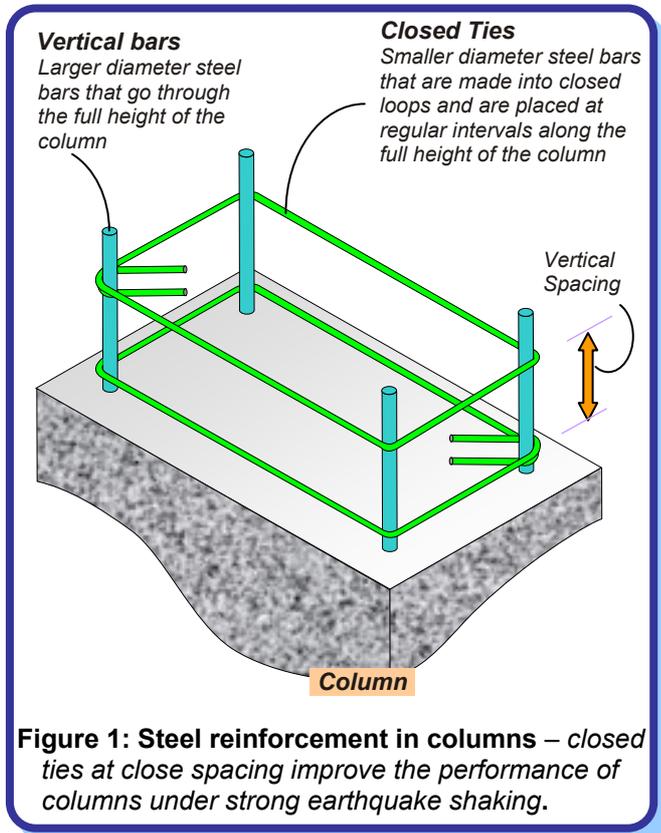


How do Columns in RC Buildings Resist Earthquakes?

Possible Earthquake Damage

Columns, the vertical members in RC buildings, contain two types of steel reinforcement, namely: (a) long straight bars (called *longitudinal bars*) placed vertically along the length, and (b) closed loops of smaller diameter steel bars (called *transverse ties*) placed horizontally at regular intervals along its full length (Figure 1). Columns can sustain two types of damage, namely *axial-flexural (or combined compression-bending) failure* and *shear failure*. Shear damage is brittle and must be avoided in columns by providing transverse ties at close spacing (Figure 2b).

