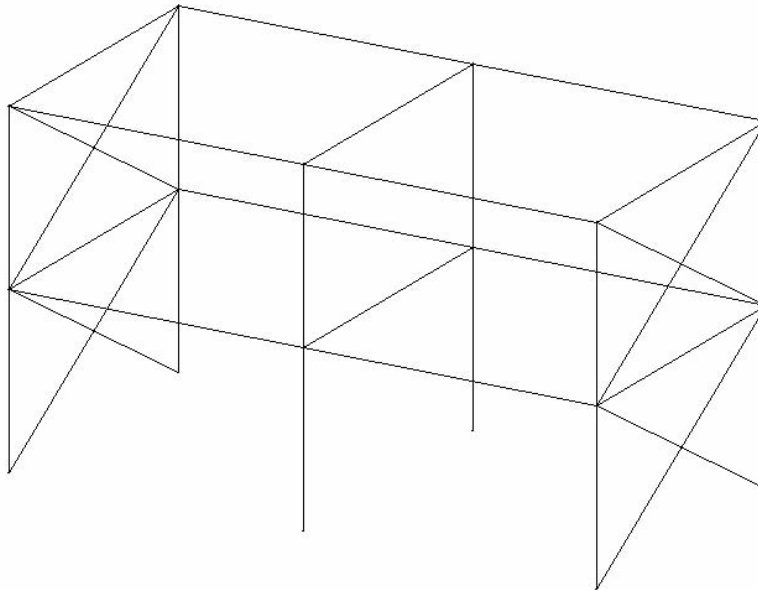


12. Definition of a PushOver Analysis Case

The example presents a definition of a PushOver analysis. The approach allows the user to estimate the state of a structure after an earthquake based on the capacity curve (which is the result of the analysis) and on the assigned code coefficients defining the seismic zone. A simple 3D steel frame presented below will be defined in the example.

Data units: (ft) and (kip).



The following rules apply during structure definition:

- any icon symbol means that the relevant icon is pressed with the left mouse button,
- (x) stands for selection of the 'x' option in the dialog box or entering the 'x' value,
- LMC and RMC - abbreviations for the **L**eft **M**ouse button **C**lick and the **R**ight **M**ouse button **C**lick.


To run structure definition start the **Robot** program (press the appropriate icon or select the command from the taskbar). The vignette window (described in chapter 2.1 of the manual) will be displayed on



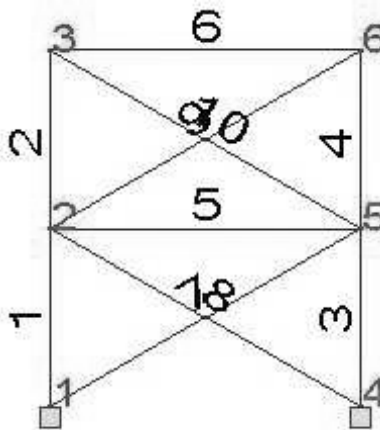
the screen and the last but one icon in the first row (**Frame 3D Design**) should be selected.

NOTE: The American section database (AISC) has been used in this example.



