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Rehabilitation at Hondarribia Castle, in Hondarribia, Guipuzcoa.

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1. Introduction

The castle, nowadays used as a hotel, houses the Tourism "Parador" (State-owned hotel) "Emperador Carlos V", which belongs to the State-Owned Hotel Network.

Founded in the 11th century by Sancho Abarca, it has been declared a National Historic-Artistic Monument and it is set in the old part -walled enclosure- of Hondarribia.

After various extensions and reforms, the last intervention took place between 1990 and 1993, in accordance with the Project and Rehabilitation Works carried out under my direction.

2. Brief summary of the history of the Castle

Attributed to Sancho Abarca, King of Navarra, the following works have been on record since 1194 with the extension carried out by Sancho el Fuerte, which continued with the Catholic Monarchs, who reinforeced and enlarged the fabric of the walled enclosure. Later, Emperor Carlos V ordered the construction of the Palace, and the castle acquired its present appearance.

With the taking of the square by the French in 1794, a demolition process began which, fortunately, was brought to a halt by the signing of the Paz de Basilea (Basilia Peace Agreement).

The advance of military technology led to the castle falling into disuse. In 1886, it passed into private hands, then in 1929 into the hands of the Town Council, before being handed over to the State Hotel Network in 1968 for its first rehabilitation and subsequent use as a hotel. The second and current rehabilitation is the subject of this conference.

3. The building as a whole

Two parts which are completely differentiated in form and time, make up the whole:

The Fortress (W) and the Palace, with three wings (N.E and S) (the latter in ruins), which closes off the central courtyard.

The Fortress' walls and vaults are made of granite ashlar and the rest is made of limestone rubblework.

In the 1968 intervention, new floors were organized, based on prestressed joists and lightened arches, 12 rooms and their ensuite facilities being added.

4. The 1990 rehabilitation project

The number of rooms with their corresponding facilities and installations rose to 36 and a floor was erected above the N and E wings of the Palace. The structural elements affected were reinforced, the courtyard was closed off with a skylight, and an area (E) housing the new machine rooms and a skylight closing off the courtyard was added.

5. State of Conservation

In general, the masonry was in good condition, (and even where there existed serious cracks, these were caused by old differential settlings), given that this is a building with very rigid areas (walls), the foundations of which are laid on heterogeneous land (there is a large marble lentil (W) below the Plaza de Armas which runs under the centre and sides of the building, alternating with clayey strata and broken rock).

At any rate, the construction "adapted" itself to the existing geotechnical conditions and this, together with the great thickness of the walls (up to 3 metres), guaranteed its stability.

Heyman's affirmation proved once again correct: "The masonry structure is, essentially, extremely stable".

This was not the case with the "new" floors which, once uncovered by dismantling floorings, partition walls and false ceilings, revealed various kinds of damage which made it necessary to carry out a thorough pathological study for the purpose of verifying the seriousness the for mention damage.

There were other defects of lesser importance which lack of space prevents us from dealing with today.

6. Pathological Study

This referred to the following:

6.1. Inspection of the building.
6.2. Analysis of materials.
6.3. Theoretical resistance checks.
6.4. Conclusions and recommendations.
6.5. Proposed courses of action.

6.1. Inspection:

Although the investigation was general in nature, we will focus on the confirmation of structural damage (walls, vaults, floors and main joists)

6.1.1. Walls.
Artillery grenade blows (not important given the great thickness of the walls) and stabilized cracks.

6.1.2. Vaults.
Stabilized cracks.

6.1.3. Floors.
Lack of compression layer and losses (not widespread) of covering on lower face with presence of corrosion in prestressed cables.

6.1.4. Main joists.
Electrochemical corrosion (welts and craters) with loss of thicknesses.

6.2. Analysis:

Objective and results.

6.2.1. Conglutinators.
Determination, of the nature and condition of the components, by means of X-ray diffraction with the following results:

- Concrete of joists: very rich in cement with presence of carbonatation, particularly severe in areas of support and gutter pipes.
- Mortars: made of lime with carbonated Portland base (harder) with low presence of "strignite" (expansive element), therefore not dangerous.

