THE IMPORTANCE OF EXTERNAL WALLS IN ENERGY EFFICIENCY OF BUILDINGS

MICHAEL VAN DER MERWE[1]
Compiled 22 September 2011

An article for the category: **Quantity surveying** (Kenneth Humphreys award ICEC 2012)

[1] Department of quantity surveying and construction management, University of the Free State, Bloemfontein, South Africa. Phone: 051 401 3322 or 0828727092, Email: versterj@ufs.ac.za

Table of contents

Page number

List of tables

THE IMPORTANCE OF EXTERNAL WALLS IN ENERGY EFFICIENCY OF BUILDINGS

ABSTRACT

This paper identifies the importance of the external walls of a building for internal thermal comfort of occupants, thereby achieving energy efficiency within the building, which aids sustainability within the built environment. By identifying this important issue, the behaviour of the public could be swayed towards sustainable energy-efficient buildings. A structured questionnaire, comprising nine questions, was sent to 165 architect firms across South Africa. The subjects were asked to grade their responses on a Likert scale in order to tally the frequency of responses which were then converted into percentages. The results indicated that sustainability plays a role in the architects' design and that they regard energy-efficiency building standards as important. Although the clients seldom request energy-efficiency advice for building design, the architects often advise their clients. Passive solar design and the type of external wall are important and necessary for energy efficiency and thermal comfort in a building, resulting in substantial energy saving. It was found that the perception of the public towards energy efficiency in buildings needs to be changed. This may be done by convincing the public of the importance and benefits of energy-efficient buildings by using external walls and passive solar design.

1. INTRODUCTION

The single most important element of a building's character is probably its external walls. The external wall needs to be strong, stable and durable, resisting the weather and ground moisture as well as the passage of heat as well as airborne and impact sound. The external wall should provide security and contribute to fire safety. These are the typical functional requirements of the external wall (Barry cited in Potgieter, 2008: 5).

Energy efficiency has increasingly become the subject of attention within the design and operation of buildings as the built environment has been shown to make a substantial contribution to environmental degradation. It has been estimated that approximately 15% of the world's fresh-water resources and 40% of the world's energy are used by buildings through construction, operations and deconstruction impacts. It was also found that approximately 23-40% of the world's greenhouse gas emissions are produced by buildings (CIDB, cited in Gunnell, 2009: 3). There is an apparent need for sustainable construction.

One of the strategies to reduce or eliminate the negative impact of buildings on the environment and its occupants is to focus on the energy efficiency of a building (Gunnell, 2009: 6).

It is also known that the external wall contributes to the energy efficiency of a building due to its traditional thermal mass properties that allow for natural warming and cooling within a structure.

Natural warming and cooling is achieved by integrating a combination of features into the building design to collect, store and distribute solar energy (heat) by welcoming the heat in the winter and rejecting it in the summer. This concept of design is referred to as passive solar design (NREL, 2001: 1). The theme of passive solar design revolves around achieving indoor thermal comfort by naturally ventilating and heating buildings through climate conscious design. Thermal comfort may be defined as the reaction of human beings to climate factors. To achieve thermal equilibrium the human body reacts to thermal deviations (cold or hot). This equilibrium is known as thermal neutrality which essentially is thermal comfort. Indoor thermal comfort is achieved by the energy which is used for the heating and cooling of space. Therefore, a designed building that makes use of a minimum of artificial heating or cooling in order to achieve thermal comfort is an energy-efficient building (Holm & Engelbrecht, 2005: 9).

The need for energy-efficient buildings in South Africa has been noted as building standards have been published by the South African Bureau of Standards (SABS) for energy efficiency in buildings. Requirements for energy efficiency through the external walls have been included (SABS, 2010: 8). It should be noted that the requirements pertaining to the thermal resistance together with the thermal capacity or thermal mass presented by the external walls, which is appropriate for the energy-efficiency improvement of buildings, has in no country been included in such legislation that is mandatory. This is despite the availability of well-documented building physics which may assist designers (Holm & Harris 2010: 3).

