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BUILDING MATERIALS LIFETIME NEAR THE COAST

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Abstract- This research work is focused on the lifetime of building construction materials, near the coast. This is a historic building located near the coast. The defining characteristic of this building's renovation is its focus on longevity, boasting a lifespan exceeding 93 years. Situated in close proximity to the Adriatic Sea, it stands just 150 meters away from the shoreline. The analysis has been centered around two important approaches. One approach involved obtaining diverse samples of main construction materials like concrete, steel bars, and masonry bricks. The other approach involved non-destructive testing (NDT), specifically using a sclerometer, to derive stability parameters for the various elements. These analyses offer valuable insights into both the operational effectiveness of the facility and the resilience of the construction materials. It's clear that the longevity and performance of these materials will also depend on the ongoing maintenance efforts carried out through the facility's users over the years.

Keywords: Construction Materials, Non-Destructive Measurements, Lifespan, Durability of Materials.

1. INTRODUCTION

This research works about to outline the perfect approach for restoring the BANK Durres building. Extensive fieldwork and laboratory testing have been conducted in partnership like the "A.L.T.E.A and GEOSTUDIO 2000 ltd" laboratory. Understanding and assessing the condition of the building components of the structure will serve as foundational data for determining the most efficient reconstruction methods. Prolonging the lifespan of this building will be significantly influenced by its level of degradation, particularly considering the impact of chemical factors resulting from its proximity to the seashore, alongside other physical and atmospheric influences [1-9].

Upon assessing the on-site conditions, our research group opted to conduct a series of tests with and without demolition situated at various points throughout the structure of the building [1]. Prior to this, a visual inspection of the structure was conducted to identify critical elements warranting attention due to their physical and mechanical properties essential for further calculations by the design team.

This included key components such as main pillars located centrally within the building, primary facade columns, and segments of supporting masonry. To facilitate this assessment, the plaster covering these elements was removed to ascertain their construction type (e.g., concrete, iron, brick masonry, etc.). Subsequently, samples were extracted from the reinforced concrete elements for laboratory compression testing, followed by non-destructive sclerometer assessments. The physical and mechanical analysis has been applied on existing brick masonry [10-15].

In its entirety, the technical team exercised meticulous caution to uphold the sustainability of the facility, with particular emphasis on preserving the facade, renowned for its profound historical, social, and cultural significance. To this end, all testing procedures were conducted within the interior of the building, ensuring minimal impact on its outward appearance. Following this, surveys were extended to include the exterior facade, necessitating the removal of exterior coatings for thorough assessment. Figure 1 below illustrates a section of the eastern facade prior to the commencement of reconstruction efforts.

Figure 1. National Bank facade building, located in Durres city

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2. METHODOLOGY

2.1. Non-Destruction Test

The evaluation of concrete's compression resistance through non-destructive means, utilizing a sclerometer, stands as a widely adopted practice due to its non-invasive nature, safeguarding the structural integrity of the building. This method adheres to [16]. The process involves determining the concrete mechanical resistance by measuring the rebound force in sclerometer hammer when it strikes the concrete surface [14]. For accurate results, the concrete element under examination should possess a minimum thickness of 100 mm. Prior to testing, the surface to be assessed must be meticulously cleaned and smoothed using abrasive stone.

Furthermore, to ensure proper functioning of the device in alignment with technical specifications, initial test strokes should be conducted as per the guidelines outlined in the device's manual. When utilizing the sclerometer, it's imperative to ensure that the ambient temperature falls within the range of 10 °C to 35 °C. Any deviation from this range should be noted and included in the subsequent analysis report. The striking action of the hammer must be directed to the surface of concrete, achieved by applying pressure gradually [8-10]. The distance between the impact point and the ribs of the element should not exceed 25 mm. The sequence of impacts is also documented. Results are documented after each impact, and the test concludes once a minimum of 10 strikes per element has been reached. Subsequently, the calibration of sclerometer undergoes by following the specification of technical device.

Following the calculation of the average measurements and graphical analysis based on the impact orientation, the compressive strength value is determined [13]. Afterward, multiple structural positions were chosen for conducting sclerometer tests. After identifying the columns of interest, efforts were made to minimize damage to the building's finish during the process. Partial removal of plaster was undertaken on these columns, followed by the execution of three tests on each.

