SCOTS

Society of Chief Officers of Transportation in Scotland
Natural Stone Materials Working Group

Report

on

Whole Life Costing for Natural Stone Streetscape Works

By

ID Consultants

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FOREWORD

Society of Chief Officers of Transportation in Scotland
Natural Stone Materials Working Group

Whole Life Costing for Natural Stone Streetscape Works

Following the publication of the SCOTS; Natural Stone Surfacing-Good Practice Guide in October 2000, SCOTS commissioned ID Consultants to prepare the above research report and the following related reports.

- Technical Evaluation using Natural Stone Surfacing in Streetscape Schemes in Scotland
- Street Cleansing Practice in Natural Stone Streetscape Areas in Scotland.

The three ID Consultants reports are written to complement each other and should be read in conjunction with the Good Practice Guide.

The Good Practice Guide can be found on the SCOTS website (http://www.scotsnet.org.uk/).

The views and recommendations forwarded in all three reports are entirely those of ID Consultants and are based upon questionnaires, site visits and discussions with designers and maintenance staff on 24 selected streetscape sites in Scotland constructed over the last decade.

We are extremely grateful for their co-operation, hospitality and willingness to share experiences, both good and bad, that made it possible to produce these reports.

The reports recommendations represent what we believe should be adopted as Best Practice but that does not mean that in the future further improvements will not be made and we hope that the website can be a forum to express such views.

If anyone wishes to discuss any aspect of these reports we shall of course be pleased to do so.

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Executive Summary

For the past decade streetscape schemes using natural stone materials have been justified in preference to man made or asphalt on the basis of the durability and high life expectancy of the stone. This rather crude justification is at best simple and at worst misleading calling for a more mathematical and accountable method of selecting natural stone versus other products. What is required is a method yielding a robust argument which will guide designers and policymakers in making more informed decisions whether or not to invest in high quality streetscape schemes.

In July 2002, the Society of Chief Officers of Transportation in Scotland (SCOTS) as part of their ongoing research programme into the use of natural stone in urban streetscapes, commissioned ID Consultants to examine the theory behind whole life costing and to develop a model which could be used for comparing schemes.

Whole Life Costing (WLC) is a means of transferring the value of future years costs or payments into the present. All transactions are taken back to a base year by adjusting for the amount of interest these monies would have earned if invested in a bank or similar financial institution. The rate of interest assumed is referred to as the discount rate and the total value or cost of a transaction transferred back to the base year is called the Net Present Value (NPV). The whole life cost of a scheme is the total value of all transactions over the whole life of the scheme.

This method will therefore allow comparison between competing projects as well as comparisons of different alternatives for each individual scheme. In the case of streetscape schemes there is no direct income, so the WLC will be negative and the best scheme will be the scheme with the lowest negative value.

On the other hand a high quality streetscape scheme is intended to bring positive values in the form of increased economic activity; stop or reduce shop closures; increase tourism and create a ‘feel good’ factor by providing an aesthetically pleasing environment

The first part of this report is a literature search reporting upon the theory and the main factors affecting the whole life cost of a street asset in a broad sense. The second part develops a model to compare streetscape schemes by setting discounting rates and establishes construction

and maintenance costs, such that the value of an individual investment can be evaluated over time.

To quantify the benefits to retail, business, tourism and the feel good factor, a model has been developed allowing the designer to include positive contributions for these factors. The model is calibrated to give an overall positive WLC for deserving schemes and negative values if the use of natural stone is not justifiable. In order to establish the sensitivity of the various cost assumptions the model has been tested for both high and low costs of asphalt, man made and natural stone schemes.

The report concludes that:

- The whole life cost of an asphalt scheme will always be cheaper than a natural stone scheme when considering only construction and maintenance costs

- If whole life costs include benefits to the local community, natural stone schemes may well offer better value than asphalt schemes

- For natural stone schemes to be economically justifiable the designer must ensure that future maintenance burdens are minimized and a robust maintenance system must be in place to safeguard the investments made.

- Whole life costing is dominated by the discounting rate used in the model calculations but the relative comparison between asphalt, man made and natural stone products remains fairly stable. The main consequence is that a high interest rate will reduce the value of future costs or payments much more rapidly than lower rates.

- In practicable terms whole life costs do not change after about 50 years for high interest rates and 100 years for low interest rates

- In world global terms stone has a low whole life cost being a natural material that requires relatively few secondary processes before being used.

- Further studies are required to quantify more accurately the social and economic benefits to the fabric of an environment having been improved by quality streetscape works

1 Introduction

1.1 During the past decade many urban centres all over the country have undergone a major transformation through the use of natural stone, in order to rejuvenate an area by providing a visual and tactile environment suitable for creating a more pedestrian friendly space. The main problem in financial terms has been to justify the use of stone since it is more expensive than modern man made road making materials

1.2 For many years, whole life costing (WLC) issues have been intuitively understood, and considered at a broad macro level. Common sense tells us that in general natural stone will last longer than man-made materials by a factor of many years. Stone as a raw material should have a very long service life, well beyond the normal modern day design life. However it is how the stone is laid and handled that will determine the life of the pavement rather than the quality of the stone itself. The adaptation of traditional as well as innovative new skills in using stone materials is of critical importance to the life span of any scheme.

1.3 Maintenance and other costs must not be ignored during the design and construction stages since clients expect to know their total future costs in advance of embarking upon construction. Industry is gradually moving towards Best Value rather than lowest capital cost procurement as the most efficient way forward, and the aim is to optimize expenditure over the entire service life of a street asset. Government and industry both recognize that procuring on an initial cost only basis is not sustainable nor cost-effective, and that a better way may be to use whole life costing as a tool to measure best value by linking financial and environmental issues.

2 Whole Life Cost Concepts and Benefits

2.1 Whole life costing can be defined as a set of techniques to assess the costs of acquiring and operating an asset over its life. Within the construction sector, WLC seeks to consider all of the costs and revenues associated with the asset. At a macro level, WLC techniques can also be used to assess life-time environmental impacts expressed for example, in level of harmful emissions or some other quantitative measure.

2.2 Whole life costing can also be defined as :

"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 their subsequent operational costs" ie WLC can be used to inform design and investment decisions identifying the costs of alternative approaches to achieving the same objectives over the life time of the asset on a common basis.

2.3 Similarly WLC can be used to assess the total costs of a single asset, so that an appropriate provision can be made to finance it and to maintain it in the future. It is a good support tool to :

- *Provide assurance to clients of their investment's long term performance*
- *Allow all parties involved in the use and maintenance of the scheme to know how much the scheme will cost to use and how successfully it will continue to meet user needs and requirements.*
- *Determine if higher initial cost is justified by reductions in future costs*
- *Identify whether a proposed change is cost-effective against the "do-nothing" alternative.*

2.4 It is sometimes thought that WLC is about increasing capital costs to produce long life assets. If that were the case, cash-constrained clients would have no incentive to take up WLC. However, whilst WLC can of course identify the need to improve asset life, that is not its primary purpose. Its focus is on meeting client need, and it is just as useful in identifying the lowest cost/shortest life asset, if that is what is needed.

2.5 In the public sector, managing assets through the use of whole life costing has not been traditionally used. In 2000, a survey by the DTI indicated that the use of WLC nationally is very limited, being mainly used for large private finance projects. DTI concluded that the complexity of WLC and the inherent uncertainty of forecasting asset life, financial values etc., meant that analyses are highly variable. For this reason, investors tend to focus on more short term issues that are more manageable and understandable. As money reduces in value over time, investors are more concerned about expenditure today than about expenditure in the future.

2.6 Whole life costing has many benefits such as:

- Better understanding of project priorities and where valuable resources should be most effectively applied.
- Increased clarity in the client's understanding of the scope of the design and the construction process.
- Optimisation between capital and operational expenditures.
- A structured, traceable method to manage the risks inherent in construction procurement.
- Reduced costs due to over-specification of the service life of materials or components.
- Improved risk management by quantifiable decision making.
- Clear guidance, allocation and transference of responsibilities in the design and construction phases.
- Improved construction quality, particularly of the aspects critical to service life.
- Ability to assess the implication of variations during a project and mitigate the impact of such variations.
- Planned maintenance scheduling and reduced disruption associated with repairs
- Reduction in risk and uncertainty and improvements in budgetary control.

