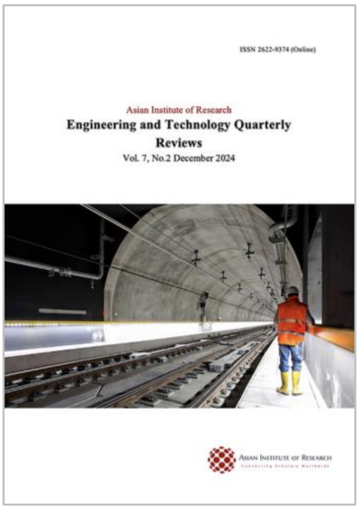

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Comparative Analysis of Seismic Resistance and Cost Efficiency in Lift Core Construction Using Masonry Wall-Column Systems and Shear Wall Systems

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Abstract

This research paper presents a comparative analysis of seismic resistance and cost efficiency in lift core construction using masonry wall-column systems and shear wall systems. High-rise structures' lift cores are crucial vertical conduits that provide the necessary structural stability. To support the best practices in building design and construction, the seismic performance and financial effects of various lift-core construction techniques are examined. The study compares the seismic resistance implied on a structure by lift cores built with masonry wall-column systems, which combine load-bearing masonry walls with reinforced vertical columns to lift cores built with shear wall systems, which rely on reinforced concrete to withstand lateral forces. Analytical modeling and simulation approaches are used to evaluate seismic performance in scenarios involving severe earthquakes. A variety of loads, including dead loads, live loads, partition loads, wind loads, seismic loads, and load combinations that were pursued in accordance with BNBC 2020 standards, have been applied to both types of structures. Four required metrics were evaluated for the analysis of both structures: storey drift, overturning moment, storey shear, and storey stiffness. Furthermore, a thorough cost study is performed to evaluate the two building systems' economic viability. Each method's associated material costs for the construction of the lift core are taken into account in the analysis. By conducting thorough research, we summarized that although masonry wall lift cores with columns at four corners act better resistant to seismic action, the Shear wall lift core system overall performed better as it is more economically feasible and it's decent resistant to seismic force. The findings of this study provide important insights into the trade-offs between seismic performance and cost efficiency when choosing lift-core construction techniques. The findings are intended to help engineers, architects, and developers make informed judgments about building safety and economic sustainability in seismically-prone places.

Keywords: Masonry Wall, Shear Wall, Lift Core, Storey Drift, Stiffness, Storey Shear, Overturning Moment, ETABS

1. Introduction

Lift cores are critical components of high-rise buildings, enabling vertical circulation and structural stability. Masonry wall-column systems and shear wall systems are two popular methods for building lift cores; each has advantages and disadvantages related to cost-effectiveness and seismic resilience.

Significant studies have been conducted on the seismic behavior of the shear wall and masonry structure. Reinforced masonry (RM) and reinforced concrete (RC) shear walls were compared across seismic hazard zones in Canada, revealing comparable material quantities and costs. Despite differences in seismic demands and structural properties, both materials exhibit similar economic viability for shear wall construction (El-Sokkary & Galal, 2020). Also, the UHPC method is cost-effective in comparison to high-strength concrete in the construction of tall buildings. UHPC grade: 185 MPa shows the best results in cost analysis and seismic performance (AlHamaydeh et al., 2022). Comparative research shows rocking walls outperform traditional RC walls in terms of damage resistance and self-centering properties, but are more affected by higher modes in terms of shear and bending moments, especially at higher intensities (Aragaw & Calvi, 2020). Researchers have pioneered hybrid soft-computing models for predicting the shear capacity of reinforced concrete shear walls, offering enhanced accuracy and reliability compared to traditional empirical models (Keshtegar et al., 2022). Meanwhile, the modular approach to high-rise construction introduces a paradigm shift by utilizing precast concrete modules as shear walls, challenging conventional methods and potentially reducing construction time and costs (Wang et al., 2020). The SC-RRCSW model is proposed by researchers which introduces an innovative seismic design approach, emphasizing repairable connections and the use of replaceable structural fuses to minimize damage. It exhibits high initial stiffness, substantial energy dissipation, and the potential for quick recovery after seismic events, offering promising prospects for practical implementation in various structures (Parsafar & Moghadam, 2017). Also, special RC shear walls significantly improve structural response compared to their ordinary counterpart with negligible impact on initial investment cost (Nader Aly & Galal, 2020). An investigation shows peripheral RC shear walls at the corners presented the smallest displacement and base shear compared to the other positions with hard soil (Al Agha et al., 2021). The available formulas for predicting shear amplification in ductile walls and dual systems (wall-frames) were presented in Rutenberg's research article (Rutenberg, 2013). Another research delves into the optimal positioning of lift core shear walls within multi-storied buildings, exploring configurations such as central placement versus edge or corner placement. Their analysis encompasses a comprehensive array of parameters, including displacement, story drift, mode frequencies, and participation, to assess the seismic response of different configurations (Saxena & Pahwa, 2018). Similarly, an investigation suggests the significance of lift cores in fortifying structures against seismic events of magnitude M_w = 6.5 or higher. Their study scrutinizes the influence of lift core location on seismic forces in buildings of varying heights and soil types, emphasizing the critical role of lift cores in seismic resilience (Shashwati Sanjay Vahadane & A. W. Yerekar, 2016). Torsional effects in L-shaped buildings with lift cores are scrutinized by Sushil Adhikari, who evaluates various models with lift cores positioned at different locations. Parameters such as drift ratio, displacement, and torsional irregularities are examined to gauge the structural response of L-shaped buildings to seismic loading (Adhikari et al., 2020). A research by Baral & Suwal focuses on the seismic performance of reinforced concrete buildings, investigating the impact of lift core wall positions and the inclusion of shear walls. Their research underscores the role of properly located shear walls in enhancing lateral stiffness, optimizing column design, and influencing architectural considerations (Baral & Suwal, 2023). Meanwhile, Botsa & Dasgupta's research explores the seismic capacity of five-story RC frame buildings concerning the placement of staircase and elevator core walls. Their findings from nonlinear static analysis highlight the significance of core wall orientation in determining lateral shear forces and structural stability (Botsa & Dasgupta, 2017).

This paper offers a comprehensive performance assessment of two G+10 storied residential buildings, one with a lift core built with masonry walls and columns at the four corners, and the other with shear wall lift core configurations in Bangladesh's most seismically active zone. ETABS 2019 version was used for modeling and analysis of the structures. CSiDetail 18 software was used for reinforcement calculation and building diagram drawings of different frame sections as well as isometric reinforcement diagrams of the structure. Load patterns and load combinations for this analysis were considered as per BNBC 2020 and lateral loads were assigned following Indian IS 875:2015 and IS 1893:2016 code. For four desired parameters- storey drift, overturning moment, storey shear, and stiffness, a comparative analysis was done for Structures with both types of Lift core models. Also, this study's evaluation includes cost estimation for both types of lift core models to identify the most cost-effective approach.

2. Methodology

For this study, a G+10-story commercial building was chosen. Two of the same structures were designed by ETABS software with two different types of lift core methods- one with masonry wall with four columns at four columns and connected beams (figure 1) and another one with reinforced shear wall (figure 2). For both of the designs, stability and balance were carefully considered, producing visually pleasing and robustly functional results. Each structure was created by meticulous planning and drafting with the proper integration of engineering principles. For both of the structural plans same number of columns and beams were used to emphasize enhanced acceptance through uniformity and optimized structural design. The dimensions for both structures were also kept the same 75’ in length and 39’ in width.