2.1.1. Compressive Strength Evaluation

In pursuit of precision, the concrete's compressive strength was further assessed through sampling and analysis using the Drop-Hammer method. This approach aligns with the guidelines outlined in the [16].

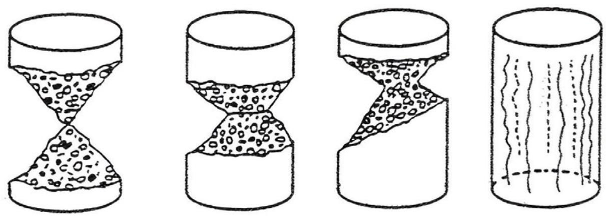

Figure 2. Normal shape destruction test

The procedure involves meticulously sampling the structures, conducting thorough examinations, preparing the samples by refining or leveling their surfaces, and subjecting them to compression tests to ascertain resistance. Beforehand, the sample is extracted perpendicular to the concrete surface, with the sampling device securely fixed in place [9, 14, 15]. The analysis report should document the destruction pattern of each sample, distinguishing between normal (N) and abnormal (A) patterns. The evaluation of the sample destruction test is conducted in accordance with the procedure depicted in Figures 2 and 3.

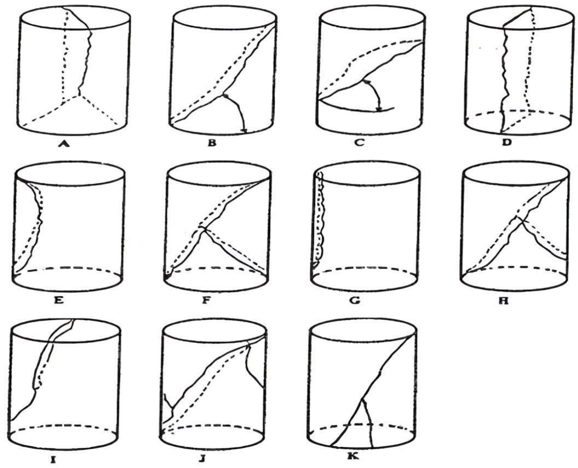

Figure 3. Abnormal shape destruction test

2.2. Pacometer Test for Determination of Steel Bars

Pacometer test has been used as non-destructive test for determination the quality of the iron bars. Furthermore, this technique enables the determination of the concrete's protective layer thickness, as well as pinpointing the location and steel bars diameter within the reinforced concrete. The steel bar depth has been recognized by using this method at 180 mm [10-15].

2.3. Pressure Resistance Determination of Masonry Sample

Masonry sample is undertaken to assess its physical and mechanical characteristics. Initially, a visual examination is conducted to identify the type of masonry and its constituent elements. Furthermore, sampling locations are carefully selected to preserve the integrity of the masonry. For brick masonry, it's possible to extract either a portion of the entire masonry unit or individual elements. The collected samples undergo laboratory preparation to facilitate the required tests. This process involves cutting and flattening the samples to the appropriate dimensions before commencing the testing procedures [10-16].

3. MEASUREMENT RESULTS

The entire building features retaining walls, with an additional feature of six columns on the basement floor adorned with tiles. The tiles have been removed from columns through the reconstruction process. Upon inspection process, it becomes apparent that the columns do not adhere to all standard specifications, as no concrete protective layer is observed. Consequently, the steel bar within the columns is exposed to the environmental conditions, leading to noticeable the corrosion signs and consequent reduction in the structure's lifespan, as depicted in Figure 4.

Figure 4. Column on the ground floor displaying visible indications of iron bar corrosion

One of these columns was chosen at random for sclerometer testing, aimed at assessing the compressive strength of concrete. The test results are shown in Figure 5. From the above results it has been seen that compressive strength correspond to the 20.0 N/mm2 and the standard deviation correspond to the value 4.8 N/mm2.

3.1. Compressive Strength Results of the Concrete

Following the extraction of concrete column samples from the ground floor, the sample results are outlined in Table 2 [9, 11]. From the various tests conducted within the building, three columns were chosen, and samples were prepared. These included two columns such as K1/1 and K1/2 at B9 axis where one comes from K2 at A9 axis. Cylindrical samples have been prepared where ratio of 1:1 correspond to height and diameter, adhering to [17].

Below are depicted various stages involved in the acquisition, preparation, and examination of cylindrical concrete samples within the laboratory (Figures 6-10).

