

Example 12. Analysis of joint in a steel truss of circular shapes

In this lesson you will learn how to:

- analyse joint of a truss.
- edit defined parameters.

Description:

Model of the truss and its boundary conditions are presented in Fig.12.1.

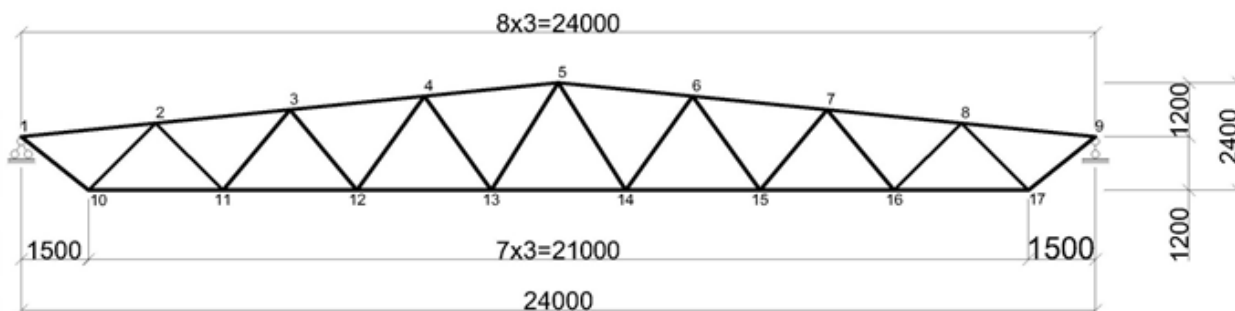


Figure 12.1 Geometry of steel truss

Assumed sections of truss elements:

- top chord – hot-rolled seamless pipe (Труба бесшовная горячекатаная), shape 159x7.5 mm;
- bottom chord – hot-rolled seamless pipe (Труба бесшовная горячекатаная), shape 133x5 mm;
- extreme diagonal elements of truss 1-10, 2-10, 9-17, 8-17 – hot-rolled seamless pipe (Труба бесшовная горячекатаная), shape 76x5 mm;
- the rest of diagonal elements of truss – hot-rolled seamless pipe (Труба бесшовная горячекатаная), shape 63.5x5 mm.

Steel: ВСт3кп.

Service conditions factor $\gamma_c=0.9$.

Safety factor $\gamma_n=0.95$.

Design forces in a joint are presented in Fig.12.2:

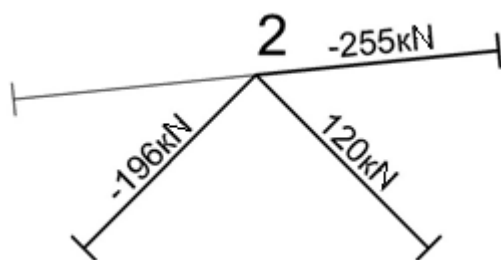



Figure 12.2 Joint of steel truss

- ⇒ On the taskbar, click the **Start** button, and then point to **All Programs**. Point to the folder that contains **LIRA SAPR / LIRA-SAPR 2014** and then click **STC-SAPR 2014**.

Step 1. Defining input data for analysis of joint in steel truss

- ⇒ To define new joint, on the FILE menu, point to **New** and click **Joint** (button  on the toolbar).
- ⇒ In the **Select joint type** dialog box (see Fig.12.3), select **Trusses / Pipes** in the list and then select the type of joint as presented in the figure.
- ⇒ Click **OK**.

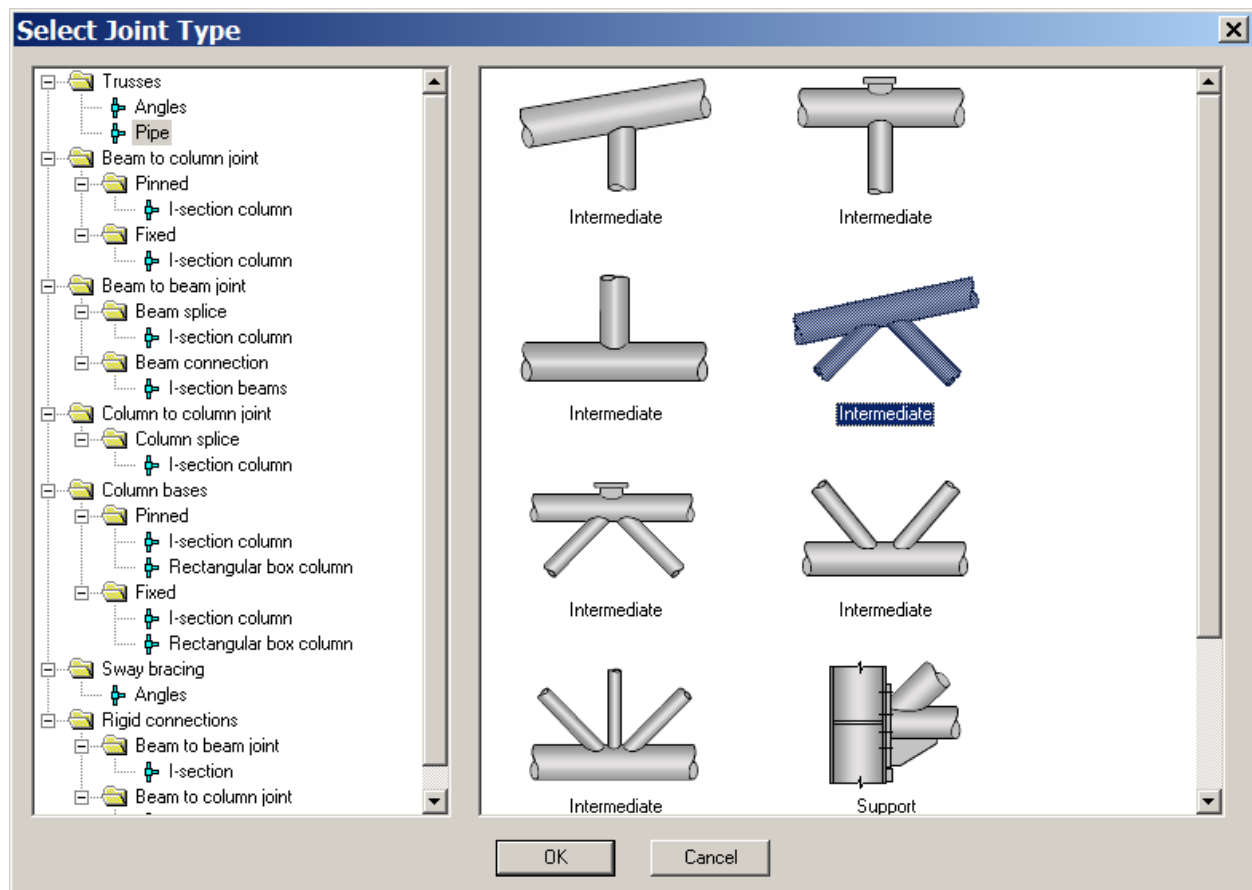
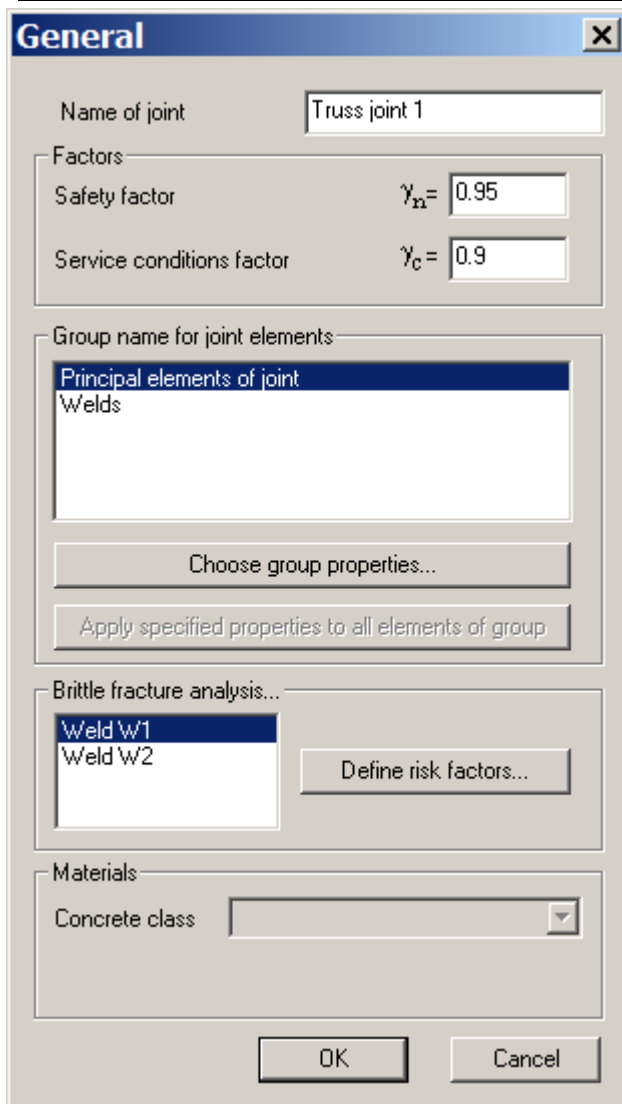


Figure 12.3. **Select joint type** dialog box

- ⇒ In the **General** dialog box (see Fig.12.4), define the following parameters:
- name of joint – Truss joint 1;
 - safety factor – $\gamma_n=0.95$;
 - service conditions factor – $\gamma_c=0.9$.

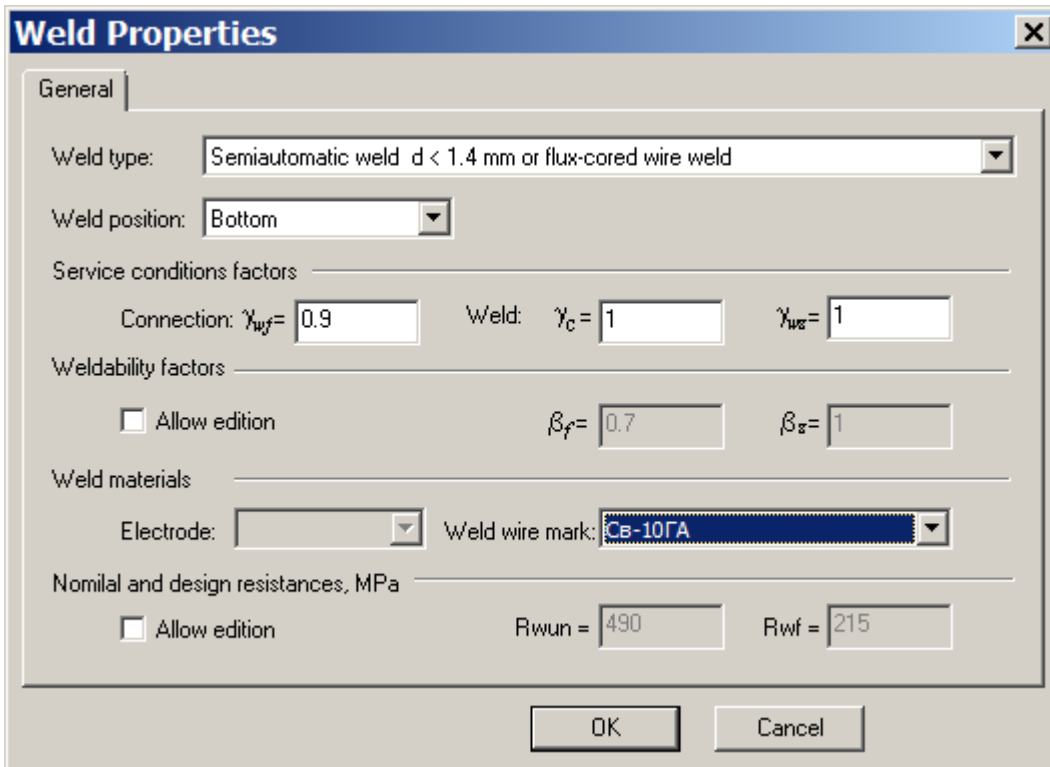


The dialog box is titled "General" and contains the following sections:

- Name of joint:** A text field containing "Truss joint 1".
- Factors:**
 - Safety factor:** $\gamma_n =$ 0.95
 - Service conditions factor:** $\gamma_c =$ 0.9
- Group name for joint elements:**
 - A list box containing "Principal elements of joint" and "Welds".
 - Buttons: "Choose group properties..." and "Apply specified properties to all elements of group".
- Brittle fracture analysis...**
 - A list box containing "Weld W1" and "Weld W2".
 - Button: "Define risk factors..."
- Materials:**
 - Concrete class:** A dropdown menu.
- Buttons:** "OK" and "Cancel" at the bottom.

Figure 12.4 **General** dialog box

- ⇒ Then in the **Group name for joint elements** area, modify parameters for group of welds. To do this, select **Welds** row and click **Choose group properties**.
- ⇒ In the **Weld properties** dialog box (see Fig.12.5), define the following parameters:
 - service condition factor for connections – 0.9;
 - weld wire mark – CB-10ГA;
 - other parameters remain by default.
- ⇒ Click **OK**.



Weld Properties

General

Weld type: Semiautomatic weld d < 1.4 mm or flux-cored wire weld

Weld position: Bottom

Service conditions factors

Connection: $\gamma_{wf} = 0.9$ Weld: $\gamma_c = 1$ $\gamma_{wg} = 1$

Weldability factors

☐ Allow edition $\beta_f = 0.7$ $\beta_g = 1$

Weld materials

Electrode: Weld wire mark: Св-10ГА

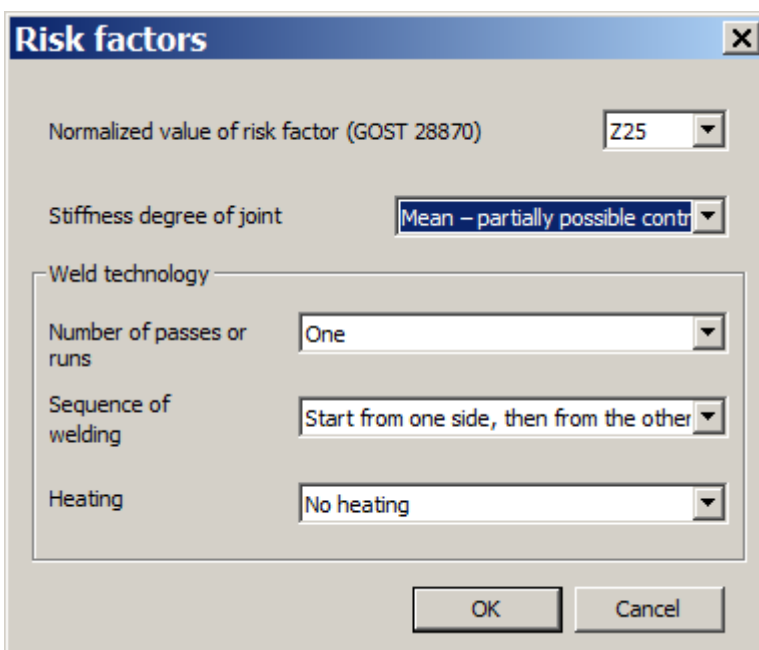
Nominal and design resistances, MPa

☐ Allow edition $R_{wun} = 490$ $R_{wf} = 215$

OK Cancel

Figure 12.5 Weld properties dialog box

- ⇒ If required, it is possible to modify risk factors. To do this, in the **General** dialog box, in the **Brittle fracture analysis** area, click **Define risk factors**.
- ⇒ In the **Risk factors** dialog box (see Fig.12.6), there is a list of parameters that may be modified.
 - in the **Normalized value of risk factor** (GOST 28870) box, select **Z25**.
 - in the **Stiffness degree of joint** box, select **Mean - partially possible contraction of weld and deformation of structure**.
- ⇒ Click **OK**.



Risk factors

Normalized value of risk factor (GOST 28870) Z25

Stiffness degree of joint Mean – partially possible contr

Weld technology

Number of passes or runs One

Sequence of welding Start from one side, then from the other

Heating No heating

OK Cancel

Figure 12.6 Risk factors dialog box


- ⇒ To confirm all modifications, in the **General** dialog box, click **OK**.

- ⇒ In the **Design forces** dialog box (see Fig.12.7), define the following values of axial forces N_x for the chord and two diagonal elements:
- chord – 255 kN;
 - diagonal 1 – 120 kN;
 - diagonal 2 – 196 kN.
- ⇒ To input data, click **OK**.

N	Element	FE	sect.	N_x, kN	M_y, kNm	Q_z, kN	M_z, kNm	Q_y, kN
1	Chord	-1	-1	-255.000	0.000	0.000	0.000	0.000
2	Diagonal 1	-1	-1	120.000	0.000	0.000	0.000	0.000
3	Diagonal 2	-1	-1	-196.000	0.000	0.000	0.000	0.000

Figure 12.7 **Design forces** dialog box

Step 2. Modifying parameters of joint

- ⇒ On the EDIT menu, click **Joint parameters** (button  on the toolbar).
- ⇒ In the **Joint properties** dialog box (see Fig.12.8), define sections and steel grade for element of the truss as well as lengths of elements and their slope angles.

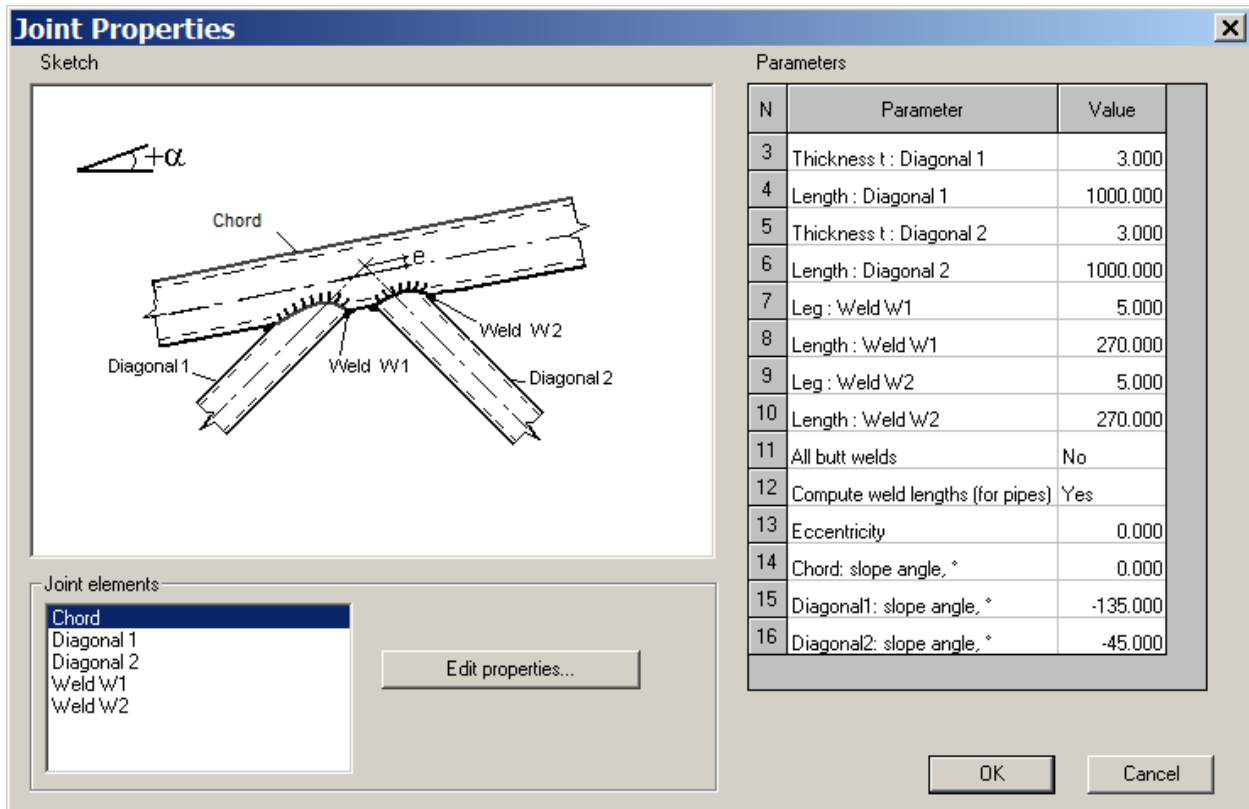


Figure 12.8 Joint properties dialog box

- ⇒ In the **Joint elements** area, select **Chord** in the list and click **Edit properties**.
- ⇒ In the **Steel cross-section** dialog box (see Fig.12.9), define the following parameters for the section:
 - steel table – Труба бесшовная горячекатаная. Актуализированный;
 - shape – 159x7.5 mm;
 - steel – ВСт3кп.
- ⇒ Click **OK**.

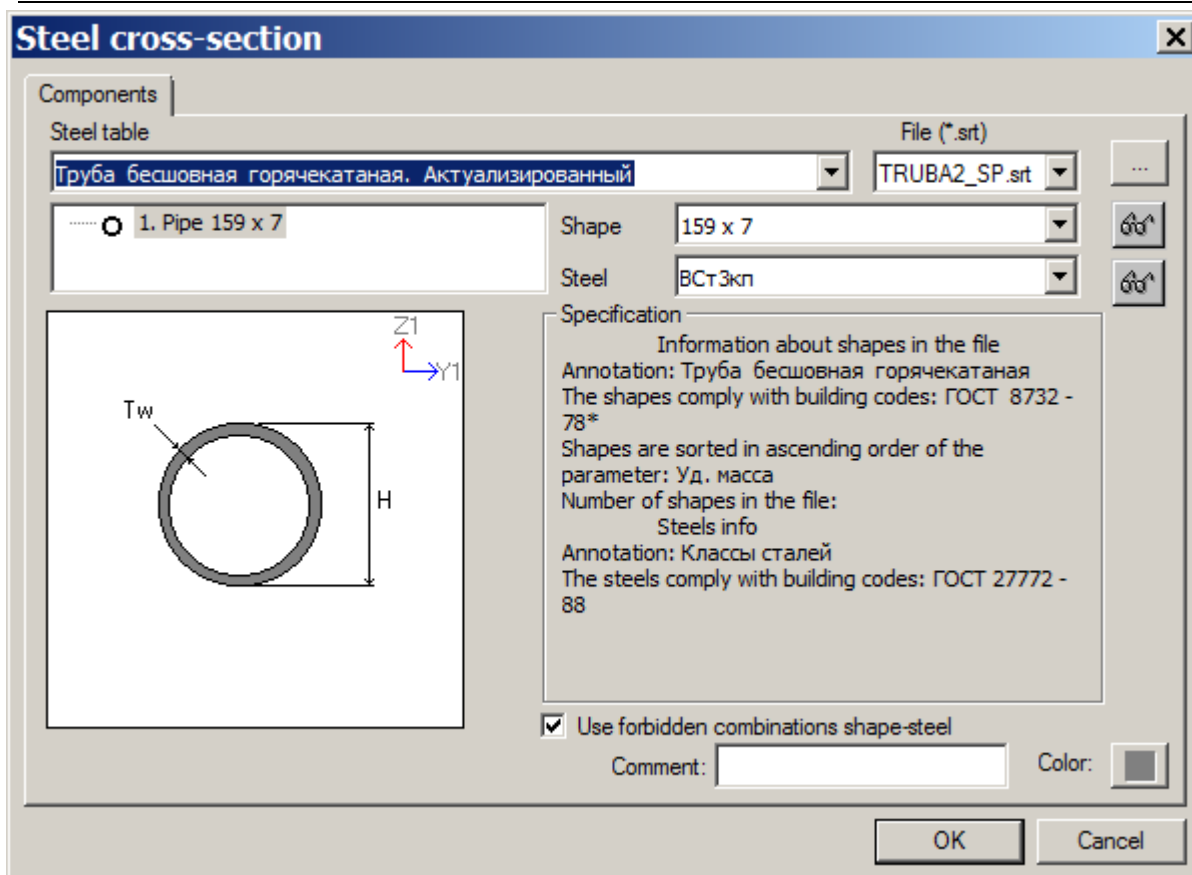


Figure 12.9 Steel cross-section dialog box

- ⇒ In a similar way define parameters for diagonal element 1:
 - steel table – Труба бесшовная горячекатаная. Актуализированный;
 - shape – 63.5x5 mm;
 - steel – ВСт3кп.
- ⇒ Click **OK**.
- ⇒ In a similar way define parameters for diagonal element 2:
 - steel table – Труба бесшовная горячекатаная. Актуализированный;
 - shape – 76x5 mm;
 - steel – ВСт3кп .
- ⇒ Click **OK**.
- ⇒ In the **Joint properties** dialog box (see Fig.12.10 and Fig.12.11), modify length of chord and diagonal elements as well as their slope angles and define the following values:
 - length of chord – 3015 mm;
 - length of diagonal element 1 – 2121 mm;
 - length of diagonal element 2 – 2121 mm;
 - slope angle of chord – -5,42°;
 - slope angle of diagonal element 1 – -135°;
 - slope angle of diagonal element 2 – -44,59°.
- ⇒ Click **OK**.

Joint Properties

Sketch

Joint elements

- Chord
- Diagonal 1
- Diagonal 2**
- Weld W1
- Weld W2

Edit properties...

Parameters

N	Parameter	Value
1	Thickness t : Chord	7.500
2	Length : Chord	3015.000
3	Thickness t : Diagonal 1	5.000
4	Length : Diagonal 1	2121.000
5	Thickness t : Diagonal 2	5.000
6	Length : Diagonal 2	2121.000
7	Leg : Weld W1	5.000
8	Length : Weld W1	231.000
9	Leg : Weld W2	5.000
10	Length : Weld W2	315.000
11	All butt welds	No
12	Compute weld lengths (for pipes)	Yes
13	Eccentricity	0.000
14	Chord: slope angle, °	-5.420

OK Cancel

Figure 12.10 Joint properties dialog box (lengths)

Joint Properties

Sketch

Joint elements

- Chord
- Diagonal 1
- Diagonal 2**
- Weld W1
- Weld W2

Edit properties...

Parameters

N	Parameter	Value
3	Thickness t : Diagonal 1	5.000
4	Length : Diagonal 1	2121.000
5	Thickness t : Diagonal 2	5.000
6	Length : Diagonal 2	2121.000
7	Leg : Weld W1	5.000
8	Length : Weld W1	231.000
9	Leg : Weld W2	5.000
10	Length : Weld W2	315.000
11	All butt welds	No
12	Compute weld lengths (for pipes)	Yes
13	Eccentricity	0.000
14	Chord: slope angle, °	-5.420
15	Diagonal1: slope angle, °	-135.000
16	Diagonal2: slope angle, °	-44.590

OK Cancel

Figure 12.11 Joint properties dialog box (slope angles)

Check results for joint properties are presented in Fig.12.12.

Truss joint 1 : Check Results (SP 16.13330.2011)								
Parameter	Property	Value	Utilization ratio, %	Internal forces				
				N, kN	My, kNm	Qz, kN	Mz, kNm	Qy, kN
Chord	Thickness t	7.5 mm	111.3	-255.000*	0.000	0.000	0.000	0.000
	Length	3015.0 mm						
Diagonal 1	Thickness t	5.0 mm	100.4	120.000*	0.000	0.000	0.000	0.000
	Length	2121.0 mm						
Diagonal 2	Thickness t	5.0 mm	111.5	-196.000*	0.000	0.000	0.000	0.000
	Length	2121.0 mm						
Weld W1	Leg	5.0 mm	92.2	120.000*	0.000	0.000	0.000	0.000
	Length	231.0 mm						
Weld W2	Leg	5.0 mm	110.4	-196.000*	0.000	0.000	0.000	0.000
	Length	315.0 mm						
All butt welds	--	No	--	--	--	--	--	--
Compute weld lengths (for pipes)	--	Yes	--	--	--	--	--	--
Eccentricity	--	0.0 mm	--	--	--	--	--	--
Chord: slope angle, °	--	-5	--	--	--	--	--	--
Diagonal1: slope angle, °	--	-135	--	--	--	--	--	--
Diagonal2: slope angle, °	--	-44	--	--	--	--	--	--

Figure 12.12 Check results for joint properties

⇒ It is obvious from analysis results that not all elements are adequate. To provide the bearing capacity of elements, modify their stiffness properties and allow some redistribution of forces in them (see Fig.12.9 and Fig.12.10):

- chord – pipe Ø159x8mm;
- diagonal element 1 – pipe Ø63.5x5.5mm;
- diagonal element 2 – pipe Ø76x6 mm;
- leg of weld W2 – 6 mm.

⇒ Click **OK**.

New check results for joint properties are presented in Fig.12.13.

Truss joint 1 : Check Results (SP 16.13330.2011)								
Parameter	Property	Value	Utilization ratio, %	Internal forces				
				N, kN	My, kNm	Qz, kN	Mz, kNm	Qy, kN
Chord	Thickness t	8.0 mm	99.6	-255.000*	0.000	0.000	0.000	0.000
	Length	3015.0 mm						
Diagonal 1	Thickness t	5.5 mm	90.7	120.000*	0.000	0.000	0.000	0.000
	Length	2121.0 mm						
Diagonal 2	Thickness t	6.0 mm	91.4	-196.000*	0.000	0.000	0.000	0.000
	Length	2121.0 mm						
Weld W1	Leg	5.0 mm	92.2	120.000*	0.000	0.000	0.000	0.000
	Length	231.0 mm						
Weld W2	Leg	6.0 mm	92.0	-196.000*	0.000	0.000	0.000	0.000
	Length	315.0 mm						
All butt welds	--	No	--	--	--	--	--	--
Compute weld lengths (for pipes)	--	Yes	--	--	--	--	--	--
Eccentricity	--	0.0 mm	--	--	--	--	--	--
Chord: slope angle, °	--	-5	--	--	--	--	--	--
Diagonal1: slope angle, °	--	-135	--	--	--	--	--	--
Diagonal2: slope angle, °	--	-44	--	--	--	--	--	--

Figure 12.13 Check results for joint properties