"OVIDIUS" UNIVERSITY OF CONSTANTA

DOCTORAL SCHOOL OF APPLIED SCIENCES

AREA OF STUDY – CIVIL ENGINEERING AND INSTALLATIONS

CONTRIBUTIONS REGARDING THE RESTORATION AND CONSOLIDATION OF MUSLIM WORSHIPS BUILDINGS

ABSTRACT OF DOCTORAL THESIS

Thesis advisor

Ph.D.Prof.Eng. GRĂMESCU ANA MARIA

Doctoral candidate,

Eng. SULIMAN SEVER

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FOREWORD

During the bachelor's, master's and later doctoral programs within the Doctoral School of Applied Sciences, the field of Civil Engineering and Installations within the "Ovidius" University of Constanța, Mrs. Prof. Dr. Eng. Grămescu Ana Maria, with the others teaching staff cultivated my love for the construction engineer profession, which I proudly practice today, but especially for the protection of historical monuments. Having reached the maturity of my thinking, possessing a rich knowledge of civil engineering acquired within the university education, I appreciated that a scientific research program could create a new beginning of my professional path. Regarding this last aspect, I was supported in the decision taken by Mr. Lecturer Dr. Eng. Gelmambet Sunai. 5 years ago I didn't know the subject of my scientific research, which is the field in which I will be able to carry out an activity, so that the results of the research can be applied, visible, tangible and in the future.

The idea came from Mrs. Prof. Dr. Ing. Grămescu Ana Maria, who asked me immediately after admission: "Would you like to carry out a research in the field of conservation, protection, restoration of Muslim worship places in the area of Dobrogea?". This theme came as the most noble subject, it was a topical theme, I realized that Dobrogea is rich in mosques and minarets that are the symbols of Islamic architecture, and that my theme from now on will respond to national interests as historical monument objectives of Romania and equally of my Muslim community. This gives me the reasons in these moments to thanks again to Mrs. Prof. Dr. Ing. Gărmescu Ana Maria who, during the 5 years of my doctoral studies, sent to me the passion, the ambition, the dedication to go through this research project with high feelings of gratitude, for the support throughout these studies, to the Muslim community, the mufti and all those who made it easier for me to carry out research, stratigraphic expertise, parament, historical studies and any information.

Along with all of them, I sincerely thank for their support to the professors from the guidance committee: Mrs. Prof. Dr. Eng. Omer Ichinur, Mrs. Prof. Dr. Eng. Carmen Maftei, Mr. Lecturer Dr. Eng. Gelmambet Sunai. Throughout this time, I was supported by the Faculty of Construction at the "Ovidius" University in Constanța teaching staff, to whom I thank and express my feelings of gratitude for the passion and dedication with which they taught me both engineering knowledge and the way in which I dress this profession with fairness and dignity.

I wish to express my thanks and appreciation to my wife, to all my family, for all the support and understanding they have shown throughout this journey, in which at every moment I thought of my parents who ennobled me with high qualities as a man, as an engineer, as a husband, and more recently as a father.

To all I thank and express my highest respect and full gratitude.

Eng. Suliman Sever

Content

Chapter 1. Introduction

1.1. Importance of the proposed research theme

The research project as a whole falls within the concerns of cultural policies for the promotion of heritage values and at the same time, the topic addressed is of utmost importance in the promotion of interethnic cultural policies and the results obtained have contributed to the development of knowledge of over 500 years of the constructions history in Dobrogea.

Of course, the results obtained through the current research project have opened new research directions and favour the application of new techniques and methods in the intervention measures adoption. Thus, through the current research project we were able to initiate a bridge between the past and the future. The chosen topic is of great interest, motivated by the lack of documents, the lack of studies and research up to this point with reference to these particularly important constructions for the Muslim cult but also for the national and even international heritage. The studies and investigations carried out within the research project allowed the discovery of new and valuable information in the field of civil engineering, the development of knowledge in the field of civil engineering. The investigations carried out for each mosque classified as a historical monument and existing in the Romanian heritage register allowed the identification of the structural design, the functional design, the execution technologies, aspects that allowed highlighting the elements of authenticity, uniqueness, rarity, criteria that define the value historical monument. In the investigations carried out, we even resorted to some excavations to do stratigraphic studies or face studies to identify the quality, the geometry of the brick or stone masonry, the execution technology, respectively if it is a wet or dry masonry.

Throughout this process, I inspected and analyzed each mosque with accuracy, made structural drawings, studied the history of each building, the modifications and interventions made over time, elements that I synthesized in detailed analytical sheets, identifying and interpreting the specific structural elements through analogies or comparisons. We appreciated that without this research, a knowledge base could not be created that could be offered to restorers in their efforts to preserve and protect these Muslim religious buildings.

The analytical sheets created represent a very valuable database for the Muslim community in the allocation of restoration and consolidation funds, or for specialists in establishing intervention measures. At the same time, the sheets represent a valuable synthesis

that will argue for the inclusion of these objectives in the tourist circuit and that emphasize the expressiveness of the spiritual life, of the historical road, of the architectural elements as a whole, of all the very valuable components. The mosques in Dobrogea can be successfully included in the list of international heritage belonging to the states opening to the Black Sea as an expression of the presence of the Muslim community over time. Currently, researchers all over the world are concerned with preserving their own values through specific techniques and methods. There is a tendency for restoration and consolidation work to be carried out by specialists in that country.

Cultural heritage represents an expression of values, beliefs and knowledge, of traditions transmitted over time as evidence of the interaction of human factors with natural ones.

This process is in continuous evolution and has a particularly active role in the development of humanity and the increase in the quality of life. This field represents the essential resource in Romania's identity, it contributes to the development of society, stability and cultural identity, the promotion of peace, democracy, the rule of law, and the strengthening of interethnic relations.

As is known, this policy is part of the whole of European policies, with Romania having the mission of promoting, applying and consolidating the activities of conservation and restoration of the national heritage.

The analysis of national policies highlights the fact that both in the period 2015-2018 and in the period 2019-2022, an important role was played by cultural heritage and its sustainability. In this context, international cultural relations were developed, working groups were initiated that addressed relevant themes, promoting mobilities, intercultural dialogue, the integration of heritage in economic and social development.

Through the research project, I studied the constituent materials as much as possible from the construction of the mosque, to understand their behavior to external actions that lead to collapse, but also to appreciate their load-bearing capacity, their characteristic resistances. This analysis allowed me to recommend the most appropriate solutions for future intervention works in the intervention methods and techniques in chapter 4. In the restoration of historical monuments, modern materials can only be used to the extent that they do not affect the originality and symbolism.

Due to their destination, these buildings have a special spiritual, economic and social value, values defined as follows:

- Spiritual value – these places represent the place where Muslim believers come and pray;

- Economic value - they are old buildings, with a special history and architecture, they annually attract tourists who visit these worship places, but also the cities where they are located;
- Social value – represents the place where the Muslim community often receives its guests from various social activities, and educational courses/meetings for adults and children are also held.

The principles of conservation, restoration, repair of historical monuments, at the international level, are adopted and elaborated, through international congresses of architects and technicians of historical monuments, documents entitled "Charters". One of the most important such documents, adopted in Venice between May 25-31, 1964, is entitled "Venice Charter".

The historical monument concept covers not only the isolated architectural work, but also the rural or urban ensemble in which the testimony of a particular civilization, a significant development or a historical event can be found. This applies not only to major works of art, but also to more modest works of the past that have accumulated cultural significance over time. The preservation and restoration of monuments must use all the science and technology that can contribute to the study and protection of the architectural heritage. The purpose of conservation and restoration of monuments is to protect them both as works of art and as historical testimonies [117].

1.2. Objective and contents of the doctoral thesis

This doctoral thesis entitled "Contributions regarding the restoration and consolidation of Muslim worship buildings" had the following objectives:

1. Identification of Muslim worship buildings on the territory of Dobrogea, classified as historical monuments;
2. Analysis of materials and technologies specific to Muslim worship buildings;
3. Identification of architectural and functional elements characteristic of these types of constructions;
4. The research of each objective in order to quantify the degradations and the causes that generated them;
5. Quantification of the degree of vulnerability;

6. Identification of intervention measures, measures that do not affect the classification criteria of historical monuments with reference to authenticity, rarity, uniqueness, as measures to enhance the value of these heritage buildings;
7. Development of an integrated research base;
8. Elaboration of documents of originality by the doctoral student that allow the development of knowledge, that allow the adoption of compatible intervention measures;
9. The application of calculation programs based on a researcher's own modeling, modeling that takes the minaret into account;
10. Initiation of a manual entitled restoration guide, and an administration guide particularly useful both nationally for restorers and the mufti but equally useful internationally for states that have such constructions and that are located in similar areas;
11. Promoting knowledge with reference to the national heritage, by initiating courses in the educational system, an action that is also included in the government program of the Ministry of Culture;

1.3. The mosque and the minaret as a symbol of Islamic architecture in Romania

Islamic architecture is related to spirituality and human wisdom, so the spiritual teachings and cultural beliefs are based on a very voluptuous, dynamic architecture, able to respond to the spiritual, material, social needs of an era. In this context, the Islamic religion from the earliest times to the present has provided an arena for exhibiting the most valuable works in a perfect combination of the artistic element with the progressive element of civil engineering. The mosques architecture shows peaks where the aesthetic starts from a religious belief and has a divine inspiration.

The mosque represents the Muslims worship place, where they meet for religious and social activities.

From an etymological point of view, the word mosque comes from the Arabic language, having its origins in the word "masjid" which means "prayer place" or "worship". It is a word that dates to the 5th century BC, and comes from the Aramaic language, related to Arabic and Hebrew. In the Romanian language, the word "mosque" comes from the French "mosquee", which in turn comes through mediation from Italian and Spanish from the Arabic word "masjid".

The original concept of the architecture of a mosque in the Islamic religion consists in simplicity, which creates a special functionality of the space for religious activities. One of the most important aspects, which have a special role in the architecture of Muslim worship places, is the orientation of the Qibla wall, depending on which the orientation of the entire construction is chosen.

The oldest mosque in the world is the Quba Mosque in Medina (Saudi Arabia), built in 622 AD. The oldest mosque in Romania is in Dobrogea in Mangalia which is also a historical monument is the Esmahan Sultan mosque, whose founder is named after him, and was built in 1573 (the year that can be found at the entrance to the prayer hall and according to the list of historical monuments it is 1590) by the daughter of one of the greatest sultans of the Ottoman Empire, Selim II.

The architecture of Muslim worship places is specific to Islamic architecture through the presence of arches, domes and minarets. The spread of mosques around the globe led to the adoption of some elements characteristic of the location areas, such as the shape of the roof, or some building procedures and techniques (making the stone foundation on a layer of sand, dry masonry, masonry with mortar or joining the frame elements by the transition from wooden frames, stone masonry, brick masonry, mixed masonry from yellow earth mortar to lime-sand mortar or the transition from a masonry dome to a concrete dome, or replacing the dome with flat wooden elements) .

The elements that determined the adoption of forms and styles in the evolution of these constructions are due both to local factors, in terms of local materials, the economic power of the localities, but also to some factors that have in mind the economic power that has the effect of the migration of Muslim believers, cultural policies.

Religion from ancient times until today has provided the arena for the display of valuable works of progress of any artistic concepts. As it is known, the worship place has a priority role among the first edifices made for the community, and expresses the characteristic of the religious confession, the specific architecture, the people customs, the building technique.

The building criteria for Muslim worship places in the Dobrogea area were:

- to provide safety, resistance over time;
- to show appropriate resistance to the actions of climatic and biological factors of the environment;
- to express the tranquility, the peace of those who pray;
- the furniture should be simple and beautiful;
- the existence of the arches and the dome;

- designing a volumetric building in which it can be compatible with the local climate of a community;
- to ensure adequate acoustics;
- separating the spaces occupied by men from those occupied by women;
- the use of decorative materials, mosaic veneers, tiles;
- the use of quotations from the Koran;
- prohibiting the presence of face paintings;
- to ensure fire resistance;
- providing comfort to Muslims during prayer.
- symbolizes the culture, history and traditions of local Muslims.

Another architectural feature of the mosques is the shape of the ceiling which can be in the following forms: dome, pyramidal, flat. This aspect also influences the brightness of the prayer hall. Lightness is special in the Muslim worship places architecture, because it provides excitement to prayers, the perception of space and the interior atmosphere, and it is also useful for the people inside to see each other and communicate. The emotion transmitted to the believers is achieved by highlighting the interior architecture and their elements, thanks to the appropriate brightness.

The minaret is a very important component, it expresses a cycle of human existence, in human ascent towards purification or spiritual elevation. The minaret usually has heights between 25-70m and various shapes. A mosque can have one or more minarets. Also, the height of the minaret depends on the importance of the mosque. The section of the minaret can be: square, hexagonal, octagonal, circular. Vertically, the minaret may or may not have a pedestal.

The mosques characteristics made in the former Ottoman Empire are with a rectangular pedestal, from where the actual structure of the minaret is circular and having at the top a conical wooden component, covered with lead sheet. Minarets are made of stone masonry with a round metal core, this form in the Islamic tradition conferring maximum security on spiritual service in relation to divinity. The interior staircase in most situations is a spiral built staircase in a similar design of the minaret. A minaret can have one or more balconies depending on its height. In Dobrogea they all have one balcony.

In Dobrogea there are situations where the minaret is made of reinforced concrete, in the case of the Carol I mosque, or in the case of Isaccea where it is mixed masonry. In some situations, interior stairs can also be made of wood.

1.4. The international status of Muslim worship places

The spread of the Islamic religion throughout the world has also led to the appearance of mosques in those areas. The mosques have always been a mirror of the presence of Muslim communities in the areas where they were built.

Most mosques are found in Asia, Southeast Europe, North Africa, but with the spread of Islam, mosques have appeared in Western Europe, North America, and the rest of Africa.

The oldest mosque built by Muslims is the Quba Mosque from Medina built in 622 AD, according to the Islamic religion being built by the Prophet Muhammad, and the most important Muslim worship place is Masjid al-Haram Mosque in Mecca built between 634-644.

