International Journal of Science and Engineering Applications
Volume 8–Issue 11,485-491, 2019, ISSN:-2319–7560

Study on Effects of Opening Patterns in Shear wall on Setback building

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Abstract: This article presents the effects of opening on shear wall for thirteen-storeyed U shape RC building, which is situated in seismic zone (4).This structure is setback building. The elevations and plans of this structure are irregularity in shape. Special moment resisting frame is considered in this structure. This structure is analyzed under dead load, live load, wind load, earthquake load and all necessary load combinations are considered by using UBC 97. The modeling and analyzing of each member is done by ETABS 16.0.3. All of structural members are designed by ACI 318-14. Response spectrum analysis is used for dynamic analysis. First, the proposed building is analysed and design by using ETABS software. The shear wall of proposed building is opened with various percentage of opening and three different patterns. There are three types of patterns opening patterns (center 0pening,staggered opening and two vertical opening).The size of openings of shear wall are 13.6%, 25% and 35% of shear wall area. This article include comparative study of storey displacement, storey shear and storey moment under seismic force due to three configurations of openings in shear walls. According to the comparisons of these results, the maximum structural response is occurred at the structure having shear wall is with two vertical opening.

Keywords: seismic zone 4; setback; opening; response spectrum; shear wall

1.INTRODUCTION

We Nowadays,a large number of tall buildings are emerged due to the growth of populations. The highly function of vertical structure elements is to resist not only the gravity loading from the weight of the buildings but also the lateral load such as wind and possible earthquake loads. When these forces are acting on the structure, high shear forces and bending moments in structural members are causing the failure of the structure. Irregularities of plan and elevation give to damage the structural members. Shear wall is a wall column designed to resist the lateral loads.The strength of the shear wall depends on the type, size and use of materials. To attain a structure with sufficient strength and ductility to assure life safety, it is necessary to know about the configuration of opening of shear wall

2. DATA PREPARATION FOR PROPOSED BUILDING

All loadings on superstructure are considered according to UBC-97.Required loads and structural configurations of the proposed building are as follow:

2.1Site Location and Structural Framing System

Type of building : Thirteen-Storeyed RC building

Shape of building : U-shape (Vertical Irregular)

Location : Seismic zone 4

Type of occupancy : Commercial (Hotel)

Size of building :Length =131ft

Width =106.5ft Height of building

Typical storeyed height =12ft

Base to GF Storeyed height =10ft

GF to1st Storeyed height =16ft

1st to2nd storyed height =14ft

Overall height from ground floor =181ft

2.2 Material properties and design property data used for the proposed building

Modulus of elasticity , E_c = 3604 ksi

Poisson's ratio , = 0.2

Coefficient of thermal expansion = 5.5×10^{-6} in / in per degree F

Bending reinforcement yield stres (f_y) = 50ksi Shear reinforcement yield stress (f_{ys}) = 50ksi Concrete cylinder strength (f'_c) = 4ksi

2.3. Loading Consideration

Two kind of loads are considered in this study, which is gravity load, that include dead and live load, lateral load that include wind and earthquake load

2.3.1 Dead Load

The weight of all material and fixed equipments incorporated into the building are considered as dead load.

Consideration of dead loads for proposed building are as follows:

4.5" thick brick wall = 55 lb/ft^2
Unit weight of concrete = 150 lb/ft^3
Superimposed dead load = 25 lb/ft

2.3.2 Live load

Live loads are gravity load produced by the used and occupancy of the building and do not include dead loads, construction loads, or environmental loads such as wind and earthquake loadings are based on to UBC-97.

Unit weight of water = 62.4 lb/ft^3
Live load on floor area = 40 lb/ft^2
Live load on roof = 20 lb/ft^2
Live load on stair case = 100 lb/ft^2
Live load on lift = 100 lb/ft^2

2.3.3 Wind Load

The wind pressure on a structure depends on the wind response of the structure. Required Data in designing for wind load:

Exposure type = Type B
Basic wind velocity = 80 mph
Total height of building = 181 ft
Windward coefficient = 0.8
Leeward coefficient = 0.5
Importance Factor = 1.0

2.3.4 Earthquake Load

The purpose of seismic design is to proportion the structures so that they can withstand the displacements and forces induced by the ground motion.

