

Section 2
Key Issues
Second Edition 2004

KEY ISSUES

2.1 Introduction

This Section of the guide discusses key issues, which have to be considered when embarking on the installation of stone pavements. It is intended to provide an overview of the issues and introduces new concepts, which have been developed from the research undertaken. These are then discussed in more detail in later sections, where fuller guidance is given on all aspects of pavement design and construction.

2.2 Functions of a Streetscape

Streets are multi-functional serving numerous activities including pedestrian and vehicular traffic. Streets also have an aesthetic value which should be recognised in their planning Streetscape are dynamic and change over time. For example an open area that is normally pedestrian only might be used infrequently as an event space when large vehicles are used to deliver portable facilities and apparatus. If the surface has only been designed to take light traffic loading then these heavier vehicles will damage the surface and reduce its life span. The uses and functions of the street should be assessed in detail as part of developing the brief for the design and construction teams. The brief must include consideration of maintenance requirements and the long-term maintenance regimes to be applied over the life of the pavements that will influence design choices. Care has to be taken when assessing the loadings, which might occur over the lifetime of the street to determine the worst case of traffic loading during the early stages of design.

Guidance

Streetscapes are multi functional and dynamic spaces, which change over time. Stone pavements should be capable of adapting to a variety of uses and loadings.

Traffic loadings can change over time and the worst case loading must be assessed at the design stage.

The maintenance regimes available during the life of the pavement influence design choices and must be included in the brief for the project.

2.3 Traffic Loading

The primary factors influencing the design of the surface layer, and the support structure, are the magnitude and type of loading applied to the paved area. The predominant parameter is vehicle traffic. This comprises two components, the weight of the vehicle and the frequency with which vehicles pass over the surface.

2.3.1 Frequency of Traffic Load

In terms of the frequency of load, BS 7533 Part 10 defines a number of basic categories of site loading with a number of sub categories depending on how many heavy vehicles will pass over the surface in a day as shown in Figure 2.1.

Site Category	Heavy Vehicles per Day	Typical applications
IA	<100	Adopted highways and commercial developments used regularly by heavy vehicles
IB	<30	
IIA	<10	Adopted Highways and other roads e.g. Cul-de-sac. Petrol station forecourts. Pedestrian projects subject to regular heavy traffic
IIB	<5	Car Parks receiving occasional heavy traffic Footways regularly overridden by vehicular traffic
IIIA	<1	Pedestrian projects receiving only occasional heavy traffic Footways overridden by occasional vehicular traffic
IIIB	NIL	Car parks receiving no heavy traffic Footways likely to be overridden by no more than occasional vehicular traffic.
IV	NIL	Private drives, paths, patio, hard landscaping Areas receiving pedestrian traffic only e.g. school playgrounds.

Note 1 Access ways to commercial and business premises and public buildings should be placed in Category I, II or IIIA depending upon the estimate of the total heavy vehicle traffic likely to use the pavement.

Note 2 Category IV should only be selected where it can be guaranteed as a result of physical barriers that no heavy vehicles will use the pavement, otherwise it should be assumed that at least 1 heavy vehicle will use the pavement.

Note 3 In determining the site category, the use of the surface of the pavement by any construction traffic should be assessed and allowed for.

Figure 2.1 Site Categories of Traffic Loading for Natural Stone Pavements

2.3.2 New Concept - Single Critical Heavy Load

Stone surfaces are different to other forms of surfaces in how they react to composite loading.

For most other surfaces the frequency of load predominates and produces a fatigue type failure after a substantial number of passes.

However, the testing carried out for this guide found that stone surfaces could fail under a single pass of a very heavy load. This combination of failure modes has to be taken into account during the structural design of the pavement. This is discussed in detail in Section 4.

2.3.3 New Concept - Influence of Layout and Geometry

Research for this guide has also found that stone surfaces are strongly affected by secondary loadings which are induced by the layout and geometry of a particular site, e.g. gradients, junctions, road width etc. Again, this is a new concept, which is particular to stone surfaces.

