EFFECT OF VARIATION IN STIFFNESS OF TRANSFER GIRDER ON STIFFNESS OF FRAME FLOATING FROM IT

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Abstract-

Most of the international codes requires uniformity of the stiffness in the frame to resist lateral forces. I.S.1893 :2016 (Part 1) (Sixth Revision) requires equal or more stiffness of lower storey than the storey above. For the ease in vehicular moments often basements are made column free and the columns of above structure are floated from transfer girders as per planning requirement. An analytical study is made here to understand variation of stiffness of frame in accordance with variation of stiffness of transfer girder through which it is floated from. Results indicate the soft storey condition of a frame founded from foundation remains unchanged when the same frame is floated from transfer girder with variation in stiffness of transfer girder and placement of frame on it.

***Keywords*—- I.S. 1893: 2016, I.S. 1893: 2002, Lateral Stiffness, Soft Storey, Transfer Girder, Floating Columns.**

Introduction

Most of International codes guide to avoid vertical
irregularity such as soft storey condition in the structure as soft storey is subject to severe deformation during seismic episode demanding high strength and ductility in design. I.S. 1893: 2016 has become more demanding of uniformity of stiffness along the height of structure than what it allowed in its previous version of I.S. 1893: 2002 i.e., lateral stiffness of a storey to 70% of lateral stiffness of storey above or 80% of the average lateral stiffness of the three storeys above.

In the metro cities like Mumbai, as per development control rules certain number of parking has to be provided in proportion to the built-up area of the building. Sometimes, to accommodate this requirement, avoid this, such columns are floated from transfer girder. Ref. Fig.1

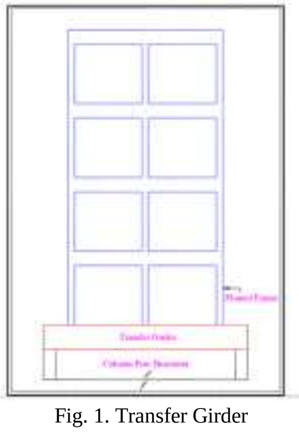

Fig. 1. Transfer Girder

The introduction of transfer girder introduces irregularity of lateral stiffness in the vicinity of its level. This may bring in soft storey formation under lateral loads and requires high ductility in the elements in the vicinity of transfer floors(Zhangand Ling[14], Abdelbasset et al.[1]). Thus, during design stages, such irregularities should be taken into consideration to resist it to become a major source of building damage.
The flexural stiffness and strength of the transfer girder car parking towers, parking pit, podiums and basements are proposed. In case of basements the columns of the buildings come in between basement floor are and some columns may obstruct the movements of vehicles. To
is higher than the columns or shear walls of upper structure floated from it. Transfer girders are usually idealized as deep beams. However, local flexural rotations of transfer girder do exist and it cannot be ignored. Variation in

stiffness of transfer girder and end support condition of transfer girder may affect the stiffness of frame floated from it. Also, placement of frame on transfer girder, can create differential settlement in the frame under gravity and lateral loads bringing large ductility demand and increase in strength requirements. This aspect is not clearly addressed by the code and hence a systematic analytical study of effect of variation in stiffness of transfer girder on stiffness of frame floating from it is made.

ANALYTICAL MODELDESCRIPTION

Model M - – Four Storey, Bare Frame having single bay span of 4.8m, with each storey height of 3.6m. The cross-section of columns at every storey and beams at all floor levels is kept constant as 300mmx600mm. All members are considered having same Modulus of elasticity of concrete. Supports of frame are taken as fixed base on ground. Ref. Fig.2

