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Dynamic Analysis of the Twin-Tower High-Rise Structure with Basement

Jadav Bhavesh Bhanajibhai[1], N. B. Umravia[2]

M. Tech, Student, Government Engineering College, Dahod, Gujarat, India[1]

Assistant Professor, Government Engineering College, Dahod, Gujarat, India[2]

Abstract: Structural development in the metro city has rapidly increased as there are many high-rise construction projects that have been carried out. Structural analysis is the fundamental part of the design of the high-rise structure which shad the same height and same geometry. It is effective solution for residential purpose however; few of the challenging problems have been facing such as vehicle parking and other basic enmities space. Therefore, many structures provide a common either in single, multiple floors, or underground basements parking in this kind of structure often seen in the residential as well as a commercial complex. In present paper to study on considering effects of influence parameters like the height of the tower, connection with basement and depth of basement with two parallel towers (Twin-Tower) having a common basement. The main object of the study the twin tower in linear dynamics earthquake analysis have been considering on the behaviours of structure G+20, G+25, and G+ 30 stories symmetrical twin tower without an underground basement, with 2, and 4 number of Basement. The seismic response of the superstructure was studied by observing the variation of internal stress results such as base shear, storeys displacement, storeys drift, and storeys shear. The analysis results obtained from all models were performed by using various linear dynamic structure analysis approaches such as Equivalent Static Force Method (ESFM), Response Spectrum Method (RSM), and Time History Analysis (THA).

Keywords: Basement connected, Seismic, Response spectrum analysis, Time history analysis, ETABS.

I. INTRODUCTION

Normally, the structures are considered to be tall structure, if its structural analysis and design are in some way affected by the lateral loads, particularly sway caused by such loads. When the two adjacent buildings connected at some level is defined as twin tower (i.e, PETRONAS Twin Towers in malaise, Indonesia 1 Tower). The two adjacent buildings connected by the bottom, middle, and top of the building with providing this link it is structurally strength to support such kind of structure and contest seismic and wind loads. In a metro city, urbanization growth aesthetic look in infrastructure is expanding the structure vertically mean the need for a high-rise structure in developing city. It is good for residential and commercial purpose however there are facing the problem of vehicle parking. The solution may be provided either in single, multiple floors or underground single, and multiple basement parking. In structural engineering it is required to analysis and designs a single tall reinforced concrete frame (high rise) structure analysis under the effect of the earthquake many researchers have been worked, however, it is difficult to analysis twin tower with a common basement have consisted of the tall frame-shear wall structure system. The wind and earthquake loadings are the two major types of lateral dynamic excitations experienced by high-rise buildings. Both loads are mandatory for study in structural analysis for civil engineering. An efficient design must ensure the safety of structural and non-structural components of a building as mention load separately. Many researchers are work for the assessment of wind load on structure is generally carried out using a wind tunnel and Computational Fluid Dynamics (CFD) approach.

II. LITERATURE REVIEW

The Studied on the performance of parallel tower heights of 72 m are considered and the effect of sky-bridge height on the induced dynamic responses of connected twin tall buildings was investigated and analysed in both longitudinal and transverse directions these towers are analysed for earthquake load (Mahmoud, 2019). The displacements, shear forces and moments at the base, and the accumulative energies of the structure appreciably changed over time. Changes in the responses were much more pronounced when the linking bridge was fixed at the top storeys. They performed a detailed shake-table model test under minor, moderate, and major earthquake levels, and compared their experimental results with those of a three-dimensional finite-element model of ETABS & SAP2000. (Guo et al., 2019). These Studied based © behaviour of twin-tower under the effect of the earthquake using ETABS and the shake table test. The structural damage evolution, dynamic characteristics, and responses are analysed based on the test results. Moreover, a three-

