THE INFLUENCE OF THE GEOMETRIC SHAPE ABOVE THE VULNERABILITY OF BUILDINGS - KULA TYPE FROM OLTENIA AND MUNTENIA REGIONS

Abstract: The main goal of this paper is to highlight the vulnerability during the life time of kula buildings from Oltenia and Muntenia Regions from Romania. This research highlights the characteristic features of massive kula type buildings by masonry built before 1900. A general presentation of these buildings is being performed, from the point of view of unique and particular features, in two distinct cases. The analysis carried out highlights common and different features for each construction. The behavior and the previsions about the lifetime duration of the massive masonry are influenced by parameters such as the constructive system, the geometric shape, the buildings materials properties. These are the parameters analyzed in this paper in order to be used as input in modeling the structures subjected to occasional loads (strong winds, massive snow accumulations, earthquakes, extreme temperatures, humidity, erosion and biological degradation). In such situations the destruction of the masonry elements and the collapse occur due to the accumulated fatigue in the component elements. All the conclusions can be used for performing a fatigue analysis of these buildings for determining the expected life duration.

Key words: Geometric shape, constructive type, massive masonry, vulnerability

1. INTRODUCTION

Kulas are constructions whose presence occurs in Balkan areas. Characteristic traits are given by the range area and origin. The present paper is intended to be a study of their structure, a historical and technical analysis capable of clarifying the use of architectural elements.

Kula is a fortified home, a tower-like house, a cityfortress, this type of construction did not occur accidentally, but arose due to social necessities imposed by the circumstances. During the XIX-th and XX-th centuries, the extra-urban residential architecture has been transformed from a house-fortress-type structure of popular influence or features architectural language elements of the Brancovenesc-Cantacuzino and Oriental architecture to a Western-style architecture.

2. GENERALITIES FOR ARCHITECTURAL DESIGN AND CONSTRUCTIVE SYSTEM OF KULA – TYPE BUILDINGS

An influence on the kula's architecture had some tower constructions or bell towers, as well as the architecture of the cellars has as its starting point the architecture of the 17th-century aristocratic houses, having influences from the southern Danube area, thus realizing a type of deeply original building found only in Oltenia and Muntenia.

Kula buildings are is a sort of building that will be encountered almost everywhere in the Balkan Peninsula, and mostly in Serbia, Albania, Bulgaria and Macedonia. Kulas were also built North of the Danube, in Romania, more specifically in the historical provinces of Oltenia and Western Muntenia (Southern Romania) [8]. "Kula" is a Turkish word meaning "tower".

In the Romanian architecture, Kula is a fortified two/three-story-building of a compact and simple shape and sizing, having a square or rectangular cross-section,

which was used for defense, observation, distress signaling and residential purposes [4].

The present paper is intended to be a study of their structure, a historical and technical and an analysis on unique architecture elements. Kula is a fortified home, a tower-like, a dwelling-fortress, this type of construction did not occur accidentally, but emerged as a result of social necessities imposed by the time-circumstances.

An influence on the architecture of these type of buildings had some constructions like tower or bell towers.

The starting point of decorating elements that are used at Kulas buildings are aristocratic houses from the 17th-century, which having influences from the southern Danube [3]. In this way it was created as a type of deeply original building that was found only in Oltenia and Muntenia regions [3].

Kulas are thick-walled stone or brick masonry towers, with small windows and embrasures (ramparts). Groundfloor doors are solidly reinforced. Hiding places can often be found inside the kulas. The ground-floor was always used for storage, whereas the upper floors were used for residential purposes. The stairs connecting the floors were always well protected and built in the central area of the kula.

Kulas took over a number of elements from the Romanian architecture, such as the rooftop pavilion and veranda that accommodated the guards and improved the residential comfort of the whole building.

3. ORIGIN AND ACCOMPLISHED FUNCTION

The characteristics of these types of construction are the existence of a massive high ground floor, illuminated only by very narrow openings, as well as an interior staircase for access to different levels.