Seismic zone = 4
Seismic Source Type = A
Soil Type = S_D
Structure =Special Moment Resisting Frame
Seismic Response Coefficient, Ca = 0.44 Na
Seismic Response Coefficient, Cv = 0.64 Nv
Near Source factor, Na = 1
Near Source factor, Nv = 1
Zone Factor = 0.4
Importance Factor, I = 1.0
Response Modification Factor, R = 8.5
C_T value = 0.03

2.4. Modeling of Proposed Building

Architectural view for ground floor plans, fifth to sixth floor plan, seventh to nine floor plan, tenth to twelve floor view and three dimensional view (3D) of proposed building are shown in Figure 1, 2, 3, 4, and 5 respectively. Figure 6 ,7 and 8shows the sample opening pattern of the shear wall.

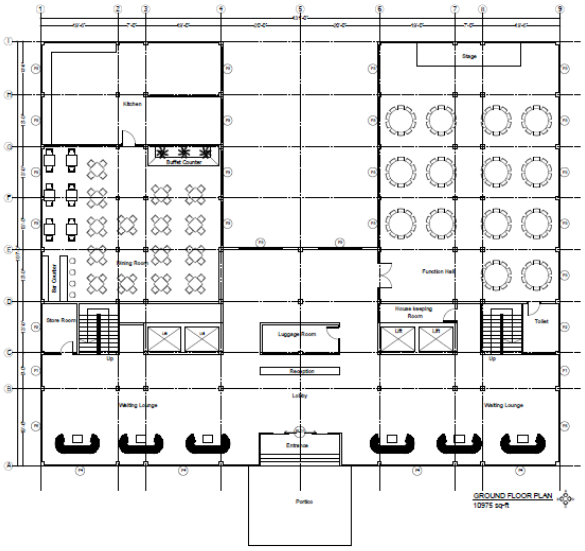

