"POSITIONING OF WATER TANK ON BUILDING TO MINIMIZE THE EARTHQUAKE EFFECT"

A PROJECT

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

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

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by

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT SOLAN – 173 234

HIMACHAL PRADESH INDIA

June, 2016

CERTIFICATE

This is to certify that the work which is being presented in the project title **"POSITIONING OF WATER TANK ON BUILDING TO MINIMIZE THE EARTHQUAKE EFFECT"** in partial fulfillment of the requirements for the award of the degree of Bachelor of technology and submitted in Civil Engineering Department, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by ***Shivank Srivastav and Arvind Guleria*** during a period from July 2015 to June 2016 under the supervision of ***Mr. Chandra Pal Gautam*** Assistant Professor, Civil Engineering Department, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of my knowledge.

Date: - ………………………

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ACKNOWLEDGEMENT

It is our proud privilege and duty to acknowledge the kind of help and guidance received from several people in preparation of this report. It would not have been possible to prepare this report in this form without their valuable help, cooperation and guidance.

The topic **"**Positioning of water tank on buildings to minimize the earthquake effect**"** was very helpful to us in giving the necessary background information and inspiration in choosing this topic for the project. Our sincere thanks to Asst. Prof. **Chandra Pal Gautam** Project Guide and Asst. Prof. **Abhilash Shukla,** Project Coordinator for having supported the work related to this project. Their contributions and technical support in preparing this report are greatly acknowledged.

ABSTRACT

In the contemporary building designs, civil engineering has been benchmarking the construction techniques of the modern day civilizations. But not many of the conventional approaches towards producing a layout of a building acknowledge the impact of the placement of water tanks.

We took it as an initiative to study the relative influences this factor can exert over the results of an efficient building design and to our consternation, these were substantial enough to be considered while working out the deliverables. The relative positioning of the water tanks yields, to our consternation, impervious conclusions to the earthquake analysis of the structure and paves way for a fitter prototype. The building is of G+4 storey. The seismic zone taken is zone V. Moreover the building taken is of unsymmetrical nature. To obtain the results static analysis is done.

CONTENTS

Chapter 1

INTRODUCTION

Our project involves analysis and design of multi-storeyed [G + 21] using a very popular designing software STAAD Pro. We have chosen STAAD Pro because of its following advantages:

1. easy to use interface,
2. conformation with the Indian Standard Codes,
3. versatile nature of solving any type of problem,
4. Accuracy of the solution.

STAAD.Pro 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 is the professional's choice for steel, concrete, timber, aluminium and cold-formed steel design of low and high-rise buildings, culverts, petrochemical plants, tunnels, bridges, piles and much more.

STAAD.Pro consists of the following:

The STAAD.Pro Graphical User Interface: It is used to generate the model, which can then be analyzed using the STAAD engine. After analysis and design is completed, the GUI can also be used to view the results graphically.

The STAAD analysis and design engine: It is a general-purpose calculation engine for structural analysis and integrated Steel, Concrete, Timber and Aluminium design.

To start with we have solved some sample problems using STAAD Pro and checked the accuracy of the results with manual calculations. The results were to satisfaction and were accurate. In the initial phase of our project we have done calculations regarding loadings on buildings and also considered seismic loads.

Structural analysis comprises the set of physical laws and mathematics required to study and predicts the behaviour of structures. Structural analysis can be viewed more abstractly as a method to drive the engineering design process or prove the soundness of a design without a dependence on directly testing it.

To perform an accurate analysis a structural engineer must determine such information as structural loads, geometry, support conditions, and materials properties. The results of such an analysis typically include support reactions, stresses and displacements. This information is then compared to criteria that indicate the conditions of failure. Advanced structural analysis may examine dynamic response, stability and non-linear behaviour.

The aim of design is the achievement of an acceptable probability that structures being designed will perform satisfactorily during their intended life. With an appropriate degree of safety, they should sustain all the loads and deformations of normal construction and use and have adequate durability and adequate resistance to the effects of seismic and wind. Structure and structural elements shall normally be designed by Limit State Method. Account should be taken of accepted theories, experiment and experience and the need to design for durability. Design, including design for durability, construction and use in service should be considered as a whole. The realization of design objectives requires compliance with clearly defined standards for materials, production, workmanship and also maintenance and use of structure in service.

CHAPTER 2

LITERATURE REVIEW

1. Topic:- Use of Overhead Water Tank to Reduce Peak Response of the Structure

   Author:- Bhosale Dattatray, G. R. Patil, Sachin Maskar

   Abstract:-This paper presents analytical investigation carried out to study the use of over head water tank as passive TMD using SAP. Three multi-storey concrete structures, three, five and fifteen storey were taken for the study. The water tank was placed at the roof. The mass and frequency of the tank including its water, walls, roof, beams and columns were tuned to the optimized values. The behaviour of the tank subjected to three earthquake data, namely, Elcentro, Bhuj, Washington was studied under three conditions, namely building only with empty tank, two third full tank and full tank with damping. The results shows if the tank is tuned properly it can reduce the peak response of structures subjected to seismic forces.

2. Topic:- SEISMIC ANALYSIS OF OVERHEAD CIRCULAR WATER TANKS – A COMPARITIVE STUDY

   Authors:- Krishna Rao M.V, Rathish Kumar. P, Divya Dhatri. K

   Abstract:- This paper compares the results of seismic analysis of overhead circular water tank carried out in accordance with IS: 1893- 1984 and IS: 1893-2002 (Part-2) draft code. The analysis is carried out for elevated circular tank of 1000 Cu.m capacity, located in four seismic zones (Zone-II, Zone -III, Zone-IV, Zone-V) and on three different soil types (Hard rock, Medium soil, Soft soil). Further, three different tank-fill conditions - tank full, tank 50% full, tank empty are also considered in this study. The seismic responses of circular tanks are computed and compared based on the theoretical procedures of IS: 1893-1984 and IS: 1893-2002(Part-2) draft code. The analysis was performed using SAP-2000 software package also. The parameters of comparison include base shears, base moments, impulsive and convective hydrodynamic pressures on tank wall and base slab. The results of the analysis showed an increase in base shear, base moment, hydrodynamic pressure and time period with increasing zone factor for all soil types and tank fill conditions considered. The increase in base shear and base moment are found to be in the range of 54% -260% in the analysis performed using draft code over the values of IS: 1893-1984. The hydrodynamic pressure increased in the range of 54%-280% with the use of draft code over the values obtained based on IS: 1893-1984. The results of SAP-2000 are found to be in agreement with those of the draft code.

3. Topic:- SEISMIC PERFORMANCE OF ELEVATED WATER TANKS

Authors:- Dr. Suchita Hirde, Ms. Asmita Bajare, Dr. Manoj Hedaoo

Abstract:- Elevated water tanks are one of the most important lifeline structures in earthquake prone regions. In major cities and also in rural areas elevated water tanks forms an integral part of water supply scheme. These structures has large mass concentrated at the top of slender supporting structure hence these structures are especially vulnerable to horizontal forces due to earthquake. Elevated water tanks that are inadequately analyzed and designed have suffered extensive damage during past earthquakes. The elevated water tanks must remain functional even after the earthquakes as water tanks are required to provide water for drinking and fire fighting purpose. Hence it is important to check the severity of these forces for particular region. This paper presents the study of seismic performance of the elevated water tanks for various seismic zones of India for various heights and capacity of elevated water tanks for different soil conditions. The effect of height of water tank, earthquake zones and soil conditions on earthquake forces have been presented in this paper with the help of analysis of 240 models for various parameters.

4. Topic :- Earthquake Analysis of Multi Storied Residential Building - A Case Study

Authors :- E. Pavan Kumar, A. Naresh, M. Nagajyothi, M. Rajasekhar

Abstract:- Earthquake occurred in multistoried building shows that if the structures are not well designed and constructed with and adequate strength it leads to the complete collapse of the structures. To ensure safety against seismic forces of multi-storied building hence, there is need to study of seismic analysis to design earthquake resistance structures. In seismic analysis the response reduction was considered for two cases both Ordinary moment resisting frame and Special moment resisting frame. The main objective this paper is to study the seismic analysis of structure for static and dynamic analysis in ordinary moment resisting frame and special moment resisting frame. Equivalent static analysis and response spectrum analysis are the methods used in structural seismic analysis. We considered the residential building of G+ 15 storied structure for the seismic analysis and it is located in zone II. The total structure was analyzed by computer with using STAAD.PRO software. We observed the response reduction of cases ordinary moment resisting frame and special moment resisting frame values with deflection diagrams in static and dynamic analysis. The special moment of resisting frame structured is good in resisting the seismic loads.

REASERCH GAP:

From the above following research papers we can conclude that, positioning of water tank over a building to minimize the earthquake effect was never calculated. Though the positioning of water tank will affect the building when a earthquake is striked.

CHAPTER 3

LOADS CONSIDERED

3.1 DEAD LOADS:

All permanent constructions of the structure form the dead loads. The dead load comprises of the weights of walls, partitions floor finishes, false ceilings, false floors and the other permanent constructions in the buildings. The dead load loads may be calculated from the dimensions of various members and their unit weights. the unit weights of plain concrete and reinforced concrete made with sand and gravel or crushed natural stone aggregate may be taken as 24 kN/m" and 25 kN/m" respectively.

3.2 IMPOSED LOADS:

Imposed 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. Imposed loads do not include loads due to wind, seismic activity, snow, and loads imposed due to temperature changes to which the structure will be subjected to, creep and shrinkage of the structure, the differential settlements to which the structure may undergo.

3.3 SEISMIC LOAD:

Design Lateral Force

The design lateral force shall first be computed for the building as a whole. This design lateral force shall then be distributed to the various floor levels. The overall design seismic force thus obtained at each floor level shall then be distributed to individual lateral load resisting elements depending on the floor diaphragm action.

Fundamental Natural Period

The approximate fundamental natural period of vibration (T,), in seconds, of a moment-resisting frame building without brick in the panels may be estimated by the empirical expression:

Ta=0.075 h0.75 for RC frame building

Ta=0.085 h0.75 for steel frame building

Where,

h = Height of building, in m. This excludes the basement storeys, where basement walls are connected with the ground floor deck or fitted between the building columns. But it includes the basement storeys, when they are not so connected. The approximate fundamental natural period of vibration (T,), in seconds, of all other buildings, including moment-resisting frame buildings with brick lintel panels, may be estimated by the empirical Expression:

T=.09H/√D

Where,

h= Height of building

d= Base dimension of the building at the plinth level, in m, along the considered direction of the lateral force.

Dynamic Analysis-

Dynamic analysis shall be performed to obtain the design seismic force, and its distribution to different levels along the height of the building and to the various lateral load resisting elements, for the following

Buildings:

a) *Regular buildings* -Those greater than 40 m in height in Zones IV and V and those Greater than 90 m in height in Zones II and 111.

b) *Irregular buildings* – All framed buildings higher than 12m in Zones IV and V and those greater than 40m in height in Zones 11 and III.

The analytical model for dynamic analysis of buildings with unusual configuration should be such that it adequately models the types of irregularities present in the building configuration. Buildings with plan irregularities cannot be modelled for dynamic analysis.

For irregular buildings, lesser than 40 m in height in Zones 11and III, dynamic analysis, even though not mandatory, is recommended. Dynamic analysis may be performed either by the Time History Method or by the Response Spectrum Method. However, in either method, the design base shear (VB) shall be compared with abase shear (VB)

Time History Method-

Time history method of analysis shall be based on an appropriate ground motion and shall be performed using accepted principles of dynamics.

Response Spectrum Method-

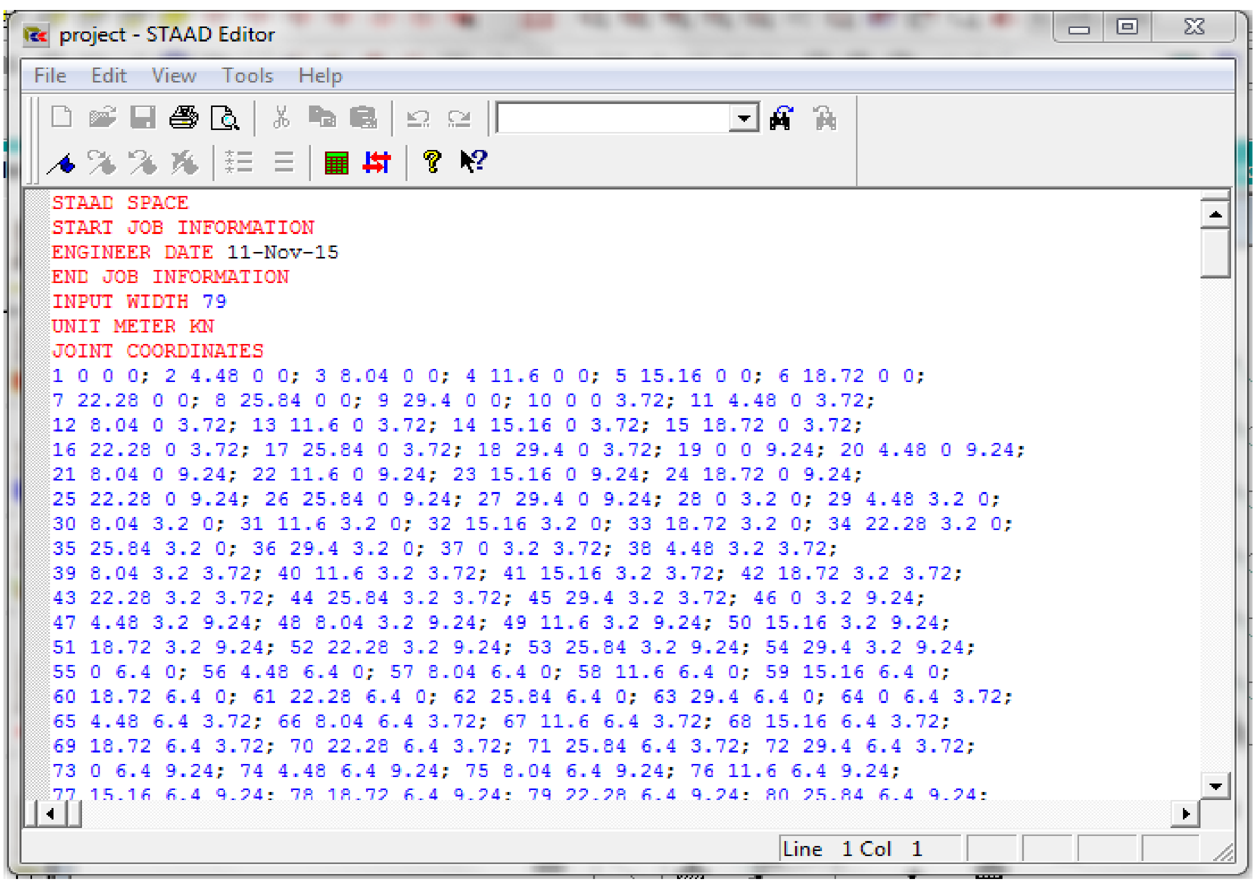
Response spectrum method of analysis shall be performed using the design spectrum specified, or by a site-specific design spectrum mentioned.

CHAPTER 4

WORKING WITH STAAD.Pro:

4.1 Input Generation:

The GUI (or user) communicates with the STAAD analysis engine through the STD input file. That input file is a text file consisting of a series of commands which are executed sequentially. The commands contain either instructions or data pertaining to analysis and/or design. The STAAD input file can be created through a text editor or the GUI Modeling facility. In general, any text editor may be utilized to edit/create the STD input file. The GUI Modeling facility creates the input file through an interactive menu-driven graphics oriented procedure.



4.2 Types of Structures:

A STRUCTURE can be defined as an assemblage of elements. STAAD is capable of analyzing and designing structures consisting of frame, plate/shell and solid elements. Almost any type of structure can be analyzed by STAAD.