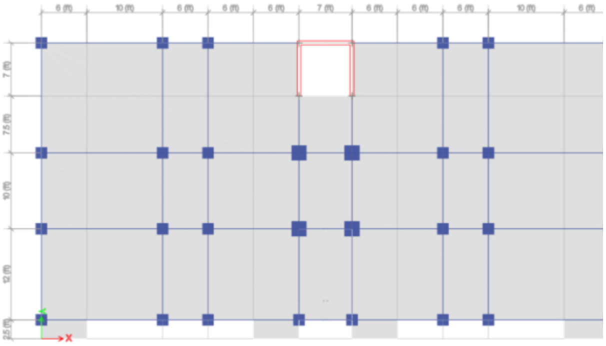


Figure 1: Structure with Shear wall lift core

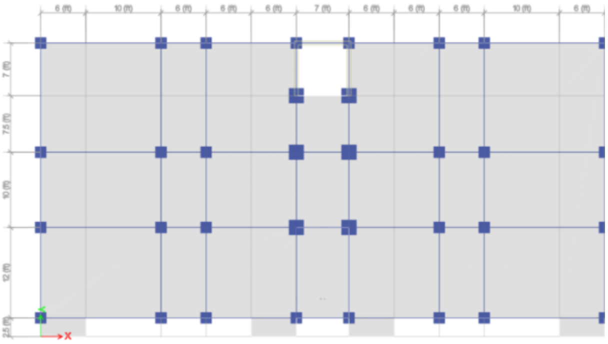


Figure 2: Structure with Masonry wall lift core

2.1 Material and Section Properties

In this Step, suitable material properties (Table 1) and section properties (Table 2,3) were chosen for both of the structures. However, the properties were kept the same for both structures.

Table 1: Material Properties

Name	Unit Weight, lb/ft^2	Modulus of Elasticity, lb/in^2	Grade
Concrete 4000psi	150	3604996.53	f’c=4000psi
Rebar 60,000psi	490	29000000	f’c=60000psi

Table 2: Frame Properties

Name	Material	Section Shape
Beam 1.5’x 1’	Concrete 4000psi	Concrete Rectangular
Great Beam 2’x 2’	Concrete 4000psi	Concrete Rectangular
Column 1.5’x 1.5’	Concrete 4000psi	Concrete Rectangular
Column 2’x 2’	Concrete 4000psi	Concrete Rectangular

Table 3: Shell Properties

Name	Material	Thickness, (in)
Shear Wall Lift 6”	Concrete 4000psi	6
Masonry Wall Lift 6”	Masonry 3000psi	6

Floor Slab 6”	Concrete 4000psi	6
Waist Slab 8”	Concrete 4000psi	8

At this point, the isometric view of structures was developed. In Figure 3 and Figure 4, the isometric view of structures is shown, and in Figure 5 and Figure 6, the elevation view is classified.

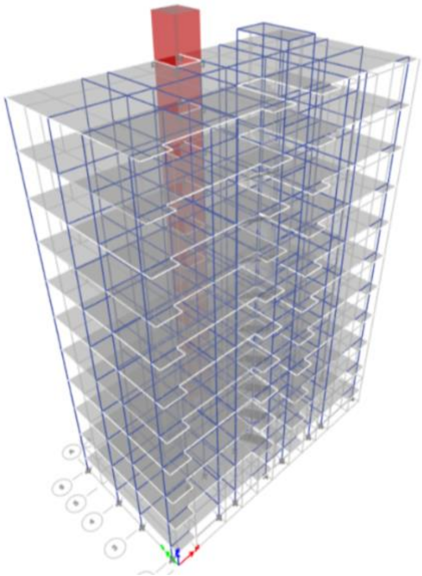


Figure 3: Structure-Shear wall lift core (Isometric View)

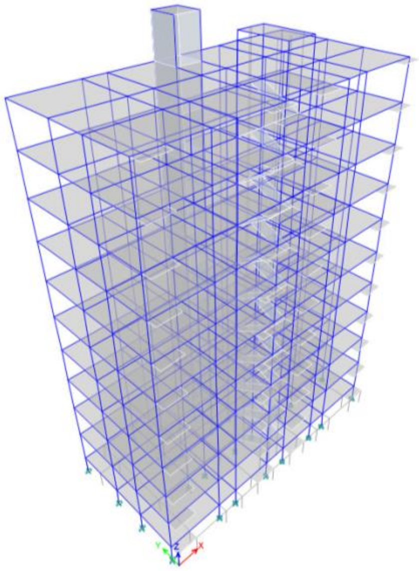


Figure 4: Structure-Masonry wall lift core (Isometric View)

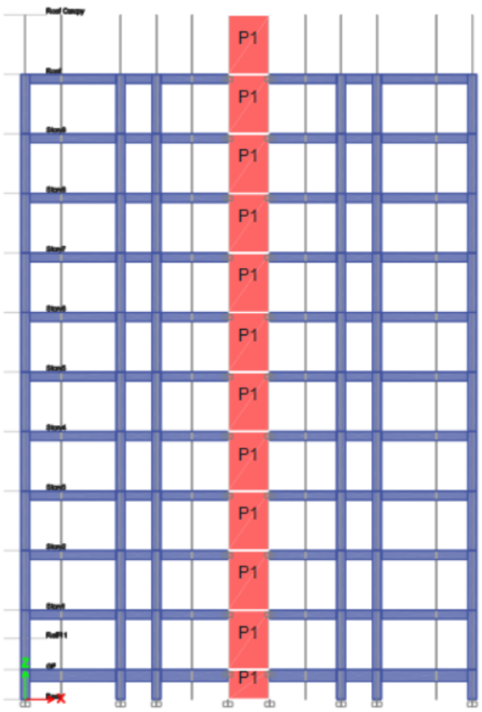


Figure 5: Structure with Shear wall lift core (Elevation)

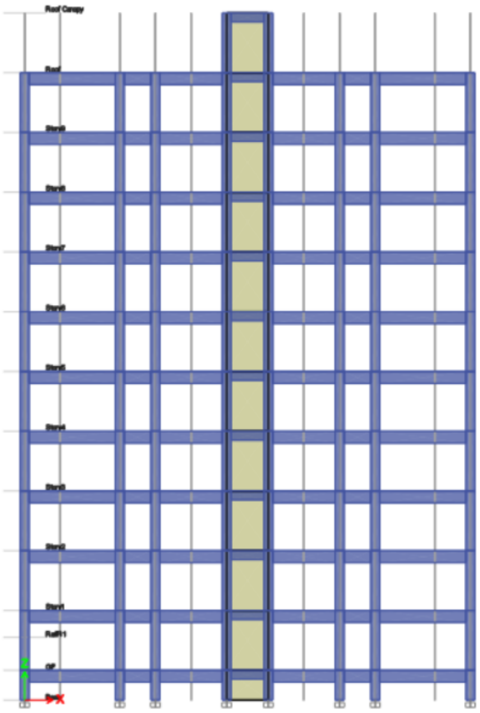


Figure 6: Structure with Masonry wall lift core (Elevation)

2.2 Assigning Supports, Pear level, Diaphragm, and Mass Source

At the base of the structure, the fixed restrain supports were assigned selecting all the columns. Pear level was assigned for shear wall section at the lift core. Then we assigned diaphragms selecting all the elements at every story level. Also, Mass Source for the structure after defining all loads.

2.3 Load Pattern and Load Combination

All the load configurations are first defined and then assigned. The loads in ETABS are defined using the static load cases command in the define menu by following the BNBC 2020. There are four types of loads- Dead load, Live load, Seismic load, and Wind load. Additional loads such as Partition load, and Floor Finish are sort of dead load which is classified as Super Dead load. For the seismic load, IS 1893:2016 code was used for load assignation in ETABS and for the wind load, IS 875:2015 code was used for load assignation in ETABS (Table 4) (Table 5). Then Load Combination was added following the BNBC 2020 (2.7.2.1 & 2.7.3.1, Page 3264-3265). Then Envelope load was assigned where all the combinations were added (Table 6).

