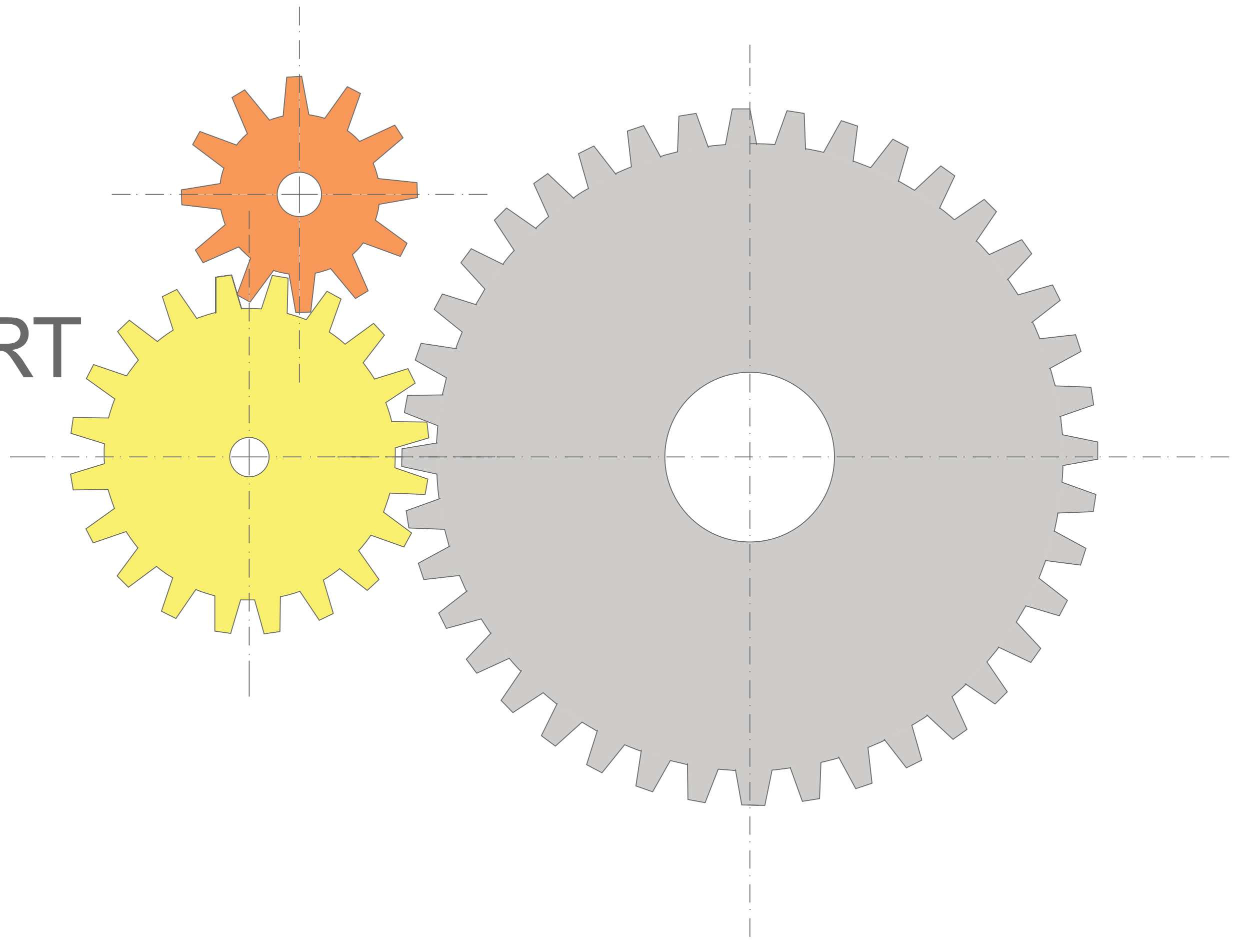
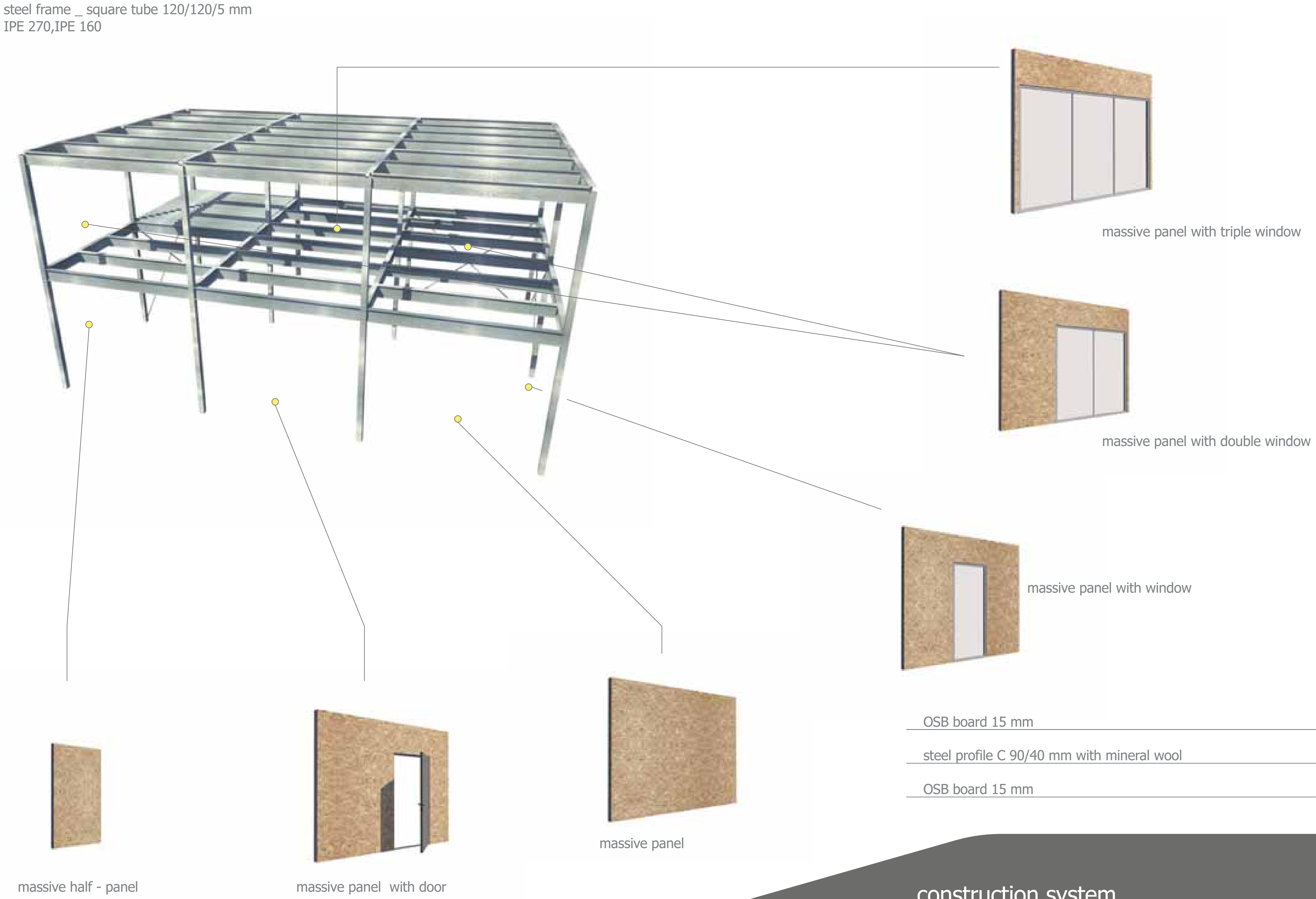
CONSTRUCTION PART





