INFLUENCE OF MASONRY INFILL WALL IN CONTROLLING DISPLACEMENT OF RCC STRUCTURE UNDER DYNAMIC LOADING

[1]FARJANA KHANAM, [2]ANIK DAS, [3]MD. ROKANUZZAMAN, [4]SHOVONA KHUSRU

[1,2,3]Undergraduate Student, Department of Civil Engineering, Ahsanullah University of Science and Technology, Dhaka 1208
[4]Assistant professor, Department of Civil Engineering, Ahsanullah University of Science and Technology, Dhaka 1208
E-mail: [1]khanamfarjana2@gmail.com, [2]anikdas503@gmail.com, [3]md.rokanuzzaman135@gmail.com

Abstract - This paper investigates and compares effect of masonry infill on the behavior of RCC Structures in resisting the lateral loads caused by earthquakes. A six-storied real building comprising of 1300 square feet plan area has been considered as case I. The building was conventionally designed with sophisticated finite element software SAP 2000 V14 by incorporating gravity load as per BNBC. To study the effect of masonry infill on the frame structure the building was optimally redesigned with strut in all floors as case II and alternate floors as case III. Acceleration data of Earthquake Array06-1 have been used for time history analysis. Joint displacement and serviceability of the interior, exterior and central column were studied. It can be concluded from observation of the results of dynamic analysis that that the structure without strut (case-I) gives the larger displacement than the structure with strut in all stories (case-II) is 3.58 times and the structure with strut in alternate storey (case-III) is 2.53 times respectively. The study concludes that the structure with strut in all storeys is considered safer due to the displacement.

Keywords - Time history analysis, Static analysis, RCC structure, Equivalent diagonal strut, soft storey.

I. INTRODUCTION

Normally in RC frame structures, brick masonry is just for architectural point of view and to make partition and other aspects. In many countries situated in seismic region, reinforced concrete frames are infilled fully or partially by brick masonry panels with or without openings. The term infilled frame is used to represent a composite structure
formed by the combination of a moment resisting RC frame and infill walls. To understand the effect of infill on frame elements, equivalent strut method was used.

This paper is developed to produce the civil engineers a scenario on the effectiveness of infill wall under lateral loading. Joint displacement under various strut (replacing infill wall for analytical purpose) arrangement for same loading condition will also be provided in an understandable way.

II. LITERATURE REVIEW

Multi storey reinforced-concrete framed structure in recent time have a special feature, The ground storey is left open for the purpose of social and functional needs this space is used for vehicle parking, shops, reception lobbies, a large space for meeting room or a banking hall etc. Soft storey can form at any level of a high rise building to fulfill required functional necessity and serve various purposes. Due to various functional needs a soft storey is also unavoidable, such buildings are called open ground storey buildings or soft story buildings or stilt floors.

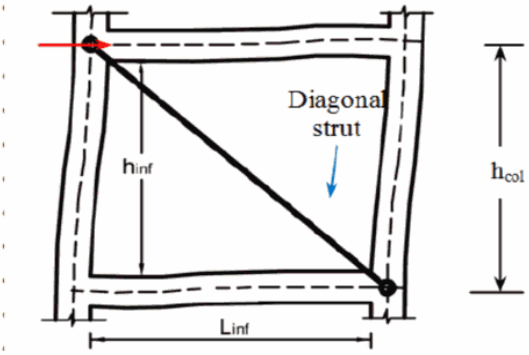


Fig 1: Concrete Masonry Infill as a Diagonal Strut

A soft storey is the one in which the lateral stiffness is less than 70% of that in the storey above or less than 80% of the average stiffness of the three storey above (BNBC,2006). The structures having relatively flexible lateral load resisting system, infill can play a significant role in total stiffness. Although this masonry infill contribute to stiffness and strength of the RC frame, however they are generally neglected in the design because of lack of knowledge of composite behavior of the in filled frame. Lateral displacement of a story is a function of stiffness, mass and lateral force distributed on that storey. It is also known that the lateral force distribution along the height of a building is directly related to mass and stiffness of each story. Properly designed infill walls increase the overall strength, lateral resistance and energy dissipation of the structure.
The design is based on braced frame model, with the masonry infill serving as an equivalent strut. The width of strut is determined from equation 1.

$$W_{inf} = \frac{0.3}{\lambda strut \cos\theta strut} \qquad \text{Eqn. 1}$$

Where,

$$\lambda_{strut} = \sqrt[4]{\frac{Em\ tnet\ inf \sin 2\theta strt}{4Ebc.Ibc.hinf}} \qquad \text{Eqn. 2}$$

Where,

W_{inf} = Width of the strut, T_{net} = Net thickness of infill, Θ_{strut} = The angle of the diagonal with respect to horizontal, E_{bc} =Modulus of elasticity of bounding column, I_{bc} =Moment of inertia of bounding columns for bending in the plane of the infill. The term λ_{strut}, developed by Stafford Smith and Carter **(Stafford, 1969)** in the late 60s, is the characteristic stiffness parameter for the infill and provides a measure of the relative stiffness of the frame and the infill.

