Ilkogretim Online - Elementary Education Online, 2022; Vol 21 (Issue 3): pp. 79-97
http://ilkogretim-online.org
doi: 10.17051/ilkonline.2022.03.06

The Role Of Digital Craftsmanship By "Hybrid Re-Assemblage" Technique In The Restoration Of Historical Buildings

Marwa Abdul Raouf Hassan Architecture, Engineering Basra university , Basra,Iraq,
ae.19.11@grad.uotechnology.edu.iq

Prof. Asmaa M.H. al-Moqaram Architecture, engineering University of Technology, Baghdad,Iraq
asmaa.m.almoqaram@uotechnology.ed.iq u.iqil.com

Dr. Bilal Samir Ali Architecture, engineering University of Technology Baghdad,Iraq,
90098@uotechnology.edu.iq

Abstract:
Historical buildings are considered as a heritage that needs different restoration methods and techniques to support building from cracking or collapsing and returning it to its original image both in detail and location. The research suggests employing a technique "Hybrid Re-assemblage" in the local reality, depending on combining two integrate digital fabrication with traditional crafts. Thus, the research problem was Determined as **"the need to investigate the role of Hybrid Re-assemblage technique in the restoration of local historical buildings"**.

The aim was to identify practical procedures for the Hybrid Re-assemblage technique in the restoration and craftsmanship of local historical buildings through its creative dimensions. This needs a quantitative methodology based on building a theoretical framework, and applying the techniques on the historic building - Iwan (Taq) Kisra was chosen as a case study. The procedures combining two creative processes that rarely interfere, by first: building damaged or destroyed handcrafted models, second: making a 3D scan with a CAD program, third: building and digitally printing a model that can be used to reconstruct this product. The research concluded that such techniques can contribute to improving the restoration process, documenting important buildings, and creating completely identical pieces, with the possibility of linking them to the original building in its own shape and history without the need for major change. Furthermore. It allows the restorer, designers, craftsmen, and artists create works that preserve important features of the craft as well as impart new aesthetic values.

Keywords: historical buildings, restoration, digital techniques, Hybrid Re-assemble, Hybrid restoration.

1. Introduction:

Historic buildings are characterized by a great variety of shapes and materials, and the research does not aim to replace handicrafts, but rather only refer to the future, as some activities in the material formation process can be replaced by easier steps, thus creating a mixture of tradition and technique. And since the preservation of historic buildings is about promoting a deep appreciation of these famous structures and learning more about their reasons for their existence, where instead of just keeping

historical structures tall and looking beautiful as they always have been, the preservation of true historic buildings aims to achieve a high level of authenticity, reproduction of materials. Historical techniques are as accurate as possible, using modern technologies and in a subtle way that will not affect the historical character of the structure's appearance.

1.1 Historical buildings and their preservation:

The architecture is a result of the neighborhood's content, and the importance of the framework arises from a single or multiple environment and culture, similar to that can illustrate history since ancient times (Al-Sayigh, and Al-Moqaram, 2017, p.18) A historical building is defined as the building that carries a value. Architectural or historical special shape (1)." Felden" defines the historical building as every building that gives us a sense of wonder and makes us want to know more about the people and the culture that produced it, he specifies that a building that survives a hundred years' events and is of benefit is called historical. A traditional building built of mud, bricks, stone or wood can become historic if it lived and survived for hundreds of years and when it is useful for three generations and acquired Gradually the value of age and scarcity (Feilden, 1994, p. 11)

In the early nineties, problms began to appear in how to deal with historical buildings with the concept of preservation. Therefore, new ideas and methods appeared, especially after the technological revolution,

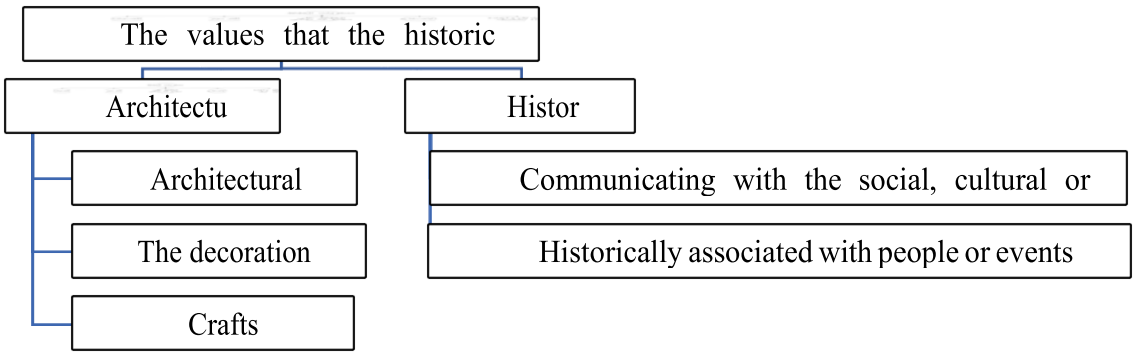

Figure (1): The values preserved by the historical building - the source (Feilden, 1994, p.11)

so new fields began to appear in the field of preservation (Al-Issawi, 2012). Preservation works include multiple verbs that have been classified by many researchers, including (Mosesian, 2001, p. 58) to:

1-Replacing the damaged parts with copies that are completely identical to the original but with a different material.

2-Introducing a new composition to the building that is identical to the original in form and materials and clarifies the same idea of the fleeting original.

3-Replacement of damaged or ephemeral parts by projections with the same material for the original building, but it refers to the general lines and layouts of the form only.

1.2 Preservation Levels:

According to Imad El-Sherbiny's study, contemporary trends in conservation can be classified into several levels:

A- **Maintenance**: A treatment process that is done periodically for a defect or damage that affects the building that has actually occurred or is likely to occur.

B - **Restoration**: restoring the building to its original state by rebuilding what was demolished or repairing it according to its condition.

C - **Preserving groups of buildings**: This is done by preserving the building itself and returning it to its origin by tracing the quality of the building and its historical and archaeological backgrounds and others.

D- **Rehabilitation and reuse**: it focuses on the necessity of dealing with buildings to highlighting those buildings as an effective value that interacts with the surrounding environment, by developing and adapting their use and supporting the surrounding urban areas, influencing and affected by them (El-Sherbiny, 2004, p. 18).

