Analysis of Non-Parallel Lateral Force System Irregularity in RCC Structure Using ETAB

Meraz Ali
Civil department
SSIPMT
Raipur,India
merazali0212@gmail.com

Barkha Verma
Civil department
SSIPMT
Raipur,India
barkha.verma@ssipmt.com

Article Info
Page Number: 9630 - 9642
Publication Issue:
Vol 71 No. 4 (2022)

Article History
Article Received: *15 September 2022*
Revised: *25 October 2022*
Accepted: *14 November 2022*
Publication: *21 December 2022*

Abstract: — the impact of various irregularity types on the seismic response of structures need to be evaluated more thoroughly because irregularities are a major concern in structural engineering. That is using nonlinear response spectrum analysis; it was determined how non-parallel systems irregularity affected the torsional behaviour of RC buildings with non-parallel shear walls. According to the findings, the presence of non-parallel parts in lateral force resisting systems can enhance the torsional response, which in turn can have a big impact on how seismically resilient a building is. Additionally, it is noted that in the tested models, the torsion ratio rose more noticeably in the direction of the shear wall as opposed to the perpendicular direction.
Keywords— Etab, shear wall, Torsion, Earthquake, Irregularities

1. Introduction

Buildings are among the most prevalent types of structures, and it is crucial for engineers to enhance their performance under various loads, particularly the lateral loads caused by earthquakes. Since these uneven structures are more frequently vulnerable towards earthquakes, it is crucial to take loads of earthquake into account while constructing these structures (1).For structural engineers, it goes without saying that regular structures often perform better than irregular ones and are simpler to evaluate. A building needs to have four key characteristics in order to perform well during an earthquake: a simple, regular layout, enough lateral strength, stiffness, and ductility (2). Due to site conditions or a decision made by architects, it is frequently impossible to have regular blueprints, which results in irregular structures. ETABS analyses gravity, thermal, and lateral loads in both static and dynamic modes (3). In these circumstances, it is necessary to conduct more precise analyses. When facing earthquakes, especially strong ones, structure having regular geometric arrangements are generally resistant to them than those with dissimilar geometric configurations (4). Research also on tectonic behaviour of the structure with non-parallel system irregularity is surprisingly limited. With the advancement of seismic design theory, it has become widely accepted that the torsion effects caused by the irregular layout of the structure should be taken into account(5).It is crucial that the structure has enough strength to withstand vertical loads and enough stiffness to withstand lateral stresses(6). Asymmetric constructions are more likely to collapse or sustain structural or non-structural damages, according to the way they behaved during previous earthquakes(7).The maximum story response and the impact of non-parallel lateral systems (non-parallel shear walls) on the torsion ratios of reinforced concrete buildings are explored in this article. Stress walls are constructed to lessen the effects of lateral stress placed on such a building. Shear walls are outside, straight walls that usually form a box and give the building all of its lateral support (8).

In high structure, it is crucial to guarantee appropriate lateral constraint to resist lateral force. To minimise total torsion, shorten the distance between the centre of stiffness (CS) and the centre of mass

(CM) during design phase. The primary objective of this study is to present the theoretical method for minimising torsion by shortening the gap between CM & CS at each floor level of the construction. (9). It has already been noted that as a structure's eccentricity grows, the displacement caused by an earthquake excitation also increases, so it is essential to design infrastructures for impact loading (10). Assuring structural safety during severe earthquakes seems to be the primary goal of structural systems for seismic forces. How a structure behaves to seismic events is governed by how weight, stiffness, and strength were spread inside the horizontal and angular planes of the building (11). The primary criteria for designing RCC structures in seismic zones just at moment seems to be the management of lateral forces brought on by lateral stresses. Torsional irregularity increases uneven displacements at the building's margins and may stress the lateral load-resisting components there. Due to its structural effectiveness and versatility in architectural designing, the diagrid structural system is used in tall buildings (12). For the building to function effectively and reliably, it is crucial to assign shear wall in the correct place. Shear walls use their great structural rigidity to transmit seismic loads downward to the foundation. Such dual systems interact at the horizontal floor slabs when subjected to lateral loads because of the deflected shapes of the wall and frame (13). The analyses demonstrated the torsional effects that resulted from the building's non-symmetrical horizontal plan when it was subjected to lateral excitation, as well as how to minimise or eliminate these effects by using suitable shear walls with particular properties in particular locations throughout the structure. For the building to function effectively and reliably, it is crucial to place the shear wall in correct place (14). Therefore, it is crucial that the structure has enough strength to withstand vertical loads in addition to having enough stiffness to withstand lateral stresses.

The displacement of one story of a multi-storey structure away from the level below is known as story drift. Inter story drifts, that occurred when a structure sways during an earthquake, is just the gap between both the displacements of the any given story's roof and floor, standardized by story height. The twisting moment that causes torsion in structures. It is known as the displacement type loading, also represented as the load-deformation curve of the building or a structure, and occurs when a building is subjected to a random ground motion or vibration at its base. This creates inertia forces in the building that in turn induce stresses (15). Buildings' seismic response can be considerably altered by torsional effects, which have resulted in serious damage or structural collapse in a number of previous earthquakes. Different factors, such as uneven mass distribution, stiffness and strength, among others, contribute to these impacts. Examples of structural eccentricity include a lack of symmetric or irregularity among shape, mass, stiffness, too. (16).

