Mathematical evaluation of measuring heat transfer through buildings (case study: a stone and glass facades in two public buildings in Jordan)

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Thermal resistance of building materials is considered of great importance nowadays. The growing concern for environmental pollution as a result of energy consumption has raised the importance of thermal resistance in many parts of the World and Jordan is among them. Jordan buildings' used to be constructed from masonry in the past with thickness of about 0.5 meter to reach sometimes 1.0 meter. During the last century builders continued to use the stone as a main building
material but reduced the thickness to 0.06 to 0.08 meter as a facing material only. This type of construction is named cladding system. Since 1980 and especially during 1990s the concern of architects in Jordan is shifting towards the glass, despite the wide existence of stone material in different parts of Jordan. Glazing material has a nice and beautiful appearance and even a large amount of people see it better than the stone, but its thermal insulation is weak, as noticed in this paper. Many problems started to appear in those glass faced buildings due to the climatic conditions of Jordan and the large amount of energy needed in the summer for cooling and in winter for heating.This study is examining two different internal environments inside two buildings. The first building is constructed using stone facing material and the second is constructed using glass in elevations. The temperature of both environments is measured during a whole year. The heat transfer is calculated mathematically for both environments and a number of conclusions are reached stressing on the importance of the use of the stone facing material in walls instead of large areas of glass.

يعتبر العزل الحراري وخواص الحوائط وموادها من أهم العوامل المؤثرة في المحافظة على البيئة. قديما كانت المباني في الأردن تبنى من مادة الحجر بأسماك مختلفة قد تصل الى المتر أحيانا. ولكن مع التطور الزمني أصبحت مادة الحجر عبارة عن أسلوب للتكسية الخارجية فقط بسمك لا تتجاوز ٨ سنتيمترات نتيجة لارتفاع سعر الحجر وللوقت الطويل الذي يستغرقه للبناء بالطريقة التقليدية. منذ أوائل الثمانينات من القرن العشرين وخاصة في التسعينيات أخذت المباني العامة في الأردن طابعا معماريا جديدا باستعمال مادة الزجاج بشكل كبير. تهدف هذه الدراسة الى عمل مقارنة بين مبنيين أحدهما استعمل مادة الحجر والأخر استعمل الزجاج في الواجهات الخارجية وتشمل المقارنة دراسة البيئتين الداخليتين للمبنيين. توصى الدراسة بضرورة الرجوع الى استخدام مادة الحجر في التكسية الخارجية للمباني العامة والتقليل من المساحة الزجاجية الخارجية وخاصة في المناطق ذات الحرارة المرتفعة نسبيا مثل الأردن. هذا ويمكن تطبيق مبدأ هذه الدراسة على مناطق وأقاليم أخرى مختلفة.

Keywords: Insulation, Stone, Glass, Heat transfer, Internal/ External Environment, Measurment.

1. Introduction

Natural stone has been the principal material in the past for most buildings in the World and Jordan is among them [1]. Jordan continued using stone in the 20th century due to its availability but in a different method of construction. Stone in Jordan is widely used in modern time as a cladding system of a thickness of not more than 0.06 to 0.08 meter due to its high cost. The thickness of the old walls of buildings used to reach one meter [2]. As Cowan and Smith mentioned stone is now invariably fixed to concrete after casting [3]. Stone cladding has many advantages and disadvantages as any other building material. Among the advantages, its durability under different environmental effects and conditions [4]. Table 1 illustrates various kinds of stones in Jordan and shows their durability as a building material. Jordanian stone durability varies from excellent to medium according to its type.