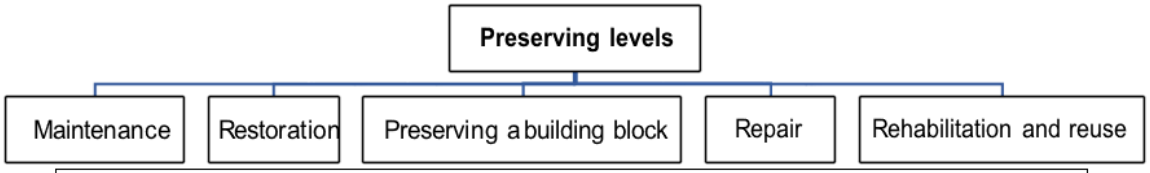

Figure (2): shows the levels of preservation of historical buildings (El-Sherbiny, 2004)

The preservation process in dealing with historical buildings adopts two directions Figure (3), the first of which is based on the practical dimension of preservation, while the second is based on the intellectual dimension of preservation, in a way that provides greater flexibility in selecting appropriate formal formulas to transmit these values (Previous source, p.20).

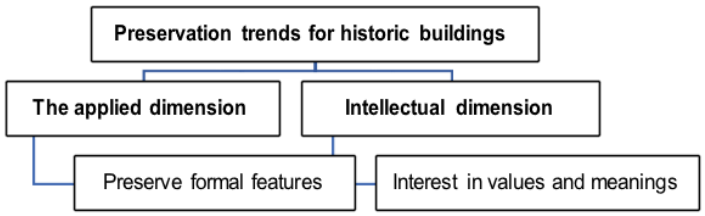

Figure (3): Explain trends in preserving historical buildings (El-Sherbiny, 2004)

1.3 Restoration Historic Buildings:

in this paragraph, Restoration will be addressed and its reasons as one method of preserving historical buildings:

Vienna Charter defines restoration as a highly specialized process whose goal is to preserve and reveal the historical and artistic value of the sign and depends on respect for the original material and real documents. the principle of restoration was based on presenting optimal suggestions for removal and addition work regarding the historical building and the principles that must be adhered to (Al-Muqarm, Yunus, 2015, p. 385). The restoration work includes removing extraneous elements, and replacing the rotten pieces with new ones, provided that they are distinguished from their old counterpart, this mechanism represents the current adopted in many global experiences during the past decades. This mechanism also includes a policy of re-assembly * anastylosis (or reconstruction by analogy), which is the reconstitution of the lost structure by Re-assemblage its scattered pieces and by merging with new materials only when necessary and on the basis of reliable and real historical evidence and documents (Jagilil, 2016, pp. 7-8).

1.4 Reasons of Restoration historical buildings:

Buildings are distinguished by historical, symbolic, artistic, architectural, or social value, and are characterized by the characteristics, acceptance of society, that is, they are accepted and positively interacted by society in a way that allows them to continue, and as a cultural and social phenomenon expressing material, moral or intellectual phenomena in a certain period of time, and steadfastness And continuity (Al-Muqarm et al., 2015, p. 187), the reasons for building restoration often fall into five main categories (Rocchi, 2015) as follows:

A- **Value** - Buildings have intrinsic value not only in the history of the building, how it was used, but also in how it was built.

B- **Architectural design** - buildings have specific architectural characters and elements that make the building unique and more valuable. Keeping these unique features is ideal.

C- **Sustainability** - restoring a building for a purpose other than its original purpose called adaptive reuse. Restoring a building and adapting it for modern use rather than creating a new site is better financially.

D- **Cultural importance** - Some sites are linked to the nation's identity which makes the site more valuable for what it offers to culture than if it were torn down.

E- **One chance rule** - guided by the idea that there is only one chance to regain a site and losing that opportunity can destroy a site of unknown importance.

1.5 Previous studies that dealt with the preservation in historical buildings:

A group of studies will be discussed on the subject of preserving historical buildings by means of restoration and using modern technologies.

(Vanhellemont et al., 2016) study - this study Provides an overview of several digital technologies, their potential, and future prospects. It explores how techniques such as additive manufacturing (3D printing) and CNC (computer numerical control) can help produce items that can be used directly in the restoration of buildings, especially the complex and sculptural parts of them. Its possible applications are in the field of natural stones (as well as alternatives to artificial stone), metals (bronze, brass, cast iron). it provided an example of applying this technique to the "Clock wing of St Martin's Cathedral in Flanders" based on the original remains of the tower Figure (5). CAD technologies were combined with scanned models to produce a final model, which was automatically carved into stone and cut based on a digital model, connecting to the existing building (without removing the original materials) and (when selecting the correct adhesives) in a reversible manner. The study shows that this technique can be used on a variety of metal objects, such as metal door handles, decorations on fences or other materials that are subject to shrinkage during production (such as ceramics),

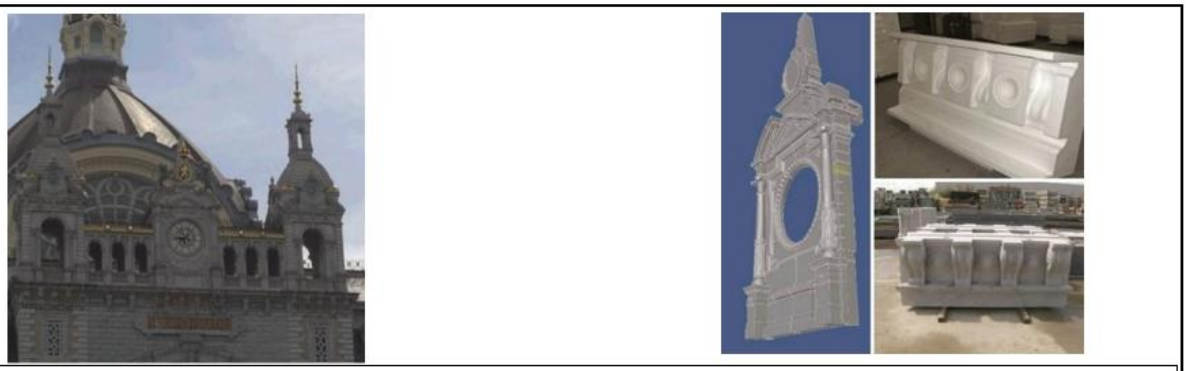

Figure (5): Various stages of rebuilding the clock wing of Antwerp Central Station. From left to right: part of the digital model of the watch wing (Verstraete&Vanhecke)the completed clock suite (Vanhellemont et al., 2016, p.146)

(Khoshelham, 2018) Study-The study provided an overview of techniques and methodologies for data acquisition and spatial information modeling for heritage buildings. Based on the experience of a case study for the Royal Gallery Building (REB) - the first building in Australia to achieve the World Heritage List - who was built in 1880 Figure (6). The data acquisition process included digital techniques such as aerial laser scanning, ground laser scanning, Zeb scanning, and photographic capture, The Phoenix lidar system was used to record a dataset of 105 million points covering the building's roof and surrounding gardens. To capture overlapping images of the roof and Interface, a small DJI drone with dedicated cameras was used. For the interior, a Faro ground laser scanner combined with a camera was used to record more than 40 scans on the ground floor and first floor, the resulting model contains the reconstructed elements in a hierarchical structure according to the standard IFC data model.

