

DS.601

Structural design of pavement upper layers

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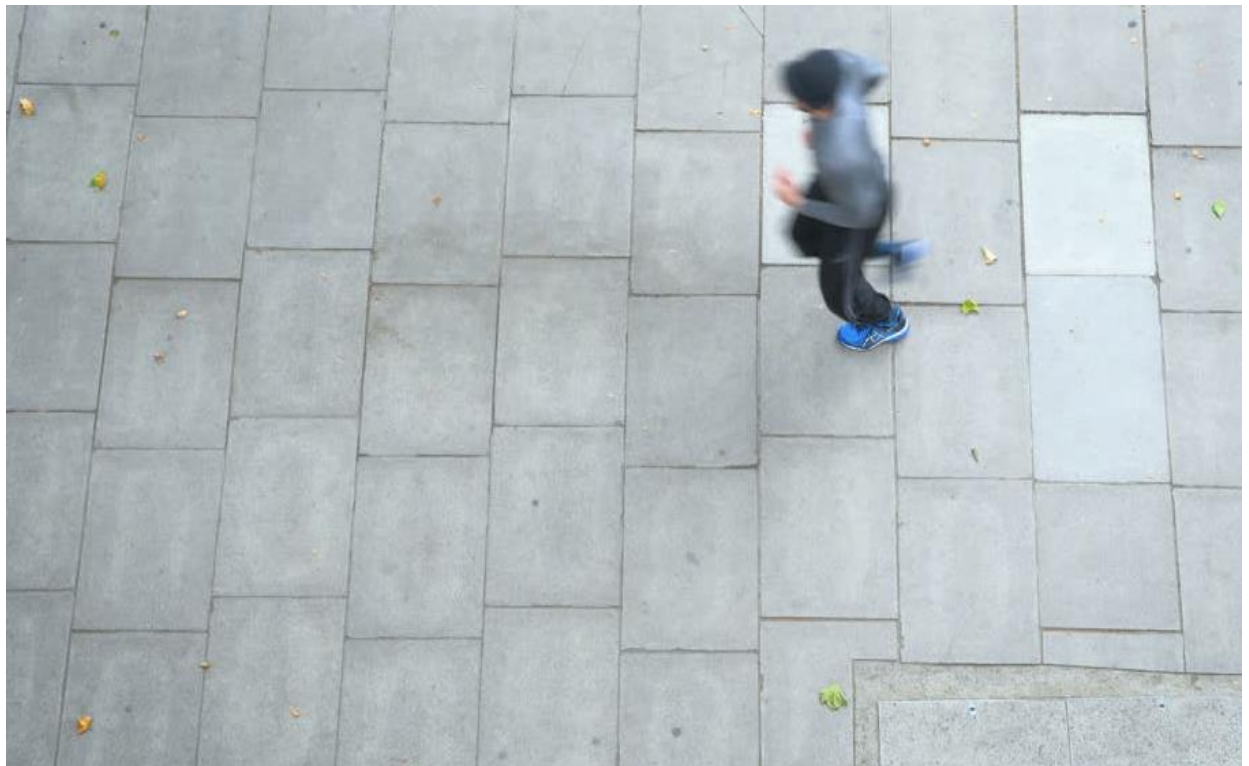


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1 Introduction

1.1 Notes

- a. This standard explains design requirements for the upper layers of pavements. It is applicable to carriageway pavements, footway pavements and other non-carriageway pavements. Pavement upper layers include the pavement surface course, laying course (or binder course), base course and associated inter-layers.
- b. This standard does not consider the visual design of pavement surfaces. See SSDM Surfacing Material palettes for details of acceptable materials and standard DS.130 for broader surface landscaping requirements. It does not consider the design of subbases and capping layers (and associated inter-layers) for which see instead standard DS.602.
- c. Designers must submit an accompanying Pavement Design Statement, setting out workings, constraints and assumptions and explain the logic behind proposed designs.
- d. A 20 year serviceability design life should be assumed for pavements. If all underground services can be located elsewhere then longer serviceability design lives may be permitted. Where the standard 20 year serviceability design life value cannot be achieved, developers will need to pay commuted sums for the cost of one full reconstruction of the upper pavement layers. Any materials from the original construction that can be reused will be deducted from this. Commuted sums may also be required for other reasons, including the presence of sustainable urban drainage or other specialist drainage or engineering features within the pavement. Where existing pavements are being brought up to adoptable standards then commuted sums are not normally required providing the materials and methods are as per normal requirements.
- e. Designers are required to carry out a full traffic evaluation.
- f. For modular unit surfaced pavements, unbound surface construction is preferred.
- g. If entirely new pavements must be constructed over the roots of existing trees within previously soft landscaped areas then bespoke 'no-dig' design solutions will be needed. See standard DS.501 for further related information.
- h. The first 1.5m of footway shall be constructed as heavy overrun area in new developments.

2 General requirements for pavements of all types

2.1 Pavement Design Statements (PDS)

- a. The purpose of a PDS is to explain and justify the nature of proposed pavement constructions based on site investigation information, constraints and design aspirations. They need not be lengthy documents but must be sufficiently detailed to allow approving officers to understand the logic behind design proposals and reasons for design choices. Broadly the information required includes:
 - *Structural statement: Justification of the proposed pavement construction and maintenance implications with details of informing design values (e.g. CBR, traffic evaluation, element stiffness or compressive strength values for proposed materials etc.) and calculations (e.g. filter criteria at layer interfaces, equivalence calculations where material substitutions made). Where geo-cellular unit assemblies or other geo-technical structures are involved (including basements) then this must be cross referenced to information from geo-technical design reports.*
 - *Pavement sub-drainage statement: Justification of steps taken to prevent or minimise surface water and ground water infiltration into pavements or to dispose of water should this be unavoidable else deliberately intended. Maintenance implications must also be explained.*

All the above information relates specifically to the construction of pavements. Separate more detailed Design Statements on surface water drainage and design for street trees must also be produced. These are discussed in standard DS.501 and DS 503.

2.2 Surface landscaping of modular unit pavements

- a. See standard DS.130 for requirements about the visual design of pavement surfaces, including requirements for selecting surfacing products.
- b. For modular unit surfaced pavements, standard DS.130 also provides information about introducing intermediary restraints, and selecting laying (bond) patterns for surface courses. These are not only visual concerns as both can play important structural roles.

2.3 Commuted sums

2.3.1 Method of design

Only designs that are likely to allow surface course units to be re-used by the Highway Authority or Statutory Undertakers to carry out maintenance or reinstatement works to pavements are within the Highway Authority’s adoptable standards.

2.3.2 Responsibility for maintaining pavements within serviceability limits

- a. If publicly adopting a new or existing Highway is proposed then the proponent must cover the costs of maintaining associated pavements within serviceability limit states for a period of 20 years. If the serviceability design life of a pavement is less than this then this will mean providing commuted sums to cover the cost of pavement reconstruction/rehabilitation works to maintain the pavement for the residual period. Such sums should cover both the works and the materials. Precise commuted sums will be advised by approving officers on a case specific basis with reference to the submitted design proposals for the initial design life and the following principles:
 - i. It should be assumed that all pavement upper layers will require removal and replacement (rather than overlaying or inlaying).
 - ii. Only minimal re-profiling works to subbase layers should normally be assumed as a result of ‘i’. However, if the subbase materials are known to have a serviceability design life that is less than that of the pavement as a whole (as may be the case for some geo-cellular unit systems) then replacing these should also be included.
 - iii. If existing surface course and other pavement materials from the expired pavement are capable of being incorporated back into the works, then the value of these should be deducted from the cost. Table 1 states serviceability design life values that should be assumed for surface courses for the purposes of determining whether these can be reused in reconstruction. However, crack and seat techniques may not be assumed.
 - iv. Works should be costed using the Highway Authority’s current term contractor rates.

| Surface course material | Assumed durability before serviceability expiry (years) for footways (see note) | Assumed durability before serviceability expiry (years) for carriageways (see note) |
|---------------------------------------|---|---|
| Bituminous mixture | 25 | 20 |
| Hydraulically pressed concrete blocks | 25 | 20 |
| Imitation clay pavers | 70 | 60 |
| Natural stone setts | 70 | 60 |
| Hydraulically pressed concrete flag | 20 | N/A |
| Natural stone slab | 70 | N/A |

NOTE

If it is permitted to lay modular units as part of a bound surface (as sections 4 or 6) then, unless agreed otherwise, it should be assumed that these will be damaged beyond reuse as part of any reconstruction works and therefore require replacement.

Table 1. Assumed maximum durability before serviceability expiry for surface course materials

2.3.3 Increased Maintenance Liabilities

- a. Referenced British Standards and other national and international standards for pavement design typically impose maximum limits on cumulative design life trafficking of pavements. Though using a construction beyond these limits may still be permitted by departure, commuted sums may be required to cover the likely increased cost of care and the potential need to fully or partially reconstruct or reset the pavement. Where this is the case then sums will be determined by approving officers on a case specific basis.

NOTE: In some instances the maximum traffic limits given in British Standards may be modified by this design standard. If this is the case then the maximums in this design standard prevail and commuted sums as above may be required if it is permitted to use such constructions where trafficking is predicted to exceed that limit.

2.3.4 Sustainable urban drainage features

Commuted sums may be required if pavements incorporate surface water infiltration or attenuation features. This is owing to the likely need to periodically cleanse related geotextiles, aggregates and other filtration or drainage infrastructure. In some instances this may mean excavating these from the pavement, replacing them, and reinstating the pavement.

