RESEARCH ARTICLE OPEN ACCESS

Seismic Response and Economic Viability of Voided Two-Way Slabs Using U-Boot Beton

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Abstract:

The reinforced concrete slab is one of the most prevalent elements in contemporary building construction. In order to reduce the self-weight of the structure, new and creative concrete slab systems with voids have been devised, all the while retaining the same load-bearing capability as solid slabs. The flat slab of reinforced concrete is filled up with U-Boot Beton material. The U-Boot Technology technique essentially removes all concrete from the center of a floor slab, which serves no structural use. These voided slabs have the ability to lower the quantity of concrete needed for building construction. As a result, there is less strain on the building's base and columns, which is advantageous from both an economic and seismically active standpoint. The current study examines the analysis of multistory flat slab buildings using Indian Standard Code in contrast to void slab lightened with U-Boot Beton buildings. Using SAP-2000 software, the Response Spectrum approach in accordance with IS 1893 Part-1 was compared with the Indian Standard code to assess the buildings' seismic response. Time periods, dead weight, base shear, and lateral displacement results Flat slab buildings' interstory drift and cost analysis are contrasted with voided slab lighting in U-boot Beton buildings.

Keywords — **Flat slab, voided slab, U-Boot Beton Seismic performance, response spectrum analysis**

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I. INTRODUCTION

The span of the slab between the columns is the main restriction when designing a reinforced concrete construction. Large span designs necessitate the use of support beams or extremely thick slabs, which increases the weight of the structure and calls for a lot of concrete. Support beams can also result in higher floor-to-floor heights, which raise the cost of finished materials. In seismically active areas, heavier structures are less preferred than lighter ones since a building's bigger dead load increases the force of inertia. Voided slabs are a novel approach to enhance the span of a two-way R/F concrete slab system while decreasing the weight of the concrete structure. Although void slabs weigh somewhat less than standard slabs, they have a comparable load-bearing capacity. Voided slabs achieve the same load capacity as solid slabs by removing concrete from non-critical areas and replacing it with hollow plastic void formers. By using Sap-2000 software, we can determine the dead weight, seismic response, and cost of a multi-story flat slab building when we employ U-boot beton material instead of concrete in non-critical areas.

II. RESPONSE SPECTRUM METHOD

The response of a multi-degree-of-freedom system is determined by the superposition of modal responses, each of which is determined from spectral analysis of a single-degree-of-freedom system. These responses are then combined to determine the total response, which is helpful for those kinds of structures where modes other than the primary one have a significant impact on the structure's response. The majority of the time, industries employ this technique. The linear dynamic response spectrum approach is used to assess the structural reaction to short, transitory, nondeterministic dynamic events, such as earthquakes and shocks. It can be acquired using the SRSS or CQC methods. The SRSS approach can be used when frequencies are widely apart, whereas CQC is recommended when frequencies are tightly spaced. To determine the building's peak structural reaction, it operates in a linear range. It is feasible to build earthquake-resistant structures by using that linear range to determine the lateral forces that have evolved in the structure as a result of ground motions and earthquakes.

III. METHODOLOGY

The following structural model is considered for comparison.

TABLE I
STRUCTURAL MODEL

Storey	G+5, G+8,G+10
Storey height (m)	3.6
Plan Area (m2)	900
Plan Dimension (m)	30*30
Type of frame	OMRF
Thickness of slab (mm)	250
Plinth height (m)	1.8
Concrete grade	M20, M25
Steel grade	Fe 500
Seismic zone	V
Importance factor	1
Response reduction factor	5
Type of soil	III
Unit weight of Concrete (kN/m^3)	25
Live Load (kN)	3
Floor Finish (kN)	1
Roof Live (kN)	1.5
Roof Treatment (kN)	1

