"Seismic Resistant Design of Multistorey Building"

A PROJECT

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"Seismic Resistant Design of Multistory Building"** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering and submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Mohammad Tabrej Alam (141613), Akshay Kapoor (141667) & Mukul Dev (141621)** during a period from August 2017 to May 2018 under the supervision of **Mr. Kaushal Kumar & Mr Abhilash Shukla**, Assistant Professor, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

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Last however not the minimum, we generously welcome each one of those individuals who have helped me straightforwardly or in a roundabout way in making this project a win. In this unique situation, I might want to thank the various staff individuals, both educating and non-instructing, which have developed their convenient help and facilitated my undertaking

ABSTRACT

The principle objective of this project is to analyze and design a multi-storeyed building [Ground + 1] (3 dimensional frame)] using STAAD.Pro software. The design involves load calculations manually and analyzing the whole structure by STAAD.Pro software. The design methods used in software STAAD-Pro analysis are Limit State Design conforming to Indian Standard Code of Practice. STAAD.Pro software has features a state of the art user interface, visualization tools, powerful analysis and design engines with advanced finite element and dynamic analysis capabilities. From model generation, analysis and design to visualization and result verification, STAAD.Pro software is the professional's choice. Analysis of a Ground plus one storey building is done all possible load combinations [dead, live, and seismic loads].

A 3-D RCC frame is considered with the dimensions 55.17m × 35.20m. The numbers of total beams in each floor are 28 and the number of columns used are 16. The ground floor height is 4m. The structure is subjected to self weight, dead load, live load and seismic loads under the load case details of STAAD.Pro software.

Seismic load calculations were done following IS 1893-2002. The materials were specified and cross-sections of the beam and column members were assigned. The supports at the base of the structure were also specified as fixed. The codes of practice to be followed were also specified for design purpose with other important details. Then STAAD.Pro was used to analyses the structure and design the members. In the post-processing mode, after completion of the design, we can work on the structure and study the bending moment and shear force values with the generated diagrams. The deflection of various members under the given loading combinations was also checked. The design of the building is dependent upon the minimum requirements as prescribed in the Indian Standard Codes.

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CHAPTER 1: INTRODUCTION

1.1. General

Earthquakes around the world are single-handedly responsible for the destruction to life and property in large numbers. In order to mitigate such hazards, it is important to incorporate norms that will enhance the seismic performance of structures.

According to the Seismic Zoning Map of IS 1893:2002, India is divided into four seismic zones, in ascending order of a certain zone factor which is assigned to them on the basis of their seismic intensity. Earthquake causes random ground motions, in all possible directions emanating from the epicenter. Vertical ground motions are rare, but an earthquake is always accompanied with horizontal ground shaking. The ground vibration causes the structures resting on the ground to vibrate, developing inertial forces in the structure. As the earthquake changes directions, it can cause reversal of stresses in the structural components, that is, tension may change to compression and compression may change to tension. Earthquake can cause generation of high stresses, which can lead to yielding of structures and large deformations, rendering the structure non-functional and unserviceable. There can be large storey drift in the building, making the building unsafe for the occupants to continue living there.

1.2. How the ground shakes?

Shaking of ground on the Earth's surface is a net consequence of motions caused by seismic waves generated by energy release at each material point within the three-dimensional volume that ruptures at the fault. These waves arrive at various instants of time, have different amplitudes and carry different levels of energy. Thus, the motion at any site on ground is random in nature with its amplitude and direction varying randomly with time.

1.3. Earthquake waves

Earthquake waves are seismic waves that are created when energy builds up in rocks and they fracture. Scientists estimate there are several million earthquakes each year. Every earthquake produces P waves and S waves but only larger earthquakes produce

Love waves and Rayleigh waves. These are the four major types of seismic waves.

1.3.1 These waves are of three types :

1. **Primary or P waves** are considered as push and pull waves. These waves are also called the longitudinal waves. These waves resemble sound waves, since both are compression rarefaction waves. In these waves each particle vibrates to and fro in the direction of propagation as shown in Figure 1.1. P(Primary) waves pass through gases, liquids and solids in the same manner. These waves travel outward from the point of disturbance in all directions and in Straight lines. They are the fastest of all earthquake waves. Their average velocity is 5.3 km a second and a maximum of 10.6 km per second. P waves are the first to reach the epicenter. The path followed by these waves through the earth is concave.

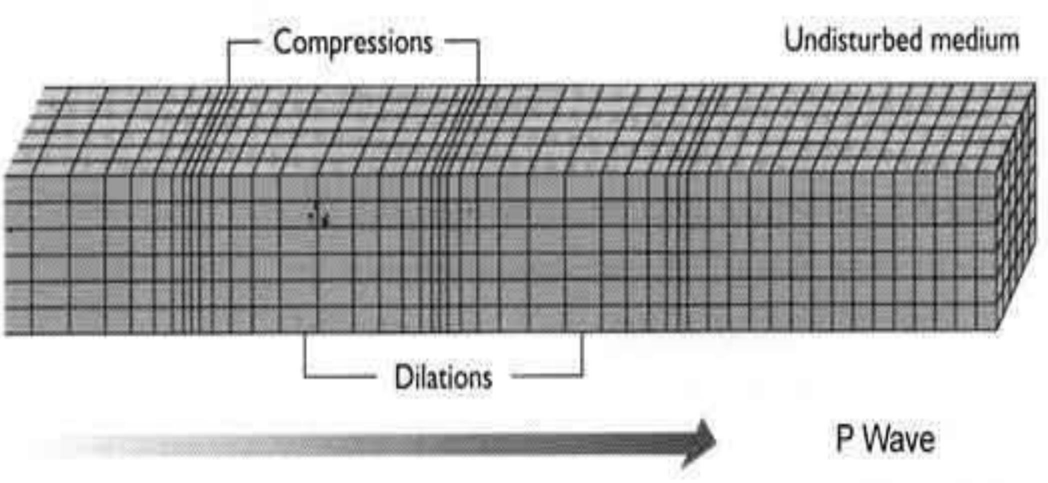

Figure 1.1 Primary waves produced during an earthquake [10]

2. **Secondary, S or Shear Waves.** In these waves the particles vibrate at right angles to the particular direction in which they travel (the direction of propagation). S(Secondary) waves passes only through solids, they cannot pass through liquids. It's an amazing fact that the same kind of rock the speeds of travel of P and S waves are different because they depend on different properties. The velocity of P waves is governed by the density and compressibility of the rock, whereas that of S waves depends on its density and rigidity. As a matter of fact, P waves travel at about 1.7 times the speed of shear waves as shown in Figure 1.2. However, shear waves closely follow the P waves. Even though the velocity of S wave is less than that of P wave, the former (S wave) is more destructive. P and S waves cause the rocking motion of the earth.

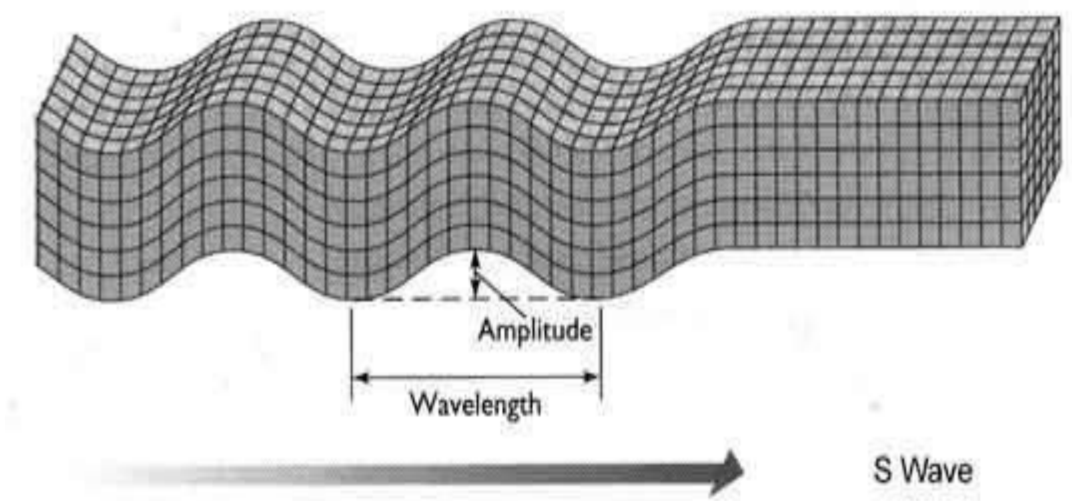

Figure 1.2 Secondary waves produced during an earthquake [11]

3. **R and L Waves** reach the earth's surface after P and S waves. Surface wave travels with a lower velocity than the other two around the surface of the earth. Surface wave is very destructive.

   There are two types of L waves:

   (i) Raileigh Waves

   (ii) Love Waves.

Raileigh waves are characterized by the motion of particles in elliptical orbits in the plane of propagation as shown in Figure 1.3. In the second kind of waves i.e. love waves, the motion of particles is horizontal and at 90° angle of the direction of their movement. Both of these waves provide very valuable information for distinguishing between the continental and oceanic types of crust. Besides the above named three major waves i.e. P, S, and L, there are some other minor waves called 'microseism'. It is worth remembering that the epicenter of an earthquake can be located when its distance from the three conveniently placed stations are known. By a close analysis of the record of P and S waves, the thickness of the earth's crust and its variation in different parts of the earth can be calculated.

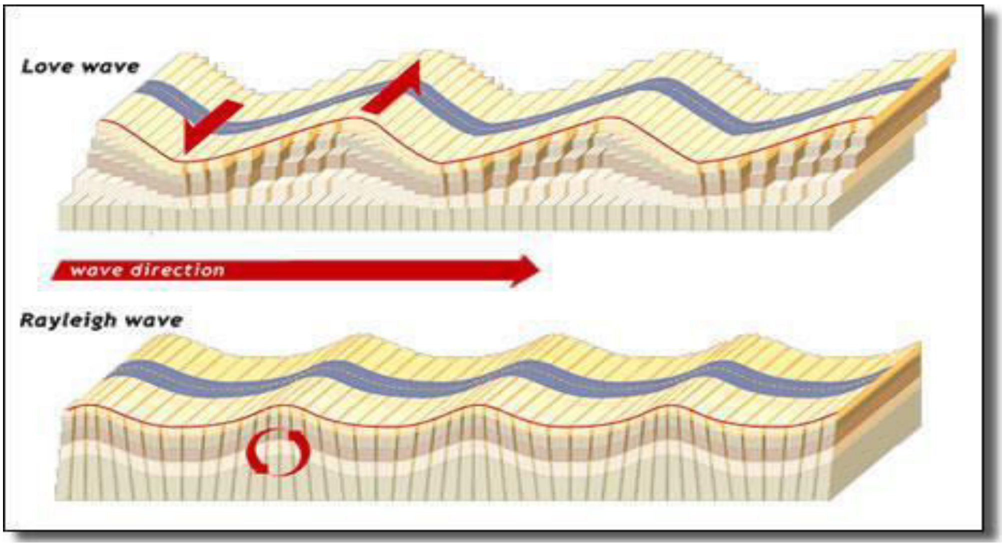

Figure 1.3 R and L waves produced during an earthquake [12]

1.4. Seismic Zone of India

The varying geology at different locations in the country implies that the likelihood of damaging earthquakes taking place at different locations is different. Thus, a seismic zone map is required so that buildings and other structures located in different regions can be designed to withstand different level of ground shaking. The current zone map subdivides India into four zones - II, III, IV and V as shown in Figure 1.4.

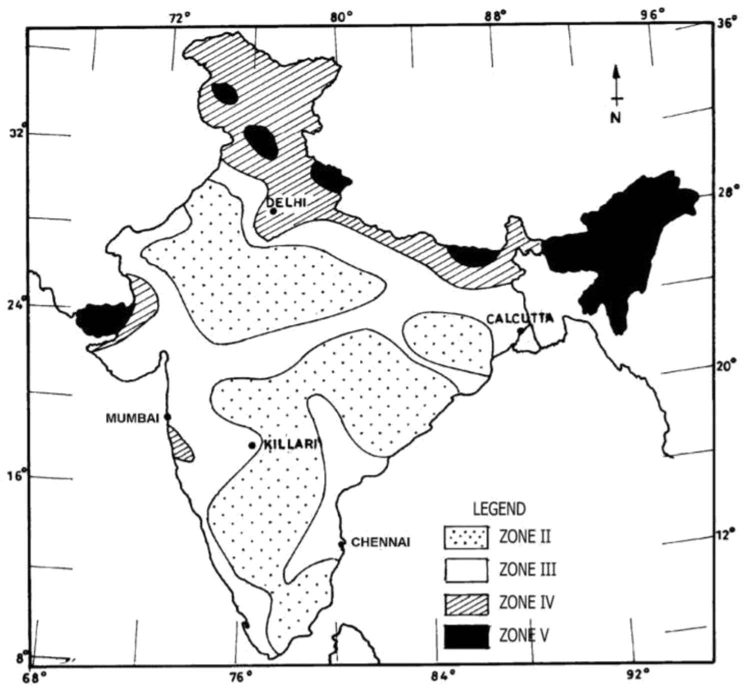

Figure 1.4 Seismic Zones in India [IS 1893-2002]

1.5. Methods of Elastic Analysis

It is the based on the approximation that the effects of yielding can be accounted for by linear analysis of the building using the design spectrum for inelastic systems. Forces and displacements due to each horizontal component of ground motion are separately determined by the analysis of an idealized building having one lateral degree of freedom per in the direction of the ground motion component being considered. Such analysis may be carried out by the following methods:

1) Equivalent lateral force procedure (Static Method)
2) Response spectrum analysis procedure (Dynamic Method)
3) Elastic Time History Method

1.6. Sources of weakness in reinforced concrete structure

- Continuous load path/interrupted load path/irregular load path
- Lack of deformation capability of structural members
- Quality of workmanship and materials

1.7. Origin of the Project

Few methods was carried out to understand the seismic behaviour of earthquake on any building and where will be the maximum damage in it. Those methods can be applied on any building using software like STAAD.Pro.

1.8. Objectives

1. Apply following methods on a building using STAAD.Pro
   i. Seismic coefficient method
   ii. Time history method

2. Perform design and RCC detailing of different members.

CHAPTER 2: LITERATURE REVIEW

2.1. Reviews

- **A Study on Earthquake Resistant construction Techniques**

  (Mohammad Adil Dar, Prof (Dr) A.R. Dar , Asim Qureshi ,Jayalakshmi Raju) Disasters are unexpected events which have adversely affected humans since the dawn of our existence. In response to such events, there have been attempts to mitigate devastating effects of these disasters. Results of such attempts are very encouraging in developed countries but unfortunately and miserably poor in developing countries including ours.

  Earthquakes are one of the nature's greatest hazards on our planet which have taken heavy toll on human life and property since ancient times . The sudden and unexpected nature of the earthquake event makes it even worse on psychological level and shakes the moral of the people. Man looks upon the mother earth for safety and stability under his feet and when it itself trembles, the shock he receives is indeed unnerving.

  In addition to the main earthquake design code 1893 the BIS(Bureau of Indian Standards)has published other relevant earthquake design codes for earthquake resistant construction Masonry structures (IS-13828 1993)

  - Horizontal bands should be provided at plinth ,lintel and roof levels as per code
  - Providing vertical reinforcement at important locations such as corners, internal and external wall junctions as per code.
  - Grade of mortar should be as per codes specified for different earthquake zones.
  - Irregular shapes should be avoided both in plan and vertical configuration.
  - Quality assurance and proper workmanship must be ensured at all cost without any compromise.

  In RCC framed structures (IS-13920)

  - In RCC framed structures the spacing of lateral ties should be kept closer as per the code
  - The hook in the ties should be at 135 degree instead of 90 degree for better anchor management.
  - The arrangement of lateral ties in the columns should be as per code and must be continued through the joint as well.

- Whenever laps are to be provided, the lateral ties (stirrups for beams) should be at closer spacing as per code.

- **Seismic response of RC frame Buildings with soft First storeys (Jaswant N. Arlekar, Sudhir K. Jain and C.V.R. Murty)**

  Open first storey is a typical feature in the modern multistorey constructions in urban India. Such features are highly undesirable in buildings built in seismically active areas; this has been verified in numerous experiences of strong shaking during the past earthquakes. This paper highlights the importance of explicitly recognizing the presence of the open first storey in the analysis of the building. The error involved in modeling such buildings as complete bare frames, neglecting the presence of infills in the upper storeys, is brought out through the study of an example building with different analytical models. This paper argues for immediate measures to prevent the indiscriminate use of soft first storeys in buildings, which are designed without regard to the increased displacement, ductility and force demands in the first storey columns. Alternate measures, involving stiffness balance of the open first storey and the storey above, are proposed to reduce the irregularity introduced by the open first storey

CHAPTER 3: Modelling of Structure

3.1 General details

- A 3-D RCC frame occupying an area of 55.176m×35.20m in XZ plane. The y-axis consisted of G+2 floors with pitched roof at top as shown in Figure 3.1.

- The building will be used for lectures, award ceremonies, dramatic plays, musical theatre productions, concert performances of orchestra, band, chorus, jazz band, battles of the bands, dance competitions, rehearsal, presentation, performing arts productions, or as a learning space.

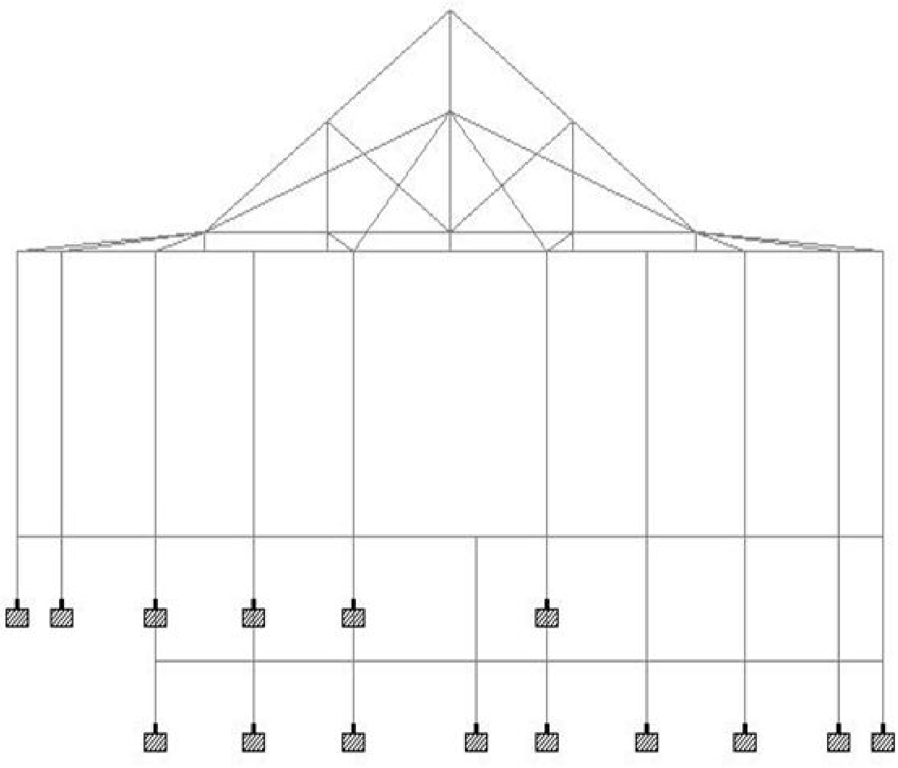

Figure 3.1: View from –z axis of the structure in STAAD.Pro

3.2 Design Data Considered

Table 3.1: Design data considered

Live load	4.0 kN/m2 at Sitting Area
	2.0 kN/m2 at Toilet Area
Floor finish	1.0 kN/m2
Terrace sheet	0.131 kN/m2
Location	Mandi, Himachal Pradesh
Wind load	As per IS: 875-Not designed for wind load,
	since earthquake loads exceed the wind loads
Earthquake load	As per IS-1893 (Part 1) – 2002
Depth of foundation below ground	2.0 m
Type of soil	Type II, Medium as per IS:1893
Storey height	First floor: 9.20 m, GF: 3.5 m
Floors	G.F. + 1 upper floor.
Ground beams	To be provided at 450 mm below G.L.
Plinth level	0.45 m
Walls	230 mm thick brick masonry walls

