TURKISH CONSTRUCTIONAL STEELWORK ASSOCIATION (TUCSA)
COLD-FORMED STEEL STRUCTURES WORKSHOP
Istanbul, 25th of March 2013

Seismic Design of Cold-formed Steel Framing Residential Buildings. The Prescriptive Design Methodology and Case Studies

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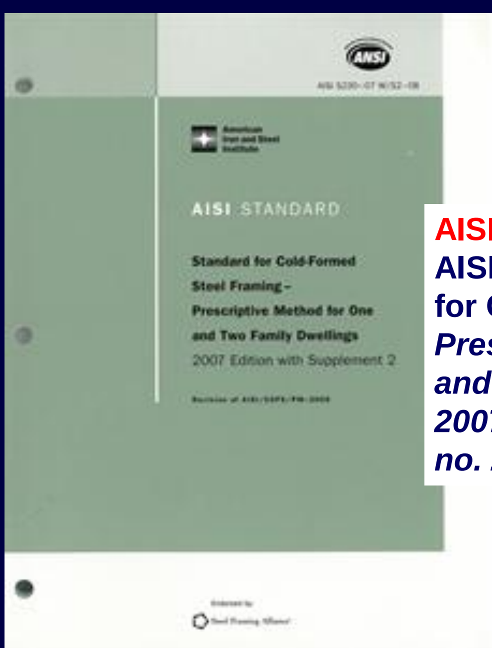
Content

1. Introduction to Prescriptive Method.
2. A Romanian case study on cold-formed steel framing residential buildings.
3. Steps to apply *Prescriptive Method* on residential buildings in Turkey.

Prescriptive Method for *Cold-Formed Steel Framing Residential Buildings* offers practical recommendations to builders, architects and designers on the application and performance of this type of construction system.

Prescriptive Method provides basic descriptive information on steel framing that architects, builders, and regulatory officials need to assess its use. It standardizes the basic cold-formed steel members, the connections, provides labeling guidelines, and gives minimum corrosion protection requirements. The methodology includes tables with recommended spans for floor joists, ceiling joists, rafters, and studs, as well as requirements for wall bracing and connections.



AISI-S230-07w-S2-08
AISI North American Standard for Cold-Formed Steel Framing
Prescriptive Method for One and Two Family Dwellings, 2007 Edition with Supplement no. 2

lsk European Light Steel Construction Association   greisch   arcelor Flat Carbon Steel

The Prescriptive Method by Arcelor

The Prescriptive Method is devoted to the construction of simple single family houses and low-rise office buildings (ground floor + 1 floor + attic).

It is a simplified method in which the houses are designed by means of a series of abacuses, which have been calculated based on Eurocodes. Plenty of constructional details are given.

The objective is to make the design of cold-formed steel buildings easier to architects, builders or design offices.

Clearly defined scope

+

Conception rules

+

Design method by abacuses

+

Construction details

Scope

The method applies to single family houses or office buildings with ground floor plus one first floor and allows the possibility of an attic, depending on the type of roofing.

Only flat roofs or roofs with two-equal slopes are considered.

The structure is made of cold-formed steel profiles, basically C-U shaped which are joined by self-drilling screws.

The structure is subdivided in three main parts roof, floor and walls/façades.

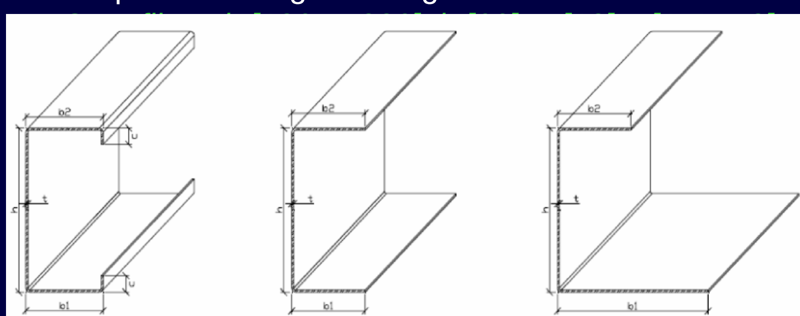
Several abacuses are provided for each part in order to determine which profiles must be used. The separation between studs or between purlins is assumed to be 600 mm max, whereas the separation between trusses is between 600 and 1200 mm.

The method is restricted to a series of European countries and cannot be used if some given values for loads are overpassed:

- The countries are: Belgium, Luxembourg, Spain, France, Netherlands and Portugal.
- Maximum loads: snow < 300 kg/m^2 and wind < 1600 kg/m^2.

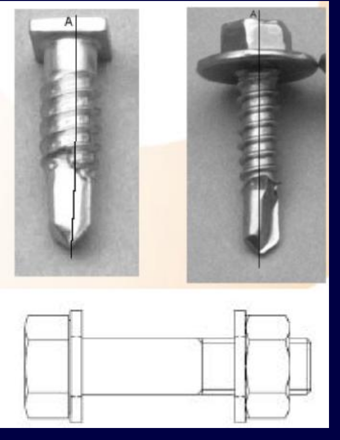
The structural elements, connections and steel grade are:

- Steel grade: 350 N/mm^2 (galvanised steel).
- C-U profiles of a given range of dimensions.



- Fasteners:

1. Self-tapping screws ϕ4.8 and ϕ6.3.
2. M6 to M16 bolts of quality 8.8 are used for the steel trusses.
3. M10 for the anchorage, except for frames with X-braces in which chemical anchors M20 are used.



Loads

- Permanent loads (G), for the different elements of the structure. The method gives the values for the different types coverings. Thus, for example, for a light roof made of sandwich panels G equals 25 kg/m^2 or for a composite floor steel + concrete, G equals 260 kg/m^2.

- Imposed loads (Q) are defined based on EN1991-1-1:2002:

1. Floors: the method considers two categories of buildings: category A (domestic, residential areas with a q_k of 2 kN/m^2) and category B (office areas, with a q_k of 3.0 kN/m^2).
2. Roofs: The method considers category H, corresponding to non-accessible roofs, in which q_k is defined depending on the slope of the roof.

Loads

- Snow loads (S) are defined on the basis of EN1991-1-3:2003. Several abacuses are given to calculate the snow load s_k depending on the geographical area and the altitude where the buildings is placed.
- Wind pressure (W) are defined based on EN1991-1-4:2005. The wind pressures can also be obtained from a series of abacuses for different geographical areas, which depend on the height of the building.

The combination of loads used to calculate the different design abacuses, follows the rules of EN1990:2002.

Hypothesis of design

The abacus have been calculated so that the structure fulfils the following criteria:

•Resistance and stability design criteria according to EN1993-1-1, EN1993-1-3 and EN1993-1-5.

•Deflection criteria:

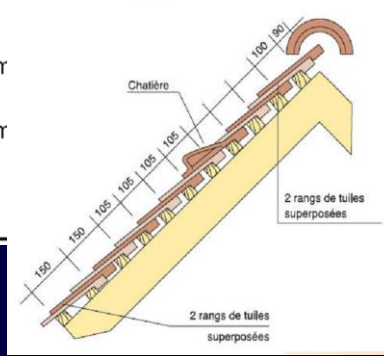
1. For the roof, δ_{max} = L/200 under total loads and δ_{max} = L/250 under single variable loads;
2. For the floors: δ_{max} = L/400 under total loads and δ_{max} = L/500 under single variable loads;
3. For the studs: δ_{max} = L/500 under variable loads.

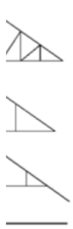
•Vibration of floors: The prescriptive method applies, in order to ensure the comfort of the occupants, the following limitation: $f \geq 5$ Hz.

Roofs

Types of roofs considered in the method

System	Spacing	Slopes	Schema
Truss	1200 mm	15º, 25º, 35º & 45º	
Fr	/ 1200 m		
Fr	/ 1200 m		
Fl			





T ... l into

Different types of covering materials are taking into account, i.e. light roofs covered by sandwich panels and heavy roofs with tiles + lathwork + insulation.

In order to design the roof, the user has to use the appropriate abacus with the following data:

- Geometrical parameters: Slope of the roof, overflowing, spacing (600 mm or 1200 mm, when allowed) and span. In the case of framework, also the position of the tie-beam.
- Loads as described: snow and wind loads obtained from the corresponding abacuses, the dead load depending on the roofing panel and the live load.

