SCAD Structure

WEST

A software application for calculating loads and actions in compliance with SNiP 2.01.07-85* and DBN- V.1.2-2:2006

U s e r m a n u a l

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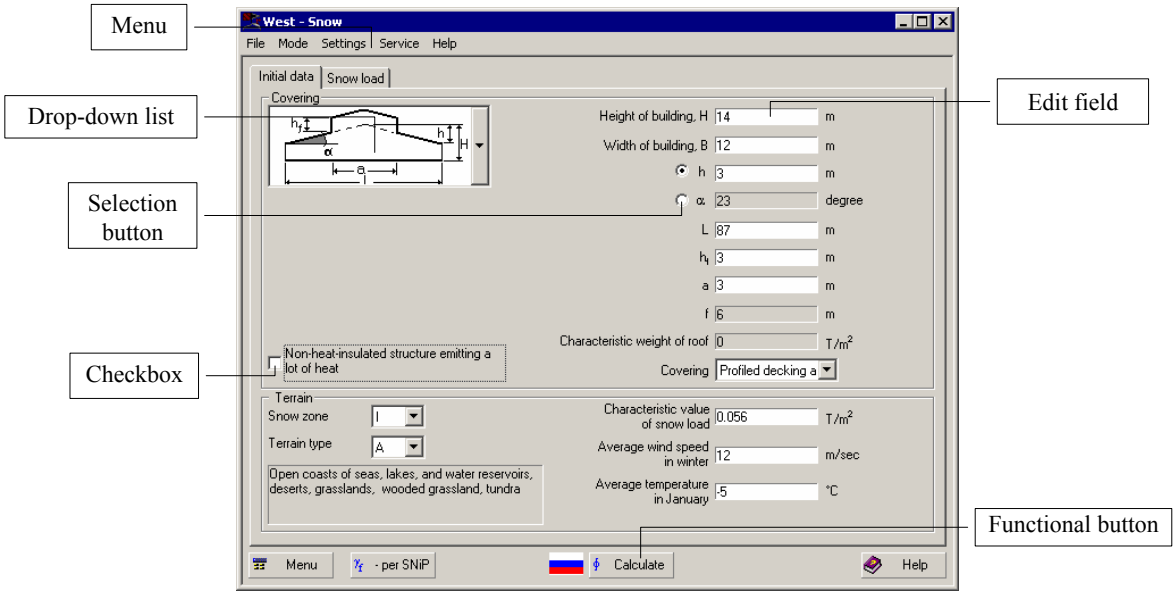
1. General management

1.1 Controls

Principles and controls that this software application uses provide a consistent user interface. The application makes use of standard multi-tab dialog boxes. To switch to a page in a multi-tab dialog box, click the respective tab at the top of the dialog. Additional controls and access methods include (see Figs. 1.1-1):

- menus, which you open in the same way as those of any MS Windows[1] applications, by clicking the left mouse button (left-clicking);
- functional buttons, clicking or pressing which (by placing the mouse pointer onto them and left-clicking once) will activate certain functions, actions, or modes;
- selection buttons or boxes of various kinds, which help make a choice from a number of suggested options;
- text edit fields which you use to specify source data for analyses. All source data are numbers. If a non-integer is to be entered, its integral part must be divided from its fractional part by period or another separator. The separators are selected by the user as part of the system settings (see **Settings | Regional Settings | Number**). In addition, scientific notation can be used to enter numbers, for example: 1.56e-7;
- drop-down or static lists, to select data items from;
- tables, to enter and display tabular data;
- dynamically digitized diagrams, where you can point at a function's argument and in this way have the function's value displayed.



Figs. 1.1-1. Controls of the application window

[1] Microsoft, Windows are registered trademarks of Microsoft Corporation. All other mentioned trademarks are registered property of the respective companies and corporations.

1.2 Settings

The **Settings** dialog box can be called up at any time when working with the application. It is used to choose general settings that affect the working session. Generally, the dialog contains the following tabs: **Units of Measurement**, **Report and Languages**, **Visualization** and **Profile Databases**.

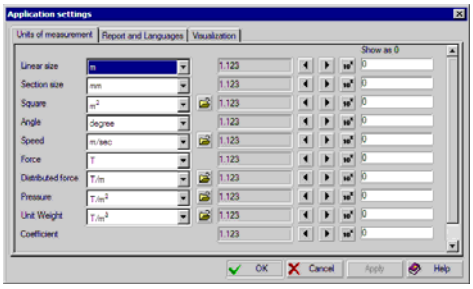


Fig.1.2-1. *The* **Units of Measurement** *tab*

Each tab opens a property page that helps set up a particular class of the application's settings.

The **Units of Measurement** tab (Fig. 1.2-1) defines what measurement units will be used to describe physical quantities. It contains two groups of data. The first one specifies units of measurement for sizes of the construction in question, forces, moment etc.

Compound units (such as moments of forces, pressure etc.) can be defined by separately choosing their component units (for example, force units and arm measurement units together define a moment unit).

To do it, use the button .

Second group helps choose the representation and precision of numeric data. Data representation is defined by edit field controls where you specify the amount of significant digits in the fixed-point or scientific notation.

The data precision (the number of significant digits after the decimal point) is set using the buttons (increase) or (decrease), while the button turns on the scientific notation. In addition, the respective edit fields let you define what value of a certain unit of measurement should be interpreted as "very small" so that it is displayed as 0 as soon as its absolute value is less than the specified threshold.

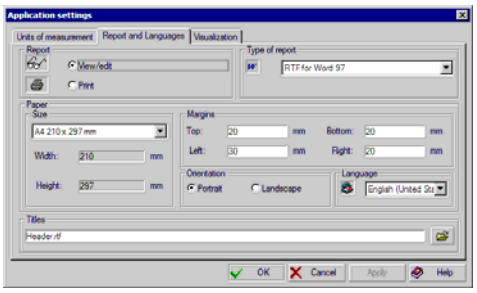


Fig. 1.2-2. *The* **Report and Languages** tab

The **Report and Languages** tab (Fig. 1.2-2) lets you choose a language in which to present all texts or captions in dialog boxes and a final report.

To work with the report document, you can choose between the **View/Edit** and **Print** modes.

When in the **View/Edit** mode, clicking the **Report** button in any working window will bring the report on the screen for you to view and edit it. An application associated with the RTF file format (Rich Text Format) will be called up (such as MS Word Pad or MS Word).

Obviously, it is the user who is responsible for any corrections made to the report (results of an analysis can be edited, too).

There are differences in the RTF file formats used by the MS Word v.7 and MS Word 97 (2000) applications. Therefore you can choose either format in the settings, in the **Report Type** mode. Clicking the **Print** button in the **Report** group will print out the report in the form it has been generated by the application.

In the **Headers/Footers** field, you can indicate an RTF file name that contains desired headers and footers for the pages of the report document. The file is selected from a standard list by clicking the button .[2]

The **Paper Size** lets you set up the size of paper on which to print the report (a drop-down list is used to select the desired size).

[2] If you wish to use MS Word to modify the header/footer RTF file shipped with the application, you need to remember it is not enough to just enter a new text — you have to use the menu item **Tools|Language|Set Language** and set *Russian* as the language for the newly entered text.

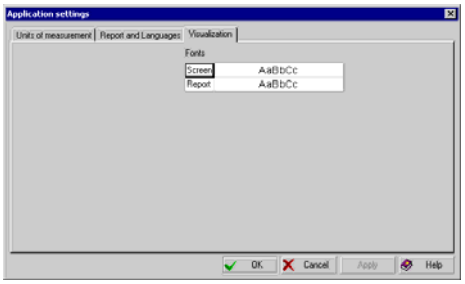


Fig. 1.2-3. *The* **Visualization** *tab*

In addition, you can set indentation and page orientation for the report document.

The **Visualization** tab (Fig. 1.2-3) has two groups of controls: **Colors** and **Fonts**. Each group contains a list of controls and displays their respective attributes (color and font). Double right clicking opens a standard Windows dialog box for setting up the color and font as desired.

1.3 Menus

File The **File** menu contains two items: **Menu** and **Exit**.
Menu — this item switches to the main window (it duplicates the button under the same name).
Exit — finishes the working session.

Modes The **Modes** menu contains a list of all working modes available in the application and helps switch to any of them without having to go to the main window.

Settings This menu is used to call up the **Application Settings** dialog box where you set up various preferences of the application (it duplicates the respective button).

Tools While working, the user often wants to do some additional calculations. The **Tools** menu lets you launch a standard Windows calculator application (provided it has been installed with the system), a formula calculator, and a measurement unit converter.

Help This menu provides reference help on management and functionality of the application.

1.4 Working with tables

Source data for the application are in most cases specified as tables (Fig. 1.4-1). To enter data in tables, follow these rules:

- tabular data are decimal numbers; what separator is used between the integral and fractional parts of a number (a period or a comma) depends on the Windows environment settings;
- in cases when the number of rows in a table is user-defined, the table has the buttons **Add** and **Delete** next to it; the former lets you add a new row after the one currently selected, and the latter deletes one or more selected rows;
- to select (highlight) one or more successive rows, place the mouse pointer on No. of the first one, click and hold the left mouse button, and drag the pointer over Nos. of the rows to be selected;
- to switch between cells of the table, use the **Tab** (tabulation) key on your keyboard.

