IJMRSETM

e-ISSN: 2395 - 7639


# INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH

## IN SCIENCE, ENGINEERING, TECHNOLOGY AND MANAGEMENT

Volume 10, Issue 6, June 2023

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.580

International Journal of Multidisciplinary Research in Science, Engineering, Technology & Management (IJMRSETM)

| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 7.580| A Monthly Double-Blind Peer Reviewed Journal |

| Volume 10, Issue 6, June 2023 |

# Seismic Analysis of multistorey Buildings with Ground Soft Story with & without Masonry Infill Action

**Ms. Ankita Muley [1], Prof. Girish Sawai [2]**

[1] PG Scholar, Civil Engineering Department, V.M. Institute of Engineering and Technology, Dongargaon, Nagpur, Maharashtra, India

[2] Assistant Professor & Head of the Department, Civil Engineering Department, V.M. Institute of Engineering and Technology, Dongargaon, Nagpur, Maharashtra, India

**ABSTRACT:** R.C.C. framed structures are being widely used for high rise buildings due to the increase in demand for best utilization of land. R.C.C frames with infill walls were usually analyzed and designed as bare frame without considering the strength and stiffness contribution of infill. Masonry infilled walls were treated as non-structural elements and are not considered during the analysis & design of the structure. Now it has been realised that it is necessary to model the effect of the walls on the lateral stiffness and strength of the building. Infill wall are modelled as equivalent diagonal strut as per IS-1893(part-1):2016, analysis and design has been carried out by software ETABS. Analysis has been carried out for the bare frame, fully infill frame & frame with alternate infill at ground storey. Three basic methods are available for analyzing the responses of a structure subjected to seismic ground wave: Static analysis. Response spectra analysis. Time history analysis. The results indicate that the presence of non-structural masonry infills can significantly modify the seismic response of reinforced concrete "frames".

**KEYWORDS-** ETABs, RCC Frame, Multi Storey Building, Seismic Analysis, Soft Storey

## I. INTRODUCTION

According to IS 1893:2016 unreinforced masonry infill panel shall be modelled as an Equivalent diagonal strut. Model suggested by IS code is based on following assumptions a) connection between RC frame and strut is pin-jointed; b) empirical formula is given to calculate the width of diagonal strut; and c) if both the ratio of height to thickness & length to thickness of infill panel are less than 12 then thickness of strut is original thickness of panel and code is silent if the above requirement is not fulfilled. Strength and stiffness of infill panel reduce when openings are present. IS code recommended not to reduce the width of the equivalent diagonal strut if openings are present. In general design practice infill walls are treated as a non-structural element and consider it as the only dead load on supporting beams. Seismic Response of masonry infill RC frame’s structure change tremendously if masonry infill panel is considering in the analysis. The behaviour of infill walls has been analysed and studied by many researchers manipulating with various parameter and verticals of structural analysis and civil engineering by changing the percentage of openings in infills, with and without infills, open first storey, change in infill material, analysis with different software accompanied by different methods of analysis, etc.A large portion of India is susceptible to damaging levels of seismic hazards. Hence, it is necessary to take in to account the seismic load for the design of high-rise structure. The different lateral load resisting systems used in high-rise building are: 1.Bare frame 2. Shear wall frame. In tall building the lateral loads due to earthquake are a matter of concern. These lateral forces can produce critical stresses in the structure, induce undesirable stresses in the structure, induce undesirable vibrations or cause excessive lateral sway of the structure. Todays tall buildings are becoming more slender and leading to the possibility of more sway in comparison with earlier high-rise buildings.

## II. LITERATURE REVIEW

**[1] Analysis And Design of A Multi Storey Building with Flat Slab (C+G+9) Using ETABS Syed Asim Aman, Mohd Abdul Khaliq , Mohd Jameel Uddin , Syed Imranuddin , Syed Khaja Rizwanuddin5, Syed Sabeel Pasha [2018]-** A popular form of concrete building construction uses a flat concrete slab (without beams) as the floor system. This system is very simple to construct, and is efficient in that it requires the minimum building height for a given number of stories. Unfortunately, earthquake experience has proved that this form of construction is vulnerable to failure, when not designed and detailed properly, in which the thin concrete slab fractures around the supporting columns and drops downward, leading potentially to a complete progressive collapse of a building as one floor cascades down onto the floors below. Although flat slabs have been in construction for more than a century now, analysis and design of flat slabs are still the active areas of research and there is still no general agreement on the best design procedure. The present day Indian Standard Codes of Practice outline design procedures only for slabs with regular geometry and layout. But in recent times, due to space crunch, height limitations and other factors, deviations from a regular geometry and regular layout are becoming quite common. Also behavior and response of flat slabs during earthquake is a big question. The lateral behavior of a typical flat slab building which is designed according to I.S. 456- 2000 is evaluated by means of dynamic analysis. The inadequacies of these buildings are discussed by means of comparing the behavior with that of conventional beam column framing. Grid slab system is selected for this purpose. To study the effect of drop panels on the behavior of flat slab during lateral loads, flat plate system is also analyzed. Zone factor and soil conditions -- the other two important parameters which influence the behavior of the structure, are also covered. Software ETABS is used for this purpose. In this study relation between the number of stories, zone and soil condition is developed.

