SCAD Soft

Structure CAD software system
for Windows 95/98/NT

SCAD Structure

C O M E T - 2

A system for analysis and design of steel structural joints

User manual

SCAD Soft 2007

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COMET-2. A system for analysis and design of steel structural joints. User manual.

The manual gives basic information about COMET-2, a software system for analysis and design of steel structural joints used in construction engineering. All the beginner user needs to know about COMET-2 for successful working with it is presented in sufficient detail, with plenty of illustrations and examples.

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A COMET software system

1.1 General information

The **COMET** software application is used to perform a structural assessment of design decision and to develop designs of typical joints of steel bar structures widely used in civil and industrial engineering. The application helps perform the structural appraisal of a steel joint according to requirements of SNiP II-23-81* [17] and design a steel structural joint based on a particular prototype.

Unlike invention, prototype-based engineering consists of using available decision. This is the approach implemented in the **COMET** software; it is based on choosing from a set of parametrized standard structural designs of joints (prototypes). Available parameters of a prototype depend on what design conditions are predefined (material, internal forces etc.); they cannot be determined independently because a certain interrelationship usually exists between them.

The **COMET** application is oriented at the above approach and thus enables the engineer to improve the efficiency of his work by providing him with a wide range of prototypes. In this way the highly qualified personnel does not have to do a routine technical work of checking and correcting a multitude of parameters to comply with building codes and design specifications.

After a structural scheme is selected for the joint, the system helps determine all parameters of it, which must comply with building codes, a number of structural (design) constraints, and catalogues of steel members. Both the building requirements and structural constraints are obligatory, and any violation of those is not an option. However, there are also design constraints violating which would cause only a warning, and the application can generate a decision with the violations thus made.

The source data for computer-aided design of steel structural joints include the joint configuration, the types and sizes of cross-sections of load-bearing connected members, and the internal forces acting in the members.

The user has the options of either accepting the suggested decision or modifying it to his preferences, in order to take into account:

- the technology used to manufacture the involved steelwork members;
- requirements of unification of the structural scheme within the framework of a project or anything else (design team, manufacturing plant etc.);
- the usage of standard decisions commonly used in the project or team;
- the quality assurance system, marking system etc.

Having done this, the software performs structural appraisal of the joint and generates a drawing: a sketch of the joint's design where all involved parameters and properties are laid out. In order to be able to make additions or changes to the design thus generated, or to alter the format of representation (such as dimensioning, legends etc.), the system can export the graphical results of the design procedure as a DXF (AutoCAD) file.

1.2 Decision-making sequence

The overall process of designing a steelwork joint with the help of **COMET** is presented in Fig. 1.2-1 as a flow chart. Below you will find some additional commentaries given in order to define a number of principles for decision making, which are implemented in the software and thus have to be taken into account by the users.

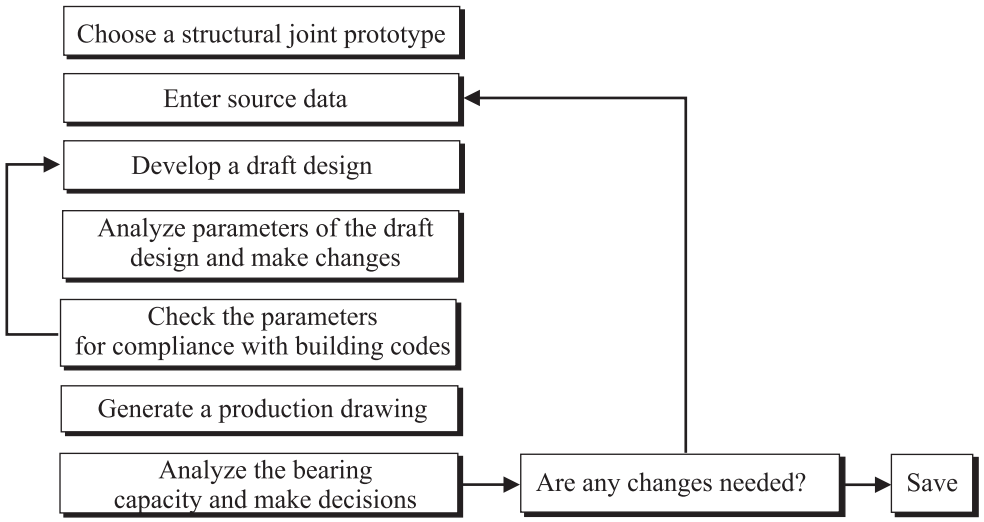


Fig. 1.2-1. A flow chart of the design process

A set of incoming parameters and a set of outgoing parameters are defined for each of joint prototypes (design parameters for structural decisions); there are known methods for determination of both parameter groups. The representation of a structural joint becomes a basis on which a mathematical model of the design problem is formulated. The mathematical model includes a set of design variables (unknown parameters of the design decision for the joint) and a set of constraints.

The set of constraints comprises:

- *Constraints by bearing capacity* of connected members (strictly speaking the load-bearing ability of connected members should be ensured before starting the design or structural assessment of the joint; the checks performed here are just additional majority-decision checks which ensure the members are strong enough in the elastic stage of their behavior); these constraints are defined by building requirements.
- *Constraints by catalogues of rolled steel*, such as sheet, plate and shaped.
- *Structural constraints*, which reflect the conditions of manufacturing of structural members, constraints posed by an allowed mutual arrangement of the members, the possibility of using welded and bolted connections, the possibility to weld together members of different thickness, and others.

As a joint is being designed or assessed, its **constraint utilization factors** are to be found. A coefficient, K_j, of this kind is used to determine the available reserve of strength, stability, or other parameter of quality subject to design. If a constraint posed by the building codes is fulfilled with a reserve, the respective constraint utilization factor will be equal to a relative exhaustion of the code requirement (for example, $K_j = 0.7$ corresponds to a reserve of 30%). If for some constraint $K_j > 1$, then the constraint is obviously violated, and the constraint utilization factor describes the magnitude of overload in this case.

The structural assessment of a joint implemented in the application complies with requirements of building codes. It consists of a one-time calculation of the structural system's response for given input parameters and also a calculation of all K_j the values of which are presented to the user.

The design of a joint (determination of unknown numerical parameters in the joint's structural scheme) is implemented as a goal-seeking iterative improvement of a certain initial joint design toward the fulfillment of a set of constraints and criteria. An optimum design is not warranted for the joint; what is warranted is a *reasonable* engineering decision that complies with all building codes and the set of catalogue-based and structural constraints.

In cases when it is not possible to generate a design for the joint with particular source data specified by the user, which would comply with building code requirements, the software application does an analysis (diagnostics) of the bearing capacity of the joint's structural design, displays the results of the analysis, and gives recommendations how to improve the joint's bearing capacity.

All design modes of the application (except for the "Beam-To-Column Joints" mode) assume all connected members and all auxiliary elements of the joint (gusset plates, ribs, support tables etc.) are made of the same steel.

Structural assessment and design of steelwork joints are usually performed for action of certain number of load case combinations, which can be either defined by the user or imported into the COMET environment from outside.

It should be noted that the sequence of load case combinations can affect the result of the design in some cases.

1.3 Main window

When the application starts, the first thing to appear on the screen is its main window (Fig. 1.3-1) which contains a set of buttons to choose from a number of design modes. The modes are divided into two groups:

- *information modes* which provide information and perform helpful operations, grouped under the **Information** group of controls;
- *design modes* which implement structural assessment and design of steel structural joints, grouped under the **Design** group of controls.

The following sections of this manual give detailed descriptions of each of the modes. Here we present a short characterization.

Fig. 1.3-1. *The main window of the* **COMET** *application*

The information modes include:

- **Steel** is a mode to implement the recommendations from building codes on selection of steel grades (Table 50* of SNiP II-23-81* [17]). The mode also gives help on correspondence between steel classes from SNiP II-23-81* [17] (from GOST 27772-88* [14]) and steel grades from GOST or TU (Table 51-b of SNiP II-23-81* [17]), and help on design strength (Table 51* of SNiP II-23-81* [17]);
- **Catalogue of Rolled Profiles** is a mode in which catalogues of shaped steel can be browsed;
- **Catalogue of Sheet and Plate Steel** is a mode in which catalogues of sheet and plate steel can be browsed;
- **Welding Materials** is a mode that implements requirements from section 2 of SNiP II-23-81* [17] related to selection of materials for welded connections and to design strength of welded connections;
- **Service Factors** is a mode to browse and select values of service factors for steel structural (γ_c), as well as those for bolted connections and connections with high-strength bolts (γ_b) in compliance with SNiP II-23-81* [17];
- **Bolts** is a mode that provides you with the capability of browsing the catalogue of bolts (manufacturer data as of 1998) where recommended classes of bolts are listed in reference to given service conditions of a structure;

- **High-Strength Bolts** is a mode that provides information about the design, sizes, and mechanical properties of preloaded bolts, and also lists nuts and washers for such bolts specifying the sizes and geometric properties thereof;
- **Anchor Bolts** is a mode that provides information about the design, sizes, and mechanical properties of anchor bolts;
- **Normals for Matching Members** is a mode that lists properties of full splice joints between rolled beams which are connected by strapped welding;
- **Scratching** is a mode to give information about positioning of holes for bolts in rolled profiles;
- **Concrete Class** is a information mode that provides the characteristic strength of concrete and the design strength for first and second groups of limit states depending on the concrete's compression strength class in compliance with SNiP 2.03.01-84* [18];
- **Concrete Grade** is a mode that helps browse values of the design and characteristic strength of concrete of various grades in compliance with SNiP II-21-75 [16], and provides information about the correspondence between the classes and the grades of concrete as in GOST 26633-91 [12].

The group of *design modes* comprises the following:

- **Rigid Column Bases** is a mode intended to do a structural assessment and design of joints in the bases of columns which implement a rigid connection of a column to its foundation;
- **Pinned Column Bases** is a mode for performing the structural assessment and design of nominally pinned joints in the bases of columns;
- **Beam-To-Beam Joints** is a mode to make the structural assessment and design of joints between beams where connecting straps or end-plate are used;
- **Truss Panel Points** is a mode to make the structural assessment and design of truss joints;
- **Beam-To-Column Joints** is a mode for structural assessment and design of decisions for rigid and nominally pinned joints between beams and columns;
- **Standard Joints** is a mode to design standard joints between beams in the same level, where bolts or a bearing angle are used.

When any of the above modes is invoked, a multi-tab dialog box appears where you can enter source data and analyze the generated results.

The main window of the application contains a number of buttons which are common controls for all working modes. These include the buttons **Exit**, **Settings**, and **Help**. The **Help** and **Exit** buttons do things common in Windows applications: provide reference information or shut the application down, respectively.

The **Settings** button opens the **Application Settings** dialog box where you can set up various parameters and choose options which regulate the operation of the application (see Sec. 1.4).

Use the **Menu** button to return to the main window of the **COMET** application from any of the working modes.

1.4 Settings

The **Application Settings** dialog box can be opened at any moment while working with the application. It is used to set up general properties and parameters of the application. The dialog contains four tabs, each corresponding to a certain group of settings: **Catalogues of Sections**, **Units of Measurement**, **Report and Languages**, and **Visualization**. Each of the tabs opens a property page where the respective settings are to be selected.

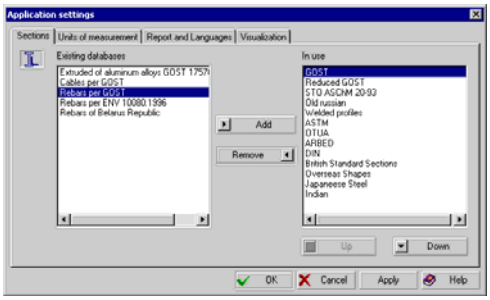


Fig. 1.4-1. *The* **Catalogues of Sections** *tab of the* **Application Settings** *dialog box*

The **Catalogues of Sections** tab (Fig. 1.4-1) is used to select catalogues of rolled steel to be used in further operations. The left list represents the titles of catalogues available in the application, while the right list includes those already selected for work. To copy the selected (highlighted) catalogues from the left list to the right one, or to delete them from the right list, use the respective buttons **Add** and **Delete**. No catalogue can be deleted from the left list.

The catalogues included in the right list can be arranged in a convenient order (in which they will be then displayed in the list or in dialog boxes where rolled members are selected).

To move the selected catalogues up or down in the list, use the buttons under the respective names.

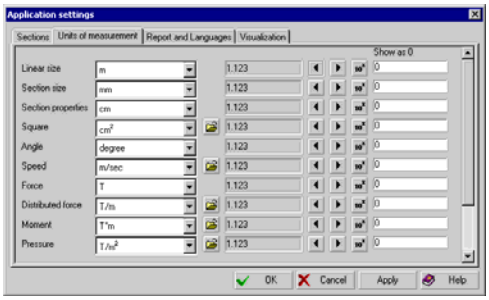


Fig. 1.4-2. *The* **Units of Measurement** *tab of the* **Application Settings** *dialog box*

The **Units of Measurement** tab (Fig. 1.4-2) defines what units of measurements will be used with physical values. It contains two control groups.

The first group specifies units of measurement to be used with the sizes of constructions, forces, moments etc.

For compound units (such as moments of forces, pressure etc.), it is possible to choose units of measurement for particular components separately (such as a unit for force and a unit for arm, if we are to define a unit for moment of force). To do this, use the button  .

The second group of controls regulates the notation (form of representation) and precision of numerical data. Particular controls are used to set the formats of data representation. This includes the number of significant digits in either the fixed-point or scientific notation.

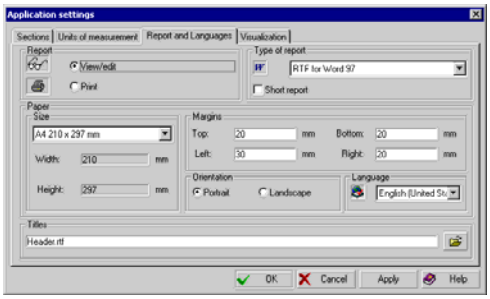


Fig. 1.4-3. *The* **Report and Languages** *tab of* **Application Settings** *dialog box*

The numerical data precision (number of significant digits after decimal point) is set using buttons  (decrease) and  (increase), and the scientific notation is turned on by the button  . Also, particular input fields help define what value of a unit of measurement should be interpreted as “very small”, so that a numerical value is displayed as 0 if its absolute value is less than the number specified in the respective field.

The **Report and Languages** tab (Fig. 1.4-3) enables you to choose a language to be used in all descriptions and labels in dialog boxes, and also in the report of results.

For working with the report document, there are two modes: **View/Edit** and **Print**.

When in the **View/Edit** mode, clicking the **Report** button in any working dialog enables you to browse the report on the screen and make corrections as needed. An application associated with the RTF format (Rich Text Format) is invoked to edit the file (such as MS Word Pad or MS Word).

Obviously, it is the user who is responsible for any corrections made to the report (note that even the results of the design can be edited).

There are difference in the RTF formats used by the MS Word v.7 and MS Word 97 (2000) applications. Therefore the settings include the **Report Type** group where one of the formats can be selected. Clicking the **Print** button in the **Report** group will print the report in the form it has been generated by the application.

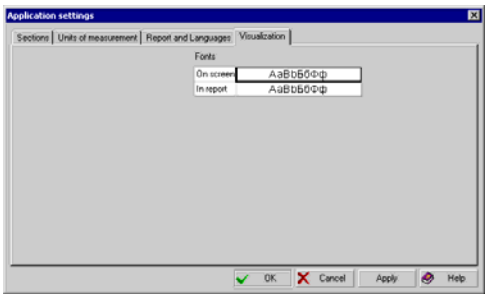


Fig. 1.4-4. *The* **Visualization** *tab of* **Application Settings** *dialog box*

The **Headers and Footers** field lets you specify an RTF file from which to take the headers and footers for the pages of the report document. The file can be selected from a standard Windows list after clicking the button [1].

The **Paper Size** group lets you choose a paper format to print the report on (a drop-down list is used to do this).

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

The **Visualization** tab (Fig. 1.4-4) shows current font attributes in the control group **Fonts**. Double-left-clicking on a font sample line will open a standard Windows dialog for setting up the font.

Use the **OK** button to return to the main window of **COMET** and apply modifications of the settings you have made; use the **Cancel** button to return without applying the modifications.

1.5 Menu

File The **File** menu contains two items: **Menu** and **Exit,** when it is accessed from the application's main window, and four items: **Menu**, **Open**, **Save As…**, and **Exit,** when accessed from the design modes.
Menu is an item to switch to the application's main window (the item duplicates the button of the same name).
Open lets you retrieve previously saved data.
Save As… lets you save the entered data to an external file. The directory and filename to save the data in are specified by the user in a standard Windows dialog.
Exit shuts down the current application's session.

Modes The **Modes** menu contains a list of all working modes available in the application and lets you access all of those from any of the current modes without having to return to the main window.

Settings This menu is used to call up the **Settings** dialog box where you set up general properties and parameters of the application (it duplicates the action performed by the button under the same name).

Tools When working with the application, you may want to perform some additional calculations. The **Tools** menu provides you with the capability of invoking a standard Windows calculator (if it has been installed in the system), a formula calculator, and a converter of units of measurement.

Help This menu provides reference help on how to control the application and what actions are available in its environment.

1.6 Information modes

1.6.1 Steel

The **Steel** mode is used to choose a steel grade for load-bearing and structural members in steel structural joints being designed. The steel grade is chosen for four groups of constructions according to Table 50* of SNiP II-23-81*. The procedure of classifying a construction into a certain group is based on results from [15].

The **Conditions of Application** tab (Fig. 1.6.1-1) contains six groups of data.

[1] If you wish to modify the header/footer RTF file shipped with the application using MS Word, remember it is not enough just to enter a new text. You should also use the menu **Tools|Language|Set Language** and select a language for the new text, such as *English (US)*.

The **Responsibility Class as per GOST 27751-88** [13] is used to choose one of four cases stated in the code. One should keep in mind the safety factor for responsibility, γ_n, for unique objects is set equal to $\gamma_n = 1.2$ by default.

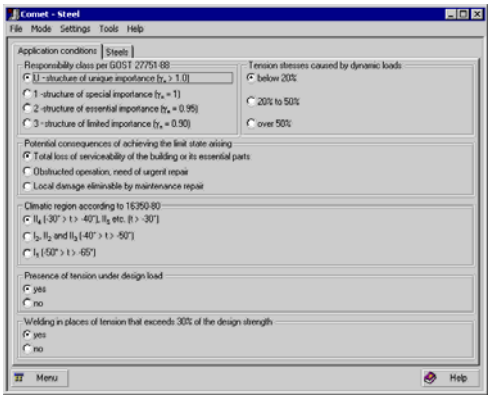


Fig. 1.6.1-1. *The* **Conditions of Application** *tab of the* **Steel** *mode*

The **Possible Consequences of Limit State Reaching** group suggests you to choose from a variety of possible consequences which may happen when a limit state is reached.

Other groups are used to choose characteristics of stressed state (**Presence of Tension under Design Load** and **Tension Stresses caused by Dynamic Loads**), or to specify a temperature conditions of the construction in service (**Climatic Region as per GOST 16350-80**) [9]. The latter group requires there be an indication of presence of welding in the tensioned area (**Welding in Tensile Zone that Exceeds 30% of Design Strength**).

Having filled in all data fields and having set all options on the first tab, switch to the **Steel** tab of the dialog.

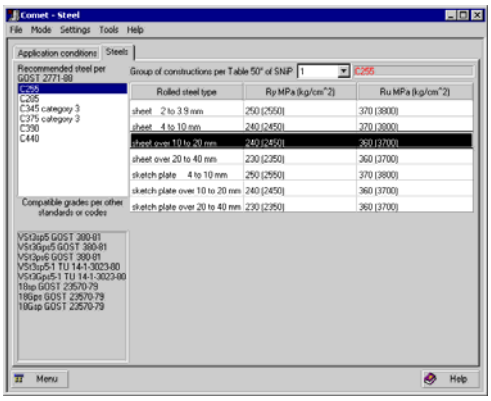


Fig. 1.6.1-2. *The* **Steel** *tab of the* **Steel** *mode*

The **Steel** tab (Fig. 1.6.1-2) contains a reference to a group of constructions according to Table 50* of SNiP II-23-81*, which conform to the service conditions specified on the previous tab. Other thing found on the tab include a list of steel grades recommended for this group according to GOST 27772-88* [14] and a list of steel grades from other standards and specifications which can be used instead of the main recommended steel. This same tab also contains information data about design yield strength (R_y) and design ultimate tensile strength (R_u) depending on steel grades.

A particular group of constructions may require a higher-quality steel than that recommended by SNiP II-23-81*. It is possible to take a better (by no means worse!) material for the group by choosing its No. from a drop- down list (**Group of Constructions as per Table 50* of SNiP**). The list of recommended steel grades will changed respectively.

If you select a row in the rolled steel table and click the **Apply** button, the information about the selected steel grade and its design strength will be used in the check of the bearing capacity of steel structural joints.

It should be noted that the application does not list all parts which are obligatory in the bill of steel, such as ones in notes to Tables 50* and 51-*b* of SNIP II-23-81*. The bill of steel is composed using primary engineering codes and manuals. Neither there are any reference help on steel for pipes according to Table 51-*a*.

1.6.2 Catalogue of rolled profiles

The **Catalogue of Rolled Profiles** mode enables you to browse catalogues of rolled steel from **COMET**'s database.

The dialog box for this mode presents a list of catalogues, **Catalogue of Rolled Profiles**, as a tree-like structure on the left. When a particular profile type is clicked, the information window displays a table of properties of the respective profiles (Fig 1.6.2-1). As soon as you choose a profile, the same window will display the profile's cross-section with dimensions (Fig. 1.6.2-2).