construction system
growing steel house - family rules

IN - composition

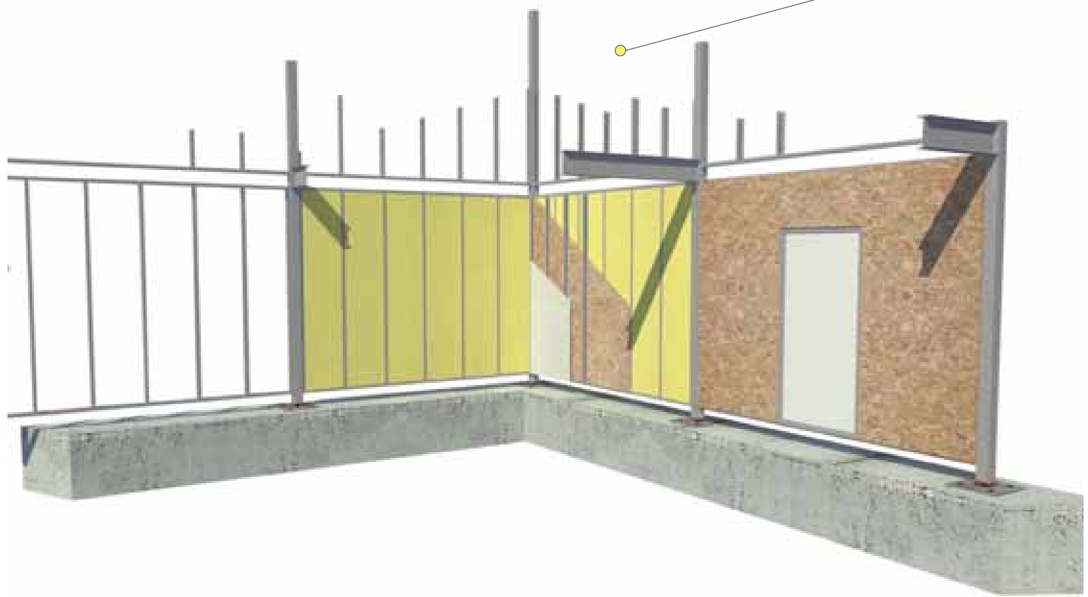
steel shape C 90/40 + mineral wool

OSB panel 15 mm

air space 50 mm

gypsum plasterboard 13 mm

surface conditioning



EX - composition

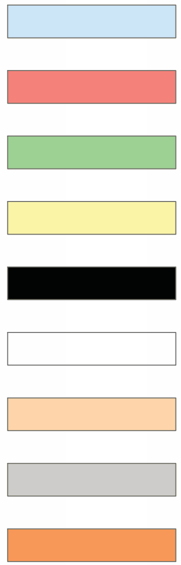
OSB panel 15 mm

mineral wool 120 - 220 mm

air space 50 mm

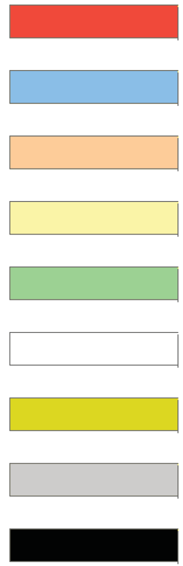
surface conditioning

plaster



plaster design

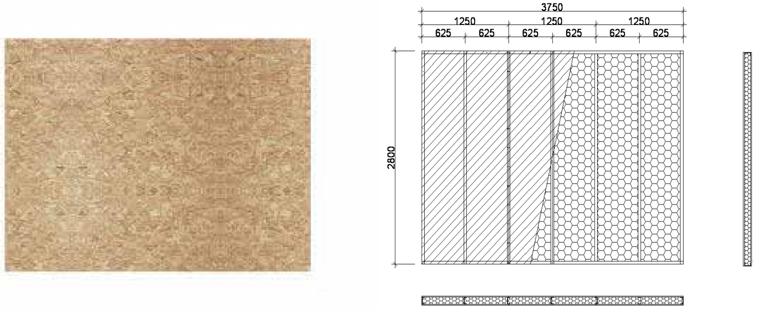
veneer desk



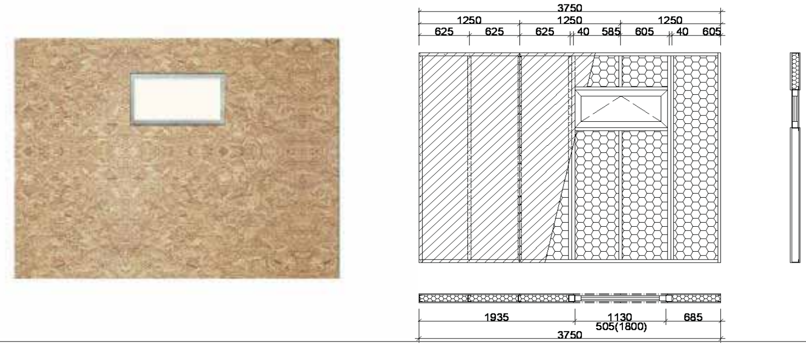
veneer design

construction system - external walls
growing steel house - family rules

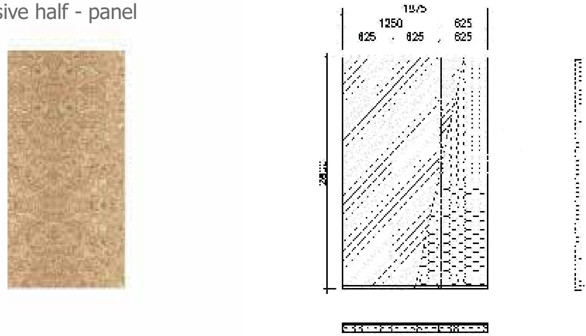
massive panel



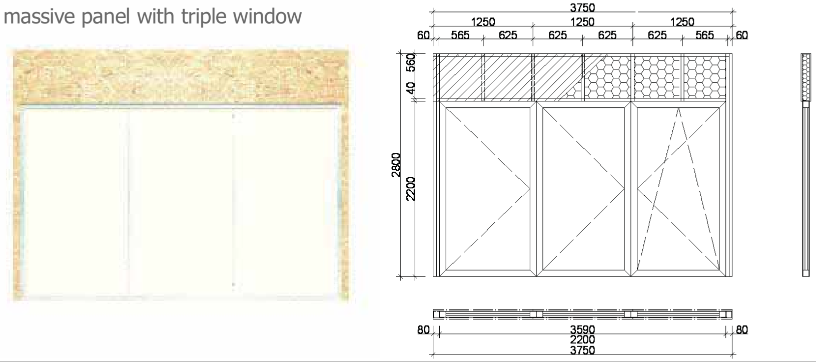
massive panel with small window



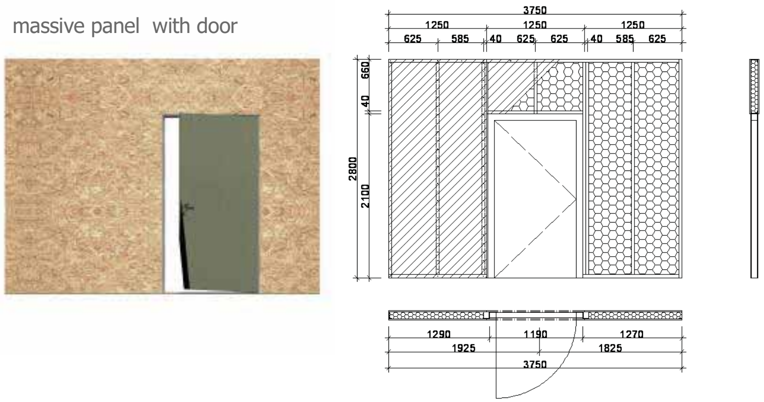
massive half - panel

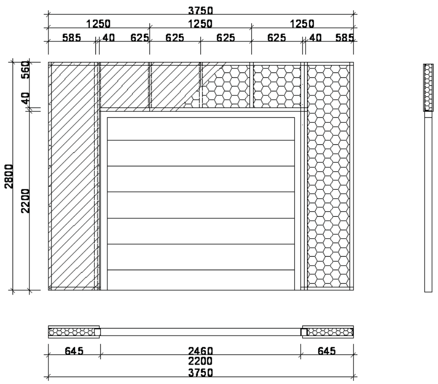


massive panel with triple window



massive panel with door

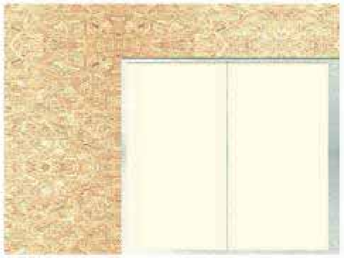


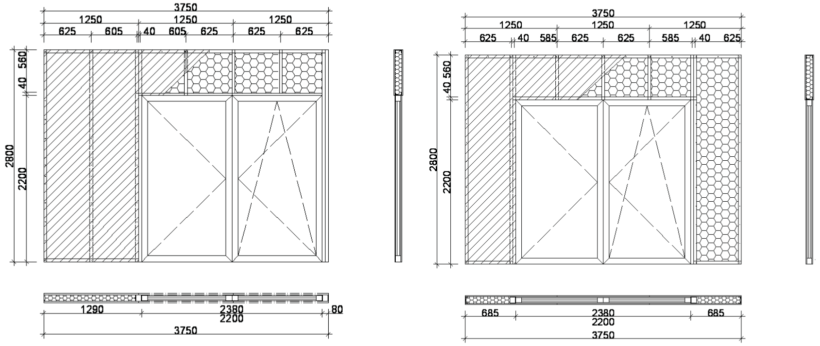


massive panel with garage door

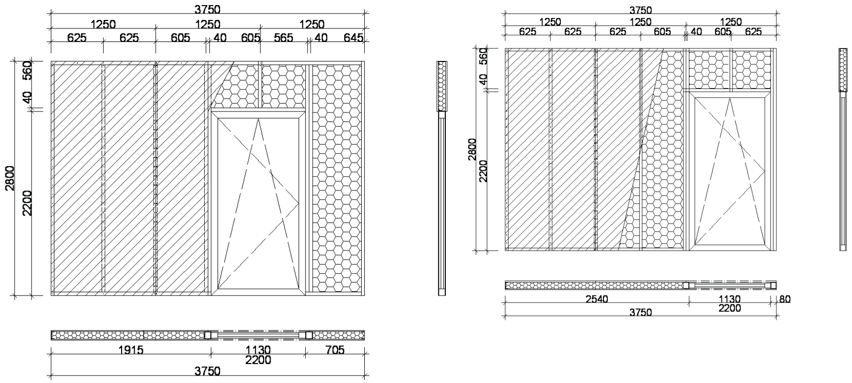
design of panels
growing steel house - family rules