The building's L.F.R.S.(lateral force-resisting system) could be of a variety of types. Shear walls, frame-shear wall dual systems, and special moment resistant frames are the most prevalent types of these systems in a structure (17).Shear walls are typically used as an upward underlying component to resist the horizontal loads that may be induced by the effect of wind and tectonic loads (18).Structural walls made of reinforced concrete, also known as shear walls, serve as the main components of an earthquake-resistant building. Shear walls are particularly useful in tall buildings that are subject to lateral wind and seismic forces (8).The effective bracing system and source of lateral load resistance are structural walls. Shear walls are typically offered in thicknesses between 200 and 400mm.The minimum and maximum percentages of steel needed for the shear wall are 0.25% and 4%, respectively. Shear walls, which lessen lateral sway and hence lessen structural damage (19).It was crucial to properly assess the seismic reaction of the walls because the characteristics of these tectonic shear-walls dictate the response of buildings. Given the presence of floating columns, it may be said that many buildings cover the greatest amount of appropriate space.

During both shear and bending, The side forces throughout the wall level will be transmitted by a vertical structural member (shear wall)(20).Effective understanding exists of the potential effects of torsion on several parameters. We can see these parameters by starting with a building's basic construction and then including factors like infill walls, shear walls, and base isolation (21).One of the often utilised lateral load reducing systems in RCC constructions is the reinforced concrete shear wall. Due to its great strength and in-plane stiffness, it can withstand significant horizontal forces and support a load at the same time (22).The (G+15) storey building was examined in this study using various shear-wall configurations. Therefore, choosing the basic plan arrangement of the structure is crucial to the structural design. The choice of the conceptual design will have an impact on how well the building can endure earthquake ground shaking (23). Along with the weight of the building and its occupants, lateral pressures brought on by wind, earthquakes, and uneven settlement loads produce strong twisting (torsion) forces. A building can be actually torn apart by these pressures. Due to its indirect ground contact, the lower portion of a building is more likely to shake during an earthquake. However, the forces of inertia maintain the top position (24). A frame can be strengthened by adding a stiff wall inside of it or by attaching one to it. This keeps the frame's shape and prevents rotation at the joints. Shear walls become particularly important for high structures prone to lateral wind and seismic pressures because of unequal mass and stiffness ratios in multi-story concrete structures lead those civil structures to just be torsion sensitive under dynamical applied loads like seismic events or wind. The structural layout affects a building's behaviour and stability in a sloped area. In practically every nation, including India, irregular buildings are being developed more and more frequently as a result of the fast global urbanisation trend. Seismic analysis on a vertical irregular building with a flat slab on a plain and varied slopes of ground under the seismic zone V and compared the RSA results to establish how both building layouts would respond (25).

2. Objective

Main aim of the current work is to use response spectrum analysis to investigate the tectonic response of irregular R.C. multi-story buildings in India that are situated in earthquake zone and have medium soil types (iii).

1. In IS code 1893(part 1):2016 table 5 of serial no.5 page no 16 there is no defined percentage in a non-parallel lateral force system that allows us to determine the maximum lateral force that will cause a structure to fail.
2. Utilising response spectrum analysis to investigate the seismic reaction of an RC multi-story building with torsional irregularity.
3. To choose, out of the models under consideration, the building arrangement that is most efficient.

3. Narrative of Model

In the current work, regular and irregular buildings in the same region with varied shear wall positions are analysed. Modelling and analysis for G+15 tales are done in this project. Utilizing the ETABS-2018 programme, modelling and analysis are performed. The Base model dimensions are 16 metres by 16 metres for normal buildings. For irregular buildings, the dimensions are same only the angle of one side of building is increasing by 3^0. These 5 models are located by the shear wall in same positions with five different angle i.e.(3^0,6^0,9^0,12^0,15^0). In regular and irregular buildings 5 each models are done by ETABS.A strong tool called ETABS was created by Computers and Structures Inc. in Berkeley, California, USA. It can significantly improve engineer's ability to analyse and designing part of structural systems (26).

4. Building Descriptions

TABLE I-Material Specification

S.No	Specification	Details
1	Grade of Concrete,M30	F_{ck}=30N/mm^2
2	Grade of Steel	f_y=415N/mm^2
3	Density of Concrete	Υ_c=25kN/m^2

TABLE II- Summarized of specification

S.No	Specification	Details
1	Building height	48m
2	Stories above ground	G+15
3	Number of basements below ground	0

4	Type of building	RC frame
5	Software used	ETABS 2018

TABLE III-Building Data

S.No	Specification	Details
1	Column dimensions	500X500mm
2	Beam dimensions	500X300mm
3	Slab Thickness	150mm
4	Shear wall Thickness	250mm
5	Live load	$4KN/m^2$
6	Importance factor	1.15
7	tectonic zone factor	3
8	Response reduction factor	5

5. Methodology

ETABS-2018 software is utilised in this study to analyse the building model.

The parameters in the table given above were taken into account when modelling the structure in ETABS.To test the capacity of the building model's basic structural member dimensions, the model in all figure was put under both dead load and live load conditions**.** Only when all members have passed a design assessment and are therefore safe are seismic analyses performed.