**[2] Comparative Analysis of Design Methodologies for Design of Gravitational RCC Framed Structure via Using Staad Pro Series 4.0 and E-Tabs 2015 Rishanksharma ,Mahendra Saini [2019]-** As the advancement in the world is occurring use of computers in every field has become prominent and with the help of computer we are able to give results as fast as possible now days we are using various software for designing a structure. Most commonly used structural designing software's are ETABS and STAAD PRO so in this following research we design a structure RCC framed structure according to IS 456:2000 which is gravitationally loaded or there is no transverse loads like seismic load and wind load there is only the presence of live load and dead load on the structure which are gravitationally influenced loads in E-Tabs and STAAD PRO. In the following we have go through the procedure followed in the designing of a structure via E-TABS and STAAD PRO and we have compare both software design methodologies and graphical user interfaces and conclude which software is better when we are designing a gravitationally loaded RCC structure in following software's for which we have divided methodology into GUI, modeling, properties assignment, loading, analysis and design and how a software is better than other and what features of a software is better than other and how and what are the problems occurs in the software during designing and how the other software's responds to those problems. The various advantages and disadvantages of a design software procedure over other software design procedure.

**[3] Wilkinson et al** -A tangibly non-direct plane-outline model is presented that is fit for investigating elevated structures exposed to tremor powers. The model speaks to each floor of the structure by Associate in Nursing get together of vertical and even shaft segments The model presents yield pivots with perfect plastic properties in a normal plane casing. The relocations are spoken to by the elucidation (influence) of each floor and along these lines the pivot of all beam– segment crossing points. The mass is basically identified with the interpretations, thus the examination are regularly apportioned as a static buildup of the turns, joined with combination of the dynamic conditions for the interpretations. The dynamic incorporation is here apportioned by utilization of the Runge–Kutta topic. This methodology allows a structure to be displayed by m(n + 2) degrees of opportunity (where m is that the assortment of story's and n is that the assortment of sounds). The position of the dense solidness network is basically m. Its development, which needs the reversal of the motility, rank m(n + 1), solidness framework, is required exclusively at time-steps wherever the example of yielding has adjusted from the past time-step. This model is particularly captivating for non-straight reaction history investigation of tall structures since it is prudent, allows each floor to have various redundancies, and each affiliation Three confirmation precedents are given and subsequently the outcomes from static push-over examination are contrasted and time– history results from the streamlined model. The outcomes confirm that the model is equipped for action non-straight reaction history investigation on normal elevated structures.

**[4] Naser, M** The first essential in basic designing is that the style of simple fundamental components and individuals from structure viz., pieces, bars, sections and footings. the essential advance in any style is to settle on a choice the mastermind of the genuine structure. the arrangement of pillars and segments square measure decided. At that point the vertical hundreds like dead The greater part of the sections structured amid this task were thought of to be pivotally stacked with uniaxial twisting. At long last, the footings square measure structured bolstered the stacking from the section and conjointly the dirt bearing capacity cost for that singular space. All component parts square measure checked for quality and strength. The structure was abdominal muscle initio planned according to IS 456: 2000 while not considering quake hundreds abuse STAAD.pro PC code. At that point the structure was broke down for seismic tremor hundreds according to Equivalent static examination procedure and once getting the base shear according to IS1893.

**[5] Mohammad Adil Dar, et al.** Catastrophes are unpredicted activities which have negatively influenced human's existence due to the fact that the start of the day of our reality. due to such occasions, there have been endeavors to alleviate overpowering impacts of these fiascos. results of such endeavors are very guide in urbanized countries however tragically and miserably terrible in developing international locations collectively with our personal. Seismic tremors are one of the nature's most outstanding dangers on our planet that have taken overwhelming toll on human lifestyles and belongings considering the fact that antiquated activities . The abrupt and sudden nature of the tremor event aggravates it even on mental dimension and shakes the lesson of the overall populace. man views the mom earth for safety and power beneath his feet and whilst it itself trembles, the stun he receives is in reality scary. Notwithstanding the primary seismic tremor configuration IS code 1893 the BIS (Bureau of Indian Standards) has distributed other pertinent quake configuration codes for tremor safe development Masonry structures (IS-13828 1993).

**[6] Seismic Analysis of Multi-Storey Building with and without Floating Column (2015)-** In present scenario buildings with floating column is a typical feature in the modern multi storey construction in urban India. Such features are highly undesirable in building built in seismically active areas. Earthquakes occurred in recent past have indicated that if the structures are not properly designed and constructed with required quality may cause great destruction of structures. This fact has resulted in to ensure safety against earthquake forces of tall structures hence, there is need to determine seismic responses of such building for designing earthquake resistant structures by carrying seismic analysis of the structure. This study highlights the importance of explicitly recognizing the presence of the floating column in the analysis of building. Alternate measures, involving stiffness balance of the first storey and the storey above, are proposed to reduce the irregularity introduced by the floating columns. Time history analysis is one of the important techniques for structural seismic analysis especially when the evaluated structural response is nonlinear. In the present work dynamic analysis of G+14 multistoried RCC building considering for Sumatra earthquake is carried out by time history analysis and response spectrum analysis and seismic responses of such building are comparatively studied and modeled with the help of ETABS software. The floor displacement, inter storey drift, base shear are computed for both the building with and without floating column.

