cype
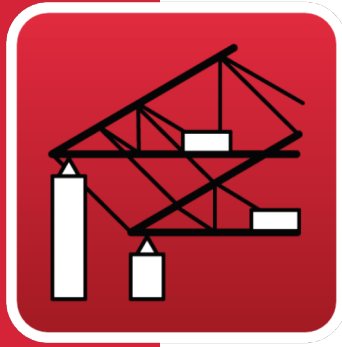
Portal frame generator

User's Manual

Geometric generator of rigid portal frames and simple and multiple trusses. Automatic generation of wind and snow loads. Design and optimisation of roof and lateral purlins. Exports the geometry and loads to the program CYPE 3D.
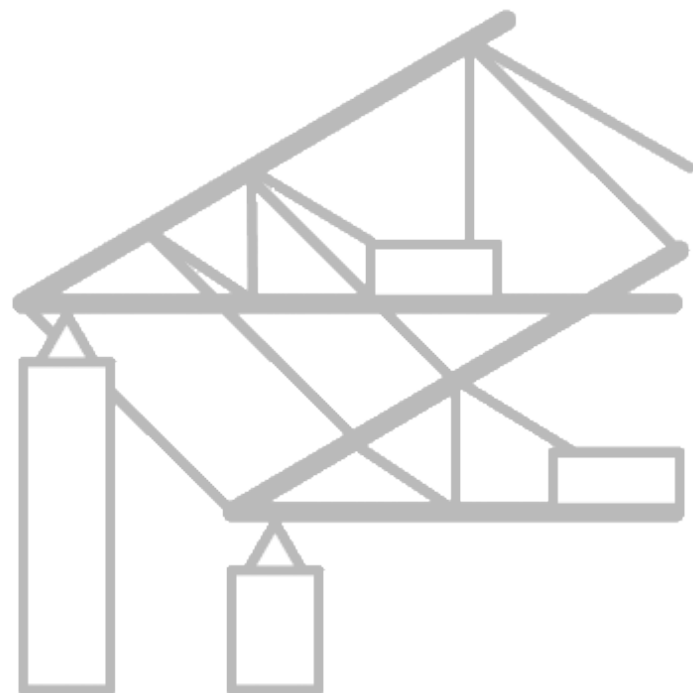
Contents

1 **Calculations**

The loads due to climatic conditions applied to the frames are calculated in accordance with what is indicated in the selected code.

When designing the purlins, the program uses the continuous beam model with a variable number of spans, defined by the user. The program calculates the stresses and deflections in accordance with the selected code.

The purlins are checked so they do not fail due to maximum deflection or stress. Additionally, in the case of rolled steel sections, checks are undertaken for lateral buckling, and in the case of cold-formed sections checks for warping and buckling are included as part of the stress checks as contemplated in the corresponding code.

Therefore, with this program, the user can safely design both roof and lateral steel purlins for warehouses.

The program only allows for the design of parallel and equidistant frames, hence only one value is sought to establish the distance between the frames.

The geometry in two or three dimensions can also be generated, as well as defining the applied loads and buckling coefficients so to continue with the warehouse design in CYPE 3D.

Other properties of the program worth highlighting include:

- Generation of wind loads in accordance to a range of design codes.

- Generation of snow loads in accordance to a range of design codes or simply apply a generic snow load.

- A library containing cold-formed, rolled and welded steel sections, which may be edited and is compatible with CYPE 3D.

- Report of data introduced and design results.

- Drawing composition using the configured peripherals.

- Stress design in accordance to a range of design codes.

2   **Program description**

2.1   Frame creation

Upon creating a new job and introducing the data of the job, the program inquires if a new frame is to be introduced.

If the user replies **No**, the screen remains empty however, later on, the user may click on the screen area and introduce a new frame. If the user selects **Yes**, a window appears where the user may choose between a mono pitch frame or a dual pitch frame.

If the option **Mono pitch** is selected, the *Mono pitch portal frame generation* dialogue box will open. If the **Dual pitch** option is selected, the dialogue box shown in Fig. 2.1 appears. Either of the two dialogue boxes contains the geometrical data of the frame.
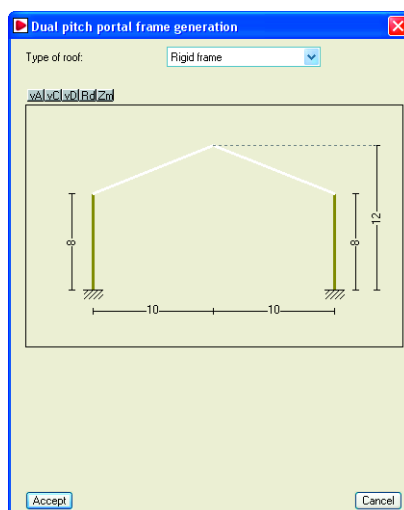

Fig. 2.1

Within the window that appears, the user is to select the type of roof the frame is to have. Having done so, the dimensions and data presented by the program may be modified.

Once this window has been accepted, the program will display the defined configuration on screen. By clicking in the middle of the screen, the **Edit menu** appears whereby the user can insert, edit, delete, etc. This menu may also be accessed, but with different options by clicking to the left of the first frame or to the right of the last frame.

2.2 Types of frames

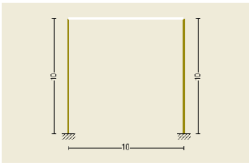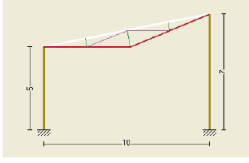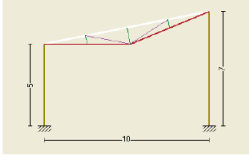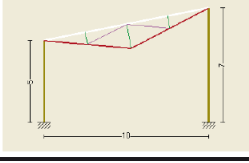Displayed in the following table are the types of frames available with the program.

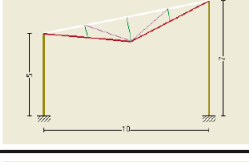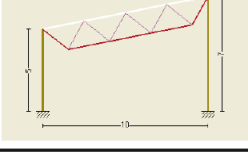| Type of roof	Diagram	Properties
Rigid frame		3 elements of data are required: - Height of the left column - Height of the right column - Span of the frame
Straight Fink truss		The number of divisions the truss is divided into has to be specified. In this case, it is recommended that: Height 1 – Height 2 $\neq$ 0 Otherwise a flat truss is obtained.
Straight inverted Fink truss		The number of divisions the truss is divided into has to be specified.
Fink truss with raise		The number of divisions the truss is divided into and its height have to be specified.
Inverted Fink truss with raise		The number of divisions the truss is divided into and its height have to be specified.
Trussed beam		The number of divisions the truss is divided into and its height have to be specified.