3 Key Whole Life Cost Factors

3.1 In many cases the initial purchase price can be well under half of the whole life cost. In some cases costs, which are notoriously difficult to calculate (life expectancy, value to the community, disposal, repair etc.) are of paramount importance in making the final choice, as is the case for streetscape and similar public realm projects.

3.2 Whole life cost considerations can be very complex and apply to all stages of scheme development and implementation to a greater or lesser degree. Some of the most common considerations, split into ‘financial’ and ‘community’ issues, are shown in table 1.

Financial	*Community*
Compatibility with other areas	Disposal of waste products
Cyclical (running) costs	Employment
Design costs	Environmental issues (incl. Energy costs)
Disposal costs	Health and Safety needs
Disposal of waste products	Life expectancy
Employment	Quality of installation
Health and Safety needs	Reliability and durability
Installation costs	Security
Life expectancy	Value to Community
Maintenance/repair costs	Tourism
Modification costs	
Procurement process costs	
Quality of installation	
Reliability and durability	
Spares availability	
Staff training	

Table 1

3.3 The confidence which comes from having a robust accountable way of modeling asset behaviour will inevitably lead to rising expectations. Such expectations have been rising due to many factors for many years, and the public has now a much greater understanding and appreciation of the need to look after public realm investments.

3.4 Table 1 highlights the main issues which could be considered when examining the whole life aspects of any construction project including urban streetscape. These issues should be looked at in more detail to determine their impact and level of importance in determining total life cycle costs on an individual project by project basis.

3.5 The financial issues are those where, if appropriate, allowance should be made in the calculation of whole life cost. The ‘community’ issues are those factors which cannot really be considered in terms of money, being almost unquantifiable, but should still be considered in terms of the wider assessment of any project.

Financial Issues

3.6 For most construction projects disposal costs can be reasonably estimated at an early stage through a detailed knowledge of construction materials and their operational characteristics. However, with natural stone street surfacing, this is not so straight forward. For whilst the underlying road pavement might fail after a number of years, the stone surfacing materials should in theory be reusable indefinitely. If we can make this assumption the disposal costs associated with natural stone should most likely be positive rather than negative.

3.7 A streetscape project has the potential to create a mix of general and specialist temporary jobs. It is the specialist jobs which have the greatest potential to extend into ongoing maintenance as clients start to develop formal strategies for properly maintaining their high quality assets. In financial terms the temporary site jobs for the initial installation are not worth considering in life cycle modeling. However, the long term employment opportunities offered in specialist maintenance can be quantified in broad terms. Experience in some towns suggests that a squad of three competent and experienced operators could cost around £50,000 per annum.

3.8 The installation and future maintenance of natural stone schemes requires specialist skills and equipment. There is a premium to pay for this depending on the size of the investment being made. A large city centre will require expenditure on equipment whereas smaller projects, unless they can be linked into a series of other projects, are more likely to hire labour and equipment.

In terms of public safety, enhanced streetscape environments should reduce considerably the risk of litigation being initiated by the public. Any reduction in the amount of public liability claims paid out by the local authority should have a significant financial impact on the authority which could be reflected through the whole life modeling.

3.9 Looking after an investment is the major element of the whole life cost modeling. It is critical in achieving the required life span and to justify the WLC argument made to funders at the project inception stage. Traditional reactive maintenance activities are not sufficient for urban centres. A more holistic and wide ranging view of the street is required and for this reason the term ‘life care’ is perhaps more appropriate. Pro-active life-care will allow for whole life costing and improved budgetary control. It is dependant on the function, accessibility, component elements, and management arrangements of the street. Reactive life care will result in only defects being repaired without any consideration being given to the whole range of street activities and features. Over time this may well result in the investment falling short of attaining its desired service life.

3.10 Quality of installation is a vital component of life cycle analysis. Higher initial capital investment to achieve the highest quality of workmanship should pay dividends in the long run. It is however difficult to determine actual figures, and in general, clients should not try to save on quality of materials or workmanship as a way of reducing overall costs. Quality of materials can be rigorously checked and verified throughout the supply chain. However when the material arrives on site to be laid, the next stage of quality becomes much more subjective relying upon the skill of the layer and the experience of the supervisory staff. The small additional investment for experienced and rigorous site supervision will provide an added confidence to the client that nothing less than an excellent product has been produced. After the contractor has left, the quality must be maintained and sustained through pro-active maintenance and repair.

3.11 Given the wide variety of stone and the range of street furniture and street lighting types used in streetscape projects, the availability and storage arrangements for replacement materials must be considered seriously. Some designers tend to select materials from a limited pallete and limit the amount of bespoke and specially designed elements. Some other designers do not, and it is likely in these schemes that problems will arise in the future trying to find matching materials. The purchase of additional materials and furniture at the installation stage using the capital money will offset the impact of this issue to some extent, but at some stage even these materials may be exhausted. The amount of extra material purchased will depend on the nature of the installation but typically 10% extra of the principal materials are now being stored. Any design which has not considered this basic sustainability issue may incur additional whole life costs.

Community Issues

3.12 The overall global goal of environmental management should be an environmental, social and economic sustainable development. This is essential to continuously improve the quality of life for the world's population. Over many years, different environmental management approaches have been developed, one of which is Life Cycle Assessment. LCA is a technique for assessing the potential environmental impact associated with products, processes, usage and disposal. The term life cycle refers to the consecutive and interlinked stages of a product from the extraction of natural resources to the final disposal. LCA has two main strengths firstly it helps to avoid 'problem shifting' where a solution to a particular environmental problem causes a deterioration in another part of the life cycle. Secondly, it accounts for all resources used and wastes generated per unit of 'value' to the customer, thereby permitting a value: impact type assessment.

3.12 Local Authorities have certain carrots and sticks they can use to arrange LCA. It is at the level closest to where firms and industry operate, and have an obligation to manage the micro and local environment on behalf of local people and communities. Within the context of local government in urban communities, the LCA concept can be contextualised for streetscaping projects as shown in Table 2.

Consideration	*Reason*
Materials Extraction	
Use materials which are renewable, recyclable and/or recycled, minimise use of thermosets or mixed polymers	Decrease the amount of non-renewable materials to be extracted from the earth
Design products in a way that reduces material use, use better design rather than over-dimensioning	Decrease the amount of materials to be removed from the earth
Design for minimum waste production during production	Decrease amount of material wasted during production
Minimise numbers of materials used	Increase recyclability and ease the sorting process
Production	
Avoid or minimise the use of hazardous, toxic or in any other way environmentally unfriendly materials	Decrease amount of harmful gaseous, liquid or solid emissions during production
Minimise and recycle residues and waste from production processes within the manufacturing plant or outside it	Decrease the amount of raw material required and the amount of waste created by the production process
Transport, Distribution and packaging	
Optimise efficiency transport modes following these rules : 1. Transport by container ship or train is preferable over transport by lorry 2. Transport by air is to be avoided	Decrease energy use and emissions from transport and avoid environmentally harmful ways of transport (such as flight)
Minimise long distance transport by maximising work with local suppliers and markets	Decrease long distance transport and all energy use and emissions from such source
Maximise efficiency of transportation by use of standardised transport packaging, bulk packaging, such as Europallets and transport of larger amounts of goods simultaneously	Increase efficiency of transport
Maximise use of refillable or reusable containers where appropriate	Decrease amount of material needed for packaging by re-use of containers
Use	
Optimise life time of product by increasing reliability and durability	Decrease need for new products, hence decrease material and energy use for production

Design for easier maintenance and repair by having clear instructions and guidelines for maintenance and repair	Increase life span of product by easier repair and maintenance
End of life design, design for recycling	
Stimulate possible reuse of the product by classic design and sound constructions	Extend possible life span therefore decreasing need for new materials
Stimulate possible refurbishing by having opening instructions for ease of non-destructive removal	Extend possible life span therefore decreasing need for new materials
Stimulate possible recycling of materials by using materials with an existing sustainable market	Decrease need for virgin materials

Table 2 - Life Cycle Assessment considerations

3.14 In a recent MORI survey (2001) which examined paving material options, 82% agreed that paving is important to the local environment while 80% wanted their council to spend more on maintaining and upgrading their pedestrian surfaces. In addition, 70% of the public preferred small element paving whilst only 8% preferred bituminous materials and 12% preferred concrete slabs. From this it is clear that the value of small elemental paving cannot be underestimated.

