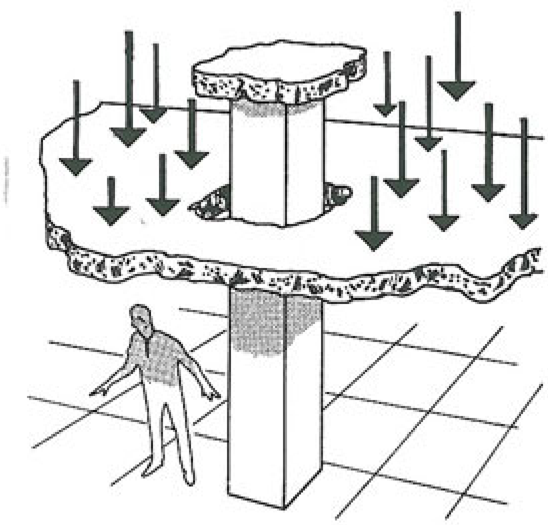
Punching Shear Force in Post-Tension Floor, Part 1

Post tension floor is a beamless concrete floor that relies on the concrete floor to bear the load and transfer it directly to the column. It is therefore necessary to prevent failure such as punching shear failure, most of which has to do with controlling the floor thickness. It is crucial to add a column capital or a drop panel. It is therefore essential to find the correct punching shear force occurred and the shear reinforcement the floor has. Details related to punching shear in post tension floor are complex therefore they can be divided into sections. The author will try to gradually post all of them.

General pattern of punching shear failure comes in a form of fracture around the column as shown in the picture.

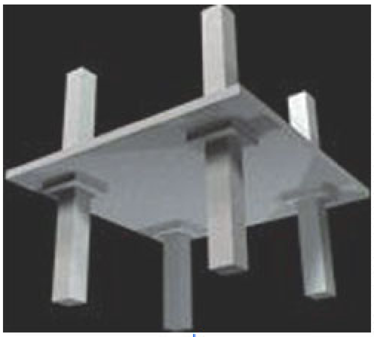


(PUNCHING SHEAR FAILURE IN A TEST SPECIMEN AT UNIVERSITY OF WATERLOO, ONTARIO) When failure occurs, punching shear causes the floor to detach from the column where a concrete cone is left at the column.


This type of failure would occurs without warning sign or deflection unlike failures from bending stress. Therefore, the design of shear reinforcement is a very important part of beamless floor design.

In general, post tension floor design will specify the initial floor thickness then check the punching shear force to see if the designed thickness can handle such force. Finding actual punching shear force is important. Not only it comes from the vertical load, but also the unbalanced moment and the effect lateral forces of the building (wind, earthquake, etc.) which result in higher total punching shear force. In part one of this section, several steps of calculation have been discussed. The author therefore leaves a note, in a form of file, on article on punching shear force calculation for the audience to download at the end.

In the case where the specified floor thickness can be designed for the strands to handle the bending stress but the punching shear force and increasing floor thickness at column head would not affect any architectural work and systems, column capital is often used to increase the shear reinforcement. Commonly used column capital contains the following shapes:


รูปที่ 1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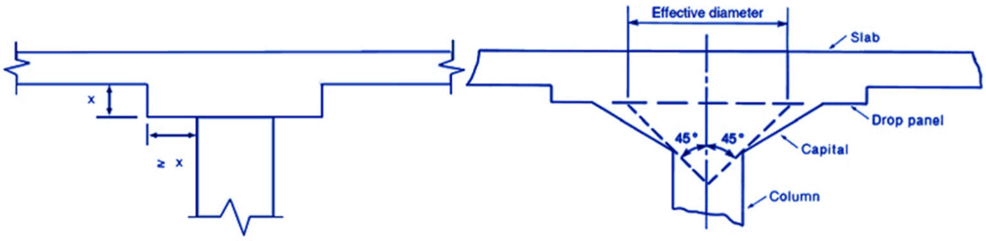
รูปที่ 3

According to the figure, it can be seen that there are numerous shapes a column capital can be made into including direct increase of rectangular thickness as shown in figure 1, round cone shape as shown in figure 2, and the pyramid cone shape as shown in figure 3.

ACI318 contains characteristic specifications of column capital in section 13.2.6 as follows:

> **13.2.6** — When used to increase the critical condition section for shear at a slab-column joint, a shear cap shall project below the slab and extend a minimum horizontal distance from the face of the column that is equal to the thickness of the projection below the slab soffit.

It can be elaborated as shown in the picture below.