BS 7533 - Part 10 recognises the additional effect of these site conditions is to impose extra, often high value, horizontal loading on the surface. The horizontal stresses are both compressive and tensile. Normal cement bound systems have little tensile strength and the imposition of these high tensile loads can cause failure in the horizontal plane. The structural design of the overall pavement in terms of vertical loading remains unchanged but, because of the higher horizontal tensile stresses, design should be reconsidered.

BS 7533 - Part 10 requires that in localised area of high horizontal loading, the traffic figures should be multiplied by a factor of 2 before carrying out the design of the surface.

Research for this guide suggests that the impact of site geometry is in fact greater than previously assumed and that the factor of 2 given in the BS Part 10 might be too conservative.

To allow for this secondary loading the designer might wish to consider the guidance in Figure 2.2 where sites have been classified according to their impact on the loading of the surface. The weighting factors are applied to the number of heavy vehicles per day in Figure 2.1, to adjust the basic loading. Where one or more of the site categories occurs, the lower factor should be ignored and only the higher factor should be applied.

Site Category	Weighting Factor	Description
A	1.0	Standard carriageway dimensions or wide-open area. Level site and traffic movement linear.
B	2.0	As above with radius of curvature < 100m and/or gradient > 10%. Vehicles turning.
C	3.0	Sub-standard carriageway width.
D	4.0	As above with radius of curvature < 100m and/or gradient > 10%.

Figure 2.2 Categories of Site Condition for Stone Pavements

For example on a minor adopted road with a sub standard carriageway width, the basic 10 heavy vehicles a day would have to be increased by a factor of 3 giving a weighted vehicle load of 30. Thus, the site would move upwards in terms of load from a Site Loading Category of 3IIa to a Site Loading Category of 2IB. This is also discussed in detail in Section 4.

Guidance

For stone surfaces, the ultimate loading is a combination of fatigue and single overload.

Loading Category and Site Category combine to define the load applied to the surface for structural design purposes. Section 4 gives more detail on loadings.

Careful judgement is required in selecting loading categories to assess the worst case, which might be applied in the lifetime of the surface.

2.4 Stone Elements

Stone elements are used to form a stable, safe and durable paved surface for people and vehicular movements. Stone elements are typically cuboids and come in forms that can be categorised as, cubes, setts, blocks, tiles and flagstones as shown below. There are other smaller units such as dice and shivers, which can be used as trims and in-fills.

The ranges of stone element sizes and shapes are shown in Figure 2.3.

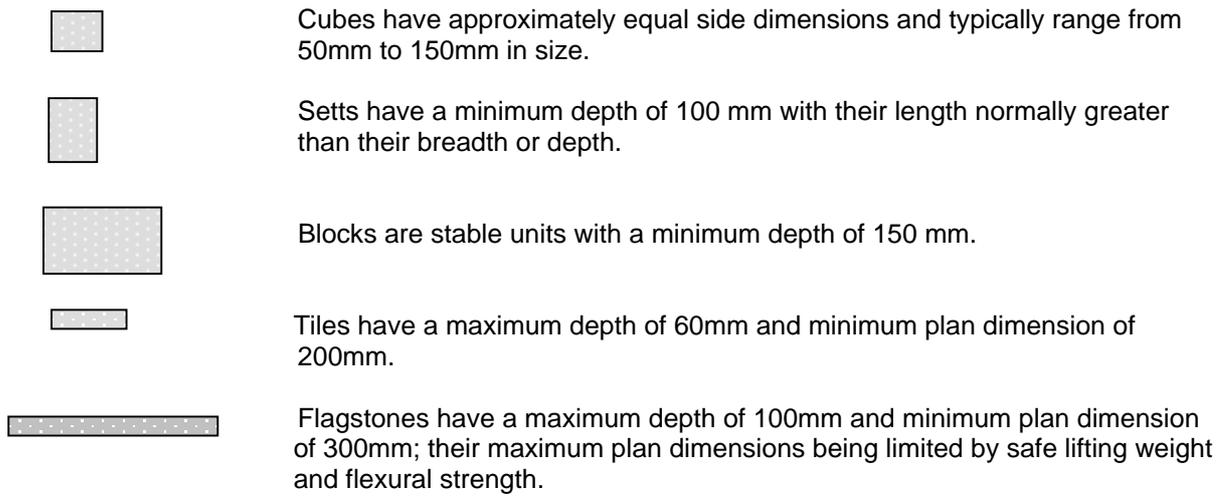


Figure 2.3 Size and shape relationship for different stone elements

2.4.1 New concept – Influence of Shape of Stone Unit on Structural Capacity

A new concept reached during the research for this guide is that the shape of the stone unit determines how the stone surface responds under load and the way in which the load will be resisted. Therefore, certain shapes of units are better suited to particular forms of construction in terms of structural response as discussed below and in Section 4.

