Column
Part 1-Introduction

Columns are vertical elements subjected to compressive stress or the loading is along the longitudinal axis, but, in case of beams, the loading is perpendicular to longitudinal axis.

Question: Explain the categories of columns according to ACI.
Concrete columns can be of three categories:

1) Short compression blocks or pedestals
2) Short reinforced concrete columns
3) Long or slender reinforced concrete columns

Short compression blocks or pedestals—If the height of an upright compression member is less than three times its least lateral dimensions, it may be considered to be a pedestal. The ACI (2.2 and 10.14) states that a pedestal may be designed with unreinforced or plain concrete with a maximum design compressive stress equal to $0.85\phi f'_c$, where ϕ is 0.65.

Short reinforced concrete columns: When a reinforced concrete column fail due to primary stresses and initial material failure, it is classified as a short column. The load that it can support is controlled by the dimensions of the cross section and the strength of the materials. The majority of reinforced concrete columns are subjected to primary stresses caused by axial force, flexure, and shear. Secondary stresses associated with deformations are usually very small. These columns are referred to as "short columns." Short columns are designed using the interaction diagrams. The capacity of a short column is the same as the capacity of its section under primary stresses, irrespective of its length.

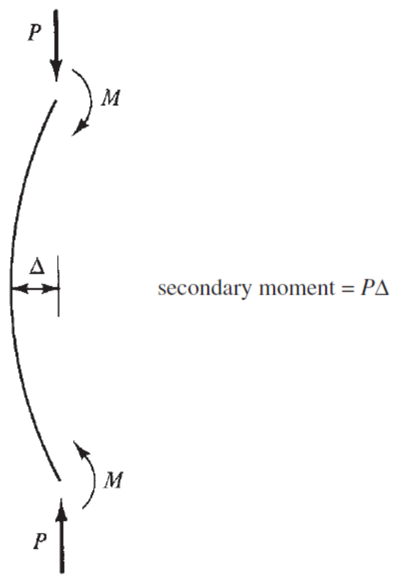
Long or slender reinforced concrete columns: As columns become more slender, bending deformations will increase, as will the resulting secondary moments. If these moments are of such magnitude as to significantly reduce the axial load capacities of columns, those columns are referred to as being long or slender. Long columns have small cross-sectional dimensions, and columns with little end restraints thus may develop secondary stresses associated with column deformations, especially if they are not braced laterally. These columns are referred to as "slender columns". Fig. 3-1 illustrates secondary moments generated in a slender column by P-δ effect. Consequently, slender columns resist lower axial loads than short columns having the same cross-section. Failure of a slender column is initiated either by the material failure of a section, or instability of the column as a member, depending on the level of slenderness. The latter is known as column buckling.

The classification of a column as a “short column” or a “slender column” is made on the basis of its
“Slenderness Ratio,” defined below.

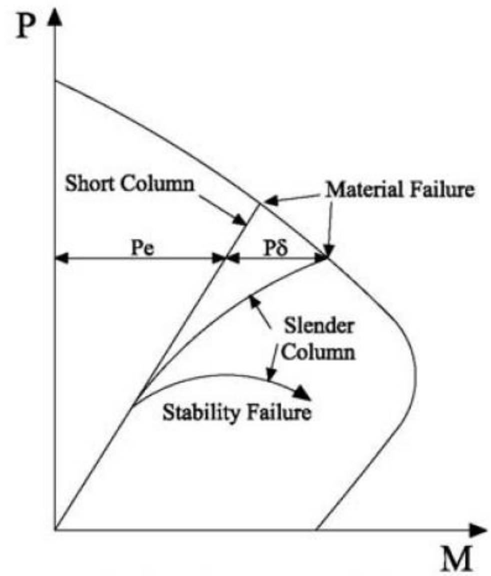
$$\text{Slenderness Ratio: } k\ell_u / r$$

where, l_u is unsupported column length; k is effective length factor reflecting end restraint and lateral bracing conditions of a column; and r is the radius of gyration reflecting the size and shape of a column cross-section.

A column that has large secondary moments is said to be a slender column, and it is necessary to size its cross section for the sum of both the primary and secondary moments. The ACI’s intent is to permit columns to be designed as short columns if the secondary or P-Δ effect does not reduce their strength by more than 5%.



Secondary or $P\Delta$ moment.



Failure Modes in Short and Slender Columns

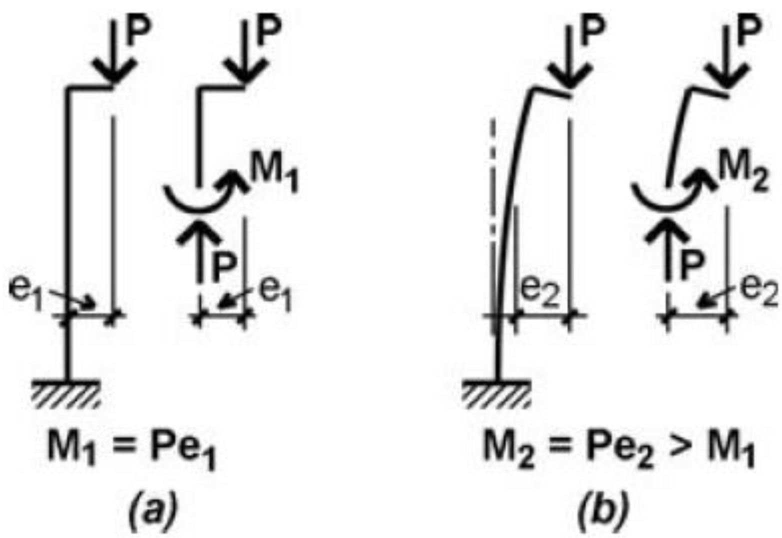


Figure: Increase of bending moment in a column due to load-induced deflection or P-Δ effect