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A PROCESS MODEL FOR SUSTAINABLE DESIGN OF BUILDINGS

TOWARDS AN ADAPTABLE 'ROUTE MAP' FOR GREEN CODE COMPLIANCE

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ABSTRACT:

The paper relates an ongoing project whose aim is to construct a generic process model for the sustainable design of buildings.

The construction and use of buildings accounts for around 50% of 'greenhouse' gas emissions, making their design a key issue in the global challenge to cope with climate change. Accordingly, several codes and methods of measuring compliance have been designed. Starting with BREEAM and LEED in the UK and USA respectively, they have now proliferated, and some have been adapted for international use.

There is a brief comparative discussion of these methods. One of the main objectives of the work we are presenting is to integrate key sustainability design criteria within a workable building design process model. Basic process models for building design have existed for some time, and the suitability of a number of models is considered.

An account is given of the development of the sustainable design process model, its transfer into an electronic format, and its testing in the particular context of the newly-emerging green compliance code for Egypt. It is intended that he resulting sustainable design process model should be adaptable to any national or regional green compliance code. Its format will also enable the integration into the model of links to energy and carbon assessment tools and other performance simulation packages.

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Green codes, process models, sustainable design.

1. INTRODUCTION

There is global concern over the impact of anthropogenic climate change, a principal cause of which is believed to be the so-called ‘greenhouse’ gas emissions, and, in particular, carbon dioxide (CO_2). Taking the UK as an example, it has been estimated that about 50% of the country’s total CO_2 emissions come from ‘buildings and their appliances’ with ‘around one third of carbon emissions arising from the domestic sector alone’ (Tyndall Centre, 2005). This share will no doubt differ within and between countries, but will be significant in all of them. In fact, in their estimating of global benchmark thresholds for consumption and emissions by the various sectors, Zimmermann et al. (2005) use the same figure of 50%.

The overall challenge in seeking to reduce such emissions involves the location, design, construction, use and disposal of buildings. None of these activities can be ignored: an owner’s brief might severely limit the possibility of a low-carbon design; an innovative design solution might not be properly implemented at construction; and the ‘energy behaviour’ of the users of a building is at least as important as the potential ‘energy performance’ of the building that they are provided with by its designers and constructors (see, for example, Greenwood et al., 2009). Thus an environmentally excellent brief and design will not *per se* guarantee satisfactory results: they are necessary, but not sufficient conditions. However, whilst recognizing this, and not denying the other activities, the present paper is limited to consideration of the briefing and design stages of building projects.

Brandon (1999: p. 394) neatly summarizes ‘aspects upon which we must be clear’ if we are to achieve any of this. Briefly, these are:

1. A clear definition and understanding (‘of what we mean by sustainability’);
2. A shared understanding of the relationships between ‘the different complex factors contributing to sustainability’;
3. A robust classification system to enable modelling, communication, and greater knowledge;
4. A related measurement system that ‘allows progress to be calibrated’;
5. An integral ‘development and occupation cycle’ management framework that supports sustainability;
6. A decision making protocol that operates with the management framework.

Furthermore, Brandon continues, ‘a protocol for decision making must be established … which challenges those involved in the decision process to respond to sustainability in a positive way (Brandon, 1999: 392). In our present work we will refer to these aspects in turn, though we are operating on the assumption that there is a considerable amount of information already available on aspects 1-5 from the list. This should not be taken to imply that these are entirely clear, consistent or universally accepted; this is far from the case, as we shall see later. But it is the last aspect identified, namely, a ‘decision making protocol that operates within current frameworks’, that is the focus of our current work, and the basis for the process model for the sustainable design of buildings that this paper describes.

2. BUILDING PROCESS MODELS

Process modeling has been described as one of ‘the most important and fundamental elements of business process’ (Soliman, 1998) and particularly so when the issue concerns the re-engineering of a particular process. Decision processes can be conceptualized in two ways: one is by means of a ‘top down’ (structural modeling) analysis that focuses on an end result and finds a ‘best fit’ function to conjoin the information input with the required judgmental output; the other uses a (‘bottom up’) process tracing approach, that empirically maps the actual trains of thought that lead to a decision (see Svenson, 1979; Harte et al., 1994). The results of these analyses can be presented in a process diagram or flow chart, and a wide range of proprietary software exists to enable these to be held in digital form and represented on computer.