massive panel with double window

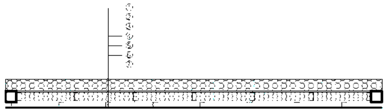




massive panel with window

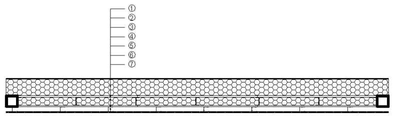


STRUCTURE OF BUILDING PANEL AND INSULATION THICKNESS 120 mm



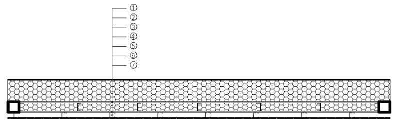
① [illegible]
② [illegible]
③ OSB BOARD TYPE 2 THICKNESS 15 mm
④ [illegible]
⑤ OSB BOARD TYPE 4 THICKNESS 15 mm
⑥ CW PROFILE
⑦ PLASTERBOARD

STRUCTURE OF BUILDING PANEL AND INSULATION THICKNESS 180 mm



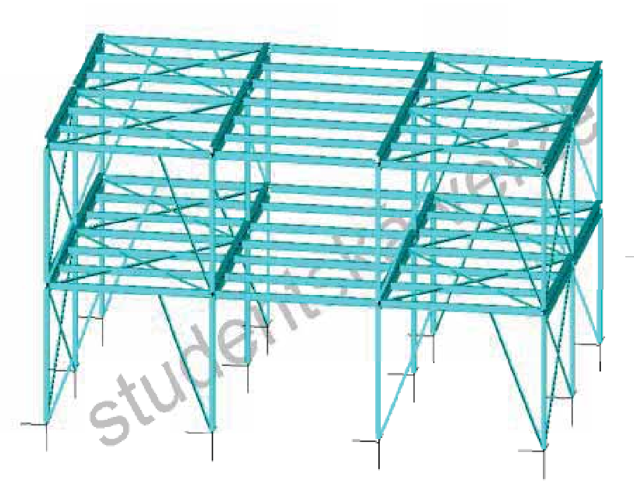
① OUTSIDE SURFACE TREATMENT
② ROCK WOOL- THICKNESS 120 mm
③ OSB BOARD TYPE 2 THICKNESS 15 mm
④ ROCK WOOL- THICKNESS 90 mm + STEEL PROFILE U 90
⑤ OSB BOARD TYPE 4 THICKNESS 15 mm
⑥ CW PROFILE
⑦ PLASTERBOARD

STRUCTURE OF BUILDING PANEL AND INSULATION THICKNESS 220 mm

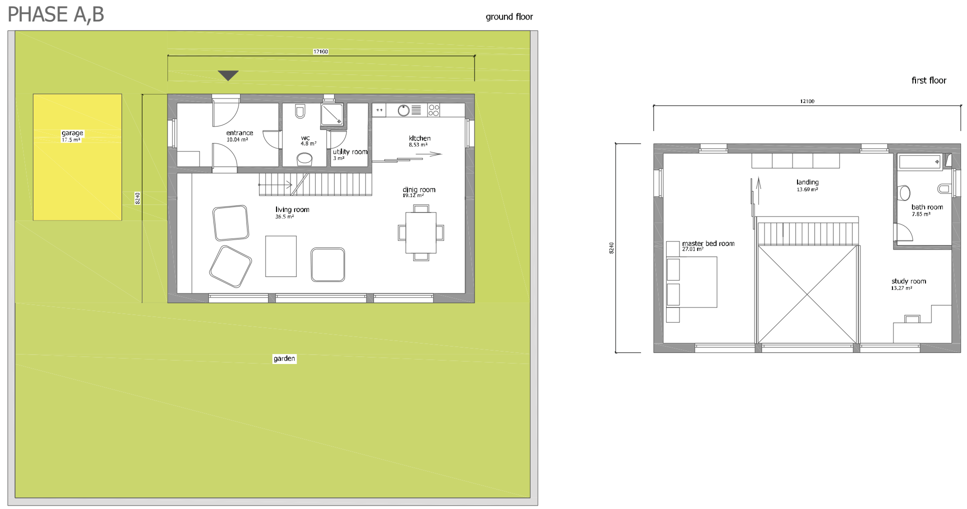


① OUTSIDE SURFACE TREATMENT
② ROCK WOOL- THICKNESS 120 mm
③ OSB BOARD TYPE 2 THICKNESS 15 mm
④ ROCK WOOL- THICKNESS 90 mm + STEEL PROFILE U 90
⑤ OSB BOARD TYPE 4 THICKNESS 15 mm
⑥ CW PROFILE
⑦ PLASTERBOARD

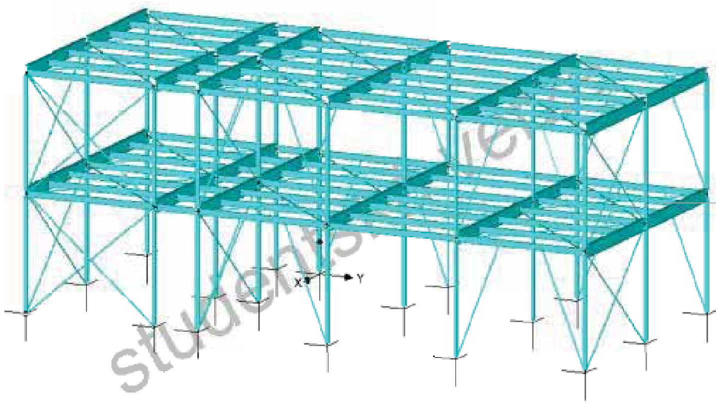
STATIC CALCULATION



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)

