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Structural Engineering

USER'S MANUAL FOR SAFIR (version 2025)

A COMPUTER PROGRAM FOR ANALYSIS OF STRUCTURES

SUBJECTED TO FIRE

Frequently asked questions

by

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1. Commercial information

1.1 Conditions for commercial licence

The software can be purchased on the website of Gesval S.A.:
https://www.gesval.be/en/catalogue

Licence conditions, pricing, and purchase procedures are described on the Gesval website.

1.2 How to buy without a credit card

It is indeed possible to buy a licence if you don't have or don't want to use a credit card. The procedure will just take a little bit longer before you receive the licence as we have to verify that the money has arrived on our account.

The procedure is described on the Gesval website:
https://www.gesval.be/en/catalogue
(look under "Pro forma invoice" after selecting the appropriate type of licence):

1.3 Update policy

The update policy is described on the Gesval website:
https://www.gesval.be/en/catalogue

1.4 Free demonstration version

It is possible to request a free demonstration version of SAFIR through the Gesval website.

This version has limited capabilities (number of nodes, of elements…) and cannot be used for commercial applications. It can be used for evaluation, for teaching or for research purposes.

1.5 Training

Training sessions can be organized on demand, in Liege, in Baltimore, on site, or online. Contact info@safirsupport.be or tgernay@jhu.edu for availability and conditions.

2. Information on SAFIR

2.1 Web site

You can find plenty of information on the web site of SAFIR:
https://engineering.jhu.edu/safir/

2.2 How do I install SAFIR?

The installation of the software SAFIR is very simple: you copy the file "safir.exe" that you will receive in the folder of your choice in one disk of your computer, and you copy the file "identity.key" that you will receive IN THE ROOT DIRECTORY of the same disk, and this is finished.

Visit the SAFIR website for more information:
https://engineering.jhu.edu/safir/resources/installation/

3. Problems during installation

3.1 Libiomp5md.dll and Ordinal 747

Possibly, you may have messages related to the Dynamic Link Library “libiomp5md.DLL” because it is either missing on your computer (Figure 1), or not properly registered or the version that SAFIR is using on your computer is not the one that SAFIR needs (see Figure 2).

Figure 1: libiomp5md.dll message

Figure 2: Ordinal 747 message

If this is the case, download the redistributable Intel libraries from this web site:

https://software.intel.com/content/www/us/en/develop/articles/redistributable-libraries-for-intel-c-and-fortran-2020-compilers-for-windows.html?wapkw=Intel%C2%AE%20Fortran%20Compiler%202017%20for%20Windows*%20-%20Update%205%20redistributable%20library%20package

In the box "Links to the redistributable packages", click on “Redistributable Library Package” below “Intel® Fortran Compiler 19.1 for Windows”

Figure 3: Link for download

If the problem is still not solved, search on your hard disk the location where the most recent version of the DLL has been installed and copy it in the same folder as “safir.exe”.

3.2 Identity.key

If you read the message reproduced in Figure 4

```
ERROR from SAFIR in subr. VERIF.
  SAFIR requires a key code that is contained in the file "IDENTITY.KEY".
  The IDENTITY.KEY file could not be opened.
     It may be missing or it is not located in the root of the device where the input file is located.
```

Figure 4: "identity.key" error

locate the file “identity.key” that you received in the root of the folder where you located SAFIR and its input files. Most likely, this is in C:

3.3 SAFIR from a command window

Is it possible to run SAFIR from a command line?
Yes, it is.
Either you simply type “SAFIR” and the prompt asks you to type thereafter the name of the input file, “th_hole” in Figure 5.
Or you type directly “SAFIR th_hole”, as shown on Figure 6

