Application of Data-Driven Modeling Techniques for Predicting the Shear Strength of Reinforced Concrete Beams

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Supplementary Information Overview

Table S1: Experimental studies used to compile the reinforced concrete beam database and the corresponding number of specimens contributed by each reference.

Tables S2. Empirical shear-strength prediction equations and their applicability limits for reinforced concrete beams collected from the literature.

Table S1: Experimental studies used to compile the reinforced concrete beam database and the corresponding number of specimens contributed by each reference.

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Tables S2. Empirical shear-strength prediction equations and their applicability limits for reinforced concrete beams collected from the literature.

Author's	Empirical Equation's	Limits
ACI [113]	$\vartheta_{cr} = 0.16\sqrt{f'_c} + 17.2\rho\frac{Vd}{M}$	$\leq 0.3\sqrt{f'_c}$ $\frac{a}{d} > 2.5$
	$\vartheta_{cr} = \left(3.5 - 2.5\frac{a}{d}\right)\left[0.16\sqrt{f'_c} + 17.2\rho\frac{Vd}{M}\right]$	$\leq 0.3\sqrt{f'_c}$ $\frac{a}{d} \leq 2.5$
ACI [113]	$\vartheta_u = 2.3(f'_c\rho\frac{d}{a})^{0.333}$	$\frac{a}{d} \geq 2.5$

	$\vartheta_u = \left(\frac{2.5}{\frac{a}{d}}\right)\left[2.3(f'_c\rho\frac{d}{a})^{0.333}\right]$	$\frac{a}{d} < 2.5$
Zsutty [114]	$\vartheta_u = 0.366\sqrt[3]{f'_c} + 0.49$	$\frac{a}{d} = 3.5$
	$\vartheta_u = \eta\left[1.8\left(f'_c\,\rho\frac{d}{a}\right)^{0.333}\right]$	For $3 \le \frac{a}{d} \le 6$ $\eta = 1 - 0.00265\left[\frac{(d-135.9)^{0.85}}{\left(\frac{a}{d}\right)^{0.63}}\right]$ For $\frac{a}{d} \le 3$, $\eta = 1 - 0.03985\left[\frac{(d-135.9)^{0.8}}{\left(\frac{a}{d}\right)^{2.84}}\right]$
Zsutty [34]	$\vartheta_{cr} = 1.8\left(f'_c\,\rho\frac{V_u d}{M_u}\right)^{0.38}$	For $\frac{a}{d} \ge 2$
	$\vartheta_{cr} = 0.2\sqrt{f'_c}$	For $\frac{a}{d} \ge 2$
Mphonde, Frantz [53]	$\vartheta_{cr} = (0.07 + 10\rho)\sqrt{f'_c}$	For $\frac{a}{d} \ge 2$
	$\vartheta_n = 4.13\left(f'_c\rho\frac{d}{a}\right)^{0.66}$	For $\frac{a}{d} \le 2$, $40 < f'_c < 110$ Mpa
Shuaib H Ahmad, A.R. Khaloo, Poveeda [115]	$\vartheta_n = 3.05\left(f'_c\rho\frac{d}{a}\right)^{0.55}$	For $\frac{a}{d} > 2$, $40 < f'_c < 110$ Mpa
	$\vartheta_{uc} = \xi\left[0.97\rho^{0.46}\sqrt{f'_c} + 0.2\rho^{0.91}f'^{0.38}_c\, f^{0.96}_{yl}\left(\frac{a}{d}\right)^{-2.33}\right]$ Where $\xi = \frac{1}{\sqrt{1+\frac{d}{25\,d_a}}}$ f_{yl} = Yielding Strength of longitudinal reinforcement.	For High strength Concrete Beam without Shear Reinforcement
Kaiss F. Sarsam, Janan M.S. Al-Musawi [116]	$\vartheta_{uc} = \min(\upsilon_{Rd1}, \upsilon_{Rd2})$, Where, $\upsilon_{Rd1} = 0.035\, f'^{2/3}_c\, k\,(1.2 + 40\rho)$, $\upsilon_{Rd2} = 0.3\,\upsilon\, f'_c$	$k = 1.6 - d \ge 1$ $\rho \le 0.02$, $\upsilon = 0.7 - \frac{f'_c}{200} \ge 0.5$, Where d is in m and f'_c is in Mpa
	$\vartheta_{cr} = 0.215\gamma_m\xi\sqrt[3]{100\rho f_{cu}}$, where $\gamma_m = 1.25$ $\xi = \sqrt[3]{\frac{250}{h}}$	$1 \le \xi \le 1.2$
Canadian Code [117]	$\vartheta_u = 3.5\, f'^{1/3}_c\rho^{3/8}\left(0.4 + \frac{d}{a}\right)\lambda(d)$ Where $\lambda(d) = \frac{1}{\sqrt{1+0.008d}} + 0.18$	$\frac{a}{d} \ge 3$
	$\vartheta_u = 3.5\, f'^{\propto/3}_c\rho^{3/8}\left(0.4 + \frac{d}{a}\right)\lambda(d)$ Where $\propto = 2 - \frac{\frac{a}{d}}{3}$	For $1 \le \frac{a}{d} < 3$