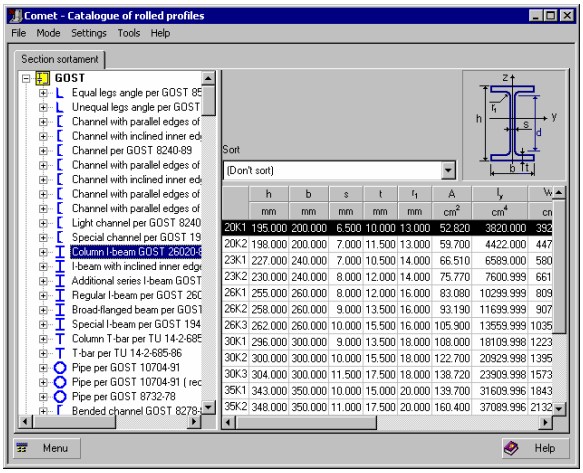


Fig. 1.6.2-1. *The dialog box for the* **Catalogue of Rolled Profiles** *mode* (a profile type has been selected)

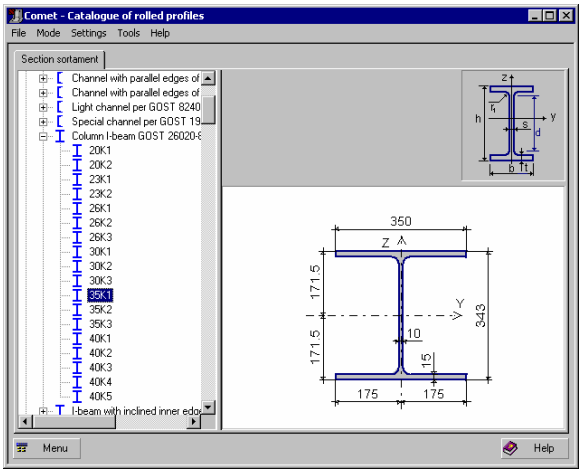


Fig. 1.6.2-2. *The dialog box for the* **Catalogue of Rolled Profiles** *mode* (a particular profile has been selected)

1.6.3 Catalogue of sheet and plate steel

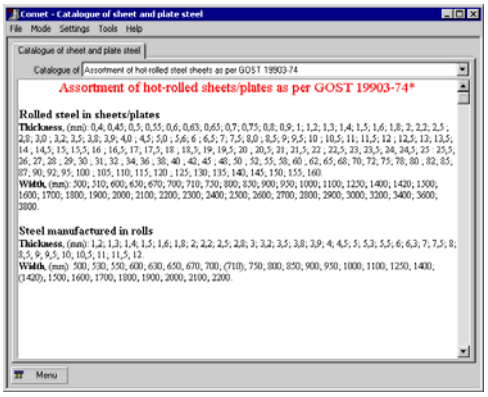


Fig. 1.6.3-1. *The dialog box for the* **Catalogue of sheet and plate steel** *mode*

The **Catalogue of sheet and plate steel** mode (Fig. 1.6.3-1) lets you browse the catalogues of hot-rolled steel sheets as per GOST 19903-74 [7], cold-formed steel as per GOST 19904-90 [8], all-purpose hot-rolled wide strip steel as per GOST 82-70* [1], and hot-rolled strip steel as per GOST 103-76* [2].

To choose a particular catalogue of steel sheet, use the drop-down list **Catalogue**. After you have selected a catalogue, the information window will display a line of thickness and width of available steel sheets or plates.

1.6.4 Welding materials

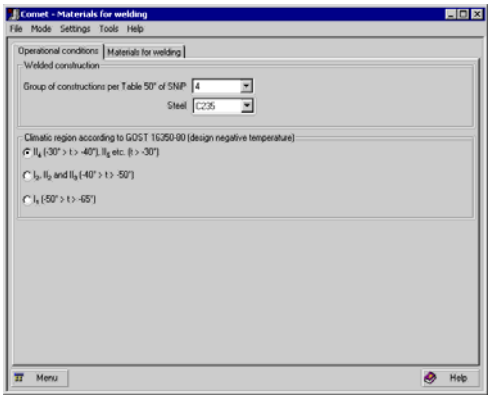


Fig. 1.6.4-1. *The* **Conditions of Application** *tabof the* **Welding Materials** *mode*

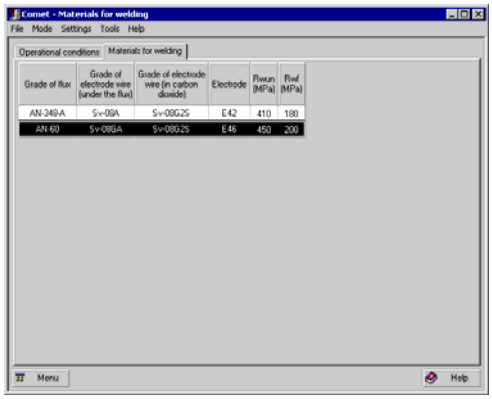


Fig. 1.6.4-2. *The* **Welding Materials** *tab of the same mode*

The **Welding Materials** mode is used to choose welding materials for the purpose of design of welded connections. The selection of the welding materials is based on instructions from Table 55* of SNiP II-23-81*.

The dialog box of the mode contains two tabs: **Conditions of Application** and **Welding Materials**.

The **Conditions of Application** tab (Fig. 1.6.4-1) contains two groups of controls. The **Construction Properties** group is used to specify No. of construction group (according to Table 50* of SNiP II-23-81* or after results obtained in the **Steel** mode) to which the construction (one to be welded) belongs, and to specify steel grade the construction is to be made of.

The **Climatic Region according to GOST 16350-80** [9] **(Negative Design Temperature)** group is used to choose one of temperature conditions of the construction in service defined by SNiP II-23-81*.

After you have filled all data fields on the first tab, switch to the next one of the dialog box — **Welding Materials**.

The **Welding Materials** tab (Fig. 1.6.4-2) contains a list of recommended welding materials (flux grades and welding wire, types of electrodes). After you select a needed row in the list and click the **Apply** button, the data related to the selected materials will be used in subsequent design modes of the application.

1.6.5 Service factors

The **Service Factors** mode is used to browse and select values for the service factors of steelwork members (γ_c) in the design of joints, and for service factors of bolted connections (γ_b).

The dialog box of this mode contains three tabs: **Connected Members**, **Connections Made With Non-Preloaded Bolts**, and **Connections Made With Preloaded Bolts**.

The **Connected Members** tab (Fig. 1.6.5-1) presents values of the service factors, γ_c , according to items 1, 2 of Table 6* and Sec. 3, 4 of notes to Table 6* of SNiP II-23-81* [17].

The **Connections Made With Non-Preloaded Bolts** tab (Fig. 1.6.5-2) presents tables of values for the service factors of bolted connections, γ_b , in compliance with Table 35* of SNiP II-23-81* [17]. The notation used in the table is described in a separate window at the bottom of the tab.

The **Connections Made With Preloaded Bolts** tab

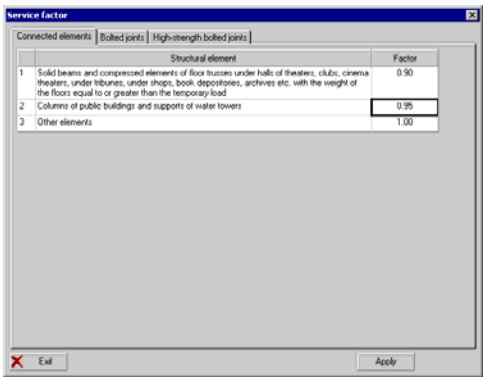


Fig. 1.6.5-1. *The* **Connected Members** *tab of the* **Service Factors** *mode*

(Fig. 1.6.5-3) contains information about values of the service factors for the high-strength bolted connections, γ_b, given in Sec. 11.13* of SNiP II-23-81* [17].

Clicking the **Apply** button will assign the selected values of the service factors, γ_c, and the service factors for bolted connections, γ_b, for use in the application's design modes.

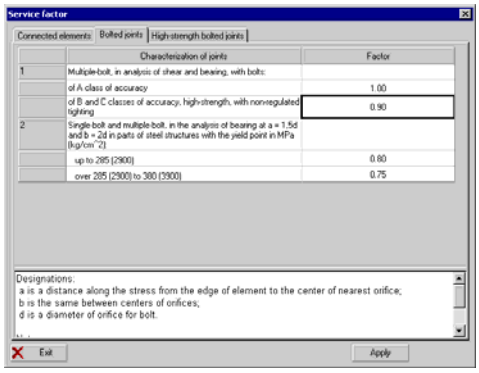


Fig. 1.6.5-2. *The* **Connections Made With Non-Preloaded Bolts** *tab of the* **Service Factors** *mode*

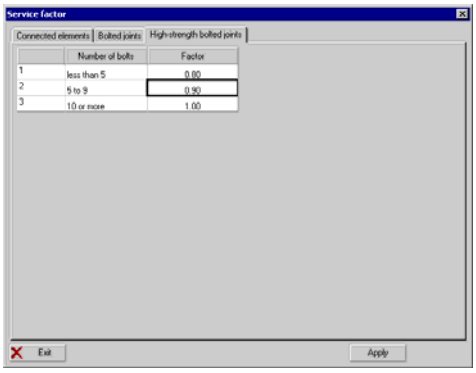


Fig. 1.6.5-3. *The* **Connections Made With Preloaded Bolts** *tab of the* **Service Factors** *mode*

1.6.6 Bolts

The **Bolts** mode helps browse the catalogues of bolts where also their class for selected structural service conditions and the intended behavior of the bolted connections are indicated. The selection of bolts can be done for four construction groups, according to Table 57* of SNiP II-23-81*.

The **Service Conditions** tab (Fig. 1.6.6-1) contains three groups of controls:

- **Type of Construction**, where you choose one of two cases, defined in the building standards, as related to requirements to the endurance of bolted connections;
- **Category of Bolted Connections** — this is to choose a type of stress experienced by the bolts in the connection;
- **Climatic Region as per GOST 16350-80** [9], where one of the temperature conditions of the construction in service defined by SNiP II-23-81* is indicated.

When you have filled all data fields on the first tab, switch to the second tab of the dialog box, **Bolts**.

The **Bolts** tab (Fig. 1.6.6-2) contains a list of recommended bolt grades and information about bolt catalogues, depending on given structural service conditions and the intended type of stress in the bolted connection.

The **Standards and Codes** tab provides you with a list of building standards used to design the bolted connections.

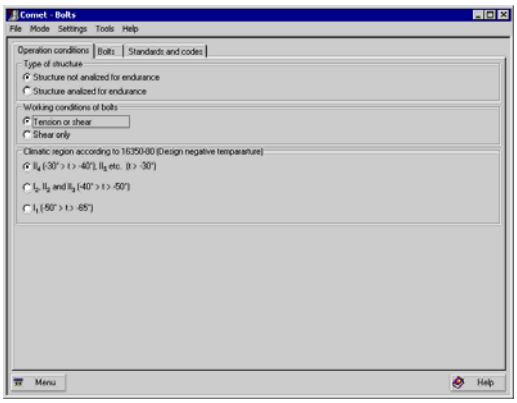


Fig. 1.6.6-1. *The* **Service Conditions** *tab of the* **Bolts** *mode*

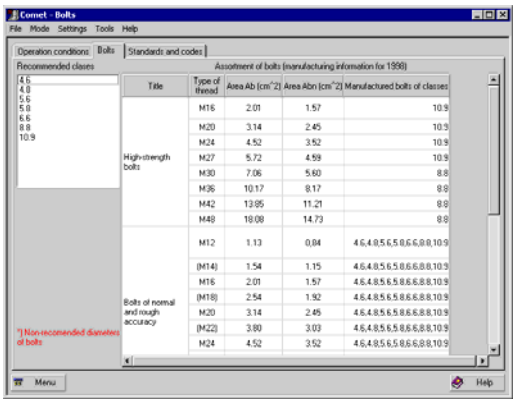


Fig. 1.6.6-2. *The* **Bolts** *tab of the* **Bolts** *mode*

1.6.7 High strength bolts

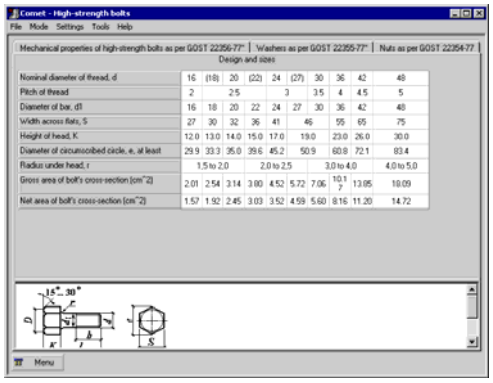


Fig. 1.6.7-1. *The dialog box of the* **High Strength Bolts** *mode*

The **High Strength bolts** mode (Fig. 1.6.7-1) provides information about the design, sizes, and mechanical properties of high strength structural bolts (the respective tabs **Design and Sizes** and **Mechanical Properties of High Strength bolts as per GOST 22356-77*** [10]) which can be used in joints between steel structural members. In addition, the tabs **Nuts as per GOST 22356-77*** [10] and **Washers as per GOST 22356-77*** [10] provide lists of the nuts and washers, respectively, for such bolts, indicating their sizes and geometric properties.

This information is presented in tables and accompanied by all necessary graphics (Fig. 1.6.7-1).

1.6.8 Anchor bolts

The **Anchor Bolts** mode is intended to provide reference information about anchor bolts, giving also their design tensile strength.

The dialog box of this mode contains four tabs: **Anchor Bolts**, **General Sizes**, **Steel Grades**, and **Design Tensile Strength**.

The **Anchor Bolts** tab (Fig. 1.6.8-1) provides graphical data about types of anchor bolts. The **General Sizes** tab (Fig. 1.6.8-2) contains tabular data about the geometric dimensions and the effective area of cross-sections, depending on type and diameter of anchor bolts. The **Steel Grades** tab (Fig. 1.6.8-3) provides data about steel grades used to make anchor bolts, depending on a climatic region of the construction site. The **Design Tensile Strength** tab (Fig. 1.6.8-4) lists design tensile strength values vs. the diameter and steel grade of anchor bolts.

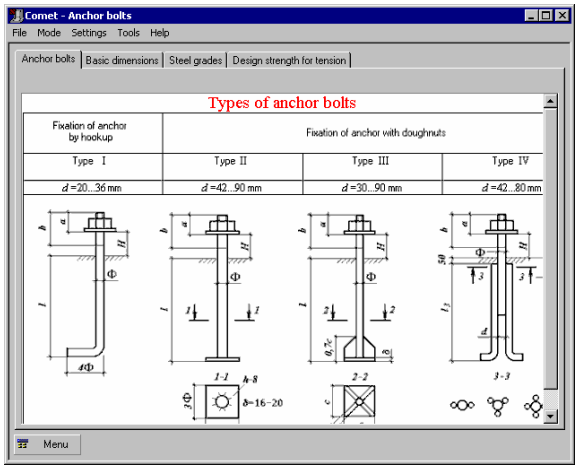


Fig. 1.6.8-1. *The* **Anchor Bolts** *tab of the same mode*

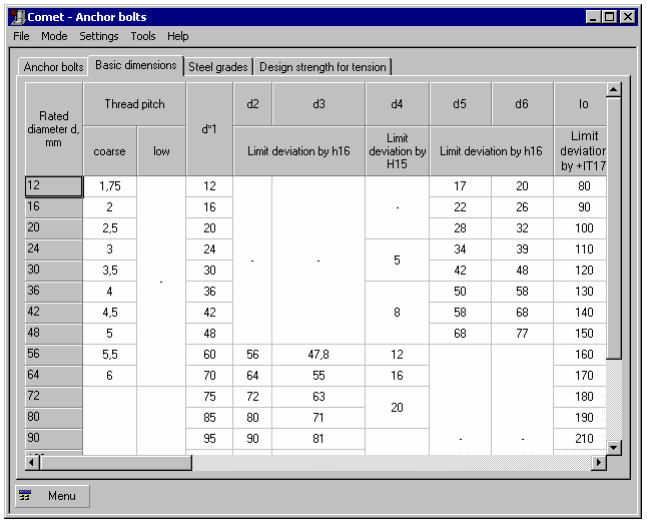


Fig. 1.6.8-2. *The* **General Sizes** *tab of the* **Anchor Bolts** *mode*

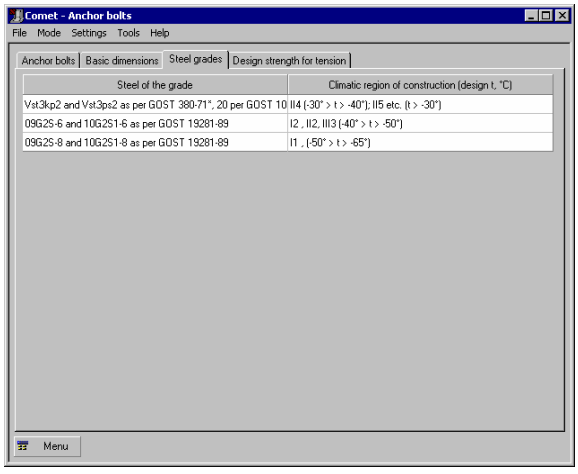


Fig. 1.6.8-3. *The* **Steel Grades** *mode of the* **Anchor Bolts** *mode*

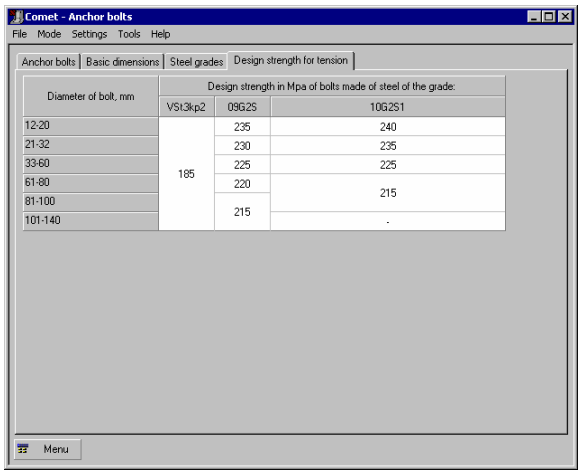


Fig. 1.6.8-4. *The* **Design Tensile Strength** *tab of the* **Anchor Bolts** *mode*

1.6.9 Normals for matching members

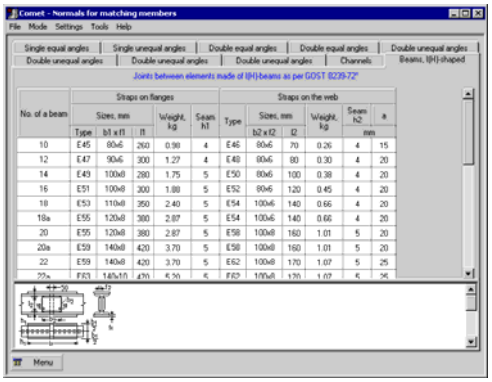


Fig. 1.6.9-1. *The dialog box of the* **Normals for Matching Members** *mode*

The **Normals for Matching Members** mode (Fig. 1.6.9-1) presents properties of full splice joints between rolled steel beams connected by strapped welding [20].

The dialog box for this mode contains ten tabs which provide a full description of structural schemes of joints between I-beams as per GOST 8239-89 [3], channels as per GOST 8240-89 [4], single and double equal angles as per GOST 8509-86 [5], single and double unequal angles as per GOST 8510-86 [6].

1.6.10 Scratching

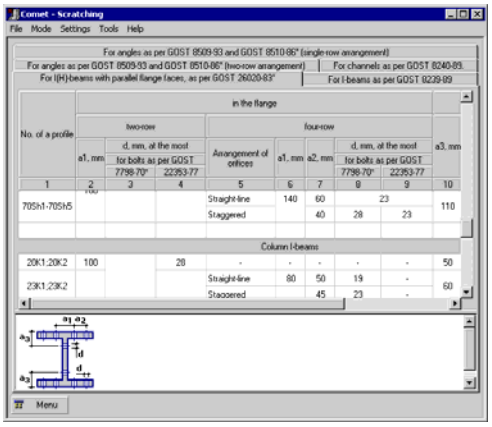


Fig. **Error! Reference source not found.**-1. *The dialog box of the* **Scratching** *mode*

The **Scratching** mode (Fig. **Error! Reference source not found.**-1) is used to get help on a recommended positioning of bolt holes on the surface of a rolled profile [21]. This information is presented in tables, for angles according to GOST 8509-86 [5] and GOST 8510-86* [6] (for one and two rows of bolts), for channels as per GOST 8240-89 [4], for I-profiles as per GOST 8239-89 [3], and for H-profiles as per GOST 26020-83* [11]. The information window at the bottom of the dialog box gives the graphical representation of a particular profile with the notation and sizes as listed in the table.

1.6.11 Concrete class

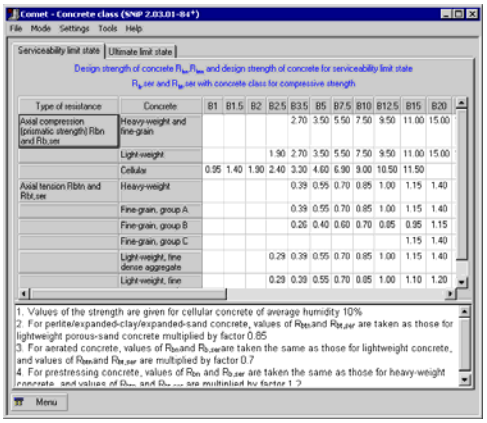


Fig. 1.6.11-1. *The dialog box of the* **Concrete Class (SNiP 2.03.01-84*)** *mode*

The **Concrete Class** mode **(SNiP 2.03.01-84*)** (Fig. 1.6.11-1) is used to choose values for the characteristic strength of concrete and for the design strength of concrete at the ultimate limit state (the **Ultimate Limit State** tab) and the serviceability limit state (the **Serviceability Limit State** tab), depending on the concrete class by compressive strength in compliance with SNiP 2.03.01-84* [18].

