SCADA Pro™
Structural Analysis & Design

Example 8

Simulation and solution Flat Plates

ACE HELLAS
INTEGRATED SOLUTIONS

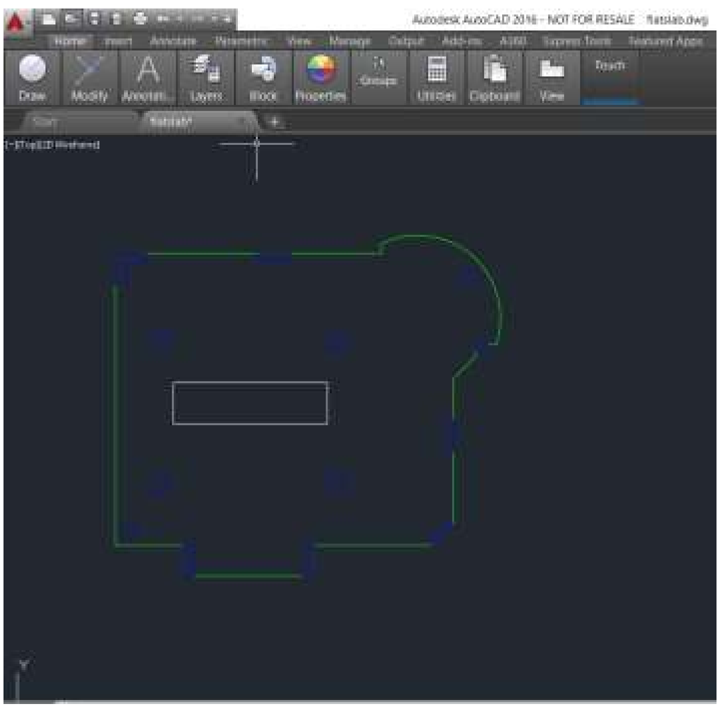
CONTENTS

FLAT PLATES

Flat slabs are slabs that are created in the absence of beams.
These are closed contours simulated with surface finite elements connected to the supporting columns.

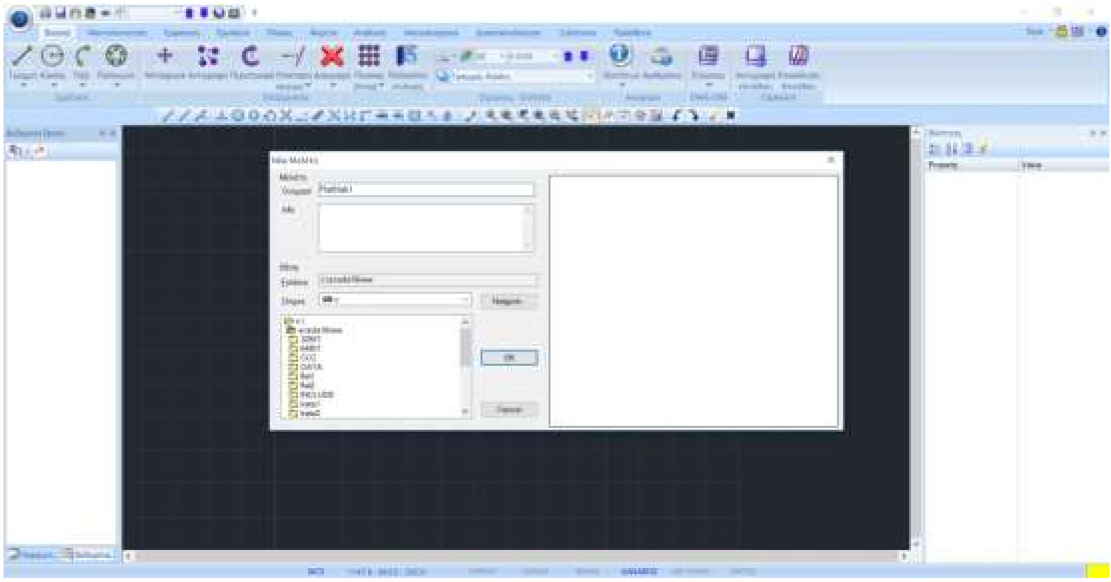
1. Simulation process

Initially we could have created a design file in order to use it as a help file. The basic requirement is that the outlines of the columns should be closed, belong to their own layer and the lines of the outer outline should not pass over them (i.e. they should stop where they meet the line of the column and start again after the column) and they should also belong to their own layer.

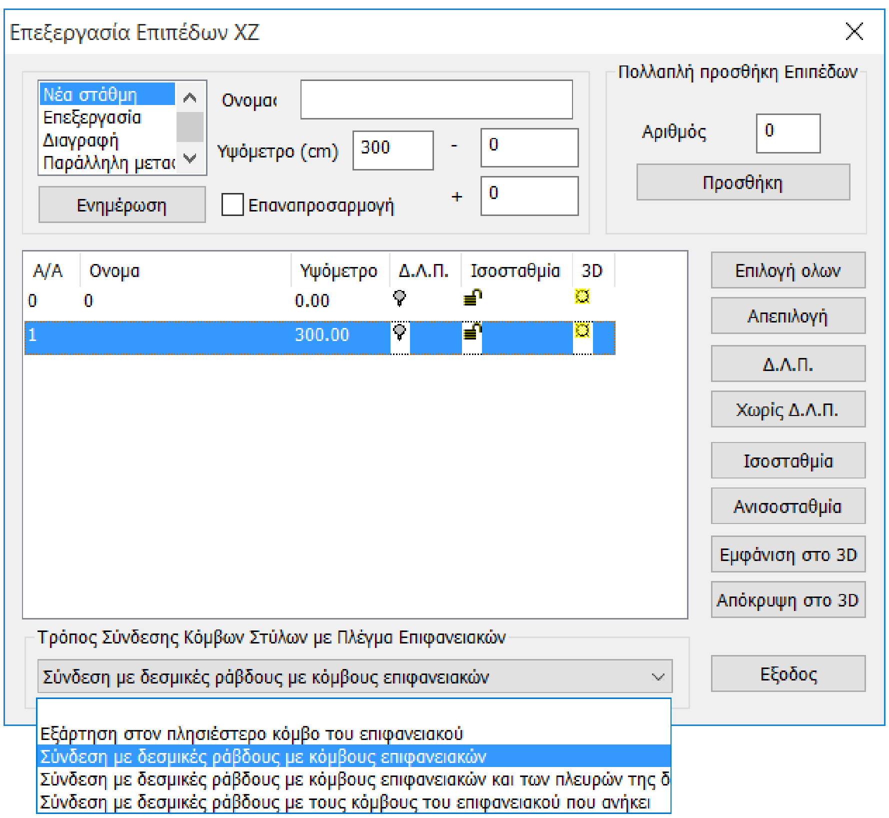


Otherwise we can create the floor plan directly in the Scada environment using the design and modelling commands.

