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DIGITALLY VERIFIED RECORD

**BURO ENGINEERS** (I) PRIVATE LTD.,
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21 years Service of Excellence

**A PERAMAIYAN (M.E. Struct., M.I.E.,)**
**Registered Structural Engineer,**
**Chennai Metropolitan Development Authority,**
**Registration No.SE/GR-I/19/03/026,**
**31/14, Besant Avenue Road,**
**Adayar, Chennai — 600 020.**

**Email : peram@buroengineers.in**
**Mobile: +91 9962545630**

## STABILITY CERTIFICATE

The detailed engineering and structure design of the proposed residential building comprising **42 Flats (1 Basement + Stilt + 11 Floors + Roof) in project named "ISHA'S GEETHANJALI"** comprised in **Door No. H-46, H-47, H-48 & H-49, Old Survey No. 40/1 (Part), 40/2B (Part), T.S. No. 71, Ward No. 1, Block No. 11, situated at Thiruvanmiyur Neighbourhood Scheme Layout at Kamaraj Nagar, L.B. Road, Thiruvanmiyur, Chennai, Tamil Nadu – 600 041** has been done by me based on the report of Geotechnical investigation (soil test) done by GEOMARINE CONSULTANTS (P) LTD., Report no. _GT2468_ dated_17/12/24 and considering the functional requirement of the building.

2. It is certified that among other factors, the proposed building has been designed to resist earth quakes. I have checked various parameters and found that the proposed building would be safe.

3. It is further certified that:

(i) The minimum grade of concrete is M25.

(ii) The design and analysis has been done using the code of practice for plan and reinforced concrete as per IS 456, design loads as per IS Code No. 875 (2015) and design of earthquakes resistant structure as per IS Code No. 1893 (2016).

4. The building will be safe and sound when used for the purpose for which it is designed.

Date : 09-02-2026

Place : Chennai-600020

Stamp and Signature

A. PERAMAIYAN, M.E., (Struct.), M.I.E.
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Encl: Structural Design Calculation

CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY
'ThalamuthuNatarajan Building', No.1, Gandhi Irwin Road,
Egmore, Chennai-600 008.

# PROFESSIONAL REGISTRATION CERTIFICATE

This is to certify that the **Thiru. A. PERAMAIYAN** has enrolled as **Registered Structural Engineer Grade-I (SE)** with Chennai Metropolitan Development Authority (CMDA) who has the qualification of **M.E.,(Structural Engg.)** and experience in the relevant field for **17years.**

He has been given the Registration No. **SE/GR-I/2019/03/026** Renewed on **22.03.2024.** He shall be required to comply with the duties and responsibilities prescribed by the Government of Tamil Nadu in Part-V, "Registration of Professionals", Tamil Nadu Combined Development and Building Rules, 2019 approved vide G.O.(Ms) No.18 MAWS (MA1) Dept. dated 04.02.2019.

This Registration is valid upto **21.03.2029.**



CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY
CHENNAI-600 008.

22/3/24

**(A. MEGANATHAN)**
**Superintendent**

A. PERAMAIYAN, M.E., (Struct.), M.I.E.
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# STRUCTURAL DESIGN CALCULATION REPORT

**THE PROPOSED CONSTRUCTION OF EXTENDED BASEMENT FLOOR + STILT FLOOR + 11 FLOORS (INDOOR GAMES,MULTI-PURPOSE HALL & GYM @ 1st FLOOR LVL) RESIDENTIAL BUILDING WITH 74 DWELLING UNITS (WITH HEIGHT 30.00m) AT LATTICE BRIDGE ROAD, THIRUVANMAIYUR,CHENNAI AND COMPRISED IN T.S. NO. 71, BLOCK NO. 11 OF THIRUVANMAIYUR VILLAGE, VELACHERRY TALUK AND WITHIN THE LIMITS OF GREATER CHENNAICORPORATION.**

**CLIENT:**

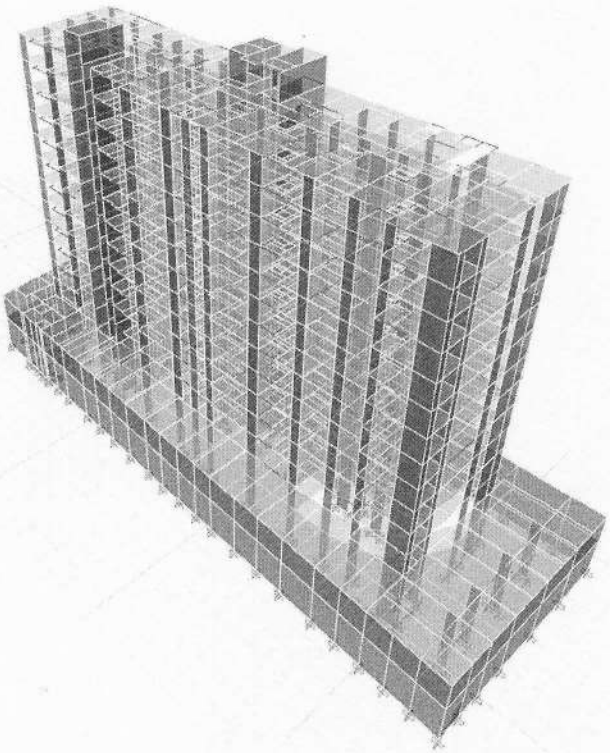
**M/s. Isha Homes India (P) Ltd,**
CHENNAI, TAMILNADU.

**ARCHITECT:**

**INDRAJIT.S.KEMBHAVI,**
BANGALORE, KARNATAKA.

**STRUCTURAL CONSULTANT:**

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| REV NO. | DATE | DESCRIPTION | STATUS | PREPARED BY | REVIEWED BY | APPRVD. BY |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| R0 | 17.09.2025 | Design Basis Report | OK | T.PRAKATHISH | PERAM | PERAM |

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- Design of Wall
- Design of Beam
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- Structural Drawings

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# DESIGN INFORMATION AND CRITERIA

## 1. INTRODUCTION

M/s. Isha Homes India (P) Ltd., has proposed to construct Residential Building comprises Two Basement + Stilt + 11th Floors + Roof at Lattice Bridge road, Thiruvanmaiyur, Chennai and Comprised in T.S NO. 71, Block no. 11 of Thiruvanmaiyur village, Velachery taluk and within the limits of Greater Chennai Corporation. Architecturally, it is designed with Two Basement +Stilt + 11 Floors + Roof structure. In which, the Two Basement + Stilt floor is designed to facilitate parking where as 1st floor to 11th floor are designed for Residential use.

This report covers design basis of Residential development comprises a Residential building having Two Basement+Stilt+1st Floor to11th Floor+Roof. In the Residential building the Basement & Stilt floors accommodates car parking and 1st floor to 11TH floors are designed for residential use. The covered area podium slab has been designed to accommodate landscape with 300mm filling whereas the stilt floor extended basement roof area has been designed for fire tender lorry movement. Architecturally, the building is designed to be a linear & rectangular in shape. Structurally the building is designed to be a framed structure with Columns, RC Walls, Beams and slabs, are directly connected to the columns/RC walls which are together forms a lateral load resisting system. Foundation is designed to be Raft Foundation at a depth of 8.4m below existing ground level.

The raft is connected monolithically with Basement wall forms the water tight basement structure shall be protected by applying the approved water proofing on positive side taking the water table likely to rise up to the ground level during peak monsoon. Superstructure is designed to be a shear wall structure with Slab connected directly to the shear walls and Beams are provided in few locations where opening/door is provided.

This report provides the information on Codes of Practice, Design loading, Material Strength considered for the Design and Analysis of the building. In addition, this report includes information on Structural system, Foundation system, Parameters & Method statement of structural analysis which will be adopted for design and analysis of the building.

## 2. CODES OF PRACTICE

In the analysis, design and detailing of the building, the following Indian Standard codes will be used.

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## 2.1 Design Loads (Other Than Earthquake Loads)

| IS Code | Description |
|---|---|
| IS 875 (Part 1): 1987 | Dead Loads (Unit Weight of Building Material and Stored Material) |
| IS 875 (Part 2): 1987 | Imposed Load |
| IS 875 (Part 3): 2015 | Wind Load |
| IS 875 (Part 5): 1987 | Special Loads and Combinations |

## 2.2 Design for Earthquake Resistance

| IS Code | Description |
|---|---|
| IS 1893(Part-1) :2016 | Criteria for Earthquake Resistance design of structures. |
| IS 4326: 1993 | Earthquake Resistant Design and Construction of Buildings – Code of Practice |
| IS 13920: 2016 | Ductile Detailing of Reinforced Concrete Structures subject to Seismic Forces - Code of Practice. |
| IS 16700: 2017 | Criteria for Structural Safety of Tall Concrete Buildings |

## 2.3 Design of Steel Structural Elements

| IS Code | Description |
|---|---|
| IS 800: 2007 | Code of Practice for General Construction in Steel |
| IS 2062: 1999 | Steel for General structural purposes |

## 2.4 Design of Concrete Elements

| IS Code | Description |
|---|---|
| IS 456: 2000 | Plain and Reinforced Concrete - Code of practice |
| IS 6403 -1981 | Code of practice for determination of bearing capacities of shallow foundations. |
| IS 8009 -1976 (Part I): | Code of practice for calculation of settlement of foundations – Shallow foundation |
| IS 1904 | Indian Standard Code of practice for design & construction foundations in Soil: General Rééquipements |
| IS 2950 (Part 1):1981 (Reaff. Nov 2013) | Code of practice for design and construction of raft foundations : Part 1 Design (second revision). |

| | |
|---|---|
| IS 2974 | Code of practice for design & construction of machine foundation |
| SP 16 | Structural use of concrete, Design charts for singly reinforced beams, doubly reinforced beams and columns. |
| SP 34 | Hand book on Concrete Reinforcement & Detailing |
| SP 7(Part IV)-2015 | National Building code of India |
| IS 1786-2007 | Specification for high strength deformed bars and wires for concrete Reinforcement. |
| IS 432 (Part 2) 1982 | Specification for Mild Steel and Medium Tensile Steel Bars and Hard Drawn Steel Wire for concrete reinforcement – Hard Drawn Steel Wire |
| IS 3370 (part I) | Code of practice for concrete structure for the storage of liquids |

## 3. DESIGN PARAMETERS

### 3.1 Materials of Construction

The building is predominantly Shear wall connected with slab/beam. The lateral load resisting system of Shear walls/Columns are well connected in orthogonal direction along with the centrally located Lift Core wall which are connected by floor slab is act as diaphragm in distribution of lateral forces.

#### 3.1.1 Concrete Grade

Concrete grade shall be M35 for Basement wall, Basement slab, etc. whereas Shear wall, RC Column, RC beam & RC slab shall be M40 with minimum 28-day strength of 35 & 40 MPa respectively.

Concrete Mix M10 has been used in filling, plum concrete, levelling courses (PCC) and other non-structural items.

Density of reinforced concrete is assumed as 25 kN/cu.m.

Minimum cement content, water cement ratio etc. shall conform to IS 456:2000 code provisions for durability and strength criteria. The approved design mix shall be used for producing concrete.

**Grade of Concrete for various structural elements: (TOWER / NON TOWER)**

| | |
|---|---|
| Raft | M35 |
| Basement Wall | M35 |
| Basement Slab | M35 |
| Columns | M40 |
| Shear wall | M40 |
| RC Beam | M35 |
| RC Slab | M35 |

### 3.1.2 Cement

Ordinary Portland cement of grade 43 or higher confirming to IS 8112 and IS 12269 is specified for concrete M35 for Basement wall & Slab whereas the grade is to be M40 for RC shear wall, column, Beam, RC Slab etc. with cement content appropriate to the desirable compressive strength and slump. The design mix using the intended brand of cement together with material test report including tests on coarse aggregate, fine aggregate etc. shall be submitted to the consultant's review and approval.

### 3.1.3 Aggregates

The sizes of coarse aggregates confirm to IS 383. Nominal maximum size of coarse aggregate to be 20 mm, suitably graded as per the requirement of mix design. The fine aggregates confirm to the specifications of IS 383.

### 3.1.4 Water

Water used for construction shall complied with stipulations given in IS 456: 2000.

### 3.1.5 Reinforcement

High yield strength deformed bars conforming to IS 1786 with $f_y$ = 550 N/ sq.mm has been used with elongation not less than 14.5 %.

### 3.1.6 Structural Steel

MS steel with yield strength $f_y$ = 250 N/ sq.mm shall be used for Structural steel work wherever necessary which shall conform to IS 226 and IS 2062 for Indian steel sections.

### 3.1.7 Concrete Cover

Cover to reinforcement considered for various elements with Fire rating considered - 2hrs. are as follows.

a. Raft = 60mm
b. Column = 40mm
c. Shear Wall
   300mm thick. = 40mm
   200mm thick. = 30mm
d. Beam = 30mm (Bottom and sides)
e. Slab = 25mm (Top and Bottom)
f. Basement wall/Water tanks/Sump tank
   On water face = 40mm (Top and Bottom)
   On other face = 40mm (Top and Bottom)

### 3.1.8 Development Length

Unless otherwise specified in the good for construction drawing, the Development length of 50 times diameter of bar is to be considered in the BBS & Fabrication.

### 3.1.9 Soil Parameters

Based on the soil report No. GT-2468 dated 17.12.2024, there are 3 nos. of bore holes were done at different locations of the plot spread across the development which includes BH-01 to BH-03. All the bore holes are terminated at around 17m by reaching the hard layer or hammer rebound whichever reach earlier. The top layer up to 1m is sandy silty clay. Below it is very soft silty clay with sand mixture having "N" value in the range of 2 which continues up to 5m. From 5m it is a clayey silty sand that continues up to 7.5m having "N" value in the range of 8 to 19. Below it is a poorly graded sand-silty sand upto a depth of 9m having "N" value of 25. The same soil continues up to 12m with "N" value 40. Very dense clayey silty sand exists up to 14m having "N" value more than 100. Highly to moderately weathered rock encountered at a depth of 14m with "N" value more than 100. Below 2.25m and up to 3m it is very dense of fine to coarse sand with gravel with "N' value more than 100. Weathered rock continues below up to the termination depth of 17m with varying grade of rock such as W4, W3, W2 & W1 at 14m, 15m, 16m & 17m respectively. Ground water table is reported during the investigation period of November-2022 is around 0.5 below NGL. However, it is advisable to design the Basement structure/UG structure for the head of water up to Ground level as the water table likely to raises up to ground during peak monsoon.

## 3.2 Loading Standards

**Table: Structural Configuration and Floor heights:**

| Building Floor Height Details | Two Basement+Stilt+11+ Roof |
|---|---|
| Basement-1 (Car Park) | 4.875m |

| | |
|---|---|
| Stilt floor height (Car Park) | 3.60m |
| Stilt Floor to 1st Floor height(Car Park) | 3.00m |
| 1st Floor to Roof height (Residential) | 3.00m |
| Head Room | 3.00m |
| LMR | 2.05m |
| | |
| **Type of Foundation** | **Raft (Uniform)** |
| Grade of concrete for Raft | M35 |
| Grade of concrete for Basement Wall | M35 |
| Grade of concrete for Columns | M40 |
| Grade of concrete for Shear Walls | M40 |
| Grade of concrete for RC slabs | M35 |
| Grade of concrete for RC beams | M35 |
| Grade of Steel | Fe 550 |

**Table: Unit Weight of Materials:**

| **Material** | **Floor Heights** |
|---|---|
| Plain Cement Concrete | 25.00 kN/Cu.m |
| Brick Work | 20.00 kN/Cu.m |
| **Block Work (ACC Block)** | **7.50 kN/Cu.m** |
| Mortar Finishing | 20.00 kN/Cu.m |
| Dry soil | 18.00 kN/Cu.m |
| Saturated soil | 10.00 kN/Cu.m |
| Glass | 28.00 kN/Cu.m |
| water | 09.81 kN/Cu.m |

**Table: Gravity Load Calculations:**

| **Floor Slab:** | | |
|---|---|---|
| Self weight of 125 mm thick Slab | 0.125x25 = 3.125 kN/Sq.mt. | |
| Self weight of 150 mm thick Slab | 0.150x25 = 3.750 kN/Sq.mt. | |
| Self weight if 175mm thick slab | 0.175x25 = 4.375 kN/Sq.mt. | |
| Self weight if 200mm thick slab | 0.200x25 = 5.000 kN/Sq.mt. | |
| Self weight if 225mm thick slab | 0.225x25 = 5.625 kN/Sq.mt. | |
| Self weight if 250mm thick slab | 0.250x25 = 6.250 kN/Sq.mt. | |
| **Residential Building External/Internal Wall Line Load:** | | |
| Basement-1 | = (0.2x4.425x7.5)+(0.03x4.425x20) | = 9.30 kN/m |
| Stilt Floor | = (0.2x3.15x7.5)+(0.03x3.15x20) | = 6.20 kN/m |
| First Floor to Roof | = (0.1x2.55x7.5) +(0.03x2.55x20) | = 3.45 kN/m |
| First Floor to Roof | = (0.2x2.55x7.5) +(0.03x2.55x20) | = 5.36 kN/m |
| Terrace Parapet Wall | = (0.2x1.25x7.5) +(0.03x1.25x20) | = 2.63 kN/m |

### 3.2.1 Imposed Loads on Slab

The following are the imposed loads in the structural slabs, in addition to the self-weight and the floor finishes. *(Self-weight of slab will be as per the thickness mentioned in the respective drawings Floor finishes of 50mm thickness have been considered on all floors*

**Table: Superimposed Dead Load (SDL) & Live Load (LL)**

| **BASEMENT (Car Parks & Driveway)** | | |
|---|---|---|
| | **SDL (kN/Sq.mt.)** | **LL (kN/Sq.mt.)** |
| Finishes | 1.8 | - |
| Services | 0.6 | - |
| Live Load | - | 3.0 |
| Partition Load | - | - |
| **Total** | **2.4** | **3.0** |
| **BASEMENT (Lobby)** | | |
| | **SDL (kN/Sq.mt.)** | **LL (kN/Sq.mt.)** |
| Finishes | 1.80 | - |
| Services | - | - |
| Live Load | - | 3.0 |
| Partition Load | - | - |
| **Total** | **1.80** | **3.0** |
| **STILT FLOOR (Car Parks & Driveway)** | | |
| | **SDL (kN/Sq.mt.)** | **LL (kN/Sq.mt.)** |
| Finishes | 1.8 | - |
| Services | 0.6 | - |
| Live Load | - | 3.0 |
| Partition Load | - | - |
| **Total** | **2.4** | **3.0** |
| **STILT FLOOR (Fire Track)** | | |
| | **SDL (kN/Sq.mt.)** | **LL (kN/Sq.mt.)** |
| Loaded Vehicle | 20.0 | - |
| Services | - | - |
| Live Load | - | 3.0 |
| Partition Load | - | - |
| **Total** | **20.0** | **3.0** |
| **STILT FLOOR (Electrical Room)** | | |
| | **SDL (kN/Sq.mt.)** | **LL (kN/Sq.mt.)** |
| Finishes | 1.80 | - |
| Services | - | - |
| Live Load | - | 7.5 |
| Partition Load | - | - |
| **Total** | **1.80** | **7.5** |
| **STILT FLOOR (Pump Room)** | | |
| | **SDL (kN/Sq.mt.)** | **LL (kN/Sq.mt.)** |

| | | |
|---|---|---|
| Finishes | 1.8 | - |
| Services | - | - |
| Live Load | - | 7.5 |
| Partition Load | - | - |
| **Total** | **1.8** | **7.5** |
| **STILT FLOOR (Ramp)** | | |
| | **SDL (kN/Sq.mt.)** | **LL (kN/Sq.mt.)** |
| Finishes | 2.4 | - |
| Services | - | - |
| Live Load | - | 5.0 |
| Partition Load | - | - |
| **Total** | **2.4** | **5.0** |
| **First Floor (Multipurpose Hall)** | | |
| | **SDL (kN/Sq.mt.)** | **LL (kN/Sq.mt.)** |
| Finishes | 2.4 | - |
| Services | - | - |
| Live Load | - | 5.0 |
| Partition Load | - | - |
| **Total** | **2.4** | **5.0** |
| **First Floor (Pre Function Area)** | | |
| | **SDL (kN/Sq.mt.)** | **LL (kN/Sq.mt.)** |
| Finishes | 2.4 | - |
| Services | - | - |
| Live Load | - | 5.0 |
| Partition Load | - | - |
| **Total** | **2.4** | **5.0** |
| **First Floor (Billards / TT Room)** | | |
| | **SDL (kN/Sq.mt.)** | **LL (kN/Sq.mt.)** |
| Finishes | 2.4 | - |
| Services | - | - |
| Live Load | - | 5.0 |
| Partition Load | - | - |
| **Total** | **2.4** | **5.0** |
| **First Floor (Gym / Yoga / Indoor Games)** | | |
| | **SDL (kN/Sq.mt.)** | **LL (kN/Sq.mt.)** |
| Finishes | 2.4 | - |
| Services | - | - |
| Live Load | - | 5.0 |
| Partition Load | - | - |
| **Total** | **2.4** | **5.0** |
| | | |
| **First Floor to 11$^{th}$ Floor (Bed / kitchen / living / dining Room)** | | |

| | SDL (kN/Sq.mt.) | LL (kN/Sq.mt.) |
|---|---|---|
| Finishes | 1.25 | - |
| Services | - | - |
| Live Load | - | 2.0 |
| Partition Load | - | - |
| **Total** | **1.25** | **2.0** |

**First Floor to 11th Floor (Toilet)**

| | SDL (kN/Sq.mt.) | LL (kN/Sq.mt.) |
|---|---|---|
| Finishes + Filling | 2.6 | - |
| Services | - | - |
| Live Load | - | 2.0 |
| Partition Load | - | - |
| **Total** | **2.6** | **2.0** |

**First Floor to 11th Floor (Utility)**

| | SDL (kN/Sq.mt.) | LL (kN/Sq.mt.) |
|---|---|---|
| Finishes + Filling | 2.2 | - |
| Services | - | - |
| Live Load | - | 2.0 |
| Partition Load | - | - |
| **Total** | **2.2** | **2.0** |

**First Floor to 11th Floor (Balcony)**

| | SDL (kN/Sq.mt.) | LL (kN/Sq.mt.) |
|---|---|---|
| Finishes + Filling | 2.6 | - |
| Services | - | - |
| Live Load | - | 3.0 |
| Partition Load | - | - |
| **Total** | **2.6** | **3.0** |

**First Floor to 11th Floor (Corridor)**

| | SDL (kN/Sq.mt.) | LL (kN/Sq.mt.) |
|---|---|---|
| Finishes | 1.25 | - |
| Services | - | - |
| Live Load | - | 3.0 |
| Partition Load | - | - |
| **Total** | **1.25** | **3.0** |

**First Floor to 11th Floor (Lobby)**

| | SDL (kN/Sq.mt.) | LL (kN/Sq.mt.) |
|---|---|---|
| Finishes | 1.25 | - |
| Services | - | - |
| Live Load | - | 3.0 |
| Partition Load | - | - |
| **Total** | **1.25** | **3.0** |

| First Floor to 11th Floor (Staircase) | | |
|---|---|---|
| | SDL (kN/Sq.mt.) | LL (kN/Sq.mt.) |
| Finishes | 3.0 | - |
| Services | - | - |
| Live Load | - | 3.0 |
| Partition Load | - | - |
| **Total** | **3.0** | **3.0** |

| Roof Terraces | | |
|---|---|---|
| | SDL (kN/Sq.mt.) | LL (kN/Sq.mt.) |
| Finishes (weathering courses) | 3.0 | - |
| Services | - | - |
| Live Load | - | 3.0 |
| Partition Load | - | - |
| **Total** | **3.0** | **3.0** |
| **LMR / OHT** | | |
| | SDL (kN/Sq.mt.) | LL (kN/Sq.mt.) |
| Finishes | 20.0 | - |
| Services | - | - |
| Live Load | - | 3.0 |
| Partition Load | - | - |
| **Total** | **20.0** | **3.0** |

Permissible reduction in imposed load on each floor is considered for design of columns and foundation as per IS 875 Part (2), clause.3.2.