2.4 Assumed level of trafficking

2.4.1 Footway pavements

- a. Table 2 below states minimum daily levels of commercial vehicle overrun assumed to different parts of footway pavements (and other non-carriageway pavements). Pavement designs for different areas should be based upon the cumulative trafficking across the required serviceability design life that follows from projecting these daily values (see sections 2.5 & 2.6). Using lower values requires level 1 departure. This is only likely to be considered if physical measures are put in place to prevent commercial vehicles from gaining access to pavements (for example, bollards).

| Serviceability design life (years) as section 2.6 | Pavement area | Assumed minimum number of daily commercial vehicle standard axles over running pavement (see note 3) in World and Town areas | Assumed minimum number of daily commercial vehicle standard axles over running pavement (see note 3) in all other areas |
|---|---------------------------------|--|---|
| Typically 20 | Heavy Overrun Area (see note 1) | 2.25 | 1.5 |
| Typically 20 | Light Overrun Area (see note 2) | 1.25 | 0.5 |

NOTES

- 1) Heavy Overrun Areas are the front 1.5m of the pavement width at the carriageway edge, unless the pavement is $\leq 2.75m$ in width in which case it applies to the entire width. This distance includes any kerb or other edge restraint at the carriageway edge. Inset Parking Bays should be treated as part of the carriageway and this specification must therefore continue around the kerb inset they create.
- 2) Light Overrun Areas are the residual width of the pavement after Heavy Overrun Areas.
- 3) The stated values in this Table are before applying multipliers on account of channelised trafficking, slow moving traffic, dynamic loading/impact or traffic growth factors. As per section 2.5 these should always be applied.
- 4) The only instances when minimum assumed trafficking levels do not form the basis of pavement design are for bituminous mixture and self-binding gravel surfaced footway and cycleway pavements (other than at commercial Vehicle Crossings). See sections 9 and 10 for further information.
- 5) Notwithstanding these assumed minimums, a full

evaluation of predicted cumulative trafficking as section 2.5 is still required for all pavements. If these minimum values are exceeded by assessments then the greater alternative values should be used instead.

- 6) See section 2.13 about trafficking assumptions for Level Surface streets and spaces.

Table 2. Minimum design life and assumed daily levels of commercial vehicle over run for footway pavements (and other non-carriageway pavements).

2.4.2 Carriageway pavements

- a. The road should be assigned to one of the Road Categories given in Table 3 based upon the findings of this evaluation. The upper limit value for that Road Category should be assumed for design purposes.
- b. If modular unit surfacing is proposed to carriageway pavements then the Highway Authority reserves the right to either refuse this or to permit it subject to commuted sums being provided for particular agreed types of modular unit being used.

| Road Category (see note 1) | Lower design life trafficking thresholds (million standard axles) (see note 2) | Upper design life trafficking thresholds (million standard axles) (see note 2) (maximum value to be assumed for design purposes) |
|----------------------------|--|--|
| 0 | 30 | N/A (value to be determined on case specific basis) |
| 1A | > 20 | ≤ 30.0 |
| 1B | > 10 | ≤ 20.0 |
| 2A | > 5.0 | ≤ 10.0 |
| 2B | > 2.5 | ≤ 5.0 |
| 3A | > 1.0 | ≤ 2.5 |
| 3B | > 0.5 | ≤ 1.0 |
| 4 | 0 | ≤ 0.5 |

NOTES

- 1) The Road Categories in this Table are based on those given in 'New Roads and Streetworks Act: Specification for Reinstatements of Openings in the Highway, Third Edition' (DfT, HAUC, 2010) (SROH). All Road Categories assume a 20 year serviceability design life.
- 2) Values are inclusive of multipliers for channelised trafficking, slow moving traffic, dynamic loading and impact (or other stresses) and traffic growth factors.

Table 3. Road Category classifications and associated design life commercial vehicle overrun assumptions for carriageway pavements

2.5 Evaluating predicted motor vehicle trafficking

- a. Notwithstanding the minimum daily standard axle trafficking values stated for different parts of pavements in section 2.4, all design submissions for Highway pavements should include an evaluation of the predicted level of cumulative trafficking across the pavement serviceability design life. This should be based on the process described in the informing pavement design standard that is prescribed in sections 3-8 for the type of pavement in question (e.g. DMRB HD 26 or relevant parts of BS 7533). In addition:
- i. Any amendments to that process or particular assumptions that are specified in sections 3-9 should be followed.
 - ii. For carriageway pavements:
 - The measured or estimated level of traffic in the busiest running lane should be adopted for all other lanes to that section of carriageway.
 - Growth factors should be assumed.
 - If an individual lane width is < 3.5m, or if the width of the carriageway as a whole is ≤7.3m then channelised trafficking should be assumed.
 - iii. For modular unit surfaced footway and other non-carriageway pavements as sections 3-7:
 - Worst case factors for dynamic loading/impact, channelised trafficking etc. (as specified in the relevant traffic prediction methodology or elsewhere in this standard) should be assumed to Heavy Overrun Areas (see Table 2).

2.6 Site investigation reports

- a. See standard DS.602 about undertaking various site investigation reports as the basis for design proposals.

2.7 Substituting materials and component overlay/inlay design methods

2.7.1 Substituting materials

- a. If alternative pavement course materials to those recommended in the required informing design standard document (e.g. BS 7533 or HD 26) are required or permitted by this standard or DS.602 then, unless exact thicknesses for those alternatives are specified at the same time; designers should apply equivalence factors (sometimes referred to as material

conversion factors, see note) to determine the installed thicknesses that will provide equivalent structural capacity to the omitted material. This applies both to:

- i. Pavement upper layer designs as per this standard.
- ii. Pavement foundation layer designs as per standard DS.602 (though see also 'b').

NOTE: Equivalence factors used for substituting pavement course materials should be based on published sources reporting the results of empirical analysis or laboratory testing results. Some known sources of equivalence factors include BS 7533-1:2001, 'Londonwide Asphalt Specification, 3rd edition (Road Consultants, 2013)' and 'Interpave L534 Heavy Duty Pavements'. See also '8.2.1a' for substitute minimum stiffness modulus values to be used in place of named bituminous mixtures within DMRB HD26/01 design graphs.

- b. For foundation layers to main carriageway running lane pavements that have bituminous mixture surfaces, if alternative materials are permitted or required (see note 1) to be substituted for those recommended for Standard Designs/Restricted Designs as Highways Agency 'Design Manual for Roads and Bridges' HD 25; then Performance Design as HD 25/06 and Southwark Highway Specification Clauses 890-896 is required. This will entail both laboratory characterisation of materials and the construction and assessment of demonstration areas (see note 2). Application of equivalence factors as 'a' is not permitted and requires level 1 departure (see note 3).

NOTE 1: See standard DS.602 for details of permitted materials to pavement foundation layers.

NOTE 2: Because of the cost and programme implications of performance design, this is only likely to be practical (and cost effective) for schemes to construction considerable lengths of new Highway.

NOTE 3: As greater experience of alternative materials is gained and equivalence factors for these are determined, use of these may be permitted to simplify design and validation.

2.7.2 Overlay/Inlay design methods

- a. Existing pavements may be overlaid or inlaid using the component method described in BS 7533-1:2001, section 7.3. Retained parts of the existing pavement must provide an equivalent structural capacity to omitted layers that would otherwise be required if the pavement was

being reconstructed from the subgrade up (see note to '2.7.1a'). Condition factors should also be applied to any retained existing courses as BS 7533-1:2001, clause 7.3.1.4.

NOTE: Older parts of BS 7533, as used for the design of modular pavements, are based on the use of CBMs where semi-rigid base courses are required. So too is DMRB HD 26/01 (which may be used for the design of bituminous mixture surfaced pavements in preference to the newer HD 26/06 where wished - see section 8). CBMs are no longer included in current SHW clauses which have been updated to newer CBGM mixtures. These have a lower 28 day strength compared with the old CBM specifications. Where use of CBMs is prescribed in the pavement design standards called up in the this design standard then any of the modern HBMs or wet lean concretes as Table 4 should be used in their place. Note that the compressive strength class of each has been promoted one class to correct for the lower 28 day strength (and other issues).

| Historic CBM grade | Equivalent CBGM (see notes 1-3) | Equivalent SBM (see notes 1-3) | Equivalent FABM (see notes 1-3) | Equivalent wet lean concrete (see note 1 and 4) |
|--------------------|---------------------------------|--------------------------------|---------------------------------|---|
| CBM3R | [CBGM-B/R-C10] | [SBM-B1/R-C12] | [FABM1-R-C12] | [C-WL3] |
| CBM4R | [CBGM-B/R-C15] | [SBM-B1/R-C16] | [FABM1-R-C16] | [C-WL4] |
| CBM5R | [CBGM-B/R-C20] | [SBM-B1/R-C20] | [FABM1-R-C20] | [C-WL5] |

NOTES

- 1) See section 2.10 about pre-cracking requirements.
- 2) All base course CBGMs, SBMs and FABMs should use crushed rock aggregate with a coefficient of thermal expansion $<10 \times 10^{-6}$ per °C. Use of materials with gravel aggregate is not acceptable.
- 3) See also standard DS.602 about strength requirements for concrete and HBM courses prior to trafficking/overlay.
- 4) Wet lean concrete is generally only appropriate for pavement foundation layers (e.g. subbase) as standard DS.602. It should not be used to upper layer base courses.

Table 4. Equivalent modern HBMs and wet lean concretes that may be directly substituted for CBMs for use to pavement courses.

Overlaying modular unit surfaces onto existing bound courses

Where it is permitted to overlay existing impervious bituminous mixture, CBGM, HBM or concrete courses with unbound modular unit surfaces then, unless these are already open graded or pervious materials, this is subject to agreeing appropriate measures to allow for the through-drainage and dispersal of any surface water that may succeed in penetrating the surface course (see note). In the case of bituminous mixture courses, coring 75mm diameter holes on a 750mm x 750mm grid will generally be acceptable. In the case of CBGM, HBM, or concrete courses, appropriate measures are less easy to define and will likely require innovation by the designer and contractor. Gradual cracking of such materials should not be relied upon.

NOTE: If any surface water that penetrates the pavement surface is allowed to stand in the laying course then it is likely to contribute to early failure.

Cold mix in situ recycling of bituminous mixture surfaced pavements

If using cold mix bituminous mixtures is permitted as an option for an upper layer course to a carriageway pavement (see section 8.3.1 and Appendix B), full or partial in-situ cold mix recycling of that layer and all those beneath must be considered. *If cover is limited and this prevents overlaying, then planing the upper layers and in-situ recycling should be considered.*

Slurry surfacing, micro-surfacing and micro-asphalt surface treatments

Slurry surfacing, micro-surfacing and micro-asphalt surfacing may be used to existing bituminous mixture surfaces. Products will be agreed on a case specific basis. However, this may be for cosmetic or retexturing purposes only. It may not be for structural purposes and no extension in pavement life may be assumed as a result.

