

Aлизé-Aéronautique



User Manual

Version 1.5

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Written by: Juliette BLANC, Jean-Maurice BALAY, Michael BROUTIN, Jessica CLAVEL, Pierre HORNYCH, Jean-Michel PIAU

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Introduction

This manual presents the Alizé-**Aéronautique** module, which is part of version 1.5 of the Alizé-LCPC software.

The module Alizé-Aéronautique implements the design method for flexible (i.e. bituminous) airfield pavements, described in the guide: "Rational Design Method for Flexible Airfield Pavements" (STAC, 2014). Familiarity with this guide is therefore necessary in order to use the software. In particular, the user should refer to the STAC guide for the choice of the various calculation parameters (material characteristics, design life, calculation risk, calibration coefficients, etc.).

The Alizé-Aéronautique module is derived from the road design software, Alizé Routes, and uses the same basic principles:

- Same calculation method based on an axisymmetric multilayer elastic linear model
- Same description of the basic tyre loads by circular imprints, to which a uniform load pressure applies.
- Same description of the structures, by the choice of elastic moduli E , Poisson's ratios ν layer thicknesses.
- Interfaces between layers assumed to be fully-bonded.
- Same design criteria - since the software is limited to bituminous pavements, the only design criteria taken into account are:
 - o The maximal horizontal tensile strain at the bottom of the bituminous layers ϵ_t (fatigue criterion)
 - o The maximal vertical compressive strain at the top of the subgrade ϵ_z (rutting criterion)

The use of Alizé-Aéronautique V1.5 does not require familiarity with Alizé Routes V1.5. However, the two software systems are quite similar.

The main differences between Alizé-Aéronautique and Alizé Routes relate to the following points:

1. Types of pavement structures:

Only asphalt pavements are taken into account. For ease of reference, an initial structure template (called Flexible Model Mf1) is provided to the user, and can then be modified. Since the structure type is unique, some parameters related to the structure (K_s , Sh coefficients) are predefined and must no longer be entered by the user.

2. Characteristics of materials:

The material libraries proposed are the standard libraries from the NFP 98-086 road design standard. However, for airfield pavements, only certain types of materials can be used. For further information, the user should refer to the design method (STAC, 2014) and the "Guide application des normes" (STAC, 2009, in French).

3. Description of loads and traffic

In the airfield module, the calculation does not take place with an equivalent load, but with the load characteristics corresponding to each aircraft circulating on the considered pavement; each aircraft is described by the loads of all the wheels of its landing gear (silhouette of the aircraft).

A database (STAC FICAV database) is made available to the user, which contains the geometry of most of the current aircraft received by French airports. If necessary, other databases can be used.

The **traffic** is then described by specifying the number of passes for each aircraft, the equivalent temperature and the speed associated with these passages, as well as a wander parameter which characterises the lateral dispersion of the passage positions of each aircraft.

4. Damage calculation

The design is based on a cumulative damage concept. Although the traffic consists of different aircraft, the positions through which the landing gear of these aircraft passes are all different. For this reason, the design cannot be performed for a single maximal strain value, calculated at a single point. It is necessary to take into account the positions of the different aircraft (and of the lateral wander), and to calculate the **damage level curves**, which represent the variation in the value of the fatigue damage D according to y (i.e. perpendicularly to the pass of the loads). These damage level curves are first computed separately for each aircraft and then cumulatively for the whole traffic. The design of the structure is considered as optimised when the cumulative damage curve reaches a value equal to 1 for at least one transverse position value y .

5. Iterative calculation

An iterative calculation method is also proposed. This can be used to automatically search for the thicknesses of pavement layers leading to an optimised design (damage equal to 1 in at least one point).

1. Launching Alizé-Aéronautique



Alizé-Aéronautique

1.1. Home page

Alizé-Aéronautique is launched by selecting "Airfield pavement Module" in the Alizé-LCPC V1.5 launch window (Figure 1).

A window with a warning message opens. Click on "Close".

The Alizé-Aéronautique window is then displayed.

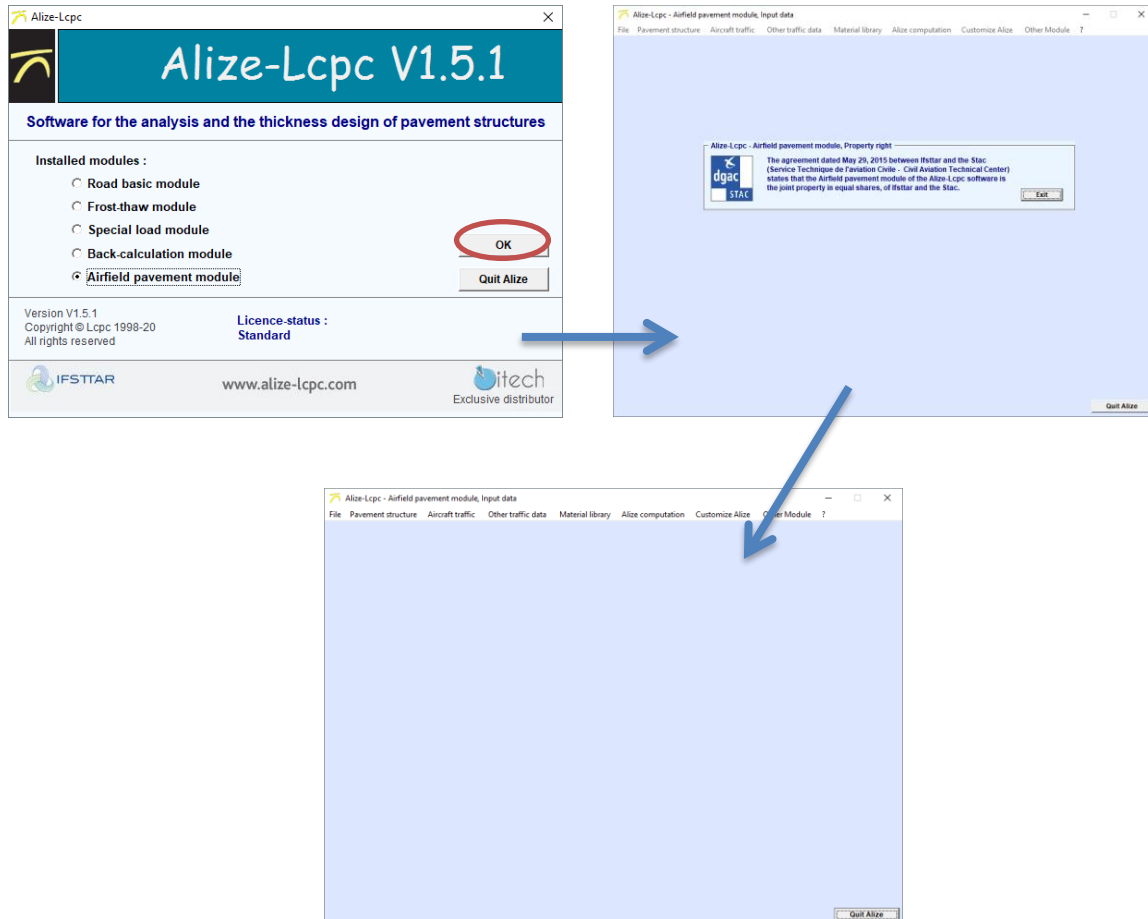


Figure 1: Alizé-Aéronautique launch window

1.2. Alizé-Aéronautique main menu bar

The main menu bar of Alizé-Aéronautique enables accessing to several features.
The "File" drop-down menu is detailed in the Figure 2 below.

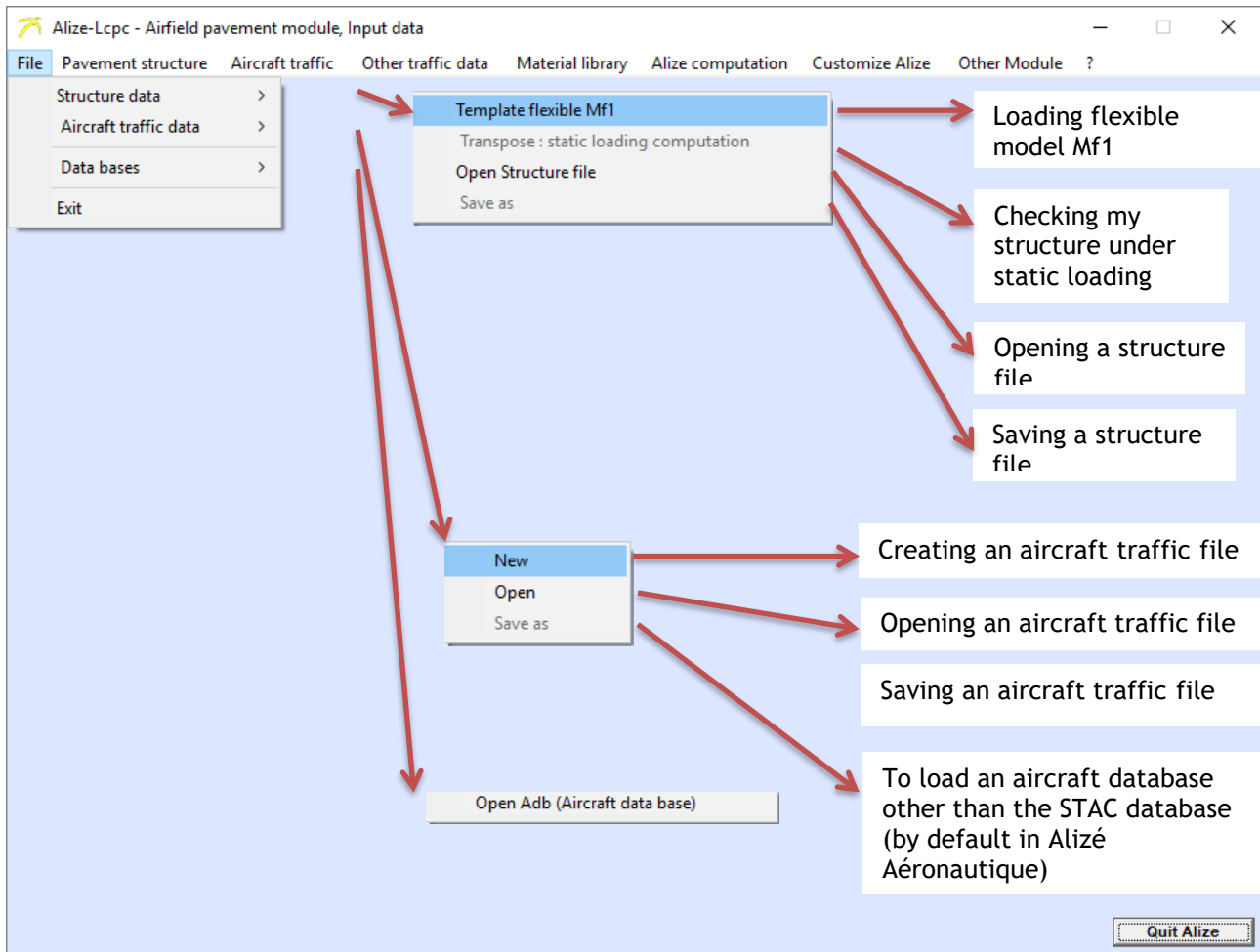


Figure 2. Main menu bar

The other features of the main drop-down menu are detailed on the Figure 3.

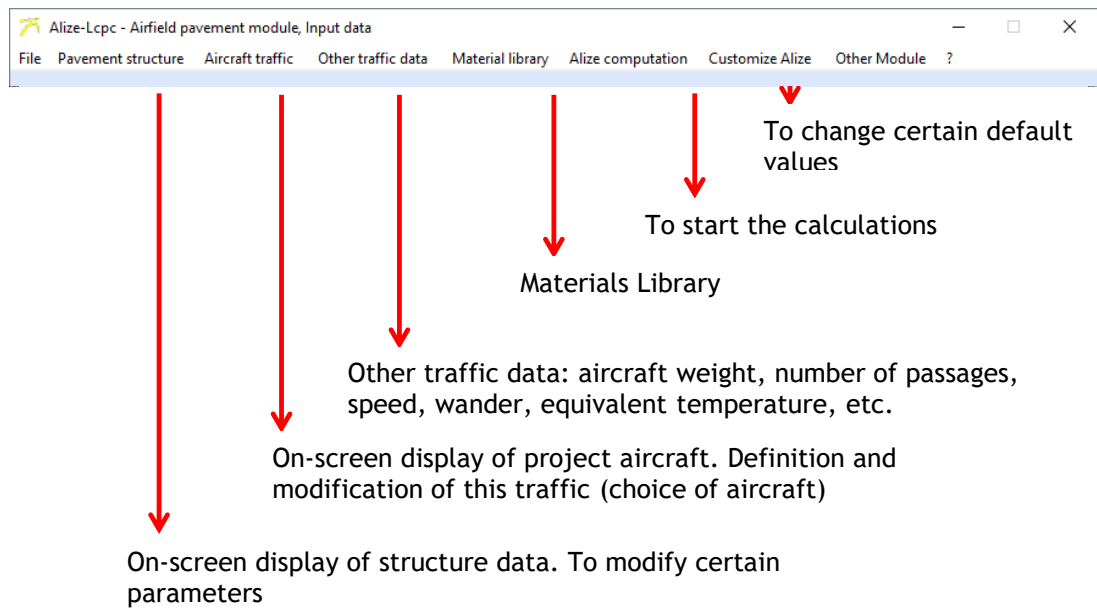


Figure 3. Main menu bar (cont'd)

Each feature will be explained in detail in the rest of this manual.

2. Pavement structure



2.1. Loading the flexible structure model

Once the Alizé-Aéronautique module has been launched, the displayed window is empty, no structure is loaded yet and no air traffic is defined.

A flexible structure model is predefined.

As explained on the Figure 4, in the main menu, this model can be loaded by clicking on File, then Structure Data, then Flexible model Mf1. The model consists of the following initial structure:

- 6 cm of BBME
- 18 cm of GB3
- 50 cm of category 1 UGA divided into two layers (UGA is named "gnt" in Alizé-Aéronautique)
- Infinitely thick subgrade

The two design criteria (horizontal strain at the bottom of the bituminous layer and vertical strain at the top of the subgrade) are displayed along with the various parameters.

These criteria are detailed in chapter 2.5 of the design method (STAC, 2014).

The various design parameters are detailed in chapter 2.7 of the design method (STAC, 2014). The values of these different parameters are imposed by this method and cannot therefore be modified in Alizé-Aéronautique.

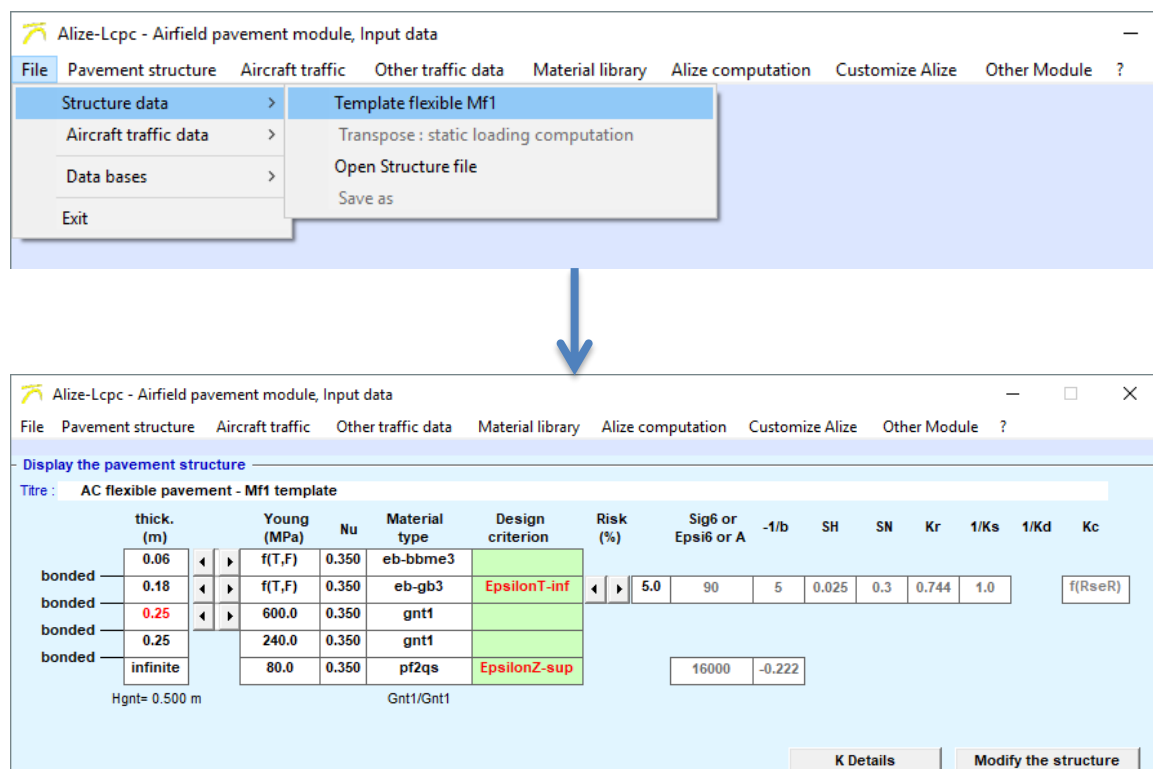


Figure 4. Loading a flexible structure

2.2. Modifying the flexible structure model to fit the project data

The modifications that can be made to the flexible structure model in order to adapt the project data are:

- The types of materials
- The materials elastic moduli and Poisson's ratios
- The layer thicknesses
- The risk coefficient

The various changes that can be made are detailed below.

2.2.1. Changing thicknesses

As explained in the Figure 5, the thicknesses of the surface and base courses can be changed using the "thickness" sliders.

The UGA thicknesses can be changed using the "thickness" slider of the upper UGA layer.

Some adjustments are automatically made, such as:

- dividing the total thickness of UGA into sub-layers with a maximum thickness of 0.25 m
- the values of the moduli of the different sub-layers, in relation with the category of UGA (UGA1 or UGA2 or UGA1/UGA2) and the modulus of the underlying layer
- the coefficient K_s of the base course: $K_s = f(E_{\text{subjacent}})$
- the Sh coefficient (standard deviation on the thickness H) and hence the value of the risk coefficient $K_r = f(Sh)$ for the base course.

Layer thickness modification with the appropriate slider

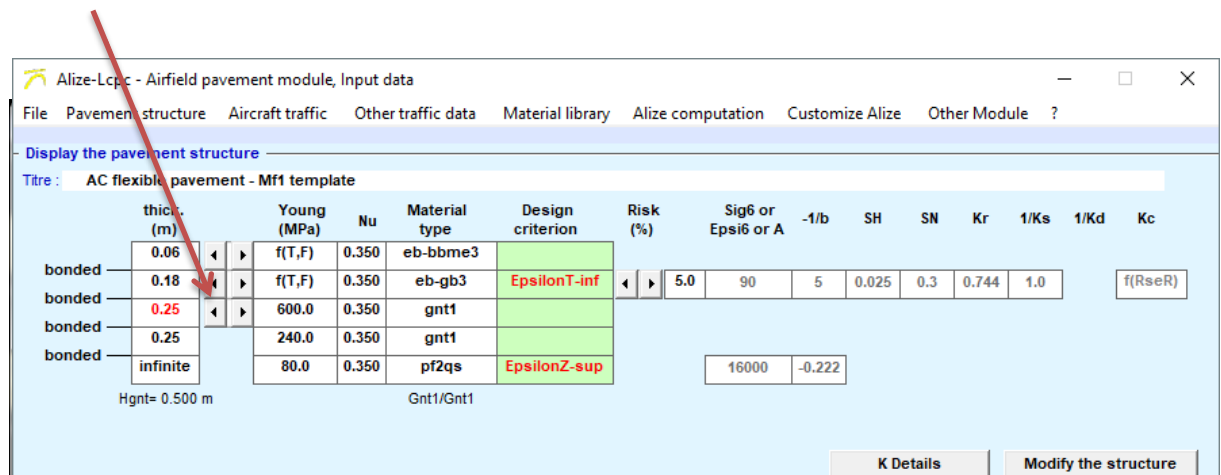


Figure 5 : Changing thicknesses

2.2.2. Modification of the types and classes of materials

All of the materials can be modified. As indicated on the Figure 6, this is done by double-clicking on the box "type of material" and selecting the wanted material.

For bituminous materials, a window with the library of standard materials as per standard NF P 98-086 is displayed. The choice of material is made by selecting the line corresponding to the required material and then clicking on the box "OK". The various mechanical parameters related to the selected material will then be automatically modified.

The bituminous materials that can be used for airfield pavement and their characteristics are detailed in paragraphs 5 and 6 of the design method (STAC, 2014).

For granular materials, a window with the different category of UGA used for the subbase layer is displayed. The choice of the category of UGA according to the class of traffic is specified in section 6.7.5 of the design method (STAC, 2014).

The category of UGA can be selected and validated by clicking on the "OK" box. The UGA moduli are then automatically adjusted according to the UGA category as well as the modulus of the underlying layers and the coefficient Ks of the base course.

For the platform, a window with the library of standard materials for the UGA and subgrade according to standard NF P 98-086 is displayed. Click on the line corresponding to the required material and then click on the "OK" box. The different mechanical parameters of this course, as well as the modulus of the upper UGA layers, will then be automatically modified accordingly.

In this window, two categories of UGA are proposed: UGA-inv and UGA-be. If the user clicks on one of these two lines, an error message is displayed indicating that it is impossible to choose these materials. Only the different types of platforms can be selected.

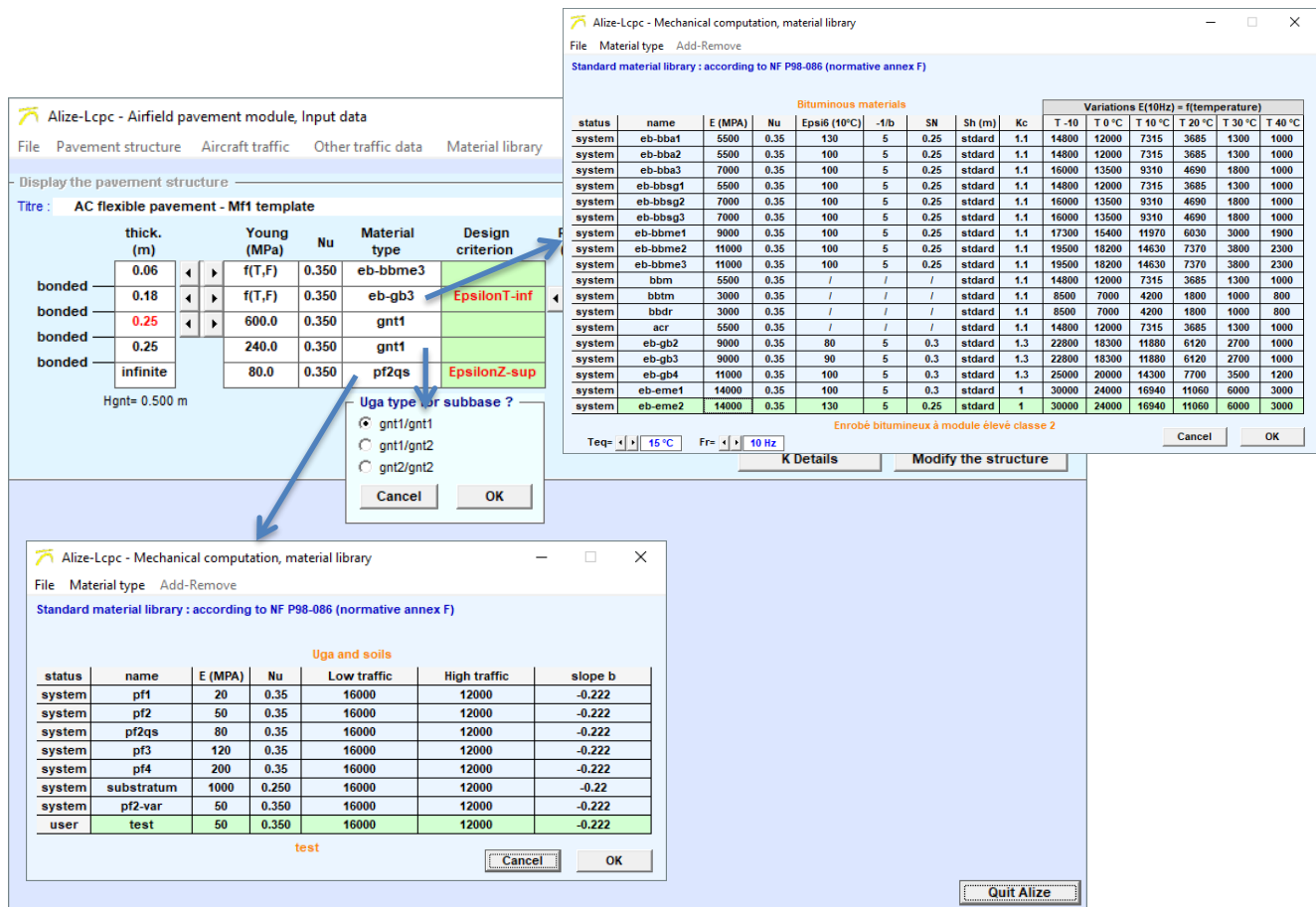


Figure 6. Choice of materials

2.2.3. Utilisation of non-library material

It is possible to use a non-library material by adding it manually. As explained on the Figure 7, proceed as follows:

- In the main menu bar, go to "Materials Library"
- In the "Materials Library" menu bar, choose "Add-Remove", then "Add Material"
- A window is displayed indicating that a new material with the "user" status has been added at the end of the list and its characteristics must be chosen.

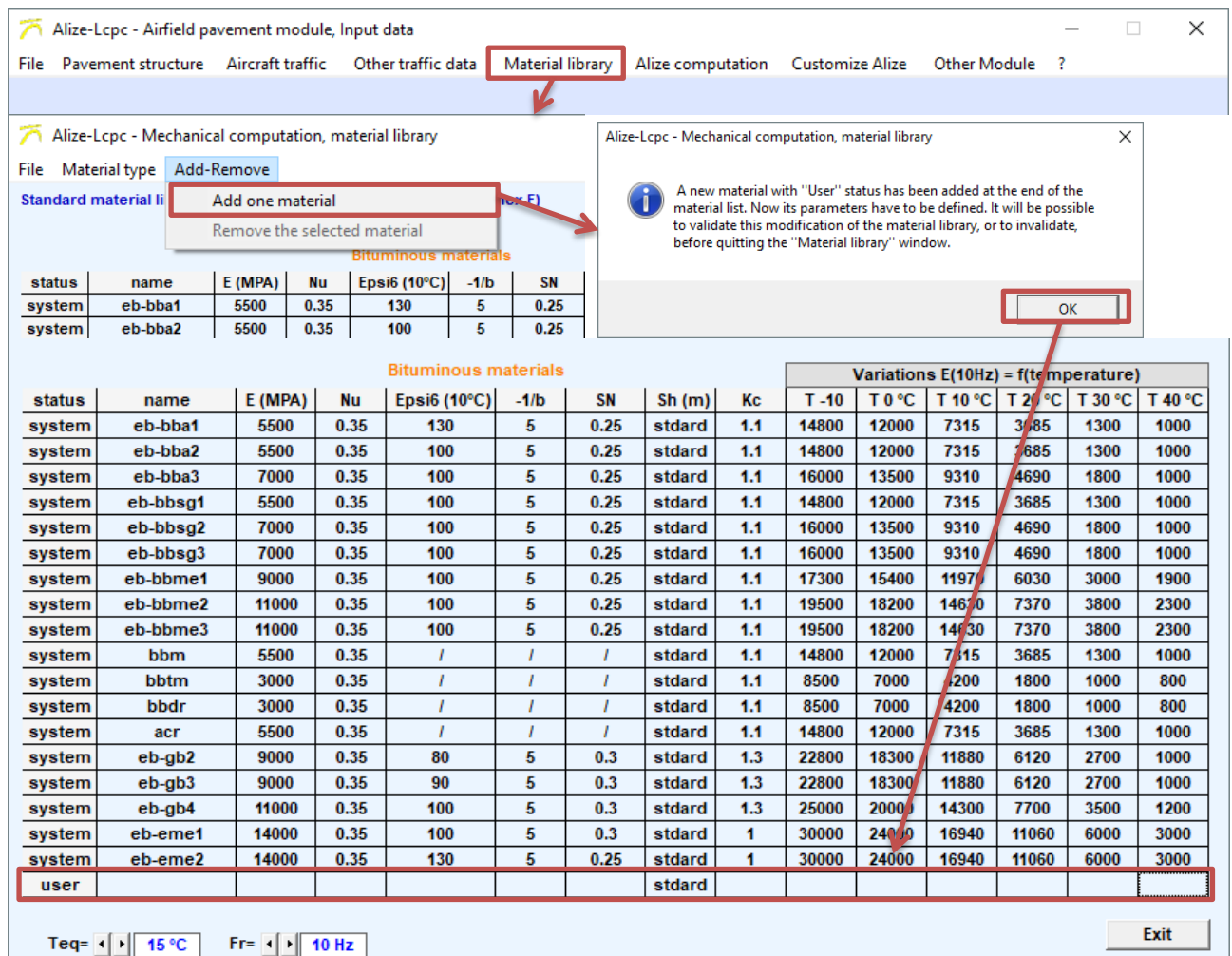


Figure 7. Adding a new material to the library

It is now necessary to manually define these new material parameters and save it in the library.

In the example of the Figure 8, a new material is defined. It is called "eb-new" and its parameters are chosen arbitrarily.

When entering the modules of the materials (not in the 2nd column, which cannot be edited, but in columns 9 to 14), a window is displayed indicating that it is necessary to enter at least two values and a maximum of 6 values corresponding to a frequency of 10 Hz and at different temperatures among those proposed. The modulus at 15°C and 10 Hz is automatically calculated from the entered values and displayed in the 2nd column.

2. Pavement structure

The screenshot displays the Alize-Lcpc software interface. At the top, a table lists various material systems and their properties. The 'user' row, labeled 'eb-new', is highlighted in green and has a red box around it. Below the table, there are input fields for 'Teq' (15 °C) and 'Fr' (10 Hz). A red arrow points from the 'Exit' button to a 'Caution' dialog box that asks if the user wants to save the modification. Another red arrow points from the 'Exit' button to the 'Material type' column in the 'Display the pavement structure' window, where 'eb-new' is selected. This window also shows design criteria like 'EpsilonT-inf' and 'EpsilonZ-sup'.

system	eb-gb2	9000	0.35	80	5	0.3	stdard	1.3	22800	18300	11880	6120	2700	1000
system	eb-gb3	9000	0.35	90	5	0.3	stdard	1.3	22800	18300	11880	6120	2700	1000
system	eb-gb4	11000	0.35	100	5	0.3	stdard	1.3	25000	20000	14300	7700	3500	1200
system	eb-eme1	14000	0.35	100	5	0.3	stdard	1	30000	24000	16940	11060	6000	3000
system	eb-eme2	14000	0.35	130	5	0.25	stdard	1	30000	24000	16940	11060	6000	3000
user	eb-new	17500	0.35	135	5	0.25	stdard	1	35000	30000	20000	15000	10000	5000

Alize-Lcpc - Mechanical computation, material library

Caution :
The library has been modified, cf. library
Bituminous materials
Do you want to save this modification, or not ?

Oui Non Annuler

Alize-Lcpc - Airfield pavement module, Input data

File Pavement structure Aircraft traffic Other traffic data Material library Alize computation Customize Alize Other Module ?

Display the pavement structure

Titre : AC flexible pavement - Mf1 template

	thick. (m)	Young (MPa)	Nu	Material type	Design criterion	Risk (%)	Sig6 or Epsi6 or A	-1/b	SH	SN	Kr	1/Ks	1/Kd	Kc
bonded	0.06	f(T,F)	0.350	eb-bbme3										
bonded	0.18	f(T,F)	0.350	eb-new	EpsilonT-inf	5.0	135.0	5.0	0.025	0.25	0.765	1.0		
bonded	0.25	600.0	0.350	gnt1										
bonded	0.25	240.0	0.350	gnt1										
bonded	infinite	80.0	0.350	pf2qs	EpsilonZ-sup		16000	-0.222						

Hgnt= 0.500 m Gnt1/Gnt1

K Details Modify the structure

Figure 8. Choice of new material

Once all the parameters have been filled in, click on "Close". A window is displayed asking if the modifications have to be saved. Clicking on "Yes", another window is displayed indicating that the update library has been saved.

