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Seismic Performance Assessment of Solid and Hollow Concrete Members in R.C.C Framed Building Under Different Soil Conditions

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Abstract: Due to continuous rise in the prices of steel reinforcement and cement leads, there is need for ways to reduce the amount of concrete. Because this represents the total construction cost of the project. Hollow reinforced concrete members help in reducing superstructure weight and are light in weight and hence seismic mass can be reduced as compared to conventional solid reinforced concrete beams and columns. The economical convenience in the use of hollow reinforced concrete member is due to the cost saving afforded by reduced section area. The building is analysed using STAADPROV8i software. Steel bracing are provided to the building which improves stability and resists lateral loads. The analyses are done for both regular and irregular building with bracings. The behaviour of building is analysed by taking three different types of soils namely hard, medium and soft.

Keywords: Hollow (box-type) Members, Plan Irregularity, Displacement, STAADPROV8i

I. INTRODUCTION

Use of huge amounts of cement and steel has significant effect on environmental problems. In order to solve the problems hollow or box type members are designed. In an RCC framed structure building the floor area is greater to some percentage when compared to a load bearing walled building. Hence, this type of building is preferably economical where the value of land is very high. The tall bridge piers constructed using rectangular hollow reinforced concrete (HRC) column is good way in which superstructure weight and seismic mass is minimized. The column strength and stiffness is maintained whilst significantly reducing the construction cost. There is currently reluctance among bridge designers to specify the use of ductile hollow columns for tall bridge piers due to the unknown performance of the plastic hinge regions under severe seismic disturbances.

1) *Hollow members*: Hollow members make the superstructure safer as compared to solid concrete members. Also this kind of structural member may be economically viable as to the solid ones. Hollow blocks are often used to build large structures like boundary fences. The reduced volume of concrete for making each blocks add up to a significant savings in cost for the materials for the whole wall. Their lighter weight also makes them easier to lift. The blocks and bricks are made out of mixture of cement sand and stone chips. Hollow blocks construction provides facilities for concealing electrical conduit, water and soil pipes.

Fig.1 Hollow Beam (Ardra et.al, 2019)

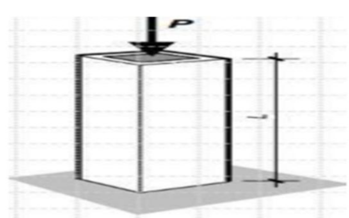

Fig. 2 Hollow Column (Ardra et.al, 2019)

Hollow concrete members can safely withstand the atmospheric action up to an extinct and it requires no protective covering. It requires only low maintenance and are economical. They have only less weight and encourages quick execution of work ie; They can be of uniform and regular size and have less weight. This facilitates rapid execution of work. It spares space and increment floor zone . Diminishes construction cost and thereby help in help in saving construction materials and therefore use of these members can reduce construction cost. Use of larger size members reduces number of joints in work and hence helps in saving mortar. They have good insulation properties against sound, heat and dampness.

II. NEED FOR THE STUDY

The basic requirement from concrete is to provide strength and durability. Hollow concrete blocks, possess adequate strength and structural stability, are highly durable, fire resistant. In addition they provide better architectural features and improve the aesthetic beauty. The dead load of hollow concrete block is much lesser than a solid block. The purpose of this study is to compare the seismic performances of the hollow concrete members with that of solid concrete members and thereby to know the feasibility of using them in construction field in an economical way in different soil conditions.

III. SCOPE AND OBJECTIVES

Hollow (Box-type) members help in decreasing superstructure weight and are lighter in weight and hence help in minimizing seismic mass compared to conventional solid reinforced concrete beams and columns. The analysis is performed using STAADPROV8i

The main objectives area :

- *A.* To carry out the seismic analysis of RCC framed building using solid and hollow concrete members.
- *B.* To find out how irregularity in plan influence the RCC framed building under seismic loading.
- *C.* To find out the seismic behaviour of RCC framed buildings in seismic zone II and different soil conditions.
- *D.* To find the effect of bracings in buildings
- *E.* Analyse the Storey Displacement

IV. METHODOLOGY

A ten storeyed commercial building which is situated in seismic zone II is considered for the analysis. Buildings are modelled with X- type (cross) bracings. After structure is modelled, loads such as Dead load, live load and seismic load is applied This analysis is conducted on 3D frame models using STAAD Pro. After analysis results are obtained such as storey displacement. The analysis is done on both regular and irregular buildings which are located in seismic zone II and three different soil conditions, such as hard, medium, soft soil. Bracings are provided only on corners of the building.