NOTE 1: Applying slurry surfacing, micro-surfacing and micro-asphalt surface treatments to pavements with existing structural defects will only serve to mask them. Information about specifying slurry surfacing, micro-asphalt surfacing and micro-asphalt surface treatments can be found in the following documents:

- PD 6689:2009 Surface treatments, Guidance on the use of BS EN 12271 and BS EN 12273
- TRL Road NOTE 39.
- SHW clauses 918 and 922 and NG 922 and NG918.
- Road Surface Treatment Association Codes of Practice
- DMRB HD 37/99

2.8 Trafficking of pavements courses during construction works

The base course thicknesses and materials prescribed in this design standard assume that heavy vehicles will not traffic the base course during construction of the pavement. Designers must explicitly confirm within traffic evaluations as section 2.5 whether or not such trafficking will occur and (if so) the extent of it. If site trafficking will take place then they must set out in Pavement Design Statements as section 2.1:

- i. How proposed pavement course thicknesses have been adjusted to accommodate the additional standard axles and loading.
- ii. Any other steps that are proposed to prevent damage to the pavement (see note 1).

All proposed measures and adjustments are subject to agreement by approving officers. The same also applies if trafficking foundation layers is proposed (see note 2).

NOTE 1: For modular unit surfaced pavements, relevant parts of BS 7533 Part 101:2021 typically provide alternative adjusted thickness values that should be assumed where base courses will be used by construction traffic.

NOTE 2: For adjustment of subbase layers to accommodate construction traffic, reference should be made to TRL Report LR1132. See in particular figure C.3. See also standard DS.602 about the potential use of geo-grids to protect foundations subject to trafficking by construction vehicles.

2.9 Movement joints and pre-cracking within concrete, CBGM and HBM slabs to modular unit surfaced pavements.

Denser cement concretes, CBGMs and other HBMs with low void contents are typically subject to significant thermal expansion and contraction. Movement joints often need to be extended all the way up through to the surface of the pavement. This can have a considerable negative visual impact if joints are not sensitively designed and spaced. In addition, units located close to joints carry an increased risk of failure. Consequently, if introducing movement joints cannot be avoided, they must be carefully designed and detailed. This requires close liaison between engineers and those responsible for surface landscaping of the pavement. See BS 7533 Part 101:2021 for modular surfacings.

2.9.1 Use requirements

Movement joints should be provided in semi-rigid and rigid concrete, CBGM and HBM courses beneath modular unit surfaced pavements as directed in each of the following circumstances.

- i. [C-NF-C20] or [C-NF-C15] no-fines concretes: N/A owing to low elastic modulus.
- ii. [C-PQC-C40] pavement quality concrete surface and base slabs: Slabs should be laid with expansion, contraction, warping and isolation joints as '2.9.2'
- iii. All other HBMs and wet lean concretes (including CBGMs).

Where used to base courses

Slabs should be laid and transverse pre-cracked and sealed in accordance with '2.9.2.e.'

Where used to the upper subbase (or entire subbase) of modular unit surfaced pavements that do have a separate base course

Slabs should be transverse pre-cracked and sealed in accordance with '2.9.2.f.'

Where used to subbases of modular unit surfaced pavements that include a separate base course

Not applicable.

2.9.2 Design requirements

Pavement quality concrete (PQC) base slabs

- a. Requirements for reinforcing PQC base slabs will be agreed on a case specific basis with approving officers. This includes whether
 - i. They are to be URC, JRC or CRCB/CRCR (see notes).
 - ii. Additional micro or macro fibre reinforcement is needed.
- b. If slabs are used to carriageway pavements, their thickness will typically need to be locally increased along the footway edge as per HD 26 requirements. This is owing to the near certain absence of tied-shoulder details.
- c. Transition details and movement, warping and isolation joints should be designed in accordance with the following drawings: LBS/1100/01 to LBS/1100/48
 - i. for movement, warping and isolation joints.
 - ii. for transition details other than at ramps.
 - iii. for transition details at ramps.
 - iii. Joint spacing should generally be in accordance with DMRB HD 26/06.

Typically:

- Expansion joints should be provided every third contraction joint.
- Isolation and warping joints should be provided:

- At significant horizontal or vertical changes in direction of the pavement (including to ramps and at crowns or troughs).
 - Around vulnerable structures (including manhole and access chambers).
 - UJC and JRC slabs should use limestone aggregate as this permits some increase in joint spacing due to its lower coefficient of linear thermal expansion. See HD 26/06 for further details.
 - As per HD 26/06, increasing the thickness of the base slab will often permit an increase in joint spacing. Subject to expert advice, modest additional increases in joint spacing above the values permitted in HD 26/06 may be permitted on the basis of either:
 - Depth of cover (e.g. if very deep setts are used over the slab).
 - Using steel or plastic fibre reinforcement.
- iv. For footway and other non-carriageway pavements, given the lesser degree of overrun, it may not always be necessary to:
- Dowel movement joints.
 - Tie slabs to carriageway edge kerbs.
 - Provide other transition kerbs/details when transitioning into other types of pavement (e.g. when transitioning from a bound flag surfaced pavement with a PQC base slab into an unbound flag or block surfaced pavement).
 - Provide warping joints if the relative switch in grades in the slab can be kept shallower than 4° (equivalent to a switch from flat to a slope of ~1:15 or shallower). However, taper cutting any surface units over the joint is still likely to be necessary to retain required joint widths.
- v. For carriageway pavements:
- Longitudinal joints must be kept out of wheel paths. This may be an issue in narrower carriageways if a conventional crowned profile is adopted (bearing in mind that a longitudinal warping joint will normally be required to the crown line, though see next bullet).
 - Adopting a side-hung profile may provide a solution, though this is likely to create other surface drainage issues due to the need to locate all gullies down a single side of the carriageway at a closer spacing.
 - On Road Category 4 and 3B streets (Table 3) it may be acceptable to omit longitudinal warping joints if the relative switch in grade can be kept to 1.7° or less (equivalent to a joint between two pavements each with opposing ~1:70 falls). However, this may not always provide adequate drainage.
- At road junctions between multiple carriageway pavements that each have a PQC base slab, great care must be taken when determining overall joint arrangements and slab/surface gradients in order to address the various concerns of:
 - Keeping the design (and later construction works) simple.
 - Minimising the negative visual impact of the joints on surface landscaping.
 - Ensuring effective surface drainage by providing adequate surface falls to achieve positive drainage to collector inlets.
 - Minimising in-service maintenance by keeping lateral joints clear of wheel paths and ensuring correct detailing of restraints for surface units.
- iv. Avoiding disrupting the visual appearance of surface courses should be an important concern in all instance since similarly aligned joints must also be provided within the surface course and laying course. This is likely to require adjustments to laying patterns. See standard DS.130 for further information. The colour of all joint sealants used within the surface course should match that of the finish of adjoining paving units. Products must be confirmed with approving officers in advance of use.

NOTE 1: For carriageway pavements, using JRC slabs is likely to be the most appropriate option in the majority of instances since this strikes a reasonable balance between maximising joint spacing (which will typically be in the order of 20-30m as per HD 26/06) and ease of construction. Whilst CRCB/CRCR slabs can all but eliminate transverse joints (other than construction joints) they are substantially more complicated and costly to construct since they require ground beam anchors and lengthy transition bays. They are therefore highly unlikely to be practical in most applications.

NOTE 2: For footway and other non-carriageway pavements, UJC slabs are likely to be most appropriate the majority of the time, since the steel mesh reinforcement used to JRC slabs introduces practical difficulties with locating cables and underground services. Only where these can be located/relocated elsewhere is use of JRC slabs likely to be permitted.

CBGMs, other HBMs and wet lean concretes

- e. Where this paragraph applies then wet lean concrete, CBGM and other HBM base courses slabs should be transverse pre-cracked and sealed at 3-3.5m spacings in accordance with Southwark Highway Specification Clause 818. The individual width of wet lean concrete or HBM base course should be $\leq 4.75\text{m}$ in order to reduce the risk of early longitudinal cracking if used to carriageway pavements.
- f. Where this paragraph applies then wet lean concrete, CBGM and other HBM subbases should be transverse pre-cracked and sealed at 3-3.5m spacings in accordance with Southwark Highway Specification Clause 818.

2.10 Laying courses and compacting surface course units to modular pavements

2.10.1 Using laying courses for regulating purposes

- a. Laying courses to modular unit surfaced pavements should be strictly to the specified installed thickness. They should not be used as a regulating course (e.g. varied in depth in order to achieve certain gradients). Instead, the pavement construction should respond to falls by varying the gradient of the underlying base course or subbase (whilst staying within the minimum thickness requirement for these layers) whilst retaining the consistent thickness of the laying course and surface course above.
- b. The depth of a laying course may be varied by up to 10mm in order to accommodate differences in the thickness of modular units when different types of paver directly interface without any intermediary restraint (see note). However, an edge restraint must always be used between the two constructions if:
 - i. The difference in unit thickness exceeds this maximum value; or
 - ii. There is a material difference in the form of construction used to each interfacing area.

NOTE: For instance, if a 72mm thick flag is laid unbound to the Heavy Overrun Area at the front of the footway it would be acceptable to lay a 63mm thick flag unbound besides this to adjoining Light Overrun Areas away from the footway edge.

2.10.2 Compacting the surface course and laying course

- a. For modular pavements with unbound granular mixture laying courses, notwithstanding any alternative techniques for compacting surface course units permitted in BS 7533 Part 101:2021 (as specified for use elsewhere in this design standard), in all instances:
 - i. If more than one option exists for the compaction equipment and methods, only that for a vibratory plate compactor with a minimum mass of 200kg should be used.
 - ii. Neoprene plate covers should be used to prevent damage to paving units.

