

Advanced Concept Training Punching Design

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Theoretical background

1. General

Punching shear can result from a concentrated load or reaction acting on a relatively small area, called the loaded area Aload of a slab or a foundation.

The most common situations where punching shear has to be considered is the region immediately surrounding a column in a flat ceiling plate or where column is supported on foundation plate. The following problem types can be distinguished: interior, edge and corner columns. Design of punching shear reinforcement is based on clause 6.4 of EN 1992-1-1: 2004 / A1:2014 + National Annexes.

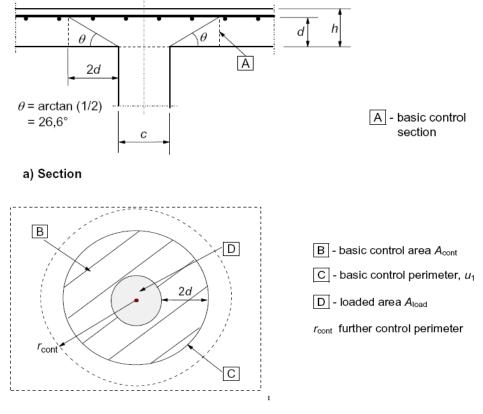
The verification reveals either that the load-bearing capacity of the reinforced concrete is sufficiently high, or that punching shear reinforcement must be designed and installed. If the verification limits are exceeded, the verification result is marked as not permissible. In this case, the user must change the model parameters or select a suitable design alternative.

The verification of punching failure at the ultimate limit state can be resumed as follows:

 Check of the shear resistance at the face of the column noted u₀, and at the basic control perimeter named u₁.

• If shear reinforcement is required, a further perimeter u_{out,ef} should be found where shear reinforcement is no longer required.

Those control perimeters are shown in the following pictures:

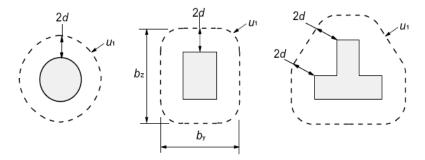


b) Plan

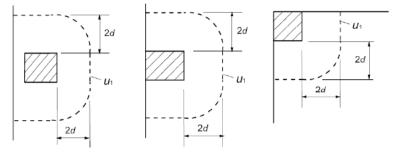
2. Load distribution and basic control perimeter

Basic control perimeter u1

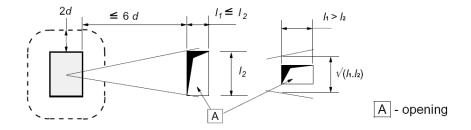
The basic control perimeter u₁ is taken at a distance 2d from the loaded area, where d is the effective depth.



In case the loaded area is close to an edge or a corner:



In case there is openings near the loaded area, they are dealt with according to clause 6.4.2(3). If the shortest distance between the perimeter of the loaded area and the edge of the opening does not exceed 6d (see figure), part of the control perimeter contained between two tangents drawn to the outline of the opening from the center of the loaded area is ineffective.



In SCIA Engineer, openings inputted in the Structure menu are automatically considered according to the previous criteria.

Effective depth deff

The effective depth of the slab, is assumed constant and is calculated according to formula 6.32 from EN1992-1-1:

$$d_{\rm eff} = \frac{\left(d_y + d_z\right)}{2}$$

where d_y and d_z are the effective depths of the reinforcement in two orthogonal directions.

3. Punching shear calculation

The punching shear calculation is done according to EN1992-1-1 art.6.4.3.

First the design shear resistances along the control sections are calculated:

- v_{Rd,c} design value of the shear resistance of a slab *without* punching shear reinforcement along the control section considered
- v_{Rd,cs} design value of the punching shear resistance of a slab with punching shear reinforcement along the control section considered
- v_{Rd,max} design value of the maximum punching shear resistance along the control section considered

Then the following checks should be performed.

Check at the column perimeter u₀

At the column perimeter u_o, or at the perimeter of the loaded area, the maximum punching shear stress should not be exceeded.

۱

 $\begin{array}{ll} v_{Ed0} & design \ shear \ stress \ at \ the \ column \ perimeter \ u_0 \\ v_{Rd,max} & = 0.4 \cdot \ v \cdot fcd \\ v & = 1 \ - \ f_{ck} \ / 250 \end{array}$

Check at the basic control perimeter u1

At the basic control perimeter u1:

- If $v_{Ed} \le v_{Rd,c}$ Punching reinforcement is not needed
- If $v_{Ed} > v_{Rd,c}$ Punching reinforcement is needed

The punching shear resistance of a plate V_{Rd,c} is calculated according to formula 6.47, EN1992-1-1:

$$v_{\rm Rd,c} = C_{\rm Rd,c} k (100 \rho_{\rm l} f_{\rm ck})^{1/3} + k_{\rm l} \sigma_{\rm cp} \ge (v_{\rm min} + k_{\rm l} \sigma_{\rm cp})^{1/3}$$

