

SCOTS

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

Report



on

**Technical Evaluation of Natural Stone Surfacing
in Streetscape Schemes in Scotland**

by

ID Consultants

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FOREWORD

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

Technical Evaluation of using Natural Stone Surfacing in Streetscape Schemes in Scotland

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.

- Whole Life Costing for Natural Stone Streetscape Works
- 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 (scots-website.org.uk) and our reports will in due course be placed on this site.

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

During the past decade, towns and cities all over the country have been the subject of extensive reconstruction of their public realm streetscape infrastructure. Many of these schemes have incorporated natural stone materials for street surfaces because of its exceptional aesthetic quality, durability and sustainability.

As part of their ongoing national research into all aspects of street improvements using natural stone materials, SCOTS wished to evaluate the technical, economic and aesthetic characteristics of a selection of 24 completed schemes around the country. ID Consultants were appointed to carry out this evaluation in September 2002.

Detailed questionnaires along with site visits and meetings with local operational managers, have provided detailed information about each scheme, from inception through to maintenance. During site visits a checklist of standard characteristics was used to objectively assess each scheme on a common basis.

Based on the scheme analyses, this report concludes with recommendations providing guidance to future practitioners on good practices, on pitfalls identified in past projects and to give information required to justify the use of natural stone materials in streetscape designs.

Gaps in knowledge of design and aftercare of stone surfaced paved areas have been identified and recommendations made for topics for further research and investigation.

It was agreed from the outset that all information gathered would be treated as confidential and that the final report would not identify individual schemes therefore only generic information has been included.

The main conclusions from our study are:

- ❑ Client responses showed that 50% of the schemes were worse than expected and only 25% better than expected
- ❑ Our technical evaluation of existing streetscape schemes constructed over the last decade revealed that most of the schemes functioned fairly well with only minor faults but some schemes have failed fairly dramatically requiring continuous maintenance or reconstruction.

The two areas of main concern were:

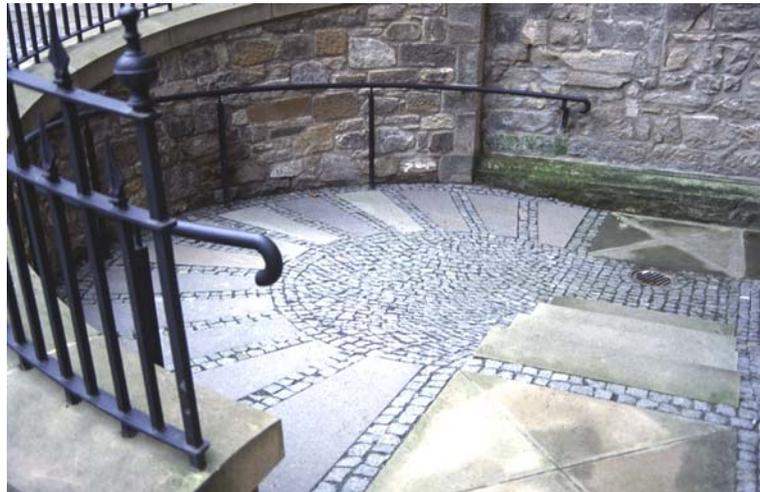
- Allowing heavy vehicles on slabbed surfaces
- Use of stone surfaces on roads with very high traffic volumes

Even under these circumstances some schemes behaved better than others due to better specifications and workmanship. It seems the vulnerability of slabs may be very dependant upon the skill of the slab layer and the correct design of the bedding and jointing systems will allow setts to carry substantial traffic volumes. However designers should be aware of the risk of failures in these circumstances.

- Many streetscape schemes have fairly low traffic flows and in these circumstances the critical design factor may well be the action of suction sweeping and cleaning vehicles which tend to loosen up the joints.
- There seems to be a perception that natural stone schemes should not require maintenance because of the infinitive life of the stone and the high cost of the works. This is not the case, stone streetscape schemes need more maintenance attention than standard asphalt roads because of the jointing system, aesthetic standards and the public's expectations.
- Most of the schemes that we inspected had minor defects such as the occasional loose joint, rocking slab and cracking around interfaces with channels and street furniture. Such defects have to be repaired before they become the starting point for a more catastrophic failure.
- Most designs were carried out prior to the SCOTS design guide published in October 2000 and sand/cement ratios were specified for bedding and jointing materials rather than target strengths. Also in many cases the contractors seem to have been allowed to change bedding and jointing specifications either because they were inadequate or the contractors had their own preferred methods.
- It seems that site controls have been too weak in ensuring compliance with the specification and in controlling and testing bedding and grouting materials. It may be better in the future to attempt to design out some of these uncertainties by

specifying proprietary brands that only need the addition of water even if these mixtures are more expensive than ordinary cement mortars.

- ❑ Fair criticisms have been voiced by maintenance engineers and cleansing managers that their views have not been sought at the design stage and they are left to maintain street furniture that is not functional and too expensive to replace.
- ❑ It is recommended that maintenance manuals, agreements and funding should be discussed at the design stage rather than be addressed by ad hoc or reactive maintenance procedures.



A successful scheme

- ❑ National standards should set the levels of inspections and maintenance regimes for streetscape works allowing for their special nature and status.
- ❑ Highway authorities must ensure that public utilities carry out reinstatements to the same quality and standard as the original work. This may be achieved by using term contractors specialising in streetscape works
- ❑ Aesthetically the biggest concerns are for removal of cement stains during the construction stage and later chewing gum removal as a part of ongoing routine maintenance.
- ❑ Further research and development should in our opinion be centred around:
 - Grouting specifications

- Slab laying techniques
- How to replace depleted joints
- Damage to joints caused by suction sweeping or pressure washing equipment
- Cement stain removals
- Chewing gum removal.

1 Brief

1.1 Objectives of Brief

The objectives of the brief were to obtain an independent view on technical performance in relation to design, construction, and subsequent maintenance and management, and in the interests of Best Value to provide recommendations of 'value' to aid future works of this kind.

At the inception of the project, the client and consultant agreed the schemes to be reviewed. Some 24 schemes were selected, representing 18 of the 32 Scottish local authorities.

1.2 Scope of Brief

a. Design and Construction Procedures

Review the design and construction standards and material specifications for all elements of the paving works, street lighting and street furniture and report on how the design and specification for the paving works compares with best practice at the time of construction and current best practice.

Undertake a visual inspection of the completed works and provide :

- A summary of the key design procedures
- Details of further investigation and/or testing which may be appropriate including estimated costs and benefits.

b. Maintenance and aftercare procedures

Discuss current inspection and maintenance procedures with appropriate Council staff and review and report on the extent to which there is an appropriate and auditable inspection and maintenance regime in place.

Undertake a visual inspection of the completed works and provide :

- A summary of the key maintenance procedures
- An opinion on the form and frequency of inspection and maintenance records
- Where Maintenance Manuals exist, review them and comment on their usefulness and adequacy.

2 Background

2.1 Many prestigious city or town centre spaces have during the last one hundred years passed through a cycle of changes from originally being constructed in stone, later to be overlaid by asphalt surfaces or concrete pavements to finally completing the circle by being relaid in stone again.

The original streets were 'designed' for horse drawn carriages but over time the carriages were replaced by trams and motor vehicles. The latest development is generally to reduce the impact of the motor vehicle and give priority to pedestrians to create a more attractive environment for local people, businesses and visitors alike.

2.2 While the research and development of modern road making materials has surged ahead to become ever more sophisticated the old skill of laying cobbled streets disappeared. After the second world war the use of stone as a carriageway material virtually ceased in the UK only to slowly reappear in the nineteen nineties by which time the practical skills and knowledge of laying stone had been lost. The stone work was a craft carried out by skilled layers and the knowledge passed from father to son. Very few written records seem to have been made about how to select, lay and maintain our old cobbled streets.



Old Glasgow setts still in use and in good order

2.2 With hindsight, it is therefore not surprising that some of the new stone schemes have had problems, since we have 'lost' the practical skill, and not been able to support new schemes with sufficient theoretical knowledge.

Our present situation is more complex than in previous times in that we now have a choice in how much and what type of traffic should be allowed to occupy our main town and city centre streets,. New stone materials can be imported from any part of the world

and modern design is much more complex involving several layers of professional input and public consultations.

2.4 In order to understand how the 'new' stone schemes have evolved and study the successes and problems with completed schemes we concentrated our study around the following issues:

- Consultation processes
- Procurement
- Traffic levels
- Stone design
- Bedding and jointing design
- Street furniture design
- Aesthetics
- Supervision
- Maintenance
- Costs

2.5 The report describes our current knowledge about each of these aspects and how in our opinion the schemes included in the survey approached them.

QUESTIONNAIRE RESPONSES

3 Scheme Questionnaires

3.1 The questionnaires were composed to gain the maximum information from each scheme whilst at the same time trying to avoid the respondent having to write lengthy answers. As far as possible most questions could be answered by inserting a tick in boxes offering alternative replies. We were interested in the views expressed by clients, designers, contractors, site supervisors and the post contract comments by road maintenance and cleansing managers

For these reasons we prepared, in conjunction with the SCOTS Natural Materials Group, five different questionnaires to be answered by the following:

- Client /Designer
- Designer
- Contractor/ Site Supervisor
- Roads Maintenance Engineers
- Cleansing Manager.

The schemes to be included in the survey were selected by the SCOTS Natural Materials Group members to allow for a typical cross section of materials used, traffic conditions, location and size. SCOTS contacted the various Head of departments to get their agreement to participate in the survey and to obtain a main contact in each council who would be able to select the most appropriate people to complete the various forms.

