Case study no. 8

TERME ZREČE, HOTEL DOBRAVA

1. General information

Date:	5.7.1999
Price:	approx. 12 mil. EUR
Investor:	Unior,d.d., Kovaška c. 21, Zreče, Slovenia
Design studio:	Karlovšek d.o.o., ul. Antona Skoka 7, Domžale, Slovenia
Construction company:	Lumar Hiše d.o.o., Šmatevž 26, Gomilsko, Slovenia
Location:	Zreče, Slovenia
Materials used:	timber, reinforced concrete

2. Investment design

Hotel for approx. 300 people.

3. Bearing system

3.1. General description

The structure is 6-level building with overall ground-plan dimensions of 38 m x 18,60 m. The first two levels are classical - made from reinforced concrete, while the upper four consist of prefabricated timber elements (**Fig. 1**).

Fig. 1: Photo of the hotel from the east side.

3.2. Prefabricated wall elements

Prefabricated timber walls as main vertical bearing capacity elements of actual dimensions *h=2760 mm* and *b=1250 mm* are composed of a timber frame and of sheets of board-material fixed by mechanical fasteners to the both sides of the timber frame (**Fig. 2a,b**). The timber frame consists of three studs with dimensions of *120 x 120 mm* and two girders with dimensions of *120 x 120 mm*. The sheathing boards of the Fermacell type and thickness of *t=15 mm* are fixed to the timber frame using staples of *Φ1.53 mm* at an average spacing of *s = 60 mm* in the both edge studs and at an average spacing of *s = 120 mm* in the middle stud (**Fig 2a**).

