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THE RESIDENTIAL CONTEXTUAL FAÇADE TECHNIQUES IN IMPROVING INDOOR COMFORT FOR HOT ARID CLIMATE OF BASRA CITY: A REVIEW

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ABSTRACT

Climate change is causing Iraq to experience extreme high temperature. This phenomenon has affected residents' sense of comfort and incurred high energy consumption. The Residents' thermal Comfort is still the main problem in hot and arid climate country such as Iraq particularly during summer resulting in expensive energy usage. This paper seeks to investigate how Basra City residents could achieve indoor comfort using contextual façade techniques. This study analysed factors that can affect residents' indoor comfort and identified a balance between indoor comfort and energy usage. The desktop result suggested that contextual double skin façade and double-glazing typologies could improve indoor thermal comfort for residents. Using this contextual façade typology could potentially lead to energy saving. This study is limited to understanding the effect of contextual double skin and double glazing to residents in hot and arid climate. This study aids in reducing climate change and sustainable residents' fiscal in energy consumption. Future development of this contextual façade typology could provide future guidelines and policies for façade treatment in hot and arid countries.

Keywords: *Contextual Façade, Energy use, Façade typologies, Hot arid climate, Indoor comfort.*

INTRODUCTION

Currently, Iraq's residential demands for providing comfort and energy saving have rapidly increased due to the country's climate change (Fattah et al., 2018). Laina Hilma et al. (2020) and Zulkarnain et al. (2021) foresee the need for satisfying residential demands as one of the major challenging issues over the world especially in the middle east and southeast Asian climate environment. In southern Iraq specifically such as Basra City, the inappropriate and energy shortage in residential conditions are still the main problems in providing comfort and energy saving (Ramezani et al., 2021). Based on the World Bank (2018) data (refer to Figure 1), the city of Basra in the south and the west have the highest solar radiation throughout the year especially from May to September (summer). Haraty et al. (2019) argued that the high temperature in summer is due to the weak supply of electricity. Istepanian (2020) and Salman et al. (2017) found that when temperature reaches more than 50 °C in summer, the electrical energy and discomfort also rapidly increased. Fadhil & Burhan (2021) found that the condition is similar to Iraqi's resident problems in Basra City due to the 1980's war and economic crisis.

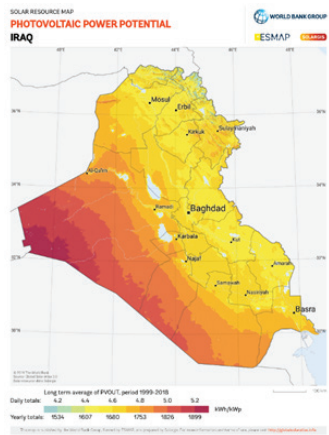


Figure 1. Solar Radiation for a Whole Year in Iraq and Basra city.
Source: World Bank, (2018)

The World Bank (2018) highlighted that the residential shortage in the country represents 25% of the total residential stock in the country specifically in Baghdad and Basra city. This is because of different significant factors such as house production, inefficient financial system, poor construction and materials availability, weak infrastructure services, and spreading of slums in Iraq (ibid). Here, this study agrees with Mohammed & Jasim (2017) that low-cost solutions on the comfort and energy consumption are needed to overcome the problem. In the same vein, this study agrees with Al-Hafith et al. (2018) and Kamal et al. (2019) that deteriorating energy supply and current residential design are becoming major issues to achieve optimal indoor comfort for hot and arid climate such as Iraq. In this manner, this study foresees an urgent need to study how to achieve comfort for Iraqi residential buildings due to severe temperature.

