ArcelorMittal INERD

Innovation for earthquake-resistant design

User's manual

Global Research and
Development Esch

Version 1.0.0

June 2009

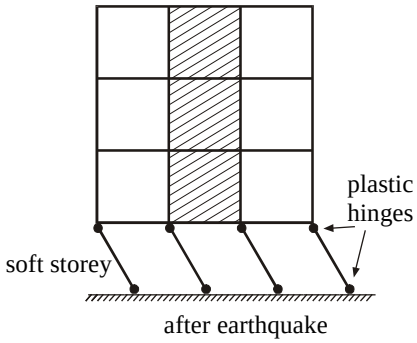
INERD – USER'S MANUEL

CONTENTS

1 INTRODUCTION

1.1 Purpose

The INERD concept is an additional constructive system independent of analysis and design that can be applied to reinforced concrete frame structures. It intends to bring to the structure the robustness required by Eurocode 1 [prEN 1991-1-7: 2004 §1.5.14], i.e. “the ability of the structure to withstand events like fire, explosions, impact or the consequences of human error, without being damaged to an extent disproportionate to the original cause”. The particular objective of the INERD system is to avoid progressive failure, i.e. a chain in which a local failure at the bottom storey generates a global failure out of proportion with the original local problem.



More precisely, the INERD concept for concrete frames consists in placing a steel profile inside the reinforced concrete columns of the ground storey of the building. This profile is not considered in the structural design, which is carried out as usual for RC structures, and is assumed to act as a safety belt activated only in case of unexpected deficiencies of the concrete under earthquake action, due for example to presence of infill panels, uncertainties on the seismic action and in particular on its vertical component, uncertainties on the actual concrete properties.
The essential purpose of the INERD software is to help the designer for the selection of the most appropriate profile to be placed inside the concrete columns of the bottom storey in order to prevent the occurrence of soft storey mechanisms.

1.2 Required configuration

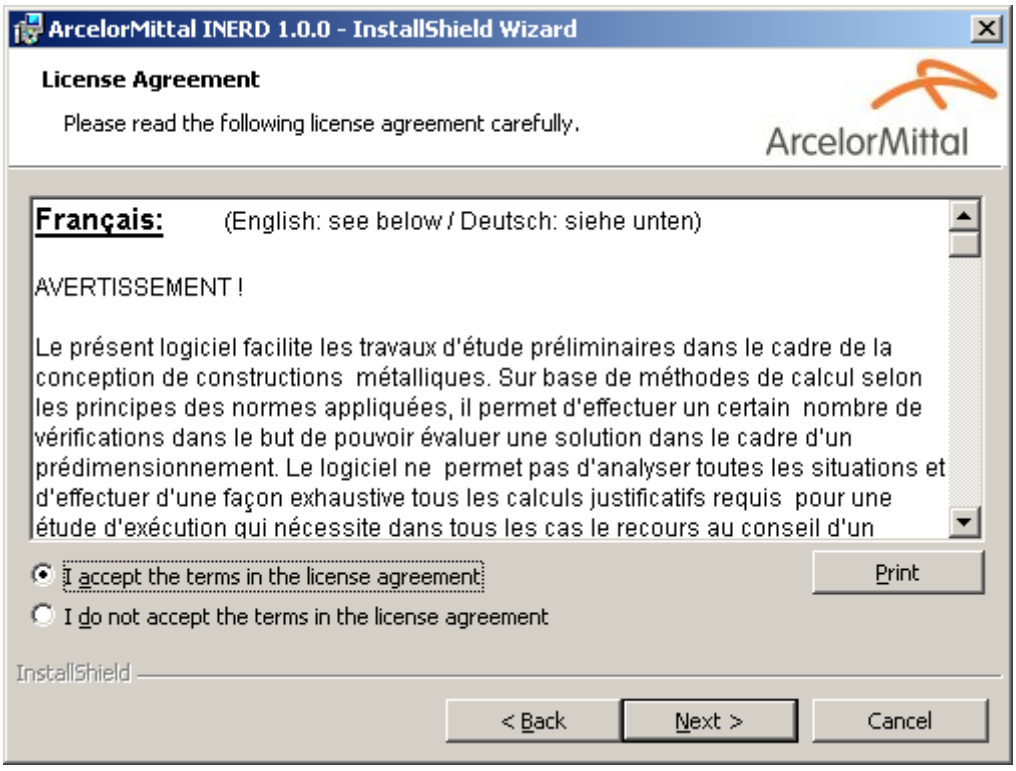
The software is designed for Microsoft Windows. The software has been tested on Windows XP. It should also run under Windows 2000 and Windows Vista, but this is not assured. To install and run the software 512 MB memory and 15 MB hard disk space is required.
The software is developed for the Microsoft .NET framework. If the .NET framework is not installed yet, this will be done automatically by the setup procedure. In this case additional 280 MB disk space must be available to install the .NET framework.
Finally the Adobe Reader is required to view the results of the calculation. The Adobe Reader is not provided with the installation file, it can be downloaded for free from the Adobe website: www.adobe.com/reader.