A SPACE structure, which is a three dimensional framed structure with loads applied in any plane, is the most general.

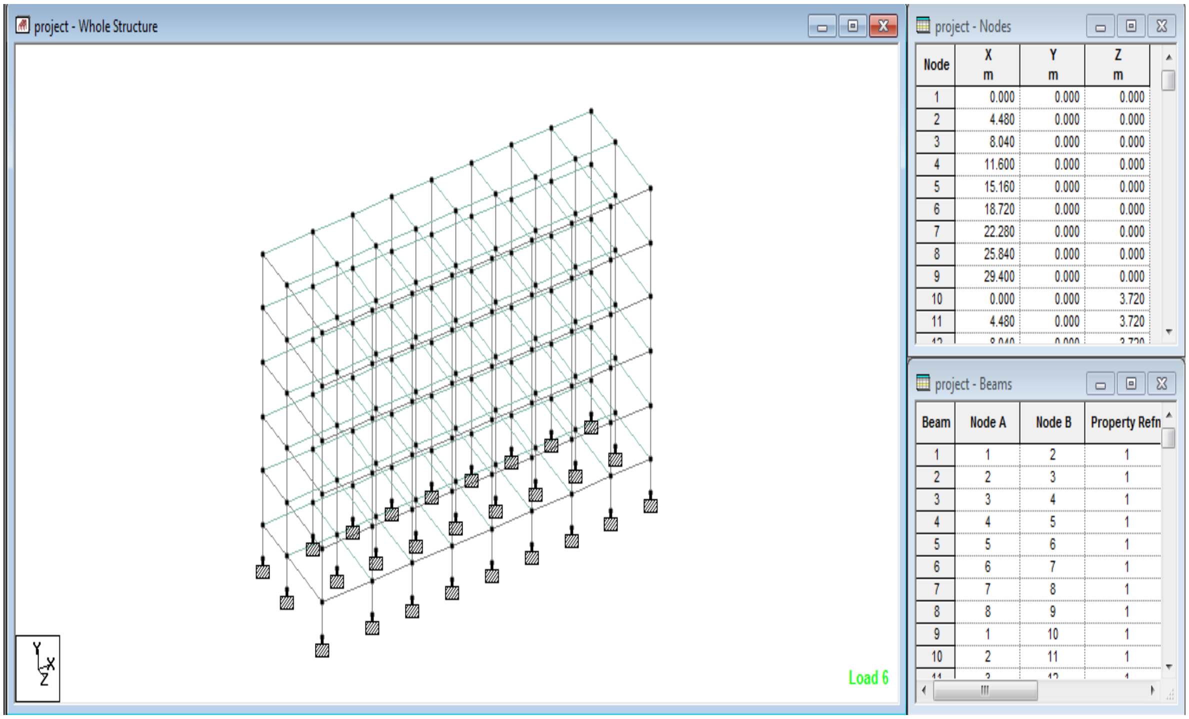
A PLANE structure is bound by a global X-Y coordinate system with loads in the same plane.

A TRUSS structure consists of truss members which can have only axial member forces and no bending in the members.

A FLOOR structure is a two or three dimensional structure having no horizontal (global X or Z) movement of the structure [FX, FZ & MY are restrained at every joint]. The floor framing (in global X-Z plane) of a building is an ideal example of a FLOOR structure. Columns can also be modeled with the floor in a FLOOR structure as long as the structure has no horizontal loading. If there is any horizontal load, it must be analyzed as a SPACE structure.

4.3 Generation of the structure*:*

The structure may be generated from the input file or mentioning the co-ordinates in the GUI. The figure below shows the GUI generation method.



4.4 Material Constants:

The material constants are: modulus of elasticity (E); weight density (DEN); Poisson's ratio (POISS); co-efficient of thermal expansion (ALPHA), Composite Damping Ratio, and beta angle (BETA) or coordinates for any reference (REF) point. E value for members must be provided or the analysis will not be performed. Weight density (DEN) is used only when self weight of the structure is to be taken into account. Poisson's ratio (POISS) is used to calculate the shear modulus (commonly known as G) by the formula,

G = 0.5 x E/ (1 + POISS)

If Poisson's ratio is not provided, STAAD will assume a value for this quantity based on the value of E. Coefficient of thermal expansion (ALPHA) is used to calculate the expansion of the members if temperature loads are applied. The temperature unit for temperature load and ALPHA has to be the same.

4.5 Supports:

Supports are specified as PINNED, FIXED, or FIXED with different releases (known as FIXED BUT). A pinned support has restraints against all translational movement and none against rotational movement. In other words, a pinned support will have reactions for all forces but will resist no moments. A fixed support has restraints against all directions of movement. Translational and rotational springs can also be specified. The springs are represented in terms of their spring constants. A translational spring constant is defined as the force to displace a support joint one length unit in the specified global direction. Similarly, a rotational spring constant is defined as the force to rotate the support joint one degree around the specified global direction.

4.6 Loads:

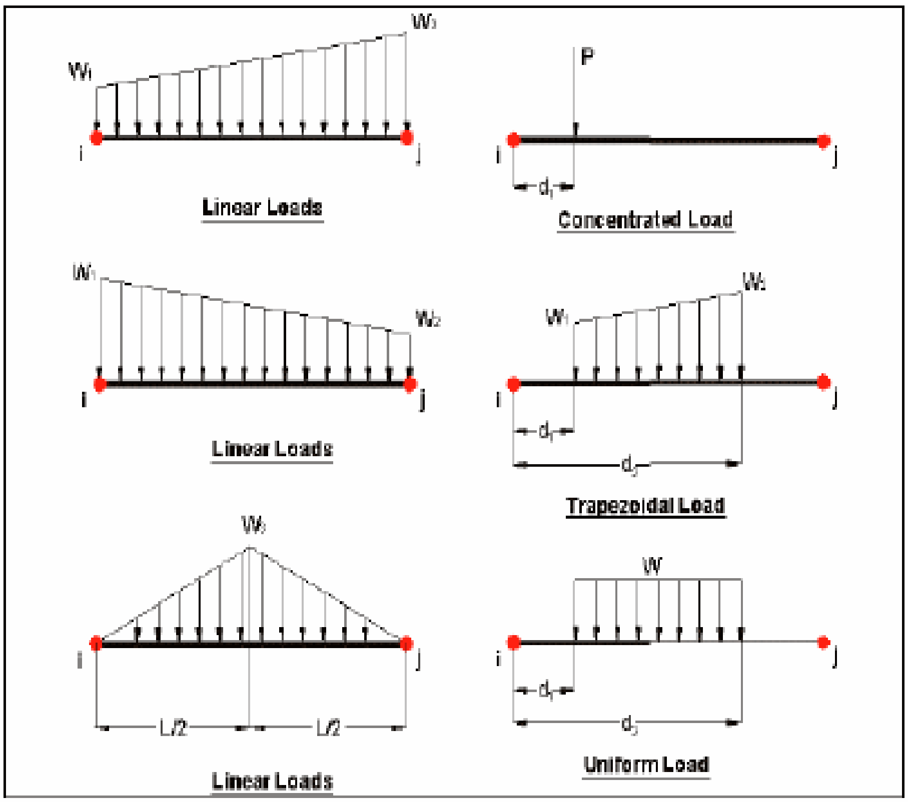
Loads in a structure can be specified as joint load, member load, temperature load and fixed-end member load. STAAD can also generate the self-weight of the structure and use it as uniformly distributed member loads in analysis. Any fraction of this self weight can also be applied in any desired direction.

Joint loads:

Joint loads, both forces and moments, may be applied to any free joint of a structure. These loads act in the global coordinate system of the structure. Positive forces act in the positive coordinate directions. Any number of loads may be applied on a single joint, in which case the loads will be additive on that joint.

Member load:

Three types of member loads may be applied directly to a member of a structure. These loads are uniformly distributed loads, concentrated loads, and linearly varying loads (including trapezoidal). Uniform loads act on the full or partial length of a member. Concentrated loads act at any intermediate, specified point. Linearly varying loads act over the full length of a member. Trapezoidal linearly varying loads act over the full or partial length of a member. Trapezoidal loads are converted into a uniform load and several concentrated loads. Any number of loads may be specified to act upon a member in any independent loading condition. Member loads can be specified in the member coordinate system or the global coordinate system. Uniformly distributed member loads provided in the global coordinate system may be specified to act along the full or projected member length.



Member load configuration

Area/floor load:

Many times a floor (bound by X-Z plane) is subjected to a uniformly distributed load. It could require a lot of work to calculate the member load for individual members in that floor.
However, with the AREA or FLOOR LOAD command, the user can specify the area loads (unit load per unit square area) for members. The program will calculate the tributary area for these

members and provide the proper member loads. The Area Load is used for one way distributions and the Floor Load is used for two way distributions.

Fixed end member load:

Load effects on a member may also be specified in terms of its fixed end loads. These loads are given in terms of the member coordinate system and the directions are opposite to the actual load on the member. Each end of a member can have six forces: axial; shear y; shear z; torsion; moment y, and moment z.

Load Generator – Moving load, Wind & Seismic:

Load generation is the process of taking a load causing unit such as wind pressure, ground movement or a truck on a bridge, and converting it to a form such as member load or a joint load which can be then be used in the analysis.

Moving Load Generator:

This feature enables the user to generate moving loads on members of a structure. Moving load system(s) consisting of concentrated loads at fixed specified distances in both directions on a plane can be defined by the user. A user specified number of primary load cases will be subsequently generated by the program and taken into consideration in analysis.

Seismic Load Generator:

The STAAD seismic load generator follows the procedure of equivalent lateral load analysis. It is assumed that the lateral loads will be exerted in X and Z directions and Y will be the direction of the gravity loads. Thus, for a building model, Y axis will be perpendicular to the floors and point upward (all Y joint coordinates positive). For load generation per the codes, the user is required to provide seismic zone coefficients, importance factors, and soil characteristic parameters. Instead of using the approximate code based formulas to estimate the building period in a certain direction, the program calculates the period using Raleigh quotient technique. This period is then utilized to calculate seismic coefficient C. After the base shear is calculated from the appropriate equation, it is distributed among the various levels and roof per the specifications. The distributed base shears are subsequently applied as lateral loads on the structure. These loads may then be utilized as normal load cases for analysis and design.

4.7 Section Types for Concrete Design:

The following types of cross sections for concrete members can be designed.
For Beams Prismatic (Rectangular & Square) & T-shape
For Columns Prismatic (Rectangular, Square and Circular)

4.8 Design Parameters:

The program contains a number of parameters that are needed to perform design as per IS 13920. It accepts all parameters that are needed to perform design as per IS: 456. Over and above it has some other parameters that are required only when designed is performed as per IS: 13920. Default parameter values have been selected such that they are frequently used numbers for conventional design requirements. These values may be changed to suit the particular design being performed by this manual contains a complete list of the available parameters and their default values. It is necessary to declare length and force units as Millimeter and Newton before performing the concrete design.

4.9 Beam Design:

Beams are designed for flexure, shear and torsion. If required the effect of the axial force may be taken into consideration. For all these forces, all active beam loadings are prescanned to identify the critical load cases at different sections of the beams. For design to be performed as per IS: 13920 the width of the member shall not be less than 200mm. Also the member shall preferably have a width-to depth ratio of more than 0.3.

Design for Flexure:

Design procedure is same as that for IS 456. However while designing following criteria are satisfied as per IS-13920:

1. The minimum grade of concrete shall preferably be M20.
2. Steel reinforcements of grade Fe415 or less only shall be used.
3. The minimum tension steel ratio on any face, at any section, is given by:
   $\rho_{min} = 0.24\sqrt{fck}/fy$

The maximum steel ratio on any face, at any section, is given by $\rho_{max} = 0.025$

4. The positive steel ratio at a joint face must be at least equal to half the negative steel at that face.
5. The steel provided at each of the top and bottom face, at any section, shall at least be equal to one-fourth of the maximum negative moment steel provided at the face of either joint.

Design for Shear:

The shear force to be resisted by vertical hoops is guided by the IS 13920:1993 revision. Elastic sagging and hogging moments of resistance of the beam section at ends are considered while calculating shear force. Plastic sagging and hogging moments of resistance can also be considered for shear design if PLASTIC parameter is mentioned in the input file. Shear reinforcement is calculated to resist both shear forces and torsional moments.

4.10 Column Design:

Columns are designed for axial forces and biaxial moments per IS 456:2000. Columns are also designed for shear forces. All major criteria for selecting longitudinal and transverse reinforcement as stipulated by IS: 456 have been taken care of in the column design of STAAD. However following clauses have been satisfied to incorporate provisions of IS 13920:

1 The minimum grade of concrete shall preferably be M20

2. Steel reinforcements of grade Fe415 or less only shall be used.

3. The minimum dimension of column member shall not be less than 200 mm. For columns having unsupported length exceeding 4m, the shortest dimension of column shall not be less than 300 mm.

4. The ratio of the shortest cross-sectional dimension to the perpendicular dimension shall preferably be not less than 0.

5. The spacing of hoops shall not exceed half the least lateral dimension of the column, except where special confining reinforcement is provided.

6. Special confining reinforcement shall be provided over a length lo from each joint face, towards mid span, and on either side of any section, where flexural yielding may occur. The length lo shall not be less than a) larger lateral dimension of the member at the section where yielding occurs, b) 1/6 of clear span of the member, and c) 450 mm.

7. The spacing of hoops used as special confining reinforcement shall not exceed ¼ of minimum member dimension but need not be less than 75 mm nor more than 100 mm.

4.11 Design Operations:

STAAD contains a broad set of facilities for designing structural members as individual components of an analyzed structure. The member design facilities provide the user with the ability to carry out a number of different design operations. These facilities may design problem. The operations to perform a design are:

• Specify the members and the load cases to be considered in the design.

• Specify whether to perform code checking or member selection.

• Specify design parameter values, if different from the default values.

• Specify whether to perform member selection by optimization.

These operations may be repeated by the user any number of times depending upon the design requirements.

Earthquake motion often induces force large enough to cause inelastic deformations in the structure. If the structure is brittle, sudden failure could occur. But if the structure is made to behave ductile, it will be able to sustain the earthquake effects better with some deflection larger than the yield deflection by absorption of energy. Therefore ductility is also required as an essential element for safety from sudden collapse during severe shocks. STAAD has the capabilities of performing concrete design as per IS 13920. While designing it satisfies all provisions of IS 456 – 2000 and IS 13920 for beams and columns.

4.12 General Comments:

This section presents some general statements regarding the implementation of Indian Standard code of practice (IS: 800-1984) for structural steel design in STAAD. The design philosophy and procedural logistics for member selection and code checking are based upon the principles of allowable stress design. Two major failure modes are recognized: failure by overstressing, and failure by stability considerations. The flowing sections describe the salient features of the allowable stresses being calculated and the stability criteria being used. Members are proportioned to resist the design loads without exceeding the allowable stresses and the most economic section is selected on the basis of least weight criteria. The code checking part of the program checks stability and strength requirements and reports the critical loading condition and the governing code criteria. It is generally assumed that the user will take care of the detailing requirements like provision of stiffeners and check the local effects such as flange buckling and web crippling.

Allowable Stresses:

The member design and code checking in STAAD are based upon the allowable stress design method as per IS: 800 (1984). It is a method for proportioning structural members using design loads and forces, allowable stresses, and design limitations for the appropriate material under service conditions. It would not be possible to describe every aspect of IS: 800 in this manual. This section, however, will discuss the salient features of the allowable stresses specified by IS: 800 and implemented in STAAD. Appropriate sections of IS: 800 will be referenced during the discussion of various types of allowable stresses.