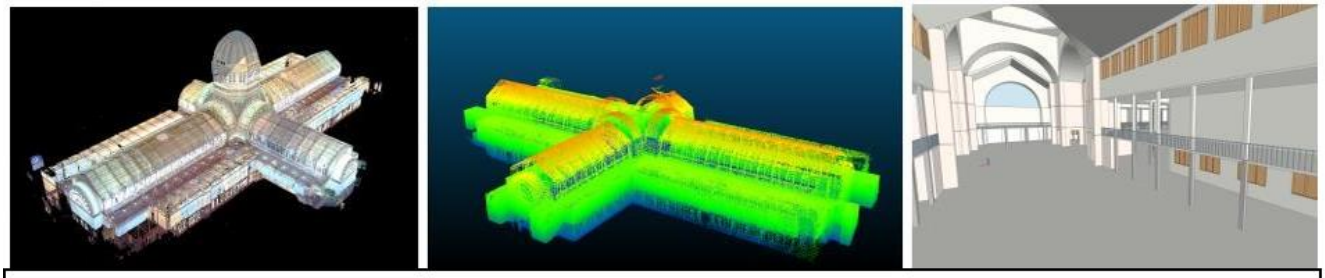

Figure (6) in-ground laser scanner data (left), Zeb-1 inside data (middle), and BIM generated from ground based laser scanner data (right). Source / (Khoshelham, 2018, p.6)

(Abdul Hakim-2016 study)- The study aims to identify the most important technologies produced by information technique in preserving urban heritage and electronic cities to create a relationship between them and heritage cities and how to apply those technologies and applications in reaching an electronic heritage city, the study relied heavily on the information systems program GIS geography in all stages, as well as the virtual reality technique concerned with simulation. By using these two technologies, the researcher has established an electronic heritage city on three levels: (**level of information),** which depends on searching in Site WEB, in addition to the geographic information analysis system. (**Interface level**) Virtual reality technique is the key to this level to clarify the urban environment within this heritage city, through which it is possible to identify the shape of the city. (**Level of interaction**) The use of social studies previously introduced in the digital model of the city helped in creating a type of social interactions that are identical to the reality of the heritage city.

As for (**Abdul Hadi's study – 2013)** - It dealt with the role of digital technologies in the development of areas related to the preservation and restoration of the various architectural heritage,

this was done through a review of the most prominent of these technologies, whether they are hardware, equipment or software ,in relation to **devices**, 3D Scanner devices used In monitoring and documenting a real anthropomorphic or a small facility or a large building or an entire site and converting it into a three-dimensional digital copy, as for **the software**, including virtual reality techniques, to create environments that simulate physical reality, whether it is present or extinct. And 3D Display Devices, which specializes in connecting the third dimension and giving a stereoscopic image to the viewer to show realism, dazzling and convincing the shows to appear as real. As for Augmented Reality technique, it differs from virtual reality technique, in that it can modify the realistic image instead of replacing it with an imaginary environment that simulates reality. The study ends with a discussion of the pros and cons of these applications, for use in the formulation of the necessary controls and standards in the field of preservation.

We note that the digital technologies used in preservation vary in the way they are used, as some focus on the digital restoration of certain parts of a building, some are concerned with digital documentation, other focus on simulation through digital virtual reality, the research focuses on a technique taken from another field (Handicraft field) to be used in the restoration , as it achieves two aspects (documenting the building and digitally restoring it) while preserving the historical value of the building and without exposing the rest of its parts to damage. So, research problem Appeared represented by "**the cognitive need to investigate the role of Hybrid Re-assemblage technique in the restoration of local historical buildings**", so the goal is to "**define practical procedures for the technique of Hybrid Re-assemblage in the restoration and craftsmanship of local historical buildings through its creative dimensions**". to solution this problem required the adoption of a quantitative approach, based on a theoretical framework around this technique.

2. Theoretical framework for hybrid restoration techniques:

The development of digital technique has expanded the designer's capabilities, especially in the field of generating shapes of formal and curved complexity, which are difficult to implement by traditional methods of construction, which led to the search for new methods that work to achieve them physically, so the concept of digital manufacturing has emerged in architecture (Al-Khafaji and Al-Khafaji, 2016, pg. 275) Zoran's work on hybrid baskets, pottery, and utensils alludes (Figure 7) to a new form of restoration and sustainable heritage preservation. The combination of broken artifacts with a digitally designed and 3D printed structure allows for two creative processes to take place, as Zoran and Buechley claim, processes that rarely overlap, this work may not only be adopted in museums, but may result in many New antique pieces that can be easily integrated into modern interiors and used even in architectural building elements) Zoran and Buechley, 2013, pp. 8-9).

1.6 Hybrid Re-Assemblage:

It is a design Gestalt that falls across the cross section of the practice of digital design and the tactile qualities of traditional crafts. It extends over an area in which the artifact value is produced through robotic production as well as the human self. This work is an exploration of two different worlds: the world of emerging computational technologies - and the traditional hand-engraved practice, Zoran introduces hybrid Re-Assemblage a new way of thinking about the machine, as a generator of control and efficiency, the unique and unexpected nature of raw and manual (Zoran, 2013, p. 3), and integrates the

individual qualities of the media non-computational with computational ones (Zoran and Buechley, 2013, pp. 8-9).

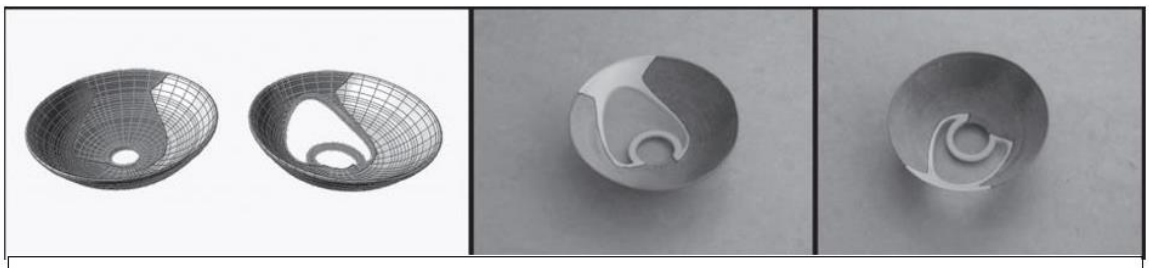

Figure (7): (Left) the hypothetical model of a 3D scanned bowl that was designed in (Rhino). (Right) The restored vessel with 3D printed SLS element, e-boxy glue, and spray paint. ((Zoran Amit, 2013, p.6)

1.6.1 Technique description:

By reassembling a broken object using contemporary manufacturing techniques, a unique artifact that retains traces of the original has been restored. The motivation is twofold:

First - integrating digital fabrication with traditional crafts, thus combining two creative processes that rarely overlap.

