Architecture Factors affecting the re-selection of the new suitable function for industrial heritage buildings in the process of their adaptive reuse

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Abstract

Due to modern technologies, industrial heritage buildings are going to be demolishing by investors because their functions have become non-existent and they are no longer used at the present time. Due to the distinctive identity and values of industrial history sites, that areas required adaptive reuse instead of redevelopment or demolition, but unfortunately during the period of adaptive reuse some of these buildings face a problem of non-continuity due to not choosing the suitable & optimal new function of those buildings. This paper focuses on reaching the architectural factors affecting the selection of new function of industrial building during the adaptive reuse as a result of this paper. This paper will mention results through literature review of linking the Architecture Attributes & values of industrial heritage buildings during adaptive reuse with focusing on attributes of the industrial building itself & its location, with the options of functions in Adaptive reuse of industrial heritage buildings (new function). This for mentioning and discussing the architecture factors affecting the selection of new function for industrial building during the adaptive reuse. Finally, mentioning and discussing those factors as the result of this paper, will help in selecting the optimal new function that will contribute positively in expanding the life of industrial heritage buildings in adaptive reuse, and reaching this, has positive effects that will help lowering energy consumption, pollutions, and material costs.

Keywords

Industrial architectural heritage, adaptive reuse, new function, Architecture Attributes.

الملخص

بسبب التقنيات الحديثة، سيتم هدم مباني التراث الصناعي من قبل المستثمرين لأن وظيفتها أصبحت معدومة ولم يعد لها استخدامات في الوقت الحاضر. و بسبب الهوية والقيم المميزة لمواقع مبانى التاريخ الصناعي، حيث تتطلب المناطق إعادة الاستخدام التكيفي بدلاً من هدمها و إعادة تطويرها، ولكن للأسف خلال فترة إعادة الاستخدام التكيفي لبعض هذه المباني تواجه مشكلة عدم الاستمرارية نتيجة عدم اختيار الوظيفة الجديدة المناسبة والأمثل لتلك المباني لذا يركز هذا البحث على الوصول إلى العوامل المعمارية التي تؤثر في اختيار الوظيفة الجديدة للمبنى الصناعي خلال إعادة الاستخدام التكيفي كنتيجة لهذه الورقة . هذه الوظيفة الجديدة الأمثل التي من شأنها أن تساهم بشكل إيجابي في توسيع عمر التراث للمباني الصناعية في عملية إعادة استخدام المباني التكيفية، والوصول إلى ذلك له آثار إيجابية تساعد في خفض الطاقة و الاستهلاك والتلوث والتكاليف المادية.

الكلمات المفتاحية
.التراث المعماري الصناعي، إعادة الاستخدام التكيفي، الوظيفة الجديدة، سمات الهندسة المعمارية

1. Introduction:

The adaptive reuse of industrial building is a very common tendency. Early efforts were undertaken in U.S. cities such as Boston and San Francisco where the conversion of the Ghirardelli chocolate factory into mixed uses between 1964 and 1968 and the subsequent conversion of the nearby icehouses are often seen as the first successful adaptive reuse developments of industrial heritage buildings. and all of those buildings lost their original function to another new function due to (agricultural and industrial changes, and economic, social, architecture reasons...etc.). (Douet, 2012; Douglas, 2006) . The cause of the fast growing of this tendency, is the growing concern about the environment and awareness of the need to revitalize towns and cities besides pleas for the conservation of industrial buildings which brought adaptive reuse with converting the original function of the building into another. But it is concerned with converting buildings into other, but more effective and efficient uses, and more effective here means that the adapted property serves the new requirements better and gives the building an extended useful life. This with changing some of the physicality of the building itself and its location. (Douglas, 2006). But although finding a new function of adaptive reuse of industrial heritage buildings, yet sometimes new function didn't continue due to unsuitability of this new function and (the existing surrounding or site layout and some other factor this paper will mention). Finally, adaptive reuse can have many significant shapes. For instance, it is feasible to convert abandoned industrial plants (into retail malls or churches or office buildings, etc.). So, Property managers should be aware of creative reuse options for unused space and always consider how to put existing buildings to better use, as the new function of adaptive reuse must be suitable and long lasting. (Douglas ,2006). So, mentioning the architecture factors affect the selection of new function of industrial building during the adapting is very important to set a new function that suits and becomes long last.

