

# Example 9

# Integrated example of Flat Plates





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# **FLAT PLATES - EXAMPLE**

The following example analyses the following operator. It is the same vector that is analyzed in the CSI Safe 2014 tutorial, and the reason for this choice is to draw useful conclusions from the comparison of the results.



# 1. Simulation process

1. The process starts by creating a New Project and naming the file.



2. Then we set the levels. At the level where the Flat Plate will be defined, we turn off the diaphragm mode and select how to connect the nodes of the columns to the surface grid.

Ηλο στόθμη Επεξεργασία Διαγραφή Παράλληλη μεται Υ Ενημέρωση	Очорон         Полкалку           Учеретро (cm)         300         -         0           Епачапроворраф         +         0         -	προσθήκη Επιπέδων iς 0 Προσθήκη
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At the bottom of the window there is a choice of the way of connecting the nodes of the columns with the surface grid, for the selected level, we choose the connection with tie rods and with the nodes of the surface grid. At the end we press Update.



3. The floor plan of the model we will simulate is described in the following image

4. We activate Level 1 and insert the columns and beams using the modeling commands and with dimensions as shown in the following pictures:



▲ For the core we choose the composite cross-section simulation because of its large dimensions. We use cross-sections of rectangular poles, which we will then join with rigid rods to give the rigidity of the element.



#### Level 1



5. With Copy-Paste Level we copy to Level 0 and delete the beams.



6. The next step involves defining and creating the surface mesh that defines the flat plate.





and with the command Outer Boundary we define the outline of the grid. The definition of the outline can be set automatically, simply by selecting one of the lines that define it and right-clicking.

Prerequisites:

- the contour shall be closed and free of ramifications; and
- the external columns are excluded from this.

We should therefore define an outer boundary like the one depicted in the figure with an orange solid line.

The outer boundary of the hole in the centre will be defined later as the Hole.



#### NOTES!!!!

To draw the outer boundary we can make use of Scada's draw and drag commands and the Edit



Layers that allows us to manage Layers by making them Invisible and Uneditable for ease of design.

Επεξεργασία Στρώσεων					×
Εργασίας Γραμμές, Η	(ύκλοι				Επίπεδα ΧΖ - Οροφοι
Νέο Γραμμές, Κά	ύκλοι				Update
Αριθμός	Орато̀	Επεξεργάσιμο	Χρώμα	^	Επιλογή όλων
Γραμμές, Κύκλοι Υπ/τα Σκυροδέματος Μανδύες Σκυροδέματος	0 *	 	2 10		Αποεπιλογή όλων
Δοκοί Σκυροδέματος	*	<b>≙</b>	31		Ορατό
Πεδιλοδοκοί Συνδετήριοι Δοκοί	<del>泰</del> 泰	<b>≙</b>	37 38		Μη ορατό
Πέδιλα	*	<b>≙</b>	12		Επεξεργάσιμο
Μεταλλικά Υπ/τα Μεταλλικές Δοκοί	*	₽ ₽	34 34	~	Μη Επεξεργάσιμο
Διαγραφή Δεδομένων					
Μοντέλο Συνολικά Βάσει	επιπέδου XZ	Βάσει Στρώσης	Móvo I	Μοντέλ	o OK Cancel

Another way is to import an auxiliary file with the drawing of the outer boundary and use the Layers command to the conversion of its lines to Scada lines.





#### ATTENTION!!!!

**NOTE:** In cases where there are beams at the boundary of the slab, we must ensure that the surface elements of the slab are connected to the members of the perimeter beams.

Therefore:

the outer limit of the plate shall <u>coincide</u> with the axis of the beam,



after creating the mesh and the mathematical model, the command that breaks the members of the beams and connects them to the elements that grid.





Select the command and left-click on one of the contour lines. Right click and the dialog box for defining the subgrid appears.



In case the perimeter at any point not closed, an **X** will appear on the screen at that point.

We select the Holes command and show the outline of the hole in a manner similar to the outer boundary, left click on a line and right click to complete.



Having completed the definition of the shape and properties of the mesh, the next step is to calculate it. We select the command and the list of subgrids appears in the dialog box that opens. In this particular example there is a subgrid S1. The number inside the brackets (1) indicates the number of holes defined for this grid.

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However, in addition to the central hole, there should also be holes in the position of the inner posts. These holes are automatically created by selecting the command

Δημιουργία Οπών στις θέσεις των Στύλων

and their number is added to the value in brackets.

The Υπολογισμός command is used to calculate the grid.





The modelling is completed with the creation of the Mathematical



#### NOTE:

A Immediately after creating the surface mathematical model, always remember to open the "Grid Group Calculation" window and press "Auto".

1 FlatSlat	))		~		Yn	okoyo	σμός	\$ 1 C	
Αριθμός	Ορατά	Χρώμα σ		A	ναγή	Фор	άς	Auto	

> After the **Modeling**, the **Load Import**, the **Analysis** and the creation of the **Combinations** follow as usual.

