mm thick, Ø12@100 C/C btm, Ø16@100 C/C top per AUW-PDR-003	100%	Site Engineer	Rebar check sheet
Bottom Slab (+96.70m)	Pre-concrete	600mm thick, Ø16@125 C/C top & btm per AUW-PDR-003	100%	Site Engineer	Rebar check sheet
Ground Slab (+99.50m)	Pre-concrete	250mm thick, Ø12@125 C/C T&B, manhole openings per AUW-PDR-003	100%	Site Engineer	Rebar check sheet
Wall Reinforcement	Pre-concrete	12Ø@125c/c & 16Ø@125c/c per AUW-PDR-004, 4-D16 around manholes	100%	Site Engineer	Rebar inspection report
Top Roof Slab (+102.75m)	Pre-concrete	250mm thick, 12Ø@125 C/C alt. cranked, 2-12mmØ ext. top per AUW-PDR-005	100%	Site Engineer	Rebar inspection report
Concrete Strength	Post-pour	f'c ≥ 35 MPa at 28 days, cyl D=100mm H=150mm	Per 50m³	Lab Technician	Cylinder test report
Diffuser Installation	MEP	10-inch diffusers, 3-inch PVC pipe, UPVC tee, brick blocks per AUW-PD-004	100%	MEP Engineer	Installation record
STP Tank Hydrostatic Test	Post-construction	Fill with water; monitor 72hr; level drop ≤10mm/24hr; inspect for seepage	100%	QC Inspector	Hydrostatic test record

8.1 Key Structural Parameters (STP)

- Bottom Slab at +95.55m: 600mm thick; 12Ø@100 C/C bottom, 16Ø@100 C/C top; clear cover 75mm bottom.
- Bottom Slab at +96.70m: 600mm thick; 16Ø@125 C/C both ways.
- Ground Slab at +99.50m: 250mm thick; 12Ø@125 C/C top and bottom; 4-D16 bars at manhole openings.
- Walls: 12Ø@125c/c and 16Ø@125c/c; wall thickness 300mm.
- Top Roof Slab at +102.75m: 250mm thick; 12Ø@125 C/C alternately cranked.
- Overall STP: 20.85m long × 5.80m wide (internal clear).

MEP QC Checkpoints: WTP, STP & UGWR

System	Activity	Acceptance Criteria	Test Method	Frequency	Record
WTP	Raw Water Reservoir (256.5m³)	Correct capacity per AUW-DD-02	Dimensional survey	Once	Survey report
WTP	ACF & MF Filter install	Per AUW-DD-03, correct pipe connections	Visual + flow test	Each unit	Commissioning sheet
WTP	Softener & Dosing system	Correct position per AUW-DD-03, gate valves operable	Visual + function test	Each unit	Commissioning sheet
WTP	Micro-filtration unit	Connected to treated reservoir, backwash to drainage	Flow test	Once	Test report
Fire	Fire Reservoir (346.5m³)	Correct capacity per drawing	Dimensional survey + fill test	Once	Survey + fill record
Fire	Low-level cutoff switch	Installed per drawing, function test performed	Function test	Once	Test record
STP	Air blower (3 sets)	Flow 180-200m³/hr, vibration ≤4.5mm/s per AUW-PD-003	Run test + vibration	Each unit	Commissioning sheet
STP	Sewage drainage gradient	S200ND & S300ND slopes 1:200 per AUW-DD-01	Survey	Each run	Survey record
STP	Outlet flow verification	Per AUW-PD-004/005, post-treatment unit outlet OK	Flow test	Once	Test report
General	Cable tray install	600mm x 100mm per AUW-DD-01, secure fixing	Visual + dimensional	100%	Inspection report

9.1 WTP Process Flow Verification

- Production Tube Well → Raw Water Reservoir (256.5 m³, Level +99.50m)
- Raw Water Reservoir → Feed Pump → ACF (Activated Carbon Filter) → MF (Multi-grade Filter)
- MF → Dosing System → Micro-filtration Unit → Water Tank → Softener Filter
- Softener Filter → Existing Underground Treated Water Reservoir (potable supply)
- Side stream: → Chiller Water Reservoir (40.5 m³, Level +96.20m)
- Overflow pipe verified → To Fire Reservoir; Backwash → Existing Drainage System

9.2 Fire System Verification

- Production Well → Fire Water Reservoir (346.5 m³, Level +91.85m)
- Fire Water Reservoir → Fire Pump Room → Fire Distribution Network
- Low-level cutoff switch function tested at Level +91.85m
- Fire pipe IL: 92.00m and Water pipe IL: 96.25m confirmed by survey
- Hydrostatic pressure test on all fire pipework – hold 2 hours at 1.5× working pressure

9.3 STP Process Flow Verification

- Inlet Waste Water → Grit Chamber → Anaerobic Tank (3 compartments)
- Anaerobic Tank → Aerobic Tank (with 30 No. 250mm diffusers, 3-inch PVC air pipe lines from blowers)
- Aerobic Tank → Sedimentation Tank → Post-Aeration Tank → Post-Treatment Unit (ACF/MGF)
- Treated Effluent → Outlet to Drain / Gardening and Vehicle Wash Pipeline
- Air blower (3 sets) → 4-inch gas pipe headers → diffuser network function test: uniform bubble pattern across full tank area

Concrete Clear Cover Requirements

Structural Member	Location / Condition	Required Clear Cover (mm)
PC / MAT / Footing	Side	75
PC / MAT / Footing	Bottom (above soling)	75
PC / MAT / Footing	Bottom (on ground/soil)	75
Column	Above Mat	40*
Wall	Above Mat	75*
Floor Beam	Top and Side	40**
Floor Beam	Bottom	40**
Slab and Stair	Top and Bottom	20
Retaining Wall	Exterior face	65
Retaining Wall	Interior face	40
Water Tank Wall	Water face	60
Water Tank Wall	Other face	50

** From tie bar ** From stirrups*

Spacer bars for slabs/mats: Chairs of 20Ø bar at 1150 C/C. Spacer bars for beams (second layer): 25Ø spacer bars.

LAP Length Verification

Bar Dia (mm)	Tension Lap (mm)	Compression Lap (mm)
10	400	300
12	480	360
16	640	480
20	990	600
25	1240	730
28	1380	840
32	1580	960
35	1730	1050
40	1980	1200

Column/shear wall laps must be tension laps. Maximum 50% of bars to be spliced at one location. Lap splices to be confined by hoops at maximum spacing d/4 or 100mm.

NON-Conformance Management

12.1 NCR Process

Step	Action	Responsible Party	Timeline
1	Non-conformance identified and tagged with NCR number	QC Inspector / Site Engineer	Immediately
2	NCR form raised and distributed to Contractor and PMC	QC Inspector	Within 24 hours
3	Root cause analysis and corrective action proposed	Contractor QC Manager	Within 48 hours
4	Corrective action reviewed and approved by PMC	PMC	Within 72 hours
5	Corrective action implemented on site	Contractor	Per agreed schedule
6	Re-inspection and verification of corrective action	QC Inspector	Post-implementation
7	NCR closed upon satisfactory re-inspection	PMC / Design Consultant	Upon verification

12.2 NCR Classification

- Critical (CAT A): Non-conformance with structural or safety integrity implications – immediate stop-work. Examples: wrong rebar diameter, incorrect concrete strength, missing water stopper, pump installed with wrong rotation, pipeline pressure test failure.
- Major (CAT B): Non-conformance affecting functional performance or durability – corrective action within 48 hours. Examples: rebar spacing out of tolerance >20%, cover less than specified, equipment vibration exceeding limits.
- Minor (CAT C): Non-conformance with minor impact – corrective action within 7 days. Examples: surface finish defects, minor dimensional tolerance exceedance, labelling errors on panels.

12.3 Rejection and Removal

Concrete failing the 28-day strength test (f'c < 35 MPa) or equipment failing its acceptance test shall result in an automatic CAT A NCR. The PMC shall determine whether the element is to be demolished/replaced, or whether a structural/functional assessment (core tests, re-test, etc.) is sufficient. No decision to retain sub-standard material or equipment shall be made without written approval from both the PMC and Design Consultant.

13.1 Drawing Control

- Only the current approved revision of drawings shall be used on site. Current revision: REV 04, dated 07 May 2026.
- Superseded drawings shall be removed from site and marked SUPERSEDED.
- All drawings shall be controlled and distributed through the PMC (Surbana Jurong).
- Proposed deviations from approved drawings shall be raised as an RFI through the PMC before work proceeds.

13.2 Quality Records Register

Document / Record	Prepared By	Reviewed By	Retention Period
QA Plan (this document)	Esolve International	Surbana Jurong / AUW	Project life + 10 years
Inspection and Test Plan (ITP)	Contractor QC Manager	PMC / Consultant	Project life + 10 years
Daily Site Inspection Reports	Site Engineer	PMC	Project life + 5 years
Rebar Inspection Sheets	Site Engineer	PMC / Consultant	Project life + 10 years
Concrete Pour Records	Site Engineer	QC Inspector	Project life + 10 years
Concrete Cube / Cylinder Test Reports	Approved Lab	Design Consultant / PMC	Project life + 10 years
Rebar Material Test Certificates	Approved Lab (BUET/CUET)	Design Consultant	Project life + 10 years
Non-Conformance Reports (NCRs)	QC Inspector	PMC / Design Consultant	Project life + 10 years
Corrective Action Reports (CARs)	Contractor QC Manager	PMC	Project life + 10 years
Pump Factory & Site Test Records	Pump Contractor	PMC / MEP Consultant	Project life + 10 years
Vessel Hydrostatic Test Records	Contractor	PMC / Design Consultant	Project life + 10 years
Pipeline Pressure Test Records	Contractor	PMC	Project life + 10 years
Diffuser Bubble Test Photo Log	MEP Contractor	PMC / MEP Consultant	Project life + 10 years
Air Blower Commissioning Records	MEP Contractor	PMC / Design Consultant	Project life + 10 years
Electrical Panel Test Certificates	Electrical Contractor	PMC	Project life + 10 years
Flow Meter Calibration Certificates	Supplier / Contractor	PMC / Design Consultant	Project life + 10 years

Document / Record	Prepared By	Reviewed By	Retention Period
MEP Commissioning Records	MEP Engineer / Contractor	PMC / Design Consultant	Project life + 10 years
Effluent Quality Test Results	Approved Lab	PMC / Regulatory Authority	Permanent
Pressure Test Records (fire & water)	Contractor	PMC	Project life + 10 years
Shop Drawing Submission Log	Contractor	Design Consultant	Project life
RFI Log	Contractor / Site Engineer	Design Consultant / PMC	Project life
As-Built Drawing Register	Contractor	Design Consultant / PMC	Permanent
Handover Certificate	PMC / Client	All parties	Permanent

Commissioning and Testing

14.1 WTP Commissioning Sequence

- Pre-commissioning: Verify all pipework connections as per drawing; valves operational; power connected.
- Water fill test: Fill raw water reservoir to design level (+99.50m); check for leaks; hold 24 hours.
- Pump function test: Operate feed pump; confirm flow rates through ACF, MF, micro-filtration unit.
- Dosing system calibration: Set dosing rates per water quality requirements; sample and test treated water.
- Fire reservoir fill test: Fill to design level; verify low-level cutoff switch activation.
- Final treated water quality test: Submit results to AUW Client and PMC.

14.2 STP Commissioning Sequence

- Pre-commissioning: Inspect all tanks, diffuser positions, pipe connections as per drawing.
- Air pressure test: Pressurize 4-inch gas pipe lines at 1.5× working pressure; hold 30 minutes.
- Blower run test: Operate each blower individually; check diffuser performance, uniform bubble pattern.
- Hydraulic fill test: Fill aerobic and anaerobic tanks with clean water; monitor for seepage 72 hours.
- Pump commissioning: Run sludge transfer pumps; verify flow/head against duty curve.
- Process trial: Introduce diluted wastewater; monitor through all treatment stages for minimum 7 days.
- Effluent quality test: Submit samples to DoE-approved lab; results to meet criteria in Section 7.9.
- Filter function test (ACF/MGF): Verify flow rates and backwash cycle per design.

14.3 Handover Requirements

- All NCRs closed or formally accepted by PMC and Client.
- All test records, pressure test certificates, and commissioning results reviewed and accepted.
- As-built drawings submitted and approved.
- Operation and Maintenance (O&M) manuals submitted for all equipment.
- Operator training completed for WTP and STP plant operators.
- Defects Liability Period (DLP) to be agreed between Client and Contractor.

QA Audits and Reviews

15.1 Internal QA Audits

- The PMC shall conduct site QA audits at minimum monthly frequency, or as triggered by NCRs.
- Audit findings shall be recorded and distributed to all parties within 5 working days.

15.2 Site Meetings

- Weekly site progress and quality meetings shall be held: Contractor, PMC, and Design Consultant.
- Minutes shall be distributed within 3 working days and actions tracked to closure.

15.3 QA Plan Review

This QA Plan shall be reviewed and updated if: (a) significant change to scope or design; (b) major NCR reveals systemic quality issue; (c) PMC or Client requests formal review; (d) at project midpoint.

Health, Safety and Environmental Considerations

16.1 Interface with HSE Plan

- Concrete works: Safe systems for formwork and falsework; confined space entry for tank work.
- Reinforcement works: Manual handling, sharps management, cut and bend area safety.
- Chemical dosing installation (WTP): COSHH assessment for dosing chemicals; MSDS review on site at all times.
- Pressure testing: Exclusion zones during hydrostatic and pneumatic testing; pressure test supervisor present.
- Blower and mechanical installation (STP): Noise assessment (≤85 dBA at 1m); PPE (hearing protection) required in blower room.
- Electrical testing: Permit-to-work system; only qualified electricians to perform IR and continuity tests.

16.2 Environmental Management

- Concrete washout: Designated areas away from water bodies; no washout to site drainage or watercourses.
- STP construction: Temporary bypass of existing sewage managed under a separate environmental control plan.
- WTP construction: Protection of existing production tubewells from contamination during construction.
- Chemical storage: All dosing agents stored in bunded areas with secondary containment.
- Effluent disposal during testing: Treated test water from hydraulic tests to approved discharge point.

Comprehensive MEP Design for STP

Client:

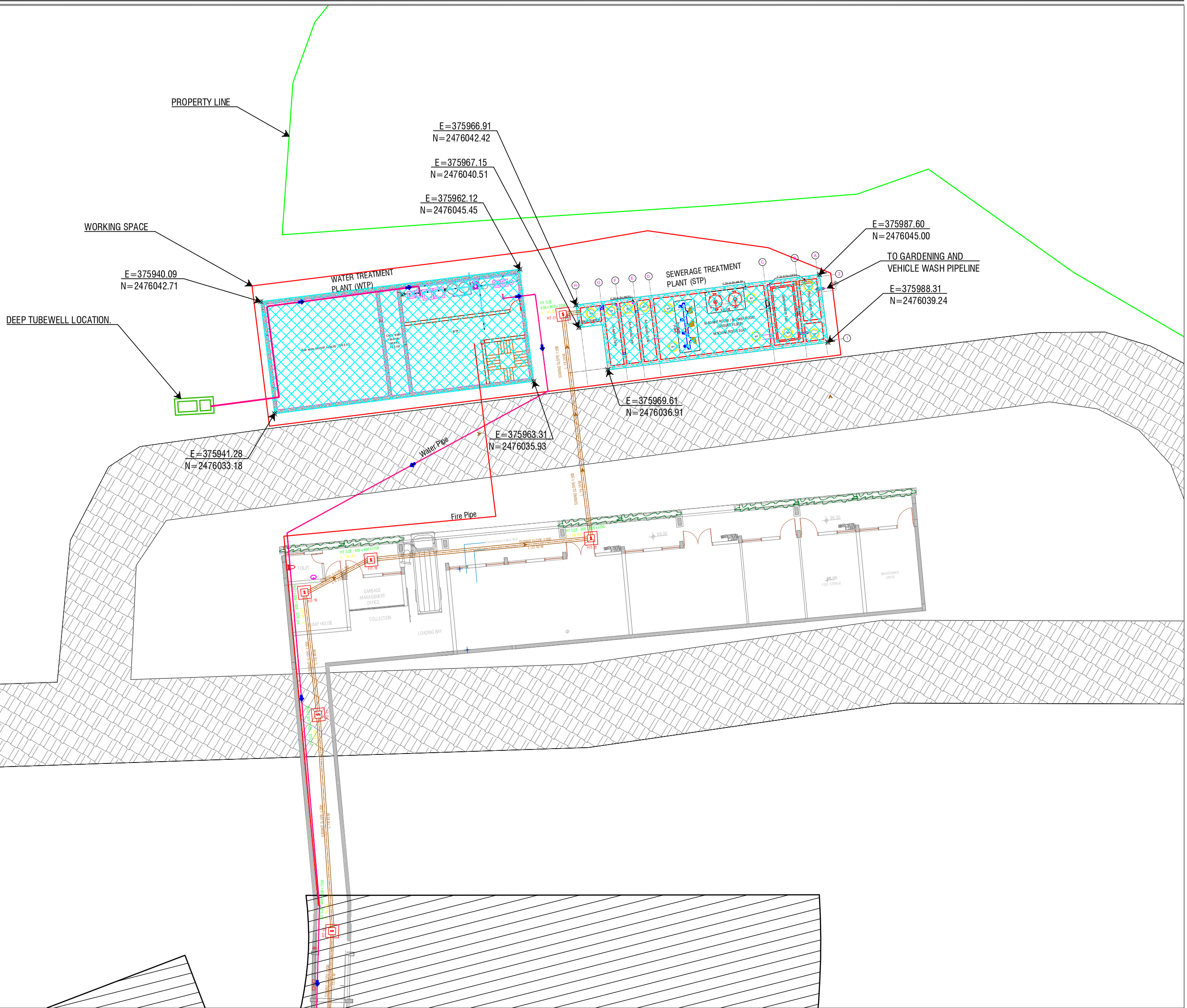
Asian University For Women

PMC:

SURBANA JURONG

Real impact,
made together.