1.6.12 Concrete grade

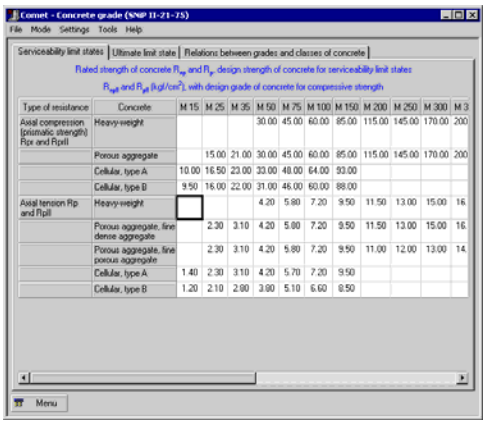


Fig. 1.6.12-1. *The dialog box of the* **Concrete Grade (SNiP II-21-75)** *mode*

The **Concrete Grade** mode **(SNiP II-21-75)** (Fig. 1.6.12-1) is used to get help on the characteristic and design strength of concrete at the ultimate limit state (the **Ultimate Limit State** tab) and at the serviceability limit state (the **Serviceability Limit State** tab), depending on the concrete grade based on compressive strength in compliance with SNiP II-21-75 [16].

The **Correspondence between Concrete Grades and Classes** tab contains information about how the grades and classes of concrete by compressive strength in compliance with GOST 26633-91 [12] relate to one another.

1.7 Design modes

1.7.1 Rigid column bases

The **Rigid Column Bases** mode is used to design and make assessments of the bearing capacity of structural schemes for joints in the bases of columns which implement a rigid connection of the column to its foundation. The mode comprises a wide range of structural designs for this kind of joints, such as:

- Column bases with milled end (Fig. 1.7.1-1);
- Column bases with wing plates and stiffening ribs (Fig. 1.7.1-2);

- Column bases with external wing plates (Fig. 1.7.1-3).

The mode operates in compliance with SNiP II-23-81* [17] and makes the following checks:

- Resistance of the basic components of the joint (base plate in bending under compression in combination with foundation concrete in local bearing, wing plate and anchor beams in bending, stiffening ribs with overheads in bending, anchor bolts in tension);
- Resistance of welded connections (fixation between base plate and end of column, between wing plate and column flanges, between wing plate and base plate, between stiffening ribs and column flanges, between stiffening ribs and wing plate);
- Some structural and catalogue-based constraints.

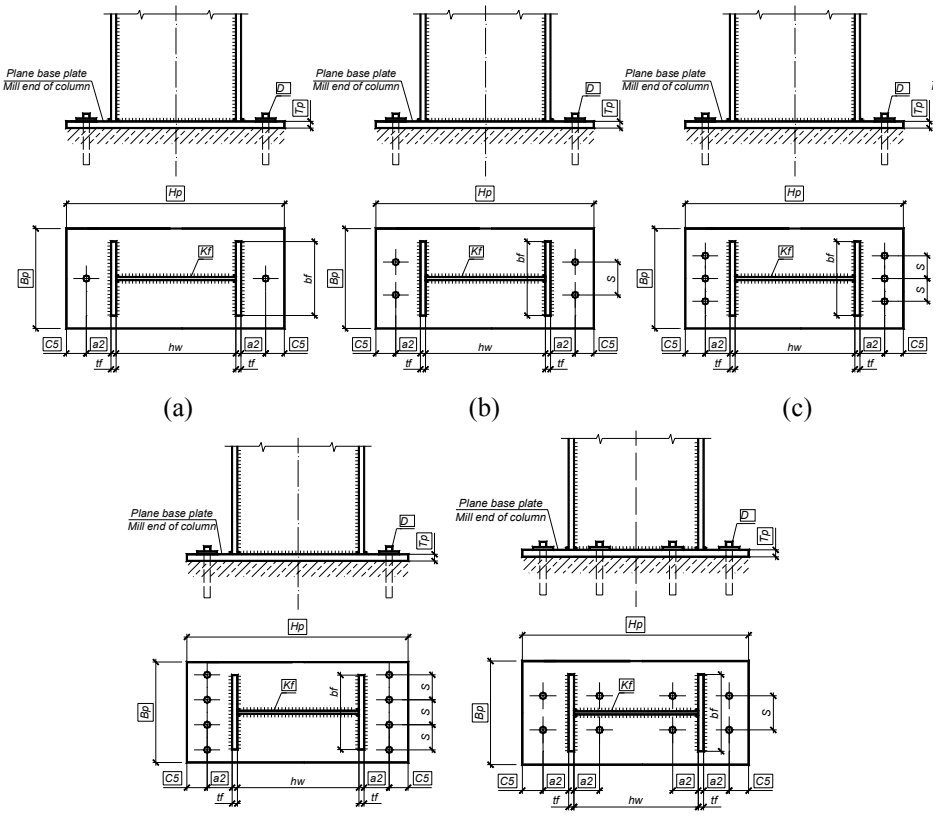


Fig. 1.7.1-1. Structural schemes for rigid column bases with milled end.

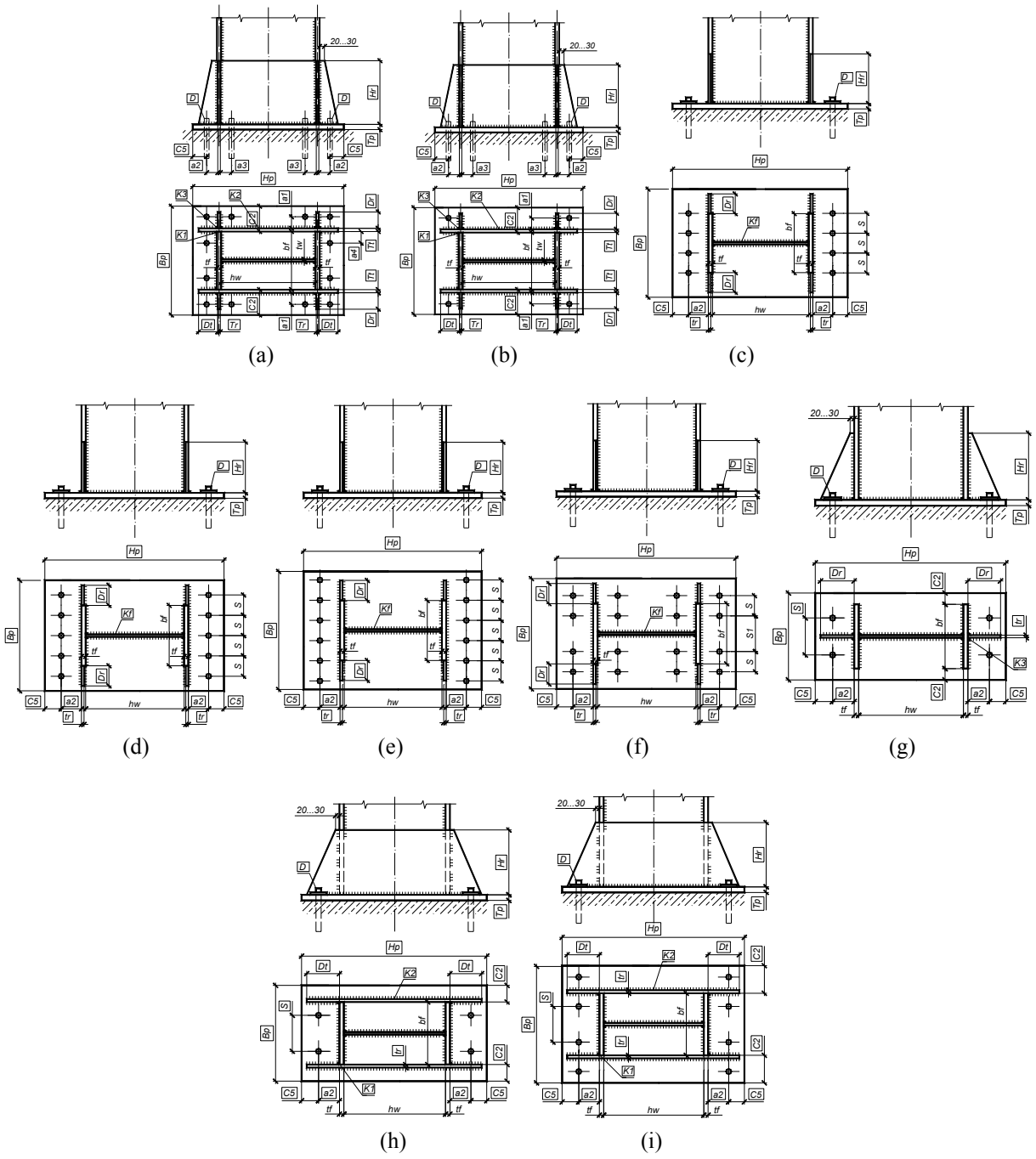
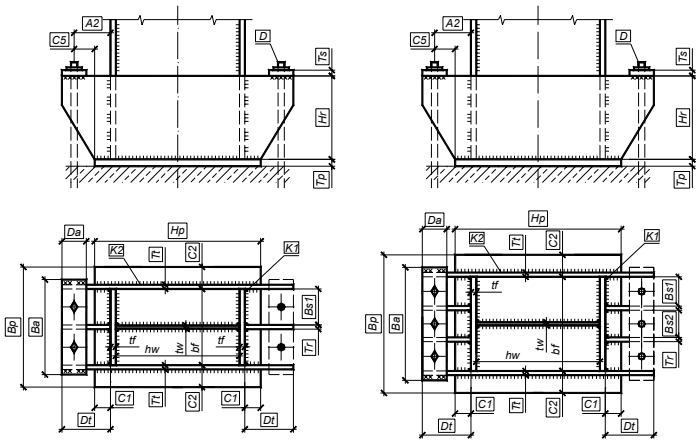


Fig. 1.7.1-2. Structural schemes for rigid column bases with wing plates and stiffening ribs.



(a) (b)

Fig. 1.7.1-3. Structural schemes for rigid column bases with external wing plates.

The main dialog box of the **Rigid Column Bases** mode contains three tabs: **Configuration** (Fig. 1.7.1-4, 1.7.1-5), **Construction** (Fig. 1.7.1-9), and **Drawing** (Fig. 1.7.1-10).

To get started in the **Rigid Column Bases** mode, begin with choosing your column's cross-section type. This is done by clicking one of the buttons: **Rolled Section** or **Weldable Section**. According to the choice you have made, the appearance of the **Configuration** tab will change (Fig. 1.7.1-4, Fig. 1.7.1-5). If the selected column's cross-section type is a rolled I-section or H-section, further you need to choose a catalogue and No. of the desired profile in the catalogue. The **Choose Profile** dialog box (Fig. 1.7.1-6) is used to do this; it opens as soon as you click the **Choose Column Section** button.

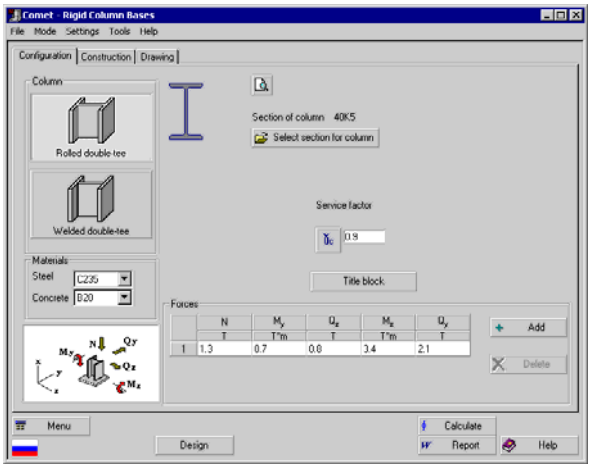


Fig. 1.7.1-4. *The* **Configuration** *tab of the* **Rigid Column Bases** *mode* (a rolled I-section is selected as the column's cross-section type)

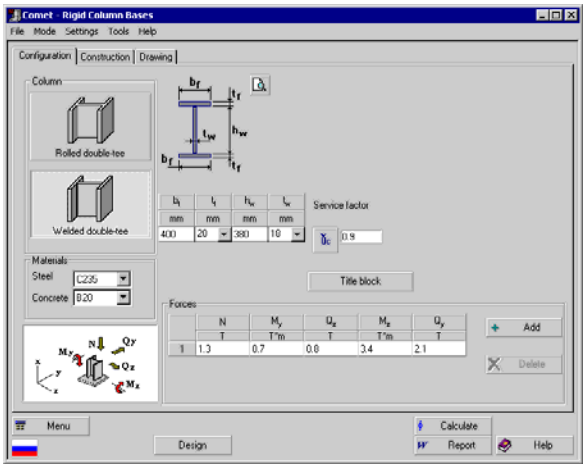


Fig. 1.7.1-5. *The* **Configuration** *tab of the* **Rigid Column Bases** *mode* (a weldable H-section is selected as the column's cross-section type)

When a weldable I- or H-section is selected as the column's cross-section type, you need to define the sizes of the column's cross-section: the height, h_w, and the thickness, t_w, of the web; the width, b_f, and the thickness, t_f, of the flanges. The sizes of the column's cross-section should be entered in the table manually (Fig. 1.7.1-5). Note that the thickness of the web and of the flange can be either entered manually or selected from a drop-down list

which contains the set of thickness values according to the catalogue of sheet and plate steel. The column's cross-section can be checked visually in a preview window (Fig. 1.7.1-7) which becomes available as soon as you click the **Preview** button ( ).

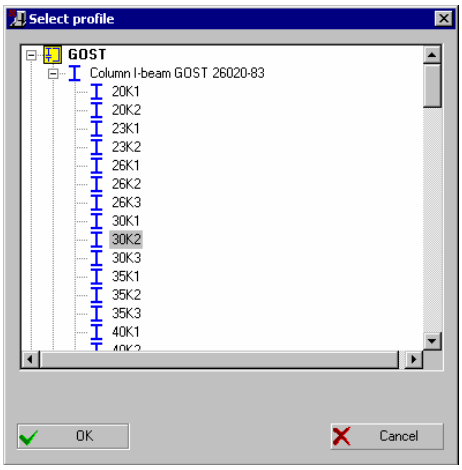


Fig. 1.7.1-6. *The* **Choose Profile** *dialog box*

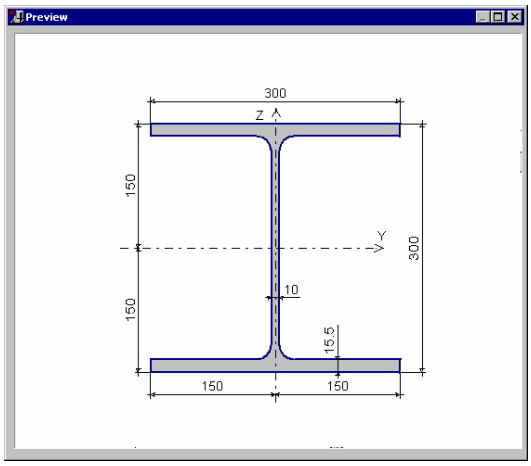


Fig. 1.7.1-7. *The* **Preview** *window*

Materials to be used for design and analysis of a rigid column base joint can be defined in the drop-down lists **Steel** and **Concrete**, which suggest the respective sets of steel grades for steel connected members of the column base joint and of concrete grades for the foundation.

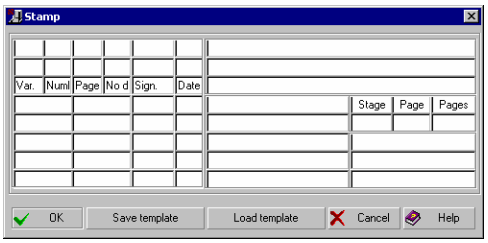


Fig. 1.7.1-8. *The* **Title Block** *dialog box*

The same tab is used to specify the internal forces which act in the connected members: an axial force, N; bending moments in two planes, M_y and M_z; their respective shear forces, Q_z and Q_y [2]. After you click the **Add** button, the table of internal forces shows a new row in which you enter the design values of the internal forces for the current load case combination. The number of the design load case combinations can be anything. Units of measurement for the design internal forces in the connected members are defined in the **Units of Measurement** tab of the **Application Settings** dialog box (see Sec. 1.4). The default unit for axial force and shear forces is ton, for bending moment ton×meter.

Clicking the **Title Block** button will provide access to a dialog box under the same name; this is to fill in the title block of the drawing (Fig. 1.7.1-8) used as a draft of the rigid column base's structural scheme. The **Save As Template** button helps save the entered data as a template of the title block for the current session of the application. The saved template can be used, however, both in the current and in subsequent sessions or modes by clicking the **Load Template** button.

You can enter the service factor for the connected members in an appropriate text field, or it can be selected in the **Service Factors** dialog box (see Sec. 1.6.5) after clicking the button located nearby ( ).

The **Construction** tab contains a group of buttons to select a design (structural scheme) for the rigid column base's joint (Fig. 1.7.1-9).

To perform a structural assessment (i.e. check the bearing capacity according to SNiP II-23-81* [17]) of a

[2] To set a proper orientation of the given internal forces or stresses with respect to the principal axes of inertia of the cross-sections that meet in a joint, each bar/beam of the joint is referred to a local coordinate system, *xyz*. The application implements the following orientation of the local coordinate systems at bars and beams: the $x - x$ axis goes from the beginning of a bar (its start node) to its end (its end node), the $y - y$ and $z - z$ axes (the principal central axes of inertia of the bar's cross-section) make up a right-hand Cartesian coordinate system together with the $x - x$ axis. The $y - y$ axis is parallel to the *XOY* plane of the global coordinate system, and the $z - z$ axis goes to the upper half-space.

known structural design of the column base, you need to provide all design parameters of the joint. The parameters include the sizes and thickness of structural connected members, the diameters of anchor bolts, sizes which regulate the mutual arrangement of the basic components, leg lengths of welds, the number of bolts, the number of rows of bolts etc. The design parameters of the joint are entered in the table on the right. The diameter, the steel grade, and the number of foundation bolts (for some types of bases) are to be specified in appropriate drop-down lists united into the **Anchor Bolts** group. The default units of linear measurement are millimeters.

Clicking the **Design** button will invoke the mode of automatic proportioning of the parameters for the given rigid column base joint. This mode assumes the parameters to be previously unknown; they are to be found from the conditions of proper bearing capacity plus structural constraints defined by building standards. Any previously specified data are ignored in this mode. In addition, this mode calculates the value of maximum factor K_{max} (a constraint utilization factor) and indicates a type of code-defined check in which this maximum takes place. Then a production drawing of the joint design at the detail design stage is generated.

When you click the **Calculate** button, the application performs the check of bearing capacity of the connected members and of connections between them as defined by SNiP II-23-81* [17]. If some of numerical parameters have not been defined, the application will obtain them automatically from the conditions of proper bearing capacity and structural constraints defined by building codes. The result will include the value of maximum factor K_{max} (a constraint utilization factor) and a type of standard-defined check in which this maximum takes place. A complete list of the checks and values of the respective constraint utilization factors is available by clicking the **Factors** button.

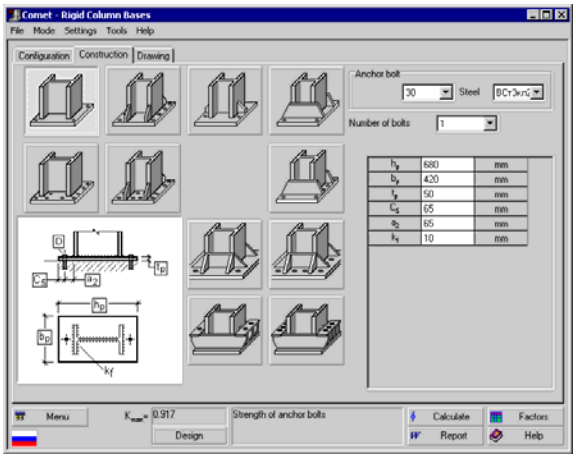


Fig. 1.7.1-9. *The* **Construction** *tab of the* **Rigid Column Bases** *mode*

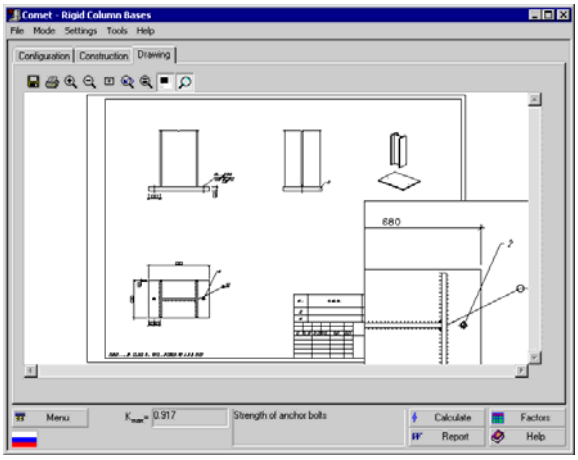


Fig. 1.7.1-10. *The* **Drawing** *tab of the* **Rigid Column Bases** *mode*

By using the **Factors** button in the **Factor Diagram** dialog box you can browse values of all other constraint utilization factors. The list of checks of bearing capacity of the connected members and connections in the rigid column base joints, which the application can perform, is presented in Table 1.7.1-1.

The **Report** button provides you with the capability of generating a report document which contains the source data and the analysis results. This document is exported to an RTF file and then can be viewed or edited in an application like Microsoft Word.