3.15 Each town and city has a business community offering retail, manufacturing, construction, property and development opportunities and this sector provides important employment as well as direct income to the Council through rates and taxes. Each local area will compete to provide the infrastructure that will attract various forms of business activities, and part of this strategy will be to invest in streetscape schemes. Such investments may be defensive in the sense that the local Council is prepared to spend money on retaining existing customers in the fear that they may otherwise move.

3.16 Tourists generally come to a place to see its built heritage. The attractiveness or otherwise of each place both vertically (buildings) and horizontally (streetscene) will have a major impact on the visitor's impression and ultimately enjoyment of the place. Individuality along with regional variations are key issues in this debate. In older areas, conservation will be a driving force for streetscape works and it is important to recognise the individuality of traditional materials and how they combine in form, function and performance. Towns and cities continually compete with one another in this potentially very lucrative market.

Determining the 'value' of an individual piece of streetscaping in terms of tourism is therefore very difficult. It is a combination of many factors, for example :

- National public image/perception of the place
- Historical interest

- Initial impact upon arrival (at transport links for example)
- Time/season of year

- Quality of retailing
- Marketing/advertising

3.17 Local participation and understanding of a streetscape project should lead to a sense of pride in the place. The greater the initial involvement by the public the more local satisfaction should be gained on completion. This pride is often referred to as a “feel good” factor where people’s enthusiasm for life is enhanced through the improvement of their immediate environment. This should then lead to improved business activity whilst reducing crime and vandalism.

4 Model Costs

4.1 A whole life cost model can be developed for streetscape pavements surfaced with natural stone or any other material taking into account the most relevant issues and factors highlighted in the preceding sections. This type of model can be used to compare different schemes as well as to compare different surface options for each individual scheme.

Life cycle costing techniques are based on the principle that the total value is equal to the present value of all future cash flows. A simple formula can be used to calculate this :

$$L_t = C_0 + C_{at} + C_{ot} - D$$

Where :

L_T is the present discounted life cycle cost measured over a prescribed time period t

C_0 is the total cost of procurement and installation at time zero

C_{at} is the annual recurring cost which should be regarded as continuous

C_{ot} is the cost of non continuous work which will not happen on an annual basis

D is the value of the asset at the end of its service life at disposal, allowing for all costs of the disposal. This variable will allow for any possible gains to be included in the model.

The Whole Life Cost (WLC) is the value of all the money transactions referred to in the above formula over the lifespan of a scheme.

4.2 The discount rate is the rate of interest used to convert 'future money' into present money. For all but the initial costs of a project, it is necessary to discount these costs back to the base year. Therefore if £ 10 is required to pay a bill in one year's time and the interest rate is 10%, only £ 9.09 will have to be lodged in the bank straight away because this will grow to £ 10 when the interest is added.

The outcome of any whole life cost model is highly sensitive to the discount rate selected and should reflect possible long term changes, the type of project and possibly the degree of risk acceptable to the client. The Treasury Rate in 2000 was set at 6%.

$\underline{C_0}$

4.3 The total cost of procurement and installation (C_0) must include works, land, design, supervision and all overheads. In order to compare standard asphalt, man-made and natural stone schemes, typical cost bands per square metre of construction based on current market costs should be used.

4.4 All main urban schemes are expensive to construct regardless of the surfacing materials used because of vehicle and pedestrian traffic, shop accesses and public utility constraints. Urban schemes are likely to have a sophisticated level of street furniture and street lighting provision. For these reasons it could be assumed that the all-in cost for standard asphalt schemes inclusive of design and supervision will be in the region of £100 -125 per square metre. The direct additional surfacing cost from asphalt to man made products will be in the region of £20 - 40 per square metre. However the cost of a longer construction period and probably more elaborate street furniture and lighting will have the effect of making the unit cost £120 - 180 per square metre. Similarly the material and laying cost differences between asphalt and natural stone will be in the order of £50-100 depending upon the particular materials used. Stone products normally have a long ordering time and the schemes using them are usually more embellished with street furniture, art works and the like than for the other two alternatives. For this study the cost range for natural stone schemes has been taken as between £180 - 260 which were confirmed as reasonable overall costs in our technical evaluation study.

4.5 The procurement of the stone will be a major part of the cost in a natural stone scheme since generic natural stone can be obtained abroad from £ 20 per square metre. However if a particular quarry is specified in order to obtain an exact colour or local stone source specified the basic stone cost could be £ 100 per square metre or more. Similarly if designers opt for complicated stone cutting and carvings the cost will increase significantly. In the same way, one- off designs for lighting, street furniture and art works could increase the cost of any project by say £ 50 per square metre. It is the client and his designers' choice to select the type of stone to be used and how many embellishments to include in the scheme .

4.6 Prestigious schemes may aspire to allow higher levels of spending and the whole life costing model assessment will help to justify such decisions. On the other hand if initial costs are influential in determining if a natural stone scheme can be afforded or not it is possible in most cases to construct stone schemes at the lower cost ranges indicated.

The above costs for different construction materials have been derived to compare the whole life cost differences. In the final model the designer will have full control over all costs allowing for the costs appropriate for the scheme

C_{at}

4.7 Annual recurring cost (C_{at}) will reflect the level of commitment of the owner to maintain and sustain the development. It will depend on whether proactive or reactive strategies are being used. In the case of reactive, this cost variable may be difficult to determine and will be dependent on the quality of the original installation, subsequent repairs and interventions. As a guide figure, the amount of funding given before the works were carried out should give an indication of the likely future expenditure. It would be much more preferable to be proactive in which case this cost should include for at least the following.

- Cyclical maintenance - gully clearing, weed killing etc.
- Repair defect materials as they occur
- PU interventions
- Management and inspection
- Supply of replacement materials
- Staff training

4.8 It is difficult to obtain accurate figures for the cost of annual cyclical maintenance and what is actually included in any such figure. The costs will typically allow for carriageway and footway repairs, gully cleaning, lighting and signing repairs etc., but may exclude street furniture repairs, street cleaning and the like. Limited information obtained from one local authority suggests a value of £ 0.50 per square metre per annum could be assumed for general cyclical road maintenance activities. Since any urban centre may be more expensive to maintain we have assumed a range of £ 0.50 - .75 per square metre for asphalt roads. Even less information is available about man-made or natural stone schemes but for the reason that cobbles and slabs may be subject to loss of joints, rocking and trip hazards the need for maintenance will be higher than for asphalt schemes. The term maintenance contract from one authority substantiates this assumption and based on the past two years' costs, they have assumed an annual value of £1 - 2 per square metre as the typical maintenance range.

4.9 There is some evidence to suggest that town centre schemes constructed with concrete products have traditionally been under-maintained which has led to a shortened lifespan and increased whole life cost.

The assumptions made above are based on sustainable maintenance and represent figures that <u>should</u> perhaps be allocated rather than actual spending.

4.10 PU work will on the whole be paid for by the individual utility and it is up to each authority to ensure that the road surfaces are reinstated to their original condition - that being asphalt, man- made or stone. This is particularly important for stone schemes because the costs are much higher and the expertise to relay may not be immediately available. A lack of competent reinstatements can have catastrophic consequences upon the whole life costs. However, since the cost should be borne by the public utility company, these have not been included in the later analysis.

