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Shear Strength Capacity of Reinforced Concrete Corbels

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Keywords:
Corbels; Shear capacity; Span-depth ratio; Main reinforcement percentage; Horizontal reinforcement percentage; Concrete compressive strength.

Highlights:

- *Proposed equation to predict the ultimate shear strength (Vn).*
- *Reinforcement ratio effect for the corbel's nominal shear strength.*
- *Compressive strength effect (f_c') for the corbel's nominal shear strength.*

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Abstract: Many researchers had experimentally investigated the parameters influencing the reinforced concrete corbel behavior and shear capacity. The main parameters studied in these researches were the influence of concrete compressive strength (f_c'), shear span to effective depth ratio (a_v/d), longitudinal reinforcement percentage (ρ_s), horizontal reinforcement ratio (ρ_h), and effective depth (d). All specimens were tested under monotonic vertical load up to failure. Shear strength of corbels is essentially based on empirical or semi-empirical equations. In this work, a total of (47) tests of reinforced concrete corbels from the available in the literature and covered the main parameters are adopted to predict a proposal formula for the nominal shear strength of the corbel. This proposal is compared with ACI-318M- 2019 provisions and with the expressions proposed by other researchers. For the present proposed equation, the coefficient of variation (COV%) factor, which equals to 29.75% for the ultimate load, is the least (COV%) factor compared with other proposed equations. It was also found that the shear span to the effective depth ratio (a_v/d), the amount of horizontal reinforcement (stirrups) (ρ_h), the amount of main reinforcement (ρ_s), the compressive strength of concrete (f_c') have a significant effect on the nominal strength of reinforced concrete corbels.

سعة مقاومة القص للكتائف الخرسانية المسلحة

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الخلاصة
قام العديد من الباحثين بإجراء دراسة تجريبية على العوامل المؤثرة على سعة مقاومة القص للكتائف الخرسانية. اهم العوامل المثرة التي تم دراستها في هذه الابحاث هي تأثير مقاومة الانضغاط للخرسانة (f'_c)، تأثير نسبة فضاء القص الى العمق الفعال (a_v/d)، نسبة حديد التسليح الطولي (ρ_s)، نسبة حديد التسليح الافقي (ρ_h) والعمق الفعال (d). تم اختبار جميع النماذج تحت تأثير الحمل العمودي الساكن حتى الفشل. تعتمد مقاومة القص للكتائف بشكل اساسي على معادلات تجريبية او شبه تجريبية. تم اعتماد (٤٧) نموذج من الـcorbel الخرسانية المسلحة من المصادر المتوفرة والتي تغطي العوامل الرئيسية للتنبؤ بصيغة مقترحة لمقاومة القص الاسمية للكتائف. تم مقارنة المعادلة المقترحة مع الكود الامريكي ACI- 318M- 2019 ومعادلات مقترحة لباحثين اخرين. بالنسبة للحمل الاقصى فان معامل التباين (COV%) للمعادلة المقترحة والذي يساوي 29.75% هو العامل الاقل (COV%) مقارنة مع المعادلات المقترحة الاخرى. كما وجد ان نسبة فضاء القص الى العمق الفعال (a_v/d)، نسبة حديد التسليح الافقي الاتاري (ρ_h)، نسبة حديد التسليح الرئيسي الطولي (ρ_s) ومقاومة الانضغاط للخرسانة (f'_c)لها تأثير فعال على المقاومة الاسمية للكتائف الخرسانية المسلحة.

الكلمات الدالة: الأقواس، قدرة القص، نسبة الامتداد إلى العمق، نسبة التسليح الرئيسي، نسبة التسليح الأفقي، قوة ضغط الخرسانة.

1.INTRODUCTION

Corbels (or brackets) are critical structural components that support prefabricated beams, steel girders, and bridges. To support heavy, concentrated loads, corbels are typically erected monolithically with columns (or walls) [1]. Yasin et al. [2] represents a historical review, state of art review on the experimental researchers carried on corbels. The corbels discussed are made of normal, height strength, and self-compacting concrete and subjected to monotonic and repeated loading. Shear friction (SF) and strut-tie modeling (STM) methods were used to analyze reinforced concrete corbels, studying the effect of main parameters on the strength of corbels. Comparisons were shown between the results of two methods [3]. Abdul-Razzaq et al. [4] submitted a review of previous studies on reinforced concrete corbels. These parameters affect the behavior of corbels. CFRP strengthening effect on the behavior and ultimate capacity of reinforced concrete corbels was investigated experimentally by Abdulrahman et al. [5]. Test results indicated an improvement in the behavior and capacity of strengthened corbels. The same results were obtained by Tobeia [6], where numerical modeling was performed to study the CFRP's effect on the corbels' shear strength. Nonlinear finite element was used to analyze reinforced concrete corbels by Reginato et al. [7]. The numerical results of several modeling choices were investigated and compared with the test results from the literature. A new method and code provisions are used to calculate the capacity of 47 reinforced concrete corbels tested up to failure in the following six studies. The method and code provisions are used to determine the corbels' capacity [8-13]. Only those references that provided sufficiently complete information on the test set-up and material properties were adopted in this investigation. Many researchers and committees present formulas that deal with the nominal shear strength of reinforced concrete corbels to obtain accurate values that predict the load-carrying capacity. Based on the experimental results from the literature, the estimated nominal shear strength of reinforced concrete corbels is obtained using analytical formulas. In this work, the present predicted model for the shear capacity of RC corbels is compared with estimations models by [14-19].

2.EXPERIMENTAL TEST DATA

The RC corbels considered in this study include several factors influencing the design, such as (a_v/d), compressive strength, ratio of longitudinal (ρ_s), and horizontal reinforcement (ρ_h). The present study introduces a novel approach for calculating the shear strength of reinforced concrete corbels. The proposed model's shear strength predictions are compared to experimental data acquired from 47 reinforced concrete corbels loaded vertically.