By default, the library is saved under:

D:/ "User name" / Documents / Alize-Lcpc my-files / Libraries

The file name is "matuser.lib".

Once the new material has been saved, as shown on the Figure 8, it is possible to choose it in the structure. As stated in paragraph 0, double-click on the "Material type" box, the window with the materials of the library opens and it is then possible to choose the material that has been created.

It is important to note that when an added material is used in a structure as a base course, during the design calculations, a window is displayed asking the Kc parameter to be defined. The user is prompted to choose from a law of evolution of the same type as that a GB or an EME2. The user must then specify "gb" or "eme2" in the window before launching the calculations.

To delete this material from the library:

- In the main menu bar, go to "Materials Library"
- Select the material to be deleted
- Choose "Add-Remove", then "Delete selected material"
- A window is displayed stating that the new material has been deleted

2.2.4. Modification of Poisson's ratios for the materials

It is possible to modify the Poisson's ratios for all materials. To do so, double-click to the relevant box.

For the Poisson's ratio, a window is displayed. It is possible to choose the value of this ratio. If the user enters a value other than the default value (0.35), a warning message is displayed. This message indicates that the chosen value does not comply with the rational design method for flexible airfield pavements.

The Figure 9 shows this possibility:

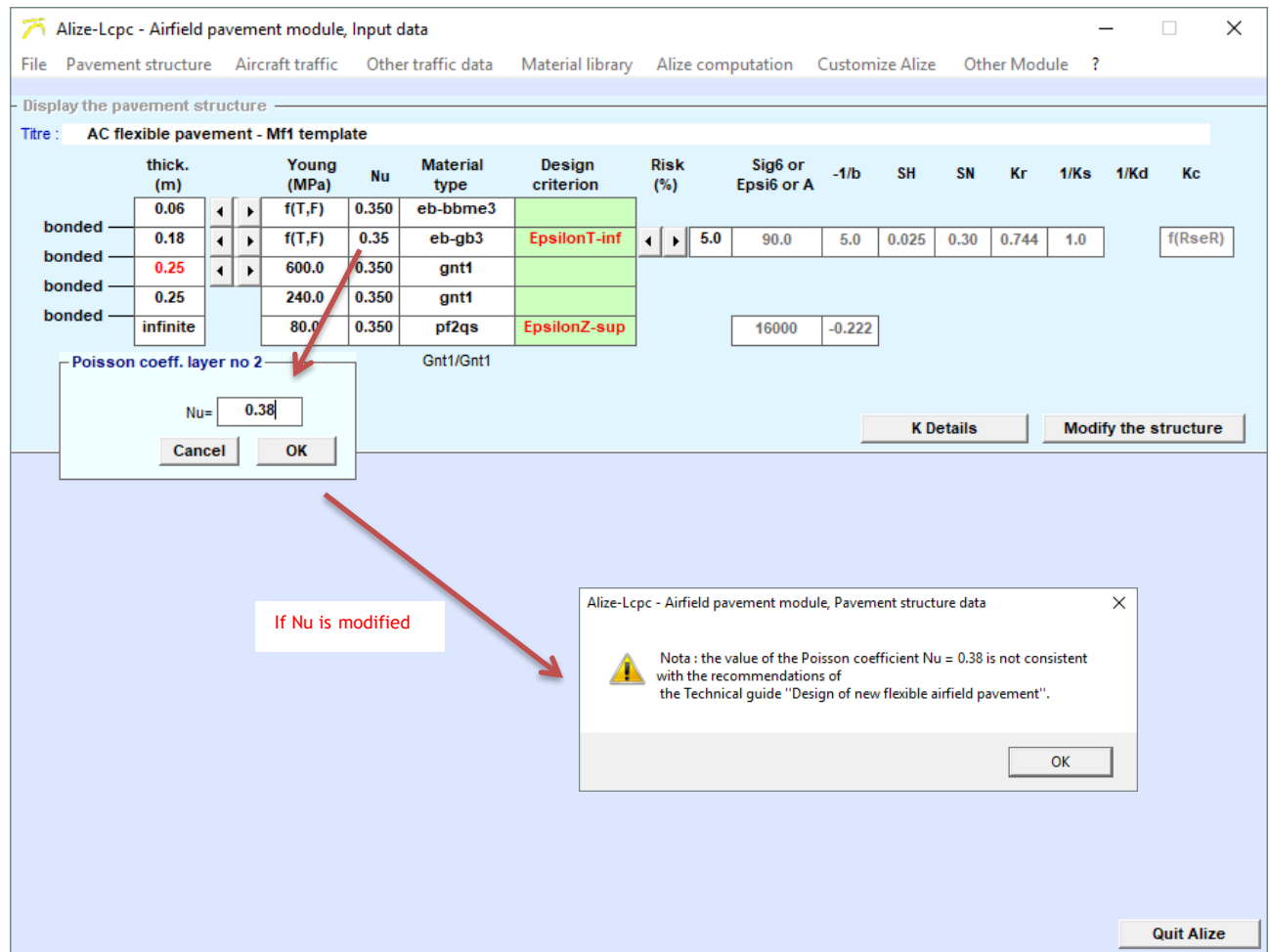


Figure 9. Modification of Poisson's ratios

2.2.5. Modification of the risk

In paragraph 3.1.1 of the design method (STAC, 2014), some risk values are recommended (related to the traffic class) even if this parameter should be set by the contracting authority.

As explained on the Figure 10, it is possible to modify the risk values by clicking on the cursors.

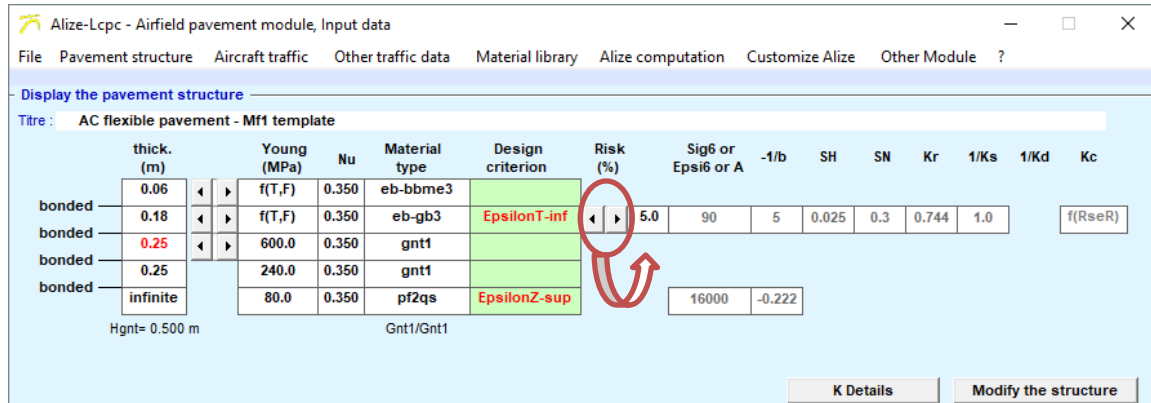


Figure 10. Modification of the risk

2.3. Modifying the flexible structure model: other features

2.3.1. Adding a bedrock

In section 4.6.1 of the design method (STAC, 2014), it is specified that if a bedrock is located at a depth of between 2 and 6 meters, its presence in the model must be taken into account by dividing the supporting bed into two layers. One has a finite thickness and the other, representing the bedrock, has an infinite thickness.

In order to add bedrock, as indicated on Figure 11, double click on the "infinite" box. A message is displayed asking the user to confirm the choice. Click on "OK".

To remove this bedrock and getting back to a homogeneous semi-infinite subgrade: double-click again on the "infinite" box.

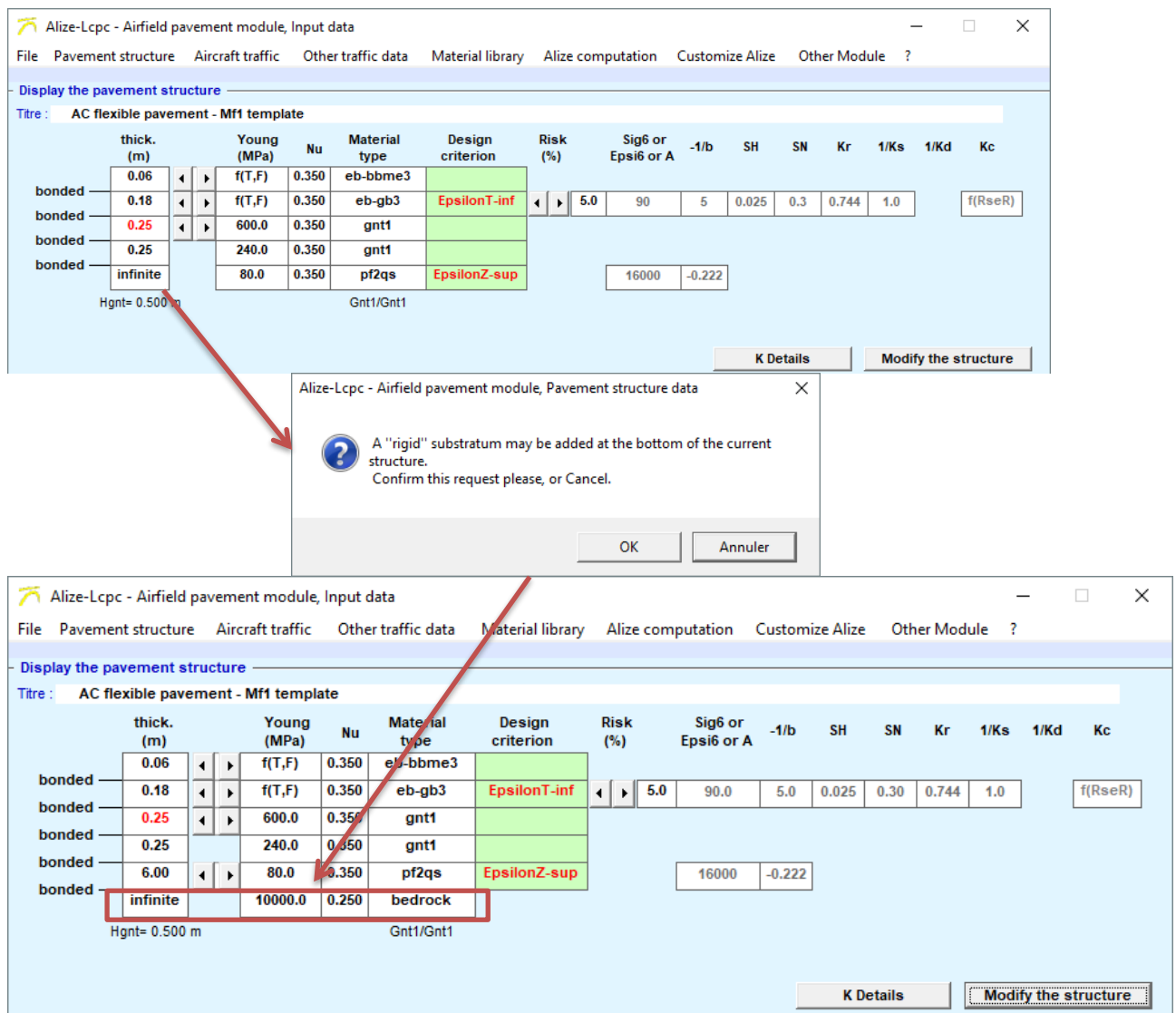


Figure 11. Adding a bedrock

2.3.2. "K Details" command

Under the pavement structure displayed, on the right, there is a "K Details" button.

"K Details" command is used to edit on the screen the synthesis of the mechanical parameters used for subsequent damage calculations. In particular, the modules of the hydrocarbon materials $E=f(T,F)$, as a function of the equivalent temperature and the speed associated with each aircraft in the traffic, and the permissible values $\epsilon_T\text{-adm}$ and $\epsilon_z\text{-adm}$.

Since some of these parameters depend on the temperature and speed set for each aircraft, Aircraft traffic must be defined before using the "K Details" function.

2.3.3. Deleting the asphaltic base layer

Paragraph 1.2 (and 2.6) of the design method (STAC, 2014) specifies that when the design traffic is low and not very aggressive with respect to the wearing course in question, the base course may be made of granular materials.

Its implementation in Alizé-Aéronautique is done simply by deleting the base asphalt mix.

To delete the base asphalt mix, click on the left cursor of the base course thickness setting until the thickness is equal to zero. Then a window is displayed to confirm the removal.

By clicking OK, the asphaltic base layer is automatically deleted (Figure 12) and the granular base course is integrated into the subbase layer as a UGA.

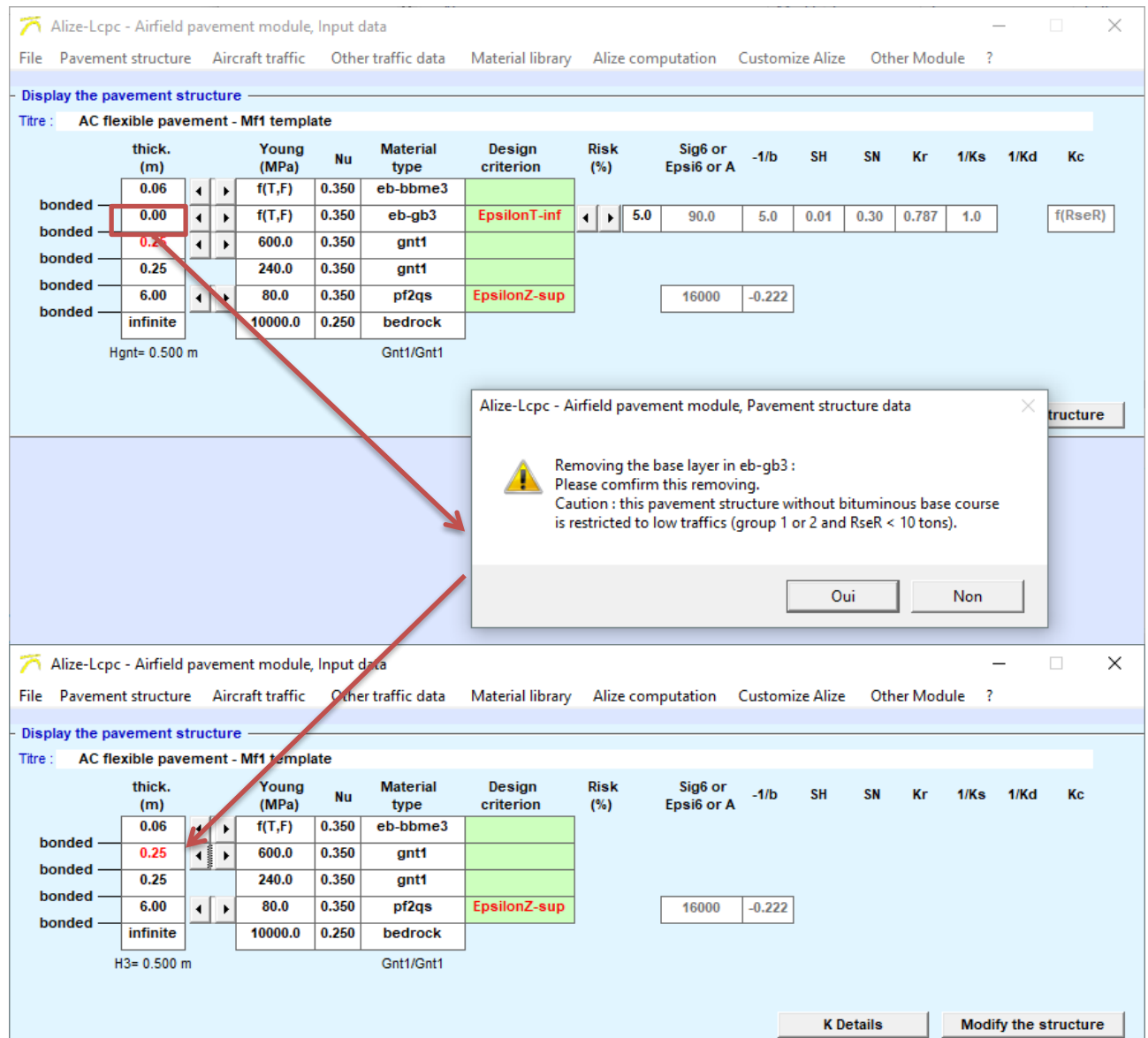


Figure 12. Delete the base asphalt mix

2.3.4. Adding a binder course

It is possible to add a binder course by double-clicking on the thickness box of the wearing course. A window is displayed and asks if the user wants to add a binder course; click on Yes.

A 5 cm layer of BBSG-3 is then automatically added to the flexible model (Figure 13). It is possible to modify the different parameters of this course.

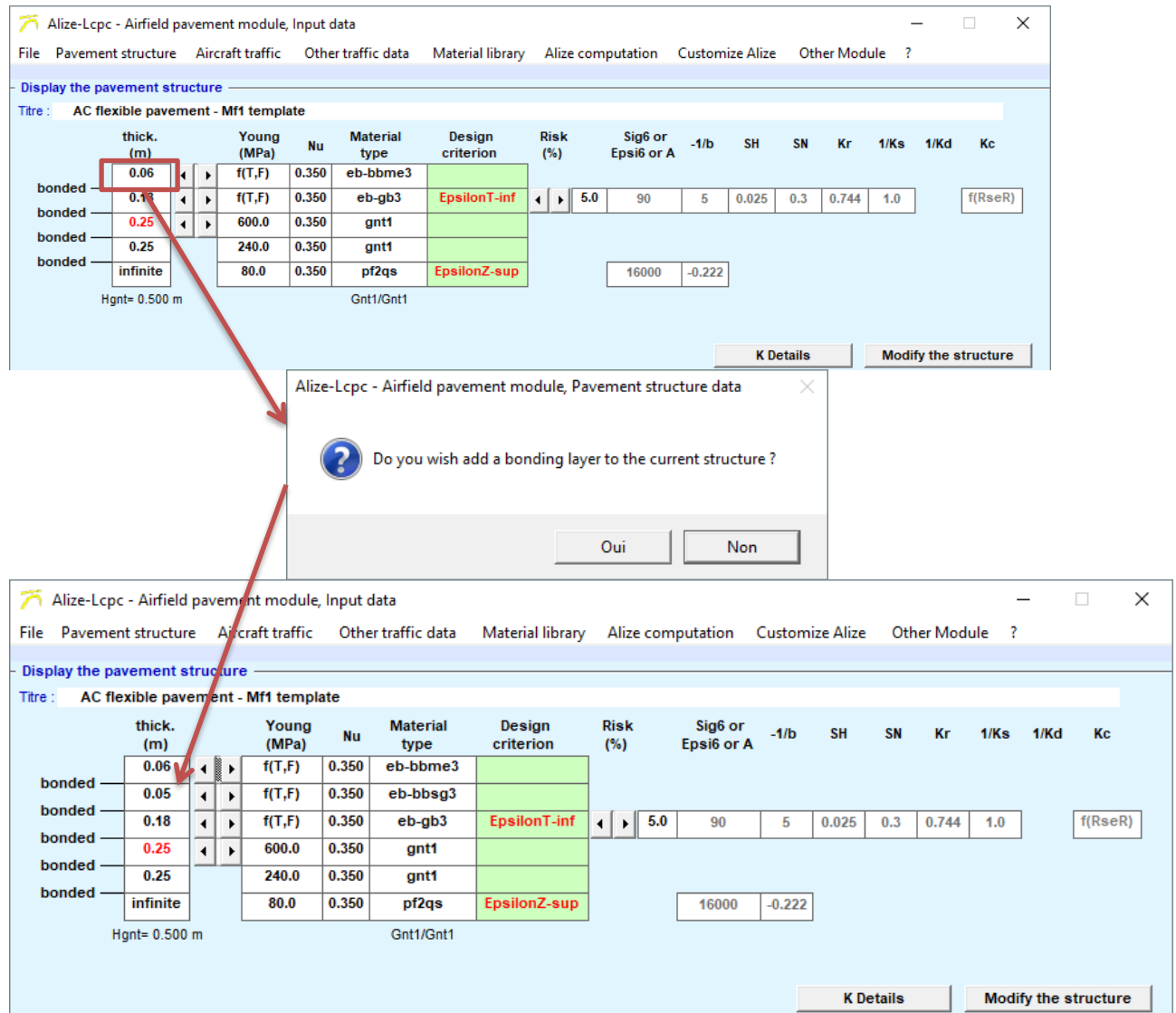


Figure 13. Add a binder course

It is possible to delete the binder course by double-clicking on the thickness box of the wearing course. A window is displayed and asks if the user wants to delete the binder course. Click on "yes".

2.3.5. "Modify structure" button

The "Modify structure" button displays a help window. Different explanations are given: how to change the thickness of a course, etc. (Figure 14).

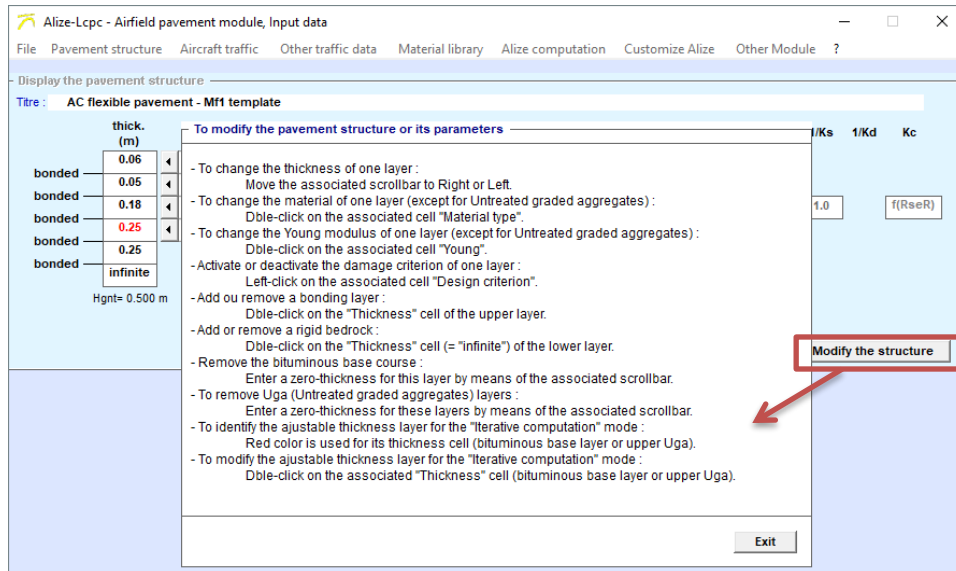


Figure 14. Modification of the structure

2.4. Saving pavement structure

It is possible to save the pavement structure by clicking on (Figure 2):

- "File"
- "Structure Data"
- "Save as"
- A window is displayed
- The default path is: "Libraries\Documents"
- The file name is to be completed
- The extension is ".dat"

3. General configuration of Alizé-Aéronautique



Alizé-Aéronautique

It is possible to modify some default settings of Alizé-Aéronautique.

In the main menu bar, in the "Configure Alizé" tab, then in "General configuration" (Figure 15), it is possible to modify:

- The equivalent temperature
- The "Click yellow Alizé" parameters
- The display format (expanded fonts)
- The access path to the default save file
- The default new material save access path
- The language (French or English)
- Country options, units and sign conventions are also recalled by clicking on the corresponding buttons

The "Click yellow Alizé" settings are only used to change the colour of the "Design criterion" boxes, which are green by default.

By default, the equivalent temperature is 15°C. This temperature is applicable for oceanic, Mediterranean or continental climates, according Paragraph 3.1.4 of the design method (STAC, 2014). Other values of equivalent temperatures depending on the type of climate or location are also specified.

It is not possible to modify the standard library of materials. The rational design method for flexible airfield pavements (STAC 2014) specifies that the material parameters are by default those indicated in the Standard Application Guide (STAC, 2009), corresponding to the library "Standard NF P 98-086".

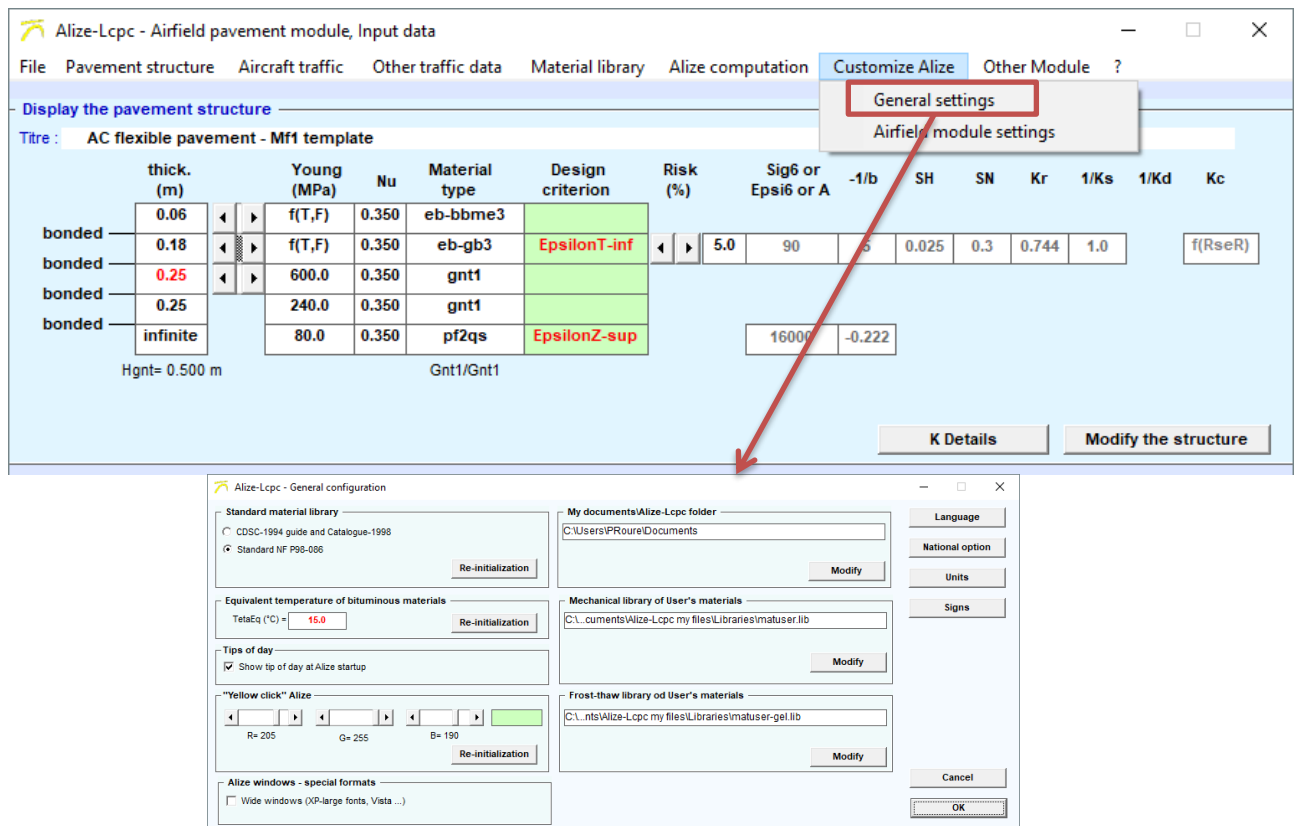


Figure 15 : Configuring Alizé: general configuration

In the main menu bar, on the "Configure Alizé" tab, then in "Aeronautical preferences" (Figure 16), it is possible to modify some default settings such as:

- Cumulative traffic: which is fixed at 36,500 passages
- Lateral wander: the fixed value is 1.5m. This value is that indicated in section 3.1.3.2 of the Design Guide (STAC, 2014) for high-speed sections.
- Aircraft speed: the set value is 100 km/h. This value is that indicated in section 3.1.3.1 of the Design Guide (STAC, 2014) for high-speed sections.
- The service life: the fixed value is 10 years. Paragraph 3.1.1 of the design method (STAC, 2014) states that the calculation period is generally 10 years.

It is also possible to take into account the nose wheel of the aircraft.

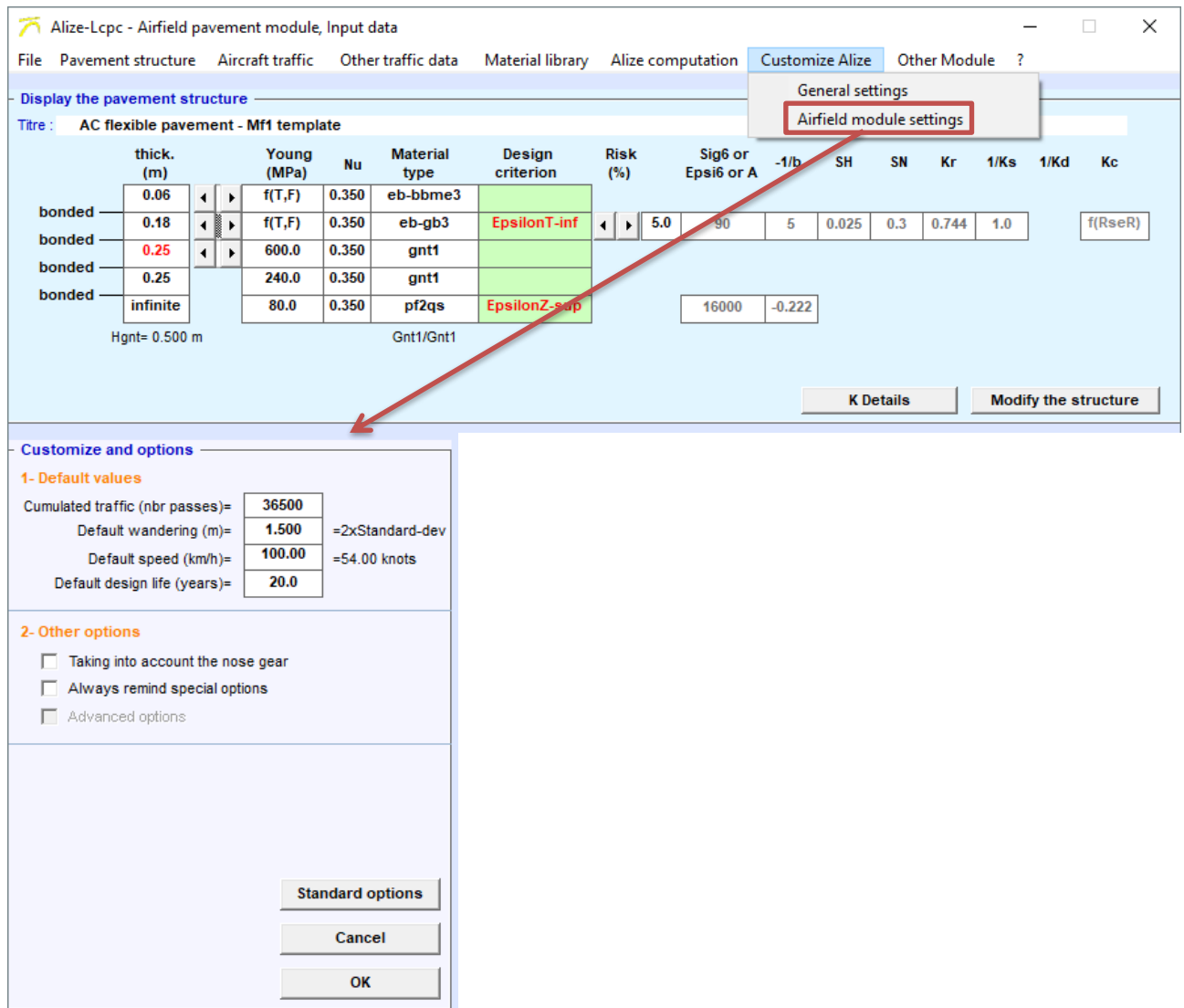


Figure 16. Configuring Alizé: aviation preferences

4. Definition of the traffic



Alizé-Aéronautique

The loading of the Aircraft Database (Bda) is mandatory. Usually, the STAC Bda is automatically loaded by Alizé-Aéronautique.

A missing or defective load is indicated by the message: "Cannot activate the Aircraft Traffic menu. The Aircraft Database (Bda) has not been loaded, or incorrectly loaded."