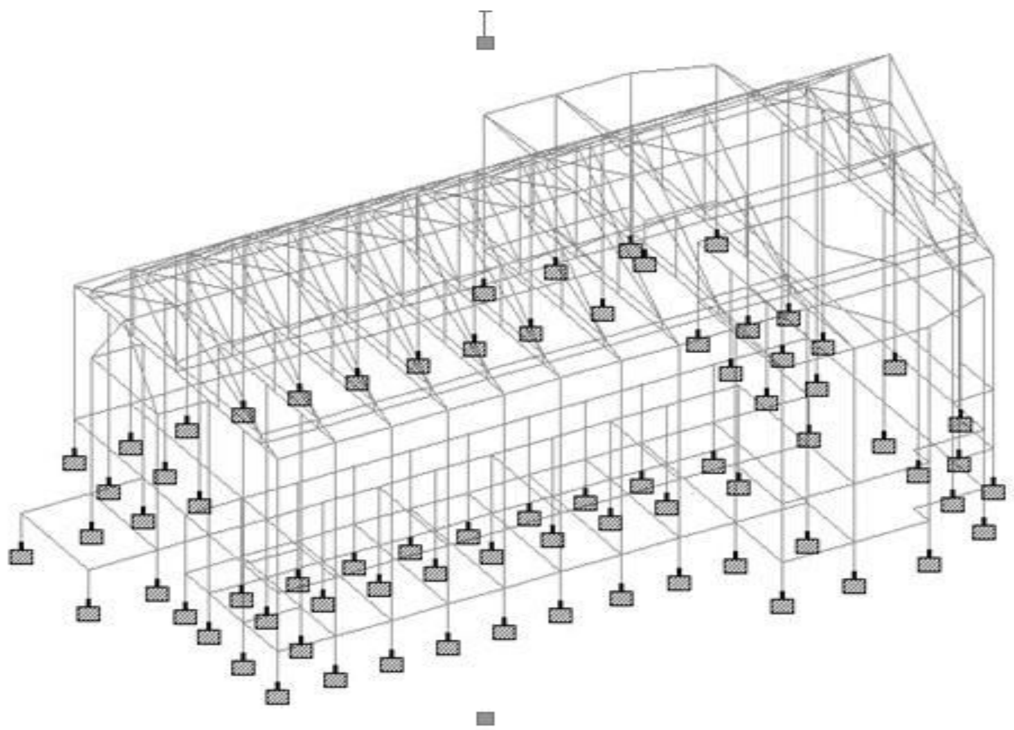

Figure 3.2: Isometric View of the structure in STAAD.Pro

Material Properties

- **Concrete**

All components unless specified in design: M25 grade all

0

$$Ec = 5000 \sqrt{(f_{ck})} \ N/mm^2$$

$$= 25000 \ N/mm^2$$

$$= 25000 \ MN/m^2.$$

Ec = Elastic Modulus of Concrete

- **Steel**

HYSD reinforcement of grade Fe 415 confirming to IS: 1786 is used throughout

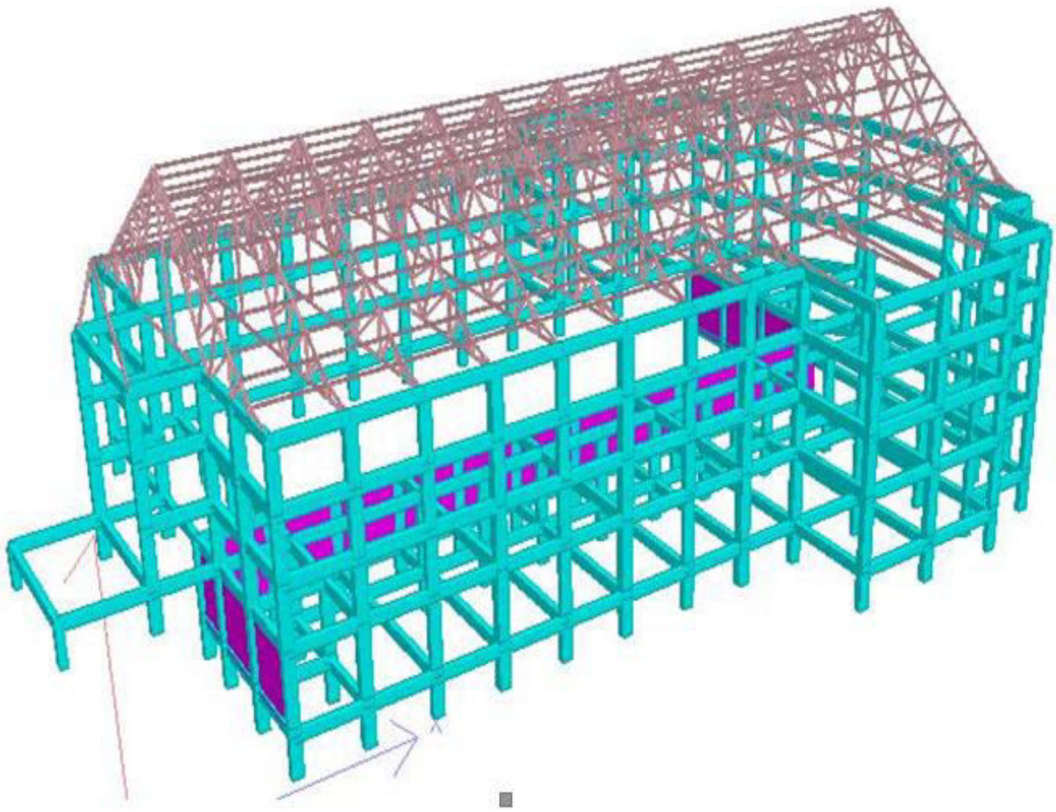

Figure 3.3: 3-D View of the structure in STAAD.Pro

3.3. Loads Considered

Dead Loads : Dead loads are permanent or stationary loads which are transferred to structure throughout the life span. Dead load is primarily due to self weight of structural members, permanent partition walls, fixed permanent equipments and weight of different materials. It majorly consists of the weight of roofs, beams, walls and column etc. which are otherwise the permanent parts of the building.

Dead load calculations will be done following IS 875 (Part 1) – 1987

Imposed Loads : Live load is produced by the intended use or occupancy of a building including the weight of movable partitions, distributed and concentrated loads, load due to impact and vibration and dust loads. These loads are assumed to be produced by the intended use or occupancy of the building including weights of movable partitions or furniture etc. The minimum values of live loads to be assumed are given in IS 875 (Part 2)–1987.

Seismic Loads: Seismic load calculations will be done following IS 1893(Part 1)-2000. The seismic weights are calculated in a manner similar to gravity loads. The weight of columns and walls in any storey shall be equally distributed to the floors above and below the storey. Following reduced live loads are used for analysis (as per IS : 1893 (part 1): 2002)

- Terrace – 0%
- Other floors - 50%

CHAPTER 4: SEISMIC COEFFICIENT METHOD

4.1. Introduction

Earthquake shaking is random and time variant. But, most design codes represent the earthquake-induced inertia forces as the net effect of such random shaking in the form of design equivalent static lateral force. This force is called as the Seismic Design Base Shear V_b and remains the primary quantity involved in force-based earthquake-resistant design of buildings. This force depends on the seismic hazard at the site of the building.

Seismic analysis of most of the structures are still carried out on the basis of lateral (horizontal) force assumed to be equivalent to the actual (dynamic) loading. The base shear is calculated on the basis of structure mass and fundamental period of vibration and corresponding mode shape. The base shear is distributed along the height of structures in terms of lateral forces according to code formula (IS: 13920: 1993). This method is usually conservative for low to medium height buildings with regular conformation.

4.1.1 Determination of base shear

The total design lateral force along any principal direction shall be determined by the following expression, Clause 7.5 of IS 1893 (Part 1): 2002

$$V_b = A_h W$$

0

A_h (Design horizontal acceleration spectrum value) = 0.099

$$A_h = \frac{ZIS_a}{2RG}$$

Z (Zone factor) = 0.36 (Mandi is in Zone V as per IS 1893 (Part1): 2002)

I (Importance factor) = 1.5 (assembly building)

R (Response reduction factor) = 5.0 (assume special RC moment resisting frame)

S_a/g (Spectral Acceleration) = 1.835 (assume medium soil and 5% damping)

W = Seismic weight of the building (calculated in STAAD.Pro)

4.2 Gravity Load calculations

4.2.1 Unit load calculations

Assumed sizes of beam and column sections are:

Main columns: 300 m × 600 m at all typical floors

Area, A = 0.18 m^2, I = 0.0054 m^4

Main beams: 300 m × 600 m at all floors

Area, A = 0.18 m^2, I = 0.0054 m^4

Secondary beams: 350 × 650

Area, A = 0.23 m^2, I = 0.008 m^4

Secondary columns: 400 × 600

Area, A = 0.24 m^2, I = 0.0072 m^4

Steel tube section properties (as per IS : 1161 – 2014)

Nominal Bore (NB) = 100 mm

Outside Diameter (OD) = 114.3 mm

Thickness = 5.4 mm

Self Weight = 14.5 kg/m

4.2.2 Member self- weights:

Main beam (300 × 600)

0.30 × 0.60 × 25 = 4.5 kN/m

Secondary beams (350 × 650)

0.20 × 0.50 × 25 = 2.5 kN/m

Slab (120 mm thick)

Slab Load = 0.12 × 25 = 3.0 kN/m^2

(Floor finish + Insulation + marble flooring + partition walls) = 3.0

kN/m^2 Total dead load on slab = 6.0 kN/m^2

Brick wall (230 mm thick)

0.23×19 (wall) $+2 \times 0.012 \times 20$ (plaster) = 4.6 kN/m^2

Partition brick wall (5'' thick)

0.115×19 (wall) $+2 \times 0.012 \times 20$ (plaster)= 2.67 kN/m^2

4.2.3 Truss Load Calculations

Loading Calculation for dead load:

GI sheeting = 0.085 kN/m^2

Fixings = 0.025 kN/m^2

Services = 0.100 kN/m^2

Total load = 0.210 kN/m^2

Roof dead load = $0.21 \times 23.76 \times 3.95 = 19.71$ kN

Weight of purlin (0.142 kN/m) = $0.142 \times 3.95 = 0.56$ kN

Self-weight of one truss* = $0.1016 \times 3.95 \times 23.76 = 9.53$ kN

Total dead load = 29.42 kN

(For welded sheet roof trusses, the self-weight is given approximately by w = 53.7 + 0.53 A = 53.7 + 0.53 × 3.8 × 23.76 = 0.1016 kN/m^2)*

Calculation for nodal dead loads:

Since the truss has 17 internal nodes at the top chord,

Intermediate nodal dead load (W) = 29.42/17 = 1.73 kN

Dead load at end nodes (W/2) = 1.73/2 = 0.865 kN

Intermediate nodal dead load + purlin load (W)' = 1.73 + 0.54 = 2.27 kN

Dead load at end nodes + purlin load (W/2)' = 0.865 + 0.54 = 1.405 kN

Live load Calculation (as per IS 875: 1987 (Part 2)) - Table 2)

For sloping roof with slope greater than 10 degrees, the imposed load is given by the equation

I.L = $0.75 - 0.02 \times (\theta - 10^0)$ (in kN/m^2) , θ = slope of the truss

I.L = 0.23 kN/m^2 (θ =36^0)

Total live load = 0.23 × 3.95 × 23.76 = 21.59 kN

Intermediate nodal live load (W) = (21.59)/17 = 1.27 kN

Intermediate nodal live load (W/2) = 1.27/2 = 0.635 kN

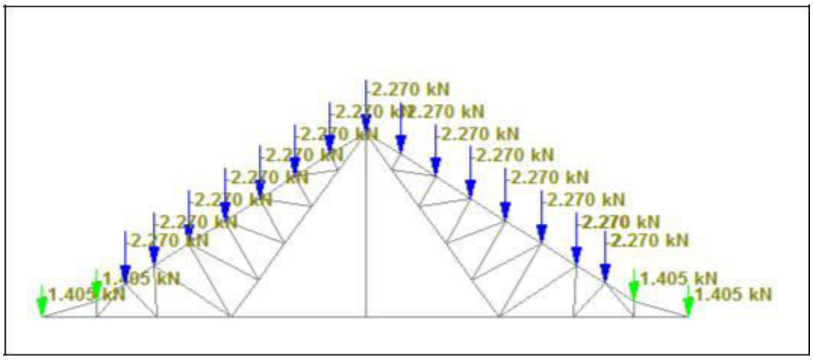

Figure 4.1: Load distribution on Truss of the structure (STAAD.Pro)

4.3 Summary of different loads acting on a structure

Table 4.1 : Summary of loads acting on structure

S.No.	Structural Members	Dead Load	Live Load* (kN/m^2)
1	Slab		
1.1	Toilet area	6 kN/m^2	2
1.2	Stage area	6 kN/m^2	5
1.3	Assembly area	6 kN/m^2	4
2	Brick Wall		
2.1	Main Wall - GL (230 mm)	18.4 kN/m	
2.1	Main Wall - Ist Floor (230 mm)	14 kN/m	
2.2	Partition Wall (125 mm)	10 kN/m	

*(*As per IS 875 : 1987 (Part 2) - Table 1)*

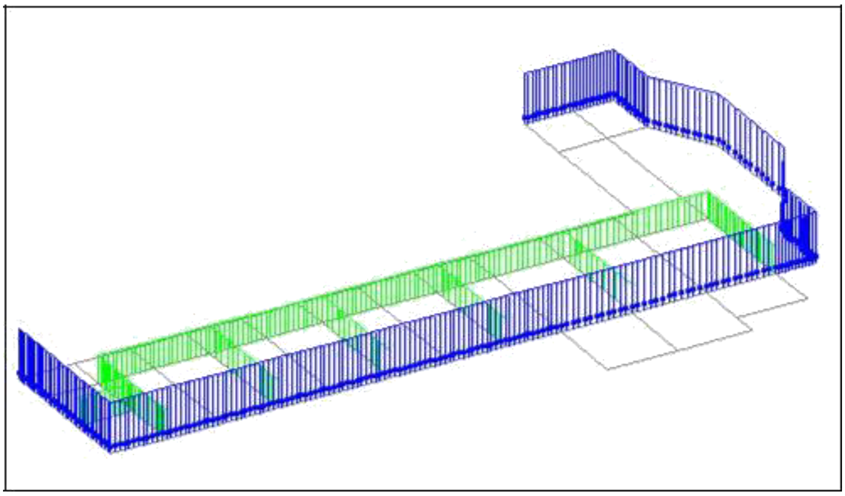

Figure 4.2 : Load distribution on 1st of intensity 18.4 N/mm floor of the structure (STAAD.Pro)

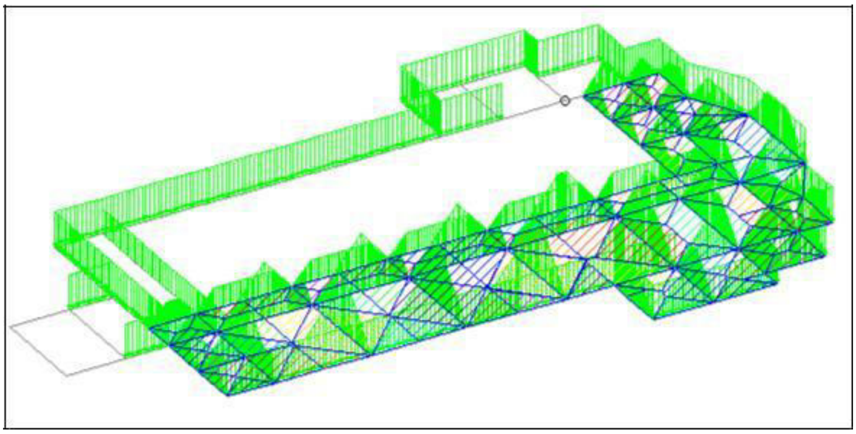

Figure 4.3 : Load distribution on 1st of intensity 18.4 N/mm floor of the structure (STAAD.Pro)

4.4 Earth Pressure on Retaining Wall

Active pressure is the condition in which the earth exerts a force on a retaining system and the members tend to move toward the excavation

Earth Pressure Calculation

The soil parameters for the given site are angle of internal friction (ø) = 18 kN/m^3 and unit weight (γ) = 25^0. The earth pressure is given by the following equation$P_a = k_a \gamma H$

Where, k_a * = active earth pressure coefficient

H = height of the retaining wall over which the earth pressure is acting

So, Pa = 29.22 kN/m^2 (~ 0.029 N/mm^2)

*k_a = (1 - sin ø)/(1 + sin ø)

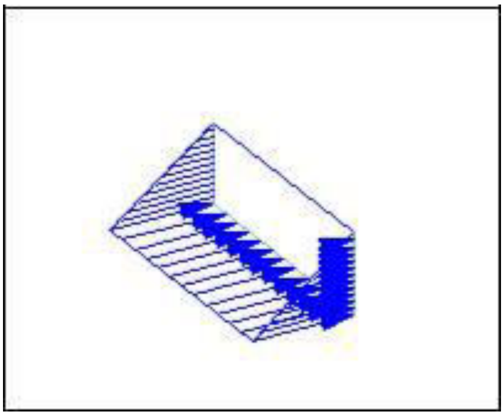

Figure 4.4 : Active earth pressure on retaining wall of pressure 0.029 N/mm^2 of the structure (STAAD.Pro)

4.5 Seismic Weight

It is the total dead load plus appropriate amounts of specified imposed load.

Seismic Mass

It is the seismic weight divided by acceleration due to gravity.

4.5.1 Seismic Weight Calculations

The seismic weights are calculated in a manner similar to gravity loads. The weight of columns and walls in any storey shall be equally distributed to the floors above and below the storey. (IS: 1893 (Part 1): 2002, Clause 7.4)

Table 4.2 : Seismic Weight Calculation of floor of structure

Slab	Dead Load (kN/m^2)	Imposed Load (kN/m^2)	Seismic Weight (kN/m^2)
Toilet area	6	0.5	6.5
Stage area	6	2.5	8.5
Assembly area	6	2	8

4.6 Analysis by Space Frames

The space frame is modelled using software STAAD.Pro. The gravity loads are taken from table 1, while the seismic weights are taken from table 2. The basic load cases are shown in table 3, where X and Z are lateral orthogonal directions.

Table 4.3 : Load Cases

S.No.	Load Case	Direction
1.	Dead Load (DL)	Downwards (Along – Y axis)
2.	Live Load (LL)	Downwards (Along – Y axis)
3.	Earthquake Load (EQx)	Along Z axis
4.	Earthquake Load (EQz)	Along Z axis

4.6.1 Load Combinations

As per IS 1893 (Part 1): 2002 Clause no. 6.3.1.2, the following load cases have to be considered for analysis:

1) 1.5 (DL + IL)

2) 1.2 (DL + IL ± EL)

3) 1.5 (DL ± EL)

4) 0.9 DL ± 1.5 EL

Earthquake load must be considered for +X, -X, +Z and –Z directions. Moreover, accidental eccentricity can be such that it causes clockwise or anticlockwise moments. Thus, ±EL above implies 8 cases, and in all, 25 cases.

It is possible to reduce the load combinations to 13 as shown in table 4.4 instead of 25 by not using negative torsion considering the symmetry of the building.

Since large amount of data is difficult to handle manually, all 25-load combinations are analysed using software.

Table 4.4: Load Combinations Applied

S.No.	Load Combinations
1	1.5 (DL + IL)
2	1.2 (DL + IL + EQx)
3	1.2 (DL + IL + EQz)
4	1.2 (DL + IL – EQx)
5	1.2 (DL + IL – EQz)
6	1.5 (DL + EQx)
7	1.5 (DL + EQz)
8	1.5 (DL – EQx)
9	1.5 (DL – EQz)
10	0.9 DL + 1.5 EQx
11	0.9 DL + 1.5 EQz
12	0.9 DL - 1.5 EQx
13	0.9 DL - 1.5 EQz

4.7 STAAD.Pro Results of the designed structure

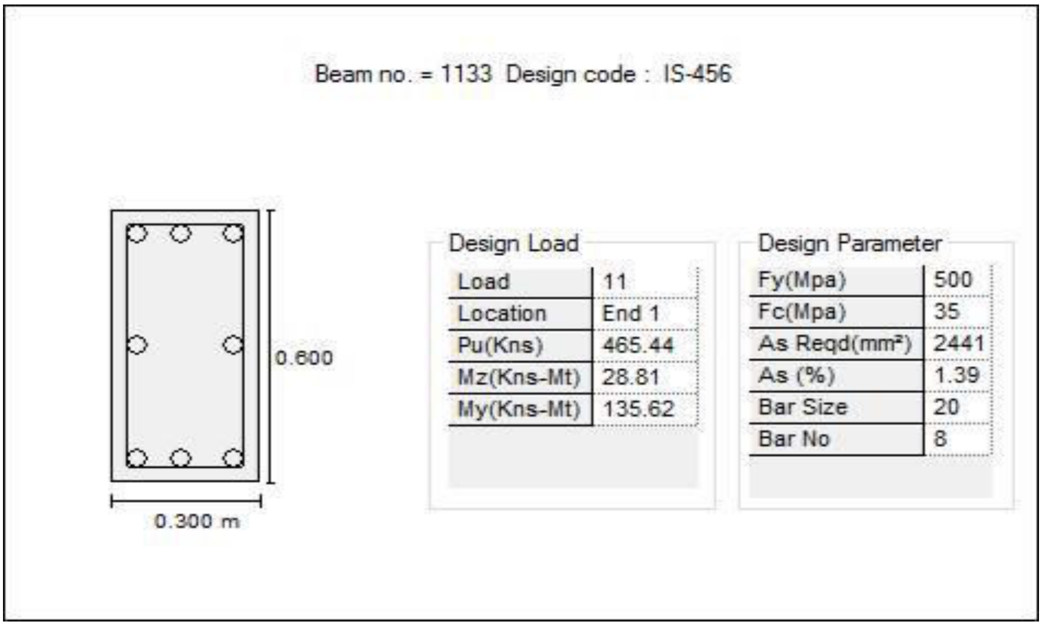

Figure 4.5 : Design results of critical member of structure

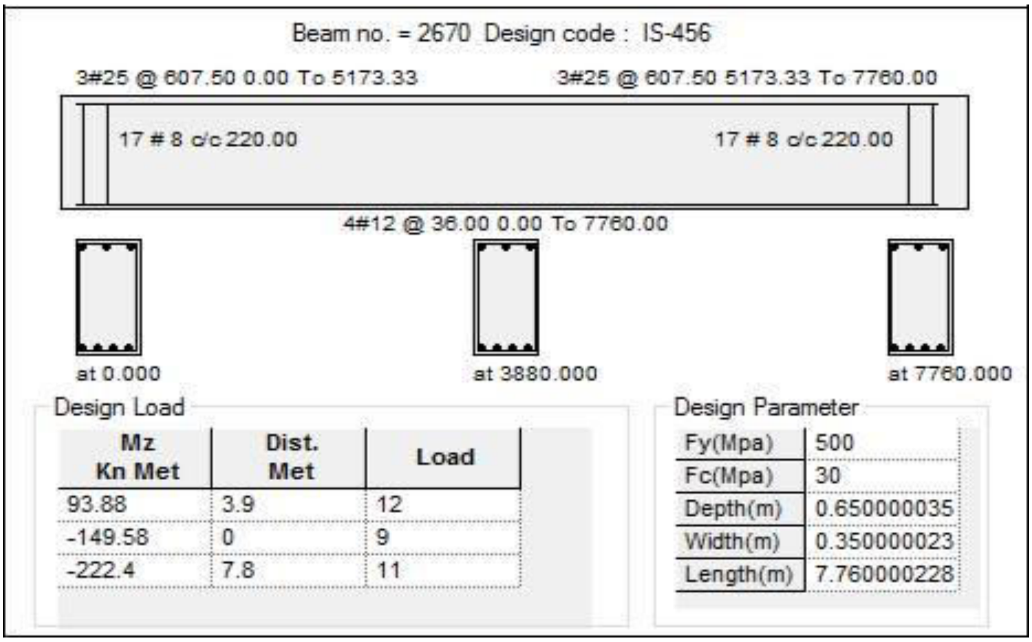

Figure 4.6 : Design results of critical member of structure

CHAPTER 5: TIME HISTORY METHOD

5.1 Introduction

A linear time history analysis overcomes all the disadvantages of model response spectrum analysis, provided non – linear behavior is not involved. This method requires greater computational efforts for calculating the response at discrete times. One interesting advantage of such procedure is that the relative sign of response quantities are presented in the response histories. This is important interaction effects are considered in design among stress resultants. Dynamic response of the plane frame model with infills to a specified time history compatible to IS code spectrum for 5% damping at rocky hard soil has been evaluated using mode superposition method.

