# ANALYSIS AND DESIGN OF A COMMERCIAL BUILDING WITH POST-TENSIONING SLAB BY USING ETABS

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**Abstract -** In this paper analysis and design of flat slab with beams spanning in loner span direction with post-tensioning is carried out.. The analysis is done for ground floor slab level and G+4 slab level. A finite element based software ETABS (vr.2016) is used for analyzing parameters like strip wise bending moments, shear force and displacements. A comparative analysis is carried out for maximum values of bending moments, shear force and displacements found in PT flat slab in ground floor and G+4 floor. The present work also provides comparative results between RC slab and PT slab at the same loading conditions.

***Key Words***: Flat slab, Post-tensioning, Etabs.

## 1.INTRODUCTION

Structures are the significant pointer of social advancement of the country. Each human wants to have agreeable homes on a mean commonly one invests his two-third life energy inside the houses. These are the couple of reasons which are mindful that the individual do most extreme exertion and spend hard-procured saving in claiming houses.

Now-a-days, high rise buildings and multi-bay-multi-storey buildings are quite common. The analysis of frames of multistoried buildings proves to be rather cumbersome because the frames have an outsized number of joints which are liberal to move. Albeit the commonly used Moment distribution method is applied to all or any the joints, the work involved shall be tremendous.

Structural analysis is that the backbone of engineering. During recent years, there has been a growing emphasis on using computer aided softwares and tools to research the structures. There has also been advancement in finite element analysis of structures using Finite Element Analysis methods or matrix analysis. These developments are most welcome, as they relieve the engineer of the usually lengthy calculations and procedures required to be followed while large or complicated structures are analyzed using classical methods.

## 2. POST-TENSIONING

Prestressed concrete is essentially concrete during which internal stress of an appropriate magnitude and distribution are deliberately introduced in order that the stresses resulting from external loads are counteracted to a desired degree. Prestressing is usually how to beat concrete weakness in tension.

In post-tensioning, the concrete units are first cast by incorporating ducts or grooves to deal with the tendons. When the concrete attains sufficient strength, the high-tensile wires are tensioned by means of jack pertaining to the top face of the member and anchored by wedges or nuts. The forces are transmitted to the concrete by means of the top anchorages and, when the cable is curved, through the radial pressure between the cable and therefore the duct. The space between the tendons and therefore the duct is usually grouted after the tensioning operation.

Most of the commercially patented prestressing systems are based on the following principles of anchoring the tendons:
1. Wedge action producing a frictional grip on the wires.
2. Direct bearing from rivet or bolt heads formed at the end of the wires.
3. Looping the wires around the concrete.

## 2.1 MATERIALS

Prestressed concrete requires concrete which features a high compressive strength at a fairly early age, with comparatively higher lastingness than ordinary concrete. low shrinkage, minimum creep characteristics and a high value of young's modulus are generally deemed necessary for concrete used for prestressing members. Many desirable properties, like durability, impermeability and abrasion resistance, are highly influenced by the strength of concrete. High strength concrete is important in prestressed concrete, because the material offers high resistance in tension, shear, bond and bearing. within the zone of anchorages, the bearing stresses being higher, high strength concrete is invariably preferred to minimum costs. the utilization of high strength concrete leads to reduction within the cross sectional dimensions of prestressed concrete structural elements. With a reduced dead weight of the fabric , longer spans become technically and economically practicable.

