Mini Project

On

"SEISMIC ANALYSIS OF MULTISTOREYED BUILDING WITH FLOATING COLUMNS"

A Project
Report

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

degree in**BACHELOR OF TECHNOLOGY**

IN

CIVIL ENGINEERING

BY

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Under the Guidance of

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DEPARTMENT OF CIVIL ENGINEERING

Kavitha Memorial Educational

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VIJAYA ENGINEERING COLLEGE

(Approved By AICTE New Delhi & Affiliated To JNTU-

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KHAMMAM-507305 **2022-2023**

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BONAFIDE CERTIFICATE

This is to certify that Project Report entitled **"SEISMIC ANALYSIS OF MULTISTOREYED BUILDING WITH FLOATING COLUMN"** is Submitted by

LAKAVATH MOUNIKA - [20BR5A0116]

In partial fulfillment for award of degree of Bachelor of Technology in Civil Engineering of Jawaharlal Nehru Technologies University Hyderabad, during the academic year 2022-2023.

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EXTERNAL VIVA-VOCE HELD ON:

EXTERNAL EXAMINER:

DECLARATION

I, here by declare that the Project Report titled **"SEISMIC ANALYSIS OF MULTISTOREYED BUILDING WITH FLOATING COLUMN"** under the guidance of Mr J.Vijay Kumar, Department of CIVIL, **Vijaya Engineering College, Khammam,** submitted in partial Fulfillment of the requirements for the award of thedegree in **Bachelor of Technology In Civil Engineering.**

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ACKNOWLEDGEMENT

I wish to convey my sincere thanks to **Mr P. Usha Kiran Kumar** M tech, Secretary of VijayaEngineering College.

I hereby thank the Vice Chairperson **Smt P. Vijaya Laxmi** for providing every requirement needed for completion of this Mini project report.

I hereby thank the Principal **Dr.G. John Babu** phd for providing every requirementneeded for completion of this Mini project report.

I offer my sincere thanks to **Smt B.Rajitha** M tech Head of the Department ,CIVIL for providing every requirement needed for completion of this Mini project report.

I heartily thank my guide **Mr.J.Vijay Kumar** M tech for suggesting and giving the support to complete this Mini project report.

ABSTRACT

Structural engineering is a part of civil engineering dealing with the analysis and design of structures that support or resist loads. This project deals with the study of architectural drawing and the framing drawing of the building having floating columns. The load distribution of the floating columns and the various effects due to it is also being studied. The importance and effects due to the line of action of force are also studied. In this we are dealing with the comparative study of seismic analysis of multistoried building with and without floating columns. Column rest on the beam without foundation are called floating column Which are purposed to hold parking at ground floor or open halls at higher floors They are designed for gravity loads not designed for earthquake loads. This study deals with the stiffness balance of all the storey and is proposed to reduce the irregularity introduced by the columns which are floating in the building. For this whole work of buildings with floating columns, we used Finite element method codes for a two-dimensional, multi-story frame building that is used to study the response of a structure type to different types of seismic excitation.

Keywords: FEM, G+9 Building, Hanging Column, Seismic Loading, Drifts.

CONTENTS

LIST OF SYMBOLS

P Axial force in member

Δ Global lateral deformation

δ Local deformation

L Length of member

P_d Design strength in axial compression

e Eccentricity

T Natural period of vibration

V Design shear force

P_z Design wind pressure

h Height of building

V_z Design wind velocity

V_b Basic wind speed

A Surface area of structural element or cladding

F Wind load

INTRODUCTION

1.1 Introduction

Today, several multi-story urban buildings in India are unavoidably accessible in the first floor. This is used primarily for parking or reception lobbies on the first level. Although the overall seismic basis shear encountered by an earthquake building depends on its natural duration, the distribution of seismic force depends on a height distribution of steepness and mass. In addition to the way the earthquake forces are brought to the ground, the action of a building in an earthquake depends critically upon its overall form, size and geometry. At different rates in a building the earthquake forces have to be carried down by the shortest path down the height to the ground; any inconsistency or discontinuity in this load transfer path contributes to a poor building efficiency.

Vertical reverse buildings (such as a hotel with few floors wider than the others) cause the earthquake forces to unexpectedly leap at discontinuity. Buildings with less columns or walls or with an unusually high amount appear to damage or collapse in the storey. Throughout the 2001 Bhuj earthquake, several buildings in Gujarat with open ground floor to parking were collapsed or seriously damaged. Buildings with columns hanging or Hanging on beams in an intermediate floor that do not meet the base have discontinuities in the transmission route for loads

1.2 What is Floating column?

The floating column is a vertical member which rests on a beam but doesn't transfer the load directly to the foundation. The floating column acts as a point load on the beam and this beam transfers the load to the column below it. The column may start off on the first ir second or any other intermediate floor while resting on a beam. Usually, columns rest on the foundation to the transfer then load from the slabs and beams. But the floating column rests on the beam. The columns in a building as shown below figure,

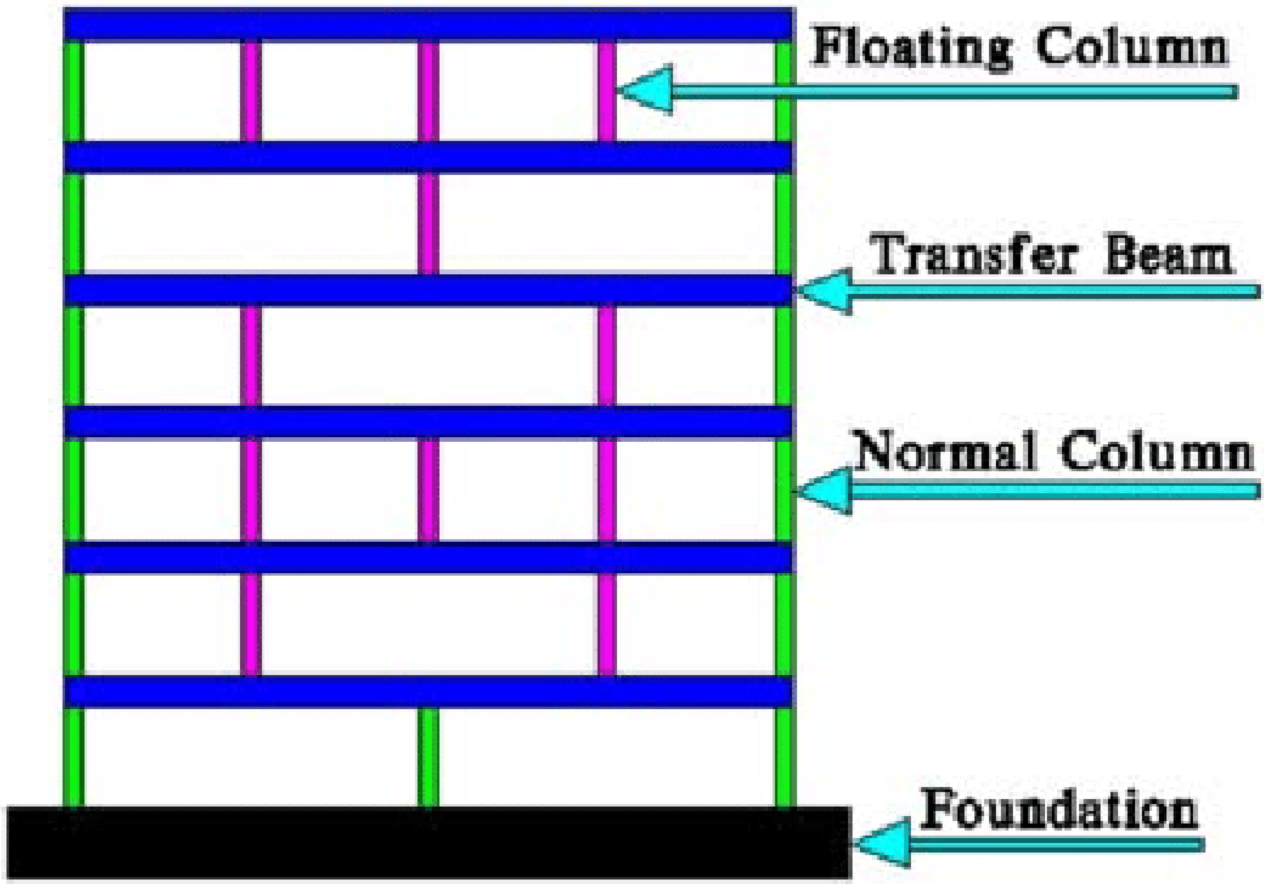


Figure 1: Hanging Column

In modern times the buildings are become complex particularly the mix-use ones. There are different uses on different floors and hence to follow it structural grid becomes difficult as columns on any floor would become a hindrance . Even in residential buildings when there is parking on the ground floor or lower stories are taken to exploit ambiguities in local by laws for gaining more free spaces, the lower floors need column-free spaces for easy movement of vehicles; while on upper floors which are more in a number of the columns have been designed based on room layout. They are also frequently used when there are shops on the ground floor and residences on the upper floors. Rather than finding an architectural solution one easily take recourse to float columns and remove columns on lower stories, which is a dangerous proposal.