2.11 Considering filter and separator criteria at material interfaces

- a. Particles from within layers of different unbound granular mixtures have the potential to migrate into one another if the grading of each mixture is not compatible. The same is true at interfaces between foundations and the subgrade (particular where the latter is cohesive). This can affect stability and permeability. Designers should include within Pavement Design Statements a filter and separator compatibility assessment of all unbound pavement layers.

2.12 Level Surface and Shared Surface streets and spaces

- a. If it is agreed to allow the creation of Level Surface or Shared Surface areas that will be trafficked by motor vehicles (see standard DS.224) then all pavements (including those to notional footways) should be constructed to carriageway trafficking standards unless level 1 departure is agreed. This is because of the heightened risk of vehicle overrun and related damage to pavements. Commuted sums may also be required for maintenance of these.

2.13 Surface channels within pavements

- a. If it is necessary to introduce surface channels within sections of pavements for drainage purposes then these features should be designed as per relevant details within SSDM/TDR drawings LBS/1100/01-48.

NOTE: These details always require surface units to surface channels to be mortar bedded onto concrete or HBM footings, even if the pavements they are laid within use an unbound construction as per sections 3 or 5 of this standard. See standard DS.130 about the selection of surfacing materials for surface channels within footway pavements.

3 Precast concrete flag and natural stone slab surfaced pavements (unbound surface)



3.1 Use requirements

- a. This method of pavement design should not be used to carriageway pavements.
- b. This method of pavement design should not be used to footways (or other non-carriageway areas) in any of the circumstances given in Table 6 (see section 4.1). If using flag or slab surfacing is desired or required in these circumstances, then only bound surface design as section 4 is acceptable.

3.2 Design requirements

- a. Pavements of this type should be:
 - i. Designed in accordance with BS 7533-Part 101:2021.
 - ii. Constructed in accordance with BS 7533-Part101:2021.

- iii. Highways Agency 'Design Manual for Roads and Bridges' CD 239 revision 1, 'Footway and Cycleway Pavement Design' (March 2020).

The remainder of this section states supplementary Southwark specific requirements that may vary from the recommendations of those documents.

- b. The assumed minimum levels of daily standard axle overrun for pavement design purposes to different areas should be as section 2.4 and 2.5.
- c. For Heavy Overrun Areas, the estimated level of daily standard axle overrun should always be multiplied by a factor of 2 to account for dynamic loading and impact.
- d. If some intentional commercial vehicle trafficking is permitted by design then it may be necessary to introduce concealed transverse intermediary restraints into the pavement to prevent lateral movement of units and loss of interlock between these. It is the responsibility of designers to raise this prospect with approving officers when they foresee a risk, though approving officers have discretion to instruct introduction if they consider it appropriate. If they are required then the restraints should be designed as per relevant details from SSDM/TDR drawing LBS/1100/01-48. Spacings between intermediaries will typically be in the order of 8-14m.

| Layer | Pedestrian Only footways & cycleways | Light Vehicle footways & cycleways | Light Vehicle footways & cycleways | Heavy Vehicle footways & cycleways | Heavy Vehicle footways & cycleways |
|-----------|--------------------------------------|--|--|--|--|
| Surfacing | ≥50mm | 300x300x60mm or 400x400x65mm or 450x450x70mm | 300x300x60mm or 400x400x65mm or 450x450x70mm | 300x300x60mm or 400x400x65mm or 450x450x70mm | 300x300x60mm or 400x400x65mm or 450x450x70mm |
| Binder | 25mm laying course | 25mm laying course | 25mm laying course | 25mm laying course | 25mm laying course |
| Base | - | 70mm dense AC or CBGM A C5/6 (or stronger) | 70mm dense AC or CBGM A C5/6 (or stronger) | 90mm dense AC | 100mm CBGM A C5/6 or stronger |
| Subbase | 100mm | 200mm | 150mm | 165mm | 150mm |
| Subgrade | ≥2.5% CBR | 2.5%≥CBR≤5% | CBR> 5% | 2.5%≥CBR≤5% | CBR> 5% |

Note: Refer to the materials palette for information about materials.

Table 4a. Required layer thicknesses for unbound flagged or slabbed mixture surfaced footways.

Base course

- e. Pedestrian only pavements of this type do not require a base course and should be laid directly onto subbase foundation layers. See also section 2.8.2 about overlaying units onto existing bound pavements

Laying course

- f. The laying course should be [L-SS1] sharp sand. However:
- i. Alternative materials may be permitted by level 1 departure.
 - ii. Approving officers have discretion to instruct that alternative materials are used based upon the advice of modular unit manufacturers.
- g. The compacted thickness of the laying course should be 25-30mm.

Surface Course

- h. Precast concrete flags should:
- i. Conform to BS EN 1339:2003.
 - ii. Meet the breaking load requirements given in Table 5.
 - iii. Have an aspect ratio (length: width) of $\leq 3:2$. The length should be ≤ 900 mm.
 - iv. Be ≥ 63 mm but ≤ 90 mm thick. The difference in thickness of units used to neighbouring Heavy Overrun Areas and Light Overrun Areas (see section 2.4) within a given length of pavement should be ≤ 10 mm.
 - iv. Have tolerances/deviations on work dimensions as BS EN 1339:2003.

| Use area (see section 2.4) | Required BS EN 1339:2003 breaking load (min) |
|----------------------------|--|
| Light Overrun Area | Class 140 Minimum value 15.0 kN |
| Heavy Overrun Area | Class 140 Minimum value 21.0 kN |

NOTES

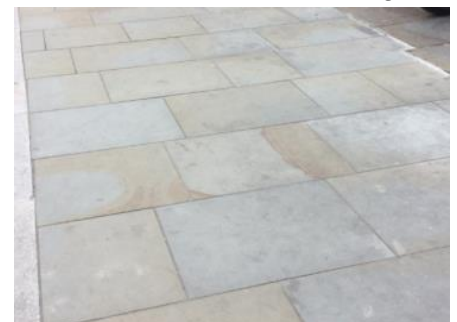
- 1) *As general guidance, the closer to square the upper face of a flag or slab is, then the greater the breaking load will be. Units with aspect ratios (width: length or vice versa) exceeding 2:3 for Light Overrun Areas or 3:4 for Heavy Overrun Areas are unlikely to achieve the necessary minimums as per this Table.*
- 2) *Part of the reason for these values is to correct for the fact that the design method in BS 7533:2021 assumes that maximum 450x450mm flags are used. These are smaller than the 600x600mm units that are typically used in Southwark (as well as other central London Boroughs). Being larger these units are likely to carry increased loads and so require a greater minimum Breaking Load for the design method to remain valid.*

Table 5. Strength requirements for precast concrete flags for unbound use to footways and other non-carriageway areas.

- i. Natural stone slab units should:
 - i. Conform to BS EN 1341:2012.
 - ii. Have a minimum breaking load of 21kN to BS EN 1341:2012 (see notes 1 and 2). Approving officers have discretion to instruct that increased breaking loads of up to 25kN are met in areas where significant and regular vehicle overrun and parking is likely (for instance, alleys in commercial areas that have narrow unprotected footways).
 - iii. Have an aspect ratio (length: width and vice versa) of $\leq 3:2$. The length should be ≤ 900 mm.
 - iv. Be ≥ 63 mm but ≤ 90 mm thick. The difference in thickness of units used to neighbouring Heavy Overrun Areas and Light Overrun Areas (see section 2.4) within a given length of pavement should be ≤ 10 mm.
 - v. Be sawn (fine textured) to all sides with square/sharp arris. In addition, if slabs are composed of:
 - Granite (or other igneous rock) then, further to sawing, their upper faces should be flamed to achieve a coarse texture.



- Yorkstone (or other sedimentary rock) then their upper faces should not be subject to any further treatment after sawing.



- vi. Have tolerances as BS EN 1341:2012 of:
 - Class 2 (P2) for plan dimensions.
 - Class 2 (D2) for diagonals.
 - Class 2 (T2) for thickness.

NOTE 1: Part of the reason for this value is to correct for the fact that the design method in BS 7533 Part 101:2021 assumes that maximum 500x500mm slabs are used. These are smaller than the 600x750-900mm units that are typically used in Southwark (as well as other central London Boroughs). Being larger these units are likely to carry increased loads and so require a greater minimum Breaking Load for the design method to remain valid.

NOTE 2: Achieving the breaking load requirement relies upon units having sufficient flexural strength and dimensions. Broadly, shallow units with a longer plan form will be able to sustain lesser breaking loads than deeper units with a squarer plan form. Providing the flexural strength (lower expected value) of a material is known then the necessary dimensions for a unit can be calculated using the formula provided in BS EN 1341:2012, Annex A. The safety factor selected from Table A.1 should be as per those for where slabs are laid on sand or aggregate.

Joints

- j. Precast concrete flag surfaces should be 2-5mm close jointed with [J-SS1] sharp sand. If there is concern that cleansing regimes may cause attrition of this material then [J-X1] stabilised jointing sand should be used instead (see note). Approving officers have discretion to instruct this.
- k. Natural stone slab surfaces should be 5-7mm jointed with [J-X1] stabilised jointing sand. Subject to level 1 departure, using [J-X2] stabilised gravel may be permitted to allow even wider joints for aesthetic purposes.

NOTE: If natural stone slab surfacing is retrofitted to existing pavements as an inlay or overlay then special attention must be paid to draining the laying course during service. This is to account for the likelihood of greater penetration of surface water (owing to the wider joints than used for precast concrete flags) and the possibility that the existing subbase may not include adequate drainage measures to disperse it. This may require additional sub drainage measures to be included in lower pavement courses. Appropriate measures will be agreed with approving officers on a case specific basis.

4 Precast concrete flag and natural stone slab surfaced pavements (bound surface)



Yorkstone flags

Granite flags

4.1 Use requirements

- a. In existing streets and spaces, other than in the limited circumstances described in ‘c’ and ‘d’ below, level 2 departure is required to use this method of pavement design. This is because of its problematic nature and related maintenance risks (see discussion in section 3 of Appendix A). It must be demonstrated to the satisfaction of Approving officers that:
 - i. That those risks are proportionate and appropriately covered by commuted sums (see ‘e’ and note below).
 - ii. why using an unbound surface flag or slab construction as section 3 is inappropriate on structural or maintenance grounds.