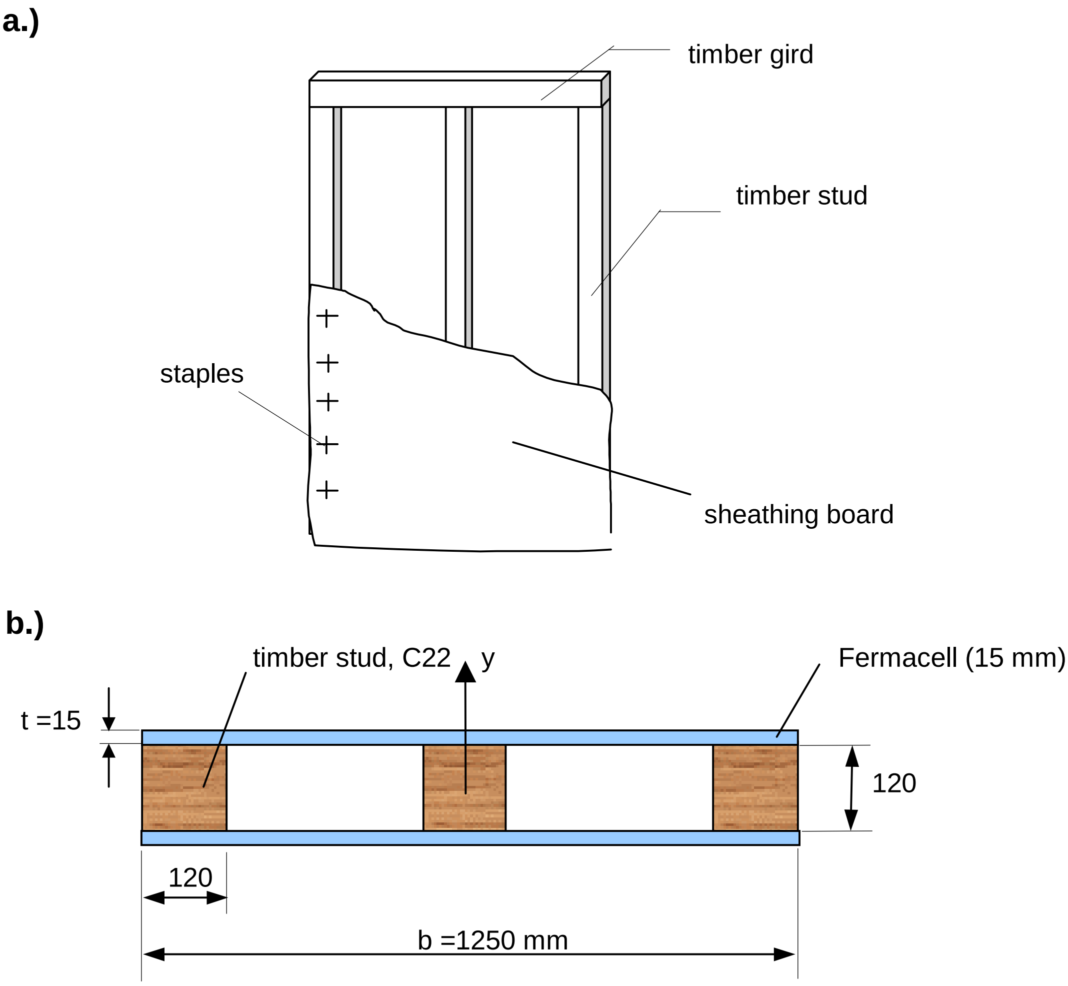
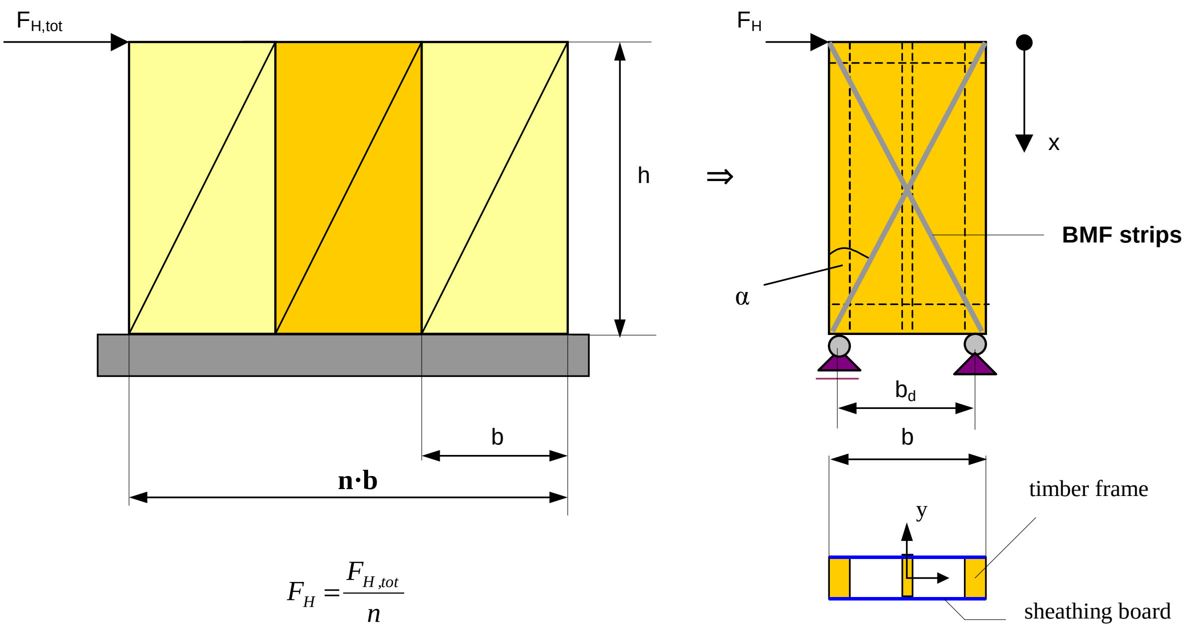


Fig. 2: Dimensions of the prefabricated timber-framed walls.

3.3. Reinforcing of wall elements in the first and second level

Although gypsum is a healthy material and assures a good fire protection, in a structural view its tensile strength is very low, approximately 10-times lower than the compressive one, and cannot be compared with the strength of the timber frame at all. Since the walls by horizontal force acting at the top of the wall actually behave like deep composite elements, the fiber-plaster boards (FPB) are usually a weaker part. Thus, especially in multi-level buildings located in seismic or windy areas, cracks in FPB usually appear. Therefore, each side of the wall in the first and in the second level was reinforced with two BMF steel diagonals of a cross-section *60x2mm* with the module of elasticity $E_s = 210.000\ N/mm^2$ (**Fig. 3**).



$$F_H = \frac{F_{H,tot}}{n}$$

Fig. 3: Reinforcing of the walls with BMF steel strips.

