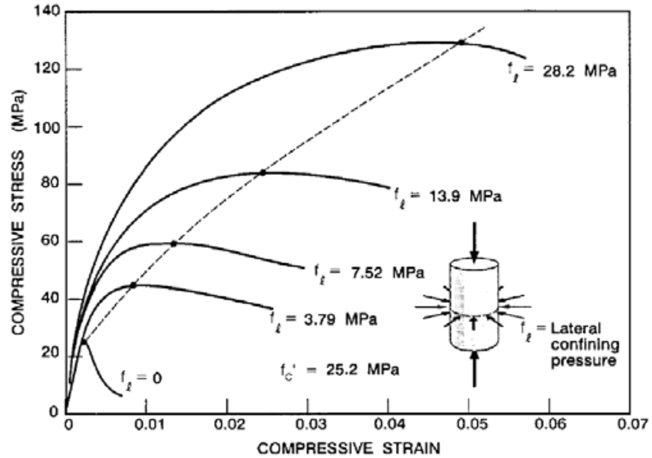


Figure 1-1: Influence of Lateral Confining Pressure on Compressive Response

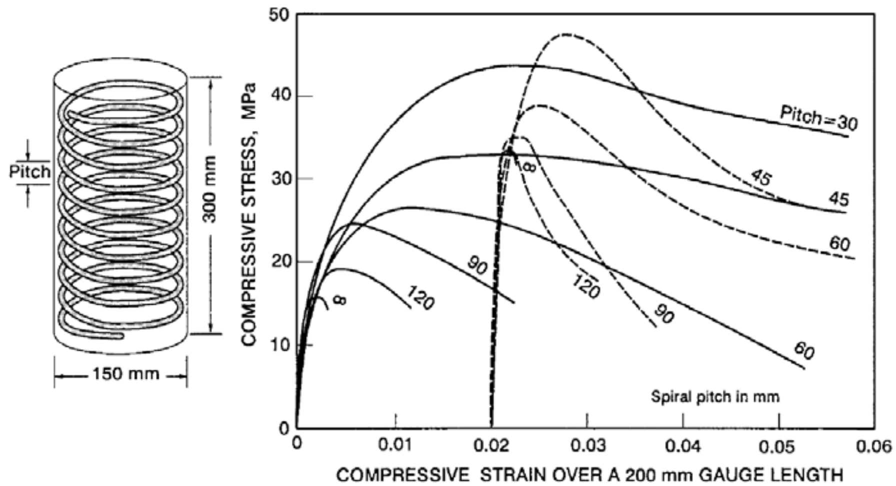


Figure 1-2: Influence of Passive Spiral Confinement on Compressive Response

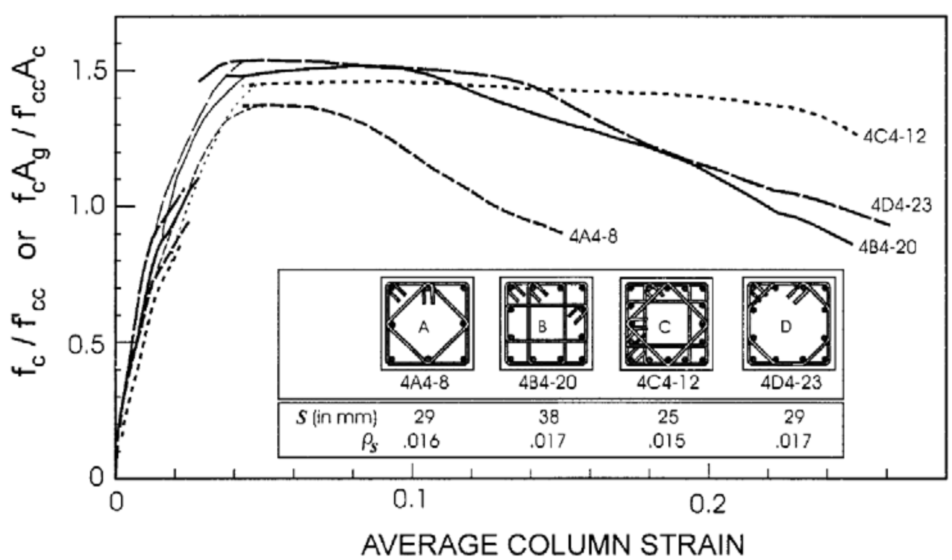


Figure 1-3: Compressive Response of Passively Confined Rectangular Columns

Modified Kent and Park (Ref. 2.35)

The very influential confinement model by Kent and Park published in 1971 (Ref. 2.40) was based on square column tests with four corner bars and square ties. It suggested that confinement reinforcement increased the ductility, but not the strength of columns.

After the results from more extensive experimental investigations were available, this model was modified to include a strength enhancement factor (K). This factor was made a function of the strength of the confinement provided and the compressive strength of the concrete.

This model is described in Equations 2.5a-g, and Figure 2.5.