NOTE: Surveys to locate subsurface statutory undertakers apparatus are always required to demonstrate the level of risk.

- b. In new streets and spaces, except for in the limited circumstances described in ‘c’, level 1 departure is required to use this method of pavement design. To obtain this, proponents must demonstrate to the satisfaction of approving officers that:
 - i. They have made robust provisions to have services corridorised elsewhere and concluded suitable agreements with Statutory Undertakers to ensure this.
 - ii. The overwhelming majority of existing services will be diverted so as to be beyond the construction.
 - iii. The risk of having to excavate the construction during its service life for other reasons has been designed out or minimised to acceptable levels.
- c. As an exception from both ‘a’ and ‘b’ above, this method of pavement design may be used to footway and carriageway pavements for the features as Table 6 without requiring any form of departure. This applies to both new and existing streets and spaces. Conversely,

unbound surface design as section 3 may not be used for these features. Therefore, if using flag and slab surfacing is desired for these features then only bound surface design in accordance with this section is acceptable.

- d. As an exception from both 'a' and 'b', approving officers have discretion to instruct that this method of pavement design is used within new

or existing streets and spaces in circumstances other than those given in Table 6; but only to very limited areas of footway pavement (or other non-carriageway pavement) that are exposed to significant risk of regular commercial vehicle overrun (the majority of immediately neighbouring surfaces using unbound slab or flag constructions as section 3).

| - | Feature | Further details/requirements |
|---|--|---|
| 1 | Dropped Kerbs | This requirement applies also to associated flares if such details are used (see '4.2c.iv.') |
| 2 | Plateaus to Vehicle Crossings serving commercial premises | This requirement applies only to Occasional Use Crossings (as defined in standard DS.132) |
| 3 | Footway/Cycle Track pavements around corners at road junctions | This requirement applies to each arm within 2.5-7m back from the junction intersection (see note 2). However, it may be omitted or varied by level 1 departure. This will generally only be permitted where use of looser junction geometry is permitted (see note 3) and/or substantial kerb steps are used to the carriageway edge giving confidence that larger vehicles will not overrun footways when turning through the junction |
| 4 | Footway/Cycle Track Build Outs at the carriageway edge | Build Outs that have a Total Length measured along the carriageway of $\leq 6m$ this requirement applies to their entire length (see note 4). Build Outs that have a Total Length measured along the carriageway of $> 6m$ this requirement applies to the entire length of each Taper at each end plus the first 0.8 to 1.2m of the Body (see note 4) |
| 5 | Pavement on steep gradient | Any area of pavement with a surface gradient equal to or steeper than 1:15 |

NOTES

- 1) The extent of such areas of bound construction should be locally minimised around the feature whilst keeping a logical boundary. See '4.2c' for further information.
- 2) For each side of each arm, this distance should be measured from the projected point of intersection of the edges of the two intersecting carriageways having excluded corner radii. The actual distance used with the range should be kept to the minimum within which occasional heavy vehicle overrun might be expected (given the geometry and traffic conditions) whilst keeping a logical boundary. Approving officers have discretion to instruct the necessary distance within the range to be increased/ decreased as they consider appropriate to context.
- 3) Designers should note that 'slack' corner geometry is not normally acceptable. Designers are normally required to make junctions as tight as practical whilst accommodating those vehicles that can typically be expected to pass through them (rather than the largest vehicle possible at all times). See standard DS.106 for further information.
- 4) As per standard DS.118, Build Outs are considered to consist of Tapers (one at each end) and a Body. Tapers are the length of the feature during which the kerb line is shifting out or in. The Body is the length during which the Build Out is at its characteristic width (measured across the street). The Total Length is the sum of the Body and both Tapers.

Table 6. Circumstances where (for slab and flag surfaces) bound construction as per Section 4 is mandatory and unbound construction as Section 3 is prohibited.

Commuted sums

- e. Within existing streets and spaces, except in the limited circumstances explained in 'c-d', this method of pavement design is outside Highway Authority adoptable standards. The Highway Authority therefore requires commuted sums should it permit use via departure.

measures have been taken to reduce or remove the risk of disturbance by Statutory Undertakers (e.g. by relocating utilities elsewhere within confined corridors) then commuted sums may be reduced or removed at the discretion of approving officers. Similarly, if it is agreed to permit weak cement: sand laying course and jointing mortars to be used on the assumption of no vehicle trafficking then approving officers should not normally request commuted sums as it is much easier to lift and reuse surface units where these materials are used.

NOTE: Where it can be demonstrated that suitable

- f. Within new streets and spaces, if using this method of pavement design is approved by departure as 'b' then the need for commuted sums will be agreed with approving officers on a case specific basis. However, if 'c' or 'd' apply no commuted sums are required.

4.2 Design requirements

- a. Pavements should be:
 - i. designed in accordance with BS 7533-Part 101:2021
 - ii. constructed in accordance with BS 7533-Part 101:2021

The remainder of this section states supplementary Southwark specific requirements that may vary from the recommendations of those documents.

- b. The assumed minimum levels of daily standard axle overrun for pavement design purposes to different areas should be as section 2.4. The estimated level of daily standard axle overrun should be multiplied by a factor of 2 to account for dynamic loading/impact and channelised trafficking (even where applied to footways or Cycle Tracks).

NOTE: For this method of construction the estimated levels of trafficking will influence foundation design only since standard thicknesses are prescribed for most structural layers in the paragraphs that follow, including the base course.

- c. If it is necessary to use a bound construction to a feature located to the front of a footway or other non-carriageway area (for instance to a Dropped Kerb, Vehicle Crossing ramp or Build Out) then:
 - i. If the footway width is < 3.5m in width, for ease of construction, the bound construction should generally be extended to its entire width for that local length of pavement about the feature (unless an obvious break point exists, like a surface channel or necessary switch in falls).
 - ii. If the footway width is ≥ 3.5m in width, the extent of the bound construction should normally be limited to the width of the feature only and not extended to the entire footway width locally about the feature. For example:
 - If Build Outs are introduced, only the width of the Build Out should use a bound construction. An unbound construction

should be used for the characteristic width of the footway beside this.

- If pedestrian Dropped Kerbs are introduced at the edges of existing footways that use unbound constructions, only the ramp and flares to features (and any brief areas beyond associated rakes – see 'iv) should use a bound construction. The residual footway (including most of the plateau behind the ramp) should normally use an unbound construction.
- d. In some instances this may mean cutting slabs or flags to create a straight interface with a neighbouring area of unbound construction. However wherever possible the edge of the construction should be aligned with joints between uncut slabs or flags
- e. If the limit of the bound construction is in the vicinity of any rakes in the surface (e.g. such as those used to flares associated with ramps to Dropped Kerbs and Vehicle Crossings) then the limit of the bound construction should normally extend a single flag or slab beyond the top of the cut line to each rake. This is because the joint between the units at the rake will often be quite wide and will therefore need to be mortar filled. This will only be possible if the units to either side of the joint both use a common underlying bound construction.

Base course

- f. The base course should be [CBGM-B/R-C20]. This should be:
 - i. 200mm thick in Heavy Overrun Areas.
 - ii. 160mm thick in Light Overrun Areas.
- g. Exceptionally, approving officers may instruct that even greater thicknesses are used based upon the results of traffic evaluations (see section 2.5). See also section 6.3 of standard DS.602 about strength requirements prior to trafficking/overlay. Using a [C-PQC-C40] pavement quality concrete slab as recommended in BS 7533-Part 101:2021 requires level 1 departure (see note 2). This is only likely to be considered if extreme vehicle overrun is anticipated or if there are special structural concerns (like basements extending beneath the footway).

NOTE 1: If the base course will be trafficked during construction then these thicknesses should be increased by a further 25%.

NOTE 2: Pavement quality concrete typically requires regular movement joints and steel reinforcement to be introduced. As well as significantly increasing complexity of construction and maintenance, any steel reinforcement will interfere with cable identification tools.

Laying course

- h. Paving units should be laid on a 25mm finished thickness of [L-MH1] or [L-MHX] high performance bedding concrete. This specification is for a 30 MPA compressive strength mortar as BS 7533-4:2006, Table 4. Priming mortar slurry should always be applied to the pavement quality concrete base slab prior to application as BS 7533-4:2006 clause 5.4.4.1. [L-MHX] is a rapid setting mortar and should only be used where such qualities are specifically required.
- i. Exceptionally, if a departure is agreed permitting it to be assumed that no commercial vehicle overrun of the pavement will occur over its design life (see section 2.4) then a weaker [L-MWK12] plastic mortar may be used as an alternative to 'h' above. This specification is for a class M12 mortar to BS EN 998-2:2003 (e.g. 1:3 cement: sand mortar). Applying priming mortar slurry to the pavement quality concrete base slab is not necessary if this is used.

Surface course

NOTE 1: See section 2.2 about selecting surface unit products and laying patterns.

NOTE 2: When 'h' applies then the back faces of paving units should be primed with a fine mortar slurry prior to placing them on the laying course in accordance with BS 7533-4:2006, clause 5.4.4.2.