Table 1
Some types of stones in Jordan and their properties

Type	Colour	Change in colour	Defects	Absorption of water	Hardness	Availability	Durability
Maan stone	White with darkness	Retains color	Vents and holes	Poor	Moderate hard	Very abundant	Good
Jammeen stone	Crystal white	Retains color	Vents	Poor	Very hard	Very abundant	Excellent
Ajlun stone	white	Retains Color	Vents	Poor	Moderate hard	Rare	Excellent
Kabatieh stone	Pure White	Changes to yellow with rain	Very Absorbent	High	Moderate hard	Very abundant	Medium
Al-Al stone	White	Changes to light yellow with rain	Very Absorbent	High	Rather hard	Rare	Medium
Al-Azrak stone	White	Changes to yellow with rain	Absorb water	High	Soft stone	Very abundant	Poor
Yattah stone	Beige	Retains color	Vents	Poor	Very hard	Rare	Excellent
Taybeh stone	White	Retains color	Vents	Poor	Moderate hard	Rare	Excellent
Asera stone	White	Retains color	Vents	Poor	Hard	Rare	Excellent
Kaw stone	White	Retains color	Vents	Poor	Hard	Abundant	Excellent
AlManfiy stone	White	Retains color	Vents	Moderate	Hard	Abundant	Excellent
Muwgar stone	White	Change to beige with rain	Absorbs Water	High	Soft stone	Abundant	Medium
Irbid stone	White	Change to beige with rain	Absorbs Water	High	Soft stone	Abundant	Medium
Wadi butm stone	White	Retains color	Vents	Moderate	Moderate hard	Abundant	Excellent

Source: collected from different resources listed in references.

The occurrence of stone in Jordan is wide, but the cost of using it as building material is relatively high due to high cost of cutting, dressing and polishing stone in general [5]. The availability of stone in Jordan depends on its type. Some types are very abundant and some others are rare. Jordanian stone colour is usually white, but some types are beige. Their natural colour might change in some types to yellow due to rain absorption. It's hardness varies from very hard to soft according to type [6]. Stone is strong in compression, but weak in tension. There are three types of stones in general: 1. Ingneous stone 2. Sedimentary stone, 3. Metamorphic stone [7]. The second type is the most available one in Jordan. It is classified into two categories: Sandstone and Limestone. Sandstone consists of several types: siliceous sandstone, calcareous sandstone, magnesium sandstone, ferruginous sandstone and gritstones. Sandstone consists of fine particles of quartz with felspar or mica bound together with natural cement. Limestone consists of calcium carbonate in the form of calcite, which was formed by the deposit of solids in seas or lakes or by its deposit from solution. Limestone consists of three categories: Oolitically stones formed by the deposit of concentric layers of calcite above fragments of sand which is cemented together by calcite. Organically stones formed from accumulation of shells and other animal and plant remains. Crystallization solution formed by evaporation of water around geysers [8]. In Jordan the calcareous sandstone and the limestone exist and used for construction. The appearance of stone is good but is subject to deterioration due to several factors among them: The atmospheric pollution especially formed from Sulphur dioxide caused from burning oil. Sulphurous acid, which when dissolved in rainwater, reacts with carbonates in limestone and calcareous sandstone thus causing damage to stone. Forest damage due to the expansion from occuring frozen water during the winter. The soluble salt action derived from soil exerts expansive force after they crystallization and causes decay. Limestone is soluble in rain and dissolve away. Corrosion of metals due to zinc salts released by galvanization causes stone decay. Some vegetation types cause decay to stone such as fungi. Expansion and contracting caused by rainwater when it penetrates in depth and then dries out [9]. The industrial applications of limestone depend on its physical and mechanical properties and less on its chemical composition. Limestone is the most important of the industrial rocks [10]. Its product range from crushed aggregate to pure limestone used as filler. It is also used in the production of Portland cement, food industry, glass making and of course as construction stone [11].

2. Research methodology

The research method used in this study involves a comparison between two types of walls of buildings at the same conditions. The first type is constructed using stone facing and the second using mainly single glass. The thermal transmittance, "*U*" value, is calculated according to certain equation in both cases depending on universal thermal conductivity of materials shown in table 2 which also summarizes the required materials used in the study and calculates the assumed thickness of each of them.

Many constant values and assumptions are used in both cases to achieve a comparison study. The surface area calculated for heat transfer is the same for both cases. The outside and inside climatic conditions of wind velocity at 15 kilometer per hour and moisture are the same. The same materials of floors and roofs are used. The only difference is the type of wall construction and thickness. "*U*" value is the heat in watts that will be transferred through one square meter of a construction where there is a difference of one degree celsus between the temperature of the air on opposite sides. The "*U*" value is the inverse of its insulating value resistance $U = 1/R$. The higher the "*U*" value the lower the insulation of a material [12].