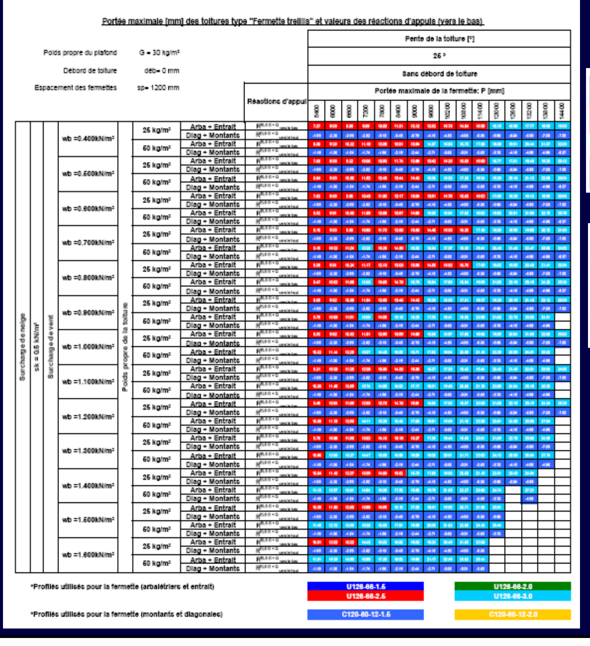
Geometrical parameters:
- Slope
- Overflowing of the roof: Y/N
- Span

Load parameters:
- Snow load
- Wind load
- Live load
- Dead load

ABACUSES

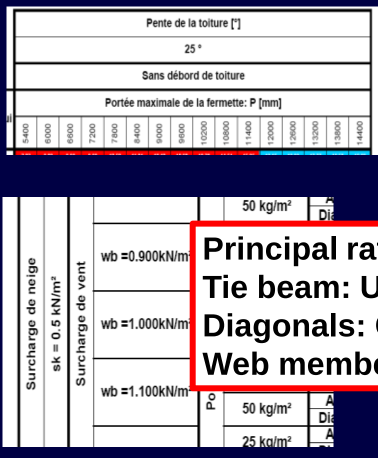
For a given set of data, the user gets:
- the profiles to use and
- the reaction loads that will be used later on for the design of studs and lintels.

Abacus for the design of a steel truss



U126-66-1.5
U126-66-2.5
C120-60-12-1.5

U126-66-2.0
U126-66-3.0
C120-60-12-2.0



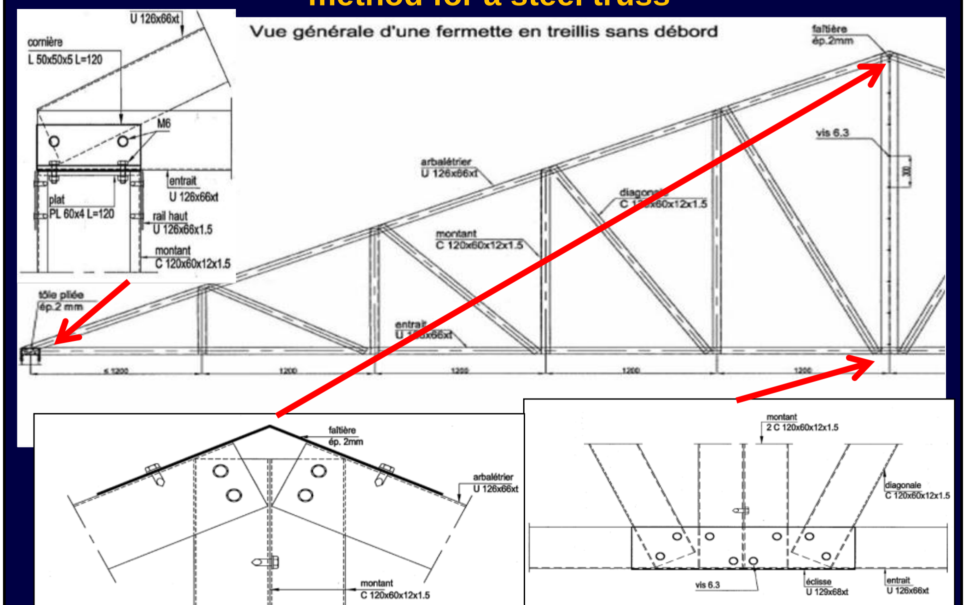
2.82	-3.13	-3.45	-3.79	-4.15	-4.53
3.00	14.08	15.16	16.25	17.33	18.41
1.74	-1.96	-2.19	-2.44	-2.71	-3.00
1.91	12.90	13.89	14.89	15.88	16.87
2.82	-3.13	-3.45	-3.79	-4.15	-4.53
3.37	14.48	15.59	16.71	17.82	18.94
					-3.00

Principal rafters: U126-66-2.5
Tie beam: U126-66-2.5
Diagonals: C120-60-12-1.5
Web members: C120-60-12-1.5

U126-66-2.0
U126-66-3.0
C120-60-12-2.0

The colour of the cell above
⇨ the profile section for the principal rafters and the tie beam
The colour of the cell below ⇨ the profile section for the diagonals and the web members
The figures in the cell ⇨ Reaction loads on the façade studs

Example of some constructional details given by the method for a steel truss



General information given by the method for steel trusses

The basic constitutive elements found in this system:

- *Bottom chord*: U126X66xt, with t from the abacuses.
- *Top chord*: U126X66xt, with t obtained from the abacuses.
- *Vertical stud*: C120x60x12x1.5. The central one composed of two back-to-back profiles joined with ϕ6.3 screws.
- *Diagonal girders*: C120x60x12x1.5.
- *Steel ridge tile*: 2 mm thick is fixed to the top chord with 3 ϕ6.3 screws.
- *Angles and special devices* for joining the trusses to the façades are also defined.
- *Ties* to keep the trusses well separated, composed of tubes ϕ27*1 S350.
- *Bracing systems*, crosses with U40X40X2.0 S350 profiles are defined. Constructional details for the disposition of these bracings are also provided.

General information given by the method for steel trusses

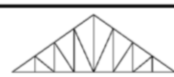
The method defines also the space between the different members, both between trusses or between the girders of the truss.

Description about the fixing of the roof panels, the false ceilings or the fixing of the trusses to the vertical structure is provided.

The number and types of self-drilling screws for the truss and its bracings are also given, with the reference to the proper constructional details.

Similar information / abacuses are given for:

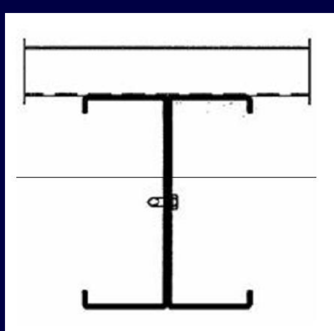
Types of roofs considered in the method

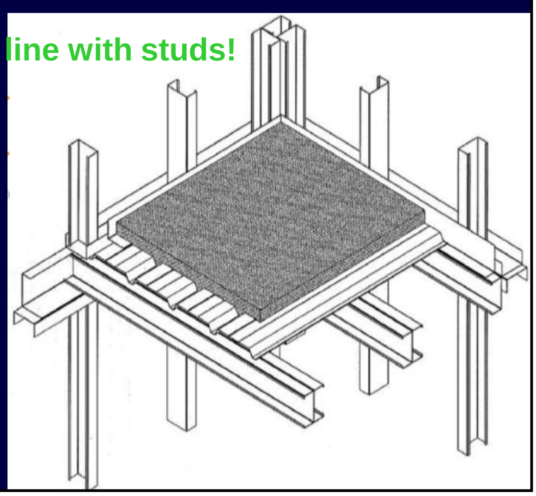
System	Spacing	Slopes	Schema
Truss	1200 mm	15º, 25º, 35º & 45º	
Framework	600 / 1200 mm	15º, 25º, 35º & 45º	
Framework with mansard	600 / 1200 mm	15º, 25º, 35º & 45º	
Flat roof	600	-----	

Floors

The method considers 3 different types of floors (from light floors, to composite steel-concrete slabs). The spacing between purlins is defined as a maximum of 600 mm and they must be supported over a stud or a lintel.

The joists have to fall into line with studs!

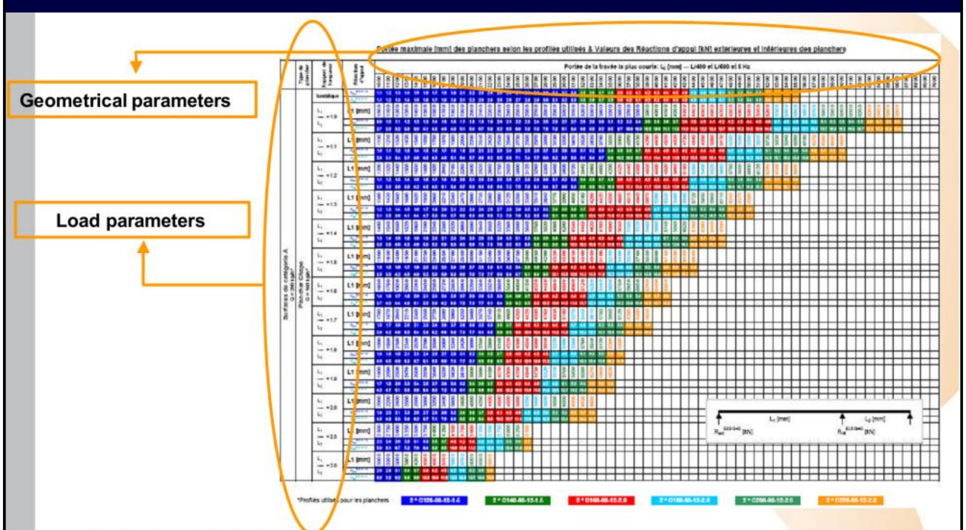




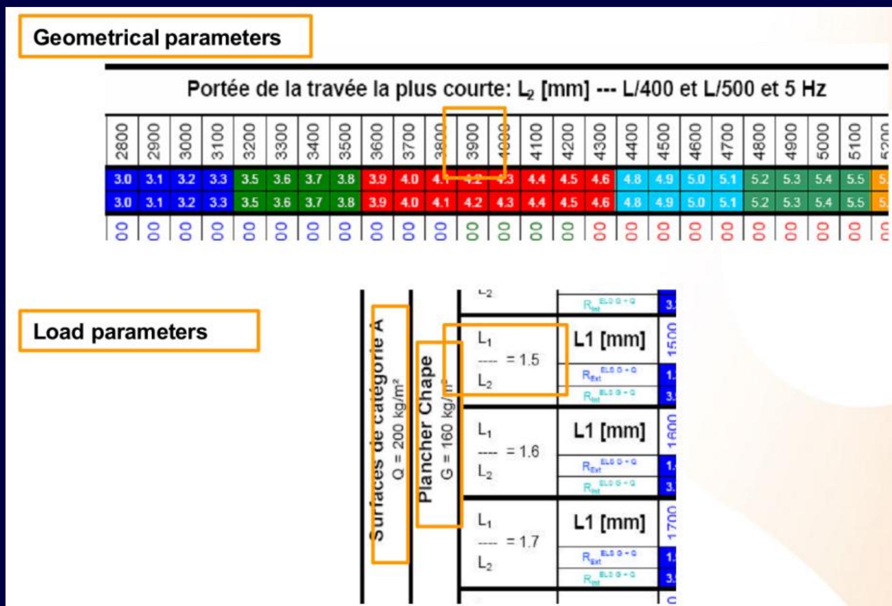
The main elements of the floor are:

- Purlins: two back-to-back C-profiles of dimensions CHx60xt, H and t to be defined by the corresponding abacus. It is recommended to use hyperestatic two-span purlins.
- The joists gatherers are unsymmetric U-profiles of dimensions U123x(H+4)x50x2, where H is the height of the corresponding joists.
- Decking: in the case of light floors, OSB panels directly supported by the purlins are considered. There are a series of abacuses to design the floors, similar to those of roofs.
- Regarding the lateral bracing of the floors, in the case of light floors, the method proposes x-braces with steel straps of 120 mm width and 1.5 mm thickness, joined with 3 ϕ4.8 screws. In the case of composite concrete-steel slabs, it is considered that the diaphragm effect is ensured thanks to the concrete plus the peripheral angle.

Abacus for the design of a steel joists



Abacus for the design of a steel joists

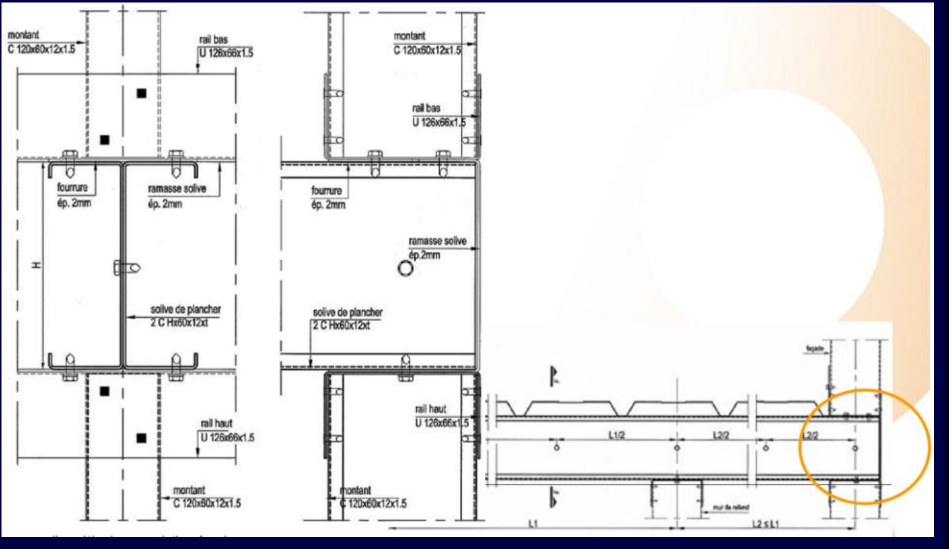


The **color** of the cells below ⇨ the profile section for the joist
The figures in the cell above ⇨ External reaction loads on the façade studs
The figures in the cell below ⇨ Internal reaction load on the cross wall

⇨ Purlins: 2×C200-60-12-2.0

2 * C120-60-12-1.5	2 * C140-60-12-1.5	2 * C160-60-12-2.0
2 * C180-60-12-2.0	2 * C200-60-12-2.0	2 * C220-60-12-2.0

Example of some constructional details given by the method for a steel joists



Façades

A stud-spacing of 600 mm is considered.

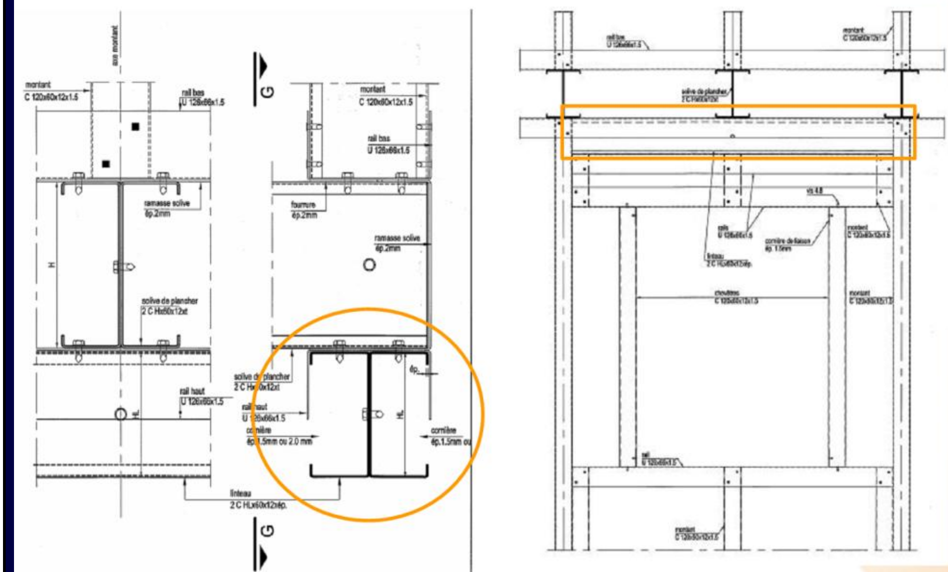
Two different types of covering materials are considered: sandwich panels and stone-finishing.

The different structural elements are the following:
Studs: C-profiles 120x60x12x1.5 which can be simple or doubled.
Tracks: U-profiles 126X66X1.5.
Lintels: built with 2 C-profiles back-to-back joined to the studs by clip-angles.
X-bracings: two or three modules for the lateral resistance

Structural details are provided for the connection between façades. The method provides different abacuses for the design of lintels, X-bracings and studs.

Façade: Lintel – Conception rules

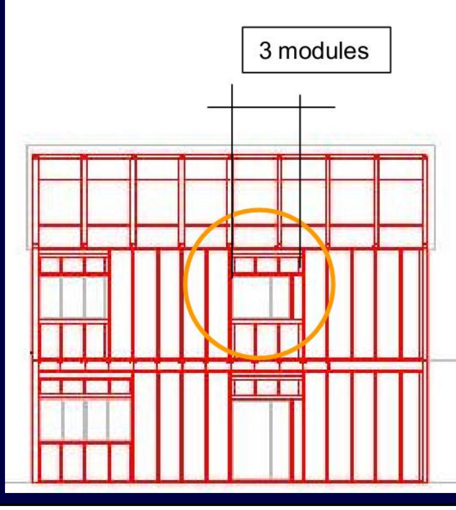
The lintel is constituted with 2 C-profiles back-to-back

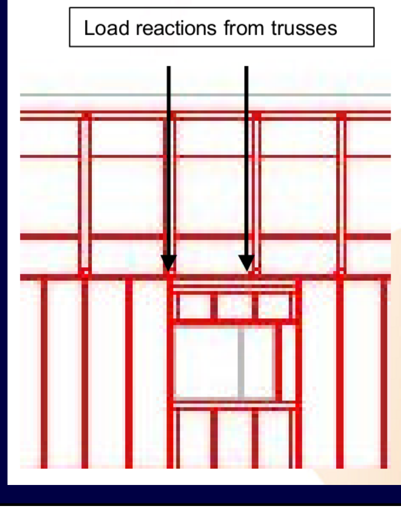


Façade: Lintel – Configuration

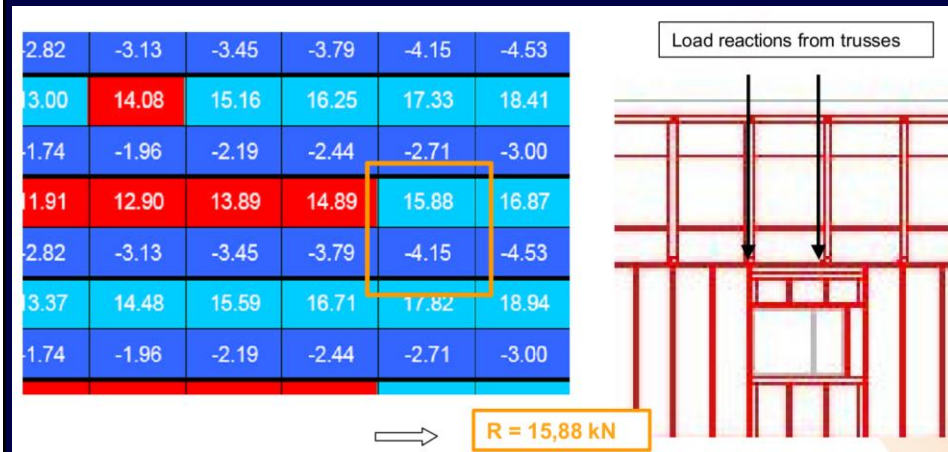
Geometrical parameters:
Number of modules of 600mm

