

## STRESS CHECK OF POST-TENSIONED FLOORS USING EUROPEAN CODE EC2<sup>1</sup>

Bijan Aalami<sup>2</sup>

The European code EC2<sup>3</sup> is not as detailed and prescriptive on design of post-tensioned floor slabs, as ACI 318. A full account of its procedure for serviceability and safety checks are given in reference [Aalami, 2014]. This Technical Note explains the extraction of “design stress”, often referred to as “hypothetical” extreme fiber tensile stress for serviceability checks of EC2 code.

The information specific to the design of column supported flat slabs is given in Appendix I of the code. The following statements from appendix I of EC2 are used in ADAPT software for the analysis of floor systems, and extraction of tributary moments for design.

ADAPT’s computations follow the Appendix I of EC2 given below:

- ❖ *Analysis may be based on equivalent frame, grillage, finite elements, or yield line*
- ❖ *Stiffness based on gross-sections.*
- ❖ *For vertical loads, stiffness based on full width of the tributary*
- ❖ *100% of load to be used for analysis in each direction*

With respect to safety of design strips, the required non-prestressed reinforcement in excess of the post-tensioning computed, must be placed over and in close proximity of the column supports. For the safety design of the floor, the entire cross-sectional geometry of each tributary (design strip) resists the entire tributary moment, but all the associated reinforcement beyond the existing post-tensioning, if any, is placed over the column region.

For crack control in service condition, for each design strip a single hypothetical extreme fiber tensile stress is computed for both EC2 and ACI 318. Recognizing the higher stresses, and the greater probability of crack formation around the column region, EC2 recommends a larger than the “average” stress for each design strip to be used as the hypothetical value for code check. The enlarged value in EC2 is based on the familiar concept of “column strip/middle strip” distribution of design strip moment. Based on the same concept, ACI 318 recommends a smaller allowable stress for column supported members compared to wall support floors, rather than increasing the hypothetical stress. Both target the same objective. The following reviews the EC2’s recommendation and its treatment in ADAPT software, using the column strip/middle strip concept.

Figure 1 from Appendix I of EC2 shows the subdivision of panel into column strip and middle strips.

<sup>1</sup> EC2 1992-1-1: 2004(E), Appendix I , copyright adapt corporation 2016

<sup>2</sup> Professor Emeritus, San Francisco State University; Principal, ADAPT Corporation

<sup>3</sup> EC2 1992-1-1: 2004(E)

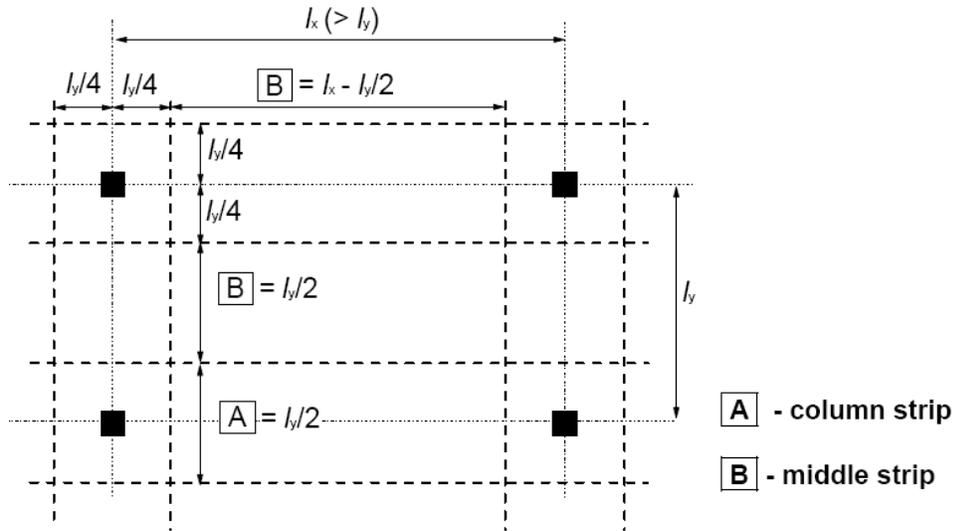


FIGURE 1 Division of Flat Slab into Column and Middle Strips

EC2 states that “ *Tributary moment obtained from the analysis should be distributed into column and middle strip as given in Table I.1 shown below*”

Table I.1 Simplified apportionment of bending moment for a flat slab

	Negative moments	Positive moments
Column Strip	60 - 80%	50 - 70%
Middle Strip	40 - 20%	50 - 30%
Note: Total negative and positive moments to be resisted by the column and middle strips together should always add up to 100%.		