Two buildings are selected the first, whose outer walls are constructed from stone is the Jordanian Islamic Bank, and the second building is the Mutahide Company, whose outer walls are constructed from glass. Both buildings have similar conditions in terms of climate, location, height, size, width, volume and construction of floors and roofs, as will be seen later in field investigation. In the first building an empty room is selected for the study during the year 2003. For the second building the whole building is vacant since 2001. The heat transfer through the building construction is different from one month to another depending on climatic conditions of temperature, humidity, wind velocity and other climatic factors. These variables are assumed to be fixed for both cases except for temperature, which this study will investigate. The temperatures are measured at different days and months of the year starting from January of 2003 until end of December of 2003 without using any mechanical instrument either for cooling or heating inside the two buildings. The readings are measured three times in the day and the average is represented in table 3.

Table 2
The different types of materials used in constructing walls in Jordan where K is the thermal conductivity R is the thermal resistance. All the numbers are based on the American society of heating, refrigerating and air-conditioning engineers handbook of fundamentals 1967after transforming it into metric units

Material	Thickness	"K" value in w/mdegc	"R" value in m^2c/w
Stone	0.05 meters	12.5	0.625
Concrete	0.15 meters	12.0	0.50
Polystyrene	0.025 meters	0.28	3.57
Concrete blocks	0.10 meters	9.60	1.40
Plaster	0.025 meters	5.0	0.20
Single glass	0.025 meters	1.13	0.17
Double glazing	0.025 meters	0.65	0.35
Outside air	Not applicable	6.0	0.16
Inside air	Not applicable	1.65	0.60

Table 3
The field investigation of average temperatures outside and inside the two environments. The minus value means the environment needs heating and the plus value means that the environment needs cooling

	Outside temp. (A)	Inside temp. envi. 1 (B)	Inside temp. envi. 2 (C)	Difference between A and B	Difference between A and C	Difference between B and comfort Temp.	Difference between C and comfort temp.
January	11	15	12	-4	-1	-6	-9
February	12	16	13	-4	-1	-5	-8
March	20	21	18	-1	-2	0	-3
April	26	23	25	+3	+1	+2	+4
May	31	24	29	+5	+2	+3	+8
June	32	26	32	+6	0	+5	+11
July	34	28	34	+6	0	+7	+13
August	35	28	34	+7	+1	+7	+13
September	30	25	29	+5	+1	+4	+8
October	22	19	21	+3	+1	-2	0
November	15	16	17	-1	-1	-5	-4
December	12	15	13	-3	-1	-6	-8

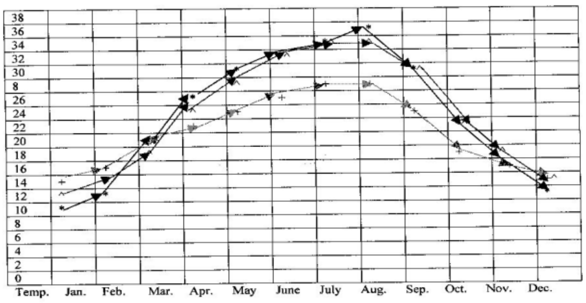

Fig. 1. Diagram demonstrates table 3 into simple lines, where the dark line (*) represents outside temperature (A), the light line (+) represents inside temperature of environment 1 (B) and the medium line (^) represents inside temperature inside environment 2 (C).

The analysis of data is grouped according to the type of wall construction. The difference between the temperature in each environment and the outside temperature is also calculated and represented by lines as in fig. 1 assuming a comfort temperature of 21°C. The difference between each environment and the comfort temperature of 21 degrees celsus is also calculated and presented in fig. 1.

Finally the heat transfer between each environment and outside is calculated and presented in table 4. Fig. 2 draws the lines of heat transfer for both environments from table 4 in a simplified way.

Table 4
Heat transfer between outside air temperature and environments 1 and 2 where the inside room temperature is calculated at 21°C and the outside wind velocity assumed at 15 kilometers per hour. The minus value means that the space requires heating, while the plus value means that the space requires cooling. The unit for this table is kw

	Environment 1	Environment 2	Difference between environments 1 & 2
January	-80.52	-143.10	62.58
February	-67.10	-127.20	60.10
March	0.0	-47.70	47.70
April	+26.84	+63.60	36.76
May	+40.26	+127.20	86.94
June	+67.10	+174.90	107.80
July	+93.94	+206.70	112.76
August	+93.94	+206.70	112.76
September	+53.68	+127.20	73.52
October	-26.84	0.0	26.84
November	-67.10	-63.60	3.50
December	-80.52	-127.20	46.68

