

Issues in the Design and Selection of Sustainable Multi-Glazed Windows: a study of qualitative issues in Scotland.

Dr. G.F. Menzies (née Weir) BEng, PhD, CEng, MInstE, ILTM

Dr. J.R. Wherrett MA, MSc, PhD

School of the Built Environment, Heriot-Watt University, Edinburgh

Summary

Initiatives which address holistic sustainable development in the built environment are generally not adopted on a widespread basis. In terms of window design and component selection, financial related issues can dominate, resulting in less sustainable options being chosen; there are few incentives for designers and builders to select sustainable options. This paper will examine the results of a number of focus groups and in-depth interviews with professionals from the building industries. The aim is to elicit professional preferences in the design and selection of multi-glazed windows and to provide feedback which will act as a guide to architects, designers and specifiers alike in the selection of multi-glazed windows which meet sustainable development initiatives. The results presented herein are part of a longer-term project which will simultaneously consider the satisfaction of building end-users and the Life Cycle Assessment (LCA) of window components ⁽¹⁾ through a number of key and relevant case studies.

Acknowledgements

This research is funded by the Engineering and Physical Sciences Research Council (EPSRC). Thanks are extended to the many professionals throughout architectural practices and housing associations in Scotland for the time and effort devoted to focus group and interview work. Thanks are also extended to Nor-Dan (UK) Ltd for industrial support in terms of additional funding and client networking.

1.0 Introduction

Architects, building services engineers, designers and facilities managers are daily presented with a multi-disciplinary challenge in the design and operation of sustainable buildings: high quality indoor environments which provide thermal, aural and visual comfort are required, yet the challenge is to use raw materials, energy and resources sustainably.

“Principle 1: human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature” ⁽²⁾.

Industry, business and the professions must respond to these demands, with engineers, designers, facilities managers and other professionals taking the lead in developing a safe and clean environment for future generations to enjoy without compromise.

“Humanity has the ability to make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs” ⁽³⁾.

2.0 Background

In the UK and Western Europe buildings account for 50% of primary energy use (and the corresponding CO₂ production). This outweighs both transportation and manufacturing. World-wide, buildings account for 40% of energy use, 40% materials use, 25% timber use and 16% fresh water consumption. Multi-glazed windows play a significant role in the management of buildings; their design has influence over the choice of ventilation, heating and lighting systems, and their use in-situ affects thermal, aural and visual comfort. Their lifecycle from raw material extraction,

through manufacturing and use, to final disposal impacts extensively upon fuel consumption and gaseous emissions ⁽⁴⁾. The selection of materials used in window frames can also significantly affect the embodied energy of the window as a unit, and the building in terms of its sustainability; it is a well known fact that aluminium production is an energy intensive process ⁽⁵⁾, while UPVC can present many challenges in terms of longevity and recycling issues. Windows in dwellings alone are estimated to account for 6% of the total UK energy consumption ⁽⁶⁾.

The adoption of sustainable and energy efficient initiatives are, however, still not widespread in the industrial and commercial setting. Financial or performance related issues can dominate, leading clients and designers to choose less sustainable options in window design and component selection. Clients who are not responsible for the long term management of buildings tend to have little interest in running costs and energy consumption, while others are deterred by higher capital costs, despite the attraction of reduced lifecycle costs. Many remain wholly influenced by the performance of buildings in operation, selecting components which are perceived to permit greater control over the indoor environment and the comfort of its occupants, but which are less sustainable. It is not often recognised that both these criteria can be met in one well thought-out and designed window option.

Different responses tend to prevail amongst a variety of professional sectors (e.g. architects and consultants) and client sectors (e.g. building managers, private owners, local authorities). Compounding the problem is the fact that there are few current incentives in place to encourage clients and designers to select sustainable options.

3.0 Methods

The overall aim of this project is to elicit professional preferences for the design and selection of multi-glazed windows in new and retrofit building projects, and to provide valuable feedback to the design, specification and construction stages from a number of case studies. The purpose is to provide data, information and advice for the setting of clearer sustainability initiatives and policies.

The research has two distinct phases. The first phase concerns the attitudes, perceptions and choices of designers and specifiers with regard to multi-glazed windows using Focus Groups and Semi-structured Interview techniques. Focus Groups are an informal technique that can be used to help assess user needs and feelings both prior to the design phase of a project, and long after implementation. Following the focus group work, Semi-structured Interview techniques were used to make a series of comparisons and trade-offs in order to elicit preferences, providing a systematic way of establishing the relative values individuals place on different aspects of choice.

The second phase of the project will focus on the preferences and satisfaction of building users with the indoor environment via Post Occupancy Evaluation techniques throughout a number of case studies, and is due to be completed in early 2004. The combination of results from these two perspectives will help to identify any areas where there is a shortfall in consideration of sustainability criteria.