Figure 1. Architectural View for Ground Floor Plan

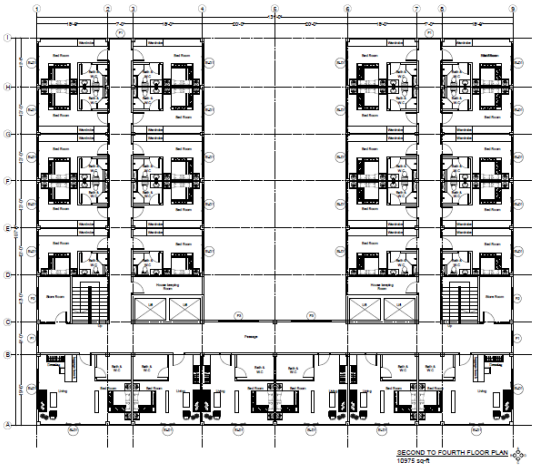

Figure 2. Architectural View for 1st to 4th Floor Plan

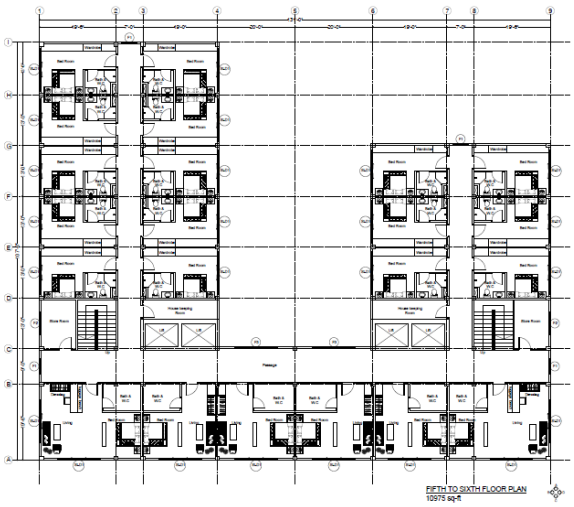

Figure 3. Architectural View for 5st to 6th Floor Plan

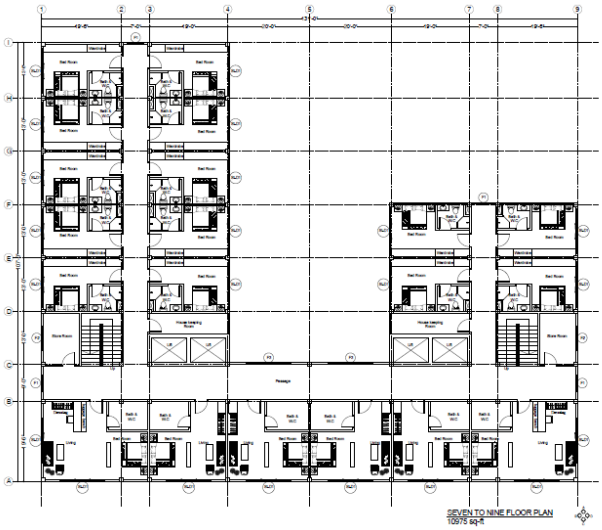

Figure 4. Architectural View for 7st to 9th Floor Plan

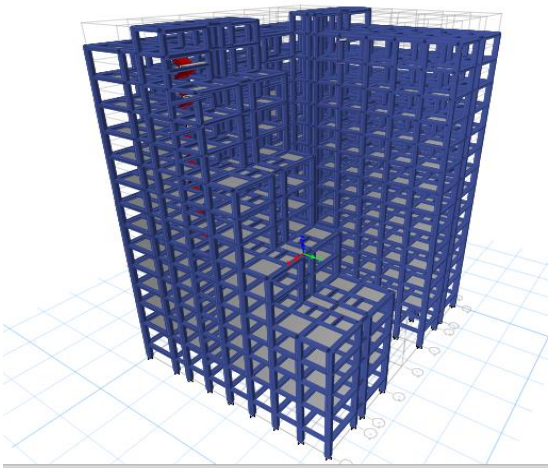

Figure 5. 3D View of Proposed Building

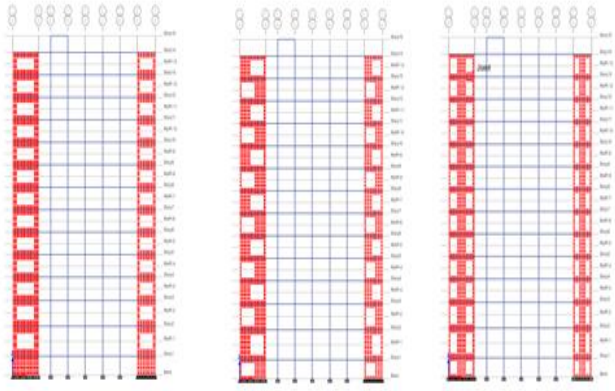

Figure 6. opening patterns of Propose Building(35%)

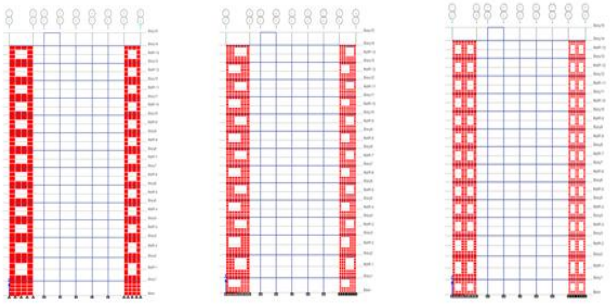

Figure 7. opening patterns of Propose Building(25%)

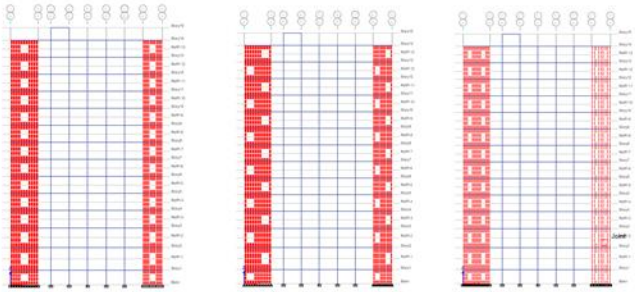

Figure 8. opening patterns of Propose Building(15%)