Load parameters:
Reaction load from trusses, floor and studs from upper floor





Façade: Lintel – Configuration



2.82	-3.13	-3.45	-3.79	-4.15	-4.53
3.00	14.08	15.16	16.25	17.33	18.41
1.74	-1.96	-2.19	-2.44	-2.71	-3.00
1.91	12.90	13.89	14.89	15.88	16.87
2.82	-3.13	-3.45	-3.79	-4.15	-4.53
3.37	14.48	15.59	16.71	17.82	18.94
1.74	-1.96	-2.19	-2.44	-2.71	-3.00

Façade: Lintel – Design

Geometrical parameters:
3 modules of 600mm

Load parameters:
Reaction load from trusses 15,88kN on the first and the third studs
0 kN on the others

ABACUSES

- **Sections of the lintel**
- **Reaction load to consider for studs adjacent to lintel**

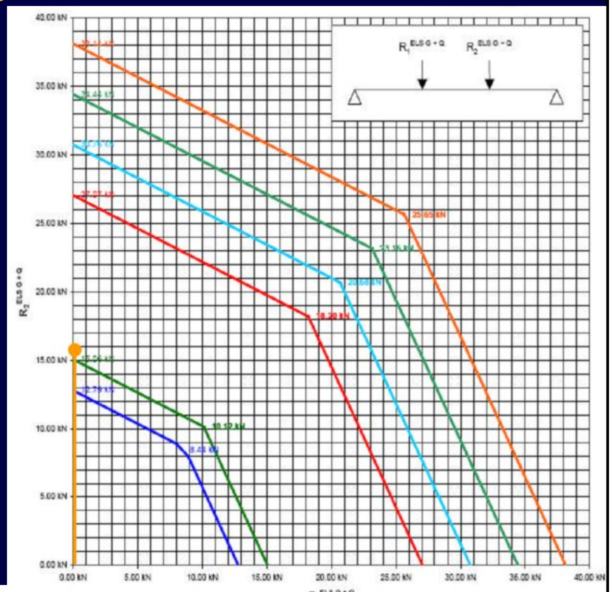
Façade: Lintel – Design

R1 = 0 kN

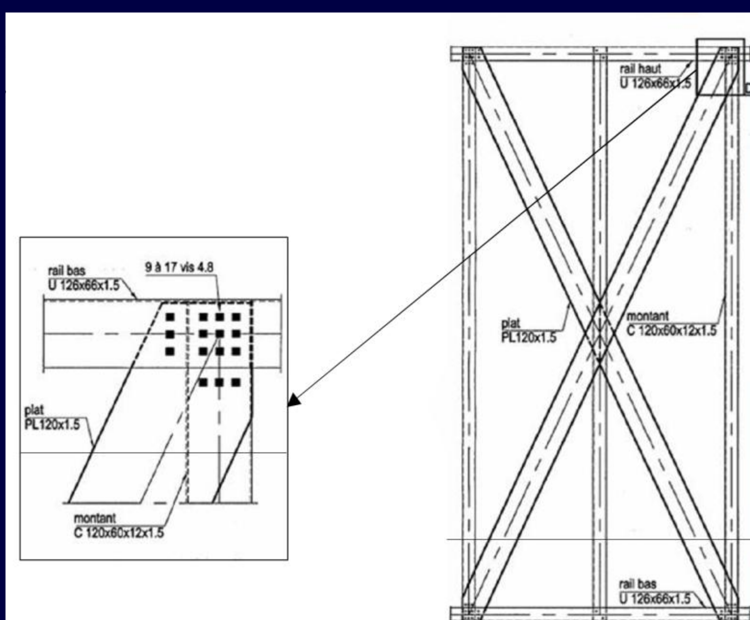
R2 = 15,88 kN

↓

Lintel = 2*C160



Façade: Wind bracings – Conception rules



Façade: Wind bracings – Design

Geometrical parameters:
- Length of side facade
- Slope of the roof
- Height of the studs for each floor

⇨ Surface of side facade to be considered for the design of wind bracing (Ground floor and first floor)

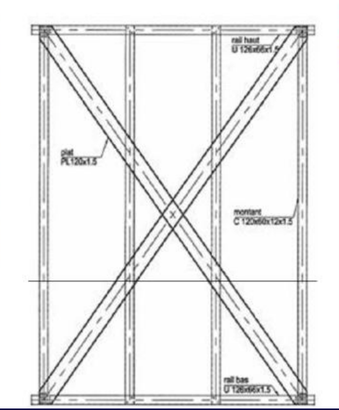
Load parameters:
Wind load

ABACUSES

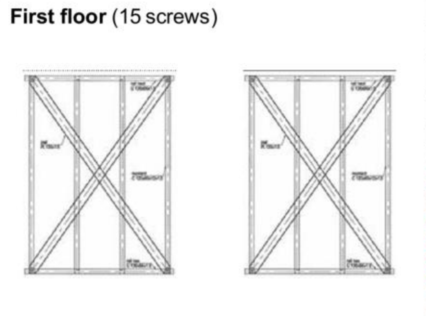
- Number of modules of wind bracings in the facade
- Number of screws at each edge of the flat profile

Façade: Wind bracings – Design

Montant Longueur < 3000 mm		Hauteur des montants du niveau cons									
		≥ 15									
		Surface offerte au vent [m²]									
		≤ 20	≤ 30	≤ 40	≤ 50	≤ 60	≤ 70	≤ 80	≤ 90	≤ 100	≤ 110
Pression de base du vent: w_b [kN/m²]	≤ 0.400	2	2	2	2					2	2+2
	≤ 0.500	2	2	2	3					3	3+3
	≤ 0.600	2	2	3	3					3	
	≤ 0.700	2	2	3	2+2						
	≤ 0.800	2	3	2+2	2+2						
	≤ 0.900	2	3	2+2	2+2						
	≤ 1.000	2	3	2+2	2+3						
	≤ 1.100	2	2+2	2+2	3+3						
	≤ 1.200	3	2+2	2+3	3+3						
	≤ 1.300	3	2+2	2+3							
	≤ 1.400	3	2+2	3+3							
	≤ 1.500	3	2+2	3+3							
	≤ 1.600	2+2	2+3								



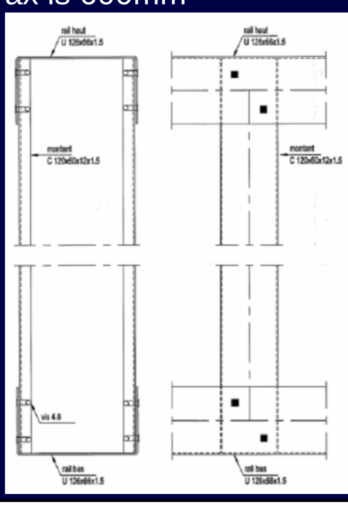
Façade: Wind bracings – Design

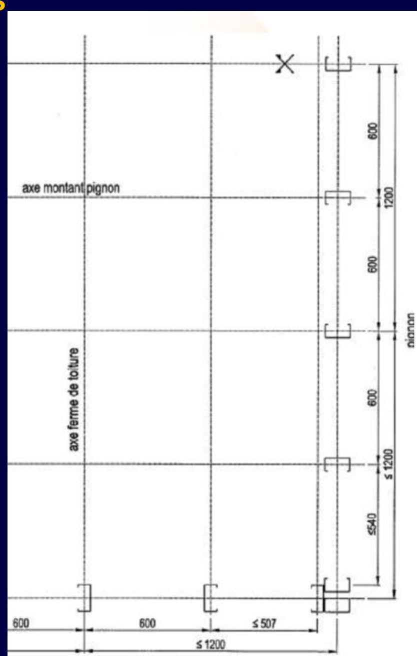


Pression de base w_b [kN/m²]	Hauteur des montants du niveau cons									
	≥ 15									
	Surface offerte au vent [m²]									
			40	≤ 50	≤ 60	≤ 70	≤ 80	≤ 90	≤ 100	≤ 110
			2	2	3	3	2+2	2+2	2+2	2+2
			2	3	3	2+2	2+2	2+2	2+3	3+3
			3	3	2+2	2+2	2+3	2+3	3+3	
			3	2+2	2+2	2+3	3+3	3+3		
			+2	2+2	2+3	3+3				
≤ 0.900	2	3	2+2	2+2	2+3	3+3				
≤ 1.000	2	3	2+2	2+3	3+3					
≤ 1.100	2	2+2	2+2	3+3						
≤ 1.200	3	2+2	2+3	3+3						
≤ 1.300	3	2+2	2+3							
≤ 1.400	3	2+2	3+3							
≤ 1.500	3	2+2	3+3							
≤ 1.600	2+2	2+3								

Façade: Studs – Conception rules

The façade is constituted with C120 profiles (sometimes double).
The C-profiles are placed alternately.
The interax is 600mm