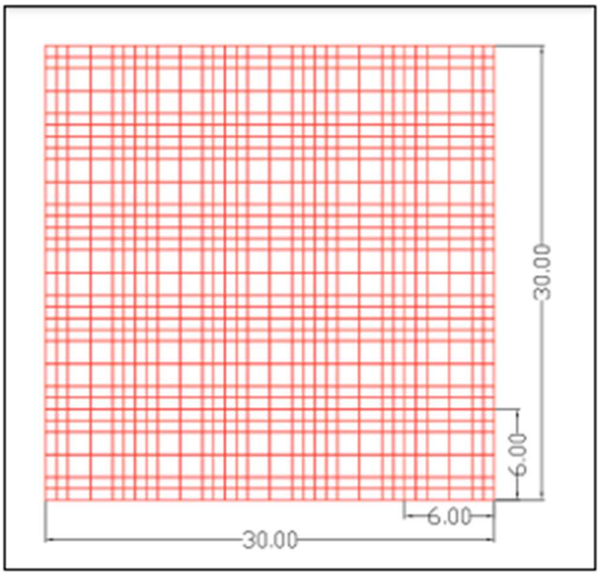


Fig. 1 A building plan considered from (SAP-2000 Window)

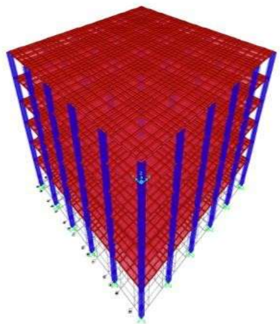


Fig. 2 3D Model of flat slab building (SAP-2000 Window)

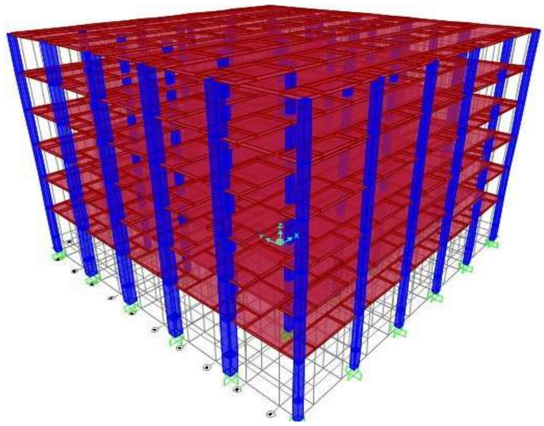


Fig. 3 3D Model of flat slab building using U-Boot Beton (SAP-2000 Window)

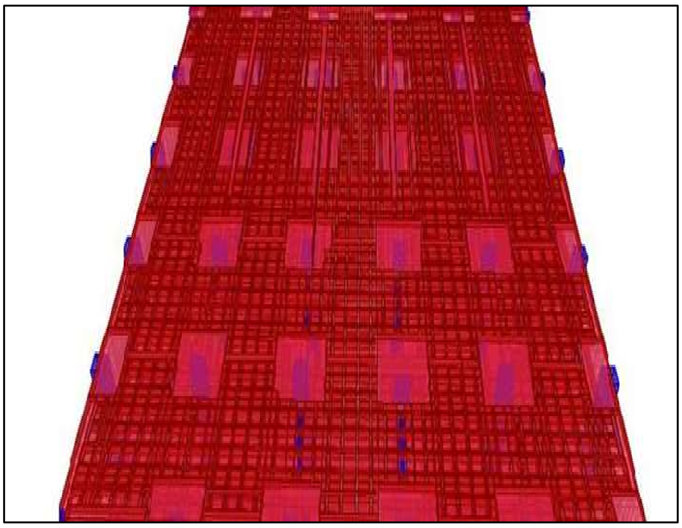


Fig. 4 Betoning Position view of Finite Element Model (SAP-2000 Window)

