Disc. 116-S117/From the September 2019 *ACI Structural Journal*, p. 247

Novel Empirical Expression to Predict Shear Strength of Reinforced Concrete Walls Based on Particle Swarm. Paper by Hadi Baghi, Hani Baghi, and Sasan Siavashi

Discussion by Jimmy Chandra and Susanto Teng

Department of Civil Engineering, Petra Christian University, Surabaya, Indonesia; School of Civil and Environmental Engineering, Nanyang Technological University, Singapore

The authors have to be congratulated for developing a new method for shear analysis of structural walls. The discussers do have some queries that they hope the authors can help clarify. They are as follows:

1. In engineering practice, structural reinforced concrete (RC) walls are always provided with shear or web reinforcements. Therefore, the discussers' method[2] assumed that RC walls were always provided with web reinforcements and the derivations of the governing equations for the discussers' method[2] assumed that web reinforcements were provided. As such, specimens that have no web reinforcement were excluded from the discussers database.[2] The excluded specimens were Specimens B4-2 and B5-4 tested by Barda et al.[14]; Specimens SW-10, SW-11, and SW-12 tested by Cardenas et al.[15]; and Specimens 24, 28, and 32 tested by Hidalgo et al.[39] However, those excluded specimens were included in the authors' database (Table 2). Naturally, the discussers' method[2] should not be used to calculate the shear strengths of those excluded specimens. Doing so would not be right and it could unnecessarily make the discussers' method[2] to appear less accurate than it actually is.

2. The discussers' method[2] is intended for calculating shear strengths, not flexural strengths of RC walls. For calculating the flexural strengths of RC walls, a reasonably accurate procedure using the flexural theory for RC flexural members can be used. Therefore, the method as presented in the discussers' paper[2] is only for calculating the shear strength of RC walls. Thus, comparisons between experimental shear strengths and calculated shear strengths as calculated by the discussers' method,[2] the authors' own method, as well as ACI shear strength equations, should only be done for specimens failing in shear (not in flexure). Yet, the authors included in their comparisons specimens that failed in flexure, such as: Specimens HW1, HW2, and HW3 tested by Yun et al.[25]; Specimens Wall-7, Wall-8, and Wall-9 tested by Li and Li[27]; all specimens tested by Li et al.[29]; and all specimens tested by Kuang and Ho.[36] The shear resistances that were recorded when the specimens failed in flexure were not the shear strengths of the specimens and they could not be used for comparison between experimental shear strengths and nominal shear strengths of RC walls as calculated by the discussers' method[2] or by other shear strength methods. Furthermore, those specimens tested by Hidalgo et al.[39] were loaded in such a way to model double curvature walls. The discussers' method[2] is not intended for double curvature walls because the derivation of the governing equations and boundary conditions were intended for normal cantilever walls.

3. The authors might have made some errors when comparing the shear strengths of specimens as calculated using the discussers' method[2] against the experimental shear strengths of the specimens as tested by Looi et al.[26] The discussers' method[2] was shown (as calculated by the authors) in Table 2 to produce V_{exp}/V_{ana} of 0.00 for three specimens (ALR02, ALR03, and ALR04). However, according to the discussers' calculations, V_{exp}/V_{ana} should be 0.76, 0.73, and 0.74 for Specimens ALR02, ALR03, and ALR04, respectively. Those errors would affect the statistics significantly.

4. In the current paper, the authors show in Table 3 that the minimum value for V_{exp}/V_{ana} for the discussers' method[2] is 0.10. However, we could not find this number (0.10) in the detailed results as presented in Table 2. In addition, the authors also show in Fig. 5 that there are three specimens that have the values of V_{exp}/V_{ana} of approximately 0.10. Again, the discussers could not find those specimens in Table 2. They hope that the authors can list those specimens because the minimum value for V_{exp}/V_{ana} of 0.10 shows that the method[2] can be very unsafe, which may not be true.

The discussers hope that the authors can clarify these four aforementioned issues.

AUTHORS' CLOSURE

The authors appreciate the valuable queries of the discussers. The answer to these queries is provided as follows:

1. Please refer to the response to comment No. 2.

2. The authors have investigated Chandra et al.'s[2] concerns. It is important to note that the method that the authors proposed can accurately predict the shear capacity of reinforced concrete (RC) wall specimens with no web reinforcement as well as shear capacity of RC wall specimens that failed in flexure. Thus, this method can cover most types of the shear walls. However, in response to Chandra et al.'s[2] request, a fair comparison was conducted by excluding the specimens that are mentioned in comments No. 1 and No. 2 in the authors database. Tables 5 and 6 are based on the excluded specimens in the authors database. As it can be