Second - to explore the process of restoring artifacts that preserves the shape of the original and the history that bears it while simultaneously recognizing the effects of damage.

Zoran's study shows a shattered ceramic vessel that has been digitally restored with the "hybrid Re-Assemblage " technique. This process started with designing the (vase) in Rhino program (Fig. 8). Then many large parts of the broken vase were selected and re-bonded back together, after that a 3D scan of the vessel was made using a "Konica Minolta VIVID 910 scanner". Then the manufacture was done. Models of other missing pieces from the vessel are digitally scanned and then the broken pieces of the vase are held together by a 3D printed grid that follows the original shape to contrast and complement the glazed ceramics of the original ceramic vessels, the remaining ceramic pieces refer to the shape of the unbroken vase. The network, rather than duplicating or replacing lost pieces, emphasizes its absence. The resulting vase serves as a monument that preserves, traces of the entire life cycle of the object of construction, destruction and restoration (Zoran, 2013, p.5).

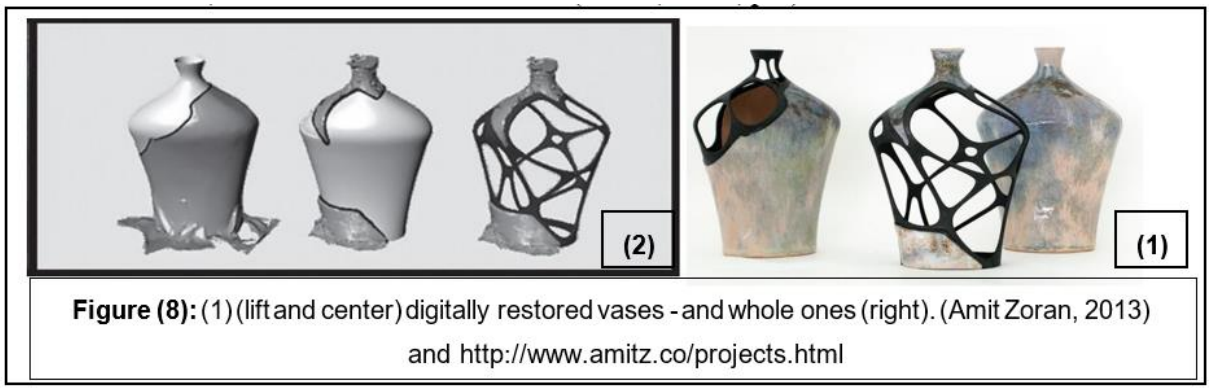

Figure (8): (1) (lift and center) digitally restored vases - and whole ones (right). (Amit Zoran, 2013) and http://www.amitz.co/projects.html

1.6.2 Technique features:

The advantages of "hybrid Re-assemblage " can be summarized as follows:

A- Reduces risks: The goal of the restorer is to preserve the original characteristics of the work and hide any external interference. Manufacturing is used as a restoration process, and a means of acknowledging and reconciling with the risks inherent in handicrafts. In new machines and **technologies**, engineers rely on prior technical work and search for optimal solutions, which reduces from design and implementation process risks as few as possible. (Hung and Magliaro, 2007) Digital work are constantly endangered in the same way as hand work, however, digital artisans can edit, modify and save their work as digital files. This means that the risks of digital design are much less compared to craftsmanship (Zoran and Buechley, 2013, p. 4).

Professional and machine knowledge provides inputs on materials or production and manufacturing methods that enable the risks of the restoration process to be minimized as much as possible as a result of prior planning and the search for optimal solutions during the design process.

B- Seeking Efficiency: Incorporating new technologies into design and manufacturing processes (such as additive manufacturing, laser cutting, etc.) can contribute to enhancing efficiency, creativity and interactivity. It also improves production processes by accelerating production and increasing volumes while retaining aesthetic properties and unique craft qualities through factory and manual hybrid production (Garlick, 2018) efficiency in both theoretical and practical aspects leads to the ultimate control over the craft work. It is the basis on which it builds One has to perform successfully, for technical mastery is only part of becoming a successful work, the artist who has many tools must decide which of them to use, when and how, these choices form the heart and craftsmanship of the artistic (Eisner, 1984, p. 21).

The ability to 3D scans any component of a building is a game-changer when it comes to saving time and energy in recreating important pieces. Compared with traditional techniques, 3D printing can be a more efficient process.

C- Enabling Automation: Automation has been further developed using CNC machines in recent years, as technique has moved forward from mechanization to digitalization. Digital methods of design and manufacturing allow discovery through continuous experimentation, with scanners and 3D printers, modern day designers can capture the exact shape of existing objects and reproduce with precision (Balık and Allmer, 2017). Zoran shows that the use of these tools and processes can benefit the industry by facilitating new creative approaches and argues that this is a new type of craft process that provides insight into the relationships between traditional crafts and modern technique and design (Zoran, 2013, p.7).

D- Preserves the origin: by reassembling a broken object using contemporary manufacturing techniques, the "restored" vessel no longer retains its function and instead commemorates the original with an acknowledgment of the occurrence of fracture and subsequent loss of function. The contrasts between the new and the old parts are emphasized by different surfaces, shapes, textures and colors (Previous source, p.9).

Access to CAD software, 3D printing, and scanning enabled restoration to be used as an integral part of the craft process. These new tools can allow the creation of works that preserve the important features of the letter. This enables the preservation of the original, while providing new aesthetic possibilities at the same time.

1.6.3 Values maintained by technique:

Buildings have specific architectural personalities and elements that make the building unique and more valuable. Preserving these values within the building is ideal and necessary, these values are:

1.6.3.1 Authenticity:

Due to the importance of historical buildings, their preservation revolves around a deep appreciation of these famous structures and knowing more about the reason for their existence. The preservation of them aims at a high level of authenticity, reproducing historical materials and techniques as accurately as possible (Van Sanford, 2015) Authenticity conveys the reality of the ancient environment, the building It is authentic only if it maintains the original and a high proportion of material (Wells, 2010, p. 2). It is necessary in the restoration process to clarify the difference between the original shapes and the additions that required the restoration process, and whoever looks closely at the restored historic buildings will notice that the colors of the stucco and carved wood that the restorer added differ from the colors of the original decorative elements, which indicates the sophistication of the restoration philosophy and respect for the principle of originality and this is what It is confirmed by most international conventions (Al-Hawari, 2011).