1.3 TRANSFER BEAM

Transfer beams are required at places where column locations are changing, and to transfer the
forces from column above to column below.

To design the transfer beams, consider the point loads at the locations where the columns are stopping. This point load will actually to be equal to the magnitude of the column reactions. Add the other loads which might act on the beam. Then check for shear and flexure, similar to a normal beam.

1.4 OBJECIVES ABD SCOPE OF WORK

The objective of the present work is to study the behavior of multistory building with floating columns. The base of the buildings frame is assumed to be fixed. Usually, all multistoried buildings are 3 types they are

- Load bearing construction
- Framed construction
- Composite construction

But among the above 3 types, in the present stage, all the multistoried structures are framed construction that are durable. An engineering structure is an assembly of members of elements transferring the loads and providing a firm space and art of designing, with economy and elegance, a durable structure is that which can safely carry the forces and can serve the desire function satisfactorily during its expected serve life span, The entire process of structural planning and designing requires not only imagination and conceptual thinking but of practical aspects, such as relevant design codes and by laws backed up by ample experience, institutions and judgement. The process of design commences with the planning of a structure, primarily to meet the functional equipment of the user or client. The functional requirements and the aspects of the aesthetics are looked into normally by an architect while the aspect of safety, serviceability, durability and economy of the structure for its intended use over the life span.

Some pictures showing the buildings built with Floating column

Figure 3: Hanging Columns on a Single support column

Figure 4: L&T head quarter at Manipakkam, Chennai

Figure 5: Hanging column – Palestra Building in London

Throughout urban areas, multi-story buildings are designed for different purposes by providing Hanging columns in the ground floor. Such Hanging column buildings under gravity loads are considered secure and are therefore built only for such loads. However, these buildings are not built for earthquake loads and thus in seismic-prone areas these buildings can be unsafe. For seismically prone structures, where the Hanging columns are used, a column or a shear wall share the whole system's earthquake without recognising the involvement of Hanging columns.

1.5 Floating Column & Earthquake

Though Hanging columns have to be discouraged, there are many projects in which they are adopted, especially above the ground floor, where transfer girders are employed, so that more open space is available in the Ground Floor. In the earthquake zones, the transfer girders which are employed have to be designed and detailed properly with care. If there are no lateral loads, the design and detailing is not difficult.

Figure 6: construction of Hanging column

The Hanging column principle primarily involves the interrupting movement of the EQ force transition.

- Hanging columns should be equipped as a regular compressor.
- But it is constructed as a beam with all the column load as one single point load when designing transmission beams.
- Nevertheless, it is important to be aware that the EQ force produced has to be down the shortest route, i.e. load distributed between two intermediate columns that support this beam.

High shear capacity beams / deep beams sustain the Hanging base. We can't prevent Hanging columns in some cases. It is therefore prudent to review the deep beam code provisions.

1.6 Research Significance

In urban areas, multi-story buildings are designed for the various purposes mentioned above by having Hanging pillars in the ground floor. Such Hanging column buildings are built for gravity loads and safely subject to gravity loads, but not for earthquake loads. Therefore, in seismically prone areas these buildings are dangerous. Throughout the earthquake-resistant architecture of multi storage buildings, the project aims to raise understanding of these problems.

02. LITERATURE REVIEW

Sreadha A.R, April (2020), discussed the critical location of a Hanging column for G+5 and G+7 RC buildings for region 2 and zone 5 in vertically irregular buildings and also the effects of Hanging column load beams and columns were evaluated. In order to test the results obtained using the **STAAD pro.V8i** program, building responses such as stove drift, shelf displacement and store shear are used.

The following conclusions were taken from the study and results: Based on:

Because of their low efficiency, Floating columns should be avoided in Zone 5 high-rise buildings.

- The presence of Floating column enhances the shifting and drift of the warehouse.
- The displacement of the store on Floating column increases with the rise in load.
- In presence of a Floating column, shelf shear decreases due to the reduction of column mass in the structure.
- Increased beam size and columns boost building efficiency by decreased store

displacement and store drift values with Hanging base. Increased measurements of single -floor beams and columns will not minimize floor displacement and floor drift in upper floors, and thus measurements should be increased for improved building efficiency over two consecutive floors.

Y.R Dhesmukh et. al. [2018], The seismic activity with and without Hanging columns of the RC multi-section buildings has been observed. Research is performed using STAAD software for multi-story G+3 buildings in zone IV. The fundamental components such as interlayer drift, lateral displacement and fundamental time period were analyzed using **STAAD pro.V8i** software in order to determine seismic behavior of buildings with and without Floating columns for Zone IV. To the report. Objective Static analog and spectrum response approaches are employed. Objective Multistory structures of 6 floors with and without Floating columns for study are considered for this building layout RC.

The average building height is 18.0 m and the ground floor height is 15.0 m. Buildings are held symmetrically in both orthogonal directions in the design to prevent tensioning under mere lateral forces.

The following conclusions are taken on the basis of analysis:

- The cycles of natural time from the scientific expressions do not match the theoretical cycles of existence. Complex STRUCTURING must therefore be done before these structures are evaluated. The study may also suggest that the span of natural time depends on the design of the house.
- The building height of the lateral change rises. The Floating column buildings are being replaced more than the regular building.
- The gap between the stories decreases as the number of shops rises. In the Floating column buildings the floor drift becomes more significant, because the mass becomes reduced, which means the drift increases.
- As weight and rigidity also increase the base shear.

The basis shear is thus more critical than the traditional buildings for the Hanging columns. Therefore it can be inferred from the analysis that Floating columns can, in seismic prone areas , in particular, be avoided as far as possible.

S.P Jadhay et. al. [2020], Examines the effects of the irregularity of the structure caused by the discontinuity of the column of a seismic building. In this paper, the static and dynamic study of a multiple-story building with and without floated columns is performed using the response spectrum approach. The position of Hanging columns is wise and inside the foundation. Different cases of the building are studied. The structural response to basic time, spectral acceleration, basehear, shop drift and shop displacement is investigated by the building STRUCTUREs.

The evaluation is done with **STAAD pro.V8i** software. The study is completed. A multi-story (G+6) 18.00 * 15.00 building was chosen, with a special moment resistant frame. The building has a one-stroke wall, the outside is half-stroke, around the periphery. It was assumed to be found on Type II soil of Zone IV. First a standard building (NB) is STRUCTURED in this analysis without Hanging columns. Two kinds of STRUCTUREs are then STRUCTURED, namely 1 and 2. On the first floor of STRUCTURE 1, the Floating columns are placed on the ground and on the second floor. Three different cases of the position of Hanging columns are studied for each
STRUCTURE.

In all six cases have been studied namely-NB, 1A, 1B, 1C, 2A, 2B and 2C.
Two STRUCTUREs were studied for study, namely:

- SKETCH 1 – a building that comprises Floating columns on the ground floor.
- SKETCH 2 – Built in the first floor with rotating columns.
- SKETCH 1 – In the following cases, Floating columns have been found in this STRUCTURE
- CASE1A – Floating columns are the corner columns and reverse external columns around the two long sides.
- CASE 1B – Corner columns and columns in the center are Floating columns around the short bottom.
- CASE 1C – Floating columns are alternate columns in the outside frame in the two long corners except for the corner ones.
- SKETCH 2 – In the following instances, the position of Floating columns was based on this STRUCTURE –
- CASES 2A — On two long sides Floating columns are the corner columns and

alternate columns in the outside structure.

- CASE 2B – Corner columns and all middle columns are Floating columns around the short-rim.
- CASE 2C – The two long rims of alternate columns, with the exception of the corner, are Floating columns in the middle of the largest cell along the short side.

Some of the conclusions taken from this analysis are given below.

- It was found that there is an improvement in the fundamental length in both X-direction and Z-direction in buildings with Floating columns compared with buildings without Hanging columns (NB).
- By inserting Floating columns on the base of a structure, shear and speed decreases. This also has this technological and practical advantage over traditional construction.
- Displacement of the Floating columns in the building increases. In contrast with Sketch 2, variations were higher in Sketch 1, showing that buildings with Floating columns in the ground floor during the earthquake are more prone. Deflections in the Floating columns were also found to be somewhat more marginal.

Amit jhosil & Murtara Safdari et. al. [2018], The architectural design and the construction of the structure with Floating columns were studied. For the implementation of the project work, existing residential buildings consisting of G+ 7 structures were selected. There is also a review in the paper on the load distribution on the Floating columns and the results. We also discuss the significance and consequences of the line of power. The present paper includes a comparative study of seismic performance in multi-story buildings with Hanging columns and without them. The analogous static analysis is performed using STAAD Pro V8i, and the comparison of these STRUCTUREs is carried out for the entire project mathematical 3D STRUCTURE.

It allows us to identify the different analytical characteristics of the system and can also enable us to build very reliably and cost-effectively. We also concluded that the provision of Floating columns is advantageous to the building's FSI development but is a risky factor and increase the construction 's vulnerability.

Yogesh Dhesmukh et. al. [2018], The negative effects of Floating building columns were investigated. Frame STRUCTUREs are developed to perform comparative analysis of structural parameters such as natural length, base form and horizontal shifts under seismic excitation for multi-stage buildings with and without fluctuation columns. The findings obtained indicate that an alternative measure of lateral bracing should be taken to decrease lateral deformation. After the lateral bracing the RC building is examined with Floating column.