1.3 Installation procedure

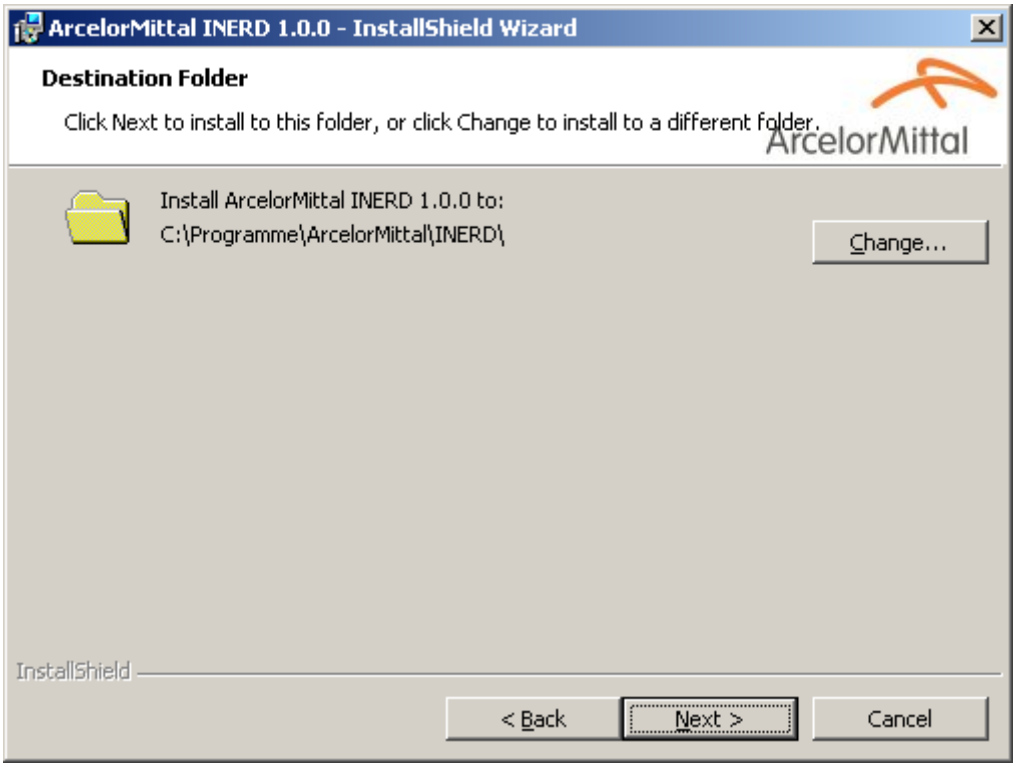
In order to install the INERD software on a PC just execute the provided installation file “Inerd_Setup_1.0.0.exe”. The following screen appears:

Press “Next” to continue.

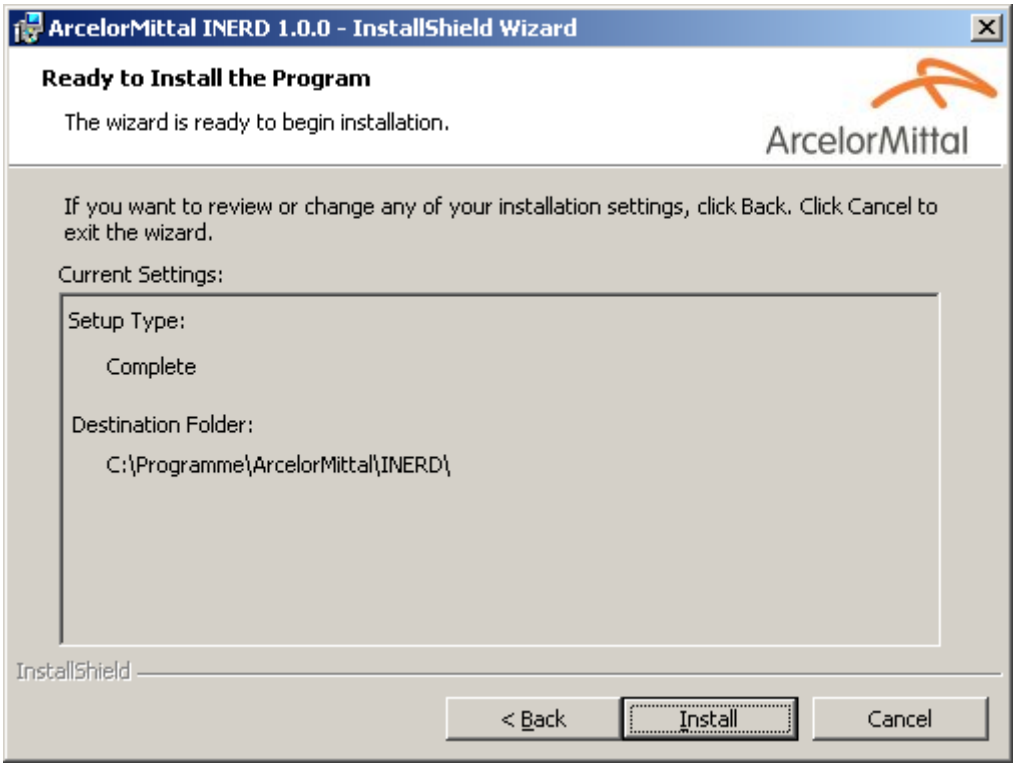
The following screen shows the license agreement in French, English and German language. Please scroll down the text box in order to read the full agreement. To accept the license agreement click on “I accept the terms in the license agreement” and then press “Next”.