There is an important relationship between the depth of the unit and its plan area. This is often termed the modular ratio of the paving unit. The modular ratio determines how the unit will react under load in two ways. Firstly, it determines if an individual unit of a given strength will fracture under a directly applied load. Secondly, it influences how the paving surface will resist loading and how the surface will react in different ways under load depending on the ratio of their depth to plan area, see Figure 2.4.

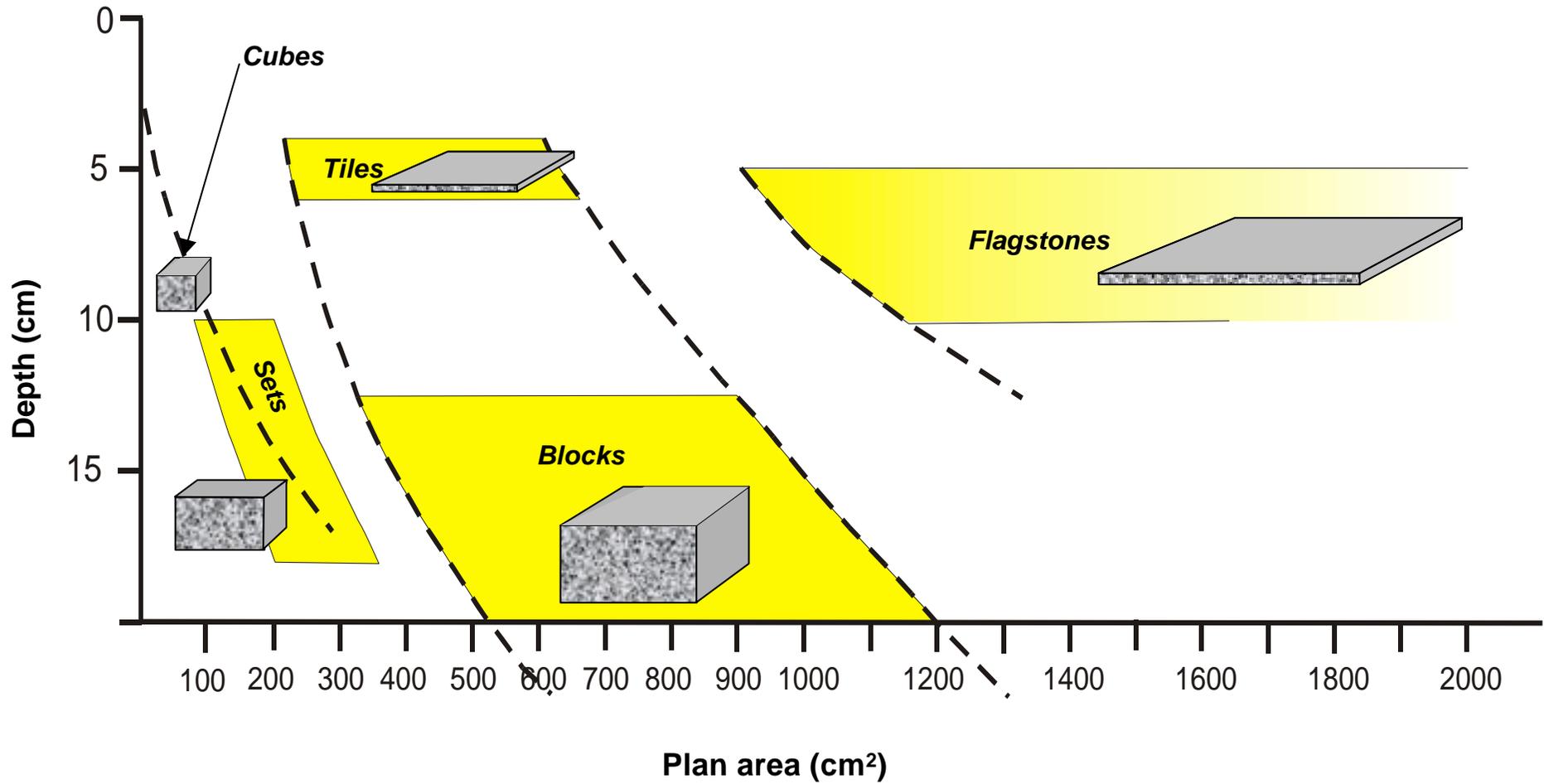


Figure 2.4 Size and Shape of Natural Stone Elements

At the left side of the diagram are cubes and setts. Individually these elements are intrinsically strong under vertical loading. The research for this guide indicates that for the overall surface the primary resistance to load is generated by shear in the joints. The degree of this shear resistance is a function of area of the vertical sides or walls of the stone element, which in turn is a function of its depth.

In the centre of the diagram lie tiles and blocks. Tiles can sustain some vertical loads in their own right but depend mostly on the layers below for resistance to load. Blocks are at the other end of the spectrum and virtually support the loads on an individual basis without transferring stresses through the joints to their neighbours and are less dependent on joints than on the lower layers.

At the right of the diagram lie flagstones, which offer least individual resistance to vertical loads and are very dependent on the support layers.

This is a much-stylised version of how shape influences load-bearing capacity. Often stone surfaces react in a composite manner mobilising a number of different resistance mechanisms. For example, shallower setts, which lie on the boundary between the first and second shape classifications, are thought to behave in a composite manner generating resistance to load in both joints and beds.

Guidance

The shape of the stone element will determine the principal form of resistance generated in the surface with which the load applied on the surface by vehicles is supported.

In surfaces of cubes, setts and blocks, the resistance is predominantly through shear in the jointing.

In tiles and flagstones, the resistance to load comes predominately from the bedding.

Section 3 gives fuller information on selection of stone.

Section 4 develops the concept of structural capacity being dependent on shape.

2.5 Types of Construction of Stone Surface

