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ENTER

A BDA STUDY INTO BRICK SKIN THERMAL PERFORMANCE

BRICK DEVELOPMENT ASSOCIATION

Contents

INTRODUCTION

The envelope of any modern building must fulfill a number of, sometimes contradictory, requirements. It needs to turn the weather, provide comfortable internal conditions, resist fire, be flood resilient, etc. This means being dense for acoustic reasons but lightweight for thermal reasons. Consequently most wall structures consist of layered constructions, with each layer fulfilling one or more functions. Specifically there is usually one layer of lightweight material providing thermal insulation.

The concept of Thermal Mass whereby some relatively heavy materials are used to fulfill functions within the insulating layer are well understood eg the inner leaves of cavity walls. These materials, as well as providing structure, moderate temperature changes by absorbing heat from the internal atmosphere and subsequently re-radiating it to warm the atmosphere as it naturally cools.

Housing in the south of England will receive significant benefit through using thermal mass combined with shading to mitigate the effect of summer time peak temperatures.

(Tuohy et al)

Until relatively recently the role of heavyweight materials outside the insulated envelope has been largely unconsidered. This is somewhat surprising as the effect of massive construction in historic buildings, for example our cathedrals, is well established.

In 2012 Altherman began to discuss the potential for moderating the thermal behavior of a building interior by utilizing the thermal resistance of various other building elements.

It is clear that a more representative parameter than U Value is required to fully capture the dynamic thermal behavior of a walling system. A relatively simple metric which encapsulates the contribution of all physical parameters influencing the thermal performance is required.

(Altherman)

What Altherman is exploring in the case of walls is the concept of Thermal Shielding. The provision of materials outside the insulating layer that have a high thermal capacity is extremely beneficial as they absorb considerable amounts of heat as the external temperature rises before significant temperature gradients exist in them to drive heat to the interior. This attribute of brickwork adds to those of weather resistance, fire resistance, structural and acoustic performance, together with a warm, attractive appearance.

The Britten Pears Archive by Stanton Williams, as seen overleaf, is a great example of a ‘fully breathable’ structure, which uses well insulated walls of solid load-bearing facing brickwork to help moderate the temperature and relative humidity between the outside environment and the material within. Therefore, the building protects the world class and fragile collection of Benjamin Britten’s work without the aid of mechanical temperature control.

CASE STUDY THE BRITTEN PEARS ARCHIVE

The Britten Pears Archive by Stanton Williams is a red brick archive building which compliments the site of The Red House in Aldeburgh, Suffolk, the Grade II listed former home of Britten. The building is designed firmly within context and uses pioneering low-energy methods to provide an optimum passive environment to preserve the Britten collection.

The Britten Pears Archive ©PhilipVile

Stanton Williams worked with engineers, Max Fordham, on this project to investigate and test ideas in order to create a passive archive where the internal environment is controlled with minimal energy input. As the structure required good thermal shielding, brick provided the ideal solution.

A recent Australian study, conducted by The University of Newcastle, measures how well the internal surface responds to the external surface temperature. The performance of various external walling systems, exposed to dynamic weather variables (influenced by ambient temperature, solar radiation and wind speed) have been recorded. The study looks at and includes the interactions of all of the wall components under all weather parameters giving an accurate view of wall thermal performance.

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CASE STUDY THE BRITTEN PEARS ARCHIVE

Over the testing period, across 4 seasons, a range of walling systems were used to test Altherman's theory. The performance of each module was observed with the interior space being either in a 'free-floating' state (directly influenced by real weather conditions), or with the interior heated or cooled to a pre-set temperature.

The Britten Pears Archive ©Hufton & Crow

From the study it emerged that the Insulated Cavity Brick module performed the best due to the accurate combination of thermal shielding and the insulation layers. The outer skin was proven to have a positive contribution on the overall performance and as expected thermal mass located internally within a wall played a significant role in appropriate moderation of internal temperature.

The key to all of this is thermal capacity which provides both Thermal Shielding and Thermal Mass depending where heavyweight materials are located in the building. Both properties cause the difference between the maximum and minimum external and internal temperatures to be reduced. The internal temperature reaches a peak or trough after a time lag from either occurring externally. The time lag is known as a 'decrement delay' and is illustrated on the next page.

