People's Democratic Republic of Algeria Ministry of Higher Education and Scientific Research



# 8 May 1945 Guelma University Faculty of Science and Technology Department of Civil Engineering & Hydraulics

# **TP Computer-Aided Design**



Intended for students in the 3<sup>rd</sup> year of Licence in Civil Engineering.

**Elaborated by : Dr LAFIFI Brahim** 

# **Programme**

Semestre : 6

Unité d'enseignement : UEM 6.1

Matière : Calcul assisté par ordinateur

VHS: 37h30 (TP: 2h30)

Crédits:3

**Coefficient : 2** 

#### **Objectifs de l'enseignement :**

Familiariser les étudiants aux logiciels de calcul en génie civil. L'étudiant doit connaitre les fonctionnalités essentielles d'un logiciel de calcul, en se basant sur un projet existant, et doit être capable de maitriser l'interface du logiciel et saisir correctement les données et récupérer les résultats.

**Connaissances préalables recommandées :** 

Informatique 1 et 2 et informatique 3

#### Contenu de la matière :

Chapitre 1 : Concept de base sur les logiciels de calcul	(3 semaines)
Mode de fonctionnement et méthodes de calcul utilisées, les le	ogiciels fermés, les
logiciels ouverts, avantages et limites des logiciels.	
Chapitre 2 : Prise en main d'un logiciel disponible.	(6 semaines)

#### Chapitre 2 : Prise en main d'un logiciel disponible.

Présentation de l'interface, l'environnement de travail, les données, les options, les résultats (numériques et graphiques), interprétation.

# Chapitre 3 : Etude et suivi d'un projet réel (6 semaines) Mode d'évaluation :

Contrôle continu : 100%

#### **Références bibliographiques :**

1. Manuel d'utilisation du logiciel hôte.

# **Program**

Semester : 6 Teaching unit: UEM 6.1 Subject : Computer-aided design VHS: 37h30 (TP: 2h30) Credits : 3 Coefficient : 2

### **Teaching Objectives:**

Familiarize students with civil engineering calculation software. The student must be acquainted with the essential functionalities of a calculation software, based on an existing project, and must be capable of mastering the software interface, correctly inputting data, and retrieving results.

#### **Recommended prerequisite knowledge:**

Computer Science 1 et 2 et Computer Science 3

### **Content of the subject:**

#### Chapter 1 : Basic concept on calculation software (3 weeks)

Operating mode and calculation methods used, closed software, open software, advantages and limitations of software.

### Chapter 2 : Getting started with Robot Structural Analysis software.

### (6 weeks)

Presentation of the interface, the work environment, the data, the options, the results (numeric and graphical), interpretation.

### Chapter 3 : Study and monitoring of a real project using RSA 2010.

#### (6 weeks)

**Evaluation method:** Continuous assessment: 100%

### **Bibliographic references:**

1. User Manual of the host software.

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# **Chapter I**

**Basic concept on calculation software** 

# **I.1 Introduction**

Calculation software, also known as computational software or mathematical software, is a type of computer program designed to perform mathematical and numerical calculations. It provides tools and algorithms for solving complex mathematical problems, performing data analysis, and simulating various mathematical models. It is utilized in various fields, including engineering, physics, chemistry, economics, finance, data analysis, and scientific research. It provides efficient and accurate methods to solve complex mathematical problems, analyze data, and model and simulate real-world phenomena, aiding professionals and researchers in their work.

Calculation software incorporates numerical methods to solve mathematical problems that cannot be solved analytically. These methods involve approximations and iterative algorithms to find numerical solutions for equations, optimization problems, differential equations, and other mathematical models. It often provides tools for statistical analysis and data visualization. Users can perform tasks such as data importing, cleaning, filtering, and statistical calculations like mean, median, standard deviation, regression analysis, and hypothesis testing. Visualization features allow for the creation of charts, graphs, and plots to better understand and present data.

Many calculation software packages provide programming and scripting languages that allow users to create custom algorithms, automate calculations, and extend the software's functionality. Users can write scripts or programs to perform repetitive tasks, implement specific algorithms, and integrate with other software or systems.

# I.2 Fundamental Understanding of Calculation Software

Calculation software serves as a tool that assists engineers, designers, and analysts in performing complex mathematical computations and simulations related to various fields such as engineering, physics, finance, and more. These software applications are designed to automate calculations, reduce manual errors, and enhance efficiency in solving intricate problems.

It automates repetitive and time-consuming mathematical tasks, freeing professionals from manual calculations and allowing them to focus on analysis and decision-making.

It handles complex equations, formulas, and algorithms that may be challenging or timeconsuming to solve manually. It performs calculations much faster and accurately than human calculations.

It ensures high precision and accuracy in numerical computations, reducing the risk of errors inherent in manual calculations.

Some software allows for iterative analysis, enabling engineers to refine designs, conduct sensitivity studies, and optimize solutions by easily modifying input parameters.

Many calculation software provides visual representations of data, results, and trends. Graphs, charts, and diagrams help users understand complex relationships and patterns within the data.

Some software offers simulation capabilities, allowing users to model real-world scenarios and predict outcomes based on various inputs and assumptions. It helps in analyzing and interpreting large datasets, identifying trends, outliers, and correlations within the data.

Complex calculations that would take hours or days to complete manually can be accomplished within seconds or minutes using calculation software.

Software tools typically generate reports and documentation detailing the calculations performed, methodologies used, and results obtained. This documentation is essential for validation, communication, and regulatory compliance.

# I.3 Operation Mode and Calculation Methods Used

**I.3.1 Operation Mode**: This refers to how a software application functions and interacts with users. In the context of calculation software, the operation mode determines how users input data, initiate calculations, and interpret results.

**I.3.2 Calculation Methods**: These are the mathematical algorithms and techniques used by the software to perform calculations. Depending on the software's purpose, it may employ numerical methods, analytical methods, finite element methods, optimization algorithms, and more.

# I.3.3 Closed-Source Software

**a) Definition**: Closed-source software, also known as proprietary software, is developed by a specific company or organization. Its source code is not publicly available, and users only have access to the compiled executable program.

**b**) Advantages: Closed-source software often comes with official support, regular updates, and comprehensive documentation. Companies have control over intellectual property and can maintain consistent user experiences.

**c)** Limitations: Users lack the ability to modify the software's source code, limiting customization and adaptability. Dependency on the software vendor for updates and bug fixes can pose challenges.

# I.3.4 Open-Source Software

**a) Definition**: Open-source software has publicly available source code that can be freely accessed, modified, and redistributed by users. This collaborative approach encourages community contributions.

**b)** Advantages: Open-source software promotes collaboration, innovation, and customization. Users can modify the software to suit their needs and contribute improvements to the community.

**c) Limitations**: Support may be community-driven, leading to varying levels of assistance. Not all open-source projects receive regular updates or have comprehensive documentation.

# I.4 Presentation of the Software Robot Structural Analysis (RSA)

Robot Structural Analysis is a software program used for structural analysis and design of buildings and other structures. It is developed by Autodesk and provides engineers and structural designers with advanced tools and capabilities to analyze the behavior and performance of various structural elements. The software incorporates finite element analysis (FEA) techniques to simulate and evaluate the structural response under different loading conditions, such as static, dynamic, and seismic loads. It enables users to perform comprehensive structural analysis, including calculations for forces, displacements, stresses, and deformations. With its intuitive user interface and extensive library of building codes and design standards, Robot Structural Analysis helps in optimizing the design and ensuring structural integrity and safety.

Robot allows users to create structural models using graphical tools. Users can define various types of structural elements, such as beams, columns, bracings, slabs, and walls. The modeling environment supports both 2D and 3D structures.

The software includes extensive libraries of materials and cross-sectional profiles, enabling accurate representation of real-world materials and components. Some additional details about the software are presented below:

**1.4.1 Analysis Types:** Robot Structural Analysis supports a wide range of analysis types, including linear and nonlinear static analysis, dynamic analysis, buckling analysis, and response spectrum analysis. These analysis capabilities allow engineers to assess the behavior of structures under different loading conditions and evaluate their stability and performance.

**1.4.2 Structural Elements:** The software offers a variety of predefined structural elements, such as beams, columns, slabs, walls, and foundations. Users can create and customize these elements to accurately model the structural components of their projects. It also supports advanced features like curved beams, pre-stressed elements, and composite structures.

**1.4.3 Material Modeling:** Robot Structural Analysis allows users to define material properties for different construction materials, including concrete, steel, timber, masonry, and more. The software incorporates material libraries with predefined properties based on international standards, simplifying the process of assigning material properties to structural elements.

**1.4.4 Loads and Load Combinations:** Engineers can apply various types of loads to the structural model, such as point loads, distributed loads, temperature loads, and wind loads. Robot Structural Analysis enables the creation and customization of load combinations according to design codes, considering different load cases and load factors.

**1.4.5 Design Code Compliance:** The software includes a comprehensive library of design codes and standards from around the world, allowing engineers to ensure compliance with local regulations and industry-specific requirements. By selecting the appropriate design code, Robot Structural Analysis performs automatic code checks and provides detailed reports on the structural elements' design status.

**1.4.6 Advanced Analysis Features:** Robot Structural Analysis offers advanced analysis features, such as nonlinear material behavior, large deformation analysis, soil-structure interaction, and time history analysis. These capabilities enable engineers to tackle complex structural problems and simulate real-world scenarios accurately.

**1.4.7 Design Optimization and Exploration:** The software provides tools for design optimization and exploration, allowing engineers to iteratively refine and improve their structural designs. Users can set design objectives and constraints, and the software automatically adjusts the structural elements' dimensions to find optimal solutions based on predefined criteria.

