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Performance of Different Dilatation Methods to Reduce the Effect of Seismic Loads

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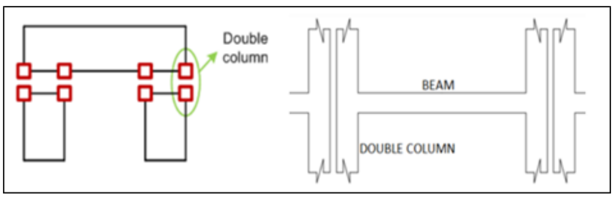
Abstract - *This paper summarizes the research work on adding certain disjoints to the building to convert it to regular building blocks thereby minimizing irregularity problem. Console beam, cantilever beam, Double Column and Gerber beam methods are the different types of disjoints we can apply to the building. For modelling and response spectrum analysis finite element package ETABS 2015 is used. All the calculations done on the work is as per IS codes*

***Key Words*: Dilatation, Irregularity, Beam and column modification, Separation gap, Pounding, Response Spectrum analysis, Torsion, Eccentricity, Stiffness**

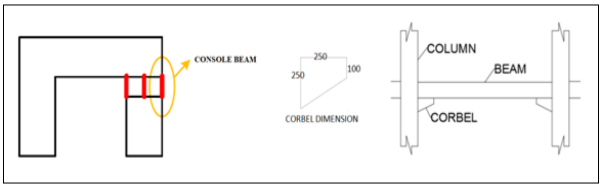
1. INTRODUCTION

Seismic deterioration of the buildings is mainly due to irregularity problem, low quality of material, reinforcement insufficiency etc. For minimizing the irregularity problem we can introduce certain disjoints to the building to convert it to regular building blocks. It is called Dilatation. For this purpose, the use of separation joints can be implemented by double column method even though the foundation may be the same. Console beam, cantilever beam, and Gerber beam methods are the different types of disjoints we can apply to the building without giving separation gap. Through Load Deflection curves we can assess the response of structure.

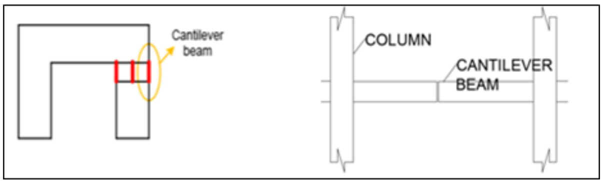
Double column method means providing extra column near the intersection. Console beam method means simply supporting the ends of beam in corbels. Cantilever beam method is providing cantilever beams in between the building blocks. In Gerber beam method, a small beam is simply supported in cantilever overhangs. Refer Figure 1



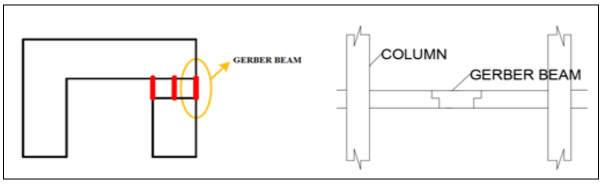
a) Double column method



b) Console beam method



c) Cantilever beam method



d) Gerber beam methods

Fig. 1. Dilatation methods

When two structures are close together, it is expected that they will pound against each other during the seismic activity. In order to mitigate this, sufficient separation gap should be provided. As per IS1893:2016-Part1 separation gap should be R times the sum of peak displacements of adjacent buildings where R is response reduction factor (Clause 7.11.1). If no space to provide sufficient separation gap, stitching of beams can be done between double columns using concrete or steel beams. Separation Joints in slabs are filled with elastic materials and then weather-proofed. All separation joints should be wide enough to accommodate differences in lateral movement between the two structures

2. SOFTWARE USED

***2.1* ETABS** *(Extended 3D (Three-Dimensional) Analysis of Building Systems).*:ETABS is a structural analysis and design software. It can be used for linear, non-linear, static and dynamic analysis and for the design and detailing of any type of building and its components.