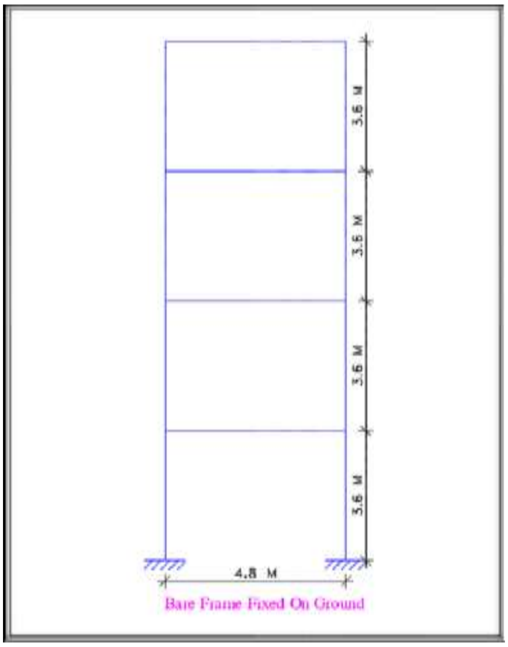

Fig.2. Model M

Model M1 **–**This model is similar to Model M but **t**he frame is placed centrally on a transfer girder having span of 9.6m. The connection between the frame columns and transfer girder is considered as rigid connections. Ref. Fig.3.

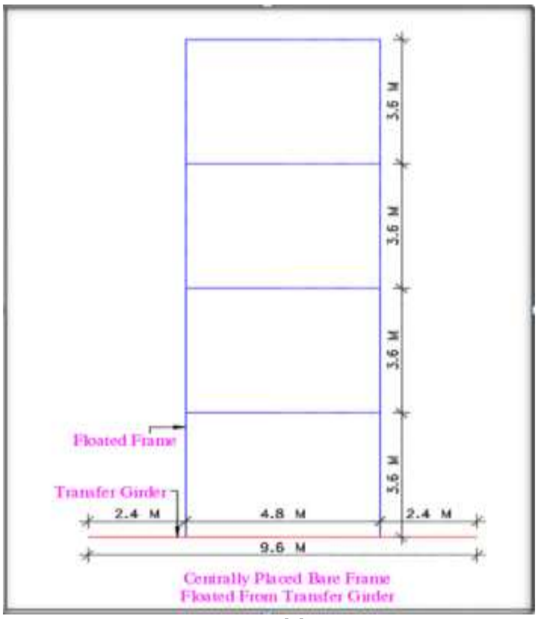

Fig.3. Model M1

Model M2 **–** This model is similar to Model M1, with addition of 230 mm thick concrete block wall in top 3 storeys only. First storey is kept open. Refer Fig. 4.

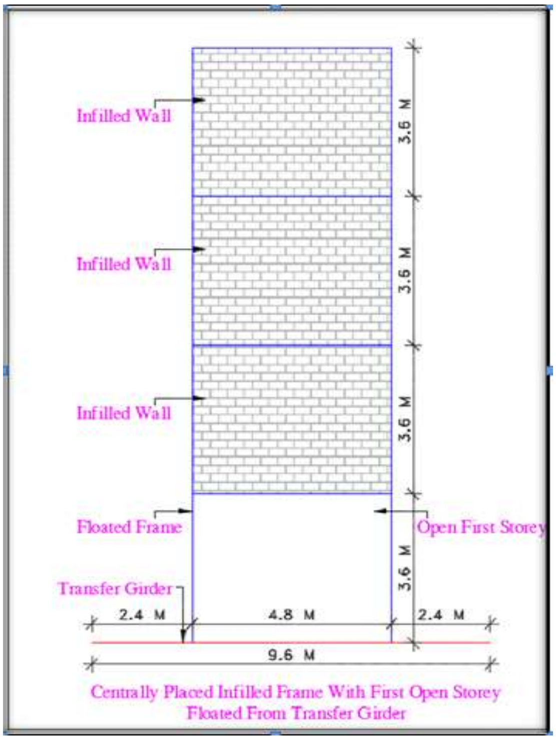

Fig.4. Model M2

For both the models M1 & M2, transfer girder depths were varied as 1000 mm, 1500 mm and 2000 mm. The support conditions for transfer girder were kept pinned and fixed for each of these variation in depth of transfer girder.

For the models M, M1 and M2 the graphs for floor level deflections w.r.t. floor level was plotted. Also graphs of stiffness of 1st storey to percentage ratio of stiffness of 1st storey to stiffness of 2nd storey and also graphs for stiffness of 1ststorey to the percentage ratio of stiffness of 1ststorey to average of stiffness of 2nd, 3rd and 4th storey were plotted.

