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Research article

Dynamic transparency in design: the revival of environmental sustainability in design elements of Iraqi buildings

Tamarah A. Alqalami *

Department of Reconstruction and Projects, University of Baghdad, Iraq

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ABSTRACT

Buildings in Iraqi cities such as Baghdad and Mosul suffer from several problems such as the application of new materials in modern buildings that changed not just the identity of architectural heritage but also the quality of thermal comfort in façade design. This, unfortunately, adds to the damage regarding environmental sustainability and cultural values away from adaptable solutions to improve energy efficiency in building performance. One of the measures that must be taken to correctly plan in harmony with the Iraqi cities is to ensure the environmental control as part of the overall performance of building façade to maintain an active, healthy indoor environment while preserving the propriety of facade design elements, screen pattern, order and details. Therefore, there are many sustainable trends that vary in their usefulness such as biomimetics examples inspired from natural models in which form and function dictate one another. This is in order to maintain the integrated design relation between transparency, function, and elegance in the overall performance of façade elements. The research question is, how important is the choice of material in developing a sustainable element that revives environmental control while preserving the identity and values of façade design?

The main goal of the research study is to identify the role of advanced technologies and the choice of smart glazing materials to revive the quality of thermal comfort in a way that not just sustains the identity of facade elements socially and culturally, but also to be responsive to the changes of climate conditions. Therefore, this research utilizes more than one technological tool such as Revit as a BIM tool with the application of smart dynamic materials such as Photovoltaics and Electrochromic in order to restore part of the design expression and enhance the building performance through its elements in contemporary façade design and its details. In this work, it can be seen that applying a set of technological tools allows to clearly illustrate the impact of smart dynamic materials to improve the quality of design and comfort while protecting the identity of contemporary façade elements when compared to static or traditional materials, aesthetically, and functionally.

1. Introduction

Architecture reflects its time, place and culture through its elements that also show cultural differences. In this sense, the use of the traditional Baghdadi window/wall/balcony "*shanashil*" element as an important, shading device has various interpretations such as clarity, transparency, delight, privacy and intelligibility, as described by Kenzari and Elsheshtawy [1]. For example, the natural colours and shades of wood and local materials as fired brick are more familiar to design identity of traditional facade elements in Iraqi cities such as Baghdad and Mosul [2]. The same traditional shanashil design element is found in other countries in the Middle East such as Egypt and is called mashrabiy'ya. Alkhalidi [3] argued that the opposition of light and shade is dramatically expressed in the architecture of the screen patterns. It is an essential aesthetic factor in these buildings in which different patterns of light are reflected through the transparency of the screen design pattern, and by that adding a quality of elegance and beauty to be part of the room design, as seen in Figure 1.

However, Kenzari and Elsheshtawy [1], Fethi and Al-Madfai [4], and Al-Khafaji & Alkilidar [5] pointed out that the screen design pattern is fixated by the idea of preserving privacy. Al-Bayati [6] explained that the same order governed the privacy and public state of the day to day life due to its effect on the building regulations, with traditional houses sharing party walls with the minimum street elevation. The elevation in general had small windows on the ground floor while the upper floor projected shanashil wooden balconies.

* Corresponding author.
E-mail address: tamarahameen@uobaghdad.edu.iq.

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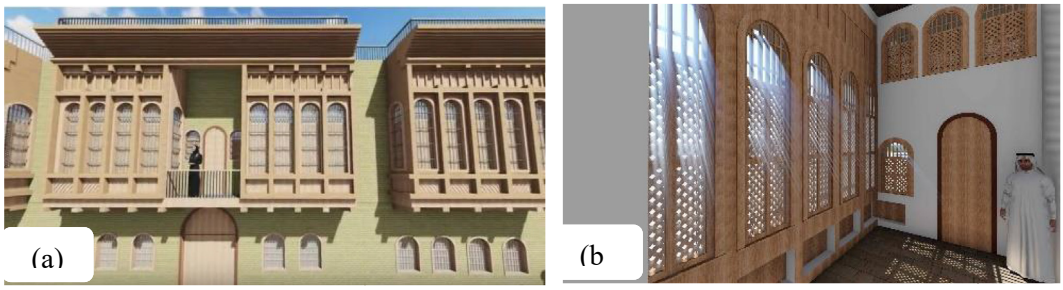

Figure 1. (a) The use of "shanashil" screen pattern as a device in one of the buildings in Mosul city, and (b) the display of daylight in a decorated pattern (Source: author).

Nevertheless, there is a quality of delight in the shanashil screen pattern that can be seen in the use of timber providing a rich pattern of soft and rich harmonies of light and shade [7, 8]. More importantly, such screen design pattern allows sunlight to enter through limited spaces of the screen design pattern. This way gives a more comfortable space that passively controls the amount of heat as well as daylight entering the indoor environment [9]. Allen & Iano [10] explained that the integration of a design pattern allows transparency, natural air ventilation, and sunlight through weaving techniques to provide visibility, shade and thermal comfort while protecting privacy that is sacred to cultural and social aspects of certain cultures. The same device pattern allowed women and family members to partake in public life while preserving their privacy.

Hence, the role of transparency in "*shanashil*" as a window/wall/balcony element is about flexibility with control to maintain balance between thermal comfort, privacy, and public needs as well as the screen design pattern and colours. This is in order to express an elegant façade that blends in harmony with the identity of the place, environmentally, socially and culturally.

Moreover, passive design of traditional buildings and elements in the old compact cities were naturally adapted to create a comfortable indoor and outdoor environment [11, 12]. However, Alqalami [13] explained that not all parts of traditional buildings were all made of the local materials. For instance, the timber in traditional shanashil was imported from the East Indies [14]. This is because the choice of wood was based on a careful consideration that it must be resistant to termite attack. Such type was not available in Iraqi local materials.

This is a proof that even the builders at that time did choose different materials as a necessity to explore new adaptable solutions for problems associated with surroundings. More importantly, Al-Haidary [14], and Al-Khafaji,& Al-Qaisi [15] and Al-Ahbabi [16] argued that it is difficult to isolate the city pattern from the rapid changes that inevitably changes the community's needs and people's lifestyle. For example, the transformation of the old introverted city pattern and its narrow streets in Baghdad to mimic a modern extroverted city pattern with wide streets in USA [17].