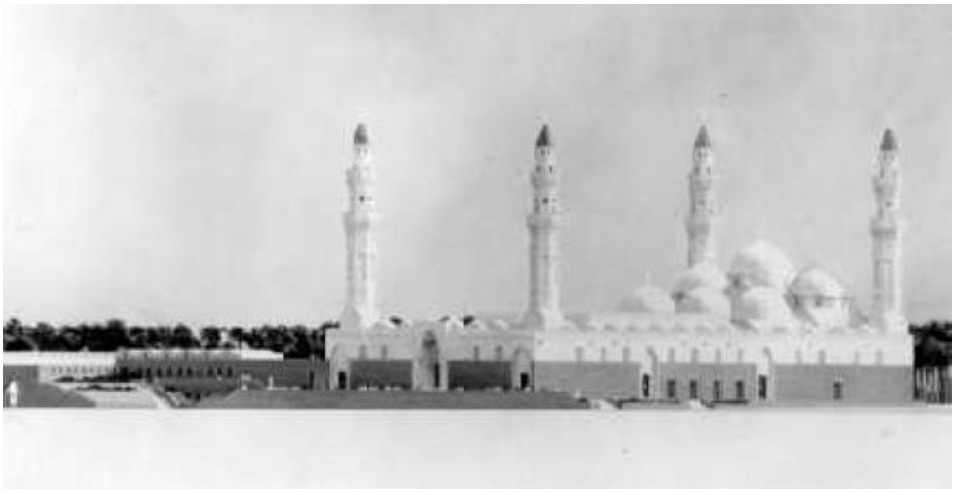


Fig.1.1. The Quba Mosque in Medina [81]

The first mosque built in the Ottoman Empire was the Hagia Sophia, built in 537. It was first the cathedral of the Byzantine Empire, and later became the mosque after the Ottoman conquest of Constantinople. Practically, Hagia Sophia is the starting point of mosques in the Ottoman Empire, in terms of the architecture adopted. These types of mosques will continue to be found in countries such as Greece, Bosnia and Herzegovina, Albania, Serbia, Bulgaria, Macedonia, countries under Ottoman rule in the past. In Western Europe, mosques were built later with the emigration of Muslims to the mainland, especially in the 21st century. We meet mosques in Rome, London, Munich, Paris. The number of mosques in the United States has also risen sharply with the spread of Islam.

Some of the most famous mosques in the world are:

- The Al-Aqsa Mosque from Jerusalem is the third holy place in Islam;
- Al-Azhar Mosque from Cairo, Egypt;
- Umayyad Mosque from Damascus, Syria;

- Al-Kadhimiya Mosque from Baghdad, Iraq;
- Imam Ridha Mosque from Mashhad, Iran;
- Faisal Mosque from Islamabad, Pakistan;
- Grand Mosque of Cordoba Cordoba, Spain;
- Sultan Ahmed Mosque (Blue Mosque) from Istanbul, Turkey;
- Jama Mosque from Delhi, India;
- Istiqlal Mosque from Jakarta, Indonesia;
- Hassan II Mosque from Cassablanca, Morocco.

An essential structural component in Muslim worship places globally is the minaret. Throughout history, the minarets of many Muslim worship places have been built using different building materials and structural systems, depending on their location. Despite the architectural variations, it can be said that minarets are generally found in the form of four characteristic types:

1. Egypt and Syria area minarets – the size of the minarets is variable depending on their height. This shape ensures an efficient distribution of the material and at the same time a better behavior in seismic action. As a rule, they have several balconies, and at the top of the minarets there is a dome that ends with a peak that represents the connection with the divinity, unlike the minarets in Dobrogea where the peak is in the form of a cone trunk, the cone being made of wood with lead sheets. With reference to the base area of the minaret, it is specified that a common element represents the geometry of this base, which is a square prism.

a)

b)

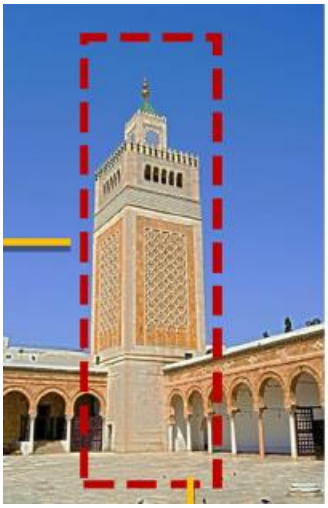
c) d)

Fig. 1.2. Egipt and Syria minarets:

a) Yaqout El Arshi mosque ; b)Abu El Abbas mosque [73]

c)Sh.Zayed bin Sultan Al-Nahyan mosque ; d)Zainab bint Jahsh mosque [76]

2. Morocco and Spain minarets – their characteristic is the geometric section of the whole minaret which is not round and has the shape of a square made of brick with decorative patterns. Even if the minarets have several balconies, the call to prayer is made from the lower balcony by the muezzin. In Morocco and Spain, the upper part of the minaret is provided with a small pavilion, also with a prismatic shape but with a much smaller section.



a) b)

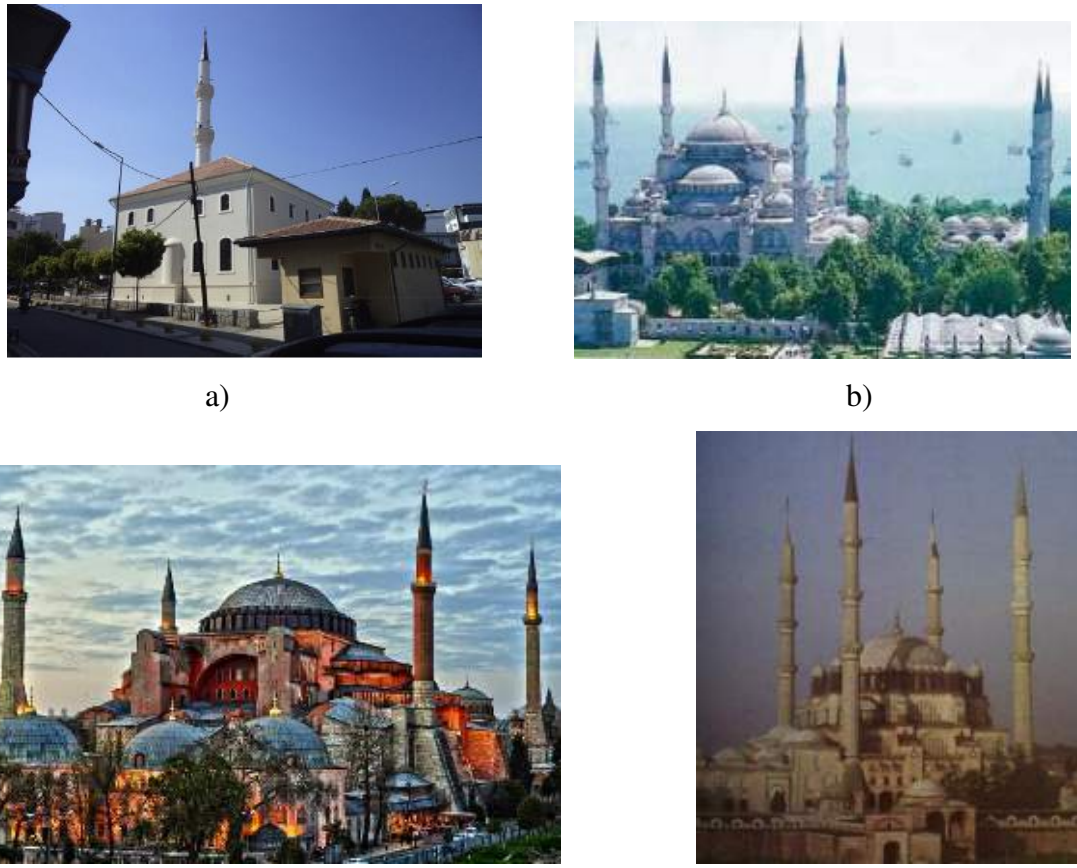
Fig.1.3. Morocco and Spain minarets

a)Al Zitouna mosque, Tunis [63]; b)Cordoba mosque, Spain [164]

3. Minarets in the Persian areas – they are characterized by a specific geometric shape in the form of tall, slender, conical or round turrets generally arranged in pairs and which outline an entrance way.

Fig.1.4. Minarets in the Persian areas, Yazd city, Iran [84]

4. Turkish minarets - they resemble Persian minarets with a slender structure, having a conical, round or polygonal shape. Turkish minarets can even have two or three balconies.



a) b)

c) d)

Fig.1.5. Turkish minarets

a)Carși mosque, Manisa, Turcia [109]; b)SultanAhmet mosque, Istanbul [43]

c)Haghia Sofia mosque, Istanbul [163]; d)Selimiye mosque, Edirne [22]

1.5. The historical context of the Muslim worship places construction on the territory of Dobrogea

As is known over time, populations in continuous movement have contributed to the history of the land based on balance, interethnic harmony, based on mutual respect, contributing to the promotion of cultural traditions and specific civilization.

Dobrogean land is known as the paradise of multiculturalism. Here we meet numerous ethnic groups such as: Romanians, Aromanians, Turks, Tatars, Greeks, Lipovans, Ukrainians, Italians, Jews, etc., among which there have been no inter-ethnic conflicts over time. Knowing the cohabiting nationalities and promoting good coexistence relationships presupposed an affective and cognitive development and a desire for collaboration based on respect and trust on sincere feelings of friendship and admiration for the personal way of seeing the world.

On the territory of Dobrogea, the first actual Turkish peoples appear starting from the 9th century: the Pechenegs, the Cumans, the Tatars, the Seljuk Turks and then the Ottoman Turks (Ottomans). All these groups of Turks arrived in this territory from Central Asia, traveling huge distances through the north and south of the Black Sea.

The Turkish population origin in Dobrogea descends both from the inter-ethnic groups that arrived on the road of the North-Pontic steppes, and from the Oguz groups that arrived on the southern, Balkan road. The groups of Pechenegs, Uzi, Cumans, Tatars and Oguz have a common hearth of formation (Central Asia) and belong to the same great community of Turkish peoples. As for the Tatar branch of the ancestors of the Dobrogean Turks, the oldest document known so far in connection with the history of the Turks, namely the Orhon River valley inscriptions, dating from the time of Khan Kul Tighin, the chirftain of the Old Turks, mentions this ethnic branch among the Turkish tribes who formed the confederation headed by the mentioned, Kul Tighin. The Turkish origin writer Mahmut Kaşgarli mentions the Tatars among the ten Turkish tribes of the northern group of Asia. This information also comes from other Muslim sources from the 10^{th}-11^{th} centuries, the respective authors place the Tatars in the family of the Oguz Turks.[14]

One of the peculiarities of the history of the Turks lies in the fact that they, over the centuries, created states and empires that existed and carried out their activity in parallel. We refer in particular to the Seljuk Empire and the Golden Horde, and later to the Ottoman Empire and the Golden Horde, the Crimean Khanate, the Kazan Khanate and the Astrakhan Khanate. The existence of these states should not mislead about the ethnogenesis of the Turkish people

which is unitary from the point of view of the hearth of formation, traditions, customs, language, etc.

Thus, the Islamic religion is also strongly consolidated among the Turkish peoples of Dobrogea when, starting from the 13th century, Sari Saltik Baba, a semi-legendary Muslim mystic of Central Asian and Anatolian origin, whose tomb is found in Babadag, settled in the land Dobrogea. Thus, the city of Babadag becomes the spiritual-religious center of the Muslim community in Dobrogea, a place of pilgrimage for Muslims from the area but also from everywhere. Before the appearance of the Islamic religion, the Turkish peoples of Dobrogea also came into contact with other religions and beliefs such as: Buddhism, Manichaeism, Nestorianism, shamanism. The latter being their old dominant faith before the advent of Islam.

1.6. Criteria for analysis and classification as a patrimonial value

As is well known, a building that is classified as a historical monument in Romania must have special significance for national and universal history, culture and civilization. These types of buildings classified as historical monuments are protected by law and are part of the national cultural heritage. The protection of these monuments consists in the adoption of a set of scientific, legal, administrative, financial, fiscal and technical measures aimed at ensuring the identification, research, inventory, classification, record, conservation, including guarding and maintenance, consolidation, restoration, enhancement of historical monuments and their socio-economic and cultural integration in the life of local communities according to "Law no. 422 on the protection of historical monuments". [133]

The Ministry of Culture is the specialized central public administration authority that deals with the development of strategies and specific rules for the protection of historical monuments in Romania, monitors and ensures their application.

In order for a Muslim worship place to be classified as a historical monument, it must meet the following criteria: the criterion of antiquity, the criterion of rarity, the criterion of authenticity, the criterion of uniqueness, memorial value.

Tab. 1.1. The list of Muslim worship places on the Dobrogea territory classified as historical monuments

No.	Mosque name	Building year	Cod HML
1	Esmahan Sultan Mosque from Mangalia	1573	CT-II-m-A-02901.01
2	Gazi Ali Pasa Mosque from Babadag	1610	TL-II-m-A-06000
3	Mosque from Cernavoda	1756	CT-II-m-A-02874
4	Mosque from Isaccea	1771	TL-II-m-A-06006
5	Sultan Mahmut Mosque from Harsova	1812	CT-II-m-A-02892
6	Mosque from Amzacea	1850	CT-II-m-B-02864
7	Sultan Abdul Mecid Mosque from Medgidia	1861	CT-II-m-A-02904
8	Mestan Aga Mosque from Macin	1860	TL-II-m-A-06009
9	Aziziye Mosque from Tulcea	1865	TL-II-m-A-05984
10	Hunchiar Mosque from Constanta	1862	CT -II - m - A -02851
11	Carol I Mosque from Constanta	1913	CT -II - m - A -02796

For example, in the case of the Mosque from Cernavoda, the HML code: CT-II-m-A-02874 can be explained as follows:

- CT – represents the acronym of Constanța County;
- II – means an architectural monument;
- m – represents a monument;
- A – is a historical monument of national or universal value;
- 02874 – represents the unique order number throughout the country.