# 2. Loads

We load the plate with Permanent (1.44KN/m2) and Mobile (2.39KN/m2) loads. The value of the permanent that we define by entering the loads does not include the same weight.

This is why we choose the Same Weight on the Permanent in the Load Determination.

Ιδιον Βά	ρος	Κινητά Φορτία	<ul> <li>Εισαγω</li> </ul>
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and with a window across hile (2.39KN/m2) as stresses on the Plates.

the floor plan. We enter Permanent (1.44KN/m2) and Mobile (2.39KN/m2) as stresses on the Plates.

Load Property		
Load Type	Load Kind	
Plate $\vee$	Pressure	$\sim$

# 3. Analysis

We create a Static Analysis script and run a simple static analysis.

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Βασικό Μοντελοποίηση Εμφάνιση	Stiffness Matrix BANDWIDTH
Static (2)	Elapsed Time
Νέο Ένεργό Σενάριο Εκτέλεσε	Reading Input Data
Σενάρια	Creating Block
Asônusya Envou	Decomposing Block
	Vector Assembly
	Writting Output
-Θ Κύκλοι	Εκτέλεση Stop Εxit

Then, we create the combination 1,20G+1,60Q in the combination field and enter it.

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# 4. Results

In the **Results** field we can read the values of the different sizes either by means of the colour display or by reading the values of the selected size within the surface of the surface element, by activating the Values in the lower horizontal bar.



As well as the value of the isovalue on them





In the Dimensioning field is the Flat Plates command and the necessary subcommands to solve them.

So after calculating the combinations, we select the command and follow the procedure below:



### 5.1 Parameters

	Παράμετροι διαστά	ασιολόγησης Flat Slab	×
NUT	Layer		
	Flat	Flat Slab	$\sim$
	Drop Panel	Drop Panel	$\sim$
	Support Line xx	Support Line xx	$\sim$
	Support Line zz	Support Line zz	$\sim$
		OK Cancel	

In the dialog box you set the correspondence of the Layers.

Εργασίας Γραμμές, Η	Κύκλοι				Επίπεδα ΧΖ - Οροφοι
Néo Flat Slab					Update
Αριθμός Ξύλινοι Μετωπικοί	Ορατό <mark>Φ</mark>	Επεξεργάσιμο 🗗	Χρώμα	^	Επιλογή όλων
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lat Slab	Q	≣	8		Μη ορατό
)rop Panel	Ø	<b>₽</b>	8		
Support Line xx	Ø	<b>₽</b>	8		Επεξεργάσιμο
Support Line zz	Ø	<b>₽</b>	8		Μη Επεξεογάσιμο
ιαγραφή Δεδομένων				•	uni cueseri dolho

Scada's default list of Layers includes the layers related to the Flat Plates.

In the "Flat Slab" layer we transfer the outline of the floor plan (including the external columns) and assign it to the "Flat" layer.

Draw the outline of the floor plan with lines.

To transfer the contour lines from the "Lines-Circles" layer to the "Flat Slab" layer,

- Freeze all Layers, except "Lines-Circles"
- Select the Multiple Options command
- Left-click to select all the lines of the floor plan contour
- Right click to complete
- In the dialog box, in the Design, we change the Layer to "Flat Slab"

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	Ξαλινε Αντιαν Κατακόρωφα	
	The Steel	
	Drop Panel	
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- ▲ For more convenience we can select the "Flat Slab" layer from the beginning, immediately after selecting the Line or Polyline command, so that the outline belongs to the correct layer without having to be moved.
- Similarly, in the "Drop Panel" layer drag the Lines that define area around the poles, where you will increase the thickness of the slab locally.

"Drop Panels" are optionally inserted around the pillars of the slab relieving it of shear stress.



 In the same way, in the Layers "Support Lines xx" and "Support Lines zz" you transfer the Lines that define the Support Lines.

These are lines that enter in both X and Z directions between successive points on the plate. They usually connect pillar nodes and end at the contour of the slab.

# § Instructions for the introduction of support lines on flat slabs

- 1. The support lines should start from a support column and end in a support (or free end). In all cases they must include at least one support.
- 2. The support line should only reach the contour of the plate when it is free edge. Otherwise it may stop at the contour or at the node of the column.
- 3. When the boundary conditions (i.e. what is to the right and left of the support line) change along the line, the line must break at these points.



Drop Panels and Support Lines

Based on the Support Lines you define, the corresponding Loading Lanes will be created (design strips).

# 5.2 Calculation of Loading Lanes



According to Annex I of EC2 the flat plate is divided into Loading Lanes. These are areas automatically created by the program on either side of the Support Lines, according to Figure I.1 of EC2.

