5-E YIELD
REDUCTION FACTORS

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APPENDIX 5-E

JUSTIFICATION FOR YIELD REDUCTION FACTORS

(Ø - FACTORS) USED IN

DETERMINING YIELD STRENGTH OF CONTAINMENT STRUCTURE

The Ø factors are provided to allow for variations in materials and workmanship. In the ACI Code 318-63, Ø varies with the type of stress or member considered; that is, with flexure, bond or shear stress, or compression.

The Ø factor is multiplied into the basic strength equation, or, for shear, into the basic permissible unit shear, to obtain the dependable strength. The basic strength equation gives the "ideal" strength, assuming materials are as strong as specified, sizes are as shown on the drawings, the workmanship is excellent, and the strength equation itself is theoretically correct. The practical, dependable strength may be something less, since all these factors vary.

The ACI Code provides for these variables by using these Ø factors:

Ø = 0.90 for concrete in flexure

Ø = 0.85 for diagonal tension, bond, and anchorage

Ø = 0.75 for spirally reinforced, concrete compression members

Ø = 0.70 for tied compression members

Ø is larger for flexure because the variability of steel is less than that of concrete and the concrete in compression has a fail-safe mode of behavior; that is, material understrength without failure. The Ø values for columns are lower (favoring the toughness of spiral columns over tied columns) because columns fail in compression where concrete strength is critical. Also, it is possible that the analysis might not combine the worst combination of axial load and moment, and since the member is critical in the gross collapse of the structure, a lower value is used.

The additional Ø values used represent Bechtel's best judgment of how much understrength should be assigned to each material and condition not covered directly by the ACI Code. The additional Ø factors have been selected based on material quality in relation to the existing Ø factors.

Conventional concrete design of beams requires that the design be controlled by yielding of the tensile reinforcing steel. This steel is generally spliced by lapping in an area of reduced tension. For members in flexure, ACI uses Ø = 0.90. The same reasoning has been applied in assigning a value of Ø = 0.90 to reinforcing steel in tension, which now includes axial tension. However, the code recognizes the possibility of reduced bond of bars at the laps by specifying a ϕ of 0.85. Mechanical and welded splices will develop at least 125 per cent of the yield strength of the reinforcing steel. Therefore, ϕ = 0.90 is recommended for this type of splice.

The only significantly new value introduced is ϕ = 0.95 for prestressed tendons in direct tension. A higher ϕ value than for conventional reinforcing has been allowed because (1) during installation the tendons are each jacked to about 94 per cent of their yield strength, so in effect, each tendon has been proof tested, and (2) the method of manufacturing prestressing steel (cold drawing and stress relieving) ensures a higher quality product than conventional reinforcing steel.

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