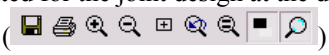
Table 1.7.1-1. A list of checks of bearing capacity of the connected members and connections in structural schemes of rigid column bases, in compliance with SNiP II-23-81*

No	Entitlement of check	Type of base	Reference to SNiP II-23-81*
1.	Resistance of the base plate in bending under normal stresses in areas supported along the whole contour	Fig. 1.7.1-2,a,b, h,i; Fig. 1.7.1-3	Sec. 5.12, (28)
2.	Resistance of the base plate in bending under normal stresses in areas supported on three sides	Fig. 1.7.1-2; 1.7.1-3	Sec. 5.12, (28)
3.	Resistance of the base plate in bending under normal stresses in areas supported on two sides meeting at an angle	Fig. 1.7.1-2,a,b,g	Sec. 5.12, (28)
4.	Resistance of the base plate in bending under normal stresses in cantilever areas of the plate	Fig. 1.7.1-3	Sec. 5.12, (28)
5.	Resistance of the base plate in bending under normal stresses in free trapezoid areas of the plate	Fig. 1.7.1-1; 1.7.1-2; 1.7.1-3	Sec. 5.12, (28)
6.	Resistance of the foundation's concrete in local bearing under the plate	Fig. 1.7.1-2; 1.7.1-3	
7.	Resistance of the welded connection between end of column and base plate	Fig. 1.7.1-1	Sec. 11.2*, (120)-(121)
8.	Resistance of the welded connection between wing plate and column flanges	Fig. 1.7.1-2,a,b, h,i; Fig. 1.7.1-3	Sec. 11.2*, (120)-(121)
9.	Resistance of the welded connection between wing plate and base plate	Fig. 1.7.1-2,a,b, h,i; Fig. 1.7.1-3	Sec. 11.2*, (120)-(121)
10.	Resistance of the welded connection between stiffening rib and column flanges	Fig. 1.7.1-2,c,d, e,f; Fig. 1.7.1-3	Sec. 11.4, (33), (119)
11.	Resistance of the welded connection between stiffening rib and wing plate	Fig. 1.7.1-2,a,b,g	Sec. 11.5, (120)-(123), (126)
12.	Resistance of the anchor bolts in tension	Fig. 1.7.1-1; 1.7.1-2; 1.7.1-3	Sec. 11.7*, (127), (129), Sec. 11.8, (130)
13.	Resistance of the wing plate in bending under shear stresses	Fig. 1.7.1-3	Sec. 5.12, (29)
14.	Resistance of the wing plate in bending under coexistence stresses	Fig. 1.7.1-3	Sec. 5.14*, (33)
15.	Resistance of the wing plate in bending under normal stresses	Fig. 1.7.1-3	Sec. 5.14*, (33)
16.	Resistance of the stiffening rib in bending under shear stresses	Fig. 1.7.1-3	Sec. 5.12, (29)
17.	Resistance of the stiffening rib in bending under coexistence stresses	Fig. 1.7.1-3	Sec. 5.14*, (33)
18.	Resistance of the stiffening rib in bending under normal stresses	Fig. 1.7.1-3	Sec. 5.14*, (33)
19.	Resistance of the anchor beam in bending under shear stresses	Fig. 1.7.1-3	Sec. 5.12, (29)
20.	Resistance of the anchor beam in bending under coexistence stresses	Fig. 1.7.1-3	Sec. 5.14*, (33)
21.	Resistance of the anchor beam in bending under normal stresses	Fig. 1.7.1-3	Sec. 5.14*, (33)

Notes:

1. The design resistance of the deposited metal in the fillet welded connections is defined according to Table 56 SNiP II-23-81* as for the manual welding with E-42 electrodes.
2. The design resistance of the fusion boundary in the fillet welded connections is defined by the formula from Table 3 of SNiP II-23-81* as for manual welding with E-42 electrodes.
3. The design resistance of the butt welds is defined by the formula from Table 3 SNiP II-23-81* if there are no physical quality control methods.
4. Analysis of the base plate takes into account the service factor according to item 11, Table 6* of SNiP II-23-81*.
5. Analysis of bolted connections takes into account the service factor according to item 1, Table 35* of SNiP II-23-81*, for the bolts being of Class B and C accuracy.
6. The leg length of fillet welds are taken from analysis but not shorter than minimum leg length defined by structural requirements and listed in Table 38* of SNiP II-23-81*, and not longer than maximum one defined in Sec. 12.8 of SNiP II-23-81*.
7. The design length of longitudinal fillet welds is determined so as not to exceed the maximum value defined in Sec. 12.8, (d) of SNiP II-23-81*.

As you switch to the **Drawing** tab (Fig. 1.7.1-10), the application does a check and design of the joint, similarly to the **Calculate** mode. If the results of structural assessment of the joint are not in contradiction with structural and building code requirements, a drawing will be generated for the joint design at the detail design stage.

The top part of the **Drawing** tab contains a toolbar of buttons () which enable you to zoom the image in or out, save the drawing as DWG (DXF) for the AutoCAD software, or print it out.

1.7.2 Pinned column bases

The **Pinned Column Bases** mode is used to design and make a structural assessment of structural schemes for column base joints which implement a nominally pinned connection between a column and its foundation. This mode comprises a wide range of structural designs for the joints of this type, such as:

- Column bases with wing plates and stiffening ribs (Fig. 1.7.2-1);
- Column bases with the milled end (Fig. 1.7.2-2).

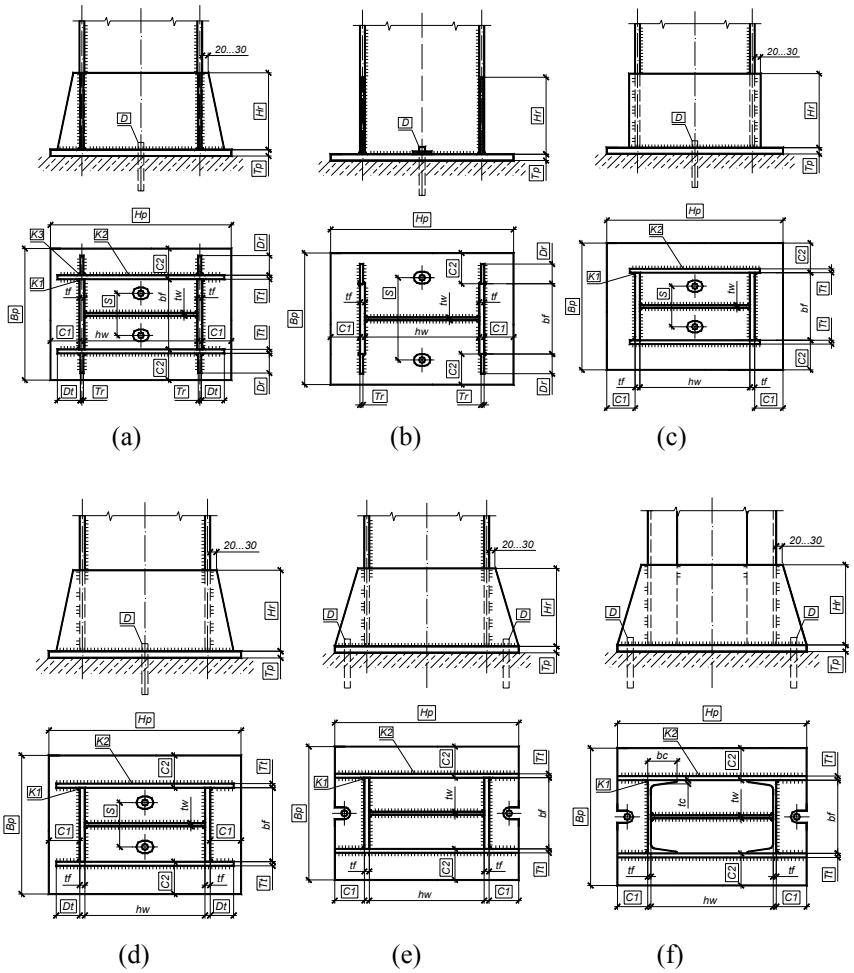


Fig. 1.7.2-1. Structural schemes for pinned column bases with wing plates and stiffening ribs

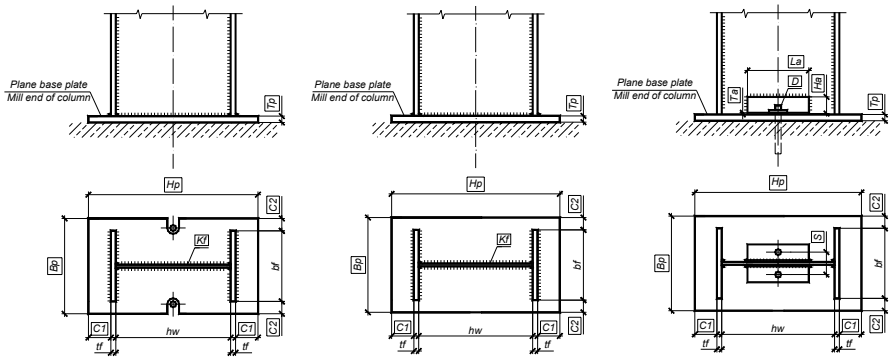


Fig. 1.7.2-2. Structural schemes for pinned column bases with milled end

This mode performs the following checks, in compliance with SNiP II-23-81* [17]:

- resistance of structural connected members (base plate in bending under compression in combination with foundation concrete in local bearing, wing plates in bending, stiffening ribs with overhead in bending, anchor bolts in tension);
- resistance of the welded connections (fixation between base plate and end of column, between wing plate and column flanges, between wing plate and base plate, between stiffening rib and wing plate, between stiffening rib and column flanges);
- some structural and catalogue-based constraints.

The main dialog box of the **Pinned Column Bases** mode contains three tabs: **Configuration** (Fig. 1.7.2-3), **Construction** (Fig. 1.7.2-6, 1.7.2-7), and **Drawing**.

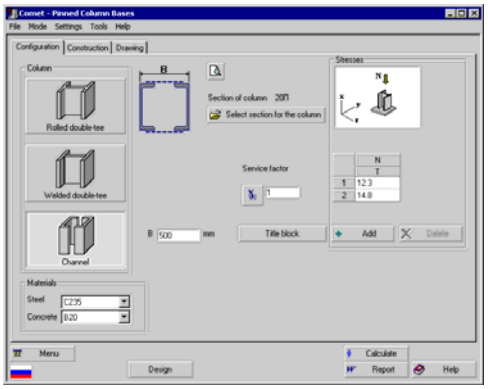


Fig. 1.7.2-3. *The* **Configuration** *tab of the* **Pinned Column Bases** *mode* (a channel has been selected as a column cross-section type)

To get started in the **Pinned Column Bases** mode, begin with choosing your column's cross-section type. To do it, click an appropriate button in the **Configuration** tab (Fig. 1.7.2-3). The mode suggests three types of cross-sections: a rolled I- or H-section, a weldable I- or H-section, and a compound section made of two rolled channels. The sizes of the weldable cross-section and No. of profile of the rolled cross-section are defined in the same way as in the **Rigid Column Bases** mode.

If the selected column cross-section type is the compound section of two rolled channels, you need to specify a catalogue and No. of the channel in it. Use the **Choose Profile** dialog box (Fig. 1.7.2-4) to do it. It opens when you click the **Choose Column Section** button. In addition, use the text field **B** to specify the distance between the external faces of the channel webs.

You can check up a graphical representation of your column's cross-section in a preview window (Fig. 1.7.2-5) which becomes available by clicking the **Preview** button ( ).

The same tab is used to specify the design compressive force N which is transferred from the column onto its foundation. When you click the **Add** button, a new row is added to the stress table, where you enter a design value of the axial force for the current load case combination. Any number of design load case combinations is allowed. The default unit for the axial force is ton. Other units of measurement for axial force acting in the joint can be defined using the **Units of Measurement** tab of the **Application Settings** dialog box (see Sec. 1.7.2).

The service factor for the connected members, materials used for design and analysis of the pinned column

base joint are specified in the same way as in the **Rigid Column Bases** mode. The functionality of the **Title Block** button is also the same as that in the **Rigid Column Bases** mode.

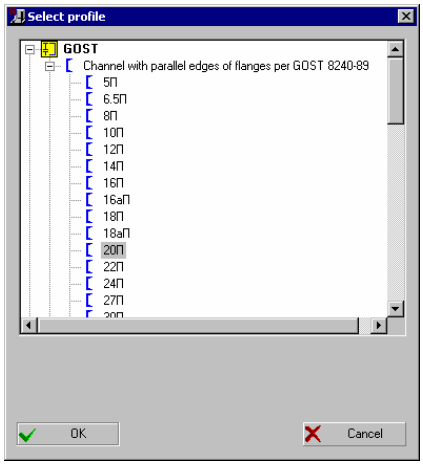


Fig. 1.7.2-4. *The* **Choose Profile** *dialog box*

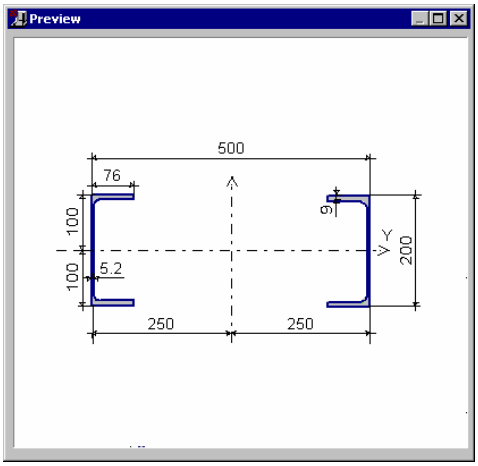


Fig. 1.7.2-5. *The* **Preview** *window*

The **Construction** tab contains a group of buttons for choosing a structural design for the pinned column base joint (Fig. 1.7.2-6, 1.7.2-7).

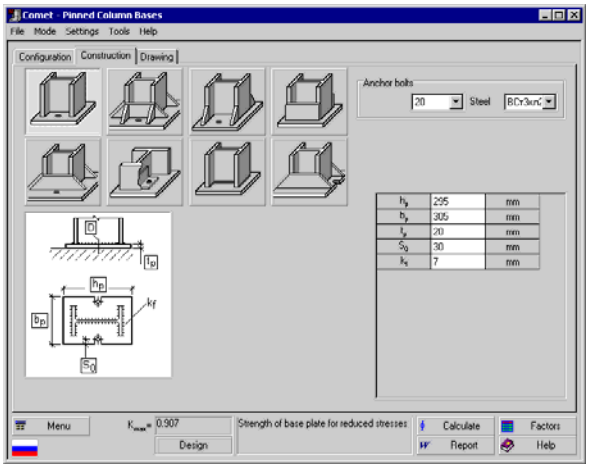


Fig. 1.7.2-6. *The* **Construction** *tab of the* **Pinned Column Bases** *mode* (a rolled or weldable I- or H-section has been selected as a column cross-section type)

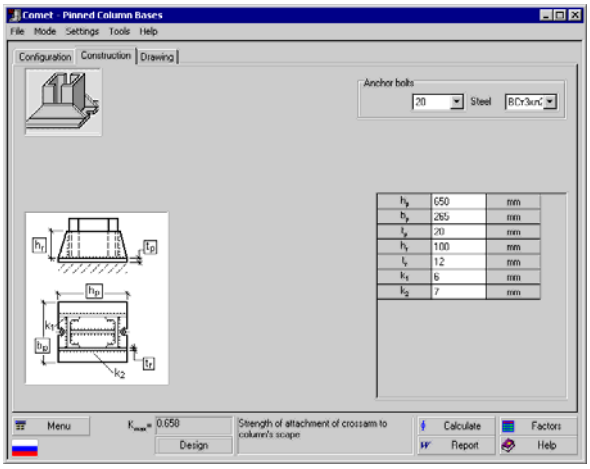


Fig. 1.7.2-7. *The* **Construction** *tab of the* **Pinned Column Bases** *mode* (a compound section from channel has been selected as a column cross-section type)

To assess the bearing capacity of a given column base structural design, you need to specify the design parameters of the joint in a table found in the **Design** tab. The diameter and steel grade of anchor bolts are defined in appropriate drop-down lists combined into the **Anchor Bolts** group. The default unit of all linear measurements is millimeter.

Table 1.7.2-1. A list of checks of bearing capacity of the connected members and connections in structural scheme of pinned column bases, in compliance with SNiP II-23-81*

No	Entitlement of check	Type of base	Reference to SNiP II-23-81*
1.	Resistance of the base plate in bending under coexistence stresses	Fig. 1.7.2-2	Sec. 5.14*, (33)
2.	Resistance of the base plate in bending under normal stresses in areas supported along the whole contour	Fig. 1.7.2-1, a,c,d,e,f	Sec. 5.12, (28)
3.	Resistance of the base plate in bending under normal stresses in areas supported on three sides	Fig. 1.7.2-1, a,b,d,e,f	Sec. 5.12, (28)
4.	Resistance of the base plate in bending under normal stresses in areas supported on two sides meeting at an angle	Fig. 1.7.2-1, a	Sec. 5.12, (28)
5.	Resistance of the base plate in bending under normal stresses in cantilever areas of the plate	Fig. 1.7.2-1, e,f	Sec. 5.12, (28)
6.	Resistance of the base plate in bending under normal stresses in free trapezoid areas of the plate	Fig. 1.7.2-1, a,b,c,d; Fig. 1.7.2-2	Sec. 5.12, (28)
7.	Resistance of the foundation's concrete in local bearing under the plate	Fig. 1.7.2-1, Fig. 1.7.2-2	
8.	Resistance of the welded connection between end of column and base plate	Fig. 1.7.2-2, a,b	Sec. 11.2*, (120)-(121)
9.	Resistance of the welded connection between wing plate and column flanges	Fig. 1.7.2-1, a,c,d,e,f	Sec. 11.2*, (120)-(121)
10.	Resistance of the welded connection between wing plate and base plate	Fig. 1.7.2-1, a,c,d,e,f	Sec. 11.2*, (120)-(121)
11.	Resistance of the welded connection between stiffening rib with overhead and column flanges	Fig. 1.7.2-1, b	Sec. 11.4, (33), (119)
12.	Resistance of the welded connection between stiffening rib with overhead and wing plate	Fig. 1.7.2-1, a	Sec. 11.5, (120)-(123), (126)
13.	Resistance of the bolted connection between anchor angle and base plate	Fig. 1.7.2-2, c	Sec. 11.7*, (127)-(128), Sec. 11.8, (130)

Notes:

1. The design resistance of the deposite metal in fillet welded connections is defined by Table 56 of SNiP II-23-81* as for manual welding with E-42 electrodes.
2. The design resistance of the fusion boundary in fillet welded connections is defined by the formula from Table 3 of SNiP II-23-81* as for manual welding with E-42 electrodes.
3. The design resistance of butt welds is defined by the formula from Table 3 of SNiP II-23-81* if there are no physical quality control methods.
4. Analysis of the base plate takes into account the service factor according to item 11, Table 6* of SNiP II-23-81*.
5. Analysis of bolted connections takes into account the service factor according to item 1, Table 35* of SNiP II-23-81*, the bolts being of Class B and C accuracy.
6. The leg length of fillet welds are taken from analysis but not shorter than minimum leg length defined by structural requirements and listed in Table 38* of SNiP II-23-81*, and not longer than maximum one defined in Sec. 12.8 of SNiP II-23-81*.
7. The design length of longitudinal fillet welds is determined so as not to exceed the maximum value defined in Sec. 12.8, (d) of SNiP II-23-81*.

Clicking the **Design** button will invoke the mode of automatic proportioning of the parameters for the given pinned column base joint. This mode assumes the parameters to be previously unknown; they are to be found from the conditions of proper bearing capacity plus structural constraints defined by building requirements. Any previously specified data are ignored in this mode. In addition, this mode calculates the value of maximum factor K_{max} (a constraint utilization factor) and indicates a type of code-defined check in which this maximum takes place. Then s drawing of the joint design at the detail design stage is generated.

When you click the **Calculate** button, the application performs the check of bearing capacity of the given connected members and of the connections between them as defined by SNiP II-23-81* [17]. If some of numerical

parameters have not been defined, the application will obtain them automatically from the conditions of proper bearing capacity and structural constraints defined by building codes. The result will include the value of the maximum factor, K_{max} (a constraint utilization factor) and a type of code-defined check in which this maximum takes place. A complete list of the checks and values of the respective constraint utilization factors is available by clicking the **Factors** button.

As you switch to the **Drawing** tab, the application does the check the joint as in the **Calculate** mode. If the results of structural assessment of the joint are not in contradiction with structural and building code requirements, a drawing will be generated for the joint design, at the detail design stage.

The functionality of the **Report** button and of controls in the **Drawing** tab is similar to that described for the **Rigid Column Bases** mode (see Sec. 1.7.1).

1.7.3 Beam-To-Beam joints

The **Beam-To-Beam Joints** mode is used to design and assess the bearing capacity of structural designs of erection joints between I- beams or H-beams where high strength bolts or ordinary bolts are used together with straps or end-plates. This mode comprises a wide range of possible structural designs for erection joints between beams:

- Beam-To-Beam joints with straps, using connections made with preloaded or non-preloaded bolts (Fig. 1.7.3-1);
- Beam-To-Beam joints with end-plate of various configurations, using connections made with high-strength bolts (Fig. 1.7.3-2).

The strap-based erection Beam-To-Beam joint has an advantage over Beam-To-Beam joints with end-plates: it does not require the members to be manufactured with a high accuracy. However, this kind of joint usually requires a much greater amount of bolts in comparison to Beam-To-Beam joints with end-plates, therefore it takes more effort to mount the structures. In addition, the strap-based joint entails the weakening of the cross-sections of connected members by holes. Sometimes this circumstance requires spending more steel for basic members of structures.

The Beam-To-Beam joints with end-plates are usually designed in such way that the height dimension of the end-plate conforms to that of the beam, or nearly so (see Fig. 1.7.3-2, a). If the bending moment acting in connected beams can hardly be resisted by bolts placed between the beam flanges, it becomes necessary to use structural schemes that involve external rows of bolts. The latter expand the end-plate dimension downward (see Fig. 1.7.3-2, b, d) or upward (see Fig. 1.7.3-2, c, e), depending on the prevailing sign of the bending moment. If there are significant alternating-sign bending moments, you should use structural designs for the Beam-To-Beam joints with end-plates where external bolts are placed on both sides of the beam (see Fig. 1.7.3-2, f, g).

