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A Comparative Study of Flat Slab with Perimeter Beams and Conventional Slab Structures under Seismic Conditions

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ABSTRACT: *Flat slab structure are more convenient, economical and provide better architectural visibility over conventional slab structure. But flat slab structures are flexible in nature and thus pose a threat to the safety of the structure which brings us to find a method to overcome this disadvantage. Therefore,perimeter beams are provided which imparts rigidity to the structure.Thispaperfocuses onthe comparative study ofconventional slab structureto flat slab structure having perimeter beams. In this study, ETABS software is used for the analysisof different structures in Indian seismic zones III, IV and Vhaving 10, 12 and 15 storeys. The models taken in this study have Rectangular and L shape configurations. On the basis of the analysis results, the paper discusses the distinctions of structure's behaviour under different heights in terms ofmaximum reaction, maximum storey displacement, maximum overturning moments and maximum storey drift.*

KEYWORDS: *Flat Slab, Conventional Slab, Seismic Analysis, Perimeter Beams, Seismic Zones, ETABS.*

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I. INTRODUCTION

Now-a-days flat slab structures are replacing conventional slab structures as they are more feasible to construct, take less time and shows good aesthetic appearance. But the major disadvantage of flat slab is its high flexibility due to which many problems like motion sickness, high storey displacement etc occurs so to overcome this the concept of Perimeter beams is adopted which reduces the flexibility of the flat slab structure to a much greater extend.Due to the flexibility of Flat slab structures, they must be made stiffer or their rigidity must be increased by any means. Perimeter beams or Edge beams are provided with flat slabs for increasing their stiffness and for withstanding the lateral loads in high seismic zones.Perimeter beams are used in place of shear wall in flat slab structures because shear walls have many disadvantages such as they increase the cost of the structure, they make the structure so rigid that application of lateral forces results in cracks, if we provide shear wall then positioning of shear wall is also a critical study that's why provision of perimeter beams as an alternative to shear wall in flat slab structures is adopted.

Generally, to reduce the amount of negative moment reinforcement over a column or to reduce shear stresses near column a drop panel of rectangular cross-section should be provided in flat slab structure.

Fig. 1.1: Flat slabs with Drop Panels

II. METHODOLOGY

In this research work, the analysis based on linear static method is used and seismic zones 3, 4 and 5 are considered of India.Cases of a Building Models which has been considered in the study are given below:

Software used	Configuration of Building	Model Dimensions	Storey	Remarks
ETABS	Rectangular	40m x 30m	10	Seismic load of ZONE 3, 4&5 as per IS: 1893:2002.
			12	
			15	
ETABS	L- Shape	40m x 30m **Longer Edge**-40m x 20m **Shorter Edge**- 30m x 15m	10	Seismic load of ZONE 3, 4&5 as per IS: 1893:2002.
			12	
			15	

Following are the Specifications which are considered in this work:

Typical Storey Height - 3.5 m, Base Storey Height - 1.5 m, No. of Bays in X-Direction - 6, No. of Bays in Y-Direction – 8, Bay Length in X-Direction - 5 m, Bay Length in Y-Direction - 5 m, Concrete Grade - M-35, Density of R.C.C. - 25 KN/m^3, Density of Masonry - 20 KN/m^3, Columns - 350 mm x 500 mm, Perimeter Beams - 300 mm x 350 mm, Slab Thickness - 150 mm, Drop Panel Size - 3 m x 3 m, Drop Panel Thickness - 100 mm, Overhangs along X-Direction-Left Edge Distance - 0.15 m, Right Edge Distance - 0.15 m, Overhangs along Y-Direction-Top Edge Distance - 0.15 m, Bottom Edge Distance - 0.15 m, Bottom Support Conditions – Fixed, Floor Diaphragm Rigidity - Semi-Rigid, Live Load – Roof - 1 KN/m^2, Rest of the structure- 2 KN/m^2, Soil Conditions - Medium Soil (Type II), Damping Ratio - 5%, as per IS-1893: 2002 (Part-1), Poisson Ratio - 0.2, Response Reduction Factor – 3, Importance Factor - 1, Zone Factor - As per IS-1893: 2002 (Part-1) for differentSeismic Zones.