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

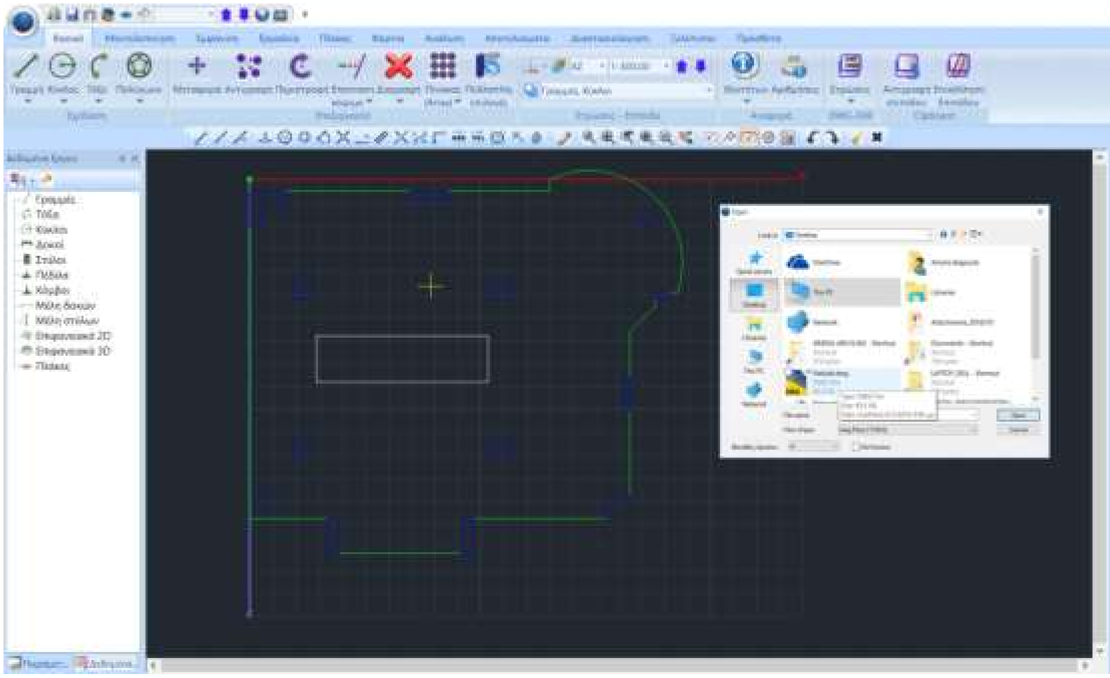


2. Then we set the levels. At the level where the Flat Plate will be defined, we turn off the diaphragm mode and select how to connect the nodes of the columns to the surface grid.

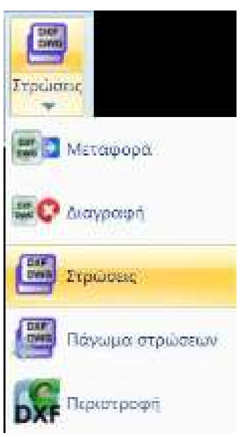


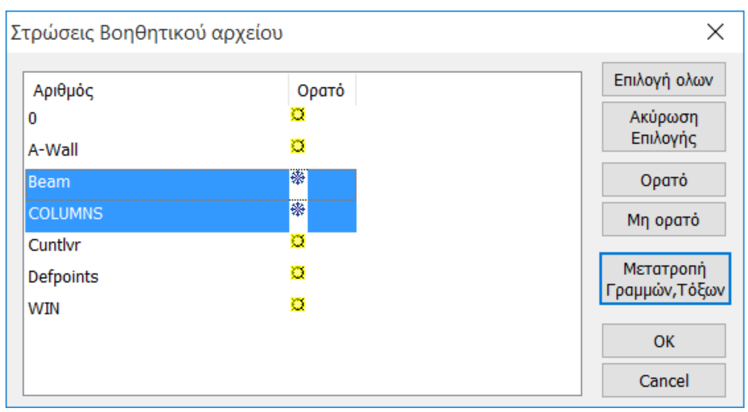
At the bottom of the window there is a choice of the way of connecting the nodes of the columns with the surface grid, for the selected level, we choose the connection with tie rods and with the nodes of the surface grid. At the end we press Update.

3. We activate Level 1 and import the auxiliary file.

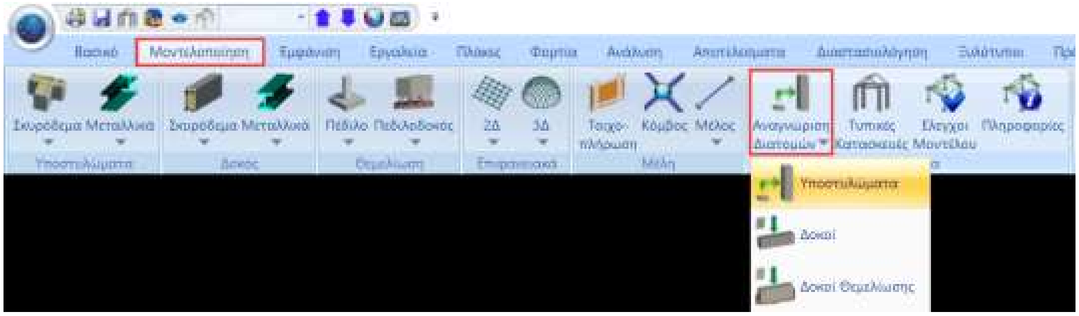


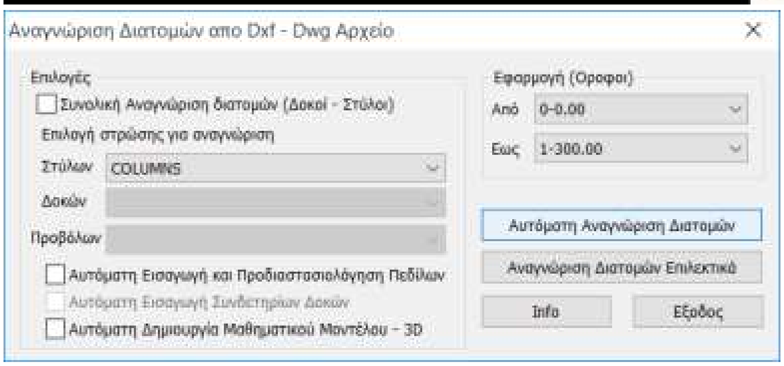
4. With the Layers command we convert the lines of the pillars and the outer contour of the auxiliary to Scada lines.



