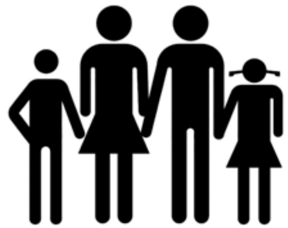
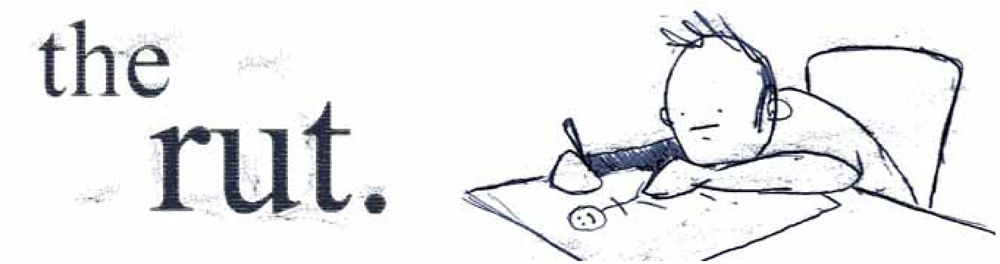
THE GROWING STEEL HOUSE



FAMILY RULES



The growing steel house

The concept of the house is to address low cost housing that attracts a wide clientele. Architectural design of the project focuses to provide openness of the house and surrounding area. To ensure the variability and flexibility of the concept, the structural design uses prefabricated panels and a steel skeleton. The basic proposal of the house is a starting two floored unit designed for the young generation, with an open concept design allowing for rapid conversion of space.

Ground floor contains the entrance, changing room, basic toilet and water tank room. Living room is connected with the dining room and kitchen.The first floor bears a study room, bathroom and bedroom. Optical interconnection of the ground floor and the first floor ensures throughview in the middle of the house.

Windows are oriented to the south in order to produce a dominant impression. However, they also serve the important function of illuminating the interior of the house as well as linking it to the garden outside, thus further enhancing the open concept of the house.

Since the concept is designed for a younger generation if there is an addition to the family, due to the open concept, re-organizing the space can be achieved rapidly and with relative ease.

The studyroom can be converted to another children's room. Further addition/expansion, not neccessarily another child but perhaps a car, it is possible to transform the house on a larger scale. For example, on the ground floor there is space to extend and merge the walls with that of the garage, and in the first floor two children rooms with bath room.

The basic building block of the building is a steel skeleton composed of square tube size 120 x 120 mm. Peripheral walls are provided by prefabricated system.Offer of panels starts at the solid panel, the panel with window (smaller and larger format), the panel containing the door, the half panel .... ect. Precast panels have uniform dimensions 2800 x 3750 x 120 mm. Their construction is based on the skeleton formed by U-shaped profiles (90 x 40 mm), the space inside is filled with mineral wool. Sheathing is done with the help of OSB board with a thickness of 15 mm. The interior board has a larger diffusion resistance, avoiding the need to use a vapour barrier, but we have to seal joining of panels and columns. Bars in the interior are made of plasterboard sandwiches with thickness of 150 mm. Construction of the ceiling and also roof provides a cross-oriented steelgirders (profile IPE 270). Distribution of forces from the ceiling is also done by purlins (profile IPE 160) and trapezoidal plates with concrete grout with a thickness of 60 mm. The whole building is carried by strip foundations. Facade is overlayed with Cembrit templates. There is the Solarwall system used for air heating, see solarwall : www.solarwall.com

Beginning idea was to propose a house according to the evolving needs of the owner. The house is like a man - living organism which is adapting to. Man is developing and changing his needs during his life. We tried to design a house which would evolve with people. That it would fulfill their needs and requirements. Young couple can find freedom without barriers in it and on the other side people with children certainties and enough space to live. According to this there are no partitions in the first face and this will develop to the last face where there is much more space but divided in rooms. The last face (face C, fully grown house) is made by no interference with the living space.

One of the other opportunities which the house gives is close connection of the interior with the nature and surrounding. This is thanks to the south façade which is fully glassed.

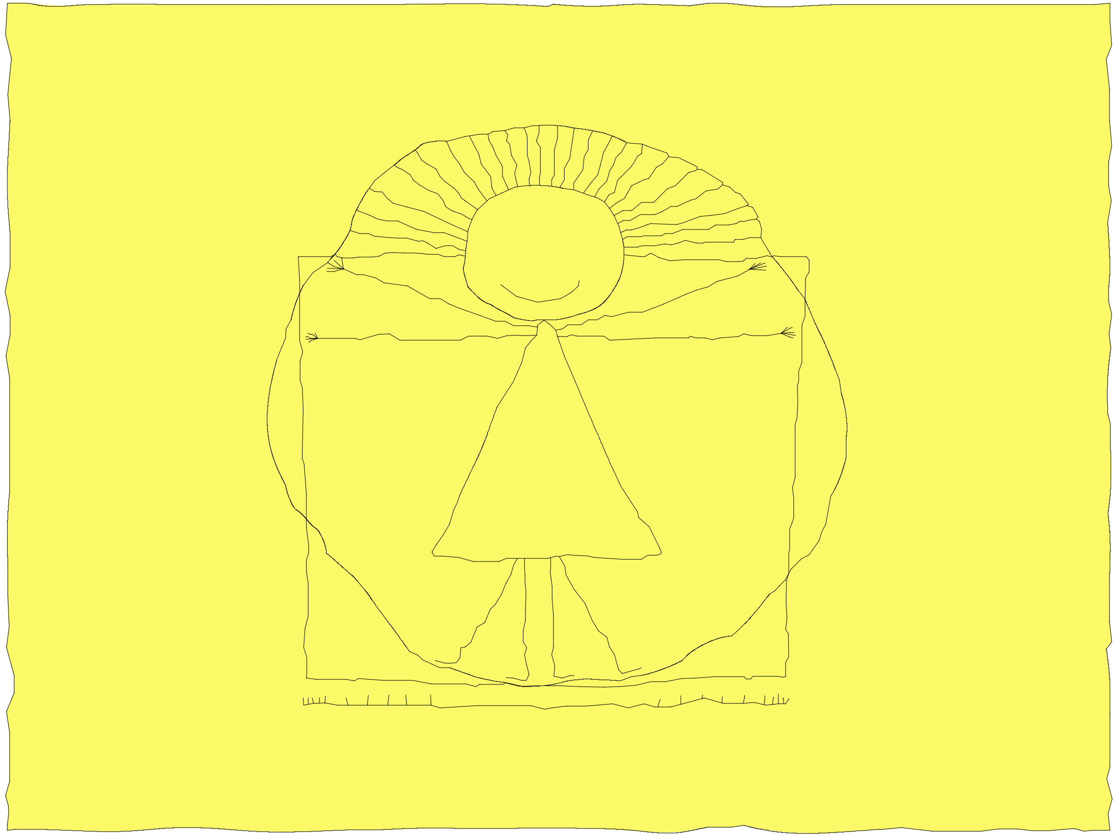
One of the main ideas that also influenced the architectonical design was the aspiration to make a house that could be built easily a quickly. That is because of the need of young people to move from a flat they are selling. To accomplish this need, there are used just screw connections and the majority of components used in the house is prefab and delivered directly to the construction.

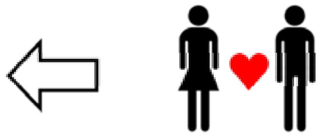
Every owner can design the façade as they wish. This can partly ensure the urban variety, when there are more houses at one area.

The house was also designed as a study of various thicknesses of thermal insulation. Basically there are 80 mm of thermal insulation in prefab panels and then three types of contact insulation system (120, 180 and 220 mm). This was done to see the influence of thermal insulation on energy demandingness of heating. As for the thickness of 220 mm of thermal insulation we got on the standard of passive house. Nowadays this is quite important for the area of the Czech Republic because of the influence on the environment and also because there is a donation programme of the Ministry of the environment. They give extra money to people who build their house in a passive standard.

The fully glassed façade orientated to the South allows us to use the solar gains during the winter time to low down the energy needed for heating. On the other side there are outdoor blinds to reduce the solar gains and energy needed for cooling during the summer time. On the same façade there will be installed the solarwall system which will help to heat up the air coming to the interior during the winter time.

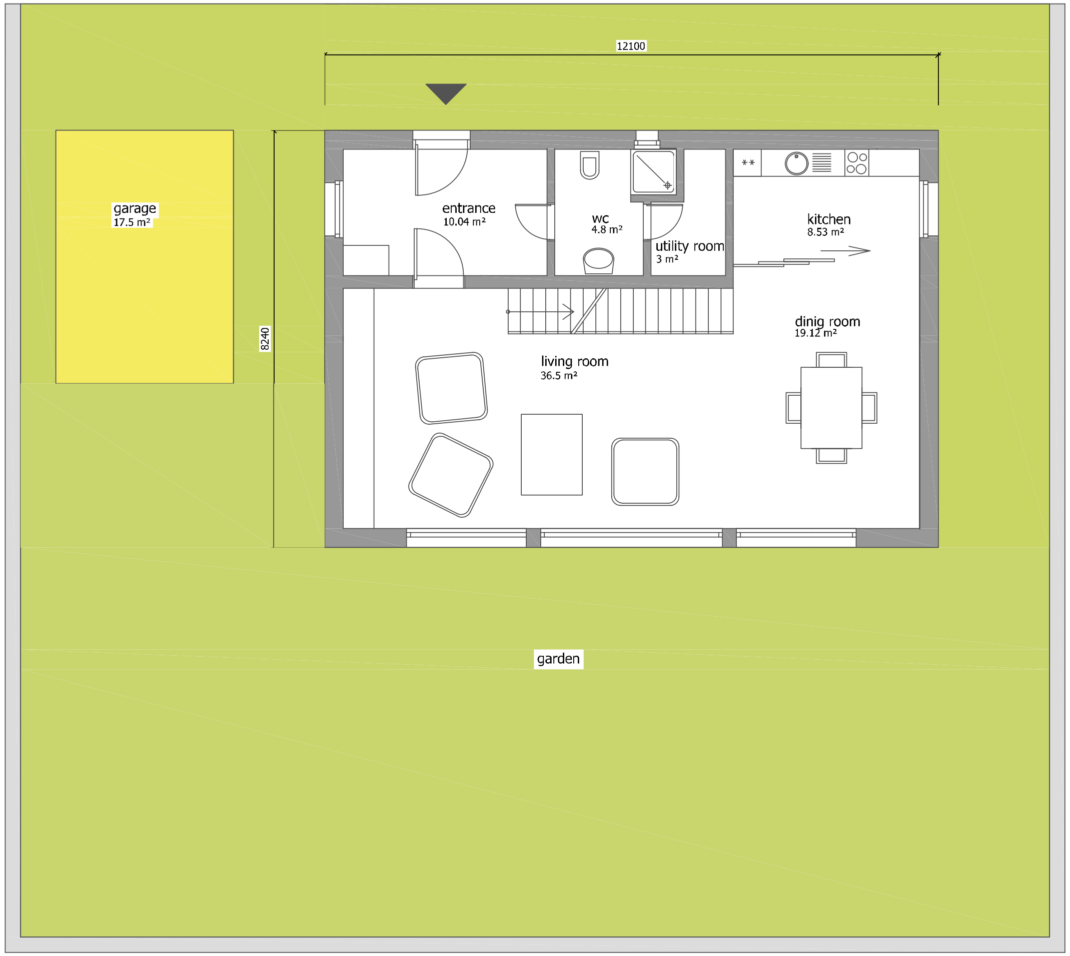
ARCHITECTURE PART



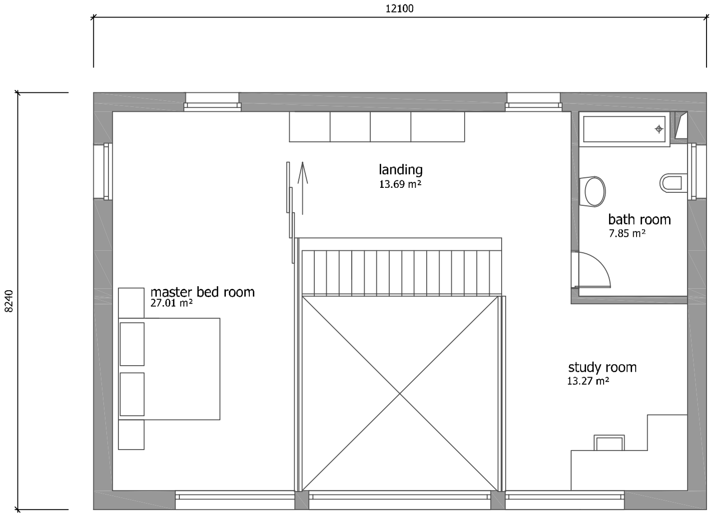


PHASE A

ground floor



first floor



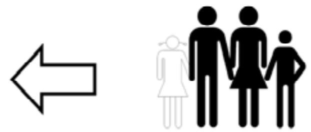
1 : 100

starting unit for young couple

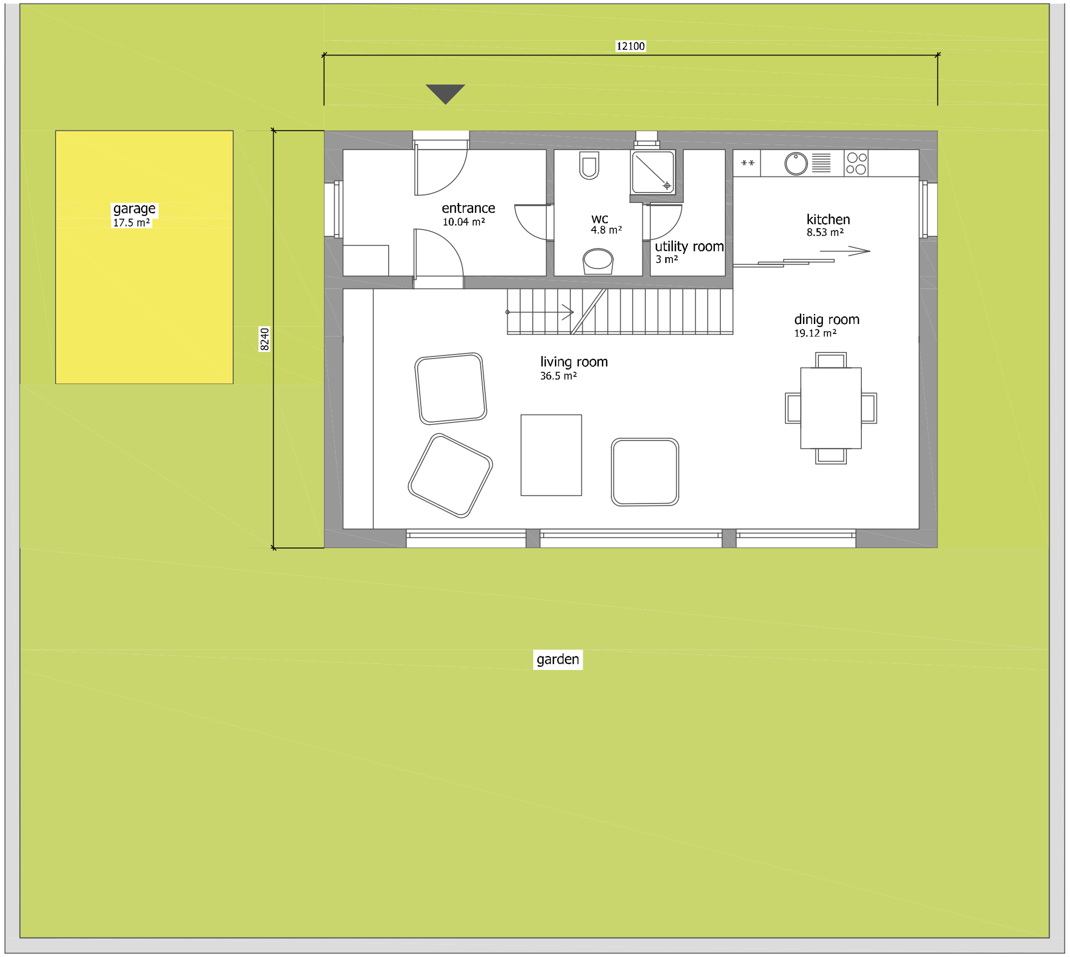
open space / master bed room and bed room

open-ended / master bed room or bed room

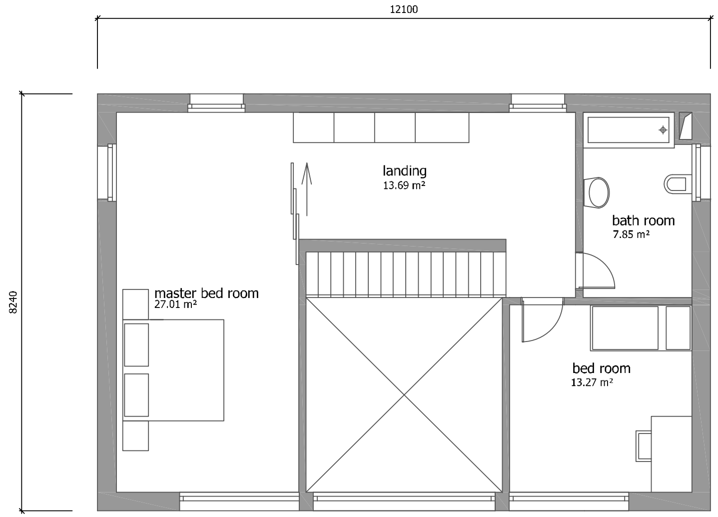
PHASE B



ground floor



first floor



1 : 100

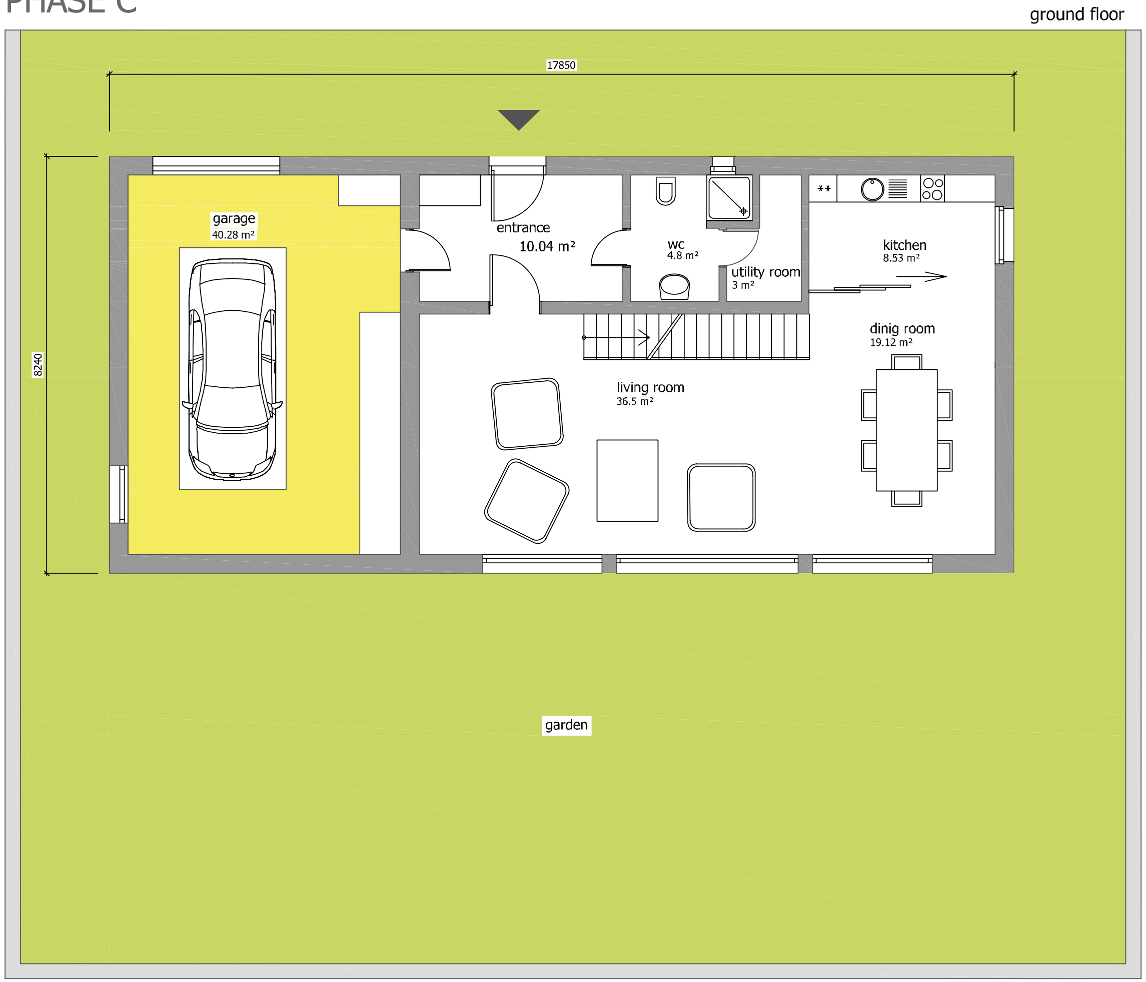
young couple with baby

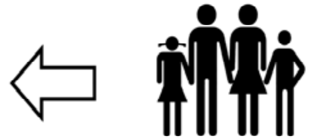
change in plan arrangement / study room to bed room

