FEASIBILITY STUDY OF POWER SAVING BASED ON USING EMMEDUE M2 BUILDING SYSTEM

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ABSTRACT

The present work concentrates on the feasibility of the heat load reduction by utilizing some structural material with very poor heat conductivity as isolators for heat transmission. Average annular heating and cooling load is estimated for a typical building of certain area and design using ordinary structural material and EMMEDUE M2 building system. The basic element of the new structural material is made of a foam polystyrene core that is self extinguishing and chemically inert with varying density and thickness depending on panel type. The calculations are based on the average maximum and minimum monthly temperature in Baghdad. Building heating load could mainly depend on the average temperature difference per each daily hour per year, while building cooling load components are; direct solar radiation, transmission load, ventilation/infiltration load and internal load. Except the transmission load which depends on the same average temperature difference the other factors could be calculated separately.A reduction of 55% in the annual load is estimated per each house using the new building technology. For a district sums up 1000 houses of the new structural design the total saving of power will be 10.45 MW. The saving in heating and cooling cost is estimated based on capital cost of the diesel generation system and the fuel consumption cost. It has been concluded that the passive structural heat isolation is a very effective manner in countries like Iraq which has severe temperature differences between the summer and winter seasons.

الخلاصة:

يتركز البحث على مدى عملية تقليل الحمل الحراري بأستخدام مواد بناء ذات توصيل حراري ضعيف كمواد عازلة للأنتقال الحراري. تم تخمين معدل الحمل الحراري والتريد السنوي لبناية نموذجية ذات مساحة وتصميم معين بأستخدم مواد بناء عادية مقارنة بمادة بناء EMMEDUE M2. العنصر الأساسي في مادة البناء الجديدة مكونة من مادة البوليسترين الرغوية ذات قابلية الأطفاء التلقائي وغير الفعالة كيمياويا وبكثافات مختلفة وسمك يعتمد على نوع القطعة.تم بناء الحسابات على معدل القيم العليا والسفلى لدرجات الحرارة الشهرية في مدينة بغداد. يعتمد الحمل

الحراري على معدلات فرق درجات الحرارة اليومية على مدار السنة بينما يعتمد حمل التبريد على: أشعة الشمس المباشرة، الحمل الأنتقالي، حمل التهوية، والحمل الداخلي. بأستثناء الحمل الأنتقالي الذي على نفس معدلات فروقات درجات الحرارة فأن بقية العوامل تحسب بشكل منفصل.
تم تخمين مقدار النقصان في قيمة الحمل السنوي بقيمة مقدارها ٥٥% لكل بناية يتم فيها أستخدام مواد البناء العازلة والمشار اليها في البحث. لحي سكني مكون من ١٠٠٠ بناية مبنية من مادة البناء العازلة يكون مقدار الأدخار في طاقة التدفئة والتبريد ١٠.٤٥ ميكاواط. تم حساب معدل الأدخار في كلفة التدفئة والتبريد بناءا على القيمة الفعالة لمنظومة التوليد وكلفة الوقود المتسخدم لمدة سنة. حيث تم الأستنتاج من البحث أن أستخدام مواد البناء العازلة في دول ذات مناخ قاري يكون ذا جدوى اقتصادية عالية جدا.

KEYWORDS
EMMEDUE M2, Heating & Cooling Load, Feasibility, Annual Load

INTRODUCTION

From the beginning of recorded human history people have sought shelter from wind, rain, and snow either in caves or in buildings which they have built for that purpose. In addition to shelter from the elements the buildings provide an opportunity to control the temperature and humidity of the air inside them. People are most comfortable when the temperature is around 70°F and the humidity is moderate. When the outside air is very cold, a furnace or some kind of a heat source inside the building can heat the inside air. When it is very hot outside, we try to control the flow of heat energy into the building and we may even cool the air with air-conditioning equipment. In either case the choice of building materials plays a critical role in our ability to maintain a comfortable temperature inside. The ground tends to remain cool, so caves, basements....buildings built partially underground tend to be cool in those parts that are underground. Certain types of brick or clay change in temperature slowly and tend to "hold in" the heat. Walls of these materials might heat up during the day - soaking in heat from the sun and from the inside air, and cool down at night - radiating to the cold night sky and also radiating energy to the inside air. Thick walls of brick, clay, or stone often provide a cool daytime shelter and a warm night shelter in hot climates. Thinner walls made of wood planks will not have the same properties. Unless we add other materials to those walls it will usually be difficult to maintain a different temperature inside relative to the outside temperature.
Heat energy flows from hot spaces to cold spaces and the rate at which this energy flow increases as the temperature difference increases. The material which separates the temperature extremes has a certain resistance to energy flow. When the resistance is high, the rate at which energy flows through the material is low; when the resistance is low, high energy flow rates are expected. We insulate walls to lower the rate at which energy flows through the walls. Insulation increases the thermal resistance or "R value" of the wall.