Multiple Analyses:

Structural analysis/design may require multiple analyses in the same run. STAAD allows the user to change input such as member properties, support conditions etc. in an input file to facilitate multiple analyses in the same run. Results from different analyses may be combined for design purposes. For structures with bracing, it may be necessary to make certain members inactive for a particular load case and subsequently activate them for another. STAAD provides an INACTIVE facility for this type of analysis.

4.13 Post Processing Facilities:

All output from the STAAD run may be utilized for further processing by the STAAD.Pro GUI.

Stability Requirements:

Slenderness ratios are calculated for all members and checked against the appropriate maximum values. IS: 800 summarize the maximum slenderness ratios for different types of members. In STAAD implementation of IS: 800, appropriate maximum slenderness ratio can be provided for each member. If no maximum slenderness ratio is provided, compression members will be checked against a maximum value of 180 and tension members will be checked against a maximum value of 400.

Deflection Check:

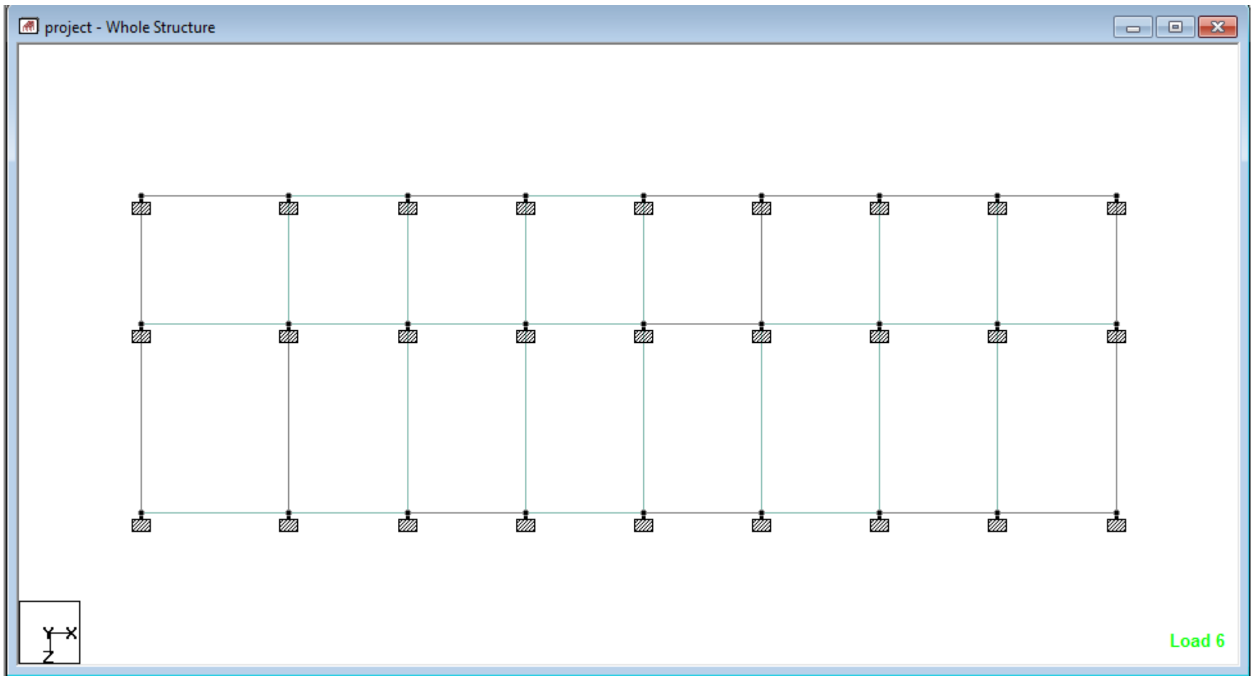
This facility allows the user to consider deflection as criteria in the CODE CHECK and MEMBER SELECTION processes. The deflection check may be controlled using three parameters. Deflection is used in addition to other strength and stability related criteria. The local deflection calculation is based on the latest analysis results.

Code Checking:

The purpose of code checking is to verify whether the specified section is capable of satisfying applicable design code requirements. The code checking is based on the IS: 800 (1984) requirements. Forces and moments at specified sections of the members are utilized for the code checking calculations. Sections may be specified using the BEAM parameter or the SECTION command. If no sections are specified, the code checking is based on forces and moments at the member ends.

CHAPTER 5

ANALYSIS OF G + 4 RCC FRAMED BUILDING WITHOUT WATER TANK USING STAAD.Pro



Plan of the G+4 storey building

All columns and columns = 0.40 * 0.45 m

All slabs = 0.125 m thick.

5.1 Physical parameters of building:

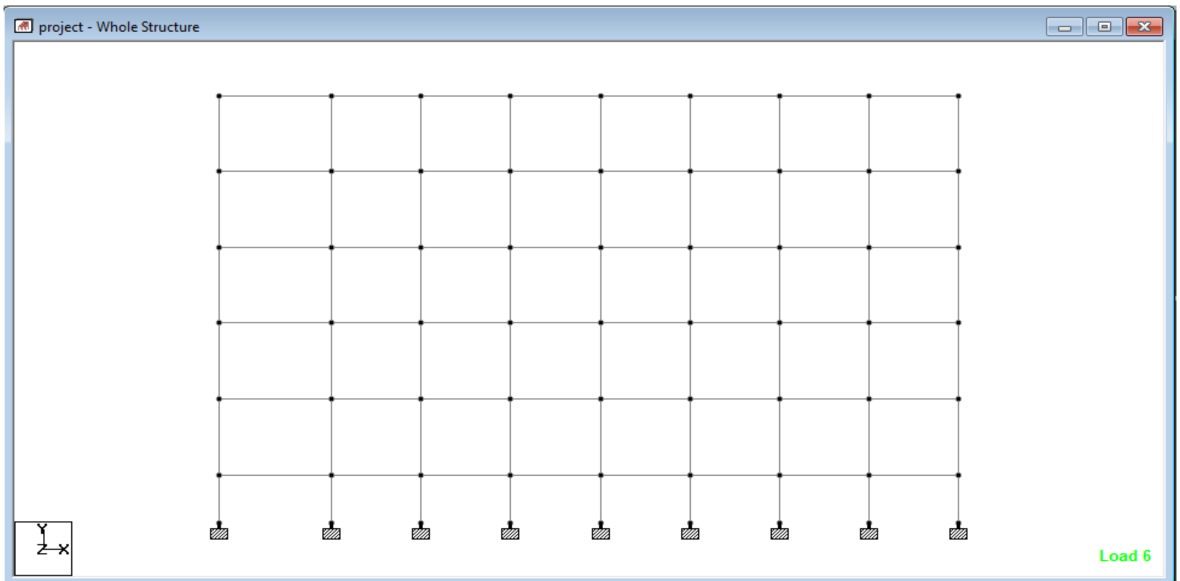
Length = 29.4 m

Width = 9.24 m

Height = 18 m

Live load on the floors is 2kN/m2 & 3kN/m2

Live load on the roof is 3kN/m2



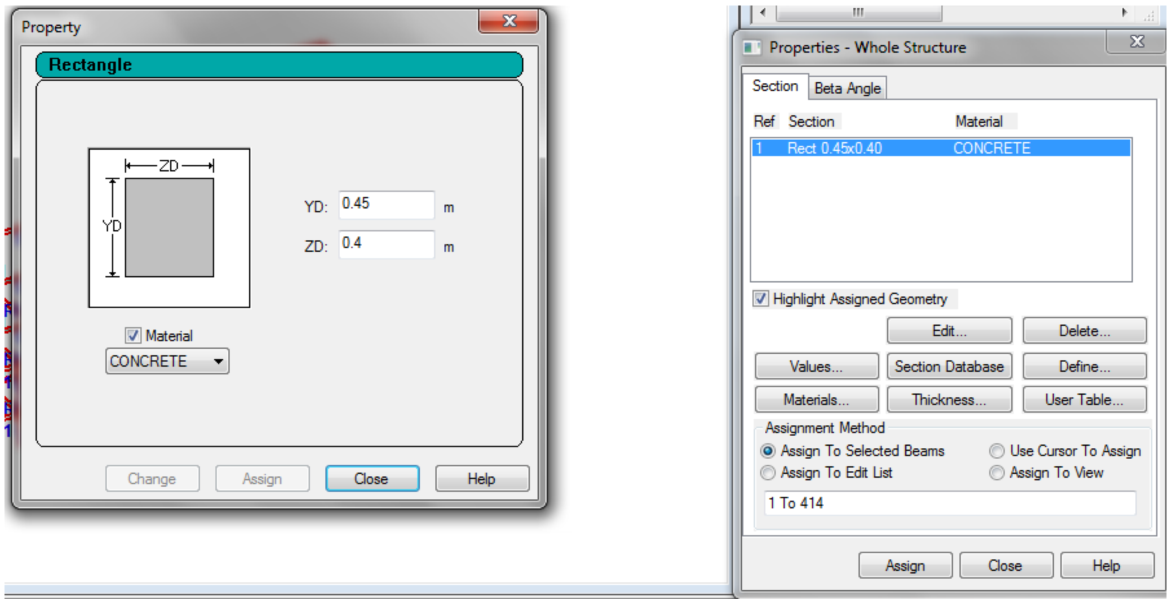
Elevation of G+4 storey building

Grade of concrete and steel used:

Used M30 concrete and Fe 415 steel

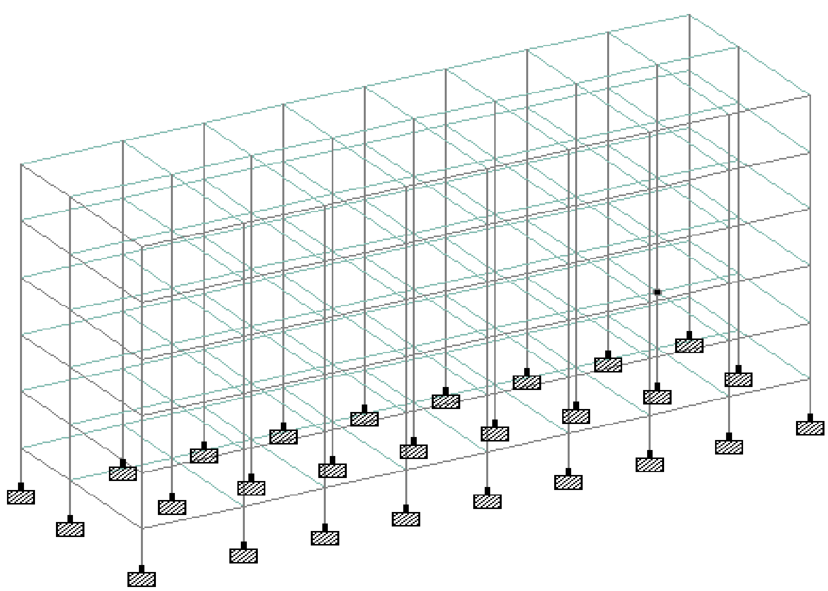
5.2 Generation of member property:

Generation of member property can be done in **STAAD.Pro** by using the window as shown above. The member section is selected and the dimensions have been specified. The beams are having a dimension of 0.4 * 0.45 m and the columns are having a dimension of 0.4 * 0.45 m.



5.3 Supports:

The base supports of the structure were assigned as fixed. The supports were generated using the STAAD.Pro support generator.



Fixing supports of the structure

5.4 Materials for the structure:

The materials for the structure were specified as concrete with their various constants as per standard IS code of practice.

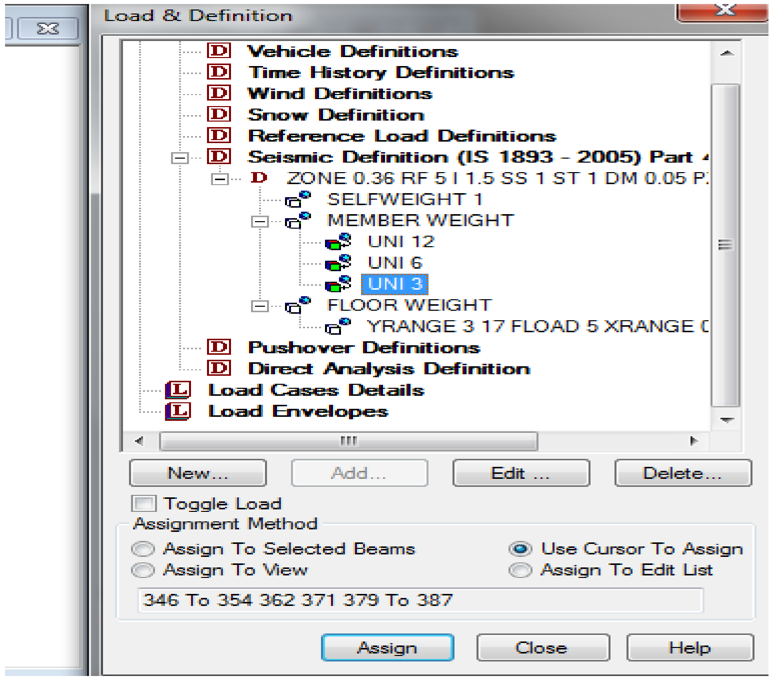
5.5 Loading:

The loadings were calculated partially manually and rest was generated using STAAD.Pro load generator. The loading cases were categorized as:

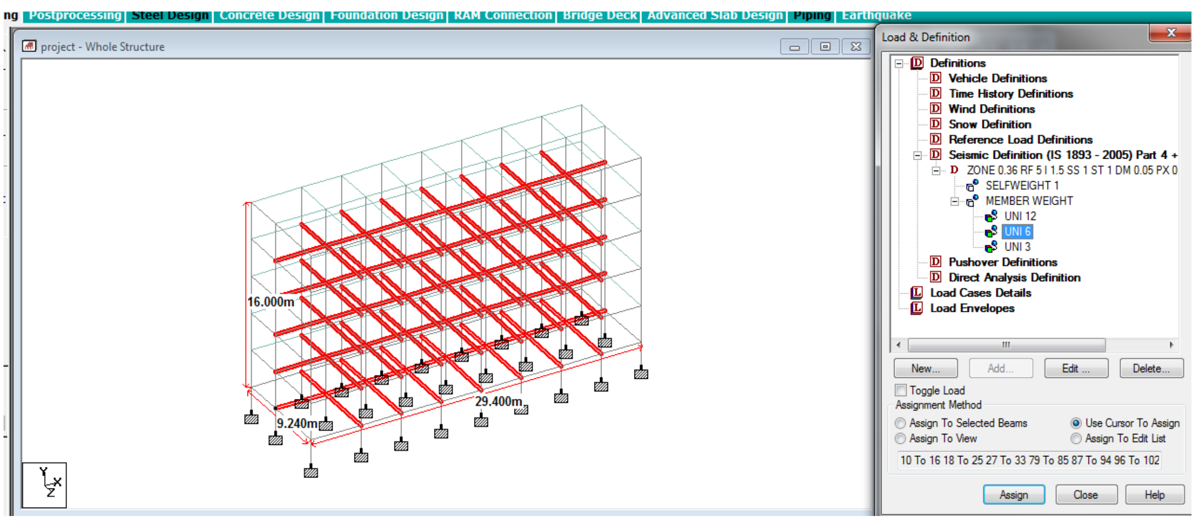
- Self-weight
- Dead load from slab
- Live load
- Seismic load
- Load combinations