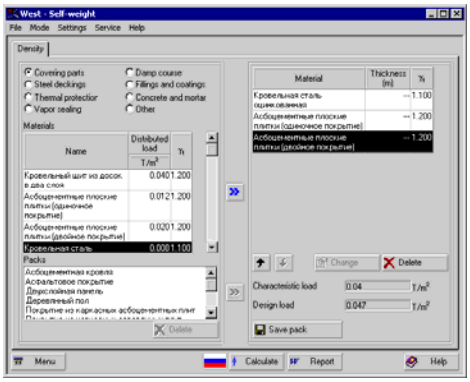


Fig. 1.4-1. *An example of a table*

New rows will be added after the currently selected one, so if you need to add one before the very first row of the table, follow these steps:

- highlight (select) first row of the table and click the **Add** button to add a new row after it;
- select first row of the table and press the **Ctrl+Insert** keys at the same time; this will copy the first row's contents to the **Clipboard** (a Windows memory buffer for copying);
- select second (new) row of the table and press the keys **Shift+Insert** together; this will put the contents of the clipboard in the cells of second row, and now you can fill first row with desired data.

The above steps can be used also to copy one or more selected rows of a table.

1.5 Saving data

All analysis modes have the capability of saving the entered data in an external file. To do it, use the menu item **File|Save As** when in the respective working mode. This will open a standard Windows dialog box for choosing a directory and a file where to save the data. The filename and its extension are to be specified by the user.

To retrieve the saved data later, use the **File|Open** menu item.

2. The WeST software application

The **WeST** application is used to perform calculations of loads and actions applied to structural constructions in compliance with provisions of four regulatory codes: SNiP 2.01.07-85, which is an international document among the CIS countries; SNiP 2.01.07-85* with an amendment as of 2003 N2 concerning snow loads which is in effect in Russian Federation; DBN V.1.2-2:2006, which regulates loads and actions; and DSTU B V.1.2-3:2006, which regulates deflections and displacements and is in effect in Ukraine.

The application implements only the most frequent loading cases, and also those for which the necessity to comply with SNiP involves a complicated logic which often leads to mistakes — as evidenced by practice.

In addition to this functionality, to some extent the **WeST** application is a reference manual which can be used to check data concerning zoning of territories for loads and actions or to obtain other reference information.

Finally, the application can be used to accumulate structural concepts frequently applied by an engineer, in order to create one's own reference data storage.

Further descriptions of the **WeST** functionality merge together general capabilities and focus only on most significant features related to the implementation of differences or amendments in design codes. This is chiefly in regard to the differences between two editions of SNiP [1, 2] and DBN [4]. DSTU [3] that regulates deflections and displacements replaces Chapter 10 of both editions of SNiP [1, 2]; it contains no actual differences in comparison to that Chapter.

We do not distinguish between SNiP 2.01.07-85 and SNiP 2.01.07-85* in our further description because they are identical in the data that you have to provide and in the form in which the results are to be presented.

2.1 Main window

Fig. 2.1-1. *The main window*

When the application is launched, it is its main window that appears first on the screen (Fig. 2.1-1). The main window contains a set of buttons for selecting a working mode. The modes can be divided into two distinct groups:

- reference modes — ones used to get reference information and to perform auxiliary actions of determining loads and actions;
- design modes — ones that implement calculations of loads/actions in compliance with provisions of SNiP and DBN (to select one, use the **Design Codes** drop-down list.

Subsequent sections provide detailed descriptions of each available mode and differences between those caused by different requirements in the design codes. Here we present only a brief characterization.

The reference modes include:

- **Densities** — reference data concerning the densities of main building materials;
- **Terrain** — determining properties of loads that depend on where the construction site is situated geographically;
- **Coefficients** — reference data on the safety factor for load, γ_f;
- **Deflection limits** — reference data on deflection/displacement limits as defined in the codes.
- **Operation life** (as per DBN) — reference data on the lifetime of buildings and engineering structures.

The group of **design modes** include:

- **Self-weight** — finding a value of the self-weight load from a multi-layer pack of different materials per unit of area;

- **Temporary** — determining values of uniformly distributed temporary loads in various rooms, in compliance with instructions from Table 3 of SNiP and Table 6.2 of DBN;
- **Wind** — calculating the static component of a wind load for structures of various types, from a set of those listed in Annex 4 to SNiP and Annex I to DBN;
- **Wind. Pulsation** — calculating the static component of a wind load for prismatic structures, rectangular in their plan, and determining the dynamic amplification factor through a procedure defined by SNiP;
- **Full Wind** — calculating wind loads allowing for a dynamic action of the pulsation component on vertical prismatic and cylindric structures as per Sec. 9.4 through 9.13 of DBN;
- **Snow** — calculating a snow load on structures of various types from those listed in Annex 3 to SNiP and Annex Zh to DBN;
- **Snow**. **Two-span buildings** — calculating a snow load on two-span buildings of various types from those listed in Annex 3 to SNiP and Annex Zh to DBN;
- **Temperature** — determining temperature actions according to provisions of Section 8 of SNiP and Section 11 of DBN;
- **Ice on cables and ropes —** calculating loads caused by ice glaze and by wind acting on cables and ropes covered by ice deposits in compliance with Section 8 of SNiP and Section 11 of DBN;

To exit to the main window from any of the modes, use the **Menu** button. Also, you can switch directly from one mode to another — by using the **Modes** menu of the application.

2.2 Settings

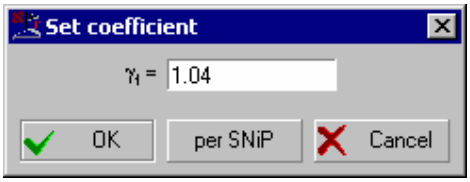


Fig. 2.2-1, *a*. A safety factor for load (as per SNiP)

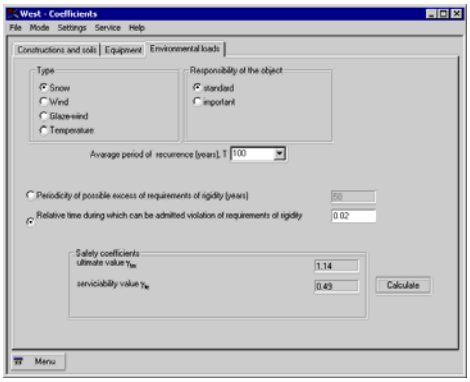


Fig. 2.2-1, *b*. A safety factor for load (as per DBN)

A specific feature in this particular application is that the button  is available in most modes. This is used to set a value for **Safety factor for load** (γ_f) (Fig. 2.2-1). The reason for this is that all working modes make use of the factor γ_f as recommended by the respective provisions of SNiP and DBN. However, for some specialized structures (such as nuclear power objects) other values of γ_f are recommended by other applicable design codes.

In one of those cases you should specify a different value in the **Safety factor for load**, which will be used in calculation of the design load values (the rated value will remain the same in each case).

If you use the **per SNiP** button to set the factor, then in the **Snow** and **Wind** modes the value γ_f= 1,4 will be used, which is good for all cases except for a snow load on buildings with light roofs (see Paragraphs 5.7, 6.11 of SNiP 2.01.07-85*).

2.3 Reference modes

2.3.1 Densities

Tables of the **Densities** mode (Fig. 2.3.1-1) contain data taken from reference manuals and related to the weight of unit of volume (or unit of area) of the following groups of building materials or structural parts:

- covering/roofing parts;
- steel decking;
- heat insulation;
- steam sealing;
- water insulation;
- fillings and coatings;
- concretes and mortars;
- other.

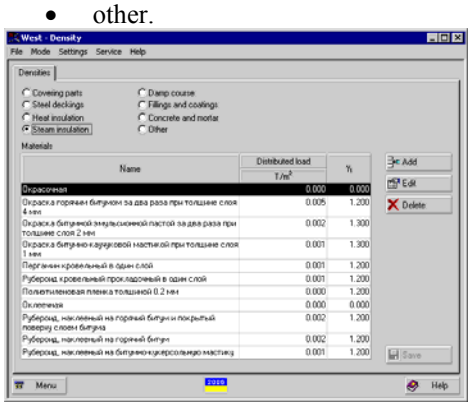


Fig. 2.3.1-1. *The* **Densities** *dialog box*

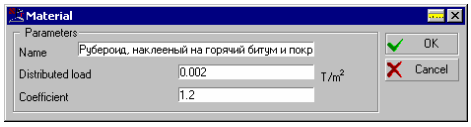


Fig. 2.3.1-2. *The* **Material** *dialog box*

Choosing one of the groups using their respective radio buttons will open a table that contains names, weights of unit of volume/area, and safety factors for loads, all related to materials according to recommendations of Table 2 of SNiP and Table 6.1 of DBN.

The **Modify** button lets you enter new property values to replace those suggested by the table. Clicking it will open the **Material** dialog box (Fig. 2.3.1-2) that contains a name and properties of the material from the row selected (marked) in the table. The natural usage for this functionality is to edit or refine previously specified data (for example, if the specifications have been changed). The same result as the one you get by clicking the **Modify** button can be obtained by double-clicking the left mouse button on a table row that should be modified.

The **Add** button lets you supplement any of the reference tables with additional rows that describe new building materials or products. The name and properties of a new material should be entered in the edit fields of the **Material** dialog box that opens when you invoke the action.

To delete a material from the list, use the **Delete** button.

2.3.2 Terrain

In many cases, data concerning loads and actions are associated with the geographic location of a construction site. These data can be searched for using the **Terrain** dialog box (Fig. 2.3.2-1) where there is a tree-like structure of political division in the **Find** field of the dialog. If you select a construction site in the tree, the **Results** group will display climatic data and its field **Orientation** will also display the respective map fragment. Using the **Find** button, you can set up a search for the name of a political unit or a town of interest in the respective dialog box that appears.