5.2. Tine history data taken for time history analysis

5.2.1. El Centro Method

The 1940 El Centro earthquake (or 1940 Imperial Valley earthquake) occurred at 21:35 Pacific Standard Time on May 18 (05:35 UTC on May 19) in the Imperial Valley in south-eastern Southern California near the international border of the United States and Mexico. It had a moment magnitude of 6.9. It was the first major earthquake to be recorded by a strong-motion seismograph located next to a fault rupture. The earthquake was characterized as a typical moderate-sized destructive event with a complex energy release signature. It was the strongest recorded earthquake to hit the Imperial Valley, and caused widespread damage to irrigation systems and led to the deaths of nine people.

5.2.2. Kobe Method

The earthquake of 17 January, 1995 near Kobe city in Japan has provided strong motion records at several locations. The earthquake measured 7.2 on the Richter scale and inflicted significant damage to the prosperous city of Kobe. There were extensive liquefaction induced failures in the reclaimed areas and sea-front sites. Most notable of these failures were the quay walls which failed following liquefaction and led to failure of heavy machinery like overhead cranes, gantries and even effected nearby buildings. This report concerns itself with the analyses of ground motions recorded at the Port Island site which is one of the reclaimed areas. Strong motion records at different observation sites in Kobe were recorded by CEORKA (the Committee of Earthquake Observation and Research in the Kansai Area).

5.2.3. Northridge Method

The 1994 Northridge earthquake occurred on January 17, and had its epicentre in Reseda, a neighborhood in the north-central San Fernando
Valley region of Los Angeles, California. It had a duration of approximately 10–20 seconds. The blind thrust earthquake had a moment magnitude (M_w) of 6.7, which produced ground acceleration that was the highest ever instrumentally recorded in an urban area in North America, measuring 1.8*g* (16.7 m/s^2) with strong ground motion felt as far away as Las Vegas, Nevada, about 220 miles (360 km) from the epicentre. The peak ground velocity at the Rinaldi Receiving Station was 183 cm/s (4.09 mph or 6.59 km/h), the fastest peak ground velocity ever recorded. In addition, two 6.0 M_w aftershocks occurred, the first about one minute after the initial event and the second approximately 11 hours later, the strongest of several thousand aftershocks in all. The death toll was 57, with more than 8,700 injured. In addition, property damage was estimated to be between $13 and $50 billion, making it one of the costliest natural disasters in U.S. history.

CHAPTER 6: Results of STAAD.Pro

6.1 Results for Seismic Coefficient

Table 6.1 Node Displacement of seismic coefficient

			Horizontal	Vertical	Horizontal	Resultant	Rotational		
	Node	**L/C**	**X mm**	**Y mm**	**Z mm**	**mm**	**rX rad**	**rY rad**	**rZ rad**
Max X	1881	9 DL+EQ(X)	132.644	-13.911	2.878	133.403	0	0	0.004
Min X	1869	6 DL+LL (TOP STOREY)	-56.133	-32.679	0.138	64.952	0	0	-0.008
Max Y	1790	1 EQ IN X	63.467	2.463	0.06	63.515	0	0	-0.001
Min Y	1684	6 DL+LL (TOP STOREY)	-0.73	-122.53	1.562	122.538	0	-0.001	0.002
Max Z	1836	19 0.9DL+EQ(Z)	-0.741	-7.774	135.646	135.871	-0.001	0	0
Min Z	1513	6 DL+LL (TOP STOREY)	-0.741	-24.672	-13.108	27.948	0	0	0
Max rX	1666	6 DL+LL (TOP STOREY)	0.326	-96.906	0.089	96.907	0.015	0	0.001
Min rX	1901	6 DL+LL (TOP STOREY)	1.002	-73.972	5.242	74.164	-0.025	0	0.001
Max rY	1818	9 DL+EQ(X)	52.964	-13.11	2.629	54.626	0.001	0.014	0.005
Min rY	1795	9 DL+EQ(X)	57.69	-13.101	3.133	59.242	-0.001	-0.013	0.005
Max rZ	1801	6 DL+LL (TOP STOREY)	-0.059	-25.074	-0.877	25.09	-0.001	-0.007	0.013
Min rZ	1347	17 0.9DL+EQ(X)	32.53	-1.272	2.519	32.652	0	0	-0.017
Max Rst	1836	19 0.9DL+EQ(Z)	-0.741	-7.774	135.646	135.871	-0.001	0	0

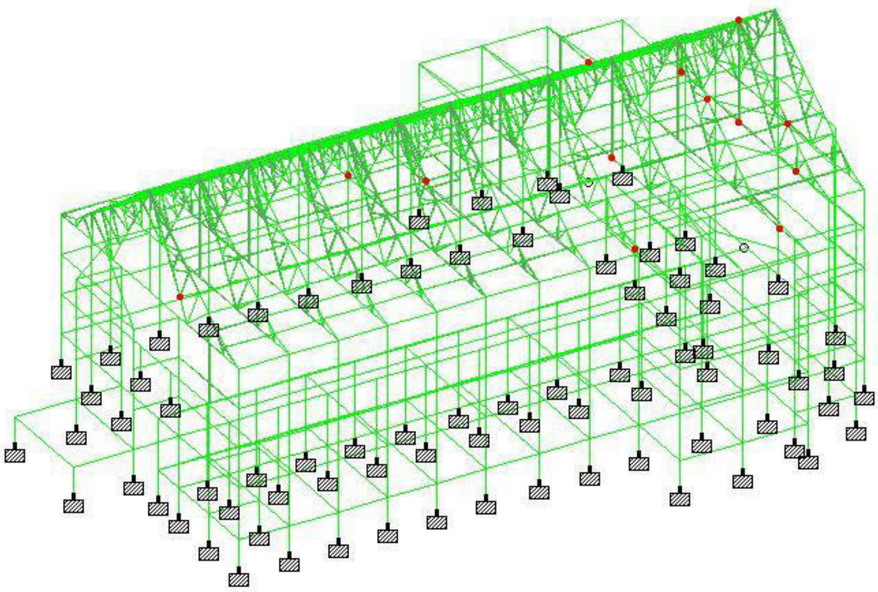

Figure:- 6.1 Node displacement of seismic Coefficient

Table 6.2 Beam End Moment of Seismic Coefficient

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	1649	9 DL+EQ(X)	907	1237.463	19.481	-13.519	-1.349	5.498	29.123
Min Fx	1546	9 DL+EQ(X)	674	-541.724	84.873	-0.465	-2.796	9.211	81.748
Max Fy	1833	6 DL+LL (TOP STOREY)	669	60.717	267.947	1.104	0.321	-4.625	376.672
Min Fy	2517	6 DL+LL (TOP STOREY)	1233	44.484	-306.86	0.506	0.469	2.63	435.938
Max Fz	2650	19 0.9DL+EQ(Z)	1306	-39.37	-23.539	149.59	3.775	-225.32	-33.819
Min Fz	1669	11 DL+EQ(Z)	920	796.259	1.791	-547.20	-17.86	599.52	9.37
Max Mx	2619	19 0.9DL+EQ(Z)	1287	-14.179	38.915	8.198	93.927	7.107	30.7
Min Mx	2546	19 0.9DL+EQ(Z)	1257	151.46	-4.724	-36.85	-113.05	63.023	-8.062
Max My	1669	11 DL+EQ(Z)	920	796.259	1.791	-547.21	-17.86	599.523	9.376
Min My	1669	11 DL+EQ(Z)	600	779.295	1.791	-547.21	-17.86	-494.89	5.793
Max Mz	1833	11 DL+EQ(Z)	620	-108.056	-229.06	-0.659	-0.038	-4.796	558.731
Min Mz	2686	19 0.9DL+EQ(Z)	1306	-11.98	-105.06	-10.488	2.118	13.434	-422.675

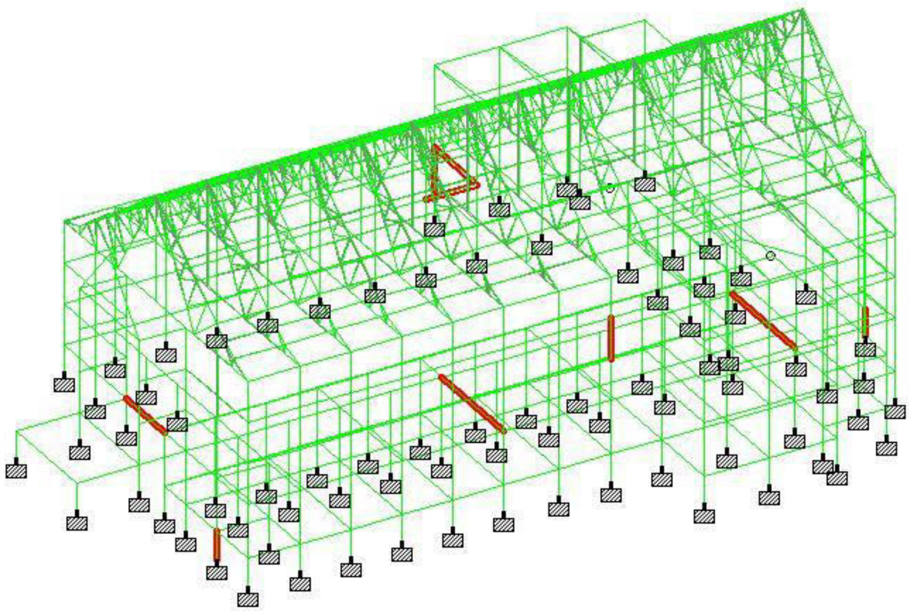

Figure:- 6.2 Beam End Moment of seismic Coefficient

6.2 Result for Time History Analysis

1. Elcentro Earthquake

Table 6.3 Node Displacement of Time History Analysis (Elcentro)

			Horizontal	Vertical	Horizontal	Resultant	Rotational		
	Node	**L/C**	**X mm**	**Y mm**	**Z mm**	**mm**	**rX rad**	**rY rad**	**rZ rad**
Max X	1821	12 0.9DL+EQ(X)	335.597	-16.114	-8.668	336.095	0	-0.001	0.004
Min X	1301	12 0.9DL+EQ(X)	-3.82	-0.338	0.46	3.862	0	0	-0.002
Max Y	1790	12 0.9DL+EQ(X)	281.319	2.267	-9.086	281.475	0	0.001	0.001
Min Y	1684	10 DL+25%LL+EQ(X)	187.445	-65.707	5.931	198.717	0	-0.011	-0.004
Max Z	1292	12 0.9DL+EQ(X)	4.287	-0.401	9.831	10.733	-0.001	0.001	0
Min Z	1741	12 0.9DL+EQ(X)	66.054	-1.203	-14.329	67.601	0	0.01	-0.022
Max rX	1666	10 DL+25%LL+EQ(X)	11.226	-52.821	4.057	54.153	0.008	0.007	-0.004
Min rX	1901	10 DL+25%LL+EQ(X)	10.583	-40.023	8.498	42.262	-0.013	0.001	-0.003
Max rY	1823	12 0.9DL+EQ(X)	241.475	-17.617	-8.939	242.282	0	0.039	0.004
Min rY	1822	12 0.9DL+EQ(X)	243.447	-17.675	-8.416	244.233	0	-0.038	0.004
Max rZ	1493	12 0.9DL+EQ(X)	102.098	-7.039	1.277	102.348	0.001	0.019	0.01
Min rZ	1347	12 0.9DL+EQ(X)	76.334	-0.614	-2.574	76.38	0	-0.004	-0.055
Max Rst	1821	12 0.9DL+EQ(X)	335.597	-16.114	-8.668	336.095	0	-0.001	0.004

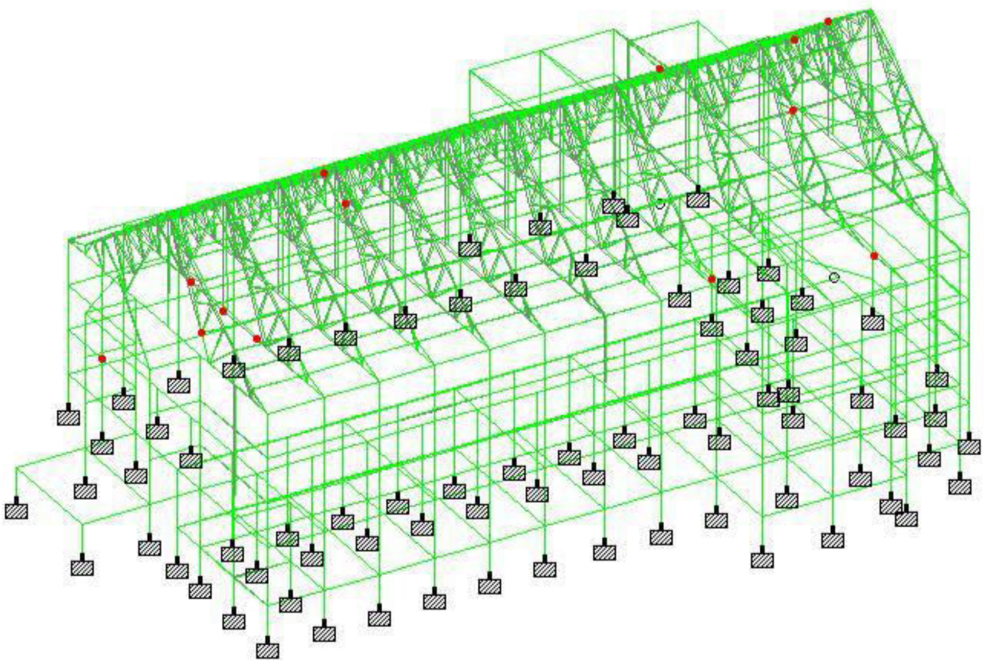

Figure:- 6.3 Node Displacement of Time History Analysis (Elcentro)

Graph 6.1 - Time History Graph of Elcentro for Node-1881

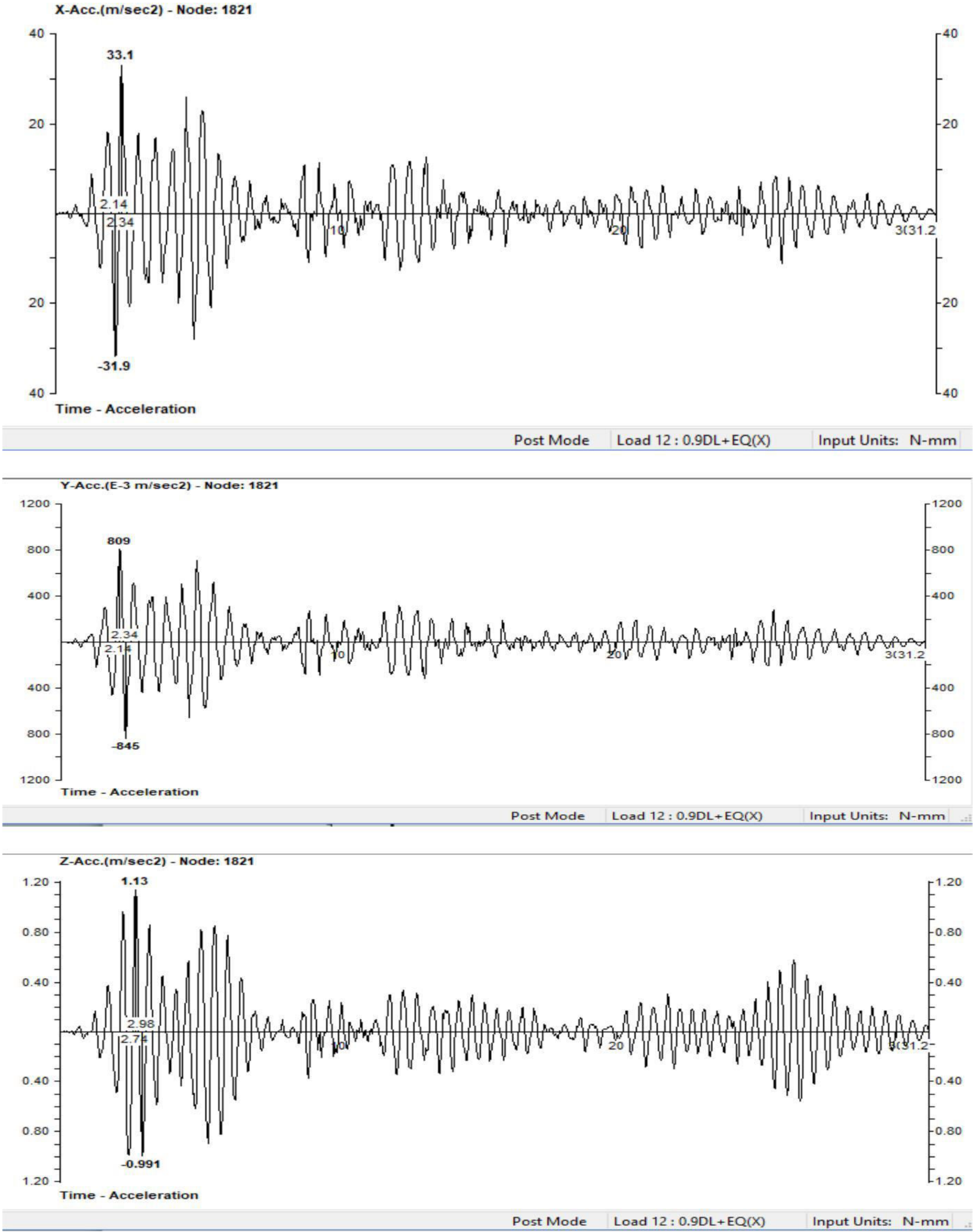

Table 6.4 Beam End Moment of Time History Analysis (Elcentro)

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	1651	10 DL+25%LL+EQ(X)	908	1067.77	27	38.735	-0.297	-39.365	70.579
Min Fx	1546	10 DL+25%LL+EQ(X)	674	-441.16	59.15	-0.423	-1.643	7.308	44.386
Max Fy	1832	10 DL+25%LL+EQ(X)	667	47.94	162.137	-1.681	2.629	-10.042	235.807
Min Fy	2575	12 0.9DL+EQ(X)	1265	-26.718	-166.72	28.704	2.351	38.958	204.389
Max Fz	1360	12 0.9DL+EQ(X)	794	40.757	-7.429	109.343	74.958	-97.96	-12.524
Min Fz	1669	10 DL+25%LL+EQ(X)	920	607.302	19.697	-294	-15.385	323.24	41.5
Max Mx	3609	12 0.9DL+EQ(X)	1772	56.838	-7.238	64.823	80.999	-83.546	25.694
Min Mx	2707	12 0.9DL+EQ(X)	1334	55.478	-40.871	-65.557	-83.013	-14.817	-0.325
Max My	1669	10 DL+25%LL+EQ(X)	920	607.302	19.697	-294	-15.385	323.24	41.5
Min My	1669	10 DL+25%LL+EQ(X)	600	593.731	19.697	-294	-15.385	-264.759	2.105
Max Mz	2517	10 DL+25%LL+EQ(X)	1233	31.402	-162.28	2.169	1.155	8.73	236.977
Min Mz	1522	12 0.9DL+EQ(X)	595	404.252	97.275	-10.809	-8.176	-25.928	-201.867

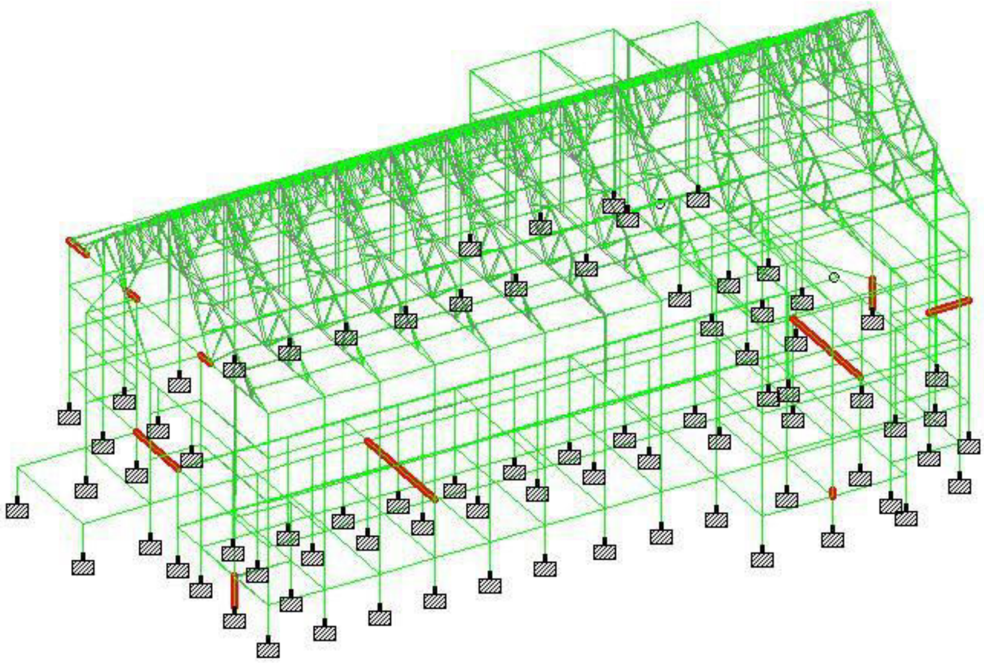

Figure:- 6.4 Beam End Moment of Time History Analysis (Elcentro)

2. Kobe Earthquake

Table 6.5 Node Displacement of Time History Analysis (Kobe)

			Horizontal	Vertical	Horizontal	Resultant	Rotational		
	Node	**L/C**	**X mm**	**Y mm**	**Z mm**	**mm**	**rX rad**	**rY rad**	**rZ rad**
Max X	1485	12 0.9DL+EQ(X)	149.912	-9.073	-1.431	150.193	0	-0.007	0.003
Min X	1869	8 DL+EQ(X)	-216.11	-22.27	-2.603	217.27	0	0	-0.005
Max Y	728	12 0.9DL+EQ(X)	-8.586	0.13	10.211	13.342	0	-0.003	0.001
Min Y	1684	5 DL+LL (TOP STOREY)	-0.729	-122.53	1.562	122.538	0	-0.001	0.002
Max Z	1782	8 DL+EQ(X)	-11.08	-0.827	12.961	17.072	0	0	-0.00
Min Z	1513	8 DL+EQ(X)	-136.139	-15.162	-14.308	137.726	0	-0.007	0.004
Max rX	1666	5 DL+LL (TOP STOREY)	0.326	-96.906	0.089	96.906	0.015	0	0.001
Min rX	1901	5 DL+LL (TOP STOREY)	1.003	-73.972	5.241	74.164	-0.02	0	0.001
Max rY	1642	8 DL+EQ(X)	-132.791	-23.706	-1.885	134.904	-0.00	0.025	-0.005
Min rY	1643	8 DL+EQ(X)	-134.034	-23.177	-3.32	136.064	0.001	-0.025	-0.007
Max rZ	1347	8 DL+EQ(X)	-45.768	-1.771	1.607	45.83	0	0.004	0.034
Min rZ	1340	8 DL+EQ(X)	-89.034	-1.486	8.647	89.465	0	0.001	-0.025
Max Rst	1869	8 DL+EQ(X)	-216.11	-22.27	-2.603	217.27	0	0	-0.005