Figure 1 illustrates some representative examples for highlighting the sober external decorations for kula buildings.

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Fig. 1 Details of outdoor decoration for the kula-type building: a) Cula Cernatescu, Dolj county, b) exterior details in Cula Cutui, Mehedinti county [1]., c) kula Groserea, Gorj county

Although varying in size and appearance, kulas exhibit certain features of the plan and structure that allow a contour of this constructive type. They are square, or almost square, with a length of 5-6 m in the exterior, at the small buildings (the Kula in Siacu, the Kula in Frasinet) and 10-12 m in the big ones (The kulas from Curtisoara, Maldaresti-Greceanu) [8].

The walls between 0.80-1.5m thick are made of brick or stone and brick, and are whitewashed.

Most buildings of this type are built on 3 levels: ground floor and 2 floors. The ground floor had the purpose of sheltering tools, supplies, and animals in case of distress, never used for living. The technical literature recalls the existence of well-hidden tunnels that connect with the exterior.

The walls of the ground floor are provided with very narrow openings in the interior and with a large interior wall like defense ramparts. The 2 floors included the living quarters or the shelter in the number of one to four in each level depending on the size of the building. Also there is an access staircase, always interior made of oak slats trapped in the walls of the shed.

The last floor was provided with a verandah, a kind of turret, quite wide, provided with trilobal arches supported on thin and thick cylindrical columns of wall [4]. Typically, this kind of surveillance balconies were placed on the side of the building that led to the area to be supervised.

The exterior decoration of these buildings is bleak, with only rectangular panels with corrugated corners in the wall. The separation between the ground floor and the first floor is marked by a bra. The building was covered with a sieve [3].

Heritage buildings were built in the Oltenia and Muntenia Regions over a period of four centuries [4].

The walls between 0.80-1.5m thick are made of brick or stone and brick, and are whitewashed. The embossed architectural ornaments used for the decoration of all facades and interiors have as a starting point the geometrical constructions [6,9].

3.1 Kulas from Oltenia region

Their specificity is the presence of the wide open to the outside arcade, being an artistically valuable work of the Oltenian craftsmen being specific and found only in this geographical area.



Fig. 2 Front view of Kula Duca from Maldaresti [1]

This is an element of great fame of these buildings. No matter how good it would have been, this semi-open room was a vulnerable point in case of attack. The influence of peasant houses and Brancoven era architecture can be observed.

Two very important kulas for the Oltenia area, picturesque and representative by their old age and architecture, is located in the valley of Luncavat, 4 km from the city of Horezu, Valcea.

The monumental ensemble of Maldaresti includes Greceanu kula, the Church, the Duca Kula and the memorial house I.G.Duca [3].

The kula has a single entrance, solidly reinforced, opens onto the cellar, made of oak planks, resting on beams embedded in your masonry [2]. To the right of the entrance, and to the massive wooden steps embedded in the two lateral walls, climbs to the second floor [2].

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Fig. 3 Back view of Kula Duca from Maldaresti [1]

Kula Duca of Maldaresti was built in 1812-1827 by G. Maldarescu, being an imposing building with a unique architecture. It is an immaculate white prism, from which the belvedere wrests and consistent volume of shadow [2].



Fig. 4 Ground-floor and first floor Duca Kula Plans [2]

Kula Duca is a compact solid, rectangular plan with a solid ground floor over which 2 levels are placed (Fig.4, Fig.5).



Fig. 5 Second floor plane Duca Kula Plans [2]

Higher levels include living quarters; ramparts meet at all levels. Fireplaces, present in every living room, have varied shapes and are decorated.

Featuring a new style of decoration, it has a unique architectural style. To the rear, the dock has an extension, on three levels, which shelters the sanitary annex. The exterior decoration of the cell is made up of six long panels and a massive band (Fig.6).