In this situation, it is possible to load the Aircraft Database manually. The STAC Bda is stored in the ficav2016-10-13.bda file under the following directory:

C:\Program Files\Alize-Lcpc Routes

This database is loaded from the main menu bar (File - Database - Open Bda).

If a new version of the database is provided, you will have to place it in the same directory. The next time you launch Alizé-Aéronautique, it will automatically suggest that you replace the old base with the new one.

4.1. Select an aircraft

Aircraft traffic is selected from the main menu bar. Choose "Aircraft Traffic" (Figure 17).

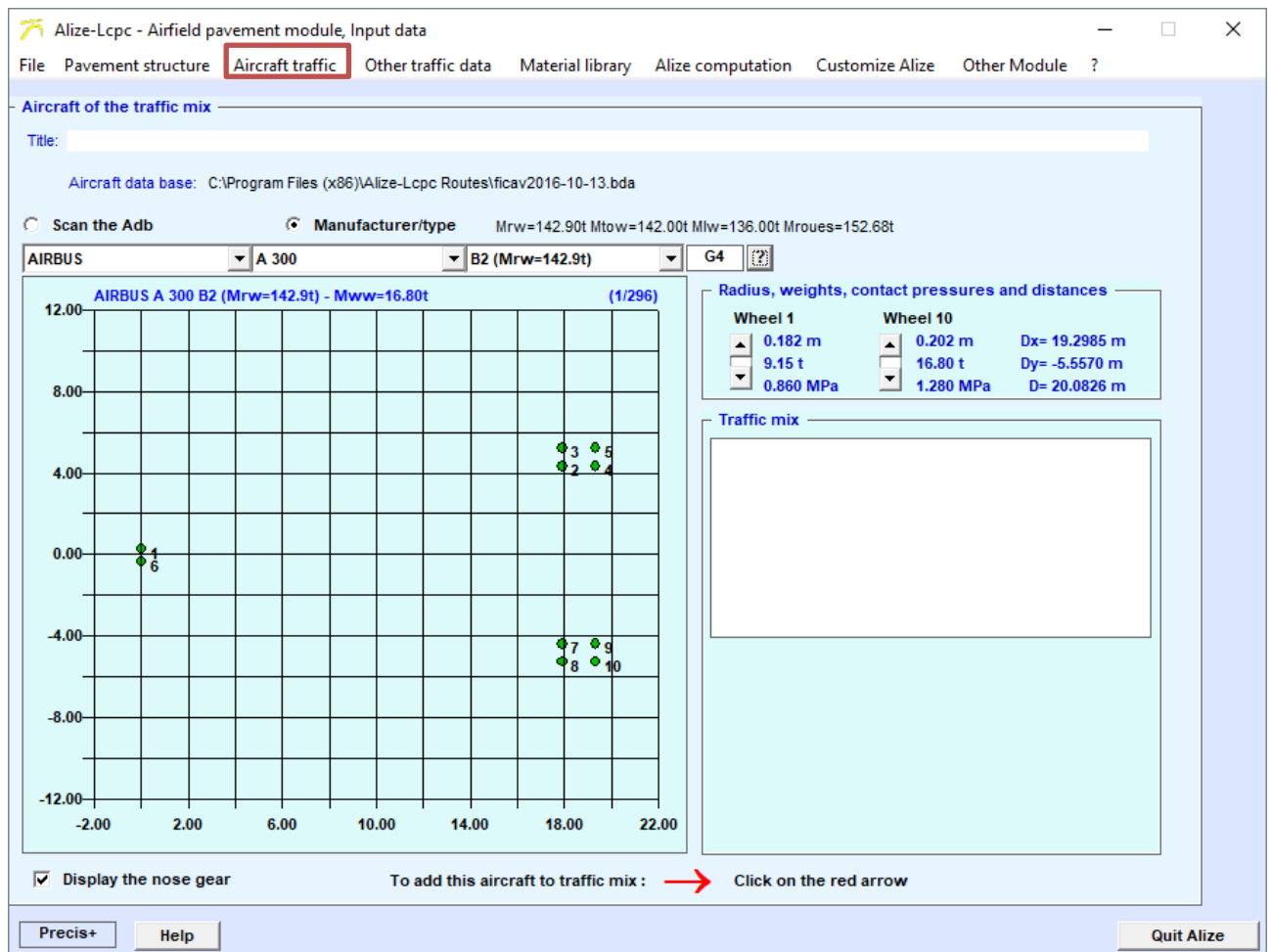


Figure 17. Defining project traffic in the main menu

4. Definition of the traffic

It is now necessary to select the aircraft of the project traffic.

This selection of aircraft is carried out by manufacturer, type and model of aircraft, from the drop-down menus as indicated on the Figure 18, Figure 19 and Figure 20.

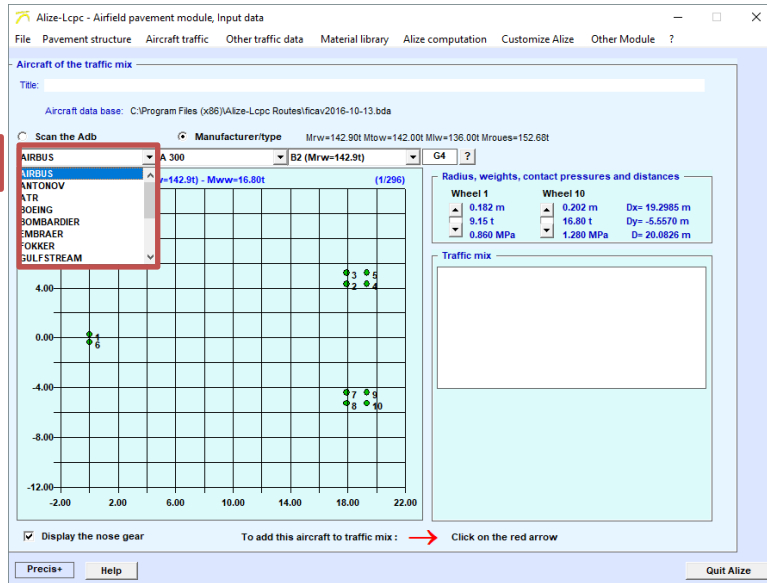


Figure 18. Selecting the make of aircraft to add to the project traffic

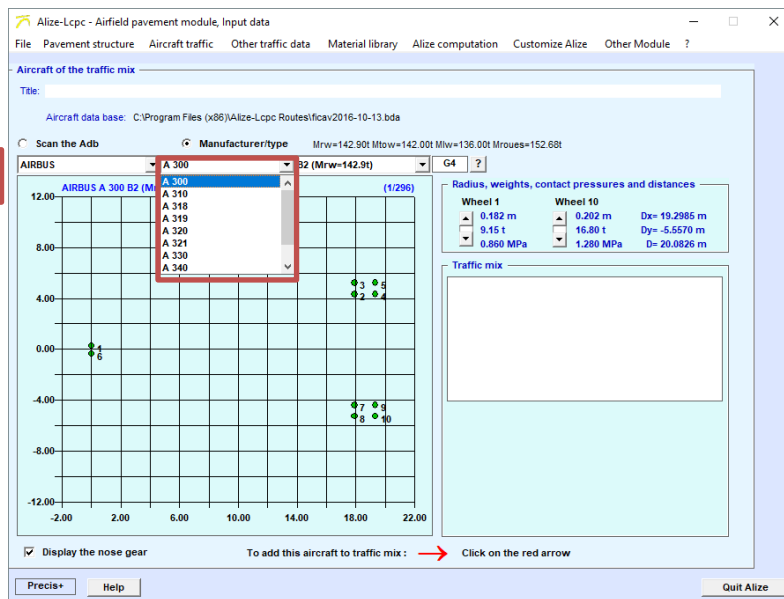


Figure 19. Selecting the type of aircraft to add to the project traffic

4. Definition of the traffic

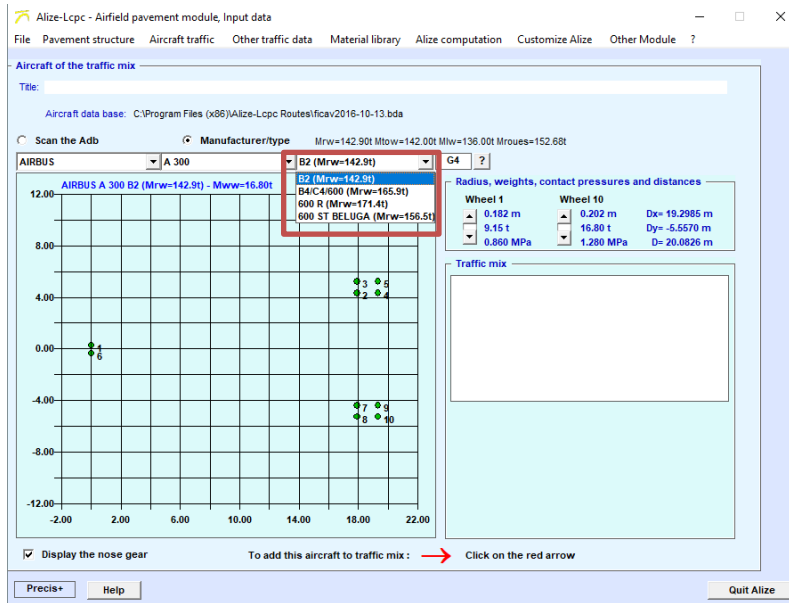


Figure 20. Selecting the model of aircraft to add to the project traffic

Information on the radius, weight and pressure of the wheels, as well as distances, are displayed automatically on the main window (Figure 21).

The group number of the aircraft (according to the GAN) is also automatically indicated.

It is possible to have more information on the selected aircraft by clicking on the "?".

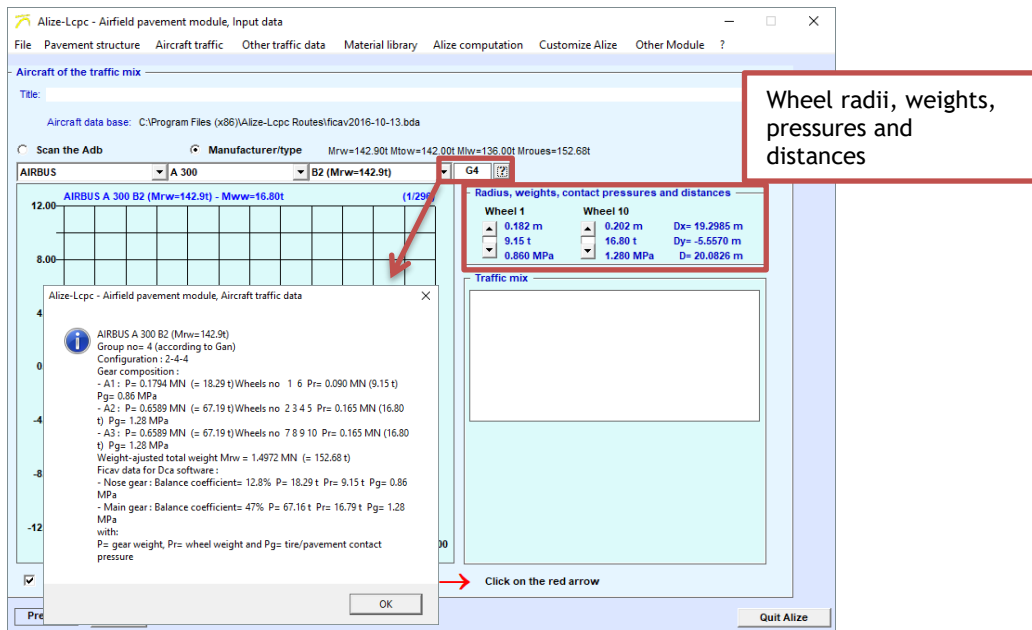


Figure 21. Information about the selected aircraft

4.2. Adding the selected aircraft

To add the selected aircraft to the traffic, simply click on the red arrow at the bottom of the main window (Figure 22).

When the aircraft is added, it is automatically displayed in the "Project traffic composition" window.

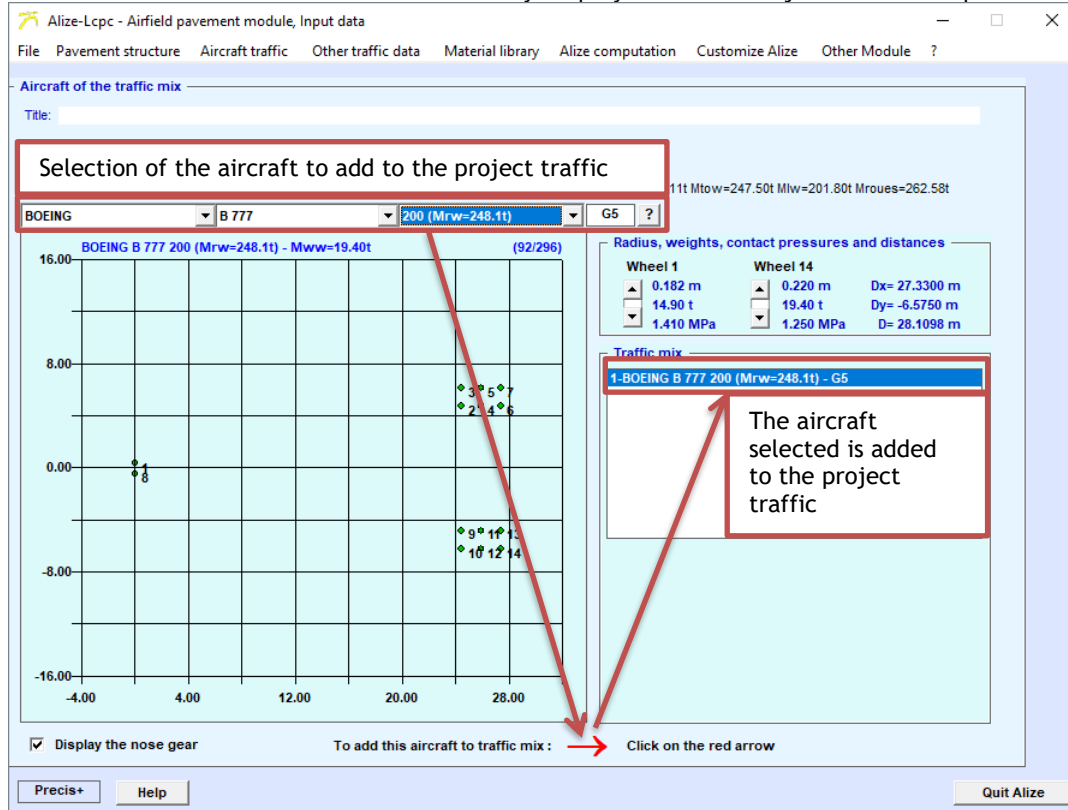


Figure 22. Add the selected aircraft to project traffic

4.3. Other settings

It is possible to obtain further information on the selected aircraft such as the bearing axes (Figure 23).

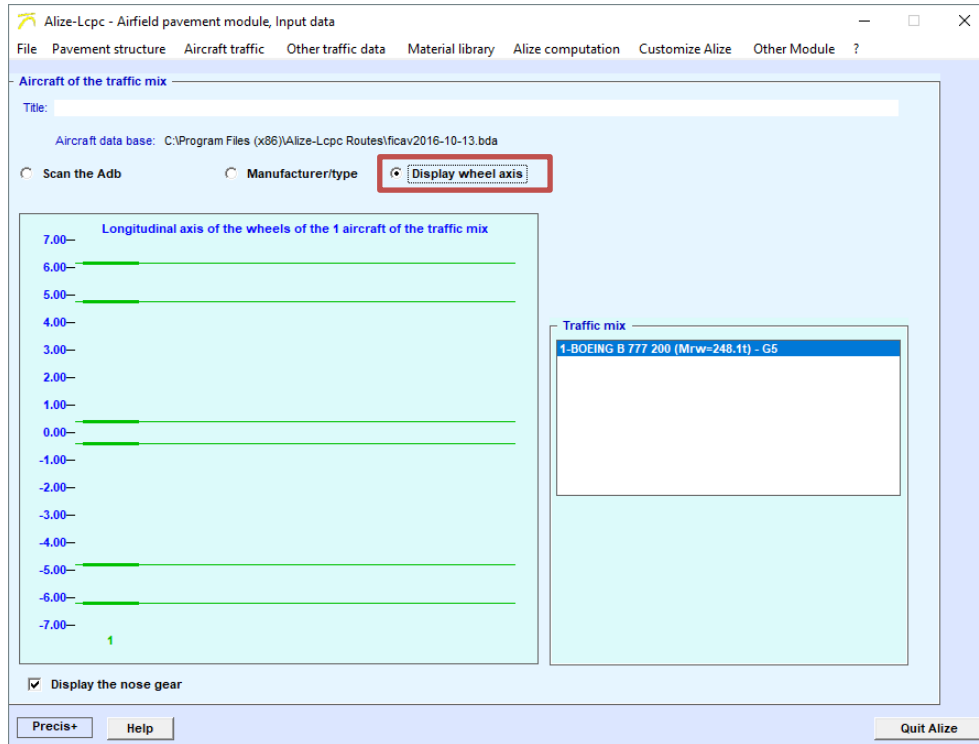


Figure 23. Display of bearing axes

It is also possible to remove the front landing gear. In this case, deselect the option "Draw the front landing gear" (Figure 24).

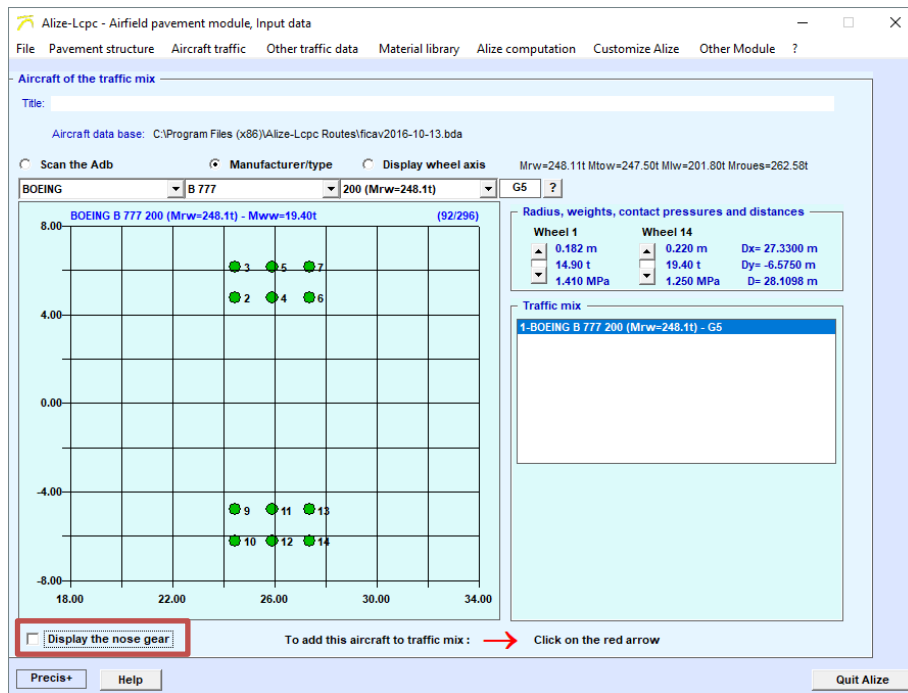


Figure 24. Remove the front landing gear

5. Other traffic data setting

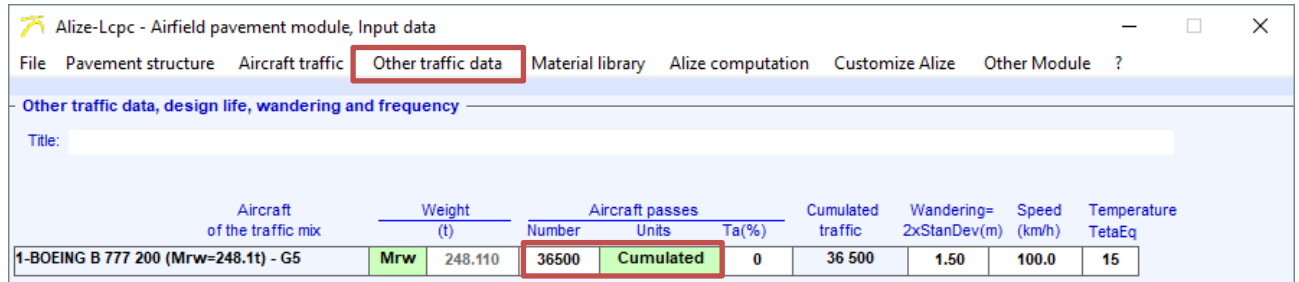


Alizé-Aéronautique

5. Other traffic data setting

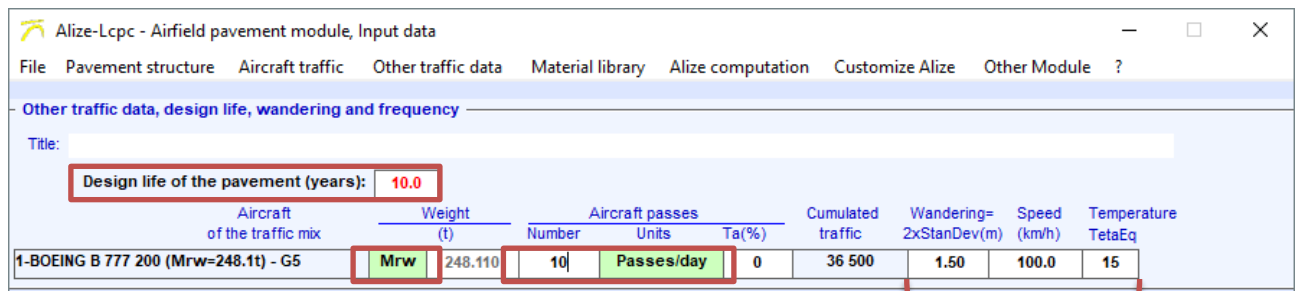
The other parameters can be selected from the main menu bar by clicking on the tab "Other traffic data" (Figure 25).

The default settings are those defined in the "Configure Alizé" menu, then "Aeronautical preferences" (see Chapter 5).



Aircraft of the traffic mix	Weight (t)	Aircraft passes		Ta(%)	Cumulated traffic	Wandering= 2xStanDev(m)	Speed (km/h)	Temperature TetaEq	
		Number	Units						
1-BOEING B 777 200 (Mrw=248.1t) - G5	Mrw	248.110	36500	Cumulated	0	36 500	1.50	100.0	15

OR



Aircraft of the traffic mix	Weight (t)	Aircraft passes		Ta(%)	Cumulated traffic	Wandering= 2xStanDev(m)	Speed (km/h)	Temperature TetaEq	
		Number	Units						
1-BOEING B 777 200 (Mrw=248.1t) - G5	Mrw	248.110	10	Passes/day	0	36 500	1.50	100.0	15

Parameters that can be modified

Figure 25. Settings for other traffic data

5.1. Choice of weight

Several weights are supplied by the aircraft manufacturers and can be selected by clicking on the green box "Mrw". :

- the maximum weight for taxiing indicated in the Airworthiness Certificate (or maximum ramp weight Mrw) corresponding to the maximum permissible aircraft weight when taxiing on the aprons.
- the maximum take-off weight, Mtow, indicated in the certificate of airworthiness corresponding to the maximum permissible weight of the aircraft on take-off.
- the maximum landing weight, Mlw, indicated in the certificate of airworthiness corresponding to the maximum permissible weight of the aircraft on landing.
- "Other"

As stated in chapter 3.1.2.2 of the design method (STAC, 2014), in the absence of more precise information, the following weights supplied by manufacturers will be used:

- the maximum ramp weight Mrw for take-off's.
- the maximum landing weight Mlw for landings.

Note: If another weight than Mrw, Mtow or Mlw is to be used, it is possible to select "Other" and manually enter the required weight.

5.2. Choice of the number of movements

As indicated on the Figure 25, the number of movements is a parameter to be defined for each aircraft. By default, the number of cumulative movements is displayed, which is set to 36,500.

The default value of 36,500 can be changed in the "Configure Alizé" section by selecting "Aeronautical preferences" (see Chapter 5).

By clicking on the green box "cumulative movements", it is possible to choose between different ways of indicating the cumulative traffic, independently from one aircraft to another:

- The number of cumulative movements ("Cumulative Mvts" box), i.e. the number of movements of the aircraft over the entire calculation period. In this case, neither the calculation period nor the rate of increase can be modifying.
- The number of movements per day (box "Mvts/day"). In this case, various parameters are expected in order to automatically calculate the cumulative traffic:
 - the calculation period (by default, 10 years),
 - the number of movements per day,
 - The rate of increase (box "Ta(%)").
- The number of movements per week ("Mvts/week" box). In this case, various parameters are expected in order to automatically calculate the cumulative traffic:
 - the calculation period (by default, 10 years),
 - the number of movements per week,
 - the rate of increase (box "Ta(%)").
- The number of movements per month ("Mvts/month" box). In this case, various parameter are expected in order to automatically calculate the cumulative traffic:
 - the calculation period (by default, 10 years),
 - the number of movements per month,
 - the rate of increase (box "Ta(%)").

5.3. Adjusting the lateral wander, speed and equivalent temperature

In Alizé-aéro, the lateral wander, speed and equivalent temperature settings can be changed.

The lateral wanders and speed default parameters are the high speed cross section design parameters. The default wander value is 1.5 m and the default speed is 100 km/h.

Some recommendations are given in order to define these parameters:

- Table 4 of the design method (STAC, 2014) shows the displacement velocities as a function of the section type.
- Table 5 of the design method (STAC, 2014) shows the standard deviations (wander=2× standard deviation) as a function of the type of section.
- Chapter 3.1.4 of the design method (STAC, 2014) indicates the equivalent temperature values depending on the type of climate or geographic area.

5.4. Saving project traffic

It is possible to save project traffic by clicking on (Figure 2):

- "File"
- "Aircraft traffic data"
- "Save as"
- The default path is: "Libraries\Documents"
- The file name is to be completed
- The extension is ".dap"

6. Calculations



Alizé-Aéronautique

It is now assumed that the structure has been defined, as well as the traffic. The next step consists in launching the calculations.

Two calculation options are available:

- "Single calculation" of strains and damage for selected Structure and Traffic data (no iterations on thicknesses). Thickness adjustments for a cumulative damage value of 1 have to be done manually.
- "Iterative calculation": iterations on thicknesses with a cumulative damage value equal to 1. According to the choice of the user, the iterations will be made by adjusting the thickness of the base course (GB, EME) or the subbase layer (UGA), for flexible structures "Mf1". The layer thickness to be adjusted is indicated by the red colour of its "thickness" box.

The calculations can be launched from the main menu bar by selecting "Alizé calculation" then "Single calculation" or "Iterative calculation" (Figure 26).

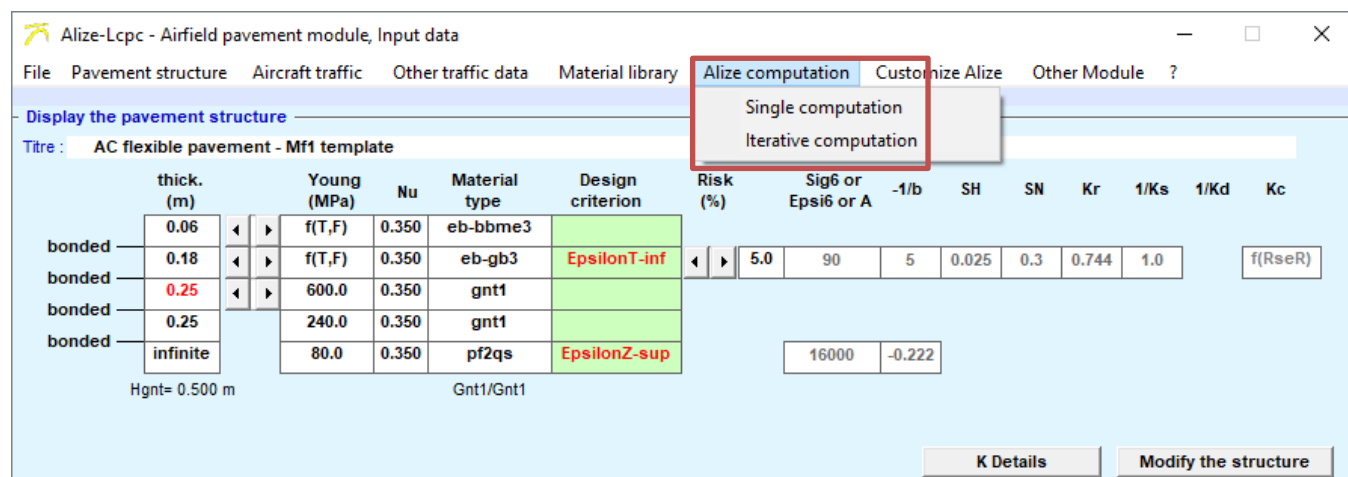


Figure 26. Launching the calculations

Single mode Calculation In order to illustrate the calculation process according to the "single calculation" mode, project traffic with two aircraft has been defined:

- An Airbus A300 B2
- A Boeing B777 200

The selected traffic settings are the default settings.

6.1.1. Launching the calculations

The calculation can be launched from the main menu bar, "Alizé calculation", then "Single calculation" (Figure 27). In that case, a window is displayed indicating that the default traffic has not been changed and asking if the user wants to continue/carry on.

After clicking on "OK", another window is displayed, indicating the values:

- of the Equivalent Single wheel Load (ESWL), which is defined in chapter 2.6 of the design method (STAC, 2014),
- of the calibration coefficient K_c of the bituminous materials, calculated as a function of the ESWL (see chapter 2.7.1.2 of the design method (STAC, 2014).

Click "OK" again.

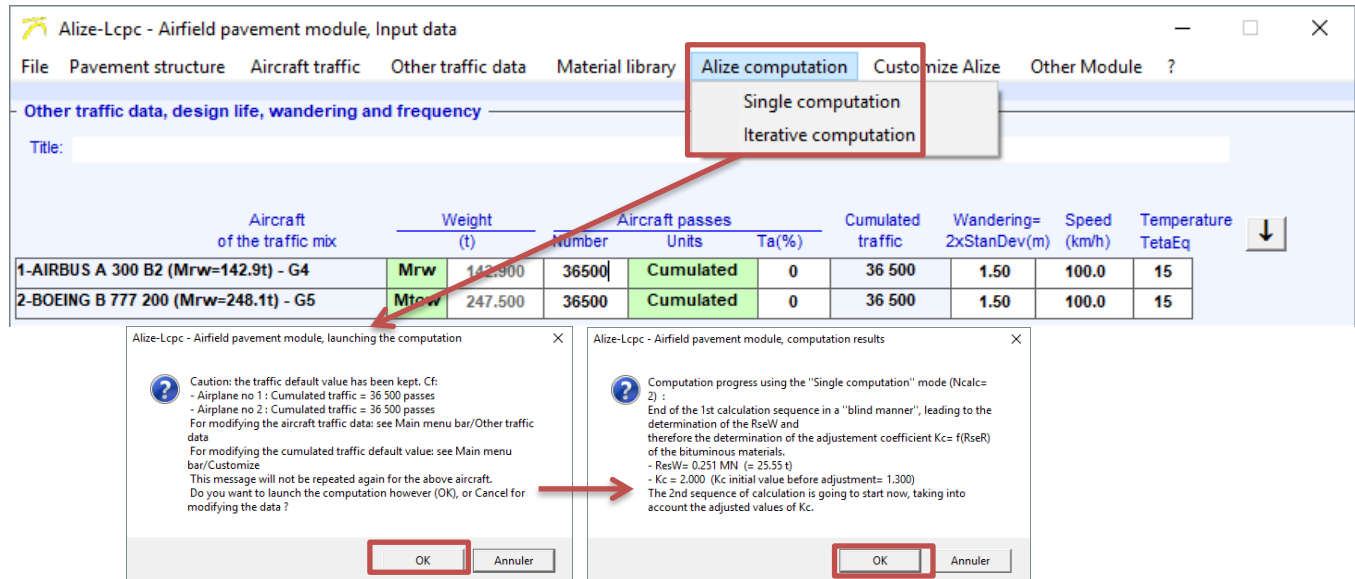


Figure 27. Launching the calculations according to the "Single Calculation" mode

Once the calculations are launched, a window is displayed (Figure 28). This is the first calculation result: the damage with wander at the base of the layer made of bituminous materials for the first aircraft of the project traffic.