3.RESEARCH SIGNIFICANCE

This work estimates the RC corbels' shear capacity for ACI 318M-19 [14]. For a suitable database of 47 tests, it is found that including the effect of vertical and horizontal reinforcement percentages leads to a significantly improved COV from the literature. From the available literature, the best value of COV is 30.5%, while the proposed equation leads to a COV of 29.75%.

4.EXPERIMENTAL INVESTIGATIONS

The (47) RC corbels, taken from the literature [8-13], failed in shear. All the main variables and corbel details adopted in these studies were the same but with different values. The range of variables in all adopted tests is indicated in Table 1. Figure 1 shows the typical corbels geometry configuration.

Table 1 Range Data of Measured Variables [8-13].

Variable	Unit	Range
f_c'	MPa	23.8-48.6
a_v/d	----	0.22-1.022
b_w	Mm	127-254
h_1	Mm	125-203
h_2	Mm	250-406
ρ_s	----	0.17-3.1%
ρ_h	-----	.02-1.75%
d	mm	206-356
f_y	MPa	380-510
$b_w * d$	mm²	26162-90424
Vu	kN	95.64-700.6

Where:

f_c' is the concrete cylinder compressive strength (MPa), a_v is the Shear span, measured in millimeters, is the distance between the center of concentrated stress and the center of support for simply supported components, d is the distance between the extreme compression fiber and the centroid of the longitudinal tension reinforcement (mm), ρ_s is the ratio of $A_s/b_w d$, ρ_h is the ratio of $A_h / b_w h_2$, f_y is the specified yield strength of main (primary) and horizontal (stirrups) reinforcement (MPa), and b_w is width (mm).

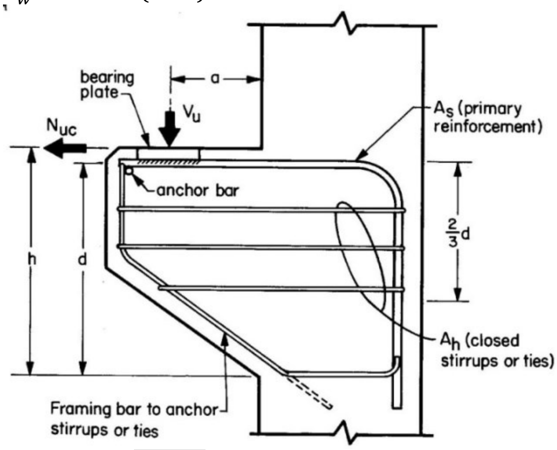

Fig. 1 Typical RC corbel.

5.CODE EQUATION OF RC CORBELS SHEAR CAPACITY

1- ACI 318M-19 Method [14].

$$V_{nACI-S} \le \left[\begin{matrix} 0.2\, f_c' b_w d \\ (3.3 + 0.08\, f_c') b_w d \\ 1.1\, f_c'\, b_w d \end{matrix}\right] \qquad (1)$$

Where $V_{nACI[14]}$= "estimated shear capacity per ACI 318 [14]," N.

6.EXISTING RESEARCH MODELS OF RC CORBELS SHEAR CAPACITY

1- Kassem [15].

$$V_{n\,kassem[15]} \le \left[\begin{matrix} \rho_{vf} f_y\, \mu\, b_w d \\ \frac{\rho_s\, f_y jd}{[a_v(1+\alpha(h-d))]} b_w d \end{matrix}\right] \qquad (2)$$

Where:

$$\rho_{vf} = \rho_s + \rho_h \qquad (3)$$

$$jd = \frac{d-(Asf_y - Nu)}{0.88\, f_c'} \qquad (4)$$

Where:

$V_{nwael\ kassem}$ is the Shear strength per Kassem [15] (N), ρ_{vf} is the reinforcement friction ratio, μ is the coefficient of friction (taken as 1.4 for monolithic construction), jd is the level arm (mm), and α is the ratio of horizontal to vertical loads.

2- Kriz and Raths [16]

$$V_{nKriz\&Raths[16]} = \left(6.5\, b_w d\sqrt{f_c'}\right)(1 - 0.5)^{\frac{d}{a}}\,(1000\,\rho)^{\frac{1}{3}} \qquad (5)$$

$$\rho = \frac{A_s + A_h}{b_w d} \le 0.02 \qquad (6)$$

Where $V_{nKriz\&Raths[15]}$ is the shear strength per Kriz and Raths [16] (N), ρ is the reinforcement ratio at column face, A_s is the area of main reinforcement (mm²), A_h is the area of the horizontal stirrups (mm²),

3- Aziz [17]

$$V_{nAziz[11]} = 2.38\left[\frac{f'c\,\frac{k}{d}(\rho_s+\rho_h)}{\frac{a}{d}}\right]^{0.175} b_w d \qquad (7)$$

Where $V_{nAziz[17]}$ is the shear strength per Aziz [17] (N), and k is the property of section (mm).

4- Zrar [18]

$$V_{nZrar[18]} = 0.0863\left[\left(\frac{f'c\, b_w d}{100}\right)\left(\rho_s f_y\, d + 440\rho_h\ f_{yh}\right)\frac{d}{a}\right]^{0.4626} \qquad (8)$$

Where $V_{nZrar[18]}$ is the shear strength per Zrar [18] (N), f_{yh} is the yield strength of horizontal reinforcement (MPa)

5- Al-Zahawi [19]

$$V_{nAl-Zahawi[19]} = \frac{1}{30}(b_w d)^{0.45}\, f_{ct}^{0.75}\left[\left(\frac{\rho_s f_y d}{90} + 1000\rho_h\ f_{yh}\right)\frac{d}{a}\right]^{\frac{1}{3}} \qquad (9)$$

Where $V_{nAl-Zahawi[19]}$ is the shear strength per Al-Zahawi [19] (N), and f_{ct} is the tensile strength of concrete (MPa).