3.4. Prefabricated floor elements

Prefabricated floor elements of actual wide of *1250 mm* consist of three timber beams with dimensions of *80 x 220 mm*. They are covered with a *19 mm* thick plywood at the top and with a Fermacell fibre-plaster board of thickness *15 mm* at the bottom (**Fig. 4**).

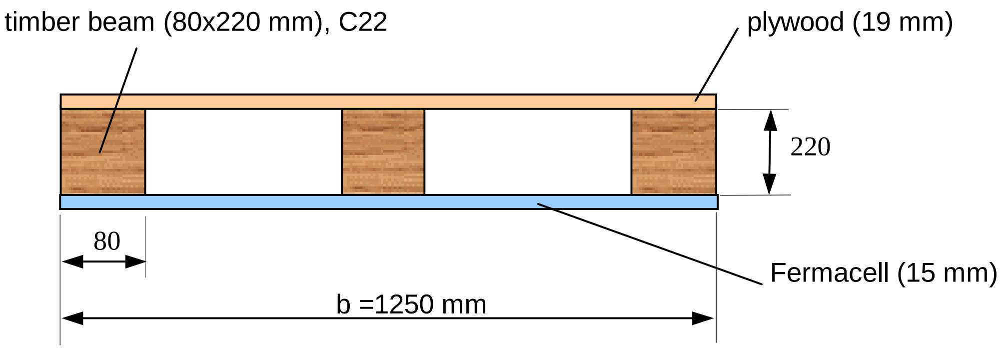


Fig. 4: Cross-sectiondDimensions of the prefabricated timber floor elements.

Properties of the used materials are listed in **Table 1**.

	$E_{0,m}$ [N/mm^2]	G_m [N/mm^2]	$f_{m,k}$ [N/mm^2]	$f_{t,0,k}$ [N/mm^2]	$f_{c,0,k}$ [N/mm^2]	$f_{v,k}$ [N/mm^2]	ρ_m [kg/m^3]
Timber C22	10000	630	22	13	20	2.4	410
Fermacell boards	3000	1200	4.0	2.5	20	5.0	1050
BMF steel strips	210000	/	/	400	/	/	7850

Table 1. Properties of used materials.

4. Computational models used

4.1. Static design for the floor elements

By a static design of the floor elements the continuous system with a constant beam span of *3800 mm* was used (Fig 5).

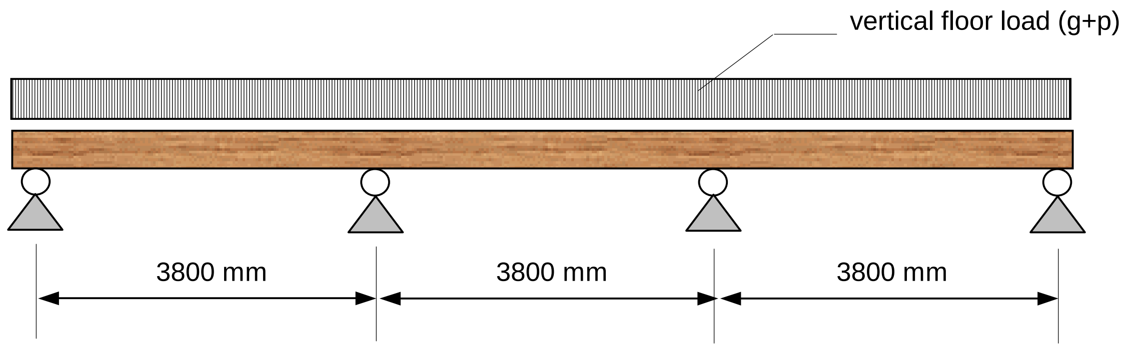


Fig. 5: Static design of the prefabricated floor elements.

4.2. Static design for the wall elements

Horizontal force distribution on walls was calculated according to the shear stiffness ratio between the walls. For walls in y-direction the following static design (**Fig. 6**) was used to calculate the axial forces, shear forces and bending moment due to vertical and horizontal loads.