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dimensional FEM for the prototype structure is built and time history analyses are performed. The connecting diagonally trusses and rigid connection joints by which the corridor is generally connected to shear wall and behave well during strong seismic excitations, indicating the design of the connected structure is reliable and reasonable. The displacement responses of each tower agree well with the test result in general under x-directional loading, the discrepancy between test and numerical analyses for most floors is less than 10% and under y-directional loading, the discrepancy becomes a little larger, but most of them are less than 15%. (Chaurasiya & Jamle, 2018).A multi-storeyed building is taken for analysis with 13 floors in which floor twins is modelled up to 12th floors the Total of 13 cases are proposed with floor twins are varies floor height and the optimum condition is identified to resist seismic action the tower is analyzed for zone 4 against medium soil type and the Equivalent static and response spectrum analysis carried out by STAAD.PRO. The study is completed against various seismic parameters consists maximum displacement and storey drift in both x & z directions and the research is done on optimization of connecting part in the middle of building at varying height. (Zhou et al., 2018)The proposed of comparative study of four buildings are connected at large bottom podium with 2-different plan size which one is 57x14.2m and second one is 34.2x14.2m with large podium size is 164.2x81m and single building 57x14.2m with large podium building is 79.8x36m. Test was Performed two shake table tests and corresponding nonlinear time history analyses under earthquake scenarios. Multi-tower buildings, the modes are coupled by the strong connection effect of the bottom podium. Likely, the interaction between the towers has an adverse effect on the seismic performance, but if the bottom podium provides a sufficient constraint effect, the adverse effect could be eliminated in this case. The torsion effect of the single tower is more apparent. In general, the floor displacement and drift of A model are smaller than the B model, but A model sustained larger floor shear and overturning moment.(Lu et al., 2013)the conducted test was Performed shaking table test in 14-storeys with the 7-floor podium. RC core wall and connecting should be designed with sufficient load carrying capacity and enough ductility. More braces may be needed to improve the lateral stability of members of connecting trusses. Being located at the perimeter of the structure, the RC shear walls of tower B may be strengthened through structural and configuration measures, say, setting edge-reinforcing steel at the corners of the shear wall to increase structural resistance to torsion. The lapping transfer columns, considering aesthetic requirement in elevation, lead to a complex system of vertical force transfer and are capable of coordinating the stories to resist lateral forces even under extremely strong earthquakes.(Mu et al., 2011)the studied on the double-tower connected structure with the trusses of changing rigidity. The twin tower height is 544m and connected trusses between two towers and change the rigidity of the trusses by modifying the height of the trusses as 2 layers, 4 layers, 8 layers, and 16 layers. Overall the response of the structure in the x-direction, the base shear in the wind load decreases when the height of connected trusses increases. Base shear in the seismic load increases when the height of the connected trusses increases. The base shear does not change when in the wind load imposed on y-direction. The maximum storeys drift decreases monotonically with the layers of the truss increases. Wind load the axial force of the connected trusses increases with its location increased. A load of seismic, the axial force of the truss at the bottom is small, while on the top is very large and shows a trend of increasing with the height of the truss increases.(Lee & Kim, 2001)The seismic response of comparison of frame structure (structure type A) and frame structure with core wall (structure type B) with and without basements dynamic analysis performed by ETABS program observed by the number of stories in the basement increases, the rotation at the bottom of columns in the first storeys increases because of the flexibility introduced by the basement structure. Especially in the case of the framed structure with a core, this tendency was more significant. Natural periods of a structure considering the effects of the basement are longer than that of the structure without basement structure. The accelerations of the structure with a basement tend to be smaller, because the natural periods of the structure types A5 and B5 are longer than those of the structures A0 and B0, respectively. Building structures with shear walls, the effect of the basement on the seismic response turned out to be more significant.

III. BUILDING CONFIGURATION AND STRUCTURE MODELLING

In all structural especially any frame structure of the building model, It was affected through material properties, section properties of various structural elements mean influence with the geometric shape of a structure. Whenever the structural elements need to analysed under the earthquake, or in wind load. Its geometry was major affected. In this present study total 9 variable model with and without basement have been selected based on symmetrical geometry G+ 20, G+ 25, G+ 30, (i.e. without basement), 2B+G+ 20, 2B+G+ 25, 2B+G+ 30 (with double Basement), 4B+G+ 20, 4B+G+ 25, 4B+G+ 30 (with the four depth basement); where, G- Ground floor; B – Basement. These all models were selected to studies the behaviours of structures and the structural element under the dynamic excitation with increasing the number of stories and number of basement mean height of structure and depth of immerged in the ground of structure. Structural models were selected as rectangular symmetrical geometry basic and its element of structure like column, beam, slab thickness, external wall, internal wall, shear wall, and basement wall dimension as per structural models were selected as rectangular symmetrical geometry basic and its element of structure like column, beam, slab thickness, external wall, internal wall, shear wall, and basement wall dimension as per.

Table 1. Details of building and structural element

Structural element		Size
Plan area (L X B) (m)		44x 35
Basement height (m)		4.0
Typical storeys height (m)		3.2
Beam size (B x D) (m)	Secondary Beam	0.230 x 0.300
	Main Beam	0.300 x 0.500
Column size (m)	Up to 5th Story	0.900 x 0.900
	6th to 10th Story	0.700 x 0.700
	11th to 15th Story	0.600 x 0.600
	16th to 20th Story	0.500 x 0.500
	21th to 30th Story	0.400 x 0.400
Slab thickness (m)	Basement Floor	0.200
	Typical Floor	0.150
External wall thickness (m)		0.230
Internal wall thickness(m)		0.110
Shear wall thickness(m)		0.300
Basement wall thickness(m)		0.400