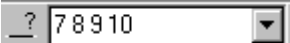
12.1 Structure Model Definition

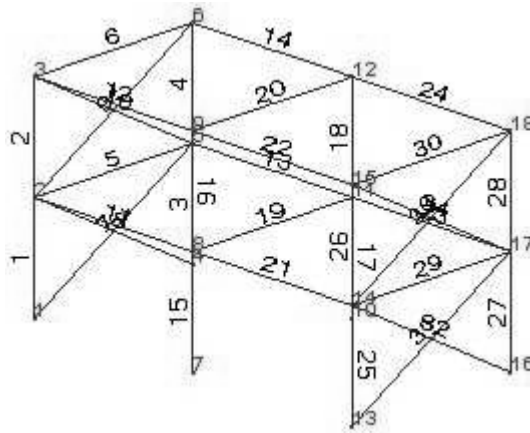
PERFORMED OPERATION	DESCRIPTION
 Structure Model/Bars	Selects the BARS layout from the list of available Robot Millennium layouts.
While the graphical field is displaying the structure view as active (highlighted), select from the menu: <i>View / Projection / Yz</i>	The structure will be presented as projected on the yz plane (x coordinate is assumed to equal 0).
LMC on the <i>Bar Type</i> field and select <i>Column</i> LMC on the <i>Section</i> field and select (W 12x96)	Selects bar properties. The section from the American section database (AISC) has been used. <i>Note: If the W 12x96 section is not available on the list, the user should press the (··) button located beside the Section field and add this section to the active section list in the New section dialog box</i>
LMC on the <i>Beginning</i> field (background color changes to green)	Starts definition of bars in the structure (structure columns).
Enter the following points in the <i>Beginning</i> and <i>End</i> fields. (0,0,0) (0,0,11.5), Add (0,0,11.5) (0,0,23), Add (0,20,0) (0,20,11.5), Add (0,20,11.5) (0,20,23), Add	Defines four columns of the frame.
LMC on the <i>Bar Type</i> field in the Bars dialog box and select <i>Beam</i> LMC on the <i>Section</i> field and select (HP 10x42)	Starts definition of a beam and selects its properties. The section from the American section database (AISC) has been used. <i>Note: If the HP 10x42 section is not available on the list, the user should press the (··) button located beside the Section field and add this section to the active section list in the New section dialog box</i>
LMC on the <i>Beginning</i> field (background color changes to green)	Starts definition of beams in the structure.
Enter the following points in the <i>Beginning</i> and <i>End</i> fields. (0,0,11.5) (0,20,11.5), Add (0,0,23) (0,20,23), Add	Defines two beams.
LMC on the <i>Bar Type</i> field in the Bars dialog box and select <i>Simple bar</i> LMC on the <i>Section</i> field and select (L 1.5x1.5x0.1875)	Starts definition of bracings and selects their properties. The section from the American section database (AISC) has been used. <i>Note: If the L 1.5x1.5x0.1875 section is not available on the list, the user should press the (··) button located beside the Section field and add this section to the active section list in the New section dialog box</i>
LMC on the <i>Beginning</i> field (background color changes to green)	Starts definition of bracings in the structure.

Enter the following points to the <i>Beginning</i> and <i>End</i> fields. (0,0,0) (0,20,11.5), Add (0,20,0) (0,0,11.5), Add (0,0,11.5) (0,20,23), Add (0,20,11.5) (0,0,23), Add	Defines four bracings.
LMC on the field for selection of the Robot Millennium program layouts Structure Model/Supports	Selects the Robot Millennium layout which allows support definition.
In the Supports dialog box, LMC on the <i>Current Selection</i> field (the cursor is blinking in the field)	Selects the structure nodes for which supports will be defined.
Switch to the graphic viewer; pressing the left mouse button select with the window all the lower column nodes	Selected nodes 1 and 4 will be entered to the <i>Current Selection</i> field.
From the Supports dialog box select the fixed support icon (the icon will be highlighted)	Selects the support type.
LMC on the Apply button	Selected support type will be assigned to the chosen structure nodes; the defined structure is displayed in the drawing below.
LMC on the field for selection of the Robot Millennium program layout Structure Model/Start	Selection of the initial Robot Millennium program layout.
<i>View / Projection / YZ</i>	
<i>View / Display</i> Move to the <i>Structure</i> tab Switch on display of numbers of nodes and bars as well as supports.	





<i>Geometry / Properties / Sections</i>	Selects the bar section.
From the Sections dialog box select the HP 12x63 section	The selected section will be assigned to the bars created by the dragging option - e.g. <i>Translate</i> with the <i>Drag</i> option turned on.

LMC on the Close button	Closes the Sections dialog box.
<i>View / Projection / 3d xyz</i>	Selects the isometric structure view.
LMC in the list of the bar selection  Enter the numbers of all columns and beams press Enter on the keyboard	Selects all columns and beams, i.e. bars 1 to 6.
LMC in the list of the node selection  Enter the numbers of the beam nodes press Enter on the keyboard	Selects beginning and end nodes of both beams, i.e. nodes 2 3 5 6.
<i>Edit / Edit / Translate</i>	Opens the Translation dialog box.
LMC on the <i>Drag</i> check box	Turns on the dragging option so that the successive copies of the selected nodes are joined together by bars.
LMC on the <i>Number of repetitions</i> field and enter the value: (2)	Defines the number of repetitions for the performed translation operations.
LMC on the <i>Translation vector</i> field and enter the vector: (20,0,0)	Defines the translation vector.
LMC on the Execute button	Copies the selected elements.
LMC on the View edit viewer	Click on the screen outside the structure to clear the bar and node selection lists.
LMC in the list of the bar selection  Enter the numbers of all bracings press Enter on the keyboard	Selects all bracings, i.e. bars 7 to 10.
LMC on the <i>Number of repetitions</i> field and enter the value: (1)	Defines the number of repetitions for the performed translation operations.
LMC on the <i>Translation vector</i> field and enter the vector: (40,0,0)	Defines the translation vector.
Execute, Close	Translates the bracings and closes the Translation dialog box.




