Efficient environmental architectural design for educational buildings in Iraq: An environmental study of the computer engineering building in the University of Technology, Iraq.

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Abstract: The topic of the thermal environment of architectural buildings is important in current architectural design. This research thus discusses the state of the computer engineering building in the University of Technology of Baghdad through the lens of climate elements and the principles of sustainability with the aim of achieving increased comfort for those occupying this building during office hours. The research thus proposes several solutions including creating a mask for the building, as well as making decorations commensurate with the goal that highlight elements of Arab Islamic architecture while also creating shadows that may decrease direct solar radiation. Further ideas include tilting the glass inwards in some windows, and replacing the capon panels with concrete structures that separate them from the building to create a buffer distance, as well as shifting room locations from one place to another, and adding afforestation around the building in a thoughtful manner.

Key words: environmental-architectural design, thermal comfort, educational buildings, total integrated environmental scale, environmental design treatments after implementation.

1. Introduction.

Environmental architectural design is one of the most important aspects for achieving appropriate thermal comfort for those occupying buildings. One of the most important things the recipient of the building must do after implementation is to measure the efficiency of the building in terms of environmental requirements at the site of construction, especially where the building is for educational purpose [¹]; however, the measures used in accurately determining the thermal and environmental performance of buildings are detailed and complex [²], and thus researchers have provided more general, comprehensive and relatively simple scales that can help building owners and those acting on their behalf to form a general idea about the environmental efficiency of the building to be occupied that can be used to develop a set of recommendations to improve various design elements to increase environmental efficiency and improve thermal comfort [³]. As an experimental study, the current applied research discusses the case of the computer engineering building in the University of Technology complex based on various climate and sustainability elements intended to ensure the comfort of the occupants of this educational building both during normal working hours, for the comfort of users, and beyond (in a secondary manner), in order to keep the equipment and furniture within a normal acceptable thermal range [⁴]. This system thus summarises the problems identified and allows the development of proposed solutions, based on using existing tables to calculate shading and thermal efficiency and to make the necessary adjustments to the architectural plans.
2. Research Methodology

The research methodology is based on the use of an overall integrated environmental-architectural design scale built and developed by the researchers in a previous research project; this serves as the intellectual framework upon which this research is based. The scale is applied to evaluate the extent of environmental efficiency after implementation as well as studying the possibility of avoiding environmental gaps built in by the designer for many reasons. This is done by analysing the plans, facades, interior design, and the effects of solar radiation on occupants and furniture. Based on these factors, a hypothesis was developed for the research that the most important environmental treatments to be designed and adopted in ill-directed buildings are through the work of external shields and a review of the functional distribution of the building.

3. Research Objectives.

The research aims to re-adapt a building to its spatial environment by determining the minimum requirements for an environmental-architectural design of the selected educational building after implementation. The research thus aims to find suitable solutions to improve the thermal environment of the building for the benefit of people, furniture, and appliances, thus suggesting quick, appropriate and economically inexpensive solutions for the lowest level of changes at the architectural and structural level to achieve an effective design.

4. Research Problem.

The research problem is applying an environmental architectural design at a scale appropriate to the goal to be achieved.

5. The Situation.

The Computer Engineering Building is one of the most modern buildings within the educational buildings complex at the University of Technology. It is located in the north of the university's educational complex, behind the group of buildings overlooking the Muhammad Al-Qasim highway, being separated it from the buildings in front of it (Applied Sciences and a Hall Complex). A wide street, the main road inside the university, is next to it, and the building is bordered on the east by a multi-storey garage. On the west, it is bordered by the old applied sciences building in an architectural style that dates to the beginning of the university's foundation in the 1970s. At the south, it is bounded by the back facade of the Laser Engineering Department.

Architecturally, the facades are coated with double metal on a steel frame (locally referred to as a Capon). These differ in nature from the architectural encapsulation by bricks of the buildings located to the west and south, but are compatible with the buildings located to the north and east (parking garages). The facades of the building try to highlight its symbolic character while introducing a heritage dimension, such as the use of an arch at the central entrance, which harks back to the Sharabian schools in the Abbasid era, as well as around the windows in an extended manner on the other facades.