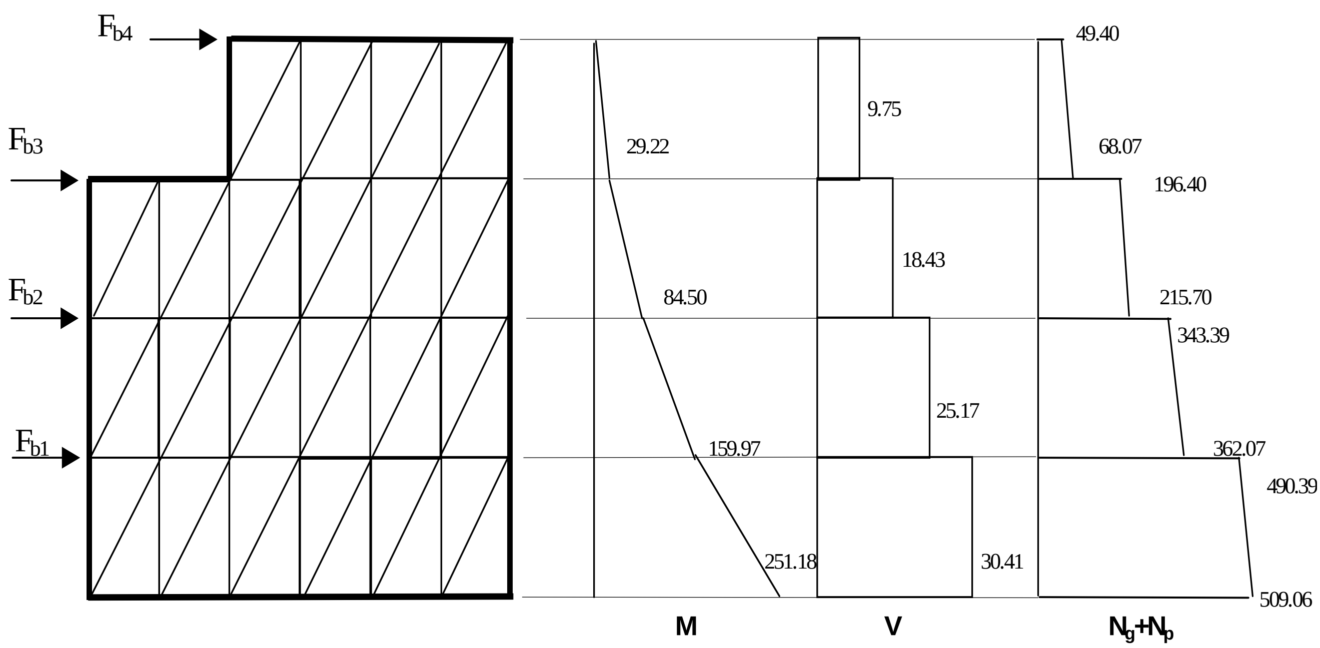


Fig.6: Static design of the prefabricated wall elements in the y-direction.

5. Actions on structure

Actions on structures according to in year 1999 valid Slovenian standards.

1. Dead load
2. Live load $p = 1.50\ kN/m^2$
3. Snow $s = 1.25\ kN/m^2$
4. Wind $w_0 = 0.60\ kN/m^2$, $c_{pe} = 0.80, -0.40$
5. Seismic force VII. MCS

Actions of vertical and horizontal loads are presented on **Fig. 7** and **Fig. 8**.