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## 2.2 LOSS OF PRESTRESS

The initial prestress in concrete undergoes a gradual reduction with time from the stage of transfer due to various causes. This is generally referred to as 'loss of prestress'. A reasonably good estimate of the magnitude of loss of prestress is necessary from the point of view of design. The different types of losses encountered in the pretensioning and post-tensioning systems are

1. Loss Due to Elastic Deformation of Concrete
2. Loss of Prestress due to Shrinkage of Concrete
3. Loss of Prestress due to Creep of Concrete
4. Loss of Prestress due to Relaxation of Stress in Steel
5. Loss of Prestress due to Friction
6. Loss due to Anchorage Slip

## 3. WORKING WITH ETABS

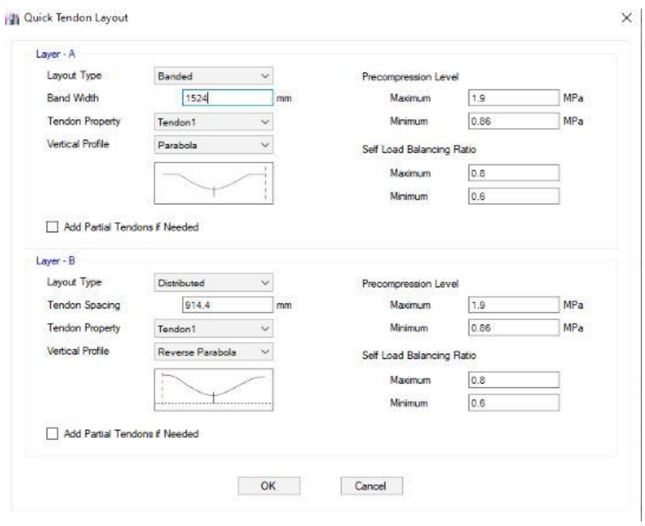


**Fig.1** Defining Tendon layout in Etabs

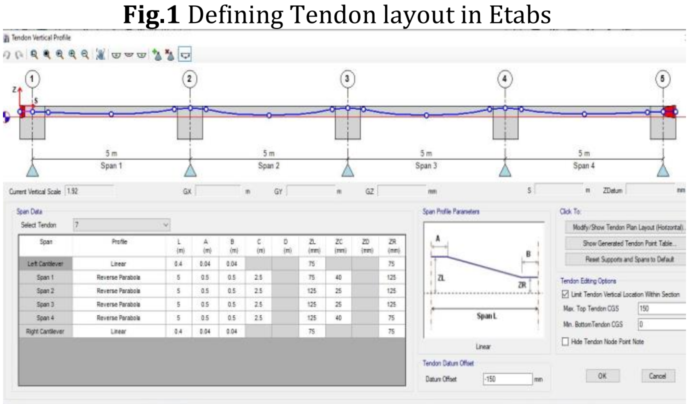

**Fig.2** Distributed Tendon Profile

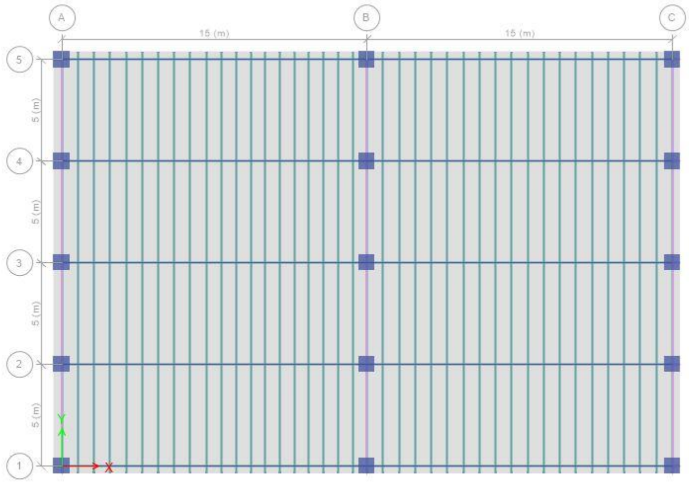


**Fig.3** Plan view of tendon layout

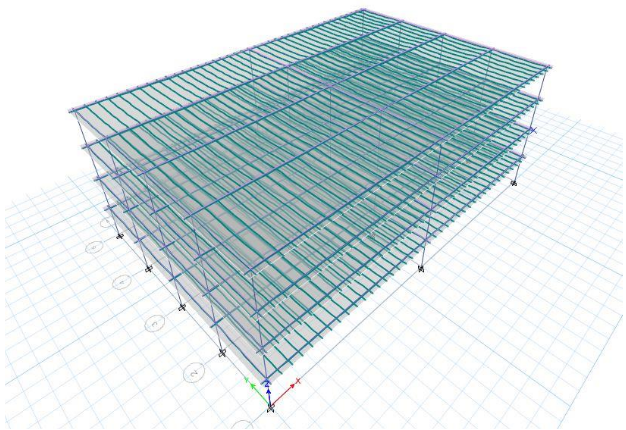

**Fig.4** 3D view of the structure

## 4. RESULTS

### 4.1 STRIP MOMENT IN G+4SLAB

**Table 1** Strip moments in PT slab in G+4 floor

| S.No | NATURE | LOCATION | STRIP MOMENT (kN -m) |
