

EFFICIENCY OF POLYSTYRENE INSULATED CEMENT BLOCKS IN ARID REGIONS

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ABSTRACT: Polystyrene insulated cement blocks emerged recently as an energy saving building material in construction practice. Expanded polystyrene of 5cm thickness or more is introduced as a middle fill layer within the cement block in order to improve the thermal properties of walls. This study is made to investigate the efficiency of insulation provided by this type of treatment. Two chambers were constructed in an open area where the walls are subjected to variable weather conditions ranging from moderate to hot weather for a period of three months. The arid region selected was Riyadh, Saudi Arabia. Temperature was found to vary between day and night through this period from as low as 9 °C to as high as 48 °C. Each chamber is built in the form of four block walls 20 cm in thickness, one meter wide and one meter high. The chambers were founded on grade slabs with a wood board used as a roof. The two chambers are identical except for the type of blocks; one is built using polystyrene insulated blocks and the other without insulation. Construction was carried out the same way as used in local practice. Thin mortar layer is used for bonding blocks. 5TE sensors and a data logger were used to record ambient temperature and temperature inside each chamber. Hourly records throughout the testing period were used to evaluate and compare the insulated and non-insulated blocks. It was found that the improvement provided by the polystyrene cement blocks is less efficient in hot temperature than in moderate temperature. The insulation provided by the blocks as constructed is very poor and heat transfer is enabled through mortar filled gaps and joints. The temperature gradient has influence on the polystyrene insulation material.

Keywords: Polystyrene, Cement-block, Temperature, Insulation, Weather.

1. INTRODUCTION

This work is aimed at investigating issues related to polystyrene insulated cement blocks introduced to masonry industry in recent decades. The thermal conductivity is a term commonly used to define the ability of the material to transfer heat from a warmer part to a less warm part per unit time for unit area over a given temperature gradient. The unit of thermal conductivity is $\text{W m}^{-1} \text{K}^{-1}$. Materials of good thermal properties include mineral wool, EPS, XPS, polyurethane and others. Expanded polystyrene ranks second in use as insulation material in Europe and many other countries [1]. However, the flow of heat through any material is influenced by several factors and is not correctly predicted without considering all significant parameters. The flow of heat through materials, is affected by moisture, humidity and air content as prime factors. Reference [2] stated that heat conduction is influenced by the soil composition, structure, density, porosity, and grain geometry and pore or opening size. The same factors can be reflected to cement sand building materials. Moisture absorption, density and air

components of EPS can cause thermal properties to change. In addition to material related properties the overall settings of the insulation system may also have its influence. Energy Efficiency and Renewable Energy (EERE) of the United States quoted that filling the block cavities or special block designs can improve a block wall's thermal characteristics, but doesn't reduce heat movement very much when compared to insulation installed over the surface of the blocks either on the exterior or interior of walls [3]. The present practices involve mortar between brick layers and some block designs include web of concrete that can transfer heat. Figure 1 presents two typical designs used in construction. It is becoming a routine to examine thermal properties of newly introduced construction material [4] and [5]. This study follows a similar approach in order to highlight the efficiency of polystyrene insulated cement blocks.

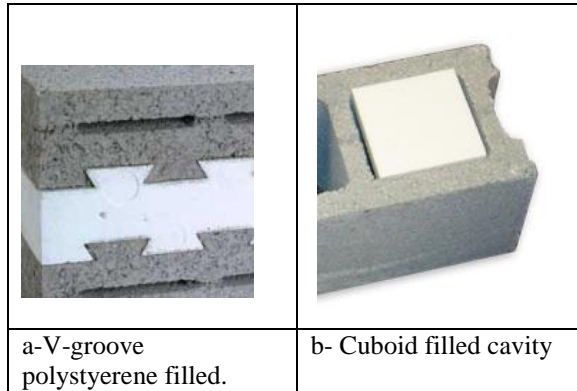


Fig 1. Two typical designs used in construction.

2. MATERIALS AND TESTING PROGRAM

Commercial cement blocks of dimensions 200mmx250mmx400mm with and without polystyrene insulation were obtained for the purpose of constructing two chambers in an open yard of college of civil engineering in King Saud University. The chambers are 1m by 1m rooms of 1m height covered with a plywood board. The construction was performed in a similar way as practiced in wall construction. Mortar prepared with 1:2 water cement ratio and 1:2 cement sand ratio was used. Thin mortar was applied in between layers. No plastering was made as the goal of the study was to compare the types of cement blocks with regard to heat transfer and energy savings. Figure 2 presents the two chambers as constructed. Arrangements were made to have equipment for recording temperature inside each chamber and also ambient temperature.

Variations in volumetric water content, temperature and electrical conductivity were recorded using 5TE Decagon sensors connected to Em50 data logger. The sensors were set to take records every one hour intervals. In order to reduce heat losses, 1cm thick pvc tube was used to guide wires through the walls in order to place the sensors right in the middle and mid-height of the chambers.