(a) (b)

To increase the perimeter around critical cross section, BO at D/2 distance from column edge, it can be done by adding a depth particularly to the column area by specifying that the extending range from column edge must be greater than the distance from which the thickness is added as shown in Figure (A) or if the thickness is added conically, the angle must be greater than 45 degrees as shown in Figure (B).

In case when the designed floor thickness cannot handle punching shear force and negative moment, similar measures as done with column capital can also be done to fix the issue but it has to be further extended or called drop panel which is as exhibited in the picture.

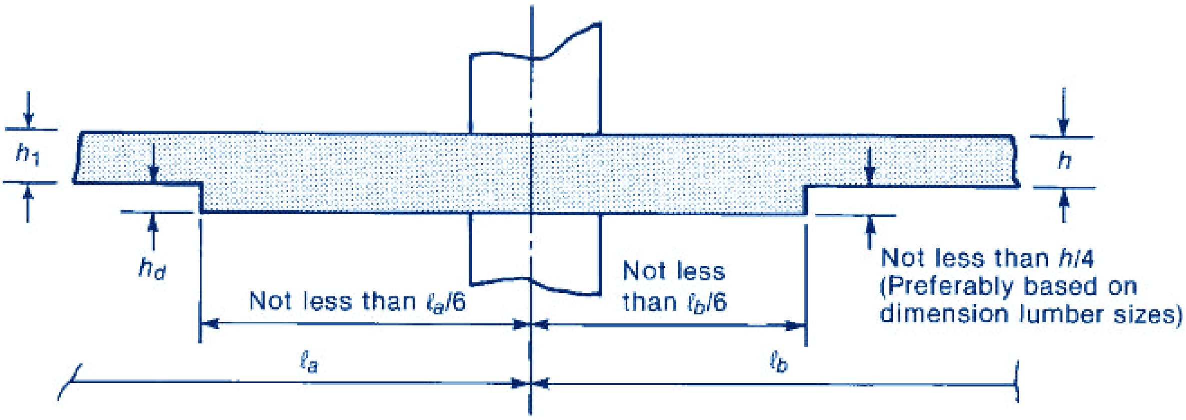
Extending range must be in accordance with ACI318 requirements section 13.2.5.

13.2.5 — When used to reduce the amount of negative moment reinforcement over a column or minimum required slab thickness, a drop panel shall:

(a) project below the slab at least one-quarter of the adjacent slab thickness; and

(b) extend in each direction from the centerline of support a distance not less than one-sixth the span length measured from center-to-center of supports in that direction.

It can be elaborated as shown in the picture below.



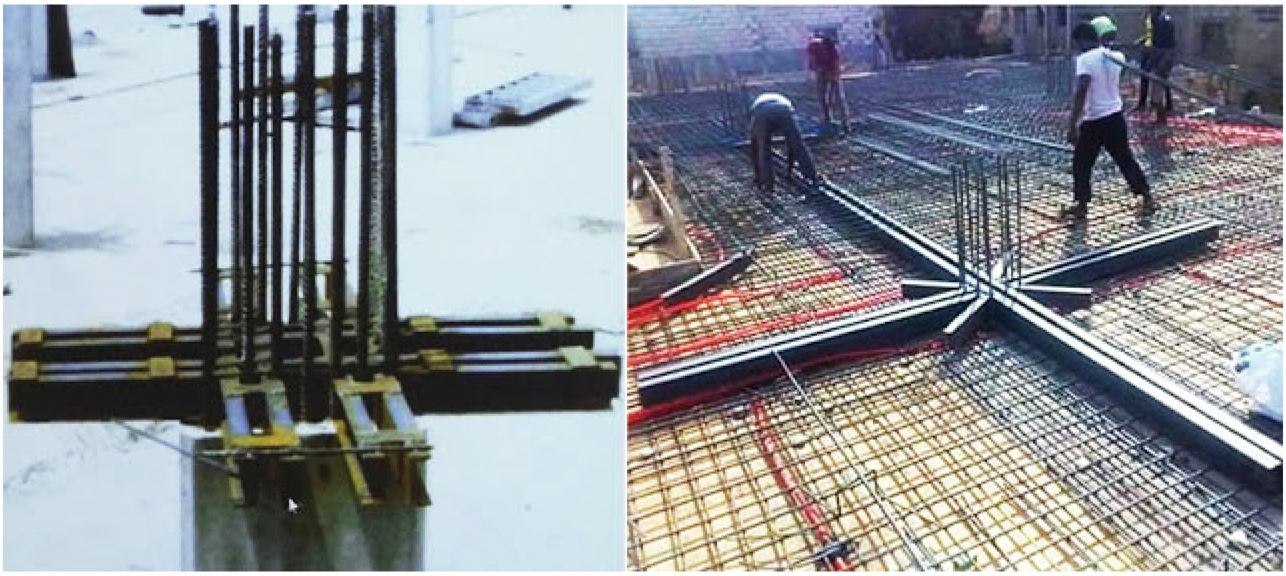
Minimum size of drop panels—ACI Section 13.2.5

To increase the strength to counter negative moment at column head and punching shear, drop panel can be used to improve such strength. The length of each side of the drop panel must be at least 1/6 of the length of the column of that particular side (L/6) and must be at least 0.25 times thicker than original floor thickness.