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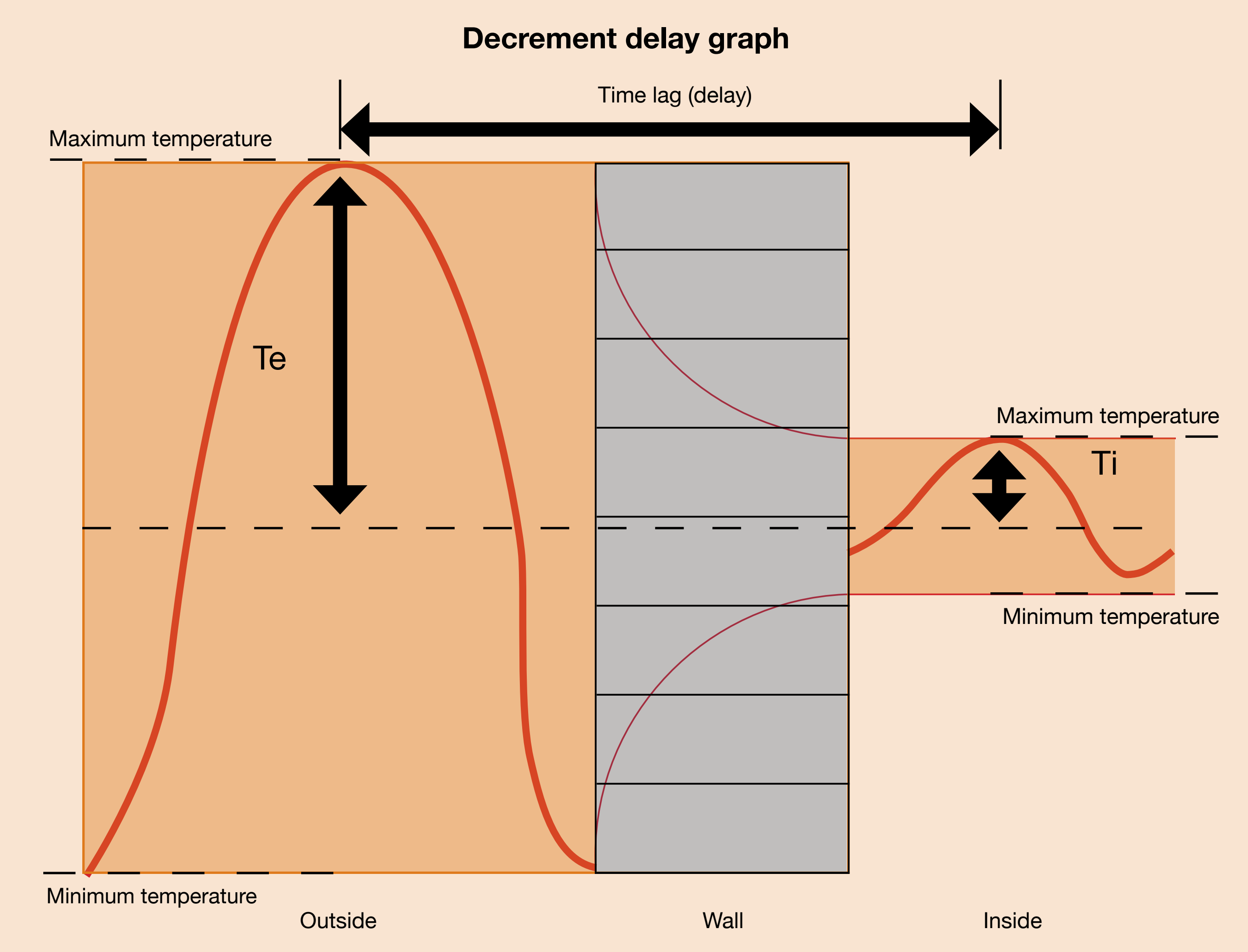
DECREMENT DELAY



Decrement delay

Different materials allow the passage of heat to travel at different rates. The period of time it takes the peak temperature on the outside skin of a building (such as wall or a roof) to make its way to a peak temperature on the inside face, is called the 'time lag' or, more scientifically, known as 'Decrement Delay'.