The expanded polystyrene material used in cement blocks insulation is white in colour and sandwiched between two parts of the cement block. The polystyrene is shaped with a V groove to interlock with the block concrete. The expanded polystyrene density is in the range of 25/29 Kg/m³. As marked by the manufacturer, the insulation brick has many advantages, such as heat

preservation (coefficient of thermal conductivity is 0.045 ~ 0.065 W/m k., sound proofing and better fire prevention. This typical cement block insulation is widely used in Southeast Asia, India, Middle East and other countries [6]. Reference [7] stated that fissures and cracks within the construction material can be due to the nature and properties of that particular material.

3. TEST RESULTS AND DISCUSSION

Temperature was found to vary between day and night throughout the investigation time from as low as 9 °C to as high as 48 °C. Two periods were considered for comparing the cement blocks. The first period is the February month, referred to as moderately hot, with temperature range during the day in the order of 10 °C to 35 °C degrees and the second period is end of May which is referred to as hot period where temperature range within the day is 25 °C to 48 °C degrees.

It can be seen that from Fig. 3 that both types of block provide a heat shield and reduce the maximum daily temperature from 35 °C degrees to an average of 24 °C and also elevate the minimum temperature from 10 °C to an average of 16 °C. The improvement of heat insulation indicated 1 °C or less than 2 °C degrees difference. The improvement is also reflected as time delay or shift. The improvement during the hot period is less compared to the moderately hot period. Difference in peaks is hardly observed but shift of graph reflect the delay due to the lower conductivity of the insulated cement blocks.

The improvement could have been much better if the mortar between the bricks is not used. Dry stacking will require other structural bonds like steel bars or joining mechanism. Other better alternatives include overall external or internal shielding with polystyrene board.

The present block laying method is not efficient. If mortar can be limited to the concrete portions of the bricks and the polystyrene is protruding by a centimeter or so to fix with other polystyrene face then the heat transfer through mortar can be eliminated.

The time shift associated with polystyrene insulated blocks can be clearly observed in Fig. 4. This is clearer in Fig. 5 which shows a 24 hour temperature profile during the hot period. Fig. 6 presents the ambient temperature site records over three months.

The insulation provided by the blocks as constructed is very poor and heat transfer is enabled through mortar filled gaps and joints. The temperature gradient has some influence on the polystyrene insulation material.

Measurement carried out by Yucel et al 2003 [1] showed that thermal conductivity coefficient is indirectly proportional to the density. The thermal conductivity is between 0,036 and 0,046 W/mk, for densities of expanded polystyrene between 10 and 30 kg/m³. Water absorption was measured as 3.5% for 30 kg/m³ and 5.5% for 15 Kg/m³.



Fig.2 View of the two chambers constructed.

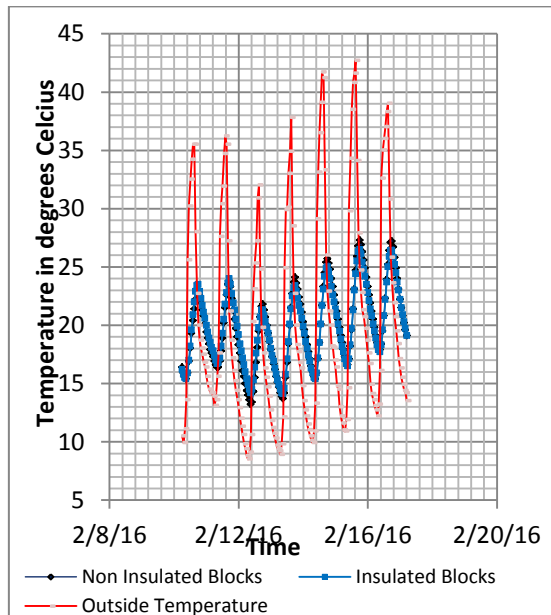


Fig 3. Temperature of insulated and non-insulated blocks compared to outside temperature.

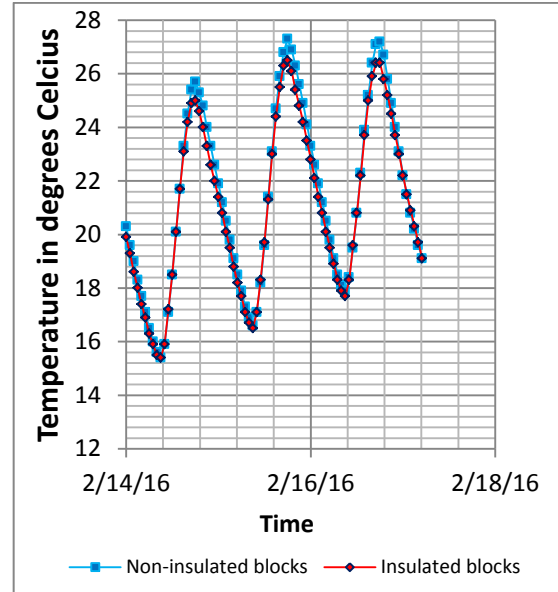


Fig 4. Comparing Insulated and non-insulated blocks temperature profile over three days in moderately hot period (February).