The vault is richly decorated in the interior: the ceilings and frames of the windows are decorated with vegetal motifs, fantastic characters and animals. The balustrade of the ladder is carved, and the stair rafter is painted. Stoves, present in every living room, have varied shapes and are decorated (Fig.8).



Fig. 6 External architectural details of Duca kula [2]

This building presents a new style of decoration being imposing and having a unique architecture specific to the Romanian houses.



Fig. 7 Interior architectural details of Duca kula [2]

Due to the regular shape of the plan, making a 3D model for this type of building is easily accessible by using appropriate software. For this, the details of each plan must be well known [10].

Kula is bountiful decorated in the interior (Fig.7): ceiling and window frames are decorated with geometric elements as well as vegetal motifs, fantastic characters and animals.

The prospective view is impressive for its size. It occupies the whole of the long side of the building, and a third of its width. The parapet does not have gun slits. The columns and trefoil arches, although not very graceful in proportion, are rigorously geometrical in design [2].

The Kula has been used for filming many Romanian historical scenes.

Between the 1962-1966 the entire complex was rebuilt and in 1972 it was inaugurated as a museum complex [3].

3.2 Kulas from Muntenia Region

Because of the small number, the Muntenia Region Kulas did not enjoy a great appreciation. Another criteria that leads to their marginalization is the bleak, robust The Influence of the Geometric Shape above the Vulnerability of Kula Type Buildings from Oltenia and Muntenia Region

aspect, lacking the cerdac and the originality of the Oltenia region kulas.



Fig. 8 Stoves from Duca Kula [7], [2]



Fig. 9 The Racovita Kula Arges country [1]

Among the kulas of this area, a representative kula is the Racovita kula. It is located on the left bank of Arges river at about 20 km from Pitesti. This kula was built in 1850 by the priest Nicolae Racoviceanu, with Byzantine style arcades [3].

The Racovita kula (Fig.9) is a tower-shaped, squareshaped base with a side of 8.5m and a considerable height of about 20m. The thickness of the walls is about one meter.

It has three levels. The square ground plan, with sides each measuring 8,5 m on the lower story, was divided in two by a wall down the middle (Fig.10).

The second floor (Fig.11), recreated after the 70's restoration, has a single room, intended to be a museum space [3]. The gaps at the first two levels are in the form of ramparts.

The second floor, with more numerous and relatively larger windows on each side, but without interior dividing walls, was a kind of closed veranda. Although it was a closed space, it served as a lookout post, the see as the familiar veranda of other kula. [2]

The cellar was to the north-east, paved with flagstones and fitted with a wide door and crooked slits.



Fig. 10 Ground-floor and first floor The Racovita Kula plans [1]

The other half was further divided into two chambers: a living room with a stove and a staircase to the floor above.



Fig. 11 Second floor The Racovita Kula plans [1]

The first floor was symmetrically divided into four rooms, those to the south-east being equipped with stoves that had flues inside the exterior wall, but without chimneys on the roof, through which smoke rose into the attic. It was a method of camouflage as well as a means of protecting the shingles against mold [2].

Kula is rebuilt in 1806 after a fire. Kula burnt in 1877 and was restored in 1878, and the interior space is restructured.

Repairs are also being done between1910-1914. Beginning with September 12, 1970, kula is restored and hosts the Ethnographic Museum in Mioveni [3].

There is a cellar behind these areas, with a separate access door, on the Northern side. The windows on the first two floors are shaped as embrasures.

Thanks of the efforts of C.Nastase, the Mioveni Ethnographic Museum was created, preserving in good condition both the monument and exhibits that include ceramics, folk costume, arms, coopery, coins and religious artefacts. [2]

Images from the 1930s and 1970s show the kula before restoration (Fig.13), having just two floors, and the massive stone frames of the embrasures are visible too [7].