As far as the design of buildings is concerned one of the earliest and most enduring is the UK’s Royal Institute of Architects’ (RIBA) ‘Plan of Work’. Hughes (2003), comparing the (original) 1964 version of the document with a version published in 2000, observes that

> Although the RIBA plan of work is widely known and has formed the basis for organizing construction work for decades, the warning that accompanies it [sc. the 2000 Version] is ample evidence that it is inappropriate for today’s construction projects. (Hughes, 2003, pp. 303-304)

Figure 1, below gives an example of the two earliest stages (A and B) of the design process and of the level of detail involved.

RIBA Work Stages			Description of key tasks
Preperation	A	Appraisal	Identification of client’s needs and objectives, business case and possible constraints on development. Preparation of feasibility studies and assessment of options to enable the client to decide whether to proceed.
	B	Design Brief	Development of initial statement of requirements into the Design Brief by or on behalf of the client confirming key requirements and constraints. Identification of procurement method, procedures, organisational structure and range of consultants and others to be engaged for the project.

Fig.1 Example of the level of detail of the RIBA Plan of Work

Later revisions of the model (Royal Institute of British Architects, 2001; 2007) have addressed some of this criticism, and despite the provision of more comprehensive and arguably ‘smarter’ alternatives (see for example, Austin, et al., 1996; Cooper et al., 1998, Kagioglou et al., 1998) the model has remained the *de facto* reference for the building design process in the UK and many other parts of the world.

3. SUSTAINABLE BUILDING COMPLIANCE CODES

Regarding the primary requirement (see above) of ‘a clear definition and understanding’ there appears to be a general consensus on the adoption of the so-called ‘Brundtland’ definition of sustainable development, namely development that ‘meets the needs of the present without compromising the ability of future generations to meet their own needs’. (WCED, 1987). Like the more general concept of *sustainable development* the concept of *sustainable building* has been defined in a variety of ways. Without entering this high-level and abstract debate, we will assume that we are aiming at something along the lines of the approach of Zimmermann et al. (2005) namely, that:

> 'Buildings shall be classed as (ecologically) sustainable where the environmental loads resulting from their construction, operation and demolition/dismantling and their energy demand do not exceed their allotted share of the permissible environmental loads… [in terms of] …critical pollutant flows … and the permissible greenhouse gas emissions…' (Zimmermann et al., 2005: 1151)

The second item in our checklist is a 'shared understanding'. In the past, construction industry practitioners and researchers would frequently refer to the process 'from inception to completion' of a building (see, for example, Cherns and Bryant, 1984). Latterly, it has become more common to consider the whole process as including the *commissioning, use, renovation, alteration*, eventual *demolition* and (ideally) *recycling* of a building (see, for example, Pavitt and Gibb, 2003). This change is not least due to the need to consider issues of sustainability: all of the above stages have potential to consume energy and natural resources and to impact upon the environment and upon people. There is now a consensus that such over-arching issues as Sustainability, like Health, Safety and Security should be considered over this wider conceptionalization of the process.

Inevitably, when aspirations arise (such as the aspiration to design, build, and use buildings sustainably) there is a need for classification systems that allow actual performance to be measured against targets. In terms of sustainable building a number of codes and methods of measuring compliance have been designed; typically, they have been developed locally (starting in the UK and USA and now proliferating) and some have been adapted for international use. Two of the earliest and most familiar examples of these rating tools were BREEAM and LEED.

The Building Research Establishment Environmental Assessment Method (BREEAM) was developed from 1990 by the UK's Building Research Establishment (BRE). It is designed to enable 'developers and designers to prove the environmental credentials of their buildings to planners and clients' using a scoring system that purports to be 'straightforward transparent, easy to understand and supported by evidence-based research' maintained by 'rigorous quality assurance and certification' (BREEAM, 2009). The rating of a particular building design is made by the BRE itself based upon a report by an accredited external assessor. Under the basic 'BREEAM Buildings' scheme the scoring system involves the award of performance credits under the areas of Management, Health and Wellbeing, Energy, Transport, Water, Material and Waste, Land-use & Ecology, and Pollution. Scores are weighted and combined to produce a single score which in turn elicits a result of Pass, Good, Very good, Excellent, or Outstanding. As the system has grown in maturity the BRE has developed 'tailored criteria' within 'Bespoke BREEAM' versions that include law courts, healthcare facilities, industrial buildings, prisons, and offices. An international version exists and BRE offer assistance to countries or regions outside the UK that wish to create a local version.

