ESTIMATING SERVICE LIVES USING THE FACTOR METHOD FOR USE IN WHOLE LIFE COSTING

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Abstract

Construction projects have traditionally been costed on the basis of the initial capital cost. The privatisation of many infrastructure providers, the use of private equity to finance construction projects for the public sector and ever-tighter constraints on public spending have generated demands in the UK to predict the overall cost of a project over its whole working life. This concern extends to demands for predictable building service lives and costs of ownership. Until very recently there have been no standard methodologies for approaching this problem. This paper explores the concepts included in whole life costing, in particular that of factored estimates of service life, and reports on the current commercial and practical issues driving adoption of whole life cost procurement of construction works.

Keywords: Factor method, service life estimates, whole life costs, standards, construction procurement, risk.

1 Introduction

Construction projects have traditionally been costed and funded on the basis of the initial capital cost. Privatisation of many infrastructure providers, use of private equity to finance construction projects for the public sector and ever-tighter constraints on public spending have generated demands in the UK and elsewhere to predict the overall cost of a project over its whole working life. This concern extends to demands for predictable costs of ownership. Until very recently there have been no standard methodologies for approaching this problem.

ISO TC59 SC14, Service life planning, is developing an International Standard, ISO 15686, Service Life Planning of Buildings. The first part is entitled “General Principles”. It provides a methodology for defining service life requirements during design and a basis for evaluating the ability of the design to meet the design life requirements of the client. In combination with part 5, Maintenance and Life Cycle Costing, (currently under development), this will give
a methodology for evaluating whole life costs, enabling designers or clients to address whole life cost issues and to estimate costs of ownership of a proposed project at an early stage of design.

Part 2 of the standard provides a generic methodology for predictions of component life based on known performance and rate of deterioration under proposed service conditions; part 3 addresses auditing of service life plans; part 4 covers data formatting and reporting and part 6 addresses sustainability in relation to service life planning.

This paper explores the concepts of whole life costing and estimation of service life, and reports on current commercial and practical issues driving adoption of whole life cost procurement of construction works.

2 Estimating service lives - ISO 15686 factored estimates

The Standard describes two approaches to the prediction of service life. Ideally, service life should be predicted from the known performance and rate of deterioration of the building and its components under the proposed service conditions. A generic methodology for such predictions is given in Part 2 of the Standard. However, the information required to make such a detailed prediction may not be available. In such cases, a method of estimating the service life, taking account of the available data, is available. This method is known as the Factor Method.

2.1 Reasoning behind the factor method of estimating service lives

The Factor Method is based on a concept developed by the Architectural Institute of Japan (AIJ, 1993) and Construction Audit Ltd (CAL, 1992). It is intended as a means of estimating expected service life when more accurate scientific prediction is not possible. It seeks to provide a common framework for developing estimates of service life in the absence of more reliable data. It is therefore an attempt to break out of the cycle of lack of data inhibiting service life prediction and lack of service life prediction suppressing demand for data, first proposed by Heller (Heller 1968).

A discussion paper by BRE (Bourke & Davies, 1997) gives details of the theoretical basis for the system, emphasising that the priority was to produce a simple system which could be readily adopted in advance of substantial extensions to the admittedly limited knowledge base on long-term performance of components. The proposed system has been modified in the light of comments from the international committee steering development of the standard, and comments from both academic and industry reviewers within the UK.

The adoption of the approach was considered to offer a means of forming a considered and objective assessment of alternative options or design solutions, but it was recognised that the performance assessment offered would not be wholly reliable. Since that date further commentary on the method has been offered, and several issues have been raised as potential changes or modifications to the approach. In particular, a paper by Hovde (1998) indicates proposed areas to improve reliability and user-friendliness, and a paper by Hed (1998) gives details of a project where the method was assessed.
Comments have indicated some unease with the factor method as set out in the draft ISO. Concerns include the misapprehension that the method provides a single value answer, rather than a range or distribution; the element of individual subjective judgement in assessing values for factors, and the possibility of providing misleading results. Each of these criticisms has value, and the method needs to be used with due attention to the changing state of the art of service life prediction. The standard demonstrates why urgent production of a simple working methodology, which recognised the limited knowledge base, dictated certain features of the approach. Criticisms have not prevented its fairly rapid adoption within the context of whole life costing of construction. Indeed, whilst the method has limitations, no other more suitable method of estimation has been proposed for use in the absence of accurate data.

2.2 Elements within factored estimates

There are three critical elements within a factored estimate: the required design life, the reference service life and the factors used to amend the reference service. If the estimate exceeds the required design life required then the proposed design meets the performance required.

The three elements in the estimating process are as follows:

2.1.1 Required Design Life

The required design life is the length of time for which the component is expected to remain serviceable, and is derived from the overall design. It is based on the client’s requirements.

2.1.2 Reference service life

The reference service life (RSLC) is the period in years that the component or assembly can normally be expected to last under specified service conditions. The Standard gives various sources for the basis of this assessment - but no schedule of reference service lives is provided - it was considered impossible to identify on an international basis what the normal anticipated performance would be. National schedules have been suggested as a possible route forward, and at least one standards committee in the UK has proposed a set of reference service lives for windows and associated sub-components. There are also commercially produced lists of expected service life for some components in particular building types, such as the Component Life Manual (CAL, 1992).

