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# STIFFNESS MODIFIERS IN RC AND PT BEAMS AND THEIR IMPACT ON STRUCTURAL BEHAVIOR

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**Abstract**: In the current circumstance many codes and researchers have recommended stiffness modifiers values for R.C.C. structure analysis. Because stiffness is the most important quality of any element, it demonstrates its ability to resist external force and solidity. In linear structural analysis programmes, stiffness modifiers are employed to account for the development of concrete fractures and the bond slip of steel reinforcement. The global and local deformations of the structure, as well as the internal force distribution in the elements, are all factors in seismic design. The aim of current study was found out the stiffness modifiers which can be applied for the same size of PT beam in analysis software. The study was carried out in ETABS V18 software. The structural behaviour of the structure is analysed after applying the new results of stiffness modifiers**.**

**Keywords**: Stiffness Modifiers, Effective Stiffness, PT beams, displacement, storey drift, Structural performance.

## I. INTRODUCTION

### 1.1 What are stiffness modifiers?

Stiffness modifiers in ETABS are the factors to extend or decrease some properties of the cross section as an example area, inertia, torsional constant etc.
Generally they are used to decrease stiffness of concrete sections to model for cracked behaviour of concrete. They are only applied to concrete members as they crack under loading.

### Background

Internal forces such as flexure, shear, torsion, and axial forces cause concrete fibres to compress or tension. Concrete is strong in compression, but only about 10% of its compressive strength is available in tension. Concrete cracks, shrinking in area and stiffness at this limit. It is no longer able to withstand tensile forces. The ability to attract moments decreases as stiffness decreases. Some of the moment that was present in this segment (for example, at beams) gets transferred to other, uncracked areas (for example columns). The redistribution of moments is caused by the reshuffling of stiffness across the structure. As a result, these uncracked sections (such as columns) must be constructed for more moment than they received prior to moment redistribution. Redistribution of moments is the term for this occurrence. When the concrete in that region hits its tensile capacity limit, those regions that were not cracked and acquired extra moments from cracked parts will crack as well. As a result, until all of the members have been cracked, this cycle of moment redistribution continues. Steel reinforcement that had been idle up until this point now begins to absorb these redistributed moments.

### 1.2 Why we need to change stiffness, what is gross/cracked section analysis and are these modifiers for service or ultimate design?

The stiffness of the structure will be affected by cracking, which will alter the deflection and forces. Nobody knows how real the cracking would be, how extensive it would be, or how altered the load distribution would be as a result. There is a fluctuating moment of inertia in the portion because of the cracking. There is a lower moment of inertia in cracking zones, and a substantially higher moment of inertia in non-cracking parts. Cracking also develops as the load increases. The moment of inertia varies depending on the load. Because our deflection equations are non-linear with respect to loading due to the changing moment of inertia, we can't use superposition to derive load combinations.

### 1.3 What values to use?

It shall be permitted to use the following properties for the members in the structure:
Moments of inertia, I
(a) Compression members:
Columns ................................................. 0.70Ig
Walls
    —Uncracked. .......................................... 0.70Ig
    —Cracked............................................... 0.35Ig
    Flexural members:
    Beams ...................................................... 0.35Ig
    Flat plates and flat slabs......................... 0.25Ig
(b) Area.......................................................... 1.0Ag

### 1.4 What impact stiffness modifiers will make on overall analysis?

When comparing the structural analysis results to the model with 100% gross moment of inertia, there will be two primary impacts:
1) The overall rigidity of the structure will be lowered because of the reduced moment of inertia. The structure will be comparatively flexible as a result of the reduced rigidity, attracting lesser seismic forces.
2) Because the structure is rather flexible, it will drift more.

### 1.5 What will happen if we consider unique stiffness modifiers for both serviceability and ultimate conditions?

The stiffness modifiers for serviceability and ultimate conditions are generally different. The stiffness modifiers established in IS 1893(Part 1): 2016 are for the final condition, as previously stated. When the same stiffness modifiers are used for the serviceability condition, the moment at the beam column junction is larger and the span moment is lower than when the model is not stiffness modified.

