Smart aspects for safeguarding heritage

M. Y. Tewfik & R. H. Mohamed
Department of Architecture, The Higher Institute of Engineering, El Shorouk, Egypt

Abstract

In the past era, the aspects of integrating a new building with a heritage one appeared to be concerning the lateral appearance or features of the heritage context while, after the call of sustainable development, the aspects of designing a building varies to suit the sustainability. So conservation, which mainly is to remind us of where we come from, doesn't match with the morphology only as we cannot live in museums. Smart sustainable preservation is about evolving our existing building stock, instead of razing and building new. At the same time, the intelligence of the materials and the aspect of intelligent building seems to accomplish the need of sustainability as intelligence actually is mental and sensitively deals with the matter which promotes motion and actions to solve many issues concerning it, but within these aspects there is not a clear criterion to deal with heritage spaces in a smart manner without losing style and taste. On the other hand, full respect is not given for the future response of the urban design of such heritage sites which could be treated in such a smart manner. So the liability issue concerns the search for the main conventional applications which could be followed to support the presence of new buildings placed in heritage places but defiantly in a smart manner supposing that using techniques and tools being developed today to make complete high performance products is one of the main hypotheses that could be followed and the second is the multi functioning of any element of the space. The followed methodology is the measurable one as measuring the main approaches applied in the smart or the intelligent aspects to deduce the main aspects must be used to inform the integration between the new building and the heritage urban context.
Keywords: smart aspects, heritage context, sustainability, efficiency, clever system, performance.

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1 The preamble

Both then and now, architecture represents the mediation between techniques, images, and the panorama of culture that presents itself in every instant. So there will be a struggle between the past and the new to reach the norm of the era. Referring to the means of integrating the old and the new there are two options: the integration through harmony, or the integration through contrast. As using the harmonious approach keeps the character of the place, which could be achieved through assimilating the style, scale, morphology, construction and finishing details of the old buildings. Another option is using transitional events to link the new with the old, respecting the skyline and area building codes which should create good solutions. Another way is by making mental associations to the history of the place, and symbolic architecture. On the other hand, the integration through contrast depends on the power of exploring the unknown and new ideas for solving problems. This can be achieved through the use of transparency, hiding underground, separating old from new, or making a striking new building on the historical classical site if the new is a really important building, politically or socially [1]. Heritage conservation for the 21st century varies as it will focus on the sustainability issue as the sustained use of older buildings rather than protecting them from change [2]. And many other sustainable aspects will be used. Today, architects are beginning to look forward to using the developments of technology which seem to be smart or intelligent as smart materials which bring new solutions to longstanding problems involved in developing new building functions, forms, and responses. As they have a wide variety which have great potential for use in architecture and, moreover, dramatically reduce the energy and material cost of the buildings, enabling the human to design direct and discrete environments that provide better conditions in space for human occupants [3]. But to what extent could the intelligence support the heritage places specially while integrating the new with the old?

This paper consists of three parts, as the first refers to the measurement of the main aspects of intelligence, the second is applying these aspects to the integration of the new building with the old one and the third part concerns the results.

2 The measurement of the main aspects of intelligence

Referring to intelligence in architecture, there are three calls for it to appear; smart materials, intelligent element and the smart building, and in order to find the aspects of intelligence all of them have to be deduced and analyzed.

2.1 Smart materials

According to early definitions, smart materials are materials that respond to their environments in a timely manner. It has been expanded to materials that receive, transmit, or process a stimulus and respond by producing a useful effect that may include a signal, which the materials are acting upon it. Some of the stimuli that may act upon these materials are strain, stress, temperature, chemicals, electric field, magnetic field, hydrostatic pressure, different types of radiation, and other forms of stimuli. The effect can be caused by absorption of a proton, of a chemical reaction, of an integration of a series of events, of a translation or rotation of segments within the molecular structure, of a creation and motion of crystallographic defects or other localized conformations, of an alteration of localized stress and strain fields, and of others. The effects produced can be a colour change, a change in index of refraction, a change in the distribution of stresses and strains, or a volume change [4]. This ability to produce a useful effect refers to the characteristics of smart materials; we discover that they directly focus on their actuation events, the ability of prognosis, and immediate response to the environmental conditions.

