REPRESENTING AND ASSESSING SUSTAINABILITY IN CONSTRUCTION

Panagiotis D. Panagiotakopoulos[1] and Paul W. Jowitt[2]

[1]*School of Built Environment, Heriot Watt University, Edinburgh, EH14 4AS*
[2]*School of Built Environment, SISTech LTD., Heriot Watt University, Edinburgh, EH14 4AS*

The construction industry has recently started to face the challenge of operating in a more sustainable way. This paper presents a methodology based on System Theory and Mind Mapping that is appropriate to study the case of sustainability in a construction project. Results drawn from a case study that develops a sustainability reporting tool for a property development company are used to examine the methodology. The implications of the methodology and the case study in developing a Sustainability Management System for the company are finally shown.

Keywords: mind mapping, property development, sustainability, systems theory

INTRODUCTION

Following the international environment and sustainability summits and the increasing public demands for sustainable development, the construction industry has started to face the challenge of operating in a more sustainable way. The challenge of Sustainable Construction, as it is widely known, is often realised as a mainly technological problem, i.e. a matter of developing new, more efficient construction methods. During the last decade, however, the soft character of the problem has been recognised, which is realising the concepts and principles of sustainability and putting them into practice. This is a difficult task, as the problem of delivering and operating sustainable construction projects involves the realisation of many complex linked parameters and, based on them, making decisions for much extended spatial and time scales.

Many approaches have been developed to help organisations improve their sustainability performance. It is agreed by many, though, that the most appropriate one is the use of systems thinking. Systems theory principles and methodologies help in the structuring and solving of complex problems like those of sustainability (Kagioglou 2001, Ngowi 1998).

Research aim

The aim of the research is the development and application of a methodology that aids in the analysis and conceptualisation of sustainable construction. It uses Systems Theory and methodology combined with the Mind Mapping technique to capture and visualise ideas. It is applied and tested in the development of a Sustainability Management System (SMS) for a property development company.

[1] P.Panagio@hw.ac.uk, [2] paul.jowitt@sistech.co.uk

Panagiotakopoulos, P D and Jowitt, P W (2004) Representing and assessing sustainability in construction. *In:* Khosrowshahi, F (Ed.), *20th Annual ARCOM Conference*, 1-3 September 2004, Heriot Watt University. Association of Researchers in Construction Management, Vol. 2, 1305-11.

SUSTAINABILITY MODELS/ FRAMEWORKS

Since sustainability is still a very new and complex issue, there is not yet an agreed definition, model or frame work to conceptualise it and implement it.

Triple Bottom Line – 5 Capitals

When referring to sustainability, organisations usually mean balancing the Financial, Environmental and Social aspects of their activities, in other words their **Triple Bottom Line** (Elkington 1998). This approach is widely used to realise the organisation's sustainability aspects and to easily raise awareness. The **5 Capitals Model** (Ekins 2003) is more elaborate, in stating that the operation of the economy and every company is based on five forms of capital namely the *natural*, *manufactured*, *social*, *human* and *financial*, that need to be balanced.

The Natural Step

The Natural Step is promoted internationally as a framework with which to orient public and corporate decision-making towards socio–ecological sustainability. Its core principles (*systems conditions*) are intended as a scientifically defensible, minimal representation of the requirements of sustainability - that is, a "common denominator" upon which all should be able to agree (Upham 2000).

Sustainable Construction

In order to study the meaning of sustainability in construction, the above general approaches are intended to be integrated with more construction specific approaches, such as CIB's Agenda '21(CIB 1999), to formulate a framework that will be used as a reference throughout the research.