In SCIA Engineer, normal concrete stresses are not taken into, so $k_1 \cdot \sigma_{cp} = 0$. This results in the following formula:

$$V_{\rm Rd,c} = C_{\rm Rd,c} k (100 \rho_{\rm l} f_{\rm ck})^{1/3} \ge V_{\rm min}$$

 $C_{Rd,c} = 0.18 / \gamma_c$

 $k = 1 + \sqrt{\frac{200}{d}} \le 2,0$ *d* in mm

 $\begin{array}{ll} \rho_l & \mbox{average reinforcement ratio in specific distance around column} \\ f_{ck} & \mbox{characteristic concrete compressive strength in MPa} \\ v_{min} & = 0.035 \cdot k^{3/2} \cdot f_{ck}^{1/2} \end{array}$

The maximum shear stress v_{Ed} is calculated for considered control perimeter u_i according to clause 6.4.3(1) as follows:

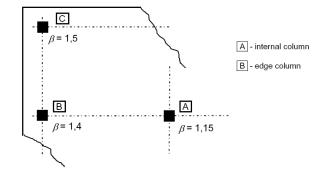
$$V_{\rm Ed} = \beta \, \frac{V_{\rm Ed}}{u_{\rm i} d}$$

The β -factor is to consider the non-uniform load transfer (due to unbalanced bending moment). If the load transfer is non-uniform, local peak loading should be compensated by help of this β -factor.

In case that lateral stability of the structure does not depend on frame action between the slabs and the columns, and where the adjacent spans do not differ in length by more than 25%, approximate values for β may be used according to clause 6.4.3(6).

In SCIA Engineer, the user must decide whether these approximate values can be used, because the program cannot check the preconditions described above.

By default, the recommended approximated values are:



Those values might be different according to the National Annexes and can be viewed in the National Annexes setup:

	Concrete setup	×
EC-EN General Concrete On-prestressed reinforcement Prestressed reinforcement Durability and concrete cover	 □ ULS □ General □ Punching □ National annex □ C_{Rd,c} 	^
ULS General Funching SLS General	Value [-] 0.18 ▷ k1 - factor considering effects of axial loa Value [-] 0.10	
Prestressing Allowable stress Stress limitation StS stress limitation Detailing provisions Common detailing provisions	Vmin - min. value of shear resistance Formula Formula Vmin, - min. value of max. shear resist Formula Formula	
Columns Beams - 2D structures and slabs - Punching	ε β _{int} - coeff. to increase shear stress aroun Value [-] 1.15 ε β _{edge} - coeff. to increase shear stress arou Value [-] 1.40	
	β _{cor} - coeff. to increase shear stress arour Value [-] 1.50 k _{max} - factor limiting shear capacity of ap	
	Value [-] 1.50 k _{out} - factor defining placement of last pe Value [-] 1.50 1.50	
	 SLS Allowable stress Detailing provisions 	~
Refresh	Load default NA paramete	rs OK Cancel

Otherwise, as described in art 6.4.3, the β -factor can be calculated by the following general formula:

$$\beta = 1 + \sqrt{\left(k_{y} \cdot \frac{M_{Ed,y}}{V_{Ed}} \cdot \frac{u_{1}}{W_{1y}}\right)^{2} + \left(k_{z} \cdot \frac{M_{Ed,z}}{V_{Ed}} \cdot \frac{u_{1}}{W_{1z}}\right)^{2}}$$

Calculation of β -factor with general formula can be set in Concrete setup > Punching:

	conci	ete setti	193					
ational annex:					Find	View 🔻	Advanced	Default
Description	Symbol	Value	Defaul	t Unit	Chapter	Code	Struct	CheckT
<al></al>	<all> 🔎</all>	<all></all>	Q <all></all>	ρ	<all> 🔎</all>) <all> 🔎</all>	<all> 🔎</all>	<all> 🔎</all>
Solver setting								
H General								
Internal forces								
Design As								
Interaction diagram								
H Shear								
Torsion								
Punching		_	_					
Type of Beta factor	Туре β	Formula	 Approx 	i	6.4.3(3-6)	EN 1992-1-1	Plate	Solver s
Control perimeter		Approxima						
Distance of control perimeter for ceiling plate	coeff k _{u1,ce}	Formula (I		-	6.4.2(1)	EN 1992-1-1	Plate	Solver s
Distance of control perimeter for foundation plate			2.00	-	6.4.2(1)	EN 1992-1-1	Plate	Solver s
Distance from column face to consider openings	coeff konen	6.00	6.00	-	6.4.2(3)	EN 1992-1-1	Plate	Solver s

Design of punching reinforcement if required

In case that v_{Ed} > $v_{Rd,c}$, punching reinforcement should be designed.