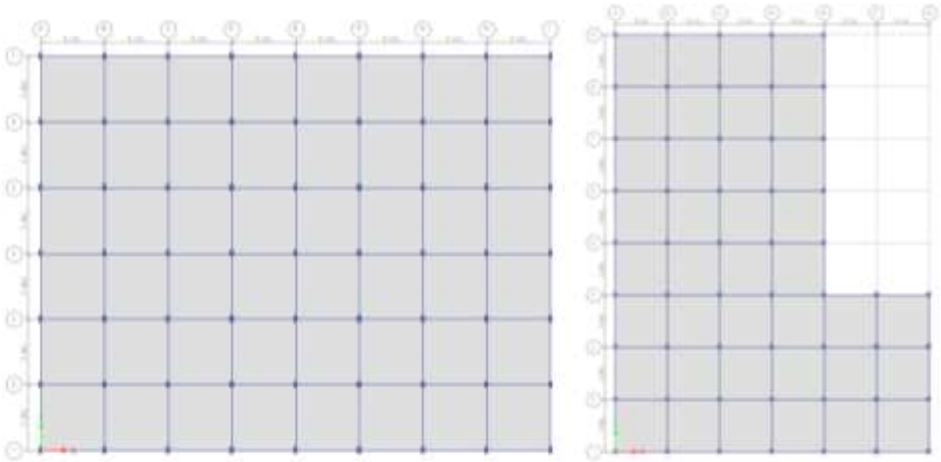


Fig 1.2: Plan of a Conventional SlabStructure

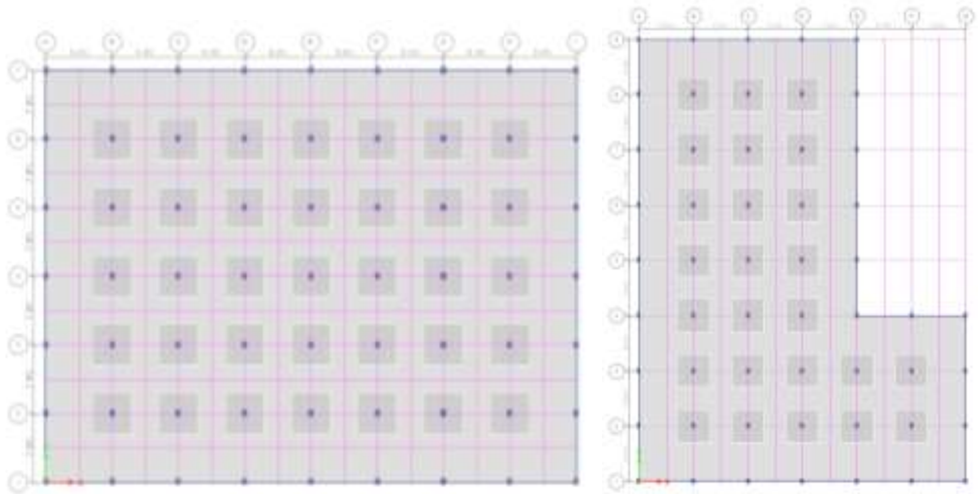


Fig 1.3: Plan of a Flat SlabStructure

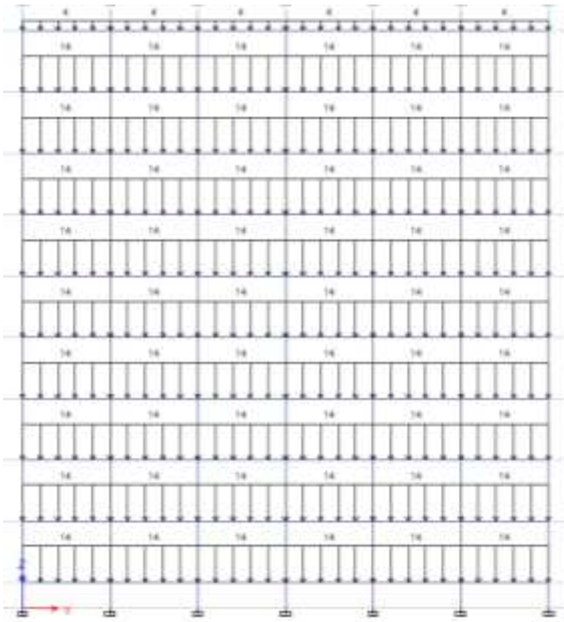


Fig 1.4: Loading on structural frame

LOAD CASE DETAILS

In the analysis of structure, various types of loading conditions are studied and as given below:

a. Static or Dead Load:

These are the loads which acts vertically downward and arises due to the self-weight of the structure. Dead loads include mass of the structural member such as beams, columns, slabs etc. as well as that of non-structural elements such as floor coverings, false ceilings, masonry walls etc. Dead load is evaluated as per its cross-sectional area multiply with the density of material used.