The second important factor which is taken under consideration is the heat capacity of the building materials. Heat capacity is a measure of a material's ability to store heat energy. Metals tend to have low heat capacities. When heat energy flows through a metal, it changes temperature quickly. On the other hand, stone or cement has a much higher heat capacity. When heat energy flow into stone it changes temperature very slowly and tends to "store" the heat energy. Passive solar homes usually include a large mass of stone, rock, or other material with a high heat capacity. This thermal mass will heat up during the day when the sun shines. At night when it is cooler, energy can be drawn from the thermal mass.

ANSARI investigated the effect of building parameters like orientation, windows type wall insulation and roof & floor type on heating and cooling load calculations. ASHREE Handbook is based for all the heating and cooling load calculations.
One of the structural materials which have common use now in the world is the

EMMEDUE M2 Building System.

The IRISH agreement board proved that the EMMEDUE system meets the requirements of the building regulations 1997-2002, as indicated in section 1.2 of their certificate.

DESCRIPTION OF EMMEDUE BUILDING SYSTEM

Fundamentals of the System

The basis of the EMMEDUE construction system is based on a serious of a polystyrene panels and steel wire mesh, whose shape has been especially designed to apply structural plaster during panel installation. The aim is that of providing a system of industrialized modular panels that bodies requiring shorter erection time compared to the conventional systems, permits to copy with structural and load bearing functions, offering in the same time a fast assembling and laying, high thermal and sound coefficient and a wide range of shapes and finishes that may be achieved during the building process.

Composition of the EMMEDUE Panel

The basic element is made of:

1. A foam polystyrene core that is self extinguishing and chemically inert with varying density and thickness depending on panel type, see **Fig. (1)**.
2. Electro welded steel wire mesh made of galvanized drawn steel wires placed on both sides of polystyrene sheet and connected by means of joints of the same material. The wire gauge of the net varies according to panel type and mesh direction.

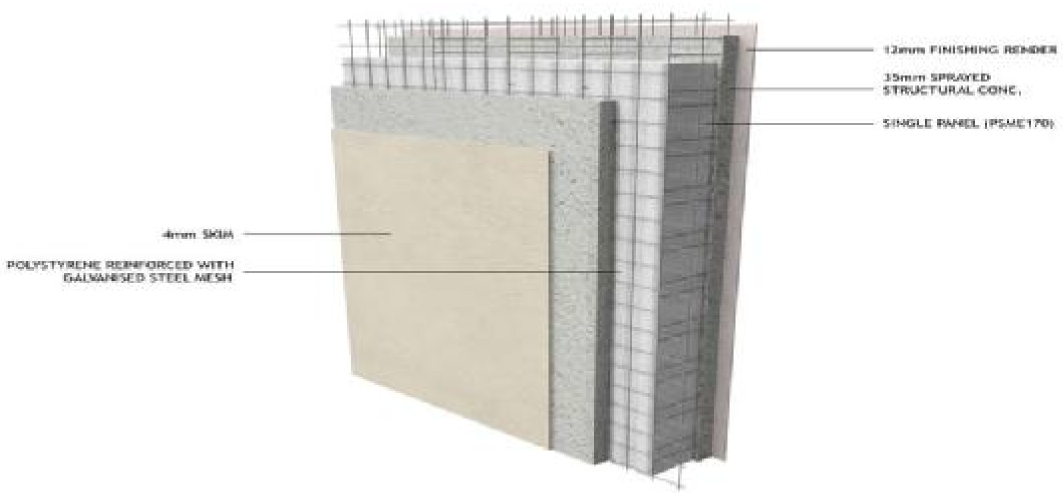

Fig. (1): EMMEDUE single panel Figure

Plastering

After Panel assembly, structural plaster should be sprayed and / or poured on the panel depending on the panel type.

