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Comparative Study of Analysis, Design and Total Cost Differences between Monolithic Structure and Conventional Structure

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Abstract: *The primary objective of this research is to investigate the behavior of conventional buildings featuring non-structural walls as AAC blocks and all the remaining things same, with monolithic structure buildings constructed using tunnel formwork. To compare the design steel and total cost between these two types of structures subjected to seismic loads, as defined by the IS codes. To achieve this, a comprehensive seismic analysis was conducted using the Linear Dynamic Response Spectrum Method in ETABS 2020 software.*

Keywords: Monolithic structure, seismic performance, Mivan structure, Tunnel formwork, Special Moment Resisting Frames (SMRF).

I. INTRODUCTION

This research paper compares monolithic structures constructed using tunnel formwork and conventional structures with AAC blocks as non-structural walls.

Monolithic structures offer seamless integration of various elements, reducing construction time and costs. Tunnel formwork allows rapid assembly and pouring of concrete, ensuring high-quality results. Conventional construction with AAC blocks provides lightweight, thermally-insulated walls. The study aims to evaluatecost-effectiveness, structural performance, Design comparison and sustainability. The findings of this research will provide valuable insights into the comparative performance of monolithic structures using tunnel formwork and conventional structures with AAC blocks, aiding in the selection of appropriate construction methods for improved efficiency and cost-effectiveness.

II. AIM OF STUDY

The aim of this study is compare the analysis of monolithic structure in terms of storey displacement, storey drift, storey shear, storey stiffness and design steel comparison in column, beam, walls and cost comparison. For this we have used 8 different plans

III. BUILDING CONFIGURATIONS

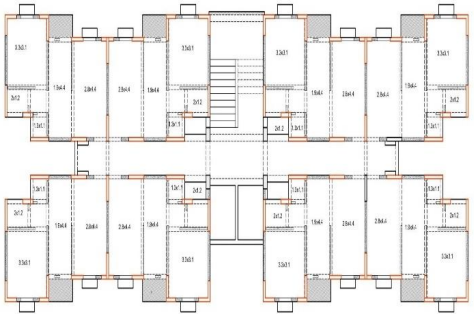

Fig 1: Plan 1 (G+23)

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Columns	300x600 mm
Beams	200x450 mm
Walls	160 mm
Slab	125 mm

Table 1: Plan 1 details

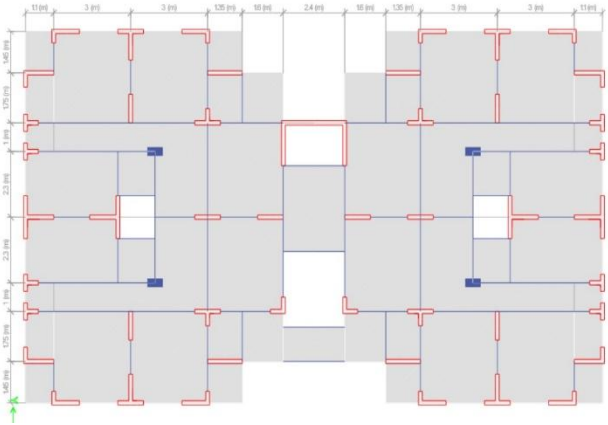

Fig 2: Plan 2 (G+25)

Columns	300x600 mm
Beams	250x530 mm
Walls	150 mm
Slab	125 mm

Table 2: Plan 2 details

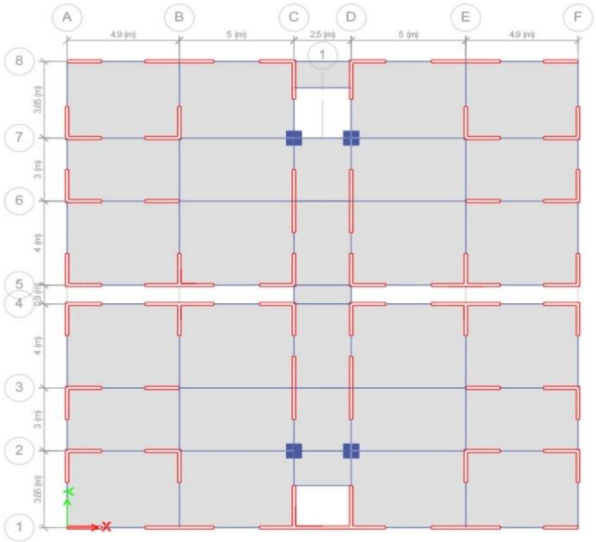

Fig 3: Plan 3 (G+30)