Density of following material:

Density of RCC member = 25 kN/m^3.

Density of PCC member = 20 kN/m^3.

b. Live load (IS 875: Part II and IV):

Live loads are those which may change in position and magnitude. According to IS 1893, table 8, Percentage of Imposed Load which is to be appraised in Seismic Weight Calculation are shown as

Percentage of Imposed Load

Imposed Uniformity Distributed Floor Loads (kN/ m^2)	Percentage of Imposed Load
Up to and including 3	25
Above 3	50

c. Load Combinations:

According to IS 1893 (Part 1): 2002, Clause 6.3.1.2 the following load combinations of gravity and lateral loads with approximate Partial safety factors for limit state design of reinforced concrete structures and prestressed concrete structures are-

1) 1.5 (D.L. + I.L.)
2) 1.2 (D.L. + I.L. ±E.L.)
3) 1.5 (D.L. ±E.L.)
4) 0.9 D.L. ±1.5 E.L.

Here, 1.5, 1.2 and 0.9 are partial safety factors and DL, IL and EL stand for the response quantities due to dead load, imposed load and designated earthquake load respectively. The structure is then analysed and designed for the combination that yields the most critical value.

d. Seismic Loads (IS 1893: 2002)

When a structure is subjected to ground motion or ground vibration it responds in shaking fashion. The random stirring of structure is possible in all possible directions i.e. in Horizontal (X) and (Y) direction and also in Vertical (Z) direction. This motion causes the structure to vibrate in all three directions. These seismic forces are evaluated from IS: 1893:2002.

III. PROBLEM DEFINITION

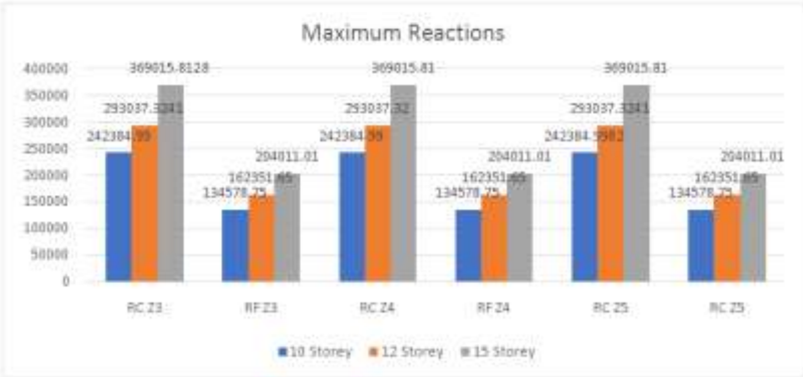
In this research work we have considered conventional slab frame building with flat slab frame building having perimeter beams with semi-rigid diaphragm condition in different seismic zones of India. Overall 36 cases have been formed for Comparative Analysis of the Structures.

IV. RESULT AND DISCUSSION

The above cases are analysed and their results on the basis of various parameters are shown below-

