A PARADIGM SHIFT TOWARDS WHOLE LIFE ANALYSIS IN ADAPTABLE BUILDINGS

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Abstract
Economic evaluation is a significant consideration in the initiation of a facility. This evaluation process should take into account all costs, benefits and performance associated with a facility in its through life cycle. There are a number of techniques available for economic evaluation, however, the practical application is poor in most of the techniques. Whole Life Analysis (WLA) is identified as a comprehensive approach for economic evaluation. At present there is a growing trend towards designing buildings to be more adaptable within the UK property market. Hence, economic evaluation of adaptable buildings needs to be undertaken as early as possible for appropriate long term decisions. This paper examines the paradigm shift required for a WLA approach for adaptable buildings while identifying the benefits and barriers of its practical application. A comprehensive literature review was undertaken to analyse how WLA could be used as a decision support technique for adaptable buildings. Literature reveals WLA as one of the best decision support techniques for use in the building industry, and it seems logical to adopt it for adaptable buildings. However, detailed economic evaluation remains an untapped area within adaptable buildings. Being involved in the 'Adaptable Futures' research project at Loughborough University, the authors have blended their thoughts with available literature and attempt to identify how important in undertaking WLA is for an adaptable facility while identifying the barriers of current applications. Stakeholder input is crucial towards the betterment of WLA particularly concerning its understanding and application in adaptable buildings.

Key words: economic evaluation, whole life analysis, adaptable buildings, barriers, benefits, stakeholders' role

INTRODUCTION

Economic evaluation is a mandatory process which has frequently been undertaken in today's business world. Simply stated it's an analysis of costs, benefits and performance of a facility during its whole life with a main objective to find the optimal solution that provides the greatest benefits at the lowest cost (Kirk and Dell'Isola, 1995). The total construction duration of many buildings are considerably longer than that of manufacturing products. The main reasons lie in traditional construction, procurement practices and product behaviour. Hence, buildings tend to fail in capturing future business markets and exceed expected budgets. In this sense, the use of economic analysis to evaluate alternative construction materials, assemblies, and building services to minimise unnecessary cost is essential. Although mushroom businesses have a high turnover (quickly enters to the market and suddenly disappears). As a result building redundancy can occur because the available space doesn't fit the next purpose. If the building could accommodate this change the developers might not loose time and profit margins by refitting the available space/building for the intended next use. Many buildings are designed for long structural lives although they face a number of functional transitions during the cradle to grave life span. Kincaid (2000) noted that many structures have survived over hundreds and in some cases thousands of years, while they are performing functions for present day requirements. Structural robustness of a building is of paramount importance when buildings are designed for long lives. However, building redundancy/vacancy is one of the problems currently faced by UK property developers. The main reason is that existing stock is not functionally adaptive to fit a reseasonable range of purposes; while alternatively, scrap and build doesn't appear as an economically viable or environmentally sustainable solution in most cases. Hence there is an urgent need to construct buildings with a greater capacity for future transformations with minimum change to the main structure.

Therefore, we define adaptable buildings as dynamic systems that carry the capacity to accommodate a set of evolving demands regarding space, function, and componentry. A maladaptive building is one which can not match the new demand placed upon whether being technically unviable or cost inefficient. The line between the two can often become blurry, and depends on a set of exogenous and endogenous demands which through careful evaluation can be determined. Open building design provides a similar conceptual philosophy, but falls short of providing a clear criteria for evaluation, and focuses primarily on the separation of long and short-term componentry. At present, a growing demand for adaptable buildings can be seen in the UK property market. In fact, property developers are more interested to foresee the returns on their investments in adaptable properties. However, economic evaluation of adaptable buildings needs to be conducted to provide the needed 'hard' evidence to show these buildings provide a more economically sound answer than a more typical fit-to-use solution. Capital cost itself is no longer the only deciding factor for initiating a facility in the 21st century moving far beyond that criterion towards whole life thinking. The report on *Rethinking Construction* noted that many construction clients are interested only in the finished product, its cost, whether it is delivered on time, quality and functionality (Egan, 1998). In addition the report clearly identifies the role of Government initiatives and the desires of sustainability towards the economic feasibility of current projects in the UK. Although, there are a number of techniques available for economic evaluation, the selection of a proper tool depends on the context and the availability of project information. Literature suggests simple payback, cash flow, discounted cash flows, net benefits – net savings, benefits to cost ratio/ savings to investment ratio, internal rate of