As the climatic territorial zones have fairly vague boundaries on maps, the boundaries are not assumed to coincide with those of the political units, i.e. a political unit may not belong entirely to a certain climatic zone but be divided between two zones. Large cities where intensive housing takes place are separated within the tree structure. According to DBN, climatic actions for those can be explored more thoroughly through the zone's loads and actions defined by Annex E. The respective tabs of the modes have the button clicking which will open a dialog box with a list of towns. Choosing a town and clicking the **Apply** button will put the refined characteristic value of the action to the analysis source data fields.

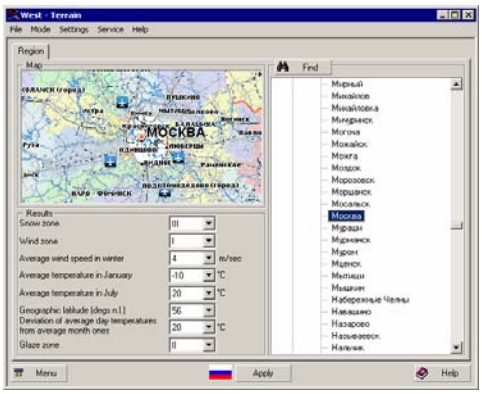


Fig. 2.3.2-1. *The* **Terrain** *dialog box*

After you indicate the location of the construction site, the fields of the **Results** group will show the following data:

- No. of snow zone (Map 1* of Annex 5 to SNiP, Fig. 8.1 in DBN);
- No. of wind zone (Map 3 of Annex 5 to SNiP, Fig. 9.1 in DBN);
- No. of ice glaze zone (Map 4 of Annex 5 to SNiP, Fig. 10.1 in DBN);
- average wind velocity in the winter (Map 2 of Annex 5 to SNiP);
- average month temperature in July (Map 6 of Annex 5 to SNiP);
- average month temperature in January (Map 5 of Annex 5 to SNiP);
- geographic latitude used to determine the maximum sun radiation value (SNiP 2.01.01-82);
- deviation of average day-and-night temperatures from the average month ones as defined by SNiP;
- No. of wind zone for a gust-and-glaze load (Fig.10.2 in DBN).

All these values can be modified by the user; to do so, make a selection in a drop-down list.

Click the **Apply** button to store the selected values for the future use by the design modes of the application.

2.3.3 Coefficients

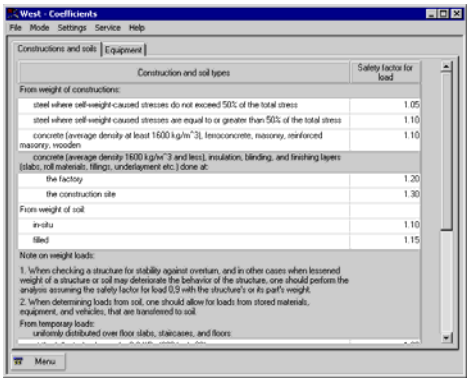


Fig. 2.3.3-1. *The* **Coefficients** *dialog box The* **Constructions and soils** *tab*

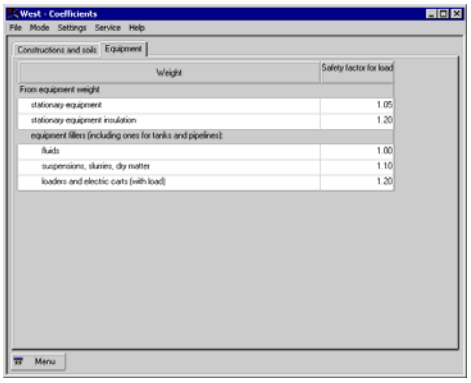


Fig. 2.3.3-2. *The* **Factors** *dialog box The* **Equipment** *tab*

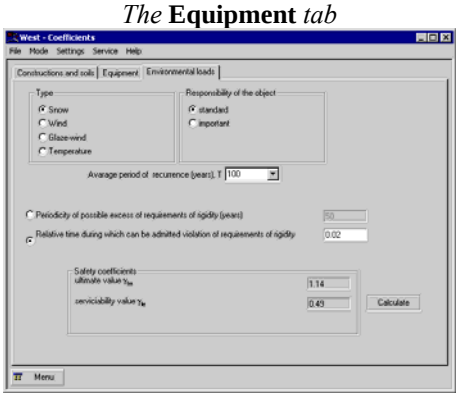


Fig. 2.3.3-3. *The* **Factors** *dialog box The* **Climatic loads** *tab*

This mode is used to get reference information concerning values of safety factors for load, γ_f, defined by SNiP and DBN. The **Constructions and soils** tab (Fig. 2.3.3-1) presents values from Table 1 of SNiP and Table 5.1 of DBN, and the **Equipment** tab (Fig. 2.3.3-2) those from Table 2 of SNiP and Table 6.1 of DBN.

The **Climatic loads** tab (Fig. 2.3.3-3) provides reference information concerning the safety factors for load, γ_f, for wind, snow, and combined gust-and-glaze according to DBN, which depend on the service life, the degree of responsibility of a structure or building, and the time of operation during which the limiting inequalities of the second limit state group could be violated.

The safety factors for load are based on provisions of the following DBN clauses:

- for wind load — 8.11, 8.12;
- for snow load — 9.14, 9.15;
- for gust-and-glaze load — 10.10, 10.11.

2.3.4 Deflection limits

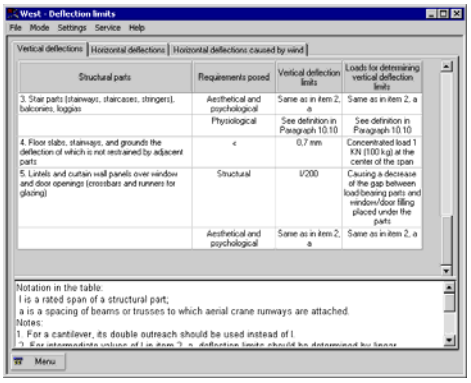


Fig. 2.3.4-1. *The* **Deflection Limits** *dialog box*
The **Vertical deflections** *tab*

This mode is used to get reference information concerning values of vertical deflection limits (Fig. 2.3.4-1), and horizontal ones caused by cranes and wind, as defined in Tables 19, 21, 22 of SNiP and Tables 1, 3, 4 of DSTU.

2.3.5 Operation life

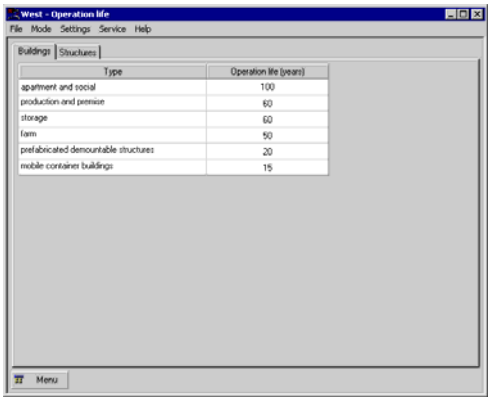


Fig. 2.3.5-1. *The* **Operation Life** *dialog box*

This mode is used only when working with DBN. It provides reference data on the service life of structures and buildings in compliance with Annex V of DBN (Fig. 2.3.5-1). This information is required to set the safety factors for load, γ_f, for snow, wind, and gust-and-glaze loads.

2.4 Design modes

2.4.1 Self-weight

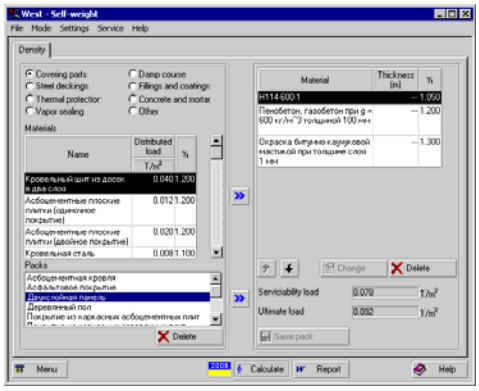


Fig. 2.4.1-1. *The* **Self-weight** *dialog box*

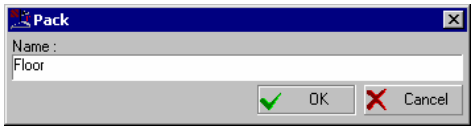


Fig. 2.4.1-2. *The* **Pack** *dialog box*

The **Self-weight** mode is used to calculate loads caused by the self-weight of a pack composed of multiple layers of different materials. This functionality is implemented in the respective dialog box (Fig. 2.4.1-1) where the left half contains a table of materials and the right one contains a table that lists selected materials included in the pack.

To specify each layer of the pack, you should select a group to which the material of the current layer belongs. To do this, select a radio button of the respective group (covering parts, steel decking, heat insulation, steam sealing, water insulation, fillings and coatings, concretes and mortars, other). After selecting a group, you will see a list of materials contained in it, in the left table. Each row of the table contains a material's title, its volume weight or that of unit of area of a ready-made construction part, and a value of the safety factor for load according to Paragraph 2.2 of SNiP and Paragraph 6.2 of DBN.

Using the upper button  lets you carry the material over from a selected (highlighted) row of the left table to the right (working) table where in this way you are accumulating the pack.

If the thickness of layers is fixed and may not be changed, the respective row of the table will contain a blank dash. Otherwise, double clicking on a desired row of the working table lets you enter the layer thickness data in the **Thickness** column.