The proposed structure is a RCC framed structure with columns and shear walls predominantly forming vertical components. In which, the vertical structural systems are formed such that the RC wall & columns are transfers its base shear in proportion to its stiffness in their loading direction of wind & seismic.

## 3.3 Thermal Effects

Temperature variation produces stresses in the structure, as it tends to expand and contract. In the structures, with large geometrical dimensions, the effect of temperature is important in the behaviour and final design. Due to deformation of expansion & contraction - between Day time and nights, and between winter and summer - the effect on the durability of structure and on the supported finishes is significant to produce considerable results.

In this case, the size of the structure below ground level is about 96mx67m, structurally divided from the phase-II by an expansion joint whereas the size of the super structure is 87.5mx16.5m. The temperature effect over the building design has been captured by applying the differential temperature over the exposed area like roof & terraces.

### 3.3.1 Shrinkage Effects

The Building length is 96m below ground level and it is 87.5m above ground level. The temperature effect in the building has been considered in the design of structural elements as the length of building falls close to the limitation stimulated in IS 456: 2000, clause.27.2. However the shrinkage shall be controlled by introducing pour strip with adopting the sequence of construction appropriately.

### 3.3.2 Expansion Joints

Expansion joints are normally provided when the structure is more than 45m length as per IS-456-2000, clause 27.2. In this case, the size of the structure below ground level is about 77.66mx26.21m whereas the size of the super structure is 61.34mx16.94m. The temperature effect over the building design has been captured by applying the differential temperature over the exposed area like roof & terraces as the length of the building falls beyond the limitation stimulated in IS 456: 2000, clause.27.2. The differential temperature of 15° C has been applied over the exposed areas like Roof & Terraces.

## 4. PROPOSED APPROACH OF STRUCTURAL ANALYSIS

The building is a R.C.C columns connected by beams as framed structure. Slabs acting as rigid in-plane diaphragms have been considered in the model. After preliminary sizing of various structural members, a computer model of the structural frame of the building is generated for carrying out computer analysis for the effects of vertical and lateral loads that are likely to be imposed on the structure.

The building structure has been analysed using the ETABS v2018 software for the following computer models of the building floor analysis of all floors - for vertical loads with the entire building space frame. ETABS v2018 have been thoroughly tested, validated and recognized internationally by several organizations and are well suited for the analysis of building systems.

Geometrical dimensions, member properties and member-node connectivity, including eccentricities will be modeled in the analysis problem. Variation in material grades, if present, will also be considered. The permissible values of the load factors and stresses will be utilized within the purview of the Indian Standards.

The computer analysis will produce accurate individual member forces, reactions at foundation level and deflection pattern of the entire structure as well as individual members. This data will then be used to confirm/review the member sizes and arrive at the most appropriate design of the structural members. Some re-runs of the analysis program might be

required for arriving at the optimum structural space frame characteristics that satisfy the strength and stability criteria in all respects.

Design of different structural elements will be carried out using In-house developed spreadsheets and packages.

The following model assumptions used in E-TABS 3D modeling and the load applications are done as listed below,

| | |
|---|---|
| **Column** | : Frame Element |
| **RC Wall** | : Shell Element |
| **Beam Element** | : Frame Element |
| **Slab** | : Shell Element |

- Modulus of Elasticity of Concrete -5000$\sqrt{fck}$
- Consideration of Diaphragm - Rigid Diaphragm.
- Slab/Wall element considered as Shell element

The structural model and its behaviour has been checked for the following

a) Storey Drift.

b) Storey Weight/Column Loading.

c) Soft Storey Effect.

d) Deformation.

e) Design Forces.

The following methods of modeling are adopted in creating ETABS 3D model,

- The 3D ETABS model generated based on the shuttering drawing prepared using preliminary sizes.
- Sectional properties are assigned to all the structural elements as per the preliminary shuttering drawing.
- Mesh size assigned in size of 1m x 1m approx.
- External & Internal filler wall loads are assigned as uniformly distributed line load on beams and as area load if the wall is intended to distribute on slab directly. These loads are assigned under SDL type load case.
- Slabs are modelled as shell element in Flat Plate area and the same has been modelled as membrane in Beam-slab system which are assigned with horizontal diaphragms.

- Live Load reduction is considered in the design of Foundation and Column as per the Code: IS 875-1987 (Part-II), clause.3.2.1.
- Area design load i.e. Live load/SDL or any other load is applied at floor relevant to its usage.
- All lateral loads & parameters are assigned as per Codes IS 1893-2016 & IS 875-2015.
- Temperature loads are applied on to the terraces which are directly exposed to sun includes podium, Roof etc.
- Beams under Torsion is required to maintain Equilibrium will be designed for Torsion in accordance with IS 456-2000, clause 41.1 to 41.4 and for all other beams torsional stiffness is neglected in the analysis by applying stiffness modifier as 0.01 to torsional constant "J". Hence no specific design for Torsion is required for these beams.
- Chennai is zone-III. Hence ductile detailing is followed in the design and detailing of structural elements.
- Concrete cover to reinforcement complied accordance with IS 456-2000, Tabl.16 & 16A.
- All vertical wall elements are assigned with auto meshing/manual messing appropriately in order to achieve accuracy in results.
- UG Sump is designed for 0.2mm and STP is designed for the crack width of 0.1mm.
- Secondary beams are not designed for ductile detailing.
- Long term deflections are checked by manual calculation using excel spread sheet wherever necessary. Crack width calculation will be done using spread sheet wherever necessary.

**Area Load & Application:** Applied as uniformly distributed area load with intensity proportionate to its usage as mentioned in the Loading items in the DBR.

**Line (Wall) Load & Application:** Filler wall loads are calculated appropriately considering light weight Brick Work and Applied as uniformly distributed line load.

**Lateral Load Resisting Systems:** The Building is primarily shear wall structure with Floor Beams and slabs are connected rigidly. The vertical structural systems are formed such that the RC wall transfers its base shear in proportion to its stiffness in their loading direction for both wind & seismic. Hence Buildings with Ductile RC Structural walls adopted.

## 5.0 LATERAL LOADS

### 5.1 Wind Loads

The wind pressure shall be calculated based on the basic wind speed and other provisions laid in IS 875 (part 3) – 2015. The basis wind speed is considered in the analysis for Chennai, TN is 50 m/sec. The design parameters for wind load calculation are as follows,

Design Wind Pressure $Vz = 0.6\ Vz^2$

But $Vz = Vb*k1*k2*k3*k4$

Where Vz - Design Wind Speed

k1 – 1.0 probability factor or risk coefficient

k2 – 1.14, Terrain height (36.0m ), structure size factor

(measured from stilt floor) with terrain Category–2

k3 – 1.0, Topography factor

k4 – 1.0, Importance factor for the cyclonic region, for all other

Structure as per IS 875-Part3, clause 6.3.4.

Hence the Design Wind Pressure = 0.6x (50x1.0*1.14*1.0*1.0)^2
= 1949.4 N/m^2 ≈ 1.950 kN/m^2

The design wind load will be calculated based on the surface area with the calculated design wind pressure and it shall be applied on surface area of the building in both the orthogonal direction.

As per IS-875-2015 clause 9.1(a), the building is classified as not a slender structure which doesn't requires wind dynamic analysis. But as per clause 9.1(b), wind dynamic analysis shall be carried out as the frequency is less than 1 Hz works out along the transverse direction. Hence wind dynamic analysis performed in ETABS along transverse direction.

## 5.2 Earthquake Loads

Chennai is classified under Earthquake Zone III (Moderate) as per the latest classification. The loading due to earthquake shall be assessed based on the provisions of IS 1893 – 2016 The design parameters adopted are as follows:

Seismic Zone III with seismic zone factor Z = 0.16 (Moderate) and Response reduction factor is to be 4.0 considering Building with RC Structural Wall as per IS: 1893-2016, Table-7 and Soil considered as Type-II Medium soil.

### Base Shear Calculation for Static Analysis

As per IS 1893:2016, the total design lateral force or design seismic base shear ($V_b$) is determined by the following expression.

$$V_b = A_h W$$

Where Ah is Design horizontal acceleration spectrum value using fundamental natural period and W is Seismic weight of the building.

The Seismic weight is estimated based on Full dead load + 25 % Live load for Residential building i.e. for Live Load < 3 kN/Sq.mt. the reduction considered is 25%.

The Fundamental natural period of vibration (Ta) in seconds of a RC building is estimated by using the following formula, Ta = 0.09*h/(d)^0.5.

Where h is the height of the building in meters. d is the base dimension of the building at the plinth level, in m along the considered direction of the lateral force.

Height of the building = 36.0m (measured from Stilt floor)
d (along-y, length of the building) = 61.34 m
b (along-x breadth of the building) = 16.88 m
Ta (along x) = 0.09 x 36.0/(61.64)^0.5

= 0.4127 Sec.

Ta (along y) = 0.09 x 36.0/(16.88)^0.5

= 0.7887 Sec.

From IS 1893: 2002, Clause 6.4.2, Design horizontal seismic coefficient

$$Ah = \frac{Z\ I\ Sa}{2\ R\ g}$$

Where,

Z for Zone III = 0.16

I for Building has occupants more than 200 = 1.2 (Refer to IS 1893-2016, Table.8)

R for Building with Ductile RC Structural walls i.e. 4.0

as per (Table 9).

Sa/g (Hard soil) X-Dir. = 1.0/0.6345=1.576 (Refer to IS 1893-2016, page 13, Fig 1)

Sa/g (Hard soil) Y-Dir. = 1.0/0.7415=0.69 (Refer to IS 1893-2016, page 13, Fig 1)

Design horizontal seismic coefficient $Ah_x$ = 0.0378

Base Shear $Vb_x$ = 0.0378 W

Design horizontal seismic coefficient $Ah_y$ = 0.016

Base Shear $Vb_y$ = 0.016 W

## 5. LOAD COMBINATIONS

The various loads shall be combined in accordance with the stipulations in IS 875 (Part 5) 1987 and IS 456: 2000. The structural elements shall be designed for the combination that produces most unfavorable effect out of the following combinations.

The results obtained from the computer analysis in the form of member forces and reactions will be used for design the structural members. Following load combinations of the member forces will be considered for arriving at the design forces. The analysis considered load factor is as follows,

| Load Combination | LOAD FACTORS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | D.L. | I.L. | T.L | EQX | EQY | SPECX | SPECY | WX | WY |
| Limit State Of Serviceability (LSS) Combinations | | | | | | | | | |
| LC1 | 1.0 | - | 1.0 | - | - | - | - | - | - |
| LC2 | 1.0 | 1.0 | 1.0 | - | - | - | - | - | - |
| LC3 | 1.0 | - | 1.0 | 1.0 | - | - | - | - | - |
| LC4 | 1.0 | - | 1.0 | -1.0 | - | - | - | - | - |
| LC5 | 1.0 | - | 1.0 | - | 1.0 | - | - | - | - |
| LC6 | 1.0 | - | 1.0 | - | -1.0 | - | - | - | - |
| LC7 | 1.0 | - | 1.0 | - | - | - | - | 1.0 | - |
| LC8 | 1.0 | - | 1.0 | - | - | - | - | -1.0 | - |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| LC9 | 1.0 | - | 1.0 | - | - | - | - | - | 1.0 |
| LC10 | 1.0 | - | 1.0 | - | - | - | - | - | -1.0 |
| LC11 | 1.0 | - | 1.0 | - | - | 1.0 | - | - | - |
| LC12 | 1.0 | - | 1.0 | - | - | -1.0 | - | - | - |
| LC13 | 1.0 | - | 1.0 | - | - | - | 1.0 | - | - |
| LC14 | 1.0 | - | 1.0 | - | - | - | -1.0 | - | - |
| LC15 | 1.0 | 0.8 | 1.0 | 0.8 | - | - | - | - | - |
| LC16 | 1.0 | 0.8 | 1.0 | -0.8 | - | - | - | - | - |
| LC17 | 1.0 | 0.8 | 1.0 | - | 0.8 | - | - | - | - |
| LC18 | 1.0 | 0.8 | 1.0 | - | -0.8 | - | - | - | - |
| LC19 | 1.0 | 0.8 | 1.0 | - | - | - | - | 0.8 | - |
| LC20 | 1.0 | 0.8 | 1.0 | - | - | - | - | -0.8 | - |
| LC21 | 1.0 | 0.8 | 1.0 | - | - | - | - | - | 0.8 |
| LC22 | 1.0 | 0.8 | 1.0 | - | - | - | - | - | -0.8 |
| LC23 | 1.0 | 0.8 | 1.0 | - | - | 0.8 | - | - | - |
| LC24 | 1.0 | 0.8 | 1.0 | - | - | -0.8 | - | - | - |
| LC25 | 1.0 | 0.8 | 1.0 | - | - | - | 0.8 | - | - |
| LC26 | 1.0 | 0.8 | 1.0 | - | - | - | -0.8 | - | - |
| Limit State Of Collapse (LSC) Combinations | | | | | | | | | |
| COMB1 | 1.5 | - | 1.0 | - | - | - | - | - | - |
| COMB2 | 1.5 | 1.5 | 1.0 | - | - | - | - | - | - |
| COMB3 | 1.2 | 1.2 | 1.0 | 1.2 | - | - | - | - | - |
| COMB4 | 1.2 | 1.2 | 1.0 | -1.2 | - | - | - | - | - |
| COMB5 | 1.2 | 1.2 | 1.0 | - | 1.2 | - | - | - | - |
| COMB6 | 1.2 | 1.2 | 1.0 | - | -1.2 | - | - | - | - |
| COMB7 | 1.2 | 1.2 | 1.0 | - | - | - | - | 1.2 | - |
| COMB8 | 1.2 | 1.2 | 1.0 | - | - | - | - | -1.2 | - |
| COMB9 | 1.2 | 1.2 | 1.0 | - | - | - | - | - | 1.2 |
| COMB10 | 1.2 | 1.2 | 1.0 | - | - | - | - | - | -1.2 |
| COMB11 | 1.2 | 1.2 | 1.0 | - | - | 1.2 | - | - | - |
| COMB12 | 1.2 | 1.2 | 1.0 | - | - | -1.2 | - | - | - |
| COMB13 | 1.2 | 1.2 | 1.0 | - | - | - | 1.2 | - | - |
| COMB14 | 1.2 | 1.2 | 1.0 | - | - | - | -1.2 | - | - |
| COMB15 | 1.5 | - | 1.0 | 1.5 | - | - | - | - | - |
| COMB16 | 1.5 | - | 1.0 | -1.5 | - | - | - | - | - |
| COMB17 | 1.5 | - | 1.0 | - | 1.5 | - | - | - | - |
| COMB18 | 1.5 | - | 1.0 | - | -1.5 | - | - | - | - |
| COMB19 | 1.5 | - | 1.0 | - | - | - | - | 1.5 | - |
| COMB20 | 1.5 | - | 1.0 | - | - | - | - | -1.5 | - |
| COMB21 | 1.5 | - | 1.0 | - | - | - | - | - | 1.5 |
| COMB22 | 1.5 | - | 1.0 | - | - | - | - | - | -1.5 |
| COMB23 | 1.5 | - | 1.0 | - | - | 1.5 | - | - | - |
| COMB24 | 1.5 | - | 1.0 | - | - | -1.5 | - | - | - |
| COMB25 | 1.5 | - | 1.0 | - | - | - | 1.5 | - | - |
| COMB26 | 1.5 | - | 1.0 | - | - | - | -1.5 | - | - |
| COMB27 | 0.9 | - | 1.0 | 1.5 | - | - | - | - | - |
| COMB28 | 0.9 | - | 1.0 | -1.5 | - | - | - | - | - |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| COMB29 | 0.9 | - | 1.0 | - | 1.5 | - | - | - | - |
| COMB30 | 0.9 | - | 1.0 | - | -1.5 | - | - | - | - |
| COMB31 | 0.9 | - | 1.0 | - | - | - | - | 1.5 | - |
| COMB32 | 0.9 | - | 1.0 | - | - | - | - | -1.5 | - |
| COMB33 | 0.9 | - | 1.0 | - | - | - | - | - | 1.5 |
| COMB34 | 0.9 | - | 1.0 | - | - | - | - | - | -1.5 |
| COMB35 | 0.9 | - | 1.0 | - | - | 1.5 | - | - | - |
| COMB36 | 0.9 | - | 1.0 | - | - | -1.5 | - | - | - |
| COMB37 | 0.9 | - | 1.0 | - | - | - | 1.5 | - | - |
| COMB38 | 0.9 | - | 1.0 | - | - | - | -1.5 | - | - |

**DL**: Dead Load **EQX** : Earthquake Load in X-dir. **WX**: Wind Load in X-dir.

**IL**: Imposed Load **EQY** : Earthquake Load in Y-dir. **WY**: Wind Load in Y-dir.

## 6. COVER AND FIRE RATING

Fire rating considered - 2hrs. Cover to reinforcement considered for various elements are as follows.

| | |
|---|---|
| Raft | 60 mm |
| Columns | 40 mm |
| Shear Wall | 40/30 mm |
| Beams | 30 mm |
| Slabs | 25 mm |

## 7. DEFLECTION CRITERIA

### 7.1 Lateral Deflection (Wind)

Overall Deflection< Height/500

Storey Deflection < Storey height/500

### 7.2 Lateral Deflection (Seismic)

Overall Drift < H / 250

Storey Drift < 0.004 times storey height

### 7.3 Vertical Deflection of Beams and Slabs due to Gravity Loads

Total Deflection (DL + LL) < Span/250 up to 20 maximum

Deflection including the effects of Temperature, Creep and Shrinkage Occurring after erection of partitions and the application of finishes < Span/350 or 20mm whichever is less

## 8. CONSTRUCTION JOINT

Construction joints and shrinkage strips will be planned with the contractor and only be used in locations pre-approved by consultants.

1) No construction joint is allowed in the sunken portion
2) Construction joint shall be provided in slab/beam at l/3 from support.
3) Construction joint shall be placed at accessible location for maintenance purpose.
4) Joints are common source of weakness, therefore it is desirable to avoid or at least minimize them.

## 9. DESIGN OF STRUCTURAL ELEMENTS

For the design of R.C.C. elements, the Limit State Method will be used as per IS 456-2000. Materials of construction will be predominantly concrete with consideration for strength and durability. The grade of concrete adopted in the Analysis and Design is M35 for Raft, Basement slab, Basement wall etc whereas the vertical elements like shear wall/columns are designed using M40 considering the level of stresses to be borne by the members both in compression as well as flexural.

High Yield Strength Deformed bars conforming to IS: 1786 with $F_y$ = 550 MPa will be used as reinforcement. Structural steel, if any with Fy = 250 Grade shall be used.

Covers to reinforcement shall be in accordance with IS: 456:2000 corresponding to **moderate exposure conditions** for the super-structure or severe exposure conditions for the sub-structure and to satisfy a fire rating of 2 hrs as per National building code of India- SP7 (part IV).

## 10. FOUNDATION

The proposed Residential building comprises Two Basement+Stilt Floor+1st Floor to 11th Floor+Roof (Residential Use) storey structure located in Thiruvanmaiyur, Chennai. Based on the analysis results, it is noticed that the vertical elements are considerably loaded being a MSB.

As per the column load intensity and the Soil consultant recommendation laid down in the report, the building is designed with Raft (uniform) Foundation. Raft Foundation has been designed using the recommended Safe Bearing Capacity of 400 kN/m^2 with the modulus of subgrade reaction of 40,000 kN/m^2.

## 11. STABILITY OF STRUCTURES

1. For the purpose of stability of the structure as a whole against overturning, the restoring moment shall not be less than 1.2 times the maximum overturning moments due to dead load plus 1.4 times the maximum overturning moments due to imposed loads. In case where dead load provides the restoring moments only 0.9 times in dead load shall be considered. The restoring moments due to imposed loads shall be ignored.