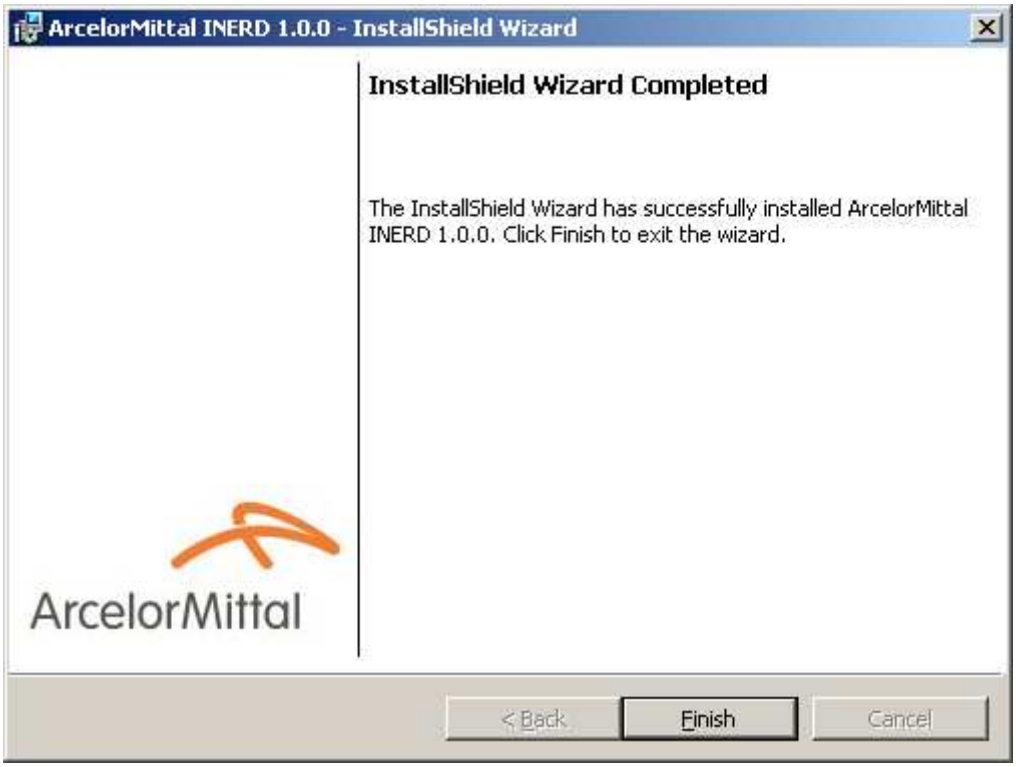
On this screen you can specify the installation folder. Press “Next” to continue.



Now click “Install” to start the installation process.



Press “Finish” to quit the installation procedure.



INERD is now installed on your PC.

1.4 Launch INERD

To launch the INERD software click on the INERD icon on your desktop, or select “Start→Program Files→ArcelorMittal→INERD→INERD 1.0.0”.

1.5 Examples

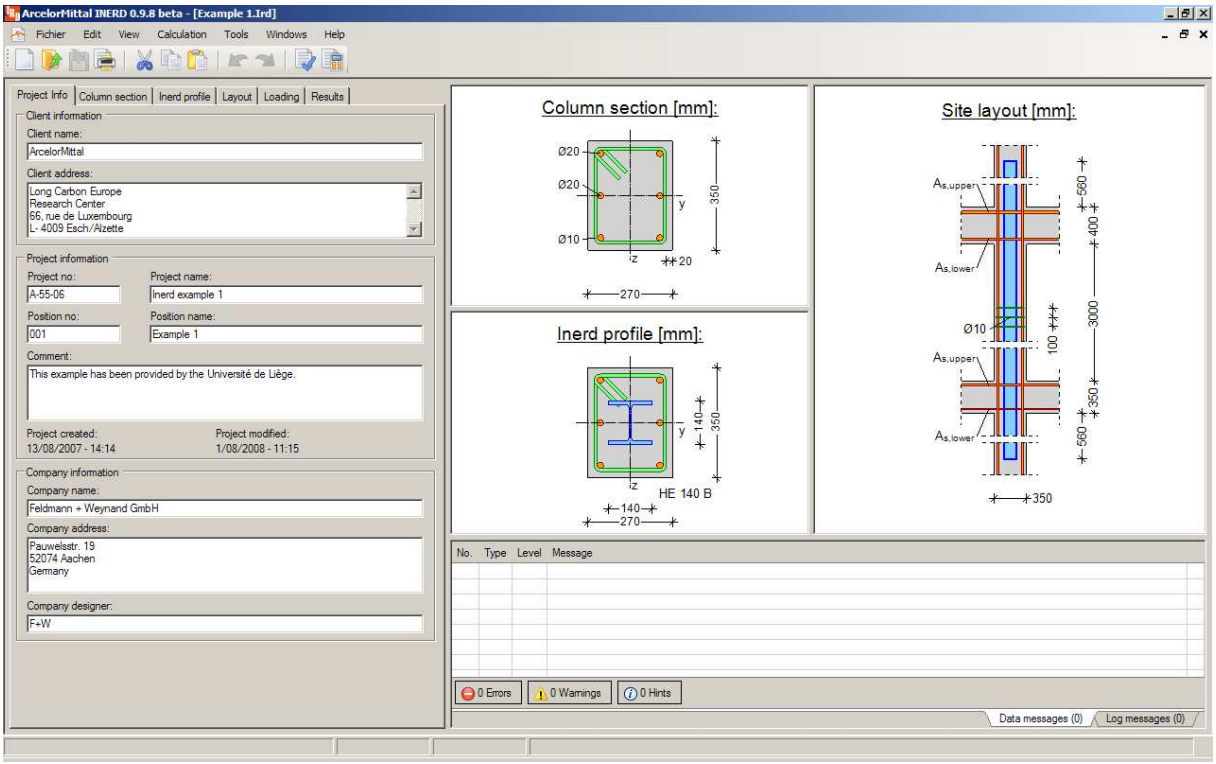
You can find some example files in the folder “<INERD installation folder>\Examples\” (In a typical installation this folder would be “C:\Program files\ArcelorMittal\INERD\ Examples\”. For guidance to open INERD files reference is made to section 2.2.1)

2 DESCRIPTION OF THE GRAPHICAL USER INTERFACE

2.1 General

2.1.1 Description of the main window

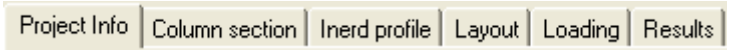
The general layout of the main screen is similar to most software's in the Windows environment and includes from the top to the bottom:



- Title bar,
- Menu bar,

- Tool bar,

- Set of tab-sheets,



- Graphical area,
- Warning/errors table,
- Status bar.

"Menu" bar contains:

- "File" menu,
- "Edit" menu,
- "View" menu,
- "Calculation" menu,
- "Tools" menu,

- "Windows" menu,
- "Help" menu.

