

DETERMINATION AND STUDY OF RESIDUAL CAPACITY IN OLD BUILDINGS: CASE STUDY OF A VERY OLD BUILDING IN RABAT - MOROCCO

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ABSTRACT: The rehabilitation of old buildings implies a change of destination and use of the building. But the change of destination involves renovation works and therefore different live and operating loads. Indeed, the purpose of this article is to determine the influencing factors on the bearing capacity of old buildings: reinforced concrete buildings (poles structure - beams) or masonry buildings (walls bearing structure and metal floor). In order to answer this issue, we will review the different diagnostic methods and study their performance and their applicability in this particular case. The example of this old building presents a case study of calculating the actual capacity of an old building in the historic center of the city of Rabat. The discussed building has structural pathologies. The aim of this study is to recalculate the building's capacity using the actual characteristics (reinforcing section, coating, concrete quality, masonry quality and the current operating loads based on the current building use) in order to determine the rate of the building's load. To identify the supporting structure of the building, we have conducted a survey of structural elements on site, which has also identified the structural pathologies. The diagnostic work, developed in this article, has confirmed the structural elements and allowed us to conclude about the bearing capacity of the structure.

Keywords: Rehabilitation, Raise of existing buildings, Overload, Reinforcement, Lining posts

1. INTRODUCTION

Over time, built heritage has undergone physical, chemical and biological mechanisms of degradation that have destroyed historical monuments and affected the main structure and its stability. The stone's mechanisms of degradation are very complex and the stone's microscopic and macroscopic heterogeneity makes the description of the degradation process very complicated. These deterioration processes are mainly due to climatic conditions: temperature variations, wind action, humidity fluctuations, frost exposure [1-5].

In recent decades, studies and research concerned with stone degradation due to aggressive climatic conditions have become more numerous in order to address the lack of information necessary for understanding the causes and mechanisms responsible for this degradation. Buildings degradation affects not only the architectural appearance, but also the bearing capacity of the building. The bearing capacity refers to the ability of a structure to support different loads [6-8].

Indeed, each material (homogeneous or heterogeneous) has a rated load capacity. The design of structural elements and their definition is based on the nominal value of the residual capacity. Over time, monuments have evolved and degraded through the combined action of the environment

and men. This change reduces the bearing capacity of the building and consequently imposes one of the two options:

- Reducing the loads on the building
- Strengthening the load bearing parts

In this document, we will value the residual capacity of a historic building to check its good performance.

2. PRESENTATION OF THE CASE STUDY

The case study focuses on one of the buildings of the first military hospital in Rabat, Morocco. This is the "Marie Feuillet" hospital built during the French colonial period in Morocco.



Fig.1 Ground plane

Figure (1) shows the ground plane of the hospital with its different buildings. The value of B2 building, called Pavilion Central, is its central location opposite the main entrance of the hospital / hotel. In addition, the art-deco style facade is considered national heritage.

The “B2” building, figure (2), built in 1917, has very advanced structural pathologies. The horizontal structural elements, beams and floors made from reinforced concrete slab, have a very advanced state of corrosion with a burst of concrete cover. The restoration of these elements seems technically very complicated and inefficient. So we decided to opt for a demolition and reconstruction of these elements.



Fig.1 Building B2

The vertical structure is constructed of bearing walls built from calcarenite bound by a cement mortar. The average thickness of these walls is 55cm.

The shear walls also have the same thickness, which hinders the definition of the new distribution of space in the new building (the hotel). So, we will keep only the facades of the building.

The new structure type is Colum /beams made of concrete. It's an independent structure from the existing façades. The purpose of this work is to verify if the conserved façade is freestanding.

3. DIAGNOSIS OF THE EXISTING STRUCTURE

To estimate the bearing capacity of the building, we will rely mainly on the results of the hammer test. The hammer test or the calculation of the rebounding index is a non-destructive testing. It's based on measuring the bounce distance of a rod following the action of the spring. In fact, a mass driven by a spring projects the striker pin in contact with the surface. This tool was originally designed to perform nondestructive tests on concrete but its field of use has rapidly expanded to include rock (Katz and al.2000, Kahraman 2001, 2007, Del Rio and al. 2006, Goudie 2006 Kahraman&Yeken 2008 Török 2008). Completion

of the test is done by using the Schmidt hammer.

The hammer is made of steel and compressed by a spring which, when released, projects a steel striker pin in contact with the concrete surface. The speed of the hammer movement produced by the spring must be consistent and reproducible. The steel hammer rebound relative to the steel striker pin must be measured on a linear scale secured to the frame of the instrument.



Fig.2The Hammer Test

The testing protocol is the NF EN 12504-2 standard. The main guidelines to follow are:

- The test surface must be prepared for the test: rough sand or resistant difficult surfaces or wet surfaces should be avoided.
- Operate the hammer at least three times before using it for a series of tests.
- Check the calibration of the tool.
- Maintain the test hammer perpendicularly in relation to the test surface to allow the stem perpendicular to strike.
- Gradually increase the pressure on the rod until the outbreak of the shock.
- The sclerometer records the index rebound
- For reliable results, try at least nine tests.
- The minimum distance between two tests and shocks is 25mm.
- Examine each footprint left on the surface and if the shock causes crush or puncture a surface area close to a vacuum, the result should not be considered.