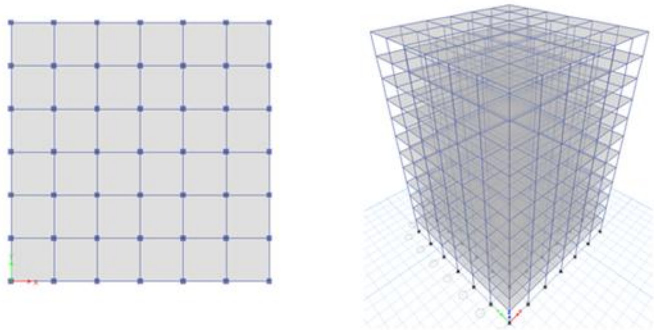
3. MODELLING

Table 1 shows different types of properties assigned in the models and Figure 2 shows the models created in ETABS 2015

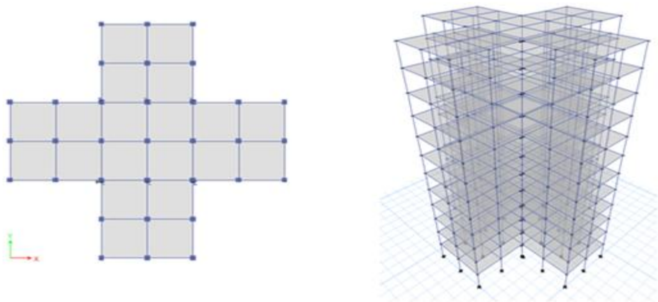
TABLE 1

Properties of the Model

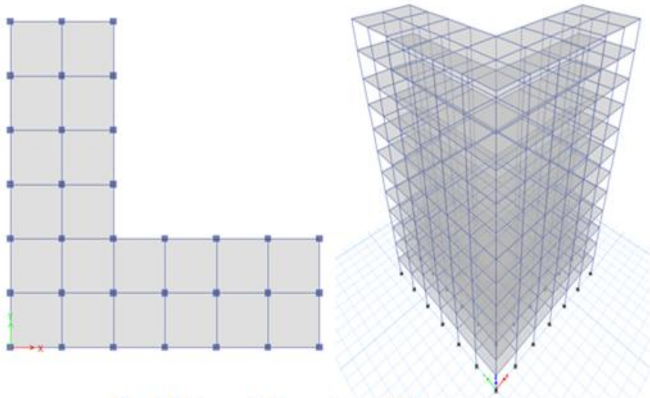
Sl No	Particulars	Data
1	Grade of concrete	M30
2	Grade of steel	HYSD 500
3	No. of storeys	12
4	No. of bays in x & y direction	6
5	Span of bays	4m
6	Beam size	230mmx500mm
7	Column Size	500mmx500mm
8	Slab thickness	120mm
9	Double Column	GAP element is modelled as linear inelastic link. Stiffness = 20 times stiffness of the building. Gap= R times sum of building displacements
10	Console Beam	Both sides of the beam provided as simply supported on the corbels projecting from the column. Corbels are modeled as rigid links
11	Cantilever Beam	Mid-portion of the beam is split with a gap of 10mm. Since the gap should be filled with flexible joint sealer, a flexible linear link is provided.
12	Gerber Beam	A small beam of length 1m is provided in between the beams projecting from the column



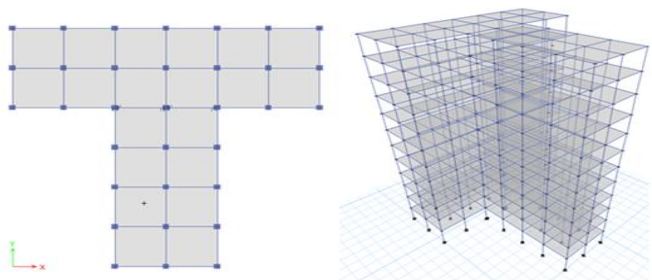
a) Plan and Model of square shape building