If punching reinforcement is required, the outer control perimeter u_{out} beyond which the reinforcement is no longer needed is calculated acc. to clause 6.4.5(4):

$$u_{out,ef} = \frac{\beta V_{Ed}}{V_{Rd,c}d}$$

Calculation of the required punching reinforcement

In SCIA Engineer, the shear reinforcement is designed using the following assumptions:

- the distribution of the shear links is considered as radial only
- only vertical shear links are supported
- the shape of reinforcement perimeters around the column is the same as for the shape of the basic control perimeter

The required area A_{sw,req} of one perimeter of shear reinforcement around the column assumed as radially distributed vertical shear links is calculated as:

Asw, req =
$$\frac{(vEd, u1 - 0.75 \cdot vRd, c) \cdot u1 \cdot sr}{1.5 \cdot fywd, ef}$$

 $\begin{array}{l} f_{ywd,ef} & \mbox{effective design strength of the punching reinforcement acc. to formula:} \\ f_{ywd,ef} = 200 + 0.25 \cdot d_{eff} \leq f_{ywd} \end{array}$

Detailing provisions for the punching reinforcement

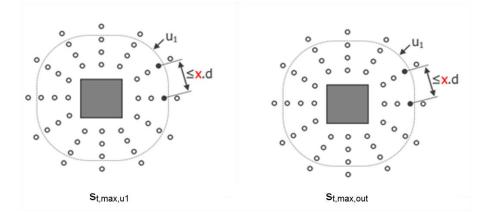
The required area might be adjusted to fulfil detailing provision rules acc. to clause 9.4.3(1), so that number of shear links n_s per each reinforcement perimeter is:

$$n_{s} = max \left\{ \frac{4 \cdot A_{sw,req}}{\pi \cdot d_{s}^{2}}; \frac{u_{1,last}}{s_{t,max,u1}}; \frac{u_{s,last}}{s_{t,max,out}} \right\}$$

ds diameter of shear link

 $\frac{u_{1,last}}{s_{t,max,u1}}$ condition of maximum allowed tangential spacing of links of reinforcement perimeters placed within the basic control perimeter (u_{1,last} is length of last perimeter of shear reinforcement there)

 $\frac{u_{s,last}}{s_{t,max,out}}$ condition of maximum allowed tangential spacing of links of reinforcement perimeters placed outside the basic control perimeter (u_{s,last} is length of last perimeter of shear reinforcement there)



In SCIA Engineer, limitation of spacing $s_{t,max,u1}$ and $s_{t,max,out}$ are set in Concrete setup > Detailing provisions > Punching:

				(Concre	ete s	etting	IS							
National annex										Find	Vie	w 👻	Adva	nced D	efault
Description		Symbol	Value		Default		Unit	Chapter		Code		Structu	ire	CheckTy	e ^
<9 >	ρ	<all></all>) <all></all>	ρ	<all></all>	ρ	< Q	<9 >	ρ	<all></all>	ρ	<all></all>	ρ	<all></all>	ρ
Cracking forces															
Deflections															
Detailing provisions															
🗄 Beam (Rib)															
Beam slab															
⊞ Column															
Hate, Shell(Plate)															
⊞ Wall, Shell(Wall)															
⊞ Deep beam															
Punching															
Check min. shear reinforcement			1		1			9.4.3(2)		EN 1992-1-	1	Plate		Solver set	tti
Check distance of the first perimeter of shear links			\mathbf{V}		1			9.4.3(1,4)		EN 1992-1-	1	Plate		Solver se	tti
Min. distance from column face		coeff s _{0,min}	0.30		0.30			9.4.3(1)		EN 1992-1-	1	Plate		Solver set	tti
Max. distance from column face		coeff s _{0,max}	0.50		0.50			9.4.3(4)		EN 1992-1-	1	Plate		Solver set	tti
Check max. radial spacing of shear links			\checkmark		V			9.4.3(1)		EN 1992-1-	1	Plate		Solver sel	tti
Max spacing of shear links		coeff s	0.75		0.75			9.4.3(1)		EN 1992-1-	1	Plate		Solver set	tti
Check max. tangential spacing of shear links			1		V			9.4.3(1)		EN 1992-1-	1	Plate		Solver set	tti
Max. tangential spacing within the first control perimet	er	coeff s _{t.max,u}	1.50		1.50			9.4.3(1)		EN 1992-1-	1	Plate		Solver sel	tti
Max. tangential spacing outside the first control perim		coeff st.max.or			2.00			9.4.3(1)		EN 1992-1-	1	Plate		Solver se	tti
Check minimum number of perimeters of shear links			7		V			9.4.3(1)		EN 1992-1-	1	Plate		Solver se	tti
Min. number of perimeters of shear links		n _{per,min}	2		2			9.4.3(1)		EN 1992-1-	1	Plate		Solver set	tti 🗸