2.2 An intelligent element

It is the element which, without the supporting infrastructure element, acts as a clever system and does not stop performance of peripheral systems. As architectural design always involves integrated systems and materials, then the biggest potential application of smart materials will result in the separation of the specific components – the development of smart materials will be involved in a variety of components such as sensors, actuators, the shape-memory alloys, etc. – behaviours or indoor environment [5].

2.3 Smart buildings

It could be defined as the automation involved somehow makes managing and operating buildings more efficient. Smart buildings can be defined as the US-based engineering and design firm; as the integration of building, technology, and energy systems. These systems may include building automation, life safety, telecommunications, user systems and facility management systems. Smart buildings recognize and reflect the technological advancements and convergence of building systems, the common elements of the systems and the additional functionality that integrated systems provide smart buildings with actionable information about the building or the space within a building to allow the building owner or the occupant to manage the building or space."

According to the Smart Buildings Institute – a new Texan non-profit organisation that has developed a smart building certification process, a smart building is that which, "1. Provides actionable information regarding the performance of building systems and facilities; 2. Proactively monitors and detects errors or deficiencies in building systems; 3. Integrates systems to an enterprise business level for real-time reporting and management utilization of operations, energy and occupant comfort; 4. Incorporates the tools, technologies and resources to contribute the energy conservation and environmental sustainability".

Referring to the European Commission, "smart buildings mean buildings empowered by ICT (information and communication technologies) in the context of the merging Ubiquitous Computing and the Internet of Things: the generalization in incrementing buildings with sensors, actuators, micro-chips, micro- and nano-embedded systems will allow us to collect, filter and produce more and more information locally, to be further consolidated and managed globally according to business functions and services.

IBM says “smarter buildings are well managed, integrated physical and digital infrastructures that provide optimal occupancy services in a reliable, cost effective, and sustainable manner. Smarter buildings help their owners, operators and facility managers improve asset reliability and performance that in turn reduces energy use, optimizes how space is used and minimizes the environmental impact of their buildings” [6].

2.4 The main aspects of intelligence

Finally, we deduce that the smart or intelligent aspects mainly concern the production of the useful effect, acting as a clever system which does not stop performance and efficiency.

3 Applying the intelligent aspects to the integration of a new building with an old one

The same aspects of intelligence deduced have to be measured within the building while integrating with the urban context, as they are as follows:

3.1 Production of the useful effect;
3.2 Acting as a clever system and does not stop performance;
3.3 Efficiency.

3.1 Production of the useful effect

This aspect refers to the performance, which is the synonym of effectiveness; as this term concerns the degrees to which objectives are achieved and the extent to which targeted problems are solved. In contrast to efficiency, effectiveness is determined without reference to costs, whereas efficiency means “doing the thing right,” effectiveness means “doing the right thing” [7].

These aspects could be measured within the unique design: functional effectiveness; security; energy effectiveness and smart actions.

3.1.1 The unique design

The architectural conceptual design should be unique and creative to achieve the objectives of the project. The conceptual vision should be in accordance with the importance and significance of the building. As it is a must to exploit individuality, uniqueness and the differences between places [8].

As shown in the Reichstag dome which has been constructed on the top of the rebuilt Reichstag building in Berlin. As it was designed to have a distinctive appearance so it became a landmark (Figure 1).

(a) (b) (c)

Figure 1: (a) The Reichstag before the war with original dome; (b) the transparent design of the new dome makes it a unique landmark; (c) the right use of the daylight shining through the mirrored cone [9].

The Reichstag dome is a large glass dome with a 360 degree view of the surrounding Berlin cityscape and a mirrored cone in the centre of the dome directs sunlight into the building involving the use of the daylight and decreasing the carbon emissions of the building. Finally, the dome appears to be multi-functional as it responds to the morphological aspect and sustainability.

3.1.2 Functional effectiveness

It is the functional relationship between spaces and the circulation zoning of uses that should provide vitality and encourages people to enter the building. So, mixed uses and variable activities that are well distributed provide vitality (as shown in Figures 2 and 3) [10, 11].