AUW WTP, STP & UGWR DESIGN PROJECT			
TABLE OF CONTENT			
S/N	DRAWING TITLE	DRAWING NUMBER	REVISION
1	WTP & STP SITE LAYOUT PLAN	AUW-PD-01	5
2	GENERAL ARRANGEMENT PLAN AT THREE DIFFERENT LEVEL AT (+99.50,+98.50,+96.40)	AUW-PD-02	5
3	GA DWAWING OF STP(ABOVE GROUNG PLAN & SECTION A-A)	AUW-PD-03	5
4	GA DWAWING OF STP PIPE LINE(BELOW GROUNG PLAN & SECTION A-A)	AUW-PD-04	5
5	GA DWAWING OF STP (ABOVE GROUNG PLAN & SECTION A-A)	AUW-PD-05	5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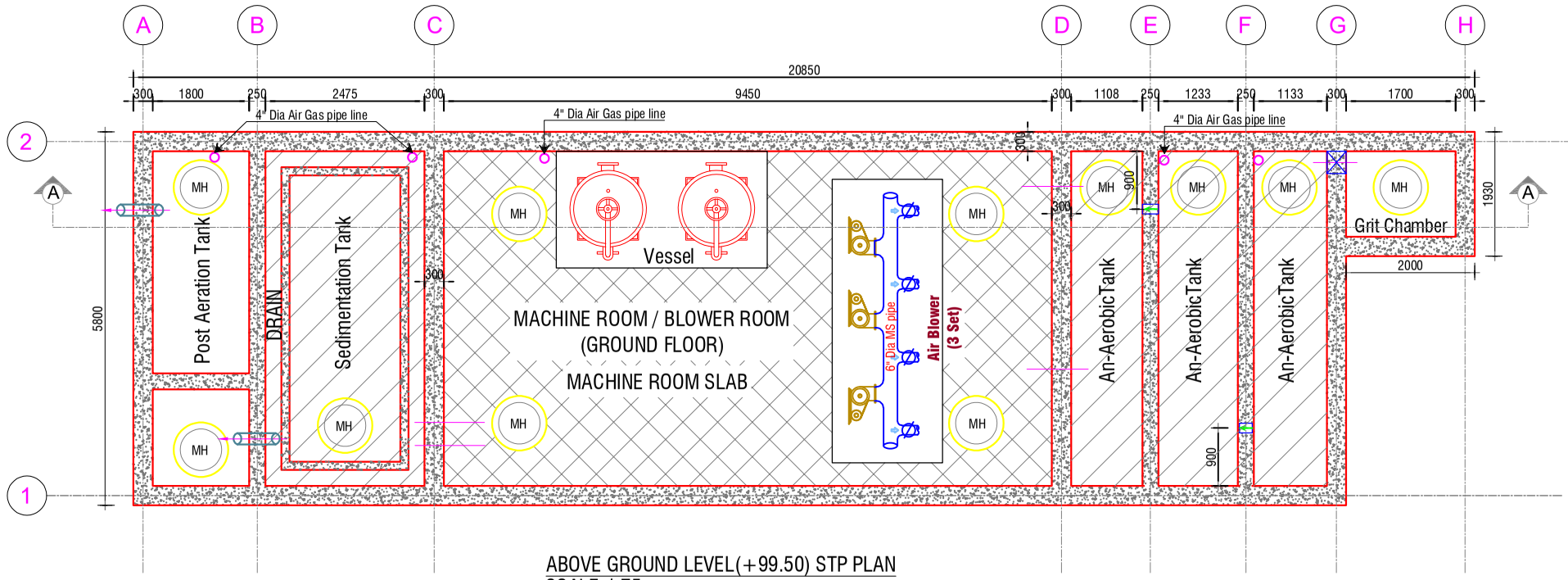
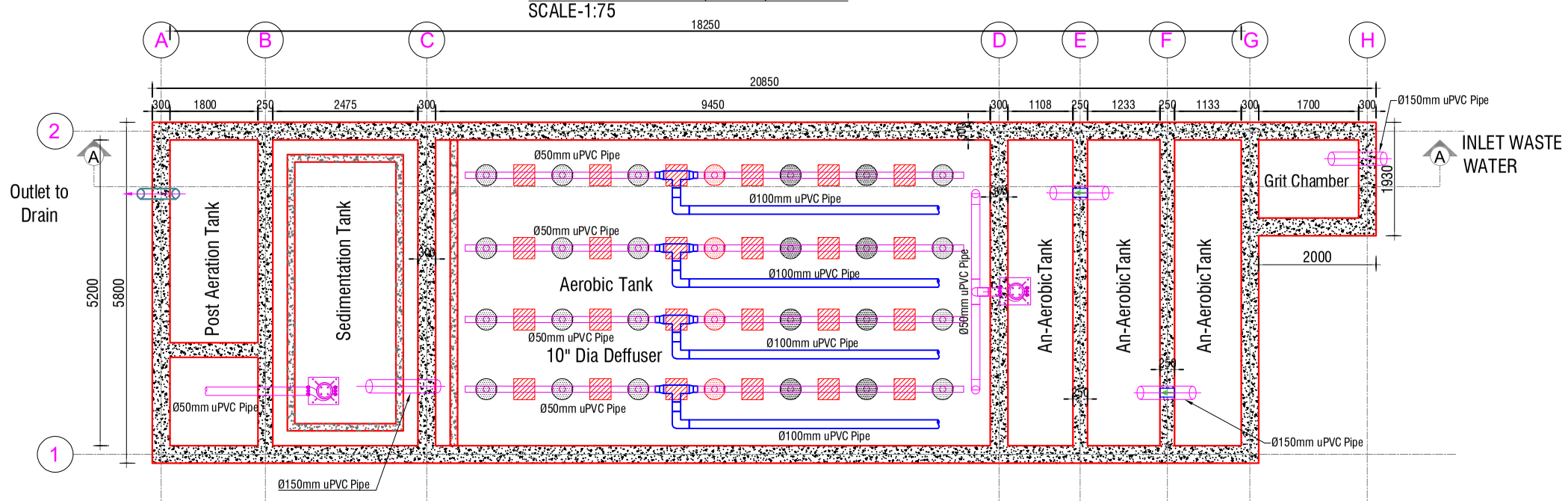
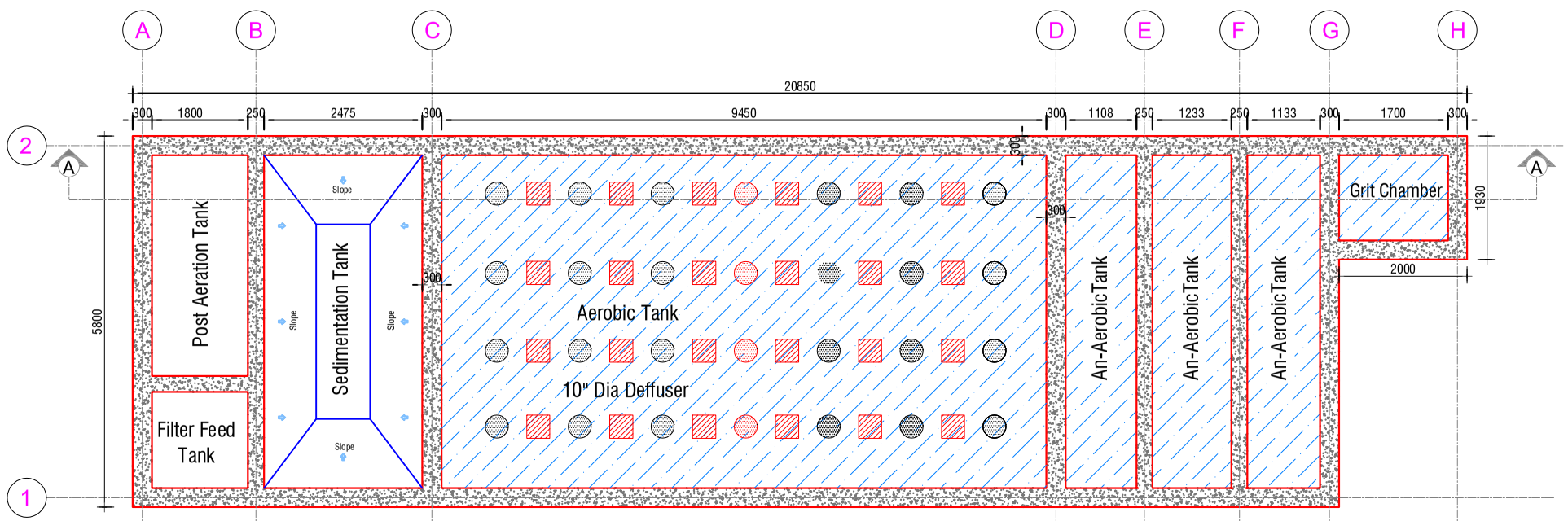
E=375966.91
N=2476042.42
E=375967.15
N=2476040.51
E=375962.12
N=2476045.45
WORKING SPACE
E=375940.09
N=2476042.71
DEEP TUBEWELL LOCATION.
WATER TREATMENT PLANT (WTP)
SEWERAGE TREATMENT PLANT (STP)
E=375987.60
N=2476045.00
TO GARDENING AND VEHICLE WASH PIPELINE
E=375988.31
N=2476039.24
E=375969.61
N=2476036.91
E=375963.31
N=2476035.93
E=375941.28
N=2476033.18
Water Pipe
Fire Pipe
TOILET
GARBAGE MANAGEMENT OFFICE
COLLECTION
LOADING BAY
PUMP HOUSE
FUEL STORAGE
MAINTENANCE OFFICE



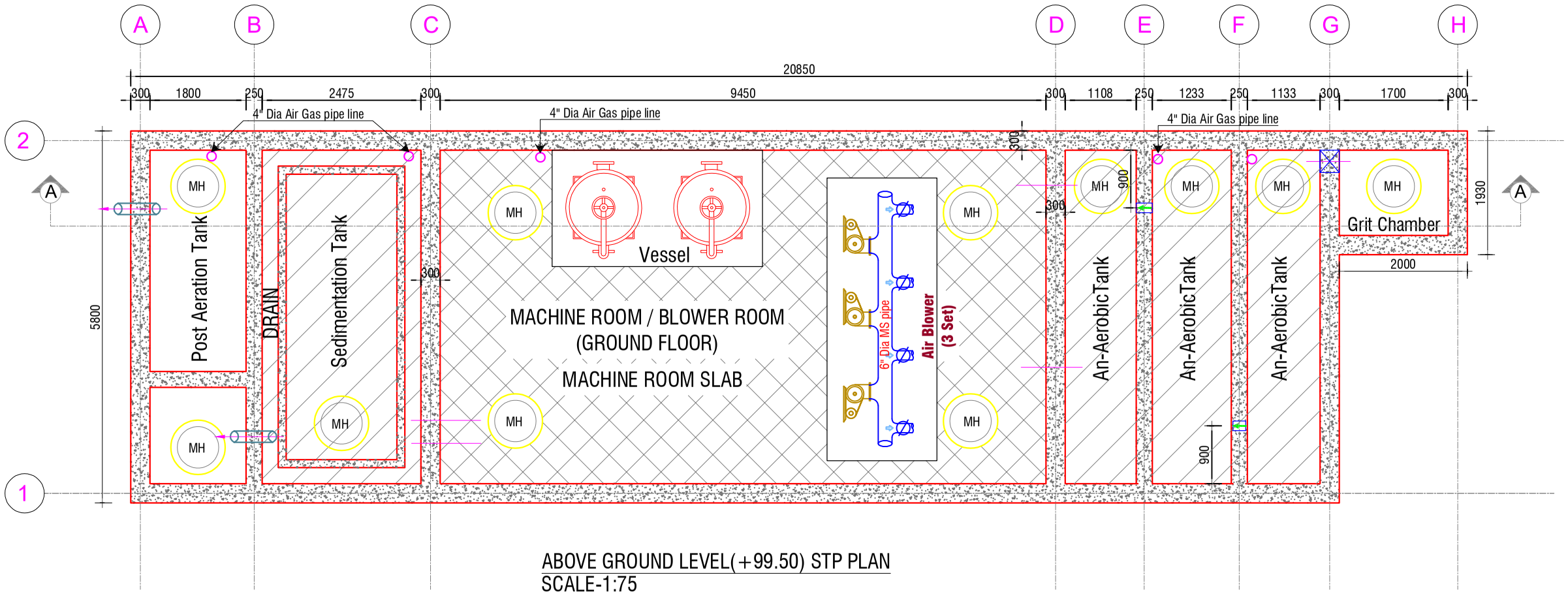
ABOVE GROUND LEVEL(+99.50) STP PLAN
SCALE-1:75



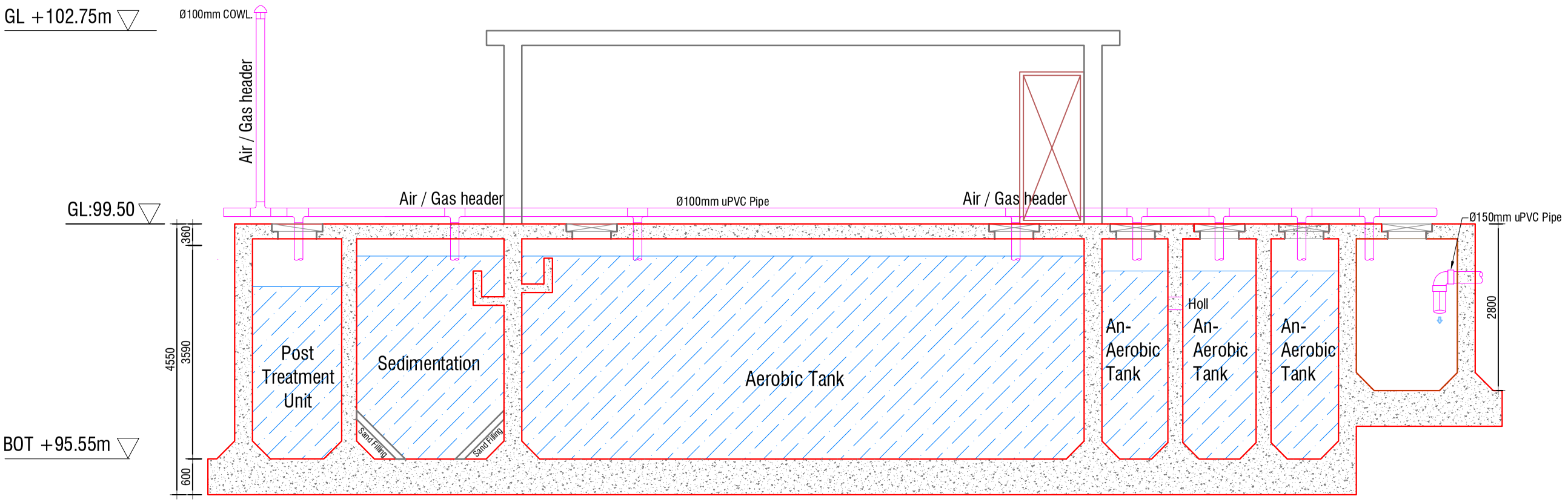
BLEOW GROUND LEVEL AT(+98.50) STP PIPE LINE PLAN
SCALE-1:75



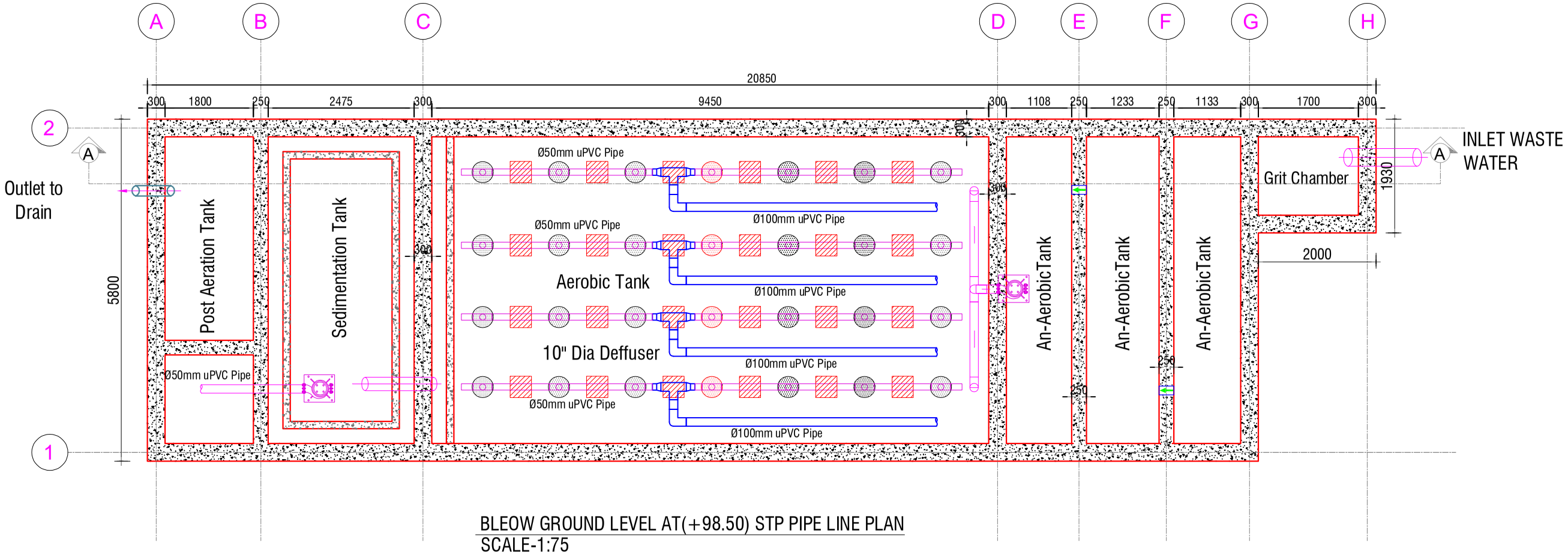
BLEOW GROUND LEVEL AT(+96.40) STP PLAN
SCALE-1:75



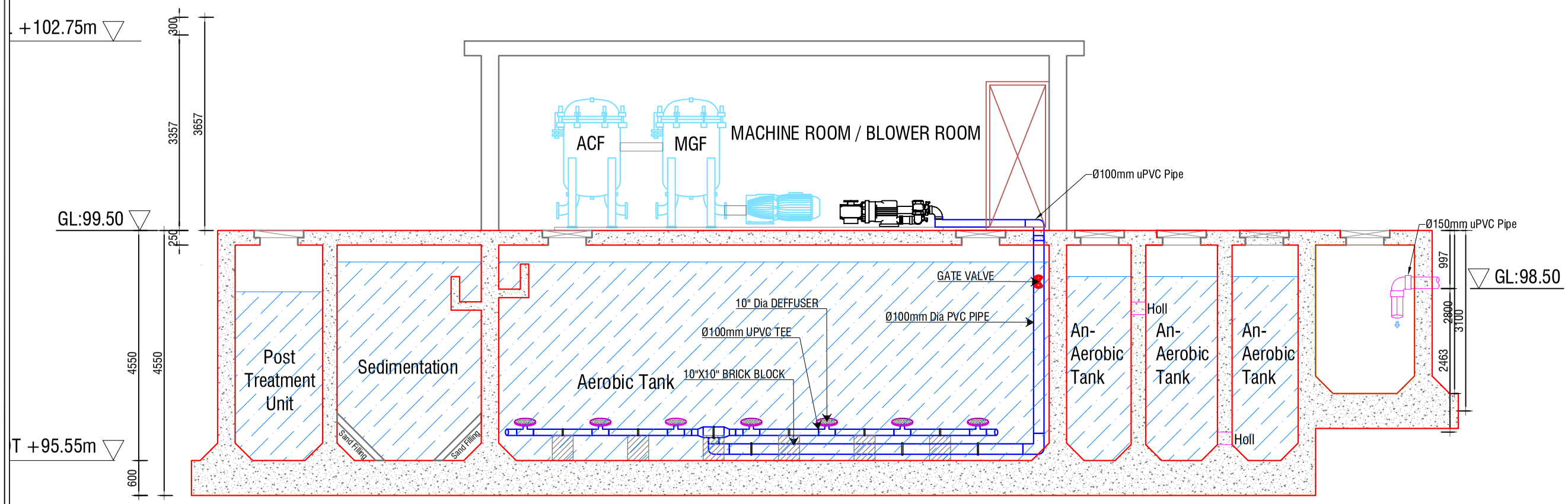
ABOVE GROUND LEVEL(+99.50) STP PLAN
SCALE-1:75