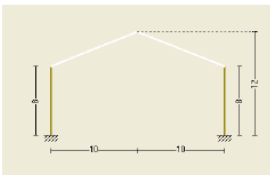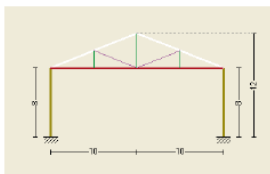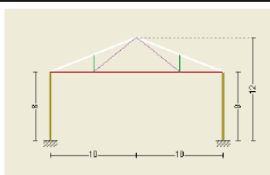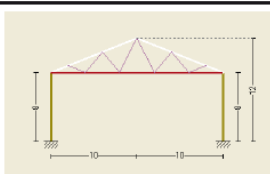Fig. 2.2. Available types of mono pitched roofs
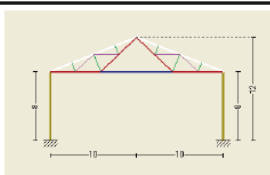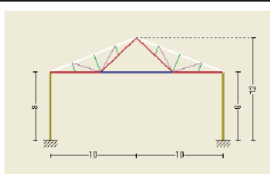
Type of roof	Diagram	Properties
Rigid frame		3 elements of data are required: - Height of the left column - Height of the right column - Span of the frame (2 dimensions: at either side of the ridge)
Howe truss		The number of spans on the left and right the truss is divided into have to be specified.
Pratt truss		The number of spans on the left and right the truss is divided into have to be specified.
Warren truss		The number of spans on the left and right the truss is divided into have to be specified.
Straight Fink truss		The number of spans on the left and right the truss is divided into have to be specified.
Straight inverted Fink truss		The number of spans the truss is divided into and its height have to be specified.

Fig. 2.3. Available types of dual pitched roofs

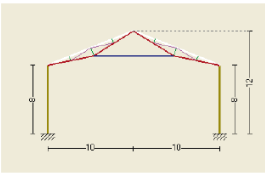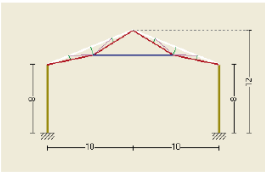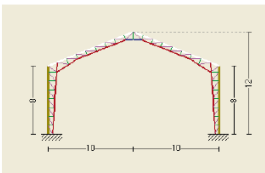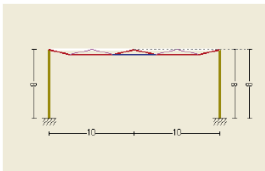| Type of roof	Diagram	Properties
Fink truss with raise		The number of spans on the left and right the truss is divided into have to be specified as well as their respective heights.
Inverted Fink truss with raise		The number of spans on the left and right the truss is divided into have to be specified as well as their respective heights.
Trussed frame		The number of spans on the left and right the truss is divided into have to be specified.
Trussed beam		The number of spans on the left and right the truss is divided into have to be specified as well as the height of the truss on the right and left.

Fig. 2.4. Available types of dual pitched roofs

2.3 Drawings and Reports

2.3.1 Reports

The program provides reports on the job data introduced, checks carried out on the purlins, their take off, and the loads on bars.

The reports are obtained by clicking on **File > Print > Job Report.**

The reports can be sent to a printer (with optional page preview, page setup, etc.) or alternatively generated as HTML, PDF, RTF or TXT files.

2.3.2 Drawings

Drawings can be obtained by clicking on **File > Print > Job Drawings**.

3 Example

3.1 Problems to solve

The object of this manual is to teach the user how to use the program by designing a steel warehouse.

The Portal frame generator carries out the following tasks:

1. Designs the roof purlins
2. Designs the lateral purlins
3. Generates the design specifications
4. Provides drawings of the frame with its purlins
5. Generates the structure in CYPE 3D so the remaining bars may be designed.

3.1.1 Preliminary data

The example that has been chosen consists of a warehouse composed of three different adjacent frames.

The first is a single sloped frame with a 10 m span. The second frame is a straight Fink truss with a 30 m span and 10 m in height. The third frame is a dual pitch frame with a 16 m span and 8 m height. The warehouse contains 7 sets of frames at 7 m intervals.

3.1.2 Loads

- Dead loads

    - Self weight of the purlins

    - Roofing material (sandwich panel composed of galvanised sheet with polyurethane foam: 0.12 kN/m^2)

- Live loads:

    - Assume a live load of 0.4 kN/m^2

- Wind action:

    In accordance with EC1

- Snow loading:

    In accordance with EC1

For this example the warehouse will be assumed to not have any openings.

N.B.: The weight of the purlins does not have to be added to the dead loads; the program will automatically calculate their applied self weight upon exporting to CYPE 3D.

3.1.3 Frame geometry

The geometry of the warehouse to be studied is generic and contains several types of frames. This way the user can become familiar with nearly all the options of the program.
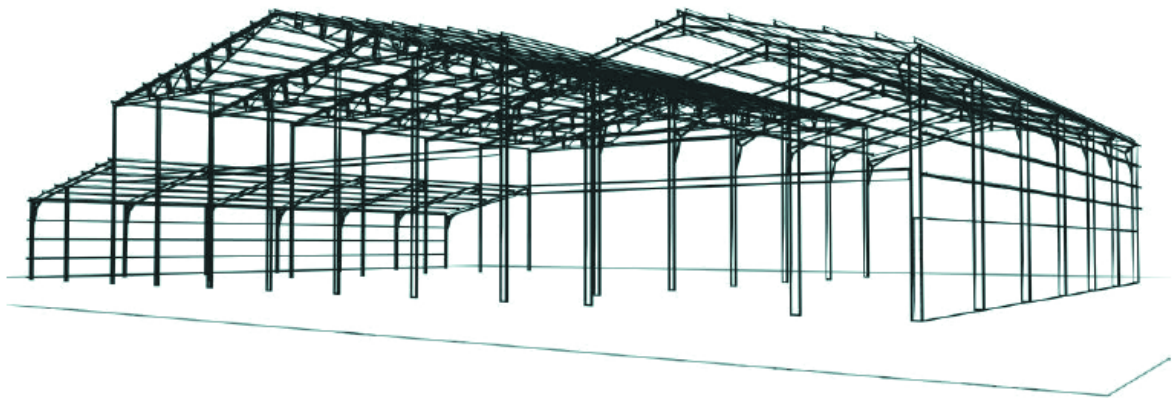
Fig. 3.1. General view of the warehouse

