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A Brief Study of Hybrid Masonry Structural Frame

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ABSTRACT
In Bangladesh many buildings are found which are not so strong to resist lateral forces such as seismic and wind forces. This research work has been performed to investigate the way of improving the lateral load resisting capacity of buildings. The deflection of different case of structure such as a) Concrete Frame, b) Steel Frame c) Hybrid Masonry Frame system has been investigated in this research work by using civil engineering based finite element analysis software STAAD Pro.-2006.

Four (4) sides of a 15 story commercial building has been considered in this research work. The four sides of the frames are the front side frame, back side frame, left side frame, and right side frame respectively.

For Front side frame, the highest value is 11.858" for concrete frame and the lowest deflection value is 4.241" for the hybrid masonry frame. Therefore, deflection of the hybrid masonry frame is reduced by 73.66% with respect to concrete frame structure.

For Back side frame, the highest value is 11.455" for concrete frame and the lowest deflection value is 4.129" for hybrid masonry frame. Therefore, deflection of hybrid masonry frame is reduced by 73.50% with respect to concrete frame structure.

For Left side frame, the highest value is 11.863" for concrete frame and the lowest deflection value is 3.101" for the hybrid masonry frame. Therefore, deflection of the hybrid masonry frame is reduced by 79.30% with respect to concrete frame structure.

For Right side frame, the highest value is 11.455" for concrete frame and the lowest deflection value is 2.993" for the hybrid masonry frame. Therefore, deflection of the hybrid masonry frame is reduced by 79.28% with respect to concrete frame structure.

Keywords
Hybrid masonry, concrete, steel, deflection, frame, STAAD Pro., finite element analysis, civil engineering.

1. INTRODUCTION
Hybrid masonry is a structural system that utilizes reinforced masonry infill walls with a framed structure. While the frame can be constructed of reinforced concrete or structural steel and the masonry can be concrete masonry units or structural clay brick units, the discussion here will include steel frames in combination with reinforced concrete masonry walls [1]. The masonry walls are used as part of the lateral load resisting system.

Load-bearing masonry as a structural system is often in competition with frames of structural steel or concrete as the primary structural system for a building. The interaction of masonry with a frame often leads to construction interferences, particularly with diagonal bracing in building frames. Masonry can be used in combination with steel- or concrete-framed construction to create an efficient hybrid structure that uses the specific qualities of each structural material [2]. Hybrid masonry offers many benefits and complements framed construction. By using the masonry as a structural element for in-plane loads, the constructible of the masonry with the frames is improved, the lateral stiffness are increased, the redundancy is improved, and opportunities for reduced construction costs are created [3].

2. OBJECTIVE OF THE WORK
The objectives of the study are as follows:

- To find the vertical load and lateral load shearing aspects of the hybrid steel and masonry.
- To find the greater stiffness with the hybrid masonry system in comparisons with braced frame or moment frames.
- Comparisons lateral deflection between RCC, steel structure and steel structure with hybrid masonry wall.

3. BACKGROUND
Masonry has been used as structure since man began building structure. Over time, new uses have been developed for masonry that includes performing as backup, infill, or fireproofing. It has been used as infill for other structural systems for decades.

Since the 1950s, architects and engineers have primarily used cavity walls with framed structures. The backup masonry walls are generally termed infill walls. They support out-of-plane loads on the wall and are isolated from the frame so as not to participate in the lateral load resistance. Codes usually require that these walls be isolated from the lateral movement of the frame so no lateral loads are imparted to the masonry. The hybrid system is a variation of the confined masonry system. It incorporates the beneficial qualities of transitional buildings and the characteristics of the cavity wall construction. It differs from cavity wall construction in that the infill masonry walls participate with the frame and provide strength and stiffness to the system. The masonry can be used as single Wythe or cavity wall construction. Hybrid masonry structures are constructed of reinforced masonry, not unreinforced masonry, as was common in transitional buildings. Hybrid masonry/framed structures were first proposed in print in 2006[1] .There are several primary reasons for its development. One reason is to simplify the construction of framed buildings with masonry infill.