4.0 Results and discussion

4.1 Focus Groups

Focus groups often bring out users' spontaneous reactions and ideas and let the moderator observe group dynamics and organisational issues. The strength of focus groups lies in the dynamics of group interaction, providing insight into why certain opinions are held. Focus groups can improve the planning and design of new programmes, provide means of evaluating existing ones, and

produce insights for developing marketing strategies ⁽⁷⁾. Five groups were held: one in Edinburgh, one in Arbroath and three in greater Glasgow. Each group had a combination of architects, maintenance managers and housing association professionals. Meetings were held over lunchtimes, and typically lasted one and a half hours. All discussions were transcribed, in addition to notes being taken during the meetings. Examination of the transcripts allowed counts to be made of the number of times issues were identified as being of major importance.

Table 1: Issues of major importance in window selection

| Number of mentions | Issues |
|---------------------------|---|
| 9 | Maintenance, Performance |
| 6 | Aesthetics, Cost, Materials |
| 5 | Clients |
| 4 | Planning |
| 3 | Architects, Availability, Building type, Experience of supplier, Quality, Sustainability, Usability |
| 2 | Information |

4.2 Semi-structured interviews with architects

The theme of the semi-structured interviews were set, in part, by the outcomes of the focus groups. Participants were asked about:-

1. The relative importance of capital, running and lifecycle costs throughout the intended life of multi-glazed window units.
2. The relative importance of longevity, durability, maintainability and other sustainable development criteria of multi-glazed window units.
3. The importance of generating a 'green' image for their company/ client's company.
4. The importance of multi-glazed window specification in creating comfortable, productive working environments and the wellbeing of building occupants *per se*.

Using the most important issues from the focus groups, architects were asked to rank the following five criteria, from their own point of view and from how they believed a client would consider them.

Table 2: Rank of window selection criteria
(ranking from 1 – most important to 5 – least important)

| Issue | Average rank (Architect) | Average rank (perceived Client) |
|--------------|---------------------------------|--|
| Aesthetics | 2.48 | 3.73 |
| Cost | 4.09 | 1.50 |
| Maintenance | 3.61 | 2.77 |
| Materials | 3.17 | 4.14 |
| Performance | 1.30 | 2.68 |

The perceived attitudes of clients compared to the actual opinions of architects shows that there is a strong difference between the two groups. Architects consider the practicalities of performance and

the aesthetic and design aspects of a building first, whereas clients are more likely to consider the initial cost before considering performance and maintenance issues.

Respondents were asked to rank a number of different cost types, again from their own point of view, from the point of view of a client and for a hypothetical building which was to be built with sustainability as a high priority.

Table 3: Rank of different cost types for window selection
(ranking from 1 – most important to 5 – least important)

| Cost type | Average rank (Architect) | Average rank (perceived Client) | Average rank (Sustainable building) |
|------------------|-------------------------------------|--|--|
| Capital cost | 2.48 | 1.58 | 3.65 |
| Life cycle cost* | 2.22 | 3.42 | 1.22 |
| Maintenance cost | 2.43 | 2.21 | 2.83 |
| Running cost | 2.87 | 2.79 | 2.30 |

*Life cycle cost is the sum of capital, maintenance and running costs over the life of a given project.

In terms of the importance of different cost types, architects looked at the four costs on a fairly level basis, with none standing out as being far more or less important. The architects perceived that clients considered capital cost as far more important than maintenance or running costs, and that life cycle costs were barely acknowledged. This result was unsurprisingly reversed for a sustainable building.

It is interesting to note that while architects consider life cycle costs as the most important cost type for both general buildings and sustainable buildings, far more architects place life cycle costs as the most important criteria for sustainable buildings, emphasising that sustainability criteria are as important as they could be in general building design.

Client type and building type were clearly important issues for the focus groups, and the interviews sought to find out if architects believed these different situations affected the importance of various window selection criteria. Eight criteria were ranked by order of importance for four different building types.

Table 4: Overall rank of eight different criteria for four building types

| Criteria | Office, design and build | Office, owner- occupier | Dwelling, private | Dwelling, housing association |
|---------------------------------|---|--|------------------------------|--|
| Choice of materials | 2 | 3 | 1 | 2 |
| Comfort and productivity issues | 3 | 2 | 2 | 3 |
| Locality of materials | 5 | 6 | 5 | 6 |
| Reliability and maintenance | 1 | 1 | 3 | 1 |
| Re-use and recycling | 6 | 5 | 6 | 5 |
| Security issues | 4 | 4 | 4 | 4 |
| Source of power for manufacture | 8 | 8 | 8 | 8 |
| Transportation distance | 7 | 7 | 7 | 7 |

There was little difference between the four types of building. Choice of materials, comfort and productivity issues, and reliability and maintenance were considered the three most important in all cases, with source of power for manufacture and transportation distance unimportant for all four building types. Locality and materials, and re-use and recycling shared fifth and sixth place equally. The architects were finally asked to choose five criteria, from a list of sixteen, which they believed were the most important when considering which windows to select.