The last condition, which must be fulfilled acc. to clause 9.4.3(2) is minimum reinforcement area of single shear link $A_{sw1,min}$ acc. to formula (9.11):

$$A_{sw1,min} = \frac{0.08 \cdot \sqrt{f_{ck} / f_{ywk}} \cdot s_r \cdot s_t}{1.5}$$

sr spacing of shear links in the radial direction

st spacing of shear links in the tangential direction

The final designed area of each perimeter of shear reinforcement around the column is:

$$A_{sw} = n_s \cdot \pi \cdot d_s^2 / 4 \ge n_s \cdot A_{sw1,min}$$

The required number of shear reinforcement perimeters around column, n_{per} , is determined based on clause 6.4.5(4), which specifies that the outermost perimeter of shear reinforcement, $a_{s,last} = s_0 + s_r \cdot n_{per}$, should be placed at a distance not greater than $k_{out} \cdot d_{eff}$ within u_{out} . The following formula for n_{per} is derived:

 $n_{per} = [(a_{out} - s_0 - k_{out} \cdot d_{eff}) / s_r] + 1 \ge n_{per,min}$

- k_{out} coefficient to determine the maximum distance of last perimeter from u_{out}. Default value is 1,5. This is a National Annexes parameter.
- n_{per,min} minimum number of reinforcement perimeters around column required acc. to clause 9.4.3(1). Default value is 2 in Concrete setup > Detailing provisions > Punching.

a_{out} distance of the outer perimeter u_{out}.

The total amount of shear reinforcement Asw,tot around the column is then calculated as:

$$A_{sw,tot} = n_{per} \cdot A_{sw}$$

Punching Design in SCIA Engineer

1. Configuration

Summary

N63

The punching check in SCIA Engineer is only available when a real column or a nodal support have been connected to a plate. No punching check can be performed for a point load or a little surface load applied to the plate.

SCIA Engineer supports circular and rectangular cross sections only for the punching check.

The column position with regard to the edges of the plate and the openings is recognize. Also, for the punching check, all edges and angles of the plate are taken as straight... so if they are not in your model, the program makes an approximation.

SCIA Engineer doesn't support all punching cases of column-plate connection. The list of all current limitations can be found in our webhelp. Each unsupported configuration is mentioned in the list of Errors/warning/notes of the report in the punching check report.

Name	Case	Punching case	Punching shape	UCvrd, [-]		CvRd,c [-]		Shear nforcemen erimeters	t [-]		UCAsw,det [-]	UC [-] Check	Errors, warnings, notes
N61	ULS/1	N/A	N/A	3	3.00	3.00	N/A	L.	-	-		3.00 NOT OK	W6/131
N63	ULS/1	N/A	N/A	3	3.00	3.00	N/A	l	-	-		3.00 NOT OK	W6/124
Concret	Concrete												
Name	Case	Punching case	Punching shape	V _{Ed} [kN] β [-]	M _{Ed,y} [kNm] M _{Ed,z} [kNm]	Pla h [mi		Material f _{cd} [MPa]	d _{eff} [mm] ρι [%]	U0 [m] U1 [m]	VEd,u0 [MPa] VEd,u1 [MPa]	V _{Rd,max} [MPa] V _{Rd,c} [MPa]	UC _{vRd,max} [-] UC _{vRd,c} [-]
N61	ULS/1	N/A	N/A	-	-	N/A		N/A	-	-	-	-	3.00

N/A E/W/N Present on members

ULS/1

N/A

W0/131	NOI		
W6/124	N63		
E/W/N	Des	scription	Solution
W6/131		for punching. The connected	
	column has not supported	type of cross-section.	
W6/124		for punching. The connected	Split the column in the node to get a separate column
	column goes through the	plate.	above and below the plate.

N/A

N/A

2. Choice of reinforcement

The punching design will check if the longitudinal reinforcement As in the plate is sufficient to resist to the shear force around a column-plate or nodal support-plate connection.

In SCIA Engineer the user can choose between 2 types of reinforcement for the punching check/design:

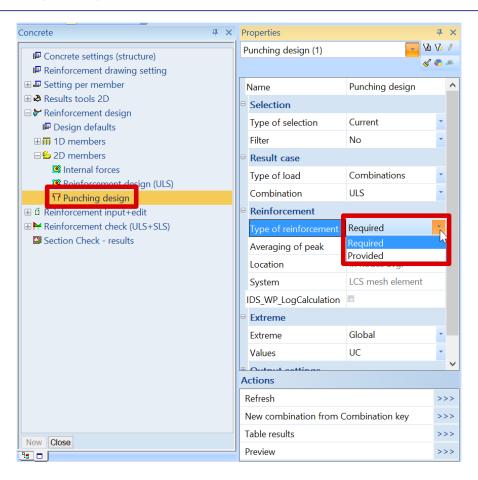
- As, required calculated by the software for a specific load combination •
- As, provided user set in Reinforcement design > Design defaults •

NOTE: practical reinforcement inputted by user manually in Reinforcement input+edit > Reinforcement 2D is not considered for punching design!