- j. Precast concrete flag units should:
- i. Conform with BS EN 1339:2003.
 - ii. Have a minimum thickness as BS 7533-12:2006, Table B.3. This should be:
 - ≥ 50mm in any circumstance when 'f' applies.
 - ≥ 63mm when 'i' applies.
 Greater widths may be required to avoid damaging units when they are being lifted and installed. The maximum thickness should be ≤ 100mm.
 - iii. Meet or exceed the requirements of BS 7533-12:2006 Table C.2:
 - Class 1 where used to footways (and other non-carriageway areas).
 - Class 2 where used to carriageways.
 - iv. Have tolerances/deviations on work

dimensions as BS EN 1339:2003 of:

- Class 3R for tolerances on length, width and thickness.
 - Class 3(L) for maximum difference between measurements on diagonals.
- i. Natural stone slab units should:
- i. Be to BS EN 1341:2012.
 - ii. Have a minimum thickness as BS 7533-Part 101:2021, Table 23. This should be:
 - ≥ 50mm in any circumstance when 'h' applies.
 - ≥ 63mm when 'i' applies.
 Greater thickness may be required to avoid damage during lifting for installation. The maximum thickness should be ≤ 100mm. In all instances, the difference in the thickness of the units used to neighbouring Heavy Overrun Areas and Light Overrun Areas (see section 2.4) within a given length of pavement should be ≤ 10mm
 - iii. Meet or exceed the requirements of BS 7533- Part 101:2021, Table 23.
 - Class 1 where used to footways (and other non-carriageway areas).
 - Class 2 where used to carriageways.
 - iv. Be sawn (fine textured) to all sides with square/sharp arris. In addition, if slabs are composed of:
 - Granite (or other igneous rock) then, further to sawing, their upper faces should be flamed to achieve a coarse texture.
 - Yorkstone (or other sedimentary rock) then their upper faces should not be subject to any further treatment after sawing.
 - v. Have tolerances as BS EN 1341:2012 of:
 - Class 2 (P2) for plan dimensions.
 - Class 2 (D2) for diagonals.
 - Class 2 (T2) for thickness.

NOTE 1: Achieving the breaking load requirement relies upon units having sufficient flexural strength and dimensions. Broadly, shallow units with longer plan forms will be able to sustain lesser breaking loads than deeper units with squarer plan forms. Providing the flexural strength (lower expected value) of a material is known then the necessary dimensions for a unit can be calculated using the formula provided in BS EN 1341:2012, Annex A. If [L-MH1 or [L-MHX] high performance mortar is used for the laying course as 'h', then the safety factor selected from Table A.1 should be as per those for where slabs are laid on mortar. However, if [L-MWK12] weak mortar is used for the laying

course as 'i', then the safety factor should be as per those for where slabs are used on sand or aggregate.

NOTE 2: Flaming the surface of units may not be appropriate where this method of pavement design is used to carriageway pavements as it can structurally weaken them. Fine picking may be required instead to provide necessary slip/skid resistance.

Joins

- j. Where 'h' applies, joints should be filled with [J-MH2] or [J-MHX] high performance jointing mortar to achieve a 5-8mm joint width (see note).

NOTE: The above specification is for a mortar to BS 7533-4:2006 clause 5.4.4.4. This requires the mortar to have a minimum compressive strength of 40mpa and high adhesive strength. [J-MHX] is a rapid setting mortar and should only be used where such qualities are required.

- k. Where 'i' applies, joints should be filled with [J-MWK6] weak mortar to achieve a 5-8mm joint width. This specification is for a class M6 mortar to BS EN 998-2:2003 (e.g. 1:4 cement: sand mortar).
- l. Surface course joints should be aligned to any movement joints in the concrete base slab below.

5 Precast concrete block and clay paver surfaced pavements (unbound surface)



5.1 Use Requirements

5.1.1 Conventional pavements

- a. Except if 'b' applies, conventional unbound surfaces composed of precast concrete blocks and clay pavers may be used within the trafficking limits given in section 5.2 without

requiring any form of departure approval.

- b. Conventional unbound surfaces composed of precast concrete blocks and clay pavers should not be used in any of the circumstances identified in '6.1c'. If precast concrete blocks, clay pavers or natural stone setts is desired or required in these circumstances then only bound construction as section 5.2.2 is acceptable.

Commuted sums

- c. If 'b' applies, this method of pavement design is not to Highway Authority adoptable standards. The Highway Authority therefore reserves the right to require commuted sums.

5.1.2 Pervious pavements



- a. Subject to level 1 departure, pervious block surface designs may be used where:
 - i. The street:
 - Is Road Category 4, 3B or 3A (see Table 3).
 - Has a 20mph speed limit or is part of a 20mph zone.
 - ii. The pavement in question:
 - Is part of an Inset Parking Bay (see note 1) which has an under-pavement rooting zone for street trees beneath it (see note 2).
 - Is set to falls so that water sheds positively across it to a conventional collector drainage inlet that has been sized to accommodate this.
 - Does not receive any run-off shed directly or indirectly from main carriageway running lanes.

NOTE 1: Using pervious block surfaces may also be permitted to other types of parking bay too, provided these are protected from general vehicle overrun. Examples include spaces in parking courtyards at the ends of cul-de-sacs. Exceptionally, limited use may also be permitted to footways immediately surrounding tree pits, though this will require a level 1 departure. Approving Officers will need to be satisfied that introducing block surfacing will not visually undermine the intended surfacing character for the location as per the relevant SSDM/SER/Surfacing Materials palette. In particular, where the standard footway surfacing material for the location is slabs or flags then, as per the requirements of DS.130, avoiding creating the impression of a continuous front of footway block-paved verge should be paramount.

NOTE 2: *Constructing under-pavement rooting zones will require load-bearing subbase systems to be used to support the trafficked pavement above (without compacting the soil within the zone). Examples of such systems include ‘soil vaults’ constructed from load bearing geo-cellular unit assemblies, and granular rooting zones constructed using load bearing ‘structural soil’ unbound granular mixtures. Resorting to using such systems should be avoided wherever possible by providing as much of the required soil volume to support a tree as is feasible within a large open bed. However, at space constrained sites, locating the majority of a rooting zone beneath the pavements surrounding a tree pit may be unavoidable. See standards DS.501 and DS.602 for further information.*

- b. Pervious block surface designs should not be used in circumstances other than ‘a’. However, the Highway Authority is keen to explore the wider use of full attenuation or infiltration designs for sustainable urban drainage management purposes. It may therefore permit or instruct Design Pilot dispensations to facilitate this on Road Category 4 streets within limited areas outside of main carriageway running lanes.

NOTE 1: *Notwithstanding the current general prohibition on pervious upper layer constructions, under-pavement surface water infiltration/attenuation reservoirs (which are permitted in many circumstances as standards DS.602) may still be*

created where surface water can be conveyed to them using more conventional collector drainage systems (albeit via solids/hydrocarbon separator gullies or channels to reduce the risk of clogging and restrict the majority of maintenance to easily accessible surface locations).

Commuted sums

- c. Pervious block surfaced pavements are not fully supported by adoptable standards at this stage. Consequently, they will require commuted sums. Exact sums will be advised by approving officers on a case specific basis. In general, if they are used as described in ‘a’ (with the pavement being set to falls so that much of the water passing over it will ultimately be shed to a conventional collector drainage inlet) then only nominal sums should be required in order to cover the costs of:
 - i. Periodic vacuum cleansing and re-topping of joints on an approximate 6-8 year cycle.
 - ii. Potential total replacement (or cleansing) of jointing and laying course materials (and any geo-textiles immediately beneath the laying course) on at least one occasion during the pavements serviceability design life.

5.2 Design requirements

5.2.1 Conventional pavements

- a. Pavements of this type should be:
 - i. Designed in accordance with BS 7533-Part 101:2021 or (for non-carriageway pavements only where appropriate for the predicted level of trafficking).
 - ii. Constructed in accordance with BS 7533-3:2005.
 - iii. Design is to a bespoke local specification based on Highways Agency ‘Design Manual for Roads and Bridges’ CD 239 revision 1 ‘Footway and Cycleway Pavement Design’ (March 2020).

| Layer | Pedestrian Only footways & cycleways | Pedestrian Only footways & cycleways | Light Vehicle footways & cycleways | Light Vehicle footways & cycleways | Heavy Vehicle footways & cycleways | Heavy Vehicle footways & cycleways |
|-----------|--------------------------------------|--------------------------------------|--|--|------------------------------------|------------------------------------|
| Surfacing | ≥50mm clay pavers | ≥60mm concrete blocks | ≥50mm clay pavers | ≥60mm concrete blocks | ≥50mm clay pavers | ≥60mm concrete blocks |
| Binder | 30mm laying course | 30mm laying course | 30mm laying course | 30mm laying course | 30mm laying course | 30mm laying course |
| Base | - | - | 70mm dense AC or CBGM A C5/6 (or stronger) | 70mm dense AC or CBGM A C5/6 (or stronger) | 90mm dense AC | 100mm CBGM A C5/6 or stronger |
| Subbase | 100mm | 100mm | 200mm | 150mm | 165mm | 150mm |
| Subgrade | ≥2.5% CBR | ≥2.5% CBR | 2.5%≥CBR≤5% | CBR> 5% | 2.5%≥CBR≤5% | CBR> 5% |

Note: Refer to Materials Palette for information about materials.

Table 6a. Required layer thicknesses for bituminous mixture surfaced footways.

The remainder of this section explains supplementary Southwark specific requirements that may vary from the recommendations of those documents.

Base course

- b. For footway pavements (and other non-carriageway pavements):
 - i. Base course may be omitted if this is permitted for the anticipated level of trafficking. However, a base course must always be provided to commercial Vehicle Crossings.
 - iv. If a base course is required then materials should be as Table 7. The thickness should be as BS 7533-Part 101:2021 using equivalent performance thicknesses for the selected material (see section 2.8).

Laying course

NOTE: The Highway Authority may permit or instruct Design Pilots to trial innovative bound laying course materials that differ from the requirements below. Examples include bituminous mixture based materials to protect base courses from surface water penetration and related damage.

- d. For footways and other non-carriageway areas, the laying course should comprise of [L-SS1] sharp sand.