The same passive system does not work in a modern city pattern because of the lack of environmental comfort in the traditional shanashil due to wider streets suitable for vehicles and parking lots. As a result, the traditional shanashil lost their functional qualities because they were no longer able to provide the shading needed to overcome the harsh environment. Thus, there is a need to add new ways to improve the level of environmental comfort [18, 19, 20]. As a result, the traditional shanashil lost their functional qualities and gradually disappeared from the façade scene. This affects the quality of design, identity and cultural values by ignoring the nature of place and the uniqueness of its elements.

Finally, there is a need to discuss the origins of the role of materials and idea of sustainability in the history of Iraq to improve design quality that can be explored through biomimetics approach and smart materials because it caters for the study of both function and form and is applicable to the designs of façade and elements. The Role of transparency and building materials in ancient Iraq.

2. The role of transparency and building materials in ancient Iraq

Both nature and culture are closely intertwined with each other within the parts that create the whole since nature is a source of raw material. The building materials in ancient Iraq have catered for the relationship of transparency, natural material, and daylight in design. For instance, a natural material reed has been used for thousands of years in Iraq [14], as shown in Figure 2. Ochsenschlager [21] agreed that the inevitable use of natural material as part of the surrounding environment is observed in the Marshes where indigenous population used sturdy reeds found in rivers to build their houses, walls, windows, vaults, arches, or shading devices.

Accordingly, nature and its materials have always inspired architecture during the imitation process of design elements throughout history.

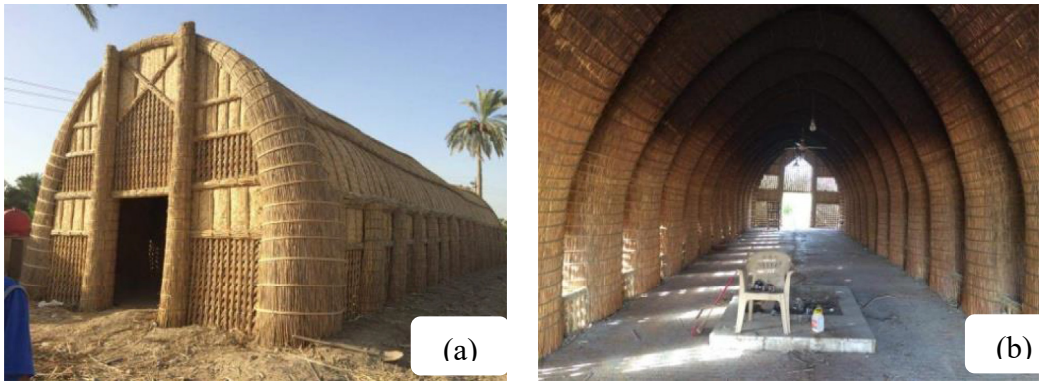

Figure 2. (a) House made of reed similar to the design of Sumerian Artifact from the Marshes designed in Mishkhab, Iraq (Source: author), and (b) illustration of the material flexibility in the arched wall and window with its impact on indoor environment of marshes's houses (Source: author).

The indigenous society who lived in these marshes were able to build their houses with walls and simultaneously create flexible windows by using a natural material (reed) to allow daylight and natural ventilation into indoor environment. The same material were perfect for climate adaptation whether in conserving the heat in winter or providing shade in summer [22]. The reed, for instance, is a multifunctional natural building material that is durable, flexible [23], less labour intensive, had excellent thermal properties and acoustic insulator qualities [24], also with a good resistance to water.

Thus, the same transparency that is the result of the woven screen pattern by reeds in the marshes is seen in the traditional Baghdadi houses. As a result, Traditional houses were considered simple and small in sizes, however they were famous for their sustainable adaptable strategies, for instance, the use of the available material (reed) in marshes' floating houses or (fired brick) in traditional Baghdadi houses. Designers and engineers should learn from the success behind ancient techniques, natural material in a way that perfectly adopt to the changes of the surrounding environment.

In this sense, the role of materials and idea of sustainability can be inspired from nature to improve design quality. This research study uses biomimetics approach because it caters for the study of both function and form and is applicable to the designs of different branches of science.

3. Design quality: between biomimetics and sustainable design pattern

When discussing the sustainability of design, Reisner [25] noted that what is really important is the quality of the outcome which is expressed on the surface, and what lies beyond the surface of 3D manipulations in form and material. The idea of sustainability includes all the different developmental elements such as well-being of the population and environmental quality [26]. Bruckner [27] mentioned that biomimetics design approach focuses on the inspiration from an important and detailed design pattern that tackles the interwoven aspects of form and function as means to adapt to the surrounding environment. One of the examples is seen in the multi-layered design pattern of the nocturnal moth eye. The pattern of this eye in particular has two important parts. The first part is unique in its shape and function which are well known as a misconstructed cornea. The second part lies in the hexagonal array of non-closed-packed sub-wavelength pillars that are also an important layer behind the uniqueness of this cornea, specifically in providing a good antireflection light quality at night [28]. Pettit and Brinker [29] mentioned that such quality is useful in the layers of double glazing or triple glazing coatings issues to maintain the clarity in its transparent state. Subsequently, the role of advanced and smart glazing material is important to be implemented in architectural facades, layers and patterns.

4. Technology and the application of smart dynamic materials in design

The role of technological development is changing the fixed image of the façade elements due to the increase in energy consumption. In the United States, the lighting energy and Heating, Ventilation, & Air Conditioning (HVAC) loads in commercial buildings are 20% and 26%, respectively. As for Residential buildings, they are 20% for lighting energy, and 26% for HVAC loads [30]. Thus, there is the constant demand to develop windows with advanced thermal properties, since the energy saving potential from improved windows is considered very promising [31]. In architecture, glass established itself as an element that provides cohesion between the inside and the outside, for its transparency, and it is one of the few building materials that combine tradition with technological innovation. The flexibility of the material is also due to the fact it is 100% recyclable [32].

Accordingly, this research approach is discussing two types of smart dynamic glazing. One type is about Building Integrated Photovoltaics (BIPV). The primary objective of BIPV is to generate electricity, but also it is to ensure that the module is a functionally integrated element of the building's envelope [33], such as the façades of the Future Business Centre in Cambridge.