2. The factor of safety against sliding shall not be less than 1.40.

3. Factor of safety against buoyancy shall be not less than 1.20 ignoring the superimposed loading

## 12.0 OTHER DATA

Specific requirements of floor and wall cutouts for services, sinking (extent & depth) of floors in services, kitchen, utility and toilet areas, external architectural features, and entrance canopies are provided as required by Architects and Service Consultants. The relevant information is obtained from them in the form of drawings. Lift loads and lift machine room equipment and cut out layouts will be obtained from the lift manufacturers. An impact factor of 100% will be considered in the lift supporting structures.

## 13.0 R.C Design

The structures are analyzed for the various load combinations as per IS: 456-2000. The design of structural elements are carried out by ETABS/RCDC Ver.6.1 for all structural elements for the worst forces extracted from the ETABS analysis output whereas the slab design is being done using in house spread sheet. For the design of R.C.C structural elements carried out, the recommendations stipulated in IS: 456-2000 is followed. Limit State method of design is adopted with appropriate load factors with the various load combinations for the different structural elements appropriately.

### 13.1. Foundation

Raft Foundation has been designed using Safe Bearing Capacity of 400 kN/m^2 and it is analyzed for the modulus of subgrade reaction of 40,000 kN/m^2. The design has been carried out using SAFE for the exported forces/reactions from the ETABS model.

### 13.2. Column/Wall

Vertical elements carry both gravity and lateral loads like Columns/RC Walls are designed for the worst combination results using ETABS.

### 13.3. Beam

Beams are designed for the worst combination results using ETABS/RCDC/in house spread sheet.

### 13.4. Slab

Flat Plate/irregular slab is designed using SAFE and the conventional Slabs are designed using in house spread sheet as per IS-456 Annexe-D, Table-2

## 14.0 COMPUTER PROGRAMS USED

The following Software / spreadsheet are used to carry out Structural design.

14.1 PROKON Ver 2.3 - Wall & Beam design

14.2 ETABS Ver 2021 -Three Dimensional FEM analysis and Design Programs

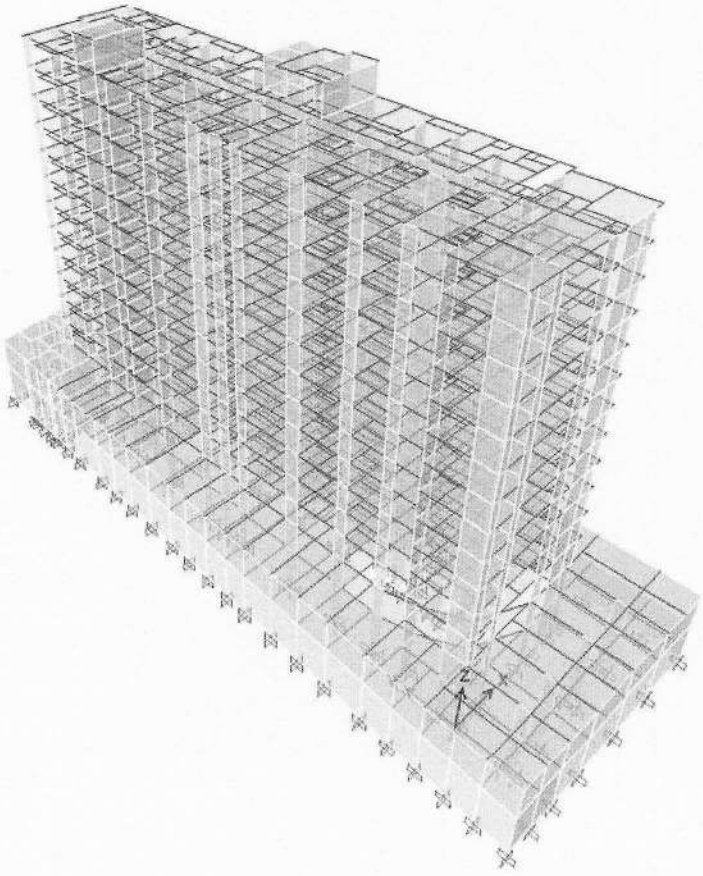
14.3 SAFE 2020 Ver 20 - Used mainly for B Floor Slab Analysis & Design

14.4 In-House Spreadsheet - One way/ Two way slab design

14.5 RCDC V.8.0 - Design Software for all Structural Elements except Raft.

# 3D MODEL
# &
# ANALYSIS SUMMARY REPORT

# ETABS®



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# 1 Structure Data

This chapter provides model geometry information, including items such as story levels, point coordinates, and element connectivity.

## 1.1 Story Data

**Table 1.1 - Story Definitions**

| Tower | Name | Height m | Master Story | Similar To | Splice Story | Color |
|---|---|---|---|---|---|---|
| T1 | HEAD ROOM | 3 | Yes | None | No | Yellow |
| T1 | ROOF | 3 | Yes | None | No | Yellow |
| T1 | 11TH | 3 | Yes | None | No | Yellow |
| T1 | 10TH | 3 | Yes | None | No | Yellow |
| T1 | 9TH | 3 | Yes | None | No | Yellow |
| T1 | 8TH | 3 | Yes | None | No | Yellow |
| T1 | 7TH | 3 | Yes | None | No | Yellow |
| T1 | 6TH | 3 | Yes | None | No | Yellow |
| T1 | 5TH | 3 | Yes | None | No | Yellow |
| T1 | 4TH | 3 | Yes | None | No | Yellow |
| T1 | 3RD | 3 | Yes | None | No | Yellow |
| T1 | 2ND | 3 | Yes | None | No | Yellow |
| T1 | 1ST | 3 | Yes | None | No | Yellow |
| T1 | STILT | 3.6 | No | 1ST | No | Gray8Dark |
| T1 | BASE-1 | 4.875 | No | 1ST | No | Blue |

# 2 Properties

This chapter provides property information for materials, frame sections, shell sections, and links.

## 2.1 Materials

**Table 2.1 - Material Properties - General**

| Material | Type | SymType | Grade | Color | Notes |
|---|---|---|---|---|---|
| DUMMY | Other | Isotropic | Unknown | Green | |
| HYSD415 | Rebar | Uniaxial | HYSD Grade 415 | Yellow | |
| HYSD550 | Rebar | Uniaxial | HYSD Grade 550 | Gray8Dark | |
| M35 | Concrete | Isotropic | M35 | Yellow | |
| M40 | Concrete | Isotropic | M40 | Yellow | |
| Tendon | Tendon | Uniaxial | Unknown | Gray8Dark | |

## 2.2 Frame Sections

**Table 2.2 - Frame Section Property Definitions - Summary (Part 1 of 3)**

| Name | Material | Shape | Color | Area cm2 | J cm4 | I33 cm4 | I22 cm4 | I23 cm4 | As2 cm2 |
|---|---|---|---|---|---|---|---|---|---|
| B 200X380 | M35 | Concrete Rectangular | Cyan | 760 | 67948.2 | 91453.3 | 25333.3 | 0 | 633.3 |
| B 200X450 | M35 | Concrete Rectangular | Cyan | 900 | 86509.3 | 151875 | 30000 | 0 | 750 |
| B 200X600 | M35 | Concrete Rectangular | Blue | 1200 | 126434.6 | 360000 | 40000 | 0 | 1000 |
| B 200X750 | M35 | Concrete Rectangular | Gray8Dark | 1500 | 166414.2 | 703125 | 50000 | 0 | 1250 |
| B 300X1050 | M35 | Concrete Rectangular | Magenta | 3150 | 774994.5 | 2894062.5 | 236250 | 0 | 2625 |
| B 300X600 | M35 | Concrete Rectangular | Red | 1800 | 370785.9 | 540000 | 135000 | 0 | 1500 |
| DUMMY | DUMMY | Concrete Rectangular | Red | 100 | 1408.3 | 833.3 | 833.3 | 0 | 83.3 |

**Table 2.2 - Frame Section Property Definitions - Summary (Part 2 of 3)**

| Name | As3 cm2 | S33Pos cm3 | S33Neg cm3 | S22Pos cm3 | S22Neg cm3 | Z33 cm3 | Z22 cm3 | R33 mm | R22 mm | Cw cm6 | CG Offset 3 mm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B 200X380 | 633.3 | 4813.3 | 4813.3 | 2533.3 | 2533.3 | 7220 | 3800 | 109.7 | 57.7 | | 0 |
| B 200X450 | 750 | 6750 | 6750 | 3000 | 3000 | 10125 | 4500 | 129.9 | 57.7 | | 0 |
| B 200X600 | 1000 | 12000 | 12000 | 4000 | 4000 | 18000 | 6000 | 173.2 | 57.7 | | 0 |
| B 200X750 | 1250 | 18750 | 18750 | 5000 | 5000 | 28125 | 7500 | 216.5 | 57.7 | | 0 |
| B 300X1050 | 2625 | 55125 | 55125 | 15750 | 15750 | 82687.5 | 23625 | 303.1 | 86.6 | | 0 |
| B 300X600 | 1500 | 18000 | 18000 | 9000 | 9000 | 27000 | 13500 | 173.2 | 86.6 | | 0 |
| DUMMY | 83.3 | 166.7 | 166.7 | 166.7 | 166.7 | 250 | 250 | 28.9 | 28.9 | | 0 |

**Table 2.2 - Frame Section Property Definitions - Summary (Part 3 of 3)**

| Name | PNA Offset 3 mm | PNA Offset 2 mm | Area Modifier | As2 Modifier | As3 Modifier | J Modifier | I33 Modifier | I22 Modifier | Mass Modifier | Weight Modifier |
|---|---|---|---|---|---|---|---|---|---|---|
| B 200X380 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| B 200X450 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| B 200X600 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| B 200X750 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| B 300X1050 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| B 300X600 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| DUMMY | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

## 2.3 Shell Sections

**Table 2.3 - Area Section Property Definitions - Summary**

| Name | Type | Element Type | Material | Total Thickness mm | Deck Material | Deck Depth mm |
|---|---|---|---|---|---|---|
| S 125 | Slab | Shell-Thin | M35 | 125 | | |
| S 150 | Slab | Shell-Thin | M35 | 150 | | |
| S 175 | Slab | Shell-Thin | M35 | 175 | | |
| S 200 | Slab | Shell-Thin | M35 | 200 | | |
| W 200 | Wall | Shell-Thin | M40 | 200 | | |
| W 300 | Wall | Shell-Thin | M40 | 300 | | |
| W 450 | Wall | Shell-Thin | M40 | 450 | | |
| W 625 | Wall | Shell-Thin | M40 | 625 | | |

# 3 Loads

This chapter provides loading information as applied to the model.

## 3.1 Load Patterns

**Table 3.1 - Load Pattern Definitions**

| Name | Is Auto Load | Type | Self Weight Multiplier | Auto Load |
|---|---|---|---|---|
| ~LLRF | Yes | Other | 0 | |
| ~SPEC X(D)ECC | Yes | Other | 0 | |
| ~SPEC X(S)ECC | Yes | Other | 0 | |
| ~SPEC Y(D)ECC | Yes | Other | 0 | |
| ~SPEC Y(S)ECC | Yes | Other | 0 | |
| ~SPEC Z(D)ECC | Yes | Other | 0 | |
| Dead | No | Dead | 1 | |
| EQ X | No | Seismic | 0 | IS 1893:2016 |
| EQ Y | No | Seismic | 0 | IS 1893:2016 |
| LIVE<3 | No | Reducible Live | 0 | |
| LIVE>3 | No | Reducible Live | 0 | |
| ROOF | No | Roof Live | 0 | |
| SDL | No | Super Dead | 0 | |
| TEMP | No | Temperature | 0 | |
| WALL | No | Super Dead | 0 | |
| WL X | No | Wind | 0 | Indian IS 875:2015 |
| WL Y | No | Wind | 0 | Indian IS 875:2015 |

## 3.2 Load Sets

**Table 3.2 - Shell Uniform Load Sets**

| Name | Load Pattern | Load Value kN/m2 |
|---|---|---|
| BALCONY | SDL | 3.25 |
| BALCONY | LIVE<3 | 3 |
| BED/KITCHEN/LIVING | SDL | 1.25 |
| BED/KITCHEN/LIVING | LIVE<3 | 2 |
| BILLIARDS / TT ROOM | SDL | 1.25 |
| BILLIARDS / TT ROOM | LIVE>3 | 5 |
| COMMUNICATION ROOM | SDL | 1.25 |
| COMMUNICATION ROOM | LIVE<3 | 3 |
| CORRIDOR | SDL | 1.25 |
| CORRIDOR | LIVE<3 | 3 |
| DRIVEWAY | SDL | 2.4 |
| DRIVEWAY | LIVE<3 | 3 |
| ELETRICAL ROOM | SDL | 1.25 |
| ELETRICAL ROOM | LIVE>3 | 7.5 |
| FIRE TRACK | SDL | 20 |
| FIRE TRACK | LIVE<3 | 3 |
| GYM/YOGA/INDOOR GAMES | SDL | 1.25 |
| GYM/YOGA/INDOOR GAMES | LIVE>3 | 5 |
| LMR/OHT | SDL | 20 |
| LMR/OHT | LIVE<3 | 3 |

**Table 3.2 - Shell Uniform Load Sets (continued)**

| Name | Load Pattern | Load Value kN/m2 |
|---|---|---|
| LOBBY | SDL | 1.25 |
| LOBBY | LIVE<3 | 3 |
| MULTI PURPOSE HALL | SDL | 1.25 |
| MULTI PURPOSE HALL | LIVE>3 | 5 |
| PARKING | SDL | 2.4 |
| PARKING | LIVE<3 | 3 |
| PRE-FUNCTION AREA | SDL | 1.25 |
| PRE-FUNCTION AREA | LIVE>3 | 5 |
| PUMP ROOM | SDL | 1.25 |
| PUMP ROOM | LIVE>3 | 7.5 |
| TERRACE | SDL | 3 |
| TERRACE | LIVE<3 | 3 |
| TOILET | SDL | 3.25 |
| TOILET | LIVE<3 | 2 |
| UTILITY | SDL | 3.25 |
| UTILITY | LIVE<3 | 2 |

## 3.3 Auto Wind Loading

**Table 3.3 - Load Pattern Definitions - Auto Wind - Indian IS 875 2015 (Part 1 of 3)**

| Name | Exposure Set | Is Auto Load | Exposure Source | Top Story | Bottom Story | Include Parapet | Parapet Height m | Cp Windward | Cp Leeward | Wind Speed meter/sec |
|---|---|---|---|---|---|---|---|---|---|---|
| WL X | 1 | No | Diaphragms | ROOF | STILT | Yes | 1.25 | 0.8 | 0.5 | 50 |
| WL X | 1 | No | | | | | | | | |
| WL X | 1 | No | | | | | | | | |
| WL X | 1 | No | | | | | | | | |
| WL X | 1 | No | | | | | | | | |
| WL X | 1 | No | | | | | | | | |
| WL X | 1 | No | | | | | | | | |
| WL X | 1 | No | | | | | | | | |
| WL X | 1 | No | | | | | | | | |
| WL X | 1 | No | | | | | | | | |
| WL X | 1 | No | | | | | | | | |
| WL X | 1 | No | | | | | | | | |
| WL X | 1 | No | | | | | | | | |
| WL Y | 1 | No | Diaphragms | ROOF | STILT | Yes | 1.25 | 0.8 | 0.5 | 50 |
| WL Y | 1 | No | | | | | | | | |
| WL Y | 1 | No | | | | | | | | |
| WL Y | 1 | No | | | | | | | | |
| WL Y | 1 | No | | | | | | | | |
| WL Y | 1 | No | | | | | | | | |
| WL Y | 1 | No | | | | | | | | |
| WL Y | 1 | No | | | | | | | | |
| WL Y | 1 | No | | | | | | | | |
| WL Y | 1 | No | | | | | | | | |
| WL Y | 1 | No | | | | | | | | |
| WL Y | 1 | No | | | | | | | | |

**Table 3.3 - Load Pattern Definitions - Auto Wind - Indian IS 875 2015 (Part 2 of 3)**

| Name | Exposure Set | Terrain Category | Importance Factor | Risk Coefficient | Topography | Width Type | Direction Angle deg | Story | Diaphragm |
|---|---|---|---|---|---|---|---|---|---|
| WL X | 1 | 2 | 1.00 | 1 | 1 | Auto | 0 | ROOF | D2 |
| WL X | 1 | | | | | | | 11TH | D1 |
| WL X | 1 | | | | | | | 10TH | D1 |
| WL X | 1 | | | | | | | 9TH | D1 |
| WL X | 1 | | | | | | | 8TH | D1 |
| WL X | 1 | | | | | | | 7TH | D1 |
| WL X | 1 | | | | | | | 6TH | D1 |
| WL X | 1 | | | | | | | 5TH | D1 |
| WL X | 1 | | | | | | | 4TH | D1 |
| WL X | 1 | | | | | | | 3RD | D1 |
| WL X | 1 | | | | | | | 2ND | D1 |
| WL X | 1 | | | | | | | 1ST | D1 |
| WL Y | 1 | 2 | 1.00 | 1 | 1 | Auto | 90 | ROOF | D2 |
| WL Y | 1 | | | | | | | 11TH | D1 |
| WL Y | 1 | | | | | | | 10TH | D1 |
| WL Y | 1 | | | | | | | 9TH | D1 |
| WL Y | 1 | | | | | | | 8TH | D1 |
| WL Y | 1 | | | | | | | 7TH | D1 |
| WL Y | 1 | | | | | | | 6TH | D1 |
| WL Y | 1 | | | | | | | 5TH | D1 |
| WL Y | 1 | | | | | | | 4TH | D1 |
| WL Y | 1 | | | | | | | 3RD | D1 |
| WL Y | 1 | | | | | | | 2ND | D1 |
| WL Y | 1 | | | | | | | 1ST | D1 |

**Table 3.3 - Load Pattern Definitions - Auto Wind - Indian IS 875 2015 (Part 3 of 3)**

| Name | Exposure Set | Depth m | X m | Y m |
|---|---|---|---|---|
| WL X | 1 | 16.83 | 8.415 | 30.5175 |
| WL X | 1 | 16.83 | 8.415 | 30.5175 |
| WL X | 1 | 16.83 | 8.415 | 30.5175 |
| WL X | 1 | 16.83 | 8.415 | 30.5175 |
| WL X | 1 | 16.83 | 8.415 | 30.5175 |
| WL X | 1 | 16.83 | 8.415 | 30.5175 |
| WL X | 1 | 16.83 | 8.415 | 30.5175 |
| WL X | 1 | 16.83 | 8.415 | 30.5175 |
| WL X | 1 | 16.83 | 8.415 | 30.5175 |
| WL X | 1 | 16.83 | 8.415 | 30.5175 |
| WL X | 1 | 16.83 | 8.415 | 30.5175 |
| WL X | 1 | 16.83 | 8.415 | 30.5175 |
| WL Y | 1 | 61.035 | 8.415 | 30.5175 |
| WL Y | 1 | 61.035 | 8.415 | 30.5175 |
| WL Y | 1 | 61.035 | 8.415 | 30.5175 |
| WL Y | 1 | 61.035 | 8.415 | 30.5175 |
| WL Y | 1 | 61.035 | 8.415 | 30.5175 |
| WL Y | 1 | 61.035 | 8.415 | 30.5175 |
| WL Y | 1 | 61.035 | 8.415 | 30.5175 |
| WL Y | 1 | 61.035 | 8.415 | 30.5175 |

**Table 3.3 - Load Pattern Definitions - Auto Wind - Indian IS 875 2015 (Part 3 of 3, continued)**

| Name | Exposure Set | Depth m | X m | Y m |
|---|---|---|---|---|
| WL Y | 1 | 61.035 | 8.415 | 30.5175 |
| WL Y | 1 | 61.035 | 8.415 | 30.5175 |
| WL Y | 1 | 61.035 | 8.415 | 30.5175 |
| WL Y | 1 | 61.035 | 8.415 | 30.5175 |

### 3.4 Auto Seismic Loading

**Table 3.4 - Load Pattern Definitions - Auto Seismic - IS 1893 2016 (Part 1 of 3)**

| Name | Period Used sec | Coeff Used | Weight Used kN | Base Shear kN | Is Auto Load | X Dir? | X Dir Plus Ecc? | X Dir Minus Ecc? | Y Dir? | Y Dir Plus Ecc? | Y Dir Minus Ecc? |
|---|---|---|---|---|---|---|---|---|---|---|---|
| EQ X | 0.789 | 0.041369 | 133125.6477 | 5507.2511 | No | Yes | No | No | No | No | No |
| EQ Y | 0.412 | 0.06 | 133125.6477 | 7987.5389 | No | No | No | No | Yes | No | No |

**Table 3.4 - Load Pattern Definitions - Auto Seismic - IS 1893 2016 (Part 2 of 3)**

| Name | Period Used sec | Coeff Used | Weight Used kN | Base Shear kN | Ecc Ratio | Top Story | Bottom Story | Period Type | User T sec | Z |
|---|---|---|---|---|---|---|---|---|---|---|
| EQ X | 0.789 | 0.041369 | 133125.6477 | 5507.2511 | 0.05 | ROOF | STILT | User Defined | 0.789 | 0.16 |
| EQ Y | 0.412 | 0.06 | 133125.6477 | 7987.5389 | 0.05 | ROOF | STILT | User Defined | 0.412 | 0.16 |

**Table 3.4 - Load Pattern Definitions - Auto Seismic - IS 1893 2016 (Part 3 of 3)**

| Name | Period Used sec | Coeff Used | Weight Used kN | Base Shear kN | I | R |
|---|---|---|---|---|---|---|
| EQ X | 0.789 | 0.041369 | 133125.6477 | 5507.2511 | 1.2 | 4 |
| EQ Y | 0.412 | 0.06 | 133125.6477 | 7987.5389 | 1.2 | 4 |

## IS 1893:2016 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern EQ X according to IS 1893:2016, as calculated by ETABS.

