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STUDY OF WIND ANALYSIS OF MULTI-STORY COMPOSITE STRUCTURE FOR PLAN IRREGULARITY

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ABSTRACT

ETABS 2015 (Extended three dimensional analysis of building system) is the tool to analyses the multi story structure, for the system of forces, Earthquake analysis, Time history analysis, and Wind analysis. In this case study the effect of wind on multi story composite structure for plan irregularity is observed. In addition, the effect of shape on wind analysis is also discussed. In this study the comparison of impact of wind for Square, Rectangular, U-shape, and H-shape building structure is presented. The post analysis consist typical characteristic comparison related to storey displacement, storey drift, time period, base reaction, etc. The categorization of structure as Class-B, Class-C of wind code consideration for different height is used for modelling of structure. Modelling of as category-2 is taken constant to compare the result. This study of composite structure for plan irregularity concludes that which shape is more dominant for story displacement, story drift, time period etc. and also which shape is safer for wind effect.

Keywords - ETABS, Composite structure, Multi story building, Plan Irregularity, Wind Analysis.

I. INTRODUCTION

1.1 General

For design of structure as safe it is important to have knowledge of various types of loads and its effect on structure. Therefore it is essential to have knowledge of their worst combination to which it may be subjected during its life span. And also to have knowledge about lateral loads such as earthquake and wind load. The effect of lateral load is very important to consider for high rise composite structure. In some cases the effect of wind is found greater than earthquake effect. It depends on the zone factor defined by codes.

Lateral loads due to wind which acting on multi story building can cause shake in the upper stories. This could be effect caused due to wind at upper stories as the wind intensity is increasing with graduating heights. Thus the multi-story building also act as a portal frame the moment concentrating at base due to lateral wind forces are greater. Thus it is important to nullify displacement in lateral direction by appropriate design. The effect of shape is playing an important role in wind analysis. Taking into consideration of wind effect the multi story building like Bhurj khalifa have given importance of shape. Similarly plan irregularity of composite structure have discussed in the case study.

1.2 Literature review

Syed Rehan, S.H. Mahure [1]: Presented the work on analysis and design of (G+15) Stories under the effect of earthquake and wind for Composite, Steel and RCC structure. The modelling and analysis is done by using Staad pro. And they compare the result of Composite, RCC and steel building such as story displacement, story drift and Maximum bending moment and shear forces. They suggest that composite structure is better option compare to RCC and Steel.

Abhay Guleria [2]: They presented the work on structural analysis of multi story building under the effect of earthquake for RCC structure for different plan configuration. The modelling and analysis is done by using ETABS software. And they compare the result of different plan configuration buildings such as story overturning moment, story shear, story drift and mode shapes.

Jawad Ahmed, H S Vidyadhar [3]: They presented the work on wind analysis of multi story buildings with different lateral load resisting system for different aspect ratio. The modelling and analysis is done by using ETABS software and the total forty five models are prepared. They suggest that RC shear wall is better to resist lateral loads compared to RC double bracing.

Swati D. Ambadkar, Vipul S. Bawner [4]: They presented the analysis of (G+11) multi story building for different terrain category in significant relation of moment, forces and displacement. The modelling and analysis is done by using Staad pro. Software. For the analysis basic wind speed are taken 44 m/s, 47m/s, and 50m/s. They conclude that wind speed increases bending moment values also increases according to category.

1.3 Objective

Based on the analysis and result discussion of above literature the study of this paper consist of work of analysis of wind on multi story composite buildings for different plan irregularity, study also contributed for analysis the various effect caused due to wind lateral load like Displacement, Storey drift, Base shear and comparative study. Also the plan irregularity importance in different heights of structures is discussed.

Parameters of lateral load have greater impact for analysis and to take further assessment to improve structural behavior like Displacement, Storey drift, Base shear, Column forces, Time period, Overturning moment, Storey stiffness and Maximum Bending moment of beam.