**[7] Seismic Behaviour of Building with Soft Storey: Review (2023)**
The high-rise building in which ground storey consists of open space is known as building with soft floor. Such floor plays an important role in seismic performance of the building. This is due to the abrupt changes in lateral stiffness and strength caused by such storey. In the present era there is increase in population, finding parking for flats in congested areas has become a significant issue. As a result, erecting multistory structures with an open first floor is now a widespread practice. These Buildings that have all upper storeys enclosed by masonry walls but no infill masonry walls in the ground story are referred to as \"Soft Storey\" or \"Open Ground Storey Buildings.\" Compared to regular buildings, irregular structures the drift is observed to be effectively reduced by larger columns, while the shear force and bending moment on the first floor are increased. During a violent earthquake, the Soft Storey buildings function poorly. Understanding the behavior of is this study\'s primary goal to the building in a seismically active area and to assess the effects of Storey overturning moments, Storey drift, displacement, and

design Base shear. For comparison, G-15 story building with five completely distinct shapes a square, an L-shaped building, a T-shaped building, a plus shape building and a C-shaped building is used. ETABS 2018 version is used to analyze the entire set of models. Dynamic Analysis has been examined in the current work to assess the deformation of all five-shape building with and without soft storey considering at different level. When the soft story is offered at a higher level, displacement is reduced. Several studies on this subject that have been done in the past are reviewed in this paper. Reviewing research papers let us know about the conclusive results, which served as the basis for the objective of our future study.

**[8] A Review on Seismic Analysis of Multi-Story Building with underneath Satellite Bus Stop having Service Soft Storey and Moment Transfer Beams (2016)**

Generally, RC framed high rise structures are designed without regards to structural action of masonry infill walls present. Masonry infill walls are widely used as partitions. They are considered as non- structural elements. RC frame building with open first storey is known as soft storey, a similar soft storey effect can also appear, at intermediate storey level if a storey used as a service storey. The soft storey located in the lower part of the high rise building especially the first storey is very undesirable as it attracts severely large seismic forces. In satellite bus stops the ground soft story is of double height than the normal buildings and has sufficiently larger spans for movement of buses, so the effect will be more. At the same time, the soft storey located in the upper part of the high-rise building does not significantly affect the performance compared to the performance of the fully infill frame.

**[9] Analysis of Multi-Story Buildings Infill and Without Infill Walls by Simulation Tool (2018)**

The present study attempts to estimate typical variations in magnification factor of a mid rise open ground storey building accounting for the variability of compressive strength and modulus of elasticity of infill walls with various infill arrangements so that it can help designers facing trouble with heavy designs for a structure of mid-size, with the given material properties, geometry and loadings in particular. For the present study Equivalent static analysis (ESA) and Response spectrum analysis (RSA) is considered for the comparative study. The building will be analyzed for two different cases: i) Considering infill mass but without considering infill stiffness. ii) Considering both infill mass and infill stiffness. From the present results it is found that building with soft storey will exhibit poor performance during a strong shaking. But the open ground storey is an important functional requirement of almost all the urban multi-storey buildings and hence cannot be eliminated. Alternative measures need to be adopted for this specific situation. The under-lying principle of any solution to this problem is in i) increasing the stiffness of the ground storey; ii) provide adequate lateral strength in the ground storey. The possible schemes to avoid the vulnerability of open ground storey buildings under earthquake forces can be by providing stiff columns in open ground storey buildings or by providing adjacent infill walls at each corner of soft ground storey buildings.

**[10] Seismic Analysis of Multistorey Building with and Without Soft Storey (2018)**

To resolve the issues of parking in congested metropolitan cities, the concept of soft storeys can be adopted in high rise buildings. But, through the conclusion of this report, it can be found that using soft storeys in earthquake prone areas can make the entire structure less sustainable during an earthquake. For this project, a model of G+12 storeys was created and analysed for tall structure including soft storey for different levels using ETABS . More over ,for Zone 5 ,and other ten models were created and the performance of the structure was analysed by considering ground storey, ground and 1st storey, 3rd and 4th storey, ground and 6th storey , 6th storey , ground , 12th storey , 12th storey and ground, 1st and 2nd storey as soft storeys. To understand further the characteristic point the soft storey Equivalent static method and Response spectrum method has been used in this report.

## III. AIM & OBJECTIVES

### 3.1 AIM OF THE STUDY

Seismic Analysis of multistorey Buildings with Ground Soft Story With & Without Infill Masonry Action.

### 3.2 OBJECTIVES OF THE STUDY

1. The main objective of this study is to know the contribution of masonry infill panel in enhancement of lateral strength and lateral stiffness of building.
2. The present work attempts to study the seismic response and performance level of different RC buildings located in seismic zone-V.
3. To study, 3D analytical model of multistorey buildings has been generating for different buildings models and analysing using structural analysis tool 'ETABS'.
4. To assess the effect of varying the infill arrangements on the analysis results by taking various combinations of infill thickness, strength, modulus of elasticity and openings.
5. This Project incorporates the equivalent static as well as the dynamic method provided in the Indian Standard codes for evaluating the buildings strength and its performance.
6. The innovative and revolutionary new ETABs is the ultimate integrated software package for the structural analysis and design of buildings.