For three STRUCTUREs there is a comparative analysis of the results obtained. After bracing the building with Floating columns, seismic efficiency improved. This research was mainly aimed at evaluating the seismic performance of the RC building by Floating columns and seismic performance of the RC building by supplying lateral bracings with Floating columns. The RSA is carried out with the consideration of three STRUCTUREs (without Floating columns, with Floating columns and Floating columns with bracings). This spectrum analysis is used.

SABARI S et. al. [2014], This stressed the significance of specifically acknowledging the Floating Column 's role in the design study. The Floating Columns suggest alternative steps to minimize the anomalies, including the stiffness balance of the first and the above floors. FEM research carried out with and without a Floating column for 2D multi-storage frames to study the response of a structure under various excites of earthquake with different frequency contents, which hold the PGA and time factor constant. In both frames with and without Floating column, the background is measured for the period of roof displacement, inter-story drift, base shear and the column axial force. It is assumed that the overall displacement and interlayer drift values are decreased by increasing the column size.

SREEKANTH GANDLA NANABALA et. al. [2014], The study of a standard G+5 floor and a Floating column building on a floor G+5 for external lateral forces was studied. SAP 2000 is used for the study. Researchers also analyzed the differences of the two structures by applying the intensities of the past earthquakes i.e. by adding the ground motions to the two structures. The goal of this study is to find out if the structure with a Floating column is safe or insecure when constructed in seismically active areas. The following findings were taken on the basis of the inquiry.

- The motions of Floating column building in X and Y directions on each floor are less than average but displacement of Hanging column building in Z direction compared to normal building is better by the application of lateral loads in X and Y. Therefore, compared to a standard structure, the Floating column building is vulnerable to construction.
- It is observed that in measuring lateral rigidity on every point for the buildings Column building Floating can undergo extreme soft storage effects where normal building is free of the soft storage effect. And it's dangerous to install the Floating board.
- Based on structural research, the contrast is measured between the sum of steel and concrete from which there are 40% more rebar stainless steel Floating column buildings as well as a 42% more concrete than standard building. Therefore, the Hanging column construction is not cost-effective for the standard house.
- From a historical study, we note that there are more displacements in the Floating column building than in a regular building. The Floating structure of the column is also dangerous than a standard building. The final assumption is that Floating column buildings do not want to be constructed. Further displacements than ordinary buildings also grew, with the proportions of all members, and the construction costs have increased. It prohibits the construction of Floating columns.

3.0 METHODOLOGY

The methodology is the theoretical and systematic analysis of the methods used for the study area. This involves the systematic study of an variety of approaches and concepts connected to a information branch. **Load taken into Account**

Dead loads

The dead load involves the weight of the walls, divisional flooring, false ceilings, false floors and the other permanent structures. A load set in its size and location is called the dead load. Dead loads may be determined by the scale and weight of various members.

For floors; unit weight of reinforces cement concrete= 25 kN/m^3 Unit weight of steel is = 78.5 kN/ m^3

Live loads

The imported load shall be generated by the intended use or occupation, in which the weight and vibrating loads and dust loads, including the weight of mobile partitions, loads dispersed and concentrated. Charges levied shall not include charges caused by the wind, the seismic activity, the snow and loads place on the structure, the differential settlements to which the structure which experience a temperature change, creeping and shrinking.

For residential buildings such as Hostels, hotels, boarding houses, lodging houses, dormitories, residential clubs: Living rooms, bed rooms and dormitories = 4.0 kN/m^3 (IS: 875, Part 2- 1987).

Wind loads

The strength of a structure due to the wind effect. As the building height increases the wind impact. At high wind speeds the wind typically blows horizontally to the ground.

Design of Wind Pressure

The following relation between wind pressure and wind speed shall be used to measure wind pressure at any height above the level of the earth:-

$$P_{ZZ} = .6\, V^2$$

Where P_Z is design wind pressure in N/m^2 at height z and V_z is design wind velocity in m/s at height z,

Design Wind Speed (V_z)

The fundamental wind speed (Vz) for each site is measured and amended to incorporate the following effects to achieve design wind speed for the given structure at any height.

(a) level of risk;

(b) Ruggedness, height and structure scale of the terrain; (c) Topography in the surrounding area.

It can be mathematically expressed as follows:

$V_Z = V_b \times k_1 \times k_2 \times k_3$

Where V_b is basic wind speed

k_1 is Probability factor (risk coefficient)

k_2 is terrain, height and structure size factor

k_3 is topography factor

Note: design wind speed up to 10m height from mean ground level shall be considered constant (IS: 875, Part 3- 1987).

Calculation of Wind Load:- $F = (C_{pe} - C_{pi})\, AP_z$

Seismic loads

If earthquakes happen, a structure is dynamically shifted. The inert force of the building is contrary to the rise of the intensity of the earthquake. The forces of inertia, known as seismic loads, are usually controlled by taking external forces. Earthquake motions are inconsistent with time and acceleration forces are inconsistent with time and distance. In terms of time and space, seismic loads are not constant. Once buildings are built, the highest degree of shear force , i.e. static seismic load is considered the most important. Earthquake activity records are also used to examine high-rise buildings and their seismic design elements and material. Dynamic design earthquake movements are called earthquake STRUCTURING movements.

List of Indian Standards on Earthquake Engineering:-

1. IS 1893 (Part I), 2002: Indian Standard Criteria for Earthquake Resistant Design of Structures
2. IS 4326, 1993: Indian Standard Code of Practice for Earthquake Resistant Design & Construction of Buildings.
3. IS 13827, 1993: Indian Standard Guidelines for improving Earthquake Resistance of Earthen Buildings

4. IS 13828, 1993: Indian Standard Guidelines for Improving Earthquake Resistance of Low Strength Masonry Buildings
5. IS 13920, 1993 Indian Standard Code of Practice for Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces.
6. IS13935, 1993: Indian Standard Guidelines for Repair and Seismic Strengthening of Buildings

A Review of Analysis (IS 1893 (Part I), 2002):-

- Equivalent Static Analysis
- Response Spectrum Analysis
- Time History Analysis

Equivalent Static Analysis – An Overview

The most basic method of analysis is the analogous static form. Force here depends on the basic structural period established by the IS Code 1893:2002 with certain adjustments. The first is the measurement and distribution of design basis shear for the entire house, based on the formulas found in the code. This is also suitable only for buildings with a normal mass and rigidity distribution.

Below are the key steps in seismic intensity determination:

Determination of Base shear

The entire lateral design force or design base shear is determined according to the expression:

V = AW

Where,

A = horizontal seismic architecture for construction

W = seismic building weight

The horizontal coefficient of seismic design for structure A is given by:-

A = (ZISa)/ 2Rg

Z is the zone factor in Table 2 of IS 1893:2002

(part 1). I is the importance factor

R is the response reduction factor;

Sa/g is the average acceleration response coefficient for rock and soil locations as given in figure 2 of IS 1893:2002 (part 1).

For 5% damping of the structure, the values are given.

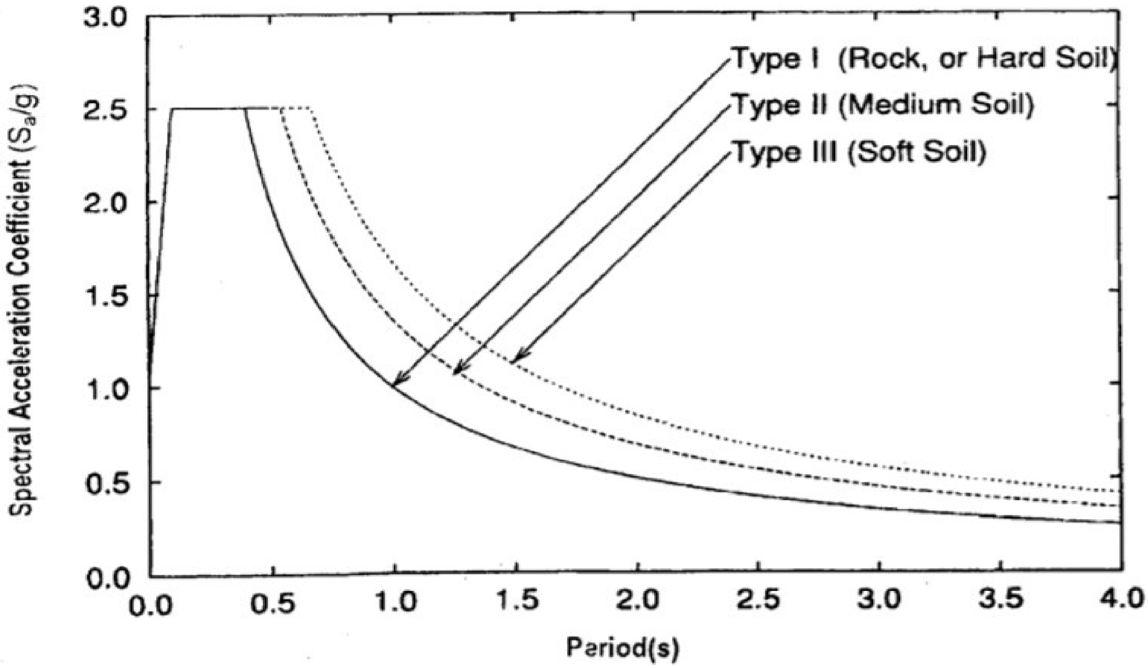


Figure 7: Spectral Acceleration Coefficient Vs. Period

T is the fundamental natural period for buildings calculated as per clause 7.6 of IS 1893:2002 (part1).