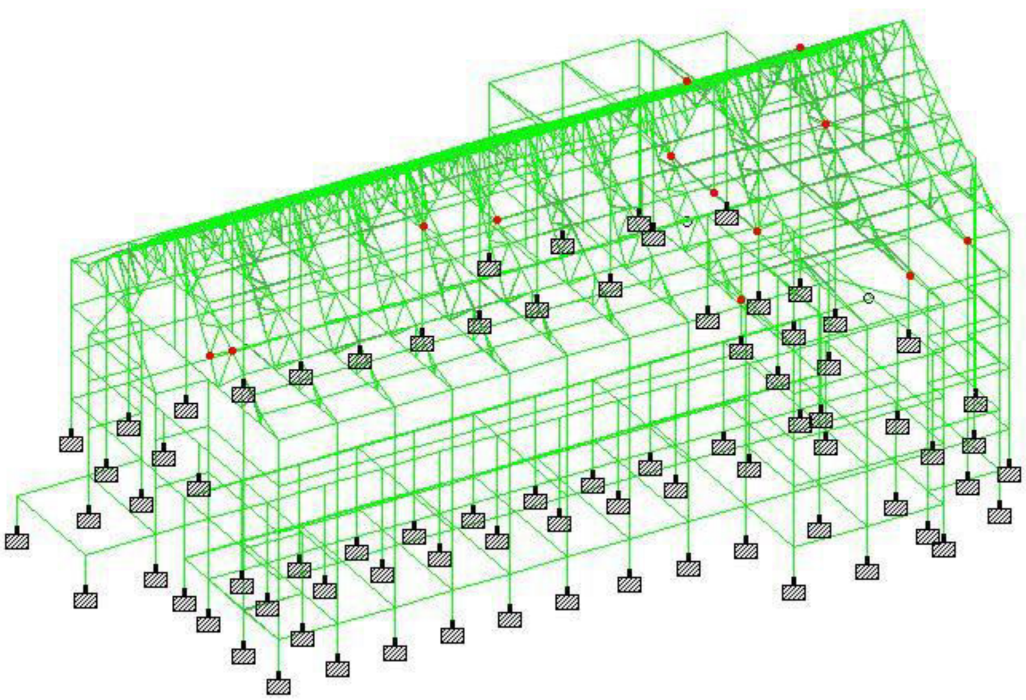

Figure:- 6.5 Node Displacement of Time History Analysis (Kobe)

Graph 6.2 Time History Graph of Kobe for Node-1485

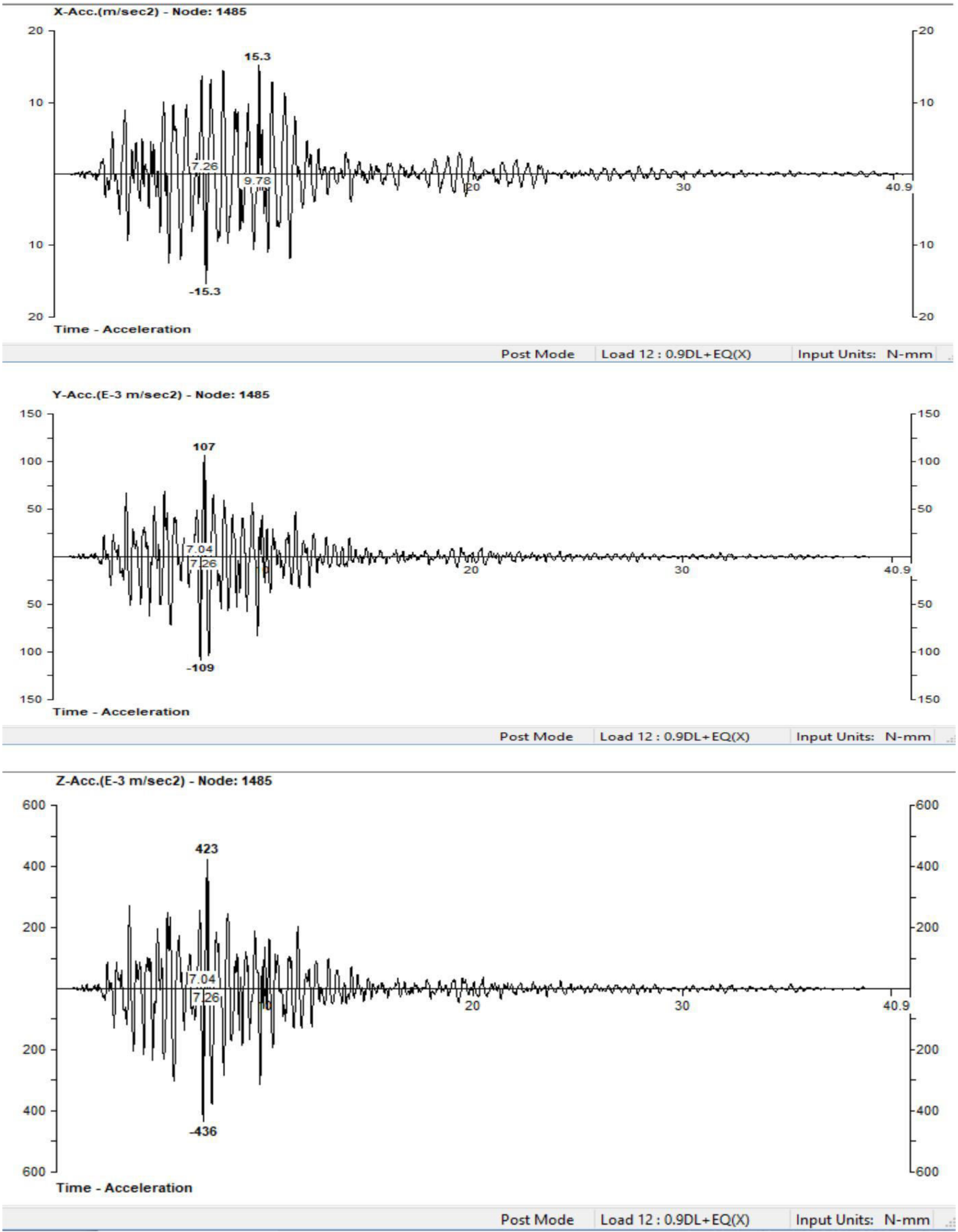

Table 6.6 Beam End Moment of Time History Analysis (Kobe)

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	1612	5 DL+LL (TOP STOREY)	888	1205.349	34.39	-36.383	0.226	24.277	51.668
Min Fx	1546	8 DL+EQ(X)	674	-548.588	75.96	0.475	-0.628	6.17	60.203
Max Fy	1833	5 DL+LL (TOP STOREY)	669	60.717	267.947	1.102	0.321	-4.616	376.671
Min Fy	2517	5 DL+LL (TOP STOREY)	1233	44.478	-306.85	0.505	0.415	2.624	435.845
Max Fz	1061	5 DL+LL (TOP STOREY)	622	905.96	17.03	72.713	7.752	-212.361	34.69
Min Fz	1669	6 DL+LL(BOTTOM STOREY)	920	863.952	-2.588	-402.00	-15.229	441.17	1.557
Max Mx	2707	8 DL+EQ(X)	1334	-48.048	-19.631	39.528	51.657	10.818	-31.55
Min Mx	3609	8 DL+EQ(X)	1772	-49.406	50.493	-42.314	-50.932	-47.826	27.477
Max My	1669	6 DL+LL(BOTTOM STOREY)	920	863.952	-2.588	-402.00	-15.229	441.17	1.557
Min My	1669	6 DL+LL(BOTTOM STOREY)	600	846.988	-2.588	-402.00	-15.229	-362.846	6.734
Max Mz	2517	5 DL+LL (TOP STOREY)	1233	44.478	-306.85	0.505	0.415	2.624	435.845
Min Mz	4138	5 DL+LL (TOP STOREY)	1819	12.273	-80.19	-26.24	-1.18	46.639	-160.76

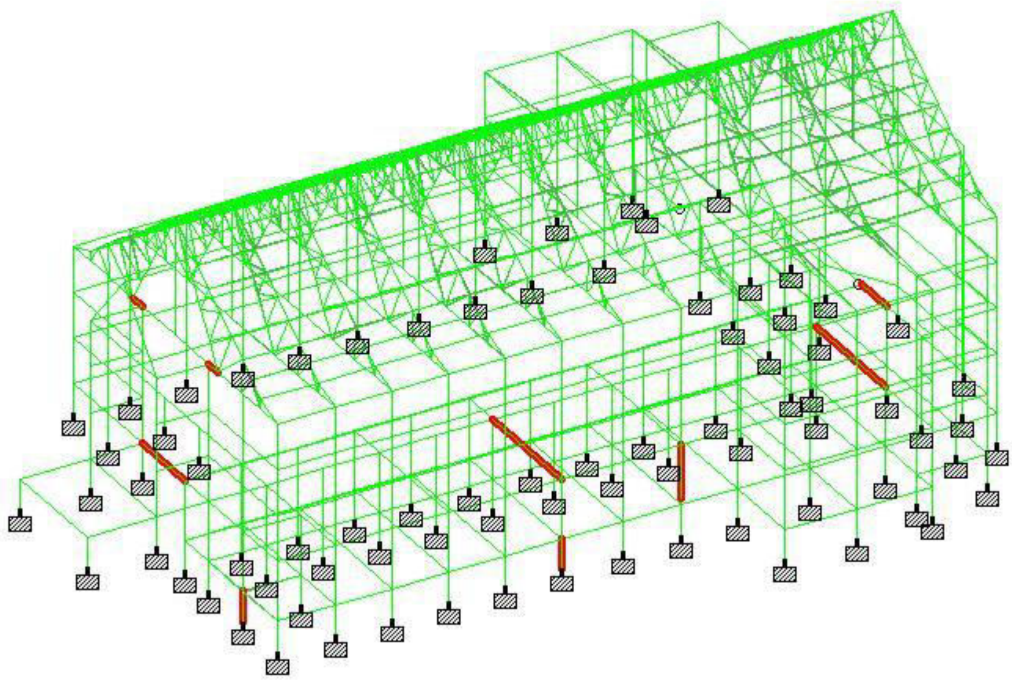

Figure:- 6.6 Beam End Moment of Time History Analysis (Kobe)

3 Northridge Earthquake

Table 6.7 Node Displacement of Time History Analysis (Northridge)

			Horizontal	Vertical	Horizontal	Resultant	Rotational		
	Node	**L/C**	**X mm**	**Y mm**	**Z mm**	**mm**	**rX rad**	**rY rad**	**rZ rad**
Max X	1821	12 0.9DL+EQ(X)	363.839	-16.836	-7.639	364.308	0	0	0.005
Min X	1869	7 DL+LL(FOR BEAMS)	-56.131	-32.679	0.138	64.951	0	0	-0.008
Max Y	1790	12 0.9DL+EQ(X)	304.707	3.322	-10.291	304.898	0	0.001	0
Min Y	1684	7 DL+LL(FOR BEAMS)	-0.729	-122.53	1.562	122.538	0	-0.001	0.002
Max Z	1388	8 DL+EQ(X)	251.505	-24.421	13.512	253.048	0	0.016	-0.004
Min Z	1292	8 DL+EQ(X)	4.68	-0.682	-21.349	21.867	0	0.001	0
Max rX	1666	7 DL+LL(FOR BEAMS)	0.326	-96.906	0.089	96.906	0.015	0	0.001
Min rX	1901	7 DL+LL(FOR BEAMS)	1.003	-73.972	5.241	74.164	-0.025	0	0.001
Max rY	1823	12 0.9DL+EQ(X)	261.634	-18.417	-7.896	262.4	0	0.042	0.004
Min rY	1822	12 0.9DL+EQ(X)	264.185	-18.449	-7.429	264.933	0	-0.041	0.004
Max rZ	1801	7 DL+LL(FOR BEAMS)	-0.057	-25.074	-0.877	25.09	-0.001	-0.007	0.013
Min rZ	1347	12 0.9DL+EQ(X)	82.765	-0.602	-1.877	82.789	0	-0.005	-0.06
Max Rst	1821	12 0.9DL+EQ(X)	363.839	-16.836	-7.639	364.308	0	0	0.005

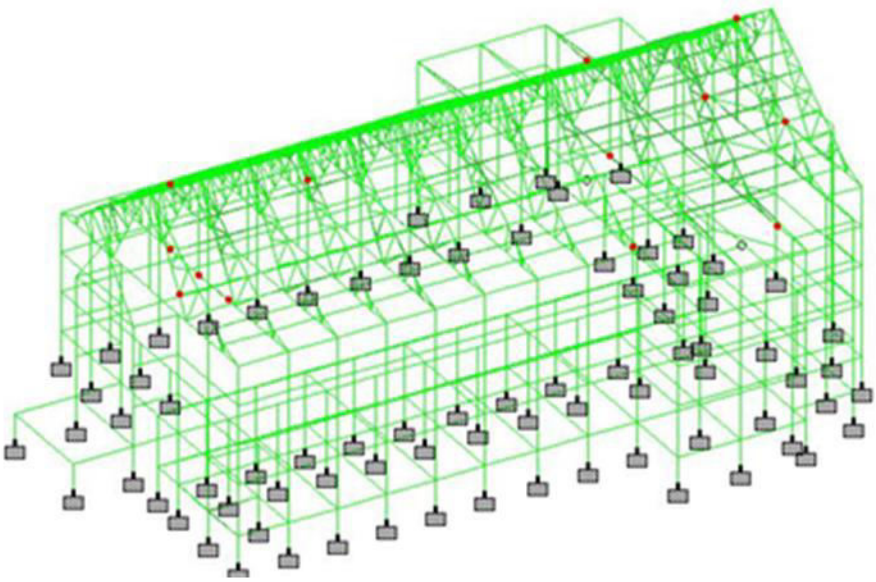

Figure:- 6.7 Node Displacement of Time History Analysis (Northridge)

Table 6.8 Beam End Moment of Time History Analysis (Northridge)

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	1651	8 DL+EQ(X)	908	1330.642	33.883	52.088	-0.347	-53.679	91.96
Min Fx	1546	7 DL+LL(FOR BEAMS)	674	-537.76	80.42	1.905	2.337	1.92	69.174
Max Fy	1833	7 DL+LL(FOR BEAMS)	669	60.717	267.947	1.102	0.321	-4.616	376.671
Min Fy	2517	7 DL+LL(FOR BEAMS)	1233	44.478	-306.85	0.505	0.415	2.624	435.845
Max Fz	1869	12 0.9DL+EQ(X)	977	435.233	31.495	127.249	-12.787	-157.322	46.302
Min Fz	1669	8 DL+EQ(X)	920	738.563	27.148	-444.46	-19.729	486.681	56.731
Max Mx	3609	12 0.9DL+EQ(X)	1772	62.716	-10.99	70.424	87.877	-90.298	-11.767
Min Mx	2707	12 0.9DL+EQ(X)	1334	61.757	2.618	-71.039	-90.037	-16.793	1.733
Max My	1669	8 DL+EQ(X)	920	738.563	27.148	-444.46	-19.729	486.681	56.731
Min My	1669	8 DL+EQ(X)	600	721.598	27.148	-444.46	-19.729	-402.246	2.435
Max Mz	2517	7 DL+LL(FOR BEAMS)	1233	44.478	-306.85	0.505	0.415	2.624	435.845
Min Mz	1522	8 DL+EQ(X)	595	723.112	108.922	31.252	-8.83	56.389	-226.31

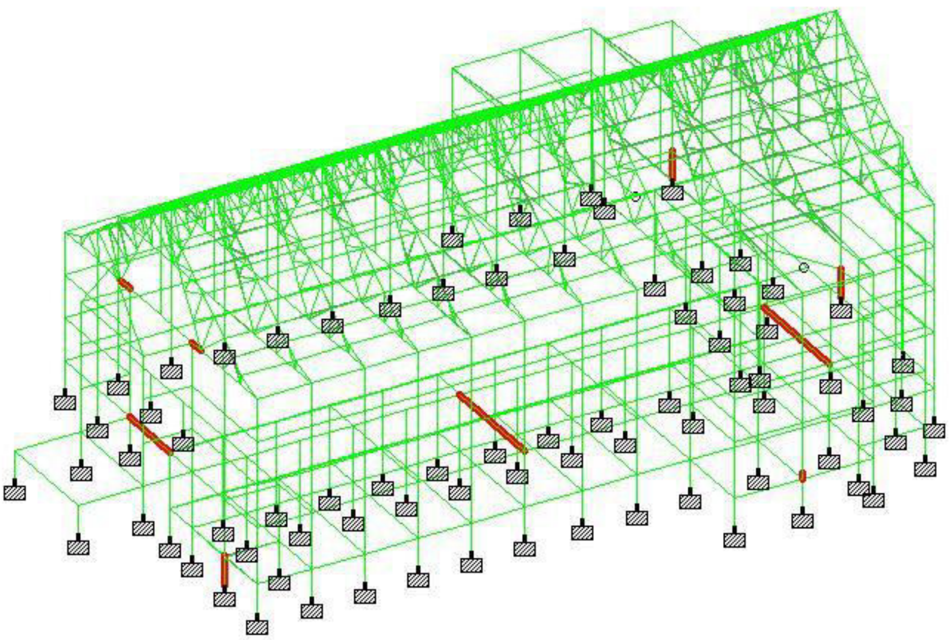

Figure: - 6.8 Beam End Moment of Time History Analysis (Northridge)

CHAPTER 7: EARTHQUAKE PROTECTIVE SYSTEMS

7.1 Passive control system

Passive control system includes turn mass dampers, seismic (base) isolation system, mechanical dissipaters and the like. Those systems have significant application to buildings, bridges and industrial plants. Seismic base isolation is the most develop system at the present time. This basic concept of seismic isolation reduce the response to earthquake motion by

i. Reducing the stiffness
ii. Increasing natural period of system
iii. Provision of increased damping to increase the energy dissipation in the system

7.2 Active protective system

In this system mechanical devices are incorporated into the building, which actively participate in the dynamic behavior of the building in response to the measurement of its behavior during the earthquake round motion. Thus in the system the structure characteristic are modified according to seismic input to the building the goals of active system are to keep forces, displacement and acceleration of structure below specific bounds, in order to reduce the damage in cause of a strong earthquake.

7.3 Hybrid (semi active) protective systems

Hybrid systems are system implying the combine use of passive and active control systems. For example – a base isolated structure is equipped with actuators which actively control the enhancement of its performance.

CHAPTER 8: DESIGNING DETAIL

8.1 Design of Retaining Wall

Following assumptions are made while designing RC Wall:

a. Characteristic Strength of concrete, f_{ck}=25 N/mm^2

b. Yield strength of steel, f_y =415 N/mm^2

c. Coefficient of friction between soil and concrete, μ =0.45

Soil parameters:

a. Safe bearing capacity of soil, q =160 kN/mm^2

b. Unit weight of earthen backfill, γ =18 kN/mm^2

c. Angle of internal friction of soil, ϕ =25°

Height of embankment = 4m

i. Coefficient of active earth pressure (k_a)

$$k_a=(1-\sin\theta)/(1+\sin\theta)$$

$$k_a=0.41$$

ii. Minimum depth of foundation (h_{min})

$$h_{min}=(q_o/\gamma)\ (1-\sin\theta)/(1+\sin\theta)^2$$

$$h_{min}=1.5 \text{ m}$$

Total height of the retaining wall = depth of foundation + height of embankment

$$H = 1.5 + 4 = 5.5 \text{ m}$$

iii. Base Width (b) = 0.4H to 0.6H

= 0.5×5.5=2.75m =2.8m

Length of toe Slab = 0.3b to 0.4b

= 850 mm (say)

Thickness of Base Slab = H/10 =5500/10

= 550 mm

iv. Thichness of Vertical Wall or Stem

Pressure at the base of the stem = $k_a\gamma h$ = 6.351 kN/m^2

Moment at the base of stem = 0.5 $k_a\gamma h$×h×h/3

= 149.18 kNm

Ultimate Moment at the base of stem $= 1.5\times149.18$

$= 223.78$ kNm

v. Minimum depth required for balanced section (d_{reqd}) = 255 mm

($d_{reqd} = \sqrt{M_u/R_u b}$, from Annex G, IS 456: 2000)

Overall depth (D) = d + clear cover

= 255 + 60 = 315 mm

Taking, D = 320 mm (at bottom)

D' = 150 mm (at top)

vi. Forces Acting on Retaining Wall

Table 8.1 Calculation of forces

Types of Forces	Magnitude of Forces (kN)	Position of force from toe end (m)	Bending moment at toe end (kNm)
1.Overturning Force $P_{ah}=0.5K_a\gamma H^2$	111.62	H/3= 1.83m	204.26 kNm
2.Restoring Forces (a) Weight of Backfill (W_1) (b)Weight of Stem (i)Weight of Rectangular portion(W_{21}) (ii)Weight of Triangular Portion (W_{22}) (a)Weight of Base Slab (W_3)	W_1=145.23 W_{21}=10.52 W_{22} =38.5 W_3 =18.36	2.18-(1.63/2)=1.985 1.095 0.96 1.4	288.28 20.32 10.1 53.9
	$\sum W$=212.81 kN		$\sum M_R$=372.6 kNm

Stability Checks

1. Overturning $0.9\ M_R/M_o = 1.64 > 1.4$ Hence OK

2. Sliding $0.9\ F_R/F_S = 0.77 < 1.4$

Hence shear key is to be provided to increase the resistance against sliding.

