Original Scientific Paper

PROPOSAL OF MODIFICATION OF EUROCODE 2 IN TERMS OF CALCULATION OF THE PUNCHING SHEAR CAPACITY OF RC COLUMN FOOTINGS

UDC 624.012.45
624.153.524

Zoran Bonić[1], Elefterija Zlatanović[1*], Nebojša Davidović[1], Nikola Romić[1], Nemanja Marinković[1]

University of Niš, Faculty of Civil Engineering and Architecture, Niš, Serbia

Abstract. *The paper first presents the calculation of the punching shear capacity of concentrically loaded reinforced concrete column footings according to the current Eurocode 2, which can be carried out in two ways: by conducting an iterative procedure and by a simplified procedure applying the diagrams. By using these procedures, the punching shear capacity calculation was performed for the footings examined within the experimental research of the authors of this study, as well as for the footings that were considered by experiments conducted by other authors. Based on the conducted analysis of the calculation results and experimentally recorded results, a modification of the expression of the current Eurocode 2 with regard to the calculation of the punching shear capacity of concentrically loaded RC column footings is proposed. The proposed modification more realistically takes into account the influence of compressive strength of concrete and the reinforcement ratio in the footing, so that its application provides the results of punching failure forces that are closer to the results recorded by experimental tests.*

Key words: *RC column footing, Eurocode 2, punching shear, concrete compressive strength, reinforcement ratio*

1. INTRODUCTION

The construction of monolithic reinforced concrete skeleton construction systems of buildings with floor structures in the form of flat slabs and foundations in the form of foundation slabs and column footings is very widespread. At the same time, there is a constant tendency to improve the calculation methods and the way of designing the mentioned structural elements in order to achieve savings in work and materials, i.e. to increase the economy of both these elements and the entire structure. On the other hand, we are witnessing a growing number of buildings in the world where damage has occurred, and even the collapse of the structure, which results not only in material damage, but, unfortunately, also in human casualties. Such events often occur due to exceeding the load-bearing capacity of individual columns or footings under them, which leads to their damage or, in certain situations, to failure. As a consequence, the forces are further redistributed to the adjacent columns and associated footings, thus causing significantly increased loads in them, which can cause their fracture, i.e. lead to a chain reaction and progressive failure of the entire structure. With all this in mind, in recent times, the attention of researchers is increasingly focused on increasing the resistance to progressive failure of buildings and structures in general, and thus their sustainability, reliability, and durability. Related to this is the growing number of studies with regard to the bearing capacity of foundations, in particular the punching shear capacity of column footings, as a type of unannounced failure. Control of foundations to punching shear is an obligatory part of the foundations design, primarily of column footings and foundation slabs, which are exposed to the action of concentrated forces in the columns. The behavior of these types of foundations under load will depend on the characteristics of the foundation and soil, as well as on the intensity of the load.

In most national and international regulations, an empirical method of calculating the punching shear capacity of concentrically loaded reinforced concrete foundations based on experiments conducted on flat floor slabs and foundations resting on a simulated subsoil has been adopted. When it is necessary to check whether the foundation is safe in terms of punching shear, for the known load and characteristics of the foundation, the calculation is based on first calculating the shear stress v in the critical section, at a certain distance from the column face, for a known force in the column. Then, the shear stress calculated in this way is compared to the punching shear resistance of concrete v_d. If $v < v_d$, then there is no risk of punching shear event, otherwise, the height of the foundations needs to be increased as well as the class of concrete, or the reinforcement to secure against punching shear needs to be designed. The critical section is the section along the effective depth of the foundation slab or footing and along the perimeter of the critical section which is at a certain distance from the column face (the so-called critical perimeter as presented in Fig. 1). Shear stresses in the critical section are calculated according to the expression:

$$v = \frac{V_{c,red}}{u_{cs} \cdot d} \tag{1}$$

where: $V_{c,red}$ – is the reduced force in the column,
u_{cs} – is the critical section perimeter, i.e. the length of the critical perimeter,
d – is the effective depth of the footing (a mean value for two perpendicular directions).