Frame 1
Total span: 10 m
Height left column: 5 m
Height right column: 7 m

Frame 2
Total span: 30 m
Height left column: 10 m
Height right column: 10 m
Fink truss with 8 spans to the left and right

Frame 3
Total span: 16 m
Height left column: 8 m
Height right column: 8 m
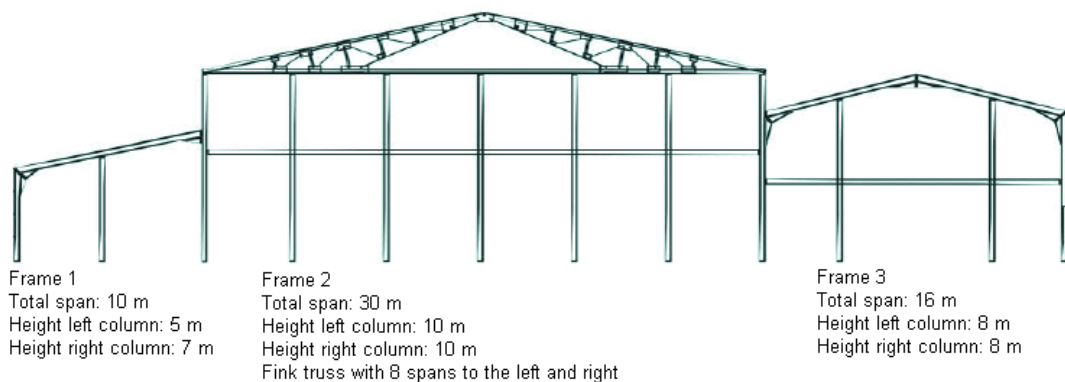
Fig. 3.2. Dimensions of the main frame section

3.2   Data introduction

In this section, the data defining the warehouse is introduced.

3.2.1   *Creating a new file*

Upon opening the program, the job which was previously being worked on will automatically appear. If a job has not been created yet or the last job which was being worked on did not have any defined frames, a window will open prompting the user on whether a new frame is to be introduced.

If **Yes** is selected, the program will guide the user through a series of steps to introduce the frame.

If the option **No** is selected, the dialogue box will close and the user can then click on **File > File manager** so to select a saved job or on **File > New to create a new job**.

If this window appears, answer **No**. Then click on **File > New**. If the last job or example appears, click on **File > New to create a new job**.

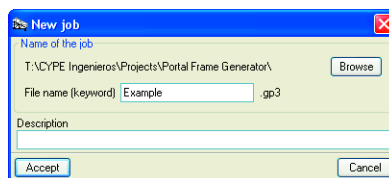A window will open prompting the user for a name (*Example*).

Fig. 3.3.

3.2.2   *General data of the job*

Having confirmed the name of the job, the **Job data** window will open (can also be accessed by clicking on **Job data > General job data**).

Introduce the following data:

- Number of spans: 7

- Distance between frames: 7 m

- Roof covering. Activate the **With roof covering** box. Two further options will appear:

  - External wall weight: Introduce a value of 0.12 kN/m^2.
  - External wall live load: Introduce a value of 0.40 kN/m^2.

- Lateral wall covering. As the warehouse has external walls, activate the **With lateral covering** box and introduce a value of 0.12 kN/m^2 for the external wall weight.

  For the wind load, select **Eurocode 1**, reference speed **26 m/s**, terrain category **Single** and **IV**, **Flat** land in the X and Y directions and a service period of **50** years.
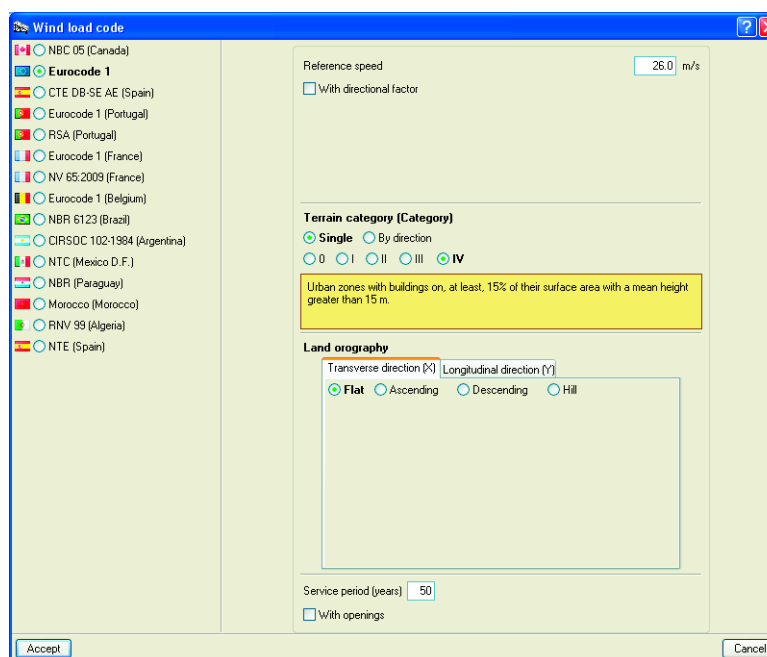