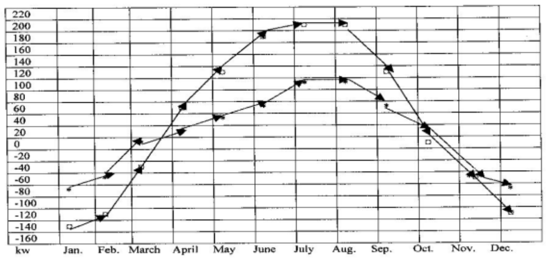

Fig. 2. Diagram shows the difference of heat transfer between environment 1 and 2 where the light line (*) represents environment 1 and the drak line (*) represents environment 2. Fig. 2 is a representation of table 4.

3. Stone construction properties

The cost of using stone as building material for constructing walls is relatively high because of great care taken during quarrying and construction. Only a skilled labor can extract it from quarry, also cut, dress and polish it, and a skilled builder can build it. There is also a great deal of waste and several special stone shapes are used between windows for example or at corners or above doors and windows and other part of the building according to the architect design and details [13]. The natural stones usually retain their good appearance according to its type as seen in table 1. Stones have a special property of being not exactly identical in appearance, even if they are cut from one quarry and this add visual interest for users [14]. The surface smoothness of stone determines the amount of light reflected. There are many surface shapes used in Jordan such as rough picked, fair picked, axed, sawn, and ribbed and others [15]. Limestone used in Jordan varies widely in hardness, but generally they are less hard and easier to work than sandstone. Many limestone types are suitable for carving and making different shapes and some are soft enough to cut by hand [16]. To maintain good appearance and minimize decay stones should be cleaned regularly and defective joints should be raked out. Limestone is freely washed by rain thus the required period of cleaning might take up to ten years depending on the amount of air pollution. Stones can be cleaned by mechanical means of brushing or by hydrofluoric acid [17]. Decay of stones that might occur is usually slow [18]. Some stones have vents in their outer surface according to their durability as shown in table 1. Thermal conductivity of stone "*k*", meaning the rate of heat transfer through the material is relatively high. It is equal to 12.5 w/mdegc, where w: watts, m: unit thickness, degc: unit temperature difference between faces. If this value is compared to other materials we'll find that "*k*" value of concrete of thickness 0.10 meter is equal to 0.4 w/mdegc, cement mortar of thickness 0.0125 meter results in "*k*" value equal to 5.0 w/mdegc [19], as shown in table 2. The "*k*" value of materials varies from 0.029 to 3725 w/mdegc. Thermal conductivity will help us in calculating the resistance of the material "*R*" and the "*U*" value [20].

4. Climate of the selected study environments

The selected study environments are located at the capital of Jordan, Amman, where the climate of the Mediterranean Sea approximately prevails. There are mainly two seasons: winter and summer. Amman is located north of Jordan and adjacent to the desert. During winter, temperature varies from 5 degrees celsus during night to 8 or 10 degrees celsus during day, and in some times a drop to zero degrees celsus occurs. During summer the degrees varies from 20 degrees celsus during night to as high as 35 degrees celsus during day, and in some cases it reaches 38 degrees celsus but for a few days only [21]. The difference of temperatures between day and night and summer and winter raises the question of what type of material to adopt in wall construction that has good thermal resistance "R" value. The typical section for a wall used in most private and public buildings is shown in figure3. The total thickness of wall is usually 0.35 meter [22]. The stone facing thickness is from 0.04 to 0.05 meter. It is followed by concrete of 0.15 meter. Then by insulation material such as polystyrene or gypsum boards of 0.025 meter, followed by concrete blocks of 0.10 meter. Finally it is followed by plaster of 0.025 meter or [23]. On the contrary the glass facing building section is constructed mainly from a single or double glazing panels supported between floors and roofs slabs as shown in fig. 4.