You select the Calculate Load Strips command and the program automatically creates them. Each Loading Strip is divided into sections along its length perpendicular to the Support Line. In each section Scada integrates the internal forces of the finite surface elements of the intersecting sections. From this integration the bending moment about the axis of the section is obtained. This intensive quantity is used to calculate the reinforcement in each individual section.

# 5.3 Display X, Z



You choose to display the Charge Strips in both directions to display them.



Loading strips along the X-axis



Loading strips along the Zaxis

# 5.4 Diagrams X, Z



# § Comparison with the results of CSI Safe 2014

By creating the same loading strips in the corresponding Safe vector (Design Strip Objects - where only Column Strips must be defined to match the definition adopted in Scada) the following moment diagrams are obtained. The relevance between the two programs is evident.





Looking in more detail at the loading strips 14-15 along the X-axis (the numbering is shown in the previous figure), we see that Safe's diagram gives a maximum value at facet 14 equal to 254.3348 kNm.



The corresponding value calculated by Scada Pro is equal to 245.990 kNm, i.e. the difference between the values is in the order of 3% (value found from the scades\_FlatSlab folder of the study, file L\_14.txt).

## 5.5 Results

Αποτελέσματα

The Results command opens the results file from within the Report.

Each page is for one Charging Lane.

First, the characteristics of the Strip are described.

							Page : 1
Description	Value	Units	Code	Description	Value	Units	Code
Floor	1			Starting point	corner	column	9.4.1&2
# of strip	1			Drop panel	Y	es	
Orientation	x-x			Thickness	182.88	(cm)	
Length	815.48	(cm)		Width		(cm)	
Concrete	C20/25			Finishing point	internal	column	9.4.1&2
É*	20	(MPa)	Table 3.1	Drop panel	Y	es	
£m	2.20	(MPa)	Table 3.1	Thickness	182.88	(cm)	
Steel	S400s			Width		(cm)	
f <sub>vk</sub>	400	(MPa)		Minimum reinforcement			
Cover	20	(mm)		Tension reinf.	0.00145	(cm <sup>2</sup> /m)	9.2.1.1(1)
Slab thickness	0.25	(cm)		Compression reinf. (% of span reinf.)	25	%	9.3.1.2

Then the results of the upper and lower arming are shown in detail for each zone, dividing them into sub-zones.

- Left-Right -> red zone
- L-C R-C-> blue belt
- Center-> blue zone



			Analysis	orcomon	•			Top		
		202.0		Results al	iu Kein	orcement		төр		
	м	205.0	Cffi (Lstart)	•		м	407.74	Cfff (Lcentre)	•	
Zone	(kNm)	(cm)	(cm <sup>2</sup> /m)	A <sub>e,prvd</sub> (cm²/m)	Φ/s	(kNm)	(cm)	A <sub>srqd</sub> (cm²/m)	A <sub>s.grvd</sub> (cm²/m)	Φ/s
Left		400.0		3.246	8/15		401.1		0.812	8/20
L-C		400.0		3.246	8/15		85.3		1.763	8/20
Center	-80.283	46.0	27.271	27.271	14/5		170.5		6.818	8/7
R-C							85.3		2.043	8/20
Right							103.8		1.471	8/20
		203.8	7 cm (L <sub>end</sub> )			ן				
Zone	M (kNm)	Width (cm)	A <sub>s.rqd</sub> (cm <sup>2</sup> /m)	A <sub>e,grvd</sub> (cm²/m)	Ф/s					
Left	-88.070	401.1	2.873	3.246	8/15					
L-C	-44.824	85.3	7.054	7.054	8/7					
Center	-152.524	170.5	12.422	12.422	10/6					
R-C	-51.588	85.3	8.172	8.172	8/6					
Right	-45.848	103.8	5.886	5.886	8/8	]				
			Analysis	Results ar	nd Reint	forcement			Bot	tom
		203.8	7 cm (L <sub>start</sub> )				407.74	cm (L <sub>centre</sub> )		
Zone	M (kNm)	Width (cm)	A <sub>srqd</sub> (cm <sup>2</sup> /m)	A <sub>e,grvd</sub> (cm²/m)	Φ/s	M (kNm)	Width (cm)	A <sub>s.rqd</sub> (cm <sup>2</sup> /m)	A <sub>a,grvd</sub> (cm <sup>2</sup> /m)	Φ/s
Left	9.207	400.0	0.294	0.812	8/20	70.543	401.1	2.293	3.246	8/15
L-C	9.207	400.0	0.294	0.844	8/20	21.929	85.3	3.377	3.377	8/14
Center	80.591	46.0	27.408	27.408	14/5	43.857	170.5	3.377	3.377	8/14
R-C						21.929	85.3	3.377	3.377	8/14
Right						25.982	103.8	3.284	3.284	8/15
		203.8	7 cm (L <sub>ent</sub> )			]				
Zone	M (kNm)	Width (cm)	A <sub>s.rqd</sub> (cm <sup>2</sup> /m)	A <sub>e,prvd</sub> (cm²/m)	Φ/s					
Left	17.335	401.1	0.555	0.812	8/20					
L-C	6.505	85.3	0.984	0.984	8/20					
Center	23.135	170.5	1.762	1.762	8/20					
R-C	3.583	85.3	0.539	0.844	8/20					
Right	3.311	103.8	0.409	0.821	8/20					
						-				

# 6. Perforation



The perforation test can be performed selectively for each pole or overall on all poles in the plan view.