7.STATISTICAL PROPERTIES OF DATABASE

The variables that will be included in the proposed equation are:

- "Specified concrete cylindrical compressive strength" $f'c$
- "Ratio of shear span to effective depth ratio" $(\frac{a_v}{d})$
- "Longitudinal reinforcement ratio" ρ_s
- "Horizontal shear reinforcement" ρ_h
- "Effective depth" d

$$V_n = V_c + V_s$$

Terms used in the proposed equation to predict concrete shear strength V_c are as follows. The first term is related to the compressive strength of concrete f'_c and the percentage of the primary reinforcement ρ_s (dowel action); therefore, it can be represented as one of the following proposed forms:

1: $L * (f‘c^{M} * \rho_s^{N})$
2: $L * (f‘c^{M} + \rho_s^{N})$
3: $L * (f‘c^{M} + N * \rho_s)$
4: $L * (f‘c^{M} * K^{N})$

where K is the depth of the un-cracked compression zone calculated as follows:

$$K = \sqrt{\rho_s\, n^2 + 2\rho_s\, n} - \rho_s\, n$$

$$n = {E_s}/{E_c}$$

where:

E_s is the modulus of elasticity of main reinforcement, and E_c is the concrete modulus of elasticity. The second term in the proposed expressions depends on the corbel geometry or shear span to effective depth ratio $(a_v/d/)$. It can be represented as one of the following proposed forms:

5: $(a_v/d)^R$

6: $\dfrac{O}{P + (a_v/d)^R}$

7: $O + \dfrac{P}{(a_v/d)^R}$

The third term included in the proposed expressions depends on the effective depth d. It is included to account for the size effect on the diagonal shear strength of the corbel. The following form represents it:

8: $\left(\dfrac{S}{d}\right)^T$

Terms used in the proposed equation to predict shear reinforcement strength V_s are related to the percentage of horizontal shear reinforcement ρ_h, which can be represented as:

10: $k_h * \rho_h * f_{yh}$

Table 2 illustrates the proposed empirical equations used in the present investigation to predict the corbels' nominal concrete shear strength. The proposed formulas' coefficients and exponential (L-T) are obtained by nonlinear regression analysis. Using these formulas after substituting the test results of the nominal shear strength for the selected (47) RC corbels instead of (V_n) in these formulas, the SPSS statistics-23 program has been used to perform the regression analysis. The proposed model that minimizes the mean absolute error (MAE), root mean square error (EMSE), and the coefficient of multiple determination (R^2) was selected as an optimum empirical equation. After the regression analysis process, the following proposed equation is selected to predict the nominal shear strength of RC corbels, as it has the minimum values of (COV%):

$$\boldsymbol{V_{n,PROP.} = 0.005 \left(f_c'^{\,0.4} + 0.65\, \rho_s \right) \left(\frac{a_v}{d}\right)^{-0.5} \left(\frac{1}{d}\right)^{0.4} b_w d + (7\, \rho_h) * 10^{-6}\, f_y\, b_w d} \quad \textbf{(10)}$$

Where $V_{n,PROP.}$ is the estimated shear strength by the proposed equation (N).

8.EVALUATION OF EXPERIMENTAL RESULTS

For a detailed comparison between the proposed equation and the existing methods used in codes, a comparison was made for the ratio of (V_{exp}/V_n), as shown in Appendix (A), Where:

V_{exp} = Shear capacity of tested corbel, N

V_n= Calculated nominal shear capacity using different formulas of prediction, N

Appendix (A) and Table (3) compare the results of the different methods based on the ratio of (V_{exp}/V_n).

Table 2 Proposed Empirical Equations to Predict the Concrete Shear Strength of Corbels.

Proposal No.	Terms of combination	Empirical Equation
1	1*7*8+ (9+10)	$L * f‘c^{M} * \rho_s{}^{N} * (O + P/(a_v/d)^R) * (\frac{S}{d})^T * (b_w\, d) + k_h\rho_h * f_{yh} * b_w\, d$
2	2*5*8+ (9+10)	$L * (f‘c^{M} + \rho_s{}^{N}) * (\frac{a_v}{d})^R * (\frac{S}{d})^T * (b_w\, d) + k_h\rho_h * f_{yh} * b_w\, d$
3	2*7*8+ (9+10)	$L * (f‘c^{M} + \rho_s{}^{N}) * \left(O + \frac{P}{(a_v/d)^R}\right) * (\frac{S}{d})^T * (b_w\, d) + k_h\rho_h * f_{yh} * b_w\, d$
4	3*6*8+ (9+10)	$L * (f‘c^{M} + N * \rho_s) * \left(\frac{O}{P + (av/d)^R}\right) * (\frac{S}{d})^T * (b_w\, d) + k_h\rho_h * f_y * b_w\, d$
5	3*7*8+ (9+10)	$L * (f‘c^{M} + N * \rho_s) * \left(O + \frac{P}{(a_v/d)^R}\right) * (\frac{S}{d})^T * (b_w\, d) + k_h\rho_h * f_{yh} * b_w\, d$
6	4*7*8+ (9+10)	$L * f‘c^{M} * K^{N} * \left(O + \frac{P}{(a_v/d)^R}\right) * (\frac{S}{d})^T * (b_w\, d) + k_h\rho_h * f_{yh} * b_w\, d$

Table 3 Comparison of the Analysis Results Ratio of (V_{exp}/V_n) for all 47 Tested Corbels with Code and Previous Works.