Fig. 3.4

For the snow loads, select **Eurocode 1**, **United Kingdom, Republic of Ireland**, Zone **3**, **Normal** landscape and a topographic height of **0** m.
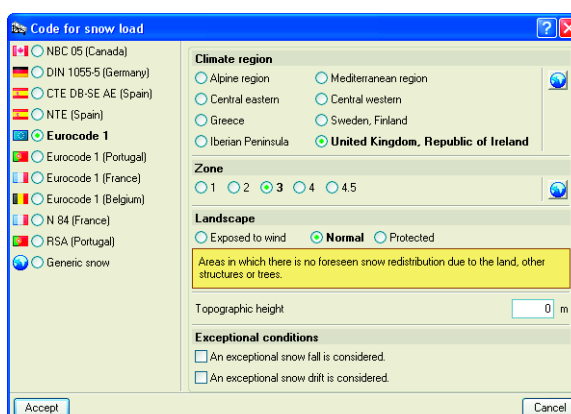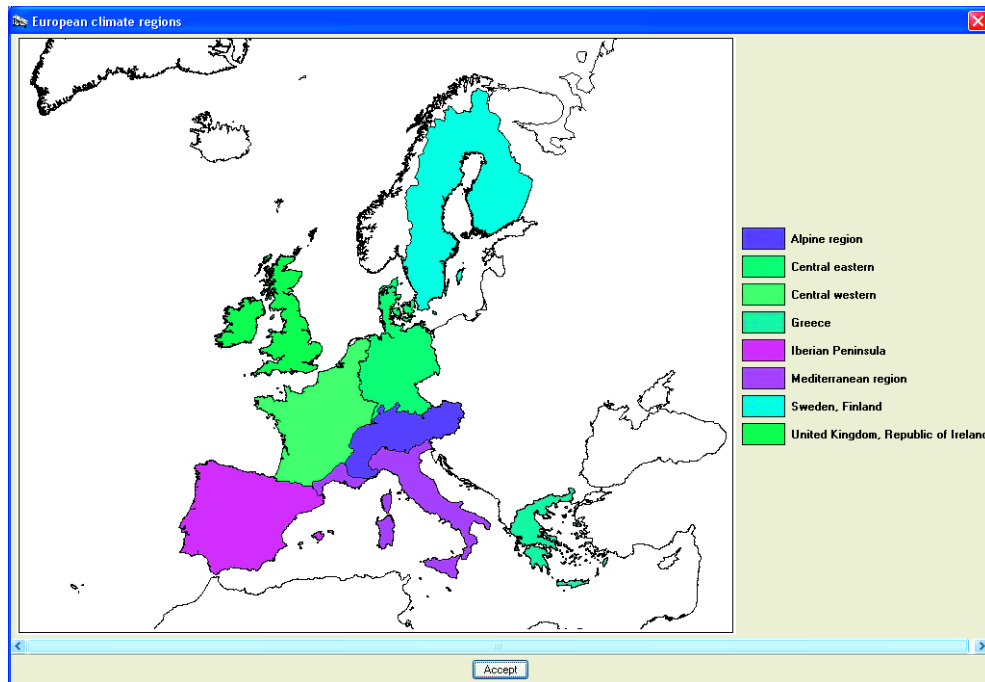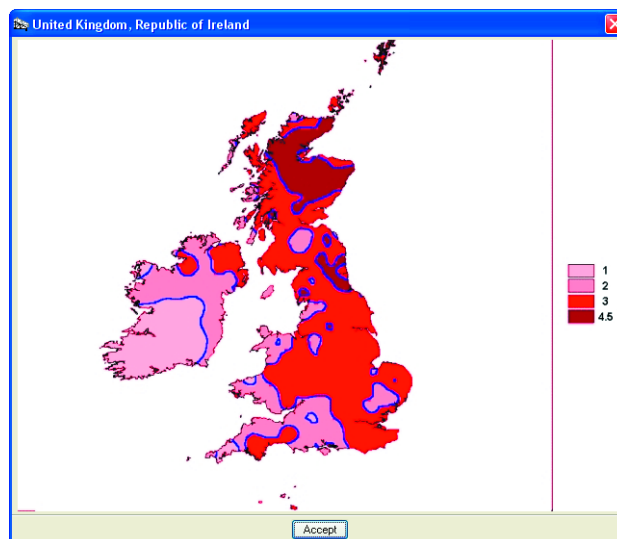

Fig. 3.5

Fig. 3.6

Fig. 3.7

For the load combinations, select Building category **E: warehouses** and for the snow: **Remaining CEN Member States, H ≤ 1000 m**.
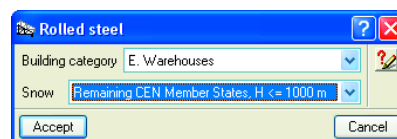

Fig. 3.8

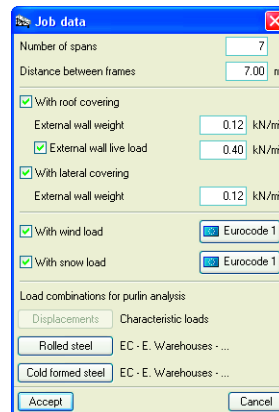The *Job data* window should be as shown below:

Fig. 3.9

3.3 Defining the geometry

Description of Frame 1

Upon accepting the *Job data* window, the program will ask *'Do you wish to introduce a new frame?'*. Click on **Yes**.

Another dialogue box will appear asking whether the frame is to consist of a mono pitched roof or dual pitched roof. Click on **Mono pitch**.

Fig. 3.10

Within the *Mono pitch frame generation* dialogue box, select **Rigid frame** and change the dimensions in the diagram:

- Height of the left column: 5 m
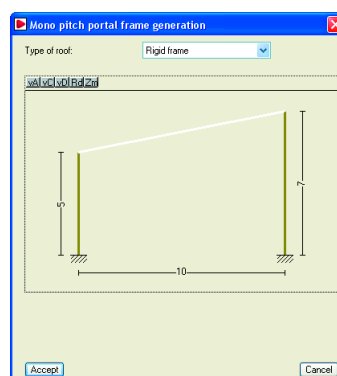- Height of the right column: 7 m
- Span: 10 m

Fig. 3.11

To change the dimensions, click on the displayed value and type in the new dimension. Click on **Accept** to close the description window for the first frame.
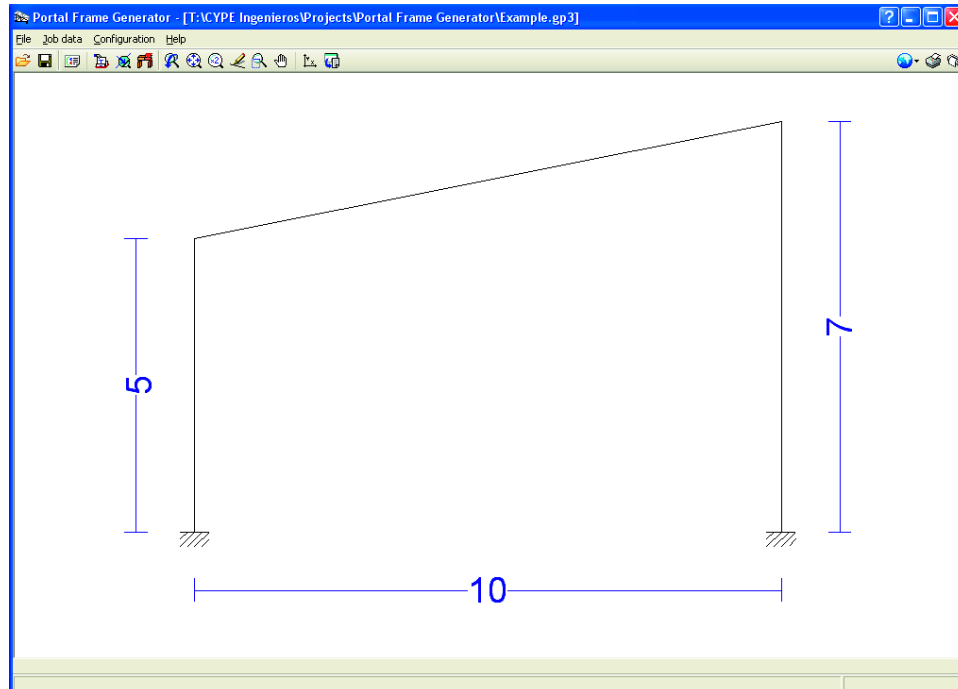

Fig. 3.12

To generate or modify a frame, click on the central area of the screen. A new window will appear displaying all the edition options.