There are a number of traditional terms used to describe types of stone surfaces, flexible, rigid, bound, un-bound. Traditionally stone surfaces formed with unbound aggregates have been thought of as “Flexible” whilst those formed with bound aggregates have been described as “Rigid”.

Throughout this guide the types are based on the **structural behaviour** of the overall pavement construction; and in particular the stone surface: -

- *Flexible surfaces deform in an elastic manner under load and revert to or near to their original profile once the load has passed.*
- *Rigid surfaces are not intended to deform under load but should remain rigid.*

These terms are familiar to those engaged in road design as a flexible response is the type of structural behaviour exhibited by asphaltic roads and paving block surfaces. A rigid response is exhibited by concrete surfaces.

No surface is either truly flexible or rigid but the type of structural response is a fundamental characteristic of the surface and determines the overall design of the pavement.

Flexible constructions typically fail under fatigue i.e. under the cumulative effect of a number of cycles of load. The research for this guide has shown that flexible stone surfaces cannot sustain heavy traffic loading and that they are only effective for category III and IV loading. It is recognised that there are examples both here and on the Continent of this type of surface surviving category I and II loading but as yet there is no conclusive evidence to determine why this is the case. Every case should be treated individually and it is therefore recommended that before adopting flexible surfacing under heavy loading the designer uses the fully analytical process backed up with extensive trials.

Rigid constructions typically fail under a combination of very heavy single loads and fatigue failure. A single instance of overload can produce a shear failure of the joint and bearing failure of the laying course under the punching action. Rigid pavements can be designed to have an indefinite life, however in heavily loaded conditions, a design life for the pavement may be appropriate. This design life method should provide for most typical applications (See Section 4.)

Research for this guide indicates that rigid surfaces are capable of sustaining heavy loads for a long period provided the integrity of the surface is not compromised during its life. This requires appropriate levels of maintenance during the life of the surface as discussed in Section 8.

Guidance

There are two forms of construction of stone surfaces defined by their structural behaviour under loading

Flexible Construction, which responds to loading by deforming in an elastic manner.