|---|---|---|---|
| 1 | POSITIVE | OUTER STRIP | 70 |
| 2 | NEGATIVE | OUTER STRIP | 149 |
| 3 | POSITIVE | MIDDLE STRIP | 139 |
| 4 | NEGATIVE | MIDDLE STRIP | 287 |
| 5 | POSITIVE | CENTER STRIP | 139 |
| 6 | NEGATIVE | CENTER STRIP | 292 |
| 7 | POSITIVE | OUTER STRIP | 139 |
| 8 | NEGATIVE | OUTER STRIP | 263 |

| | | | |
|---|---|---|---|
| 9 | POSITIVE | MIDDLE STRIP | 229 |
| 10 | NEGATIVE | MIDDLE STRIP | **467** |
| 11 | POSITIVE | CENTER STRIP | 128 |
| 12 | NEGATIVE | CENTER STRIP | 259 |

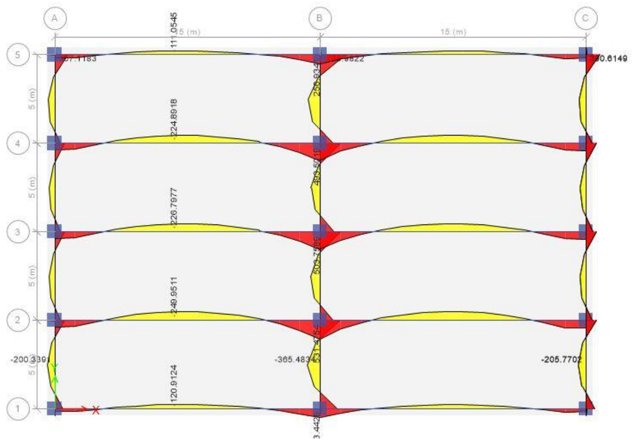

**Fig.5** Strip moments in G+4 floor In PT slab

### 4.2 STRIP MOMENT IN GROUND FLOOR SLAB

**Table 2** Strip moments in PT slab in Ground floor

| S.No | NATURE | LOCATION | STRIP MOMENT (kN -m) |
|---|---|---|---|
| 1 | POSITIVE | OUTER STRIP | 86 |
| 2 | NEGATIVE | OUTER STRIP | 185 |
| 3 | POSITIVE | MIDDLE STRIP | 142 |
| 4 | NEGATIVE | MIDDLE STRIP | 301 |
| 5 | POSITIVE | CENTER STRIP | 137 |
| 6 | NEGATIVE | CENTER STRIP | 292 |
| 7 | POSITIVE | OUTER STRIP | 116 |
| 8 | NEGATIVE | OUTER STRIP | 224 |
| 9 | POSITIVE | MIDDLE STRIP | 198 |
| 10 | NEGATIVE | MIDDLE STRIP | **417** |
| 11 | POSITIVE | CENTER STRIP | 115 |
| 12 | NEGATIVE | CENTER STRIP | 226 |