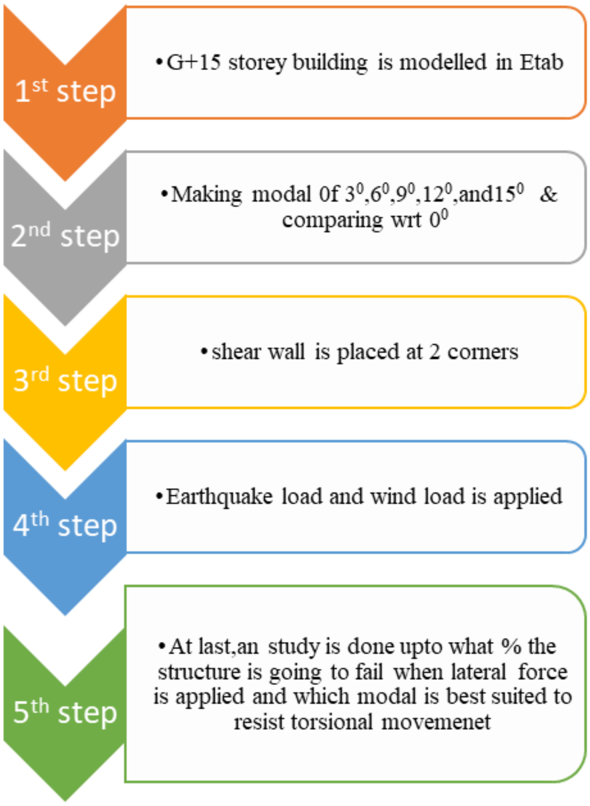


Chart 1.Methodology of work

6. Etabs Model Generation

In Etabs ver. 18.0.2, the 6 various buildings are examined. In the figure below, the angle of the ground's with respect to the horizontal has been calculated as 3^0,6^0,9^0,12^0,and15^0 & comparing wrt 0^0,3^0,6^0,9^0,12^0,and15^0 .

