

A Study on the Effect of Partial Moment Releases on the Behaviour of Steel Structure

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ABSTRACT: A G+3 storey symmetrical steel model is designed. The entire structure is given partial moment releases. The study is carried out using STAAD pro. The percentage of moment release provided are 20%, 40%, 60%, 80%, 100%. The reduction in member forces and the required cross-sectional area for each section is computed and tabulated to find out the behaviour of the structure under varying moment release percentage as compared to that when no moment release is provided. This study is made with an attempt to find out the most economic percentage of moment release that can be provided to the steel structure.

KEYWORDS: Moment capacity, Partial Moment Release, Steel Structure, Symmetrical Structure.

I. INTRODUCTION

Moment resisting frames are among one of the most popular structural configurations used in different building structures in their versatility to provide open facades and continuous interior spaces. In order to fulfil the required seismic structural demands in high risk zones, moment resisting frames must provide sufficient stiffness, strength and ductility capacity during strong earthquakes. The beams to column connections definitely play the most vital role in providing the above-mentioned criteria. While the beams and columns are usually designed properly to satisfy the seismic demand, the beam to column connection should have the mandatory ability to transfer the seismic and gravity actions from beam to column and to maintain the structural integrity. In addition to the required rigidity level and the ultimate strength capacity, the rigid connections have to present an appropriate rotational ductility capacity to withstand nonlinear deformations imposed by strong earthquakes.

There has been extensive study done in the field of moment capacity of the joints and connections. The details on the behaviour of the steel structure under moment release are however, very vague. The Indian code does not provide a guideline pertaining to a certain percentage of moment release that would be useful in understanding the behaviour and requirement of the steel structure.

The present study deals with the application of moment capacity of the joints of the structure. The partial moment release given to a section transfers a certain percentage of the forces. This causes reduction in the design forces, thereby enabling the use of a section with a smaller cross sectional area. However, there is a need to understand the behaviour of the structure. The transfer of the released forces will lead to an increment in the design forces of other sections at that particular joint. Thus, this study focuses on finding the most economic percentage of moment release that will serve as a balance between beams and columns, and also, give overall structural economy of steel.

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II. OBJECTIVE OF THE STUDY

The main objectives in this paper are as follows

- To compare the structure with different moment releases on the basis of multiple parameters, they are
 - On the basis of the individual member forces of the entire structure
 - On the basis of the economy of the design of the beam section.
 - On the basis of the economy of the design of the column section.
 - On the basis of the overall economy of the entire structure.
- To plot a trend with the changing moment releases in order to obtain the behaviour of the steel structure that can be used as the basis for the further studies.
- To derive the optimum percentage of moment release using the obtained results.

III. MODELLING DETAILS

A G+3 storey steel moment resisting frame is modelled in STAAD pro. The sections chosen are from SP6, which are used and available in the industry. The loading is done according to IS 875 Part 2. The seismic loading is taken from IS1893 Part 1. The table 1 shows all the details of the model.

Plan	(18x18) m
Thickness of the slab	200 mm
Wall thickness	230 mm
Floor Height	3.5 m
Floor finish	1 KN/m ²
Live Load	5 KN/m ²
Dead Load	1 KN/m ²
Zone	Mumbai
Response Reduction Factor (R)	3

Table 1: Model Details

The load cases are taken according to IS800-2007. The entire loading and modelling details are carried in STAAD pro. The model is first optimised for the given loading to the minimal cross sectional area required to carry the forces.

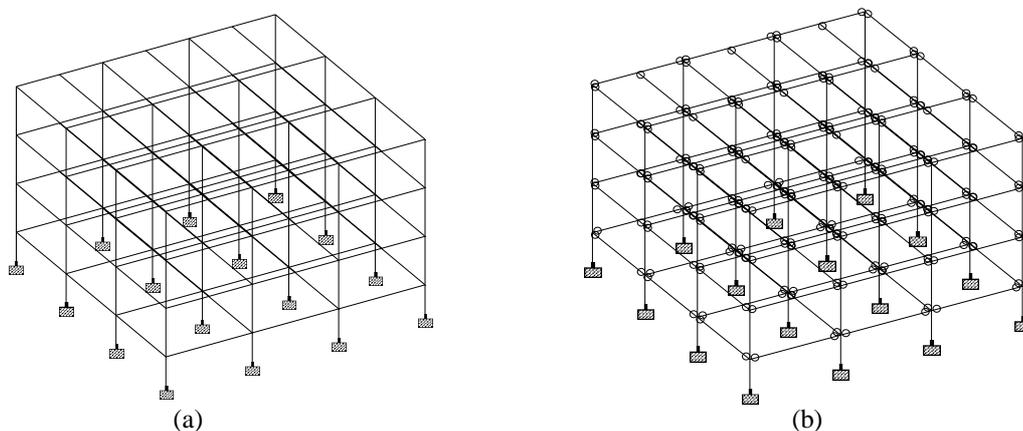


Fig.1 Isometric view of the model: (a).When the model is not provided with moment release. (b). When partial moment release is provided to the model.