return, overall rate of return, net present value as tools which can be used for economic evaluation of products (Ellingham and Fawcett 2006; Ashworth 2004; Ruegg and Marshall 1990). In the past construction clients focused on initial cost reductions; where as today's clients expect 'value for money' from their products. Therefore it is necessary to select a proper economic evaluation tool in advance, which delivers value for money.

The technique, Whole Life Analysis (WLA) takes into account the present value of future costs and benefits of a product and uses discounted methods to evaluate them in monetary terms. More specifically this paper addresses how WLA could be used as an economic evaluation technique for adaptable buildings. It appears the role of WLA as a future decision support tool is desirable; however, the practical dissemination of WLA is considerably poor in the building industry especially in adaptable building markets.

RESEARCH METHODOLOGY AND DATA COLLECTION

This paper is based on the findings from a comprehensive literature review undertaken in two phases. The first phase identifies and defines WLA and its current application in the construction industry. The next phase looked at adaptable building technology and its benefits for existing demand and supply. The authors' main intent is to propose how important it is to evaluate the economic cost/benefits of adaptable buildings for property developers and in essence how WLA could be used to achieve this target. Information is gathered from journal articles, conference papers and books relating to the subject area. In addition the thoughts of the authors were blended together with available literature in an attempt to identify existing gaps in literature relevant to whole life analysis for adaptable buildings.

LITERATURE REVIEW

Building redundancy is identified as one of several critical issues in the UK property market. The problem occurs due to factors like building depreciation and/or obsolescence. Hence some designers are interested in designing buildings for adaptation which provide a more economically and environmentally sound answer. On the other hand, the UK government has made a decision to make all its construction procurement choices on the basis of Whole Life Cost (WLC) – as stated in the HM Treasury guidance (BSRIA, 2008). As well as, WLA has started to become an important approach because of environmental concerns and the concept of sustainability (Kirk and Dell'Isola 1995; Bakis *et al.* Cited 2003 Flanagan and Jewell 2005, Ruddock 2007). Moreover, they clearly have identified the capability of the WLA approach to cope with sustainability issues and WLC considerations while dealing with future risk and uncertainties. Hence it is of interest to evaluate the practicality of undertaking WLA for adaptable buildings while identifying the benefits and challenges of the approach. In fact it is a dynamic approach which provides up-to-date forecasts on cost and performance throughout the building life (Boussabaine and Kirkham, 2004).

The meaning associated with WLA has changed over the years and the technique has previously been referred to as terotechnology, Life Cycle Costing (LCC), through-life-costing, costs-in-use, total life costing, total cost of ownership, ultimate life cost, total cost and whole life appraisal (Kirk and Dell'Isola 1995; Hodges 1996; Seeley 1996; Whyte *et al.* 1999; Edwards *et al.* 2000, Bakis *et al.* cited 2003, Flanagan and Jewel 2005). LCC is the term frequently used in construction for the investigation of the total cost of a facility. The term 'Whole Life Analysis' is used in this study to mean a 'systematic consideration of all

costs (including the initial capital cost and cost of adaptations), benefits, risk and performance of a building for its total functional lives expressed at present day values'. However the performance of a facility is subjective in nature and difficult to measure in monetary terms. Hence, weighted evaluation methods will be used to calculate the performance of the facility. The term *'total functional lives'* is used in preference to '*whole life'* to emphasise that adaptable buildings have a higher capacity to accommodate future functional transitions (i.e. changes in use). Literature suggests that designing for long structural life and making the building fit for future re-arrangements are significantly cost effective solutions which minimise building redundancy whilst optimising sustainability (Geraedts, 2008). This simple separation between long-term asset (base building) and short-term depreciation opportunities (infill) is the leitmotif of open building philosophy (Kendall 1999, Kendall and Teicher 2000).