However, there are several challenges that should be considered when designing with BIPV to improve flexibility and sustainability of design. For instance, the colour range, shade and intensity choices are limited and of dark shades only such as black and blue as colours and shades is critical to the efficiency of solar cell performance. In addition, there are regions that receive high solar irradiance such as Bangladesh, Saudi Arabia, Kwait, Abu Dhabi and others [34], dust accumulation has a detrimental effect on the performance of solar cells and collectors. For example, Iraq faced 122 sand-dust storms in 2013 [35]. Baghdad, for instance, has the highest tendencies for dust storms. Commercial Photovoltaic (PV) panel's efficiency is between 15% and 20%, however, dust accumulation on a PV panel reduces their efficiency further and increases cleaning needs [36]. Therefore, the use of BIPV is still limited in improving the flexibility of design due to fixed properties regarding the state of transparency and location. Hence, there is a need for more flexible material characteristics that provide transparency, daylight, and privacy while lowering energy consumption at the same time to fulfil the function of the window as part of the vertical fenestration in architectural design.

This leads to the second type of smart dynamic glazing called Chromogenics. For instance, Electrochromic (EC) material, in particular, changes properties as a function of applied voltage for maintaining a comfortable level of sunlight throughout the day while controlling glare, transparency and opaque state. This is through reversible properties such as Visible Transmittance (Tvis) and Solar Heat Gain Coefficient (G-Value) in response to an electric current of (5 voltage less than 60 Watt bulb) [37], to change its opacity from coloured to bleached or anywhere in between but not to maintain a particular shade. The same properties reduce energy consumptions regarding lighting energy and HVAC requirements [38]. Moreover, Dynamic glazing provides a smart visible light transmission that can be varied from 10% to 70%, and switching times that are relatively fast and use a low level of power [39], as seen in Table 1.

Kaneko and Miyake [41] and explained that the transparent conductors are a significant cost of the switchable glazing. However, Electrochromic glazing can be comparable to and in some cases lower in expense than the high-performance static windows, supported by additional methods of shading. The Lawrence Berkeley National Laboratory (LBNL) conducted an assessment showing that using EC smart dynamic windows can save up to 60% of daily lighting energy [42, 43]. U.S. Department of Energy (DOE) predicts that commercial buildings relying on EC window systems could save up to 28% in energy costs when compared to buildings with static types. The U.S. DOE also reports that Electrochromic glass products can help save 10–20% operating cost savings; up to 25% decrease in HVAC system size; and reducing maintenance [44]. Therefore, this gives flexibility of the design element having switchable, reversible properties to deliver an efficient integrated design relationship between transparency/colour, and private/public states that bring aesthetic satisfaction with sustainability aspects.

5. Research method

The research approach connects the different research parts such as the research question, the conceptual approach to the topic, and methods as a whole in a coherent manner to be adopted in achieving the research aim and its rationale. Ding [45] explained that the methodology is a combination of various techniques used to investigate about a specific situation. The developmental approach and flexibility of design science allows it to be mixed with other research strategies or methods [46]. This is achieved in three stages: Pre-development, Development, and Post-development stage. The approach of Design science has an innovative problem-solving pattern with an aim to create and improve an object

and then evaluate it to develop a solution. It was also appropriate during the evaluation process where the knowledge was already generated and needed to be identified and refined by experts on the role of screen design pattern.

5.1. Interview method

The literature shows that the main problem in improving the design flexibility is not only in what technology offers in terms of smart material, but also in the preconception of the main dynamic characteristics which in this case are transparency, privacy, light and shade manipulation, and thermal comfort. The main aim is to explore the dynamic characteristics which contribute to the effectiveness of part-to-whole integrated design relationships to restore part of the lost comprehensively, design identity and values.

It was essential to select qualitative method because it produced a wealth of detailed data on a small sample. In addition, the study was exploratory in nature and little was known about the subject under investigation. Ospina [47] argued that qualitative methods are needed when there are questions that cannot be answered by way of quantification. The researcher had a clear idea of which interviews are needed with their knowledge of the characteristics of traditional shanashil. The researcher then asked the interviewees in which extra attention was paid to ensure that the interviewees were already engaged in the field of architectural design, and have deep knowledge and experience about the traditional design element shanashil. This is important to understand design identity and values including the choice of material and its effect on part-to-whole design relationships with the surroundings and type of climate. This technique is suitable to discover views, perceptions, meanings and opinions of architects about smart dynamic glazing material. The opinions of the interviewees were analysed and interpreted into themes, and sub themes.

5.2. The sample

The sample of interviewees was selected according to their knowledge of architectural design profession, buildings, elements, and modern materials. Interviewees were also selected based on their knowledge about the city development of Baghdad, its traditional elements shanashil, and the role of change associated with modern planning and transportation means including industrial and technological advancement. Creswell [48] suggested that between 5-25 interviews are enough for an interpretive study.

A purposeful sampling technique was initially used to identify those willing to participate in the study. The profile of interviewees was based on a subset of Iraqi architects, either professors or consultants. In order to increase the overall sample size snowball sampling was then used in this research to identify further interviewees through mutual association [49]. Overall twenty one interviews were conducted with architects taken from academic and private practice. Interviewees had qualifications that varied between the highest academic level of professors, and senior consultants in architectural design. 10 out of the 21 interviewees had between 30 to 50 years of experience of working in the Middle East, mostly in Iraq. They were working in ministries, such as the Ministry of Regional Planning Commission, Ministry of Housing & Construction, Ministry of Higher Education, or Universities such as The University of Baghdad, University of Technology, University of Basrah, and municipality of Baghdad, National Center for Engineering Consultancy, in Iraq.

5.3. Thematic analysis

Braun and Clarke [50] mentioned that there are different methods to analyse qualitative data such as thematic analysis which allows researchers to identify, analyse and report themes within data by organizing and describing the significance of the patterns in rich detail and it presents experiences, meanings, similarities and differences as well as the reality of participants. In this research study, step 1 was achieved through the researcher transcribing the interviews. The researcher wrote down any impressions and initial ideas during the interview regarding the use of design tool to ease the visualisation of dynamic characteristics and to engage the interviewees to use this in the design process. The approach to step 2 focuses on the analysis of interviewees answers. Interviews' questions are considered under the themes as they emerged. The main themes which guided this study were as follows:

- Traditional design element: Identifying the characteristics that provided for the idea of elegance, sustainability, and functional beauty;
- Smart material:
  a) Exploring the perception of the interviewees on aspects that are important for the smart material to improve quality of design whether aesthetic or functional;
  b) Identifying the issues and challenges of a contemporary façade design.