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The model is then given partial moment release and similar procedure to optimise the model to the minimal cross sectional area is being done. The reduction in the member forces and the steel in beams and columns are calculated and tabulated. A comparison is then done with the varying moment releases and the original model. A graph is plotted with help of the obtained results.

IV. EXPERIMENTAL RESULTS

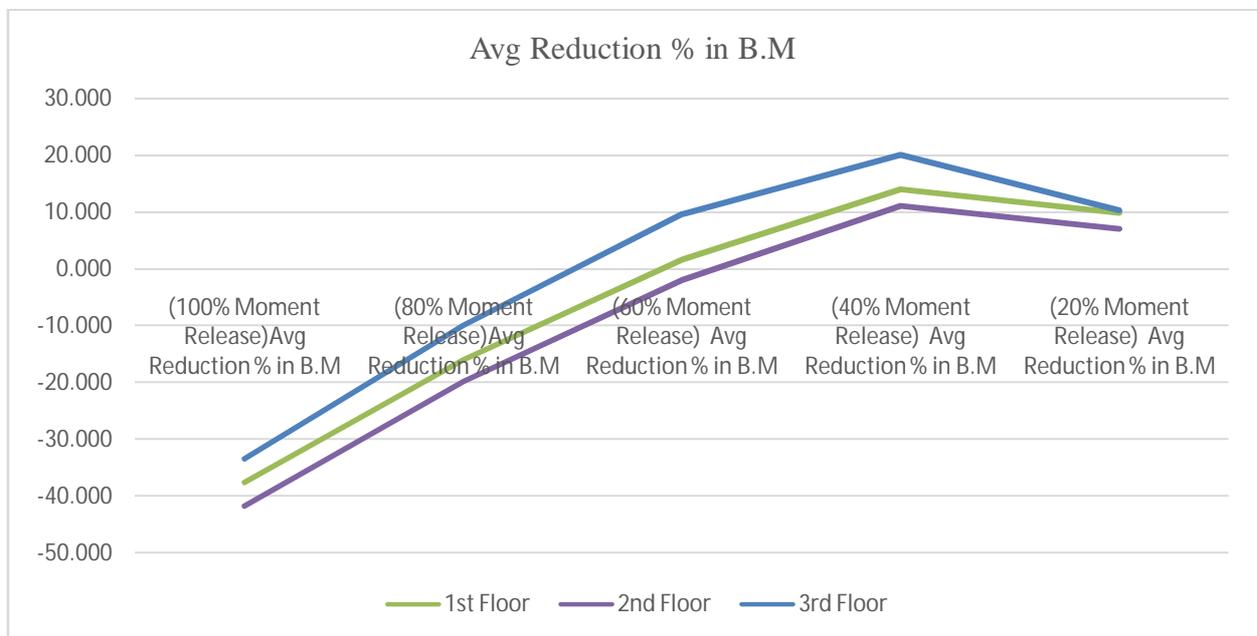


Fig.2. Average Reduction percentage in Bending Moment in End span Secondary beams.

It is observed from Fig.2 that there is a significant reduction in bending moment in secondary beams. The highest reduction being 20% occurring when 40% moment release is provided to the structure. A trend can be anticipated from the results that the reduction in B.M increases steadily as the moment release is increased until reaching a maximum point and decrease thereafter steadily.

Fig3. Shows the graph for the behaviour of the shear forces in the secondary beams. It can be observed that the reduction is not high. The shear force in a member increases with the increase in the moment release provided to the structure.