12.2 Definition of the PushOver Analysis Case

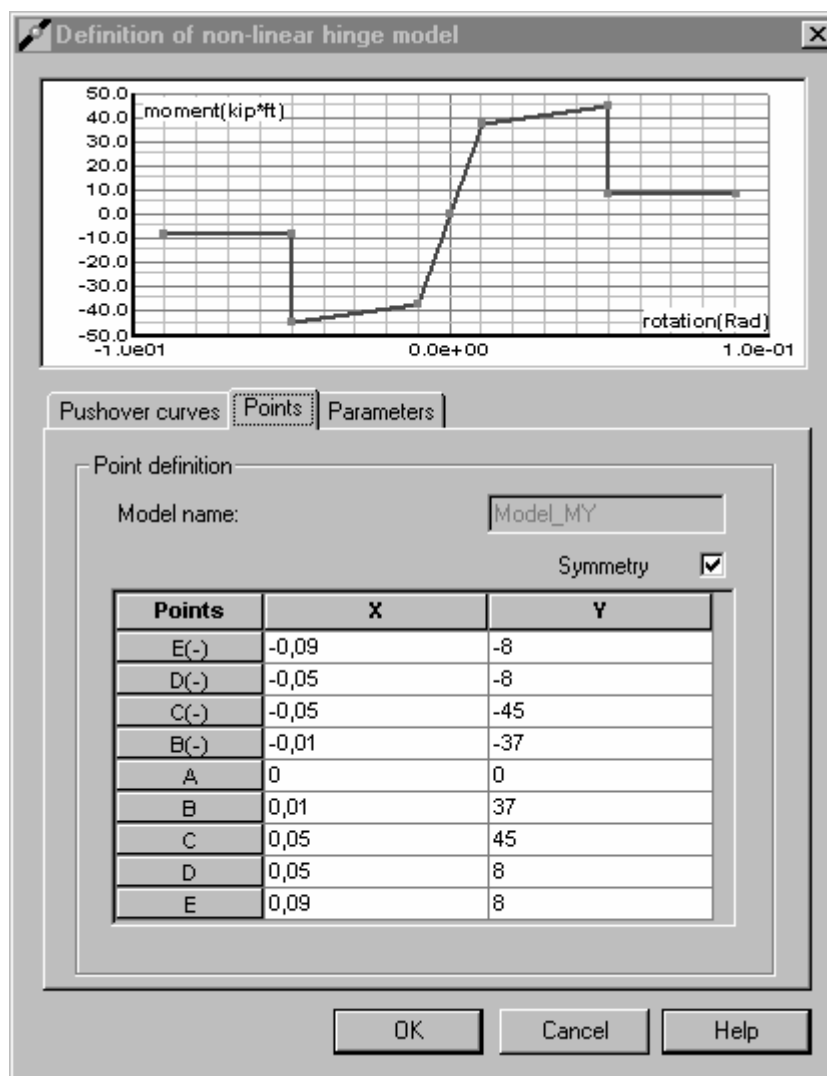
LMC on the box for selection of the Robot Millennium layout Structure Model/Loads	Selects the Robot Millennium program layout allowing for the structure load definition.
LMC on the New button located in the Load Types dialog box	Defines a <i>dead load (self-weight)</i> with a standard name DL1.
<i>Analysis / Analysis types</i>	Opens the Analysis Type dialog box.
LMC on the New button	Opens the New Case Definition dialog box.
LMC on the OK button	Opens the Modal Analysis Parameters dialog box.
LMC on the OK button	Defines a new modal analysis case with the default parameters assigned.
LMC on the New button	Opens the New Case Definition dialog box.
LMC on the <i>PushOver</i> option LMC on the OK button	Opens the dialog box for definition of the PushOver analysis case.
LMC on the <i>Case</i> field: PushOver	Defines the name of the PushOver case.
LMC on the <i>Node number</i> field: (3)	Defines the controlling node, the displacement of this node is checked at each load increment.
LMC on the <i>Direction</i> field, select: (UX+)	Defines direction of an external factor affecting the structure in the global coordinate system.
LMC on the <i>Maximum displacement</i> field: 8 (in)	Defines the maximum displacement in the selected node.
LMC on the <i>According to unit acceleration in the given direction</i> option	Defines the method of the load definition.
LMC on the Parameters button	Opens the dialog box for definition of the Arc-length method parameters.