Fig.1.6. Location of Muslim worship places in the Dobrogea area

Chapter 2. Studies and research regarding the composition of Muslim worship places on the territory of Dobrogea as a historical monuments. Construction techniques and material used

2.1. The structural and architectural composition of a mosque in Dobrogea

In Dobrogea, the Muslim worship place expresses the characteristics of the Islamic religious confession, Islamic architecture, specific materials and techniques, specific traditions and customs. Thus, an assembly of the worship place consists of the following:

- The mosque;
- The minaret;
- The cemetery;
- The fountain;
- The mosque courtyard;

The mosque is composed of the prayer hall and other rooms intended for the prayers washing, the storage of shoes, as well as the office of the imam or the archive room. The minaret represents a slender structure that forms a common body with the mosque and that represents the relationship between believers and divinity. It is the holy place of calling the Muslims to prayer and transmitting spirituality to the divinity.

The cemetery is the place adjacent to the mosque where personalities of the Islamic community are buried.

The fountain has a very important meaning in the Muslim religion, having the meaning of the purity that the people adopts before praying. The mosque courtyard is the site of all spiritual activities, it includes the location of the mosque, the minaret, the cemetery, the fountain.

2.1.1 The mosque building

The construction of the mosque is made in close connection with the function it has so that it must respond to the mission of transmitting spiritual teachings and cultural beliefs. Therefore, the construction is made of a main room with an appreciable volume, where the plan dimensions are comparable to the height. This represents the prayer hall of worship place which is structured on 2 levels, namely the ground floor intended for Christian Muslim men, and is

bordered on 3 sides by a gallery formed by beautifully ornamented wooden pillars on which the balcony discharges. The balcony is intended for Muslim women, access is from the antechamber of the mosque. In some mosques, the balcony is structured on one side. This characteristic is found when the aspect ratio L/l is higher (eg. Esmahan Sultan Mosque, Hunchiar Mosque).

Fig.2.1. The balcony – mosque from Medgidia [108]

The free side that is in front of the central balcony and in front of the prayers on the ground floor is for the imam. There is the mihrab (similar to the altar), the orientation of this wall is towards Mecca and is called the Qibla wall. This wall is not ornamental, where a niche is found, and quotations from the Koran are found.

Fig. 2.2. The mosque from Cernavoda mihrab [18]

The ceiling has valuable artistic components generally made of wood, when the ceiling is flat, and in larger mosques it benefits from an assembly of arches, domes, or domes. This prayer hall presents a gateway as the first element to divinity and in the Islamic religion signifies the symbol of the movement from diversity to unity. When the ceiling is curved it discharges on the arches which in the Islamic religion, the arch represents integrity, it is the spiritual

element recognized by Islam as coming from the distant past and rising towards the divine creation of the future. The arch represents the essential and spiritual element of the believers and it comes to create a prelude to the minaret. The arch and the dome can be found at the Carol I Mosque in Constanta. In Islamic architecture the dome above the prayer hall is the expression of the attribute of divine glory and beauty. In Romania, the Carol I Mosque has a dome inspired by the Constantinople mosque, made of reinforced concrete by Gogu Constantinescu, it is the first such element made in Romania. In Dobrogea the interior finishes of the prayer hall are simple, with the exception of the Carol I mosque which has a mosaic similar to mosques in Western Europe. The floors are usually made of wood, some of which have their own floor heating system, the floors are generally covered with carpets. The carpet of the Carol I mosque is brought from the Ada-Kalleh island mosque.

The furniture is simple and beautiful, the whole environment must express the peace and tranquility of the one who prays. Adjacent to this prayer hall are the spaces that provide ancillary services, namely foot washing, shoe storage, the imam's office, archive rooms.

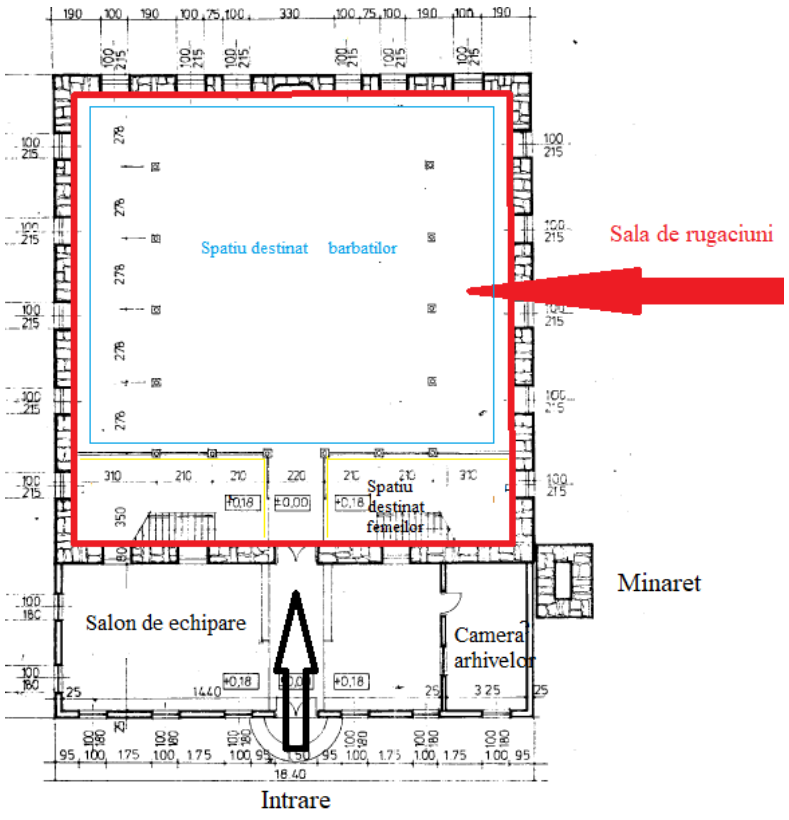


Fig.2.3. Mosque general plan

The typology of mosques architecture differs. The Carol I Mosque adopted Byzantine architectural elements through the presence of the dome and the shape of the windows. The

ceiling of the mosque is plastered and painted, with colors and shapes of divine beauty. The dome does not exist at the other mosques in Dobrogea. The roof is made of wood, and the interior ceiling is beautifully decorated with planks. Ceilings in Islamic architecture represent heaven, and the presence of figures drawn on ceilings and walls is prohibited in Islamic architecture, as believers must have the power to imagine divine power. The prayers on their way to the prayer hall intersect with the door that represents the first element of the mosque, most of which are made of beautifully carved wood.

Fig. 2.4. Plastered and painted ceiling – Carol I mosque (author's photo)

Fig.2.5. Wooden ceilings – left: mosque from Cernavoda; - right: mosque from Medgidia[18]

Above the actual building and the minaret is the symbol of Islam: the crescent.

Fig.2.6. The crescent [108]

In some situations, the mosque construction is provided with a veranda, which can be made of wood or stone masonry and which can be found at the Esmahan Sultan Mosque in Mangalia in the wooden version. At the one in Harsova, from the research carried out, it appears that the veranda was abolished, observing the initial situation following an expertise of the facade. The analysis of the research project highlighted the fact that the mosque from Harsova had an open veranda similar to the one from the mosque from Isaccea and Babadag, which was later closed. At the Harsova mosque, access from the minaret is from the vestibule, similar to the situation in Medgidia. Unlike the other mosques in Dobrogea where the entrance from the minaret is from the upper gallery. Another veranda made in a mixed version can be found at the mosque from Isaccea, where the elements on which the roof rests are made of beautifully ornamented wood.

Fig.2.7. The mosque from Isaccea veranda

The lighting of the prayer rooms is achieved both naturally through the presence of a large number of windows arranged on one or two levels, and artificially. In the case of the Carol I mosque in Constanța, there are also windows at the level of the dome, thus creating a very good light. The sizes of the windows vary according to the constructive characteristics of the mosque: they are found both in circular form (Carol I mosque), rectangular or finished with arches at the top (Hunchiar mosque), rectangular (the mosque in Harsova and Cernavoda). Windows are usually arranged on the walls perpendicular to the wall where the niche is located, and on the wall in front of it. Unfortunately, the window frames have not been preserved from the construction until now, the vast majority of them having PVC frames but also wood or iron. The artificial method of lighting is achieved by using electric current. In the middle of the prayer halls there are large chandeliers and they have shapes that fit perfectly into the architecture of the prayer halls.

a)

b)

c)

d)

Fig. 2.8. Window types (author's photo) : a) mosque in Medgidia, b) mosque in Tulcea, c) mosque in Macin, d) Carol I mosque

As elements specific to the Islamic religion that we find in the architecture of the minarets are: the mihrab, the niche, the minber, the kursi.

The mihrab represents the place from where the imam holds his services and is distinguished by the presence of the niche, which is signaled by arches and domes and has the role of improving the acoustics of the service. The niche always faces the Muslim holy city of Mecca. The wall on which the mihrab and the niche are located is called the Qiblah wall, being the opposite of the wall where access to the prayer room is made. The decoration of the niches varies, with each mosque having a different niche. The mihrab is positioned in the middle of the Qiblah wall.

Fig. 2.9.1. Mihrab positioning

Fig. 2.9.2. Mihrab and niche – left: mosque in Cernavodă, right: Carol I mosque [108]

Minber (the big pulpit) comes from the Arabic "nebr" which means raising. It is an important architectural element of mosques, being the place from where the imam is better seen and better heard when he delivers sermons on Fridays and holidays. In the prayer hall it is located on the right side of the mihrab, being one of the most decorated or sculpted elements. The dimensions of the minber vary depending on the dimensions of the mosque and is shaped like a pointed and stepped tower.

Fig. 2.10. Minber – left: mosque in Macin; right: Carol I mosque (author's photo)

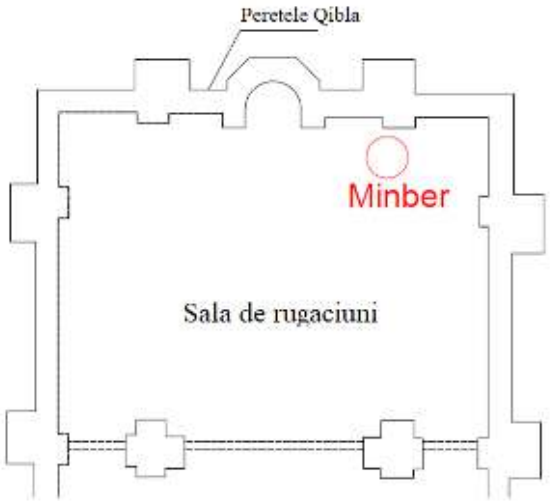


Fig. 2.11. Minber positioning

The Kursi (Small Pulpit) is where the imam delivers his sermons. It is located on the left side of the mihrab.

Fig. 2.12. Kursi – mosque in Babadag [108]

Fig.2.13. Kursi positioning

*2.1.2 **Minaret***

Etymologically, the phrase "minaret" comes from the Arabic "manarat", meaning "place of illumination", "lighthouse", the term being used both in Turkish (minaret) and similarly in French. The minaret is a particularly important component of a mosque, it expresses the cycle of existence, of ascent to purification, an aspect that justifies its geometric shape, i.e. a slender, high construction, with a balcony located near the top, and with a simple top cone-shaped or with a sphere ending in a crescent. The minaret can be attached to the mosque construction or it can be separated. Common structure, based on the facing expertise, we have identified the situation where the base of the minaret forms a common body with the mosque (Mangalia, Harsova, Babadag) as well as isolated, as is the minaret of the mosque from Macin.

The architecture of the minarets of Dobrogea was taken from the architecture of the Turkish minarets. The architectural and structural style of these construction categories varies greatly due to the construction materials used and the technologies used. In Dobrogea they are generally cylindrical or conical, based on a parallelepiped with a square base, and the transition from this shape to the circular one is made by means of a truncated cone. Their height varies between 20-40m with the specification that the glass in Mangalia had a 25-30m high minaret, and following the lightning strike of 1891, it was destroyed and rebuilt with a lower height. An image of the minaret with the higher height can be seen in the watercolor painting by Hector de Bearn in 1828, existing image in the library of the Romanian Academy.

The main components of a minaret are:

- Foundation;
- the parallelepiped base;

- the transition area;
- the round body which can be cylindrical or conical (the middle part);
- the spiral staircase that descends on the central shaft but also on the wall of the minaret;
- the central spindle;
- the balcony;
- the upper part of the body (its structure/roof, ornament, crescent);

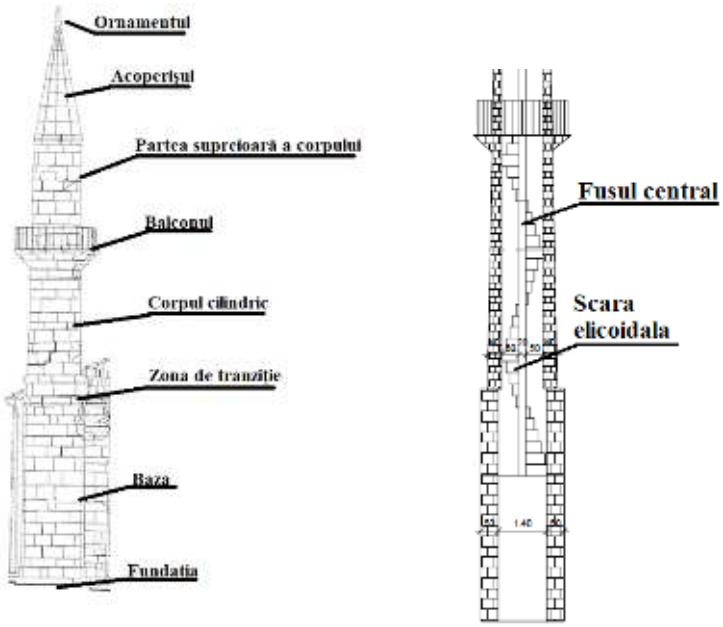


Fig.2.14. The minaret from Dobrogea components

2.2. Construction materials used for the mosques building. Execution techniques

The resistance structure of the existing mosques in the Dobrogea area is made of stone masonry, brick masonry, or a mixed system. The research carried out during the doctoral internship highlighted the fact that the materials used in Muslim worship places are closely related to the period of their construction, as follows: the oldest windows are made of stone masonry with or without mortar, the stone used is stone either from the ancient ruins of Greek cities either limestone or combinations of stone and brick.