Detail	ACI [14]	Kassem [15]	Kriz&Raths [16]	Aziz [17]	Zrar [18]	Al-Zahawi [19]	Proposed method
Equation used	(1)	(2)	(5)	(6)	(7)	(8)	(9)
Mean	1.17398	1.043	1.075614	3.0178655	0.71978	1.701	2.23047
Standard deviation	0.41619	0.6574	0.328401	1.1453509	0.32619	0.785	0.66373
COV %	35.4514	63.028	30.53149	37.952351	45.318	46.16	29.7573
Max. ratio	2.63029	3.4348	2.061952	7.0322118	1.80648	4.102	4.51991
Min. ratio	0.63074	0.1758	0.390897	1.2559271	0.19362	0.522	0.7544
Range (max/min)	4.17	19.54	5.27	5.60	9.33	7.86	5.99
*Number < 1	17	31	23	0	38	5	1

* The number of specimens out of (47) for which $V_{exp} < V_n$.

Where:

(1) The mean value of the average of ratios of (V_{exp}/V_n) for all corbels is calculated using the following formula Eq. (11):

$$\mathbf{Avg.} = \sum_{i=1}^{N} (\mathbf{V_{exp}/V_n})_i / \mathbf{N} \qquad \mathbf{(11)}$$

N is the total number of corbels, which equals 47 in the present investigation.

(2) Standard deviation (*S.D.*) for values of (V_{Exp}/V_n) calculated by the following formula Eq. (12):

$$\mathrm{S.D} = \sqrt{\frac{\sum_{i=1}^{N}((\mathbf{V_{exp}/V_n})_i - \mathbf{Avg.})^{2}}{\mathbf{N}}} \qquad \mathbf{(12)}$$

(3) The coefficient of variation (*COV*) for (V_{Exp}/V_n) can be determined by the following formula Eq. (13):

$$\boldsymbol{COV}(\%) = \frac{\mathbf{S.D}}{\mathbf{Avg.}}\mathbf{x100} \qquad \mathbf{(13)}$$

(4) Maximum value (*Max.*) is used to predict the maximum ratio of shear capacity.

(5) Minimum value (*Min.*) is used to predict the minimum ratio of shear capacity.

(6) Range value, determined by the following formula Eq. (14):

$$\mathbf{Range = Max./Min.} \qquad \mathbf{(14)}$$

The last column in Table 3 shows the values of COV% range between (29.75% - 63.028%). It can be seen from Table 3 that the COV% values from Eq. (5) [16] yield the lowest COV of all existing methods (30.53%). It is clear from the proposed method that the effect of horizontal reinforcement ratio (ρ_h), the proposed equation, Eq. (10), has significantly improved the COV% for shear capacity prediction to a value of (29.75%). In contrast, the reference [16] indicates a significant prediction of the influence of f_c', ρ_s%, ρ_h%, and a_v/d, as shown in Figs. 2-5, respectively, compared with another existing method. With the proposed design method, Eq. (10), Figs. 2-5 show insignificant change in safety factor with the effect of f_c', ρ_s%, ρ_h%, and a_v/d, respectively. Figure 6 shows good agreement between the experimental and theoretical results for the Ref. [16] and the proposed equation by comparing the existing equations. The data points of the proposed equation are more convergent than with other methods.

9.CONCLUSIONS

Based on 47 tests of RC corbels obtained from the literature failing in shear tests, the following conclusions are made:

1- Six equations are proposed to predict the ultimate shear strength (V_n) based on regression analysis of experimental data, which includes the variables that affect the ultimate shear strength. All these proposed equations were more accurate than existing ones compared to the test results. The proposed selected (Eq. (10)) is the best of the six proposed equations and agrees well with test results compared to the existing equations. Eq.(10) gives average values of experimental ratios to predict ultimate shear strength values at 2.23047 and the coefficient of variation of the ratio of experimental to predicted ultimate shear strength values at 29.75%.

2- A comparison between the test values and those predicted using the ACI 318M-2019 Building Code provision shows that the code method becomes too conservative by neglecting the contribution of reinforcement.

3- Increasing the reinforcement ratio (ρ_s % *and* ρ_h%) increased the corbel's nominal shear strength. This effect is not included in the ACI 318M-2019 provisions, making the code proposal conservative.

4- The increase in compressive strength (f_c') from (23.8MPa) to (48.6 MPa) (the range of tested corbels) increased the nominal shear strength.