Figure 2: Wonderful oriental art centre in Shanghai. It is constructed to be a mixed use building [10].

Figure 3: Opera and culture house. It amalgamates opera, library, school, cultural and youth facilities [11].

3.1.3 Security

Security can be classified into two phases as the first concerns the security inside the building itself and the second concerns the security of the whole physical urban context that the building represents a part of.

3.1.3.1 Security inside the building The building should be characterized by security and safety. It should be provided with fire alarm and fire fighting systems in addition to control and security systems [5].

3.1.3.2 The security of the whole physical urban context refers to the extent to which streets enable people to use, enjoy and move around the outside environment without fear of tripping or falling, being run-over or being attached. Safe streets have buildings facing onto them, separate bicycle lanes and wide, well-lit, plain, smooth footways [12].

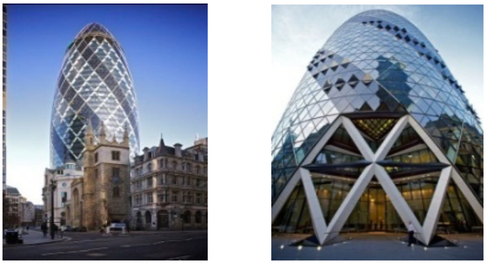
3.1.4 Energy effectiveness

With using techniques, tools and forms of buildings which are being developed today to make complete high performance products, energy effectiveness concerns the following:

- Using renewable energy such as wind, sun, geothermal, etc.
- Using smart technology to moderate energy and water use.
- Using the smart form to be adapted with the surrounding environment.

As shown in the skyscraper 30 St Mary Axe in the City of London, completed in December 2003, with 40 floors, the tower is 180 meters tall, and stands on the former site of the Baltic Exchange building, the building uses energy-saving methods which allow it to use half the power a similar tower would typically consume. Gaps in each floor create six shafts that serve as a natural ventilation system for the entire building even though required firebreaks on every sixth floor interrupt the "chimney". The shafts create a giant double glazing effect; air is sandwiched between two layers of glazing and insulates the office space inside as architects limit double glazing to avoid the inefficient convection of heat. The shafts pull warm air out of the building during the summer and warm the building in the winter using passive solar heating. The shafts also allow sunlight to pass through the building, making the work environment more pleasing, and keeping the lighting costs down. *Finally, the shafts appear to be multi-functional as they respond to the ventilation and the lighting.*

On the other hand, using a fully triangulated perimeter structure, which makes the building sufficiently stiff without any extra reinforcements to control the wind-excited sways, the building also appears as a unique item in the urban realm with a smart form, which offers good ventilation to the surroundings (Figure 4 [13]).



(a) (b)

Figure 4: (a) The 30 St Mary Axe building appears within the old urban realm and (b) the dilapidated triangulated perimeter structure appears.

3.1.5 Smart actions

The building should be known for its smart actions within the following:

- It should provide actionable information regarding the performance of building systems and facilities;
- The presence of the proactive monitors which detect the errors or deficiencies in the building systems;
- It should integrate systems to an enterprise business level for real-time reporting and management utilization of operations, energy and occupant comfort;
- Incorporates the tools, technologies, resources and practices to contribute to energy conservation and environmental sustainability [5] (see the example of The Eden Project later).

3.2 Acting as a clever system and does not stop performance

This aspect could be measured within the continuity and the flexibility.

3.2.1 The continuity

The continuity could be divided into two sectors: as the continuity during the integration with nature and the continuity during the integration with the urban physical context.

3.2.1.1 Integration with nature Lately, the equivalence of learning from nature and using nature for ecological accounting methods which results in making nature visible and explicit as depending on formal harmony and coherence with external context through transparency, continuity, and openness of formal surface to afford extension and communication with the landscape. So the concept of integration with nature could be directed as the following:

(a) – Making nature visible – depending on using intelligent glass over a formal surface to control the quantity of interior lighting and loss or gain of heating.
(b) – Using nature for ecological accounting methods – depending on using an open courtyard to increase climatic efficiency, formal treatment like staggering, waving, interposition, and hierarchy to reduce heating loss or gain.
(c) – Formal harmony and coherence with external context – through transparency, continuity, and openness of the formal surface to afford extension and communication with the landscape, efficient formal orientation, reducing the proportion of depth of the formal building to supply more daylight [14].