The composition of the pack defined in the working table can be edited using the **Delete** and **Modify** buttons. If the pack that you have entered is a typical or standard one, you can store it under a convenient name of your choice using the **Save pack** button. Clicking the button will open a dialog box (Fig. 2.4.1-2) where you specify a name for the pack.

The saved pack will be added to the **Packs** list, so afterwards it can be retrieved from that list into the working table using the lower button,  . The pack can be supplemented with new layers, or some of the layers can be removed from it.

Clicking the **Calculate** button will display the respective values of the load per unit of area caused by the pack's self-weight in the **Rated load** and **Design load** fields (for SNiP) or in **Operation load** and **Limit load** fields (for DBN).

2.4.2 Temporary loads

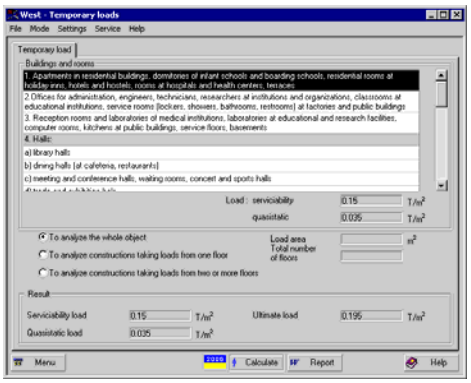


Fig.2.4.2-1. *The* **Temporary loads** *dialog box*

This mode (Fig. 2.4.2-1) implements functionality for choosing uniformly distributed temporary loads on floor panels, stairways, floors etc. in compliance with Paragraphs 3.5 to 3.9 of SNiP and Paragraphs 6.5 to 6.9 of DBN.

The mode determines full and lowered values of the rated and design loads (for SNiP), characteristic and quasi-permanent ones (for DBN) using lowering factors that allow for a loaded area — one actually subjected to the load (see Paragraph 3.8 of SNiP and Paragraph 6.8 of DBN) — and combination factors that take into account the number of loaded floor panels in multi-storey buildings (see Paragraph 3.9 of SNiP and 6.9 of DBN).

A room type is selected in the **Buildings and rooms** list. A type of structure for which this analysis is performed can be selected by one of the respective radio buttons.

To obtain the load value, click the **Calculate** button; this will display rated and design load values (for SNiP), or operation, limit, and quasi-static loads (for DBN).

2.4.3 Wind

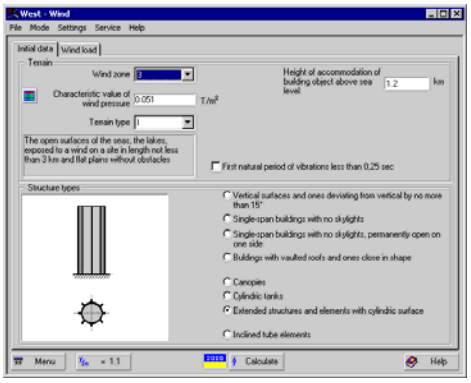


Fig. 2.4.3-1. *The* **Wind** *dialog box The* **General** *tab*

This mode is used to calculate a wind load on some of the buildings, structures, and structural parts the designs of which are presented in Annex 4 to SNiP and in Annex I of DBN. In all cases this mode determines a static value of the wind load normal to the structure's surface. A two-tab dialog box entitled **Wind** is used to enter source data and get the results.

Its first tab, **General** (Fig. 2.4.3-1), is used to enter information concerning a terrain type and wind zone in which the object of interest is situated. The **Wind zone** list and the **Rated value of wind pressure** field (SNiP) or **Characteristic value of wind pressure** (DBN) retrieve their values from the **Terrain** dialog box (if the **Apply** button has been clicked in the latter). However, if the user desires so, he can choose a wind zone independently from the respective list. If a rated value of the wind pressure is different from that specified in regulations, then the list will not show the wind zone's name.

If you are using DBN as a working code, the button  will provide access to a list of cities of Ukraine that lists refined data (based on Annex E) concerning the characteristic load values. Selecting a desired city and clicking the **OK** button will carry the load's characteristic value over to the source data.

The terrain type is selected in the respective list. To set a structure's type, use the available group of radio buttons.

After you have entered all the required data on the **General** tab, switch to the next one, **Calculate wind load** (Fig. 2.4.3-2), where you specify additional source data needed for the analysis and where you get the result. Below there is a description how this window looks when working with various types of structures.

The **sign convention** for the wind pressure used with all types of structures is established in compliance with rules from Paragraph 6.6 of SNiP and 9.8 of DBN: the positive wind pressure is such that it is directed towards the surface in question, and the negative pressure is one directed away from the surface.

Limitations of the implementation

For all structures (except for canopies) and walls of buildings, a variation of the wind's velocity head with elevation is taken into account. It is assumed for all roofs that the wind load does not vary over their height; it maintains the value defined for the top of the roof.

Vertical surfaces and ones declined from vertical by no more than 15°

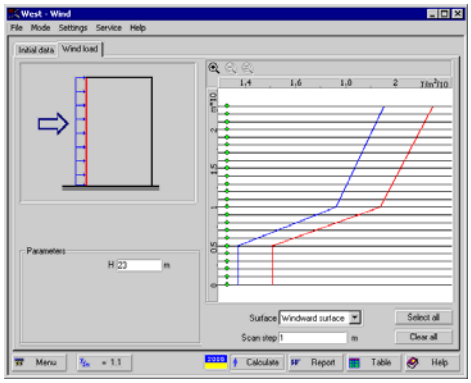
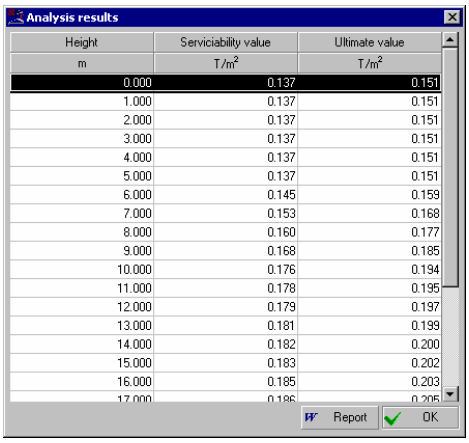


Fig. 2.4.3-2. *The* **Calculate wind load** *tab*



Height	Serviciability value	Ultimate value
m	T/m²	T/m²
0.000	0.137	0.151
1.000	0.137	0.151
2.000	0.137	0.151
3.000	0.137	0.151
4.000	0.137	0.151
5.000	0.137	0.151
6.000	0.145	0.159
7.000	0.153	0.168
8.000	0.160	0.177
9.000	0.168	0.185
10.000	0.176	0.194
11.000	0.178	0.195
12.000	0.179	0.197
13.000	0.181	0.199
14.000	0.182	0.200
15.000	0.183	0.202
16.000	0.185	0.203

Fig. 2.4.3-3. *The* **Results** *dialog box*

When this type of structures is selected (Scheme 1 from Annex 4 to SNiP or Annex I to DBN), in the **Calculate wind load** tab (Fig. 2.4.3-2) you enter the height of the structure, *H*, and specify a scanning step for the result (its value is preloaded by default). From a drop-down list available in this window, you choose a type of the surface (windward, leeward) for which the wind load should be calculated.

The result window displays a plot of the load vs. height. This plot can be dynamically digitized, i.e. when you point at a certain height the screen shows the respective load value. The heights will correspond to the scanning step selected before.

Green points (marks) on the ordinate axis indicate at what intermediate points this calculation takes place. The spacing between them conforms to the specified scanning step. The marks can be deleted and restored by moving the mouse pointer onto them and left-clicking. Wind pressure values in locations with marks that remain undeleted will be displayed in a table generated when you click the **Table** button and then shown in the **Results** dialog (Fig. 2.4.3-3).

The **Select all** and **Clear** buttons let you, respectively, include all points that conform to the scanning step in the table (plot) or remove those from that.

There are zooming buttons on top of the load plot. The 'plus' sign marks the zoom-in button clicking which will double the plot every time. The 'minus' sign button is used to zoom out the picture and becomes accessible only after the plus button is clicked. To return to the original size of the plot, just click the "equal" button, and you'll be back in one step.

Similar buttons are used in all modes where there are plots of loads.

Single-span buildings with no skylights

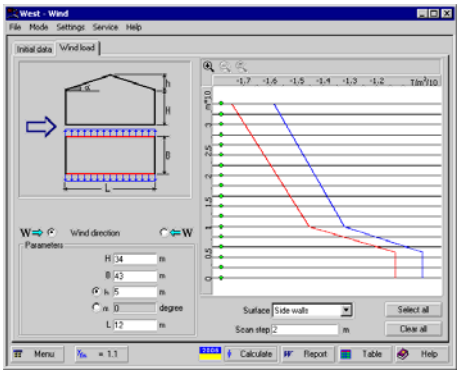


Fig. 2.4.3-4. *The* **Calculate wind load** *tab*

For buildings of this type (Schemes 2 from Annex 4 to SNiP or Annex I to DBN), the **Calculate wind load** tab (Fig. 2.4.3-4) requires the sizes of the building. A drop-down list available here is used to select a surface type (roof, left wall, right wall, side walls) for which to calculate the wind load, and there are options of the design wind direction to choose from.