Model M3 - This model is similar to Model M1, except that now the frame is placed eccentrically on transfer girder with left leg of frame spaced at 1.2m from left end of transfer girder. Refer Fig.5.

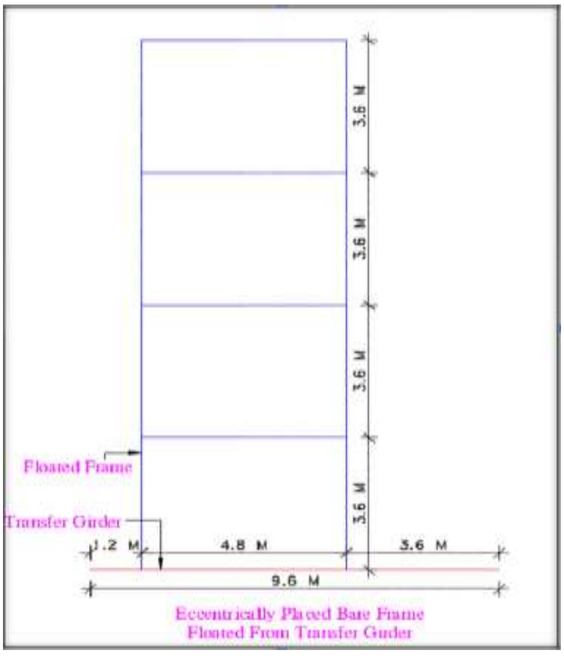

Fig.5. Model M3

The support condition of the transfer girder was kept pinned for both the models Model M1 & Model M3 and the depths of transfer girder, were varied as 600mm, 800 mm, 1600 mm, 2400 mm, 3200 mm, 4000 mm & 4800 mm.

For the models M1 & M3, the graphs for stiffness of 1st storey to deflection under columns of frame and difference of deflection under column of the frame were plotted.

I. OBSERVATIONS FROMRESULTS

1. From the graphs G1 & G2 for Model M1 and the graphs G3 & G4 for Model M2, it is seen that,

- The deflections of all floor levels go on decreasing as the stiffness of transfer girder is increased. However, these deflections are not less than that of frame founded on foundations. As the deflections of frame floated from transfer girder were more, the stiffness of the fame was lesser than that of the frame founded on foundations.
- As the support condition of transfer girder is changed from pinned support to fixed support, the deflections of all floor levels go on decreasing, yet these deflections are not less than that of the frame founded on foundation.
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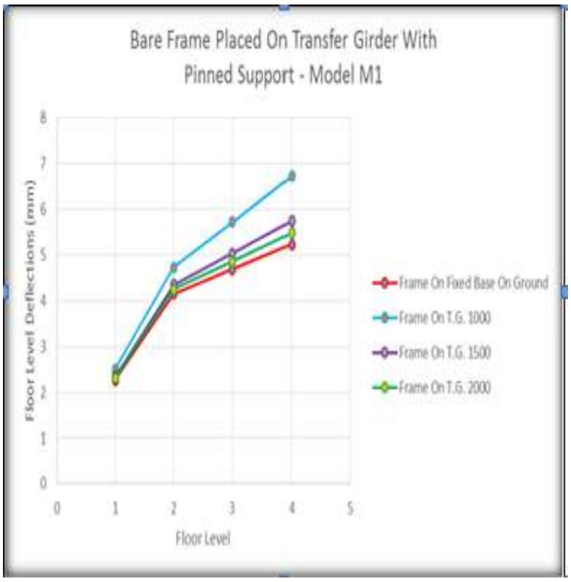