3. LOAD COMBINATIONS

According to ACI 318-14 and UBC- 97, static design load combinations and dynamic design load combinations (Response Spectrum analysis) for zone (4) are as follows:

1. 1.4DL
2. 1.2DL+1.0LL
3. 1.2DL+1.6LL
4. 1.2DL+0.5Wx
5. 1.2DL-0.5Wx
6. 1.2DL+0.5Wy
7. 1.2DL-0.5Wy
8. 1.2DL+1.0LL+1.0Wx

9. 1.2DL+1.0LL-1.0Wx
10. 1.2DL+1.0LL+1.0Wy
11. 1.2DL+1.0LL-1.0Wy
12. 0.9DL+1.0Wx
13. 0.9DL-1.0Wx
14. 0.9DL+1.0Wy
15. 0.9DL-1.0Wy
16. 1.2DL+1.0LL+1.0EQX
17. 1.2DL+1.0LL-1.0EQX
18 1.2DL+1.0LL+1.0EQY
19 1.2DL+1.0LL-1.0EQY
20 0.9DL+1.0EQX
21 0.9DL-1.0EQX
22 0.9DL+1.0EQY
23 0.9DL-1.0EQY

4. Modeling the Structure with Static Analysis

The column section, beam sections and shear wall sizes of the proposed building with static analysis are shown in Table 1 and 2. Layout plan for beam, and location of shear walls of the proposed building are shown in Fig 6, 7, 8,9, 10, 11, 12,and 13 respectively

Table 1 Design Section of Columns

Beam Name	Type	Section (in × in)
B1	Main Beam	14 × 20
B2	Main Beam	12 × 15
B3	Main Beam	10 × 12
B4	Main Beam	9× 12
SB	Secondary Beam	9 × 12

Table 2 Design Section of beams

Column Name	Storey Level	Section (in × in)
C1	Base to Story 6	20 × 20
	Story 7 to Story 11	18 × 18
	Story 12 to Roof	16 × 16
C2	Base to Roof	16×16

Shear wall thickness is 12 in from base to level 13. The thickness of slab is 6 in for all room and 7 in for landing.Function of column C 1 is not only exterior column but also interior column for all room. Column C2 is only for lift room.

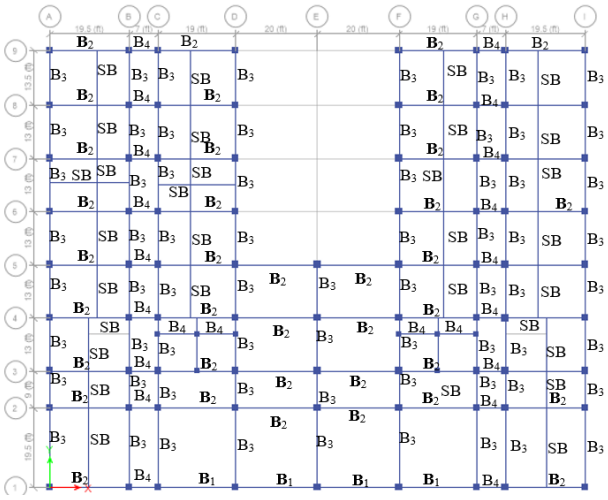

Figure 9. Beam layout plan

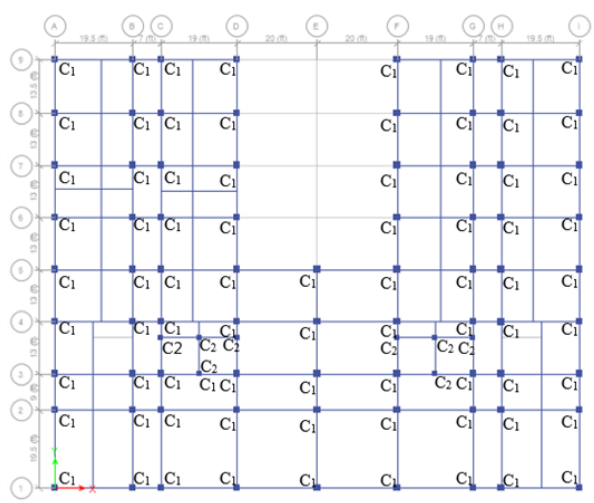

Figure10. Column layout plan

5. Comparing the Results

The results of openings are compared form the following figures.Figure,11,12,13,14,15 and 16 are the comparing results of 13.6% opening in storey displacement, shear and moment.

