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Old and Modern Construction Materials In Yemen: The Effect In Building Construction In Sana'a

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Abstract: Sana'a city in Yemen is one of the oldest cities in the worlds, which has different forms of building built with different types of materials. In the present work, the old and new forms of building construction and the building materials used in Sana'a, the sources available for the new material, the effects of new material usage on building forms are all presented with the advantages and disadvantages of each material. The old shapes of buildings in Yemen and the classical and modern forms of construction using different types of materials are considered in the study. Survey is used to investigate the building forms and material types in Sana'a. Several conclusions are submitted showing that, the new building material, such as concrete block, is preferred in building comparing with old material, such as stone, which makes it the best choice for the low income people but sometimes the limited resources make old material the only available choice. Several steps needed to develop and encourage the use of new building materials are recommended.

Key words: Building material, concrete block, Yemen architecture

INTRODUCTION

Old Sana'a can be considered as a record expressing the real story of the human civilization and development in Yemen. A Yemen's architecture styles of construction are special and unique. Yemen's early history is very vague. It just begun at the beginning of century BC until 8 or 9 with Ceiba 1800, with an emergence of specific historical integrity of the information. In 600 BC around 7 century, the royal rulers are replaced. At that time, Sana'a the capital was moved to the eastern part near Marib. Sana'a was reselected to be the new capital of the Republic of Yemen in 1962 finishing an eight years of civil war. The promulgation of the constitution and the establishment of the new government of the Republic of Yemen are conducted at 1970, which represent the new political history of the capital. However, from an engineering viewpoint, the materials used in the development of Sana'a building throughout the history are of main interests. At the last century, stone building is the most common type used and still used until now in regular building in Sana'a city. Such material necessitates certain style in building. The effect of building's material on the architecture style of Sana'a city and alternative available are of mainly interest. Using new building material other than stone in house building has an effect on the architecture style, economy and time consuming.[1] The use of newly building materials is needed to accompany the development.[2] The using of newly developed materials in building construction is highly recommended, which is supposed to develop the architecture styles.[3] The present work aims to investigate the main building materials used in building in Sana'a, the sources available for the new material, effects of new material usage on building development; the necessary steps suggested which is required to support the new development process.

Building construction materials in Yemen: Since, architectural models are depend on several types of material, the stone, mud, straw with soil and wood represent the traditional types of material used in ancient Sana'a, Fig. 1, which have properties stated as:

1. The rocks (stone) usually used to form the traditional shape of building with thick walls supporting two or three floors in maximum, Fig.1d.
2. All types of soil mixed with straw are used to form the huts, Fig. 1c.
3. The burn mud or firebrick is used as building materials all around the capital Sana'a, Fig. 1b.
4. Wood called Shibam cities wood and tree trunks used for ceiling mud with straw used to form wood building, Fig. 1a
5. The sticking plaster material used for constructing interior walls, blinds, internal and external decoration for buildings.
6. The Shibam city's limestone material used in the walls to pick up residential soil which used as wall glazing.
7. The gravel with adhesive material is used in dome, the pool roof, kitchen and bathrooms to prevent water seepage. In the last century, the use of newly building materials, such as

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concrete block or brick with cement mortar, mainly affect the building style.[2] The use of stone as main building material produce special building style noticed in Sana'a.

The arch in windows is one of the most common styles of building in Sana'a, easily constructed but it is time consuming with high costs. Stone walls need larger spaces and sever from limitation on number of floors allowed. Nowadays, cost of building by rock and limitation of area necessitate the use of alternatives materials such as concrete block. [3]

The stones and concrete block as a main materials used in building

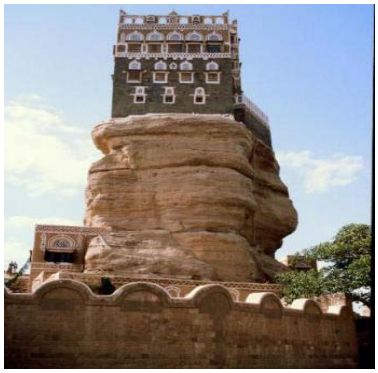
Advantages and disadvantages of stone: Several advantages and disadvantages may be stated using different types of material. The stone with cement mortar has some advantages can be stated as[4]

1. Provide high strength walls used as bearing wall
2. Have good thermal insulation
3. Flexible in controlling wall size
4. Different colors of stone facilitate the selection process or identify the desired color of house.

a. Wood housing in rural areas around Sana'a

b. Mud houses in ancient Sana'a

c. Straw housing in rural areas around Sana'a



d. Stone house in Sana'a

Fig. 1 Types of building in Yemen according to the material constructed with.

Some disadvantages of constructing using stone can be stated as:

1. Time consuming.
2. Higher cost, whereas, cost of stone building affected by cost of transformation. Also cost of workers with time needed to build is high. The high cost is also from using cement mortar to fill blanks between irregular spaces of stone. Nowadays, building using stone in Yemen cost about 15 USD per square meter.
3. Required large spaces for wall, since the bearing wall required a thickness of about 500 mm.

Concrete block advantages and disadvantages: In the present, the main alternative material available is concrete block, which has several advantages stated as:

1. Fast in construction
2. Give more spaces, whereas bearing wall can be constructed with 200mm thick
3. A relatively low cost, since cement mortar used is much less than that required for stone. Nowadays, building using concrete block in Yemen cost about 1.5USD per square meter
4. Have good and acceptable bearing strength make it applicable for constructing bearing wall.