Fig. 12 Details inside Kula Racovita [2]

4. ANALYSIS OF THE CHARACTERISTIC FEATURES FOR ANALYZED STRUCTURES

The term "kula" is borrowed from the Turkish-Bulgarian vocabulary, but in terms of the structural and functional system, as well as the architectural and aesthetic, the only thing common with the kulas located in the South of the Danube is the name.

In presenting and analyzing the hills in the Oltenia and Muntenia areas, their historical, architectural value, the constructive system used and their social role should be taken into account.

The construction of these small fortresses was a necessity of the past, the constructive system being adapted to the social life and to the needs imposed by the environment, the influence of local customs and traditions led to the creation of a unique and specific zonal style.

Using the advanced computation method, important results can also be obtained in the field of construction, even if this approach has not been used too often in this area but based on more experimental results already achieved [10].

The way of construction was a well-chosen one, much more careful than the one used in ordinary homes. The laying of the bricks in the mass of the masonry was done in a detailed manner, without overlapping two joints and maintaining a regularity, thus at the corners or intersecting areas of the two walls, the bricks are braided so that in the upper row the chosen position is the reverse in front of the bottom row [5].

Following the constructive way, their placement on the land on these small fortresses, a purpose was imposed on them from the construction phase. Thus, we can say that the most important functions were: rescue and defense kulas, alarm signaling kulas, permanent dwelling-houses type of kulas [8].

When constructing both the presented kulas, the same method of masonry was used to put the materials into operation, the method that is no longer used, because of the economics of the execution and the time of work. Brick masonry type of construction is a little thicker, 27 cm long, 13 cm wide and 5.5-6 cm thick, bound with lime mortar mixed with grained sand with narrower

joints ranging from 2 to 21/2 cm thick. This pattern is met where the good ground for making bricks and firewood is easily found for a long and prolonged combustion of bricks.

A special feature is the way of access for each building. While Kula Duca has only one access to the inside of the building, Kula Racovita has 2 openings.

Also another special feature is the plan shape. The Racovita kula has a square shape, which looks like a tower, compared to the rectangular shape of Kula Duca.

It should be remembered the way of layout and the construction of the stairs that ensures the connection between levels. In the case of Duca, the stairs are stacked and stretched over the entire height of the building while in the case of Racovita kula the staircase is only continuous up to the first level and the access to the last level is made by means of removable stairs, being a way of defense in the case of danger.

The ornamentation used for the artistic decoration of the kula buildings is made of decorative motifs, that is, of figures obtained from geometrical elements called geometrical motives or elements of nature [6].

Both Kula Duca and Kula Racovita initially had the purpose of building for refuge and for defense [5].

Massive masonry during its lifetime is subject to extraordinary charge, occasional loads (such as strong winds, massive snow accumulations, earthquakes, etc.), human movement. Submission to various environmental factors such as extreme temperatures, wind, rain and snow, erosion and biological degradation, represent variable time loads, which greatly affect the structure when the number of loads or the effect is long [11].

In such situations the destruction of the masonry elements and the collapse occur due to the accumulated fatigue in the component elements.

Both buildings had a good faith with a privileged regime over time. So both were consolidated and repaired periodically. In the case of the Racovita Kula, it is actually a reconstruction. Good care and attention have made both buildings to be in a good state today.

The Oltenia-Muntenia kulas were used for housing, defense or shelter, watch and alarm, have locally specific constructions, built in the local ethnic style, the Oltenia style and depicting the talents and skills of the local craftsmen who lived, adopting the constructive system at the time and place [8].

The assessment of the degradation condition of the two objectives presented by the comparative study of the mechanical characteristics of the masonry elements subjected to external agents would relieve the environmental agents such as wind, snow, moisture [11].

5. CONCLUSION

Presenting a variety of architectural shapes and styles of local or international influence, kula buildings, the properties of the long-standing socio-cultural elites, are a special architectural phenomenon and today represent a component valuable cultural heritage.