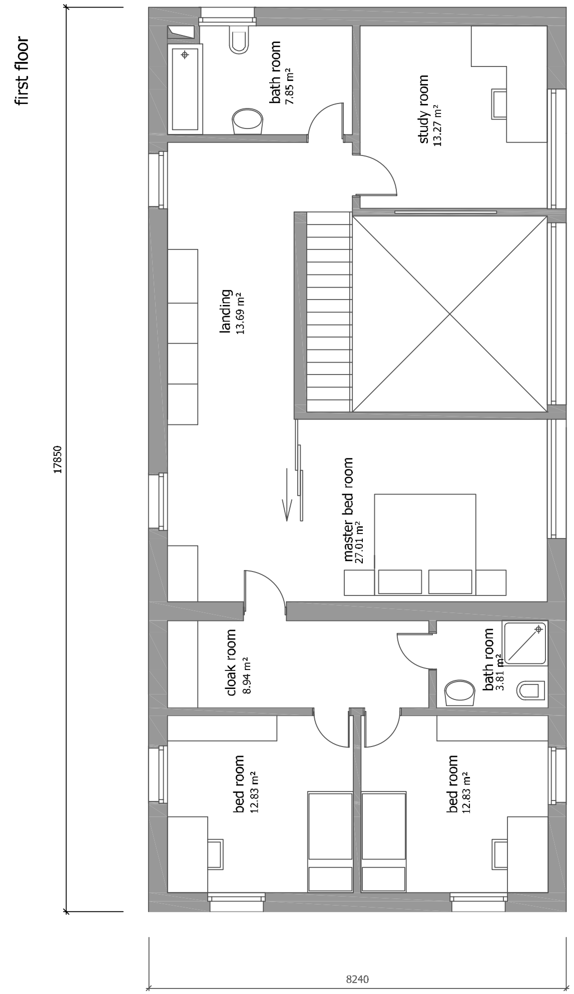
closed space / master bedroom and bed room

