Seismic Performance of Multi-storied R.C Framed Structure with Corner Floating Column using IS: 1893-2016

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Abstract – Now a days multistoried building construction are with advanced technology and aesthetic purposes, structure design and analysis methods are modernized day by day. The requirement of parking space and storage area movement are needed with the provision of floating column. But this kind of structures are highly dangerous in higher earthquake zone and cause the damage. In this paper the floating column structure are analyzed for regular structure and considering corner floating columns in different storeys in structure, using regular placing floating column in G+10 storey building IS:1893-2016. The result is analyzed for parameter, Storey displacement, storey drift, storey shear and fundamental time period by response spectrum method using ETABS 2018 Software.

***Key Words*: Multi-storeyed building, earthquake, floating column,** Response **spectrum method, ETABS 2018**

1. INTRODUCTION

Earthquake is a natural phenomenon which causes the shaking of earth surface. The principle that cause the damages of buildings like irregularity of the structure, conditions of soil, material of the structures, vertical geometric irregularity, soil and foundation effect, pounding of adjacent structure corrosion of reinforcement and inadequate ductile detailing of members, During earthquake the structure depend on its response of its overall configuration, geometry and dimensions along with the path of seismic force carried to the ground. (Irregularity in building structure refer to non-uniform response of structure due to non-uniform distribution of structural properties. In some time of situation building become vertical irregular at planning stage itself due to its architectural design and functional reasons and this type of irregularity cause the reduction in the strength and stiffness). The beams are also known as transfer girder. They are frequently used in multi-storey building to have large column free area especially in lower floors. The structural behavior of frame with floating column can be quite different due to the discontinuity of load path A structure having floating column can be classified as vertically irregular distribution of mass, strength and stiffness along the building height.

1.1 What is Floating column?

The floating column is a vertical member which rest on a beam and doesn't have a foundation. The floating column act as a point load on the beam and this beam transfers the load to the columns below it. But such column cannot be implemented easily to construct practically since the true columns below the termination level are not constructed with care and hence finally cause to fail.

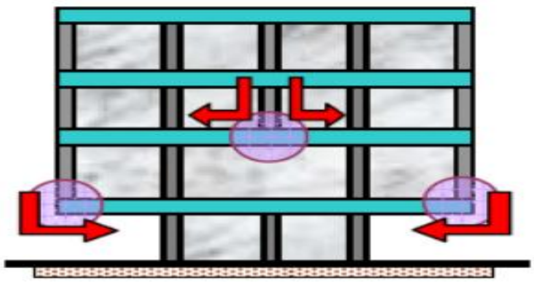

Fig-1 Floating column in building

2. OBJECTIVES

The main objectives of this study are to evaluate the seismic performance of floating column in the building and they are,

i. To study the behaviour of multi-story floating column building under earthquake load, and comparing the performance with regular building under Zone II and Zone V.
ii. Comparison study and seismic analysis behaviour of the above with IS 1893-2002 and IS 1893-2016 using Response spectrum method.

2.1 Scope of study

The concept of floating column is widely used in the urban area for storage and architectural requirements. The building was regular or irregular structure may cause the effect of the building during earthquake for the floating column differs then the regular. Reinforced concrete structure or other structures may cause the differs the way of load transfer the deviation of the load cause the damage in the building. Hence, it is importance to study the Behaviour of structure in particular that incorporates floating column in its structural frame.

3. METHOD OF ANALYSIS

3.1 RESPONSE SPECTRUM METHOD: This method may be performed for any building using design acceleration spectrum specified or by site specific design acceleration spectrum. When design acceleration spectrum is developed specific to a project site, the same may be used for design structures of the project. In such cases, effects of the site specified spectrum shall not be less than those arising out of the design spectrum specified in this standard.

4.MODELLING OF BUILDING

To study the influence of floating column on seismic response of multistory building, a reference Model is considered and analysed using ETABS-2018 Software**.**

4.1 Regular plan Model descriptions

The Model considered for the present study are regular frame structure of G+10 storey consisting of 4x4 bays with a typical storey height of 3.5m. The analysis includes corner floating column. And the Comparison is made by introducing floating column at each storey level in model.