## IV. PROPOSED METHODOLOGY

### 4.1 BUILDING SPECIFICATIONS

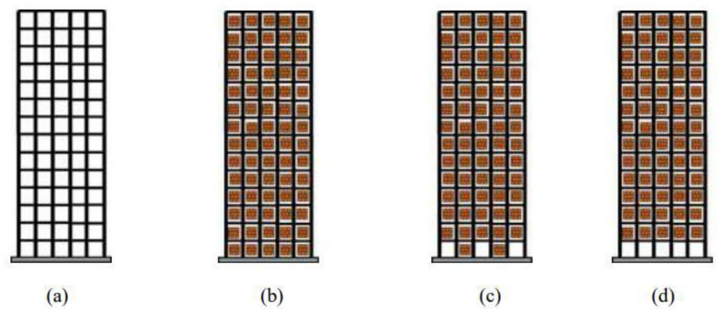
**Table 4.1: Sectional properties of the structural members**

| **Storey** | **6** |
|---|---|
| **Total height** | 18.0 m |
| **Column size** | 550×550 mm |
| **Beam size** | 375×550 mm |
| **Slab thickness** | 125 mm |
| **Masonry wall thickness** | 230 mm |
| **Equivalent width of strut** | 750 mm |

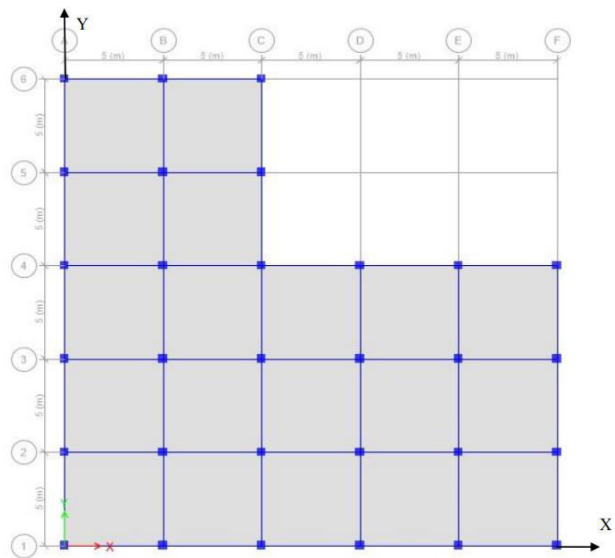
### 4.2 BUILDING CONFIGURATIONS

Figure 4.1 shows the different configurations of the building considered for analysis. Further figure 4.2-4.3 shows these configurations for six Storey structure modelled in ETABS software. The configuration of masonry infill includes:

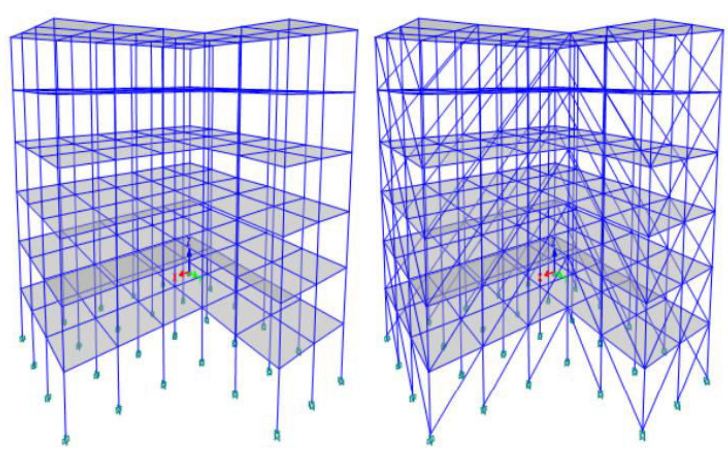
- Bare frame
- Fully infill frame
- Frame with partial (alternate) infill at ground storey
- Frame with soft ground storey (i.e., there is no infill wall at the ground storey)



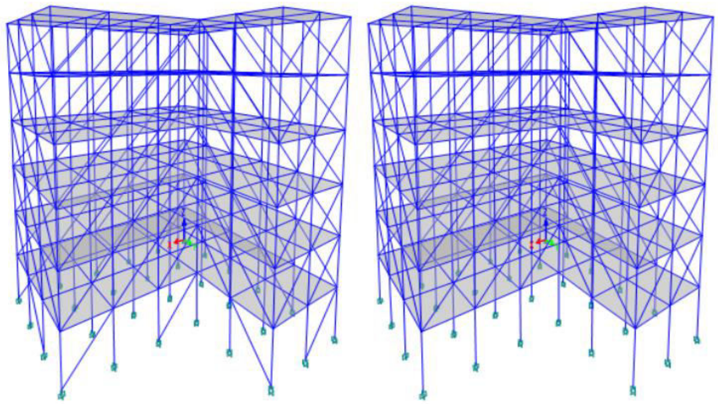

**[Fig.4.1: (a) Bare frame. (b) Fully infill frame. (c) Frame with partial (alternate) infill at ground storey. (d) Frame with soft ground storey (i.e., there is no infill wall at the ground storey)]**