#### 6.1 Selectively



Select the command Selectively, left-click to point to the node of a pole and right-click to open the dialog box where you will set all the necessary parameters.

- In this example, we select the node of an Inner Pillar, node 40.
- The following clarifications are given for the other positions of the poles in relation to the perimeter of the plate.



Κόμβος Ελέ	ухои	Συνδυ	οσμοί											
40		Συνδυ	ασμοί	•	ΔN(kN)	626.50	ο Δ	My(kN	m)	34.283	<sup>3,</sup> ∆M	lz(kNm	n) 7	6.143
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Υλικό (MPa	)							Περι	γράμ	ιμα <mark>τ</mark> α Ο	ρόφο	ov		
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Αυτόματη	N.		c1(cm)	46	c2(cm]	46.00	)	Aut	όματ	η	•	ax O		ay O
Στοιχεία Πλ	άκας					Οπλισ	µoi							
Ταχος	Αυτόματη		t(cm)	40.6	54		Au	τόματ	n	•	EĘ,	ωтερικ	κός	X 🔻
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			κάτω(cm)	2		Ανω Κάτω	Φ	10	1	15	Φ	10	1	15
Συντελεστή	ις β	0	πλιση	_				(Y	πολα	ινισμός				
Αυτόματο	ς προσε 🔻	Tú	πος [/	Ακτινα	λπή 			A	ιοτε/	ιέσματα			C	Ж
β	1.15	-	Ιληθος ακτι	νων	0		6.						Car	rel

κόμβος Ελέγχου The number of the selected node is automatically filled in and is not editable.

40 Συνδυασμοί							
Συνδυασμοί	-	ΔN(kN)	626.50	ΔMy(kNm)	34.283	ΔMz(kNm)	76,143
Συνδυασμοί Χρήστη				Κατανεμημά	ένο Φορτί	o.(kN/m2)	0

In the Combinations field:

- The Combinations option, makes the program automatically find the combination that results in the worst Axial Dn, and displays its value along with the corresponding moments.
- The User option, allows to set user values for axial and moments in the respective fields, as well as to set a distributed load

Κατανεμημένο	50	which works by "relieving" the plate at that point, resulting
in a reduced calculation	cutting	force compared to the original one.

Αρχική τέμνουσα (V <sub>Εά,αρχ.</sub> )	626.5	(kN)
Κατανεμημένο φορτίο (p)	50.0	(kN/m <sup>2</sup> )
Απομειωμένη τέμνουσα (V <sub>Ed,τελ.</sub> )	478.8	(kN)

In this example we have considered only one combination 1,20G+1,60Q and therefore the values of the intensities are derived from it.

Y	λικά (MPa)					
	Αυτόματη	$\sim$	fck	20	fyk	400
-0	Αυτόματη Χρήστη					

In the Material field the coefficients fck and fyk are filled in automatically with the Automatic option or defined by the user with the User option.

Περιγράμματα Ορόφων		In Floor Cor	ntours you select the Layer that	contains the
Flat Slab	~	outline of tl	he slab including the columns th	at are in the
Μαθηματικό Μοντέλο Μαθηματικό Επιφανειακό Πλέγμα 3D Πλέγμα 2D Πλάκες-Τομές Μεταλ.Υποστυλώματα Μεταλ.Δοκοί Μεταλ.Κεφαλοδοκοί Μεταλ.Τεγίδες Μεταλ.Μετωπικοί Μεταλ.Μετωπικοί Μεταλ.Αντιαν.Οριζοντια Μεταλ.Αντιαν.Κατακόρυφα		outline. So we select lines that de	efine the overall outline of the sla	is exactly the b.
Ξύλινα Υποστυλώματα Ξύλινες Δοκοί Ξύλινες Κεφαλοδοκοί Ξύλινες Τεγίδες Ξύλινες Μηκίδες Ξύλινοι Μετωπικοί Ξύλινα Αντιαν.Οριζοντια Ξύλινα Αντιαν.Κατακόρυφα Flat Slab Drop Panel Support Line xx Support Line zz perigramma				
Φορτιζόμενη επιφάνεια Αυτόματη <ul> <li>C1(cm)</li> <li>Αυτόματη</li> <li>Ορθογωνικη</li> <li>Κυκλική</li> </ul>	46	c2(cm) 46.00(	The Loadable Area is defin equivalent surface area of the s	ned as the elected pole.