PROBLEM STATEMENT

According to the Ministry of Construction and Housing (2010), the Iraqi Ministry established a National Housing Policy to provide indoor thermal comfort for Iraq's residential buildings. Rawaf et al. (2014) highlighted that there have been a lack of independence, continuity, and economic conditions that could provide stimulus to solve the housing policy implementation in Iraq. These ideas towards studying and evaluating the housing topology and situation based on the current policies and material capabilities have been highlighted by Al-Shaibani & Popov (2019). Alkindi (2016) argued that the policy setup on certain approaches based on economic conditions, demographic characteristics, and normative contexts of Iraq could provide housing thermal comfort and energy saving solutions to increase an adequate level of housing comfort for residents. This study anticipates that there is a need to address effective façade features in residential buildings in order to provide optimal thermal comfort living environment for residents through programs and sustainable policies. This study agrees with Hussein & Uzunoğlu (2020) that the current Iraqi residents' priorities are mostly focused on achieving indoor thermal comfort for any situation particularly during summer, as residents need to stay indoors most of the day. This is because thermal comfort and health have a strong relationship and are linked to long-term and short-term illness (Bueno et al., 2021).

Salih (2019); Homod et al. (2021) and Al-hafith et al. (2017) affirmed that the house topology and façade shape, and material in Iraq's residential buildings play a key role in decreasing the thermal discomfort for residents whilst providing energy saving and privacy especially in southern cities such as Baghdad and Basra. Façade is a part of building envelope that influences the sustainability of house structure, which regulates the thermal comfort of the building (Kalús et al., 2021). However, many building façades in Iraq do not meet the different aspects such as economic, social, and environmental aspects in terms of energy and thermal comfort (Krajčík & Šikula, 2020). Mirshojaeian Hosseini et al. (2020) suggested that in order to improve the façade performance, studies regarding the functionalities of building façade technologies on conventional façade systems are needed. This has been identified by Pastore & Andersen (2022) that the façade functionality is affected by two factors: façade design and façade components technology. Hosseini et al. (2019) highlighted that the façade design was misgauged due to poor standard performance required by residents. Among poor standard performance suggested by Hosseini et al. are façade variability that increases thermal discomfort and energy. Since façade variability is related to façade components used in building, the tendency to have poor thermal characteristics are high (Pujadas-Gispert et al., 2020). Several studies on façade components adaption have been done to ensure the best technical façade that meets the resident thermal requirements (Hu et al., 2017 and Zhang et al., 2016). However, these studies are conducted in moderate hot climate which differs from hot and arid climate conditions. Poor material properties (Al-Qaraghuli & Alawsey, 2016; Rashid & Voelker, 2019; Abaas, 2020); and selective material usage and façade shapes (Hasan, 2018; Hassan et al., 2019; Homod et al., 2021) could increase surface temperature behaviour due to solar radiation. Rashid & Voelker (2019) suggested the use of double skin façade layering as an element in controlling thermal comfort performance in Iraqi's residential buildings. Here, this study agrees with Al- Yasiri et al. (2019) and Kamal et al. (2019) that thermal comfort in hot and arid climate residential buildings of Iraq are facing major problems in terms of poor energy supply and material used.

From the study above, it clearly showed that studies on housing policy and façade components technology could benefit the goal of adapting a variety of conditions to improve indoor thermal comfort environment in Iraq. The housing policy could be improved when it is focused on economic

condition for thermal comfort whilst considering façade topology, and resident's climatic environment as part of the housing policy requirements. The foreseen inappropriate façade designs and poor façade components are creating major gaps in dissatisfaction of the façade functionality toward comfort. Hence, there is a need to overcome lack of strategy and criteria for selecting inappropriate façade technological options that meet both residents and climatic requirements toward thermal indoor comfort. Therefore, this study is keen to investigate the challenges and recommend the best contextual façade typologies for Basra City residential building residents to achieve indoor comfort.

METHODOLOGY

This desktop review study was done using a comprehensive search of peer-reviewed journals based on a wide range of keywords such as indoor comfort, hot arid climate, façade topologies, façade techniques, and improving thermal comfort. Several databases are searched including Scholars Portal Journals, Google Scholars, digital library, and Academic Search Premiere. From the literature review, the analysis of 74 articles (from 2015-2022) revealed three different themes that direct towards current challenges of Iraq's residential buildings toward indoor comfort, façade techniques for hot and arid climate, and the best contextual façade techniques to improve indoor comfort. However, there are limitations in terms of studies regarding residential thermal indoor comfort.