## II. LITERATURE REVIEW

**Tang et al**. looked into seismic analysis of concrete structures at maximum earthquake loads and found that lower stiffness was required. Other flexural components are vulnerable to both flexural stiffness and shear degradations, but structural walls are not. Accessible experimental data show that it can overstate shear stiffness by more than double, causing real-time predictions of building periods and shear load distributions among vertical elements to be hampered. Furthermore, the consistent malleability constraint that was stipulated was met. The available better shear and flexural models were investigated in this work. Perspectives on recommended flexural and shear stiffnesses by well-known plan codes, such as ACI318-11, Euro code 8, and CSA, are included. To evaluate the exhibition of each model, a database including dividers exposed to turn about cyclic stresses is framed. It was observed that their existing models might easily outperform moderate systematised values in terms of employment.

**Castel et al.** The deflection regulator is an important performance principle for the serviceability and sustainability of R.C.C. construction. The author conducted research in order to model the effects of both short-term and long-term loading on the immediate stiffness of R.C.C. flexural elements. The results of the experiment reveal that extreme live loading causes both steel-concrete interface damage (i.e. cover-controlled cracking) and time subordinate impacts, such as creep and shrinkage, which decrease beam stiffness. The finite element model that depicts the impact of outer cover zone-controlled cracking on instantaneous stiffness has been proposed in several forms. The author only considered the temporary reaction to the stack in his display. By using a damage variable to reduce the bond at the steel-concrete interface when the stacking expands or during a period of shrinkage and prolonged stress. A model for the initiation of cover control cracks is also described, which is based on a maximum assessment of the steel stress at the crack region.

**Dren S. Gashi** conducted research to see which method, reinforced concrete or post-tensioning, is better for transfer beam design and construction. To that purpose, the study includes precise questions and objectives that establish the primary aspects on which transfer beam technologies should be compared and distinguished. Structure capacity, deflection performance, and, most significantly, design economy are all factors to consider in this context. Case studies have been demonstrated to improve the quality of research by offering similar data that is utilised to draw conclusions about design economy. In this regard, the findings reveal that post-tensioned transfer beams outperform their counterparts by a significant margin.

**Das et al**. investigated how stiffness is affected by strength. The force distribution and deformation are influenced by incorrect or insufficient member stiffness estimation, resulting in an inaccurate structural response. As a result, in nonlinear assessments to determine the real performance of a building under seismic conditions, the use of real effective stiffness based on strength is critical. Nonlinear investigations were conducted on the planned structure, which included net stiffness, genuine compelling stiffness based on strength, and effective stiffness as defined by FEMA-356. The findings of the nonlinear time history inquiry revealed that structures with net solidity exhibit extraordinarily preservationist float and superior levels when compared to structures with viable stiffness based on strength. The order level is in the centre of those with gross stiffness and effective stiffness dependent on strength, according to FEMA. The estimation of true effective stiffness for the column element was acknowledged as a difficult task.

## III. OBJECTIVES OF STUDY

- To calculate the stiffness modifiers which can be applied for the same size of PT beam in analysis software.
- To check the deflection of beam after applying the modifiers and control the limit with respect to the code.
- To study the behaviour of the building due to stiffness modifiers in the structure.
- To compare the different parameters such as storey displacement, storey drift, before applying modifiers and after applying modifiers.

## IV. NUMERICAL STUDY

Problem description

The structure is 2B+G+17 storey in which the deflection of the beam having the same size as the PT beam is used to control.

Problem parameters of the building:

TABLE I PROBLEM PARAMETERS OF THE BUILDING

| BUILDING PARAMETERS | |
|---|---|
| **No of storeys** | 20 |
| **Storey height** | 3.45 m |
| **Plan dimensions** | 26.9 m*31.1 m |
| **Total height** | 62.3 m |

| SECTIONAL PROPERTIES | |
|---|---|
| **Size of RCC beam** | 0.23m*0.75m, 0.3m*0.75m |
| **Size of PT beam** | 0.6m*0.45m, 0.45m*0.45m |
| **Size of column** | 0.45m*1.5m, 0.6m*1.5m |

| | |
|---|---|
| **Slab thickness** | 0.15 m |
| **Grade of concrete** | M35 |
| **Grade of steel** | Fe500 |

| **SEISMIC-FACTORS** | |
|---|---|
| **Dead load** | 1.5 kN/m$^2$ |
| **Live load** | 3 kN/m$^2$ |
| **Seismic zone** | III |
| **Importance factor** | 1 |
| **Soil conditions** | Medium |
| **Wall load** | 6 kN/m |

