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STUDY OF STRUCTURAL BEHAVIOUR OF INTZE WATER TANK THROUGH AN USER FRIENDLY PROGRAM DEVELOPED BY VISUAL BASIC AND BY SAP

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Abstract – *This project presents a critical review of the current practice in the design of Overhead Intze water tank. 0The design is based on IS: 3370-1965 design code for water retaining structures. The program is written by employing powerful window complaint Visual Basic 6.0 programming language. User friendly program is developed for the design of water tank which will have provision for the user to choose tank capacity, grade of concrete and steel, unit weight of material etc. The tank is designed to resist stresses as per IS: 3370(Part II) - 1965, seismic design as per IS: 1893-2002. The program will provide default values like height of staging, bracing interval, diameter of cylindrical tank etc. Due to fluid structure interactions, the seismic behaviour of elevated tanks has characteristics of complex phenomena. The main aim of the study is to understand the behaviour of the supporting system with SAP software. Here two different supporting system with such as radial bracing and cross bracing are compared with basic supporting system for various fluid conditions and for different capacity. Tank responses including base shear, overturning moment, bending moment at bottom of column and story displacement has been observed, and then the results have been compared.*

***Key Words*: Intze water tank, visual basic, Simple bracing, Radial bracing, cross bracing, Base shear, bending moment, displacement.**

1. INTRODUCTION

The water tower will be essential structure supporting of a water tank constructed at an elevation suitable to drive of a water source system for a supply of potable water and to provide an emergency storage of fire protection. The word standpipe is used for exchangeable and it refers to a water tower, one with tall and another with narrow proportions especially in some places.

1.1 INTZE TANK

The Intze guideline is a German word: Intze– Prinzip, these name provided to build different standards named after water powered engineer "Otto Intze (1843-1904)", in one case the Intze standard identifies water tower and other case is requesting dam. The basic preference for this kind of tank is the inward radial thrust of the conical base to balance an outward radial thrust of the spherical lowest components. This can be discovered to store considerable amount of water for a raised spherical tank to provide flat floor slab expectations work out to a uneconomical configuration. The main principle of these floor slab turns into excessively thick to more tanks of diameter, it suits to best for Intze tank under this condition. An Intze tank basically made of top dome (roof), floor slab and the cylindrical shaped wall which may be a consolidation for base spherical dome and conical dome. Subjected to regulate compression, the thickness of conical floor slab considerably meet expectations and a chance to prove another economical flat slab floor.

The proportions of base dome and conical dome are arranged to outward thrust with bottom domed and floor only balances the internal thrust because of conical dome. The diameter of lowest components of dome is preferably about 65 to 70% of the diameter of the tank. Incline of conical dome is in between 50 to 55 degree level according to consideration. The tank needs to support one staging that comprises an amount of columns to be spaced uniformly along the perimeter of base ring beam through these columns.

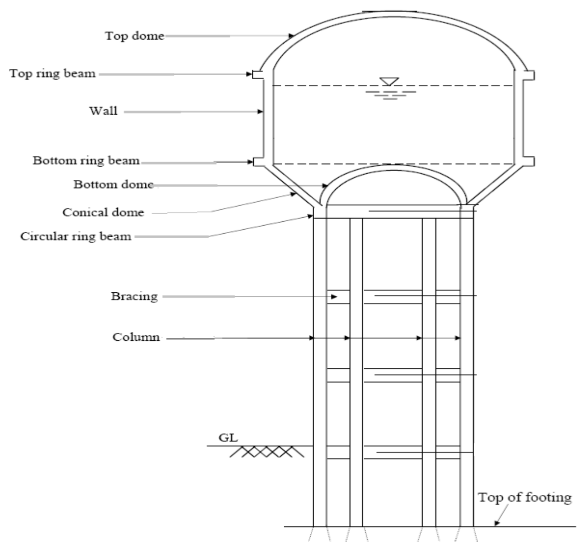

Fig-1 Different components of Intze tank.

1.2 Design procedure of Intze tank

- Outline for top dome and top ring beam.
- Design of cylindrical wall.
- Design of ring beam at the intersection of cylindrical shaped wall to conical dome.
- Design of conical dome and bottom spherical dome,
- Design of bottom ring beam.
- About staging i.e. the design of supporting structure,
- About foundation design.