Description of Frame 2

Click to the right of the first frame. The *Edit* menu is displayed.
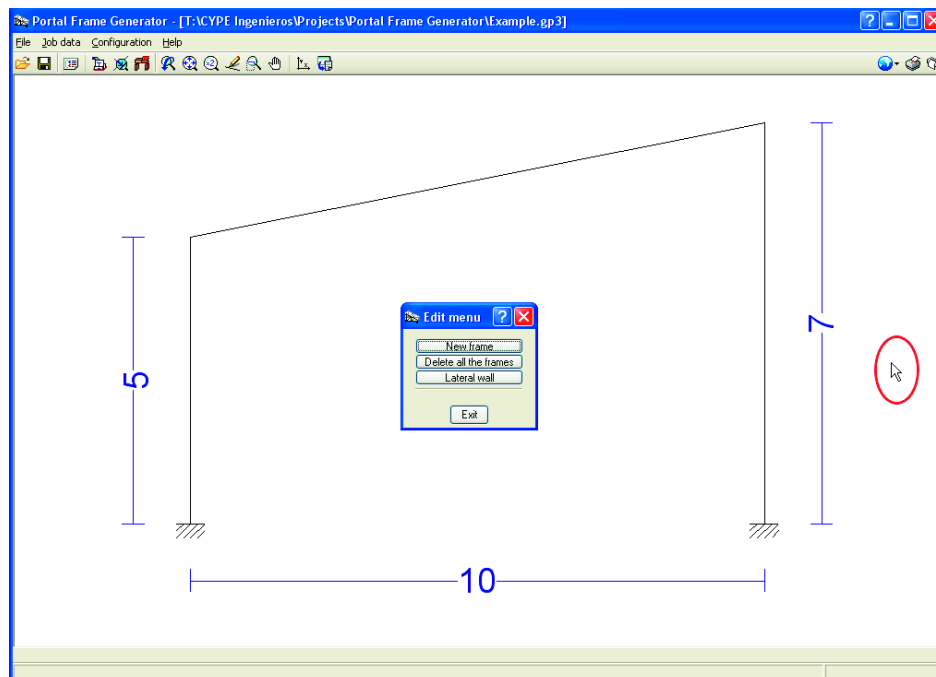
Fig. 3.13

Click on **New frame** and the dialogue box enquiring whether a mono pitch or dual pitch roof is to be introduced appears.

Select **Dual pitch** and from the *Dual pitch frame generation* window, select a **Straight Fink truss**. Introduce the following data:

- Height of the left column: 10 m
- Height of the right column: 10 m
- Height of the ridge: 13 m
- Half-span to the left: 15 m
- Half-span to the right: 15 m
- Internal spans on left: 8
- Internal spans on right: 8

Fig. 3.14

Description of Frame

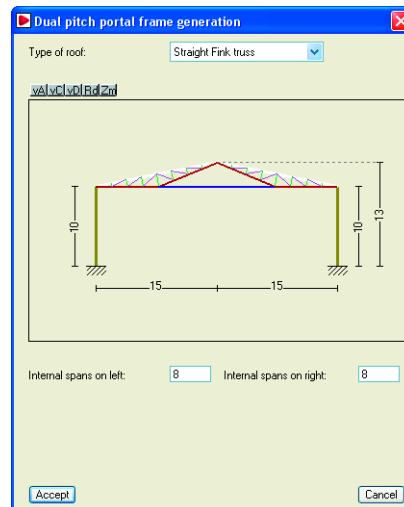Repeat the same creation process as with Frame 2, only now with the following data:

- Dual pitch roof

- Rigid frame

- Height of the left column: 8 m

- Height of the right column: 8 m

- Height of the ridge: 10 m

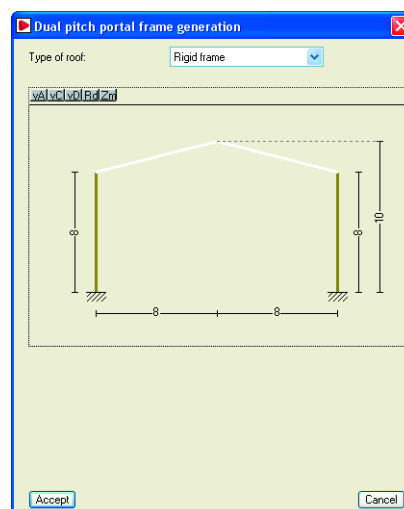- Half-span to the left: 8 m

- Half-span to the right: 8 m

Fig. 3.15

Once the geometry of Frame 3 has been defined, the global image of the complete frame is obtained:
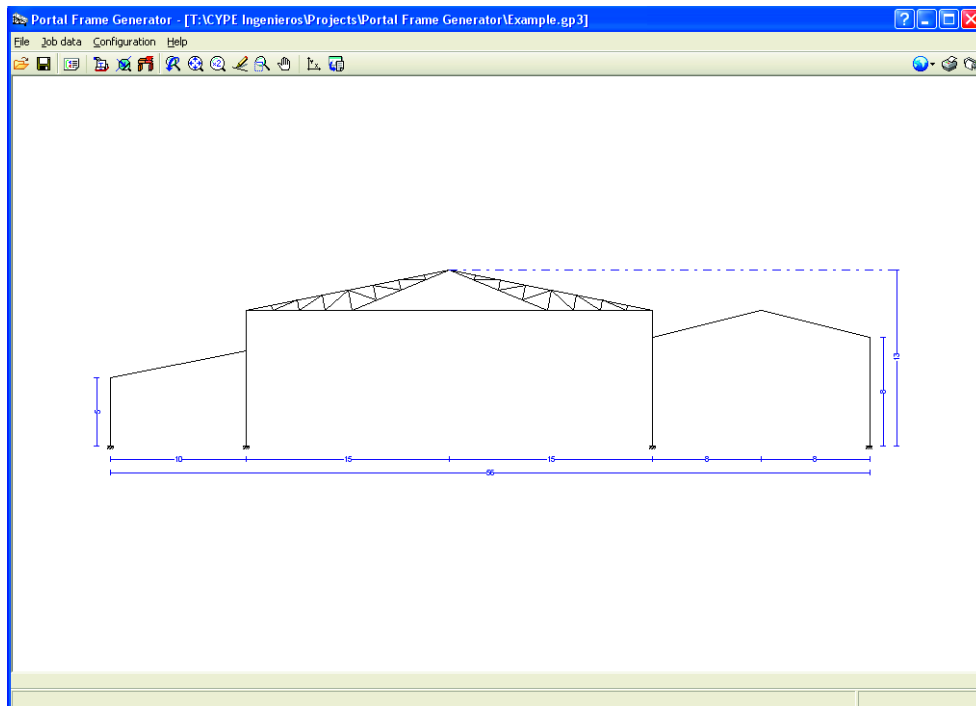