Example: The Eden Project [9]

The Eden Project is the world's largest greenhouse. Inside the artificial biomes are plants that are collected from all around the world (Figure 5). The complex is dominated by two huge enclosures consisting of adjoining domes and each enclosure emulates a natural biome. The domes consist of hundreds of hexagonal and pentagonal, inflated, plastic cells supported by steel frames.

The domes provide diverse growing conditions, and many plants are on display.

Nature as model and mentor

- **Form:** regardless of size, be considered sustainable. The efficiency of spherical geometries is minimum surface area for maximum volume sounded to allow direct sunlight to enter perpendicular to the surface at all times of the day, thus maximizing the free energy.
- **Position:** Maximizing solar penetration was a key target and knowing where this asset lay determined the optimal positions for the biome structures. So the design should be linear in profile with lean-to structures built against south-facing cliffs and a replicated foam geometries attached by linking bubbles in three dimensions, carefully following the solar boundaries.
- **Learning from nature:** studying nature for possible solutions came across a dragonfly's wing as a model for how minimal surfaces, which when packed tend to form hexagons, intersect with straight edges such as support ribs.
- **Cladding systems:** a transparent Teflon foil system fabricated as triple-skin pillows inflated to 300 pounds per square inch. These pillows allow greater penetration of low-frequency ultraviolet light, are better thermal conductors and weight less. Maximum panel size on the biomes is 53 square meters, which greatly reduced the weight of primary steel structure and its subsequent shading effect. *This shows the perfect multifunctioning.*

(a) (b)

Figure 5: Eden project to the left the panoramic view of the geodesic biome domes, to the right the hex angle structure [9].

3.2.1.2 Integration with the urban physical context to achieve the proper urban solution, with an urban scale. We need clear appreciation of the morphological context. New proposals must have a positive relationship to the existing morphology by harmonizing with it, by adapting to it or, where there are clear reasons so to do, by contrasting with it [8]. And this could be achieved by using the Regulating Plan and Form-Based Code. As Form-based codes focus on building form and how it affects public spaces. On the other hand, it guides the creation of active and sustainable neighbourhoods as these codes are as follows:

(a) Codes of Form: each building type has its regulations frequently includes acceptable ranges, such as minimum and maximum heights or a build to zone rather than a setback. These ranges allow for flexibility in development, and there is reassurance in the level of predictability that they provide. Since each code is created based upon the preferences of the community, the facade requirements, especially, will vary in their level of details. At a minimum, pedestrian-oriented characteristics such as entrance location, transparency level, base type (treatment of the ground-story front facade), and cap type will be regulated, and a city may choose to include additional requirements [14].

Example: Novel Opera House

As in 1985 the City decided to re-build the opera house, within the shell of the existing 1831 building which refers to the Italian style (Figure 6), the architect succeeded in wedding the past to the future by doubling the height of the building and creating a steel and glass barrel vault which hid the fly tower [15].

(a) (b)

Figure 6: (a) A new addition on the roof kept the opera house up to date but the base of the old building and the surrounding building returns to the past as shown in (b) [15].

(b) Regulating Plan: districts are created, each allowing for the development of at least one building or open space type. Each district is mapped in the regulating plan, similar to a conventional zoning map; this is done by examining each parcel and block individually, and it is not favoured in form-based codes to establish large swathes of one type of district. The regulating plan also details how the street types are developed in association with the building and opens space types [14].

3.2.2 Flexibility

Adaptive buildings should be characterized by flexible functions, spaces and furniture so that change could occur by time. And the structure used in this era is searching for a response to this issue as shown in the hyper green building in Paris (Figure 7), as the core system stands as a structure fulfilling the presence of a free space which could be used as a multi-functional space [16]. And also tractability could be satisfied in the prefabricated building which is designed

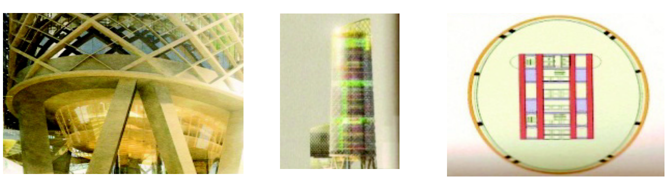


Figure 7: The hyper green building, designed by Jack Freer [16].

