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Seismic Analysis of Multi Storied Buildings with Floating Columns

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ABSTRACT: In Present scenario buildings either commercial or residential of higher occupancies need a wide amount of space for parking at ground floor levels, for the parking space needs the columns shouldn't be spaced nearly. Avoiding of columns will impact severe effect on the performance of the Building. To avoid this type of Performance failure of structures, Floating columns are introduced in Buildings. The Floating columns are mainly laid and supported over the beams. In recent days, the floating columns are also using for structural appearance of buildings. To avoid the structural failure due to Floating Columns whenever there is a sudden impact of seismic waves occurs, it should be analyzed for seismic loads before its construction. In our design work, the floating columns are analyzed for seismic zone – II using ETABS Software and is compared with the building with and without floating column for Base Shear, Time Periods, Storey Displacements, Storey drifts of each floor, as per IS Codal Recommendations.

KEYWORDS: Floating Column, Seismic Analysis,

I. INTRODUCTION

The floating column is a vertical member which rest on a beam but doesn't transfer the load directly to the foundation. The floating column acts as a point load on the beam and this beam transfers the load to the columns below it. The column may start off on the first or second or any other intermediate floor while resting on a beam. Usually columns rest on the foundation to transfer load from slabs and beams. But the floating column rests on the beam. The most important application of floating column is for the construction of soft storey in the ground floor to facilitate free space for parking or entrance corridors. This free space will provide parking option for residential, industrial and commercial buildings. In banquet halls, lobbies, conference room, large interrupted column free space is required for free movement of people and vehicles. This must avoid closely spaced columns in the area. A wrong practice that has come into force is to solve such problems by providing floating column.

II. LITERATURE REVIEW

Arlekar, Jain & Murty [2], (1997) said that such features were highly undesirable in buildings built in seismically active areas; this has been verified in numerous experiences of strong shaking during the past earthquakes. They highlighted the importance of explicitly recognizing the presence of the open first storey in the analysis of the building, involving stiffness balance of the open first storey and the storey above, were proposed to reduce the irregularity introduced by the open first storey.

Awkar and Lui [3], (1997) studied responses of multi-story flexibly connected frames subjected to earthquake excitations using a computer model. The model incorporates connection flexibility as well as geometrical and material

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nonlinearities in the analysis and concluded that the study indicates that connection flexibility tends to increase upper stories inter-storey drifts but reduce base shears and base overturning moments for multi-story frames.

ISHA ROHILLA et. al. [2015], discussed the critical position of floating column in vertically irregular buildings for G+5 and G+7 RC buildings for zone II and zone - V. **ISHA ROHILLA et. al. [2015]**, has concluded that Floating columns should be avoided in high rise building in zone 5 because of its poor performance, Storey displacement and storey drift increases due to presence of floating column. Storey displacement increases with increase in load on floating column. Storey shear decreases in presence of floating column because of reduction mass of column in structure. Increase in size of beams and columns improve the performance of building with floating column by reducing the values of storey displacement and storey drift. Increasing dimensions of beams and columns of only one floor does not decrease storey displacement and storey drift in upper floors so dimensions should be increased in two consecutive floors for better performance of building.

III. MODEL DESCRIPTION

Here for this Case Study, we have considered a G+12 Storey Building with Cellar, assuming the building to be with and without Floating Columns. The Building was analysed for the Seismic experiences by introducing the floating columns concept and the test results were compared with the Normal Building. The Building was located in the Earthquake Zone – II as per the Seismic Zoning Map of India and the Soil Structure Considered was Moderate (Zone – II) as per IS Code. As the Load from the Floating Column acts as a point load, the section properties of the lower stories needs to be increased. But here in this case study, we haven't modified the section properties of the Building, instead of changing the section properties. We have changed the amount of load applied by Walls from Masonry walls to Light Weight Concrete (CLC) Blocks. The Plan of the Building Considered for analysis is shown in fig.1 and the preliminary data of the Building is given in Table 1.