While many designers prefer masonry infill walls as the backup for veneers in framed buildings, there is often a conflict created when steel bracing is required and positioned such that conflicts arise with the location of the masonry infill. This leads to detailing difficulties and construction interferences in trying to fit the masonry around braces. One solution is to eliminate the steel bracing and use reinforced masonry infill as shear wall and bracing [2]. Hybrid masonry/steel structures also provide structural redundancy that can be utilized to limit progressive collapse. The reinforced masonry infill results in an alternative load path for the gravity loads of the frame that provides redundancy. The resulting system is more efficient than either a frame or a bearing wall system alone when subjected to progressive collapse design conditions. If a steel column is damaged in a hybrid structure, gravity loads will transfer to the reinforced masonry [4].

4. MODELING OF STRUCTURE

Methodology of deflected shapes and values due to the application of different types of frames are obtained here due to following cases,

a. Concrete Frame

b. Steel Frame

c. Hybrid Masonry Frame

A 15 story commercial building is considered here as a standard structure. Dimension of structure 51ft. 2inch × 63 ft. 2inch. For concrete frame, sizes of beamsB1 18” X 10” B2 18” X 12”and columns are C1 20” X 10” C2 20” X 12” C3 24” X 16” respectively. For steel and hybrid masonry frame Column HP14×102, Main beam W24×76, Sec. beam W21X104 and bracing W21×122. Floor height of 10ft. using linear elastic analysis with the help of finite element software STAAD Pro. under earthquake loads in the equivalent static analysis.

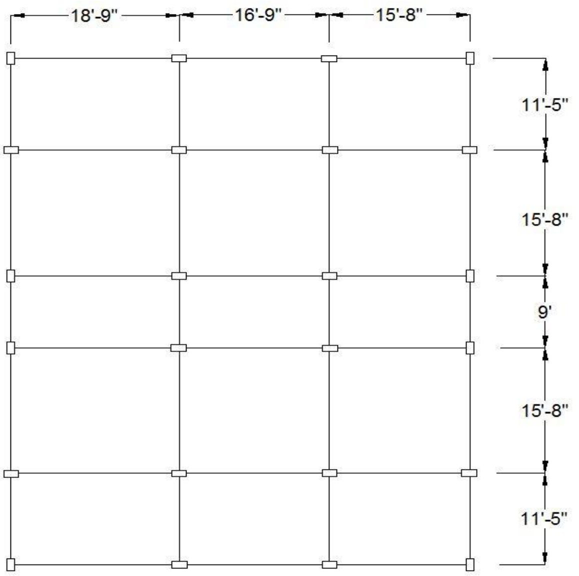

Fig 01: Column layout of the building

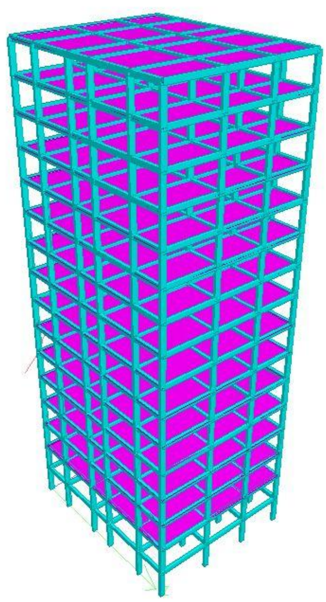

Fig 02:View from STAAD Pro.