The main themes and sub-themes were then organised. The researcher then presents the findings with clear connections to the existing literature where connections are possible. The data analysis details and findings are further discussed in the next section.

6. Case study

The use of smart dynamic glazing does not give the exposure as seen in the static materials in conventional glass types, nor in traditional wooden screen and its lack of quality control and effectiveness due to changes associated to modern planning. On the contrary, it is an innovative design approach that focuses on the dynamic characteristics of smart materials to enhance the overall building performance in order to meet energy efficiency requirements in a way that improves functionality of its contemporary façade elements without sacrificing design aesthetics. This is because the dynamic characteristics, particularly, the colouration efficiency presented a difficulty in visualising the integrated 2D-3D relationships between traditional principles reinforced by identity and cultural values, and the implementation of dynamic material characteristics of contemporary elements. Accordingly, a solution is divided into three development stages to improve design quality. The following three stages are as follows:

Table 1. The switchable dynamic properties of EC Double and Triple glazing [40].

EC Double Glazed Properties				EC Triple Glazed Properties		
Glass State	T_{vis} (%)	G- Value	U-Value	T_{vis} (%)	G-Value	U-Value
Fully Tinted	1	0.05	1.1	1	0.03	0.8
Intermediate 1	7	0.07		6	0.06	
Intermediate 2	20	0.13		19	0.12	
Intermediate 3	40	0.23		40	0.26	
Fully clear	59	0.38		54	0.35	

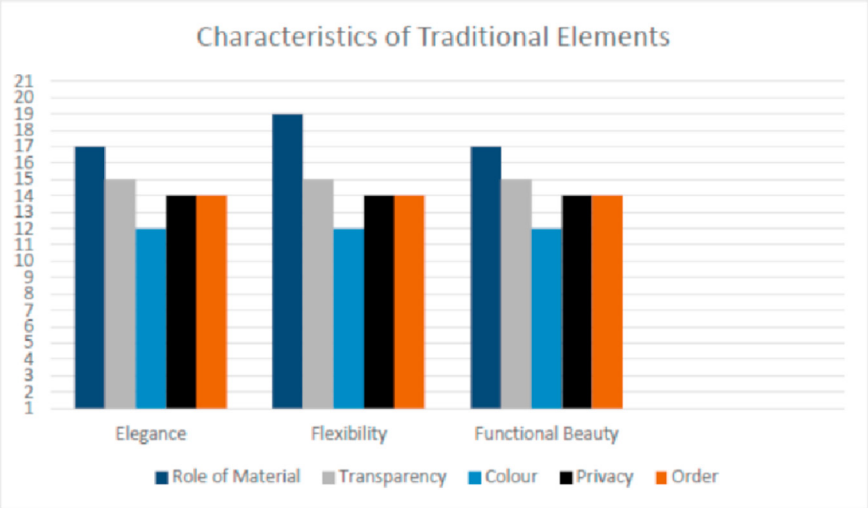

Figure 3. Opinions of the interviewees regarding elegance, flexibility and functional beauty (Source: author).

6.1. *Pre-development stage*

Pre-Development involves developing an awareness of the problem highlighted in section 1, which is in the lack of consistency in the use of traditional elements in a way that affected the identity of building façade in its 2D-3D design relationship, particularly, in the sustainability aspects environmentally, socially and culturally of architectural facade. It also proposes a suggestion of a potential solution as an output to develop a smart contemporary design element using a certain adaptability associated with switchable transparency and colour.

6.2. *Development stage*

The research study developed and assessed a contemporary design approach based on the comparison of two models in second stage.

6.2.1. *Transparency in traditional design elements shanashil*

The objective of this section is to explore the main characteristics of traditional material that made it successful as a distinctive feature of facade identity. The main question was, *what are the distinctive feature(s) of the traditional design element shanashil in traditional Baghdadi Buildings?* 19 of the interviewees agreed that it is the screen pattern that made the traditional elements distinctive, aesthetically and functional. Whilst 17 of the interviewees argued that the role of material is what provided the elegance of the design element, and 15 of the interviewees discussed the important role of transparency in which such design element provided. However, 19 of the interviewees noted that it is the role of material in the traditional screen design pattern which delivered a successful flexible design element. All interviewees argued that such relationships catered for a multifunctional design quality. 17 out of 21 interviewees argued that it was the role of the material that dominated the elegant design element and enhanced the overall quality of it. 15 out of 21 interviewees also specified the meaning of transparency which shanashil presented. 14 out of 21 interviewees noted that order and proportion was illustrated in the screen pattern while maintaining privacy which also made the design distinctive. 12 out of 21 interviewees also mentioned that colour is important in a way to provide for the harmony of design to blend within

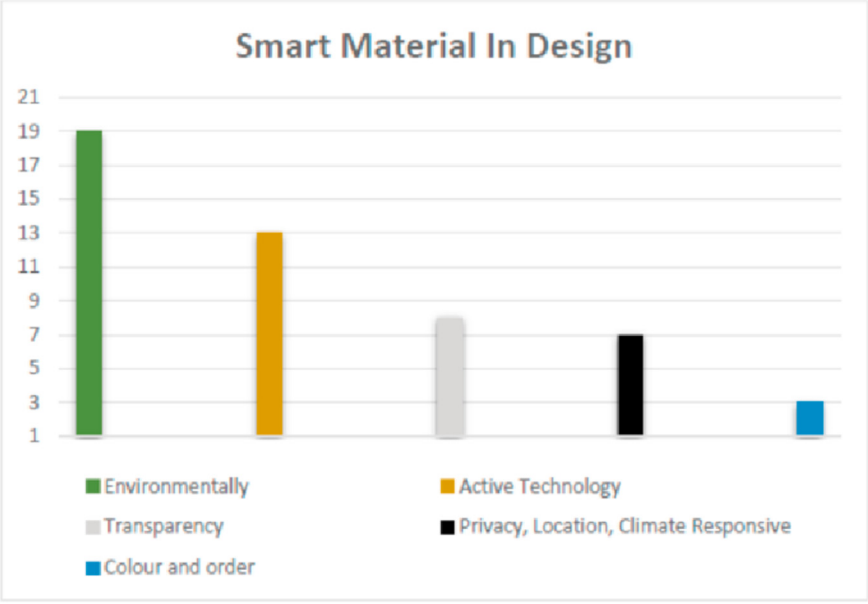

Figure 4. Opinions of the interviewees regarding the definition of smart material in design (Source: author).