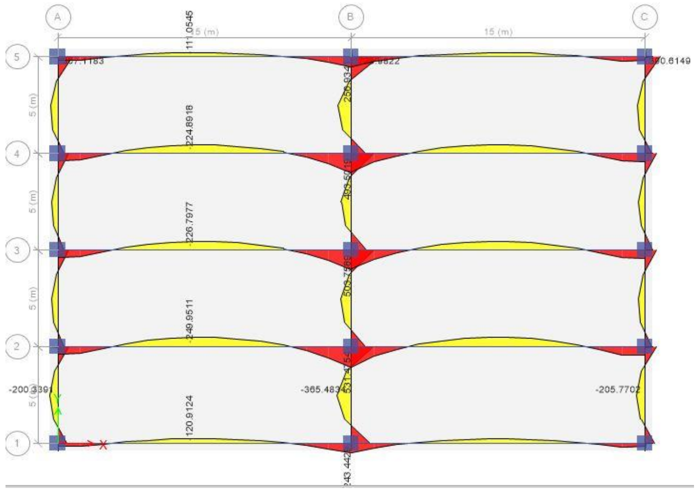

**Fig.6** Strip moments in Ground floor in PT slab

### 4.3 STORY 1 Vs STORY 4

### STRIP MOMENT (kN -m)

**Table 3** Strip moments in RC slab Ground floor v/s G+4 floor

| S.No | LOCATION | STORY 4 (kN -m) | STORY 1 (kN -m) |
|---|---|---|---|
| 1 | OUTER STRIP | 70 | 86 |
| 2 | OUTER STRIP | 149 | 185 |
| 3 | MIDDLE STRIP | 139 | 142 |
| 4 | MIDDLE STRIP | 287 | 301 |
| 5 | CENTER STRIP | 139 | 137 |
| 6 | CENTER STRIP | 292 | 292 |
| 7 | OUTER STRIP | 139 | 116 |
| 8 | OUTER STRIP | 263 | 224 |
| 9 | MIDDLE STRIP | 229 | 198 |
| 10 | MIDDLE STRIP | **467** | **417** |
| 11 | CENTER STRIP | 128 | 115 |
| 12 | CENTER STRIP | 259 | 226 |

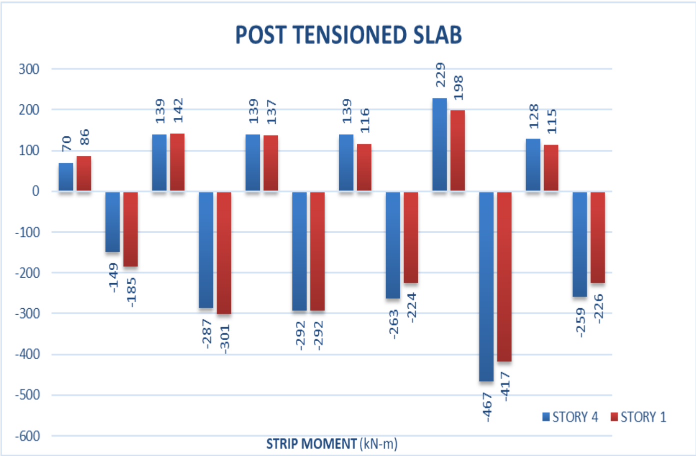


**Fig.7** comparitive graph between story 1& story 4

## 4.4 STRIP SHEAR IN G+4 SLAB

**Table 4** Strip shear in PT slab in G+4 floor

| S.No | LOCATION | STRIP SHAER (kN) |
|---|---|---|
| 1 | OUTER STRIP | 71 |
| 2 | MIDDLE STRIP | 135 |
| 3 | CENTER STRIP | 135 |
| 4 | OUTER STRIP | 216 |
| 5 | MIDDLE STRIP | **395** |
| 6 | CENTER STRIP | 223 |