6.2.2. Steels.
Determination of chemical composition and identification of resistance by means of traction and hardness tests, and measuring of thicknesses with DM2 ultrasonic apparatus, with the following results:

- Profiles: A.37 steel, weldable with oxidations and up to 10.5% loss of thicknesses.
- Reinforcements: AH.1770, and depassivation in certain cases.

6.2.3. Masonry.
Ashlar work: non-decomposed granite, resistance to compression = 5N/mm^2.
Rubblework: gravelly, limy boulder, resistance to compression = 0.8 N/mm^2.

6.3. Theoretical resistance checks.

6.3.1. On Floors.

The joist used was the same for the three existing spans therefore it was deflection-tested by assimilating it to a double "T" of equal section, determining prestressed strains, deformations and stresses, an extreme resisting moment of Mu = 1.134 m. T being obtained.

Then the characteristic resisting moment Mk for the doubly-supported standard joist was determined in each span for the estimated load of 605 Kg/m^2 (without compression layer) and a joist axle base of 0.55 m.

The safety coefficient S was also determined, the results being collected together in the following table:

SPAN m	Mu	Mk	S
6.05	1.134	1.520	0.75
5.50	1.134	1.260	0.90
5.85	1.134	1.420	0.80

Note that S was well below the minimum of 1.60 prescribed in the Instruction.

6.3.2. On the metallic main joists in the courtyard vestibule.

The profile used was IPN 300, and once the section had been checked, as for the doubly-supported beam, for the existing conditions, a 340 calibre was seen to be necessary.

6.3.3. On masonry.

The high working stresses determined for the stone, together with the strong wall sections, made theoretical resistance checking unnecessary.

6.4. Conclusions y Recommendations.

6.4.1. Floors.

What has been described so far meant that it was necessary to take immediate action, and the reason a collapse did not occur, (As S was below even 1.00), was due to the fact that fortunately, all the actions envisaged by the Instruction had not presented themselves simultaneously.

It was therefore concluded that the problem concerning the degradation of the floors was much more serious.

6.4.2. Main joists in the courtyard vestibule.

The problem detected (corrosions, losses of thickness and the insufficiency of sections) required urgent intervention, as above.

6.4.3. Masonry.

Its general good health had to be consolidated by means of cleaning operations.

6.5. Proposed courses of action.

6.5.1. Strengthening of floors (see Illustration 1).

At first, the idea was to get rid of the existing floors, without dismantling them, and to use them as the lost formwork of a new one, meshed and supported by edged joists which in turn would be supported by short brackets clamped to the strong walls every 5 metres.

However, the advantage of having a new, correctly calculated and controlled floor was outweighed by the disadvantages, namely the high cost, the variation in levels, the loss of clear heights, etc., and therefore it was decided to use the existing floors, after cleaning them (cleaning and protection of framework and restoration of coverings with cement without contraction) and subsequent reinforcement.

This operation was based on the standard joist and it was determined that bearing distance L would be capable of coping with the existing load conditions.

Mu being: Mk = S and the figures being:

Mu = 1.134.

MK= $(705 \times 0.55 \times L^2) : 8$ m.T.

S = 1.60.

L = 3,82 m (1) was obtained.

As the floor bearing distances were greater, the spans had to be divided into two, meaning that the admissible (1) was never exceeded.

The solution found would consist in arranging cross joists (parallel to the floor direction) in IPN 330 profiles, supported by vaulted niches made in the walls every 5 metres and by a continuous longitudinal IPN 300 header beam which would prop up, in the centre, the floor joists.

Finally, in order to cover the negative resisting moment (very low, it should be said) in the central support area, it was necessary only to reinforce the new compression layer (8 cm. thick and 15 x 15 cm^2 mesh with diameter 10).

An epoxy solution applied to the upper wing of the joists ensured adhesion, preventing longitudinal shears.

Another system of reinforcement was necessary in the floors (in the fortress) which were decorated, on their lower side, with ("fastened") multicoloured wooden joists.