Columns	600x600 mm
Beams	250x530 mm
	300x850 mm
Walls	150 mm
Slab	125 mm

Table 3: Plan 3 details

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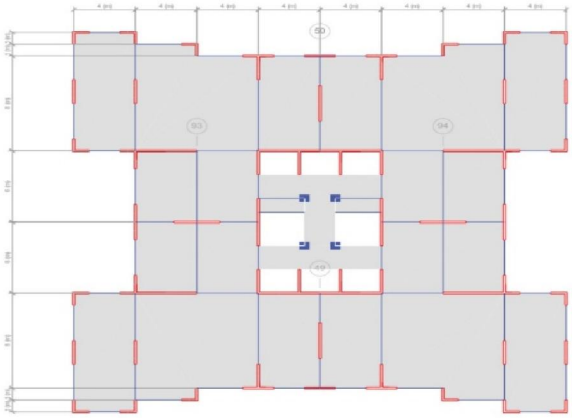

Fig 4: Plan 4 (G+35)

Columns	650x650 mm
Beams	300x600 mm
	300x900 mm
Walls	150 mm
Slab	125 mm

Table 4: Plan 4 details

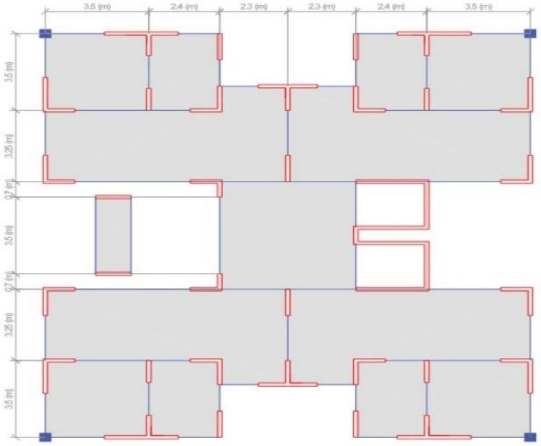

Fig 5: Plan 5 (G+25)

Columns	400x400 mm
Beams	230x430 mm
Walls	150 mm
Slab	125 mm

Table 5: Plan 5 details

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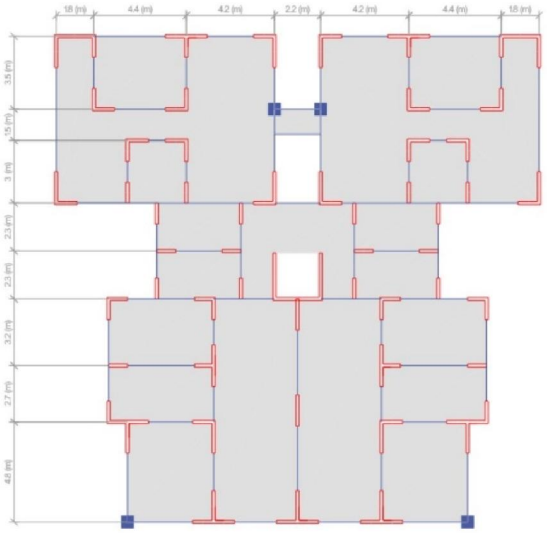

Fig 6: Plan 6 (G+25)

Columns	600x600 mm
Beams	300x650 mm
Walls	150 mm
Slab	150 mm

Table 6: Plan 6 details

Floor height=3m(all buildings)