SECTION:A-A
SCALE-1:75



BLEOW GROUND LEVEL AT(+98.50) STP PIPE LINE PLAN
SCALE-1:75



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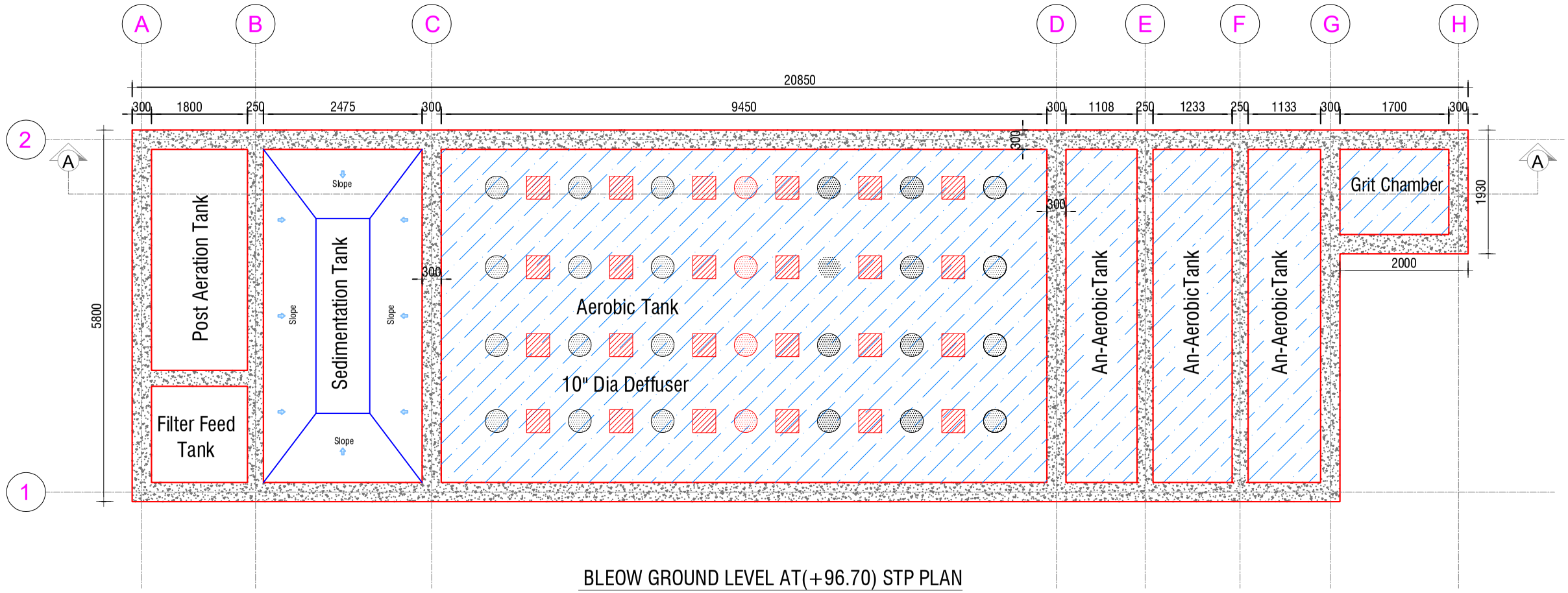
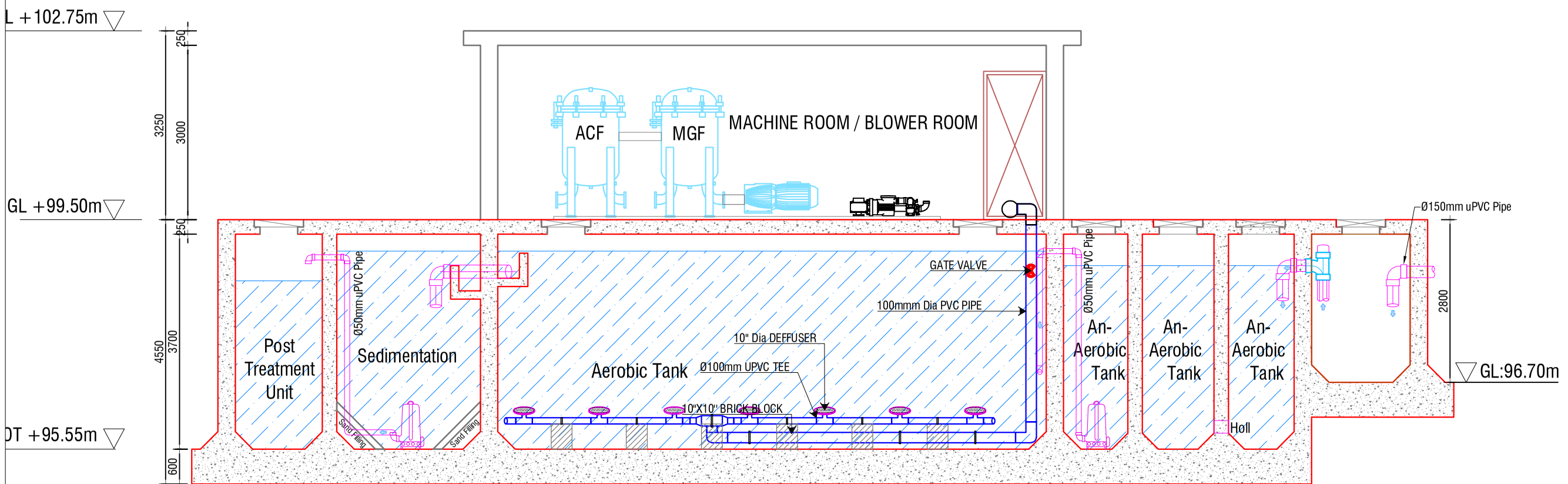
SCALE-1:75



BLEOW GROUND LEVEL AT(+96.70) STP PLAN
SCALE-1:75



SECTION:A-A
SCALE-1:75

Comprehensive Civil Design for STP

Client:

Asian University For Women

ASIAN UNIVERSITY FOR WOMEN

PMC:

SURBANA JURONG

SJ Real impact, made together.

AUW WTP, STP & UGWR DESIGN PROJECT			
TABLE OF CONTENT			
S/N	DRAWING TITLE	DRAWING NUMBER	REVISION
1	GENERAL NOTE-01	AUW-PDR-001	5
2	GENERAL NOTE-02	AUW-PDR-002	5
3	REINFORCEMENT PLAN OF BOTTOM SLAB (LEVEL AT +95.55m), (LEVEL AT +96.70Mm & GROUND SLAB (LEVEL AT +99.50m)	AUW-PDR-003	5
4	REINFORCEMENT PLAN OF WALL & GROUND SLAB MANHOLE OPENING (LEVEL AT +99.50m)	AUW-PDR-004	5
5	REINFORCEMENT DETAIL OF TOP ROOF SLAB LEVEL AT 102.75m & SECTION A-A & B-B	AUW-PDR-005	5

GENERAL STRUCTURAL NOTES

1. GENERAL

a. ULTIMATE STRENGTH DESIGN METHOD IS USED AS PER BANGLADESH NATIONAL BUILDING CODE (BNBC 2020), ASCE 7-05 AND ACI 318-08 .ALL THE STRUCTURAL DRAWINGS SHALL BE READ IN CONJUNCTION WITH RELEVANT ARCHITECTURAL & MEP DRAWINGS.

b. FOLLOW BNBC 2020 FOR SPECIFICATIONS/STRUCTURAL REQUIREMENTS NOT MENTIONED IN THE DRAWINGS OR IN THIS NOTE SHEET .

c. ANY DETAILS NOT SHOWN IN THE DRAWING SHOULD BE DONE ACCORDING TO ACI DETAILING MANUAL.

d. BASIC WIND SPEED = 80 m/s

e. SEISMIC ZONE -3

f. OTHER LOADS AS PER BNBC 2020, ASCE 7-05

2. MINIMUM LIVE LOADS AS PER BNBC 2020, ASCE 7-05

3. FOUNDATION

a. FOOTING FOUNDATION .

4. CONCRETE :

a. CONCRETE 28 DAYS COMPRESSIVE STRENGTH CONSIDERED AS FOLLOWS :

- FOR ALL , f'c = MINIMUM 35 MPa
- WHICH ARE TO BE CONFORMED BY TRIAL MIX DESIGN.

b. MINIMUM CYLINDER STRENGTH: BASED ON CYLINDER TEST OF

- DIAMETER, D = 100mm & HEIGHT, H = 150mm.

c. CURING OF R.C.C WORK :

- CURING TIME MINIMUM 21 DAYS
- METHOD OF CURING :
- HORIZONTAL SURFACE - BY PONDING OF WATER
- OTHER SURFACES-BY WRAPPING MOIST JUTE FABRIC AND
- SPRINKLING WATER BY HOSE PIPE FREQUENTLY.

5. STEEL REINFORCEMENT

d. COLUMN, WALLS & BEAM REINFORCEMENTS ARE OF 500MPa HIGH STRENGTH DEFORMED BAR MADE FROM BILLET STEEL.

e. SLAB, WATER TANK, STAIR, LINTEL ETC. REINFORCEMENTS ARE OF 500MPa HIGH DEFORMED BAR MADE FROM BILLET STEEL.

f. YIELD STRENGTH OF STEEL fy = 500.0 MPa CONFORMED TO ONE OF THE FOLLOWING SPECIFICATIONS :i) BDS 1313 : 1991, ii) ASTM A615M.

g. THE FOLLOWING TESTS FOR REINFORCING BARS FROM RANDOM SAMPLES SHALL BE CONDUCTED AT BUET,CUET OR ANY OTHER RECOGNISED INSTITUTE AS PER BDS 1313 : 1991 AND TEST RESULT SHALL BE SUBMITTED TO THE ENGINEER FOR CHEECKING AND RECORD :

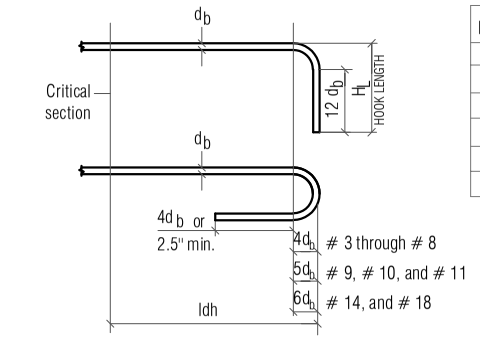
- TENSILE STRENGTH TEST
- PERCENTAGE ELONGATION TEST.
- BEND/REBEND TEST STRUCTURAL STEEL MEMBERS SHALL BE CONFIRMING TO ASTM A36/A36-M

6. LAP LENGTH

UNLESS OTHERWISE MENTIONED IN THE DRAWINGS, LAP LENGTH (Ld) OF BARS SHALL BE :

BAR DIA (mm)	TENSION (mm)	COMPRESSION (mm)
10	400	300
12	480	360
16	640	480
20	990	600
25	1240	750
28	1380	840
32	1580	960
35	1730	1050
40	1980	1200

COLUMN/ SHEAR WALL LAPS MUST BE TENSION LAPS



BAR DIA	HOOK LENGTH, H_L
10	175 mm
12	200 mm
16	250 mm
20	325 mm
25	400 mm
28	450 mm

7. HOOKS OF REBAR

a) FOR ALL RE-BAR : PROVIDE 90° STANDARD HOOKS (L-BENT) IF NOT SHOWN IN THE DRAWINGS.

8. SPACER BARS

TO SUPPORT SECOND LAYER BARS IN BEAMS USE 25Ø SPACER BARS @ 1000 C/C WHERE REQUIRED.

9. CHAIRS

USE CHAIRS OF NECESSARY DIMENSION MADE OF 20Ø BAR TO SUPPORT TOP BARS OF MAT @ 1150 C/C.

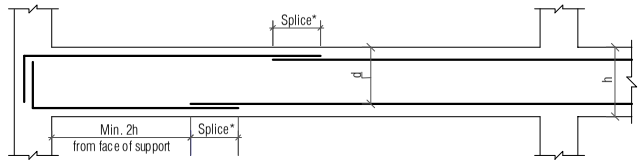
10. LAP LOCATION :

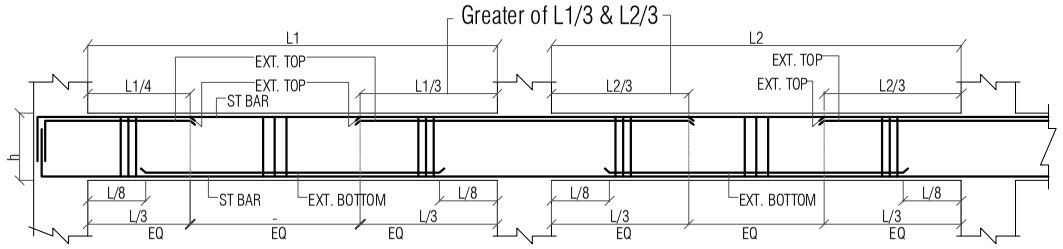
a) FOR BEAM BOTTOM BAR, LAP NOT TO BE PROVIDED AT MIDDLE THIRD ZONE OF THE SPAN

b) FOR BEAM TOP BAR, LAP MAY BE PROVIDED AT MIDDLE THIRD ZONE OF THE SPAN

c) NOT MORE THAN 50% OF THE BARS SHALL BE SPLICED AT ONE PLACE

d) LAP SPLICES ARE TO BE CONFINED BY HOOPS WITH MAXIMUM SPACING OR PITCH OF d/4 OR 100 WHERE d IS THE EFFECTIVE DEPTH OF THE BEAM.





TYPICAL SECTION OF BEAM LONG SECTION (IF NOT MENTIONED IN THE DETAILS)

11. DEVELOPMENT LENGTH

ALL BEAM AND SLAB REBARS SHOULD BE EXTENDED INTO THE SUPPORT UPTO DEVELOPMENT LENGTH.

12. ALL ADMIXTURE

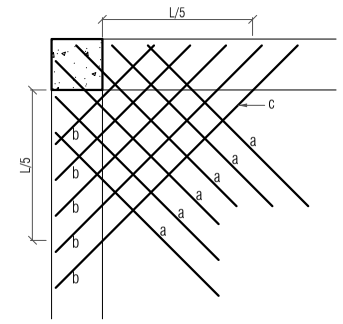
APPROVAL BY THE ENGINEER IN CHARGE.

13. WATER STOPPER

225mm WIDE PVC WATER STOPPER TO BE USED AT ALL CONSTRUCTION JOINTS BELOW GROUND IN MAT, RETAING WALL & WATER TANK WALL.

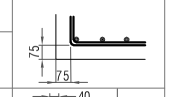
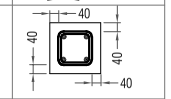
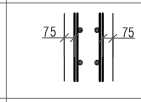
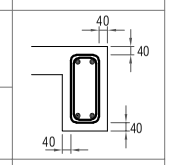
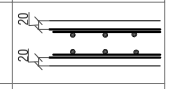
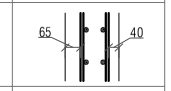
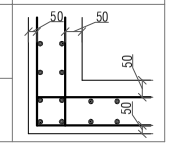
14. CORNER REINFORCEMENT ('CR')

CORNER REINFORCEMENT FOR BEAM SUPPORTED 2-WAY SLABS



L = LONGER CLEAR SPAN
a = TOP BARS
b = BOTTOM BARS
a = c
SPACING OF CORNER BARS = SPACING OF MAXIMUM POSITIVE BARS

15. CONCRETE CLEAR COVER FOR REINFORCING BARS

Member	Location/Condition	Clear Cover (mm)	Figure
PC/MAT/FOOTING	Side	75	
	Bottom	75	
Column	Above Mat	* 40	
Wall	Above Mat	* 75	
Floor Beam	top, side	** 40	
	bottom	** 40	
Slab and stair	Top and bottom	20	
Retaining Wall	Exterior	65	
	Interior	40	
Water tank	Water face	50	
	Other face	50	

* From tie
** From stirrups

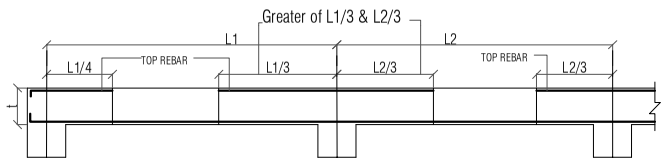
17. MAXIMUM BARS IN BEAMS IN SINGLE LAYER

MAXIMUM NUMBER OF BARS AS A SINGLE LAYER IN BEAM STEM SHALL BE AS PER ACI DETAILING MANUAL.

18. MINIMUM BAR SPACING OF COLUMN LONGITUDINAL BARS

CLEAR DISTANCE BETWEEN LONGITUDINAL BARS SHALL NOT BE LESS THAN 1.5 TIMES BAR DIAMETER, 1.5 TIMES OF THE MAXIMUM SIZE OF COARSE AGGREGATE NOR 40mm.