Table 01: Node displacement summary of concrete frame

Node Displacement Summary

	Node	L/C	X (in)	Y (in)	Z (in)	Resultant (in)	rX (rad)	rY (rad)	rZ (rad)
Max X	398	10:COMB:DL+L	**9.413**	-0.507	-0.001	9.427	0.000	-0.000	-0.002
Min X	388	11:COMB:DL+L	**-0.492**	-0.216	11.443	11.455	0.003	0.001	0.001
Max Y	1	7:COMB:DL+LL	0.000	**0.000**	0.000	0.000	0.000	0.000	0.000
Min Y	405	7:COMB:DL+LL	-0.357	**-1.358**	-0.001	1.404	0.001	0.000	0.000
Max Z	385	11:COMB:DL+L	-0.483	-0.274	**11.840**	11.853	0.003	0.000	-0.001
Min Z	395	7:COMB:DL+LL	-0.337	-0.902	**-0.008**	0.963	-0.002	0.000	0.000
Max rX	122	11:COMB:DL+L	-0.135	-0.177	5.273	5.278	**0.006**	0.000	0.000
Min rX	395	7:COMB:DL+LL	-0.337	-0.902	-0.008	0.963	**-0.002**	0.000	0.000
Max rY	345	11:COMB:DL+L	0.017	-0.665	11.031	11.051	0.001	**0.001**	0.000
Min rY	301	10:COMB:DL+L	8.400	-0.411	-0.000	8.410	-0.001	**-0.001**	-0.003
Max rZ	390	7:COMB:DL+LL	-0.368	-0.871	0.001	0.945	-0.000	-0.000	**0.001**
Min rZ	86	10:COMB:DL+L	2.327	-0.139	0.000	2.332	0.000	-0.000	**-0.007**
Max Rst	401	11:COMB:DL+L	-0.405	-0.931	11.825	**11.868**	0.002	0.001	0.000

Table 02: Node displacement summary of steel frame

Node Displacement Summary

	Node	L/C	X (in)	Y (in)	Z (in)	Resultant (in)	rX (rad)	rY (rad)	rZ (rad)
Max X	398	10:COMB:DL+L	**4.479**	-0.306	-0.001	4.489	0.000	-0.000	-0.001
Min X	388	11:COMB:DL+L	**-0.230**	-0.155	5.038	5.045	0.001	0.001	0.000
Max Y	1	7:COMB:DL+LL	0.000	**0.000**	0.000	0.000	0.000	0.000	0.000
Min Y	403	7:COMB:DL+LL	-0.192	**-0.825**	0.001	0.847	-0.000	-0.000	-0.000
Max Z	386	11:COMB:DL+L	-0.225	-0.279	**5.446**	5.458	0.002	-0.000	-0.000
Min Z	395	7:COMB:DL+LL	-0.170	-0.567	**-0.008**	0.592	-0.001	0.000	-0.000
Max rX	146	11:COMB:DL+L	-0.076	-0.128	2.884	2.888	**0.002**	-0.000	0.000
Min rX	395	7:COMB:DL+LL	-0.170	-0.567	-0.008	0.592	**-0.001**	0.000	-0.000
Max rY	328	10:COMB:DL+L	3.985	-0.246	0.000	3.993	0.000	**0.001**	-0.001
Min rY	325	10:COMB:DL+L	3.985	-0.246	-0.000	3.993	-0.000	**-0.001**	-0.001
Max rZ	390	7:COMB:DL+LL	-0.201	-0.564	0.001	0.599	-0.000	-0.000	**0.001**
Min rZ	86	10:COMB:DL+L	1.125	-0.077	0.000	1.128	0.000	-0.000	**-0.003**
Max Rst	403	11:COMB:DL+L	-0.158	-0.606	5.438	**5.474**	0.000	0.000	-0.000

Table 03: Node displacement summary of hybrid masonry frame

Node Displacement Summary

	Node	L/C	X (in)	Y (in)	Z (in)	Resultant (in)	rX (rad)	rY (rad)	rZ (rad)
Max X	398	10:COMB:DL+L	**5.219**	-0.211	0.006	5.223	0.000	-0.001	-0.002
Min X	388	11:COMB:DL+L	**-0.187**	-0.161	2.956	2.966	0.001	0.002	0.000
Max Y	60	10:COMB:DL+L	0.756	**0.009**	0.010	0.756	-0.000	0.000	-0.002
Min Y	403	7:COMB:DL+LL	-0.170	**-0.811**	0.001	0.829	-0.000	-0.000	-0.000
Max Z	386	11:COMB:DL+L	-0.178	-0.245	**3.927**	3.939	0.002	-0.001	0.000
Min Z	100	10:COMB:DL+L	1.293	-0.313	**-0.017**	1.330	-0.000	0.001	-0.002
Max rX	146	11:COMB:DL+L	-0.067	-0.113	2.157	2.161	**0.002**	-0.001	0.000
Min rX	395	7:COMB:DL+LL	-0.119	-0.553	-0.008	0.565	**-0.001**	0.000	0.000
Max rY	328	10:COMB:DL+L	4.268	-0.165	0.010	4.271	0.000	**0.003**	-0.002
Min rY	325	10:COMB:DL+L	4.338	-0.162	0.008	4.341	-0.000	**-0.003**	-0.002
Max rZ	390	7:COMB:DL+LL	-0.181	-0.525	0.001	0.556	-0.000	-0.000	**0.001**
Min rZ	110	10:COMB:DL+L	1.763	-0.061	0.007	1.764	0.000	-0.000	**-0.003**
Max Rst	406	10:COMB:DL+L	5.207	-0.614	-0.002	**5.243**	0.000	-0.001	-0.000