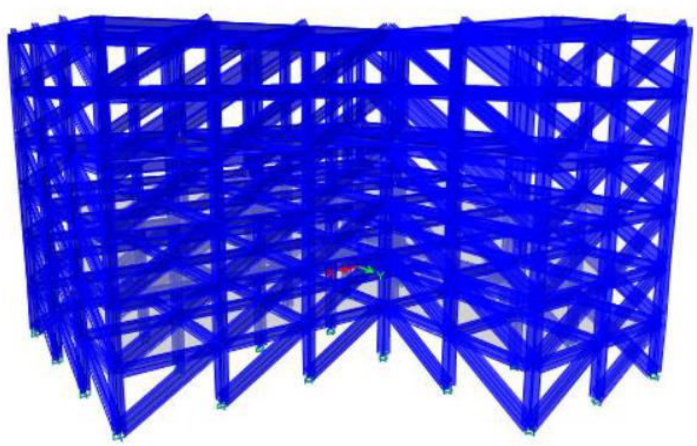

**[Fig.4.2: Plan of six storey building]**



**[Fig.4.3: (a) Bare frame and (b) Fully infill frame]**



**[Fig.4.4: (a) Frame with partial infill at ground storey and (b) Frame with soft ground storey]**



**[Fig.4.5: 3-D view of six storey frame]**

## 4.3 MATERIAL

**Table 4.2: Material properties of concrete**

| Grade of concrete | M 30 |
|---|---|
| Compressive strength of concrete | 30 N/mm$^2$ |
| Density | 25 KN/m$^3$ |
| Modulus of elasticity | 27386.135 N/mm$^2$ |
| Poisson's ratio | 0.2 |
| Coefficient of thermal expansion | 0.0000055 /°C |

**Table 4.3: Material properties of steel**

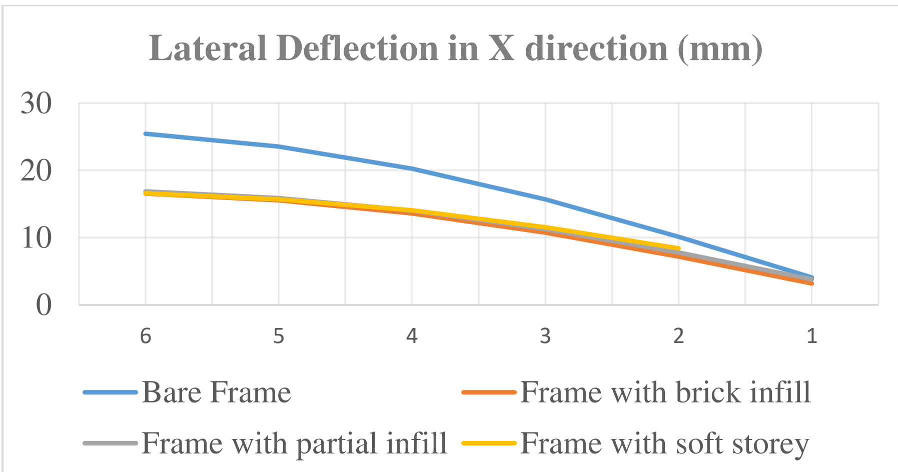
| Grade of steel | Fe 415 |
|---|---|
| Density | 76.825 KN/m$^3$ |
| Modulus of elasticity | 200000 N/mm$^2$ |
| Coefficient of thermal expansion | 0.0000117 /°C |

**Table 4.4: Material properties of brick infill**

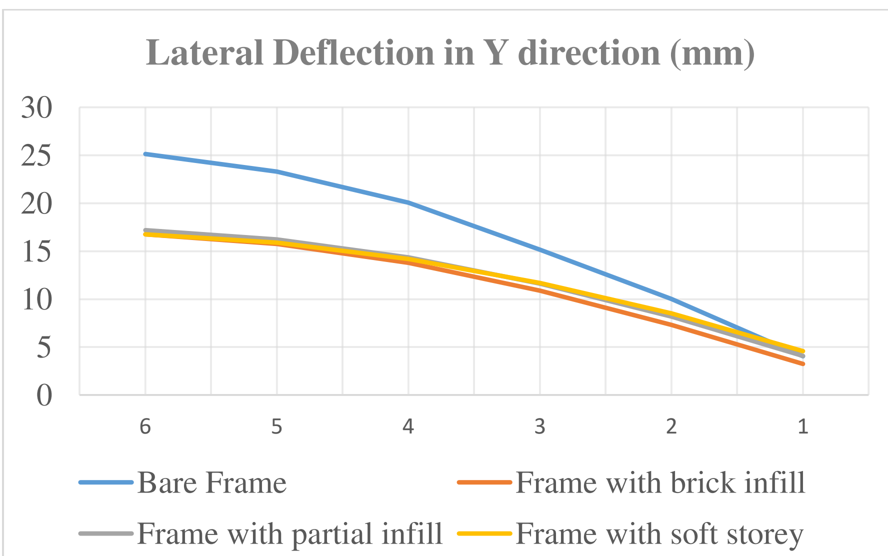
| | |
|---|---|
| **Compressive strength of concrete** | **4.4673 N/mm$^2$** |
| **Density** | 20 KN/m$^3$ |
| **Modulus of elasticity** | 2457.045 N/mm$^2$ |
| **Poisson's ratio** | 0.2 |
| **Coefficient of thermal expansion** | 0.0000081 /°C |