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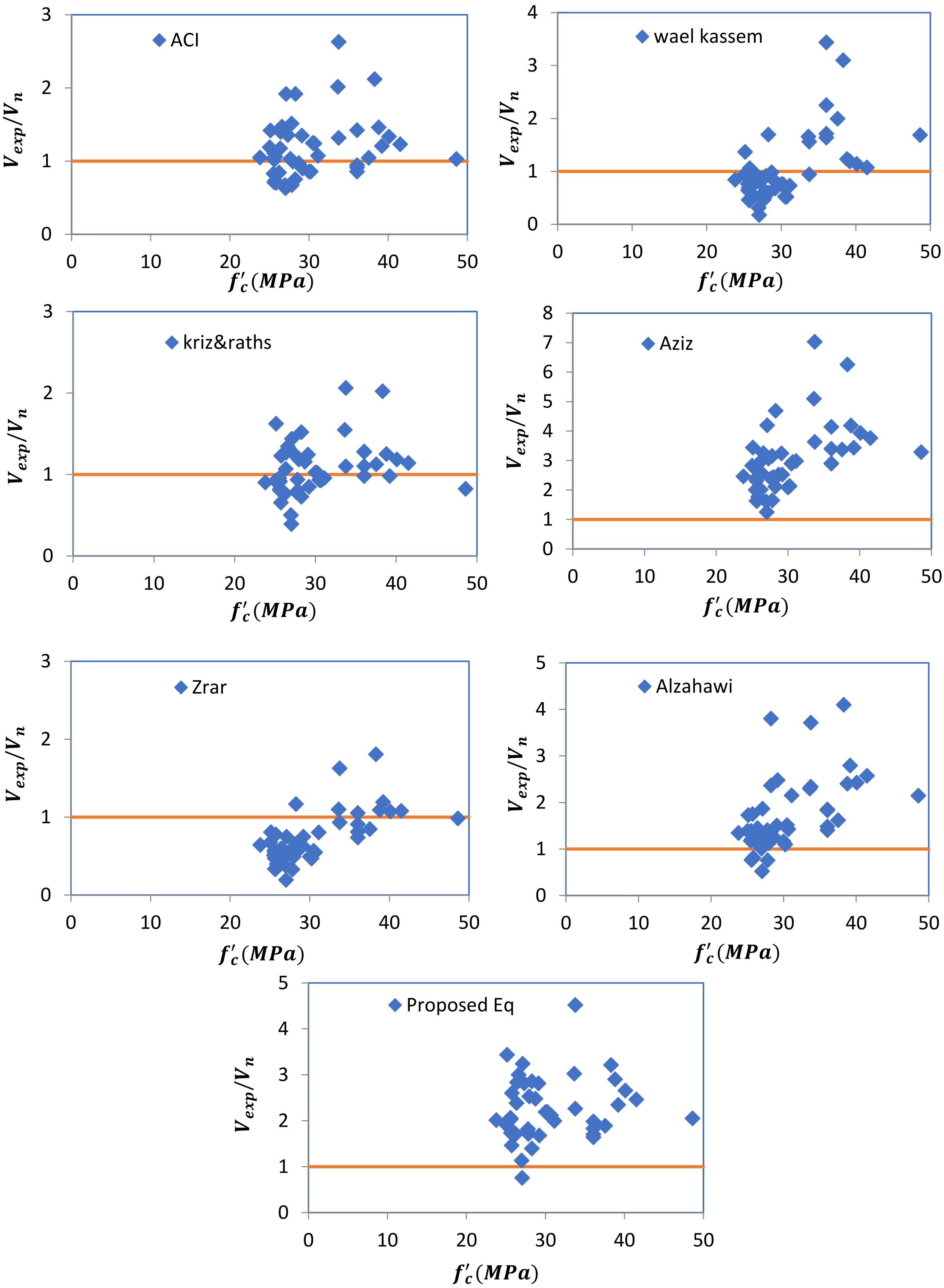

Fig. 2 Effect of f'_c (MPa) on the Ratio of (V_{exp}/V_n).

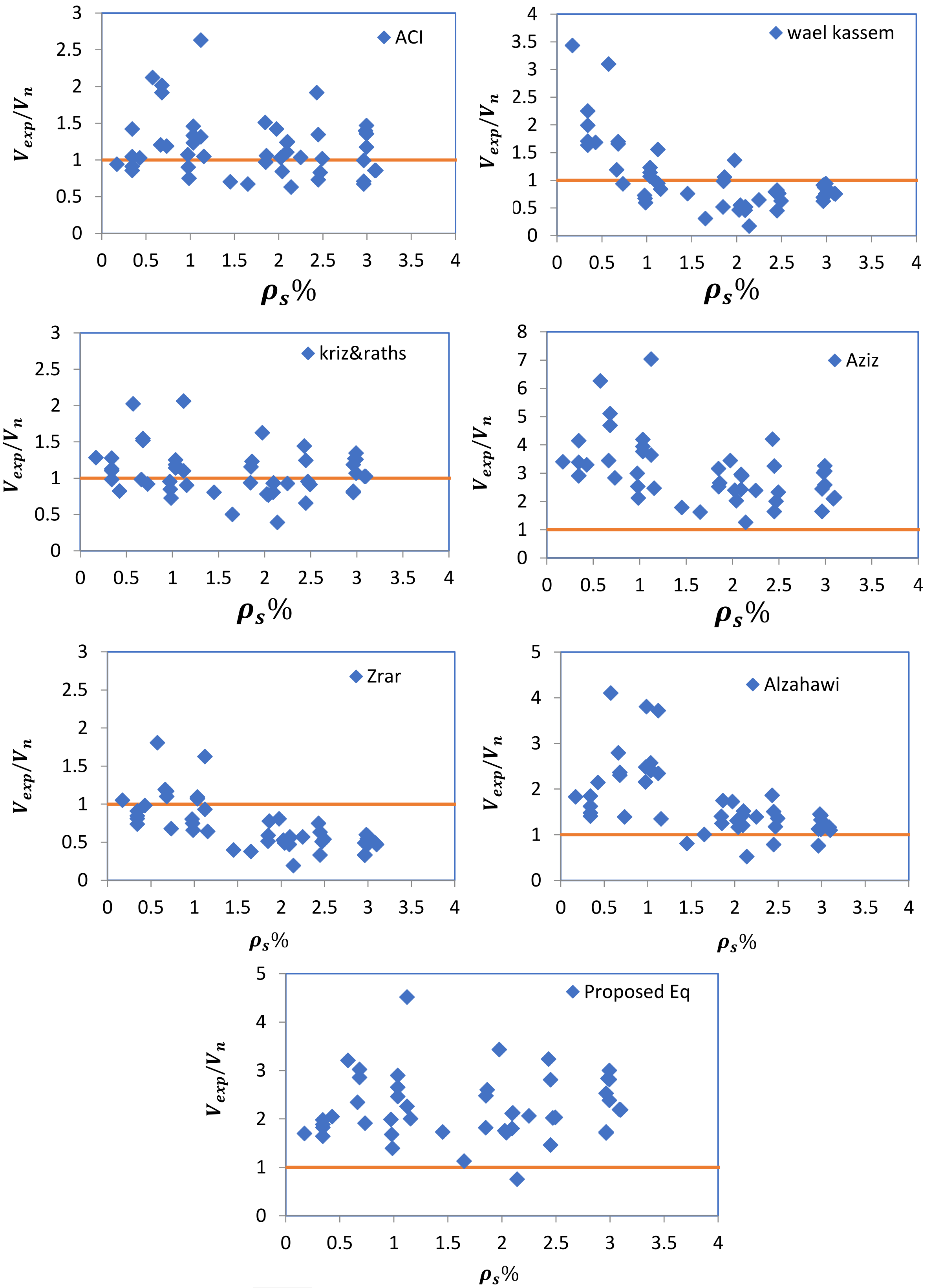

Fig. 3 Effect of $\rho_s\%$ on the Ratio of (V_{exp}/V_n).