There is a voluntary standard, SANS 204 of 2010 (Committee Draft), which incorporates thermal mass into the requirements for external walls by requiring a minimum thermal capacity and resistance product (CR Product) in hours for the different building occupancy types within the different climatic regions in South Africa (SABS, 2010: 8). The CR Product of the external walls enhances and ensures thermal comfort in buildings and is therefore a step in the right direction towards energy efficiency. Life Cycle Cost evaluation was also compared so that financial justification could be provided for specifying the amount of active thermal capacity that is necessary to ensure comfort in buildings, for various types of occupancy, in the varying climatic regions of South Africa (Holm & Harris, 2010: 3).

Given this profound research, this is all in vain if the public (clients requesting buildings) and the designers of buildings do not use or implement energy efficiency in buildings. A study was therefore necessary to determine the mindset of designers and their perception of their clients' needs towards energy efficiency in buildings and the role of external walls.

2. RESEARCH

Since the energy-efficiency standards and regulations are affected nationally, the study was extended throughout South Africa where the chosen subjects for the study were architects registered with the South African Institute of Architects (SAIA). This method of data collection is a descriptive method involving the opinions of respondents. However, a platform for analysing the data is provided by

using the Likert scale where subjects grade their responses on a scale between 1 and 5.

The questionnaire consisted of nine questions, each capturing an important element to the identified problem. Each question had its own separate answers on an intensity scale. The subjects were given a brief description of the study to give them an idea of the study without leading them towards a certain opinion, so that they themselves decide the appropriateness of each question. The questions involved the role which they thought sustainability had within designing buildings and the importance of energy-efficiency standards along with the advice which clients may require and be given. The questionnaire also included the use of passive solar design and the likely importance of internal thermal comfort and its natural attainability by means of the external walls, along with likely energy savings.

3. RESULTS AND DISCUSSION

The questionnaire was successfully sent to 165 architect practices, of which 24 responses were received. This equates to a response rate of 14.5%. The frequencies of the responses were calculated and converted into percentages for each question. These results were then tabulated. The tables and discussion for each question follow.

Table 1: Role of sustainability within building design

Question: How often does sustainability play a role when designing a building?		
Possible answers	Frequency (N=24)	Total % (100)
1 - Never	0	0.00%
2 - Hardly ever	2	8.33%
3 - Sometimes	5	20.83%
4 - Most of the time	10	41.67%
5 - Always	7	29.17%

Table 1 shows that 70.84% (41.67% and 29.17%) of the respondents were of the opinion that sustainability plays a role when designing a building either most of the time or always. This indicates the importance thereof and, should the results of this question be used and architects consider these in their designs, it may be safe to say that there is a committed movement towards sustainable development through the role of sustainability in the building designs of architects. Only 8.33% believed that sustainability hardly ever has a role in designing a building, whereas the remaining 20.83% of the respondents were of the opinion that sustainability sometimes has a role in building designs.

The subjects of the empirical study were then asked to rate the importance which they thought energy-efficiency standards may have for buildings. The results are shown in Table 2. Only 4.17% of the respondents mentioned that energy-efficiency standards for buildings are of little importance. This means that 95.83% of the respondents were of the opinion that energy-efficiency building standards are important. The opinion of 12.50% of the respondents was crucial; 50% believed

that these standards are very important and 33.33% mentioned just important. Nonetheless, these energy-efficiency standards are regarded as an important platform for achieving sustainable energy-efficient buildings.

Table 2: Importance of energy-efficiency standards for buildings

Question: How important do you rate energy-efficiency standards for buildings?		
Possible answers	Frequency (N=24)	Total % (100)
1 - Not important	0	0.00%
2 - Of little importance	1	4.17%
3 - Important	8	33.33%
4 - Very important	12	50.00%
5 – Of utmost importance	3	12.50%

Another question was asked as to whether these standards, as published in SANS 204 and SANS 10400 XA, are being implemented or not by architects in their designs. The answer to this question relies on the third and fourth question of the questionnaire based on the advice clients may require or be given.