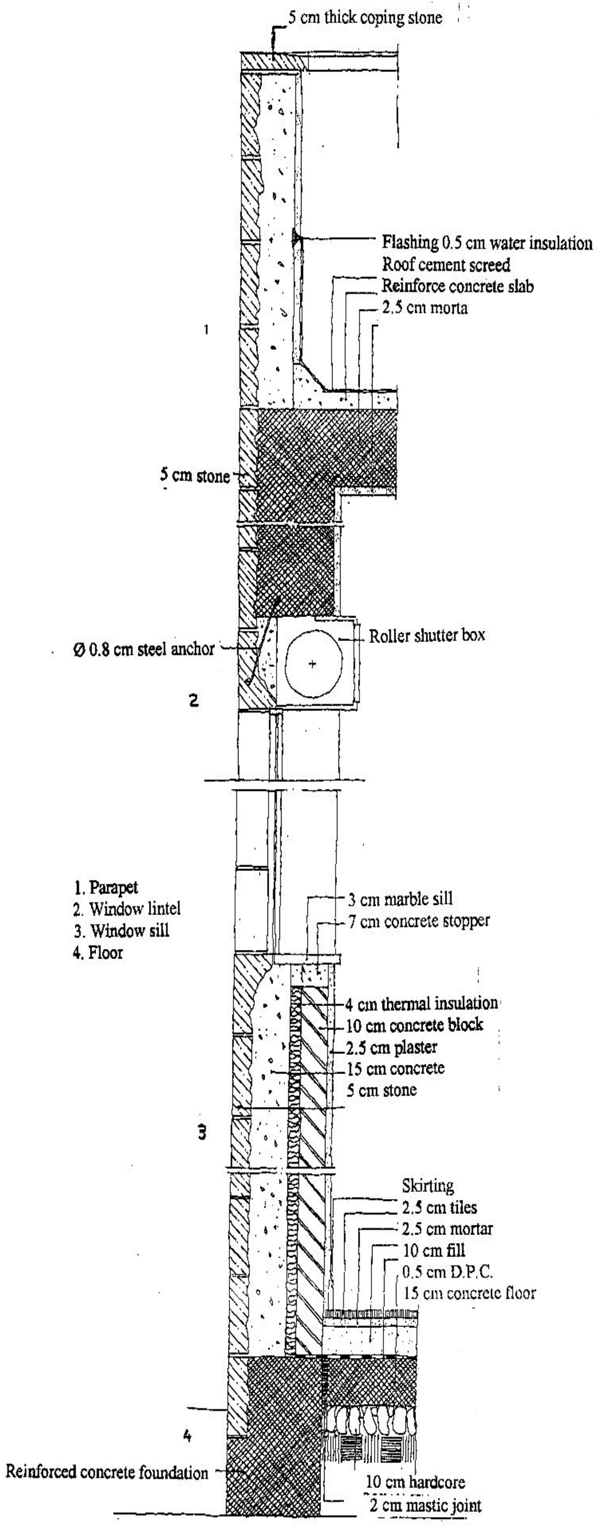

Fig. 3. typical section through a stone facing wall in Jordan approx. scale: 1:200 source: author 2004.

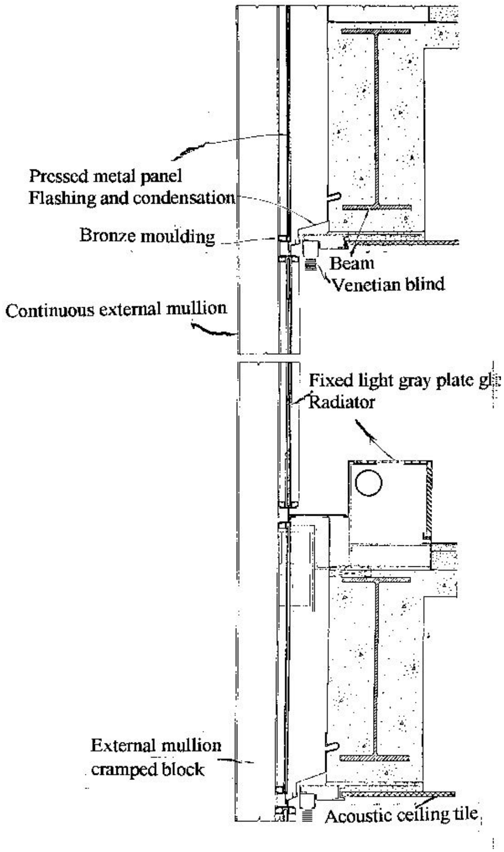

Fig. 4. Typical section through a glass facing building in general source: best of architects' working details, 1982 approx. scale: 1:200.