EC2 leaves it to the judgment of the designer to select a value from 60 % to 80% for the moment assigned to the column strip. For conventionally reinforced concrete ACI-318<sup>4</sup> recommends 65/35 ratio for distribution of moment between the column strip and middle strip. In the absence of more specific value recommendation in EC2, the default value for EC2 option in ADAPT software is based on 65/35% distribution, while giving the user the option to modify the ratio.

Figure 2 shows the computed distribution of tributary moment at the face of a column-support floor together with the idealization recommended by EC2 and its application in ADAPT software, to arrive at the hypothetical design stress for the serviceability check of the code.

<sup>4</sup> ACI 318-11 13.6.4

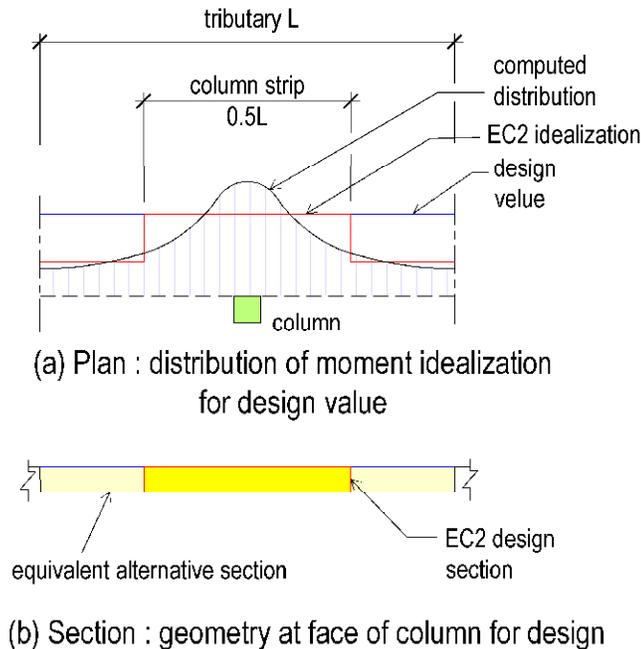


FIGURE 2 Idealization of Tributary Moment for EC2-Based Designs (PTS824)

Using the ratio  $k_c$  for allocation of tributary moment  $M_t$  to the column strip with total tributary moment area  $A_c$ , the applied moment per unit width of the column strip will be:

$$\text{Average value of moment over column strip used for hypothetical stress check} = (k_c M_t) / A_c$$

If the above average value is applied over the entire tributary, as marked in Fig. 2 with “design value,” the design strip moment is increased by:

$$[(\text{average moment}) / (\text{area of column strip})] * \text{tributary area}$$

$$[(k_c M_t) / A_c] * A_t = k_c M_t * (A_t / A_c)$$

In the common case  $(A_t / A_c) = 2$   
 Selecting from the Table I-1  $k_c = 0.65$

$$\text{The hypothetical moment for the common case} = 0.65 * 2 M_t = 1.30 M_t$$

The above leads to the conclusion that the hypothetical stress for EC2 code check should be increased by 30 %, if the computation is based on the application of the entire tributary moment to the entire cross section of the tributary.

The recommended range for distribution of moment between the column and middle strips given in Table I.1 of EC2 is between 60% and 80% of the tributary moment. This translates to a magnification of the average moment between from 1.20 to 1.60 times the entire tributary moment applied to the entire tributary section.

REFERENCES

Aalami, B. O. (2014), “Post-Tensioned Buildings; Design and Construction,” [www.adaptsoft.com](http://www.adaptsoft.com); [www.PT-Structures.com](http://www.PT-Structures.com), Redwood City, CA, 2014.