1.1 Methodology:

- This paper aims to reaching the architecture factors affecting the selection of new function of industrial building during the adaptive reuse, as mentioning and discussing those factors will help selecting the optimal new function .this through literature review of linking the Architecture Attributes & values of industrial heritage buildings during adaptive reuse with focusing on architecture attributes of the industrial building itself & its location, with the options of functions in Adaptive reuse of industrial heritage buildings (new function). This is for mentioning and discussing the architecture factors affecting the selection of new function of industrial building during the adaptive reuse at final.

- **1.2 Research problem:** During the adaptive reuse some of these buildings face a problem of non-continuity due to not choosing the suitable optimal new function for those buildings.
- **1.3 Research importance:** The importance of this paper crystallizes in helping in selecting the optimal new function that will contribute positively in expanding the life of industrial heritage buildings in adaptive reuse. Reaching this has positive effects that will help lowering energy consumption, pollutions, and material costs.

2. Literature review:

2.1 Industrial heritage: Industrial heritage consists of the remains of industrial culture which consists of sites, structures, complexes, areas and landscapes, which have historical, technological, social, architectural or scientific value. These remains consist of (buildings and machinery, workshops, mills and factories, mines and sites for processing and refining, warehouses and stores…), or records that show the extraction of raw materials, their transformation into products, and the associated energy and transportation infrastructures, as well as previous or present industrial production processes (Evan Sugden,2017). Industrial heritage is defined by the International Committee for the Conservation of Industrial Heritage (TICCIH) as having historical, technological, social, architectural, or scientific values and including any infrastructures used for social activities, such as workshops, mills, factories, warehouses, and stores. (Tam V W Y,2016).

2.2 Adaptive reuse at industrial heritage: Literature defines it as a way of breathing new life into existing buildings by leaving the basic structure and fabric of the building intact, and changing its use. According to Burchell and Listokin (1981) adaptive reuse is, "a neighborhood revitalization strategy which employs a series of linked procedures to plan for; inventory, acquire, manage and reuse surplus or abandoned real estate…The underlying concept of adaptive reuse is its attempt to maximize the often-hidden value of real property and provide a process for the reemployment of this property. Adaptive reuse is thus the embodiment of preservation, conservation and recycling objectives for previously used, now-surplus, real property, in another way Adaptive reuse means that an old site can be adapted for a new purpose, therefore not letting beautiful architecture or historical landmarks (values) go to waste. It is best described as a process that changes a disused or ineffective item into a new item that can be used for a different purpose.(Bullen,2010). The process of transforming buildings to other, more efficient and effective uses so that they can better serve user demands and have a useful extended life is known as adaptive reuse. Adaptive reuse is a sort of building adaptation in which physical changes to the building are virtually always made to meet the new usage. (Douglas, 2006), and it's a tool for preserving threatened heritage values of buildings. (Douet, 2012).

- **2.3 Architecture Attributes of industrial heritage buildings during adaptive reuse:** Douglas illustrates several options for reusing industrial buildings. As the common architecture attributes of industrial buildings are clear. As it's always large and single-storey buildings, as some industrial buildings are capable of being converted into sports facilities, industrial museums, or art galleries. With large open spaces and volumes, the spaces can provide room for exhibitions or open for public use, this depends on attributes of this type of buildings itself (industrial heritage buildings) and where this building exists (location attributes). (Douglas, 2006). Firstly: We will analyze the attributes related to the buildings itself

- 2.3.1Architecture attributes of building itself:

2.3.1.1 Building appearance (first impression): Industrial architecture has the same catachrestic and the industrial structures emphasis on uniformity, functionality, and efficiency reveal a key concept of modern architecture. And industrial buildings follow the principle of "form follows function" and the geometric aesthetics, logicality and construction that conform to industrial production have become the governing rules that influence the architectural expression, and are still of important meaning and realistic value till now. (WANG Jianguo, JIANG Nan,2007)**.**

2.3.1.2 Building type: Single-purpose industrial buildings, such as mines, metal-working factories, and power plants, are thought to be more difficult to adaptively reuse and choosing for it a suitable new function, than universal industrial structures that may be used for many purposes. These buildings are also very huge. (Bullen & Love, 2010; Douet, 2012; Douglas, 2006). As Industrial buildings are frequently built using cutting-edge technology, the most of them are solid, sometimes the inside space is not fully compatible with function due to the specific function and space requirements. Some warehouses and factory structures have dual purposes. As it shows the ability of function changeability (WANG Jianguo, JIANG Nan,2007).