**1.4.8 Integration with Other Software:** Robot Structural Analysis can be integrated with other software applications, such as Autodesk Revit and AutoCAD. This integration facilitates seamless data exchange, enabling users to import structural models, collaborate with architects and other disciplines, and export analysis results for further documentation and detailing.

# I.5. Definition of engineering problems using RSA

To ease the user's work, the RSA software features a comprehensive set of tools that simplify the analysis of structures:

✓ The Concept of Objects: In RSA, the creation of the structure model is carried out using typical construction objects: beams, columns, bracings, floors, walls. Thanks to this, during this stage of the study, structural elements acquire specific attributes of their own (including regulatory attributes). Thus, during the model definition stage, all regulatory parameters of the structure are set, enabling an immediate transition to regulatory analysis right after static calculations. The same applies to nodes. The traditional notion of nodes

has lost its meaning as they are automatically defined during the creation of various objects.

- ✓ **Construction Lines** can be used as modeling aids.
- ✓ A wide range of editing tools: plane symmetry, translation, rotation, horizontal and vertical mirroring, division for a specific bar or a group of bars, intersection, etc.
- ✓ Powerful Selection Tools: Effective selection tools include mouse pointer selection, selection by attribute (section, thickness, etc.), window selection, capture selection, plane selection, and more.
- ✓ **Option to Define Custom Display Attributes**: Capability to define customized display attributes such as menus, toolbars, colors, fonts, views, and window arrangements.
- ✓ Adding Dimensions to the Structure Model
- ✓ Automatic Verification of Model Consistency: For instance, searching for instabilities, missing supports, isolated bars and nodes, etc.
- ✓ Utilization of Configurable Standard Structure Libraries: The Robot software comes equipped with a set of standard structural components that are commonly used in engineering projects. These components are pre-defined with standard properties and attributes, saving engineers time by eliminating the need to manually input these details for each individual element.
- ✓ Automatic Component Labeling Capability: The "Automatic Component Labeling Capability" in the Robot Structural Analysis software refers to the functionality that enables the software to automatically generate labels or identifiers for different components within a structural model. This feature simplifies the process of identifying and managing individual elements in a complex structural model, enhancing organization, communication, and analysis efficiency.
- ✓ Capability to Create and Archive Parameters: Ability to create and save parameters such as any material, elastic supports, and various types of loads. This feature allows engineers to define custom material properties beyond the built-in material libraries. Engineers can input specific material properties, such as elastic modulus, density, and Poisson's ratio, for materials that are not included in the default library. This is particularly useful when working with specialized or non-standard materials.
- ✓ Quick Input Function for creating climatic loads such as snow and wind, along with automatic weighting. The "Quick Input Function" streamlines the process of defining climatic loads, such as snow and wind loads, which are essential for structural analysis and design. Instead of manually inputting each load value, this feature offers a faster and more convenient way to specify these loads.
- ✓ Climatic Load Parameters: For snow and wind loads, engineers typically need to define parameters such as intensity, direction, exposure category, and more. The quick input function simplifies this process by offering a user-friendly interface that guides engineers through the required parameters.
- ✓ Automatic Weighting: The automatic weighting feature enhances accuracy by calculating loads based on predefined standards and codes. This ensures that the loads are applied correctly to the structure, considering factors such as location, building height, and other design-specific criteria.

- ✓ Simultaneous Views: The "Multi-Windowing Feature" allows users to work with multiple views or windows of the same model or different models simultaneously. This feature enhances productivity by providing a comprehensive overview and enabling users to perform various tasks concurrently.
- ✓ Comparative Analysis: Engineers often need to compare different analysis results, load combinations, or design variations. The multi-windowing feature enables side-by-side comparison of these views, aiding in making informed decisions and identifying differences.
- ✓ RSA allows opening multiple windows of the same type, which enables, for instance, in the graphic area, the simultaneous consultation of different objects, even those that are far apart, using separate windows with their own display settings (zoom, projection, etc.).
- ✓ Work Areas: At each stage of the structural analysis, the software window can comprise three distinct work areas:
  - o Graphical Definition Area (controlled with the mouse),
  - o Definition Dialog Box Area (interacted with through the keyboard),
  - Spreadsheet Area containing all the objects defined up to that point for the given class.



Figure I.1 Graphical interface of the RSA software.

# I.6. Presentation of data and results

Data and results can be presented in both graphical and text modes: • Views of the structural model with node and bar numbers, support symbols, load diagrams with values, descriptions of sections used in the structure, drawings of the structure respecting the shape and

dimensions of sections, internal force diagrams, structural deformations, stress maps, displacements, and deformations for surface elements.

- Tables containing model descriptions.
- Tables displaying results.

# I.6.1 Graphical presentation

- The software offers graphical representations of the structural model and analysis results. This visual presentation includes views of the structure, complete with labeled node and bar numbers for easy identification.
- Support symbols are displayed to indicate the location and type of supports in the structure.
- Load diagrams provide a visual representation of applied loads and their magnitudes. This helps engineers understand the load distribution and effects on the structure.
- Section descriptions are displayed, allowing users to quickly reference the specific sections used in the design.
- Drawings of the structure are generated, accurately representing the shape and dimensions of the sections used. This aids in visualizing the structure's physical appearance.



Figure I.2 Graphical representation of the results.

### I.6.2 Tabular presentation

- In addition to graphical representations, the software provides tabular presentations of both model descriptions and analysis results.
- Model description tables list all the elements and attributes defined in the structural model, offering a comprehensive overview of the model's components.

• Result tables present numerical data obtained from the analysis. This includes values such as forces, displacements, reactions, and more.

# **I.7** Calculation notes

RSA software offers highly advanced tools for generating calculation notes. Thus, during the structural analysis, the content of the graphical screen or the active table can be captured at any moment. All the captured screens saved under a user-defined name can be inserted into the calculation notes. With this option, it is possible, for instance, to print the support table along with the structural plan featuring highlighted supports.

The "Print Composition" option available in RSA allows the user to freely compose the format and content of the calculation notes, including:

- Free composition of cover pages, headers, and footers (including graphic insertions).
- Defining the order of document elements to be printed.
- Composing the appearance of each page and table, even from the print preview.



Figure I.3 Automatic generation of calculation notes.

# I.8 Aid tools

A particularly crucial aspect for a powerful software like RSA is an assistance system that helps users master the system. Therefore, a significant effort has been made to provide effective aid tools, including:

- Contextual help for all menu commands and for each displayed object in dialog boxes and spreadsheets.
- Index of accessible help topics.
- Hierarchical access to information on the given subject.
- Descriptions of icons and menu commands displayed in the status bar at the bottom of the screen.
- Tooltips displaying the names of icons when the mouse pointer is placed over them.
- Similar tooltips accompany the mouse pointer during graphical input of structural elements. Their function is to inform the user of the effect that clicking the left mouse button can produce (for example, inputting the origin or end of a bar).
- The CD-ROM contains the complete "User Manual" and the "Quick Start Guide," which step-by-step presents the process of defining various structures (with explanations).



Figure I.4 Software help section.

# **Chapter II**

Getting started with Robot Structural Analysis software

# **II.1 Launching the Robot Structural Analysis software**

At the software startup, the following window appears to select the type of structure or element you want to study.

43	X
Select project:	

Figure II.1: Various Applications of Robot Structural Analysis software.

To facilitate modeling, they have included several modules to choose from, such as 2D or 3D options like Frames.

- Analysis of a planar portal frame.
  Analysis of a spatial truss.
  Analysis of a shell.
- Design of a building.

You can bring up this window at any time by clicking on the File menu, then selecting New Project. From there, you will choose the module that facilitates the modeling of walls and solid slabs.



The main window will appear (Fig II.2), which contains the default menu and toolbars at the top and bottom, and on the right, and the Object Manager window on the left. We will see later how to customize the default workspace and the toolbars.

Autodesk Robot Structural Analysis	Professi	onal 20	)10-Ur	regist	ered ve	rsion	Projec	t: Stru	cture -	Result	s (FEM):	none	- [View	]														-		- 0	×
Reg File Edit View Geometry Lo	oads A	nalysis	Rest	ults -	Tools	Wind	ow He	elp																							- 8 ×
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Figure II.2: The main windows of the software.

# **II.2** Adjusting preferences and project-specific preferences

To adjust preferences (language, display, etc.) and project-specific preferences (units and formats, materials, catalogs, design standards, etc.), click on the menu (Fig II.3):

Languages General Parameters View Parameters Desktop Settings Toolbar & Menu Printout Parameters Authorization Key Advanced	Regional settings: Working language: Printout language:	France English English		
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Figure II.3: General preferences of the software.

Through this window, you can, for example, change the working language from French to English.

You can change the background color by clicking on View (Fig II.4).

a Preferences			? ×
Contraction Contractions of the second secon	D Set DCEAN Range: Screen Element: cross pointer Color Font	-10.0 0.0	10.0 20.0  1 100 UX 2 200 UY 3 300 PX 4 400 RY
Update Preferences on exit		Accept C	ancel Help

Figure II.4: Changing the color of the graphical interface.

🔜 Job Preferences		? ×
DEFA	ULTS Zero format: Default units Metric	• 0.0 Imperial
🙀 <u>O</u> pen default p	arameters	
Save current param	eters as default	OK Cancel Help

Figure II.5: Job preferences of the software.

#### **II.2.1 Units and formats**

Through this window, you can modify the units for dimensions, forces, angles, and displacements, among others (Fig II.6).