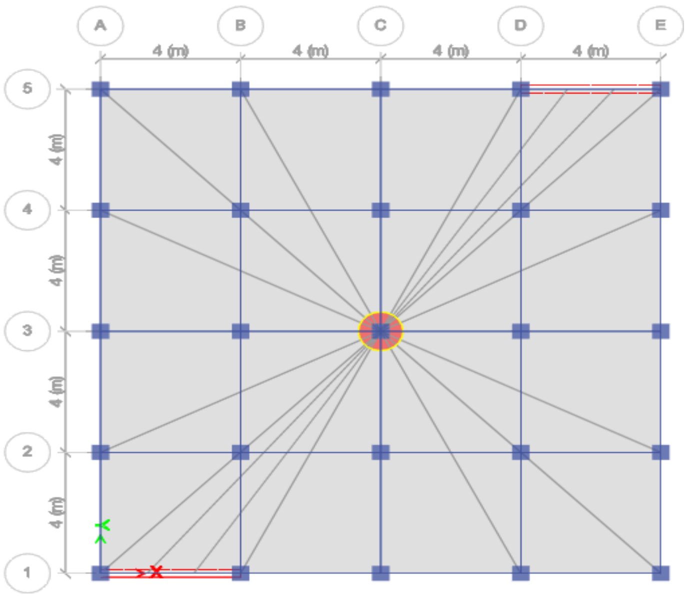


Fig.1 Base Modal 0 degree

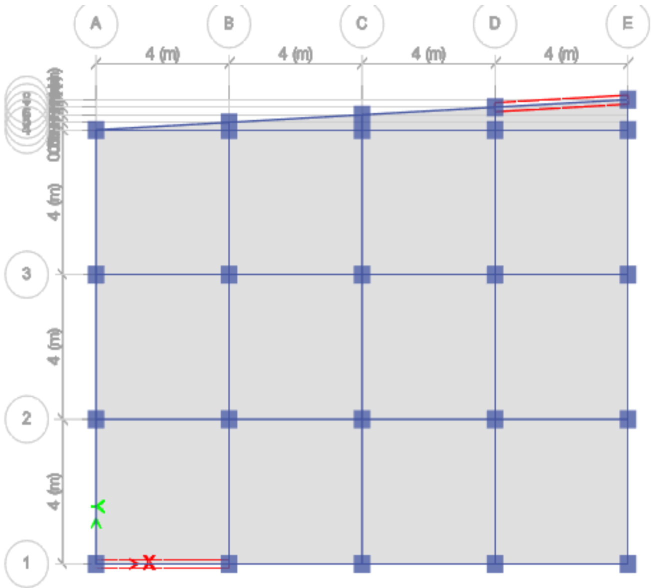


Fig.2 degree

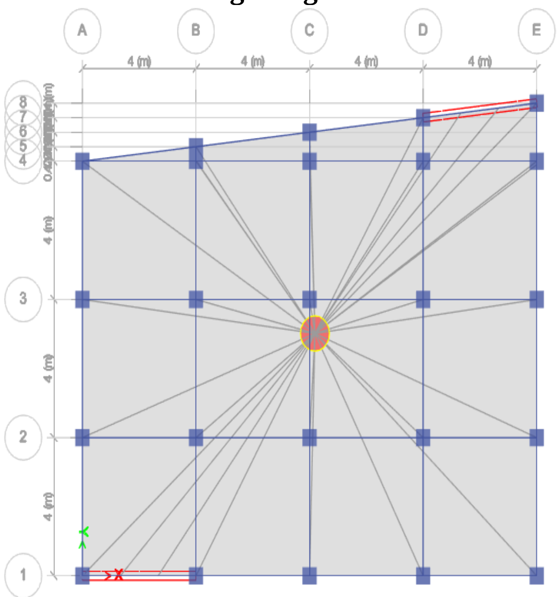


Fig.3 degree

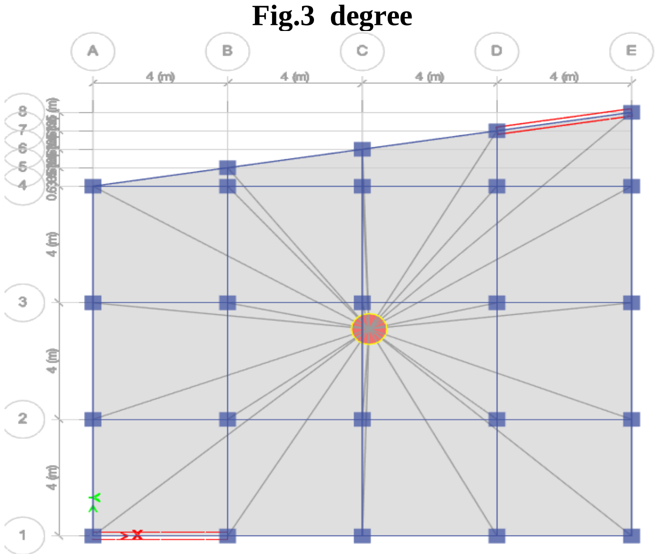


Fig.4 degree

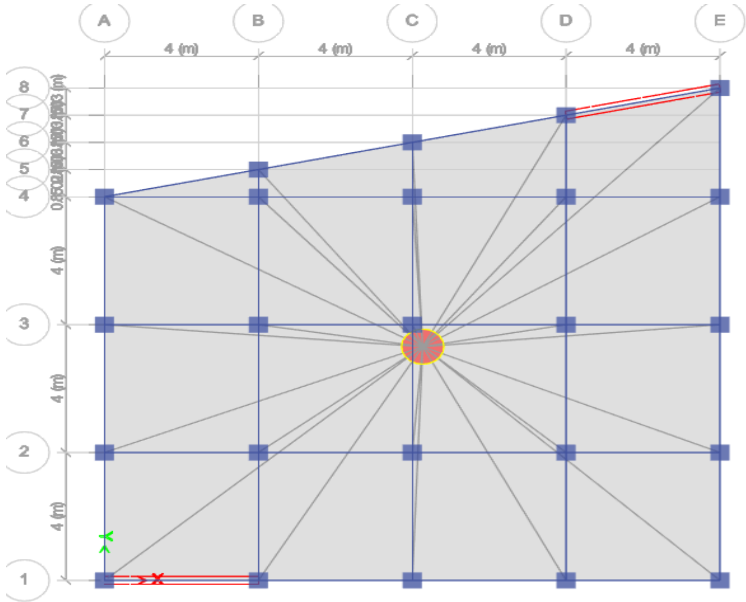


Fig.5 degree

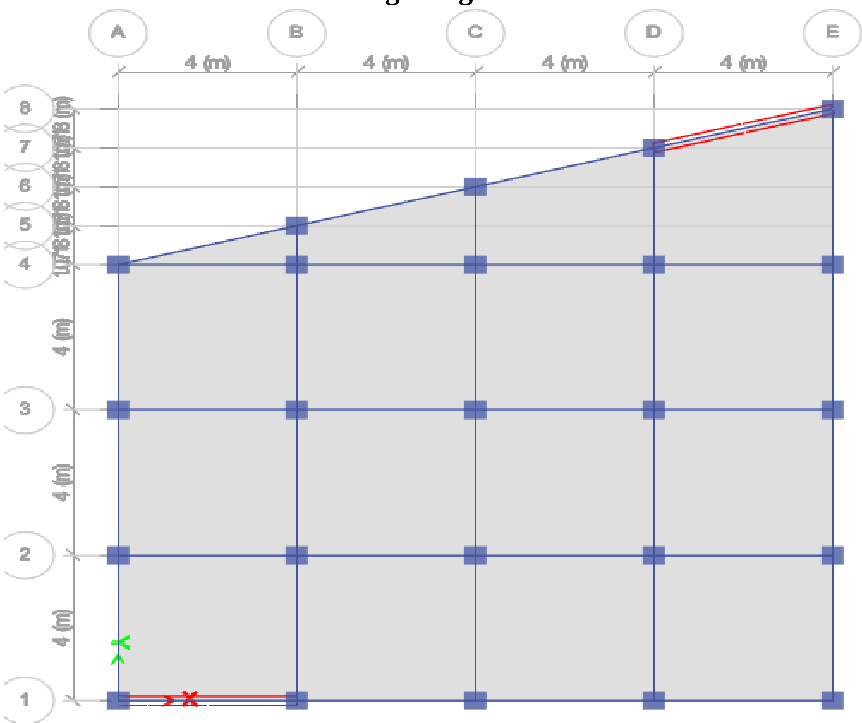
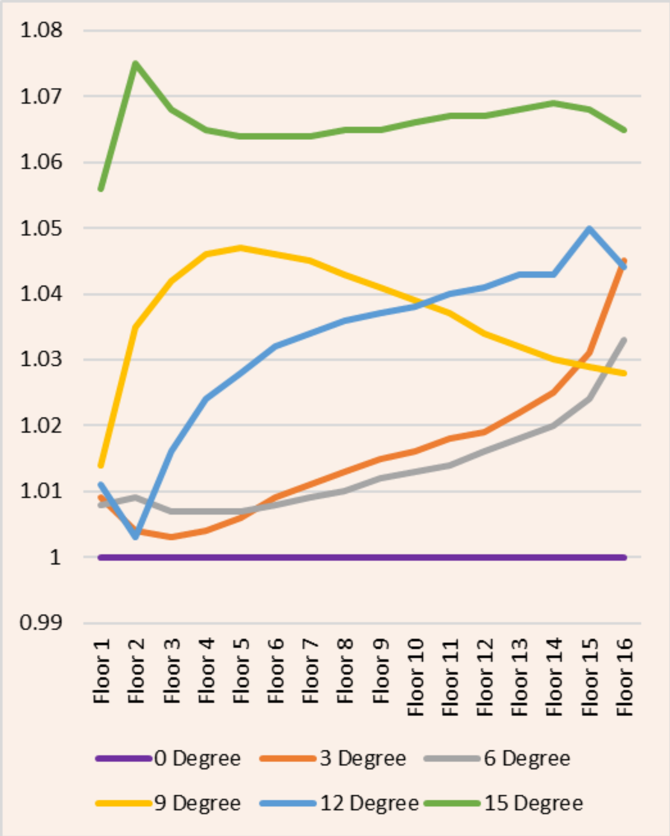