Table 2. Building loads and material property

Loading		Value
Live load (KN/m^2) (LL)	Basement floor	5
	Typical floor	3
	Roof	1.5
Floor finish (KN/m^2)		1.0
Mass source		1 DL + 0.25 LL
Grade of concrete		M-25
Grade of steel		Fe-415
Unit weight of concrete(KN/m^3)		25
Unit weight of masonry(KN/m^3)		20

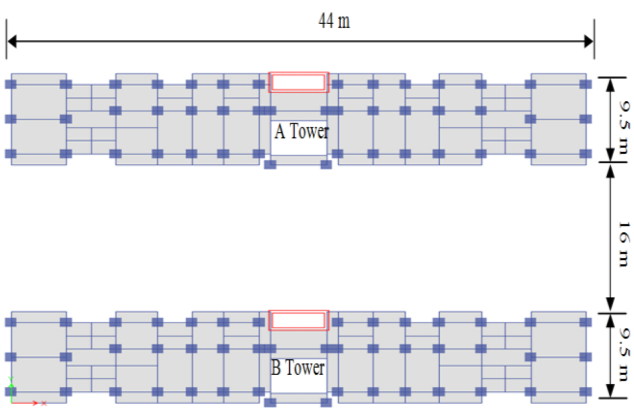
All twin Multi-Storied models with and without basement structures are under seismic analysis by using ETABs. In all models were select under the affected area zone 5 for seismic analysis, medium soil for Foundation and Bhuj, Gujarat, time history data consider. Their values are described in table 3. In this study, the basement soil and basement walls were considered during the response spectrum analysis. Major parameters were influenced by soil unit weight soil load carrying capacity and soil shear parameter consider as per table4.

Table 3. Seismic design data

Zone factor	V (0.36)
Soil type	II (Medium soil)
Response reduction factor	5 (SMRF)
Importance factor	1.2
Damping	5%
Earthquake	Bhuj Earthquake – (Station: Ahmadabad) [Reference: Strongmotioncenter]

Table 4. Soil details

Unit weight of soil (KN/m^2)	22
Soil bearing capacity (KN/m^2)	200
The angle of internal friction (ø)	30˚
Co-efficient of friction(µ)	0.55



Fig,1:Typical Floor Plan of Twin-Tower Model In ETABs

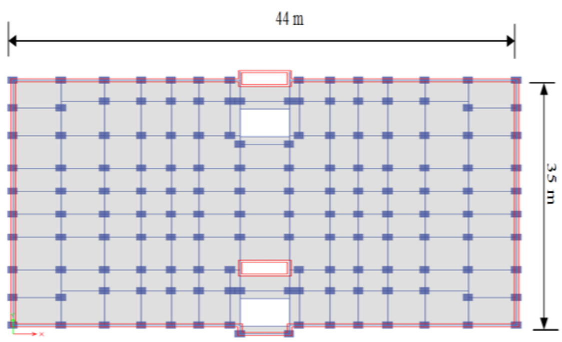
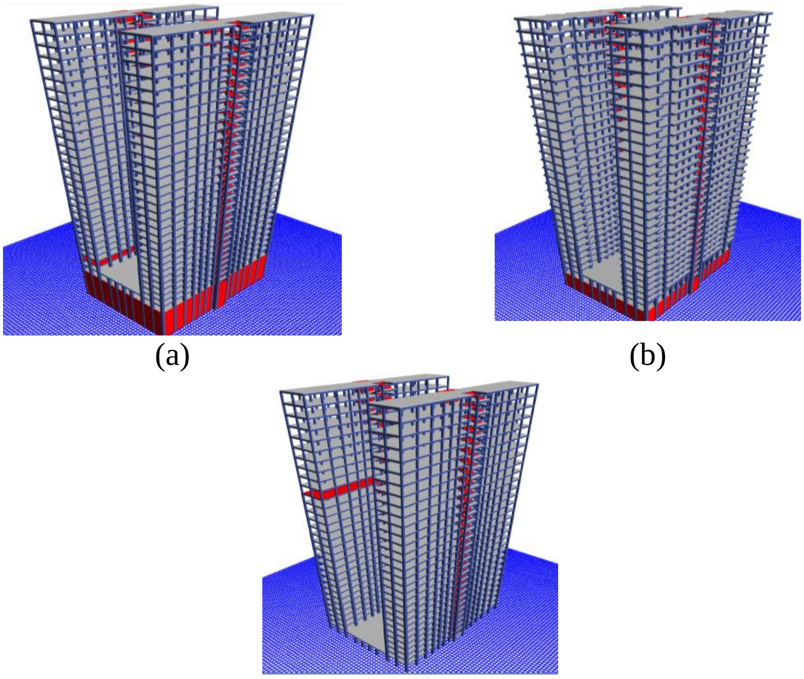


Fig.2: Twin-Tower connection with basement plan



(a) (b)

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Fig. 2 **:** Twin-Tower Modeling 3D view (a) 4B+G+30, (b) 2B+G+30, ;(c) G+30

In all the model has been considered the earthquake in X direction means the seismic effect on the longer length and Y direction mean seismic effect on the shorter direction of the structure. Fig.1 shows the geometry of the twin-tower its length is 44 m and width is 9.5 m. proposed common basement geometry was according to Fig. 2.

