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TECHNICAL NOTICE STRUCTURE

CHATEAU

Reconstruction on metallic structure

Feasibility study

Réf : SC_ REBC_ STR-NDC_ 0		
0	30/11/2021	

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1. Introduction

1.1 Purpose of the document

This notice is written within the framework of the reconstruction project of a **chateau** dating from the 19th century. The mission entrusted to us is to carry out a structural feasibility study in order to propose a reconstruction solution based on a metallic structure. As the location of the building is not known, the study is conducted according to the French standards in force.

This notice includes :

- The definition of the design assumptions,
- The dimensioning and the general design of the metallic structure,
- The principle of the constructional system of the walls and floors.

It is completed by the reference plan book SC_REBC_PLN-ind0.

1.2 Documents provided

The massing, elevation and section plans under development have been made available (Plans in Process - AutoCAD-20210906T150209Z-001).

1.3 Description of the original building

The building is a neoclassical castle dating from the 19th century, originating in the Bordeaux region.

It is a stone masonry construction composed of a main body of 3 levels (basement, ground floor and one floor) and two lateral extensions of 2 levels (basement and ground floor). The whole was covered with accessible roof terraces. The facades have large openings, and the presence of pediments.

Original state before dismantling

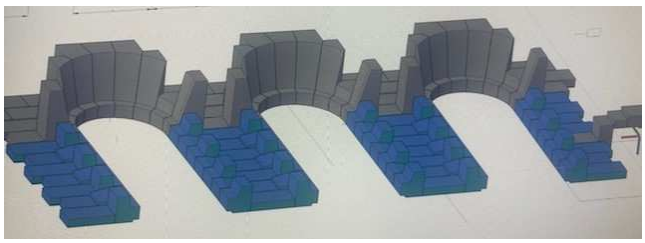
The walls consisted of an exterior facing of ashlar and an interior masonry of rubble with bands and quoins. The interior structure probably consisted of stone masonry walls and wooden floors.

The castle was dismantled 33 years ago and the ashlars of the facades were preserved, referenced and stored.

1.4 Description of the project

The project foresees the reconstruction of the **chateau** by reusing the stones of the preserved facades. A metallic structure will ensure the interior distribution of the floors and the stability of the facades. The underground part of the building will be made of concrete walls and posts that will take up the loads of the metallic structure. A waterproofing and insulation complex will be provided in the thickness of the walls and floors.

Storage of the blocks



Example of the preserved facing (@Planète Pierre)

2. Design assumptions

The study is conducted according to the characteristics of the land and the current French standards.

2.1 Regulatory framework

- Regulations NF EN 1990 : Structural Eurocodes – Basis of structural design ;
  - NF EN 1991 : Eurocode 1 – Actions on structures ;
  - NF EN 1993 : Eurocode 3 – Metal structures;
  - NF EN 1996 : Eurocode 6 – Design of masonry structures ;
- Professional rules in force

2.2 Materials

2.2.1 S235 steel

- f_y = 235 MPa
- f_u = 335 MPa
- E = 210000 MPA

2.2.2 Characteristics of the masonry

- Stone :
  - Density = 2200 kg/m^3

2.3 Climatic actions

- Wind W :

The wind actions are those resulting from the application of the NF EN 1991-1-4 standard.

The reconstruction is considered located in region 3 with a reference wind speed **$V_{b,0}$ = 26 m/s**. in terrain category **II.**

Roughness II (open country)

- Snow S :

The characteristic value of the snow load is estimated at à S_k = 0.45 kN/m^2

2.4 Geotechnics

2.4.1 Seismicity

The project site is classified in seismicity zone 1: very low.

2.4.2 Bearing capacity of the soil

The bearing capacity is estimated at an average value of 1 bar.