METHODOLOGY

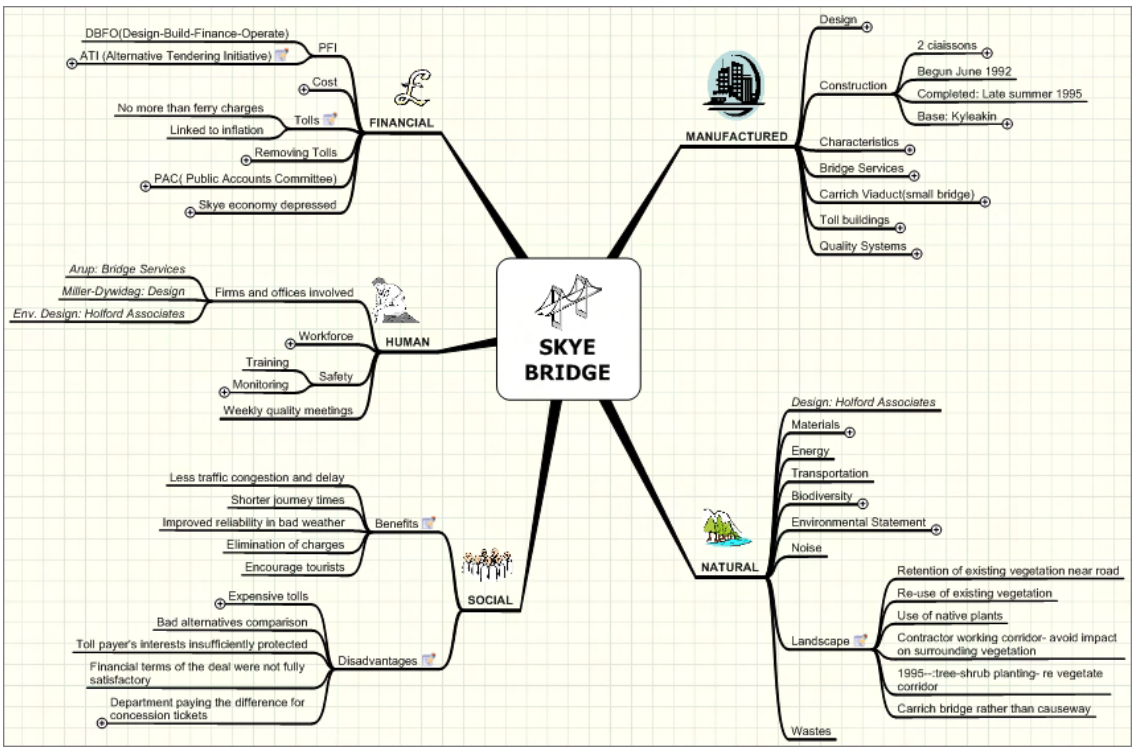
Mind Maps

Mind Maps, as proposed by Buzan (1993), are a way of drawing ideas that are particularly useful in brainstorming. They are extensively used throughout the research for brainstorming, as well as a data gathering tool, with the aid of the Mind Mapping software Mind Manager (www.mindjet.com).

Initially, Mind Maps were used in a small case study that attempted to compare the sustainability performance of the **Baltic Millennium Bridge** in Newcastle and the **Skye Bridge** in the Isle of Skye, using the 5 Capitals Model. The assessment was based on data available from the internet that were mostly qualitative (comments, written descriptions, judgements) and a few quantitative (construction characteristics, financial data). They were aggregated using the mind mapping technique, as shown in **Figure 1**, by representing each of the 5 capitals with a different branch and classifying the data under the appropriate branch. It must be noted that a redefinition of the model had to be made in order to be implemented for a construction project, since it originally aims to be used at the company level of operation. So while the original model is describing stocks and flows of different forms of capital, in the study they are rather used as different *sustainability aspects*. Also, the man-made capital was used in the broad sense of infrastructure and technical characteristics of the project, rather than material goods that contribute but don't get embodied in the output of the process. The conclusions drawn from the study were, first of all, that the 5 capitals model has certain limitations when used to assess a construction project. By regarding all the capitals of equal importance, it fails to capture the hierarchy and different

importance of the issues involved in such a complex system as a construction project. However, combined with the use of Mind Maps, it was found very useful in organising ideas and raising awareness for companies interested to realise their sustainability aspects.

Figure 1: 5 Capitals Mind Map of Skye Bridge



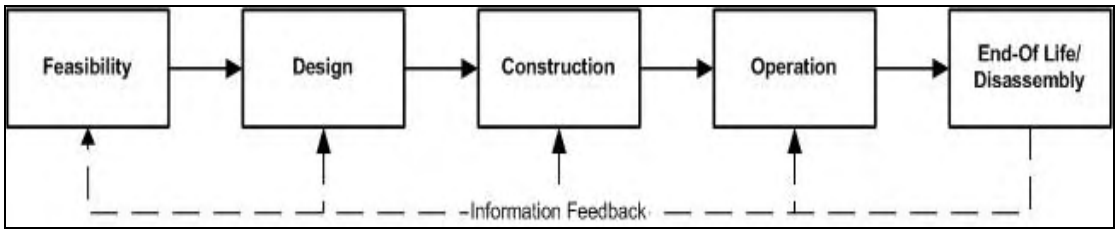
Systems Methodology

Systems methodology uses four steps to develop a systems model (Dekleris 1986) (Banathy 2000):