Therefore in tall building dynamic analysis is required. The following sections describe the methodology and findings affected under the ground motion. All the models were analyzed by using the linear static method which is also known as equivalent static force method (ESFM), a linear dynamic method known as response spectrum method (RSP) and nonlinear dynamic method also known as time history analysis (THA).In this present study earthquake time history analysis Bhuj earthquake, Mandvi district Gujarat (23 02 N, 72 38 E) was used for the analysis of all the models were carried out by using a software ETABs2017.

IV. RESULTS AND DISCUSSION

In this study, considering the twin-tower structure having a building with a basement analysed by using different structural analysis methods to study the various parameters of building such as base shear, displacement, and drift to evaluating the optimum number of basements on building based on their performance during an earthquake.

A. *Base shear*

Base shear is the maximum expected lateral force that will occur due to seismic ground acceleration at the base of the structure. It depends upon the soil properties therefore it may vary with site condition. Base shear (V) can calculate using the equation no. 1. Base shear forced is also dependent upon the lateral forces act every floor. In tall structure, the maximum laterals forced are act at bottom stories height.

From IS 1893-2016, Clause 7.6.1, the design base shear

$$V_b = A_h W \qquad \text{…..……….(1)}$$

Vb - Base shear; W - Seismic weight of the building; Ah - Horizontal seismic coefficient,

As per IS 1893-2016 Clause 6.4.2

$$A_h = Z\ I\ S_a/2Rg \qquad \text{……………(2)}$$

Where, Z- Seismic zone factor; I – Importance factor; Sa/g – Design acceleration coefficient for different soil type; R – Response reduction factor.

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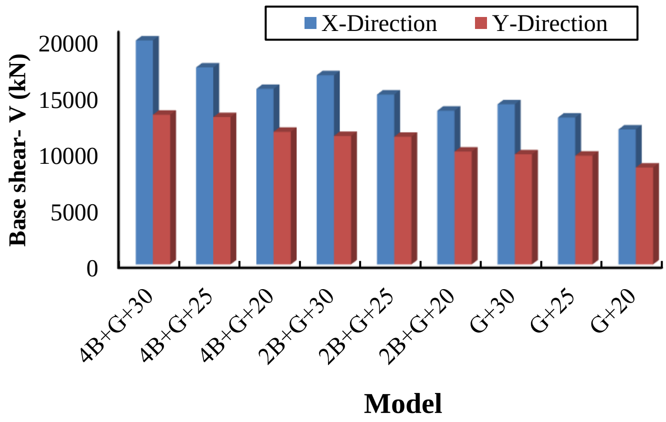


Fig.4: Base Shear Value concerning X direction and Y direction of EQ.

Building with basements is increased the numbers of floors it's more flexible then attracts base shear compare to without basement of buildings. So the results shown in Fig. 4, the maximum X and Y base shear values result from applying the ground motion in directions that are the building's principal axes. Base shear value is depended upon the types of soil and earthquake zone. Present study soil has been considered as a medium type of soil and seismic zone (v) respectively. The result shows the base shear values in the x-direction are more than in y-direction. To compare the results of base shear for Model without the basement and with 2 basements G+30 are increased 18.159 % in the X direction and 16.617 % in Y direction respectively, similarly the 2 basements and 4 basement G+30 storeys model 18.434 %.in the X direction and 16.578% in the Y direction. Other models G+25 and G+20 storeys with-out to 2 basement and2 basement to 4 basement base shear value increased 15.705, 16.0163 and 13.935, 14.193 % in the X direction and 17.40, 15.487 and16.485, 17.527 % in Y direction Respectively. According to the results, it shows that when the depths of the basement increase the shear values of that structure are significantly increased.

