

Impact of Materials on Conservation of the Built Environment: Case Study of Historic Mosques in Mosul Old City

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Abstract: Conservation of the built environment through reusing historic buildings maximizes the use of existing materials. The research question is how to retain the integrity of historic mosques through using sustainable material? The main purpose of this study is to investigate the impact of materials on conservation of historic mosques in old Mosul city with sustaining the integrity of the mosques. The study applies qualitative method of analysis. The method of collecting data is by making direct observation. The techniques for collecting data are by writing descriptions and making an inventory of the variety and arrangement of the materials used in the historic mosques. The research uses open coding to analyse the data by identification of emerging themes from the raw data. The goal is to create descriptive and multi-dimensional categories and build a conceptual model from the categories, which are grouped. This study highlights the themes of materials used in historic mosques in Mosul old city and show that the integrity of mosques affected by the materials, which were used in these mosques. The research showed that the elements that the damages occurred in as a result of the use of inadequate materials which used in such elements. The research recommends that experience is vital in conversation of the historical buildings and require to performed identification, evaluation, registration and treatment activities. In some cases, additional areas or levels of expertise may be needed, depending on the complexity of the task and the nature of the historic building involved.

Key words: Built Environment; Historic Character; Integrity; Materials; Mosques; Mosul.

INTRODUCTION

Historical review: Mosul is Iraq's second city and was originally built on a hill called *Qlea't*, on the right bank of the Tigris opposite the site of ancient Nineveh. The area was inhabited as early as 6000 BC. History is alive in Mosul: there are plenty of archaeological ruins dating back to Assyrian times [1]. By the 8th century AD, it had become the principal city of northern Mesopotamia. In succeeding centuries a number of independent dynasties ruled the city, which reached its political zenith under the Zangid dynasty (1127–1222), but the region's prosperity ended in 1258 when the Mongols ravaged it. The Ottoman Turks ruled the region from 1534 to 1918, during which time Mosul became a trade centre of the Ottoman Empire and the headquarters of a political subdivision. After World War I (1914–18) the Mosul was occupied by Britain until a border settlement (1926) placed it in Iraq rather than in Turkey. The city's commercial importance thereafter declined because it was cut off from the rest of the former Ottoman Empire [2]. Fig. 1 shows the changing plans of Mosul old city. Old Mosul has 38 living quarters called *Mahala*, each self-contained

with its own market, baths (spa), church, mosque and cemetery [1]. The research selected 30 existing historical mosques, one in each living quarter as a sample of this study. Fig. 2 shows the locations of the selected historic mosques in Mosul.

Conservation of Built Environment and Sustainability: According to architect Carl Elefante: "the greenest building is the one that is already built"[3]. Historic buildings are inherently sustainable. Sustainability begins with conservation. Conserving historic buildings is essential to understanding our nation's heritage, and preserves the historic character of older towns and cities. In addition, it is an environmentally responsible practice. Conservation maximizes the use of existing materials and infrastructure, reduces waste. The energy embedded in an existing building can be 39% [4] of the embedded energy of maintenance and operations for the entire life of the building. By reusing existing buildings historic conservation is essentially a recycling program of 'historic' proportions.

Existing buildings can often be energy efficient through their use of good ventilation, durable materials, and spatial relationships.

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An immediate advantage of older buildings is that a building already exists; therefore, energy is not necessary to create new building materials, and the infrastructure is already in place.

Mosques do not need any modifications to adopt new uses because there are no changes in their functions. Systems can be upgraded to meet modern building

requirements and codes. This not only makes good economic sense but also conserves the legacy and is an inherently sustainable practice. Modern materials and buildings are often rather different from the traditional structures and the natural surroundings; they do not fit the environment as monuments or even common, existing historic buildings do.