2.3. The Esmahan Sultan Mosque from Mangalia

This building is one of the most important Muslim worship places in Dobrogea, built in 1573 by the daughter of one of the greatest sultans of the Ottoman Empire, Selim II, in memory of his father. It is located in Mangalia, in a protected historical value area. It is located about 200m from the Black Sea shores. The frost depth is 80 cm, and the foundations of the mosque and the minaret are located about 1,5 m from the ground level.

The construction has the following general characteristics:

- Site characteristics: corner period T_c = 0,7s and terrain acceleration a_g = 0,2g;
- Dimensions: 23,9m x 12,1m (including the veranda);
- Height regime: H_{reaves} = 5,2m, H_{roof} = 7,37m, $H_{minaret}$ = 15,39m;
- Built area: 312sqm (including veranda and minaret);
- The surface of the prayer hall: 193sqm.

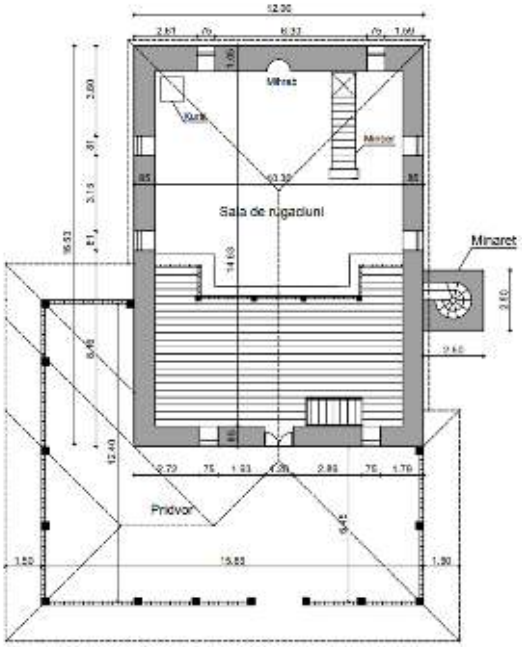


Fig.2.15. Esmahan Sultan mosque plan

2.4. The Hunchiar Mosque from Constanta

The mosque was built in 1862 by Sultan Abdul Aziz, the mosque was originally called Aziziye, today it is called Hunchiar, representing one of the emblems of Muslim religious architecture.

As a composition it consists of:

- Main building;
- Minaret.

Site features:

The mosque site has the following characteristics:

- from the land surface to a depth of 1,5… 2m there is a layer of fillings consisting of dusty clay, brown, with remnants of brick and rubble, shells and crushed stone;
- further up to 14,00 m deep there is a layer of clay dust (loess);
- between 14,00 and 20,00 m the maximum depth of the borehole is a layer of clay;

Up to a depth of 20m, the groundwater level was not intercepted and did not affect the construction foundations.

According to the norm P100-1/2013 the construction is classified in the second class of importance and exposure to the earthquake, having the coefficient $\gamma_i = 1.20$, the location has the following characteristics:

- land design acceleration $a_g = 0,2g$;
- amplification coefficient $\beta = 2,5$;
- corner period $T_c = 0,7sec$.

General characteristics of the construction:

- Dimensions: 14,8m x 12,5m;
- Height regime: $H_{reaves} = 6,70m$, $H_{roof} = 9,30m$, $H_{minaret} = 20,80m$;
- Built area: 225,49sqm;
- The surface of the prayer hall: 139,1sqm.

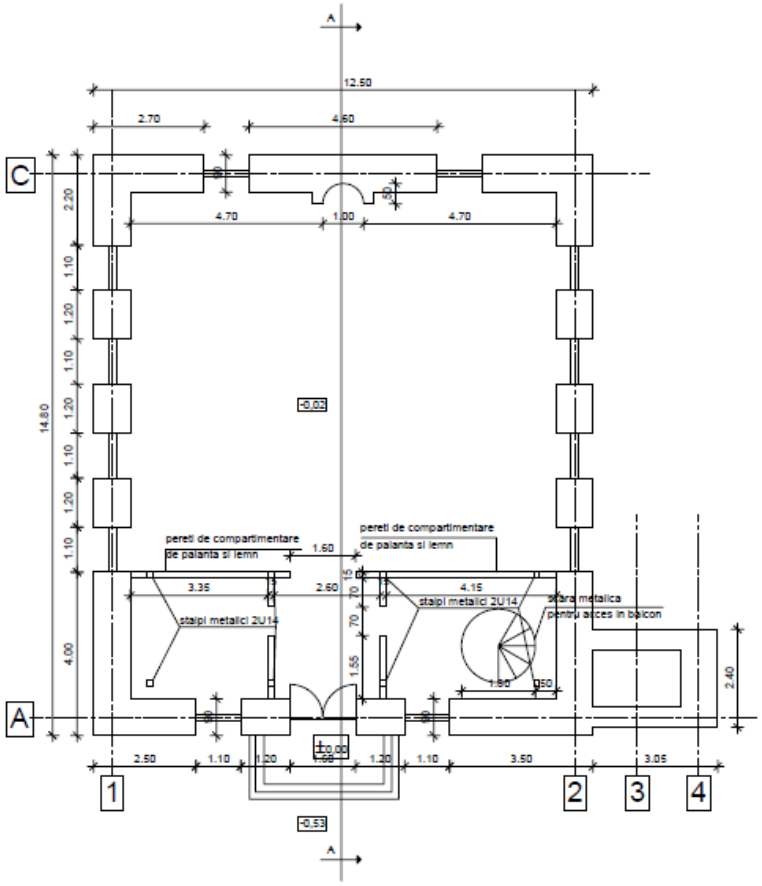


Fig.2.16. Hunchiar mosque plan

2.5. The Carol I Mosque from Constanța

The Carol I Mosque from Constanța was built in 1913 by the Romanian state, during the reign of King Carol I, which is why the mosque was named after the king, and is also known as the royal mosque. According to the documents on the site of the mosque, there was another older mosque before it was built, which was demolished and was named Mahmudia. The latter had been built by Sultan Mahmud II order.

The construction began in 1910, when the king decided to build a magnificent mosque in Constanța, the city with the largest Muslim population in the country. The architect Victor Ștefănescu, one of the most famous architects of the time, and the engineer Gogu Constantinescu, an exceptional inventor in the field of reinforced concrete that he used in the construction of the dome and the minaret, were hired to build the project.

According to the norm P100-1/2013 the construction is classified in the second class of importance and exposure to the earthquake, having the coefficient $\gamma_i = 1,20$, the location has the following characteristics:

- land design acceleration $a_g = 0,2g$;
- amplification coefficient $\beta = 2,5$;
- corner period $T_c = 0,7$sec.

General characteristics of the construction:

- Dimensions: 20,29m x 16,5m;
- Height regime: $H_{dome\ inf} = 20,64$m, $H_{dome\ sup} = 26,29$m, $H_{minaret} = 39$m;
- Built area: 628,44sqm (including basement);
- The surface of the prayer hall: 272,9sqm.

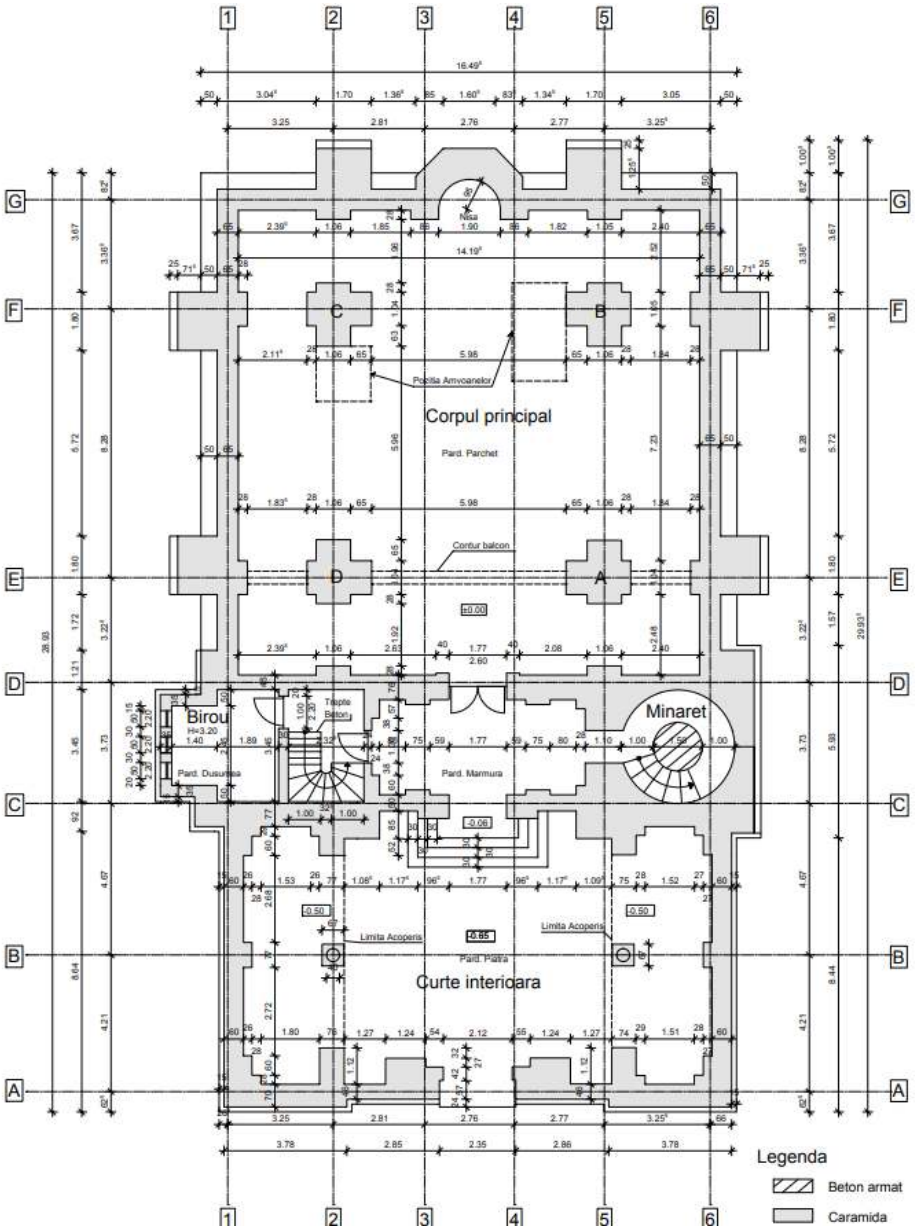


Fig.2.17. Carol I mosque plan, 1st level

2.6. The Gazi Ali Pasa Mosque from Babadag

The mosque was built in 1610 and is located in the center of Babadag, on the road between Constanța and Tulcea and more precisely on Geamiei street, number 2. In the courtyard of the mosque there is also the parish house, as well as the graves of General Gazi Ali Pasha and to Sari Saltik Dede. The Babadag Mosque impresses architecturally both inside and out. The mosque went through a fire during the Russo-Turkish War in 1771. After the fire, the roof and ceiling were replaced, additional doors were opened on the sides of the building, and a new minaret was built. The last restoration caused by the destruction is recorded in 1828 when the minaret was rebuilt, the ceiling and the roof were modified, two vestibules were added which were removed after approx. 160 years. The mosque had a museum function until 1989, and in 1990 the restoration works will begin.

According to the norm P100-1/2013 the construction is classified in the second class of importance and exposure to the earthquake, having the coefficient γ_i = 1,20, the location has the following characteristics:

- land design acceleration a_g = 0,20g;
- amplification coefficient β = 2,5;
- corner period T_c = 0,7sec.

The construction has the following general characteristics:

- Dimensions: 21,13m x 14,95m (including the veranda)
- Height height: H_{reaves} = 7,20m, H_{roof} = 9m, $H_{minaret}$ = 23m;
- Built area: 334sqm (including veranda and minaret)
- The surface of the prayer hall: 250sqm.
- The foundations of the mosque are made of stone masonry and are continuous under the walls of the mosque.

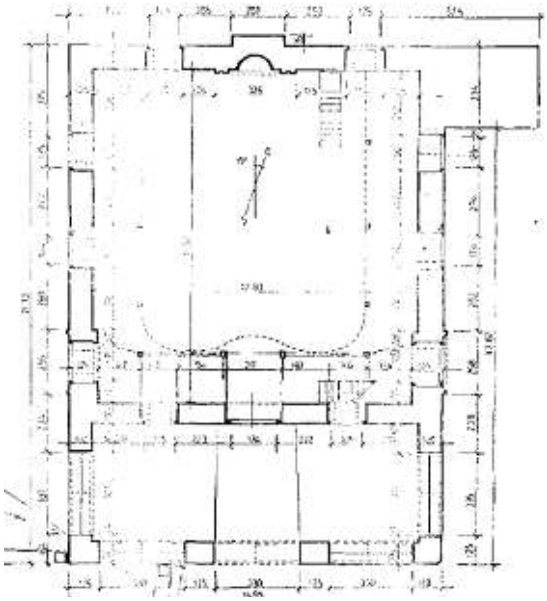


Fig.2.18. Mosque plan in Babadag [18]

2.7. The Hunchiar Mosque from Cernavoda

This mosque was built in 1756 during the reign of Sultan Osman III. It is a structure made of stone, and according to the documents the stone that was used to build the mosque, was used before to an old bridge over Carasu Lake. The mosque is located on Anghel Saligny Street, being very close to the Danube-Black Sea canal.

The building has the following general characteristics:

- site characteristics: corner period T_c = 0,7s and terrain acceleration a_g = 0,2g;
- Dimensions: 15,79m x 10,69m;
- Height regime: H_{reaves}= 5,7m, H_{roof}=7,7m, $H_{minaret}$=17m;
- Built area: 290sqm;
- The surface of the prayer hall: 163,32sqm;
- The foundations are continuous under the mosque walls, and are made of stone.

2.8. The Mahmud Yazigi Mosque from Isaccea

The Isaccea Mosque dates from 1771 and is located on 15 Decembrie 1918 street, number 15. It is an old mosque that over time was restoration works in 1886 and 1916. The building has a Mediterranean architecture made by foreign craftsmen and includes a room with a prayer hall.