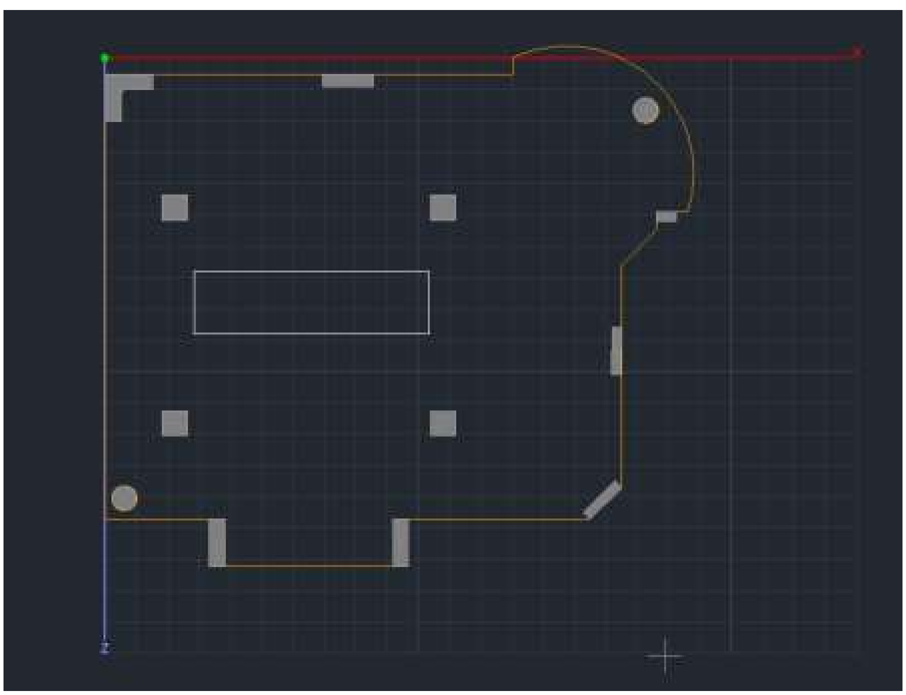


5. With the command Identify Cross-sections Columns

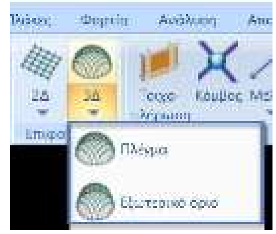




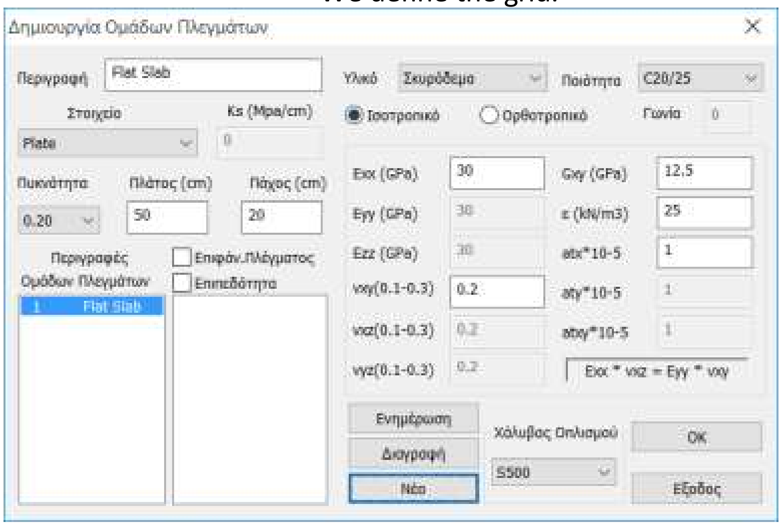
The cross-sections of the poles belonging to the corresponding Layer are automatically identified.



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



We define the grid:



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.

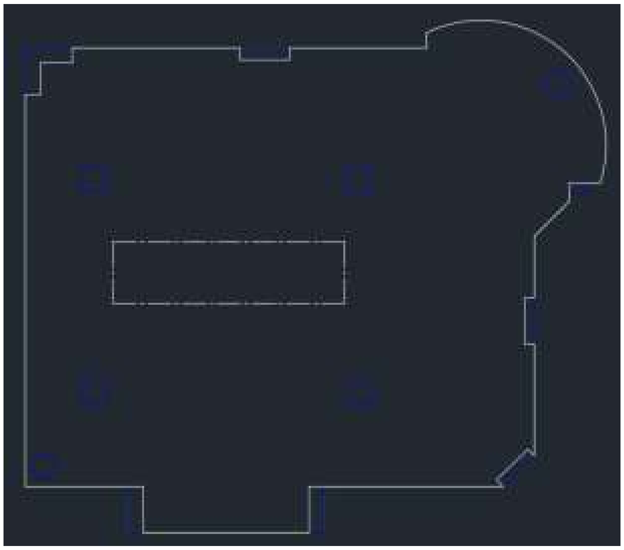
Prerequisites:

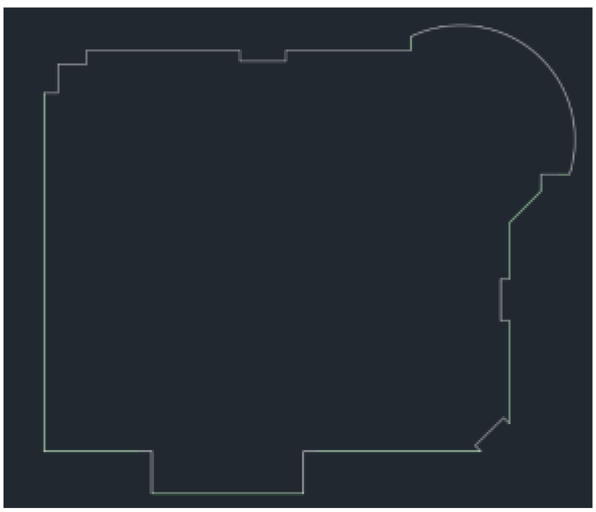
- the contour shall be closed and free of ramifications; and
- the external columns are excluded from this.

We should therefore define an outer boundary like the one depicted in the figure with a white continuous line.