Pre-Peak Response (Parabola) : $f_c = K \times f'_c \times \left[\frac{2 \times \varepsilon_c}{.002K} - \left(\frac{\varepsilon_c}{.002K} \right)^2 \right]$ { Equation 2.5a }

Post-Peak Response: $f_c = K \times f'_c \times [1 - Z_m(\varepsilon_c - .002\ K)] \geq 0.2 \times K \times f'_c$ { Equation 2.5b }

where $K = 1 + \frac{\rho_s \times f_{yh}}{f'_c}$ and $\rho_s \cong \rho = \frac{A_{spiral}}{A_{gross}}$ {Equations 2.5c&d}

$$Z_m = \frac{0.5}{\varepsilon_{50u} + \varepsilon_{50h} - .002K}$$ { Equation 2.5e }

$$\varepsilon_{50u} = \frac{.3 + .29 \times f'_c}{145 \times f'_c - 1000}, \quad \varepsilon_{50h} = \frac{3}{4} \times \rho_s \times \sqrt{b''/s_h}$$ {Equations 2.5f&g}

f_{yh} = hoop yield stress

b'' = width of confined core measured to outside of hoops, s_h = vertical spacing of hoops,

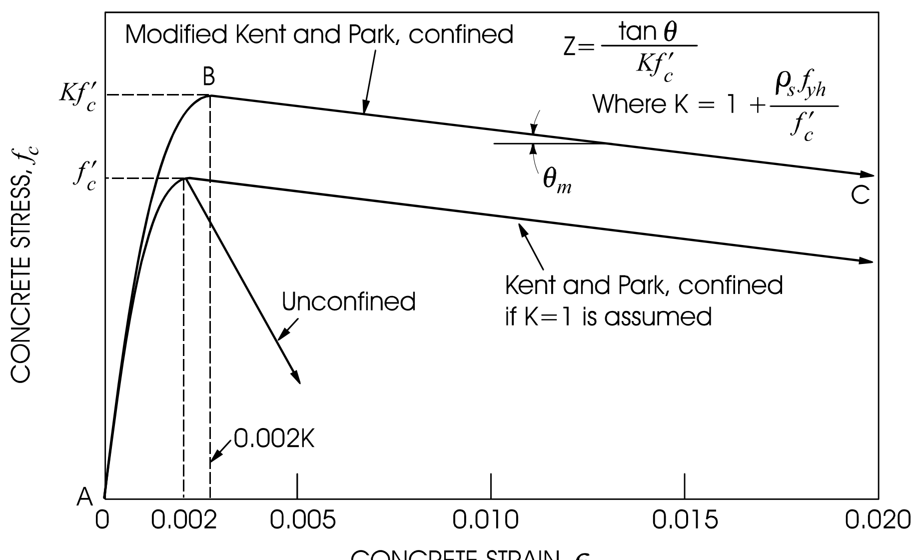


Figure 2.5 : Prediction of Modified Kent and Park Confinement Model

Sheikh and Uzumeri (Ref. 2.41)