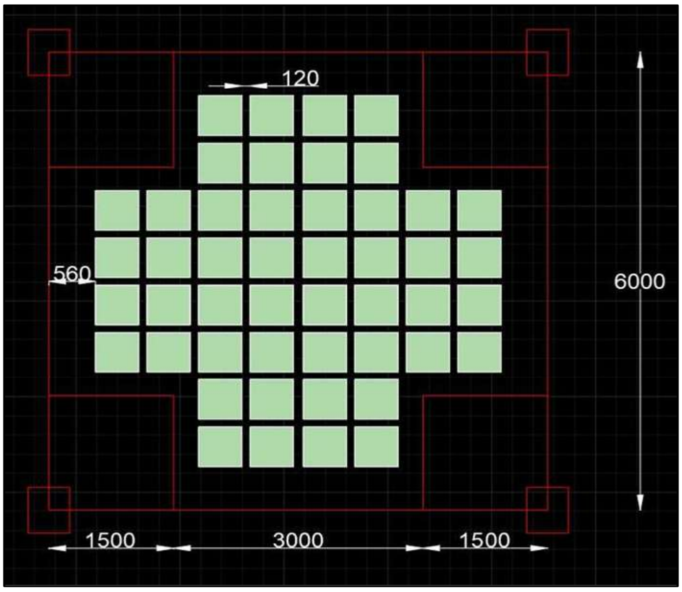
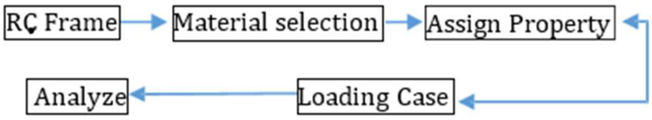


Fig. 5. Betoning position view of cad

The response spectrum approach, a linear dynamic analysis technique, is employed in this work to determine the maximum seismic response of a structure by measuring the contribution from each natural mode of vibration. Here, base shear is computed using,

$$V_b = A_h * W$$

Analysis in Software: The response spectrum approach is employed for analysis; steel and concrete are the material properties supplied to the models; the loading conditions of multi-story structures are LSM; and the load assigned is the structure's self-weight.



Objectives:

- Formulation of problem statement, development of methodology and possible validation with high quality research article.
- Analysis of multistory flat slab building and evaluation of seismic response of the building.
- To find the cost of conventional two way slab building and voided two way slab using u-boot beton.