Façade: Stud – Design

Geometrical parameters:
Height of the studs

Load parameters:
Reaction load from:
Trusses
Lintel
Wind load

↓

ABACUSES

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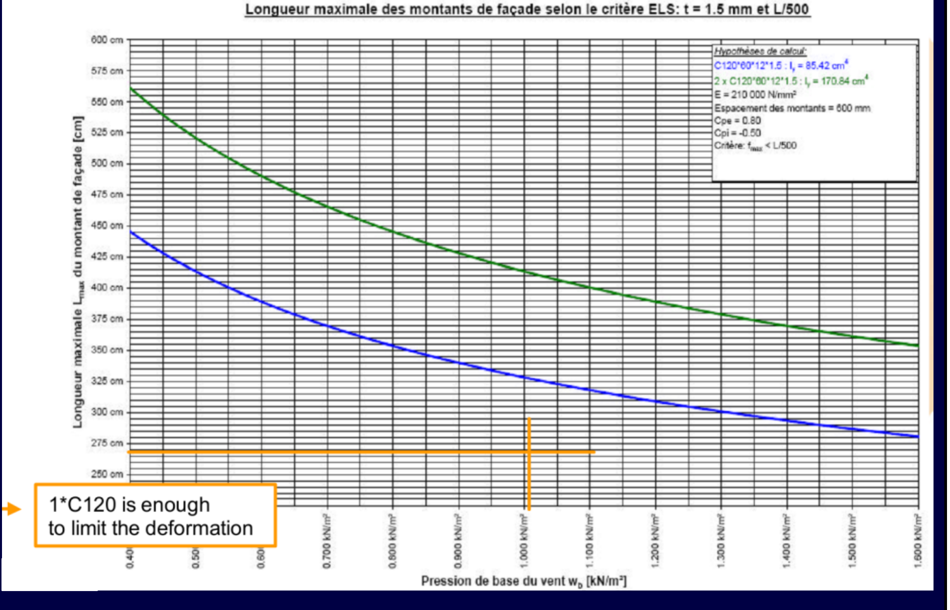
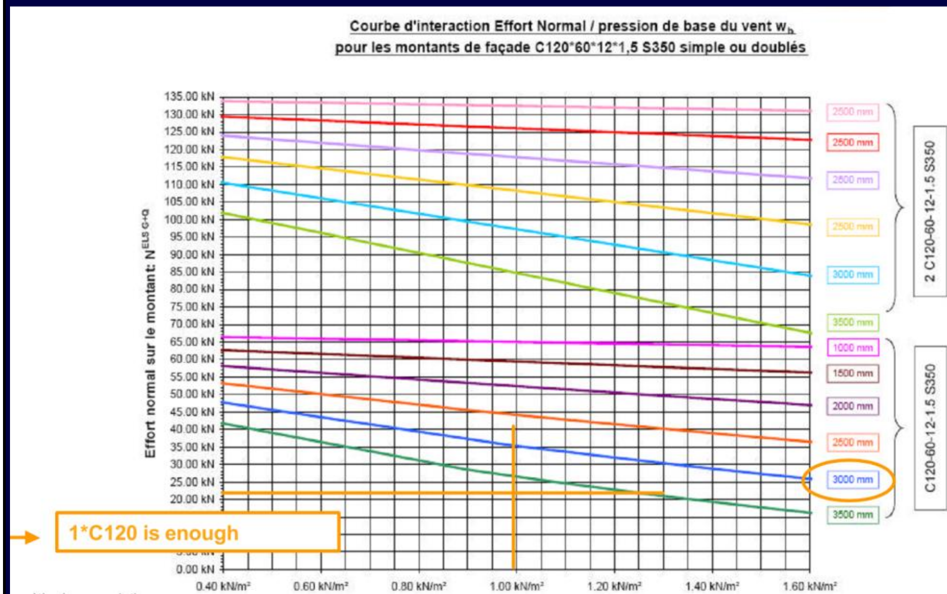
One or two studs to:
- Limit the deformation due to wind
- Bear interaction effort between wind and axial load

Façade: Stud – Design



Façade: Stud – Design



Conclusions

- A simple but complete method;
- Allow a larger diffusion of the system thanks to a wide accessibility
- Saving of time and money
- Efficient method

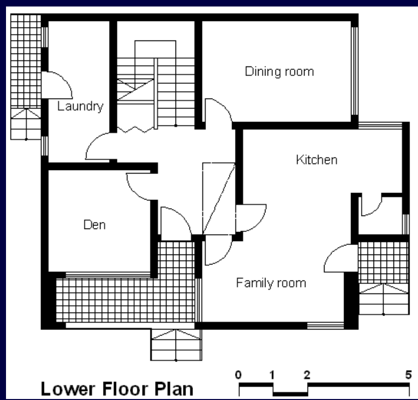
⇨ Weight difference < 10% in comparison with a specialized software method

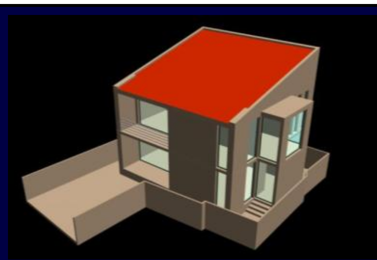
Constantin’s Family House, Ploiesti, Romania

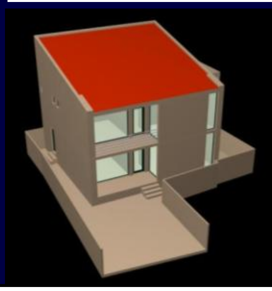
Cold-formed steel framing for housing are usually made of class 4 or 3 sections e.g.

- **Slender sections prone to local buckling;**
- **Non-plastic;**
- **Non-dissipative.**

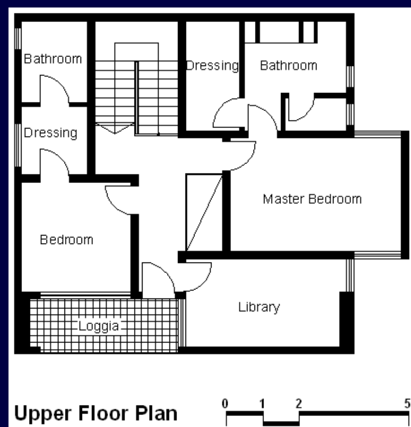
Seismic design codes are either restrictive or penalizing the use of these structures in seismic zones.







84m² of built area on each of the two floors



Location: ***Ploiesti/Romania, a high seismic region*****.**

The *<u>main structure</u>* is made of light-gauge steel profiles, sheeted with Oriented Strand Board – OSB (cladding), or steel sheeting and OSB (flooring and roofing).

<u>Cladding</u>**: (in/out)**
gypsum board (12.5mm); vapor barrier (0.5mm); OSB board (15mm); Lindab C150/1.5 joists; terwoolin mineral wool (150mm); OSB board (15mm); basaltic mineral wool (40kg/m³/40mm); mineral plastering BAUMIT (8mm)

<u>Roofing</u>**: (out/in)**
waterproofing membrane reinforced with mineral aggregates (3mm); waterproofing membrane (3mm); OSB board (20mm); basaltic mineral wool (155kg/m³/150mm); Lindab corrugated sheet (LTP 45); Lindab C200/1.5 profiles; vapor barrier 0.5mm; gypsum board (12.5mm)

- structural skeleton is made of light-gauge C shaped profiles (C150/1,5…600 mm);
- connection: self-drilling screws;
- the load bearing beams in the slab were C200/1,5 profiles at 600mm intervals;
- roof purlins are Z150/1,5 profiles at 1200 mm;
- the walls were stiffened using 10 mm thick OSB plates provided on both sides of the structural walls;
- the floor diaphragms were designed using trapezoidal steel sheaths both at the level of the slab and at the roof;
- no over-concreting was used in the slab.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Problems during the design of such a structure is the evaluation of the load bearing capacity and of the rigidity of the sheathing system of walls and slabs.

Experimental results were the basis of the evaluation both for shear capacity and rigidity reported to 1m length of the wall.

Design assisted by testing

$$E_{s,i} < R_{s,i}$$

$$R_{s,i} = R_k \cdot L_i$$

where,

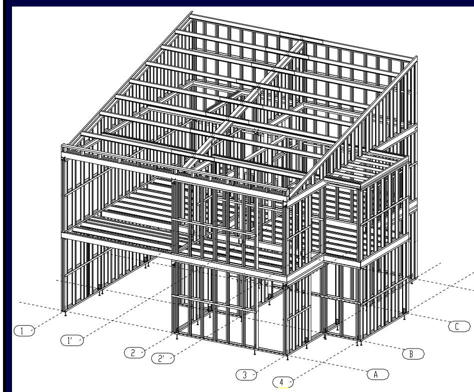
$E_{s,i}$ = total shear force induced by seismic action on "i" direction (kN);

$R_{s,i}$ = total shear wall resistance on "i" direction (kN);

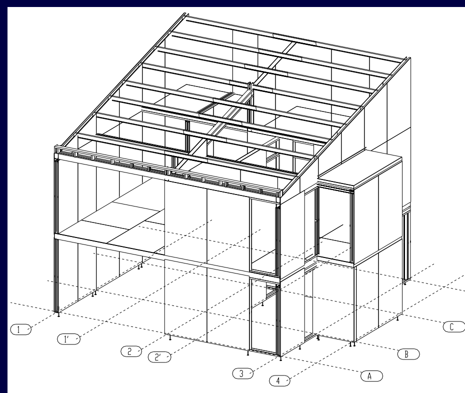
R_k = characteristic strength of shear wall (kN/m);

L_i = length of shear wall on "i" direction (m).

