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ELEMENTS OF SPECIFICITY REGARDING THE TECHNICAL STATE OF HISTORICAL CONSTRUCTIONS WITH DEFENSE ROLE

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Abstract. Historical defensive construction is a term that defines a construction designed to provide protection, capable of serving military action and having implications for local, national and universal history, culture and civilization. The construction of the fortifications, their type and strategic positioning required a special architecture, special siege weapons, the choice and adoption of a strategy and tactics appropriate for conquest or defense. For a proper assessment of the technical state of a historic building with a defense role, particular attention should be paid to specific architectural elements such as: defense walls built of earth or stone, defense towers that can have shapes, ramparts, firing holes, guard roads, water supply, cellars, the reserve of building materials, made up for the reconstruction of the enemy's destruction, not least, these elements with a strategic, technical and tactical role are added to the living quarters, the care of the wounded, the preparation of the food and the rest.

Keywords: historical defensive construction; fortifications; technical state; degradation, stone.

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1. Introduction

In particular, in the case of historical constructions, knowledge and assessment of constructive features is an important source of information for establishing the course of the rehabilitation.

The defense architecture includes fortifications of cities, border towns, refuge towns, courtyards, city castles, feudal castles, fortified mansions, churches, monasteries and fortified hermitages, town houses and fortified households.

The main causes of damage to historical buildings are: constructive causes; improper use of the construction; degradation of materials; interaction with the foundation ground; catastrophic actions.

The assessment of the technical condition of a building must include information on: the structural system; the type of foundation used; foundation ground and field conditions; general dimensions and composition of the structural elements; the mechanical properties of the building materials used; defects in the quality of the materials and/or deficiencies in the construction of the elements, including foundations, the destination and mode of use of the construction, and the actions applied to the construction during the exploitation period; the nature and extent of structural and non-structural degradation; maintenance work, current repairs, capital repairs, consolidations or upgrades.

2. Technical State of Historical Constructions with Defense Role

The construction of the fortifications was a preoccupation of the heads of states and the military leaders, who could employ the necessary financial and human resources, the elaboration of a general conception of the settlement, the size, the architecture, the strategy and the tactics of their use.

The construction of the fortifications, the type and positioning of the fortifications required the construction of a special architecture, siege fighting and special defense means, the choice and adoption of a strategy and appropriate tactics for conquest or defense.

The fortifications have evolved from earth waves, with or without wooden palisades, facing a natural spring or a flooded ditch, to fortification of wood, earth, and sometimes stone or brick, up to fortresses with massive stone walls.

The defense architecture includes fortifications of cities, fortress, border towns, refuge towns, courtyards, city castles, feudal castles, fortified mansions, churches, monasteries and fortified hermitages, town houses and fortified households.

The fortress is a permanent military fortification, specific to the antiquity and the Middle Ages, which is identified as a building surrounded by walls that have a defense role. The architectural elements that characterize a fortress are:

– defense walls: of earth or stone, characterized by height and thickness;

– defense towers: square, rectangular, circular and semicircular;

– ramparts: built at the top of walls and defense towers, allowed to carry archery with arrows, crossbows, firearms, throwing objects, etc.;

– battlements for shootings: protective spaces through which the shooting were executed;

– guard roads: made of stone or wood;

– water source;

– cellars: for the constitution of the food supply;

– reserve of building materials: built to rebuild enemy destruction;

– to these elements with a military, technical and tactical role are added to the living quarters, the care of the wounded, the preparation of the food and the spaces for other social activities.

Fortified churches and monasteries have played a very important role in defending national territory since the first half of the 15th century when the existing churches were initially fortified, starting with the second half of the 16th century, religious churches were designed with fortifications of considerable dimensions and capacities, but still below the defense fortresses (Giurcă & Zaharia, 2010).