open-ended / master bed room or bed room

PHASE C







1 : 100

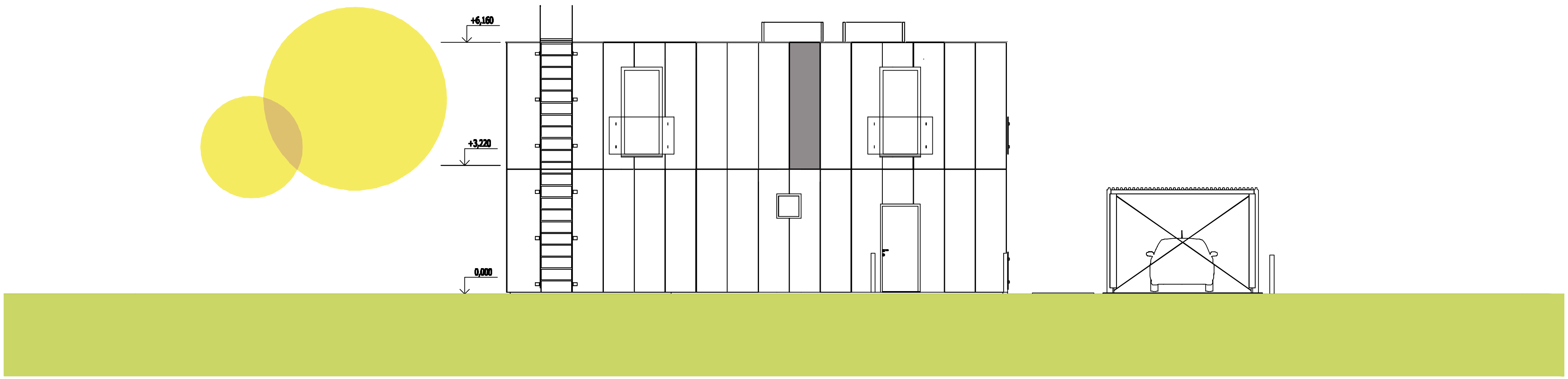
couple with 2 children

expanded by 2 bed rooms and garage

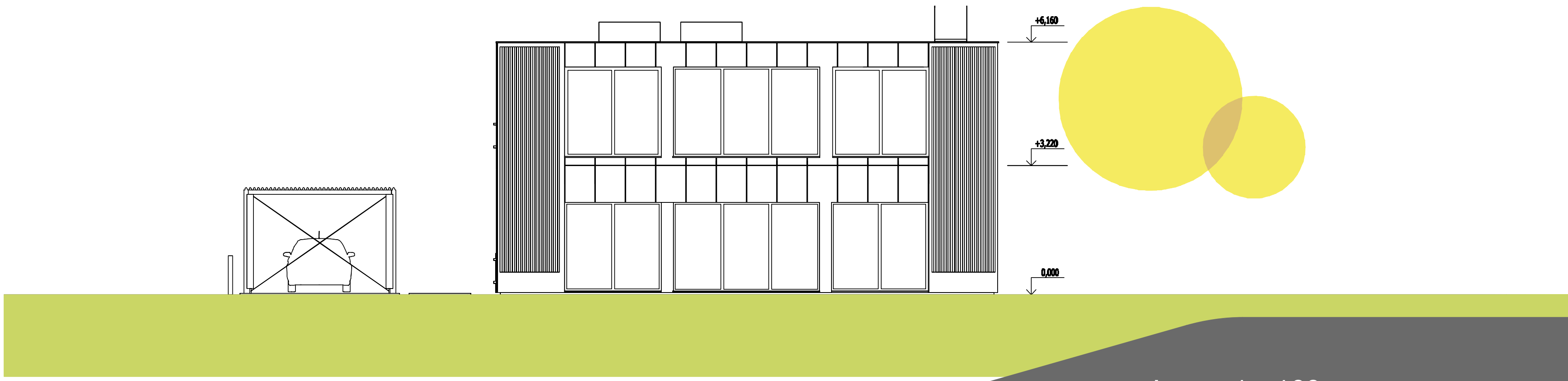
study room

phase C - couple with two children
growing steel house - family rules

north

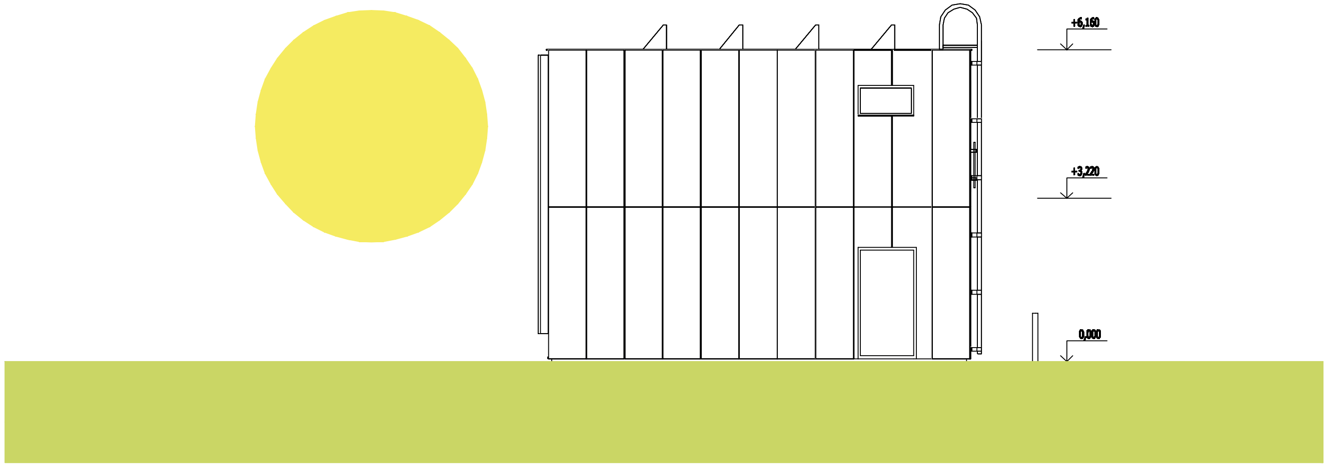


south

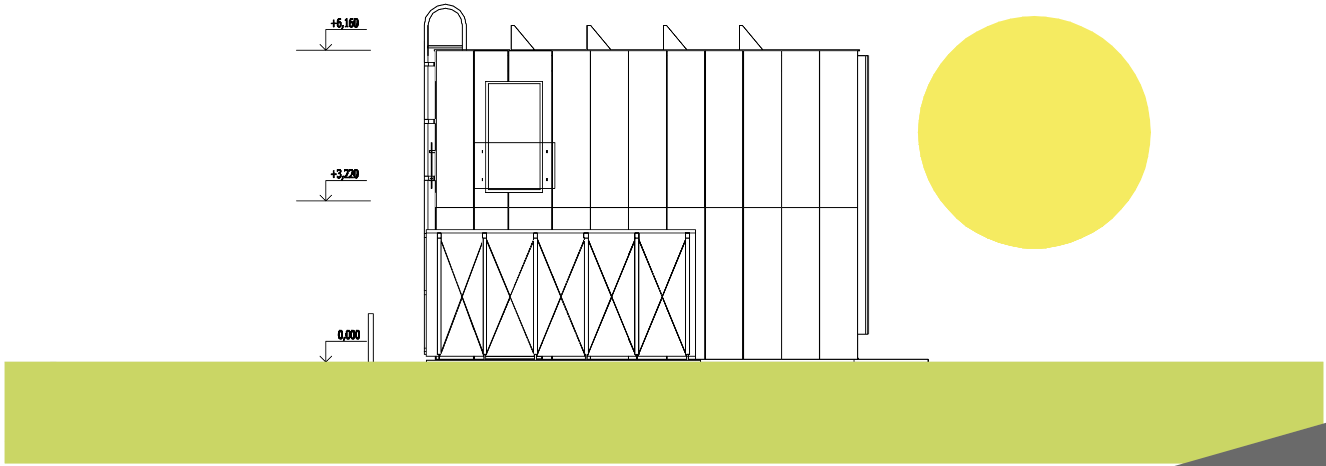


views - 1 : 100
growing steel house - family rules

east



west



views - 1 : 100
growing steel house - family rules

exterior views
growing steel house - family rules

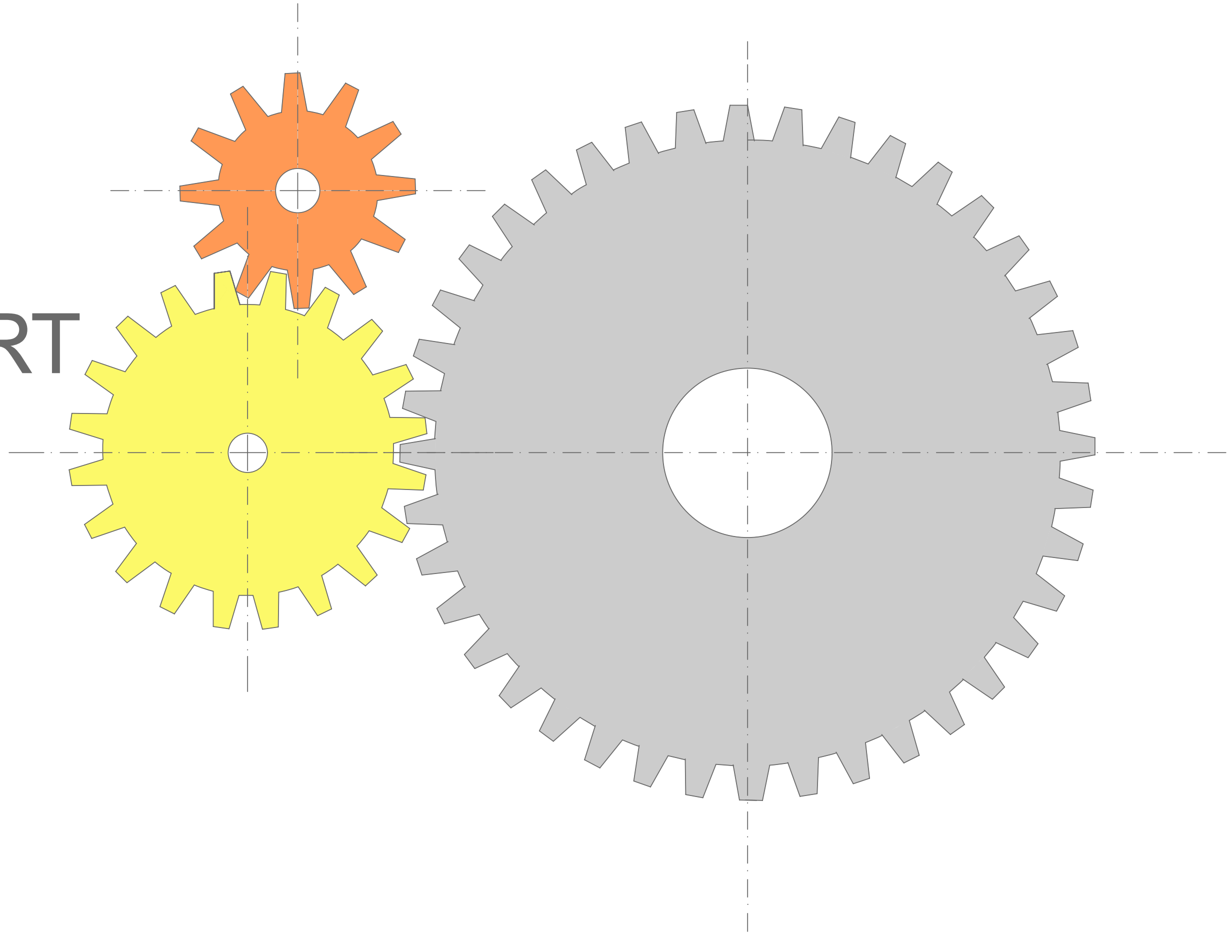


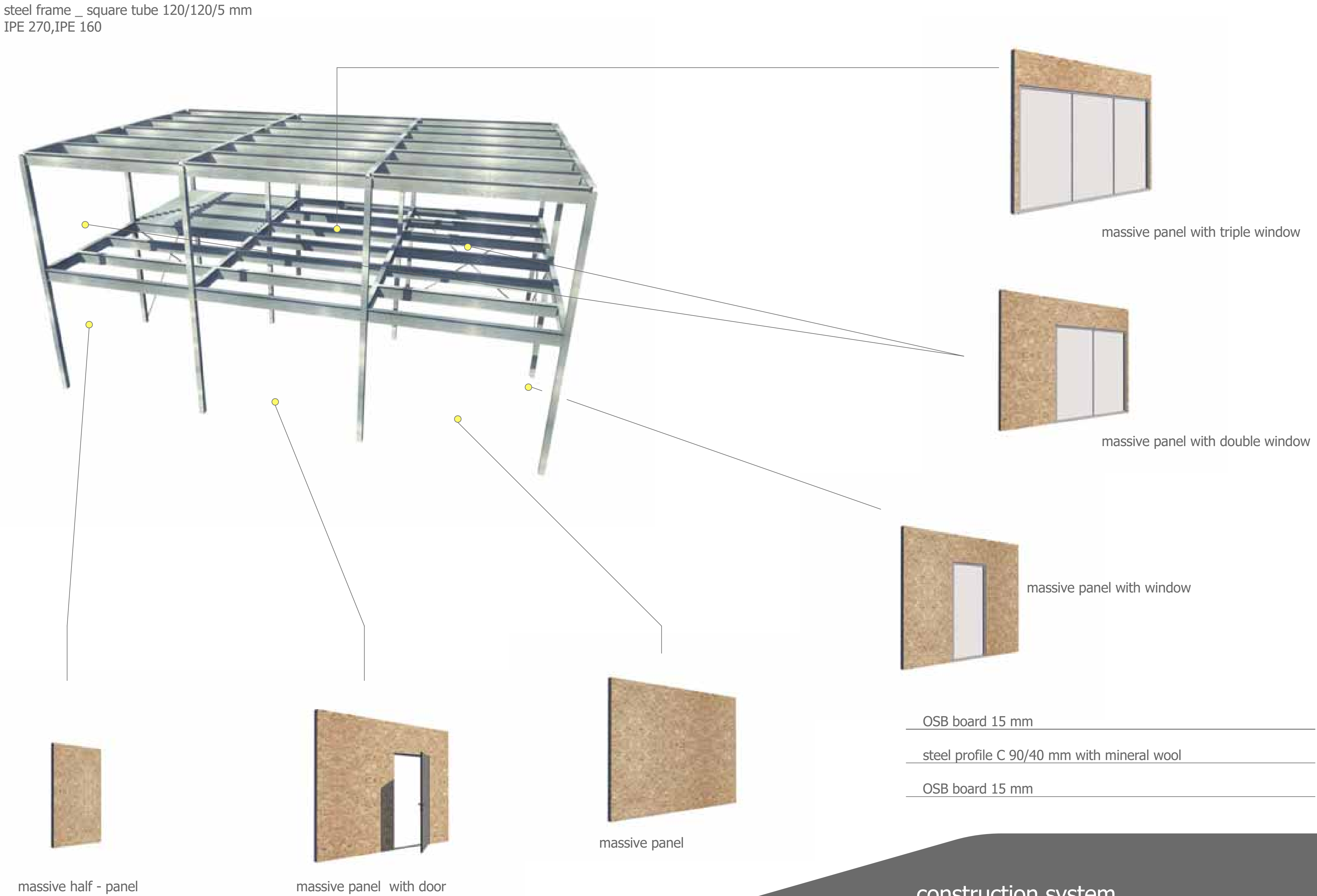
MORE COLOURS



combination of colours
growing steel house - family rules

CONSTRUCTION PART





construction system
growing steel house - family rules

IN - composition

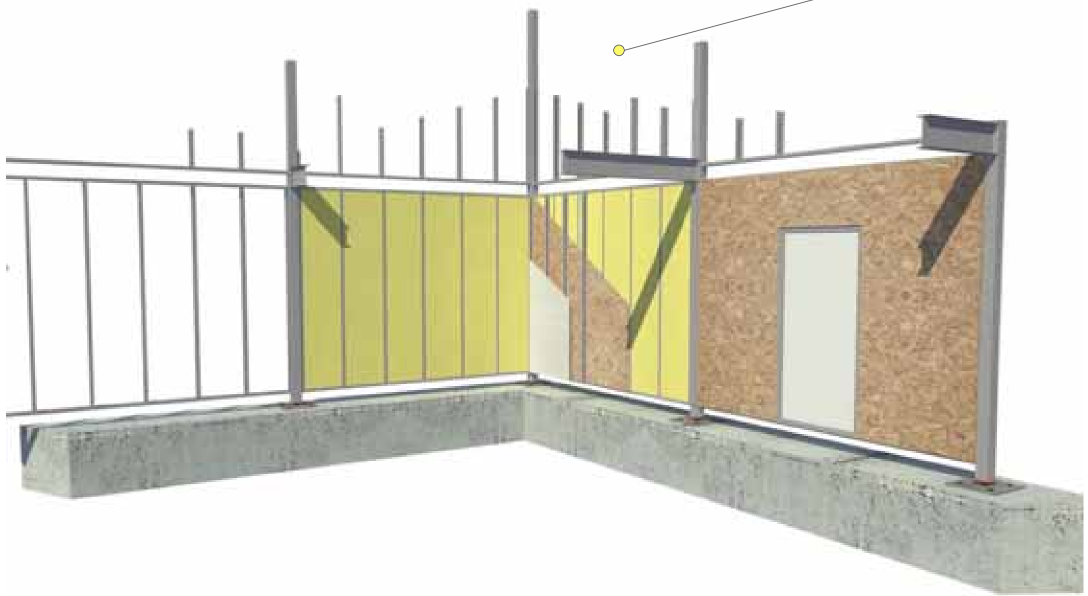
steel shape C 90/40 + mineral wool

OSB panel 15 mm

air space 50 mm

gypsum plasterboard 13 mm

surface conditioning



EX - composition

OSB panel 15 mm

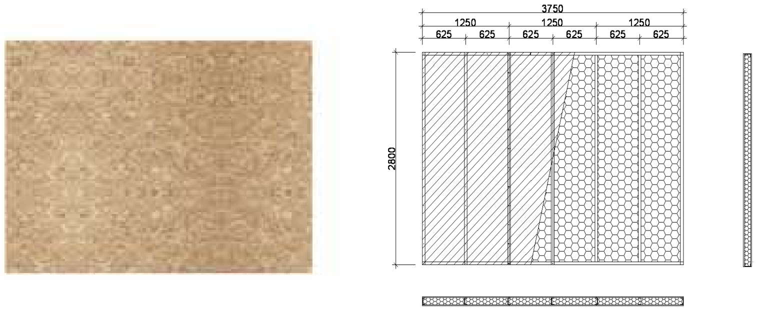
mineral wool 120 - 220 mm

air space 50 mm

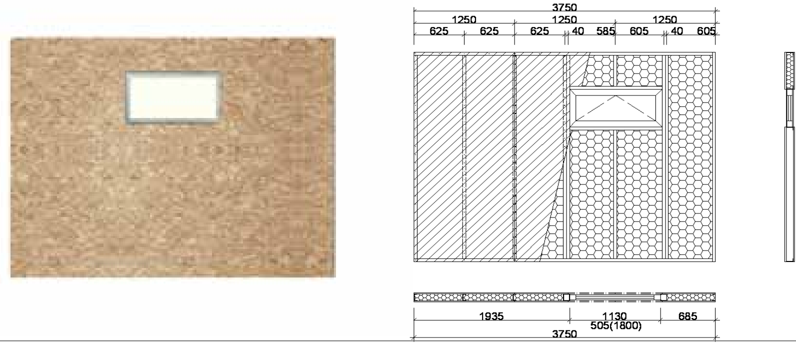
surface conditioning

construction system - external walls
growing steel house - family rules

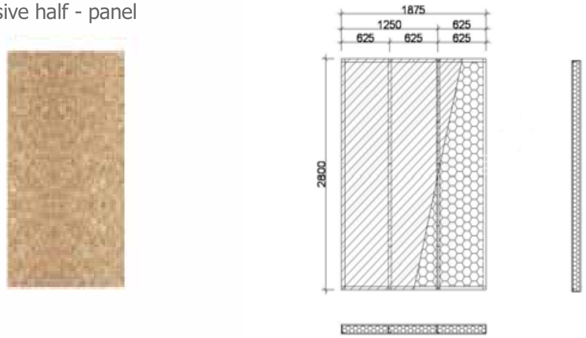
massive panel



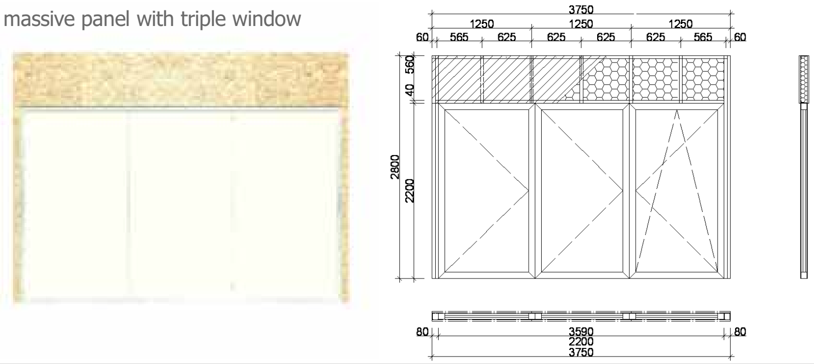
massive panel with small window



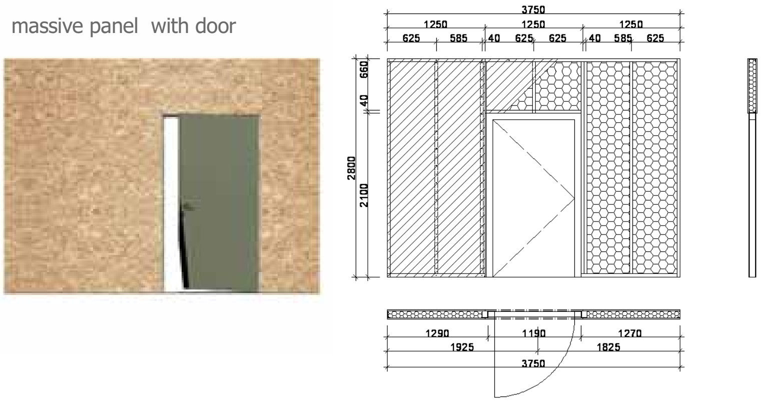
massive half - panel

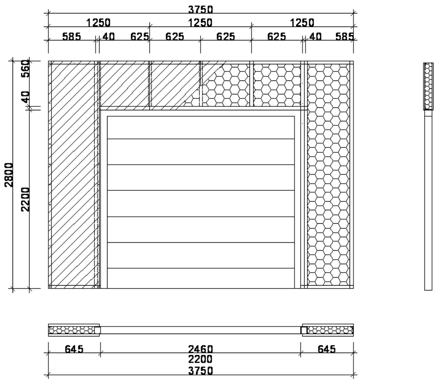


massive panel with triple window



massive panel with door

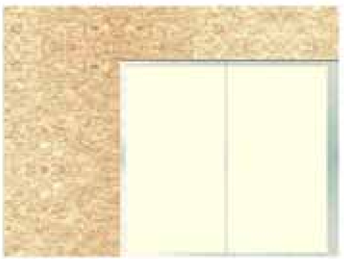


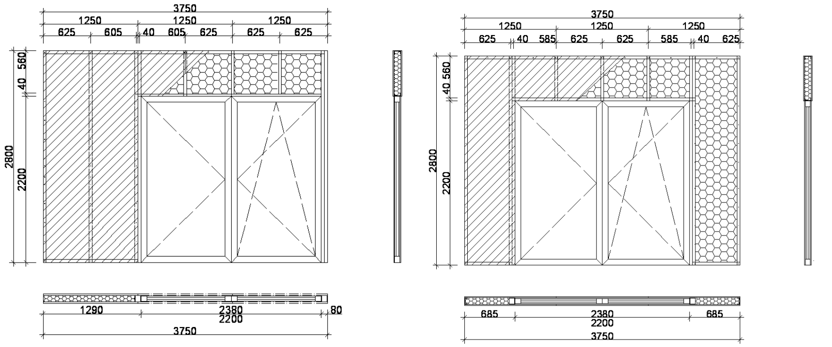


massive panel with garage door

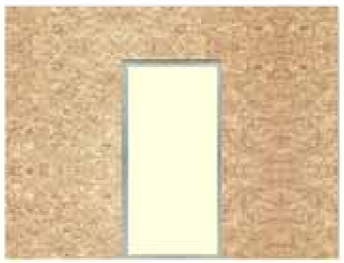
design of panels
growing steel house - family rules

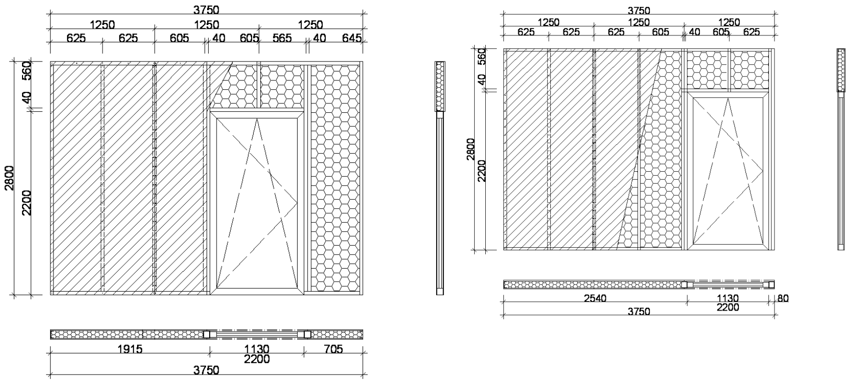
massive panel with double window



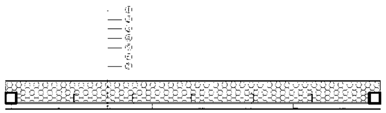


massive panel with window

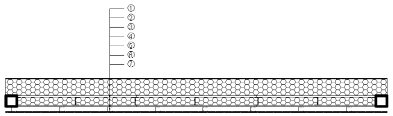




STRUCTURE OF BUILDING PANEL AND INSULATION THICKNESS 120 mm

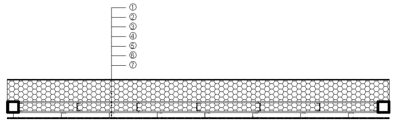


STRUCTURE OF BUILDING PANEL AND INSULATION THICKNESS 180 mm



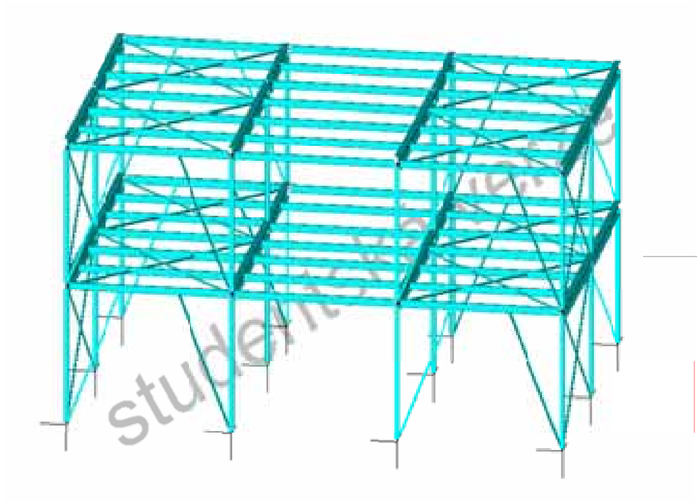
① OUTSIDE SURFACE TREATMENT
② ROCK WOOL- THICKNESS 120 mm
③ OSB BOARD TYPE 2 THICKNESS 15 mm
④ ROCK WOOL- THICKNESS 90 mm + STEEL PROFILE U 90
⑤ OSB BOARD TYPE 4 THICKNESS 15 mm
⑥ CW PROFILE
⑦ PLASTERBOARD

STRUCTURE OF BUILDING PANEL AND INSULATION THICKNESS 220 mm

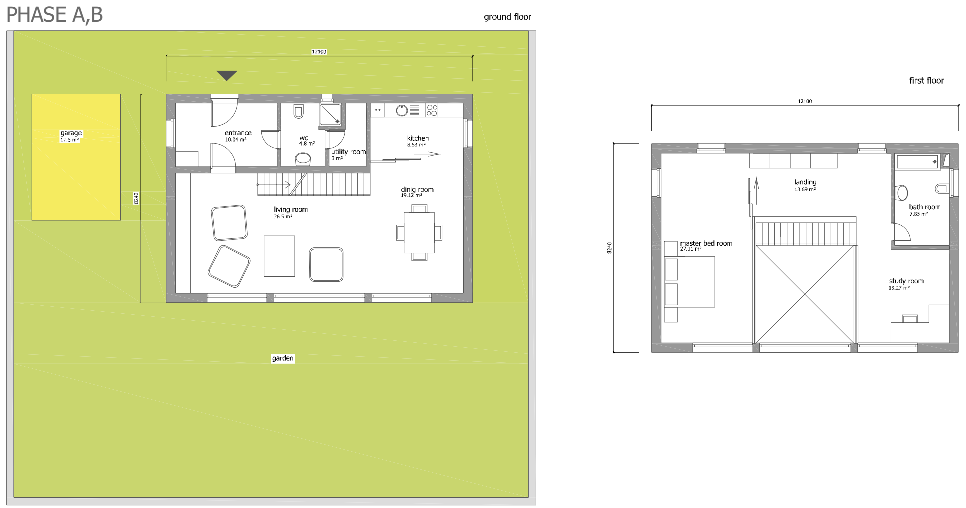


① OUTSIDE SURFACE TREATMENT
② ROCK WOOL- THICKNESS 120 mm
③ OSB BOARD TYPE 2 THICKNESS 15 mm
④ ROCK WOOL- THICKNESS 90 mm + STEEL PROFILE U 90
⑤ OSB BOARD TYPE 4 THICKNESS 15 mm
⑥ CW PROFILE
⑦ PLASTERBOARD