5. Field investigation

Two case studies or environments are examined. The first is the Jordanian Islamic Bank. It is a stone building located in Jabal Al-Hussien district in Amman. It was completed in 1996. This post modern building has a typical section where the thickness of stone facing measures 0.04 meter. The building consists of nine storeys and three basements for car parking and maintenance fig. 5. As mentioned before an empty room is used for measuring temperatures which is not heated or cooled. The second environment is the Mutahide Company, which is a commercial building, having a marble stone base and a tower of glass above. It is located in Al-Shmisani district in Amman and was completed in 1980. It is considered one of the first glass facing buildings in Amman, fig. 6.

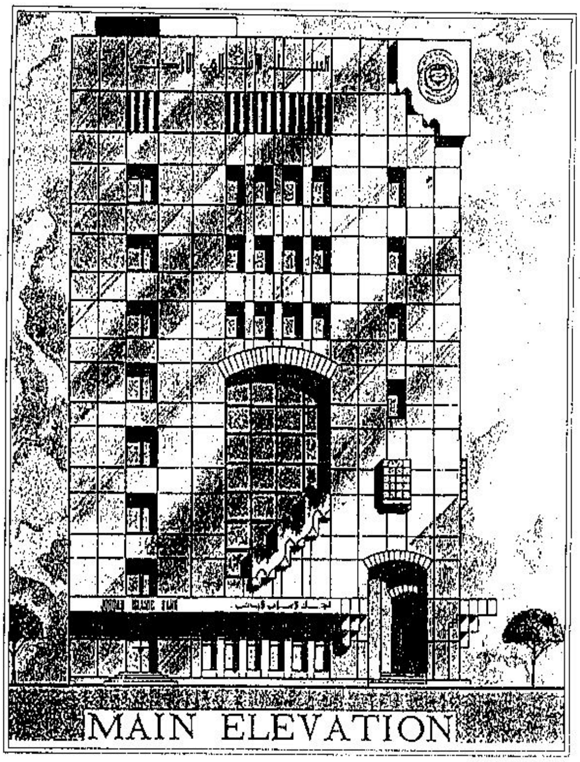

Fig. 5. Elevation of Jordanian islamic bank, environment one source: bitar association, 2001. approx. scale: 1:250.

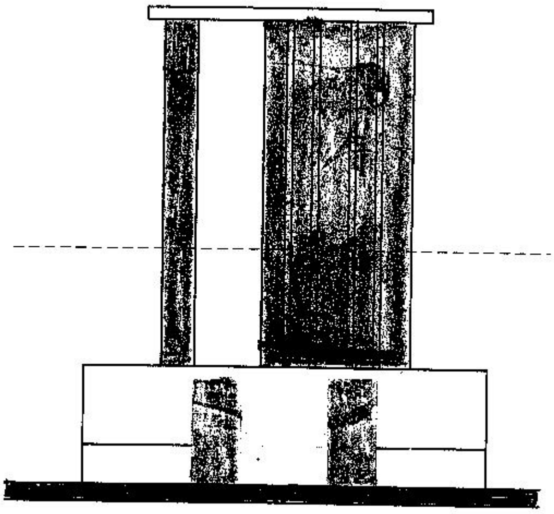

Fig. 6. Elevation of mutahide company source: author, 2004. Approx. scale: 1:400.