**Direction and Eccentricity**

Direction = X

**Structural Period**

Period Calculation Method = User Specified

User Period $T = 0.789\ sec$

**Factors and Coefficients**

Seismic Zone Factor, Z [IS Table 3] $Z = 0.16$

Response Reduction Factor, R [IS Table 9] $R = 4$

Importance Factor, I [IS Table 8] $I = 1.2$

Site Type [IS Table 1] = II

**Seismic Response**

Spectral Acceleration Coefficient, $S_a/g$ [IS 6.4.2] $\frac{S_a}{g} = \frac{1.36}{T}$ $\frac{S_a}{g} = 1.723701$

**Equivalent Lateral Forces**

Seismic Coefficient, $A_h$ [IS 6.4.2] $A_h = \frac{Z I \frac{S_a}{g}}{2R}$

**Calculated Base Shear**

| Direction | Period Used (sec) | W (kN) | $V_b$ (kN) |
|---|---|---|---|
| X | 0.789 | 133125.6477 | 5507.2511 |

**Applied Story Forces**

| Story | Elevation | X-Dir | Y-Dir |
|---|---|---|---|
| | m | kN | kN |
| HEAD ROOM | 47.475 | 0 | 0 |
| ROOF | 44.475 | 1062.0499 | 0 |
| 11TH | 41.475 | 1062.8653 | 0 |
| 10TH | 38.475 | 878.4011 | 0 |
| 9TH | 35.475 | 711.5049 | 0 |
| 8TH | 32.475 | 562.1767 | 0 |
| 7TH | 29.475 | 430.4496 | 0 |
| 6TH | 26.475 | 316.301 | 0 |
| 5TH | 23.475 | 219.6535 | 0 |
| 4TH | 20.475 | 140.5782 | 0 |
| 3RD | 17.475 | 79.0753 | 0 |
| 2ND | 14.475 | 35.1446 | 0 |
| 1ST | 11.475 | 9.0511 | 0 |
| STILT | 8.475 | 0 | 0 |
| BASE-1 | 4.875 | 0 | 0 |

| Story | Elevation | X-Dir | Y-Dir |
|---|---|---|---|
| | m | kN | kN |
| Base | 0 | 0 | 0 |

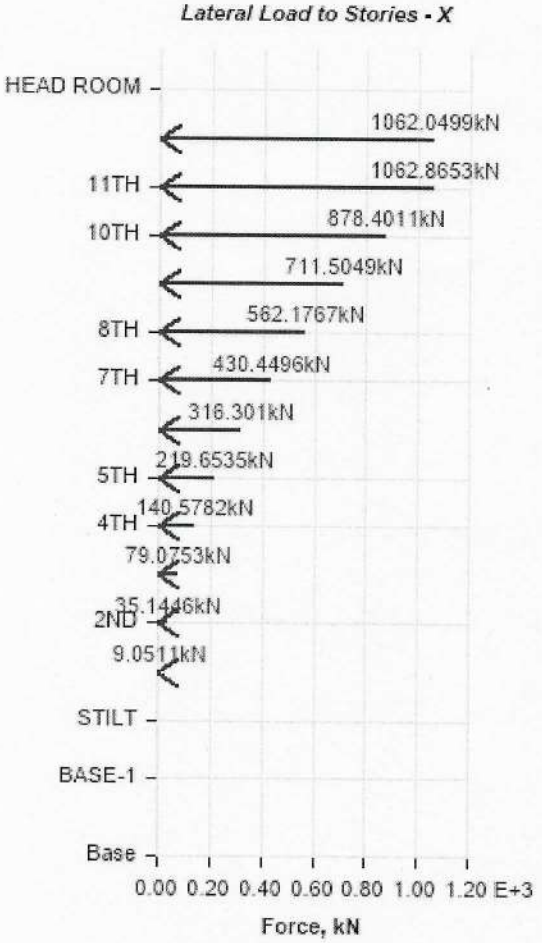



Figure 3-1-Set 1

# IS 1893:2016 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern EQ Y according to IS 1893:2016, as calculated by ETABS.

**Direction and Eccentricity**

Direction = Y

**Structural Period**

Period Calculation Method = User Specified

User Period $T = 0.412\ sec$

**Factors and Coefficients**

Seismic Zone Factor, Z [IS Table 3] $Z = 0.16$

Response Reduction Factor, R [IS Table 9] $R = 4$

Importance Factor, I [IS Table 8] $I = 1.2$

Site Type [IS Table 1] = II

**Seismic Response**

Spectral Acceleration Coefficient, $S_a/g$ [IS 6.4.2] $\frac{S_a}{g} = 2.5$ $\frac{S_a}{g} = 2.5$

**Equivalent Lateral Forces**

Seismic Coefficient, $A_h$ [IS 6.4.2] $A_h = \frac{Z I \frac{S_a}{g}}{2R}$

**Calculated Base Shear**

| Direction | Period Used (sec) | W (kN) | $V_b$ (kN) |
|---|---|---|---|
| Y | 0.412 | 133125.6477 | 7987.5389 |

**Applied Story Forces**

| Story | Elevation | X-Dir | Y-Dir |
|---|---|---|---|
| | m | kN | kN |
| HEAD ROOM | 47.475 | 0 | 0 |
| ROOF | 44.475 | 0 | 1540.3628 |
| 11TH | 41.475 | 0 | 1541.5455 |
| 10TH | 38.475 | 0 | 1274.0045 |
| 9TH | 35.475 | 0 | 1031.9437 |
| 8TH | 32.475 | 0 | 815.3629 |
| 7TH | 29.475 | 0 | 624.3102 |
| 6TH | 26.475 | 0 | 458.7528 |
| 5TH | 23.475 | 0 | 318.5783 |
| 4TH | 20.475 | 0 | 203.8901 |
| 3RD | 17.475 | 0 | 114.6882 |
| 2ND | 14.475 | 0 | 50.9725 |
| 1ST | 11.475 | 0 | 13.1274 |
| STILT | 8.475 | 0 | 0 |
| BASE-1 | 4.875 | 0 | 0 |

| Story | Elevation | X-Dir | Y-Dir |
|---|---|---|---|
| | m | kN | kN |
| Base | 0 | 0 | 0 |

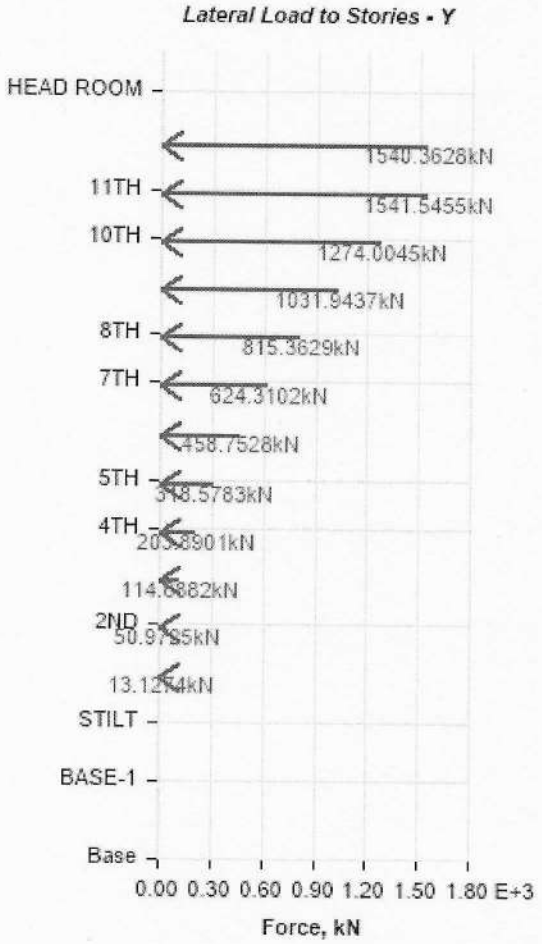



Figure 3-2-Set 1

## 3.5 Load Cases

**Table 3.5 - Load Case Definitions - Summary**

| Name | Type |
|---|---|
| Dead | Linear Static |
| Live>3 | Linear Static |
| Modal | Modal - Ritz |
| SDL | Linear Static |
| WALL | Linear Static |
| LIVE<3 | Linear Static |
| ROOF | Linear Static |
| TEMP | Linear Static |
| EQ X | Linear Static |
| EQ Y | Linear Static |
| WL X | Linear Static |
| WL Y | Linear Static |
| SPEC X(D) | Response Spectrum |
| SPEC Y(D) | Response Spectrum |
| SPEC X(S) | Response Spectrum |
| SPEC Y(S) | Response Spectrum |
| SPEC Z(D) | Response Spectrum |

# 4 Analysis Results

This chapter provides analysis results.

## 4.1 Story Results

**Table 4.1 - Story Stiffness**

| Story | Output Case | Case Type | Step Type | Shear X kN | Drift X mm | Stiff X kN/m | Shear Y kN | Drift Y mm | Stiff Y kN/m |
|---|---|---|---|---|---|---|---|---|---|
| HEAD ROOM | EQ X | LinStatic | Step By Step | 0 | 4.975 | 1.201E-05 | 0 | 0.247 | 0.001 |
| ROOF | EQ X | LinStatic | Step By Step | 1062.0498 | 4.7 | 225963.381 | 1.585E-06 | 0.197 | 0 |
| 11TH | EQ X | LinStatic | Step By Step | 2124.9062 | 5.175 | 410639.874 | 2.794E-06 | 0.16 | 0 |
| 10TH | EQ X | LinStatic | Step By Step | 3003.2998 | 5.329 | 563542.388 | 6.869E-06 | 0.159 | 0 |
| 9TH | EQ X | LinStatic | Step By Step | 3714.7976 | 5.435 | 683465.832 | 1.573E-05 | 0.154 | 0 |
| 8TH | EQ X | LinStatic | Step By Step | 4276.9683 | 5.476 | 780973.139 | 2.43E-05 | 0.151 | 0 |
| 7TH | EQ X | LinStatic | Step By Step | 4707.4123 | 5.432 | 866624.859 | 2.385E-05 | 0.146 | 0 |
| 6TH | EQ X | LinStatic | Step By Step | 5023.7079 | 5.291 | 949427.315 | 2.421E-05 | 0.139 | 0 |
| 5TH | EQ X | LinStatic | Step By Step | 5243.3572 | 5.043 | 1039719.208 | 2.445E-05 | 0.129 | 0 |
| 4TH | EQ X | LinStatic | Step By Step | 5383.9339 | 4.673 | 1152191.695 | 2.667E-05 | 0.113 | 0 |
| 3RD | EQ X | LinStatic | Step By Step | 5463.007 | 4.165 | 1311604.385 | 2.679E-05 | 0.094 | 0 |
| 2ND | EQ X | LinStatic | Step By Step | 5498.1511 | 3.509 | 1566654.54 | 2.715E-05 | 0.083 | 0 |
| 1ST | EQ X | LinStatic | Step By Step | 5507.2013 | 3.297 | 1670211.444 | 2.441E-05 | 0.104 | 0 |
| STILT | EQ X | LinStatic | Step By Step | 5507.2013 | 0.974 | 5653969.086 | 2.43E-05 | 0.131 | 0 |
| BASE-1 | EQ X | LinStatic | Step By Step | 5507.2013 | 0.504 | 10919115.236 | 2.444E-05 | 0.1 | 0 |
| HEAD ROOM | EQ Y | LinStatic | Step By Step | 0 | 0.236 | 0 | 3.787E-05 | 4.184 | 0.009 |
| ROOF | EQ Y | LinStatic | Step By Step | 1.239E-06 | 0.493 | 0 | 1540.3629 | 5.957 | 258580.624 |
| 11TH | EQ Y | LinStatic | Step By Step | 0.0004 | 0.524 | 0 | 3081.9083 | 6.938 | 444214.565 |
| 10TH | EQ Y | LinStatic | Step By Step | 0.0007 | 0.53 | 0 | 4355.9128 | 7.932 | 549180.571 |
| 9TH | EQ Y | LinStatic | Step By Step | 0.001 | 0.533 | 0 | 5387.856 | 8.875 | 607105.81 |
| 8TH | EQ Y | LinStatic | Step By Step | 0.0012 | 0.529 | 0 | 6203.2184 | 9.67 | 641485.113 |
| 7TH | EQ Y | LinStatic | Step By Step | 0.0014 | 0.519 | 0 | 6827.5285 | 10.235 | 667066.878 |
| 6TH | EQ Y | LinStatic | Step By Step | 0.0016 | 0.5 | 0 | 7286.2813 | 10.517 | 692783.585 |
| 5TH | EQ Y | LinStatic | Step By Step | 0.0018 | 0.466 | 0 | 7604.8596 | 10.464 | 726740.794 |
| 4TH | EQ Y | LinStatic | Step By Step | 0.0019 | 0.424 | 0 | 7808.7495 | 9.992 | 781526.809 |
| 3RD | EQ Y | LinStatic | Step By Step | 0.002 | 0.369 | 0 | 7923.4377 | 8.975 | 882839.631 |
| 2ND | EQ Y | LinStatic | Step By Step | 0.002 | 0.321 | 0 | 7974.4101 | 7.192 | 1108747.164 |
| 1ST | EQ Y | LinStatic | Step By Step | 0.002 | 0.302 | 0 | 7987.5373 | 4.66 | 1714189.378 |
| STILT | EQ Y | LinStatic | Step By Step | 0.002 | 0.23 | 0 | 7987.5373 | 0.89 | 8974570.814 |
| BASE-1 | EQ Y | LinStatic | Step By Step | 0.002 | 0.048 | 0 | 7987.5373 | 0.101 | 78759937.414 |

## 4.2 Modal Results

**Table 4.2 - Modal Participating Mass Ratios (Part 1 of 2)**

| Case | Mode | Period sec | UX | UY | UZ | SumUX | SumUY | SumUZ | RX | RY |
|---|---|---|---|---|---|---|---|---|---|---|
| Modal | 1 | 1.879 | 0.0068 | 0.4943 | 1.446E-06 | 0.0068 | 0.4943 | 1.446E-06 | 0.1498 | 0.0053 |
| Modal | 2 | 1.68 | 0.4977 | 0.0116 | 0 | 0.5044 | 0.5059 | 1.609E-06 | 0.0031 | 0.4009 |
| Modal | 3 | 1.526 | 0.0268 | 0.01 | 1.004E-05 | 0.5312 | 0.5159 | 1.165E-05 | 0.0031 | 0.0249 |
| Modal | 4 | 0.544 | 0.0002 | 0.0943 | 0 | 0.5314 | 0.6102 | 1.171E-05 | 0.0261 | 2.405E-05 |
| Modal | 5 | 0.421 | 0.1522 | 0.0003 | 4.173E-05 | 0.6836 | 0.6105 | 0.0001 | 3.561E-05 | 0.0997 |
| Modal | 6 | 0.358 | 0.0366 | 0.0004 | 0.0001 | 0.7202 | 0.6109 | 0.0002 | 1.262E-05 | 0.02 |
| Modal | 7 | 0.269 | 0.0001 | 0.0535 | 0.0001 | 0.7202 | 0.6644 | 0.0002 | 0.0085 | 1.076E-06 |
| Modal | 8 | 0.231 | 0.0025 | 0.0002 | 0.1918 | 0.7227 | 0.6646 | 0.192 | 0.0304 | 0.0092 |
| Modal | 9 | 0.187 | 0.0643 | 0.0001 | 0.2095 | 0.787 | 0.6647 | 0.4016 | 2.94E-05 | 0.0748 |

**Table 4.2 - Modal Participating Mass Ratios (Part 1 of 2, continued)**

| Case | Mode | Period sec | UX | UY | UZ | SumUX | SumUY | SumUZ | RX | RY |
|---|---|---|---|---|---|---|---|---|---|---|
| Modal | 10 | 0.163 | 0.1198 | 1.534E-06 | 0.1506 | 0.9068 | 0.6647 | 0.5522 | 0.0024 | 0.093 |
| Modal | 11 | 0.117 | 2.836E-05 | 0.2338 | 0.0002 | 0.9069 | 0.8984 | 0.5524 | 0.0706 | 1.837E-06 |
| Modal | 12 | 0.106 | 0.0111 | 0.0001 | 0.26 | 0.918 | 0.8985 | 0.8124 | 0.0017 | 0.0128 |

**Table 4.2 - Modal Participating Mass Ratios (Part 2 of 2)**

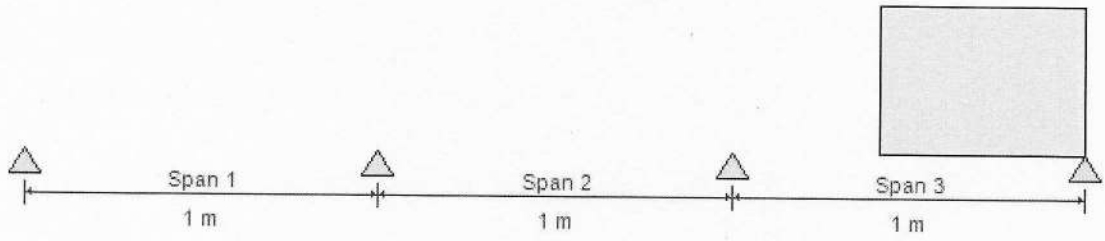
| Case | Mode | RZ | SumRX | SumRY | SumRZ |
|---|---|---|---|---|---|
| Modal | 1 | 0.0144 | 0.1498 | 0.0053 | 0.0144 |
| Modal | 2 | 0.0174 | 0.1529 | 0.4062 | 0.0317 |
| Modal | 3 | 0.3677 | 0.156 | 0.4311 | 0.3995 |
| Modal | 4 | 0.001 | 0.1821 | 0.4311 | 0.4004 |
| Modal | 5 | 0.0228 | 0.1821 | 0.5308 | 0.4232 |
| Modal | 6 | 0.0674 | 0.1821 | 0.5509 | 0.4906 |
| Modal | 7 | 0.0001 | 0.1906 | 0.5509 | 0.4907 |
| Modal | 8 | 0.0002 | 0.2211 | 0.5601 | 0.4909 |
| Modal | 9 | 0.0132 | 0.2211 | 0.6349 | 0.504 |
| Modal | 10 | 0.0136 | 0.2235 | 0.7279 | 0.5176 |
| Modal | 11 | 0.0001 | 0.2942 | 0.7279 | 0.5177 |
| Modal | 12 | 0.0007 | 0.2959 | 0.7407 | 0.5184 |

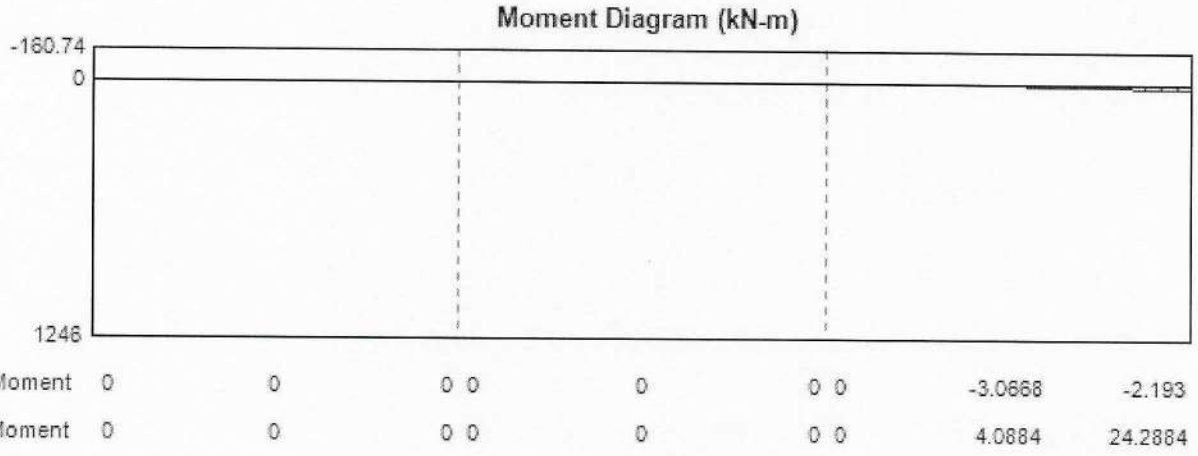
# DESIGN OF RAFT FOUNDATION

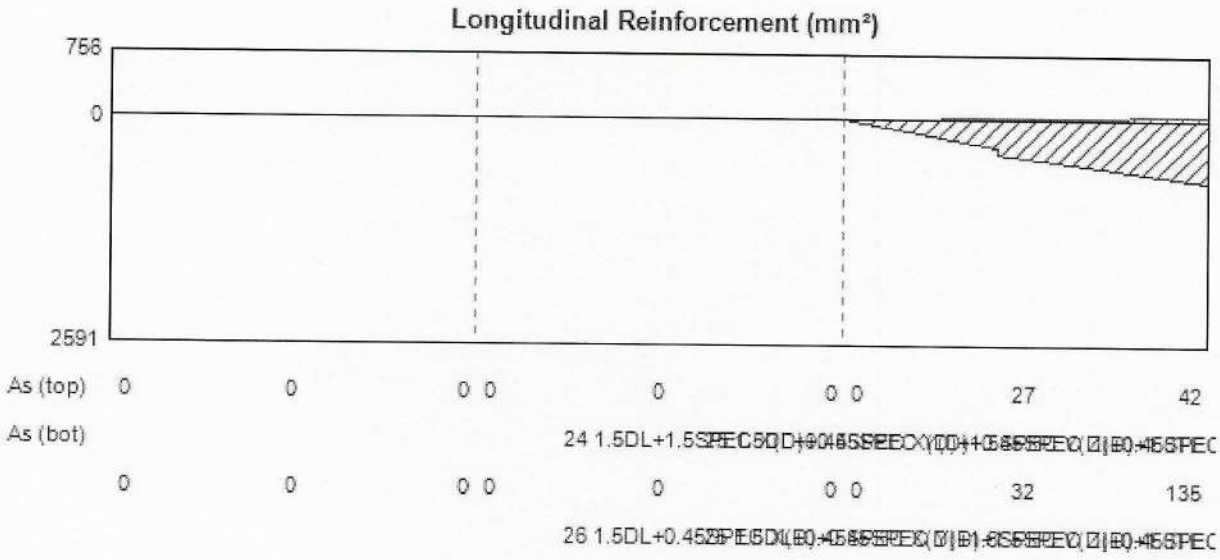
# IS 456:2000 Concrete Strip Design

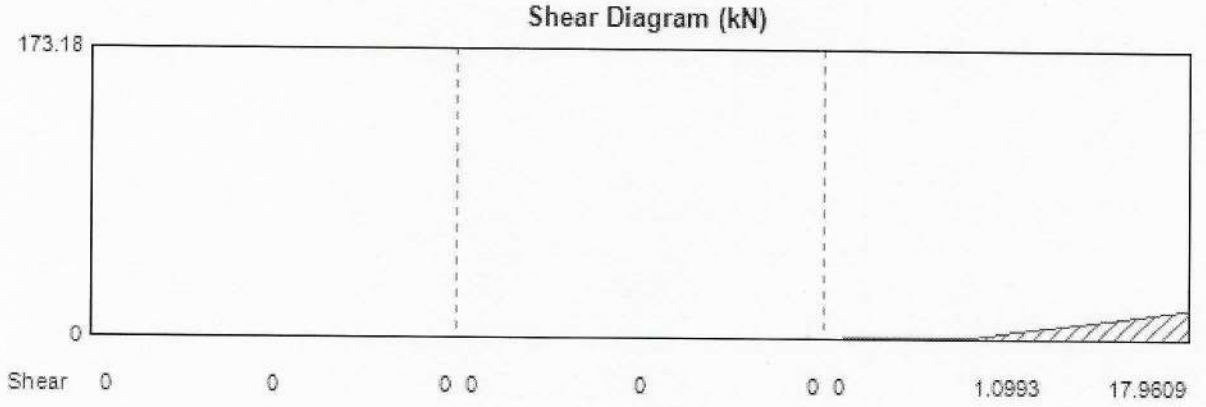
| Geometric Properties |
|---|
| Combination = Overall Envelope |
| Strip Label = SB48 |
| Length = 28.31 m |
| Distance to Top Rebar Center = 90 mm |
| Distance to Bot Rebar Center = 90 mm |