Each article was then inferenced following these approaches: year of study, façade technique used, approach of the study, study area or location, improving indoor comfort, and study limitations. The relevance and credibility of all the articles are considered and a list of variables were identified for experimental testing in the next stage of the research. This will be discussed in the next paper.

LITERATURE REVIEW

This study would firstly discuss about the challenges faced by the current Basra residents toward achieving indoor comfort. Then,

this study would discuss the best façade techniques for hot and arid countries to achieve a satisfactory level of comfort. Finally, this study will recommend the best contextual façade techniques to improve the comfort of Basra City's residents and suggest potential variables for the experimental stage.

Challenges Faced by the Current Basra Residents toward Achieving Indoor Comfort

Basra city is located in the south of Iraq. It is the second largest city after the capital of Iraq (Baghdad). The highest temperature in Basra during summer is 55 °C. The highest and lowest humidity is 70.65% and 14.2% respectively. Basra has different typological residential houses; historical, traditional, colonial, and social housing (Almusaed & Almssad, 2015) as seen in Figure 2. Currently, increasing high energy demands in Iraq have been a major issue due to the need to improve indoor comfort conditions. In particular, the residential sector occupied 60% of the total building infrastructure in Iraq (Mohsin et al., 2020). This has led to increased demands for energy consumption and deterioration of the comfort levels. Due to the war crisis in Iraq since the 1980's until the US attack in 2003, the residential sector suffered from many challenges in terms of energy shortage, air conditioning, heating, and thermal comfort (Mills & Salman, 2020). The crisis was further aggravated when the Iraqi government was pressured to build fast track shelter to accommodate war civilians (ibid). Among the problems related to fast-track shelter are inappropriate structure shapes (Mohamed et al., 2015); uncomfortable indoor comfort qualities (Yousefi et al., 2017); high temperature during the day, and energy shortage to generate air ventilation (Hasan, 2018; Mahdi & Abbas, 2018). These factors have relatively caused great suffering to the Iraqi residents in achieving indoor comfort. Almusaed & Almssad (2015) found that old building code, old construction techniques, and the absence of policies and regulations had further worsened conditions which led to the residents' discomfort.

(a)

(b)

(c)

Figure 2. Residential houses in city of Basra. (a) Traditional house "Shanasheel", (b) old building "1990's", (c) new house "2010's".

Source: Author

Several studies on thermal comfort have been conducted in mid-arid climates, however studies are still lacking in hot-arid climates (Zhao et al., 2020). A study by Song et al. (2018) concluded that thermal comfort adaptation was suitable at a temperature of 32° C for hot-arid climate zones. Another study by Lai & Chen (2016) and Golasi et al. (2016) on mid-arid climate showed that comfortable adapted thermal condition temperature is between 20° -25°C. Moreover, Hailu et al. (2021) highlighted that suitable thermal neutrality of modern houses in hot-arid Western Australia is 23.3°C. Whilst a study by Mohd Ariffin et al. (2018) confirmed that the suitable temperature for thermal comfort for Algeria's modern and traditional houses is 32°C. Here, this study foresees that regionally, climatic environment plays an important role in identifying the best level of thermal comfort for contextual locations. Since Basra city is a hot and arid country, this study concurred with Song et al. (2018) and Mohd Ariffin et al. (2018) that optimal thermal comfort for Basra City resident would be suitable at 32° C.

Different studies in developing countries showed the lack of design technology and availability of structure materials (Manzano-Agugliaro et al., 2015). According to Mohd Ariffin et al. (2018) traditional houses have a better ability in providing thermal comfort than modern houses due to thinner walls and low thermal conductivity. Regrettably, poor local materials such as concrete in traditional/modern houses has increased thermal discomfort. Other studies by Karyono (2015) and Fernandes et al. (2015) found that conventional design and materials construction such as high roof, poor heat transfer material, passive strategies in building and shortage of local materials are among the factors that increased thermal discomfort for residents.