Table 3: Clients' request for energy-efficiency advice

Question: How often do your clients require advice regarding energy-efficiency design for their buildings?		
Possible answers	Frequency (N=24)	Total % (100)
1 - Never	2	8.33%
2 - Seldom	10	41.67%
3 - Sometimes	2	8.33%
4 - Often	7	29.17%
5 - Always	3	12.50%

Table 3 shows that, according to 41.67% of the respondents, clients seldom request advice regarding energy efficiency for their building needs. On the other hand, 29.17% of the respondents were of the opinion that their clients often require such advice and a further 12.5% mentioned always. It may be presumed that, if 50% of the study's subjects' clients do not require advice about energy efficiency, this could be because they are not aware of the need for or possible benefits of energy efficiency within buildings. Clients may be aware thereof, but may be of the opinion that it could be too expensive. Whichever reason it may be, the solution is to properly promote to the public the need for and the benefits of energy efficiency within buildings, thereby attempting to shift the public's behaviour towards energy-efficient buildings.

This could be affected by informing the clients (public) of the potential benefits. It appears that the majority of architects are already doing so, as revealed in Table 4. The response from the subjects indicated that 50% of them advise their clients often and that a further 33.33% advise their clients always on energy-efficient techniques and design. Only 8.33% seldom advise their clients and a further 8.33% advise their clients sometimes.

Table 4: Subjects advising clients on energy efficiency

Question: How often do you advise your clients on energy-efficient techniques and design?		
Possible answers	Frequency (N=24)	Total % (100)
1 - Never	0	0.00%
2 - Seldom	2	8.33%
3 - Sometimes	2	8.33%
4 - Often	12	50.00%
5 - Always	8	33.33%

As the energy-efficiency standards are becoming mandatory, energy efficiency will need to be incorporated into a building's design by adhering to the National Building Regulations (NBR). It is therefore necessary to further question the subjects on passive solar design, thermal comfort and the role of external walls.

Table 5 shows that 45.83% of the subjects mentioned that they always use passive solar design principles and another 25% stated that they use such principles often. This indicates that 70.83% of the tested subjects use passive solar design principles regularly within their designs to achieve energy efficiency whereas the rest use it only sometimes (16.67%) and seldom (12.50%).

Table 5: Use of passive solar design principles

Question: How often do you use passive solar design principles for energy efficiency in your designs?		
Possible answers	Frequency (N=24)	Total % (100)
1 - Never	0	0.00%
2 - Seldom	3	12.50%
3 - Sometimes	4	16.67%
4 - Often	6	25.00%
5 - Always	11	45.83%

The subjects were also asked how much energy could be saved in buildings by using passive solar design techniques. All the subjects agreed that a saving in energy is achievable: that a reasonable amount of energy is saved, according to 33.33% of the subjects, and that a substantial amount is saved, according to 54.17% of the respondents, with 12.5% claiming that more than a substantial amount is saved. These results are indicated in Table 6.

Table 6: Energy saving obtained by means of passive solar design techniques

Question: How much energy saving can be obtained in buildings by making use of solar passive design techniques?		
Possible answers	Frequency (N=24)	Total % (100)
1 - None	0	0.00%
2 - Very little	0	0.00%
3 - Reasonable amount	8	33.33%

4 - Substantial	13	54.17%
5 - More than substantial	3	12.50%

Internal thermal comfort is achieved by using passive solar design techniques. The subjects were then asked about the importance of thermal comfort. The response, shown in Table 7, was convincing: 100% of the subjects agreed that internal thermal comfort is important; 62.5% of these subjects rated it as of utmost importance, and 33.33% as very important.