Select:

- Automatic so that the program can calculate the surface area of any type of column by reducing it to an equivalent rectangular one and calculating the corresponding dimensions c1 and c2.
- Rectangular so that the user can define his own dimensions c1 and c2 to calculate the loaded rectangular surface
- Circular in order to calculate a circular loading area of diameter equal to the value c1 to be specified by the user

Θέση φορτιζόμενης	επιφάνειας
Αυτόματη 🗸 🗸	ax 0 ay 0
Αυτόματη	
Εσωτερικό	
Πλευρικό 1	
Πλευρικό 2	
Πλευρικό 3	
Πλευρικό 4	
Εξεχουσα 1	
Εξεχουσα 2	
Εξεχουσα 3	
Εξεχουσα 4	
Εισεχουσα 1	
Εισεχουσα 2	
Εισεχουσα 3	
Εισεχουσα 4	

The Load Surface Position can be set either automatically or selectively. It depends on the contour of the plate and the position of the selected post on it. The proposed positions are:

- Internal
- Lateral in 4 directions
- Prominent in the 4 directions
- Incoming in 4 directions

Select the position of the selected pole and set the distances from the perimeter ax and ay (except the inner) according to the following figures:



INTERNAL











**EXECUTIVE 1** 

**EXPERIENCE 2** 







**REGISTRANT 2** 



**INCOMING 4** 

**REGISTERED 3** 

- Στοιχεία Πλ	άκος		
Παχος	Αυτόματη 🔻	t(cm)	40.64
Επικάλυψη	Αυτόματη 🔻	avω(cm)	2
		κάτω(cm)	2



The Thickness and Coating of the panel are either taken into account automatically or modified by the User by selecting the corresponding option and defining the corresponding values for the thickness and coating of the upper and lower panel (here the thickness of the drop panel is taken).

In the Reinforcements field, the longitudinal reinforcement resulting from the calculation of the Flat Plates in the area of the selected column is specified.

With the Automatic selection the longitudinal reinforcement is taken into account:

- Upper for positive (+DN) (e.g. top floor slab)

- Down for DN negative (-DN) (e.g. foundation)

The External X or Y option determines the direction of the external reinforcement in the longitudinal reinforcement grid the slab (either upper or lower grid).

Σ	Ευντελεσ	τής β	
	Αυτόμα	гос проо: 🖂	Αυτόματος προσεγγις
	β	1.15	Αυτοματος θεωρητικα Χρήστη

The Coefficient b for the calculation of Perforation can be calculated automatically in two ways:

- Automatic approximate or
- Automatic theorist.

The Approximate mode is a function of the position of the loaded surface and ax, ay.
 The Theoretical mode is a function of Torques My, Mz.

The User option allows you to enter any value for Coefficient b.

Οπλιση	
Τύπος	Ακτινωτή 🗸
Πλήθος ακ	Ακτινωτή Σταυροειδής
τεταρτημά	οιο

Finally, in the Arborization field you define the type of arrangement of the perforation reinforcement by choosing between Radial and Cruciform.

For the Radial array you also set the Number of rays per quadrant. The figure below shows a quadrant of the radial array in the black

box. The initial perimeter has 3 reinforcement spans, while the third perimeter is thickened to 5 spans due to constraints on the spacing between reinforcement strands. ScadaPro automatically checks whether the spacing constraints are met on the first perimeter and increases the number of reinforcement spars where required (even on the first perimeter if the number of spars selected by the user is not sufficient).



Υπολογισμός The Calculate command performs all the necessary checks on perforation, taking into account all the above parameters.

Αποτελέσματα The Results command displays the results file:

Data: list of all data specified in the previous window and required for the perforation test.

					Page : 1				
Δεδομένα									
Περιγραφή	Tun	Moved free	Περιγραφή	Τιμή	Movedag				
Οροφος.	1		Euvreitentric (B) (EC2-6.4.3)	1.150	1010100				
# του κάμβου	40		Πέχος πλάκας	40.6	(010)				
Συνδοασμός	1		Επικάλυψη απλιομού	2.0	(011)				
Αρχική τέμνουσα (V <sub>BLUE</sub> )	626.5	040	Διάμττρος εξωτερικού	10	(mm)				
Καταγεμημένο φορτίο (p)	0.0	(khi/m²)	quantury payahon						
Απομεκομένη τέμνουσε (Vεετιλ)	626.5	040	Απόσιεση εξωτ. διεμήκη οπλ.	15.0	ECHO)				
Kayman Ponn (M.)	34.3	(kNm)	Διάμετρος εσωτερικού	-10	Innell				
Kaymish Ponh (M)	76.1	(kblm)	διαμήκη οπλισμού	100	fund.				
Σχήμα φορηξόμενης περιοχής	OpBoyumen	1.00	Απόσταση εσωτερικού	145.0	1 friends				
Millioc to (cané nov áčova x)	46.0	ýcm).	διαμήκη υπλιαμού	12.0	(00)				
Μέχιος ε <sub>2</sub> (κατά τον άξεινα γ)	46.0	icm)	Emplofique (L)	20.0	(MPa)				
Διάμετρος c		(cm)	Χάλυβας (f <sub>a</sub> )	400.0	MP <sub>40</sub>				
Θέση φορηζόμενης περιοχής	Eckotspecie		Διάταξη απλισμού	Activate					
Απόστοση πλάκος κατά x (a,)		(cm)	Αριάμ γραμμών οπλισμού						
Απάσταση πλάκας κατά γ (Α,)		Jerro .	ανά τεταρηγεόρια:						