The sequence of calculations is as follows:

- calculation of the damage at the bottom of the layer of bituminous materials for each aircraft of the project traffic
- calculation of the damage at the top of the layer of unbound materials for each aircraft of the project traffic

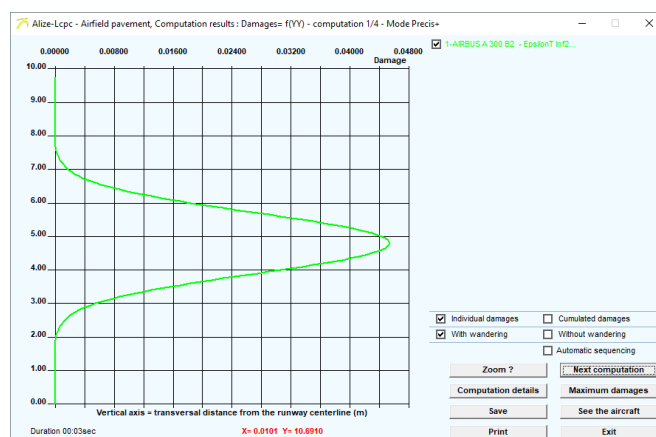


Figure 28. First calculation result

6.1.2. Calculation sequence

To perform all the calculations, the user could both (Figure 29):

- click on "Next Calculation" at the end of each calculation
- or check the box "Auto sequencing" and then click on "Next calculation", in which case the calculation sequence is automatic

"Manual" calculation sequencing

Individual damages ☒ Cumulated damages ☐
With wandering ☒ Without wandering ☐
Automatic sequencing ☐
Zoom ? **Next computation**
Computation details Maximum damages
Save See the aircraft
Print Exit

OR

Automatic calculation sequencing

Individual damages ☒ Cumulated damages ☐
With wandering ☒ Without wandering ☐
Automatic sequencing ☒
Zoom ? **Next computation**
Computation details Maximum damages
Save See the aircraft
Print Exit

Figure 29. Calculation sequence

6. Calculations

When all the calculations have been made, the graph displayed shows the cross-sectional damage profiles (for the two criteria) for each aircraft, with wander (Figure 30).

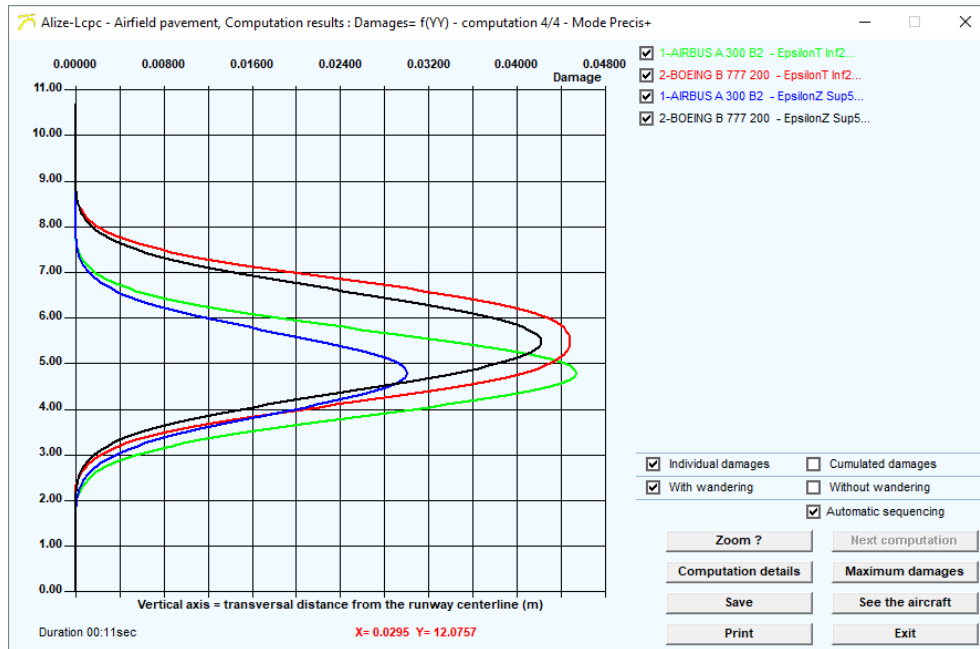


Figure 30. Calculation results: damage with wander per aircraft

It is possible to display other curves by selecting the various boxes surrounded in red on the Figure 31. For example:

- Damage per aircraft with wander
- Damage per aircraft without wander
- Cumulative damage with wander
- Cumulative damage without wander

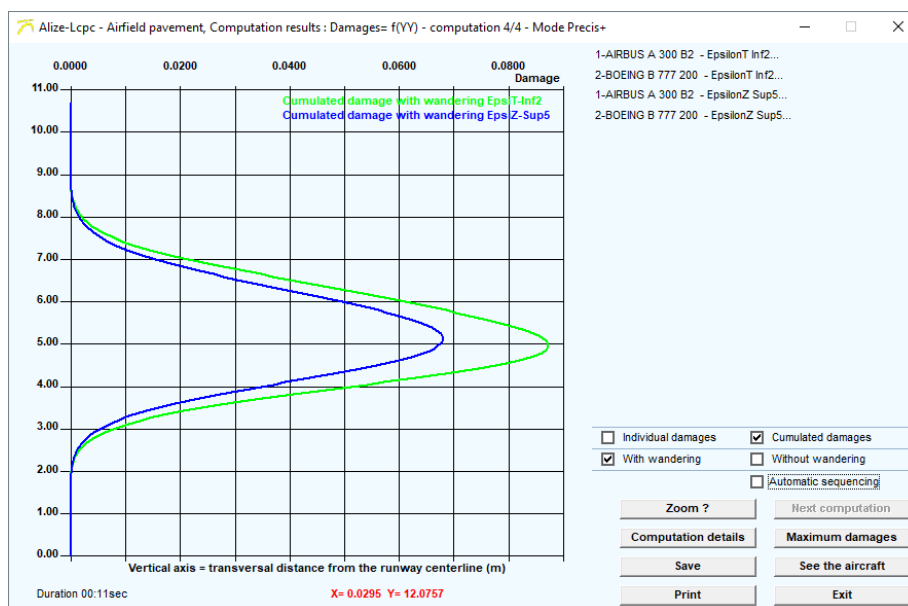


Figure 31. Calculation results: cumulative damage with wander

6.1.3. Zoom

It is possible to zoom directly on the graphic displayed on the screen. To do so, click on the "Zoom?" button (Figure 32).

A window is displayed, explaining how to zoom in on the graph. Click on "OK" and with the mouse left-click without releasing to set the zoom window. Then press the "Enter" key. The zoom is done automatically. To zoom out, double-click on the graph.

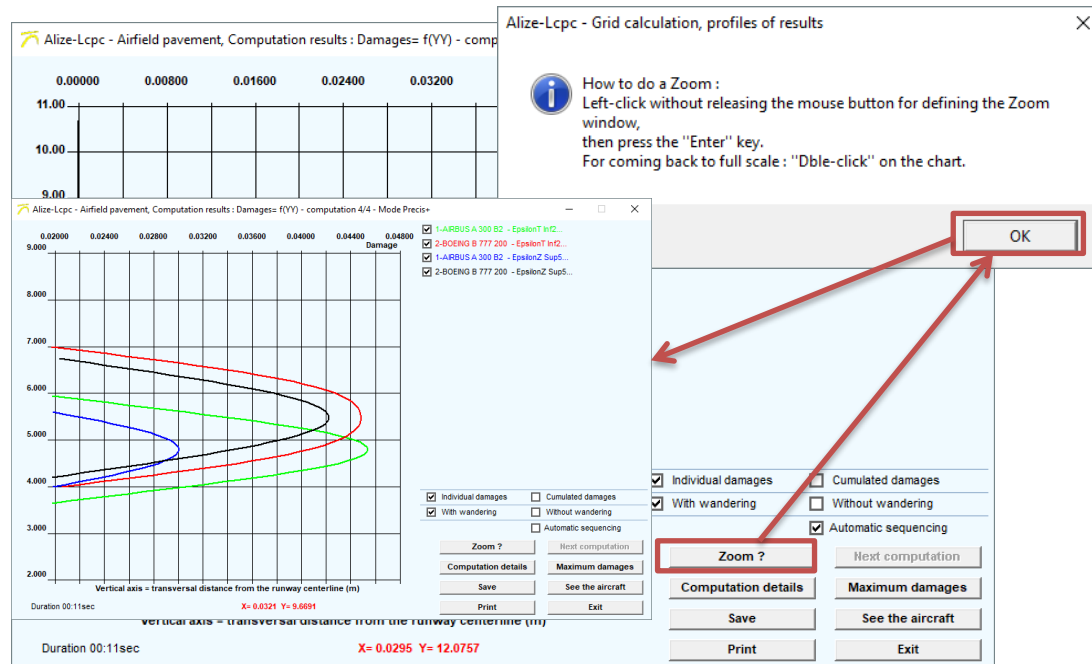


Figure 32. Zoom

6.1.4. Calculations details

Some calculation details (such as tabular results) can be obtained by clicking on the "Calculations Details" button (Figure 33).

It is important to note that these calculation details are displayed for the last calculation performed (i.e. if all calculations have been started, the details of the calculations will concern the parameters necessary to calculate the damage for the unbound materials for the last project traffic).

To have the details for ϵ_T criterion or for another aircraft, calculations have to be done one by one, and have to click on "Calculations Details" each time before to go to the next calculation..

In this case, the Boeing B 777 200 has been considered and the calculation has been done regarding the ϵ_z criterion (vertical strain at the top of the subgrade).

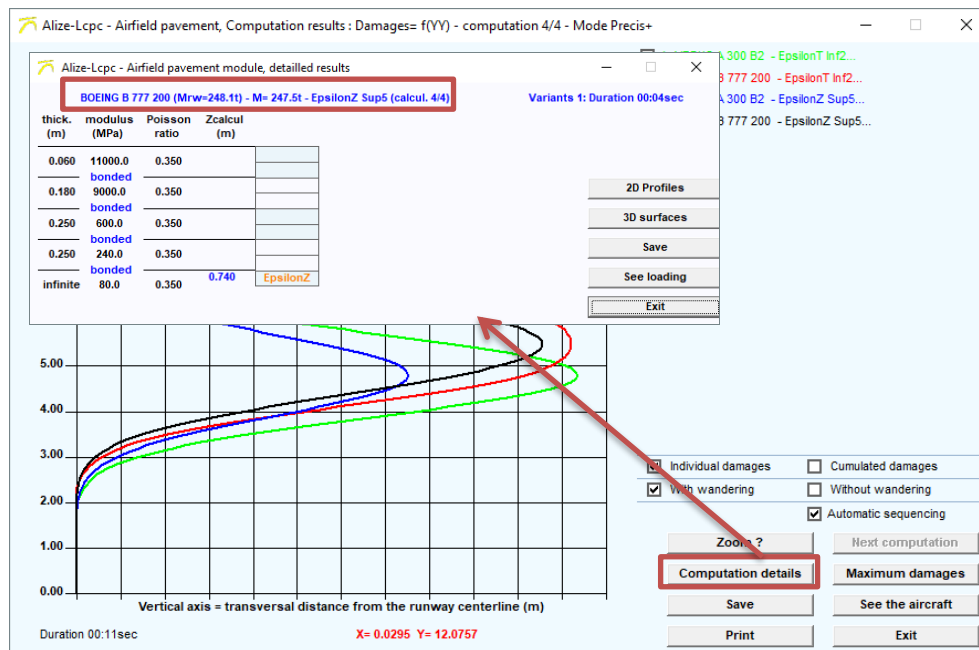


Figure 33. Details of calculations

In the "Detailed Results" window, there are 5 different buttons:

- 2D Profiles
- 3D Surfaces
- Save
- See loading
- Close

The different actions associated with these buttons are explained in the following paragraphs.

6.1.4.1. 2D Profiles

By choosing "2D Profiles", it is possible to directly display some curves characterising the mechanical response of the structure. These are displayed in the "Curves to be plotted" box (Figure 34).

Therefore, it is possible to plot the deflection or the vertical strain at the top of the subgrade (layer no.5).

By taking over the previous example, the vertical strain at the top of the subgrade has been plotted ($\epsilon_{ZZ-5-Sup}$).

Choice of profile, according to xx or yy

Graphs are plotted in both longitudinal of transversal plan. By default, the longitudinal plan is displayed (xx axis).

To change that, simply select "profiles according to YY" (Figure 34).

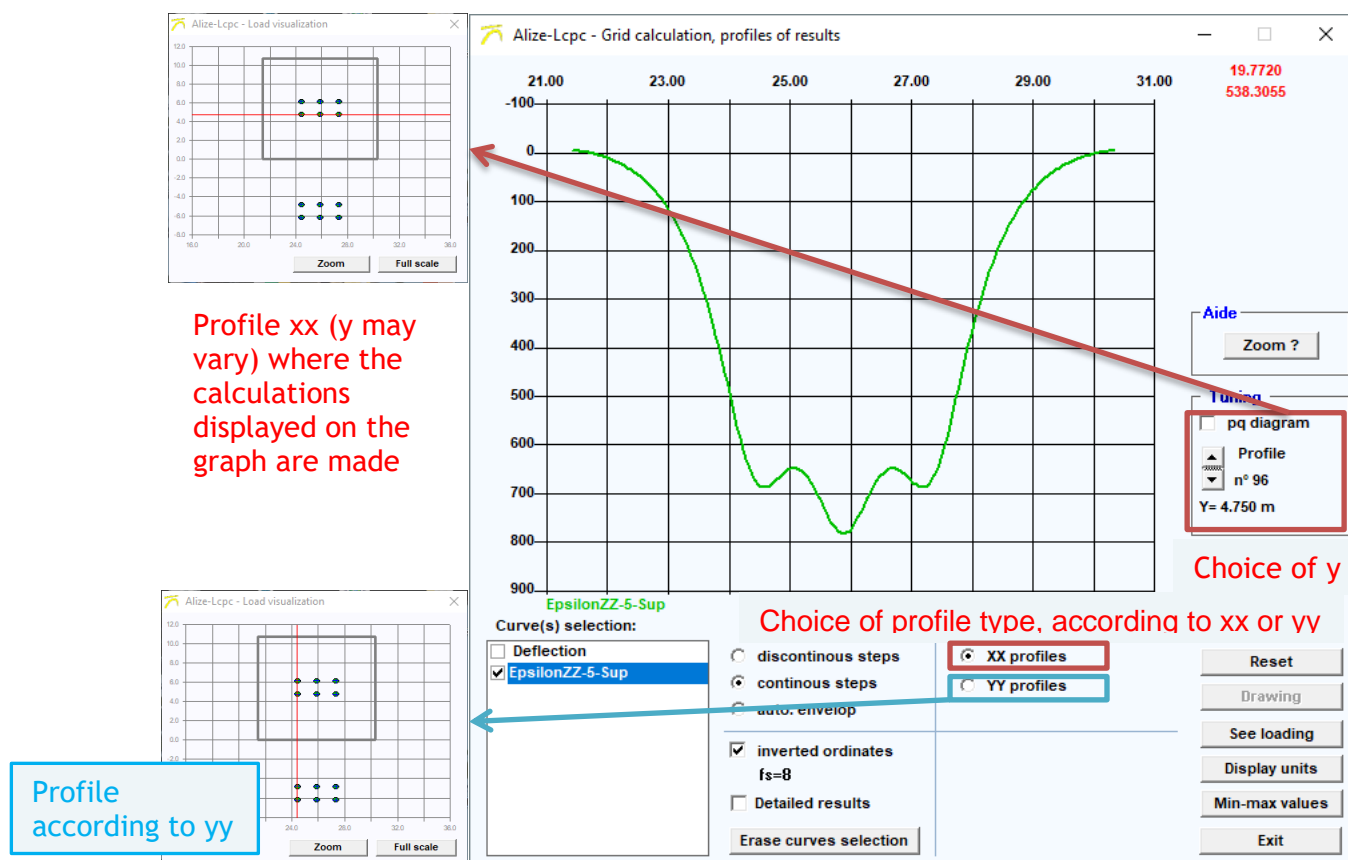


Figure 34. Choice of profile, according to xx or yy

Curve plotting

To display the curves, once the profile according to xx or according to yy has been chosen, it is necessary to choose the value of the Y ordinate where the calculations will be made (profile according to xx) or the value of the X abscissa (profile according to yy). In the following example, the profiles have been plotted according to xx. To do so, proceed as follows (Figure 35):

- Check "continuous step-by-step" (checked by default)
- Then in the "Settings" section, select the value of Y by scrolling the values using the sliders.

The curves are displayed automatically, and the line according to which the calculations are performed is displayed in red on the "Loading view" window. In this example, as the graphic displayed is the vertical strain at the top of the subgrade, the calculation is done under the inner wheels of the main landing gear of the aircraft.

It is also possible to display on the same graph all profiles according to xx or yy. To do so, proceed as follows:

- Choose the profile according to xx or yy (for our example, according to xx)
- Check "Auto Envelope"
- click on the "Draw" button

All of the curves are then automatically displayed (Figure 35).

It is also possible to choose to plot a single curve without seeing the others. In this case:

- Check "Manual step-by-step"
- Choose the profile according to xx or yy
- Choose the value of Y or X
- Click on the "Draw" button

The selected curve is then displayed.

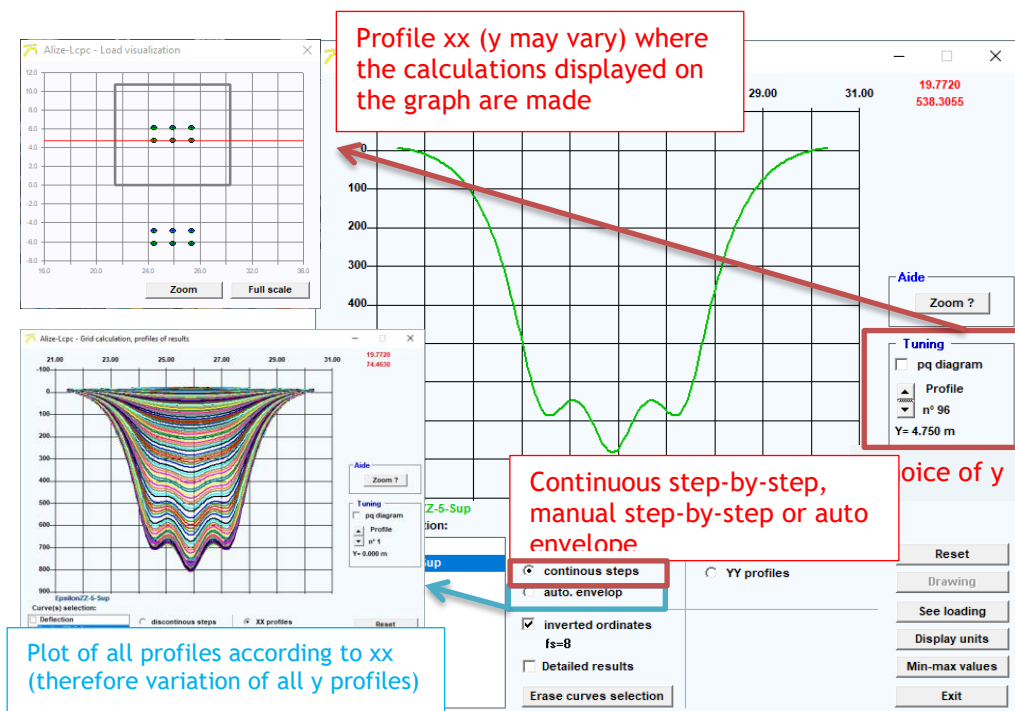


Figure 35. Curve plotting: continuous step-by-step, manual step-by-step or auto envelope

Axis direction

It is possible to choose the axis direction of the plotted curves.

Alizé follows the sign convention in soil mechanics, i.e. positive sign in compression and negative in traction.

By default, the positive signs are downwards. If the positive signs should be upwards, check the "Reverse ordinates" box (Figure 36).

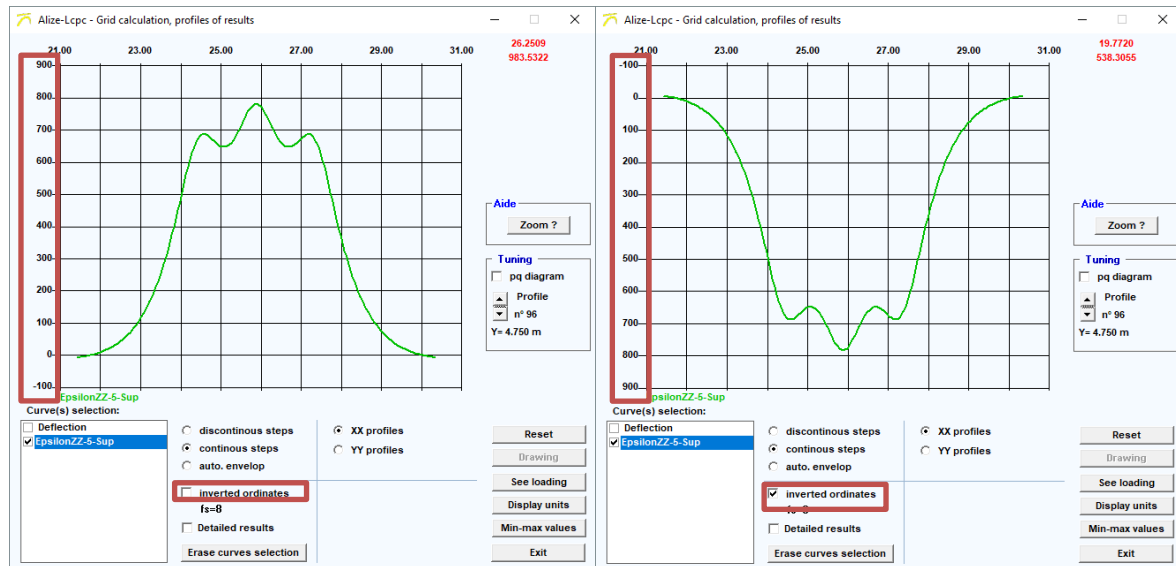


Figure 36. Direction of ordinates

Detailed Results

By default, in the "Curves to plot" box, only a few of the main parameters are displayed. It is possible to choose others. To do so, check the "Detailed Results" box (Figure 38).

Concerning the bituminous layers damage, the curves that can be plotted are:

- By default:
 - The deflection
 - ϵ_2 : minimal principal strain in algebraic value at point P in the corresponding plane (X, Y) (or maximum extension value, in absolute value, at point P)
 - The vertical strain at the bottom of the asphaltic layers
- Detailed results:
 - The deflection
 - The strain in the X direction at the bottom of the asphaltic layers
 - The strain in the Y direction at the bottom of the asphaltic layers
 - ϵ_2 : minimal principal strain in algebraic value at point P in the plane (X, Y) in question (or maximum extension value, in absolute value, at point P)
 - The vertical strain at the bottom of the asphaltic layers
 - The volume strain at the bottom of the asphaltic layers
 - The deviatoric (or shear) strain at the bottom of the asphaltic layers
 - P_{moy} : average pressure at the bottom of the asphalt course
 - Q_{dev} : shear stress at the bottom of the asphalt course

Concerning the damage to the subgrade, the curves that can be plotted are:

- By default:
 - The deflection
 - Vertical strain at the top of the subgrade
- Detailed results:
 - The deflection
 - Vertical strain at the top of the subgrade
 - Volume strain at the top of the subgrade
 - Deviatoric (or shear) strain at the top of the subgrade
 - The vertical stress at the top of the subgrade
 - Pmoy: Average pressure at the top of the subgrade
 - Qdev: shear stress at the top of the subgrade

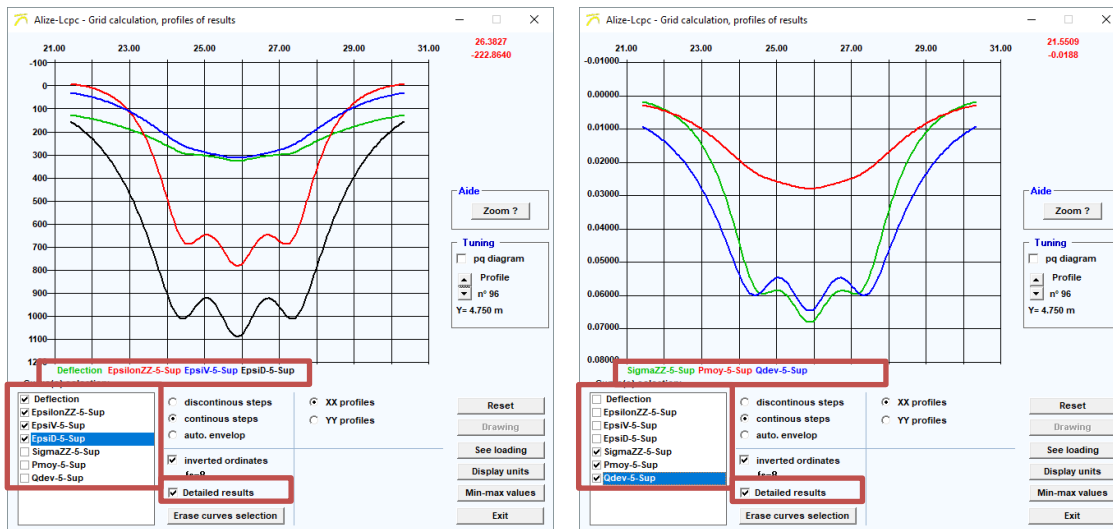


Figure 37 : Detailed results

Minimum and maximum values

By clicking on the "Mini-maxi" button (Figure 38), a window opens and displays an array where each row corresponds to the parameters calculated and displayed in the "detailed results" previously listed.

From left to right, the columns indicate:

- The minimum value of the parameter,
- The abscissa of the point corresponding to this minimum value,
- The ordinate of the point corresponding to this minimum value,
- The maximum value of the parameter,
- The abscissa of the point corresponding to this maximum value,
- The ordinate of the point corresponding to this maximum value,

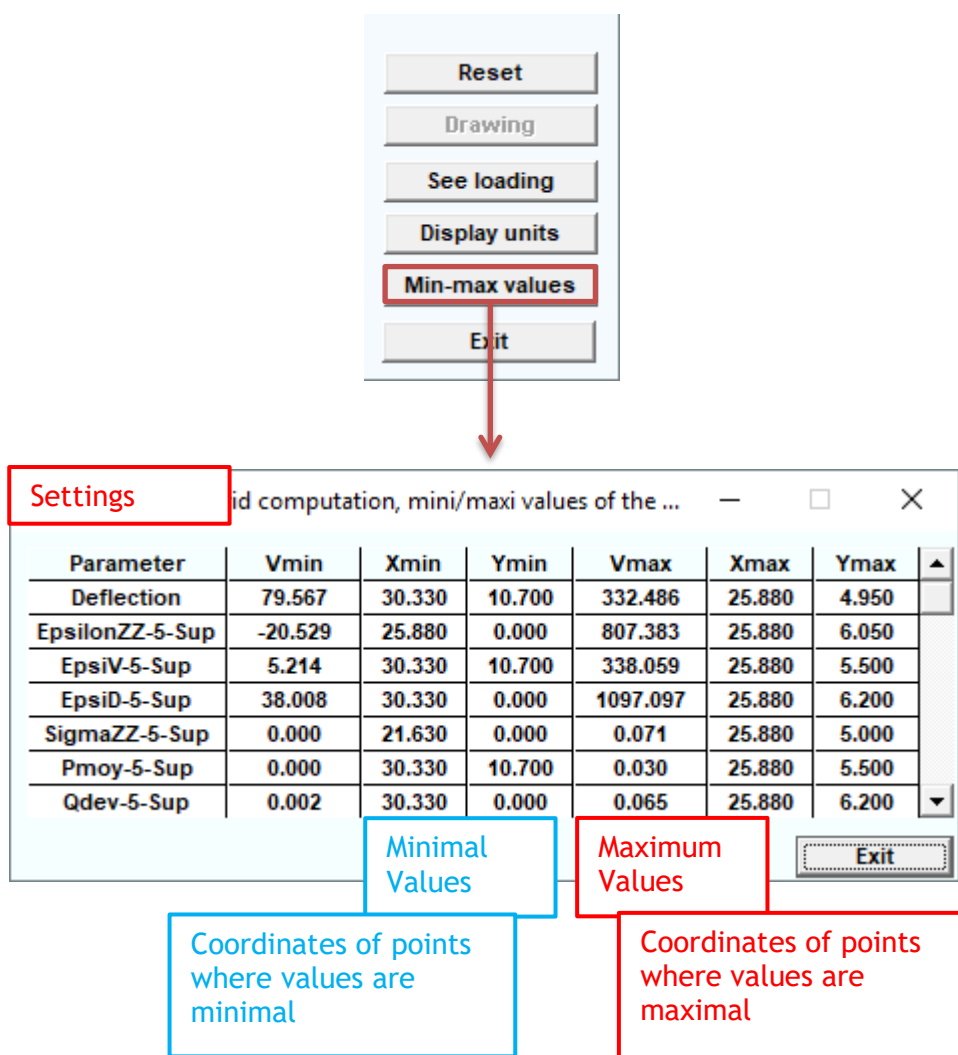


Figure 38. Min and max values

Display in the XOY plane of the loads and observation profiles

By clicking on the button "See loading" a window pops up (Figure 39) is opened, and can be used to display:

- The area where the calculations are made,
- The chosen observation profile,
- The footprint of the wheels of the aircraft concerned by the calculation,

6. Calculations

- The wheel numbers,
- The loads of the different wheels of the aircraft (load, pressure, wheel radius) [marked with their number],
- If necessary, clicking on the "Symmetries?" button ", a search for the axes of symmetry is carried out.

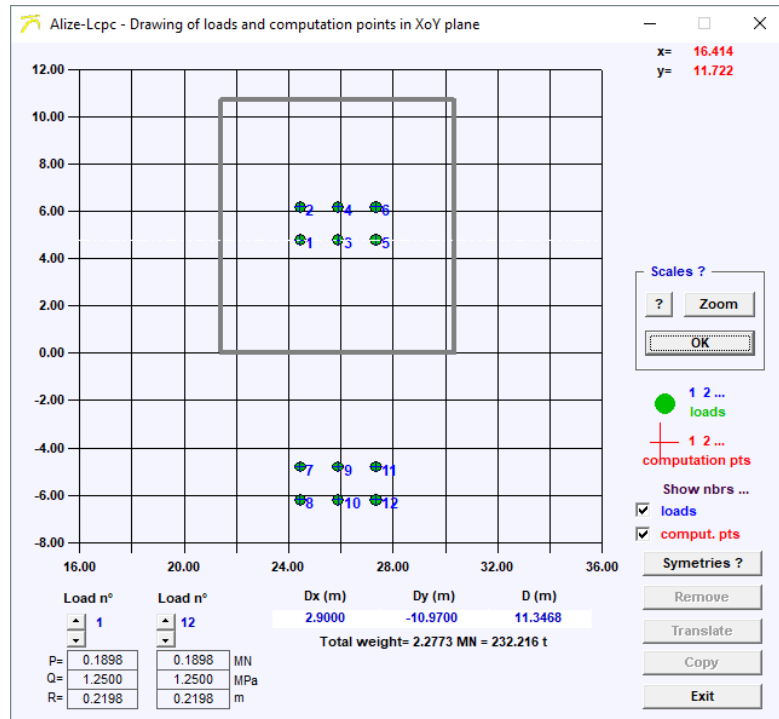


Figure 39 : Display in the XOY plane of the loads and observation profiles

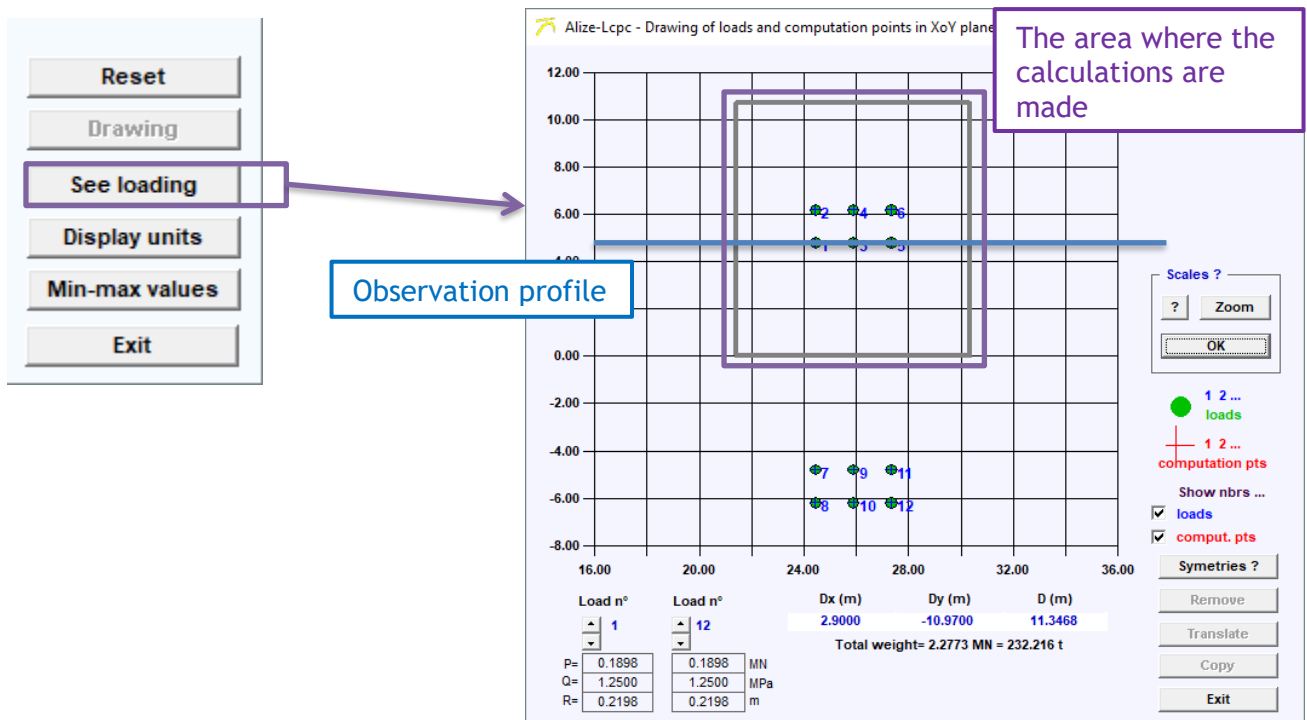


Figure 39 : Display in the XOY plane of the loads and observation profiles

6.1.4.2. 3D Surfaces

It is possible to display the 3D graphs of the various parameters according to the X or Y coordinates. To do so, proceed as follows:

- Click on "3D Surfaces",
- Choose the parameter to be displayed,
- Click on "OK",
- A window with the 2D surface representation of the selected parameter opens,
- To have a 3D representation, check the "3D Drawing" box (Figure 40).