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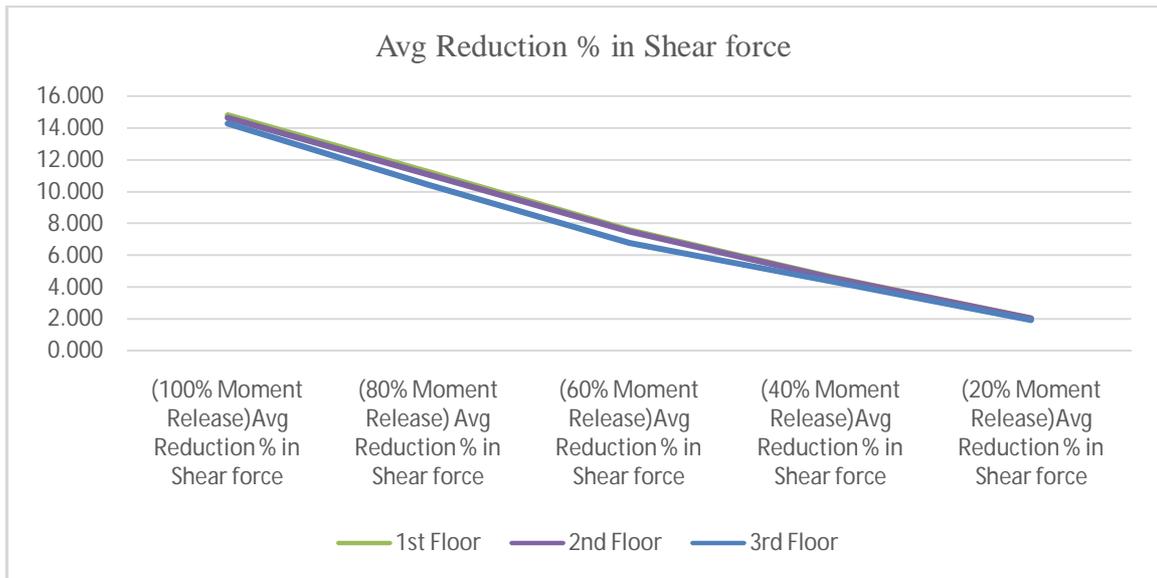


Fig.3. Average Reduction percentage in Shear force in End span Secondary beams

Fig.4. shows the graph plotted on the behaviour of reduction in B.M in the intermediate peripheral beams along the X- direction. It can be observed that the reduction is negligible and there is a steady increase in the bending moment in those members with the increase in the moment release.

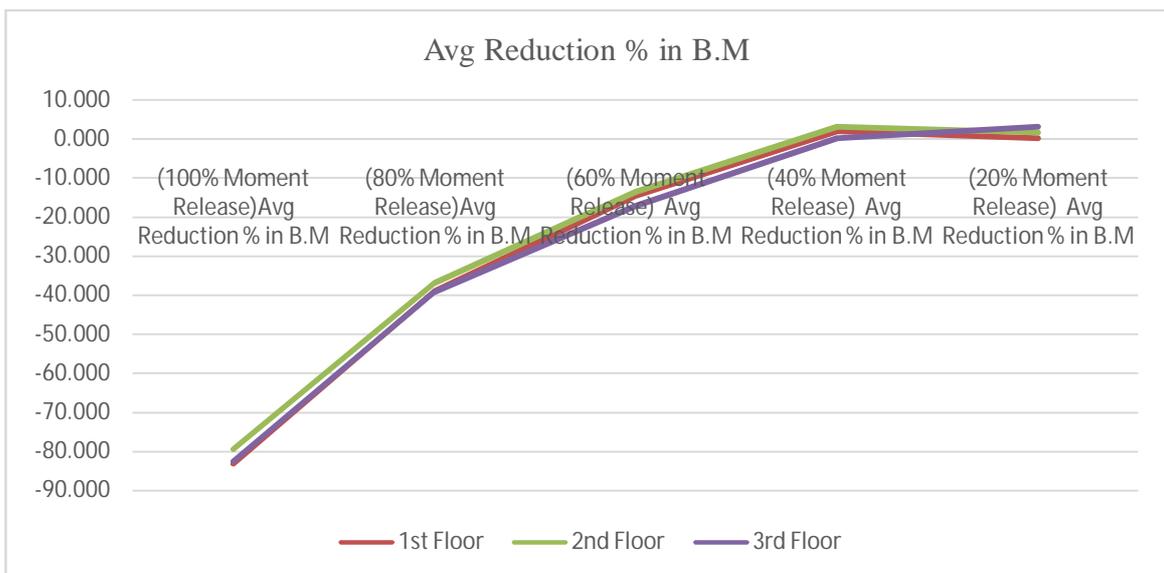


Fig.4. Average Reduction percentage in B.M in intermediate peripheral primary beams along X-direction