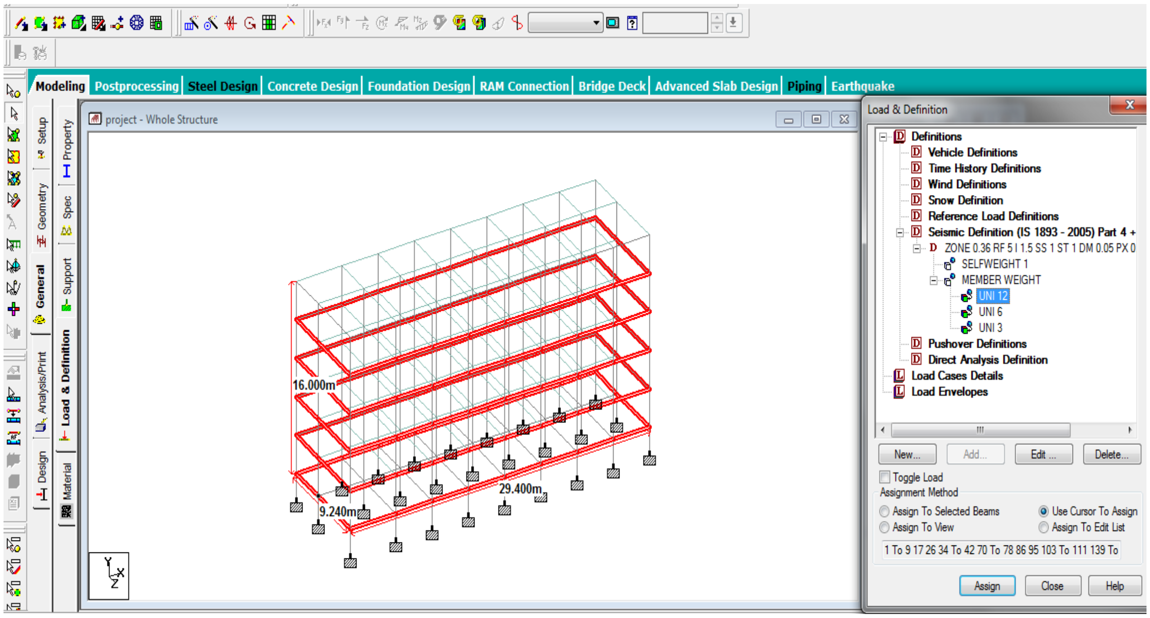
Self-weight

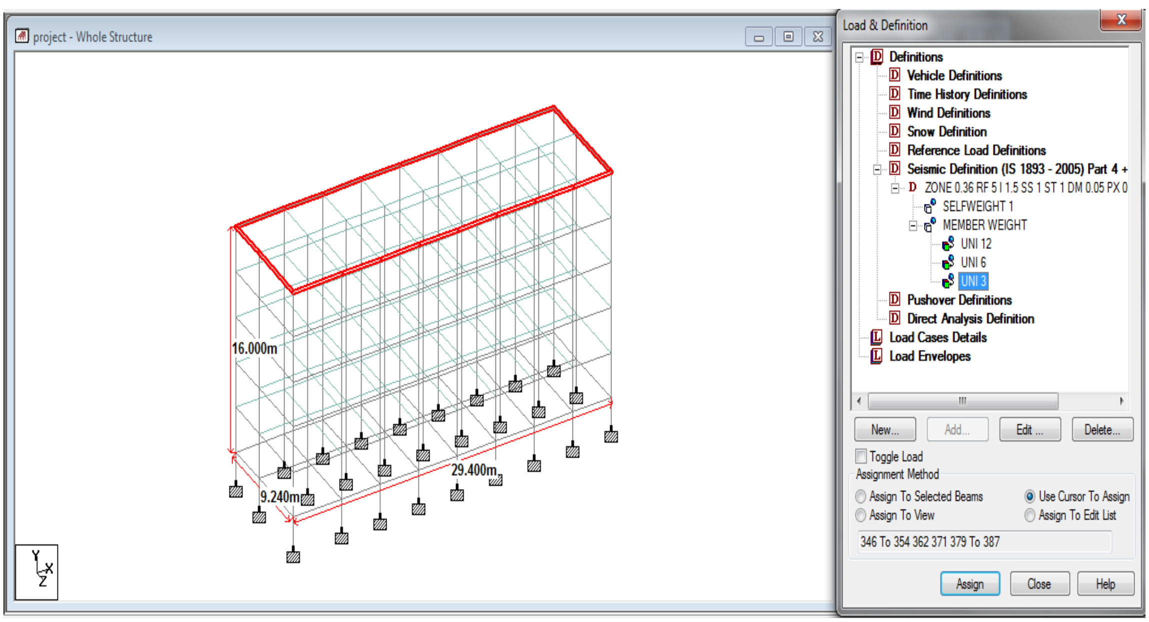
The self weight of the structure can be generated by STAAD.Pro itself with the self weight command in the load case column.



Self weight and member weight



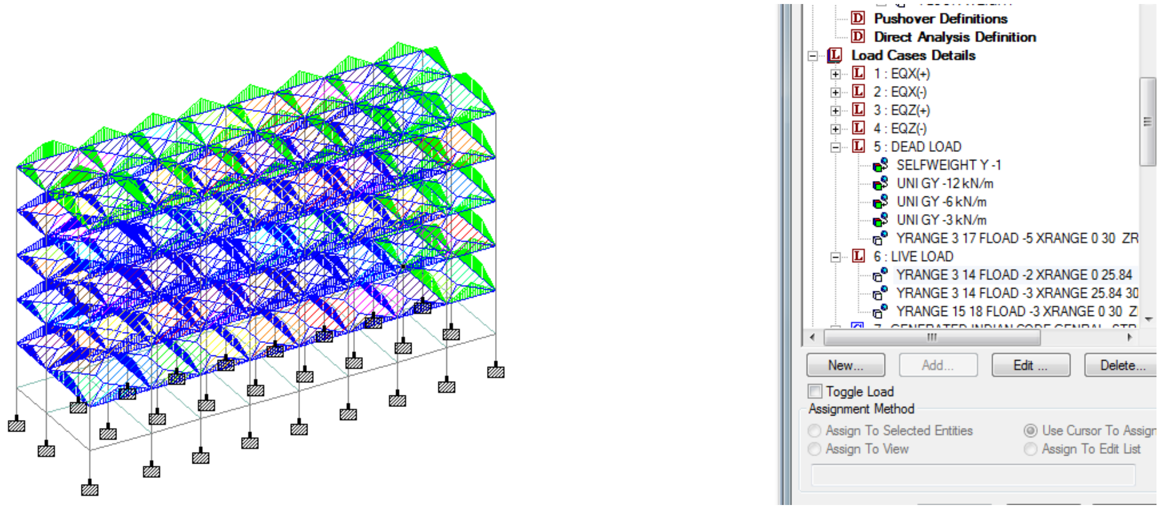




Different member weights acting on beams.

Live load:

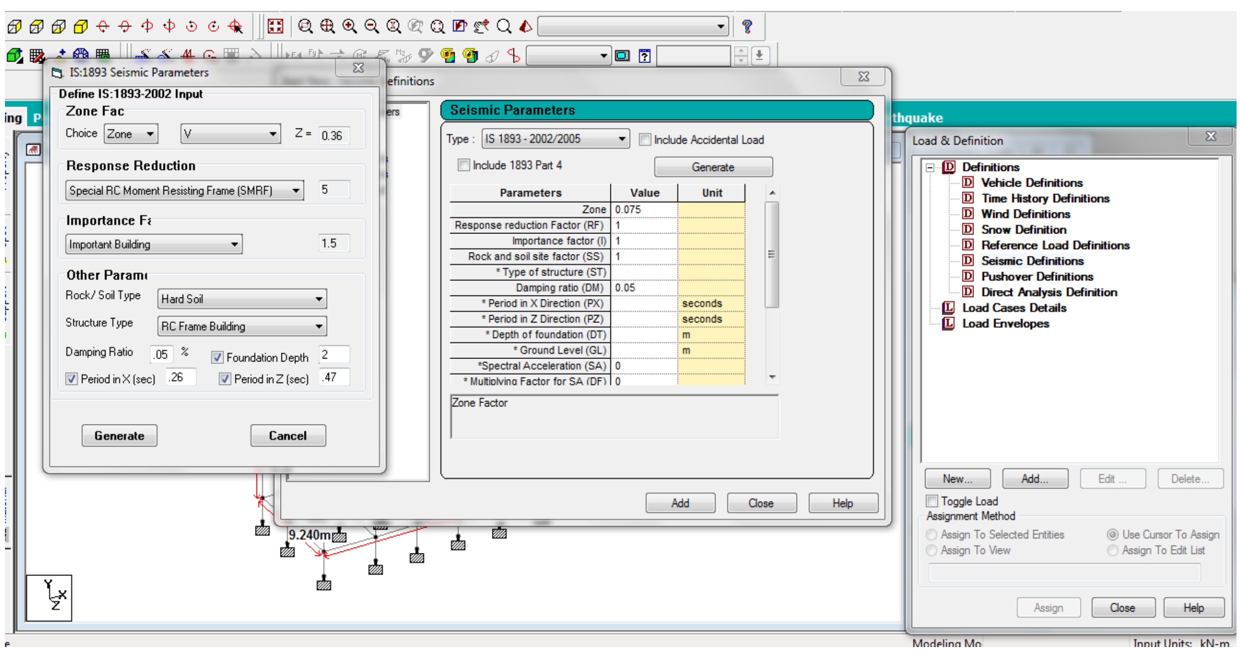
The live load considered in each floor was 2 & 3KN/sq m and for the terrace level it was considered to be 3 KN/sq m. The live loads were generated in a similar manner as done in the earlier case for dead load in each floor. This may be done from the member load button from the load case column.

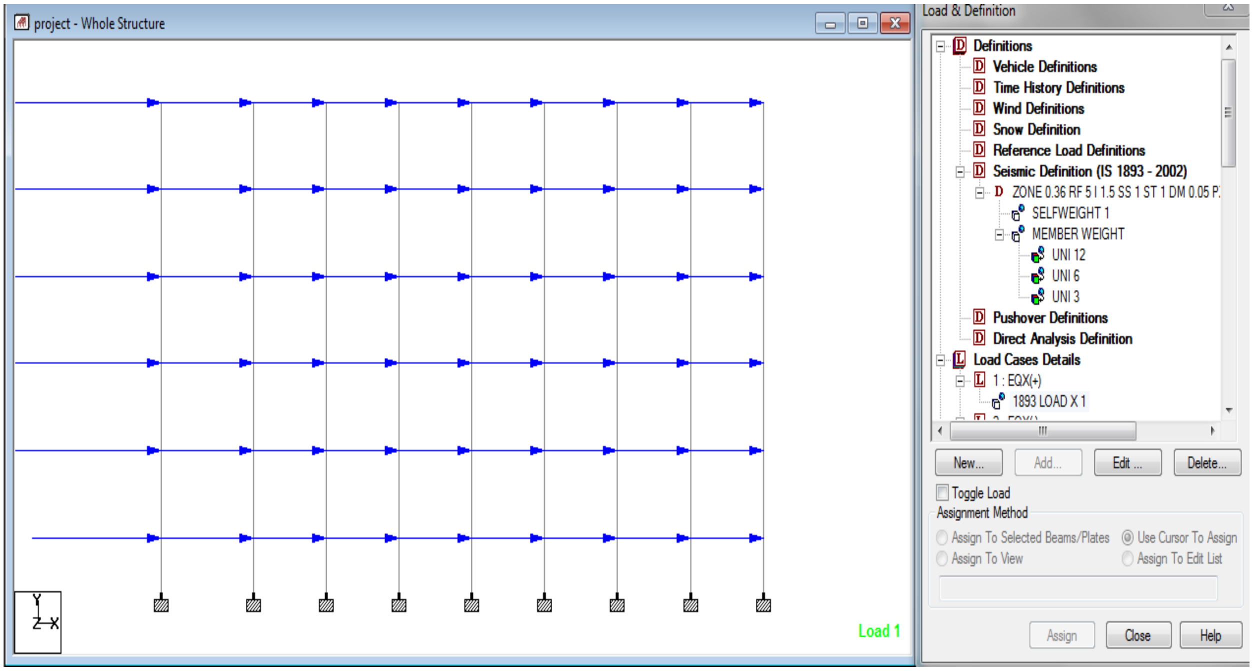


<u>Live load acting on building</u>

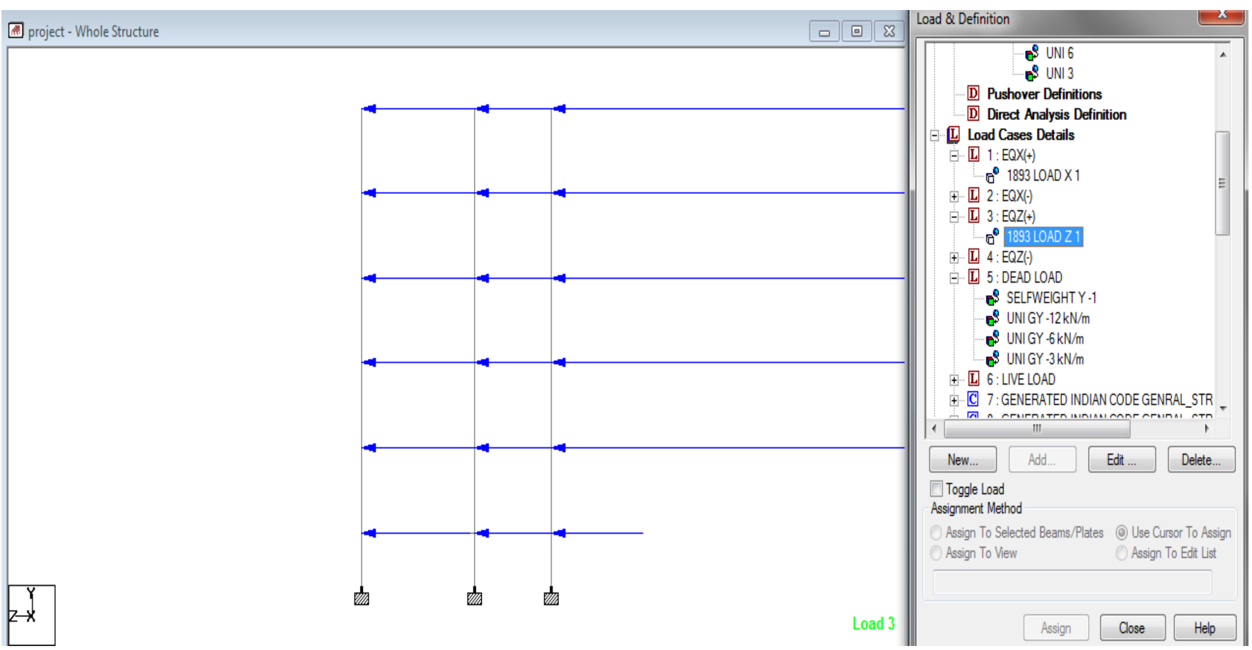
Seismic load:

The seismic load values were calculated as per IS 1893-2002. STAAD.Pro has a seismic load generator in accordance with the IS code mentioned.





Earthquake load acting on + X axis



Earthquake load acting on + Z axis

Load combination:

The structure has been analyzed for load combinations considering all the previous loads in proper ratio. In the first case a combination of self-weight, dead load, live load and wind load was taken in to consideration.