Structural design based on tested panels



Steel skeleton of the structure



The skeleton with the structural OSB sheeting

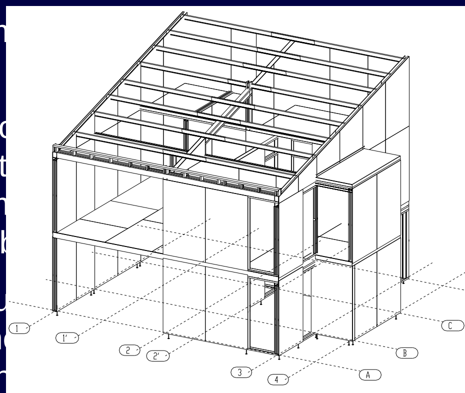
Technical support for design assisted by testing

An extensive research program was carried out at the *PU of Timisoara* in order to evaluate and characterize the seismic performance of cold-formed steel framed houses by tests and numerical simulations on shear panels and connection behavior.

Seismic design

The perforn

For the 3D he sheathing has been replac and considering the frame t d test results on wall specin rate the area of equivalent b



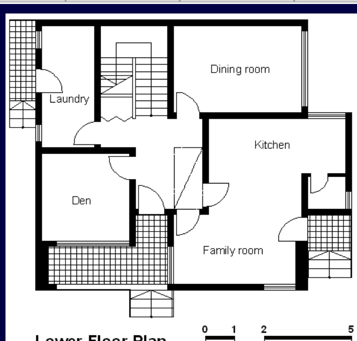
The structu g an earthquake because th sheathed, while the ones or all the openings.

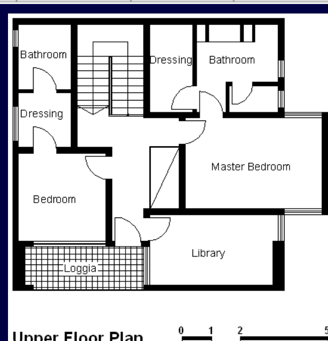
From the point of view of earthquake, the most critical wall panel is the one from axis A on the ground floor. The maximum shear force in this wall was 43 kN (12.8 kN/1m).

Due to the configuration of the structure, the analysis can be divided following the two principal directions, i.e. transversal and longitudinal ones.

The lengths of the shear wall panels for the TWCF structure (in meters).

Transversal	Axis 1	Axis 1'	Axis 2	Axis 2'	Axis 3	Axis 4	*Total*
Ground floor	8.1	3.2	3.2	2.18	1.62	3.25	*21.55*
First floor	9.05	-	3.2	-	1.62	3.25	*17.12*
Longitudinal	**Axis A**	**Axis B**	**Axis C**	**Axis D**	**-**	**-**	***Total***
Ground floor	3.37	1.5	3.3	9.05	-	-	*17.22*
First floor	3.37	-	-	9.05	-	-	*12.42*





In a first step, the total mass of the structure is evaluated, at the level of the first floor and at the roof level, taken into account the loads and safety coefficients, considered for the special combination of seismic action:

$$\sum_{j=1}^{n} G_{k,j} + \gamma_I A_{E,k} + \sum_{i=2}^{m} \psi_{2,i} Q_{k,i}$$

where:

$A_{E,k}$ – Characteristic value of seismic action;

$\psi_{0,i}$ – Factor for combination value of the variable action *i*;

Q_i – 0.4 for snow load and live load.

It results: (i) the total mass at the floor level $M_{ground\ floor}$ = 23.07 t and (ii) the total mass at the roof level $M_{first\ floor}$ = 11.71 t.

The total seismic force applied on the structure is:

$$S_e(T) = \gamma_I \cdot a_g \cdot \beta(T) \cdot g \cdot M = \\ = 1 \cdot 0.28 \cdot 2.75 \cdot 9.81 \cdot (23.07 + 11.71) = 262.72 \text{ kN}$$

Considering the deformation is linear in regard with the height, the horizontal load is distributed to both levels as follows:

$$S_1 = S_r \cdot \frac{z_1 \cdot G_1}{\sum(z_j \cdot G_j)} = 262.72 \cdot \frac{3 \cdot 23.07}{3 \cdot 23.07 + 7 \cdot 11.71} = 120.27 \text{ kN}$$

$$S_2 = S_r \cdot \frac{z_2 \cdot G_2}{\sum(z_j \cdot G_j)} = 262.72 \cdot \frac{7 \cdot 11.71}{3 \cdot 23.07 + 7 \cdot 11.71} = 142.45 \text{ kN}$$

The total seismic force corresponding to both levels are:

$$T_{\text{ground floor}} = S1 + S2 = 262.72\ \text{kN}$$
$$T_{\text{first floor}} = S2 = 142.45\ \text{kN}$$

Based on experimental work, for the analysed shear wall panels the shear capacity under cyclic loadings was found of 69844 N, which means for a length of 3.6 m of the tested panels an experimental reference capacity of 19.40 kN/m.

According to *AISI–1998: Shear Wall Design Guide*, Publication RG-9804, for a similar shear wall panel, sheeted on one side (OSB 7/16” and self drilling screws No. 8x1in., placed at every 4in.), the shear capacity is of 14.59 kN/m.

The AISI code allows to determine the shear capacity of shear walls with a ratio length / height smaller than ½. The shear capacity of such a shear wall can be obtained by multiplying the reference value of 14.59 kN/m by 0.6, which gives a shear capacity of 8.754kN/m.

Considering the fact the walls of the analysed structure are sheeted on both sides, the shear capacity is doubled, becoming P_{calc} = 17.51 kN/m.

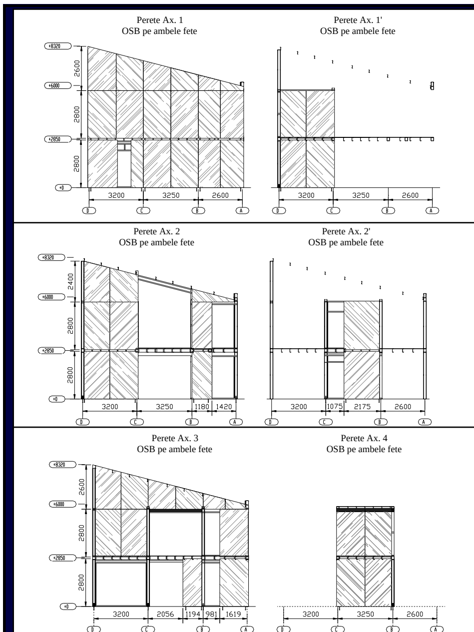
The length of walls necessary to provide the shear capacity results as:

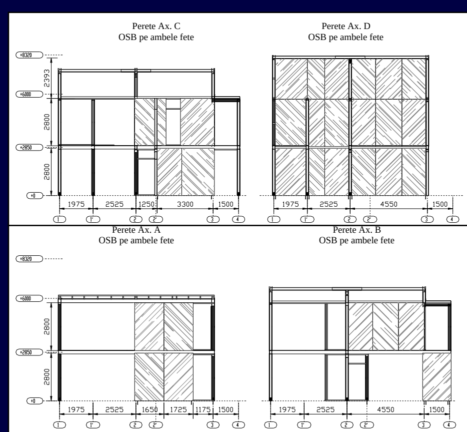
$$L_{\text{ground floor}} = \frac{T_{\text{ground floor}}}{P_{\text{calc}}} = \frac{262.72}{17.51} = 15.00\text{ m} < 21.55\text{m (transversal)}$$

$$< 17.22\text{m (longitudinal)}$$

$$L_{\text{first floor}} = \frac{T_{\text{first floor}}}{P_{\text{calc}}} = \frac{142.45}{17.51} = 8.14\text{ m} < 17.12\text{m (transversal)}$$

$$< 12.42\text{m (longitudinal)}$$





Demand

L_g =15 m, L_f =8.14m

Supply

Transversal:

L_{gf} =21.55 m, L_{ff} =17.12 m

Longitudinal:

L_{gf} =17.22 m, L_{ff} =12.42 m

Conclusions

- Structural design based on tested panels confirmed;
- Besides the advantage of high quality/price ratios, both for structural performance and building physics characteristics, such a light gauge steel framed house can be considered the ideal solution for seismic zones.

Steps to apply *Prescriptive Method* on residential buildings in Turkey

To elaborate a simplified method in which the houses are designed by means of a series of abacuses, calculated based on Eurocodes, and accompanied with constructional details, information about limits of the structural solution, guidelines for fabrication and erection, to be easier to architects, builders or design offices.