The choice between As, required and As, provided is done in the Properties window for Punching design:

3.00

3.00 3.00



3. Punching check

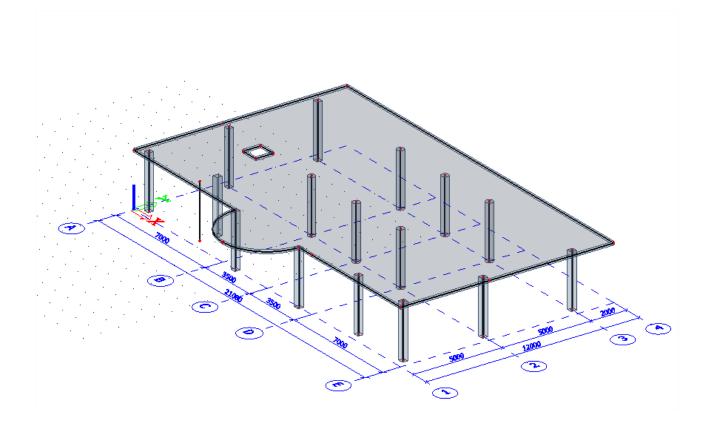
Studied example: punching.esa

Geometry: Concrete class C30/37 Reinforcement class B500B Plate thickness 200 mm Column cross-section 10 x R 300x300 mm² and 6 x circular C400 mm²

Plate and columns are connected to each other by means of the action Connect members/nodes.

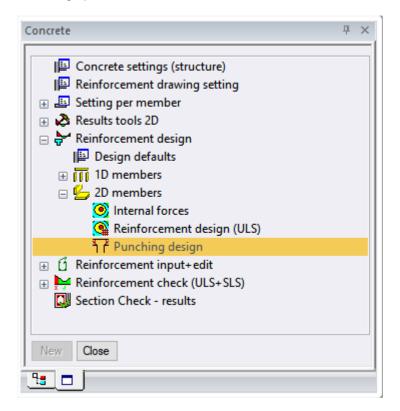
Loading: *Load cases SW: Self weight DL: Dead Load = Surface load -1 kN/m² + Line force on edges -1 kN/m LL: Live Load = Surface load -1 kN/m² LL1: Additional case for further study= -25 kN/m², to be explained later

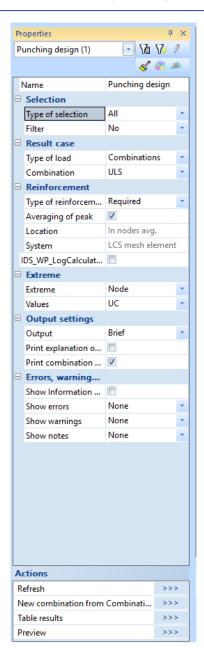
*Combinations ULS (Type EN – ULS (STR/GEO Set B)) = SW, DL, LL SLS (Type EN – SLS Quasi Permanent) = SW, DL, LL



Work method

The **Punching Design** command can be selected in the tree menu of service Concrete > Reinforcement design > 2D members. The command is available, when EC - EN national code is selected in Project data and the linear or non-linear static analysis is done for the model containing 2D members from concrete material. Once the command is selected, appropriate parameters are listed and can be adjusted in property window with following options:

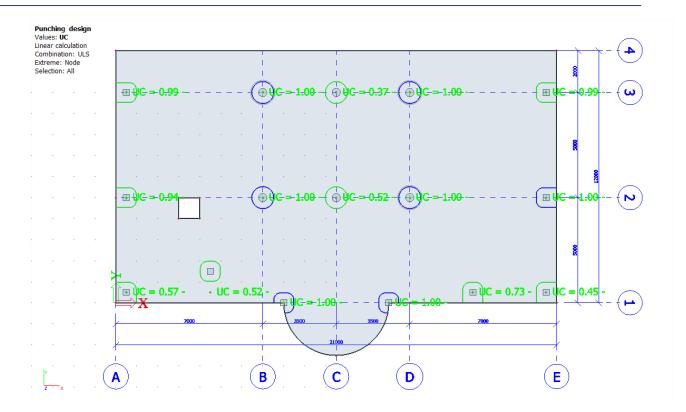




• Set the type of Selection to ALL, the Type of load to Combination ULS and the type of Reinforcement to Required then click Refresh

You will notice that the UC for every node will be displayed along with the control parameter in colour. In total there are 3 colours (Green, blue and red).