The different loads have considered to analysis the structure like:

a) Dead load consider from Indian Standard Code of Practice for Design loads (other than Earthquake) for Buildings and Structures, IS: 875(Part 1)-1987

b) Imposed load consider from Indian Standard Code of Practice for Design loads (other than Earthquake) for Buildings and Structures, IS: 875(Part 2)-1987

c) Wind load consider from Indian Standard Code of Practice for Design loads (other than Earthquake) for Buildings and Structures, IS: 875(Part 3)-1987

The intensity of Basic wind speed (V_b), Design wind speed (Vz), based on the Indian standard and parameters in correlation to these standards have considered in design and provided as a input through ETABS in analysis the structures. Basic Wind speed (Vb) is taken from (IS 875: part 3) as 50 m/s.

By using the following formula the design wind speed is calculated.

$$Vz = Vb*K1*K2*K3$$

Where, K1= Probability Factor (Risk Co-efficient)

K2= Terrain, Height and Structure size Factor

K3= Topography Factor

After calculating of design wind speed than calculate the design wind pressure. By using following formula the design wind pressure is calculated.

$$Pz = 0.6(Vz)^2$$

Where, Pz = design wind pressure in N/mm^2 at height z

Vz = Design wind velocity in m/s

For calculating the wind load on individual member such as roof, cladding and walls, it is important to take the pressure difference between opposite faces. For clad building it is necessary to know the external pressure and internal pressure. For calculating the wind load on individual member acting normal to member is:

$$F = (Cpi-Cpe)\ A*Pz$$

Where, F = Wind load on individual member in KN

Cpi = Internal pressure coefficient

Cpe = Internal pressure coefficient

The plan irregularity which is discussed in the study consist of square shape building, rectangular shape building, H-shape building, U-shape building. Generally these plan irregularity is commonly adopted in Residential apartment, Hospitals, Educational institute buildings and Commercial buildings. The comparative data of displacement have discussed in each aspect of design.

For selection of effective load combination in which the ultimate effect regarding all parameter have chosen. 1.2(DL+LL+WindX) have taken as critical combination. Where, WindX is the design wind pressure in x-direction, which gives the maximum displacement as compared to other direction of wind pressure. For internal pressure coefficient, the percentage of opening between 5% to 20% is consider. And external pressure coefficient is computed from IS: 875 (Part 3)-1987 code. For all composite structure cladding is to be consider and wind load is calculated.

II. SYSTEM DEVELOPMENT

In this Study a multi storied composite structure of 15X15m Plan dimension is considered and the building is considered as commercial building. The structural properties and dimensions are elaborated below. And also Fig. shows the basic plan of square composite building.

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In addition , the composite structure are analyzed for different load combination such as dead load , live load and wind load as per IS Code 875 (Part 5)-1987. Various specification of loading which are taken is shown in Table.

Fig. 1 Plan view of Square building

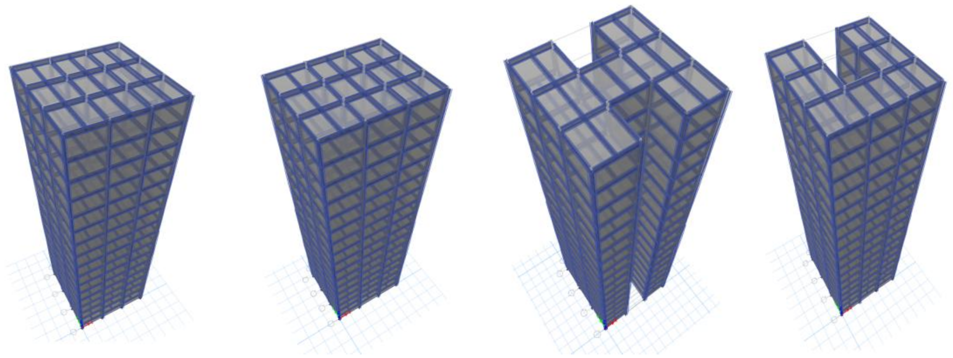

Fig. 2 3D View of Square, Rectangular, H-Shape, U-Shape Buildings

Table 1: Specification of Buildings

Plan dimension	15mx15m
(G+5) 7 story	20 m
(G+15) 17 story	50 m
(G+25) 27 story	80 m
Height of each story	3 m
Thickness of deck/slab	0.150 m
Thickness of wall	0.23 m