Ta = 0.075h0.75 for moment resisting frame without brick infill walls

Ta = 0.085h0.75 for resisting steel frame building without brick infill

walls Ta = 0.09h/√d for all other buildings including moment resisting

RC frames

h is the height of the building in m and d is the base dimension of building at plinth level in m

Lateral distribution of base shear

The whole base shear must be distributed over the building height. At any point, the basic shear depends on the building's mass and deformed shape. The powers of the earthquake appear to redirect the building into various ways, the normal way, which depends on the degree of the building's independence. Each floor has a lumped mass STRUCTURE which in effect transforms a multi-story house, which has an infinite degree of freedom into one degree of freedom when moving sideways, which means the degree of freedom is the same as the number of floors.

The magnitude of lateral force at floor (node) depends upon:-

- Mass of that floor
- Distribution of rigidity over the structure height
- Nodal displacement in given mode

According to this equation is the distribution of base shear along the height:

$$Q_i = V_B \times \frac{W_i h_i^2}{\sum_{j}^{n} W_j h_j^2}$$

Where,

Qi = Design lateral force at floor i,

Wi = Seismic weight of floor i

hi = Height of floor i measured from base and

N = Number of storeys in the building at which the masses are located

Load calculations

Loads and Load combinations are given as per Indian standards. (IS 875:1984, IS 1893:2002 and

IS 800:2007)

Seismic Loading

Seismic load is given as per IS 1893- 2002. Following are the assumptions that are considered for the calculation. Zone factor – 0.24

Soil type – Hard Soil

Importance Factor – 1.0

Response reduction – 3.00

Damping Ratio - 0.05

Dead loads

For floors; unit weight of reinforces cement concrete= 25 kN/m 3

Unit weight of steel = 78.5 KN/m 3

Assume depth of slab= 125 mm

Wall Self Weight = 2.00 KN/m2

Floor Load

Slab Dead Weight + Floor Finish = 4 KN/m2

Total Dead Floor Weight = 4 KN/m2

Imposed loads

For residential buildings i.e. Hostels, hotels, boarding houses, lodging houses, dormitories, residential clubs: Living rooms, bed rooms and dormitories = 4.0 kN/m 2 (IS: 875, Part 2-1987)

Load combinations

1) 1.5 (DL+ IL)
2) 1.2 (DL+ IL + EL)
3) 0.9 DL+ 1.5 EL

04. ANALYSIS OF THE STRUCTURE

General

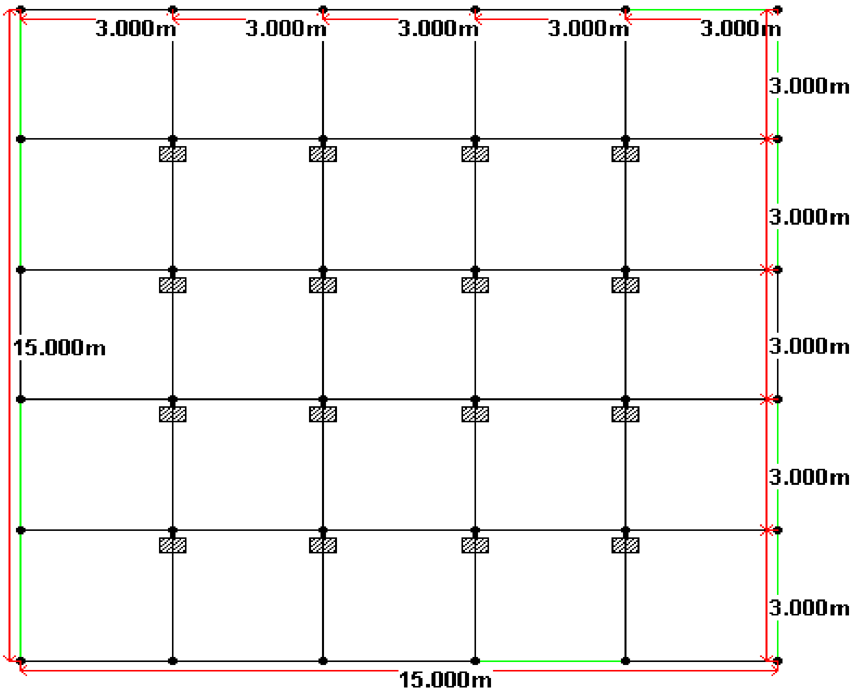
The building employed in this study was designed according to the IS 800: 2007 and IS 1893 criteria (Part 1): 2002.

STAAD Pro analyses a multi-story steel structure.

The architecture of the building depends on the minimum standards as laid down in the Indian Standard Codes. The basic standards for structural protection in buildings shall be protected by the concept of basic design loads to be assumed by the structure to bear for dead loads, imposed loads and other external loads.

Steel Frames

A 10 (G+9)-story steel frame is used for this analysis. The average height of the floor is 3 m and the building is 30 m. As shown in Figure 4.1, the laterals cover 24 meters by 20 meters and are divided into 4 square meter bays.

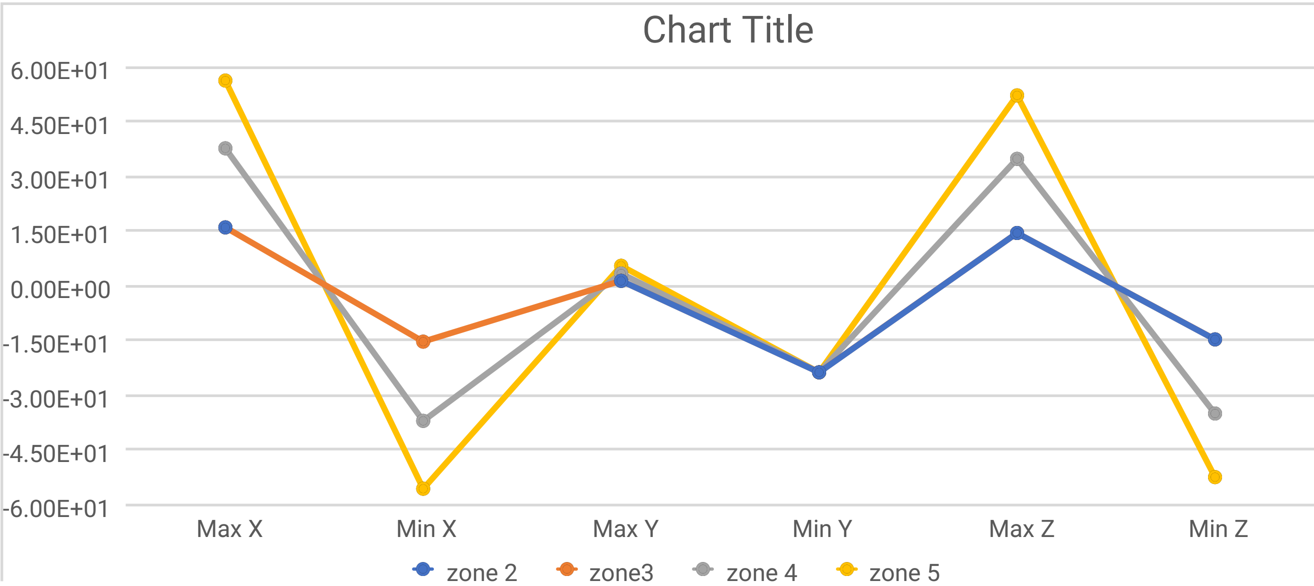


For research , the following STRUCTUREs are examined:

- A Rectangular Structure without a Hanging base.
- Rectangular, Hanging column structure on the ground floor
- The rectangular structure with the 3rd floor Hanging column
- The Rectangular Structure at fifth floor with Hanging column

05. RESULTS AND DISCUSSIONS

Node displacement:



	ZONE 2	ZONE 3	ZONE 4	ZONE 5
Max X	2.571E+01	5.59E+01	2.571E+01	2.571E+01
Min X	-2.571E+01	-5.59E+01	-2.571E+01	-2.571E+01
Max Y	0.784	2.348	0.784	0.784
Min Y	-61.121E+01	-61.121E+01	-61.121E+01	-61.121E+01
Max Z	1.211E+01	7.523E+01	1.211E+01	1.211E+01
Min Z	-1.211E+01	-7.523E+01	-1..211E+01	-1.211E+01

The above table shows the maximum and minimum value of Displacements for the critical load combination which may possible to occur in the bridge.