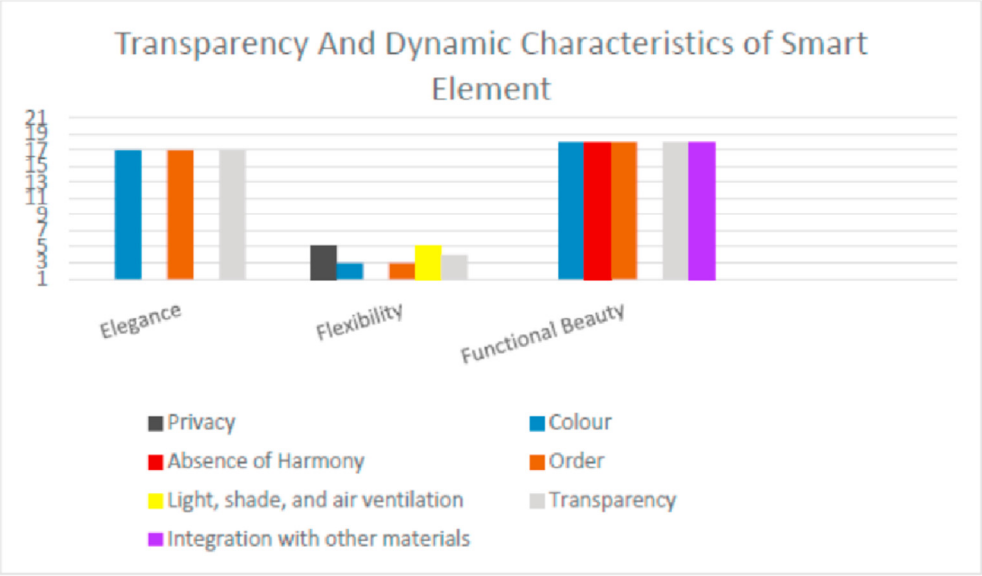

Figure 5. Opinions of the interviewees regarding the use of smart dynamic material and its impact to revive the traditional elements (Source: author).

the surroundings as in the location, and type of climate, as shown in Figure 3.

It can be therefore concluded that the use of traditional design elements particularly in the use of material, expressed the idea of functional beauty through the elegant order, transparency, colour and privacy that allowed the flexibility within control of traditional screen pattern as a whole.

All the interviewees mentioned that there is a need to deliver a better alternative for a more adaptable and flexible screen design, with a material that would regain part of environmental control on the indoor environment in terms of heat, daylight, and glare. However, 3 of the interviewees did not comment because they did not share the same Iraqi background. Such loss has led to the disappearance of the design elements from the buildings' façade and the architectural scenery as a whole. Moreover, the interviewees argued that modern planning is one of the reasons that caused the loss of such distinctive features in façade design in addition to the advancement in technology and change in peoples' lifestyle and the meanings of transparency, and privacy at the same time. As a result, there is now a need to find an alternative in terms of a smart dynamic material that mimics the multifunctional material quality which used to be part of traditional design element shanashil.

6.2.2. The impact of smart material: role of transparency as part of new adaptable strategies in design

19 out of 21 interviewees defined smart material based on its adaptability in design such as being climate responsive. However, 18 of the 21 interviewees had criticised smart materials because they were sceptical of the role of their transparency in the use of smart glazing in the screen pattern. Nevertheless, 8 out of 21 interviewees focus on its role regarding energy efficiency in less use of material and energy consumption. Moreover, 7 out of 21 interviewees defined it based on its potentials in providing privacy, social and cultural aspects. 3 out of 21 interviewees defined smart material based on aesthetic aspects as in colours, order. 13 out of 21 interviewees focused on the role of active technology as part of the smart material definition, and 2 interviewees talked on the passive role of technology, as shown in Figure 4. The

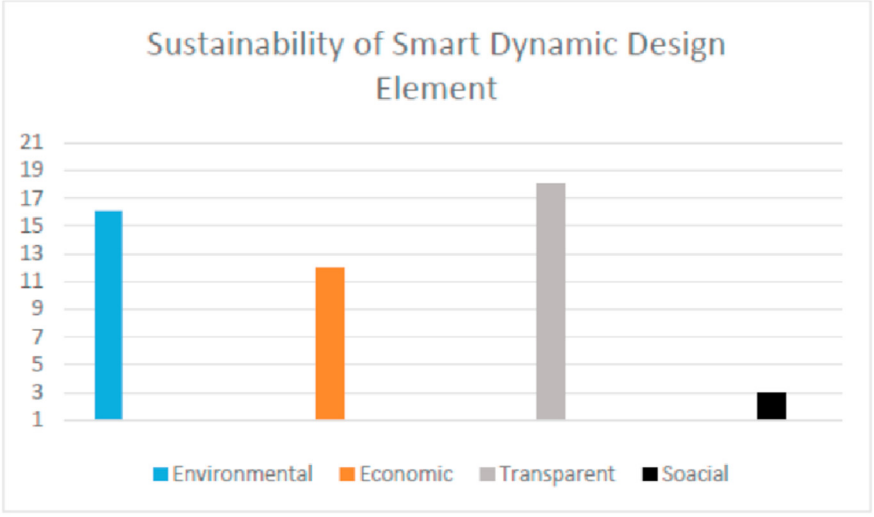

Figure 6. Opinions of the interviewees regarding the role of smart material and its impact on design sustainability (Source: author).