IV. RESULTS

Modal Analysis of Multistorey Flat slab building With U-Boot Beton

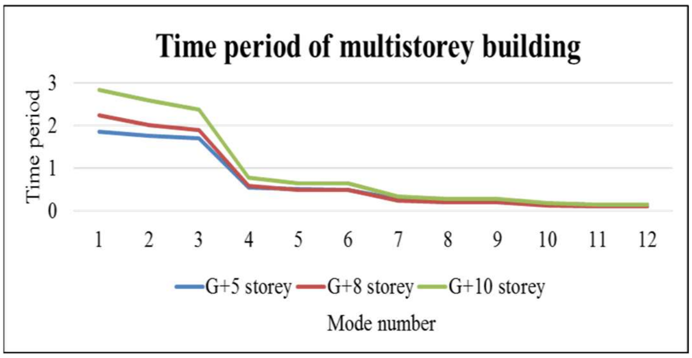


Fig. 6. Time period of multistorey building

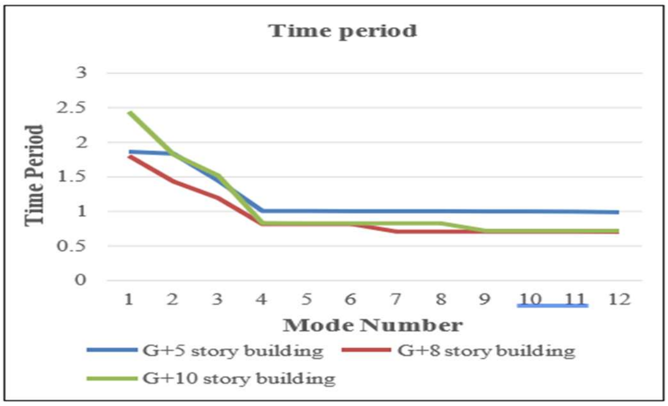


Fig. 7. Modal Analysis

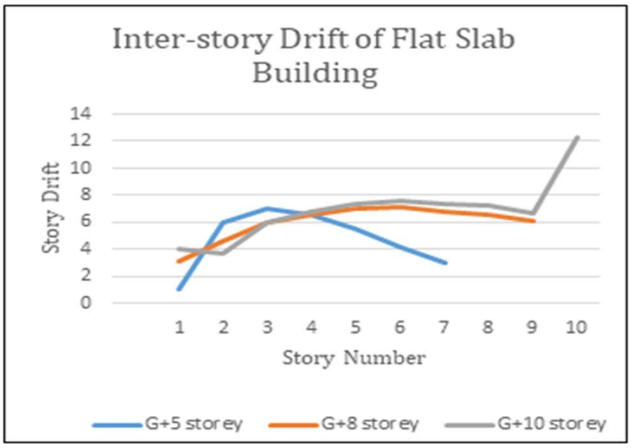


Fig. 8. Inter-storey drift of flat slab building

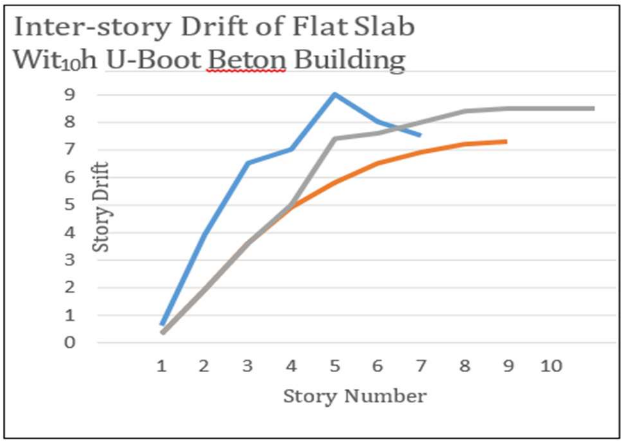


Fig. 9. Inter-storey drift of flat slab with U-Boot Beton Building

TABLE III
RESPONSE SPECTRUM ANALYSIS RESULTS OF FLAT SLAB BUILDING

Parameter studied	Software Results of (G+5) story Building	Software Results of (G+8) Story Building	Software Results of (G+10) Story Building
Base shear	1479KN	2635KN	2613KN
Maximum Displacement	33.3mm	53.8mm	58.8KN
Time Period	1.856 s	2.23 s	2.83
Mass Participation Ratio	83.60% for UX and 85.15% for UY direction	71.14% for UX and	71.38 for UX and
		73.26 for UY direction	73.58 for UY
Dead weight	40056 KN	83842KN	102085KN

TABLE IIIII
RESPONSE SPECTRUM ANALYSIS RESULTS OF FLAT SLAB WITH VOIDS USING U-BOOT BETON MATERIAL

Parameter studied	Software Results of G+5 building	Software Results of G+8 building	Software Results of G+10 building
Base shear	237.6 KN	395KN	371KN
Maximum Displacement	44.7mm	51.7mm	57.3 mm
Time Period	1.84 s	1.798 s	2.43 s
Mass Participation Ratio	75.10% for UX and 81.15% for UY direction.	66.78% for UX and 71.94% for UY direction	65% for UX and 70% for UY direction
Dead weight	23009 KN	67293KN	81708KN

TABLE IVV
COMPARISON OF (G+5) STORY FLAT SLAB BUILDING AND FLAT SLAB WITH VOIDED SLAB BUILDING

Parameter	Flat slab building (G+5)	Flat slab building with Voided Slab (G+5)	Remark
Time Period	1.856 s	1.84 s	Approximately same time period
Base shear	1479 KN	237.6 KN	83.93% Decrease
Displacement	33.30mm	44.7mm	16.23% Increase
Dead Weight	40056 KN	23009 KN	42% Decrease
Slab Thickness	250mm	200mm	50mm Reduce
Column size	500mm×600 mm	400mm×500 mm	100mm×100 mm Reduce

