Earthship Architecture:

Post occupancy evaluation, thermal performance & life cycle assessment

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Abstract

Minimising environmental impact from buildings and building construction processes while providing thermal comfort to the occupants are some of the main goals of green building design. Many different approaches exist to achieve these goals, one of which is the “Earthship”, invented by American architect Michael Reynolds. The Earthship is an earth-sheltered autonomous house with walls made substantially from waste products, most notably, discarded car tyres. This thesis presents original research to investigate claims about Earthship performance: that it provides passive thermal comfort in any climate and is the most sustainable green building design in the world. This investigation has been conducted by using Life Cycle Assessment (LCA) to evaluate the overall environmental impact of the Earthship and to compare it to a variety of similar building types characterised by their wall construction materials and other design features. To support assumptions in the LCA, a Post Occupancy Evaluation and a Thermal Performance study were conducted to estimate heating and cooling energy use in a variety of climates. The environmental credentials of the Earthship are then compared to that of other housing types, using both the LCA and thermal modelling approaches.

A post occupancy evaluation (POE) of Earthship homes in Taos, New Mexico, USA, was conducted. This included interviews and surveys of the occupants, and monitoring of the indoor thermal environment. Some aspects of the POE were also extended to an international cohort of Earthship occupants to help justify the assumptions that Earthships provide a level of amenity comparable to conventional housing. The indoor monitored data were also used to calibrate a thermal simulation model of an Earthship home in Taos to ensure the accuracy of the model. The tested approach and parameters to model this Earthship were then used in a model to predict the indoor temperature and theoretical heating and cooling energy requirement of an Earthship design in cold climates and in a warm Mediterranean climate of Adelaide, Australia – the particular context of the LCA study. Thermal modelling of other building types, characterised by their wall materials, was conducted for the Adelaide climate, to predict the heating and cooling energy requirement which was needed for the comparative LCA study.

The research produced the following results. Firstly, in the extreme climate of Taos, the Earthship is able to provide thermal comfort without active heating and cooling systems, and that people are generally very satisfied with the level of comfort and amenity provided. Secondly, in the Adelaide climate, Earthship performance would be similar to Taos; approaching zero energy use for heating and cooling, while in cold and overcast climates minimal space heating may be required. Finally, in the Adelaide climate and context, of all the house types considered, the Earthship had the least environmental impacts and these were considerably less than conventional grid connected homes. The Earthship’s comparatively low environmental impact arises from the holistic design, in particular the greenhouse and earth-sheltering, which enable occupants to be extremely energy and water efficient, and therefore live within the limits of modestly sized “off-grid” systems (autonomously) while still enjoying a high level of comfort and amenity. The use of tyres to construct the Earthship’s external walls proved to be a low impact method for constructing a retaining wall capable of being earth-sheltered.

The study has provided scientific evidence about the thermal performance and environmental credentials of the Earthship and other housing types, supporting claims that Earthships can provide passive thermal comfort in many climates and that it may be the most sustainable green building design compared to the other building types investigated by this study.

Publications

Publications arising from this research are listed below.

Freney, M., Soebarto, V., & Williamson, T. J. (2013). Earthship monitoring and thermal simulation. *Architectural Science Review, 56*(3), 208-219.

Freney, M., Soebarto, V., & Williamson, T. J. (2013). Thermal comfort of global model earthship in various European climates. Paper presented at the 13th International conference of the International Building Performance Simulation Association, Chambery, France.

Freney, M., Soebarto, V., & Williamson, T. J. (2012). Learning from 'Earthship' based on monitoring and thermal simulation. Paper presented at the 46th Annual Conference of the Architectural Science Association, Griffith University, Queensland Australia.

Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

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