From the analysis we can see that although they are located in geographically different areas they have common traits given by the purpose and the role for which they were built. These features are also those that highlight their unique architectural features and historical significance.

The constructive mode of these buildings is a specific one of the Balkan region, emerging from the need for defense, and is an important feature of those hard times.

From the point of view of the architecture of the extra-urban wall residences, the Oltenia and Muntenia areas are individualized in the Romanian cultural space through the kula buildings.

The analysis is bringing it at highlighting the specific architectural geometric shapes from Romanian kulas. The specific geometric shape and architecture, the design of the walls and roofs, the mixture between the massive masonry and wood structural elements gives the input parameters for the analysis of the time behavior and lifetime previsions for these types of buildings.

A major issue, throughout the engineering world, is the safety, maintenance, consolidation and, above all, the rehabilitation of worship and patrimony buildings like these. The analysis carried out is aimed at highlighting the specific characteristics of the Romanian kulas, which make the kula type buildings to be considered as unique and authentic buildings.

If for the two buildings presented, the current state is a very good one, many other kulas in the Oltenia and Muntenia Regions are in pre-collapse condition being forgotten and abandoned. From a total of 57 kulas that were raised and identified in the technical literature, over 20% are in ruins and over 45% are missing.

Both buildings had a good faith with a privileged regime over time. So both were consolidated and repaired periodically. In the case of the Racovita Kula, it is actually a reconstruction. Good care and attention have made both buildings to be in a good state today.

REFERENCES

- Zamora L. Bonciocat S., (2007), Cule case boieresti fortificate din Romania, Publischer Igloo Patrimoniu, Bucuresti, Romania, ISBN 978-973-87938-5-9.
- [2] XXX (2014) Cule: case fortificate intre fala si ruina, Publischer Igloo Patrimoniu, Bucuresti, Romania, ISBN 978-606-8026-39-8.
- [3] Atanasescu I., Grama V., (1974), Culele din Oltenia, Publisher Scrisul Romanesc, Craiova, Romania.
- [4] Atanasescu I., Popescu P., (2013) Culele din Olteni si evolutia lor pana astazi, Publisher Alma DCMI, Colectia Patrimoniu Cultural National, Craiova, Romania, ISBN 978-973-0-15178-7.

- [5] Barbu A.M., (2018), Comportarea de lunga durata a peretilor din zidarie masiva, Teza de doctorat, Cluj Napoca, Romania.
- [6] Sass L., (2002), Desen Geometric, Publischer Tehnica-Info, Chisinau, Republica Moldova.
- [7] https://www.kule.ro/en/about-kulas, Kulas Past and perspective, Institutul National de Patrimoniu. Accessed 2019-02-08.
- [8] Mogosanu A.M., Kopenetz L.Gh., (2018) The Practice of Structural Analysis at the Kula Constructions, C65 International Conference-" Tradition and Innovation - 65 Years of Constructions in Transilvania", Universitatea Tehnica Cluj Napoca.
- [9] Sass L., Duta A., Mogosanu A.M., (2014), Appications of Geometrical Drawing in the Popular Art from Oltenia-Romania, International Scientific Conference moNGeometrija June 20th - 22nd, Vlasina, Serbia, 2014, ISBN 978-86-88601-14-6.
- [10] Vasiluta P., Cofaru N., Popa D., (2012) Ecological Landfill folded Geomembranes behaviour during virtual Experiments, Academic Journal of Manufacturing Engineering, vo 10. No.4, pp.130-135.
- [11] Popa A. D., Mogosanu A. M., Popa D. L., Duta A., Teodorescu A, (2017), Virtual and Rapid Prototyping Methods Applied in Civil Engineering. Snow, Wind and Earthquake Simulations on a Five Storey Building, FME Transactions, no.2 Issue 45, ISSN1451-2092, http://www.mas.bg.ac.rs/istrazivanje /fme/start

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