$\underline{C_{ot}}$

4.11 Cost of non continuous work which will not happen on an annual basis (C_{ot}) will allow for future modifications to the street environment, utility operations and emergency repairs. These are completely unknown until they happen but due allowance must be made as these occurrences are inevitable at some point during the service life of the street. Asphalt carriageways have a theoretical design life of 20 years but this does not mean they are reconstructed after that time. The need for refurbishment however tends to be higher in busy city centre areas than would be the average for the national network. It is recognised that carriageway surfaces are fairly regularly scarified and resurfaced with a new wearing course in order to maintain the skid resistance, comfort and safety of the surface. The whole life cost calculations therefore assume a 10 year cycle and a cost range of £10 -20 per square metre for asphalt schemes.

4.12 Many urban centre schemes were reconstructed with man-made products in the 1970-80's and it seems that many of these schemes have since been changed and relaid with stone products. There are a number of reasons for this :

- the surfaces might be worn ;
- there has been a lack of general maintenance and repair ;
- there has been a shortage of replacement materials ;
- there has been poor quality public utility reinstatements.

In order for these products to sustain a theoretical infinite life cycle it should be assumed that the surface materials are lifted and relaid with replacement new materials every 15 years at a cost of £30 -60 per square metre

4.13 It is often said that natural stone has an infinite life, as some old cobbled streets in Glasgow and Edinburgh tend to demonstrate. There is however also ample evidence that new natural stone clad streets have failed miserably only a short time after scheme completion. The reasons for this have been subject to much discussion in recent years but can be due to a combination of lack of knowledge, poor specifications, poor workmanship and inexperienced contractors. Clearly the whole life costing advantage of the ”infinite life” of stone will be lost unless the correct type and size of stone, bedding and joint specifications are used that will be compatible with the whole life of the parent stone. It should be assumed that bedding and joint repairs are covered by the annual maintenance cycle. On this basis we have assumed that no further refurbishment costs will be required for natural stone schemes.

<u>D</u>

4.14 Future value of the asset at disposal (D) will allow for the residual value of the asset to be considered at the completion of the assessment period. For natural stone this should provide a positive value of £ 20-50 per square metre even after disposal costs are considered.. However whole life costing and discounting techniques will show that the residual value of the stone in net present value terms will be close to zero which does not reflect the durability and reusable value that natural stone has in comparison with asphalt and man made products. Since the stone will have a real value at the end of the scheme the disposal value has been counted as a base year benefit. On the other hand at the end of the whole life cycle, asphalt and man-made schemes have no materials that are worth salvaging.

5 Discounted Cash Flows

5.1 The theory of discounted cash flow as already stated is that future cash transactions are converted to reflect their current or present value. Therefore instead of paying £10 in one years time, slightly less money could be paid straight away such that if the money was put in the bank it would be worth £10 in one year by the interest earned.

This can be expressed by the following formula:

$$NPV = \frac{R}{(1 + i)^t}$$

Where NPV = Net Present Value

R = Amount (£)

i = Interest Rate (Discount Rate)

t = Time (Years)

Whole life costing implies that costs must be calculated for an infinite period, but in reality the NPV becomes insignificant after a number of years and particularly so if the interest rate is high. For example, in the above formula, £100 in 100 years time is worth only £ 0.007 in today's money if the interest is 10% ; £ 0.30 if the interest is 6% and £ 13.80 if the interest is at 2%.

5.2 It is normal to add 2% to the Bank of England base rate to define the discount rate, therefore 6% has been applied as the main rate, but the effect of using 2 and 10% has also been used to check the sensitivity. At first glance it may appear pointless to evaluate whole life costs when the interest rate is so sensitive but this study shows that the relative difference between the construction alternatives will remain the same.

5.3 In order to assess at what stage time becomes insignificant, NPV has been calculated for 20, 40, 60, 80 and 100 year periods. The whole life cost (WLC) is the accumulation of the NPV's for each year. Further, to explore the sensitivity of the various cost assumptions, NPV's have been calculated for both the high and low end of the assumed cost ranges referred to in the previous section. The cost assumptions are summarized in the Table 3 and it should be borne in mind that these are the direct costs to the client authority without attributing any economical, aesthetic or social benefits that an improvement may bring to the council or the local community. Equally the cost of the global effects of using natural stone with regard to energy, environment and the economy of third world countries are not included.

Material	Procurement Cost	Annual Maintenance	Refurbishment	Residual
Asphalt	£ 100-125 sq.m	£ 0.5-0.75 sq.m	£ 10-20 sq.m every 10 years	None
Man made	£ 120-180 sq.m	£ 1-2 sq.m	£ 30-60 sq.m every 15 years	None
Stone	£ 180-260 sq.m	£ 1-2 sq.m	None	Included

Table 3

5.4 The NPV matrix has been tested for the following:

MATERIALS	*TIME*	*INTEREST RATE %*	*COST*
	20		
Asphalt	40	2	Low
Man made	60	6	High
Stone	80	10	
	100		

Table 4

By running a series of models using the Table 3 and 4 parameter cost assumptions Table 5 below shows WLC for the low end cost range and Table 6 for the high end. The model uses the formula in Paragraph 5.1 as illustrated by the spreadsheet in Appendix A in columns showing Construction, Maintenance , Refurbishment and Residual

5.5 Whole Life Costs (WLC) for low and high cost assumptions, allowing for construction and maintenance but excluding any positive benefits are as follows

	YEARS	*20*	*40*	*60*	*80*	*100*
ASPHALT	2%	-123	-134	-147	-155	-144
	6%	-121	-119	-121	-122	-117
	10%	-119	-111	-112	-112	-110
MAN MADE	2%	-158	-187	-207	-229	-238
	6%	-144	-154	-157	-159	-160
	10%	-136	-140	-140	-140	-140
STONE	2%	-182	-213	-219	-230	-237
	6%	-196	-212	-215	-216	-217
	10%	-201	-209	-210	-210	-210

Table 5 WLC's Low costs (£ per sq.m)

	YEARS	*20*	*40*	*60*	*80*	*100*
ASPHALT	2%	-160	-187	-210	-225	-191
	6%	-159	-158	-163	-164	-150
	10%	-153	-145	-146	-140	-140
MAN MADE	2%	-257	-313	-354	-397	-415
	6%	-229	-248	-255	-258	-259
	10%	-213	-219	-221	-221	-221
STONE	2%	-311	-340	-360	-374	-384
	6%	-313	-327	-332	-333	-334
	10%	-312	-319	-320	-320	-320

Table 6 WLC's High Costs (£ per sq.m)

5.6 From Tables 5 & 6 and Fig 1 it can be observed that the graph levels out fairly rapidly for 6 and 10% interest rates and it seems that little change takes place in the WLC's after about 50 years however the 2% curves are still climbing slightly after 100 years.