2.5 Load assumptions

	Permanent loads G	Operating loads Q
Floor	200 daN/m²	250 daN/m²
Flat roof	350 daN/m²	250 daN/m²
Ceiling, suspended loads	50 daN/m²	
Partitioning, coverings	50 daN/m²	
insulation/waterproofing	50 daN/m²	
Surface mass of the stone (estimation)	600 daN/m²	

Note: The average wall thickness is considered to be 9.84 in.

2.6 Combinations of actions

- Ultimate limit states of resistance (ULS) :

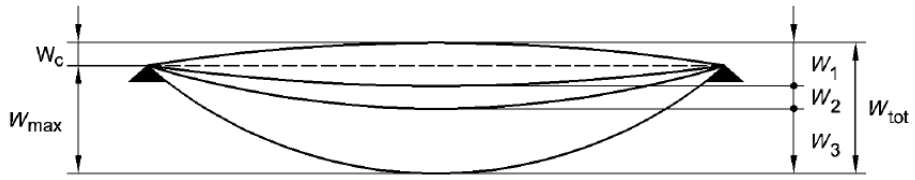
  1.35*G + 1.5*Q
  1.35*G + 1.5*Q + 0.75*S + 0.9*W
  1.35*G + 1.05*Q + 1.5*S + 0.9*W
  1.35*G + 1.05*Q + 0.75*S + 1.5*W

- Serviceability Limit States (SLS) :

  1*G + 1*Q
  1*G + 1*Q + 0.5*S + 0.6*W
  1*G + 0.7*Q + 1*S + 0.6*W
  1*G + 0.7*Q + 0.5*S + 1*W

2.7 Limitations of deflections of steel sections

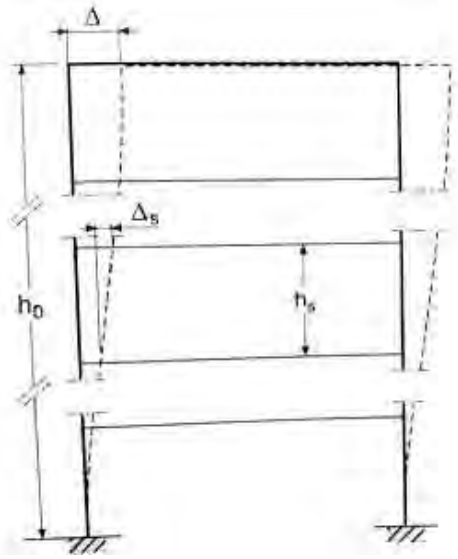
2.7.1 Limits of vertical deflections



Final deflection :
w_{max} = L/250

Deflection due to live loads :
w_3 = L/350

2.7.2 Limits of horizontal displacements



Structures of multi-storey buildings

$$\Delta \leq \frac{h_0}{300}$$

$$\Delta_s \leq \frac{h_s}{250}$$

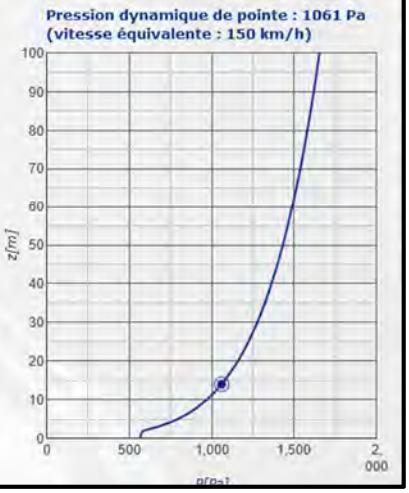
3. Technical study of the structure

3.1 Determination of wind forces

Data		
Total height z	14	m
Length	40	m
Width	13.5	m
e	28	m
Region	3	
Terrain category	II	
	z_0 = 0,05 m z_{min} = 2 m $z_{0,II}$ = 0,05 m	
Air density	1.225	kg/m²
Reference wind speed V_b	**26**	**m/s**
Peak dynamic pressure $q_p(z)$	**106**	**daN/m²**