Elements that give the character of a fortification to churches and monasteries were similar to the fortresses, with the indication that they were made for use by pedestrian forces, rarely by artillery, even the small caliber. Walls and defense towers are smaller and narrower than fortifications, there is only one enclosure, while ramparts and embrasures (battlements for shootings) are designed to be used by individual fighters. The guard roads are narrower, with a lower support force, made of both stone and hardwood, usually oak.

The first constructions with a defense role on the territory of Romania, appear in antiquity, during the dacian state. Through this period, the dacian fortresses have a multiple role: cultural, economic and military development. Fortresses were called *"dava"* and represented tribal centers of dacian society; in the dacian language, *"dava"* means "locality", "settlement". Today, the suffix "*dava"* appears in the name of most of the ancient localities: Petrodava, Sucidava, Zargidava, Cumidava, Buridava, Argidava, etc.

Most of the Dacian fortresses were built by the old method: in a higher area, the settlement was built, and around it lay defensive trench, waves of earth over which were thick palisades of thick round wood.

Specifically from this period, remains *"murus dacicus"* (in latin the "dacian wall"), which is a technological mixture between the hellenistic and celtic cyclopian walls. The dacian wall (typical for the Orăștie Mountains) consists of two parapets made of rectangular stone blocks, processed, wood beams and stone and earth padding. On the sides of the limestone blocks joints have been formed (it seems that no mortar has been used), thus ensuring a very good joining of them. The two parapets were connected to each other with wooden beams arranged very often, giving an additional elasticity to the wall, maintaining the intact structure and preventing the slipping of the padding.

During the Middle Ages, constantly threatened from all directions, Moldova was obliged to pay due attention to the fortifications of the southern, eastern and northern frontiers, making full use of the advantages granted by the land space in the Focsani area and the fluvial-terrestrial area of the Danube and Nistru.

In the flourishing period of Moldavia during the reign of Alexandru cel Bun (1400-1432) and Ştefan cel Mare (1457-1504) allowed the realization and development of a fortresses fortificated system, which, through the arrangement of the constituent elements (Crăciuna, Chilia, Cetatea Albă, Tighina, Orhei, Soroca, Hotin, Teţina, Suceava, Neamț), highlighting a clear awareness of their place and role in defending the country (Gheorghiu, 1985, p. 192-208).

Particularly in the case of historical constructions, the knowledge and assessment of constructive features is a source of important information for establishing the course of the rehabilitation. Information such as: original building materials and building technology's, usages of the constructions over time, changes in constituent elements, repairs carried out over time can define the intervention necessities for preservation or consolidation of the monument. Knowing the particularities of traditional construction materials and techniques is an indispensable prerequisite for a correct approach to an intervention on a historic building.

Depending on the methods of knowledge used and the level of knowledge established, the assessment of technical condition and construction involves collecting information from sources such as:

– the technical design and construction documentation of the examined construction;

– the structural system and the type of foundation used

– the technical norms in force or the practices used at the construction date;

historical and architectural study;

– field investigations;

– measurements and tests in situ and/or laboratory;

– usages of the constructions, as well as the actions applied to the construction during the exploitation period;

– the typology and properties of construction materials in the area close to the construction;

– consideration should be given to the possibility of providing materials with properties similar to those used for the construction of the monument in question;

– causes and level of degradation of structural and non-structural elements.

From the consolidation experience, the difficulty in discovering the causes of the degradation of historical buildings is quite high, because most of the times, the causes have a simultaneous action, and it is difficult to fix the boundary between cause and effect.

The presence of one or more causes, the imbalance of the inner forces, giving rise to forces that must be taken by the structure of resistance within the limits of material elasticity. If the elastic limits are exceeded, the structure will display a new state of equilibrium by highlighting some deformations, which are plastic deformations, such as: base drops, crushing, buckling, horizontal pushing in the vertical elements, vertical downsizing of the vaulting systems. Each of these failures corresponds to specific manifestations and constitutes a diagnostic criterion.

The intervention to consolidate a historical building presupposes first of all the knowledge of the causes that caused the plastic deformations; otherwise the intervention is not recommended and sometimes harmful.