1. Identification of the system and setting of its boundaries. (*Where is the system?*)
2. Description of the role and function of the system in relation to its environment- higher system. (*What does the system do?*)
3. Description of the internal structure of the system. (*How is the system?*)
4. Description of the successive system states; evolution of the system through time. (*Where does the system go?*)

This methodology is used to analyze the construction project, which is one of the main research subjects. It was considered appropriate to first describe the evolution of a given construction project, since it usually extends to a large period of time and goes through a series of qualitatively different phases. Thus, the project is conceived as a flow of successive processes (phases) throughout its life cycle, in a way similar to the Life Cycle Analysis (LCA) methodology. These processes are the *feasibility*, the *design*, the *construction*, the *operation* and the *end-of-life*/*disassembly* as shown in **Figure 2**. They are effectively a series of interrelated systems, each having a different purpose and structure, which are now easier to analyse with the first three steps of the methodology.

Figure 2: Construction Project Life Cycle



Methodology Benefits

The benefit of studying the sustainability of a construction project with a systems methodology is, first of all, that the importance of the feasibility and design phase is immediately recognised. The decisions made at these stages affect the way the following systems of the life- cycle will operate, therefore affecting the sustainability performance of the whole project. Consequently, it is very important that the appropriate information feedback from the construction and operation phases is given to the design team, in order to design for better sustainability performance.

Moreover, by studying the relation of each phase to its operational environment, their sustainability impacts can be separated (e.g. energy used during construction and during operation) and their relative importance recognised (the energy used during operation is usually many times the energy used during construction). This systems view combined with the aforementioned sustainability Framework, allows for a better formulation of sustainability performance criteria.

CASE STUDY

Developing a reporting tool for a property development company

Project

The research case study is based on a consultation project that aims to develop a **Triple Bottom Line Report** for a property development company. The company is based in Edinburgh and its portfolio includes housing, retail, offices and area regeneration projects. The project requirements were to develop a reporting tool that would allow the company to annually report its sustainability performance to its various stakeholders. It was made clear from the beginning that this tool should not be a management system.

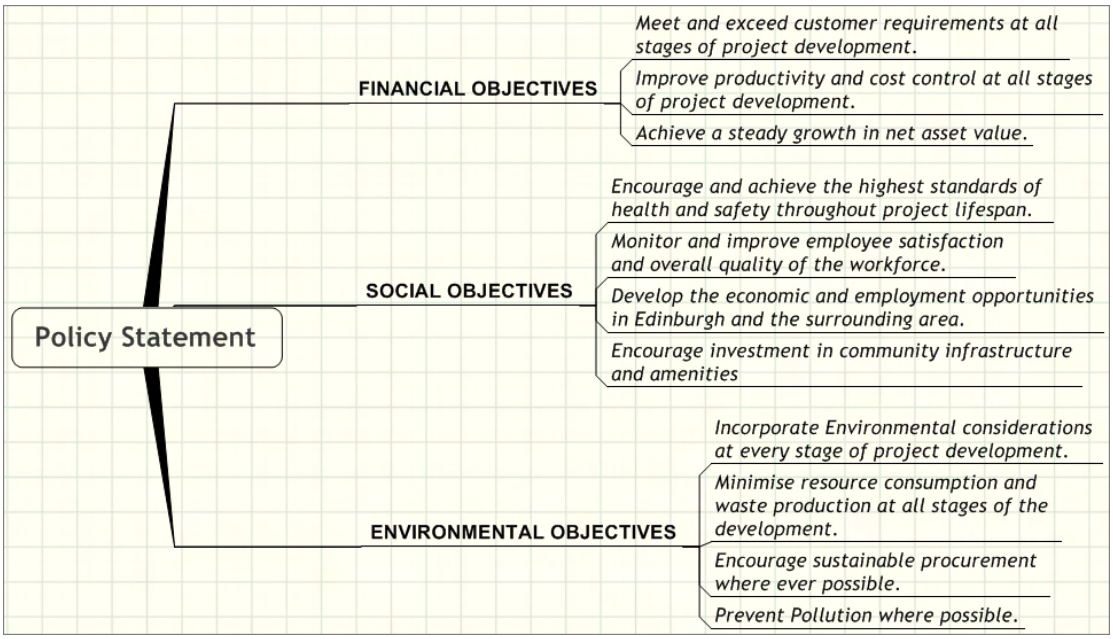
Reporting Tool

The first step in developing the reporting tool was to formulate the company's policy and from it to build a hierarchy of performance objectives and possible targets. This hierarchy was drawn in a Mind Map as shown in **Figure 3**. The use of Mind Maps was found to be very useful in ensuring top-level commitment to the project and in the staff training and raising awareness processes.