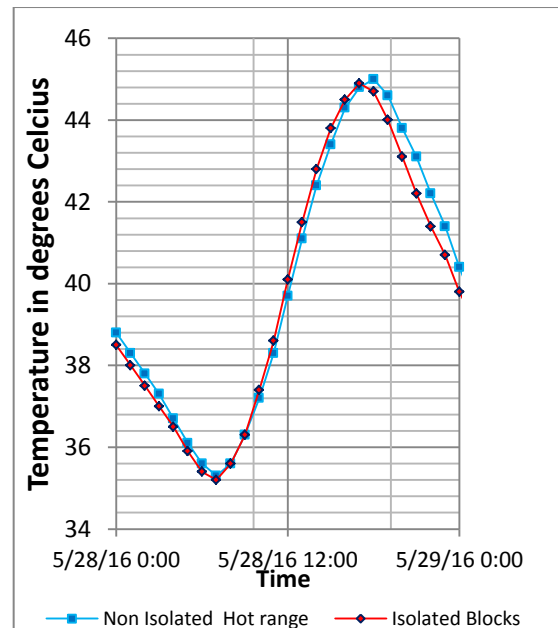


Fig 5. Comparing Insulated and non-insulated blocks temperature profile over 24 hours during hot period (End of May).

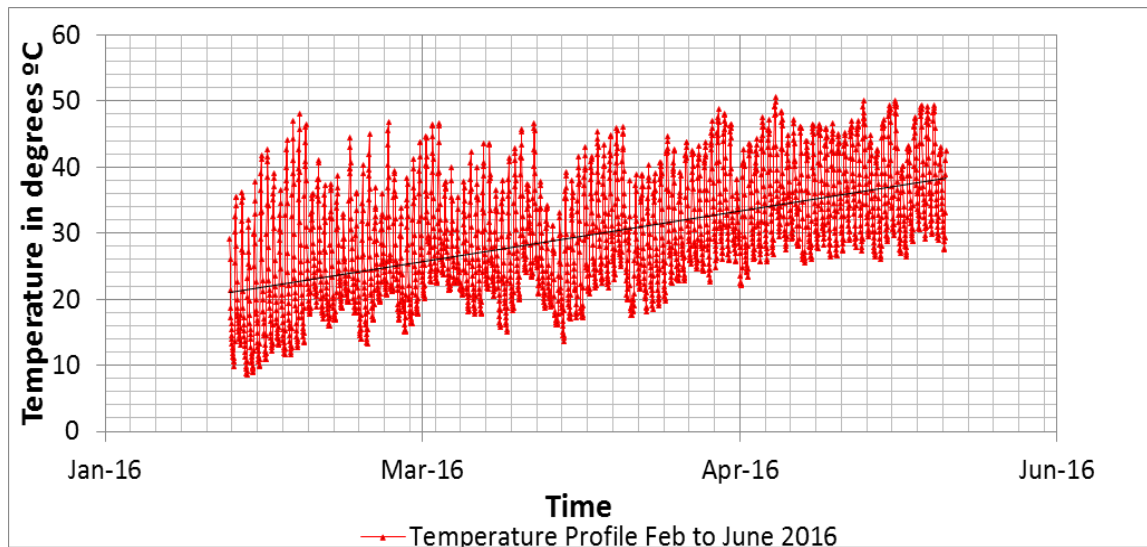


Fig. 6 Temperature site records over three months

4. CONCLUSION

The polystyrene insulated cement blocks behave differently for different temperature gradients and different levels of heat. The insulation provided by the blocks as constructed in general practice is very poor and heat transfer is enabled through mortar filled gaps and joints. The temperature gradient has influence on the polystyrene insulation material.

Reliable insulation can be achieved if use of mortar is limited to fix the concrete parts alone. External and internal heat insulation using polystyrene boards can be more efficient but may not stand strong to weather or impact conditions. Designers can use this nature as required to provide extended hours of comfortable times. In winter times insulated walls will retain the heat for several hours and provide relatively warm conditions. In summer times, the insulated cement blocks will shield the rooms during the day.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

[1] K. T. Yucel, C. Basyigit and C. Ozel, (2003). Thermal insulation properties of expanded polystyrene as construction and insulating materials. 15th Proceeding of Symposium on

Thermo-physical Properties, in Boulder, Colorado, NIST/ASME, pp.54-66.

- [2] Farouki, O.T., 1986. "Thermal properties of soils.", series on rocks and soil mechanics, Vol.11, Trans Tech Publications, Germany.
- [3] The U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE).
<http://energy.gov/energysaver/energy-saver>.
- [4] Edremit, A., 1997. Performing Economical Analyses of Insulation Materials by Determining Physical Properties; Master Thesis, Yıldız Technical University of Istanbul, p. 114.
- [5] Dafalla, M. A. and Samman, A. (2016). Soil and backfill material of environmental friendly thermal properties. International Journal of Geomate, Vol 10, Issue 22, 2083-2087.
- [6] Gotop high-tech co.,ltd .China Polystyrene Injection molded Thermo block Insert Thermo Block Insert manufacturer).
- [7] F Al Fouzan and M A Dafalla (2014). Study of cracks and fissures phenomenon in Central Saudi Arabia by applying geotechnical and geophysical techniques . Arabian Journal of Geosciences 7 (3), 1157-1164.

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