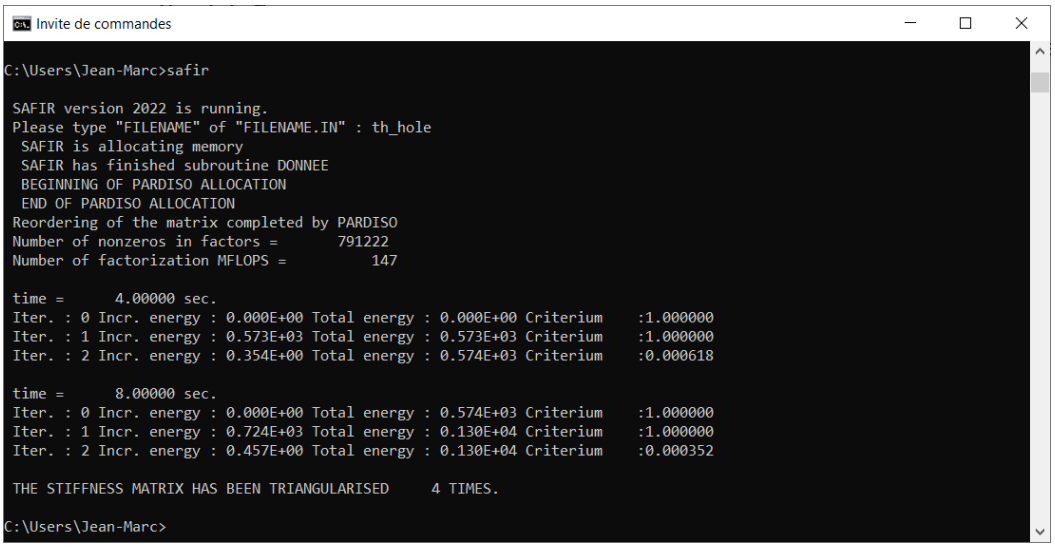


Figure 5: typing "SAFIR"

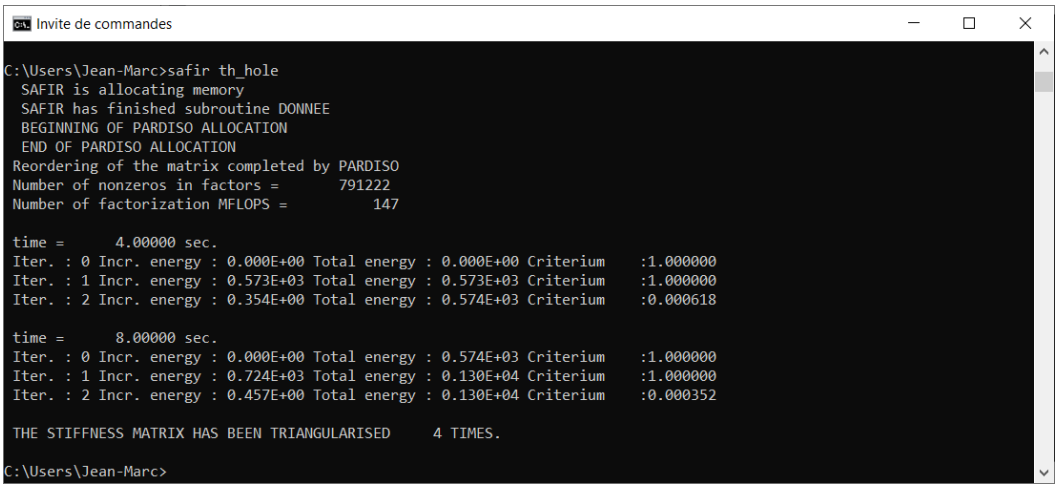
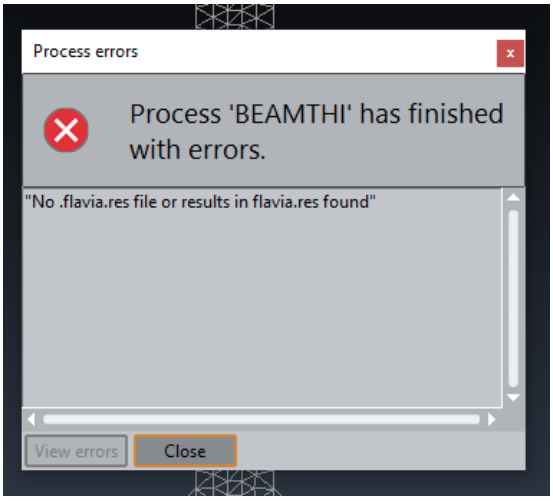