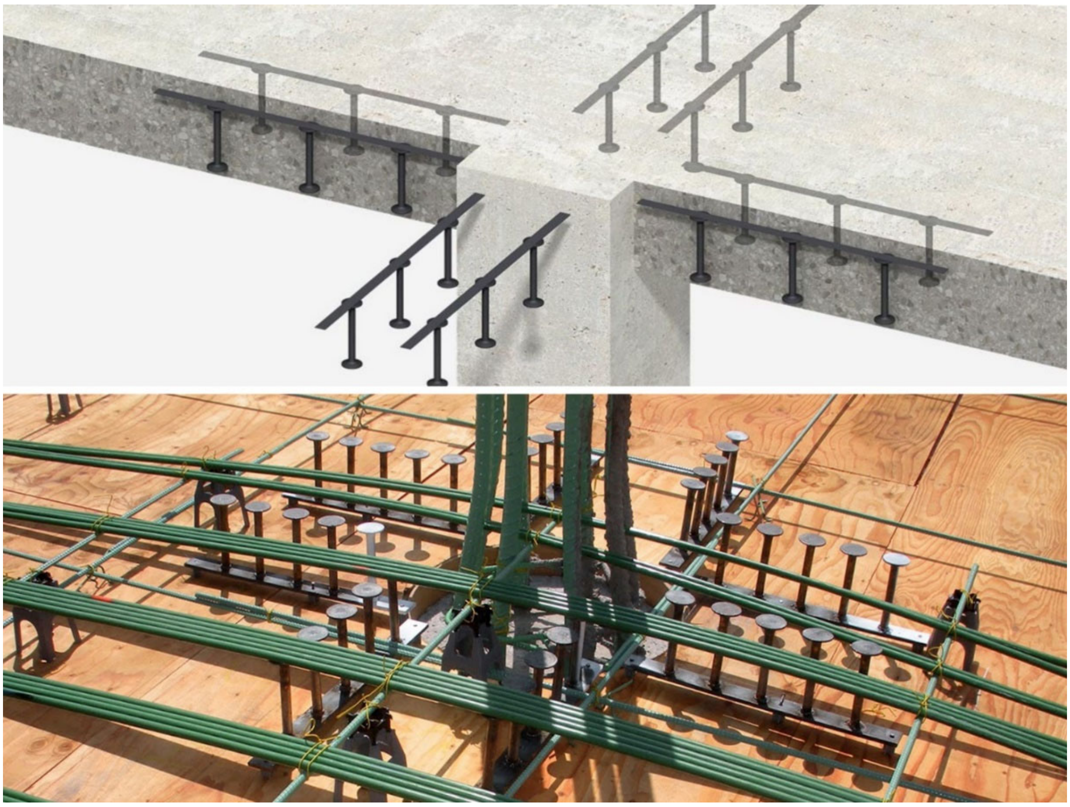
In cases where the occurred punching shear cannot be handled by floor thickness and drop panel or column capital is not a preferred option, it is also possible to add shear reinforcement using reinforcing steel which the details of steel reinforcement are indicated in ACI318 via three following methods:

1. Shear reinforcement consisting of bars

2. Shear reinforcement consisting of steel i or c shaped sections, shearhead



3. Sheaded shear stud reinforcement, shear studs



"Details regarding installation and design calculation of all three methods will be discussed in the next occasion."

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Reference document

1. ACI COMMITTEE 318; "BUILDING CODE REQUIREMENTS FOR STRUCTURAL CONCRETE (ACI 318-11) AND COMMENTARY"

2. M.E. KAMARA, L.C. NOVAK; NOTES ON ACI 318-11 BUILDING CODE REQUIREMENTS FOR STRUCTURAL CONCRETE WITH DESIGN APPLICATION

3. J.G. MACGREGOR, J.K. WIGHT ; "REINFORCED CONCRETE MECHANICS AND DESIGN"6 EDITION