Fig. 6. Graph G1

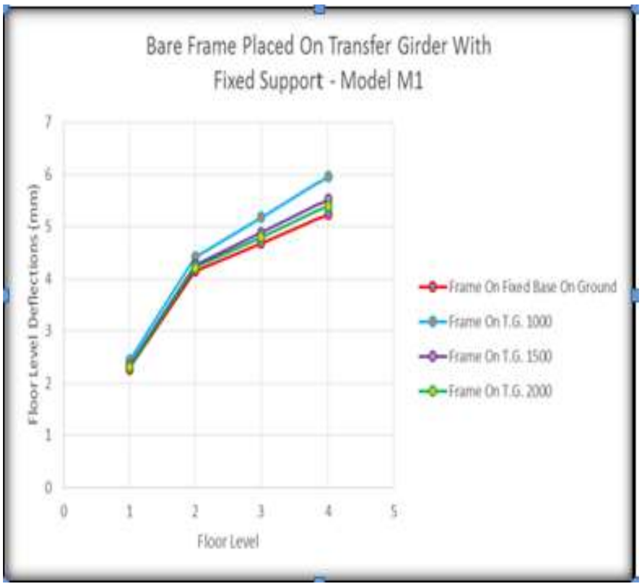

Fig. 7. Graph G2

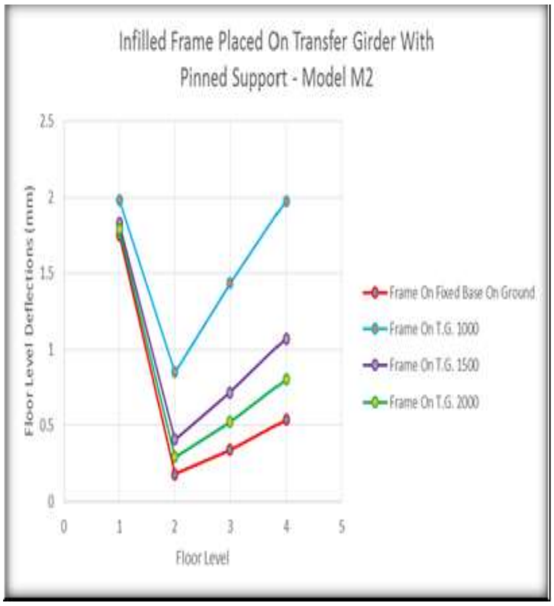

Fig. 8. Graph G3

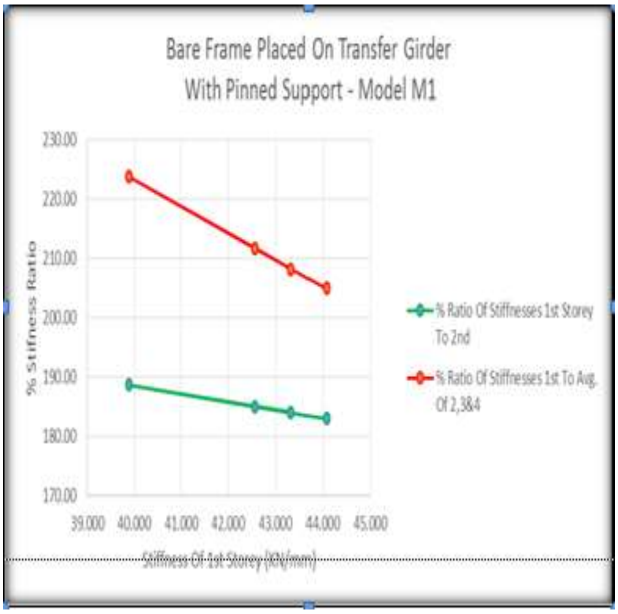

Fig. 9. Graph G4

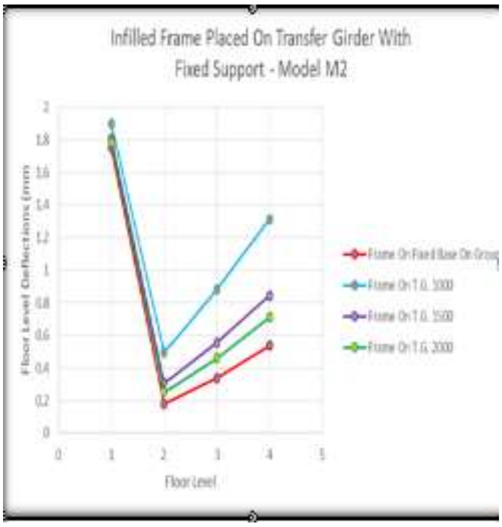

Fig. 10. Graph G5

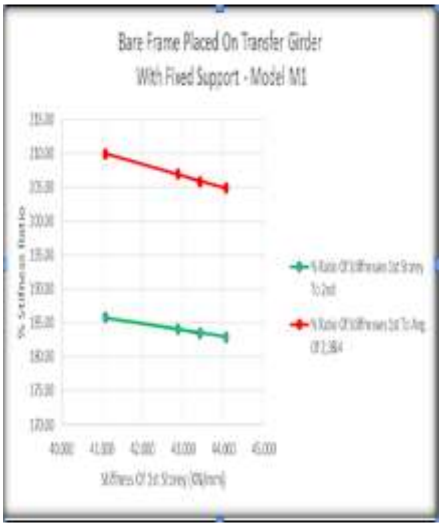

Fig. 11. Graph G6

2. From the graphs G5 & G6 for Model M1 and the graphs G7 & G8 for Model M2, it is seen that,

- The percentage ratio of stiffness of 1ststorey to stiffness of 2ndstorey goes on decreasing as the stiffness of transfer girder is increased. However, it is not less than that for the frame founded on foundations.
- The percentage ratio of stiffness of 1ststorey to average of stiffness of 2nd, 3rd and 4thstorey goes on decreasing as the stiffness of transfer girder is increased. However, it is not less than that for the frame founded on foundations.
- The soft storey condition of the first storey remains unchanged irrespective of the variation of stiffness of transfer girder.

From both points mentioned above, it is clearly observed that, the variation in stiffness of transfer girder affects the stiffness of frame as a whole and not to stiffness of any particular storey only.