LMC on the <i>Load increment number</i> field: (20)	Defines the number of the load increments.
LMC on the OK button	Applies the changes and closes the dialog box.
While in the Push over dialog box LMC on the OK button	Closes the Push over dialog box and defines a new PushOver case.
LMC on the Close button in the Analysis Type dialog box	Closes the Analysis Type dialog box.
LMC in the list of the load case selection  select the modal case: (2)	Selects the modal case.
<i>Loads / Load Definition</i>	Opens the Load Definition dialog box.
While on the <i>Self-weight and mass</i> tab LMC on the <i>Added masses - nodes</i> icon 	Opens the Nodal mass dialog box.
LMC on the X field: 22 (kip) LMC on the Y field: 22 (kip) LMC on the Z field: 22 (kip)	Defines the values of the added masses.
LMC on the Add button	Accepts the definition of added masses.
While in the Load Definition dialog box LMC on the <i>Apply to</i> field: (all) Apply, Close	Applies the added masses to all the nodes. Closes the Load Definition dialog box.

12.3 Definition of a Non-linear Hinge

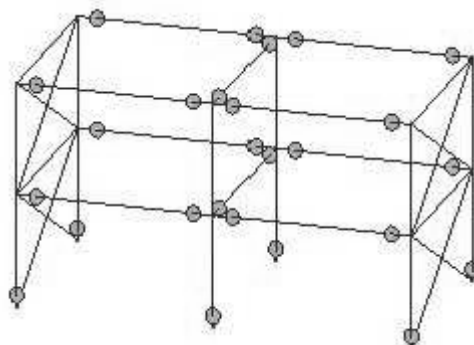
LMC on the box for selection of the Robot Millennium program layouts Structure Model / Start	Selects the initial layout of the Robot Millennium program.
<i>Geometry / Additional attributes / Non-linear Hinges</i>	Opens the Non-linear Hinges dialog box.
LMC on the New hinge type icon 	Opens the Non-linear Hinge Definition dialog box.
LMC on the <i>Label</i> field: Hinge_1	Defines the name of the hinge label.
LMC on the Definition of hinge model button	Opens the Definition of non-linear hinge model dialog box.
LMC on the <i>Model name</i> field: Model_MY	Defines the name of the hinge model.

LMC on the Add button	Creates the hinge model.
LMC on the <i>Points</i> tab	Switches to the <i>Points</i> tab.
LMC on the following fields: <ul style="list-style-type: none"> • point B column X: (0.01) • point B column Y: (37) • point C column X: (0.05) • point C column Y: (45) • point D column X: (0.05) • point D column Y: (8) • point E column X: (0.09) • point E column Y: (8) 	Creates a diagram of the hinge model (see the drawing below).




LMC on the <i>Parameters</i> tab	Switches to the <i>Parameters</i> tab.
LMC on the <i>Type</i> field, select: (moment-rotation)	Defines the type of the hinge, in that case it is moment versus rotation, thus the previously defined column Y stands for moment and X stands for rotation.