It is discovered that for storage of more capacity of water an elevated circular tank provide floor slab works out to an uneconomical design. It is mainly on account of the fact that the floor slab becomes too thick for large diameters tanks. Intze tank is best suitable under such circumstances. An Intze tank essentially consist of a top dome (roof), the cylindrical wall and the floor slab, which is a combination of conical dome and bottom spherical dome. Being subjected to direct compression the thickness of the domical floor, works out to be much less and hence it proves to be economical alternative to flat slab floor. The proportion of the conical dome and the bottom dome are so arranged that the outward thrust from the bottom domed part of the floor balances the inward thrust due to the conical domed part of the floor. The diameter of the bottom dome should preferably be about 65 to 70% of the diameter of the tank. From considerations of economy, the inclination of the conical dome should be between 50 to 55° with the horizontal.

1.3 INTRODUCTION TO VISUAL BASIC

Fundamental VISUAL is a large amount of modifying programming language starting with the advanced earlier version of DOS form known as BASIC. BASIC means Beginners universally symbolic typical direction book code. It may be a generally not to take difficult modifying programming language. The code takes a look to considerable measure in English programming language. Various software organizations has been changed the typical forms for BASIC such as Microsoft's QBASIC, QUICKBASIC, GWBASIC, IBM BASIC and so on. However, today individuals want to utilize fundamentals of Microsoft Visual Basic, similarly as it may be a great form of modifying programming language to support resources to help all around. Now, there exists plenty of VB forms exists in the market. The most prominent majority is still utilizes various VB programmers none other than VISUAL BASIC 6. Similarly likewise we need VB.NET, Visual Fundamental 2005, Visual Basic 2008 and the recent version is Visual Basic 2010. Both VB 2008 and VB 2010 are fully turned into object oriented programming language.

1.4 Need for the present study

- The water tanks are visually simple but the analysis and design are difficult.
- Generally there are shell type structures. These structure's methods are involved in complicated analysis and design.
- The membrane theory is employed for design of the elements of water tank. The membrane action will be occur in joints with the ring beams this may cause in local bending and this condition is more rigorous, which necessitates in the elaborate analysis, detail and design. An elevated water tanks involves considerable amount of water mass at the top a slender staging which are most critical respect for disappointment of tank through seismic activity.
- The conventional design for liquid tank is mostly based on loading conditions; loading will be axi-symmetric load by wind and seismic loads. Most of the designs are based on it, it is more complicated to do hand computations.

2. OBJECTIVES

- The main objective of the system is to develop a user friendly computer program for the design of water tank using Visual basic and SAP 2000. This system will have the provision to choose namely Tank capacity, Grade of concrete and steel, bearing capacity of soil, Unit weight of the material etc.
- The tank dimensions obtained using Visual Basic Programming are taken in SAP and the model is analyzed for 3 different capacities like 500m3, 1000m3 and 1500m3 each capacity comprises of different loading cases.
- Comparison of results for different models in terms of base shear, displacement, overturning moment.

3. DESCRIPTION OF THE MODEL

For consideration purpose, 3d Intze RCC overhead tank with typical capacities is taken. This design is taken for every analysis methods to join with Indian Standard Codes for practice. The water tank dome can be planned by working stress method, supporting columns and braces via limit state method

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Table-1 Details of the specimen used for study of structural behavior of Intze water tank.

GEOMETRY OF THE TANK AS PER VISUAL BASIC PROGRAM			
Capacity of the Tank	500m³	1000m³	1500m³
Unit Weight of Concrete	25kN/m³	25kN/m³	25kN/m³
Thickness of Top Dome	0.1m	0.1m	0.1m
Rise of Top Dome	2m	2m	2m
Size of Top ring Beam	0.2m*0.2m	0.25m*0.52 m	0.25m*0.25 m
Diameter of Tank	10m	12m	16m
Height of Cylindrical wall	6m	8m	10m
Thickness of Cylindrical wall	0.25m	0.3m	0.4m
Rise of Conical Dome	2m	2.4m	3.2m
Thickness of Conical shell	0.2m	0.25m	0.3m
Rise of Bottom dome	1.25m	1.5m	2m
Thickness of Bottom dome shell	0.3m	0.4m	0.5m
Number of Columns	8	10	12
Number of Bracing level	3	3	4
Size of Bottom ring Beam	0.3m*0.2m	0.4m*0.6m	0.4m*0.6m
Distance between Intermediate bracing	3m	5m	4m
Height of staging above Foundation	12m	16m	20m
Diameter of Columns	0.5m	0.7m	0.8m
Size of Bracing	0.35m*0.35m	0.45m*0.45 m	0.5m*0.5m