Single-span buildings with no skylights, permanently open on one side

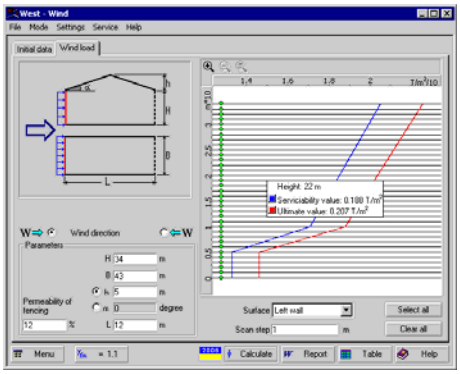


Fig. 2.4.3-5. *The* **Calculate wind load** *tab*

If this type of structures is selected (Schemes 9 from Annex 4 to SNiP or Annex I to DBN), the **Calculate wind load** tab requires (Fig. 2.4.3-5) sizes of the building. Use a drop-down list to choose a surface type (roof, left wall — solid, right wall — permeable, side walls) for which to calculate the wind load. Select also a wind direction for the analysis.

In this case we deal with a simultaneous action of the wind pressure outside and inside the building, so the result will be an overall load on the selected surface.

The aerodynamic coefficient of internal pressure, C_i, at a given permeability between 5% and 30%, will be calculated by interpolating between limit values indicated in Schemes 9 of Annex 4 to SNiP or Annex I to DBN.

Buildings with vaulted and geometrically similar roofs

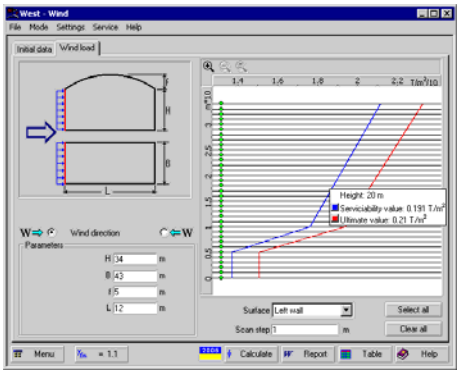


Fig. 2.4.3-6. *The* **Calculate wind load** *tab*

If this type of structures is selected (Schemes 3 from Annex 4 to SNiP or Annex I to DBN, the **Calculate wind load** tab (Fig. 2.4.3-6) will require sizes of the building. Use the drop-down list to select a surface type (roof, left wall, right wall, side walls) for which to calculate the wind load. Select also a direction of the wind for the analysis using the radio buttons.

Canopies

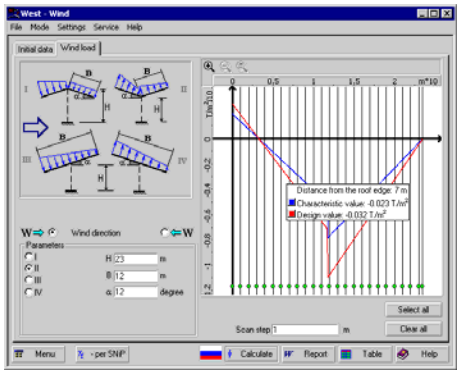


Fig. 2.4.3-7. *The* **Calculate wind load** *tab*

For this type of structures (Schemes 11 from Annex 4 to SNiP or Annex I to DBN) you should use controls on the **Calculate wind load** tab (Fig. **Error! Reference source not found.**-7) to choose a design of the canopy, enter sizes, and select a wind direction to use.

The load on the roof will be represented as a plot with which you can do a dynamic digitizing. However, instead of selecting an elevation of the point of interest, you choose its ordinate on the roof's horizontal projection.

Cylindric tanks

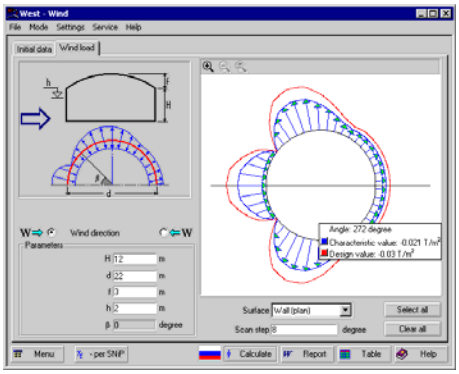


Fig. 2.4.3-8. *The* **Calculate wind load** *tab*

If this type of structures is selected (Schemes 12, *b* from Annex 4 to SNiP or Annex I to DBN), the **Calculate wind load** tab (Fig. 2.4.3-8) will require sizes of the building. Use the drop-down list to choose a surface type (spherical roof, elevation of a wall, plan of a wall, internal pressure) for which to calculate the wind load. Use radio button controls to indicate a wind direction to be used.

This version of the application does not deal with conical roofs, therefore the roof surface is specified as "spherical".

As the internal pressure can take place only if there is no roof or if the floating roof is in its lower position, the internal pressure values are presented here separately without being summed with the external pressure on the wall. Which design case to choose (either the overall value or the separated ones) is up to the user, who also has to consider various options of the tank's filling which means where (at what elevation) the internal pressure begins.

The distribution of the pressure over the tank's surface is described by two plots:

- in a horizontal plane at the level defined by the *h* property — **Wall (in plan)** which is included in the **Surface** drop-down menu;
- on a vertical, the position of which is determined by an angle, β, between a radius that crosses the vertical and the horizontal axis — **Wall (elevation)** in the **Surface** drop-down menu.

Depending on which of the plots has been selected, the result will be:

- a distribution of the wind pressure across the plan at a given elevation;
- a variation of the wind pressure with height in a given position of the vertical.

Extended structures and elements with cylindrical surfaces

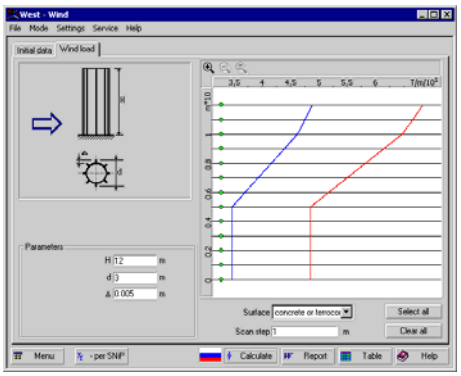


Fig. 2.4.3-9. *The* **Calculate wind load** *tab*

For structures of this type, unlike ones described before, the load is referred to unit of length rather than to unit of area. After you select this type of structures (Schemes 14 from Annex 4 to SNiP or Annex I to DBN) in the **Calculate wind load** tab (Fig. 2.4.3-9) you need to specify the height and diameter of the structure, and choose a surface type from a drop-down list (wooden, steel, concrete/ferroconcrete, masonry) thus defining the surface's degree of roughness, Δ. If necessary, this property can be entered explicitly in the respective edit field.

The result of the calculation will be represented as a plot of the load per unit of line vs. elevation. This plot can be dynamically digitized, i.e. when you point at an elevation with the mouse pointer, you get the load value displayed on the screen.

Limitations of the implementation

The wind pressure value depends on Reynolds number, *Re*, for which SNiP and DBN specify a range of values up to $Re = 3{,}2 \cdot 10^6$. When the limit is exceeded, the value of the aerodynamic coefficient, $C_{x\infty}$, is assumed to remain constant.

The relative roughness property, Δ/d, is determined by linear interpolation between plots presented in Table 14 of Annex 4 to SNiP or Annex I to DBN. In the cases of $\Delta/d < 10^{-4}$ and $\Delta/d > 0{,}05$ the value of $C_{x\infty}$ will be determined by the ultimate curves.

Oblique tubular elements

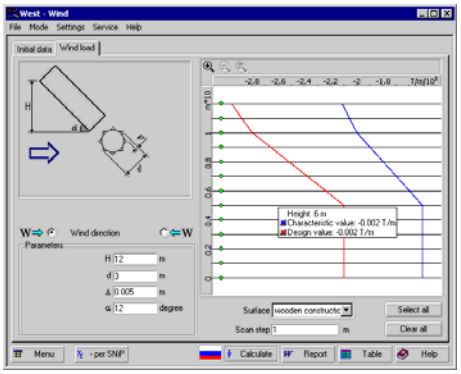


Fig. 2.4.3-10. *The* **Calculate wind load** *tab*

When this type of structure is selected (Schemes 18 from Annex 4 to SNiP or Annex I to DBN) the **Calculate wind load** tab (Fig. 2.4.3-10) requires sizes of the element and a wind direction. As in the previous case, here a load per linear unit will be determined, and only a component perpendicular to the element's axis is under consideration.

The sign convention for loads: a load is assumed to be positive if its projection onto the vertical is downward, i.e. if the weight and wind effects are added up.

The result of the calculation is presented in the form of a 'linear load vs. elevation' plot. The plot can be digitized dynamically, i.e. you can point at an elevation to see its respective load value.

2.4.4 Wind. Pulsation

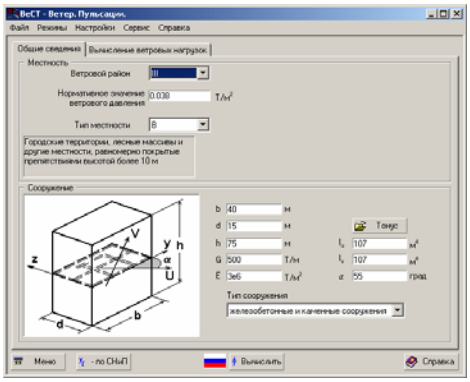


Fig. 2.4.4-1. *The* **General** *tab*

This mode is used to calculate a wind load on a building or structure which is prismatic and rectangular in its plan and has a constant stiffness along its height; this includes also structures that can be simulated by this model approximately (Scheme 13 in Annex 4 to SNiP).

Unlike the **Wind** mode (see above), this one does more than evaluation of a static wind load. The mode also evaluates a dynamic pulsation effect and gives recommendations on whether a detailed dynamical analysis is required. In addition, it gives an estimate of the dynamic amplification factor which can be the basis for making the decision whether a detailed analysis is really necessary and whether the pulsation component should be taken into account.