2.3.1.3 Building age

According to Bullen and Love (2011c), a building's residual service life helps determine its adaptive reuse possibilities and affect choosing new function during adaptive reuse. Because structures with short residual service life, frequently have structural and fabric issues that necessitate considerable and costly alterations. (Bullen and Love ,2011). Generally, a building's material lifespan outlasts its functional longevity. This is especially true of industrial structures, whose use may alter significantly over the course of their material longevity. (WANG Jianguo, JIANG Nan,2007). Bullen claimed that because of the negative environmental impact and the significant technical challenges involved in renovation, buildings' long lifetime may be detrimental. It may cost 12% more to renovate a building that required to contribute to sustainability than to just reuse it. (Bullen,2010).

2.3.1.4 Building structure

The structure of the building is vital for adaptive reuse. (Douglas, 2006). According to a Canadian study, it is difficult to extend industrial buildings using wooden constructions because the structure cannot handle the additional stresses induced by construction loads, as the functions of wooden construction are very limited. (Wilson, 2010). On the other hand, because of old industrial building`s thick solid walls, many old brick or stone buildings provide exceptional thermal mass, moisture regulation, and strength for construction handling. (Douet, 2012; Douglas, 2006).

2.3.1.5 Building condition: The building condition is vital for adaptive reuse. (Douglas, 2006). This is because a damaged structure and fabric will necessitate more costly maintenance and repair, lowering building costs. (Bullen & Love, 2010, 2011b).

2.3.1.6 Building shape: It is considered important for adaptive reuse (Bullen & Love, 2010; Douglas, 2006). According to Douglas (2006), square or rectangular buildings are easier and less expensive to adapt or reconfigure spatially than circular or irregular-shaped buildings. (Douglas, 2006).

2.3.1.7 Building size: According to Ball (2002), small industrial buildings have more market appeal than huge ones, yet the huge can be more appealing to developers for subdivision. (Ball ,2002) According to a British survey, large structures are chosen by industry specialists for residential conversions over small buildings and small buildings for other purposes.(Gann & Barlow, 1996), and there are other studies that say the opposite.

2.3.1.8 Building height: According to Bullen and Love (2010, 2011c), low-in height buildings are less appropriate for adaptive reuse than taller structures. Douglas (2006) observed that building height has a significant impact on interior and exterior adaption. According to Gann and Barlow (1996), building height is an important feature in adaptive reuse. (Bullen and Love (2010, 2011c). Douglas ,2006. Gann & Barlow, 1996).

2.3.1.9 Building length: According to Gann and Barlow (1996), buildings of 15 meters height or fewer in length are excellent for uses requiring good natural light, whereas buildings larger than 15 meters will require artificial lighting. The final deciding factor is the distance between the core and the windows. This is because the greater the distance, the more problems with natural light and ventilation will exist in areas adjacent to the core, particularly in residential areas. (Gann & Barlow, 1996).

2.3.1.10 Ceiling height: Ceiling height is crucial in adaptive reuse because it influences what services can be installed within raised floors or ceiling voids. Although the appropriate ceiling height varies depending on the application, it has been argued that buildings with low ceilings are harder to adapt to new applications. (Douglas, 2006).

2.3.1.11 Window area: The window area is considered crucial for adaptive reuse since larger window areas are simpler to adapt than smaller window areas (Gann & Barlow, 1996; Stratton, 2000). Large window spaces, on the other hand, may induce solar heat gain or loss due to the insulating qualities of the glass. (Stratton, 2000).

2.3.1.12 Building accessibility: Building accessibility relates to the ease or difficulty of entering a building and is vital for adaptive reuse, particularly for disabled and less-mobile people. According to studies, the more entry points a building has, the better it is suited for diverse adaptive reuse. (Bullen & Love, 2011a; Gann & Barlow, 1996).

2.3.1.13 Layout: The layout of a building is significant for adaptive reuse (Douglas, 2006; Gann and Barlow, 1996). Buildings with open interior spaces and columns that are widely spaced, according to Bullen and Love (2011b) and Stratton (2000), provide for greater flexibility for adaptive reuse, which may affect the viability and function of adaptive reuse.