This building was vacant throughout the whole study during 2003. Its typical section is similar to universal sections as clarified in fig. 2. It has a 0.006 meter fixed light gray plate glass. It is consisted from nine floors and two basements. Both buildings have almost the same height of about 27 meters, square plan of a width of about 15 meters and the same floor and roof construction materials. They lie almost 3 kilometers apart, thus result in the same climatic conditions which facilitates the field study comparison. A measurement of temperature throughout the year starting from January 2003 until December 2003 for both buildings are taken at three times in the day and then a summary of one day is calculated. An average for the whole month is shown in table 3. The field investigation emphasis the difference of the internal temperatures between environments one and two. The first building which used a stone facing cladding system has a difference between inside and outside temperatures larger than the other building which used the glass element only. This means the thermal insulation resistance of the first environment is higher than the second environment. During months of March, April and October the difference between temperature of the internal building one and the comfort temperature of 21 degrees celsus is minimal and almost a comfort zone is achieved in. Contrary to the second building where the difference of temperature between the inside environment and the comfort temperature is minimal only during the month of March as seen in table 3. During other months of the year especially January, February, July, August and December the difference between the inside temperature of environment two and the comfort temperature increases to reach thirteen degrees celsus. The maximum temperature difference between environment one and comfort temperature is during July and August where it reaches seven degrees celsus as shown in table 3. Table 3 demonstrates the difference in temperature between the two environments and the comfort temperature which varies in environment one from minus six to plus seven, almost 13 degrees celsus, while in environment two the variation is from minus nine to plus thirteen, almost 21 degrees celsus. The minus value means that the environment needs heating and the plus value means that environment needs cooling. The heating and cooling amounts needed must be compared to the human comfort degree of 21 celsus as shown in table 3. Table 3 shows also the difference in temperature between outside temperature and inside temperature for both environments. The difference is higher in environment one, where it reaches seven degrees celsus, while in environment two the difference is only two degrees celsus. This emphasis the good quality of thermal insulation resistance in environment one. The higher the value of temperature difference during summer and winter the more the efficiency of wall is.

6. Mathematical calculations

Using tables 2 and 3 and the general equation for calculating heat transfer gives the result in table 4 results. The values in table 4 are calculated using the following equations:

$$Q=kAdt/dx. \quad (1)$$

$$Q=kAt_2\text{-}t_1/\Delta X . \quad (2)$$

Applying $R=\Delta X/kA$. (3)

$$Q\Delta t/R . \quad (4)$$

$$R=1/U. \quad (5)$$

$$Q=AU\Delta t . \quad (6)$$

Where *Q*: heat transfer through the building construction. *R*: resistance. ΔX: thickness of wall material. *A*: surface area of heat transfer. *U*: overall coefficient of heat transfer. *k*: or λ (lambda) thermal conductivity. Δt: differnce of temperature. Δ: difference. ΔX the difference in wall thickness, Δt the difference of outside and inside temperatures. Taking one example to calculate «*Q*» for July for the first building:

R (of stone wall) = *R* (outside) + *R* (stone) + *R* (concrete) + *R* (polystyrene) + *R* (concrete blocks) + *R* (plaster) + *R* (inside).
R (of stone wall) = 0.166 + 0.625 + 0.5 + 3.57 + 1.4+ 0.2 + 0.60 = 7.961 m^2c/w (from table 2)
U= 0.14

Assuming the area of a typical floor façade to be 3 meters in height from floor to ceiling and 5 meters long, with a window of 1 by 2 meters:
$AU= A1U2 + A2U2$ (where *A*1 is the area of solid wall and *A*2 is the area of the window)
AU= (15-2) 0.14 + 2(5.8) = 13.42
Q (July) = 13.42 x 7 (the difference between outside temperature and the comfort degree of 21 celsus taken from table 3) = 93.94 kw.

Taking another example to calculate «*Q*» for July for the environemnt two:
R (of glass wall) = *R* (outside) + *R* (single glass) + *R* (indoor).
R = 0.166 + 0.17 + 0.6 = 0.936 m^2c/w
(from table 2)
U= 1.06

Assuming the area of a typical floor façade to be 3 meters in high from floor to ceiling by 5 meters long, and the same conditions for the first environment,
Q (July) = 1.06 x 15 x 13 (the difference between outside temperature and the comfort degree of 21 celsus taken from table 3) = 206.70 kw.

If the heat transfer for the two environments is compared, it can be seen that there is a large difference of about 112.76 kw during July in favor of the environment one. Table 4 shows the above-mentioned calculations for each month for each environment for the whole year. The maximum difference of 112.76 kw. Between the two environments resulted during the summer, in July and August months, while the minimum difference is during October, only 12.6 kw. This is in line with the previous temperature measurement of table 3, where the difference in temperature between outside environment two and comfort temperature is maximum, thirteen degrees during months of July and August, and the minimum temperature difference between outside environment two and the comfort degree is zero during October.

7. Results

Field measurements of temperatures carried out during the year of 2003 which are shown in table 3 and the calculation of heat transfer shown in table 4 express the large amount of heat transfer in environment two.