1.6.3.2 Aesthetic value:

Aesthetic meanings refer to technical proficiency, dexterity, and a delicate skilled hand, all of which are a product of industry knowledge. The interaction between the physical elements and what is being evaluated resonates in aesthetic meanings that reflect the personal values, skills and creativity of the craftsman, and in parallel support ideas to meet the practical expectations of the outputs (Kouhia, 2012, p. 32) The advanced technique of this technique integrates different aesthetic styles in addition to processes and materials. The 1964 Venice Charter, Article 9, affirms that the aim of the restoration process is to maintain and demonstrate the aesthetic and historical value of the archaeological facility, and is based on respecting and highlighting the original material and the documented and approved documents. Any works added for an aesthetic or artistic necessity must be distinct from the architectural composition and original elements and must appear contemporary (Al-Zaini, 2018).

1.6.3.3 Creative values:

Architect Greg Lynn argues that digital technique is more than an enabler, because its function is to help the designer create creativity, aesthetics, and improvisation, just as contemporary techniques for making ornamentation show reshape skill and redefine perfection (Greg, 2004, p. 67). Digital fabrication - especially 3D printing - provides new opportunities for restoration by enabling relatively easy construction of replicas of broken pieces from original works, as well as helping to facilitate new creative approaches. Less than other technologies, allowing more creativity and space compared to other traditional means.

1.6.3.4 Historical value:

The remodeled buildings and the added pieces preserve the previously acquired history and serve as documentation of damaged pieces and as new beautiful and expressive objects in their own right. Alois Riegl (1996/1903) referred to the historical value "rests on a scientific basis and therefore can only be achieved through an intellectual reflection" (Wells, 2010, pp. 4-5). The use of the technique of "hybrid Re-

assemblage " and the desire to restore the vessel referred to by Zoran was to preserve some of the historical value it holds and the meaning it conveys (Zoran and Buechley, 2013, pp. 5-7).

historical value of the building is enhanced by using this technique by preserving the intact parts of the building and using the remains of the destroyed parts to re-create the other parts as much as possible, while compensating for the remaining parts of the building with modern materials consistent with the original with the ability to distinguish them from other parts.

3. Practical study:

In this paragraph, the most important measurement vocabulary associated with "Hybrid Re–Assemblage" technique will be defined, and the measurement method, method and sample selected for the purpose of application will be determined.

1.7 Vocabulary subject to measurement:

The secondary vocabulary of the two main vocabulary (technique characteristics, values that it maintains) was chosen which included (reducing risks, achieving efficiency, enabling automation, preserving the origin) for the first main word and (originality, aesthetic, historical and creative value) for the second main word. As shown in the table (1).

Table (1): Shows the vocabulary of the theoretical framework. Source: (researchers)

Main vocabulary	Secondary vocabulary			code
Technic features	Reducing risks	Advance planning		X1
		Searching for optimal solutions during the design process		X2
		The ability to edit and modify digital work		X3
	Achieve efficiency	Practical aspects	Accelerate production and increase volumes	X4
			time saving	X5
			Reducing effort and labor in re-creating demolished pieces	X6
		Theoretical aspects	Incorporate new technologies into design and manufacturing processes	X7
			Technical mastery and Control of tools	X8
	Enable automation	Using 3D scanners and printers		X9
		Merging traditional crafts, modern technique, art and design		X10
	Preserve the	Emphasize the	Surfaces	X11

	original	contradictions between the new and the old parts	Shapes	X12
			Colors	
		Not to affect the rest of the building		X13
Values maintained by technique	Authenticity	Clarify the difference between the original shapes and the additions that required the restoration process		Y1
		Preserving the nature of the materials used		Y2
		Not to change its features during the reconstruction process of damaged or missing parts		Y3
	Include aesthetic values	Technical competence	Respect the original forms and highlight the original article	Y4
		Skill	Maintain style	Y5
		The delicate skilled hand	The skill of using tools and materials and how to deal with them	Y6
	Creative values	Use of new tools and technologies		Y7
		A marriage between the old and the new without affecting the original		Y8
		Harmony between new and old materials and the ability to distinguish them from other parts		Y9
		High quality 3D printed templates		Y9
	Historical values	Documenting damaged items as new and expressive objects		Y10
		Maintaining healthy parts of the building		Y11
		Use the scraps of the damaged parts to recreate the others		Y12

1.7.1 Method and way of measurement:

The research adopted a quantitative approach based on the application of technique on the selected sample, along with an electronic questionnaire to measure and know the possibility and efficiency of using the technique "hybrid Re-assemblage " according to the features and values it maintains. The questionnaire included a set of pictures that represent the stages of applying the technique to the sample. As (20 respondents) were elected with an architectural specialty with no less than five years of experience, and by electronically filling out the questionnaire, the data was obtained.

1.7.2 Sample identification:

For the purpose of carrying out the application, a sample was selected for an important archaeological building in Iraq, "Taq Kisra" building, where a large part of the upper Taq was lost not long ago, due to neglect, poor restoration and weather factors, which helped to choose it as an area to apply the technique

to it and suggest it as a restoration technique that can be taken in the future for its restoration, And the following is a description of the sample selected for measurement.

1.8 Sample description:

This part includes a general description of the sample selected in the study and aims to apply the technique on it that is based on the application of detailed measurement for the purpose of knowing the efficiency of the technique for restoration, and the creative side in it to know the possibility of its use, as follows:

1.8.1 Taq Kusra - a historical overview:

(Arabic): Taq Kisra, in Latin: Haqq Kisra, it dates back to the third century, sometimes called the Arch of Ctesiphon (Farrokh, 2007). It is the surviving monument from one of the palaces of Khusra, Anu Sharwan, located south of Baghdad in the Al-Madaen area. This monument represents the largest hall for an Iwan, roofed with a wage in the form of Decades without the use of supports or armament (Ali, 2017, p. 15). The construction of the Tag dates back to the Sasanian king Khosrau in 540 and was part of the Great Iwan for the Throne. width of the brick Taq is about 26 m. The oldest photographs of the building indicate that a central part of it fell earlier and made a large gap that caused the band to split into two parts, one east and the other west, with large cracks and cracks occurring in the northern and southern walls.