- Green: Shear capacity <u>without</u> reinforcement is sufficient (UC_{vRd,c} ≤ 1.0 and UC_{vRd,max} ≤ 1.0)
- Blue: Shear capacity with shear reinforcement is sufficient (UC_{vRd,c} > 1.0 but UC_{vRd,cs} ≤ 1.0)
- Red: Plate is not designable by application of reinforcement or maximum shear capacity of concrete adjacent to the column is not sufficient (UC_{vRd,cs} > 1.0 or UC_{vRd,max} > 1.0)



- Presentation of results as a numerical output is possible via Preview and / or Table results. For the Punching Design, there is available two types of output:
 - Brief contains just a summary table with basic results

Summar	У								
Name	Case	Punching case	Punching shape	UC vRd,max/p [-] stasumman	UCvRd,c [-]	Shear reinforcement perimeters	UCvRd,cs [-]	UC Asw, det [-]	UC [-] Check
N15	ULS/1	Corner S column	Rectangle (300;300)	ins the 0.87 providing furt	sum 1.03 her semi-re	3x 7Ø8(radial) 80+2x80=240	out su 0.68 e	ented b 1.00	1.00 OK, BUT
N20The	ULS/1 o	Corner ty to dis column followin	Rectangle at a (300;300)	n of syr 0.86	ist o 1.02 0	3x 7Ø8(radial) h ⊕ 80+2x80=240	olana 0.68 r	esente 1.00	1.00 OK, BUT
N53	ULS/1	Internal column	Circle (400) lesign shear force	0.37 taken as differ	1.10 ence of axia	3x 9Ø8(radial) 80+2x80=240	0.74 er floor	1.00	1.00 OK, BUT
N55	ULS/1	Internal columnity chec	Circle (400)	0.12 shear resistand	0.37 e of plate w	not required thout shear reinforce	- ment	-	0.37 OK
N57	ULS/1	Internal column	Circle (400)	0.37 shear resistand	1.11 e at the col	3x 9Ø8(radial) 80+2x80=240	0.74	1.00	1.00 OK, BUT
N59	ULS/1	Internal column	Circle (400)	apacity 0.34	1.02	3x 9Ø8(radial) 80+2x80=240	0.68	1.00	1.00 OK, BUT
N61	ULS/1	Internal column	Circle (400)	1 0.17	0.52	not required	- Iperimeter	-	0.52 OK
N63	ULS/1	Internal column	Circle (400)	0.37	1.10	3x 9Ø8(radial) 80+2x80=240	0.73	1.00	1.00 OK, BUT
N88	ULS/1	Edge column	Rectangle (300;300)	0.43	1.00	3x 8Ø8(radial) 80+2x80=240	0.67	1.00	1.00 OK, BUT
N90	ULS/1	Edge column	Rectangle (300;300)	example :	0.99	not required	-	-	0.99 OK
N95	ULS/1	Corner	Rectangle (300;300)	0.22	0.45	not required	-	-	0.45 OK
N97	ULS/1	Edge column	Rectangle (300;300)	0.40	0.94	not required	-	-	0.94 OK
N99	ULS/1	Edge column	Rectangle (300;300)	0.42	0.99	not required	-	-	0.99 OK
N101	ULS/1	Corner column	Rectangle (300;300)	0.27	0.57	not required	-	-	0.57 OK
N103	ULS/1	Edge column	Rectangle	0.32	0.73	not required	-	-	0.73

 Standard - contains the same summary table as in Brief output supplemented by additional tables providing further semi-results

Shear Capacity without Reinforcement is sufficient

Select Node N61 and change the type of selection to current. A brief output will show:

Puncł	ning d	lesign							
Linear cal Combinati Extreme: Selection: Summar	ion: ULS Node : N61								
Name	Case	Punching case	Punching shape	UC _{vRd,max} [-]	UCvRd,c [-]	Shear reinforcement perimeters	UCvRd,cs [-]	UC Asw,det [-]	UC [-] Check
N61	VULS/1	Internal	Circle (400)	0.18	0.56	not required	-	-	0.56 OK

We can see that the UC<1, lets look at the standard output for this node:

inear cal Combinati Extreme: Gelection: Summar y	on: ULS Node N61											
Name	Case	Punching case	Punching shape	UCvRd,ma [-]	× UCvRo [-]	rein	Shear forcement erimeters	UCvRd,cs [-]	UC As [-	1	UC [-] heck	
N61	ULS/1	Internal column	Circle (400)	0.1	L8 0.	56 not r		-	-	0.5 OK	56	
Concrete	e											
Name	Case	Punching case	Punching shape	V _{εd} [kN] β [-]	M _{Ed,y} [kNm] M _{Ed,z} [kNm]	Plate h [mm]	Material f _{ed} [MPa]	d _{eff} [mm] ρι [%]	u₀ [m] u₁ [m]	V _{Ed,u0} [MPa] V _{Ed,u1} [MPa]	V _{Rd,max} [MPa] V _{Rd,c} [MPa]	UC _{vRd,max} [-] UC _{vRd,c} [-]
N61	ULS/1	Internal column	Circle (400)	128.83 1.15	0.38 10.32	Ceiling 200.00	C30/37 20.00	154.00 0.33	1.257 3.192	0.77	4.22 0.54	0.1

We can see that $V_{Ed,u1} = 0.30$ MPa < $V_{Rd,c} = 0.54$ MPa so the shear capacity without reinforcement is sufficient. The control parameter is displayed in Green colour.