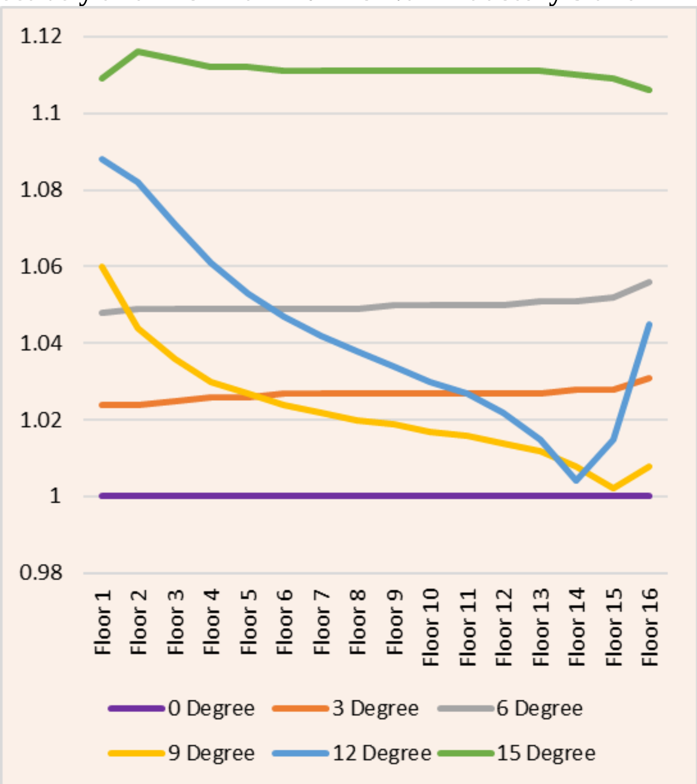
Fig.6 degree

7. Results and Discussions

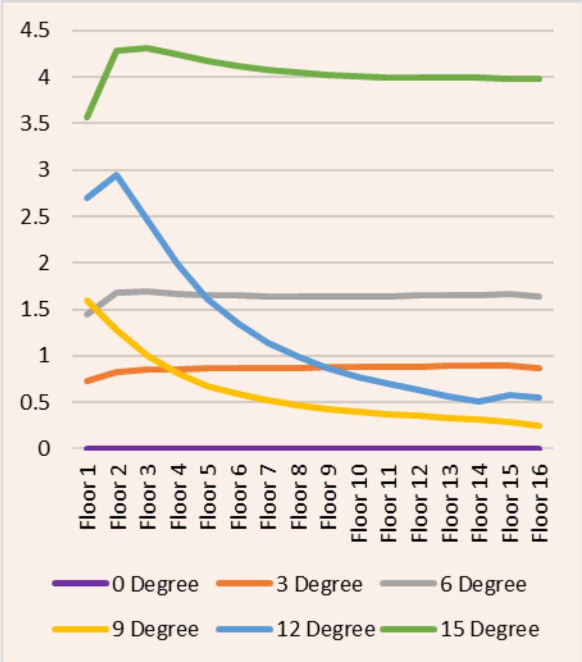
Results of the analysis about changes in the locations of the centres of mass and rigidity with respect to the various models taken into consideration and it is represented in graph 3 and 4.Also, graph 1 and 2 show the plots of torsion at earthquake load at X and Y direction for model 0^0,3^0,6^0,9^0,12^0,and15^0 respectively.Graph 5,6 and 7 shows the value of torsion in wind load at X and Y direction respectively.