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

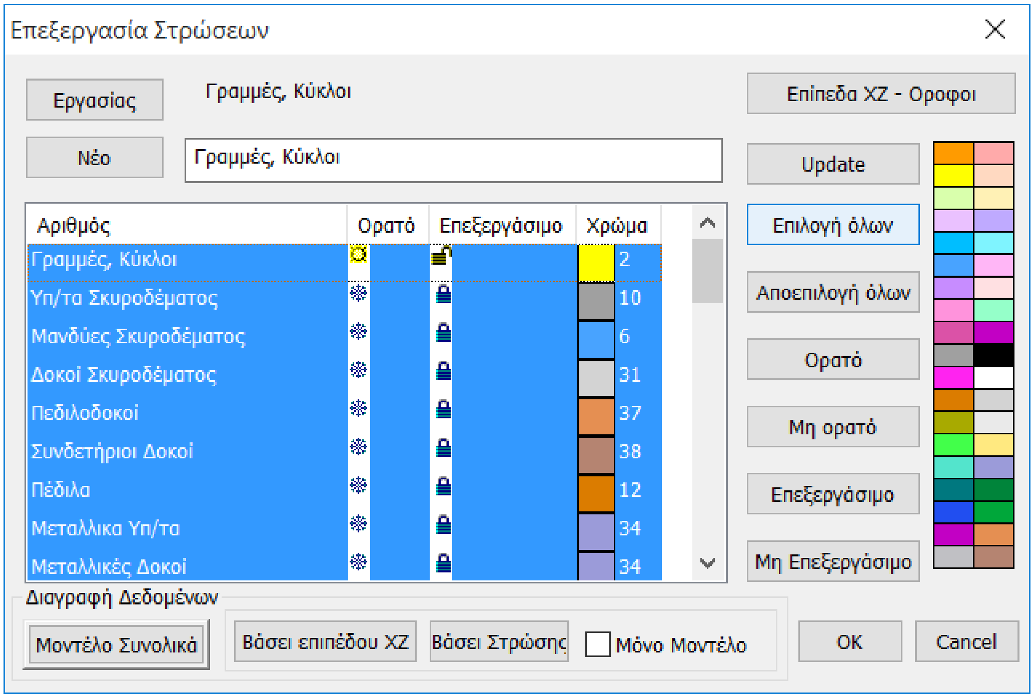
EXAMPLE 8 - FLAT PLATES



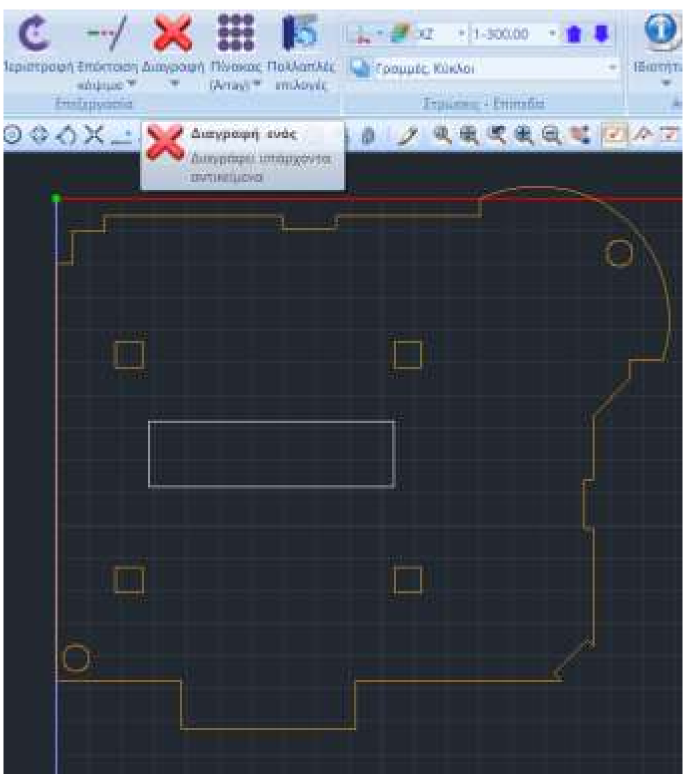


In order to create such a contour in Scada without the lines of the poles that would create unwanted branches we have to follow the following procedure:

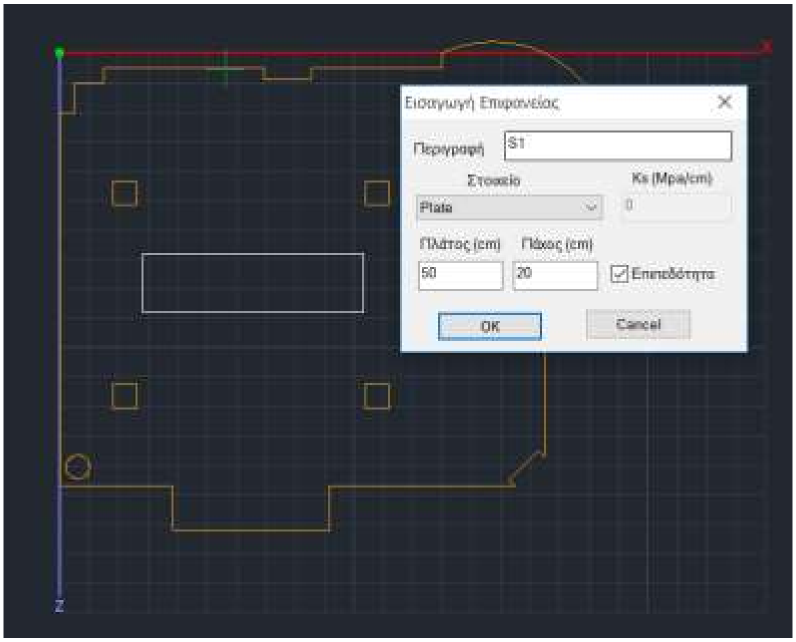
We select from the Basic the Edit Layers and with Select all we make all the layers Layers Not visible and Not editable except "Lines, Circles".



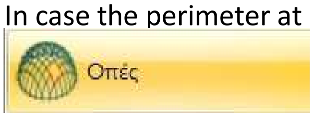
With the Delete command we then delete the lines of the poles that are outside the outline of the plate.



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

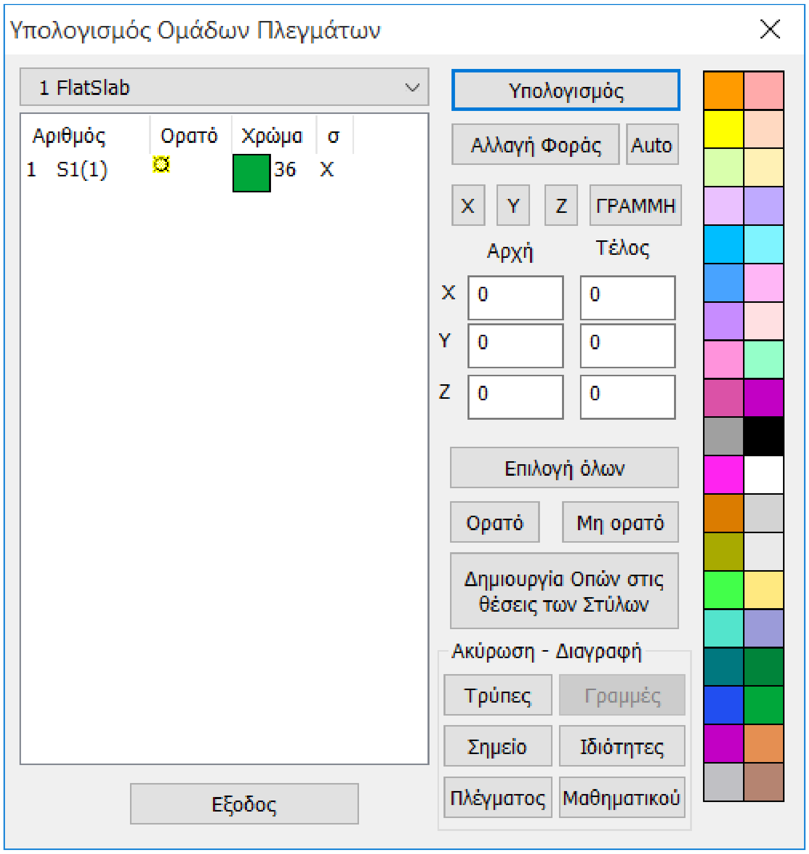


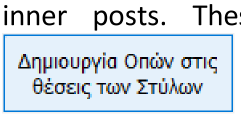
In case the perimeter at any point is not closed, an **X** will appear on the screen at that point.



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.

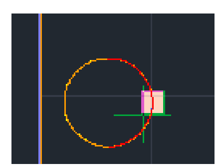


However, in addition to the central hole, there should also be holes in the position of the inner posts. These holes are automatically created by selecting the command 

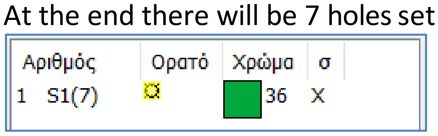
(not in the case of circular sections) and their number is added to the value in brackets.

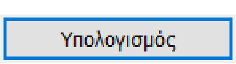
OBSERVATION

⚠ In circular sections the contour is a circle with the same starting and ending point. This creates an inability to find a contour. The solution for these cases is to draw 2 arcs at the boundaries of the circle and use the Hole command to manually define the round holes.