Table 4: Load Patterns

Load	**Type**	**Self-weight Multiplier**	**Auto Load**	**Types**	**Uniform Load Values**	**BNBC 2020 pages**
Dead	Dead	1	Self-weight	---	---	
Live	Live	0		Typical upper floor	3.60 KN/m^2	536-544
				Stair slab	4.80 KN/m^2	
Floor Finish	Dead	0	---	For 150 mm thickness	3.54 KN/m^2	533
				For 203 mm thickness	5.14 KN/m^2	
Parapet Wall	Dead	0	---	---	0.066 kip/ft	---
Partition Load	Dead	0	---	Walls have no opening	0.22 kip/ft	---
				Walls with an opening	0.154 kip/ft	---
EQ_X	Seismic	0	IS 1893:2016	---	---	---
EQ_Y	Seismic	0	IS 1893:2016	---	---	---
Wind Load X	Wind	0	Indian IS 875:2015	---	---	---
Wind Load Y	Wind	0	Indian IS 875:2015	---	---	---

Table 5: Seismic Properties

Zone	**Zone Coefficient**	**Wind Speed (m/s)**
Zone-I (Rajshahi)	0.12	49.2
Zone-II (Dhaka)	0.20	65.7
Zone-III (Chittagong)	0.28	80.0
Zone-IV (Kurigram)	0.36	65.6

Table 6: Load Combinations

Sl. No.	**Load Combination**	**Sl. No.**	**Load Combination**
1	1.4DL	17	1.2DL +LL +0.3Ex - Ey
2	1.2DL+1.6LL	18	1.2DL +LL -0.3Ex + Ey
3	1.2 DL+LL	19	1.2DL +LL -0.3Ex - Ey
4	1.2DL +0.8 Wx	20	0.9 DL + Wx
5	1.2DL +0.8 Wy	21	0.9 DL + Wy
6	1.2DL -0.8 Wx	22	0.9 DL - Wx
7	1.2DL -0.8 Wy	23	0.9 DL - Wy
8	1.2 DL +LL + 1.6 Wx	24	0.823 DL + Ex + 0.3 Ey

Sl. No.	Load Combination	Sl. No.	Load Combination
9	1.2 DL +LL + 1.6 Wy	25	0.823 DL + Ex - 0.3 Ey
10	1.2 DL +LL - 1.6 Wx	26	0.823 DL - Ex + 0.3 Ey
11	1.2 DL +LL - 1.6 Wy	27	0.823 DL - Ex - 0.3 Ey
12	1.2DL +LL + Ex + 0.3 Ey	28	0.823 DL +0.3Ex + Ey
13	1.2DL +LL + Ex - 0.3 Ey	29	0.823 DL +0.3Ex - Ey
14	1.2DL +LL - Ex + 0.3 Ey	30	0.823 DL -0.3Ex + Ey
15	1.2DL +LL - Ex - 0.3 Ey	31	0.823 DL -0.3Ex - Ey
16	1.2DL +LL +0.3Ex + Ey		* DL = DL' + FF + PW

2.4 Analysis of Model

After checking the models, they were analyzed by the ETABS. The deformed shape for different load patterns and load combinations was displayed by the software. In Figure 7 and Figure 8, the deformed shape of both structures is shown for the absolute maximum “Envelope” loading condition in an isometric view.

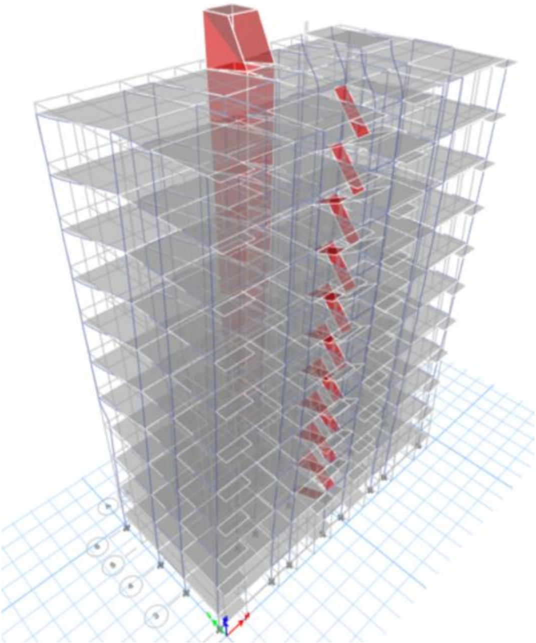


Figure 7: Structure with shear wall lift core: Deformed Shape

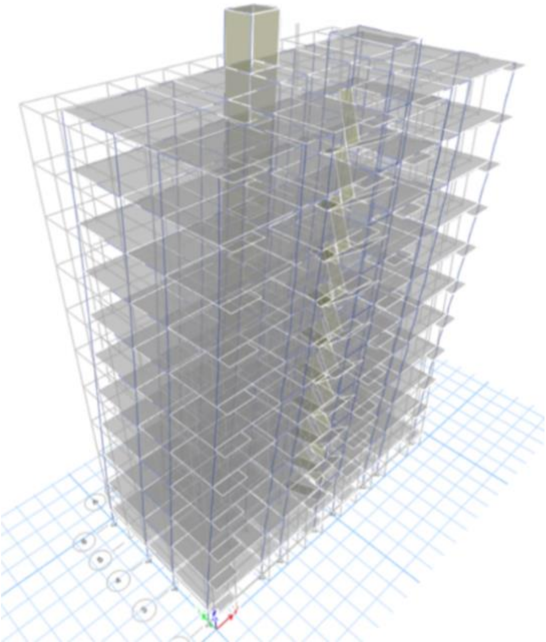


Figure 8: Structure with Masonry wall lift core: Deformed Shape

2.5 Design of Structures

In the design step, concrete frame, shear wall of lift core and slab were designed for both strictures. For the design of beam and column, the “Envelope” was chosen as the design combination. ETABS then showed the longitudinal reinforcement values for all frames in the structure. Then all failures were identified. For the design of Shear wall of the lift core, at first pier level was defined.

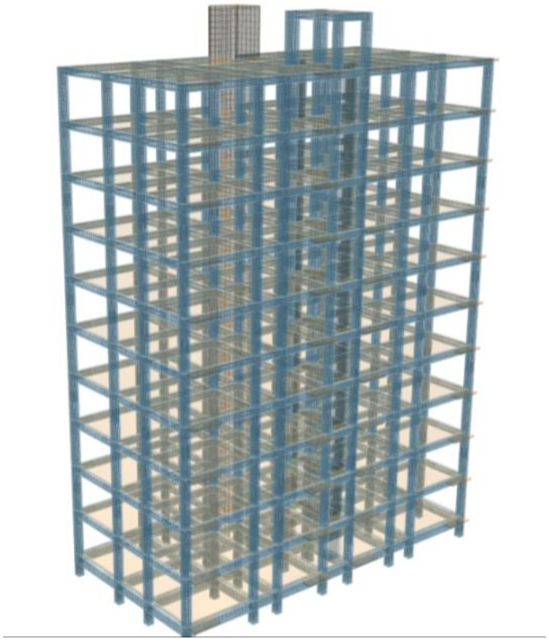


Figure 9: Structure with shear wall lift core: Rebar Diagram

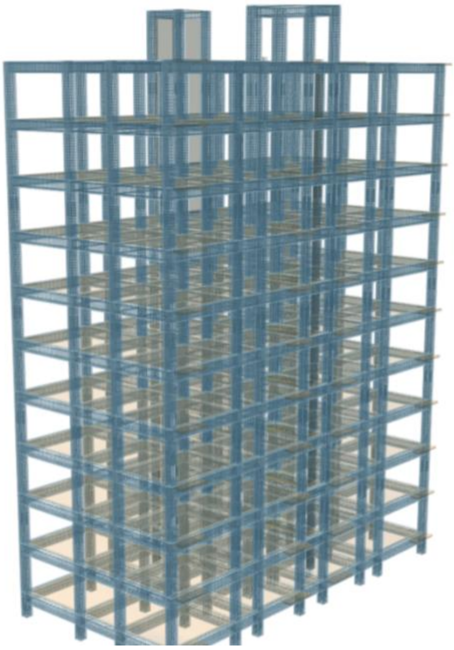


Figure 10: Structure with Masonry wall lift core: Rebar Diagram

By using “CSiDetails 18” software reinforcement details were found in diagram style. Here in Figure 9 and Figure 10, the rebar cases for all frames are shown in Isometric view for both structures. Figure 11 shows the reinforcement diagram for shear wall lift core isometric section separately and Figure 12 shows the maximum stress diagram of the shear wall lift core.