## V. RESULTS

### 5.1 LATERAL DEFLECTION

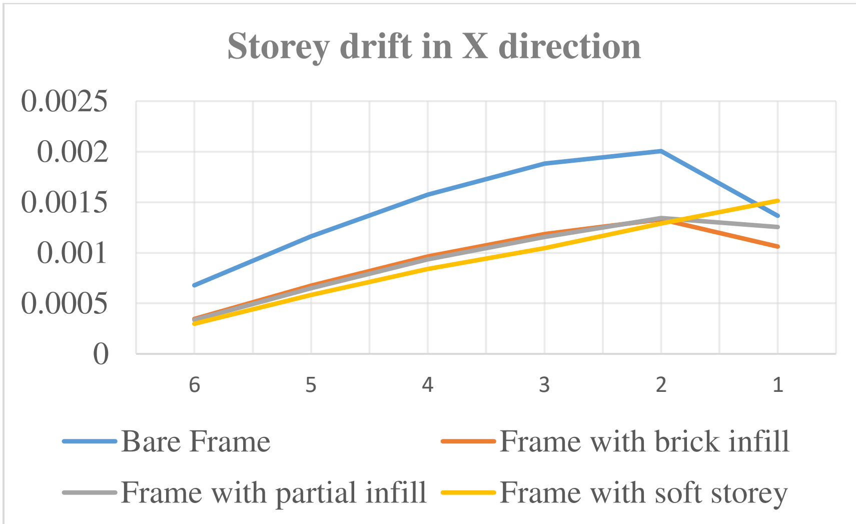



**[Fig.5.1: Comparison of lateral deflection along the storey number for six storey frames in x direction]**

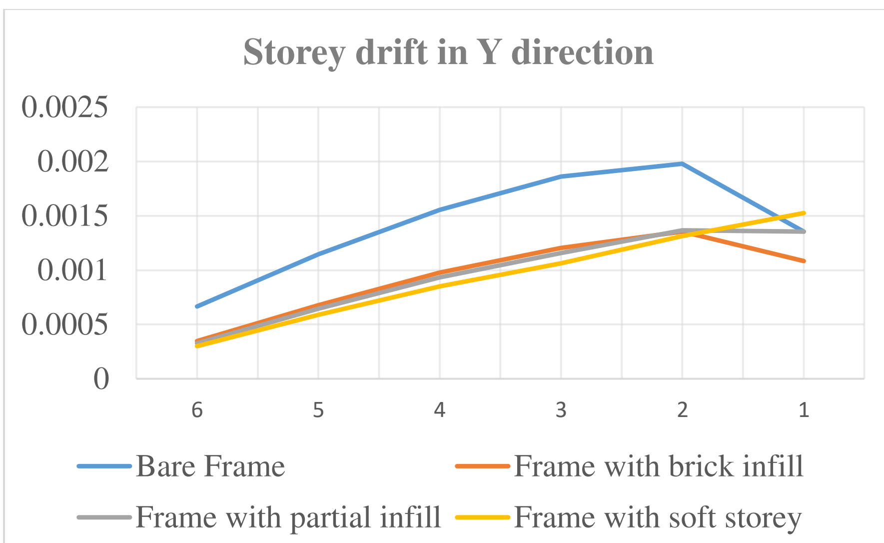



**[Fig.5.2: Comparison of lateral deflection along the storey number for six storey frames in y direction]**

**5.2 STOREY DRIFT**

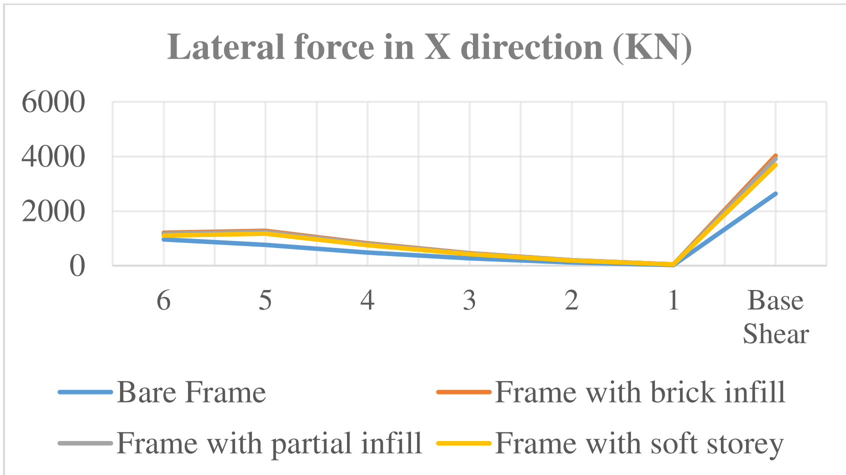



**[Fig.5.3: Comparison of storey drift along the storey number for six storey frames in x direction]**

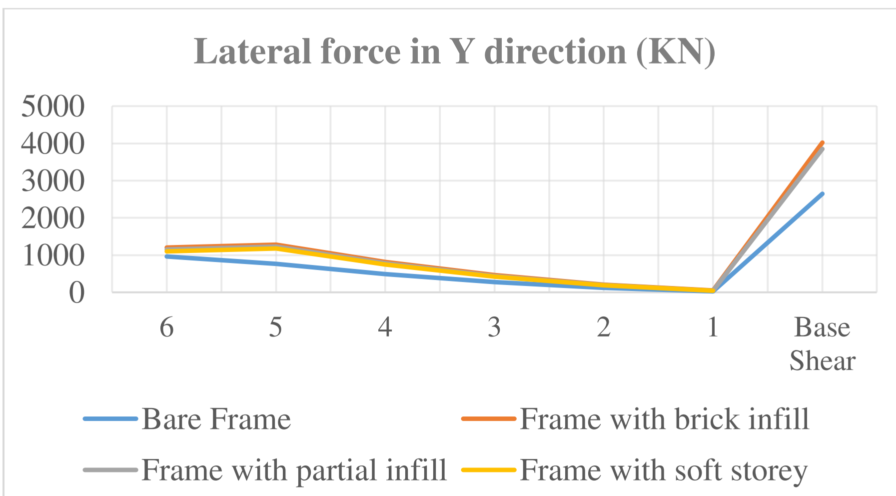



**[Fig.5.4: Comparison of storey drift along the storey number for six storey frames in y direction]**

**5.3 LATERAL FORCE**

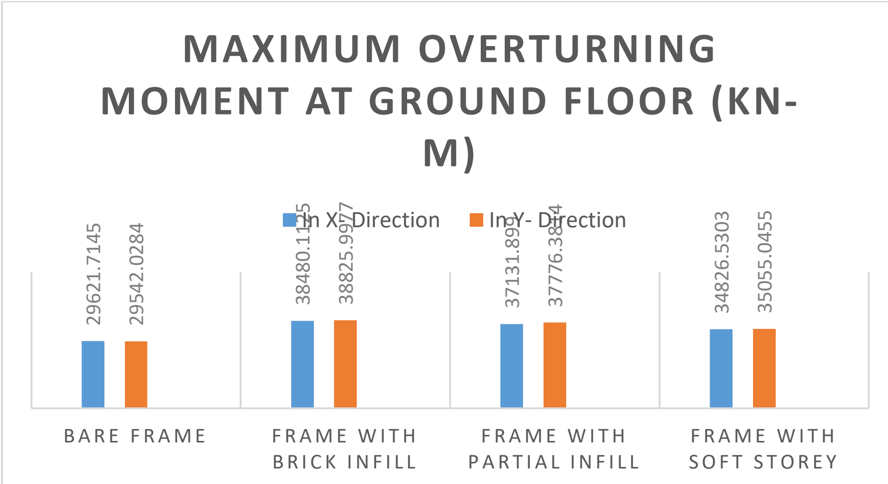



**[Fig.5.5: Comparison of lateral force along the storey number for six storey frames in x direction]**




**[Fig.5.6: Comparison of lateral force along the storey number for six storey frames in y direction]**

### 5.4 MAXIMUM OVERTURNING MOMENT




**[Fig.5.7: Comparison of maximum overturning moment along the storey number for six storey frames in x & y direction respectively]**

## VI. CONCLUSION

- From figure 5.1 & 5.2 and table 5.1 & 5.2 it is observed that the Lateral deflection of all four-configuration model is maximum at the roof. If effect of masonry infill considered lateral deflection for the infilled frame decrease up to 35% and 33.36% in X and Y direction respectively.
- There is no significant change in lateral deflection at each floor of frame with brick infill, frame with partial infill & frame with soft storey except at first floor of frame with soft storey in which lateral deflection is increase up to 42.56% and 41.11% in comparison to displacement at first floor of fully infill frame in X and Y direction respectively.
- From figure 5.3 & 5.4 and table 5.3 & 5.4 it is observed that Storey drift at second floor of bare frame is 33.70% and 31.86% more than the storey drift of fully infill frame in X and Y Direction respectively.
- When the effect of masonry infill wall (i.e., for fully infill frame) is considered maximum lateral force (from figure 5.5 & 5.6) at fifth storey is 1.24 times the maximum lateral force at fifth floor of bare frame in X and Y both directions.
- From table 5.5 & 5.6 and table 5.7 it is observed that the values of Base shear and over turning moment is minimum for bare frame and maximum for fully infill frame.