This was the first model to consider the influence of the distribution of the longitudinal reinforcement and the configuration of the rectangular column ties on the effectiveness of the confinement provided. The authors suggest a strength enhancement factor (K_s) which, in addition to being dependent on the amount and strength of the confinement steel, takes into consideration what proportion of the core is effectively confined by the longitudinal and transverse reinforcement provided. This model is described by Equations 2.6a-i and in Figure 2.6.

A : Pre-Peak Response (Parabola), ($0 \geq \varepsilon_c \geq \varepsilon'_c$)

$$f_c = f'_{cc} \times \left[\frac{2 \times \varepsilon_c}{K_s \times \varepsilon_{s1}} - \left(\frac{\varepsilon_c}{K_s \times \varepsilon_{s1}} \right)^2 \right] \qquad \text{\{ Equation 2.6a \}}$$

B : Post-Peak Response ($\varepsilon_c < \varepsilon'_c$)

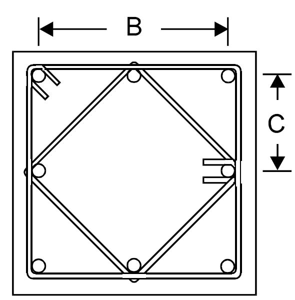
$$f_c = f'_{cc} \times \left[1 - \frac{0.15 \times (\varepsilon_c - \varepsilon_{s2})}{(\varepsilon_{s85} - \varepsilon_{s2})} \right] \geq 0.3 \times f'_{cc} \qquad \text{\{ Equation 2.6b \}}$$

where $f'_{cc} = Ks \times f_{cp}$, f_{cp} = unconfined concrete strength { Equation 2.6c }

$$K_s = 1 + \frac{B^2}{140 \times P_{occ}} \times \left[\left(1 - \frac{n \times C^2}{5.5 \times B^2} \right) \times \left(1 - \frac{S}{2 \times B} \right)^2 \right] \times \sqrt{\rho_s \times f'_s} \qquad \text{\{ Equation 2.6d \}}$$

B = outer tie dimension

C = intermediate tie spacing



$P_{occ} = 0.85 \times f'_c \times (B^2 - A_s)$ { Equation 2.6e }

n = # of bars

S = hoop spacing

ρ_s = hoop volume ratio = $A_{spirals}/A_{core}$ { Equation 2.6f }

f'_s = hoop stress

$\varepsilon_{s1} = \varepsilon'_c \times K_s$ { Equation 2.6g }

$$\frac{\varepsilon_{s2}}{\varepsilon'_c} = 1 + \frac{248}{C} \times \left(1 - 5 \times \left(\frac{S}{B} \right)^2 \right) \times \frac{\rho_s \times f'_s}{\sqrt{f'_c}} \qquad \text{\{ Equation 2.6h \}}$$

$$\varepsilon_{s85} = 0.225 \times \rho_s \times \sqrt{B/S} + \varepsilon_{s2} \qquad \text{\{ Equation 2.6i \}}$$