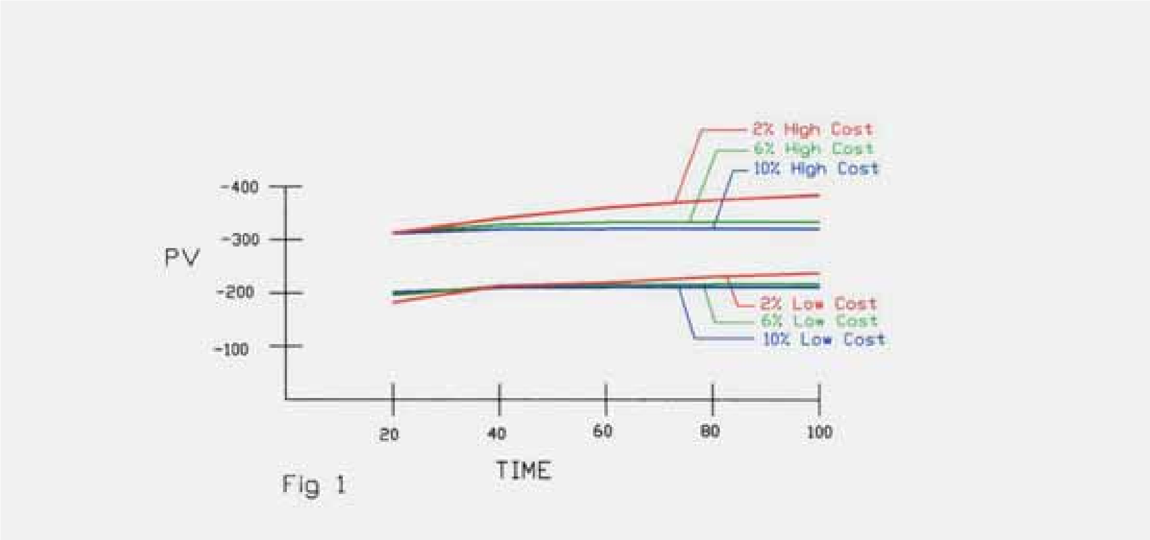

Figure 1 shows the WLC range for stone schemes over time with different interest rates and costs

5.7 Fig 2 shows without doubt that an asphalt scheme will always be considerably cheaper than the other alternatives. Man made products will typically have twice the WLC value and stone schemes may be 2 to 2.5 times more expensive. The main reason for this is that the construction cost is much more expensive for stone and man made products.

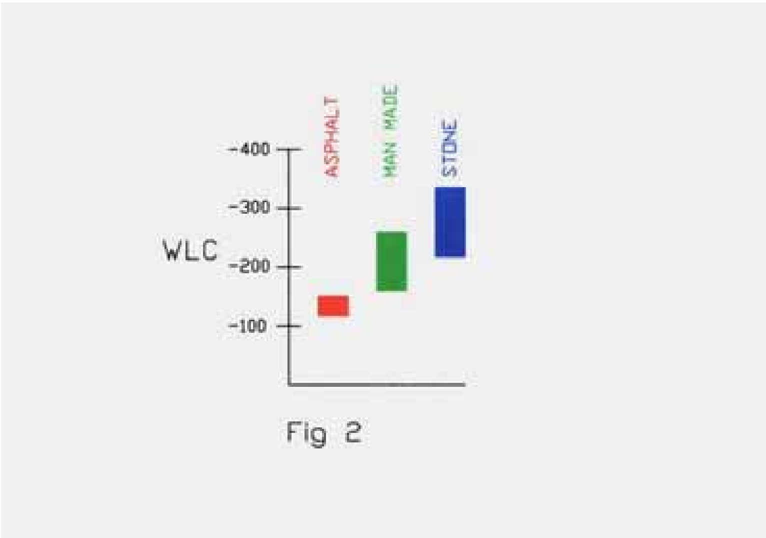

Figure 2 shows the range of WLC 's for asphalt, man made and stone schemes assuming 6% interest rate.

The upper WLC range for man made schemes overlaps the WLC for stone schemes in Fig 2 because the material and laying costs are similar to the lower stone cost range and the maintenance burden of man made products will be more demanding.

5.8 Fig 3 is a measure of the uncertainties involved in predicting WLC for the three material choices. As expected the asphalt costs are most predictable and the other two vary considerably because of the wider choice of materials and maintenance costs. Fig 4 shows the same by subtracting construction costs from the WLC's.

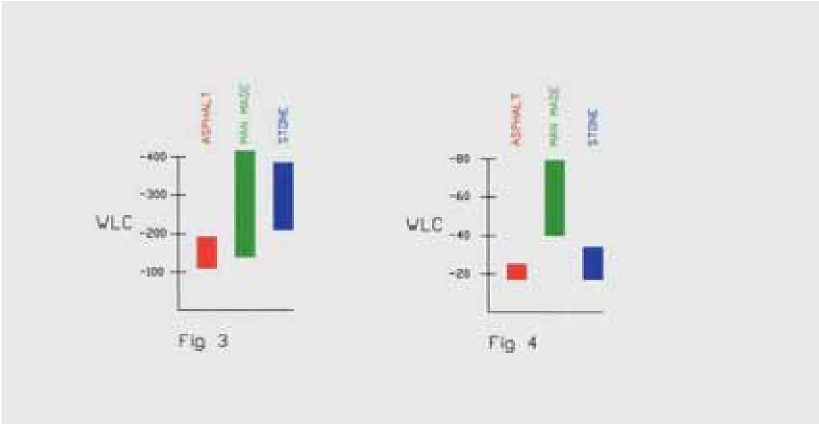

Fig 3 shows the spread of WLC's Values for asphalt, man made and stone using varying costs and interest rates

Fig 4 shows the WLC's less construction costs for asphalt, man made and stone using 6% interest rate

5.9 Fig 5 shows the relative difference in WLC between the basic asphalt schemes and the other materials. This is the gap in WLC that must be justified in discounted cash terms to construct man made or natural stone schemes . The additional cost of stone schemes are about £ 75-175 per square metre while the man made products gap is typically £25-150 per square metre.

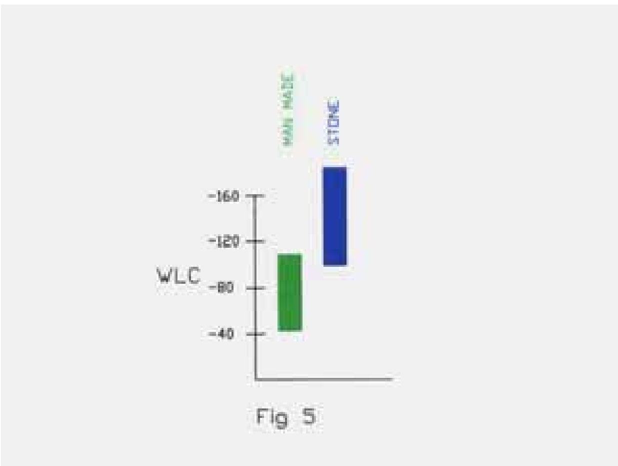

Figure 5 shows the additional WLC range between asphalt and the other alternatives

These gaps in the WLC can be justified by a number of factors such as:

- aesthetics and quality
- ‘feel good’ factors
- local civil or historic importance
- provide employment
- increase in tourism
- increase in shopping
- increase in rental values
- increase in rateable income
- retain existing shopping and tourism
- resist retail competition from neighbouring towns
- resist retail competition from out of town shopping centres
- reduce vandalism
- arrest urban decline
- global environmental benefits

5.10 It may be possible to estimate the effect on the WLC for some of these factors while others must be assessed more intuitively. In order to evaluate the magnitude of cost benefits that must be achieved to justify man made or stone products over asphalt the

following annual gains per sq.m of the road surface must be reached (using a 6% discount rate)

WLC (gap between asphalt and other scheme)	Annual benefit per sq.m
£ 50	£ 3
£ 100	£ 6
£ 150	£ 9

5.11 Various retail reports suggest the retail rental value for the main shopping areas in Scotland to vary between £ 50-220 per sq.ft while office rental values are between £ 5-30 per sq.ft. It is possible, at least fictionally, to convert these rental values to an equivalent value per sq.m of street. Therefore, if it is assumed for sake of argument that 50% of the street façade has retail shopping with 10 metre wide plots and the street is 15 metres wide the conversion will show that the annual retail rental income will vary between £ 300-1500 per square metre of road surface

5.12 If the streetscape scheme can be shown to increase rental and rateable income, occupancy rates, tourism or prevent decline to city centers, only marginal betterments are required as indicated above to justify the use of natural stone in streetscape schemes using whole life cost techniques. It may equally be possible to attribute benefits from other non economical factors such as aesthetics, feel good or city pride to justify a higher quality scheme by using the model.

5.13 To what extent quality streetscape schemes improve rental values and any other benefits may be the subject of a different study but there is at least some anecdotal evidence that this may be the case. Another conclusion from the above is that the more prestigious the street is and higher the rental value the easier it should be to justify more expensive streetscape treatments.