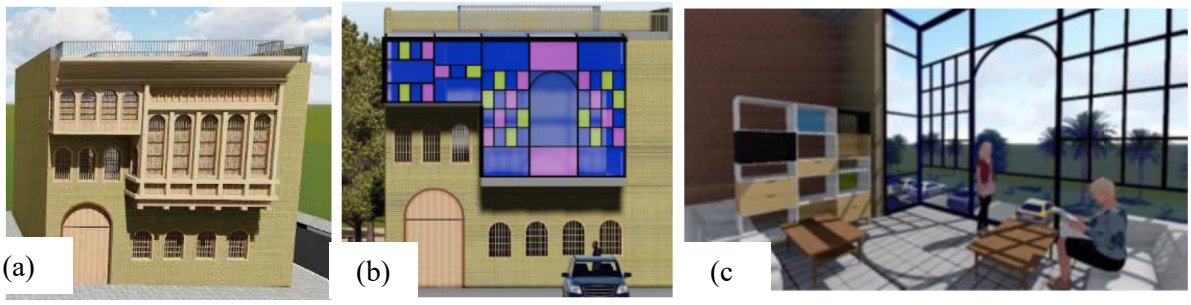

Figure 7. a) The typical example of traditional two storey building; (b) and (c) The flexibility of contemporary façade element between opaque and transparent state. Source: author.

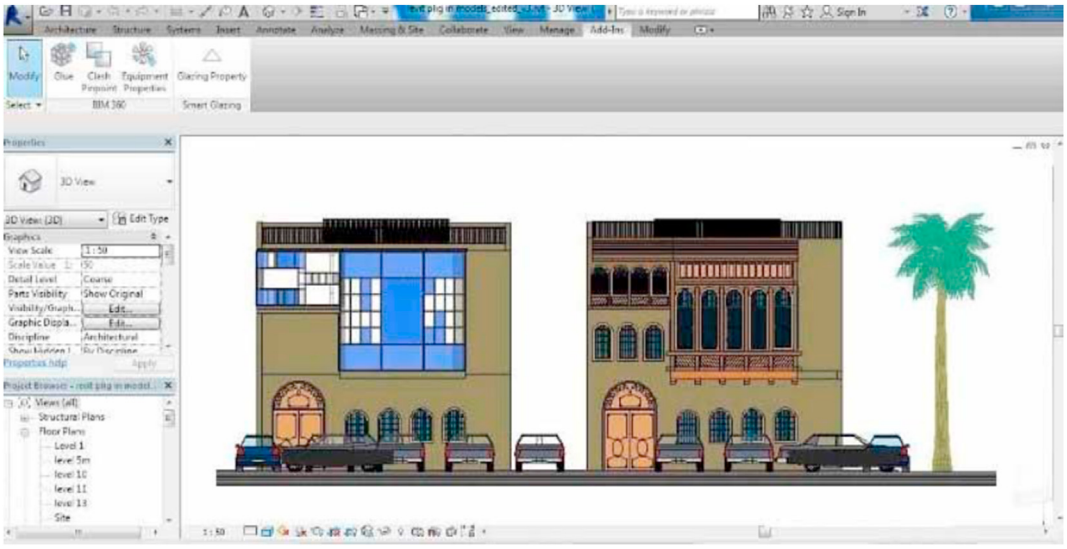

Figure 8. BIM Revit tools and Plugin reflecting the difference between traditional (right), and contemporary design approach (Left) for the window/wall/balcony. Source: author.

objective of this section is to highlight the impact of 'smart material' in façade design, particularly, in the dynamic characteristics and their integrated relationship with the transparency of smart glazing.

The interviewees expressed that flexibility in a material is to be climate responsive in order to suit the changes of the surrounding environment. Therefore, they did not object to the use of new smart material in design. Therefore, the material characteristics need to cater for the following aspects:

- The interviewees focused on the importance of functional aspects, particularly, the adaptability of design to blend in harmony with the surroundings:
  a) The interviewees gave priority to Environmental sustainability. For example, the role of material characteristics is effective in improving design flexibility taking into consideration location, type of climate, energy efficiency, cost and maintenance.
  b) There are other aspects that are deeply integrated as part-to-whole design relationships for instance social aspects are not separated from cultural aspects for both provide the identity of the place.
- The interviewees acknowledged that transparency while maintaining privacy needs is important to be part of external facades in order to maintain distribution and balance of daylight, to deliver a healthy, active, comfortable indoor environment.

6.2.3. *Transparency in smart contemporary elements*

When the interviewees were asked, *what aspects of elegance do you think the contemporary model provides in its illustration of shanashil using smart dynamic glazing?*

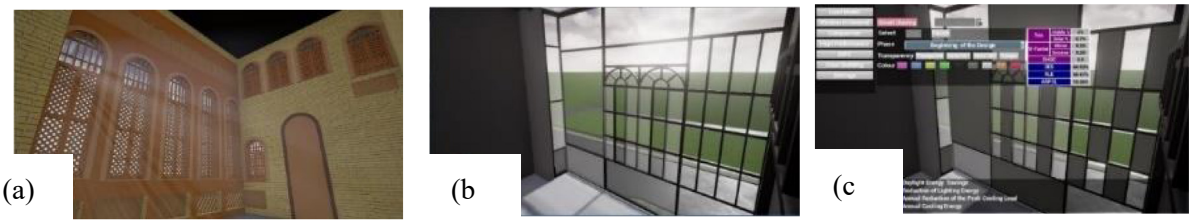

Figure 9. (a) The difference regarding the indoor environment is between the manipulation of elegant order, light and shade relationship in traditional pattern and materials; (b) and (c) Modern material and its reversible properties between transparent and opaque state. Source: author.

Figure 10. Demonstration for a variety of design suggestions of the smart dynamic element (Source: author).

Table 2. Demonstration of the evaluation results (Source: author).

Developed Aspects	Traditional element	Contemporary façade building	Suggestions
1) Elegant transparency	✓ Complexity of form (2D) and function (3D) of screen design	✓ To a certain extent, elegance aspect is improved regarding screen design lines and colours.	The use of three visualisation tools is important to: a) observe the aesthetic aspects. b) enable the interactivity for the end users c) check predefined design parameters.
2) Environmental Sustainability	✖ Used to provide environmental control	✓ Revive thermal comfort quality through switchable properties.	
3) Social and cultural sustainability	✓ Harmony with place identity and culture.	✓ To a certain extent, the choice of colour is proper with the aid of technology tools to fit the nature of the surroundings.	

18 of the interviewees objected to the use of smart dynamic glazing as an option specifically in representing the aesthetic aspects of Shanashil. This affected the idea of elegance when using modern material instead of traditional materials. This is because the application of smart dynamic glazing in the design of the contemporary façade element did not mimic the beauty of the screen design pattern due to the large dimensions in terms of arche's size and repetition of lines and colours such as blue. This makes the screen design order looks strange from its own environment. This also affects the design propriety to match the surrounding environment specifically in Iraqi buildings.

