Buckling Analysis of RC Framed Structures With and Without Bracings

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Abstract - *In general, concrete braced reinforced concrete frame is one of the structural systems used to resist buckling loads and buckling of multi-storey structures. The use of concrete bracing systems for strengthening buckling inadequate reinforced concrete frames is a viable solution for enhancing buckling resistance. Concrete and steel is economical, easy to erect and flexible to design for meeting the required strength and stiffness. A numerical method for the solution of the elastic stability of fixed frames is presented and the procedure to perform elastic buckling analysis for frame in use computing buckling loads and buckling modes in frames with fixed columns.*

In this study buckling analysis of reinforced concrete building with different types of bracings V, inverted V, X, Diagonal and K type, bare frame, P-Delta effect, slenderness ratio, and shear walls studied. The method is illustrated in detail for different cases of single storey, three storey, five storey and ten storey buildings is analysed for buckling using ETABS, one and three storeys buildings is analysed for buckling using ANSYS software. Comparing the both software's values, the bracing system improves not only the stiffness capacity but also the buckling of the structure. The main parameters considered are buckling factor, p-delta effect, slenderness ratio and shear wall.

***Key Words*: Buckling analysis of the structure using ETABS and ANSYS, performance of slenderness ratio, shear wall, P-delta, stiffness, Bracings.**

1. INTRODUCTION

Buckling concept of restrained braces was first introduced by Wakabayashi in 1973. Buckling can be defined as The basic concept of critical buckling load Pcr the structure encounters sudden failure when subjected to compressive load and its length requests of size are greater than both of its separate measurements such a column is known as a section. we can see there are 2 types of the frames regard to side sway where side sway prevented and frames with side sway permitted. In first type of the frame The buckling takes place when the applied load P is equal to critical Pcr columns, and at the top end column is flexibly limited by beam to which the column is firmly associated, and the critical load of the section depends not only on the column stiffness, additionally depend on rigidity of the beam.

1.1 Bracings

Different Story's are selected like one-storey, three-storey, five-storey and Ten-storey three bays frames was chosen and five different bracing patterns and locations were selected. Frame was modelled at Bay width as 4m and storey height as 3.5m. Bracing patterns include single Diagonal, double diagonal (X), Chevron inverted V, K and V bracings.

1.2 Shear wall

For resistance of the earthquake forces shear wall frames and concrete braced frames structural systems used. Generally Reinforced Concrete shear walls have been used as main lateral load opposing framework in medium & tall structures on account of their high lateral unbending nature.

1.3 Slenderness ratio

Slenderness ratio is the proportion length of a column and minimum range of gyration of its cross area shaped by a plane. If the slenderness ratio is smaller than (kl/r) min failure happens by crushing. If the slenderness proportion is more than (kl/r) min failure happens by buckling, deflection load or stress diminishing for more slenderness.

1.4 P-Delta

They are second order impacts which increases raise the deformations, member's method for movement and extend the effective fundamental period of the structure. P-delta effects in structure may be restrained by increasing its sidely rigidity, increasing its strength or by combining of those two.

2. MODELLING

When considering the present study, an attempt is made to quantify the influence of Buckling analysis of RC framed structure With bracing and Without bracing. and its possible to strengthen using shear wall, slenderness ratio, P-Delta effect and stiffness. For this purpose typical 1,3, 5 and 10 storey structures are modelled & analysed using ETABS and ANSYS software.

Table -1: Structural details of the model

Number of storey	1,3,5 and 10
Storey height	3.5m
Number of Bays	3 bays in both directions
Spacing of Bays	4 m in both direction
Beam Size	230x450 mm
Column size	500x500 mm
Bracing size	300x300 mm
Grade of Materials	M25 and Fe 500
Slab Thickness	150mm
Load Considered (Dead load + Floor finish + Live load)	8.2 kN/m²

2.1 Using ETABS Software

The bare frame models considered are described as following

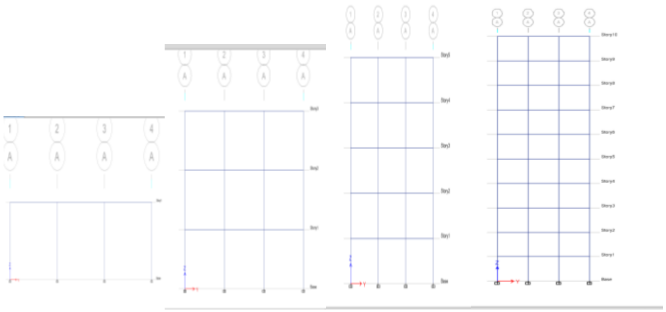

Fig-1 Shows models of Regular building without bracing 1, 3, 5 and 10 storeys structures.