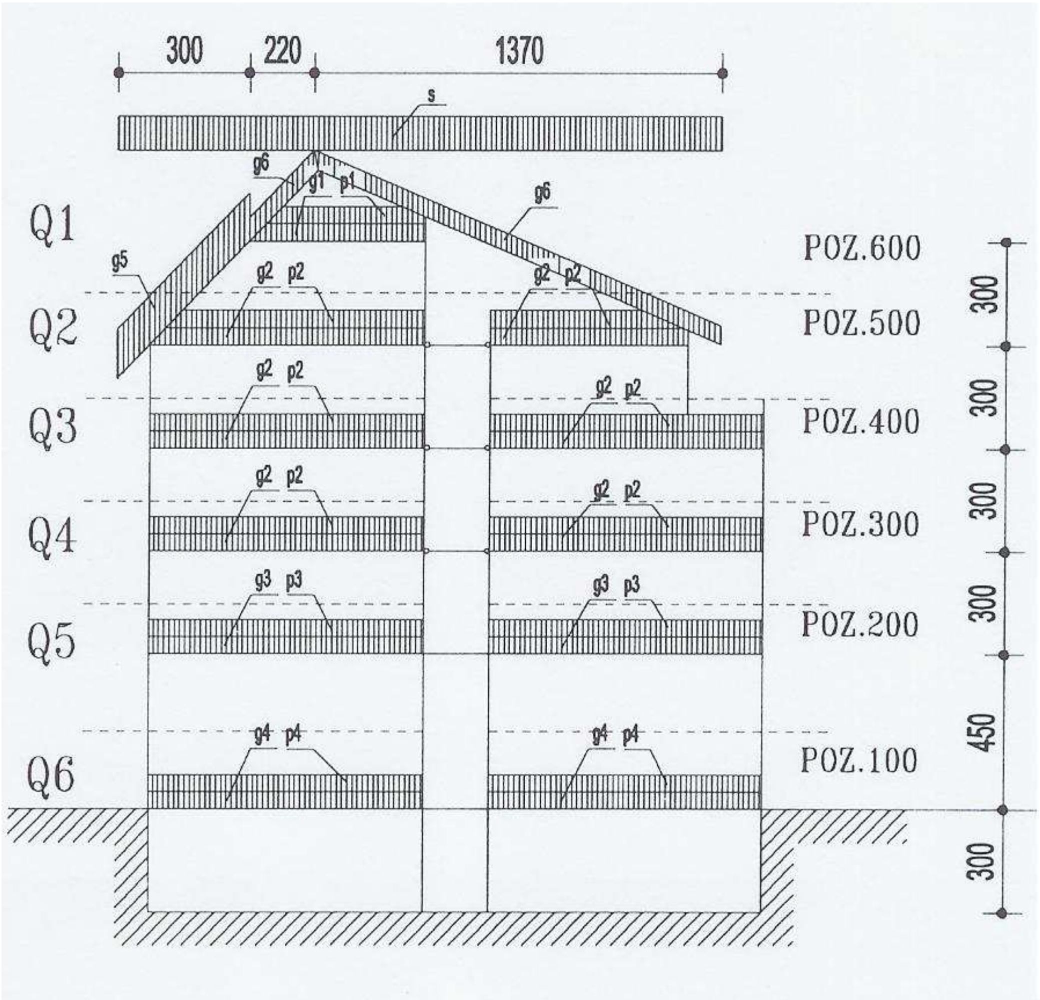


Fig. 7: Vertical load actions on the structure.