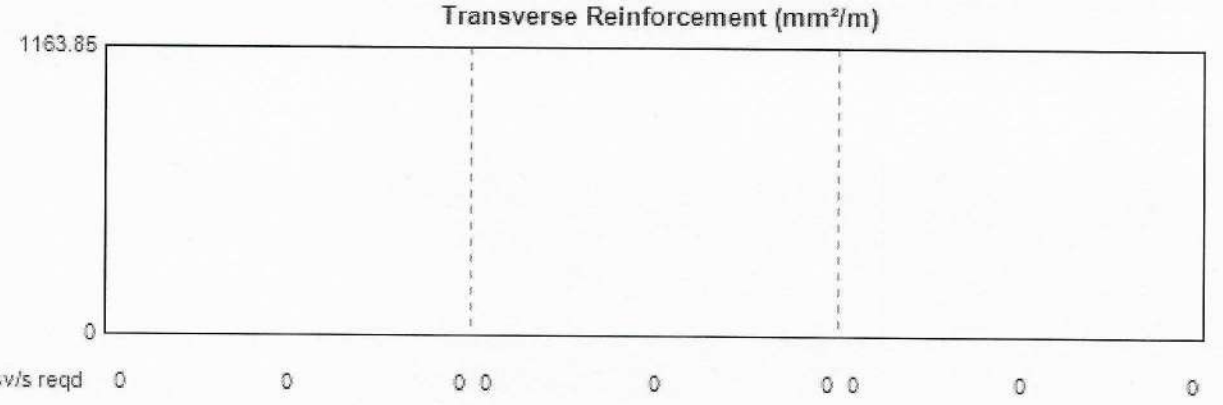
| Material Properties |
|---|
| Concrete Comp. Strength = 35 MPa |
| Concrete Modulus = 29580.4 MPa |
| Longitudinal Rebar Yield = 550 MPa |

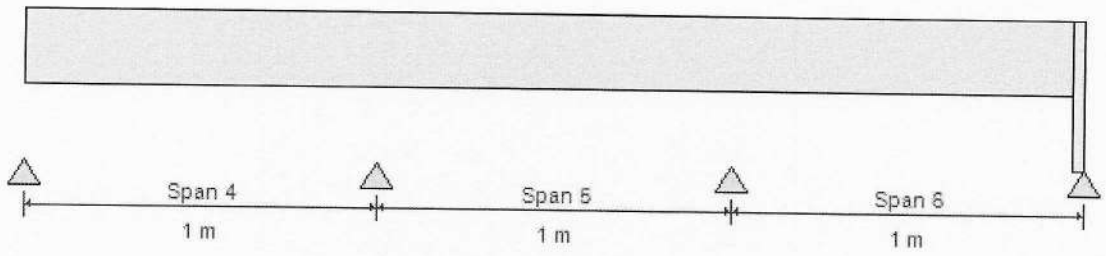


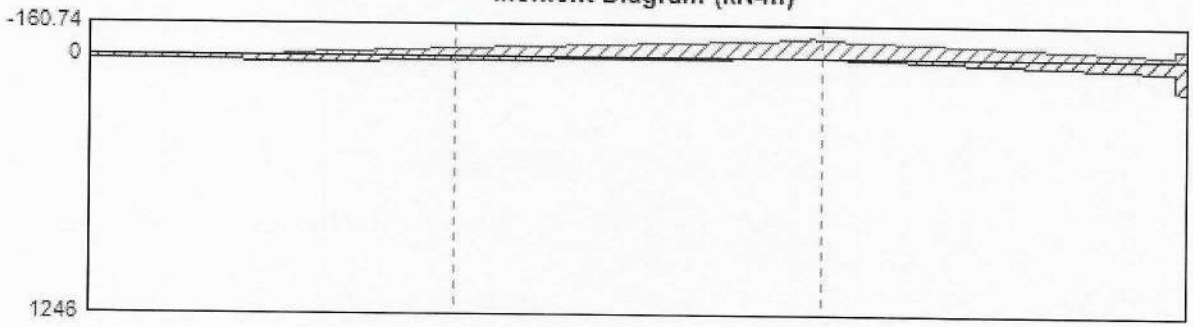

Longitudinal Reinforcement (mm²)
756
0
2591
As (top) 0 0 0 0 0 0 0 27 42
As (bot)
24 1.5DL+1.5
0 0 0 0 0 0 0 32 135
26 1.5DL+0.45


Shear Diagram (kN)
173.18
0
Shear 0 0 0 0 0 0 1.0993 17.9609


Transverse Reinforcement (mm²/m)
1163.85
0
Asv/s reqd 0 0 0 0 0 0 0 0

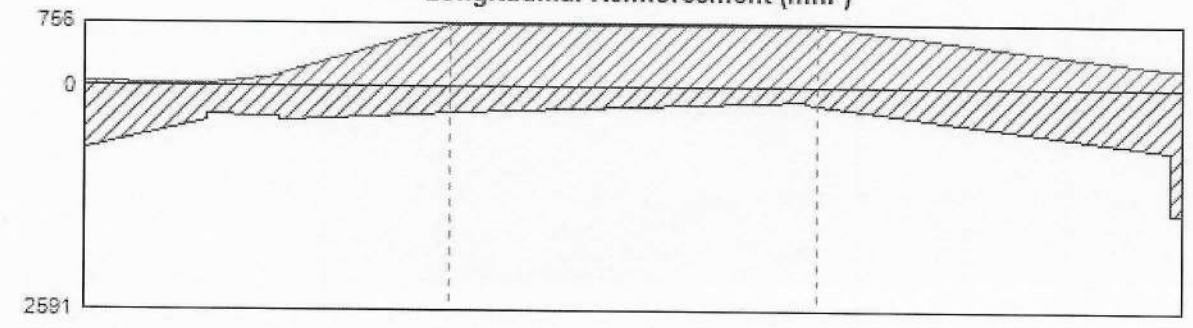



## Moment Diagram (kN-m)

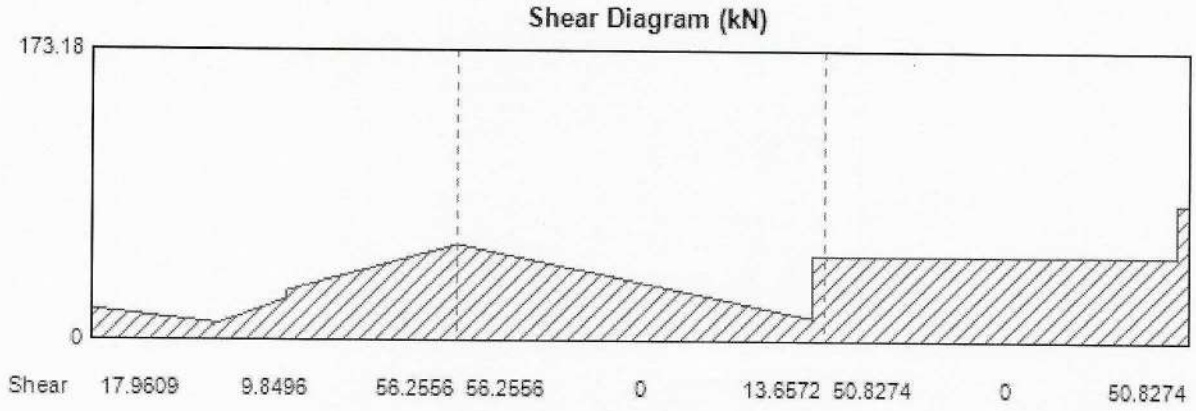


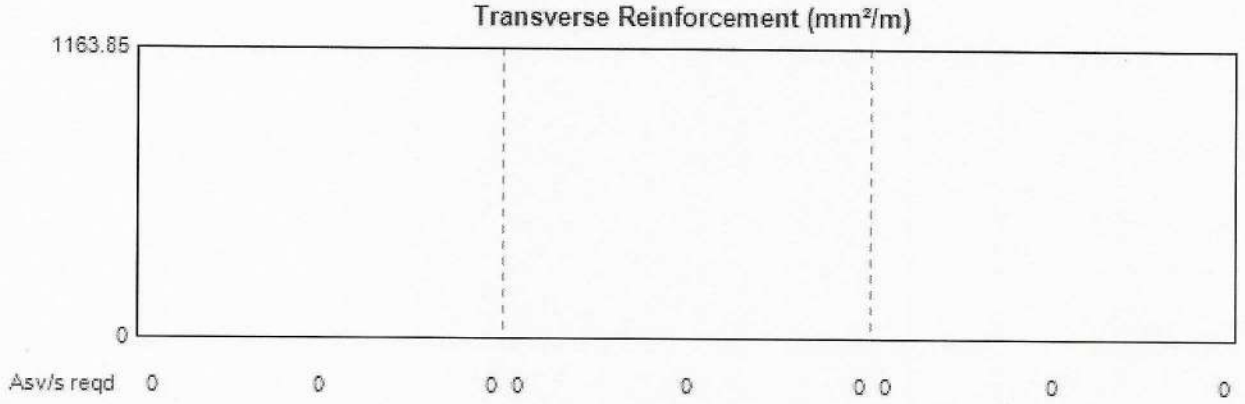

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (-)Moment | -2.193 | -5.3149 | -40.8804 | -40.8804 | 0 | -93.5528 | -91.5094 | 0 | -22.3645 |
| (+)Moment | 24.2884 | 32.7311 | 24.0984 | 24.0984 | 0 | 1.737 | 1.737 | 0 | 153.2693 |

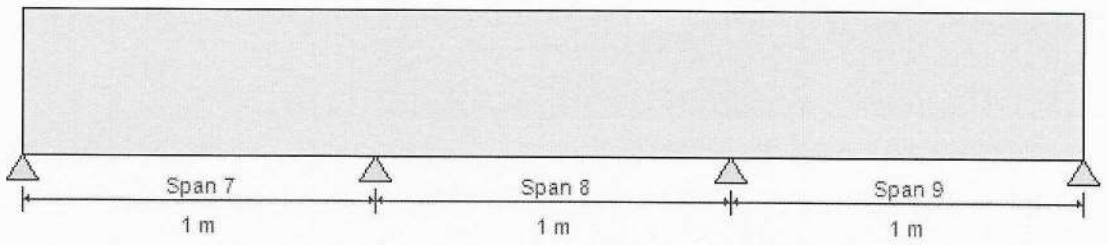
## Longitudinal Reinforcement (mm²)



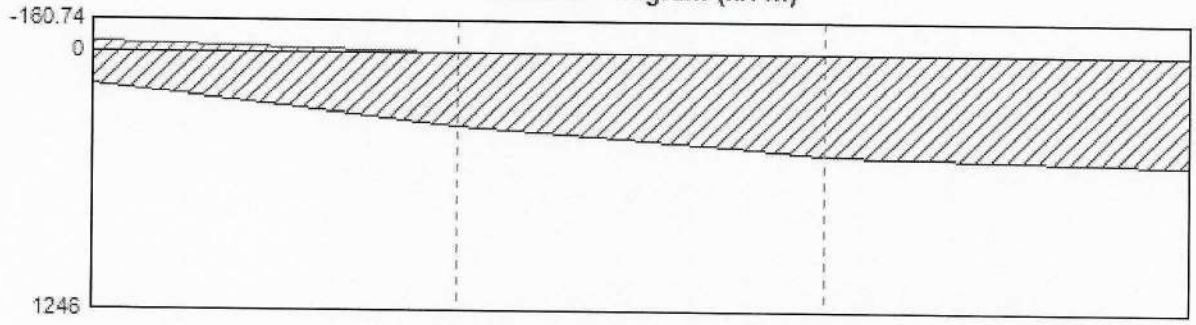

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| As (top) | 42 | 129 | 379 | 379 | 0 | 614 | 604 | 0 | 236 |
| | 135 | 256 | 300 | 300 | 0 | 201 | 201 | 0 | 445 |


Shear Diagram (kN)
173.18
0
Shear 17.9609 9.8496 56.2556 56.2556 0 13.6572 50.8274 0 50.8274


Transverse Reinforcement (mm²/m)
1163.85
0
Asv/s reqd 0 0 0 0 0 0 0 0

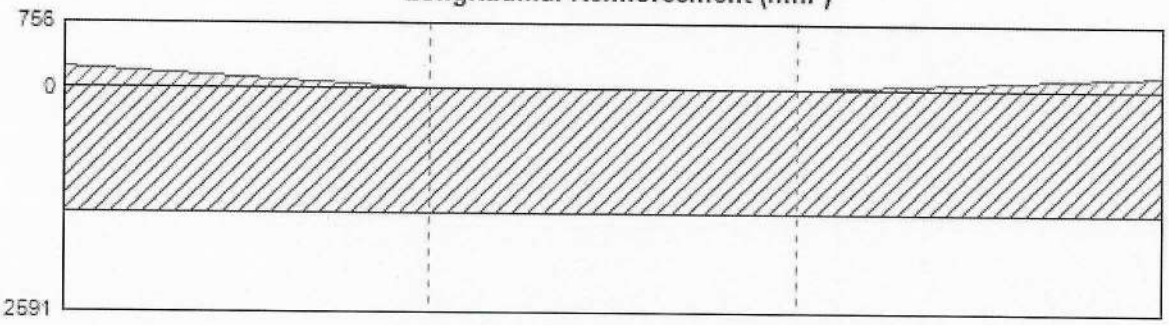

Span 7
1 m
Span 8
1 m
Span 9
1 m

## Moment Diagram (kN-m)




| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (-)Moment | -45.6691 | 0 | 0 | 0 | 0 | 0 | 0 | -1.8699 |
| (+)Moment | 153.2693 | 0 | 365.3292 | 365.3292 | 461.4569 | 500.1107 | 500.1107 | 0 | 539.871 |

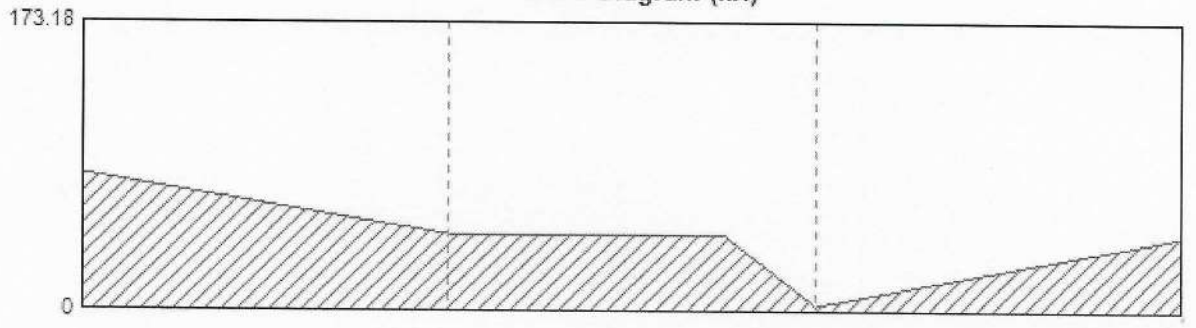
## Longitudinal Reinforcement (mm²)




| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| As (top) | 233 | 0 | 0 | 0 | 0 | 0 | 0 | 169 |
| As (bot) | 28 0.9DL+0.45SPEC X(D)+1.5SPEC Y(D)+0.45SPEC Z(D)+1.5SPEC X(D)+0.45SPEC Y(D)+0.45SPEC Z(D)+1.0TL | | | | | | | |
| | 445 | 0 | 878 | 878 | 1053 | 1125 | 1125 | 0 | 1194 |

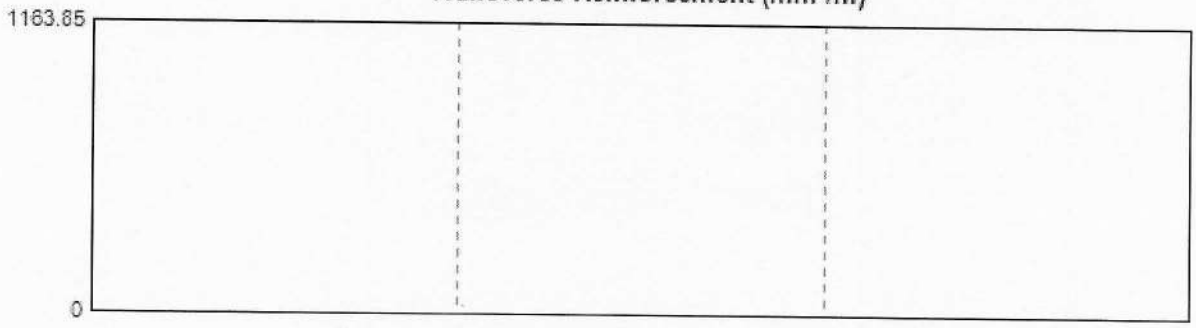
5SPEC X(D)+1.5SPEC Y(D)+0.45SPEC Z(D)+1.5SPEC

## Shear Diagram (kN)

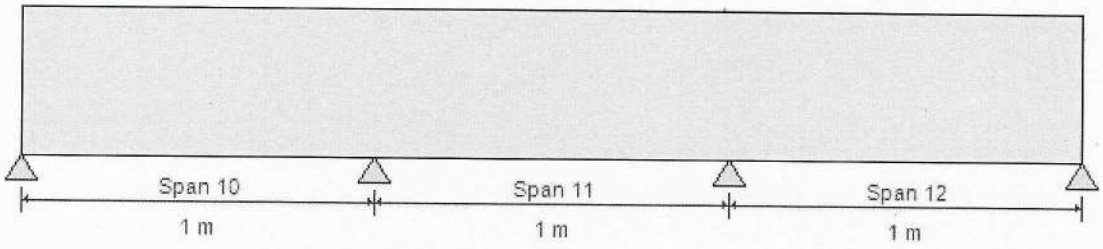



| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Shear | 82.0975 | 0 | 45.9778 | 45.9778 | 45.9778 | 45.9778 | 2.0525 | 0 | 44.0286 |

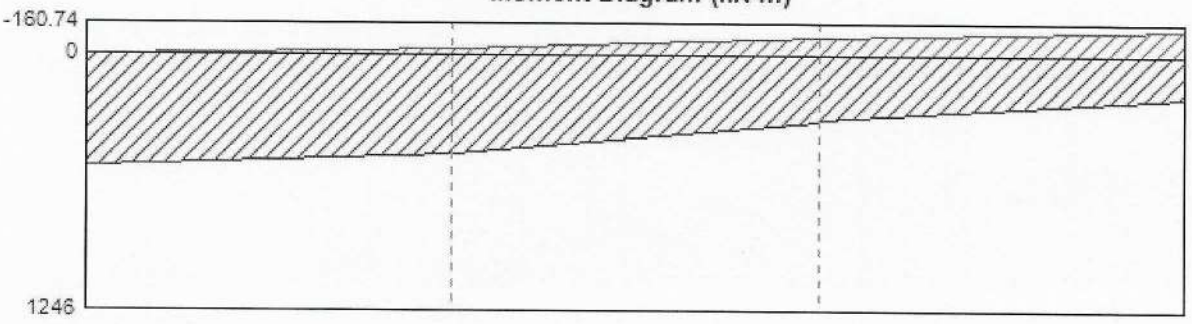
## Transverse Reinforcement (mm²/m)