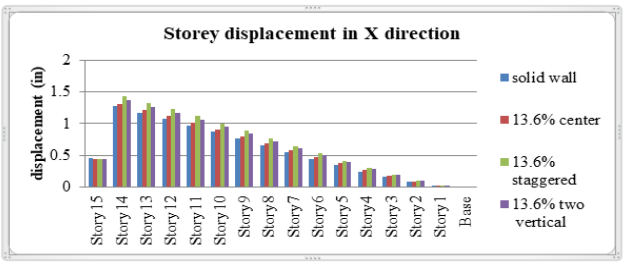

Figure11. Comparing the results of storey displacement in X direction with 13.6% opening

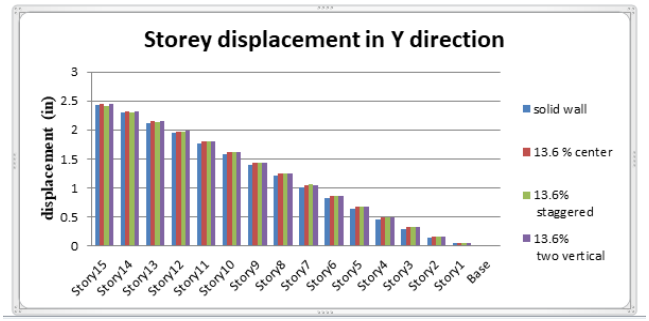

Figure12. Comparing the results of storey displacement in Y direction with 13.6% opening

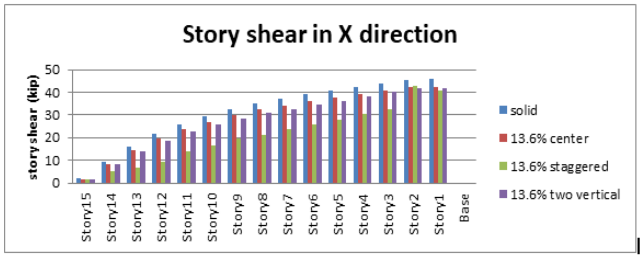

Figure13. Comparing the results of storey shear in X direction with 13.6% opening

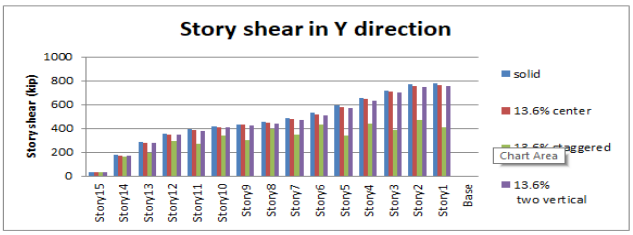

Figure14. Comparing the results of storey shear in Y direction with 13.6% opening

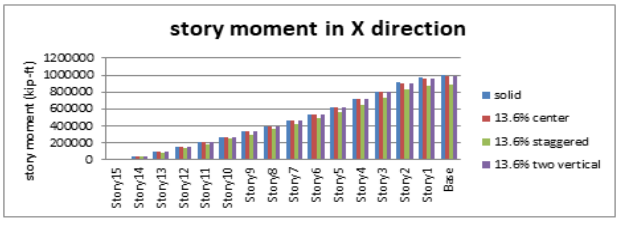

Figure15. Comparing the results of storey moment in X direction with 13.6% opening