The main causes of damage to historic buildings are: constructive causes, improper usage of the construction, degradation of materials, interaction with land, catastrophic actions.

Whether it is a subdimension of resistance elements, whether it is an inappropriate solution to foundations or walls made up of different materials with different behavior, the result may have serious or catastrophic consequences. An important element in the practice of historical constructions is to embody the constructive practice of the area and/or the period in which the construction was made, thus identifying the causes of the damage by association.

Improper usage of construction is one of the main causes of damage to a building. Having a very long lifetime on historic constructions, as in other cases, the human factor takes decisions that have direct effect on constructions without taking into account the original destination for which the construction was designed Actions such as: storing materials, making or enlarging openings, opening or closing gaps with other materials, completely removing or structural

changes, destination changes, or non-execution of maintenance and repair work may lead to modification of the initial static scheme and the appearance of plastic deformations.

Interaction with the land is a complexity problem because terrain is found in a very wide range of land types, often combined with each other, or alternations in more or less irregular layers. In the above mentioned, the role of water is also very important, which by its presence in a smaller or larger quantity can influence the behavior of the land. It should be noted that the rigid movement of the entire structure cannot produce visible damage, even if it can compromise the functionality of the structure, alter its steady state and worsen its static behavior (Niculiță & Groll, 2007, p. 42).

The actions of catastrophic phenomena are an important aspect especially in the case of long-lasting constructions. Among the catastrophic actions, the most common occurrence is earthquakes, the behavior of a seismic action depends on the following factors: the structural type and the spatial layout of the masses, the horizontal and vertical conformation, the layout of the walls and the surfaces of the voids, the materials used and their physical properties mechanical quality, execution quality, location of the construction and, last but not least, the nature of the foundation ground and the type of foundation. These unpredictable actions overstretch a structure already subject to an existing state of tension resulting from permanent loads, resulting in cutting forces and considerable moments that have detrimental effects on gravitationally designed constructions, as are the majority of historical constructions.

Humidity is another major cause of construction degradation and is the relative amount of water (unmatched by chemical) contained at one time in a building material. Removal of humidity is a fundamental issue in terms of good operation and maintenance of buildings.

Regarding the way of spreading and sources of water in construction we can identify the following possibilities: excess water left over from the construction process, spreading the outside water through the roof or walls, capillary rise of water from precipitation at the ground level, poor construction exploitation, insufficient ventilation and sweat (Frossel, 2005, p.12).

The most used material in constructing historic buildings with defense role is stone. The stone used for the fortified buildings is of local origin and we find it in the form of rough stones or rough cuts for the construction of masonry parapets and carved stone for the realization of elements such as pillars, columns, arches, anchor frames, cornices, and pavements.

The rough stone taken from the surrounding pits is of fairly good quality. The carved stone, for which better quality was required, was brought

from more distant places and carefully carved. It seems that pliers were used to pick up stones and place them. The stone blocks used in Romania's historical defense buildings are of relatively small size (usually not more than 1 meter long and 50 cm high). Their placement was directly on the mortar; this was a white lime mortar mixed with crushed brick.

The current stones used in historical buildings in Romania are limestone and siliceous (sandstone, granite, conglomerate). Traditional stone masonry has mostly plastered walls; are made up of different sizes and natures stones and, related to lime mortars, usually hydraulic, and gravel sand.

Stone degradation processes are very complex, depending on the physical-mechanical and mineralogical characteristics specific to each type of stone on the other hand by the nature, intensity and frequency of the aggressive factors and their possible interactions. It has long been considered that the main aggressive factors involved in the degradation are those of a physical nature (variations in temperature, frost, wind actions, etc.). Recent studies tend to give priority to explaining degradation phenomena based on chemical and even biological actions.

Studying the behavior of the stone shows that sometimes less harsh rocks have resisted some harsh climates, while others have been disintegrating in a milder climate. This shows that the phenomenon of erosion does not have a direct relationship between the climate and the degree of resistance of some rocks.