Table-1 Parameter considered for the analysis of model

BUILDING DESCRIPTION		
Plan	20mx20m	
Each bay dimension	5m	
Grade of concrete	M25	
Grade of Steel	Fe500	
Earthquake Zone	II	V
Seismic Zone Factor	0.1	0.36
Response Reduction Factor (R)	5	
Damping	0.05	
Structure Type	SMRF	
Importance Factor	1.2	
Soil Type	Medium (type-II)	
Number of storeys	G+10 Storey	
Height of Typical floor	3.5m	
Height of Building	38.5	
Slab Thickness	150mm	
Normal Beam Size	230mmx500mm	
Transfer beam size	300mmx750mm	
Column size	500mmx500mm	
Live Load	2.5kN/m^2	
Floor Load	1.5kN/m^2	
Live Load on roof	0.75kN/m^2	
Characteristic strength of concrete	25Mpa	
Modulus of elasticity of concrete, E_C	25000Mpa	
Modulus of elasticity of steel	2x10^{5}Mpa	
Density of Concrete	25kN/m^2	
Method of Analysis	Response spectrum method	

4.2 Load Combination

Load combination considered as per IS 1893 2016

1. 1.2 [DL+IL± (EL_X±0.3 EL_Y)] and 1.2[DL+IL± (EL_Y±0.3 EL_X)];
2. 1.5[DL± (EL_X±0.3 EL_Y)] and 1.5[DL± (EL_Y±0.3 EL_X)];
3. 0.9DL±1.5(EL_X±0.3 EL_Y) and 0.9DL±1.5(EL_Y±0.3 EL_X).

Load assigned to the structure

1) Dead load
2) Live load

Loads assumed in the present work is as per IS 875 1987 (Part-2)

Live Loads-2.5kN/m^2 Table 1 of IS 875 (Part-2) -1987 For Business and office buildings.

Roof live load-0.75kN/m^2 Table 2 of IS 875 (Part-2) 1987 For imposed load on various types of roofs, Access not provide expect for maintenance.

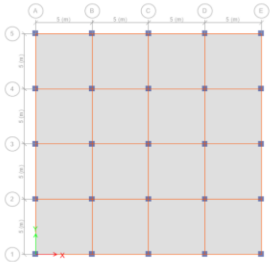
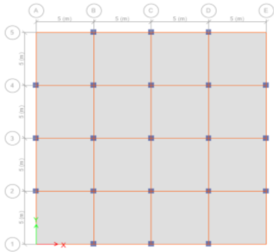

Fig-2 Plan of NFC **Fig-3** Plan of model with FC

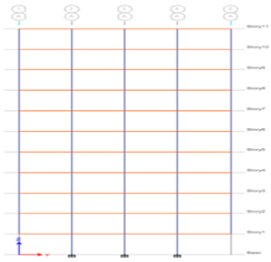
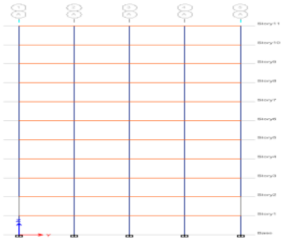

Fig-4 Elevation of M at FC-1 **Fig.-5** Elevation of M at FC-2

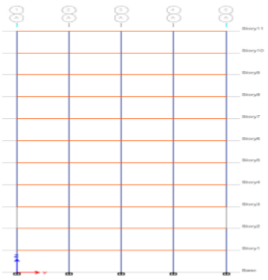
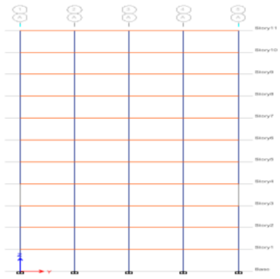

Fig-6 Elevation of M at FC-3 **Fig-7** Elevation of M at FC-4

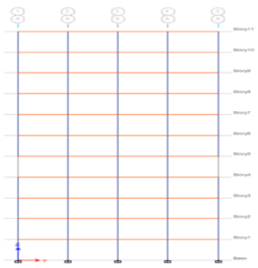
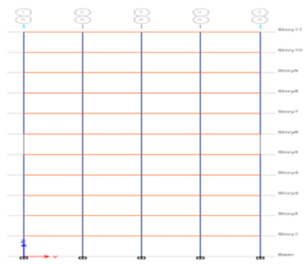