According to the norm P100-1/2013 the construction is classified in the second class of importance and exposure to the earthquake, having the coefficient $\gamma_i = 1,20$, the location has the following characteristics:

- land design acceleration $a_g = 0,25g$;
- amplification coefficient $\beta = 2,5$;
- corner period $T_c = 0,7$sec.

The construction has the following general characteristics:

- Dimensions: 16,38m x 9,74m;
- Height regime: $H_{reaves} = 6$m, $H_{roof} = 8$m, $H_{minaret} = 20$m;
- Built area: 263,47sqm (including veranda and minaret)
- The surface of the prayer hall: 218,05 sqm.

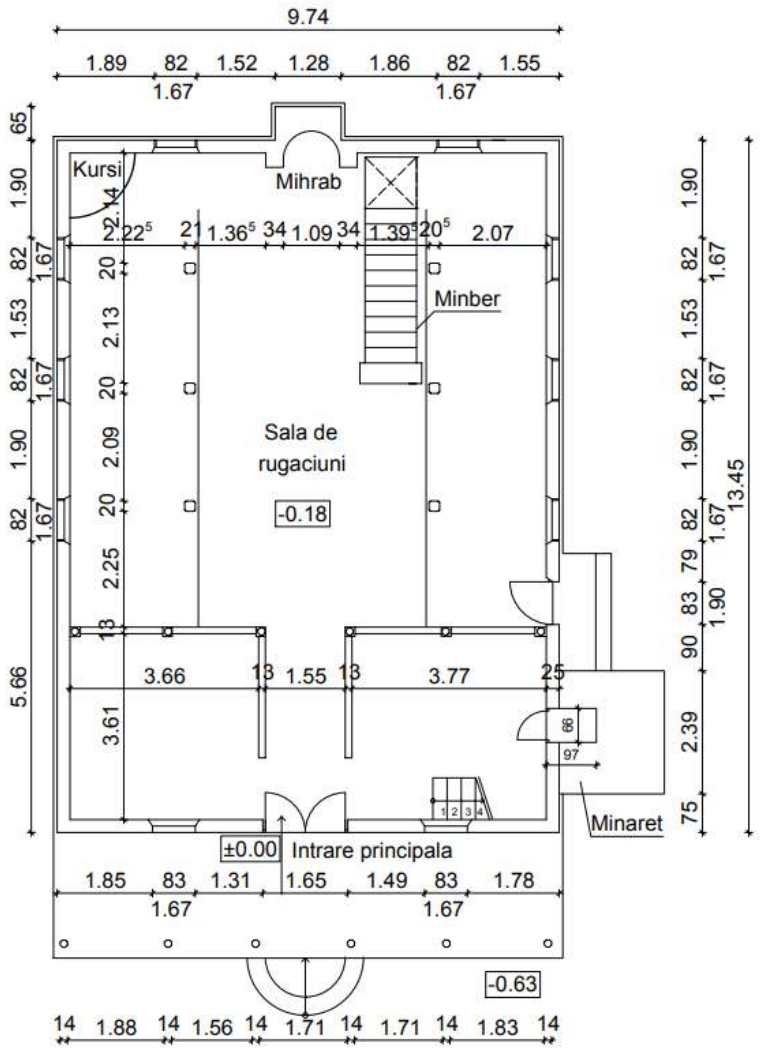


Fig.2.19. Mahmud Yazigi Mosque plan

2.9. The Sultan Mahmut Mosque from Harsova

The building is located in the city of Harsova on Vadului Street, number 8 dating from 1812. Harsova over time was a city shaken by military actions in the century. XVIII and XIX, being set on fire during the First World War. Along with the city also the mosque, it suffered massive damage, which led to the loss of much of its original appearance. In the years 1967-1969 repair works were carried out and later, at the beginning of the century. XXI the facade has been restored

According to the norm P100-1/2013 the construction is classified in the second class of importance and exposure to the earthquake, having the coefficient γ_i = 1,20, the location has the following characteristics:

- land design acceleration a_g = 0,25g;
- amplification coefficient β = 2,5;
- corner period T_c = 1,0sec.

2.10. The Sultan Abdul Mecid from Medgidia

The Sultan Abdul Mecid Mosque is one of the largest buildings of its kind in Romania, being built between 1860-1861 and is composed of two distinct bodies, located on Decebal Street, number 10. The mosque, built by Muslim craftsmen brought from Turkey , has a rectangular shape, close to the square.

In accordance with norm P100-1/2013, the location of the building has the following characteristics:

- land design acceleration a_g = 0,20g;
- amplification coefficient β = 2,5;
- corner period T_c = 0,70sec.

The building is classified in the second class of importance and exposure to earthquakes, and has a coefficient of γ_i = 1,20, the building is a hall-type construction, and it's included to the national cultural heritage.

The construction has the following general characteristics:

- Dimensions: 25,00m x 18,40m (including the veranda);
- Height regime: H_{reaves} = 8,30m, H_{roof} = 11,20m, $H_{minaret}$ = 25,57m;
- Built area: 546,23sqm (including veranda and minaret);
- The surface of the prayer hall: 390,15 sqm.

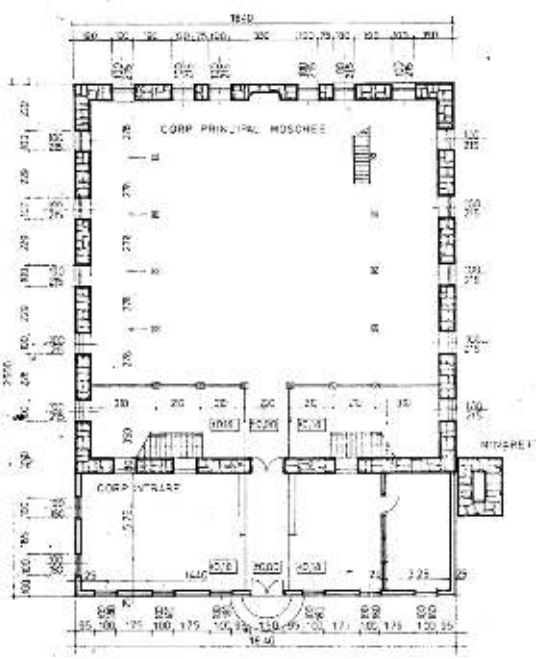


Fig.2.20. 1st floor – Medgidia Mosque[18]

2.11. The Mestan Aga Mosque from Macin

The Mestan Aga Mosque from Macin was built in 1860 by Hagi Berbe Ahmet, about 20 years after the appearance of the Macin community in Tulcea County.

The construction site has the following characteristics:

- land design acceleration a_g = 0,25g;
- amplification coefficient β = 2,5;
- corner period T_c = 1,0sec.

According to the norm P100-1/2013, the building is classified in the second class of importance and exposure to earthquakes, with a coefficient of γ_i = 1,20, the building is a hall-type construction, and it's included to the national cultural heritage.

The mosque foundations are made of limestone masonry and are continuous, made under the mosque walls. The frost depth for this site is 80cm.

The general characteristics of the construction are the following:

- Dimensions: 17,1m x 9,00m

- Height regime: H_{reaves} = 5,10m, H_{coama} = 7m, $H_{minaret}$ = 21m;
- Built area: 250sqm
- The surface of the prayer hall: 211,26 sqm.

2.12. The Azizie Mosque from Tulcea

The mosque was built in 1865, having its location on Independentei street, number 2 and called the cathedral due to its historical and cultural importance. It is one of the largest mosques in Dobrogea built by the Ottoman Empire and comparable to the mosque from Medgidia. The rectangular structure in the plan was built by Ahmed Rezim Pasha, during the reign of Sultan Abdul Aziz.

Like any old construction, it has been included in numerous destructive actions of the environment that have led to the degradation of the mosque. For example, 75 years ago the roof was torn off by the wind and replaced with a more moderately sloping roof with awnings.

The mosque passed a restoration process in 1971, carrying out roof repair work, carpentry, interior and exterior work.

According to the norm P100-1/2013 the construction is classified in the second class of importance and exposure to the earthquake, having the coefficient γ_i = 1,20, the location has the following characteristics:

- land design acceleration a_g = 0,25g;
- amplification coefficient β = 2,5;
- corner period T_c = 0,7sec.

The construction has the following general characteristics:

- Dimensions: 18,92m x 18,91m;
- Height regime: H_{reaves} = 7,13m, H_{roof}= 9,73m, $H_{minaret}$ = 21,03m;
- Built area: 597,66sqm;
- Area of the prayer hall: 457sqm.

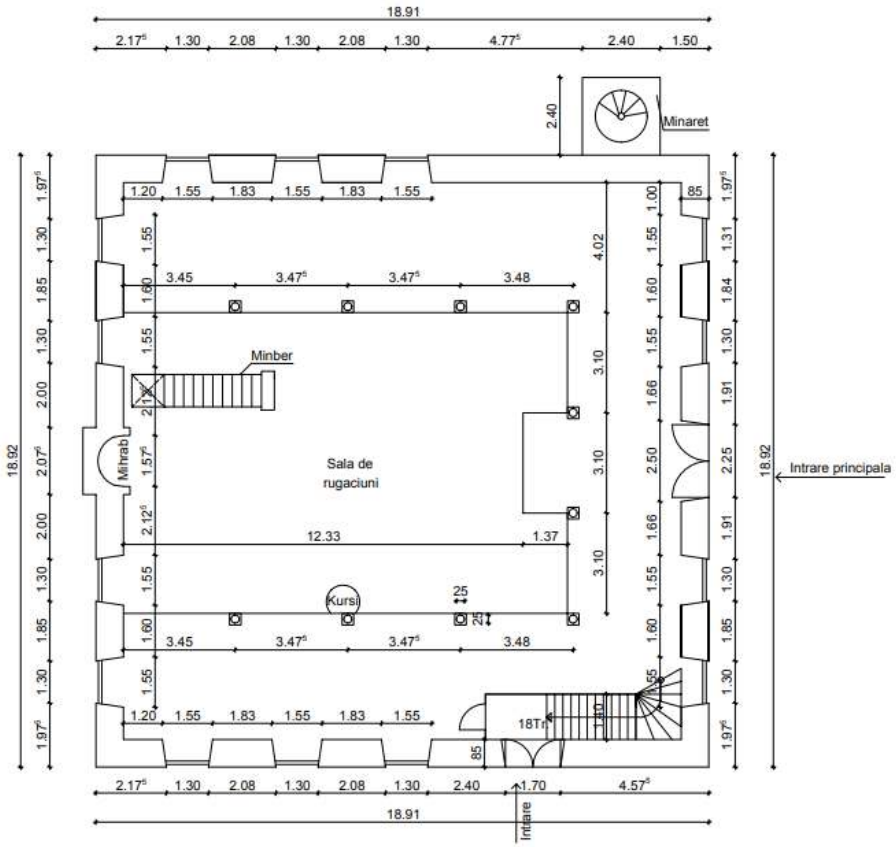


Fig.2.21. Azizie Mosque plan

2.13. The Giuma Mosque from Amzacea

Giuma Mosque is located in the village of Amzacea, the year of construction being recorded at 1850. The construction has a structure made of limestone masonry. Throughout its existence, the mosque has been the target of bombings during the Russo-Turkish wars. Thus, until 1917, the mosque kept its shape, when after a bombardment the minaret collapsed. The minaret was rebuilt only after 10 years, in 1927, but with a much lower height.

Chapter 3. Studies and research on the investigation techniques of the Muslim worship places classified as a historical monument on the Dobrogea territory

3.1. Introduction

The purpose of this chapter is to present the investigation methodology adopted within the research project for the Muslim worship places in the Dobrogea territory. These investigations were carried out for each mosque separately, aiming at the following objectives:

- identification of the resistance structure;
- infrastructure identification;
- identification through stratigraphic expertise of the finishes and also of the materials used;
- identification of the changes brought over time by means of expertise.

3.2. Degradation and damage types. Occurrence causes

3.2.1. Degradation and damage to minarets

Degradation and damage to minarets affect both the elements of the strength structure and the elements of the finishes. The main degradations encountered in the minaret area are:

- breaking masonry stones;
- binding mortar degradation;
- interior paints exfoliation;
- plasters exfoliation;
- the cracks appearance in the plaster;
- biological colonization;
- efflorescence;
- constituent materials erosion.

In the upper part of the Hunchiar mosque minaret, the masonry is severely affected due to the destructive factors of the environment, but also due to some exceptional actions. The lack of masonry mortar is very visible in many areas, due to its disintegration. The minaret is exposed to a very aggressive marine environment, and due to the high porosity of the masonry stones, substances such as water, dust, bacteria penetrate into the mass of the stones, which give rise to chemical reactions that lead to the grinding and detachment of the mortar, but also to the masonry stones alteration. Also, under the balcony, areas with chromatic alteration due to the

trickling of meteoric waters may be visible. Around the middle of the minaret its visible the appearance of plants, whose roots cause stress in the masonry and lead to the microcracks appearance. And also another problem is that water is retained by the plant organisms roots. Another degradation observed at the level of the minaret is the corrosion of the sheet metal covering, and its detachment in some places. It is subject to very aggressive environmental factors such as wind, torrential rain and hail.

Fig.3.1. Hunchiar Mosque Minaret (author's photo)

3.2.2. Degradation and damage to exterior walls

The main cause that affects the walls resistance structure of the building itself is the foundation ground. Due to the weak foundation ground, stresses and deformations arise in the resistance structure of a mosque, which lead to cracks in the masonry elements, also lead to mortar detachments and endanger the entire stability and usefulness of the worship place.

As an example, the Esmahan Sultan mosque from Mangalia is located on a terrain represented by a non-uniform lithology, consisting of brown clay fillings, limestone boulders and even ancient walls. Prior to the 2008 restoration of the mosque, a number of degradations such as cracks and fissures were discovered due to uneven settlements. It was also found that there was a movement of the mosque in a northeasterly direction, which was not dangerous, being highlighted by some cracks and swellings of the ground, on the northeast and north sides. Another factor that endangers the structure stability is the meteoric waters, which enter to the ground on the contour of the mosque.