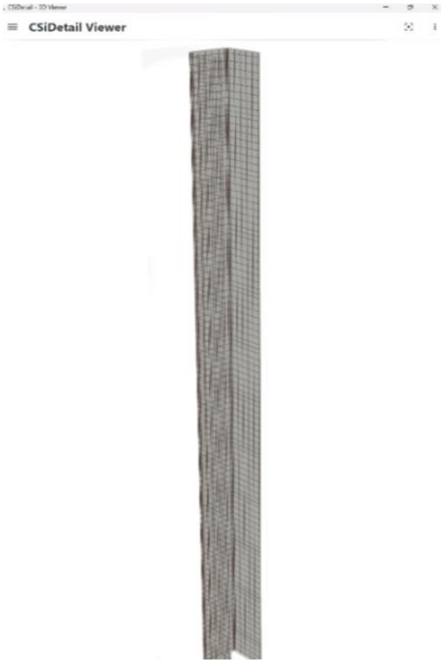


Figure 11: Reinforced Shear wall: Rebar Diagram (Isometric View)

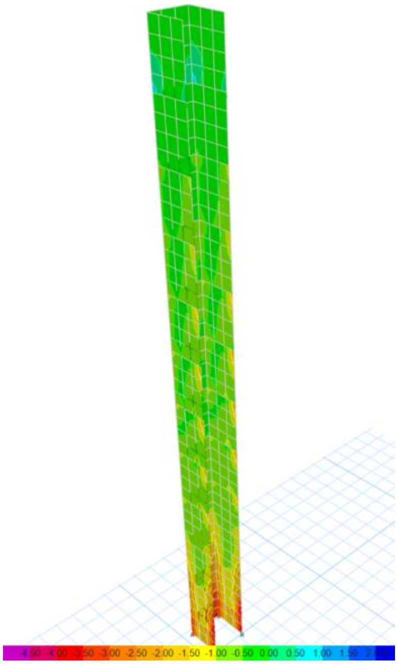
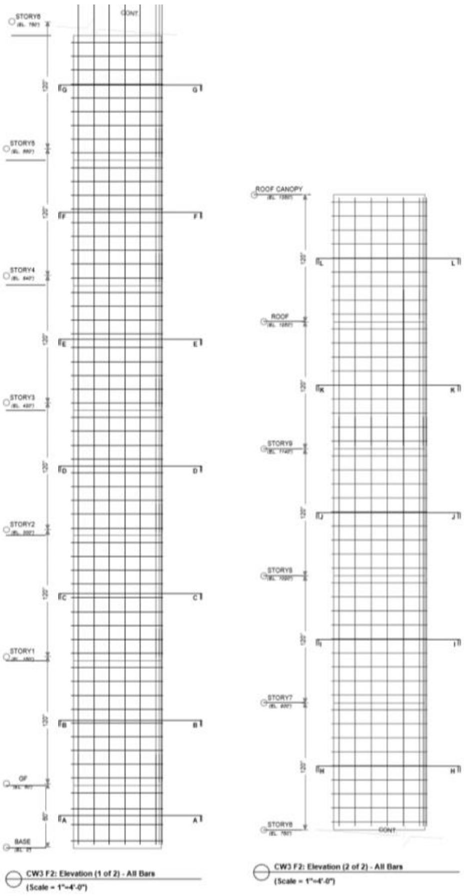


Figure 12: Reinforced Shear wall: Stress Diagram (Isometric View)



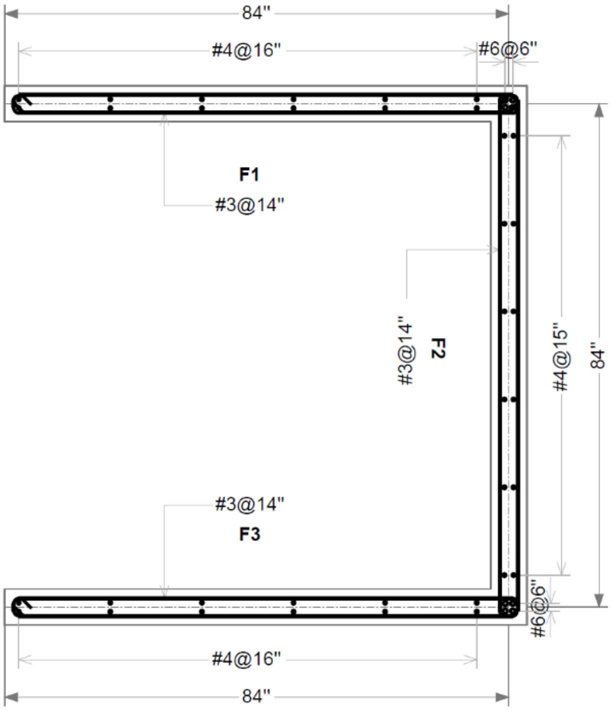


Figure 13: Rebar Diagram of Shear Wall (Elevation) Figure 14: Rebar Diagram of Shear Wall (Section View)

Here, in Figure 13, the longitudinal view of the reinforcement diagram of shear wall lift core for different section is shown. And in Figure 14, a particular section is displayed where the rebar number, rebar diameter and the amount of rebar etc. data are displayed. For the convenience of calculation, the rebar data were kept same along all sections. These data were later used for cost estimation calculation.

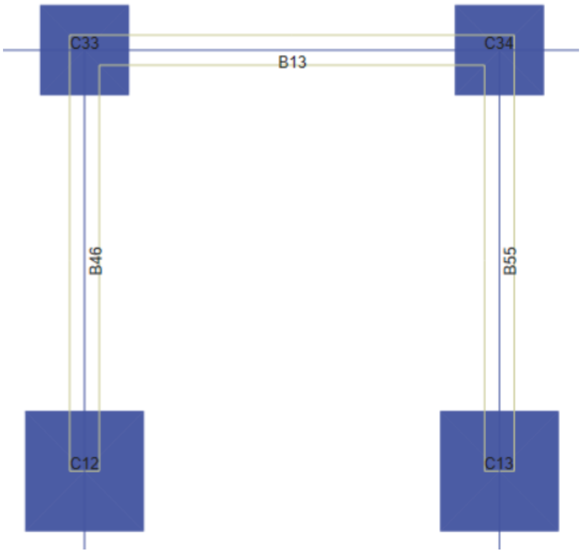


Figure 15: Column and Beam Identification Number for Masonry Wall Lift Core

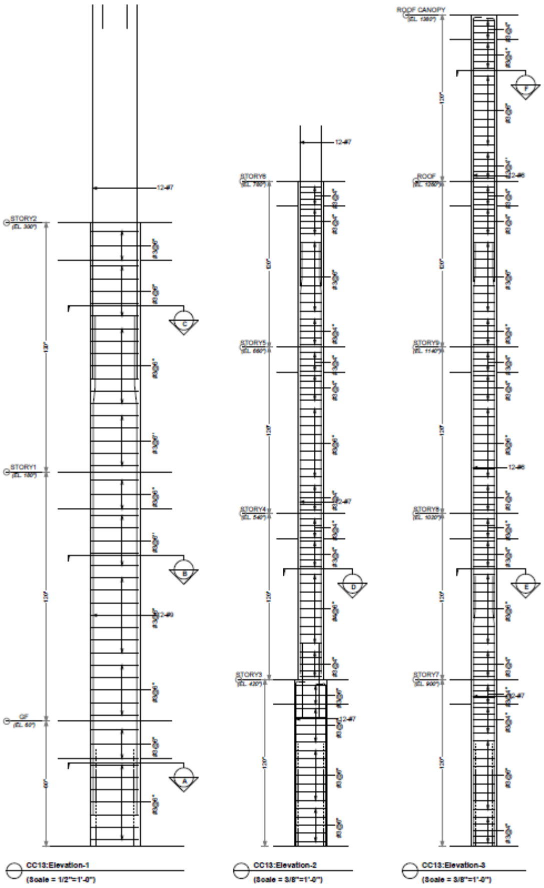


Figure 16: Column 12 & 13 (Longitudinal Rebar)