Clearly defined scope
+
Conceptual design
+
Design method by abacuses
+
Construction details
+
Guidelines for fabrication and erection

Define several typologies of the houses

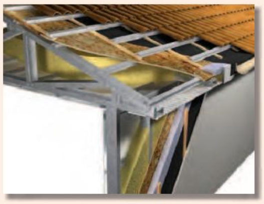
Conceptual design

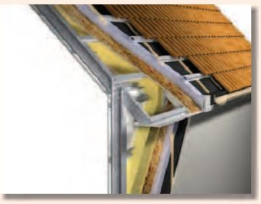
Identify the components of the structural system:

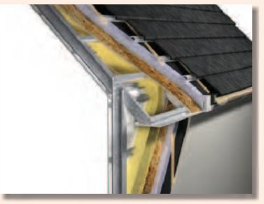
- **Roof (various solutions, i.e. flat, pitched, light, heavy)**
- **Floor (various solutions from light to heavy)**
- **Façade (plated with steel, OSB, gypsum boards etc.)**
- **Lintels**
- **Bracing system / Shear walls**
- **Studs**
- **Foundations**
- **Standardized details (particular connections)**

Define hypothesis of design / regulation frame

Characteristics of roofs with trusses with inter-axial spacing of 1,20 m







20° slope at 1,20 m

tiles	50 mm thick
battens W	30 mm thick
counter-battens 22x45	22 mm thick
snow barrier	0,2 mm thick
panel OSB 3	16 mm thick
battens	30 mm thick
filling 200 mm mineral wool	
truss	200 mm thick
horizontal channels	30 mm thick
vapour barrier	0,2 mm thick
plasterboard	12,5 mm thick

total thickness 300 mm
weight 90 kg/m²
Up < 0,21 W/m²°K
DnTw = 52 dB

45° slope at 1,20 m

tiles	50 mm thick
battens W	30 mm thick
counter-battens 22x45	22 mm thick
snow barrier	0,2 mm thick
panel OSB 3	16 mm thick
battens	30 mm thick
filling 200 mm mineral wool	
truss	200 mm thick
horizontal channels	30 mm thick
vapour barrier	0,2 mm thick
plasterboard	12,5 mm thick

total thickness 300 mm
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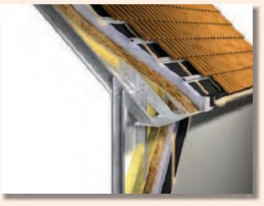
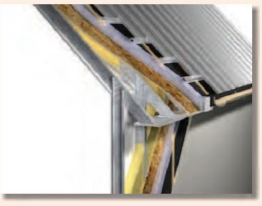
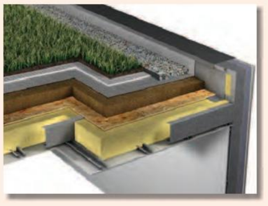
filling 200 mm mineral wool	
truss	200 mm thick
horizontal channels	30 mm thick
vapour barrier	0,2 mm thick
plasterboard	12,5 mm thick

total thickness 300 mm
weight 90 kg/m²
Up < 0,21 W/m²°K
DnTw = 52 dB

Characteristics of roofs with joists with inter-axial spacing of 0,60 m







45° slope at 0,60 m

tiles	50 mm thick
battens W	30 mm thick
counter-battens 22x45	22 mm thick
snow barrier	0,2 mm thick
panel OSB 3	16 mm thick
filling 200 mm mineral wool	
frame joist	200 mm thick
horizontal channels	30 mm thick
vapour barrier	0,2 mm thick
plasterboard	12,5 mm thick

total thickness 300 mm
weight 90 kg/m²
Up < 0,19 W/m²°K
DnTw = 52 dB

45° slope at 0,60 m

tiles	50 mm thick
battens W	30 mm thick
counter-battens 22x45	22 mm thick
snow barrier	0,2 mm thick
panel OSB 3	16 mm thick
filling 200 mm mineral wool	
frame joist	200 mm thick
horizontal channels	30 mm thick
vapour barrier	0,2 mm thick
plasterboard	12,5 mm thick

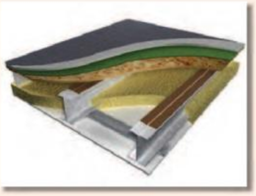
total thickness 300 mm
weight 90 kg/m²
Up < 0,19 W/m²°K
DnTw = 52 dB

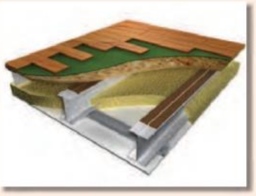
3% terrace at 0.60 m

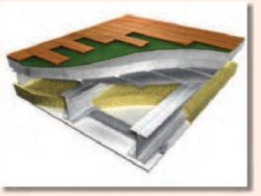
drainage protection	55 mm thick*
multilayer	20 mm thick
rigid insulation	70 mm thick
vapour barrier	0,2 mm thick
panel OSB 3	16 mm thick
filling 200 mm mineral wool	
frame joist	200 mm thick
horizontal channels	30 mm thick
vapour barrier	0,2 mm thick
plasterboard	12,5 mm thick

total thickness 430 mm
weight 150 kg/m²
Up < 0,19 W/m²°K
DnTw = 52 dB
*gravels and/or vegetalisation

Characteristics of floors with joists with inter-axial spacing of 0,60 m







Fitted carpet/vinyl

thin coating	5 mm thick
dry screed	20 mm thick
resilient	7 mm thick
panel OSB 3	16 mm thick
thin resilient	8 mm thick
filling 100 mm mineral wool	
floor joists	200 mm thick
horizontal channels	30 mm thick
plasterboard	12,5 mm thick

total thickness 300 mm
Weight < 70 kg/m²
Up = 0,19 W/m²°K
DnTw > 58 dB
LnTw = 56 dB

Floating wood flooring*

solid wood cladding	4 mm thick
particle support	10 mm thick
resilient	7 mm thick
panel OSB 3	16 mm thick
thin resilient	8 mm thick
filling 100 mm mineral wool	
floor joists	200 mm thick
horizontal channels	30 mm thick
plasterboard	12,5 mm thick

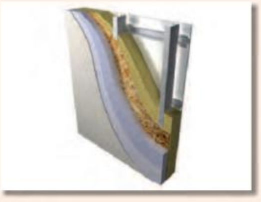
total thickness 290 mm
Weight < 70 kg/m²
Up = 0,19 W/m²°K
DnTw > 58 dB
LnTw = 56 dB

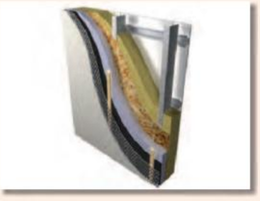
Concrete slab

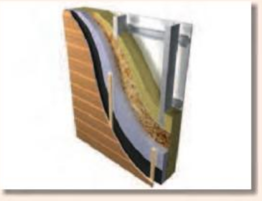
solid wood cladding	4 mm thick*
particle support	10 mm thick
resilient	7 mm thick
concrete filling	57 mm thick
profiled steel sheet	
filling 100 mm mineral wool	
floor joists	200 mm thick
horizontal channels	30 mm thick
plasterboard	12,5 mm thick

total thickness 320 mm
Weight 130 kg/m²
Up = 0,19 W/m²°K
DnTw > 58 dB
LnTw = 56 dB

Characteristics of walls, studs with inter-axial spacing of 0,60 m







Thin coating

thin plaster	5 mm thick
glued glass wall	2 mm thick
exterior insulation	80 mm thick
panel OSB 3 min.	9 mm thick
filling 150 mm mineral wool	
load-bearing studs	120 mm thick
horizontal channels	30 mm thick
Vapour barrier	0,2 mm
plasterboard	12,5 mm thick

total thickness 270 mm
Weight 50 kg/m²
Up < 0,25 W/m²°K
Rw > 58 dB
CF > 30 min

Cement coating

thin coating	15 mm thick
Metal lath	8 mm thick
cleats & air space	22 mm thick
exterior insulation	80 mm thick
panel OSB 3 min.	9 mm thick
filling 150 mm mineral wool	
load-bearing studs	120 mm thick
horizontal channels	30 mm thick
VP+ plasterboard	12,5 mm thick

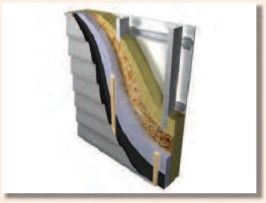
total thickness 310mm
Weight 50 kg/m²
Up < 0,22 W/m²°K
Rw > 58 dB
CF > 30 min

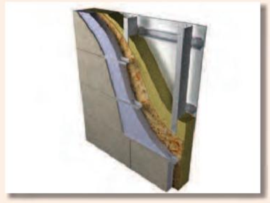
Wood clapboards

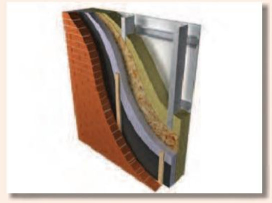
wood clapboard	25 mm thick*
cleats & air space	22 mm thick
exterior insulation	80 mm thick
panel OSB 3 min.	9 mm thick
filling 150 mm mineral wool	
load-bearing stud	120 mm thick
horizontal channels	30 mm thick
vapour barrier	0,2 mm thick
plasterboard	12,5 mm thick

total thickness 310mm
Weight 50 kg/m²
Up < 0,20 W/m²°K
Rw > 58 dB
CF > 30 min

Characteristics of walls, studs with inter-axial spacing of 0,60 m







Metal cladding

metal cladding	25 mm thick
cleats & air space	22 mm thick
exterior insulation	80 mm thick
panel OSB 3 min.	9 mm thick
filling 150 mm mineral wool	
load-bearing studs	120 mm thick
horizontal channels	30 mm thick
Vapour barrier	0,2 mm
plasterboard	12,5 mm thick

total thickness 270 mm
Weight 50 kg/m²
Up < 0,25 W/m²°K
Rw > 58 dB
CF > 30 min

Attached stone

stone coating	30 mm thick
air space	22 mm thick
exterior insulation	80 mm thick
panel OSB 3 min.	9 mm thick
filling 150 mm mineral wool	
load-bearing studs	120 mm thick
horizontal channels	30 mm thick
Vapour barrier	0,2 mm
plasterboard	12,5 mm thick