Special feature of the implementation

The pulsation component of the wind load is calculated in compliance with Paragraph 6.7 *c* of SNiP; the calculation also complies with a requirement of Paragraph 6.8 that the inertia forces should be taken into account if the oscillation takes place at a frequency greater than the ultimate one.

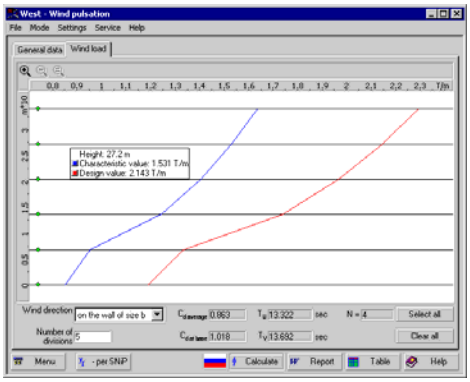
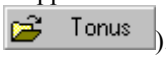


Fig. 2.4.4-2. *The* **Calculate wind load** *tab*

A two-tab dialog box entitled **Wind. Pulsation** is used to enter source data and obtain results.

Its first tab, **General** (Fig. 2.4.4-1), is used to enter information related to a terrain type and wind zone where an object of interest is situated. The **Wind zone** list and the **Rated value of wind pressure** field retrieve their values from the **Terrain** dialog box (if the **Apply** button has been clicked in it). However, the user may choose a wind zone independently — from a list. The terrain type and the structure type are also selected using the respective lists.

The same tab is used to specify these data: sizes of the building's plan, its height, the weight of the building per running meter of elevation (allowing for the weight of floor panels and sustained live load), average elasticity modulus of the material of load-bearing constructions. You also need to specify: principal moments of inertia with respect to the U, V axes, and slopes of the U, V axes with respect to Y, Z along which the wind load acts.

It is possible to define the geometric properties of a building using the **TONUS** application. Values calculated by the **TONUS** software are retrieved from a file with the .tns extension (the button ).

The building should be rectangular in its plan. Obviously, a lot of real buildings and structures can be assumed rectangular only as approximation, so the results of the analysis will be also approximate.

If the exterior contour of a building is made up by fencing rather than load-bearing constructions (as in skeleton buildings), the moments of inertia can be found in the same way as for a multi-point cross-section. To use the **TONUS** application for this purpose, you will need to specify the plan locations and sizes of cross-sections of all load-bearing parts.

Note that an accurate calculation of the pulsation component in compliance with Paragraphs 6.7 to 6.9 of SNiP requires that we know modes and frequencies of natural oscillation, i.e. a detailed information regarding the whole structure. The **WeST** application determines those as if the structure were a cantilever bar with a constant stiffness along its elevation equal to that of a bar that has a cross-section bounded by the load-bearing walls of the building.

After you have entered all the data in the **General** tab, switch to the next one, **Calculate wind load** (Fig. 2.4.4-2) where you specify:

- a wind direction ("on a wall of size b", "on a wall of size d", or "diagonally");
- a number of fragments into which the building will be divided along its elevation and on which the results will be obtained (see Paragraph 6.7 *c* in SNiP).

The result of the calculation is represented as a plot of the wind load's static component (its rated and design values) vs. elevation. The plot can be digitized dynamically, i.e. you can point at an elevation to get the respective load value displayed on the screen.

The additional results of the calculation include two dynamic amplification factors:

- one for displacements, being an averaged ratio of the wind load's pulsation component to its static component;
- one for total bending moment at the base, being a ratio of the pulsation component of the bending moment at the base of the building to the respective static value.

Having these values permits the user to make a decision whether to perform (or not perform) a detailed dynamic analysis of the structure. Generally, the dynamic analysis is not reasonable if the dynamic amplification factors are less than 0.2, while such analysis is a must if these factors are greater than 0.4.

To provide an additional check, this tab gives also higher periods of the natural oscillations in the U and V planes.

2.4.5 Full wind

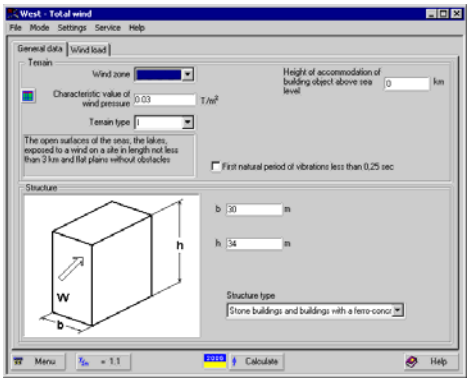


Fig. 2.4.5-1. *The* **General** *tab*

This mode calculates dynamic wind loads and takes into account a dynamic effect of the pulsation component for vertical prismatic and cylindric structures no more than 200 m high with a nearly constant stiffness along the height, as defined by Paragraphs 9.4 through 9.13 of DBN. The projection of the structure onto the vertical plane in the direction perpendicular to the wind action plane must conform to Schemes 13, 14 in Annex I to DBN.

Unlike the **Wind** mode (see above), this mode evaluates the dynamic effect of the pulsations and their mutual correlation over height in addition to the static wind load.

Special feature of the implementation

To calculate the wind load according to Paragraphs 9.4 through 9.13 of DBN, the direction factor C_{dir} and the relief factor C_{rel} are set to 1,0.

The **Full Wind** dialog box is used to enter source data and get the results.

The first tab, **General** (Fig. 2.4.5-1), is used to enter information concerning the terrain type and the wind zone where the object of interest is situated. The **Wind Zone** list and the **Characteristic value of wind pressure** field receive values from the **Terrain** dialog box (if the **Apply** button has been clicked there).

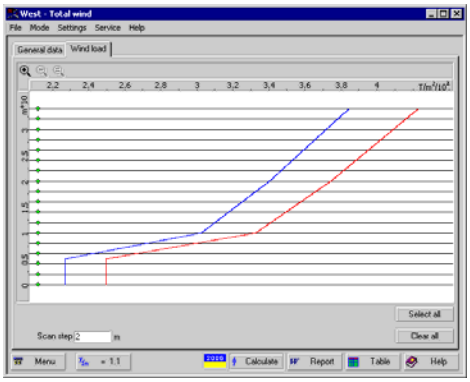


Fig. 2.4.5-2. *The* **Calculate wind load** *tab*

However, you can choose the wind zone independently from a list. The button provides access to a list of Ukrainian cities which contains refined data (based on Annex E) concerning the characteristic value of the load. If you choose a desired city and click the OK button, the characteristic value will be copied to the source data automatically. To set up the terrain type and the structure type, use the respective lists.

The same tab is used to specify the sizes of the building in its plan, in the direction perpendicular to the wind action plane, and its height.

The building or structure must be rectangular or round in plan. Many actual structures can be represented by such a model approximately, so the result of the analysis will be an approximation, too.

The **Calculate wind load** tab (Fig. 2.4.5-2) presents results of the calculation as a plot where the full wind load (its operation and limit value) varies vs. the elevation. This plot can be dynamically digitized, i.e. when you point at an elevation with the mouse pointer, you get the load value displayed on the screen.

2.4.6 Snow. Single-span buildings

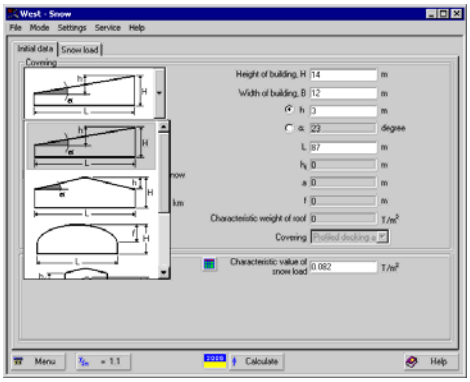


Fig. 2.4.6-1. *The* **Source data** *tab*

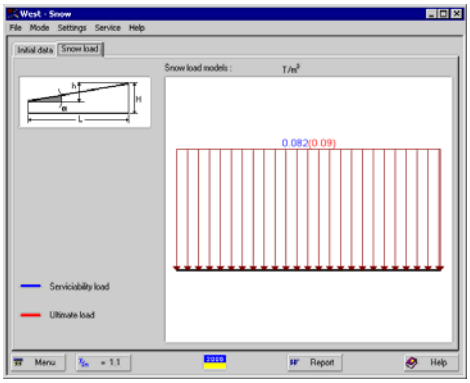


Fig. 2.4.6-2. *The* **Snow load** *tab* (*single-pitch roof*)

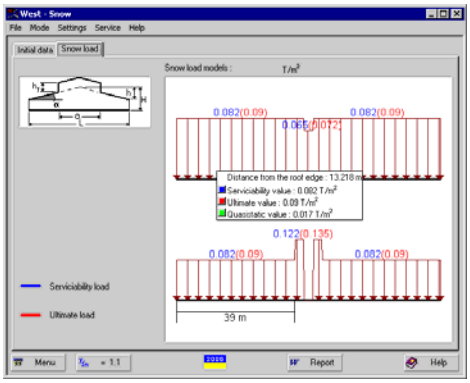


Fig. 2.4.6-3. *The* **Snow load** *tab* (*double-pitch roof*)

This mode is used to calculate a snow load on single-span buildings with the roof profiles conforming to Schemes 1, 2, 3, 10 from Annex 3 to SNiP or Annex Zh to DBN.