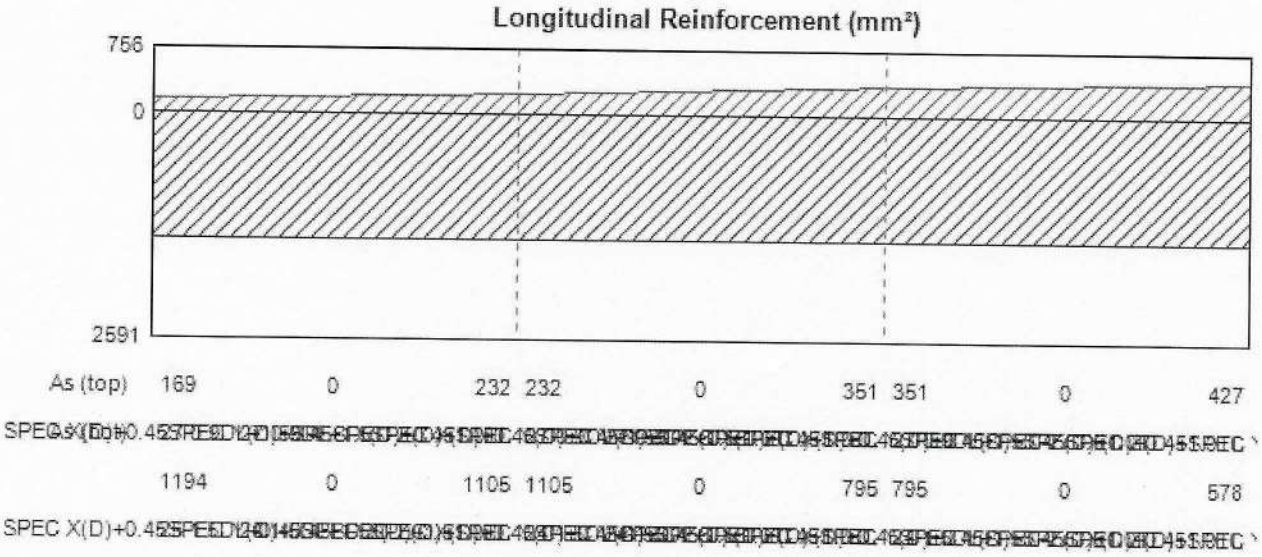

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Asv/s reqd | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

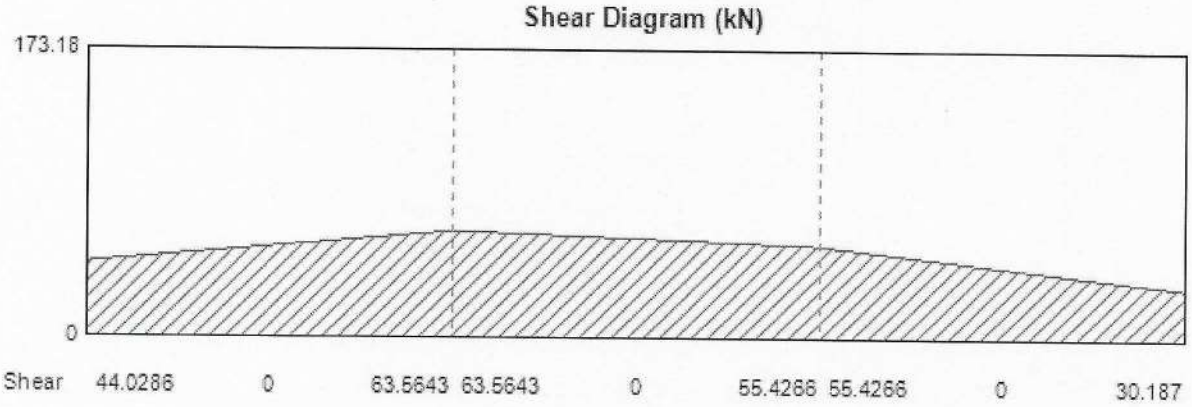


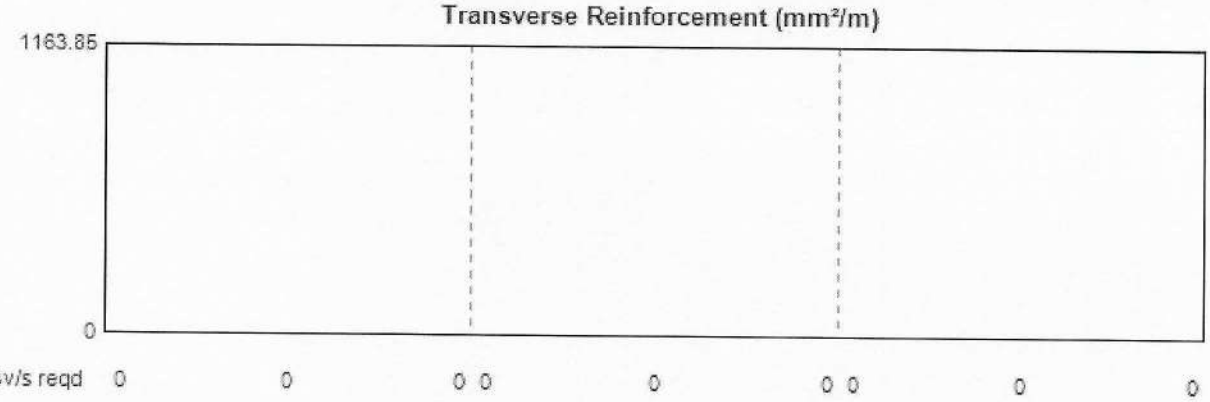

## Moment Diagram (kN-m)

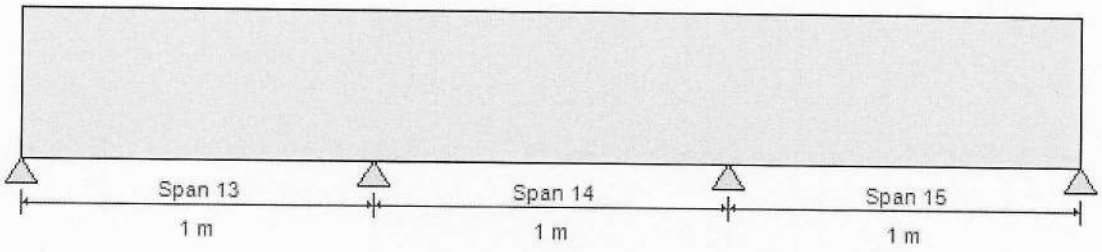



| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (-)Moment | -1.8699 | 0 | -29.9772 | -29.9772 | 0 | -86.3483 | -86.3483 | 0 | -128.3792 |
| (+)Moment | 539.871 | 0 | 481.5036 | 481.5036 | 0 | 317.9939 | 317.9939 | 0 | 205.4116 |

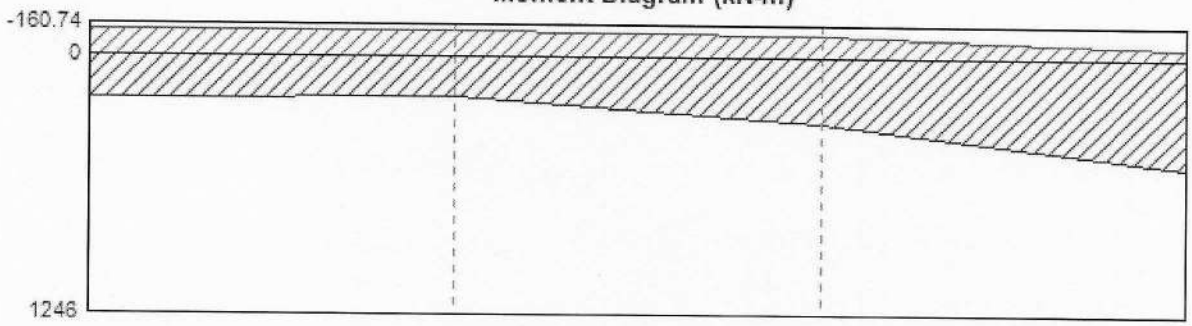

Longitudinal Reinforcement (mm²)
756
0
2591
As (top) 169 0 232 232 0 351 351 0 427
1194 0 1105 1105 0 795 795 0 578


Shear Diagram (kN)
173.18
0
Shear 44.0286 0 63.5643 63.5643 0 55.4266 55.4266 0 30.187


Transverse Reinforcement (mm²/m)
1163.85
0
Asv/s reqd 0 0 0 0 0 0 0 0 0

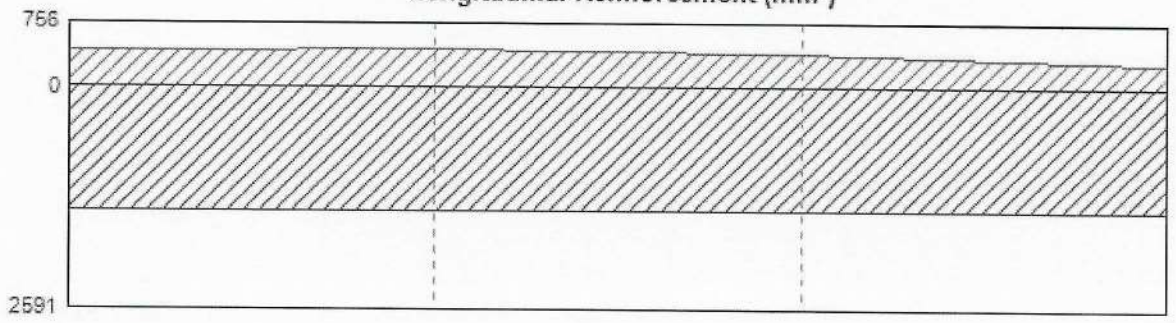



## Moment Diagram (kN-m)

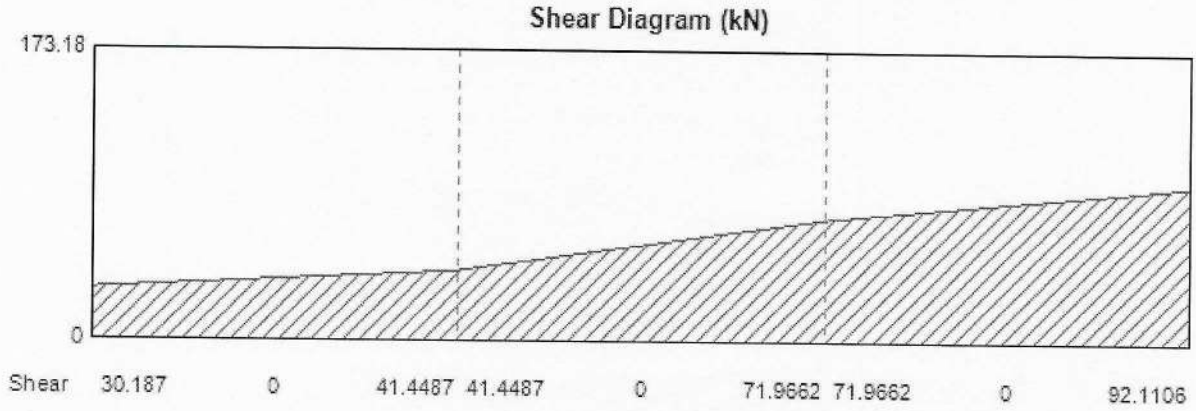


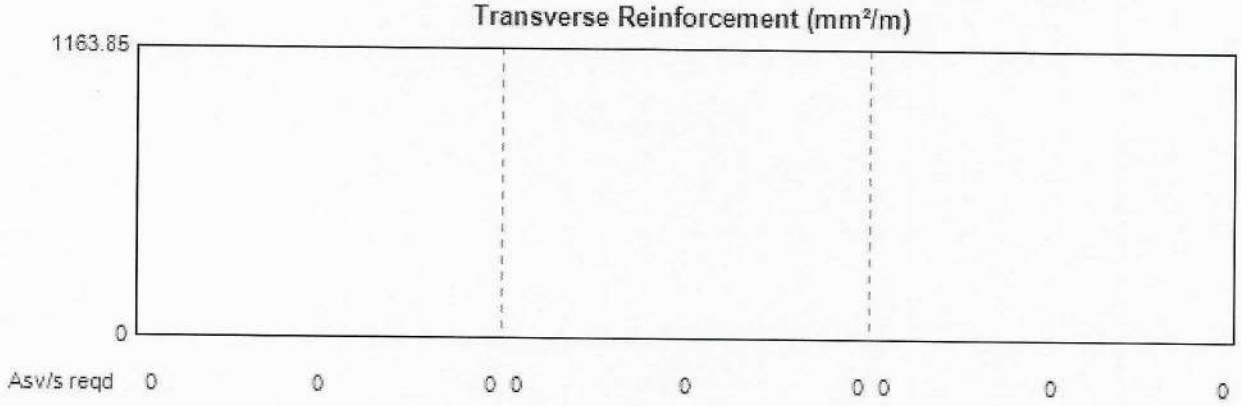

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (-)Moment | -128.3792 | 0 | -127.2664 | -127.2664 | 0 | -110.3686 | -110.3686 | 0 | -49.286 |
| (+)Moment | 205.4116 | 0 | 199.8672 | 199.8672 | 0 | 322.6977 | 322.6977 | 0 | 537.3632 |

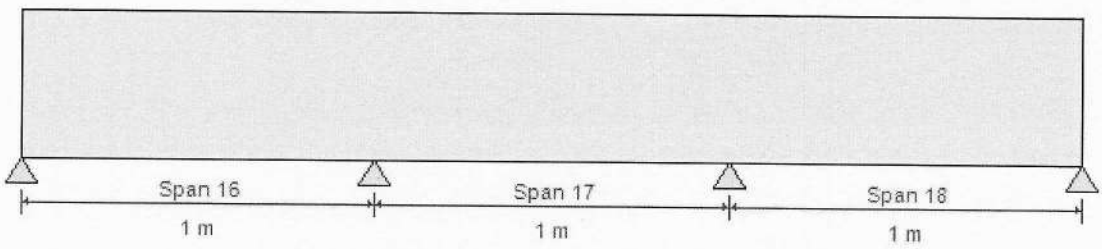
## Longitudinal Reinforcement (mm²)



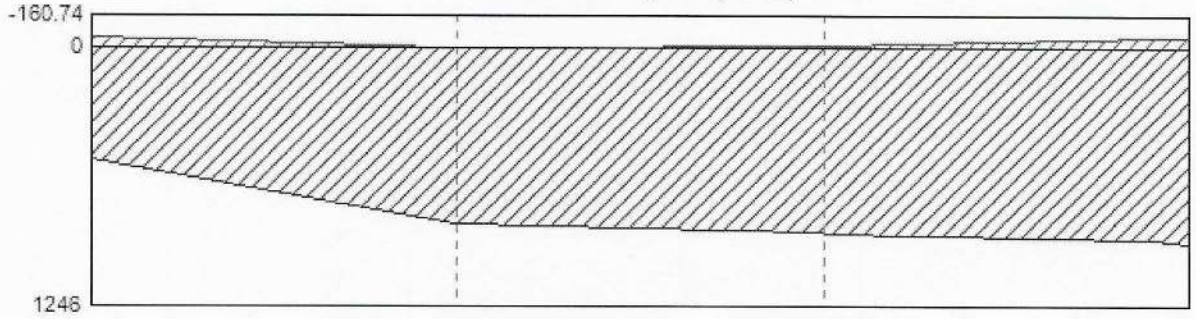

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| As (top) | 427 | 0 | 430 | 430 | 0 | 396 | 396 | 0 | 270 |
| SPEC X(D)+0.45 | | | | | | | | | |
| | 578 | 0 | 572 | 572 | 0 | 802 | 802 | 0 | 1207 |
| SPEC X(D)+0.45 | | | | | | | | | |


Shear Diagram (kN)
173.18
0
Shear 30.187 0 41.4487 41.4487 0 71.9662 71.9662 0 92.1106


Transverse Reinforcement (mm²/m)
1163.85
0
Asv/s reqd 0 0 0 0 0 0 0 0 0

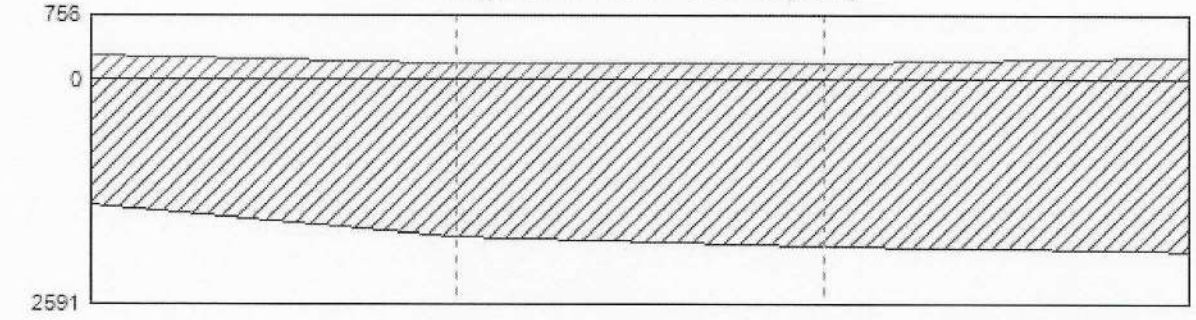

Span 16
1 m
Span 17
1 m
Span 18
1 m

## Moment Diagram (kN-m)



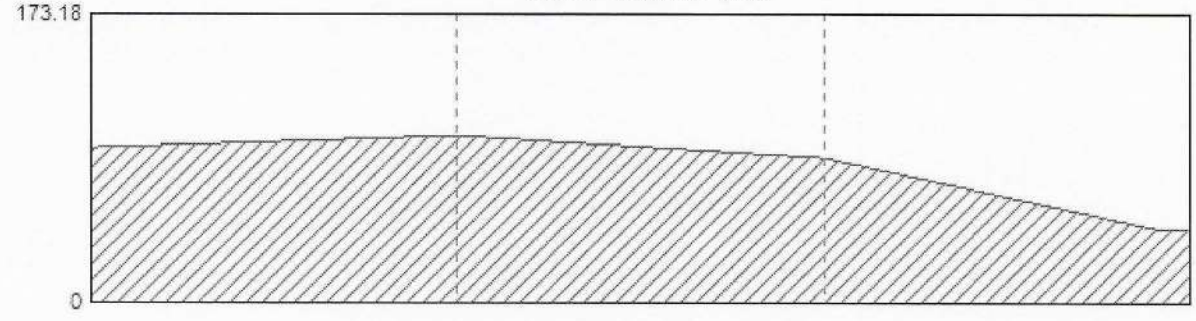

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (-)Moment | -49.286 | 0 | -2.7523 | -2.7523 | 0 | -6.4857 | -6.4857 | 0 | -47.3464 |
| (+)Moment | 537.3632 | 0 | 848.3557 | 848.3557 | 0 | 894.0685 | 894.0685 | 0 | 946.1814 |

## Longitudinal Reinforcement (mm²)



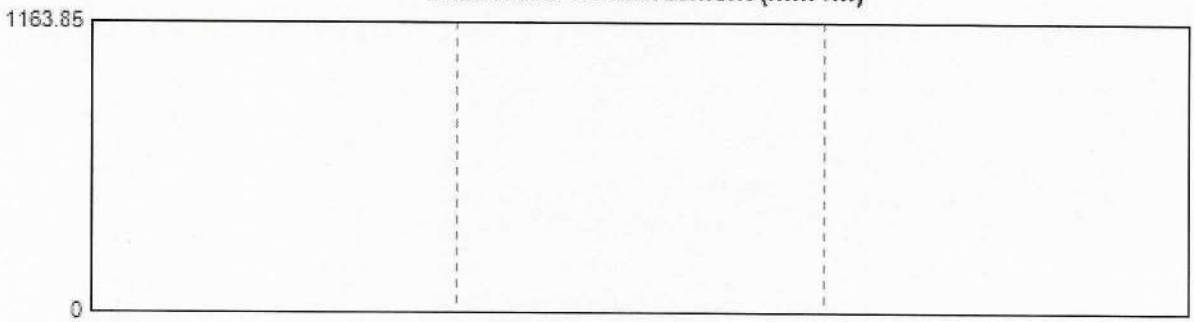

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| As (top) | 270 | 0 | 179 | 179 | 0 | 190 | 190 | 0 | 261 |
| SPEC X(D)+0.45 | [illegible] | | | | | | | | |
| | 1207 | 0 | 1823 | 1823 | 0 | 1920 | 1920 | 0 | 2007 |
| SPEC X(D)+0.45 | [illegible] | | | | | | | | |

## Shear Diagram (kN)

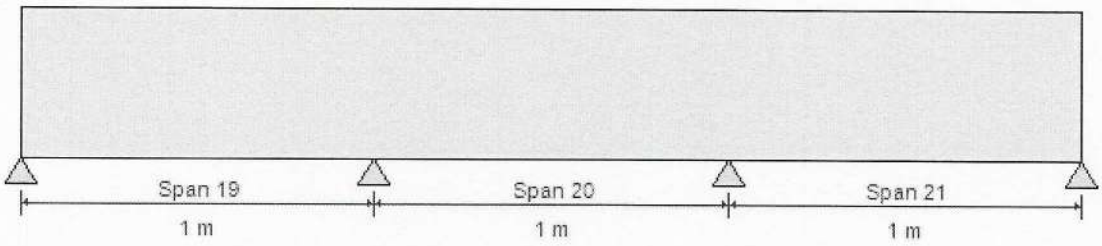



| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Shear | 92.1106 | 0 | 99.3838 | 99.3838 | 0 | 86.9509 | 86.9509 | 0 | 44.1452 |