In most of the codes, the reduced force in the column is calculated by subtracting from the force in the column V_c a part of net reactive soil pressures σ_n (without the effect of the footing dead weight) inside a considered critical perimeter having the area A_0:

$$V_{c,red} = V_c - A_0 \cdot \sigma_n = V_c - A_0 \frac{V_c}{A} = V_c \left(1 - \frac{A_0}{A}\right) \qquad (2)$$

where A is the area of the footing base. Finally, the punching shear capacity of footings is expressed through the ultimate force in the column in terms of the punching shear:

$$V_c = \frac{V_{c,red}}{1 - \dfrac{A_0}{A}} \qquad (3)$$

On the other hand, the punching shear resistance of concrete v_d depends on multiple parameters, which reflect the characteristics of the footings such as the column and footing dimensions, compressive strength of concrete, as well as the implemented reinforcement ratio and the quality of the reinforcement. For calculation of parameter v_d, the existing codes to a smaller or larger extent take into account the mentioned footing properties. Thus:

- Eurocode 2 (EC2) [1] takes into account the compressive strength of concrete, the reinforcement ratio of footing and the size-effect coefficient that depends on the effective depth of the footing;
- Current ACI 318-19 [2] takes into account only the compressive strength of concrete and the size-effect coefficient that depends on the effective depth of the footing;
- *fib* Model Code 2010 [3] takes into account the compressive strength of concrete, the reinforcement ratio of footing and the size-effect coefficient that depends on the effective depth of the footing;
- BS 8110-1:1997 [4], likewise EC2, takes into account the compressive strength of concrete, the reinforcement ratio of footing and the size-effect coefficient that depends on the effective depth of the footing;
- СНиП-84 [5] takes into account the design strength of concrete to axial tension, which is calculated depending on the concrete class, with the corresponding working conditions coefficients (types of load, environment in which the element is situated, and the method of concreting).

The method of critical section in the control of punching shear capacity does not reflect the true nature of punching, but when the properties of the footing affecting its punching shear capacity are taken into account in the appropriate correlation, the acceptable results of prediction of the footing punching shear capacity are obtained.
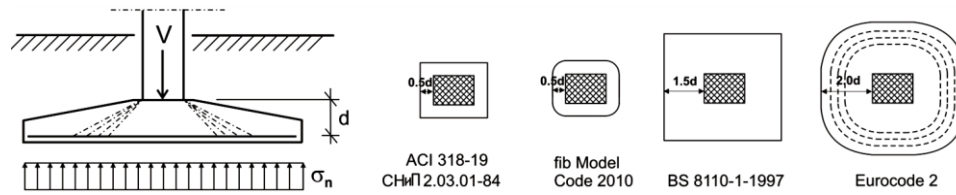
Fig. 1 Possible critical perimeters in some codes (ACI 318-19, СНиП2.03.01-84, *fib* Model Code 2010, BS 8110-1:1997, Eurocode 2) mainly based on the effective depth of the footing *d*.

Bearing in mind that in Serbia Eurocode 2 has been adopted as a code in the field of design of reinforced concrete structures, in the following part the attention is paid to determining the punching shear capacity of footings according to this standard, and to evaluation of standard expressions based on the experimental research of column footings on a real soil, both of the authors of this paper and of other researchers.

