

# Floor openings in two- way slabs



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## PREFACE:

The main objective for preparing this project, is how to you make opening in slab by true method of engineering and indicating location and size of opening where to be applied.

The main contents of this report are;

1.Introduction

2.Opening in new slab

3.Opening in existing slab

3.1 Opening in existing flat plates

3.2 Opening in slabs supported on beams

References

## **Floor Openings in Two-Way Slabs**

### **1. Introduction:**

Openings in slabs are usually required for plumbing, fire protection pipes, heat and ventilation ducts and air conditioning. Larger openings that could amount to the elimination of a large area within a slab panel are sometimes required for stairs and elevators shafts. For newly constructed slabs, the locations and sizes of the required openings are usually predetermined in the early stages of design and accommodated accordingly.

The ACI 318 Building Code permits openings of any size in any new slab system, provided that an analysis is performed that demonstrates that both strength and serviceability requirements are satisfied (ACI 318-02 13.4.1). The analysis for slabs containing openings could be complex and time consuming, as an alternative the ACI 318 Code gives guidelines and limitations for opening location and size. If the designer satisfies those requirements the analysis could be waived.

Modifications to an existing structure, although not frequent, occur in almost every structure. New slab openings or penetrations in an existing concrete building are easily accommodated in the majority of instances. However, the

analysis required, and the remedies are typically more involved than similar openings in a new slab.

The purpose of this article is to offer the structural engineer with guidance on selecting locations and sizes for openings in two-way slabs for both new and existing structures.

## **2. Openings in New Slabs:**

For the purposes of design, a two-way slab system is divided into column and middle strips in two perpendicular directions. The column strip width on each side of the column centerline is equal to one quarter the length of the shorter span in the two perpendicular directions. The middle strip is the strip bounded by two column strips.

As an alternative to detailed analysis for slabs with openings the ACI 318 gives the following guidelines for opening size in different locations for slabs without beams:

- In the area common to intersecting middle strips, openings of any size are permitted (13.4.2.1).
- In the area common to intersecting column strips, maximum permitted opening size is one-eighth the width of the column strip in either span (13.4.2.2).

- In the area common to one column strip and one middle strip, maximum permitted opening size is limited such that only a maximum of one-quarter of slab reinforcement in either strip may be interrupted (13.4.2.3).

To apply this simplified approach, ACI 318 requires that the total amount of reinforcement calculated for the panel without openings, in both directions, must be maintained; thus, reinforcement interrupted by the opening must be replaced on each side of the opening.

Figure 1 illustrates the provisions of 13.4.2 for slabs with  $l_2 > l_1$

In addition to flexural requirements, the reduction in the slab shear strength must also be considered when the opening is located: (1) anywhere within a column strip of a flat slab system and (2) within 10 times the slab thickness from a concentrated load or reaction area. The effect of the slab opening is evaluated by reducing the perimeter of the critical section by a length equal to the projection of the opening enclosed by two-lines extending from the centroid of the column and tangent to the opening; see Fig 2.

### **3. Openings in Existing Slabs:**

Cutting openings in existing slabs should be approached with caution and avoided if possible<sup>3</sup>. When cutting opening in existing slabs the effect on the slab structural integrity must be evaluated. For existing slabs it is advisable to analyze the slab first for excess capacity and possible moment redistribution before deciding on the sizes and locations of the openings.

Small openings in existing slabs are usually cored to the required diameter. Large openings are cut with a circular saw or concrete chain saws with plunge cutting capabilities. When using circular saw, circular cores can be made at the corners of the required opening first and connected by saw cutting to avoid cutting longer slot at the top than the bottom of the slab.

Reference 3 provides some guidelines for cutting openings in existing slabs. These guidelines are summarized as follow:

### **3.1 Openings in Existing Flat Plates:**

Figure 3 shows suggested areas where openings can be made. Because punching shear capacity of the floor around the column typically governs the design of flat plates, any openings in Area 3 should be avoided as much as possible. If openings must be made in this area, for example to install a drainage pipe, the suggested size of the opening should be no larger than 12 inches. It should be noted that openings cut in this area could reduce the critical section considered for resisting punching-shear as explained in ACI 318-02 Section 11.12.5.

Area 2, located at the intersection of column and middle strips is less critical than area 3.