The difference between the two environments is large and varies from 112.76 kw during July and August to 3.5 kw. During November. This result in a large consumption of fuel used for both heating and cooling this environment in addition to environmental pollution. The climatic conditions of Amman raise the question of applying the glass material in construction of walls. In order to improve this situation the use of double glazing windows and reflective double glazing windows might soften the situation but will not solve it. As seen in table 2 the resistance of double-glazing is 0.35 m^2c/w, twice the resistance of the single glazing. If we apply equations number 5 and 6, the heat transfer for the same environment two during July will become 174.70 kw. Instead of 206.70 kw, much larger than the heat transfer for environment one, which is 93.94 kw. This might improve the situation but still the solution is not achieved. The incorporation of the traditional urban design element of the past in a modern way such as the use of courtyard, which was a distinctive feature of the middle east ancient architecture successively adopting to the climate conditions, might be one of the solutions. Courtyard performed an important function as a modifier of the climate in hot arid areas [24]. Courtyards function as light-wells and as air-wells into which the cooler and denser night air sinks. They act as ventilator systems for buildings. When sun heats the air, the air rises and convection currents set up airflow that ventilates the buildings [25]. The modern use of courtyards may help in overcoming the high heat transfer of new materials. The National commercial bank at jeddah, designed by skidmore, owings and merrill at the beginning of 1980s is a good example of using modern design using a courtyard concept to overcome the climatic conditions in a high rise building. Instead of individual windows in the tower's outer walls, three landscaped openings at different levels were planned. The traditional function of the courtyard has been re-interpreted in relatively high-rise commercial building to provide for both natural light and ventilation with protection from glare and reduction of heat transfer [26]. The modern use of wooden lattice screen of traditional houses in the middle east (Mashrabiyya) used in the past might also improve the thermal insulation of modern buildings [27]. Mashrabiyya's function was associated with the reduction of direct solar radiation and glare and as thermal insulation. It was usually projected from an outside wall above a narrow street [28]. This traditional louver system of the past is used in a modern way in many projects not only in the Middle east but also throughout the world. The Arab Institute Research building located in central paris is the most obvious example. It used a special design for windows with shutters that open automatically according to the required light and heat. In general, when the circulation of air is required in such modern designed buildings the shutters that serve as the mashrabiyya are closed or the openings are minimal and the glazed windows are opened. When the cool air of the outside is required both the glazed windows and the shutters are opened, especially during the hot nights of summer [29]. The improvement of the wall materials heat resistance will help in the reduction of heat transfer. This can be achieved in both previous studied environments. The "*U*" value of the stone constructed and "*R*" value wall can be improved by increasing the thickness of insulation material to 0.05 instead of 0.025 meter. Of course the thickness of wall will increase to 0.40 meter and the cost will increase. But over a long period of time the benefit will be better and the return value of the reduction in fuel bill will compensate and even the cost will become much less after few years. If we calculate the heat transfer for environment one during July using twice the thickness of insulation material, using equations 5 and 6, the "*Q*" value will be reduced to 89.0 kw instead of 93.94 kw. Many architects discussed the importance of using insulation material in wall buildings in the middle east among them Danby, 1963, who emphasized the traditional buildings using thick stone wall as a heavyweight material combined with small openings located at high levels only. This thick stone wall construction provided adequate insulation [30]. For the environment 2, the use of reflective double glazing windows in outer walls to increase thermal resistance and the reduction of the area of glass in favour of the incorporation of insulation material and block concrete behind the double glazing will reduce the heat transfer. A calculation of the heat transfer for environment two during July using double glazing windows with area one third the previous example, assuming the glass height that can be opened, of one meter is tried. By using eqs. 5 and 6, the "*Q*" value will reduce to 124.80 kw instead of174.70 kw. Although the interior look and space of the building will change but at least the exterior will remain the same and a large reduction in heat transfer will result. The legislation of the municipality or the Engineering council should provide regulations for the heat transfer and thermal resistance allowed in buildings. This might take place in future in Jordan. At the present time no such thing exist for the insulation values or materials used in construction buildings. For example the British regulation of 1972 state the maximum value of "*U*" allowed in walls in dwellings to be 1.70 w/m^2c [31]. A similar regulation will reduce environmental pollution and will reduce the fuel bill that is rising each year in Jordan. As mentioned before there are many glass faced buildings are being constructed nowadays in Jordan and the need for such a law is urgent. A further research might examine other newly glass-faced buildings and calculate the cost of heating and cooling needed for them.

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