2. CALCULATION OF THE PUNCHING SHEAR CAPACITY OF CONCENTRICALLY LOADED RC COLUMN FOOTINGS ACCORDING TO EUROCODE 2

Calculation of punching shear of column footings and foundation slabs according to Eurocode 2 (EC2) is mostly based on the calculation concept provided in *fib* Model Code 1990. According to this code, it is necessary to check the shear stresses in two sections. The first section is the cross-section of the footing along the column perimeter, while the position of the second section is not directly determined, but is determined using the iterative procedure. Namely, unlike other codes where the position of the critical section is defined in advance, in Eurocode 2 the calculation of punching shear is performed in several control sections, and the finally adopted control section is a critical section. Thus, in order to determine the ultimate force in the column, it is necessary to consider several control perimeters within a distance of 2*d* from the edge of the column (which is the so-called basic control perimeter according to Fig. 2) and by iterative procedure to determine the position of the critical perimeter resulting in the ultimate force in the column in terms of punching shear.
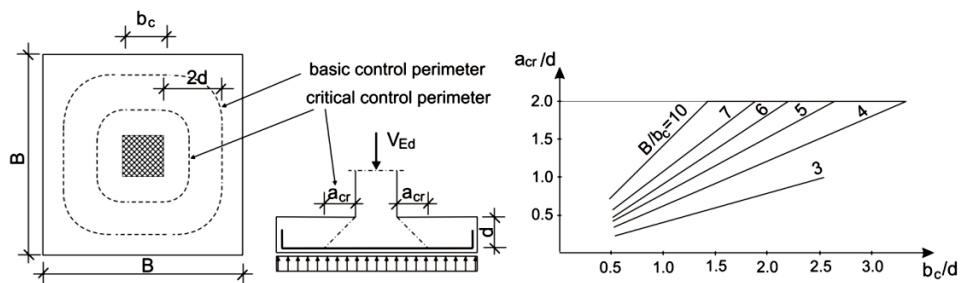

Fig. 2 Position of the critical perimeter according to the European Concrete Platform [6]

When an unknown concentric force of punching shear of the footing is to be determined for a footing of known characteristics, it is necessary to first calculate the

punching shear resistance of concrete v (marked $v_{Rd,c}$ in EC2) for each control section considered, as follows:

$$v_{Rd,c} = C_{Rd,c} \cdot k \cdot (100 \cdot \rho_t \cdot f_{ck})^{1/3} \cdot \frac{2d}{a_{EC2}} \geq v_{min} \frac{2d}{a_{EC2}} \qquad (4)$$

where:

$C_{Rd,c} = 0.18/\gamma_c$ – the empirical factor which takes into account the partial safety coefficient for concrete γ_c (1.5),

d – effective depth of footing (in mm),

$k = 1 + \sqrt{200/d} \leq 2.0$ – coefficient depending on the effective depth of footing,

$\rho_t = \sqrt{\rho_{tx} \cdot \rho_{ty}} \leq 0.02$ – average value of the reinforcement ratio in two orthogonal directions taken at a width equal to the width of the column increased for the distance $3d$ on each side of the column,

f_{ck} – characteristic value of compressive strength of concrete for a standard cylinder,

$v_{min} = 0.035 \cdot k^{3/2} \cdot f_{ck}^{1/2}$ – the minimum punching shear resistance of concrete,

a_{EC2} – distance from the edge of the column to the observed control section.

In the following step, on the basis of the calculated value of concrete punching shear resistance $v_{Rd,c}$ and expression in Eq. (1), for each considered control section of perimeter u, a reduced force in the column is calculated (in EC2 marked as $V_{Ed,red}$) in the following way: $V_{Ed,red} = v_{Rd,c} \cdot u \cdot d$. Also, for each considered control section it is necessary to calculate A_0, i.e. to determine area inside the considered control perimeter, and then using Eq. (3) calculate ultimate punching shear force, in EC2 marked as V_{Ed}. Since the described calculation procedure is performed in several chosen control sections, several values of ultimate punching force are obtained, the relevant being a force which is minimal in terms of its value. The distance of the critical control section determined in this way in relation to the edge of the column is marked as a_{cr} (Fig. 2).

Apart from the described iterative procedure, the position of the critical section can be determined somewhat more simply, based on the diagram derived from the parametric studies and presented in the European Concrete Platform – ECP [6]. The diagram for determining the position of critical section a_{cr} based on the dimensions of the cross-section of the column (b_c) and geometry of the footing (B and d) is provided in Fig. 2.