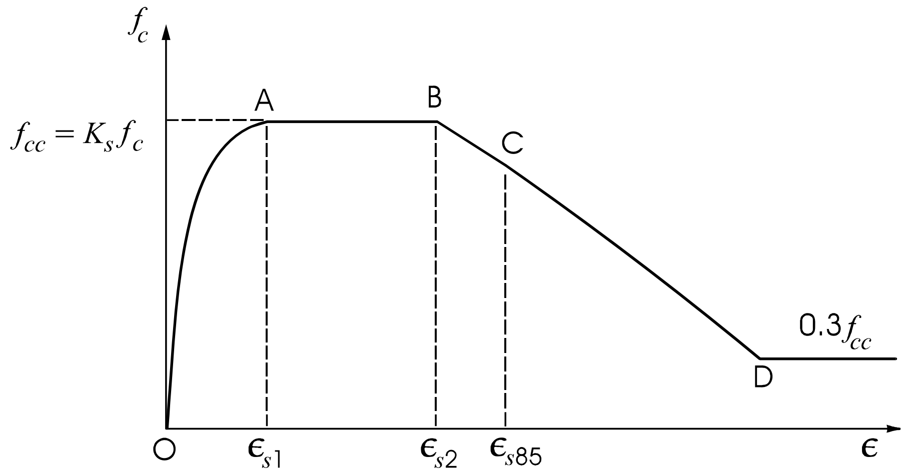


Figure 2.6 : Confinement Model for Square Columns by Sheikh and Uzumeri

Mander Priestly and Park (Ref. 2.43)

This is a general purpose confinement model capable of predicting the benefits of confinement in circular or rectangular columns subjected to either monotonic or cyclic loading. Only the features of this model that are revenant for this present study are summarized. The lateral confining pressure is evaluated assuming that the transverse reinforcement is yielding at the peak compressive stress. To account for the experimental observation that the entire core area (A_c) is not effectively confined, the authors reduce the lateral confining pressure as described in Equations 2.7a&b.

$f'_\ell = k_e \times f_\ell$ { Equation 2.7a } f'_ℓ = effective lateral confining pressure

where $k_e = A_e/A_c$ { Equation 2.7b } A_e = effectively confined concrete area

The authors have taken an approach similar to that taken by Sheikh and Uzumeri, which is to define the effective core regions as a function of the configuration and spacing of the longitudinal and transverse reinforcement. The authors assume that the unconfined region extends inwards of the centreline of the transverse and longitudinal reinforcement in the form of a second degree parabola with an initial tangent slope of 45°. Typical values for k_e are 0.95 for circular columns confined by spirals, 0.75 for confined square columns, and 0.50 for walls. In reference 2.43, expressions for the evaluation of the effectively confined area (A_e) are given.

The authors suggest that the general form of the modified Popovics expression be used to predict the compressive stress-strain response. In Equation 2.7c, the confined compressive strength (f'_{cc}) has replaced f'_c and the strain at peak confined stress (ε'_{cc}) has replaced ε'_c.

$$\frac{f_c}{f'_{cc}} = \frac{\varepsilon_c / \varepsilon'_{cc} \times n}{n - 1 + \left(\varepsilon_c / \varepsilon'_{cc}\right)^n} \qquad \{ \text{Equation 2.7c} \}$$

$$\text{where } n = \frac{E_c}{\left(E_c - f'_{cc}/\varepsilon'_{cc}\right)} \qquad \{ \text{Equation 2.7d} \}$$

The predicted confined strength for the case when the two lateral confining pressures are equal is given in Equation 2.7e. Methods are presented in the reference for when the pressures are not equal.

$$f'_{cc} = f'_{co} \times \left(-1.254 + 2.254 \times \sqrt{1 + \frac{7.94 \times f'_{\ell}}{f'_{co}}} - 2 \times \frac{f'_{\ell}}{f'_{co}} \right) \qquad \{ \text{Equation 2.7e} \}$$

where f'_{co} is the unconfined concrete compressive strength.

The strain at peak stress is predicted by the relationship suggested by Richart et al.

$$\varepsilon'_{cc} = \varepsilon'_c \left(5 \times f'_{cc} / f'_c - 4 \right) \qquad \{ \text{From Equation 2.3b} \}$$

This model is described in Figure 2.7b.

This model also presents a method for evaluating the compressive strain at failure. Failure is assumed to be reached at first hoop fracture. This event is evaluated by equating the energy at rupture in the hoop reinforcement to the compressive strain energy stored in the compressed concrete.