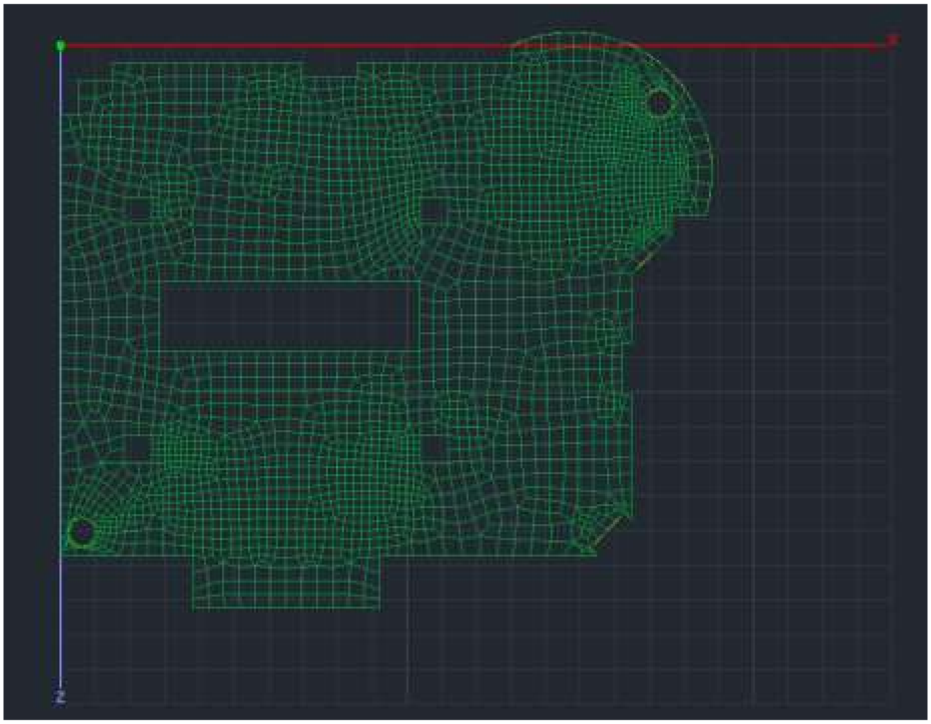


At the end there will be 7 holes set

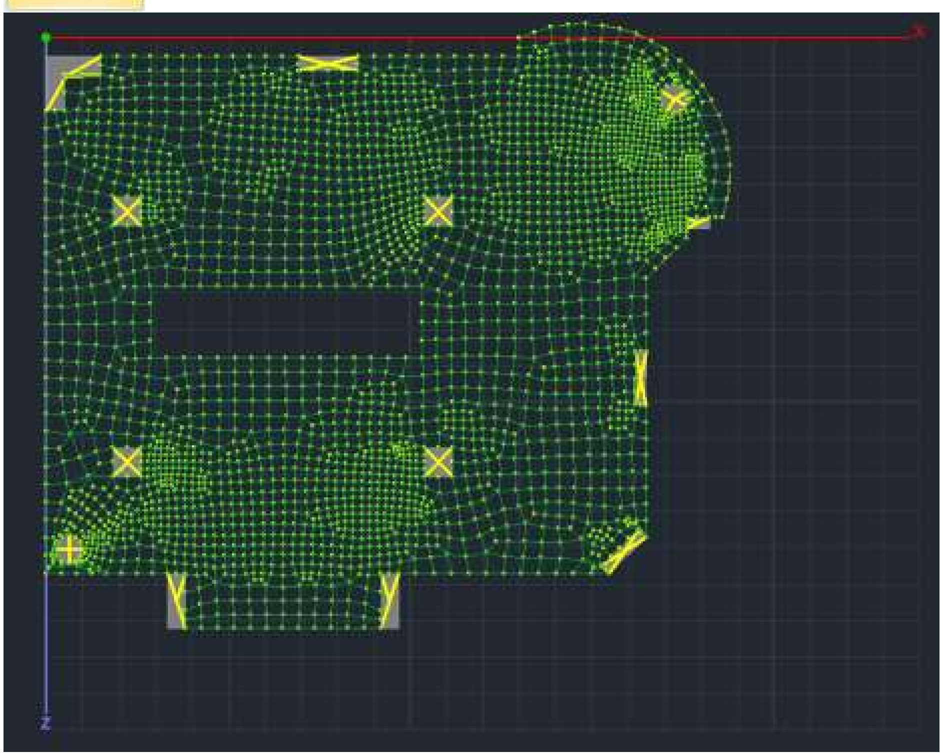


The 

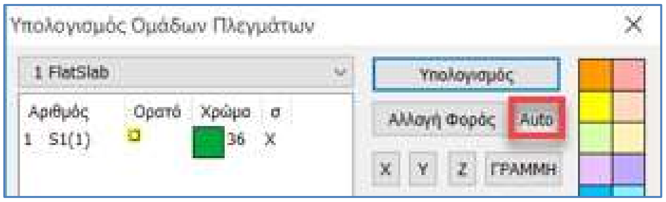
command is used to calculate the grid.



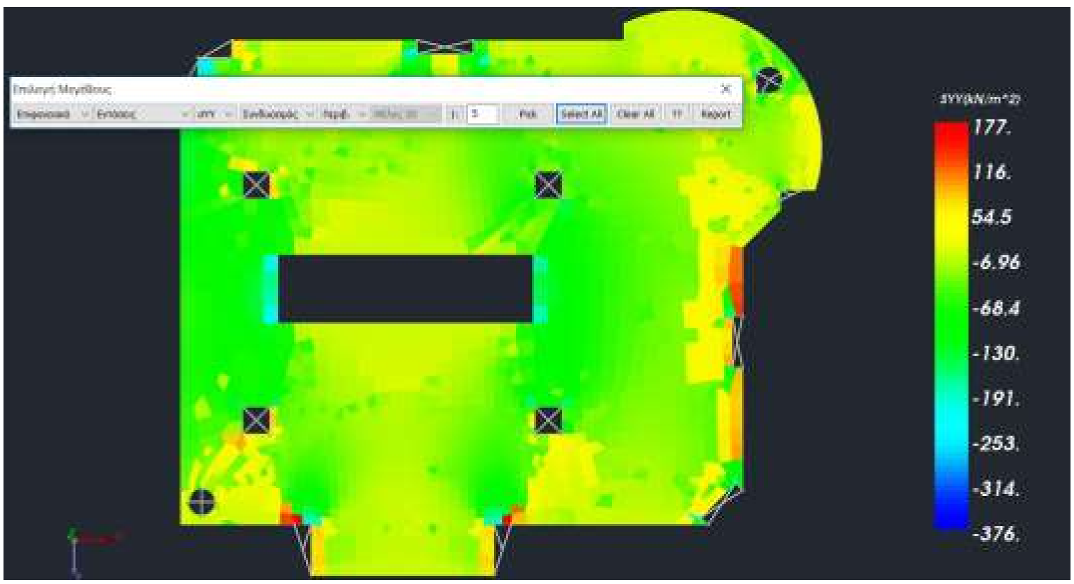
The modelling is completed with the creation of the Mathematical Model

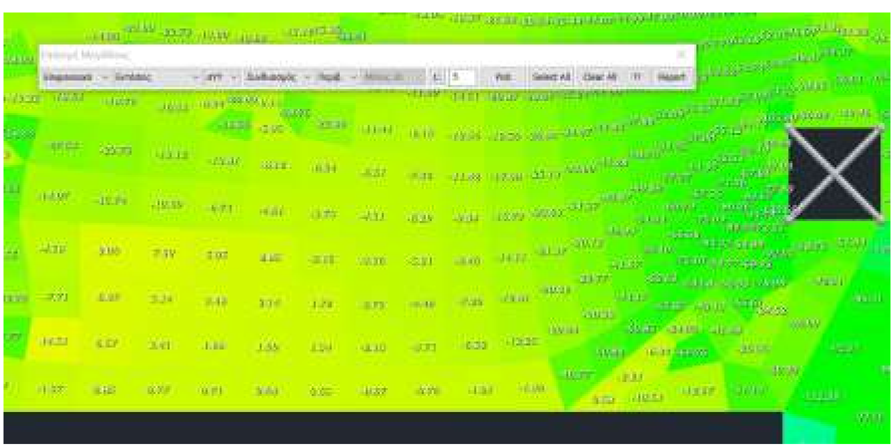


⚠ **NOTE**: Immediately after creating the Surface Math Model, always remember to open the "Grid Group Calculation" window and press "Auto".