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Fig.5 shows the graph plotting the shear force reduction behaviour in the intermediate peripheral beams along X-direction. In case of primary beams, there is an increase in the shear force with the increase in the moment release. The end span peripheral beams along X-axis and the mid span intermediate beams along Z-axis show an increase in the shear force

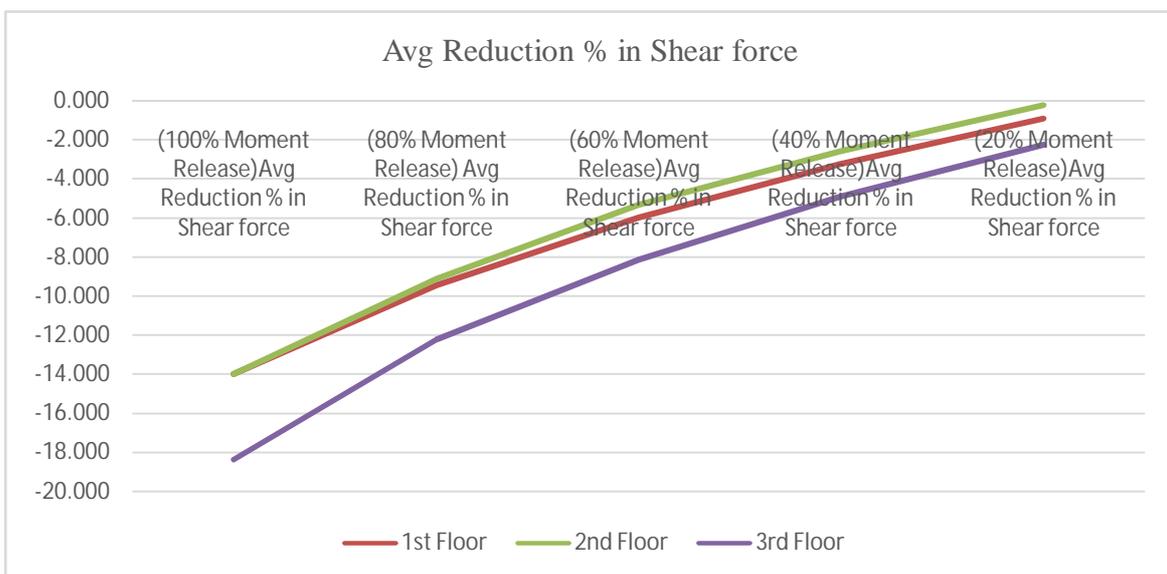


Fig.5. Average Reduction percentage in Shear force in intermediate peripheral primary beams along X-direction.

Fig.6. shows a graph plotted for the behaviour of reduction of the axial forces in Intermediate columns along X direction. It can be observed that the axial forces in columns increase with the increase in the moment release.

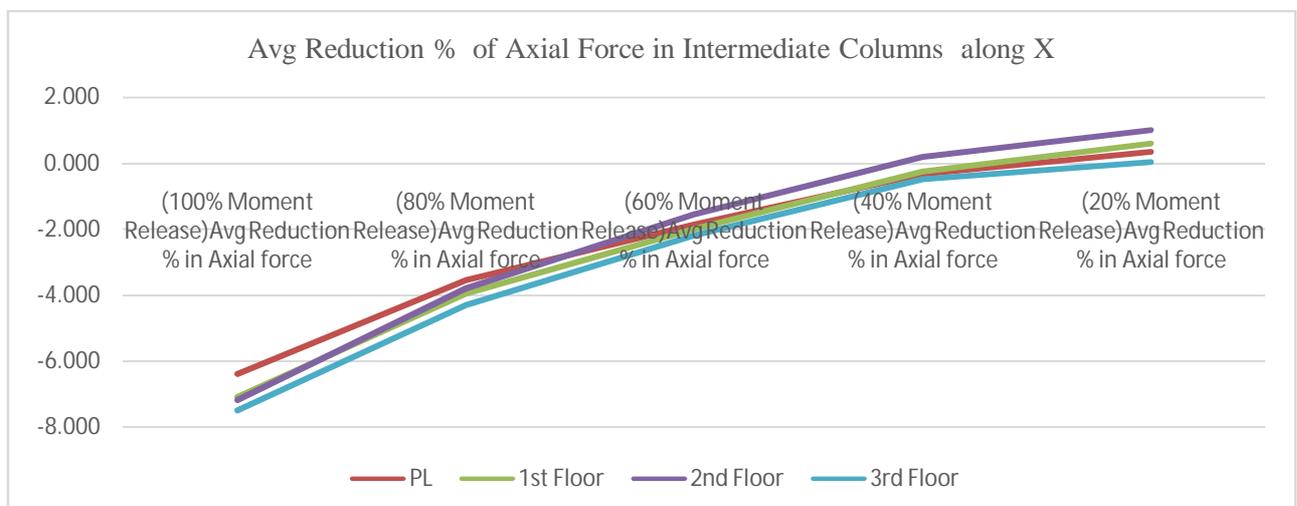


Fig.6. Average Reduction percentage in axial force in Intermediate columns along X-direction.