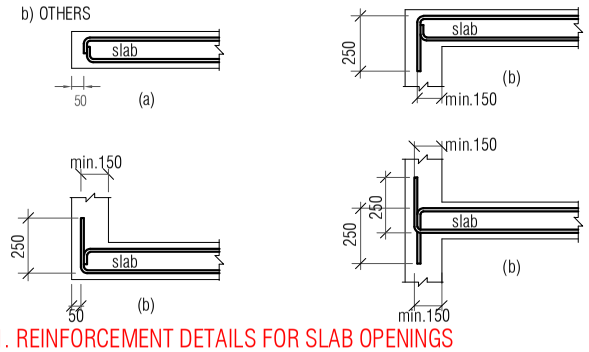
19. SLAB REINFORCING DETAILS



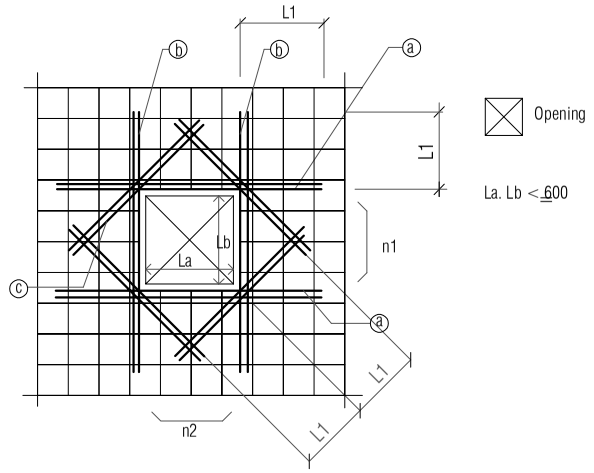
20. SLAB END REINFORCING DETAILS

a) FREE END OF SLAB INCAPABLE OF EMBEDDING OF STEEL BAR IN BEAM/WALL

b) OTHERS



21. REINFORCEMENT DETAILS FOR SLAB OPENINGS



n1,n2 : The number of bars which are cut off for opening

Ⓐ The number of extra bars > n1/2 (top and bott bars)

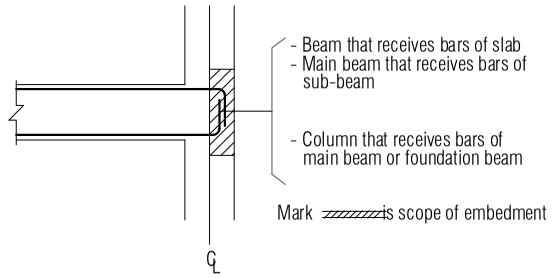
Ⓑ The number of extra bars > n2/2 (top and bott bars)

Ⓒ The number of extra bars = 2-D12 (top and bott bars)

22. RECOMMENDED END HOOKS

Bar hook	Form and Extention	Bend Angle (degree)	Bend Radius (r)	Used Bar	Location
Primary reinf.	db, r, 4db	180°	r = 4db	6 to 25	Lap splice end of anchorage
Tie/stirrups	db, 6db>75mm	135°	r = 1.25db	6 to 12	Stirrups fastening bar diagonal hoop
Primary reinf.	db, 12db	90°	r = 4db	6 to 25	Bend-up for embedment
			r = 5db	28 to32	
Slab	db	45°	r = 5db	8 to 20	Bend bar in slab

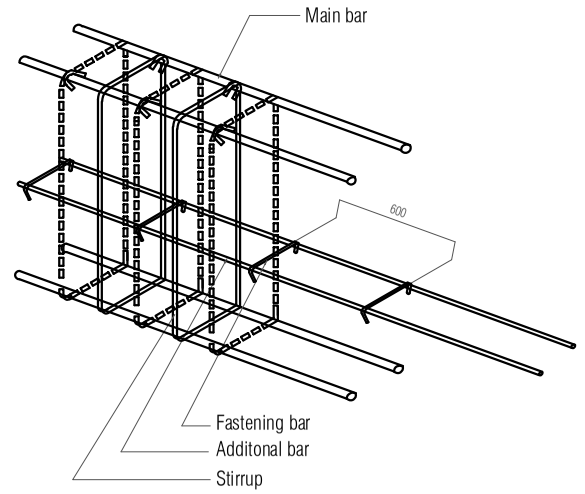
23. SCOPE OF EMBEDMENT



24. OPENING IN R.C.C. WALLS

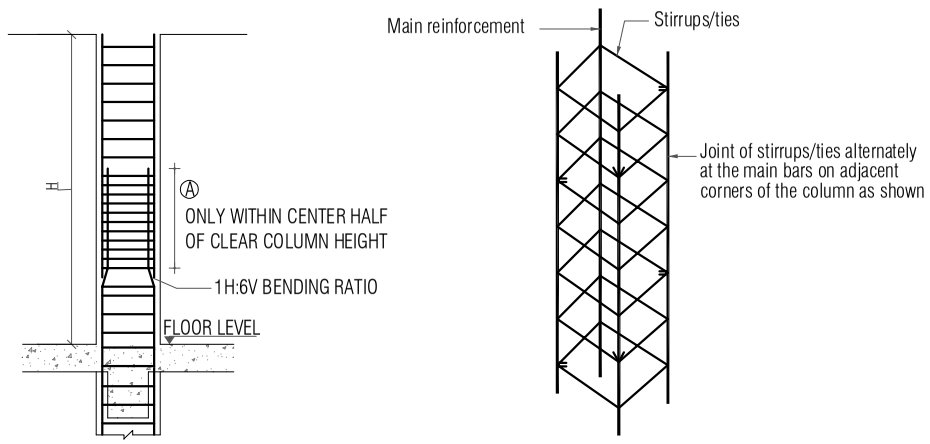
NOT LESS THAN THREE NO. 20Ø BARS SHALL BE PROVIDED AROUND ALL DOOR AND WINDOW OPENINGS IN R.C.C. WALLS. THE BAR SHALL BE EXTENDED BEYOND THE CORNERS OF THE OPENINGS TO A DISTANCE EQUAL TO THE DEVELOPMENT LENGTH BUT NOT LESS THAN 600.

25. END HOOK OF STIRRUPS



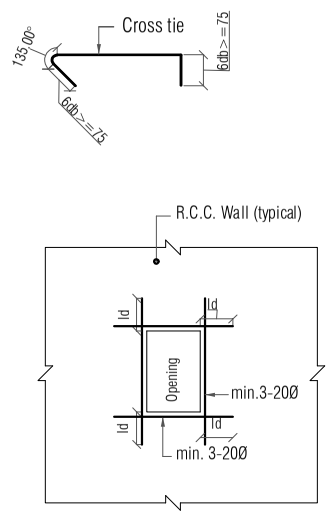
END HOOKS OF STIRRUPS ARE LOCATED ALTERNATELY AT TOP CORNER BAR OF THE SECTION.

26. COLUMN SPLICE LOCATION

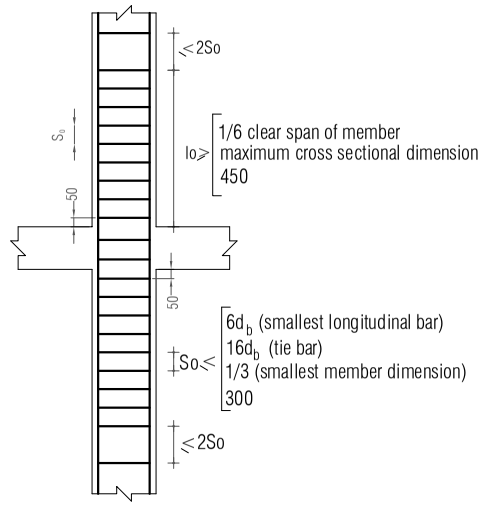


Ⓐ IS AREA FOR SPLICE OF COLUMN REINFORCEMENT. MAXIMUM 50% OF TOTAL BAR IS SPLICED AT ONE LEVEL.

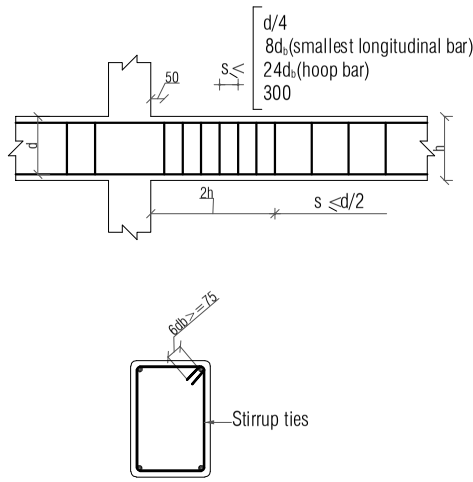
H = CLEAR COLUMN HEIGHT

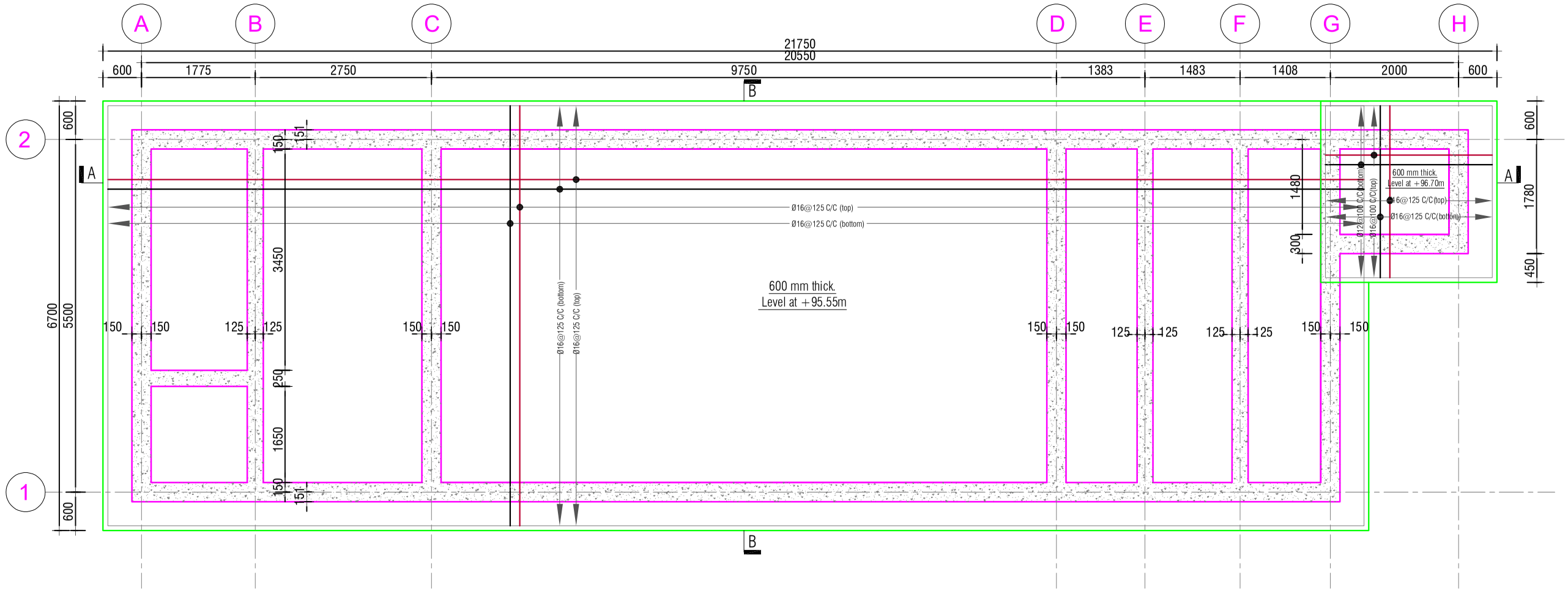


27. CONFINEMENT REQUIREMENTS OF COLUMN AT JOINTS FOR EARTHQUAKE LOADING

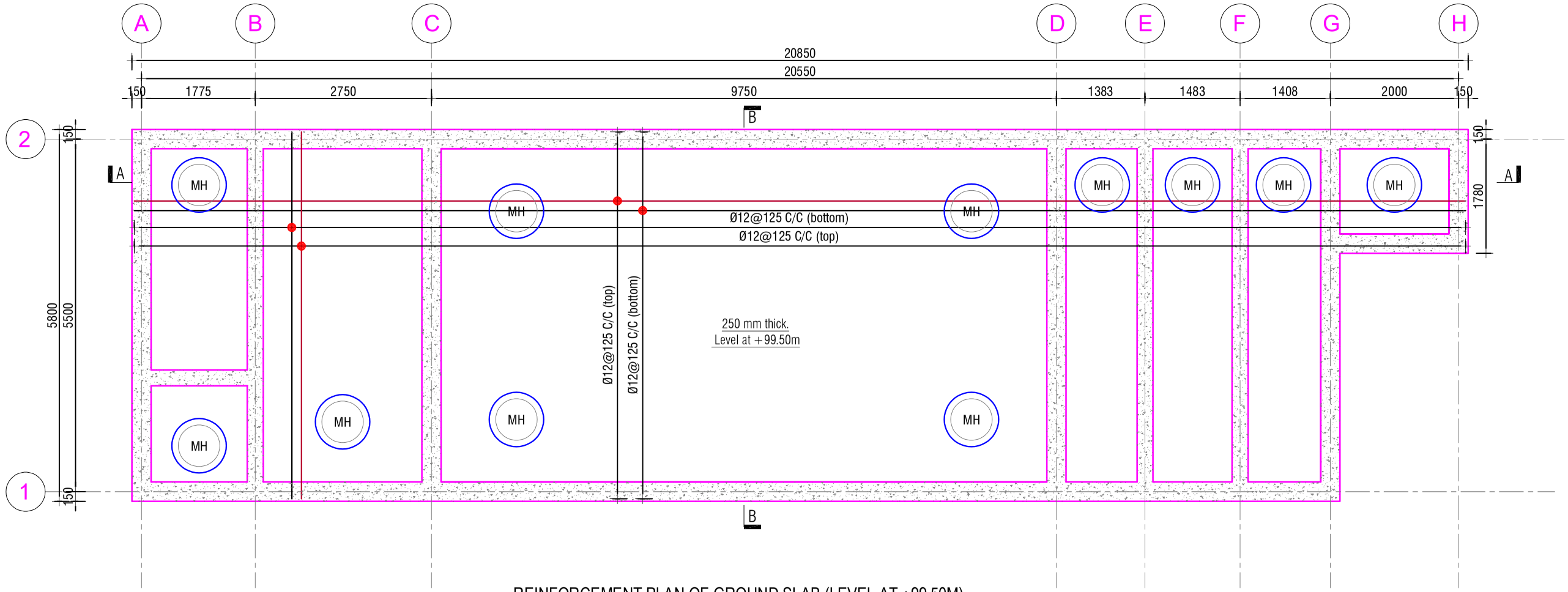


28. CONFINEMENT REQUIREMENTS OF BEAM AT JOINTS FOR EARTHQUAKE LOADING

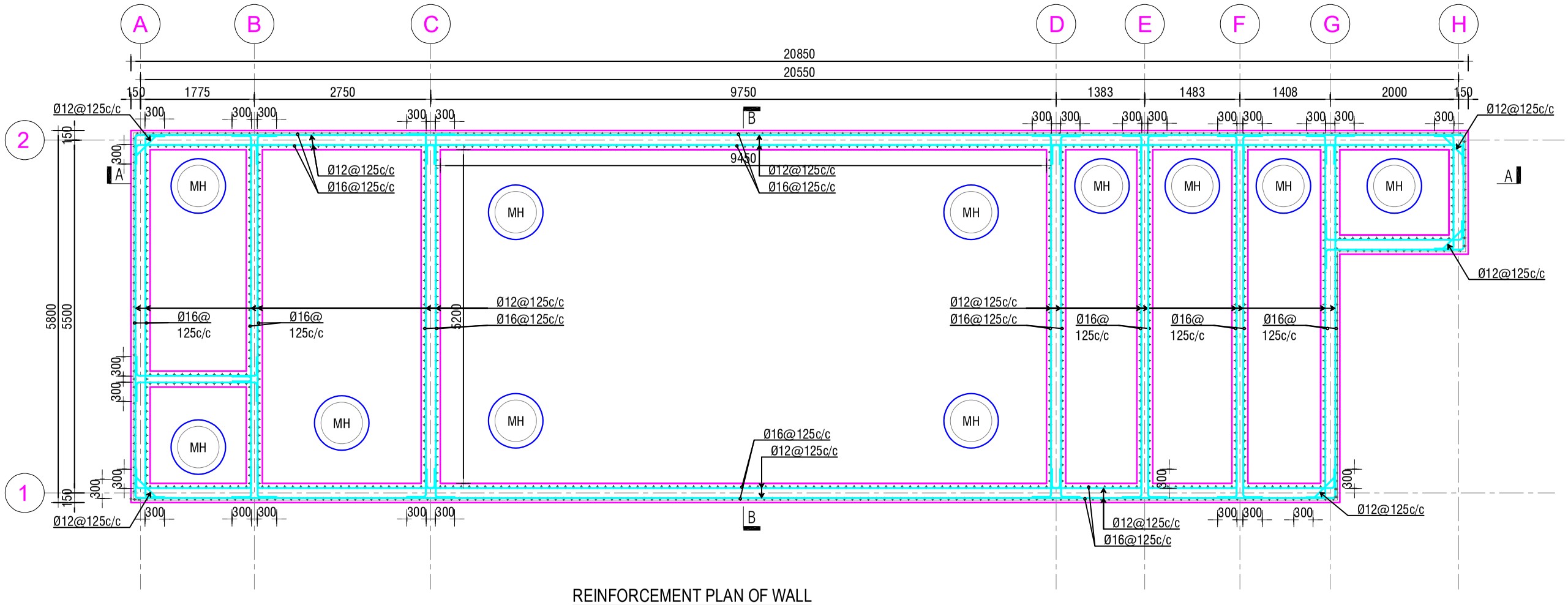




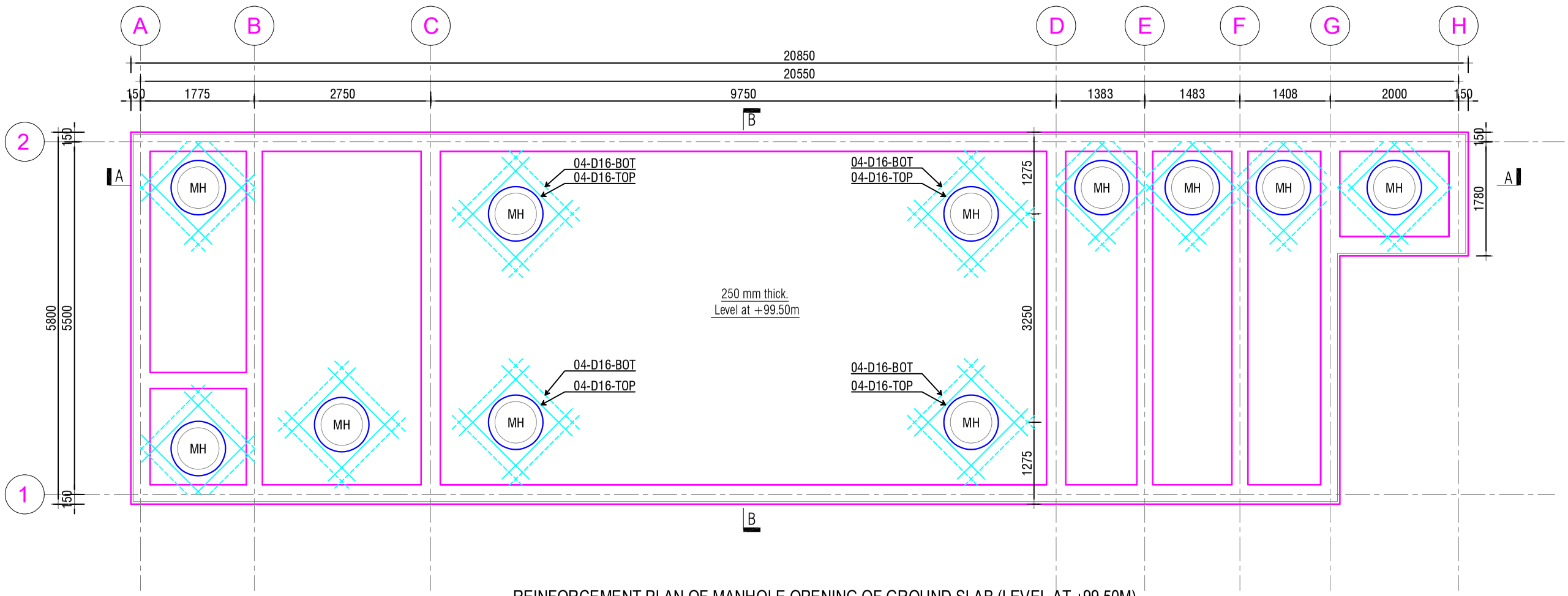
REINFORCEMENT PLAN OF BOTTOM SLAB (LEVEL AT +95.55m) & (LEVEL AT +96.70m)
SCALE-1:75