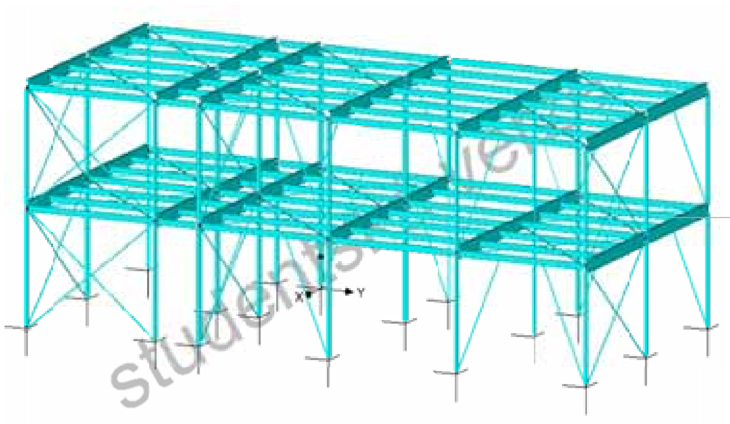
STATIC CALCULATION



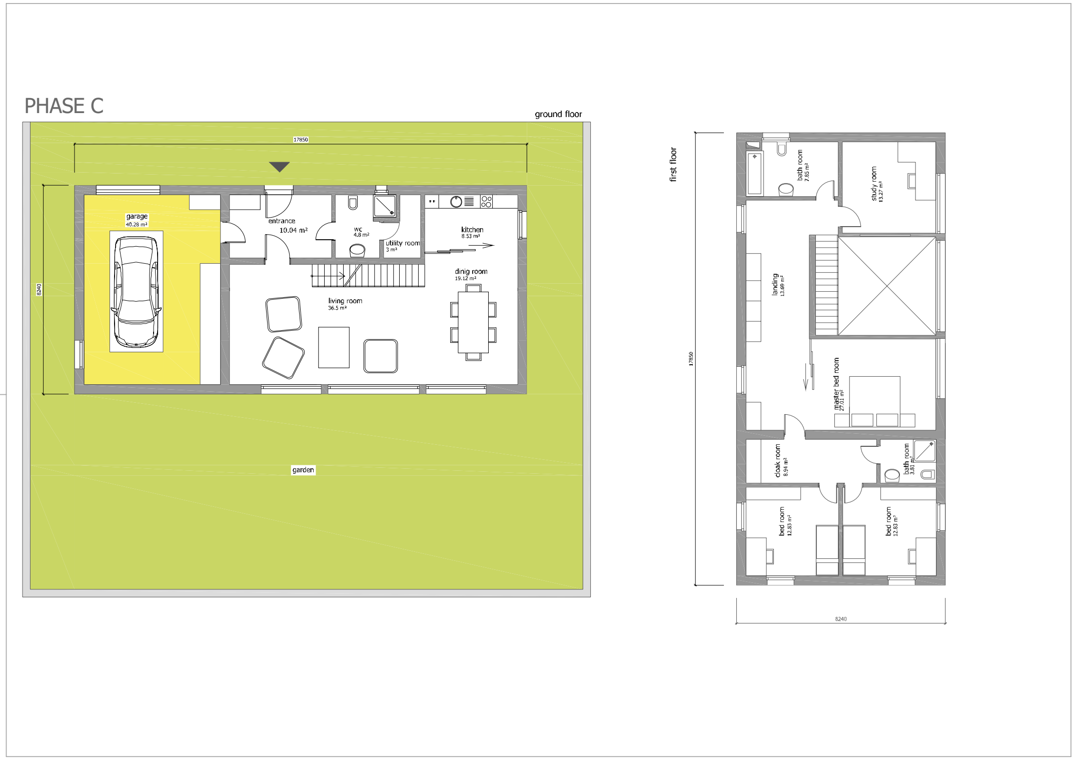
steel frame - phase A,B



disposition



steel frame - phase C



disposition

Wind load

Basic speed of the wind

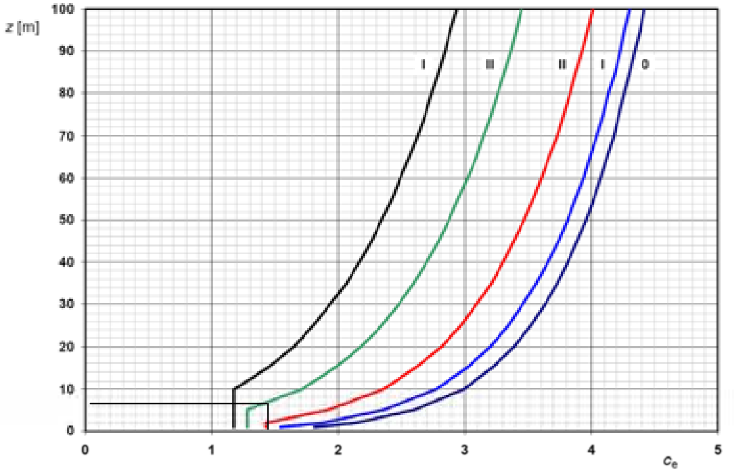
$v_b=C_{dir}*C_{season}*v_{b,0}$
C_{dir}=1,0 (coefficient - wind direction) C_{season}=1,0 (coefficient - season)
$v_{b,0}$=27,5 m/s (estimated from the map of wind speed, ČSN EN 1991-1-4, general location)
v_b=1,0*1,0*27,5=**27,5 m/s**

basic dynamic pressure of the wind

$q_b=1/2*\rho*v_b^2(z)$
ρ=1,25 kg/m^3 (density of the air)
v_b=27,5 m/s
q_b=1/2*1,25*27,5^2=**472,6563 N/m2**

maximal dynamic pressure

$q_p=c_e(z)*q_b$
c_e=1,4 (estimated as a function of height beyond terrain and the terrain cathegory, picture 4.2, ČSN EN 1991-1-4)



Obrázek 4.2 – Součinitele expozice $c_e(z)$ pro c_o = 1,0 a k_l = 1,0

terrain cathegory - III (areas equally covered by vegetation or buildings)
q_p=472,6563 N/m^2
q_p=1,4*472,6563=**661,7188 N/m^2**

wind pressure on the surface of the construction

$w_e=q_p(z)*C_{pe}$
q_p= **661,719** N/m^2

C_{pe}

area	wnd orientation θ=0°	wnd orientation θ=90°
A	-1,2	-1,2
B	-1	-1,4
C	-0,5	-0,5
D	0,75	0,8
E	-0,4	-0,5
F	-1,2	-1,2
G	-0,8	-0,8
H	-0,7	-0,7
I	0,2	0,2

w_e [N/m^2]

area	wind orientation	wind orientation
A	-794,063	-794,063
B	-661,719	-926,406
C	-330,859	-330,859
D	496,289	529,375
E	-264,688	-330,859
F	-794,063	-794,063
G	-529,375	-529,375
H	-463,203	-463,203
I	132,344	132,344

conversion of the presure to purlins θ=0°

purlin	measure 1	measure 2	w_e 1	q [kN/m´]
1-2 field	1,250	0,000	-794,063	-0,993
3. field	1,250	0,000	132,344	0,165
1-2 border field	0,625	0,000	-794,063	-0,496
3. border field	0,625	0,000	132,344	0,083

conversion of the presure to purlins θ=90°

purlin	measure 1	measure 2	w_e 1	q [kN/m´]
2-5 all fields	1,250	0,000	-794,063	-0,993
6. all fields	1,250	0,000	132,344	0,165
1 kraj všechny pole	0,625	0,000	-794,063	-0,496
7 kraj všechny pole	0,625	0,000	132,344	0,083

conversion of the pressure on the fixtures of enclosure wall panels to columns θ=0°

fixtures	distance 1	distance 2	w_e 2	Q [kN]
face wall	3,250	3,000	496,289	1,210
back wall	3,250	3,000	-264,688	-0,645
1. field	3,250	3,000	-794,063	-1,936
2. field	3,250	3,000	-661,719	-1,613
3. field	3,250	3,000	-330,859	-0,806

conversion of the pressure on the fixtures of enclosure wall panels to columns θ=90°

fixtures	distance 1	distance 2	w_e 2	Q [kN]
face wall	3,250	3,000	529,375	1,290
back wall	3,250	3,000	-330,859	-0,806
1. field	3,250	3,000	-794,063	-1,936
2.,3. field	3,250	3,000	-926,406	-2,258

Snow load

specification of snow load, done according to ČSN EN 1‹
for permanent or temporary design situations

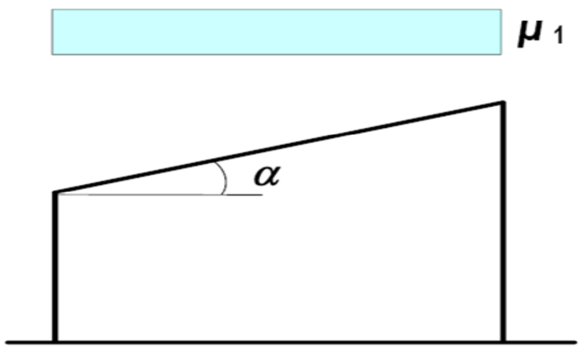
$s=\mu_i*C_e*C_t*s_k$

s_k=3,0 KN/m^2 estimated according to the map of snow areas of the Czech Republic
location generall, II. snow area

C_e=1,0 coefficient - exposition
estimated fot the normal shape of the landscape

C_t=1,0 thermal coefficient

μ form factor of snow load



μ_1=0,8 0°≤α≤30° α=0°

s=0,8*1,0*1,0*3,0=**2,4 KN/m²**

conversion of the snow pressure to purlins

distance of purlins in the ground plan l=1,25 ı

purlin	width of loading	value of loading Q [kN/m´]
boundary	0,625	1,5
middle	1,25	3

Self-weight load+ incidental load (depends on the character of using)

Construction of the floor

Self weight			characteristic load [kN/m²]	γ_F	design load [kN/m²]
clay tiles	0,008	12	0,096	1,35	0,130
anhydrit cast floor	0,04	20	0,800	1,35	1,080
thermal insulation	0,06	1,82	0,109	1,35	0,147
concrete slab	0,060	26,000	1,560	1,35	2,106
trapezoidal plate	1,000	0,150	0,150	1,35	0,203
soffit	1,000	0,150	0,150	1,35	0,203
		summary	**2,865**		**3,868**
multiplying by loading width	1,250		**3,582**		**4,835**
	0,625		**1,791**		**2,418**

Incidental load		characteristic load [kN/m²]	γ_F	design load [kN/m²]
utility load		2,000	1,5	3,000
	summary	**2,000**		**3,000**
multiplying by loading width	1,250	**2,500**		**3,750**
	0,625	**1,250**		**1,875**

Construction of roof

Self weight			characteristic load [kN/m²]	γ_F	design load [kN/m²]
soil substrate	1	1,5	1,500	1,35	2,025
thermal insulation	0,3	1,82	0,546	1,35	0,737
concrete slab	0,067	26,000	1,742	1,35	2,352
trapezoidal plate	1,000	0,150	0,150	1,35	0,203
soffit	1,000	0,150	0,150	1,35	0,203
		summary	**4,088**		**5,519**
multiplying by loading width	1,250		**5,110**		**6,899**
	0,625		**2,555**		**3,449**

Incidental load		characteristic load [kN/m²]	γ_F	design load [kN/m²]
utility load		2,000	1,5	3,000
	summary	**2,000**		**3,000**
multiplying by loading width	1,250	**2,500**		**3,750**
	0,625	**1,250**		**1,875**

Enclousure wall panel

Self weight			characteristic load [kN/m²]	γ_F	design load [kN/m²]
2*OSB slab thickness 15mm	22,50	0,100	2,250	1,35	3,038
thermal insulation	13,50	0,672	9,072	1,35	12,247
steel section	28,50	0,020	0,570	1,35	0,770
		summary	**11,892**		**16,054**

Rese

glossary:
OSB slab — weight 0,1 kN/m2 * 2 slabs * 3,75(lenght) * 3(height)
steel section (C100) — weight 0,02kN/m * lenght of all sections 3 * 3,75(horizontally) + 4 * 3(vertically)

weight of the panel carried through by one fixture [kN] **2,973** **4,014**

Load combinations

$\sum_{j\geq1}\gamma_{Gj}G_{kj}+\gamma_{Q1}Q_{k1}+\sum_{i\geq1}\gamma_{Qi}\psi_{0i}Q_{ki}$

1. self weight load + incidental load

$1{,}35*G_k+1{,}5*Q_N$

2. self weight load + incidental load + snow load

$1{,}35*G_k+1{,}5*Q_N+0{,}6*1{,}5*Q_S$

3. sself weight load + wind load

$0{,}9*G_k+1{,}5*Q_V$

Design of the purlin

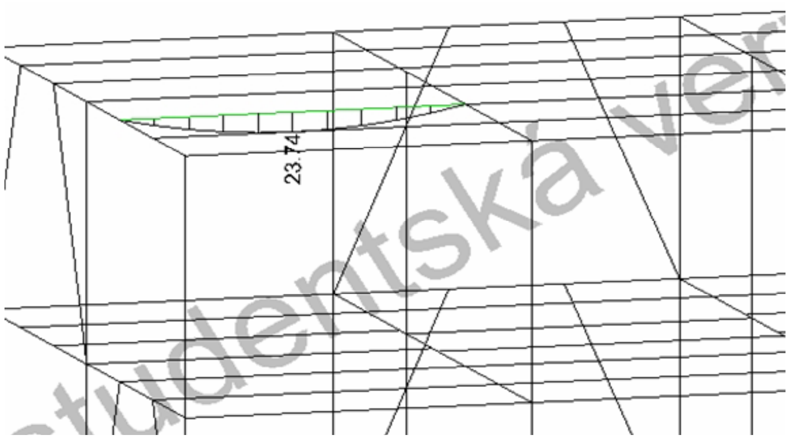
(there is used steel S 355 for the design)

Counted reactions *(counted with software FIN 3D)*

$R_{Sd}=V_{Sd}=$ 25,33 kN

Counted bending moment *(counted with software FIN 3D)*

$M_{Sd}=$ 23,7400 kNm



Horizontal module needed

$W_{min}= M_{Sd}/f_{yd}$ $f_{yd}=$ 308,7 Mpa *(steel S355)*

$W_{min}=$ 23,74*10^3/308,7

$W_{min}=$ **76,9031** mm^3

Profile design

	IPE 160	
m=	12,9	kg/m
A=	1543	mm^2
W_y=	77300	mm^3
$W_{pl,y}$=	88340	mm^3
I_y=	5412000	mm^4
A_{vz}=	764	mm^2

Recognition of the designed profile

Torque loading capacity

$M_{pl,Rd}= W_{pl,y}*f_{yd}$

$M_{pl,Rd}=$ 88340*308,7

$M_{pl,Rd}=$ **27,2706** kNm > $M_{Sd}=$ 23,7400 kNm

—>Purlin complies

Shear carrying capacity

$V_{pl,Rd}= A_{VZ}*f_{yd/}\sqrt{3}$

$V_{pl,Rd}=$ 764*308,7/√3

$V_{pl,Rd}=$ **136,1662** kN > $V_{Sd}=$ 25,33 kN

—>Purlin complies

Limit the applicability of state - deflection

(all load) $g_k=$ 5,239 kN/m $g_k + q_k=$ 10,739

$q_k=$ 5,5 kN/m

$\delta= (5/384) * (g_k*L^4)/(EI_y)$

δ= (5/384)*(5,239*3750^4)/(210000*5412000)

δ= **11,870** mm $\delta_{lim}=$ L/250= 15 mm

Summary of all purlins in the structure and their weight

number of purlins	n=	42	ks
weight of one purlin	m=	12,9	kg/m
lenght of one purlin	l=	3,75	m
weight summary	m_c=	**2031,75**	kg

Design of a girder

(there is used steel S 355 for the design)

Counted reactions from purlins *(counted with software FIN 3D)*

F_k= 50,66 kN

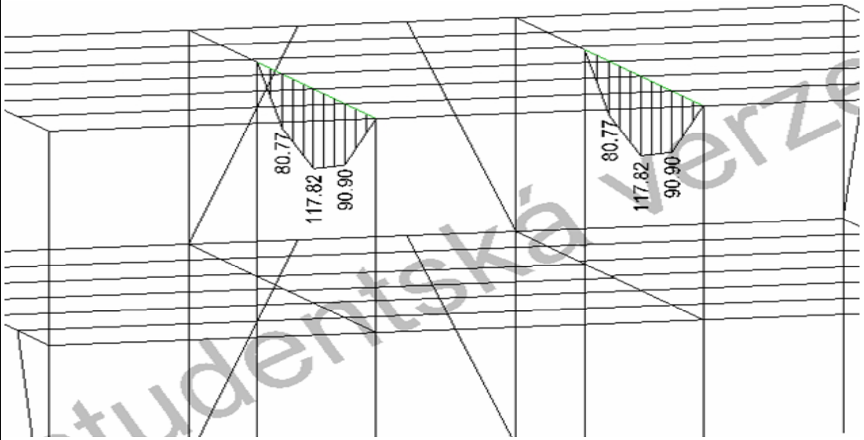
vlastní tíha nosníku je uvažována přímo vy výpočtu vnitřnch sil

Counted reactions *(counted with software FIN 3D)*

$R_{Sd}=V_{Sd}$= 97,37 kN

Counted bending moment *(counted with software FIN 3D)*

M_{Sd}= 117,8200 kNm



Horizontal module needed

W_{min}= M_{Sd}/f_{yd} f_{yd}= 308,7 Mpa *(steel S355)*

W_{min}= 117,82*10^3/308,7

W_{min}= **381,6650** mm^3

Profile design

	IPE 270	
m=	36,1	kg/m
A=	4594	mm^2
W_y=	429000	mm^3
$W_{pl,y}$=	484000	mm^3
I_y=	57900000	mm^4
A_{vz}=	2214	mm^2
b=	135	mm
t_f=	10,2	mm
h=	270	mm

Recognition of the designed profile

Plastic flexural loading capacity steel-concrete section *concrete C25/30 is used*

co-width cof oncrete slab *thickness* d= 60 mm

b_{eff}= $2b_{e1}$ f_{ck}= 25 Mpa t_p= 50

b_{eff}= L/4 f_{cd}= $0,85*f_{ck}/\gamma_c$= 0,85*25/1,5= 14,1667 Mpa

b_{eff}= 937,5 mm

presumption of a neutral axis location in the concrete slab (concrete in the rib is neglected)

balance of internal forces

N_a= N_c

$A_a f_{yd}$= $x\ b_{eff}\ f_{cd}$

4594*308,7= x*937,5*14,167

x= (4594*308,7)/(937,5*14,167)

x= **106,780** mm > 60 mm

—>It is apparent that the neutral axis lies outside the concrete slab

presumption of a neutral axis location in a steel profile

balance of internal forces

N_a= $N_c + 2N_{a1}$

N_a=	$A_s f_{yd}$ =	4594*308,7=	**1418,168**	kN
N_c=	d * b_{eff} * f_{cd}=	60*937,5*14,167=	**796,875**	kN
N_{a1}=	$(N_a-N_c)/2$=	(1418,1678-796,875)/2	**310,646**	kN

presumption of a neutral axis position in the upper flange of steel profile

x= $N_{a1}/(f_{yd}*b)$

x= 310,646*1000/(308,7*135)

x= **7,454** mm < 10,2 mm

—>The neutral axis is located in the upper flange of steel profile

Torque loading capacity

$M_{pl,Rd}$= $N_c*r_c + N_{a1}*r_{a1}$

$M_{pl,Rd}$= 796,875*(135+110-30)+310,6464*(135-3,727)

$M_{pl,Rd}$= **212,108** kNm > M_{Sd}= **117,820** kNm

—>Girder complies

Shear carrying capacity

$V_{pl,Rd}$= $A_{VZ}*f_{yd}/\sqrt{3}$

$V_{pl,Rd}$= 2214*308,7/√3

$V_{pl,Rd}$= **394,597** kN > V_{Sd}= **50,66** kN

—>Girder complies

Limit the applicability of state - deflection

(all load) g_k= 12,464 kN/m g_k+q_k= 25,490

q_k= 13,026 kN/m

δ= (5/384) * $(g_k*L^4)/(EI_y)$

δ= (5/384)*(12,464*4750^4)/(210000*57900000)

δ= **13,896** mm < $δ_{lim}$= L/250= **19** mm

(incidental load)

$δ_2$= q_k/g_k * δ

$δ_2$= 0/25,49*13,896

$δ_2$= **7,101** mm < $δ_{lim}$= L/300= **15,833** mm

Summary of all girders in the structure and their weight

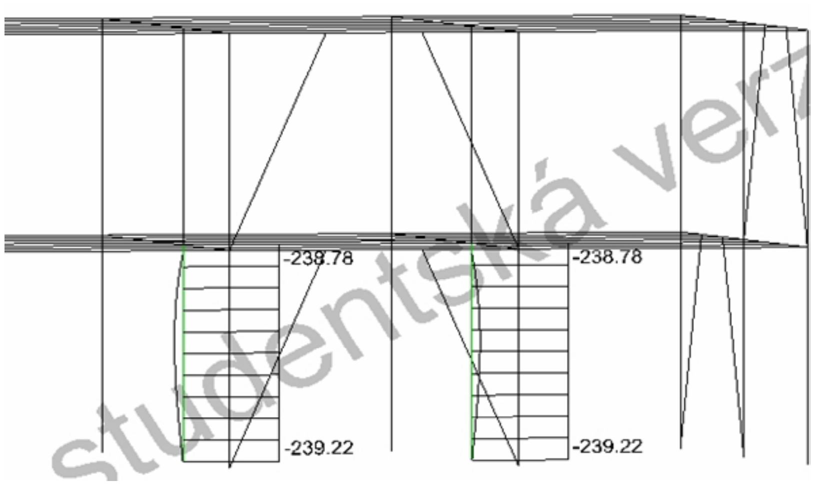
number of girders	n=	8	ks
weight of one girder	m=	36,1	kg/m
lenght of one girder	l=	7,5	m
weight summary	m_c=	**2166**	kg