3.2 The accompanying letter with the survey questionnaires emphasised that all answers would be treated in confidence. The purpose of the survey was for everyone in future schemes to learn from mistakes made and share successes. We also stated that we would like to visit each scheme and meet some of the people involved. Our study would draw on the information received from the questionnaires, feedback from informal discussions and our own impressions from visiting the sites,

Of the 24 schemes included in the survey about half of the scheme questionnaires were returned more or less completed. Another quarter returned some of the questionnaires and gave us some feedback while the last quarter failed to respond to our requests

despite efforts both by SCOTS and ourselves to engender some enthusiasm for responding.

With hindsight maybe our questionnaires were too ambitious requiring far too much detail and too many people to respond. Nevertheless the responses received from the selected authorities allowed us to identify definite trends.

The reasons for only a partial response were manifold and understandable such as the scheme had been constructed a long time ago, the key personnel were no longer in their jobs or pressure of work having to respond to more urgent matters. On the other hand many of the authorities showed genuine interest and willingness to share their experiences both by highlighting failures and successes.

4 Client Responses

4.1 In the Client/ Designer questionnaire the respondent was asked to comment on whether the scheme was better, as anticipated or worse than expected and the following responses were received

- Better than expected 25%
- As expected 25%
- Worse than expected 50%

We think this reflects fairly accurately the standard of work completed to date. These judgements are subjective and it may well be that the initial expectations were too high thinking that since stone is everlasting and expensive to lay, a perfect surface for vehicles and pedestrians alike should be forthcoming without having to spend money on maintenance.

4.2 There is no such thing as a typical natural stone scheme but the survey shows that most of the schemes were in the £ 0.5-1.0M bracket with nearly all of them partially funded by the local authority with the rest coming from external bodies such as Scottish Enterprise or EU grants. It seems the external funding has acted as a catalyst in getting the schemes off the ground and it is not clear how many schemes will be constructed in the future without such funding arrangements.

It is noticeable from the survey that more than half of the schemes exceeded the contract period typically by 10-25% and the lesson should be that we must allocate enough time to carry out the work. It must be remembered that most of the schemes take place in restricted urban areas congested with pedestrians and underground services. Another factor different from normal road building is that often the stone is imported from overseas and the designer or the contractor will not have allowed sufficient lead-in time for delivery of the stone. Typically the lead-in time for European stone is 4-6 weeks and Asian stone 8-12 weeks. Deliveries are normally dependant upon the quarry operator, agents and shipping agents. Some of the respondents have quoted stone deliveries as a reason for delays.

From the returns it seems that final contract costs are only marginally higher than tender costs typically by 5% which is quite encouraging considering the working environment and the complexity of dealing with natural stone. One of the reasons for this may be that a relatively small number of contractors are selected for streetscape works because of their expert knowledge and many of the same stonelayers are used as sub contractors.

- 4.3 At least half of the schemes seem to have been designed by the council in-house staff with some input from external consultants such as landscape architects while a third of the schemes have an external consultant as the lead designer. The contract documents are almost entirely formed from standard road construction documents and most commonly produced by road engineers. The schemes have typically used the ICE 5th edition, the Highway Works specification and the Design Manual for Roads and Bridges

Most scheme designers have anticipated that relatively few areas are pedestrian only not requiring access for emergency and maintenance vehicles. Accordingly setts or cubes have been used on the majority of the sites where vehicle access is required. Slabs are used almost universally on footways separated from the carriageway. In the few instances slabs have been specified for shared surfaces problems have often been experienced. The setts and cubes used are a mixture of re-used stock, imports from Europe or Asia. Caithness slabs dominate the slabbing market with a few schemes using sandstone or imported granite.

5 Design and Construction Responses

- 5.1 Most of the schemes included in the survey were designed as a rigid construction using cementitious bedding and jointing materials, typically with 150 mm Type 1 sub-base and 150-200 mm bituminous roadbase. This should be a perfectly adequate construction in accordance with DMRB, SCOTS or council standards for roads with low volumes of heavy axles. In most cases the sublayers are slightly over designed which in our view is prudent considering the cost of failure in having to replace the stone surfacing caused by failure of the sub-construction.



Example of Caithness used as shared surface

Road construction is usually difficult in busy urban areas and complicated by existing public utilities which often necessitate that the work must be piecemeal with leading to, at times, sub standard compaction. The additional pavement thickness will compensate for some of these shortcomings. Similarly typical footway constructions are 150 mm Type 1 and 60-100mm bituminous basecourses. This is a higher specification than would be normal for concrete slabs but is in our view fully justified for the reasons stated above. The increased footway construction also gives some protection against vehicle overrun. Often the depth of public utilities in the footways are such that any deeper construction would be difficult without costly diversions.

Only two of the study schemes have used a flexible construction in the carriageway and a few more have used it in the footway. Flexible construction will not have any cement bound materials in the bedding or jointing layers but may use an open textured bitumen as a basecourse material to strengthen the sub layers and allow surface water to percolate into the subsoil .

- 5.2 Before the SCOTS design guide was published the German code DIN 18502 was commonly referred to for material sizes and tolerances. The SCOTS guide advocates cubes should only be used for light traffic loadings but several schemes have used them for higher traffic categories without any obvious detrimental effect. More problems seem to arise by using setts with less depth than recommended in the Guide and one authority recommend the setts should be at least 150 mm deep if used for bus lanes which is interesting because all traditional setts laid in Scotland seem to be at least this depth.

The use of slabs to carry vehicle traffic with axle weights in excess of 2 tonnes is not advised by the SCOTS guide and in general this seems correct because in most cases where slabs have been used as a carriageway material, failures occur. This is not normally because the slab breaks immediately but because they are dislodged and begin to rock and eventually break unless re-bedded and re-jointed. Some authorities believe that a weak jointing system allows water ingress and this is the start of the failure process. Paradoxically in some schemes larger slabs without a bituminous base seem to survive heavy vehicle loads better than smaller slabs, but allowing vehicular traffic on any slabs is risky and should in general be avoided.

- 5.3 The bedding layer specifications used by respondents to our survey vary quite widely with mortar strengths from 1:3 to 1:6 using whin sand, sharp sand or rock aggregate normally specified in a 40-50 mm layer with the tolerances stated to be about 6 mm. The time allowed for curing also varied considerably between 7-28 days. In most cases the bedding has been mixed on site and laid dry or semi-dry. Very few scheme specifications seem to have imposed time limits for how long the bedding can be stored or ordered cube testing to gauge and control the strength of the bedding material as recommended by the SCOTS Guide.

It is also slightly alarming that in many of the schemes the bedding design was changed on site. It may be that since many of the schemes were constructed some time ago that some of the site details have been forgotten or misreported but the survey results

indicate that the specifications given may have been inadequate. Pre-mixed bedding or mixed from site silo's seems not to have been specified and the bedding has been specified as a sand/cement ratio rather than a compressive strength as recommended by the SCOTS Guide.

The grouting specification used in most schemes varies between 1:2 and 1:6 batched on site to form a slurry that could be brushed into the joints. It seems that cube testing to ascertain the strength of the mortar was rarely carried out or documented. Some mixes had plasticisers added which would reduce the amount of water required. It seems that in many schemes the contractor changed the grouting specification based upon their own or sub-contractors experiences. We do not know if this improved the design or had to be done because the specification given was not practicable. However the addition of water to a mortar to produce a slurry gives variable results unless admixtures with pre-defined parameters are used to give the required compressive strengths.

Cropped setts and cubes with narrow joints can only be filled by the slurry method and in order to achieve the strength recommended by the SCOTS Guide the most reliable way in our opinion is to use proprietary brands which only need the addition of water. This simplifies site site supervision of required and the be reduced. The been developed to bonding as well as to a few hours if



Cubes being filled by the slurry method

checking so that direct the batching is not number of cube tests can proprietary grouting has control shrinkage and reducing the curing time required. Very few of the

schemes investigated seem to have used proprietary grouting products and one of the reasons quoted for this was cost.

One authority having used slabs as a carriageway surface material experienced problems with the mortar joints loosening up and the slabs starting to rock, first attempted stronger mortar with some success. They have now started to use a proprietary bituminous compound to fill the joints claiming initial success. It will be interesting to note the long term effect of these trials. Using the bituminous compound the joints will remain flexible and keep water out.

- 5.4 Sawn joints down to about 5mm width can be hand pointed using a hand held gun and joints about 10 mm wide can be filled with a nozzle, which avoid having to use a slurry. The subsequent cleaning up action to remove the cement staining from the stone is also made easier.

With sawn stone the joint width can be controlled, and in the schemes investigated the joint varied typically between 5-10 mm. It is partially a matter of aesthetics how wide the joints should be but wide joints will be stronger than narrow ones. Considering the specification for a sawn slab tends to be +/- 2 mm and diagonal tolerances about 5 mm, these joint widths can absorb the slab tolerances. The joint width may depend upon the slab size and if the joints are to be pointed rather than slurry filled the upper half of the width band stated should be used to ensure that all of the void is filled. A few schemes have been laid butt ended but this requires even greater cutting accuracies and does not prevent damage to the arrises. The advantage is of course that grouting is not required

- 5.5 Two of the schemes included in the study were of a flexible construction avoiding the pitfalls of having to specify cement content. The strength of the construction relies upon gaining optimum compaction. For cubes and setts this requires vibrating plates, and slabs are compacted by rubber mallets. It is difficult to ensure that uniform compaction and levels are achieved. This is much more difficult than laying concrete pavements on a prepared screed and for this reason only skilled and experienced stone layers should be allowed to lay cubes or setts in a flexible construction. However if laid skillfully the result will be aesthetically pleasing and retain the natural look of the stone much better than rigid construction.