Table 5: Importance of window performance issues

| Number of times chosen | Criteria |
|-------------------------------|---|
| 25 | Thermal performance |
| 20 | Durability, Reliability |
| 17 | Choice of materials |
| 16 | Maintainability, Security |
| 9 | Light transmission |
| 8 | Availability of product information |
| 3 | Health and Safety issues, Selection of suppliers |
| 1 | Manufacturing company policy, Methods of manufacture, Source of power for manufacture |
| 0 | Ability to be re-cycled/re-used, Transportation, Use of local materials |

The criteria given to respondents were based on a number of performance and global environment issues. In the results, the six lowest ranked issues received either only one vote or no votes at all. While some respondents noted that they would like to have considered these elements, the performance issues had to be considered as the more important criteria.

In order to examine the interests of architects in sustainability issues, respondents were asked how important it was to their practices that they had a sustainable and environmentally friendly design criteria. In addition, they were asked whether environmental image was important to their clients. Out of 28 responses, 9 architects felt it was very important, and 17 quite important to have a sustainable and environmentally friendly design criteria. However, only two practices said that their clients often expressed an interest in their own company image, from an environmental perspective, with 8 of the responses showing that clients rarely or never showed an interest in this issue.

5.0 Conclusions and future action

The focus groups highlighted many of the issues to do with the design and selection of multi-glazed windows, from the viewpoint of architects, developers, maintenance officers and clients. It is clear that cost is an over-riding issue, both in publicly and privately financed developments. Only a very few of the architects spoken to had experience of a client who considered the long-term costs, embodied energy of the window and the policies of the manufacturers. In many cases, housing associations were noted as being more ‘enlightened’ than other client types.

From the interviews, it is clear that there is a wish within the architectural profession to consider environmental and sustainability issues in their designs. However, practical issues of performance, maintenance and reliability override the “softer” environmental issues like locality of materials, transportation issues, and source of power for manufacture, even in the most sustainable building – windows must be “fit for purpose”. There is scope for improving the sustainability of multi-glazed windows and from the manufacturing side this is being led by the Scandinavian and northern

European companies. It was found that many professionals accept the increased cost of slightly more expensive windows in order to improve performance and reliability.

To ascertain whether design decisions are effective and are contributing to sustainable development goals requires not simply efficient and effective initial evaluation techniques, but also monitoring of performance and continual feedback to assist in the review of design decisions. A post occupancy evaluation questionnaire will be used to gauge the level of satisfaction of building occupants with their indoor environment in terms of glare, temperature control, provision of appropriate lighting and aural comfort. Feedback of this nature will provide valuable information on the design and selection of multi-glazed windows, and will help to identify any areas where there is a shortfall in the consideration of the comfort and productivity of building occupants.

Life Cycle Assessment techniques ⁽¹⁾ will be used to assess the lifecycle energy consumption and associated emissions of windows specified in a number of case studies. This will account for embodied energy of materials, manufacturing, transportation and use. The type of building, patterns of use, modes of heating and lighting will also be considered for each case study. A comparison of the case study window type will be compared against a number of realistic alternatives, and feedback provided on the sustainability of choices made.

Feedback from both the objective and subjective analysis of the case studies will provide valuable information for the provision of future facilities. It will act as a guide to architects, designers and specifiers alike in the selection of multi-glazed windows which meet sustainable development initiatives, and which will simultaneously consider the full lifecycle of multi-glazed windows in terms of energy consumption, and issues associated with comfortable and productive working environments.

References

- (1) Weir, G. (1998), Life Cycle Assessment of Multi-Glazed Windows, Ph.D. thesis, Napier University, Edinburgh.
- (2) RDED, Rio Declaration on Environment and Development (1992), United Nations Conference on Environment and Development
- (3) WCED, World Commission on Environment and Development (1987), Our Common Future, Oxford University Press, Oxford.
- (4) Weir, G. & Muneer, T. (1998) Energy and environmental impact analysis of double-glazed windows, Energy Conversion and Management, 39 (1), 243-256.
- (5) Buchanan A.H. & Honey, B.G. (1994) Energy and carbon dioxide implications of building construction, Energy and Buildings, 20, 205-217.
- (6) DTI, Department of Trade and Industry (2000) Digest of the United Kingdom Energy Statistics, HMSO, London.
- (7) Krueger, R. A. (1994) Focus Groups: a practical guide for applied research, Sage Publications, London.