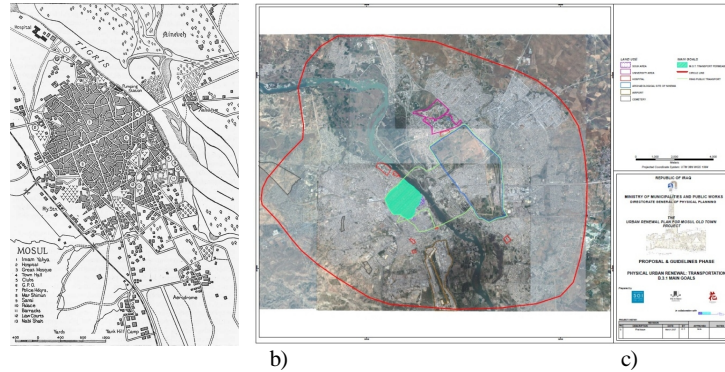


Fig. 1: The changing plans of Mosul old city, a) Mosul in 1700 A.D. b) Mosul in 1944 A.D. c) Mosul in 2004 A.D. [10].

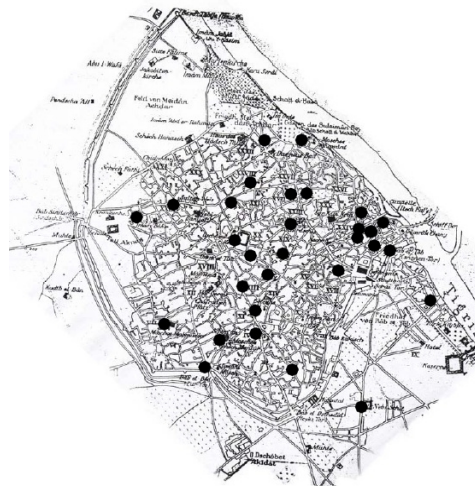


Fig. 2: Locations of historic mosques in Mosul old city.



a)



b)

Fig. 3: Arrabiea mosque. a) The verity of materials and the dome as a main feature. b) The surface qualities of materials.

Sustainable of built environment means conservation of [5]:

1. The conventional balance between natural and built environment.
2. The historical styles, traditional appearance, the scene of folk life, art and habits.
3. All the values of local human communities and nations.
4. The whole character of the built environment and its culture.

Historical Character and Integrity: The things that make a historic building special define “historic character” – it’s visually distinctive materials, features

and spaces, the architectural styling or design, and its unique methods of construction or craftsmanship [6]. Historic character may also include the features that distinguish one building from another like a dome, smokestack, decorative classical columns, stained-glass windows or mosaic tile floor. Fig. 3(a) shows the verity of materials used in *Arrabiea* mosque and included a dome as a distinguished feature. The historic character is often determined by the surface qualities of materials. The original choice of materials plays the dominant role in establishing the close-range character because of the color, texture, or shape of the materials [7], as shown in Fig. 3(b). In this instance, the variety and arrangement of the materials are important in defining the historic character.



Fig. 4: The visual character of historic interior space in two deferent mosques.