## REFERENCES

1. A. A. Mali, P. M. Mohite, Seismic Behaviour of Building with Soft Storey: Review, Ijraset Journal For Research in Applied Science and Engineering Technology, 2023-01-02, https://doi.org/10.22214/ijraset.2023.48499
2. Abhishek Shankar, Dr.Ajay Swarup, Analysis of Multi-Story Buildings Infill and Without Infill Walls by Simulation Tool, IJARIIE-ISSN(O)-2395-4396, Vol-4 Issue-1 2018
3. Alireza Ahmadnia, Mahdi Taiebat, Liam Finn, W.D., and Carlos E. Ventura. " Seismic evaluation of existing basement walls" - III ECCOMAS Thematic Conference onComputational Methods in Structural Dynamics and Earthquake Engineering.Vol 5.Pp 45-60."
4. Awkar J. C. and Lui E.M, "Seismic analysis and response of multistory semi rigid frames", Journal of Engineering Structures, Volume 21, Issue 5, Page no: 425-442, 1997.

5. Anjana C Jain,Ananya John (2016). "Seismic analysis of expansion gap for multistoried buildings" International Research Journal Of Engineering And Technology,Vol.03 (09)
6. Bharath Kumar, Prof. Vishwanath B Patil, A Review on Seismic Analysis of Multi-Story Building with underneath Satellite Bus Stop having Service Soft Storey and Moment Transfer Beams, IJSRD - International Journal for Scientific Research & Development| Vol. 4, Issue 05, 2016 | ISSN (online): 2321-0613
7. Chang-kun Chen, WeiZhang, (2011) "Experimental study of the mechanical behavior of steel staggered truss system under pool fire conditions", Thin-Walled Structures 49: pp 1442–1451
8. David Stringer, (1982) "Staggered truss and stub girder framing systems in western Canada", Canadian structural engineering conference: pp 3-8
9. Feng Zhao and Chonghou Zhang, "Diagonal Arrangements of Diagrid Tube Structures for Preliminary Design", Struct. Design Tall Spec. Build.", Volume24, Issue3, Pages 159-175, 2015
10. Fahimi M, Sreejith R, 2015, Seismic Analysis of Multi-Storey Building with and without Floating Column, INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY (IJERT) NCRACE – 2015 (Volume 3 – Issue 29)
11. Giovanni Maria Montuori, Monica Fadda, GianpaoloPerrella and Elena Mele, "Hexagrid – hexagonal tube structures for tall buildings: patterns, modeling, and design",The structural design of tall and special buildings, Volume24, Issue15, Pages 912-940, 2015
12. "IS 1893 (Part 1): 2016." Criteria for Earthquake Resistant Design of Structures. Bureau of Indian Standards.
13. "IS: 875 (Part 3) - 2015." Code of Practice for Design Loads (Other Than Earthquake) for Buildings and Structures. Bureau of Indian Standards.
14. Jinkoo Kim, Junhee Park, Sung-woo Shin and Kyung-won Min, "Seismic Performance of Tubular Structures With Buckling Restrained Braces", The Structural Design Of Tall And Special Buildings, Volume18, Issue4, Pages 351-370, 2009
15. Jinkoo Kim, Joon-Ho Lee, Young-Moon Kim, (2007) "Inelastic behavior of staggered truss systems", Wiley Interscience, Structural design of tall and special buildings 16: pp 85–105
16. Jinkoo Kim and Young Ho Lee, "Seismic Performance Evaluation of Diagrid", Struct. Design Tall Spec. Build, Volume21, Issue10, Pages 736-749,2012
17. Khushbu D. Jani and Paresh V. Patel, "Design of Diagrid Structural System for High Rise Steel Buildingsas per Indian Standards", Conference of Structures Congress 2013, Volume 51, Pages 92-100, 2013
18. Kyoung Sun Moon, "Practical Design Guidelines for Steel Diagrid Structures", Architectural EngineeringConference (AEI) 2008
19. Manthan I. Shah, Snehal V. Mevada, Vishal B. Patel, "Comparative Study of Diagrid Structures withConventional Frame Structures", Int. Journal of Engineering Research and Applications, Vol. 6, Issue5, (Part - 2), pp. 22-29, 2016
20. NiloufarMashhadiali and Ali Kheyroddin, "Progressive collapse assessment of new hexagrid structural system for tall buildings", The structural design of tall and special buildings, Volume23, Issue12, Pages947-961, 2014
21. "IS 1893 (Part 1): 2016." Criteria for Earthquake Resistant Design of Structures. Bureau of Indian Standards.
22. "IS: 875 (Part 3) - 2015." Code of Practice for Design Loads (Other Than Earthquake) for Buildings and Structures. Bureau of Indian Standards.
23. N. Umamaheswari and Dhanya Mary Alexander, "A State of The Art Report on Fatigue Behaviour of Steel Structures Strengthened with Fibre-Reinforced Polymer Composites" International Journal of Civil Engineering & Technology (IJCIET), Volume 5, Issue 3, 2014, pp. 301 - 307, ISSN Print: 0976 – 6308, ISSN Online: 0976 – 6316.
24. Scalzi JB, (1971) "The staggered truss system-structural consideration". Engineering Journal AISC; 8 (10): pp 25–30.


INNO SPACE

SJIF Scientific Journal Impact Factor

Impact Factor: 7.580

# INTERNATIONAL JOURNAL
## OF MULTIDISCIPLINARY RESEARCH
IN SCIENCE, ENGINEERING, TECHNOLOGY AND MANAGEMENT

+91 99405 72462 +91 63819 07438 ijmrsetm@gmail.com

www.ijmrsetm.com