2.3.1.14 Building aesthetics: Building aesthetics are a major consideration in architecture. They define a building's general appearance, both inside and out. Bullen and Love (2010, 2011b) stated that buildings with high aesthetic quality are more financially appealing for adaptive reuse., claimed that a building's aesthetic quality is critical to its market worth. A British study found that the architecture and heritage aspects of industrial buildings were critical to their reuse potential (Ball, 1999, 2002).

2.3.1.15 Condition of services & systems: Bullen say because of the needs of building owners and users are constantly evolving and older heritage buildings may contain facilities that fall well short of current needs, in addition to having old system that doesn't service the suggested new function this disserve the process of adaption. (Bullen,2011b).

2.3.2 Location attributes: Analysis of the industrial heritage building's location attributes. Some industrial heritage buildings may be more amenable to adaptive reuse than others, depending on their location. The most significant factor of adaptive reuse is the location of the structure; this section covers a set of location attributes that have been identified in the literature as essential determinants influencing industrial heritage adaptive reuse and the function of this adaptive reuse.

2.3.2.1 Site coverage: The percentage of the site covered by the building is indicated by the site coverage. Densely constructed places, according to Stratton (2000), are more likely to be surrounded by activity yet may be harmed by congestion. Sparsely developed sites, on the other hand, may allow for building development, parking, quicker access, and more natural light, but they may also be distant and risky. According to Stratton and Douglas (2006), a built-up area of greater than 60% is a disincentive to adaptive reuse.

2.3.2.2 On-site parking: On-site parking refers to parking available on the property and is vital for adaptive reuse. (Stratton, 2000). Usually, industrial buildings have adequate external space around the building, for access and car parking, and occasionally, they contain a basement area suitable for car parking. (Douglas, 2006).

2.3.2.3 Site contamination: The presence of substances on or beneath the site surface that are detrimental to human health or the environment is referred to as site contamination. Due to significant and costly remediation, site pollution will most certainly limit the ease and expense of adaptive reuse (Douglas, 2006; Langston et al., 2008).

2.3.2.4 Site zoning: Zoning is the classification of land based on the restrictions placed on its use and development. Because zoning restrictions may restrict or ban a new use, adaptive reuse may be discouraged (Tan, Shen, & Langston, 2014; Tan, Shuai, & Wang, T., 2018). One reason for this is because the levels of air and noise pollution from nearby (industrial) operations may exceed those specified for the intended usage. So, locations land uses can be determined as a rule depending on its location.

2.3.2.5 Location type : The location type is considered crucial for adaptive reuse (Latham, 2000; Stratton, 2000). The classification of location into urban, suburban, and rural areas is

based on population density. According to Latham (2000), market conditions might differ depending on location type.

2.3.2.6 Location visibility: The ease with which a building may be seen from as many directions and as far away as feasible is referred to as location visibility. It can be thought of in terms of the building lot's location in relation to the adjacent lots and roads, as indicated. Corner lots provide excellent visibility; the visibility of the location can also be seen in terms of the building's position in relation to the road. Buildings closer to the fronting road are undoubtedly more visible than those further away. Location visibility influences the ability of (first-time) users and customers to locate a certain building as well as the building's top-of-mind awareness, which, in the case of commercial applications, will probably result in increased sales volumes and profitability (Briggs, 2010).

2.3.2.7 Transport accessibility: The ease with which users and consumers may travel to a building is referred to as transportation accessibility. It is typically assessed in terms of distance from transportation hubs like roads, train stations, and bus and tram stop (Stratton, 2000). According to Stratton (2000), buildings in good accessibility locations are more conducive to adaptive reuse than those in poor accessibility locations. According to a British study, industrial buildings within 8 kilometers of a highway interchange are more likely to be repurposed than those further away (Ball, 2000).

2.4 values of industrial heritage buildings related to architecture during adaptive reuse: Industrial heritage adaptive reuse, as a heritage preservation method, can preserve the heritage qualities of structures endangered by alteration and demolition. As relics of the industrial past, industrial historic buildings have evidential significance. (Zhang. P, et,2021). According to Feilden (1994), they have social, cultural, architecture, commercial and legislative values as well because they are part of the chronicle of people's lives. Buildings of industrial heritage may also be scientifically and technologically significant in the history of engineering, manufacturing, and construction, or they may have aesthetic aspects derived from their architecture values or design. (Douet, 2012). So. it's important to make an analysis for industrial heritage architecture values to choose the adaptive reuse`s new function that maximize this architecture value during the adaptive reuse. Through the research and analysis of relevant literature, it is found that the research Value elements of architecture industrial heritage are divided to values related to building itself & it`s location: **2.4.1 Location values**: Older industrial buildings are often in advantageous locations due to urban sprawling so it is in city centers and close to transport making reuse (appropriate) more viable. They add to a sense of community and are often appreciated as comfortable working environments by occupants, and other time it's isolated areas. (WANG Jianguo, JIANG Nan,2007). (site layout, Location, transportation and accessibility). Some large industrial buildings, especially those that stand on waterfronts, open green spaces or near public place where there is ease to reach its location, and all this acting like a landmark (Briggs, 2010).