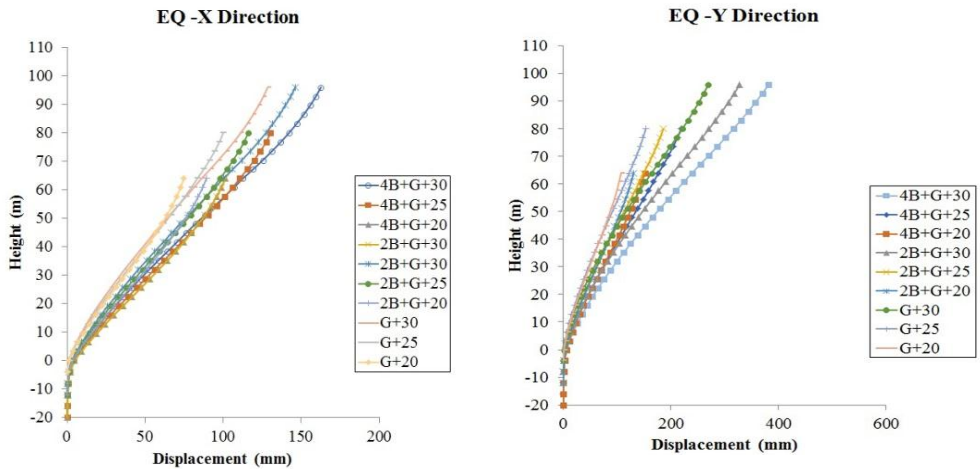
B. ***Story Displacement***

The Story displacement is often defined on structural height therefore the displacement of a story about the bottom of a structure is maximum obtained. It is a quantity of displacement of the story under the action of the lateral forces. In an Equivalent static analysis of structure with and without basement mean decrement the number of basements and numbers of the story is shown in Fig. 5. The maximum displacement under Earthquake in x-direction was 10-14% decreasing in reduced. However the decrement 2 number of the basement it reduced the 25-28% when in the y-direction in an earthquake it was found that 16-20% decreasing in displacement when reducing 2 number of the basement and 44-76% decreasing in 5 number of stories in structure respectively. In Response spectrum analysis, it has been observed form Fig.6 (a) and (b) Maximum Story displacement has been decreased after reducing the number of basements and numbers of story it has been noted that maximum model under in x-direction it was found that 5-11% decreasing in displacement when reducing 2 number of the basement and 20-25% decreasing in 5 number of stories and model under in y-direction it was found that 4-9% decreasing in displacement when reducing 2 number of the basement and 30-90% decreasing in 5 number of stories respectively.

In nonlinear time history analysis, results are shown in form Fig.7 (a) and (b), It has been found that Maximum Story displacement has been decreased after reducing the number of basements and numbers of story it has been noted that maximum model under in x-direction it was found that 5-15% decreasing in displacement when reducing 2 number of the basement and 8-16% decreasing in 5 number of stories and model under in y-direction it was found that 8-18% decreasing in displacement when reducing 2 number of the basement and 1-30% decreasing in 5 number of stories respectively.

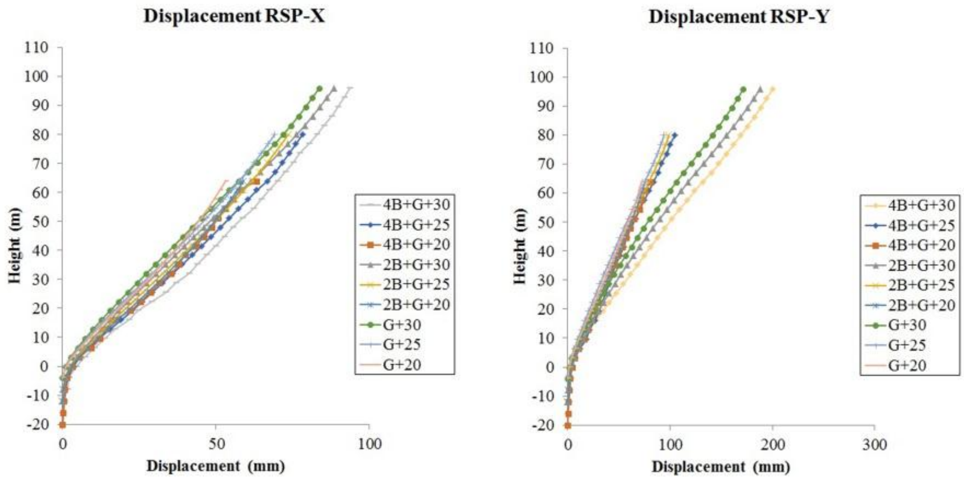
To compare the results of structure height versus displacement obtained to model G+30, G+25, and G+20 with 4 basements, 2 basements, and without basement by variable seismic analysis approach such as ESFM, RSP and THA are shown in Fig.5, Fig.6 and Fig.7 accordingly. From general observation stated that 4B+G+30 story building gives a high response to displacements than other types of buildings. Also, maximum displacement occurred at the top storey of the building. As a comparison, less displacement in x-direction compared to the y-direction.

Compare the results of for linear near- filed Soil shows the effect of lateral displacement in the structures were to increase. Normally this effect is more pronounced for soft soil. However, this effect is more dependent on the excitation parameter. The displacement of the top stories was also calculated. The following observation was made. The basement soil and foundation flexibility have a significant effect on a twin-tower response. Moreover, the basement wall backfill soil non-linearity could decrease or increased the displacement response depends upon the types of structure and effect of ground motion.