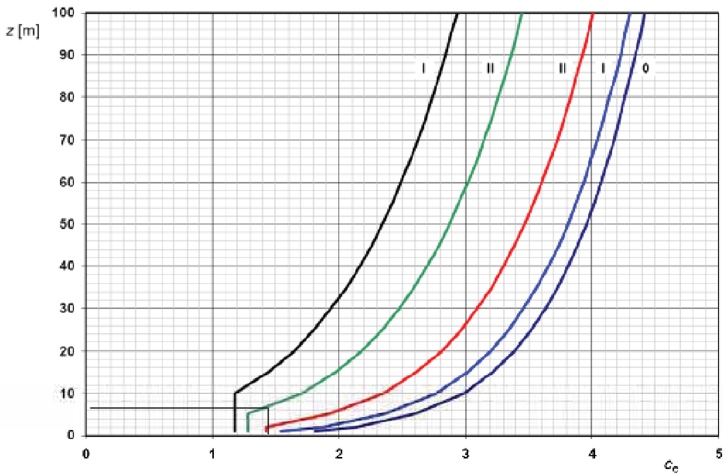
v_b=27,5 m/s

$q_b = 1/2*1,25*27,5^2$=**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_b=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

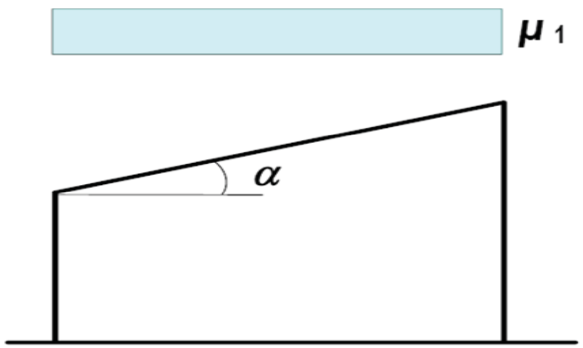
$s=\mu_i*C_e*C_t*s_k$

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/m^2**

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		1,250	**3,582**		**4,835**
width		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		1,250	**2,500**		**3,750**
width		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		1,250	**5,110**		**6,899**
width		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		1,250	**2,500**		**3,750**
width		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**

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

$$\sum_{j\geq 1}\gamma_{Gj}G_{kj}+\gamma_{Q1}Q_{k1}+\sum_{i\geq 1}\gamma_{Qi}\psi_{0i}Q_{ki}$$

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

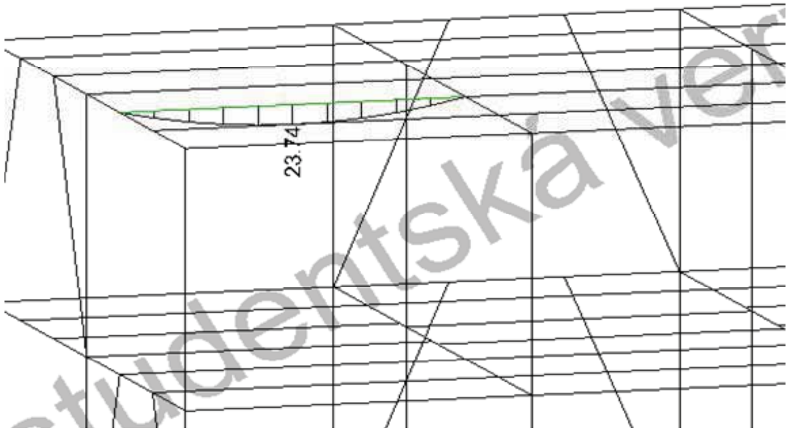
(there is used steel S 355 for the design)

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

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

$\delta=$ (5/384)*(5,239*3750^4)/(210000*5412000)

$\delta=$ **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

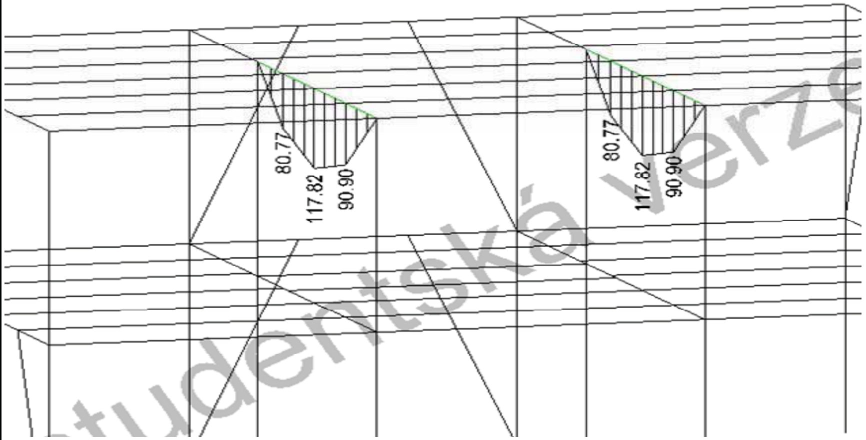
vlastní tíha nosníku je uvažována přímo vy výpočtu vnitřnch sil

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 mm

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

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

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

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

(incidental load)

$\delta_2= q_k/g_k * \delta$

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

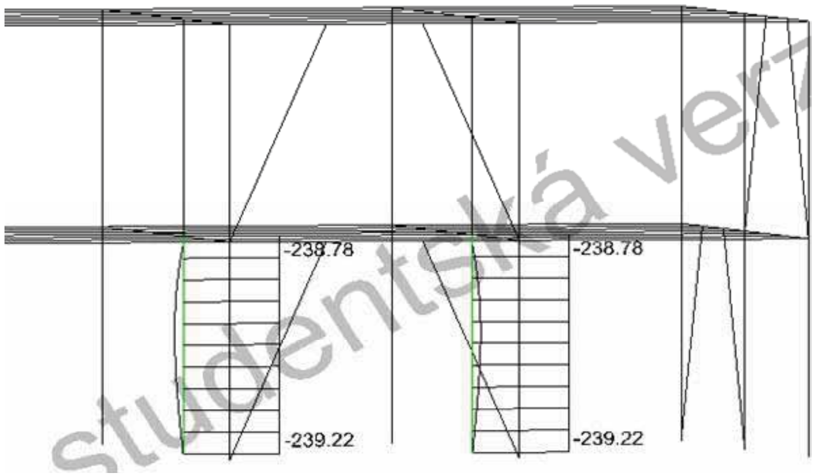
number of girders	n=	8	ks
weight of one girder	m=	36,1	kg/m
lenght of one girder	l=	7,5	m
weight summary	m_c=	**2166**	kg

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			
λ_y =	$\lambda_y/\lambda_1*\sqrt{\beta_A}$=	64,103/76,399*√1		0,8391	b	0,699
λ_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

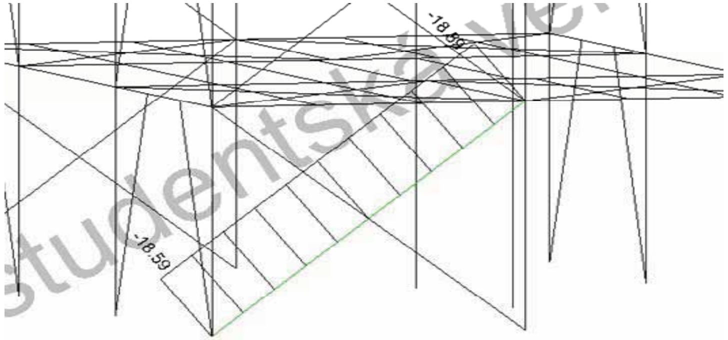
number of columns	n=	24	ks
weight of one column	m=	17,82	kg/m
lenght of one column	l=	3	m
weight summary	m_c=	**1283,04**	kg