In the middle of the building, there is a central courtyard onto which some of the building’s internal spaces open. The main entrance is on the northern facade, and this is followed by an entrance hall which appears relatively small, as it is only one floor high. Immediately after this, there are four relatively large elevators and a large medial ladder, which offers a panoramic view of the central courtyard, while at the end of the building, on its southern facade, there is a relatively large terraced hall with a capacity of about 200 people that covers two floors [5].
Figure 1 The location of the building. [6]

Figure 2 The main facade and its relationship to the urban historic context. [6]

Figure 3 Eastern Facade. [6]

Figure 4 Western Facade. [6]
Figure 5 The northern façade, showing the main entrance to the building. [6]

Figure 6 Southern facade. [6]

Figure 7 Dark interior spaces at the entrance and the corridors parallel to the east and west facades, showing the entrance area and all the spaces in front of the elevators and stairs. [6]

Figure 8 One of the two long corridors parallel to the western and eastern facades. Their southern windows can be opened for building ventilation in conjunction with the newly created air intakes. [6]

Figure 9 Stair area. The propose design would remove the roof of the arched section along the stairwell to improve ventilation and lighting. [6]
Figure 10. The central courtyard, as seen from the inside on January 28, 2015, showing direct sunlight for the sixth, fifth and fourth floors, and lighting for the rest of the floors. [6]

Figure 11. The great hall overlooking the southern (length) and eastern (width) facades. Illumination enters from the southern window openings due to the lack of sun blockers; the natural lighting is generally good. [6]

6. The knowledge framework for the study:
In the authors’ previous research (Environmental Design between heritage and contemporary), a general knowledge framework that can be used to demonstrate a building’s environmental design efficiency was developed. This is based on the compatibility of thermal comfort and sustainability elements inside a single system of work to achieve comprehensive human comfort, psychologically and physically by offering design solutions that apply appropriate available technology. [7]

Figure (12). Climate and sustainability and their relationship to climate design for the purposes of human comfort. [7]
7. Identifying Problems:
By studying the reality of the building’s condition, based on a field study of the building, several problems, both related and unrelated, emerge that must be solved. These problems related to the thermal comfort of the building occupants can be placed differentiate as follows:

7.1 Radiation
The basic concept regarding radiation is the development of shading from solar radiation while retaining adequate lighting. In this building, three facades (western, eastern, and southern) are exposed to direct solar radiation. The western facade is not generally in use at peak times, but its exposure to sunlight may affect the equipment inside the laboratories due to thermal gain. There is also a clear problem with the lighting, especially in the area in front of the elevators on all floors and in the main entrance. The main problems can be summarised as follows:

- Although the shape of the building is rectangular, but was projected onto the site such that its broadest facades are exposed to thermal radiation for most of the day. This is the opposite of the ideal state.
- No sun blockers have been used on the east, west, or even southern facades, though the windows are recessed to the inner edge. There are also no plants to reduce direct solar radiation, and the designer did not try to take advantage of the outer shell provided by the iron structure (capon), to create architectural decorations to reduce direct sunlight, despite tilting the glass.
- The natural lighting in the entrance area and the lobby in front of the main elevators is insufficient due to the large mass of the elevators and stairs which prevents the effective lighting of those spaces. The rooms on the northern facade have no view of the outside.

7.2 Wind
The basic concept regarding wind is to achieve ventilation by harnessing the wind inside and outside of buildings. In this building, the northern and western facades are semi-closed, with mainly internal spaces; developing natural air movement may thus be difficult, as a pressure vacuum may not be available despite the presence of a central courtyard. As a result, the main two problems are

- Closure of the ventilation outlets that act as a central patio. This makes the northern and western facades, through which it might otherwise be possible to capture the prevailing wind, completely closed in by interior spaces, with no space for the purposes of lighting or ventilation. This in turn reduces the possibility of natural ventilation for the building. In addition, further dysfunction is created by the length of the corridors, which stretch for as much as 40 meters without a gathering place or a central resting area, or even any areas to accommodate students as they leave the halls. There is also an absence of green vegetation around the building to soften the atmosphere.
- The location of the Health Services Unit W.C. on the western side is not suitable, because the prevailing north-western winds may transfer unpleasant odours into the building.