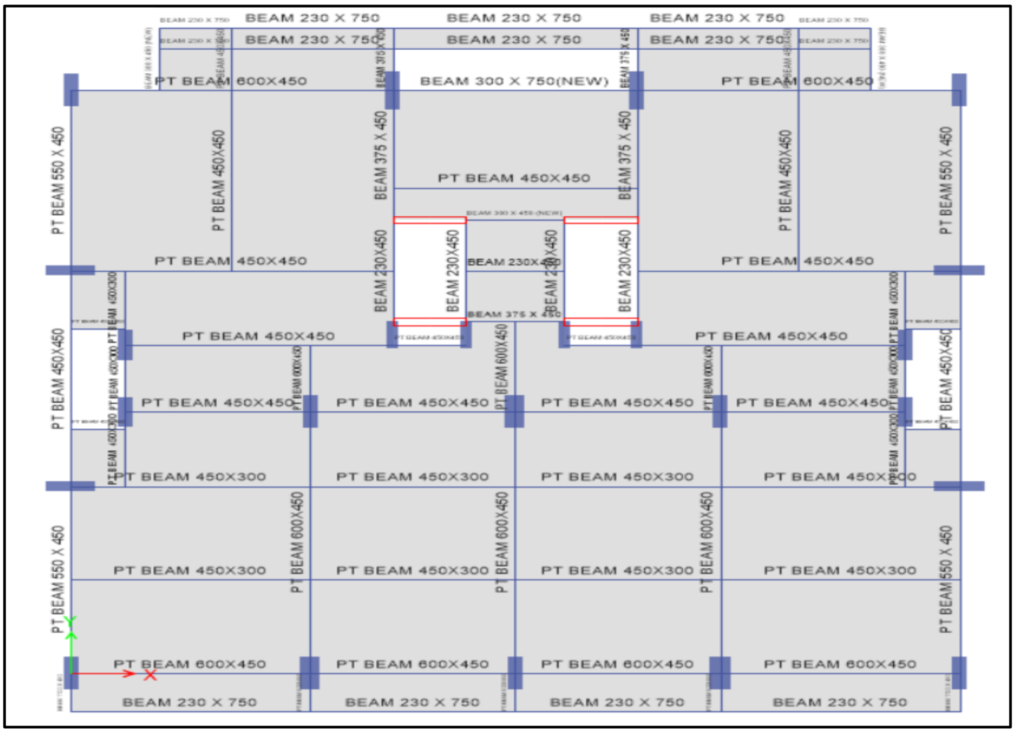

Fig 1 Plan of the Building

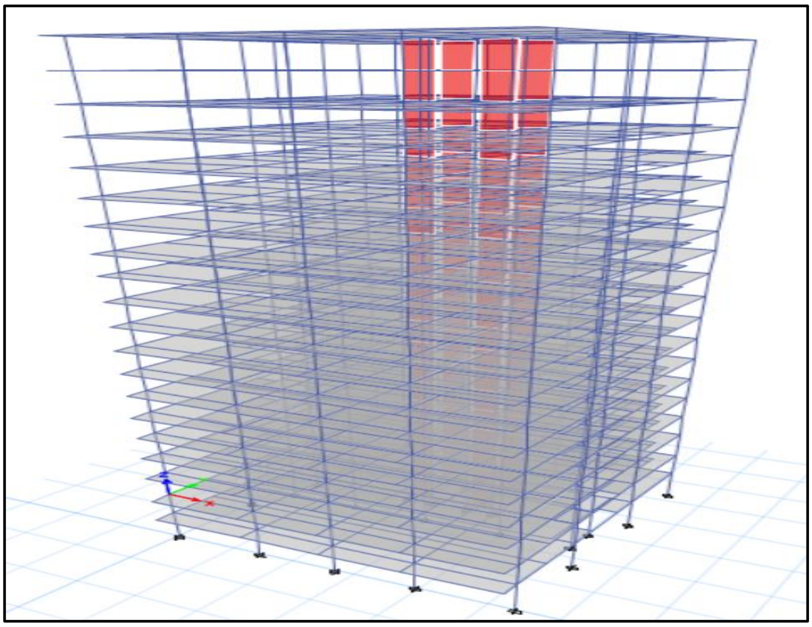

Fig 2 3D of the First Building

## V. RESULTS

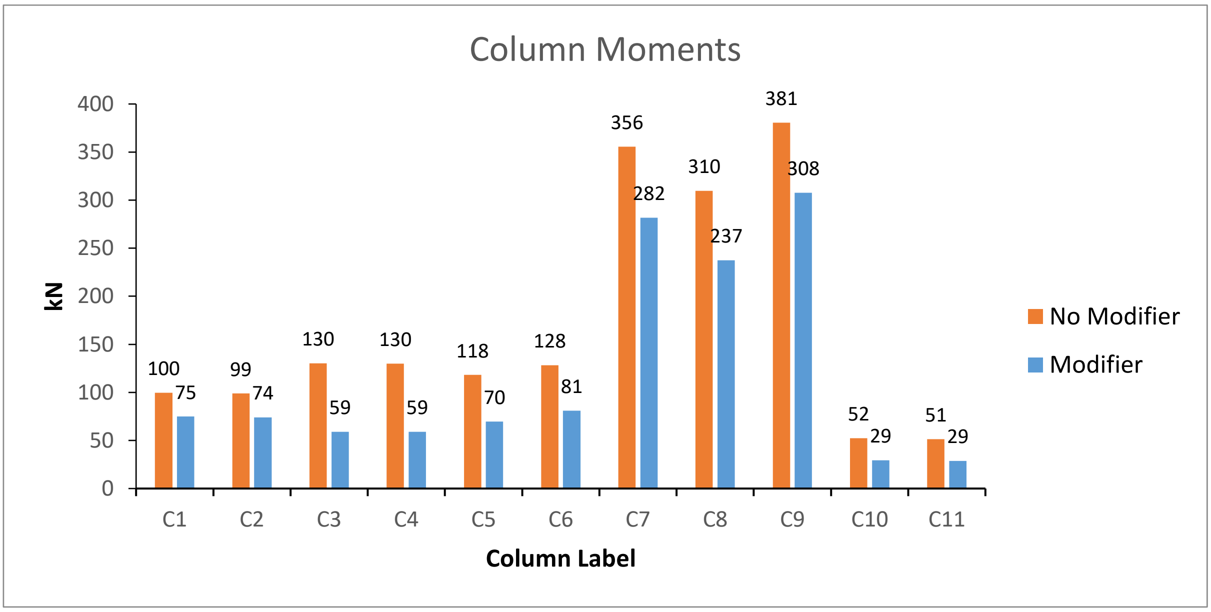

Fig 3 Column Moments

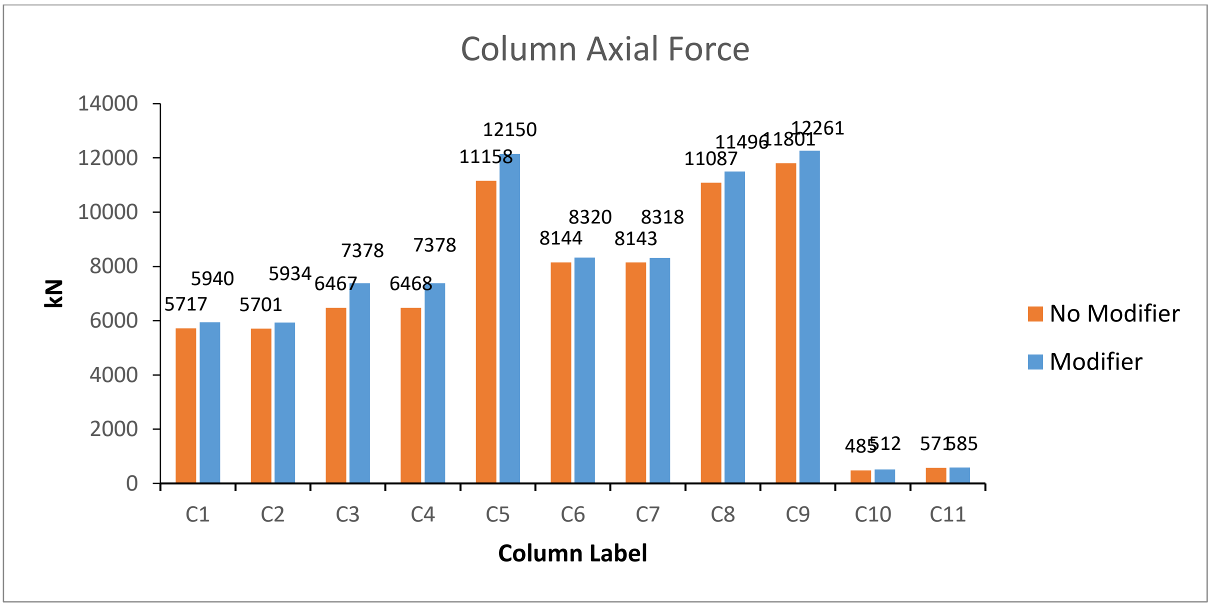

Fig 5.2 Column Axial Force

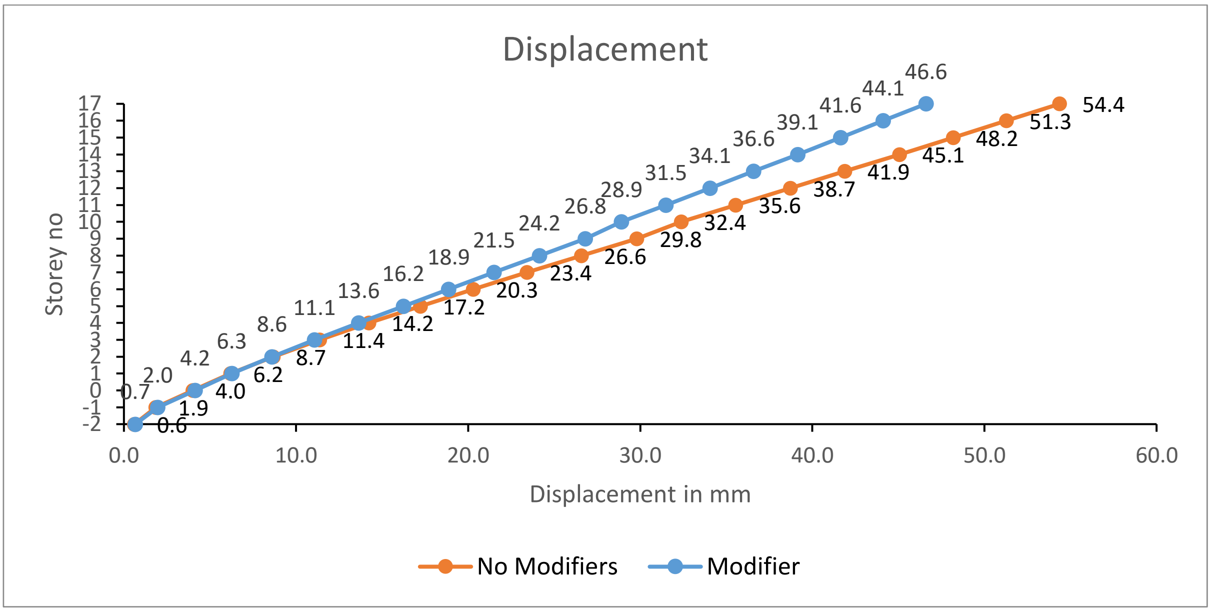

Fig 5.3 Storey Displacement

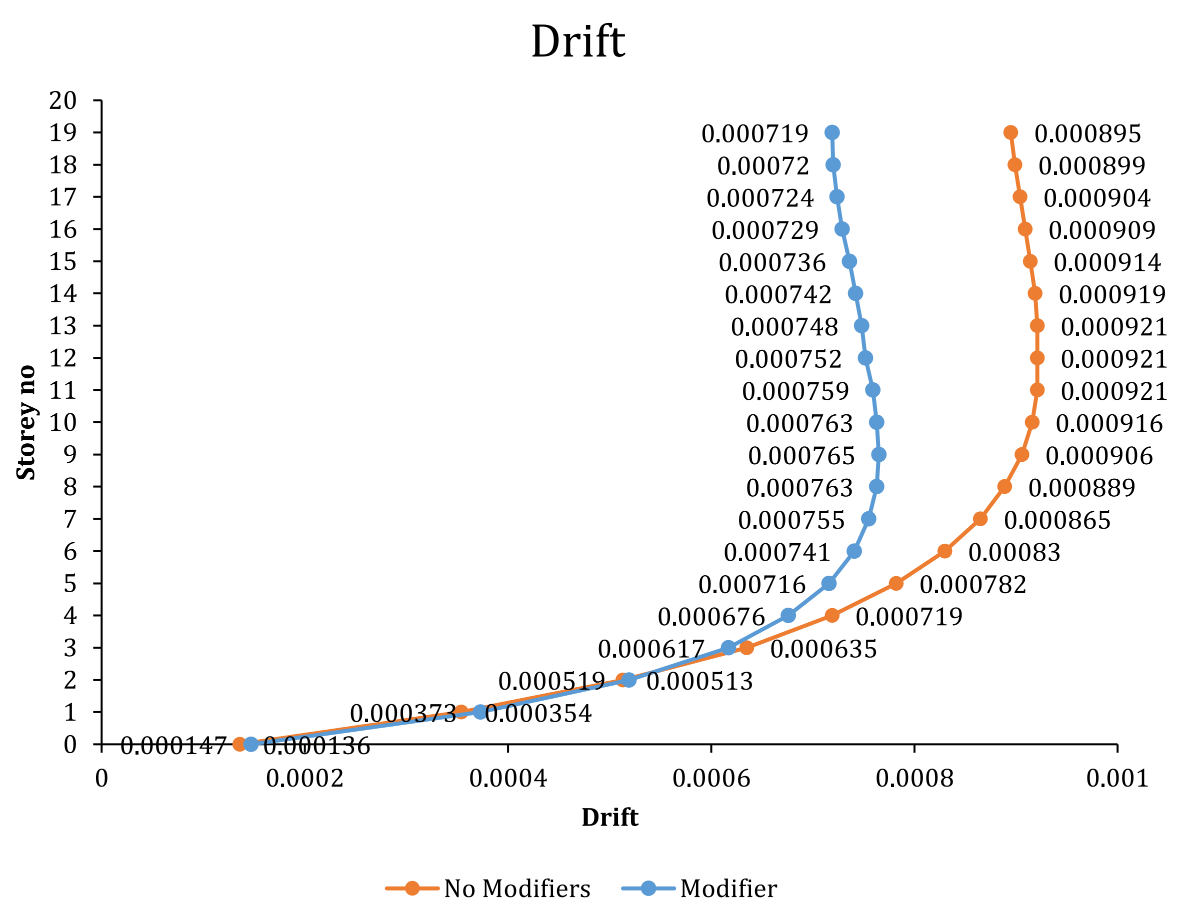

Fig 5.4 Storey Drift

## VI. CONCULSION

- By controlling the deflection of the beams as per IS code 1343:2012, the stiffness modifiers required for the same size of PT beams is 1.5.
- The Moment induced by the columns after applying the stiffness modifiers is less by 15-20% than when there are no stiffness modifiers applied in the beams.