Figure 6: typing "SAFIR th_hole"

4. Problems when building the model

4.1 No flavia.res file (when using the former preprocessor GiD)



This message is not written by SAFIR. It is written by GID. It means that an error has been made when creating the model in GID. As we cannot see all choices and clicks that you made, it is not possible for us to know what error has been produced. To help detecting the error, have a look in the folder that GID has created for your problem. There should be a file with the extension .DAT. This file is very similar to the .IN file that is needed by SAFIR.
In some cases, renaming this file from “name.DAT” into “name.IN” is enough to have it accepted by SAFIR.
If not, you can examine the content of this .DAT file and, if you are familiar with the structure of the input files of SAFIR, you may detect the part of the file which is problematic (in the materials, in the local axes…). Try then to fix that in your GID mode.
If nothing works, do your GID model again, from scratch, and be very careful in every choice and the clicks you make.

Important note
The “problem types” written for GID to be used with SAFIR are not developed any more by the SAFIR team. We recommend using *GmSAFIR*, the new, free, open-source pre-processor for SAFIR that can be found here:
https://engineering.jhu.edu/safir/resources/pre-and-post-processor/

4.2 Some tips on GID

GID is not developed by the SAFIR team. We have thus difficulties to help you when GID sends a message such as “no flavia.res” appears. It just means that you made an error when building the model in GID, but we don’t know which one.
If the message is “It seems as if this file is not present”, it has been written by SAFIR. It means that the file *name.in* that should have been created by the problem type of GID has not been created. But, most likely, a file called *name.dat* has been created by GID. You may want to open it and, with sufficient knowledge of the structure of the input file (see the users manual of SAFIR), you will perhaps be able to fix the problem in the file, then save this file as *name.in*.

4.3 Can we still use GID?

GID used to be the preprocessor favored by most SAFIR users to build their models and input files for SAFIR. Since March 2022, a new free, open-source preprocessor has been developed that can be used for such purpose: GmSAFIR.

Of course, GID can still be used to create input files for SAFIR, like any other tool that you would find or would have developed. SAFIR needs an input file written in the correct format, no matter how the file has been created.

Nevertheless, the SAFIR team will not develop any more the “problem types” written for GID but will concentrate its efforts to the development of GmSAFIR. Compatibility of these “problem types” with new versions of SAFIR will not be ensured and some new functionalities introduced in SAFIR will thus not be present in GID (such as, for example, “DIAG_CAPA” for thermal calculations introduced in SAFIR 2022).

4.4 Local axes in 2D sections and in 3D beams

The position of the node line of the beam finite element in the section (called "Global centre" in GmSAFIR) and the centre of torsion must be defined in the cross section used for the 2D thermal analysis.
In a Thermal 2D made in GmSAFIR, the local axis ***x*** is pointing to the right and the local axis ***y*** is pointing upward. The system of coordinate is drawn on the screen, see Figure 7.