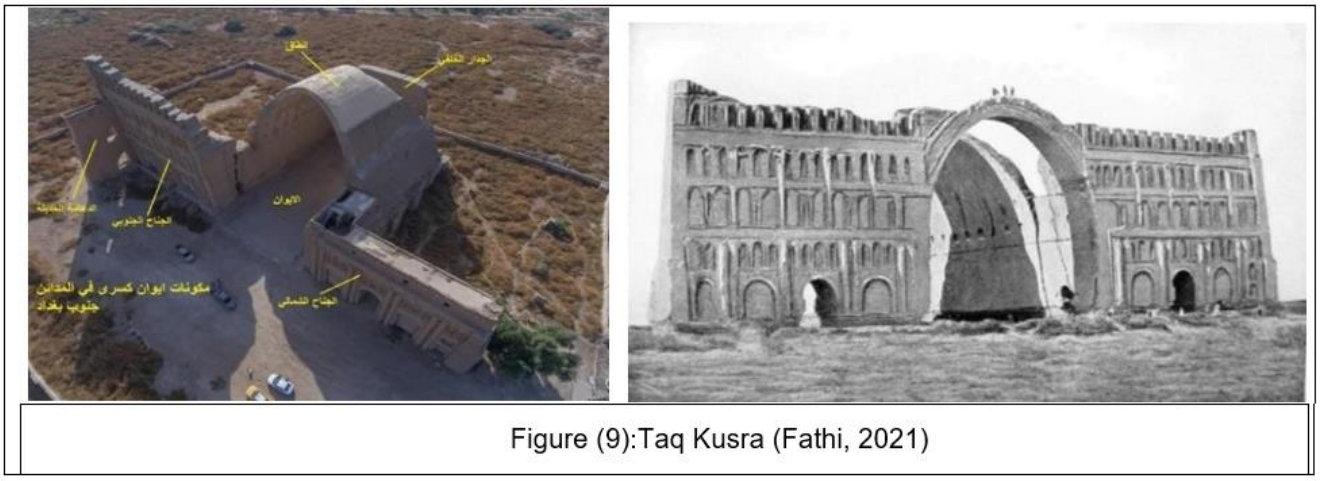

Figure (9):Taq Kusra (Fathi, 2021)

The great flood of the Tigris River 1887 caused the collapse of the entire left (northern) wing, in addition to the front façade of the building, and thus it consisted of only one Taq in the middle of a front gap and a back gap with a right (south) wing also threatened to fall (Fathy, 2021) The cracks continued to increase, forcing the Department of Antiquities to build a large, sloping concrete pillar at the end of the southern wing between 1942 and 1943, in addition to linking the wing to the Iwan with a number of iron ties. In 1963, the Directorate of Antiquities carried out maintenance and restoration of the cracks on both sides. Neglecting the Iwan and the energy for a period without any maintenance or treatment, this caused a gradual loss of quantities of the energy courses (previous refrence). Forcing the Public Authority for Antiquities and Heritage to contract with a Czech company, Avers, to restore the site. This restoration was completed in 2017. However, in March 2019, a limited collapse caused further damage to the structure only two years after the work was completed (Taq Kasra 2020).

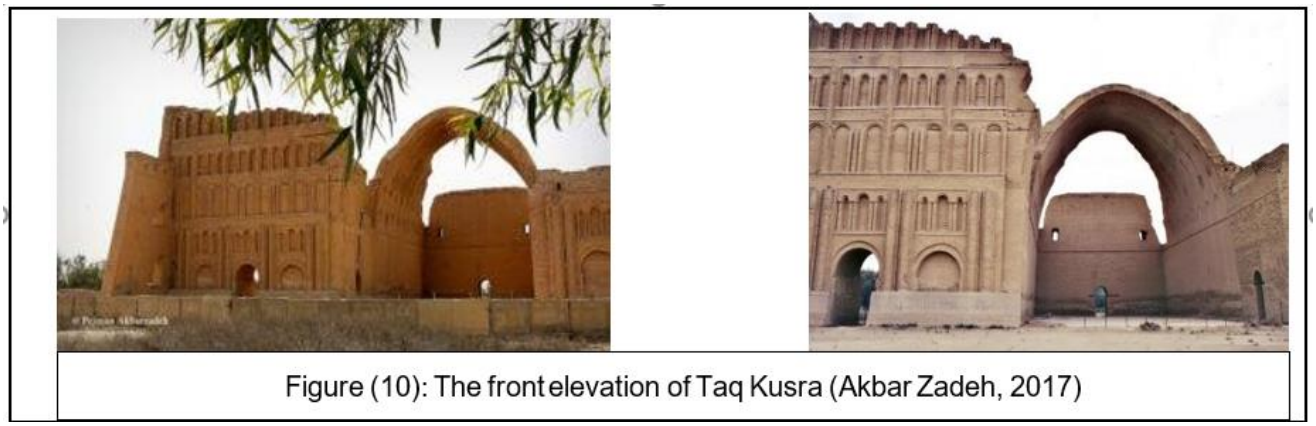

Figure (10): The front elevation of Taq Kusra (Akbar Zadeh, 2017)

1.8.2 Digital Model:

Making a digital model is the beginning of the entire process. The steps for drawing the building and implementing the restoration process are summarized as follows:

The process began with drawing the building digitally in the 3DSMAX program as it is in reality, and this is one of the advantages of the technique, as the building is first digitally documented, which helps to preserve it digitally, as well as its accuracy for drawing, application and drawing the rest of its complementary parts. As shown below in Figure (11), after drawing the building digitally, three-dimensional printed grid structures were made that follow the original shape and complement it, and it is a structural support to support the part that sits on it in addition to providing support for the rest of the arch parts as well as reducing the load resulting from the extra weight which prolongs the age of the building It does not expose the rest of its parts to damage or collapse, figure (11-1), after which models are made for the other missing pieces of the Taq that complete its shape, after it is printed digitally with a 3D printer and according to the correct measurements, they are gradually placed on the grid until the work is completed and all the pieces are installed in its place (11-3) in the restored part, the contradictions between the new and old parts are emphasized through different surfaces, shapes, textures, or colors, and the final result is represented by (Fig-12).