7.3 Temperature
The building has four free fronts, leading to increased thermal gain, especially in the three facades directly exposed to solar radiation throughout the day. The building has a central courtyard to try to improve the atmosphere, yet the main problem is the failure to drop the building on the site properly, which caused the two main functional facades (eastern and western), which are the longest, to be exposed to the largest heat load. This is the opposite of the preferred orientation, and it has increased heat gain to the maximum extent.
7.4 Humidity
The absence of vegetation around the building represents a problem in that it may reduce the humidity levels in the building.

Figure 13 The angle of inclination of the four facades of the building, relative to north. [8]
The roof plan showing the insufficient area of the central courtyard for a building consisting of seven floors, in addition to the extension of the building’s wide facades towards the east and west, in contrast to the expected extension towards the south and north.

Figure 14 Identifying the main environmental problems in the building as projected onto the plans of the building in the form of numbered zones to match the problem and solution tables. [8]
Figure 15 Study of the possibility of incorporating tilting glass in the building. [9]

Figure 16 The angles of inclination of the facades of the building. [10]
8. Design proposals

After identifying the existing problems in the building’s condition, possible solutions were developed to address these problems, based on previous studies. The resulting list of recommendations examines several elements of the atmosphere, with bonds viewed as a single system within the context of sustainability, and appropriate technology to provide human comfort recommended for the Computer Engineering building at the University of Technology, taking into account the need for the solutions to be as generally applicable as possible.

8.1 Recommendations for shading around building facades

The use of sun blockers requires building metal or concrete sun blocks, which is especially important for the southern and western facades, using Dr Al-Jawadi’s sun blocker dimension guide (as shown in the attached figures). The design proposal uses composite sun blockers due to the fact that the four facades of the building deviate at an angle of approximately 22 degrees from geographic north, as shown in the relevant figures, offering an efficiency ratio of 75% in summer, spring and autumn seasons only. These are designed to prevent direct radiation during the peak high temperatures while allowing some radiation to enter in winter, especially on the eastern and southern facades [10], with increases in exposure after four o'clock in the afternoon to preserve appliances and interior furniture from temperature differences. In the attempt to take values close to reality, and to cover most, though not all hours of work, the following results emerged:

8.1.1 The eastern facade:

requires the glass to be tilted inward. The planting of eucalyptus trees [11], which reach a height of 30 metres, is also recommended for the purposes of shade and visual isolation from multi-storey car garage building. The arches should be wrapped in bricks instead of capon to develop unity of the modern architectural context with the old.

8.1.2 The western facade:

Based on existing tables and current calculations, the best design of a composite sun blocker, offering an efficiency of 75%, 1.72 meters in width, operating until 4 pm (based on the date of June 22). As the
window glass is placed on the inner edge (with up to 0.22 m recession), the mask of shadows must be about 1.5 m to obscure the rays of the sun during the summer. However, within the peak building working hours, a compound valve with a width of 0.62 would allow the capon casing to be employed for this purpose. In general, to increase thermal efficiency and preserve the interior furniture, a mask consisting of an iron, brick-coated structure placed 2 meters away from the facade with openings (from which the background of the original packing of the building would protrude), that fits with the facade of the old applied science building adjacent to that facade is recommended to develop the unity of the architectural urban context as well as to mitigate the contradiction between the old and the modern buildings. To maintain the current facade condition, eucalyptus trees could be planted instead, but this would require consideration of the fact that their roots may extend down beyond the foundations of the building.

8.1.3 The southern facade:
replacing the capon panels with arches along the openings with a concrete structure coated with bricks selected to match the architectural context that protrude one meter above all openings would meet the recommendations of the attached blocking calculation tables.