Next, a **Data Gathering Mechanism** was built that would perform an initial performance review of the company's projects. The mechanism had the form of a questionnaire based on Key Performance Indicators (KPIs) that are relevant to the company's operation. The KPIs were selected from various literature sources and were integrated to fit the policy and performance objectives. Moreover, the KPIs were customized to match the different development stages of each project (Design,

Construction, and Operation). The initial intention was to base the Data Gathering Mechanism on Mind Maps, by having the data entered directly into the Mind Manager software. This was not fully achieved and the data were finally entered into Excel spreadsheets that were all linked to a project Mind Map.

Figure 3: Policy and objectives hierarchy (objectives are indicative).



Feedback and Assessment

The data collection was carried out by interviews with the project managers. As it was expected, only a small part of the KPIs were eventually answered due to general lack of data and because the KPIs were proven to be too detailed. Nevertheless, the interviews provided valuable feedback to the project and a picture of the company's sustainability performance started to emerge. However, the collected data could not provide a sustainability assessment, so a second assessment was decided to be made. This time the assessment will consist of higher level sustainability categories, such as Resource Use, that the project managers will be asked to assess based on their value judgments. This way, the assessment is expected to serve as a driver for change within the company, until the Data Gathering Mechanism is improved.

Problems

In developing the reporting tool several problems emerged. First of all, the data feedback indicated that the control boundaries and responsibilities of the company were not sufficiently studied. This resulted, for example, in asking for data about issues that were not under the company's control and could not be available. This was the case in assessing the operation phase, as it is more affected by the client's behaviour rather than the owner of the building.

Also, the aggregation of the data to formulate a company level assessment was proven very difficult. This was due to the fact that the company's 'product', the construction project, has each time it is produced a different set of characteristics and context of operation. Consequently, the assessment can only be meaningful on a 'per project'

basis, with the exception of very few KPIs that could be aggregated across all the company's projects.

It is believed that some of the above problems could have been avoided or better resolved, if a systems methodology had been applied from the beginning of the project, such as the study of the system's boundaries (company) and environment (project context).

Towards a Sustainability Management System

The development of the project showed that it is very difficult to develop a reporting tool separately from a management system, as the company required. This is because in order to make an assessment of the company's performance, measuring systems should be in place that need to be managed in an integrated way across the company's operations. This integration is a central part of management systems, like ISO 14001 or EMAS. Producing the Performance Report is the last step of these systems and can happen only after the measuring mechanisms have been in place for some time.

However, these established systems are focused only on the environmental aspects of an organisation, not taking into account the social or financial 'bottom lines', while other systems manage only these aspects. There is not, as yet, a Sustainability Management System that would manage all three bottom lines of an organisation, with the exception of the SIGMA project (www.projectsigma.com) which is working towards this goal.

The research is currently focused on the development of such a system for a Property Development company, using the systems methodology and drawing from the experience gained from the case study.

CONCLUSIONS

As the literature suggests and the research so far has shown, Sustainability in Construction is a highly complex issue. A construction project is a long lasting 'product' that affects and gets affected by many different stakeholders. Applying technological solutions is simply not enough, when it is not creating new problems. A systems thinking approach, as used in this study, could help in simplifying the issue without losing the whole picture and eventually aid in the creation of a more sustainable built environment.

REFERENCES

Banathy B. (2000) *A taste of systemics* (*www.isss.org/taste.html.)*

Buzan T and Buzan B (1993) *The Mind Map Book*, BBC.

CIB (1999) *Agenda '21 on sustainable construction*. CIB Report Publication 237

Dekleris M (1986) *Systems Theory of State and Law,* Komotini: Sakkoulas.

Ekins P et al. (2003) A framework for the practical application of the concepts of critical natural capital and strong sustainability, *Ecological Economics,* **44,** 165- 185.

Elkington J (1998) *Cannibals With Forks: The Triple Bottom Line of 21st Century Business.* New Society Publishing

Kagioglou, M, Cooper, R, and Aouad, G (2001) Performance Management in Construction: a conceptual framework. *Construction Management and Economics,* **19**, 85-95.

Ngowi A. B. (1998) Is construction procurement a key to sustainable development?, *Building Research and Information* **26**(6), 340-350.

Upham P. (2000) An assessment of The Natural Step theory of sustainability. *Journal of Cleaner Production*, **8**, 445-454.