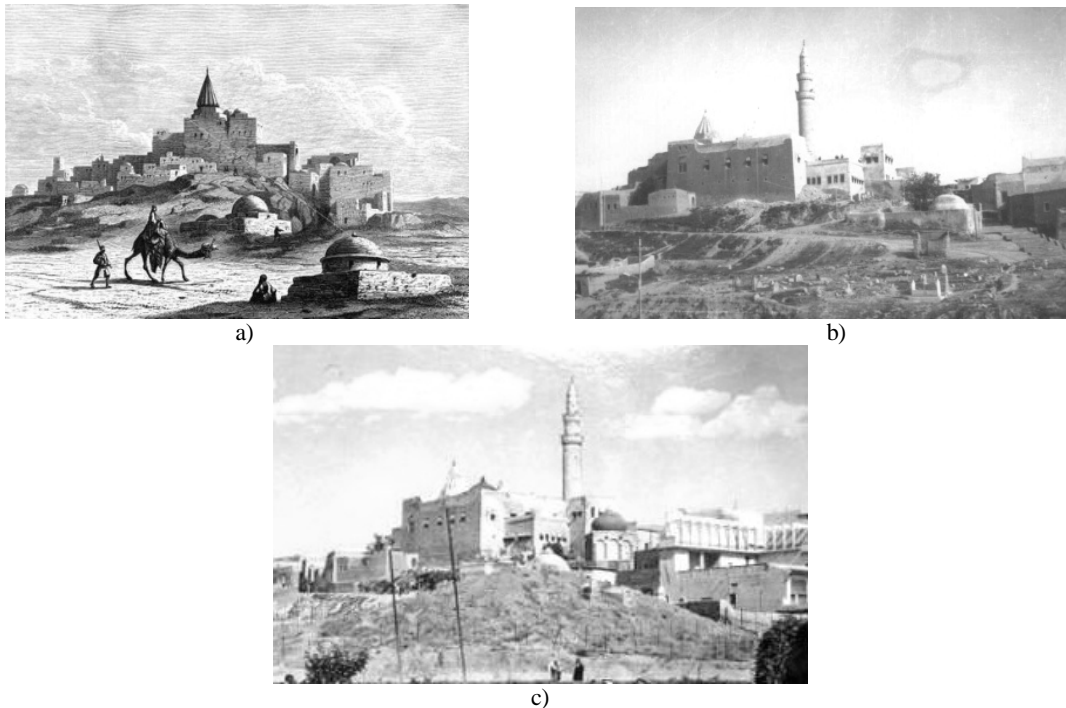


Fig. 5: The physical characteristics were survived during three historical periods for *Annabi Yunis's* mosque. a) 1800 A.D. b) 1920 A.D. c) 1970 A.D. [9].

Starting with large pieces of broken stone, which form the projecting base for the building walls, then changing to a wall of roughly rectangular stone, which varied in size, color, and texture, all with accentuated, projecting beads of mortar, then there is a rather precise and narrow band of cut and dressed stones with minimal mortar joints. And finally; the main building walls are composed of bricks, rather uniform in color, with fairly generous mortar joints. It is the juxtaposition and variety of these materials who very important to the historical character. When identifying the visual character of historic interior space one should not overlook the importance of those materials and finishes that comprise the surfaces of walls, floors, and ceilings. As shown in Fig. 4 the surfaces may have evidence of either handcraft or machine made products that are important contributors to the visual character, including patterned or inlaid designs in the wood flooring, decorative painting practices such as stenciling, imitation marble or wood grain, wall papering, tin work, tile floors, etc.

“Integrity” refers to whether a building retains these important character-defining features and has not been inappropriately changed over time [6]. Integrity is the authenticity of a building's historic identity, evidence by the survival of physical characteristics that existed during its historical period. It is also the extent to which a building retains its historic appearance. In Fig. 5, it explains the conservation of building integrity. The objectives of the study:

1. To explain the themes of materials used in historic mosques in Mosul old city.
2. To explore how the integrity of historic mosques affected by the materials which were used in them.
3. To set the elements that the damages occurred as a result of the use of materials inadequate to be used in such elements.

MATERIAL AND METHOD

Approach: The study applies phenomenology qualitative method of analysis. The method of collecting data is by direct observation. The technique for collecting data was by creating descriptions and making an inventory of the variety and arrangement of the materials used in historic mosques. In order to analyse data collected, the research uses open coding by identification of themes emerging from the raw data. The goal is to create descriptive and multi-dimensional categories. Build a conceptual model from the categories, which grouped [8]. To describe a group, it investigates and exemplifier 30 mosques aged for more than 800 years between 12th and 20th centuries as the testimonial to support the concept of classification for each category. All of the selected mosques are from same region known a Mosul old city. Each mosque in one living quarters called *Mahala*.

Although, there are 38 *Mahala* in Mosul old city but the mosques are 30 that because the study investigates the existing historic mosques only.

Data Collection: The data collected by observing, taking photos and writing notes in structural form prepared for this study for the existing historic mosques. Other data collected from available documentaries of mosques including plans, old photos and published manuscripts. The other method for ensuring all important and key buildings materials is using some historic works about mosques in Mosul e.g. Saeed Adewah Che (1963) titled ‘Mosques in Mosul in different eras’ [9]. The main function of mosques is for prayer, which is done in the main part of mosque called *mosallah*, so the data collected was from this part of the mosque. The collected data is concerned with variety and arrangement of materials used in the historic mosques. The classification of the mosques is based on their integrity as indicator of historic character for the mosques. The evaluation criteria of integrity in this study represented as shown in Table 1.