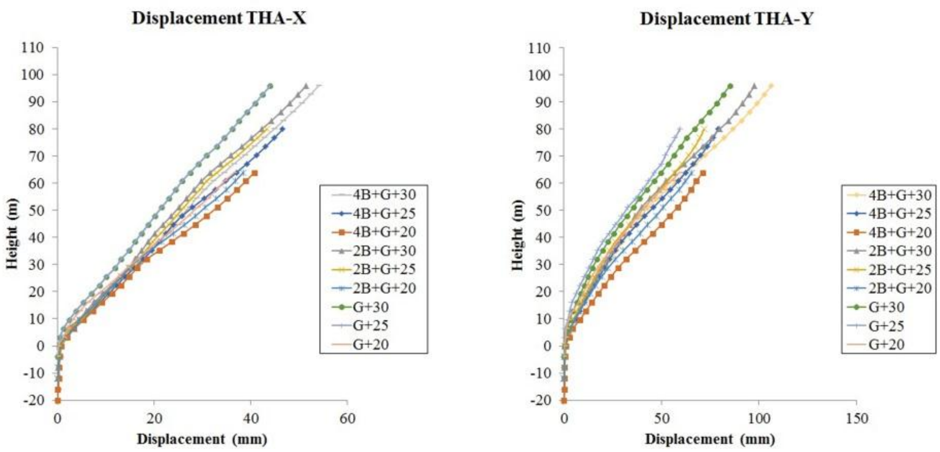
(a) (b)

Fig.3 : Relationship between height of structure and displacement Story displacement (a) EQ-X ;(b) EQ-Y.



(a) (b)

Fig.4: Relationship between height of structure and displacement Storeys displacement (a) RSP-X ; (b) RS- Y.



(a) (b)

Fig.5: Relationship between height of structure and displacement Story displacement (a) THA-X ; (b) THA - Y

In nonlinear time history analysis, results are shown in form Fig.7 (a) and (b), It has been found that Maximum Story displacement has been decreased after reducing number of basements and numbers of story it has been noted that maximum model under in x-direction it was found that 34-50% decreasing in displacement when reducing 2 number of

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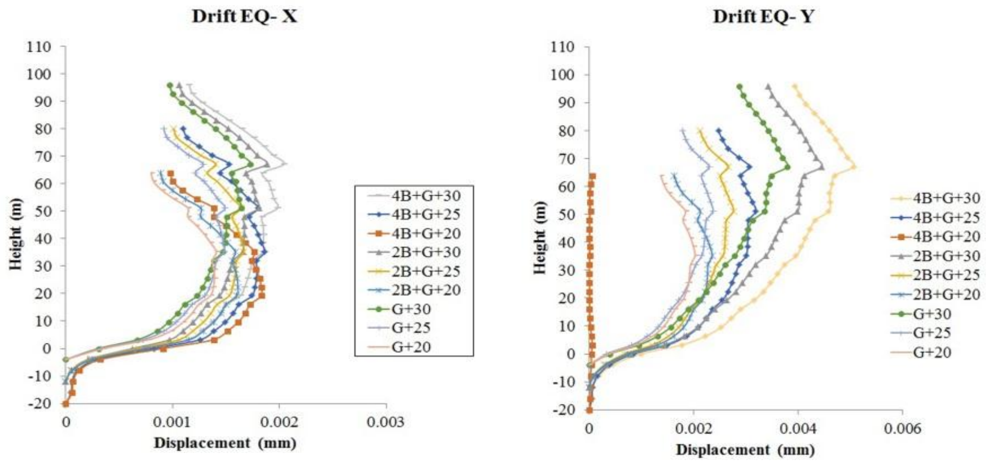
basement and 13-34% decreasing in 5 number of stories and model under in y-direction it was found that 30-50% decreasing in displacement when reducing 2 number of basement and 11-38% decreasing in 5 number of stories respectively. Compare the results of for linear near- filed Soil shows the effect of lateral dispalcement in the structures was to increased. Normally this effect is more pronounced for soft soil. However, this effect are more depend on the excitation parameter. The displacement of top stories was also calculated. The following observation were made. The basement soil and foundation flexibility has significantly effect of twine tower response. Moreover the basement wall backfill soil non-linearity could decesed or incresed the dispalcement response depend upon the types of strcture and effect of ground motion.