Table 1 Building description

Type		Regular building	Irregular building
Storey height		3 m	3 m
No of storey		10	10
Beam size	Solid	450x450 mm	450x450 mm
	Hollow	100mm thickness	100mm thickness
Column size	Solid	500x500 mm	500x500 mm
	Hollow	100mm thickness	100mm thickness
Slab thickness		150 mm	150 mm
Bracing		ISA 100X75X12	ISA 100X75X12
Grade of concrete		M30	M30
Grade of steel		Fe415	Fe415

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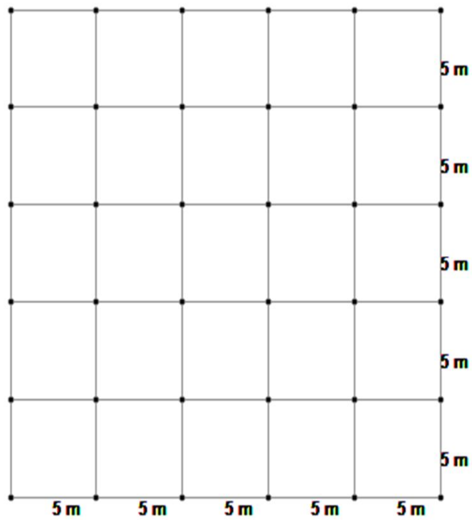

Fig. 3 Plan of regular building

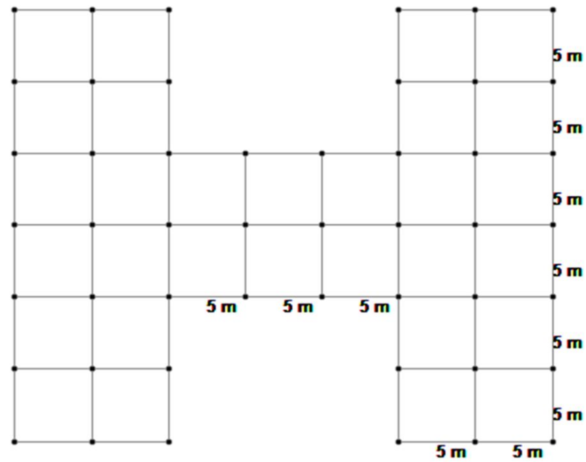

Fig.4 Plan of irregular building

The load applied to building are Dead load(IS 875 part-1 1987), Live load (IS 875 part-II 1987) and Seismic loads (IS 1893 – 2002). The load combinations used are (i) 1.5(DL+LL), (ii) 1.2(DL+LL±EL) (iii) 1.5(DL±EL), (iv) 0.9DL±1.5EL. After loads are applied , building is analysed using STAADPROV8i