3.1 Loads considered

Dead load (Floor finish)	1.0 kN/m2.
Imposed load	1.5 kN/m2
Zone factor (Z)	0.36 (Zone-5)
Importance factor (I)	1.0
Response reduction factor	5
Wind speed	33 m/s
Terrain category	2
Structural class	B
Risk coefficient	1

3.2 Load combinations

In addition load combinations are illustrated in IS 875-1987(Part 5- Special loads and combinations) with title as “Code about act to design loads with buildings and structures”. Here, the factors are need to consider are,

- ❖ 1.5 (DL + IL)
- ❖ (DL +IL ± WL or EL)
- ❖ 1.5 (DL ± WL or EL)

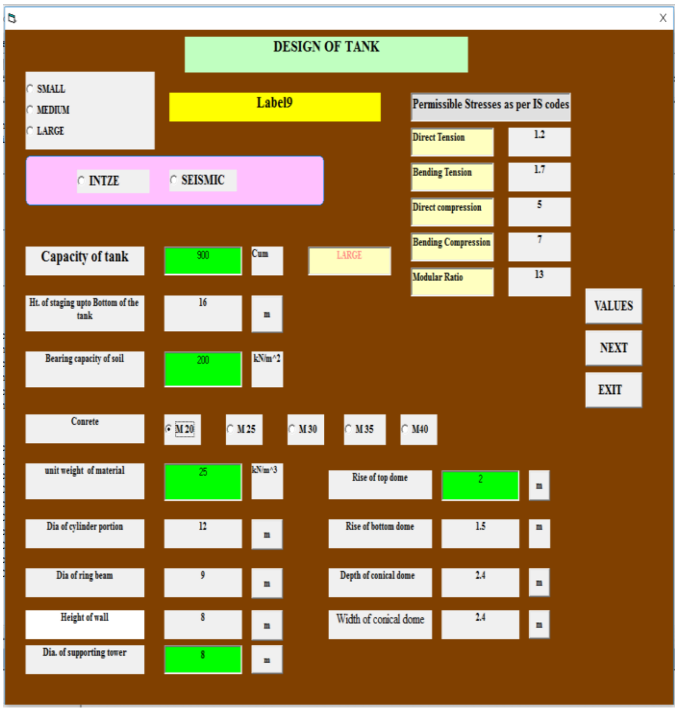


Fig-2 Screen shot showing dimensions of the Intze Water Tank in VISUAL Basic

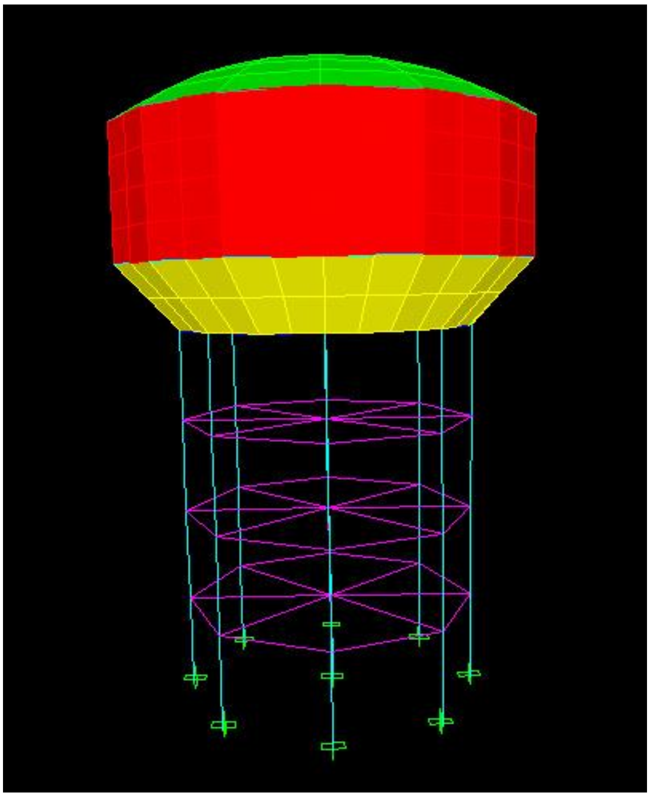


Fig-3 Intze water tank model with Radial bracing in SAP

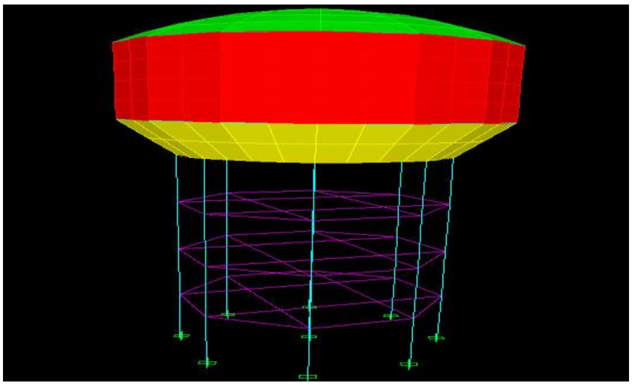


Fig-4 Intze water tank model with cross bracing in SAP

3.3 Analysis methods

The static analysis has been done on all the models considered. Both the methods are discussed in the below section.

3.3.1 Static Analysis

