

## THE TRADITIONAL CORAL STONE BUILDINGS OF THE RED SEA COAST: CASE STUDY OF HISTORIC JEDDAH

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### Abstract

Structural systems of the traditional buildings have been developed as a result of climatic and cultural responses, availability of material, and according to the level of builders' skills as well as the advancement of construction techniques of all the historic time of civilization. The Coral Stone is a distinctive traditional structure that is found in the old buildings along the Red Sea Coast. By taking the Historic District in Jeddah as a case study, where the hundreds years old coral stone buildings are still preserved, this paper will demonstrate the elements and materials of the these traditional structures and the used construction techniques. The structural system's role as a climate responsive architecture and the reasons that led to their deterioration will be investigated in order to understand how to conserve this world heritage structures.

## 1. INTRODUCTION

The city of Jeddah is one of the most important historical cities in the Kingdom of Saudi Arabia and in the Middle East region as well. The traditional structure of Jeddah's coral stone buildings is also famous in some other towns along the Red Sea coast of Saudi Arabia, as well as on the Sudanese coast at Swakin. These traditional buildings follow a structural system that consists of imported wooden courses known as gandal used to reinforce local coral blocks [1].



The location of Jeddah as a coastal city on the Red Sea shores has made it the Islamic port for the two holy cities of Mecca and Medina for thousands of years (Fig1). This connection played a great role on influencing the traditional buildings materials and construction techniques. The cross-culturalization and the diverse ethnic backgrounds in the city have enriched the architecture of Jeddah and the Hejaz region

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in general. As pilgrims came from various parts of the world, they transported and exchanged their skills with the local people. The construction skills of the people of Hejaz were also influenced by the building activities in Egypt, an evident example of that are the Rowshans or Mashrabiyas (projected screened windows). The traditional architecture of Jeddah responded to the climate in terms of form, construction techniques, material selection and the application of passive design features that maintained thermal comfort within the building in the hot humid climate [5].

The old settlement of Jeddah that is called 'Al Balad', which means a town, or referred to as Historic Jeddah is where the traditional tower houses that were built for rich merchants hundreds years ago still exist today as some of the last major surviving example of the Red Sea Coast traditional Architecture [5]. The houses were built as narrow and multistorey buildings in order to catch the breeze and to fit in the limited space within the old city wall (Fig.2). The traditional architecture of this Historic district is characterized by the construction materials, typology, and decorations [7].



Figure (2). Examples of the houses located at the old town centre (Al Balad) of Jeddah [12]

## 2. CONSTRUCTION MATERIALS

The main structure of the 5-6 storey traditional buildings in old Jeddah were possible to be built due to the use of coral stone and timber technology by special engineers and artisans [5]. The coral stones were cut from the Red Sea shore were known locally as Hajar al manqabi after Al-Manqabah lagoon at Jeddah [1]. Mangabi stone is a coquina (seashell) limestone, quite easy to cut and work with, especially when freshly excavated because it is likely to get harder when exposed to air. Mangabi stone is porous, relatively light and has good insulation properties against the salty air of the Red Sea coast (fig.3) [7].

Coral stone is a member of organic sedimentary rocks family. Organic sedimentary rocks are the resultant rocks of the biological and chemical activities of living organisms, assemblages of skeletons, crusts, or other parts. In order for these stones to come to fruition, it is necessary that there are lots of organisms and suitable conditions for their development. These rocks are composed of rock - forming organisms such as foraminifers, radiolarians, algae, sponges and especially corals, or crushed parts of them. Solid parts of the organisms have become petrified in the sea and become fossils [2,3].



Figure (3) Mangabi and Coral Stone [4]

Coral blocks were also used as their insulation and resistance quality is similar to the Mangabi stone, but more expensive to extract, that's why it was not used as standard masonry material. Coral blocks are usually found mixed with limestone masonry. The dark-brown clay, excavated from the shallow bottom of al-Manqabah lagoon, mixed with lime was used as mortar for binding the stone blocks [7].

While Jeddah was a trading port for centuries this has allowed importation of building materials not available locally. Hard timber which was transported from Africa and Indonesia was used for beams [5]. The floors and roofs construction consisted of wooden boards laid over wooden joists. The type of wood used for reinforcement and flooring was imported from India and known as gandal which a major factor behind the possibility of was constructing multistory houses. Another type of wood was imported from Java, usually used for front doors, rawshan and windows, known as Jawi, i.e. Teak. It was favored by local craftsmen despite it is harder to work with; it has more resistance to insects and humidity. In addition to Teak wood, mahogany and sisam wood were also used for doors and windows. Houses were usually whitewashed or painted in pastel shades of yellow, cream, blue and pink [5,7].