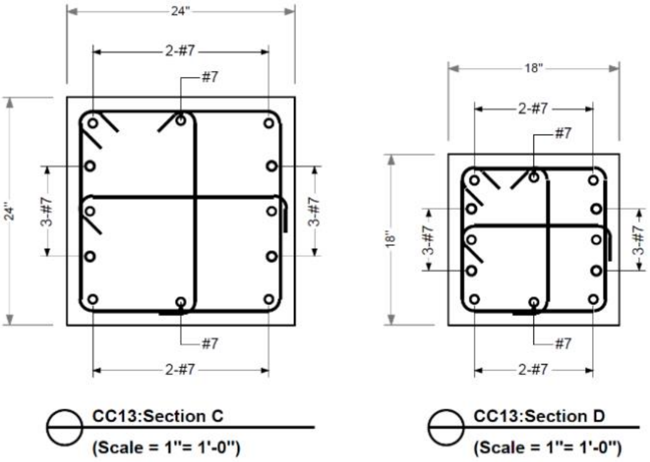


Figure 17: Column 12 & 13 (Rebar Diagram: Section)

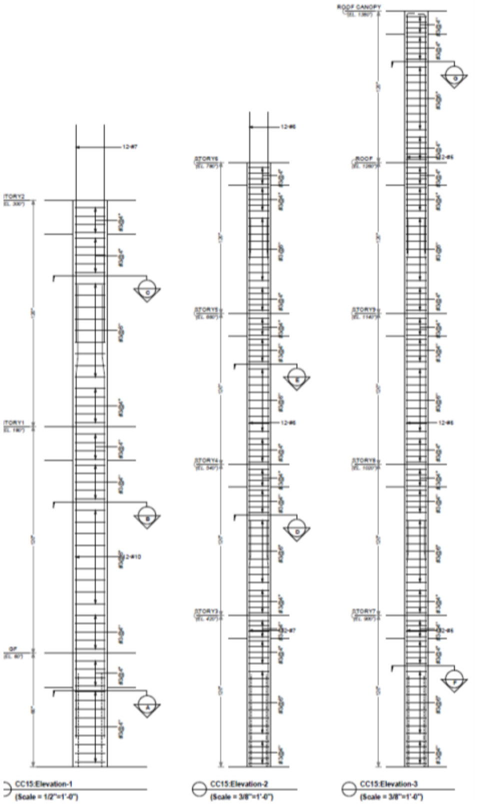


Figure 18: Column 33 & 34 (Longitudinal Rebar)

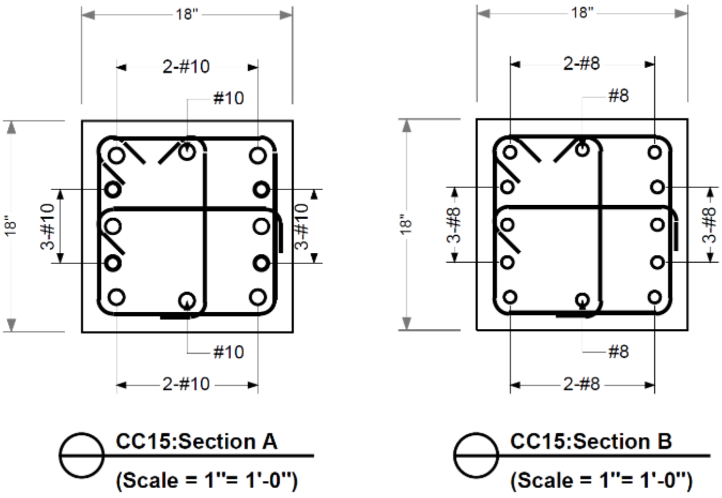


Figure 19: Column 33 & 34 (Rebar Diagram: Section)

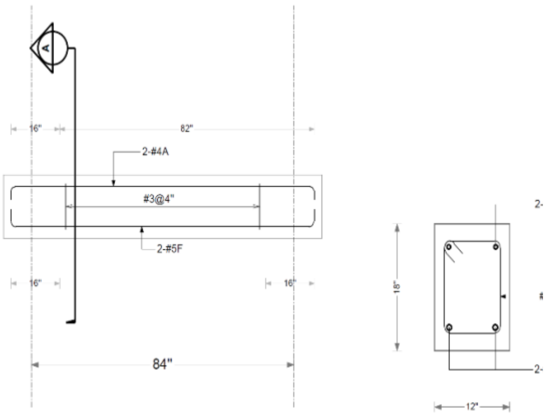


Figure 20: Beam 13 (Rebar Diagram: Section)

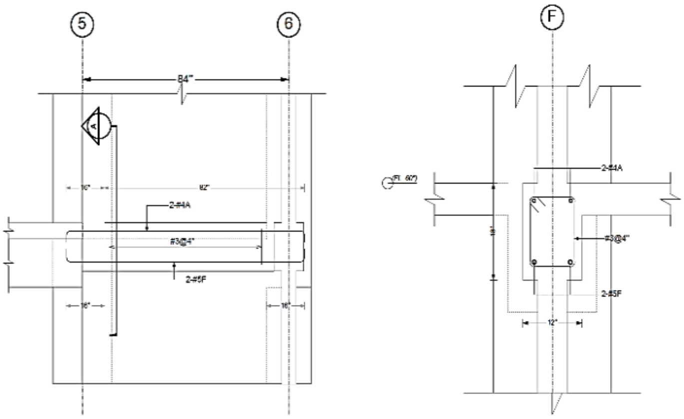


Figure 21: Beam 46 & 55 (Rebar Diagram: Section)

In Figure 15, the identification number for the columns at four corners of the masonry wall is displayed. In Figure 16 and Figure 18, the longitudinal view of the reinforcement diagram of column no 12, 13, 18, and 19 for different sections is shown. And in Figure 17 and Figure 19, section of a column is displayed where the rebar number, rebar diameter, and the amount of rebar etc. data are displayed. For the convenience of calculation, the rebar data were kept the same along all sections.

Again, in Figure 20 and Figure 21, the reinforcement diagram of beam cross section (Beam no 13, 46 and 55) is displayed where the rebar number, rebar diameter and the amount of rebar etc. data are displayed. For the convenience of calculation, the rebar data were kept same along all sections. These data were later used for cost estimation calculation.

After the analysis and design part, ETABS automatically generates the tables related to the analysis result. For this research project, five data tables were determined for both structures- Storey Drift, Base Reactions, Storey Stiffness, Storey Forces, and Storey Shear. These data tables and their comparative analytical graphs are shown in the “Result & Discussion” part.

2.6 Cost Estimation

This section will estimate the cost of constructing the elevator cores for these structures. The costs related to the lift core, such as rebar materials, concrete cast materials, and masonry construction materials, will be the exclusive emphasis of this cost estimate. By isolating these expenses, a more precise estimate may be created to contribute to the overall budget for lift core planning for the project. Tables 7, 8, 9, 10, 11, and 12 show the cost estimation for the materials used to construct lift core.