total thickness 310mm
Weight 50 kg/m²
Up < 0,22 W/m²°K
Rw > 58 dB
CF > 30 min

Brick wall

stone coating	110 mm thick*
air space	22 mm thick
exterior insulation	80 mm thick
panel OSB 3 min.	9 mm thick
filling 150 mm mineral wool	
load-bearing stud	120 mm thick
horizontal channels	30 mm thick
Vapour barrier	0,2 mm thick
plasterboard	12,5 mm thick

total thickness 310mm
Weight 50 kg/m²
Up < 0,20 W/m²°K
Rw > 58 dB
CF > 30 min

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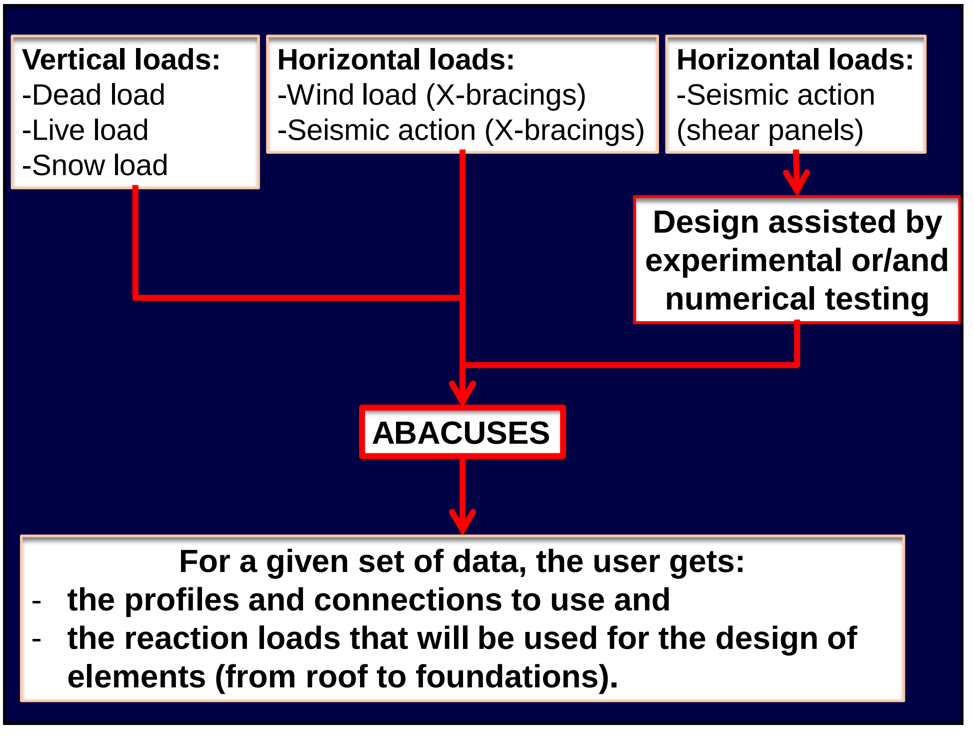
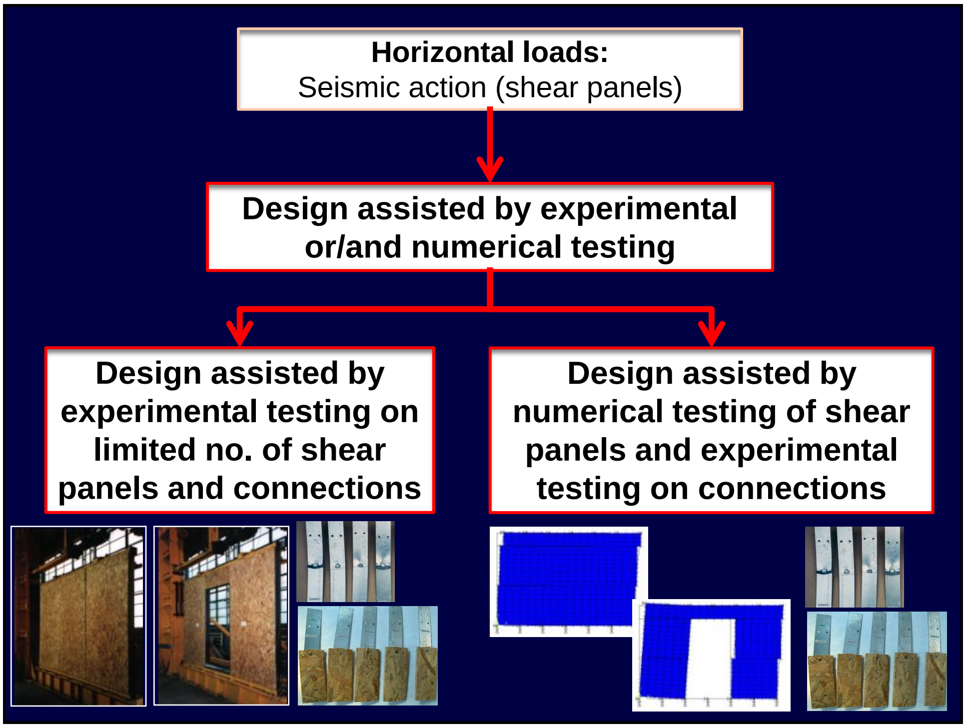
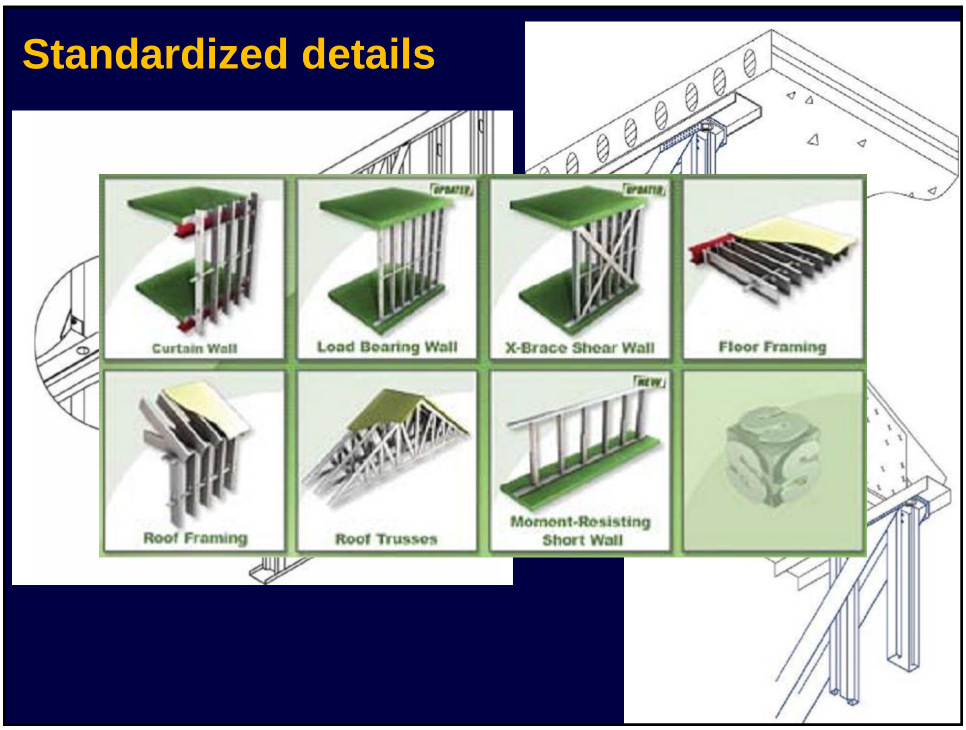
EN1991-1-7 (2006). *Eurocode 1: Actions on structures - Part 1-7: General actions - Accidental actions*. ECS, Brussels, Belgium.

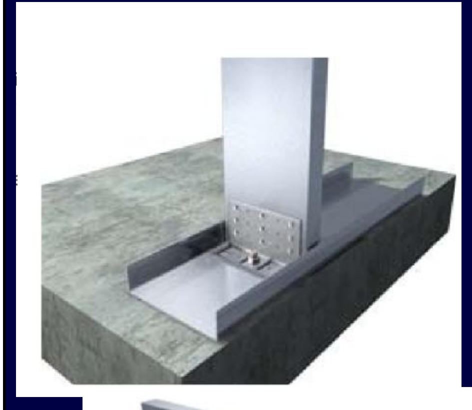
Load parameters:
- -Dead load
- -Live load
- -Snow load
- -Wind load
- -Seismic action




Horizontal loads:
Seismic action (shear panels)
Design assisted by experimental or/and numerical testing
Design assisted by experimental testing on limited no. of shear panels and connections
Design assisted by numerical testing of shear panels and experimental testing on connections


Standardized details
Curtain Wall
Load Bearing Wall
X-Brace Shear Wall
Floor Framing
Roof Framing
Roof Trusses
Moment-Resisting Short Wall

Standardized details



Conclusions. Recommendations

- Cold-formed steel framed houses have to be designed as low dissipative structures
- Light gauge steel framed house can be considered the ideal solution for seismic zones
- Prescriptive method design (abacuses):
  - Roof
  - Floor
  - Façade
  - Lintels
  - Bracing system / shear walls
  - Studs
  - Foundations
  - Standardized details (elements and joints)

Conclusions. Recommendations

- Pre-calibrated wall-stud shear panel units using:
  - numerical or experimental tests for all-steel solutions;
  - experimental tests for composite solutions (OSB-steel, GB-steel etc.);
  - calibrated models based on experimental tests for connections always .
- A simple but complete method;
- Efficient method, saving time and money