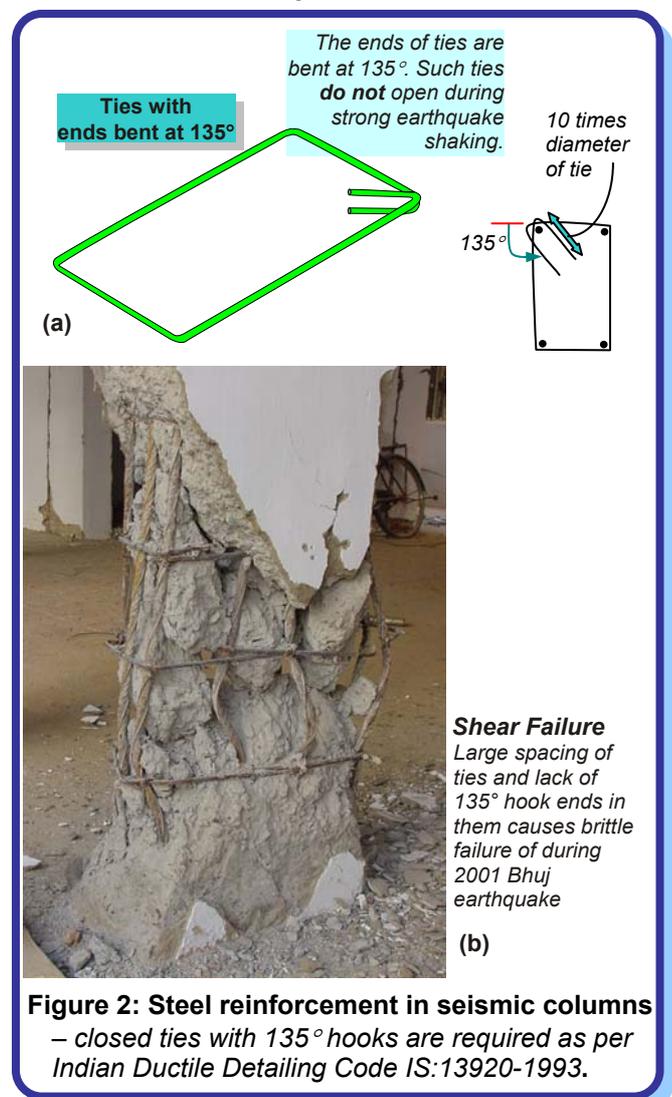


Design Strategy

Designing a column involves selection of *materials to be used (i.e., grades of concrete and steel bars)*, choosing *shape and size of the cross-section*, and calculating *amount and distribution of steel reinforcement*. The first two aspects are part of the overall design strategy of the whole building. The Indian Ductile Detailing Code IS:13920-1993 requires columns to be at least 300mm wide. A column width of up to 200mm is allowed if unsupported length is less than 4m and beam length is less than 5m. Columns that are required to resist earthquake forces must be designed to prevent *shear failure* by a skillful selection of reinforcement.

Vertical Bars tied together with Closed Ties

Closely spaced horizontal closed ties help in three ways, namely (i) they carry the horizontal shear forces induced by earthquakes, and thereby resist diagonal shear cracks, (ii) they hold together the vertical bars and prevent them from excessively bending outwards (in technical terms, this bending phenomenon is called *buckling*), and (iii) they contain the concrete in the column within the closed loops. The ends of the ties must be bent as 135° hooks (Figure 2). Such hook ends prevent opening of loops and consequently buckling of concrete and buckling of vertical bars.



The Indian Standard IS13920-1993 prescribes following details for earthquake-resistant columns:
(a) Closely spaced ties must be provided at the two ends of the column over a length not less than larger dimension of the column, *one-sixth* the column height or 450mm.

How do Columns in RC Buildings Resist Earthquakes?

- (b) Over the distance specified in item (a) above and below a beam-column junction, the vertical spacing of ties in columns should not exceed $D/4$ for where D is the smallest dimension of the column (e.g., in a rectangular column, D is the length of the small side). This spacing need not be less than 75mm nor more than 100mm. At other locations, ties are spaced as per calculations but not more than $D/2$.
- (c) The length of tie beyond the 135° bends must be at least 10 times diameter of steel bar used to make the closed tie; this extension beyond the bend should not be less than 75mm.

Construction drawings with clear details of closed ties are helpful in the effective implementation at construction site. In columns where the spacing between the corner bars exceeds 300mm, the Indian Standard prescribes *additional* links with 180° hook ends for ties to be effective in holding the concrete in its place and to prevent the buckling of vertical bars. These links need to go around both vertical bars and horizontal closed ties (Figure 3); special care is required to implement this properly at site.

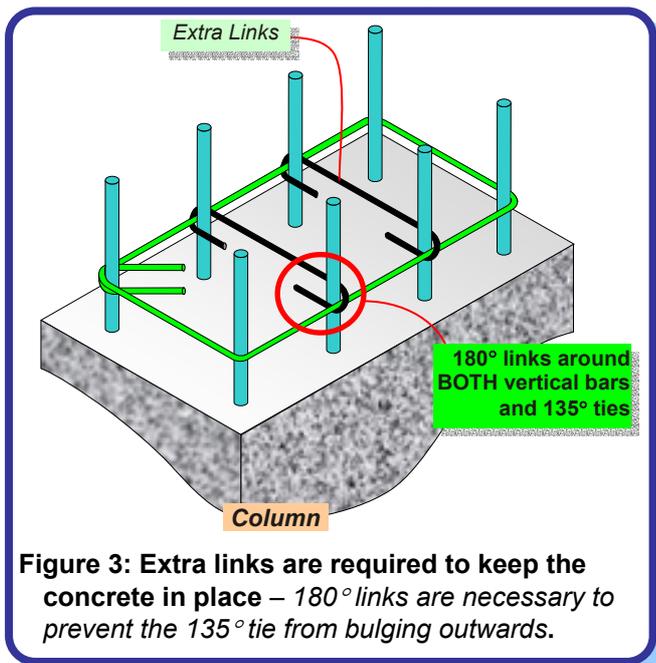


Figure 3: Extra links are required to keep the concrete in place – 180° links are necessary to prevent the 135° tie from bulging outwards.