In the same vein, this study foresees similar effect of thermal discomfort in most traditional and modern Iraqi buildings due to hot-climate region particularly in the use of traditional construction system and materials. Hence, this study anticipates that adaptation of building structure and building materials without considering new policies, regulations, new design techniques, and other alternative materials as well as hot-arid climate zone could become obstacles in achieving optimal thermal comfort for the residents of Iraq.

Façade Techniques for Hot and Arid Climate

The façade of Iraq's residential buildings plays a significant role in providing comfort and privacy for the residents (Homod et al., 2021). Al-Qaraghuli & Alawsey (2016) warrant that some passive façade such as solar control, building layout, orientation, and control of internal heat sources in Iraqi buildings have lesser thermal impact on user's comfort by penetrating less heat into a building. Whilst other strategies such as shaded windows with insulated material could increase thermal comfort (Alqalami, 2020). A study by Al- Yasiri et al. (2019) conferred that poor insulation and shape of the façade materials are among factors that increased the thermal discomfort inside the building. These factors whilst concluded that topology of façade can significantly impact indoor thermal performance and residents' comfort. Scholars argued that when glass shading device (Abrahem et al., 2020; Bakmohammadi & Noorzai, 2020; Mangkuto et al., 2022) and spacing courtyard (He et al., 2021) are implemented, heat gain and overheating can be deterred which will lead to better energy consumption. With this in mind, this study found many Iraqi buildings are still facing challenges to regulate overheating in buildings due to many usages of single skin façade which is the most conventional shading system in Middle East (Radhi et al., 2015; Vanhoutteghem et al., 2015). In conventional shading system, single skin façade and single window glazing are the main system components which reduce the cooling demand inside the building (Al- Yasiri et al, 2019). A single skin facade is an envelope construction that consists of one transparent surface separated by a cavity (Vanhoutteghem et al., 2015). According to Radhi et al. (2015), the one-layer skin can increase heat demand in summer. It is concluded that in a hot dry climate building, a single skin facade can only provide the lowest level of comfort to residents (Al-Qaraghuli & Alawsey, 2016). Here, this study foretells that the façade shape toward the spacing in courtyard could affect the thermal performance and increase the energy consumption in Iraqi buildings.

Studies by RAIS et al. (2020) and Sharma (2014) presented the double skin façade as a solution for viable and thermal comfort for hot and dry climate. The finding was a panacea because double skin façade was intended for cold climate zone such as the European region (Goia et al., 2015). Interestingly, many hot climate zones have modern buildings that use the double skin façade and claimed that the ventilation channel between

the glasses could reduce unwanted heat. From here, this study foresees the façade techniques in severe hot and dry climate is becoming more complex and dynamic. The gap from the design of openings, shading devices, and façade materials are seen as the main key sources for the overheating and thermal discomfort. In hot and dry climate countries such as the Iraq region, the existing façade technique has a great impact on providing thermal comfort. This study found that many Iraqi houses are still using conventional construction system. Factors such as single glazing, shape and material have a large impact on consuming heat gain in Iraqi houses. Here, this study recommends that double skin façade as part of the potential solution to be implemented in the façade of Iraqi houses to reduce heat gain.