LEED (Leadership in Energy and Environmental Design) is a system similar to BREEAM, developed several years later by the United States Green Building Council. Its levels are Certified, Silver, Gold and Platinum (USA, Green Building Council, 2010). The rating system is available 'online' and scores are accumulated under similar headings to BREEAM, namely: choice of site, water efficiency, energy & atmosphere, materials & resources, indoor environmental quality, locations & linkages, awareness & education, innovation in design, and regional priority. The similarities and differences between the two methods have been well covered elsewhere, and there are now many other such schemes available around the world. A reasonable sample is available in Lee and Burnett's (2008) paper describing their a systematic approach to benchmark energy assessment across a number of such systems. Another useful reference is a report completed by the Pacific Northwest National Laboratory for the US General Services Administration (Pacific Northwest National Laboratory, 2006) which compares five rating systems including BREEAM and LEED.

4. CREATION OF A SUSTAINABLE DESIGN PROCESS MODEL

As noted earlier, the overall aim of the project described in this paper was the construction of a process model for the sustainable design of buildings; a complex design process that reflected the decisions inherent in meeting typical sustainable design criteria.

In meeting that aim, a number of objectives were set for the process model to meet. These necessitated a model that:

1. integrated key sustainability design criteria within a workable building design process model;
2. recognised and addressed the impact of the actions of all the main participants in a project (client/owner, architects, 'other' designers and contractors) and not just the lead designer;
3. indicated, as early as possible, the implications upon time, cost, function and sustainability of decisions made at every stage of the process, thereby contributing to the optimization of time and cost whilst achieving the main objective of a sustainable and workable design;
4. was 'user friendly' to enable its use as a generic 'road map' for designers of sustainable buildings;
5. allowed for the later integration (through hyperlinks, for example) of 'add-ins' such as energy assessment tools, simulation packages, etc.

<u>Objective 1:</u> The standard 'technical content' of the building design process had to remain intact, whilst accommodation should be made for the new constraints imposed by environmental assessment methods (e.g. BREEAM and LEED). To start with, an assessment was made of available high-level process models for the building design process. Despite the shortcomings mentioned earlier, the 2007 version of the RIBA Plan of Work served as an adequate starting point (its lack of detail was, in this instance, a positive advantage, given the later task of having to accommodate decision criteria relating to sustainability). There followed an analysis of the most widely-used environmental assessment methods; (principally BREEAM and LEED) and their synthesis of these environmental assessment methods into a coherent whole that we considered to be potentially a generically applicable scheme. Members of the research team are accredited assessors and have experience of administering many such assessments.

<u>Objective 2:</u> In extending the model to 'other parties' i.e. beyond the remit of the traditional RIBA Plan of Work (which concentrates exclusively upon what the architect does/should do) we followed the approach of the critics of such an approach in their belief that 'the successful construction or manufacture of a building or product can only be achieved if all external (suppliers and consultants) and internal resources are utilized and coordinated effectively' (Cooper, et al., 1998). This, of course, added to the complexity of the resulting model, as it did with the 'The Process Protocol' of the above-mentioned authors.

Figure 2, below, is an extract from an early prototype of the process model, the intention is not to convey the actual content of the model, but merely to illustrate its complexity (as shown by the proliferation of arrows between decision/result boxes).