Beam Displacement Detail Summary:

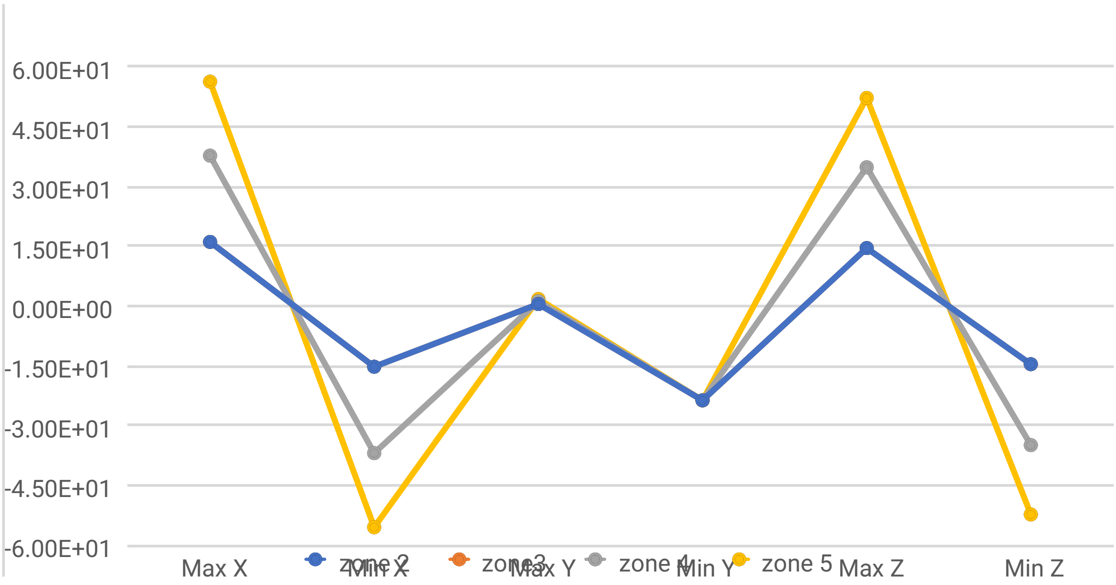
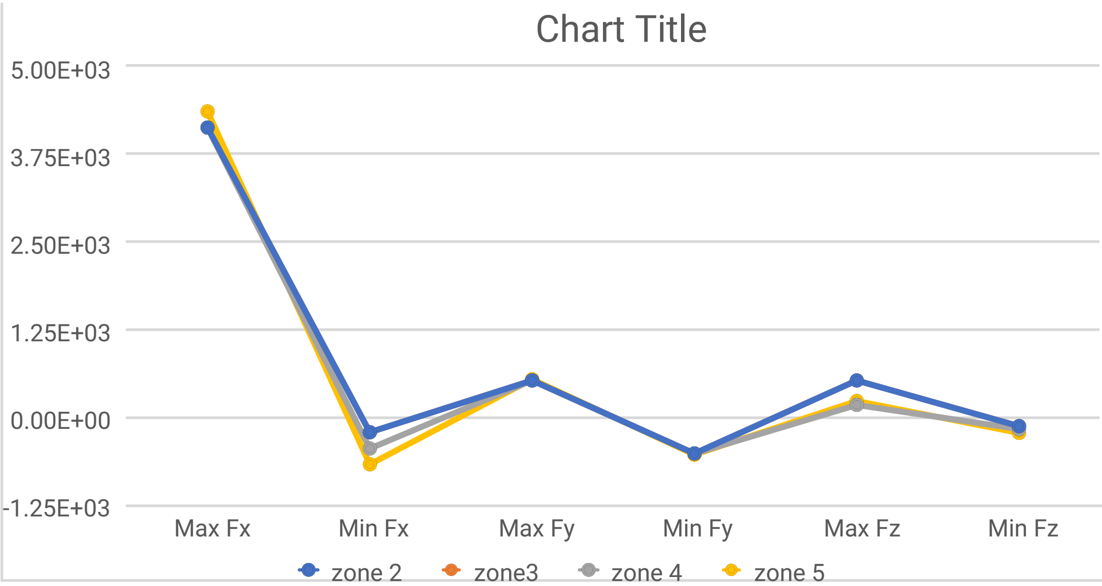


Chart Title

	ZONE 2	ZONE 3	ZONE 4	ZONE 5
Max X	2.571E+01	5.590E+01	2.571E+01	2.570E+01
Min X	-2.570E+01	-5.590E+01	-2.571E+01	-2.570E+01
Max Y	0.784	2.348	0.784	0.784
Min Y	-61.211E+01	-61.120E+01	-61.211E+01	-61.211E+01
Max Z	1.220E+01	7.523E+01	1.220E+01	1.220E+01
Min Z	-1.220E+01	-70523E+01	-1.220E+01	-1.220E+01

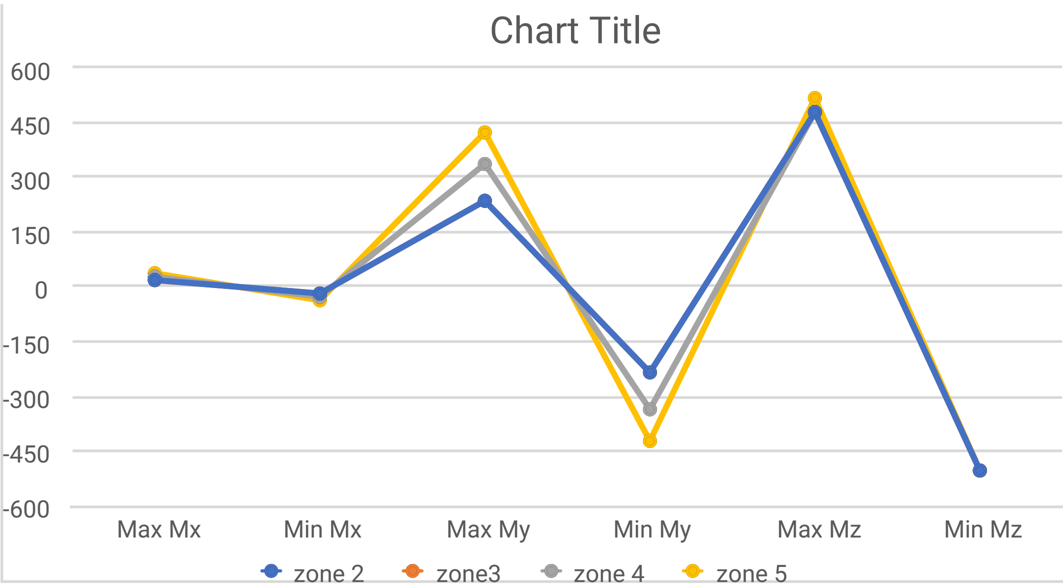
The above table shows the maximum and minimum value of Displacements for the critical load combination which may possible to occur in the Building.

Beam Force and Moment Details:



	Zone 2	Zone 3	Zone 4	Zone 5
Max Fx	7.18E+3	7.18E+3	7.18E+3	7.18E+3
Min Fx	-750.847	-750.847	750.847	-750.847
Max Fy	535.1E+02	535.1E+02	535.1E+02	535.1E+02
Min Fy	-535.1E+02	-535.1E+02	-535.1E+02	-535.1E+02
Max Fz	391.843E+01	391.843E+01	391.843	391.843
Min Fz	-391.84E+01	-391.843E+01	-391.843	-391.843

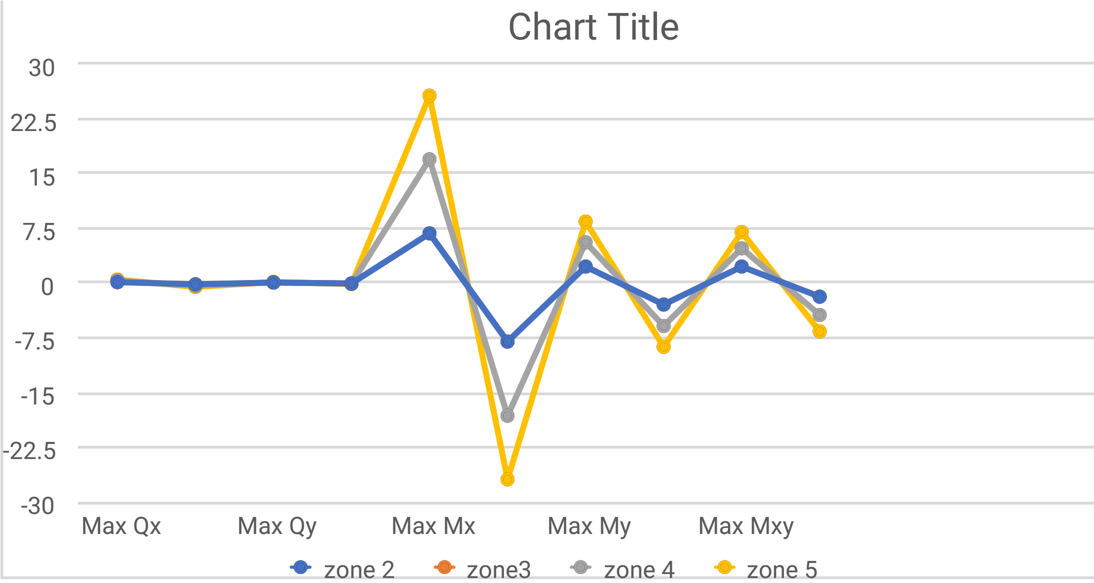
Moment details:



	ZONE 2	ZONE 3	ZONE 4	ZONE 5
Max X	2.571E+01	5.590E+01	2.571E+01	2.570E+01

Min X	-2.570E+01	-5.590E+01	-2.571E+01	-2.570E+01
Max Y	0.784	2.348	0.784	0.784
Min Y	-61.211E+01	-61.120E+01	-61.211E+01	-61.211E+01
Max Z	1.220E+01	7.523E+01	1.220E+01	1.220E+01
Min Z	-1.220E+01	-70523E+01	-1.220E+01	-1.220E+01

Plate Center Stress shear and bending:



	ZONE 2	ZONE 3	ZONE 4	ZONE 5
Max Qx	0.000	0.000	0.000	0.000
Min Qx	-0.000	-0.000	-0.000	-0.000
Max Qy	0.000	0.001	0.000	0.000
Min Qy	-0.000	-0.001	-0.000	-0.000
Max Mx	1.192	1.192	1.192	1.192
Min Mx	-0.000	-0.000	-0.000	-0.000
Max My	2.625	2.625	2.625	2.625
Min My	-0.000	-0.000	-0.000	-0.000
Max Mxy	0.000	0.000	0.000	0.000
Min Mxy	-0.000	-0.000	-0.000	-0.000

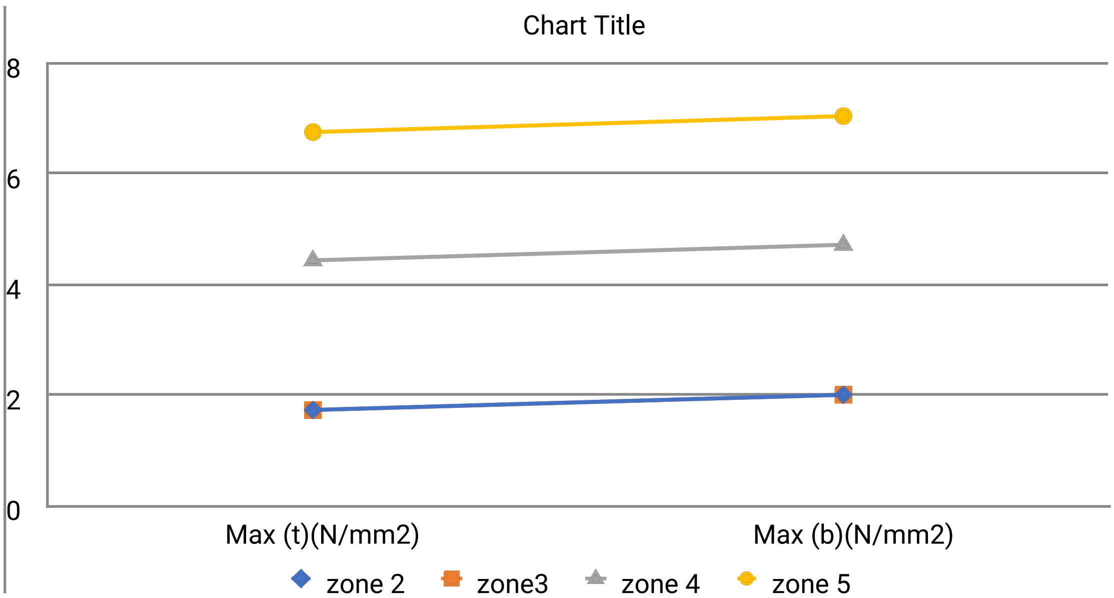
The above table showing Maximum positive and maximum negative shear force, membrane and Bending moment developed in the plate section for the critical load combination which may possible to act on the plates.
These are the forces and moments calculated at the corners of the plates, in the GLOBAL directions. These values are obtained by multiplying the plate's corner displacements with the global stiffness matrix. Unlike the local stresses and forces, which are very accurate approximations, these corner forces represent EXACT results based on linear elastic theory. Also, the local forces are listed on a 'per unit length' basis, whereas these global direction corner forces represent the total force on the plate at the corner in the given

direction, in the same way that joint reactions are reported. At any given joint, the corner forces for all plates connected to that joint should sum to zero (a requirement of equilibrium), assuming no members or boundary conditions are also present at the joint.

Plate principal stresses:

The above table showing the top and bottom principal stresses in the plate section which is in N/ mm2 for the critical load combination which may possible to occur in the bridge.

The principal stresses are the maximum and minimum normal stresses on the element at the geometric centre of the plate. The Tau Max (t_{max}) stress is the maximum shear stress. The Angle entry is the angle between the element's local x-axis, and the direction of the stress (in radians). The Von Mises value is calculated using σ_1 and σ_2, but not σ_3 which isn't available for a surface (plate/shell) element, so this Von Mises stress does not include any transverse shear forces .The angle, Φ, is the angle in radians between the maximum normal stress and the local x-axis. The direction of the maximum shear stress, t_{max}, is ± π/4 radians from the principal stress directions.

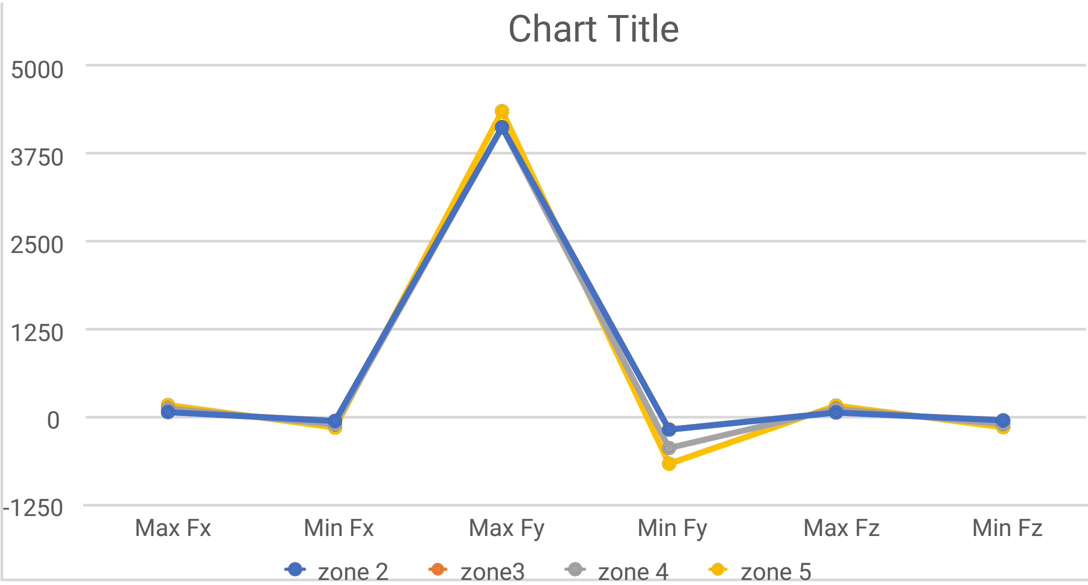


	ZONE 2	ZONE 3	ZONE 4	ZONE 5
Max (t)(N/mm2)	0.954	0.954	0.954	0.954
Max	-	-	-	-

(b)(N/mm 2)	0.045	0.045	0.045	0.045

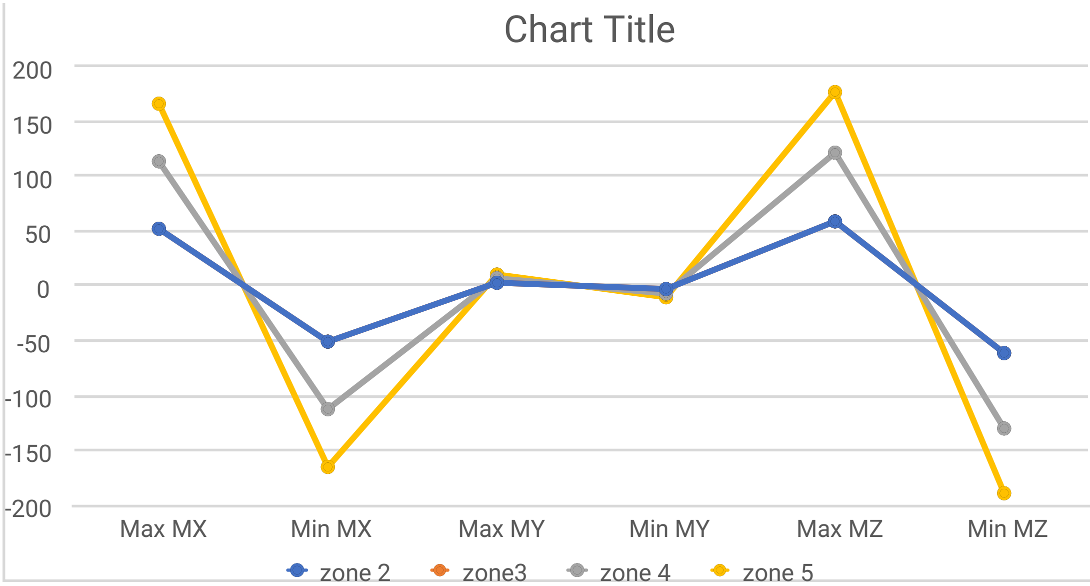
Support reactions:

Forces



	ZONE 2	ZONE 3	ZONE 4	ZONE 5
Max Fx	244.804	244.804	244.804	244.804
Min Fx	-244.804	-244.804	-244.804	-244.804
Max Fy	7.18E+03	7.18E+03	7.18E+03	7.18E+03
Min Fy	-68.297	-152.252	-68.297	-68.297
Max Fz	232.653	232.653	232.653	232.653
Min Fz	-232.653	-232.653	-232.653	-232.653

Moments:



	Zone 2	Zone 3	Zone 4	Zone 5
Max MX	248.612	248.612	248.612E+02	248.612E+02
Min MX	-248.612	-248.612	-248.612E+02	-248.612E+02
Max MY	1.337	4.614	1.337	1.337
Min MY	-1.337	-4.614	-1.337	-1.337
Max MZ	249.943	249.943	249.943E+02	249.943E+02
Min MZ	-249.943	-249.943	-249.943E+02	-249.943E+02

Support Reactions” A support prevents translation of a body in a given direction, a force is developed on the body in that direction .The forces and moments exerted on an object by its supports are called reactions.