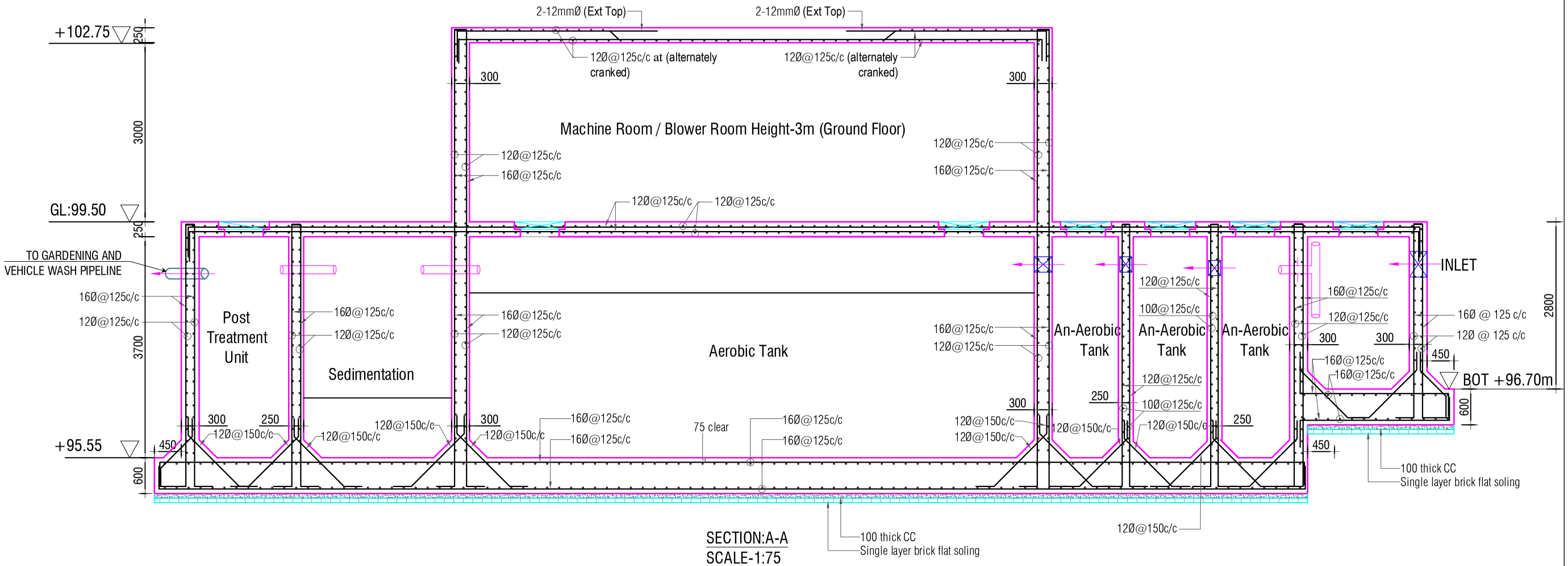
REINFORCEMENT PLAN OF GROUND SLAB (LEVEL AT +99.50M)
SCALE-1:75

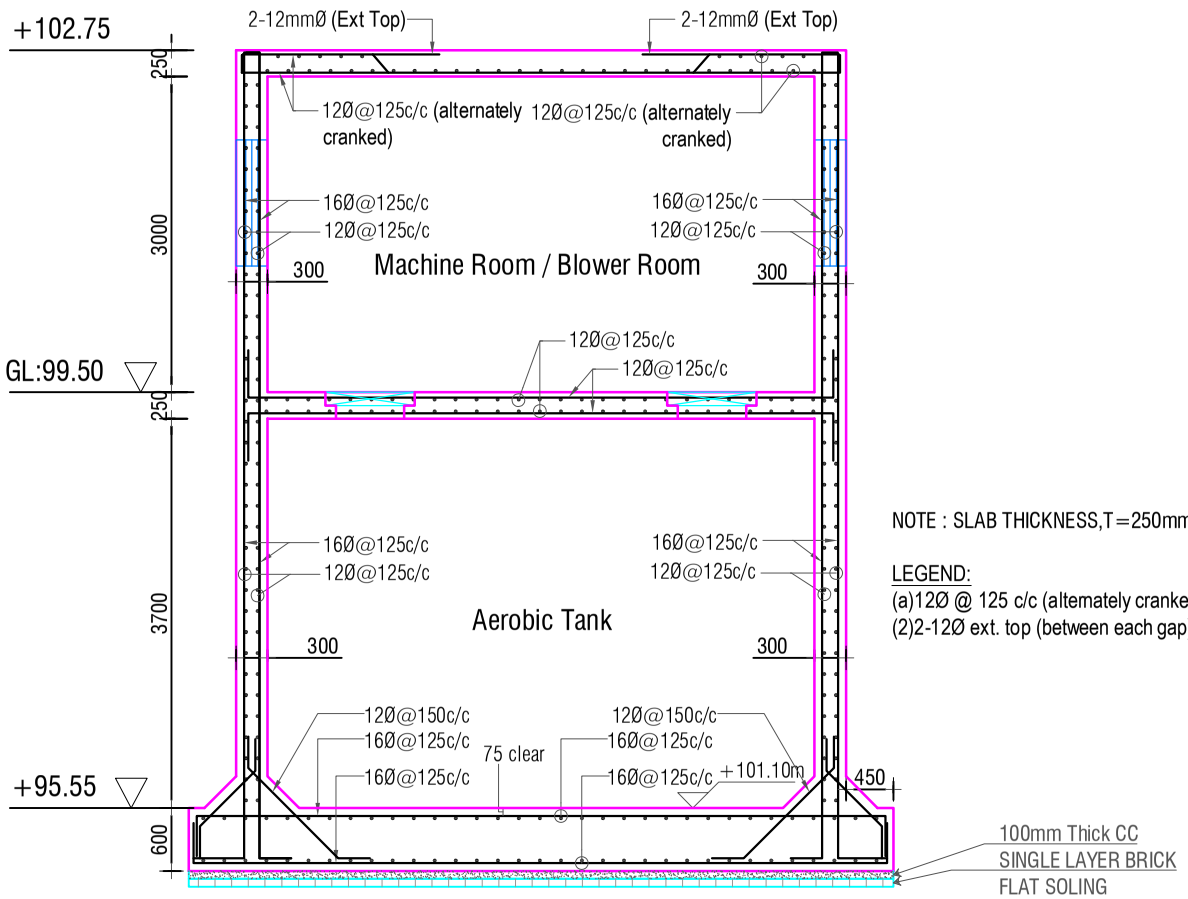


REINFORCEMENT PLAN OF WALL
SCALE-1:75



REINFORCEMENT PLAN OF MANHOLE OPENING OF GROUND SLAB (LEVEL AT +99.50M)
SCALE-1:75

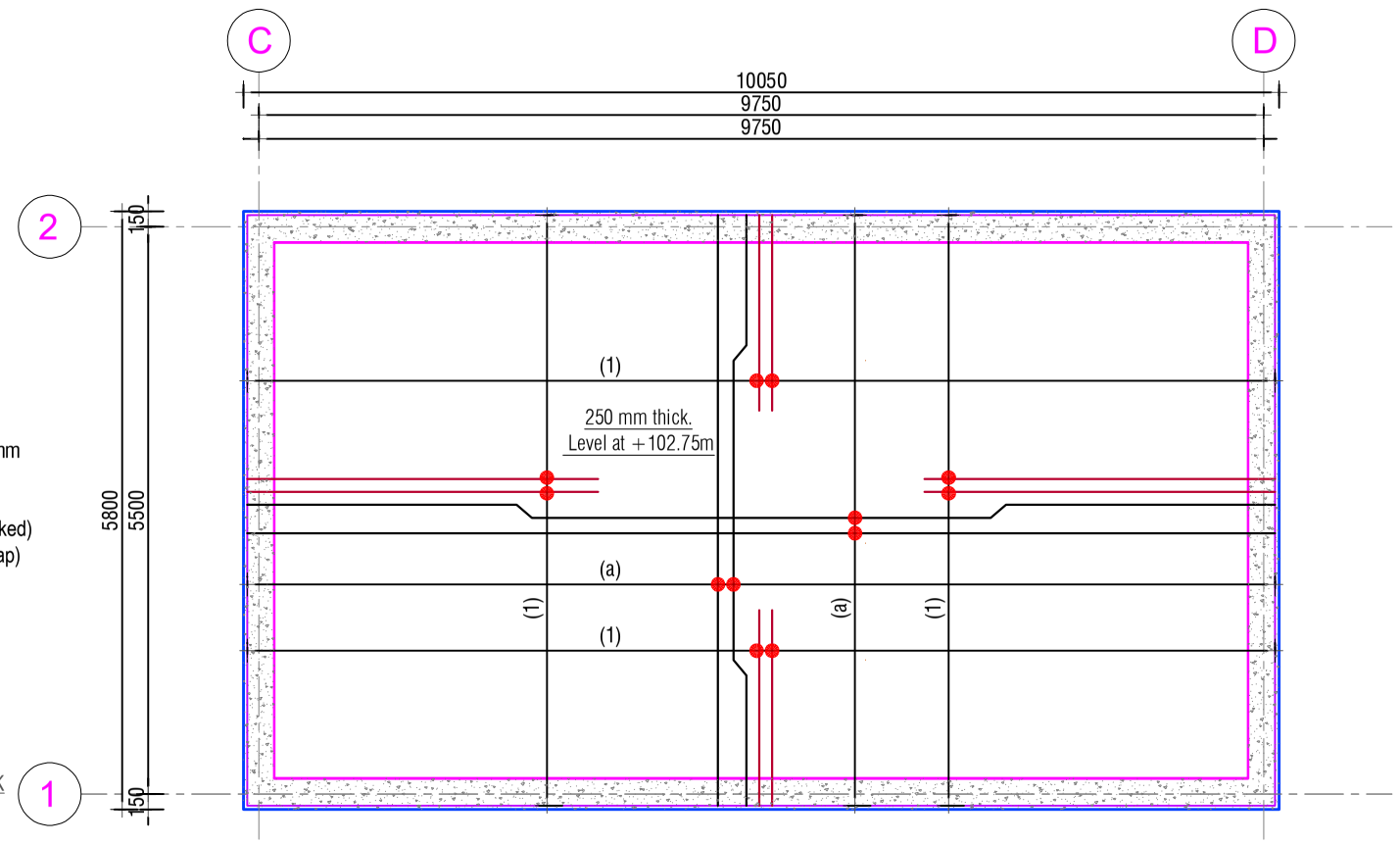




NOTE : SLAB THICKNESS,T=250mm

LEGEND:
(a)12Ø @ 125 c/c (alternately cranked)
(2)2-12Ø ext. top (between each gap)

SECTION:B-B
SCALE-1:75



REINFORCEMENT PLAN OF ROOF SLAB (LEVEL AT +102.75m)
SCALE-1:75

Comprehensive Civil Design for WTP, and UGWR (FIRE)

Client:

Asian University For Women

ASIAN UNIVERSITY FOR WOMEN

PMC:

SURBANA JURONG

SJ Real impact, made together.

AUW WTP, STP & UGWR DESIGN PROJECT			
TABLE OF CONTENT			
S/N	DRAWING TITLE	DRAWING NUMBER	REVISION
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2	GENERAL NOTE-02	AUW-PDR-02	5
3	REINFORCEMENT DETAILS OF LINTEL, PARAPET, DROP WALL	AUW-PDR-3	5
4	REINFORCEMENT PLAN OF BOTTOM SLAB (LEVEL AT +91.85M) & DETAILS	AUW-PDR-4	5
5	REINFORCEMENT PLAN OF BOTTOM SLAB (LEVEL AT +91.85M)	AUW-PDR-5	5
6	REINFORCEMENT PLAN OF RCC WALL & BOTTOM SLAB (LEVEL AT +91.85M)	AUW-PDR-6	5
7	PLAN OF ROOF SLAB,RCC WALL & ROOF BEAM LAYOUT PLAN (LEVEL AT +96.20M)	AUW-PDR-7	5
8	REINFORCEMENT DETAILS OF ROOF BEAM (LEVEL AT +96.20M)	AUW-PDR-8	5
9	PLAN OF ROOF SLAB,RCC WALL & ROOF BEAM LAYOUT PLAN (LEVEL AT +96.20M)	AUW-PDR-9	5
10	REINFORCEMENT PLAN OF ROOF SLAB ,RCC WALL & ROOF BEAM LAYOUT PLAN (LEVEL AT +96.20M)	AUW-PDR-10	5
11	REINFORCEMENT PLAN OF ROOF SLAB & ROOF BEAM LAYOUT PLAN (LEVEL+101.75m)	AUW-PDR-11	5
12	REINFORCEMENT PLAN OF ROOF SLAB & ROOF BEAM LAYOUT PLAN (LEVEL+99.50m)	AUW-PDR-12	5
13	REINFORCEMENT DETAILS OF ROOF BEAM (LEVEL AT +99.50M)	AUW-PDR-13	5
14	SECTION: A-A,B-B,C-C & REBAR DETAIL	AUW-PDR-14	5

GENERAL STRUCTURAL NOTES

1. GENERAL
   a. ULTIMATE STRENGTH DESIGN METHOD IS USED AS PER BANGLADESH NATIONAL BUILDING CODE (BNBC 2020), ASCE 7-05 AND ACI 318-08 .ALL THE STRUCTURAL DRAWINGS SHALL BE READ IN CONJUNCTION WITH RELEVANT ARCHITECTURAL & MEP DRAWINGS.
   b. FOLLOW BNBC 2020 FOR SPECIFICATIONS/STRUCTURAL REQUIREMENTS NOT MENTIONED IN THE DRAWINGS OR IN THIS NOTE SHEET .
   c. ANY DETAILS NOT SHOWN IN THE DRAWING SHOULD BE DONE ACCORDING TO ACI DETAILING MANUAL.
   d. BASIC WIND SPEED = 80 m/s
   e. SEISMIC ZONE -3
   f. OTHER LOADS AS PER BNBC 2020, ASCE 7-05

2. MINIMUM LIVE LOADS AS PER BNBC 2020, ASCE 7-05
3. FOUNDATION
   a. FOOTING FOUNDATION .

4. CONCRETE :
   a. CONCRETE 28 DAYS COMPRESSIVE STRENGTH CONSIDERED AS FOLLOWS :
   - FOR ALL , f 'c = MINIMUM 35 MPa
   - WHICH ARE TO BE CONFORMED BY TRIAL MIX DESIGN.

   b. MINIMUM CYLINDER STRENGTH: BASED ON CYLINDER TEST OF
   - DIAMETER, D = 100mm & HEIGHT, H = 150mm.

   c. CURING OF R.C.C WORK :
   - CURING TIME MINIMUM 21 DAYS
   - METHOD OF CURING :
   - HORIZONTAL SURFACE - BY PONDING OF WATER
   - OTHER SURFACES-BY WRAPPING MOIST JUTE FABRIC AND
   - SPRINKLING WATER BY HOSE PIPE FREQUENTLY.

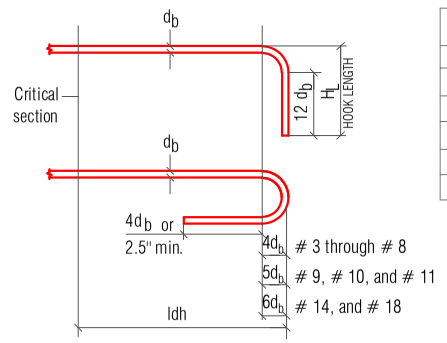
5. STEEL REINFORCEMENT
   d. COLUMN, WALLS & BEAM REINFORCEMENTS ARE OF 500MPa HIGH STRENGTH DEFORMED BAR MADE FROM BILLET STEEL.
   e. SLAB, WATER TANK, STAIR, LINTEL ETC. REINFORCEMENTS ARE OF 500MPa HIGH DEFORMED BAR MADE FROM BILLET STEEL.
   f. YIELD STRENGTH OF STEEL fy = 500.0 MPa CONFORMED TO ONE OF THE FOLLOWING SPECIFICATIONS :i) BDS 1313 : 1991, ii) ASTM A615M.
   g. THE FOLLOWING TESTS FOR REINFORCING BARS FROM RANDOM SAMPLES SHALL BE CONDUCTED AT BUET,CUET OR ANY OTHER RECOGNISED INSTITUTE AS PER BDS 1313 : 1991 AND TEST RESULT SHALL BE SUBMITTED TO THE ENGINEER FOR CHEECKING AND RECORD :
   - TENSILE STRENGTH TEST
   - PERCENTAGE ELONGATION TEST.
   - BEND/REBEND TEST STRUCTURAL STEEL MEMBERS SHALL BE CONFIRMING TO ASTM A36/A36-M

6. LAP LENGTH

UNLESS OTHERWISE MENTIONED IN THE DRAWINGS, LAP LENGTH (Ld) OF BARS SHALL BE :

BAR DIA (mm)	TENSION (mm)	COMPRESSION (mm)
10	400	300
12	480	360
16	640	480
20	990	600
25	1240	750
28	1380	840
32	1580	960
35	1730	1050
40	1980	1200

COLUMN/ SHEAR WALL LAPS MUST BE TENSION LAPS



BAR DIA	HOOK LENGTH, H_L
10	175 mm
12	200 mm
16	250 mm
20	325 mm
25	400 mm
28	450 mm

7. HOOKS OF REBAR

a) FOR ALL RE-BAR : PROVIDE 90° STANDARD HOOKS (L-BENT) IF NOT SHOWN IN THE DRAWINGS.