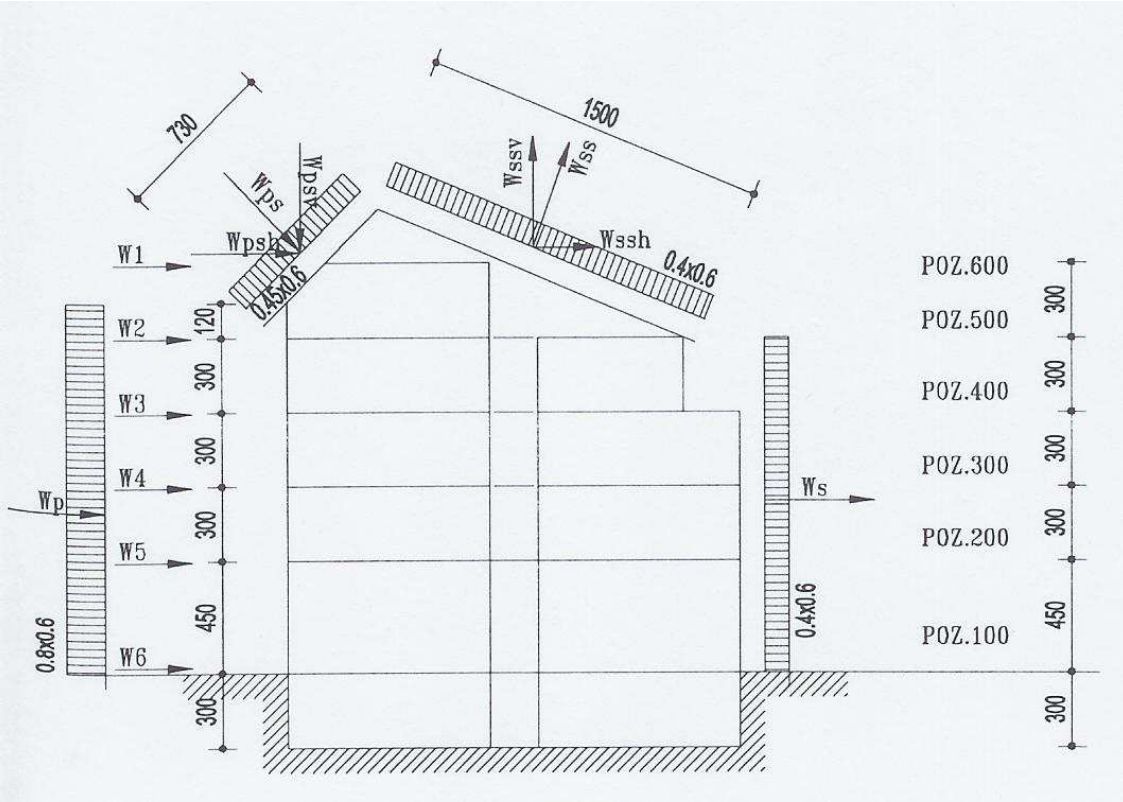


Fig. 8: Horizontal load actions on the structure in the y-direction.

6. Project documentation, plans, and drawings

6.1. Project documentation

karlovšek d.o.o.
PODJETJE ZA PROJEKTIRANJE IN INŽENIRING
Domžale, Antona Skoka 7, tel. / fax. / 061-721-266
Slovenija

investitor	UNIOR d.d. ZREČE
objekt	PRIZIDEK HOTELA - I. FAZA
projekt	STATIKA - POZICIJSKI NAČRT
faza	PGD, PZI št. proj. 11/99
odg. vodja proj.	M.KARLOVŠEK,udig.
odg. projektant	S. ŠPEGELJ, gr.ing.
obdelal	S. ŠPEGELJ, gr.ing.
pregledal	GREGOR GREGORC,udig.
datum	feb. 99 .

Fig. 9: General project documentation.

6.2. Ground plan

Ground-plan of the first four levels with overall dimensions of 38 x 18,60 m is presented on **Fig. 10**.