Have Job Preferences			? X
DEFA	AULTS Structure dimensions: Section dimensions: Section properties: Steel connections (dimensions): Diameters of RC bars: Reinforcement areas: Crack width:	m     ▼     0,21       cm     ▼     0,1       cm     ▼     0.21       mm     ▼     0,1       cm2     ▼     0,21       mm     ▼     0,1	
🙀 <u>O</u> pen default p	parameters		
Save current param	neters as default	OK Cancel	Help

Figure II.6: Adjusting job preferences.

You can also change the number of decimal places by clicking on the arrows (Fig II.7):

Job Preferences			? ×
	DEFAULTS		
Units and Formats     Units and Formats     Forces	Structure dimensions:	m v 0,21	
- Other	Section dimensions:	cm 🔻 0,1	
····· Unit Edition ····· Materials	Section properties:	cm 🔻 0,21	• • E
Databases ⊕- Design codes	Steel connections (dimensions):	mm 🔹 0,	

Figure II.7: Changing the number of decimals.

#### **II.2.2 Design standards**

Robot contains various regulations and standards, and you can select the standard used in your country from the dropdown menu (Fig II.8):

Job Preferences		? ×
······ ···· Units and Formats ···· Materials ···· Databases ···· Design codes ······ Loads ····· Structure Analysis ···· Work Parameters	DEFAULTS Code combinations: Snow/wind loads: Seismic loads:	CM66 Avril 2000       NV65 Mod99+Carte 96 04/00     RPA 99 (2003)

Figure II.8: Various regulations and standards of the software.

Job Preferences		2 <b>×</b>
	DEFAULTS Code combinations: Snow/wind loads: Seismic loads:	CM66 Avril 2000 NV65 Mod99+Carte 96 04/00   . RPA 99 (2003)
		More codes

The same applies to seismic and climatic loads (Fig II.9):

Figure II.9: Seismic and climatic loads available in the software.

If the standard you are looking for is not in the dropdown menu, you can add it from the list of standards in the menu by clicking on "More Standards" (Fig II.10):

Configuration of Code List			
Codes:			Current codes:
Seismic loads		•	Set as current
Code	Country	•	/ Code
PS 92	France		🖌 AFPS 90
PS 92:2008	France		> EN 1998-1-1:2004
R.P.S. 2000	Morocco		EN 1998-1-1:2004-General
RPA 88	Algeria	a	ENV 1998-1-1:1994 DAN francaise
RPA 99	Algeria		Monaco
RPA 99 (2003)	Algeria		🚬 PS 69 R. 82
SNiP II-7-81*:2000	Russia	=	≥ <sub>PS 92</sub>
SP 31-114-2004	Russia		PS 92:2008
Site classes (SMS)	France	-	R.P.S. 2000

Figure II.10: Adding more standards in the software.

**Note:** Preference adjustment is done only once when starting the project. If you have multiple project types, each with its own preferences (units, standards, etc.), with Robot, you can define multiple preferences and save each preference in a file. If you want to use a specific preference, you only need to open the corresponding file for the desired preference.

	DEFAULTS			
Unit Save Job Preferen     Unit Save Job Preferen	Ces Structure dimensions:	m	▼ 0,21	* * E
- Other	Section dimensions:	cm	▼ 0,1	
Unit Edition	Section properties:	cm	▼ 0,21	* * E
Databases	Steel connections (dimensions):	mm	▼]0,	1 E
Loads	Diameters of RC bars:	mm	<b>→</b> 0,1	* * E
Structure Analysis Work Parameters	Reinforcement areas:	cm2	▼ 0,21	4 × E
	Crack width:	mm	▼ 0,1	• • E
💺 🛛 🖸 pen def	ault parameters			

Figure II.11: Saving the applied modifications.

# **II.3 Modeling of Structural using RSA Software**

The representation of a real structure, whether it's made of concrete or steel, through a numerical model using Robot 2010 software requires:

- Defining the construction lines of the structure in all three directions.
- Defining the sections of the elements that make up the structure (beam elements or panels).
- Graphically representing and drawing the structure using the defined elements.
- Defining the supports within the structure.
- Defining load cases and combinations, and applying loads to the structure.

In the following, you will find the steps to follow for modeling a structure using Robot 2010. We have taken an example of a simple reinforced concrete portal frame structure for illustration. The structure is shown in the figure (Fig II.12):



Figure II.12: 3D view of the structure.

# **II.3.1** Construction lines

Construction lines or the grid of the structure represent the axes of the elements of the structure to be modeled in the three directions X, Y, Z, as well as the endpoints of the elements and the edges of the structure's faces.

On these lines and their intersections, you can subsequently draw the bars, beams, and other components, connecting them easily. For this purpose, you need the dimensions of the structure (length, width, height), along with detailed information about the spacing and dimensions of the structural elements, essentially a detailed structural plan.

Our example is a reinforced concrete structure consisting of 5 identical parallel portal frames connected by beams, with the following dimensions:

- Structure height = 6.40 m
- Structure length = 14.80 m
- Structure width = 9.60 m



Analysis of a

At the start of the Robot 2010 software, we select the module.

spatial portal frame. The main window appears, and we begin drawing the construction lines

using the command. 0+ the first icon on the toolbar located on the right side of the window (Fig II.13).

	_ 8 ×
Geometry 🗸	
<b>⊳ ~</b>	
	FRONT 4 Axis Definition

Figure II.13: Icon of the construction lines.

By clicking on this icon, the following dialog box opens (Fig II.14):

o <sup>o</sup> . Structural Axis	🖓 Structural Axis
Name:     Structure axis       Cartesian     Cylindrical       Advanced parameters	Name:     Structure axis       Cartesian     Cylindrical       Advanced parameters
X     Y     Z       Position:     No. of repet.:     Distance:       0.00     (m)     0     1     (m)       Label     Position     Insert       Delete     Delete       Delete all     Single out	Y     Z       Position:     No. of repet.:     Distance:       3.80     (m)     1       Label     Position       1     0.00       2     3.80       Insert       Delete       Delete all       Single out
Numbering: 123	✓         III         ►           Numbering:         1 2 3         ▼
New     Axis manager       Apply     Close       Help	New         Axis manager           Apply         Close         Help

Figure II.14: Drawing of the construction lines.

We use Cartesian coordinates X, Y, Z. In the "Position" field, enter the value of the distance from the reference axis 0m that you want to draw from.

In the "**<u>Repeat x</u>**" and "<u>Spacing</u>" fields, leave 0 and 1m if you don't have a consistent spacing between elements. For instance, in our case, in the Z direction, there's a spacing of 3.2m between two levels. So, in the "Repeat x" field, put 2, and in the "<u>Spacing</u>" field, put 3.2.

We perform this operation for all three axes (X, Y, and Z).

For our example, we need to input the following series of values:

For X axis: 0, 3.8, 7.4, 11.0, 14.8 m For Y axis: 0, 4.6, 9.6 m For Z axis: 0, 3.2, 6.4 m

Click on **Apply** to save:

🛱 Structural Axis	o <sup>®</sup> . Structural Axis
Name: Structure axis -	Name: Structure axis 🗸
Cartesian Cylindrical Arbitrary	Cartesian Cylindrical Arbitrary
Advanced parameters	Advanced parameters
x 🖤 z	X Y Z
Position: No. of repet: Distance:	Position: No. of repet.: Distance: <b>6.40</b> (m) 2 3.2 (m)
Label Position	Label Position
1 0.00	±0,00 0.00
2 4.60 Insert	+3,20 3.20 Insert
3 9.60 Delete	+6,40 6.40 Delete
4 14.60 Delete all	Delete all
Single out	Single out
< Þ	< Ⅲ → Stories
Numbering: 123	Numbering: Value
New Axis manager	New Axis manager
Apply Close Help	Apply Close Help

Figure II.15: Saving the construction lines.

#### Note:

You can add construction lines at any time by inserting values in the desired direction, and you can also remove existing lines by selecting the number and clicking on **Delete.** 

You can also make lines **bold.** 

In the same project, you can define multiple sets of construction lines using the **New** option in the construction lines dialog box.

You can also manage these lines (delete, activate, or deactivate specific lines) using the **Lines Manager** option.

When you activate the 3D view, you will get the following result (Fig II.16):



Figure II.16: 3D view of the construction lines.

#### **II.3.2** Section definitions

To define the sections of beam elements, we use the command

"Beam Profiles."

With this option, you can define the sections for all beam elements in the structure: columns, beams, whether they are made of concrete, steel, wood, etc (Fig II.17):



Figure II.17: Definition of the sections.

By clicking on the icon, the following dialog box opens, and by using the "Delete all unused sections" option, you can remove the default sections provided by the software (Fig II.18):



Figure II.18: Removing the default sections provided by the software.

Click on **New** to define the desired sections, and the following dialog box will open (Fig II.19):

T New Section		X
Standard Parametric Tapere	ed Compound S	ipecial Ax, Iy, Iz
	ØII	Variable (cm)
Label:	Section selectio	n
CAE 20-2	Database:	Catpro 🔻
LAE 20x3 👻	Produits siderurg	jiques francais
Color: Auto 🚽	Family:	CAE 👻
	Section: (	CAE 20x3 ▼
Gamma angle: 0 v (Deg)	) Section type: Help	Steel ▼ Steel RC beam RC column
		Timber Aluminum
		Joist FC

Figure II.19: Selection type of the section.

Select the **Profile Type** according to the case, whether it's steel, concrete beam, concrete column, etc.

In our example, since it's a reinforced concrete structure, select "**Concrete Column**." We are going to define a section (30x40) for the columns, a section (30x40) for the main beams, and a section (30x35) for the secondary beams. To do this, click on the "I-Section" (encircled icon in the image).