As already mentioned, Eurocode 2, in addition to the critical section defined by the iterative procedure or using the diagram in Fig. 2, also requires checking the shear stresses in the footing cross-section along the perimeter of the column. In the process, for the force in the column reduced for the part of soil reaction beneath the column footing, shear stress v_{Ed} along the column perimeter u_0 is calculated, and it must not exceed the value of the maximum punching shear stress $v_{Rd,max}$, i.e.:

$$v_{Ed} = \frac{V_{Ed,red}}{u_0 \cdot d} \leq v_{Rd,max} \qquad (5)$$

where:

$v_{Rd,max} = 0.5 v f_{cd}$, $v = 0.6(1 - f_{ck}/250)$,

$f_{cd} = \alpha_{cc} \cdot f_{ck} / \gamma_c$ is the design value of compressive strength of concrete,

α_{cc} is the coefficient of long-term effects on the compressive strength of concrete (1.0).

For the final conclusion on the punching shear capacity of column footings, of the two considered sections (section within a distance of $2d$ from the edge of the column and the

section along the perimeter of the footing column) is relevant the one that results in a lower value of punching shear force.

Yet, more recent research conducted by Hegger et al. [7–9], Siburg et al. [10], Ricker and Siburg [11], indicate that expression $v_{Rd,max}$ is not the most adequate for determining the values of maximum stress at punching shear, regarding that it is only a function of the compressive strength of concrete. Therefore, in the German national annex of Eurocode 2, the calculation of the punching shear force for the section along the perimeter of the column is considered obsolete and is not taken into account. Therefore, in the analyses conducted in this paper, the calculation of the punching shear force for the section along the perimeter of the column is omitted.

3. ANALYSIS OF EXPERIMENTAL RESEARCH CONDUCTED PREVIOUSLY

Although the number of studies on the punching shear capacity of column footings has been growing recently, unfortunately, a larger number of experimental tests still relate to footings that rely on some kind of simulated subgrade (springs, presses, line support). An overview of previous experimental tests of concentrically loaded reinforced concrete column footings in terms of the punching shear capacity, according to the available technical literature, is given in Table 1.

Table 1 An overview of previous experiments on reinforced concrete column footings

Author(s)	Type of support	Number of tested footings	Geometry of footing		
			Form	Dimensions [mm]	Effective depth [mm]
Zhang et al. (2019) [12]	Rubber – wooden composite blocks	3	Square	1200×1200	140
Simões et al. (2016) [13]	Hydraulic jacks	8	Square	1950 and 2120	497–516
Shill et al. (2015) [14]	Stabilized soil	1	Square	1524	212
Siburg and Hegger (2014) [15]	Hydraulic jacks	13	Square	1200–2700	400–590
Urban et al. (2013) [16]	Linear support	9	Octagon	1948–2344	118–318
Mordich et al. (2007) [17]	Sand	3	Square	2200	132–272
Hegger et al. (2006, 2007, 2009) [7–9]	Sand / Hydraulic jacks	22	Square	900–1800	150–470
Timm (2003) [18]	Linear support	10	Square	760–1080	172–246
Hallgren et al. (1998) [19]	Linear support / Hydraulic jacks	14	Square and rectangle	850–960	273–278
Tetior and Djakov (1989) [20]	Sand	6	Square and rectangle	1500×1000	125
Dieterle and Rostásy (1987) [21]	Sand	13	Square	1500–3000	320–800
Kordina and Nölting (1981) [22]	Hydraulic jacks	11	Rectangle	1500–1800	193–343
Dieterle and Steinle (1981) [23]	Hydraulic jacks	6	Square	1800–3000	700–740
Rivkin (1967) [24]	Hydraulic jacks / Clay	3 / 6	Square	650 and 1000	95
Richart (1948) [25]	Springs	149	Square and circle	610–3000	200–740
Talbot (1913) [26]	Springs	20	Square	1520	250

Experimental tests have shown that the punching shear capacity of column footings is significantly higher in the case of footings rested on a real subgrade soil compared to footings in which the subgrade is simulated. Therefore, when analyzing the influence of concrete compressive strength and reinforcement ratio on the punching shear capacity of column footings, only footings supported on the ground are taken from Table 1. In addition, the analysis included the footings examined during specially designed and constructed experimental setup in Niš, Serbia, where many tests were performed (more data can be found in Bonić et al. [27]).