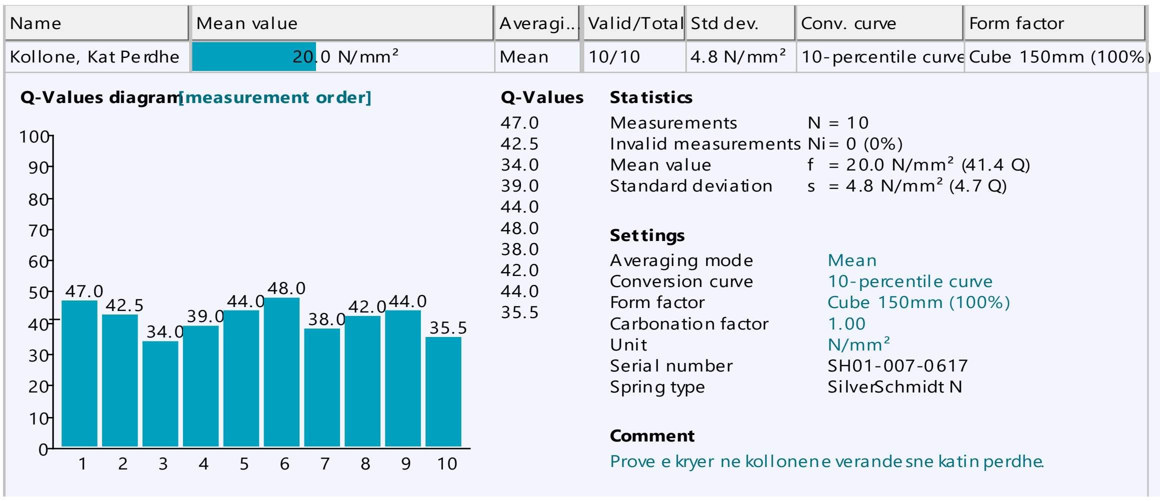

Figure 5. Column on the ground floor test results

Table 2. Test results of the concrete comparison resistance

Location Ground floor	Sample	Height (mm)	Diameter (mm)	Surface (mm^2)	Weight (g)	Volumetric weight (g/cm^3)	Load (kN)	Compression Strength (N/mm^2)
column; B9 Axis	K1/1	78.90	81.50	6430	948	2.341	144.7	22.51
	K1/2	78.90	81.50	6430	939	2.311	122.6	19.67
column; A9 Axis	K2	79.50	81.50	6479	935	2.318	138.6	21.39
column; C9 Axis	K3	79.60	81.30	6471	929	2.294	131.2	20.28

Figure 6. The procedure for extracting a sample from column K1 situated along Axis B9

Figure 7. The sampling process at K2 column on Axis A9

Figure 8. Cutting device for concrete sample preparation

Figure 9. Concrete compressive strength, K1 at B9

3.2. Mechanical Resistance of the Steel Bar

During this study we selected column K1 at the B9 axis in the basement floor and afterward the sample has been tested for mechanical resistance analysis (Figures 10 and 11) [11]. Table 3 depict the test results of the tensile strength analysis.

Through visual inspection, it is evident that the steel bars have undergone significant corrosion, primarily attributable to atmospheric conditions, exacerbated by the absence of protective concrete coating in these regions. Analysis indicates that the actual diameter of the steel bar sample measures corresponds to the values 15.44 mm, 9.55 mm and 5.57 mm. Furthermore, all the equations used in these research work for mechanical resistance of the steel bars, concrete and masonry bricks have been based on the previous research work [3, 16-18].

Figure 10. Tensile test of the steel bar sample

Table 3. Results of tensile strength of the steel bar from the building

No.	Diameter (mm)	Effective Diameter (mm)	Linear wight (kg/m)	Effective section (mm²)	Tensile strength (N/mm²)	Rupture resistance (N/mm²)	Resistance Relationship (Rm/Re)	Relative elongation (%)
K1/1	16	15.44	1.472	186.69	191.48	254.1	1.328	28.17
K1/1	10	9.55	0.892	74.813	189.42	253.2	1.344	27.69
K1/1	6	5.57	0.225	43.256	179.88	256.6	1.438	27.44

3.3. Testing of the Brick Masonry

In this study we also have assessed the physical and mechanical characteristics of the masonry components, a specimen has been extracted, comprising a complete red brick bonded with mortar (Figure 11). Subsequently, a masonry specimen was meticulously fashioned, then uniformly sliced and subjected to a compression resistance examination within a laboratory setting (Figure 12). The structure's walls are constructed entirely from such full bricks, each measuring 250×12.5×6 mm in size [19].