New Zealand Code [117]	$\vartheta_u = 19.4\, f'_c{}^{\alpha/3}\rho^{3/8}\left(0.4+\frac{d}{a}\right)\left(\frac{1}{\sqrt{d}}+0.07\right)$ For $1 \le \frac{a}{d} < 3 \quad \alpha = 2-\frac{\frac{a}{d}}{3}$ For $\frac{a}{d} \ge 3 \quad \alpha = 1$	For $d \ge 250$ mm (9.84 in)
	$\vartheta_u = 0.2\left(1-\sqrt{\rho}\right)\left(\frac{d}{a}\right)^r\left[\sqrt{f'_c}+1020\rho^{0.9}\left(\frac{d}{a}\right)^{0.6}\right]$	$r = \left(\frac{d}{a}\right)^{0.6}\rho^{-.01}$ r= internal moment arm length index
S. Sarkar, O.Adwan, B.Base [118]	$V_c = \lambda_1\left(1-0.35\frac{x_e}{h_a}\right)\sqrt{f_{cu}}bh_a$ $\lambda_1 = 0.44$	For $0 \le \frac{x_e}{h_a} < 0.7$ $\frac{x_e}{h_a}$ = clear shear span to height ratio
	$\vartheta = \frac{200}{1000+s_e}\sqrt{f'_c}$ Where $s_e = 0.9d\frac{35}{agg+16}$, agg = maximum specified coarse aggregate size, mm	Min / Max agg,mm: 0 / 30 a/d: 1 / 6 ρ, %: 0.4 / 3.85 f'_c, MPa: 20 / 99 min d,mm: 21 / 360 max d,mm: 330 / 3000
S. Sarkar, O.Adwan, B.Base [118]	$\vartheta_c = 0.4+\sqrt{f'_c\rho\frac{d}{a}}\,(10-3\,A_d)$	Where for $1 < \frac{a}{d} < 2.5$, $A_d = \frac{a}{d}$ for $\frac{a}{d} \ge 2.5$, $A_d = 2.5$
	$\vartheta_c = 0.12\left(1+\sqrt{\frac{200}{d}}\right)\left(\frac{3d}{a_s}\right)^{1/3}(\rho_s f_{ck})^{1/3} - 0.15\sigma_{cd}$	$\sigma_{cd} = \frac{N_d}{A_c}$, Where N_d =Factored Axial Force, A_c = Area of concrete
Russo, Somma, Angeli [119]	$\vartheta_c = 0.12\xi(\rho_s f_{ck})^{1/3} - 0.15\sigma_{cd}$ Where $\xi = 1+\sqrt{\frac{200}{d}}$	$f_{ck} \le 60$ Mpa $\rho_s \le 0.02$ V is in Newtons
	$\vartheta_c = \frac{0.18}{\gamma_c}\,K(100\rho_l f_{ck})^{1/3} + 0.15\sigma_{cp}$ $\vartheta_c min = 0.035k^{3/2}f_{ck}{}^{1/2}$	$f_{ck} \le 100$ MPa $k = 1+\sqrt{\frac{200}{d}} \le 2$, where d is in mm $\rho_l = \frac{A_s}{b_w d} \le 0.02$ V is in Newtons
Eurocode EC2 [120]	$\vartheta_c = (0.8+100\rho)\frac{\sqrt{f'_c}}{12}$	$\le 0.179\sqrt{f'_c}$ MPa
	$\vartheta_c = \beta_1\beta_2\beta_3\left(\frac{A_{st}f'_c}{b_w d_o}\right)^{1/3}$ Where d_o = distance of the extreme compression fiber to the centroid of the outermost layer of tensile reinforcement (not less than 80% of the overall depth of the section), in mm. β_1 =factor to account for the depth of the section and is given by	$f'_c \le 50$ MPa

	$1.1\left(1.6-\frac{d_o}{1000}\right)\geq 1.1$. β_2 =factor to account for the axial forces in the member and is equal to 1 for members with zero axial loads. β_3 =factor to account for the presence of a large, concentrated load near a support, equal to $\frac{2d_o}{a}$	

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