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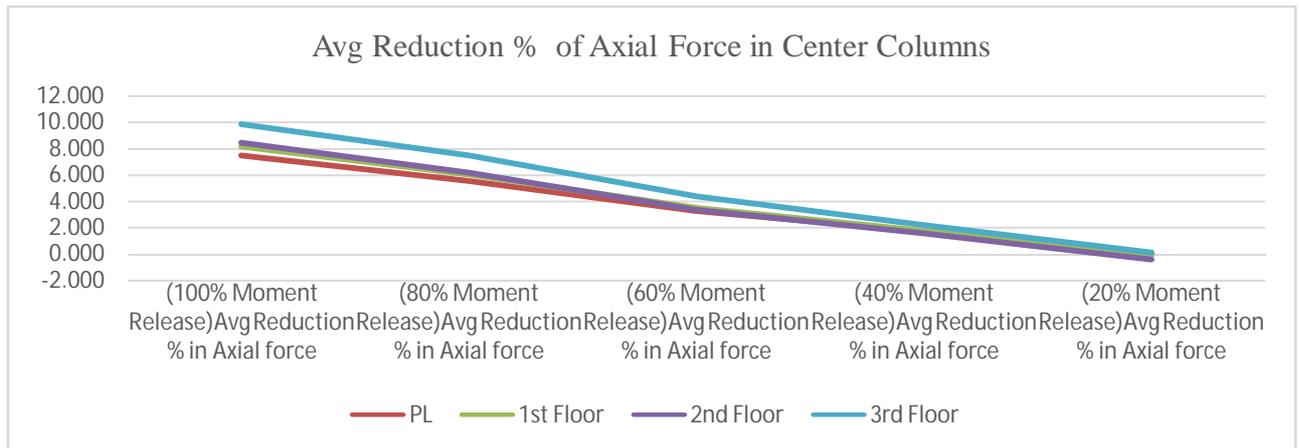


Fig.7.Average Reduction percentage in axial force in Centre Columns.

Fig.7. shows a graph plotted for behaviour of reduction in axial forces in the centre columns. It can be observed that for the centre columns, the axial force decreases with the increase in the moment release provided.

Table.2 shows the tabulated economy of the steel tonnage in beams, columns and the whole structure with varying moment releases provided. It can be observed that the highest reduction in column steel takes place at 80% moment release which is 26.33%. For beams, highest reduction takes at 40% moment release. The economy is compared with the model when no moment release is provided.

Moment Release %	Column steel (Tonnes)	% Reduction in Column Steel
100.00	27.12	-23.08
80.00	16.23	26.33
60.00	17.80	19.24
40.00	19.08	13.43
20.00	19.08	13.43
0.00	22.04	0.00

(a)

Moment Release %	Beam steel (Tonnes)	% Reduction in Beam Steel
100.00	79.72	-22.90
80.00	67.92	-4.70
60.00	64.29	0.89
40.00	61.66	4.94
20.00	63.12	2.69
0.00	64.87	0.00

(b)

Moment Release %	Total steel (Tonnes)	% Reduction in Total Steel
100.00	106.84	-22.95
80.00	84.15	3.16
60.00	82.09	5.54
40.00	80.74	7.09
20.00	82.20	5.41
0.00	86.90	0.00

(c)

Table 2. (a.) Economy of column steel. (b.) Economy of beam steel. (c.) Economy of steel of Whole structure.

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V. CONCLUSION

From the results and graphs put forth in this paper, following set of conclusions can be made

- As the stiffness of the member section is changed in every iteration for optimising the section, the actual behaviour of member forces with changing moment releases cannot be plotted.
- The bending moment in beams show the highest reduction at 40% moment release.
- The axial forces in columns increased with the increase in the moment release.
- The structure had the most reduction in steel tonnage of 7.09% at 40% moment release. Thus, the most economic moment release percentage is at 40%.

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