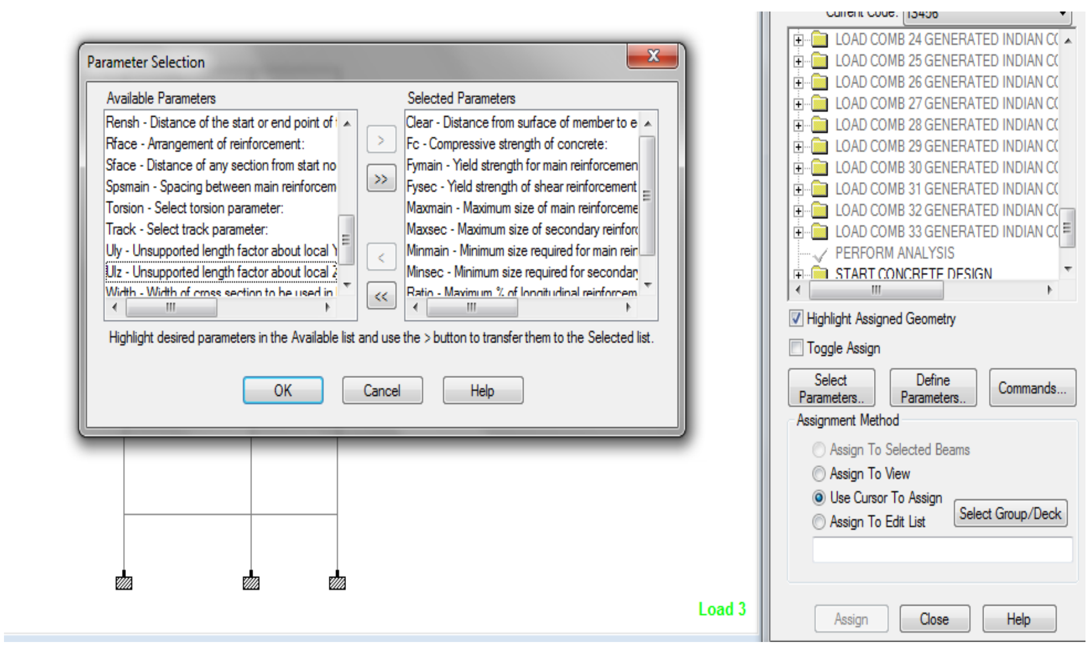
Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
7	1.5(DL+LL)	5	DEAD LOAD	1.50
		6	LIVE LOAD	1.50
8	1.5(DL+EL X+VE)	1	EQX(+)	1.50
		5	DEAD LOAD	1.50
9	1.5(DL+EL X-VE)	2	EQX(-)	1.50
		5	DEAD LOAD	1.50
10	1.5(DL+EL Z+VE)	3	EQZ(+)	1.50
		5	DEAD LOAD	1.50
11	1.2(DL+LL+EL X +VE)	1	EQX(+)	1.20
		5	DEAD LOAD	1.20
		6	LIVE LOAD	1.20
12	1.2(DL+LL+ EL X-VE)	2	EQX(-)	1.20
		5	DEAD LOAD	1.20
		6	LIVE LOAD	1.20
13	1.2(DL+LL+ EL Z+VE)	3	EQZ(+)	1.20
		5	DEAD LOAD	1.20
		6	LIVE LOAD	1.20
14	1.2(DL+LL+ EL Z-VE)	4	EQZ(-)	1.20
		5	DEAD LOAD	1.20
		6	LIVE LOAD	1.20
15	1.2(DL+LL- EL X+VE)	5	DEAD LOAD	1.20
		6	LIVE LOAD	1.20
		1	EQX(+)	-1.20
16	1.2(DL+LL- EL X-VE)	5	DEAD LOAD	1.20
		6	LIVE LOAD	1.20
		2	EQX(-)	-1.20
17	1.2(DL+LL- EL Z+VE)	5	DEAD LOAD	1.20
		6	LIVE LOAD	1.20
		3	EQZ(+)	-1.20

18	1.2(DL+LL- EL Z-VE)	5	DEAD LOAD	1.20
		6	LIVE LOAD	1.20
		4	EQZ(-)	-1.20
19	1.5(DL+EL Z-VE)	4	EQZ(-)	1.50
		5	DEAD LOAD	1.50
20	1.5(DL-EL X+VE)	5	DEAD LOAD	1.50
		1	EQX(+)	-1.50
21	1.5(DL-EL X-VE)	5	DEAD LOAD	1.50
		2	EQX(-)	-1.50
22	1.5(DL-EL Z+VE)	5	DEAD LOAD	1.50
		3	EQZ(+)	-1.50
23	1.5(DL-EL Z-VE)	5	DEAD LOAD	1.50
		4	EQZ(-)	-1.50
24	0.9 DL + 1.5 EL X+VE	5	DEAD LOAD	0.90
		1	EQX(+)	1.50
25	0.9 DL + 1.5 EL X-VE	5	DEAD LOAD	0.90
		2	EQX(-)	1.50
26	0.9 DL + 1.5 EL Z+VE	5	DEAD LOAD	0.90
		3	EQZ(+)	1.50
27	0.9 DL + 1.5 EL Z-VE	5	DEAD LOAD	0.90
		4	EQZ(-)	1.50
28	0.9 DL - 1.5 EL X+VE	5	DEAD LOAD	0.90
		1	EQX(+)	-1.50
29	0.9 DL - 1.5 EL X-VE	5	DEAD LOAD	0.90
		2	EQX(-)	-1.50
30	0.9 DL - 1.5 EL Z+VE	5	DEAD LOAD	0.90
		3	EQZ(+)	-1.50
31	0.9 DL - 1.5 EL Z-VE	5	DEAD LOAD	0.90
		4	EQZ(-)	-1.50

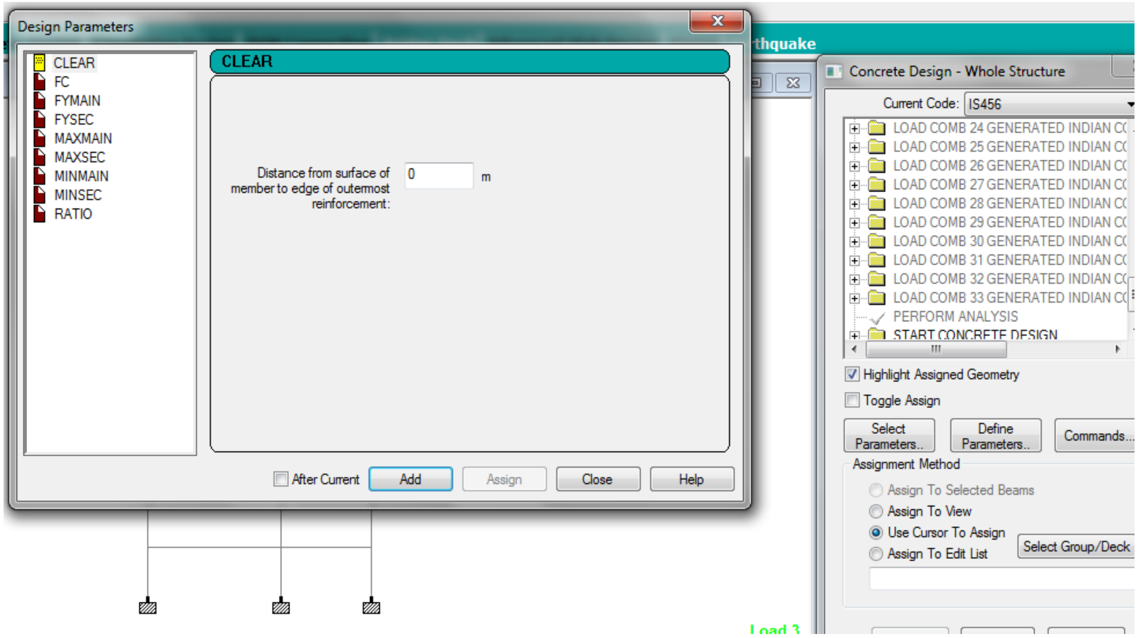
CHAPTER 6

DESIGN OF G + 4 RCC FRAMED BUILDING WITHOUT WATER TANK USING STAAD.Pro

The structure was designed for concrete in accordance with IS code. The parameters such as clear cover, Fy, Fc, etc were specified. The window shown below is the input window for the design purpose. Then it has to be specified which members are to be designed as beams and which member are to be designed as columns.



Parameters Selection



Parameters definition

CHAPTER 7

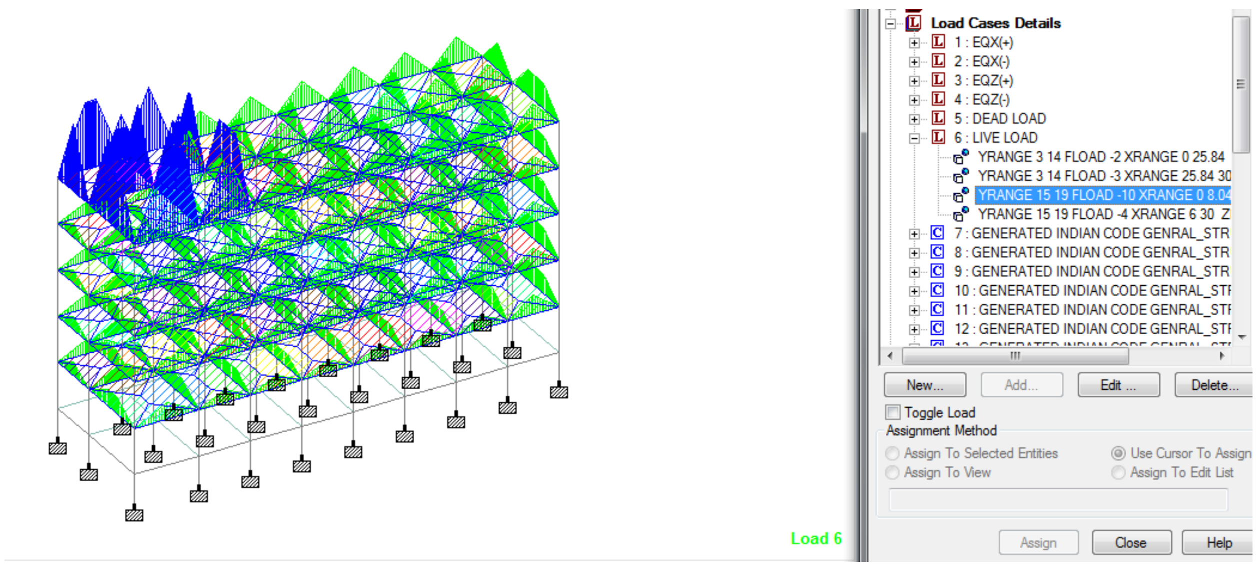
ANALYSIS AND DESIGN OF G + 4 RCC FRAMED BUILDING WITH WATER TANK USING STAAD.Pro

7.1 Extra Live Load

An extra live load of 10 Kn/m2 is applied on top of the building.

Size of tank 6m X 5m X 1m.

Live load = 10 kN/m^2



The design and analysis of this building will be same as that of previous one. Only this extra live load will act on the building and the difference is analyzed.

STAAD.Pro INPUT COMMAND FILE

```
STAAD SPACE
START JOB INFORMATION
ENGINEER DATE 11-Nov-15
END JOB INFORMATION
INPUT WIDTH 79
UNIT METER KN
JOINT COORDINATES
1 0 0 0; 2 4.48 0 0; 3 8.04 0 0; 4 11.6 0 0; 5 15.16 0 0; 6 18.72 0 0;
7 22.28 0 0; 8 25.84 0 0; 9 29.4 0 0; 10 0 0 3.72; 11 4.48 0 3.72;
12 8.04 0 3.72; 13 11.6 0 3.72; 14 15.16 0 3.72; 15 18.72 0 3.72;
16 22.28 0 3.72; 17 25.84 0 3.72; 18 29.4 0 3.72; 19 0 0 9.24; 20 4.48 0 9.24;
21 8.04 0 9.24; 22 11.6 0 9.24; 23 15.16 0 9.24; 24 18.72 0 9.24;
25 22.28 0 9.24; 26 25.84 0 9.24; 27 29.4 0 9.24; 28 0 3.2 0; 29 4.48 3.2 0;
30 8.04 3.2 0; 31 11.6 3.2 0; 32 15.16 3.2 0; 33 18.72 3.2 0; 34 22.28 3.2 0;
35 25.84 3.2 0; 36 29.4 3.2 0; 37 0 3.2 3.72; 38 4.48 3.2 3.72;
39 8.04 3.2 3.72; 40 11.6 3.2 3.72; 41 15.16 3.2 3.72; 42 18.72 3.2 3.72;
43 22.28 3.2 3.72; 44 25.84 3.2 3.72; 45 29.4 3.2 3.72; 46 0 3.2 9.24;
47 4.48 3.2 9.24; 48 8.04 3.2 9.24; 49 11.6 3.2 9.24; 50 15.16 3.2 9.24;
51 18.72 3.2 9.24; 52 22.28 3.2 9.24; 53 25.84 3.2 9.24; 54 29.4 3.2 9.24;
55 0 6.4 0; 56 4.48 6.4 0; 57 8.04 6.4 0; 58 11.6 6.4 0; 59 15.16 6.4 0;
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65 4.48 6.4 3.72; 66 8.04 6.4 3.72; 67 11.6 6.4 3.72; 68 15.16 6.4 3.72;
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77 15.16 6.4 9.24; 78 18.72 6.4 9.24; 79 22.28 6.4 9.24; 80 25.84 6.4 9.24;
81 29.4 6.4 9.24; 82 0 9.6 0; 83 4.48 9.6 0; 84 8.04 9.6 0; 85 11.6 9.6 0;
86 15.16 9.6 0; 87 18.72 9.6 0; 88 22.28 9.6 0; 89 25.84 9.6 0; 90 29.4 9.6 0;
91 0 9.6 3.72; 92 4.48 9.6 3.72; 93 8.04 9.6 3.72; 94 11.6 9.6 3.72;
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99 29.4 9.6 3.72; 100 0 9.6 9.24; 101 4.48 9.6 9.24; 102 8.04 9.6 9.24;
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ELEMENT PROPERTY
415 TO 510 THICKNESS 0.125
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
END DEFINE MATERIAL
MEMBER PROPERTY AMERICAN
1 TO 414 511 TO 526 PRIS YD 0.45 ZD 0.45
CONSTANTS
MATERIAL CONCRETE ALL
SUPPORTS
163 TO 189 FIXED
DEFINE 1893 LOAD
ZONE 0.36 RF 5 I 1.5 SS 1 ST 1 DM 0.05 PX 0.26 PZ 0.47 DT 2
SELFWEIGHT 1
MEMBER WEIGHT
1 TO 9 17 26 34 TO 42 70 TO 78 86 95 103 TO 111 139 TO 147 155 164 -
172 TO 180 208 TO 216 224 233 241 TO 249 277 TO 285 293 302 310 TO 317 -
318 UNI 12
10 TO 16 18 TO 25 27 TO 33 79 TO 85 87 TO 94 96 TO 102 148 TO 154 156 TO 163 -
165 TO 171 217 TO 223 225 TO 232 234 TO 240 286 TO 292 294 TO 301 -
303 TO 309 UNI 6
348 TO 353 362 379 382 TO 387 UNI 3
346 347 354 356 371 373 380 381 UNI 4.5
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1893 LOAD X 1
LOAD 2 LOADTYPE Seismic  TITLE EQX(-)
1893 LOAD X -1
LOAD 3 LOADTYPE Seismic  TITLE EQZ(+)
1893 LOAD Z 1
LOAD 4 LOADTYPE Seismic  TITLE EQZ(-)
1893 LOAD X -1
LOAD 5 LOADTYPE Dead  TITLE DEAD LOAD
SELFWEIGHT Y -1
MEMBER LOAD
1 TO 9 17 26 34 TO 42 70 TO 78 86 95 103 TO 111 139 TO 147 155 164 -
172 TO 180 208 TO 216 224 233 241 TO 249 277 TO 285 293 302 310 TO 317 -
318 UNI GY -12
10 TO 16 18 TO 25 27 TO 33 79 TO 85 87 TO 94 96 TO 102 148 TO 154 156 TO 163 -
165 TO 171 217 TO 223 225 TO 232 234 TO 240 286 TO 292 294 TO 301 -
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303 TO 309 UNI GY -6
348 TO 353 362 379 382 TO 387 UNI GY -3
346 347 354 356 371 373 380 381 UNI GY -4.5
LOAD 6 LOADTYPE Live TITLE LIVE LOAD
FLOOR LOAD
YRANGE 3 14 FLOAD -2 XRANGE 0 25.84 ZRANGE 0 10 GY
YRANGE 3 14 FLOAD -3 XRANGE 25.84 30 ZRANGE 0 10 GY
YRANGE 15 19 FLOAD -10 XRANGE 0 8.04 ZRANGE 0 10 GY
YRANGE 15 19 FLOAD -4 XRANGE 6 30 ZRANGE 0 10 GY
LOAD COMB 7 1.5(DL+LL)
5 1.5 6 1.5
LOAD COMB 8 1.5(DL+EL X+VE)
1 1.5 5 1.5
LOAD COMB 9 1.5(DL+EL X-VE)
2 1.5 5 1.5
LOAD COMB 10 1.5(DL+EL Z+VE)
3 1.5 5 1.5
LOAD COMB 11 1.2(DL+LL+EL X +VE)
1 1.2 5 1.2 6 1.2
LOAD COMB 12 1.2(DL+LL+ EL X-VE)
2 1.2 5 1.2 6 1.2
LOAD COMB 13 1.2(DL+LL+ EL Z+VE)
3 1.2 5 1.2 6 1.2
LOAD COMB 14 1.2(DL+LL+ EL Z-VE)
4 1.2 5 1.2 6 1.2
LOAD COMB 15 1.2(DL+LL- EL X+VE)
5 1.2 6 1.2 1 -1.2
LOAD COMB 16 1.2(DL+LL- EL X-VE)
5 1.2 6 1.2 2 -1.2
LOAD COMB 17 1.2(DL+LL- EL Z+VE)
5 1.2 6 1.2 3 -1.2
LOAD COMB 18 1.2(DL+LL- EL Z-VE)
5 1.2 6 1.2 4 -1.2
LOAD COMB 19 1.5(DL+EL Z-VE)
4 1.5 5 1.5
LOAD COMB 20 1.5(DL-EL X+VE)
5 1.5 1 -1.5
LOAD COMB 21 1.5(DL-EL X-VE)
5 1.5 2 -1.5
LOAD COMB 22 1.5(DL-EL Z+VE)
5 1.5 3 -1.5
LOAD COMB 23 1.5(DL-EL Z-VE)
5 1.5 4 -1.5
LOAD COMB 24 0.9 DL + 1.5 ELX+VE
5 0.9 1 1.5
LOAD COMB 25 0.9 DL + 1.5 EL X-VE
5 0.9 2 1.5
LOAD COMB 26 0.9 DL + 1.5 EL Z+VE
5 0.9 3 1.5