Table 2: Material Properties

Grade of concrete	M25
Grade of reinforcing steel	Fe 500 (HYSD)
Grade of structural steel	Fe 345
Density of concrete	25 KN/m³
Density of brick wall	20 KN/m³
Damping ratio	5%

Table 3: Specification of Loading

Live load	4 KN/m²
Floor load	1 KN/m²
Wall load	12 KN/m²
Basic wind speed	50 m/s
Terrain category	2
Structure class	[B,C]
Risk coefficient (K1)	1
Topography factor (K3)	1
RCC design code	IS 456:2000
Wind design code	IS 875:1987 (Part 3)
Composite design code	AISC-360-10

Table 4: Specification of (G+5) Composite Buildings

Composite	Section	Encased Section
Beam	ISWB 300	-
Column 1	350X650	ISMB 500
Column 2	300X500	ISMB 350
Column 3	300X400	ISWB 225

Table 5: Specification of (G+15) Composite Buildings

Composite	Section	Encased Section
Beam	ISWB 550	-
Column up to 9 story		
Column-1	600X900	ISWB 600-2
Column-2	450X900	ISMB 600-2
Column-3	450X700	ISWB 550-1
Column from 10 to 17 story		
Column-4	450X700	ISWB 550-1
Column-5	350X700	ISMB 550
Column-6	350X650	ISMB 500

Table 6: Specification of (G+25) Composite Buildings

Composite	Section	Encased Section
Beam	W18X311	-
Column up to 14 story		
Column-1	600X1200	W 40X277
Column-2	600X900	W 27X235
Column-3	450X900	W 27X102
Column from 15 to 27 story		
Column-4	450X900	W 27X102
Column-5	480X700	W 18X143
Column-6	350X700	W 21X55

III. RESULT AND DISCUSSION

Total twelve numbers of composite structure are modeled using finite element based software ETABS 2015. For analysis of building, Indian standard code of practice for design loads (other than earthquake for buildings and structure) IS 875(Part 3):1987 is used for computing basic wind speed (Vb), Internal pressure coefficient (Cpi), External pressure coefficient (Cpe) and Terrain, height and structure size factor (k2) etc.

3.1. Story Displacement

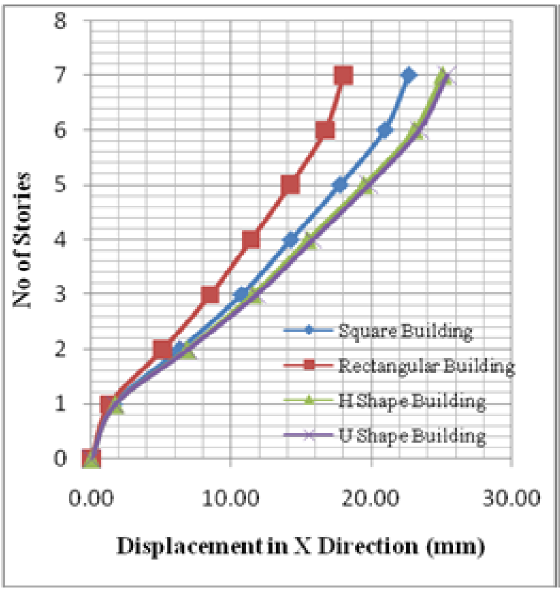

Fig. 3 Story Displacement (For G+5)