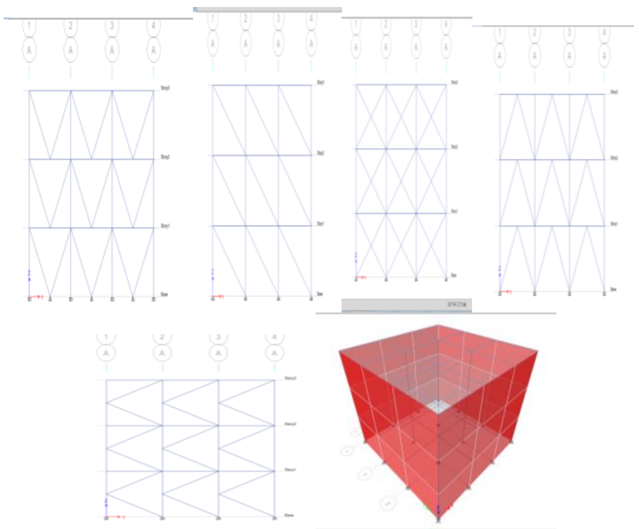

Fig-2 Shows models of Regular building with bracing 1, 3, 5 and 10 storeys structures, and 3D model of shear wall.

The analysis is carried out for the bare frame as well as for the braced frames by considering X, V , K, Diagonal,Inverted V type bracing, slenderness ratio, shear wall, Stiffness and p delta effect for the same model configuration described above. The regular building elevation views with different types of bracings are shown.

2.2 By using ANSYS

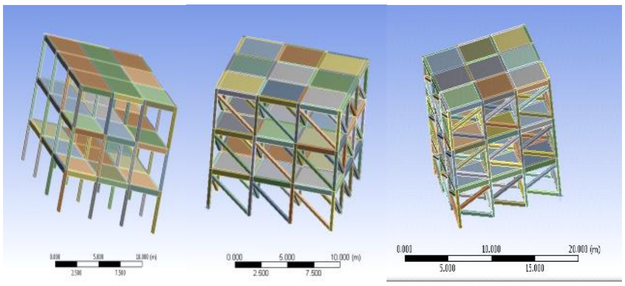

Fig-3 Bare model, Diagonal, K type bracing models using Finite element method by using ANSYS Software.

Similarly models are prepared for the 1, 3, 5 storeys and 10 storeys. A finite element buckling study determines the lowest buckling factors and their corresponding buckling modes.

The bare frame models of 5 different configurations such as Regular, one, three, five and ten are analyzed. Later X, V, Diagonal, V, Inverted V and K bracings are applied to strengthen the structures. The results are compared for structures with and without bracings for 3 storeys structures of all models. The results are basically compared to find which type of bracing will be more effective for different regular structures.

- **Buckling Analysis of frames**

Analytic buckling studies identify additional classes of instability besides Euler buckling. They include lateral buckling, torsion buckling, and other buckling modes. A finite element buckling study determines the lowest buckling factors and their corresponding modes.A buckling, or stability, analysis is an Eigen problem. The size of the scalar Eigen value is known as the "buckling load factor". The processed displacement Eigen vector is referred to as the "buckling mode" or mode shape.

The results of analysis compared include P-delta, slenderness ratio, Stiffness and Buckling of the structures with bracing and without bracings.

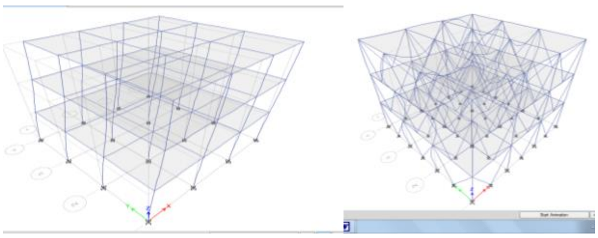

Fig-4 3D models of buckling modes (first buckling modes of models with bracing and without bracings)

Similarly buckling modes for diagonal, X, K, Inverted V type of bracings for different stories.