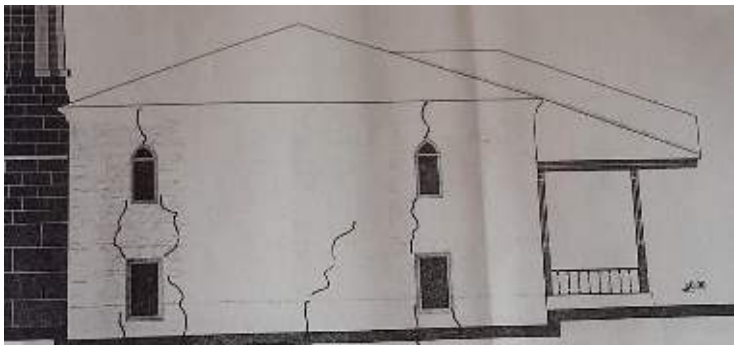


Fig.3.2. Sketch with cracks in the walls on the south side – Esmahan Sultan Mosque [1]

More than 10 years after the last restoration, cracks in the masonry stones reappeared on the walls, due to uneven settlement. Another phenomenon that occurs on masonry stone is disintegration. It is a phenomenon that can affect both the surface of the stone and its depth, and the destruction generally starts from the surface of the material.

Fig.3.3. The cracking and disintegration of masonry stones – Esmahan Sultan mosque (author's photo)

Other degradations in the masonry walls, which were observed at the Esmahan Sultan mosque in Mangalia, are:

- Cracks appearing in the masonry mortar, both in the area of the windows and on the rest of the surface;
- Mortar separation in several places;
- Chromatic alteration at the base of the walls, and biological colonization caused by high humidity;

3.2.3. Degradation and damage to interior components

The degradation of the interior finishes of the mosques differs from one case to another depending on the causes of their appearance, but also on the constituent materials of the surfaces

where appear these degradations. The main cause of degradation as well as on the outside is high humidity.

At the Carol I mosque, many areas with exfoliated paint were found both on the walls and in the dome area. Due to water infiltration in the area of the dome windows, the decorative elements of the painting have been erased. And in the case of the mosques from Cernavoda, Mangalia and Tulcea, the high humidity is the cause of degradation of the interior finishes at the base of the walls and around the windows.

Fig.3.4. Carol I Mosque – degraded areas of interior walls (author's photo)

Fig.3.5. Carol I Mosque – degraded areas on the dome (author's photo)

3.3. Analysis methods in the structural evaluation of Muslim worship places

The structural analysis of Muslim worship places was carried out through a proprietary methodology for identifying the characteristics of each building, analyzes carried out within the framework of the qualitative assessment, which was based on the provisions of the P100-3/2019 standard with the criteria and procedures contained therein. Appreciating that the Muslim worship places by their way of composition do not contravene the current regulations, the structural analysis was carried out using the procedures recommended in P100-3/2019. The basic principles were to identify an acceptable degree of confidence for the protection of life and integrity of individuals, as well as maintaining their functionality without interruption.

Although the effectiveness of seismic protection measures presents a degree of uncertainty, however, through the investigations carried out within the research project, I sought to reduce this uncertainty by approaching a level of knowledge corresponding to the adoption of a minor degree of risk. In this context, the qualitative assessment was carried out on the basis of research and studies, some engineering knowledge and knowledge of the constituent materials. In this context I analyzed:

- The plan geometry of the building through measurements and investigations;
- The geometry in space of the building;
- Identification of the structure of walls, foundations, floors and frames;
- Relief of visual degradations;
- Studies and research on the intervention works carried out and the way in which they had a positive contribution on resistance and stability;

All these procedures were based on a set of operations that consisted in the collection of information from an architectural, structural, historical point of view, of the artistic components, both from the historical records of the mosques (reports published in different situations) but also research comparisons made by me both for the mosques from the Dobrogea area and in conjunction with the mosques from other areas. In this context, valuable information was obtained by analyzing the behavior of the mosques in Turkey, given the fact that both those in Romania and those in Turkey have a comparable seismic location. From the point of view of the evaluation methodology, we can appreciate that the studies and research carried out within this project have allowed level 2 and 3 evaluation methodologies that confer a high level of complexity based on the studies and research undertaken.

Considering that the mosques of Dobrogea are historical monuments of class A, the inclusion in the class of importance, according to the normative P100-1/2013, was in class II, which confers the adoption of the coefficient $\gamma i = 1.20$. In the application of the evaluation methodology, the recommendations contained in the P100-3/2019 standard were taken into account, in conjunction with the performance requirements imposed by the legislation in force.

A special problem arises with the mosque structures that have the structure of the prayer hall solidly connected with the structure of the minaret. It seems that this concept was beneficial to the seismic behavior by helping to limit the displacements corresponding to the hall.

In the framework of the qualitative assessment, we determined the extent to which the rules for general compliance of structures and detailing of structural and non-structural elements are respected for the studied constructions. The most important criteria for establishing structural interventions as well as establishing consolidation solutions were mainly their

behavior over time, seeking to eliminate first of all the causes that led to the appearance of degradations. In the framework of the evaluation, we looked for the following conditions for the studied constructions:

- conditions regarding the load route;
- conditions regarding redundancy;
- conditions regarding the building configuration;
- conditions regarding the interaction of the structure with other constructions or elements;
- conditions related to springs;
- conditions related to non-structural components;
- specific composition conditions for different categories of structures;
- conditions regarding infrastructure and foundation land.

In the structural analysis we addressed both the preliminary qualitative assessment and the detailed qualitative assessment.

The quantitative evaluation took into account the provisions of Annex E of the P100-3/2019 standard, applied with certain limiting conditions, especially when establishing behavioral factors. Overall, the structure of the mosques is a heavy structure, which must be considered both from the point of view of the classification criteria as a historical monument, but also from the point of view of modeling the structural behavior, of their verification. The methodology applied was for the prayer hall the level 1 methodology using simplified calculation methods, and the checks were done at SLU, and for the minaret, the level 2 methodology was applied, making checks at SLU and SLS. In the structural calculation, the elastic response spectra of the accelerations with the ordinates reduced by the behavior factor q were considered. The vertical distribution of seismic forces used 2 methods: the method of equivalent static forces, and the method of finite elements. The determination of the values of the journeys to SLS was made according to the norm P100-1/2013.

The structural evaluation was actually carried out on the case study –Hunchiar mosque.

Chapter 4. Studies and research on intervention work measures on these types of constructions

4.1. Introduction

Intervention works on the mosques classified as historical monuments must be adopted depending on the importance of the monument, the average period of return of the design earthquake, and the type and degree of damages but also the causes of degradation. The proposed interventions must be effective and efficient, by conducting demonstrations through qualitative and quantitative checks. The work measures must be compatible with the architecture, technology and chemical and mechanical composition of the original building materials in order to preserve the originality of the building. Another condition that must be observed in the selection of works is the durability of the materials and execution procedures, similar to the original ones. Reversibility will also be considered in the sense that the intervention must be as reversible as possible so that it can be removed if a different solution is adopted in the future.

In the specialized literature, the following terms are found in the intervention processes: restoration, repair, conservation and consolidation works. They are defined as follows:

- restoration - reconstruction in the original form of a historical monument;
- conservation - maintenance in an unaltered state of the construction through specific works;
- consolidation - the operation by which it increases the load-bearing capacity of a construction;
- repair - work aimed at raising the level of structural safety of the building;

Also, depending on the complexity of the intervention works, they can be classified as follows:

- individual intervention works, this category includes works that are performed on a small number of elements;
- works of general construction interventions, including interventions on a large number of structural elements and can be executed with the maintenance of the existing structural system or with the modification of the existing structural system.

The condition to be met by the structure is that the seismic action has a value less than the load-bearing capacity of the structure. To ensure this condition it is necessary to adopt solutions such as: reducing seismic requirements, improving the mechanical characteristics of the structure, or by combining these measures.

In the case of reducing seismic requirements, a number of measures can be adopted to reduce design seismic forces or to reduce displacement requirements. The reduction of seismic forces can be done either by increasing the rigidity properties by increasing the dimensions of the structural elements and/or introducing some elements, or by using shock absorbers in the structural system, which by absorbing and dissipating a significant part of the seismic force induced in the structure, limit the efforts which belong to the structural elements.

The improvement of the mechanical characteristics of the structure can be done by adopting some measures that lead to the increase of the resistance of the structural elements, usually in the structures with deficit of deformability in the post-elastic field, to the extent that the improvement of the ductility properties is practically difficult to achieve. It can also be adopted to increase the stiffness to lateral forces and increase the deformation capacity in the post-elastic range.

4.2. Consolidation works

The consolidation works are aimed at increasing the strength, rigidity and ductility of the structure. The application of consolidation works is done by introducing additional structural elements only in cases where the original structure does not meet the seismic safety conditions. These works are used within a single element or structural subassemblies or within the entire structure.

The purpose of applying these works to Muslim places of worship is to reduce the probability of significant damage in a subsequent earthquake, and to increase the operating time of the building until reaching the minimum admissible level of safety.

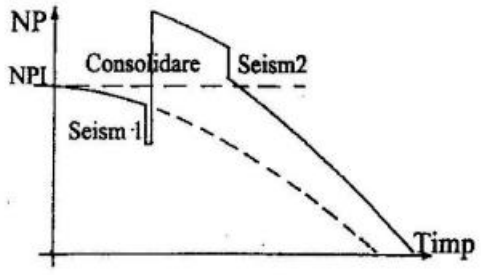


Fig.4.1. Consolidation works effect [149]

In 2008, restoration works were carried out on the Esmahan Sultan mosque in Mangalia, and as a measure to strengthen the walls, the introduction of 8 drilled belts with a diameter of 84mm, having as reinforcement a bar with a diameter of 36mm, steel PC52, was adopted. These belts were positioned two by one, in each of the 4 walls, in their middle part, being arranged at

the elevation of the foundations, and at the middle level of the construction, above the windows of the lower register.

A perimeter belt of reinforced concrete was also executed, in which the floor of the building was embedded to produce the effect of a rigid washer on the upper part of the construction.

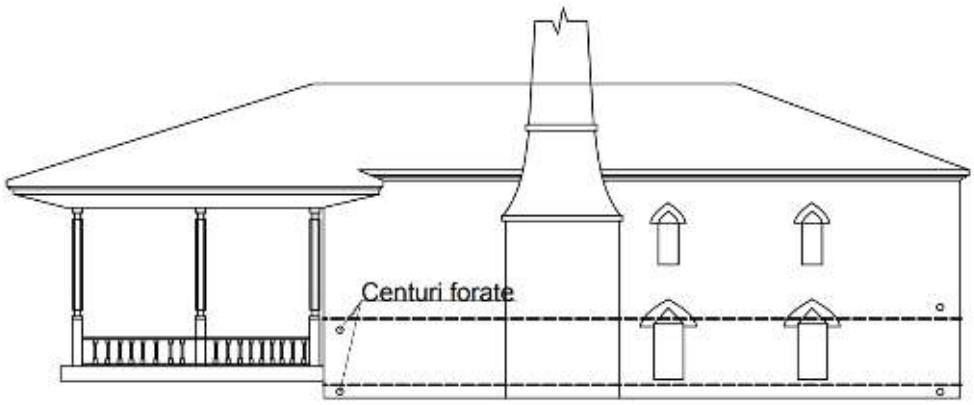


Fig.4.2. Perforated belts arrangement plan – Esmahan Sultan mosque

Other types of strengthening works were also proposed in the case of the Hunchiar mosque in Constanța by introducing horizontal bars of special stainless steel with a diameter of 16 and 20 mm, in drilled galleries, arranged above and below the level of the windows in the building area. Also, in the case of this mosque, it was proposed to build a belt of reinforced concrete at the level of the bridge above the height of the mosque walls, connected to the mosque walls with special stainless steel mandrels with a diameter of 16mm, to which the wooden roof structure will be connected.

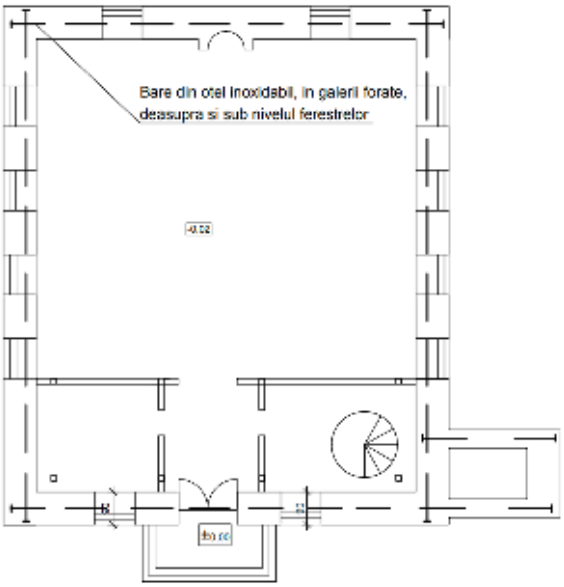


Fig.4.3. Plan with the arrangement of steel bars on a horizontal plane - Hunchiar mosque

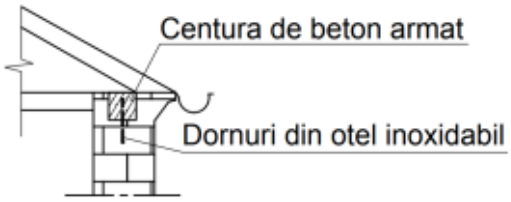


Fig.4.4. Belt positioning detail at the top of the walls – Hunchiar mosque

Another form of consolidation that is included in this study is the proposal to consolidate the Hunchiar mosque minaret from the technical expertise of 2017. The minaret reached a very advanced form of degradation as a result of the lightning strike, which led to detachment of masonry elements.

So it was proposed to dismantle the masonry of the minaret up to the height of the balcony, and then restore the masonry to be done with stones that show good resistance, and that do not show signs of degradation. Masonry elements that can no longer be used are replaced with elements that have the same characteristics. As a strengthening measure, the introduction of galvanized steel bars with a diameter of 12 and 16 mm, respectively, in drilled galleries located below the level of the balcony and up to +7.00 level is proposed. It is also proposed to build two concrete belts, one at the level of the balcony and one at the top of the minaret walls.