**Schematic arrangement of perforation reinforcement**: according to the predefined parameters and if a requirement for perforation reinforcement arises.

▲ In this example there is no reinforcement requirement in perforation and as a result no schematic reinforcement layout is shown (the figure below includes a random radial layout with two reinforcement perimeters).



The **results of** the **audits** include two audits.

If the 1<sup>th</sup> check shows *Adequacy*, then the 2<sup>th</sup> check determines the requirement or not of the perforation reinforcement.

				444			Page : 2		
		Ar	τοτελέσμα	τα ελέγχων			197		
Περιγραφή	Τιμή	Maxáðer	EC2	Περιγραφή	Τιμή	Μονάδος	EC2		
Ενεργό πάχος πλάκας (d)	37.6	(cm)	(eq6.32)	Βασική περέμετρος	657.0	- fromb	1646 151		
Περίμετρος φορτιζόμενης περιοχής (u <sub>c</sub> )	184.0	(cm)	(eq6.53)	ελέγχου (u.) Διαιμητική τάση στην	6 201	(Leng)	(1990.33)		
Διατμητική τέση στην περίμετρο οι (Vest)	1.040	(MPa)	(eq5.38)	περίμετρο u <sub>t</sub> (v <sub>ist</sub> .) Διατμητική αντοχή	0.231	(ser a)	(edo.36)		
Μέγιστη διατμητική αυτοχή (ν <sub>αλικώ</sub> )	3.680	(MPa)	(eq5.53)	ιέσπλου σκοροδέματος (Vius)	0.356	(MPa)	(eq5.47)		
					1		Page : 2		
		At	τοτελέσματ	τα ελέγχων					
Περιγραφή	Τιμή	Movóšer,	EC2	Περιγραφή	Τιμή	MovdBac	EC2		
Ενεργό πόχος πλάκος (d)	37.6	(cm)	(eq6.32)	Θασική περίμετρος	657.0	(cm)	18-48 (14)		
Περίμετρος φορτιζόμενης περιοχής (u <sub>1</sub> )	184.0	(cm)	(#q5.53)	ελέγχαιε (u+) Διατμητική τέστη στην	0.272	(MDa)	(mg/r. 15)		
Διαημητική τάση στην	1 320	(MPa)	Land, 300	ntpiptipo u <sub>1</sub> (v <sub>tdr</sub> )	0.372	(101-30)	(#do 20)		
utbittabo nt (serit)	1.000	1000.00	(eds.50)	Διστμητική σντοχή	1/2501	0.0326	somes!		
Μέγιστη διατμητική αντοχή (Veznac)	2.680	(MPa)	(eq5.53)	фоллов акировератос (//eaz)	0.356	(MPa)	(eq6.47)		
				Σταθερά (v <sub>an</sub> )	0.356	(MPa)	(eq6.3)		
$t^{q_i}\delta\lambda e_{X} a_{ij}^* v_{bax} \leq v_{baxes}$	Етаркан			$2^{N_{\rm c}}$ diagonal $v_{\rm Res}$ s $v_{\rm Res}$	Απαιτόται σπλιαμός - προσθήκη οπλισμού διάτρησης - αύξηση διαμήκη οπλισμού πλάκας				

If the 1st <sup>(1st)</sup>check shows *Non-adequacy*, then the 2nd <sup>(2nd)</sup> check is not performed and