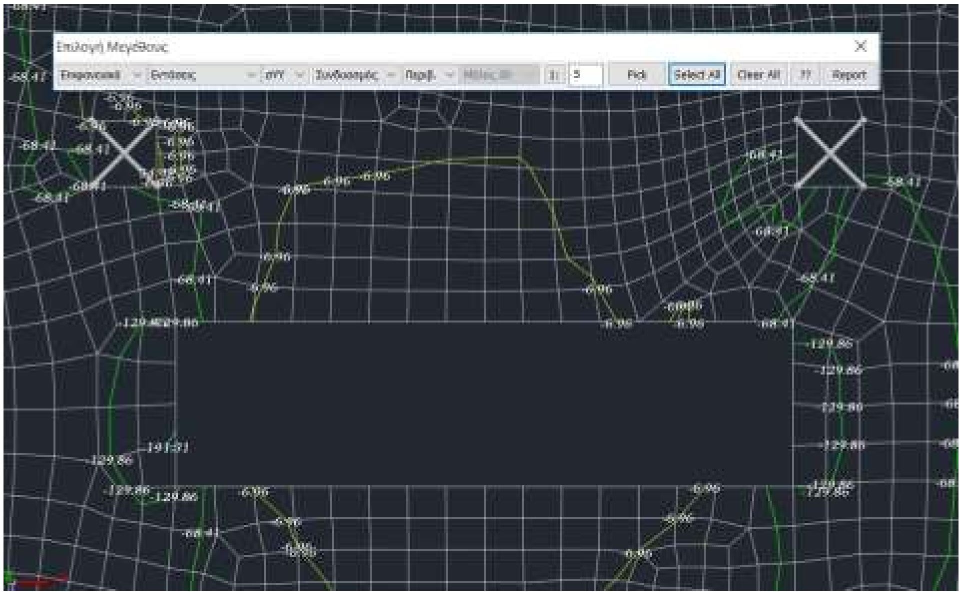


- After the **Modeling**, the **Load Import**, the **Analysis and** the **Load Import** follow as usual. and the creation of **the Combinations**.
- In the **Results** field we can read the values of the various quantities either with the help of the colour display or by reading the values of the selected size within the surface of the surface element by activating the Values in the lower horizontal bar.



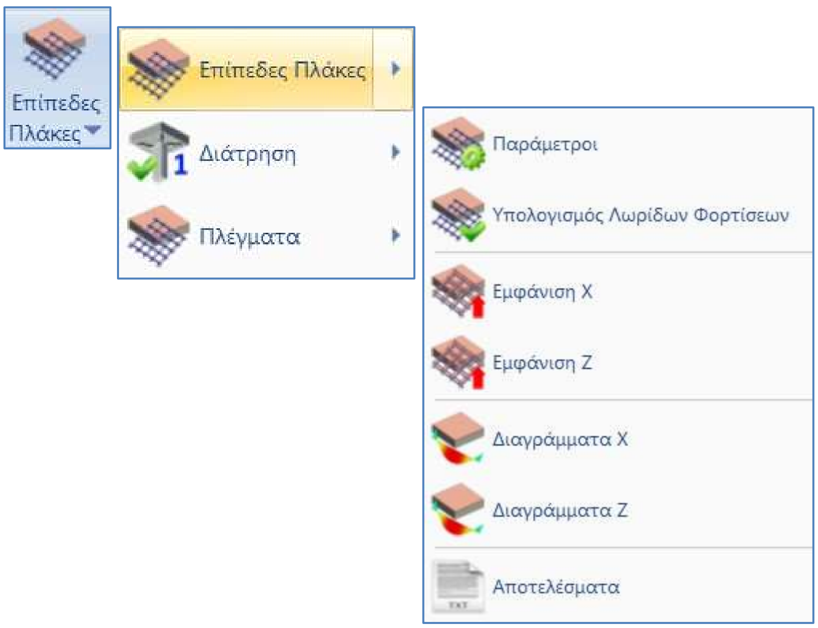


As well as the value of the isovalue on them

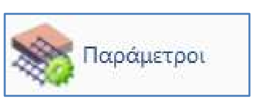


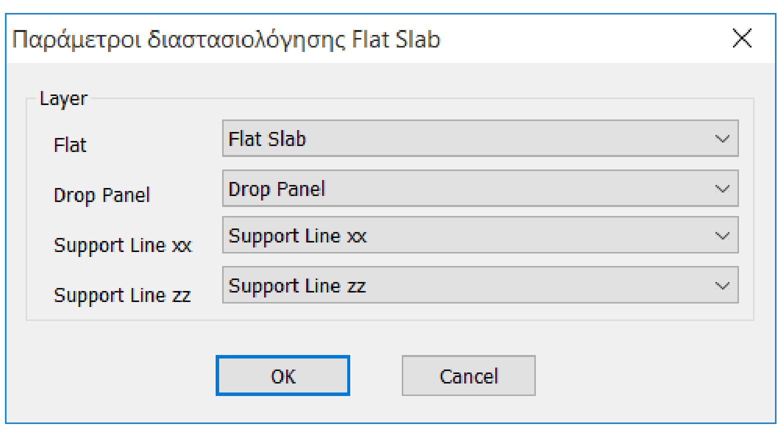
2. Resolution

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:



2.1 Parameters





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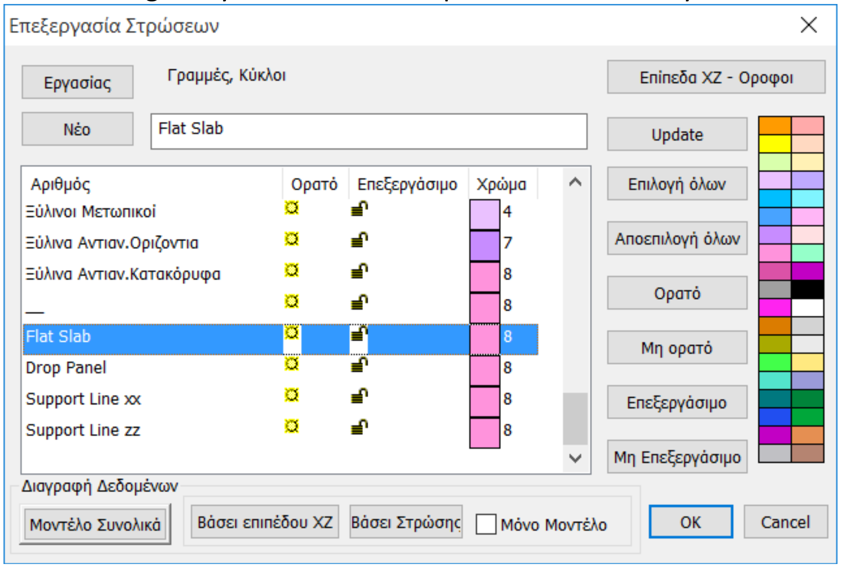
In the dialog box you set the correspondence of the Layers.