Methodology: Each category has independent characteristics that form the category. The variations are possible by adding or removing parts that do not affect the main concept, which is originally constructed on. The important factors in classification of the categories are the variety of materials for walls, ceilings, arches, ornaments and decorative writings. Floors, roofing, windows and doors are considered the factors that make variation within these categories. All previous factors affect the integrity of historical characteristic of historic mosques. The date of construction is taken into account in the classification since construction of mosque is depend on the materials availability and techniques of construction for certain types of materials used in the period of construction. According to Table 1, to classify the categories depending on the integrity of historic character of the mosque and upon the materials sustainable or changed to new materials, which mentioned as others in this study, the classification will be as follows:

- First category, which has (E) excellent integrity, if the important factors used other materials ≤ 1 time or the variation factors used other materials ≤ 2 times.
- Second category, which has (VG) very good integrity, if the important factors used other materials ≤ 1 time and the variation factors used other materials ≤ 2 times.
- Third category, which has (G) good integrity, if the important factors used other materials ≥ 2 times or the variation factors used other materials > 2 times.
- Fourth category, which has (F/P) fairly poor integrity if the important factors used other materials ≥ 2 times, and the variation factors used other materials ≥ 2 times.

Table 1: The evaluation criteria of integrity.

E	A building with no alterations that detract from its style, design or construction.
VG	Buildings with one or more alterations, the effect of which are recognizable but do not significantly detract from the style, design or construction.
G	A building with a major alteration and/or a combination of several minor alterations, the effect of which detracts from the style, design or construction.
F/P	A building with alterations, which greatly detract from the style, design or construction.

Where, E: Excellent; VG: Very Good; G: Good; F/P: Fair Poor

RESULTS AND DISCUSSION

With reference to a study of materials in historic mosques in Mosul old city, the integrity as a measure of the impact of materials changes to the building on the appreciation of its historic characteristics analysis classifies the mosques into four categories as follows:

Mosques with excellent integrity: In this category (Table 2) there are two mosques (*Arrabia* and *Annoumania*) used materials for walls, ceiling, arches,

ornaments and decorative writings sustainable its historic characters. Other two mosques (*Annabi Sheet* and *Maryam Khatoon*) are the same except the material used for ceiling was other materials. All four mosques were used other materials for floors and roofing. There are a variety of material used for walls and floors. All four mosques in this category were constructed in close period of time, which is around sixty years. The impact of materials on the appreciation of its historical characteristics achieved excellent integrity.

Table 2: Materials analysis for mosques with excellent integrity.

	Name of the Mosque	Construction Year	Integrity	Materials																									
				For Walls				For Ceiling			For Arches				For Floors			For Roofing			Windows	Doors		For Ornaments & Decorative Writings					
				Daubed Stone	Limestone	Stone	Others	Daubed Stone	Brick & Steel	Others	Limestone	Stone	Daubed	Others	Limestone	Stone	Others	Daubed	Stone	Others	Steel	Wood	Steel	Wood	Daubed	Stone	Limestone	Others	
1	Arrabia	1180A.H.-1766A.D.	E	○	○	○	○	○			○				○			○			○			○			○		
2	Annoumania	1213A.H.-1798A.D.	E	○	○	○	○	○			○	○			○			○	○		○			○			○	○	
3	Annabi Sheet	1232A.H.-1816A.D.	E	○	○	○	○	○		○	○				○	○		○			○			○	○		○	○	
4	Maryam Khaton	1241A.H.-1825A.D.	E	○	○		○	○	○		○				○	○		○			○			○			○	○	

Table 3: Materials analysis for mosques with very good integrity.