In the general menu, select the column's section type, for example, "**Rectangular**," and in the "**Dimensions**" section, input the desired dimensions, for example, b = 30 and h = 40. Assign a name to the section, for instance, "**COL**(30x40)," and for the gamma angle, set gamma = 90°.

Click on "Add" to save your selection in the profile list.

We do the same thing for the other sections, and we'll have (Fig II.20):

New Section	
Label: CLM_30x40 Color: Auto	Image: Sections         Image: Sections           Image: Sections         Image: Sections
h Reduction of mom. of inertia	Lines/Bars
Gamma angle: 90 V Deg) Section type: RC column V Add Close Help BETON20	Apply Close Help

Figure II.20: Creating the column and beam sections.

You can give the new section any name you want and choose the profile's color; otherwise, the software will use default settings.

# **II.3.3** Structure Definition

Now that we have defined the construction lines and the sections of the structural elements, we can begin drawing our structure using the previously created construction lines.

We enable the **XYZ 3D view**, which provides a three-dimensional perspective of the structure. To prevent modeling errors, we disable grid snapping. To do this, click on the snap mode icon located at the bottom left corner of the window.

The **Snap Mode** dialog box opens, uncheck the "Grid" box to disable grid snapping (Fig II.21):

	🔀 Snap Settings		
	V Nodes Structural axe:	s -	* *
	Objects     Objects     Objects     Official Endpoint     Official Midpoint	-	¢î -¥2 .
View 2D 2D/3D 3D XY YZ XZ Close Help	Advanced Perpendicu Parallel Intersection Intersection Intersection	ular ns with structura ns with the grid confirmation	ıl axes
	Default	All	None
View [1]22 開 涎 母 @ Ø	Apply	Close	Help

Figure II.21: Snap setting dialog box.

Click on the command. **Bars** 



The following dialog box appears (Fig II.22). In the "Type" field, select "Column," and in the "Section" field, select "COL(30x40)." Now, click on the "Origin" field, and begin drawing the 3 columns of this side using the construction lines. Next, move on to drawing the beams using the same principle: select "Beam" as the type and "BEAM(30x40)" as the section.

So we have defined the first portal of our structure (Fig II.23).

📉 Bars	_ <b>_</b> X
Number: 1	Step: 1
Name: H	C column_1
Properties	
Bartype:	
Section:	CLM_30x40
Default materi	al: BETON20
- Node coordin	ates (m)
×Beginning:	14,80; 0,00; 0,00
End:	
	🗖 Drag
Axis position	
Offset:	None 🔻 📖
Add	Close Help

Figure II.22: Creation of the bar elements.



Figure II.23: Construction of the first portal of the structure.

## Note:

You can always customize your working environment by displaying toolbars. For example, if you want to show the "Edit" toolbar that includes the "Split Beams" option, you can go to "Tools" > "Customize" > "Show Toolbars."

The following dialog box will open:



Figure II.24: Selection and displaying the edit toolbar.

Select all of the portal frame except for the nodes at the base of the columns. To do this, click and drag from the right to the left, as shown in the figure (Fig II.25).



Figure II.25: Selection of the portal.

After the selection, click on  $\overset{\uparrow \rightarrow \square}{\square_{\leftarrow} \downarrow}$  "Translation." The following dialog boxes will open:

In the "Number of repetitions" field, enter the number of portal frames you want to create. In the "Translation vector" field, input the distance between the portal frames (dx, dy, dz) = 3.8, 0, 0m, and then click on "Apply" (Fig II.26).

→ 1→1 Translation	
Translation vector (m) dX; dY; dZ = 3.8	03.6
Numbering increment	
Elements:	
Edit mode Copy Move	🕅 Drag
Number of repetitions:	
Execute	ose Help

Figure II.26: Setting of the translation dialog box.

To hide the construction lines, rightclick and then click on "Attributes." In the opened dialog box, click on "Structure" and uncheck the construction lines option (Fig II.27).

To get a clearer view of the drawn structure, click on "Profiles Sketch."

- Y	0
ŋ <b>-</b> ,ŋ,ඐ	
View Ct ⊻? 88 →	Support symbols



Figure II.27: Hiding the construction lines of the model.

You will have the following 3D view:



Figure II.28: 3D view of the model.

# **II.3.4** Support conditions



Figure II.28: Supports dialog box.

Definition" Through the "Support dialog box, you can define the directions to be restricted by checking the displacement and rotation boxes along the axes, as illustrated in the figure. These could be linear displacements (UX, UY, UZ) or angular rotations (RX, RY, RZ).

For instance, for a fixed support, all displacements and rotations in all directions are blocked. For a hinge support, linear displacements (UX, UY, UZ) are blocked, and rotations (RX, RY, RZ) are free.

For our example, we will choose to apply the Fixed support type for the entire structure (Fig II.29).

🖕 Support Definition
Rigid Elastic Friction Nonlinear C
Label: Support_1
Fixed Uplift directions:
UX None -
UY None -
UZ None -
RX None -
RY None -
RZ None -
Angle Support directions are compatible with the global coordinate system Direction
Advanced
Add Close Help

Figure II.29: Supports setting of the construction.

For that purpose, select "Fixed" in the Supports dialog box. Then, click in the "Current selection" field, and proceed to select all the nodes at the base of the columns. Finally, click on "Apply" (Fig II.30):

Supports			x
	X	Þ	
Nodal Linear Planar			
X Delete Appui simple Encastrement Rotule			
Current selection			*

Figure II.30: Assignment of the supports.

By enabling the "Realistic Display" of the structure and showing the sketches of profiles, you will get the following 3D view (Fig II.31):



Figure II.31: 3D view of the model with supports.

# **II.3.5** Loading

Loading a structure involves defining load cases based on the nature of the loads (permanent, live, seismic, etc.), then applying the loads (loads on members, surface loads, etc.) to the structure for the created load cases. Finally, combinations of load cases are defined.

### a- Load cases

To define load cases, click on the "Load Cases"

Through this dialogue box, the Nature of the load case to be defined is selected, as illustrated in the figure.

In the "Name" field, a name can be assigned to the load case, or the default name suggested by the software can be used.

Subsequently, clicking "New" adds the load case to the list of defined cases (Fig II.32).

∎ Load Typ	es	X
- Case desc	ription	
Nature:	dead 🗸	New
Number:	dead live	DL1
Name:	wind snow temperature	
List of defi	accidental _neige accidentelle	
No.	seismic	Nature 4
•	III	•
Modify	Delete	Delete all
	Close	Help

Figure II.32: Load dialog box.

For our example, in addition to the self-weight of the structure, we will define a dead load and a live load, both distributed over the rafters that connect the frames at the top.

Nature:	<b>_</b>	New
Number:	3 Label:	PERM3
Name:	Q	
1	PP	permane
1	PP	permane
1000		
2	G	permane
2	G Q	permane d'exploit ,
2 →3	G Q IIII	permane d'exploit ,

Figure II.33: Creation of the different load types.

#### **b-** Loads

For our example, we have three loads:

- Self-weight of the structure, PP, automatically calculated by the Robot 2010 software.
- A permanent load, G = 5 kN/m, distributed over the main beams.
- A permanent load, G = 2 kN/m, distributed over the secondary beams.
- A live load, Q = 2.5 kN/m, distributed over the main beams.
- A live load, Q = 1.0 kN/m, distributed over the secondary beams.

By selecting the PP case from the list illustrated in the previous figure, we will have (Fig II.34):



Figure II.34: Assigning the self-weight of the structure.

We will name the self-weight of the entire structure as "pp" and then click on "New." The software automatically assigns the first defined permanent load case as the default self-weight of the structure.

For the other load, we will name it "G" for dead load and "Q" for live load. The load case's name, its position in the list, and its type can be modified, or it can be deleted using this dialog box (Fig II.33).

Upon clicking "Close," we proceed to apply the "G" and "Q" loads to our structure. We select the current load case using the top toolbar.
To define the permanent load G, we select the G case from the list of load cases and click on

the "Define Loads" command:

In the dialogue box that opens, we choose "Beams" and click on the symbol for "Uniform Load," as shown in (Fig II.35):

I Load Definition	III Uniform Load
Case No: 2 : G Selected. Self-weight and mass Node Bar Surface	P 
	p (kN/m)
	Y:     0,00     0,0       Z:     -5.00     0,0
Apply to	Coord. system:    Global    Local   Projected load
Apply Close Help	Add Close Help

Figure II.35: Definition of the applied loads on beams.

We enter the value of the load in the Z direction (-5 kN/m) in the field labeled Z, and then click on "Add." Now, using the "Select Beams" tool,

A Selection
All None Inversion
Bar 🔹 🔽 Notify all
1to3 26to28 31to33 36to38 41to43 58to60 63to65 📄
Previous (1)1+ 1- 1&
Attrib. Group Geometry
Section   any CH30x35 POT30x40 PR30x40 undefined
Select from list   example
Close Help

Figure II.36: Applying loads on beams.

we select all the bars with the PR30x40 profiles as shown in the figure and then click on "Close."

Returning to the Load dialogue box, in the field labeled "Apply to All," all PR30x40 bars are selected, so we click on "Apply" to apply the load to the beams (Fig II.36).

We repeat the same process for the live load Q.



Figure II.37: Visualizing applied loads in the 3D view of the model.

### **II.3.6** Load case combinations

For our example, we will define the combination 1.35 G + 1.5 Q.