```
LOAD COMB 27 0.9 DL + 1.5 EL Z-VE
5 0.9 4 1.5
LOAD COMB 28 0.9 DL - 1.5 EL X+VE
5 0.9 1 -1.5
LOAD COMB 29 0.9 DL - 1.5 EL X-VE
5 0.9 2 -1.5
LOAD COMB 30 0.9 DL - 1.5 EL Z+VE
5 0.9 3 -1.5
LOAD COMB 31 0.9 DL - 1.5 EL Z-VE
5 0.9 4 -1.5
PERFORM ANALYSIS
START CONCRETE DESIGN
CODE INDIAN
CLEAR 0.04 MEMB 1 TO 414
FC 30000 MEMB 1 TO 414
FYMAIN 415000 MEMB 1 TO 414
FYSEC 415000 MEMB 1 TO 414
MAXSEC 12 MEMB 1 TO 414
MINMAIN 12 MEMB 1 TO 414
MINSEC 8 MEMB 1 TO 414
RATIO 4 MEMB 1 TO 414
DESIGN COLUMN 43 TO 69 112 TO 138 181 TO 207 250 TO 276 319 TO 345 388 TO 414
DESIGN BEAM 1 TO 42 70 TO 111 139 TO 180 208 TO 249 277 TO 318 346 TO 387
CONCRETE TAKE
DESIGN ELEMENT 415 TO 510
END CONCRETE DESIGN
LOAD LIST ALL
PRINT STORY DRIFT 250.000000
PRINT JOINT DISPLACEMENTS LIST 136 TO 162
FINISH
```

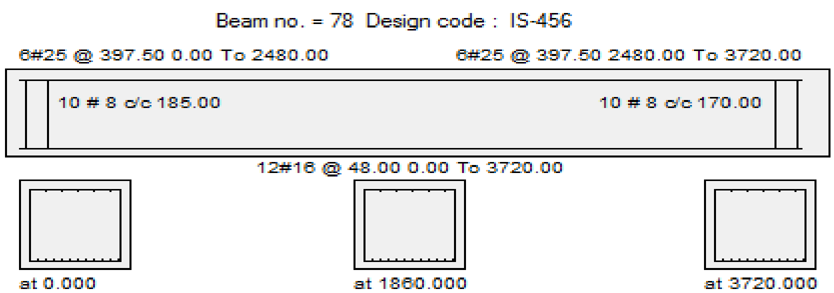
CHAPTER 8

DESIGN AND POST PROCESING RESULTS

8.1 DESIGN RESULTS

1ST Placement

BEAM NO. 78



Design Load

Mz Kn Met	Dist. Met	Load
273.76	0	26
-318.95	0	22
-287.24	3.7	10

Design Parameter

Fy(Mpa)	415
Fc(Mpa)	30
Depth(m)	0.449999988
Width(m)	0.449999988
Length(m)	3.720000028

B E A M N O. 78 D E S I G N R E S U L T S

M30 Fe415 (Main) Fe415 (Sec.)

LENGTH: 3720.0 mm SIZE: 450.0 mm X 450.0 mm COVER: 40.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

SECTION	0.0 mm	930.0 mm	1860.0 mm	2790.0 mm	3720.0 mm
TOP REINF.	2831.93 (Sq. mm)	1168.30 (Sq. mm)	370.52 (Sq. mm)	890.65 (Sq. mm)	2546.35 (Sq. mm)
BOTTOM REINF.	2385.32 (Sq. mm)	1210.57 (Sq. mm)	370.52 (Sq. mm)	941.43 (Sq. mm)	1990.45 (Sq. mm)

```
                    SUMMARY OF PROVIDED REINF. AREA
----------------------------------------------------------------------------
SECTION       0.0 mm       930.0 mm      1860.0 mm      2790.0 mm      3720.0 mm
----------------------------------------------------------------------------
 TOP         6-25í          3-25í          3-25í          3-25í          6-25í
REINF.    1 layer(s)     1 layer(s)     1 layer(s)     1 layer(s)     1 layer(s)

BOTTOM     12-16í          7-16í          3-16í          5-16í         10-16í
REINF.    2 layer(s)     1 layer(s)     1 layer(s)     1 layer(s)     2 layer(s)

SHEAR    2 legged  8í   2 legged  8í   2 legged  8í   2 legged  8í   2 legged  8í
REINF.   @ 185 mm c/c   @ 170 mm c/c   @ 185 mm c/c   @ 175 mm c/c   @ 185 mm c/c
----------------------------------------------------------------------------

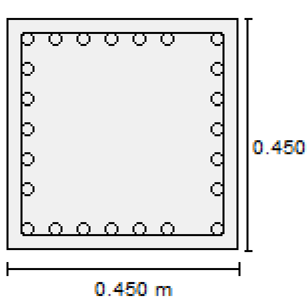

SHEAR DESIGN RESULTS AT DISTANCE d (EFFECTIVE DEPTH) FROM FACE OF THE SUPPORT
-----------------------------------------------------------------------------

SHEAR DESIGN RESULTS AT   622.5 mm AWAY FROM START SUPPORT
  VY =    177.92 MX =     -2.78 LD=    22
  Provide 2 Legged  8í  @ 160 mm c/c

SHEAR DESIGN RESULTS AT   622.5 mm AWAY FROM END SUPPORT
  VY =  -178.84 MX =      1.36 LD=    10
  Provide 2 Legged  8í  @ 170 mm c/c
```

<u>COLUMN NO 122</u>

Beam no. = 122 Design code : IS-456



Design Load

Load	30
Location	End 2
Pu(Kns)	375.23
Mz(Kns-Mt)	2.09
My(Kns-Mt)	292.79

Design Parameter

Fy(Mpa)	415
Fc(Mpa)	30
As Reqd(mm²)	4286
As (%)	2.38
Bar Size	16
Bar No	24

```
           C O L U M N   N O.    122  D E S I G N   R E S U L T S

        M30                      Fe415 (Main)                Fe415 (Sec.)

  LENGTH:  3200.0 mm   CROSS SECTION:  450.0 mm X  450.0 mm  COVER: 40.0 mm

  ** GUIDING LOAD CASE:   30 END JOINT:    65  SHORT COLUMN

--------------------------------< PAGE 33 Ends Here >---------------------------
   STAAD SPACE                                                 -- PAGE NO.   34


  REQD. STEEL AREA    :     4285.62 Sq.mm.
  REQD. CONCRETE AREA:   198214.38 Sq.mm.
  MAIN REINFORCEMENT : Provide  24 - 16 dia. (2.38%,   4825.49 Sq.mm.)
                       (Equally distributed)
  TIE REINFORCEMENT  : Provide  8 mm dia. rectangular ties @ 255 mm c/c

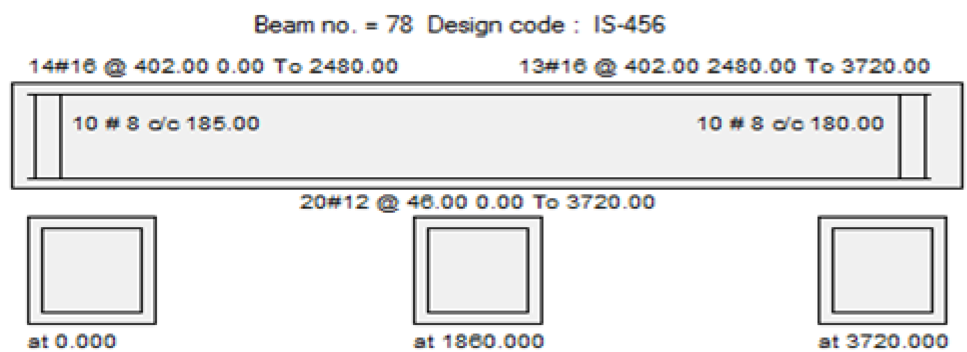
  SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)
  ----------------------------------------------------------
  Puz :    4009.79   Muz1 :    300.85   Muy1 :    300.85

  INTERACTION RATIO: 1.00 (as per Cl. 39.6, IS456:2000)

  SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)
  ----------------------------------------------------------
  WORST LOAD CASE:    30
  END JOINT:    65 Puz :   4170.54   Muz :    326.80   Muy :    326.80   IR: 0.92
```

2^{nd} PLACEMENT

BEAM NO. 78



Design Load

Mz Kn Met	Dist. Met	Load
262.47	0	26
-308.02	0	22
-277.06	3.7	10

Design Parameter

Fy(Mpa)	415
Fc(Mpa)	30
Depth(m)	0.449999988
Width(m)	0.449999988
Length(m)	3.720000028

B E A M N O. 78 D E S I G N R E S U L T S

M30 Fe415 (Main) Fe415 (Sec.)

LENGTH: 3720.0 mm SIZE: 450.0 mm X 450.0 mm COVER: 40.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

SECTION	0.0 mm	930.0 mm	1860.0 mm	2790.0 mm	3720.0 mm
TOP REINF.	2735.45 (Sq. mm)	1114.98 (Sq. mm)	370.52 (Sq. mm)	848.75 (Sq. mm)	2412.77 (Sq. mm)
BOTTOM REINF.	2235.48 (Sq. mm)	1155.68 (Sq. mm)	370.52 (Sq. mm)	900.88 (Sq. mm)	1888.17 (Sq. mm)

SUMMARY OF PROVIDED REINF. AREA

SECTION	0.0 mm	930.0 mm	1860.0 mm	2790.0 mm	3720.0 mm
TOP REINF.	14-16í 2 layer(s)	6-16í 1 layer(s)	3-16í 1 layer(s)	5-16í 1 layer(s)	13-16í 2 layer(s)
BOTTOM REINF.	20-12í 2 layer(s)	11-12í 2 layer(s)	4-12í 1 layer(s)	8-12í 1 layer(s)	17-12í 2 layer(s)
SHEAR REINF.	2 legged 8í @ 185 mm c/c	2 legged 8í @ 180 mm c/c	2 legged 8í @ 185 mm c/c	2 legged 8í @ 185 mm c/c	2 legged 8í @ 185 mm c/c

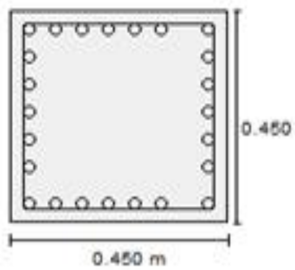
SHEAR DESIGN RESULTS AT DISTANCE d (EFFECTIVE DEPTH) FROM FACE OF THE SUPPORT

SHEAR DESIGN RESULTS AT 615.6 mm AWAY FROM START SUPPORT
VY = 172.40 MX = -2.31 LD= 22
Provide 2 Legged 8í @ 170 mm c/c

SHEAR DESIGN RESULTS AT 617.2 mm AWAY FROM END SUPPORT
VY = -173.04 MX = 0.91 LD= 10
Provide 2 Legged 8í @ 175 mm c/c

COLUMN NO 122

Beam no. = 122 Design code : IS-456



Design Load

Load	30
Location	End 2
Pu(Kns)	374.85
Mz(Kns-Mt)	1.42
My(Kns-Mt)	285.03

Design Parameter

Fy(Mpa)	415
Fc(Mpa)	30
As Reqd(mm²)	4156
As (%)	2.38
Bar Size	16
Bar No	24

```
          C O L U M N   N O.   122  D E S I G N   R E S U L T S

        M30                    Fe415 (Main)                 Fe415 (Sec.)