Figure (11): building before application of the Technique

Figure (11-1): the application of the 3D net to the building

Figure (11-2): Applying the 3D net and its complementary parts to the

Figure (11-3): final result of Taq Kusra after implementing the technique

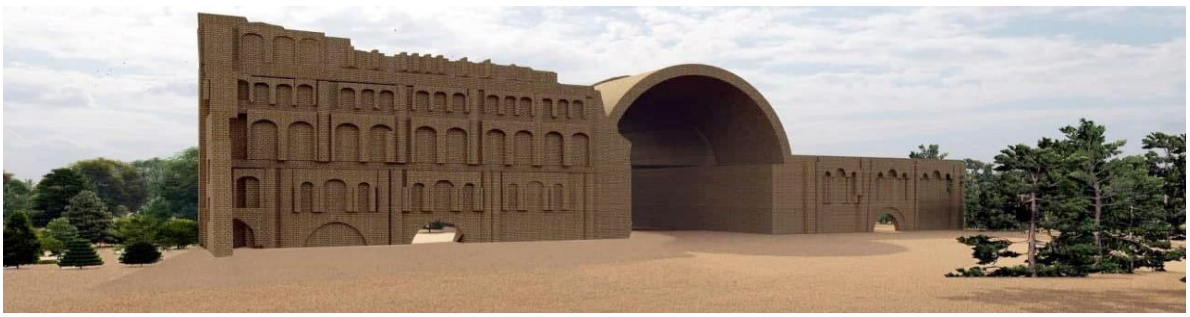

Figure (12) front elevation of a Taq Kusra after implementing the hybrid Re-assemblage technique

4. Discussion:

-Analysis of the questionnaire results for the first main item

The results of the questionnaire for the first secondary item (**reducing risks**) (X1) - (X3) indicate that the use of digital technologies in restoration can help in preventing and avoiding risks before falling into them by adopting prior planning and the possibility of editing and modification of work, as well as searching for optimal solutions during its process. the design. As for the second secondary item (**Achieving Efficiency**) (4X) - (8X), the results indicated

that technique can achieve efficiency by achieving its practical and theoretical aspects by accelerating production and saving the time and effort required in re-establishing destroyed parts. The results of the questionnaire also indicate that the technique of (hybrid Re- assemblage) represents an addition to the artist or architect's tools, and that the restored part of the fractal band works stably with the original parts, and it has a marginal effect on the rest of the Taq. In the event that this effect is present, it is an effective positive effect. Which preserves the original (9X) to (14X), which is one of the positive aspects of technique, and the results confirm the objectives of the technique by distinguishing between the original part and the added parts, and by using the same local construction materials.

- Analysis of the results for the second main item:

The results of the questionnaire demonstrated the effectiveness and efficiency of applying digital technologies in design processes by reducing effort and labor in re-creating the pieces that complete the building as well as achieving the singularity of Authenticity by achieving its indicators (Y1) - (Y3). The results also confirm the research hypothesis of enriching the technique used for future restoration operations. And preserving the aesthetic properties and values (4Y) - (6Y) of the "Taq Kisra" by preserving the style of the building and highlighting the building material itself, and that the part restored by it works stably with the original parts, and it has a marginal effect on the rest of the Taq, as for the creative values (Y7) - (Y9) was achieved, with high rates, as a result of achieving its indicators as stated in the results of the questionnaire and as shown below in Table(2), represented by the marriage and harmony between the new material and the old structural material of energy, with the distinction of the new material from the old to achieve the aesthetic and creative aspect in it. The application of the ؛ also preserved the historical symbolism (9Y) - (12Y) of the building and helped to promote digital creativity in developing solutions to the issue of the collapse of the Kisra Building, preserving and restoring it as an important landmark of Iraqi architecture, while continuing to refer to the life cycle of the Taq (construction, destruction, Restoration), and by achieving its advantages and values that it maintains n high rates as it came from the results of the questionnaire, the use of hybrid Re-assemblage technique represents the ideal solution to the application issue (the collapse of the fractal "Taq Kisra" and the urgent need to restore it).

5. Results:

1- Building restoration is considered one of the important processes concerned with preserving physical evidence of manifestations of human heritage. The historical building is not just architectural blocks that should be preserved for its ancient only, but rather a mirror that reflects human life in its historical stages.

2-The use of digital fabrication techniques benefits preservation by facilitating new creative methods. Using these tools, designers can accurately take the exact shape of existing objects and reproduce them. These tools also made it possible to use restoration as an integral part of the craft process.

3-Hybrid restoration" is theoretically considered feasible and compatible with the state of collapse that characterizes the remains of archaeological sites. Working with it avoids the total reconstruction that distorts the historical and archaeological value of the landmarks.

4-Hybrid re-assembly using digital fabrication-especially 3D printing-provides new opportunities for restoration by enabling relatively easy construction of replicas of broken pieces from original works.

5-3D printed parts in this technique combined with the original building create a hybrid effect, which folds many contrasting concepts together: old and new; Closed and open; Hand and machine making.

6-These new tools could allow the restorer, craftsmen, and artists to create works that preserve the important features of the craft and also provide new aesthetic and creative possibilities.

7-Compared to manually restoring these pieces, this technique could be more efficient. The 3D printed templates can be higher quality with less waste production than other technologies. 8- The great potential of this technique makes it not only used in the restoration parts of buildings, but also in restoration of the decorative elements of the facades and elements of historical buildings as well as allowing - in addition to its work - the digital documentation of the building to be restored.

Table (2): ratios of achieving each value from the vocabulary of the theoretical framework table. Source (researchers)

sequenc	Questions as in the form	Excellent	very good	good	Weak
1	Way of application of digital technologies in design processes	9.5	52.4	33.3	4.8
2	Reducing effort and labor in rebuilding the building's complementary pieces	17.6	52.9	17.6	11.8
3	Merging new and old technologies in design and manufacturing processes	17.6	52.9	29.4	
4	The extent of success in integrating traditional crafts (represented by existing energy) and modern technique	23.5	52.9	17.6	5.9
5	Preserving the nature of the materials used in the building	17.6	23.5	47.1	11.8
6	The extent to which the building's milestones were changed	11.8	23.5	35.3	29.4
7	To reconcile in clarifying the difference between the original forms and	23.5	29.4	41.2	5.9

	the additions required by the restoration process				
8	The extent to which the original shapes are respected and the actual material of the building is visible	29.4	23.5	35.3	11.8
9	The skill of using tools and materials and how to deal with them		64.7	29.4	5.9
10	Harmony between new and old materials and ability to distinguish parts from each other	17.6	47.1	23.5	11.8
11	Product quality of 3D printed templates	23.5	58.8	17.6	
12	The extent to which the affected pieces are able to achieve the historical value of the building	17.6	41.2	35.3	5.9
13	The possibility of maintaining proper parts of the building	29.4	47.1	17.6	5.9

Table (3): Verify the vocabulary values in the first part of the questionnaire. Source (researchers)

Table (4): values that verify the vocabulary in the second part of the questionnaire. Source (researchers)