Table 2 Punching failure forces of footings rested on the ground according to experiments and EC2

Mark	B	b_c	d	f_{ck}	ρ_t	V_{test}	$V_{EC2(i)}$	$V_{test} / V_{EC2(i)}$	$V_{EC2(ECP)}$	$V_{test} / V_{EC2(ECP)}$
	[mm]	[mm]	[mm]	[MPa]	[%]	[kN]	[kN]		[kN]	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Bonić et al.										
F1	850	175	175	30.37	0.40	1001	776	1.29	786	1.27
F2	850	175	125	30.37	0.40	1050	396	2.65	400	2.63
F3	850	175	100	16.83	0.40	430	208	2.07	210	2.05
F4	850	175	150	16.83	0.40	656	468	1.40	476	1.39
F5	850	175	125	15.28	0.40	451	315	1.43	318	1.42
F6	850	175	125	7.92	0.40	440	254	1.73	256	1.72
F7	850	175	125	15.83	0.27	527	266	1.98	282	1.87
F8	850	175	125	15.83	0.48	645	325	1.98	342	1.89
F9	850	175	125	15.83	0.91	720	401	1.80	423	1.70
Rivkin (1967) [24]										
R1	1000	200	95	16.67	0.25	180	158	1.14	191	0.94
Hegger et al. (2006, 2009) [7],[9]										
DF1	900	150	150	20.20	1.03	551	638	0.86	607	0.91
DF2	900	150	150	22.00	1.03	530	656	0.81	625	0.85
DF4	900	150	250	24.50	0.62	1251	1403	0.89	1410	0.89
DF5	900	175	250	17.60	0.73	1130	1467	0.77	1475	0.77
DF6	1200	200	395	19.00	0.87	2836	3255	0.87	3282	0.86
DF7	1400	200	395	20.90	0.87	2569	3080	0.83	3090	0.83
DF8	1200	200	250	22.50	0.88	1203	1532	0.79	1583	0.76
DF10	1200	200	250	38.10	0.91	1638	1847	0.89	1908	0.86
Shill et al. (2015) [14]										
S1	1524	200	212	13.47	0.56	640	747	0.86	736	0.87

Experimentally recorded values of punching failure forces of the analyzed footings V_{test} are provided in Table 2, column (7). Using the expression for calculation of the punching shear capacity of column footings according to Eurocode 2 in the iterative procedure, for the mentioned footings resulted in the values $V_{EC2(i)}$ that are provided in column (8), and the ratio of experimental and calculated punching shear forces $V_{test}/V_{EC2(i)}$ in column (9). In addition, for comparison, in column (10) are presented the design values of punching shear force $V_{EC2(ECP)}$, determined by using the diagram shown in Fig. 2 according to the European concrete platform (ECP, 2008), and in column (11) ratio of these forces in comparison to the experimentally recorded punching shear forces $V_{test}/V_{EC2(ECP)}$. What can be observed by comparing the values in columns (8) and (10), i.e. in columns (9) and (11), is that the extensive iterative procedure and simplified procedure using the diagram result in approximately identical results.

4. EFFECTS OF CONCRETE COMPRESSIVE STRENGTH AND REINFORCEMENT RATIO TO THE PUNCHING SHEAR CAPACITY OF CONCENTRICALLY LOADED RC COLUMN FOOTINGS

Effects of compressive strength and reinforcement ratio to the punching shear capacity of concentrically loaded RC column footings was considered on two series of footings tested by the authors of this study according to Table 2 (Bonić et al.). In each of them, all characteristics of footings, except that whose effect was considered, were approximately identical. For the analysis of the effects of considered characteristics on the punching shear capacity of column footings, the footing deflection was observed in the function of the increase of load in the footing column. There, footing deflection comprises the difference between the registered soil settlements under the column and the angle of the footing.