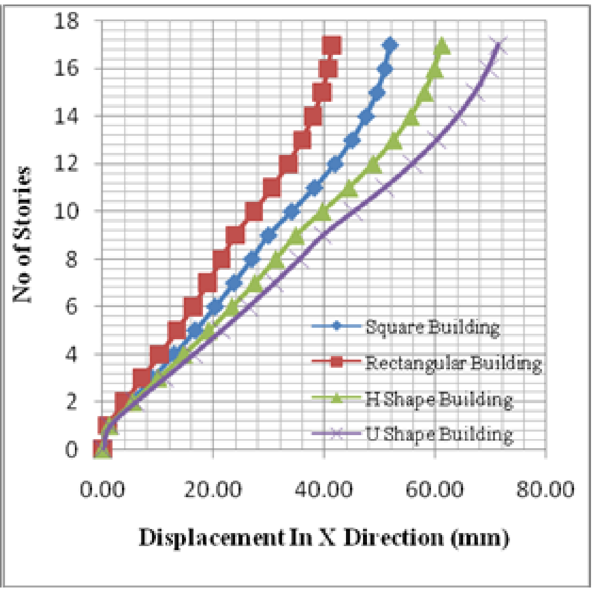

Fig. 4 Story Displacement (For G+15)

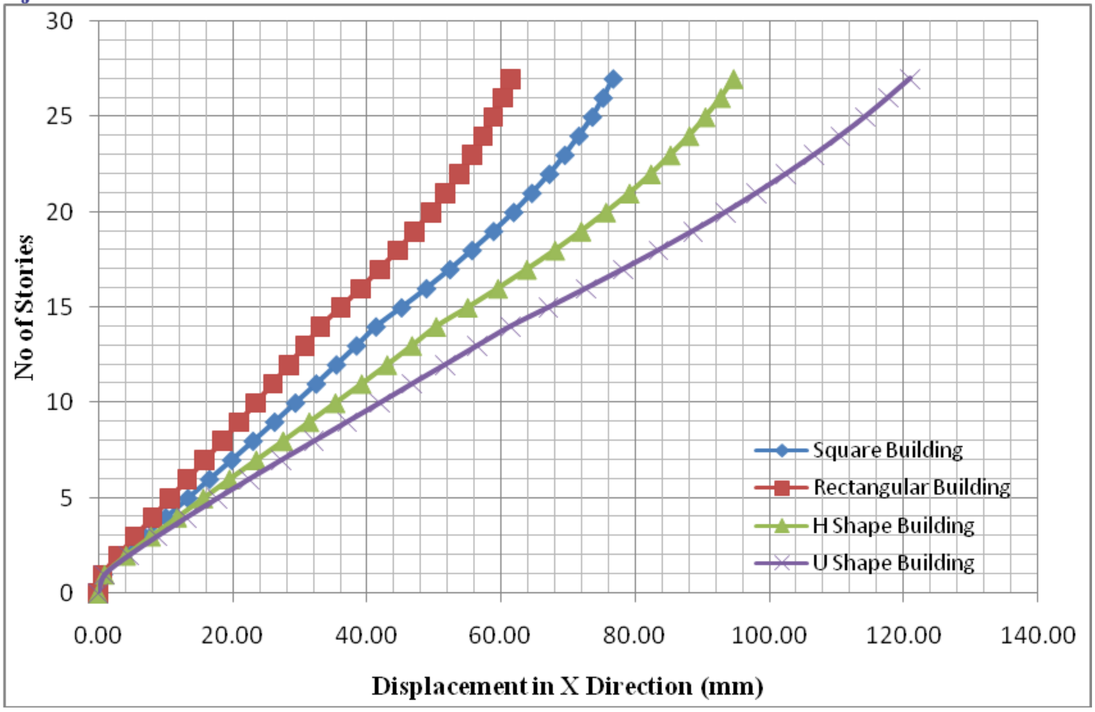

Fig. 5 Story Displacement (For G+25)

The above graph of displacement shows the displacement of (G+5) for plan irregularity similarly shows (G+15) and (G+25) displacement for different plan configuration. The above Figures suggest that the displacement is varies with increases in numbers of stories.