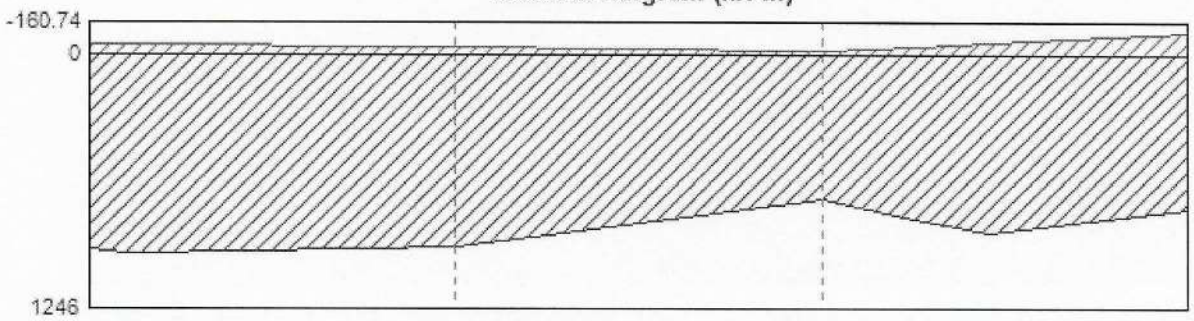
## Transverse Reinforcement (mm²/m)



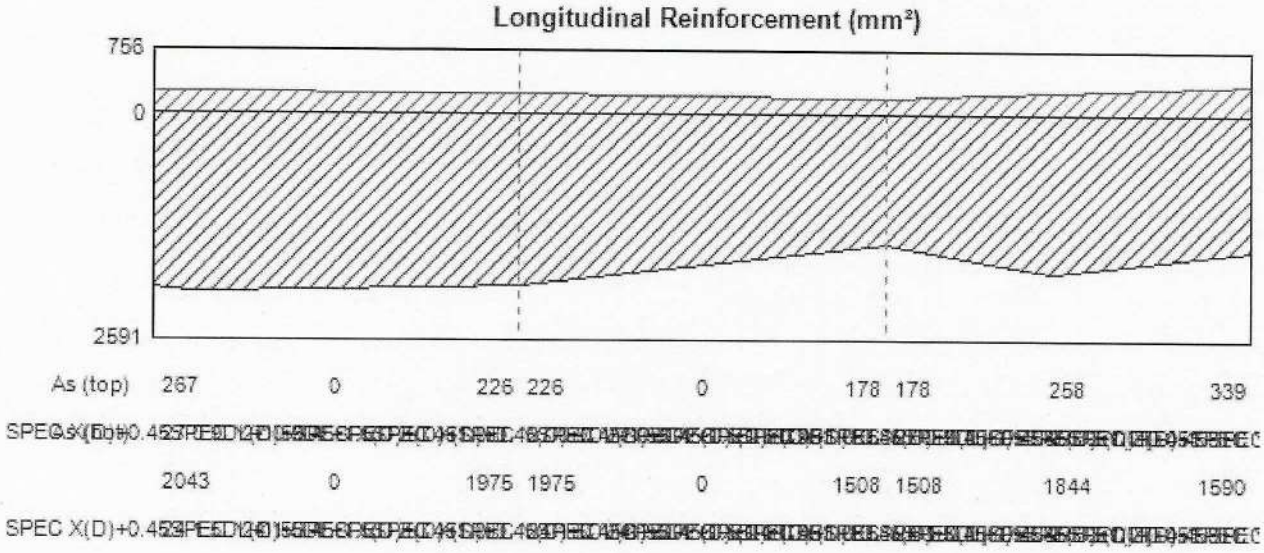

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Asv/s reqd | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

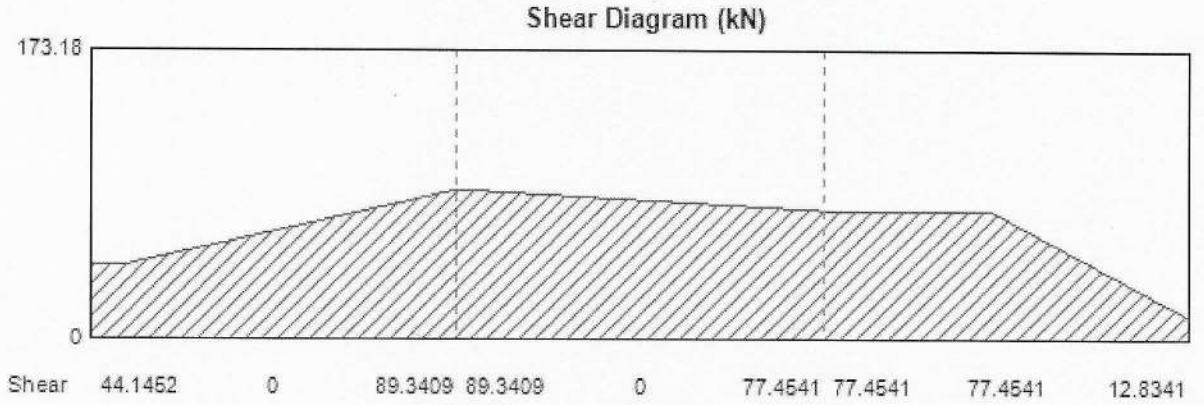


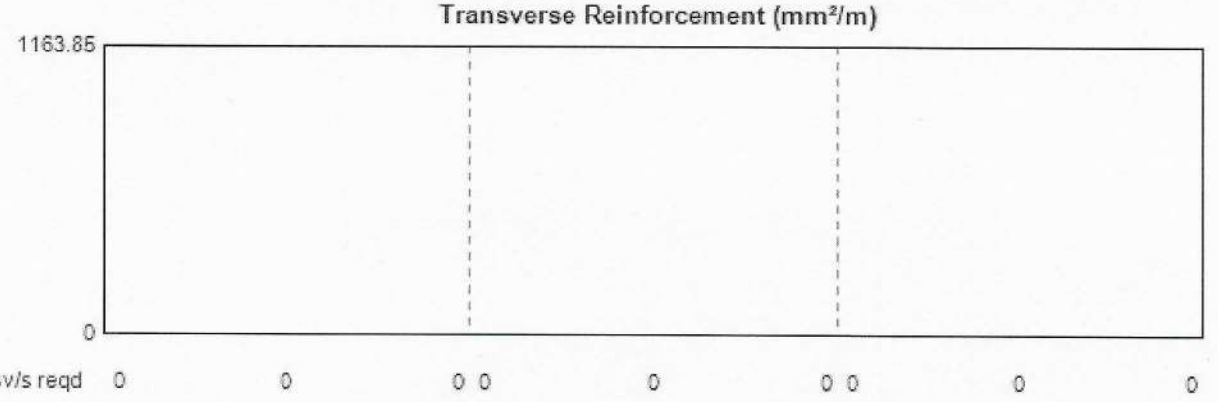

## Moment Diagram (kN-m)

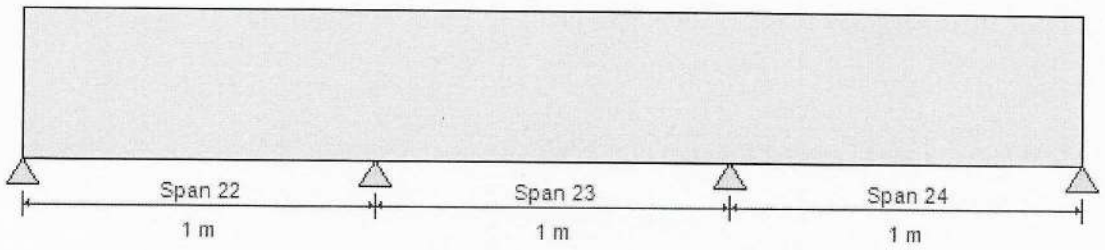



| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (-)Moment | -50.7301 | 0 | -34.8712 | -34.8712 | 0 | -16.9556 | -16.9556 | -56.5065 | -105.5868 |
| (+)Moment | 964.9871 | 0 | 934.3182 | 934.3182 | 0 | 701.4365 | 701.4365 | 873.3375 | 750.5044 |

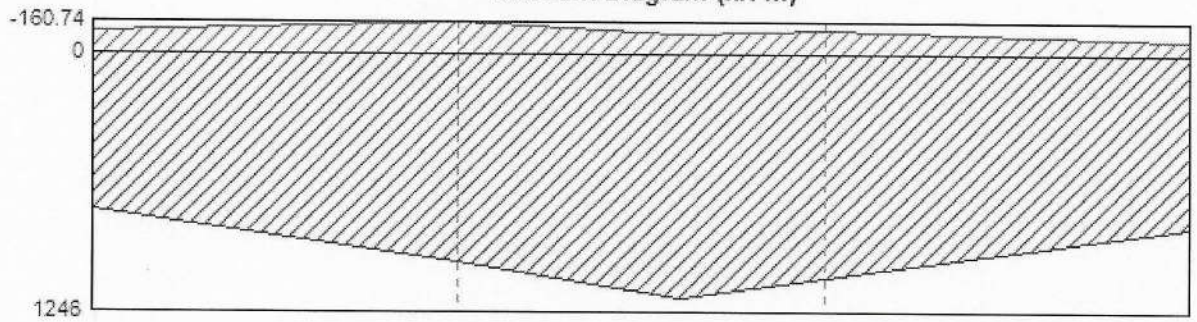

Longitudinal Reinforcement (mm²)
756
0
2591
As (top) 267 0 226 226 0 178 178 258 339
2043 0 1975 1975 0 1508 1508 1844 1590


Shear Diagram (kN)
173.18
0
Shear 44.1452 0 89.3409 89.3409 0 77.4541 77.4541 77.4541 12.8341


Transverse Reinforcement (mm²/m)
1163.85
0
Asv/s reqd 0 0 0 0 0 0 0 0 0

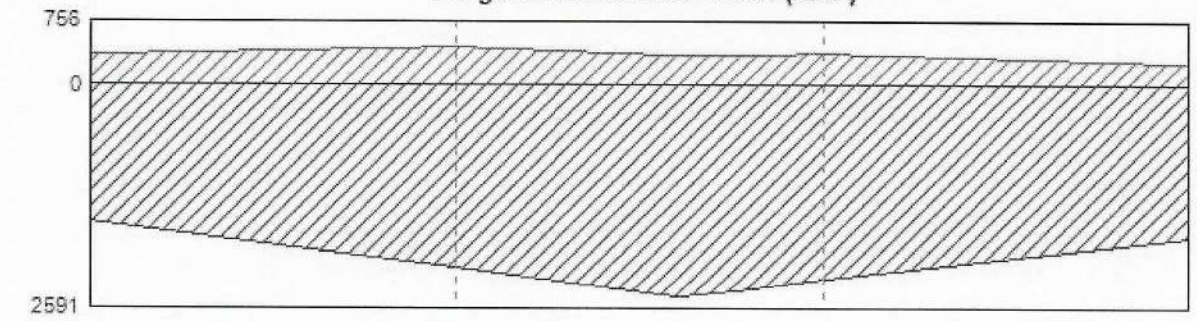



## Moment Diagram (kN-m)

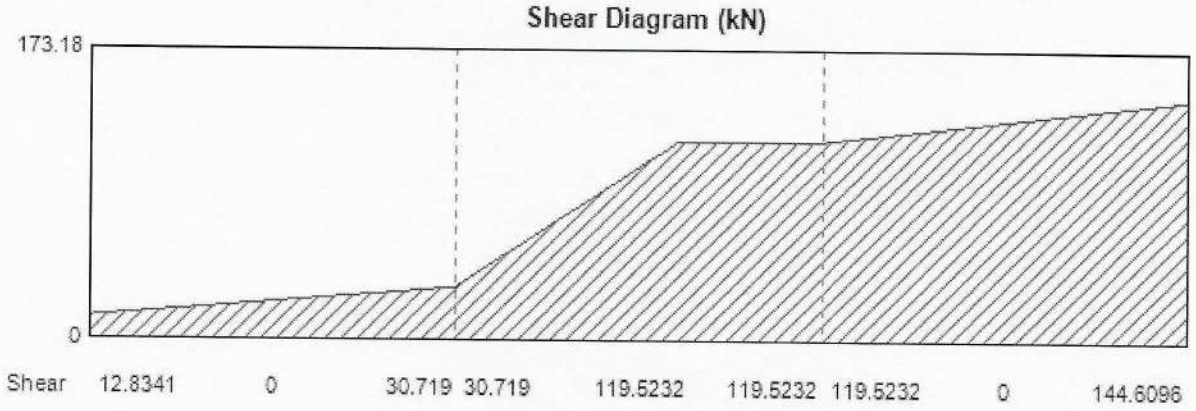


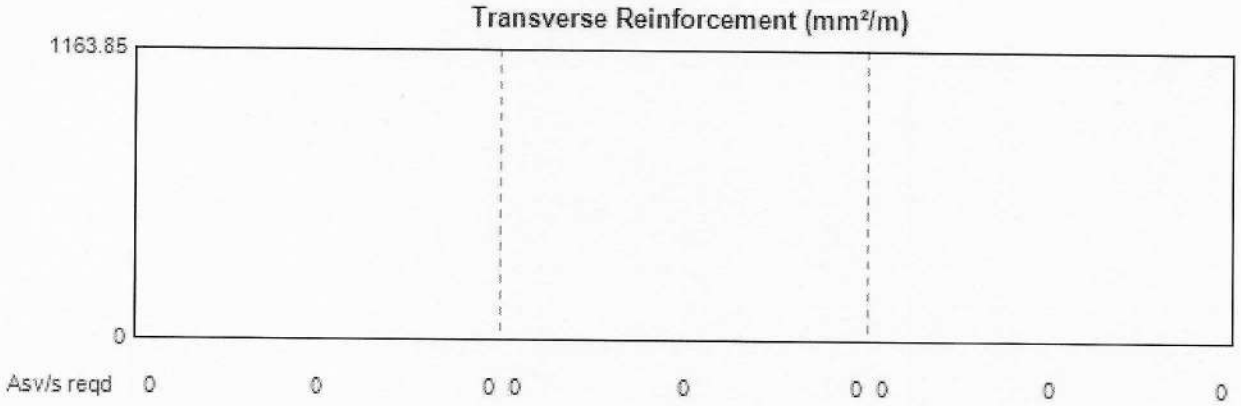

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (-)Moment | -105.5868 | 0 | -153.0849 | -153.0849 | -101.4202 | -116.0065 | -116.0065 | 0 | -66.3605 |
| (+)Moment | 750.5044 | 0 | 1006.9207 | 1006.9207 | 1186.5199 | 1134.6403 | 1084.0575 | 0 | 843.8815 |

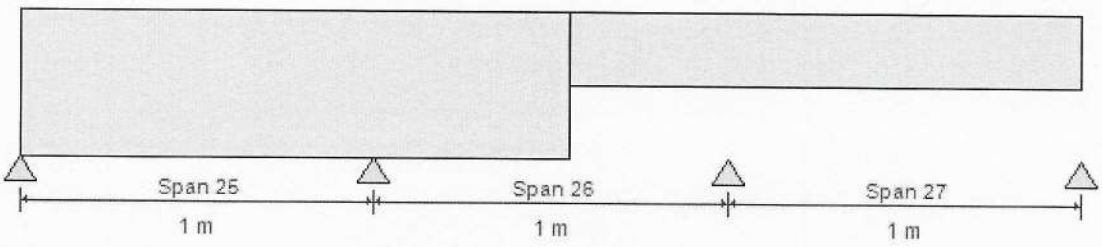
## Longitudinal Reinforcement (mm²)



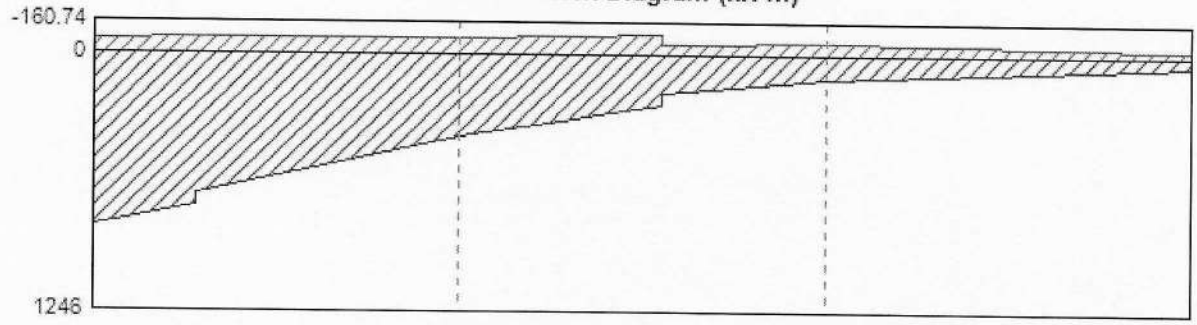

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| As (top) | 339 | 0 | 435 | 435 | 342 | 369 | 369 | 0 | 258 |
| SPEC X(D)+0.4 | [illegible] | | | | | | | | |
| | 1590 | 0 | 2105 | 2105 | 2467 | 2363 | 2261 | 0 | 1763 |
| SPEC X(D)+0.4 | [illegible] | | | | | | | | |


Shear Diagram (kN)
173.18
0
Shear 12.8341 0 30.719 30.719 119.5232 119.5232 119.5232 0 144.6096


Transverse Reinforcement (mm²/m)
1163.85
0
Asv/s reqd 0 0 0 0 0 0 0 0

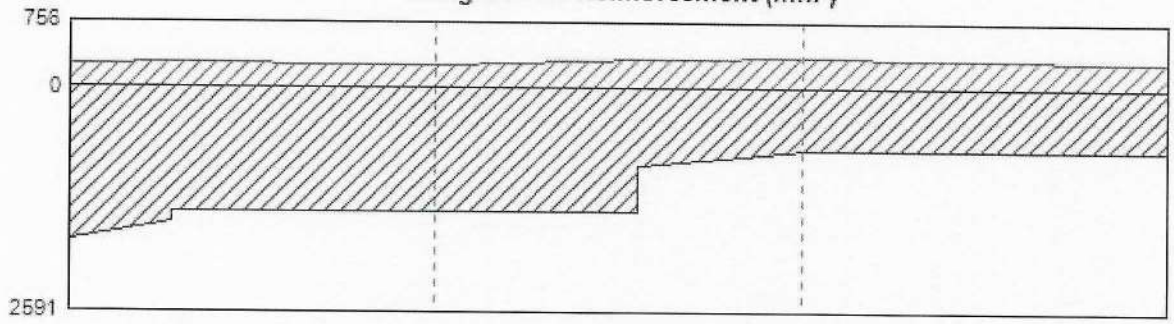

Span 25
1 m
Span 26
1 m
Span 27
1 m

## Moment Diagram (kN-m)



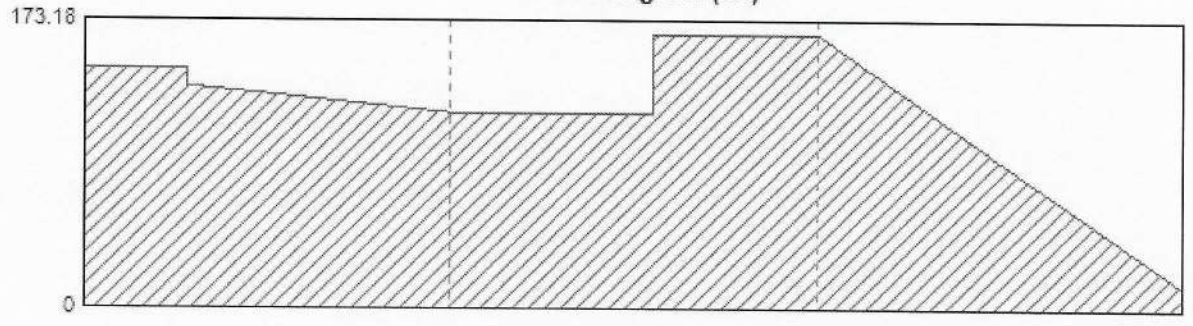

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (-)Moment | -66.3605 | -76.9618 | -75.9175 | -75.9175 | -48.5816 | -54.0971 | -54.0971 | 0 | -25.4425 |
| (+)Moment | 843.8815 | 741.3775 | 398.6692 | 398.6692 | 188.2368 | 119.838 | 119.838 | 0 | 50.5667 |

## Longitudinal Reinforcement (mm²)



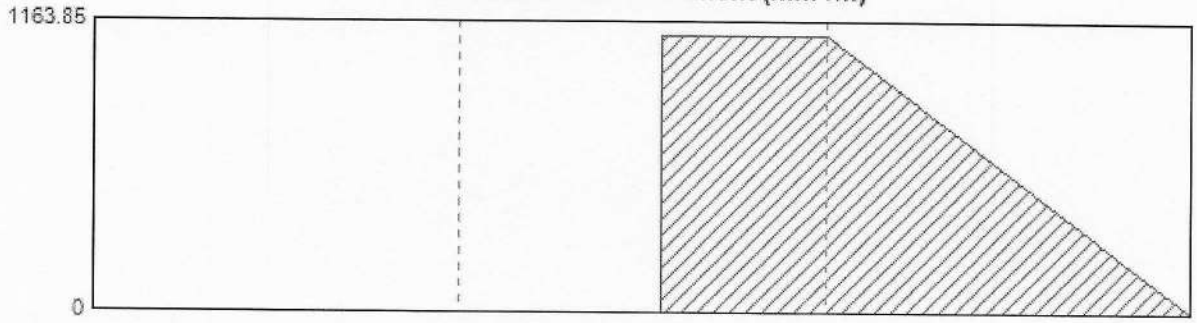

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| As (top) | 258 | 280 | 258 | 258 | 316 | 350 | 350 | 0 | 293 |
| | 1763 | 1563 | 876 | 876 | 908 | 628 | 628 | 0 | 408 |

## Shear Diagram (kN)

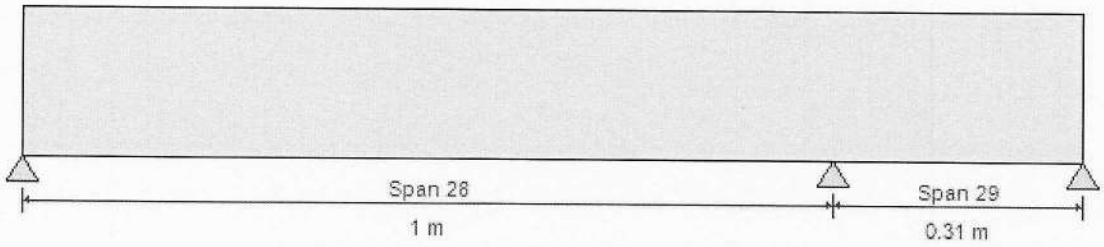



| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Shear | 144.6096 | 144.6096 | 117.5532 | 117.5532 | 164.9358 | 164.9369 | 164.9369 | 0 | 13.5561 |