						10 1	Page : 2
		At	τοτελέσματι	α ελέγχων			
Περιγραφή	Τιμή	Mavabec	EC2	Περιγραφή	Tigatj	Morófeç	EC2
Ενεργό πάχος πλάκας (d)	37.6	(070	(eq6.32)	Βασική περίμετρος	657.0	Lines .	(Ball 15)
Περίμετρος φορτιζόμενης	195.0	lent	(and 57)	ελέγχου (m)	037.0	Oben A	follor est
περιοχής (με)	104.0	leng	fede 23	Διατμητική τάση στην	1 395	(UPA)	land 385
Διατμητική τόση στην	4 981	(APA)	(and 10)	mepiperpo u, (v <sub>Er</sub> )	1.000	thin of	Seda and
mapiperpo u <sub>1</sub> (v <sub>mp</sub> )	4.001	1542.42	fedti 201	Διατμητική αντοχή		12450.00	
Μέφιστη διατμητική αντοχή (νεμική)	3.680	(MPa)	(eq6.53)	(v <sub>#al</sub> )	0.356	(MPa)	(eq6.47)
	Μη επάρκεια			Σταθερά (Vast)	0.356	(MPa)	(eq6.3)
$f^{e_{i}}$ éleyzoç v <sub>dil</sub> s w <sub>anın</sub>	<ul> <li>αύξης</li> <li>αύξης</li> <li>αύξης</li> <li>χρήσι</li> <li>χρήσι</li> </ul>	νη διαστάσ περιοχής τη πάχους η ανώπερηγ δίωστος	εων φορηζά- πλάκας ; ποιότητας	$2^{46}$ energy of $v_{211} \in w_{421}$			

some interventions are suggested for the plaque.

As mentioned, in the particular example (node 40 shown in the figure below) being solved, the loading level is not such that shear hardening is required. In other words, there is adequacy in the second check as well.



The shear test for this particular column gives a strength-to-strength ratio of 0.291/0.356 = 0.81.

# § Comparison with the results of CSI Safe 2014

The perforation test in Safe 2014 gives the corresponding ratio in the columns (figure below). An adequacy ratio of 0.78 is calculated for the column under consideration. The difference between the two programs is in the order of 4%.

We consider the substructure located two positions below by Z (node 38). For this substructure, Safe calculates an excess of strength (adequacy ratio 1.07) (figure below).



Scada also finds that there is a need for reinforcement for this particular substructure (adequacy ratio 0.394/0.356 = 1.11) and calculates the reinforcement. In detail, the results are as follows:

The first page of the results shows the input data and the arrangement of the reinforcement according to the user's choice. Here a radial arrangement with two reinforcement beams per quadrant was selected.



The second page presents the results of the tests and the details of the arming device.

Reinforcement of diameter  $\Phi$ 14 is calculated and the last table shows the reinforcement in groups of reinforcement lines with a specific number of strands in each line (useful presentation in case prefabrication is chosen).

stud-rail punching shear reinforcement system).

Here 8 lines with two strands each and 4 lines with one strand each are used. In the 8 lines the 2 strands are spaced at a distance equal to the distance  $_{sr}$  of the table (28 cm).