Consequently, the explanation of the degradation of the stone must be sought in the existence of special local conditions, which are associated with the action of the external factors or the consequences of the properties of the material. Stone conservation measures, as well as those of brickwork, are primarily aimed at removing the causes that have caused their degradation.

Brick is a very widespread material in Romanian heritage buildings. Depending on the composition of the clay used and the mode of production, the bricks have different characteristics and behavior different from the degradation process. These processes depend on the porosity characteristics, determining the water absorption capacity, as well as the presence of salts and other soluble compounds whose main transport means is water and which generate chemical processes accompanied by physical and mechanical actions.

The brick used in historical buildings is a well-burned and of very good quality, and of different sizes. The bricks used in the masonry are larger in size, from 27 × 13 × 5 cm to 30 × 14(15) × 6 (7,8) cm. The bricks used for the construction of pilasters or apses have special shapes and are sometimes longer than the usual ones, having the size determined by the width of the pilaster (29-

36) cm. The bricks used to make the interior trim are usually smaller, especially those that form the vaults, to facilitate the execution of the curves.

Wood is a highly hygroscopic material and can be considered dry when its moisture content is below 12,…,15%. At higher humidity levels, pathological phenomena occur. It is particularly affected by mixed situations (wet/dry parts) and humidity variations.

Aggressive action on wood involves the destruction of lignin or cellulose, or one and then another, if different mushrooms act successively. This process takes place in depth, the outer shape of the wood remaining unaltered; the resistance and weight of the wood are significantly reduced, with obvious consequences on static behavior. Domestic mushrooms develop in wood floors over high-humid cellars, in unventilated wooden roofs, behind wood planks over wet walls. The most common are „*Merulius lacrimans*", „*Caniophora cerebella"* and „*Lenzites abientina*" (Popescu, 2002, p.71).

Mortars used in traditional masonry are generally loose and hydraulic lime mortars, the durability of which depends on the dosage, the correctness of the preparation of the binder, and especially the quality of the sand and the water used in the preparation. Clay is obtained by burning limestone, sedimentary rock composed of calcium carbonate and variable amounts of impurities (magnesium carbonate, clay, iron oxide, etc.). In natural state, the limestone is very varied due to the state of crystallization of the impurities.

Lime mortars have two important qualities: elasticity and porosity. The elasticity allows the mortar to cushion the effects of the relative displacements of the bonded elements in a ductile masonry being a mortar adapted to the traditional buildings strategy that consider deformable constructions.

The porosity of the mortar allows the natural changes of interior-exterior vapors through the contour masonry and gives the mortar the ability to return the absorbed moisture to the environment. As with other porous materials, the main physical degradation processes of traditional mortars are related to water frost and crystallization of salts.

In the early stages of the restoration of historical monuments, the process of dismantling and rebuilding an edifice with old or new materials was used. The use of this procedure did not lead to a poor cooperation of the materials, but with the change of directions to be followed in the case of the rehabilitation of the patrimony buildings, this problem also appeared. The idea of using modern techniques and materials, mainly reinforced concrete, is developed in the fifth paragraph of the Charter of Athens (1931) (Niculiță & Groll, 2007, p.85).

The use of reinforced concrete in the rehabilitation of heritage buildings has found its use in restorations in case of consolidation of foundations, the

realization of a constructive system in support of the original structure elements, the construction of roofs and terraces. Thus, we can conclude that the use of reinforced concrete in restorations is used to restore constructive structures that do not acquire aesthetic importance, as they remain hidden and do not participate in the architectural image: foundations, floors, terraces, and roofs.

Portland cement is the main component of mortars and concrete and has been one of the most used materials for consolidating historic buildings, which international practice tends to partially eliminate or minimize harmful effects on traditional materials as a result of defects and side effects found in time.