"Tool" bar includes the classical Windows buttons (New, Open, Save, Print, Cut, Copy, Paste, Undo, Redo) and 2 specific Inerd buttons activating respectively the following modules:

- Module "Start full data check"  ,
- Module "Start calculation to perform all design checks"  .

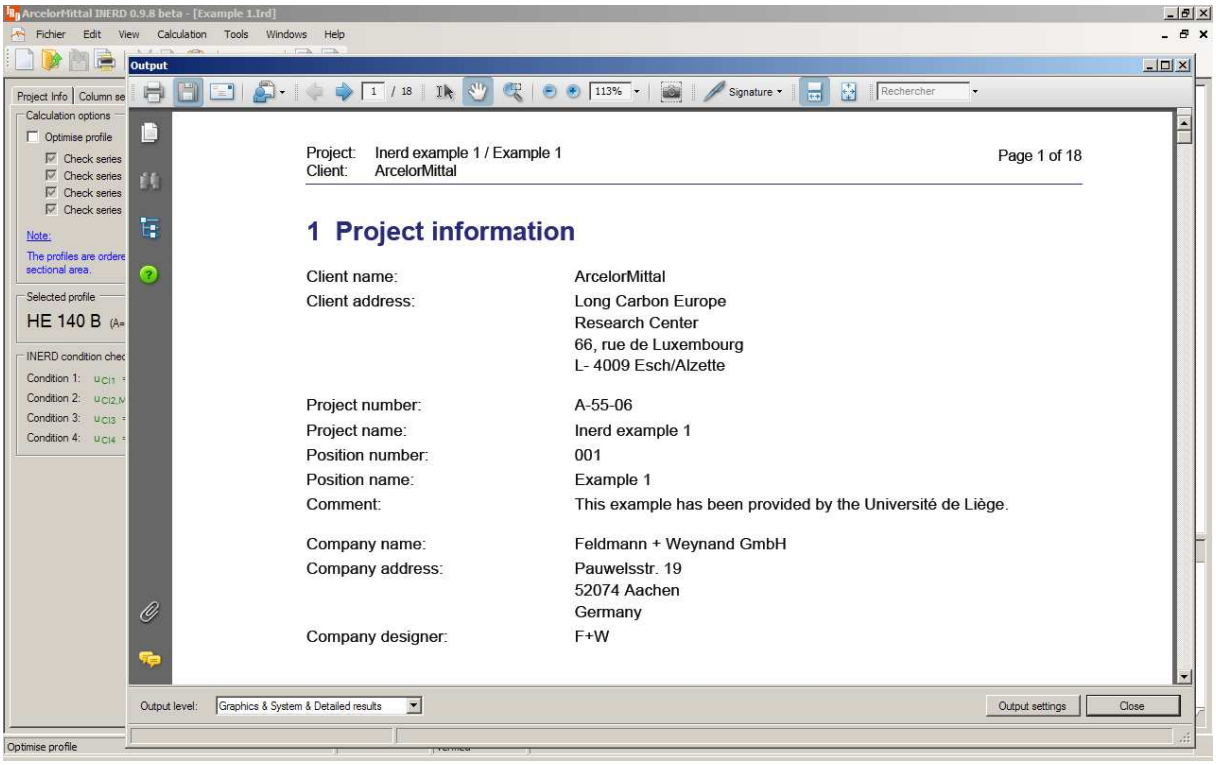
Note that access to the module "Start full data check" is not possible when the option "Optimise profile" is activated in the tab-sheet "Results" (See later for more information).

The different tab-sheets are:

- "Project Info",
- "Column section",
- "Inerd profile",
- "Layout",
- "Loading",
- "Results".

2.1.2 Data and results files management

When saving the project ("save" button or "save as…" in the "file" menu), all project data are stored in a ****.Ird*** file.



During data introduction and after processing, available data and results can be viewed and/or printed through the "outpout" file (adobe ***Pdf*** format). This file can be created through "File"

menu ("Output"), through tab-sheet "Results" ("Show output") or by clicking "Output" button in the tool bar.

A scroll list at the bottom of the "Output" window allows defining:

- "Output level"
  - "Graphics & System & Detailed results"
  - "Graphics & System & Results"
  - "Graphics & System"
  - "Graphics"
- "Output settings"

2.1.3 Units management

The software allows the following choice of force and length units.

The force units are:

- Newton (N),
- kiloNewton (kN),
- megaNewton (MN).

The length units are:

- millimeter (mm),
- centimeter (cm),
- meter (m).

When units are changed, values from data sheets and on the drawings (when displayed) are automatically updated according to the new unit definition.

2.1.4 Module "Start full data check"

This module aims at checking all data given by the user according to the rules described in the help document "General summary of the technological verifications" based on Eurocode 2 and 8 rules.

2.1.5 Module "Start calculation to perform all design checks"

This module has two possible uses:

a. Check whether a given profile fulfils all requirements in terms of
   - INERD design conditions
   - Profile anchorage check

b. Choose the optimum profile to be used for a given concrete configuration

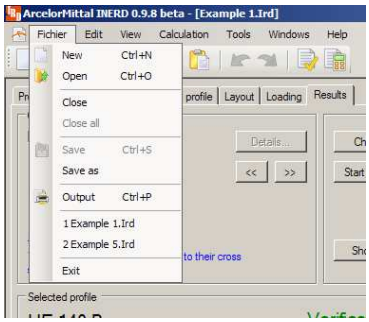
It provides also additional outputs (anchorage length of the profile, spacing of stirrups in the anchorage zone and thickness of the end plate).