WLC can be used as a decision making technique, management techniques as well as a maintenance guide (Kishk *et al.* 2003, Flanagan and Norman 1983). As a decision support tool, Flanagan and Jewell (2005, p.2) suggest that '*WLA is not about spending more; it is about making the right decision at the outset or even during the operating phase'*. Sherif (1982) stated that LCC is becoming more important in all market areas, with reliability and maintainability as the most predominant factors in decision making. Similarly Brand (1995) proposes LCC as a critical tool to assist strategic thinking with buildings. Moreover, this technique can be used to ensure the most advantageous combination of capital, operation, maintenance, and adaptation costs. Taylor (1981) proposed that LCC can be used as a forecasting tool to evaluate alternative planned capital expenditures with the aim of ensuring the optimum value from capital assets considering all future costs and benefits in present day values. However, the ultimate answer depends on future assumptions whilst it involves high risk and uncertainty. It seems a lot of research has been undertaken in the area of economic analysis, although the practical application of WLA is still in its' infant stage. Almost all explanations available for WLC confirm its ability to measure the tangible cost and benefits of a facility, however; the hidden costs/benefits associated with social and environmental issues remain untapped.

The application of WLA in buildings is not a straight forward process. Buildings are complex and the interaction of individual building elements change the WLC in diverse ways (Flanagan and Jewell, 2005). Although there are a number of cost models available for WLA in buildings (Durairaj *et al.* 2002, Sherif 1982) no one has attempted to evaluate the total cost changes related to building adaptations. There is an immediate need for adding the cost of adaptation to the WLA process with recent (demands for) adaptable buildings. A correct application of this technique for adaptable buildings might provide hitherto unimagined economic benefits to its investors. Hence, this approach is most applicable for structures with long structural and short functional lives (i.e. office buildings, apartment blocks). Moreover, the UK treasury requirement is to undertake WLA for major projects, which are procured through design and build, project finance initiatives / prime contracting or National Health Service's estates which procure 21 procurement systems (Constructing Excellence, 2008). The use of WLA in the private sector makes good sense if all parties are to achieve long term economic systems and buildings (BSRIA, 2008). Moreover, '*Constructed facilities are erected with ever shorter time horizons in mind because their owners are facing an ever more uncertain economic environment'* (Bon and Hutchinson 2000, p.313). Ive (2006) developed an economically valid conceptual framework for buildings which analyses data and calculates mean ratios for buildings with any function in any country. In addition, although literature revealed economically sound frameworks and cost models for WLA; they lack

consideration of adaptability. Therefore the importance of developing a framework for evaluating the economic costs and benefits of adaptable buildings was recognised. Even though the principles of WLA are strong in theory but poor in practical application (Kishk *et al.*, 2003) benefits can be obtained if WLA is taken into account at the earliest stages of design, and in setting initial budgets (Constructing Excellence, 2008).

WHOLE LIFE ANALYSIS FOR ADAPTABLE BUILDINGS : HOW PRACTICAL IS IT?

To survive in the competitive market manufacturers have to consider strategies for reducing the cost of the entire life cycle of a product. On the other hand, building users are demanding efficient, reliable and low running costs for their facilities that are flexible and easy to adapt (Flanagan and Jewell, 2005). The cost of adaptability is a focal factor which helps decision makers reach economically sound decisions. Although, WLA provides an initial basis for understanding the immediate and long term benefits of increasing the capacity to accommodate change (Dell'Isola and Kirk, 1983), Douglas (2006) suggests that the cost depends on the size, quality, time, complexity and location of the work; whilst Mayr (2006) strongly argues that good design leads to optimal performance in meeting current needs and requirements. The present need is to minimise building redundancy by optimising the use of existing space for future demand through innovative and cost effective solutions.