Fig-8 Elevation of M at FC-5 **Fig-9** Elevation of M at FC-6

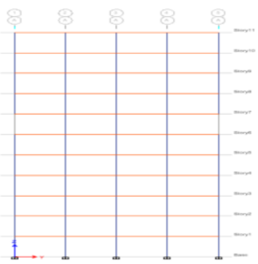
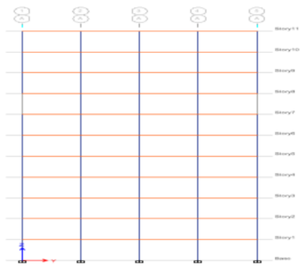

Fig-10 Elevation of M at FC-7 **Fig-11** Elevation of M at FC-8

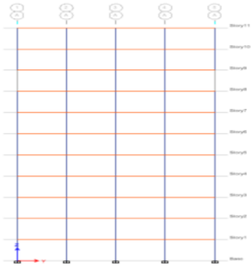
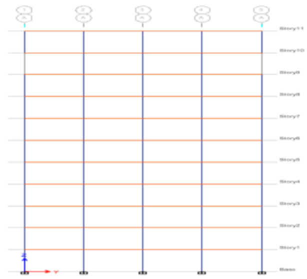

Fig-12 Elevation of M at FC-9 **Fig-13** Elevation of M at FC-10

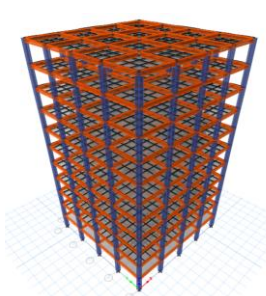
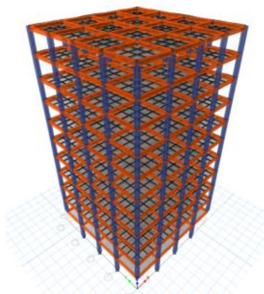

Fig-14 3D View of NFC Model **Fig-15** 3D view of Model at FC

5. RESULTS AND DISCUSSIONS

In this chapter, the results are analysised and performed from Response spectrum method, here the floating column are placed different storeys of model.

Performance of R.C. Regular framed structure with different storeys of floating columns- In this case, floating column are varied within the floor level at different storey level along the height of the building. The objective of this model is to evaluate the parameters such as storey displacement, storey drift, storey shear force and fundamental time period by Response Spectrum Method(RSM) for both the Seismic Zone II and V. And also to find the critical location of floating column.

5.1 Maximum storey displacement

The Maximum top storey displacements of different Floating Column model for Zone-II and Zone-V are presented below. The displacements obtained from Response spectrum method (RSM)

Table-2 Maximum top storey displacement of Model in Zone-II and Zone- V subjected to RSM.

MAXIMUM STOREY DISPLACEMENT (mm) Model				
Storey	IS 1893-2002 (Ref.no:7)		IS 1893-2016	
	RSM		RSM	
	Zone-II	Zone-V	Zone-II	Zone-V
NON-FC	15.573	56.061	21.155	76.1
FC-1	17.265	62.061	20.994	75.527
FC-2	17.067	61.428	20.845	74.999
FC-3	16.818	60.543	20.821	74.913
FC-4	16.578	59.678	20.883	75.137
FC-5	16.366	58.923	20.991	75.527
FC-6	16.177	58.23	21.117	75.978
FC-7	16.002	57.608	21.211	76.319
FC-8	15.843	57.042	21.245	76.44
FC-9	15.706	56.551	21.249	76.454
FC-10	15.607	56.179	21.472	77.258

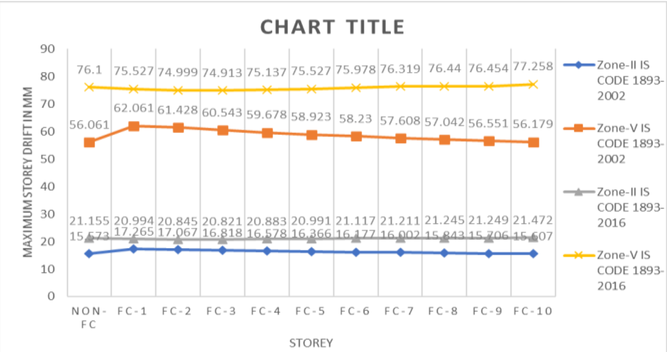

Fig-16 Maximum top storey displacement graph of model with different storey level Floating Column in Z-II and Z-V subject to RSM.