2.2 "Menu" bar

2.2.1 File

This includes the following items:

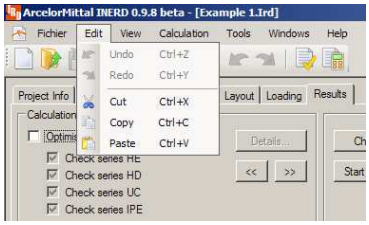
- "New" - re-initialisation of all the data in order to create another project,
- "Open" - loading of an existing file,
- "Close" - closing of the active project,
- "Close all" - closing of all the projects opened,
- "Save" - saving project in the active file (i.e. file name displayed in the status bar). If no specific file name displayed, equivalent to "Save as…",
- "Save as…" - saving project in a file for which the user indicates a new file name,
- "Output" - opening "output" file,
- "Exit" - leaving the program.



2.2.2 Edit

This includes the classical following items:

- "Undo",
- "Redo",
- "Cut",
- "Copy",
- "Paste".

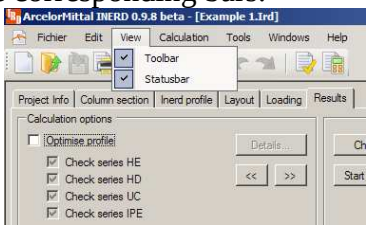


2.2.3 View

This includes the following items:

- "Toolbar",
- "Statusbar",

and allows showing or hiding the corresponding bars.

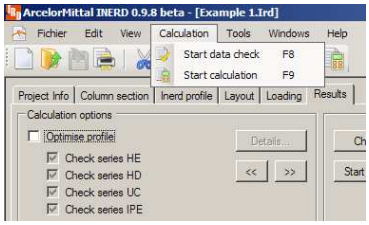


2.2.4 Calculation

This includes the following items:

- "Start data check" - Checking all data according to the rules described in the help document "General summary of the technological verifications",
- "Start calculation" - Starting either the verification of the composite column with a steel profile defined by the user or the optimisation of the steel profile to place inside the reinforced concrete section column (if the option "optimise profile" is ticked in the tab "Results").

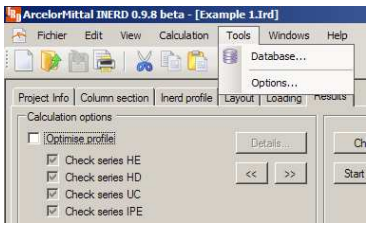
These two items have the same function than buttons "Start full data check" and "Start calculation to perform all design checks" of the Toolbar and activate the modules previously defined in 2.1.4 and 2.1.5.

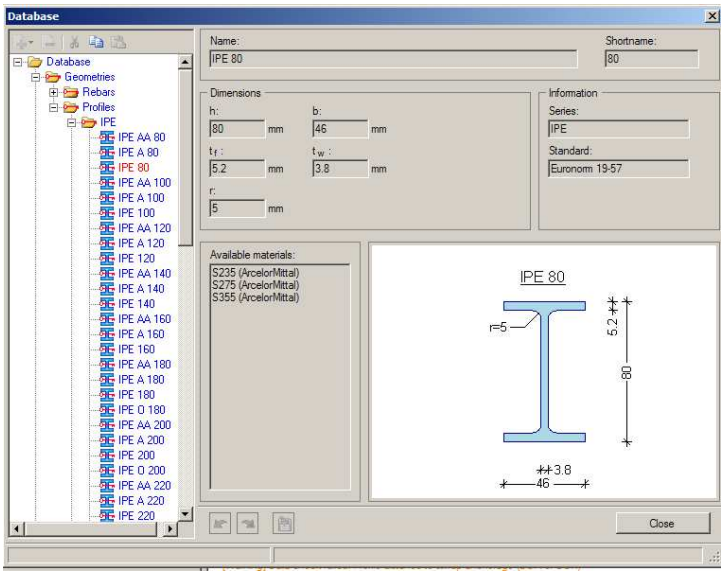


2.2.5 Tools

This includes the following items:

- "Database" - access to geometrical and material properties of steel profiles, steel rebars and concrete
- "Options":
  - "General settings",
  - "File settings",
  - "Language settings",
  - "Database settings",
  - "Units settings",
  - "Default company settings".





2.2.6 Windows

This includes the classical following items:

- "Cascade",
- "Tile vertical",
- "Tile horizontal",

- Names of the files opened.

The first 3 items can only be used when more than one project is opened.

2.2.7 Help

It includes the following items:

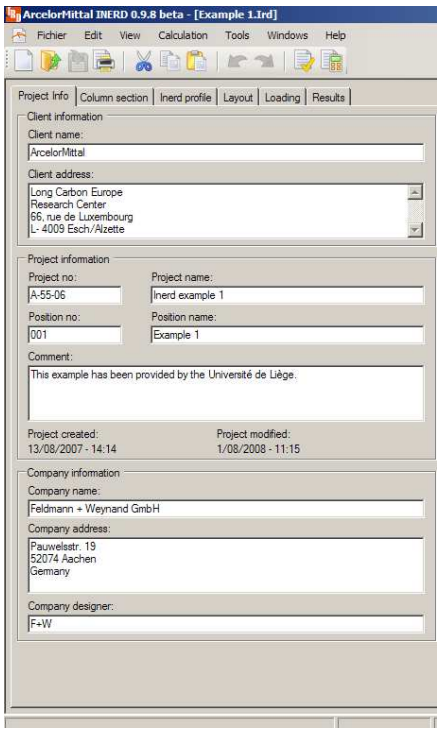
- User manual
- "Documents" - access to background information on the concept and on the software (***Pdf*** format):
    - The INERD concept,
    - General technical background of the software,
    - Anchorage of the steel profile in usual conditions,
    - Anchorage of the steel profile on a foundation,
    - Practical design of transverse reinforcement,
    - End-plates,
    - General summary of the technological verifications.
- "About" - version number and information on the technical partners