**1** 

To define load case combinations, we use the "Manual Combinations" command <sup>™™</sup> located in the "Loads" menu ► "Manual Combinations." The following dialogue box opens:

Combination number:	6
Combination name:	COMB1
Combination type:	ULS
Seismic combination t	ype
💿 CQC 🛛 🔿 SRSS	© 2SM 🛛 10%
OQC OSRSS Nature:	© 2SM © 10%

Figure II.38: Combinations dialog box.



For instance, we can name it "1.35 G + 1.5 Q," and then click on "OK."

In the dialogue box that appears, we will define our combination using the previously defined load cases (Fig II.38).

Combination: 4 : 135*G+1.	5*Q : ULS		•
ase list:	List of	cases in combin	ation:
Nature: 📶 🔻	Factor	No.	Case name
No. Case name → 3 Q	1.35 1.35 	1 2	PP G
<			
Factor: auto			

Figure II.39: Creation of the ULS combination.

Factor:	1.3		Change
ULS		Factor	*
+	dead	1.35	-
	live	1.50	-
	wind	1.80	
	snow	1.50	
12	temnerature	1.35	+
*	111		+

If the coefficients you wish to apply are different from the automatic coefficients of the defined combination, you can set them by clicking on "Define Coefficients."

In the "Coefficient" field, you input the desired value and click "Modify" (Fig II.40).

After completing this step, you click "Apply" to save the combination.

You can also define another combination by clicking on "New."

Figure II.40: Definition and modifying the combination factors.



Figure II.41: Visualizing combination loads in the 3D view of the model.

# **II.3.6** Analysis of a structure

Now that we have completed the modeling of our example, we proceed to the calculation and analysis of this structure under the defined loadings.

Before running the calculation, it's important to verify the structure for modeling errors and disconnected bars. To do this, click on "Analysis" ► "Check Structure", (Fig II.42).



Figure II.42: Structure verification dialog box.

In the dialogue box, error messages indicate the specific errors and the corresponding objects causing those errors.

```
To initiate the calculation, click on the "Calculate" command (Analysis ► Calculate).
```

# **II.3.7** Analysis results



To display the analysis results of the structure, including internal force diagrams, deformations, stresses, and reactions, select "Results" from the startup menu in the top toolbar.

You can also directly view result diagrams by going to "Results" ► "Bar Diagrams", (Fig II.43).

Results Tools Window	Help	
🚷 Res <u>u</u> lts Freeze		
<u>P</u> roperties		۲
Diagrams for Bars		
Maps on Bars		

Figure II.43: Diagram for bars toolbar.

🔀 Diagrams	_ <b>_</b> ×			
NTM Deformation Str	esses Reactions			
Diag	gram scale for 1 (cm)			
📃 🔲 Fx Force	(kN)			
Fy Force	(kN)			
Fz Force	(kN)			
📕 🔲 Mx Moment	(kN*m)			
My Moment	(kN*m)			
📃 🔲 Mz Moment	(kN*m)			
Elastic ground reactions				
📕 🔲 Ky Reaction	(kN/m)			
📕 📃 Kz Reaction	(kN/m)			
All Nor	e Normalize			
Diag	ram size: + 🕒			
🔲 Open a new window 📃 Constant scale				
Apply Clos	e Help			

Figure II.44: Diagrams for bars dialog box.

The following dialog box opens:

To view the internal force diagram, you check the checkbox for the specific internal force, for example, the Moment My, and then click "Apply."

If the diagram's appearance is not satisfactory, you can click on "Normalize" to adjust the diagram's size.

You can also change the diagram's size by clicking on "+" and "-" buttons and then clicking "Apply", (Fig II.44).

Furthermore, you can modify the diagram settings to display the values of the forces directly on the diagram.

You can view the internal force and displacement diagrams of each individual element of the structure separately by right-clicking on the specific element and then clicking on "Object Properties", (Fig II.45).



Figure II.45: Moment diagram of individual portal.

🔀 Diagrams		
Deformation Stresses	s Reaction:	s Reinfc 🔹 🕨
	<u> </u>	
Veformation		
Exact deform	nation for ba	rs
🔲 Deformation in s	structure scal	le
Diagram scale for 1		
	(ci	m)
Animation		
Number of frames:		10
Number of frames/	second:	8 🚔
Start		
All	None	Normalize
ſ	Diagram size:	+
🔲 Open a new windo	ow 📃 Co	onstant scale
	Close	Help

Figure II.46: Deformation dialog box.

To display the deformation of the structure, click on the "Displacements" icon located on the bottom right corner of the window (Fig II.46).

Cases: 4 (135*G+1.5*Q)	船
• [	
Displacements (defo	rmation)

You can also display the deformation using the "Diagrams" dialogue box and start an animation by clicking on "Start" as shown in (Fig II.47).

Using the animation control bar, you can record this animation as a (.avi) file.



Figure II.47: 3D view of the structure deformation.

# **Chapter III**

Study and monitoring of a real project using RSA 2010

# **III.1 Introduction**

This application allows for the processing of the design of a simple reinforced concrete structure using the Robot software, in order to practice the software's usage for new users.

# **III.2** Presentation of the Structure

It is a residential building with 4 floors (ground floor + 4), located in the city of Guelma (zone IIa, according to RPA 99 version 2003), with a mixed structural system (shear walls + reinforced concrete frames) providing lateral resistance.

Number of floors: Ground floor + 4

Floor height: 3.20 m for all levels.

#### **III.2.1** Dimensions of the structure

Building length = 21.4 m.

Building width = 10.75 m.

Total height = 16.0 m.

#### **III.2.2 Dimensions of structural elements**

Columns: 30x40 for all levels.

Beams: Main beams: 30x40 - Secondary beams: 30x35

Floor: Hollow core floor: 16+4

Solid slab: Solid slab with a thickness of 14 cm.

Staircase: Thickness of the landing = 16 cm

### **III.2.3** Load assessment

Typical floor:  $G = 5.0 \text{ kN/m}^2$ ;  $Q = 1.5 \text{ kN/m}^2$  (bedrooms);  $Q = 3.5 \text{ kN/m}^2$  (balconies);

Roof floor (inaccessible):  $G = 6.3 \text{ kN/m}^2$ ;  $Q = 1.0 \text{ kN/m}^2$  (inaccessible terrace).



Chapter III Study and monitoring of a real project using RSA 2010

Figure III.1: Plan view of the studied structure.

# **III.3 Modeling**

## **III.3.1** Project setup

At the start of the software, click on the "Shell Study" module, (Fig III.2), (the use of this module facilitates the modeling of walls and solid slabs):

Select p	noject.		12	-	
m		Ħ		冊	The second secon
_			×	4	
B				IJ	
100	1	110	101		07

Figure III.2: Selection of shell study module.

## **III.3.2** Preference settings

Before starting the modeling, you need to adjust the preferences (language, display, etc.) and project preferences (Units, Materials, Standards, etc.). To do this, click on the dropdown menu Tools/Preferences (or Tools/Project Preferences), (Fig III.3).



Figure III.3: Selection of job preferences.

Note: This procedure is done only once when you install the software.

#### **III.3.3** Construction lines

The first step in modeling is drawing construction lines. These lines represent the axes of the structure (X, Y, and Z). In the Robot window, go to the first icon on the toolbar located on the right side of the window, (Fig III.4).



Figure III.4: Icon of the construction lines.

The following dialog box opens:

🖓 Structural Axis					
Name: Lignes de construction 👻					
Cartesian Cylindrical Arbitrary					
Advanced parameters					
X Y Z					
Position: No. of repet.: Distance: 0,00 (m) 0 🚔 1 (m)					
Label Position					
Insert					
Delete					
Delete all					
Single out					
< +					
Numbering: 123					
New Axis manager					
Apply Close Help					

Figure III.5: Dialog box of the construction lines.

In the field (repeat), we must always enter the value 1 since we do not have repeating interaxial values (except for the Z axis where we can repeat 4 times 3.20).

In the field (spacing), enter the value of the pitch and each time click on (insert). We perform this operation for the three axes (X, Y, and Z).

The result should be as in Fig III.6):

o <sup>o</sup> . Structural Axis	o <sup>o</sup> , Structural Axis	o‡ Structural Axis
Name: Lignes de construction 👻	Name: Lignes de construction 👻	Name: Lignes de construction
Cartesian Cylindrical Arbitrary	Cartesian Cylindrical Arbitrary	Cartesian Cylindrical Arbitrary
Advanced parameters	Advanced parameters	Advanced parameters
X Y Z	X Y Z	X Y Z
Position: No. of repet.: Distance:	Position:         No. of repet.:         Distance:           0.00         (m)         0         1         (m)	Position: No. of repet.: Distance: 0.00 (m) 0 🚔 1 (m)
Label         Position           1         0.00           2         4.30           3         8.90           4         12.20           5         16.80           6         21.10	Label         Position           A         -1.45           B         0.00           C         4.15           D         7.25           E         8.85	Label         Position           -1,50         -1,50           ±0,00         0.00           +3,15         3.15           +6,30         6.30           +9,45         9.45           +12,60         12.60
•         •           Numbering:         1 2 3	Numbering:	✓     III       ✓     Stories       Numbering:     123
New Axis manager	New Axis manager	New Axis manager
Apply Close Help	Apply Close Help	Apply Close Help

Figure III.6: Drawing of the construction lines.

Click on (apply) and activate the 3D view, we will have the following result, (Fig III.7):



Figure III.7: 3D view of the construction lines.

#### Note:

- Multiple construction lines can be defined in the same project using the "new" option in the construction lines dialogue box. The management of these lines (deleting, activating, or deactivating desired lines) can also be done using the "line manager" option in the construction lines dialogue box, (Fig III.8).