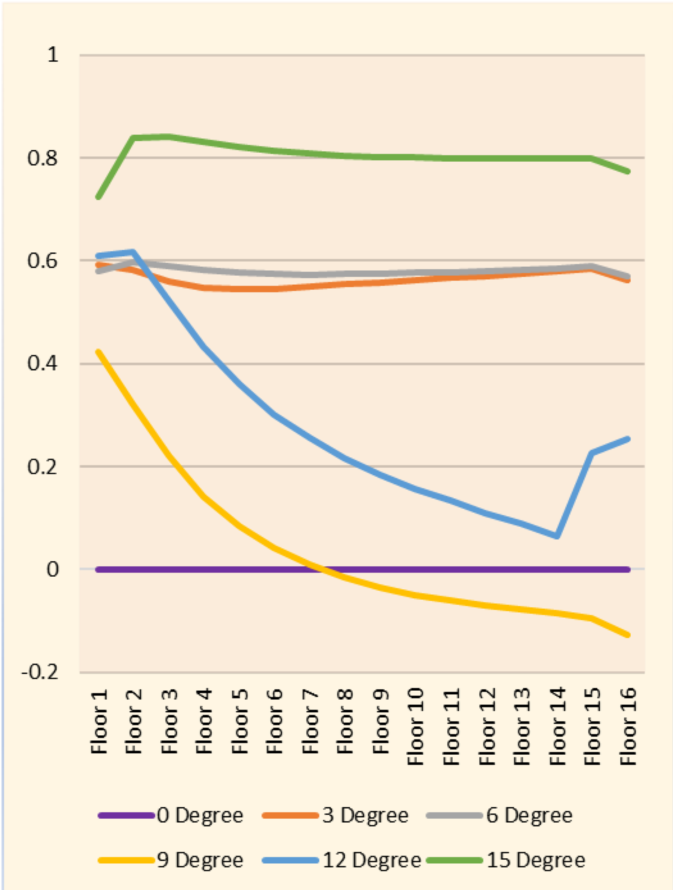
Graph 1-Torsion at Earthquake load at X direction (EQ) X-In 3^0,6^0 and 12^0 maximum torsion is at story 16 respectively and in 9^0 maximum is 1.0477 at story 5 and in 15^0 1.069 at story 2.



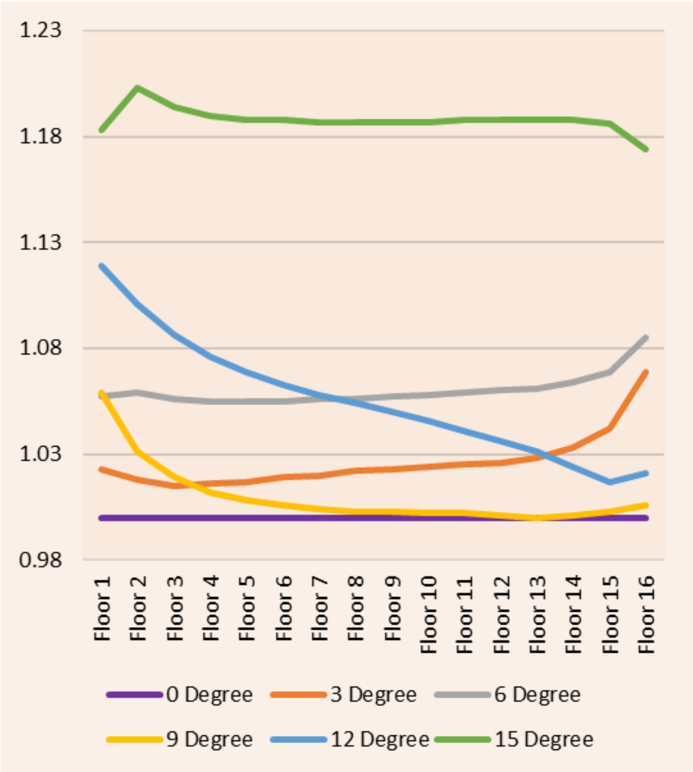
Graph 2-Torsion at Earthquake at Y direction (EQ) Y-In base modal or parallel modal torsion is 1 at all the storey. In 3^0 and 6^0 maximum torsion is at storey 16 and on the other hand maximum torsion at 9^0 is 1.044 at storey 2 and 12^0 is 1.088 at storey 1 and in 15^0 1.11 is average torsion generated at many stories.



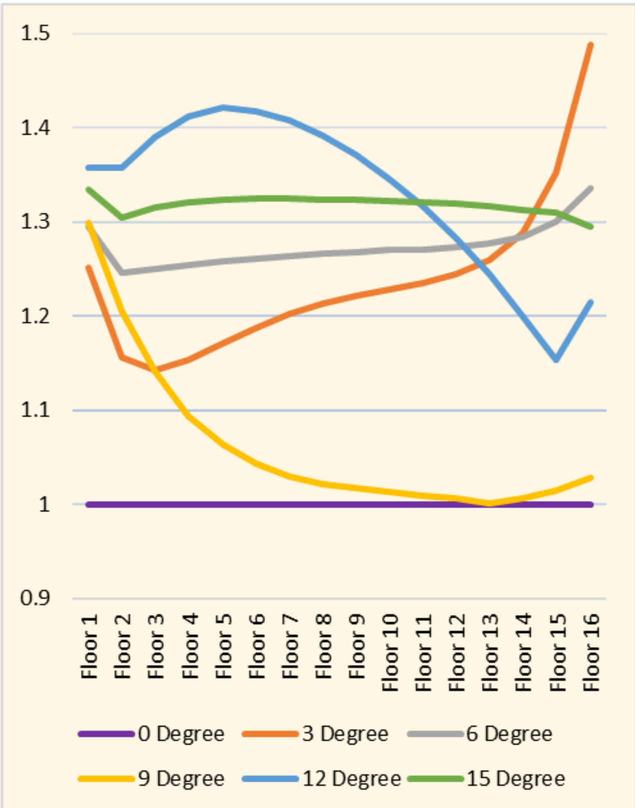
Graph 3- Distance of CM and CR in x direction (ex)-The ex-value at 16thstorey of 3^0,6^0,9^0,12^0,and$15^0$are 0.8612,1.6419,0.2463,0.5514 and 3.976 respectively.hence lowest is at 9^0 i.e 0.2463.