Contextual Façade Techniques to Improve Comfort

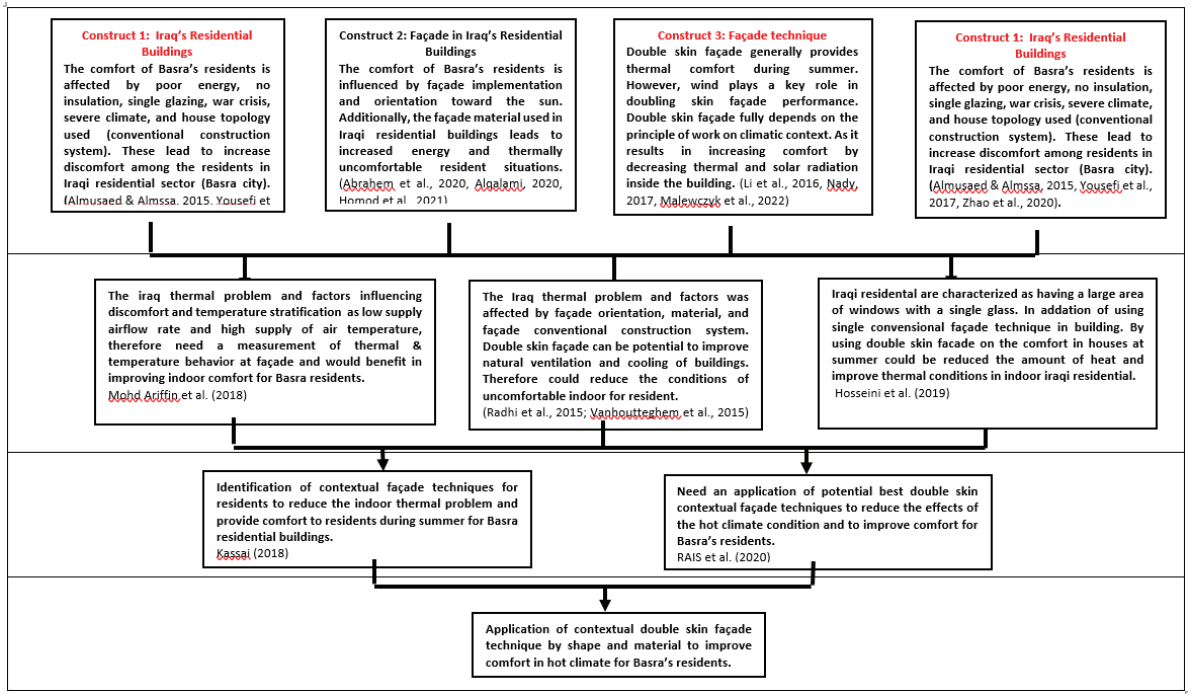
Many scholars (Li et al., 2016, Nady, 2017, Malewczyk et al., 2022) argued that façade techniques are the result of its contextual environment responses. Several façade techniques are proposed to generally improve thermal comfort in residential buildings (Zinzi et al., 2016, Rizi et al., 2021). Scholars such as Rashid & Voelker (2019) and Zhang et al. (2022) proposed that double glazing façade technique in Iraq's residential buildings could provide better comfort and energy saving even in the hottest climate period which is between July and August. Evangelisti et al. (2020) and Balali & Valipour (2020) highlighted that external shading devices when paired with natural smart material in double skin façade can boost shielding system efficiency. Al-Alwan (2020) suggested using sunscreen with double skin façade; Ibraheem et al. (2020) proposed smart or intelligent façade; whilst Alqalami (2020) recommend five types of façade materials for double skin façade.

Sung & Kim (2019) proposed that natural ventilation pairing with double skin façade during summer; whilst Lotfabadi & Hançer (2019) identified a double skin façade with ventilation could reduce cooling load by 20%. In addition, double skin façade placement direction, wind direction, and wind velocity could impact the façade performance (Ancrossed D Signelković et al., 2016, C). Double skin façade and double-glazing window are seen as possible solutions to reduce heat gain (Joe et al., 2014). However, when the temperature concentration is combined with external wind directions, it degraded the double skin façade cavity inside

the building (Andelković et al., 2015). Moreover, Hosseini et al. (2019) and Kassai (2018) further argued that despite the great performance of using double skin façade in hot and dry climate, type of material, temperature distribution, and climatic context could lower the natural ventilation and thermal comfort.

Here this study foresees that for the issue of Iraq's building façade improvement toward thermal comfort, the double skin façade technique could be a possible solution for reducing heat gain. Double skin façade could provide thermal comfort during summer. The need to control temperature, type of material, and wind play a significant role in doubling skin façade performance. Double skin façade fully depends on the principle of work on climatic context. These would have resulted in increasing the comfort level by decreasing thermal and solar radiation inside the building. Table 1 summarises the point of departure and the barriers toward comfort in façade techniques for residential buildings in Iraq.