As we can see in (Niculiță & Groll, 2007, p. 100-102), the main disadvantages of using cement in the rehabilitation of historical buildings are:

– the intervention is irreversible. Removal of cement involves the destruction of original materials;

– the lack of elasticity and plasticity, causes large mechanical stresses on old materials, speeding up their degradation;

– the coefficient of thermal expansion significantly higher than that of the masonry, induces surface stresses that lead to the separation of the two materials; the formation of this capillary film (between the contact surfaces of the materials) allows the rise of the capillary water and, as a result, the degradation caused by humidity;

– is heavily vapor permeable and prevents evaporation; causes increased capillary lift, amplifies moisture condensation and accelerates frost-condensation degradation;

– has large contractions and cracks, whereby water penetrates easily but is difficult to remove, accentuating the degradation caused by humidity;

– high thermal conductivity can generate thermal bridges when cement is used to reinforce walls by injections or with embedded concrete elements;

– produces soluble salts that can dissolve and/or degrade porous materials and decorations and cause superficial efflorescence.

Technological evolution allows for gradual transformations of cement, which aim in particular to increase mechanical strength and accelerate the intake. It is intended that cement-based mortars and cements become more impermeable in order to increase their durability, reduce the water / binder ratio thus reducing the porosity and considerably increasing the mechanical strengths.

All these improvements aimed at increasing mechanical strength and decreasing the socket time, justified by the tendency to increase reliability and structural performance, are however inconsistent with the relationship with the support when the mortars of this kind are used as plasters or elements consolidation in interventions on historical buildings.

3. Conclusions

In conclusion, we can argue that structural intervention on a historical defense construction is a highly specialized operation involving a complex training and a cultural opening that goes beyond the current knowledge of a structure engineer.

Structural interventions in the restoration of historical constructions are based on the premise that, in their case, there are no "universally valid recipes": each case is an episode to be studied and solved independently, to a sequence of phases and operations with content and objectives specific. Structural interventions have the greatest potential impact on the authenticity of the restored building due to direct involvement in the support.

The use - complementary or exclusive - of contemporary materials and techniques is strictly conditioned by their confirmed effectiveness and compatibility (including sustainability) with the historical (original) substance to which they are associated.

Experience at national and international level leads to the idea that consolidation intervention should not necessarily be based on calculations and, in any case, not exclusively, the use of analytical safety assessment is only justified in situations of exception and only to the extent that the calculations can be scientifically correlated with the reality of the monument, which necessarily implies instrumental analysis.

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ELEMENTE DE SPECIFICITATE CU PRIVIRE LA STAREA TEHNICĂ A CONSTRUCȚIILOR ISTORICE DE APĂRARE

(Rezumat)

Construcție istorică cu rol de apărare este un termen care definește o construcție menită să asigure protecție, capabilă să servească acțiunilor militare şi care are implicații pentru istoria, cultura şi civilizația locală, națională şi universală. Aceste construcții, au jucat un rol foarte important din punct de vedere militar, servind la apărarea teritoriului național de-al lungul istoriei.

Construcția fortificațiilor, tipul şi dispunerea acestora, a impus realizarea unei arhitecturi aparte, ținând cont de mijloacele de luptă de asediu şi apărare speciale, alegerea şi adoptarea unei strategii şi tactici adecvate pentru cucerire sau apărare.

Pentru o evaluare corectă a stării tehnice a unei clădiri istorice cu rol de apărare, trebui acordată o atenție deosebită elementelor specifice de arhitectură, cum ar fi: ziduri de apărare construite din pământ sau din piatră, turnuri de apărare de diferite forme, metereze, creneluri de tragere, drumuri de strajă, sursă de apă, pivnițe, rezerva de materiale de construcții, constituită pentru refacerea distrugerilor provocate de inamic, şi nu în ultimul rând, acestor elemente cu caracter tehnico-tactic li se adaugă spații pentru locuit, de îngrijire a răniților prepararea hranei şi odihnă.