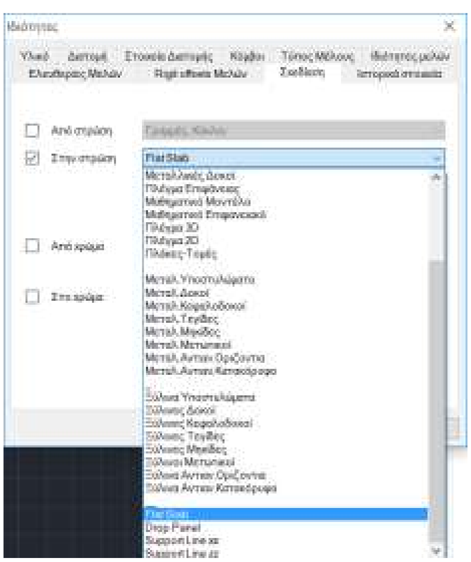
Scada's default list of Layers includes the layers related to the Flat Plates.

- 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,

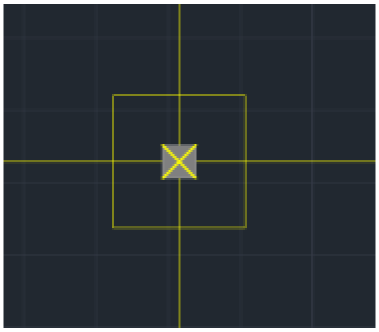
- Freeze all Layers, except "Lines-Circles"
- Select the Multiple Options command
- Left-click to select all the lines of the floor plan contour
- Right click to complete
- In the dialog box, in the Design, we change the Layer to "Flat Slab"

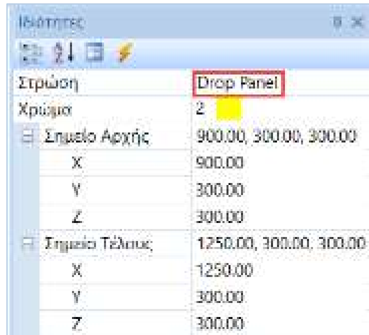


For more convenience we can select the "Flat Slab" layer from the beginning, immediately after selecting the Line or Polyline command, so the outline belongs to the correct layer without having to be moved.

- 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.

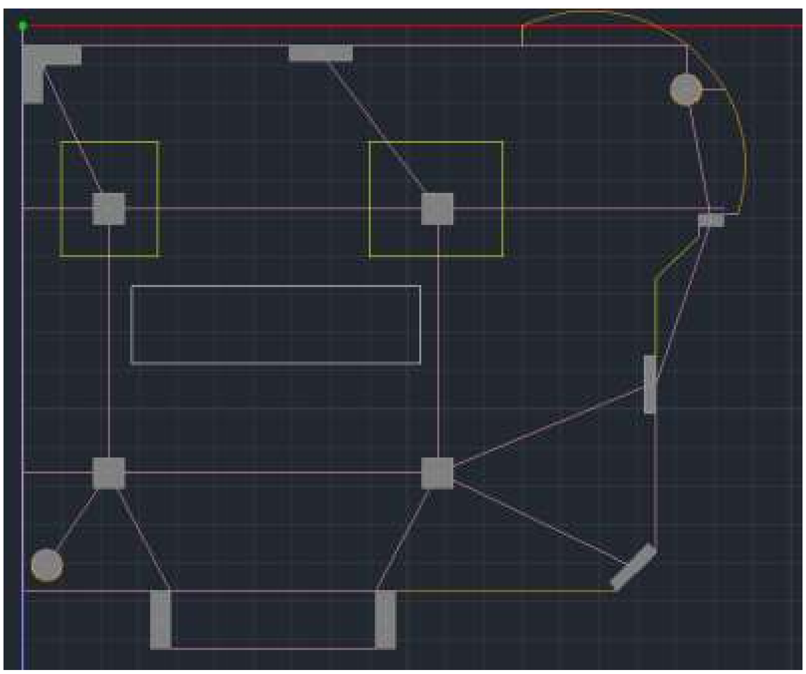
"Drop Panels" are optionally inserted around the pillars of the slab relieving it of shear stress.





- 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.



Drop Panels and Support Lines

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

2.2 Calculation of Loading Lanes

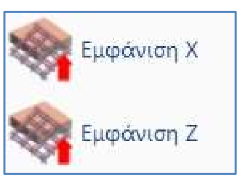
According to Annex I of EC2 the flat plate is divided into Loading Lanes. These are areas automatically created by the program on either side of the Support Lines , according to Figure I.1 of EC2.

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.

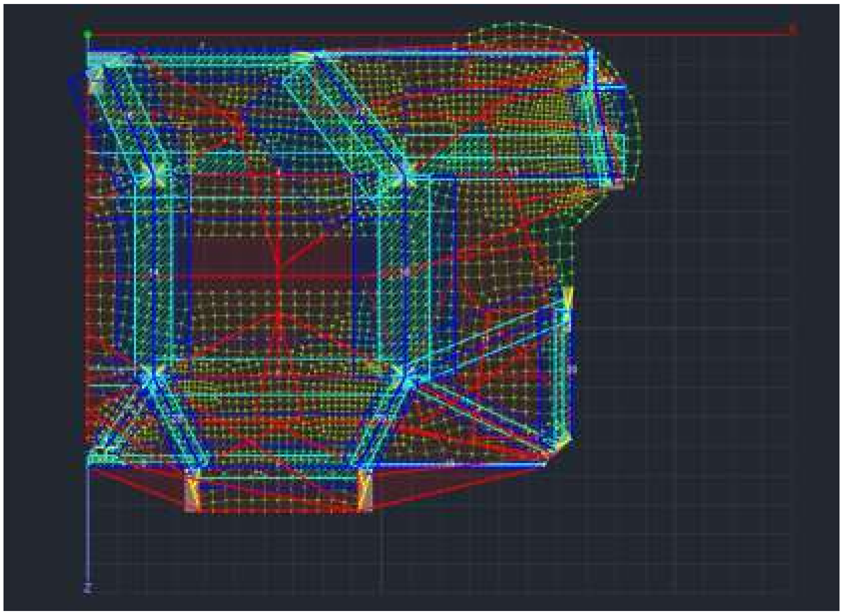
§ Instructions for the introduction of support lines on flat slabs

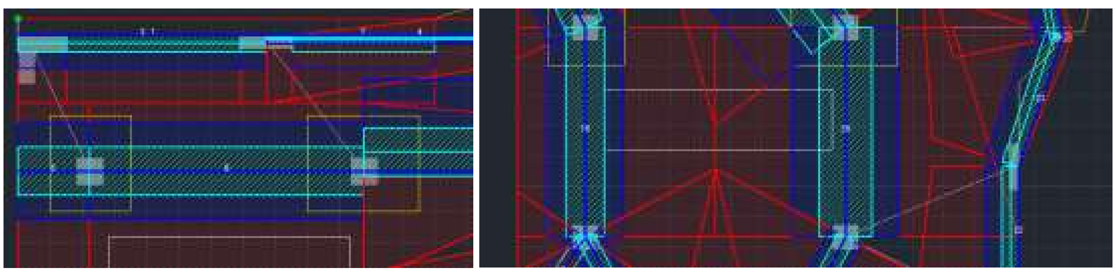
1. The support lines should start from a support column and end in a support (or free end). In all cases they must include at least one support.
2. The support line should only reach the contour of the plate when it is free edge. Otherwise it may stop at the contour or at the node of the column.
3. When 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.