8. SPACER BARS

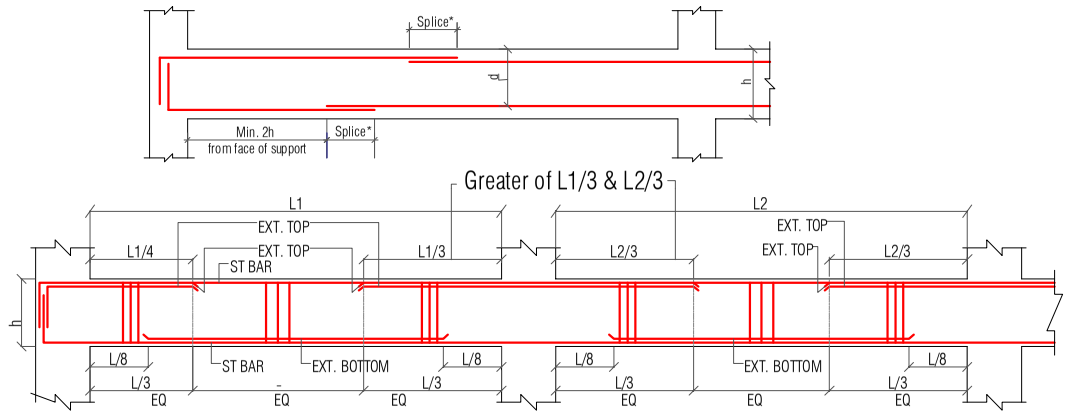
TO SUPPORT SECOND LAYER BARS IN BEAMS USE 25Ø SPACER BARS @ 1000 C/C WHERE REQUIRED.

9. CHAIRS

USE CHAIRS OF NECESSARY DIMENSION MADE OF 20Ø BAR TO SUPPORT TOP BARS OF MAT @ 1150 C/C.

10. LAP LOCATION :

a) FOR BEAM BOTTOM BAR, LAP NOT TO BE PROVIDED AT MIDDLE THIRD ZONE OF THE SPAN
b) FOR BEAM TOP BAR, LAP MAY BE PROVIDED AT MIDDLE THIRD ZONE OF THE SPAN
c) NOT MORE THAN 50% OF THE BARS SHALL BE SPLICED AT ONE PLACE
d) LAP SPLICES ARE TO BE CONFINED BY HOOPS WITH MAXIMUM SPACING OR PITCH OF d/4 OR 100 WHERE d IS THE EFFECTIVE DEPTH OF THE BEAM.



TYPICAL SECTION OF BEAM LONG SECTION (IF NOT MENTIONED IN THE DETAILS)

11. DEVELOPMENT LENGTH

ALL BEAM AND SLAB REBARS SHOULD BE EXTENDED INTO THE SUPPORT UPTO DEVELOPMENT LENGTH.

12. ALL ADMIXTURE

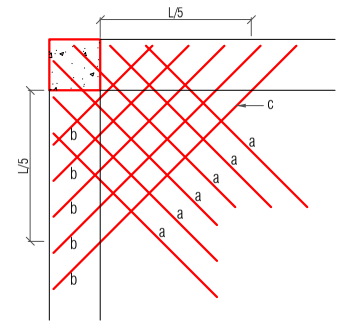
APPROVAL BY THE ENGINEER IN CHARGE.

13. WATER STOPPER

225mm WIDE PVC WATER STOPPER TO BE USED AT ALL CONSTRUCTION JOINTS BELOW GROUND IN MAT, RETAING WALL & WATER TANK WALL.

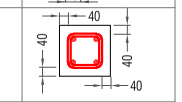
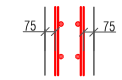
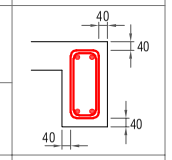
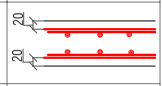
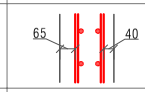
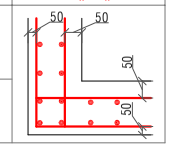
14. CORNER REINFORCEMENT ('CR')

CORNER REINFORCEMENT FOR BEAM SUPPORTED 2-WAY SLABS



L = LONGER CLEAR SPAN
a = TOP BARS
b = BOTTOM BARS
a = c
SPACING OF CORNER BARS = SPACING OF MAXIMUM POSITIVE BARS

15. CONCRETE CLEAR COVER FOR REINFORCING BARS

Member	Location/Condition	Clear Cover (mm)	Figure
PC/MAT/FOOTING	Side	75	
	Bottom	75	
Column	Above Mat	* 40	
Wall	Above Mat	* 75	
Floor Beam	top, side	** 40	
	bottom	** 40	
Slab and stair	Top and bottom	20	
Retaining Wall	Exterior	65	
	Interior	40	
Water tank	Water face	50	
	Other face	50	

* From tie
** From stirrups

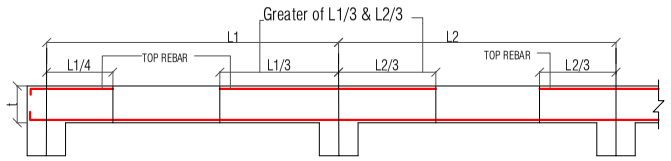
17. MAXIMUM BARS IN BEAMS IN SINGLE LAYER

MAXIMUM NUMBER OF BARS AS A SINGLE LAYER IN BEAM STEM SHALL BE AS PER ACI DETAILING MANUAL.

18. MINIMUM BAR SPACING OF COLUMN LONGITUDINAL BARS

CLEAR DISTANCE BETWEEN LONGITUDINAL BARS SHALL NOT BE LESS THAN 1.5 TIMES BAR DIAMETER, 1.5 TIMES OF THE MAXIMUM SIZE OF COARSE AGGREGATE NOR 40mm.

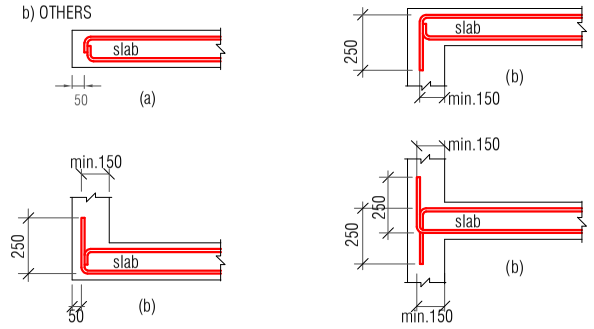
19. SLAB REINFORCING DETAILS



20. SLAB END REINFORCING DETAILS

a) FREE END OF SLAB INCAPABLE OF EMBEDDING OF STEEL BAR IN BEAM/WALL

b) OTHERS



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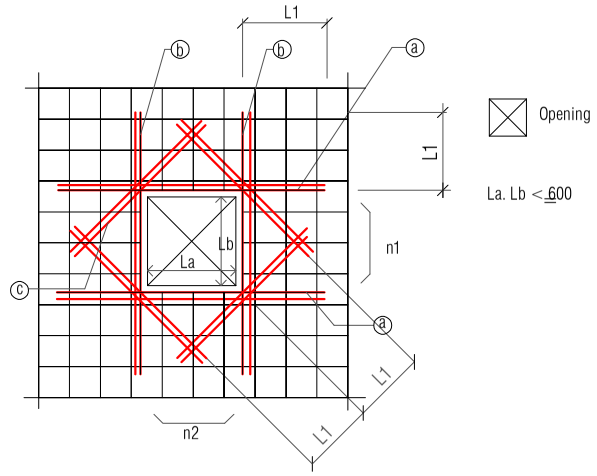


n1,n2 : The number of bars which are cut off for opening

ⓐ The number of extra bars > n1/2 (top and bott bars)

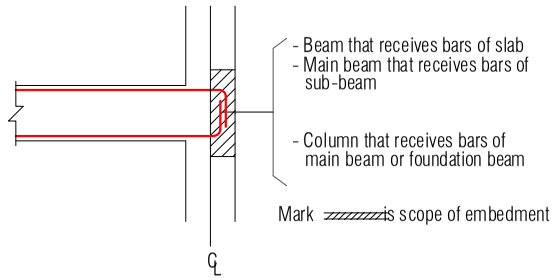
ⓑ The number of extra bars > n2/2 (top and bott bars)

ⓒ The number of extra bars = 2-D12 (top and bott bars)

22. RECOMMENDED END HOOKS

Bar hook	Form and Extention	Bend Angle (degree)	Bend Radius (r)	Used Bar	Location
Primary reinf.	db, r, 4db	180°	r = 4db	6 to 25	Lap splice end of anchorage
Tie/stirrups	db, 6db≥75mm	135°	r = 1.25db	6 to 12	Stirrups fastening bar diagonal hoop
Primary reinf.	db, 12db	90°	r = 4db	6 to 25	Bend-up for embedment
			r = 5db	28 to32	
Slab	db	45°	r = 5db	8 to 20	Bend bar in slab

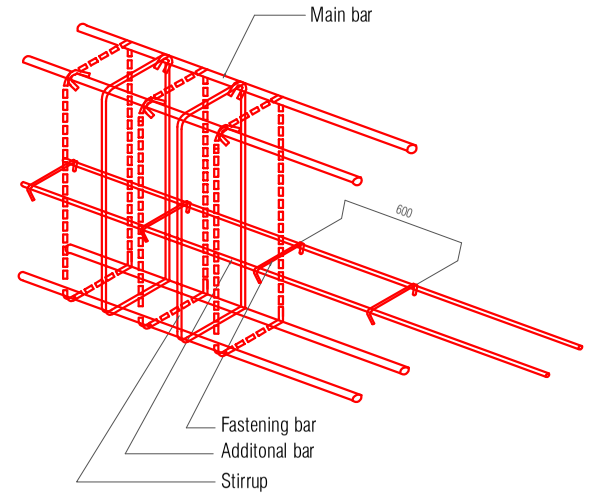
23. SCOPE OF EMBEDMENT



24. OPENING IN R.C.C. WALLS

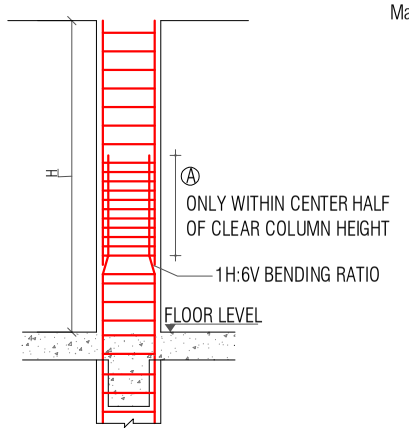
NOT LESS THAN THREE NO. 20Ø BARS SHALL BE PROVIDED AROUND ALL DOOR AND WINDOW OPENINGS IN R.C.C. WALLS. THE BAR SHALL BE EXTENDED BEYOND THE CORNERS OF THE OPENINGS TO A DISTANCE EQUAL TO THE DEVELOPMENT LENGTH BUT NOT LESS THAN 600.

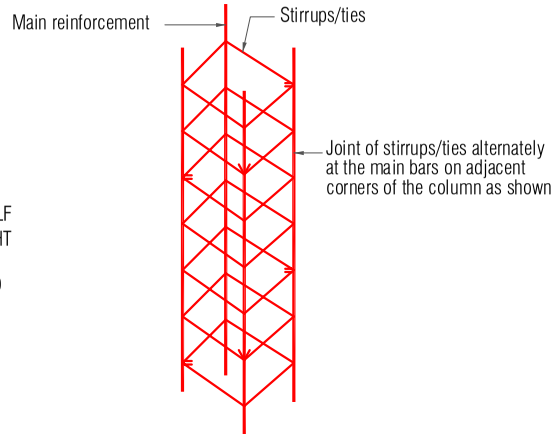
25. END HOOK OF STIRRUPS



END HOOKS OF STIRRUPS ARE LOCATED ALTERNATELY AT TOP CORNER BAR OF THE SECTION.

26. COLUMN SPLICE LOCATION

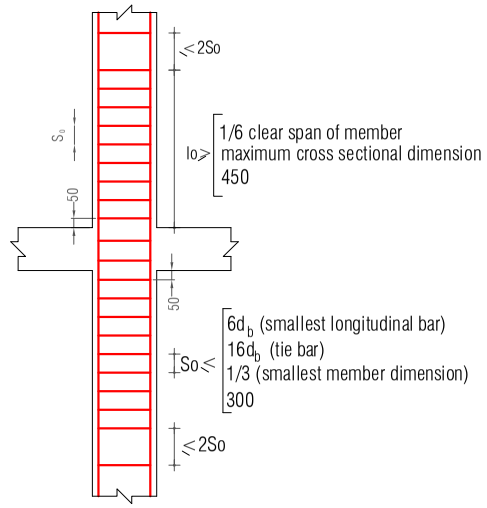




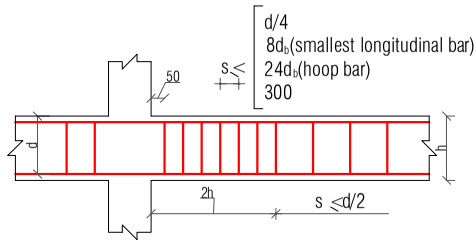
Ⓐ IS AREA FOR SPLICE OF COLUMN REINFORCEMENT. MAXIMUM 50% OF TOTAL BAR IS SPLICED AT ONE LEVEL.

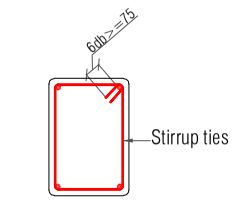
H = CLEAR COLUMN HEIGHT

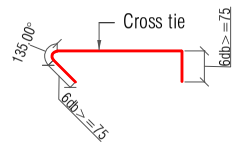
27. CONFINEMENT REQUIREMENTS OF COLUMN AT JOINTS FOR EARTHQUAKE LOADING

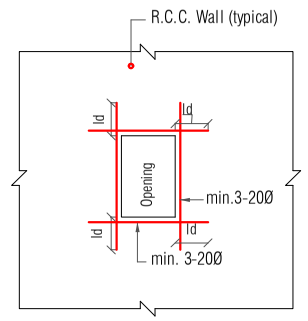


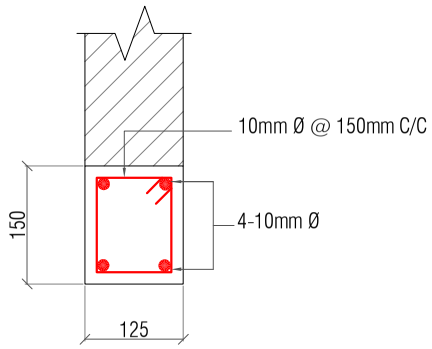
28. CONFINEMENT REQUIREMENTS OF BEAM AT JOINTS FOR EARTHQUAKE LOADING



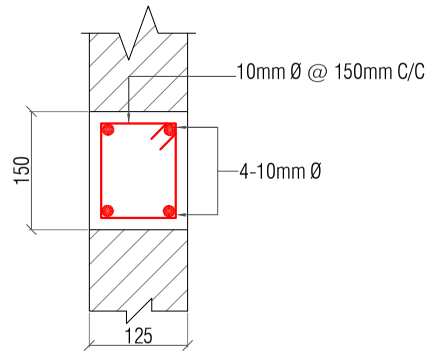




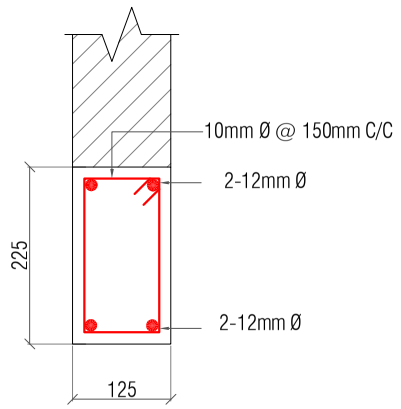




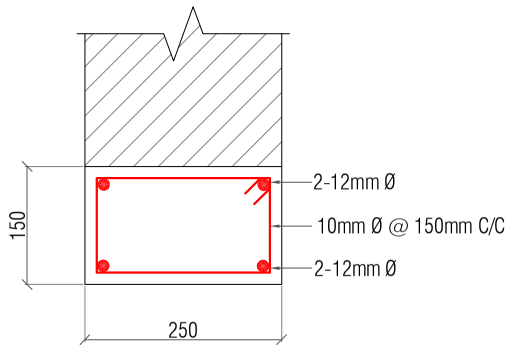
SECTION OF 125mm WIDE LINTEL UP TO 1500mm CLEAR OPENING



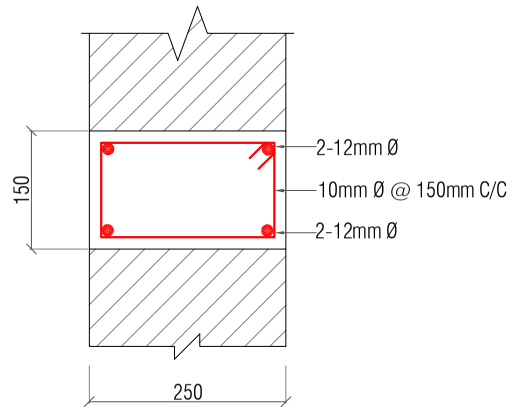
SECTION OF 125mm WIDE LINTEL ON BLIND WALL ALTHROUGH



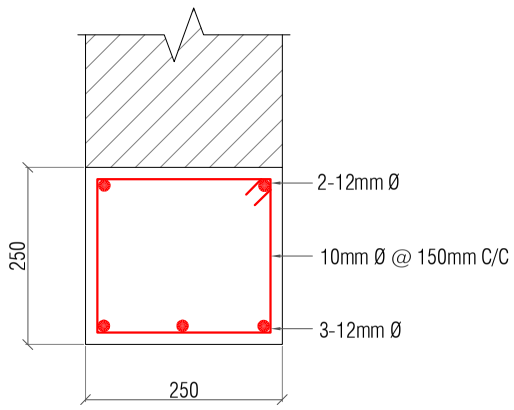
SECTION OF 125mm WIDE LINTEL ABOVE 1500mm CLEAR OPENING