Table 7: Importance of internal thermal comfort of occupants

Question: How important would you rate internal thermal comfort of occupants within buildings?		
Possible answers	Frequency (N=24)	Total % (100)
1 - Not important	0	0.00%
2 - Of little importance	0	0.00%
3 - Important	1	4.17%
4 - Very important	8	33.33%
5 – Of utmost importance	15	62.50%

The effectiveness of natural means, by using passive solar design principles together with the type of external wall, to achieve internal thermal comfort of occupants is very effective, according to 54.17% of the respondents, whereas 8.33% of the respondents agreed that it was totally effective, and 33.33% thought that it was just effective, meaning that only 4.17% of the respondents were of the opinion that it was little effective. This result is shown in Table 8.

Table 8: Internal thermal comfort effectively attained by natural means

Question: How effectively can internal thermal comfort be attained by natural means?		
Possible answers	Frequency (N=24)	Total % (100)
1 - Not effective	0	0.00%
2 - Little effective	1	4.17%
3 - Effective	8	33.33%
4 - Very effective	13	54.17%
5 - Totally effective	2	8.33%

When asked about the importance of the external wall, 100% of the respondents were of the opinion that to some degree it was important, with 66.67% mentioning that it was very important, and another 16.67% that it was of the utmost importance. The remaining 16.67% maintained that it was plainly important. Table 9 shows the results.

Table 9: Importance of external walls in attaining thermal comfort

Question: How important is the type of external wall to attain thermal comfort within a building?

Possible answers	Frequency (N=24)	Total % (100)
1 - Not important	0	0.00%
2 - Of little importance	0	0.00%
3 - Important	4	16.67%
4 - Very important	16	66.67%
5 – Of utmost importance	4	16.67%

A combination of the analysis of these results indicates that the professional designers are mostly aware of the need for sustainability when designing a building which may be partially achieved by paying special attention to the energy efficiency of the building. According to legislation, this may become mandatory to consider and adhere to. A solution would be to use passive solar design principles together with the choice of external wall as a method to obtain energy savings and internal thermal comfort of occupants within the building, working towards sustainable development.

It was also noted that, although architects are advising their clients on energy efficiency, their clients are not always requesting or requiring such advice. This may be due to the current public awareness and/or perception of the benefits and costs involved.

4. CONCLUSION AND RECOMMENDATIONS

The results of the empirical study proved valuable in understanding the issue of energy efficiency within buildings. The type of external walls and passive solar design promote the thermal performance of buildings, essentially working towards achieving internal thermal comfort naturally.

It has therefore been confirmed that, according to the architects involved in the study, some members of the public need to be convinced of the importance of energy efficiency within buildings and of the role of the external walls. The architects themselves mostly provide their clients with advice concerning the energy efficiency of buildings. However, the question arises as to whether their advice is sufficiently effective to persuade their clients to consider opting for an energy-efficient passive solar designed building.

It is therefore recommended that the public be informed of the importance and long-term cost benefits of energy-efficiency walling in South Africa (where life cycle costing was considered in the formulation of the energy-efficiency walling standards in SANS 204 of 2010) in an attempt to shift the market perception towards sustainable development.

REFERENCES

Holm, D. & Harris, C.H. 2010. *The development of a rational basis for the selection of thermal mass and thermal insulation in external walling and a set of deemed-to-satisfy requirements for external walling in the SANS 204 standard*. South Africa: WSP Energy Africa.

Holm, D. & Engelbrecht F.A. 2005. Practical choice of thermal comfort scale and range in naturally ventilated buildings in South Africa. *Journal of the SA Institution of Civil Engineering*, 47(2), pp. 9-14.

Gunnell, K. 2009. *Green building in South Africa: Emerging trends*. South Africa: CSIR.

NREL. 2001. *Passive solar design for home: Energy efficiency and renewable energy clearinghouse brochure*. Applewood: NREL.

Potgieter, A.B. 2008. *Drywall systems*. Unpublished thesis. Bloemfontein: University of the Free State.

SABS. 2010. *South African National Standard 204: Energy efficiency in buildings (committee draft)*. Pretoria: SABS Standards Division.