By controlling the Decrement Delay it is often possible to control and prevent the overheating of a building. Designing for a long Decrement Delay will ensure that during summer, peak heat gains from outside will not get through until night, which is when the risk of overheating is moderate.

Medium and heavyweight walls insulated to current standards will slow the passage of heat by around 9 to 12 hours, which provdes an optimum level of Decrement Delay [The Concrete Centre].

CASE STUDY HANSON ECOHOUSE™

The construction of the Hanson EcoHouseTM at the Building Research Establishment (BRE) in Garston, Watford, provides an outstanding concept dwelling. It brings together the latest developments in off-site masonry construction, thermal mass and natural ventilation. Constructed using masonry panels manufactured off-site in a controlled factory environment, it brings the benefits of high quality and speed of construction with little or no site wastage.

Thermal Mass

Masonry construction has high thermal mass. This inherent feature enables the dwelling to store heat and remain cooler for longer than lightweight structures, meeting the needs of climate change and keeping buildings cool in an energy efficient environment. The house has high thermal mass creating a structure to cope efficiently with extremes of temperature in both summer and winter. No matter how hot it gets outside during the day or how much cooler it gets during the night inside the house it's always comfortable.

Natural Ventilation

A ventilating roof lantern is used to give light and to enhance natural air currents, so maximizing the energy conservation potential.

Flexible Design

Masonry panels manufactured offsite in a controlled factory environment provide total flexibility in the design of dwellings. The system has been designed to meet the needs of house builders and developers and is applicable across a wide range of housing options.

Addressing the key issues of climate change, carbon efficiency and sustainable masonry construction, the Hanson build process and systems ensure a flexible range of practical and environmental solutions.

CONCLUSION

The ability to control the internal temperature of buildings so that they do not fluctuate too much is a contributory factor to human comfort. If this can be achieved by passive means, especially by the selection of appropriate materials for the construction of the fabric of the envelope, the energy usage over the lifetime of the building will be reduced. For some time it has been acknowledged that Thermal Mass is a property of heavyweight materials that is effective in restricting temperature fluctuation internally and limiting overheating in a climate of generally increasing temperature. Recently an extensive study in Australia has demonstrated the effect of Thermal Shielding which is the provision of thermal capacity in the fabric of the envelope outside of the insulating layer. This provision, which can of course be by the use of clay brickwork, helps to delay the occurrence of maximum and minimum temperature internally from their occurrence externally. Consequently the risk of overheating is reduced, the maintenance of steady temperatures is easier and energy usage is reduced. These effects are major gains in human comfort and environmental performance.

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REFERENCES

Al-Regib E., S.M. Zubair, Transient heat transfer through insulated walls, Energy20 (1995) 687–694.

Al-Sanea S.A., M.F. Zedan, S.N. Al-Hussain, Effect of thermal mass on performance of insulated building walls and the concept of energy savings potential, Applied Energy 89 (2012) 430–442.

Al-Sanea S.A., M.F. Zedan, Improving thermal performance of building walls by optimizing insulation layer distribution and thickness for same thermal mass, Applied Energy 88 (2011) 3113–3124.

Al-Sanea S.A., M.F. Zedan, Effect of insulation location on thermal performance of building walls under steady periodic conditions, International Journal of Ambient Energy 22 (2001) 59–72.

Al-Sanea S.A., M.F. Zedan, Effect of insulation location on initial transient thermal response of building walls, Journal of Thermal Envelope and Building Science 24 (2001) 275–300.

Al-Sanea S.A., Thermal performance of building roof elements, Building and Environment 37 (2002) 665–675.
Arundel et. al. Indirect health effects of relative humidity in indoor environments. Environ Health Perspect (1986); 65 pp 351-361.

Asan H., Investigation of wall's optimum insulation position from maximum time lag and minimum decrement factor point of view, Energy and Buildings32 (2000) 197–203.