6 Model Development

6.1 The preceding sections indicate that a natural stone streetscape scheme will never be able to compete with a basic asphalt scheme for a lower WLC basically because the construction costs are too high and these tend to dominate the whole life costing. It therefore follows that the reasons for carrying out streetscape works must be assigned positive values relating to the contribution these will make to the scheme. From the analysis in Section 5, it seems that the economic regeneration or prevention of economic decline must play an important part in the overall whole life cost of the street because relatively small changes in rent or rateable values may give large returns in whole life costs.

Similarly increase in tourism and visitor numbers will add increased economic values both to the council and the local economy. Finally a pleasant high quality environment carries an aesthetic value and a feel good factor that may act as a catalyst for other more tangible benefits.

6.2 These economic benefits are not easy to calculate because of the many external factors influencing the comparison between a high quality scheme and the “do nothing” scenario such as:

- Cyclic changes to the world economy
- The local economy
- Competition by other towns
- Competition by out of town shopping centres
- Loss of major employers
- Housing developments
- Planning decisions

6.3 The tourism factor may be even more difficult to calculate because each stone scheme will only be a part of the main tourist attraction to an area which will again depend upon external factors such as the economy and the willingness of people to travel as recent world wide events have proven.

6.4 There is some rationale for suggesting that the aesthetic contribution could be up to 30% of the total scheme value in that the relationship between cost and quality are sometimes referred to accordingly.

6.5 In order to establish a relationship between these contributory factors and to assess the importance of each individual scheme the matrix shown below in Table 7 has been developed but it must be stressed that at this stage we cannot accurately justify the magnitude of these other than creating a rationale for comparing them.

	Economic	Tourism	Aesthetic
Very Important	15	2.5	5
Important	10	1.5	3.5
Some Value	5	0.5	1.75
No Value	0	0	0

Table 7 Annual cost benefit per square metre of surfacing

6.6 As stated above if it is assumed that aesthetics is very important, this will contribute about 30% to the value of a typical streetscape scheme and if the economic side is very important this will justify the full cost of most schemes. However if these factors are at the lower end of the scale they will only amount to a portion of the total scheme cost. If the existing road surface needs to be replaced less justification will be required because only the difference between asphalt and natural stone will have to be bridged. Using a 6% discount rate £ 5 per annum contribution will contribute £ 85.7 per sq m whole life cost value and about 70% of this amount is obtained in the first 20 years of the scheme. The model will allow the designer to choose the length of time any of the above benefits should be taken into account. If any other local information should be available or could be provided by special studies these should of course be substituted into the whole life cost model.

6.7 As referred to previously a major part of the whole life cost is procurement and construction costs which can be evaluated from Table 8 below

		Typical Cost Range £ per sq m
Planning, Design and Supervision		15-30
Road construction to Basecourse level		60-80
Surfacing Material	Asphalt	5 -10
	Man Made	10-30
	Stone	20-150
Laying Costs	Asphalt	-
	Man Made	10-20
	Stone	20-40
Extended Contract Period	Asphalt	-
	Man Made	0- 20
	Stone	0- 30
Lighting and Street Furniture		5-50
Art Work		0-20
Any Other Scheme Cost		

Table 8

6.8 The rates in Table 8 are merely indicative values that can be substituted in real schemes as information becomes available, but they may also act as a planning tool to justify the amount of spending that should be afforded on a special scheme. After having estimated construction cost, annual maintenance and refurbishment costs using Table 3 and any benefits deemed justifiable from Table 7, costs should be inserted in the model spreadsheet shown in Appendix A. The discount rate and time spans to be assumed must also be included in the whole life cost model.

6.9 By using a whole life model as suggested in Appendix A it will be possible for the scheme designer to analyse a whole range of competing schemes or alternative solutions for each individual scheme using typical costs obtained from this report or specific scheme costs.

6.10 Appendix B contains three worked spreadsheets showing how the client or designer can choose surfacing materials, allow for different construction costs and include cost benefits attributed to retail, tourism or aesthetic improvements using values referred to in this report or obtained from any other data. The analysis can be carried out any time during the planning, detail design, construction or maintenance stage of a project.

6.11 The first spreadsheet referred to as High Street Alternative No 1 is a basic asphalt scheme with no benefits included. The whole life cost must therefore be negative and the calculations show a value of £ -141.7 per square metre. The next scheme described as High Street Alternative No 2 is a natural stone scheme in the middle cost range. It has been assumed that the scheme will provide some value to the economy and tourism. However the benefits are not sufficient to outweigh construction and maintenance costs and the whole life cost is still negative showing a value of £ -117.4 per square metre. The final spreadsheet called High Street Alternative No 3 portraying a similar scheme but given maximum economic and aesthetic cost benefits now shows a healthy positive whole life cost value of £ 92.9 per square metre.

7 Conclusions

7.1 WLC requires the appreciation of a wide range of factors either of a financial or objective nature. Every individual scheme will require an assessment of which factors should apply. If all of the benefits of streetscape schemes, both in terms of costs and aesthetics, are to be realized, an understanding of construction and maintenance costs must be derived, together with an evaluation of the benefits. Whole life cost analysis provides the basis for determining the cost/benefits of an investment such that a judgement can be made if the scheme can be justified.

7.2 Whole life cost modeling is not exact, but gives a reasoned argument for investment at initial project, construction and much later at the maintenance stages. It also allows alternative solutions to be considered on a level basis, including the comparison of man made materials with stone materials.

7.3 This report has developed a whole life cost model using historic data to investigate cost parameters and assigning benefit values that can be attributed to economic, tourism and aesthetic improvements resulting from investing in a high quality scheme. The model has been calibrated such that tangential economic benefits will result in positive whole life costs.

7.4 The model has been tested for a wide range of construction and maintenance costs using a 6% cash discount rate but also checking sensitivity by using discount rates of 2 and 10%. The model compared asphalt, man made surfacing and natural stone streetscape schemes

7.5 The report concludes that:

- The whole life cost of an asphalt scheme will always be cheaper than a natural stone scheme when considering only construction and maintenance costs

- If whole life costs include benefits to the local community natural stone schemes may well offer better value than asphalt schemes

- For natural stone schemes to be economically justifiable the design must ensure that future maintenance burdens are minimized and a maintenance system must be in place to safeguard the investments made.

- Whole life costing is dominated by the discounting rate used in the model calculations but the relative comparison between asphalt, man made and natural stone products remain fairly stable. The main consequence is that a high interest rate will reduce the value of future costs or payments much more rapidly than lower rates.

- In practicable terms whole life costs do not change after only about 50 years with a high discount rate and about 100 years with a low rate.

- In world global terms stone has low whole life costs, being a natural material that requires relatively few secondary processes before being used.

- Further studies are required to quantify more accurately social and economic benefits to the fabric of an environment having been subjected to quality streetscape works.

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- George Gray- Dundee City Council
- Angus Bodie- Renfrewshire Council

Appendix A - Model Spreadsheet

SCHEME **Model Spreadsheet**

MAIN SURFACING ELEMENT:

	ASPHALT		
	MAN MADE		
	STONE		
BASE YEAR COSTS PER SQ M OF SURFACING:	PLANNING,DESIGN & SUPERVISION		£
	ROAD CONSTRUCTION TO BASE COURSE LEVEL		£
	SURFACING MATERIAL		£
	ADDITIONAL COST OF LAYING SURFACING		£
	EXTENDED CONTRACT PERIOD COSTS		£
	STREET LIGHTING AND FURNITURE COSTS		£
	ART WORK COSTS		£
	ANY OTHER SCHEME COST		£
	TOTAL CONSTRUCTION COST:	C0	£
ANNUAL MAINTENANCE COSTS PER SQ M OF SURFACING:		M	£
REFURBISHMENT COST PER SQ M		R	£
	ASSUMED INTERVAL	N1	YEARS
RESIDUAL VALUE OF NATURAL STONE PER SQ M		V	£
DISCOUNT INTEREST RATE		r	%
ANNUAL BENEFIT TO BUSINESS RELATIVE TO DO NOTHING PER SQ M OF SURFACING		B	£
	ASSUMED BENEFIT INTERVAL	N2	YEARS
ANNUAL BENEFIT TO TOURISM RELATIVE TO DO NOTHING PER SQ M OF SURFACING		T	£
	ASSUMED BENEFIT INTERVAL	N3	YEARS
ANNUAL AESTHETIC IMPROVEMENT RELATIVE TO DO NOTHING PER SQ M OF SURFACING		A	£
	ASSUMED BENEFIT INTERVAL	N4	YEARS
WHOLE LIFE COST INTERVAL		N	YEARS