2.3 Display X, Z



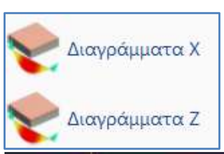
You choose to display the Charge Strips in both directions to display them.



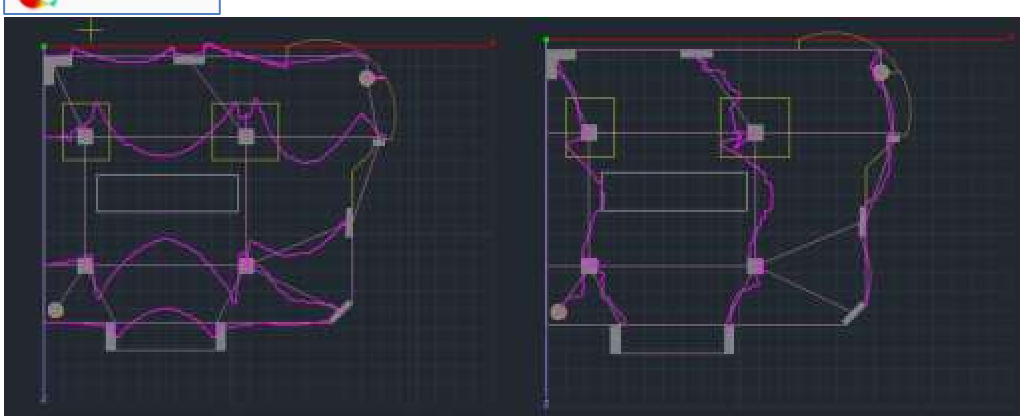


Loading strips along the X and Z axis

2.4 Diagrams X, Z



You choose to display the Charts in both directions for their display.



2.5 Results

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

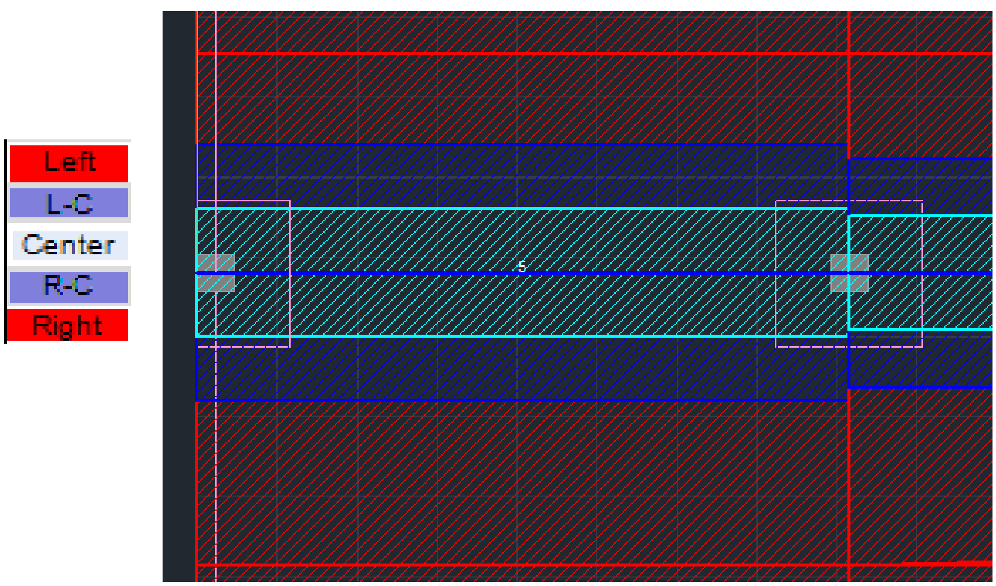
Each page is for one Charging Lane.

First, the characteristics of the Strip are described.

							Page : 1
Strip Calculations							
Description	Value	Units	Code	Description	Value	Units	Code
Floor	1			Starting point	internal column		9.4.1&2
# of strip	1			Drop panel	No		
Orientation	x-x			*Thickness*		(cm)	
Length	543.34	(cm)		*Width*		(cm)	
Concrete	C20/25			Finishing point	internal column		9.4.1&2
f_{ck}	20	(MPa)	Table 3.1	Drop panel	No		
f_{ctm}	2.20	(MPa)	Table 3.1	*Thickness*		(cm)	
Steel	S400s			*Width*		(cm)	
f_{yk}	400	(MPa)		Minimum reinforcement			
Cover	20	(mm)		*Tension reinf.*	0.0014	(cm²/m)	9.2.1.1(1)
Slab thickness	0.20	(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



EXAMPLE 8 - FLAT PLATES

Analysis Results and Reinforcement										Top
	135.84 cm (L_{start})					271.67 cm (L_{centre})				
Zone	M (kNm)	Width (cm)	$A_{s,rqd}$ (cm^2/m)	$A_{s,prvd}$ (cm^2/m)	Φ/s	M (kNm)	Width (cm)	$A_{s,rqd}$ (cm^2/m)	$A_{s,prvd}$ (cm^2/m)	Φ/s
Left										
L-C										
Center	-9.924	53.2	3.234	3.234	8/15		53.2		0.962	8/20
R-C	-7.132	53.2	2.306	2.474	8/20		53.2		0.747	8/20
Right	-5.426	106.3	0.865	2.474	8/20		106.3		0.618	8/20

	135.84 cm (L_{end})				
Zone	M (kNm)	Width (cm)	$A_{s,rqd}$ (cm^2/m)	$A_{s,prvd}$ (cm^2/m)	Φ/s
Left					
L-C					
Center	-11.747	53.2	3.846	3.846	8/13
R-C	-9.185	53.2	2.987	2.987	8/16
Right	-2.227	106.3	0.352	2.474	8/20

Analysis Results and Reinforcement										Bottom
	135.84 cm (L_{start})					271.67 cm (L_{centre})				
Zone	M (kNm)	Width (cm)	$A_{s,rqd}$ (cm^2/m)	$A_{s,prvd}$ (cm^2/m)	Φ/s	M (kNm)	Width (cm)	$A_{s,rqd}$ (cm^2/m)	$A_{s,prvd}$ (cm^2/m)	Φ/s
Left										
L-C										
Center		53.2		0.618	8/20	4.511	53.2	1.448	2.474	8/20
R-C		53.2		0.618	8/20	4.511	53.2	1.448	2.474	8/20
Right		106.3		0.618	8/20	7.025	106.3	1.123	2.474	8/20

	135.84 cm (L_{end})				
Zone	M (kNm)	Width (cm)	$A_{s,rqd}$ (cm^2/m)	$A_{s,prvd}$ (cm^2/m)	Φ/s
Left					
L-C					
Center	3.827	53.2	1.225	1.225	8/20
R-C	2.949	53.2	0.941	0.941	8/20
Right	6.372	106.3	1.018	1.018	8/20