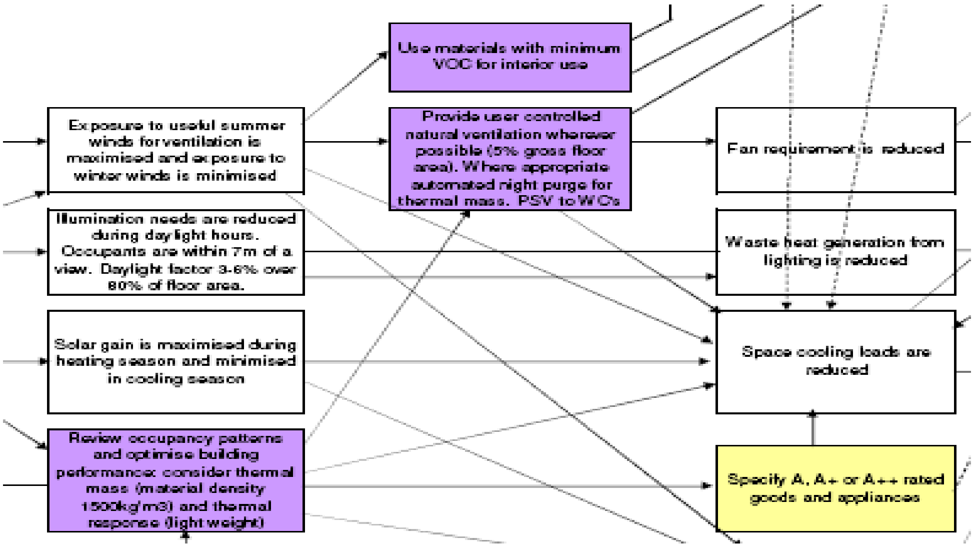

Fig.2 Example of the potential complexity of the model

The accommodation of this, and other objectives created a challenge, in that it resulted in increased visual complexity and negated Objective 4 (see below).

Objective 3: In order to highlight the implications of a particular decision upon another, further links were made, as in the example below (Figure 3).

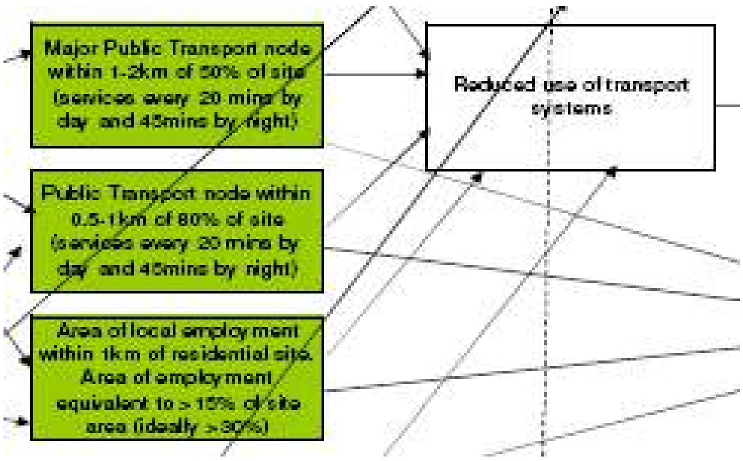

Fig.3 Example of decision implication links

In this example, the clear (unshaded) box represents the impact of an earlier decision ('Reduced use of transport systems'). Again, the complexity of the process itself and the desire to demonstrate the full consequences of decisions meant that as the model progressed it became rather unwieldy, again, as shown by the proliferation of arrows.

Objective 4: Making the process map 'user friendly' for designers of sustainable buildings was a key objective, but nevertheless one that presented a challenge due to the tendency to complexity created by the earlier objectives (see above). It was at this point that the project team decided to attempt to 'translate' the model into digital (computerized) form. This would enable the ready creation of three-dimensional models and offer linkages that would potentially 'de-congest' the prototype. There are numerous systems of business process modeling software; our selection was based on three criteria: (1) adequacy, (2) availability and (3) affordability. We selected ARIS Express (http://www.ariscommunity.com/aris-express) which is an entry-level tool that purports to be the world's first free business process modeling software, and is readily accessible via the Web. Figure 4, below, gives an example of the (less complex) representation of the model's elements.