2.4.2 Building`s values: Architecture values: Many of those industrial buildings are the symbolic landmarks of their cities, and are an important part of landscapes for people to know more about a city. In addition to various kinds of buildings in different periods constitute varied human landscapes with specified connotation. Comparing with other types of historical buildings, historic industrial buildings are a witness of the course of

civilization. And heritage industrial building shows the renovation of structure systems, from the firs reinforced concrete structure building to the steel structure new techniques which have great importance in architectural history. Furthermore, some large industrial and equipment buildings have complex designs and enormous volumes, which makes demolition more expensive than development. (Structural value). (WANG Jianguo, JIANG Nan,2007).Conservation areas are locations identified as having unique architectural or historical significance. Buildings in such locations are protected from unauthorized demolition and alteration, but the changes that can be made are limited (Douglas, 2006). Based on the foregoing, it might be claimed that being in a conservation area helps with adaptive reuse success. According to research conducted in the United States, historic textile mills in historic districts used adaptive reuse as way to conserve area with historical new function. (architecture & historical values). (Briggs, 2010).

2.5 Options of functions in Adaptive reuse of industrial heritage buildings (new function): The adaptive reuse of some industrial buildings has traditionally been less common. Nevertheless, many traditional multi-story mills and similar structures have been turned into offices, university buildings, as well as housing. The size, condition and structural configuration of the previous factors of locations affect the process of adaptive reuse to whatever housing or offices, and choose to convert the function of old factory and warehouse buildings to an alternative industrial use. Redevelopment of course is an obvious option but this is constrained by commercial, legislative, architecture, social and environmental factors. (Douglas ,2006).Some of the common options for the adaptive reuse of industrial buildings are as follows:

2.5.1 Industrial Museum: It is a viable alternative to simple preservation, it's the preservation of decommissioned industrial buildings for use as museums is frequently a reasonable solution in economic, social and architecture aspects. However, this method is best suited to older industrial structures. Disused mining facilities and mills from the nineteenth century, for example, are good living examples of old-fashioned and defunct industrial processes nowadays. (Douglas, 2006).

2.5.2 New industrial use: Industrial buildings built after 1900 are better suitable to industrial reuse than those built before 1900. The former can be divided into smaller sections for use in the workshop or storage. Alternatively, they can be modified to suit a similar usage to the one described above. Some of the changes necessary in such a conversion include enlarging or narrowing access doors to the main factory or warehouse area, as well as strengthening elements of the structure to withstand increased crane or vehicular loads. (Douglas, 2006)

2.5.3 Residential use: Many pre-1900 industrial structures, including as whisky bonded and jute mills, are excellent prospects for conversion to apartments. Their big, open spaces provide excellent options for providing substantial lodging. Despite having more than enough structural capacity for domestic use, only the frames frequently require fire protection. (Douglas, 2006).

2.5.4 Offices and hotels: Certain sorts of industrial buildings in metropolitan settings are frequently converted to offices. The extent to which such buildings may accommodate different inhabitants is determined by the building's configuration and access provision or potential. (Douglas, 2006).

2.5.5 Sports Centre: Some decommissioned factory buildings can be turned into sports facilities and other community activities. Some industrial buildings are often appropriate for

these activities due to their large expanses. A community Centre facility with meeting rooms, offices, kitchens, and bathrooms could be part of such a complex, although it may require changing the office space or adding extensions to the main factory area. (Douglas, 2006).

2.5.6 Art galleries: Large open areas and volumes are common aspects of bespoke industrial buildings like as power plants. These locations can be great for hosting art shows. The Tate Modern Gallery in London is one of the most recent renowned examples of this form of adaptive reuse, successfully utilizing the enormous spaces of the decommissioned Bankside Power Station to build a big international art museum. (Douglas, 2006).