On both floors, particularly the first floor, there are many cracks in the masonry that you can watch easily, in the same direction with those found on the corresponding first and basement floors, close to C axis near the stairs of the building. We think that these cracks are significant, with visible brick or block breakage, suggesting possible structural decomposition as cause.

Figure 11. Masonry sample taken from wall, A9

Figure 12. Masonry samples preparation

Figure 13 depict laboratory testing of the mechanical resistance of the masonry samples that correspond to the value 9.29 N/mm^2.

Figure 13. Mansory compressive strength test

4. DISCUSSION

According to the findings, the vertical elements of the concrete floor exhibit a consistent level of compression resistance and composition. Upon visual inspection of samples extracted from within the columns, it is evident that the concrete displays strong cohesion, relatively minimal porosity, and a well-dispersed aggregate grains distribution throughout its structure. In areas where the concrete protective layer has been compromised the steel bars have undergone significant corrosion-induced damage, leading to a reduction in their effective diameter.

Additional reinforcement measures will be implemented as necessary to address these damages. Should reinforcement of the current structure be required, thorough cleaning of the structure, especially of fragile removable components, is crucial beforehand. All vertical support structures must undergo plastering to assess the need for further reinforcement measures. Prior to applying resin with b/a, the exposed surface of steel bars should be meticulously cleaned of rust to ensure optimal bonding between existing steel bars and concrete and new concrete. The design engineer will conduct a comprehensive evaluation of concrete and masonry compressive strength results and provide detailed guidance on reinforcing existing structures, if deemed necessary [20-23].

The bricks demonstrate satisfactory mechanical resistance. It is advisable to substitute sections in case that the masonry was exposed, particularly close to windows, due to the detachment through the mortar and bricks. Extensive damage is evident, particularly on the ground floor, especially when viewed from that level. In such instances, reinforcing tiles at risk of plaster collapse is recommended.

5. CONCLUSIONS

The main findings of our research work are as follows:

- Buildings can maintain their longevity and functionality for over 80 years (based on Eurocode 2) with consistent maintenance.
- Columns located along Axe C near the sea can be shielded from adverse effects by implementing effective insulation on the building's external facade using insulating materials, including the bridge system. We can build durable concrete structures, if we produce a concrete with minimum pores and impermeable from many effects of the environment, as possible is crucial to prevent corrosion of the steels bar, as the most vulnerable structural elements are the protective layers of concrete section and the steel bar itself.
- Solid brick walls, properly plastered under technical specifications, have experienced minimal structural deterioration. It is essential to safeguard them against moisture, as it can lead to the separation of plaster from the masonry. Under such circumstances, the longevity of the facility primarily hinges on consistent maintenance efforts over time.
- Further research could explore and compare the factors contributing to the superior resilience of brick-walled buildings compared to concrete structures, as well as investigate the specific raw materials in bricks that contribute to their longevity.
- The data collected on the existing condition of the structures exposed in conditions of the presence of ambient chlorides, which have demonstrated that the process of penetration of CO_2 and Cl can be interpreted with an acceptable approximation, relying on the simple law of diffusion. In order to limit the rate of chloride penetration, concrete with a high resistance class should be used, which means using low ratios of water/water, super fluidification, preferably cement type 42.5 R, the cement content should be above 300 kg/m^3. The high cement content reduces the rate of penetration firstly because it gives the concrete a high capacity of combinations in contact with aggressive substances, secondly because it creates an increase in the volume of cement particles, proportionally reducing aggregate contact -parts of cement, which seems to be the "weak" link of a resistant chain. Based on the above considerations, it results that an increase in the thickness of the iron covering layer cannot compensate for either the increase in the u/c ratio or the increase in the cement content.
- The destruction of the structure of the object over time is a phenomenon that must be taken into account, therefore it is recommended, in particular for infrastructure works and for works of special importance, to carry out a systematic inspection program in order to identify and determine the extent of degradation phenomena and to establish the time of average periodic interventions from which the structure can be restored to its initial state. It is difficult for the degree of damage to be the same in every part of the structure: differences can come from microclimate changes, from incorrectly estimated effects of design details, from changes in concrete properties, from the existence of parts provided for maintenance.

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