4. TEST RESULTS

4.1 About the Hammer Test:

The sclerometer indicates the strength of a rebound mass on a hard surface. Therefore, the higher the number shown on the machine, the greater the hardness of the surface layer is important.

Correlation curves prepared on the basis of hardness tests allow the passage of rebound index to estimate the hardness. This calculation method is very convenient and provides a quick estimation of the value of hardness. However, this method has some drawbacks:

- There is no direct relationship between sclerometriques results and the strength of the element. This method provides an estimation of the surface hardness (about 3 cm of depth).
- It provides underestimated results at the presence of a hidden pore near the investigated surface.
- It gives overestimated results in the presence of a hidden pebble near the surface.
- It gives underestimated results at the presence of moisture on the surface.
- Uncertainties due to the operator, calibration, device application management (down, up, horizontal, etc.).

4.2 Adopted Protocol

On the façades of the building, we identified the most representative points to estimate the bearing capacity of the building. The following figure illustrates the sample areas.

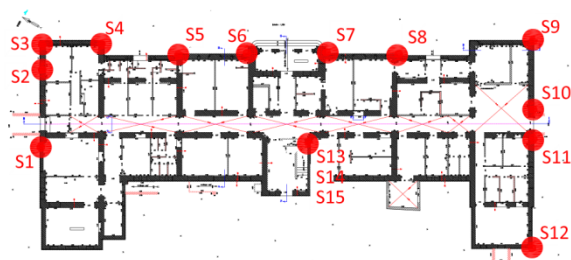


Fig.3 Testing areas

For each area, we perform several measures of hammer index. To set these points, draw a 1 meter high line from the basement/floor level. For each area, we perform several tests (9 at least). The testing points are 10cm far from each other to avoid interferences.

4.3 Expression of results:

The following table summarizes the calculation results of the rebounding index for all the testing points. Empty boxes are not considered points

The transition from the rebound index to the estimated hardness of the element is through the correlation curves of Fig.5. By using the curves of Fig.5, the correlation results are obtained and given in Table 2.

Table 1 Hammer testing results

N	Hammer testing measure												Is
S1	37	35	33	32	38	36	32	36	34	33	37	34.7	
S2	34	32	29	26	30	27	32	28	31	28	31	29.6	
S3	48	40	45	44	44	46	40	44	45	35	30	42.6	
S4	20	31	32	34	43	42	40	43	43	40	46	37.6	
S5	35	36	34	33	32	32	34	33	31	32		33.2	
S6	26	30	22	24						24		25.8	
S7	30	27	29	27	37	32	36	29	34	31	29	31.0	
S8	29	35	32	31	32	30	33	32	33	30	30	31.7	
S9	50	47	44	44	50	44	50	44	46	44	47	46.3	
S10	39	38	40	39	35	38	41	26	39	35	25	35.9	
S11	20	10	10	15	25	24	23	15	10			16.9	
S12	21	21	17	17	20	20						19.3	
S13	21	21	20	21	21	22	22					21.1	
S14	25	20	20	21	20	21	25	42				24.3	
S15	13	17	21	17	15	14	15	13	13	16	16	15.5	

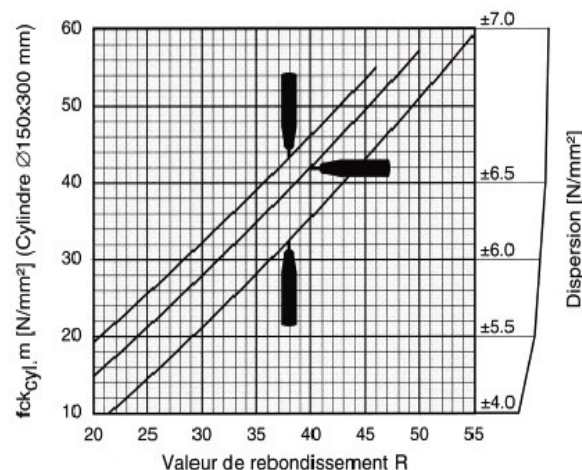


Fig.4 Correlation from rebounding index to estimated hardness

Parallel to our study of the residual capacity of the structure by calculating the rebounding index, the diagnostic laboratory has conducted a study of the compressive stress by crushing specimens. The results are shown in the Table 3.

Table 2 Correlation results

Number	Is	Rc (MPa)
S1	34.7	34
S2	29.6	28
S3	42.6	44
S4	37.6	40
S5	33.2	32
S6	25.8	22
S7	31.0	29
S8	31.7	30
S9	46.3	51
S10	35.9	35
S11	16.9	-
S12	19.3	-
S13	21.1	15
S14	24.3	20
S15	15.5	-

Table 3 Laboratory results

Number	Rc (MPa)
S1	5.4
S2	31.5
S3	3.8
S4	13.1
S5	3.2
S6	2.8
S7	8.2
S8	3.5
S9	8.4
S10	3.9
S11	17.1
S12	7.2
S13	12.3
S14	4.1
S15	11.0

5. CONCLUSION

The values of the limit constraint given by measuring the rebounding index are more reassuring than the values found in the crushing test specimens (As summarized in the previous

table). In fact, the sclerometer estimates the hardness of the element at the precise location of the test. Therefore the generalization of the results for the entire wall is equivalent to the substitution of the wall by a homogeneous rock. In other words, the calculation of the rebound index doesn't take into account the presence of the seals and the discontinuity of the rock in the calculation. In both calculations, the given measures show a good enough strength of the wall to be freestanding.

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