LMC on the <i>Unloading method</i> and select: (elastic)	Defines the unloading method, in that case return is carried out along the same path as while loading.
LMC on the OK button	Accepts the definition of the hinge model, closes the dialog box.
While in the Non-linear Hinge Definition dialog box: LMC on the <i>MY</i> option (if necessary LMC on the other check boxes to deactivate them)	It activates the <i>MY</i> option.
LMC on the <i>MY</i> field and select: (Model_MY)	Selects previously defined hinge model.
Add, Close	Accepts the definition of the hinge label and closes the Non-linear Hinge Definition dialog box.
While in the Non-linear Hinges dialog box: select the Hinge_1 label	Selects the previously defined hinge label.
LMC on the <i>relative</i> option LMC on the <i>x=</i> field: (0.1)	Sets the relative position on the bar as $x=0.1$.
LMC on the <i>Current Selection</i> field: 1, 3, 15, 17, 25, 27, Apply	Applies the label Hinge_1 at the relative position $x=0.1$ to the lower columns.
LMC on the <i>Current Selection</i> field: 11to14, 19to24, Apply	Applies the label Hinge_1 at the relative position $x=0.1$ to the all beams except for the ones from the braced walls.
LMC on the <i>relative</i> option LMC on the <i>x=</i> field: (0.9)	Sets the relative position on the bar to $x=0.9$.
LMC on the <i>Current Selection</i> field: 11to14, 19to24, Apply	Applies the label Hinge_1 at the relative position $x=0.9$ to all the beams except for the ones from the braced walls.
Close	Closes the Non-linear Hinges dialog box.



12.4 Structure Analysis


	Starts calculations of the defined structure
LMC on the box for selection of the Robot Millennium program layouts Results/Results	Opens the RESULTS layout of the Robot Millennium program. The screen will be divided into three parts: a graphic viewer containing the structure model, the Diagrams dialog box and a table with reaction values.

12.5 Result Analysis

 Select: (3: Push over)	Displays results for the push over case.
Select the <i>NTM</i> tab from the Diagrams dialog box Turn on the <i>MY moment</i> option	Displays the structure MY moment for the selected load case.
Select the <i>Deformation</i> tab from the Diagrams dialog box Turn on the <i>Deformation</i> option	Displays the structure deformation for the selected load case.
LMC on the Apply button	Displays structure deformation and MY moment diagram.
<i>Loads / Select Case Component</i>	Opens the Case component dialog box.
LMC on the <i>Current component</i> field 	Goes through the components up to the <i>Number of components</i> .
Close	Closes the Case component dialog box.
Turn off the <i>MY moment</i> and <i>Deformation</i> option in the dialog box, Apply	Turns off result display.

12.6 Results - Diagrams of PushOver Analysis

<i>Results / Advanced / PushOver Analysis - Diagrams</i>	Opens the Pushover analysis dialog box.
LMC on the Add button	Opens the Diagram definition dialog box.
LMC on the <i>UX</i> option	Displays the UX displacement diagram.
LMC on the <i>Case</i> field and select: (3: Push over)	Selects the PushOver case.
LMC on the <i>Node</i> field: (3)	Selects node 3 for which the UX displacement diagram is created.

Add, Close	Confirms the definition of the diagram and closes the Diagram definition dialog box. Note that the default diagram name is: 3_Displacement_UX_3
While in the Pushover analysis dialog box: LMC on the  button	Moves all the diagrams from the <i>Available diagrams</i> panel to the <i>Presented diagrams</i> panel.
LMC on the Apply button	Opens the Diagrams of push over analysis viewer with <i>Presented diagrams</i> displayed.
While in the Diagrams of push over analysis viewer LMC on the cross in the upper right corner While in the Pushover analysis dialog box LMC on the Close button	Closes the Diagrams of push over analysis viewer and the Pushover analysis dialog box.

12.7 Results – Capacity Curve

<i>Results / Advanced / Capacity curve</i>	Opens the PushOver curve dialog box.
LMC on the Apply button	Opens the Pushover curve diagrams viewer with <i>Displacement - reaction sum</i> diagram displayed.
LMC on the <i>Diagram type</i> field and select: (Capacity spectrum)	Selects the type of a diagram to be displayed in the viewer.
LMC on the <i>Selected demand spectrum</i> option	Activates the display of selected demand spectrum.
LMC on the <i>Lines of constant period</i> option	Activates the display of constant period lines.
LMC on the <i>Reduced spectra (damping)</i> option	Activates the display of reduced spectra.
LMC on the <i>Histeretic damping B</i> option	Selects the structure type B.
LMC on the Apply button	Displays the capacity curve.