- e. For carriageway areas, the laying course should be [L-QZ4] quartz arenite sand. However:
 - i. Using [L-SS1] sharp sand may be permitted in Road Category 4 and 3B streets (see note) by level 1 departure. It must be demonstrated that no significant regular bus or commercial vehicle turning movements will occur.
 - ii. Alternative materials may be permitted by level 1 departure. An overriding structural reason to vary must be demonstrated.
 - iii. Approving officers have discretion to instruct that alternative materials are used based upon the advice of modular unit manufacturers.
- f. The thickness of the laying course should be as recommended in either BS 7533-Part 101:2021 (based on a minimum combined 'surface plus laying course' thickness of 110mm. Therefore, if 60mm thick surface units are used, the laying course will normally be 50mm thick. By comparison, if 80mm thick surface course units are used, the laying course will normally be 30mm thick). However, if anti-shift are used then the thickness of the laying course should be 35-40mm.

| Type | Material | Footways | Carriageways (see note 1) |
|------|--|--|---|
| A | [C-NF-C15] no fines concrete, air voids content 12-16% (see note 2) | Yes, except for commercial Vehicle Crossings | No |
| B | [C-NF-C20] no fines concrete, air voids content 12-16% (see note 2) | Yes - though (A) above will normally suffice | Yes for Road Category 3A and quieter. For Road Category 2A may be used under Inset Parking Bays that are not prescribed or likely to be used for loading, but not in other carriageway locations |
| C | [B-Ba3OA] open graded asphalt concrete with 40/60 pen grade binder | Yes - though (D) below will normally suffice | Yes for Road Category 3A and quieter. For Road Category 2A may be used under Inset Parking Bays that are not prescribed or likely to be used for loading, but not in other carriageway locations |
| D | [B-Ba3OA] open graded asphalt concrete with 100/150 pen grade binder | Yes – though if exceptional overrun is predicted then approving officers have discretion to instruct that (A) or (B) is used instead | Subject to level 1 departure for Road Category 3B and quieter only No in all other instances |
| E | [Ba3C] 20 Cold Mix (see note 3-4) | Subject to level 1 departure. It must be demonstrated why using materials (A)-(D) is impractical (see note 5). | Yes for Road Category 2B Subject to level 1 departure for Road Category 3A and quieter. It must be demonstrated why using materials (B)-(C) is impractical (see note 5). No in all other circumstances |
| F | [Ba2A] dense base with 40/60 pen grade binder (see note 4) | No | Yes for Road Category 2A and busier. Subject to level 1 departure in all other circumstances. It must be demonstrated why using all other materials permitted above for the relevant Road Category is impractical (see note 5). |
| G | CBGM or HBM as Table 4 (see note 6). | Subject to level 1 departure. It must be demonstrated why using all other materials permitted above is impractical (see note 5). | Yes for Road Category 2A and busier. Subject to level 1 departure in all other circumstances. It must be demonstrated why using all other materials permitted above for the relevant Road Category is impractical (see note 5). |

NOTES

- 1) See Table 3 for details of Road Category classifications.
- 2) Though much greater void content is possible this should generally be avoided. Whilst greater air voids content increases permeability substantially, significant permeability is not the objective in this instance. Rather it is to provide just enough permeability for the base course to drain any surface water ingress satisfactorily. Increased air voids content will also reduce mechanical strength and increase the risk of laying course materials migrating. Nevertheless, greater voids values may be permitted by level 1 departure.
- 3) The grade and indirect tensile stiffness modulus of cold-mix options should be as Table 10.
- 4) Being impermeable the bituminous mixture layer may need to be perforated with 75mm diameter holes on a 750 x 750mm grid to allow downwards dispersal of any surface water ingress. Holes should typically be filled with open graded gravel that is compatible with the laying course material. Whilst [L-QZ2/6] quartz arenite sand is likely to suffice in many instances, or a fin drain or geogrid installed.
- 5) Using this material is only likely to be considered for overlay works to existing streets if existing such materials are encountered and it can be demonstrated to the satisfaction of approving officers that replacing/removing these would incur excessive cost to the Council.
- 6) As these CBGMs and HBMs are impermeable, it will be necessary to provide other drainage measures to prevent surface water that penetrates the surface from becoming trapped in the laying course.

Table 7. Permitted bound base materials for conventional modular pavements that have an unbound surface of precast concrete blocks or clay pavers.

Surface course

| Type of Unit | Location laid within | Minimum depth of unit (mm) | Maximum length of unit (mm) |
|------------------------|----------------------|--------------------------------------|--|
| Precast concrete block | Footway | 60mm | ≤ 4 times both their width and their depth |
| Precast concrete block | Carriageway | 80mm (or 100mm for anti-shift units) | ≤ 3 times both their width and their depth |
| Imitation Clay paver | Footway | 50mm | ≤ 4 times both their width and their depth. |
| Imitation Clay paver | Carriageway | 70mm | ≤ 4.15 times both their width and their depth. |

Table 8. Dimensional requirements for precast concrete blocks and clay pavers when laid unbound.

- g. The surface course should be either:
- i. Precast concrete block paving units conforming to BS EN 1338:2003.
 - ii. Clay pavers conforming to BS EN 1344:2002.
- These should meet the dimensional requirements in Table 8.
- h. If units are laid in carriageways then:
- i. If they are laid in a junction space (or other area subject to vehicle turning movements, see note) then they should be anti-shift units as permitted in the SSDM/SER/Surfacing Materials palette for the relevant SSDM/RP designation(s). They should be laid in stretcher bond perpendicular to the dominant carriageway edge as SSDM/TDR drawings LBS/1100/01-48. Using other units and laying arrangements requires level 1 departure. However, Approving Officers have discretion to instruct that other laying patterns as LBS/1100/01-48 are used if there is a legitimate structural reason for this.
 - ii. Away from areas subject to vehicle turning movements, units may be either:
 - Anti-shift units.
 - Normal units, though:
 - Only if these are permitted within the SSDM/SER/Surfacing Materials palette for the relevant SSDM/RP

designation(s).

- If the predicted level of design life trafficking meets exceeds that for Road Category 2A (see Table 1) then the Highway Authority again reserves the right to require that anti-shift units are used.

See standard DS.130 for details of acceptable laying patterns

NOTE: Examples of locations that may be subject to vehicle turning movements include junctions, turning heads and car parks.

- i. If units are laid in footways (and other non-carriageway areas) then reference should be made to standard DS.130 for details of laying pattern requirements.

Joins

- j. Units should be 2-5mm close jointed with [J-X1] stabilised granular jointing material (see note).

5.2.2 Pervious pavements

- a. Pavements of this type should be designed in accordance with BS 7533-Part 101:2021.

The remainder of this section explains supplementary Southwark specific requirements that may vary from the recommendations of those documents.

- b. The assumed minimum levels of daily standard axle overrun for pavement design purposes to different areas should be as section 2.4 (though see also section 2.5).

Base course

- c. Assuming that use of this type of pavement design is restricted to Inset Parking Bays only (and similar, see section 5.1.2) then introduction of a base course should generally be avoided. However:
 - i. See standard DS.602 about the introduction of protective [C-NF-C20] no-fines concrete upper sub-base layers to prevent disturbance to open graded unbound granular mixture lower subbase materials.
 - ii. Subject to level 1 departure, a bituminous mixture base course comprised one of the material options as per 'd' may be introduced. It must be demonstrated to the satisfaction of approving officers that

there is a significant risk of lower subbase layers becoming contaminated during construction works that cannot otherwise be prevented through reasonable phasing or site management practices. If this departure is granted then:

- Immediately prior to installing the laying course and surface course to this pavement:
 - The bituminous mixture base layers should be perforated with 75mm diameter holes on a 750 x 750mm grid to allow for downwards dispersal of any surface water ingress.
 - The holes should be filled with the same material as used for the laying course.
 - It may be possible to omit the {C-NF-C20} no-fines upper subbase layer discussed in '5.2.2c.i'. See BS 7533 Part 101:2021 for details.

d. Permitted material options and thicknesses (see note) for bituminous mixture base course are:

- i. 110mm thickness of [B-Ba2A] dense base with a 40/60 pen binder.
- ii. 130mm thickness of either:
 - [B-Ba3A] dense base with a 100/150 pen binder.
 - (If permitted as Table 10 given the nature of the street or space and its Road Category) [B-Ba3C] QVE (structural grade) cold-mix. The minimum indirect tensile stiffness modulus class should be as directed in Table 10.
- iii. (If permitted as Table 10 given the nature of the street or space and its Road Category) 190mm thickness of [B-Ba3C] SVE (storage grade) cold-mix asphalt – but only in existing streets and spaces. The minimum indirect tensile stiffness modulus class should be as directed in Table 10.

Laying course

- e. The laying course should be a 50mm thickness [L-QZ2/6] of quartz arenite sand. However:
 - i. Subject to level 1 departure other materials may be permitted. Designers must demonstrate an overriding need to vary.

- ii. Approving officers have discretion to instruct the use of alternatives based upon either the:
 - Advice of modular unit manufacturers.
 - Need to satisfy filter criteria (see 'iii).
- iii. Introducing a geo-textile separator interlayer may be necessary beneath the laying course to prevent the migration of finer particles within it through the subbase. However, this should be avoided wherever possible through consideration of filter criteria and specification of compatible materials for the two layers. See section 2.12 for further information.

Surface course

- f. The surface course should be either:
 - i. Precast concrete block paving units to BS EN 1338:2003.
 - ii. Clay pavers or BS EN 1344:2002.
 - v. These should meet the dimensional requirements in Table 8 appropriate to the location of use.
 - vi. These should allow surface water to infiltrate/ percolate via joints between the units and not through holes within the units themselves. Normally this will be achieved by using over-sized spacer nibs on the sides of the units.
 - vii. These should achieve a percolation rate $\geq 3750\text{mm/hour}$ when newly jointed and installed. The exact as-new percolation rate for the proposed units should be confirmed in a Pavement Design Statement. The design should be based on a rate equal to 10% of this in order to account for clogging over a 20 year design life.
- g. Assuming that use of this type of pavement design is restricted to Inset Parking Bays only (and similar, see section 5.1.2) then units should be laid in a stretcher bond (see drawing LBS/1100/49). This should be set perpendicular to the dominant edge of the carriageway. See also standard DS.005 about means of delineating bays through the use of surfacing materials (rather than road markings).

Joints

- h. Units should be close jointed with [J-QZ2/4] quartz arenite sand. The joint width will

depend upon the nib design of the modular units used. However:

- i. Alternative materials may be permitted by level 1 departure. Designers must demonstrate an overriding need to vary.
- ii. Approving officers have discretion to instruct alternative materials are based upon either the:
 - advice of modular unit manufacturers
 - need to satisfy filter criteria (see section 2.12).