🕂 Structural Ax	is	
Name: L	ignes de construction	•
Cartesian	Cylindrical	Arbitrary
	Advanced paramete	sis
XY	Z	
Position: 0,00 (m)	No. of repet.:	Distance: 1 (m)
Label	Position	
		Insert
		Delete
		Delete all
		Single out
•	4	
Numbering:	123 🔻	
New		manager
Apply	Close	Help

Figure III.8: Management of the construction lines.

### **III.3.4** Definition of sections for bar elements (columns and beams)

Click on the dropdown menu Structure -- characteristic -- bar profiles.



Figure III.9: Definition of the sections.

In the dialog box (profiles), click on (delete all unused sections) and then click on (new).

T Sections	New Section
C C C C C C C C C C C C C C C C C C C	Standard       Parametric       Tapered       Compound       Special       Ax, ly, lz         Image: Compound       Image: Compound </th
Lines/Bars	
Apply Close Help	Gamma angle: 0 ▼ (Deg) Section type: Steel ▼ Add Close Help RC beam RC column Timber Aluminum Joist

Figure III.10: Removing the default sections provided by the software.

In the dialog box (new section), click on the field (profile type) and select (beam BA).

Enter the name, color, and dimensions of the beam, then click "Add", (Fig III.11):

New Section	3
General Parameters	_
Label: BEAM30x40 Color Auto - h	
Reduction of mom. of inertia	
Use tapered section	
Gamma angle: 0 💌 (Deg) Section type: RC beam	-
Add Close Help CONCR	

Figure III.11: Creating the beam sections.

Repeat the same operation to define the other sections of the beams and columns (PS 30x35) and (columns 30x40), (Fig III.12).

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<b>T</b> Sections			ж
	1 %	H	Ď
CLM130x30 ■ CLM130x30 ■ CLM130x30 ■ PBM30x40			
Lines/Bars			
			*
Apply Close		Help	•

Figure III.12: Achievement of the section creation.

## **III.3.5 Structure definition**

Activate the "View Manager" dialog box and go to the XY plane at a level of 3.20:



Figure III.13: Activation of the view manager.

To avoid modeling errors, disable the grid snap by clicking on the snap mode icon (located at the bottom left of the window), (Fig III.14):

	View	X
	2D 2D/3D 3D XY YZ XZ	Close
	3,20 ▼ △ ♡	Help
<u>┣-□≝⊜€</u>		
View		
🔃 🎷 🏭 🏹 🖉 🖉	Ø	

Figure III.14: Snap mode icon.

In the snap mode dialog box, disable the grid snap and click "Apply" and "Close", (Fig III.15):

🔀 Snap Settings	5		X
V Nodes			
Structural axe	es		-
Gind			
Objects			
📝 Endpoint			
📝 Midpoint			
📝 Advanced			
📝 Perpendic	:ular		
📃 Parallel			
📝 Intersectio	ons		
🔽 Intersectio	ons with stru	ictural axes	
🗸 Intersectio	ons with the	grid	
Apply without	t confirmatio	n	
Default	All		one
	Close	H	łelp

Figure III.15: Snap setting dialog box.

Now, click on the dropdown menu "Structure - Bars". The following dialog box opens:

🛰 Bars			
Number: 3	92	Step:	1
Name: R	C beam_392	2	
Properties			
Bar type:	RC bear		
Section:	PBM	130x40	▶ •
Default materi	ial:	BETON2	0
- Node coordin	ates (m)	_	
Beginning:	21,10 . 4	5; 3,20	
End:			
	📃 Drag		
- Axis position-			
Offset:	None		▼
Add	Close		Help

Figure III.16: Creation of the bar elements.

In the field (type), select beam BA, in the field (section), select (PP 30x40). Click on the field (origin) and start drawing the main beams. Using the same principle, we can draw all the main and secondary beams on floor level 3.20.

Now we will model the columns using the command (translation) with the option (stretched). First, we need to select the nodes on floor 3.20. Go to the drop-down menu Edit -- Special Selection -- Graphic Selection Filter, (Fig III.17):



Figure III.17: Graphical selection toolbar.

In the dialog box (Graphic Selection Filter), uncheck all the boxes except for the box (node), (Fig III.18).

? Graphical Sel	lection Filter	
V Nodes Bars Panels Finite elemer Loads Texts	nts 🗾	_
Objects     Contours     Polyline	☑ Arc	cles
Complex obj	ects ects - parts	
🔽 Apply (no co	nfirmation)	
	All	None
Apply	Close	Help

Figure III.18: Graphical selection filter dialog box.

Click on apply and close.

In the dialog box (Profiles), select (column 30x40) and close. Now select the entire structure, and you will notice that only the nodes are selected (the selection of other elements is disabled).

Go to the drop-down menu Edit transformation -- translation, (Fig III.19) :



Figure III.19: Selection and displaying the edit toolbar.

Activate the 3D view and enter the value (0; 0; 3.20) in the dialog box (translation). Enable the option (stretched), (Fig III.20):

Translation vector (m)	
dX; dY; dZ = 003.2	20
Numbering increment	
Nodes:	
Elements:	)
Edit mode	
🧿 Сору	Drag
🔘 Move	
Number of repetitions:	1
Evecute Close	Help

Figure III.20: The translation dialog box.



Click on (apply), and you will get the following result, (Fig III.21):

Figure III.21: 3D view of the constructed elements.

Go to the dialog box (Graphic Selection Filter) and enable all selections. Press (Ctrl+A) to select the entire structure. Go to the dialog box (translation) and make the following adjustments, (Fig III.22):

Translation	X
Translation vector (m	]
dX; dY; dZ ≠€00	3.2
Numbering increment	
Nodes:	
Elements:	
Edit mode	
💿 Сору	Drag
🔘 Move	
Number of repetitions:	
Execute	lose Help

Figure III.22: Adjustments of the translation dialog box.

And you will get the following result:



Figure III.23: 3D view of the obtained structure.

# **III.4** Loading

Click on the drop-down menu (Loading -- Load case), and you will have the dialog box (Load case). In this dialog box, we will define two types of load cases (Permanent load G and Live load Q), (Fig III.23):

ΤĦ	Load Typ	es	_ <b>_</b> ×
ſ	Case desc	ription	
	Nature:	dead 🗸 🗸	New
	Number:	dead	DL1
	Name:	wind snow temperature	
	List of defi	accidental _neige accidentelle	
	No.	seismic	Nature A
	•		4
	<ul> <li>✓</li> <li>Modify</li> </ul>	III Delete	Delete all

Figure III.24: Load dialog box.

The self-weight will be considered with the permanent load G. For seismic loads, they will be generated automatically by the software. Other loads such as wind and snow will be neglected.

# **III.4.1 Definition of Cladding**

Click on the drop-down menu Structure -- Cladding:

🎦 File Edit View	Geometry Loads Analysis Results	Tools Windo
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	t Structure <u>Type</u> ⊕ <sup>®</sup> . A <u>x</u> is Definition Sto <u>r</u> ies ►	) 📢 🔝
Exit	<ul> <li><u>∧</u> Nodes</li> <li><u>∧</u> Bars</li> <li><u>∧</u> Panels</li> <li><u>○</u> Dijects</li> <li><u>∧</u> Structure</li> </ul>	
	<ul> <li><u>C</u>olumns</li> <li><u>B</u>eams</li> <li><u>W</u>alls</li> <li><u>F</u>loors</li> <li><u>Openings</u></li> <li><u>Claddings</u></li> <li><u>S</u>lab Wizard</li> </ul>	
	Materials Properties Code Parameters	

Figure III.25: Selection of the claddings toolbar .

In the dialog box (Cladding), define the number and direction of the cladding, and finally click on apply, (Fig III.26):

🖉 Claddings
Object No. 392
Load distribution: One-way X 🗸
Definition method
P1 Pn P2 P2 Contour © Rectangle © Circle
Geometry
Parameters
Apply Close Help

Figure III.26: Cladding dialog box.

## **III.4.2** Assignment of Loads

In the XY plane at level 3.20, go to the drop-down menu Loading -- Other loads -- Surface load on bar by 3D object, (Fig III.27):

Loads Analysis Results Tools Wine	dow Help
	☐ Q @ # ¥ & 2 M ₩ # / 1:PP - ↓ 4 - ↓
Load <u>T</u> able Combinat <u>i</u> on Table Mass Ta <u>b</u> le	
La? Select Cases Select Case Component →? Select Modes Select Result Type	
Special Loads	

Figure III.27: Selection of the loading type.

In the dialog box (Load by object), click on (define) and draw the contour representing the floor, (Fig III.28):



Figure III.28: Creation of the floor contour.

### Note:

To avoid errors in the direction of the cladding, the first vector of the contour (line 1-2) must be parallel to the global X-axis.

In the (load case) zone, choose G and enter the value (-5.0 kPa) in the Z field of the dialog box (load by object), then click on (apply), (Fig III.29).



Figure III.29: Assignment of the loading.

Repeat the same operation with load case Q, entering the value (-1.5 kPa).

We need to repeat the same operation for all other levels except for level 16.00 (inaccessible terrace), where we need to replace the value (-5.0) with (-6.30) for the load G and the value (-1.5) with (-1.0) for the live load Q.

Thus, we obtain:

For the permanent load G:



Figure III.30: Visualizing applied loads in the 3D view of the model.

#### **III.4.3 Load on solid slabs**

For solid slabs and stairs, we need to use the (define load) dialog box. Click on the dropdown menu Load -- Define load, (Fig III.31):



Figure III.31: Visualization of the loads menu.