Some General material cost is mentioned below according to Bangladeshi standard BDT currency-
Per Metric Ton rebar cost = 89,000 BDT
Per bag cement cost = 500 BDT
Per cubic feet of sand cost = 18 BDT
Per cubic feet of sand cost = 200 BDT
Per unit brick cost = 10 BDT
Water cost/1000L = 15 BDT
General Concrete Mix Ratios-
For Mortar, Water: Cement: Sand = 1:2:3
For Plaster, Cement: Sand = 1:4; Water cement ratio= 20%
For M15 Concrete, Cement: Sand: Stone=1:2:4; Water Cement Ratio= 45%

2.6.1 Cost Estimation for Shear Wall Lift Core

Table 7: Cost Estimation for Rebar materials in Shear Wall

Bar Type	**Bar Size**	**Length of Bar (Nominal) (ft)**	**No of Rebar Required**	**Rebar Weight (M. Ton)**	**Rebar Dia (in)**	**Rebar Volume (ft^3)**	**Rebar Cost (BDT)**
Tie Bar	#3@14" c/c	4172.130	106	0.712	0.375	3.199	63394
Longitudinal Bar (General)	#4@16" c/c (F1, F3) & #4@15" c/c (F2)	5118.000	130	1.598	0.5	6.979	142260
Longitudinal Bar (Corner)	#6@6" c/c	1137.330	29	0.778	0.75	3.489	69282
				Total Rebar Volume & Cost (BDT)		13.668	274936

Table 8: Cost Estimation for Concrete Materials in Shear Wall

Properties	**Value**	**Properties**	**Value**
Wall Height (ft)	115	Cement Vol (ft^3)	170.547
Wall Width (ft)	7	Cement Volume/Bag (ft^3)	1.226
Wall Thickness (ft)	0.5	No Cement Bag Need	140
No of Wall	3	Total Cement Cost (BDT)	70000
Nominal Volume of Wall (ft^3)	1207.500	Sand Vol (ft^3)	341.095
Total Rebar Volume (ft^3)	13.668	Sand Cost (BDT)	6140
Gross Volume of Concrete(ft^3)	1193.832	Stone Volume (ft^3)	682.190
Per Bag Cement Cost (BDT)	500	Total Stone Cost (BDT)	136438
Per cft Sand Cost (BDT)	18	Water Vol (Lit)	2173.211
Stone Cost per Cft (BDT)	200	Water Cost (BDT)	33
Water Cost/1000L (BDT)	15	Total Cost for Concrete (BDT)	212610

Total Cost for Lift core construction by using shear wall = Total Rebar Cost (BDT) + Total Cost for Concrete (BDT)

= (274936 + 212610) BDT

= 4,87,546 BDT

2.6.2 Cost Estimation for Masonry Wall-Column Lift Core

Table 9: Cost Estimation for Brick in Masonry Wall-Column Lift Core

Wall ID	**No of wall**	**Wall length (ft)**	**Wall Thickness (ft)**	**Wall Height (ft)**	**Wall Volume/ Wall (ft^3)**	**Brick Volume (ft^3)**	**Morter Clearance (ft^3)**	**Abs. Volume/ Wall (ft^3)**	**No of Brick Required**	**Total cost**
W1	11	7	0.46	10	32.08	0.08	7	25.08	301	33110
W2	11	7	0.46	10	32.08	0.08	7	25.08	301	33110
W3	11	7	0.46	10	32.08	0.08	7	25.08	301	33110
W4	11	7	0.46	10	18.08	0.08	7	11.08	133	14630
W5	1	7	0.46	5	16.04	0.08	4	12.04	145	1450
W6	1	7	0.46	5	16.04	0.08	4	12.04	145	1450
W7	1	7	0.46	5	16.04	0.08	4	12.04	145	1450
W8	1	7	0.46	5	16.04	0.08	4	12.04	145	1450
							Total Cost of Brick (BDT)			119760

Table 10: Cost Estimation for Mortar and Plaster in Masonry Wall-Column Lift Core

Properties	**Value**	**Properties**	**Value (Mortar)**	**Value (Plaster)**
Wall Height (ft)	115.00	Cement Vol (ft^3)	101.20	25.87
Wall Width (ft)	7.00	Cement Volume/Bag (ft^3)	1.23	1.23
Wall Thickness (ft)	0.50	No Cement Bag Need	88.00	22.00
No of Wall	4.00	Total Cement Cost (BDT)	44000.00	11000.00
Plaster Thickness	0.42	Sand Vol (ft^3)	162.00	106.78
Total Volume of Morter (ft^3)	308.00	sand Cost (BDT)	2916.00	1947.00
Total Volume of Plaster (ft^3)	129.36	Water Cement Ratio (%)	0.20	0.20
Per Bag Cement Cost (BDT)	500.00	Water Vol (Lit)	2605.15	1200.97
Per cft Sand Cost (BDT)	18.00	Water Cost (BDT)	40.00	18.00
Water Cost/1000L (BDT)	15.00	Total Cost (BDT)	47036.00	12966.00
		Total Cost for Mortar & Plaster (BDT)	60002	

Table 11: Cost Estimation for Rebar Materials in Columns and Beams in Lift Core

Beam/ Column	**Rebar Size 1**	**Num of Rebar**	**Bar Weight (lb)**	**Rebar Size 2**	**Num of Rebar**	**Bar Weight (lb)**	**Total Longitudinal Bar Cost (BDT)**	**Tie Bar**	**No of Rebar**	**Bar Weight (lb)**	**Total Tie Bar Cost**
C12	12#9	19	2545.24	12#6	122	7219.81	394212	#3@4"	164	2429.56	98081
C13	12#9			12#6				#3@4"			
C33	12#9			12#6				#3@4"			
C34	12#9			12#6				#3@4"			
B46	Top: 2#4	52	1409.57	Bottom: 2#5	52	2136.90	143170	#3@3"	90	1333.30	53825
B13	Top: 2#4			Bottom: 2#5				#3@3"			
GB46	Top: 2#4			Bottom: 2#5				#3@3"			
GB13	Top: 2#4			Bottom: 2#5				#3@3"			
Total Cost for Rebar Materials = 689288 BDT											

Table 12: Cost Estimation for Concrete Materials in Masonry Wall-Column Lift Core

Beam/ Column	Column Volume (ft^3)	Cement Vol (ft^3)	No of Cement Bag Required	Total Cement Cost	Sand Vol (ft^3)	Sand Cost	Stone Vol (ft^3)	Stone Cost	Water Vol (Lit)	Water Cost
C12	455.07	65.01	53.02	82588	130.02	2340	260.04	52008	828.39	12
C13	455.07	65.01	53.02		130.02	2340	260.04	52008	828.39	12
C33	253.82	36.26	29.57		72.52	1305	145.04	29008	462.04	7
C34	253.82	36.26	29.57		72.52	1305	145.04	29008	462.04	7
B46	41.92	5.99	4.88	23787	11.98	216	23.96	4791	76.31	1

B13	20.95	2.99	2.44		5.99	108	11.97	2394	38.14	1
GB46	230.32	32.90	26.83		65.81	1185	131.61	26323	419.28	6
GB13	115.15	16.45	13.42		32.90	592	65.80	13160	209.62	3
		Total Bag of Cement	213.00		Total Sand Cost	9391	Total Stone Cost	208701	Total Water Cost	50
Total Cost in Concrete (Column and Beam) = 324517 BDT										

Total cost for lift core construction by masonry wall-column = (119760+60002+689288+324517) BDT
= 11,93,567 BD

3. Results and Discussion

3.1 Maximum Storey Drift Due to Seismic Action

Table 13: Storey Drift

Story	**Drift X (masonry)**	**Drift X (shear wall)**	**Drift y (masonry)**	**Drift y (shear wall)**
Roof Canopy	0.000973	0.001951	0.000828	0.001734
Roof	0.000919	0.00155	0.000958	0.001871
9th Floor	0.001114	0.00171	0.001176	0.002397
8th Floor	0.0014	0.001962	0.001442	0.003036
7th Floor	0.001626	0.002205	0.001668	0.003709
6th Floor	0.00179	0.002426	0.001837	0.004355
5th Floor	0.001893	0.002622	0.001989	0.004918
4th Floor	0.001939	0.002767	0.002134	0.005315
3rd Floor	0.001924	0.002835	0.002134	0.0054
2nd Floor	0.00184	0.002756	0.001948	0.004905
1st Floor	0.001584	0.002063	0.001499	0.00325
GF	0.000555	0.000605	0.000621	0.000983

The variation in storey drift along X-axis (longer direction) is displayed in Figure 22 and Table 13. Again, the variation in storey drift along Y-axis (shorter direction) is displayed in Figure 23 and Table 13. It is visible from the figure that, drift is higher for masonry wall-column cases along X-axis (longer direction) and Y-axis (shorter direction).