V. STORY DRIFT

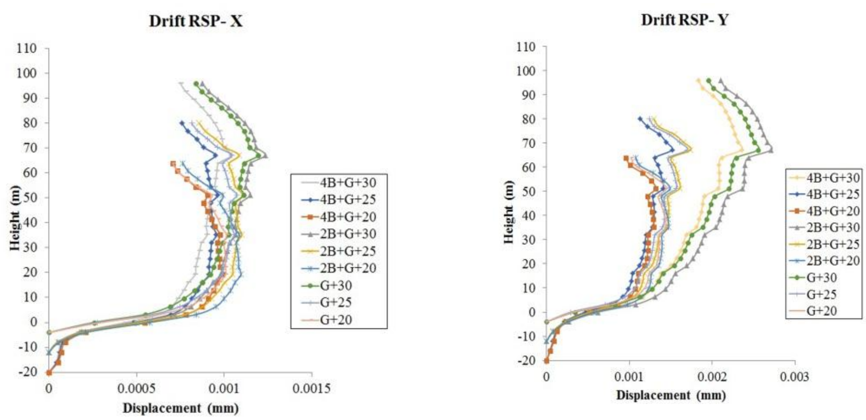
The story drift is obtained the lateral displacement of one level of the structure relative to the level above or below. Normally the story drift ratio is the story drift divided by the story height. However the relation between the height of structure and stories drift with variable method and variable EQ direction are according to the Fig. 8; Fig. 9 and Fig. 10. The results of storey drift due to EQ in x and Y direction are shown inFig.8 (a) and (b) it was observed that 8-10% decreasing in drift when reducing 2 number of basement and 5-10% decreasing in 5 number of stories and model under earthquake in y-direction it was found that 4-5% decreasing in drift when reducing 2 number of basement and 15-20% decreasing in 5 number of stories respectively



(a) **(b)**

Fig.6: Comparison result of story drift for (a)EQ – X; (b) EQ-Y

In order to comparatives study of story drift of structure in X direction and Y direction as shown in the Fig.9 (a) and (b) respectively. it was observed that 5-15% decreasing in drift when decrement 2 number of basement and 2-14% decrement in 5 number of stories and model under earthquake in y-direction it was found that 6-12% decreasing in drift when reducing 2 number of basement and 15-30% decreasing in 5 number of stories respectively.



(a) **(b)**

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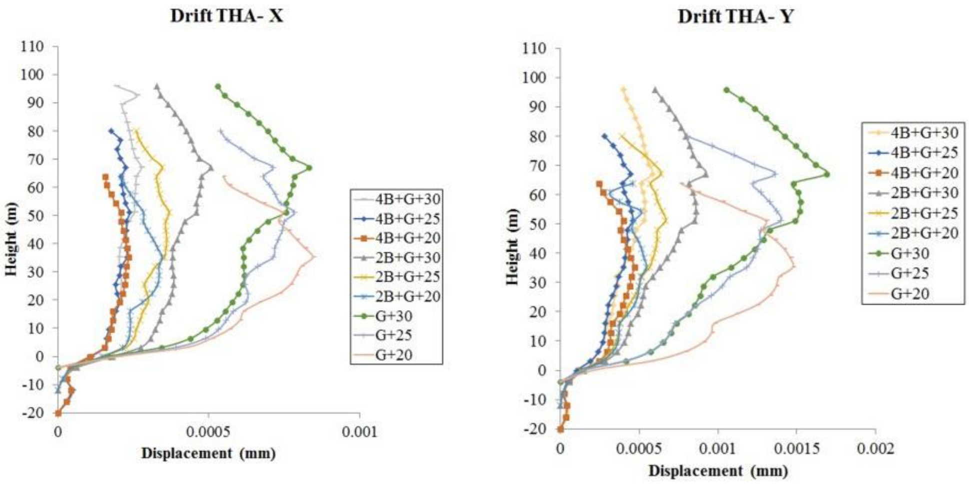
Fig.7 : Comparison result of story drift for (a) THA – X; (b) THA-Y

It can be seen from the Fig.10 (a) and (b) to study the behaviors of story drift under in x-direction it was found that 26-60% decreasing in drift when reducing 2 number of basement and 1-25% decreasing in 5 number of stories and model under in y-direction it was found that 28-50% decreasing in drift when reducing 2 number of basement and 5-35% decreasing in 5 number of stories respectively. It is clearly observed that when decreasing the number of stories, the time period has been decreased 30-34% and in decreasing the basement the time period has been decrease 2-4% respectively. As per IS: 1893 (2016) as story drift in any story shall not exceed 0.004 times the story height. The maximum story drift value in model in between storeys-14 to storeys-16 and then value decrease at top story. When a greater number of basement use drift value is decreasing so, 4B+G+30 model gives less drift value while G+30 model building gives more drift value. Therefore the story drift are reducing with depth of basement in structure.



(a) **(b)**

Fig.8: Comparison result of story drift for (a) THA – X; (b) THA-Y

VI. TIME PERIOD

It is property of system, when it is allows vibrating freely without any external force.