In the (load) dialog box, click on (surface) and then click on (uniform surface load), (Fig III.32):

Load Definition
Case No: 2 : G Selected:
Self-weight and mass
Node Bar Surface
Apply to
Apply Close Help

Figure III.32: Load definition dialog box.

In the (uniform surface load) dialog box, enter the value (-3.5 kPa) which represents the live load on the balconies. Click on (add), (Fig III.33):

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🗓 Uniform Planar Load
Values
p (kPa)
X: 0,00
Y: 0,00
Z: (35)
Coord. system: 🧿 Global 💿 Local
Projected load
Geometrical limits
Add Close Help

Figure III.33: Application of uniform planar load.

Now, in the (load case) area, select load case Q, and in the (apply to) field of the (load) dialog box, enter the names of all panels representing the balconies and click on apply, (Fig III.34):

5	elf-weight and	mass
Node	Bar	Sufface
		$\square$
-34 - 543		
26 - 12 M.		

Figure III.34: Application of Q load on the balconies.

We need to do the same to define the loads on all solid slabs and stairs.

#### **III.5** Mesh generation

Select all panels, then go to the dropdown menu (Analysis -- Calculation Model -- Mesh Options), (Fig III.35):



Figure III.35: Meshing options toolbar.

In the (mesh options) dialog box, make the following settings, (Fig III.36):

Reg Advanced Meshing Options	? ×
Available meshing methods       © Coons     often       © Delaunay     often	Finite elements Type (surface): 4-node quadrilaterals  Type (volumetric): 4-node tetrahedrons
Forcing ratio: recommended	Forcing ratio:
Mesh generation	recommended
🔿 Automatic 💿 User	Delaunay method parameters
Element size	🗸 Regular mesh
	lelaunay 💿 Kang
(m)	Delaunay and Kang
Mesh of volumetric elements	H0 = 0,30 (m)
Fine Coarse Additional meshing of solid surface Coons method parameters	H max = 1000,00 Q = 1,2 Automatic emitters: At panel characteristic points At support nodes
Panel division type:	V User emitters
<ul> <li>Triangles and equates in triangular contour</li> </ul>	Smoothing
Triangles and squares in triangular contour     Triangles and tranezoids in triangular contour     Squares in rectangular contour     Triangles in rectangular contour	Triangularization near edges Number of levels:  1 2 3 Fine Coarse
Forcing ratio:	OK Cancel Help

Figure III.36: Setting of the mashing options dialog box.

Click on OK, then go to the dropdown menu (Analysis -- Calculation Model -- Generate), (Fig III.37):



Figure III.37: Mesh generation toolbar.

Mesh generation takes some time, and you will have the following result at the end, (Fig III.38):



Figure III.38: 3D view of the obtained structure.

## **III.6 Definition of supports**

To avoid errors related to support definition, you need to disable the selection of all objects and leave only the selection of nodes enabled, (Fig III.39):

🔀 Snap Setting	gs		
Nodes	var		
Grid			/
<ul> <li>✓ Objects</li> <li>✓ Endpoin</li> <li>✓ Midpoin</li> </ul>	t	-	
<ul> <li>Advanced</li> <li>Perpend</li> <li>Parallel</li> <li>Intersec</li> <li>Intersec</li> <li>Intersec</li> </ul>	<b>licular</b> tions tions with stru tions with the	uctural grid	axes
📝 Apply witho	ut confirmatio	on	
Default	All		None
Apply	Close		Help

Figure III.39: Snap setting dialog box.

Click on the dropdown menu (Structure -- Supports), (Fig III.40):



Figure III.40: Supports icon in the geometry menu.

	🔛 📰	1 %	P	
Nodal Linear Pla	anar			
X Delete				
🕂 🖞 Encastreme				
M Fixed				
າ Pinned				
Current selection				
Current selection				~
Current selection 133to152				* *

In the (Supports) dialog box, make the following settings, (Fig III.41):

Figure III.41: Setting of the supports dialog box.

Make sure that for the support type (fixed support), all translations and rotations are locked.

In the (Current selection) area, select all nodes at level 0.00 and click on (Apply). You will notice that the fixed support symbol is displayed on all nodes at level 0.00, (Fig III.42).



Figure III.42: Plan view of the support.

### **III.7 Modal and seismic analysis**

To declare a modal analysis, click on the dropdown menu Analysis, then Analysis Types to display the calculation options dialog box:

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Analysis Results Tools Window Help	
麗 <u>A</u> nalysis Types	D 🛞 🏭 泽 D
Ealculations	
Prepare Results	🛀 🖕
Save Seismic Combination Results	0
Calculation <u>R</u> estart	y e
Calculation Report	
 Verification	
Calculation Model	
Bar Structure Design	
Design of <u>R</u> C Structure Elements	
Analysis of Pre-stressed Elements	┠┾┾┾┾┾╷┝

Figure III.43: Contents of the analysis menu.

In the (calculation options) dialog box, click on New, (Fig III.44):

🎦 Analysis Typ	e			
Analysis Types	Structure Model Load	to Mass Conversion	Combination Sign	Result f 🔺 🕨
No. 1	Name	Analysis	Туре	
1 6	PP	Static -	Linear	
2 (	G	Static -	Linear	
🔶 3 🛛 (	Q	Static - I	Linear	
New	Parameters	Change analys	is type	Delete
Uperations on	selection of cases			
Lase list				
Set para	imeters Cha	nge analysis type	Dele	te
📝 Model genera	tion	Calculations	Close	Help

Figure III.44: Definition of a new load case.

Select (modal analysis type) and click OK. In the (Modal Analysis Parameters) dialog box, make the following settings, (Fig III.45):

Chapter III	Study and mor	nitoring of a real	project using	g RSA 2010
			r John C	

Case: Modal Parameters Number of modes: 10 Tolerance: 0,0001	Analysis mode Modal Seismic Tolerance: Seismic (Pseudo mode) 0.01	
Number of iterations: 40 Acceleration: 9,80665	Method  Block subspace iteration  Parameters definit	tion
Mass matrix Consistent Uumped with rotations	Subspace iteration     Subspace iteration     Base reduction     Base reduction     Limits	١
Active mass directions	<ul> <li>Inactive</li> <li>Period, frequency, pulsation</li> <li>Percent of mass participation</li> <li>(1)</li> </ul>	i <u>i</u>
Disregard density	Seismic analysis parameters Damping: 0,07 Include damping in calculations (according to PS92)	
Simplified parameters <<		

Figure III.45: Setting of the modal analysis.

Before exiting the (Modal Analysis Parameters) dialog box, click on (eccentricity) and enter the following values, (Fig III.46):

Reginition of M	ass Eccentricities	×
Total values	6	
Relative values		
Disartan V	Eccentricity	S.
Direction X	A) 00,0	)
Direction Y	(5,00 (X	1
Method of defining	the eccentricitu	
Offset of the ma	ee matriu	
	iss induix	
O Aug nodal mass	63	
	ОК	Cancel
		189608900 2

Figure III.46: Definition of mass eccentricities.

Click OK, and you will notice the display of a new load case called "modal".

Click again on (New), choose (seismic), and select (RPA 99 (2003) (Algeria)), (Fig III.47):



Figure III.47: Definition of the seismic load.

In the (RPA99 parameters) dialog box, select the following options, (Fig III.48):

RPA 99 Parar	neters 📃
Case:	Seismic RPA 99 (2003)
🔲 Auxiliary case	
Zone	Usage 116 © 111 © 1A © 1B 🧿 2 © 3
Site S1 S2	
	Residual mode
Behavior factor:	3,5000 Direction dolinition
Quality coefficient	12000 Filters
	OK Cancel Help

Figure III.48: Setting of the seismic parameters.

Before exiting the (RPA99 parameters) dialog box, click on (Direction Definition) and make the following settings, (Fig III.49):

Chapter III Study and monitoring of a real project using RSA 2010

	Normalized	ОК
X: 1	0,7071(	Cancel
Y: 1	0,7071(	
Z: 0	0	Help
l use normalized	ce into directions	
Secolution of a for Active Combination crea Quadratic combi Active Rx 1	values ce into directions tion nation Newmark comb	ination λ [0,3]
Ose normalized     Active     Combination crea     Quadratic combi     Active     Rx 1     Ry 1	values ce into directions tion nation Newmark comb µ 0,3 □ Group 1	ination λ [0,3]
Use normalized     Iesolution of a for     Active     Combination crea     Quadratic combi     Active     Rx     1     Ry     1     Rz     1	values tion ination Newmark comb µ 0,3 ☐ Group 1 ☐ Group 2	ination λ 0,3

Figure III.49: Setting of the seismic directions.

Click OK, and you will notice the display of 2 seismic load cases, one along the X-axis and the other along the Y-axis, (Fig III.50):

Analysis Ty	pe				- 0 ×
Analysis Types	Structure Model	Load to Mass Co	nversion	Combination Si	gn Result f 🕙
No.	Name		Analysis	: Туре	
	PP G Q Modal Seismic RPA 99 (20 Seismic RPA 99 (20	103) Direction_X 103) Direction_Y	Static - Static - Static - Modal Seismic Seismic	Linear Linear Linear -RPA 99 (2003) -RPA 99 (2003)	
New	Paramete	rs Char	nge analy:	is type	Delete
Operations of Case list	n selection of cases				
Set par	ameters	Change analysi	s type	[ [	Delete
Model gener	ation	Calc	ulations	Close	Help

Figure III.50: Creation of the seismic loads.