The **Source data** tab (Fig. 2.4.6-1) is used to enter information about the roof profile and the snow zone in which the object of the analysis is situated. The **Terrain** data group has a drop-down list that you use to select a snow zone; next, its respective rated (SNiP) or characteristic (DBN) snow load value will be assigned. In addition, for the purpose of the analysis you need to specify an average January temperature and an average wind velocity in the winter (only for the SNiP-compliant analysis).

All weather data will be filled in automatically if you have selected a snow zone and clicked the **Apply** button in the **Terrain** dialog box. If the working code is DBN, the button  provides access to a list of cities of Ukraine that contains refined data (based on Annex E) concerning the characteristic values of the load. Selecting a desired city and clicking the OK button will carry the characteristic load value over automatically to the source data set.

The profile of the building's roof is selected using functional buttons that depict respective profiles available. To have the analysis done, click the **Calculate** button or point at the **Snow load** tab.

For a single-pitched roof (Fig. 2.4.6-2), there is defined only one way of applying the load; rated and design values are available for it in the SNiP analysis, as well as operation and limit values in the DBN analysis.

For a double-pitched roof (Fig. 2.4.6-3), there can be either one or two load application schemes (depending on the roof's slope); for each one you can get the load's respective rated and design values (SNiP) or its operation and limit values (DBN).

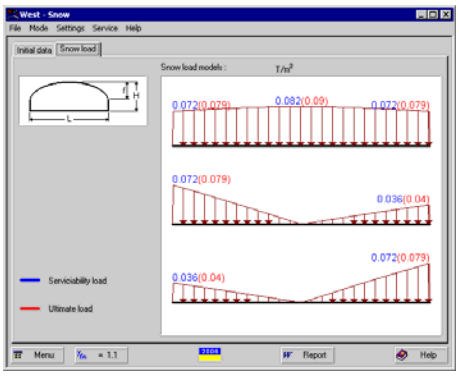


Fig. 2.4.6-4. *The* **Snow load** *tab* (*vaulted roof*)

For a roof that has a vaulted or similar configuration (Fig. 2.4.6-4) there are three load application schemes, and for each one a distribution plot will be displayed. This plot can be scanned (dynamically digitized) in the similar way as was described earlier in the section discussing the wind loads.

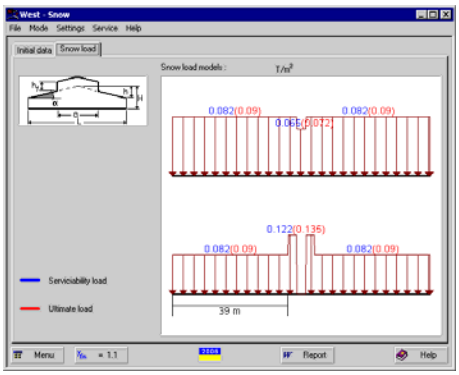


Fig. 2.4.6-5. *The* **Snow load** *tab* (*longitudinal skylight*)

For a roof that has a longitudinal skylight (Fig. 2.4.6-5), there exist two load application schemes. A load distribution plot will be displayed for each of those.

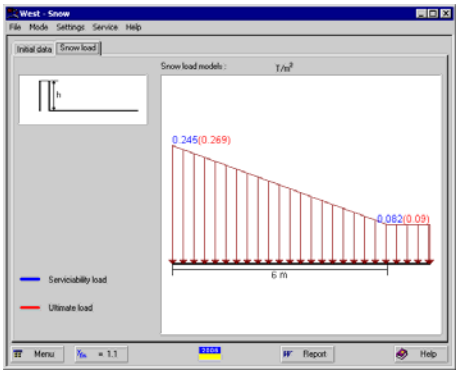


Fig. 2.4.6-6. *The* **Snow load** *tab* (*a roof with parapets*)

For a roof that has parapets (Fig. 2.4.6-6), there can be only one load application scheme. A load distribution plot will be displayed.

In the case when the snow load near the parapet must not be taken into account, the load plot will have zero values.

Limitations of the implementation

For Scheme 3 (one that defines buildings with longitudinal skylights), the snow load is determined only in the skylight area (area C in designations of SNiP and DBN).

Note 3 to Scheme 3 is not implemented.

2.4.7 Snow. Two-span buildings

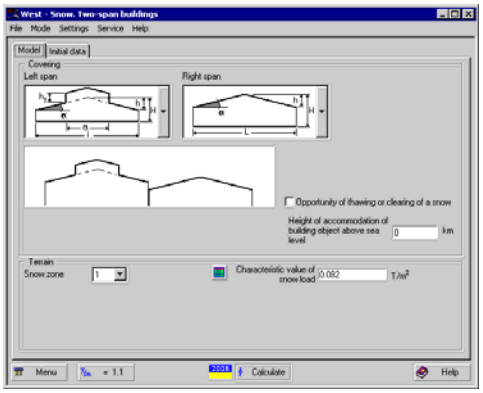


Fig. 2.4.7-1. *The* **Design** *tab*

This mode is used to calculate the snow load on two-span buildings, the roof profiles of which conform to Schemes 4, 5, 6, 7, 8 in Annex 3 to SNiP or in Annex Zh to DBN.

Two-span buildings are constructed by selecting designs for their left and right spans. Generally, each of the spans can have one of two single-pitch roofs (right or left inclined), a double-pitch, a double-pitch with a longitudinal skylight, or a vaulted roof. This produces 25 different possible designs of a two-span building.

Every two-span building may have a height difference at the boundary between its spans. The difference is counted from the ultimate right point of the left span's roof to the ultimate left point of the right span's roof. In all cases it is assumed that the ***left roof is not lower than the right one***.

The height difference will be determined automatically when analyzing source data of a selected design.

In cases when there is no height difference or it is less than a minimum value defined in Note 3 to Scheme 8, no additional load from the snow bag to the right (lowered) roof is taken into account.

In cases when the two-span building is constructed of two single-pitch roofs with their pitches equally oriented (shed roofs in compliance with Scheme 4 of Annex 3 to SNiP or Annex Zh to DBN), the snow load will not depend on the height difference between the spans.

For two-span buildings (double-pitch and vaulted), in cases when the height difference is either zero or not taken into account according to Note 3 to Scheme 8 of Annex 3, the snow load will be determined using Schemes 5 and 6 of Annex 3.

In all other cases the snow load will be determined by Scheme 8 of Annex 3 to SNiP or Annex Zh to DBN.

The calculation produces a snow load on the projections of the right and left spans of a two-span building; in necessary cases, it produces also an additional load (caused by a snow bag) on the right building.

The mode contains three property tabs:

- **Design**;
- **Source data**;
- **Snow load**.

The **Design** tab is used to select a building's design and specify source climatic data common for the whole building. Two-span buildings are constructed by choosing designs for the left and right spans from the respective drop-down lists. A design of the building that has been constructed (Fig. 2.4.7-1) will be displayed in the central part of the tab.

The **Terrain** data group contains a drop-down list where you choose a snow zone; this will assign a proper value to the snow load automatically — a rated one (SNiP) or a characteristic one (DBN). To complete the analysis, you will need also to specify an average temperature in January and an average wind speed in the winter (SNiP-compliant analysis only).

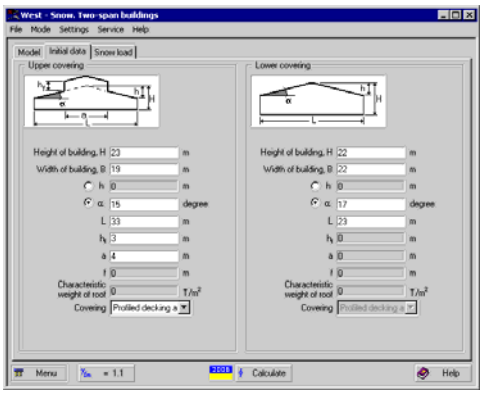


Fig. 2.4.7-2. *The* **Source data** *tab*

All weather data will be filled in automatically if you select a construction site's location (region) in the **Terrain** dialog box. In this part the mode is totally equivalent to the **Snow** mode in which a snow load on single-span buildings is specified.

The **Source data** tab is used to specify data regarding the design and roofs of the left and right spans (Fig. 2.4.7-2).

The source data are specified exactly in the same way as those for single-span buildings.

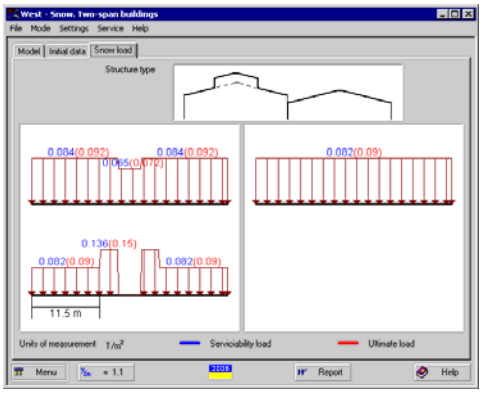


Fig. 2.4.7-3. *The* **Snow load** *tab*
(the right roof has an extra snow bag load)

The **Snow load** tab is similar to its counterpart for single-span buildings.

The tab presents plots of the design and rated values of the snow loads on the left and right roofs. When necessary, it shows an additional load on the right roof caused by a snow bag (Fig. 2.4.7-3).

Limitations of the implementation

Scheme 8 in Annex 3 to SNiP or Annex Zh to DBN considers only buildings (item *a*) and canopies (item *b*), while lowered roofs perpendicular to the main building (item *c*) are out of consideration.