5.2 Storey shear

Storey shear of different floating column values of model are shown, the values of top storey level shear force for different FC model located in Z- II and Z- V of Response spectrum (RSM) and the comparitive results are carried between IS code 1893-2002 and IS 1893-2016.

Table-3 Storey Shear of Model in Z- II and Z-V subjected to RSM.

IS 1893 2002 (Ref.no:7)		
STOREY SHEAR		
STOREY	RSM	RSM
	ZONE-2	ZONE-5
	Model-1A	model-1a
Story11	85.2806	307.0101
Story10	164.1964	591.1072
Story9	219.1191	788.8287
Story8	257.1716	925.8179
Story7	284.2339	1023.242
Story6	307.1393	1105.702
Story5	331.6824	1194.057
Story4	360.0313	1296.113
Story3	389.6382	1402.697
Story2	414.4426	1491.993
Story1	433.615	1561.014
Base	0	0

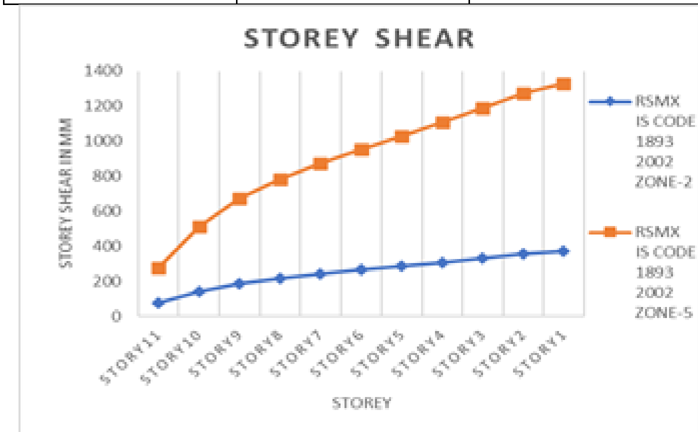

Fig-17 Storey Shear of Model in Z- II and Z-V subjected to RSM.

Table-4 Storey Shear of Models in Z- II and Z-V Along x-direction subjected to RSM.

IS 1893 2016		
STOREY SHEAR		
STOREY	RSM	RSM
	ZONE-2	ZONE-5
	Model-1A	model-1a
Story11	76.8769	276.757
Story10	141.9312	510.9525
Story9	185.9791	669.5245
Story8	217.3454	782.4435
Story7	242.4305	872.7497
Story6	264.7268	953.0166
Story5	285.7836	1028.821
Story4	307.283	1106.219
Story3	330.4441	1189.599

Story2	353.3629	1272.107
Story1	369.1336	1328.881
Base	0	0

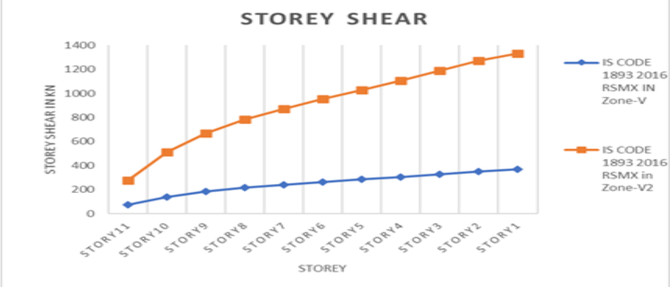

Fig-18 Storey Shear in Z- II and Z-V subjected to RSM.

5.3 storey drift

The storey drift of the different floating columns of model at seismic zone of II and V, RSM with comparison of IS 1893 2002 and IS 1893-2016 are done.

Table-5 Storey drift subjected to RSMX.