The design lateral force is first computed for the structure as a whole. This design lateral force shall then be distributed to various floor levels. The overall design seismic force thus obtained at each floor levels shall then be distributed to various lateral load resisting elements. The design base shear can be estimated as per IS 1893 (part ı): 2002, clause 7.5.3, The design horizontal seismic coefficient for a structure shall be determined as per IS 1893 (part ı): 2002, clause 6.4.2, The fundamental natural period of vibration considering without brick infill panels and with brick infill panels for a moment-resisting frame building is estimated as per the clause 7.6.1 and 7.6.2 of IS 1893 (part ı):2002. The horizontal design lateral force is then distributed to various lateral load resisting elements in the building as per the clause 7.7.1 of IS 1893 (part ı):2002.

4. RESULTS AND DISCUSSIONS

A Results for various tank capacities.

4.1 Base shear

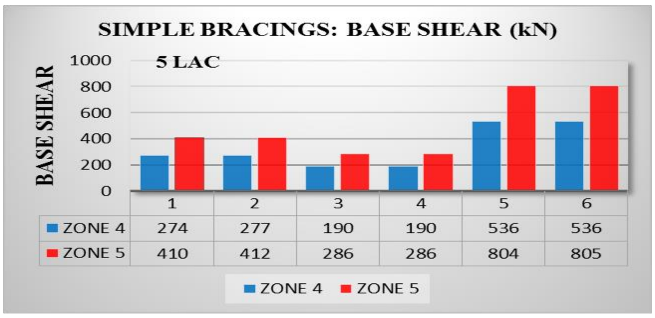


chart 1 Base shear for simple bracing.

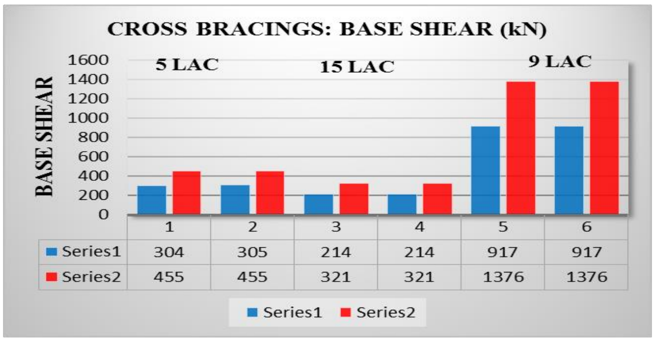


Chart 2 Base shear for cross bracing.

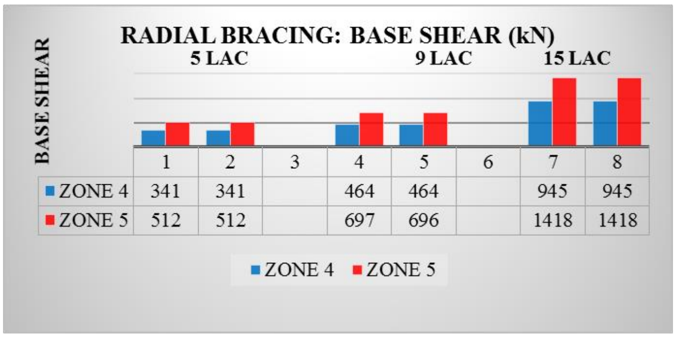


Chart 3 Base shear for Radial bracing.