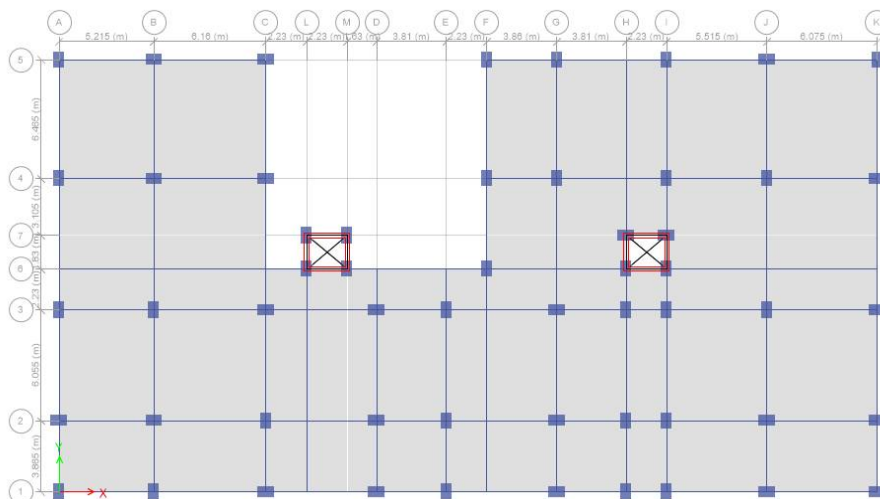


Fig. 1 Plan of the Building Considered

Three Models in the same plan are considered to analysis the Building for seismic analysis.

- Model – A : Ordinary Building with Masonry Wall Construction,
- Model – B : Building with Floating Columns with Masonry Wall Construction,

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- Model – C : Building with Floating Columns with Light weight Concrete Brick Wall Construction. Plan of the Three Models were showed in the below figures.

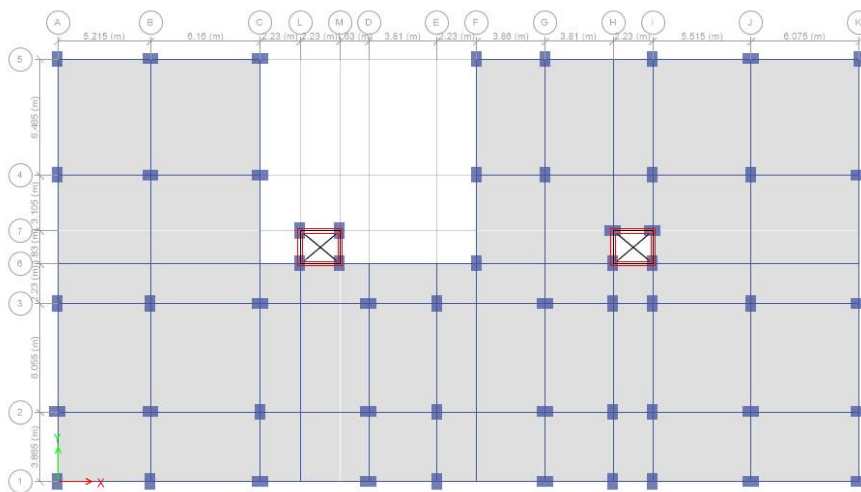


Fig. 2 Model – A: Ordinary Building with Masonry Wall Construction

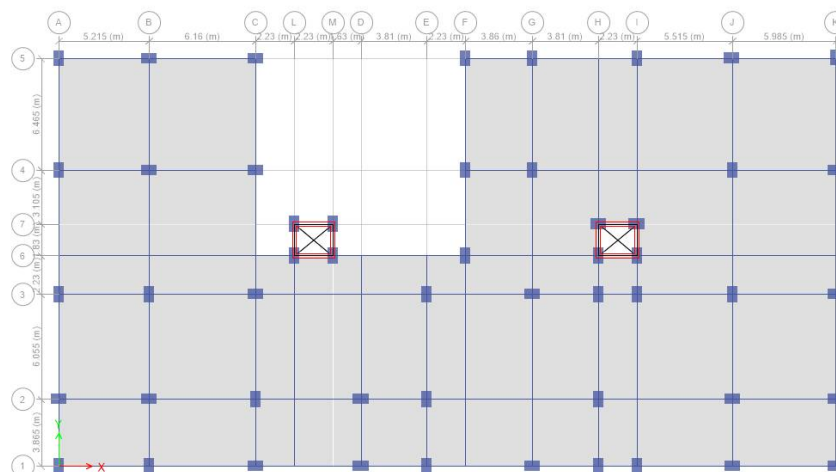


Fig. 3 Model – B & Model - C: Building with Floating Columns

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Table 1 Preliminary Data of Building