The economic life of a building can only be best extended by adaption rather than just maintenance (Douglas, 2006). Thus, adaptable buildings provide economically sound benefits over the long term. However, Williams (1984) stated in several articles in the national and trade press that in many cases the cost of adaption of existing buildings is greater than building them from scratch. It clearly appears that building adaptation is a cost consuming process, when adaptable features are not incorporated with the initial design. Therefore, there is an immediate need for integrating an appropriate level of adaptable features within new construction for market oriented building customisation. More specifically, Slaughter (2001) sketched out the whole life cycles of adaptable and maladaptable facilities through a detailed literature review.

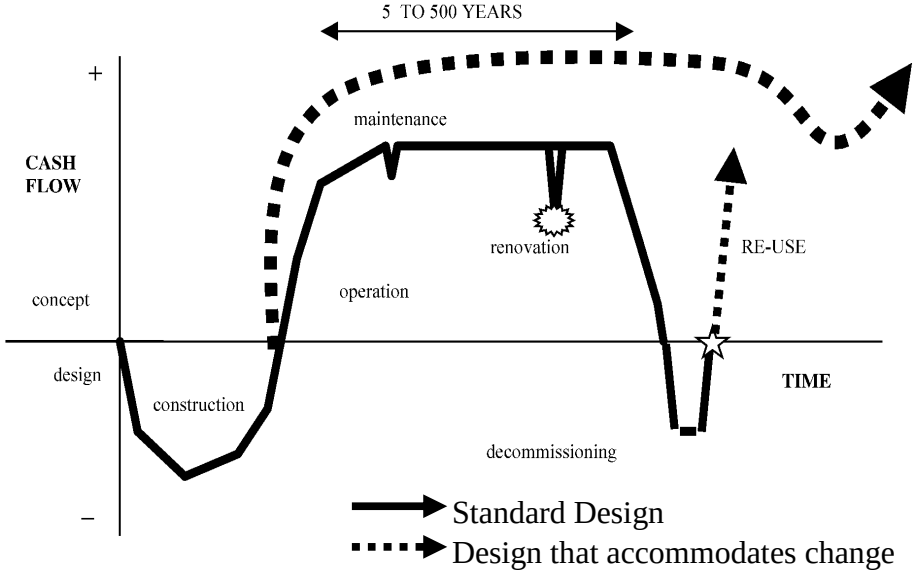

***Figure 1** : Expected life cycle of facilities and potential impact of design to accommodate change*

Source : Slaughter (2001)

Above diagram clearly illustrates the design which is flexible for change has a positive cash flow. Hence it can be assumed that adaptable buildings are more practical and income oriented process through their whole life cycle.

As an initial attempt for a paradigm shift in WLA towards adaptable buildings, the study identifies WLA as a function of all costs, benefits, risks and performance.

WLA = f\{(Expected future income) –(Initial capital cost + Cost of functional adaptation + Maintenance and operation cost $\pm$ Cost of demolitions) + Risk + Performance\}

Quantitative and qualitative variables are incorporated in the above formulae. Each variable needs to be analysed in detail. If the final answer is positive (+ value) the building adds more value for its end users. Cost of adaptation measured here is merely a cost belonging to the functional transition of a building. Any renovation, refurbishment or upgrade within the same function could be categorised under maintenance cost. When building incorporates adaptable features it is easy to alter it to a greater extent than rigid, maladaptable structures. Thus, the total time consumed for change is minimised and cash in-flows are continued quicker than maladaptable buildings - increases owner's profit levels. Moreover, Arge (2005) states that developers do invest in a certain degree of adaptability; however, the cost difference between what can be considered 'best practice' and 'worst practice' is somewhat minimal. The real benefit depends on how early and how often the need to change occurs in either function, space, or componentry. Even though in the current era of economic down turn in the UK, a growing demand can be seen for adaptable building solutions. The Government policies, and mushroom markets push the concept forward. Hence it is hoped that building adaptability provides both permanent and/or temporary solutions for building redundancy and obsolescence. Therefore it is important to evaluate the total cost and benefits of adaptability for a long term investment decision.