Fig. 3.16

Description of the lateral walls

The warehouse has an external wall to the right measuring 2 m in height. To introduce this data, click to the right of the last frame.

From the *Edit* menu that appears, select **Lateral wall**. Activate the option **With perimeter wall** with a height value of 2 m and activate the **Braces the column against buckling** and **Self-balanced** options.
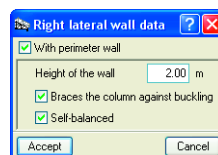

Fig. 3.17

By selecting this option, the program assumes the lateral wall braces the column against buckling outside the plane of the frame, hence modifying the corresponding buckling lengths. This option should only be activated when the user is sure this bracing will be effective.

3.4 Purlins

The program incorporates an easy to use purlin design tool for roof or lateral purlins. Click on **Job data > Lateral and roof purlin edition**.

3.4.1 *Roof purlins*

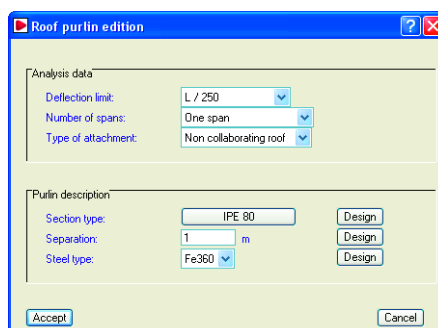Before designing the purlins, the user has to confirm or modify the data regarding their design:

Fig. 3.18

Deflection limit

This parameter establishes the maximum deflection criteria for roof purlins depending on their span. For this warehouse, leave the default value of L/250, which is the value that is usually taken for roof beams or joists.

Number of spans

The program calculates the purlins as if they were a continuous beam. To obtain the correct forces and lateral buckling lengths, the number of spans they cover has to be indicated.

> *This number is not the total number of spans the whole warehouse will have; it is the number of spans one purlin will cover. If the various spans of the purlins overlap at their ends, the transmission of forces is continuous, hence, the purlin will cover the same number of spans as the entire warehouse. For this example, select **Three or more spans**.*

Type of attachment (roof)

Depending on the type of roof that has been chosen, the program applies the loads for which the purlins are checked with. It can be one of the following three cases:

- **Case 1:** Non-collaborating roof. Asbestos cement roofs do not collaborate bracing or holding the purlins. Hence, they will have to be designed for the worst case combination including any torsion that may arise due to the eccentricities of the applied loads. In this case only rolled sections may be used.

- **Case 2:** Hook fixing. The roof is assumed to be infinitely rigid in its plane and therefore, the purlins only have to resist flexure in the plane normal to the roof. If they are attached using hooks, the torsion due to wind suction must also be resisted. Any warping is considered to be negligible.

- **Case 3:** Rigid fixing. Similar to the previous case, only here, the program assumes the roof prevents the purlins from rotating and so there is no torsional moment. The only forces they have to resist are the bending moment and shear force in the plane perpendicular to the roof.

For this example, select **Rigid fixing**.

Type of section

Here the section series and specific section to be used on the roof is selected. The default section that is shown corresponds to the first section that appears in the section library. For this warehouse example, click on the button displaying the section and the following window appears:
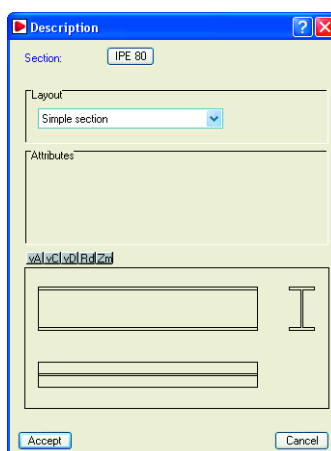

Fig. 3.19

Once again, click on the name button of the default section. In the next window, select the following options:

- Material: cold-formed

- Section data: In job series

- Section series: Cold-formed Z

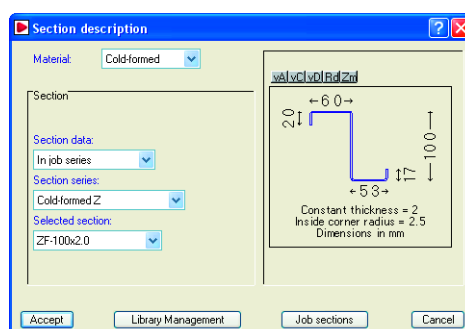- Selected section: ZF-10x2.0 (default section)

Fig. 3.20

It may occur that the cold-formed sections are not visible in the drop down menu. This is because the section series has not been imported from the section library. To import it click on the **Library Management** button and select the library series to open.

Separation

This is the separation between the purlins to check. The default value is **1 m**.

Steel type

This option refers to the type of steel used for the purlins whose elastic limit establishes the maximum stress criteria and affects stability checks (warping, buckling, etc.). Select **S-275**.