	Cellar & Ground	G+1 to G+5	G+6 to G+12
No. of Stories	G+12		
Height of Each Storey	3.2m		
Height of Bottom Storey	3.0 m		
Column Dimensions	600 mm x 900 mm	300 mm x 600 mm	230 mm x 300 mm
Beam Dimensions	300 mm x 450 mm		
Thickness of Slab	125 mm		
Thickness of Outer Wall	230 mm		
Thickness of Inner Wall	115 mm		
Seismic Zone and Factor	Zone – II ; Zone Factor – 0.16		
Type of Soil	Medium ; Zone - II		
Importance Factor	1.0		
Response reduction Factor	5		
Live Loads onto Slabs	3.5 kN/m ²		
Live Load on Terrace	1.5 kN/m ²		
Floor Finish on Slab	1 kN/m ²		
Wall Load on Exterior Beams for Masonry Walls	12.65 kN/m		
Wall Load on Interior Beams for Masonry Walls	6.325 kN/m		
Wall Load on Exterior Beams for CLC Blocks	3.795kN/m		
Wall Load on Interior Beams for CLC Blocks	1.90kN/m		
Grade of Concrete	M30		
Grade of Steel	FE500		

IV. METHOD OF SEISMIC ANALYSIS

Seismic analysis is a subset of structural analysis and the calculation of the response of a building structure to earthquake .It is a part of the process of structural design,earthquake engineering or structural assessment in region where earthquake is prevalent. A building has the potential to ‘wave back and forth during an earthquake (or even a severe wind storm). This is ‘fundamental mode’ and is the lowest frequency of building response .most building,however higher modes of response,which are uniquely activated during earthquake.

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Response Spectrum Method

A response spectrum is plot of a curves which represent peak or steady state response i.e displacement velocity, acceleration of SDOF system subjected to specified earth quake ground motion and its time period or frequency. Response spectrum describes the maximum or peak response of SDOF system to a Particular input motion dependent on damping ratio. SDOF system response is evaluated by time domain or frequency domain analysis for a given time period of a system, maximum response is taken. This process is repeated for all range of possible time period of SDOF system. Final plot with system time period on X – axis and response quantity on Y-axis is the required response spectra pertaining to specified damping ratio and input ground motion. Same process is carried with different damping ratio to obtain overall response spectra

V. EXPERIMENTAL RESULTS

Base Shear: Base shear is an estimate of the maximum expected lateral force on the **base** of the structure due to seismic activity. The variation in base shear due to introduction of floating columns in base at different locations are tabulated in Table 2 also variation in base shear are shown through graph in Fig no.4

The Base Shear is about to increase by 2.86% - 3.75% for Model – B, 23.51% - 34.27% for Model – C when compared to Model – A

Table 2 Base Shear for the Models

MODEL	X - DIRECTION BASE SHEAR (kN)	Y - DIRECTION BASE SHEAR (kN)
MODEL - A	1330.12	1364.93
MODEL - B	1380.07	1403.99
MODEL - C	1786.05	1685.89

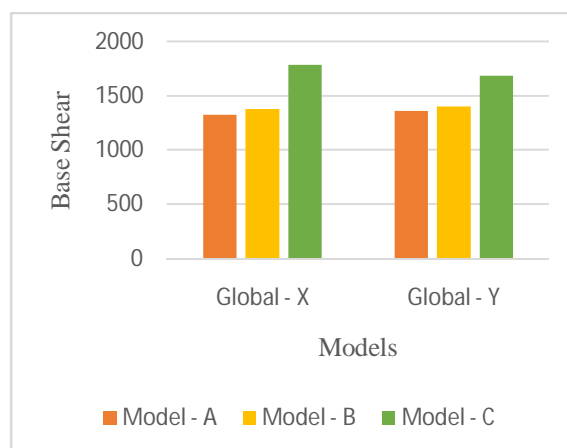


Fig. 4 Model v/s Base Shear

Time Period of Earthquake: The time taken by the wave to complete one cycle of motion is called **period** of the earthquake wave. In general, earthquake shaking of the ground has waves whose **periods** vary in the range 0.03-33sec. The variation in Time Periods due to introduction of floating columns in Building at different locations are tabulated in Table 3, also variation in Time Periods are shown through a graph in Fig no.5