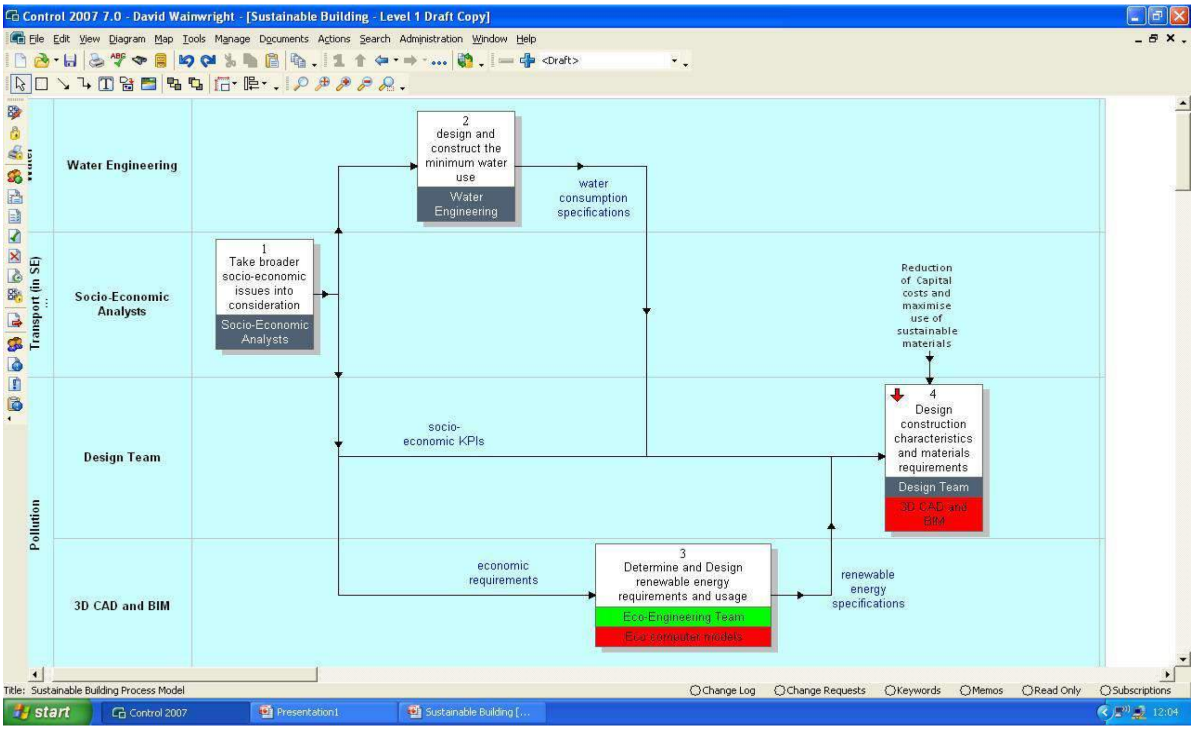

Fig.4 Example of 'ARIS Express' screenshot

Objective 5: Ultimately, the use of business process modeling software would enable the integration into the model of the energy assessment tools, simulation packages, and so on. We have not, as yet, experimented with this, but consider it to be a next stage in the development of the model.

5. APPLICATION AND TESTING OF THE MODEL IN AN EGYPTIAN CONTEXT

Whilst developing the model, the research team began work with the Egyptian Housing and Building National Research Center (HBRC), in Cairo. The HBRC is an independent governmental research establishment subordinate to the Ministry of Housing, Utilities, and Urban Development. HBRC carries out research in the various engineering specializations related to construction and is responsible for issuing all Egyptian building codes. As the body responsible for (amongst other things) developing and disseminating construction codes and technical specifications in Egypt, the HBRC has been instrumental in the formation, in 2009, of the Egyptian Green Building Council and the subsequent development of a national green building code and green building rating system, called Green Pyramid.

The Green Pyramid Rating System (GPRS), similar to BREEAM and LEED, will operate as a rating and certification scheme to define, encourage and incentivise sustainable building design and development. Its areas of focus, like similar schemes, include sustainable site development, water efficiency, energy efficiency and environment, materials selection and construction system, indoor environmental quality, design innovation, and recycling of waste.

At the time of going to press with this paper, the GPRS is in the final stages of its development, but this gave the research team an invaluable opportunity to work with colleagues at HBRC to test the 'transportability' of the sustainable design process model by adapting it, not to BREEAM or LEED, but to the Egyptian GPRS. This work is ongoing, and it is intended that the results of this application will be the subject of future publications.

6. CONCLUSIONS AND FURTHER WORK

This paper reports on an ongoing project to develop a process model for the sustainable design of buildings, that can act as a 'route map' for compliance with green building codes and rating systems.

The aim is for the model to be applicable to any typical national rating system, and a current project is testing this in the context of the Egyptian Green Building Council's Green Pyramid Rating System. If successful, the sustainable building design process model would provide a powerful and interactive tool for designers and constructors and, it is hoped, will make a modest contribution to efforts to meet the environmental challenges of building in the 21st Century.

If there is to be hope of meeting these challenges we consider it is vital that decision-makers involved in the design and development buildings become fully engaged with the demands for sustainable buildings that are being set out at national and global levels. We believe that this requires a realistic and, above all, a user-friendly normative process model that allows designers and developers to recognise where and when decisions on sustainability should be made, and with what implications. The completion of such a model remains our priority.

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