The jointing material must be well graded to suit the joint widths and vibrated or watered in to ensure the joints are filled and compacted. If this is achieved arching forces will be created in the same way as in concrete pavements. The joints will have to be refilled a few times during the maintenance period but after that detritus will tend to seal the joints and they become completely stable unless disturbed by heavy mechanical cleaning vehicles applying suction to funnel up loose materials.

6 Street Furniture Responses

6.1 From the schemes studied it seems to be a fairly even split between individually designed lighting and street furniture, bespoke and schemes using standard equipment.

Of course in some schemes the design team has decided not to replace the lighting especially when the existing lighting is wall mounted, The variation in the design approach is also reflected in the reported cost of these elements which tend to vary between 5-15% of the tender value.

It also follows from the survey that if money has been spent on street lighting the street furniture will also tend to be replaced. Typical costs of replacing street furniture appears to be in the range of 2-7% of the tender value so the norm seems to be to provide about half the amount spent on lighting on other street furniture.

6.2 Many maintenance engineers and cleansing managers have reported that individually designed street furniture has not stood up to operational needs and that no money is available for replacements. It is therefore important that the street furniture proposed by the design team should be vetted by the operators before being agreed and that all are aware of the costs of replacing damaged street furniture,

There is also some evidence that resources are not directed sufficiently towards maintaining non standard furniture even where simple matters such as painting or varnishing would prolong its life. This may be because of a lack of communication and the absence of a maintenance manual that would specify annual maintenance actions to be carried out by a named person or group.

7 Aesthetics

7.1 Aesthetics is very subjective and most stone schemes change considerably with the seasons or if seen in wet or dry weather. On the whole stone looks better when it is wet and in the summer when the grit and 'murkiness' of the winter has been cleaned up.

Some schemes show a clean appearance under most conditions. The reasons for this is that the stone is vibrant, cement stains from the construction stage are not noticeable and the stone does not retain dirt because the surface texture is dense rather than porous. Other schemes appear to be permanently dirty caused by the dullness of the stone, cement stains, the stone being porous, too light or uniformly coloured.

- 7.2 Our personal opinion is that Caithness has a bright sharp colour working well in combination with a contrasting material because by itself it may appear too dark. The riven surface is easy to clean but does show up cement stains and chewing gum.



Caithness Slabs



Porphyry Cubes

Porphyry has similar qualities to Caithness but has much more colour variations and can be used both as cubes and slabs. Quartzite is another riven slab material suitable for trims or slabbing with a bright surface, even in sunshine, so dense that the light is actually reflected off the stone.

York stones and sand stones have great variations in colour and quality with sawn or riven finishes but it should be noted that only some are suitable for streetscape works.

Granite is the most universal of all the stone materials and can be used as setts, cubes and slabs being available in almost any colour or at any cost. Granite looks best when polished but unfortunately that is not suitable for streetscape works. Granite can be cropped, sawn, textured or flame textured to produce a variety of final surface finishes. Different grain patterns and colours also alter the sharpness and the ability of the granite to hide dirt and cement stains. Because of the variable nature of the granite it can vary from being fantastic to rather dull.

- 7.3 Our inspections showed that most of the schemes are maintained reasonably well. Apart

from schemes that suffer chronic problems, where large patches of temporary bitumen surfacing is the norm, most schemes only showed a few loose joints, the odd rocking slab and often some cracking at the interface with channels and ironworks. Many inlaid manholes had cracks. Most of the schemes inspected were constructed well in advance of the SCOTS Guide and hopefully the Guide will raise standards such that major failures are avoided and the maintenance costs reduced

Our main impression was that maintenance engineers do try to repair defects on a regular basis. However most of them complained about lack of maintenance budgets ring fenced for streetscape works and sometimes lack of knowledge of how to repair or how to obtain labour for such tasks.

- 7.4 The biggest problem for most authorities seems to be the removal of chewing gum. At least 75% of the schemes visited had substantial amounts of gum showing. Various authorities are using different methods, some have bought equipment and some hire or use external contractors. No single method or treatment has yet evolved as the best solution. Aesthetically, huge amounts of gum can be very off putting and do not sit well with the money and the care taken to construct the schemes. It seems an obvious need to allocate more funds towards removal as well as pooling experiences and costs between different authorities. There is also a need to tackle the problem by convincing manufacturers to produce less sticky and bio-degradable gum if possible, start campaigns to stop people dropping gum and use legal powers to fine offenders

Another problem is that the cigarette ends seem to fit neatly into most joints unless these are flush with the stone. This is a particular problem if flexible joints have been used and the joints have not been topped up.

8 Cost Responses

- 8.1 Natural stone schemes are more expensive than asphalt schemes by roughly a factor of two. This is because the cost of procuring and laying natural stone will vary between £ 50-100 per square metre while asphalt surfacing may cost £ 10 per square metre. The cost of excavation, drainage, sub layers and public utilities work will be more or less the same.

The number of joints and complexity of bedding and grouting materials make stone schemes more expensive to maintain despite the indefinite life of the stone itself. The reason for using stone is to raise the aesthetic appearance of the street and the overall ambience of the location for the enjoyment of its users and the hope that such expenditure will assist retail, business and tourism.

The potential benefits to business, retail, tourism and any feel good factors to the environment can be given ratings and combined with the actual cost of constructing and maintaining the works. This will allow whole life costs to be developed and compared with other streetscape schemes, including alternatives for each scheme, to evaluate the overall best value scheme in economic terms. In construction and maintenance terms simple asphalt schemes will win, so the more expensive stone schemes must be justified by the benefits these can bring.

- 8.2 In order to gauge typical streetscape scheme costs our questionnaires asked for overall costs and scheme areas, such that we could calculate typical square metre costs. The survey shows that most of the schemes had a cost per square metre between £ 150-250 but we are aware that high status schemes may exceed these figures and sometimes public utility difficulties and the like will bring the cost up. As pointed out above the main cost is in the procurement and laying of the stone. Stone is a difficult material to shape such that complicated patterns, cuttings and carvings will also increase the cost considerably.

The designers have an obligation to choose materials and fittings to fulfil the client's ambitions about the status of the scheme whilst recognising whole life cost justifications.

9 Maintenance Responses

- 9.1 Around 30% of schemes involved maintenance officers in the design process. Of those most used these officers for 'approval' purposes rather than engaging them fully in the design discussions.

70% of respondents have a management strategy in place either for the specific scheme or one which includes the scheme area. Therefore 30% have no formal strategy for the aftercare of the completed streetscape scheme.

50% of respondents have formal written guidelines for paving maintenance and repair, 40% for maintenance of street furniture and street lighting.

All respondents reported that their technical staff involved in the day to day maintenance of the scheme have been made aware of the special requirements of the scheme. 30% have provided specialised training for their staff and the same number reported that their scheme had resulted in additional employment opportunities relating to aftercare.

- 9.2 50% of respondents reported that they have Maintenance Manuals. However, in only two cases this is a document containing details of all public services in the area, the rest being all roads-related functions.

Varying degrees of success through compliance with the Manual was reported with most respondents reporting that the Manual is not widely used.

- 9.3 80% of schemes are inspected by experienced inspectors with knowledge of natural stone paving. General inspection frequency varies, with 60% being once a month, 30% twice a month, and 10% being more than twice a month. In the case of street furniture, 50% inspect once a month, 40% twice a month and 10% more than twice a month

50% of respondents use term/framework contracts (e.g. schedule of rates) for paving maintenance and repair. Of these, only one uses their local Direct Labour Organisation, whilst the rest use private contractors.

All respondents advised that they have purchased spare materials for maintenance purposes. On average 5% of total area of paving is put into store but only 50% of respondents have spare street furniture in store.

- 9.4 In order to protect the quality of the street surfaces, 60% of respondents reported that they have designated their schemes as having special status under NRSWA, and have improved notification and inspection procedures as a result.

In terms of inspections and approvals of utility work, 50% have special arrangements, but only one Council inspects and approves every opening.

70% of respondents have arranged for their contractor to carry out works for utilities with appropriate recharges made. In most cases this is infrequent and in only one case can this be described as a daily routine.

- 9.5 All respondents have defects reporting procedures in place. In 80% of schemes, defects are mainly notified through routine inspection. For the rest, defects are principally notified through public complaints.

In 25% of schemes, street wardens/rangers provide “eyes and ears” on the street noting defects, vandalism etc. as well as other duties.

Only two respondents reported that specialist equipment had been purchased to aid maintenance, one of which was a sprayer for winter maintenance, and the other a chewing gum removal system.

- 9.6 60% of respondents reported that they have secured additional funding for the quality street surfaces although in only one case was an actual figure given. In this case, the additional funding equates to some £1.50 per square metre of stone surface per annum.

50% of respondents were unable to identify the additional funding that is over and above normal maintenance funding i.e. what would have been spent on the street even if the streetscaping had not been done.

Only one respondent reported that they were not constrained by funding restrictions from providing an adequate service. All other respondents required additional funding.

- 9.7 When asked if they thought that the general public were satisfied with the maintenance service being provided in high quality areas, 50% of maintenance officers considered that the public were satisfied with paving maintenance and repair, and 70% were satisfied with street furniture and lighting maintenance.

GOOD PRACTICE RECOMMENDATIONS

10 Consultations

- 10.1 Changes to main town or city centre areas envisaged for streetscape works may involve strategic planning alterations to how the main fabric of the area should be preserved, renovated or redeveloped

Early consideration should be given to how the introduction of a streetscape scheme may offer an opportunity to change the traffic management system by exploring the possibility of removing or reducing traffic in order to introduce pedestrianisation. However this may only be achieved if existing traffic can be diverted or if existing premises can be served from back street entrances. Often compromise solutions must be sought because of physical difficulties and costs in removing or reducing vehicle movements. In any case emergency vehicle access must normally be maintained and in many major public areas, the instances of emergency call-outs can be fairly regular.