3. Basic Pressure

Resultant Moment at toe end $= M_R - M_o$

$= 372.6 - 204.26 = 168.34$ kNm

Maximum Pressure at toe end (P_{max}) = 98.81 kN/m^2 < 160 kN/m^2 Hence OK

Minimum Pressure at toe end (P_{min}) = 53.21 kN/m^2 > 160 kN/m^2 Hence OK

vii. Design of Stem

Maximum Moment at the Base Stem = 149.18 kN-m

Area of steel(A_{st}) in Stem = 2935.06 mm^2

Spacing Required (using 16 mm bar) = 70 mm c/c

Distribution Steel =282 mm^2

Spacing Required (using 8mm bar) =180 mm c/c

viii. Check for Shear

Critical section for shear is at a distance d from the base of stem i.e., h = 4.69 m

Shear force at this section (V_u) = 81.165 kN

Nominal Shear Stress = V_u/bd

$\tau_c > \tau_v$ Hence OK

ix. Curtailment of tension reinforcement

$L_d = 0.87\ f_y\ \phi\ /4\tau_{bd}$

$L_d = 645$ mm

Hence no bar can be curtailed upto distance of 645 mm from base of stem. Curtailing bars at a depth of 1000 mm from the base of stem. i.e.,

4950-1000 = 3950 mm from top of stem

So, total depth of section = 150 + (3950×1000)/4950 = 285.66 mm

Taking 286 mm, Effective depth= 286-60 = 226 mm

Moment due to Earth pressure at 3.95 from top, $M_u = k_a \gamma h^3/6$

$M_u = 75.81 \times 1.5$

$M_u = 113.74$ kN-m

Area of Steel (A_{st}) = 1576 mm^2 (Annex G, IS 456: 2000)

Spacing (Using 16 mm bar) = 140 mm

Curtailment of tension reinforcement at 12ϕ (192 mm) or d (226 mm), whichever is maximum.

So, providing curtailment at 1250 mm from the base of stem.

Similarly, one more curtailment is provided at 1.7m from the top of stem.

Moment at this section = $K_a\gamma h^3/6$

$M_u = 6.043 \times 1.5$

$= 9.064$ kN-m

Depth at this Section = 150 + (320-150)×3250/4950

= 260 mm

Now

Area of Steel (A_{st}) = 126.96 mm^2 (Annex G, IS 456: 2000)

Minimum area of steel ($A_{st\ min}$) = 320 mm^2 (Clause 26.5.2.1, IS 456: 2000)

Since, $A_{st} < A_{st\ Min}$, ∴ Provide $A_{st\ Min}$.

Providing spacing @ 280 mm of base at 1.7 m from top of Stem.

x. Design of heel slab

Total load = Self wt. of heel slab + Wt. of earth supported on heel slab

=(0.55×1×25) + 89.1

=102.85 kN/m

Maximum Bending Moment= 56.18 kN-m

Ultimate Banding Moment = 84.27 kN-m

d_{req}=156.31mm < 490mm Hence OK

Area of Steel for heel Slab

Area of Steel = 393.36 mm^2 < $A_{st\ min}$ (Annex G, IS 456: 2000)

Spacing (Using 16 mm bar) = 170 mm c/c

Spacing (Using 10 mm Bar) = 120 mm c/c

xi. Design of toe slab

Maximum Bending Moment = 34.029 kN-m

Ultimate Banding Moment = 51.04 kN-m

Area of Steel for toe Slab

Area of Steel = 291.524 mm^2 < $A_{st\,min}$ (660 mm^2) (Annex G, IS 456: 2000)

Spacing (Using 10 mm Bar) = 100 mm c/c

xii. Design of shear key

Pressure at face of shear key = 84.97 kN/m

Passive earth Pressure (k_p) = (1-sinθ)/(1+sinθ) = 2.46

Let the depth of key = a

Resistance offered by shearkey (P_p) = 209.05 a

Factor of safety along with shearkey = 0.335 m (Provide 350 mm)

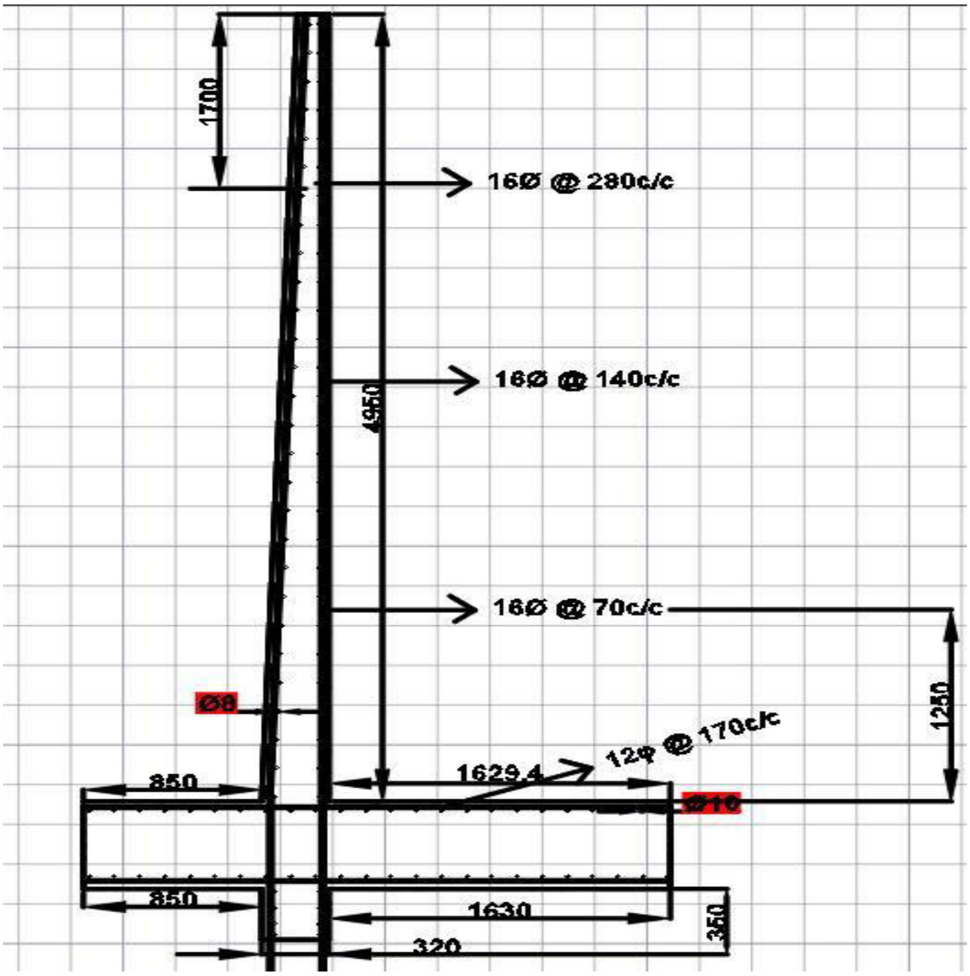

Figure 8.1 Retaining wall cross section

8.2 Design of Slab

i. Design Data

Effective span in x direction, Lx = 3.8 m

Effective span in y direction, Ly = 8.0 m

Since Ly/Lx > 2, Hence it is one way slab. (Annex D, IS 456 : 2000)

Assumption of slab thickness l/d = 26 (Clause 23.2.1, IS 456 : 2000)

Effective depth, d = l/26 = 3300/26 = 126.923 mm

So, take d = 130 mm

Assuming total depth, D = 130 + 30 = 160 mm

ii. Effective Span

W(Width of Support) = 500 mm

$L_o/12$ = 3300/12 = 275 mm

W > $L_o/12$, Hence effective span = 3300mm (Clause 22.2, IS 465: 2000)

Maximum positive Bending moment = 14.43 kN-m (Table 12, IS 465: 2000)

Maximum negative Bending moment = 16.88 kN-m (Table 12, IS 465: 2000)

iii. Check for thickness for slab

Minimum depth required d_{min} = 75 mm (d_{reqd} = $\sqrt{M_u/R_u b}$, from Annex G, IS 456: 2000)

Area of Steel for +ve BM = 320mm^2 < $A_{st\ min}$ (192mm^2)

Spacing (Using 8 mm bar) = 150 mm c/c

Area of Steel for -ve BM = 380mm^2 < $A_{st\ min}$ (192mm^2)

Spacing (Using 8 mm bar) = 130 mm c/c

Distribution Steel =192 mm^2 (Clause 26.5.2.1, IS 456: 2000)

Spacing Required (using 8mm bar) =250 mm c/c

iv. Check for Shear

At End Support :

Shear (V_u)= 20.543 kN (Table 13, IS 465: 2000)

Nominal Shear Stress = V_u/bd

$\tau_c > \tau_v$, Hence OK

At Continuous Support

Shear (V_u)= 30.00 kN

Nominal Shear Stress = V_u/bd

At Continuous Support P_t% = 0.29 %

Now, τ_c = 0.39 N/mm^2 (Table 19, IS 465: 2000)

And k×τ_c = 1.27×0.39 = 0.49 N/mm^2 (Cl. 40.2.1.1, IS 465: 2000)

Hence, $\tau_c > \tau_v$. So, section is safe.

v. Check for Development length (L_d)

a) At simple support :

L_d < 1.3 M_u/V + l_o (Cl. 26.2.3.3, IS 465: 2000)

L_d = 0.87 $f_y\phi/T_{bd}$ (Cl. 26.2.1.1, IS 465: 2000)

=300.785 mm

l_o = 64 mm (Cl. 26.2.3.3, IS 465: 2000)

M_u= 6.279 kN-m

V_u= 20.543 kN

So M_u /V_u = 305.65 mm

And we get L_d is less than 1.3 M_u /V_u + l_o. Hence OK

b) At point of inflection :

M_u /V_u = 209.3 mm

L_o is maximum of 12 ϕ = 96 mm or (Cl. 26.2.3.3, IS 465: 2000)

d = 130 mm

So, (M_u /V_u) + L_o > L_d , Hence Safe

vi. Check Against Deflection

L/d = 26 (Clause 23.2.1, IS 456 : 2000)

P_t = 0.26 %

F_s = 0.58 × 415× 318.38/335.103 = 228.69 N/mm^2

Modification Factor (k) =1.35 (Fig 4, IS 456 : 2000)

Span/Depth = 26× 1.35 = 35.1

And adopted ratio is 26.

Hence it is adequate.

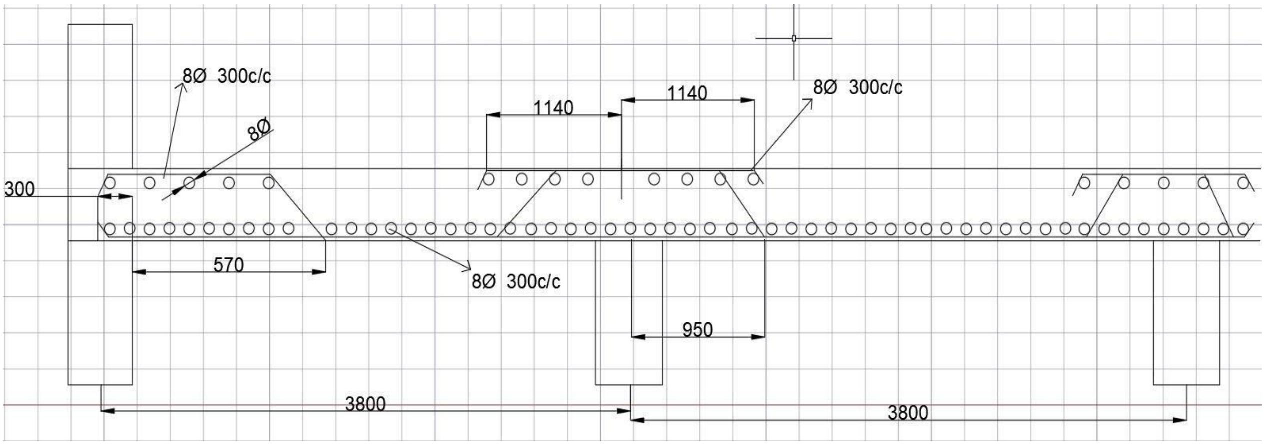

Figure 8.2 RCC Detailing of continuous slab

8.3 Column Design

8.3.1 Intermediate column no. 1067

Column Dimensions are as follows :

Width of Column, B = 300 mm

Depth of Column, D = 600 mm

Characteristic Strength of Concrete = M35

Yield Strength of Steel = Fe415

Load Data form Staad.Pro file is as follows

F_x = 823 kN

M_{uz} =132.5 kN-m

i. Designing it as Uniaxial bending

P_u= 823 kN

M_u=133 kN-m

d'/D =50/600 = 0.083~ 0.1

ii. Reinforcement distributed on two faces

Now, $P_u/f_{ck}bD$= 0.13

And, $M_u/f_{ck}bD^2$=0.035

So, p/f_{ck}= 0.02 (Using Chart No.32 from SP-16: 1980)

P=0.02×35 = 0.7%

But minimum cross sectional area of longitudinal reinforcement is 0.8% of gross croess sectional area of column (Cl. 26.5.3.1, IS 456: 2000)

So, A_{sc}= 0.8×600×300/100= 1440 mm^2

Provide 6 bars of 20ϕ diameter

iii. Design of Lateral ties (Cl. 26.5.3.2, IS 456: 2000)

Providing 8mm Dia

Spacing should be less than the least of 300mm or 15×28 or 300 mm

Hence, providing 250 mm c/c Spacing

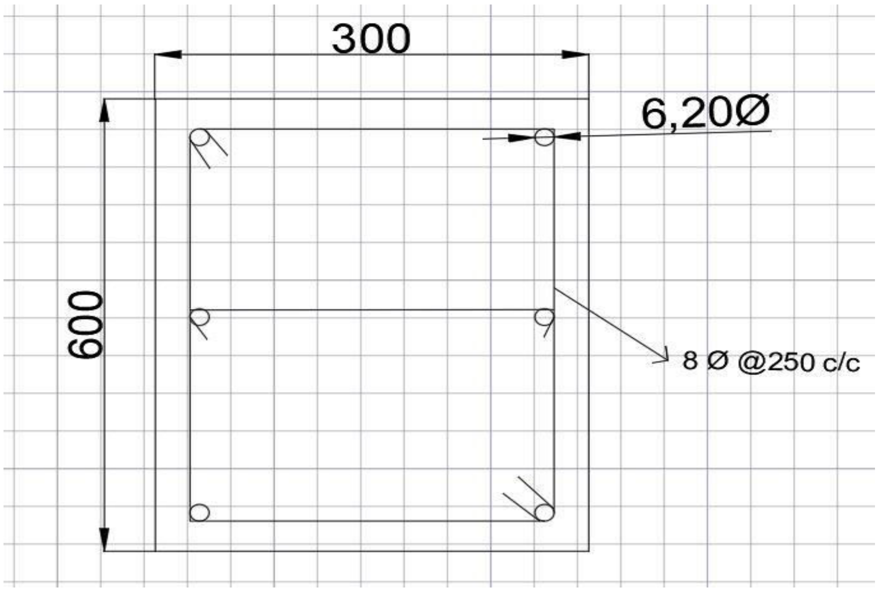

Figure 8.3 Cross section of column

8.4 Beam Design

8.4.1 Intermediate beam no. 1833

Length of beam = 8m

Cross section = 300 mm x 600 mm

Characteristic Strength of concrete = M30

Yield Strength of steel = Fe415

i. Data from Staad.Pro

Mz = 376.710 kNm

Assume 25 mm bars with 25 mm cover

$d = 600 - 12.5 - 25 = 562.5$ mm = 563 mm

$M_{ulim} = 4.14 \times 300 \times 563^2 = 393.675$ kNm

Hence the section is under reinforced

$A_{st} = 0.5 \times (f_{ck}/f_y) \times [1 - \sqrt{\{1 - 4.6\ M_u / f_{ck}bd^2\ \}}] \times bd$ (1) (Annex G, IS 456: 2000)

$A_{st} = 2280\ mm^2$

Hence provide 6-25mmØ

$p_t = 1.36\%$

Assume space between bars as 20 mm and cover 25mm

So, effective depth = 600 – 25 – 20 – 10.5 = 545 mm

Using (1)

$M_u = 380.2$ kNm > M_z (hence OK)

$p_{tmin} = 0.24\sqrt{f_{ck}}/f_y = 0.316\%$ (Cl. 6.2.1, IS 13920: 1993)

$p_{tmax} = 2.5\%$

ii. Design for Shear reinforcement

Tributary area for beam is given by yield line theory

A= 0.5 x (0.9+8.0) x 3.6 x 2.0 = 32.04 m^2

Slab weight on beam = 32.04 x 6 = 192.24 kN (Dead weight of slab = 6 kN/m^2)

Weight per meter length = (192.24/8) = 24.03 kN/m

Self weight of beam = 25 x 0.3 x (0.6 – 0.12) = 3.6 kN/m

Weight of walls on beam = 18.4 kN/m

Total Weight = 46.03 kN/m

Live load = 3 kN/m^2 (IS 875(Part2))

So total live load = 32.04 x 3 = 96.12 kN

Live load per meter length = 96.12/8 = 12.015 kN

iii. Ductility Considerations

As per Clause 6.3 of IS 13920: 1993

a) $V_a^{D+L} = 1.2 \times (46.03+12.015) \times 8/2 = 278.616$ kN

b) On the basis of Sway Analysis

Sway to right

$V_{ua} = 212.69$ kN (Clause 6.3.3, IS 13920: 1993)

V_{ub} = 344.54 kN

Sway to left

V_{ua} = 340.57 kN

V_{ub} = 216.66 kN

So, the design shear force V = 344.54 kN (Maximum)

As p_t = 1.36% and concrete grade is M30, Using table 19 of IS 456:2000

T = 0.73 N/mm^2

$V_c = \tau_c$ x b x d = 119.36 kN

$V_{us} = V_u - V_c$ = 344.54 – 119.36 = 225.18 kN

Hence provide 10 mm ø 2 – legged vertical stirrups

Hence A_{sv} = 100.5 mm^2

Spacing S_{max} should not be greater than the minimum of following (Clause 6.3.5,IS 13920: 1993)

d/4 = 545/4 = 137 mm

8 x d_{min} = 8 x 22 = 176 mm

0.87 x f_y x A_{sv} x d/ V_{us} = 138 mm

Hence provide spacing of 120 mm upto 2d from the support

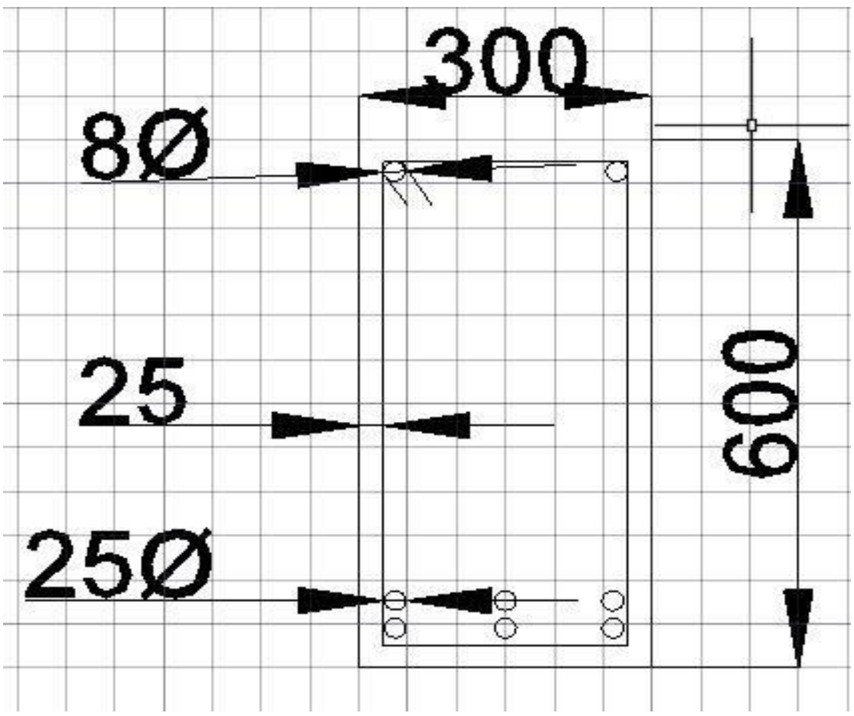

Figure 8.4 Cross section of beam

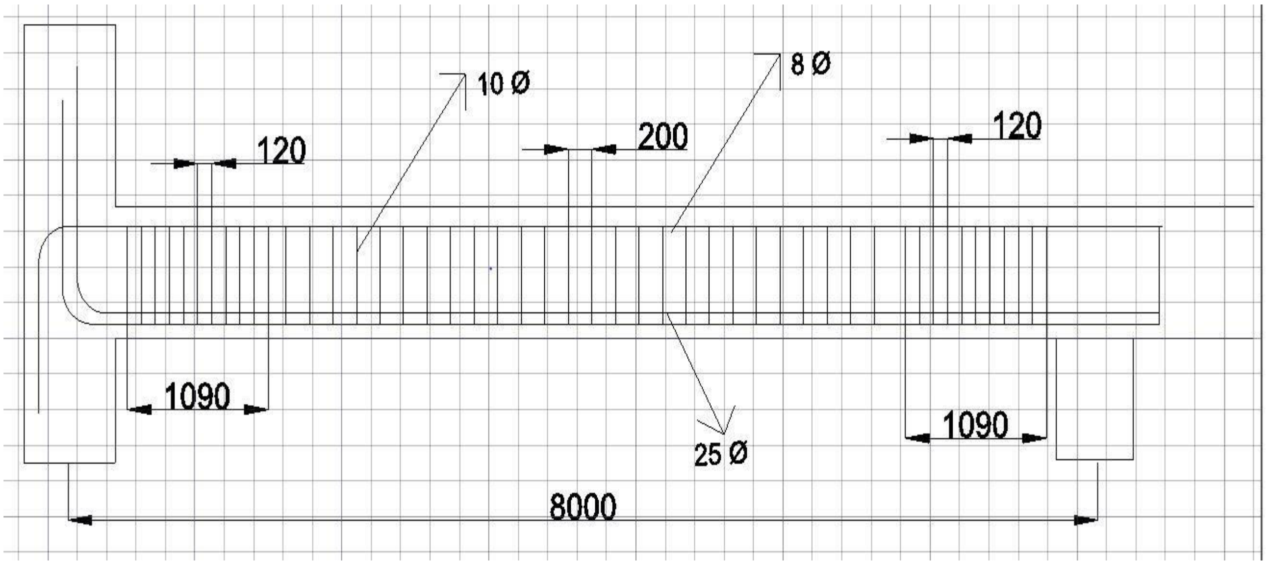

Figure 8.5 Side view of beam

8.5. Design of Exterior Column

i. Column dimensions : 500 mm x 600 mm

Length of column = 4 m

Strength of concrete = M35

Strength of steel = Fe415

Data from Staad.Pro file

Axial load, P_u = 916.097 kN

Major axis BM, M_{uy} = 221.005 kNm

Minor axis BM, M_{uz} = 31.931 kNm

Assuming p = 1%, p/f_{ck} = 0.03, d'/D = 50/600 = 0.1

Using SP-16 :1980, Chart 44, $M_u/f_{ck}bD^2 = 0.07$

$M_{uy1} = 0.07 \times 35 \times 500 \times 600^2 = 441$ kNm

$M_{uz1} = 0.07 \times 35 \times 600 \times 500^2 = 367.5$ kNm

Using SP-16 :1980, Chart 63, Puz/Ag = 19 corresponding to p = 1%,

Puz = 5700 kN

Now, $P_u/P_{uz} = 0.16$

$M_{uy}/M_{uy1} = 0.501$

$M_{uz}/M_{uz1} = 0.10$

Using SP-16 :1980, Chart 64

$(M_{uy}/M_{uy1})_{permissible} = 0.9 > (M_{uy}/M_{uy1})$

Hence design is OK

A_{sc} = 0.01 x 500 x 600 = 3000 mm^2

Hence provide 6-25mmØ and 4-16mmØ bars (A_{sc} = 3085.4 mm^2)

ii. Check of Earthquake in X-Direction

Minimum eccentricity, e = L/500 + (BorD)/30 (Clause 25.4, IS 456 - 2000)