Shear Capacity with Reinforcement is sufficient

Let us look now at the standard output for node N59:

Punching design

Linear calculation Combination: ULS Extreme: Node Selection: N59 Summary

Name	Case	Punching case	Punching shape	UC _{vRd,max} [-]	UCvRd,c [-]	Shear reinforcement perimeters	UCvRd,cs [-]	UC Asw,det [-]	UC [-] Check
N59	ULS/1	Internal column	Circle (400)	0.36		3x 10Ø8(radial) 70+2x90=250	0.73	0.92	0.92 OK, BUT

Concrete

Name	Case	Punching case	Punching shape	[kN] β	M _{Ed,y} [kNm] M _{Ed,z} [kNm]	h	Material f _{ed} [MPa]		[m] U1		[MPa] V Rd,c	UC _{vRd,max} [-] UC _{vRd,c} [-]
N59	ULS/1	Internal	Circle (400)	252.59			C30/37	154.00		1.50	4.22	0.36
		column		1.15	0.42	200.00	20.00	0.38	3.192	0.59	0.54	1.09

Reinforcement

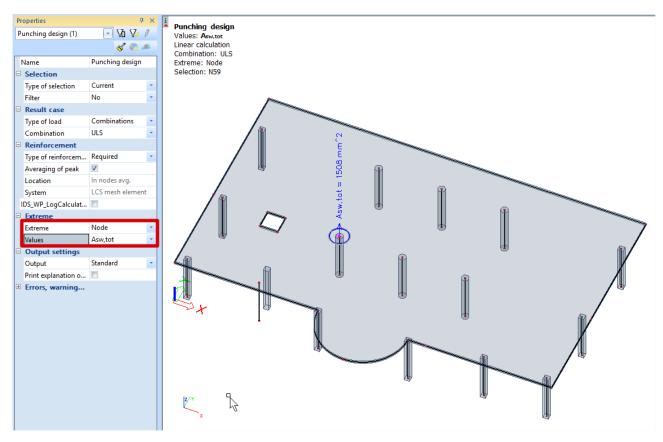
Name	Case	Shear reinforcement perimeters	U _{out} [m] a _{out} [mm]	S _{t,u1} [mm] S _{t,out} [mm]	Control perimeters (distance/capacity)	Material f _{ywd,ef} [MPa]	A _{sw,req} [mm ²] A _{sw1,min} [mm ²]	A _{sw} [mm ²] A _{sw,tot} [mm ²]	V _{Rd,es} [MPa] k _{max} v _{rd,c} [MPa]	UC _{vRd,cs} [-] UC _{Asw,det} [-]
N59	ULS/1	3x 10Ø8(radial)	3.477	283	308/73%	B 500B	122	503	1.16	0.73
		70+2x90=250	355	283		288.5	15	1508	0.81	0.92

We can see here that $V_{Ed,u1} = 0.59 \text{ MPa} < V_{Rd,c} = 0.54 \text{ MPa}$ and the $UC_{vRd,c} = 1.09 > 1$.

So shear reinforcement needs to be designed. The final value is $A_{sw,tot} = 1508 \text{ mm}^2$ which take into account detailing provisions.

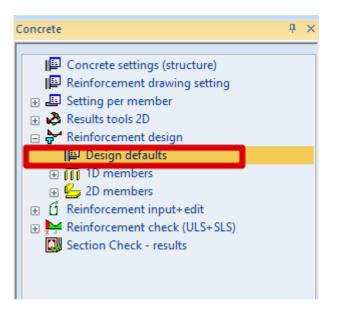
The control parameter is displayed in blue colour.

You can also show the A_{sw,tot} graphically:

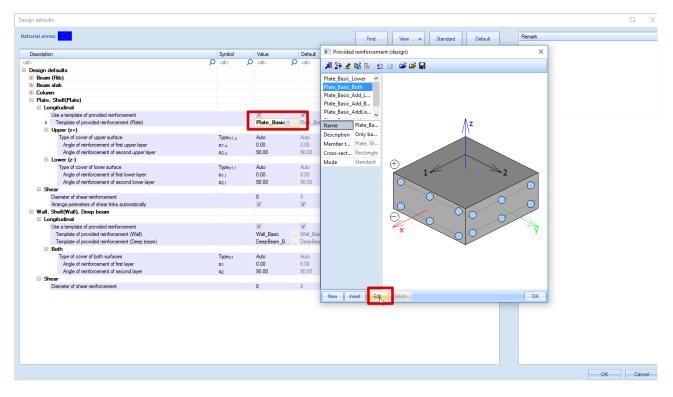


Use of Provided Reinforcement

Lets add some provided reinforcement to the plate. In the Concrete Main tree go to: Reinforcement > Design Defaults :



Activate the provided template for the plates in Reinforcement design > Design default:



Here you can choose between the different templates.

You can give a basic provided reinforcement without any additional reinforcement or allow SCIA Engineer to calculate additional reinforcement when needed.

For this example we will define the basic reinforcement without additional reinforcement and we will use diameter 16mm with a spacing of 150mm.