The first series consisted of three footings made of concrete, whose compressive strengths (average values of multiple tested specimens, on a cylinder of standard dimensions) varied and amounted to $f_{cm} = 7.92$ MPa (footing marked as F6), $f_{cm} = 15.83$ MPa (footing F8) and $f_{cm} = 30.37$ MPa (footing F2), whereas the remaining characteristics were approximately the same. In the other series of the tested footings, the used reinforcement ratios were 0.27% (footing F7), 0.48% (footing F8) and 0.91% (footing F9), whereas the other characteristics were again approximately identical. Qualitative effects of considered characteristic on the punching shear capacity of column footings are illustrated on the diagrams in Fig. 3.

In Fig. 3(a) it can be observed that the effects of compressive strength of concrete to punching shear force of the footings is considerable, because the recorded punching shear forces of the footings with markings F2, F6, and F8 were respectively 1050 kN, 440 kN, and 645 kN. Such a result was expected and it is in agreement with the previous research (Hegger et al. [7–9]; Siburg and Hegger [15]; Simões et al. [13]). Moreover, in the diagram can be seen that the footings with a lower concrete compressive strength (F6 and F8) exhibit much more ductile behavior under load.

In Fig. 3(b) it can be observed that effects of the reinforcement ratio are not as prominent as the previously observed effect, whereby the recorded punching shear forces of the footings F7, F8, and F9 were 527 kN, 645 kN, and 720 kN, respectively. This result was expected and in accordance with the previous research (Hallgren et al. [19]; Menetrey [28]). In terms of ductility, these footings showed relatively similar behavior.
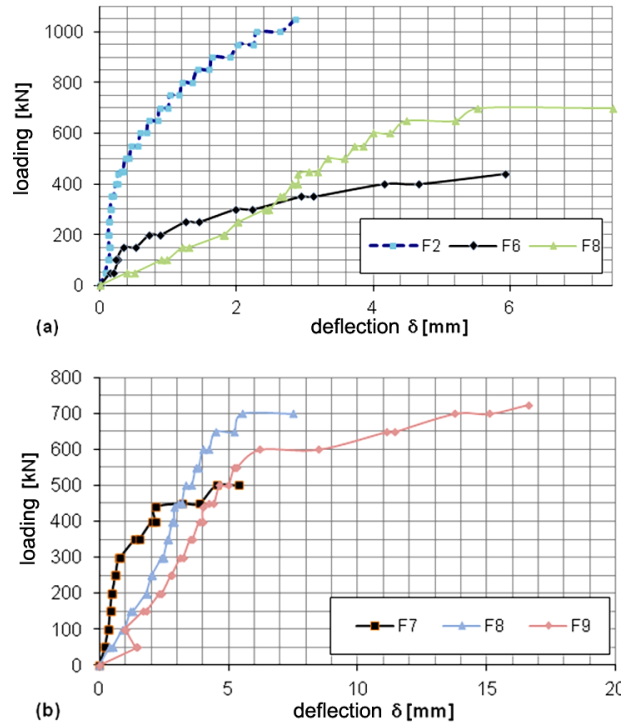
Fig. 3 Load–deflection diagrams of the footings: (a) for different compressive strengths of the concrete, (b) for various reinforcement ratios of the footings

The stress in concrete at punching shear v_{test} for the registered force of punching shear during the experiment V_{test}, was calculated in the critical cross section of the foundations with a goal of determining the quantitative impact of compressive strength and reinforcement ratio:

$$v_{test} = \frac{V_{test}\left(1 - \frac{A_0}{A}\right)}{u \cdot d} \tag{6}$$

where the designations from the previous expressions are retained.

The values used in the iterative calculation procedure according to EC2 (calculation provided in columns (8) and (9) of Table 2) are used for A_0 and u.

Fig. 4 shows the punching shear stress in concrete at the moment of punching, v_{test}, for the footings which were rested on a real subsoil (according to Table 2), depending on the compressive strength of concrete (f_{ck}) and reinforcement ratio (ρ_t) of tested footings.

The conducted regression analysis, Fig. 4(a), shows that the stress in concrete at punching shear v_{test} is proportional to the compressive strength of concrete with the exponent of 0.50. This corresponds with the conclusions of Hallgren et al. [19], which state that the punching shear capacity of slabs having a low shear slenderness, such as column footings, is proportional to the compressive strength of concrete in a ratio of 0.76,

whereas the tests with thin slabs by Braestrup and Gardner (according to [19]) showed that this impact is smaller and amounts from 1/3 to 1/2.