TABLE V
COMPARISON OF (G+10) STORY FLAT SLAB BUILDING AND FLAT SLAB WITH VOIDED SLAB BUILDING

Description	G+5			G+8			G+10		
	Flat Slab	U-Boot Beton	Cost Reduction (%)	Flat Slab	U-Boot Beton	Cost Reduction (%)	Flat Slab	U-Boot Beton	Cost Reduction (%)
Slab	10496026	9949827	5.2	16015577	14924741	6.81	2E+07	17519475	10.5
Column	9720166	10076566	-3.67	46073698	46073698	0	6E+07	56312298	0
Total	20216193	20026393	0.94	62089275	60998439	1.76	8E+07	73831772	2.71

TABLE VI
COMPARISON OF (G+8) STORY FLAT SLAB BUILDING AND FLAT SLAB WITH VOIDED SLAB BUILDING

Parameter	Flat slab building	Flat slab building with Voided Slab	Remark
	(G+8)	(G+8)	
Time Period	2.23 s	1.798 s	19.37% Decrease
Base shear	2635 KN	395 KN	85% Decrease
Displacement	53.8mm	51.7mm	3.90% Decrease
Dead Weight	83842 KN	67293 KN	19.73% Decrease
Slab Thickness	250mm	200mm	50mm Reduce
Column size	900mm×1200 mm	900mm×1200 mm	Same

V. CONCLUSION

- We discovered that the base shear was decreased to 83.93%, 85%, and 85.8% for G+5, G+8, and G+10, respectively, based on the response spectrum analysis of all the models. Therefore, we may use this technology to lessen base shear in seismically active areas.
- The U-boot Beton slab has less dead weight than traditional flat slabs, which accounts for the decrease in base shear.
- When compared to a traditional flat slab structure, the dead weight of a U-boot Beton slab structure is 42%, 19.7%, and 20% lower for G+5, G+8, and G+10, respectively.
- When compared to traditional flat slab designs, a decrease in the overall weight of the structure also results in a decrease in the thickness of the slab.
- For the G+8 and G+10 models, the time period dropped by 19% and 14%, respectively, and was the same for the G+5 model. This indicates that we can maintain both a shorter time period and reduced base shear.
- The displacement dropped by 4% and 2.5% for the G+8 and G+10 storey models, respectively, whereas it increased by 16% for the G+5 storey model.
- From a structural cost viewpoint, we find that we can save up to 5%, 7%, and 10% for the G+5, G+8, and G+10 models. This means that the cost of a slab per floor lowers as the number of stories grows.

REFERENCES

[1] *Abhay M. Pande, Anup M. Bhendale, Dr. Manish M. Bais "Voided Slab" International Journal of Latest Technology in Engineering, Management & Applied Science (IJLTEMAS) Volume VII, Issue IV, April 2018 | ISSN 2278-2540.*

[2] *Abhishek R. Pandharipande, N. J. Pathak "Analytical and Experimental Investigation on Voided Slab" International Journal of Scientific & Technology Research Volume 8, Issue 08, August 2019.*

[3] *Ajay Hirapara, Asst. Prof.Dhananjay Patel "Analysis Of Light Weight Formers In Concrete Slab Using Voids" International Journals Of Advance Engineering And Research Development VOl.4, ISSUE 4, April-2017*

[4] *Bhagat, S. Parikh, K. B. "Comparative Study Of Voided Flat Plate Slab and Solid Flat Plate Slab", International National Journal Of Innovative Research and Development, ISSN 2278-0211, 2014*

[5] *Churakov, "Biaxial hollow slab with innovative type of void construction of unique building and structure, VOL. 6(21),pp.70-88 ,2014*

[6] *Corey J. Midkiff, "Plastic Voided Slab System – Analysis and design", Department of Architectural Engineering Kansas State University, Manhattan, 2013*

[7] *DR. Manish M. Bais, Abhay M. Pande, Anup M. Bhendale, "Voided Slab" International Journals Of Latest Technology In Engineering*