Compared to shear walls alone, masonry walls with columns at the corners create a more rigid and stiff structural framework. The columns at the corners distribute lateral loads throughout the structure evenly. Because there are columns at each of the building's four corners, the lateral pressures are dispersed more equally throughout its height. This distribution helps reduce the horizontal displacement (or story drift) between different building parts during lateral loading events. Shear walls, particularly when utilized alone in a lift core, can have greater flexibility or deformability than masonry walls and corner columns. his flexibility might lead to greater story drift under lateral loads.

Drift is observed to be increased from the 3rd to 4th floor and then decreased gradually up to the roof; then again increases till the roof canopy.

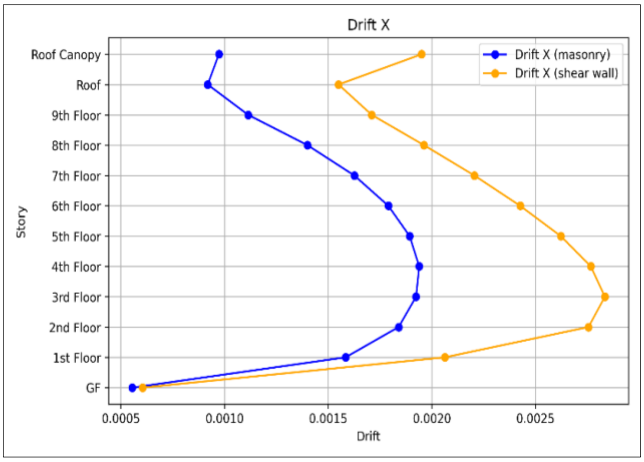


Figure 22: Variation in Storey Drift for E_x

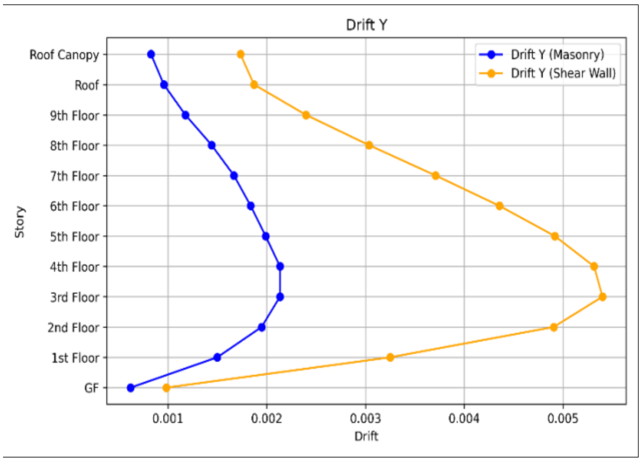


Figure 23: Variation in Storey Drift for E_Y

3.2 Maximum Stiffness Due to Seismic Action

Table 14: Storey Stiffness

Story	**Stiff X (masonry) (kip/in)**	**Stiff X (shear wall) (kip/in)**	**Stiff y (masonry) (kip/in)**	**Stiff y (shear wall) (kip/in)**
Roof Canopy	120.663	42.792	102.502	46.188
Roof	1354.185	571.078	1148.738	572.789
9th Floor	2040.838	894.205	1846.343	867.849
8th Floor	2331.142	1073.224	2197.265	986.784
7th Floor	2506.818	1182.308	2384.324	1037.354
6th Floor	2658.085	1261.724	2510.213	1066.420
5th Floor	2797.627	1336.421	2631.395	1095.309
4th Floor	2945.882	1431.505	2797.897	1141.642
3rd Floor	3145.713	1564.523	3094.106	1236.595
2nd Floor	3482.113	1819.470	3663.644	1470.922
1st Floor	4329.146	2699.378	5159.638	2364.337
GF	23163.981	18196.532	27057.123	16801.853

The variation in storey stiffness with respect to storey along X-axis is displayed in Figure 24 and Table 14. And the variation in storey stiffness with respect to storey along Y-axis is displayed in Figure 25 and Table 14. Stiffness seemed to be greater for the masonry wall-column lift core structure compared to the structure having a shear wall lift core in both longer and shorter directions. However, there's not a huge difference in stiffness along both axes for both types of structural systems.

The lift core made of masonry walls and corner columns has greater structural stiffness and rigidity than a lift core made of shear walls. The improved load path aids in evenly distributing forces and lowering localized stresses, hence increasing overall stiffness. Shear walls, on the other hand, may have more localized load patterns, which could result in higher flexibility and deformation.

The stiffness seems to have higher values at the ground floor and gradually decreases with the increase in storey height.

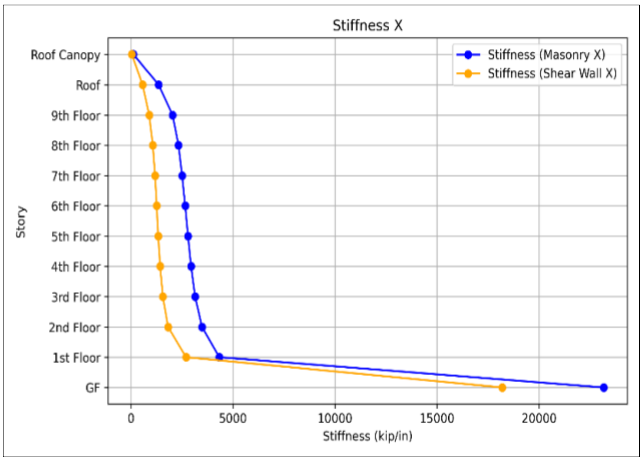


Figure 24: Variation in Storey Stiffness for E_x

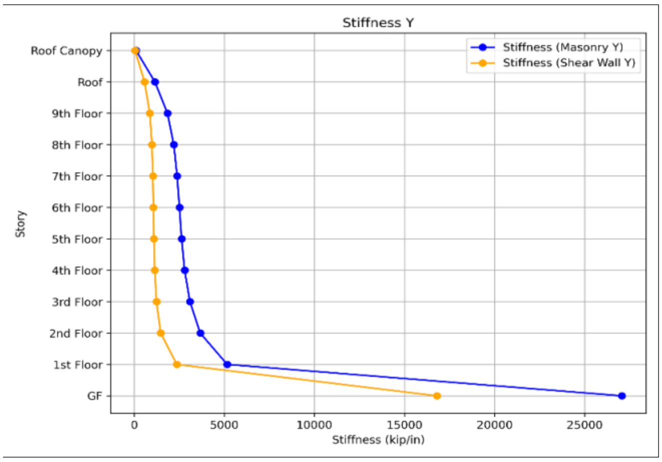


Figure 25: Variation in Storey Stiffness for E_Y

3.3 Maximum Storey Shear Due to Seismic Action

Table 15: Storey Shear

Story	**Shear X (masonry)**	**Shear X (Shear Wall)**	**Shear y (masonry)**	**Shear y (Shear Wall)**
	(kip)	**(kip/in)**	**(kip)**	**(kip/in)**
Roof Canopy	11.467	6.526	10.687	5.794
Roof	129.419	86.635	120.616	76.918
9th Floor	251.12	163.767	234.039	145.4
8th Floor	348.499	225.515	324.795	200.223
7th Floor	424.314	273.59	395.452	242.906
6th Floor	481.259	309.699	448.524	274.965
5th Floor	522.031	335.552	486.522	297.918
4th Floor	549.324	352.858	511.959	313.284
3rd Floor	565.873	363.328	527.383	322.579
2nd Floor	574.339	368.669	535.273	327.322
1st Floor	577.387	370.592	538.113	329.029
GF	577.695	370.813	538.401	329.225

The variation in storey shear with respect to storey along X-axis is displayed in Figure 26 and Table 15. And the variation in storey shear with respect to storey along Y-axis is displayed in Figure 27 and Table 15. It is portrayed from the figure that; the storey shear is higher for the structure having masonry wall lift core with corner columns compared to the structure having a shear wall lift core in both longer and shorter directions.