    LENGTH:  3200.0 mm   CROSS SECTION:  450.0 mm X  450.0 mm  COVER: 40.0 mm

    ** GUIDING LOAD CASE:   30 END JOINT:    65  SHORT COLUMN

--------------------------------< PAGE 33 Ends Here >---------------------------
     STAAD SPACE                                                  -- PAGE NO.   34


    REQD. STEEL AREA    :     4156.01 Sq.mm.
    REQD. CONCRETE AREA:   198343.98 Sq.mm.
    MAIN REINFORCEMENT : Provide  24 - 16 dia. (2.38%,   4825.49 Sq.mm.)
                         (Equally distributed)
    TIE REINFORCEMENT  : Provide  8 mm dia. rectangular ties @ 255 mm c/c

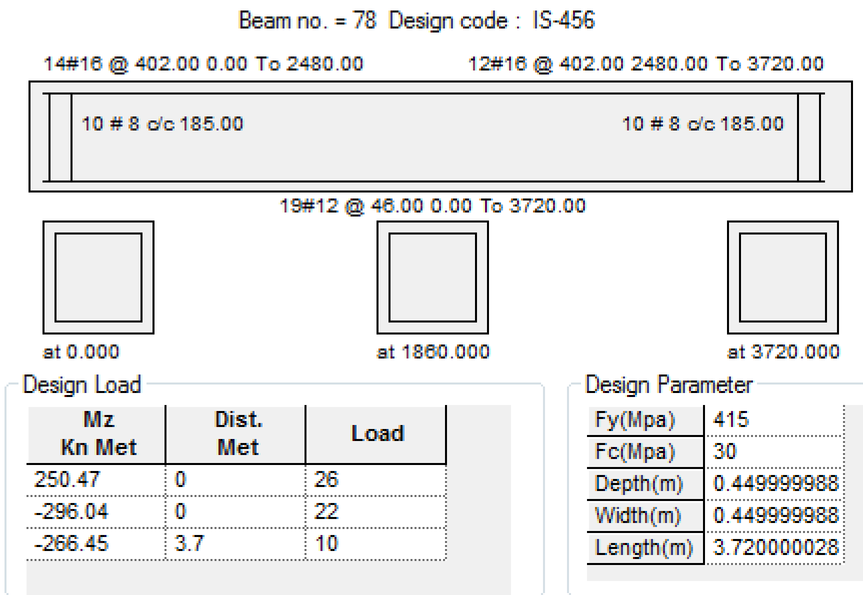
    SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)
    ----------------------------------------------------------
    Puz :   3971.20   Muz1 :    294.56   Muy1 :    294.56

    INTERACTION RATIO: 0.99 (as per Cl. 39.6, IS456:2000)

    SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)
    ----------------------------------------------------------
    WORST LOAD CASE:    30
    END JOINT:     65 Puz :   4170.54   Muz :    326.78   Muy :    326.78   IR: 0.90
```

3rd PLACEMENT

BEAM NO. 78



B E A M N O. 78 D E S I G N R E S U L T S

M30 Fe415 (Main) Fe415 (Sec.)

LENGTH: 3720.0 mm SIZE: 450.0 mm X 450.0 mm COVER: 40.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

SECTION	0.0 mm	930.0 mm	1860.0 mm	2790.0 mm	3720.0 mm
TOP REINF.	2624.39 (Sq. mm)	1057.79 (Sq. mm)	372.36 (Sq. mm)	805.10 (Sq. mm)	2288.17 (Sq. mm)
BOTTOM REINF.	2142.77 (Sq. mm)	1091.43 (Sq. mm)	372.36 (Sq. mm)	852.02 (Sq. mm)	1810.76 (Sq. mm)

```
                     SUMMARY OF PROVIDED REINF. AREA
----------------------------------------------------------------------------
SECTION       0.0 mm       930.0 mm      1860.0 mm      2790.0 mm      3720.0 mm
----------------------------------------------------------------------------
 TOP       14-16í         6-16í          3-16í          5-16í          12-16í
REINF.   2 layer(s)    1 layer(s)     1 layer(s)     1 layer(s)     2 layer(s)

BOTTOM     19-12í        10-12í          4-12í          8-12í          17-12í
REINF.   2 layer(s)    1 layer(s)     1 layer(s)     1 layer(s)     2 layer(s)

SHEAR   2 legged  8í  2 legged  8í  2 legged  8í  2 legged  8í  2 legged  8í
REINF.  @ 185 mm c/c  @ 185 mm c/c  @ 185 mm c/c  @ 185 mm c/c  @ 185 mm c/c
----------------------------------------------------------------------------

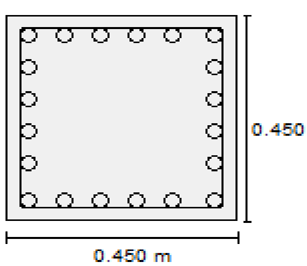

SHEAR DESIGN RESULTS AT DISTANCE d (EFFECTIVE DEPTH) FROM FACE OF THE SUPPORT
-----------------------------------------------------------------------------

SHEAR DESIGN RESULTS AT    615.6 mm AWAY FROM START SUPPORT
  VY =    166.33 MX =    -1.83 LD=    22
  Provide 2 Legged  8í  @ 180 mm c/c

SHEAR DESIGN RESULTS AT    619.0 mm AWAY FROM END SUPPORT
  VY =  -166.96 MX =     0.42 LD=    10
  Provide 2 Legged  8í  @ 185 mm c/c
```

COLUMN NO. 122

Beam no. = 122 Design code : IS-456



Design Load

Load	30
Location	End 2
Pu(Kns)	374.9
Mz(Kns-Mt)	1.67
My(Kns-Mt)	276.45

Design Parameter

Fy(Mpa)	415
Fc(Mpa)	30
As Reqd(mm²)	3977
As (%)	1.98
Bar Size	16
Bar No	20

```
          C O L U M N   N O.   122  D E S I G N   R E S U L T S

     M30                    Fe415 (Main)                Fe415 (Sec.)

 LENGTH:  3200.0 mm   CROSS SECTION:  450.0 mm X  450.0 mm  COVER: 40.0 mm

 ** GUIDING LOAD CASE:   30 END JOINT:    65  SHORT COLUMN

-------------------------------< PAGE 33 Ends Here >---------------------------
  STAAD SPACE                                                  -- PAGE NO.   34


 REQD. STEEL AREA    :     3977.21 Sq.mm.
 REQD. CONCRETE AREA:   198522.80 Sq.mm.
 MAIN REINFORCEMENT : Provide  20 - 16 dia. (1.99%,   4021.24 Sq.mm.)
                      (Equally distributed)
 TIE REINFORCEMENT  : Provide  8 mm dia. rectangular ties @ 255 mm c/c

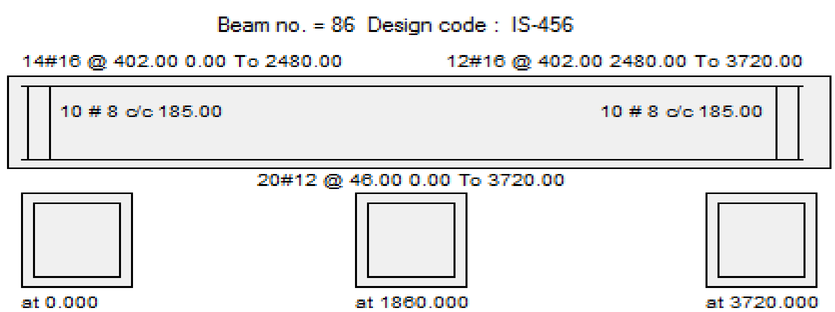
 SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)
 ----------------------------------------------------------
 Puz :   3917.96   Muz1 :    285.93   Muy1 :    285.93

 INTERACTION RATIO: 0.99 (as per Cl. 39.6, IS456:2000)

 SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)
 ----------------------------------------------------------
 WORST LOAD CASE:    30
 END JOINT:    65 Puz :   3931.07   Muz :    288.06   Muy :    288.06   IR: 0.99
```

<u>4th PLACEMENT</u>

<u>BEAM NO. 86</u>



Design Load

Mz Kn Met	Dist. Met	Load
257.24	0	26
-302.16	0	22
-272.72	3.7	10

Design Parameter

Fy(Mpa)	415
Fc(Mpa)	30
Depth(m)	0.449999988
Width(m)	0.449999988
Length(m)	3.720000028

B E A M N O. 86 D E S I G N R E S U L T S

M30 Fe415 (Main) Fe415 (Sec.)

LENGTH: 3720.0 mm SIZE: 450.0 mm X 450.0 mm COVER: 40.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

SECTION	0.0 mm	930.0 mm	1860.0 mm	2790.0 mm	3720.0 mm
TOP REINF.	2682.40 (Sq. mm)	1083.44 (Sq. mm)	372.36 (Sq. mm)	828.36 (Sq. mm)	2359.45 (Sq. mm)
BOTTOM REINF.	2216.66 (Sq. mm)	1131.09 (Sq. mm)	372.36 (Sq. mm)	869.30 (Sq. mm)	1870.17 (Sq. mm)

SUMMARY OF PROVIDED REINF. AREA

SECTION	0.0 mm	930.0 mm	1860.0 mm	2790.0 mm	3720.0 mm
TOP REINF.	14-16í 2 layer(s)	6-16í 1 layer(s)	3-16í 1 layer(s)	5-16í 1 layer(s)	12-16í 2 layer(s)
BOTTOM REINF.	20-12í 2 layer(s)	11-12í 2 layer(s)	4-12í 1 layer(s)	8-12í 1 layer(s)	17-12í 2 layer(s)
SHEAR REINF.	2 legged 8í @ 185 mm c/c	2 legged 8í @ 185 mm c/c	2 legged 8í @ 185 mm c/c	2 legged 8í @ 185 mm c/c	2 legged 8í @ 185 mm c/c

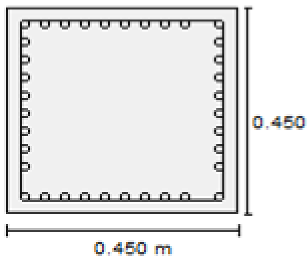
SHEAR DESIGN RESULTS AT DISTANCE d (EFFECTIVE DEPTH) FROM FACE OF THE SUPPORT

SHEAR DESIGN RESULTS AT 615.6 mm AWAY FROM START SUPPORT
VY = 169.42 MX = 1.56 LD= 22
Provide 2 Legged 8í @ 180 mm c/c

SHEAR DESIGN RESULTS AT 619.0 mm AWAY FROM END SUPPORT
VY = -170.51 MX = -0.57 LD= 10
Provide 2 Legged 8í @ 185 mm c/c

COLUMN NO. 128

Beam no. = 128 Design code : IS-456



Design Load

Load	30
Location	End 2
Pu(Kns)	347.84
Mz(Kns-Mt)	0.75
My(Kns-Mt)	279.46

Design Parameter

Fy(Mpa)	415
Fc(Mpa)	30
As Reqd(mm²)	4068
As (%)	2.01
Bar Size	12
Bar No	36

```
          C O L U M N   N O.   128  D E S I G N   R E S U L T S

       M30                    Fe415 (Main)                Fe415 (Sec.)

   LENGTH:  3200.0 mm   CROSS SECTION:  450.0 mm X  450.0 mm  COVER: 40.0 mm

   ** GUIDING LOAD CASE:   30 END JOINT:    71  SHORT COLUMN

-------------------------------< PAGE 37 Ends Here >----------------------------
    STAAD SPACE                                                -- PAGE NO.   38


   REQD. STEEL AREA    :     4067.81 Sq.mm.
   REQD. CONCRETE AREA:   198432.19 Sq.mm.
   MAIN REINFORCEMENT : Provide  36 - 12 dia. (2.01%,   4071.50 Sq.mm.)
                        (Equally distributed)
   TIE REINFORCEMENT  : Provide  8 mm dia. rectangular ties @ 190 mm c/c

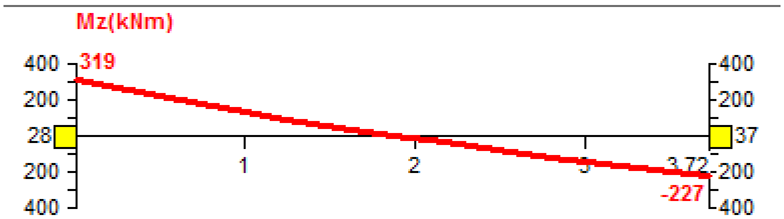
   SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)
   ----------------------------------------------------------
   Puz :   3944.94   Muz1 :    287.99   Muy1 :    287.99

   INTERACTION RATIO: 1.00 (as per Cl. 39.6, IS456:2000)

   SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)
   ----------------------------------------------------------
   WORST LOAD CASE:    30
   END JOINT:    71 Puz :   3946.04    Muz :    289.19    Muy :    289.19    IR: 0.99
```

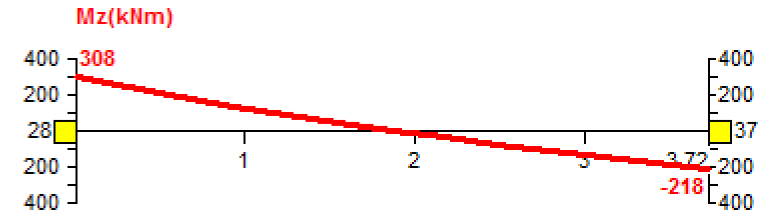
8.2 BENDING MOMENT RESULTS

1st PLACEMENT



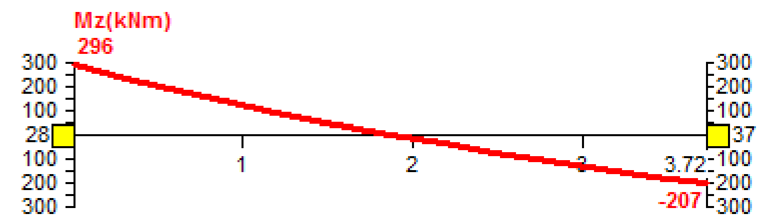
Bending Moment of Beam 78

2nd PLACEMENT



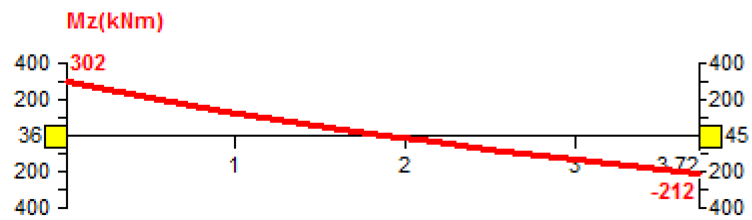
Bending Moment of Beam 78

3rd PLACEMENT



Bending Moment of Beam 78

<u>4th PLACEMENT</u>



Bending Moment of Beam 86

8.3 NODE DISPLACEMENT SUMMARY

1st PLACEMENT

Node Displacement Summary

	Node	L/C	X (mm)	Y (mm)	Z (mm)	Resultant (mm)	rX (rad)	rY (rad)	rZ (rad)
Max X	195	24:0.9 DL + 1.5	**47.866**	-0.581	1.966	47.910	-0.000	0.000	-0.000
Min X	197	9:1.5(DL+EL X	**-48.001**	-2.636	-0.300	48.074	-0.000	-0.000	0.000
Max Y	137	3:EQZ(+)	-1.105	**0.889**	38.100	38.126	0.001	0.000	0.000
Min Y	194	7:1.5(DL+LL)	-0.571	**-4.750**	1.011	4.890	0.000	0.000	0.000
Max Z	190	10:1.5(DL+EL Z	-1.761	-0.680	**60.183**	60.212	0.001	0.000	-0.000
Min Z	195	30:0.9 DL - 1.5	-1.957	-0.598	**-59.293**	59.329	-0.001	-0.000	-0.000
Max rX	46	26:0.9 DL + 1.5	0.449	-1.093	16.212	16.255	**0.003**	0.000	-0.000
Min rX	46	22:1.5(DL-EL Z	-0.461	-0.680	-16.213	16.234	**-0.004**	-0.000	0.000
Max rY	192	10:1.5(DL+EL Z	-1.799	-0.973	57.046	57.083	0.001	**0.000**	0.000
Min rY	192	30:0.9 DL - 1.5	1.596	-2.676	-56.162	56.248	-0.001	**-0.000**	0.000
Max rZ	54	9:1.5(DL+EL X	-13.939	-0.321	0.447	13.950	-0.000	-0.000	**0.003**
Min rZ	46	8:1.5(DL+EL X	13.928	-0.645	0.470	13.951	-0.000	0.000	**-0.003**
Max Rst	193	10:1.5(DL+EL Z	-0.310	-3.230	60.133	**60.221**	0.001	0.000	-0.000

2nd PLACEMENT

Node Displacement Summary

	Node	L/C	X (mm)	Y (mm)	Z (mm)	Resultant (mm)	rX (rad)	rY (rad)	rZ (rad)
Max X	195	24:0.9 DL + 1.5	**47.792**	-1.560	1.072	47.830	-0.000	0.000	-0.000
Min X	197	9:1.5(DL+EL X	**-47.910**	-2.608	0.489	47.983	-0.000	-0.000	0.000
Max Y	137	3:EQZ(+)	-0.557	**0.860**	36.855	36.869	0.001	0.000	0.000
Min Y	193	7:1.5(DL+LL)	0.029	**-4.712**	0.965	4.810	0.000	0.000	-0.000
Max Z	136	10:1.5(DL+EL Z	-0.901	-0.521	**56.619**	56.629	0.001	0.000	-0.000
Min Z	154	30:0.9 DL - 1.5	-0.988	-0.517	**-55.858**	55.869	-0.001	-0.000	-0.000
Max rX	28	10:1.5(DL+EL Z	-0.221	-0.168	15.599	15.602	**0.003**	0.000	-0.000
Min rX	46	22:1.5(DL-EL Z	-0.252	-0.634	-15.598	15.613	**-0.003**	-0.000	-0.000
Max rY	192	10:1.5(DL+EL Z	-0.951	-1.016	54.413	54.431	0.001	**0.000**	0.000
Min rY	197	17:1.2(DL+LL-	-0.867	-2.337	-42.504	42.577	-0.001	**-0.000**	0.000
Max rZ	54	9:1.5(DL+EL X	-13.945	-0.321	0.447	13.956	-0.000	-0.000	**0.003**
Min rZ	46	21:1.5(DL-EL X	13.945	-0.580	0.472	13.965	-0.000	0.000	**-0.003**
Max Rst	145	10:1.5(DL+EL Z	-0.181	-3.060	56.615	**56.698**	0.001	0.000	-0.000

3rd PLACEMENT

Node Displacement Summary

	Node	L/C	X (mm)	Y (mm)	Z (mm)	Resultant (mm)	rX (rad)	rY (rad)	rZ (rad)
Max X	195	24:0.9 DL + 1.5	**47.780**	-1.555	0.275	47.806	-0.000	0.000	-0.000
Min X	197	9:1.5(DL+EL X	**-47.903**	-2.643	1.277	47.993	-0.000	-0.000	0.000
Max Y	192	3:EQZ(+)	-0.025	**0.828**	35.882	35.891	0.000	0.000	-0.000
Min Y	194	7:1.5(DL+LL)	-0.217	**-4.702**	0.952	4.802	0.000	-0.000	0.000
Max Z	191	10:1.5(DL+EL Z	-0.116	-1.008	**54.680**	54.690	0.001	0.000	-0.000
Min Z	196	30:0.9 DL - 1.5	-0.084	-0.754	**-53.733**	53.738	-0.001	-0.000	-0.000
Max rX	28	10:1.5(DL+EL Z	-0.030	-0.197	14.935	14.936	**0.003**	0.000	-0.000
Min rX	46	22:1.5(DL-EL Z	-0.035	-0.648	-14.934	14.948	**-0.003**	-0.000	-0.000
Max rY	195	16:1.2(DL+LL-	38.203	-2.981	0.553	38.323	-0.000	**0.000**	-0.000
Min rY	197	12:1.2(DL+LL+	-38.370	-3.016	1.224	38.508	-0.000	**-0.000**	0.000
Max rZ	54	9:1.5(DL+EL X	-13.945	-0.320	0.448	13.956	-0.000	-0.000	**0.003**
Min rZ	46	8:1.5(DL+EL X	13.945	-0.581	0.472	13.965	-0.000	0.000	**-0.003**
Max Rst	191	10:1.5(DL+EL Z	-0.116	-1.008	54.680	**54.690**	0.001	0.000	-0.000

4th PLACEMENT

Node Displacement Summary

	Node	L/C	X (mm)	Y (mm)	Z (mm)	Resultant (mm)	rX (rad)	rY (rad)	rZ (rad)
Max X	197	24:0.9 DL + 1.5	**47.828**	-2.378	-1.308	47.905	-0.000	0.000	-0.000
Min X	197	9:1.5(DL+EL X	**-47.964**	-1.063	2.054	48.020	-0.000	-0.000	0.000
Max Y	143	3:EQZ(+)	0.444	**0.850**	36.467	36.479	0.001	-0.000	-0.000
Min Y	193	7:1.5(DL+LL)	0.334	**-4.701**	0.990	4.816	0.000	-0.000	-0.000
Max Z	192	10:1.5(DL+EL Z	0.590	-0.562	**56.502**	56.508	0.001	-0.000	0.000
Min Z	197	30:0.9 DL - 1.5	0.726	-0.507	**-55.653**	55.660	-0.001	0.000	0.000
Max rX	36	10:1.5(DL+EL Z	0.125	-0.150	15.210	15.211	**0.003**	-0.000	0.000
Min rX	54	22:1.5(DL-EL Z	0.143	-0.597	-15.215	15.227	**-0.003**	0.000	0.000
Max rY	195	17:1.2(DL+LL-	0.721	-2.337	-43.240	43.309	-0.001	**0.000**	-0.000
Min rY	190	10:1.5(DL+EL Z	0.616	-0.994	55.385	55.398	0.001	**-0.000**	0.000
Max rZ	54	20:1.5(DL-EL X	-13.920	-0.384	0.445	13.932	-0.000	-0.000	**0.003**
Min rZ	46	8:1.5(DL+EL X	13.930	-0.581	0.470	13.950	-0.000	0.000	**-0.003**
Max Rst	194	10:1.5(DL+EL Z	0.022	-2.986	56.454	**56.533**	0.001	-0.000	0.000

8.4 BEAM END FORCE SUMMARY

1st PLACEMENT

Beam End Force Summary

				Axial	Shear		Torsion	Bending	
	Beam	Node	L/C	Fx (kN)	Fy (kN)	Fz (kN)	Mx (kNm)	My (kNm)	Mz (kNm)
Max Fx	398	173	7:1.5(DL+LL)	**1.89E+3**	2.533	-6.262	-0.004	-3.768	-1.427
Min Fx	389	2	3:EQZ(+)	**-477.052**	-3.573	80.691	-0.379	-30.191	-2.881
Max Fy	78	28	22:1.5(DL-EL Z	2.809	**193.647**	0.031	-2.782	-0.002	318.949
Min Fy	78	37	10:1.5(DL+EL Z	-3.789	**-194.563**	-0.021	1.358	-0.101	287.245
Max Fz	122	38	22:1.5(DL-EL Z	744.832	2.141	**185.466**	1.363	-296.669	3.442
Min Fz	398	11	22:1.5(DL-EL Z	1.08E+3	3.265	**-181.508**	0.566	128.464	4.068
Max Mx	380	154	7:1.5(DL+LL)	-20.845	73.762	0.286	**5.886**	-0.403	65.170
Min Mx	381	155	7:1.5(DL+LL)	-8.778	43.811	-1.016	**-6.443**	1.781	22.435
Max My	122	65	22:1.5(DL-EL Z	721.930	2.141	185.466	1.363	**296.823**	-3.409
Min My	53	11	22:1.5(DL-EL Z	916.184	2.529	183.166	1.204	**-305.173**	4.165
Max Mz	78	28	22:1.5(DL-EL Z	2.809	193.647	0.031	-2.782	-0.002	**318.949**
Min Mz	78	28	26:0.9 DL + 1.5	-3.593	-119.513	-0.023	1.643	-0.019	**-273.763**

2nd PLACEMENT

Beam End Force Summary

	Beam	Node	L/C	Axial Fx (kN)	Shear Fy (kN)	Shear Fz (kN)	Torsion Mx (kNm)	Bending My (kNm)	Bending Mz (kNm)
Max Fx	399	174	7:1.5(DL+LL)	**1.81E+3**	-0.411	-6.297	-0.002	-3.822	0.263
Min Fx	389	2	3:EQZ(+)	**-462.998**	-2.232	78.521	-0.209	-29.382	-1.954
Max Fy	78	28	22:1.5(DL-EL Z	2.657	**188.120**	0.016	-2.310	0.024	308.021
Min Fy	78	37	10:1.5(DL+EL Z	-3.690	**-188.765**	-0.006	0.912	-0.072	277.057
Max Fz	122	38	22:1.5(DL-EL Z	741.060	1.652	**180.582**	0.746	-288.747	2.715
Min Fz	398	11	22:1.5(DL-EL Z	1.08E+3	2.946	**-176.834**	0.311	125.300	3.798
Max Mx	382	156	7:1.5(DL+LL)	-7.165	50.070	0.883	**5.777**	-1.597	33.442
Min Mx	383	157	7:1.5(DL+LL)	-7.558	47.419	-0.872	**-5.777**	1.524	28.480
Max My	122	65	22:1.5(DL-EL Z	718.158	1.652	180.582	0.746	**289.117**	-2.572
Min My	53	11	22:1.5(DL-EL Z	913.553	2.164	178.452	0.662	**-297.247**	3.617
Max Mz	78	28	22:1.5(DL-EL Z	2.657	188.120	0.016	-2.310	0.024	**308.021**
Min Mz	59	17	25:0.9 DL + 1.5	642.218	-164.708	-0.032	0.408	0.570	**-272.589**

3rd PLACEMENT

Beam End Force Summary

	Beam	Node	L/C	Axial Fx (kN)	Shear Fy (kN)	Shear Fz (kN)	Torsion Mx (kNm)	Bending My (kNm)	Bending Mz (kNm)
Max Fx	403	178	7:1.5(DL+LL)	**1.8E+3**	0.511	-6.277	0.002	-3.806	-0.352
Min Fx	389	2	3:EQZ(+)	**-446.838**	-0.817	76.155	-0.028	-28.504	-0.980
Max Fy	78	28	22:1.5(DL-EL Z	2.514	**182.052**	0.001	-1.826	0.049	296.040
Min Fy	78	37	10:1.5(DL+EL Z	-3.555	**-182.686**	0.010	0.425	-0.040	266.447
Max Fz	122	38	22:1.5(DL-EL Z	737.563	1.980	**175.140**	0.093	-279.934	3.154
Min Fz	518	160	7:1.5(DL+LL)	138.188	43.218	**-173.191**	5.053	74.433	17.403
Max Mx	384	158	7:1.5(DL+LL)	-7.531	49.973	0.865	**5.776**	-1.567	33.015
Min Mx	385	159	7:1.5(DL+LL)	-7.264	47.389	-0.889	**-5.797**	1.557	28.507
Max My	122	65	22:1.5(DL-EL Z	714.661	1.980	175.140	0.093	**280.513**	-3.182
Min My	53	11	22:1.5(DL-EL Z	911.423	2.204	173.254	0.088	**-288.530**	3.567
Max Mz	78	28	22:1.5(DL-EL Z	2.514	182.052	0.001	-1.826	0.049	**296.040**
Min Mz	59	17	25:0.9 DL + 1.5	647.113	-164.557	-0.025	0.409	0.562	**-272.391**

4th PLACEMENT

Beam End Force Summary

	Beam	Node	L/C	Axial Fx (kN)	Shear Fy (kN)	Shear Fz (kN)	Torsion Mx (kNm)	Bending My (kNm)	Bending Mz (kNm)
Max Fx	405	180	21:1.5(DL-EL X	**1.8E+3**	115.599	-16.600	-0.198	-14.037	-179.151
Min Fx	395	8	3:EQZ(+)	**-455.960**	1.012	76.692	0.111	-28.216	0.793
Max Fy	86	36	22:1.5(DL-EL Z	2.618	**185.139**	-0.013	1.564	-0.023	302.156
Min Fy	86	45	10:1.5(DL+EL Z	-3.523	**-186.233**	0.005	-0.570	0.059	272.715
Max Fz	128	44	22:1.5(DL-EL Z	693.489	0.746	**177.151**	-0.461	-283.361	1.015
Min Fz	404	17	22:1.5(DL-EL Z	1.01E+3	-0.163	**-173.282**	-0.169	122.426	-0.145
Max Mx	386	160	7:1.5(DL+LL)	-11.476	51.516	1.056	**5.581**	-1.884	34.931
Min Mx	387	161	7:1.5(DL+LL)	-1.396	41.707	-0.375	**-6.741**	1.075	17.882
Max My	128	71	22:1.5(DL-EL Z	670.587	0.746	177.151	-0.461	**283.522**	-1.374
Min My	59	17	22:1.5(DL-EL Z	852.465	0.215	174.898	-0.372	**-291.486**	0.100
Max Mz	86	36	22:1.5(DL-EL Z	2.618	185.139	-0.013	1.564	-0.023	**302.156**
Min Mz	59	17	25:0.9 DL + 1.5	651.556	-164.390	-0.012	0.407	0.537	**-272.071**

EFFECT OF CHANGE IN VOLUME OF WATER TANK

This change was observed for **3rd placement**.

Node Displacement Summary

	Node	L/C	X (mm)	Y (mm)	Z (mm)	Resultant (mm)	rX (rad)	rY (rad)	rZ (rad)
Max X	195	24:0.9 DL + 1.5	**47.780**	-1.555	0.275	47.806	-0.000	0.000	-0.000
Min X	197	9:1.5(DL+EL X	**-47.903**	-2.643	1.277	47.993	-0.000	-0.000	0.000
Max Y	192	3:EQZ(+)	-0.025	**0.828**	35.882	35.891	0.000	0.000	-0.000
Min Y	194	7:1.5(DL+LL)	-0.217	**-4.702**	0.952	4.802	0.000	-0.000	0.000
Max Z	191	10:1.5(DL+EL Z	-0.116	-1.008	**54.680**	54.690	0.001	0.000	-0.000
Min Z	196	30:0.9 DL - 1.5	-0.084	-0.754	**-53.733**	53.738	-0.001	-0.000	-0.000
Max rX	28	10:1.5(DL+EL Z	-0.030	-0.197	14.935	14.936	**0.003**	0.000	-0.000
Min rX	46	22:1.5(DL-EL Z	-0.035	-0.648	-14.934	14.948	**-0.003**	-0.000	-0.000
Max rY	195	16:1.2(DL+LL-	38.203	-2.981	0.553	38.323	-0.000	**0.000**	-0.000
Min rY	197	12:1.2(DL+LL+	-38.370	-3.016	1.224	38.508	-0.000	**-0.000**	0.000
Max rZ	54	9:1.5(DL+EL X	-13.945	-0.320	0.448	13.956	-0.000	-0.000	**0.003**
Min rZ	46	8:1.5(DL+EL X	13.945	-0.581	0.472	13.965	-0.000	0.000	**-0.003**
Max Rst	191	10:1.5(DL+EL Z	-0.116	-1.008	54.680	**54.690**	0.001	0.000	-0.000

1. From the above post processing results, we can conclude that **<u>3rd placement</u>** of water tank is the most safe position.
2. Here are the results compared for different placements of water tank.

	1st Placement	2nd Placement	3rd Placement	4th Placement
	Max.(X,Y,Z)	Max.(X,Y,Z)	Max.(X,Y,Z)	Max.(X,Y,Z)
Nodal Deflection (mm)	60.183	56.619	54.680	56.502
Bending Moment (kNm)	318.949	308.021	296.040	302.156
Shear force (kN)	194.563	188.765	182.686	186.233
Area Of Steel Of Critical Column (mm^2)	4286	4156	3977	4068

3. When the volume of tank is changed, no change is recoded in Nodal Displacements. The reason behind this was that the Load Combination generated will produce the above minimum displacement even if the volume of water tank is altered.

CHAPTER 9

CONCLUSION

The safest position estimated is 3rd placement. The reasons behind this position to be the safest are as follows:

1. As we move from 1st placement to 3rd placement, the symmetry of structure increases.
2. The effect of earthquake (X direction value) will be less on this placement than that of 1st and 2nd.
3. The 1st and 4th position are on the outer side of the roof, which means that they are more vulnerable to earthquake as the centre of mass is shifted.
4. The area covered by 1st and 2nd placement is more than that of 3rd and 4th , therefore when the tank is at 3rd position, the centre of mass is at its appropriate position.
5. There is no effect of change in volume of water tank, this is because of the reason that the load combination will generate these minimum results even if the volume is changed.

CHAPTER 10

FUTURE SCOPE

Following are the variation whose effect can be calculated on a building.

1. Number of storeys
2. Earthquake zone
3. Type of soil
4. Shape of building
5. Method of analysis

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