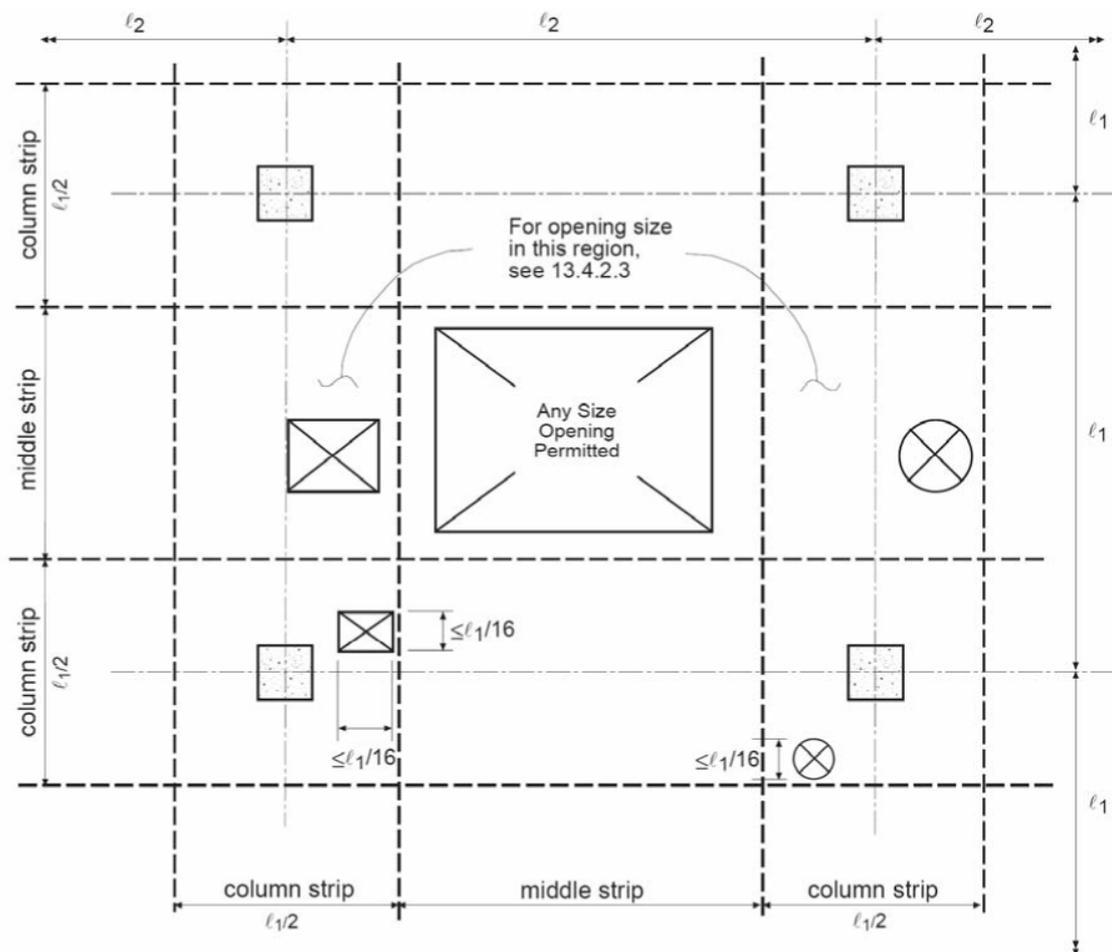
Suggested small openings having a width less than 15 percent of the span length can be made in this area.

### **3.2 Openings in Existing Slabs Supported on Beams:**

For opening locations in slabs supported on beams, the situation is reversed. Openings in zone 3, (intersection of two column strips) can be cut with dimensions up to one-quarter of the span.

Openings are not recommended in zone 2 (intersection of column strip and middle strip). Openings with maximum dimensions of one-eighth of the span can be cut in zone 1 - intersection of middle strip.

When removing entire panel of slab between beams, it is recommended to leave some overhang to allow development of reinforcing bars from adjacent spans. In this case the beams should be checked for torsion. The beams in this case may need to be strengthened. Additional information for strengthening beams can be found in Reference 3.