A full time history analysis will give the response of a structure over time during the application of dynamic loading. With the advancement of seismic design of structures time history analysis has become an effective parameter. Bangladesh being vulnerable to earthquake dynamic analysis is a must for the future design of RCC structures in major earthquake zones considering the best economic infill wall patterns. The two important parameters that can influence the type of the structural system which are supposed to be used, especially the orientation of infill wall in a structure, economy and performance parameters.

III. METHODOLOGY

For analytical application a bilateral symmetry six storied residential building of 1300 square feet floor area located at Mirpur,Dhaka-1216 has been chosen to apply time history loading as shown in figure 3.

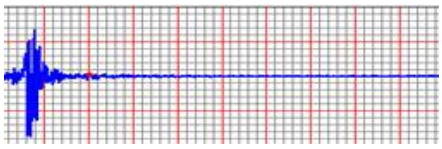
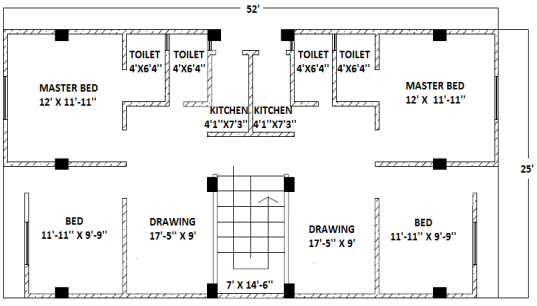
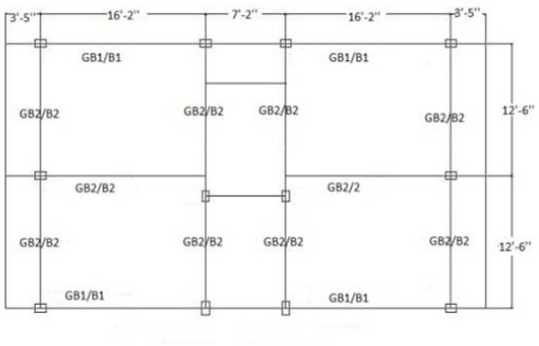


Fig 2: Time History Function Graph

The building was optimally designed following Bangladesh National Building Code (BNBC 2006) under gravity loading and then design was repeated and strut was used of two types of arrangement (the structure with strut in all storey and the structure with strut in alternate storey.



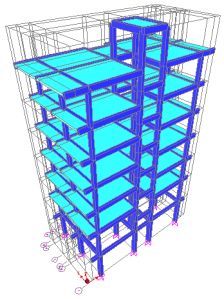
(a) Architectural Plan



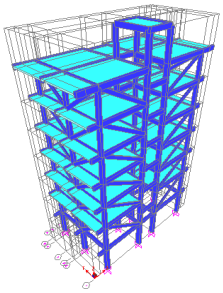
(b) Typical Floor Plan

Fig.3: (a) Architectural Plan and (b) Typical Floor Plan of the Building

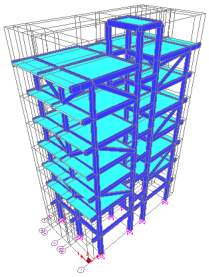
There are three longitudinal and four transverse frames with 16 beams and 12 columns. All external frames are designed providing strut placed only at corner panels in both directions.



(a) Without Strut (case-I)



(b) Strut in Every Floor (case-II)



(c) Strut in Alternate Floor (case-III)

Fig 4: Three Dimensional View of Structure (a) Without Strut (case- I), (b) Strut in Every Floor (case- II) and (c) Strut in Alternate Floor (case- III)

All buildings are considered as Ordinary Moment Resisting Frame with 6 inch concrete slab. Except grade beams (16''X12") in ground floor identical beam (18''X10'') sections have been maintained as

per requirement. In this study, fixed base restraint is used which restraint all six degrees of freedom. Six different diaphragms have been assigned for six different stories. Struts have been assigned with pinned connection to represent behavior of structure with infill wall. For the time history analysis of the said structures SAP2000 V14 had been used.

Type of load	Name of load	Value	unit
Super Dead	Floor Finish	5.63	psf
	Partition Wall	As per plan	psf
Wind load	As per BNBC		
Live load	Live	42	psf
Earthquake loading	Array06-1		

Table.1 Applied loading on the structures.