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Figure 8: Examples of prefabricated buildings [17].

according to the customers' need, mobile, economical, recyclable and environmental protective as these sorts of buildings can be perfectly adapted to the surrounding urban context (figure 8) [17].

3.3 Efficiency

In contrast to effectiveness, efficiency refers to the cost as it means "doing the thing right". So it can be measured through the integrated systems for green building standard and the integrated design.

3.3.1 Efficiency within integrated systems for green building standard

It is one of a number of voluntary leadership standards for enhancing the environmental performance of buildings. It combines minimal fixed performance requirements with an optional menu of sustainable building practices. Sustainable urbanism concludes that society will inevitably move to require high performance building (HPB).as shown in The Eden Project [18].

3.3.2 Efficiency within integrated design

Integrated design is a hallmark of the green building movement. By optimizing the performance of a building as an entire system, this design approach can improve a building's performance at little or no added cost simply by shifting money within the project. A classic illustration is to reallocate a building's construction budget to specify more insulation and better windows and recoup some or most of those costs by buying a smaller, less expensive mechanical system. The resulting building will incur a small construction premium but will produce an acceptable return of investment on that premium, using far less energy and costing far less to operate as shown in The Eden Project [18].

4 The results

4.1 Conclusions

It has been deduced that the aspects of intelligence vary and used in architecture but not by a way which can affect the urban context to make it sustainable, especially while integrating the new building with the heritage one. And the morphology of forming the city will vary while using the supposed intelligent criterion.

The following table could be considered the check list to measure the smart aspects used while integrating a new building with the heritage realm.

Table 1: The check list that used to measure the smart.

<table>
<tr><th>The main aspect</th><th colspan="3">The criterion</th><th>The Score in %</th></tr>
<tr><td rowspan="6">1. Production of the useful effect</td><td colspan="3">1.1 The unique design</td><td rowspan="15"></td></tr>
<tr><td colspan="3">1.2 Functional effectiveness</td></tr>
<tr><td colspan="2" rowspan="2">1.3 Security</td><td>1.3.1 The security inside the building</td></tr>
<tr><td>1.3.2 The security of the whole physical urban context</td></tr>
<tr><td colspan="3">1.4 Energy effectiveness</td></tr>
<tr><td colspan="3">1.5 Smart actions</td></tr>
<tr><td rowspan="6">2. Acting as a clever system and does not stop performance</td><td rowspan="5">2.1 The continuity</td><td rowspan="3">2.1.1 Integration with nature</td><td>a. Making nature visible and explicit</td></tr>
<tr><td>b. Using nature for ecological accounting methods</td></tr>
<tr><td>c. Formal harmony and coherence with external context</td></tr>
<tr><td rowspan="2">2.1.2 Integration with the urban physical context</td><td>a. Focus on form</td></tr>
<tr><td>b. Regulating Plan</td></tr>
<tr><td colspan="3">2.2 Flexibility</td></tr>
<tr><td rowspan="3">3. Efficiency</td><td colspan="3">3.1 Efficiency within Integrated systems for green building standard</td></tr>
<tr><td colspan="3">3.2 Efficiency within integrated design</td></tr>
<tr><td colspan="3">3.3 Marketing initiatives</td></tr>
</table>

4.2 Recommendations

- We call upon the architectural and planning community, professionals, decision makers and the government to acknowledge the urgent need to study, protect and revive the heritage realm and deal with it in a smart manner as this realm is an essential and progressive force to mediate the challenges of future urbanization.
- The heritage place is much more important than any individual architectural concept. Furthermore, a good understanding of the concept of the urban context is the key to solving problems of integration. So any research in such issue must highlight the importance of the aspects of the era to establish a good city.

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