According to Fig. 4(b), punching shear stress in concrete at the moment of punching v_{test} increases with the reinforcement ratio with the exponent of 0.23, which also agrees with the research by Hallgren et al. [19]. On the basis of this, it can be concluded that the reinforcement ratio has a smaller influence on the concrete punching shear resistance than the compressive strength of concrete. The obtained results indicate that Eurocode 2, which in the expression of Eq. (4) includes the impact of these two parameters with the same exponent (1/3), on the one hand underestimates the impact of compressive strength of concrete, whereas on the other hand overestimates the impact of reinforcement ratio on the punching shear capacity of RC footings.
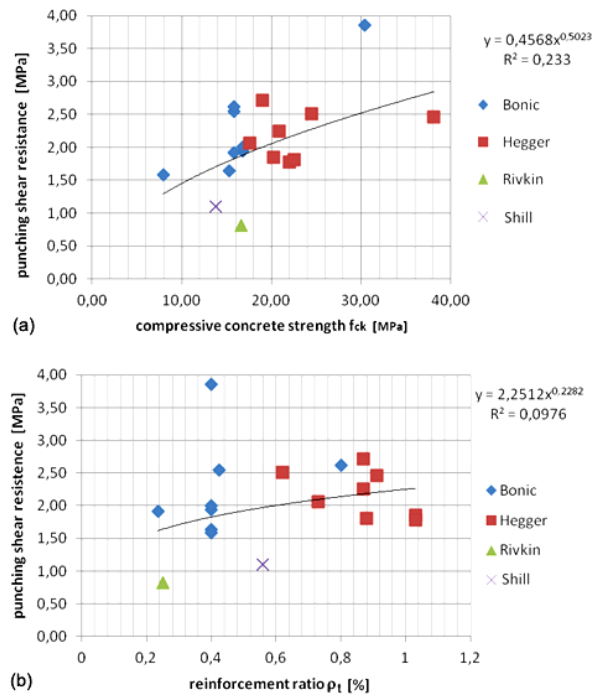

Fig. 4 Dependence of the punching shear resistance of concrete v_{test} on: (a) concrete compressive strength (f_{ck}), (b) reinforcement ratio (ρ_t)

Considering the mentioned differences in the results provided by the standing EC2 in comparison to the experimentally obtained results, in agreement with the conclusions based on the diagrams in Fig. 4, a modification of Eq. (4) for the punching shear resistance of concrete is proposed having the form:

$$v_{Rd,c} = C_{Rd,c} \cdot k \cdot (f_{ck})^{1/2} (100 \cdot \rho_t \cdot)^{1/4} \cdot \frac{2d}{a_{EC2}} \geq v_{min} \frac{2d}{a_{EC2}} \qquad (7)$$

where the coefficient k is also modified and is calculated according to the expression $k = \sqrt{200/d}$, whereas other designations and method of calculation are the same as in the expression of Eq. (4).

Finally, for the footings given in Table 2 the procedure of calculation of the ultimate punching shear force according to Eurocode 2 was repeated, but with implementation of the proposed calculation modification, provided by Eq. (7). As the relevant critical section (α_{EC2} in Eq. (7)) was taken the section determined using diagrams provided in the European concrete platform – ECP [6], i.e. according to Fig. 2.