Rigid Construction, which responds to loading in-elastically and do not deform under load.

2.6 Structural Design

2.6.1 Structural Design Options

There are three basic structural design options: -

Design Life Method for Deep Stone Units - to be used for pavements built with deeper stone units such as Cubes and Setts has been developed from the previous indefinite life models in the first version of this Guide. The new Design Life method is now based on numerical modelling combined with empirical factors and recipe specifications. It comprises a series of tables from which options can be selected to meet site-specific design criteria. This is the method adopted in BS 7533 Part 10 and is described in full in Section 4 of this Guide.

Design Life Method for Shallow Stone Units - to be used for pavements built with shallow stone units such as slabs flags and tiles is similar to typical design methods for concrete and clay shallow stone units and is based on methods developed by the Transport Research Laboratory for footways paved with shallow units. This has been developed to include stone units and is the method given in BS7533 Part 8, and is discussed in Section 4.8.

Full Analytical Design Method - can be applied to pavements built with any type of surfacing and involves carrying out a structural analysis from theoretical principals. A mathematical model is used to determine the relevant critical strains or stresses for different pavement construction and assess their ability to carry the applied loads. The technique encourages innovation and may produce cost savings. Experience and expertise is required in the application of this method.

When the surface is to be of shallow units only flexible construction is recommended unless the pavement is extensively tested. For other situations, the designer has the choice of selecting either a flexible or rigid pavement construction within the limitations of their load carrying capacity.

As in the first edition of the Guide, a risk assessment method has been developed to enable the designer to check the risk of failure of the construction specification produced. (see Appendix A)

2.6.2 New Concept – Element Profiles: Design Joint Width and Face Texture

Achieving consistent compaction in joints materials and the interaction of the joint material and the face of the stone elements are important in all types of stone surface. Their influence can reduce the design life of a surface, particularly in Rigid Construction.

The importance of these factors has led to the introduction of two **ELEMENT PROFILES** the first of which is **Design Joint Width** the second is **Face Texture** of stone elements.

Design Joint Width

Is applied to the design life method for rigid constructions and recognises that it is not always possible to achieve the design intent with the materials available or selected to meet other design requirements. Factors are applied to the design life depending on whether or not the joint width can be achieved within certain tolerances i.e.

- **Design Joint Width** – where the widths of all the joints in the surface are in a pre defined range and the full potential structural capacity can be mobilised
- **Non-Compliant Joint Width** – where joints deviate from the defined range and the structural capacity is reduced.

Face Texture

The interaction between the vertical sides of the stone and the joint concrete is crucial in all pavements. Again this is particularly relevant in the Design Life method for rigid construction where poor bond will reduce the design life. The bond between vertical faces depends on the face texture and research for this guide has shown that, units with too coarse a texture or too smooth a texture do not develop as good a bond with the joint materials as units with a mid range texture. These give better bond characteristics and therefore give better structural performance.

Combined Effect of Design Joint Width Face Texture

The combined effect of non-compliant joint widths and poor face texture is to require a higher strength joint material. Importantly this also imposes an upper limit on the structural capacity of a pavement.

The effect does not apply equally to all the basic types of rigid construction and a number of tables have been developed to reflect this. This is discussed fully in Section 4.

GUIDANCE

There are three basic structural design options: -

- *Design Life Method for deeper stone units*
- *Indefinite Life Method for shallower stone units*
- *Full Analytical Design Method*

These may be used singly or in combination to arrive at a construction specification.

The design life methods for rigid pavements introduce factors to take account of effect of non-compliant joint widths and face textures, which can reduce the design life of a stone surface.