Classification of the EMMEDUE Products

The various types of EMMEDUE panels, their fields of application, standard sizes and complementary EMMEDUE products are described EMMEDUE Me2 Building system catalogue certified by the IRISH AGREEMENT BOARD.

The thickness of the polystyrene sheets as well as the length of the panels may be customized according to different project requirements of customers.

Generally speaking the thickness the panels is usually determined according to its different conditions of heat insulation and required structural behavior. In the later case in fact, a greater moment of inertia may be achieved by increasing the interval between the concreted or plastered surfaces.

As far as the degree of heat insulation of polystyrene is concerned, a finished panel of 10 cm thickness with 4 cm thick polystyrene core corresponds to an ordinary brick wall 64 cm thickness.

HEAT LOAD CALCULATIONS

Assumptions and Postulates

The present research investigates the effect of the structural material selection on power saving based on heat load calculations for typical building in Baghdad.
Outside ambient temperature is estimated based on the annual temperature records in Baghdad for certain year.
This approach takes under consideration that the design temperature inside the building according to the national standards is 22 ^{o}C.
As the heat load is directly proportional to the temperature difference between the inside building design temperature and the surrounding temperature these differences are averaged per 12 months to facilitate the estimation of the annual power consumption saving due to implementation of the M2 material.
The dimension of the building is assumed according to a typical house building layout in Baghdad. Two types of structural material are selected for comparison purposes (conventional concrete and brick versus M2 EMMEDUE building system including the other structural material used with each of the two types).
The power saving calculation bases on the comparison between the energy required for the typical house building when two structural materials are used in construction. This calculation takes under consideration both the capital cost and the fuel cost required to ensure electric power for a district consists of 1000 house buildings per one year. The cost of the unit price of each of the constructional material is assumed to be equal.

Annual Temperature Records

The average values of the maximum and minimum temperatures per each month investigated from the annual temperature records in Baghdad is estimated based on the references of the Iraqi Meteorological Directorate, IMD, see **Table (1)**.
The calculation bases on averaging the temperature differences between the building inside design temperature and the surrounding higher temperature / or lower temperature per each day / or night intervals per each month assuming equal, (12) hours, for each of day and night, see **Table (2)**.

Table (1): Annual temperature records in Baghdad based on IMT references

Month	Minimum Temperature ^{o}C	Maximum Temperature ^{o}C
January	4	16
February	6	18
March	9	22
April	15	30
May	20	37
June	23	41
July	25	43
August	25	43
September	21	40

October	16	33
November	11	23
December	6	18

Table (2): Temperature differences between the building inside design temperature, 22 ^oC and the surrounding higher temperature / or lower temperature per each day / or night intervals per each month.

Month	Temperature difference at night, ^oC	Temperature difference at day, ^oC	Total temperature difference per day per month, ^oC
January	(22-4)	(22-16)	24
February	(22-6)	(22-18)	20
March	(22-9)	(22-22)	13
April	(22-15)	(30-22) *	15
May	(22-20)	(37-22) *	17
June	(23-22)	(41-22) *	20
July	(25-22)	(43-22)*	24
August	(25-22)	(43-22)*	24
September	(22-21)	(40-22)*	19
October	(22-16)	(33-22)*	17
November	(22-11)	(23-22)	12
December	(22-6)	(22-18)	20
Average temperature difference per each daily hour per year			18.75 ^oC

THERMAL PROPERTIES OF THE BUILDING MATERIAL

The rate at which heat gets transferred depends upon the thickness of the material, the thermal conductivity, k (this depends on the composition of the material), surface area of the material, A, and the temperature difference between the reservoirs.

In particular the rate of the heat transfer = A. k. (Th – Tc) / L. This equation shows that the thicker the material that separating the two reservoirs, the smaller the surface area that is contact, or the smaller the temperature difference, the slower the rate of heat transfer through the substance. When it comes to heating and cooling our homes, this is exactly what we need to strive for in order to reduce our energy bills.