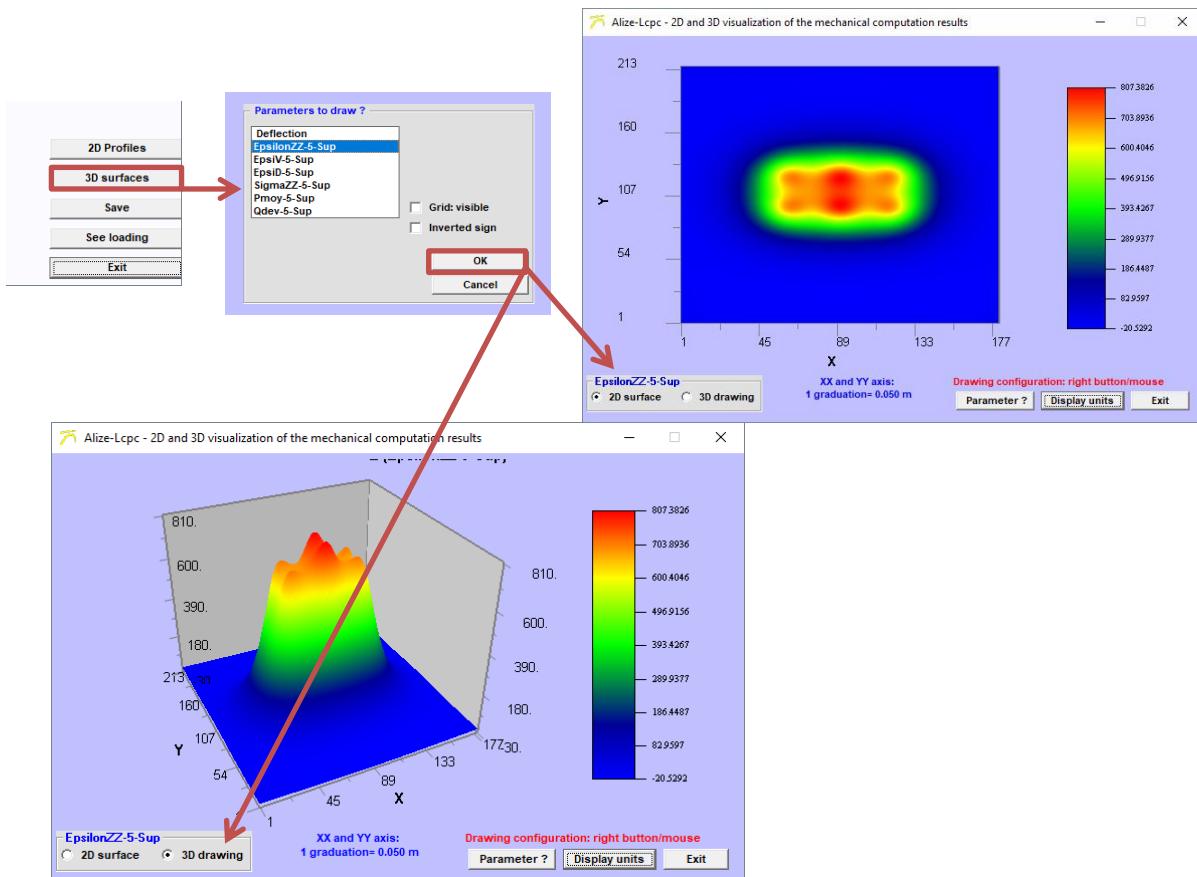


Figure 40. Display of 2D surfaces or 3D drawing

To display the calculation grid, check the "Grid visible" box (Figure 41).

The "Units?" button gives more details about the units of the graph.

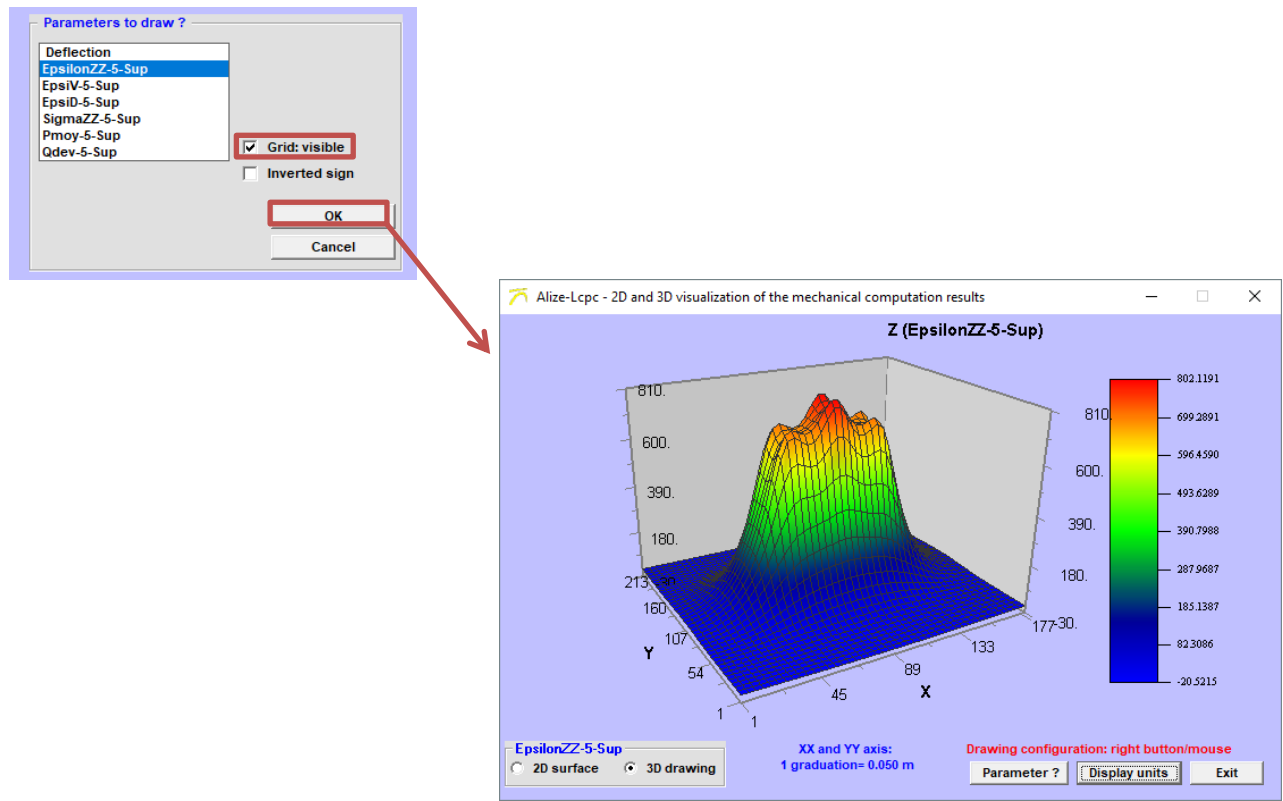


Figure 41. Display of 3D drawings with visible grid

6.1.4.3. Save

The "Save" button saves some data.

A window is displayed when the "Save" button is clicked. In this window there is a list of parameters (those obtained by clicking on "Detailed results" in the graph display window). To save some of these settings (Figure 42):

- Select the parameters to be save,
- Then click on the "Save" button,
- By default, the results are saved as: "D:/User name /Alize-Lcpc my files / Unnamed calculations,
- The file name is: Alize-Airfield- "Parameter Name" - "Layer No." -XoY,
- The extension is .gri (can be opened as a text file).

If the user has saved the structure on which the calculations were made, the files are automatically saved in the same directory (same filename).

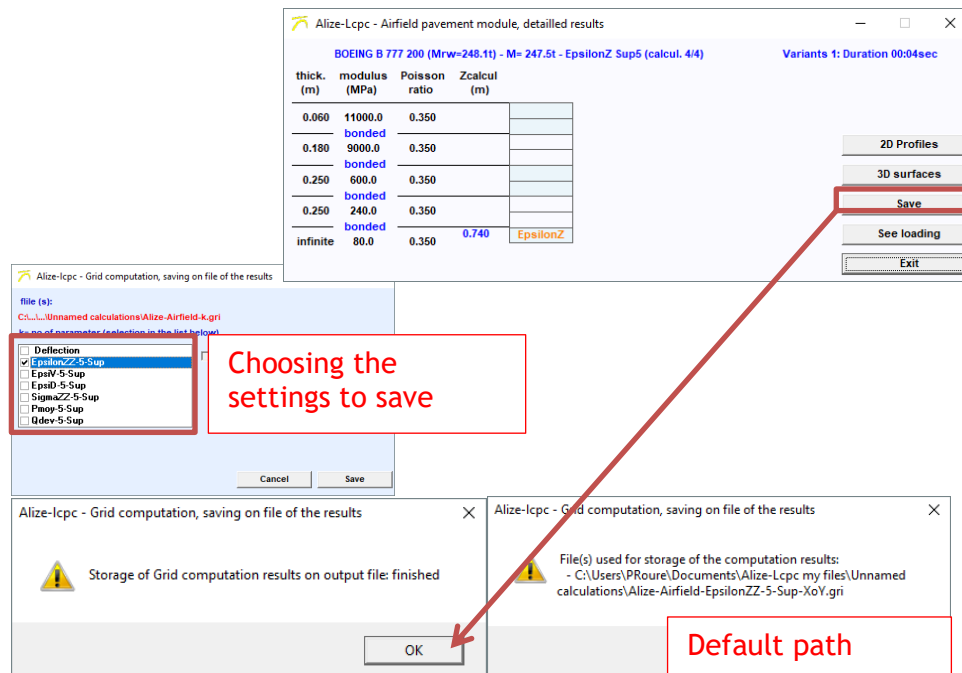


Figure 42. Recording results

6.1.4.4. See loading

By clicking on the button "See loading ", the same window as described in the Figure 39 is displayed.

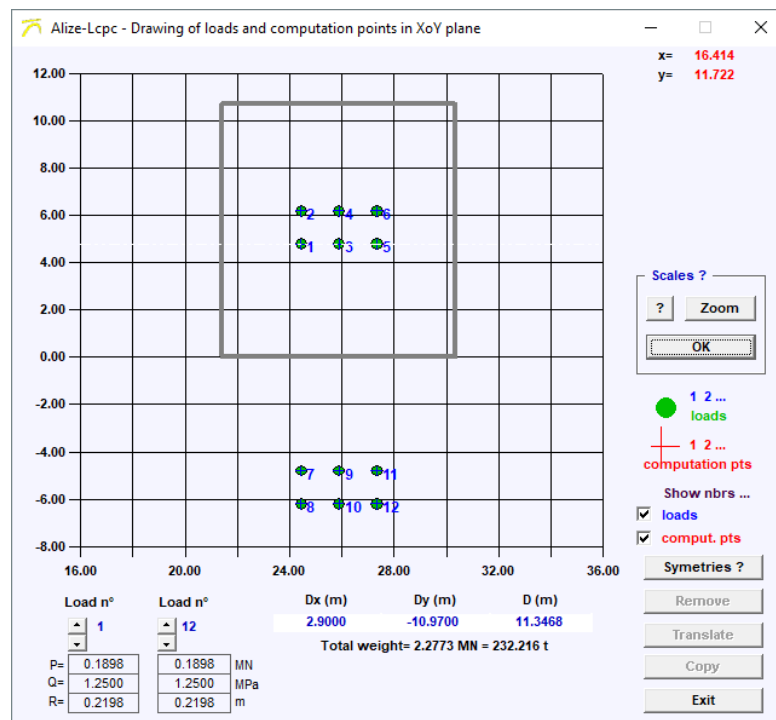


Figure 39 : Display in the XOY plane of the loads and observation profiles

6.1.5. Maximum damage

When you click on the "Max Damage" button a window is displayed (Figure 43) with a table.

All the parameters in this table are explained on the Figure 50.

From left to right, the columns give the following values :

- Name of the aircraft
- Cumulative number of passages of aircraft Type of damage criterion ϵ_T or ϵ_Z and layer number concerned
- Value of coefficients K_c or A
- ϵ_T or ϵ_Z allowable value calculated for N =cumulative number of passages of the specified aircraft ($=V_a$)
- ϵ_T or ϵ_Z maximum value field created by the aircraft at level Z defined by the damage criterion
- Equivalent value = value of the equivalent single stress ϵ_T or ϵ_Z in terms of damage, during the passage of the complete aircraft ($=V_e$) with and without wander
- Maximum damage D_{max} created by the specified aircraft regarding the damage criterion with and without wander $D_{max}=(V_e/V_a)-1/b$
- Individual contribution of the aircraft to the maximum cumulative damage value with and without wander

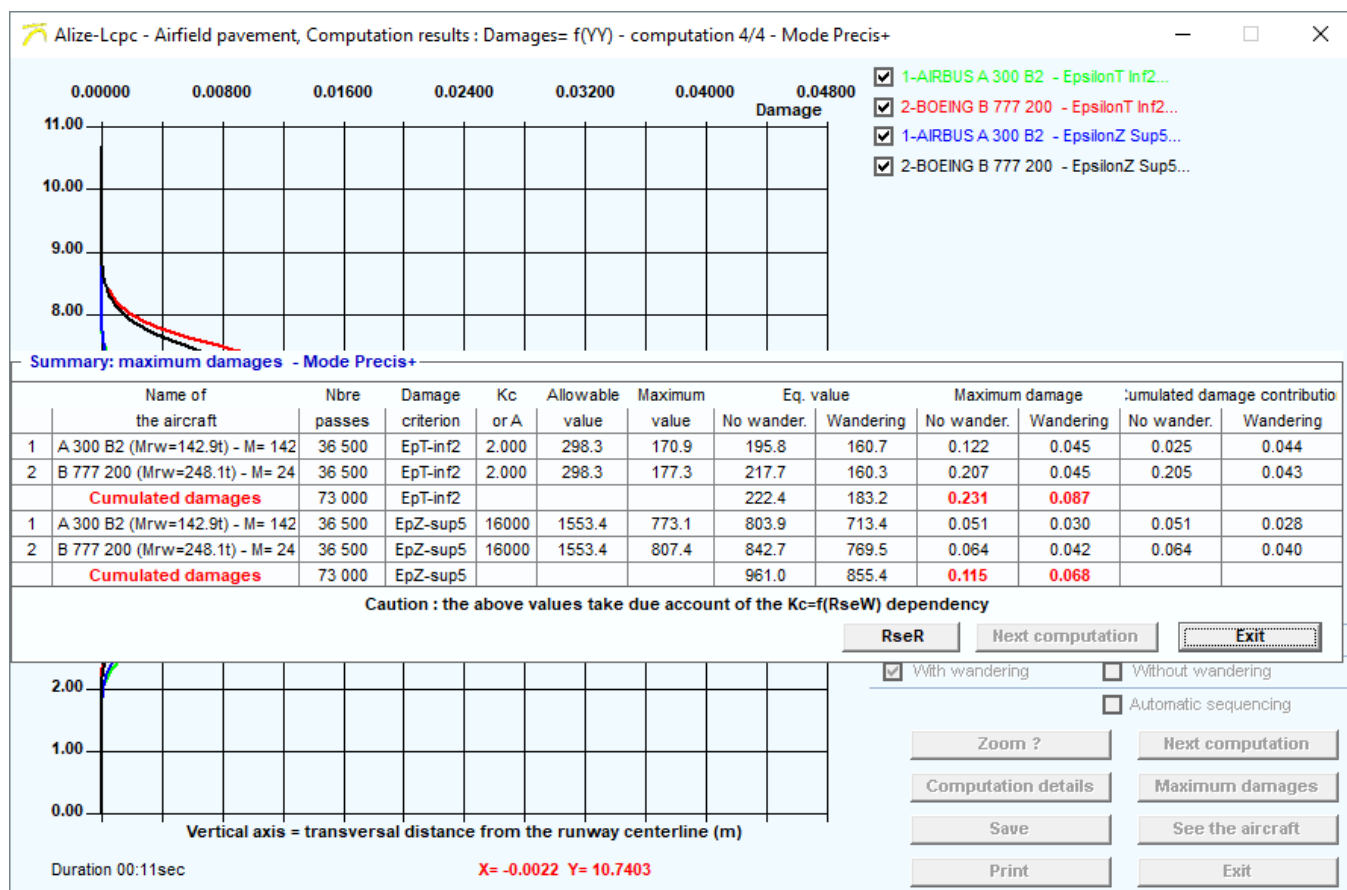


Figure 43. Summary table of maximum damage

6.1.6. Recording results

The "Save" button provides the document presented on the Figure 44.

By default, the file name is: Alizé-Airfield001.res (can be opened as a text file)

By default, the results are saved as: "D:/User name /Alize-Lcpc my files / Unnamed calculations". If the user has saved the structure, the files are automatically saved in the same folder (same filename).

The recorded document is a summary table of the results presenting:

- A reminder of the structure
- A reminder of the modules of the layers
- A reminder of the parameters
- A reminder of the project traffic, wander, speed and equivalent temperature
- A table with (same values as the table obtained by clicking on "Maximum damage"):
 - The name of the aircraft
 - Cumulative number of passages of aircraft
 - Type of damage criterion ϵ_T or ϵ_Z and layer number concerned
 - Value of coefficients K_c or A
 - ϵ_T or ϵ_Z allowable value calculated for N =cumulative number of passages of the aircraft ($=V_a$)
 - ϵ_T or ϵ_Z maximum value field created by the aircraft at level Z defined by the damage criterion
 - Equivalent value = value of the equivalent single stress ϵ_T or ϵ_Z in terms of damage, during the passage of the complete aircraft ($=V_e$) with and without wander
 - Maximum damage D_{max} created by the aircraft regarding the damage criterion with and without wander $D_{max}=(V_e/V_a)-1/b$
 - Individual contribution of the aircraft to the cumulative damage maximum value with and without wander
- A table with the damage with wander for ϵ_T or ϵ_Z , for each aircraft and the cumulative damage
- A table with the damage without wander for ϵ_T or ϵ_Z , for each aircraft and the cumulative damage

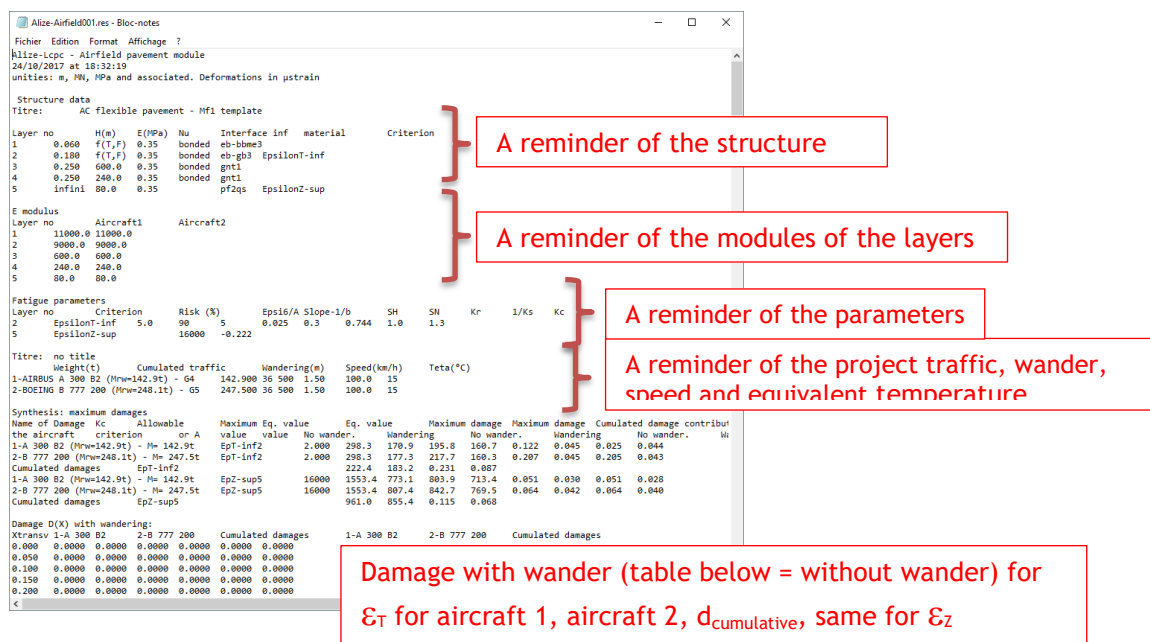


Figure 44. Summary table of results

6.2. Iterative calculation

As previously stated, the iterative calculation mode carry out a succession of calculations by varying the thickness of a layer until the maximum cumulative damage with wander equal to 1 is obtained.

According to the user choice, both the thickness of the base course (GB, EME) and subbase course (UGA) can be adjusted,

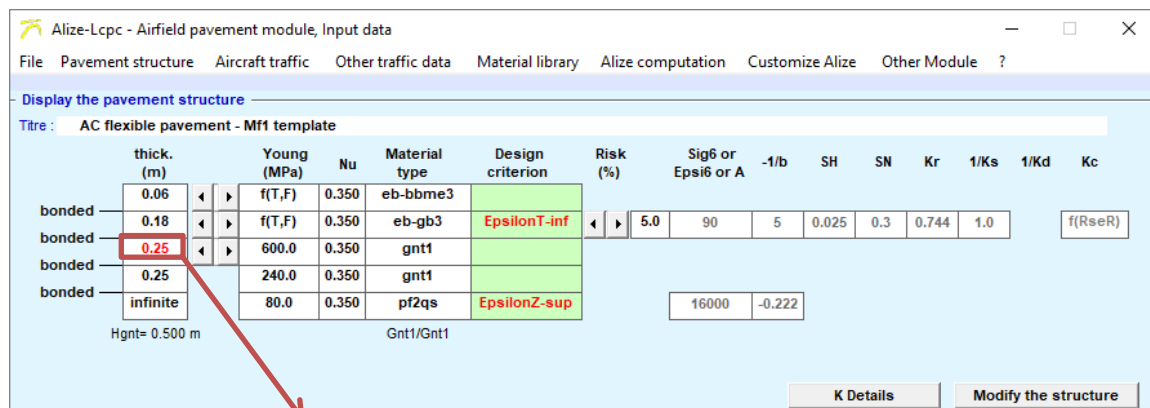
6.2.1. Choice of layer to be adjusted

The layer on which the iterations are carried out is indicated by the red colour of its "thickness" box (Figure 45).

To modify the layer on which the iterations are made, simply double-click on the "thickness" box of the chosen layer. Then, the thickness of the layer to be adjusted becomes red.

Note: the calculation times will be increasingly shorter as the initial model structure (after modifications) approaches the solution of the design problem to be solved.

Principle of resolution: the thickness of the layer is determined by dichotomy on the basis of a semi-logarithmic Damage vs Thickness relationship of the layer to be adjusted.



Iterations on the UGA layer

Iterations on the GB3 layer

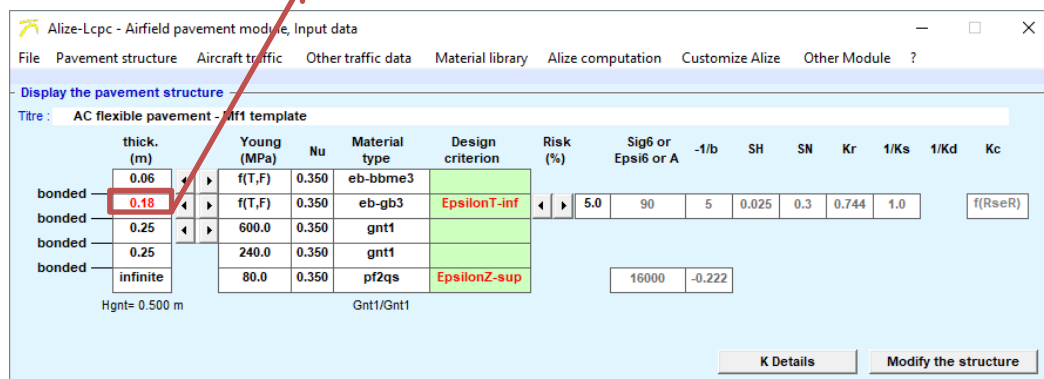


Figure 45. Choice of layer to be adjusted

6.2.2. Launching the calculations

In order to illustrate the calculation procedure according to the "Iterative calculation" mode, project traffic with five aircraft is provided:

- An Airbus A300 B2
- An Airbus A310 200
- An Airbus A320 100
- An Airbus A330 200
- An Airbus A340 200

The selected traffic settings are the default settings (36,500 cumulative movements). The calculations will be carried out in order to optimise the UGA layer thickness.

The calculations can be launched from the main menu bar by selecting "Alizé calculation" then "Iterative calculation" (Figure 46).

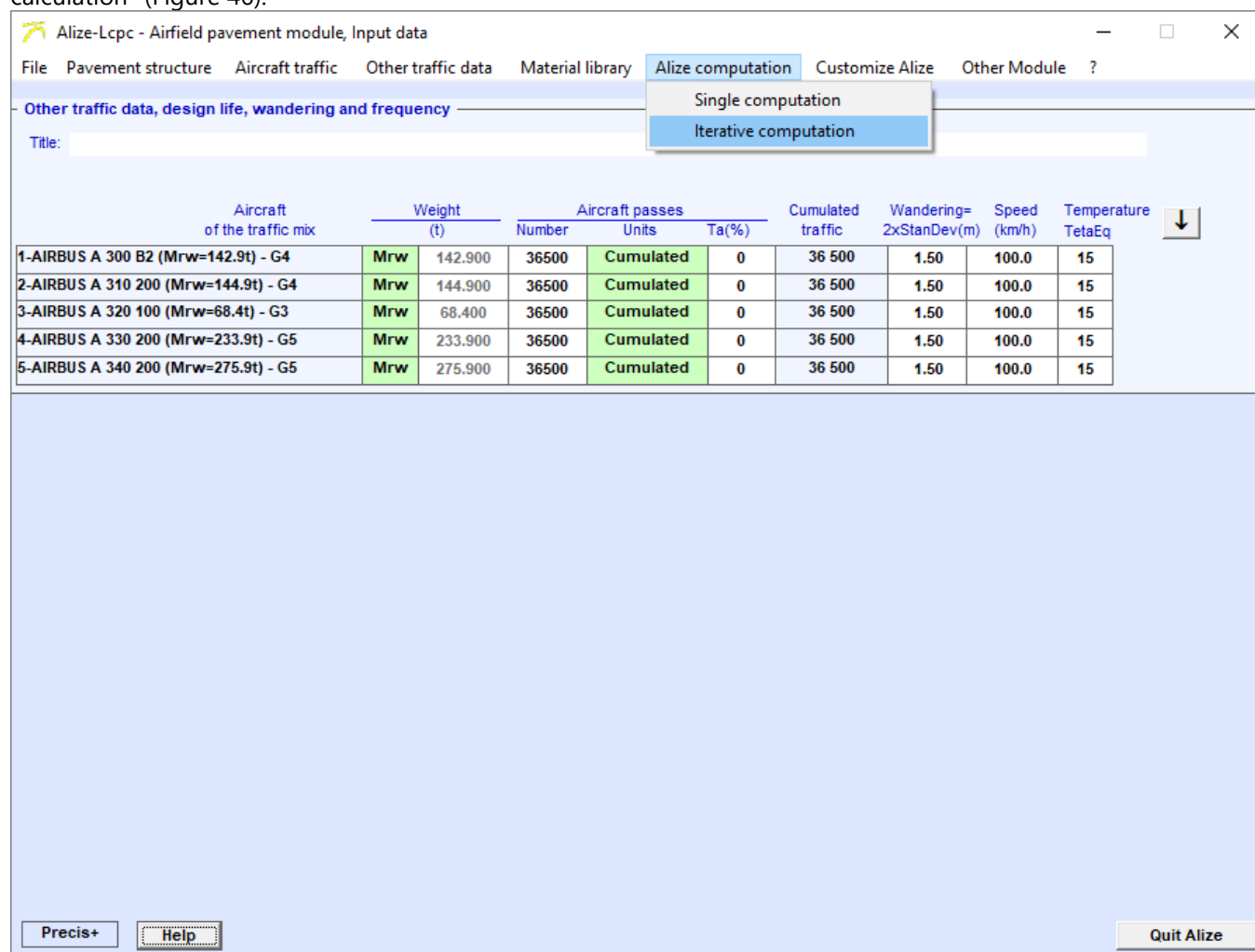


Figure 46. Launching the calculations in "Iterative calculation" mode

6.2.3. Calculation results

Once the calculations are finished, a "Calculation results" window opens (Figure 47).

Alize-Lcpc - Airfield pavement module, Input data

File Pavement structure Aircraft traffic Other traffic data Material library Alize computation Customize Alize Other Module ?

Display the pavement structure

Titre : AC flexible pavement - Mf1 template

	thick. (m)	Young (MPa)	Nu	Material type	Design criterion	Risk (%)	Sig6 or Epsi6 or A	-1/b	SH	SN	Kr	1/Ks	1/Kd	Kc
bonded	0.06	f(T,F)	0.350	eb-bbme3										
bonded	0.18	f(T,F)	0.350	eb-gb3	EpsilonT-inf	5.0	90	5	0.025	0.3	0.744	1.0	f(RseR)	
bonded	0.07	600.0	0.350	gnt1										
bonded	0.25	240.0	0.350	gnt1										
bonded	infinite	80.0	0.350	pf2qs	EpsilonZ-sup									

Hgnt= 0.317 m

16000 -0.222

Alize-Lcpc - Airfield pavement module, computation results

Nblter= 3 - Mode Fast
Dt= 00:16 s
Pavement structure :
6eb-bbme3@11000MPa
18eb-gb3@9000MPa
7gnt1@600MPa
25gnt1@240MPa
pf@80MPa
Criteria :
EpsT-inf2 et EpsZ-sup5
Traffic mix :
AIRBUS A 300 B2 (Mrw=142.9t) - M= 142.9t
AIRBUS A 310 200 (Mrw=144.9t) - M= 144.9t
AIRBUS A 320 100 (Mrw=68.4t) - M= 68.4t
AIRBUS A 330 200 (Mrw=233.9t) - M= 233.9t
AIRBUS A 340 200 (Mrw=275.9t) - M= 275.9t
Coefficient Kc= 2.000 (eb-gb3) et Kc'= 2.000
Rational equivalent single wheel ResW= 35.42 t (R= 0.2000 m, Dgb)
Computation results :
CodeF= 2 : Convergence obtained
Uga thickness= 0.317 m
Damages : CritR1 CritR2
No wander. 2.233 0.918
With wander. 1.000 0.524

Modify the structure

Precis+ Help

Clear the list ClipBoard Details Exit

Quit Alize

Figure 47. Results of calculations: iterations on the thickness of UGA

The initial 25 cm layer of UGA has been reduced to 6.6 cm. The total thickness of UGA is therefore 31.6cm. Damage values are shown in the "Calculation Results" window (Figure 48).