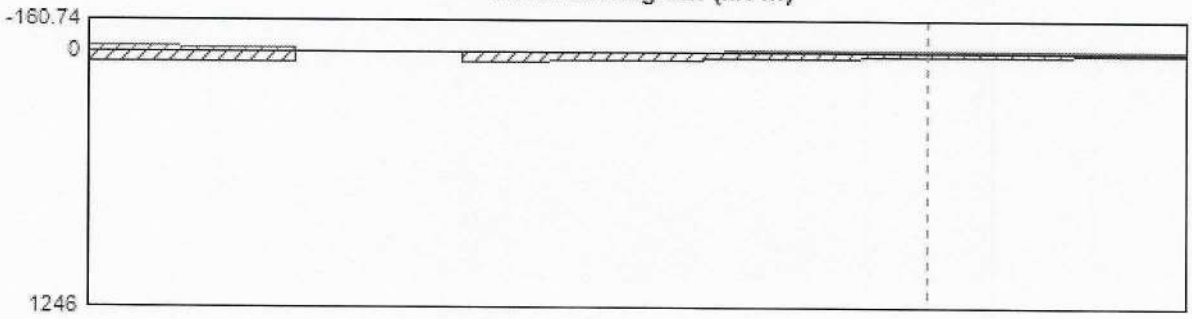
## Transverse Reinforcement (mm²/m)




| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Asv/s reqd | 0 | 0 | 0 | 0 | 1108.43 | 1108.43 | 1108.43 | 0 | 0 |

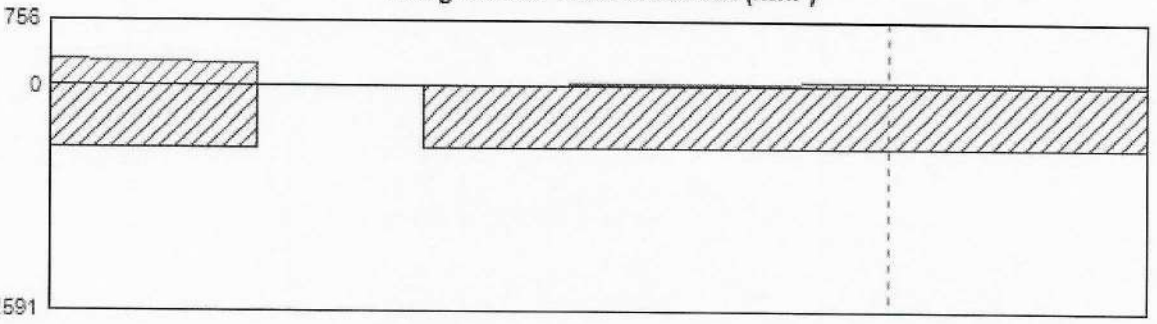



## Moment Diagram (kN-m)



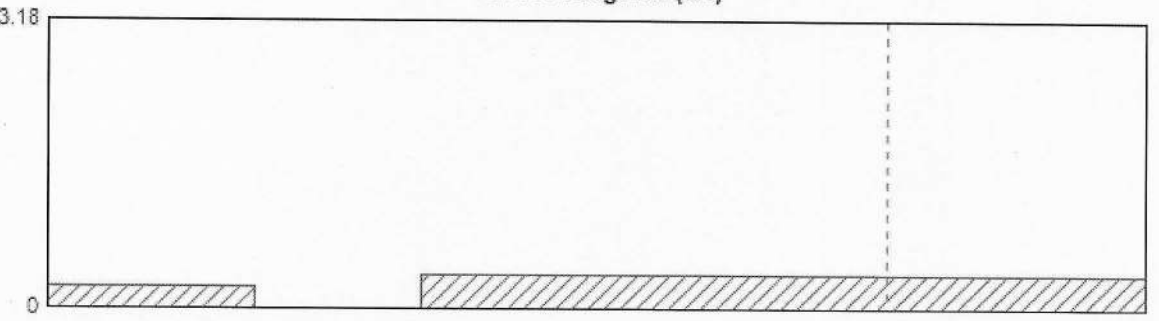

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (-)Moment | -25.4425 | 0 | -5.8344 | -5.8344 | 0 | -9.0907 | | |
| (+)Moment | 52.7637 | 47.5032 | 24.3985 | 24.3985 | 0 | 11.3657 | | |

## Longitudinal Reinforcement (mm²)



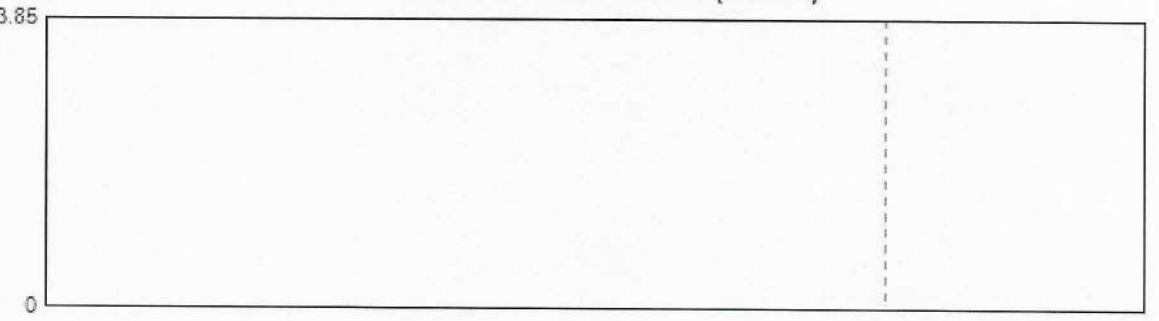

| | | | | | | |
|---|---|---|---|---|---|---|
| As (top) | 293 | 0 | 36 | 36 | 0 | 50 |
| As (bot) | 28 0.9DL+0.45SPE | | | | | |
| | 417 | 206 | 112 | 112 | 0 | 60 |
| | 25 1.5DL | | | | | |

## Shear Diagram (kN)




| | | | | | |
|---|---|---|---|---|---|
| Shear | 13.5561 | 0 | 20.1702 | 20.1702 | 0 | 20.1702 |

## Transverse Reinforcement (mm²/m)




| | | | | | | |
|---|---|---|---|---|---|---|
| Asv/s reqd | 0 | 0 | 0 | 0 | 0 | 0 |

# DESIGN OF SHEAR WALL

# ETABS Shear Wall Design

## IS 456:2000 Pier Design

### Pier Details

| Story ID | Pier ID | Centroid X (mm) | Centroid Y (mm) | Length (mm) | Thickness (mm) | LLRF |
|---|---|---|---|---|---|---|
| STILT | P42 | 1160 | 10275 | 1200 | 625 | 0.5 |

### Material Properties

| $E_c$ (MPa) | $f_{ck}$ (MPa) | Lt.Wt Factor (Unitless) | $f_y$ (MPa) | $f_{ys}$ (MPa) |
|---|---|---|---|---|
| 31622.78 | 40 | 1 | 550 | 415 |

### Design Code Parameters

| $\Gamma_S$ | $\Gamma_C$ | $IP_{MAX}$ | $IP_{MIN}$ | $P_{MAX}$ | MinEcc Major | MinEcc Minor |
|---|---|---|---|---|---|---|
| 1.15 | 1.5 | 0.04 | 0.0025 | 0.8 | Yes | Yes |

### 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 | 1160 | 9675 | 1160 | 10875 | 1200 | 625 |
| Bottom | Leg 1 | 1160 | 9675 | 1160 | 10875 | 1200 | 625 |

### Flexural Design for $P_u$, $M_{u2}$ and $M_{u3}$ (Part 1 of 2)

| Station Location | Required Rebar Area ($mm^2$) | Required Reinf Ratio | Current Reinf Ratio | Flexural Combo |
|---|---|---|---|---|
| Top | 1875 | 0.0025 | 0.0014 | 29 0.9DL+0.45SPEC X(D)+0.45SPEC Y(D)+1.5SPEC Z(D)+1.0TL |
| Bottom | 1875 | 0.0025 | 0.0014 | 29 0.9DL+0.45SPEC X(D)+0.45SPEC Y(D)+1.5SPEC Z(D)+1.0TL |

### Flexural Design for $P_u$, $M_{u2}$ and $M_{u3}$ (Part 2 of 2)

| $P_u$ kN | $M_{u2}$ kN-m | $M_{u3}$ kN-m | Pier $A_g$ $mm^2$ |
|---|---|---|---|
| 3029.1851 | 84.9182 | -316.6341 | 750000 |
| 3096.5034 | -146.6714 | -115.7855 | 750000 |

### Shear Design (Part 1 of 2)

| Station Location | ID | Rebar $mm^2/m$ | Shear Combo | $P_u$ kN | $M_u$ kN-m | $V_u$ kN |
|---|---|---|---|---|---|---|
| Top | Leg 1 | 1562.5 | 25 1.5DL+0.45SPEC X(D)+1.5SPEC Y(D)+0.45SPEC Z(D)+1.0TL | 4024.79 | 1143.0399 | -286.7417 |
| Bottom | Leg 1 | 1562.5 | 25 1.5DL+0.45SPEC X(D)+1.5SPEC Y(D)+0.45SPEC Z(D)+1.0TL | 4123.3097 | 123.0307 | -286.7417 |

### Shear Design (Part 2 of 2)

| $V_c$ kN | $V_c + V_s$ kN |
|---|---|
| 252.4462 | 793.7506 |
| 254.2196 | 795.5239 |

**Boundary Element Check (Part 1 of 2)**

| Station Location | ID | Edge Length (mm) | Governing Combo | $P_u$ kN | $M_u$ kN-m |
|---|---|---|---|---|---|
| Top–Left | Leg 1 | 600 | 26 1.5DL+0.45SPEC X(D)+0.45SPEC Y(D)+1.5SPEC Z(D)+1.0TL | 4728.2609 | -279.6227 |
| Top–Right | Leg 1 | 600 | 26 1.5DL+0.45SPEC X(D)+0.45SPEC Y(D)+1.5SPEC Z(D)+1.0TL | 4728.2609 | 464.4081 |
| Bottom–Left | Leg 1 | 0 | 26 1.5DL+0.45SPEC X(D)+0.45SPEC Y(D)+1.5SPEC Z(D)+1.0TL | 4836.0671 | -142.1597 |
| Botttom–Right | Leg 1 | 0 | 26 1.5DL+0.45SPEC X(D)+0.45SPEC Y(D)+1.5SPEC Z(D)+1.0TL | 4836.0671 | 10.3942 |

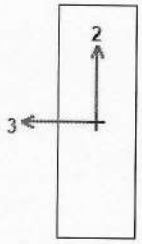
**Boundary Element Check (Part 2 of 2)**

| Stress Comp MPa | Stress Limit MPa |
|---|---|
| 8.17 | 8 |
| 9.4 | 8 |
| 7.4 | 8 |
| 6.52 | 8 |

# DESIGN OF BEAM

# ETABS Concrete Frame Design

## IS 456:2000 + IS 13920:2016 Beam Section Design (Summary)




### Beam Element Details (Part 1 of 2)

| Level | Element | Unique Name | Section ID | Combo ID | Station Loc |
|---|---|---|---|---|---|
| 5TH | B11 | 2238 | B 200X600 | 24 1.5DL+1.5SPEC X(D)+0.45SPEC Y(D)+0.45SPEC Z(D)+1.0TL | 6775 |

### Beam Element Details (Part 2 of 2)

| Length (mm) | LLRF | Type |
|---|---|---|
| 6775 | 1 | Ductile Frame |

### Section Properties

| b (mm) | h (mm) | $b_f$ (mm) | $d_s$ (mm) | $d_{ct}$ (mm) | $d_{cb}$ (mm) |
|---|---|---|---|---|---|
| 200 | 600 | 200 | 0 | 30 | 30 |

### Material Properties

| $E_c$ (MPa) | $f_{ck}$ (MPa) | Lt.Wt Factor (Unitless) | $f_y$ (MPa) | $f_{ys}$ (MPa) |
|---|---|---|---|---|
| 29580.4 | 35 | 1 | 550 | 415 |

### Design Code Parameters

| $\gamma_c$ | $\gamma_s$ |
|---|---|
| 1.5 | 1.15 |

### Factored Forces and Moments

| Factored $M_{u3}$ kN-m | Factored $T_u$ kN-m | Factored $V_{u2}$ kN | Factored $P_u$ kN |
|---|---|---|---|
| -205.0526 | 0.0035 | 170.3131 | 0 |

### Design Moments, $M_{u3}$ & $M_t$

| Factored Moment kN-m | Factored $M_t$ kN-m | Positive Moment kN-m | Negative Moment kN-m |
|---|---|---|---|
| -205.0526 | 0.0082 | 0 | -205.0609 |

**Design Moment and Flexural Reinforcement for Moment, $M_{u3}$ & $T_u$**

| | Design -Moment kN-m | Design +Moment kN-m | -Moment Rebar mm² | +Moment Rebar mm² | Minimum Rebar mm² | Required Rebar mm² |
|---|---|---|---|---|---|---|
| Top (+2 Axis) | -205.0609 | | 854 | 0 | 854 | 294 |
| Bottom (-2 Axis) | | 0 | 427 | 0 | 0 | 427 |

**Shear Force and Reinforcement for Shear, $V_{u2}$ & $T_u$**

| Shear $V_e$ kN | Shear $V_c$ kN | Shear $V_s$ kN | Shear $V_p$ kN | Rebar $A_{sv}/s$ mm²/m |
|---|---|---|---|---|
| 206.8226 | 0 | 206.8505 | 63.3637 | 1005.61 |

**Torsion Force and Torsion Reinforcement for Torsion, $T_u$ & $V_{U2}$**

| $T_u$ kN-m | $V_u$ kN | Core $b_1$ mm | Core $d_1$ mm | Rebar $A_{svt}/s$ mm²/m |
|---|---|---|---|---|
| 0.0005 | 170.3131 | 160 | 560 | 0 |

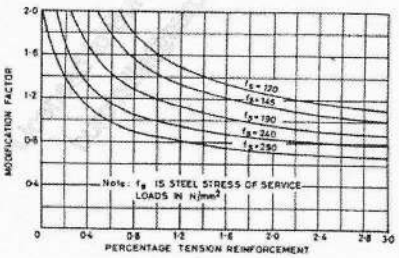
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# DESIGN OF SLAB

PROJECT

| | DESIGN OF SLAB No: | | | | | |
|---|---|---|---|---|---|---|
| 1.00 | Grade of concrete | | = | *35.00* | N/mm$^2$ | Case No: *8* |
| 2.00 | Grade of steel | | = | *550.00* | N/mm$^2$ | D+(C-D)*(E-A)/(B-A) |
| 3.00 | Cover to reinforcement | | = | *25.00* | mm | |
| | Diameter of bar | | | *8.00* | mm | |
| 4.00 | Aspect ratio $\frac{l_y}{l_x}$ = | *5.60* / *3.35* | 5.72 / 3.47 | 1.648 | < 2 | |
| 5.00 | Edge condition: One Short Edge Continuous | | | Two way slab | | |
| 6.00 | Modification factor assumed | | | *1.30* | | |
| | | 116.09 | | | | |
| 7.00 | Depth required for deflection: | | D = | *150.00* | mm | |
| | | | | 150.00 | mm | |
| | | | d = | 121.00 | mm | ok |
| 8.00 | Dead Load | | = | 3.60 | kN/m$^2$ | qa |
| 9.00 | Live load | | = | *2.00* | kN/m$^2$ | |
| 10.00 | Partitions & FF | | = | *1.25* | kN/m$^2$ | |
| 11.00 | Total load | | = | 6.85 | kN/m$^2$ | |
| 12.00 | Factored load | | = | 10.28 | kN/m$^2$ | |

| | | | | | |
|---|---|---|---|---|---|
| | | Negative | Positive | | |
| A | | *1.50000* | *1.50000* | | |
| B | | *1.75000* | *1.75000* | | |
| C | | *0.00000* | *0.07600* | | |
| D | | *0.00000* | *0.08700* | | |
| E | | *1.64823* | *1.64823* | | |
| Value | | **0.00000** | **0.08252** | | |




$f_s = 0.58\, f_y \frac{\text{Area of cross-section of steel required}}{\text{Area of cross-section of steel provided}}$

FIG. 4 MODIFICATION FACTOR FOR TENSION REINFORCEMENT

| STEP 1 | Details | S- SPAN (-ve) support($\alpha_x$) | S- SPAN (+ve) span($\alpha_x$) | L-SPAN (-ve) support($\alpha_y$) | L-SPAN (+ve) span ($\alpha_y$) |
|---|---|---|---|---|---|
| | Co-efficent ( IS:456, Table :26 | 0.000 | 0.083 | 0.057 | 0.043 |
| | $M_u$=Co-efficient*w* $l_x^2$ | 0.00 | 10.22 | 7.06 | 5.32 |
| | K= Mu/bd2 | 0.00 | 0.70 | 0.48 | 0.36 |
| | Percentage of steel required | 0.00 | 0.15 | 0.10 | 0.08 |
| | Ast required(in mm$^2$) | *0.00* | *180.69* | *123.87* | *93.07* |
| | Ast min (in mm$^2$) | 180.00 | 180.00 | 180.00 | 180.00 |
| | Ast to be provided (in mm2) | 180.00 | 180.69 | 180.00 | 180.00 |
| | Provided bars spacing (c/c) | 279.37 | 278.30 | 279.37 | 279.37 |
| | max spacing | 250.00 | 250.00 | 250.00 | 250.00 |
| | spacing | 250.00 | 250.00 | 250.00 | 250.00 |
| | Reqd bars spacing (c/c) | **250.00** | **250.00** | **250.00** | **250.00** |
| | Pvd bars spacing (c/c) | *200.00* | *200.00* | *200.00* | *200.00* |
| | Ast Provided(in mm$^2$) | **251.43** | **251.43** | **251.43** | **251.43** |
| | Percentage of steel provided | **0.21** | **0.21** | **0.21** | **0.21** |
| STEPII | $F_s$=0.58 *$f_y$ * (Ast required/ Ast provided) | | | | |
| | $F_s$ | | | 229.25 | |
| | M.F | | | *1.80* | |
| | if assumed modification factor is less than or equal to calculated the section is safe for deflection | | | safe | |
| | **OVERALL DEPTH** **D** **150.00** **mm** | | | | |
| | **EFFECTIVE DEPTH** **d** **121.00** **mm** | | | | |

| STEPIII | Crack width calculation | | | |
|---|---|---|---|---|
| | m | = | 6.8 | |
| | $E_s$ | = | 200000.0 | |
| | Ec | = | 29580.4 | |
| | Pt | = | 0.2 | |
| | k | = | 0.2 | |
| | x | = | 18.7 | |
| | $A_{st}$ | = | 251.4 | |
| | $I_{cr}$ | = | 19970343.13 | |
| | M | = | 10.2 | |
| | $f_{st}$ | = | 354.0 | |
| | $\varepsilon_m$ | = | 0.0 | |
| | Spacing | | 200.0 | |
| | $a_{cr}$ | = | 103.1 | |
| | $\omega_{cr}$ | = | 0.16 | |
| | | | < | |
| | | | 0.20 | mm (safe) |


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# STRUCTURAL DRAWINGS

THE LANDLENS SUITE

# Eight ways to know a piece of land before you pay for it.

This report covers one part of the picture. These cover the rest, drawn from the same government records, for any property in Tamil Nadu.

### LandLens One
Ask anything about a property and get an answer grounded in live government records, with the sources shown.
**/landlens/one**

### Verify My Land
Every record check run on one property and returned as a single report.
**/landlens/verify-my-land**

### Legal Opinion
An advocate's written opinion on the title, built on the records we pull for it.
**/landlens**

### One Map
Every layer on one map: the parcel, its boundary, zoning, water bodies and what sits around it.
**/landlens/one/map**

### PriceMap
What land actually changed hands for around this plot, taken from the registered deeds.
**/landlens/pricemap**

### Build Scope
What you are allowed to build here: floor space, height, coverage and setbacks.
**/landlens/build-scope**

### Property Tracker
Watch a property and hear about it when something new is registered against it.
**/landlens/property-tracker**

### Deal Room
Run the transaction in one place: documents, stamping, signatures and the parties.
**/landlens/deal-room**

FREE TOOLS · NO ACCOUNT NEEDED

# Twenty-four checks you can run yourself, at no cost.

## Records and verification

The registers themselves, read for you.

- Encumbrance Certificate
- Patta and Chitta
- Field Measurement Sketch
- EC Analyzer
- Bank charge check
- Court case search
- Seller background check
- Approval check by survey

## Value and duty

What it is worth and what it costs to register.

- Guideline value by street
- Guideline value by survey
- Stamp duty and registration fees
- Capital gains
- Floor space index
- Area unit converter

## Zoning and land use

What the plan says can happen on this land.

- Land use zone finder
- CMDA land use check
- Coastal regulation zone
- Master plan check
- Water bodies finder
- Airport height clearance

## Registers and directories

Who holds it, and which office keeps the record.

- Find your registering office
- Temple property check
- Waqf property check
- RERA register

**Every free tool**
/tools

**Services we run for you**
/services

**The LandLens suite**
/landlens/one

Verified RealEstate™

# Every claim in this document traces back to a government record.

- Legal opinions, due diligence and title verification
- Building plan, layout and sub-division approvals
- Completion and occupancy certificates, regularisation
- Escrow, negotiation and NRI property management
- Land survey, soil testing, architecture and construction

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Prepared from the registers named on the page each finding sits on. Where a register could not be read, this document says so in its place rather than leaving the gap to be read as a clean result.