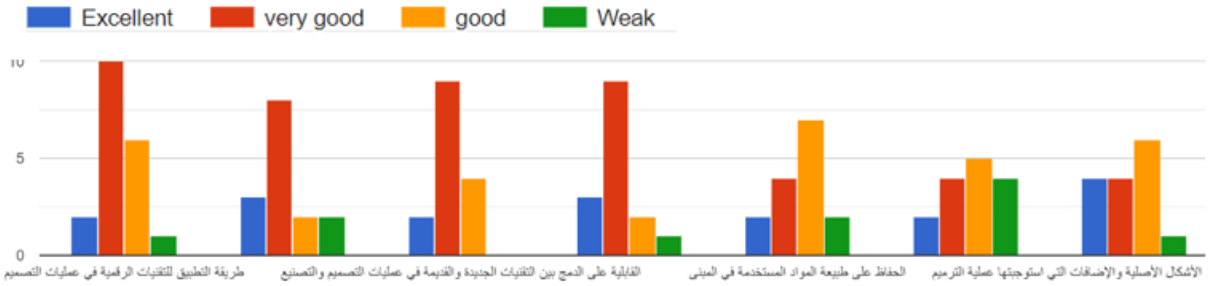

Table (5): values verifying the vocabulary of the second part. Source (researchers)

6. References:

1. "Taq Kasra: Wonder of Architecture". SOAS Centre for Iranian Studies. Retrieved 2019-08-30.
2. Abdel Hakim Al-Qadi, Ahmed Naguib, 2016. Methods of preserving the urban heritage through the techniques of the digital revolution. Journal of Al-Azhar University Engineering Sector, 11 (41).
3. Abdel-Hadi, Khaled, El-Sherbiny, Mohamed, 2013. "The role of digital technique in preserving
4. Al-Hawari, Muhammad (2011)، Restoration of Historic Buildings: Concepts, Steps, and Spotlights, Article published online, Monday, November 14th.
5. Ali, Bilal Samir, 2017, The Building of an Iraqi Man, unpublished book, Al-Walaa House for Printing and Publishing, Baghdad-Iraq.
6. Al-Issawi, Mohamed Abdel-Fattah, December 2012: Upgrading Heritage Domains of Value "A Comparative Study of Policies for Preserving Urban Heritage. Cairo: Faculty of Engineering, Fayoum University.
7. -Al-khafaji, A.M.J. and Al-khafaji, H.A.N., 2016. The Impact of Digital Fabrication in Architecture. Engineering and Technique Journal, 34(9 Part (A) Engineering). (
8. Al-Muqarim, Asmaa. Tanner, the merits. Al-Bahadli Shatha, (2015), Adaptation to Reuse in Buildings of Value by Adopting Change in the Movement System, Engineering and Technique Journal, Volume 34, Part (A), Issue 6.
9. Al-Muqarm, Asma Muhammad, Yunus, Sembel Muhammad, 2015, the role of international laws and charters in the tourism industry - A study in tourist buildings and centers, Iraqi Journal of Architecture, Issue (4) December.
10. Al-Sayigh, L.A. and Al-Moqaram, D.A.M., 2017.Architectural Design Methodology by Typology. International Journal of Architecture (IJA), 3(1).
11. Al-Zaini, Yahya, 2018, Charter for the Preservation and Restoration of Archaeological and Heritage Buildings and Sites (Venice Charter 1964), article published January 6.
12. -Balık, D. and Allmer, A., 2017. Simulating Craftwork in Contemporary Architecture. The Journal of Modern Craft.
13. Eisner, E.W., 1984. The art and craft of teaching. PUB TYPE.
14. El-Sherbiny, Imad Ali El-Din, 2004, Studies in the Integrated Introduction to Maintenance and Urban Conservation: Tasks and Roles, with a special mention of the case of Fatimid Cairo - Al- Azhar and Hussein squares, a research published within the scientific research group of the first Dubai International Conference and Exhibition "Architectural Preservation between Theory and Practice", Dubai Municipality.
15. -Farrokh, Kaveh. Shadows in the Desert: Ancient Persia at War. Oxford: Osprey, 2007
16. Fathi, Ihsan, (2021)، Save Kusra Square from complete collapse and eternal demise!، An Iraqi architect specializing in preserving the architectural heritage, published article, January 1.

17. Feilden, Bernard M: Conservation of historic buildings. London: Butterworth
18. -Garlick, Aaron. 2018, “Aaron Garlick.” THE DIGITAL CRAFTSMAN.
19. Greg Lynn, “The Structure of Ornament,” in Neal Leach, David Turnbull, and Chris Williams (eds.), Digital Tectonics (Chichester: John Wiley & Sons Ltd, 2004).
20. Hung, Shu and Magliaro Joseph. (2007). By Hand – The Use of Craft in Contemporary Art. Princeton Architecture Press, New York.
21. Jagilil, Al-Tayeb, “Evangelistic Restoration”, Methodology for Restoration of Remains of Archaeological Sites, Zian Ashour University, Algeria, Issue 25 December 2016, the eighth year.
22. Khoshelham, K., 2018. Smart Heritage: challenges in digitisation and spatial information modelling of historical buildings. In 2nd Workshop on Computing Techniques for Spatio-Temporal Data in Archaeology and Cultural Heritage.
23. Kouhia, A., 2012. Categorizing the meanings of craft: A multi-perspectival framework for eight interrelated meaning categories. Techne Series: Research in Sloyd Education and Craft Science.
24. Mosesian, Rafi Moses,2001, Master Thesis entitled: “The Dialectic of the Relationship between Heritage and Contemporary and its Impact on the Expansion of Old Buildings”, submitted to the College of Engineering, Department of Architecture / University of Baghdad, March.
25. -Rocchi, J., & National Trust. (2015, November 10). Six Practical Reasons to Save Old Buildings: National Trust for Historic Preservation. Retrieved May 1, 2020.
26. Taq Kasra Partially Collapses | Taq Kasra : 3rd-century Persian Monument in Iraq"
27. the heritage of my architecture”, published article of Benha Shubra University.
28. Van Sanford, Scott. "Historic Building Restoration, Preservation, and Renovation". Pearl Bay Corporation.
29. -Vanhellemont, Y., de Bouw, M., Dekeyser, L., Dubois, S., Vermeir, S., Van Damme, P. and Van der Have, J.A., 2016, October. Application of Digital Technologies in the Restoration of Historic Buildings and Heritage Objects. In Euro-Mediterranean Conference (pp. 141-150). Springer, Cham
30. Wells, J.C., 2010. Valuing historic places: Traditional and contemporary approaches Retrieved 28 May.
31. Zoran, A. and Buechley, L., 2013. Hybrid re-assemblage: an exploration of craft, digital fabrication and artifact uniqueness. Leonardo, 46(1).
32. -Zoran, A.A.S., 2013. Hybrid re-Assemblage: bridging traditional craft and digital design (Doctoral dissertation, Massachusetts Institute of Technique).