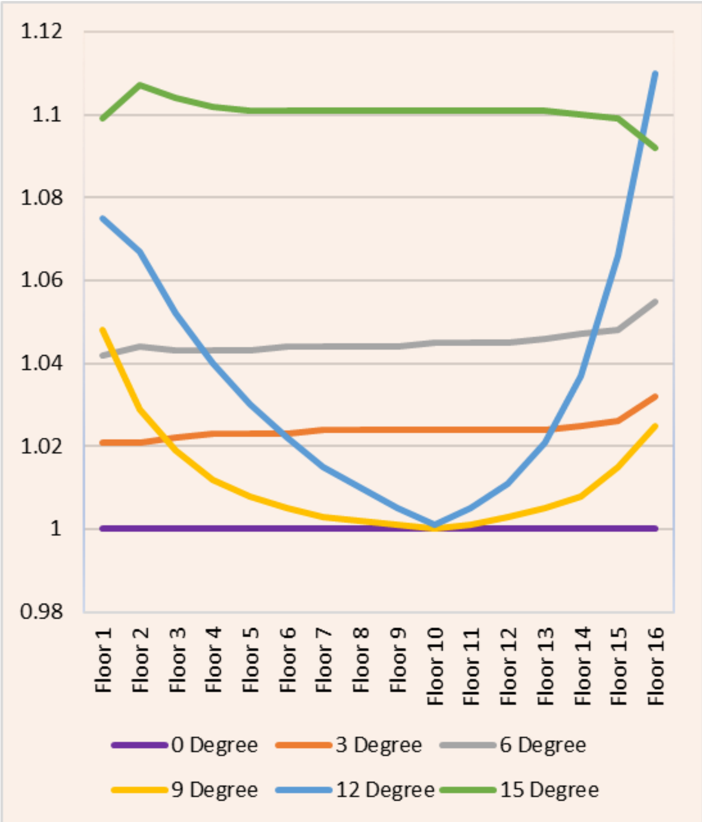
Graph 4- Distance of CM and CR in y direction (ey)-The ey-value at 16th storey of 3^0,6^0,9^0,12^0,and$15^0$are 0.5633,0.5687,-0.1276,0.2535 and 0.7749 respectively.we can see highest ey-value at 15^0 of 0.8418 at storey 3rd.



Graph 5-Torsion in wind load at X direction (WX) at diaph D1X-In the 3^0 lowest is 1.015 at storey 3rd. In 6^0 lowest is 1.055 at 4th, 5th and 6th storey respectively. In 9^0 torsion is lowest at 13th storey with a value of 1.



Graph 6-Torsion in Wind load at X direction (WX) at Diaph D1 Y-In 3^0,6^0,9^0,12^0,and15^0 the value of torsion at 16th storey are 1.488,1.336,1.028,1.215 and 1.295.Hence lowest among all 5 is at 9^0



Graph 7- Torsion in Wind load at Y direction (WY) at Diaph D1 Y- In 3^0,6^0,9^0,12^0,and15^0 the value of torsion at 16^{th} storey are 1.032,1.055,1.025,1.11 and 1.092.In 9^0 curve meets the torsion values of base modal i.e.0^0.Hence torsion value is 1 in 9^0.

8. Conclusion

Five various modelling techniques in terms of variable angle at ons side of base modal i.e. (16m X 16m) 3^0,6^0,9^0,12^0,and15^0 for seismic zone 3 of shear wall at various storey levels have been examined.From the study, the following conclusion may be drawn.upto 9^0 we can take the non parallel building or build it because above 9^0 torsion level suddenly increases as shown in all the different chart drawn above.

References

[1] *Analysis of Plan Symmetric and Asymmetric Buildings Subjected to Seismic Load using Pushover Analysis.* **B G Nareshkumar, Punith N, Thejashwini G, Lakshmi P B.** 2018, International Journal of Engineering Research & Technology.

[2] *Comparison of analysis and design of regular and irregular configuration of multi Story building in various seismic zones and various types of soils using ETABS and STAAD.* **Mr. S.Mahesh, Mr. Dr.B.Panduranga Rao.** 2014, IOSR Journal of Mechanical and Civil Engineering .

[3] *Structural Analysis of a Multi-Storeyed Building using ETABS for different Plan Configurations .* **Guleria, Abhay.** 2014, International Journal of Engineering Research & Technology (IJERT).

[4] *The study of shear wall uses in buildings during the architecture design process.* **Teddy, Livian.** 2021. IOP Conference Series: Earth and Environmental Science.

[5] *ANALYSIS OF CRITERION FOR TORSIONAL IRREGULARITY OF SEISMIC STRUCTURES.* **Chang, Nina ZHENG Zhihong YANG Cheng SHI Zhongren.** 2004, 13th World Conference on Earthquake Engineering.

[6] *Shear Wall Analysis and Design Optimization In Case of High Rise Buildings Using Etabs.* **M.Pavani, G.Nagesh Kumar, Dr. Sandeep Pingale.** 2015, International Journal of Scientific & Engineering Research.

[7] *PERFORMANCE OF ASYMMETRIC SINGLE STORY BUILDINGS BASED ON DIFFERENT CONFIGURATIONS OF CENTERS OF MASS, RIGIDITY AND RESISTANCE.* **A. AZIMINEJAD, A.S. MOGHADAM.** 2005, 4th European Workshop on the Seismic Behavior of Irregular and Complex Structures.