2.4.8 Temperature

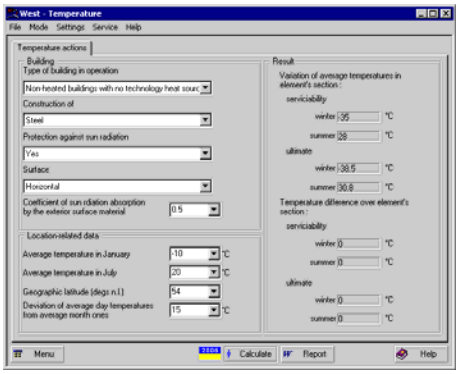


Fig. 2.4.8-1. *The* **Temperature actions** *tab*

This mode is used to calculate values of temperature-related climatic actions in compliance with provisions of Section 8 of SNiP or Section 11 of DBN.

The mode determines a variation with time of the average temperature of an element, Δt, comparing to the mounting temperature of the construction, and a temperature difference, ϑ, across the element's cross-section.

All data concerning the structure's type and design are taken from drop-down lists; they comply with formulations of Table 15 of SNiP and Table 11.1 of DBN. Construction site data can be retrieved from the **Terrain** mode or specified directly in the mode's window.

The temperature of interior air in the room is assumed to be 22°C in the warm season of the year and –16°C in the cold season.

The default safety factor for load is assumed to be 1,1.

2.4.9 Ice glaze load on cables and ropes

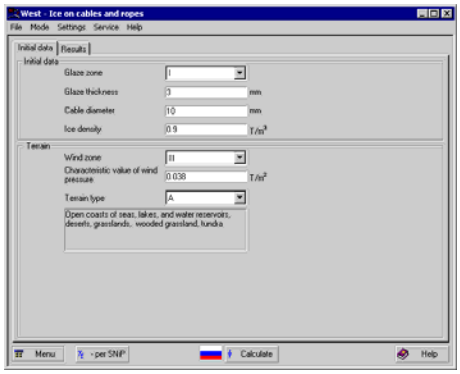


Fig. 2.4.9-1. *The* **Source data** *tab of the* **Ice Glaze (SNiP)** *mode*

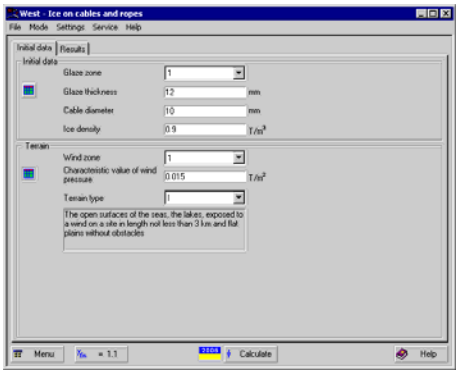


Fig. 2.4.9-2. *The* **Source data** *tab of the* **Ice Glaze (DBN)** *mode*

This mode is used to determine an ice load on cables and ropes. It implements requirements of Paragraph 7.2 of SNiP and Paragraph 10.5 of DBN in the part related to the calculations of a linear ice glaze load. The rated (as per SNiP) or characteristic (as per DBN) value of the ice load is calculated per unit of length of a cable or rope.

The design (SNiP) or limit (DBN) value of the ice load is derived by multiplying the rated or characteristic value by the safety factor for load.

In the SNiP-compliant analysis, the safety factor is set equal to 1,3 by default as defined in Paragraph 7.3 of SNiP.

The safety factor for limit ice glaze load value in the DBN-based analysis is defined by provisions of Paragraph 10.10.

The user is allowed to change the factor in the edit mode (the button γ_f).

In addition to the ice load, the mode calculates a wind load during glaze (a gust-and-glaze load).

In the SNiP-based analysis, it is calculated according to Paragraph 7.4 of SNiP. Source data regarding the wind zone as per Map 3 and the glaze zone as per Map 4 of the mandatory annex 5 to SNiP can be specified directly on the **Source data** tab (Fig. 2.4.9-1) or carried over from the **Terrain** mode using tools common for the **WeST** application.

In the DBN-based analysis, the wind load is calculated according to provisions of Paragraph 10.9. Source data concerning the wind zone during ice glaze from the map in Fig. 10.2 and those concerning the ice glaze zone from the map in Fig. 10.4 can be entered directly in the **Source data** tab (Fig. 2.4.9-2) or retrieved from the **Terrain** mode by common **WeST** techniques. If the current

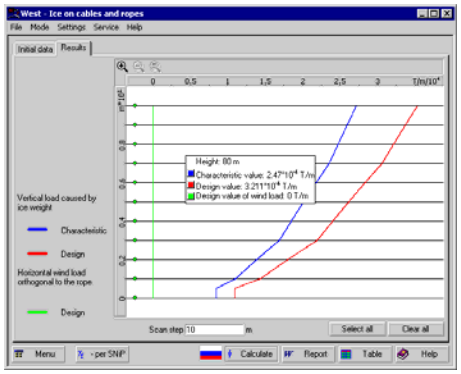


Fig. 2.4.9-3. *The* **Results** *tab of the* **Ice Glaze (SNiP)** *mode*

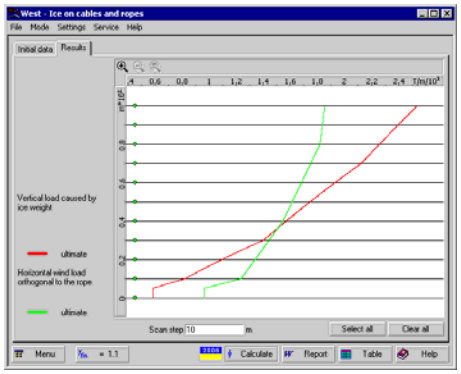


Fig. 2.4.9-4. *The* **Results** *tab* of the **Ice Glaze (DBN)** *mode*

working code is DBN, the button will provide access to a list of Ukrainian cities which contains refined data (based on Annex E) concerning the load's characteristic values. If you select a city and click the OK button, the characteristic value of the load will be carried over to the source data set. In addition, the loads can be revised on the basis of the zone loads defined by provisions of Annex E.

On the **Source data** tab, the user can specify a thickness of the ice glaze and a wind load value different from those set for the current zone by SNiP and DBN.

The *calculated results* in the SNiP-based analysis (Fig. 2.4.9-3) will consist of rated and design values of the ice glaze load, and also the wind load on cables (ropes) covered with ice.

The *calculated results* in the DBN-based analysis (Fig. 2.4.9-4) will consist of limit design values of the ice glaze load, and the limit design wind load on cables (ropes) covered with ice.

The wind load during ice glaze is calculated under the assumption that the cable (rope) is located in the plane perpendicular to the wind flow. When calculating the wind load, the application allows for the fact that the diameter of the cable (rope) is bigger than it was originally because of ice covering it.

Results of the calculation are presented in a graphical form on the respective tab. There is a capability of getting numbers by scanning the plots.

Limitations of the implementation

The ice load is calculated for cables (ropes) suspended not higher than one hundred meters above the ground.

Design codes implemented by WeST

Mode	References to clauses in codes and standards	
	in the analysis for compliance with SNiP 2.01.07-85 and SNiP 2.01.07-85*	**in the analysis for compliance with DBN V.1.2-2:2006**
Densities	Par. 2.2	Pars. 5.2, 5.3
Terrain	Annex 5, SNiP 2.01.01-82	Pars. 8.5, 9.6, 10.7, 10.9, Annex Zh
Factors	Pars. 2.2, 3.4	Pars. 5.2, 5.3, 6.8, 6.9, 8.11, 8.12, 9.14, 9.15, 10.10, 10.11, 11.8
Self-weight	Par. 2.2, Annex 5 SNiP 2.03.13-88	Pars. 5.2, 5.3, Annex 5 SNiP 2.03.13-88, DBN V.2.6-14-97
Deflection limits	Pars. 10.7, 10.11, 10.12	Pars. 5.1, 6.1, 7.1 DSTU B V.1.2-3:2006
Temporary	Pars. 3.5–3.9	Pars. 6.5–6.9
Wind	Pars. 6.1–6.7, 6.11, Annex 4 (schemes 1, 2, 3, 9, 11, 12*b*, 14, 18)	Pars. 9.2–9.10, Annex I (schemes 1, 2, 3, 9, 11, 12*b*, 14, 18)
Wind. Pulsation	Pars. 6.1–6.5, 6.7–6.10	
Full wind		Pars. 9.4–9.13
Snow. Single-span buildings	Pars. 5.1–5.7, Annex 3 (schemes 1, 2, 3, 10)	Pars. 8.10–8.12, Annex E (schemes 1, 2, 3, 10)
Snow. Two-span buildings	Pars. 5.1–5.7, Annex 3 (schemes 4, 5, 6, 7, 8*a*)	Pars. 8.10–8.12, Annex E (schemes 4, 5, 6, 7, 8*a*)
Temperature	GOST 12.1.005-88, Pars. 8.1–8.7, SNiP 2.01.01-82	Pars. 11.1-11.8
Ice on cables and ropes	Pars. 7.2–7.4	Pars. 10.2-10.5, 10.7-10.13

Bibliography

1. SNiP 2.01.07-85. “Loads and actions”. – USSR State Comm. for Construct. and Architect. – Moscow, 1986.– 36 p.
2. SNiP 2.01.07-85*. Loads and actions. Building rules and regulations / State Comm. for Construct. of Russia. – Moscow, 2001. — 44 p.
3. DSTU B V.1.2-3:2006 “Deflections and displacements”. Ministry of Construction of Ukraine, Kiev, 2006 – 10 p.
4. DBN V.1.2-2:2006 “Loads and actions” Ministry of Construction of Ukraine, Kiev, 2006 – 60 p.