Design of a column

(there is used steel S 355 for the design)

Loading force

F_{Sd}= 239,22 kN



Profile design

	square tube 120x120x5	
m=	17,82	kg/m
A=	2270	mm^2
i_y=	46,8	mm
i_z=	46,8	mm

λ_1= 93,9√(235/355)= 76,399

β_A= 1

f_{yd}= 308,7 Mpa

(steel S355)

Recognition of the designed profile

(buckling length)

$L_{cr,y} = L_{cr,z}$ = 3,0 m

					křivka vzpěrnosti	souč. vzpěrnosti
λ_y =	$L_{cr,z}/i_y$=	3000/46,8=	64,10256			
λ_z =	$L_{cr,y}/i_z$=	3000/46,8=	64,10256			
$\bar{\lambda}_y$ =	$\lambda_y/\lambda_1*\sqrt{\beta_A}$=	64,103/76,399*√1		0,8391	b	0,699
$\bar{\lambda}_z$ =	$\lambda_y/\lambda_1*\sqrt{\beta_A}$=	64,103/76,399*√1		0,8391	b	0,699

buckling pressure loading capacity

$N_{b,Rd}$= **489,82355** kN

Summary of all columns in the structure and their weight

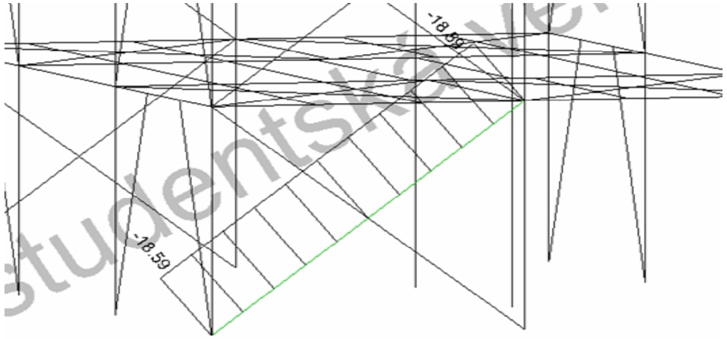
number of columns	n=	24	ks
weight of one column	m=	17,82	kg/m
lenght of one column	l=	3	m
weight summary	m_c=	**1283,04**	kg

Design of reinforcements

(there is used steel S 355 for the design)

Normal force for the design of reinforcements

N_{max}= 22,67 kN



Profile design **TR 38x4,0**

m=	4	kg/m
A=	509	mm^2
i=	14,4	mm

f_{yd}= 308,7 Mpa

(steel S355)

Design of connecion

srews	M12	5.6	
spacing	e_1=	30	mm
	e_2=	25	mm
	p_1=	40	mm

loading capacity of the shear

$F_{v,Rd}$= 17,4 kN *(single-shear, shear in the screw-thread)*

loading capacity of the deformation

$F_{b,Rd}$= 48,72 kN *(t=6mm, S355, recommended spacing)*

—>The shear loading capacity is dominant

number of screws

n= 22,67/17,4

n= 1,3

=> proposal 2 screws M12 5.6

recognition of the element itself

$L_{cr,y} = L_{cr,z}$ = 2,4 m β_A= 1

λ = L_{cr}/i= 2400/14,4= 166,6667

λ_1= 93,9√(235/355)= 76,399

λ = $\lambda_y/\lambda_1 * \sqrt{\beta_A}$= 166,667/76,399*√1 2,1815

buckling curve	buckling coefficient
b	0,176

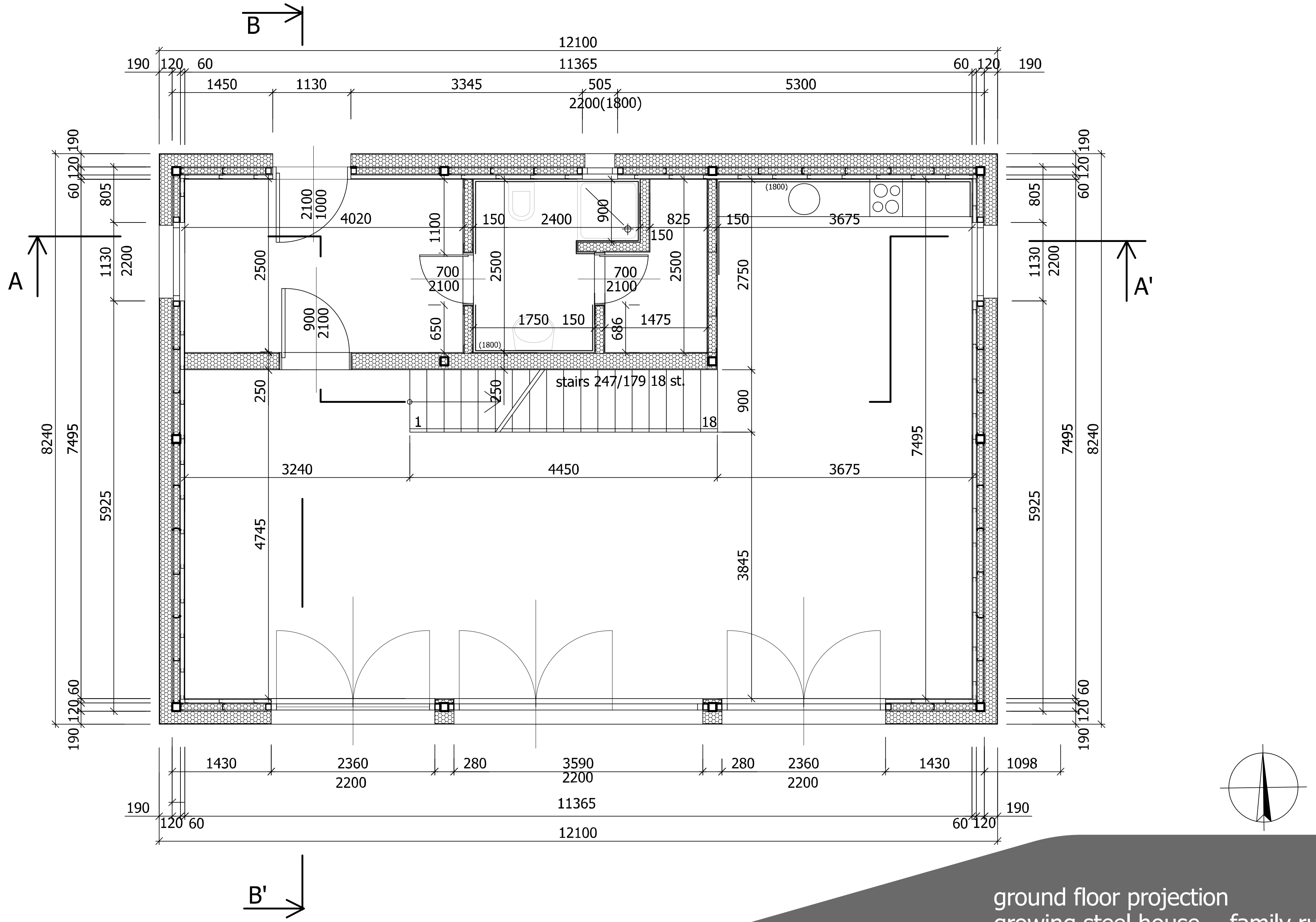
buckling pressure loading capacity

$N_{b,Rd}$= **27,65458** kN

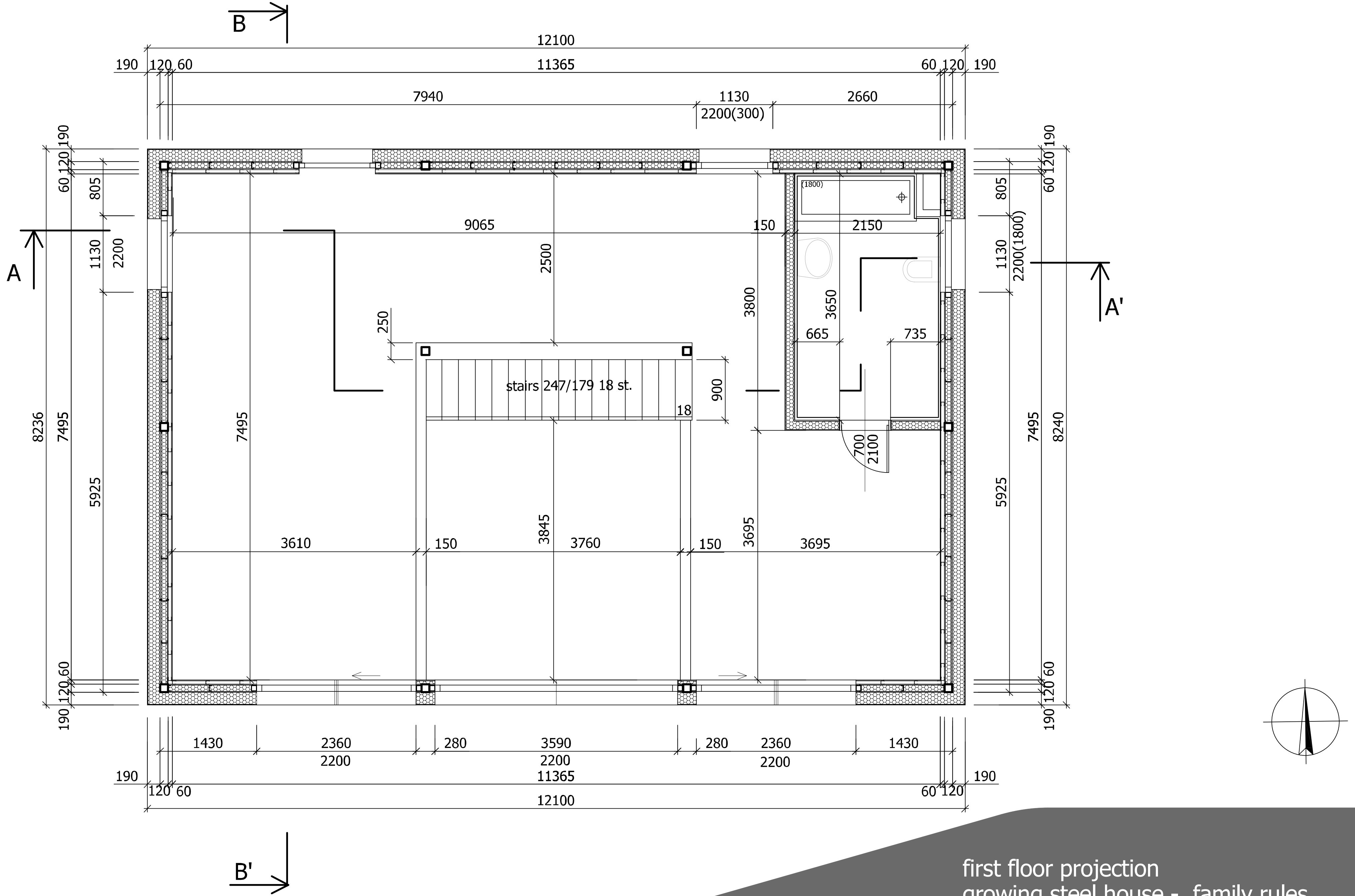
Summary of all reinforcements in the structure and their weight

number of reinforcements	n=	12	ks
weight of one reinforcement	m=	4	kg/m
lenght of one reinforcement	l=	4,8	m
weight summary	m_c=	**230,4**	kg
weight summary of all elements	m_{tot}=	**5711,19**	kg

FLOOR PROJECTION - GROUND FLOOR

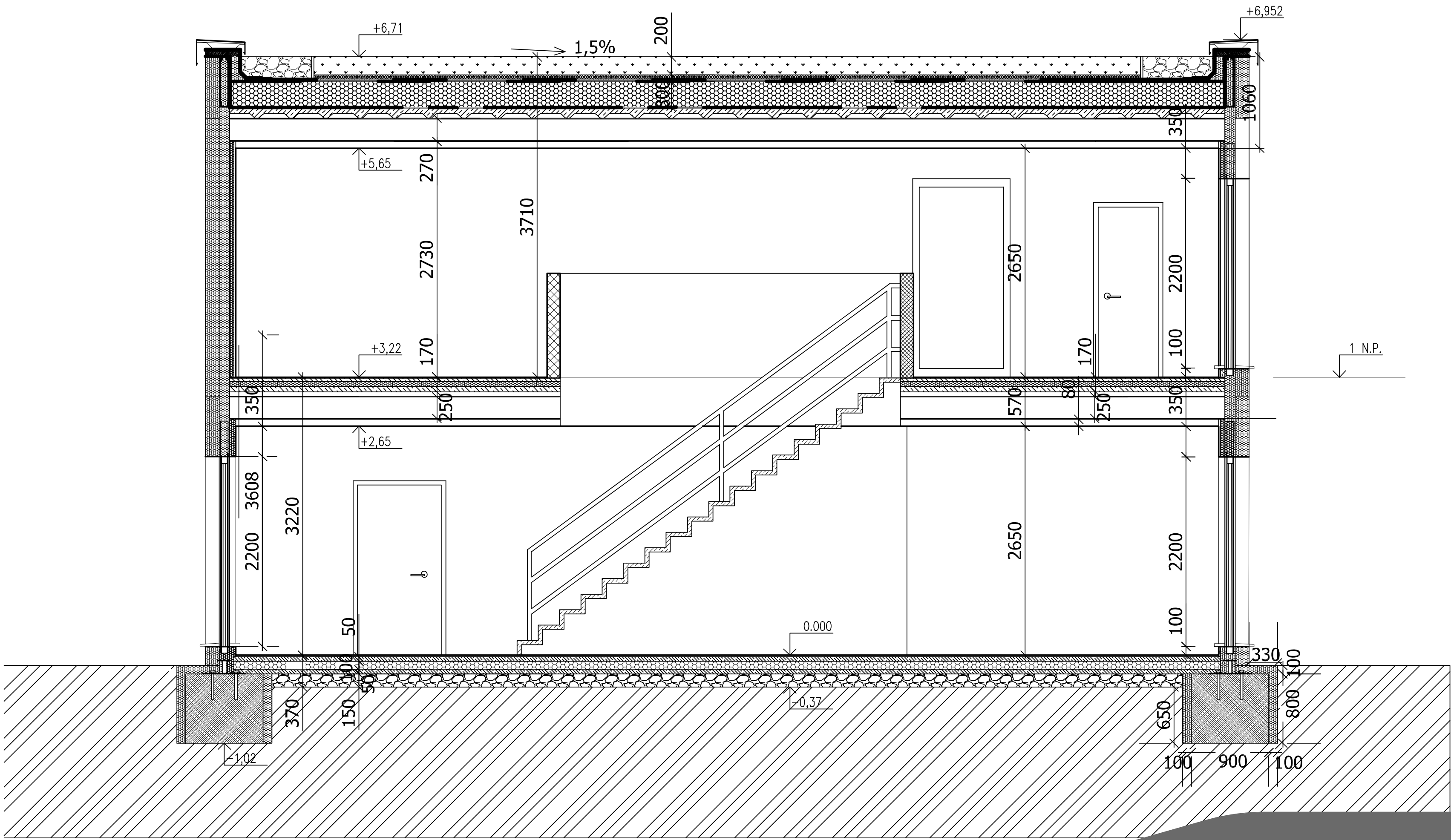


FLOOR PROJECTION - 1st FLOOR



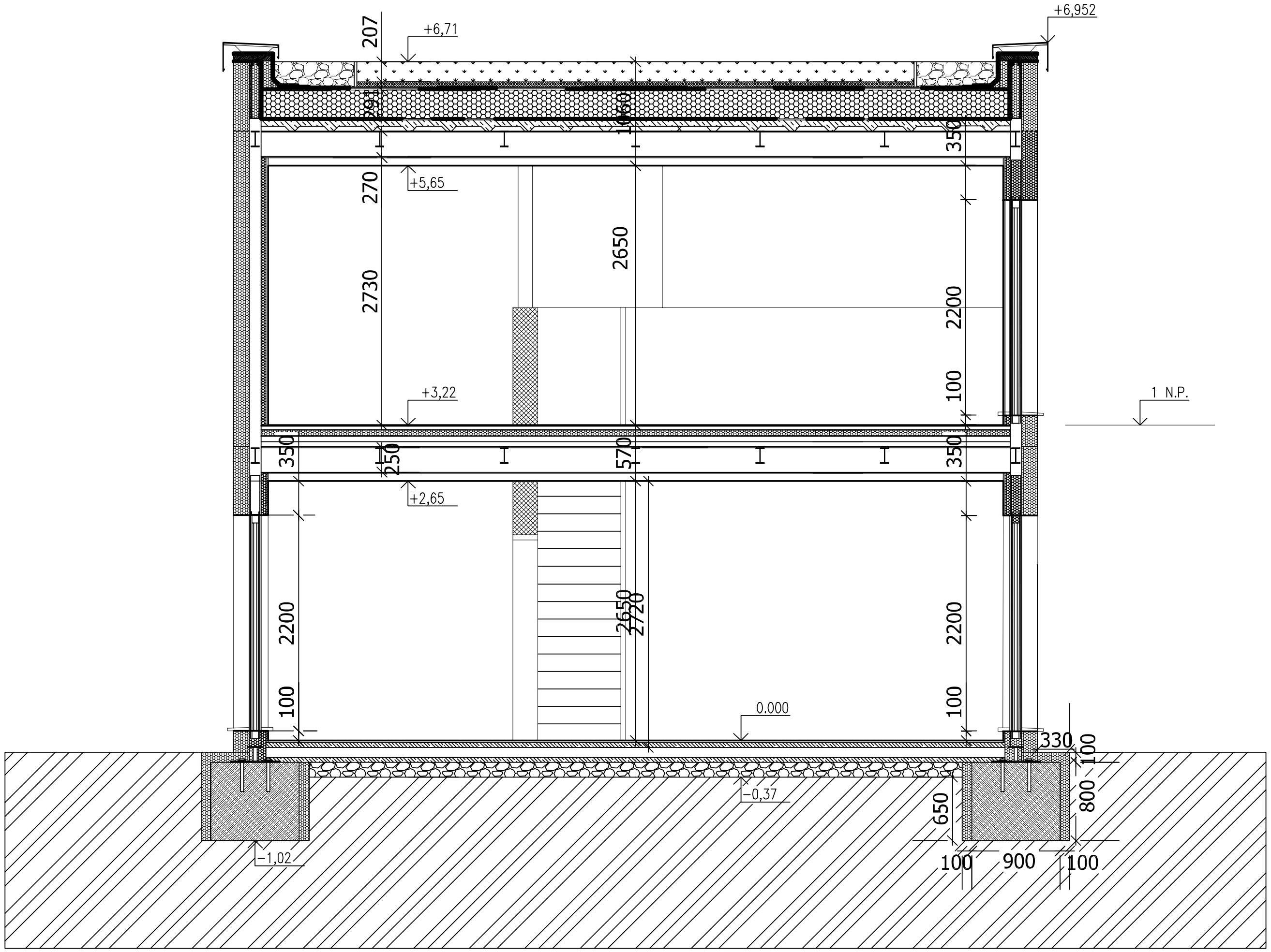
first floor projection
growing steel house - family rules