In our homes the exterior surfaces are usually comprised of more than one type of material. For instance, a wall can be composed of 3 ½ inches of fiberglass insulation which is covered by ½ inches of sheetrock on the inside and plywood and brick on the exterior. When two or more different materials are between the hot and cold reservoir, the equation on the previous page can become quite messy since there will be various thermal conductivities and thicknesses with which to deal.

The equation is greatly simplified if we consider the R-value of objects instead of their thermal conductivity. This is a measure of how well the material resists the flow of heat through it, and it combines the thermal conductivity and thickness into one term (R-value = thickness / thermal conductivity = L / k). While the common units for the R-value is ft^2. hr.°F / Btu, these are often not quoted. It is likely to just see the R-value of a substance to just be quoted as a number as in "Fiberglass R-value = 13".

The R-factor of a surface determines how quickly heat is conducted across it. The values shown in **Table (3)** illustrate some of common R-factors for surfaces found on typical homes.

Table (3): R-factors for typical construction material

Exterior walls with siding

Concrete block (8")	Factor
(a.) Concrete block (8")	2.0
With foam insulated cores	20
With 4" on non-insulated stud wall	4.3
With 4' insulated stud wall	14
Brick (4")	
With 4" non-insulated stud wall	4
With 4" insulated stud wall	4
Wooden Frame	
Non-insulated with 2"x4" construction	4.6
With 1 ½" fiberglass	9
With 3 ½" fiberglass stud; studs 16' O.C	12
With 3 ½" fiberglass and 1" foam	20

Roof /Ceiling

Material	Factor
No insulation	3.3
3 ½" fiberglass	13
6" fiberglass	20
6" cellulose	23
12' fiberglass	43
12" cellulose	46
14" cellulose	54

Windows and Sliding glass walls

Glass	Factor	Low Emissivity	Drapes	Quits
Single panel	0.9	1.1	1.4	3.2
Single w / storm window	2.0		2.5	4.2
Double pane, ¼"air space	1.7		2.2	4.0
½" air space	2.0	2.99	2.5	4.3
Triple pane, ¼" air space	2.6		3.0	4.8
Triple pane, ½"air space	3.2	3.7	3.7	5.5

PRESENT CALCULATION APPROACH

The purpose from our calculation is to estimate the annual power saving based on both cooling and heating loads rather than investigation of the design parameters and requirements for the air conditioning system which mainly depends on the maximum outside temperature conditions.

In our case building cooling load and heating load are calculated together. Building heating load could mainly depend on the average temperature difference per each daily hour per year, see **Table (2)**, while building cooling load components are; direct solar radiation, transmission load, ventilation/infiltration load and internal load.

Except the transmission load which depends on the same average temperature difference the other factors could be calculated separately.

Calculating all these loads individually and adding them up gives the estimate of total load. The load, thus calculated, constitutes total sensible load. Normal practice is that, depending on the building type, certain percent of it is added to take care of latent load. Applying the laws of heat transfer and solar radiation makes load estimations.

Step by step calculation procedure has been adequately reported in the literature issued by ANSARI.

In our case we base the effect of the solar radiation on the cooling load only for the period at which the temperature differences represent the days of the seasons when there is direct sun radiation and which are marked by (*) in **Table (2)**.

Overall heat transfer coefficients for all the components of the building are computed with the help of thermal properties of the building materials. For the design conditions and the building materials used, cooling and heating load temperature difference, solar heat gain factors and cooling load components are calculated. Principles of solar energy calculation are applied to determine the direct and indirect solar heating component of the building.

First principle is applied to yields the rates of heat transfer through different building components. All these components, when added up, give the total cooling and heating load of a building.

The following assumptions are made to estimate the heating and cooling loads:

1. One story building, shown in **Fig. (2)**, is based for the load calculations.
2. The heating and cooling load based on transmission factor uses an effect factor of (1).
3. The lightening, equipment and personnel loads use an effect factor of (1), the building dimensions and internal details is shown in **Fig. (2)**.
4. The outside air flow uses an effect factor of (1).
5. The solar radiation factor for cooling load uses an effect factor of (0.5x0.85) where 0.5 represent the percentage of the sunny hours to total day hours, while (0.58) assumes the percentage of the days within one year when the outside temperature becomes higher than the building inside temperature.
6. Referring to **Table (3)** the heat conductance of the main structural material using the foam insulated core in 8” concrete block to that without insulation for both wall and ceiling material is assumed to be (0.15) for heat transmission factor.