Storey drift of Model from FC-1 to FC-5						
IS 1893-2002						
Storey	**NFC**	**FC-1**	**FC-2**	**FC-3**	**FC-4**	**FC-5**
1	0.000354	0.000401	0.000351	0.000353	0.000353	0.000353
2	0.000595	0.000642	0.000643	0.000592	0.000592	0.000592
3	**0.000614**	**0.000656**	**0.000651**	**0.000656**	0.00061	**0.00061**
4	0.000585	0.000625	0.000625	0.000617	**0.000623**	0.000581
5	0.000546	0.000587	0.000588	0.000585	0.000577	0.000583
6	0.000506	0.00055	0.00055	0.000548	0.000545	0.000538
7	0.000464	0.000509	0.00051	0.000509	0.000506	0.000502
8	0.000413	0.000459	0.00046	0.000459	0.000457	0.000453
9	0.000345	0.000391	0.000392	0.000392	0.00039	0.000387
10	0.000256	0.0003	0.000301	0.000301	0.0003	0.000297
11	0.000153	0.000196	0.000197	0.000197	0.000196	0.000194

Storey drift of Model from FC-6 to FC-10					
Storey	**FC-6**	**FC-7**	**FC-8**	**FC-9**	**FC-10**
1	0.000353	0.000353	0.000353	0.000353	0.000353
2	0.000	0.000	0.000	0.000	0.000

	593	594	594	594	594
3	**0.000611**	**0.000613**	**0.000613**	**0.000613**	**0.000613**
4	0.000582	0.000583	0.000584	0.000584	0.000584
5	0.000544	0.000544	0.000545	0.000545	0.000545
6	0.000542	0.000505	0.000505	0.000505	0.000505
7	0.000494	0.000496	0.000463	0.000462	0.000462
8	0.000448	0.000439	0.00044	0.000412	0.000411
9	0.000382	0.000377	0.000367	0.000368	0.000345
10	0.000294	0.000289	0.000283	0.000273	0.000273
11	0.000191	0.000187	0.000181	0.000175	0.000164

Table-6 Storey drift subjcted to RSMX.

Storey drift of Model-1 from FC-1 to FC-5						
IS 1893-2016						
Storey	**NFC**	**FC-1**	**FC-2**	**FC-3**	**FC-4**	**FC-5**
1	0.000461	0.000464	0.000467	0.00047	0.000472	0.000475
2	0.0008	0.000804	0.000811	0.000817	0.000821	0.000824
3	**0.000836**	**0.00084**	**0.000847**	**0.000854**	**0.00086**	**0.000863**
4	0.000801	0.000806	0.000811	0.000818	0.000826	0.000829
5	0.00075	0.000756	0.00076	0.000766	0.000772	0.000755
6	0.000694	0.000701	0.000706	0.000709	0.000693	0.00058
7	0.000631	0.000641	0.000646	0.000632	0.000524	0.000502
8	0.000559	0.000571	0.000564	0.00047	0.000442	0.000564
8	0.000413	0.000459	0.00046	0.000459	0.000457	0.000453
9	0.000345	0.000391	0.000392	0.000392	0.00039	0.000387
10	0.000256	0.0003	0.000301	0.000301	0.0003	0.000297
11	0.000153	0.000196	0.000197	0.000197	0.000196	0.000194

Storey drift of Model from FC-6 to FC-10					
	FC-6	**FC-7**	**FC-8**	**FC-9**	**FC-10**
1	0.000353	0.000353	0.000353	0.000353	0.000353
2	0.000	0.000	0.000	0.000	0.000

	593	594	594	594	594
3	**0.000 611**	**0.000 613**	**0.000 613**	**0.000 613**	**0.000 613**
4	0.000 582	0.000 583	0.000 584	0.000 584	0.000 584
5	0.000 544	0.000 544	0.000 545	0.000 545	0.000 545
6	0.000 542	0.000 505	0.000 505	0.000 505	0.000 505
7	0.000 494	0.000 496	0.000 463	0.000 462	0.000 462
8	0.000 448	0.000 439	0.000 44	0.000 412	0.000 411
9	0.000 382	0.000 377	0.000 367	0.000 368	0.000 345
10	0.000 294	0.000 289	0.000 283	0.000 273	0.000 273
11	0.000 191	0.000 187	0.000 181	0.000 175	0.000 164

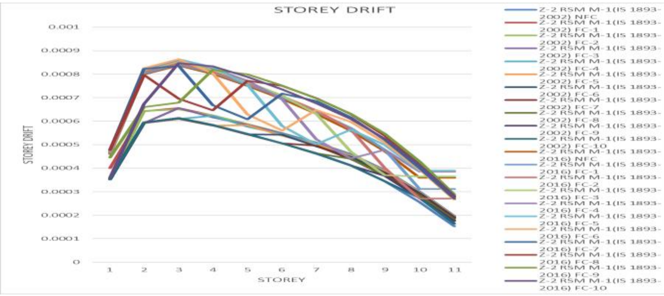

Fig-19 Storey drift of Model subjected to RSMX.