From the charts 1 to 3 along both X and Y direction it can be observed that for 5 lac capacity in zone 4 and 5 region there will be increase in 10% of base shear with change in bracing systems from simple to cross bracing system similarly 20% increase in base shear from simple to radial bracing system. For 9 lac capacity in zone 4 and zone 5 regions increase in 9% of base shear can be seen with change in bracing systems from simple to cross bracing system similarly 21% increase in base shear from simple to radial bracing system .For 15 lac capacity in zone 4 and zone 5 regions base shear increases by 3% for change in bracing systems from simple to cross bracing system and 6% increase in base shear from simple to radial bracing system can be observed. Due to change in the zone i.e. from zone 4 to zone 5 it observed that there will be 33% increase in base shear value for 5 lack capacity 33% for 15 lac capacity.

4.2Displacement

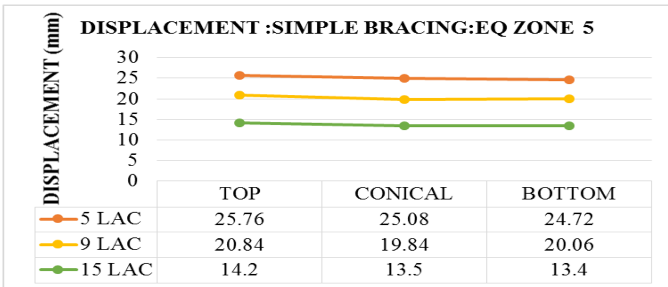


Chart-4Displacement for simple bracing in EQ zone 5.

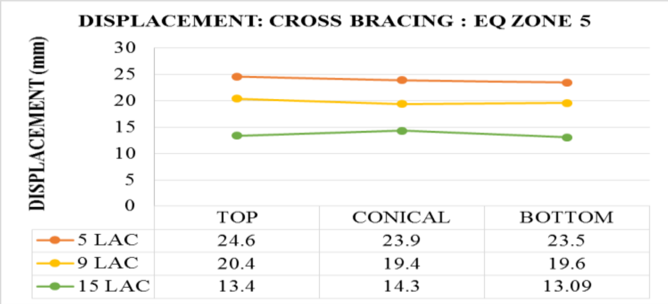


Chart-5 Displacement for cross bracing in EQ zone 5.

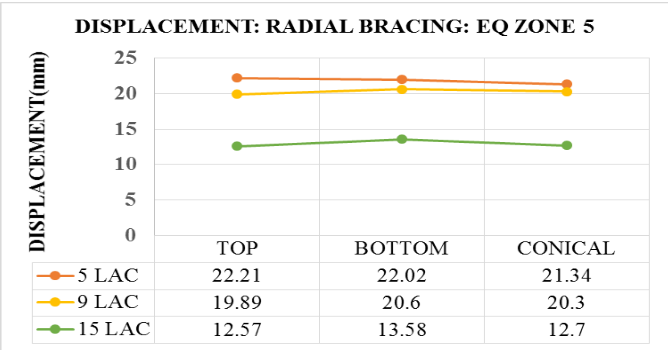


Chart-6 Displacement for radial bracing in EQ zone 5.

From chart-4 it is seen that for simple bracing displacement decreased by 40% and 35% for 15 Lac capacity and 5 lac capacity respectively when compared to displacement of 10 lac capacity tank. From chart-5 it is seen that for cross bracing displacement decreased by 42% and 37% for 15 Lac capacity and 5 lac capacity respectively when compared to displacement of 10 lac capacity tank. From chart-6 it can be seen that for radial bracing displacement decreased by 46% and 38% for 15 Lac capacity and 5 lac capacity respectively when compared to displacement of 10 lac capacity tank. From above charts it is clear that the displacement is minimum for radial bracing system when compared to simple bracing and cross bracing.