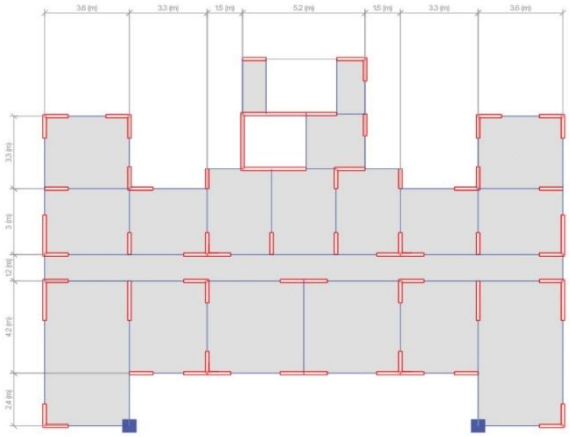

Fig 7: Plan 7 (G+25)

Columns	600x600 mm
Beams	260x630 mm
Walls	150 mm
Slab	125 mm

Table 7: Plan 7 details

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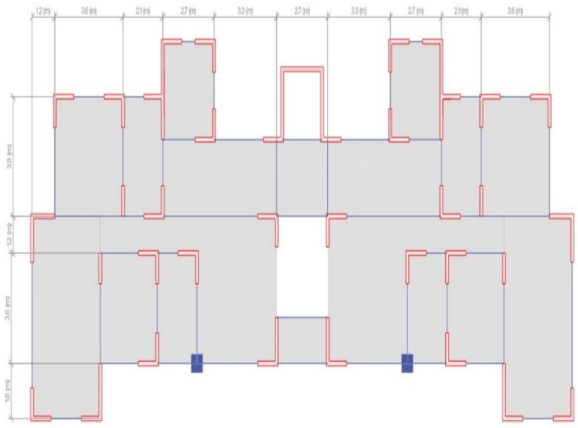

Fig 8: Plan 8 (G+23)

Columns	600x600 mm
Beams	250x550 mm
	280x650 mm
Walls	150 mm
Slab	125 mm

Table 8: Plan 8 details

In all the 8 buildings following loading parameters were used,

Loading parameters		
Live load	3 kN/m2	
Floor finish	1.5 kN/m2	
Wall load	11.25kN/m (for 150mm non-structural wall in monolithic structure)	
	1.83kN/m (for 150mm non-structural wall in Conventional structure)	
Material properties	Concrete	M30
	Steel	Fe415 for longitudinal, mild 250 for shear reinforcement
Seismic definition		
Location	Vadodara	
Earthquake load	As per IS 1893 (Part-1): 2016	
	Zone	III (Z=0.16)
	Importance factor	1.2
	Damping	5%
	Soil type	II (medium)
	Response reduction factor	5
Wind definition		
Wind load	As per IS 875(Part-3):2015	
	Wind speed	39m/s
	Terrain category	3
	Importance factor	1.15
	Risk coefficient(k1)	1
	Topography factor(k3)	1

Table 9: Loading parameters for all the buildings

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IV. RESULTS

4.1 Structure Analysis Results

- Since seismic weight of monolithic structure is high it resulted in high displacement, storey drift, storey shear and storey stiffness.
- On an average storey displacement in Monolithic structure was increased by 22%
- On an average storey drift in monolithic structure increased by 21.1%
- On an average storey shear in monolithic structure increased by 41.25%
- On an average storey stiffness monolithic structure increased by 1.89%

4.2 Cost of the structure

When it comes to total cost of the building it includes three costs(labor cost, material cost, formwork cost)

In monolithic structure as per the market rate of construction in vadodara, labor cost of conventional structure was around 200Rs-sqft of slab area while in monolithic structure (tunnel formwork) it is 175Rs/sqft slab area, there by reducing the labor cost of monolithic structure.

In monolithic structure material cost is found to be high compared to conventional structure by 18-20%

In monolithic structure initial investment in the case of tunnel formwork is very high since we have to buy all the tunnel formwork at once and it cost around 25000Rs/Sqm area of tunnel formwork, and because of this whenever No. of building was less, monolithic structure was way more costlier than conventional one but if the size of project is sufficiently high that we can use tunnel formwork for its maximum potential(i.e. upto 500 repetitions) then it turns out to be 10-12 % economical in total cost compared to conventional structur

(Note-here we can do repetition of tunnel formwork only when one slab cycle is finished because in monolithic structure everything is constructed simultaneously

and we have to implement tunnel formwork in whole slab area, therefore “no of repetitions of tunnel formwork = total no. of floors in whole project”)