Design

To find the optimum purlin section and separation, use the third design button. Upon clicking on it, the *Purlin optimisation* window will appear, where the range for the optimum separation has to be established. In this case set the parameters so to find a solution between **1.5** and **2.0 m** with an increment of **0.1**.
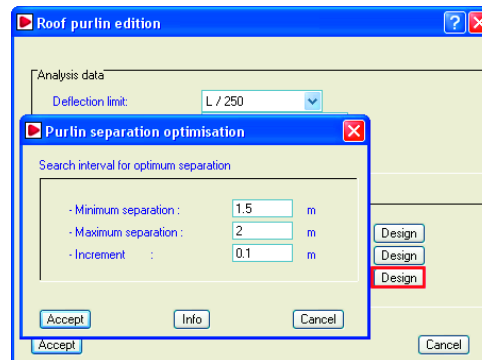
Fig. 3.21

Having accepted, the program runs through a design process and provides a list of the section sizes with their corresponding separations indicating whether or not they verify all the checks. Select **ZF-225x4.0 every 2.0 m** and **Accept**.
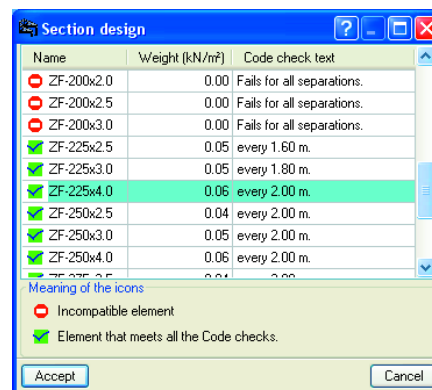

Fig. 3.22

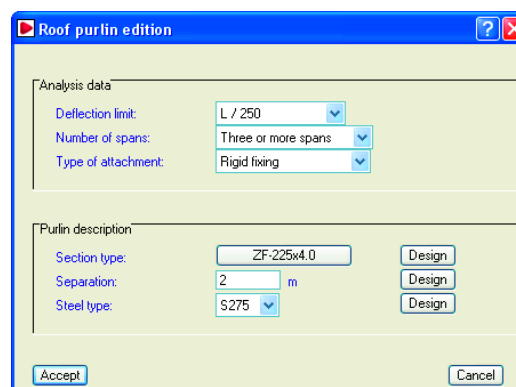The *Section selection* window will reappear displaying the selected section.

Fig. 3.23

3.4.2 *Lateral purlins*

Click on **Job data > Lateral and roof purlin edition > Purlins on sides**. The parameters and procedure are similar to the roof purlin definition. Introduce the following data:

- Deflection limit: L/250

- Number of spans: Three or more spans

- Type of attachment: Rigid fixing

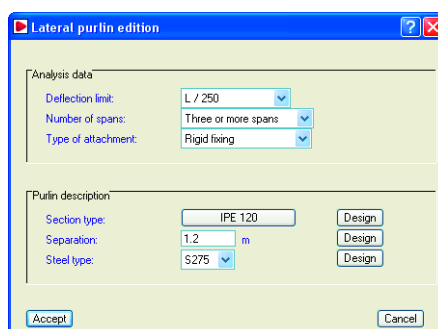- Section type: IPE-120

- Separation: 1.2 m

- Steel type: S275

Fig. 3.24

3.5 Warehouse data report

To view and print a report of the data that has been introduced and designed for the warehouse, click on **File > Print > Job report** and accept all the chapters proposed by the program.

The program will then present a preliminary view of all the information included in the report. The report can then be printed by clicking on the **Print** icon. The information can also be sent to the default Windows printer or exported as a text file. In this case the name of the file and creation directory can be modified.
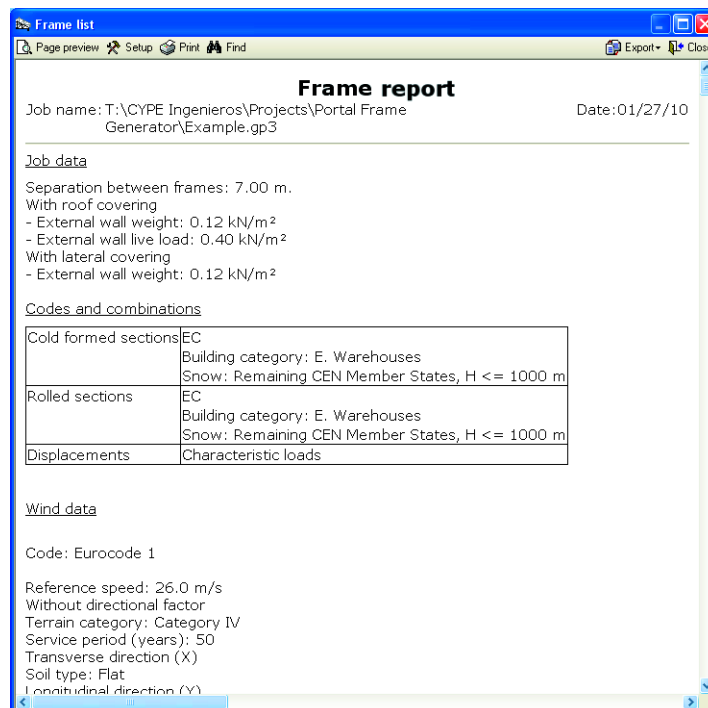
Fig. 3.25. Extract of the example report.

3.6 Drawing of the frame

To draw the frame of the warehouse, click on **File > Print > Job drawings**. The *Drawing selection* window will open.
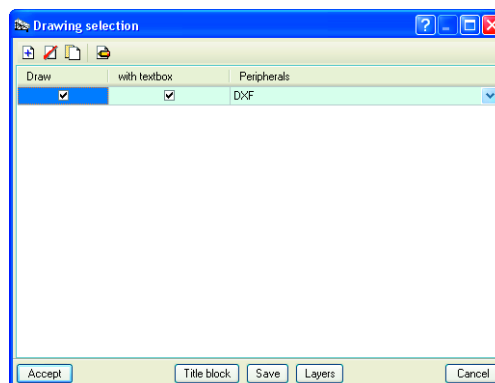

Fig. 3.26

Click on to add a new element to the list. The user can modify the scale, text height, dimension text and add details to the window presented by the program. For this example, leave all the default options.
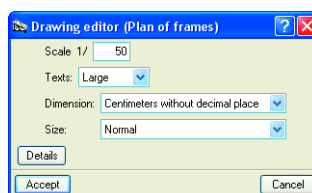
Fig. 3.27