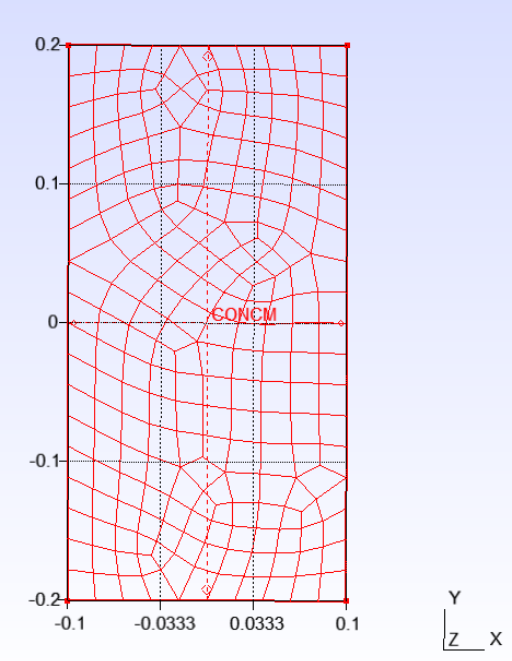


Figure 7: screen shot of GmSAFIR

In the SAFIR input file, the first coordinate corresponds to the local axis ***y*** which is pointing upward, and the second coordinate corresponds to the local axis **z** which is pointing to the right.
This is shown by the system of coordinate in Diamond, see Figure 8.

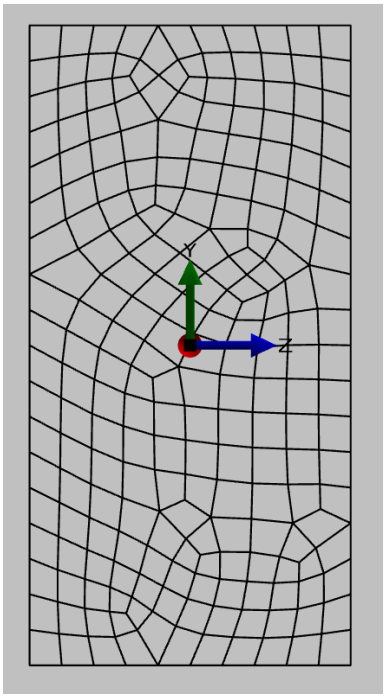


Figure 8: screen shot of Diamond

This orientation may seem weird, until you realize that the local axes ***y*** and ***z*** of the section are also the local axes ***y*** and ***z*** of the 3D beam finite element, ***x*** being the longitudinal axis of the beam. These local axes of the beam can be seen in Diamond for each beam finite element, see Figure 9, as well as in GmSAFIR for each member.

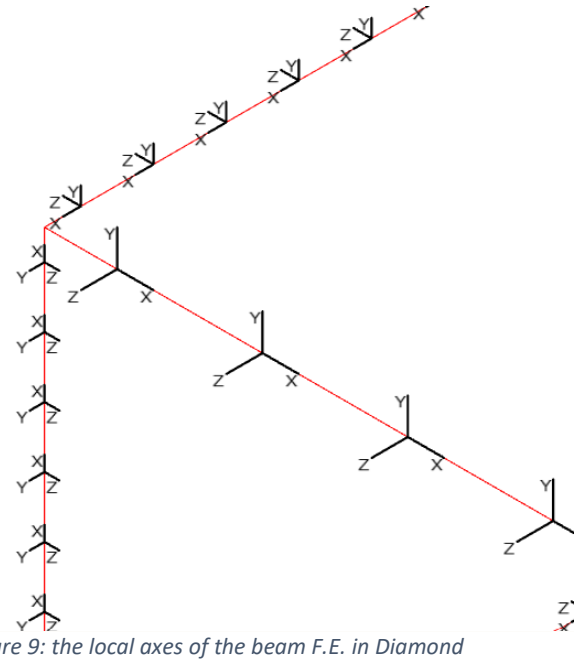


Figure 9: the local axes of the beam F.E. in Diamond

4.5 Determinant of the Jacobian < 0

The following error message may appear in a thermal 2D problem:

```
ERROR in KSOLID.
  Determinant of the Jacobian < 0 in element :      1
  This may be due to the fact that:
    either the nodes of this element are given in clockwise order,
    or the shape of the element is concave.

ERROR in KSOLID.
  Determinant of the Jacobian < 0 in element :     67
  This may be due to the fact that:
    either the nodes of this element are given in clockwise order,
    or the shape of the element is concave.
```

with the list of faulty elements possibly much longer.