The main design criteria for a streetscape scheme must, as well as being aesthetically pleasing be that the materials are suitable for the traffic conditions : that the cost can be justified and that the scheme after completion can and will be maintained properly

Far too often the future maintenance of a streetscape scheme is not sufficiently addressed at the design stage, causing later operational problems which cannot easily be remedied. This can only be avoided by consulting with maintenance engineers at an early stage about the proposed materials, construction methods, proposed layouts and how future access for maintenance equipment and vehicles will be provided. Similarly cleansing managers should be consulted about their preferred cleansing regimes and if they will be willing to change these for certain types of surface construction

If level changes are envisaged or footway areas changed to carriageways, these may seriously affect existing public utilities, requiring expensive diversions. In order to establish the magnitude of any potential utility problems, service record information must be obtained and trial holes excavated at an early stage such that any problem can be discussed with the utility managers, preferably at the feasibility stage. It should be noted that NRSWA does not require detailed consultation and consideration of diversions until final design stage, so special meetings should be held with utilities much earlier in the design process.

10.2 The key personnel to be consulted if not already part of the design group are:

- Traffic Engineers
- Road Maintenance
- Cleansing
- Street Furniture Maintenance
- Lighting Maintenance
- Public Utility Managers
- Town Centre Managers
- Economic Development Manager
- Emergency Services

10.3 As well as embracing officials, the consultation process must involve the public both at the initial strategic stages about the need for streetscape schemes and later on in the selection of materials and street furniture. The consultation process may take the form of planning applications, scheme design presentations or the laying of trial panels. The consultation process should continue after the scheme has been completed to ensure the scheme is maintained and operated in a satisfactory manner.

As well as obtaining information from the public that will ensure the robustness of the design, consultations will in the long run ensure public support rather than reap criticism after the scheme has been completed.

10.4 Public consultations may involve:

- Town Forums
- Business Forums
- Traders
- Shoppers
- Schools
- Environmental Groups
- Conservation Groups
- Disabled Groups
- Community Councils
- Residents Associations

11 Procurement

11.1 Normally procurement is associated with material acquisition, but in streetscape work there are really three main procurements, all vitally important to the success of any scheme namely:

- Procurement of the design team including lead designer
- Procurement of the contractor
- Material procurement

11.2 The design team must comprise professionals with sufficient previous experience of streetscape work to avoid any obvious pitfalls caused by lack of experience. It must be multidisciplinary, representing the main design professions required to make firm decisions and recommendations. The team should not be too large in order to avoid bureaucracy, and a clear leader should be identified able to drive the scheme forward, and 'champion' the cause.

In the case of a more strategic study involving property and traffic changes, planners, traffic engineers and economists may form the nucleus of the design team while the detailed scheme design should ideally be led by road engineers or landscape architects co-opting other groups as required. As stated earlier the involvement of maintenance engineers and cleansing managers may be crucial to the operational success of the scheme. Depending on the sophistication of the street lighting and street furniture other specialist consultants or suppliers may be included in the core design group.

The design team may be formed from:

- Client's in house team
- Consultants
- Partnerships

11.3 Commissioning of design services will most often be by open tender, with the lowest tender inevitably successful because of councils' need to follow standing orders. However the cheapest is not always the best and the use of inexperienced designers could lead to higher construction costs, future maintenance burdens, lack design flair and

innovation. There is no easy way of reconciling these conflicting interests but councils have to ensure that tenderers are suitable through appraisal of experience and previous performance. Quality / price may be obtained by a two envelope tendering procedure that will reward quality by adjusting the tender price by a predetermined percentage. Typically 30/70 or 40/60 quality/price ratios are used. However it should be noted that impressive tender presentations do not necessarily guarantee a good final design.

- 11.4 Streetscape work using natural stone requires different laying techniques and specifications from man made materials. The laying of stone setts or cubes may appear similar to the laying of concrete pavements but are fundamentally different, and only contractors with demonstrable experience and understanding of stonework should be used and assurance sought that they will provide trained layers able to carry out the works.

The best way of setting up a list of competent tenderers is to seek references from similar schemes and enquire about workmanship, management capabilities and claim attitudes. If possible it is of great assistance to visit previous schemes carried out by the contractors wishing to be included on the tender list.

- 11.5 In selecting an appropriate tendering procedure the client has typically to choose between the following:

- Lowest Price Tender
- Quality/ Price (Two Envelope)
- Partnering

All contractors selected for the tender list should be able to deliver work to a consistent high standard. The quality/price method allows the contractor to demonstrate his ability and willingness to provide quality. There is a risk that what is really judged is presentation skills and there is not a guarantee that work will be significantly better than that from the other competitors. The third option, partnering, is well suited for high quality streetscape work and will provide for the client, the designer and the contractor to jointly resolve problems and share in the decision making, often using an open book accounting system after the contractor has initially been selected by either of the first two methods. There is a danger that some of the competitiveness and drive expected of the contractor

during the contract period may be lost because the contractor is assured of his profit regardless of how long the work takes and how much it will eventually cost.

The choice of tendering method lies with the client and his designer weighing up the pros and cons of the different methods described above and previous experience working with the contractors on the tender list.

- 11.6 The final vital ingredient in a stone streetscape scheme is the stone selection and the client/design team have several options how this should be implemented t. All may have a bearing on quality, cost and timescales of a project.

These may be listed as follows:

- Re-use of existing stock
- Uplifting from existing streets
- Stone from local quarries
- Import from EU countries
- Overseas imports
- Client procurement

- 11.7 It may be the wish of the client to use local stone for traditional reasons, to match existing stone or to support local industries. This is advantageous because local established quarry products are well known and tested. Suitability can be discussed with the quarry management, delivery scheduled to tie in with works programmes and spare materials usually obtained at a later date without any problems. The main disadvantages are limited choice and potentially higher costs compared with imported stone.

The prospect of re-opening old local quarries for specific schemes can be appealing but fraught with difficulties in ensuring that the enterprise will be able to deliver and meet all the standards required at the cost initially indicated. Old quarries cannot be opened without substantial forward orders to secure the financial viability of the high initial investment.

- 11.8 Several European countries have large, well established stone industries supplying streetscape and cladding stone both for their own home markets and for export, giving a

wide choice of materials. The stone can be supplied directly from the producer, or by using stone importers acting as middlemen, usually in containers transported by ships. Because Europe has a long unbroken tradition of using streetscape stone a lot of information about suitability supported by testing is available. Since many streetscape schemes are partly funded by E.U grants it seems reasonable to use European stone if deemed suitable and cost advantageous.

- 11.9 In recent years much of the stone used in this country has been imported from China or India mainly since the costs are significantly cheaper than European stone despite long sea transports. The transportation costs may be minimal as the stone is sometimes used as ballast for container ships.

What is certain is that almost a limitless choice of stone is available from these countries but materials must be ordered well in advance because of the transport arrangements required. It is sometimes difficult to trace the exact origin and obtain reputable testing data since the material has a long delivery chain passing through several dealers with little technical knowledge. A certain amount of trust is required to ensure that the quarry will be able to produce to the specified standards and that delivery will be within the time periods promised. Complications will occur if the materials are not to the expected standards when they arrive on site and subsequently have to be returned and replaced. This could have severe contract implications and create arguments about who's



Imported granite slabs from China

responsibility it will be to rectify any errors. Difficulties may also be experienced in obtaining spare supplies at a later date for maintenance works if the origin of the stone is unclear or uncertain.

11.10 The cost of supplying the stone for a typical streetscape scheme typically constitutes 15-35% of the overall scheme cost and the selection of the stone and its country of origin may have a fundamental bearing upon the overall cost. The stone description and specification by the designer will determine to what extent an individual quarry has been selected for the supply. This will allow the producer to control the price more than if the stone had been defined in a more generic way leaving the door open for several suppliers. The latter will allow more competition to take place and lower the cost but may cause difficulties in whether to accept the lowest tender because of the stone 'offered' by the contractor.

One way of avoiding this dilemma is for the client to order the material in advance of the contract. This will also minimise the risk of delivery delays. This leaves the client fully responsible for organising, receiving and storing the materials but some clients may be reluctant to do so. There is also the possibility of the contractor using the supplied stone as an excuse for not achieving the workmanship specified in the contract documents.

The selection and procurement method used to obtain the stone is a fine balance between specifying the stone wanted and allowing as much competition as possible to achieve the lowest cost. The method adopted may depend upon the type of stone selected, the experience of the designer and the robustness of the information forwarded by the potential suppliers and the client's attitude towards risk.

11.11 Regardless of how the stone is supplied it is always sensible to lay full size trial panels if the design team or client is not familiar with the selected stone before final commitment is given to the choice of material

12 Traffic

12.1 Arguably the main consideration in deciding if and what kind of stone work would be appropriate for a streetscape scheme is the amount and type of vehicular traffic to which the scheme will be subjected. Almost any stone design will be suitable, traffic wise, for low vehicular flows, while the risk of failure will increase with flow, making, say trunk roads, clearly unsuitable for stone designs. Therefore the more heavy axle traffic, the more care will be required in the choice of materials and detailed design of the stone surface.

12.2 The traffic categories that are suitable for streetscape work can be described as follows:

- Busy city centre street allowing buses and heavy vehicles through traffic
- Town centre streets served by some heavy vehicles
- Access and delivery traffic only
- Pedestrianised areas only requiring emergency and maintenance access.