8.1.4 The northern facade:
to retain this as is with reference to the changes in the ground and first floors, the capon arch should be replaced with a brick wrapping arch suitable to the architectural context, as per the attached tables.

- Many more trees with growth of up to 20 metres, such as eucalyptus, are recommended.

8.1.5 General Recommendations to treat problems related to radiation:
- It would be best to tilt the eastern facade glass at an angle of 20 to 30 degrees inward to improve the thermal performance there, as shown in the protractor in the figure
- Creation of a courtyard (or a garage) at the entrance would improve lighting and ventilation.
- Cancelling the two terminal elevators and replacing them with window openings in the central courtyard would improve the general level of lighting.
- Opening the arched part of the stairwell to all floors for lighting and ventilation is recommended.
- Converting the rooms surrounding the central courtyard from south to far south to light sources for the interior corridors would support the creation of vitality inside the building and around the skylight.
- The use of double glazing on the ground and first floors of the entrance along with an arched facade would increase the capacity of the entrance hall to provide lighting and ventilation.

8.2 Recommendations to treat wind problems.
A central patio was attempted to create a natural wind flow in the building, but this was not completely successful. The designer placed balconies in the front (north) facade, along the corridors parallel to the western and eastern facades for the purposes of ventilation, which is useful when the windows are open on the southern facade; however, here are difficulties in controlling the balcony and this may cause social problems because it is isolated and may be closed most of the time. The suggested solutions are thus

- The creation of a small courtyard (or skylight) permitting the entrance of air, being open from the ground floor with walls of glass with wide openings for ventilation that rise to the roof and are cut off in an inclined shape. High walls are towards the east and south can focus and withstand the prevailing northwest winds, attracting ventilation to the interior of the building. This should not be covered, and thus rainwater drainage on the ground floor is required. This should attract gentle winds, as well as offering the possibility of treating its walls with materials with high thermal storage, and it should be equipped with openings for each floor. The use of gargoyles may be appropriate, to create pressure differentials between the perimeter of the building and the central courtyard to encourage movement of winds internally.
• Wind movement inside the building between the newly created spacious Muqaf and the central courtyard can be encouraged by opening the (southern) windows during the day.
• The use of double glazing on the ground and first floors of the entrance, and an arched facade would increase the capacity of the entrance hall for lighting and ventilation.
• The sanitary unit should be moved to the end of the western facade, in order to reduce unwanted odours.

8.3 Recommendations to treat temperature problems.
• The problems caused by the incorrect dropping of the building cannot be remedied.
• The designer tried to use thermostone and architectural cover in light colours (capon panels), in addition to relatively small openings; this is relatively ineffective.
• The use of double glazing for the openings in general, and on the ground and first floors (for the entrance) in particular, along with an arched facade would increase the capacity of the entrance hall with regard to lighting and ventilation of the first two floors.
• The use of glass inclined inward at an angle of 20 to 30 degrees on the eastern facade with the plantation of eucalyptus trees for shade should cool that side.
• Activating the movement of winds inside the building by encouraging differentials between the newly created spacious Muqaf and the central courtyard should moderate the heat, and opening the (southern) windows during the day at the end of the long corridors parallel to the eastern and western facades should also increase air flow and thus reduce heat.
• The use of sun blockers and shade masks on the southern and western facades, as explained in the previous paragraphs, should reduce direct solar heating.

8.4 Recommendations to treat humidity problems.
Planting perennial trees is strongly recommended. The height of the trees should be 20 or 30 metres in order to achieve air tempering with increased humidity, as well as blocking direct sunlight where possible. This raises issues of the importance of studying the selection of trees and the quality and method of cultivation so that such planting does not affect the foundations of the building, however.
Figure 18 Clear treatments on the ground floor. [6]

Figure 19 Clear treatments on the first floor. [6]
**Figure 20** North facade. [6]

**Figure 21** East facade. [6]
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