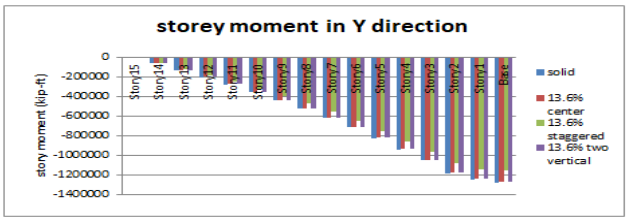

Figure16. Comparing the results of storey moment in Y direction with 13.6% opening

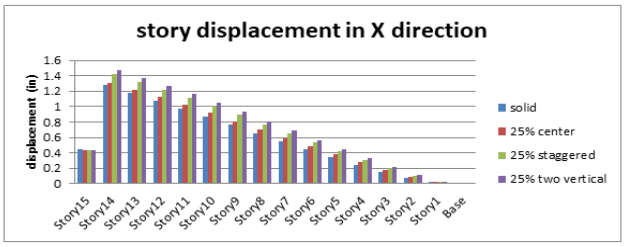

Figure17. Comparing the results of storey displacement in X direction with 25% opening

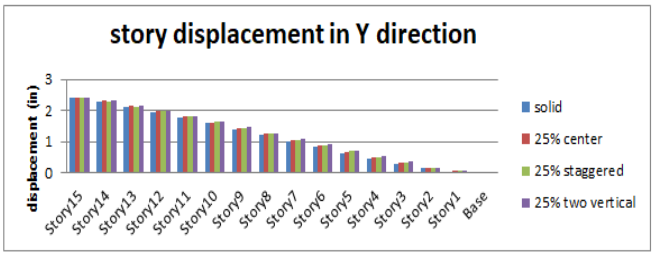

Figure18. Comparing the results of storey displacement in Y direction with 25% opening

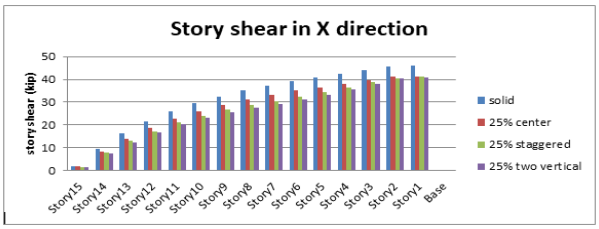

Figure19. Comparing the results of storey shear in X direction with 25% opening

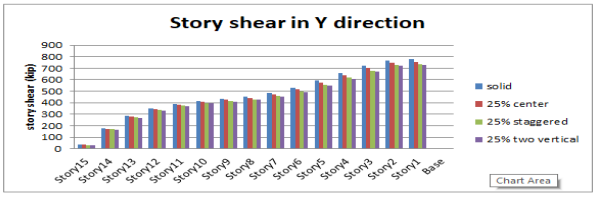

Figure20. Comparing the results of storey shear in Y direction with 25% opening

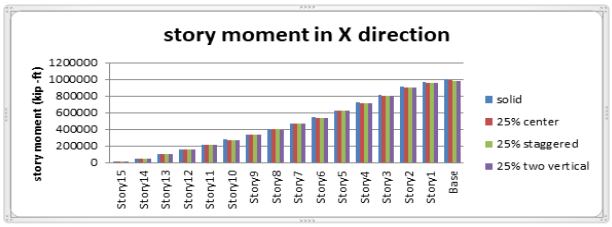

Figure21. Comparing the results of storey moment in X direction with 25% opening

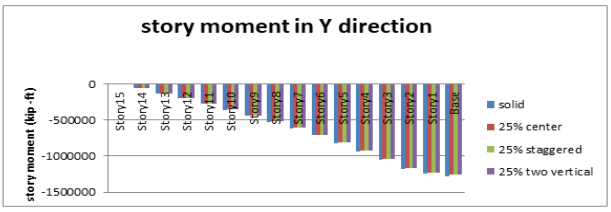

Figure22. Comparing the results of storey moment in Y direction with 25% opening

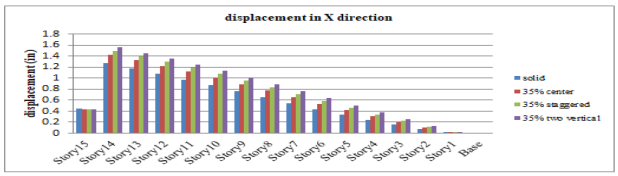

Figure23. Comparing the results of storey displacement in X direction with 35% opening