7. The heating and cooling load calculations for isolated roof and walls are based on the double glass of glass block.
8. The air flow, lightening, equipment and personnel factors are shown in **Table (4)**.
9. **Table (4)** shows the main equation used for calculating the heating and cooling load components.

ASHREA handbook is used as basis for these calculations together with the assumptions implemented by RUDOY.

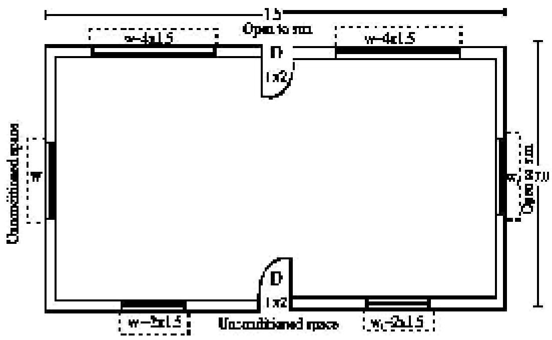

Fig.(2): Typical one story Building based for heating and cooling load calculations.

Table (4): Cooling and heating load estimations and equations

1. Direct solar radiation: (Figure all windows for each exposure, but use only the exposure with the largest load)		**For glass black reduce factor by 50%: for storm windows or double glass reduce factor by 15%.**		
Direction	**Windows Area, m2**	**No Shading Awn**	**Inside shade**	**Outside**
North-east	**4.5**	**190**	**79**	**63**
East	**12.0**	**158**	**126**	**79**
South-east		**237**	**95**	**63**
South	**4.5**	**237**	**111**	**63**
South-west		**347**	**142**	**95**
West	**6.0**	**473**	**205**	**111**
North-west		**379**	**158**	**95**
2. Window Transmission :				
Double glass of glass block (Area = 27m2)		**0.46241 + 3.026* ΔT**		
3. Walls:				
No insulation (brick, frame etc.), (Area=132m2)		**8.3932 + 1.21465* ΔT**		
4. Roofs:				

No insulation (Area= 105m2)	**48.82+1.55* ∆T**
5.Outside Air per cubic meter of flow area / 20 frequent door usage (Floor area=105m2)	**(2.01 + 0.71 * ∆T) / m2 floor area**
6. Lightening (Area=105m2)	**16.65 w/m2**
7. Equipment	**750 w**
8. Personnel	**440 w**

RESULTS AND CALCULATION

The results of the heating and cooling load calculations for a house of typical design, shown in **Fig. (2),** give a total load of 18,900 KW when ordinary concrete structure is used, while this load is reduced to 8,450 KW when the concrete structure is replaced by EMMEDUE isolated structure based on the assumptions clarified in previous section.

A reduction of 55% in the annual load is estimated per each house using the new building technology. For a district sums up 1000 houses of the new structural design the total saving of power will be 10.45 MW. The reduction in the power consumption will affect both the capital cost and the fuel consumption cost.

Based on the diesel power generation technique which is the main power generation source in Iraq and an estimated fuel consumption rate of 0.25 liter/hour/ KW the fuel consumption saving will be around 22.88xE03 cubic meter. The total fuel cost saving will be around 12 M USD in yearly base. Adding this value to the capital cost of 10.45 MW diesel generation plant price (roughly 0.35 M USD / MW), (total 3.66 M USD). The total power saving cost will be (14.11 M USD) per 1000 single story houses of around 105 square meters per each house.

These results show the effect of building isolation techniques on the power saving in Iraq rather than other countries due to the large temperature differences between the winter and summer seasons.

CONCLUSION AND RECOMMENDATION

It is concluded from the research that the cost benefit form the utilization of isolated structural material in the buildings has an effective impact on the total heating and cooling cost required in the these buildings specially in countries that have a big differences in the summer and winter temperature differences.

Using the identified structural material EMMEDUE M2 did not have any additional cost impact when it is compared to the ordinary structural material. Another benefits from using such type of material summarized in low weight reasonable strength and high acoustic insulation which add some structural privileges in addition to its excellent thermal properties.

Such type of material is became recommended in special usage building that require an optimum design specification between strength, architectural, thermal and acoustic properties.

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