∴ e_z = 28 mm, e_y = 24.67 mm

So, $M_{uz} = Pe_y$ = 22.91 kNm

Also, $P_{uz} = 0.45f_{ck}A_c + 0.75f_yA_{sc}$ (Clause 39.3, IS 456 - 2000)

∴ P_{uz} = 5636.63 kN

P_u/P_{uz} = 916.067/5636.63 = 0.16(~0.2) ϵ (0.2,0.8)

From Clause 39.6, IS 456 – 2000,

$$\left[\frac{M_{ux}}{M_{ux1}}\right]^{\alpha_n} + \left[\frac{M_{uy}}{M_{uy1}}\right]^{\alpha_n} \leq 1.0 \qquad (2)$$

(221.005/441) + (22.91/367.5) = 0.56 < 1.0 (α = 1)

Hence the section is safe

iii. Check of Earthquake in Y-Direction

$M_{uy} = Pe_z$ = 25.65 kNm

Using (2), (25.65/441) + (31.931/367.5) = 0.145 < 1.0 (α = 1)

Hence the section is safe

iv. Shear reinforcement requirement

From Staad.Pro file

Hence the section is safe

Shear force, V_u = 55.361 kN

And from analysis of beam no. 1586, V_u = 78.07 kN

$V_c = \tau_c$ x b x d = 119.36 kN

And τ_c = 0.67 x δ = 0.88 N/mm^2 (Table 19, IS 456:2000, $\delta = 1 + (3P_u/A_gf_{ck}) < 1.5$)

v. Lateral ties

The diameter of the lateral ties should be more than (Cl. 26.5.3.2, IS 456: 2000)

22/4 = 11 mm, or

6 mm

Hence provide 8 mm diameter ties

vi. Pitch of lateral ties (Cl. 26.5.3.2, IS 456: 2000)

It should not be more than the least of the following distances

Least lateral dimension = 500 mm

16Ø = 256 mm

300 mm

Hence provide #8mmØ lateral ties @ 250 mm c/c

vii. Ductility Considerations

Special confining reinforcement shall be provided over a length l_o from each joint face towards the mid span

l_o should not be less than (Clause 7.4, IS 13920: 1993)

depth of member = 600 mm

1/6 of clear span = (3.55/6) x 10^3 = 592 mm

450 mm

Spacing of hoops provided as the confining reinforcement shall not exceed of the following (Clause 7.4, IS 13920: 1993)

1/4 of minimum member dimension = 0.25 x 500 = 125 mm

Not less than 75 mm

Not greater than 100 mm

∴ Take it as 100 mm

viii. Minimum area of cross section of the bar forming the hoop is

$A_{sh} = 0.18Shf_{ck}/f_y(A_g/A_k - 1)$

$A_{sh} = 0.18 \times 75 \times 180.67 \times 35/415 \times ((600 \times 500) / (436 \times 536)) - 1)$

$A_{sh} = 60\ mm^2$

Use 8 mmØ bar (50.26 mm^2) at a spacing of 90 mm c/c.

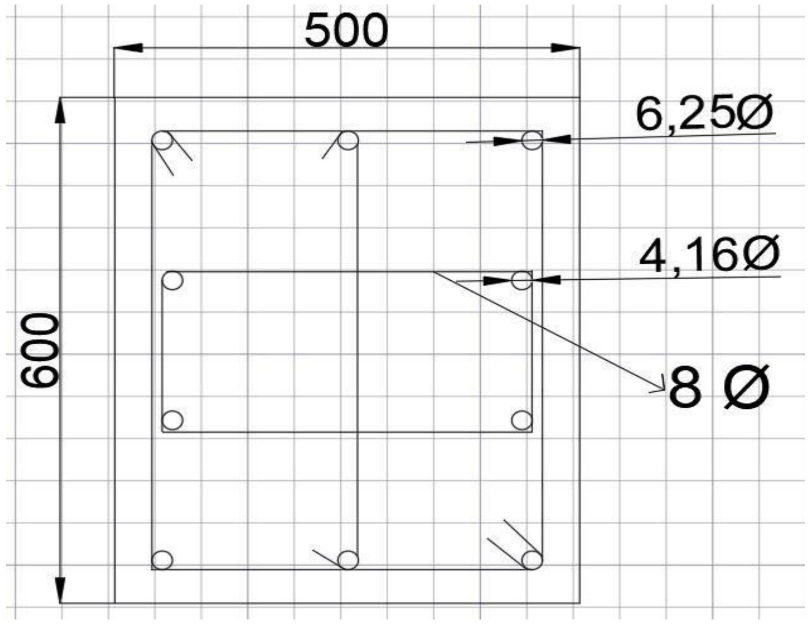

Figure 8.6 Cross section of column

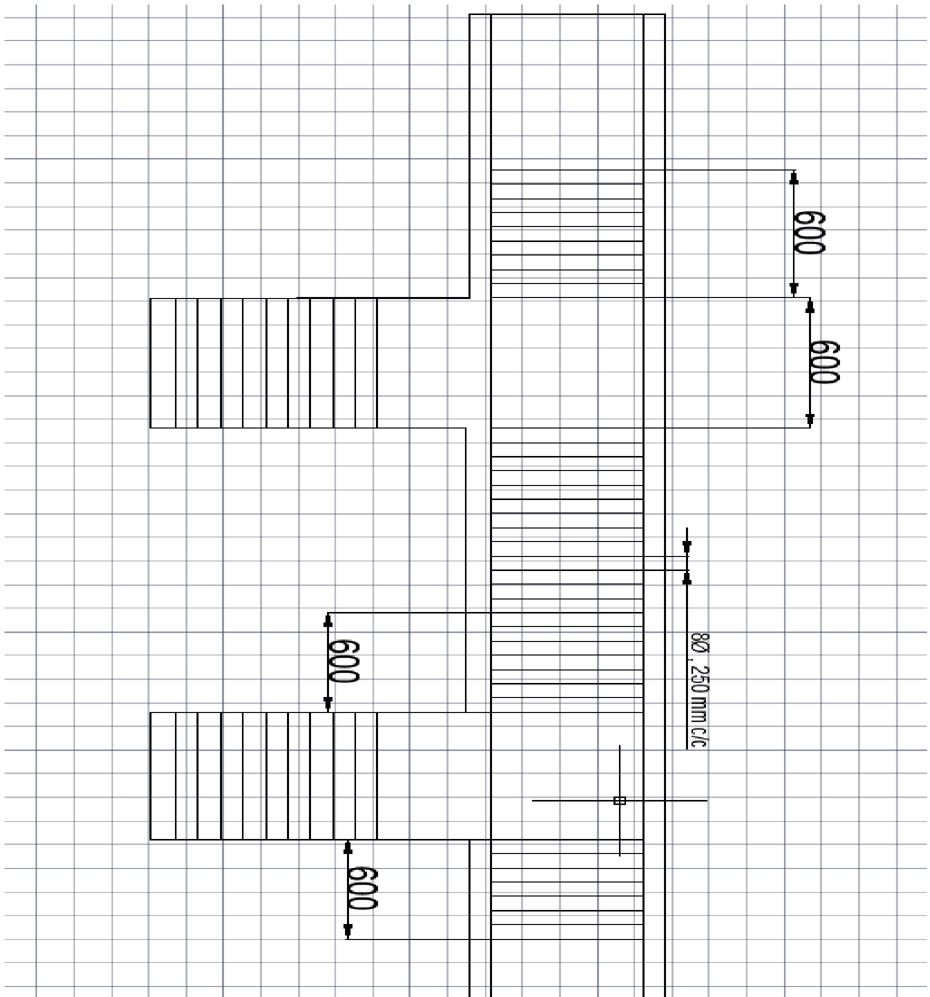

Figure 8.7 Elevation of column

8.6. Design of Combined footing

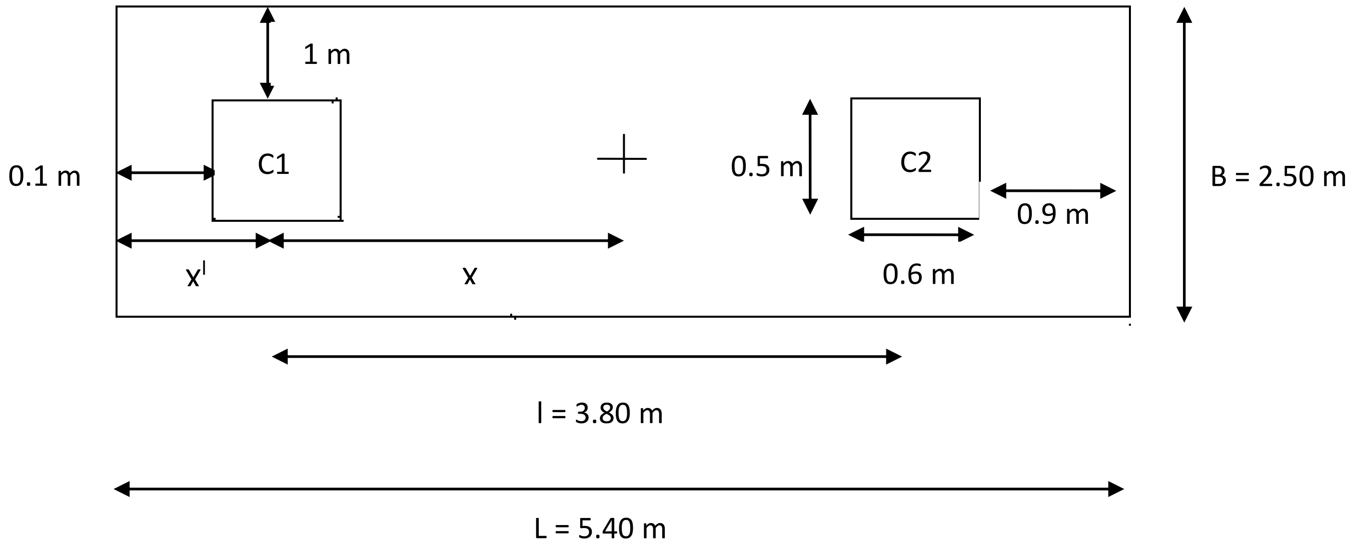

Figure 8.8 Layout of combined footing

Design of Combined Footing

Column Size C1 : 600 mm x 500 mm

C2 : 600 mm x 500 mm

Data from Staad.Pro file

Axial load from Column (C1), P_1 = 768.87 kN

Axial load from Column (C1), P_1 = 1184.077 kN

Mix Design of concrete = M20

Strength of Steel = Fe 415

Bearing capacity of soil, q = 160 kN/m^2

Distance of resultant load from column C1 : x = (P_2 x l) / (P_1 + P_2)

= 2.3 m

Also, Length of the footing, L = 2 (x^1 + x)

= 5.40 m

Total column load = 1952.947 kN

Assuming self weight of footing as 10% of total weight = 195.29 kN

Total load, P = 2148.24 kN

Area of footing, A = P/q = 13.43 m^2

Width of footing, B = A/L = 2.50 m

Upward soil pressure = P / (L x B) = 159.13 kN/m^2

Upward pressure per unit length = 159.13 x 2.5 = 398 kN/m

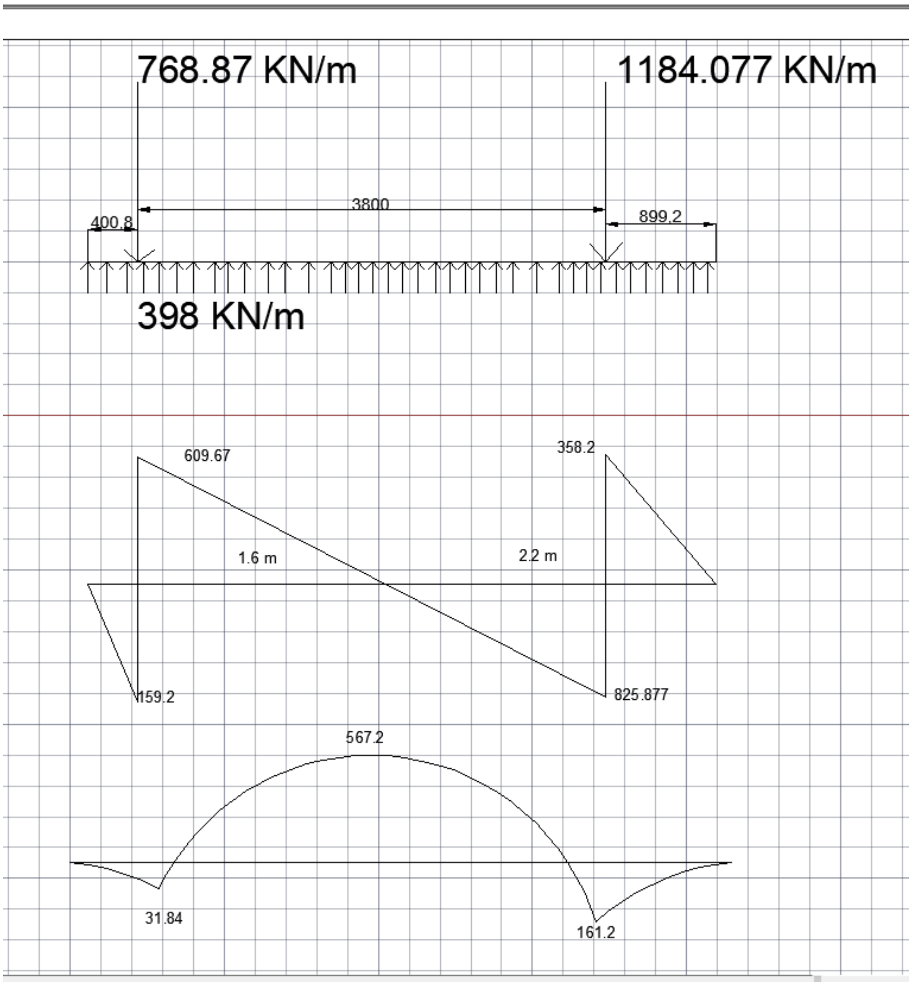

Figure 8.9 Calculation of maximum bending moment and shear force

From BMD, it is clear that M_u = 567.216 kNm

Depth of footing :

From BM consideration :

Depth required d_{reqd} = 300 mm

(using formula $= \sqrt{(M_u / R_u b)}$ and $R_u = 0.36 f_{ck} x_{ulim}/d(1-0.42 x_{ulim}/d)$)

One way shear at column C2 (heavier load)

Shear at a distance d from face of column :

$Vu = [825.877 – 398 \times (0.3 + (d/1000))] \times 10^3$ N

Asume $p_t = 0.2\%$, So $\tau_c = 0.32$ N/mm^2 (Table19, IS 456:2000)

$V_u / (B \times d) < 0.32$

d > 589.71 mm

Adopt effective depth, d = 590 mm

Overall depth, D = 640 mm

Check for two way shear

The critical section is at a distance of d/2 from the face of column

Area resisting punching shear, $A_o = b_o.d = 4 \times (600 + 590) \times 590$

Shear force at d/2

$V_u = 1184.077 – 159.13 \times (0.6 + 0.59)^2 = 958.738$ kN

$\tau_v = A_o/ V_u = 0.34$ N/mm^2

And $\tau_c = 0.25\, f_{ck} = 1.11$ N/mm^2

$\tau_c > \tau_v$, Hence safe.

Column C1

Here, $b_o = 2(600+590) + 2(600+(590/2)+100) = 4370$ mm

$V_u = 768.87 – [159.13 \times (0.6+0.59) \times (0.6+(0.59/2)+0.1)] = 580.45$ kN

$\tau_v = (580.45 \times 10^3) / (4370 \times 590) = 0.225$ N/mm^2 $< \tau_c$ (Hence safe)

Longitudinal Reinforcement

Negative Moment Reinforcement

$M_u = 567.216$ kNm

$M_u = 0.87 \times f_y A_{st} d(1-(A_{st} f_y/f_{ck} bd))$ (1)

$A_{st} = 2662.92$ mm^2

Choosing ø20 mm diameter bars

Spacing required = (254.47 x 2500) / 2663 = 260 mm c/c

Hence provide #20 mmØ @ 260 mm c/c or 11 number of bars at top near the mid span

Development length for 20 mm bars (L_d) = $0.87f_y ø/4\tau_{bd}$ = 846.21 mm

Out of these 11 bars, 5 bars can be curtailed after the outer edge of each column

A_{stmin} = 0.12 x 2500 x 640 / 100 = 1920 mm^2

Positive moment reinforcement

M_u = 161.99 kNm

Using (1)

A_{st} = 768.8 mm^2 < A_{stmin}

Provide 16 mm diameter bars

Spacing required = 201.06 x 2500 / 1920 = 261.72 mm

Provide #16 mmØ @ 250 mm c/c or 10 bars at bottom under each column and out of these 5 bars can be curtailed at a distance of 850 mm (~L_d) from inside edge of column.

Transverse reinforcement:

The transverse reinforcement is provided under each column within a band having a width equal to the width of the column plus two times the effective depth of the foundation

Bandwidth for column C1 = 0.5+0.59+0.1 = 1.29 m (On the outer side only 0.1m is available)

Upward pressure under C1 = 768.8/2.5 = 307.548 kN/m

BM at face of column = 307.548 x $1^2/2$ = 153.77 kNm

Area of steel required

$154 \times 10^6 = 0.87 \times 415 \times Ast \times 564 \times (1 - ((415 \times Ast) / (20 \times 1290 \times 564)))$

A_{st} = 771.859 mm^2

Also A_{stmin} = 0.12 x 1290 x 640/1000 = 1000 mm^2

Hence provide 16 mm diameter bars @ 240 mm c/c in the width 1.29 m

Transverse Reinforcement

Column C2

Bandwidth = 0.5+0.64+0.64 = 1.78 m

Upward pressure = 1184.07/2.5 = 473.63 kN/m

Negative moment at face of the column C2 = 473.63 x $1^2/2$ = 236.814 kNm

A_{stmin} = 0.12 x 1780 x 640/100 = 1370 mm^2

Spacing required = 201 x 1780/1370 = 260 mm

Hence provide #16 mmØ @ 240 mm c/c in the width 1.78 m and #16 mmØ @ 300 mm c/c in the middle portion.

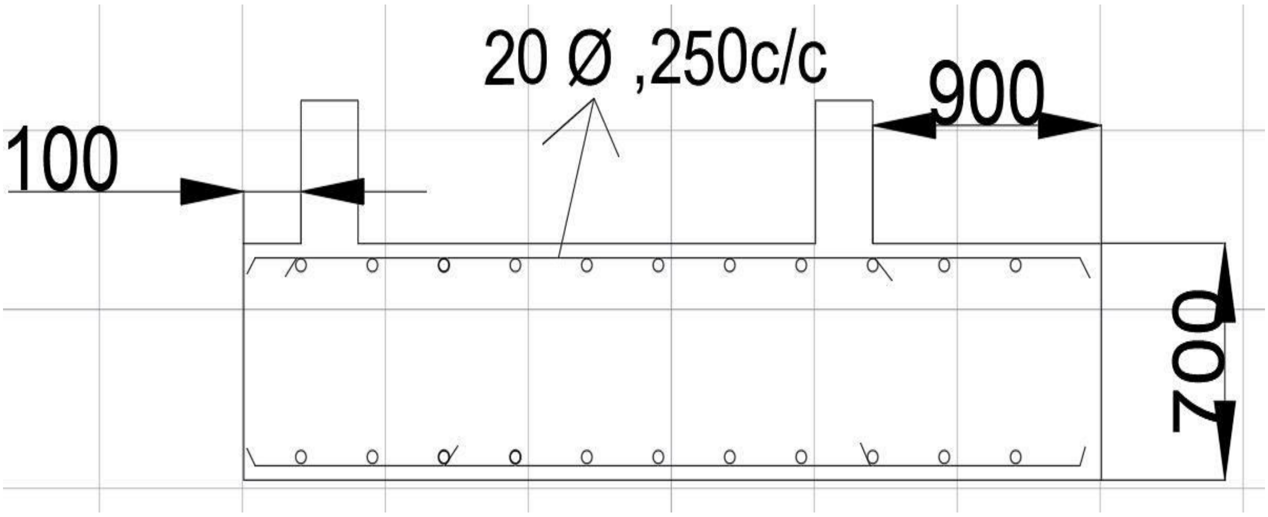

Figure 8.10 Front view of Footing

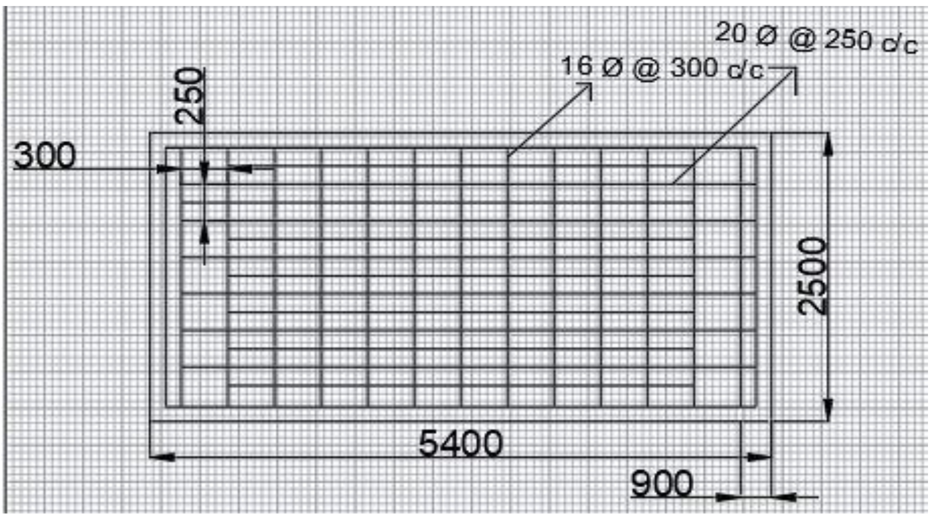

Figure 8.11 Plan of Top reinforcement

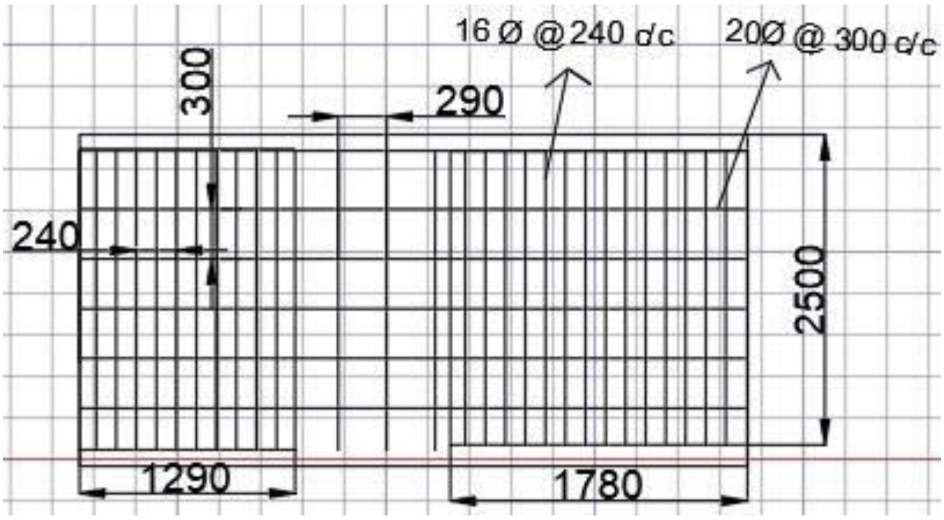

Figure 8.12 Plan of Bottom reinforcement

8.7. Conclusion:

The building is fully analyzed for seismic loads by preliminary and detailed evaluation procedure. As per the preliminary evaluation of building, the building seems sufficient for earthquakes but this criteria is not enough to conclude any building for its behavior in seismic conditions. Check needs to be done by designing and analysis in order to reach to a concrete conclusion.