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

				buckling curve	buckling coefficient
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	b	0,176

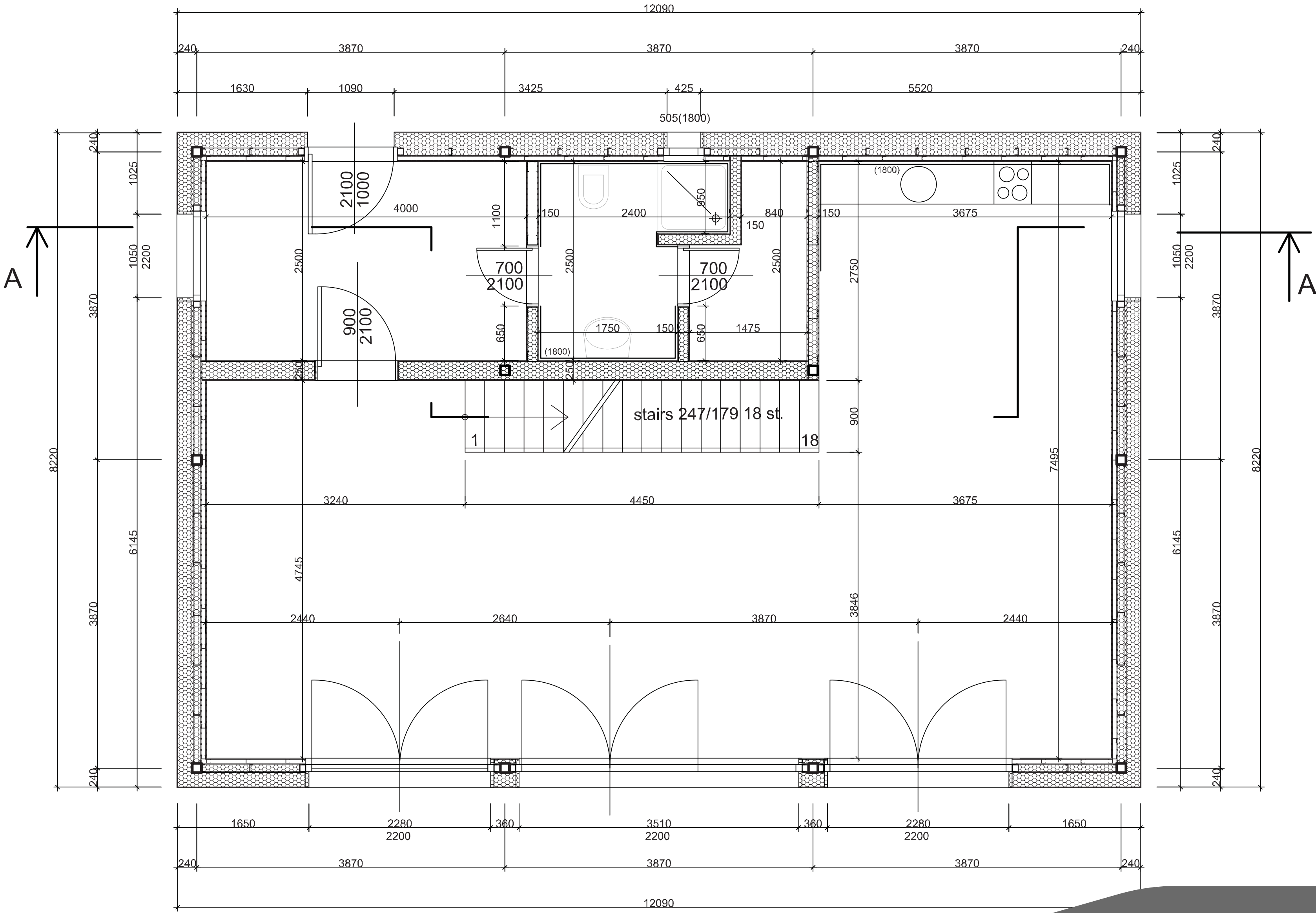
buckling pressure loading capacity

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

Summary of all reinforcements in the structure and their weight

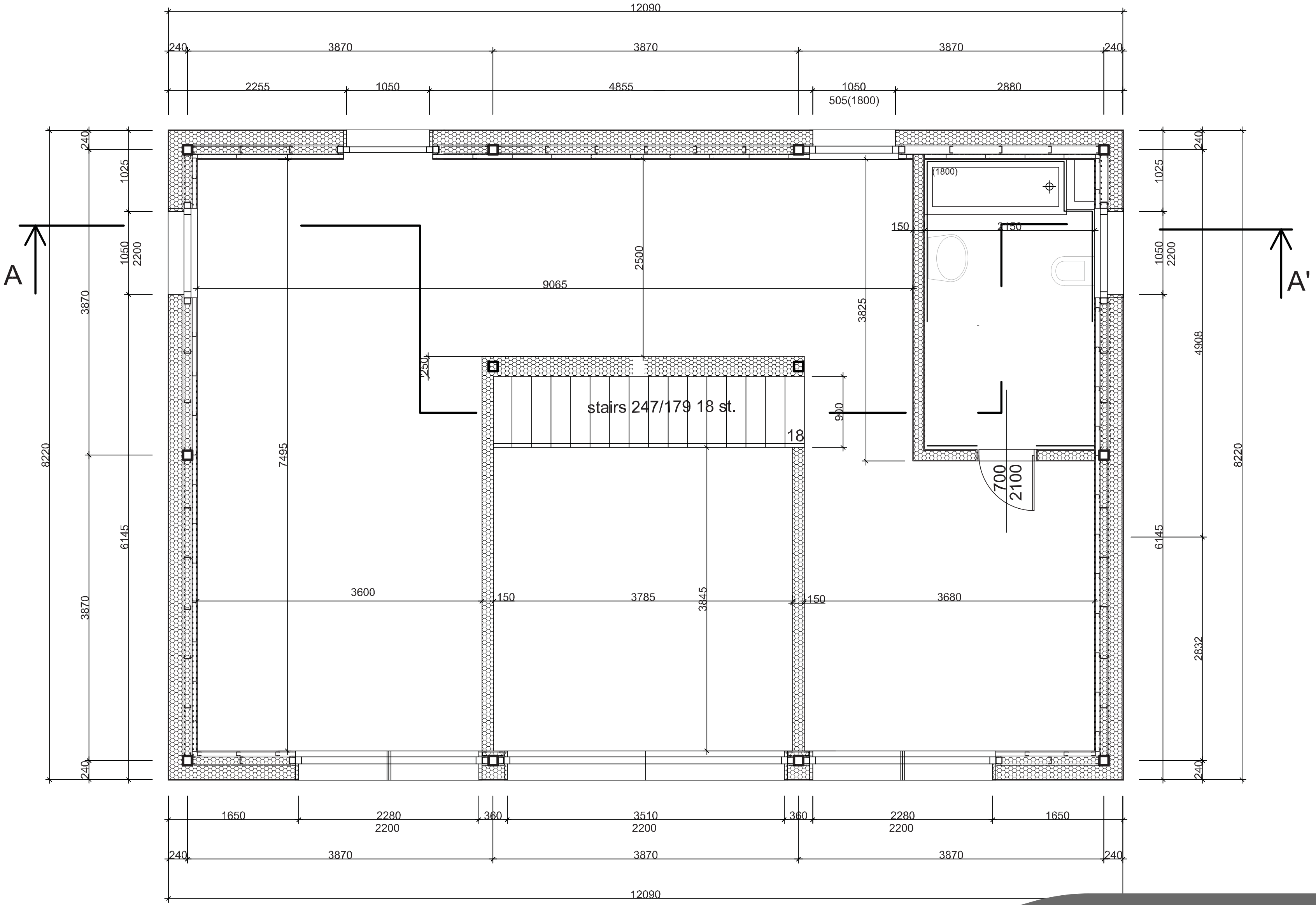
number of reinforcements	n=	12	ks
weight of one reinforcement	m=	4	kg/m
lenght of one reinforcement	l=	4,8	m
weight summary	m_c=	**230,4**	kg
weight summary of all elements	m_{tot}=	**5711,19**	kg