A risk assessment methodology has been included which allows each construction specification to be assessed in terms of the likelihood of failure. (see Appendix A)

2.7 Flexible Construction in Deeper Stone Units

A flexible construction of stone element paving normally uses unbound material in both the laying course and the joints. Key issues relating to the use of stone elements constructed using unbound aggregate are as follows:

- Flexible pavements should not be used in severe stress sites (see Section 4)
- The elements are stabilised by mechanical interlock and friction in the unbound material, normally aggregates. This interlock action spreads the vertical load and induces horizontal compression stresses in the surface. Interlock also resists direct horizontal forces on the surface from braking, turning etc.
- Achieving consistency of compaction of the unbound aggregates in joints and laying course is paramount. Inconsistent or inadequate compaction will lead to early failure of the surface. The optimum moisture content of the aggregates for full compaction should be established by laboratory tests before installation. During installation, the moisture content of the aggregate should be at, or close to, optimum to ensure compaction to at least 95% density.
- Patterns can be introduced in surfaces built with different shape elements to enhance interlock. Cubes must be laid in curved patterns described as Bogan or arc pattern in vehicular trafficked areas to ensure interlock is achieved.
- Edge details are critically important. A robust support must be provided at all edges to a flexible pavement construction to ensure interlock is generated
- The texture of the face of the stone elements affects the interlock in the surface and all elements should have textured faces. If sawn elements are to be used they should be retextured to give an appropriate face texture Alternatively sawn elements can be made to tolerances such that they can be laid in the manner of concrete block technology as defined in BS 7533 Parts 1 and 2, 1999 (See Section 4).
- The support structure must be made compatible with the surface layer; i.e. a flexible surface layer requires a flexible support structure (See Section 7). Adequate compaction of support materials (road base and sub-base) is critical to ensure a uniform support for the surface layer.
- A flexible stone surface requires joints to be topped-up in its early life with additional aggregate as the system 'shakes-down' and 'stiffens up' under traffic loading. Further topping up of joints may be required depending on traffic type, volume and environment.
- Regular attention should be paid to the surface profile of a flexible pavement since permanent deformation, i.e. non-elastic response to loading, may be an early indicator of failure.

There are several advantages of Flexible forms of construction compared to rigid forms: -

- Lower cost,
- No curing period allowing early opening to traffic,
- No problems associated with cleaning surfaces following joint filling with mortar,
- Allows for small movements without loss of stability,
- Can be lifted and re-laid seamlessly following excavation as part of PU activities,
- Improved aesthetics through introduction of laying patterns.

Disadvantages include: -

- Limitation in load carrying capacity
- The need for topping up joints in its early life as the system 'shakes-down' and 'stiffens up' under traffic loading
- Loss of joint aggregate as a result of surface cleaning operations
- Wash out through water movement such as on a vertical gradient; or through water drainage

Guidance

The primary failure mechanism of flexible surfacing is fatigue due to the cumulative passes of vehicles. This usually results in excessive deformation of the surface.

The stone units are stabilised by mechanical interlock and friction in the unbound material used in the joints and laying course. Achieving interlock is of critical importance in flexible pavements.

Flexible surfaces should be limited to lightly loaded pavements when the design life method is used.

For heavier loading, an analytical design followed by extensive trials is recommended.

2.8 Rigid construction in Deeper Stone Units

A rigid construction of stone element paving normally uses bound material in both the laying course and the joints. Typically, cement is used as the binder in fine aggregate concrete but other binders can be used. Key issues relating to the use of stone elements constructed using bound materials are as follows:

- Rigid constructions can be used in all loading conditions although a limited life should be expected in more severely loaded conditions (See Section 4).
- With cubes, setts and blocks the depth, strength and width of joints will be the primary factors controlling resistance to loading. Vertical loads are transmitted vertically with little interaction between units. Horizontal forces from braking turning etc are transmitted directly by contact through the joints and units and are dissipated through the surface.
- Achieving consistency of compaction of the unbound aggregates in joints and laying course is paramount. Inconsistent or inadequate compaction will lead to early failure of the surface. The optimum moisture content of the bound aggregate mixture for full compaction should be established by laboratory tests before installation. During installation, the moisture content of the bound aggregate mixture should be at, or close to, optimum to ensure compaction to at least 95% density.
- The thickness of the laying course is critical to the stiffness of this layer and determines the direct support provided to the surface layer. There can be difficulties in achieving the required levels in the various layers, leading to a variation in bedding depth. An excessive depth of bedding layer can result in surface layer flexure. It is vital that the laying course material is kept within tolerance required. This may require stricter than normal tolerances on the profile of the layers below.
- Joint mortars should fill a defined depth of joint.
- Curing periods for the joint and laying course materials will determine the time to opening to traffic and this can be an issue in the choice of rigid surface construction methods. This is loading category specific (see Section 4)
- The support structure must be made compatible with the surface layer; i.e. a rigid surface layer should be supported on a rigid support structure (see Section 4).
- The texture of the face of the stone elements affects the bond between the stone and the mortar and all elements should have textured faces. When sawn elements are used, all surfaces should be textured by 'picking' or shot/sand blasting (see Section 3 and Section 4).