Lapping Vertical Bars

In the construction of RC buildings, due to the limitations in available length of bars and due to constraints in construction, there are numerous occasions when column bars have to be joined. A simple way of achieving this is by overlapping the two bars over *at least* a minimum specified length, called *lap length*. The lap length depends on types of reinforcement and concrete. For ordinary situations, it is about 50 times bar diameter. Further, IS:13920-1993 prescribes that the lap length be provided **ONLY** in the middle half of column and not near its top or bottom ends (Figure 4). Also, only half the vertical bars in the column are to be lapped at a time in any storey. Further, when laps are provided, ties must be provided along the length of the lap at a spacing not more than 150mm.

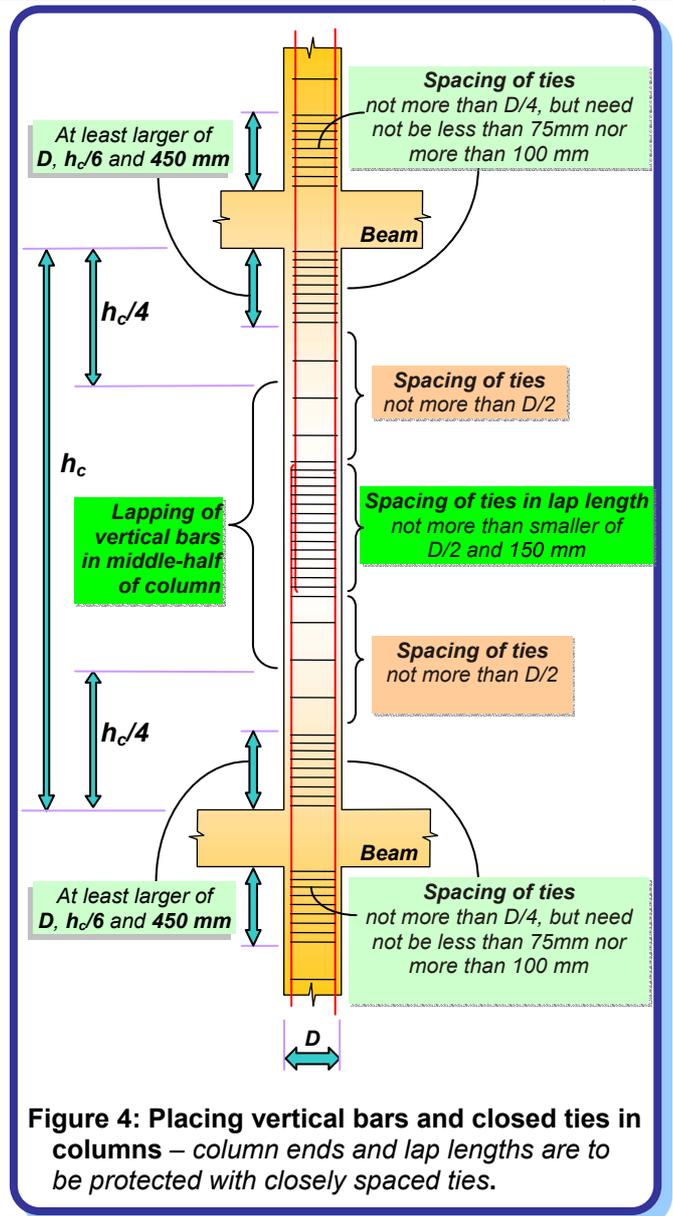


Figure 4: Placing vertical bars and closed ties in columns – column ends and lap lengths are to be protected with closely spaced ties.

Related IITK - BMTPC Earthquake Tip

- Tip17: How do Earthquakes Affect Reinforced Concrete Buildings?
Tip18: How do Beams in RC Buildings Resist Earthquakes?

Resource Material

IS 13920, (1993), Indian Standard Code of Practice for Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces, Bureau of Indian Standards, New Delhi.

Paulay, T., and Priestley, M.J.N., *Seismic Design of Masonry and Reinforced Concrete Buildings*, John Wiley & Sons, USA, 1992.

Next Upcoming Tip

How do Beam-Column Joints in RC Buildings Resist Earthquakes?

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