**Fig.8** Strip shear in G+4 floor In PT slab

## 4.5 STRIP SHEAR IN GROUND FLOOR SLAB

**Table 5** Strip shear in PT slab in Ground floor

| S.No | LOCATION | STRIP SHAER (kN) |
|---|---|---|
| 1 | OUTER STRIP | 86 |
| 2 | MIDDLE STRIP | 136 |
| 3 | CENTER STRIP | 133 |
| 4 | OUTER STRIP | 200 |
| 5 | MIDDLE STRIP | **368** |
| 6 | CENTER STRIP | 206 |

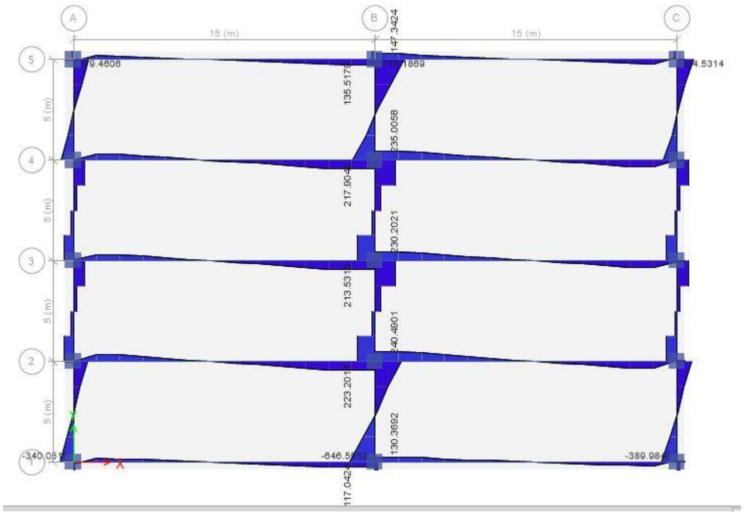

**Fig.9** Strip shear in Ground floor in PT slab

## 4.6 STORY 1 Vs STORY 4

## STRIP SHEAR

**Table 6** Strip shear in PT slab Ground floor v/s G+4 floor

| S.No | LOCATION | STORY 4 (kN) | STORY 1 (kN) |
|---|---|---|---|
| 1 | OUTER STRIP | 71 | 86 |
| 2 | MIDDLE STRIP | 135 | 136 |
| 3 | CENTER STRIP | 135 | 133 |
| 4 | OUTER STRIP | 216 | 200 |
| 5 | MIDDLE STRIP | **395** | **368** |

| | | | |
|---|---|---|---|
| 6 | CENTER STRIP | 223 | 206 |

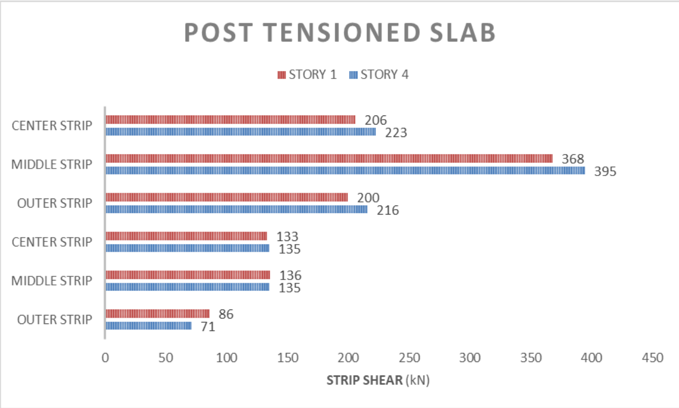


**Fig.10** comparitive graph between stoty 1 & story 4

## 5. RESULTS

### 5.1 MOMENTS

**Table 7** Bending moments in PT slab in (kN-m)

| S.NO | LOCATION | BEAM 1 | BEAM 2 | BEAM 3 |
|---|---|---|---|---|
| 1 | AT CENTER | 154.01 | 180.08 | 177.66 |
| 2 | AT LEFT CORNER | -255.11 | -316.50 | -350.86 |
| 3 | AT RIGHT CORNER | -318.20 | -398.70 | -355.01 |

The above table contains the details of the three beams bending moment at different locations at center, at left and right edge corners in the post tensioned slab.