This mode performs the following checks in compliance with SNiP II-23-81* [17]:

- Resistance of the straps and flanges;
- Resistance of the bolted and welded connections which make up the joint;
- a number of structural and catalogue-based constraints.

The main dialog box of the **Beam-To-Beam Joints** mode contains four tabs: **Materials** (Fig. 1.7.3-3, 1.7.3-4), **Efforts** (Fig. 1.7.3-5), **Construction** (Fig. 1.7.3-6, 1.7.3-7), and **Drawing**.

To get started in the **Beam-To-Beam Joints** mode, begin with assigning materials for connected members. To specify a steel grade for the connected beams, use the **Steel** dialog box which opens when you click the button Ст in the **Materials** tab**.** Sec. 1.6.1 provides a detailed description of the functionality available in this mode.

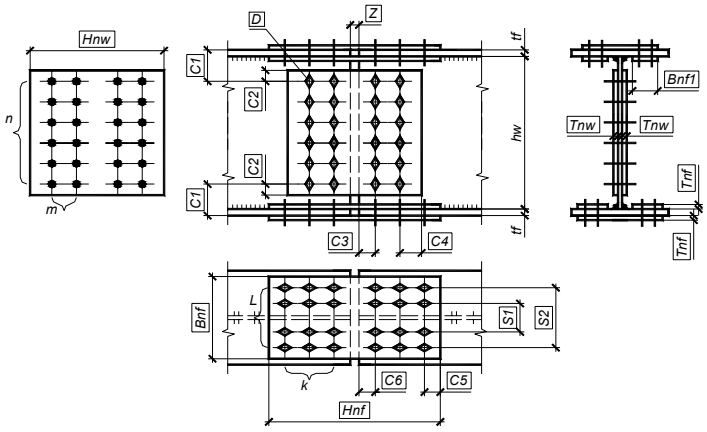
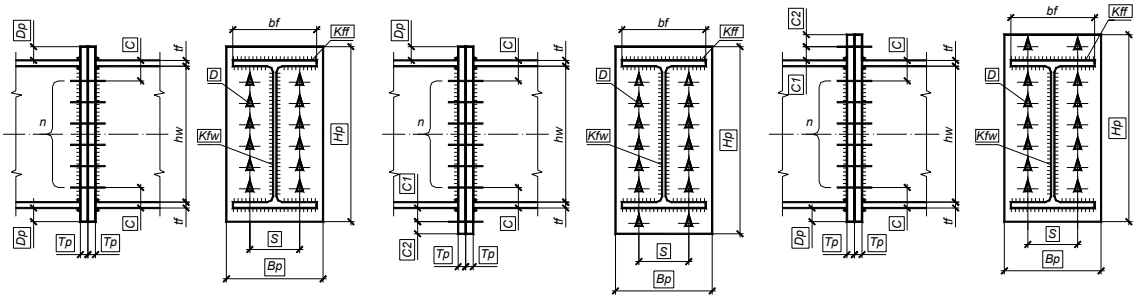
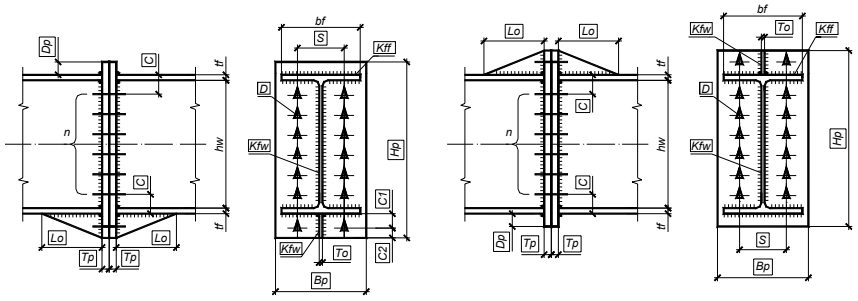


Fig. 1.7.3-1. A structural design of the Beam-To-Beam joint where straps are used





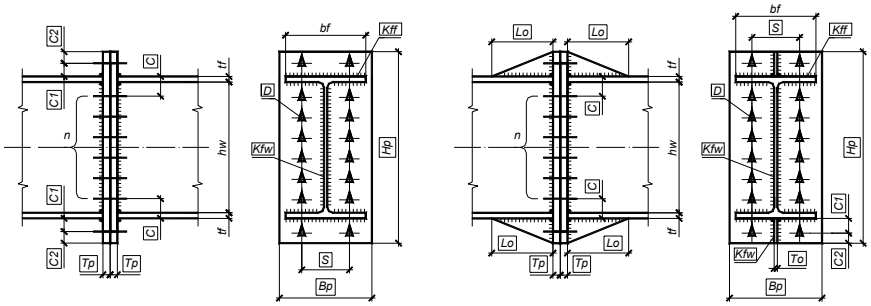


Fig. 1.7.3-2. Structural designs of the Beam-To-Beam joints with end-plate

Note that the steel grade for structural connected members (straps or end-plate) is always the same as that for the basic load-bearing members, beams.

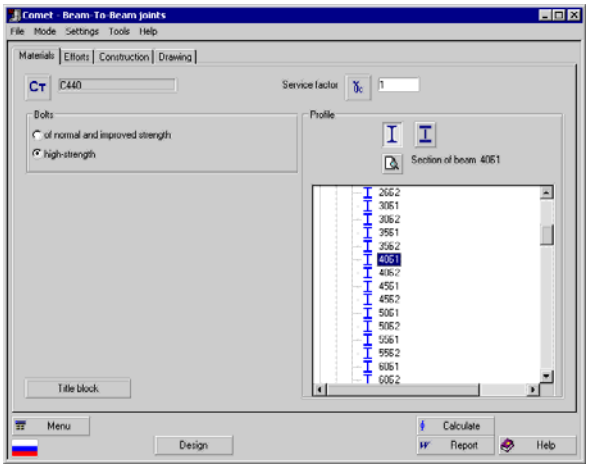


Fig. 1.7.3-3. *The* **Materials** *tab of the* **Beam-To-Beam Joints** *mode* (a rolled I- or H-section has been selected as a beam cross-section type)

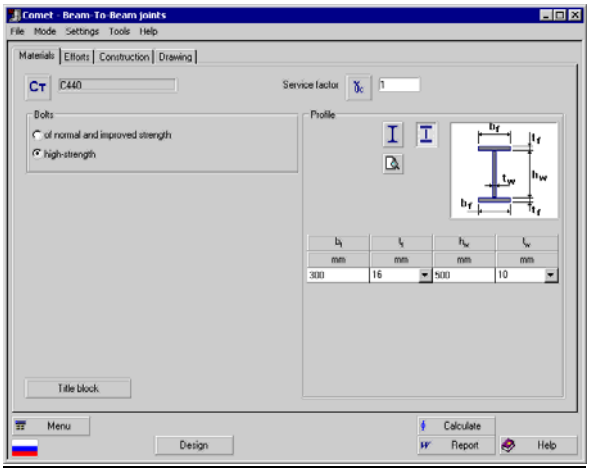


Fig. 1.7.3-4. *The* **Materials** *tab of the* **Beam-To-Beam Joints** *mode* (a weldable I- or H-section has been selected as a beam cross-section type)

The service factor for the connected members can be entered in an appropriate text field, or selected in the **Service Factors** dialog box after clicking the button nearby ( ). Sec. 1.6.5 provides a detailed description of the functionality available in this dialog box.

Use radio buttons from the **Bolts** group to set the type of bolts to be used in Beam-To-Beam joints: either preloaded or non-preloaded bolts.

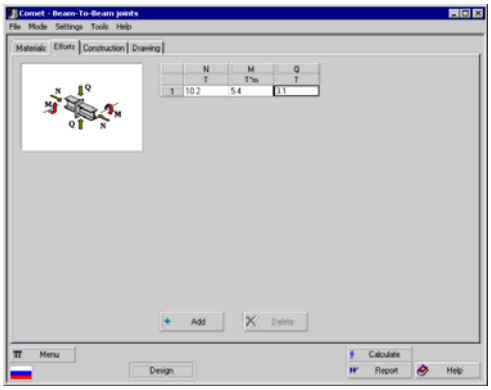


Fig. 1.7.3-5. *The* **Efforts** *tab of the* **Beam-To-Beam Joints** *mode*

Controls in the **Profile** group are used to define the type and sizes of the cross-sections of connected beams. The **Beam-To-Beam Joints** mode suggests two types of beam cross-sections: either rolled or weldable I- or H-section. The section type is assigned by clicking one of the buttons or . According to the choice you have made, the appearance of the right part of the **Materials** tab will change (Fig. 1.7.3-3, 1.7.3-4). If the beam's section type is a rolled I- or H-section, you need to find a catalogue and No. of the profile in the catalogue in a tree-like list. If the beam's section type is a weldable I- or H-section, then you need to define the sizes of the beam's cross-section: height h_w and thickness t_w of the beam's web, width b_f and thickness t_f of the beam's flanges. The thickness of the web and the flanges can be either entered manually or selected from drop-down lists where catalogue sizes of rolled steel are given.

You can check up a graphical representation of the specified beam cross-section in a preview window which opens by clicking the **Preview** button ( ).

The **Construction** tab contains buttons combined into the **Type of Joint** group, which are used to select a particular structural design for the beam-to-beam joint (Fig. 1.7.3-6, 1.7.3-7).

Clicking the **Title Block** button will open a dialog box where you fill the title block for the drawing which will be generated automatically after the structural design of the beam-to-beam joint is completed. Sec. 1.7.1 provides a full account on working with the **Title Block** dialog box.

The **Efforts** tab (Fig. 1.7.3-5) is used to specify design internal forces acting in the beam-to-beam joint: the axial compressive force, N , the bending moment, M , and its respective shear force, Q . When you click the **Add** button, the table of the internal force opens a new row where you need to enter design values of the internal forces for the current load case combination. There can be any number of the design load case combinations. The default unit of measurement for axial and shear forces is ton, and for the bending moments is ton×meter. The positive direction of the internal forces is defined by the picture to the left from the table of internal forces.

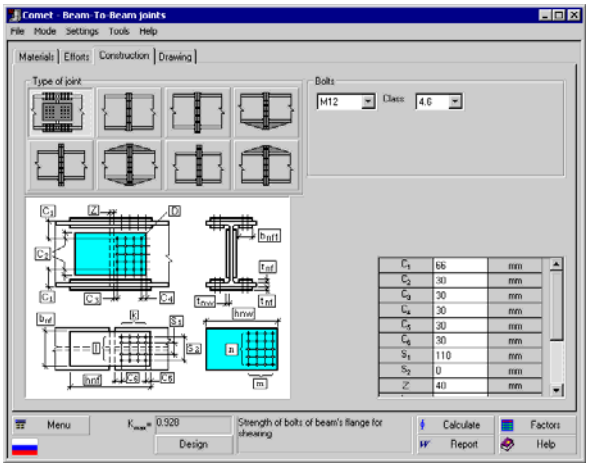


Fig. 1.7.3-6. *The* **Construction** *tab of the* **Beam-To-Beam Joints** *mode* (a beam-to-beam joint with strap and connections made with non-preloaded bolts is selected)

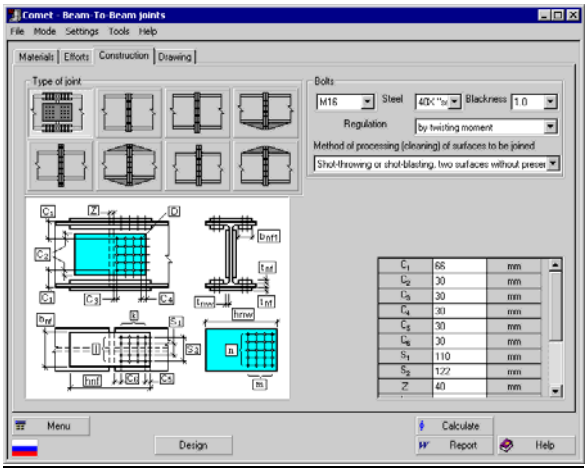


Fig. 1.7.3-7. *The* **Construction** *tab of the* **Beam-To-Beam Joints** *mode* (a beam-to-beam joint with end-plate and connections made with preloaded bolts is selected)

If non-preloaded bolts are to be used, you need to specify the grade (diameter) of the bolts and their strength class in drop-down lists under the **Bolts** group of controls. If preloaded (high strength) bolts are to be used, you need to specify the grade (diameter) of the bolts, their steel grade, their blackness (the difference between the diameter of the bolt hole and of the bolt itself), a method for regulating the bolt's tightness, and a method for processing (cleaning) the surfaces of members that participate in the joint.

To perform a structural assessment of a known structural design of the beam-to-beam joint, you need to provide all design parameters of the joint. The design parameters include the sizes and thickness of structural connected members, the diameters of bolts, sizes which regulate the mutual arrangement of the members, leg lengths of fillet welds, the number of bolts, the number of rows of bolts etc. The design parameters of the joint are entered in the table on the right. The default units of all linear measurement are millimeters.

Clicking the **Design** button will invoke the mode of automatic proportioning of the parameters for the given beam-to-beam joint type. This mode assumes the parameters to be previously unknown; they are to be found from the conditions of proper bearing capacity plus structural constraints defined by building codes. Any previously specified data are ignored in this mode. In addition, the mode calculates the value of maximum factor K_{max} (a constraint utilization factor) and indicates a type of code-defined check in which this maximum takes place. Then a drawing of the joint design at the detail design stage is generated.

When you click the **Calculate** button, the application performs the check of bearing capacity of the given basic components of the joint and of the connections between them as defined by SNiP II-23-81* [17]. If some of numerical parameters have not been defined, the application will obtain them automatically from the conditions of proper bearing capacity and structural constraints defined by building requirements. The result will include the value of the maximum factor, K_{max} (a constraint utilization factor) and a type of code-defined check in which this maximum takes place. A complete list of the checks and values of the respective constraint utilization factors is available by clicking the **Factors** button.

Table 1.7.3-1. A list of checks of bearing capacity of the basic components of the joint and connections in structural designs of beam-to-beam joints, in compliance with SNiP II-23-81*

No	Entitlement of check	Type of joint	Reference to SNiP II-23-81*
1.	Shear resistance of the bolts in connection between straps and beam's web	Fig. 1.7.3-1	Sec. 11.7*, (127)
2.	Shear resistance of the bolts in connection between straps and beam's flanges	Fig. 1.7.3-1	Sec. 11.7*, (127)
3.	Bearing resistance of the bolts in connection between straps and beam's web	Fig. 1.7.3-1	Sec. 11.7*, (128)
4.	Bearing resistance of the bolts in connection between straps and beam's flanges	Fig. 1.7.3-1	Sec. 11.7*, (128)
5.	Resistance of the bolts in connection between straps and beam's web	Fig. 1.7.3-1	Sec. 11.7*, (127), (128)
6.	Resistance of the bolts in connection between straps and beam's flanges	Fig. 1.7.3-1	Sec. 11.7*, (127), (128)
7.	Resistance of the bolts located in the area of the beam's upper flange	Fig. 1.7.3-2	Sec. 11.7*, (127), (128)
8.	Resistance of the bolts located in the area of the beam's lower flange	Fig. 1.7.3-2	Sec. 11.7*, (127), (128)
9.	Resistance of the bolts located in the area of the beam's web	Fig. 1.7.3-2	Sec. 11.7*, (127), (128)
10.	Resistance of the end-plate in bending	Fig. 1.7.3-2	
11.	Resistance of welded connection between the end plate and beam's web	Fig. 1.7.3-2	Sec. 11.2*, (120), (121), (122), (123)
12.	Resistance of welded connection between the end plate and beam's flanges	Fig. 1.7.3-2	Sec. 11.2*, (120), (121), (122), (123)

Notes: see Table 1.7.2-1.

As you switch to the **Drawing** tab, the application does a check of the joint similarly to the **Calculate** mode. If the results of structural assessment of the joint are not in contradiction with structural and building code requirements, a drawing will be generated for the joint design, at the detail design stage.

The functionality of the **Report** button and controls on the **Drawing** tab is similar to that in the **Rigid Column Bases** mode (see Sec. 1.7.1).

1.7.4 Truss panel points

The **Truss Panel Points** mode is used to design and make structural assessments of designs of truss nodes where the bars are made of double angles or rectangular (square) pipes. The mode implements a wide range of truss node designs, such as:

- Joint between truss web and truss chord (regular panel points) (Fig. 1.7.4-1, 1.7.4-2);
- Chord panel point where the chord changes its cross-section (Fig. 1.7.4-4);
- Erection joints of trusses (Fig. 1.7.4-5);
- Bearing panel point of trusses (Fig. 1.7.4-3, 1.7.4-6).

The mode performs the following checks in compliance with SNiP II-23-81* [17]:

- Resistance of the basic joint components (such as straps, bearing ribs or end-plates, nodal and bearing gusset plates);
- Resistance of welded connections (connection between truss web and gusset plate in regular nodes,

connection between truss chord and gusset plate in regular node, connection between straps and truss chord in truss nodes where the chord section changes and in erection joints, connection between bearing gusset and bearing ribs (end plate) in bearing nodes of the truss);

- Resistance of bolted connections (connection between bearing ribs (end-plate) and supporting constructions);
- Number of structural and catalogue-based constraints.

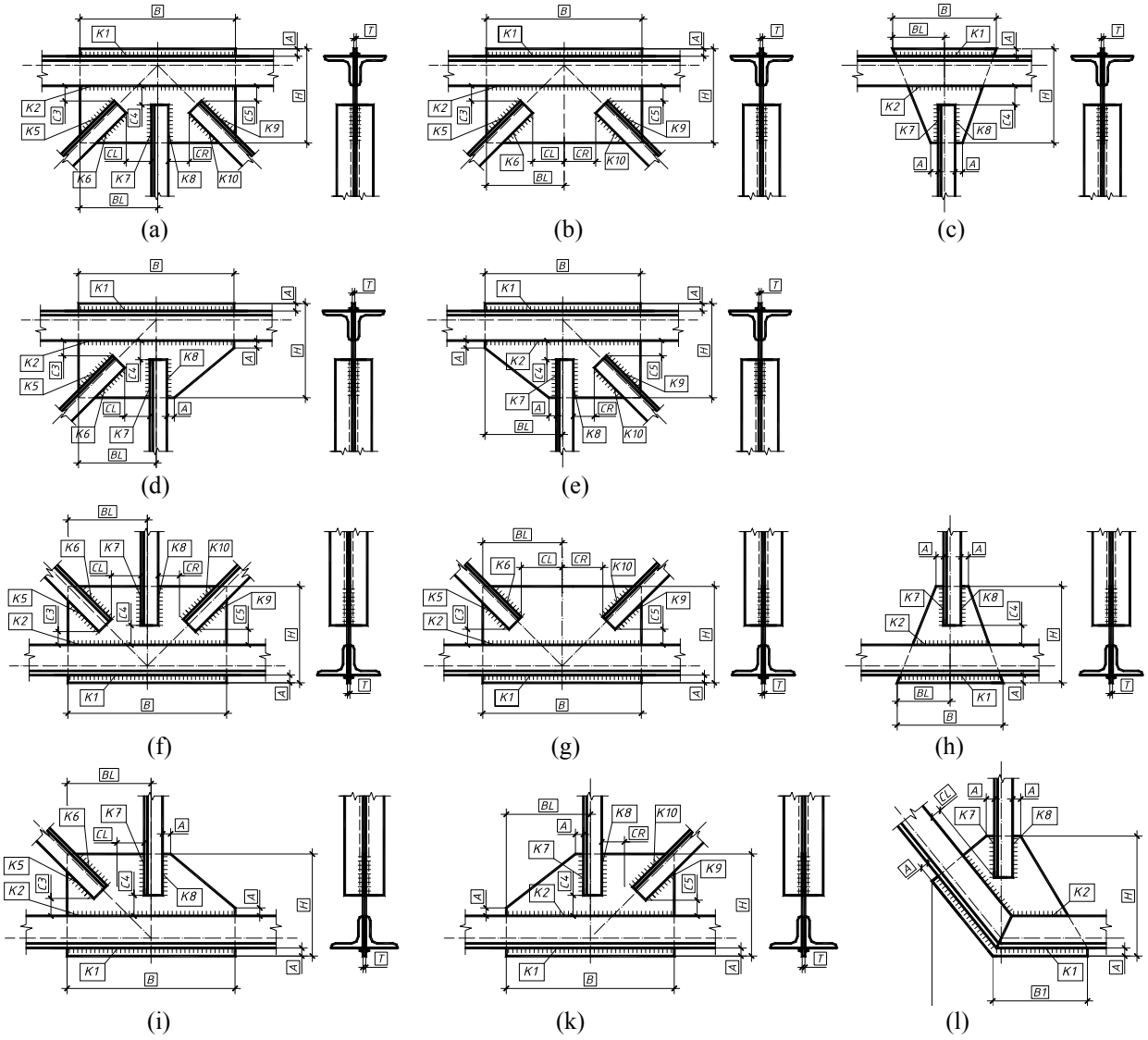


Fig. 1.7.4-1. Regular panel points in trusses with elements made of double angles

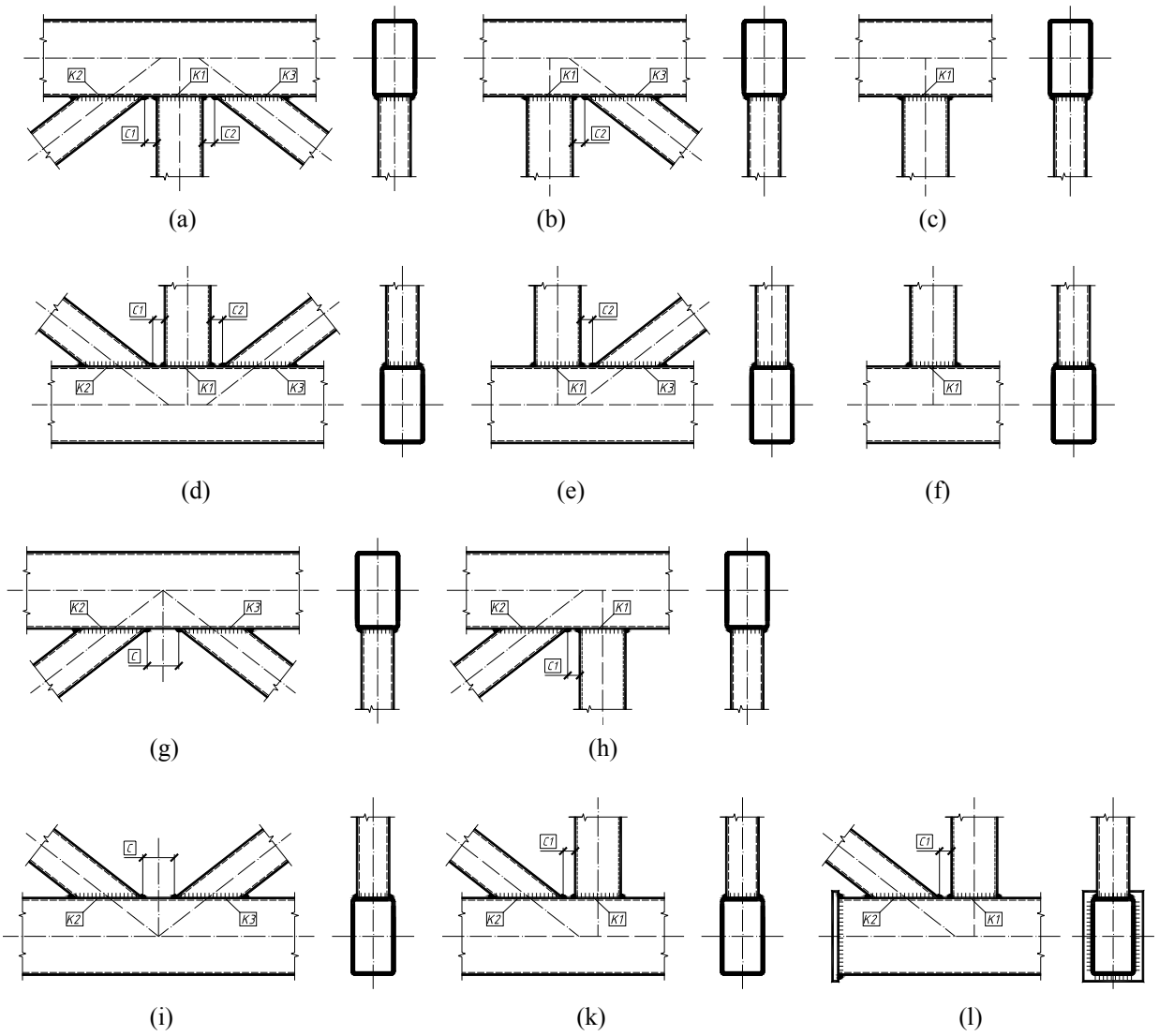
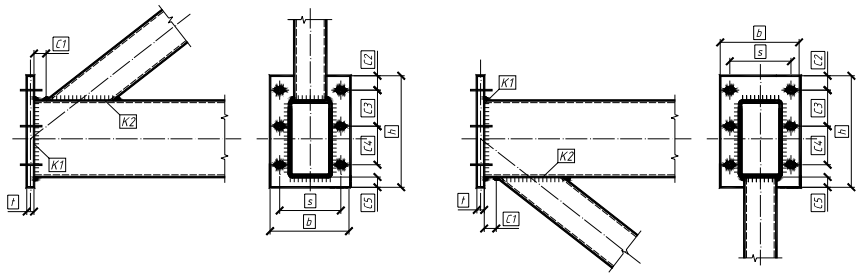
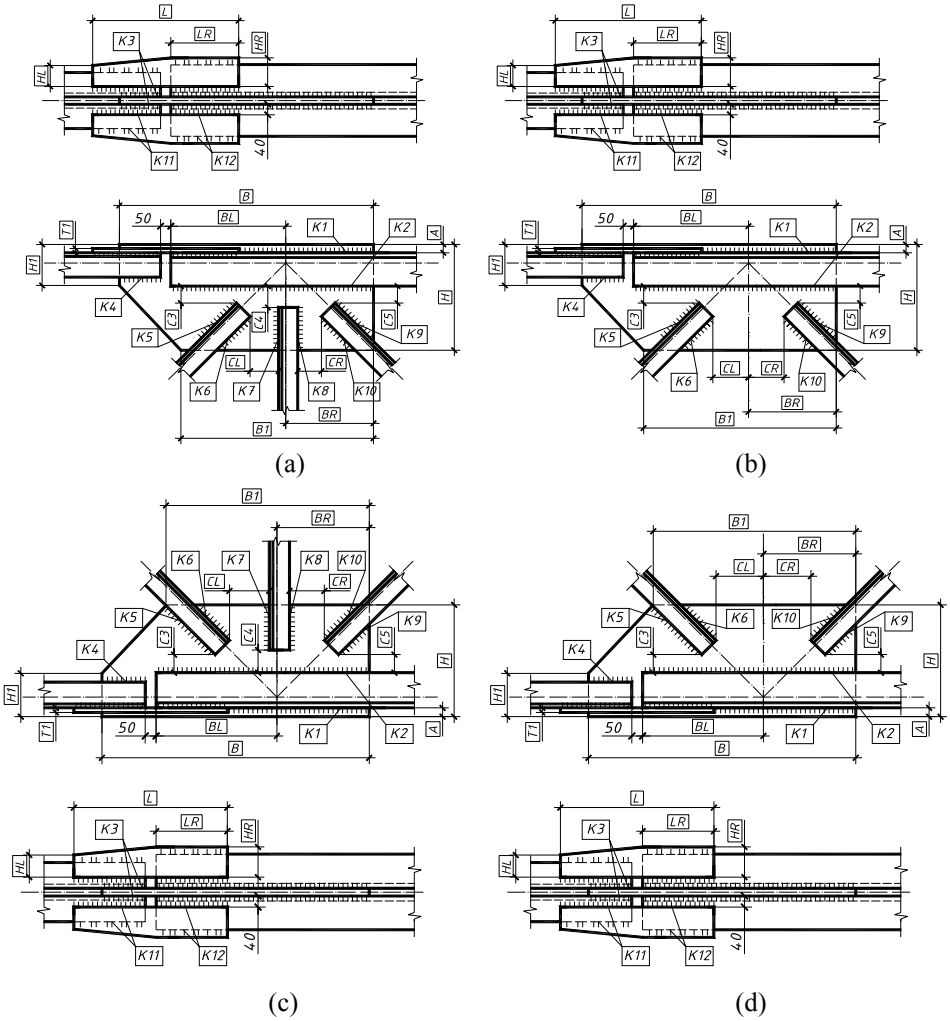


Fig. 1.7.4-2. Regular panel points in trusses with elements made of rectangular (square) pipes.



(a) (b)

Fig. 1.7.4-3. Bearing panel points in trusses with elements made of rectangular (square) pipes.



(a) (b)

(c) (d)

Fig. 1.7.4-4. Chord panel point where the chord changes its cross-section in trusses with elements made of double angles.

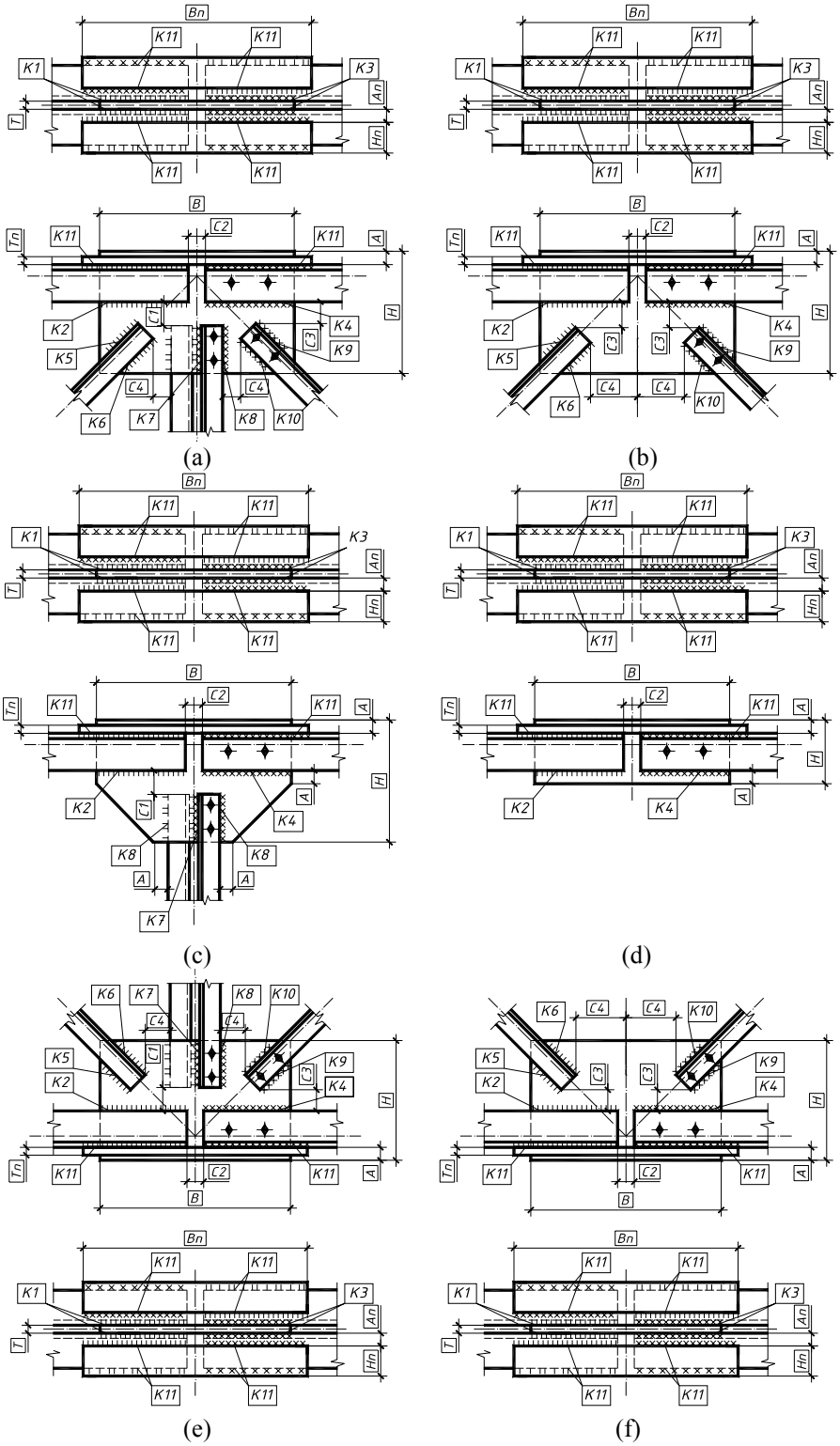
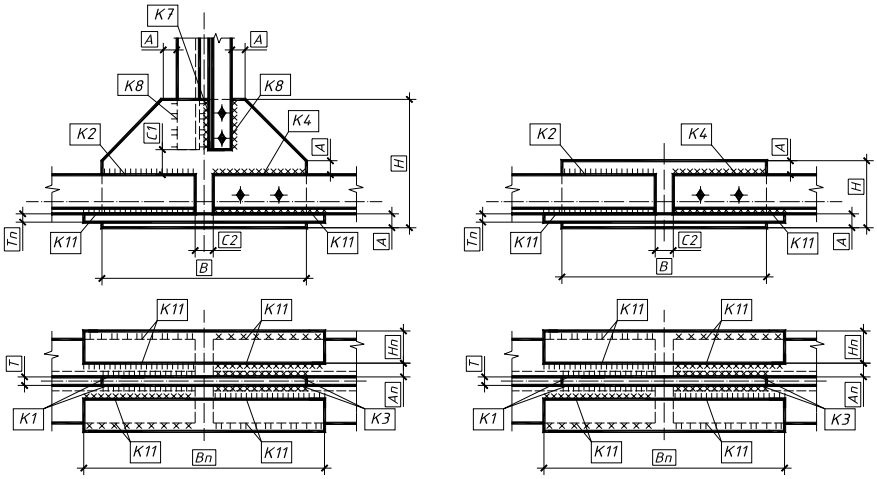
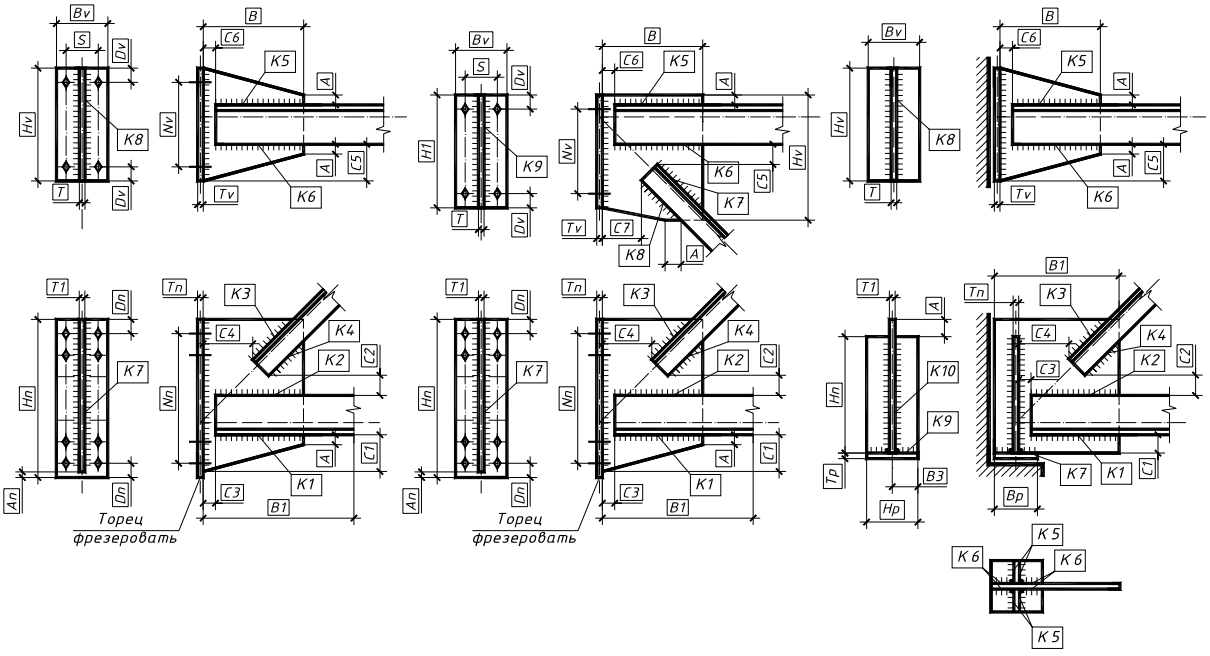


Fig. 1.7.4-5. Erection joints in trusses with elements made of double angles.



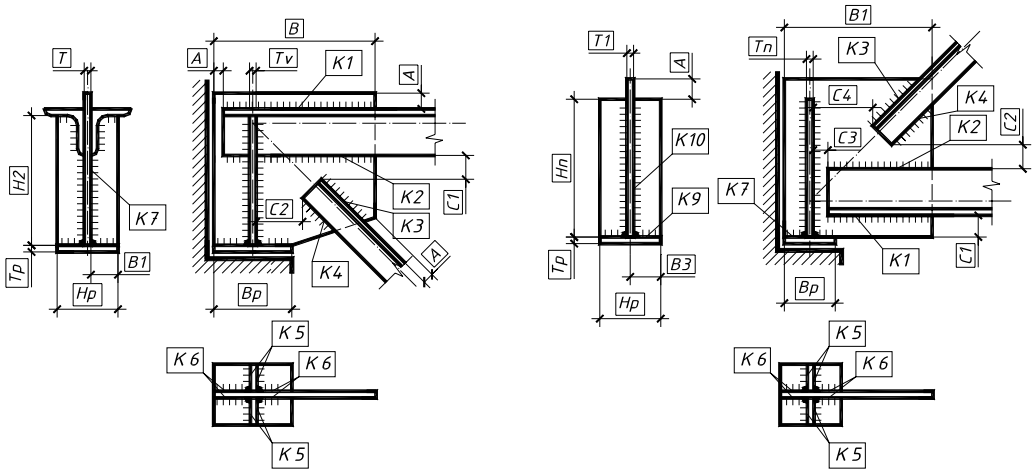
(g) (h)

Fig. 1.7.4-5 continued. Erection joints in trusses with elements made of double angles.



(a) (b) (c)

Fig. 1.7.4-6. Bearing panel points in trusses with elements made of double angles.



(d) (e)

Fig. 1.7.4-6. Bearing panel points in trusses with elements made of double angles.

The main dialog box of the **Truss Panel Points** mode contains six tabs: **Type of Panel Point** (Fig. 1.7.4-7), **Materials** (Fig. 1.7.4-8), **Efforts** (Fig. 1.7.4-9), **Members of Panel Point** (Fig. 1.7.4-10), **Construction** (Fig. Fig. 1.7.4-11), and **Drawing**.

The **Type of Panel Point** tab (Fig. 1.7.4-7) contains buttons which you use to select a truss node type (**Regular Panel Point**, **Change of Chord Section**, **Erection Joint**, or **Bearing Panel Point**) and set up its configuration. To define the type of cross-section for the bar members of the truss, use appropriate buttons in the **Structural Scheme** group.

The same tab contains the **Title Block** button. Click it and fill in the title block of the drawing which will be generated automatically after the structural design of the truss node is completed. Sec. 1.7.1 provides a full guide to working with the **Title Block** dialog box.

The **Materials** tab (Fig. 1.7.4-8) presents materials used in the construction of the truss panel point. The **General Properties** group displays the steel grade for basic components of the joint (truss web, truss chord, gusset plates, straps, bearing ribs etc.). You can choose a steel grade for these members in the **Steel** dialog box which opens when you click the nearby button Ст. Sec. 1.6.1 explains how to work with the **Steel** mode.

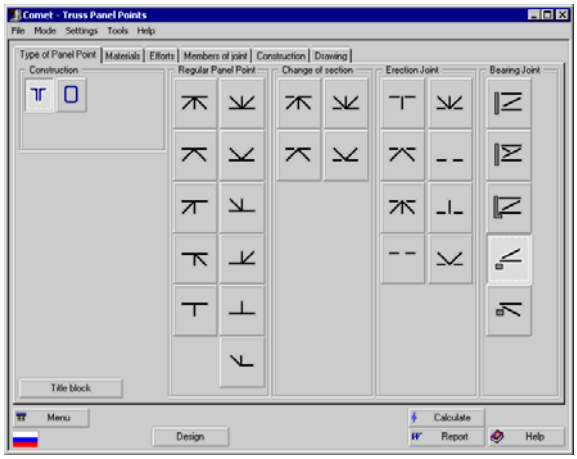


Fig. 1.7.4-7. *The* **Type of Panel Point** *tab of the* **Truss Panel Points** *mode*

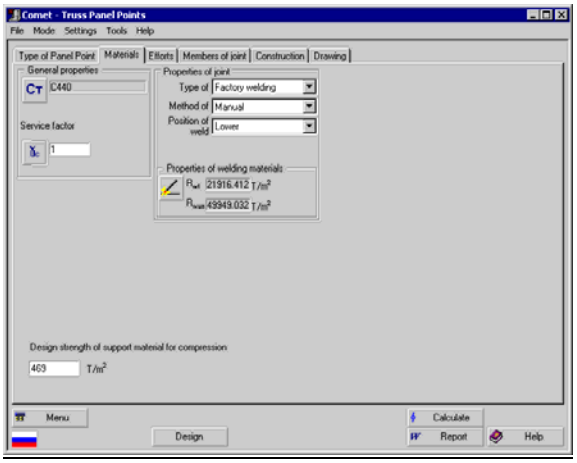


Fig. 1.7.4-8. *The* **Materials** *tab of the* **Truss Panel Points** *mode*

The **Properties of Joint** group is used to set the type and method of welding, and specify the position of the welded connection; use appropriate drop-down lists to do that. The **Truss Panel Points** mode implements methods of welding defined in Table 34* of SNiP II-23-81*, such as manual welding, semiautomatic welding with solid wire less than 1.4 mm in diameter, automatic and semiautomatic welding with the welding wire 1.4 to 2.0 mm in diameter, automatic welding with the wire 3 to 5 mm in diameter, and semiautomatic welding with flux-cored wire. The weld can be in the gravity, as well as bottom, horizontal, vertical or overhead, position. The **Properties of Welding Materials** group displays values of the design resistance of the fillet welds for conventional shear in the deposited weld metal, R_{wf}, and of the design resistance of the weld's metal, R_{wun}. These values can be set in the **Welding Materials** dialog box which opens when you click the button  . Sec. 1.6.4 provides a guide to working with the **Welding Materials** mode.

The **Efforts** tab (Fig. 1.7.4-9) is used to specify axial design forces N_i which take place in bar members of the truss panel point in question. Clicking the **Add** button adds a new row to the table where you need to enter design internal forces values for the current load case combination. The number of design load case combinations is not limited. The default unit of measurement for the axial force is ton. The sign convention for the internal forces is depicted in an image near the table of the internal forces, where their positive direction is indicated.

The **Members of Panel Point** tab (Fig. 1.7.4-10) is used to define general dimensions (width and height) of panels adjacent to the truss panel point in question (parameters *a*, *b*, *c*, and *d*). The default unit of measurement for the dimensions of truss panels is meter. The **Section** group is used to specify cross-sections of connected members and their orientation with respect to the truss plane.

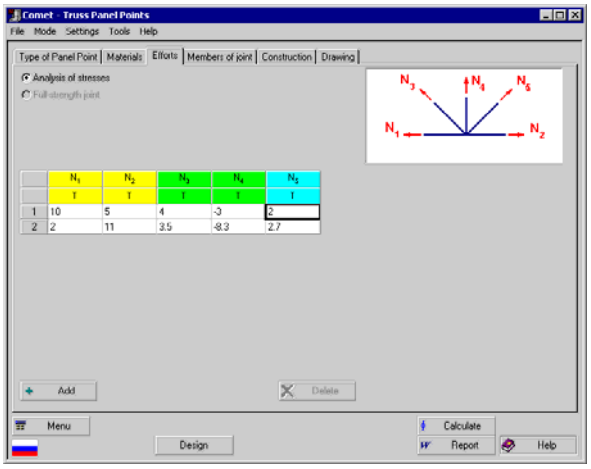


Fig. 1.7.4-9. *The* **Efforts** *tab of the* **Truss Panel Points** *mode*

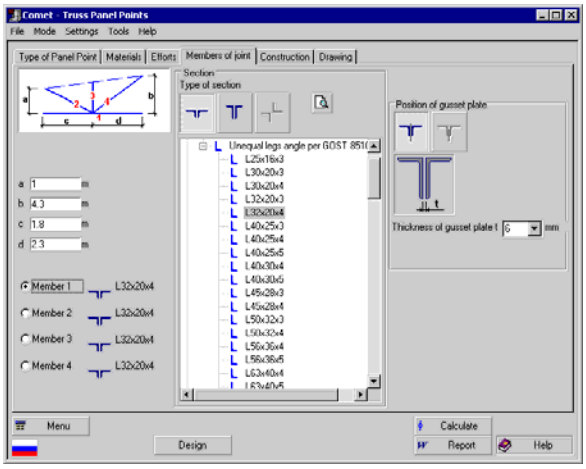


Fig. 1.7.4-10. *The* **Members of Panel Point** *tab of the* **Truss Panel Points** *mode*

The **Type of Section** buttons allow you to choose:

- a section of double equal angles or of double unequal angles the longer flange of which is perpendicular to the truss plane;
- a section of double equal angles or of double unequal angles the longer flange of which is parallel to the truss plane;
- a section of equal angles arranged as a cross, which is used for columns of a erection node;
- a rectangular pipe section the longer side of which is parallel to the truss plane;
- a rectangular pipe section the longer side of which is perpendicular to the truss plane.

Note by the way that the set of buttons **Type of Section** depends on a particular design of the node, which is

defined on the **Type of Panel Point** tab in the **Structural Scheme** group.

Each element or member in the truss panel point is associated with a number (such as 

). To assign profiles to the truss members, you need to turn on the respective radio button of the desired member and choose a profile for it from the rolled steel catalogue. To see a graphical representation of the cross-sections specified for the truss members, you can use a preview window which opens when you click the **Preview** button ().

In the **Position of Gusset Plate** group, you need to specify the position of the gusset plate by clicking appropriate buttons. Select the thickness of the gusset plate from the drop-down list of the respective title, which presents a set of thickness values from the standard sheet and plate steel catalogue.

The **Construction** tab (Fig. 1.7.4-11) shows a draft of the structural design for the truss panel point in a pane.

To perform a structural assessment of a known (specified) structural design of the truss panel point, you need to provide all design parameters. The design parameters include the sizes and thickness of the basic components of the joint, leg lengths of the fillet welds, sizes which regulate the mutual arrangement of the connected members, the diameters of bolts, the number of bolts, the number of rows of bolts etc. The design parameters of the joint are entered in the table on the left. Leg lengths of the fillet welds are entered in a table at the bottom of the dialog. The default units of all linear measurement are millimeters.

Clicking the **Design** button will invoke the mode of automatic proportioning of the parameters for the given truss panel point type. This mode assumes the parameters to be previously unknown; they are to be found from the conditions of proper bearing capacity plus structural constraints defined by building codes. Any previously specified data are ignored. In addition, the mode calculates the value of maximum factor K_{max} (a constraint utilization factor) and indicates a type of code-defined check in which this maximum takes place. Then a drawing of the truss panel point design at the detail design stage is generated.

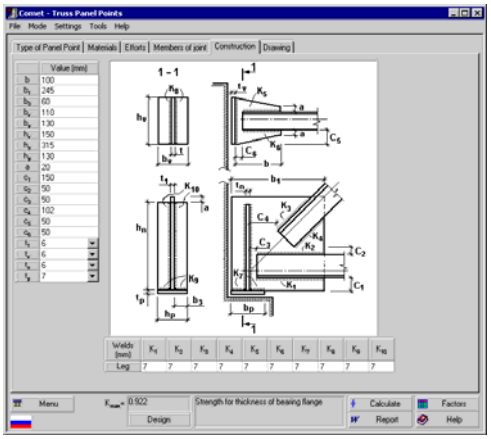


Fig. 1.7.4-11. *The* **Construction** *tab of the* **Truss Panel Points** *mode*

When you click the **Calculate** button, the application performs the check of bearing capacity of the basic components of the joint and of the connections between them as defined by SNiP II-23-81* [17]. If some of numerical parameters have not been defined, the application will obtain them automatically from the conditions of proper bearing capacity and structural constraints defined by building requirements. The result will include the value of the maximum factor, K_{max} (a constraint utilization factor) and a type of code-defined check in which this maximum takes place. A complete list of the checks and values of the respective constraint utilization factors is available by clicking the **Factors** button.

Table 1.7.4-1. A list of checks of bearing capacity of basic components of the joint and connections in structural designs of truss panel points, in compliance with SNiP II-23-81*[17] and Guide to SNiP II-23-81*[19]

No	Entitlement of check	Type of panel point	Reference to codes
	Regular panel points of trusses with elements made of double angles:	**Fig. 1.7.4-1**	
1.	Resistance of the welded connection between the truss chord and the gusset plate	a, b, c, d, e, f, g, h, i, k, l	Sec. 11.2, (120), (121) [17]
2.	Resistance of welded connection between the vertical truss member and the gusset plate	a, c, d, e, h, i, k, l	Sec. 11.2, (120), (121) [17]
3.	Resistance of welded connection between the left diagonal and the gusset plate	a, b, d, f, g, i, l	Sec. 11.2, (120), (121) [17]
4.	Resistance of welded connection between the right diagonal and the gusset plate	a, b, e, f, g, k	Sec. 11.2, (120), (121) [17]
	Regular panel points of trusses with elements made of rectangular (square) pipes:	**Fig. 1.7.4-2**	
5.	Resistance of the chord's web in punching shear	a, b, c, d, e, f, g, h, i, k, l	Sec. 15.10, 15.11, (92), (94) [19]
6.	Resistance of the chord's web in the node plane, in the place where the vertical truss member abuts	a, b, c, d, e, f, h, k, l	Sec. 15.12, (95) [19]
7.	Resistance of the chord's web in the node plane, in the place where the left diagonal abuts	a, d, g, h, i, k, l	Sec. 15.12, (95) [19]
8.	Resistance of the chord's web in the node plane, in the place where the right diagonal abuts	a, b, d, e, g, i	Sec. 15.12, (95) [19]
9.	Resistance of the vertical truss member in the area where it abuts to the truss chord	a, b, c, d, e, f, h, k, l	Sec. 15.13, (96), (97) [19]
10.	Resistance of the left diagonal in the area where it abuts to the truss chord	a, d, g, h, i, k, l	Sec. 15.13, (96), (97) [19]
11.	Resistance of the right diagonal in the area where it abuts to the truss chord	a, b, d, e, g, i	Sec. 15.13, (96), (97) [19]
12.	Resistance of the welded connection between vertical truss member and truss chord	a, b, c, d, e, f, h, k, l	Sec. 15.14, (98), (99) [19]
13.	Resistance of the welded connection between left diagonal and truss chord	a, d, g, h, i, k, l	Sec. 15.14, (98), (99) [19]
14.	Resistance of the welded connection between right diagonal and truss chord	a, b, d, e, g, i	Sec. 15.14, (98), (99) [19]
	Bearing panel points of trusses with elements made of rectangular (square) pipes:	**Fig. 1.7.4-3**	
15.	Resistance of the bearing rib in local bearing	a, b	
16.	Overall stability of the bearing rib	a, b	Sec. 5.3, (7) [17]
17.	Resistance of the chord's web in punching shear	a, b	Sec. 15.10, 15.11, (92), (94) [19]
18.	Resistance of the chord's web in the node plane, in the place where the bearing diagonal abuts	a, b	Sec. 15.12, (95) [19]
19.	Resistance of the bearing diagonal in the area where it abuts to the truss chord	a, b	Sec. 15.13, (96), (97) [19]
20.	Resistance of the welded connection between the truss chord and the bearing rib	a, b	Sec. 11.2, (120), (121) [17]

No	Entitlement of check	Type of panel point	Reference to codes
21.	Resistance of the welded connection between bearing diagonal and truss chord	a, b	Sec. 15.14, (98), (99) [19]
	Truss panel points where the chord's section changes, in trusses with elements made of double angles:	**Fig. 1.7.4-4**	
22.	Resistance of the welded connection between the truss chord and the gusset plate	a, b, c, d	Sec. 11.2, (120), (121) [17]
23.	Resistance of the welded connection between the vertical truss member and the gusset plate	a, c	Sec. 11.2, (120), (121) [17]
24.	Resistance of the welded connection between the left diagonal and the gusset plate	a, b, c, d	Sec. 11.2, (120), (121) [17]
25.	Resistance of the welded connection between the right diagonal and the gusset plate	a, b, c, d	Sec. 11.2, (120), (121) [17]
26.	Resistance of the strap in tension	a, b, c, d	Sec. 5.1, (5) [17]
27.	Resistance of the welded connection between the strap and the flange of the chord of the bigger cross-section	a, b, c, d	Sec. 11.2, (120), (121) [17]
28.	Resistance of the welded connection between the strap and the flange of the chord of the smaller cross-section	a, b, c, d	Sec. 11.2, (120), (121) [17]
	Erection joints of trusses with elements made of double angles:	**Fig. 1.7.4-5**	
29.	Resistance of the welded connection between the chord of the truss's left panel and the gusset plate	a, b, c, d, e, f, g, h	Sec. 11.2, (120), (121) [17]
30.	Resistance of the welded connection between the chord of the truss's right panel and the gusset plate	a, b, c, d, e, f, g, h	Sec. 11.2, (120), (121) [17]
31.	Resistance of the welded connection between the vertical truss member of the truss's left panel and the gusset plate	a, c, e, g	Sec. 11.2, (120), (121) [17]
32.	Resistance of the welded connection between the vertical truss member of the truss's right panel and the gusset plate	a, c, e, g	Sec. 11.2, (120), (121) [17]
	Resistance of the welded connection between the left diagonal and the gusset plate	a, b, e, f	Sec. 11.2, (120), (121) [17]
33.	Resistance of the welded connection between the right diagonal and the gusset plate	a, b, e, f	Sec. 11.2, (120), (121) [17]
34.	Resistance of the strap in tension	a, b, c, d, e, f, g, h	Sec. 5.1, (5) [17]
35.	Resistance of the welded connection between the strap and the flange of the chord of the truss's left panel	a, b, c, d, e, f, g, h	Sec. 11.2, (120), (121) [17]
36.	Resistance of the welded connection between the strap and the flange of the chord of the truss's right panel	a, b, c, d, e, f, g, h	Sec. 11.2, (120), (121) [17]
	Bearing panel points of trusses with elements made of double angles:	**Fig. 1.7.4-6**	
37.	Shear and bearing resistance of the bolts	e	Sec. 11.7*, (127), (128), Sec. 11.8, (130) [17]
38.	Tension resistance of the bolts	a, b, e	Sec. 11.7*, (129), Sec. 11.8, (130) [17]
39.	Resistance of the bearing flange (end-plate) in bending	a, b	Sec. 5.12, (28) [17]
40.	Resistance of the bearing rib in local bearing	e	
41.	Overall stability of the bearing rib	e	Sec. 5.3, (7) [17]
42.	Local stability of overhangs of the bearing rib's flanges	e	Sec. 7.23*, Table 29* [17]

No	Entitlement of check	Type of panel point	Reference to codes
43.	Resistance of the welded connection between the truss chord and the bearing gusset	a, b, c, d, e, f	Sec. 11.2, (120), (121) [17]
44.	Resistance of the welded connection between the bearing diagonal and the bearing gusset	b, c, d, e, f	Sec. 11.2, (120), (121) [17]
45.	Resistance of the welded connection between the bearing rib and the bearing gusset	d, e, f	Sec. 11.2, (120), (121), Sec. 11.3*, (122), (123), Sec. 11.5, (126) [17]
46.	Resistance of the welded connection between the bearing flange and the bearing gusset	a, b, c	Sec. 11.2, (120), (121), Sec. 11.3*, (122), (123), Sec. 11.5, (126) [17]
47.	Resistance of the base plate in bending under compression	d, f	
	Notes: see Table 1.7.2-1.		

As you switch to the **Drawing** tab, the node will undergo a structural assessment immediately, as in the **Calculate** mode. If the results obtained by analysis of parameters of the truss panel point members are not in contradiction with structural and code-based requirements, then a drawing of the node's structural design, at the detail design stage, will be generated.

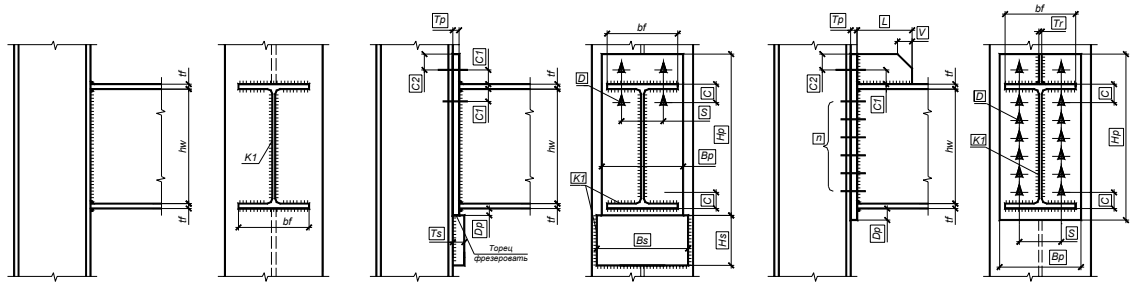
The functionality of the **Report** button and controls on the **Drawing** tab is quite similar to that in the **Rigid Column Bases** mode (see Sec. 1.7.1).

1.7.5 Beam-To-Column joint

The **Beam-To-Column Joint** mode is used to design and make structural assessments of the bearing capacity of the structural designs of the beam-to-column joints. The joints in question can be classified into the following types by the conditions of resistance to internal forces applied to the joint or by the possibility for the beam and the column to rotate mutually:

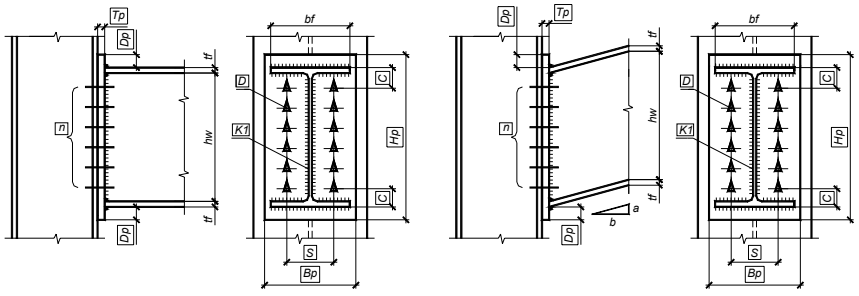
- rigid ones, which nearly immobilize the beam with respect to the column (Fig. 1.7.5-1);
- nominally pinned ones, which can hardly resist to rotation of the beam with respect to the column (Fig. 1.7.5-2).

Fig. 1.7.5-1 presents types of structural designs for rigid beam-to-column joints which are implemented in the application. There are a welded joint (see Fig. 1.7.5-1, a) and joints which use end-plate and high-strength bolts (see Fig. 1.7.5-1, b…g). Structural designs for the beam-to-column joints which use end-plate without a support table (see Fig. 1.7.5-1, c…g) are usually developed as friction joints with high-strength bolts. In cases when a significant bending moment acts in the joint, and the moment's magnitude exceeds the bearing capacity of the beam, the application can involve designs where tapered haunches are used (see Fig. 1.7.5-1, f, g).

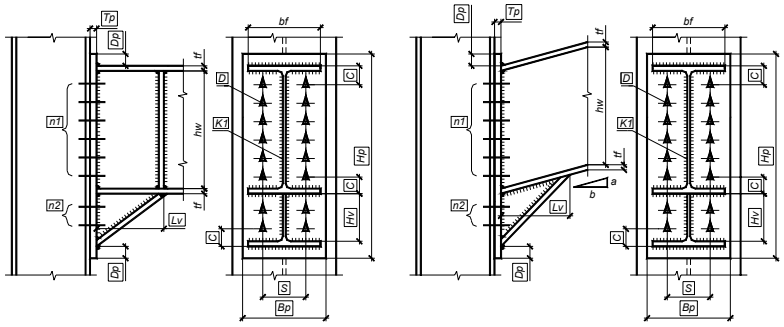


(a) (b) (c)

Fig. 1.7.5-1. Structural designs for the rigid beam-to-column joints

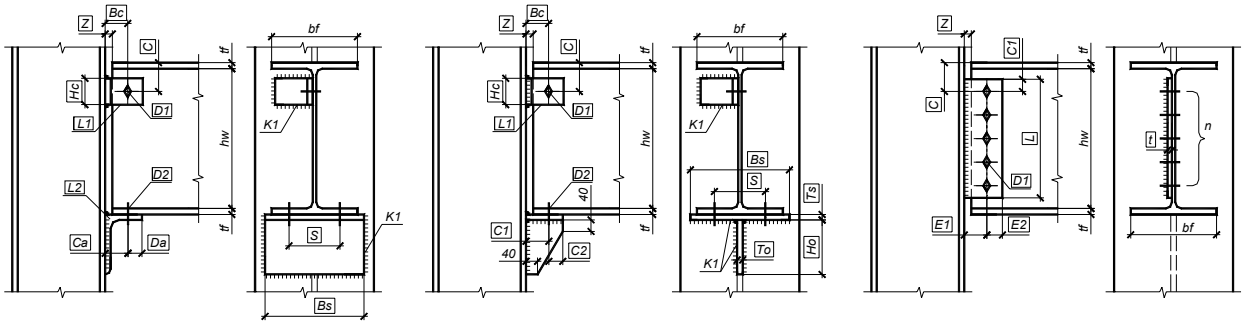


(d) (e)



(f) (g)

Fig. 1.7.5-1 continued. Structural designs for the rigid beam-to-column joints



(a) (b) (c)

Fig. 1.7.5-2. Structural designs for the pinned beam-to-column joints

Designs of the pinned beam-to-column joints, where non-preloaded bolts are commonly used, are simpler to make and to erect, they do not require a high accuracy of making, and they provide a sufficient freedom for the beam's supported cross-section to rotate about the column. Types of structural designs of pinned beam-to-column joints are presented in Fig. 1.7.5-2. The shear force which acts in the end section of the beam is transferred either onto an angle table (see Fig. 1.7.5-2, a) or onto a table welded into a tee (see Fig. 1.7.5-2, b). If the angle table is used, a part of the angle's horizontal flange can be cut off in order to avoid a big eccentricity in the transferring of the shear force (as the beam is able to rotate, the force can be transferred along the edge of the table). The application also suggests such a design of the beam-to-column joint in which the shear force is transferred via bolts onto a vertical rib welded to the column's flange (see Fig. 1.7.5-2, c).

The mode performs the following checks in compliance with SNiP II-23-81* [17]:

- resistance of the flanges, reinforcing ribs and tapered haunches;
- resistance of bolted and welded connections included in the joint;
- a number of structural and catalogue-based constraints.

The main dialog of the **Beam-To-Column Joint** mode contains five tabs: **Configuration** (Fig. 1.7.5-3), **Efforts** (Fig. 1.7.5-6), **Beam 1** (Fig. 1.7.5-7), **Beam 2** (Fig. 1.7.5-8), and **Drawing**.

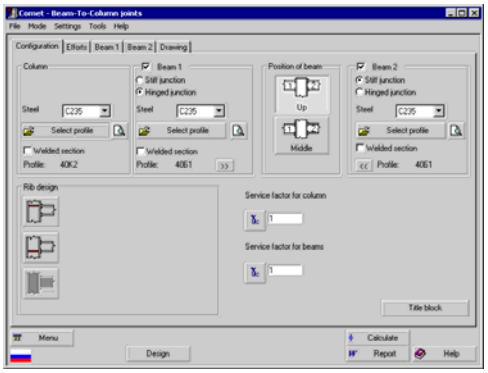


Fig. 1.7.5-3. The **Configuration** tab of the **Beam-To-Column Joint** mode

To get started in the **Beam-To-Column Joint** mode, begin with defining the general configuration of your joint in the **Configuration** tab **(**Fig. 1.7.5-3**)**. When the beam comes to the column from the left, turn on the checkbox (☑)**Beam 1**, and when it comes from the right, the checkbox **Beam2**. When there are both beams in the joint (left and right ones), both checkboxes (**Beam 1** and **Beam 2**) should be turned on. The group of buttons **Beams Position** is used to define the beams positions in their connection to the column. The upper position of the beams means a joint where the beams of the roofing are attached to the head of the column, and the middle position means the floor beams are attached to the column.

The **Column** group of controls is used to define a cross-section and a steel grade for the column. To choose the steel grade, use the **Steel** drop-down list of the **Column** group. If the column's cross-section type is a weldable I- or H-section, turn on the **Weldable Section** checkbox and click the **Choose Profile** button. In the **Sizes of Section** dialog box that appears (Fig. 1.7.5-4) you specify the sizes of the column's cross-section: height h_w and thickness t_w of the column's web, width b_f and thickness t_f of the column's flange; and then click the **OK** button. The default unit of measurement for the sizes of the column's cross-section is millimeter.

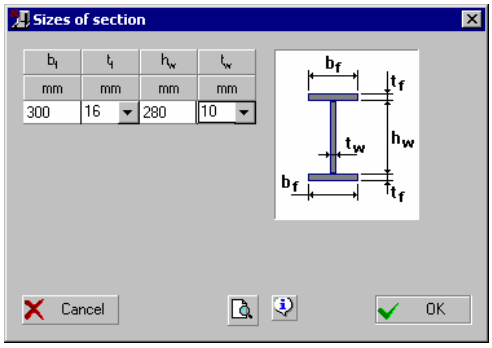


Fig. 1.7.5-4. The **Sizes of Section** dialog box

The thickness of the web and the flanges can be either entered manually or selected from drop-down lists where all catalogue sizes of sheet and plate steel are included. If the column's cross-section type is a rolled one, click the **Choose Profile** button (the **Weldable Section** checkbox should be turned off). In the tree-like list of the new dialog box, **Choose Profile** (Fig. 1.7.5-5), you select a proper catalogue and No. of the desired profile in the catalogue to associate with the column; having done so, click **OK**.

You can check you cross-section visually in a preview window which opens when you click the **Preview** button ( ).

In the same way you define the steel grade and the cross-section type for the beams in the joint. There are controls for this purpose, combined into respective groups (**Beam 1** and **Beam 2**). Also, each of the beams in the joint should have a static fixation type associated with it; use appropriate radio buttons to make your choice: **Rigid**

connection or **Pinned connection**. Clicking the button >> in the **Beam 1** group will transfer the type and sizes of the cross-section selected for Beam 1 (on the left) onto Beam 2 (on the right). Clicking the button << in the **Beam 2** group will associate the type and sizes of the cross-section set for Beam 2 to Beam 1.

The service factors for the mechanical behavior of the column and beams in the joint can be entered in appropriate text fields The factors can be also selected in the **Service Factors** dialog box; click one of the buttons next to the fields to call it up. Sec. 1.6.5 provides a detailed description of this dialog..

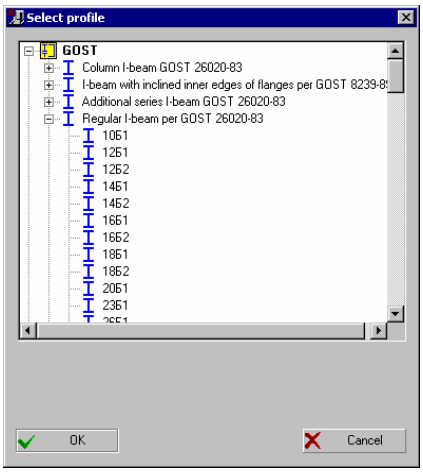


Fig. 1.7.5-5. The **Select Profile** dialog box

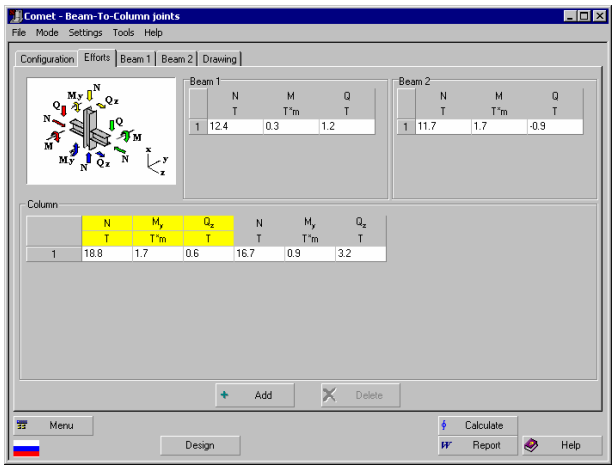
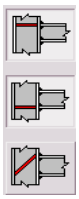


Fig. 1.7.5-6. The **Forces** tab of the **Beam-To-Column Joint** mode



When there are significant bending moments in the beam-to-column joint, it often becomes necessary to reinforce the column's web additionally by lateral stiffening ribs. The ribbing scheme for the column is specified by clicking one of the **Arrangement of Ribs** buttons which define how the stiffening ribs are to be placed: in the level of the beam's upper flange, in the level of the beam's lower flange, or obliquely. The application implements this capability thoroughly.

Clicking the **Title Block** button calls up a dialog box for filling in the title block of a drawing which will be generated automatically as soon as the design of the beam-to-column joint is completed. Section 1.7.1 gives a detailed help on working with the **Title Block** dialog.

The **Efforts** tab (Fig. 1.7.5-6) is used to specify design internal forces acting in the connected members in the beam-to-column joint. Generally, any joint has axial force N, bending moment M and its respective shear force Q transferred to it from the beam. Note that in a pinned beam-to-column joint the bending moment, M, must be equal to zero.

Also, the joint has internal forces transferred to it from the column: axial force N, bending moments M_x, M_y in both planes, and their respective shear forces Q_y and Q_x. Internal forces acting in the column are specified for cross-sections above and below the joint.

Clicking the **Add** button will add a new row to the table of the internal forces, where you enter design internal forces values for the current load case combination. The number of design load case combinations is not limited. The default unit of measurement for the axial and shear forces is ton, and for bending moments is ton×meter. The sign convention for the internal forces follows a diagram above the table of the internal forces where positive directions are indicated.

The **Beam 1** tab contains a group of buttons that helps choose a structural design for the beam-to-column joint (the beam being located to the left of the column). If a rigid joint has been declared for Beam 1 on the **Configuration** tab, the **Beam 1** tab will display structural designs for rigid joints. Such joints use only high-strength bolts.

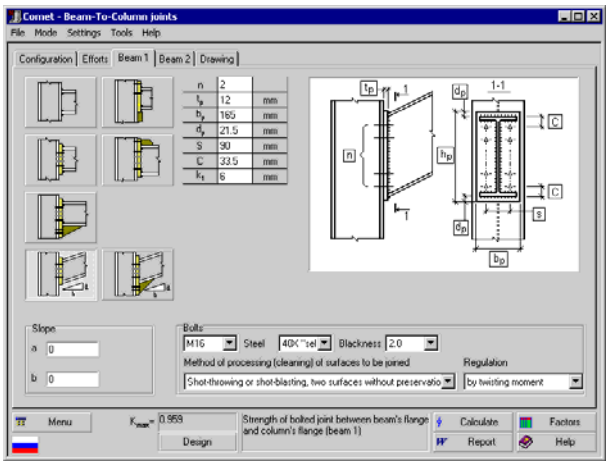


Fig. 1.7.5-7. *The* **Beam 1** *tab of the* **Beam-To-Column Joint** *mode* (rigid joint between Beam 1 and the column)

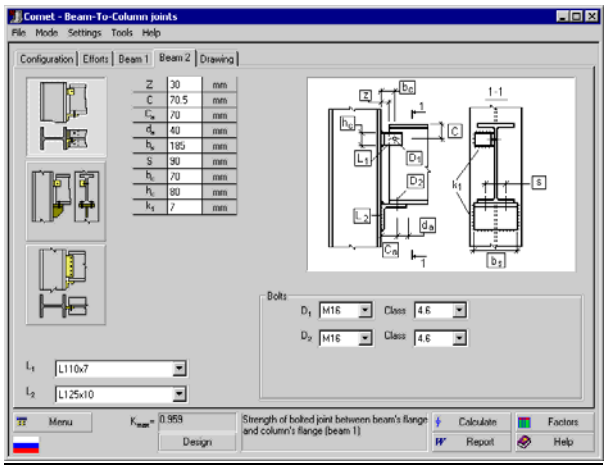


Fig. 1.7.5-8. *The* **Beam 2** *tab of the* **Beam-To-Column Joint** *mode* (pinned joint between Beam 2 and the column)

For some types of beam-to-column joints (Fig. 1.7.5-1, e, g) the application allows you to set an oblique position of the beam using values of dimensionless parameters *a* and *b* (see Fig. 1.7.5-1, e, g) in the **Slope** group (Fig. 1.7.5-7**)**.

The **Beam 2** tab contains a group of buttons to select a structural design for the joint between Beam 2 (on the right) and the column. If a pinned joint has been declared for Beam 2 in the **Configuration** tab, then the **Beam 2** tab will display only structural schemes for pinned beam-to-column joints. The pinned beam-to-column joints use non-preloaded bolts (where there is a support table, Fig. 1.7.5-2, a, b) or preloaded bolts (where there is none, Fig. 1.7.5-2, в).

Equal angles, as per GOST 8509-86 [5], are used to fix the position of the beam with respect to the column and also as support tables in some types of pinned joints (Fig. 1.7.5-2, a, b) If the user knows the sizes of the angles, he can specify those in the drop-down lists L_1 and L_2.

When high strength bolts are used, you need to use drop-down lists in the **Bolts** group to specify a steel grade for the bolts, their blackness (the difference between the diameter of the bolt hole and that of the bolt itself), a method to regulate the tightness of the bolts, and a method for processing (cleaning) the surfaces of connected members. If the diameter of high strength bolts to be used in the joint is known, you need to specify their grade (diameter) in the respective drop-down list. If the joint uses non-preloaded bolts, you need to specify the strength class and, if their diameter is known, also the grade (diameter) in the respective drop-down lists.

To assess the bearing capacity of a known (given) structural design of the beam-to-column joint, you need to specify all design parameters of the joint. These include: the sizes and thickness of the basic components of the joint, the diameters of bolts, sizes that regulate the mutual arrangement of the members, leg lengths of the fillet welds, the number of bolts, the number of bolt rows etc. The design parameters of the joint are entered in a table at the bottom of the tabs **Beam 1** or/and **Beam 2**. The default unit of linear measurement in the structural design of the joints is millimeter.

Clicking the **Design** button will invoke the mode of automatic proportioning of the parameters for the given beam-to-column joint type. This mode assumes the parameters to be previously unknown; they are to be found from the conditions of proper bearing capacity plus structural constraints defined by building requirements. Any previously specified data are ignored. In addition, the mode calculates the value of maximum factor K_{max} (a constraint utilization factor) and indicates a type of code-defined check in which this maximum takes place. Then a drawing of the node design at the detail design stage is generated.

When you click the **Calculate** button, the application performs the check of bearing capacity of the given basic components of the joints and of the connections between them as defined by SNiP II-23-81* [17]. If some of

numerical parameters have not been defined, the application will obtain them automatically from the conditions of proper load-bearing ability and structural constraints defined by building codes. The result will include the value of the maximum factor, K_{max} (a constraint utilization factor) and a type of code-defined check in which this maximum takes place. A complete list of the checks and values of the respective constraint utilization factors is available by clicking the **Factors** button.

A list of checks of bearing capacity that the application performs with members and connections in structural designs of beam-to-column joints, both rigid and pinned, is presented in Table 1.7.5-1, 1.7.5-2.

When you switch to the **Drawing** tab, the joint is checked similarly to the **Calculate** mode. If the results of analysis of the joint's parameters are not in contradiction with structural and code-based requirements, a drawing is generated for the design, at the detail design stage.

The functionality of the **Report** button and the controls in the **Drawing** tab is similar to that found in the **Rigid Column Bases** mode (see Sec. 1.7.1).

Table 1.7.5-1. A list of checks of bearing capacity of the basic components of the joint and connections in structural designs of stiff beam-to-column joints, in compliance with SNiP II-23-81*

No	Entitlement of check	Type of joint	Reference to SNiP II-23-81*
1.	Resistance of the bearing rib in local bearing	Fig. 1.7.5-1, b	
2.	Overall stability of the bearing rib	Fig. 1.7.5-1, b	Sec. 5.3, (7)
3.	Overall stability of the bearing rib	Fig. 1.7.5-1, b	Sec. 7.24
4.	Resistance of the flange in bending, weakening by holes allowed for	Fig. 1.7.5-1, b-g	
5.	Resistance of the welded connection between the beam and the column's flange	Fig. 1.7.5-1, a	Sec. 11.2*, (120), (121), Sec. 11.3*, (122), (123)
6.	Resistance of the welded connection between the beam and the bearing rib (or bearing flange)	Fig. 1.7.5-1, b-g	Sec. 11.2*, (120), (121), Sec. 11.3*, (122), (123)
7.	Resistance of the bolted connection between the bearing rib (or bearing flange) of the beam and the column's flange	Fig. 1.7.5-1, b-g	Sec. 11.13*, (131)*, (132)*
8.	Resistance of the welded connection between the support table and the column's flange	Fig. 1.7.5-1, b	Sec. 11.2*, (120), (121)
9.	Resistance of the column's web in bending under normal stresses	Fig. 1.7.5-1, a-g	Sec. 5.12, (28)
10.	Resistance of the column's web in bending under shear stresses	Fig. 1.7.5-1, a-g	Sec. 5.12, (29)
11.	Resistance of the column's web in bending under local normal stresses	Fig. 1.7.5-1, a-g	Sec. 5.13, (31)
12.	Resistance of the column's web in bending under coexistence stresses	Fig. 1.7.5-1, a-g	Sec. 5.14*, (33)
13.	Local stability of the column's web	Fig. 1.7.5-1, a-g	Sec. 7.4, (74), 7.6*, (79), Sec. 7.2* (72), (73)
	Notes: see Table 1.7.2-1.		

Table 1.7.5-2. A list of checks of bearing capacity of the basic components of the joint and connections in structural designs of rigid beam-to-column joints, in compliance with SNiP II-23-81*

No	Entitlement of check	Type of joint	Reference to SNiP II-23-81*
1.	Bearing resistance of the support table's plate	Fig. 1.7.5-2, a, b	
2.	Resistance of the support table's plate in bending	Fig. 1.7.5-2, a, b	Sec. 5.12, (28)
3.	Resistance of the support table's plate in bending, weakening by holes allowed for	Fig. 1.7.5-2, a, b	

No	Entitlement of check	Type of joint	Reference to SNiP II-23-81*
4.	Shear resistance of the strap, weakening by holes allowed for	Fig. 1.7.5-2, c	
5.	Resistance of the bolted connection between the beam and the column's flange via a strap	Fig. 1.7.5-2, c	Sec. 11.13*, (131)*, (132)*
6.	Resistance of the welded connection between the support table and the column's flange	Fig. 1.7.5-2, a, b	Sec. 11.2*, (120), (121)
7.	Resistance of the welded connection between the strap and the column's flange	Fig. 1.7.5-2, c	Sec. 11.2*, (120), (121), Sec. 11.3*, (122), (123)
	Notes: see Table 1.7.2-1.		

1.7.6 Standard joints

The **Standard Joints** mode is used to design standard beam-to-beam joints in one level where either bolts or a angle seat is used. The application implements two types of beam-to-beam joints in one level; these use straps attached to the lateral stiffening rib of the main beam and the web of the secondary beam on one or two sides with non-preloaded bolts. In addition, this mode implements six types of beam-to-beam joints with a angle seat which is attached to the upper flange of the main beam and the end section of the secondary beam's web with fillet welded connection. The type of cross-section for the connected beams in the **Standard Joints** mode can be a normal H-section as per GOST 26020-83 [11], a wide-flanged H-section as per GOST 26020-83 [11], or a channel with oblique flanges as per GOST 8240-89 [4].

The main dialog box of the **Standard Joints** mode contains just two tabs: **Construction** (Fig. 1.7.6-1) and **Drawing** (Fig. 1.7.6-2).

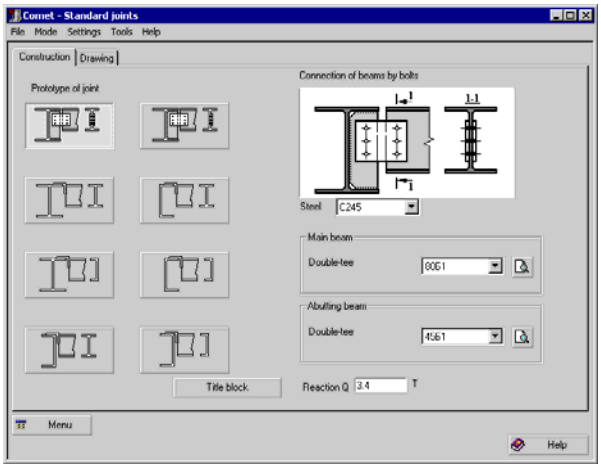


Fig. 1.7.6-1. *The* **Construction** *tab of the* **Standard Joints** *mode*

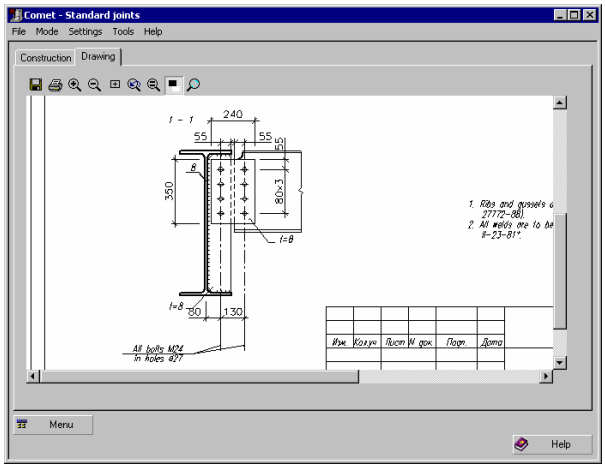


Fig. 1.7.6-2. *The* **Drawing** *tab of the* **Standard Joints** *mode*

The **Construction** tab contains a group of buttons named **Prototype of Joint**. It is used to choose a structural design for the beam-to-beam joint. The same tab contains a preview window that displays how the joint's structural design looks. Use the **Steel** drop-down list to specify a steel grade for the connected members.

The **Main Beam** group and the **Abutting Beam** group are used to specify cross-sections for the main beam and for the secondary (abutting) beam, respectively. To do it, select Nos. of desired profiles from appropriate drop-down lists. You can review graphical representations of the specified cross-sections for the beams in preview window which open by clicking the **Preview** buttons ( ) in the respective groups (**Main Beam** or **Abutting Beam**).

The **Support Reaction** field is used to enter a numerical value for the support reaction which is transferred from the abutting beam onto the main one. The default unit of measurement for the support reaction is ton.

Clicking the **Title Block** button will open the respective dialog box where you fill in the title block for a drawing which will be generated automatically as soon as the structural design of the beam-to-beam joint is ready. More details about the **Title Block** dialog box can be found in Sec. 1.7.1.

When you switch to the **Drawing** tab (Fig. 1.7.6-2), the application checks the load-bearing ability of the beam-to-beam joint, and if the result is positive, the drawing of the joint is generated into an appropriate information window.

References

[1] GOST 82-70*. Rolled steel, hot-rolled, wide-strap, all-purpose. – Moscow, USSR State Standard Committee. (in Russian)

[2] GOST 103-76*. Strip, steel, hot-rolled. – Moscow, USSR State Standard Committee. (in Russian)

[3] GOST 8239-89. Double-tees, steel, hot-rolled. A catalogue of sizes. – Moscow, USSR State Standard Committee. (in Russian)

[4] GOST 8240-89. Channels, steel, hot-rolled. A catalogue of sizes. – Moscow, USSR State Standard Committee. (in Russian)

[5] GOST 8509-86. Angles, steel, hot-rolled, equal. A catalogue of sizes. – Moscow, USSR State Standard Committee. (in Russian)

[6] GOST 8510-86*. Angles, steel, hot-rolled, unequal. A catalogue of sizes. – Moscow, USSR State Standard Committee. (in Russian)

[7] GOST 19903-74. Rolled steel, hot-rolled sheets. A catalogue of sizes. – Moscow, USSR State Standard Committee. (in Russian)

[8] GOST 19904-90. Rolled steel, cold-rolled sheets. A catalogue of sizes. – Moscow, USSR State Standard Committee. (in Russian)

[9] GOST 16350-80. Climate of USSR. Zoning and statistical parameters of climatic factors for engineering purposes. – Moscow, USSR State Standard Committee. (in Russian)

[10] GOST 22356-77*. Bolts and nuts, high-strength, and washers. General specifications. – Moscow, USSR State Standard Committee. (in Russian)

[11] GOST 26020-83*. Double-tees, steel, hot-rolled, with parallel faces of flanges. A catalogue of sizes. – Moscow, "Stroyizdat". (in Russian)

[12] GOST 26633-91. Concrete, heavy-weight and fine-grain. Specifications. International standards. – Moscow, "Standartinform". (in Russian)

[13] GOST 27751-88. Safety of structural constructions and foundations. Design fundamentals (ST SEV 384-87). – Moscow, USSR State Standard Committee. (in Russian)

[14] GOST 27772-88*. Rolled steel for steel structural constructions. General specifications. – Moscow, USSR State Standard Committee. (in Russian)

[15] A.V. Perelmuter, L.A. Gildengorn. On classification of structural constructions / Structural mechanics and analysis. – 1990. – N3. – pp. 67-70. (in Russian)

[16] SNiP II-21-75. Concrete and ferroconcrete constructions. Building norms and regulations. – Moscow, "Stroyizdat". – 1976. – 89 p. (in Russian)

[17] SNiP II-23-81*. Steelwork: Building norms and regulations / Ministry of Construction of Russia. – Moscow, 1996. – 96 p. (in Russian)

[18] SNiP 2.03.01-84*. Concrete and ferroconcrete constructions. Building norms and regulations / State Committee of Russia for Construction. – Moscow, 2001. – 76 p. (in Russian)

[19] A guide to steelwork design (annex to SNiP II-23-81*) / Kucherenko Centr. Res. Inst. for Structural Constructions, USSR State Committee for Construction, Moscow, 1989. – 148 p. (in Russian)

[20] V.T. Vasilchenko, A.N. Rutman, E.P. Lukianenko. A manual for steelwork designers. – Kiev, "Budivelnik", 1990. – 311 p. (in Russian)

[21] Steelwork. Designer's manual. Ed. by V.V. Kuznetsov. – Moscow, ASV, 1998. – 576 p. (in Russian)