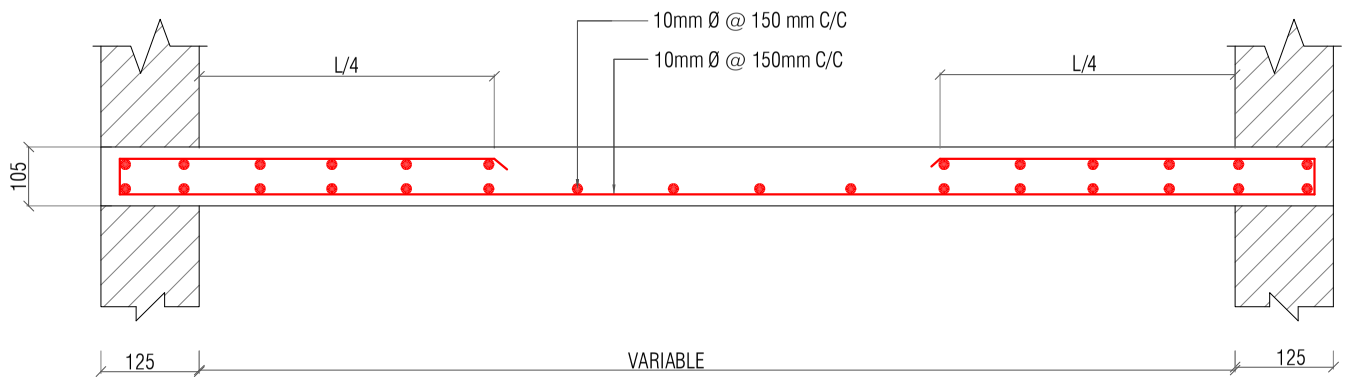
SECTION OF 250mm WIDE LINTEL UP TO 1500mm CLEAR OPENING



SECTION OF 250mm WIDE LINTEL ON BLIND WALL ALTHROUGH

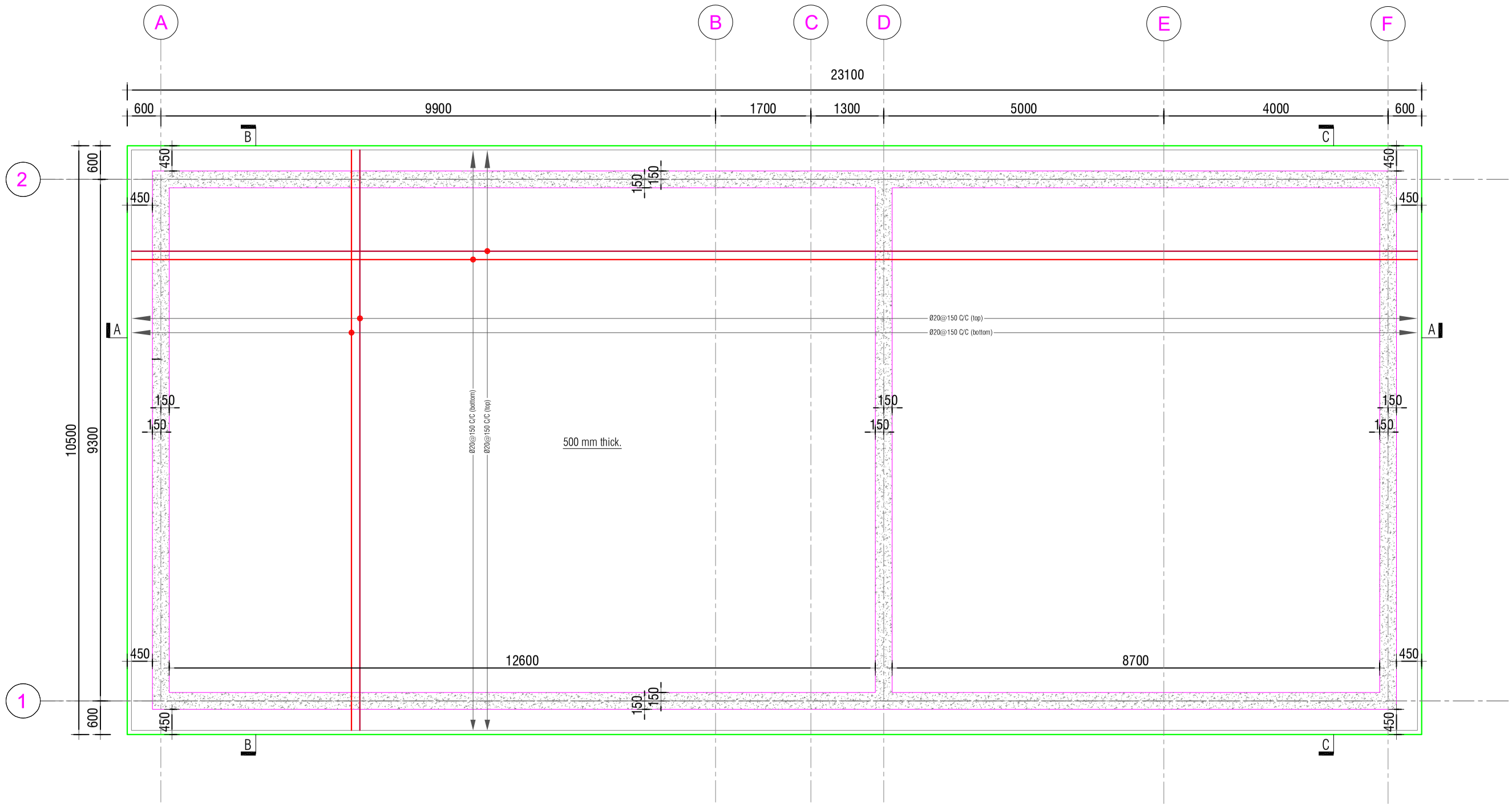


SECTION OF 250mm WIDE LINTEL 1500mm TO 2000mm CLEAR OPENING

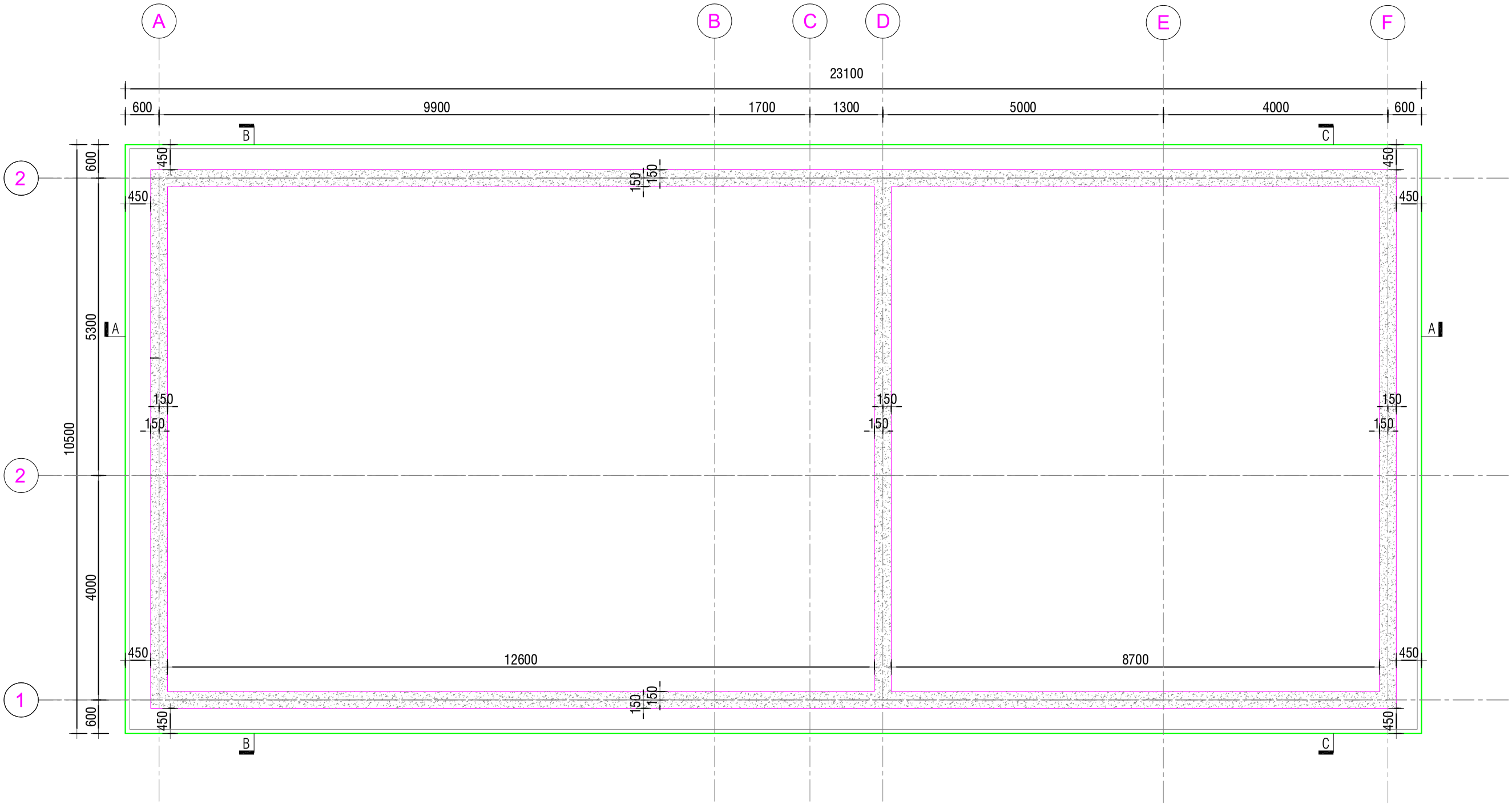


TYPICAL SEC. OF FALSE SLAB
(TO BE PROVIDED AS PER ARCHI. DRG.)

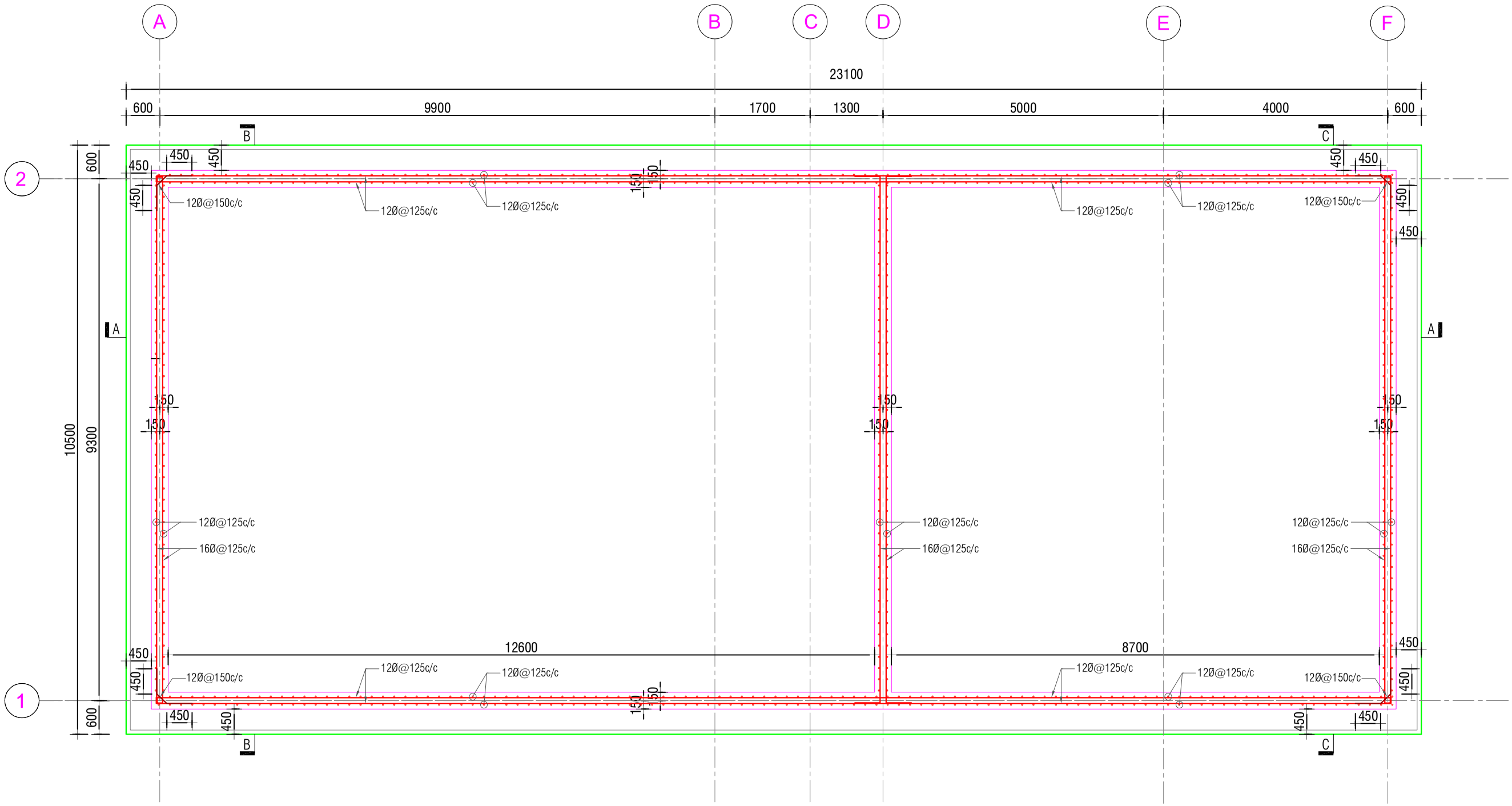
REINFORCEMENT DETAILS OF LINTEL, PARAPET, DROP WALL
SCALE=1:45



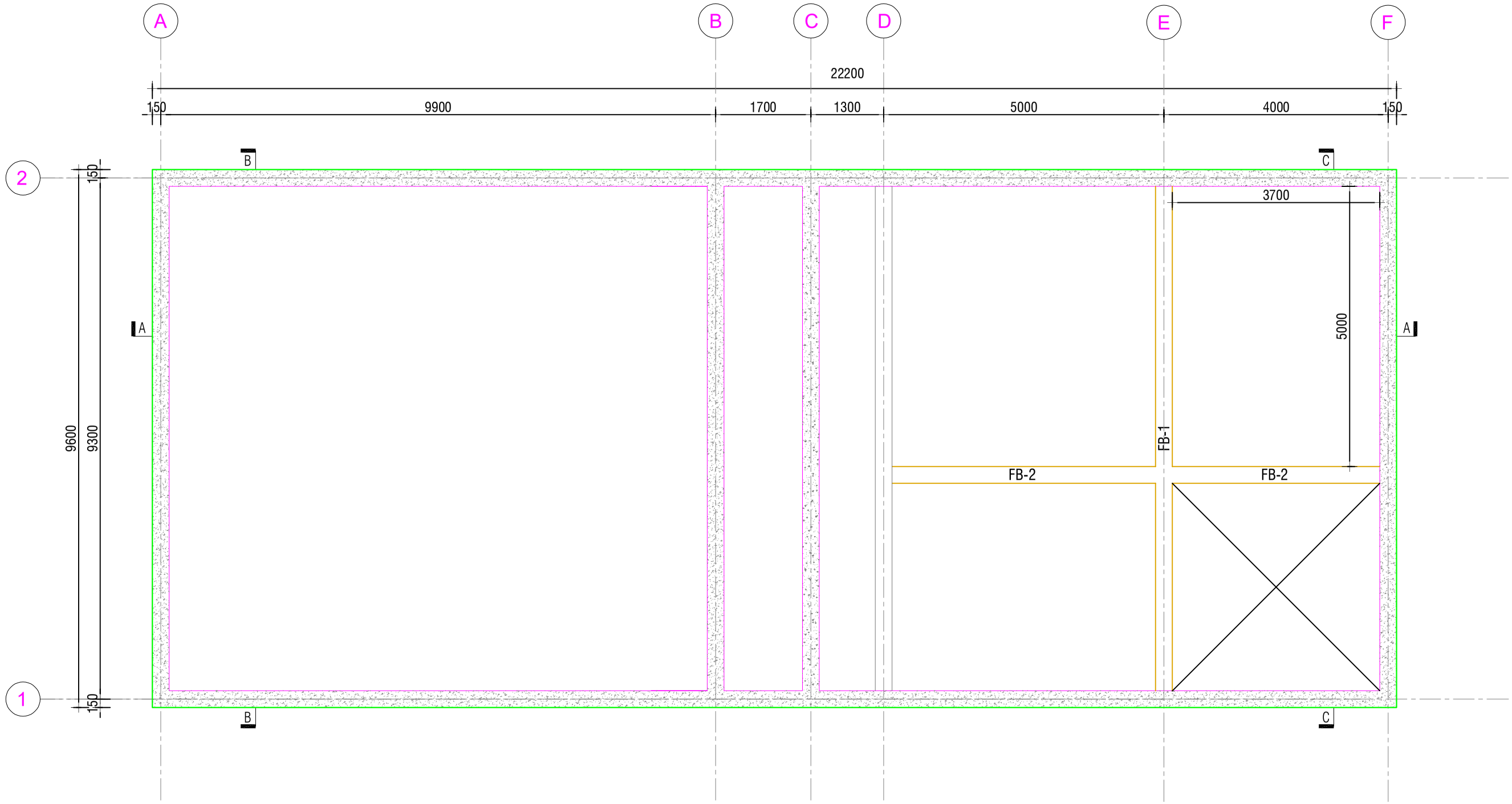
REINFORCEMENT PLAN OF BOTTOM SLAB (LEVEL AT +91.85M)
SCALE-1:80



RCC WALL PLAN OF BOTTOM SLAB (LEVEL AT +91.85M)
SCALE-1:80



REINFORCEMENT PLAN OF RCC WALL & BOTTOM SLAB (LEVEL AT +91.85M)
SCALE-1:80



PLAN OF ROOF SLAB,RCC WALL & ROOF BEAM LAYOUT PLAN (LEVEL AT +96.20M)
SCALE-1:80

Comprehensive MEP Design for WTP, and UGWR (FIRE)

Client:

Asian University For Women

ASIAN UNIVERSITY FOR WOMEN

PMC:

SURBANA JURONG

SJ Real impact, made together.