The first category may be for at least hundreds of heavy vehicles per day and the second category for less than one hundred vehicles. The boundaries between them are pretty blurred since lorries may deliberately or inadvertently overrun slabbed areas intended for pedestrian only use, army tanks may enter quiet town centre squares on recruitment drives, street lighting vehicles may overrun slabbed areas to reach remote lighting installation or scaffolding may be erected in front of buildings. These events cannot always be individually foreseen but are likely to effect most schemes at some stage. The design should be sufficiently conservative to reasonably recognise the risk from these threats.

12.3 The stone elements used in streetscape design are commonly referred to as:

- Setts
- Cubes
- Slabs

In general design terms setts are most suitable for heavy traffic, while the smaller cubes should be used for shared surfaces and slabs in pedestrian areas. Again the setts or cubes may be described as small or large and the slabs may be small, large, thick or thin depending upon further design refinements.

Traditional stone designs used large setts in the carriageway and large slabs in the footway separated by high kerbs. This design, for horse and carriages, has remained extremely robust for over 100years, often surviving into modern times despite the large increase in traffic.

There is now often pressure from planners and architects to design streets using slabs only or to eliminate the kerb between the carriageway and footway. This can lead to conflict in material choices, to what extent the design can prevent illegal vehicle movements and how to prevent clutter.

The overriding message must be:

Setts and cubes are for vehicles
Slabs are for walking

13 Stone Surfaced Pavement Design Development

- 13.1 Sett laying stopped after the second world war in this country and did not re-emerge until the 1990s by which time the practical skill of laying setts had disappeared. Craft skills were handed down from craftsman to craftsman and very few written records were made about how to lay and look after stone materials .

When landscape architects started to specify re-used granite or whin setts to be laid in landscaping areas they usually specified a concrete base and Class 1 mortar, a typical specification for brick laying. The setts were often laid as a horizontal wall with the mortar trowelled on to each course resulting in large and untidy joints showing a lot of mortar.

The next development in the stone design was to study European practices. In many countries stone laying was not abandoned after the war and some countries (France, Germany, Italy etc.) had codes recommending different stone constructions for different traffic conditions and the strength of the sub layers required. However no UK specifications were available and designers had to prepare individual contract documentation using common sense and continental influences to the best of their ability.

- 13.2 After a few early schemes in the 1990s, it was quickly realised that specialist stone laying labour was required to achieve uniform level control and a pleasing appearance. The work required a feel and an eye for laying, only acquired after having served an

apprenticeship. Different layers had their preferred methods of laying bedding and jointing materials not always strictly following the specifications stipulated. The emphasis was on surface appearance rather than structural strength, robustness and durability.

One method that emerged was to apply the jointing material as a slurry to be brushed and mopped into the joints ensuring that the joints were fully filled. A certain amount of trade secrecy developed between contractors about how the slurry should be designed, applied and cleaned up to avoid permanent staining.

13.3 By the late nineties many natural stone schemes had been constructed and some schemes started to fail quite spectacularly soon after having been opened to traffic. Two areas caused major concern, failures in heavily trafficked areas and elsewhere slabs failed when subjected to vehicular traffic. Also in many schemes, minor defects requiring maintenance not long after construction had been completed, started to emerge. As a result the Society of Chief Officers of Transportation in Scotland (SCOTS) felt it was necessary to investigate the problems with natural stone laying in urban streetscape. In 1999 , a consortium of Heriot Watt University and TRL was appointed to produce a Good Practice Guide which was published in 2000.

13.4 TRL collected information about design guides and specifications available from Europe and elsewhere, went on study tours, investigated the structural relationship between the stone, the bedding, jointing and supporting layers to produce a guide that surpassed any other information hitherto available. The guide defined different traffic categories and gave design guidance for each. The report stated that in rigid pavements the most critical factor for setts and cubes were the joints while for slabs the bedding was the most sensitive parameter. The report also highlighted the fundamental differences between flexible and rigid constructions. The former does not use any cementitious materials in the bedding and jointing materials while rigid constructions do. The guide also emphasised the importance of complying with the standards set for both specification and workmanship. The guide provided advice on the use of natural stone from the quarry face through design, laying and into aftercare.

The guide brought the stone laying technology up to date helping engineers and other professionals to understand the mechanics of good practice. However the report acknowledged that further research and development was required. Actual experience

from real schemes was one of the issues for further investigation and this technical evaluation is part of this.

14 Pavement Design Considerations

14.1 The design of streetscape works using stone in urban areas are similar to conventional road design except that the wearing course has been replaced by a stone surface sitting on a bedding layer.

The main design implications apart from the stone layer are:

- Effect of public utilities
- Possible cellars
- Construction sub-layers
- Construction management

14.2 One of the main uncertainties in the design of streetscape schemes is the risk of working around existing public utility apparatus. If the new levels are lower than existing, diversions may be required which could lead to long delays and contractual claims unless the public utility diversions have been identified at the design stage and details included in the contract documents.

The only way to safeguard the works against public utility “surprises” is to obtain utility records early in the design process and to excavate trial holes / trenches before issuing the tenders. Utility problems should be discussed in advance with the managers concerned, to establish the best solutions and if any diversion work or additional plant should be included in the streetscape tender or carried out in advance as a separate contract.

Particularly alarming is the influx of cable communication ducts added to the utility inventory in the past 15 years. Most of these have been laid shallower than the recommended minimum cover depth of 350 mm in footways.

Another decision to be made at the design stage is to what extent concrete, aluminium or steel manhole and other access chamber covers, should be replaced by natural stone inlaid or cast iron covers. Inlaid covers may look good and be successful but there is a

risk that they may not fully match the appearance of the surrounding stone. They are also heavy to lift, costly and may break up if subjected to vehicle overruns.

Alternatively existing covers may be replaced with cast iron covers since these form a suitable contrast to the stone. It could also be argued that the existing covers give some life and variety to the stone and therefore do not need to be replaced unless worn or damaged.

- 14.3 Another potential problem in many streetscape schemes is the possibility of cellars / coal shutes protruding into the footway. Sometimes these are visible from skylights but they are often hidden and even unknown to shop proprietors because they may be bricked up. If encountered during the contract they may cause delays and claims.

The only way of obtaining this information at the design stage is to contact all frontagers and a pattern will often emerge. Having established that cellars are to be found below the footway the next problem is to define the distance into the footway and depth below the footway because orientation is often very hard. The easiest way of finding the depth is to dig trial holes in the footway over the cellars.

The cellars are the legal responsibility of the owner and the local authority can serve notices on the owners to have the cellar roofs made safe. In reality the cellar owner may choose to do nothing and wait until the contractor is on site and then claim that the streetscape works have caused cracking or water ingress.

In order to protect the local authority from claims it is important that the contractor is made aware of all the cellars at the tender stage and that a condition survey will be carried out by the contractor / specialist surveyor before work commences. It is also recommended that some provisions are made in the tender document for dealing with unforeseen cellar problems that may occur during the contract. Typically this may comprise the use of corrugated steel supports for an in-situ concrete roof slab.

- 14.4 The cost of the natural stone and any subsequent failures is so high that it makes sense to ensure that the 'cheaper' sublayers in the streetscape construction will not be the cause of any failures in the future. The cost of slightly increasing the subbase or base thicknesses beyond the design requirements of DMRB or the SCOTS guidelines will be modest and a worthwhile insurance policy. However construction depth may be limited by

the location of existing utilities. One way of ensuring the strength of the sublayers can be increased in these circumstances is to maintain the same depth but substitute subbase with bituminous materials, and various publications give an equivalence factor for such substitutions.

Limited depth may also preclude the use of capping layers requiring more subbase or the use of geotextiles to prevent infiltration of clay materials into the subbase or geogrids to increase the strength of the subbase itself.

- 14.5 In a fully flexible design ie sand bedding and jointing one of the advantages is that rainwater should be able to penetrate the pavement construction and dissipate into the subsoil reducing the amount of positive surface water drainage required and ecologically clean the surface water before it enters any watercourses, to comply with basic SUDS (Sustainable Urban Drainage Systems) principles. This will be particularly effective if the sub soil is granular. Bituminous base layers may still be used provided an open textured bitumen macadam is used which allows water to pass through the bitumen layer.

Most streetscape works are carried out in restricted areas having to maintain pedestrian and sometimes vehicular accesses. In many schemes, footways will be fully excavated and brought back up using granular sub base, often blinded with dust to create a temporary walking surface. Whilst awaiting the arrival of the stone paving, this temporary surface can quickly become uneven and result in dirt and dust being carried into premises. The use of a bituminous layer instead will provide a smooth surface for pedestrians and provide extra strength for the occasional HGV overrun. It should be noted that the laying of road and basecourse layers will often have to be done by hand and in a piecemeal fashion. It is often difficult to achieve both the tolerances and compaction levels assumed in standard DMRB designs. To ensure regular thicknesses of bedding, a regulating layer of fine macadam may be used.

For the various reasons referred to above it seems reasonable to increase the strength of the sublayers if there is a risk that these may contribute towards any failures because the cost of any such strengthening is modest compared to the cost of the stone repairs

15 Bedding and Jointing

- 15.1 Most failures in natural stone streetscape schemes can be attributed to problems with bedding or jointing. The SCOTS guide states that setts and cubes are principally controlled by the jointing system while bedding is the most influential factor in slab construction. However the exact mechanisms of failure are not always readily identifiable and may often be due to a combination of bedding and jointing or a sequential consequence of not carrying out sufficient maintenance. The SCOTS guidelines and BS 7533 Part 10 both give advice upon the design of flexible and rigid pavements.

It is important that the designer is familiar with the differences between:

- **Flexible construction**
- **Rigid construction**

The former will not use cementitious material in the bedding layer nor in filling the joints, but bituminous materials, may be used in the roadbase layer.