	Name of the Mosque	Construction Year	Integrity	Materials																									
				For Walls				For Ceiling			For Arches				For Floors			For Roofing			Windows	Doors		For Ornaments & Decorative Writings					
				Daubed Stone	Limestone	Stone	Others	Daubed Stone	Brick & Steel	Others	Limestone	Stone	Daubed	Others	Limestone	Stone	Others	Daubed	Stone	Others	Steel	Wood	Steel	Wood	Daubed	Stone	Limestone	Others	
1	AL-amawi	17A.H.-638A.D.	VG	○	○	○	○	○			○				○			○			○			○			○	○	
2	AL-Mujahidi	575A.H.-1179A.D.	VG	○	○	○	○	○			○	○			○			○			○			○			○	○	
3	Annabi Gargis	796A.H.-1393A.D.	VG	○	○	○	○	○			○	○			○	○		○			○			○			○	○	
4	Khuzam	985A.H.-1577A.D.	VG	○	○	○	○	○			○	○			○			○			○			○			○	○	
5	Ajjwejati	1060A.H.-1650A.D.	VG	○	○			○	○		○				○			○			○			○			○	○	
6	Asheekh Mhmd	1081A.H.-1670A.D.	VG	○	○			○	○		○				○			○			○			○			○	○	
7	AL-Akawat	1114A.H.-1703A.D.	VG	○		○		○			○				○			○			○			○			○	○	
8	AL-Basha	1169A.H.-1755A.D.	VG	○	○			○			○				○			○			○			○			○	○	
9	Jamsheet	1212A.H.-1797A.D.	VG	○				○	○		○				○			○			○			○			○	○	

Table 4: Materials analysis for mosques with good integrity.

	Name of the Mosque	Construction Year	Integrity	Materials																								
				For Walls				For Ceiling			For Arches				For Floors			For Roofing			Windows		Doors		For Ornaments & Decorative Writings			
				Daubed Stone	Limestone	Stone	Others	Daubed Stone	Brick & Steel	Others	Limestone	Stone	Daubed	Others	Limestone	Stone	Others	Daubed	Stone	Others	Steel	Wood	Steel	Wood	Daubed	Stone	Limestone	Others
1	Annori	568A.H.-1172A.D.	G	○	○	○	○					○																
2	Asheekh Abdaal	1082A.H.-1671A.D.	G	○								○																
3	AL-Anbar	1105A.H.-1694A.D.	G	○								○																
4	Azzywani	1193A.H.-1778A.D.	G			○	○					○																
5	Hamo AL-Qaddow	1298A.H.-1880A.D.	G	○		○	○					○																
6	AL-Abbas	1346A.H.-1927A.D.	G	○								○																

Table 5: Materials analysis for mosques with fairly poor integrity.

	Name of the Mosque	Construction Year	Integrity	Materials																								
				For Walls				For Ceiling			For Arches				For Floors			For Roofing			Windows		Doors		For Ornaments & Decorative Writings			
				Daubed Stone	Limestone	Stone	Others	Daubed Stone	Brick & Steel	Others	Limestone	Stone	Daubed	Others	Limestone	Stone	Others	Daubed	Stone	Others	Steel	Wood	Steel	Wood	Daubed	Stone	Limestone	Others
1	AL-Omeria	970A.H.-1562A.D.	F/P				○																					
2	Attokandy	1085A.H.-1674A.D.	F/P			○	○																					
3	Omer AL-Aswad	1093A.H.-1682A.D.	F/P			○	○																					
4	Sultan Wayes	1095A.H.-1684A.D.	F/P			○	○																					
5	AL-Emam AL-Bahir	1178A.H.-1764A.D.	F/P				○																					
6	Baker Afandi	1205A.H.-1790A.D.	F/P				○																					
7	AL-Mahmodayn	1211A.H.-1796A.D.	F/P			○	○																					
8	Ashahwani	1219A.H.-1804A.D.	F/P			○	○																					
9	Bab Attoub	1230A.H.-1814A.D.	F/P				○																					
10	Zukak AL-Husn	1235A.H.-1819A.D.	F/P			○	○																					
11	Abdullah Beek	1285A.H.-1868A.D.	F/P				○																					