Hauteur : 14 mètres

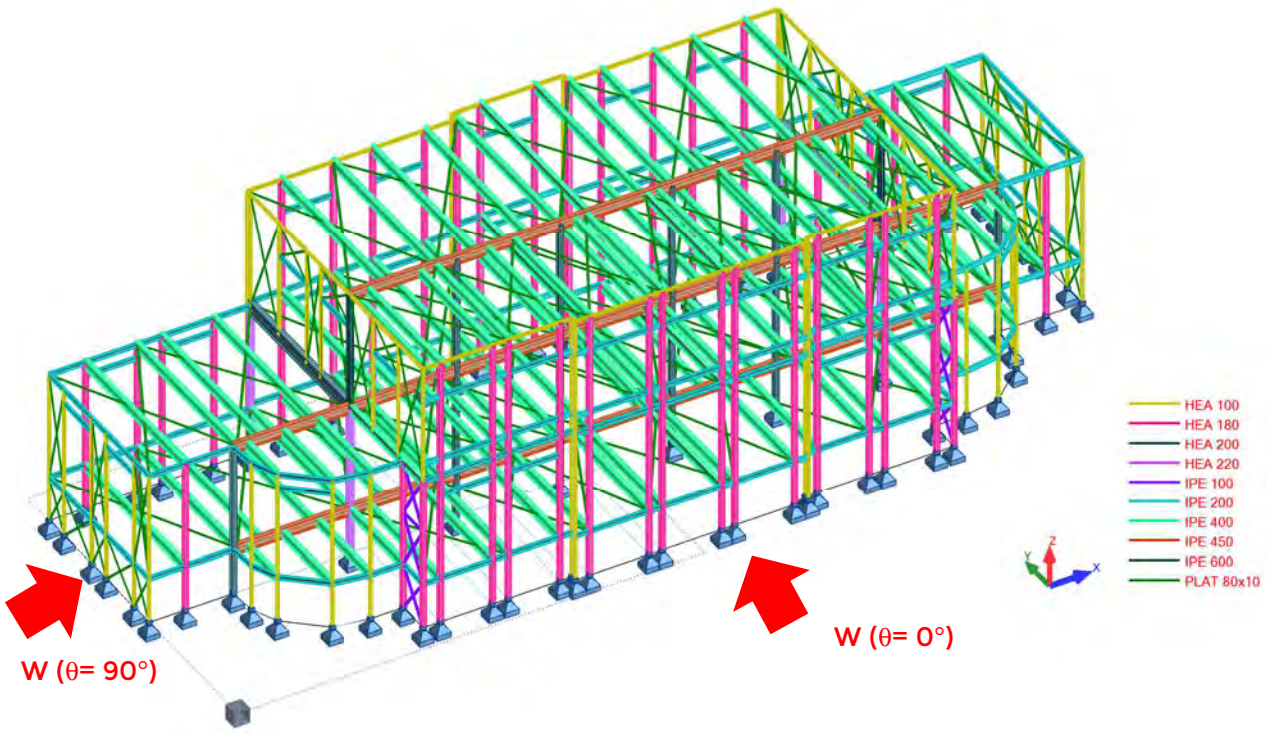
La clause **4.3.3**(2) est respectée : le terrain est plat (c_0 = 1).



			Upwind *(en daN/m²)*	Downwind *(en daN/m²)*	Perpendicular *(en daN/m²)*	Roof *(en daN/m²)*
θ=0°	Depression C_{pi}=	-0.3	138	-21	-71	-60
	Overpressure C_{pi}=	0.2	85	-74	-124	-115
θ=90°	Depression C_{pi}=	-0.3	138	-21	-35	37
	Overpressure C_{pi}=	0.2	85	-74	-88	-64