SECTION A - A'



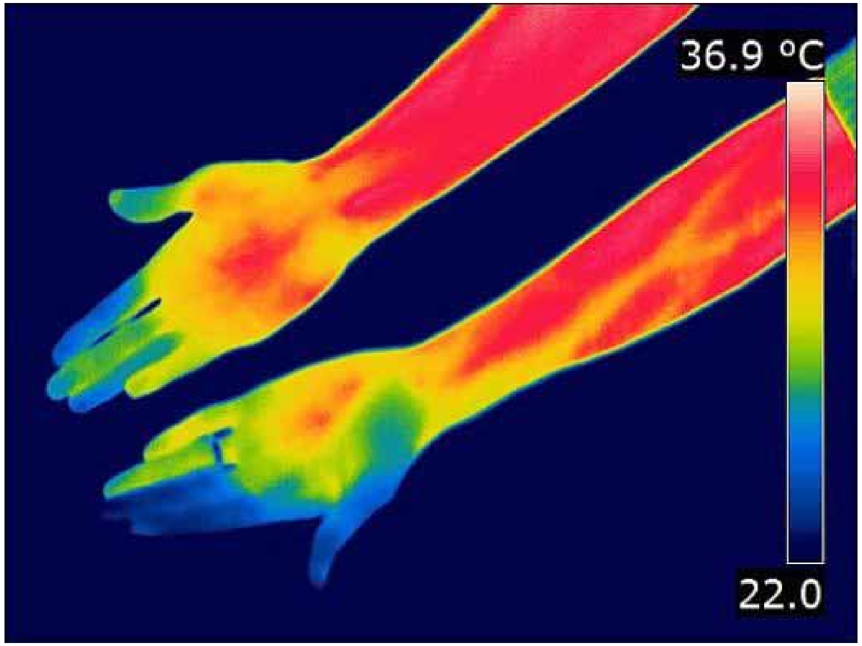
east - west section
growing steel house - family rules

SECTION B - B'

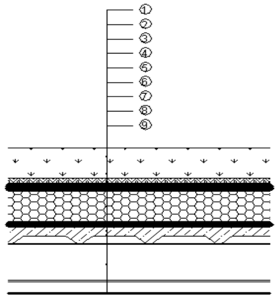


north - south section
growing steel house - family rules

BUILDING PHYSICS

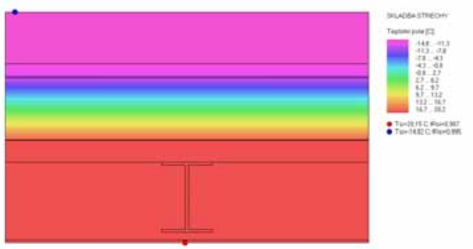


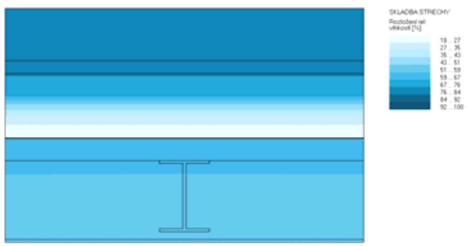
STRUCTURE OF THE ROOF
THICKNESS THERMAL INSULATION 240 mm



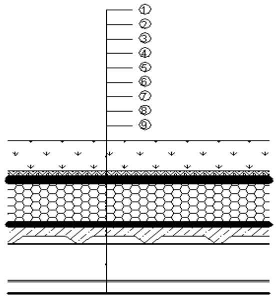
① GREENING
② MATTING
③ ASPHALT BELTS
④ CATCHMENT PLATES- THERMAL INSULATION THICKNESS 240 mm
⑤ VAPOR BARRIERS
⑥ CONCRETE SLABS THICKNESS 110 mm
⑦ TRAPEZOIC METAL SHEETS
⑧ STEEL BEAM- PROFILE IPE 270
⑨ PLASTERBOARD CEILING

U	b	L	ψ
0,124	0,9	0,117	0,007



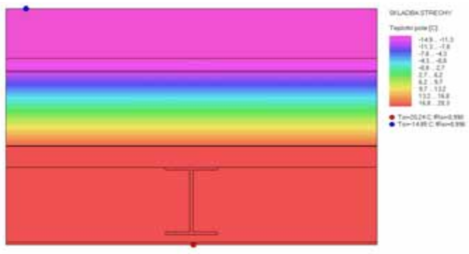


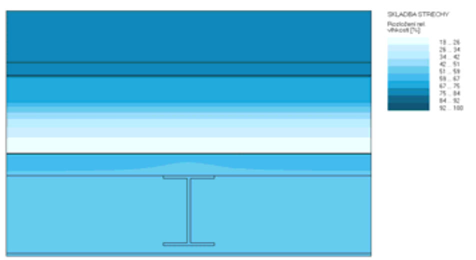
STRUCTURE OF THE ROOF
THICKNESS THERMAL INSULATION 300 mm



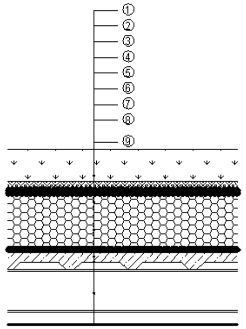
① GREENING
② MATTING
③ ASPHALT BELTS
④ CATCHMENT PLATES- THERMAL INSULATION THICKNESS 300 mm
⑤ VAPOR BARRIERS
⑥ CONCRETE SLABS THICKNESS 110 mm
⑦ TRAPEZOIC METAL SHEETS
⑧ STEEL BEAM- PROFILE IPE 270
⑨ PLASTERBOARD CEILING

U	b	L	ψ
0,101	0,95	0,095	-0,001



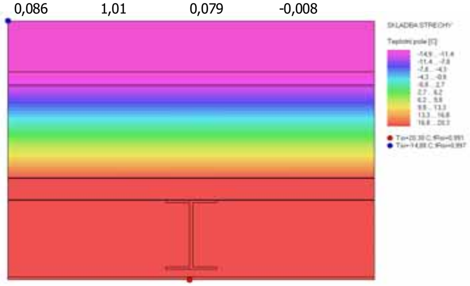


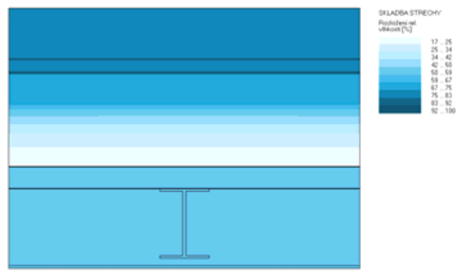
STRUCTURE OF THE ROOF
THICKNESS THERMAL INSULATION 360 mm



① GREENING
② MATTING
③ ASPHALT BELTS
④ CATCHMENT PLATES- THERMAL INSULATION THICKNESS 360 mm
⑤ VAPOR BARRIERS
⑥ CONCRETE SLABS THICKNESS 110 mm
⑦ TRAPEZOIC METAL SHEETS
⑧ STEEL BEAM- PROFILE IPE 270
⑨ PLASTERBOARD CEILING

U	b	L	ψ
0,086	1,01	0,079	-0,008

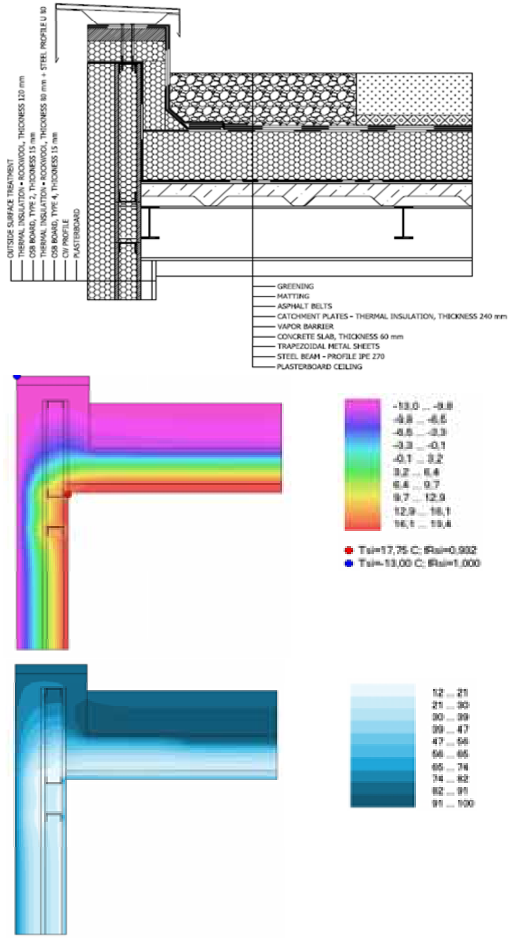




roof structure
field of temperature and humidity
growing steel house - family rules

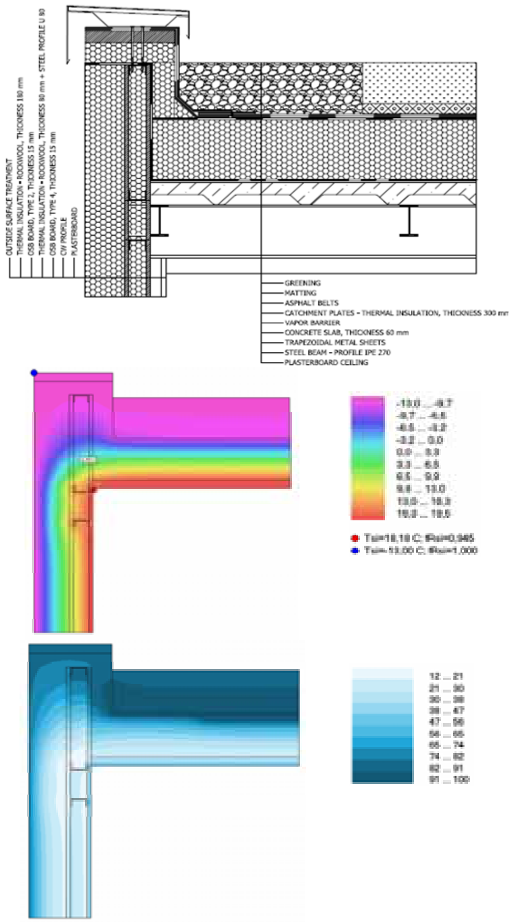
detail of attic

Detail of attic
Thickness of thermal insulation: external wall 120 mm; roof structure 240 mm



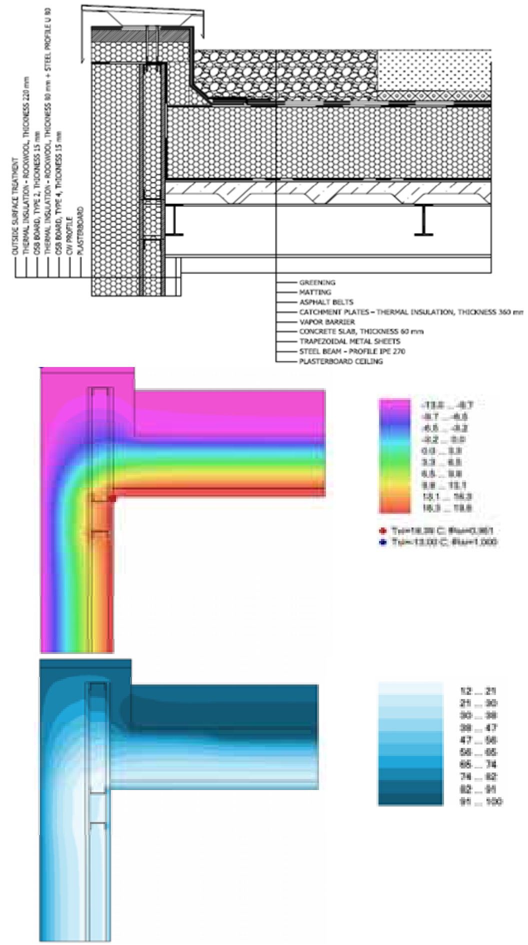
detail of attic

Detail of attic
Thickness of thermal insulation: external wall 180 mm; roof structure 300 mm



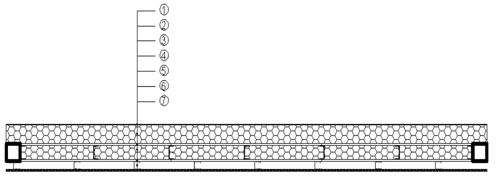
detail of attic

Detail of attic
Thickness of thermal insulation: external wall 220 mm; roof structure 360 mm



panel structure

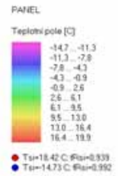
STRUCTURE OF BUILDING PANEL AND INSULATION THICKNESS 120 mm

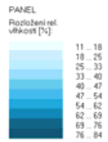


① OUTSIDE SURFACE TREATMENT
② ROCK WOOL- THICKNESS 120 mm
③ OSB BOARD TYPE 2 THICKNESS 15 mm
④ ROCK WOOL- THICKNESS 90 mm + STEEL PROFILE U 90
⑤ OSB BOARD TYPE 4 THICKNESS 15 mm
⑥ CW PROFILE
⑦ PLASTERBOARD

panel 90 + mineral wool 120 mm

compo:		tl.[mm]	λ [W/mK]
	μ [-]		
	OSB 4	15	0,130
	200		
	mineral wool	90	0,041
	2		
	OSB 2	15	0,130
	50		
	mineral wool	120	0,041
	2		
U=	**0,21**	W/m²K	

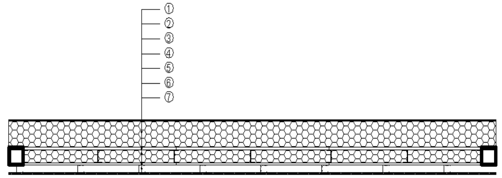




L=	**0,607**	W/mK
b=	3,02	m
U=L/b=	0,20	W/m²K
ψ=	**-0,016**	W/mK

panel structure

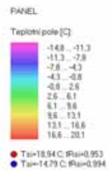
STRUCTURE OF BUILDING PANEL AND INSULATION THICKNESS 180 mm

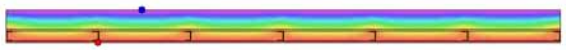


① OUTSIDE SURFACE TREATMENT
② ROCK WOOL- THICKNESS 120 mm
③ OSB BOARD TYPE 2 THICKNESS 15 mm
④ ROCK WOOL- THICKNESS 90 mm + STEEL PROFILE U 90
⑤ OSB BOARD TYPE 4 THICKNESS 15 mm
⑥ CW PROFILE
⑦ PLASTERBOARD

panel 90 + mineral wool 180 mm

compo:		tl.[mm]	λ [W/mK]
	μ [-]		
	OSB 4	15	0,130
	200		
	mineral wool	90	0,041
	2		
	OSB 2	15	0,130
	50		
	mineral wool	180	0,041
	2		
U=	**0,16**	W/m²K	

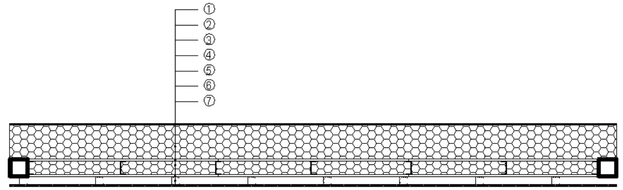




L=	**0,466**	W/mK
b=	3,14	m
U=L/b=	0,15	W/m²K
ψ=	**-0,031**	W/mK

panel structure

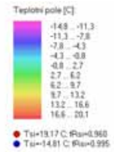
STRUCTURE OF BUILDING PANEL AND INSULATION THICKNESS 220 mm

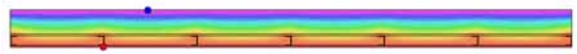


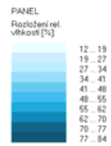
① OUTSIDE SURFACE TREATMENT
② ROCK WOOL- THICKNESS 120 mm
③ OSB BOARD TYPE 2 THICKNESS 15 mm
④ ROCK WOOL- THICKNESS 90 mm + STEEL PROFILE U 90
⑤ OSB BOARD TYPE 4 THICKNESS 15 mm
⑥ CW PROFILE
⑦ PLASTERBOARD

panel 90 + mineral wool 220 mm

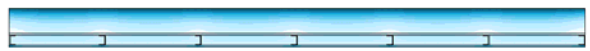
compo:		tl.[mm]	λ [W/mK]
	μ [-]		
	OSB 4	15	0,130
	200		
	mineral wool	90	0,041
	2		
	OSB 2	15	0,130
	50		
	mineral wool	220	0,041
	2		
U=	**0,14**	W/m²K	





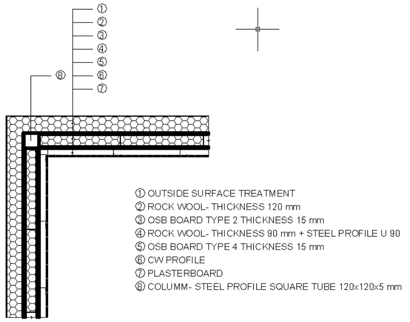


L=	**0,405**	W/mK
b=	3,22	m
U=L/b=	0,13	W/m²K
ψ=	**-0,038**	W/mK



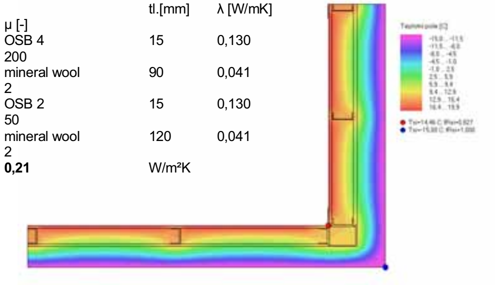
wall corner

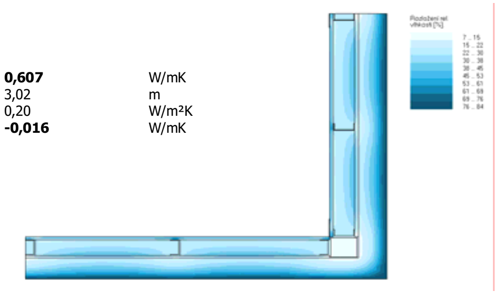
DETAIL OF THE CORNER U 90 + THERMAL INSULATION 120 mm



panel 90 + mineral wool 120 mm

compo:	μ [-]	tl.[mm]	λ [W/mK]
	OSB 4 200	15	0,130
	mineral wool 2	90	0,041
	OSB 2 50	15	0,130
	mineral wool 2	120	0,041
U=	**0,21**	W/m²K	