- The Storey Displacement of the structure is reduced by 7.5% as compared to before stiffness modifiers applied in the beams.
- The Axial Force in columns is increased by 7% in the columns when the stiffness modifiers are applied in compare to when there are no stiffness modifiers.
- There is 15% reduction in the Storey Drift after applying the new stiffness modifiers.

## REFERENCES

[1]. IS:16700-2017. 2017. “Criteria for Structural Safety of Tall Concrete Buildings.” Indian Standard.
[2]. IS 1893. 2016. “‘Criteria For Earthquake Resistant Design Of Structures,Part 1:General Provisions And Buildings.’” Bureau Of Indian Standards, New Delhi 1893(December):1–44.
[3]. IS 1343-2012. “Code of Practice for Prestressed Concrete”. Bureau of Indian Standards, New Delhi, 2012.
[4]. IS 456-2000. “Indian Standard for plain and reinforced concrete code of practice”. Bureau of Indian Standards, New Delhi.
[5]. ACI 318-19, “Building Code Requirements for Structural Concrete”, American Concrete Institute, 2019.
[6]. Mustafa E. Mithaiwala, Prof. Amol A. Patil, Dr. Navnath V. Khadake, “A Review on Effect of Different Set of Stiffness Modifiers Varying Through Height of Structure on Analysis of Multi-Story R.C.C. Structure”, International Research Journal of Engineering and Technology (IRJET).

[7]. Sourav Das, Satyabrata Choudhury, “Influence of effective stiffness on the performance of RC frame buildings designed using displacement-based method and evaluation of column effective stiffness using ANN”, Engineering Structures, Vol. 197 (2019).

[8]. Parth V Bhavsar, Abbas Jamani, “Analytical Study on the Effect of Stiffness Modifiers on the Performance of RCC Building Subjected to Seismic Force as per IS 1893(2016)”, International Research Journal of Engineering and Technology (IRJET).

[9]. Verma, N. K., & Bandewar, D. K., “Performance and Optimization of PT Beam Using Dynamic Load Condition of Larger Span Structure”, International Journal of Scientific Research in Civil Engineering.