If the model has been created with a graphic preprocessor such as GmSAFIR, the most likely reason of this error is the first one mentioned in the message: “The nodes of this element are given in clockwise order.” In GmSAFIR, this will happen if the first line chosen to define a surface has not the proper orientation. The proper orientation is when the tangent of the line is such that the surface is on the left of the line (see https://www.youtube.com/watch?v=nTOikebJ9Dw&t=634s).

The easiest way to identify the surface(s) of the GmSAFIR model which are affected is to plot the model in Diamond, plot the elements with their numbers, and identity those elements which are given as faulty by the messages printed in the OUT file. This indicates the surface(s) in the GmSAFIR for which either the direction of the first line must be reversed (invert in the script the nodes which describe this line) or another line has to be chosen as the first line of those that describe this surface.

5. Conceptual model

5.1 Dead weight

SAFIR does not know the concept of dead weight.
If you want a dead weight to be applied, you have to compute the intensity and apply it specifically, for example as a DISTRBEAM on BEAM finite elements or as a DISTRSHELL on SHELL finite elements. This applies to the dead weight of the elements themselves as to the dead weight of anything that is supported by the elements.

5.2 Can SAFIR consider the effect of concrete spalling?

The occurrence of spalling cannot be predicted by SAFIR.
It is possible to model the effects of spalling by removing a certain layer of finite elements at a given time during the thermal analysis and to continue the analysis further in the reduced section and considering that the fire exposure is now on the boundary of this reduced section. The same technique

can be applied several times, for example removing a layer of 10 mm every 15 minutes (these values to be selected by the user).
The procedure is not automatic.
In order to take the disappearance of these layer into account in the subsequent mechanical analysis, manipulation of the files produced by SAFIR is requested (the fibres of the initial section that have "disappeared" during the thermal analysis must be given a temperature of 1 200°C in order to eliminate their contribution to the load bearing capacity.

5.3 Modelling timber combustion

SAFIR does not model in detail the complex chemical reactions that prevail during wood combustion. Combustion in wood is modelled in a simplified manner as heat propagation in a solid material. The density of the material as well as the moisture content are taken into account and influence the effective thermal properties. As stated in Eurocode 5: "*The thermal conductivity values of the char layer are apparent values rather than measured values of charcoal, in order to take into account increased heat transfer due to shrinkage cracks above about 500°C and the consumption of the char layer at about 1000°C. Cracks in the charcoal increase heat transfer due to radiation and convection. Commonly available computer models do not consider these effects.*"

5.4 Can the beam element of SAFIR detect buckling ?

The 3D beam finite element of SAFIR accounts for non-uniform torsion, yet it complies with the Bernoulli hypothesis.
As a consequence, it can detect member buckling, global buckling and lateral torsional bucking.
For the later one, we recommend reducing the young modulus of steel E when doing the torsional analysis.
You can, for example, multiply it by an arbitrary factor of 0.1 for the torsional analysis, then make the mechanical analysis with the normal value of E.
You can then do a second round in which the reduction factor for the torsion analysis is the one of the Young modulus of steel at the failure temperature that you obtained during the first mechanical calculation.

The beam element will not detect local buckling, distorsional buckling and shear failure. You can get access to these failure mode by using the SHELL finite element.

5.5 Modelling connections

Semi rigid connections can be taken into account at the end of the beam finite elements. Each degree of freedom of the end nodes of beam elements can have a behaviour that is elastic – perfectly plastic, with the stiffness and the strength of the connection chosen by the user. If the beam element is heated, the values of strength and stiffness may be reduced as a function of time during the course of the fire.

Another option to model connections is to represent a joint by a dedicated beam finite element with an appropriate position and properties of different fibres of the section chosen in a way that each fibre represents one component of the joint, for example one fibre for each bolt of the joint.