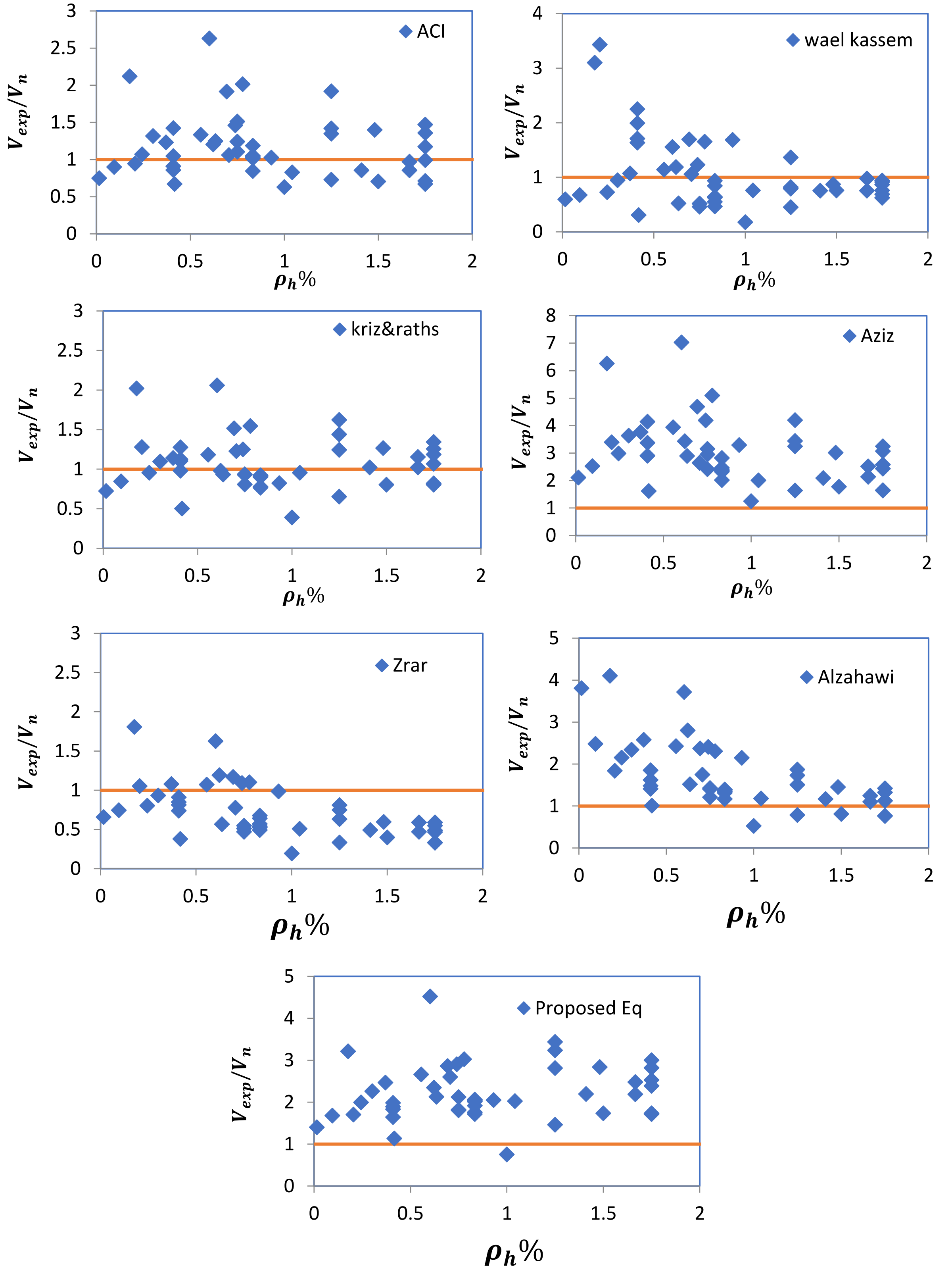

Fig. 4 Effect of $\rho_h\%$ on the Ratio of (V_{exp}/V_n).