The applied loads on the structure are given in the table 1. Linear modal time history analysis has been used in this study with damping ratio 5%. In case of selecting earthquake data for using as input in time history analysis Altadena-1, Array06-1 and Corralit-1 has been chosen.

IV. RESULT AND DISCUSSION

The lateral deflection for three columns had been determined to evaluate the most economical structural system with improved stiffness. The weight of frame has also been compared. The parameters for this analysis are-

- Joint displacement for exterior, interior and central column
- Serviceability of the structures

4.1 Joint Displacement for Dynamic Analysis

In case of dynamic joint displacement, the Array06-1 showed maximum displacement for case-I. The displacement values increased gradually from base and showed maximum values at top in all the structures.

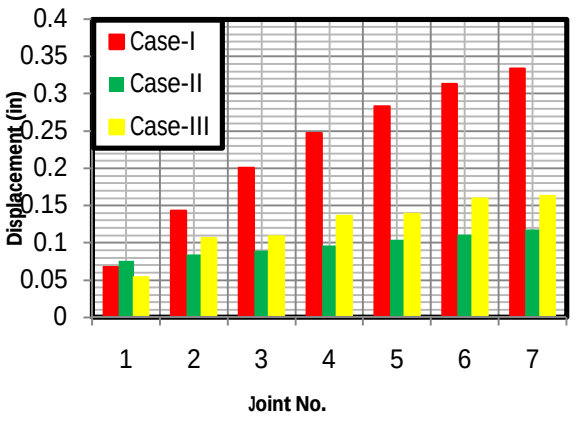


Fig 5: Exterior Column

Fig 5. showed the joint displacement at different storey levels of exterior column. The structure without strut (case-I) showed the maximum displacement value of 0.33 inch at the top whereas the minimum displacement value of 0.067 inch at the bottom. Top displacement of case-I is larger than case-II and case-III for 3 times and 2 times respectively.

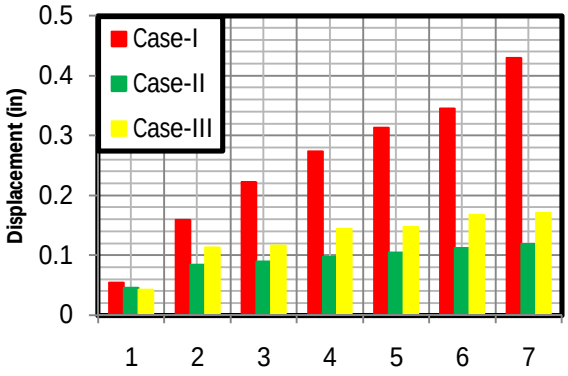


Fig 6: Interior Column

Fig 6. showed the joint displacement at different storey levels of interior column. The structure without strut (case-I) showed the maximum displacement value of 0.43 inch at the top whereas the minimum displacement value of 0.054 inch at the bottom. Top displacement of case-I is larger than case-II and case-III for 3.58 times and 2.53 times respectively.

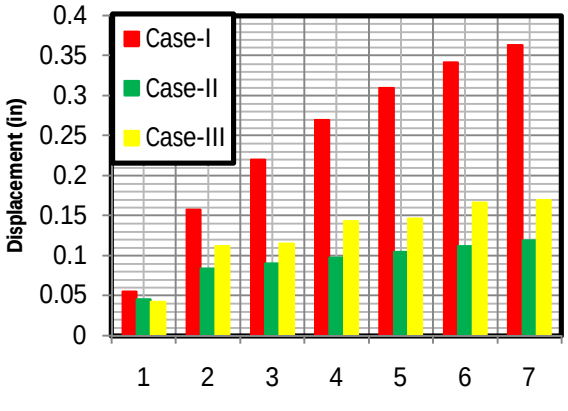


Fig 7: Central Column

Fig 7. showed the joint displacement at different storey levels of central column. The structure without strut (case-I) showed the maximum displacement value of 0.36 inch at the top whereas the minimum displacement value of 0.054 inch at the bottom. Top displacement of case-I is larger than case-II and case-III for 3 times and 2.12 times respectively.

4.2 Displacement for Static Analysis

In case of static joint displacement, the case-I showed maximum displacement. The displacement values increased gradually from base and showed maximum values at top in all the structures.