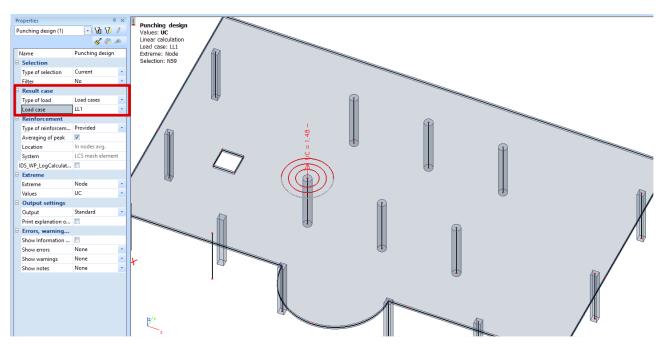
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Now look at the standard output for node N59. With the required reinforced we needed additional shear reinforcement but with the provided reinforcement set above no need for shear reinforcement:

Punct Linear ca Combinat Extreme: Selection: Summar	lculation ion: ULS Node : N59	lesign										
Name Case		Punching case	Punching shape	UCvRd,ma [-]	× UCvr [-]	rein	Shear forcement erimeters	UCvRd,cs [-]	UC As [-]	UC [-] heck	
N59	ULS/1	Internal column	Circle (400)	0.3	36 0.	83 not r		-	-	0.0 Ol	83	
Concrete												
Name	Case	Punching case	Punching shape	Vεd [kN] β [-]	M _{Ed,y} [kNm] M _{Ed,z} [kNm]	Plate h [mm]	Material f _{ed} [MPa]	d _{eff} [mm] ρι [%]	u₀ [m] uı [m]	V Ed, u0 [MPa] V Ed, u1 [MPa]	V _{Rd,max} [MPa] V _{Rd,c} [MPa]	UC _{vRd,max} [-] UC _{vRd,c} [-]
N59	ULS/1	Internal column	Circle (400)	252.59 1.15	25.08	Ceiling 200.00	C30/37 20.00	154.00 0.87	1.257 3.192	1.50 0.59		0.36 0.83

We can see that $V_{Ed,u1} = 0.59 \text{ MPa} < V_{Rd,c} = 0.71 \text{ MPa}$ so the shear capacity without reinforcement is sufficient. The control parameter is now displayed in Green colour instead of blue.

Unity check is Not OK: control perimeter in red



Change the Type of Result to Load Case LL1 and display the result for node N59:

Control perimeter is now displayed in red and the UC = 1.48 > 1.

Take a look at the Standard Output:

Punching design

Linear calculation Load case: LL1 Extreme: Node Selection: N59 Summary

Name	Case	Punching case	Punching shape	UC _{vRd,max} [-]	UC _{vRd,c} [-]	Shear reinforcement perimeters	UC _{vRd,cs} [-]	UC Asw,det [-]	UC [-] Check
N59	LL1	Internal column	Circle (400)	0.95	2.22	7x 26Ø8(radial) 70+6x110=730	1.48	0.97	1.48 NOT OK

Concrete

Name	Case	Punching case	Punching shape	β		h	Material f _{ed} [MPa]	ρι	Uı	[MPa] VEd,u1	[MPa] V Rd,c	UC _{vRd,max} [-] UC _{vRd,c} [-]
N59	LL1	Internal	Circle (400)	675.93	[kNm] 66.83	Ceiling	C30/37	[%] 154.00		[MPa] 4.02	[MPa] 4.22	0.95
		column		1.15	5.06	200.00	20.00	0.87	3.192	1.58	0.71	2.22

Reinforcement

Name	Case	Shear reinforcement perimeters	U _{out} [m] a _{out} [mm]	Տ _{էս1} [mm] Տ _{էօսt} [mm]	Control perimeters (distance/capacity)	Material f _{ywd,ef} [MPa]	A _{sw,req} [mm ²] A _{sw1,min} [mm ²]	A _{sw} [mm ²] A _{sw,tot} [mm ²]	V _{Rd,cs} [MPa] k _{max} v _{rd,c} [MPa]	UC _{vRd,cs} [-] UC _{Asw,det} [-]
N59	LL1	7x 26Ø8(radial) 70+6x110=730	7.086 929		308/148%, 616/92%, 924/67%	B 500B 288.5	850 14	1307 9148	2.15 1.07	1.48 0.97

We can also show the errors and warning in the output by checking this option in the properties window:

Properties	4 ×	Punchi	ing design							_					
Punching design (1)	- Va V/ /	Values:	ŬC 🕺	17	~	ż			N	55					
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Extreme						[mm]	[mm]				[mm ²]	[mm ²]	[MPa]	[-]	
Extreme	Node 👻		N59	LL1	9x 33Ø8(radial)	8.960	99	320/183%,	640/113%,	B 500B	974	1659	2.25	1.83	
Values	UC 🔹				80+8x120=1040	1228	236	960/82%,	1280/64%	290.0	17	14929	0.81	1.00	
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