3.2 Dimensioning of the structure

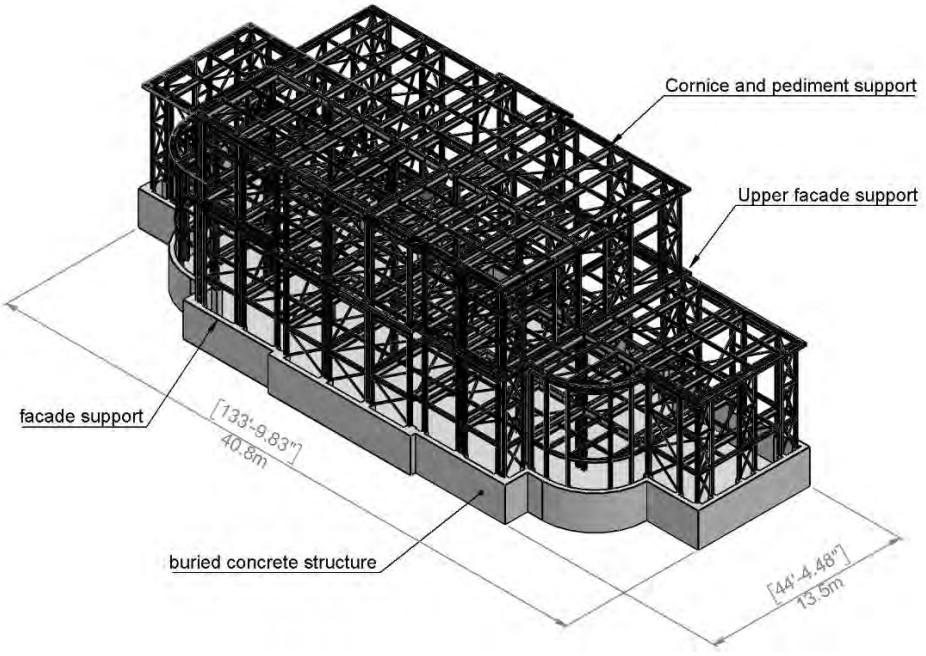
The design of the structure was carried out with the help of the finite element software Robot Structural Analysis based on the above design assumptions.



Calculation model

4. Design of the structure

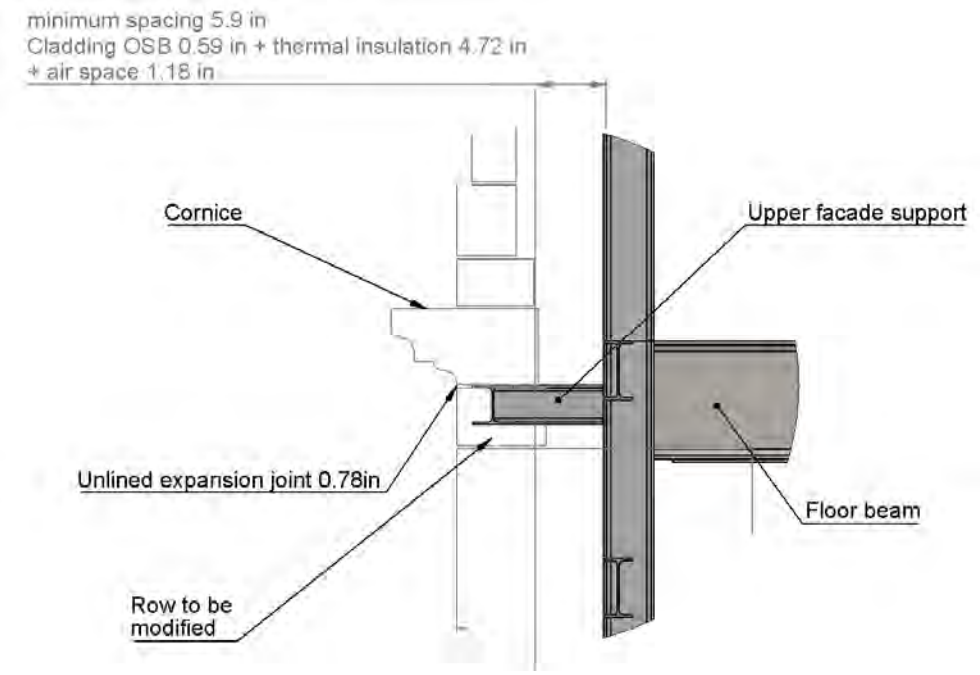
4.1 General principle



The structure of the building is composed of :