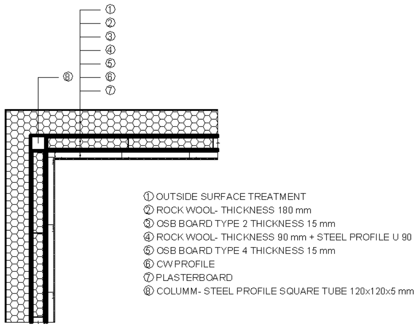




L=	**0,607**	W/mK
b=	3,02	m
U=L/b=	0,20	W/m²K
ψ=	**-0,016**	W/mK

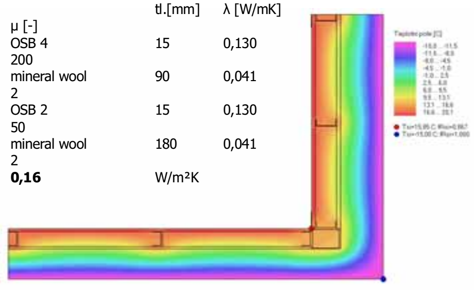
wall corner

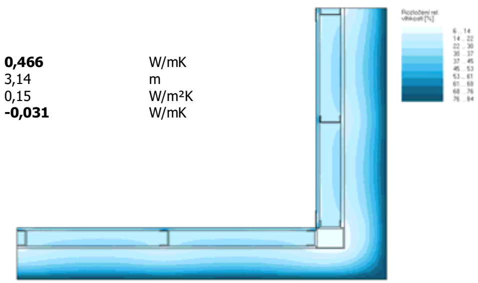
DETAIL OF THE CORNER U 90 + THERMAL INSULATION 180 mm



panel 90 + mineral wool 180 mm

compo:	μ [-]	tl.[mm]	λ [W/mK]
	OSB 4 200	15	0,130
	mineral wool 2	90	0,041
	OSB 2 50	15	0,130
	mineral wool 2	180	0,041
U=	**0,16**	W/m²K	

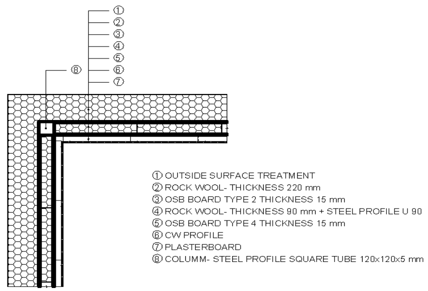




L=	**0,466**	W/mK
b=	3,14	m
U=L/b=	0,15	W/m²K
ψ=	**-0,031**	W/mK

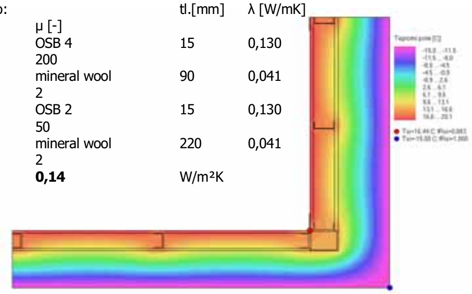
wall corner

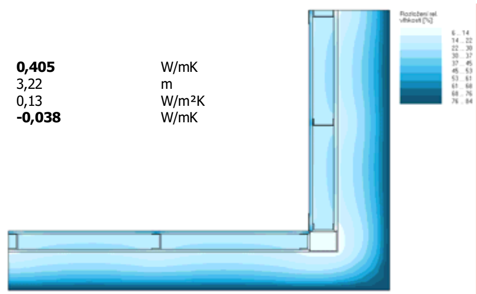
DETAIL OF THE CORNER U 90 + THERMAL INSULATION 220 mm



panel 90 + mineral wool 220 mm

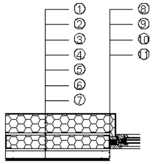
compo:	μ [-]	tl.[mm]	λ [W/mK]
	OSB 4 200	15	0,130
	mineral wool 2	90	0,041
	OSB 2 50	15	0,130
	mineral wool 2	220	0,041
U=	**0,14**	W/m²K	



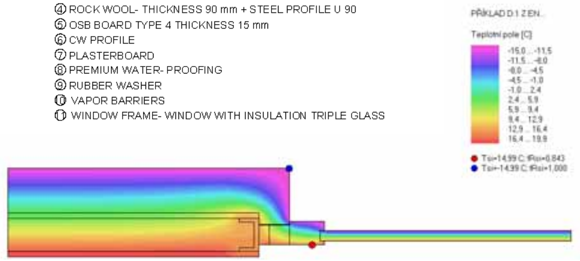


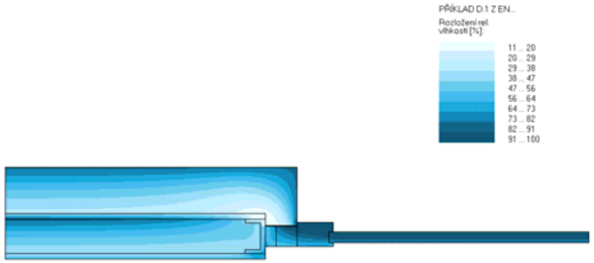
L=	**0,405**	W/mK
b=	3,22	m
U=L/b=	0,13	W/m²K
ψ=	**-0,038**	W/mK

DETAIL OF CONNECTION OF THE WINDOW
THICKNESS OF THE THERMAL INSULATION 120 mm



1. OUTSIDE SURFACE TREATMENT
2. ROCK WOOL- THICKNESS 120 mm
3. OSB BOARD TYPE 2 THICKNESS 15 mm
4. ROCK WOOL- THICKNESS 90 mm + STEEL PROFILE U 90
5. OSB BOARD TYPE 4 THICKNESS 15 mm
6. CW PROFILE
7. PLASTERBOARD
8. PREMIUM WATER- PROOFING
9. RUBBER WASHER
10. VAPOR BARRIERS
11. WINDOW FRAME- WINDOW WITH INSULATION TRIPLE GLASS





panel 90 + mineral wool 120 mm

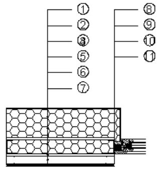
skladba:	μ [-]	tl.[mm]	λ [W/mK]
OSB 4	200	15	0,130
mineral wool	2	90	0,041
OSB 2	50	15	0,130
mineral wool	2	120	0,041
U=	0,21	W/m²K	

window

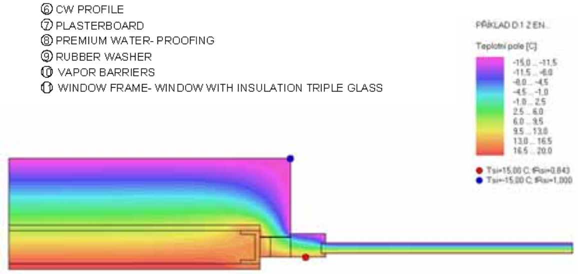
L=	**0,758**	W/mK
U_1=	0,2064	W/m²K
b_1=	0,16	m
U_2=	0,90	W/m²K
b_2=	0,56	m
ψ=	**0,081**	W/mK

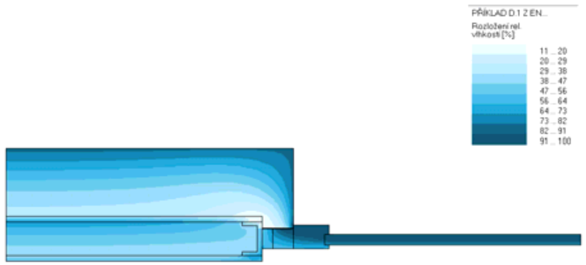
window flanning

DETAIL OF CONNECTION OF THE WINDOW
THICKNESS OF THE THERMAL INSULATION 180 mm



1. OUTSIDE SURFACE TREATMENT
2. ROCK WOOL- THICKNESS 180 mm
3. OSB BOARD TYPE 2 THICKNESS 15 mm
4. ROCK WOOL- THICKNESS 90 mm + STEEL PROFILE U 90
5. OSB BOARD TYPE 4 THICKNESS 15 mm
6. CW PROFILE
7. PLASTERBOARD
8. PREMIUM WATER- PROOFING
9. RUBBER WASHER
10. VAPOR BARRIERS
11. WINDOW FRAME- WINDOW WITH INSULATION TRIPLE GLASS





panel 90 + mineral wool 180 mm

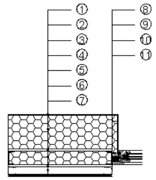
skladba:	μ [-]	tl.[mm]	λ [W/mK]
OSB 4	200	15	0,130
mineral wool	2	90	0,041
OSB 2	50	15	0,130
mineral wool	2	180	0,041
U=	0,16	W/m²K	

window

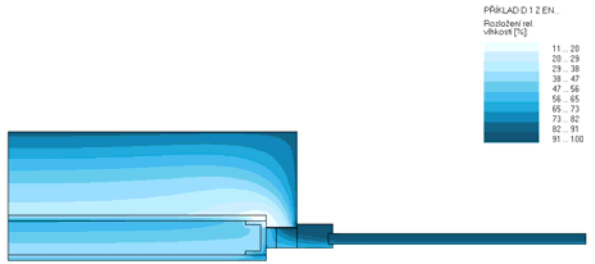
L=	**0,739**	W/mK
U_1=	0,1584	W/m²K
b_1=	0,56	m
U_2=	0,90	W/m²K
b_2=	0,56	m
ψ=	**0,089**	W/mK

window flanning

DETAIL OF CONNECTION OF THE WINDOW
THICKNESS OF THE THERMAL INSULATION 220 mm



1. OUTSIDE SURFACE TREATMENT
2. ROCK WOOL- THICKNESS 220 mm
3. OSB BOARD TYPE 2 THICKNESS 15 mm
4. ROCK WOOL- THICKNESS 90 mm + STEEL PROFILE U 90
5. OSB BOARD TYPE 4 THICKNESS 15 mm
6. CW PROFILE
7. PLASTERBOARD
8. PREMIUM WATER- PROOFING
9. RUBBER WASHER
10. VAPOR BARRIERS
11. WINDOW FRAME- WINDOW WITH INSULATION TRIPLE GLASS



panel 90 + mineral wool 220 mm

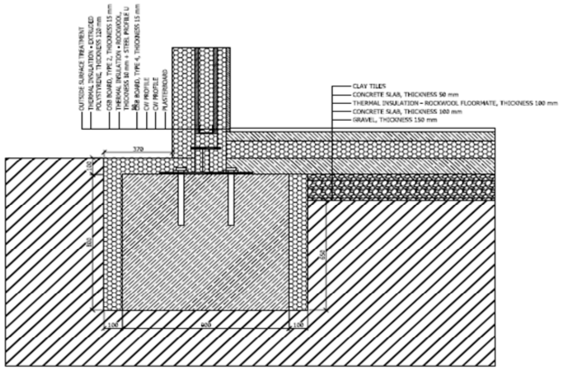
skladba:	μ [-]	tl.[mm]	λ [W/mK]
OSB 4	200	15	0,130
mineral wool	2	90	0,041
OSB 2	50	15	0,130
mineral wool	2	220	0,041
U=	0,14	W/m²K	

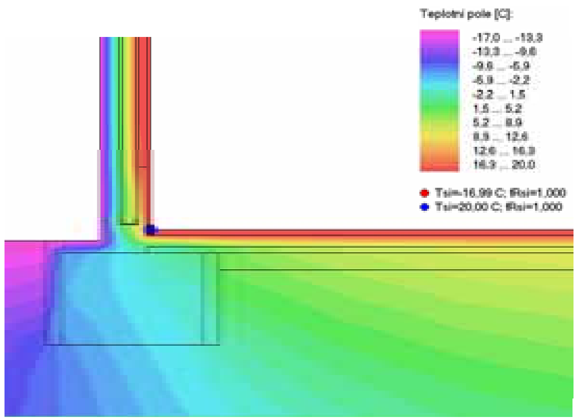
window

L=	**0,731**	W/mK
U_1=	0,1376	W/m²K
b_1=	0,56	m
U_2=	0,90	W/m²K
b_2=	0,56	m
ψ=	**0,093**	W/mK

foundation

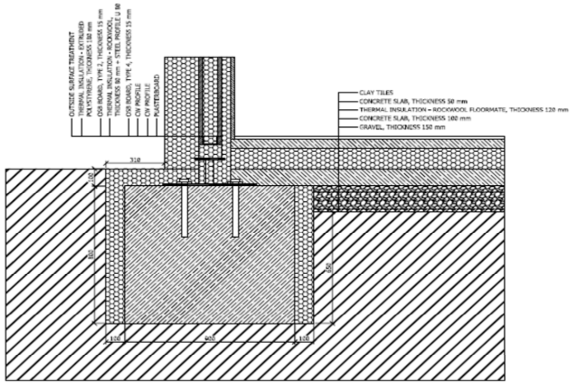
Detail of placing on the foundation
Thickness of thermal insulation: external wall 120 mm; floor structure 100 mm

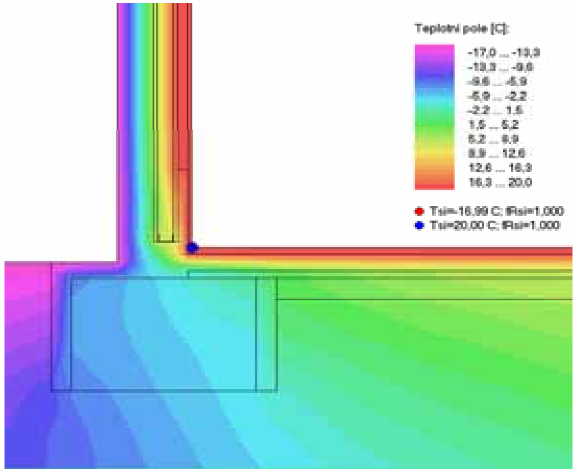




foundation

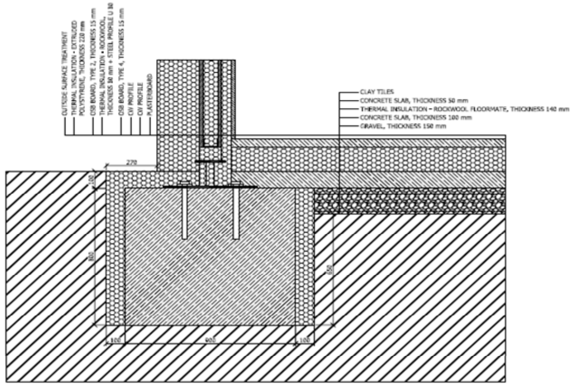
Detail of placing on the foundation
Thickness of thermal insulation: external wall 180 mm; floor structure 120 mm

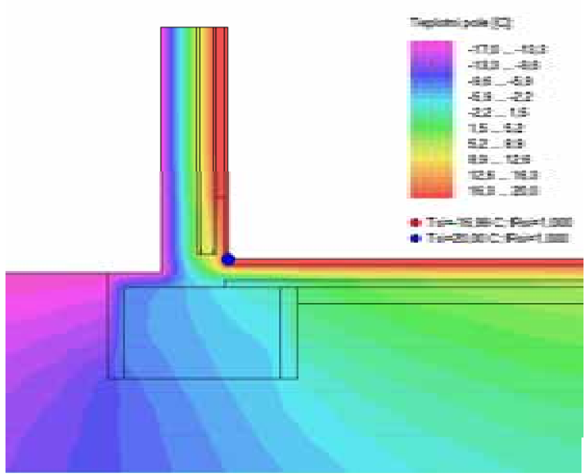




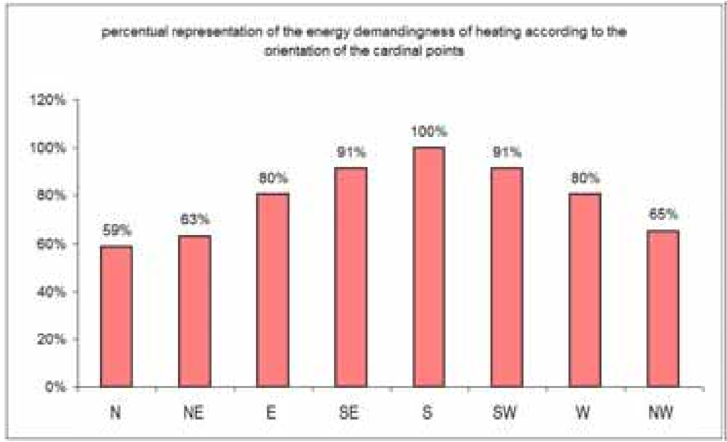
foundation

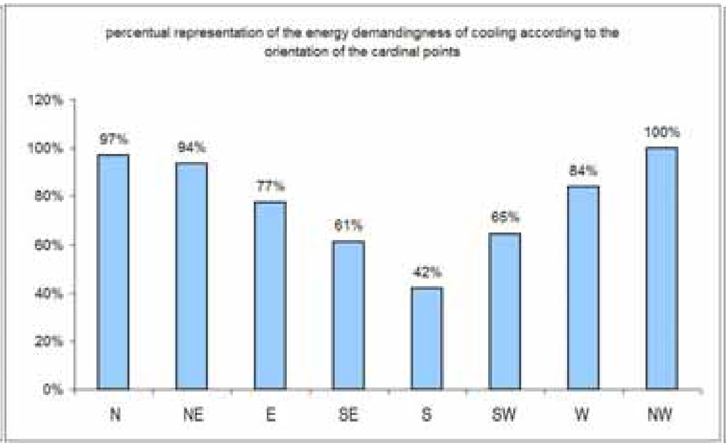
Detail of placing on the foundation
Thickness of thermal insulation: external wall 220 mm; floor structure 140 mm