2.1.3 Modifying factors

The modifying factors represent deviations from the specified service conditions used to identify the reference service life - they cover materials, design, sitework, the environment, operating characteristics and maintenance. They are used to modify the reference service life by compound multiplication, as follows:
ESLC = RSLC x A x B x C x D x E x F

Where:
- ESLC = Estimated service life of component
- RSLC = Reference service life of component
- A = Material / Component factor
- B = Design factor
- C = Workmanship factor
- D = Internal Environment factor
- E = External Environment factor
- F = In-use factor
- G = Maintenance factor

Two particular aspects of the factors need to be stressed. First, there is no pre-defined set of factors. The user of the method needs to consider the particular circumstances of the project and decide the most appropriate factors for those circumstances. For example, the factor applied to placement of in-situ concrete in the Arabian desert in summer will be considerably different from that applied to take account of driving rain in Scotland. The method requires intelligent application if the old computing adage is to be avoided: garbage in, garbage out!

The method therefore provides a structured method for identifying and evaluating the factors which will increase or reduce the performance of the component or product under the likely service conditions. It is a method which needs to be applied by suitably experienced designers: it is not appropriate for slavish application of preset figures, but for careful and considered application to well defined problems by suitable professionals. Where there is insufficient data for firm prediction of service life this approach provides a reliable and structured method for estimating the service life. Where clients are insisting on a design with a whole life cost model such an estimate is essential.

3 Whole life costing definitions – how does it compare with life cycle costing?

Once it is established that a design option exceeds the required service life, it must be established whether it is the optimum option or not on the basis of predicted whole life costs. Whole life costing (WLC) provides a “rationale for choice in circumstances where there are alternative means of achieving a given object, and where those alternatives differ not only in their initial costs, but also in subsequent operational costs” (Seeley, 1996). It is not a new approach in industry and has up until recently often been called Life Cycle Costing (LCC). The difference lies in the fact that WLC seeks to consider the whole building life and not just the period of commercial interest.

Essentially WLC is a means of comparing options and their associated cost and income streams over a period of time. An alternative definition on maintenance management (BSI, 1993) stresses that it is “for the purpose of making decisions”. The decisions involve considering future events which can be very diverse e.g. how long the building will be needed and what the long term local climate will be like. There is a lot of uncertainty in the results but they do provide a method of choosing between alternatives on the basis of what we know.
now, and what we expect the future will bring. Uncertainties are common to many of the factors, and where one approach is more prone to uncertainty than another there is nothing to prevent this uncertainty being expressed in the final results. Estimates should always be subjected to some straightforward sensitivity analysis.

3.1 Who uses whole life costing?
Whole life cost procurement in construction has been strongly advocated in the UK by long-term building owners and clients in recent years. This includes the 12 major UK construction clients (CRT, 1997), and by the association of most major construction clients in their statement of procurement policies (CCF, 1998). Clients who own and manage buildings long-term want to know their cost of ownership before being committed to a particular building or design alternative. “Avoidance of unpleasant surprises is everything” as the Construction Clients Forum state.

Recently various contractual procurement initiatives have been instituted in the UK, all of which shift long term costs of running built assets from the public to the private sector - for example the Private Finance Initiative (PFI), Public Private Partnerships (PPP), Design, Build, Finance, Operate (DBFO) arrangements etc. These are driving the adoption of WLC by constructors and designers.

A recent survey undertaken by BRE for UK government Department of the Environment Transport and Regions (DETR) indicates that whole life costing is currently used extensively only in PFI projects, and in public procurement projects, and is most frequently undertaken at the early stages of procurement. The major barriers to adoption are cited as the lack of methodology and insufficient data. Other work shows widespread interest in the approach amongst clients and more forward thinking parts of the construction supply chain. The draft ISO standard provides a methodology: the factor method provides a means of estimating service life. Those clients who require greater rigour in their predictions and whole life cost models will need to apply pressure on the supply side of the industry to begin to develop accurate service life data to support whole life costing.

3.2 What is it used for?
Once the life has been estimated, it is possible to assess the various costs that will apply during the service life of the building, including capital or initial cost, maintenance costs and, when appropriate, replacement costs. All the costs associated with the specific option are then added together to give a total cost, with future costs discounted to give a present value. The various options can then be compared on whole life cost grounds. Again, if the process has been completed in a transparent way, it is possible to compare the uncertainties applying to the various options. Part 5 of draft ISO standard aims to address these issues.

3.2.1 Which costs are considered?
Costs to be taken into account include initial capital or procurement costs, opportunity costs and future costs, maintenance or replacement. Only options, which meet the performance requirements for the built asset should be considered: those with lower costs over the period will be preferred.
Initial costs include design, construction and installation, purchase or leasing, fees and charges.