In this window, various items of information are available:

- The pavement structure is recalled
- The composition of the project traffic is recalled
- The two design criteria are recalled
- The accuracy of calculation is indicated
- The value of the ES_{WL} calculation is indicated
- The value of the coefficient K_c deducted from the calculation of the ES_{WL} is given
- There is an indication of the (non) convergence of the calculation
- The final UGA thickness is indicated
- Damage values for both criteria, with and without wander are shown

In this example, the value of the cumulative damage with wander at the top of the UGA layer is effectively equal to 1. The horizontal strain at the bottom of the asphaltic layers is the design criterion.

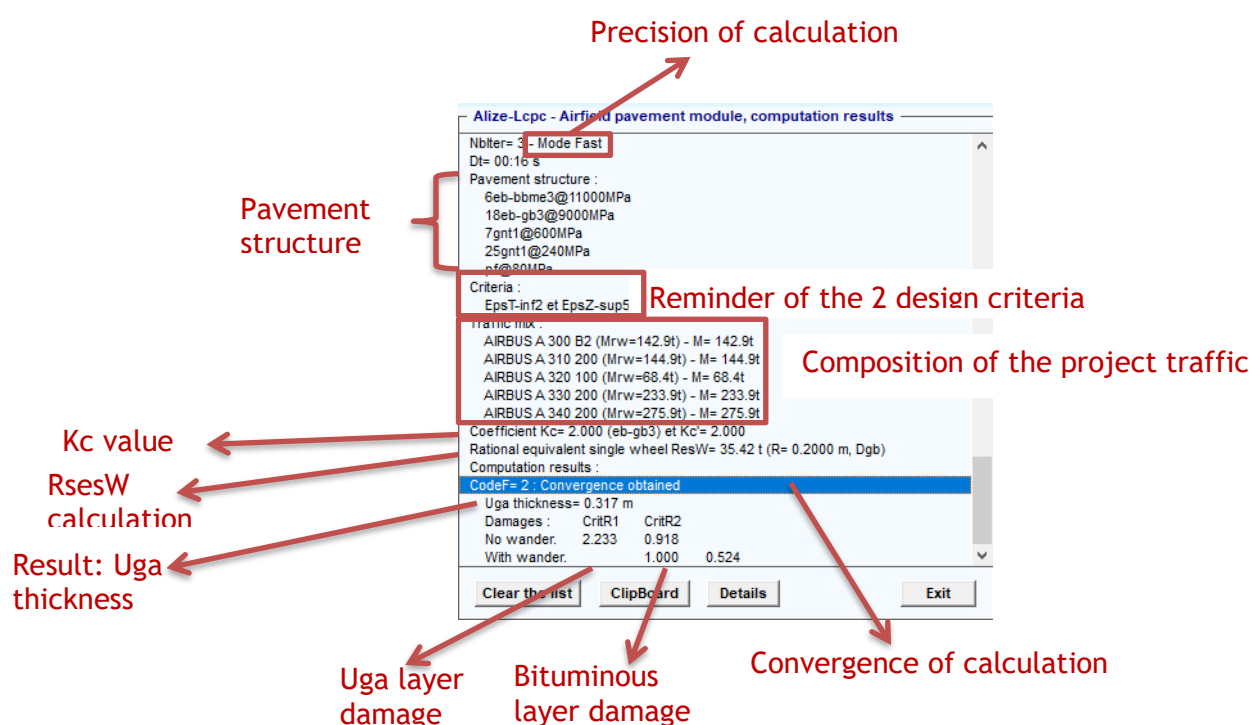


Figure 48 : Calculation results

6.2.4. Other results

Below the results window, there are four buttons. The Figure 49 indicates the role of these buttons.

"Copy" the results window

Clear the contents of the results window

Close the results window

Summary: maximum damages - Mode Fast												
	Name of the aircraft	Nbre passes	Damage criterion	Kc or A	Allowable value	Maximum value	Eq. value		Maximum damage		Cumulated damage contribution	
							No wander.	Wandering	No wander.	Wandering	No wander.	Wandering
1	A 300 B2 (Mrw=142.9t) - M= 142	36 500	EpT-inf2	2.000	298.3	204.6	233.9	192.8	0.296	0.113	<0.001	0.111
2	A 310 200 (Mrw=144.9t) - M= 14	36 500	EpT-inf2	2.000	298.3	206.3	236.0	193.1	0.310	0.114	<0.001	0.112
3	A 320 100 (Mrw=68.4t) - M= 68.4	36 500	EpT-inf2	2.000	298.3	214.6	214.6	181.8	0.193	0.084	<0.001	0.034
4	A 330 200 (Mrw=233.9t) - M= 23	36 500	EpT-inf2	2.000	298.3	266.4	305.8	246.9	1.132	0.389	1.132	0.378
5	A 340 200 (Mrw=275.9t) - M= 27	36 500	EpT-inf2	2.000	298.3	264.8	304.0	245.3	1.099	0.376	1.099	0.366
	Cumulated damages	182 500	EpT-inf2				350.3	298.3	2.233	1.000		
1	A 300 B2 (Mrw=142.9t) - M= 142	36 500	EpZ-sup5	16000	1553.4	909.8	981.8	869.9	0.127	0.073	0.117	0.072
2	A 310 200 (Mrw=144.9t) - M= 14	36 500	EpZ-sup5	16000	1553.4	899.4	973.7	865.1	0.122	0.072	0.109	0.070
3	A 320 100 (Mrw=68.4t) - M= 68.4	36 500	EpZ-sup5	16000	1553.4	727.2	727.2	647.5	0.033	0.019	0.002	0.008
4	A 330 200 (Mrw=233.9t) - M= 23	36 500	EpZ-sup5	16000	1553.4	1071.2	1234.4	1087.7	0.355	0.201	0.353	0.193
5	A 340 200 (Mrw=275.9t) - M= 27	36 500	EpZ-sup5	16000	1553.4	1060.8	1222.5	1075.5	0.340	0.191	0.335	0.183
	Cumulated damages	182 500	EpZ-sup5				1524.1	1346.1	0.918	0.524		

Caution : the above values take due account of the Kc=f(RseW) dependency

Precis+ Help Exit Quit Alize

GB calculations UGA calculation

Figure 49. Other calculation results

The different values indicated in the table that is displayed when the "Details" button is clicked are explained on the Figure 50.

Individual contribution of the aircraft in question to the maximum value of cumulative damage with and without wander

Summary: maximum damages - Mode Fast											
Name of the aircraft	Nbre passes	Damage criterion	Kc or A	Allowable value	Maximum value	Eq. value		Maximum damage		Cumulated damage contribution	
						No wander.	Wandering	No wander.	Wandering	No wander.	Wandering

Name of aircraft

Cumulative number of passages of aircraft no. j

Type of damage criterion ϵ_T or ϵ_Z and layer number concerned

Value of coefficients Kc or A

Permissible ϵ_T or ϵ_Z value calculated for N=cumulative number of passages of the aircraft in question ($=V_a$)

Maximum damage Dmax created by the aircraft in question with regard to the damage criterion in question with and without wander
 $D_{max} = (V_e / V_a)^{-1/b}$

Value of the equivalent single stress ϵ_T or ϵ_Z in terms of damage, during the passage of the complete aircraft ($=V_e$) with and without wander

Maximum value of the ϵ_T or ϵ_Z field created by the aircraft at the level defined by the damage criterion

Figure 50. The different values calculated in the "Details" table

6.3. Calculation details

6.3.1. "+Accurate" button

At the bottom left of the main window ("Pavement structure" or "Aircraft traffic" or "Other traffic data" window) is a button labelled "+Accurate" (Figure 51).

This button is used to choose the precision of the calculation grid, which defines the size of the mesh and then the calculation points.

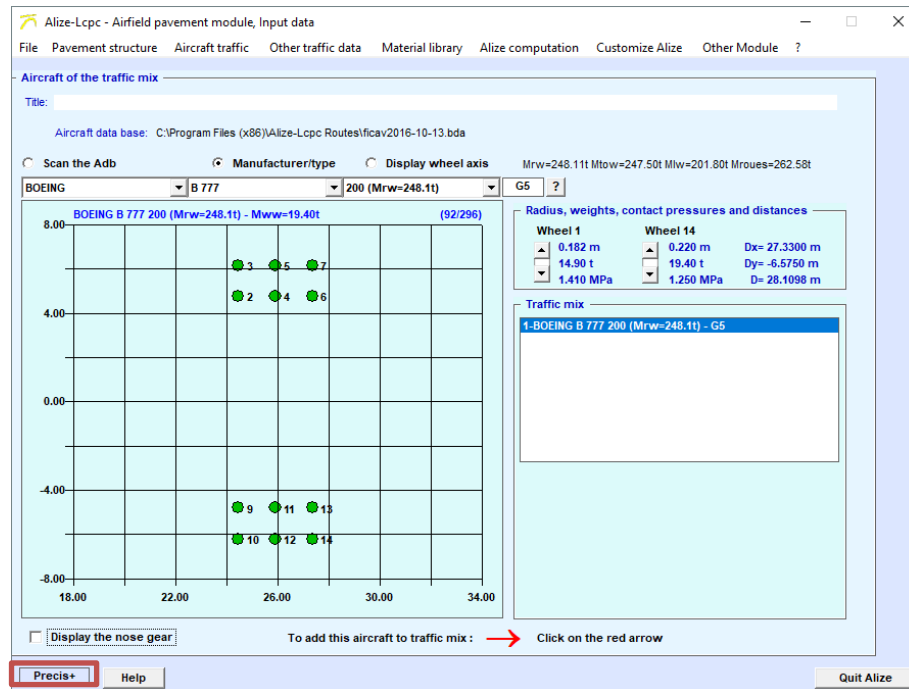


Figure 51. +Accurate mode

6.3.2. The various possibilities

By clicking on the "+Accurate" button, 4 choices are possible (Figure 52):

- +Accurate
- +AccurateF
- AverageAccuracy
- Fast

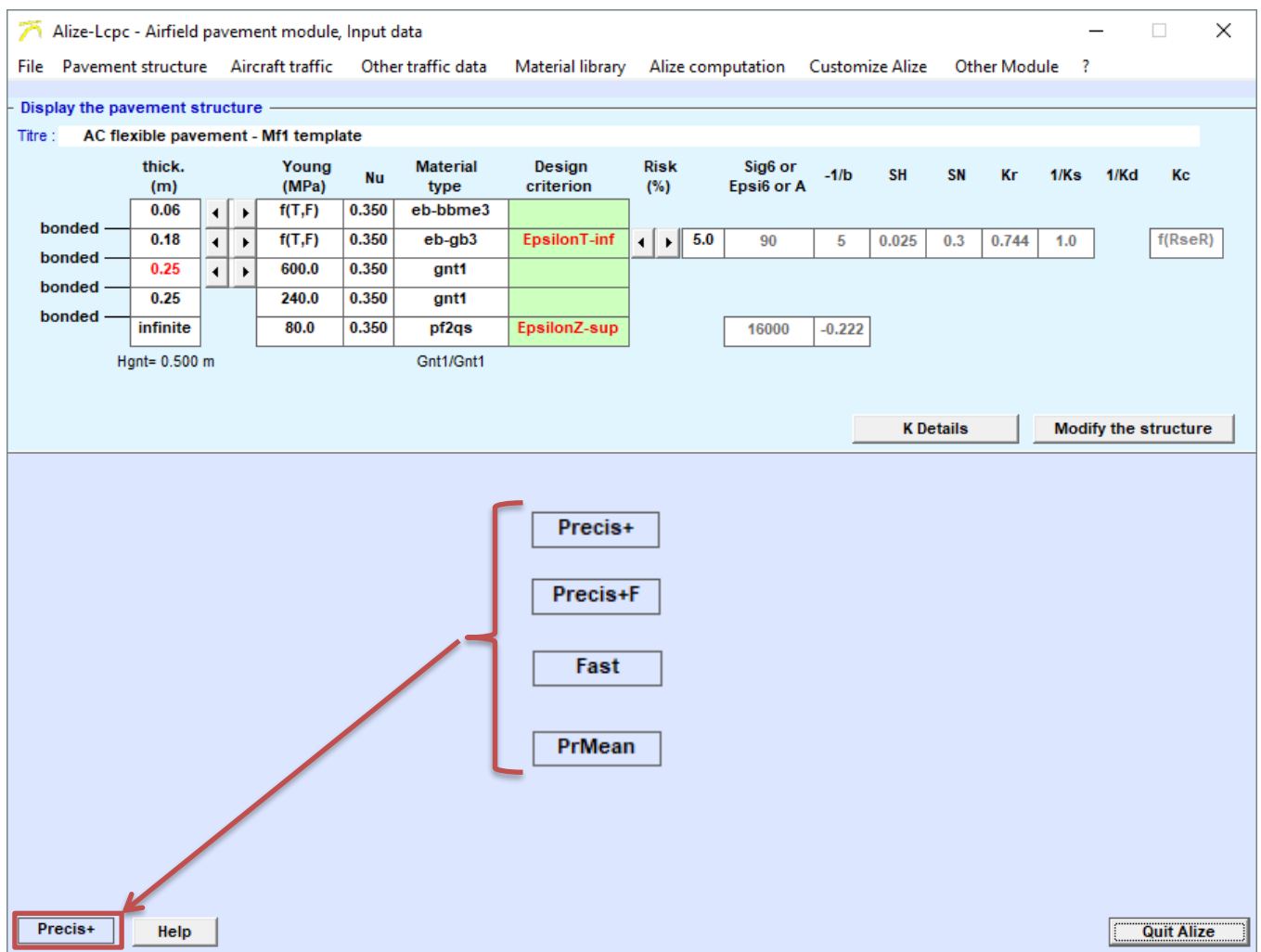


Figure 52. Adjusting the calculation grid

For each possibility, the setting of the calculation grid is different. The settings are as follows:

- **+Accurate: Maximum density mesh:** The settings of the calculation mesh are defined by the default values of the "Preferences" menu. This option guaranteeing a high level of accuracy of the results and should be used to finalise the design.
- **+AccurateF: "Forced" maximum density mesh:** Same as "+Accurate". In addition, when the "iterative calculation" mode is selected, automatic switch-over to the "Fast" option is prevented.
- **AverageAccuracy:** Medium Density mesh: This option is reserved for program debugging (do not use).
- **Fast:** Optimised Medium Density mesh: This option significantly reduces calculation times in a ratio between 5 and 8 relative to the +Accurate setting. In the majority of cases, calculations using the "Fast" option are sufficiently accurate. It can therefore be advantageously used in the pre-design phase. At the end of a design calculation using this option, it is advisable to check it by returning to the "+Accurate" option.

The settings of the calculation mesh (spacing of calculation points Δx and Δy , and total dimensions of the mesh) are given in **Erreur ! Source du renvoi introuvable.**

	Spacing ΔX	Spacing ΔY	Width L_y
+AccurateF	0.05m	0.05m	$0.5.L_{ya} + \max[1.50\text{m}; 3\sigma]$
AverageAccuracy	0.05m	0.125m	$0.5.L_{ya} + \max[1.25\text{m}; 1.75\sigma]$
Fast	0.10m	0.25m	$0.5.L_{ya} + \max[1\text{m}; 1.25\sigma]$

Where, L_{ya} is the width of the landing gear
 σ is the standard deviation of the lateral wander
 L_y is the total width of the grid along the y-axis.

By default, the option chosen in the "Iterative calculation" mode is the "Fast" setting.

The terms of the "Fast" option are:

- In "iterative calculation" mode, automatic switch-over to the "Fast" option unless the "+AccurateF" option was selected before the calculations were started.
 - Discrepancy between "+Accurate" and "Fast" results: approximately $\pm 0.2\%$ on damage with wander (i.e. ± 2 mm on the solution thicknesses), except in the case of wander < 0.70 m (standard deviation < 0.35 m)
 - For calculations with wander < 0.70 m, select "+AccurateF"
- In the finalised design phase:
- proceed with a pre-design with the settings above,
 - starting from this pre-design, launch a final check calculation with the "+AccurateF" setting

6.3.3. Example

An example of the calculation has been carried out, with the traffic used previously:

- An Airbus A300 B2
- An Airbus A310 200
- An Airbus A320 100
- An Airbus A330 200
- An Airbus A340 200

The selected traffic settings are the default settings. The calculations purpose will optimised the UGA layer. The calculations will be carried out in order to optimise the UGA layer thickness

The Figure 53 presents the results obtained with a calculation carried on in "Fast" mode and another realised in "+accurate" mode. The UGA thicknesses obtained are respectively 31.7 cm and 32 cm.

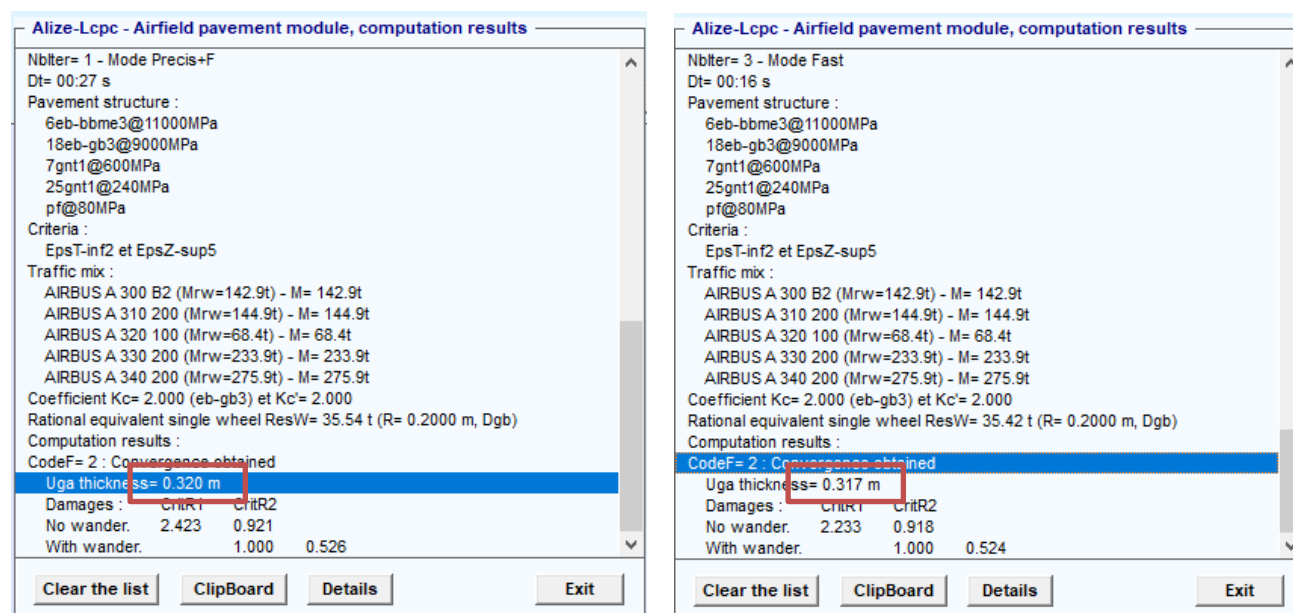


Figure 53. Results of calculations in "Fast" and "+AccurateF"

6.4. Verification of the design of an apron

According to paragraph 3.2.4 of the design method (STAC, 2014), for the design of the aprons and waiting areas a further calculation must be carried out in which the asphaltic layers should be modelled as an unbound material, associated with a modulus of 800 MPa. The parameter K of the fatigue law of the permanent deformation criterion of the platform is increased to 24,000 (instead of 16,000).

It is then necessary to check that the damage associated with this criterion remains less than 1 with the same traffic assumptions as previously.

As indicated on the Figure 54, this is implemented by clicking on "File" in the main menu bar, then "Structural data", then "Transpose: verification under static loads".

The structure is automatically modified to take into account the changes imposed by the rational design method for flexible airfield pavements:

- The modules of the asphalt mixes have a value equal to 800 MPa
- The coefficient K is equal to 24,000
- The design criterion is only ε_z

The calculation must be carried out as explained in paragraph 6.

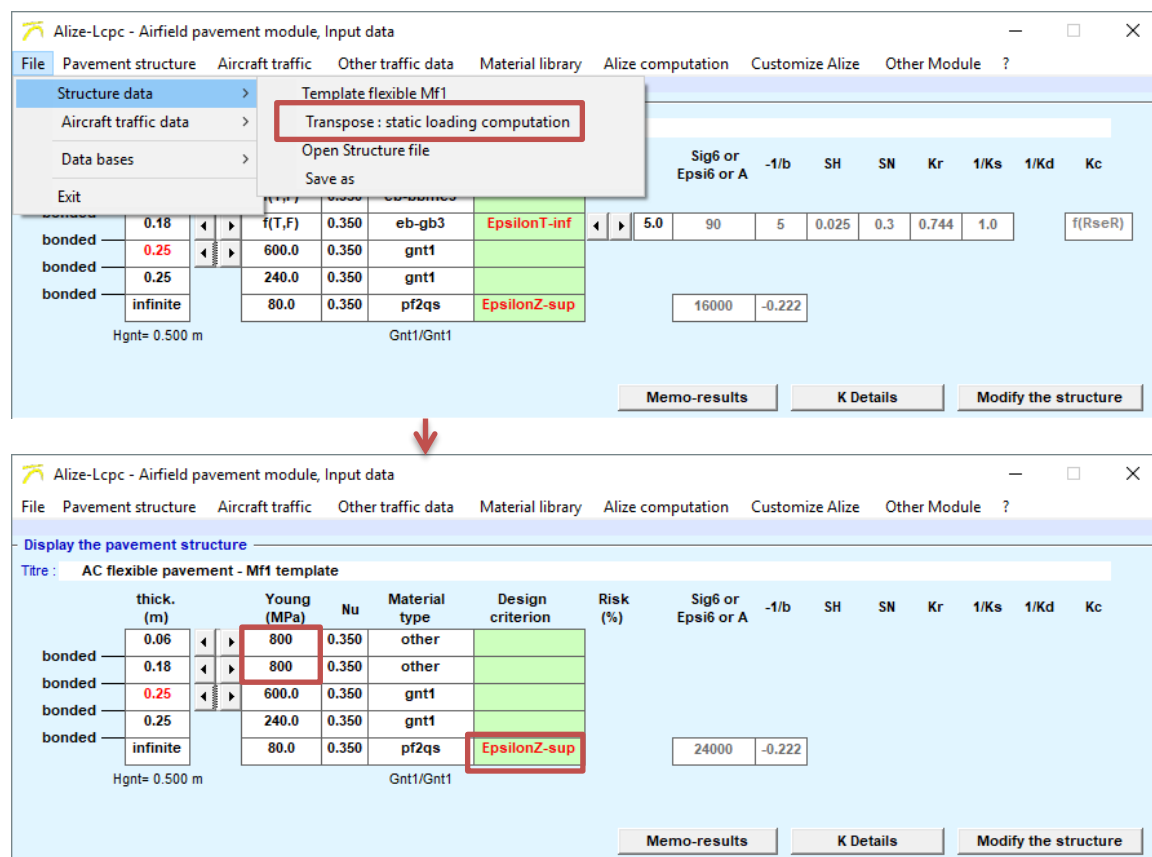


Figure 54. Design of aprons and waiting areas

7. Nomenclatures of input and output files



Alizé-Aéronautique

The nomenclatures of the input and output files are specified in the **Erreur ! Source du renvoi introuvable.**

Extension	Default folder or location	Type
.dat	"Libraries\Documents"	Structure Data
.dap	"Libraries\Documents"	Aircraft traffic data
ficav2016-10-13.bda	C:\Program Files\Alize-Lcpc Routes	Aircraft database
Alizé-Airfield001.res	C:\User name\Alize-Lcpc my files\Unnamed calculations	Results of damage calculations
Alize-Airfield- "Parameter Name" - "Layer No." -XoY.gri	C:\User name\Alize-Lcpc my files\Unnamed calculations	
"matuser.lib"	C:\ "User name"\Documents\Alize-Lcpc my-files\Libraries	Materials Library

8. Pavement design methodology



Alizé-Aéronautique

The different phases of a design study are shown in Figure 55.

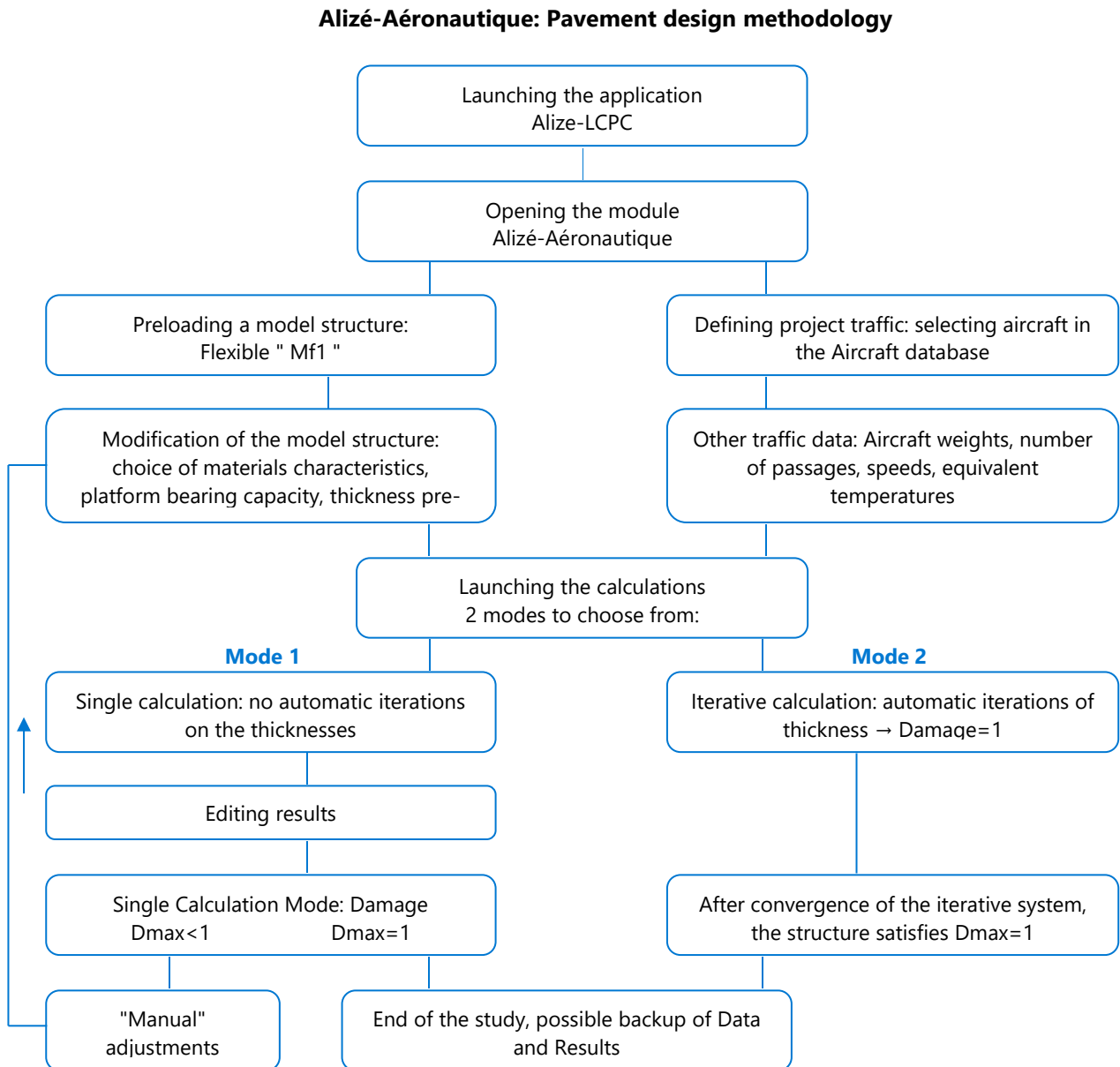


Figure 55. The different phases of a study

9. "HELP" feature



Alizé-Aéronautique

Help is available at the bottom left of the structure window (Figure 56).

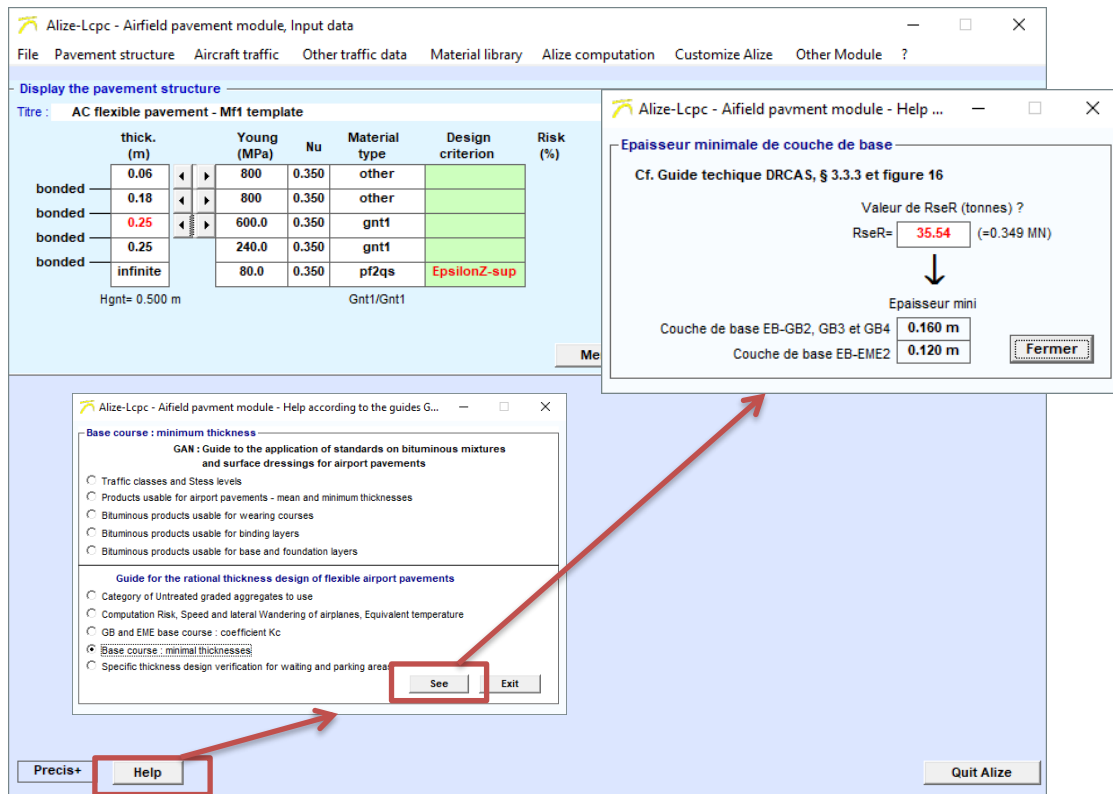


Figure 56. "Help" feature

The Help feature is divided in two parts: one with excerpts from the GAN, and one with excerpts from the design method for flexible airfield pavements.

The first part of the Help feature, with excerpts from the GAN, provides information on:

- Classes of traffic and stress levels
- Materials usable on aeronautical pavements (average and minimum thicknesses)
- asphalts that can be used for the wearing course
- asphalts that can be used for the binder course

Asphalts that can be used for the base course

The second part of the Help, with excerpts from the design method for flexible airfield pavements, gives information on:

- The categories of UGA to be used
- The risk of calculations, the speed and wander of aircraft, the equivalent temperature
- The GB and EME2 base courses: coefficient Kc [to obtain the value of Kc as a function of the value of the ESwL]
- The base course: minimum thickness [to obtain the value of the minimum thickness as a function of the value of the ESwL]
- The specific verification for aprons and waiting areas

10. Example of pavement design



10.1. Example of runway design

This example comes from the rational design method of flexible airfield pavement technical guide. It is simply illustrated with screen-shots of Alizé-aéronautique software. The text coming from the guide is in purple.