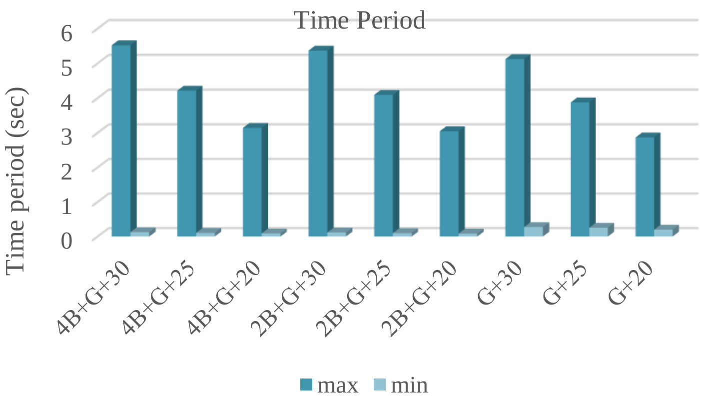


Fig.9: Comparison of Time period

VII. CONCLUSION

In this paper, results of utilization of the basement with twin tower tall buildings are presented. The structure was designed based on the requirements of IS code. Dynamic analysis based on structure behaviors, types of sub soil, and type of seismic force. Following conclusions are draft.

- Twin tower connected with the basement it has been observed that when analysis Structure with incremental 5 number of stories (16 m height) in both tower and 2 number (8 m depth) of common basement simultaneously. Its effect on the base shear has been increasing average 12-14% and 18-20% respectively. It is a linearly effect with the height of structure and depth of basement.

- Mostly structural geometry play important role in dynamic analysis and due to twin tower high stiffness in x-direction as compared to y-direction result, base shear in x-direction is grater in compared in y-direction.
- The basement depth is directly effect to the maximum base shear value. Because the basement and basement wall is supported by the twin tower tall structure. But it can reduce the story drift value.
- All dynamic analysis models under the slandered condition its result may be variable with the parametric changes such as basement wall thickness, soil saturation condition, soil saturation condition and pore water pressure soil saturation condition.
- So, as per the above consideration basements is more sustainability as compared to without basements.

REFERENCES

[1]. Chaurasiya, S., & Jamle, S. (2018). Determination of Efficient Twin Tower High Rise Building Subjected to Seismic Loading. 8(5), 1200–1203.

[2]. Guo, W., Zhai, Z., Wang, H., Liu, Q., Xu, K., & Yu, Z. (2019). Shaking table test and numerical analysis of an asymmetrical twin-tower super high-rise building connected with long-span steel truss. Structural Design of Tall and Special Buildings, 28(13), 1–27. https://doi.org/10.1002/tal.1630

[3]. Lee, D., & Kim, H. S. (2001). Efficient seismic analysis of high-rise buildings considering the basements. Structure, 4, 1–9.

[4]. Lu, X., Wang, B., Jiang, H., Li, J., & Lu, W. (2013). SHaking table tests on a complex high-rise structure with two towers and lapping transfer columns. Journal of Earthquake and Tsunami, 7(4), 1–20. https://doi.org/10.1142/S1793431112500303

[5]. Mahmoud, S. (2019). Horizontally connected high-rise buildings under earthquake loadings. Ain Shams Engineering Journal, 10(1), 227–241. https://doi.org/10.1016/j.asej.2018.12.007

[6]. Mu, Z., Wang, L., & Fan, Z. (2011). Analysis of stress response for the super high rise double-tower connected structure with the trusses of changing rigidity. Advanced Materials Research, 291–294, 1559–1563. https://doi.org/10.4028/www.scientific.net/AMR.291-294.1559

[7]. Tominaga, Y., Mochida, A., & Yoshie, R. (2008). AIJ guidelines for practical applications of CFD to pedestrian wind environment around buildings. 96, 1749–1761. https://doi.org/10.1016/j.jweia.2008.02.058

[8]. Zaidee, S. R. Al. (2015). Deterministic Analysis of Wind Loads Effects on High-Rise Buildings. 21(4), 123–137.

[9]. Zhou, Y., Chen, P., Wang, C., Zhang, L., & Lu, L. (2018). Seismic performance evaluation of tall, multitower reinforced concrete buildings with large bottom podiums. Structural Concrete, 19(6), 1591–1607. https://doi.org/10.1002/suco.201700142

BIOGRAPHIES

Jadav Bhavesh Bhanajibhai, obtained his Bachelor's degree in Civil engineering in 2017. He obtained his Graduation from Government Engineering College Bhavnagar, Gujarat, India, He is currently PG M-tech students in structural engineering in Government Engineering College Dahod, Gujarat, India. His research interests include design and Analysis of high-rise complex structure and offshore structure under the dynamic effect.

N. B. Umravia, obtained his Bachelor's Degree from M. S. University Baroda in civil Engineering in 2005. He obtained his M-tech in soil Mechanics and Foundation Engineering in 2008 from Sardar Vallabhbhai National Institute and Technology Surat, Gujarat, India. He is currently pursuing a Ph.D. in Geotechnical Engineering at SVNIT Surat, Gujarat. He is currently working as an Assistant professor in Government Engineering College Dahod. Gujarat. His researches interests are in-ground improvement Techniques, Dynamic ground response include High-rise structure and soil-structure interaction.