5. PROBLEM STATEMENT

To carefully observe the deflection of the building, we categorized the nodes of the building into three parts, these are

a. Concrete Frame

b. Steel Frame

c. Hybrid Masonry Frame

We applied different loads on the nodes of different sections of the building and run our analysis, after completing the analysis we noticed the variety of the deflections at different nodes at different sections.

6. RESULTS AND DISCUSSION

Comparisons of the node displacement curve of all frames are obtained here in this research work, three types of frame system have been considered figure 3 shows height vs. deflection curve of front side for all types of the frame system.

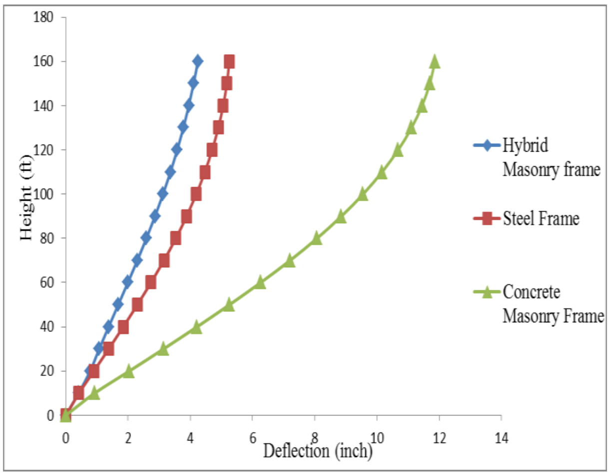

Fig 03: Height vs. Deflection curve of front side of concrete, steel & hybrid masonry frame

Deflection values of the top nodes in cases of concrete, steel and hybrid masonry frame are 11.858", 5.251", and 4.241" respectively. The highest value is 11.858" for concrete frame and the lowest deflection value is 4.241" for the hybrid masonry frame. Therefore, deflection of the hybrid masonry frame is reduced by 73.66% with respect to concrete frame structure.

Figure 4. shows height vs. deflection curve of back side for all types of the frame system.

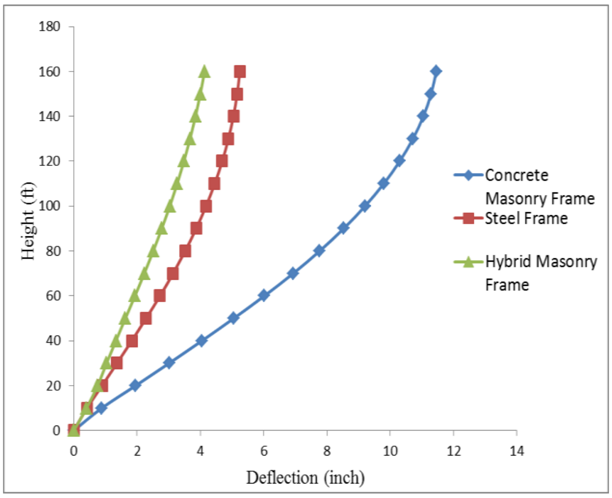

Fig 04: Height vs. Deflection curve of back side of concrete, steel & hybrid masonry frame

Deflection values of the top nodes in cases of concrete, steel and hybrid masonry frame are 11.455", 5.246", and 4.129" respectively. The highest value is 11.455" for concrete frame and the lowest deflection value is 4.129" for the hybrid masonry frame. Therefore, deflection of the hybrid masonry frame is reduced by 73.50% with respect to concrete frame structure.