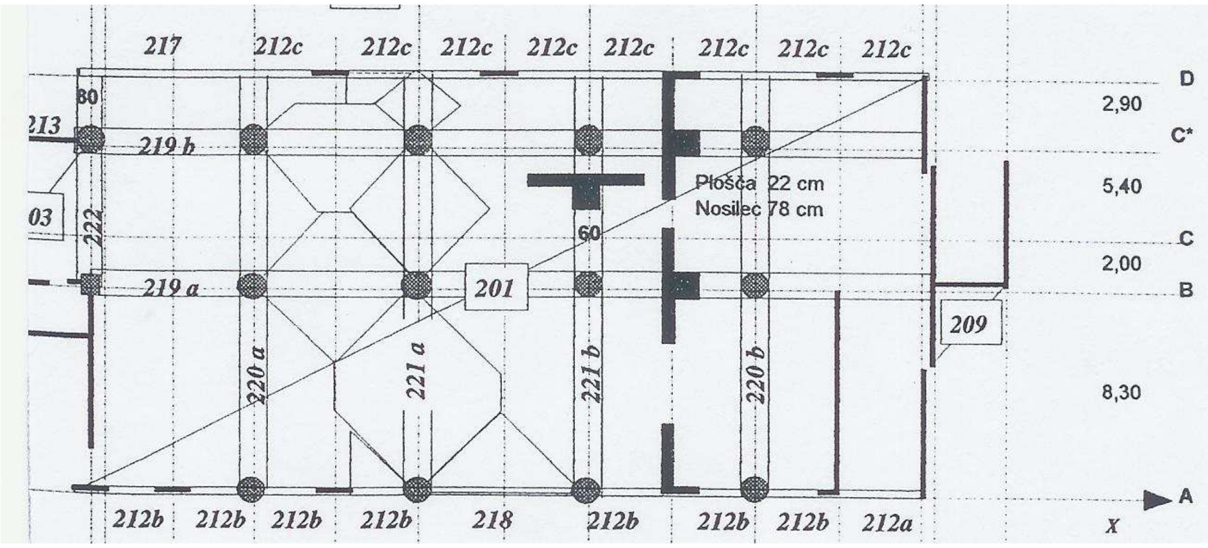


Fig. 10: Ground plan of the first four levels.

7. Erection

The first part of the building with the underground level and the ground-floor was built completely classical with a reinforced concrete of a strength class C20/25 and steel class S400 and S500.

The second part of the building, the rest four levels, were constructed using s.c. prefabricated platform timber system with the timber-framed walls (**Fig. 2** and **Fig. 3**) and the floor elements (**Fig. 4**). They were completely constructed in the assembly-plant (**Fig. 11**) and then as final products transported to the building-site.

Fig. 11: Construction of the wall elements in the assembly-plant.

8. Interesting construction details

a.) Vertical connection between the walls is presented on **Fig. 12**. Connection of the upper wall element to the floor beam is made with BMF angle element type 90 with spiral nails 4/60 mm. The floor beam is connected to the lower wall element with one additional BMF spiral nail 6/300 mm.

b.) Connection of the lowest timber wall element to the concrete wall with special steel plates and two bolts is shown on **Fig. 13**.

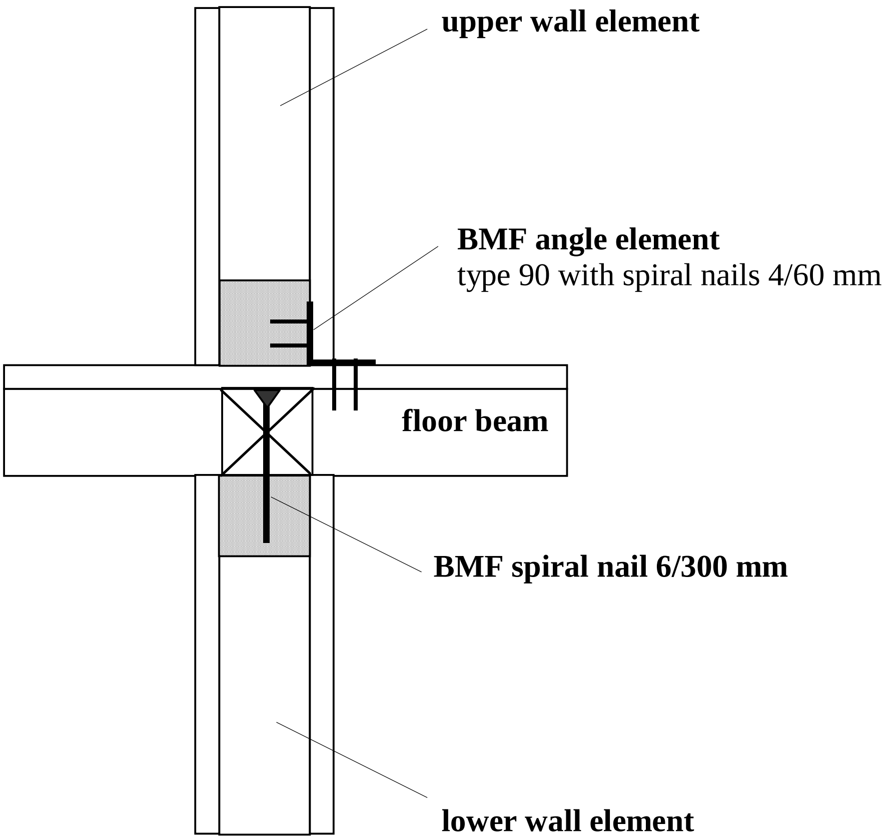


Fig. 12: Vertical connection between the walls.