Ground plan 1st floor



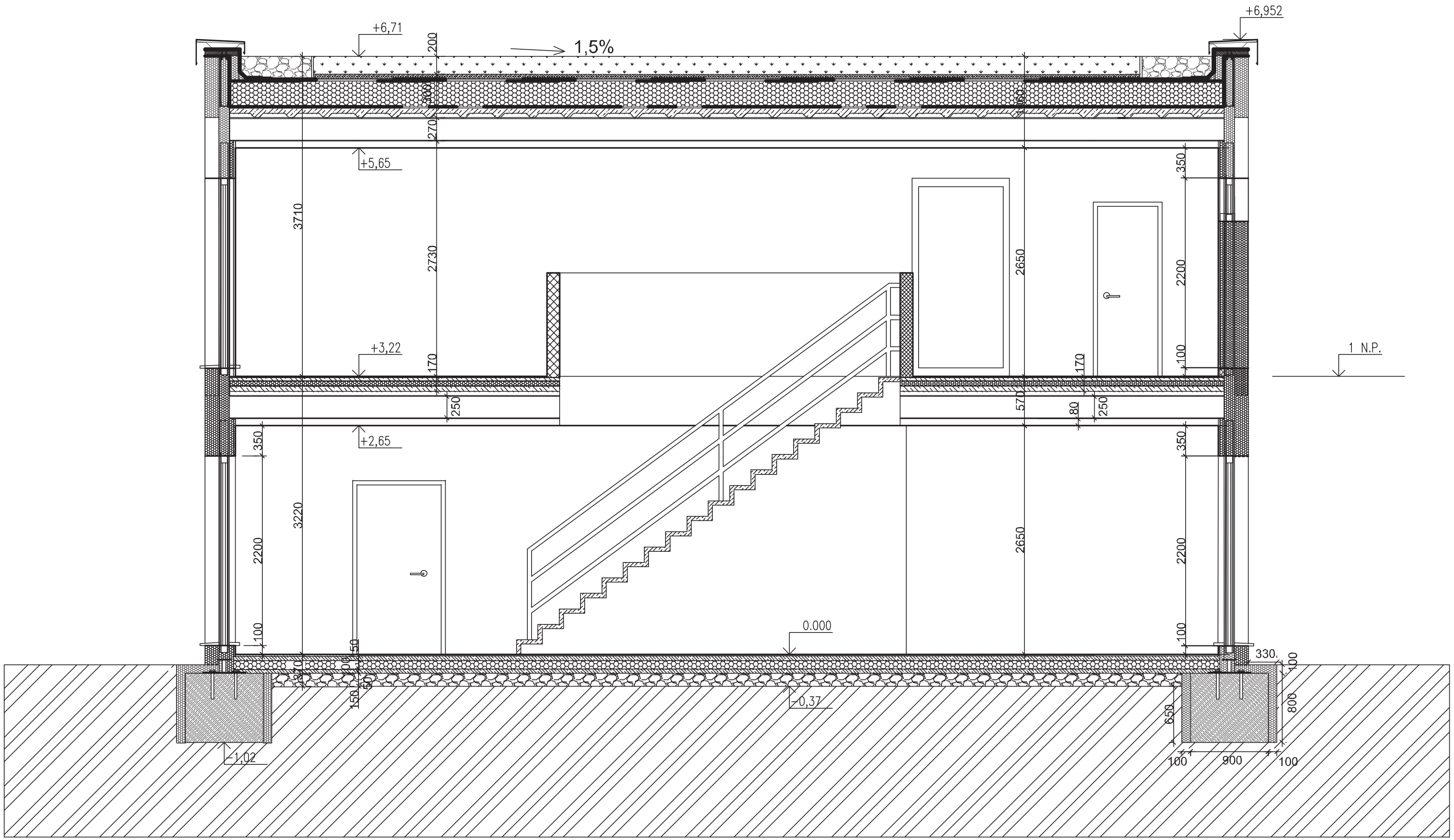
first floor projection
growing steel house - family rules

Ground plan 2nd floor



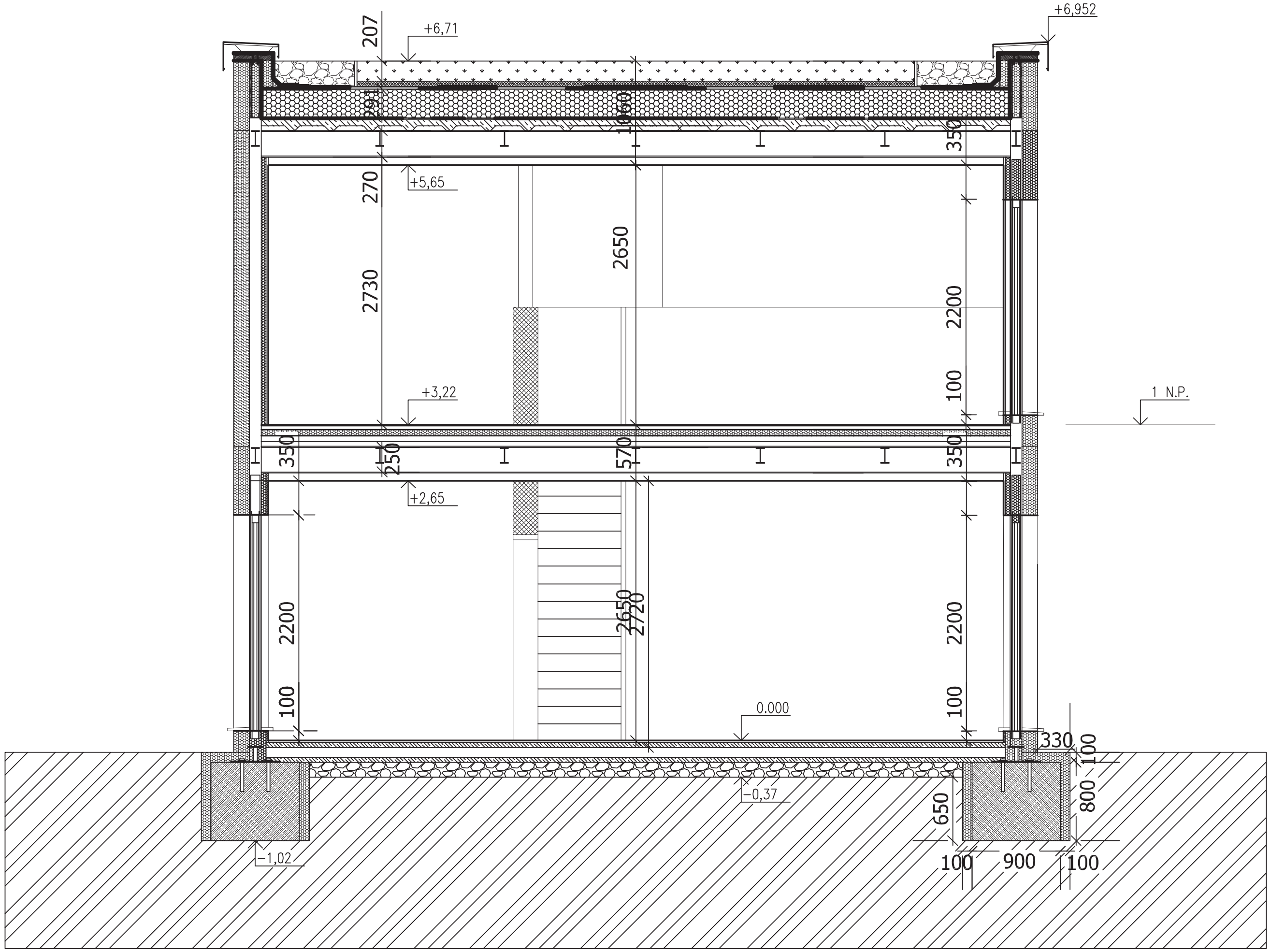
second floor projection
growing steel house - family rules