Mosques with very good integrity: In this category (Table 3) there are nine mosques (*AL-amawi*, *AL-Mujahidi*, *Annabi Gargis*, *Khuzam*, *Ajwejati*, *Asheekh Mhmd*, *AL-Akawat*, *AL-Basha* and *Jamsheet*) were used materials for walls, arches, ornaments and decorative writings sustainable its historic characters. Although, *AL-Mujahidi* mosque was used other materials for walls, which are bricks and daubed plaster, but these materials were the original materials. All mosques in this category were used other materials for ceiling. As well as all mosques in this category were used other materials for roofing and most of them were used other materials for floors. There are a variety of materials used for walls and floors. But the use of limestone is mainly for arches in all mosques in this category. All mosques in this category were constructed in long period of time, which is more than 600 years if we exclude *Alamawi* mosque. The

mosques of this category were constructed before the construction dates of the first category. The impact of materials on the appreciation of its historical characteristics achieved very good integrity.

Mosques with good integrity: In this category (Table 4) there are six mosques (*Annori*, *Asheekh Abdaal*, *AL-Anbar*, *Azzywani*, *Hamo AL-Qaddow* and *AL-Abbas*) were used other materials for walls and ceiling which weakened their historic characters. But the use of traditional materials for arches, ornament and decorative writing sustain the integrity of historic characters.

All mosques in this category were used other materials for roofing and floors and do not have variety of materials in mosques elements except (*Annori*) mosque.

The construction dates of the mosques of this category confined to within 260 years except (*Annori*) mosque. The impact of materials on the appreciation of its historical characteristics achieved good integrity.

Mosques with fairly poor integrity: In this category (Table 5) there are eleven mosques (*AL-Omeria, Attokandy, Omer AL-Aswad, Sultan Wayes, AL-Emam AL-Bahir, Baker Afandi, AL-Mahmodayn, Ashahwani, Bab Attoub, Zukak AL-Husn, and Abdullah Beek*). The mosques of this category used other materials for most of their elements except for ornaments and decorative writings. The arches were disappeared in most mosques of this category. The construction dates of the mosques of this category confined to within 315 years. The impact of materials on the appreciation of its historical characteristics due to the changes occurred in this category did not achieve integrity. So, the integrity of this group was fairly poor.

CONCLUSIONS

Local materials used in historic mosques in Mosul old city. Most of the materials, which are used in historic mosques, were achieved sustainability for most elements of the mosques except for ceilings and roofing. In order to reuse the historic mosques need conservation. In last few decades conservation done with the use of new materials such as concrete for the damaged elements. This caused lose the integrity of historic characteristics of most historic mosques. In some other mosques (*Arrabiea, Annoumania, Annabi Sheet and Maryam Khatoon*) the conservation has been done with conscious way under supervision of experts, which achieved excellent integrity. This study describes the themes of using the variety and arrangement of materials, which used in historic mosques in Mosul old city. The research shows the main materials, which used in historic mosques were:

- Daubed stone, limestone and stone for walls.
- Daubed stone for ceilings in most of the mosques, except in three mosques (*Ajwejati, Asheekh Abdaal and AL-Abbas*) steel and brick were used for ceilings.
- Limestone was used for arches in most mosques, while stone and daubed were used in some others.
- Limestone was used for floors in most mosques, while stone was used in some others.
- Daubed was used for roofing in most mosques.
- Both steel and wood were used for doors and windows.
- Daubed, stone and limestone were used for ornaments and decorative writings.

The study shows that materials, which used for ceilings, roofing and floors, were damaged due to their specifications. Materials such as daubed, daubed stone and limestone do not resist for long time under environmental conditions like rains and humidity which caused damages in element where used especially if these elements were under direct

environmental effects. Thus most elements where damaged occurred were the ceiling, roofing and outdoor floors in historic mosques.

Embodied energy deserves to be another factor in the equation of sustainable design, particularly for historic preservation. The historic built environment represents a huge resource that can be conserved and made efficient for the twenty-first-century challenge of fossil-fuel exhaustion. Conservation and design professionals will depend upon the research scientists to provide the data upon which to base embodied-energy decisions. Thus experience required to perform identification, evaluation, registration and treatment activities. In some cases, additional areas or levels of expertise may be needed, depending on the complexity of the task and the nature of the historic buildings involved. The study recommends understanding the nature and behavior of building materials, especially their behaviors under stress and under changing environmental conditions

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