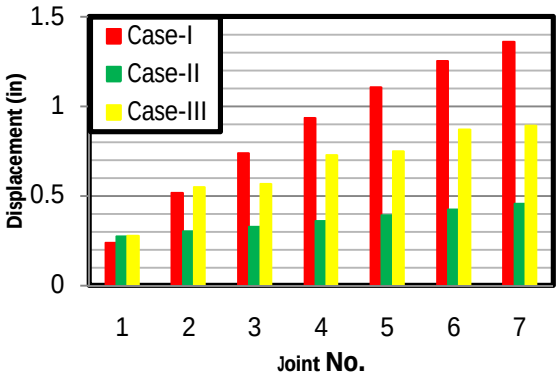


Fig 8: Exterior Column

Fig 8. showed the joint displacement at different storey levels of exterior column. The structure without strut (case-I) showed the maximum displacement value of 1.36 inch at the top whereas the minimum displacement value of 0.24 inch at the bottom. Top displacement of case-I is larger than case-II and case-III for 3 times and 1.53 times respectively.

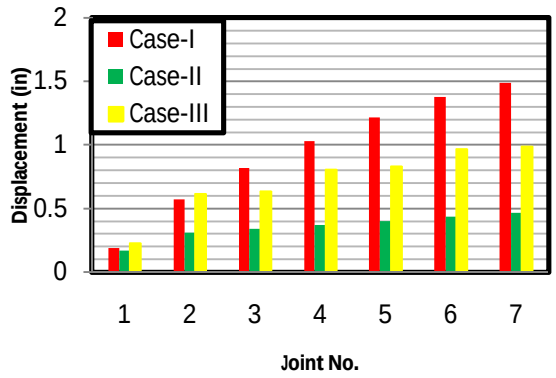


Fig 9: Interior Column

Fig 9. showed the joint displacement at different storey levels of exterior column. The structure without strut (case-I) showed the maximum displacement value of 1.48 inch at the top whereas the minimum displacement value of 0.192 inch at the bottom. Top displacement of case-I is larger than case-II and case-III for 3.16 times and 1.5 times respectively.

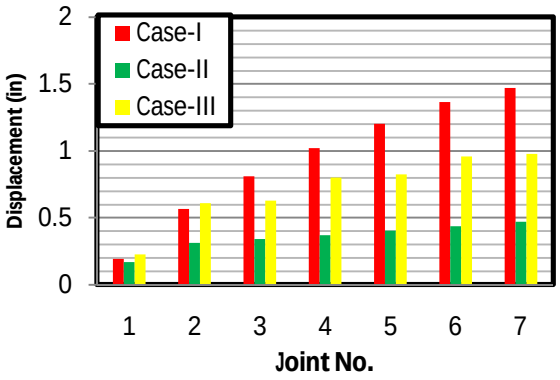


Fig 10: Central column

Fig 10. showed the joint displacement at different storey levels of exterior column. The structure without strut (case-I) showed the maximum displacement value of 1.47 inch at the top whereas the minimum displacement value of 0.192 inch at the bottom. Top displacement of case-I is larger than case-II and case-III for 3.15 times and 1.5 times respectively.
All the displacement values are less than H/480(1.55 inch, calculated as per BNBC) for both static and dynamic loading.

4.3 Variation in joint Displacement for Static & Dynamic Analysis

For joint Displacement variation in the result obtained from static and dynamic analysis is shown below:

Variations of Top floor Displacement (in times)				
Parameter		Dynamic Loading	Static loading	Variation
Displacement	Case-I			
(in)	Exterior	0.33	1.36	4.07
	Interior	0.43	1.49	3.46
	Central	0.36	1.47	4.05
	case-II			
	Exterior	0.12	0.46	3.87
	Interior	0.12	0.47	3.94
	Central	0.12	0.47	3.93
	Case-III			
	Exterior	0.16	0.89	5.48
	Interior	0.17	0.99	5.78
	Central	0.17	0.98	5.75

Table.2 Variation of Displacement for Static and Dynamic Loading

CONCLUSIONS

Each parameter of displacement among all cases shows that the structure with strut in all floors has the minimum values. The summery is given below:

In case of dynamic loading the interior column of case-I showed the maximum displacement value of 0.43 inch at the top whereas the minimum displacement value of 0.054 inch at the bottom. Top displacement is 7.96 times larger than that of bottom displacement.

In case of static loading the interior column of case-I showed the maximum displacement value of 1.48 inch at the top whereas the minimum displacement value of 0.192 inch at the bottom. Top displacement is 7.7 times larger than that of bottom displacement.

It is observed that variation of displacement varies from the maximum value of 5.78 times (case-III) to

the minimum value of 3.46 times (case-I) in interior column with respect to the structure with strut in all floors (case-II).

So, it can be concluded that the structure with strut in all floors (Case-II) is the safest one according to displacement criteria.

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