Joints can also be modelled in a detailed manner by 3D solid finite elements. This has been done regularly to determinate the temperature distribution in joints where each component is considered in the model, such as bolts, washers, stiffeners… Obtaining the mechanical behaviour of the joint on the base of this 3D model is theoretically feasible but this raises serious difficulties to be overcome such as the choice of the boundary conditions (either forces or displacements) at the interface of the model with the rest of the structure. It is indeed unfeasible to model a complete building structure with 3D solid elements. A limitation of SAFIR that can be critical for some joints is the fact that contact elements are not available in the code.

5.6 Modelling a structure in a 2 zones environment

If the conditions in the fire compartment are described by a 2 Zones model such as, e.g. the software OZone (https://sections.arcelormittal.com/design_aid/design_software/EN), the temperature in each zone can be described in a txt file to be used as a function[1] in a "FRONTIER - F" [2] condition to apply a time-temperature curve at the boundaries of the sections. A difficulty will arise for vertical elements which can switch, possibly several times, between one zone and the other one at different moments in the fire depending on the vertical position of the element, dictated by the elevation of the separation between the cold zone and the hot zone which is moving during the fire. This may require representing vertical elements into several section types, each one with its own temperature history.

5.7 NODELINE and YC_ZC

Beam finite elements are connected in a mechanical analysis by their end nodes, which are located at a certain position in the cross-section of the element.
Concentrated forces and restrained Degrees of Freedom (hence supports and reactions) are applied to the nodes of the structural model, hence at the position given in the section.
The bending moments are also calculated and printed by SAFIR with respect to this node. If the section is subjected to an axial force, the bending moment will thus depend on the position of the node in the section.
The sequence of decision is the following one:

1) The user chooses the position of the 2D system of coordinates in the section that suits him, to facilitate his life when giving the coordinates of the nodes that describe the section for the thermal analysis, either be it with GID, with GmSAFIR or with any other tool; these positions will finally end up in the input file read by SAFIR.
2) The coordinates of all nodes that make the section are introduced in this system of coordinates.

[1] see Section 5.5 in "Users manual of SAFIR 2022 – Part 1"
[2] see SERIES 16 in "Users manual of SAFIR 2022 – Part 2"

3) The user must make a choice about the position of the node of the beam finite element in the section The centre of gravity is one choice, but there may be others, depending on how the elements are connected to each other, how they are supported...
4) This position is given, with the command "NODELINE", in the system of coordinates that has been chosen.
5) If the section is used in a 3D beam element, the position of the shear centre must also be given, with the command "Yc_Zc" in the system of coordinates that has been chosen. If the beam element is used in a 2D model, this command must be present but the values given are irrelevant.

6. Common errors

6.1 FLUX command

If you apply a positive flux on the boundary of a section, the temperature will keep rising to infinite values. You should probably combine this condition with a Time- gas temperature condition (FRONTIER - F) with the gas temperature given by T20. This will allow the section to release energy to the far field as its own temperature is increasing.

6.2 List directed I/0

The message "forrtl: severe (59): list-directed I/O syntax error, unit x, file yyyyyyyyyyyyyyy" means that SAFIR encountered a list of symbols when trying to read information from the file named yyyyyyyyyyyyyyy. This will happen if SAFIR encounters a chain of characters where a real or integer number was expected, or vice-versa. This can happen if a variable is missing in an input line and SAFIR tries to find it on the next line, where the format does not with the expected format.
Check your input file and fix the incorrect format.

6.3 Thermal analyses with the HASEMI fire

A common error made by several users is that they enter the chain of character "HASEMI.TXT" whereas only "HASEMI" is needed in the FLUX command.

```
    FLUX    5          NO          NO      HASEMI        NO
```

HASEMI.TXT is the name of the file that contains the description of the localised fire(s)