10.1.1. Subgrade

The target bearing capacity of the project is PF2. In the calculation model, to determine the stresses in the pavement, the subgrade module is the range lower value, namely 80 MPa.

	thick. (m)	Young (MPa)	Nu	Material type	Design criterion	Risk (%)	Sig6 or Epsi6 or A	-1/b	SH	SN	Kr	1/Ks	1/Kd	Kc
bonded	0.06	f(T,F)	0.350	eb-bbme3										
bonded	0.18	f(T,F)	0.350	eb-gb3	EpsilonT-inf	2.5	90	5	0.025	0.3	0.703	1.0		f(RseR)
bonded	0.25	600.0	0.350	gnt1										
bonded	0.25	240.0	0.350	gnt1										
	infinite	80.0	0.350	pf2qs	EpsilonZ-sup		16000	-0.222						

Hgnt= 0.500 m Gnt1/Gnt1

Memo-results K Details Modify the structure

Figure 57 : Subgrade

10.1.2. Stress level (NS) determination

❖ Determining the "CTi" traffic class

The methodology for determining the traffic class is defined in the GAN. The application of this methodology to the selected traffic results is detailed in table 40.

Aircraft in the project traffic	"Group"	F (mvts/d)	Class of traffic
A340-200	5	1.27	CT4
B777-300 ER	5	1.73	CT4
A330-300	5	1.28	CT4
A320-200 JUM	3	4.70	CT2
A310-300	4	6.00	CT3

The traffic class of the selected project is the highest; it is therefore the **CT4 traffic class**.

❖ Determining the stress level "NSi"

The traffic class defined previously is the CT4 class.

The **climate** chosen for the design is **type 4**, predominantly tropical, with an equivalent temperature:

$\theta_{eq} = 28^{\circ}\text{C}$ (corresponding to the specific case of French Guiana, see GDCAS, paragraph 3.1.4).

► The stress level is therefore NS4.

10.1.3. Structure definition

❖ Choosing the surface layer

The choice of the surface layer (methodology detailed in the GAN [3]) depends on the "stress level" defined on the basis of the class of traffic and the type of climate.

For the NS4 stress level and for the common part of the runways, the GAN recommends a single type of product for the wearing course: EB-BBA 2 (application of paragraph 5.3 of GDCAS).

As a binder course (application of Table 13, paragraph 5.3), the two proposed products are EB-BBSG 1 or EB-BBME 1 (adding binder course is not recommended by the flexible pavement design guide).

For the rest of the study, it has been decided to retain as a surface layer only the wearing course made with EB-BBA 2 material as a surface layer (no binder course). The working thickness is set at 6 cm.

❖ Base course

For the NS4 stress level and for the common part of the runways, the GAN means that either an EB-GB 3 product or an EB-EME 2 product is retained as the base course. For this example, the material for the chosen base course is an EB-EME 2.

❖ Pavement foundation

We have chosen to use a pavement foundation category 1 untreated graded aggregate.

❖ Mechanical characteristics of materials

The mechanical characteristics of the materials selected for this example are given in Table 41. These are the minimum conventional values. The values of the modules at different temperatures and frequencies are derived from Tables 20 and 23 indicating the susceptibilities of the modules to changes in temperature and frequency.

Product	$E(15^{\circ}\text{C}, 10\text{Hz})$ (MPa)	$E(10^{\circ}\text{C}, 10\text{Hz})$ (MPa)	$E(28^{\circ}\text{C}, 10\text{Hz})$ (MPa)	$\varepsilon_6(10^{\circ}\text{C}, 25\text{Hz})$ (μdef)	$\beta = -1/b$	S_N	S_h
EB-BBA 2	5,500	7,315	1,760	100	5	0.25	-
EB-EME 2	14,000	16,940	7,000	130	5	0.25	(1)

(1) $Sh = 1$ if $e \leq 10$ cm, $Sh = 1+0.3(e-10)$ if 10 cm $< e < 15$ cm, $Sh = 2.5$ if $e \geq 15$ cm

As far as the untreated graded aggregate is concerned, it is subdivided (for the design) into sub-layers 0.25 m thick. The UGA 1 module is equal to 3 times the modulus of the underlying layer, until it does not exceed the maximum limit value of 600 MPa. The modulus of the first subgrade will therefore be equal to $80 \text{ MPa} \times 3 = 240 \text{ MPa}$, that of the second to $240 \text{ MPa} \times 3 = 720 \text{ MPa}$, limited to 600 MPa.

Using Alize-Aeronautique: choice of pavement structure

The pavement structure should be defined by starting from the flexible structure model Mf1 and then modifying it. To do so, go to the "File" tab of the main menu bar, then in "Structural data", then "Flexible model Mf1" (Figure 58).

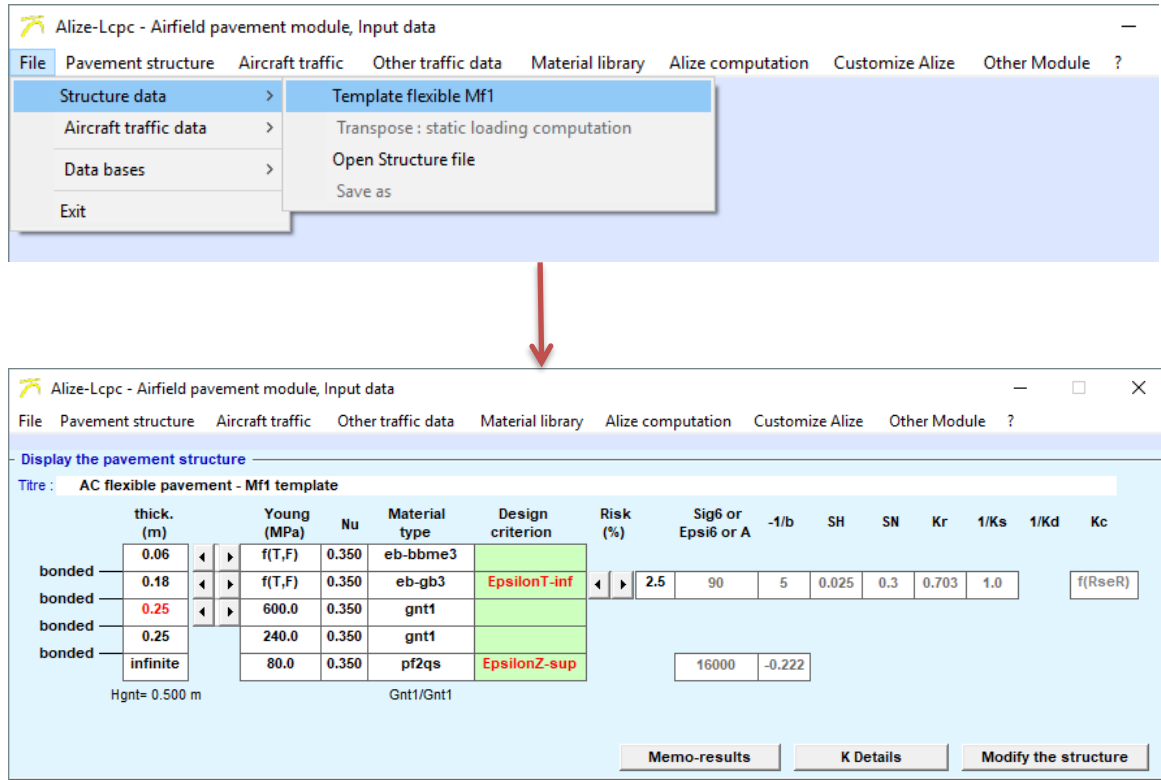


Figure 58. Obtaining the pavement structure model

According to the example, the chosen pavement structure is:

- 6 cm of BBA
- 18cm of EME2
- x cm of UGA1
- A PF2qs of 80 MPa

As indicated on the Figure 59, it is necessary to start from the flexible structure model Mf1 and to change the materials. To do so, double-click on the box of the material to be modified. A window with the library of materials is displayed. Click on the material corresponding line.

10. Example of pavement design

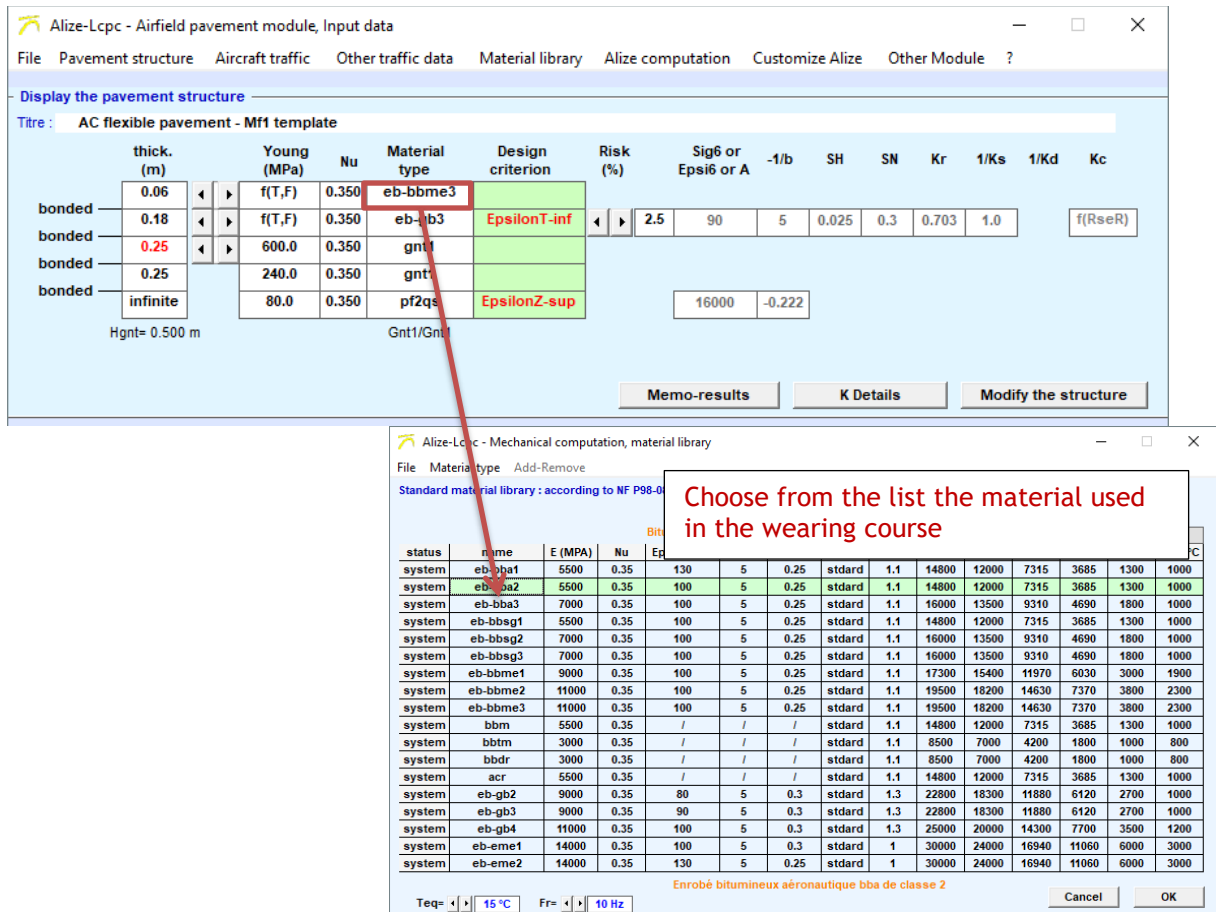


Figure 59. Selecting the material used as a wearing course

The same procedure should be done with the base course (UGA materials). The final pavement structure is presented in Figure 60.

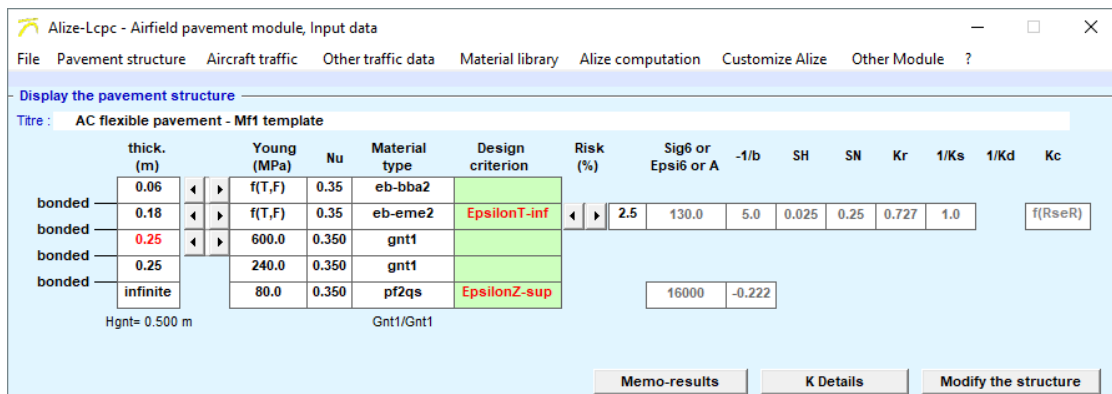


Figure 60. Pavement structure with selected materials

Damage calculations

Damage calculation is carried out at two levels in the pavement structure:

- at the bottom of the base course (EB-EME 2) - traction fatigue damage (criterion ϵ_T)
- at the top of the subgrade - compression damage by permanent deformation (criterion ϵ_Z).

10.1.4. Layers thickness

Using Alizé-Aéronautique: modification of layer thicknesses

Before launching the calculations, the thicknesses must be changed. As indicated on the Figure 61, click on the arrows to vary the thickness of the layers.

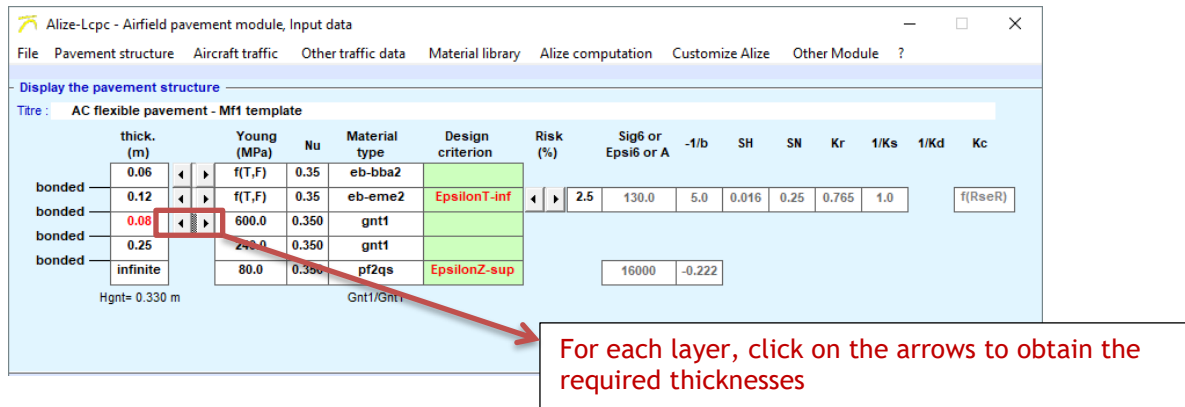


Figure 61. Changing thicknesses

10.1.5. Risk

Project data on traffic

The **calculation risk** is assumed to be equal to **2.5%** since the annual traffic class is greater than CT3 (recommendation in the guide, paragraph 3.1.1).

Using Alizé-Aéronautique: choice of risk

Once the flexible pavement structure model has been chosen, it is possible to choose the risk value. As indicated on the Figure 62, click on the arrows until you get the wanted risk value.

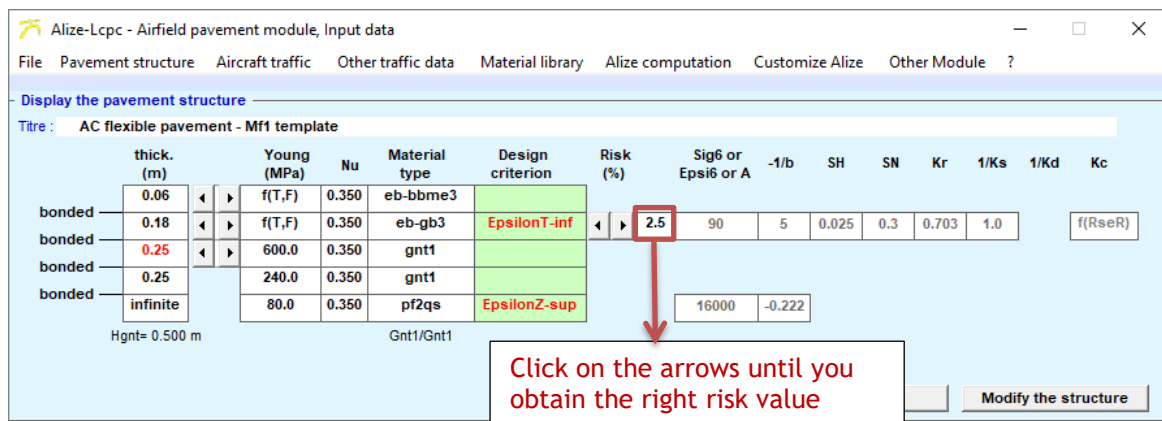


Figure 62. Choice of risk value

10.1.6. Traffic

Project data on traffic

Traffic characteristics

The information relating to aircraft likely to use the aeronautical pavement to be designed is grouped in XX. The distinction is made between take-offs and landings: the weight and the number of movements are specified for each of them. Note that a movement represents either a take-off or a landing.

Table 3. Traffic retained for design

Aircraft in the project traffic	Maximum ramp weight Mrw (t) *	Maximum landing weight Mlw (t) *	Number of take-offs /year	Number of landings /year	Cumulative traffic per type of aircraft (for 10 years)
A340-200	260	174.7	315.4	182.6	4980
B777-300 ER	341	243.8	399	231	6300
A330-300	230	184.0	296.4	171.6	4680
A320-200 JUM	71	59.5	1086.8	629.2	17160
EMB 190 LR/AR	50.3	45.8	691.6	400.4	10920
B737-100	42.4	35.1	509.2	294.8	8040
AN124	392	319.5	22.8	13.2	360
B747-400 Cargo	377.8	287.1	98.8	57.2	1560
KC135	136.8	101.1	38	22	600
B707-320B	146.8	108.3	38	22	600
A310-300	157	125.6	1387	803	21900
CASA CN325-100	15.1	13.6	1387	803	21900

*: since the data are extracted from actual traffic, the weights are less than or equal to those of the "Ficav" database, which indicates the Mrw and Mlw values recorded on the certificate of airworthiness.

The calculation period is 10 years. Over this period, traffic growth is assumed to be zero. It is then possible to calculate the number of cumulative passages of each aircraft over the calculation period. The results are shown in Table 38, column "Cumulative traffic per type of aircraft (for 10 years)".

For each aircraft, the geometry of the landing gear and the loading conditions of the landing gear are defined in the "Ficav" database of the STAC.

Since the list of aircraft using the runway is large, we propose to use the method described in paragraph 3.1.2.3 of the GDCAS in order to reduce the number of aircraft taken into account in the design.

We recall that this method takes into account, for each aircraft, the load on the largest wheel and compares it with the largest load for all traffic. The coefficient r_j calculated for each aircraft makes it possible to consider the design aircraft in the case where $r_j \geq 1\%$.

Table 39 presents the results of the application of this method. Only five aircraft are therefore retained in the remainder of the calculation (aircraft in green in Table 39).

Aircraft in the project traffic	Pr_j (in tonnes)	n_j	p_j	r_j	
A340-200	27.42	4980	5.0%	4.6%	
B777-300ER	27.17	6300	6.4%	5.5%	
A330-300	27.93	4680	4.7%	4.7%	
A320-200 JUM	18.02	17160	17.3%	1.9%	
EMB190 LR/AR	11.98	10920	11.0%	0.2%	
B737-100	11.57	8040	8.1%	0.1%	
AN-124	19.31	360	0.4%	0.1%	
B747-400ER Cargo	24.23	1560	1.6%	0.8%	
B KC135	17.82	600	0.6%	0.1%	
B707-320B	17.55	600	0.6%	0.1%	
A310-300	19.51	21900	22.1%	3.7%	
CASA CN325-100	3.8	21900	22.1%	0.0%	
	$Pr_{j_{max}} = 27.93$	$n_{tot} = 99000$			

The track to be designed is considered as a section circulated at high speed. Thus, the speed of each aircraft is set at 100 km/h (corresponding to a frequency of 10 Hz) and the lateral wander of each aircraft is then characterised by a standard deviation of 0.75 m (see paragraph 3.1.3 of the guide).

Using Alize-Aeronautique: Traffic definition

First, the aircraft should be chosen. In order to simplify this example, only the design-critical aircraft will be selected.

To do so, go to the "Aircraft traffic" tab of the main menu bar.

The selection of the 1st aircraft in the project traffic, an Airbus A340 B2, is detailed in Figure 63, Figure 64, Figure 65 and Figure 66.

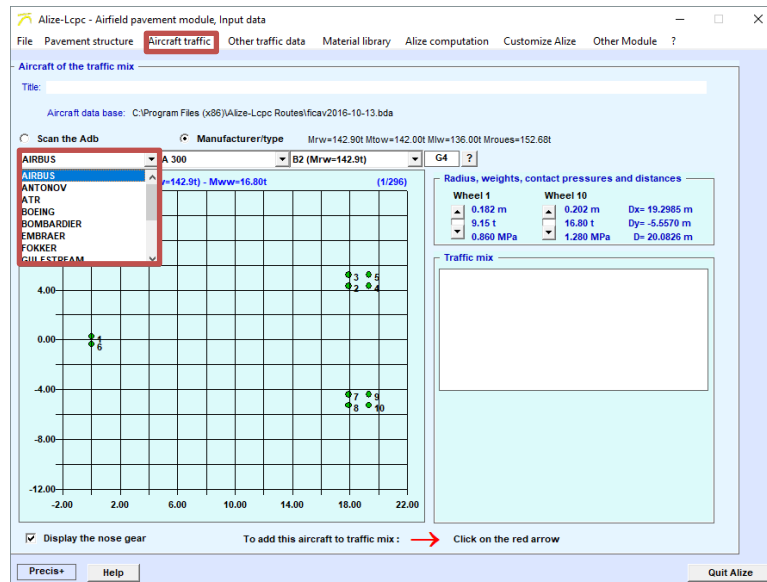


Figure 63. Selecting the of the first aircraft in the project traffic

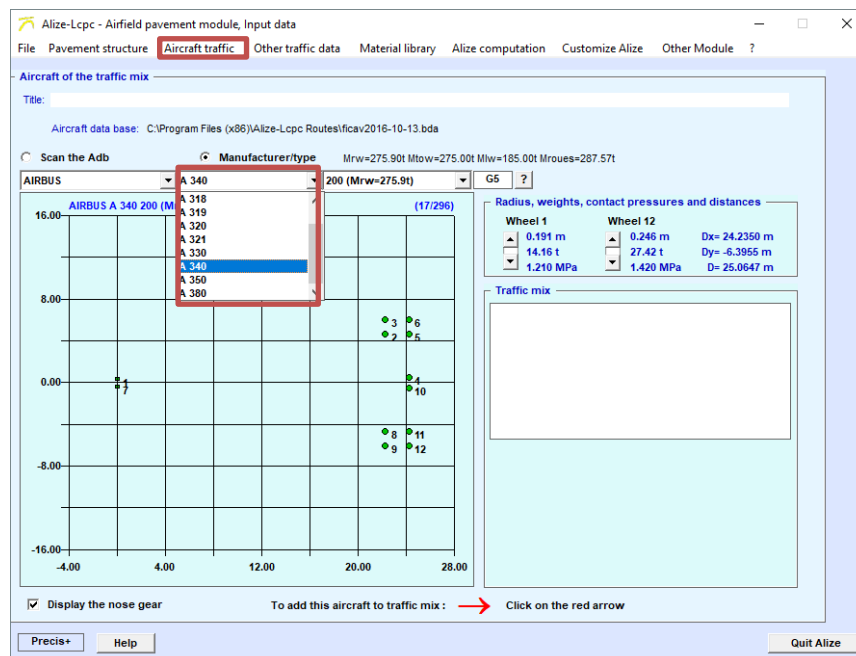


Figure 64. Selecting the type of the first aircraft in the project traffic

10. Example of pavement design

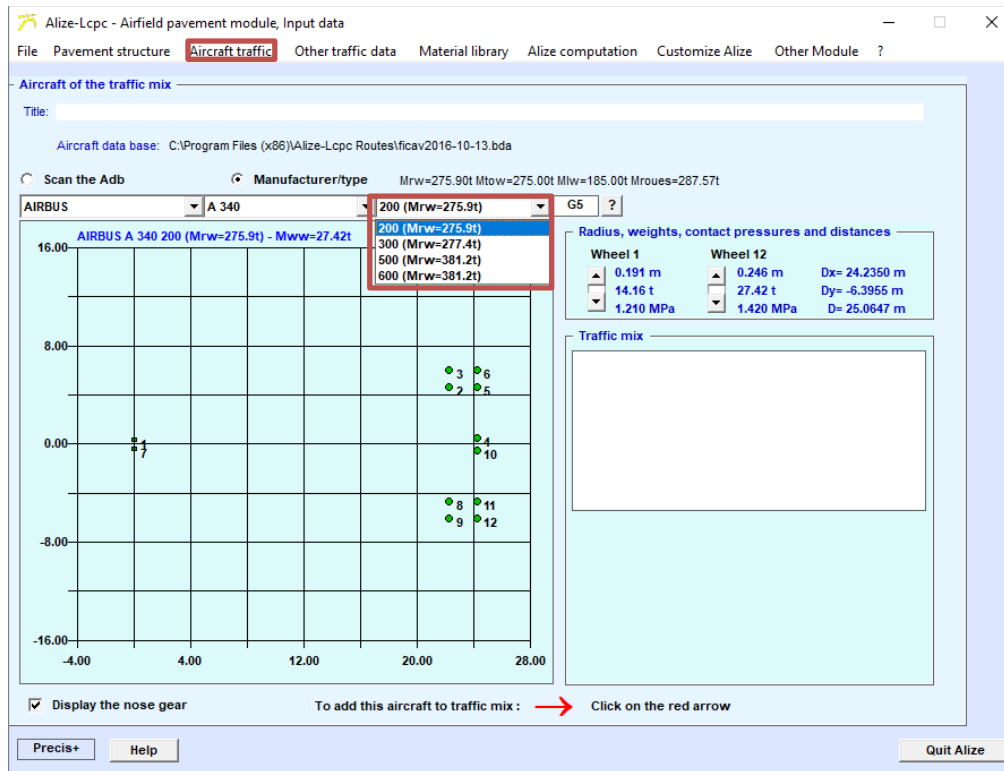


Figure 65. Selecting the model of the first aircraft in the project traffic

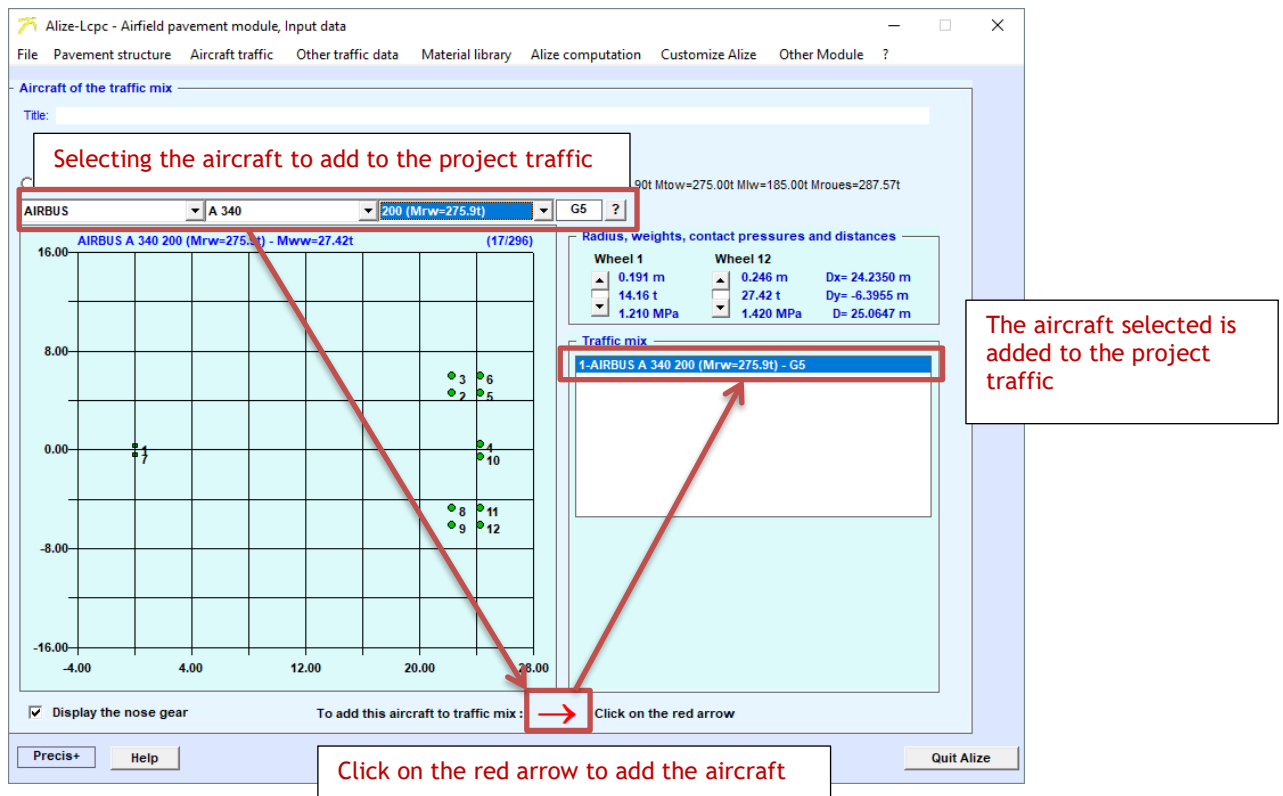


Figure 66. Adding this aircraft to project traffic

The aircraft must be added twice to the project traffic in order to be able to indicate the take-off information and the landing information (Figure 67), as the aircraft weight is different

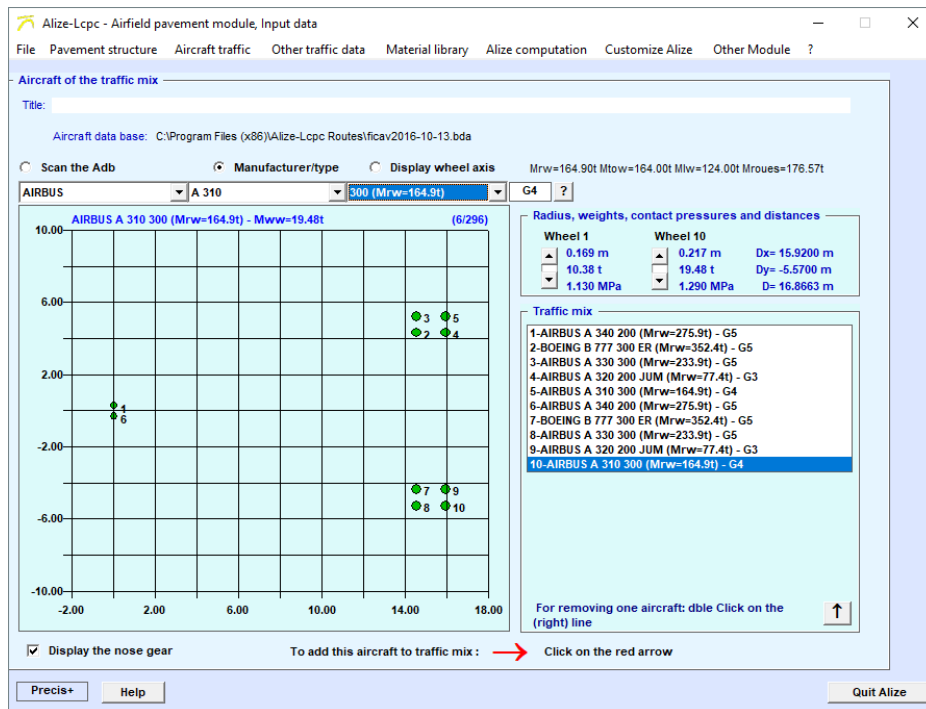


Figure 67. Final project traffic

10.1.7. Traffic detailed

After that, traffic data should be filled in in "other traffic data" window, including the weights and the number of movements. In that example, the real weights were provided. It is then decided to use them rather than the maximal loads provided by the Ficav database. . This results in more accurate calculations. The example is detailed for the last aircraft of the project traffic, for the number of landings per year: the Airbus A310 300, with 803 landings per year, and a landing weight of 125.6 tons.