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APPENDIX – A

Source code of STAAD.Pro of the Building

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STAAD SPACE
START JOB INFORMATION
ENGINEER DATE 14-Sep-17
END JOB INFORMATION
INPUT WIDTH 79
UNIT METER KN
JOINT COORDINATES
465 30.7 29.26 2; 466 35.5 29.26 2; 467 40.55 29.26 2; 564 3.8 27.26 31.26;
565 7.6 27.26 31.26; 566 11.4 27.26 31.26; 567 15.2 27.26 31.26;
568 19 27.26 31.26; 569 23.1 27.26 31.26; 570 26.9 27.26 31.26;
571 30.7 27.26 31.26; 572 35.5 27.26 31.26; 573 45.28 27.26 31.26;
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595 35.5 27.26 36.76; 596 40.55 27.26 36.76; 597 45.28 27.26 34.985;
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4246 624 1632; 4247 1630 649; 4248 667 677; 4249 669 679; 4250 671 681;
4251 673 683; 4255 1322 1321; 4256 1321 664;
ELEMENT INCIDENCES SHELL
4252 627 674 602 599; 4253 615 1096 685 613; 4254 615 1096 674 602;
START GROUP DEFINITION
MEMBER
_BOUNDRY 1360 1363 TO 1370 1464 1848 1850 1855 2041 2138 2706 TO 2708 2734 -
2750 2768 2770 2772 2776 2801 2817 2835 2837 2839 2843 2868 2884 2902 2904 -
2906 2910 2935 2951 2976 2978 2980 2984 3009 3025 3043 3045 3047 3051 3076 -
3092 3110 3112 3114 3118 3143 3159 3177 3179 3181 3185 3210 3226 3244 3246 -
3248 3252 3277 3293 3309 3315 3317 3319 3323 3348 3364 3386 3388 3390 3394 -
3419 3435 3524 3526 3528 3532 3557 3573 3599 TO 3609 3614 3633 3636 3641 -
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4152 4153 4155 4156 4158 4159 4161 4162 4164 4165 4167 4168 4170 4171 4173 -
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4197 4198 4200 4201 4203 4204 4206 4207 4209 4210 4212 4213
_COLUMN(TOP) 1105 TO 1107 1109 TO 1116 1118 TO 1120 1122 1124 1126 1129 1132 -
1133 1136 1137 1139 TO 1146 1148 TO 1154 2532 2534 2536 2538 2540 2542 2544 -
2546 2548 2549 2552 2554 2576 2577 2580 2582 2588 2594 2602 TO 2604 2606 -
2608 2610 2612 2614 2616 2618 2620 2621 2623 2625 2627 2629 2631 2633 2637 -
2639 2640 2642 2649 TO 2656 2663 2665 2666 2672 2677 2688 2695 2696 2698 -
2700 2701 3613 3616 TO 3628 3635 3638 3647 TO 3649 3657 3658 3901 -
4227 TO 4229 4236 TO 4238 4246 4247
_COLUMN(BOTTOM) 1050 TO 1073 1076 TO 1083 1086 TO 1104 1489 TO 1498 1500 1502 -
1504 TO 1514 1516 TO 1528 1530 TO 1542 1602 1604 1606 1608 1610 1612 1614 -
1616 1618 1620 1622 1625 1627 1629 1631 1633 1635 1637 1639 1641 1643 1645 -
1647 1649 1651 1653 1655 TO 1657 1659 TO 1663 1665 1667 1669 1671 1673 1675 -
1677 1679 1681 1683 1685 1687 1689 1691 1693 1695 1697 1699 1700 -
1856 TO 1874 2043 2177 2178 2511 TO 2514 2520 TO 2523 4226
_FAILEDCOLUMNS 1136 1139 1141 1143 1145 1146 1151 1152 1869 2576 2577 2650 2677
_FAILED2 1141 1143 1145
_CF3 1667 1671 1673 1693 1695 1697 1699 1872 1873
GEOMETRY
FLOOR
_SLAB(2KN) 1575 TO 1581 1583 2148 2516 4137 4241

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_SLAB(5KN) 1569 TO 1574 1592 1593 1836 1837 2044 2165 2166 2517 3895 TO 3897 -
4130 TO 4139
_SLAB(4KN) 1543 TO 1545 1549 1550 1583 TO 1591 1594 TO 1601 1832 TO 1835 2045 -
2149 2150 2167 TO 2176 2515 2517 2518 4134 4138 4139 4241 4248 TO 4251
_SLAB 1543 TO 1545 1549 1550 1569 TO 1581 1583 TO 1601 1832 TO 1837 2044 2045 -
2148 TO 2150 2165 TO 2176 2515 TO 2518 3895 TO 3897 4130 TO 4139 4241 4248 -
4249 TO 4251
JOINT
END GROUP DEFINITION
UNIT MMS NEWTON
ELEMENT PROPERTY
4252 TO 4254 THICKNESS 200
UNIT METER KN
DEFINE MATERIAL START
ISOTROPIC CONCRETE
E 2.17185e+007
POISSON 0.17
DENSITY 23.5616
ALPHA 1e-005
DAMP 0.05
TYPE CONCRETE
STRENGTH FCU 27579
ISOTROPIC STEEL
E 2.05e+008
POISSON 0.3
DENSITY 76.8195
ALPHA 1.2e-005
DAMP 0.03
TYPE STEEL
STRENGTH FY 253200 FU 407800 RY 1.5 RT 1.2
END DEFINE MATERIAL
MEMBER PROPERTY INDIAN
1052 TO 1054 1056 1058 1060 1063 TO 1065 1067 TO 1073 1076 TO 1083 -
1086 TO 1104 1106 1107 1109 TO 1116 1118 TO 1120 1122 1124 1126 1129 1132 -
1133 1137 1140 1142 1144 1148 TO 1150 1153 1154 1490 1492 1494 1497 TO 1500 -
1502 1504 TO 1514 1516 TO 1520 1523 TO 1526 1528 1530 TO 1542 1602 1606 1610 -
1614 1620 1622 1625 1627 1629 1631 1633 1635 1637 1639 1641 1643 1645 1647 -
1649 1651 1653 1655 TO 1657 1659 1662 1663 1665 1667 1671 1673 1675 1677 -
1679 1681 1683 1685 1687 1689 1691 1693 1695 1697 1699 1700 1856 TO 1865 -
1867 1868 1870 TO 1874 2043 2511 TO 2514 2520 TO 2523 2532 2536 2540 2544 -
2552 2554 2582 2588 2594 2602 TO 2604 2606 2608 2610 2612 2614 2616 2618 -
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2663 2665 2666 2672 2688 2695 2696 2698 2700 2701 3613 3617 3619 3621 3623 -
3626 TO 3628 3635 3638 3647 3649 3657 3658 3901 4226 TO 4229 4236 TO 4238 -
4246 4247 4255 4256 PRIS YD 0.6 ZD 0.3
2177 2178 PRIS YD 0.4 ZD 0.4
MEMBER PROPERTY INDIAN
1155 1167 1315 1452 1477 2155 2158 2161 2162 2179 2705 2706 2709 TO 2716 2718 -
2719 TO 2722 2724 TO 2733 2735 TO 2749 2751 TO 2763 2765 TO 2773 2776 TO 2784 -
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3128 TO 3146 3148 TO 3172 3174 TO 3182 3185 TO 3193 3195 TO 3213 -
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3659 TO 3669 3681 TO 3691 3715 TO 3725 3738 TO 3748 3761 TO 3771 -
3784 TO 3794 3807 TO 3817 3873 TO 3883 3900 3957 TO 4058 4061 TO 4075 4077 -
4078 TO 4095 4097 TO 4129 4143 TO 4214 4223 4242 4243 TABLE ST TUB1001006
MEMBER PROPERTY INDIAN
1360 1363 TO 1370 1464 1543 TO 1564 1567 1569 TO 1601 1701 1703 1705 1707 -
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2038 2041 2044 TO 2046 2133 2138 2146 TO 2150 2165 TO 2176 2505 TO 2510 2515 -
2516 TO 2518 2707 2708 2734 2750 3524 3526 3528 3599 TO 3609 3614 3636 3639 -
3640 3643 TO 3645 3651 3653 TO 3656 3895 TO 3897 4130 TO 4142 4215 TO 4217 -
4225 4234 4235 4239 TO 4241 4248 TO 4251 PRIS YD 0.6 ZD 0.3
UNIT MMS NEWTON
MEMBER PROPERTY INDIAN
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2607 2609 2611 2613 2615 2617 2619 2622 2624 2626 2628 2630 2632 2634 2635 -
2638 2641 2643 2645 2657 2658 2660 2661 2667 2668 2670 2671 2673 2674 2679 -
2680 TO 2682 2684 TO 2687 2689 TO 2692 2697 2702 TO 2704 4219 TO 4222 4230 -
4231 TO 4233 PRIS YD 650 ZD 350
MEMBER PROPERTY INDIAN
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3620 3622 3624 PRIS YD 600 ZD 500
UNIT METER KN
CONSTANTS
MATERIAL STEEL MEMB 1155 1167 1315 1452 1477 2155 2158 2161 2162 2179 2705 -
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1118 TO 1120 1122 1124 1126 1129 1132 1133 1136 1137 1139 TO 1146 -
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MATERIAL CONCRETE MEMB 4131 TO 4142 4215 TO 4217 4219 TO 4222 4225 TO
4241 -
4246 TO 4256
SUPPORTS
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ARRIVAL TIME
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DAMPING 0.05
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UNIT MMS NEWTON
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SELFWEIGHT Y 1
SELFWEIGHT Z 1
UNIT METER KN
FLOOR LOAD
_SLAB(2KN) FLOAD 6.5 GX
_SLAB(2KN) FLOAD 6.5 GY
_SLAB(2KN) FLOAD 6.5 GZ
_SLAB(4KN) FLOAD 8 GX
_SLAB(4KN) FLOAD 8 GY
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_SLAB(4KN) FLOAD 8 GZ
_SLAB(5KN) FLOAD 8.5 GX
_SLAB(5KN) FLOAD 8.5 GY
_SLAB(5KN) FLOAD 8.5 GZ
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1739 1741 1743 1745 1753 1754 1756 1758 1760 1762 1764 1766 1768 1815 1816 -
1823 TO 1827 2510 4239 UNI GY 18.4
1739 1741 1743 1745 1753 1754 1756 1758 1760 1762 1764 1766 1768 1815 1816 -
1823 TO 1827 2510 4239 UNI GZ 18.4
1549 TO 1553 1591 1701 1703 1711 1719 1727 1735 1772 1774 1776 1778 1780 1782 -
1784 1786 1789 1818 1819 2509 UNI GX 10
1549 TO 1553 1591 1701 1703 1711 1719 1727 1735 1772 1774 1776 1778 1780 1782 -
1784 1786 1789 1818 1819 2509 UNI GY 10
1549 TO 1553 1591 1701 1703 1711 1719 1727 1735 1772 1774 1776 1778 1780 1782 -
1784 1786 1789 1818 1819 2509 UNI GZ 10
1543 TO 1548 1554 TO 1564 1567 1569 TO 1580 1583 TO 1590 1838 1839 2045 2046 -
2147 2148 2556 TO 2563 2566 TO 2575 2578 2579 2584 TO 2587 2595 2597 2600 -
2601 2605 2607 2609 2611 2613 2615 2617 2619 2622 2624 2626 2628 2630 2632 -
2634 2635 2638 2641 2643 2645 2657 2658 2660 2661 2667 2668 2670 2671 2673 -
2674 2679 TO 2682 2684 TO 2687 2689 TO 2692 2697 2702 TO 2704 3895 4142 4216 -
4219 TO 4222 4230 TO 4233 UNI GX 14
1543 TO 1548 1554 TO 1564 1567 1569 TO 1580 1583 TO 1590 1838 1839 2045 2046 -
2147 2148 2556 TO 2563 2566 TO 2575 2578 2579 2584 TO 2587 2595 2597 2600 -
2601 2605 2607 2609 2611 2613 2615 2617 2619 2622 2624 2626 2628 2630 2632 -
2634 2635 2638 2641 2643 2645 2657 2658 2660 2661 2667 2668 2670 2671 2673 -
2674 2679 TO 2682 2684 TO 2687 2689 TO 2692 2697 2702 TO 2704 3895 4142 4216 -
4219 TO 4222 4230 TO 4233 UNI GY 14
1543 TO 1548 1554 TO 1564 1567 1569 TO 1580 1583 TO 1590 1838 1839 2045 2046 -
2147 2148 2556 TO 2563 2566 TO 2575 2578 2579 2584 TO 2587 2595 2597 2600 -
2601 2605 2607 2609 2611 2613 2615 2617 2619 2622 2624 2626 2628 2630 2632 -
2634 2635 2638 2641 2643 2645 2657 2658 2660 2661 2667 2668 2670 2671 2673 -
2674 2679 TO 2682 2684 TO 2687 2689 TO 2692 2697 2702 TO 2704 3895 4142 4216 -
4219 TO 4222 4230 TO 4233 UNI GZ 14
GROUND MOTION X 1 1 9.810000
LOAD 2 LOADTYPE Dead TITLE DEAD LOAD
SELFWEIGHT Y -1
FLOOR LOAD
YRANGE 31 32 FLOAD -6 XRANGE 0 51 ZRANGE 11 37 GY
YRANGE 31 32 FLOAD -6 XRANGE 41.5 49 ZRANGE 7 11.5 GY
MEMBER LOAD
1739 1741 1743 1745 1753 1754 1756 1758 1760 1762 1764 1766 1768 1815 1816 -
1823 TO 1827 2510 4239 UNI GY -18.4
1549 TO 1553 1591 1701 1703 1711 1719 1727 1735 1772 1774 1776 1778 1780 1782 -
1784 1786 1789 1818 1819 2509 UNI GY -10
1543 TO 1548 1554 TO 1564 1567 1569 TO 1580 1583 TO 1590 1838 1839 2045 2046 -
2147 2148 2556 TO 2563 2566 TO 2575 2578 2579 2584 TO 2587 2595 2597 2600 -
2601 2605 2607 2609 2611 2613 2615 2617 2619 2622 2624 2626 2628 2630 2632 -