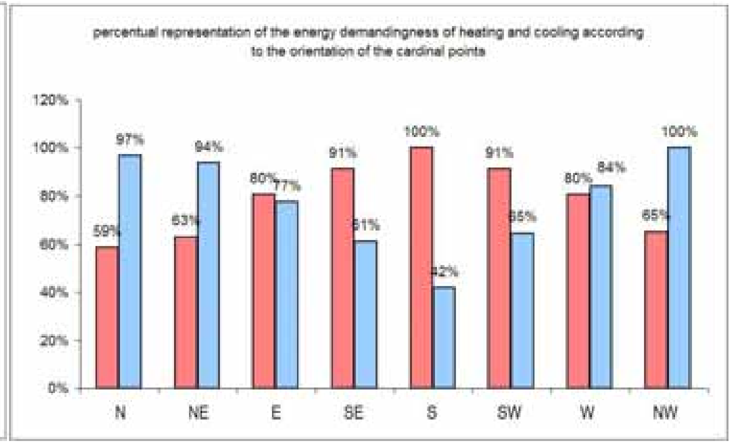


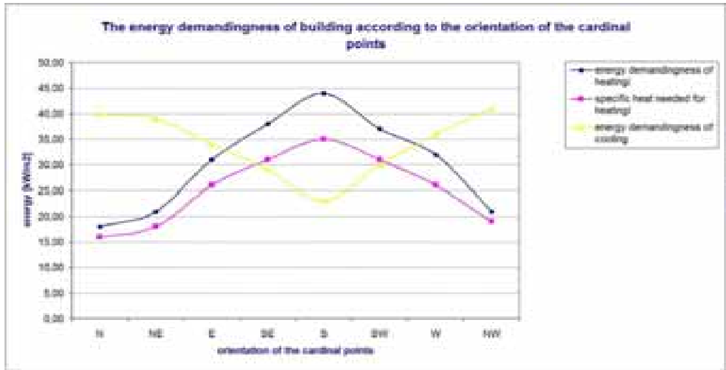


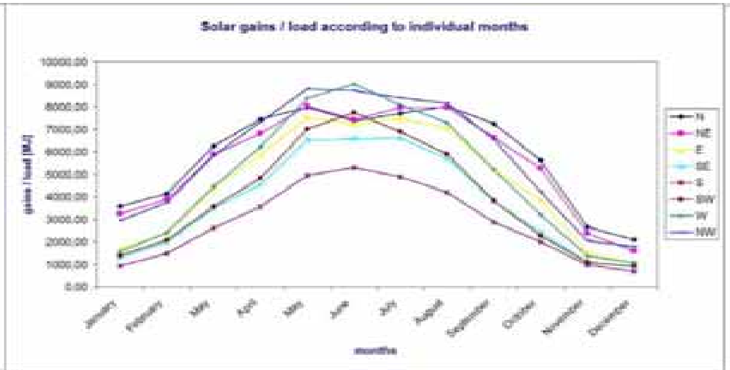
placing on the foundation
field of temperature and humidity
growing steel house - family rules

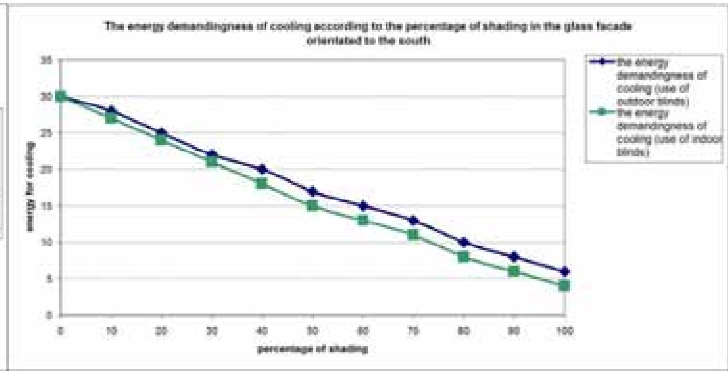












The energy demandingness of building according to the orientation of the cardinal points

orientation of the main entrance	N	NE	E	SE	S	SW	W	NW
energy demandingness of heating	18,00	21,00	31,00	38,00	44,00	37,00	32,00	21,00
specific heat needed for heating	16,00	18,00	26,00	31,00	35,00	31,00	26,00	19,00
the total annual need for heat [GJ]	7,30	8,33	12,10	14,54	16,60	14,34	12,43	8,82
energy demandingness of cooling	40,00	39,00	34,00	29,00	23,00	30,00	36,00	41,00

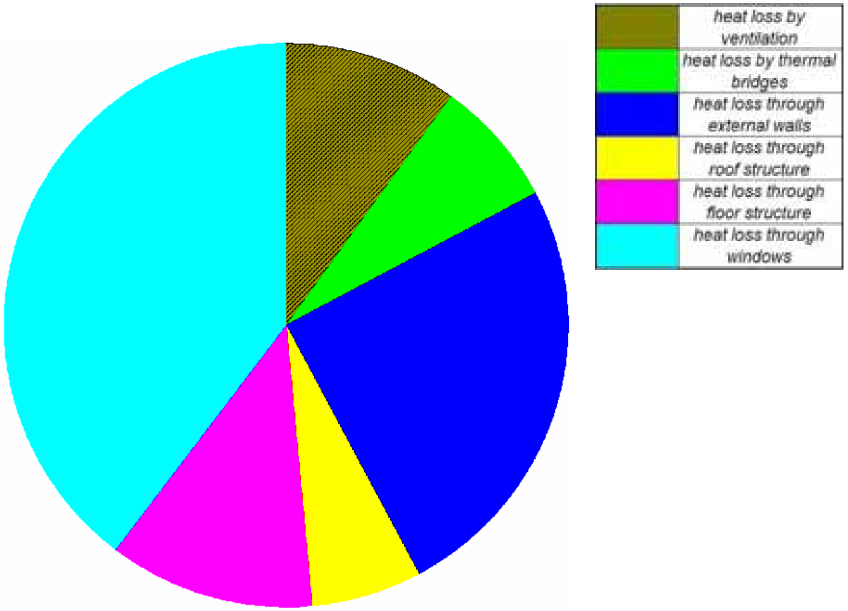
Solar gains for the individual months according to the orientation of the cardinal points

orientation of the main entrance	N	NE	E	SE	S	SW	W	NW
January	3583,30	3255,40	1712,10	1294,70	921,60	1379,50	1562,00	2948,60
February	4135,20	3876,60	2373,10	1974,60	1484,40	2069,60	2407,70	3747,80
May	6249,20	5884,40	4357,60	3485,10	2614,70	3557,00	4450,40	5844,50
April	7438,00	6817,80	5859,90	4546,70	3572,30	4823,40	6213,20	7318,20
May	7983,80	8037,00	7520,00	6517,40	4950,20	7000,60	8379,10	8800,00
June	7360,80	7425,70	7230,60	6567,50	5307,80	7738,00	9018,40	8708,20
July	7699,10	7952,80	7481,10	6608,50	4896,70	6887,10	8079,70	8399,30
August	8011,80	7970,60	7055,60	5699,60	4200,30	5896,40	7282,40	8167,30
September	7256,50	6626,70	5199,70	3793,30	2877,00	3829,40	5213,50	6550,90
October	5626,40	5264,40	3862,50	2436,90	2009,60	2285,70	3214,00	4218,10
November	2646,70	2383,40	1519,40	1094,30	972,20	1082,10	1372,30	2035,50
December	2102,70	1589,30	1046,90	883,30	685,10	936,90	1069,50	1785,90
Summary [MJ]	**70093,50**	**67084,10**	**55218,50**	**44901,90**	**34491,90**	**47485,70**	**58262,20**	**68524,30**

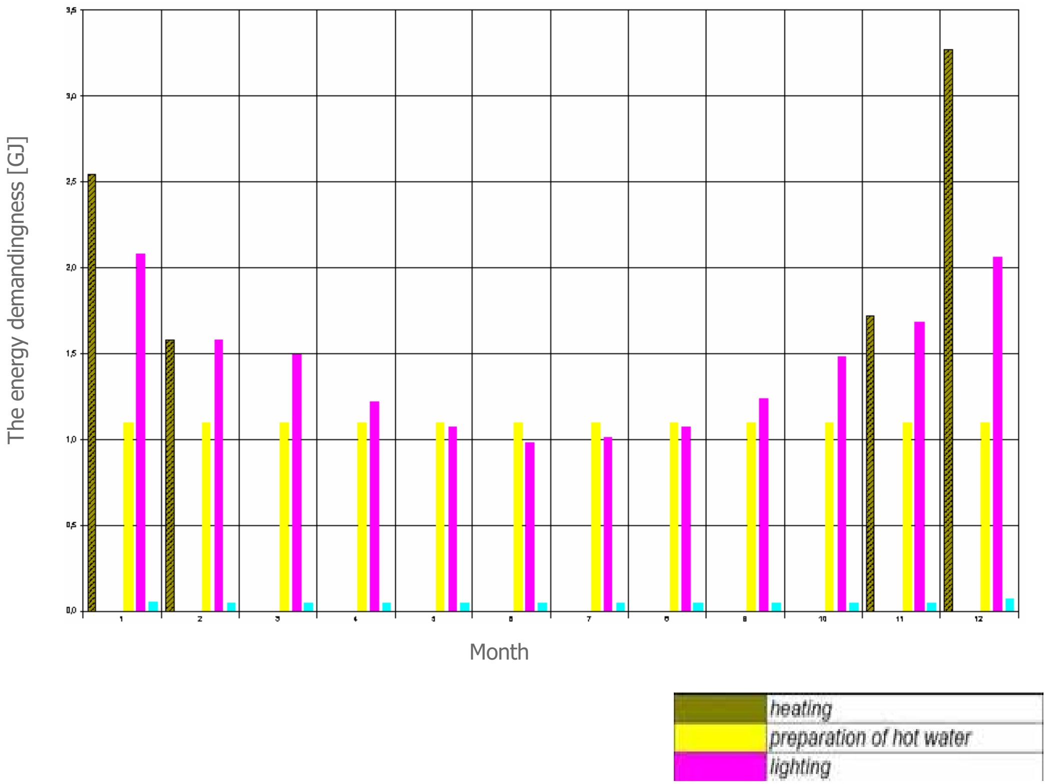
The energy demandingness of cooling according to the percentage of shading in the glass facade orientated to the south

the percentage of shading [%]	0,00	10,00	20,00	30,00	40,00	50,00	60,00	70,00	80,00	90,00	100,00
the energy demandingness of cooling (use of outdoor blinds) [kWh/m²]	30,00	28,00	25,00	22,00	20,00	17,00	15,00	13,00	10,00	8,00	6,00
the energy demandingness of cooling (use of indoor blinds) [kWh/m²]	30,00	27,00	24,00	21,00	18,00	15,00	13,00	11,00	8,00	6,00	4,00

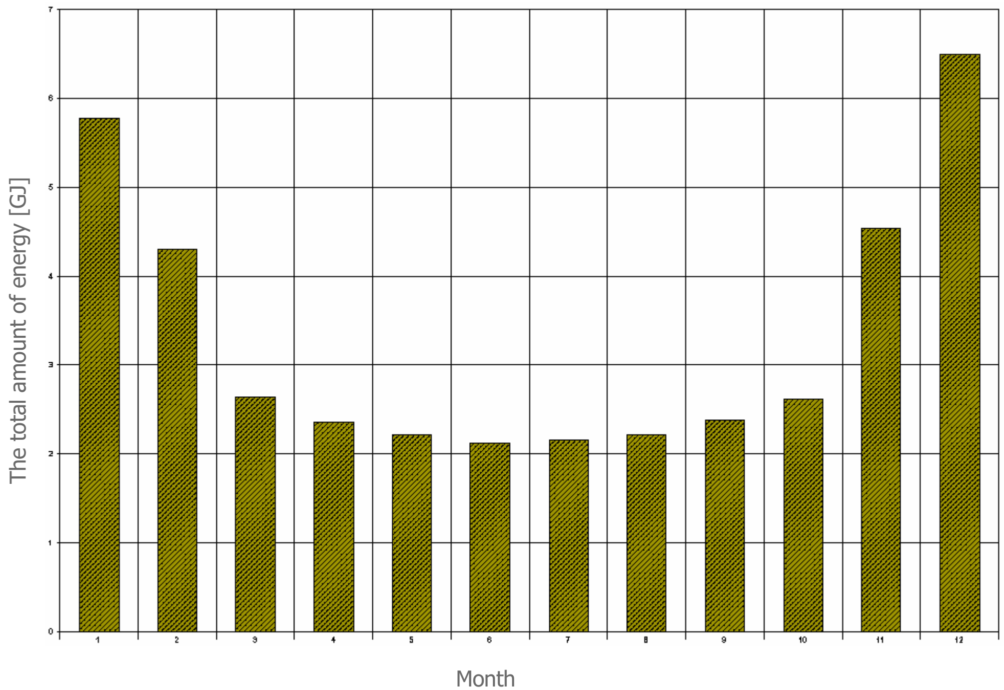
Specific heat loss of the building



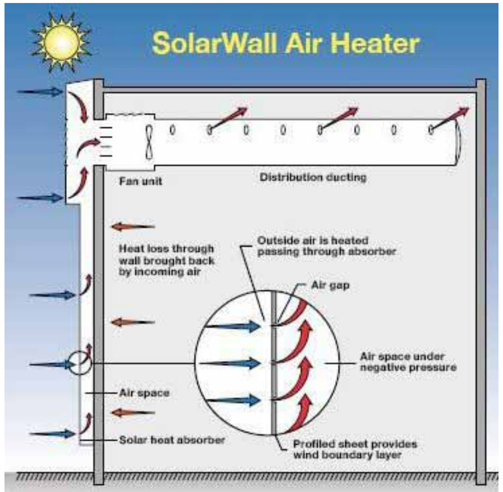
The energy demandingness supplied into the building monthly



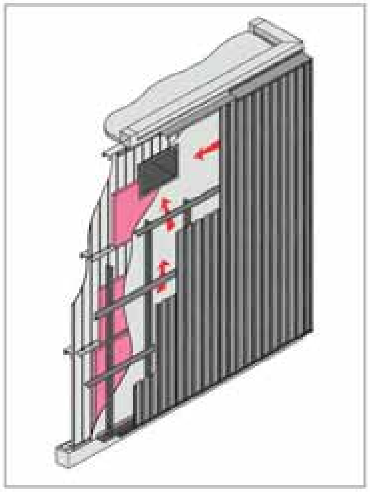
The total amount of energy supplied into the building monthly



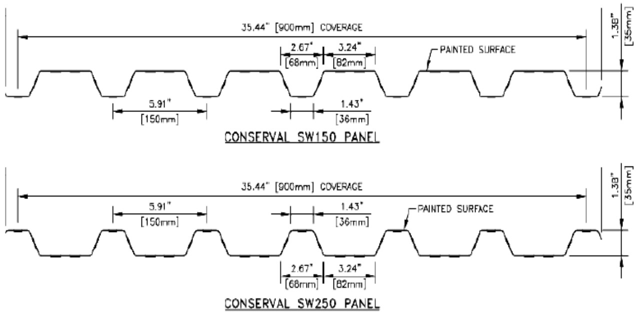
graphs supplied energy
growing steel house - family rules



SolarWall® system integrated into a wall and connected to interior fan



SolarWall® system mounted over metal wall



SolarWall® profiles

SolarWall®

The SolarWall® technology is a solar air heating system that uses solar energy as fuel to heat or ventilate indoor spaces in new or retrofit construction.Perforated collector panels are installed several inches from an appropriate wall, creating an air cavity. Sunlight heats the solar collector surface and ventilation fans create a negative pressure in the air cavity, drawing in solar heated air through the perforations in the panel. A connection to an HVAC intake allows air to be preheated before entering the air handler, reducing the load on the conventional heater. Heated air is then distributed into the building through the existing HVAC system or alternately, with separate air makeup fans and perforated ducting.

PREPARATORY WORK

Deliver products in manufacturer's original, unopened, undamaged containers with identification labels intact. Store materials protected from exposure to harmful environmental conditions and at temperature and humidity conditions recommended by the manufacturer. Verify that site conditions are acceptable for installation. Do not proceed with installation until unacceptable conditions are corrected.

METHODS

The SolarWall system is generally installed in a manner similar to that of other metal facades except that it is attached 150 - 250 mm (6" - 10") from the wall to create the cavity for collecting the solar heated air. It can be installed over or around existing wall openings, and if installed over masonry, the clip and support system can usually be fastened anywhere on the wall. If the main wall is a metal wall with support bars or girts spaced 1.2 - 1.8 m (4' - 6') apart, the supports for the solar wall panels must be connected to the structural supports and not to the metal sheets. Panels can be mounted with corrugations positioned vertically or horizontally on walls and facias, and positioned vertically on roofs. If required, additional fans and air distribution equipment can be installed using standard practices. Installation manuals and project-specific installation drawings are available. BUILDING CODES Installation must comply with the requirements of all applicable local, state and federal code jurisdictions.

ENVIRONMENTAL CONSIDERATIONS

SolarWall is a renewable energy system
that has significant environmental benefits: • Each SolarWall system supplies 1.5 - 3.5 GJ/m2 (1.5 - 3.5 therms/ft2) of heat per year using solar energy • Delivers solar collection efficiencies as high as 80% • Reduces annual CO2 production by 200 kg/m2 (40 psf) of collector when displacing natural gas heating • SolarWall metal components contain recycled material and are recyclable at the end of their life cycles • Solar collectors heat fresh air to improve indoor air quality Project with SolarWall technology may qualify for up to 6 LEED credits in "Renewable Energy," "Optimizing Energy Performance", "Improved Ventilation" and other LEED categories.

wall
integration of solarwall system
growing steel house - family rules

Advantages:

1) low cost housing for wide clientele
2) attractive appearance
3) functionality and variability of the building
4) the house changes and grows according to the social and financial needs of the family
5) it can be built in various areas
6) it can be built as low energetic or passive house
7) If is it passive it can get donations from the government
8) Quick assembling and disassembling
9) Prefab components
10) Can be used recycled steel
11) Most of used materials could be recycled

Disadvantages:

1) not fully traditional material for building houses in the Czech Republic
2) relatively higher cost of delivery on long distances
3) unification (can be both advantage or disadvantage)

Future plans:

1) Completion of construction plans
2) Final solution of problematic details of the structure
3) Overall balance of investments
4) Solving of building services (heating, cooling system; ventilation water distribution etc.)
5) Total usage of materials
6) Evaluation of environmental impacts
7) Analysis of acoustic matters
8) Calculation

THE GROWING STEEL HOUSE TEAM

Teachers / concultations: františek wald - head; karel mikeš – manager; petr hájek - sustainability building concept; jan tywoniak - building energy concept

Students / design: tereza pavlů - structural design; petr schorsch - structural design; lukáš turek - architectural concept and solution;

Students /collaboration on the text part : tomáš horálek - socio-economical evaluation; jakub holeček - socio-economical evaluation; pavel jenýš - traditional housing concept; rostislav mazáč - socio-economical evaluation; zdeňka staňková - traditional housing concept; oldřich švec - socio-economical evaluation; kristina trnková - traditional housing concept; zuzana šulcová - web page;