Section A - A'



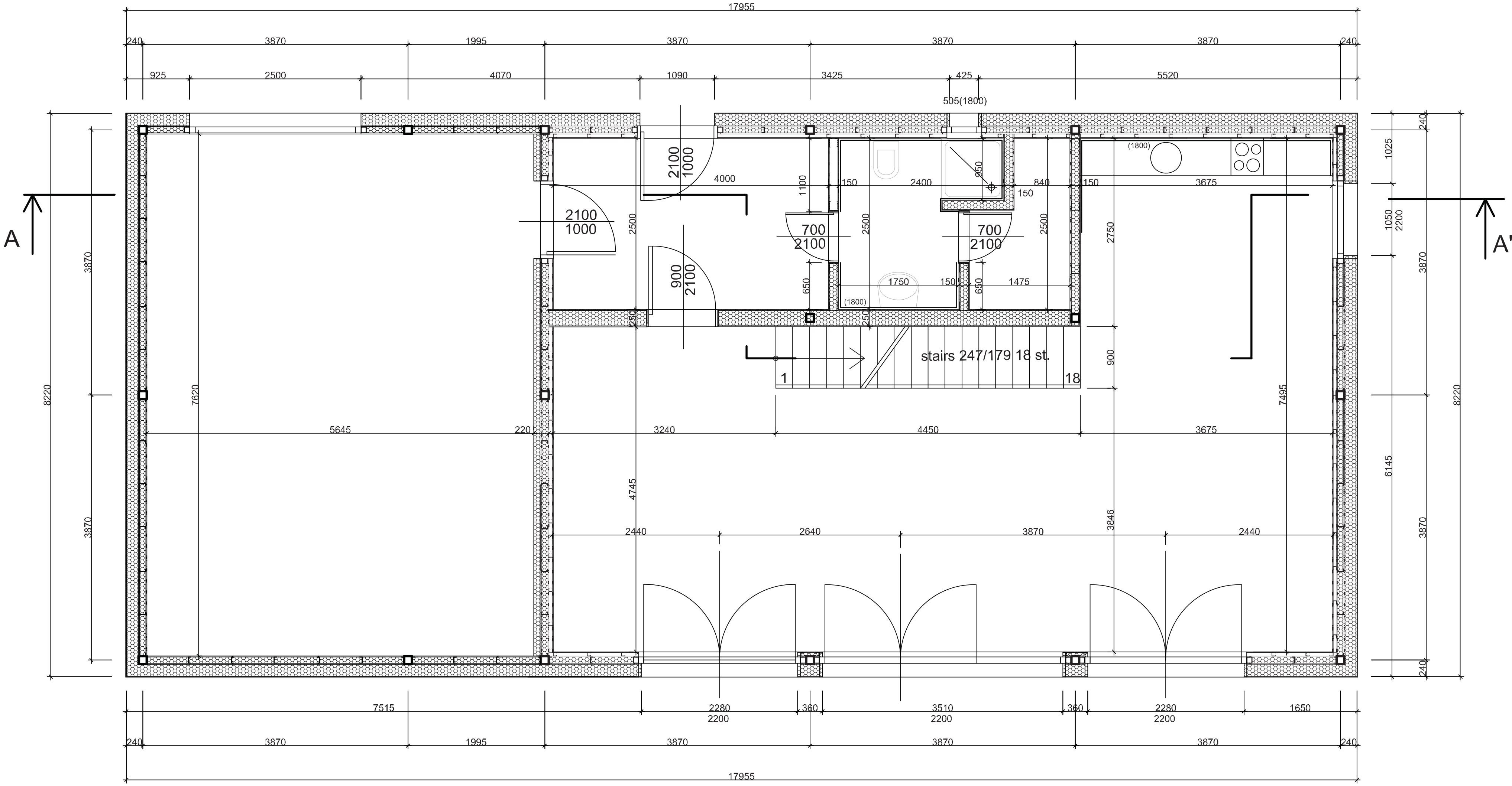
east - west section
growing steel house - family rules

SECTION B - B'



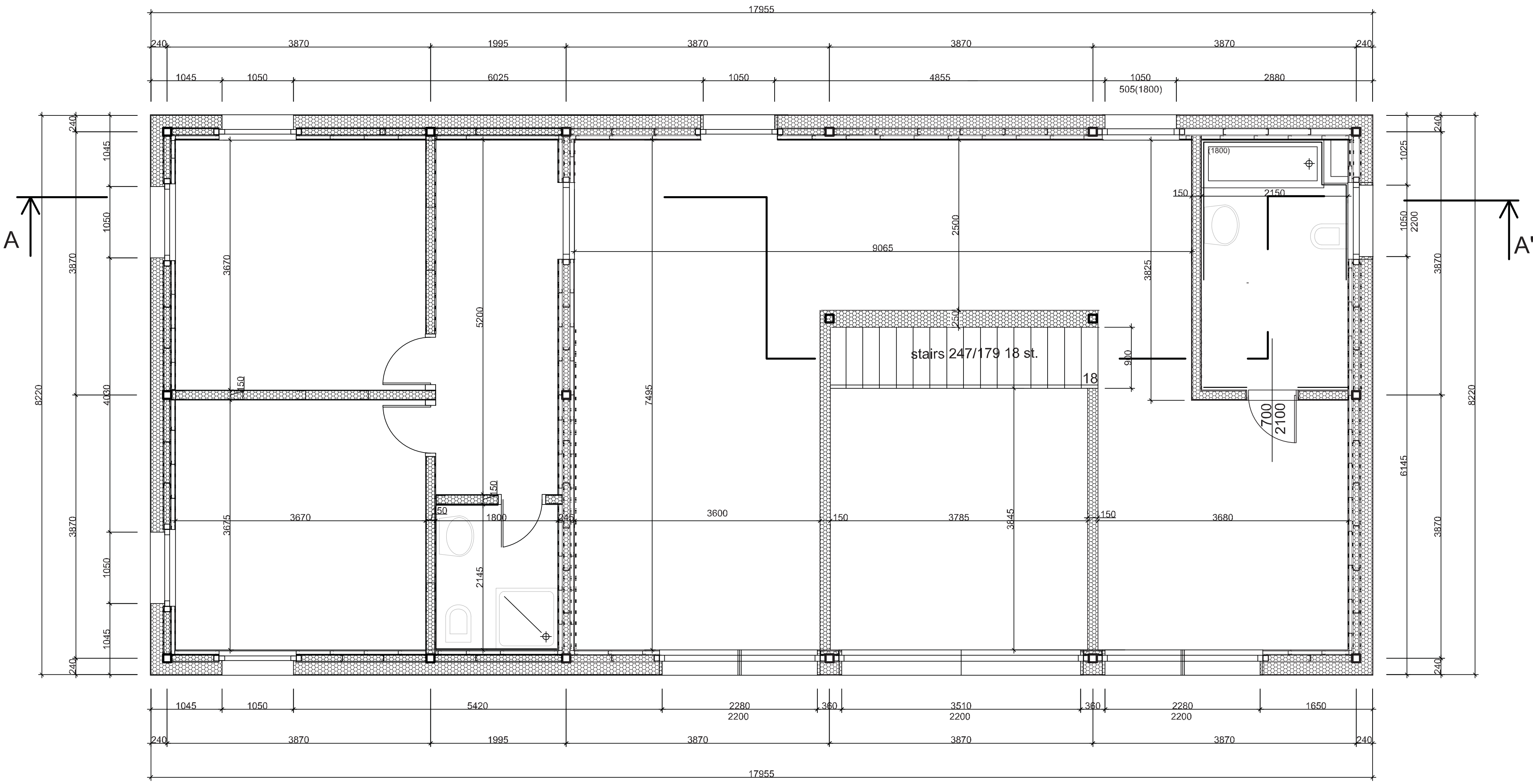
north - south section
growing steel house - family rules