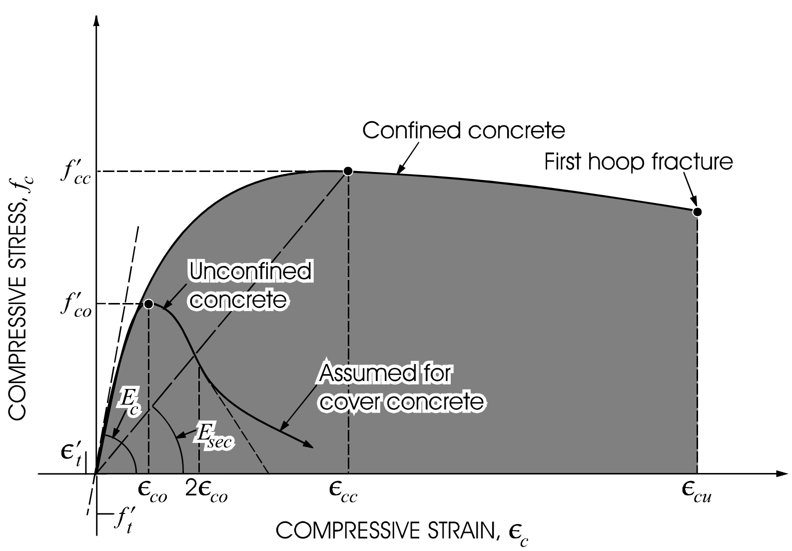


Figure 2.7b : Mander, Priestly, and Park Confinement Model

It is interesting to compare the predicted effect of confinement on high and low strength concrete using a slightly modified version of the Mander, Priestly, and Park model. This is shown in Figure 2.7c.

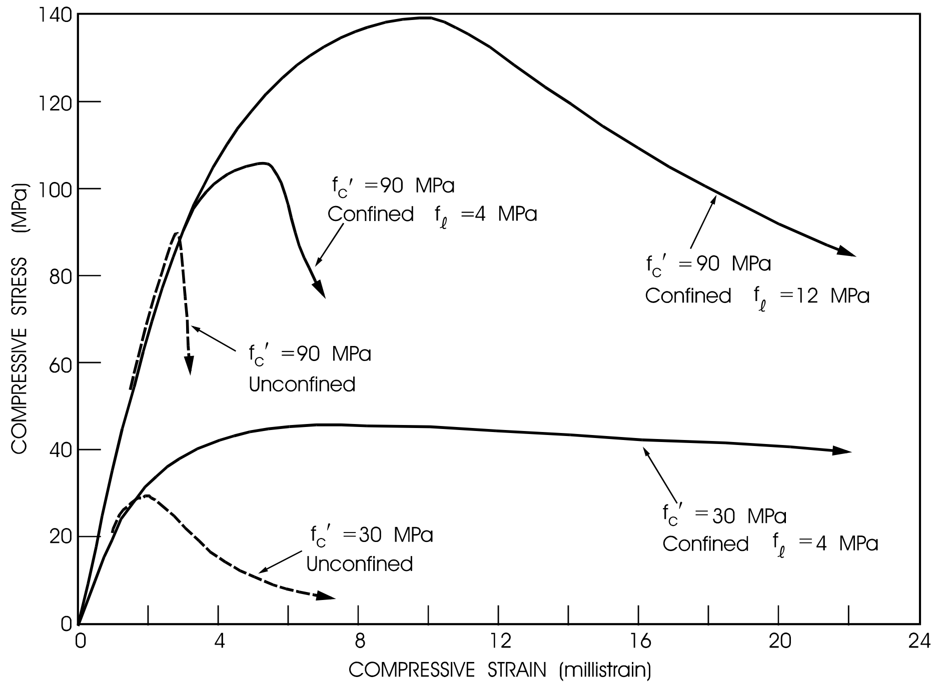


Figure 2.7c : Prediction using the Mander, Priestly, and Park Confinement Model

References for this Section

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