In order to fill the weights and numbers of movements, go to the "Other traffic data" tab of the main menu bar.

By default, Alize-aéronautique indicates a cumulative number of movements for the Mrw weight (Figure 68).

The screenshot shows the 'Other traffic data' window. It includes a title field, a design life of the pavement (years) field, and a table of aircraft data.

Aircraft of the traffic mix	Weight (t)	Number	Aircraft passes	Units	Ta(%)	Cumulated traffic	Wandering= 2xStanDev(m)	Speed (km/h)	Temperature TetaEq
1-AIRBUS A 340 200 (Mrw=275.9t) - G5	Other	260	315	Passes/year	0	3 150	1.50	100.0	15
2-BOEING B 777 300 ER (Mrw=352.4t) - G5	Other	341	399	Passes/year	0	3 990	1.50	100.0	15
3-AIRBUS A 330 300 (Mrw=233.9t) - G5	Other	230	296	Passes/year	0	2 960	1.50	100.0	15
4-AIRBUS A 320 200 JUM (Mrw=77.4t) - G3	Other	71	60	Passes/year	0	600	1.50	100.0	15
5-AIRBUS A 310 300 (Mrw=164.9t) - G4	Other	157	1387	Passes/year	0	13 870	1.50	100.0	15
6-AIRBUS A 340 200 (Mrw=275.9t) - G5	Other	174.7	183	Passes/year	0	1 830	1.50	100.0	15
7-BOEING B 777 300 ER (Mrw=352.4t) - G5	Other	243.8	231	Passes/year	0	2 310	1.50	100.0	15
8-AIRBUS A 330 300 (Mrw=233.9t) - G5	Other	184	172	Passes/year	0	1 720	1.50	100.0	15
9-AIRBUS A 320 200 JUM (Mrw=77.4t) - G3	Other	59.5	1087	Passes/year	0	10 870	1.50	100.0	15
10-AIRBUS A 310 300 (Mrw=164.9t) - G4	Mrw	164.900	36500	Cumulated	0	36 500	1.50	100.0	15

Figure 68. Default Alize-Aéronautique data for the last aircraft of the project traffic

10. Example of pavement design

The number of landings per year and the actual landing weight should be entered.

Alize-Lcpc - Airfield pavement module, Input data

File Pavement structure Aircraft traffic Other traffic data Material library Alize computation Customize Alize Other Module ?

Other traffic data, design life, wandering and frequency

Title:

Design life of the pavement (years): 10.0

Aircraft of the traffic mix	Weight (t)	Number	Aircraft passes Units	Ta(%)	Cumulated traffic	Wandering= 2xStanDev(m)	Speed (km/h)	Temperature TetaEq
1-AIRBUS A 340 200 (Mrw=275.9t) - G5	Other	260	315	Passes/year	0	3 150	1.50	100.0
2-BOEING B 777 300 ER (Mrw=352.4t) - G5	Other	341	399	Passes/year	0	3 990	1.50	100.0
3-AIRBUS A 330 300 (Mrw=233.9t) - G5	Other	230	296	Passes/year	0	2 960	1.50	100.0
4-AIRBUS A 320 200 JUM (Mrw=77.4t) - G3	Other	71	60	Passes/year	0	600	1.50	100.0
5-AIRBUS A 310 300 (Mrw=164.9t) - G4	Other	157	1387	Passes/year	0	13 870	1.50	100.0
6-AIRBUS A 340 200 (Mrw=275.9t) - G5	Other	174.7	183	Passes/year	0	1 830	1.50	100.0
7-BOEING B 777 300 ER (Mrw=352.4t) - G5	Other	243.8	231	Passes/year	0	2 310	1.50	100.0
8-AIRBUS A 330 300 (Mrw=233.9t) - G5	Other	184	172	Passes/year	0	1 720	1.50	100.0
9-AIRBUS A 320 200 JUM (Mrw=77.4t) - G3	Other	59.5	1087	Passes/year	0	10 870	1.50	100.0
10-AIRBUS A 310 300 (Mrw=164.9t) - G4	Mrw	164.900	803	Passes/year	0	8 030	1.50	100.0

Click on this box until you obtain the requisite "movement / unit"

Precis+ Help Quit Alize

Figure 69. Entering the number of landings per year

Alize-Lcpc - Airfield pavement module, Input data

File Pavement structure Aircraft traffic Other traffic data Material library Alize computation Customize Alize Other Module ?

Other traffic data, design life, wandering and frequency

Title:

Design life of the pavement (years): 10.0

Aircraft of the traffic mix	Weight (t)	Number	Aircraft passes Units	Ta(%)	Cumulated traffic	Wandering= 2xStanDev(m)	Speed (km/h)	Temperature TetaEq
1-AIRBUS A 340 200 (Mrw=275.9t) - G5	Other	260	315	Passes/year	0	3 150	1.50	100.0
2-BOEING B 777 300 ER (Mrw=352.4t) - G5	Other	341	399	Passes/year	0	3 990	1.50	100.0
3-AIRBUS A 330 300 (Mrw=233.9t) - G5	Other	230	296	Passes/year	0	2 960	1.50	100.0
4-AIRBUS A 320 200 JUM (Mrw=77.4t) - G3	Other	71	60	Passes/year	0	600	1.50	100.0
5-AIRBUS A 310 300 (Mrw=164.9t) - G4	Other	157	1387	Passes/year	0	13 870	1.50	100.0
6-AIRBUS A 340 200 (Mrw=275.9t) - G5	Other	174.7	183	Passes/year	0	1 830	1.50	100.0
7-BOEING B 777 300 ER (Mrw=352.4t) - G5	Other	243.8	231	Passes/year	0	2 310	1.50	100.0
8-AIRBUS A 330 300 (Mrw=233.9t) - G5	Other	184	172	Passes/year	0	1 720	1.50	100.0
9-AIRBUS A 320 200 JUM (Mrw=77.4t) - G3	Other	59.5	1087	Passes/year	0	10 870	1.50	100.0
10-AIRBUS A 310 300 (Mrw=164.9t) - G4	Other	125.6	03	Passes/year	0	8 030	1.50	100.0

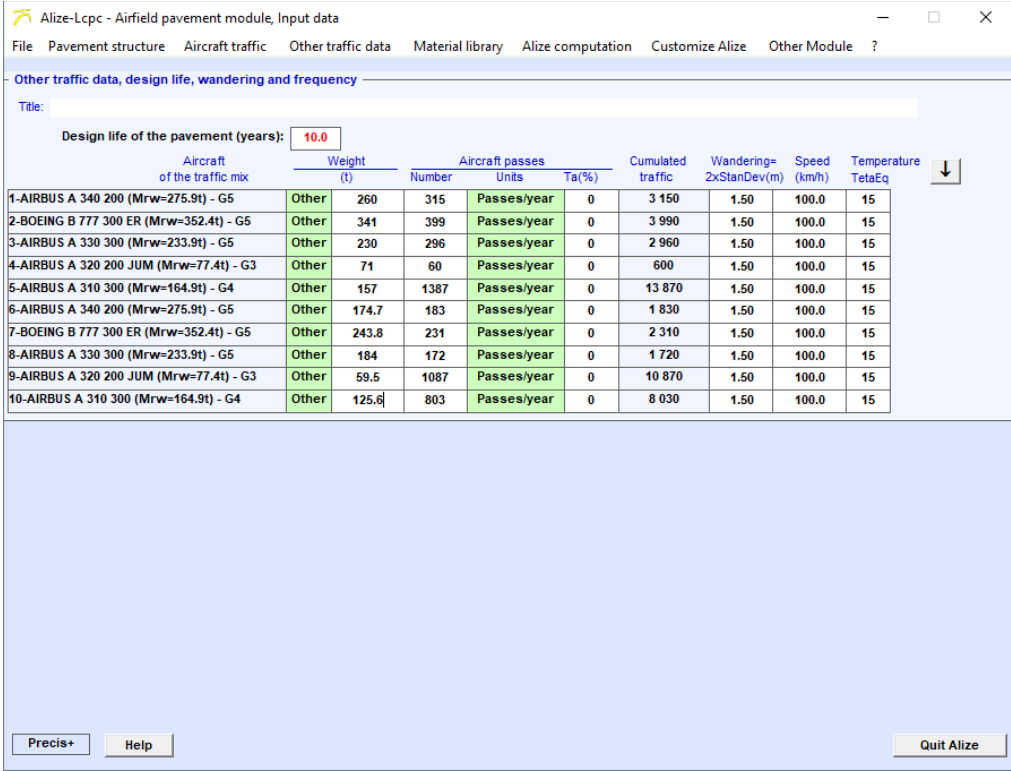
Click on this box until you obtain the requisite weight type

Precis+ Help Quit Alize

Figure 70. Entering the landing weight

10. Example of pavement design

The Figure 71 shows the other traffic data project, once everything is completed.



Alize-Lcpc - Airfield pavement module, Input data

File Pavement structure Aircraft traffic Other traffic data Material library Alize computation Customize Alize Other Module ?

Other traffic data, design life, wandering and frequency

Title: _____

Design life of the pavement (years): 10.0

Aircraft of the traffic mix	Weight (t)	Number	Aircraft passes Units	Ta(%)	Cumulated traffic	Wandering= 2xStanDev(m)	Speed (km/h)	Temperature TetaEq
1-AIRBUS A 340 200 (Mrw=275.9t) - G5	Other	260	315	Passes/year	0	3 150	1.50	100.0
2-BOEING B 777 300 ER (Mrw=352.4t) - G5	Other	341	399	Passes/year	0	3 990	1.50	100.0
3-AIRBUS A 330 300 (Mrw=233.9t) - G5	Other	230	296	Passes/year	0	2 960	1.50	100.0
4-AIRBUS A 320 200 JUM (Mrw=77.4t) - G3	Other	71	60	Passes/year	0	600	1.50	100.0
5-AIRBUS A 310 300 (Mrw=164.9t) - G4	Other	157	1387	Passes/year	0	13 870	1.50	100.0
6-AIRBUS A 340 200 (Mrw=275.9t) - G5	Other	174.7	183	Passes/year	0	1 830	1.50	100.0
7-BOEING B 777 300 ER (Mrw=352.4t) - G5	Other	243.8	231	Passes/year	0	2 310	1.50	100.0
8-AIRBUS A 330 300 (Mrw=233.9t) - G5	Other	184	172	Passes/year	0	1 720	1.50	100.0
9-AIRBUS A 320 200 JUM (Mrw=77.4t) - G3	Other	59.5	1087	Passes/year	0	10 870	1.50	100.0
10-AIRBUS A 310 300 (Mrw=164.9t) - G4	Other	125.6	803	Passes/year	0	8 030	1.50	100.0

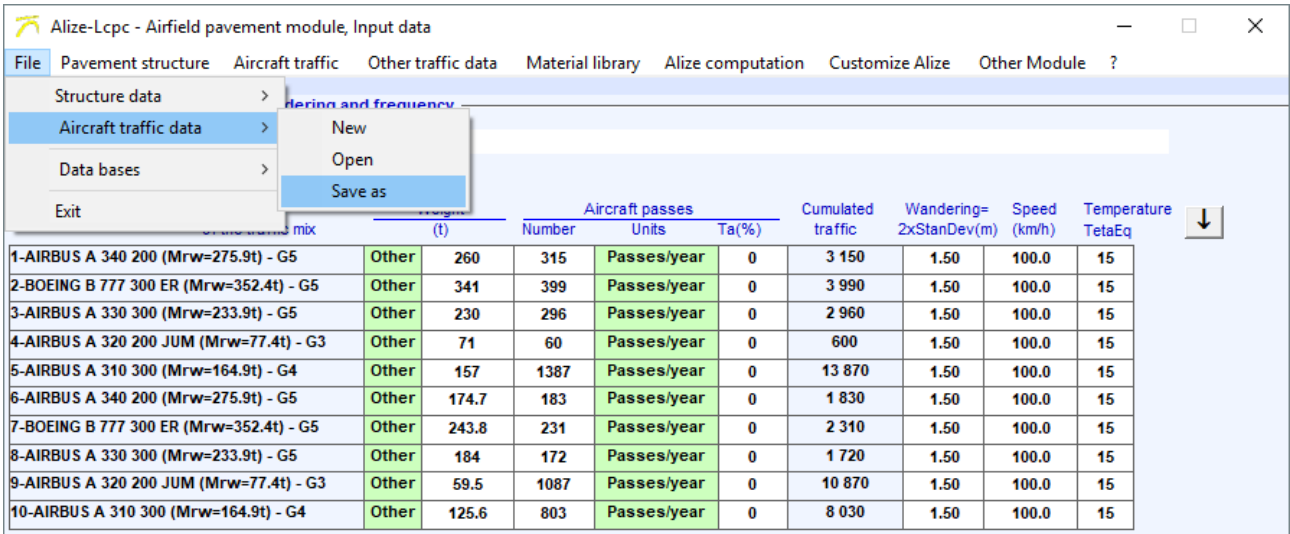
Precis+ Help Quit Alize

Figure 71. Other project traffic data

The calculation period is 10 years. Since this is the default calculation period, it was not necessary to modify it.

The same applies to speed (100 km/h) and wander (1.5 m).

At this point, it is advisable to record the project traffic. As indicated on the Figure 72, go to "File", then "Aircraft Traffic Data", then "Save As".



Alize-Lcpc - Airfield pavement module, Input data

File Pavement structure Aircraft traffic Other traffic data Material library Alize computation Customize Alize Other Module ?

Structure data >
Aircraft traffic data >
Data bases >
Exit

Other traffic data, design life, wandering and frequency

Title: _____

Design life of the pavement (years): 10.0

Aircraft of the traffic mix	Weight (t)	Number	Aircraft passes Units	Ta(%)	Cumulated traffic	Wandering= 2xStanDev(m)	Speed (km/h)	Temperature TetaEq
1-AIRBUS A 340 200 (Mrw=275.9t) - G5	Other	260	315	Passes/year	0	3 150	1.50	100.0
2-BOEING B 777 300 ER (Mrw=352.4t) - G5	Other	341	399	Passes/year	0	3 990	1.50	100.0
3-AIRBUS A 330 300 (Mrw=233.9t) - G5	Other	230	296	Passes/year	0	2 960	1.50	100.0
4-AIRBUS A 320 200 JUM (Mrw=77.4t) - G3	Other	71	60	Passes/year	0	600	1.50	100.0
5-AIRBUS A 310 300 (Mrw=164.9t) - G4	Other	157	1387	Passes/year	0	13 870	1.50	100.0
6-AIRBUS A 340 200 (Mrw=275.9t) - G5	Other	174.7	183	Passes/year	0	1 830	1.50	100.0
7-BOEING B 777 300 ER (Mrw=352.4t) - G5	Other	243.8	231	Passes/year	0	2 310	1.50	100.0
8-AIRBUS A 330 300 (Mrw=233.9t) - G5	Other	184	172	Passes/year	0	1 720	1.50	100.0
9-AIRBUS A 320 200 JUM (Mrw=77.4t) - G3	Other	59.5	1087	Passes/year	0	10 870	1.50	100.0
10-AIRBUS A 310 300 (Mrw=164.9t) - G4	Other	125.6	803	Passes/year	0	8 030	1.50	100.0

Precis+ Help Quit Alize

Figure 72. Saving project traffic

10. Example of pavement design

The equivalent temperature is 28°C. In Alize-aéronautique, the default temperature is 15°C. This value must be changed.

To do so, go to the "Other traffic data" tab of the main menu bar.

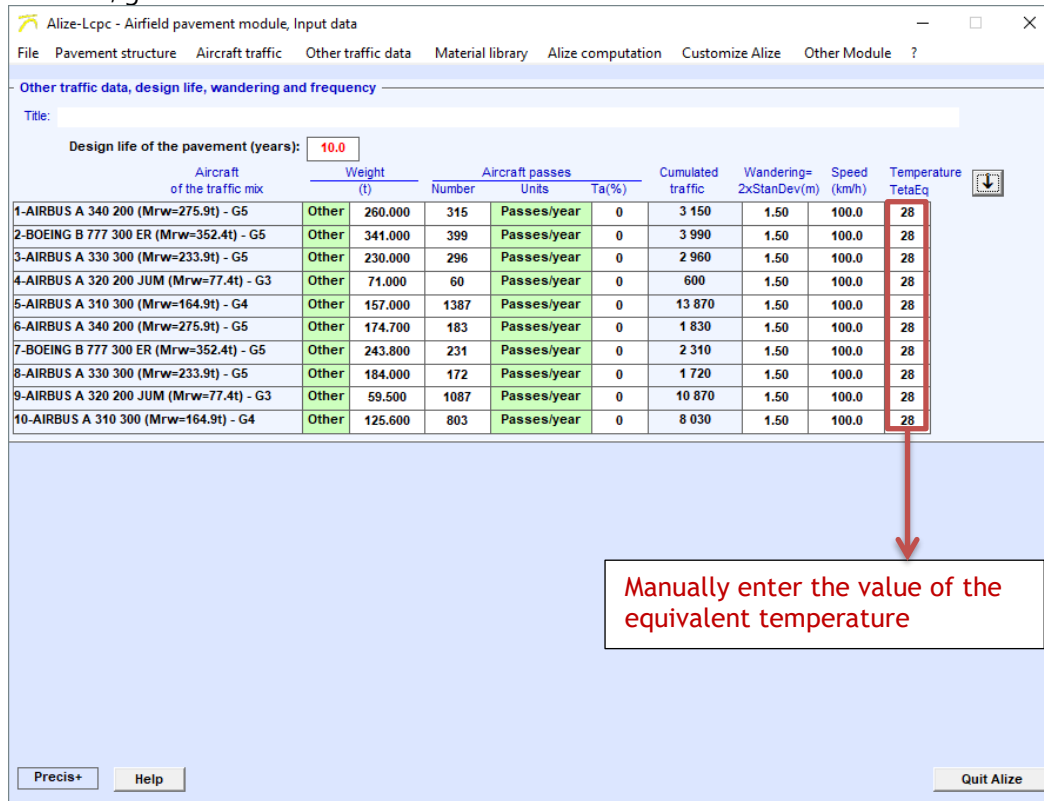


Figure 73. Choosing the equivalent temperature

10.1.8. Single Calculation

Using Alize-Aéronautique: calculation of damage

To start the calculations, as shown on the Figure 74, go to the "Alize Calculation" tab of the main menu bar and choose "Single calculation".

A window opens showing the value of the Equivalent Single wheel Load (ESWL) and the coefficient Kc. Then click OK.

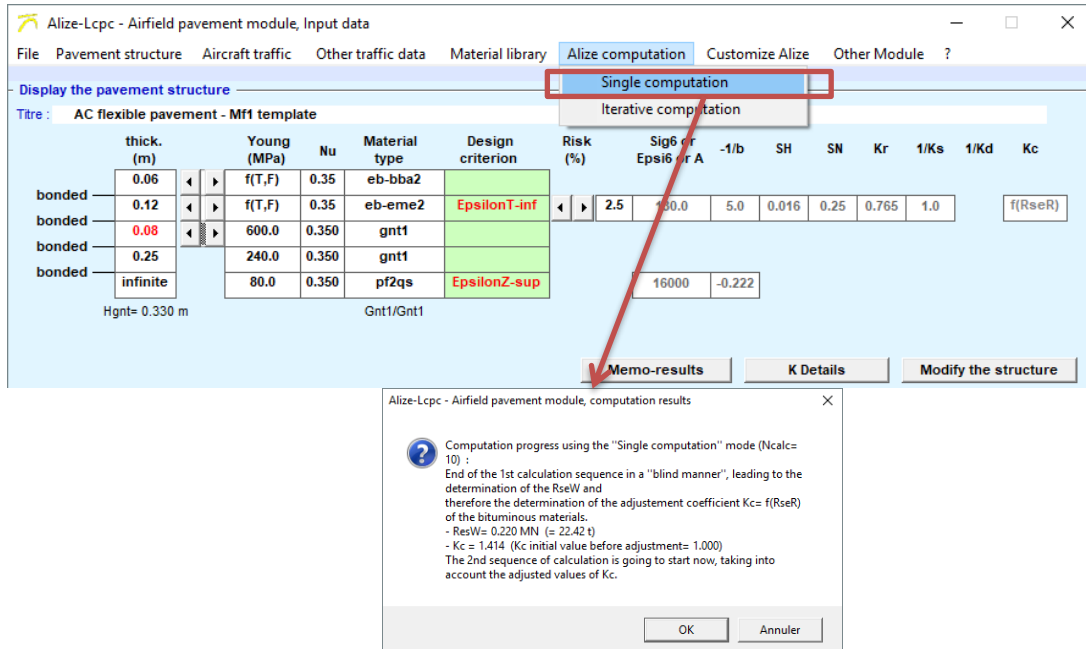


Figure 74. Launching the calculations

As indicated on the Figure 75, a window opens with the result of the first calculation: the damage to the bottom of the asphaltic layers, for the 1st aircraft in the project traffic. To sequence all the calculations, it is then necessary to check "Auto sequence" and click on "next calculation".

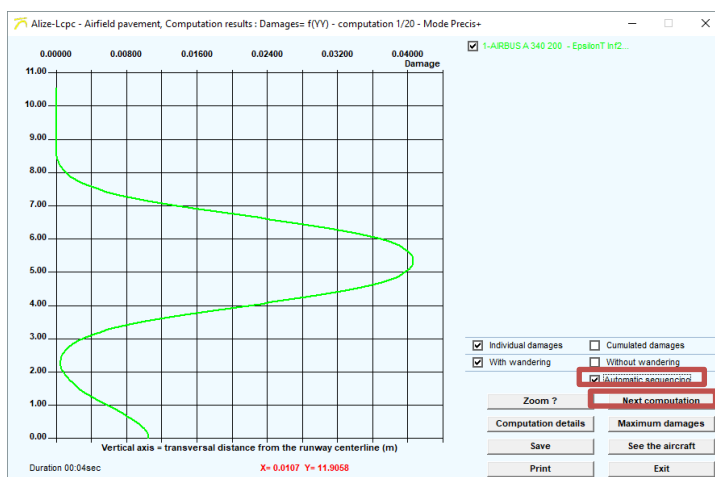


Figure 75. Calculation of the damage at the base of the asphalt courses for the 1st aircraft of the project traffic

10.1.9. Graphic representation

The Figure 76 presents the results of all the calculations: the ϵ_T or ϵ_Z curves for all the aircraft in the project traffic.

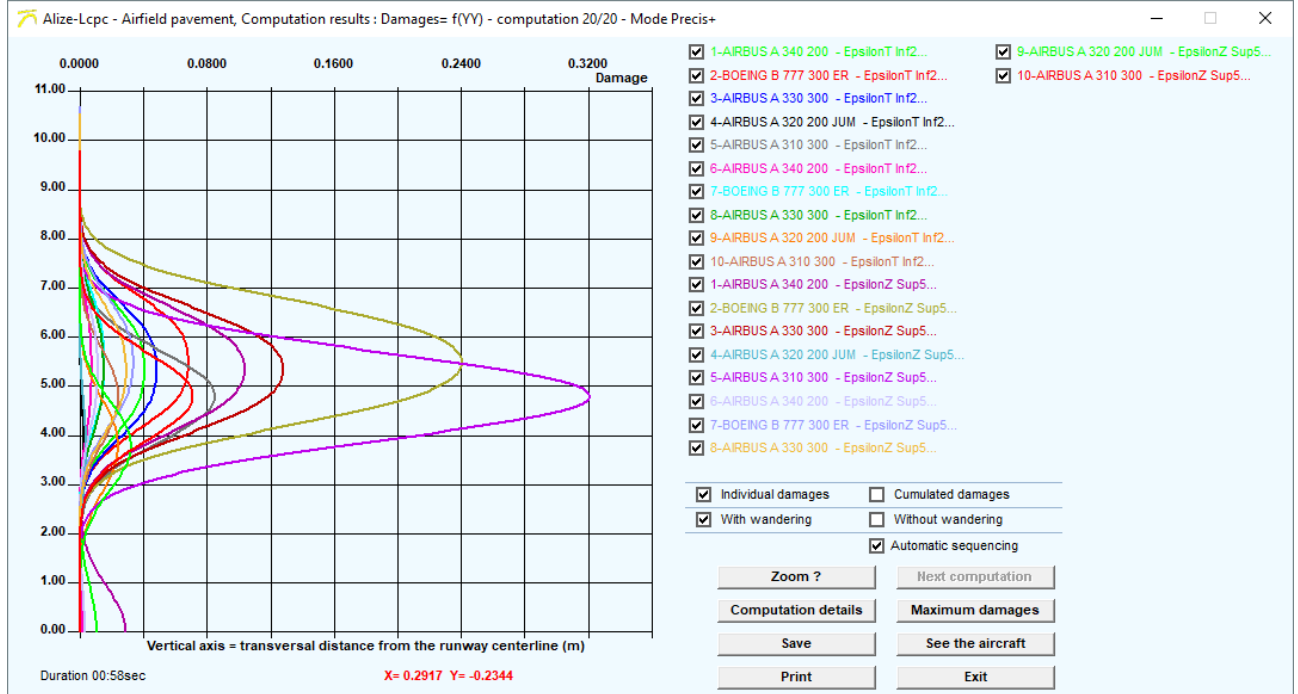


Figure 76. Calculation results: the ϵ_T and ϵ_Z damage for all the aircraft in the project traffic.

The cumulative damage can be obtained by selecting "Cumulative Damage".

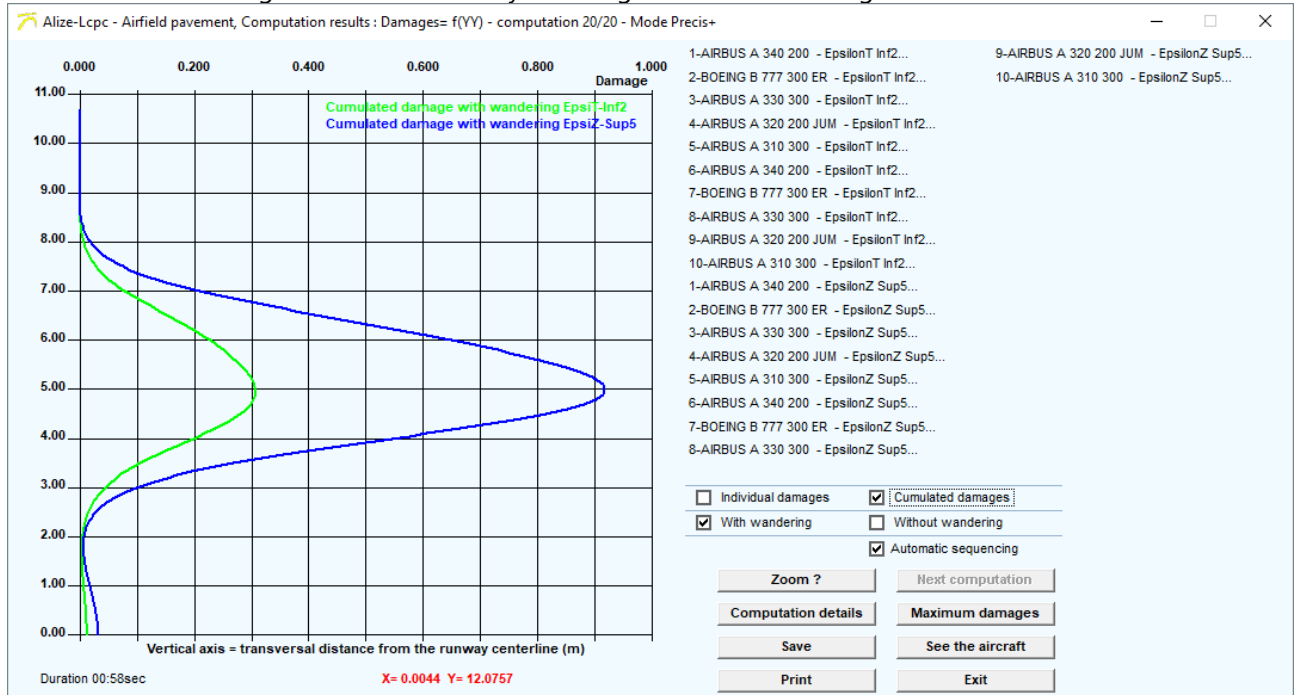


Figure 77. Cumulative Damage

10. Example of pavement design

By clicking on "Maximum damage", it is possible to obtain the summary damage table (Figure 78). The cumulative damage, with wander, is:

- For ϵ_T : 0.265
- For ϵ_Z : 0.379

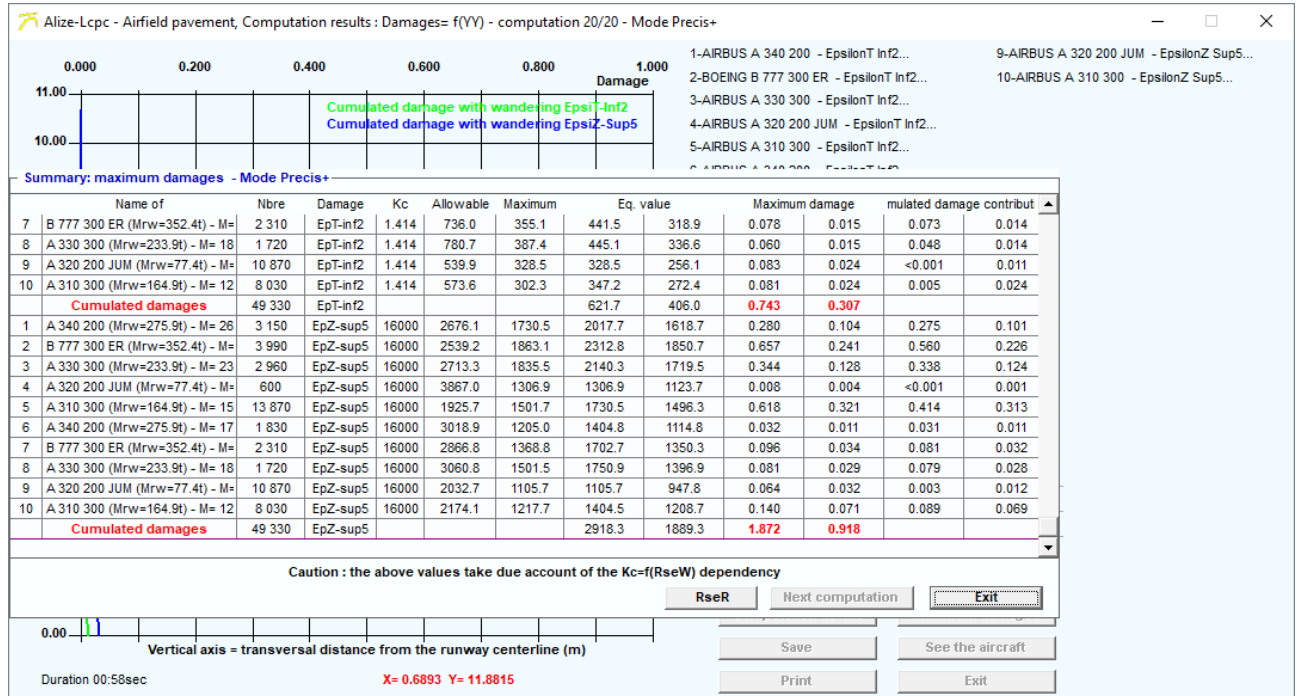


Figure 78. Summary table of damage

Software

Alizé-Aéronautique



Exclusive distributor:



8 quai de Bir Hakeim 944 10 Saint-Maurice France

Tel.: +33 (0)1 49 76 12 59

www.alize-lcpc.com