SAFIR[®] training session – level 1

Johns Hopkins University, Baltimore

Example: 2D thermal analysis of a beam

"Reinforced concrete section heated on 3 sides"

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1. General description

This example deals with a 2D thermal analysis of a reinforced concrete section.

General data:

- Section 30 cm x 30 cm in concrete
- 4 steel reinforcement bars of 20 mm diameter and with 30 mm axis cover
- Material model from Eurocode 2 part 1-2
- Exposed to ISO fire on 3 sides
- In contact with atmosphere at 20°C on the fourth side

The section file will be used for a subsequent 3D structural analysis. Therefore, it will also include a torsional analysis.

2. Create a project in 2D for Thermal Analysis

From the pull down menu select:

Data -> Problem type -> SAFIR2016 -> Safir_Thermal_2d

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2	SAFIR2016 X SAP2000	Safir_Structural_2d Safir_Structural_3d
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To save the project select (or use icons on the left): *Files->Save or or [Ctrl + s]*

Enter a file name, e.g.: RC30x30

GiD creates a directory with the name *RC30x30.gid*

GiD creates a number of system files in this directory.

When you start the SAFIR calculation the Safir . IN, .OUT and .TEM files will be created in this directory.

Note: the project's name cannot contain spaces or special characters. Regarding the names of the files, SAFIR is not case sensitive.

3. Create the geometry in the xy-plane

3.1. The concrete section

From the left bar menu, select: Create object -> rectangle



Follow the instructions in the command box: Enter first corner point



Zoom on the command box:

Creating a rec Enter first cor	tangle in the XY plane ner point
Command:	-0.15 -0.15
	Zoom: 0.601x
->-0.15-0.15	
Enter second	corner point
Command:	0.15 0.15
	Zoom: 0.601x

Press « Enter »

Press « Enter

You can Adjust the zoom to center the section on the screen. GiD displays this section:

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Enter first con Leaving. No c	rner point (ESC to leave) changes			
Command				1 10.770 10100 W

Note: the blue lines represent the contour of the section, while the pink lines represent the surfaces delimited by the blue lines. For instance, blue lines are used to assign thermal boundary conditions to the contour of a cross-section, while the pink surfaces are used to assign thermal properties to an area of the cross-section.

3.2. The rebars

Four reinforcement bars have to be introduced in the section.

First, delete the concrete surface (in pink). From the left bar menu: Delete -> surface



Select the surface and press *Esc* to validate.



Then, from the left bar menu, select: *Create object -> circle*



Following the instructions in the command box, introduce the coordinates of the center of the first rebar.

Creating a ci	Creating a circle given center,normal and radius		
Enter a cente	Enter a center for the circle		
Command:	-0.12 -0.12		

Press Enter. This window appears in GiD. Select Ok.

🖾 Enter normal 🛛 🗙					
Enter a normal for the circle					
Positive Z					
O Positive Y					
O Positive X					
O Coords: 0.0	0.0	1.0			
OK In screen Cancel					

Specify the radius of the first rebar.

Enter a norm Enter a radiu	al for the circle s for the circle	
Command:	0.01	

Press Enter. This window appears in GiD.



Then repeat 3 times this procedure in order to create the 3 other rebars with the following coordinates for the center of the circles:

(-0.12 0.12) (0.12 -0.12) (0.12 0.12) At the end, you should see this in GiD:



Now, we need to create the concrete surface that contains the 4 holes. From the left bar menu, select: *Create NURBS surface*.



Then, select all the lines that define the contour of the concrete area (including the rebars contour). Press the *Esc* key to validate. GiD displays the surface that includes the holes.



4. Assign the thermal boundary conditions

In GiD, from the pull down menu select: *Data->Conditions*



This window appears in GiD:

Conditions			×
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Temperature		~	k? 🕘
Temperature Cur	ve F0		
Assign	<u>E</u> ntities	<u>D</u> raw	<u>U</u> nassign
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Select the button ("Line"). On the first pull down list, select: *Frontier constraints*

Different time-temperature curves are predefined. Select FISO for the ISO 834 fire curve.