The table shows the maximum value of support reactions developed for the critical load combination which may possible to act on the plate. From the above it was observed that the support reactions FY, moments MX and MZ were found to be maximum and the moment MY was found to be minimum in all cases.

06. CONCLUSIONS

In comparison to the previous height classifications, a broad system classification was introduced. Various structural structures have been defined with a focus on creativity within each classification group.

The following conclusions can be drawn on the basis of the current study:

- The building with Floating column has been found to have less base shear than a building without Floating column.
- The Hanging column also falls from the lower to top level of the base shear value as the Hanging column changes.
- Building with Floating column was also found to have more displacement than building without the Floating column. •
- Moving the Floating column from the bottom to the top floors also improved displacement values.
- Building with Floating column was found to have more floor drift than building without a Floating column.
- Shift of Floating columns from bottom to top rates was also observed to increase the storey drift values.

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08. APENDIX STAAD PRO RESULT OUTPUT

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=============================================================================
              IS-456   L I M I T   S T A T E   D E S I G N
          C O L U M N   N O.   254  D E S I G N   R E S U L T S

     M25                    Fe415 (Main)                Fe415 (Sec.)

LENGTH:  3000.0 mm   CROSS SECTION:  450.0 mm X  450.0 mm  COVER: 40.0 mm

** GUIDING LOAD CASE:   36 END JOINT:   120  SHORT COLUMN
```

```
 STAAD SPACE                                          -- PAGE NO.  996


DESIGN FORCES (KNS-MET)
-----------------------
DESIGN AXIAL FORCE (Pu)              :    2612.62

                                          About Z           About Y
INITIAL MOMENTS                      :     128.29             37.16
MOMENTS DUE TO MINIMUM ECC.          :      54.86             54.86

SLENDERNESS RATIOS                   :     -                 -
MOMENTS DUE TO SLENDERNESS EFFECT    :     -                 -
MOMENT REDUCTION FACTORS             :     -                 -
ADDITION MOMENTS (Maz and May)       :     -                 -

TOTAL DESIGN MOMENTS                 :     128.29             54.86

REQD. STEEL AREA    :     3726.00 Sq.mm.
REQD. CONCRETE AREA:   198774.00 Sq.mm.
MAIN REINFORCEMENT : Provide  12 - 20 dia. (1.86%,   3769.91 Sq.mm.)
                     (Equally distributed)
TIE REINFORCEMENT  : Provide  8 mm dia. rectangular ties @ 300 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)
----------------------------------------------------------
Puz :   3395.93   Muz1 :    141.44   Muy1 :    141.44

INTERACTION RATIO: 0.98 (as per Cl. 39.6, IS456:2000)

SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)
----------------------------------------------------------
WORST LOAD CASE:    36
END JOINT:   120 Puz :   3409.10   Muz :    143.59   Muy :    143.59   IR: 0.96
============================================================================
```

```
=============================================================================
          IS-456    L I M I T   S T A T E   D E S I G N
      C O L U M N  N O.   322  D E S I G N   R E S U L T S

     M25                  Fe415 (Main)              Fe415 (Sec.)

LENGTH:  3000.0 mm   CROSS SECTION:  450.0 mm X  450.0 mm  COVER: 40.0 mm

** GUIDING LOAD CASE:   37 END JOINT:   121  SHORT COLUMN
```

```
 STAAD SPACE                                           -- PAGE NO.  997


 DESIGN FORCES (KNS-MET)
 -----------------------
 DESIGN AXIAL FORCE (Pu)              :    2277.50

                                           About Z           About Y
 INITIAL MOMENTS                      :     124.12              1.19
 MOMENTS DUE TO MINIMUM ECC.          :      47.83             47.83

 SLENDERNESS RATIOS                   :     -                 -
 MOMENTS DUE TO SLENDERNESS EFFECT    :     -                 -
 MOMENT REDUCTION FACTORS             :     -                 -
 ADDITION MOMENTS (Maz and May)       :     -                 -

 TOTAL DESIGN MOMENTS                 :     124.12             47.83

 REQD. STEEL AREA   :     2754.00 Sq.mm.
 REQD. CONCRETE AREA:   199746.00 Sq.mm.
 MAIN REINFORCEMENT : Provide  16 - 16 dia. (1.59%,   3216.99 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 :   3104.33   Muz1 :    140.31   Muy1 :    140.31

 INTERACTION RATIO: 0.92 (as per Cl. 39.6, IS456:2000)

 SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)
 ----------------------------------------------------------
 WORST LOAD CASE:    37
 END JOINT:   161 Puz :   3243.22   Muz :    163.21   Muy :    163.21   IR: 0.77
 ============================================================================
```

.

IS-456 LIMIT STATE DESIGN
BEAM NO. 174 DESIGN RESULTS

M25 Fe415 (Main) Fe415 (Sec.)

LENGTH: 2000.0 mm SIZE: 400.0 mm X 400.0 mm COVER: 25.0 mm

DESIGN LOAD SUMMARY (KN MET)

SECTION (in mm)	FLEXURE (Maxm. Sagg./Hogg./Eqv. moments) P	MZ	MX	ME	Load #	SHEAR VY	MX	VE	Load #
0.0	0.00	75.05	-0.36	75.47	3	317.62	27.82	428.90	41
	0.00	-355.70	4.75	-361.29	39				
166.7	0.00	62.11	-0.36	62.54	3	312.45	27.82	423.73	41
	0.00	-291.83	4.75	-297.42	39				
333.3	0.00	49.17	-0.36	49.60	3	307.06	27.82	418.34	41
	0.00	-228.86	4.75	-234.45	39				

STAAD SPACE -- PAGE NO. 153

500.0	0.00	36.24	-0.36	36.66	3	301.22	27.82	412.50	41
	0.00	-166.83	4.75	-172.42	39				
666.7	0.00	11.36	-15.74	29.88	2	294.94	27.82	406.22	41
	0.00	-87.81	27.82	-120.54	36				
833.3	0.00	5.99	-15.74	24.52	2	289.78	27.82	401.05	41
	0.00	-39.09	27.82	-71.82	36				
1000.0	0.00	8.59	27.82	41.32	41	283.05	27.82	394.33	41
	0.00	-0.63	15.74	-19.15	1				
1166.7	0.00	55.26	27.82	87.99	41	275.88	27.82	387.16	41
	0.00	-4.73	-15.74	-23.25	2				
1333.3	0.00	128.35	4.75	133.93	42	270.71	27.82	381.99	41
	0.00	-28.45	-0.36	-28.87	3				
1500.0	0.00	184.10	4.75	189.69	42	263.09	27.82	374.37	41
	0.00	-41.38	-0.36	-41.81	3				
1666.7	0.00	238.77	4.75	244.36	42	255.03	27.82	366.31	41
	0.00	-54.32	-0.36	-54.75	3				
1833.3	0.00	292.21	4.75	297.80	42	249.86	27.82	361.14	41
	0.00	-67.26	-0.36	-67.68	3				
2000.0	0.00	344.38	4.75	349.96	42	241.36	27.82	352.64	41
	0.00	-80.19	-0.36	-80.62	3				

SUMMARY OF REINF. AREA (Sq.mm)

SECTION (in mm)	TOP Reqd./Provided reinf.	BOTTOM Reqd./Provided reinf.	STIRRUPS (2 legged)
0.0	3343.67/3418.05(17-16í)	1700.93/1809.56(9-16í)	12í @ 175 mm
166.7	2759.73/2814.87(14-16í)	1085.50/1206.37(6-16í)	12í @ 175 mm
333.3	2186.43/2211.68(11-16í)	471.47/ 603.19(3-16í)	12í @ 130 mm
500.0	1588.82/1608.50(8-16í)	299.04/ 603.19(3-16í)	12í @ 110 mm
666.7	1031.01/1206.37(6-16í)	299.04/ 603.19(3-16í)	12í @ 95 mm
833.3	580.57/ 603.19(3-16í)	299.04/ 603.19(3-16í)	12í @ 60 mm
1000.0	334.84/ 603.19(3-16í)	325.85/ 603.19(3-16í)	12í @ 90 mm
1166.7	300.67/ 603.19(3-16í)	728.74/ 804.25(4-16í)	12í @ 95 mm
1333.3	300.67/ 603.19(3-16í)	1174.52/1206.37(6-16í)	12í @ 45 mm
1500.0	327.93/ 603.19(3-16í)	1791.22/1809.56(9-16í)	12í @ 130 mm
1666.7	514.45/ 603.19(3-16í)	2247.30/2412.74(12-16í)	12í @ 65 mm
1833.3	1021.65/1206.37(6-16í)	2722.41/2814.87(14-16í)	12í @ 175 mm
2000.0	1519.51/1608.50(8-16í)	3192.47/3216.99(16-16í)	12í @ 175 mm

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

SHEAR DESIGN RESULTS AT 576.9 mm AWAY FROM START SUPPORT
VY = 297.32 MX = 27.82 LD= 41
Provide 2 Legged 12í @ 95 mm c/c

IS-456 L I M I T S T A T E D E S I G N
B E A M N O. 177 D E S I G N R E S U L T S

M25 Fe415 (Main) Fe415 (Sec.)

LENGTH: 3000.0 mm SIZE: 400.0 mm X 400.0 mm COVER: 25.0 mm

DESIGN LOAD SUMMARY (KN MET)

SECTION	FLEXURE (Maxm. Sagg./Hogg./Eqv. moments)					SHEAR			
(in mm)	P	MZ	MX	ME	Load #	VY	MX	VE	Load #
0.0	0.00	142.51	0.83	143.49	49	171.65	-1.90	179.25	40
	0.00	-217.47	-1.90	-219.70	37				
250.0	0.00	122.42	0.83	123.40	49	166.82	-1.90	174.41	40
	0.00	-175.16	-1.90	-177.39	37				
500.0	0.00	101.52	0.83	102.49	49	160.23	-1.90	167.83	40
	0.00	-134.22	-1.90	-136.45	37				
750.0	0.00	79.64	0.83	80.62	49	153.90	-1.90	161.49	40
	0.00	-94.89	-1.90	-97.12	37				
1000.0	0.00	56.70	0.83	57.68	49	147.06	-1.90	154.65	40
	0.00	-57.33	-1.90	-59.57	37				
1250.0	0.00	35.21	0.56	35.87	41	136.47	-1.90	144.06	40

ELEMENT DESIGN SUMMARY

ELEMENT		LONG. REINF (SQ.MM/ME)	MOM-X /LOAD (KN-M/M)	TRANS. REINF (SQ.MM/ME)	MOM-Y /LOAD (KN-M/M)
897	TOP :	156.	0.45 / 11	156.	1.03 / 11
	BOTT:	156.	-0.04 / 1	156.	-0.12 / 4
898	TOP :	156.	0.47 / 11	156.	1.03 / 11
	BOTT:	156.	-0.06 / 1	156.	-0.11 / 3
899	TOP :	156.	0.39 / 11	156.	0.01 / 1
	BOTT:	156.	-0.01 / 2	156.	-1.80 / 11
900	TOP :	156.	0.20 / 11	156.	0.66 / 43
	BOTT:	156.	-0.02 / 1	156.	-0.13 / 4
901	TOP :	156.	0.21 / 24	156.	0.66 / 42
	BOTT:	156.	-0.04 / 1	156.	-0.13 / 3
902	TOP :	156.	0.25 / 11	156.	0.06 / 4
	BOTT:	156.	-0.01 / 2	156.	-1.06 / 11
903	TOP :	156.	0.22 / 11	156.	0.26 / 43
	BOTT:	156.	-0.04 / 1	156.	-0.11 / 4
904	TOP :	156.	0.23 / 24	156.	0.26 / 42
	BOTT:	156.	-0.04 / 1	156.	-0.11 / 3
905	TOP :	156.	0.06 / 1	156.	0.09 / 4
	BOTT:	156.	-0.39 / 40	156.	-1.00 / 11
906	TOP :	156.	0.29 / 11	156.	0.85 / 43
	BOTT:	156.	-0.03 / 1	156.	-0.13 / 4
907	TOP :	156.	0.29 / 11	156.	0.85 / 42
	BOTT:	156.	-0.04 / 1	156.	-0.13 / 3
908	TOP :	156.	0.10 / 1	156.	0.04 / 4
	BOTT:	156.	-0.45 / 40	156.	-1.73 / 11
909	TOP :	156.	0.22 / 24	156.	0.54 / 43
	BOTT:	156.	-0.04 / 1	156.	-0.20 / 4
910	TOP :	156.	0.23 / 24	156.	0.54 / 42
	BOTT:	156.	-0.04 / 1	156.	-0.20 / 3
911	TOP :	156.	0.10 / 1	156.	0.03 / 4
	BOTT:	156.	-0.49 / 40	156.	-1.95 / 11
912	TOP :	156.	0.19 / 24	156.	0.30 / 51
	BOTT:	156.	-0.03 / 1	156.	-0.34 / 42

913 TOP :	156.	0.19 / 24	156.	0.30 / 50
BOTT:	156.	-0.04 / 1	156.	-0.34 / 43
914 TOP :	156.	0.22 / 41	156.	0.59 / 40
BOTT:	156.	-0.10 / 48	156.	-0.09 / 1
915 TOP :	156.	0.29 / 11	156.	0.84 / 43
BOTT:	156.	-0.03 / 1	156.	-0.23 / 4
916 TOP :	156.	0.29 / 11	156.	0.84 / 42
BOTT:	156.	-0.03 / 1	156.	-0.23 / 3
917 TOP :	156.	0.12 / 1	156.	0.03 / 1
BOTT:	156.	-0.58 / 40	156.	-2.94 / 11
922 TOP :	156.	3.84 / 48	156.	0.43 / 1
BOTT:	156.	-4.68 / 41	156.	-1.01 / 40
923 TOP :	540.	23.60 / 49	169.	7.77 / 41
BOTT:	541.	-23.63 / 40	166.	-7.62 / 48
924 TOP :	156.	2.26 / 41	156.	3.52 / 48
BOTT:	156.	-2.07 / 48	156.	-5.41 / 41
945 TOP :	156.	3.94 / 48	156.	1.16 / 49
BOTT:	156.	-6.71 / 41	156.	-2.00 / 40
946 TOP :	593.	25.70 / 49	184.	8.44 / 49
BOTT:	624.	-26.91 / 40	191.	-8.73 / 40
947 TOP :	156.	2.17 / 41	156.	4.98 / 40
BOTT:	156.	-1.55 / 48	156.	-4.74 / 49
949 TOP :	156.	4.46 / 48	156.	1.54 / 49
BOTT:	156.	-4.75 / 41	156.	-1.89 / 40
950 TOP :	546.	23.81 / 49	172.	7.88 / 49
BOTT:	587.	-25.47 / 40	178.	-8.17 / 40
951 TOP :	156.	1.48 / 41	156.	4.37 / 48
BOTT:	156.	-1.17 / 48	156.	-5.23 / 41
953 TOP :	156.	3.58 / 48	156.	1.17 / 49
BOTT:	156.	-5.16 / 41	156.	-1.62 / 40
954 TOP :	472.	20.81 / 49	156.	6.88 / 49
BOTT:	536.	-23.42 / 40	164.	-7.53 / 40
955 TOP :	156.	1.04 / 41	156.	3.88 / 48
BOTT:	156.	-0.79 / 48	156.	-4.89 / 41
957 TOP :	156.	3.12 / 48	156.	1.11 / 49
BOTT:	156.	-4.31 / 41	156.	-1.26 / 40

. .

447. PERFORM ANALYSIS

```
**********************************************************
* UNITS - KN    METE                                     *
* TIME PERIOD FOR X 1893 LOADING =    0.79602 SEC        *
* SA/G PER 1893=    1.708, LOAD FACTOR= 1.000            *
* VB PER 1893=    0.1230 X    19912.12=    2449.42 KN    *
*                                                        *
**********************************************************


**********************************************************
* UNITS - KN    METE                                     *
* TIME PERIOD FOR X 1893 LOADING =    0.79602 SEC        *
* SA/G PER 1893=    1.708, LOAD FACTOR=-1.000            *
* VB PER 1893=    0.1230 X    19912.12=   -2449.42 KN    *
*                                                        *
**********************************************************


**********************************************************
* UNITS - KN    METE                                     *
* TIME PERIOD FOR Z 1893 LOADING =    0.68871 SEC        *
* SA/G PER 1893=    1.975, LOAD FACTOR= 1.000            *
* VB PER 1893=    0.1422 X    19912.12=    2831.07 KN    *
*                                                        *
**********************************************************


**********************************************************
* UNITS - KN    METE                                     *
* TIME PERIOD FOR Z 1893 LOADING =    0.68871 SEC        *
* SA/G PER 1893=    1.975, LOAD FACTOR=-1.000            *
* VB PER 1893=    0.1422 X    19912.12=   -2831.07 KN    *
*                                                        *
**********************************************************
```

447. PERFORM ANALYSIS

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* VB PER 1893=    0.1230 X    19912.12=    2449.42 KN    *
*                                                        *
**********************************************************
```

```
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*                                                        *
**********************************************************
```

```
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*                                                        *
**********************************************************
```