A lift core with masonry walls and corner columns may have higher story shear, but it provides superior strength and stability under lateral pressures. But if project-specific factors taken into consideration, the structure with shear walls can be considered better in terms of minimizing story shear. Shear walls are often designed to transfer lateral stresses more uniformly throughout the structure, resulting in less overall story shear than a system based on masonry walls and corner columns.

The shear in both cases gradually decreased with the increase in the height of the building.

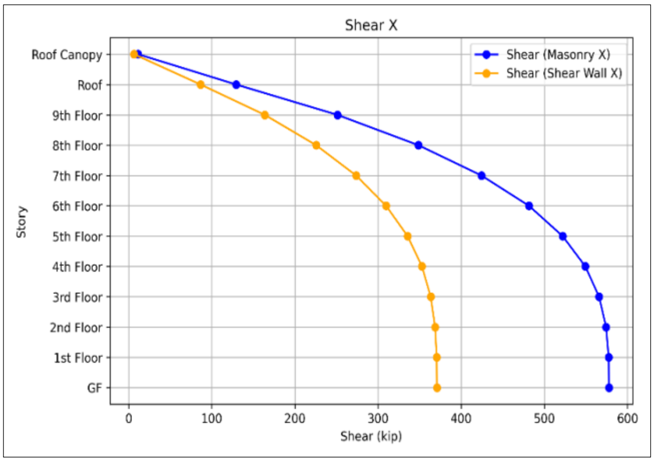


Figure 26: Variation in Story Shear for E_x

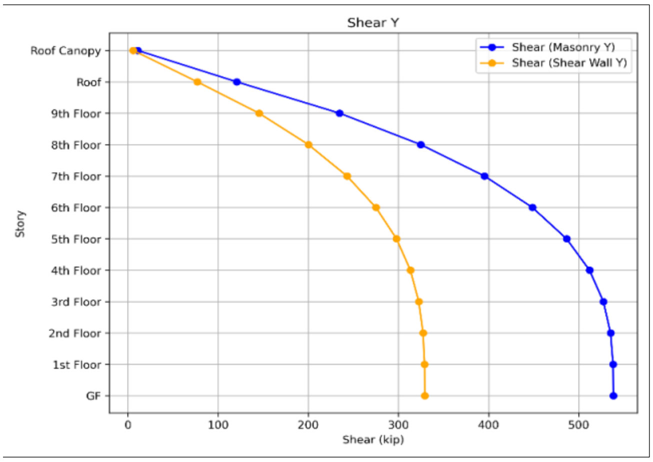


Figure 27: Variation in Story Shear for E_Y

3.4 Maximum Overturning Moment Due to Seismic Action

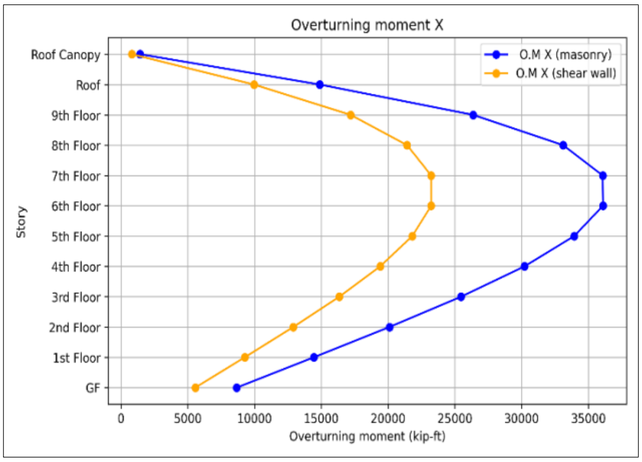
Table 16: Overturning Moment

Story	O.M X (masonry)	O.M X (shear wall)	O.M Y (masonry)	O.M Y (shear wall)
Roof Canopy	1433.375	815.750	1335.875	724.250
Roof	14883.185	9963.025	13870.840	8845.570
9th Floor	26367.600	17195.535	24574.095	15267.000
8th Floor	33107.405	21423.925	30855.525	19021.185
7th Floor	36066.690	23255.150	33613.420	20647.010
6th Floor	36094.425	23227.425	33639.300	20622.375
5th Floor	33932.015	21810.880	31623.930	19364.670
4th Floor	30212.820	19407.190	28157.745	17230.620
3rd Floor	25464.285	16349.760	23732.235	14516.055
2nd Floor	20101.865	12903.415	18734.555	11456.270
1st Floor	14434.675	9264.800	13452.825	8225.725
GF	8665.425	5562.195	8076.015	4938.375

The variation in overturning moment with respect to storey along X-axis is displayed in Figure 28 and Table 16. And the variation in overturning moment with respect to storey along Y-axis is displayed in Figure 29 and Table 16. It is portrayed from the figure that; the overturning moment is lower for the structure having a shear wall lift core compared to the masonry wall lift core with corner columns in both longer and shorter directions.

A lift core construct with shear walls has several advantages, including lesser overturning moments, more effective lateral force distribution, and potentially cheaper construction costs and complexity. In the design of buildings, lower overturning moments are desirable as they indicate lower structural stress, improve overall stability, and provide an economical solution. However, compared to shear walls, which are usually dispersed over broader regions, Masonry walls with corner columns offer a more concentrated resistance to lateral stresses. The leverage effect of lateral loads might cause increased overturning moments as a result of this concentrated resistance at the corners.

The overturning moment is observed to be increased till the 6th to 7th floor of the building and then decreased gradually giving parabolic shape to the graph.



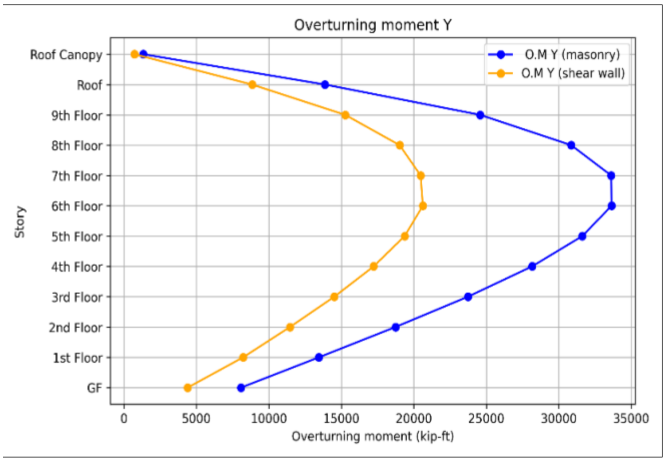


Figure 28: Variation in Overturning Moment for E_x

Figure 29: Variation in Overturning Moment for E_Y

3.5 Cost Estimation Result

From sections 2.6.1 and 2.6.2, the total cost of materials for Shear wall lift core was around 4,87,546 BDT (Bangladeshi Taka). And the total cost of materials for masonry-wall column lift core was around 11,93,567 BDT (Bangladeshi Taka). From the estimation its clear that the construction cost of masonry-wall column lift core is significantly higher than shall wall lift core.

4. Conclusions

Based on the research findings, it can be concluded that -
The Structure having a shear wall lift core shows higher drift, slightly lower Story stiffness, lower storey shear, and lower overturning moment compared to the structure having masonry wall lift core with corner columns. However, a lift core construct with shear wall is significantly cost effective also compared to masonry wall-column system. Here, the main three factors that exhibit the seismic performance are- drift, stiffness, and overturning moment. Although masonry wall-column lift core structure has lower drift, it has a higher overturning moment value. Lower storey drift is always preferable for structure. However, In the design of buildings, lower overturning moments are desirable as they indicate lower structural stress, improve overall stability, and provide an economical solution. And in terms of stiffness, neither of the structures showed huge advantages over the other. Because of its lower cost, lower story shear, and less overturning moment, the lift core with shear wall can be regarded as superior overall. The shear wall lift core is a better option for specifically high-rise construction projects due to its cost-effectiveness and acceptable performance qualities, even though it could show somewhat less stiffness and drift than the lift core with masonry walls and corner columns.

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