5.4 Fundamental time period

The time period for different floating column model are presented in below

Table-7 Fundamental time period

Fundamental time period in seconds	
IS 1893-2002 (Ref.no:7)	
Storey	**Model**
NFC	1.9
FC-1	2.002
FC-2	1.984
FC-3	1.967
FC-4	1.949
FC-5	1.934
FC-6	1.921
FC-7	1.911
FC-8	1.904
FC-9	1.899
FC-10	1.897
NFC	1.9
Fundamental time period in seconds	
IS 1893-2016	
storey	**Model-1**
NFC	2.450
FC-1	2.668
FC-2	2.591
FC-3	2.453
FC-4	2.443
FC-5	2.435
FC-6	2.428
FC-7	2.422
FC-8	2.416
FC-9	2.411
FC-10	2.405

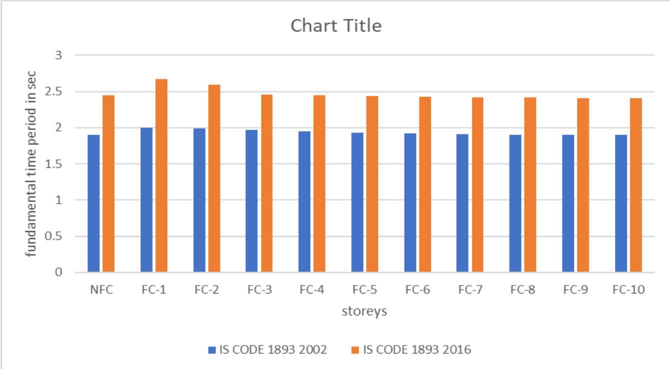

Fig-20 Natural time period graph of different position floating column models

5.5 Result analysis

Model (Corner Floating column) with FC at **1st** storey(FC-1) gives maximum displacement of **0.75%** in both Zone-II and Zone-V of Response spectrum method, as per **IS code 1893 2016.**

It is noticible that displacement goes on descrease with higher storey level of FC upto **9.60%** in Zone-II and **9.47%** Zone-V RSM from FC-1 to FC-10 **IS code 1893-2002**. Displacement goes increase with storey **2.2%** in both Zone-II and Zone-V in RSM from FC-1 to FC-10 as per **IS code 1893-2016.**

Maximum Storey drift of Model is observed, the FC at storey level (FC-1). It displaces that **13.42%** larger storey drift than NFC in Zone-II follows 3rd and 4th storey under EQX as per **IS code 1893-2002**.

Maximum storey drift is observed the FC at storey level (FC-1). It displaces that **0.5%** larger than NFC in Zone-II and also shows in increment up to storey 8th and goes decreases in 10th storey under RSMX method as per **IS code 1893 2016**.

In different floating column model storey shear decrease with increase in height of the building. Maximum value is observed at the bottom storey level, Model show **14.76%** in as per **IS code 1893 2016** lesser then **IS code 1893 2002** under RSMX of Zone-II.

In different floating column model storey shear decrease with increase in height of the building. Maximum values are observed at the bottom storey level, in model FC-10 of Model show **9.85%** in **IS code 1893-2016** lesser then **IS code 1893 2002** under RSMX of Zone-V**.**

Maximum fundamental time period is observed in FC-1 of Model, it's shows **5.09%** larger time period than NFC in both Zones as per **IS code 1893 2002**.

Maximum fundamental time period is observed in FC-1 of Model, it's shows **8.17%** larger time period than NFC in both Zones as per **IS code 1893 2016**.

6. CONCLUSIONS

The following conclusion shown below.

1. It's observed that the introduction of floating column increases the criticality of the structure.
2. It was noticed that the floating column, model (corner floating column) has larger displacement and storey drift in Zone-II and Zone-V in IS:1893-2016.
3. The fundamental time period for model is found to be higher in IS 1893-2016 than IS 1893-2002.
4. From the result of storey displacement, storey shear and storey drift, it was observed that Z-V has higher magnitude than Zone-II.

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