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The Time Periods is about to decrease by 0.50% - 2.10% for Model – B, and about to increase by 65.79% for Model – C.

Table 3 Time Periods for Different Modes

MODE	MODEL - A	MODEL - B	MODEL - C
1	1.836	1.822	3.044
2	1.744	1.706	2.825
3	1.700	1.676	2.683
4	0.592	0.585	1.075
5	0.488	0.477	0.961
6	0.453	0.448	0.941
7	0.294	0.291	0.624
8	0.214	0.211	0.533
9	0.198	0.197	0.527
10	0.180	0.178	0.410
11	0.126	0.126	0.353
12	0.124	0.124	0.344

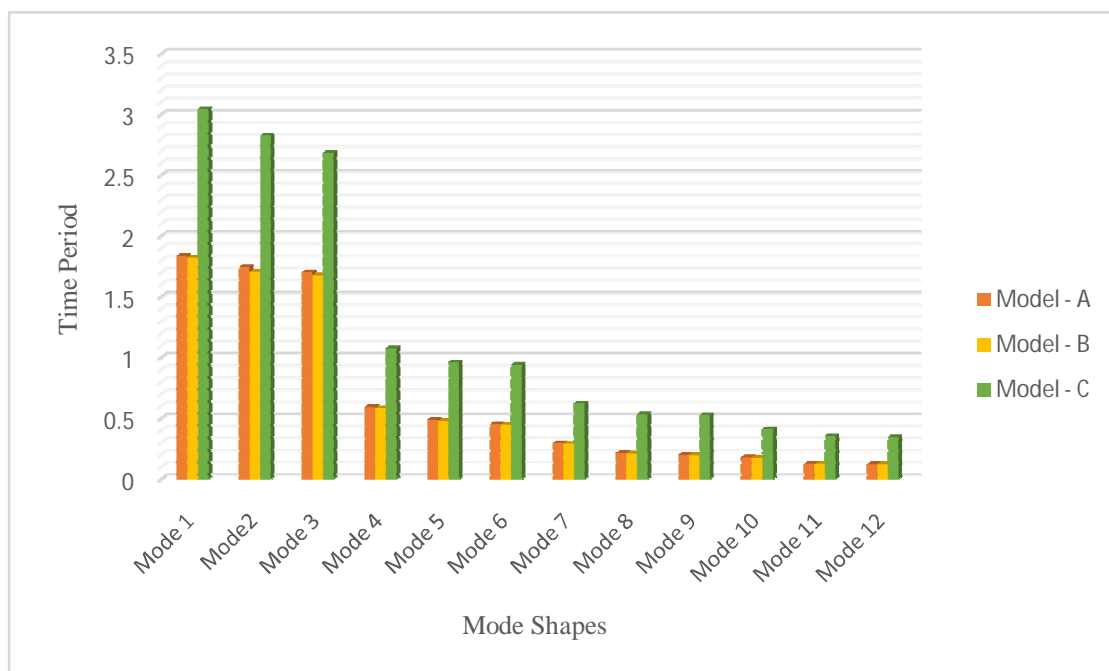


Fig. 5 Mode v/s Time Periods

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Storey Displacements: Storey displacement is the lateral movement of the structure caused by lateral force. The deflected shape of a structure is most important and most clearly visible point of comparison for any structure.