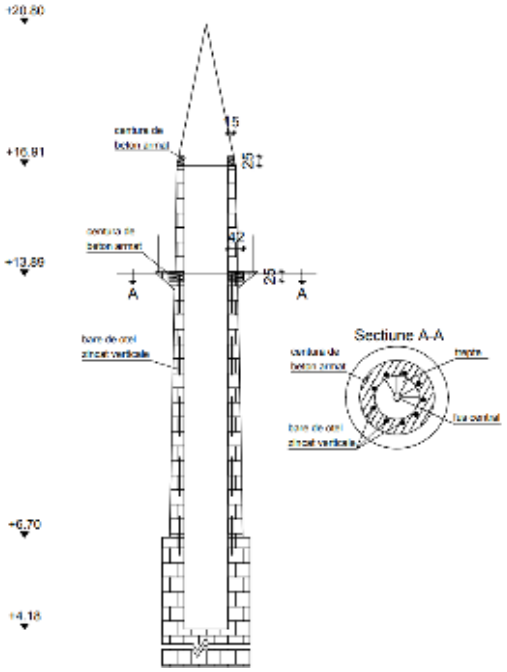


Fig.4.5. Minaret consolidation – Hunchiar mosque

4.3. Repair works

Repair interventions are recommended in the case of constructions with weakly affected masonry, generally for degradation due to non-seismic causes, or can also be performed in the case of constructions with serious damage, these being as preparatory measures for further consolidation works.

The purpose of carrying out the repair work is either to return to the level of structural safety available at the time of the last earthquake, or to return to the level of initial structural safety or as close as possible to its level. This can extend the life of the building beyond the projected duration.

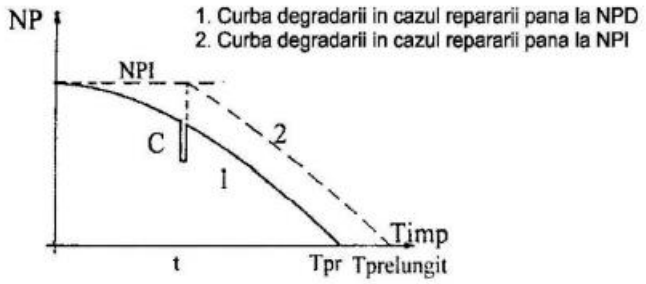


Fig.4.6. Repair works effect [149]

The intervention types are chosen according to a number of factors such as:

- masonry typology;
- available technological processes;
- the construction degradation state due to seismic and/or non-seismic causes.

4.4. Conservation measures for Muslim worship places

In-depth knowledge of the causes of mosque damage, as well as knowledge of the techniques of building and restoring these types of buildings can lead to the preservation of these buildings, which can maintain the life and operation of the building, as long as possible. Properly applied conservation procedures can also have a favorable effect on the economic factor, as intervention works will be done less frequently.

Inside the building, conservation measures must combat the appearance of condensation, the result of a decrease in temperature as a result of which the relative humidity increases, reaching the so-called dew point. Instead, on the outside, conservation measures must combat the action of climatic and atmospheric environmental factors.

Preservation techniques are also adopted depending on the constituent materials, such as stone, brick, wood, concrete, metal. The implementation of these conservation measures

must be taken with particular care so as not to accelerate the occurrence of degradation and its further development.

Chapter 5. Case Study – Structural analysis of Hunchiar Mosque from Constanta

5.1. Introduction

Fig. 5.1. Hunchiar mosque (author's photo)

Following the investigations according to the investigation stages presented in the study, the results necessary for the structural and functional mosque analysis were thus obtained.

The mosque shape is rectangular with the dimensions of the sides of the actual construction of 12,5m x 14,8m. The minaret on the southern side is attached to the nave and has a parallelepipedal shape with plan dimensions of 2,60m x 2,28m. The height of the ship is +6,70m at the cornice compared to the elevation ± 0,00, the maximum height at the crest being 9,30 m compared to the elevation ±0,00. The maximum height at the top of the minaret is 20,8m from the elevation ±0,00.

The construction is made of stone masonry, the main building walls having a thickness of 90 cm, and the walls of the minaret having a thickness of 50 cm at the base and a thickness varying between 40 and 20 cm on the height of the minaret. In the area of the minaret balcony the consoles have a thickness of approx. 80cm.

The floors and the frame are made of wood, and the roof is made of tiles. According to the documentation, the structural materials used are shaped stone (sandstone or limestone) with a compressive strength of 45 daN / cm2, and lime mortar brand M15.

According to the norm P100-1 / 2013 the construction is classified in the second class of importance and exposure to the earthquake, having the coefficient $\gamma_i = 1,20$, the location has the following characteristics:

- land design acceleration $a_g = 0,2g$;
- amplification coefficient $\beta = 2,5$;
- corner period $T_c = 0,7$sec.

The behavior factor *q* established for simple masonry structures is 1,50.

According to the norm MP025-04, the construction is included from a structural architectural point of view to the category of "hall type" constructions, and, from a functional point of view, the building is included into the category of "cult constructions".

Due to a comprehensive research from both documentation and field inspections, a confidence factor of CF = 1,10 was taken into account, an intermediate value between a complete and a normal knowledge.

According to CR 1-1-3/2012, the characteristic value of the snow load on the ground is 150 daN / m2.

According to CR 1-1-4 / 2012 the reference wind pressure is 50 daN / m2.

The maximum frost depth for the construction site according to NP112-2012 is 80-90cm.

The methodology that is applied in the case of the evaluated mosque is level 2 due to the fact that this methodology applies to all buildings with structural walls of unreinforced masonry and masonry confined with floors without significant rigidity in the horizontal plane, regardless of seismic area and height regime.

Level 2 methodology consists of:

- detailed qualitative assessment;
- evaluation by calculating the equivalent static seismic forces method or the modal calculation method with response spectra, for the effects of seismic action in the plane of the walls;
- evaluation by calculation for the seismic action perpendicular to the plane of the walls.

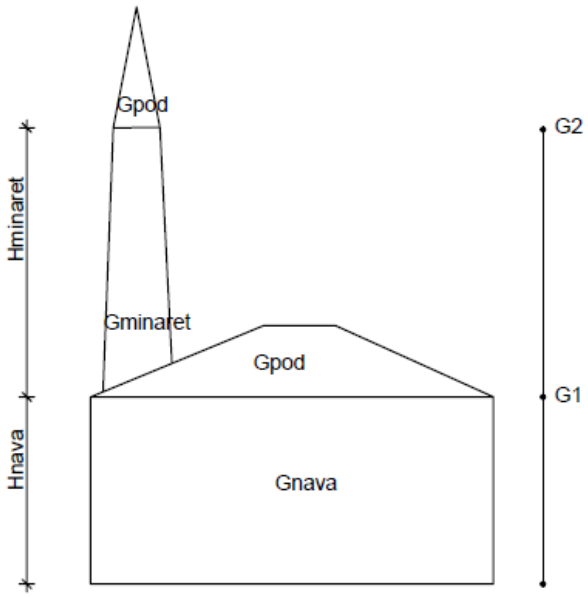


Fig.5.2. Weight distribution on the building height – Hunchiar mosque

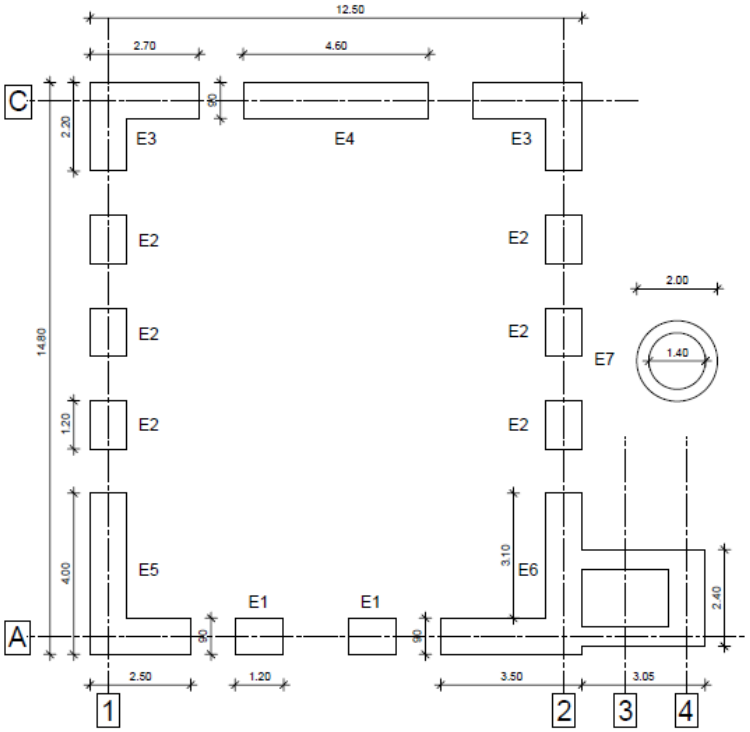


Fig.5.3. Structural elements scheme – Hunchiar mosque

THE STRUCTURAL MODELING RESULTS OF THE HUNCHIAR MOSQUE FROM CONSTANTA

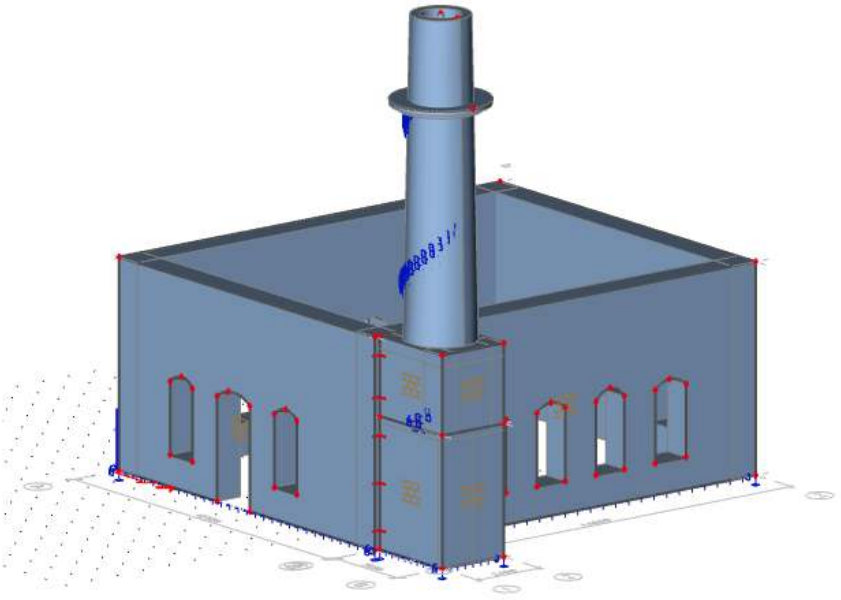


Fig.5.4. Structure modeled shape

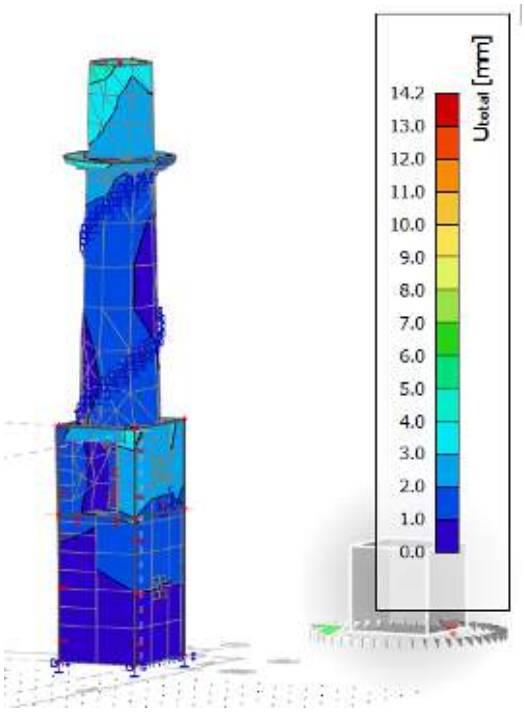


Fig. 5.5. Minaret deformed shape

Chapter 6. Final conclusions

As part of this research project, we conducted studies and researches for each mosque in terms of the materials and technologies used. At the same time, the research focused on architectural elements for both the prayer hall and the minaret.

The research carried out is original, there are no analytical sheets for each objective until now with detailed records highlighting in detail the criteria of authenticity, rarity and uniqueness. All these obtained results were based on my personal identifications but also a deepening of knowledge by consulting archival documents, specialized publications and many historical publications. In addition to the identification elements that can be detached, an element of originality is the comparative analysis, between the mosques from Dobrogea and other mosques from the various countries presented in the attached Analytical Sheets. Starting from a major objective – the importance of the conservation and restoration of the mosques, what is the state of degradation of each individual construction and what restoration, repair and consolidation measures have been adopted since the building up to the present day, the research aimed to identify materials, technologies and the behavior of these types of constructions over time, through specialized studies (geometry, excavations, analyses), but also to develop knowledge for the adoption of intervention measures compatible with the constituent materials. Thus, I went through the following stages quantified as elements of originality of my research:

- The research of each mosque with the preparation of documentation, surveying, photography, identification of degradations, a historical study, as well as the historical evolution of the interventions;
- The study of existing documentation in the archives of the National Institute of Heritage, in the archives of the Muslim community, state archives, in the national and international specialized literature;
- Preparation of analytical sheets completed with the elements of originality of each construction but also with the common or different aspects for the windows: the Esmahan Sultan mosque from Mangalia, the Hunchiar mosque from Constanța, the Carol I mosque from Constanța, the Gazi Ali Paşa mosque from Babadag, the Mahmud Yazigi mosque from Isaccea, the Mosque from Cernavodă, the Mestan Aga mosque from Măcin, the Azizie mosque from Tulcea, the Sultan Abdul Mecid mosque from Medgidia;
- Comparative study of the construction technology, their geometry, the defining elements of the balconies or the roofs of the minarets;

- Elaboration of a complete case study with qualitative and analytical evaluation both for the construction of the mosque and separately for the minaret;
- The use of a real mathematical model as a result of the research carried out based on finite elements within a modeling program to determine the deformations of the minaret;
- Promoting a set of measures for conservation, protection, restoration;
- Highlighting in the content of the analytical sheets some new elements that can be developed in the future and respectively researched, by other PhD students in the framework of future projects;
- Through the results of the obtained research, a particularly valuable material was created that can be constituted in a guide for the Muslim worship places restoration as well as in a guide for their administration, very useful for administrators;
- The premises were created for the initiation of collaborative research project relationships for this category of constructions with all the states that have a rich national heritage and whose similar constructions are located in seismic risk areas;

ANALYTICAL SHEET – monument research

These analytical sheets represent the synthesis of the research activity related to objectives 1,2,3,4 of the doctoral research project

They were drawn up based on the structure of the DJC Constanța classification sheet, the information from the materials from the INP Bucharest records, the consulted bibliography, and the investigations carried out within the research project.