B. Results for varying fluid level condition

4.3 Base shear

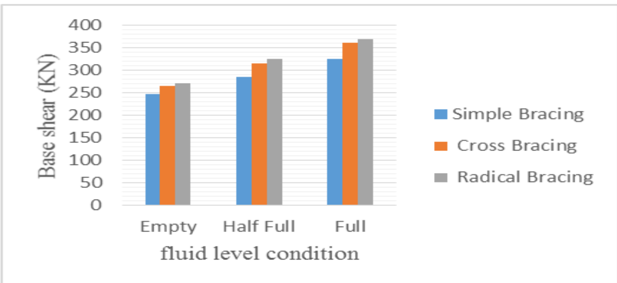


Chart 7 Base shear for different types of bracings in Tank Empty, Half Full and Full condition

From Chart7 it is seen that for there is an increase in base shear of 10% for Simple bracing to Cross bracing in empty half full and full condition. Similarly the base shear is increased by 13% for Simple bracing to Radial bracing in empty, half full and full condition

4.4 Maximum bending moment

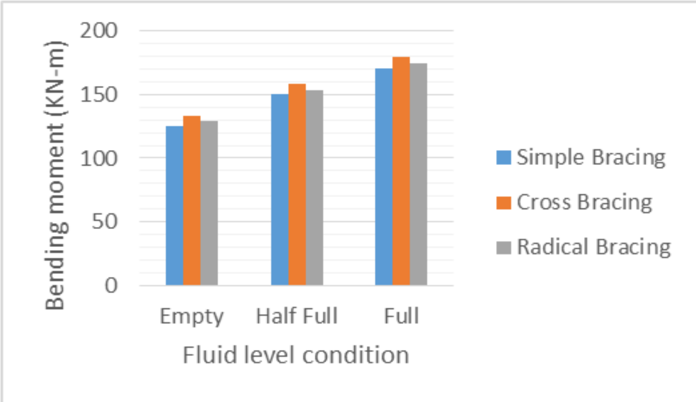
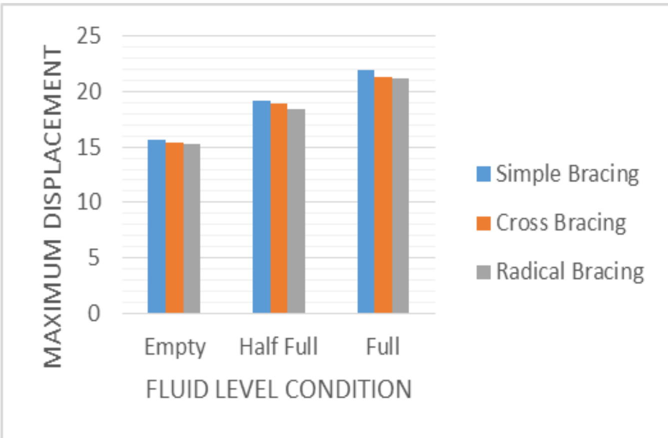


Chart 9 Maximum bending moment for different types of bracings in Tank Empty, Half Full and Full condition.

From the Chart- 9 it is observed that the maximum bending moment is increased by 5% for simple bracing to Cross bracing in Empty, Half Full and Full condition. Maximum bending moment is increased by 2% for Simple bracing to Radial bracing in Empty, Half full and full condition.

4.5 Maximum Displacement



From the Chart-10 it can be seen that there is a decrease in Maximum story displacement of 1.83% for simple bracing to Cross bracing in Empty, Half full and full condition. Similarly, there is a decrease of maximum storey displacement by 3.3% for Simple bracing to Radial bracing in Empty, Half Full and Full condition.

5. CONCLUSIONS

- Overhead water tank design includes formulae for mathematical calculation and consumed time duration, which results the computer program gives a correct answer over the issues. This program is developed by using Visual Basic which acts like a preliminary design for the modeling of water tank using software's like SAP, STAD PRO etc. If the trial and error method is adopted then it is somewhat tedious to handle an economic section.
- With the increase in capacity of water tank and staging height, base shear increases by 60% for simple bracing, 56% for cross bracing and 50% for radial bracing. Change in zone also increases the base shear by 33% for different capacities, which is consistent with the codal specifications.
- With the change in bracing pattern, base shear and over turning moment varies and is found to be increased by 10% for simple to cross bracing and by 13% for simple to radial bracing.
- The Simple bracing (simple bracing) is effective in reducing the bending moment by 2% compared to radial bracing and by 5% compared to cross bracing at the base of the column.
- Story displacements get reduced with the inclusion of bracings. However, the radial bracings are found to be effective in reducing the story displacement. It is of the order of 4% of simple bracing and by 2% of cross bracing.

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