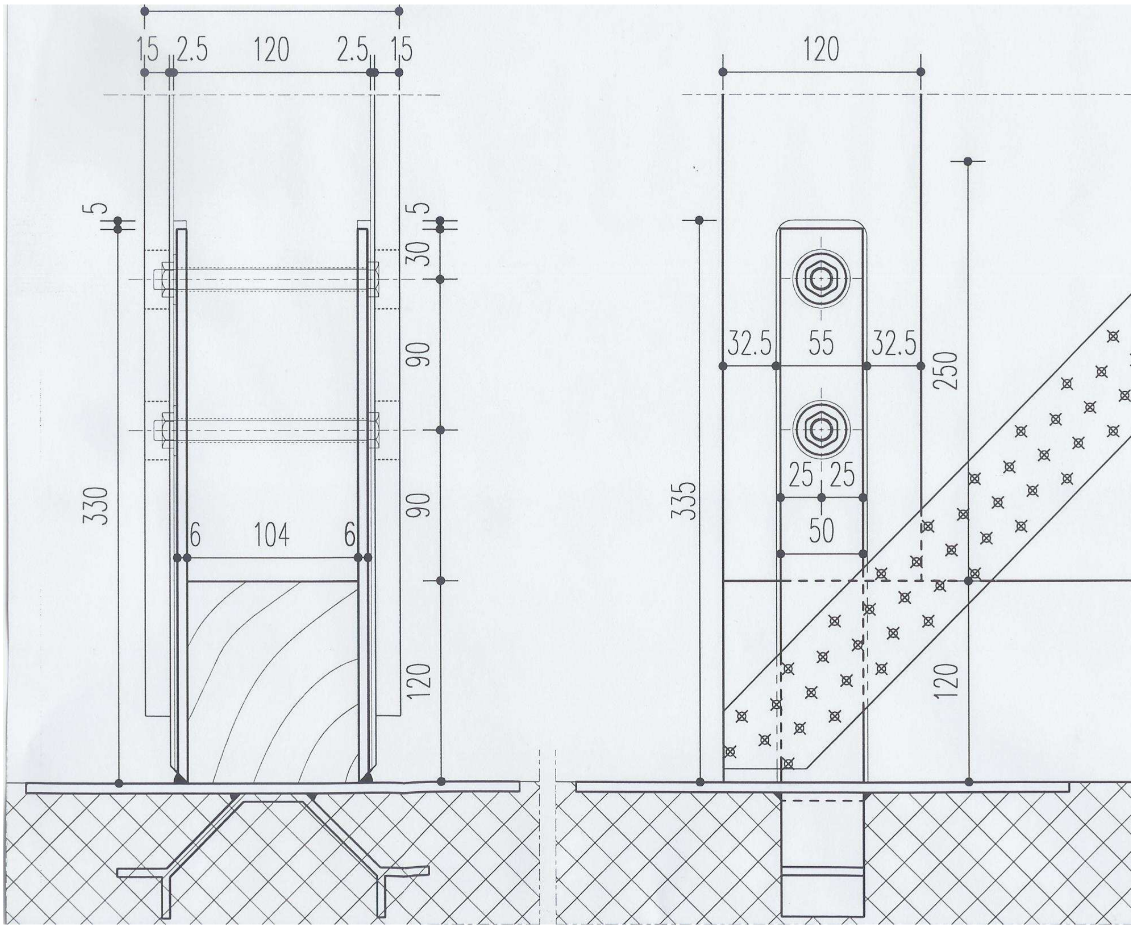


Fig. 13: Connection of the wall element reinforced with BMF diagonal to the lower concrete wall.

9. Protection from weather effects

To assure a horizontal protection of the building (for example strong wind effects) each side of the wall in the first and in the second prefabricated timber level was reinforced with two BMF steel diagonals of a cross-section *60x2mm* with the module of elasticity $E_s = 210.000\ N/mm^2$ (**Fig. 3**).

10. Economical and ecological aspects

As presented in **Fig. 1** the building is very undesturbing incorporated in a beautiful green Pohorje mountain landscape. Additionally, gypsum used as a sheathing material by timber-framed walls and floor elements is a healthy natural material and is consequently particularly desired for residential buildings.

Instructions and case study no 8 were prepared by Assoc.Prof.Dr. Miroslav Premrov.