Conditions	Conditions • • • Frontier constraints	× *? <i>2</i>	Conditions	× ×
Conditions belonging to that level are displayed Temperature curve FISO	Frontier constraints Flux constraints Void constraints Temperature	* *	Temperature curve	FISO FISO FISO0 ASTME119 HYDROCARB F1000THPS F20 F100 USER
Assign Entities Draw Unassign	Assign Entities Draw	<u>U</u> nassign	Assign Entities I	<u>D</u> raw <u>U</u> nassign

Click on the Assign button and assign it to the section as shown below.

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Press [Esc] or click on Finish to confirm

Then select F20 as temperature curve and assign it to the upper side of the section.

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	Temperature curve	F20	_
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Select *DRAW->Colors* in the Conditions dialog box to display the frontier constraints Press *[Esc]* or click on *Finish* to leave this view mode.

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Conditions	0	0	
Finish Press Tinish' to end selection			
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5. Assign a torsion constraint (for the torsional analysis)

The torsion constraint needs to be applied on a node that is on an axis of symmetry of the section. To create such a node, from the pull down menu select: *Geometry -> Edit -> Divide -> Lines -> Num divisions*

GD GiD x64 Project: RC30x30 (SAFIR2016\Safir_Thermal_2d) Files View Geometry Utilities Data Mesh Calculate Cross-Section About Problem Type Help 🜔 🎾 🎯 View geometry 💼 🗮 🔷 🕸 🛛 Layer0 🖂 📚 😻 🤋 🚽 ۰ Create . Delete . 🔎 🌽 Edit Move point Divide Lines Num divisions 2 **3 6** ▶ √ Polylines Join Near point . Lines operations 🕤 Surfaces ٠ Parameter E; . Swap arc Relative Length Polyline Length SurfMesh Rebuild surface by boundary Edit NURBS Convert to NURBS ٠ Simplify NURBS ٠ Hole NURBS surface Collapse ۲ Uncollapse

Enter number of divisions: 2. Select the line at the top of the section. Validate with Esc.



Then, from the pull down menu select:

Data->Conditions

Select the 📃 button

On the pull down list: Torsion constraints

Tick the box *Constraint* (only in GiD problem types versions prior to 1.4)

Conditions				×
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Torsion Constrain	it		~	2
Constraint:				
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Close				

Select the node on the axis of symmetry and validate with Finish.

6. Assign the materials

From the pull down menu select:

Data->Materials Select STEEL from the dialog box pull down list The Thermal tab is active. Then select: STEELEC2EN as Material Type A Convection Coeff hot of 25 A Convection Coeff cold of 4

A Relative Emission of 0.7

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STEELEC2EN	•		
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Then select the *Mechanical* tab. Input:

- A Young modulus of 210 000 MPa
- A Poison ratio of 0.3
- A Yield strength of 500 MPa

Materials			×
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Thermal	Mechanical		
E-M	odulus (Young) Poisson ratio ength (N/m^2)	2.1e11 0.3 5.0je8	
<u>A</u> ssign	<u>D</u> raw	<u>U</u> nassign	Exchange
		<u>C</u> lose	

Click on *Assign-> Surfaces* and assign it to the steel rebars surfaces. Press *[Esc]* or *Finish* to confirm. Then, select *CONCRETE* from the dialog box pull down list. The *Thermal* tab is active. Select:

SILCON_ETC as Material Type

Modify the thermal properties of the material if needed. Modify the mechanical properties if needed in the *Mechanical* tab. Then assign the material to the concrete surface.