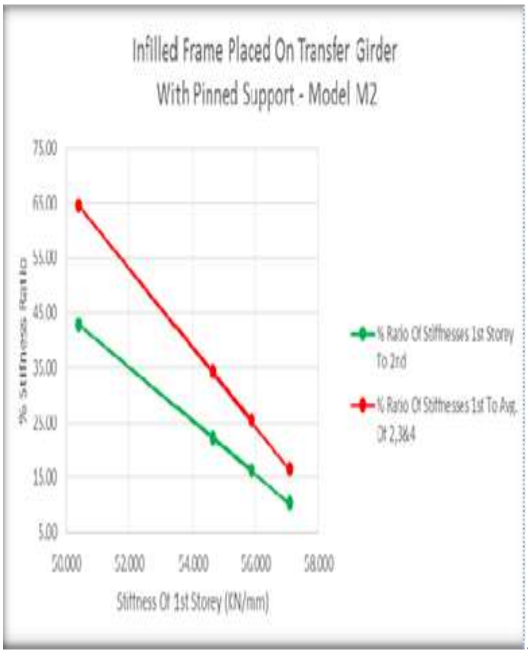

Fig. 12. Graph G7

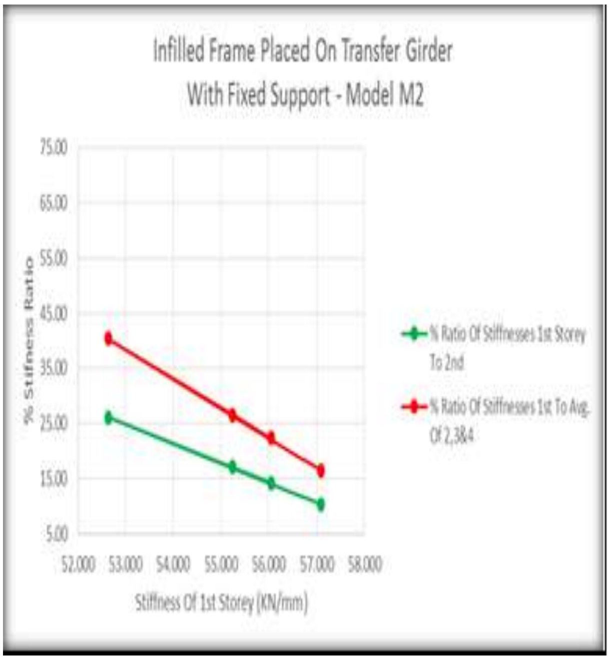

Fig. 13. Graph G8

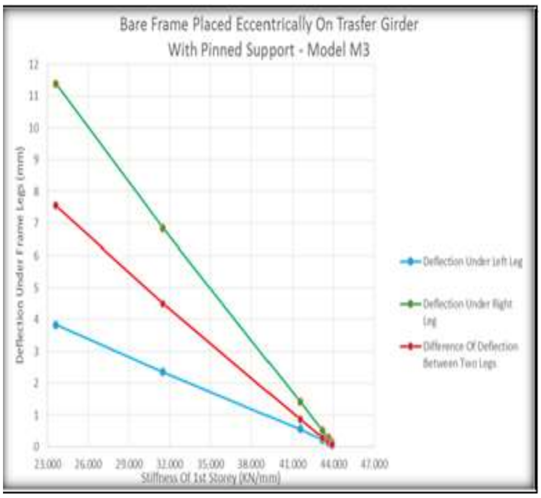

Fig. 14. Graph G9

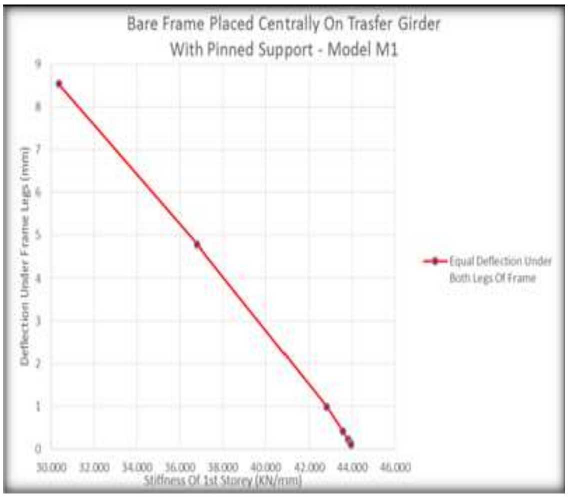

Fig. 15. Graph G10

3. From the graph G9 for Model M1 and the graph G10 Model M3, it is seen that,

- For the frame placed centrally on transfer girder, the deflections under both legs of frame are same. The deflection under both legs of frame goes on reducing as the stiffness of transfer girder increases. However, the difference of deflection under both legs remains zero. This indicates, the stiffness of the frame is affected by the variation in stiffness of transfer girder only.
- For the frame placed eccentrically on transfer girder, the deflections under both legs of frame are different. The deflection under both legs of frame goes on reducing as the stiffness of transfer girder increases. Also, the difference of deflection under both legs goes on reducing as the stiffness of transfer girder increases. This indicates, the stiffness of the frame is affected by the variation in stiffness of transfer girder and also difference in deflections of transfer girder at the points under the legs of the frame.
- For the very high stiffness of transfer girder, the stiffness of frame placed eccentrically is almost equal to that of the frame placed centrally, as the difference of deflection under both legs of the frame goes on reducing towards zero.

CONCLUSION

1. When a frame, bare or with in filled upper storey, is floated from transfer girder, it will have larger deflections and lesser lateral stiffness than the same frames which are supported on foundations. Since frames floated from transfer girder may bring condition of soft storey, the revised I.S. 1893: 2016 rightly restricts to take floating columns as part of lateral load resisting system.
2. A frame on independent foundation, if has a soft storey condition, it remains unchanged when the same frame is floated from transfer girder irrespective of variation in stiffness of transfer girder. This is because these variations of stiffness of transfer girder due to change in its sizes or end support condition, affects the stiffness of frame as a whole and not to stiffness of any individual storey only.
3. Unlike the stiffness of the frame placed centrally and is directly affected by variation in stiffness of the transfer girder, the stiffness of the frame placed eccentrically is affected by both, the variation in stiffness of the transfer girder and the difference of deflections of the transfer girder at the points under the legs of frame. However, for very stiff transfer girder the later stiffness of frame placed eccentrically is almost equal to the frame floated centrally.
4. If frame is modeled along with the transfer girder, the advantage of lesser stiffness of frame can be taken to increase natural period of vibration and attract reduced forces under earthquake episode.

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