Future costs include all operating costs, such as rent, rates, cleaning, inspection, maintenance, repair, replacements / renewals, energy and utilities use, dismantling, disposal, security and management over the life of the built asset. Loss of revenue may also need to be taken into account – reflecting the non-availability of the revenue-generating building during maintenance work for example.

The timing of future costs must be taken into account in the comparison of options. Future cost flows are discounted by a rate that relates present and future money values – which may include an allowance for inflationary changes. Opportunity costs represent the cost of not having the money available for alternative investments (which would earn money) or the interest payable on loans to finance work.

To convert real costs to discounted (present day) equivalents a discount rate\( (f) \) is applied as follows:

\[
\frac{1}{(1 + d)^n}
\]

and
\( d = \) the discount rate per annum  \( n = \) the number of years between the base date and the occurrence of the cost

### 3.3 The essential features of whole life costing

There are several important elements to WLC calculations, and if they are incorrectly assessed the results will be misleading.

#### 3.3.1 Discount rates and inflation

The discount rate is used to represent the present value of a future income stream or cost. It is specific to the client, and includes the degree of risk return required in a commercial context, or the rate of interest payable where loans are required to finance the construction work. If it is set too high, future costs will appear insignificant and will be favoured by the calculation. If it is set too low, capital costs will discouraged, but high operational costs may result. Similarly, sometimes inflation is taken into account in the discount rate, and if rates are substantially different in practice the calculation may lead to inappropriate choices.

#### 3.3.2 Allowances for tax

The tax regime within which the building owner is operating may determine which future costs are allowable for tax – for example capital allowances are currently allowable on new industrial buildings, hotels, industrial and commercial buildings in Enterprise Zones, agricultural buildings and small workshops. Many items of plant and equipment and leased plant are available for allowances, and sometimes associated builders work is also permissible. These allowances also vary depending on the financial situation of the building owner – whether there is a taxable profit against which allowances can be claimed or not.
For major projects specific guidance should be sought on the assumptions made in the calculation, and the applicable rules at the time.

3.3.3 Obsolescence

A building or component may be functional and yet be obsolete, inefficient or unwanted. It is notoriously difficult to assess when or how obsolescence will strike – but changing land values on which the building stands, changing information technology cabling requirements and changing safety requirements have all contributed to render certain buildings obsolete. At present, it is fair to state that rapid technological progress in building services equipment and high fuel costs mean that WLC calculations should assume limited lives for such components.

3.3.4 Building / component life

The period during which the building or component is assessed is an important variable – the building life being considered makes a big difference, because certain major components (such as roof coverings) require replacement at varying intervals. An increase in the required service life of the building of just five years may mean that a major unplanned expenditure is incurred, or conversely if the building is required for a shorter period than planned then high cost, low maintenance options may prove cost-ineffective. Data on the future performance of components are not always readily accessible, and often depend on estimates from accelerated tests. Where a long service life is essential it may be pay to be cautious, and select tried and trusted options. Innovative solutions may however offer good value for money, if the assumptions made are borne out in practice.

Different organisations will have different expectations of building life – and the client may have a limited foreseeable use for the building. Not all clients want or need their buildings to last 60 or 100 years. At the end of a relatively short building life the residual value and/or demolition costs may be significant factors.

3.3.5 Managing uncertainty within the factor method.

Given the accuracy of the information used in this process it is essential to assess the impact of changes in the key assumptions by carrying out a sensitivity analysis. This will establish the degrees of uncertainty in the estimates of service life and, therefore in the whole life costs. The sensitivity analysis can be undertaken to test the impact of different building lives, factors, discount rates and even maintenance costs or replacement costs. Table 1 sets out an example of the sensitivity analysis that might be undertaken to consider the whole life implications of three options available during design or specification. **Option 1 considers refurbishment of an existing component, option 2 and 3 considers two quality levels of replacement components.**
Table 1: Example of WLC sensitivity analysis

Capital Costs

Option 1 = £203,000
Option 2 = £1,164,900
Option 3 = £1,262,100

<table>
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<tr>
<th>Discount rate</th>
<th>Service Life</th>
<th>Net Present Values</th>
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<tbody>
<tr>
<td></td>
<td>Option 1</td>
<td>Option 2</td>
</tr>
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<td>6%</td>
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3.4 Improving the balance between capital and operational costs

A key aim of whole life costing is to identify the optimum balance between capital and operational costs. The ratio of operating costs to initial or capital costs varies between building types, and on the selected discount rate and life of the building. However, it is higher than generally considered, and savings in this area are well worth pursuing. Estimated ratios of capital to operating costs can be as high as 1:10 on some UK projects.

4 Conclusions

The prediction of whole life costs of buildings is becoming increasingly important, for economic and environmental reasons. The Factor method has been developed as a tool to support such prediction in cases where there is a lack of adequate or reliable quantitative data. It can assist in the development of whole life cost models, and can help to overcome the lack of data. It must be used with care and understanding of the method and the project under consideration, but is a useful tool to enable constructors to better meet client needs in the early part of the next millennium.

5 References

CRT (1997). *Agenda for Change*. Construction Round Table