#### **III.8** Combination of load cases

For our example, we will define the combination at ultimate limit state 1.35 G + 1.5 Q and the combination at serviceability limit state G + Q.

To define the load case combinations, click on the dropdown menu Loads, then Manual Combinations, (Fig III.51):



Figure III.51: Contents of the loads menu.

The following dialog box opens, (Fig III.52):

Combination number:	7
Combination name:	1.35*G+1.5*D
Combination type: 👘	ULS
	and the second se
Seismic combination t	уре
Seismic combination ( © CQC © SRSS	уре © 2SM © 10 <sup>2</sup>
Seismic combination t CQC  SRSS Nature:	ype © 2SM © 107 dead

Figure III.52: The combination dialog box.

Choose the combination type and give the desired name to the combination you are going to define, for example, the name 1.35 G + 1.5 Q, and click OK.

In the opened dialog box, define the combination using the previously defined load cases, (Fig III.53):

С	ombination: 7 : 1.35*G+1.5*Q :	ULS			<u> </u>
ase list:			List of cas	es in combin	ation:
Nature:	All	F	actor	No.	Case name
No.	Case name		1.35	1	PP
	Q Seismic RPA 99 (2003) Directi Seismic RPA 99 (2003) Directi		->	2.57	
∢ [ Factor:	auto				
	Factor	4	2		

Figure III.53: Creation of the ULS combination.

If the coefficients you want to apply are different from the automatic coefficients of the defined combination, you can define them by clicking on Define Coefficients.

actor:	(1,35	240	Change
ULS		Factor	
<b>→</b>	poids propre dead live wind	1.35 1.35 1.50 1.80	ш
€	snow III	1.50	•
		ose	Help

Figure III.54: Definition and modifying the combination factors.

Enter the desired coefficient value in the Coefficient field and click Modify, (Fig III.53).

At the end of this operation, click Apply to save the combination. You can define another combination by clicking New and repeating the same steps, changing the coefficients for each combination.

#### **III.9** Analysis and analysis results

#### **III.9.1** Calculation and analysis

Now that we have finished modeling our structure, we proceed to the calculation and analysis of this structure under the defined loading.

Before running the calculation, we need to check the structure for modeling errors and disconnected bars. To do this, click on the Analysis menu  $\blacktriangleright$  Verify Structure, (Fig III.55).



Figure III.55: Verification of the structure.

In the dialog box, the error message indicates the error and the object related to this error as shown in the figure III.56:

Roo Structure verification	
Number of errors:0 Number of warnings:0	Display Errors Warnings Notes Verify Close
Highlighting a line with an error message or warning selects ob	jects connected with it.

Figure III.56: Structure verification dialog box.

To start the calculation, click on the Analysis menu, then Calculate (Analysis ► Calculate), (Fig III.57).
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Analysis Results Tools Window Help	
麗 <u>A</u> nalysis Types	D 🛞 😤 🏒
<u>Ealculations</u>	
Prepare Results	🛀
Save Seismic Combination Results	
Calculation <u>R</u> estart	
Calculation Report	
 Verification	E
Calculation Model	AT -
Bar Structure Design	
Design of <u>R</u> C Structure Elements	
Analysis of Pre-stressed Elements	
+9,45	

Figure III.57: Initiating of the calculation.

#### **III.9.2** Analysis results

To display the desired results (diagrams, reactions, displacements, stresses, deformations, etc.), click on the "Results" menu. If you want to display them in tabular form, simply right-click and choose "Tables", (Fig III.58).

🗌 🚧 Rigid Links	*
🗆 🎦 Offsets	
🗔 🔏 Geometrical Imperfections	
🗀 開 Stories	
🗔 🔡 Quantity Survey	=
🔲 📲 Cost Estimation	1
🗹 🚧 Loads	
🔲 📫 Added Masses	
🗌 🏦 Combinations	
🗌 🧛 Reactions	
🗆 🎦 Bar Deflections	
🗆 🎵 Nodal Displacements	
Forces	-
Table opening mode	
Full table (selection highlighted)	
Table filtered to current selection	

Figure III.58: Displaying tabular results.

# a. Results Verification

Right-click and then click on "Tables", check the "Eigenmode" box, and the results related to modal analysis will be displayed.

Case/	Mode	Frequency (Hz)	Period (sec)	Rel.mas.UX (%)	Rel.mas.UY (%)	Rel.mas.UZ (%)	Cur.mas.UX (%)	Cur.mas.UY (%)	Cur.mas.UZ (%)	Total mass UX (kg)	Total mass UY (kg)	Total mass UZ (kg)
6/	1	1,28	0,78	66,00	0,01	0,00	66,00	0,01	0,00	980429,17	980429,17	980429,17
6/	2	1,46	0,68	66,01	83,79	0,00	0,01	83,78	0,00	980429,17	980429,17	980429,17
6/	3	1,55	0,64	85,13	83,89	0,00	19,12	0,10	0,00	980429,17	980429,17	980429,17
6/	4	3,73	0,27	93,01	83,89	0,00	7,88	0,00	0,00	980429,17	980429,17	980429,17
6/	5	4,27	0,23	93,01	93,02	0,04	0,00	9,13	0,04	980429,17	980429,17	980429,17
6/	6	4,62	0,22	93,42	93,03	0,04	0,41	0,00	0,00	980429,17	980429,17	980429,17
6/	7	6,23	0,16	95,66	93,03	0,04	2,24	0,00	0,00	980429,17	980429,17	980429,17
6/	8	7,40	0,14	95,67	95,41	0,09	0,01	2,38	0,05	980429,17	980429,17	980429,17
6/	9	8,02	0,12	95,71	95,41	0,09	0,04	0,00	0,00	980429,17	980429,17	980429,17
6/	10	8.77	0 11	96 14	95.41	0.09	0.43	0.00	0.00	980429 17	980429 17	980429 17

Tableau III.1: Results of the modal analysis.

# **b.** Reaction Verification

Perform the same previous operation by checking "Reaction".

	FX (kN)	FY (kN)	FZ (kN)	MX (kNm)	MY (kNm)	MZ (kNm)
MAX	6,48	32,67	1296,91	9,27	5,32	0,56
Node	136	145	145	138	136	145
Case	4 (C)	4 (C)	4 (C)	4 (C)	4 (C)	4 (C)
MIN	-10,98	-12,89	13,90	-17,04	-6,45	-0,77
Node	145	138	142	145	145	147
Case	4 (C)	4 (C)	3	4 (C)	4 (C)	4 (C)

#### Tableau III.2: Reactions results.

#### c. Node Displacement Verification

Perform the same previous operation by checking "Node Displacements".

	UX (cm)	UY (cm)	UZ (cm)	RX (Rad)	RY (Rad)	RZ (Rad)
MAX	0,0	0,1	0,0	0,001	0,002	0,000
Node	244	338	325	464	302	418
Case	4 (C)	4 (C)	3	4 (C)	4 (C)	4 (C)
MIN	-0,0	-0,1	-0,5	-0,001	-0,002	-0,000
Node	1270	108	361	330	277	252
Case	4 (C)	4 (C)	4 (C)	4 (C)	4 (C)	4 (C)

 Tableau III.3: Results in term of displacements.

# d. Deflection Verification

Perform the same previous operation by checking "Bar Deflection".

	UX (cm)	UY (cm)	UZ (cm)
MAX	0,0	0,1	0,0
Node	244	338	325
Case	4 (C)	4 (C)	3
MIN	-0,0	-0,1	-0,5
Node	1270	108	361
Case	4 (C)	4 (C)	4 (C)

Tableau III.4: Results in term of deflections.

# e. Verification of Bar Forces

If you want to display internal forces in the columns, select them and choose the combination for which you want to obtain the results.

	FX (kN)	FY (kN)	FZ (kN)	MX (kNm)	MY (kNm)	MZ (kNm)
MAX	1296,91	12,84	150,50	11,77	53,85	20,84
Bar	307	221	359	371	213	196
Node	145	92	22	16	114	103
Case	4 (C)	4 (C)	4 (C)	4 (C)	4 (C)	4 (C)
MIN	-38,57	-14,19	-130,19	-12,00	-99,84	-20,86
Bar	357	13	358	371	359	221
Node	16	17	22	22	22	118
Case	4 (C)	4 (C)	4 (C)	4 (C)	4 (C)	4 (C)

Tableau III.5: Results in term of forces.

#### f. Displaying Bar Force Diagrams

In the "Results" menu, select "Diagram" and click on the "Parameter" box to adjust the display of the diagrams. Then make your choices in the different tabs (NTM, Deformation, Stress, Reactions, ...), (Fig III.59) and (Fig III.60).

NTM Deformation Stresse	s Reactions	NTM	Deformation Stresses	Reactions •
Diagram	scale for 1 (cm)			
Fx Force	(kN)		Deformation	
Fy Force	(kN)		Exact deformation for ba	81.
Fz Force	(kN)		Deformation in structure sca	ile
Mx Moment	(kN*m)	D	iagram scale for 1 (c	:m)
My Moment	(kN*m)	-A	nimation	
📕 🔲 Mz Moment	(kN*m)	N	lumber of frames:	10
Elastic ground reactions			iumber of frames/second:	8 🌲
Ky Reaction	(kN/m)		Start	
📕 🔲 Kz Reaction	(kN/m)			
All None	Normalize		All None	Normalize
Diagram	size: + -		Diagram size	: + -
Open a new window	Constant scale		Jpen a new window 🛛 🕅 C	onstant scale
	Help		Apply Close	Help

Figure III.59: Diagrams for bars dialog box.





Figure III.60: 3D view of the structure deformation.

# **Bibliography**

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