Original contributions of the author of the doctoral thesis

ESMAHAN SULTAN MOSQUE

1.IDENTIFICATION

1.1.	Code HML	CT-II-m-A-02901.01
1.2.	CategorY	National or universal value, architectural monument
1.3.	Official name	Esmahan Sultan Mosque

2.ADMINISTRATIVE LOCATION

2.1.	Country	Romania
2.2.	District	Constanta
2.3.	City	Mangalia
2.4.	Geographical references	In the Mangalia center, south of Mangalia House Culture

3.DATING

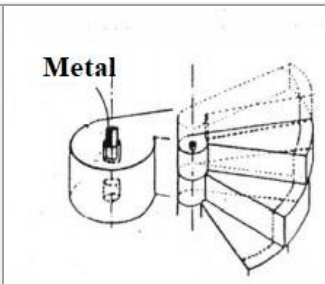
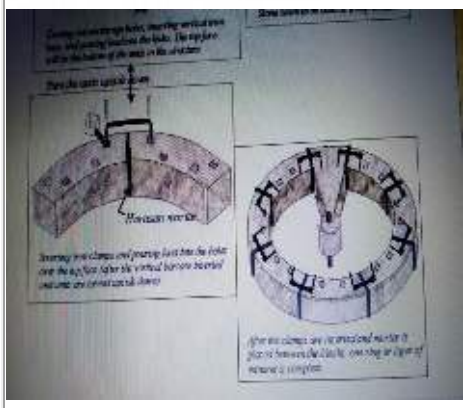
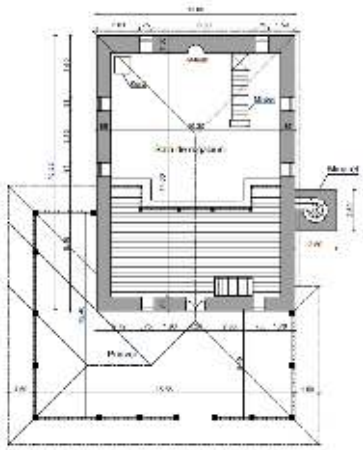
4.1.	Era	
4.1.1.	Start date	1590 (some historical sources 1573)
4.1.2.	Date end	
4.2.	Dating by periods	
4.3.	Dating by date ranges	
4.4.	Precise dating	

5.HISTORIC. PERSONS AND EVENTS ASSOCIATED WITH THE MONUMENT HISTORY

5.1.	Historic	-
5.2.	Author	-
5.3	Limited Partner	-
5.4.	Founder	Esmahan Sultan, in honor of her father Selim II
5.5.	Worker	-
5.6.	Painter	-

6.DESCRIPTION

6.1.	Actual functionality	Muslim worship place
6.2.	Plan	Rectangular shape
6.3.	Facades	Polished exposed masonry
6.4.	Roof shape	Pitched roof
6.5.	Anexes  	Veranda – unique for this mosque. The veranda is made of oak wood.
6.6.	Structure	Masonry structure
6.7	Building material	Carved limestone
6.8.	Roof building material	Wooden frame, wool covering
6.9.	Building techniques	Limestone masonry carved by Turkish master masons with manual technology, the masonry is bound with metal screeds, but lime-sand mortar is also found. It is the only

	 	mosque that uses cast-in-place steel frames, both in the minaret and in the construction itself for tying the stones. It is the only mosque in Dobrogea where this technology is found. The mihrab is made in Moorish style. 
6.10.	Characteristic elements – uniqueness Identified in the research 	Mihrab architecture in the Moorish style; Bonding stone blocks with metal; The niche in the ceiling that provides acoustics; The veranda before the entrance; The use of prefabricated elements in the construction of the staircase from the minaret;
6.11.	Dimensions 	Length: 23,9m, width: 12,1m Built area (including veranda and minaret): 312 sq m Area of the prayer hall: 193 sq m Height of the building: 7,37m

7. CONSERVATION, RESTORATION, THREATS

7.1.	General conservation state	Very good working condition
7.2.	Previous restoration work	2008 –walls, minaret and roof consolidation ABRAL ARTPRODUCT S.R.L. București, Botez Aurel Ioan Eugen, Dobrescu Gheorghe, Spoială Laurențiu, Moldoveanu

		M. Clement, Sion Gheorghe, Braghină Nicolae, Pavel Gh. Constantin, Popescu Greacă Alexandru – Consolidare-restaurare Geamia Esmahan Sultan din Mangalia, No. Project 10/2006 1965 1892 – the minaret was rebuilt after a lightning strike 1947 invested in current repairs 50.000 lei
7.3.	Risks	Earthquakes: 1894, 1908, 1940, 1977, 1986,1990 Lightning strike: 1891
7.4.	Erosion	Exposure to the aggressive marine environment

8.DOCUMENTARY

8.1.	Bibliography	Grămescu Ana Maria, Mihaela Pericleanu, Suliman Sever – *Istoria științei și tehnicii construcțiilor expresie a civilizației turco-tătare din Dobrogea*, Ed. MATRIX ROM, București 2018; 1828 – it was painted in watercolor by Hector de Bearn \it exists in the library of the Romanian Academy INP Bucharest Library ABRAL ARTPRODUCT S.R.L. București, Botez Aurel Ioan Eugen, Dobrescu Gheorghe, Spoială Laurențiu, Moldoveanu M. Clement, Sion Gheorghe, Braghină Nicolae, Pavel Gh. Constantin, Popescu Greacă Alexandru – *Consolidare-restaurare Geamia Esmahan Sultan din Mangalia*, Nr. Proiect 10/2006
8.2.	Files and reports, in the archives	List of historical monuments – Constanța County Directorate for Culture
8.3.	Maps, plans, drawings 	Watercolor by Hector de Bearn 1828

8.4.	Photographs, investigations, stratigraphy	Photographs taken in the ground during the research project Investigations carried out together with the PhD supervisor

9. CLASSIFICATION LEVEL according to the record sheets from DJC Constanța

9.1.	Value group - A - B	A
9.2.	Category by nature of objective - I - II - IV	II

10. RESEARCH

10.1.	The institution in which the study file was drawn up	"Ovidius" University of Constanța, Doctoral School of Applied Sciences, Field: Civil Engineering and Installations
10.2.	The author of the analytical sheet and its quality	Eng. Suliman Sever, PhD student

New research directions

Other aspects were highlighted in the research project which, in my view, could represent a potential continuation of the research within a postdoctoral program. Another important direction that in my view can represent a new research vision is the impact of intervention works carried out on these works, as well as the impact of climate change on the behavior over time of the facades of Muslim worship places.

This last direction of research is very important given the fact that facades are elements of the load-bearing structure, and the effects of the current stage generated by climate change can exacerbate the vulnerabilities of constructions, through the effect produced by temperature variations, wind speed, the impact of acid rain or the effects of very large amounts of precipitation, which diminishes the strength of the limestone in masonry or the strength of wood for those with a wooden structure. A problem for the future is the analysis of conservation measures aimed at reducing the impact of facades with the effects of climate change by applying protective film substances suitable for each individual constituent material. The development of knowledge in the field of building techniques for Muslim worship places, which must be applied in the activity of conservation and consolidation, can also be a direction of research in the future, research that can be carried out within the framework of some educational programs,

some schools of summer initiated both in Romania, or based on a Romanian-Turkish partnership, where special techniques for restoring the resistance and durability of Muslim worship places can be presented. In this context, taking into account the similarity applied to the mosques in Dobrogea with the Nuruosmaniye Mosque in Istanbul, which is also a stone masonry mosque, I appreciate that the realization of such a partnership may in the future lead to the formation of restoration collectives with complex training that to promote the most effective restoration measures. As architecture, it resembles the Carol I mosque in Constanța. At the mosque in Istanbul, wooden piles were inserted during the construction of the foundations.

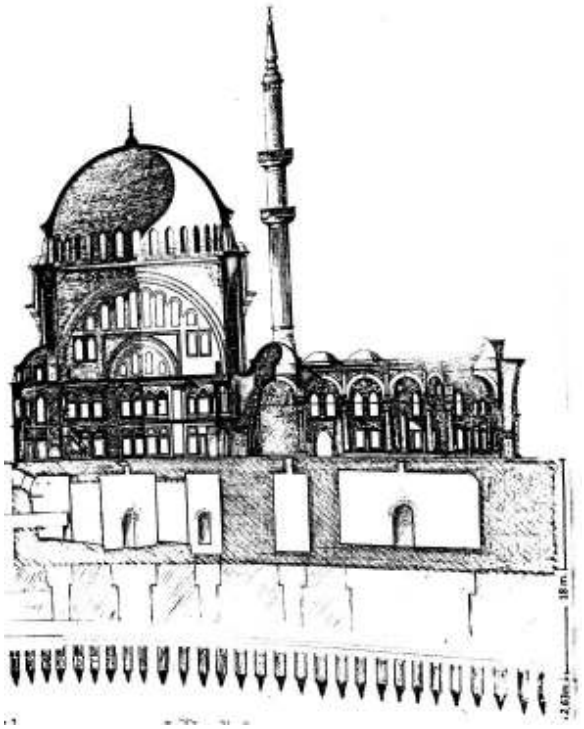


Fig.6.1. NuruOsmaniye mosque in Istanbul [26]

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[131] GP 122-2014: Ghid privind reabilitarea utilitară și funcțională a acoperișurilor la clădirile existente;
[132] Legea nr. 10/1995 privind calitatea în construcții;
[133] Legea nr. 422/2001 privind protejarea monumentelor istorice;
[134] ME-003-2007: Metodologie privind investigarea de urgență a siguranței post-seism a clădirilor și stabilirea soluțiilor cadru de intervenție;
[135] MP007-99: Metodologie de investigare a zidăriilor vechi;
[136] MP 025-04: Metodologie pentru evaluarea riscului și propunerile de intervenție necesare la structurile construcțiilor monumente istorice în cadrul lucrărilor de restaurare ale acestora;
[137] MP 029-03: Metodologie privind executarea hidroizolației cu materiale composite la zidării de piatră cu emplecton pentru clădiri de patrimoniu. Studiu de caz: Biserica Sfântul Nicolae Făcătorul de Minuni – Mânăstirea Popăuți;
[138] MP 030-2003: Metodologie pentru consolidarea stratului suport (zidărie, tencuieli) și tratamentul suprafețelor pictate la construcțiile vechi cu valoare de patrimoniu, în condiții de umiditate excesivă și existența biodegradării. Studiu de caz: Biserica Sfântul Nicolae Făcătorul de Minuni – Mânăstirea Popăuți;
[139] MP 031-03: Metodologie privind programul de urmărire în timp a comportării construcțiilor din punct de vedere al cerințelor funcționale;
[140] NP 005-2003: Normativ privind proiectarea construcțiilor din lemn;

[141] NP 019-1997: Ghid pentru calculul la stări limită a elementelor structurale din lemn;
[142] NE 036-2014: Cod de practică privind executarea și urmărirea execuției lucrărilor de zidărie;
[143] Norme metodologice din 18 aprilie 2008 de clasare și inventariere a monumentelor istorice;
[144] NP 069-2014: Normativ privind proiectarea, execuția și exploatarea învelitorilor acoperișurilor în pantă la clădiri;
[145] NP 112-2014: Normativ privind proiectarea fundațiilor de suprafață;
[146] Ordinul nr. 2237 din 27 aprilie 2004 privind aprobarea Normelor metodologice de semnalizare a monumentelor istorice, Publicat în Monitorul Oficial, Partea I nr. 220 din 16 martie 2005;
[147] Ordinul nr. 2260/2008 privind aprobarea Normelor metodologice de clasare și inventariere a monumentelor istorice;
[148] P100-1/2013: Cod de proiectare seismică – Partea I;
[149] P 100-3/2019: Cod de proiectare seismică- Partea a III-a- Prevederi pentru evaluarea seismică a clădirilor existente;
[150] P 130-1999 : Normativ privind comportarea în timp a construcțiilor;
[151] Quattro Design – Arhitecți și urbaniști asociați – *Strategia de Dezvoltare Teritorială a României, Studii de funamentare. Studiul 20: Protecția monumentelor istorice și a patrimoniului construit,* 2014;
[152] SR EN 1991-1-1:2004 – Eurocod 1: Acțiuni asupra structurilor. Partea 1-1: Acțiuni generale. Greutăți specifice, greutăți proprii, încărcări utile pentru clădiri;
[153] SR EN 1992-1-1:2004 – Eurocod 2: Proiectarea structurilor de beton. Partea 1-1: Reguli generale și reguli pentru clădiri;
[154] SR EN 1994-1-1:2004 – Eurocod 4: Proiectarea structurilor composite de oțel și beton. Partea 1-1: Reguli generale și reguli pentru clădiri;
[155] SR EN 1995-1-1:2004 – Eurocod 5: Proiectarea structurilor de lemn. Partea 1-1: Generalități. Reguli comune și reguli pentru clădiri;
[156] SR EN 1996-1-2:2005 – Eurocod 6: Proiectarea structurilor de zidărie. Partea 1-2: Reguli generale. Calculul structurilor la foc;
[157] SR EN 1997-1:2004 – Eurocod 7: Proiectarea geotehnică. Partea 1: Reguli generale;
[158] SR EN 1998-1:2004 – Eurocod 8: Proiectarea structurilor pentru rezistența la cutremur. Partea 1: Reguli generale, acțiuni seismice și reguli pentru clădiri;
[159] STAS 10109/1-82: Lucrări de zidărie. Calculul și alcătuirea elementelor;