1) Rectangular Configuration-

a. Maximum Reaction



b. Maximum Storey Displacement

Fig.: Maximum Storey Displacement in X direction inall Seismic Zones

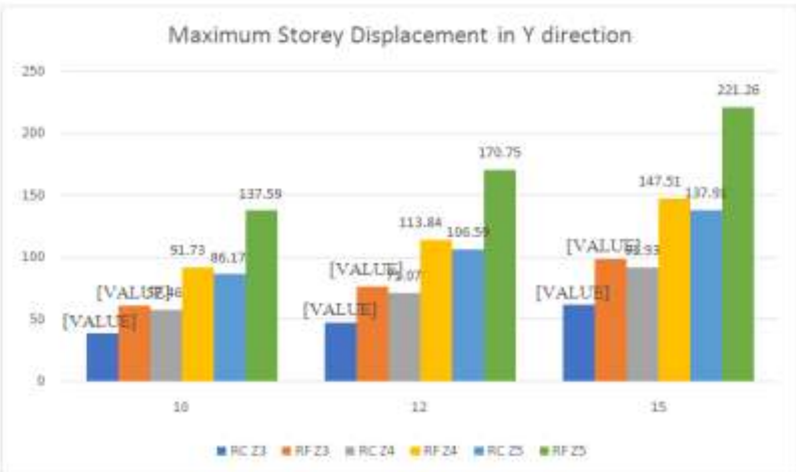


Fig.: Maximum Storey Displacement in X direction inall Seismic Zones

a) **Maximum Overturning Moments**

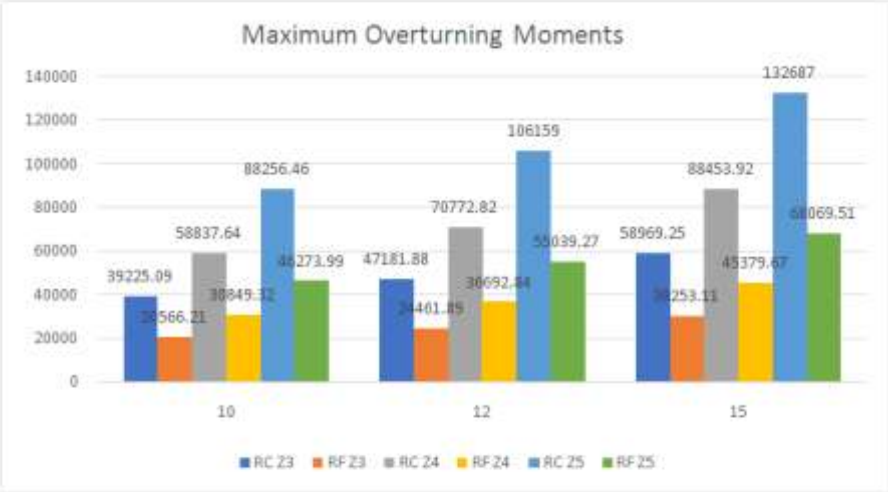


Fig.: Maximum Overturning Moments in all Seismic Zones at all Structural Heights

b) **Maximum Storey Drift**

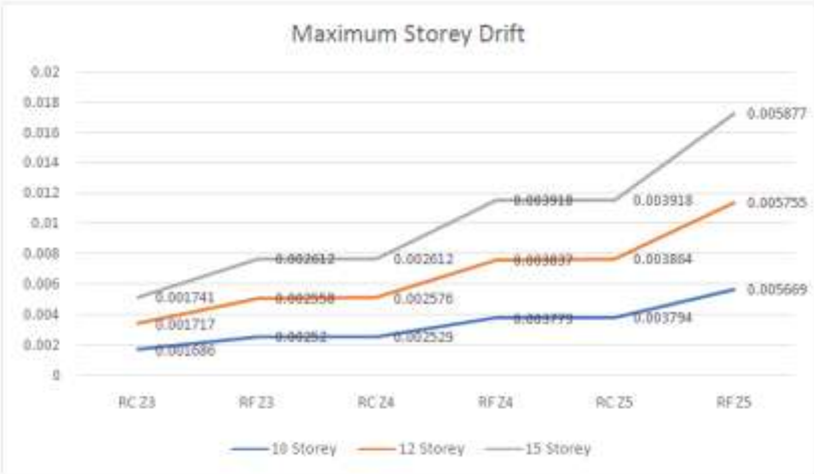


Fig.: Maximum Storey Drift in all Seismic Zones at all Stories

2) **L – Shape Configuration-**

a) **Maximum Reaction**

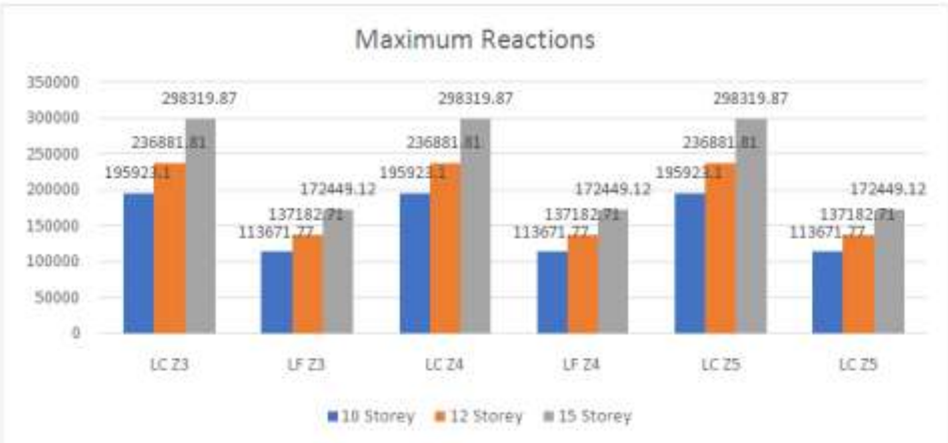


Fig.: Maximum Reaction in all Seismic Zones

b) Maximum Storey Displacement

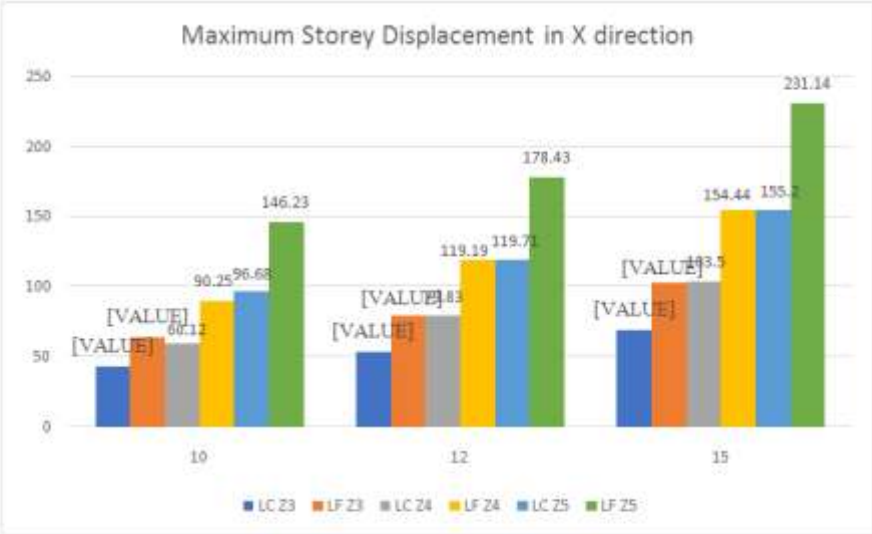


Fig.: Maximum Storey Displacement in all Seismic Zones

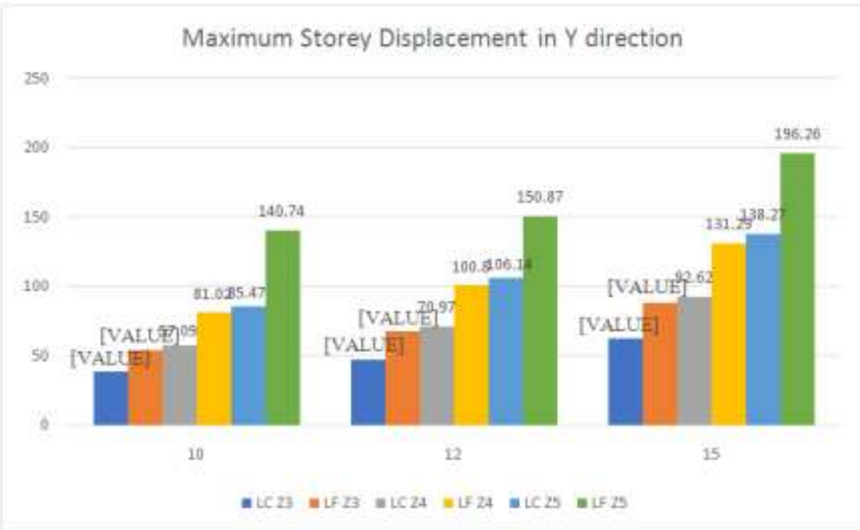


Fig.: Maximum Storey Displacement in all Seismic Zones

c) Maximum Overturning Moments

Fig: Maximum Overturning Moments in all Seismic Zones at all Stories

d) Maximum Storey Drift

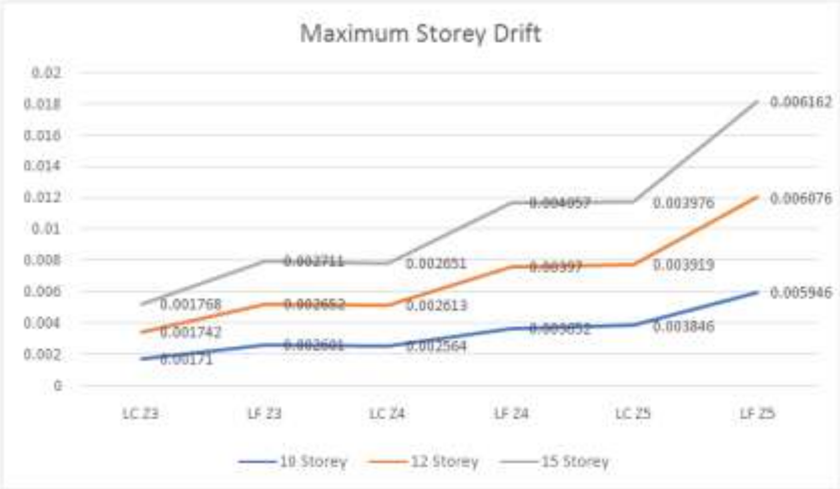


Fig: Maximum Storey Drift in all Seismic Zones at all Stories

V. FUTURE SCOPE

1) This study was done between flat slab with perimeter beams and conventional slab in future flat slab with perimeter beams comparison with drop and without drop can also be studied for all seismic zones.