Materials	×	Materials
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Thermal Mechanical		Thermal Mechanical
MaterialType SILCON ETC Specific mass 2400. Moisture content 48 Convection Coeff hot 25 Convection Coeff cold 4 Relative Emission 0.7 Parameter of thermal conductivity 0.5		Poisson ratio 0.2 Compressive stengh (fc) +3.0e7 Tension strength (fc) +1.0e6
Assign <u>D</u> raw <u>U</u> nassign	Exchange	Assign Draw Unassign Exchange
<u>C</u> lose		Close

Select *DRAW->all materials* in the Material dialog box to display Materials Press *[Esc]* or *Finish* to leave

Materials	·	
CONCRETE V 🐼 🖒 🗶 💷 🧔		
Thermal Mechanical		
MaterialType SILCON ETC -		
Specific mass 2400.		
Convection Coeff hot 25		
Convection Coeff cold 4		
Relative Emission 0.7		
Parameter of thermal conductivity 0.5		
Finish Press 'Finish' to end selection Exchange	TÎ .	
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### 7. Assign the general data

From the pull down menu select: *Data->Problem Data* 

In the Problem Data dialog mask enter: TIMESTEP, UPTIME, TIMEPRINT as needed Do not forget to tick the box *Autorun Torsion Analysis* Also tick the box *Consider reduction of torsional stiffness* and leave the value as 0.1

Click on the Accept data button

Problem data		×
		k? 🥏
Title 1	Safir_Thermal	
Title 2	Mesh_from_G	
TETA	0.9	
TINITIAL	20.0	
SOLVER	PARDISO -	
NCORES	1	
Type of calculation	MAKE.TEM -	
Global center (Yo)	0	
Global center (Zo)	0	
Center of torsion(Yc)	0	
Center of torsion(Zc)	0	
NVOID	0	
TIMESTEP	12	
UPTIME	3600	
TIMEPRINT	60	
Auto run torsion anaysis a	nd insert result in T	em file
Consider reduction of tors	ional stiffness	
reduction coeff	0.1	
Accept	Close	

### 8. Create the mesh

Select Mesh -> Structured -> Lines -> Assign number of cells

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۵ .		Structured	Lines	Assign number of cells	
		SemiStructured	Surfaces	Assign size	
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		Generate mesh	Ctrl-g		
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Enter 8 as the number of cells

Enter valu	ue window	×	
0	Enter number of cells to assign to lines		
	8		
[	Assign	Close	

Assign to the lines that form the contour of the rebars.

![](_page_14_Figure_8.jpeg)

Select *Mesh->Generate mesh or use* [Ctrl + g]Enter 0.024 as size of elements to be generated Validate with *OK* 

Mesh generation ×				
Enter size of elements to be generated				
0.024 ~				
Get meshing parameters from model				
OK Cancel				

Click on View mesh to visualize the mesh

![](_page_15_Figure_4.jpeg)

Note: the number of elements is limited here in order to be suitable for the demonstration version of SAFIR. For users of the full version, a smaller size of elements should be preferred for a reinforced concrete section.

### 9. Start the calculation

From the pull down menu select: *Calculate->Calculate window* Click the *Start* button Click the *Output View* button

GiD creates a .IN file in the project directory and starts the calculation. In the output window you can see the calculation progress from SAFIR and the GiD interface program which generates GiD postprocessor files from the .OUT file.

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	y ↓ ↓ ×	Comput Info for RCDOAD Fit Jun 15 142957 Generating output for GiD-PF, Pos: 1 / Generating output for GiD-PF, Pos: 1 / Gene	TIME = 2280.00000 TIME = 2340.00000 TIME = 2460.00000 TIME = 2460.00000 TIME = 2500.00000 TIME = 2500.00000 TIME = 2760.00000 TIME = 2800.00000 TIME = 2800.00000 TIME = 3000.00000 TIME = 3120.00000 TIME = 3360.00000 TIME = 3360.00000 TIME = 3460.00000 TIME = 3460.00000 TIME = 3460.00000 TIME = 3600.00000 TIME = 3600.00000	Process window Process info Process info Process 'RC3i Jun 15 14:29:5 QK Utiput view Terminate Start start remote	Dx30' started at Fri       57 has finished.       Eostprocess       Pemote	
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Click on "Ok", save, and open the postprocessor Diamond to visualize the results.

![](_page_16_Figure_4.jpeg)