The main advantages of rigid forms of construction over flexible forms are:

- Higher load carrying capacity over longer life span,
- Generally, lower maintenance cost if correct maintenance regimes are adopted, which provide for early intervention.

The main disadvantages are: -

- Cement staining can be a problem during filling of joints,
- Joint materials may be washed off during filling, any surplus mortar needs to be trapped prior to it being washed into drainage systems,
- Staged construction can be difficult with rigid pavement design. The curing of the bedding layer can become variable where an edge is exposed along the construction joint. More importantly, adequate compaction of the bedding along the construction joint is difficult, leading to the possibility of localised failures,
- Rigid surfacings are difficult to repair following failure or access by Public Utilities providers.

Guidance

The failure mechanism for rigid construction is a combination of fatigue under cumulative loading and shear failure as result of a single instance of overload.

Rigid pavements can be designed to have an indefinite life, however in heavily loaded conditions, a design life for the pavement may be appropriate.

The performance of the Jointing and Laying course materials is critical to the performance of the surface and requires tight control of joint width and bed depth and of the compaction of the bound aggregate mixture.

Where non-typical applications occur a full analytical design backed up by extensive trials is recommended.

2.9 Construction in Slabs, Flagstones and Tiles

Key issues relating to the use of flagstones and tiles are as follows:

- Slabs, Flagstone and Tiles should be laid in a Flexible Construction with flexible bedding and jointing and are recommended only for the lightest loading conditions. This form of flexible construction should not be specified for areas carrying vehicles unless the specific construction to be used has been thoroughly tested (see Section 4).
- It is recognized that a Rigid Construction of Slabs, Flagstones and Tiles can with careful design be successful in category III and IV traffic load, where the site category is A; but it is recommended that specific constructions are tested before use.
- Flagstones have a large plan area in relation to the area of the sidewall and the support for elements is supplied by the bedding and support structure. The joints play little part in structural terms.
- Achieving consistency of compaction of the unbound aggregates in joints and laying course is paramount. Inconsistent or inadequate compaction will lead to early failure of the surface. The optimum moisture content of the aggregates for full compaction should be established by laboratory tests before installation. During installation, the moisture content of the aggregate should be at, or close to, optimum to ensure compaction to at least 95% density.
- With flexible construction, joints should not be filled with cement mortar, but should be filled with fine aggregates. Where the joint material may be subject to washout or suction cleaning, alternatives such as urethane compounds, which fill and seal joints, but also allow movement, can be used.
- Joints should allow for thermal movement of the elements otherwise the edges of adjacent units might come into contact and cause spalling. To allow for thermal effects the dimension of joints should be a minimum of 2mm.

Guidance

Flexible construction of slab, flag and tile is not suitable for vehicular areas.

The laying course plays the critical role in providing support.

Achieving consistent compaction of the unbound aggregates in the laying course and joints is paramount to the performance of the pavement.

Although not recommended it is understood that a rigid construction with slabs and flagstones tiles can be designed with care to carry light traffic.

2.10 Workmanship during Construction

European experience stresses that the use of skilled and properly trained personnel is of paramount importance in streetscape projects.

Research for this guide demonstrates that achieving tolerances on joint widths and laying courses and achieving optimum compaction of materials both unbound and bound is fundamental to the performance of the finished stone surface.

These parameters are used in the design process. The design intent must be transferred to the installation process otherwise, the pavement will not perform as intended. This reinforces the need for skilled operatives and good quality control on site.

Some important issues relating to workmanship during construction are as follows: -

- The Contract must specify that only properly trained stone laying staff and operatives should be employed.
- The Contractor should be required to demonstrate that only properly trained and experienced staff and operatives will be used in his stone laying teams.
- References from previous successful schemes should be sought.
- The Client should ensure skilled and experienced supervision is provided.
- The Contract should require construction of demonstration panels.
- Materials should be stored and used in good conditions during all stages of installation.