2.3 Buckling modes of 3 storey structures by using ANSYS

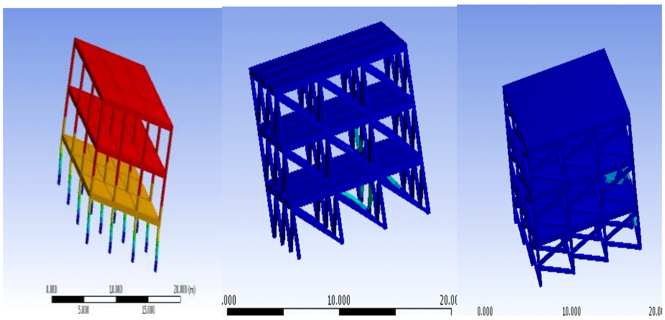

Fig-5 first buckling modes of 3 storey structures

Table-2 Variations of buckling modes values for 3 strorey structures.

Bare model	X	Diagonal	K
61.888	327.27	206.96	347.24

Results of the buckling analysis were compared between the ETABS and ANSYS the variations of buckling factor for bare model 38%, X bracing 22%, K bracing 17% and diagonal bracing 39%. The average difference between both software values is 25%.

Similarly the buckling factor results are calculated for one, five and ten storey by using ETABS and buckling factor is calculated for one and three storey using ANSYS.

2.4 Graphical representation of buckling factor values

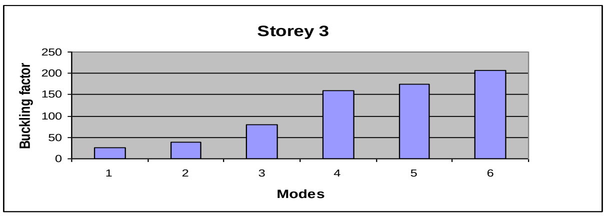

Fig- 6 Buckling modes v/s Buckling factor

Table-3 Buckling factor values for storey 3

Buckling mode	1	2	3	4	5
Storey 3	26.686	38.557	79.223	160.2	175.06

The columns sizes for three storey structures considered C300x300. The above graphs shows variations of buckling factor for different modes. Number of stories increases the buckling factor goes on decreases.

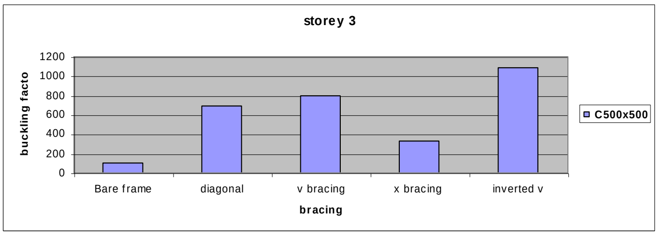

Fig-7 bracing v/s buckling factor.

Table-4 Variations of buckling modes values for 3 storeys. for different bracings by using ETABS software

Bare	Inv V	V	X	Diagonal	K
100.753	942.67	369.979	421.508	726.077	286.075

Type of bracing system as lateral load resisting system, material of bracing system also increases the stiffness and ductility of the structure. Bracing system is good practice of scheme for high rise RCC structures to strengthen against buckling. So it can be concluded that Inverted V bracing system is good practice for implementation in high rise structures and reduces the damages in RCC structures during lateral load resisting capacity of the structures.

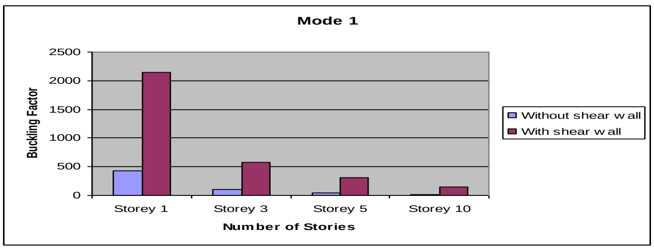

Fig-8 comparison of without shear walls and with shear walls for different stories.

Table-5 buckling modes values for 3 strorey without shear wall and with shear wall.

Buckling mode	Without Shear wall	With shear wall
1	100.753	580.709

As per analysis, it is concluded that buckling factor for three storey building with shear wall is 82% more as compared to R.C.C. building Without Shear Wall.

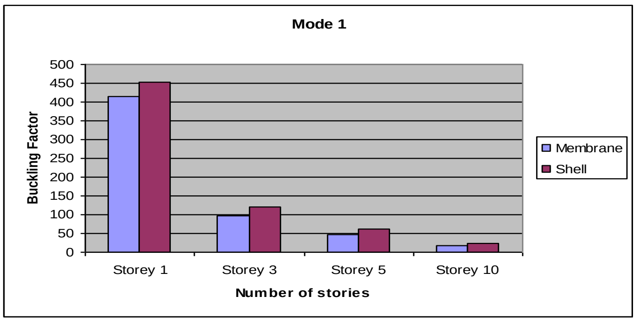

Fig-9 Comparison of membrane and shell

Table-6 Buckling factor values for membrane and shell

Buckling Factor				
Membrane	100.753	197.817	360.656	559.848
Shell	123.556	218.873	402.887	627.082

Load which is applied to the membrane objects transfers directly to supporting structural objects, whereas meshed shell objects have bending stiffness and therefore resist a portion of the load through flexural deformation. As a result, less load will be available to transfer to beams located under a shell, while 100% of the load will transfer through a membrane.