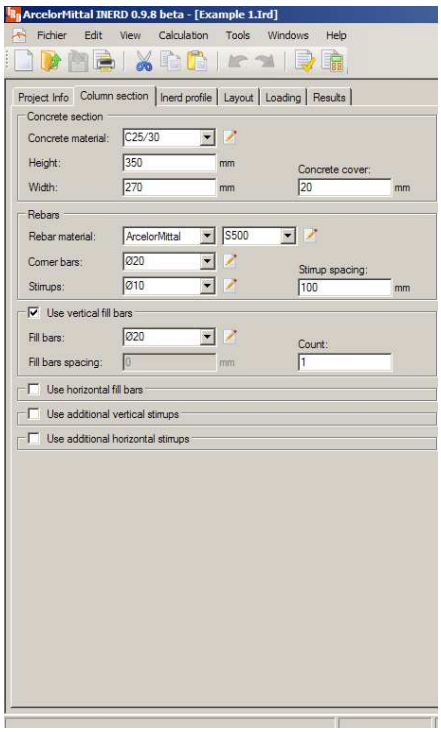
2.3 Description of the tab sheets

2.3.1 Project Info

This tab sheet includes the following items:

- "Client information" - definition of client name and address,
- "Project information" - description of the project,
- "Company information" - definition of company name, address and designer.





2.3.2 Column section

This tab sheet includes the following items:

- "Concrete section":

  - "Concrete material" - from C12/15 up to C90/105,
  - "Height" - height of the concrete column section,
  - "Width" - width of the concrete column section,
  - "Concrete cover".

- "Rebars":
  - "Rebar material" - provider and yield strength of the steel rebars,
  - "Corner bars" - diameter of the corner bars (the list is limited to diameters of steel rebars offered by the selected provider),
  - "Stirrups" - diameter of the main stirrup (the list is limited to diameters of steel rebars offered by the selected provider),
  - "Stirrup spacing" - spacing of the main stirrups.

- "Use vertical fill bars" - definition of fill bars additional to the corner bars on the height of the column cross-section,
  - "Fill bars" - diameter of vertical fill bars,
  - "Fill bars spacing" - distance between vertical fill bars (available only if the count is more than 1),
  - "Count": number of vertical fill bars.

- "Use horizontal fill bars" - definition of fill bars additional to the corner bars on the width of the column cross-section,
  - "Fill bars" - diameter of horizontal fill bars,
  - "Fill bars spacing" - distance between horizontal fill bars (available only if the count is more than 1),
  - "Count": number of horizontal fill bars.

- "Use additional vertical stirrups" - definition of stirrups additional to the main one and having the same height as this main one,
  - "Corner bars" - corner bars diameter of additional vertical stirrups
  - "Stirrups" - diameter of additional stirrups,
  - "Offset" - horizontal distance between corner bar of the main stirrup and corner bar of the additional stirrups.

- "Use additional horizontal stirrups" - definition of stirrups additional to the main one and having the same width as this main one,
  - "Corner bars" - corner bars diameter of additional horizontal stirrups
  - "Stirrups" - diameter of additional stirrups,
  - "Offset" - horizontal distance between corner bar of the main stirrup and corner bar of the additional stirrups.

Where available, a click on the icon  provides all details related to the corresponding data,

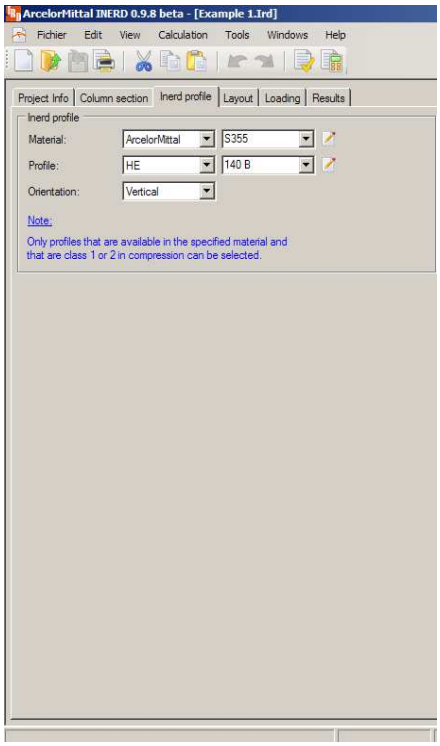
2.3.3 Inerd profile

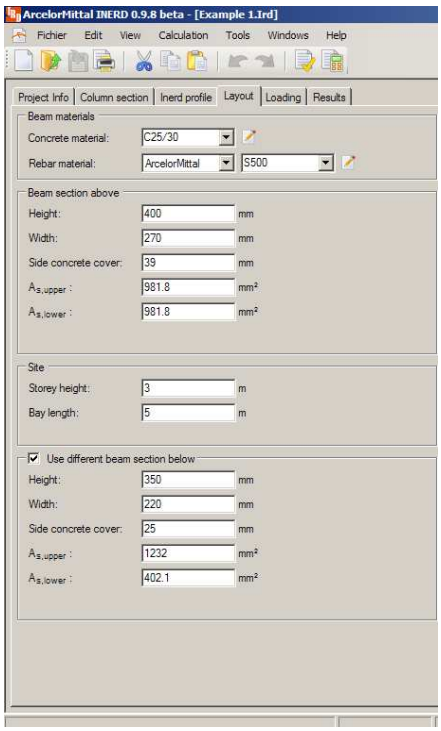
This tab sheet defines the properties of the profile to insert in ground columns:

- "Material" - provider and yield strength of the steel profile,
- "Profile" - choice of the steel profile type and dimension (IPE, HE, HD, UC).
  Only profiles that are available in the specified material and that are class 1 or 2 in compression can be selected.

- "Orientation" - definition of the steel profile orientation (vertical or horizontal).

Where available, a click on the icon provides all details related to the corresponding data,





2.3.4 Layout

This tab sheet includes the following items:

- "Beam materials":
  - "Concrete material" - from C12/15 up to C90/105,
  - "Rebar material" - provider and yield strength of the steel rebars.