3. Case studies

○ In the case studies, some successful and unsuccessful cases will be analyzed to prove that during the process of adaptive reuse of industrial buildings and choosing the new function for them, the choice of this function does not deviate from the specific points that will be collected in the conclusion and discussion later:

○ **3.1Tobler Chocolate Factory in Bern to library of Bern University (case study 1):** The building of Tobler Chocolate Factory in Bern, the capital of Switzerland which was reconstructed into the library of Bern University is a successful case. Tobler was originally one of the most famous chocolate brands in Switzerland. Its factory was close to the old campus of Bern. University that located in urban areas. In 1982, when the government of Canton district decided to regenerated the factory as library into a new campus with an artistic atmosphere. (WANG Jianguo, JIANG Nan,2007). This is considered a successful example and the reason for transferring it to its new function confirms point (2.3.2 Location attributes), which is that the location has great importance in determining the new function of the building in the process of adaption reuse.

○

Figure: Relationship between old factory buildings and newly extended buildings. (WANG Jianguo, JIANG Nan,2007).

3.2 The Tate Modern Museum in London. (case study 2): Tate Modern is a modern art gallery in London. It is the largest museum of modern and contemporary art in the world. This building is well-known as a former power plant (Bankside Power Station was built in 1947). It was closed from 1981 - 2000, and it reopened to the public as the Tate Modern. Adaptive reuse of original structure and materials is more attractive to visitors and locals, and it has become an impressive cultural icon.

It created galleries, public spaces, and educational spaces while preserving the façade and the materials of the industrial building. The original turbine hall was converted into a unique space for exhibition. The large volume of the industrial building was able to be converted to exhibition

spaces. The turbine hall is perhaps the most famous of all the galleries in the Tate Modern. the entire space of the hall which is all free to the public and acts like a covered street, allowing public to view these massive art installations.

Working with this existing building (that once housed enormous turbines in its main hall and boilers in the north wing) created a situation that Herzog & de Meuron embraced. With such large equipment this allowed large open spaces that are looked at very openly and graciously by the art world. (Sharma, Anukrati, Shruti Arora,2024). This is considered a successful example and the reason for transferring it to its new function confirms point (2.3.1Architecture attributes of building itself), the building structure, building height and building size etc...) have great importance in determining the new function of the building in the process of adaption reuse.

Figure2:. turbine hall Tate modern Adaptation

Figure3: turbine hall Tate modern –Pre-Post-Adaptation

3.3 The Sanlinqiao Nitro Thermos Factory in China. (case study 3): This Factory boasts a rich history spanning over three decades, and in fort of this factory a huge manufacturing park of Shanghai Sanlinqiao Nitro Thermos Guts Factory. The vicinity surrounding the park is characterized by a limited availability of land resources and a dearth of public spaces for communal engagement. So, this case considered as an example of successful adaptive reuse as it transformed the area into a community cultural center, cultural exhibition, and recreational complex effectively utilize the land, and simultaneously cater to the public's demand for cultural activities, entertainment, and recreation. (Song, Jinghua, Junyang Chen, Xiu Yang, and Yuyi Zhu,2024). And all This and the reason for transferring it to its new function confirms point (2.3.2 Location attributes), which is that the location of the garden affected the choice of new function.

Figures 4,5: show the building and the surrounding open area (park).

3.4 the Winterthur Industrial Quarter in Switzerland. (case study 4): The Jean Nouvel took part in the Winterthur Industrial Quarter in Switzerland. Despite taking the first prize in the plan competition in the adaptive reuse, but he had to create a new plan because the project contradicted the land use right. (WANG Jianguo, JIANG Nan,2007). This is an unsuccessful example and the reason why this new function did not survive confirms point (2.3.2.4 Zoning of the site), and this is why the new function didn't continue or why the adaptive reuse process doesn't occur perfectly because the new function was not identical to the function specified in land use right and the legitimate layout of this site.