AUW WTP, STP & UGWR DESIGN PROJECT			
TABLE OF CONTENT			
S/N	DRAWING TITLE	DRAWING NUMBER	REVISION
1	MEP UWGR, WTP & STP LAYOUT PLAN	AUW-DD-01	5
2	MEP PLAN OF UWGR, WTP, FIRE WATER RESERVOIR & FIRE PUMP ROOM	AUW-DD-02	5
3	MEP BLOW UP PLAN OF WTP	AUW-DD-03	5
4	MEP SECTION OF UWGR, WTP & FIRE WATER RESERVOIR, FIRE PUMP ROOM PLAN	AUW-DD-04	5
5	SECTION DETAILS OF FIRE PIPE & WATER PIPE	AUW-DD-05	5
6	ROOF HATCH & EXTENSION LADDER PLAN	AUW-DD-06	5

Property Line

Working Space

Deep tubewell location

DETAILS "A"

DETAILS "B"

Fire Pipe

450mm Dia. Water Pipe

6.46

LEVEL + 35.00m

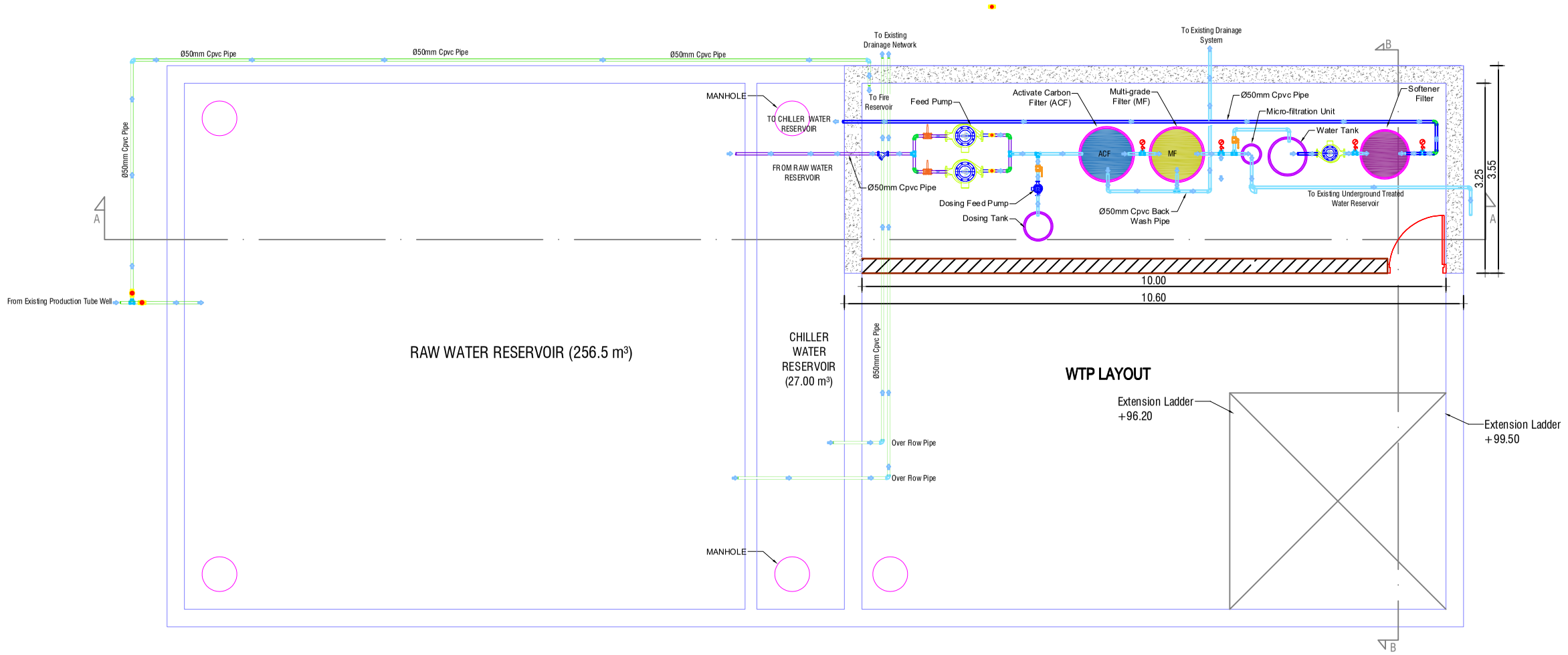
EXISTING
4 STORIED BUILDING

EXISTING
4 STORIED BUILDING

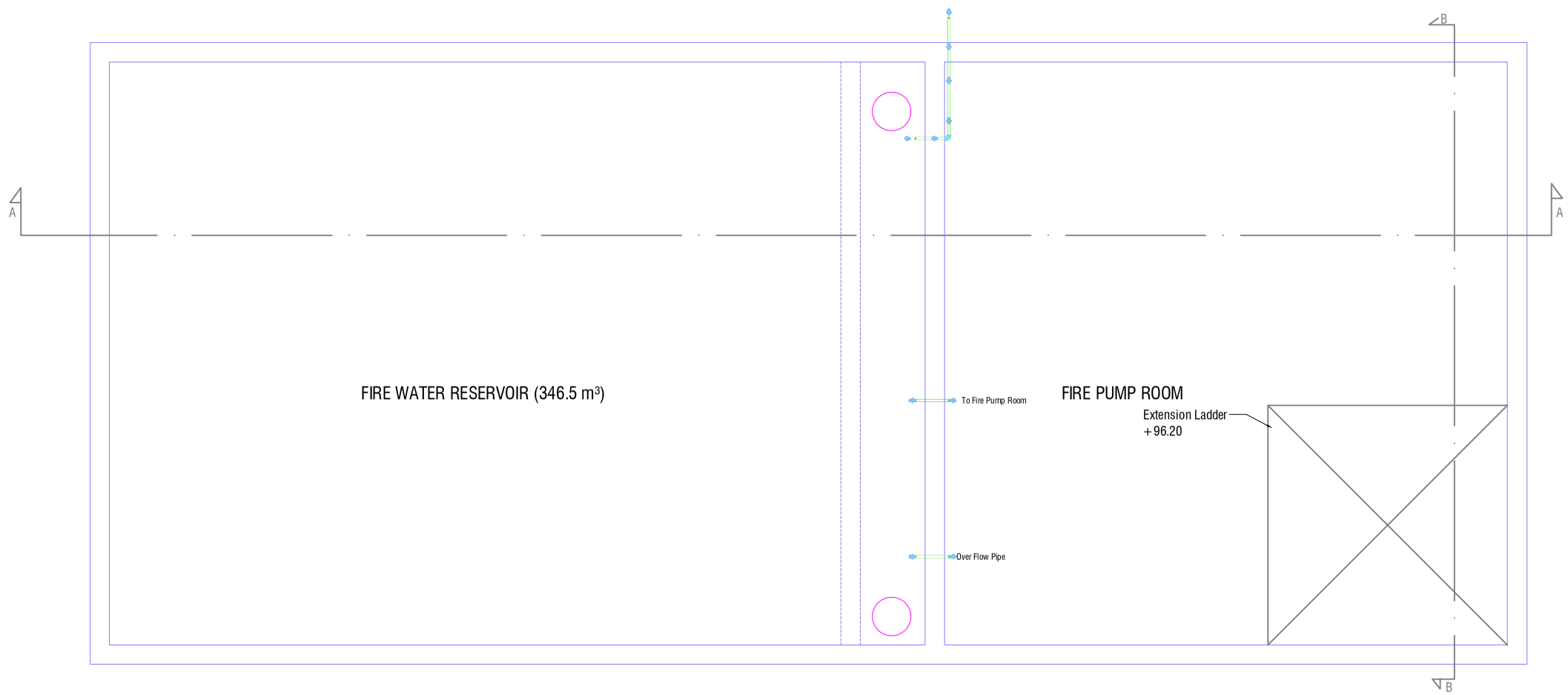
EXISTING
4 STORIED BUILDING

WTP & STP LAYOUT PLAN

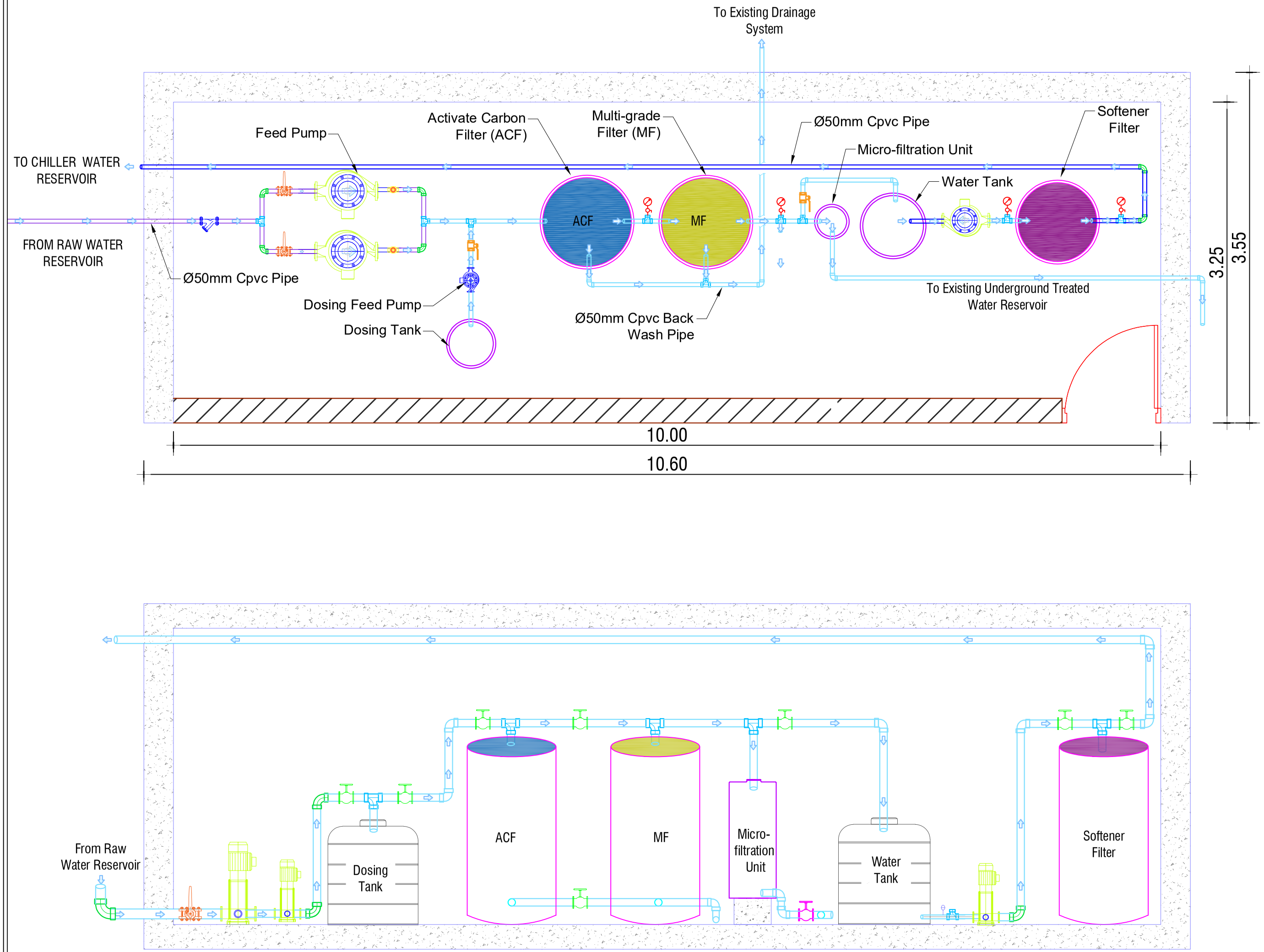
SCALE-1:250

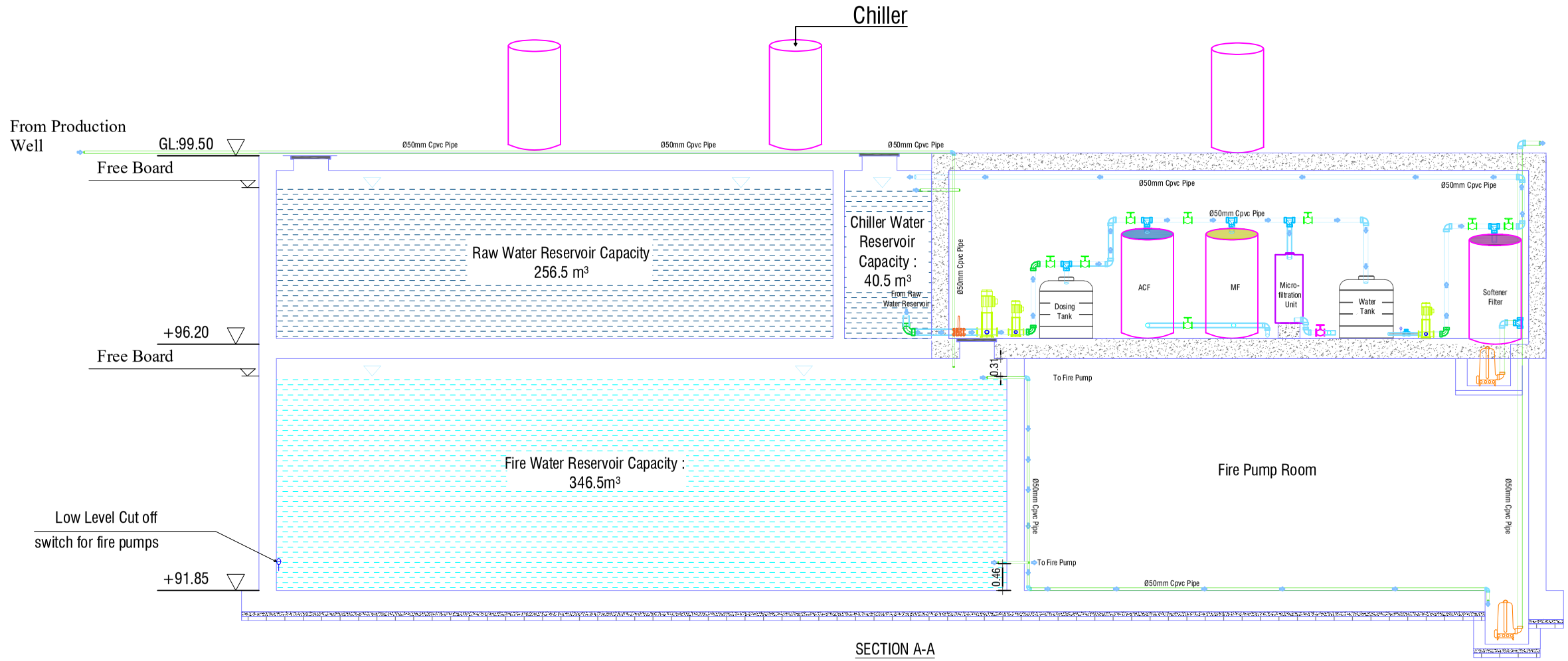


RAW WATER AND WTP PLAN (LEVEL +101.75m)
SCALE-1:90

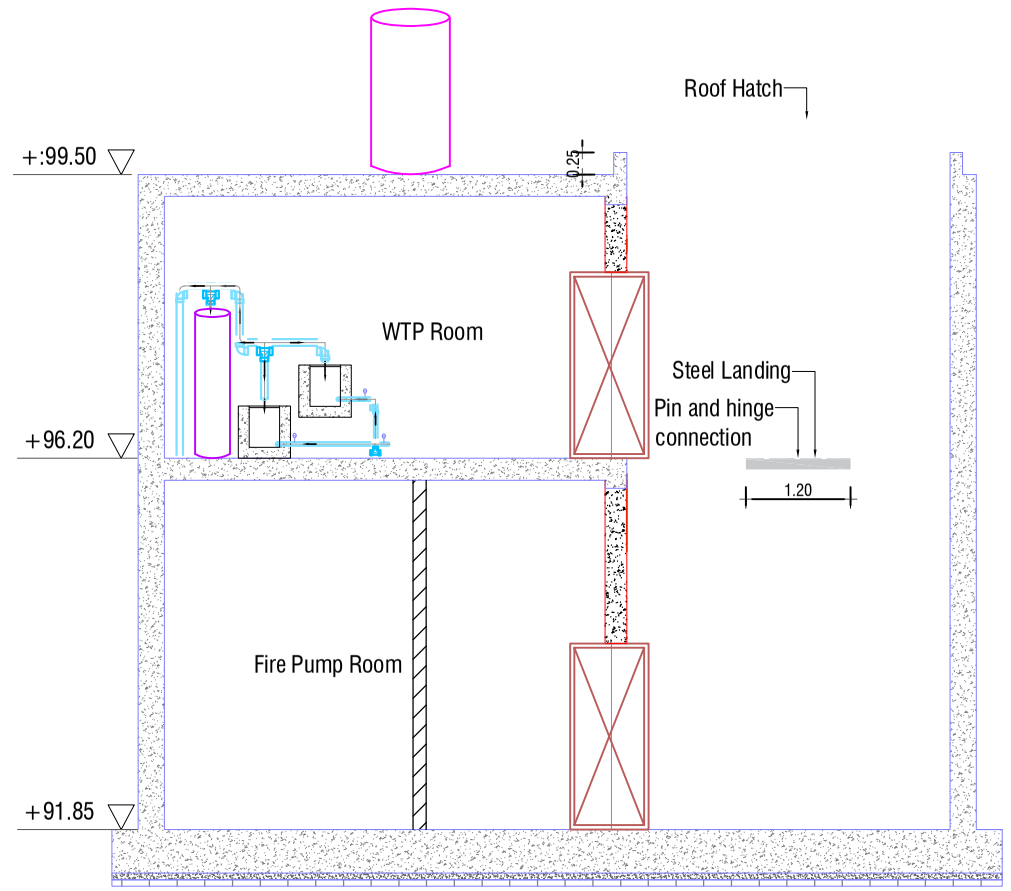


FIRE WATER RESERVOIR & FIRE PUMP ROOM PLAN (LEVEL + 105.75m)
SCALE-1:90


To Existing Drainage System
Activate Carbon Filter (ACF)
Multi-grade Filter (MF)
Ø50mm Cpvc Pipe
Softener Filter
Feed Pump
Micro-filtration Unit
TO CHILLER WATER RESERVOIR
Water Tank
ACF
MF
FROM RAW WATER RESERVOIR
Ø50mm Cpvc Pipe
Dosing Feed Pump
Dosing Tank
Ø50mm Cpvc Back Wash Pipe
To Existing Underground Treated Water Reservoir
3.25
3.55
10.00
10.60
From Raw Water Reservoir
Dosing Tank
ACF
MF
Micro-filtration Unit
Water Tank
Softener Filter



SECTION A-A
SCALE-1:90



SECTION B-B
SCALE-1:90