- 15.2 In a flexible design the strength of the pavement is dependant upon optimum compaction of the bedding layer and getting as much jointing material as possible into narrow joints to activate arching forces. The compaction of flexible construction is achieved by using vibrating plates after the setts or cubes have been laid. Sometimes water is used to assist in filling the joints fully. After laying, the effects of rain and trafficking will further compact the joints, requiring the joints to be topped up. This process may have to be repeated a few times until an equilibrium has been reached and the joints stabilised.

Similarly slabs must be compacted after laying by rubber mallets and the like which is made more difficult by the fact that riven slabs like Caithness do not have exact thicknesses and can only be delivered in bands of similar thickness. Therefore compaction levels achieved and bedding layer thicknesses will vary from slab to slab.

Another important aspect of flexible design is that all edges must be contained using building lines, kerbs and channels to stop movements and allow arching forces to be created.

Both the bedding and jointing materials used in flexible construction must be well graded using grits or crushed rocks with a specified maximum aggregate to suit bedding thicknesses and joint widths to ensure optimum compaction

- 15.3 If adequate compaction has been achieved, the edges constrained and the joints maintained, flexible constructions using setts or cubes should not experience any dramatic failures because small movements caused by heavy loads or turning movements can be accommodated by the elasticity in the system. The most likely failures will be rutting in heavy vehicle paths and differential settlements around constraints sitting on concrete foundations such as kerbs, channels and ironwork.

Dramatic failures will however occur if the joints are not maintained allowing setts and cube rotation to occur or slabs to start rocking. This may be caused by a cleansing regime using large mechanical brushes with suction, long term negligence of joint maintenance or by allowing too many heavy vehicle to traffic the scheme.

- 15.4 The main advantage of flexible designs are:

- No cement needed
- No curing required
- Cement staining avoided
- Easy to lift and relay
- Seamless reinstatements

The following are the drawbacks

- Joints can be sucked up by sweeping machines
- Joints need to be refilled.

Flexible construction can be used successfully
Joints must be topped up during the maintenance period
Heavy suction road cleaners must be avoided

- 15.5 In a rigid construction using cement, the design of bedding and jointing systems are extremely important to ensure the integrity of the overall design.

As for flexible construction the depth of the bedding layer and joint thicknesses are very fundamental and every effort should be made to ensure that these are laid as accurately as possible. Base courses should be regulated to achieve constant bedding layer thickness rather than allowing the bedding layer to vary in thickness and suitable stone units must be carefully selected.

The design must specify in detail the type of mortars that will be acceptable and the strengths that must be obtained. The more demanding the traffic loads being allowed to use the streetscape works, the stronger bedding and jointing mortars should be used.

The strength achieved for the bedding and the joints depend upon the quality of construction management, the implementation of the design specified and the regularity of the cube tests. Site staff must ensure that the cubes are as representative as possible of the materials actually laid. The lack of moisture in the bedding for example may prevent hydration taking place or too much moisture may reduce strengths and if this is not mirrored in the cube testing the results will be misleading. Cubes must be cured on site and tested as specified by the designer to check if sufficient strengths have been gained to allow construction to proceed. It is therefore important that testing results are immediately returned to the site management

15.6 Site batching of bedding or jointing materials may result in a lack of consistency leading to patches of substandard mixes. This can easily happen because:

- Operators are not supervised
- Incorrect cement/sand ratios
- Incorrect amount of water used

Pre-mixed batching will eliminate many of these potential pitfalls and ensure that a much more uniform standard of mortar is achieved. Bedding materials can be sourced from on site pre-mixed silos or by import from quarry plants. Grouting materials can be pre-bagged only requiring the addition of an exact amount of water.

Proprietary brands of joint grouting materials have been designed for strength, workability and shrinkage, these may have both retarders and accelerators added to them to allow workability for a suitable length of time followed by rapid setting which will allow the works to be opened to traffic after only a fraction of the time required for

ordinary cement to set. This may in many schemes have an important commercial advantage in that the contractor will not have to wait for the cement to cure before starting the next section of the works.

- 15.7 Rigid construction failures may start by individual setts or cubes being punched through weak bedding; insufficient bonding strength; hairline cracks in the joint caused by vehicle braking and turning movements or gradual loss of jointing material. Once a failure mechanism has started it is difficult to arrest the failure because sealing or refilling of the joints cannot easily be made to last. If the jointing materials are allowed to dislodge, setts and cubes will start to rotate and eventually become loose. The only option currently available is to rake out the whole joint and re-grout if the base is sound or relay the whole stone construction including the bedding materials if the setts are loose. There is some research ongoing to develop in-situ repair methods of jointing systems using proprietary mixes.

Premature failure in stone schemes are most likely to be caused by bedding and grouting problems and future scheme designs should ensure that special attention is given to these matters.

- 15.8 Slabs laid in rigid construction rely upon the bedding strength and a sealed bond between the slabs and the bedding. If voids are left below the slab breakages may occur because the slab will have to span the void and may fail in tension or rocking may commence which will eventually break or dislodge the slabs when subjected to traffic.

Where joints fail with material lost from the joint, water will get in and eventually result in the debonding of the base of the slab from the bedding material. The slab will then rock and if the joints are narrow, adjacent units will touch and arrises will crack.

The use of slabs in areas subjected to vehicular traffic is a contentious subject since in some instances it seems large slabs are able to accept heavy traffic without significant damage while in other places small slabs subjected to less traffic will fail. The most likely explanation for this must be if the quality of the slab laying is good, ensuring compaction, cement hydration and a uniform bond, slabs may be capable of carrying heavier loads.

One authority has carried out extensive local trials on slabs and setts under a range of

vehicle loads which may help designers to decide if they are willing to risk using slabs for vehicular traffic.

Compressive strengths must be specified to suit traffic loads
Contractors must demonstrate how strengths are obtained
Cube tests must be taken
Cubes must represent as laid materials
Water ratio must not be too high nor too low

16 Streetscape Furniture

16.1 Most streetscape schemes involving the replacement of manmade materials with natural stone also involve changes to the following

- Lighting
- Street furniture
- Art works

The extent and cost of these supplementary design features will vary considerably depending upon the condition of existing facilities, costs, the designer's preferences and the prestige of the scheme.

16.2 In the planning of new streetscape schemes a view must be taken about the standard of the existing lighting and street furniture, evaluate the purpose they serve and the need to provide new facilities.

In some instances the drive may be towards simplifying the clutter of existing street furniture and road traffic signs that has accumulated over time to give the street a more clean and open appearance, and to make it more accessible for disabled users.

The main choice to be made in renewing street furniture or lighting may be to decide whether to have:

- **Standard catalogue items**
- **Bespoke furniture**
- **Specifically designed**

The latter may be the most exciting solution but also the most costly and risky because prototypes will be required to prove that it can be made, that it is robust enough, and that the client likes it. However it is likely that this approach will suffer from the teething problems of both production and maintenance normally associated with new products. This could be even more adverse if the detailed design of the street furniture is carried out directly by a design team without previous experience in such designs, or if allowed to become “designed by committee”.



Bespoke Furniture

The intermediate solution of using bespoke designs, where standard items are altered to give an individual appearance, offers many advantages in that the costs are reduced and the product manufacturers can be involved in the scheme at the design stage contributing their experience in defining the product with regard to suitability and maintenance. However, this will inevitably involve choosing a single supplier and introduce the inherent risk of having a sole nominated supplier.

Standard “off the shelf” items will offer the most cost effective and least risk solution with quality and supply virtually assured. Few designers like to copy equipment used elsewhere as they attempt to put their mark on a scheme, which is the likely explanation for the amount of bespoke and original furniture used around the country.

- 16.3 The proportion of cost that should be allocated towards lighting and street furniture should be agreed at an early stage in the scheme development. It seems fairly rational that the higher the cost of the stonework and importance of the scheme more justifiable will be the cost of street furniture and lighting if these are required.

It is easy to enthusiastically prescribe specially commissioned street furniture at considerable cost without analysing how these will be maintained and if the scheme maintenance authority can afford to buy replacements at a later date if these should be required.

Normally most street furniture and lighting installations will be put to the test by vandals not long after the scheme has been completed. Another benefit of bespoke and “off the shelf” furniture is that the manufacturers will have spare parts and that their products will have been tested against vandalism during product development.

There are also other considerations to be made such as to what extent street furniture will be a risk to disabled people, able to perform in the case of large crowds gathering and not provide a security risk in the event of visitation by VIP's.

Designers must consult maintenance operators

- 16.4 Another aspect of streetscape design that has become increasingly familiar is to incorporate various sorts of artworks into the schemes which may typically take the form of vertical sculptures or horizontal patterns inscribed into the stone.

With modern laser cutting equipment it is now possible to scan pictures and drawings of the object to be inserted into the base stone, cut the relief by laser and infill matching pieces of contrasting materials also cut by laser. Alternatively artwork may be created by traditional means using skilled artists or indeed combine both methods in allowing the laser to do the initial cutting to be completed by crafts people.

Some features will incorporate the use of water. Such features bring their own set of maintenance difficulties, for example cleaning, winter operations or shut down.

- 16.5 The scheme designers will have to decide if any or what type and amount of

artwork would be appropriate for each scheme. This may depend upon the historic background or setting of the scheme and if grants from various art councils form part of the funding.

The cost of artwork incorporated into each scheme may vary enormously depending upon the amount and type of art commissioned. The artwork may be originated by a design competition from briefs prepared by the client, local artists may be invited to submit proposals or local schools may set up art projects using the proposed scheme as a theme from which ideas can be gleaned.