Table 1. The Challenges and Barriers toward Thermal Comfort for Iraqi's Residential Buildings



Source: Author

DISCUSSION

Challenges Faced by Iraq's Residential Buildings and the Use of the Facade Technique in Providing Thermal Comfort

Iraq's residential buildings faced several challenges due to its design topology specifically their façade topology. Poor energy, severe hot temperature, and lack of regulations are the factors that have an impact on both aspects which include energy saving and thermal comfort. According to previous studies, the severe climate besides the façade topology have greatly affected the indoor thermal comfort of the residents. In such a city as Basra, it has been found that using the conventional construction system increases the indoor discomfort as single glazing and single façade skin are mainly used in the building design. In addition, it has been found that the increased level of indoor discomfort in Basra's residential buildings comes from the building orientation that is facing the sun. Similarly, one of the factors of the increasing level of indoor discomfort in Basra city is the façade shape and material used in the building design. This leads to the need of a measurement of thermal & temperature behaviour at façade which would improve indoor comfort for Basra residents. Hence, it is crucial to focus on the identification of contextual façade techniques for residents to reduce the indoor thermal problem and provide comfort to residents during summer for Basra residents.

Façade Parameters toward Thermal Comfort

As previously mentioned, the façade parameters such as shape, shading, material, and orientation have a great impact on the performance of indoor comfort especially in severe climate zones. Possible ways to implement these parameters in the building can play a key role in providing low heat gain and natural ventilation. In addition, there is also the matter of the facade shading size and openings which controls the air flow inside the building envelope. For severe climate zones such as the one in Basra city, these façade parameters are significant in providing indoor comfort for residents. As a result, double skin façade and double shading (glazing) are proposed as one of the improvement methods to improve natural ventilation and cooling of buildings. Therefore, it could reduce the conditions of

indoor discomfort for residents. Hence, there is a need for the application of potential best double skin contextual façade techniques to reduce the effects of the hot climate condition and to improve the comfort level of Basra residents.

Double Skin Façade for Thermal Comfort Improvement

Iraqi residential buildings are characterized as having a large area of windows with a single glass. In addition, the façade sizes of the Iraqi's houses are quite large than usual. This leads to the use of single conventional façade technique in building. Hence, the level of indoor discomfort is increased particularly during summer. Double skin façade technique is proposed to reduce the effects of the indoor discomfort in Basra city. However, adding another façade layer requires an appropriate material with suitable or low thermal properties. This results in identification of contextual façade material for residents to reduce the indoor thermal problem and provide comfort to residents during the summer for Basra residential buildings. A proposal of potential best double skin contextual façade shape and material are needed to provide the best performance of indoor comfort for Basra residents. In which the final approach is to achieve an application of contextual double skin façade technique by shape and material to improve comfort in the hot climate for Basra residents.

CONCLUSION

In this paper, the best contextual façade techniques for improving thermal comfort of Iraq's residential buildings have been investigated. Despite the current existing techniques of façade design provided by Al-Hafith et al. (2018), Hassan et al. (2019), and Mohamed et al. (2015) to improve thermal comfort, there is still a lack of literature in defining the optimal façade techniques toward increasing the comfort level in Iraqi houses. This study finds that the most critical challenges affecting the level of comfort in the residential buildings in Iraq are structural topology of building, façade topology, and façade shapes and materials. This study also finds that the best solution to be adopted in façade techniques in improving the comfort level is by implementing the double skin façade and glazing for building envelope. Future direction is to determine the performance assessment of

applying optimal double skin façade on the existing traditional and modern houses in Iraq. This will contribute towards understanding the façade behaviour and the best façade design for hot-arid climate region. Also, this could further help the Iraqi architects and designers to fulfil the successful contextual façade design in order to provide better indoor comfort for residential housing in Iraq.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTION

The manuscripts/ articles were originally written by the authors.

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