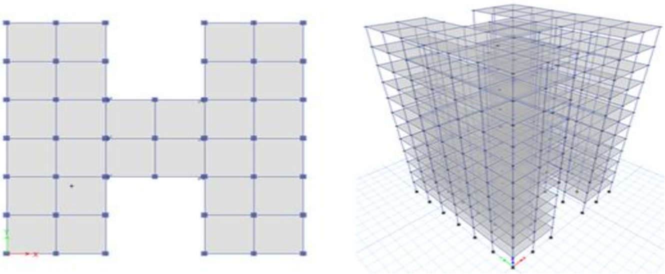
b) Plan and Model of plus shape building



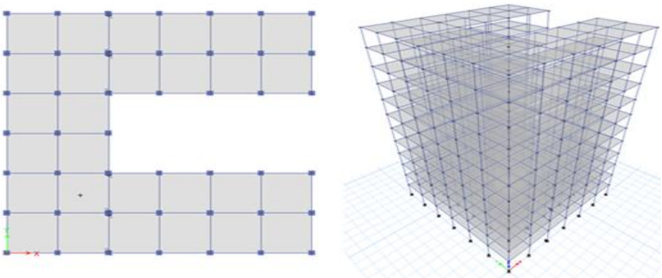
c) Plan and Model of L shape building



d) Plan and Model of T shape building



e) Plan and Model of H shape building



f) Plan and Model of C shape building

Fig. 2. Models created in ETABS 2015

4. RESPONSE SPECTRUM ANALYSIS

Response spectrum analysis is a linear-dynamic statistical analysis method which measures the contribution from each natural mode of vibration to indicate the likely maximum seismic response of an essentially elastic structure.

As per IS 1893:2018, the response reduction factor was taken as 5 for moment resisting frame and importance factor 1 for residential building and the damping ratio as 5% for rigid structure. The zone factor 0.16 was taken for the seismic zone 3. The response spectrum for the medium soil was used in the analysis

5. RESULT AND DISCUSSION

5.1 CHECKING FOR IRREGULARITY

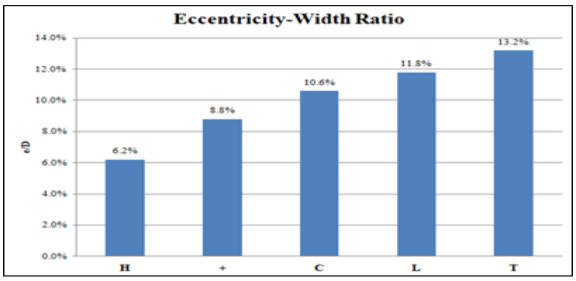


Chart -1 Plan Geometric Irregularity

As per IS 1893 (Part I): 2016, Horizontal Irregularity consist of horizontal geometric irregularity and torsional irregularity. Horizontal geometric irregularity exists when eccentricity to width ratio is greater than 15% and torsional irregularity exists when the ratio of maximum storey drift to average storey drift is greater than 1.2.

From chart 1 & 2, it is clear that Irregularity increases in the order H, +, C, L and T shaped building respectively

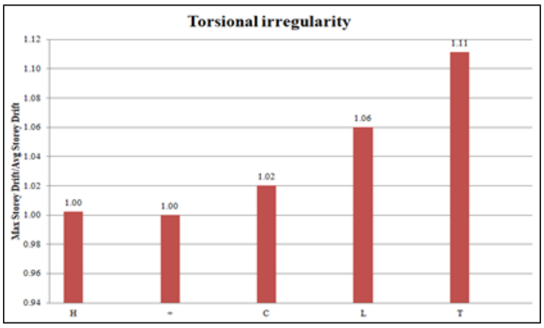


Chart 2 .Torsional Irregularity

5.2 TYPE OF OSCILLATION IN MODELS

From Table 2, we can see two types of special movements. The effect of these opening closing type and dog tail wagging type modes of oscillation induce high stress concentration at the re-entrant corners that may cause significant structural damage. So T-shape and Plus shape building cause more structural damage in high intensity earthquakes

TABLE 2

Types of Oscillation in Models

Modes	L	T	C	H	Plus
1	Y	Y+T	X	T	X+T
2	X	X+T	Y	Y	Y+T
3	T	T	T	X	T
4	OC	OC	OC	OC	OC
5	M	DW	M	M	DW
6	M	M	X	M	M

*X-Translation in X-direction
Y-Translation in Y-direction
T-Torsion
OC-Opening and Closing
DW-Dog tail Wagging