EXPECTED BENEFITS AND CHALLENGES OF WLA FOR ADAPTABLE BUILDINGS

Benefits and challenges of WLA in buildings have been identified by many researchers and recognised institutions (Constructing Excellence 2008, Ive 2006 Flanagan and Jewell 2005, ISO 15686 -V 2008). However, very few attempts have been made for applying this technique considering building adaptations. In addition a limited number of ongoing projects are available for the study on their practical adaptation. However the following benefits and challenges could be proposed when applying WLA for adaptable buildings.

Benefits

- The final decision derives from WLA representing the total cost commitment of a facility, risk and performance rather than limited to the initial cost only
- Provide high possibility to select the best alternative which fits for requirement
- Identify alternative ways to reduce unnecessary cost
- A higher degree of flexibility to react to changing business needs. Hence the developer can get an idea on how much he/she needs to spend in addition for new function/s
- The provision of a framework within which to compare options at all stages of development

Challenges

- Adaptable buildings (specifications/ written to a set of guidelines, with specific design intent) are new to the building industry, hence the practical application is poor
- Ignorance by the client and lack of awareness of importance of future costs (e.g. maintenance, cost of adaptation)
- Involves a level of risk regarding future application and depends on market demands and existing supply
- Lack of framework for collecting relevant data, together with standard techniques for modifying rule of thumb data to specific projects
- Lack of availability of adaptable building projects and reliable cost data
- The complex and theoretical relationship between money now and money spent or received in the future
- The long time lag between the design process and the data becoming available on the running/operating costs

Because of the aforesaid strengths and weaknesses of WLA approach it could be used for evaluating adaptable buildings in their economic conditions. However; acquisition of precise cost information from previous 'adaptable' buildings is quite difficult. Thus, it is recognised that cost information from all the project stakeholders is necessary for the success of WLA in adaptable buildings. It helps the client to make a correct economic decision about his/her product in advance.

STAKEHOLDERS' ROLE TOWARDS THE SUCCESS OF WHOLE LIFE ANALYSIS

Building construction is a complex process that needs to involve the supply chain if it is to be successful. In between the initiation and the demolition of a building, many stakeholders influence the building demands according to their needs and requirements. A WLA process must reflect the many inputs from these stakeholders across time if it is to be successful. The client/ developer must have a clear idea on the cost of land, professional fees and other design related costs and expected future incomes. The financial institutions must contribute through loan/credit facilities and establish interest rates which can be used in WLA calculations. Contractors, sub contractors and suppliers precise cost estimations on initial capital and subsequent adaptation cost play a vital role towards the accuracy of WLA as do maintenance and operation costs of the building after completion. These can be gathered from facilities managers and particular project quantity surveyors. Finally, all these measurable costs/benefit information are expressed in present day values. It can be seen therefore that the project stakeholders hold critical knowledge and play key roles in the betterment of WLA for adaptable buildings. Their contribution towards the information supply controls the accuracy of the WLA outcome.

CONCLUSIONS

Adaptable buildings are identified as a leading requirement of the UK Government; however, adaptable features for the most part lack in the existing building stock, and it tends to be economically unviable to rearrange them as adaptable. Therefore modern construction industry led approaches need to consider how to ensure adaptable features are included at the earliest possible phase of design. Literature reveals the initial capital cost of adaptable

building as a critical challenge, although the cost in-use is comparatively low in adaptable buildings. Therefore the analysis of whole life cost/benefits of an adaptable facility is a critical milestone in long term decision making. In a sense, designing buildings for a long structural live and short functional live is identified as one of the economical and environmentally well balanced requirements. Moreover, it was identified that WLA is the best approach available at the moment for evaluating total costs (including expected future costs) and benefits of a facility, however, the technique has some limitations.

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