To get the maximum benefit of tunnel formwork we can use it for 500 repetitions e.g. 20 storey building is used then total 25 such buildings can be turned out to be (20x25 =500 floors) and hence we can get maximum benefit of tunnel formwork

Total cost comparison for plan 1 is shown in following table, similar is done to all the plans. Following table includes total cost inclusive of material cost, labor cost and formwork cost

No. of towers	Conventional structure(crore)	Mivan structure(crore)	percentage saving in mivan structure	
1	4.92	8.29	-68.4959	%
4	19.71	20.63	-4.66768	%
8	39.44	37.1	5.933063	%
12	59.16	53.55	9.482759	%
16	78.89	70.02	11.2435	%
20	98.62	85.77	13.02981	%

Table 10: Plan 1 (G+23) total cost comparison.

	Str. elements	conventional	Monolithic	% increase in monolithic
Plan 1	Beams	499mm2 (for B200x450)	599mm2 (for B200x450)	20%
	Columns	1441mm2(for C300x600)	1814mm2 (for C300x600)	25.8%
	walls	0.25%	0.68%	172%
Plan 2	Beams	742mm2(for B250x530)	756mm2 (for B250x530)	1.88%
	Columns	1459mm2 (for C300x600)	1890mm2(for C300x600)	29.5%
	walls	0.26%	0.42%	61.5%
Plan 3	Beams	1187mm2(for 300x650)	1212mm2(for 300x650)	2.16%
	Columns	7555mm2(for 600x600)	9426mm2(for 600x600)	24.76%
	walls	1.3245%	1.76%	32.88%

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Plan 4	Beams	1280mm2(for 300x650)	1382mm2(for 300x650)	7.96%
	Columns	8634mm2(for 600x600)	9939mm2(for 600x600)	15.11%
	walls	2.55%	2.95%	15.68%
Plan 5	Beams	735mm2(for 200x450)	820mm2(for 200x450)	11.56%
	Columns	1870mm2(for 400x400)	2673mm2(for 400x400)	42.94%
	walls	0.454%	0.76%	67.4%
Plan 6	Beams	1200mm2(for 300x650)	1249mm2(for 300x650)	4.08%
	Columns	3881mm2(for 600x600)	5141mm2(for 600x600)	32.46%
	walls	0.98%	1.39%	41.83%
Plan 7	Beams	995mm2(for 260x630)	1042mm2(for 260x630)	4.72%
	Columns	3623mm2(for 600x600)	5571mm2(for 600x600)	53.76%
	walls	0.68%	1.146%	68.52%
Plan 8	Beams	856mm2(for 250x550)	897mm2(for 250x550)	4.78%
	Columns	3772mm2(for 600x600)	5673mm2(for 600x600)	50.39%
	walls	0.505%	0.87%	72.27%

Table 11: Design steel comparison in structural members

V. CONCLUSION

In summary, the structural analysis revealed that monolithic structures have higher displacement, storey drift, storey shear, and storey stiffness compared to conventional structures due to their increased seismic weight.

In monolithic structure steel consumption in column increased by 34.34% on average. In monolithic structure steel consumption in beam increased by 7.14%. In monolithic structure steel consumption in structural wall increased by 66.5%

Although monolithic structures can reduce the labor costs through the use of tunnel formwork, the material cost is higher by 18-20%. The initial investment for tunnel formwork is substantial, making monolithic structures more expensive for smaller projects. However, for larger projects with significant repetition potential, monolithic structures can be 10-12% more cost-effective in terms of total cost.

But it is also important to note that some time project completion time is more important than cost of project in such cases monolithic structure can be implemented even though cost of it might be more compared to conventional structure.

It is essential to consider the specific project requirements and repetition potential when deciding between monolithic and conventional structures.

VI. ACKNOWLEDGEMENT

I am deeply honored to express my gratitude to my guide, Dr. V. R. Patel, Assistant Professor in the Department of Applied Mechanics and Structural Engineering. His invaluable guidance, innovative ideas, patience, inspiration, encouragement, and moral support for my research work have been truly remarkable.

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