The same considerations regarding maintenance, disabled bodies points of view and vandalism must be given to art projects as to street furniture and lighting referred to above.

17 Aesthetic Design Aspects

17.1 One of the main reasons for carrying out any streetscape scheme is simply to improve the aesthetics of an area. Aesthetic considerations form part of the whole process from:

- Material choice
- Detailed design
- Construction supervision
- Maintenance

17.2 Normally the best looking designs are based upon simplicity and respect to the form and purpose of the scheme as a working street, square or any other space. Too many shapes or changes of materials cause confusion and each element of the scheme such as a kerb or channel should have a purpose. Only special focus points should be allowed to have special features included.

The relationship between different materials and the use of delineation lines should be well proportioned and harmonic. The choice of material must be suitable for its purpose and not cause future maintenance problems.

All design efforts will be in vain if poor workmanship occurs particularly when visible even to an inexperienced eye showing, for example, excessively wide and uneven joints, trips, wide mortar infills around manholes and cement stains on stone surfaces. However stone is a natural occurring material that cannot be mass produced to form an exact shape and allowances have to be made for acceptable tolerances.

- 17.3 Cement staining is one of the main difficulties with rigid construction because cement is used for bedding and jointing materials. This will be affected by the texture of the stone surface with smoother surfaces being easier to clean. Sometimes the joints can only be filled by pouring a slurry over the whole surface brushed into the joints. This will obviously stain the stone unless the cement residue can be removed before the cement sets. This can be easier said than done because if water is applied too early the joints will wash out, and if too late the stains cannot be moved. Such processes require accurate timing and sound judgement by the operatives because different mortars will have different setting times which will also vary with the temperature and humidity.

Another difficulty is to clean off large areas with water using hoses to push the water towards a gully or other outlets, because the water will tend to deposit sediments in dips and troughs hardly visible to the eye. Slight staining is not visible on wet surfaces and may only be seen after the surface has dried out as a dull discoloured cement sheen.

Another method of reducing cement staining is to spread sawdust over the area after first cleaning off as much as possible by light water hosing. The saw dust will help to soak up any remaining water. Wire brushing is often specified to remove staining after the cement has set but it seems in most instances to be fairly ineffective. It is also possible to use proprietary brands to remove mortar stains usually containing bleach or acids. This may be feasible for small individual areas but would require large amounts of liquid to clean a whole scheme which could be thousands of square metres and may cause damage to the stone and the surrounding environment.

Cement staining not only occurs during joint filling but also when laying setts and slabs because inevitably workman will walk on the stone after laying with wet dirty boots carrying cement. It may be possible to avoid this whilst laying cubes and small slabs but large slabs require suction lifting gear and several people to lift, making it very difficult to avoid contamination.

Disposal of cement stained water or indeed acids into underground drainage systems may be acceptable but can cause severe problems if directed into a clean sensitive surface water system. In such cases it may be necessary to collect the run off in settlement ponds and dispose elsewhere. If in doubt these matters should be discussed with SEPA and the local water authority in advance of letting the work and appropriate clauses inserted in the contract documents.

Some stone layers will argue that the cement staining will disappear through time by the action of weather, trafficking and road sweeping. This may to some extent be true but a badly stained stone will never recover and if insufficient strength mortar has been used the joints will dislodge before the stains disappear.

- 17.4 Schemes laid in a flexible construction without cement will retain the natural colour and brightness of the stone better than a rigid construction but it will also dull down with time due to pedestrian and vehicle traffic, spillages, wear and tear. This may be much more noticeable if the stone has a uniform colour and when the colour is light rather than dark.

Finally much of the aesthetic value of the scheme may be lost if the scheme is not properly maintained. Loose joints or rocking slabs are very noticeable and if damaged setts or slabs are replaced by asphalt or concrete it will not be long before the integrity of the scheme is lost. Equally litter or large amount of chewing gum allowed to accumulate

will very quickly destroy the aesthetic value. Any defects in a high quality stone scheme seem to become much more obvious and annoying than in an ordinary expectation and not be ignored. Public perception must



destroy the aesthetic value. Any defects in a scheme seem to become much more obvious and not be ignored.

Example of poor maintenance

- 17.5 As confirmed by the questionnaires and site visits one of the biggest problems with the aftercare is how to deal with the removal of chewing gum and cigarette ends. These matters should be considered at the design stage and a strategy developed for how to deal with these.

- Decide cleaning regime
- Invest in machinery
- Organise public education campaigns

Avoid cement stains
Control use, disposal and removal of gum
Ensure joints are filled up to prevent cigarette ends

18 Site Supervision

18.1 Most streetscape schemes take place in built up areas having to maintain pedestrian accesses and often vehicular traffic while working around a myriad of shallow public utilities necessitating the work to be carried out in a piecemeal fashion. This may be fairly normal for city centre road works but in addition, high quality finishes and tight tolerances must be achieved for the stone finishes. The role of the supervising team is to provide guidance to the contractor, ensure specifications and quality finishes are achieved whilst controlling costs and keeping to the programme.

As much information as possible should be obtained prior to commencing on site but excavation work in urban settings tend to spring surprises regarding location of services, poor ground or other unforeseen matters. These will have to be resolved as quickly as possible on site to avoid delays and consequential claims. The supervisor may need to adjust the design, use provisional items or substitute materials to overcome any problems.

18.2 The specification for natural stone work comes under scrutiny when site work commences. If the design team have not fully understood how the stone should be used, the supervisor will have to augment any missing information or change the specification. The contractor will often try to impose his own specification if the tender is unclear, because the contractor has used a different method previously or because his alternative is cheaper. The supervisor will have to respond to these pressures and decide if any

alternatives offered are valid and in the best interest of the client. In order to make such decisions, experience and a proper understanding of streetscape works are required.

The supervisor also has to be the arbiter in deciding what should be the bench mark standard for quality finishes. Since the use of stonework in streetscapes has re-emerged as a new industry the specifications and guidelines have not yet been fully developed and tested unlike road construction using bituminous materials. The SCOTS Design Guide and more recently the new BS7533 Parts 7,10 and 11 offer the best current assistance.

- 18.3 The supervisor has to push the contractor to achieve high quality standards without being unreasonable and impractical, attracting massive claims or forcing the contractor towards bankruptcy. It should be remembered that very often the contractor has had to submit the lowest tender and there is often a natural conflict between low rates and high quality.

The compromise between cost and quality can only be minimised if the specification is exact and the contractor has a proven track record in laying natural stone understanding the quality standards required, whilst being able to take on board the many difficulties normally experienced in urban street works.

The most successful site supervision will only occur when the contractor and the supervisor can work together as a team where the supervisor will assist the contractor when he can, show some understanding towards contractual disputes and design changes wanted by the contractor. The contractor has to use all his influence to achieve high quality finishes and show willingness to redo sections of the work not reaching adequate standards. Partnerships both formal and informal may be a way to achieve this.

- 18.4 It is preferable that the site supervisor has also been responsible or at least involved in the design of the scheme. This will allow the supervisor to judge the merits of any design changes proposed by the contractor. Knowledge of the design problems and background information allow the supervisor to act with more confidence.

The amount of site supervision required is always a problem and will depend upon the experience of the site staff provided by the contractor. A well organised contractor intent upon delivering a good scheme will only require a minimum amount of supervision. However any amount of supervision will not necessary rescue a scheme having a

disorganised contractor not interested in quality and only wanting to make as much profit as possible.

- 18.5 A further key role for the site supervisor will be to liaise with the public, particularly with those directly affected by the construction works. Good communications are essential to a truly successful outcome.

Particularly for smaller schemes, site supervision becomes proportionately more expensive and part-time supervision may be the only available option. Also the designer has often to tender for design and site supervision to obtain the work, and in order to stand any chance of winning the tender insufficient site supervision time may have been allowed.

A better method of providing site supervision may be that in the tender, only rates per hour or day are submitted allowing the client and the consultant to jointly decide what level of supervision is required at each stage of the construction period. Alternatively the client may specify exactly the manpower to be supplied for site supervision.

Site supervision involves strategic decisions about how the work should evolve and detailed decisions about finishes. Ideally this may be resolved by having a part time engineer familiar with stone design and a full time inspector briefed upon the detailed standards to be achieved.

19 Maintenance considerations

- 19.1 It is vital that maintenance staff who will ultimately be responsible for the future maintenance and aftercare of the scheme are given the opportunity to contribute to the design process. Not just as an 'approver' of a final design proposal but right at the centre of the decision making process. This will tend to bring a practical down-to-earth perspective to any design. Even if not all of their recommendations are eventually incorporated, they will feel that their views have been heard and they may even change their mind having listened to everyone else's views.

Examples of this could be in:

- Geometry
- Lighting
- Street furniture design
- Pavement design
- Material selection

In basic street geometry, it may be desired to narrow streets which might preclude the passage of certain maintenance vehicles or mean that there is not enough space for vehicles to pass if part of the street has to be closed for say utility works. The decision on whether to have flush surfaces or kerb upstands will be a major concern to maintenance staff. A lack of kerbs in a trafficked area will inevitably lead to vehicles straying off the areas where they should be.

In street lighting design the choice of lighting column type or whether to mount brackets on buildings will be decided partly on maintenance issues. The selection of bespoke or non-standard equipment may lead to much higher maintenance costs and replacement problems.

Similarly, the use of catalogue items of street furniture may be undesirable to those trying to create a unique design for their scheme, but the replacement (or addition maybe) of furniture will be greatly simplified if standard items are used. Bespoke and designed furniture will be expensive to develop and prototype, with these costs continuing after the works are first installed.