Figure 4.27 shows Height vs. Deflection curve of left side of concrete, steel & hybrid masonry frame

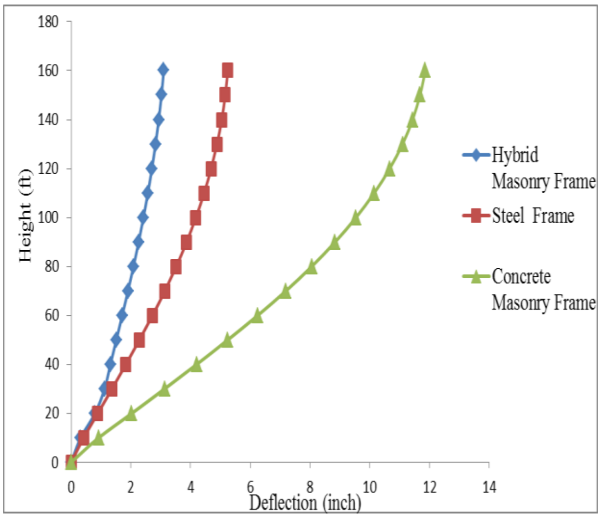

Fig 05: Height vs. Deflection curve of left side of concrete, steel & hybrid masonry frame

Deflection values of top nodes in cases of concrete, steel and the hybrid masonry frame are 11.863", 5.246", and 3.101" respectively. The highest value is 11.863" for concrete frame and the lowest deflection value is 3.101" for the hybrid masonry frame. Therefore, deflection of the hybrid masonry frame is reduced by 79.30% with respect to concrete frame structure.

Figure 6 shows height vs. deflection curve of right side for all types of frame system.

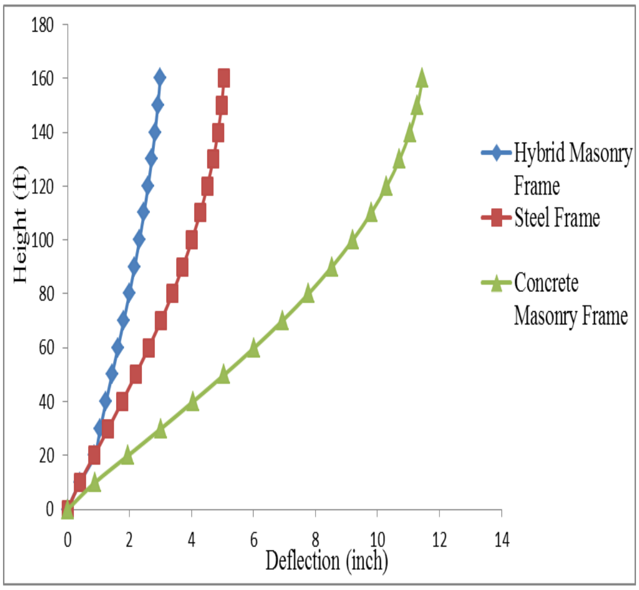

Fig 6: Height vs. Deflection curve of right side of concrete, steel & hybrid masonry frame

Deflection values of top nodes in cases of concrete, steel and the hybrid masonry frame are 11.455", 5.049", and 2.993" respectively. The highest value is 11.455" for concrete frame and the lowest deflection value is 2.993" for the hybrid masonry frame. Therefore, deflection of the hybrid masonry frame is reduced by 79.28% with respect to concrete frame structure.

7. CONCLUSIONS

As steel is not widely popular in Bangladesh as a construction, material so it was not possible to describe all properties based on this country. We tried to describe these as a concept, based on other neighboring and foreign countries. So for further research, suggest to analyzing all properties and designing concepts of steel based on feasibility concern in Bangladesh. Here is the deflection of the hybrid masonry frame is less than the concrete frame structure. Therefore, for compliments frame construction this hybrid masonry frame is more preferable than the others frame. It is also important to increase lateral stiffness of the structure, to improve the redundancy factor, increase frame ability to prevent a possible progressive collapse. Adopting steel frame with hybrid wall could be a transitional step towards modernizations of construction methods in developing countries.

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