4. H												Page : 2
					Απο	τελέ	έσματα	ελέγχων	97.			
Περιγρα	φή		Τιμή	Mov	άδες	EC	22	Περιγραφή		Τιμή	Μονάδες	EC2
Ενεργό τ	τάχος πλάκαα	ç (d)	37.6	(0	m)	(eq6	3.32)	Βασική πε	ρίμετρος	657.0	(cm)	(fig6 15)
Περίμετρ περιοχής	ος φορτιζόμε ; (u <sub>0</sub> )	νης	184.0	(c	m)	(eq6	5.53)	ελέγχου (ι Διατμητική	μ₁) η τάση στην	0.204	(MDe)	(190.10)
Διατμητικ περίμετρ	κή τάση στην ο u <sub>o</sub> (ν <sub>εα o</sub> )		1.406 (MPa) (ed		(eq6	(6.38) περίμετρο u <sub>1</sub> (v		u <sub>1</sub> (ν <sub>εd,1</sub> ) ι αντοχή	0.394	(IVIPa)	(eqo.36)	
Μέγιστη (v <sub>Rd,max</sub> )	διατμητική αν	/τοχή	3.680	(M	Pa)	(eq6	5.53)	άοπλου σκυροδέματος (v <sub>Rd.c</sub> )		0.356	(MPa)	(eq6.47)
								Σταθερά (	ταθερά (v <sub>min</sub> )		(MPa)	(eq6.3)
1 <sup>α</sup> έλεγχ	ος: $v_{Ed,0} ≤ v_{Rc}$	l,max	Επάρκεια					2 <sup>ος</sup> έλεγχο	$\varsigma$ : $v_{Ed,1} \leq v_{Rd,c}$	Απαιτε - προσ διάτρη - αύξη οπλισι	:ίται οπλισμ σθήκη οπλια ισης ση διαμήκη μού πλάκας	ός: τμού
				Аπ	οτελέσμ	ατο	ι οττλια	τμού διάτ	ρησης			
Περιγρα	φή		Т	μή	Μονάδες		EC2	Περιγραφ	νή	Τιμή	Μονάδες	EC2
Περίμετρ	ος u <sub>out,ef</sub>		73	27.0	(cm)	(e	eq6.54)	Απόσταση	η (d <sub>3</sub> )		(cm)	
Απόστασ	νη 1 <sup>ης</sup> περιμέτ	ιοου						Απόσταση	] (d₄)		(cm)	
οπλισμοι	ύ από φορτιζ	όμενη	1	8.8	(cm)			Γωνία (φ)		90.0	0	
επιφανει Οριακή α 0.3·d ≤ a	πλισμού από φορτιζόμενη πιφάνεια (a) ιριακή απόσταση: .3·d ≤ a ≤ 0.5·d		1	1.3<=	 a<=18.8	(9.4.3)		Εφαπτομε απόσταση σκελών οτ τελευταία	νική των πλ. στην περίμετρο	91.8	(cm)	
περιμέτρ την περίμ	ου οπλισμού μετρο u <sub>outer</sub> (f	από )	5	6.6	(cm)			τελευταία περίμετρο όπλισης (s <sub>t last</sub> ) Οριακή απόσταση:		75.3	(cm)	
Οριακή α 1.5 d	πόσταση: k∘	d =	5	6.5	(cm)	(	6.4.5)	2.0·α Δρώσα τιμ	ιή νί αυτοχής	344.1	(MPa)	
Ακτινική πεοιμέτο	απόσταση τυ ων οπλισμού	VU (S.)	2	8.0	(cm)			οπλ. διάτρ	ρησης (f <sub>ywd,ef</sub> )	544.1	(wir a)	(006 52)
Οριακή ο	πόσταση: 0.3	75∙d	2	8.2	(cm)	(	9.4.3)	Απαιτούμε σκέλους ο	ενη διατομή πλισμού	1.532	(cm <sup>2</sup> )	(640.52)
Εφαπτομ σκελών α περίμετρ	ιενική απόστα οπλισμού στι ο u <sub>1</sub> (s <sub>t1</sub> )	αση τω γν	9	1.8	(cm)			οιατρησης Ελάχιστη σκέλους (/	: (A <sub>sw,1</sub> ) διατομή A <sub>sw,min</sub> )	1.532	(cm <sup>2</sup> )	(eq9.11)
Οριακή α Μήκος (μ	ιπόσταση: 1.( <sub>0</sub> )	5-d	5	6.5 8.1	(cm) (cm)	(	9.4.3)	Διάμετρος που χρησι	σκέλους μοποιείται	14	(mm)	
Απόστασ	τη (d <sub>1</sub> )			9.9	(cm)			Διατομή σ	κέλους που	4 500	4 2	
Απόστας	ση (d <sub>2</sub> )		1	9.9	(cm)			χρησιμοπο	ວເຂົາເຊ	1.539	(cm )	
2				-	Λιάταξη		τλισμο	ύ διάτοησ	inc		1.00	
Ομάδα	Ομάδα Αριθμός Φ γραμμών (mm)		י) /	Αριθμός σκελών ανά γραμμή			Ύψο	Ύψος σκέλους (cm) Γερίμετρος βρίσκεται σκέλος της γ		ς όπου Απόστα το 1° σκέλου γραμμής φορτιζόμ.		αση 1 <sup>∞</sup> ις από επιφάνεια
1	8	14			2			36.6	1		18.	82
2	4	14	2	1				36.6	2		46.	82



The details of the arrangement referring to the drilling reinforcement results are explained in the Memo on the third page below.



The diameter of the reinforcement strands can be reduced if more reinforcement beams per quadrant are selected. For example, if 5 reinforcement spans per quadrant are selected then the following arrangement is proposed, and the table of reinforcement arrangement is as follows, i.e. a group of reinforcement lines with two F8 strands in each line, spaced 28 cm apart.

Διάτοξη οπλισμού διάτρησης								
Ομάδα Αριτμός γρομμών	(mm)	Αριθμός σκελών ανά γραμμή	Ywog andhowg (cm)	Περίμετρος όπου Βρίσκεται το Τ΄ πούλος της γραμιής	Απόσταση τ" σκέλους από φορτίζου, επτφάνεια			
1	20		2	36	1	16.02		
	-							

In the same substructure if the user attempts to increase the level of loading and selects a value for the axial load of 1400 kN (user value)

Διάταξη οπλισμού διάτρησης								
Ομάδο Αριθ γραμ	Αριθμός γραμμών	0 (mm)	Αριθρός σκελών ονά γραμμί	Ύφος ακίλαυς (cm)	Περιμετρος όπου βρίσκεται το 6' σκελος της χραφισής	Απόσταση Τ΄ σείλους από φορηζόμ. επιφάνεια		
.9	12	1E :	5	36.6	1.	18.82		
.2	8	16	3	36.6	3	74.82		

then radial armouring with 3 reinforcement beams per quadrant gives the following results with F16 reinforcement strands (84 reinforcement strands).



Choosing a cruciform arrangement we have arming with  $\Phi$ 16 strands also (80 strands of reinforcement).



The corresponding memo for a cross-shaped arrangement is as follows: