Case study no. 13

SPORT HALL ROGLA

1. General information

Date:	1987
Price:	
Investor:	Unior,d.d., Kovaška c. 21, Zreče, Slovenia
Design studio:	Razvojni center Celje, TOZD Projektiva, Ul. XIV. Divizije 14, Celje, Slovenia
Construction company:	
Location:	Rogla, Pohorje muintain, Slovenia
Materials used:	glue-laminated timber, reinforced concrete

2. Investment design

Sport hall Rogla is situated on Pohorje mountain area in the north part of Slovenia. The hall is a part of a huge sport complex, today it is one of the most famous sports centres in the middle of Europe. The whole sport complex is placed on the top of Pohorje Mountain on the altitude of approx. 1500 m., therefore it is very convenient for acclimatisation training of sportsmen. The hall is purposed for indoor sports with a playground for basketball, volleyball and tennis.

Since the hall is situated on mountain area on a relative high altitude (1520 metres), wind and especially snow actions can be very heavy. In April 2006 a snow of total height of 2.5 metres, and consequently, some cracks appeared around the support and the middle hinge. Consequently, a special project for a reconstruction of the both supports and the middle hinge was proposed.

3. Bearing system

3.1. General description

The main structure bearing system consists of 10 glue-laminated arch beams which are placed on a constant distance of 5 meters. The beams of the overall span of 35.2 meters are supported with rigid reinforced concrete foundations (*Fig. 1*). The overall ground-plan dimensions of the hall are 40.40 x 45.35 m^2, total floor area A = 1832.14 m^2.

Fig. 1: Inside photo of the hall.

3.2. Description of the glue-laminated beams

Main bearing capacity beam elements are glue-laminated arch beams with a various height *h(x)* which varies between 130 cm and 120 cm according to the shear stress distribution along the beam element. The width is 20 cm and it is constant along the span. The beam inclination (*α*) according to the horizontal axis is not constant and varies between 58^0 at the support and 15.8^0 at the first third of the span (*Fig. 2*).

Geometrical properties of the beam cross-section according to their position on the longitudinal x-axis (*Fig. 2*) are listed in *Table 1*.

	Cross-section 1 20/130 cm	Cross-section 2 20/130 cm	Cross-section 3 20/130 cm	Cross-section 4 20/129 cm	Cross-section 5 20/124 cm	Cross-section 6 20/120 cm	Cross-section 7 20/120 cm
α	58^0	30^0	15.8^0	15.8^0	15.8^0	15.8^0	15.8^0
A_x [m^2]	0.260	0.260	0.260	0.258	0.248	0.240	0.240
I_y [m^4]	0.0366	0.0366	0.0366	0.0358	0.0318	0.0288	0.0288
W_y [m^3]	0.0563	0.0563	0.0563	0.0554	0.0512	0.0480	0.0480

Tabel 1:Geometrical properties of the cross-section location according to Fig. 2.

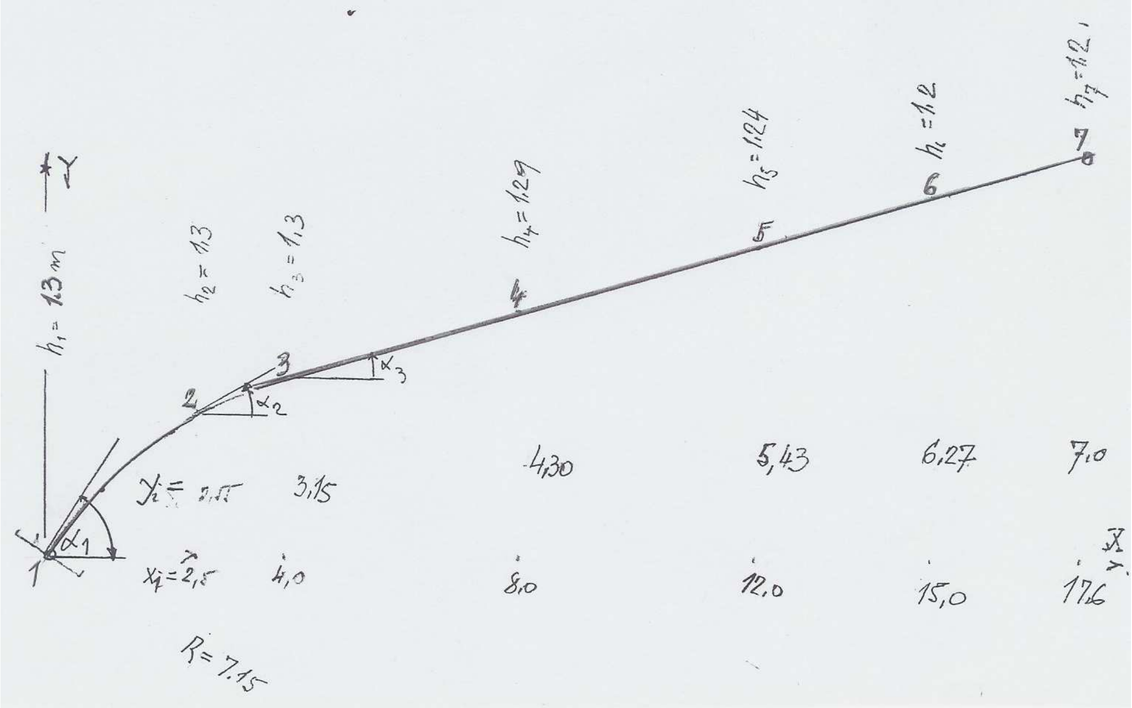


Fig. 2: Scheme of cross-section position of the main beam element.

Timber lamels were produced from middle class of slovenian pine (conifers II. class according to at that time valid slovenian standards JUS.U.C9.300). Therefore, according to Eurocode 5 classification (EN 1194) the used timber material can be clasified as class Gl 28c.

Foundation was made of reinforced concrete C25/30. Properties of the used materials are listed in *Table 2*. Beam connection to the reinforced concrete foundation is made using classical stell elements (steel quality S220). A detail description of the connection is given in Section 8.

	$E_{0,m}$ [GPa]	G_m [GPa]	$f_{m,k}$ [N/mm^2]	$f_{t,0,k}$ [N/mm^2]	$f_{c,0,k}$ [N/mm^2]	$f_{v,k}$ [N/mm^2]	ρ_k [kg/m^3]
Timber Gl 28c	11.60	0.59	28	16.5	24	2.7	410
Reinforced concrete C25/30	29.0	12.1	2.6	2.6	25	0.30	2500
Steel S220	200	76.9	220	220	220	127	7850

Table 2. Properties of the used materials.

4. Computational models used

For the beam element a static design with a simple supported beam with a middle hinge is used (*Fig. 3*). Supports A and B simulate the rigid concrete foundations.

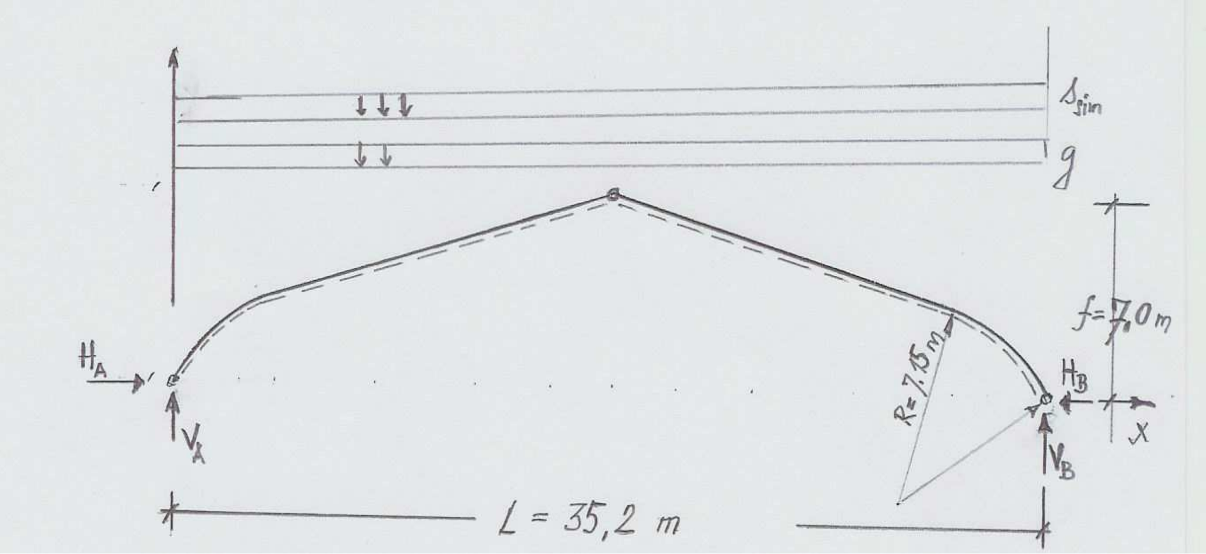


Fig. 3: Static design with two supports and the middle hinge.

Statically analysis was made using known analytical expressions. The results were controlled using a simple computer programme for planar frames (programme FRAME).

5. Actions on structure

Loads were determinate according to in year 1987 valid Slovenian standards.

1. Dead load: g = 0.4 kN/m^2 (roof load) + beam dead load

2. Live load: /

3. Snow: $s = 1.25 + \frac{H - 500}{400} = 1.25 + \frac{1500 - 500}{400} = 3.75\,kN/m^2$

3a. Full snow (s_{sim} = 3.75 kN/m^2) symmetrically (*Fig. 3*).

3b. Full snow (s = 3.75 kN/m^2) and a half of snow load (s/2) asymmetrically.

4. Wind: w_0 = 1.1 kN/m^2, (*Fig. 4*)

Considering aerodynamically coefficients (c_{pe} = ± 0.4) for a different roof inclination the calculated wind load was:

$$w = \pm 0.4 \cdot 1.1 = \pm 0.44\,kN/m^2$$

5. Seismic action: VI. MCS – not considered.

Actions of loads are presented on *Fig. 3* (dead load, snow) and *Fig. 4* (wind).

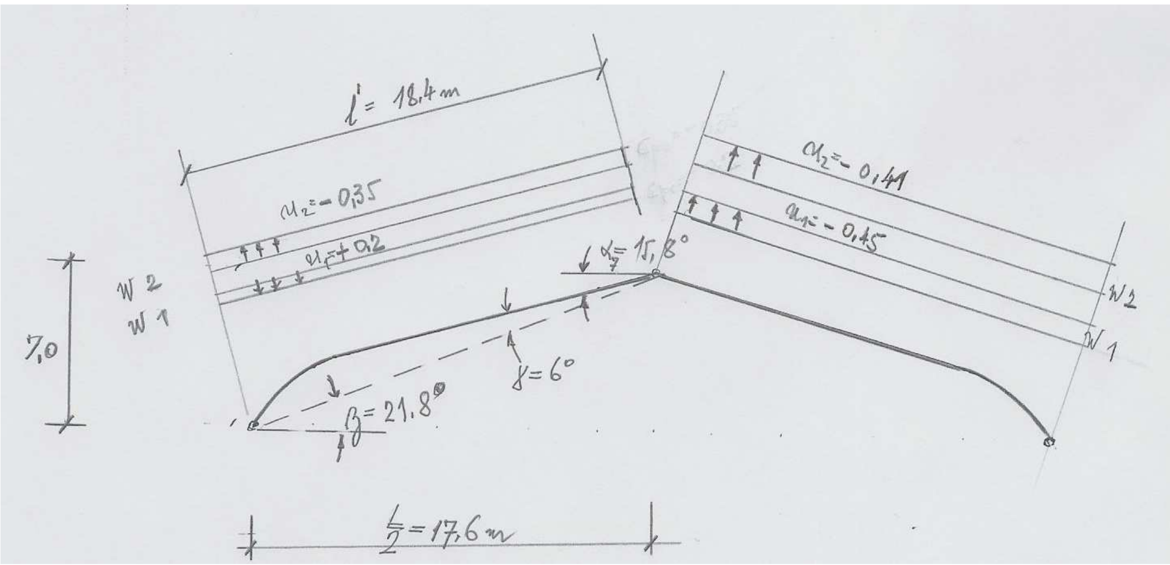


Fig. 4: Wind load actions on the main bearing element.

The dimensions of the timber beam were determinate according to the maximal force actions. Actions (bending moments, shear and axial forces) on the main beam element due to symmetrically vertical load (g + s_{sim}) are schematically presented in *Fig. 5*.

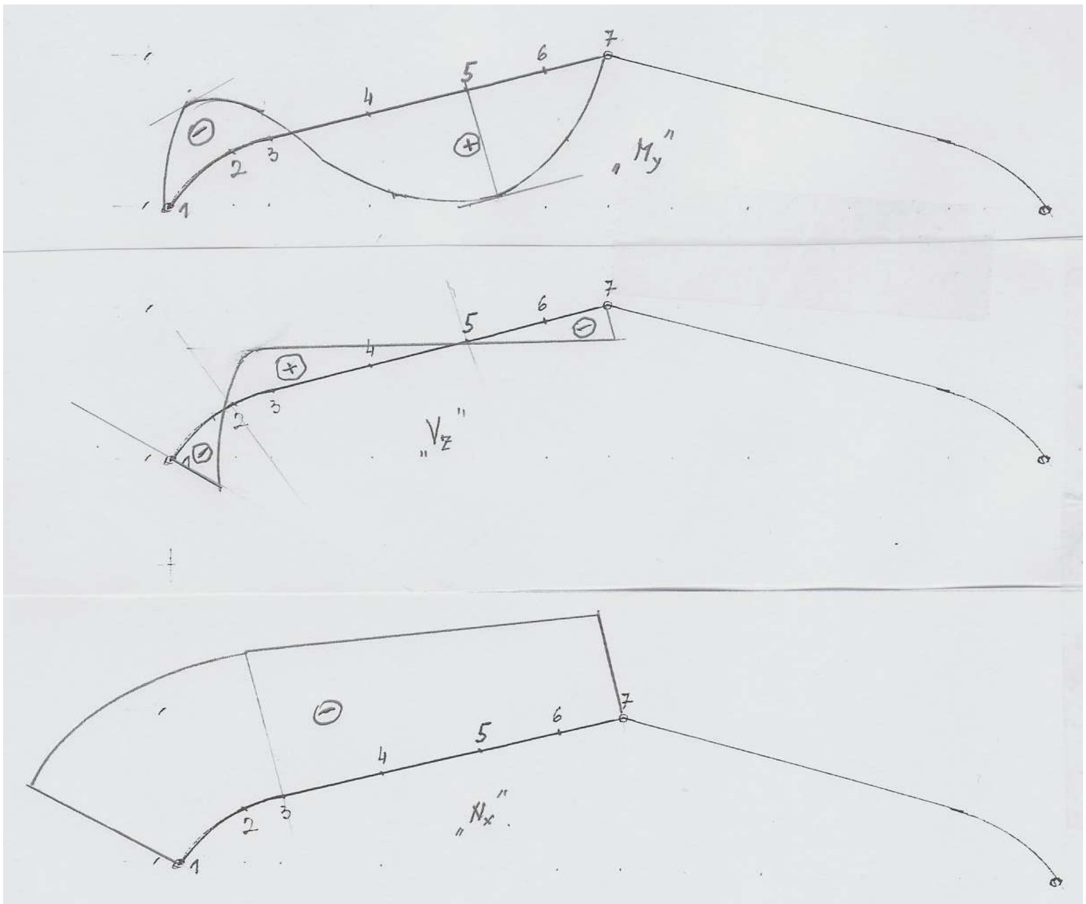


Fig. 5: Schematically presentation of bending moments, shear and axial forces due to symmetrically vertical loads (g + s_{sim}).

6. Project documentation, plans, and drawings

6.1. Project documentation

Investitor: UNIOR ZREČE

Objekt: ŠPORTNA DVORANA NA ROGLI

Št.proj.: 030/87

Faza: PGD

PREDMET: S T A T I Č N I R A Č U N

Odg.vodja proj.: Jože Kopitar, dipl.ing.arh.

Odg.projektant: Mitja Pangeršič, dipl.ing.gradb.

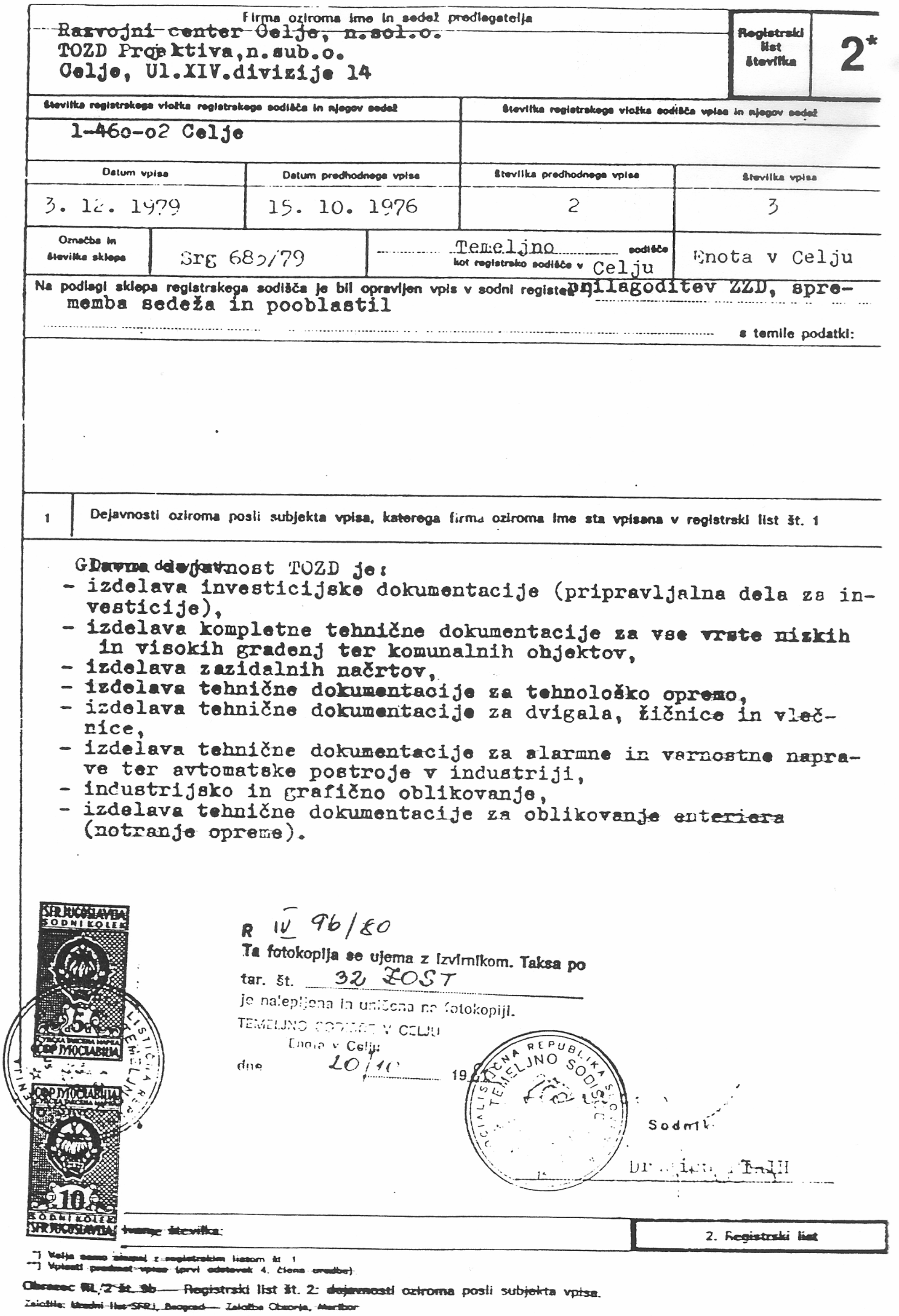
Projektant: Vinko Kuzman, dipl.ing.gradb.

Odg. projektant za leseno strešno konstrukcijo:
Janez Štupnik, dipl.ing.gradb.

Izdelano: RAZVOJNI CENTER CELJE,
TOZD PROJEKTIVA

Celje, april 1987

Fig. 6: General project documentation.



Firma oziroma ime in sedež predlagatelja

~~Razvojni center Celje, n.sol.o.~~
TOZD Projektiva,n.sub.o.
Celje, Ul.XIV.divizije 14

Registrski list številka 2*

Številka registrskega vložka registrskega sodišča in njegov sedež	Številka registrskega vložka sodišča vpisa in njegov sedež
1-460-02 Celje	

Datum vpisa	Datum predhodnega vpisa	Številka predhodnega vpisa	Številka vpisa
3. 12. 1979	15. 10. 1976	2	3

Označba in številka sklepa			
Srg 682/79	Temeljno sodišče kot registrsko sodišče v Celju	Enota v Celju	

Na podlagi sklepa registrskega sodišča je bil opravljen vpis v sodni register prilagoditev ZZD, sprememba sedeža in pooblastil s temile podatki:

1 Dejavnosti oziroma posli subjekta vpisa, katerega firma oziroma ime sta vpisana v registrski list št. 1

Glavna dejavnost TOZD je:
- izdelava investicijske dokumentacije (pripravljalna dela za investicije),
- izdelava kompletne tehnične dokumentacije za vse vrste nizkih in visokih gradenj ter komunalnih objektov,
- izdelava zazidalnih načrtov,
- izdelava tehnične dokumentacije za tehnološko opremo,
- izdelava tehnične dokumentacije za dvigala, žičnice in vlečnice,
- izdelava tehnične dokumentacije za alarmne in varnostne naprave ter avtomatske postroje v industriji,
- industrijsko in grafično oblikovanje,
- izdelava tehnične dokumentacije za oblikovanje enteriera (notranje opreme).

SFR JUGOSLAVIJA SODNI KOLEK 5
SFR JUGOSLAVIJA SODNI KOLEK 10

R IV 96/80
Ta fotokopija se ujema z izvirnikom. Taksa po tar. št. 32 ZOST
je nalepljena in uničena na fotokopiji.
TEMELJNO SODIŠČE V CELJU
Enota v Celju
dne 20/10 19..

SOCIALISTIČNA REPUBLIKA SLOVENIJA TEMELJNO SODIŠČE

Sodnik
Dr. [illegible]

... številka: 2. Registrski list

Velja samo skupaj z registrskim listom št. 1
Vpisati predmet vpisa (prvi odstavek 4. člena uredbe)
Obrazec RL/2 št. 3b — Registrski list št. 2: dejavnosti oziroma posli subjekta vpisa.
Založila: Uradni list SFRJ, Beograd — Založba Obzorja, Maribor

Fig. 7: Special project documentation.

7. Erection

The foundations were built completely classical with a reinforced concrete of a strength class C30/37 and steel class S400. The glue-laminated beams of a half of total span (17.60 m) were produced in company Hoja and then transported to the building-site. The both parts were connected together as a hinge connection, as presented in *Fig.8* (for details see Section 8).

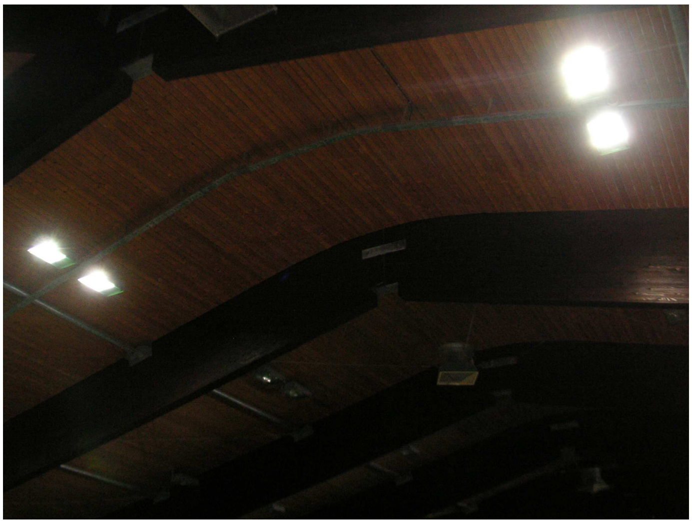


Fig. 8: A hinge connection between two curved beam elements.

8. Interesting construction details

Connection of the main timber beam element to the concrete foundation was made as a hinge using a special steel box (s.c. "shoe" connection). The box was with two steel stirrups and a special tube connected two another two steel stirrups which were fixed to the base. A simple scheme is presented in *Fig. 9*, whereas photos from two different sides are presented in *Fig. 10*.

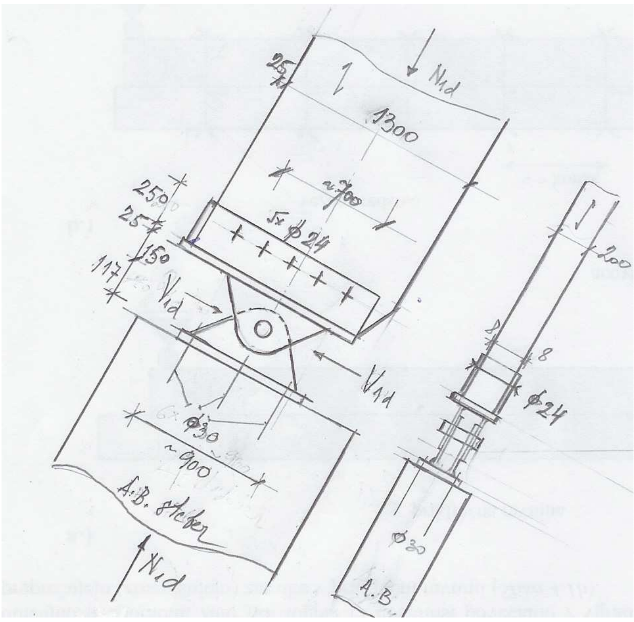


Fig. 9. Schematically presentation of the hinge connection of the timber beam to the foundation.

Fig. 10: Connection of the main timber element to the concrete foundation.

9. Protection from weather effects

To assure a horizontal protection of the building a classical bracing system using steel diagonals were built in the upper horizontal plane of the curved beam element (*Fig. 11*).

Fig. 11: A steel bracing system in the upper horizontal beam plane.

In April 2006 a heavy snow of a total height of 2.50 meter fall (*Fig. 12*). Therefore, the snow load was bigger as it was predicted in the statically analysis (3.75 kN/m^2) using at that time valid Slovenian codes.

Fig. 12: A heavy snow in April 2006.

Because the snow load was not symmetrically distributed on the roof, some cracks appeared in the timber beams close to a base connection (*Fig. 13a*) and around the middle hinge (*Fig. 13 b*).

a.)

b.)

Fig. 13: Cracks by the connection to the base (a) and in the middle hinge (b).

Because of that a special project for reconstruction of the main timber beam element was done (Dobrila, Premrov) inserting a special plywood board in the middle of the beam span (*Fig. 14*). Additionally, a special analysis was made to calculate the maximal permitted snow load for the actual dimensions of the main timber bearing capacity beam element.

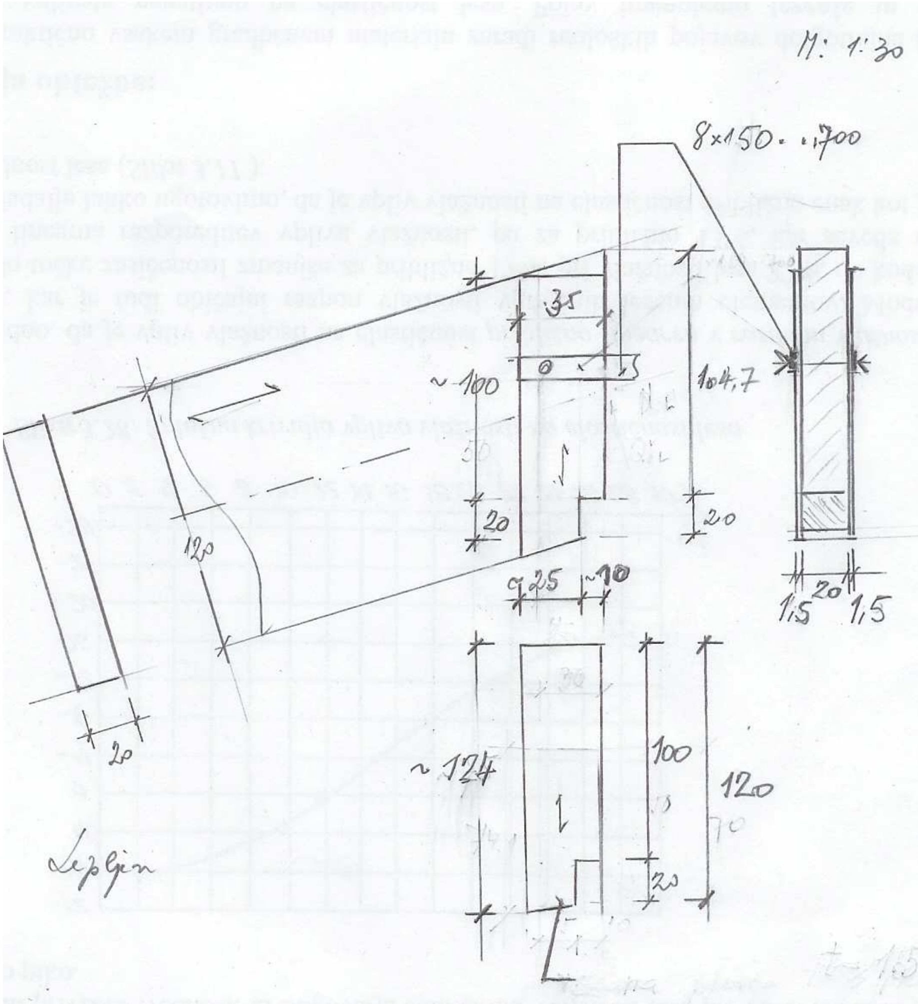


Fig.14: Reconstruction in the middle hinge using a special plywood board.

10. Economical and ecological aspects

As presented in *Fig. 1* the building is very undesturbing incorporated in a beautiful green Pohorje mountain landscape. Additionally, timber is a healthy natural material and is consequently particularly desired for sports activities.

Instructions and case study no 13 were prepared by Assoc.Prof.Dr. Miroslav Premrov.