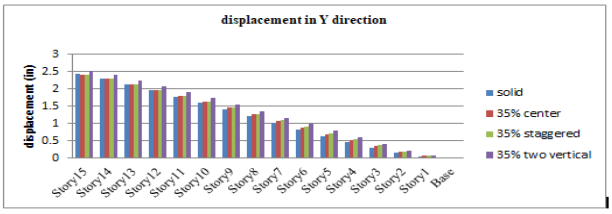

Figure24. Comparing the results of storey displacement in Y direction with 35% opening

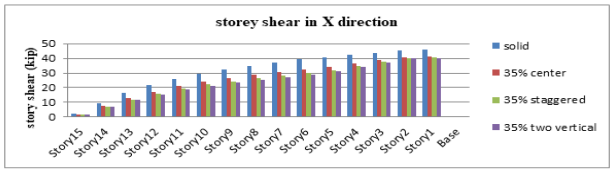

Figure25. Comparing the results of storey shear in X direction with 35% opening

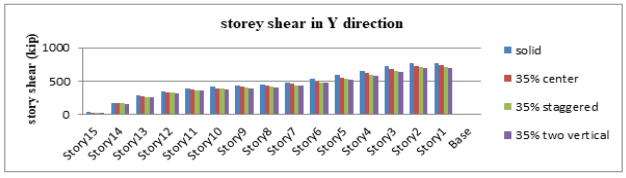

Figure26. Comparing the results of storey shear in Y direction with 35% opening

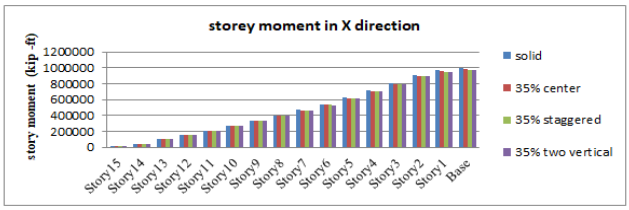

Figure27. Comparing the results of storey moment in X direction with 35% opening

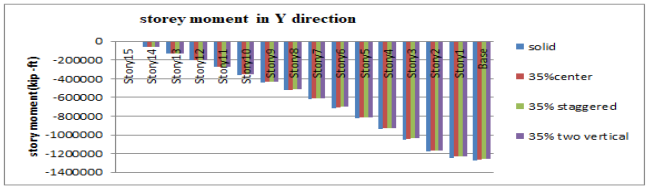

Figure28. Comparing the results of storey moment in Y direction with 35% opening

from the above figures, figure17,18,19.20,21 and 22 are the comparing results of 25% opening in storey displacement, shear and moment .And,figure,23,24,25,26,27 and28 are the comparing results of 35% opening in storey displacement, shear and moment.

6. Conclusion

In this study, the proposed building is vertical irregularities (setback) U-shape building. The shear wall is situated in Y direction of the structure .So the results of the structure is clearly different in X direction and the results of the structure in Y direction is nearly the same.

In comparison of analysis of results, the maximum value of storey displacement and minimum value of storey shear and moment at the two vertical opening of the structure.And minimum value of storey displacement and maximum value of storey shear and moment are occurred at center opening .

So it can be considered that the center opening is more suitable than the other opening pattern (staggered and two vertical). And two vertical opening is not suitable for the opening in shear wall structure.

ACKNOWLEDGMENT

The author of this paper would like to thank Dr. Thein Gi, Rector, Technological University (Thanlyin) for her kind permission to carry out this research work. The author is also thank to Dr Nyan Phone, Professor, Head of the Department of Civil Engineering of Technological University (Thanlyin) .The author special thanks to her supervisor Dr. Kyaw Lin Htat, Professor, Department Civil Engineering of the Technological University (Thanlyin) for his invaluable advice and suggestion to carry out this experimental work. The author would like express my deepest thanks to all who help her with necessary assistance for this study

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