To finish off, accept the two windows. The *Drawing composition* window is generated displaying a preliminary view of the drawing.
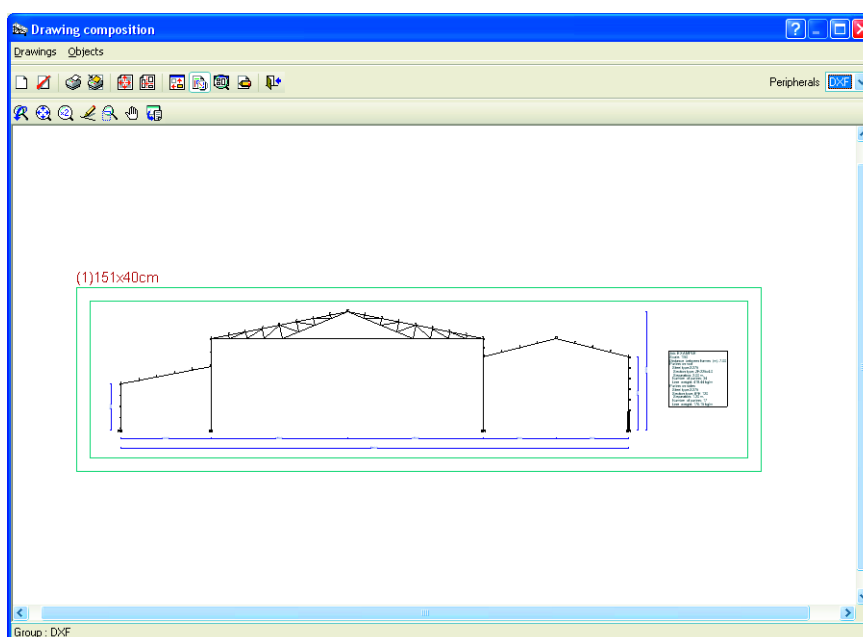

Fig. 3.28

If the user is satisfied with the arrangement, click on **Drawings > Print > Print all**. The drawing will be sent to the selected peripheral.

Please recall that CYPE 3D is a program which designs any structure made up of bars. To do so, it uses the matrix method. The process is especially designed for metallic elements.

3.7 Exporting to CYPE 3D

The last operation to be carried out consists of generating the structure in CYPE 3D.

From the main display, click on **Job data > Export to CYPE 3D**. A dialogue box will open where the selected roof purlin has to be confirmed. Click on **Yes**. Then in the next window, confirm the selected lateral purlin.

The **Options for exporting to CYPE 3D** window will open.

For this warehouse and to configure the type of support, select **Fixed frames**. This option refers to the type of support the columns will have. It also affects the buckling lengths.

In the **Buckling options** section, activate **Buckling in non-sway frames**.

For the Type of generation select **3D frame generation**.

For the grouping options activate **Group central and end**.
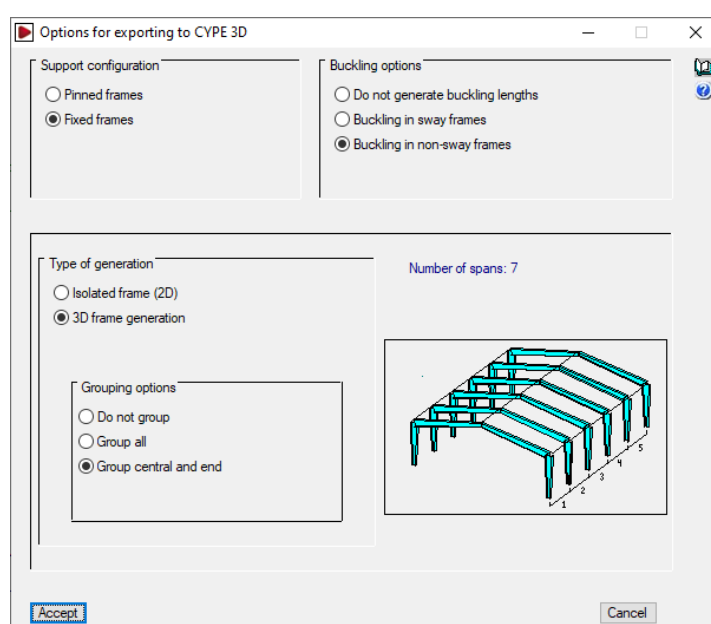
To validate the options, click on **Accept**.

Fig. 3.29

The program will ask whether the user wishes to export. Click on **Yes**, and confirm the job is to be saved. The **Portal frame generator** will close and **CYPE 3D** will automatically open.

Complete the series of initial options indicated by the program within the *New job* window that appears (these can be modified at a later date). The program will ask for the job to be assigned name (the name provided in the **Portal frame generator** will appear as the default option). Upon accepting, the global structure will appear.
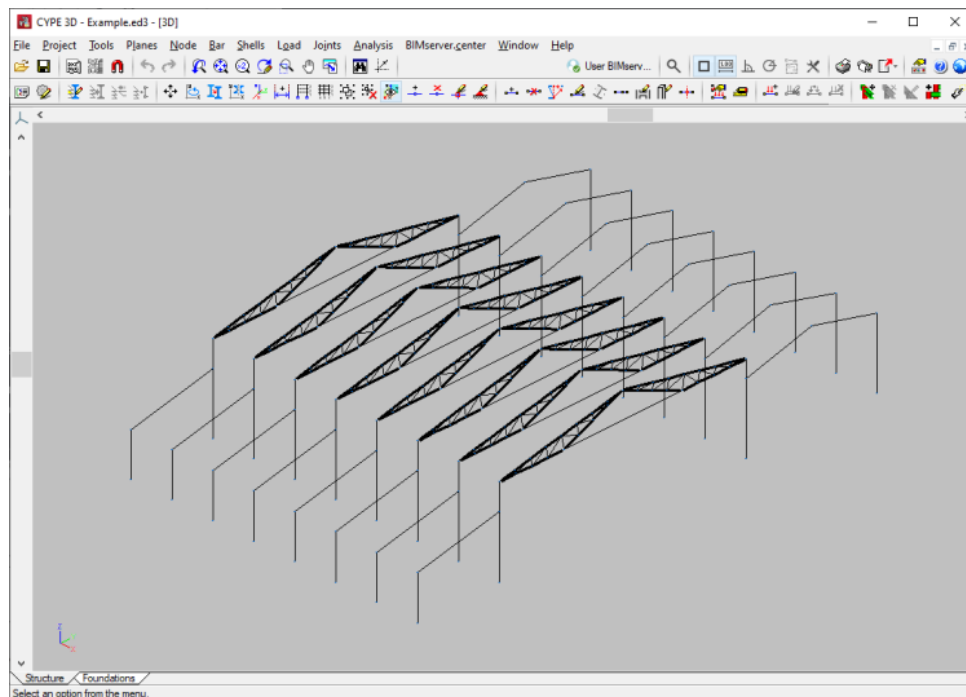
Fig. 3.30

The main steps that now have to be carried out in CYPE 3D are:

- Describe the sections

- Check the buckling coefficients with respect to the local xy plane

- Check the moment coefficients for lateral buckling of the elements

Describe the nodes to activate the design of pad footings and baseplates.