The obtained results are provided in Fig. 5. As previously observed, the iterative procedure and procedure using the ECP diagram result in almost identical values. By comparing the results according to the standing Eurocode 2 and to the proposed solution, it can be seen that the proposed solution provides the results which are considerably closer to the experimentally registered values. For the footings F1 to F9, the proposed modified solution gives the values of V_{test} / V_{calc} that are significantly less conservative (closer to 1.0) compared to the current Eurocode 2. On the other hand, for the remaining footings from Figure 5, for which the original Eurocode 2 gives the ratio V_{test} / V_{calc} lower than 1.0 (which is an undesirable situation), by the proposed modified solution values equal to or greater than 1.0 are achieved, which is on the safety side.
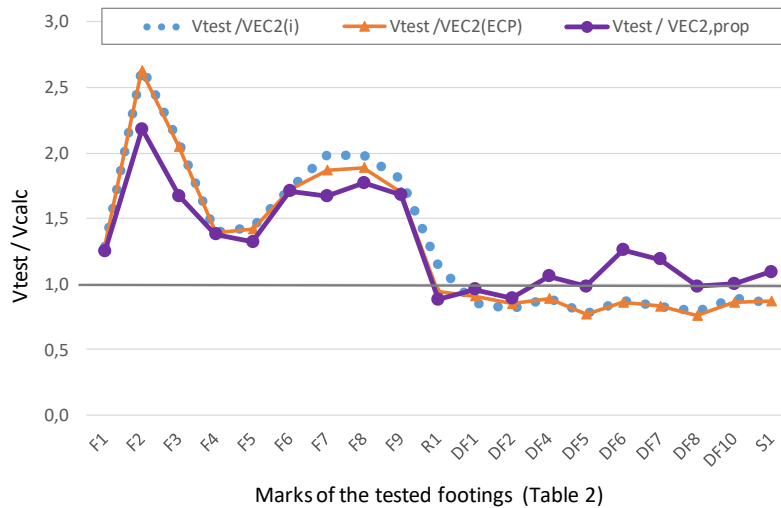

Fig. 5 Comparison of the ratio V_{test} / V_{calc} for different methods of calculation considering the experimentally tested footings

5. CONCLUSION

Based on the performed experiments of concentrically loaded RC column footings rested on real soil and conducted analyses related to the punching shear capacity of footings, the following conclusions can be drawn:

- Recommendations for determining the position of the critical perimeter based on the diagram proposed by the European concrete platform − ECP yield almost the same results as the calculation which identifies the minimum punching force inside the area bounded by the basic control section (iterative procedure). Therefore, the use of this diagram can be recommended instead of a complicated iterative procedure;
- The conducted regression analysis of the footings rested on the real soil indicates that the punching shear capacity is more affected by the compressive strength of concrete than reinforcement ratio, even though Eurocode 2 takes them in the calculation in the same measure. It is proposed to calculate the compressive strength of concrete and reinforcement ratio with the exponents of 1/2 and 1/4 respectively, when calculating punching shear capacity of footings, instead with the same exponent of 1/3 for both characteristics;
- The proposed calculation modification according to Eurocode 2, which in a different way takes into consideration the impact of the size-effect coefficient (k), reinforcement ratio (ρ_t), and compressive strength of concrete (f_{ck}), provides the results which are considerably closer to the experimental results in comparison to the current Eurocode 2.

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PREDLOG MODIFIKACIJE EVROKODA 2 U POGLEDU PRORAČUNA NOSIVOSTI AB TEMELJA SAMACA NA PROBIJANJE

U radu je najpre predstavljen proračun nosivosti centrično opterećenih armiranobetonskih temelja samaca na probijanje prema aktuelnom Evrokodu 2, koji se može sprovesti dvojako: sprovođenjem iterativnog postupka i primenom zamenjujućih dijagrama. Primenom ovih postupaka, urađen je proračun nosivosti pri probijanju za temelje ispitivane u okviru sopstvenih eksperimentalnih istraživanja, kao i za temelje koji su bili sagledani eksperimentima sprovedenim od strane drugih autora. Na osnovu sprovedene analize rezultata proračuna i eksperimentalno registrovanih rezultata, predložena je modifikacija izraza aktuelnog Evrokoda 2 u pogledu proračuna nosivosti centrično opterećenih AB temelja samaca na probijanje. Predložena modifikacija realnije uzima u obzir uticaj čvrstoće na pritisak betona i procenta armiranja temelja, tako da se njenom primenom dobijaju rezultati sila probijanja koji su bliži rezultatima registrovanim tokom eksperimentalnih ispitivanja.

Ključne reči: *AB temelj samac, Evrokod 2, probijanje, čvrstoća na pritisak betona, procenat armiranja*