The results variation of storey displacement due to different location of floating columns are tabulated in table no 4, also variation of storey displacement are shown in a graph in fig no.6& 7

The Storey Displacements are about to increase by 5.27% in Global – X Direction and Reduced about 40.14% in Global – Y Direction for Model – B when compared to Model – A

The Storey Displacements are about to increase by 80.42% in Global – X Direction and Reduced about 10.60% in Global – Y Direction for Model – C when compared to Model – A

Table 4 Storey Displacements for Three Models

STOREY	GLOBAL X - DIRECTION			GLOBAL Y - DIRECTION		
	MODEL - A	MODEL - B	MODEL - C	MODEL - A	MODEL - B	MODEL - C
12	11.251	12.252	20.170	8.476	4.609	8.292
11	10.249	11.136	19.106	7.848	4.187	7.922
10	9.292	10.010	17.739	7.177	3.769	7.399
9	8.302	8.882	16.069	6.456	3.359	6.708
8	7.285	7.762	14.147	5.689	2.965	5.863
7	6.255	6.661	12.024	4.891	2.588	4.885
6	5.231	5.588	9.762	4.085	2.225	3.813
5	4.278	4.556	7.623	3.304	1.870	2.800
4	3.424	3.610	6.311	2.642	1.522	2.260
3	2.601	2.710	4.972	2.002	1.175	1.726
2	1.826	1.875	3.552	1.395	0.835	1.182
1	1.122	1.131	2.098	0.840	0.513	0.653
GROUND	0.530	0.526	0.941	0.377	0.238	0.248
CELLAR	0.170	0.168	0.286	0.121	0.075	0.082
BASE	0	0	0	0	0	0

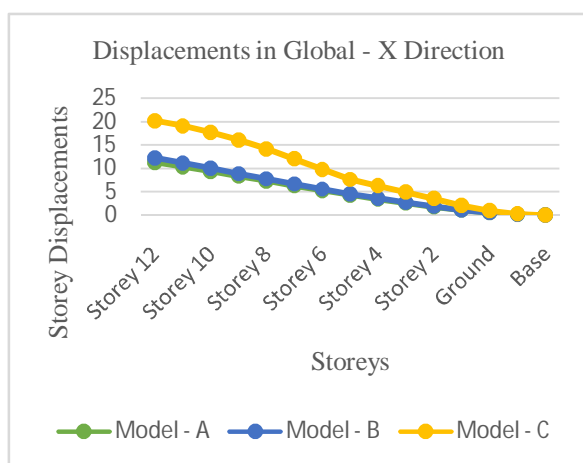


Fig. 6 Displacements in Global X Direction

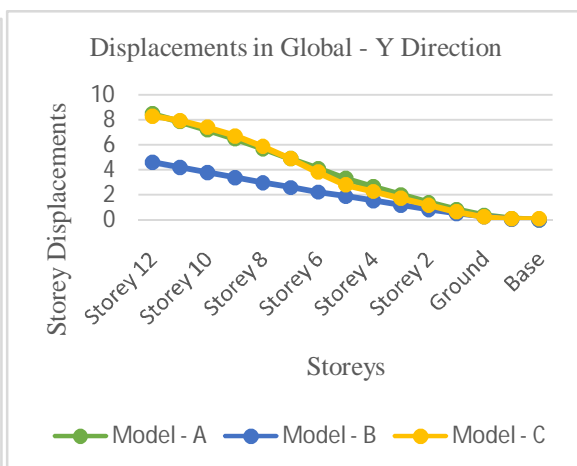


Fig. 7 Displacements in Global Y Direction

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Storey Drift: Storey drift is the drift of one level of a multi-storey building relative to the level below. Inter story drift is the difference between the roof and floor displacements of any given story as the building sways during the earthquake, normalized by the storey height.

The results variation of storey drift due to different location of floating columns are tabulated in table no 5, also variation of storey drifts are shown in a graph in fig no.8 & 9

The Storey Drifts are about to increase by 4.60 % in Global – X Direction and Reduced about 41% in Global – Y Direction for Model – B when compared to Model – A

The Storey Drifts are about to increase by 86.35% in Global – X Direction and Reduced about 21% in Global – Y Direction for Model – C when compared to Model – A