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2634 2635 2638 2641 2643 2645 2657 2658 2660 2661 2667 2668 2670 2671 2673 -
2674 2679 TO 2682 2684 TO 2687 2689 TO 2692 2697 2702 TO 2704 3895 4142 4216 -
4219 TO 4222 4230 TO 4233 UNI GY -14
JOINT LOAD
784 1336 TO 1342 1349 TO 1355 1364 1368 1369 1376 TO 1381 1386 TO 1391 1398 -
1402 1403 1410 TO 1415 1420 TO 1425 1432 1436 1437 1444 TO 1449 1454 TO 1459 -
1466 1470 1471 1478 TO 1483 1488 TO 1493 1500 1504 1505 1512 TO 1517 1522 -
1523 TO 1527 1534 1538 1539 1546 TO 1551 1556 TO 1561 1568 1572 1573 1580 -
1581 TO 1585 1590 TO 1595 FY -2.27
698 712 TO 718 721 746 760 1361 TO 1363 1395 TO 1397 1429 TO 1431 -
1463 TO 1465 1497 TO 1499 1531 TO 1533 1565 TO 1567 FY -1.405
1599 1603 1604 1611 TO 1616 1621 TO 1626 1635 1639 1640 1647 TO 1652 1657 -
1658 TO 1662 1671 1675 1676 1683 TO 1688 1693 TO 1698 FY -3.17
699 729 TO 731 744 756 1631 1633 1634 1667 1669 1670 FY -1.87
1786 1790 1791 1798 TO 1803 1809 TO 1814 FY -1.66
1780 1782 1784 1785 FY -1.11
1741 1745 1746 1753 TO 1758 1763 TO 1768 FY -1.356
728 1738 TO 1740 FY -0.879
1105 FY -6.5
711 726 FY -3.5
UNIT MMS NEWTON
ELEMENT LOAD
4252 TRAP GX Y 0 0.029
4253 TRAP GX X 0.029 0
4254 TRAP GZ X 0.029 0
UNIT METER KN
LOAD 3 LOADTYPE Live REDUCIBLE TITLE LIVE LOAD
FLOOR LOAD
YRANGE 31 32 FLOAD -2 XRANGE 30 46  ZRANGE 31 37  GY
YRANGE 31 32 FLOAD -5 XRANGE 40 51  ZRANGE 7 31.5  GY
YRANGE 31 32 FLOAD -4 XRANGE 0 46  ZRANGE 20 32  GY
JOINT LOAD
784 1336 TO 1342 1349 TO 1355 1364 1368 1369 1376 TO 1381 1386 TO 1391 1398 -
1402 1403 1410 TO 1415 1420 TO 1425 1432 1436 1437 1444 TO 1449 1454 TO 1459 -
1466 1470 1471 1478 TO 1483 1488 TO 1493 FY -1.27
698 712 TO 715 721 746 760 1361 TO 1363 1395 TO 1397 1429 TO 1431 -
1463 TO 1465 FY -0.63
1500 1504 1505 1512 TO 1517 1522 TO 1527 1534 1538 1539 1546 TO 1551 1556 -
1557 TO 1561 1568 1572 1573 1580 TO 1585 1590 TO 1595 1599 1603 1604 1611 -
1612 TO 1616 1621 TO 1626 1635 1639 1640 1647 TO 1652 1657 TO 1662 1671 1675 -
1676 1683 TO 1688 1693 TO 1698 FY -1.72
699 729 TO 731 744 756 1497 1498 1500 1504 1505 1512 TO 1517 1522 TO 1527 -
1531 1532 1534 1538 1539 1546 TO 1551 1556 TO 1561 1565 1566 1568 1572 1573 -
1580 TO 1585 1590 TO 1595 1599 1603 1604 1611 TO 1616 1621 TO 1626 1631 1633 -
1634 TO 1635 1639 1640 1647 TO 1652 1657 TO 1662 1667 1669 TO 1671 1675 1676 -
1683 TO 1688 1693 TO 1698 FY -0.86
1741 1745 1746 1753 TO 1758 1763 TO 1768 1786 1790 1791 1798 TO 1803 1809 -
1810 TO 1814 FY -1.59
728 1738 TO 1740 1780 1782 1784 1785 FY -0.79
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LOAD COMB 4 DL+LL(FOR RXNS)
2 1.0 3 0.9
LOAD COMB 5 DL+LL (TOP STOREY)
2 1.5 3 1.5
LOAD COMB 6 DL+LL(BOTTOM STOREY)
2 1.5 3 1.35
LOAD COMB 7 DL+LL(FOR BEAMS)
2 1.5 3 1.5
LOAD COMB 8 DL+EQ(X)
2 1.5 1 1.5
LOAD COMB 9 DL+EQ(-X)
2 1.5 1 1.5
LOAD COMB 10 DL+25%LL+EQ(X)
1 1.2 2 1.2 3 0.3
LOAD COMB 11 DL+25%LL+EQ(-X)
1 1.2 2 1.2 3 0.3
LOAD COMB 12 0.9DL+EQ(X)
1 1.5 2 0.9
LOAD COMB 13 0.9DL+EQ(-X)
1 1.5 2 0.9
PERFORM ANALYSIS
LOAD LIST 4
PRINT SUPPORT REACTION ALL
LOAD LIST 7 TO 13
START CONCRETE DESIGN
CODE INDIAN
UNIT MMS NEWTON
CLEAR 30 MEMB 1360 1363 TO 1370 1464 1543 TO 1564 1567 1569 TO 1601 1701 1703
-
1705 1707 1709 1711 1713 1715 1717 1719 1721 1723 1725 1727 1729 1731 1733 -
1735 1737 1739 1741 1743 1745 1747 1748 1753 1754 1756 1758 1760 1762 1764 -
1766 1768 1771 1772 1774 1776 1778 1780 1782 1784 1786 1789 1790 1792 1794 -
1796 1798 1800 1802 1804 1806 1808 TO 1816 1818 TO 1829 1832 TO 1844 1850 -
1855 2038 2041 2044 TO 2046 2133 2138 2146 TO 2150 2165 TO 2176 2505 TO 2510 -
2515 TO 2518 2556 TO 2563 2566 TO 2575 2578 2579 2584 TO 2587 2595 2597 2600 -
2601 2605 2607 2609 2611 2613 2615 2617 2619 2622 2624 2626 2628 2630 2632 -
2634 2635 2638 2641 2643 2645 2657 2658 2660 2661 2667 2668 2670 2671 2673 -
2674 2679 TO 2682 2684 TO 2687 2689 TO 2692 2697 2702 TO 2704 2707 2708 2734 -
2750 3524 3526 3528 3599 TO 3609 3614 3636 3639 3640 3643 TO 3645 3651 3653 -
3654 TO 3656 3895 TO 3897 4130 TO 4142 4215 TO 4217 4219 TO 4222 4225 4230 -
4231 TO 4235 4239 TO 4241
FC 30 MEMB 1360 1363 TO 1370 1464 1543 TO 1564 1567 1569 TO 1601 1701 1703 -
1705 1707 1709 1711 1713 1715 1717 1719 1721 1723 1725 1727 1729 1731 1733 -
1735 1737 1739 1741 1743 1745 1747 1748 1753 1754 1756 1758 1760 1762 1764 -
1766 1768 1771 1772 1774 1776 1778 1780 1782 1784 1786 1789 1790 1792 1794 -
1796 1798 1800 1802 1804 1806 1808 TO 1816 1818 TO 1829 1832 TO 1844 1850 -
1855 2038 2041 2044 TO 2046 2133 2138 2146 TO 2150 2165 TO 2176 2505 TO 2510 -
2515 TO 2518 2556 TO 2563 2566 TO 2575 2578 2579 2584 TO 2587 2595 2597 2600 -
2601 2605 2607 2609 2611 2613 2615 2617 2619 2622 2624 2626 2628 2630 2632 -
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2634 2635 2638 2641 2643 2645 2657 2658 2660 2661 2667 2668 2670 2671 2673 -
2674 2679 TO 2682 2684 TO 2687 2689 TO 2692 2697 2702 TO 2704 2707 2708 2734 -
2750 3524 3526 3528 3599 TO 3609 3614 3636 3639 3640 3643 TO 3645 3651 3653 -
3654 TO 3656 3895 TO 3897 4130 TO 4142 4215 TO 4217 4219 TO 4222 4225 4230 -
4231 TO 4235 4239 TO 4241
FYMAIN 500 MEMB 1360 1363 TO 1370 1464 1543 TO 1564 1567 1569 TO 1601 1701 -
1703 1705 1707 1709 1711 1713 1715 1717 1719 1721 1723 1725 1727 1729 1731 -
1733 1735 1737 1739 1741 1743 1745 1747 1748 1753 1754 1756 1758 1760 1762 -
1764 1766 1768 1771 1772 1774 1776 1778 1780 1782 1784 1786 1789 1790 1792 -
1794 1796 1798 1800 1802 1804 1806 1808 TO 1816 1818 TO 1829 1832 TO 1844 -
1850 1855 2038 2041 2044 TO 2046 2133 2138 2146 TO 2150 2165 TO 2176 2505 -
2506 TO 2510 2515 TO 2518 2556 TO 2563 2566 TO 2575 2578 2579 2584 TO 2587 -
2595 2597 2600 2601 2605 2607 2609 2611 2613 2615 2617 2619 2622 2624 2626 -
2628 2630 2632 2634 2635 2638 2641 2643 2645 2657 2658 2660 2661 2667 2668 -
2670 2671 2673 2674 2679 TO 2682 2684 TO 2687 2689 TO 2692 2697 2702 TO 2704 -
2707 2708 2734 2750 3524 3526 3528 3599 TO 3609 3614 3636 3639 3640 3643 -
3644 TO 3645 3651 3653 TO 3656 3895 TO 3897 4130 TO 4142 4215 TO 4217 4219 -
4220 TO 4222 4225 4230 TO 4235 4239 TO 4241
FYSEC 500 MEMB 1360 1363 TO 1370 1464 1543 TO 1564 1567 1569 TO 1601 1701 -
1703 1705 1707 1709 1711 1713 1715 1717 1719 1721 1723 1725 1727 1729 1731 -
1733 1735 1737 1739 1741 1743 1745 1747 1748 1753 1754 1756 1758 1760 1762 -
1764 1766 1768 1771 1772 1774 1776 1778 1780 1782 1784 1786 1789 1790 1792 -
1794 1796 1798 1800 1802 1804 1806 1808 TO 1816 1818 TO 1829 1832 TO 1844 -
1850 1855 2038 2041 2044 TO 2046 2133 2138 2146 TO 2150 2165 TO 2176 2505 -
2506 TO 2510 2515 TO 2518 2556 TO 2563 2566 TO 2575 2578 2579 2584 TO 2587 -
2595 2597 2600 2601 2605 2607 2609 2611 2613 2615 2617 2619 2622 2624 2626 -
2628 2630 2632 2634 2635 2638 2641 2643 2645 2657 2658 2660 2661 2667 2668 -
2670 2671 2673 2674 2679 TO 2682 2684 TO 2687 2689 TO 2692 2697 2702 TO 2704 -
2707 2708 2734 2750 3524 3526 3528 3599 TO 3609 3614 3636 3639 3640 3643 -
3644 TO 3645 3651 3653 TO 3656 3895 TO 3897 4130 TO 4142 4215 TO 4217 4219 -
4220 TO 4222 4225 4230 TO 4235 4239 TO 4241
MAXMAIN 32 MEMB 1360 1363 TO 1370 1464 1543 TO 1564 1567 1569 TO 1601 1701 -
1703 1705 1707 1709 1711 1713 1715 1717 1719 1721 1723 1725 1727 1729 1731 -
1733 1735 1737 1739 1741 1743 1745 1747 1748 1753 1754 1756 1758 1760 1762 -
1764 1766 1768 1771 1772 1774 1776 1778 1780 1782 1784 1786 1789 1790 1792 -
1794 1796 1798 1800 1802 1804 1806 1808 TO 1816 1818 TO 1829 1832 TO 1844 -
1850 1855 2038 2041 2044 TO 2046 2133 2138 2146 TO 2150 2165 TO 2176 2505 -
2506 TO 2510 2515 TO 2518 2556 TO 2563 2566 TO 2575 2578 2579 2584 TO 2587 -
2595 2597 2600 2601 2605 2607 2609 2611 2613 2615 2617 2619 2622 2624 2626 -
2628 2630 2632 2634 2635 2638 2641 2643 2645 2657 2658 2660 2661 2667 2668 -
2670 2671 2673 2674 2679 TO 2682 2684 TO 2687 2689 TO 2692 2697 2702 TO 2704 -
2707 2708 2734 2750 3524 3526 3528 3599 TO 3609 3614 3636 3639 3640 3643 -
3644 TO 3645 3651 3653 TO 3656 3895 TO 3897 4130 TO 4142 4215 TO 4217 4219 -
4220 TO 4222 4225 4230 TO 4235 4239 TO 4241
MAXSEC 12 MEMB 1360 1363 TO 1370 1464 1543 TO 1564 1567 1569 TO 1601 1701 -
1703 1705 1707 1709 1711 1713 1715 1717 1719 1721 1723 1725 1727 1729 1731 -
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1850 1855 2038 2041 2044 TO 2046 2133 2138 2146 TO 2150 2165 TO 2176 2505 -
2506 TO 2510 2515 TO 2518 2556 TO 2563 2566 TO 2575 2578 2579 2584 TO 2587 -
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2670 2671 2673 2674 2679 TO 2682 2684 TO 2687 2689 TO 2692 2697 2702 TO 2704 -
2707 2708 2734 2750 3524 3526 3528 3599 TO 3609 3614 3636 3639 3640 3643 -
3644 TO 3645 3651 3653 TO 3656 3895 TO 3897 4130 TO 4142 4215 TO 4217 4219 -
4220 TO 4222 4225 4230 TO 4235 4239 TO 4241
MINSEC 8 MEMB 1360 1363 TO 1370 1464 1543 TO 1564 1567 1569 TO 1601 1701 1703
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1705 1707 1709 1711 1713 1715 1717 1719 1721 1723 1725 1727 1729 1731 1733 -
1735 1737 1739 1741 1743 1745 1747 1748 1753 1754 1756 1758 1760 1762 1764 -
1766 1768 1771 1772 1774 1776 1778 1780 1782 1784 1786 1789 1790 1792 1794 -
1796 1798 1800 1802 1804 1806 1808 TO 1816 1818 TO 1829 1832 TO 1844 1850 -
1855 2038 2041 2044 TO 2046 2133 2138 2146 TO 2150 2165 TO 2176 2505 TO 2510 -
2515 TO 2518 2556 TO 2563 2566 TO 2575 2578 2579 2584 TO 2587 2595 2597 2600 -
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2634 2635 2638 2641 2643 2645 2657 2658 2660 2661 2667 2668 2670 2671 2673 -
2674 2679 TO 2682 2684 TO 2687 2689 TO 2692 2697 2702 TO 2704 2707 2708 2734 -
2750 3524 3526 3528 3599 TO 3609 3614 3636 3639 3640 3643 TO 3645 3651 3653 -
3654 TO 3656 3895 TO 3897 4130 TO 4142 4215 TO 4217 4219 TO 4222 4225 4230 -
4231 TO 4235 4239 TO 4241
RATIO 4 MEMB 1360 1363 TO 1370 1464 1543 TO 1564 1567 1569 TO 1601 1701 1703 -
1705 1707 1709 1711 1713 1715 1717 1719 1721 1723 1725 1727 1729 1731 1733 -
1735 1737 1739 1741 1743 1745 1747 1748 1753 1754 1756 1758 1760 1762 1764 -
1766 1768 1771 1772 1774 1776 1778 1780 1782 1784 1786 1789 1790 1792 1794 -
1796 1798 1800 1802 1804 1806 1808 TO 1816 1818 TO 1829 1832 TO 1844 1850 -
1855 2038 2041 2044 TO 2046 2133 2138 2146 TO 2150 2165 TO 2176 2505 TO 2510 -
2515 TO 2518 2556 TO 2563 2566 TO 2575 2578 2579 2584 TO 2587 2595 2597 2600 -
2601 2605 2607 2609 2611 2613 2615 2617 2619 2622 2624 2626 2628 2630 2632 -
2634 2635 2638 2641 2643 2645 2657 2658 2660 2661 2667 2668 2670 2671 2673 -
2674 2679 TO 2682 2684 TO 2687 2689 TO 2692 2697 2702 TO 2704 2707 2708 2734 -
2750 3524 3526 3528 3599 TO 3609 3614 3636 3639 3640 3643 TO 3645 3651 3653 -
3654 TO 3656 3895 TO 3897 4130 TO 4142 4215 TO 4217 4219 TO 4222 4225 4230 -
4231 TO 4235 4239 TO 4241
DESIGN BEAM 1360 1363 TO 1370 1464 1543 TO 1564 1567 1569 TO 1601 1701 1703 -
1705 1707 1709 1711 1713 1715 1717 1719 1721 1723 1725 1727 1729 1731 1733 -
1735 1737 1739 1741 1743 1745 1747 1748 1753 1754 1756 1758 1760 1762 1764 -
1766 1768 1771 1772 1774 1776 1778 1780 1782 1784 1786 1789 1790 1792 1794 -
1796 1798 1800 1802 1804 1806 1808 TO 1816 1818 TO 1829 1832 TO 1844 1850 -
1855 2038 2041 2044 TO 2046 2133 2138 2146 TO 2150 2165 TO 2176 2505 TO 2510 -
2515 TO 2518 2556 TO 2563 2566 TO 2575 2578 2579 2584 TO 2587 2595 2597 2600 -
2601 2605 2607 2609 2611 2613 2615 2617 2619 2622 2624 2626 2628 2630 2632 -
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2674 2679 TO 2682 2684 TO 2687 2689 TO 2692 2697 2702 TO 2704 2707 2708 2734 -
2750 3524 3526 3528 3599 TO 3609 3614 3636 3639 3640 3643 TO 3645 3651 3653 -
3654 TO 3656 3895 TO 3897 4130 TO 4142 4215 TO 4217 4219 TO 4222 4225 4230 -
4231 TO 4235 4239 TO 4241
END CONCRETE DESIGN

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LOAD LIST 5 8 TO 13
START CONCRETE DESIGN
CODE INDIAN
FC 35 MEMB 1105 TO 1107 1109 TO 1116 1118 TO 1120 1122 1124 1126 1129 1132 -
1133 1136 1137 1139 TO 1146 1148 TO 1154 2532 2534 2536 2538 2540 2542 2544 -
2546 2548 2549 2552 2554 2576 2577 2580 2582 2588 2594 2602 TO 2604 2606 -
2608 2610 2612 2614 2616 2618 2620 2621 2623 2625 2627 2629 2631 2633 2637 -
2639 2640 2642 2649 TO 2656 2663 2665 2666 2672 2677 2688 2695 2696 2698 -
2700 2701 3613 3616 TO 3628 3635 3638 3647 TO 3649 3657 3658 3901 -
4227 TO 4229 4236 TO 4238 4246 4247
FYMAIN 500 MEMB 1105 TO 1107 1109 TO 1116 1118 TO 1120 1122 1124 1126 1129 -
1132 1133 1136 1137 1139 TO 1146 1148 TO 1154 2532 2534 2536 2538 2540 2542 -
2544 2546 2548 2549 2552 2554 2576 2577 2580 2582 2588 2594 2602 TO 2604 -
2606 2608 2610 2612 2614 2616 2618 2620 2621 2623 2625 2627 2629 2631 2633 -
2637 2639 2640 2642 2649 TO 2656 2663 2665 2666 2672 2677 2688 2695 2696 -
2698 2700 2701 3613 3616 TO 3628 3635 3638 3647 TO 3649 3657 3658 3901 4227 -
4228 TO 4229 4236 TO 4238 4246 4247
FYSEC 500 MEMB 1105 TO 1107 1109 TO 1116 1118 TO 1120 1122 1124 1126 1129 -
1132 1133 1136 1137 1139 TO 1146 1148 TO 1154 2532 2534 2536 2538 2540 2542 -
2544 2546 2548 2549 2552 2554 2576 2577 2580 2582 2588 2594 2602 TO 2604 -
2606 2608 2610 2612 2614 2616 2618 2620 2621 2623 2625 2627 2629 2631 2633 -
2637 2639 2640 2642 2649 TO 2656 2663 2665 2666 2672 2677 2688 2695 2696 -
2698 2700 2701 3613 3616 TO 3628 3635 3638 3647 TO 3649 3657 3658 3901 4227 -
4228 TO 4229 4236 TO 4238 4246 4247
MAXMAIN 32 MEMB 1105 TO 1107 1109 TO 1116 1118 TO 1120 1122 1124 1126 1129 -
1132 1133 1136 1137 1139 TO 1146 1148 TO 1154 2532 2534 2536 2538 2540 2542 -
2544 2546 2548 2549 2552 2554 2576 2577 2580 2582 2588 2594 2602 TO 2604 -
2606 2608 2610 2612 2614 2616 2618 2620 2621 2623 2625 2627 2629 2631 2633 -
2637 2639 2640 2642 2649 TO 2656 2663 2665 2666 2672 2677 2688 2695 2696 -
2698 2700 2701 3613 3616 TO 3628 3635 3638 3647 TO 3649 3657 3658 3901 4227 -
4228 TO 4229 4236 TO 4238 4246 4247
MAXSEC 12 MEMB 1105 TO 1107 1109 TO 1116 1118 TO 1120 1122 1124 1126 1129 -
1132 1133 1136 1137 1139 TO 1146 1148 TO 1154 2532 2534 2536 2538 2540 2542 -
2544 2546 2548 2549 2552 2554 2576 2577 2580 2582 2588 2594 2602 TO 2604 -
2606 2608 2610 2612 2614 2616 2618 2620 2621 2623 2625 2627 2629 2631 2633 -
2637 2639 2640 2642 2649 TO 2656 2663 2665 2666 2672 2677 2688 2695 2696 -
2698 2700 2701 3613 3616 TO 3628 3635 3638 3647 TO 3649 3657 3658 3901 4227 -
4228 TO 4229 4236 TO 4238 4246 4247
MINMAIN 12 MEMB 1105 TO 1107 1109 TO 1116 1118 TO 1120 1122 1124 1126 1129 -
1132 1133 1136 1137 1139 TO 1146 1148 TO 1154 2532 2534 2536 2538 2540 2542 -
2544 2546 2548 2549 2552 2554 2576 2577 2580 2582 2588 2594 2602 TO 2604 -
2606 2608 2610 2612 2614 2616 2618 2620 2621 2623 2625 2627 2629 2631 2633 -
2637 2639 2640 2642 2649 TO 2656 2663 2665 2666 2672 2677 2688 2695 2696 -
2698 2700 2701 3613 3616 TO 3628 3635 3638 3647 TO 3649 3657 3658 3901 4227 -
4228 TO 4229 4236 TO 4238 4246 4247
MINSEC 8 MEMB 1105 TO 1107 1109 TO 1116 1118 TO 1120 1122 1124 1126 1129 1132
-
1133 1136 1137 1139 TO 1146 1148 TO 1154 2532 2534 2536 2538 2540 2542 2544 -
2546 2548 2549 2552 2554 2576 2577 2580 2582 2588 2594 2602 TO 2604 2606 -
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2608 2610 2612 2614 2616 2618 2620 2621 2623 2625 2627 2629 2631 2633 2637 -
2639 2640 2642 2649 TO 2656 2663 2665 2666 2672 2677 2688 2695 2696 2698 -
2700 2701 3613 3616 TO 3628 3635 3638 3647 TO 3649 3657 3658 3901 -
4227 TO 4229 4236 TO 4238 4246 4247
TRACK 1 MEMB 1105 TO 1107 1109 TO 1116 1118 TO 1120 1122 1124 1126 1129 1132 -
1133 1136 1137 1139 TO 1146 1148 TO 1154 2532 2534 2536 2538 2540 2542 2544 -
2546 2548 2549 2552 2554 2576 2577 2580 2582 2588 2594 2602 TO 2604 2606 -
2608 2610 2612 2614 2616 2618 2620 2621 2623 2625 2627 2629 2631 2633 2637 -
2639 2640 2642 2649 TO 2656 2663 2665 2666 2672 2677 2688 2695 2696 2698 -
2700 2701 3613 3616 TO 3628 3635 3638 3647 TO 3649 3657 3658 3901 -
4227 TO 4229 4236 TO 4238 4246 4247
DESIGN COLUMN 1105 TO 1107 1109 TO 1116 1118 TO 1120 1122 1124 1126 1129 1132 -
1133 1136 1137 1139 TO 1146 1148 TO 1154 2532 2534 2536 2538 2540 2542 2544 -
2546 2548 2549 2552 2554 2576 2577 2580 2582 2588 2594 2602 TO 2604 2606 -
2608 2610 2612 2614 2616 2618 2620 2621 2623 2625 2627 2629 2631 2633 2637 -
2639 2640 2642 2649 TO 2656 2663 2665 2666 2672 2677 2688 2695 2696 2698 -
2700 2701 3613 3616 TO 3628 3635 3638 3647 TO 3649 3657 3658 3901 -
4227 TO 4229 4236 TO 4238 4246 4247
END CONCRETE DESIGN
LOAD LIST 6 8 TO 13
START CONCRETE DESIGN
CODE INDIAN
FC 35 MEMB 1050 TO 1073 1076 TO 1083 1086 TO 1104 1489 TO 1498 1500 1502 1504 -
1505 TO 1514 1516 TO 1528 1530 TO 1542 1602 1604 1606 1608 1610 1612 1614 -
1616 1618 1620 1622 1625 1627 1629 1631 1633 1635 1637 1639 1641 1643 1645 -
1647 1649 1651 1653 1655 TO 1657 1659 TO 1663 1665 1667 1669 1671 1673 1675 -
1677 1679 1681 1683 1685 1687 1689 1691 1693 1695 1697 1699 1700 -
1856 TO 1874 2043 2177 2178 2511 TO 2514 2520 TO 2523 4226
FYMAIN 500 MEMB 1050 TO 1073 1076 TO 1083 1086 TO 1104 1489 TO 1498 1500 1502 -
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MAXMAIN 32 MEMB 1050 TO 1073 1076 TO 1083 1086 TO 1104 1489 TO 1498 1500 1502 -
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MAXSEC 12 MEMB 1050 TO 1073 1076 TO 1083 1086 TO 1104 1489 TO 1498 1500 1502
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RATIO 6 MEMB 1050 TO 1073 1076 TO 1083 1086 TO 1104 1489 TO 1498 1500 1502 -
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1856 TO 1874 2043 2177 2178 2511 TO 2514 2520 TO 2523 4226
END CONCRETE DESIGN
*PARAMETER 4
*CODE IS800 LSD
*CHECK CODE MEMB 1155 1167 1315 1452 1477 1848 2155 2158 2161 2162 2179 2705
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*2706 TO 2707 2709 TO 2722 2724 TO 2749 2751 TO 2763 2765 TO 2773 2776 TO 2804 -
*2806 TO 2830 2832 TO 2840 2843 TO 2871 2873 TO 2897 2899 TO 2907 -
*2910 TO 2938 2940 TO 2964 2973 TO 2981 2984 TO 3012 3014 TO 3038 -
*3040 TO 3048 3051 TO 3079 3081 TO 3105 3107 TO 3115 3118 TO 3146 -
*3148 TO 3172 3174 TO 3182 3185 TO 3213 3215 TO 3239 3241 TO 3249 -
*3252 TO 3280 3282 TO 3306 3309 TO 3320 3323 TO 3351 3353 TO 3377 -
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*3381 TO 3391 3394 TO 3422 3424 TO 3448 3521 TO 3523 3525 3527 3529 -
*3532 TO 3560 3562 TO 3586 3588 TO 3598 3609 3611 3631 3633 3636 3641 3650 -
*3651 3659 TO 3669 3681 TO 3691 3715 TO 3725 3738 TO 3748 3761 TO 3771 3784 -
*3785 TO 3794 3807 TO 3817 3873 TO 3883 3900 3957 TO 4058 4061 TO 4095 4097 -
*4098 TO 4129 4143 TO 4214 4223 4242 4243
*STEEL TAKE OFF LIST 1155 1167 1315 1452 1477 1848 2155 2158 2161 2162 2179 -
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*2776 TO 2804 2806 TO 2830 2832 TO 2840 2843 TO 2871 2873 TO 2897 -
*2899 TO 2907 2910 TO 2938 2940 TO 2964 2973 TO 2981 2984 TO 3012 -
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*4098 TO 4129 4143 TO 4214 4223 4242 4243
FINISH