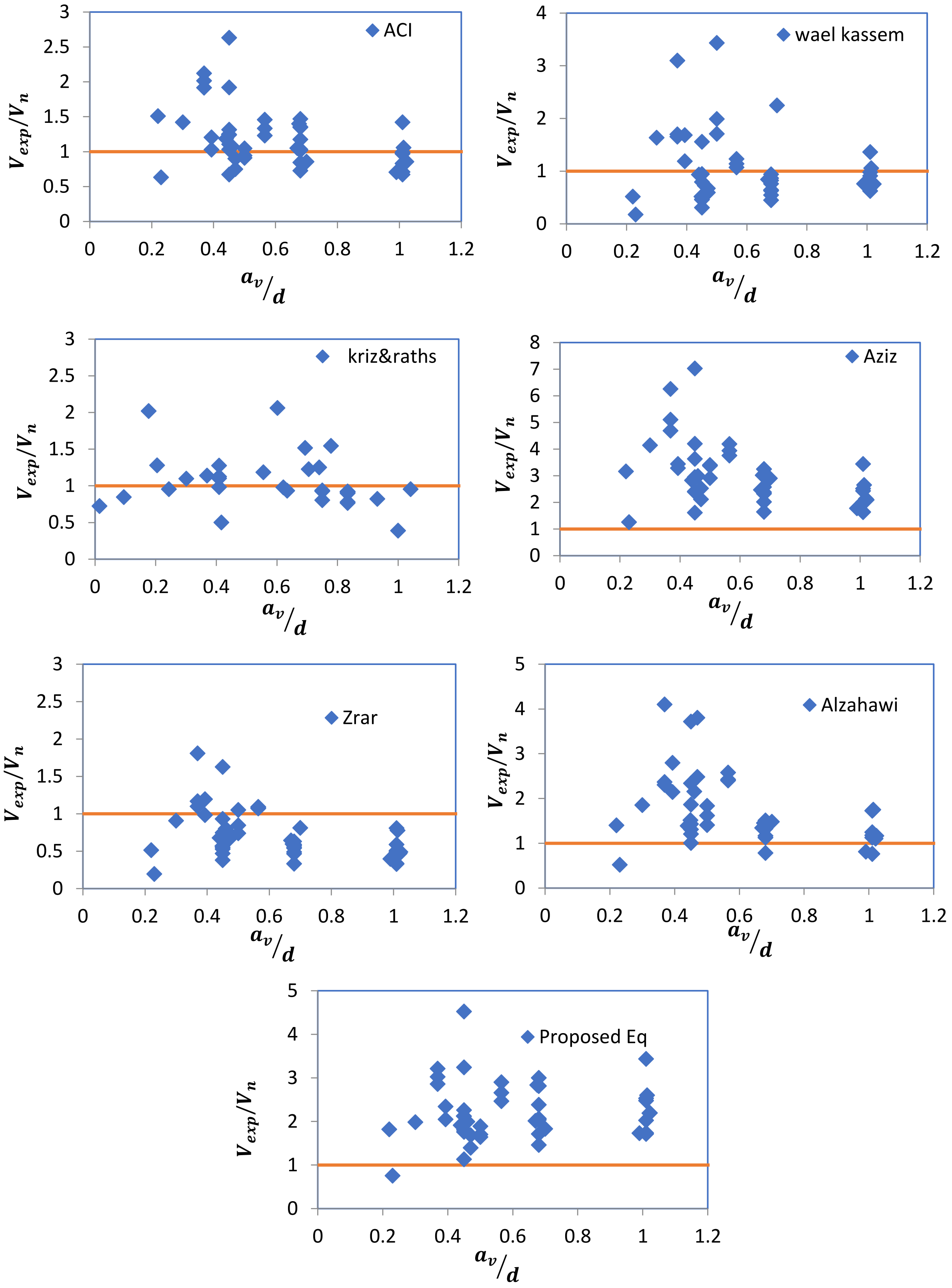

Fig. 5 Effect of $^{a_v}/_d$ on the Ratio of (V_{exp}/V_n).