#### Construction Techniques

The traditional buildings in Jeddah follow a structural system that consists of gandal wooden courses which are used horizontally to reinforce the coral block walls at every 1.20 m. or so [1]. The construction process starts with one meter deep excavation for footings and wall foundations that were made out of compact, firmly bound coral stone and clay layer. Load-bearing walls were constructed approximately 50-60 centimeters thick, starting thicker then reduced in thickness on upper floors, reinforced with horizontal wooden members spread out vertically leaving a one meter gap between each one. The last and uppermost tier of the wooden reinforcement were tied to the cross joists of the floors, to form a firm structural frame. The reinforcing members were visible on both external and internal faces of walls (fig.4) [6].

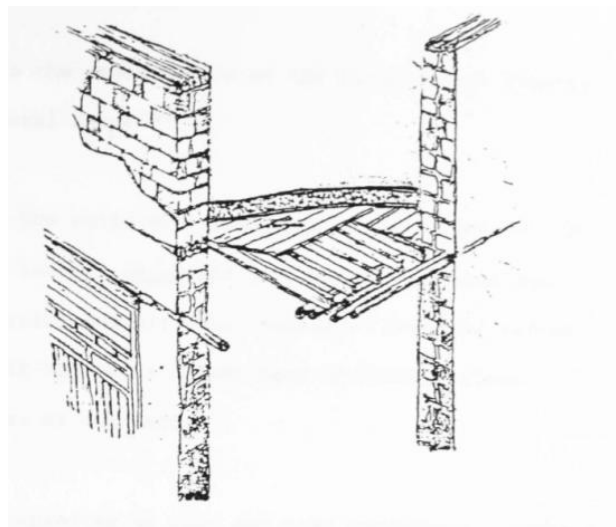


Figure (4) Structural Detail [6]

The floor structure consists of timber boarding laid on timber joists, which are about 15 centimeters in diameter, covered with straw mats, followed by layers of four centimeters wet earth, three centimeters dry earth, three centimeters mixture of pulverized pebbles and lime bonded with lime mortar, finally covered with floor tiles. As for Roofs they were constructed in a similar way but with an addition of a thick bed of limestone below the wet earth layer, and water-resistant lime plaster on the top (fig. 5) [6].

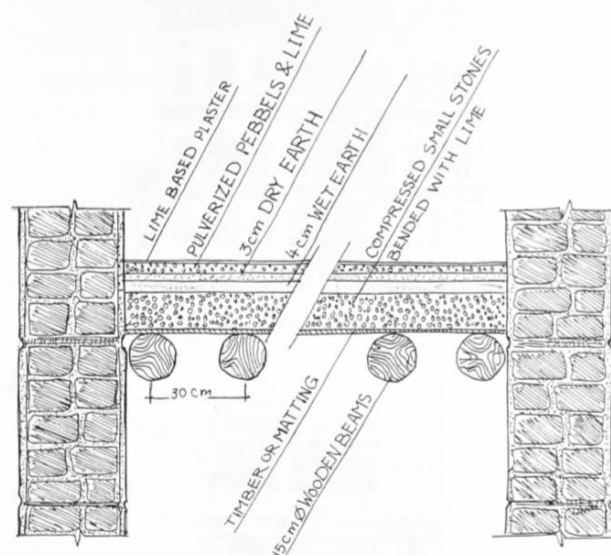


Figure (5) Typical section showing roof and ceiling construction [6]

The staircase was one of the contributors to the strength of the traditional coral tower house. It was looped around a central pier enclosed throughout its height by thick walls, acting as a massive hollow column. The steps of the stair were also constructed of coral blocks, and then plastered by a five by five centimeters wooden log at the front edge, rested on top of three long wooden sticks. The openings consisted of timber lintels or masonry arches, depending on the span and loads. The common practice was to use lintels of stout parallel timbers across the thickness of the wall, tied into the masonry on both sides of the opening allowing a good length by distributing the high concentration of stresses that are settled at the corners of the opening [6].

The lime based plaster layer painted by lime wash is commonly used for covering the wall of the coral rocks buildings, as the thick coat of white or ochre plaster shields the coral stones from humidity, heat and salinity's effects [1].

#### Climate Response of The Coral Stone Structure

The traditional buildings in old Jeddah have evolved in respect to the local climatic which is clearly reflected in the buildings' form, orientation and layout.

The materials that construct this traditional structure were also used effectively by the builders against the climate. As the 50-60 cm. thick coral stone walls (fig. 6) at the lower floors provide a considerable resistance to the passage of heat due to the low thermal conductivity of the material. The considerable thickness of the construction is capable of absorbing heat and delaying its passage to the interior [6].