Guidance

Workmanship is of critical importance and it is imperative that trained and skilled operatives undertake the laying of stone surfaces.

Equally important is that those who are involved in supervising the laying of stone surfaces should have appropriate training and experience.

2.11 Construction

Achieving a suitable design for a natural stone pavement is of little use if it is not translated into a construction that is fit for purpose. There are a number of construction techniques applicable to the installation of stone surfaces. The recommended techniques are discussed in Section 7.

2.11.1 New Concept – Consistent Compaction of Materials Is Vital To Structural Capacity

A fundamental factor in under performance of constructed stone pavements is the inconsistent levels of compaction of materials in both joints and laying course. This applies to both flexible and rigid surfaces. Therefore the crucial issues during construction are to ensure that materials are supplied to the work in optimum conditions and that they are placed and compacted to a consistent degree.

2.11.2 Key Issues Associated With Construction

General

- Stone elements should be sorted to facilitate laying to achieve the required tolerances on joint widths and depth of laying course. This is vital to achieving proper compaction of materials in the joints and laying course
- The surface profile of the structural support layer must not vary by more than 5mm over 3m from the profile of the finished surface.
- Adjacent elements must never be in contact.
- If possible, services should be re-routed to common ducts within footways or to where they can be maintained with minimum disruption to the fabric of the surface and use of the street.

Flexible Construction

- The structural support layers must be properly compacted. If the structural support layer is of granular material, then it must be compacted at optimum moisture content.
- Robust support must be provided at all edges of a flexible construction.
- Consistent compaction of the laying course is essential. The laying course must be compacted at optimum moisture content.
- Normally with unbound materials, a surcharge height is specified to allow for the compression of the material under compaction plant. The height of surcharge should be confirmed by insitu tests before the main works start.
- Consistent compaction of the joint materials is important and the material should be compacted at optimum moisture content. Joints must be topped up in early life.

Rigid Construction

- Construction joints will be required in cement stabilised road bases.
- Fine concrete for the laying course and joints requires a blend of workability, strength, durability and low shrinkage. Fine Concrete should be mixed to ensure full hydration of the cement binders- it should never be semi dry.
- The laying course material must be properly compacted and must be compacted at optimum moisture content.
- The joint material must be properly compacted and must be compacted at optimum moisture content.
- Vertical surfaces of units should be clean and wetted prior to inserting the joint material.
- It is vital to fill the joints completely. Laying course material should not be allowed to rise up the joints, unless it is to the same specification as the joint materials.

Guidance

There are numerous construction techniques for both flexible and rigid pavements, but the fundamentals are to ensure that: -

- *the laying course thickness is constant and that this material is fully compacted,*
- *the joint widths are constant and that this material is fully compacted.*

2.12 Maintenance

The key issues associated with the maintenance of paved surfaces are as follows:

- Maintenance must be considered at the design stage. Many problems can be overcome if maintenance activities and regimes are considered, costed and approved prior to the implementation of a scheme.
- Technical and management advice concerning aftercare maintenance operations should be recorded in a Maintenance Manual. The document should be regularly reviewed and updated.
- Informal partnerships should be encouraged to control public utility activities.
- An allowance for the procurement and storage of surplus material, typically 10%, should be made at the tender stage.
- To ensure maintenance treatments are cost effective, consideration should be given to the maintenance history of the paved surfacing, its future use and the likely failure mechanism.
- Stone surfacings will become slippery with time and trafficking and an appropriate re-texturing technique should be used to restore skid resistance.
- The skills needed to maintain a paved surface are the same as those required to construct it. The key issues discussed above in respect of operatives and contractors during the construction period, apply to maintenance.

These issues are discussed in detail in Section 8.

Guidance

- *Maintenance regimes are fundamental to the success of a stone pavement and should be considered and agreed as part of the design process. Regimes should recognise the importance of early interventions.*
- *A maintenance manual should be developed as the design progresses.*
- *The skills needed for construction are needed for maintenance.*