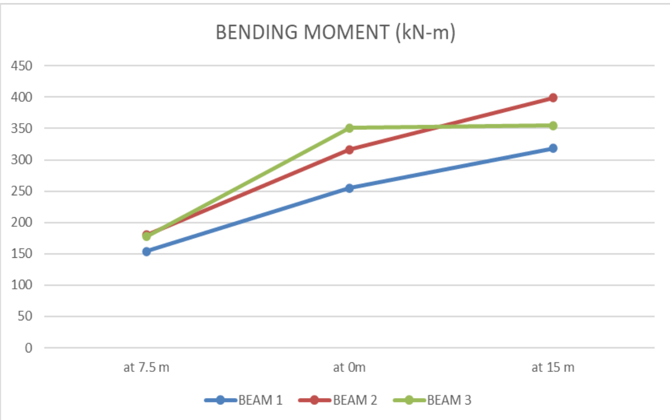


**Fig.11** Graph of Bending moments in PT slab

### 5.2 SHEAR FORCE

**Table 8** Shear force in PT slab in (kN)

| S.NO | LOCATION | BEAM 1 | BEAM 2 |
|---|---|---|---|
| 1 | AT CENTER | 4.53 | 8.74 |
| 2 | AT LEFT CORNER | 406.74 | 485.31 |
| 3 | AT RIGHT CORNER | 532.46 | 455.23 |

### 5.3 BASE SHEAR IN POSTTENSIONED SLAB

**Table 9** Base shear in PT slab

| S.No | LOCATION | BASE SHEAR (kN) |
|---|---|---|
| 1 | OUTER EDGE COLUMN | 1866.43 |
| 2 | CENTER COLUMN | 4882.35 |
| 3 | MIDDLE COLUMN | 2584.72 |