3.2. Story Drift

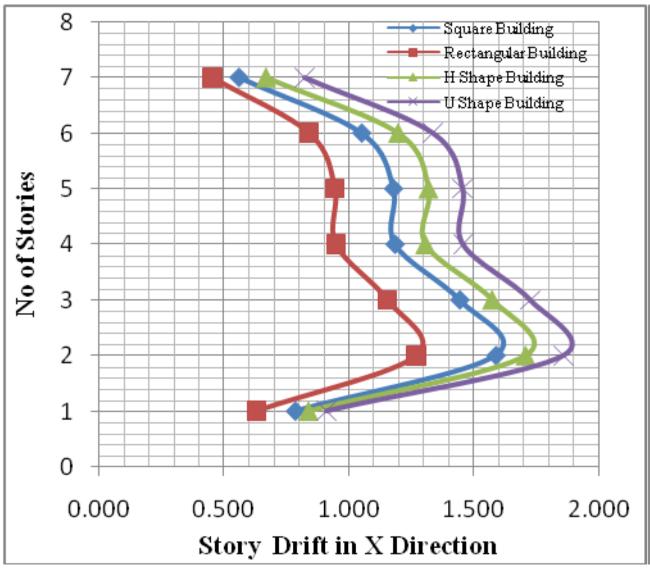

Fig. 6 Story Drift (For G+5)

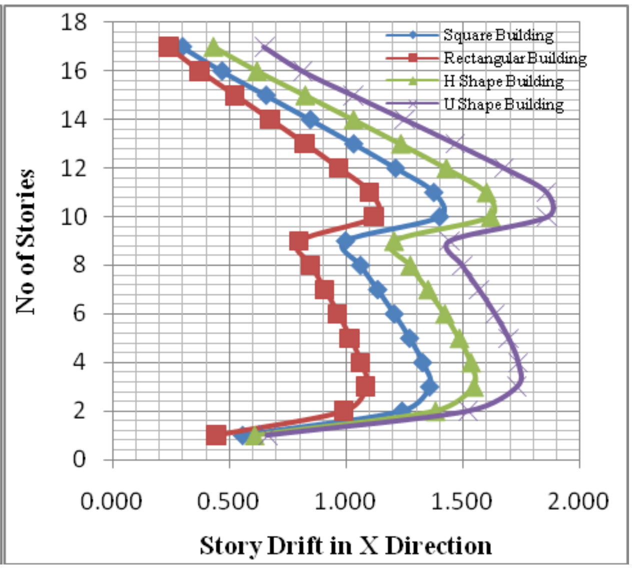

Fig. 7 Story Drift (For G+15)