YEAR	Construction	Maintenance	Refurbuishm.	Residual	Bus. Benefit	Tour. Benefit	Aesth. Benefit	
N	C0	M	R	V	B	T	A	
1		M/(1+r)^1			B/(1+r)^1	T/(1+r)^1	A/(1+r)^1	Sum
2		M/(1+r)^2			B/(1+r)^2	T/(1+r)^2	A/(1+r)^2	Sum
3		M/(1+r)^3			B/(1+r)^3	T/(1+r)^3	A/(1+r)^3	Sum
4		M/(1+r)^4			B/(1+r)^4	T/(1+r)^4	A/(1+r)^4	Sum
5		M/(1+r)^5			B/(1+r)^5	T/(1+r)^5	A/(1+r)^5	Sum
6		M/(1+r)^6			B/(1+r)^6	T/(1+r)^6	A/(1+r)^6	Sum
7		M/(1+r)^7			B/(1+r)^7	T/(1+r)^7	A/(1+r)^7	Sum
8		M/(1+r)^8			B/(1+r)^8	T/(1+r)^8	A/(1+r)^8	Sum
9		M/(1+r)^9			B/(1+r)^9	T/(1+r)^9	A/(1+r)^9	Sum
10		M/(1+r)^10			B/(1+r)^10	T/(1+r)^10	A/(1+r)^10	Sum
11		M/(1+r)^11			B/(1+r)^11	T/(1+r)^11	A/(1+r)^11	Sum
12		M/(1+r)^12			B/(1+r)^12	T/(1+r)^12	A/(1+r)^12	Sum
13		M/(1+r)^13			B/(1+r)^13	T/(1+r)^13	A/(1+r)^13	Sum
14		M/(1+r)^14			B/(1+r)^14	T/(1+r)^14	A/(1+r)^14	Sum
15		M/(1+r)^15			B/(1+r)^15	T/(1+r)^15	A/(1+r)^15	Sum
16		M/(1+r)^16			B/(1+r)^16	T/(1+r)^16	A/(1+r)^16	Sum
17		M/(1+r)^17			B/(1+r)^17	T/(1+r)^17	A/(1+r)^17	Sum
18		M/(1+r)^18			B/(1+r)^18	T/(1+r)^18	A/(1+r)^18	Sum
19		M/(1+r)^19			B/(1+r)^19	T/(1+r)^19	A/(1+r)^19	Sum
20		M/(1+r)^20			B/(1+r)^20	T/(1+r)^20	A/(1+r)^20	Sum
N1		M/(1+r)^N1	R/(1+r)^N1		B/(1+r)^N1	T/(1+r)^N1	A/(1+r)^N1	Sum
N2		M/(1+r)^N2			B/(1+r)^N2	T/(1+r)^N2	A/(1+r)^N2	Sum
N3		M/(1+r)^N3				T/(1+r)^N3	A/(1+r)^N3	Sum
N4		M/(1+r)^N4					A/(1+r)^N4	Sum
N		M/(1+r)^N		V				Sum
						WHOLE LIFE COST		SUM

Appendix B – Worked Examples

SCHEME ***High Street Alternative No 1***

MAIN SURFACING ELEMENT:

ASPHALT	***Asphalt***			
MAN MADE				
STONE				
BASE YEAR COSTS PER SQ M OF SURFACING: PLANNING,DESIGN & SUPERVISION			£	***15***
ROAD CONSTRUCTION TO BASE COURSE LEVEL			£	***80***
SURFACING MATERIAL			£	
ADDITIONAL COST OF LAYING SURFACING			£	
EXTENDED CONTRACT PERIOD COSTS			£	
STREET LIGHTING AND FURNITURE COSTS			£	
ART WORK COSTS			£	
ANY OTHER SCHEME COST			£	***20 (Drainage)***
TOTAL CONSTRUCTION COST:		C0	£	***115***
ANNUAL MAINTENANCE COSTS PER SQ M OF SURFACING:		M	£	***0.75***
REFURBISHMENT COST PER SQ M		R	£	***15***
ASSUMED INTERVAL		N1	YEARS	***10***
RESIDUAL VALUE OF NATURAL STONE PER SQ M		V	£	
DISCOUNT INTEREST RATE		r	%	***0.06***
ANNUAL BENEFIT TO BUSINESS RELATIVE TO DO NOTHING PER SQ M OF SURFACING		B	£	***0***
ASSUMED BENEFIT INTERVAL		N2	YEARS	***20***
ANNUAL BENEFIT TO TOURISM RELATIVE TO DO NOTHING PER SQ M OF SURFACING		T	£	***0***
ASSUMED BENEFIT INTERVAL		N3	YEARS	***20***
ANNUAL AESTHETIC IMPROVEMENT RELATIVE TO DO NOTHING PER SQ M OF SURFACING		A	£	***0***
ASSUMED BENEFIT INTERVAL		N4	YEARS	***20***
WHOLE LIFE COST INTERVAL		N	YEARS	***30***

YEAR	Construction	Maintenance	Refurbuishm.	Residual	Bus. Benefit	Tour. Benefit	Aesth. Benefit	
N	-115	-0.75		0	0	0	0	-115.75
1		-0.7075472			0	0	0	-0.7075472
2		-0.6674973			0	0	0	-0.6674973
3		-0.6297145			0	0	0	-0.6297145
4		-0.5940702			0	0	0	-0.5940702
5		-0.5604436			0	0	0	-0.5604436
6		-0.5287204			0	0	0	-0.5287204
7		-0.4987928			0	0	0	-0.4987928
8		-0.4705593			0	0	0	-0.4705593
9		-0.4439238			0	0	0	-0.4439238
10		-0.4187961	-8.3759217		0	0	0	-8.7947177
11		-0.3950906			0	0	0	-0.3950906
12		-0.372727			0	0	0	-0.372727
13		-0.3516293			0	0	0	-0.3516293
14		-0.3317257			0	0	0	-0.3317257
15		-0.3129488			0	0	0	-0.3129488
16		-0.2952347			0	0	0	-0.2952347
17		-0.2785233			0	0	0	-0.2785233
18		-0.2627578			0	0	0	-0.2627578
19		-0.2478848			0	0	0	-0.2478848
20		-0.2338535	-4.6770709		0	0	0	-4.9109244
21		-0.2206166						-0.2206166
22		-0.2081288						-0.2081288
23		-0.1963479						-0.1963479
24		-0.1852339						-0.1852339
25		-0.174749						-0.174749
26		-0.1648575						-0.1648575
27		-0.155526						-0.155526
28		-0.1467226						-0.1467226
29		-0.1384176						-0.1384176
30		-0.1305826	-2.611652					-2.7422346
						WHOLE LIFE COST (AFTER 30 YEARS)		-141.73827

SCHEME ***High Street Alternative No 2***

MAIN SURFACING ELEMENT:

ASPHALT

MAN MADE

STONE ***Granite***

BASE YEAR COSTS PER SQ M OF SURFACING: PLANNING,DESIGN & SUPERVISION		£	***20***	
ROAD CONSTRUCTION TO BASE COURSE LEVEL		£	***80***	
SURFACING MATERIAL		£	***60***	
ADDITIONAL COST OF LAYING SURFACING		£	***25***	
EXTENDED CONTRACT PERIOD COSTS		£	***10***	
STREET LIGHTING AND FURNITURE COSTS		£	***5***	
ART WORK COSTS		£	***5***	
ANY OTHER SCHEME COST		£	***20***	***(Drainage)***
TOTAL CONSTRUCTION COST:	C0	£	***225***	
ANNUAL MAINTENANCE COSTS PER SQ M OF SURFACING:	M	£	***1.5***	
REFURBISHMENT COST PER SQ M	R	£	***0***	
ASSUMED INTERVAL	N1	YEARS	***100+***	
RESIDUAL VALUE OF NATURAL STONE PER SQ M	V	£	***30***	
DISCOUNT INTEREST RATE	r	%	***0.06***	
ANNUAL BENEFIT TO BUSINESS RELATIVE TO DO NOTHING PER SQ M OF SURFACING	B	£	***5***	
ASSUMED BENEFIT INTERVAL	N2	YEARS	***20***	
ANNUAL BENEFIT TO TOURISM RELATIVE TO DO NOTHING PER SQ M OF SURFACING	T	£	***0***	
ASSUMED BENEFIT INTERVAL	N3	YEARS	***20***	
ANNUAL AESTHETIC IMPROVEMENT RELATIVE TO DO NOTHING PER SQ M OF SURFACING	A	£	***3***	
ASSUMED BENEFIT INTERVAL	N4	YEARS	***20***	
WHOLE LIFE COST INTERVAL	N	YEARS	***30***	

YEAR	Construction	Maintenance	Refurbuishm.	Residual	Bus. Benefit	Tour. Benefit	Aesth. Benefit	
N	-225	-1.5	0	30	5	0	3	-188.5
1		-1.4150943			4.7169811	0	2.8301887	6.1320755
2		-1.3349947			4.4499822	0	2.6699893	5.7849769
3		-1.2594289			4.1980964	0	2.5188578	5.4575253
4		-1.1881405			3.9604683	0	2.376281	5.1486088
5		-1.1208873			3.7362909	0	2.2417745	4.8571781
6		-1.0574408			3.5248027	0	2.1148816	4.5822435
7		-0.9975857			3.3252856	0	1.9951713	4.3228712
8		-0.9411186			3.1370619	0	1.8822371	4.0781804
9		-0.8878477			2.9594923	0	1.7756954	3.84734
10		-0.8375922			2.7919739	0	1.6751843	3.629566
11		-0.7901813			2.6339376	0	1.5803626	3.4241189
12		-0.745454			2.4848468	0	1.4909081	3.2303009
13		-0.7032585			2.3441951	0	1.4065171	3.0474536
14		-0.6634514			2.2115048	0	1.3269029	2.8749563
15		-0.6258976			2.0863253	0	1.2517952	2.7122229
16		-0.5904694			1.9682314	0	1.1809389	2.5587008
17		-0.5570466			1.8568221	0	1.1140933	2.4138687
18		-0.5255157			1.751719	0	1.0510314	2.2772346
19		-0.4957695			1.6525651	0	0.991539	2.1483346
20		-0.4677071			1.5590236	0	0.9354142	2.0267307
21		-0.4412331						-0.4412331
22		-0.4162576						-0.4162576
23		-0.3926959						-0.3926959
24		-0.3704678						-0.3704678
25		-0.3494979						-0.3494979
26		-0.329715						-0.329715
27		-0.3110519						-0.31105
28		-0.2934452						-0.29345
29		-0.2768351						-0.27684
30		-0.2611652						-0.26117
						WHOLE LIFE COST (AFTER 30 YEARS)		-117.388

SCHEME ***High Street Alternative No 3***

MAIN SURFACING ELEMENT:

ASPHALT

MAN MADE

STONE ***Granite***

BASE YEAR COSTS PER SQ M OF SURFACING:	PLANNING,DESIGN & SUPERVISION		£	***20***
	ROAD CONSTRUCTION TO BASE COURSE LEVEL		£	***80***
	SURFACING MATERIAL		£	***30***
	ADDITIONAL COST OF LAYING SURFACING		£	***35***
	EXTENDED CONTRACT PERIOD COSTS		£	***20***
	STREET LIGHTING AND FURNITURE COSTS		£	***5***
	ART WORK COSTS		£	***5***
	ANY OTHER SCHEME COST		£	***20 (Drainage)***
	TOTAL CONSTRUCTION COST:	C0	£	***215***
ANNUAL MAINTENANCE COSTS PER SQ M OF SURFACING:		M	£	***1.5***
REFURBISHMENT COST PER SQ M		R	£	***0***
	ASSUMED INTERVAL	N1	YEARS	***100+***
RESIDUAL VALUE OF NATURAL STONE PER SQ M		V	£	***20***
DISCOUNT INTEREST RATE		r	%	***0.06***
ANNUAL BENEFIT TO BUSINESS RELATIVE TO DO NOTHING PER SQ M OF SURFACING		B	£	***15***
	ASSUMED BENEFIT INTERVAL	N2	YEARS	***30***
ANNUAL BENEFIT TO TOURISM RELATIVE TO DO NOTHING PER SQ M OF SURFACING		T	£	***1***
	ASSUMED BENEFIT INTERVAL	N3	YEARS	***30***
ANNUAL AESTHETIC IMPROVEMENT RELATIVE TO DO NOTHING PER SQ M OF SURFACING		A	£	***5***
	ASSUMED BENEFIT INTERVAL	N4	YEARS	***30***
WHOLE LIFE COST INTERVAL		N	YEARS	***30***

YEAR	Construction	Maintenance	Refurbuishm.	Residual	Bus. Benefit	Tour. Benefit	Aesth. Benefit	
N	-215	-1.5	0	20	15	1	5	-175.5
1		-1.4150943			14.150943	0.9433962	4.7169811	18.396226
2		-1.3349947			13.349947	0.8899964	4.4499822	17.354931
3		-1.2594289			12.594289	0.8396193	4.1980964	16.372576
4		-1.1881405			11.881405	0.7920937	3.9604683	15.445826
5		-1.1208873			11.208873	0.7472582	3.7362909	14.571534
6		-1.0574408			10.574408	0.7049605	3.5248027	13.746731
7		-0.9975857			9.9758567	0.6650571	3.3252856	12.968614
8		-0.9411186			9.4111856	0.6274124	3.1370619	12.234541
9		-0.8878477			8.878477	0.5918985	2.9594923	11.54202
10		-0.8375922			8.3759217	0.5583948	2.7919739	10.888698
11		-0.7901813			7.9018129	0.5267875	2.6339376	10.272357
12		-0.745454			7.4545405	0.4969694	2.4848468	9.6909026
13		-0.7032585			7.0325853	0.468839	2.3441951	9.1423609
14		-0.6634514			6.6345145	0.442301	2.2115048	8.6248688
15		-0.6258976			6.2589759	0.4172651	2.0863253	8.1366687
16		-0.5904694			5.9046943	0.3936463	1.9682314	7.6761025
17		-0.5570466			5.5704663	0.3713644	1.8568221	7.2416062
18		-0.5255157			5.2551569	0.3503438	1.751719	6.8317039
19		-0.4957695			4.9576952	0.330513	1.6525651	6.4450037
20		-0.4677071			4.6770709	0.3118047	1.5590236	6.0801922
21		-0.4412331			4.412331	0.2941554	1.470777	5.7360304
22		-0.4162576			4.1625765	0.2775051	1.3875255	5.4113494
23		-0.3926959			3.9269589	0.2617973	1.3089863	5.1050466
24		-0.3704678			3.7046782	0.2469785	1.2348927	4.816082
25		-0.3494979			3.4949795	0.2329986	1.1649932	4.543473
26		-0.329715			3.2971504	0.21981	1.0990501	4.286296
27		-0.3110519			3.1105193	0.207368	1.0368398	4.043675
28		-0.2934452			2.9344521	0.1956301	0.9781507	3.814788
29		-0.2768351			2.7683511	0.1845567	0.9227837	3.598856
30		-0.2611652			2.611652	0.1741101	0.8705507	3.395148
						WHOLE LIFE COST (AFTER 30 YEARS)		92.91421