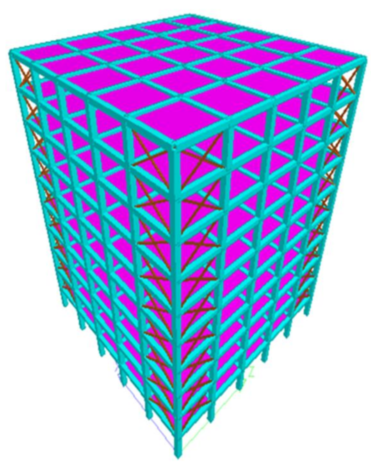

Fig.5 3D view of regular building with solid members

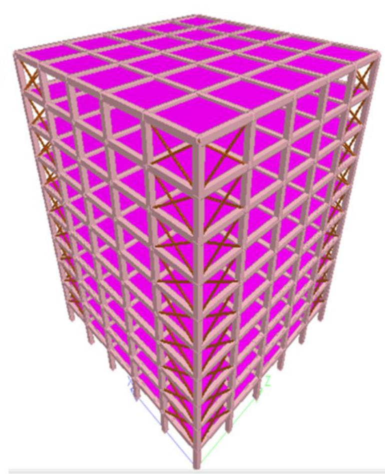

Fig.6 3D view of regular building with hollow members

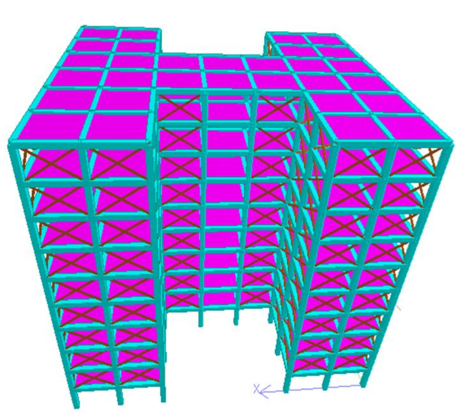

Fig.73D view of irregular building with solid member

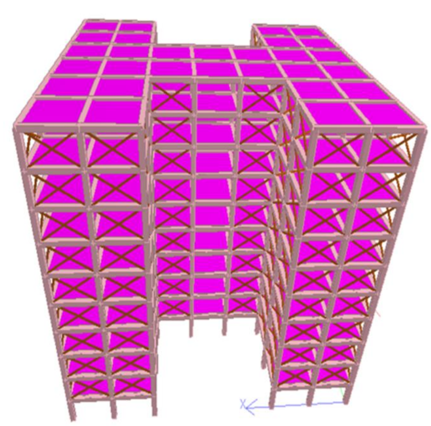

Fig.83D view of irregular building with hollow member

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V. RESULT AND DISCUSSION

A. *Storey Displacement*

After analysis, storey displacement of the building is obtained.

Table.2 Storey displacement for regular and irregular building solid and hollow members in hard soil

Storey	Storey displacement (mm)			
	Regular solid	Regular hollow	Irregular solid	Irregular hollow
10	58.875	49.46	80.013	75.29
9	55.979	46.754	75.448	67.998
8	51.899	43.082	69.518	62.537
7	46.593	38.494	62.149	55.8445
6	40.327	33.219	53.614	48.183
5	33.381	27.483	44.251	39.857
4	26.012	21.493	34.4	31.118
3	18.464	15.445	24.392	22.491
2	11.026	9.546	14.607	14.089
1	4.226	4.113	5.668	6.32
Base	0	0	0	0

Table.3 Storey displacement for regular and irregular building solid and hollow members in medium soil

Storey	Storey displacement (mm)			
	Regular solid	Regular hollow	Irregular solid	Irregular hollow
10	68.868	65.848	83.375	78.537
9	65.572	62.231	78.644	73.539
8	60.839	57.339	72.483	67.539
7	54.65	51.231	64.813	60.172
6	47.332	44.209	55.62	51.816
5	39.186	36.572	46.161	42.799
4	30.547	28.598	35.888	33.452
3	21.692	20.546	25.449	24.101
2	12.959	12.697	15.24	15.085
1	4.968	5.472	5.914	6.763
Base	0	0	0	0

Table.4 Storey displacement for regular and irregular building solid and hollow members in soft soil

Storey	Storey displacement (mm)			
	Regular solid	Regular hollow	Irregular solid	Irregular hollow
10	76.595	69.611	86.819	81.662
9	72.955	65.731	81.776	76.628
8	67.738	60.502	75.264	70.309
7	60.882	54.001	67.223	62.982
6	52.741	46.578	57.948	53.982
5	43.688	38.514	47.801	44.6
4	34.064	30.109	37.144	34.867
3	24.193	21.629	26.329	25.124
2	14.455	13.366	15.763	15.728
1	5.543	5.757	6.115	7.052
Base	0	0	0	0

The storey displacement for regular and irregular building for hard, medium and soft soil conditions are found out and compared. The storey displacement will always be maximum at the top and minimum at the base of the structure. The storey displacement decreases from top to bottom storey. The base is fixed, so the displacement at the base is 0. Braced regular hollow building has reduced displacement compared to braced regular solid building and that braced irregular hollow building has reduced displacement compared to braced irregular solid building. 6 it is found that braced regular hollow building perform better than braced irregular hollow building. Bracings are provided at corners of the building. Displacement of braced frame is lesser due to the presence of X type steel bracings which causes increased stiffness.

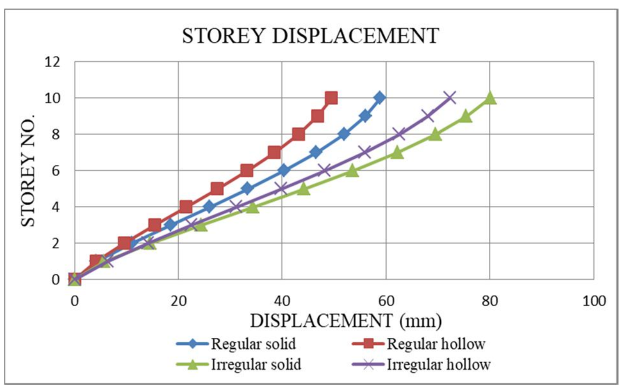

Fig 9 Storey displacement for regular and irregular building with solid and hollow member in hard soil