Ground plan 1st floor



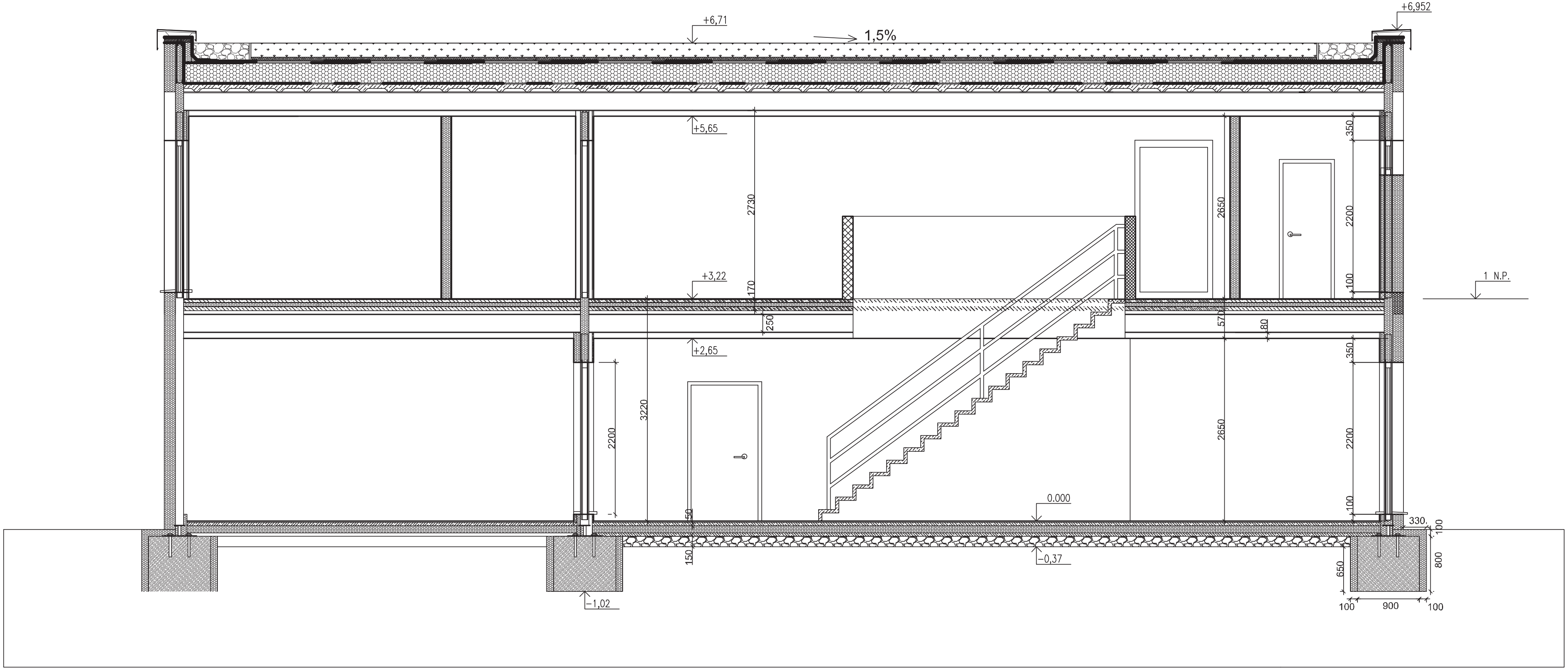
first floor projection
growing steel house - family rules

Ground plan 2nd floor



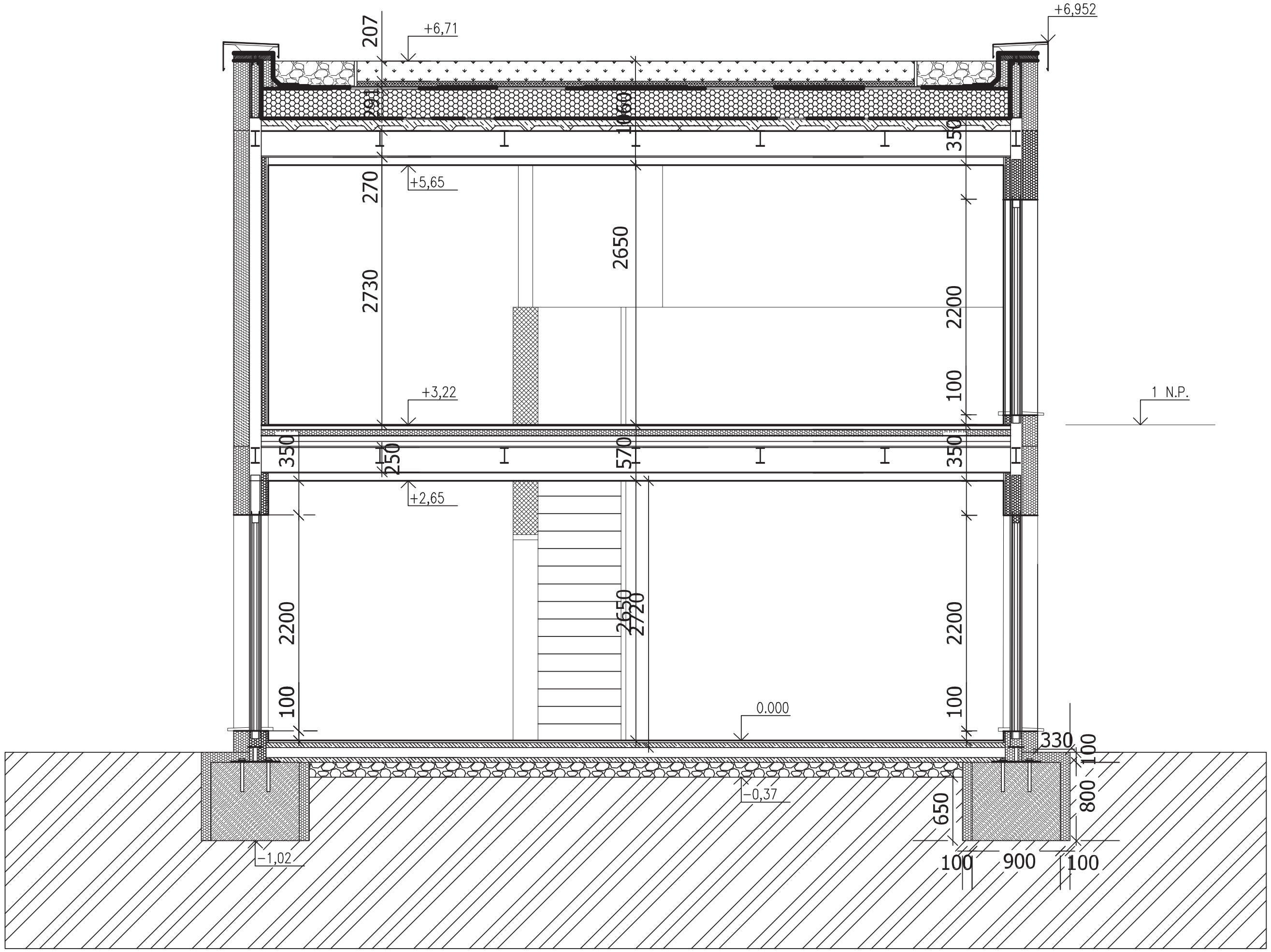
second floor projection
growing steel house - family rules

Section A - A'



east - west section
growing steel house - family rules

SECTION B - B'



north - south section
growing steel house - family rules