[8] *A REVIEW PAPER ON EARTHQUAKE RESISTING SHEAR WALL USING ETABS.* **ASIL BHAT, PRATIBHA DANGARANE,RHUSHIKESH DHAKANE.** 2019, IJARIIE-ISSN.

[9] *A Method for Reducing of the Overall Torsion for Reinforced Concrete Multi-Storey Irregular Structures.* **Marius Florin Botis, Camelia Cerbu.** 2020, Applied Sciences.

[10] *Assessment of Location of Centre of Mass and Centre of Rigidity for Different Setback Buildings.* **B G Naresh kumar, Punith N, Bhyrav Raj B, Arpitha T P.** 2017, International Journal of Engineering Research and Technology (IJERT).

[11] *Seismic Analysis of RCC Building with and Without Shear Wall.* **P. P. Chandurkar, Dr. P. S. Pajgade.** 2013, IJMER .

[12] *Stability Analysis Of Shear Wall At Different Locations In Multi-Storeyed Geometrically Irregular Building Using ETABS.* **Pandey, Nikhil.** 2021, International Journal of Engineering Research in Current Trends (IJERCT).

[13] *EFFECT OF CURTAILED SHEAR WALL ON DYNAMIC ANALYSIS OF RC BUILDING.* **Yash Joshi, Sagar Jamle, Kundan Meshram.** 2019, International Journal of Management, Technology And Engineering.

[14] *A Study on Positioning of Different Shapes of Shear Walls in L Shaped Building Subjected to Seismic Forces.* **MD Afroz Patel, Prof. Shaik Abdulla.** 2016, International Journal of Engineering Research and Technology (IJERT).

[15] *Seismic Analysis of a High-rise RC Framed Structure with Irregularities.* **B, Kusuma.** 2017, International Research Journal of Engineering and Technology (IRJET).

[16] *Review of Analysis of Irregular Building.* **Jerin Mathew Jose, Kesiya Josy V, Likhith Koruthe Varghese, Nayana P P Adithya Viswambaran.** 2021, International Journal of Engineering Research & Technology.

[17] *Dynamic Analysis of the RC Structure in Non-Parallel System with Different Position of Shear Wall: A Review.* **Ratnesh Madheshiya, Rajeev Kishan Pandey.** 2021, International Research Journal of Engineering and Technology (IRJET) .

[18] *Seismic Analysis of Symmetric and Asymmetric Structures with and without Shear wall using Etabs software.* **Singh, Kamalroop Kaur and Balwinder.** 2021. IOP Conference Series: Earth and Environmental Science.

[19] *STUDY AND ANALYSIS OF REGULAR AND IRREGULAR BUILDINGS WITH DIFFERENT SHEAR WALL POSITION USING ETABS.* **Chethana, Sowmya K B.** 2018, International Research Journal of Engineering and Technology (IRJET) .

[20] *THE EFFECT OF SHEAR WALL LOCATIONS IN RC MULTISTOREY BUILDING WITH FLOATING COLUMN SUBJECTED TO SEISMIC LOAD.* **Israa H. Nayel, Shereen Q. Abdulridha, Zahraa M. Kadhum.** 2018, International Journal of Civil Engineering and Technology (IJCIET).

[21] *Impact of Shear Wall to Reduce Torsional Effect for Unsymmetrical R.C. Frames with and without Infill Walls.* **Prof. R.B. Ghodke, Prof. S.D.Kangiri, Prof. V.N.Bande, Prof. R.S.Dahatre.** 2020, International Research Journal of Engineering and Technology (IRJET).

[22] *Seismic Analysis of Buildings with Shear Wall having Horizontal Irregularity.* **Rajat Singh, Mohd. Adnan.** 2019, International Research Journal of Engineering and Technology (IRJET) .

[23] *STUDY OF TORSIONAL IRREGULAR MULTISTOREY STRUCTURE UNDER SEISMIC FORCES.* **Rajesh Siroya, Dr. V. R. Patel.** 2021, International Research Journal of Engineering and Technology (IRJET).

[24] *Earthquake Analysis of Building Configuration with Different Position of Shear Wall.* **Chandiwala, Anuj.** 2012, International Journal of Emerging Technology and Advanced Engineering.

[25] *SEISMIC RESPONSE OF IRREGULAR BUILDING ON SLOPING GROUND.* **Anjeet Singh Chauhan, Rajiv Banerjee.** 2021, International Journal of Advanced Research in Engineering and Technology.

[26] *Study on Seismic Behaviour of Tall Irregular Buildings under Influence of Non Parallel and Offset Irregularities.* **Gangadhar, N Lohith Kumarn B C Manjunath N K.** 2017, International Research Journal of Engineering and Technology (IRJET).

[27] *STUDY ON EARTHQUAKE RESISITANT BUILDINGS ON GROUND SURFACE BY USING ETABS.* **S.Kusuma, CH.Rambabu.** 2016, International Research Journal of Engineering and Technology.

[28] Molla, J. P., Dhabliya, D., Jondhale, S. R., Arumugam, S. S., Rajawat, A. S., Goyal, S. B., . . . Suciu, G. (2023). Energy efficient received signal strength-based target localization and tracking using support vector regression. Energies, 16(1) doi:10.3390/en16010555

[29] Vadivu, N. S., Gupta, G., Naveed, Q. N., Rasheed, T., Singh, S. K., & Dhabliya, D. (2022). Correlation-based mutual information model for analysis of lung cancer CT image. BioMed Research International, 2022, 6451770. doi:10.1155/2022/6451770