- 19.2 Detailing of surfacing materials around ironwork is an issue of great concern to all maintenance staff. It is the most common cause of failure in streets, and where stone materials are used, the implications of failure are greatly increased. It is likely that the most knowledgeable person on any design team in terms of dealing with ironwork will be the maintenance expert.
- 19.3 Maintenance staff generally have continual close contact with local utility companies, and this networking should be used to assist the design team in planning for future utility requirements on any scheme. Again, their experience of inspection and specification requirements of the New Roads and Streetworks Act (NRSWA) will be invaluable to any design team.

- 19.4 The preparation for a maintenance manual should begin long before the scheme starts. Throughout the design process decisions will be taken which affect future maintenance and these should be catalogued for future reference.

During the implementation stages of the contract, records of ground conditions, location of services and other relevant issues (particularly those which are buried underground) must be brought together, along with details of actual materials used. At the completion of the works this information can be used to create record drawings for the scheme which will be vital for future maintenance. The aim should be to have a maintenance manual ready for the completion of the works to start during the contract defects correction period

The success or otherwise of any manual will depend on who is involved in the preparation of the document. If everyone involved in public services in the street is fully consulted and given the chance to actively contribute to the process, then their support will be guaranteed. If only one party prepares the manual and tries then to impose it on others then it will not work.

Ultimately a manual should contain fully detailed guidelines and service commitments of all public services being undertaken in the area. This will not only mean cross departmental working within the local authority but will also require the input of other public agencies as well as the public themselves, particularly local businesses.

- 19.5 It is inevitable that any new scheme will be disturbed by utility works at some point during its service life. This should not be a problem assuming that there are adequate procedures in place to ensure that the works are carried out with care and that the surfacing materials are completed at least as well as they were originally laid and has been inspected and approved by the local authority prior to surfacing. In natural stone surfaced areas such inspections should be carried out on every utility opening and not just the 5% normally inspected by local authorities.

NRSWA provides the opportunity to classify streets as:

- **High Amenity**
- **Traffic Sensitive**
- **Engineering Difficulty**

At first this sound promising to help protect the quality of the street. However they actually offer little assistance other than to raise the profile of the street and to alert utilities that there is something different in these areas and perhaps encourage alternative routes to be considered to avoid the expense of working in the high quality areas.

- 19.6 Even with the tightest controls on openings and reinstatements of surfaces, ultimately it will be the quality of the workmanship of the reinstatement which will have the greatest bearing on the protection of the surface. There are few contractors with the knowledge and specialist skills to lay natural stone materials, let alone lift and relay it. There are no standard qualifications for such work.

Until recognised accredited training is available nationally, then local knowledge of individual contractor ability is the only way to determine suitability. The nature of maintenance of stone surfacings tends to be a mixture of piecemeal reactive work (e.g. rocking slabs, setts which have popped out, occasional broken material), planned work (e.g. regular topping up of joints), and utility openings. An ideal situation would be to have a skilled squad available all of the time with good local knowledge and enough work between these types of work to keep them going. A framework (schedule of rates) form of contract would fit this well, particularly if competitive rates are achieved. For in this way, it is possible that local utility companies may be able to use the same contractor as the local authority.

- 19.7 From the initial budget stages onwards, allowance should be made for the additional revenue needed to be able to look after a completed streetscape scheme to the standard required to prevent deterioration of quality. There are two elements to this.

Firstly, an assessment of the possible risk to features and their likely damage/lifespan should lead to a requirement for spare materials to be purchased through the contract and placed into store for future use. The amount of material acquired for this will depend on the characteristics of the street.

Secondly, from the first day after opening to the public, the maintenance procedures in addition to those required if the street were asphalted, must be in place and appropriate funding provided. A time lapse between public use and funding being provided will result

in a backlog of maintenance developing and this will allow a gradual deterioration to begin.

- 19.8 It is vital that all of the people involved in aftercare understand the importance of sustaining both the appearance and structural integrity of the street. There are no formal ways of gaining such knowledge, it will only be through time of being involved in schemes. There is therefore a need for those with knowledge to share it through workshops, seminars and courses.

The additional resources required to keep a scheme looking in it's original condition must be sustained. It is likely that funding will be found for maintenance immediately after a scheme is completed. But what happens say five years later or longer. What if staff change, and all those involved in the scheme move on ? Councils must be committed to long term maintenance and have policies enabling officers to provide adequate funding year on year.

The purchase of specialist equipment for example a suction lifting device or a chewing gum removal machine are expensive purchases and should be costed over their useful life which might be over ten years, rather than just being used initially and then abandoned.

Similarly, additional materials may be purchased for future use through the original contract, but what happens when this supply runs out. Again it may be some years after completion and without written records, including detailed specification and cost information, it may not be possible to obtain the materials originally used. This has been a very common problem in schemes carried out in the 1980s, where repairs for utility work quickly used up supplies of concrete paving materials and exact replacements could not be obtained.

- 19.9 In this increasingly litigious society, the instances of public liability claims are constantly increasing. Many modern streetscape schemes are replacing 1970s and 80s materials with new ones, in particular natural stone. However, for installation reasons, small element units are still used and with them the potential remains for movement and settlements. The more joints there are in the surface the more potential trips there are.

The nationally accepted “trip” height of 20mm is still used in most authorities, but streetscaping an area should eliminate this degree of height difference. Reducing them to less than 10mm may reduce public liability claims provided adequate maintenance is maintained

- 19.10 Most roads authorities will have an inspection regime established to identify potential safety defects. This might mean that an area is visited say once a month at best and defects listed for action on this timescale. For an urban streetscape, inspections should be more frequent, not only to identify defects which might lead to litigation, but also to identify problems in the street surface which should be treated before further deterioration occurs.

The development of call centre technology and the increasing willingness of people to report defects, will inevitably lead to ‘inspections’ becoming more frequent without the authority doing anything. However, this should not be relied upon as a substitute for professional inspections.

One ideal method of identifying problems in the street, is to have “eyes and ears” actually on the street in the form of street wardens or rangers. This is quite a commitment to an authority, but given a range of duties and responsibilities, such a person could make a great difference to the whole streetscape area.

- 19.11 As with all public services there is a need to constantly review and improve services. Performance can be measured in terms of contractual obligations of service delivery in addition to assessing public opinion on services. Both of these, in combination should result in focussed cost effective service delivery to the local community.

National performance indicators do not currently identify urban areas separately from the whole of a local authority’s area. However, more detailed and targeted indicators will eventually come. For example a specific street cleansing indicator is being issued by the Scottish Executive in 2003, based on a checklist of inspection criteria.

Community involvement should not be seen as a particular ‘stage’ in a process. It should be continuous from project inception, through implementation and into aftercare. It is particularly vital in aftercare as the street belongs to the people and councils are responsible for its maintenance (within reason). Damage caused through anti social or

illegal activity or just laziness on the part of a minority of people, can only be prevented through community action. Councils can only realistically deal with the symptom not the cause.

Consult the maintenance operators

Prepare Maintenance Manual

Provide after care funding

Inspect regularly with experienced staff

Conclusions

Our technical evaluation of existing streetscape schemes constructed over the last decade revealed that most of the schemes functioned fairly well with only minor faults and most of the schemes were well maintained.

On the other hand a few schemes have failed requiring continuous maintenance or reconstruction and half of the clients responded that their schemes performed worse than expected.

The two areas for major concern were:

- Allowing heavy vehicles on slabbed surfaces
- Use of stone surfaces on roads with very high traffic volumes or high axle loads

Even under these circumstances some schemes behaved better than others due to better specifications and workmanship. It seems the vulnerability of slabs may be very dependant upon the skill of the slab layer and the correct design and construction of the bedding and jointing systems will allow setts to carry substantial traffic volumes. However designers should be aware of the risk of failures in these circumstances.

Many streetscape schemes have fairly low traffic flows and in these circumstances the critical design factor may well be the action of suction sweeping and cleaning vehicles which tend to loosen up the joints.

There seems to be a perception that natural stone schemes should not require maintenance because of the infinite life of the stone and the high cost of the works. This is not the case and stone streetscape schemes need more maintenance attention than standard asphalt roads.

Most of the schemes inspected had minor defects such as the occasional loose joint, rocking slab and cracking around interfaces with channels and street furniture. Such defects have to be repaired before they become the starting point for a more catastrophic failure.

Most designs were carried out prior to the SCOTS Guide published and sand/cement ratios were specified for bedding and jointing materials rather than target strengths. Also in many cases the contractors seem to have been allowed to change bedding and jointing specifications either because they were inadequate or the contractors had their own preferred methods.

It seems that site controls have been too weak in ensuring compliance with the specification and in controlling and testing bedding and grouting materials. It may be better in the future to attempt to design out some of these uncertainties by specifying proprietary brands that only need the addition of water even if these mixtures are more expensive than ordinary cement mortars.

Fair criticisms have been voiced by maintenance engineers and cleansing managers that their views have not been sought at the design stage and they are left to maintain street surfaces and furniture that are not functional and too expensive to repair or replace.

It is further recommended that maintenance manuals, agreements and funding should be discussed at the design stage rather than be sorted by ad hoc or reactive maintenance procedures.

National standards should set the levels of inspections and maintenance regimes for streetscape works allowing for their special nature and status.

Highway authorities must ensure that public utilities carry out reinstatements to the same quality and standard as the original work. This may be achieved by using term contractors specialising in streetscape works

Aesthetically the biggest concerns are removal of cement stains caused by the construction sequences and thereafter chewing gum removal as a part of ongoing routine maintenance.

Further research and development should in our opinion be centred about:

- Grouting specifications
- Slab laying techniques
- How to repair loose joints
- Damage to joints caused by suction sweeping equipment
- Cement stain removals
- Chewing gum removal.
- Specialist streetscape training

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