A solution was then found from the lower side by means of a mixed system based on IPN 200 joists (of the same height as that of the floors), inserted every 2.50 metres in the spaces between the floor mouldings which were concreted to a skin reinforcement frame, creating genuine (or encased) rat-joists. With T 80.80 connectors, and like a compression head , a 10cm. doubly reinforced steel concrete slab (20 x 20 cm^2 meshes with upper diameter of 8 and lower diameter of 10).

As in the previous case, longitudinal shears were prevented with an epoxy emulsion, whereby this double reinforcement system was completed.

6.5.2. Reinforcement of main joists in the courtyard vestibule (see Illustration 2).

The oxidations and losses described, together with the insufficiency of sections determined the following remedies:

1°.- Cleaning of profiles with descaling up to SA 2.5 (SIS), epoxy priming, rich in Zn and 25 micra chlororubber finish, all of this on the basis of the aggressive nature of the maritime climate.

2°.- The section insufficiency could be made up for by adding plates in order to reach the resistant model necessary but, as in the case of the floors, the solution opted for would involve reducing the span by dividing it, in this case, into three parts (1.30 + 3.00 + 1,30 metres).

For this purpose, a permanent prop consisting of four varnished and multicoloured wooden porticos (one for each main joist) was made, fastened to the walls by means of short brackets and inserted footings.

The clear height of the enclosure was 7.60 m. which allowed plenty of room for the planned assembly.

A false ceiling (whose chamber housed the horizontal network for the disposal of waste from the bathrooms of the four new bedrooms) was crossed by the spindles which would determine the intermediate supports in each main joist.

6.5.3. Cleaning of masonry.

As well as the dirt accumulated over the years, the masonry work also revealed diverse and inadequate fillings, diverse vegetation, etc.

The treatment therefore would involve initially the removal of these blemishes, followed by the general cleaning of surfaces and facings, both inside and outside, with a low-pressure hot water spray.

7. The glazed enclosure of the courtyard
(see Illustration 3)

New work within the General Rehabilitation:

The Castle, with its robust walls and small recesses, creates a powerful sensation of quiet seclusion, in accordance with its austere character, but this, together with the wet and foggy climate of the Basque Country, lends it an atmosphere which is as melancholic as it is sombre.

The halls are large yet dark, and due to the climate, the use of the courtyard, the only open space, was restricted to the merely visual (although it should be said that it affords both a relaxing and romantic contemplation of the old ruin, shields, stelas, etc.), and its new use as a hotel meant that the Castle lacked a sizeable and bright meeting place and a space for relaxation.

In order to make up for this deficiency, it was only possible to cover the courtyard, and for this purpose a light, glazed structure was designed which would not only facilitate active use of the courtyard but also fit in with the surrounding architecture as a whole.

In formal terms, the solution would consist of a square-based glazed pyramid pavilion (11 x 11 m^2) with a gradient of 30 % (1.65 m. high).

It would be a helm roof, but it would have to satisfy a special requirement: it should not bear out-thrusts for reasons which are outlined below.

The four sides of the courtyard which would support the structure were made up of wall W, of great thickness, and therefore easily capable of bearing out-thrusts; the newly-built N and S walls had been erected with the minimum thickness for guaranteeing both thermic insulation and the loads of the roof slab, but were incapable of bearing horizontal loads. And the 4th side, due to there not being a wall, consisted of a very thick and smooth beam, in order to save the existing bearing distance, which made it incompatible with the twisting stress which the pressures of a traditional helm roof would generate.

In order to resolve this problem, a stacking or juxtaposition structure was designed, which apparently corresponded to a conventional vault but which mechanically behaved like a vault without out-thrusts.

Starting from the idea of the Serlio floor, three homothetic rings would be arranged, superimposed in descending order of size and from top to bottom.

Each ring was made up of four glue-sealed laminated wooden beams and each one of them was propped up on one side of the courtyard at one end with the other end supporting the beam perpendicular to it.

It was thus ensured that in each support (4 per ring) only vertical reactions would be caused, the unwanted out-thrusts having therefore been avoided.

The beams in the support areas ended in a "flute mouthpiece" following the gradient of the gables, which in turn were covered with rafters on the plane and with hips on the arrises, the enclosure being achieved with glass plates reinforced with butyl sheet.