**Figure 1 – Suggested opening sizes and locations in flat plates**

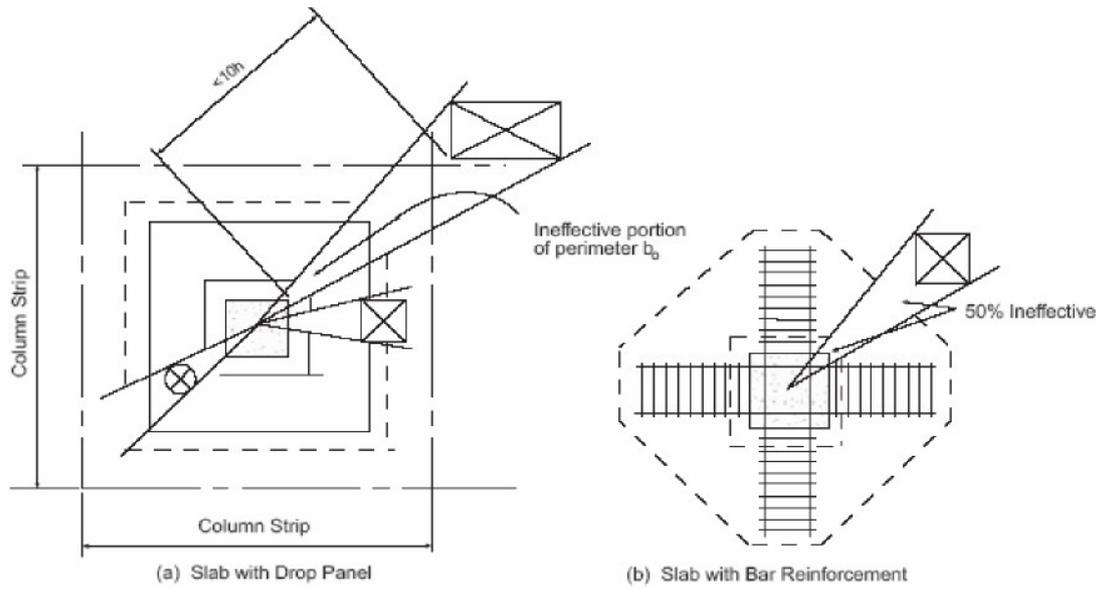


Figure 2 – Suggested slab opening locations in vicinity of column

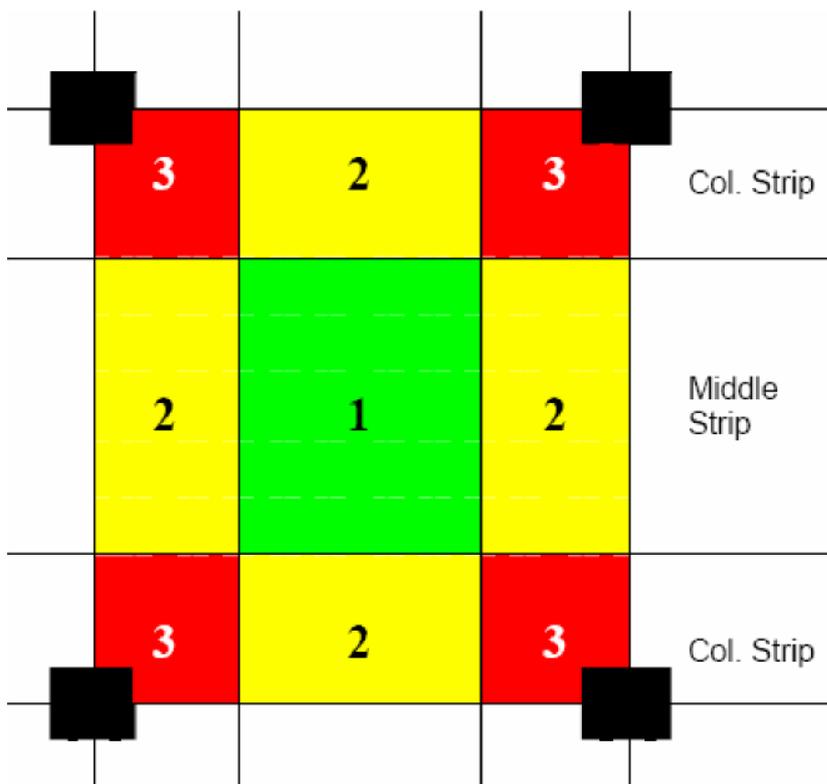


Figure 3 – Suggested openings in slab



(505 Fifth Avenue, NYC – Courtesy: Rosenwasser/Grossman, NYC)

**Figure 4 – Large opening in flat slab floor**

**References:**

1. Building Code Requirements for Structural Concrete, ACI 318-02, American Concrete Institute, Farmington Hills, MI, 2002
2. Notes on ACI 318-02, 8<sup>th</sup> Edition, EB702, Portland Cement Association, Skokie, Illinois, 2002
3. Alexander Newman, “Structural Renovation of Buildings - Methods, Details, and Design Examples, “McGraw-Hill, 2001
4. Robert Park, “Reinforced Concrete Slabs” Second edition, Wiley, 2000