Table 5—Comparison of predicted and measured shear strength

Statistical indicator	$\lambda = V_{exp}/V_{ana}$		
	Proposed model	ACI 318-14[3]	Chandra et al.[2]
Min.	0.43	0.35	0.0
Max.	1.92	3.05	2.06
Avg.	1.13	1.08	1.08
Std. Dev.	0.35	0.52	0.39
COV, %	31	48	36
SSE	8,421,978	10,490,113	23,531,398
R2	0.64	0.57	0.21
RMSE	227	253	379

Table 6—Comparison of predictive strength of different approaches according to modified demerit points classification criteria

$\lambda = V_{exp}/V_{ana}$	Proposed model		ACI 318-14[3]		Chandra et al.[2]	
	No. of samples	Total penalty points	No. of samples	Total penalty points	No. of samples	Total penalty points
<0.5	3	30	9	90	15	150
[0.5 to 0.85]	35	175	57	285	30	150
[0.85 to 1.15]	57	0	44	0	47	0
[1.15 to 2]	69	69	43	43	70	70
≥2.0	0	2	11	22	2	4
Σ PEN		274		440		374

Table 7—Calculation of nominal shear strength according to Chandra et al.[2]

Beam label	σ_r	ζ	σ_d	f_v	θ	A_{sb}	D_u	V_n	V_{exp}/V_n
ALR01	0.58	15.01	15.07	480	68	0	0	335	0.75
ALR02	0.52	13.51	13.51	480	90	0	0	0	0
ALR03	0.56	14.55	14.55	480	90	0	0	0	0
ALR04	0.56	15.55	14.55	480	90	0	0	0	0

seen in Tables 5 and 6, and by comparing the metrics that are described in the paper, the authors' proposed method can predict the shear capacity of RC wall specimens more accurately comparing to method proposed by Chandra et al.[2]

3. Refer to Table 7, which shows the results of the shear walls tested by Looi et al.[26] It was observed that the method proposed by Chandra et al.[2] cannot predict V_{exp}/V_n for walls ALR02, ALR03, and ALR04 because this method is not able to accurately predict the shear inclination for the walls under high axial load. More information about the step by step procedure to develop the nominal shear capacity can be found in Chandra et al.[2]

4. Based on the results presented in response to comment No. 3 (refer to Table 7), the model proposed by Chandra et al.[2] predicts V_{exp}/V_{ana} equals zero for ALR02, ALR03, and ALR04 RC walls. Because it was not feasible to calculate the sum of squared errors of prediction (SSE) if V_{exp}/V_{ana} equals zero, the authors adopted a higher value (0.10) for these samples.

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Torsional Behavior of Reinforced Concrete Beams with High-Strength Steel Bars. Paper by C. Kim, S. Kim, K.-H. Kim, D. Shin, M. Haroon, and J.-Y. Lee

Discussion by Emil de Souza Sánchez Filho

Full Professor of Fluminense Federal University, Rio de Janeiro, Brazil

The authors must be congratulated for their remarkable and excellent investigation on the behavior of reinforced concrete beams subjected to torsion. The authors have made a useful contribution to the experimental study of torsion of high strength steel bars. However, the discusser would like to address the following questions and point some special aspects in this study. The objective of this discussion is to give suggestions so that the authors can improve their analyses.

The statistical analysis of the experimental data provides for the ratios

- $T_{max}/T_{ACI318\text{-}14}$, mean = 0.93, SD = 0.22, CV = 24.09%
- $T_{max}/T_{EC2\text{-}04}$, mean = 1.01, SD = 0.21, CV = 20.79%

These values are very close. However, for the parameter $\rho_t f_{yt}/\sqrt{f_c'}$, mean = 0.64, SD = 0.20, and CV = 31.25%, which shows a greater variability of this ratio. Therefore, it is difficult to evaluate the influence due to the variability of the tensile strengths of steel and the compressive strengths of concrete using this approach.

Why did specimens T1-C70S60 and T2-C70S60, with compressive strength greater than 50 MPa, and with different parameters, have the same ratios $T_{max}/T_{ACI318\text{-}14}$ = 0.62 and $T_{max}/T_{EC2\text{-}04}$ = 0.75?

In experimental research, average values for the compressive strength of concrete are used, but the text shows the parameter f_c'. Is this a characteristic value?

The discussers would like to point out that the ACI compressive strength of concrete f_c' is statistically different from the characteristic compressive strength f_{ck} of EC 2-04 (Brazilian Standard NBR 6118:2014[42] follows the EC2-04 philosophy). In ACI 318-19 (or -14), the probability is that only 1% of the sample universe is admitted as having strength lower than the characteristic resistance, while in EC2-04 this probability is 5%, which has more flexibility than the American prescription. This difference increases sharply if the standard deviation increases. For concrete with good quality control and with normal strength <50 MPa this