Accordingly, 18 out of 21 interviewees preferred certain colours instead of blue colour. Out of 21 interviewees only 4 interviewees noted elegance in the transparency role, order, and colour. Moreover, 18 out of 21 interviewees favoured integration between transparency and traditional screen pattern. In addition, 4 interviewees acknowledged the switchable, reversible properties regarding transparency, and only 3 interviewees accepted the role of colours and order in design. Only 5 out of 21 interviewees acknowledged the added value of dynamic characteristics in its flexibility regarding heat, light, shade, glare, and air ventilation while maintaining privacy needs. 18 out of 21 interviewees did not find the harmony between the design element and the surroundings in design collectively using smart dynamic glazing material, as shown in Figure 5. Therefore, the post development stage will consider the role of order, transparency, and colour of any object to reflect design identity to blend in harmony with surroundings.

6.2.4. Sustainability aspects in smart contemporary elements

Interviewee were asked, what aspects of sustainability do you think the contemporary model provides to design quality?

Although many interviewees objected to the use of transparent material aesthetically as an option instead of traditional materials, most interviewees 16 out of 21 interviewees agreed that the new modern material is better at providing sustainability aspects specifically environmental control and thermal comfort. 16 interviewees agreed that the transparency of smart dynamic material improves the sustainability of environmental aspects when compared to traditional materials.

As for sustainability of social and cultural aspects, although only 3 out of 21 interviewees agreed that control of the transparency between private and public needs improves the design flexibility, 18 out of 21 interviewees were critical about the added value of transparency of smart material in design regarding sustainability aspects including location and type of climate. However, 16 out of 21 interviewees identified the added value to design sustainability regarding environmental aspects when compared to traditional elements Thus, 18 of the interviewees, except the 3 interviewees that do not share the same background, noted that there is a need to provide better illustrations for the contemporary screen pattern that mimic the traditional pattern order and proportion regarding colours, lines, curves, and harmony for the design to reflect the identity of place, social and cultural values, as shown in Figure 6.

As a result, three visualisation tools were utilised to show the integrated 2D-3D relationship of the screen design pattern as follows:

1. The first tool used is Lumion 3D video demonstration (see Figure 7). The tool is limited as it only produces a video. With this tool, the designer is not able to change design properties between static and dynamic characteristics.
2. The second tool used is the customised Revit plugin tool to illustrate inyegrated relationships of switchable properties between the SHGC and Glazing state (T*vis*) However, there is a limitation in providing a clear indoor environment (see Figure 8). Hence, there is a need for another tool.
3. Third tool depends on the smart dynamic glazing VR prototype to provide better the realistic lighting condition of indoor environment such as the elegant relationship between shade, lighting intensity and light shaft (see Figure 9).

Subsequently, the results are as follows:

- Aesthetic aspects are not presented. This issue is related to lack of scale and size in a way that mimics the traditional façade elements.
- The colours mostly favoured is totally different in order to match identity and blend in harmony with surroundings.
- The functional aspects of the smart dynamic material out-weighed the traditional ones, particularly, in the control of environmental aspects.

6.3. Post-Development Stage

This stage is focusing on the solution taking into consideration the importance of mimicking the essence of the screen pattern context to match collectively the surroundings regarding location, and type of climate. The 3D prototype is further developed to include multi-storey buildings in which their facades mimic part of traditional pattern in lines, arches and colours, and then evaluated in the Post- Development Stage, as seen in Figure 10 and Table 2. The evaluation suggests for the contemporary window/wall/balcony elements to focus on the different positioning of design elements in the design alternatives of the same element in the architectural façade building with control of environmental aspects. Thus, design harmony in a multistoreied building is achieved through understanding the elegant screen design pattern and its integrated relationship with sustainability aspects, environmentally, socially and culturally, as shown in Table 2.

7. Results and discussion

The methods used in this subject depend on both, the qualitative interviews and the important role of BIM technology tools and virtual reality demonstrated in three stages. The first stage is based on the knowledge and information collected in the Pre-Development Stage. All the end results of the Development stage, and suggestions of Post-Development Stage are demonstrated in a 3D digital prototype. This is due to many reasons which are as follows:

- The nature of the research cannot be illustrated clearly without analysing interviews with qualified and experienced Iraqi architects in traditional elements which are hard to find worldwide;
- Another reason is to allow the interviewees to interact with the 3D digital and make important notes, on one hand;
- On the other hand it enables the designer to be able to modify the details of the facade elements. Such act would never be possible without the role of visualisation tools in design.

The Pre-Development stage focused on collecting the information regarding the material characteristics of traditional shanashil elements. It highlighted the important characteristics of traditional elements that must be considered when creating the contemporary shanashil design element. This stage took 2 months to be completed.

The Development Stage demonstrated not only a sense of elegance inspired from traditional material but also the impact of smart dynamic material applied in a contemporary facade of Baghdadi houses. It also focused on identifying the material characteristics of smart dynamic glazing suitable to express the contemporary shanashil design element. This stage also took 2 months to be completed with the use of three technological tools. One of these tools is smart serious game to illustrate the impact of smart material on the quality of indoor environment. Other tools were used to ease the visualisation of the aesthetic aspects as well as the difference between the traditional facade and smart contemporary facade design such as Lumion 3D video demonstration, and the BIM Revit tool.

The Post-Development Stage focused on the end results of the contemporary facade design in a way that caters for the sustainability and efficiency of design. This stage also took 2 months to conclude that the smart dynamic material can deliver a flexible facade to blend in harmony with surroundings, environmentally, socially and culturally.

The key findings are discussed below with respect to the three stages.

7.1. The aesthetic aspects of dynamic transparency

In relation to aesthetic aspects, the interviewees favoured the contemporary design elements in the suggestions of Post-development stage, as seen in Figure 6. This is because of the integrated relationship between the transparency meaning, order, texture, and colour as an essential part of screen pattern. The design pattern had an elegant order that combined the parts such as lines, arches' size, and colours in unity within the design context as a whole. It delivered a conscious sense that conveyed functional beauty and it was visually satisfying to the whole regarding the arrangement of architectural elements with the other principles of symmetry, beauty of the details, and propriety. Similarly, the use of wood provided flexibility as in the manipulation of form and function regarding 2D screen ornaments, to 3D balcony sizes, scales and colour.