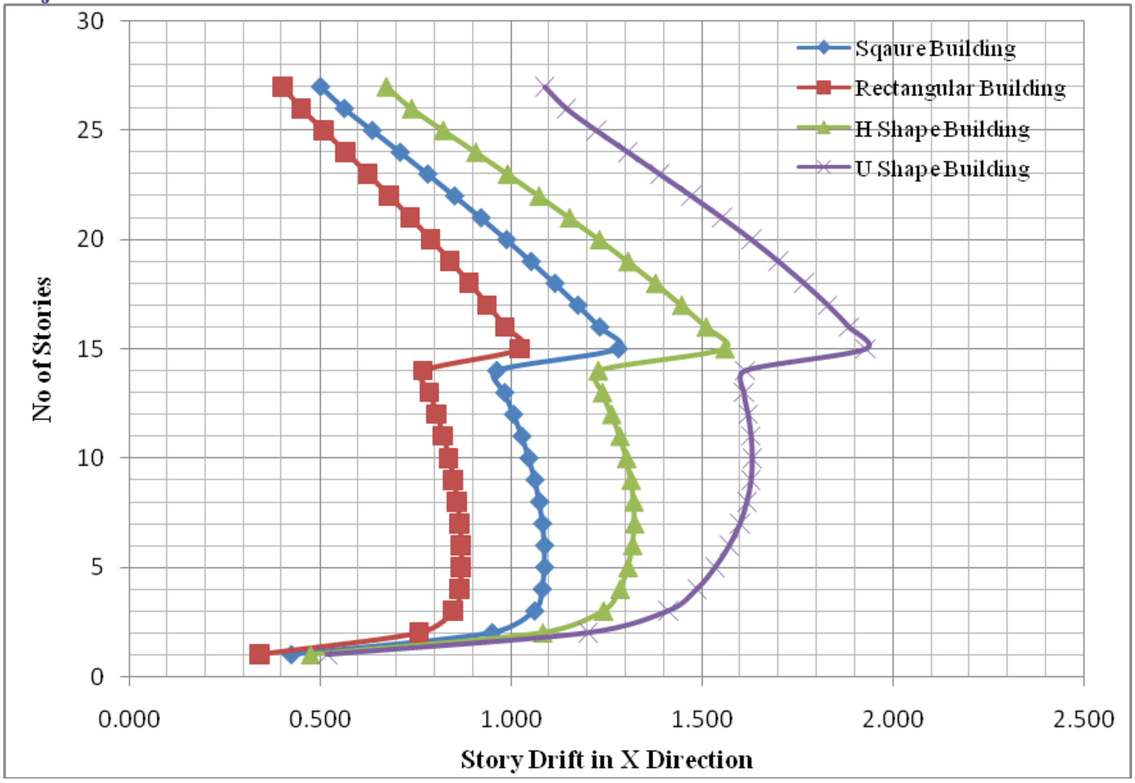

Fig. 8 Story Drift (For G+25)

Above Figure 6, 7, 8 shows the story drift for different story such as (G+5),(G+15) and (G+25) for different shapes of buildings. Story drift increases with increase in height and also story drift is maximum in U shape building compare to other shape buildings.

3.3. Time period

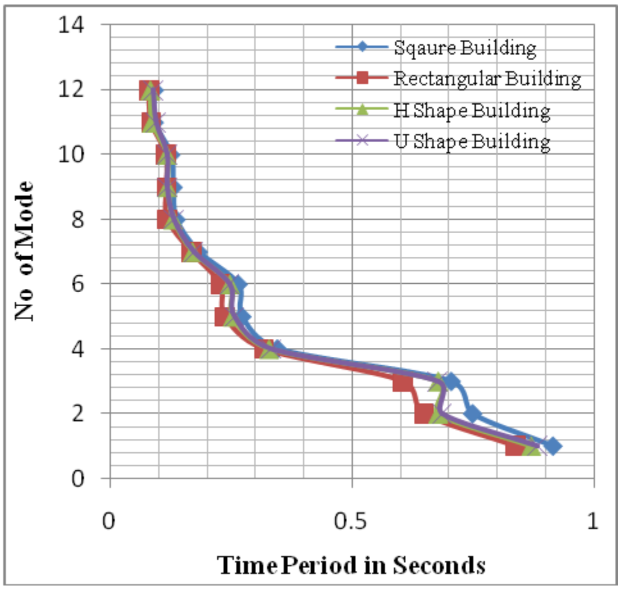

Fig. 9 Time Period (For G+5)

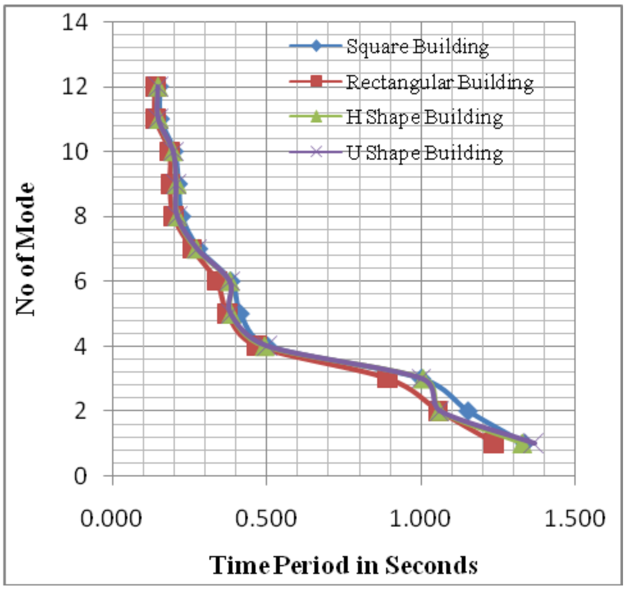

Fig. 10 Time Period (For G+15)