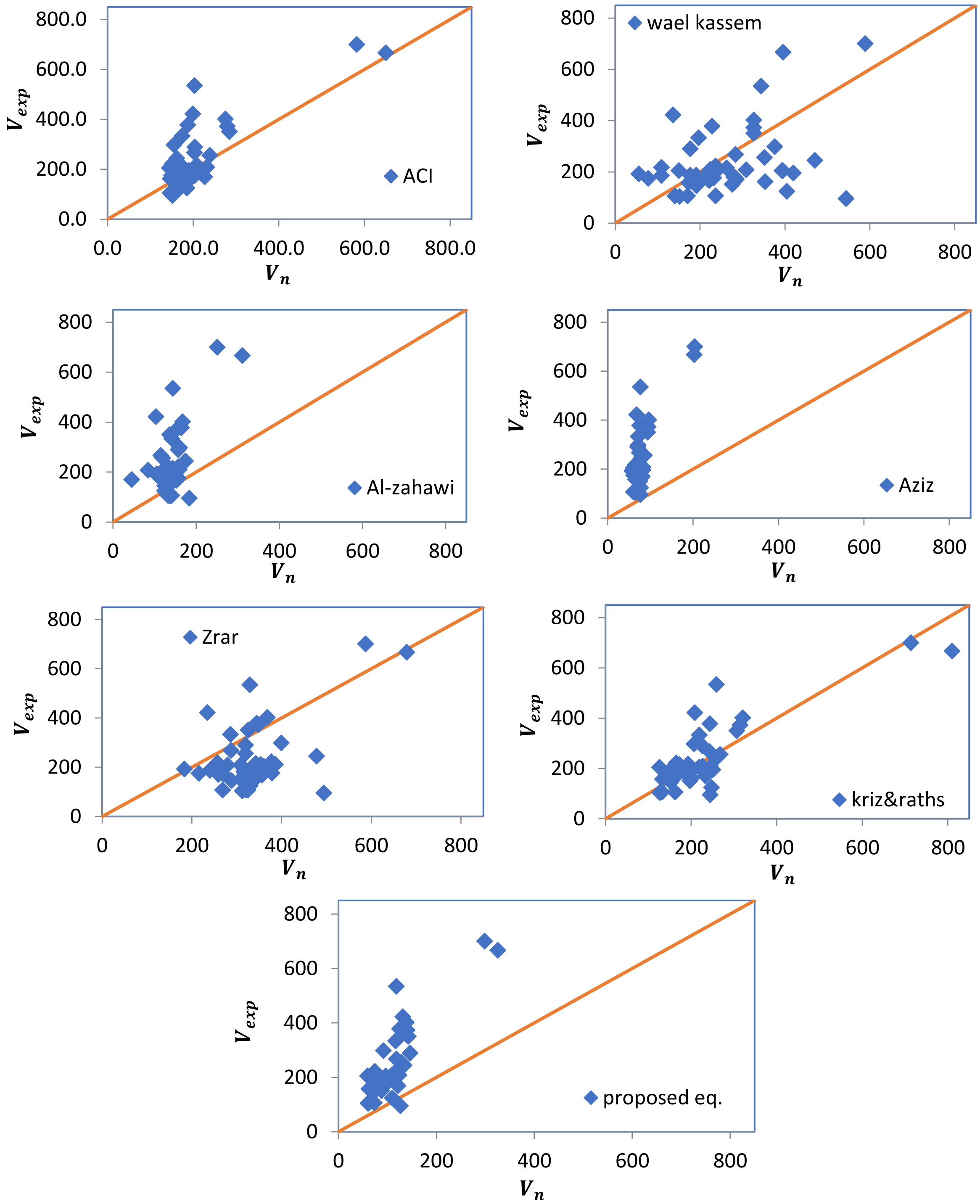

Fig. 6 Comparison between Predicted Nominal Shear Strength (V_n) and Experimental (V_{exp}) for Existing and Proposed Empirical Equation.

Appendix (A) Comparison of the Ratio of (V_{exp}/V_n) for all 47 Corbel Tests with Code and Existing Equations.

Ref. No.	Beam No.	$V_{Exp.}$ (kN)	$V_{nACI-S[8]}$	$V_{nwael\ kassem[9]}$	$V_{nKriz\&Raths[10]}$	$V_{nAziz[11]}$	$V_{nZrar[12]}$	$V_{nAl-Zahawi[13]}$	$V_{n,Proposed}$
2	1	186.0	204.1	108.9	189.2	63.9	252.1	132.2	113.3
	2	217.5	208.0	109.2	193.1	64.4	256.8	134.2	115.1
	3	175.0	204.1	77.8	158.6	60.3	215.8	118.2	95.8
	4	290.0	204.1	177.2	227.3	69.9	319.3	156.7	146.2
3	5	192.5	204.1	56.0	150.2	56.6	183.0	104.9	113.2
	6	350.6	284.8	326.7	307.2	93.1	325.2	136.1	142.3
	7	373.1	280.0	326.7	314.7	94.6	348.1	153.8	140.4
	8	402.0	275.5	326.7	321.1	95.9	368.0	167.2	138.6
	9	267.5	203.4	283.5	243.4	73.6	287.1	114.3	118.3
	10	535.0	203.4	343.5	259.5	76.1	329.1	144.0	118.4
4	11	667.2	650.0	395.9	810.2	202.6	678.9	310.8	325.5
	12	333.6	174.1	196.6	219.6	71.1	285.5	140.9	116.7
	13	378.1	187.6	228.3	244.4	74.1	343.8	164.2	125.1
	14	422.6	199.3	136.3	209.0	67.5	233.9	103.0	131.6
	15	187.0	176.6	177.0	152.1	70.5	240.3	106.9	71.9
	16	167.2	195.5	220.8	163.2	79.8	340.9	143.3	76.3
	17	204.6	164.0	393.4	218.9	70.6	360.3	134.8	96.2
	18	210.8	150.9	242.4	166.2	69.8	353.1	145.2	74.3
5	19	170.2	226.9	285.7	234.3	80.4	258.9	44.7	121.8
	20	208.4	231.7	308.8	245.7	82.4	279.3	84.0	124.0
	21	256.2	239.2	351.9	268.2	85.7	319.4	119.0	128.6
6	22	700.6	582.0	589.0	714.0	203.7	587.2	250.5	298.9
7	23	209.1	176.1	223.6	227.1	73.9	308.8	150.3	109.3
	24	173.0	164.9	205.6	191.9	70.1	269.3	128.6	86.1
	25	187.3	193.1	191.1	161.9	74.2	317.5	150.2	75.6
	26	195.7	189.7	420.0	250.8	81.7	372.4	149.3	111.2
	27	177.9	175.0	282.8	194.9	76.6	329.5	131.0	87.4
	28	180.2	174.5	279.7	194.7	75.5	315.9	129.7	87.3
	29	167.3	195.3	222.1	163.4	78.2	355.7	151.9	76.5
	30	124.6	185.5	404.5	247.7	76.9	329.5	123.6	110.0
	31	151.2	179.2	275.8	197.3	74.9	308.3	129.9	88.2
	32	145.9	176.0	191.6	152.6	72.7	287.8	124.1	72.1
	33	244.7	162.0	470.7	261.1	77.4	478.1	174.3	134.5
	34	204.6	165.0	395.4	220.2	69.3	373.4	143.2	96.6
	35	215.7	160.2	262.5	173.1	66.5	342.0	143.1	76.7
	36	157.9	159.1	172.8	133.2	64.8	322.9	140.3	62.4
	37	162.4	146.9	353.3	201.2	67.1	346.3	134.7	89.9
	38	106.8	146.4	236.3	162.8	65.0	320.7	136.0	73.0
	39	106.8	158.8	170.9	132.8	64.7	324.8	140.9	62.3
	40	104.5	147.3	151.7	127.5	63.8	312.2	136.4	60.3
	41	106.8	151.6	140.6	132.5	60.1	268.1	131.7	61.7
	42	95.6	151.6	543.9	244.7	76.1	493.9	183.3	126.8
	43	298.0	155.4	376.0	206.9	70.9	399.1	159.6	92.0
	44	222.4	151.3	236.7	165.5	68.3	377.1	156.4	74.1
	45	210.8	155.4	243.5	167.7	68.6	386.0	159.2	74.9
	46	176.1	149.9	231.8	164.7	68.2	378.1	156.6	73.8
	47	205.1	144.5	150.3	126.2	59.5	253.8	118.7	59.7