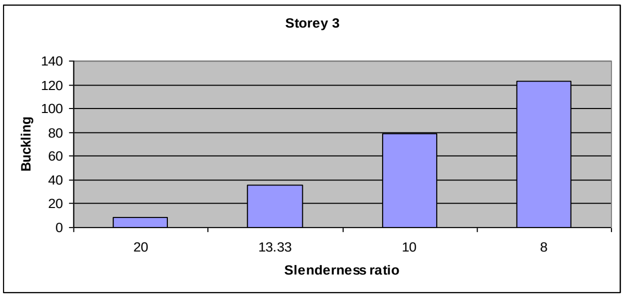

Fig-10 Slenderness ratio v/s buckling factor.

Table-6 Slenderness values and buckling factor values

Storey 3	Slenderness Ratio	Buckling
C200X200	20	5.962
C300X300	13.33	26.686
C400X400	10	62.475
C500X500	8	100.753

From the above mentioned graph it can be observed that slenderness ratio (L/D) ratio is less. The deflection rate considerably increases when L/D ratio is more.

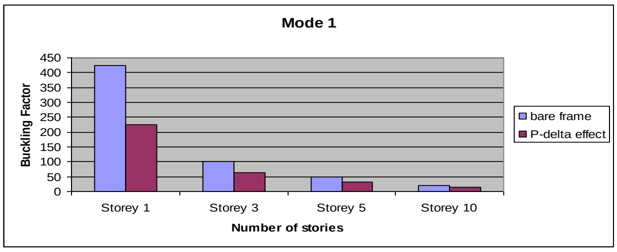

Fig-11 Comparison of bare frame v/s p-delta effect.

Table-7 buckling factor values of p-delta effect

Storey 3		
Buckling mode	**Bare frame**	**P-Delta effect**
1	100.753	61.475

One, three, five and 10 storey buildings were analysed with P-delta effect and bare models. The buckling factor of the building with P-delta effect and bare model that were compared from the result shows that the buckling factor for 3 storey 40% less than without P-delta effect. Hence building with P-delta effect resists the load effectively.

3. CONCLUSIONS

From the comparative study of various parameters, it is observed that the building with bracings demonstrate better performance over the building without bracings

The following conclusion has been drawn based on the results obtained from the present study.

- Storey forces are reduced in the building frame with bracings, which gives the stability of the building. Subsequently the use of bracings is viewed as more secure than the without bracings in the building.
- by Comparing the buckling factor values for a frame with and without bracing, the buckling factor of building increases using bracings like K type by 65%, V type 73%, X bracing 76%, diagonal 86%, and Inverted V by 89%. So Inverted V type of bracing have more buckling factor.
- The maximum buckling factor is observed in case of Inverted V bracing model for all i.e. 1, 3, 5, and 10 stories building frames.
- Slenderness ratio of the column play very important role in buckling analysis of the RC buildings. From the results observed that, as the slenderness ratio of the column increases the buckling factor will decrease as there will be a minimum buckling factor even on maximum load.
- Buckling factor values for a frame is better when slab is considered as shell instead of membrane. The Variations between buckling factor values for storey one is 12%, storey three it is 18%, for five storeys 21 % and for ten storeys it is 23%. From the results

observed that shell model will give more bulking factor for the frame.

- 1,3,5, & 10 stories buildings were analyzed with and without P-delta effect for bare models. From the results it shows that the buckling factor for 1 storey is 47%, for 3 storey 40%, 5 storey 36% and for 10 storey it is 34% less than without P-delta effect. Hence building with P-delta effect resists the load more effectively.
- From the results, it is concluded that buckling factor for the building with shear wall is more as compared to R.C.C. building Without Shear Wall.
- Results of the simulations were compared between the ETABS and ANSYS, the variations of buckling factor value are 0-25%.
- From the results, adding bracings to the RC moment resisting frame, it will increase strength and stiffness to the structure.

FUTURE SCOPE

- It is concluded that as per the analysis with the help of ANSYS software it can used to develop five and ten storey models with bracing and without bracing.
- And models like V and Inverted V bracings can also be prepared.

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