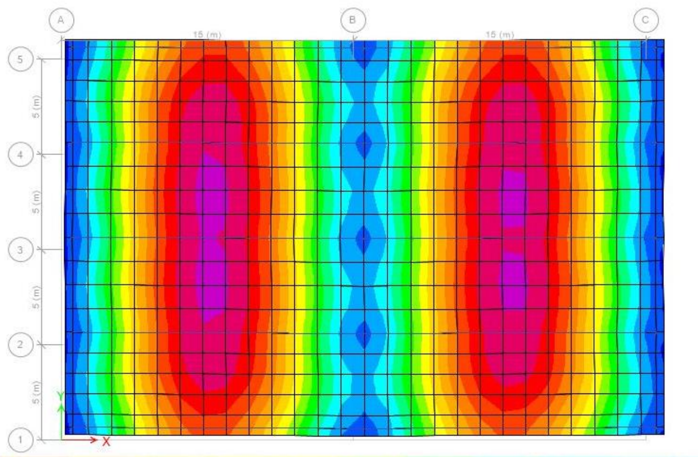

**Fig.12** Deflection of story 4 slab in PT slab

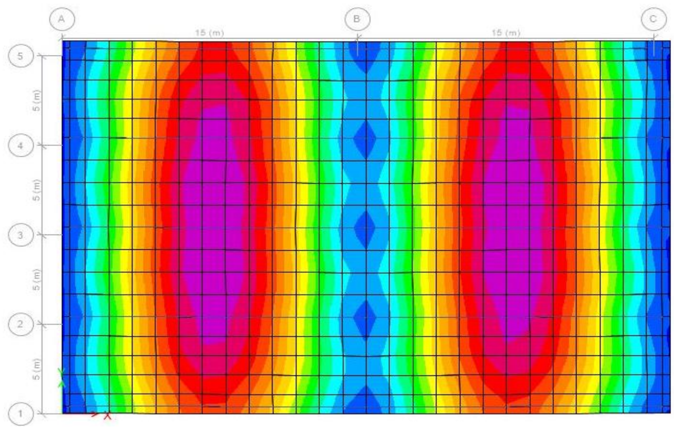

**Fig.13** Deflection of story 1 slab in PT slab

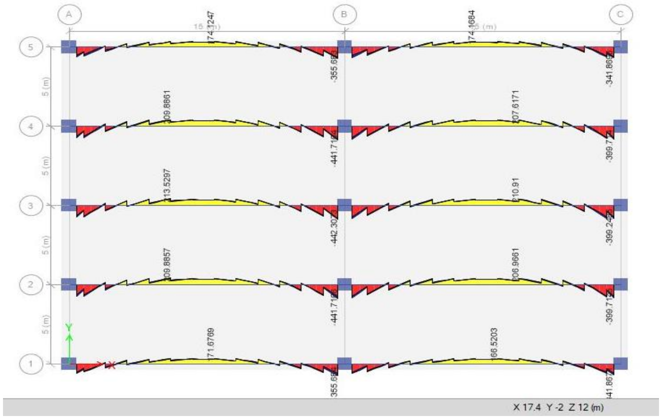

**Fig.14** BMD Diagram of story 4

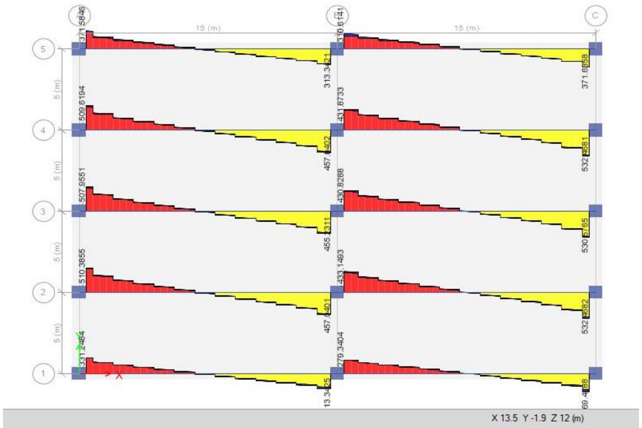

**Fig.15** SFD Diagram of story 4

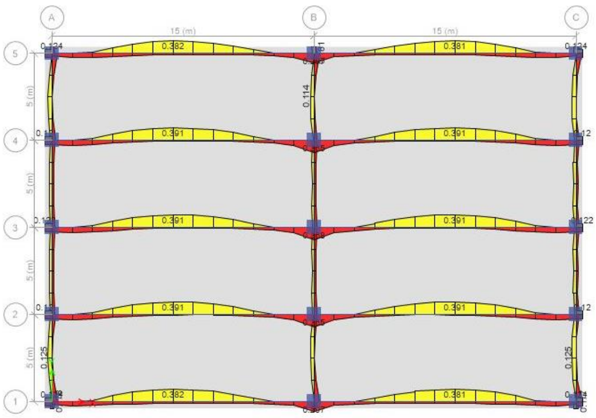

**Fig.16** Demand to capacity ratio in compression at transfer of prestress

## 6. CONCLUSIONS

1. Post-tensioned flat slab are analyzed in this dissertation with beams spanning In longer span direction. Analysis is done for plan for story starting from Ground floor and G+4, Bending moment, shear force and displacements are presented in tabular formats which will be helpful for comparative analysis.
2. Maximum bending moment values decreases for Post-tensioned flat slab for Ground floor and G+4 top level slab for plan.
3. It is observed that the drop in bending moment in post tensioned slab to RC slab is between 58 – 66%.
4. The maximum shear force and displacement values are considerably less in PT flat slab as compared to RC flat slab for both the spans.
5. The bending moment, shear force and displacements decreased in post-tensioned flat slab as compared to RC flat slab, therefore more slender sections are possible in post-tensioned flat slab.

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