Disadvantages of constructing using concrete block can also be stated as: (1) Have poor thermal isolation. (2) Building using concrete block required a relatively regular shape of wall.[4]

Building cost and material availability: The studies prepared by the federal bank during duration from 1975 to 1981 show that cost of building in Yemen increased by about 262% and the growth of skilled workers cost increased of about 600%. These are some of reasons make the style of building architecture differs from place to another depending on space requirement and income level. Therefore, true differences in building style are appeared. Among many sources of materials, only stones or concrete block are existed as a competitive material used in building in Yemen in last years. [6]

Several types of precious stones are less than price of half dollars to rise to price of stone of about five dollars are available. The price of concrete block is very cheap, as measured that the price per square meter blocks about 4.5 dollars. This because of great proliferation of concrete block factory in Yemen, but poor quality of concrete block did not encourage people to use it. Nevertheless, block factory spread in Yemen and rise in chaotic spread in last ten years, example in Sana'a number of concrete block factory raised from 10 to be about 150 factories.

The cement material is mainly affects on building cost. In Yemen there are five factory produced cement which can't cover the increasing requirement in the market for cement and the domestic demand, which made the price increased from 60 dollars per ton to be 120 dollars per ton within the last 6 years. Thus, domestic production of cement in Yemen has a shortening usually covered by importing cement from the neighbor countries. Another important material used in building's construction is the steel reinforcement, which is completely unavailable in Yemen and depends entirely on importing from Turkey, Russian, Korea, with price reaches to about 620 dollar per ton.

Building construction forms: In the last decades the building architecture form in Yemen especially in Sana'a has been changed randomly due to the changes in construction material. The use of stone for building houses began to be extremely expensive not only because of the stone price but also because of cement cost rising and label cost rising associated with the long duration required for construction. The stone building suffers from space requirement whereas the inner spaces are eliminated in houses. The limitations of building using stone are also affecting on the overall shape of the building and especially the front view of building and number of floor to be constructed. The arch used in classical building using stone can be shown in Fig. 2a

All of those reasons associated with the increasing in people and the increase requirement for houses necessitate the search for better alternative method and material of construction which can be used to construct modern houses with the Yemen's style form. [5]

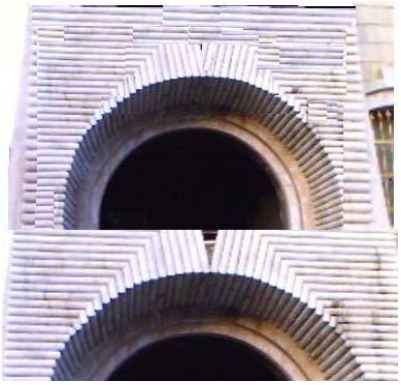
The use of concrete block in the last years appears to be the best alternative for stone due to low price, faster construction time and give a large space which is the main requirement for low cost building especially for small areas. The use of such new material is associated with the change in the form of buildings therefore several alternatives are available following the western style instead of using arches and old shape of building. According to survey made by the authors the new building style is the most common type of construction used in the new houses built in Sana'a.

RESULTS

The use of new material in building would increase the free space required. Using the stone to build 24m^2 clear room areas, with 0.6m wall thickness, required an actual area of 37.44m^2, while using block for the same clear area, with 0.2m wall thickness, area required only 28.16m^2, which is 33% lesser than stone. Therefore, the author performed survey includes more than 1000 house in Sana'a aiming to estimate the percentage of houses used the concrete blocks and those used stone which is built in the last 20 years, from 1987 to 2007, in areas near old Sana'a and center of city, as shown in Fig. 3.

As an eye survey results the authors found that about 61% of houses built using concrete blocks while the rests is built with stone.

The use of new style of arch, Fig.2b, is found to be about 18%, the classical style of arch is 15%, and commercial shape of arch, shown in Fig. 4, are 47% and the other is constructed with regular windows shapes.



a. Classical arch shape

b. Modern arch shape

Fig. 2: Types of arches used in Sana'a

Fig. 3: Types of material used in Sana'a houses

Fig. 4: Commercial types of arches used in Sana'a

Conclusions

According to the above, it concluded that,

- Using of new building material such as concrete block appears to be the best choice available for the low income people in Yemen.
- Although the cost of stone building is about 10 times the block, the use of these materials are continues because of poor quality of concrete block.
- The use of new types of material should be accompanied with development of material sources.
- Encouraging the establishment of concrete block factories should be associated with establishment new cement factories and enhancing the quality of the products. These should be developed according to plan given and supported by government in order to avoid the random distribution and their harmful effects, especially in treating wastes produced from such factories and their effects on environments. Change in building style due to the use of concrete block accompanied with changes in outside decoration and inner spaces which allow for more spaces to be used. At the same time using such material would be so useful especially for the limited income employers.

Recommendations: According to the above, several recommendations can be stated as:

1. The use of concrete block is a good alternative can be chosen and adopted in houses construction in Sana'a, depending on the large number concrete factories, but enhancements on products should be conduct
2. The government should support establishing new cement factories and enhancing products of the available factories in order to support Yemen citizens helping them to build their own houses. Whereas, the available number of cement factories is not enough to support the concrete block factories
3. Since the use of such new material provided more inner spaces, thus constructing houses on smaller areas would give houses with an acceptable inner spaces and even outer decorations
4. In such cases government can provide people with lands of smaller areas and acceptable price.
5. The construction form can be demonstrated and achieved according to the ancient Yemen style or according to the western style or mixed from the two types using the new types of material
6. The architectures in Yemen have a great rule to participating in the development process through saving Yemen ancient style using new materials

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