The support apparatus (genuine joints) were resolved by means of zinc-plated steel plates inserted in the web of the beams and fastened by screws; this means that the structure may be dismantled at any time, thereby guaranteeing the Principle of Reversibility.

In order to conclude, it only remains to be said that the wood used was red fir, this wood being ideal in terms of the relation between its price and mechanical characteristics.

The elements were obtained by arranging boards measuring 4 x 11 cm^2 in successive layers and with the fibres parallel to the shaft of the piece.

Finally, they were glued and protected with resorcin, resistant to both heat and damp and quite capable of handling fire and U.V.A. rays

And it was constructed as it was designed.

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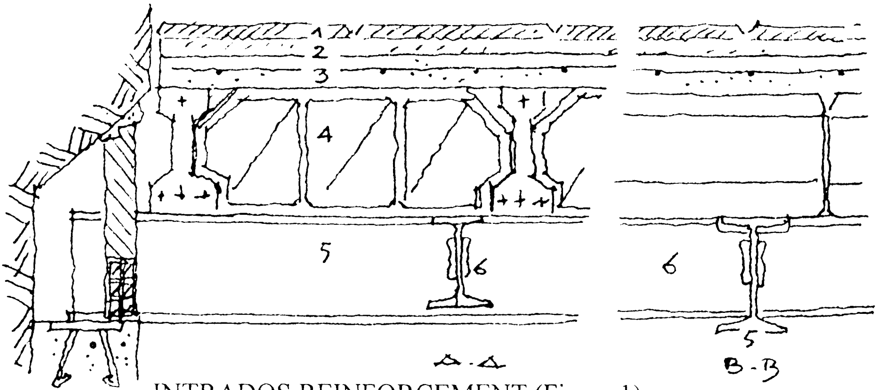
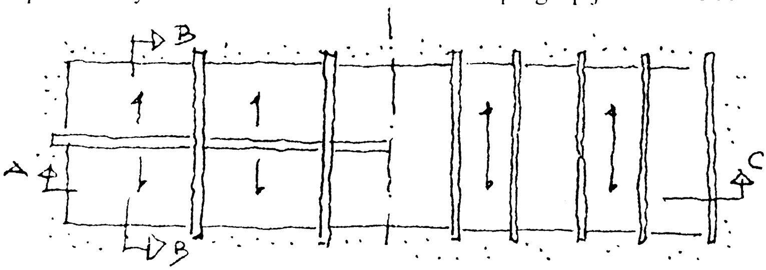


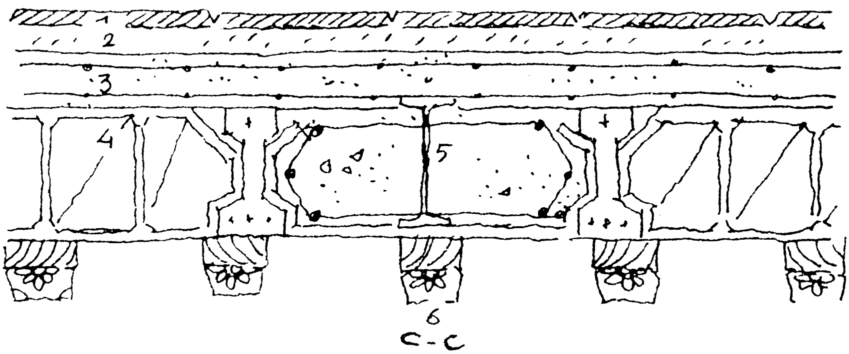
INTRADOS REINFORCEMENT (Figure 1)

1. Flooring
2. Mortar
3. Compresion layer
4. Floor
5. Cross joist IPN 330
6. Proping-up joist IPN 300



(Figure 2)