4. Result & discussion:

- Through analysis & linking literature reviews and case studies showed that: Architecture Attributes of industrial heritage buildings during adaptive reuse which related to physical attributes of buildings itself & factors of its location, architecture value and options, considered as the main point that give us the main factors of (industrial heritage) that affect choosing the new function are:

o **4.2**. (Factors are previously mentioned at 2.3.1Architecture attributes of building itself):

o 4.2.1. Building appearance (first impression): As industrial architecture has the same catachrestic, and follows the principle of "form follows function", so the new function of industrial heritage building can be chosen according to the building appearance.

o 4.2.2. Building type: Single-purpose industrial buildings, such as mines, metal factories, and power plants can be converted to limited functions such as museum and galleries, unlike universal industrial structures that may be used for many other purposes from (point 3.5).

o 4.2.3. Building age: Building's service life, residual service lives of building affect choosing the new function, because its frequently old buildings have fabric issues that necessitate considerable and costly alterations. Which will affect choosing the new function. For example, choose to reuse an old industrial building to a residential use as its the lowest use to renovate.

o 4.2.4. Building structure: The shape & type of the building structure influence the choice of the new purpose of the building after adaptive reuse. Where, for example, it is not possible to convert a building consisting of stones and its structure is a load-bearing walls to a building whose function is a house of worship.

o 4.2.5. Building condition: Good condition of building lead to low cost in adaptive reuse and this help in finding various new function of building.

o 4.2.6. Building shape: The function of square and linear building can suit the function of another circular buildings. For example, a circular industrial building supposed to be office or hotel and not supposed to be reused as residential building.

o 4.2.7. Building size: Size affects choosing the new function, as huge industrial heritage building usually are reused to a function that need this huge size like museums**.**

o 4.2.8. Building height: Building height of industrial buildings can affect choosing new function during adaptive reuse, for example low-in height buildings can refunctioned to residential purpose and low buildings usually don't suit functions need large height as exhibitions or huge galleries.

o 4.2.9. Building length: Buildings length affects new function of industrial adaptive reuse, as building with length below 15 m can be refunctioned to functions require nature light and didn't use artificial light like residential uses.

o 4.2.10. Ceiling height: High ceiling have varieties in choosing new function during industrial adaptive reuse. Because museum and galleries need high celling, and usually some other function which need false ceiling like office building also need high ceiling.

o 4.2.11. Window area: Using large opening help in adaptive reuse with function doesn't need mechanical ventilation (like residential uses) in hot areas and small windows in cold areas. Large windows let natural light in and industrial buildings with large openings are choices for functions require nature light.

o 4.2.12. Building accessibility: Numbers of entrances affect choosing the new function, because functions like office buildings or malls need many entry points.

o 4.2.13. Layout: Layout is important, because buildings with open interior spaces and columns that are widely spaced, are supposed to be reused as art galleries for example.

o 4.2.14. Building aesthetics: Buildings with high aesthetic quality are known to be transformed into museums.

o 4.2.15. Condition of services & systems: Its Condition can affect choosing new function, for example the old function of the building is a factory and the new function is a hotel, and hotel supposed to have service system like service & scape stairs and other service helping the hotel function.

o 4.3. (Factors are previously mentioned at 2.3.2Location attributes):

o 4.3.1. Site coverage: The percentage of the site coverage is compared with the ability of adding extensions or parking slots to help the new function in adaptive reuse.

o 4.3.2. On-site parking: Parking areas in adaptive reuse of industrial heritage refers to the availability for more valid functions that are necessary for being a parking because of huge number of users with cars such as office buildings, museums and galleries.

o 4.3.3. Site contamination: It will constrain the new Function that will be chosen, because it is logical not to choose to convert an existing industrial building in a polluted area during the process of adaptive reuse into a school.

o 4.3.4. Site zoning: New function can be chosen as a rule depending on location`s land uses, for example an industrial building exist in industrial area and its new function is for industrial uses also this according to its land use.

o 4.3.5. Location type: Choosing new function according to its type of location as this new function may be viable in the city and may not be profitable in the rural, and vice versa.

o 4.3.6. Location visibility: Buildings visibility condition according to its location can affect new function. For example, industrial building with a good visibility condition can be adapted into a commercial market as it's a function which need good visibility conditions to be used efficiently.

o 4.3.7. Transport accessibility: Building and its distance from transport affect new function of industrial adaptive reuse, for example a building in remote areas and with far distance from transports stops can't be used for function that need ease communication like office buildings and markets, as they are daily used functions**.**

o 4.4 Values of industrial heritage buildings related to architecture during adaptive reuse:

o Knowing architecture values to take the use of it to choose the adaptive reuse`s new function that maximize this architecture value during the adaptive reuse.

o 4.4.1. Architecture values related to building itself (structure, historical or aesthetic.)values.

o 4.4.2. Value related to location: - Historical area -existing in conservation area -or value from surrounding (landmarks).

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