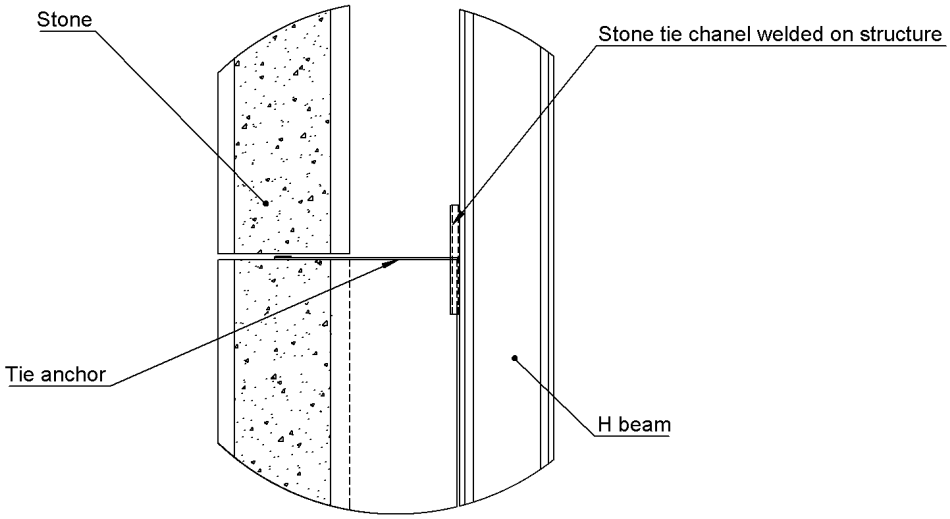
- a buried concrete structure serving as a foundation that will also take the loads of the facade walls of the ground floor
- a metallic structure made of posts and beams with H-shaped sections which will carry the upper facades and will ensure the stability of the building and the distribution of the floors.

Peripheral brackets will take the loads at the level of the floors of the second floor and the roof terrace under the cornices. The lower row will have to be modified to insert metal beams.
All the other original ashlars will not need to be modified. We recommend only that the long length of the keystones be cut back for the round-headed openings.



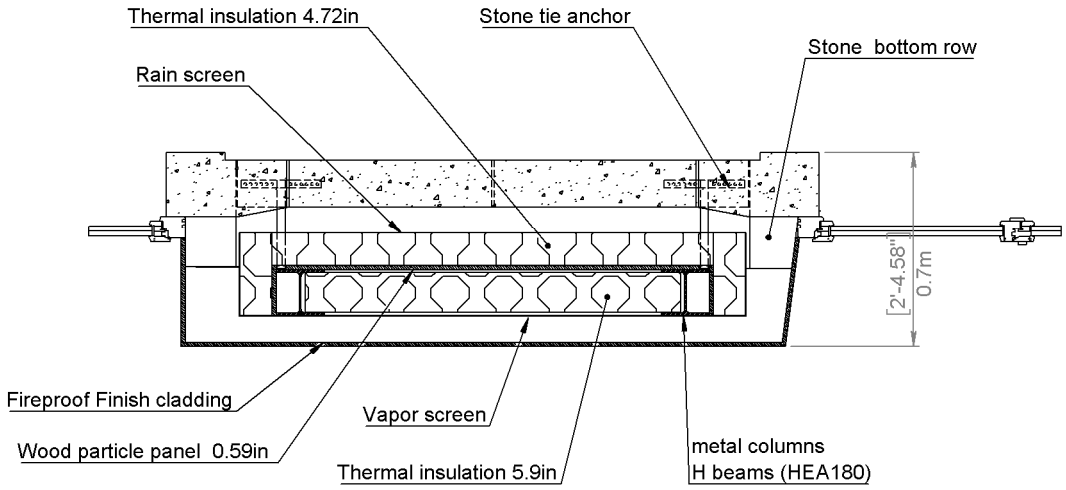
Detail of the cornice support

The lateral holding of the facade stones is ensured by adjustable metal anchors with rails welded on the metal posts at each joint.