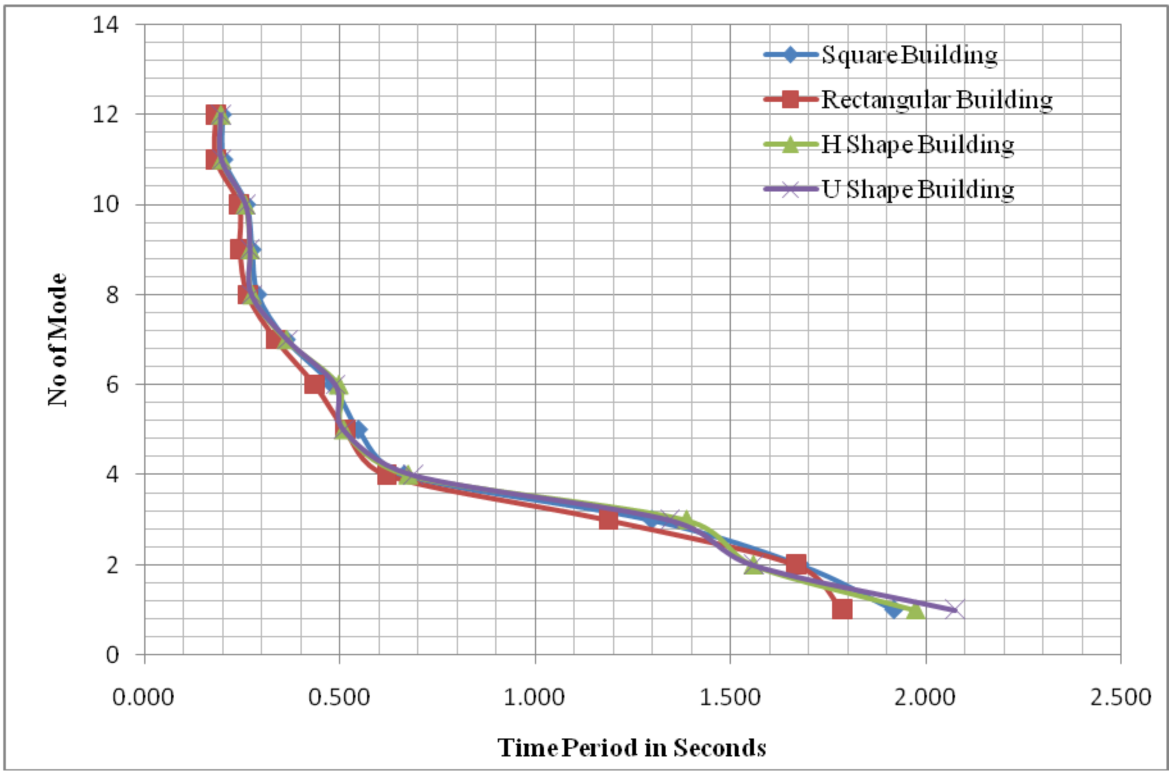

Fig. 11 Time Period (For G+25)

The time period of (G+5), (G+15) and (G+25) shown in above Figures for different number of modes. The maximum time period is in U shape building compare to other shapes buildings. Time period are shown for twelve modes of buildings. Maximum time period are found for mode one in U shape building.

IV. CONCLUSION

This study presented an assessment of wind effect on multi story composite structure for different shapes and overall analysis result of G+5, G+15, and G+25 shows that

1) Composite structure need to prefer because of the speed in construction due to ease in installation of structural element.

2) The composite frames are light in weight which reduces the dead load on structure that can reduce the whole load of building. This reduces dimension of structural member tending to economical aspect.

3) The displacement in U-shape structure increases abruptly as increase in height of story so the U-shape structure is not preferable in wind prone zone.

4) Overall analysis suggests rectangular structure for along wind or across wind direction is preferable due to large stiffness and less displacement against wind.

5) In High rise structure the wind pressure is mainly depends on exposed area of building against the wind intensity So that the exposed area of building need to be altered or needs to deviate to some angle to reduce wind pressure.

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