5.3 SEPARATION GAP IN DOUBLE COLUMN METHOD

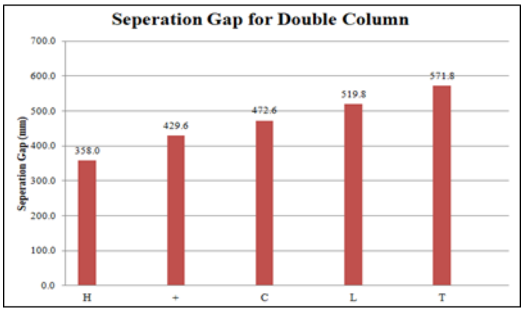


Chart -3 Separation gap

As buildings plan layout become irregular their resistance to seismic pounding decreases.

5.4 BEAM STITCHING IN DOUBLE COLUMN

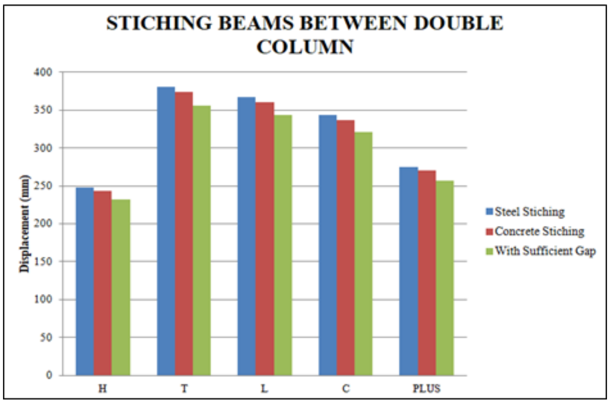


Chart -4 Stitching of beams

If no space to provide sufficient separation gap between double columns, stitching of beams can be done. Concrete Beam stitching reduces displacement about 5.2% and Steel beam reduce displacement about 5.8%. Stitching reduce deflection 1.8% more than giving minimum separation gap but it is not economical

5.5 OPTIMUM LENGTH OF GERBER BEAM

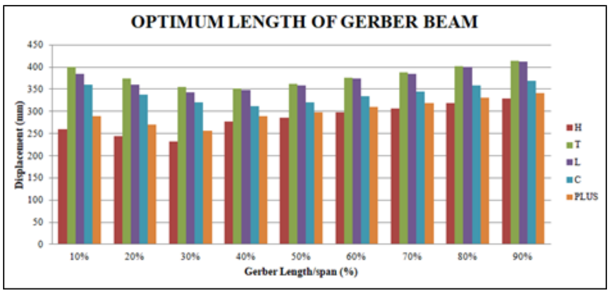
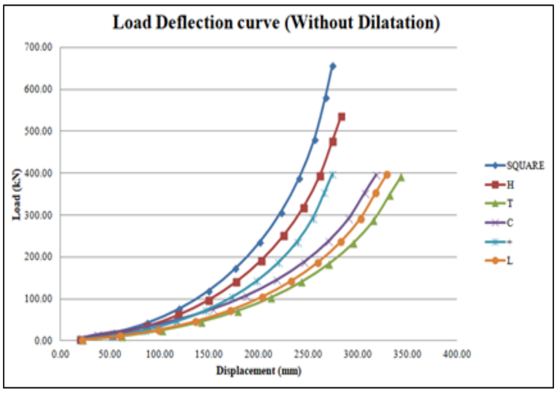


Chart.5.Optimum Length of Gerber Beam

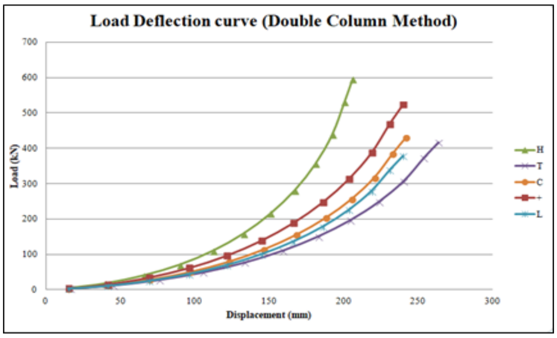
From the analysis, it is clear that optimum Gerber Beam length is 30-40% of the overall length of the beam