- "Beam section above" - definition of data related to the beam above the ground storey,
  - "Height",
  - "Width",
  - "Side concrete cover",
  - "$A_{s,upper}$" - section of longitudinal rebars in the upper part of the beam,
  - "$A_{s,lower}$" - section of longitudinal rebars in the lower part of the beam.

- "Site" - definition of the bay and storey dimensions,
  - "Storey height",
  - "Bay length".

- "Use different beam section below" (optional) - definition of data related to the beam (or the slab) at the base the ground storey if different from the beam above the ground storey,
  - "Height",
  - "Width",
  - "Side concrete cover",
  - "$A_{s,upper}$" - section of longitudinal rebars in the upper part of the beam,
  - "$A_{s,lower}$" - section of longitudinal rebars in the lower part of the beam.

Where available, a click on the icon provides all details related to the corresponding data,

2.3.5 Loading

This tab sheet includes the following items:

- "Loading"
  - "N_{Ed}" - Design normal force in the column corresponding to gravity loads such as considered in the seismic load combination.

    The value of the design axial force N_{Ed} is given directly by the user. This value should be evaluated as follows:

    N_{Ed} is the compression force in a 1st storey column due to the non seismic actions participating in the seismic load combination. It may be computed based on a weight W calculated as: $W = \sum G_{kj} + \sum \psi_{Ei} \cdot Q_{ki}$

    Where G_{kj} are the dead loads and Q_{ki} are the variable loads.

    The coefficient ψ_{Ei},used to estimate a likely value of service loads, is computed as: $\psi_{Ei} = \varphi \cdot \psi_{2i}$

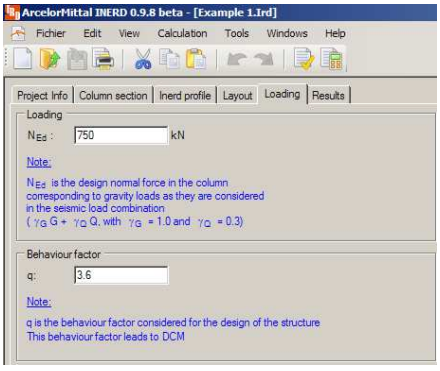
    Values of ψ_{2i} (quasi-permanent combination coefficient as given by Eurocode 1) and φ (reduction factor given by Eurocode 8) are summarized in Table 1 for usual situations. For example, in an office buildings in which all levels are used independently: $\psi_{Ei} = \varphi \cdot \psi_{2i} = 0,5 \times 0,3 = 0,15$

Table 1. Coefficients $\psi_{2,i}$ and φ

Specific use	$\psi_{2,i}$	Storey	φ
Cat. A : residence Cat. B : office Cat. C: meeting rooms, places where people congregate	0,3 0,3 0,6	Roof Storeys with correlated occupancies Independently occupied storeys	1,0 0,8 0,5
Cat. D : shopping area Cat. E : storage, accumulation of goods Cat. F : traffic (vehicle ≤ 30 kN)	0,6 0,8 0,6		1,0

,

- "Behaviour factor":
  - "q" - behaviour factor considered for the design of the original RC structure.



2.3.6 Results

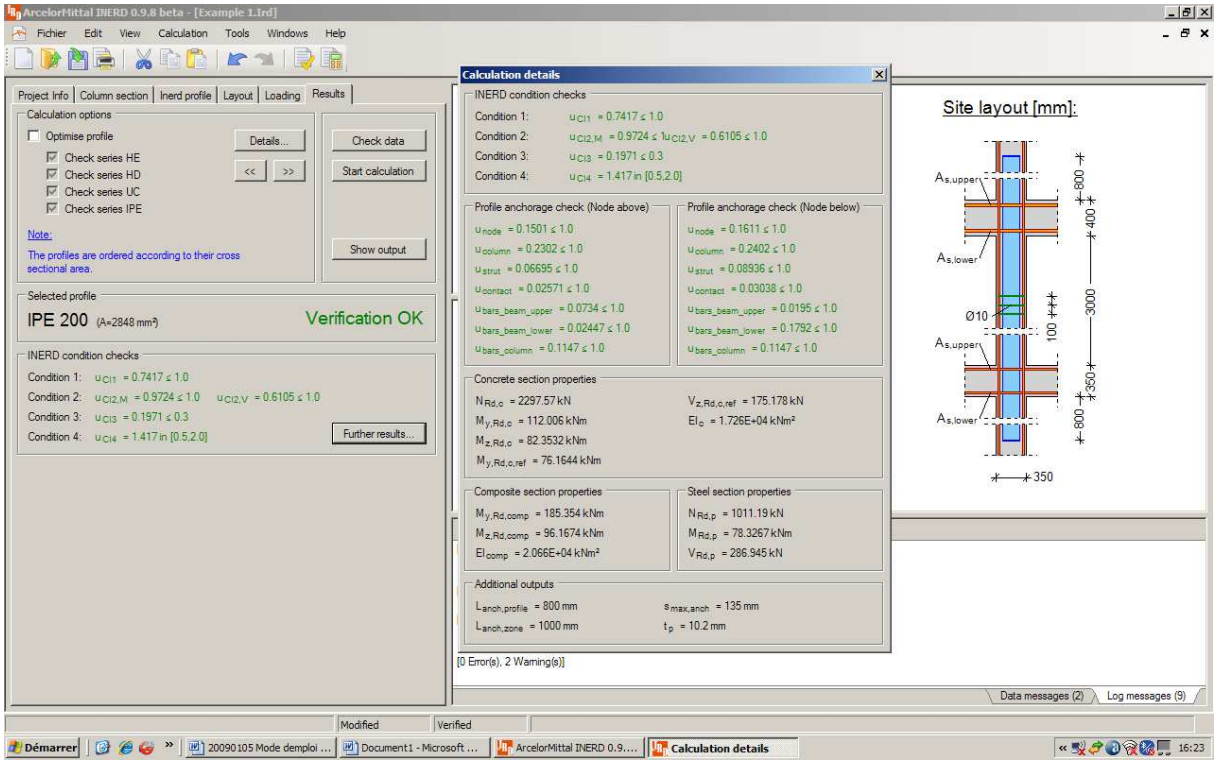
This tab sheet includes the following items:

- "Calculation options"
  - "Optimise profile" - Activates the optimal choice of profile.