Bojic M., F. Yik, W. Leung, Thermal insulation of cooled spaces in high rise residential buildings in Hong Kong, Energy Conversion and Management 43(2002) 165–183.

Braham, D. et al. Building Research Establishment Digest 454, Part 1: Thermal mass in office buildings, an introduction.

BRE., 2001. Information Paper 6/01 Modelling the performance of thermal mass.. Garston: Building Research Establishment (BRE).

BRE., 2006. BR 489 Part L Explained – The BRE Guide. Garston: Building Research Establishment (BRE).
CIBSE, 2004. Guide F Energy efficiency in buildings. 2nd Edition. London: Chartered Institute of Building Services Engineers.

CIBSE, 2007. Guide C Reference Data. London: Chartered Institute of Building Services Engineers.

CISBE, Avoiding or minimising the use of air conditioning. www.cibse.org/pds/GIR031.pdf.

C. Chai, Brick homes: the energy efficient building solution; ceramic industry vol 163 n2 pp23-25 (2013)

Howieson, S. (2005) Housing and asthma. Spon Press, London ISBN 0-415-33646-5

Kontoleon K.J., D.K. Bikas, The impact of temperature variances on thermal inertia factors of opaque elements of the building envelope, in: Eight International Conference on Environmental Science and Technology Lemnos Island, Greece, (2003), pp. 485–492.

Kontoleon K.J., D.K. Bikas, The effect of south wall's outdoor absorption coefficient on time lag, decrement factor and temperature variations, Energy and Buildings 39 (2007) 1011–1018.

Kontoleon K.J., E.A. Eumorfopoulou, The influence of wall orientation and exterior surface solar absorptivity on time lag and decrement factor in the Greek region, Renewable Energy 33 (2008) 1652–1664.

Kossecka E, J. Kosny, Influence of insulation configuration on heating and cooling loads in a continuously used building, Energy and Buildings 34 (2002)321–331.

Lj Bojic M., D.L. Loveday, The influence on building thermal behaviour of the insulation/masonry distribution in a three-layered construction, Energy and Buildings 26 (1997) 153–157.

Minke, G. (2000) Earth construction handbook: The building material earth in modern architecture. Billerica, MA, WIT Press. ISBN: 185312-805-8

Minke, G. (2006) Building With earth: design and technology for a sustainable architecture. Birkhauser, New York. ISBN: 3-7643-7477-2
Morton, T., Stevenson, F., Taylor, B., and Charlton Smith N. (2005) Low cost earth brick construction: 2 Kirk Park, Dalguise: Monitoring and evaluation. Arc Architects. ISBN 0-9550580-0-7. Download from www.arc-architects.com/downloads/ Low-Cost-Earth-Masonry MonitoringEvaluation-Report-2005.pdf

Ozel M., K. Pihtili, Investigation of the most suitable location of insulation apply-ing on building roof from maximum load levelling point of view, Building and Environment 42 (2007) 2360–2368.

Ozel M., K. Pihtili, Optimum location and distribution of insulation layers on building walls with various orientations, Building and Environment 42 (2007)3051–3059.

Ozel M., K. Pihtili, Effect of insulation location on the heat gain and losses for different climatic conditions, Energy Education Science and Technology Part A: Energy Science and Research 28 (2012) 515–524.

Page A., B. Morghtaderi, D.Alterman, S. Hands. A study of the thermal performance of Australian housing. Priority Research Centre for Energy & the University of Newcastle. www.thinkbrick.com.au (2011)

Rennie D., Parand, F. BR 345: Environmental design guide for naturally ventilated and daylit offices. Garston: Building Research Establishment (BRE) (1998).

Tuohy et al, Thermal mass, insulation and ventilation in sustainable housing - an investigation across climate and occupancy – (2004)
The Concrete Centre, (2005). Thermal mass: a concrete solution for the changing future. The Concrete Centre.

The Concrete Centre, (2012). Thermal Mass Explained.

Seaman A., Martin, A., Sands, J. 2000. Application Guide 11/2000 HVAC Thermal Storage: Practical application and performance issues. Bracknell: Building Services Research and Information Association.

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