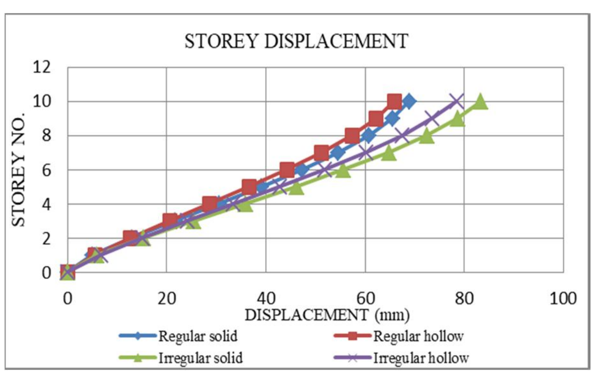

Fig 10 Storey displacement for regular and irregular building with solid and hollow member in medium soil

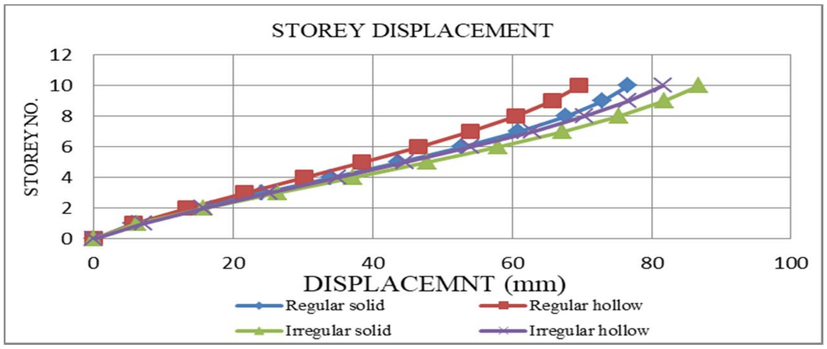

Fig 11Storey displacement for regular and irregular building with solid and hollow member in soft soil

By comparing models after analysis, buildings located in hard soil has reduced displacement compared to building in medium and soft soil. Buildings having hollow members have reduced displacement than solid buildings. It is also noted that regular building have reduced displacement compared to irregular buildings.

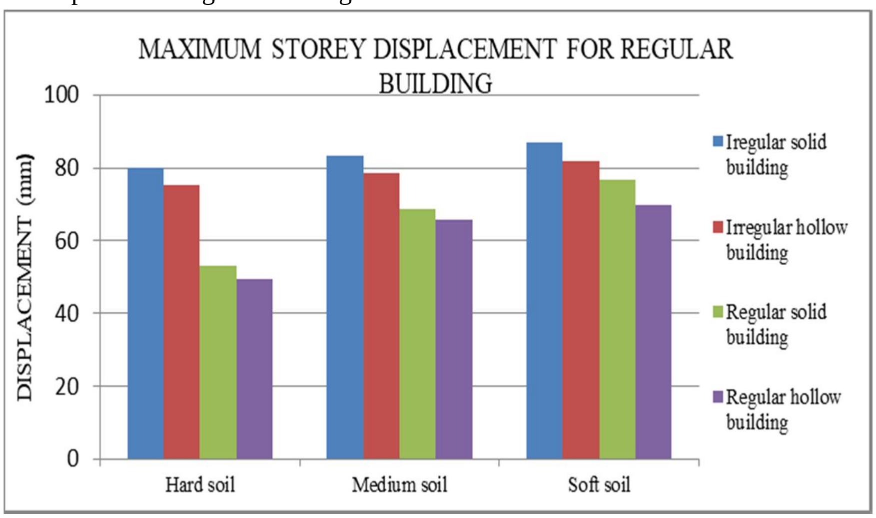

Fig.12 Comparison of maximum storey displacement for regular and irregular building

VI. CONCLUSIONS

The analysis of a 10 storeyed RCC building with bracing for regular and irregular building with solid and hollow members located in seismic zone II are conducted using STAAD Pro V8i is considered to find out the parameters such as storey displacement for hard, medium and soft soil conditions. The following conclusion can be made;

A. Maximum storey displacement occurs on the top floor of the building and storey displacement increases with increase in storey height.
B. Buildings having hollow members has reduced storey displacement than in case of buildings having solid members
C. Regular building has reduced displacement than irregular buildings
D. It is noted that buildings located in hard soil has reduced displacement than buildings located in medium and soft soil.
E. Buildings located in soft soil have larger storey displacement and storey drift. But most of the construction works are done in medium soil, because of the difficulty in construction on hard soil.
F. Buildings constructions on medium soil are most preferred.

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