In Figure 4, discussions of Development stage focused on the importance of understanding the aesthetic aspects of the screen design pattern as an essential part of the identity of facade design. There are four essential aspects intertwined with each other in order to maintain an elegant facade that projects the idea of functional beauty: the first aspect is Transparency in which the traditional old façade is known to deliver through the screen design pattern and order, while maintaining its intertwined relationship with the second aspect; the second aspect is the privacy needs through the screen design pattern and order that allows residents from inside the shanashil to overlook the outside without allowing people on the street to invade their own privacy; the third aspect considers the colours of the screen design pattern in which the choice of material (wood) in Figure 8 blends in harmony with the local material called Fired brick; the forth aspect is about the choice of a material that is flexible to combine all the three aspects which are transparency, privacy and colour, all through the design of the screen pattern.

7.2. The sustainability aspects of dynamic transparency

7.2.1. Sustainability of environmental aspects

In relation to environmental sustainability, the interviewees favoured the contemporary expression of traditional facade, order, colours, and shades. This is because of the following reasons:

1. The contemporary design element was able to deliver dynamic transparency as part of the elegant screen design pattern to reflect the traditional order in terms of line, and arches that blended in harmony with the surroundings.
2. Differences between Dynamic and Static Glazing: 18 of the interviewees were sceptical about the role of transparency in the contemporary element including location and type of climate. However, 16 of the interviewees identified the added value of a new modern material to design sustainability regarding environmental

aspects when compared to traditional elements wood and static glazing.

Thus, the application of smart dynamic material adds value to the contemporary design element even though the role of transparency can be critical when compared to traditional wooden elements and nature of the surroundings. However, the smart material provides a dynamic transparency with switchable properties that mimic the needed characteristics to Baghdadi houses which are as follows:

- The important role of dynamic transparency to maintain daylight needs and natural air ventilation for a healthy indoor environment in the smart dynamic windows, as demonstrated in Figure 6.
- The important role of dynamic transparency and its integrated relationship with energy efficiency: the smart dynamic material plays an important role in lowering energy consumption by providing environmental control in a way that neither static glazing nor traditional materials can provide. This can be seen in the switchable properties regarding Visible Transmittance (T*vis*) and Solar Heat Gain Coefficient (G-Value) in response to an electric current of (5) voltage less than 60 Watt bulb), as illustrated in Table 1, and its impact on indoor environment as seen in the relationship of light and shade in Figure 10.

7.2.2. Sustainability of social and cultural design aspects

In relation to social and cultural aspects, the interviewees in the Development stage favoured traditional material (wood) in Fig, 5, and 7 as part of the identity and a distinctive feature of the design element. However, it is essential to realize that wood itself is not part of the surrounding environment, because it was imported from other places throughout the world such as Southeast Asia. This strategy by the builders was necessary at that time to adapt to the challenges in the hot, arid climate of Baghdad in a way that blended in harmony with the surroundings (narrow streets and lanes) including local materials and type of climate.

Therefore, there is a need for a different strategy in design such as smart dynamic glazing that mimics the adaptability in traditional design elements to suit the changes of the pattern context as a whole.

As discussed in Development and Post-Development Stages, the choice of a smart material depends on its adaptability to the surrounding environment including the role of climate such as the hot, arid climate in Baghdad city. This is achieved because the material is flexible, particularly, in its dynamic design characteristics as follows:

- The important role of dynamic transparency and its integrated relationship with Privacy to maintain the needs of household members that allows them to stay in touch with surroundings and simultaneously prevent them from being overlooked by people at the street, as demonstrated in Figure 5.
- The important role of dynamic transparency and its integrated relationship with color: the smart dynamic material provides flexibility in its switchable reversible properties that changes from the transparent state to the opaque state through the role of colour, as demonstrated in Figures 9 and 10.

As a result, the consistency of screen design pattern was achieved in the suggestions of contemporary elements to a certain extent regarding aesthetic satisfaction of screen design pattern, order and colour, as illustrated in Figure 10 and Table 2. Thus, the smart dynamic material provides better adaptability in terms of colour, privacy, as well as environmental control to façade design when compared to static glazing and traditional wooden screen pattern.

8. Limitation of the research

Due to time and practical limitations, the dynamic characteristics could not then be implemented on a live building project. This would have provided further feedback on the material characteristics in terms of colour, texture, and design order in relation to location.

9. Conclusion

With the results of the three stages in this research study, it is clearly affirmed that the choice of the design science methodology is important to demonstrate the design of the contemporary multistoried facade elements, particularly, in the evaluation of aesthetic aspects in a way that complements the point of view of sustainability aspects, environmentally, socially and culturally. Consequently, the idea of maintaining a harmony between function and cultural identity are the key to understand the design quality of the elements of Iraqi buildings. This is achieved through the use of visualisation tools in design and the following key conclusions can be drawn:

- Concerning the aesthetic aspects, the smart 2D & 3D design of contemporary screen pattern expresses variety of design when it comes to positioning of contemporary elements and simultaneously sustain the elegant façade design both socially and culturally in terms of colours, lines, and arches.
- Concerning the functional aspects, sustainability of design is about the balance between transparency, thermal comfort, and privacy and the use of minimum energy to achieve maximum performance for creating an efficient, healthy, and active indoor environment.
- Through the use of more than one visualisation tool, the 3D digital prototype provides a clearer understanding of the integrated design relationships between 3D extended window/wall/balcony element and 2D of screen design pattern.

10. Future research Recommendations

Whilst this study has provided a contemporary design pattern of smart dynamic characteristics to facilitate the use of a multifunctional window/wall/balcony element mimicking the traditional material characteristics of shanashil in its appearance and function. The following areas of study would be subject for future research:

- Development of technological tools to enhance the visualisation of the flexibility in the smart dynamic glazing material.
- Smart dynamic materials to express a wider range of colours, shades, and textures to be tested in differing locations.
- Further studies are required on the flexibility of contemporary façade elements in differing climatic zones.
- Recommendations of this study should be implemented on real projects.

Declarations

Author contribution statement

TAMARAH A. ALQALAMI: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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