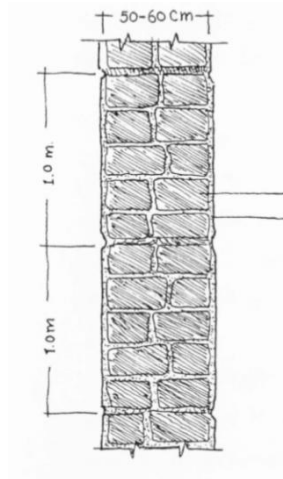


Figure (6) Typical section in the load bearing external wall

The heavy roof construction (fig. 6) retains high heat insulating qualities and heavy thermal mass to ensure less consumption of solar heat and the least heat flux entering the living spaces beneath. As Earth is a good insulator of heat, 7 cm layer of pressed dry earth was placed below the top layer of pulverized pebbles to reduce the amount of heat penetrating to the limestone layer during the day [6].

The existence of an architectural feature called al-mabit built on the uppermost floor is another factor responding to the climate (fig. 7). This room was constructed of paneled woodwork with movable louvers, and a light roof, in contrast with the massive lower floors that stay cool during the daytime in the summer but tend to warm up in the late night. Al-mabit, would be warm during the daytime but tends to cool down quickly at night, so it could be used for sleeping. The white lime wash covering the walls and the roof of the whole building reflects 80% or more of solar radiation received, reducing the heat transmission through the walls and roof structure during the day [6].



Figure (7) House of Nassif (Beit Nassif) in Historic Jeddah [9]

### 3. DETERIORATION & CONSERVATION

Since the economic development invaded the Kingdom of Saudi Arabia, and led to the emergence of concrete buildings, the old district of Jeddah has been subjected to severe neglect of the built environment which had led to its deterioration, families moved to live in the new urban expansion leaving the old district occupied with poor non-Saudi workers.

The early conservation attempts appeared in the 1970s, when the government had started its first plan for conserving historic Jeddah. The old district has been subjected to many conservation policies later on until it was inscribed as a world heritage site by the UNESCO in 2014 [7]. Although conservation plans were designed professionally, their applications were minimal and their managements were poor at first, that's why neglect and lack of maintenance is considered the major cause of deterioration in Historic Jeddah.

Other factors have contributed to the deterioration and collapsing of the coral stone buildings as well, and one of them is the coral stone itself, as it is vulnerable to weathering that's why they were rendered to be protected. The neglect and lack of maintenance have led to the loss of renders and leaving the wall surfaces exposed to sandstorms and rainfall. It's common to see deterioration of stones to start from corners where joints have been exposed and mortar is lost [8].

Another reason behind the collapsing was the lack of adequate foundations. The traditional Houses were fragile and tended to collapse partly due to the poorly laid foundations and unstable soil [7]. Finally, the inappropriate use of new materials in repairing the traditional buildings as well as the unwell planned and executed interventions, such as: the addition of floors, the use of cement-based screeds on floors and roof terraces that adds more weight to the structure, as well as adding heavy water tanks and metal structure on the roof, all these alterations have caused failure of even collapsing of the traditional buildings [8].

In order to conserve this cultural heritage, municipal intervention must deal with repair works on structures, and it must be done with qualified workmanship who is experts in traditional construction. The new function of these building is an important factor in the conservation process; historical buildings in Jeddah are being used or suggested to be used as museums, cafes, and hotels. Each must be treated in order to its functional needs, but the two major general considerations in restoration will be the glazing of unglazed windows and the insertion of modern-day standards bathrooms and kitchens [8].



Figure (8) Al-Shafi'i Mosque exterior during and after Restoration [10]

## CONCLUSION

The historical coral stone buildings found on the shores of the Red Sea are significant cultural assets that reflect unique buildings material, construction techniques, distinctive climate responsive features and iconic architectural elements. This architecture has evolved through the years with a mixture of different ethnic background and architectural styles, until it gained a singular identity that represents the religion, culture, and climate of its region. It's our responsibility to conserve this heritage, be proud of it, and pass it to the next generations, and this begins with raising the public awareness which was successfully achieved in the case of Historic Jeddah. As it's still a vibrant neighborhood in the City, especially in the last years as people were drag back to celebrate many religious and national occasions at Historic Jeddah through many festivals held there. By repairing, conserving and restoring these traditional buildings and giving them new function, the area was revived, the people were reminded of their culture and the area also promoted tourism in the city. Still there is a lot to be done to achieve a successful conservation of the area and this only can be done under clear plan and strict roles by the authority, as well as by training the workers on the traditional construction skills and repairing techniques.

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