- "Check series HE": if ticked, the software will take into account the HE series for steel profile optimisation,
- "Check series HD" if ticked, the software will take into account the HD series for steel profile optimisation,
- "Check series UC" if ticked, the software will take into account the UC series for steel profile optimisation,
- "Check series IPE" if ticked, the software will take into account the IPE series for steel profile optimisation,

o "Details" - Provides a table defining whether design conditions and criteria are fulfilled (✓) or not (✗) for each steel profile of the selected series. These conditions and criteria are detailed in the Help document "General technical background of the software". Profiles are sorted according to their cross sectional area. The optimal profile is the first of the list (i.e. with the smallest cross section) for which all conditions and criteria are fulfilled.

- "Check data" - Same as the module "Start full data check" defined in 2.1.4.
  Note that access to the button "Check data" is not possible when the option "Optimise profile" is ticked.
- "Start calculation" (replaced by "Start optimisation" if the option "Optimise profile" is ticked) - Launches the module "Start calculation to perform all design checks" defined in 2.1.5.
- "Show output" - Opens directly the "output" file with all data and results.
- "Selected profile" - Shows the profile taken into account during the computing. Two arrows allows moving in the steel profiles list sorted by cross section areas.
- "INERD condition checks" - These conditions are detailed in the Help documents "General technical background of the software" and "Anchorage of the steel profile in usual conditions". Results of the application of Inerd conditions 1 to 4 are automatically displayed. A click on "Further results…" displays additional results related to cross section properties, anchorage checks…

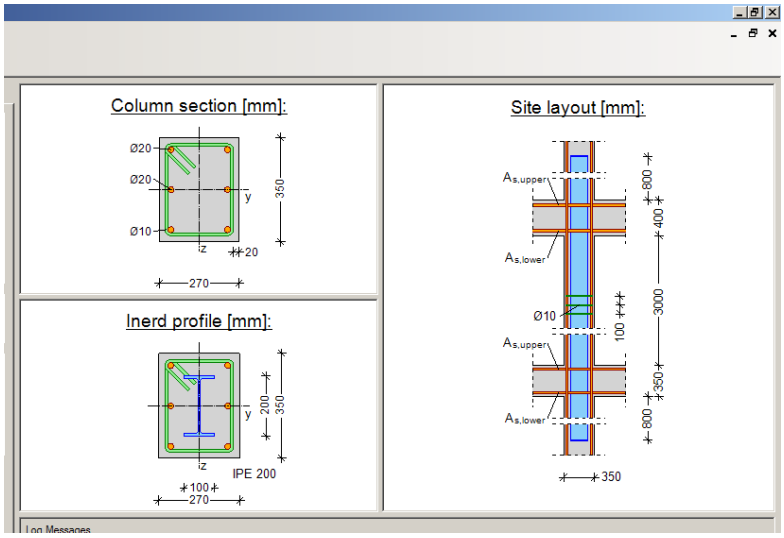


2.4 Graphical area

The graphical area comprises 3 windows:

- "Column section" - Drawing of the concrete cross section geometry,
- "Inerd profile" - Drawing of the composite cross section geometry,
- "Site layout" - Drawing of the global situation, including beams above and below, storey height, stirrups spacing and anchorage length of the steel profile.

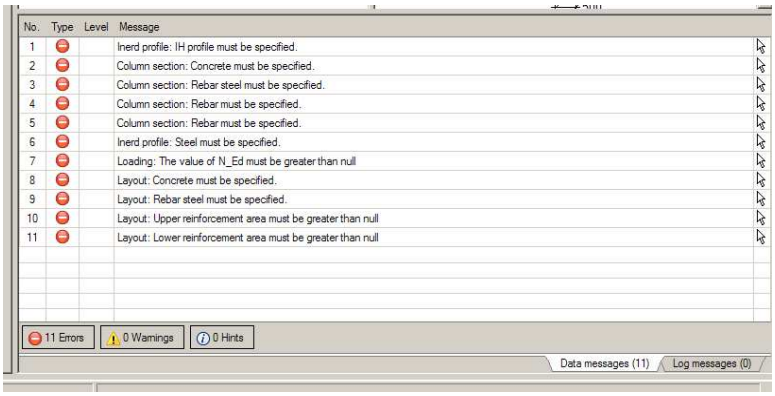
A click on any dimension in the graphical area directly links to the corresponding numerical data in tab sheets.



2.5 Warning/error table

"Data messages" - Indicates errors , warnings or hints .
For more details, just keep the mouse arrow on the text of the error, warning or hint and a detailed text will appear. In case of problems with data definitions, a double click on the or in the "data messages" area links directly to the corresponding data in tab sheet.

"Log messages" - Provides a record of events during calculation.



3 DESCRIPTION OF THE DESIGN PROCEDURES

See help document "General technical background of the software"

4 REFERENCES

[1] Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings. EN 1992-1-1: 2004. European Committee for standardisation.

[2] Eurocode 3: Design of steel structures – Part 1.1: General rules and rules for buildings. ENV 1993-1-1. European Committee for standardisation.

[3] Eurocode 4: Design of composite steel and concrete structures – Part 1-1: General rules and rules for buildings. EN 1994-1-1: 2004. European Committee for standardisation.

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