5.5 LOAD DEFLECTION CURVES

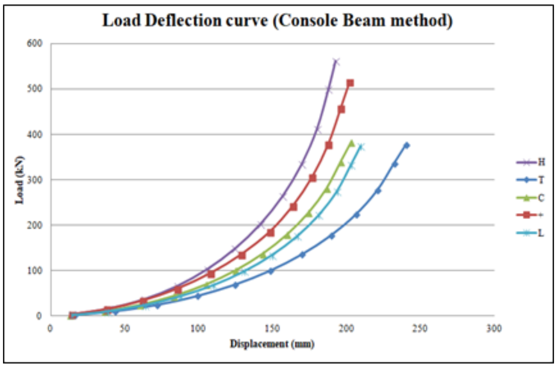
Using Double Column, Console Beam, Cantilever beam and Gerber Beam as disjoints, displacement decreases about 11.4, 13.2.8 and 9.2% respectively. Displacement increases in the order H, +, C, L and T



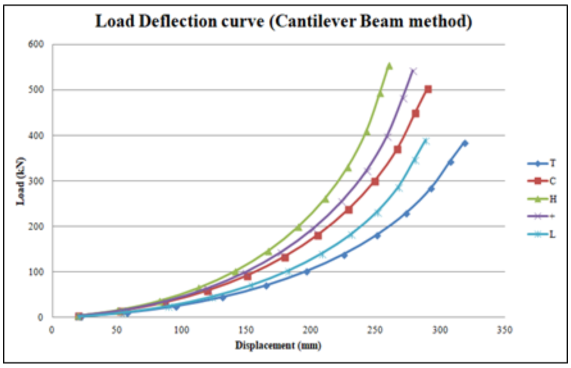
a) Without Dilation



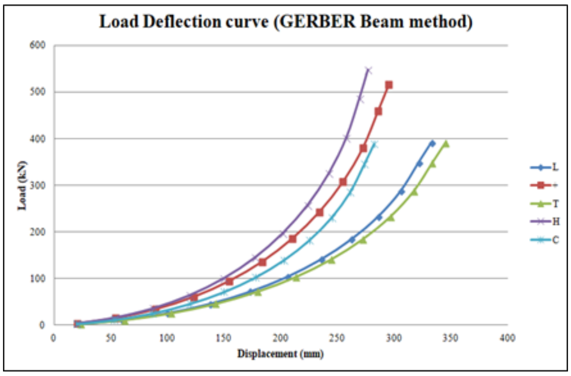
b)Console Beam Method



c) Console Beam Method



d)Cantilever Beam Method



e) Gerber beam Method

Chart.5. Load Deflection Curves

6. CONCLUSIONS

From the Response Spectrum Analysis of five types of plan irregular buildings it is clear that T-shape building experience more irregularity and displacement than H, L, C and Plus shape buildings.

From the analysis, it is clear that optimum Gerber Beam length is 30-40% of the overall length of the beam.

Concrete Beam stitching reduces displacement about 5.2% and Steel beam reduce displacement about 5.8%. Stitching reduce deflection 1.8% more than giving minimum separation gap but it is not economical.

As buildings plan layout become irregular their resistance to seismic pounding decreases.

The effect of these opening closing type and dog tail wagging type modes of oscillation induce high stress concentration at the re-entrant corners that may cause significant structural damage. So T-shape and Plus shape building cause more structural damage in high intensity earthquakes

When Dilatation applied to the buildings to mitigate irregularity problem, Console Beam Dilatation method performs very well in reducing displacement due to earthquake. Displacement increases in the order H, +, C, L and T shaped building respectively.

Using Double Column, Console Beam, Cantilever beam and Gerber Beam as disjoints, displacement decreases about 11.4, 13.2.8 and 9.2% respectively.

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