Table 5 Storey Drifts for Three Models

STOREY	GLOBAL X - DIRECTION			GLOBAL Y - DIRECTION		
	MODEL - A	MODEL - B	MODEL - C	MODEL - A	MODEL - B	MODEL - C
12	0.000349	0.000371	0.000413	0.000233	0.000152	0.000135
11	0.000357	0.000380	0.000541	0.000242	0.000156	0.000188
10	0.000360	0.000384	0.000645	0.000250	0.000158	0.000239
9	0.000357	0.000383	0.000720	0.000256	0.000155	0.000283
8	0.000348	0.000375	0.000771	0.000264	0.000149	0.000321
7	0.000337	0.000361	0.000799	0.000265	0.000140	0.000350
6	0.000323	0.000344	0.000743	0.000254	0.000130	0.000332
5	0.000284	0.000309	0.000457	0.000213	0.000120	0.000173
4	0.000267	0.000290	0.000434	0.000204	0.000115	0.000170
3	0.000248	0.000265	0.000450	0.000192	0.000110	0.000172
2	0.000222	0.000234	0.000456	0.000175	0.000102	0.000166
1	0.000186	0.000190	0.000389	0.000145	0.000086	0.000127
GROUND	0.000120	0.000119	0.000222	0.000085	0.000054	0.000055
CELLAR	0.000057	0.000056	0.000095	0.000041	0.000025	0.000028
BASE	0	0	0	0	0	0

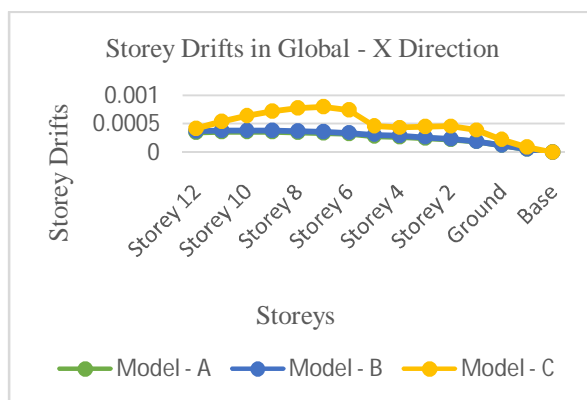


Fig. 8 Storey Drifts in Global – X Direction

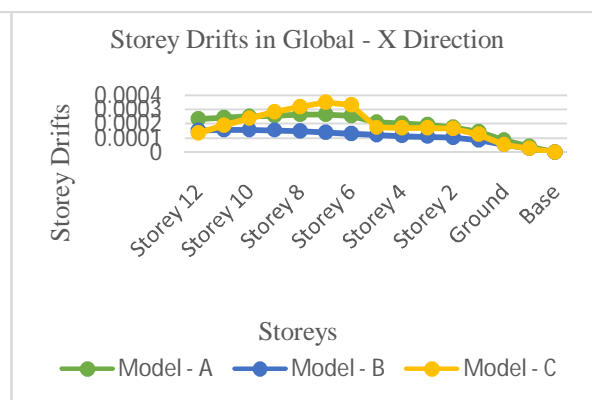


Fig. 9 Storey Drifts in Global – Y Direction

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VI. CONCLUSION

In the Present study, an attempt has been made to compare the seismic response of multi - storied building with floating columns introduced at different locations of the Building. For this purpose a Multi – Storied Building was considered for analysis point of view.

- From the results, the base shear for Model – B is quite just High as compared to Model – A and Model – C has shown higher Base Shear Value When Compared with Model – A. Even the Weight of the Building (Model – C) is less, due to its flexibility, the Base Shear got increased.
- The Displacements for the Model – C is very high when compared to Model – A and Model – B, because of its flexibility, lighter in weight and Greater Height, when the Model is subjected to Earthquake excitations and Wind forces, the Displacements in the building will increase.
- Storey Drifts are also lesser in Percentages for Model – B when compared to Model – C.
- Time Period of execution is High for Model – C as the Time Periods for the Model – A and Model – B has slighter in variation and these two models will withstand for Earthquake forces even when Floating Columns is introduced in Model – B

Model – C which is Building Constructed with Light Weight Concrete Blocks was not recommended for Building with Floating Columns. As the forces, time period and displacements are high, there may be chance of Collapse or failure of Building and is Risky for the People living in it.

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