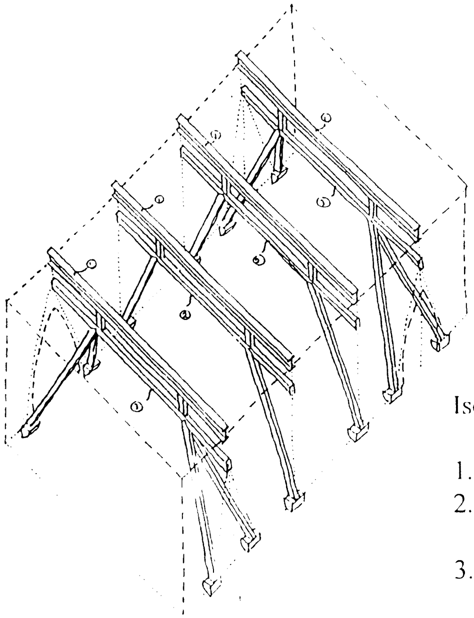
INTRADOS REINFORCEMENT EXTRADOS REINFORCEMENT



EXTRADOS REINFORCEMENT (Figure 3)

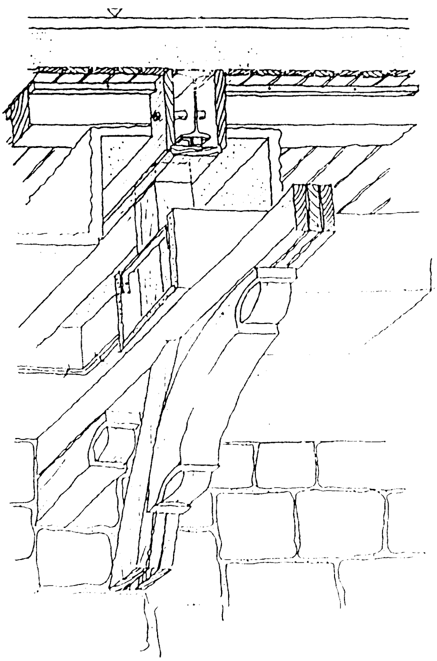
1. Flooring
2. Mortar
3. Compresion layer
4. Floor
5. IPN 200
6. Multicoloured joist

Illustration 1: Floor Reinforcement



Isometric View (Figure 4)

1. Metallic joist to unload.
2. Portico prop with simple oblique beam.
3. Id. with double oblique beam.



Detail (. 'gure 5)

Illustration 2: Main Joist Reinforcement in Vestibule

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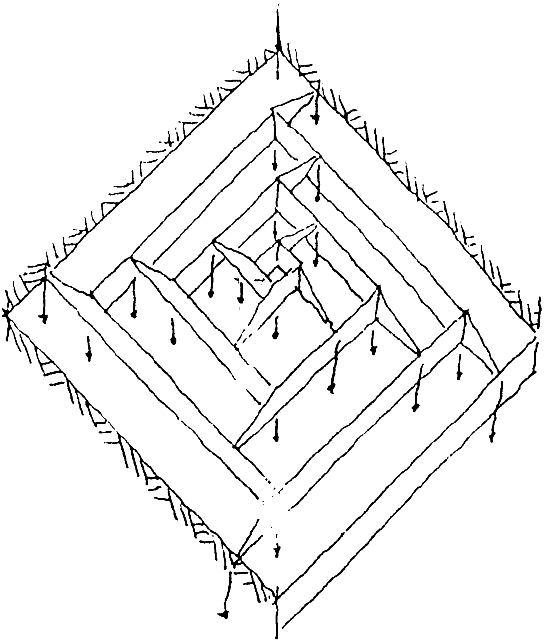
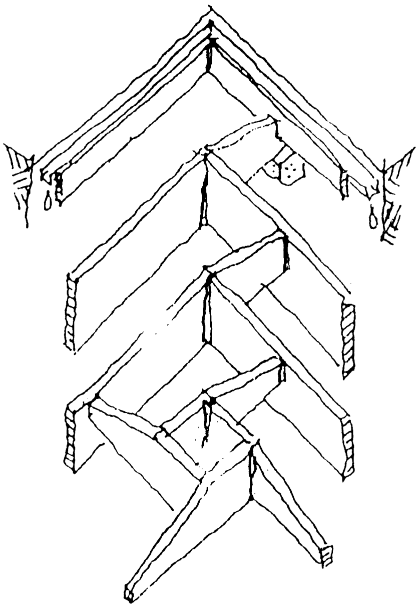


Isometric View (Figure 6)



Detail (Figure 7)

Illustration 3: Glazed enclosure of the courtyard