4.2 Facade wall complex

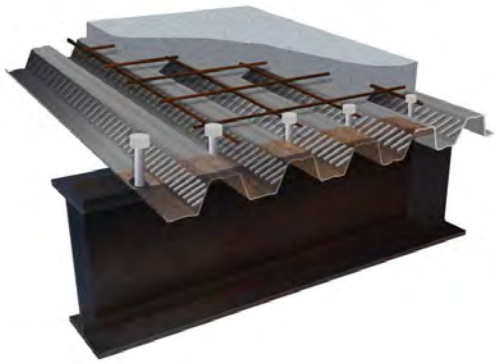
The walls are made of an insulation and waterproofing complex and allow the passage of domestic networks and pipes.

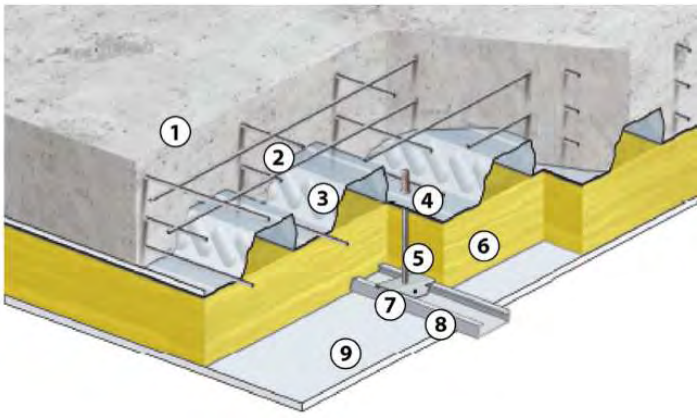


Section of facade wall

4.3 Floors

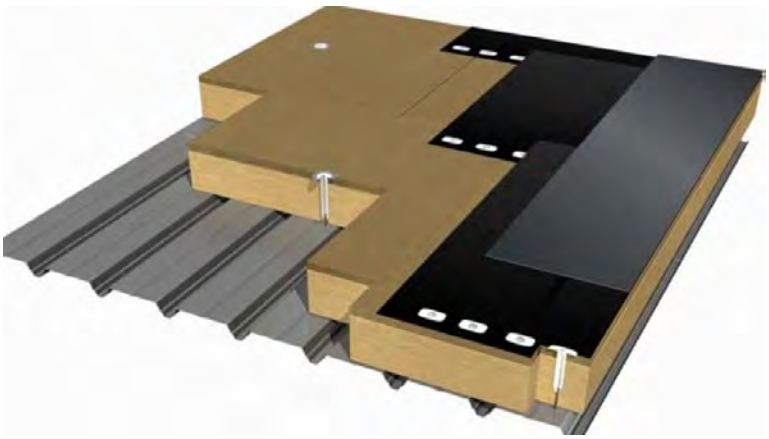
The horizontal structures are composed of collaborative floors in metal and concrete. The roof terrace includes an insulation and waterproofing complex.





1 - Concrete slab
2 - Welded mesh
3 - Collaborative formwork
6 - Insulation
8 - Rail
9 - Plasterboard

Example of a collaborative floor



Example of an insulated flat roof

5. Conclusion

The objective of this study was to verify the feasibility of the project of reconstruction of the building on a metallic structure. It can be modified according to a new distribution of the interior spaces.

It was conducted according to the French standards in force. Additional studies must be carried out according to the specificities of the planned location, including climatic, seismic and soil characteristics.

It is completed by reference plan book SC_REBC_PLN-ind0.