2) This analysis was done using ETABS software further this could be done using various different available software also.
3) In future, analysis of flat slab structure with perimeter beams can be done while considering different soil types along with different seismic zones.
4) In this study, fixed supports are considered for the analysis of the structure. In the future, it can be extended for different support conditions.

VI. CONCLUSIONS

On the basis of above investigation and analysis of the results, following conclusions can be drawn here:

Conclusion based on Parameters

a) Maximum Reaction

It shows that if we increase the height of the structure from 10 story to 12 story as well as from 12 story to 15 story, observed value increases by an amount of 20% and 25% respectively in both Conventional and Flat Slab structures having Perimeter Beams.

b) Maximum Story Displacement

It shows that when we increase the height of the structure from 10 story to 12 story as well as from 12 story to 15 story, observed value increases approximately by an amount of 24% and 30% respectively along X and Y direction in both Conventional and Flat Slab structures having Perimeter Beams.

c) Maximum Overturning Moment

It shows that when we increase the height of the structure from 10 story to 12 story as well as from 12 story to 15 story, observed value increases by an amount of 20% and 25% respectivelyin both Conventional and Flat Slab structures having Perimeter Beams.

Conclusions based on Comparison between Conventional Slab Structure and Flat Slab Structure having Perimeter beams

a) Rectangular shape configuration

1. Maximum reaction shows 80% reduction in Flat slab structures having Perimeter Beams as compared to Conventional slab structure.
2. Maximum story displacement shows 46% increment along X direction and 60% increment along Y direction in Flat slab structureshaving Perimeter Beams as compared to Conventional slab structure.
3. Maximum Overturning Moment shows approximately 92% reduction in Flat slab structures having Perimeter Beams as compared to Conventional slab structure.
4. Maximum Story Drift shows 50% increment in Flat slab structureshaving Perimeter Beams as compared to Conventional slab structure.

b) L shape configuration

1. Maximum reaction shows 72% reduction in Flat slab structureshaving Perimeter Beams as compared to Conventional slab structure.
2. Maximum story displacement shows 50% increment along X direction and 41% increment along Y direction in Flat slab structureshaving Perimeter Beams as compared to Conventional slab structure.
3. Maximum Overturning Moment shows approximately 92% reduction in Flat slab structureshaving Perimeter Beams as compared to Conventional slab structure.
4. Maximum Story Drift shows 53% increment in Flat slab structureshaving Perimeter Beams as compared to Conventional slab structure.

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