6 Precast concrete block, clay paver or natural stone sett surfaced pavements (bound surface)

6.1 Use requirements



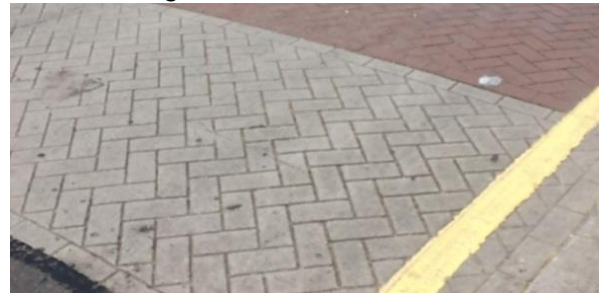
- a. In existing streets and spaces, other than in the limited circumstances described in 'c' and 'd', a level 1 departure is required to use this form of pavement design. This is because of maintenance risks. Designers are advised that departures are most likely to be granted where:
 - i. Use is confined to relatively small areas that minimise the need for movement joints and otherwise avoid design and construction complexity (see notes 4).
 - ii. The risk of future disturbance to the pavement by Statutory Undertakers.
- b. In new streets and spaces, requirements are as follows (appropriate to the type of surfacing).
 - i. Natural stone sett surfacing
 Except for in the limited circumstances described in 'c' and 'd', using this form of pavement design requires level 1 departure (see note). In general, it must be demonstrated to the satisfaction of approving officers that robust provisions have been made to have services corridorised elsewhere, with suitable



agreements reached with Statutory Undertakers to ensure this:

- Any existing services can and will be relocated beyond the construction.
- The risk of needing to excavate the construction during its service life for other reasons has been designed out or minimised to acceptable levels.

ii. Precast concrete block and clay paver surfacing



- c. Except for in the limited circumstances described in 'c' and 'd', using this form of pavement design is not permitted. An unbound constructions as section 5 should be used instead.
- c. Subject to 'e' this form of pavement design may be used in both new and existing streets and spaces for:
 - i. Ramps and plateaus to Vehicle Crossings.
 - ii. Other areas of pavement with a gradient of 1:15 or steeper.
 - iii. Footways in the immediate vicinity of cellar access hatches to pubs and bars where kegs and barrels are likely to be unloaded. Conversely, unbound surface construction as section 5 may not be used to these features.
- d. If precast concrete block, clay paver or natural stone sett surfacing is required or permitted to:
 - i. The ramps (but not plateaus) of Raised Tables in the carriageway
 - ii. Rumble Strips in the carriageway
 Then, subject to 'e', this method of pavement design should always be used. However, in

these instances those sections of pavement should be designed as per SSDM/TDR drawings.

- e. For carriageway pavements, if a natural stone sett surface course is proposed then, with the exception of ramps to Raised Tables and Rumble Strips, this method of pavement design:
 - i. May only be used to 20mph streets where either:
 - The mean average speed is ≤ 20 mph.
 - (If it is currently greater than the above) it can be demonstrated to the satisfaction of approving officers that the proposed works will succeed in reducing the mean average speed to ≤ 20 mph.
 - ii. May not be used within the controlled area (defined by zig zag markings) of any controlled Formal Crossing unless a level 1 departure is agreed. In order for this to be granted, it must be demonstrated that the setts will achieve an appropriate polished skid resistance value. Values and testing standards will be agreed on a case specific basis and should be confirmed with approving officers prior to commissioning of tests.

Commuted sums

- f. In existing streets and spaces, this method of pavement design is outside Highway Authority adoptable standards. The Highway Authority therefore reserves the right to require commuted sums. The exception to this is when 'c' or 'd' apply in which case commuted sums are not required.

6.2 Design requirements

- a. Pavements of this type should be designed and constructed in accordance with BS 7533-Part 101:2021 (see note).

NOTE: The remainder of this section states supplementary Southwark specific requirements that may vary from the recommendations of those documents.

Base course

- b. In footways (and other non-carriageway areas), the base course should be one of the rigid or semi-rigid bound materials in Table 9. The thickness of the selected material should be as BS 7533-Part 101:2021 for the assumed level of vehicle trafficking.
- c. In carriageways:
 - i. The base course should be [C-PQC-C40] pavement quality concrete.
 - ii. The thickness of the materials should be as BS 7533-Part 101:2021 for the assumed level of vehicle trafficking.
 - iii. Transitions into flexible bituminous mixture or unbound precast concrete block/natural stone sett/clay paver surfaced pavements should be detailed as per drawing LBS/1100/01-48.
 - iv. Where movement and warping joints are required as per section 2.10 then they should be detailed as per drawing LBS/1100/01-48. They must extend through to the surface of the pavement.

Laying course

- d. The laying course material and thickness should be as BS 7533-Part 101:2021. If that BS requires:
 - i. Type A bedding concrete then [L-MH3] fine bedding concrete should be used.
 - ii. Type B bedding concrete then [L-MH2] fine bedding concrete should be used.

Optionally in either instance, if a rapid setting bedding concrete is required then [L-MHX] fine bedding concrete may be used.

- e. In footways and other non-vehicle trafficked areas it may exceptionally be permitted by level 1 departure to use a [L-MWK12] weak mortar laying course if the footway will be physically protected from potential vehicle overrun of any kind using bollards or other appropriate measures.

Surface course

- f. Surface course units should be either
 - i. Precast concrete blocks to BS EN 1338:2003.
 - ii. Natural stone setts to BS EN 1342:2012.
 - iii. Imitation Clay pavers to BS EN 1344:2002.

The specification of the units should be in keeping with any recommendations for the site category given in BS 7533-Part 101:2021.

Joints

- g. Except where 'i' applies, jointing material should be as BS 7533-Part 101:2021. If that BS requires a:
 - i. 25 N/mm² mortar then [J-MH2] high performance mortar should be used.
 - ii. 40 N/mm² mortar then [J-MH3] high performance mortar should be used.

Optionally in either instance, if a rapid setting jointing mortar is required then [J-MHX] high performance jointing mortar may be used instead. Joint widths should not exceed the mid-value of the permitted joint range of BS 7533-Part 101:2021. *E.g. 10mm for a Size Category 3 sett with a design joint width range of 8-12mm.*

- h. For precast concrete block and imitation clay paver surfaces (but not natural stone sett surfaces), if the pavement is both:
 - i. Within a footway (or other non-carriageway area)
 - ii. To one of the features as '6.1c.i' or '6.1c.ii', then units should be jointed

using materials and widths required for unbound surfaces in section 5.

- i. Exceptionally, if it is permitted by level 1 departure to use a [LK12] weak mortar laying course, then it may also be permitted by the same level 1 departure to use [J-MWK6] weak mortar for joints. Joint widths should again be as permitted in 'g'.
- j. At changes in the surface gradient (including where these coincide with movement joints or edge or transition restraints) the sides of surface units should be taper cut if necessary to maintain the required joint widths.

| Type | Material | Is use of material permitted? |
|------|--|--|
| A | [C-NF-C15] no fines concrete, air voids content 12-16% (see note 1) | Yes, except to commercial Vehicle Crossings. |
| B | [C-NF-C20] no fines concrete, air voids content 12-16% (see note 1) | Yes. |
| C | [B-Ba3OA] open graded asphalt concrete with a 40/60 pen binder | Yes (though since this will require machine laying it may not always be practical given likely footway widths and other constraints). |
| D | [Ba3C] 20 Cold Mix (see notes 2 and 3) | Subject to level 1 departure. It must be demonstrated to the satisfaction of approving officers why use of any of the materials as (firstly) A-B and (secondly) C is not feasible or suitable (see note 4). |
| E | [Ba3A] dense base with either a 40/60 or 100/150 pen binder (see note 3) | Subject to level 1 departure. It must be demonstrated why use of any of the materials as (firstly) A-B and (secondly) C-D is not feasible or suitable. Use of the 40/60 pen binder option is only likely to be permitted where excessive vehicle overrun (including by construction traffic) is possible and machine-laying is practical. |
| F | CBGM or HBM as Table 4 (see notes 4 and 5) | Subject to level 1 departure. It must be demonstrated why the use of any of the materials as (firstly) A-B and (secondly) C-E is not feasible or practical. Use is only likely to be considered for overlay works to existing streets where existing such materials are encountered and replacement/ removal of these would incur excessive cost to the Council. |

NOTES

- 1) *Though much greater void content is possible this should be avoided. The objective is to provide just enough permeability for the base course to satisfactorily drain any surface water that succeeds in penetrating the layers above. Increased air voids content will also reduce mechanical strength and increase the risk of laying course materials migrating. Nevertheless, greater voids values may be permitted by level 1 departure.*
- 2) *The grade and indirect tensile stiffness modulus of cold-mix options should be as Table 10.*
- 3) *This bituminous mixture layer should be perforated with 75mm diameter holes on a 750 x 750mm grid to allow downwards dispersal of any surface water ingress. Holes should typically be filled with open graded gravel that is compatible with the laying course material. Whilst [L-QZ2/4] quartz arenite sand is likely to suffice in many instances, exact materials should be agreed with approving officers in advance on a case specific basis having considered filter criteria (see section 2.12).*
- 4) *As these concrete, CBGM and HBM materials are impermeable to water, other drainage measures to prevent surface water ingress from becoming trapped in the laying course will need to be introduced. Designers are responsible for proposing suitable measures when making departure requests. For CBGMs and HBMs, gradual development of cracks should not be relied upon.*
- 5) *See section 2.10 for general requirements and discussion about pre-cracking and provision of movement joints and reinforcement within concrete, HBM and CBGM base courses.*

Table 9. Permitted bound base course materials for conventional modular pavements to footways (and other non-carriageway areas) that have a bound surface of precast concrete blocks, natural stone setts or clay pavers.

7 Natural stone sett surfaced pavements (unbound surface)



7.1 Use requirements

- a. Using unbound surfaces composed of natural stone setts may be permitted or instructed as a Design Pilot. If no such dispensation is agreed then using this design method requires level 2 departure.

Commuted sums

- b. If it is permitted to use this design method then the Highway Authority reserves the rights to require commuted sums should the agreed specification suggest the need for a considerable degree of maintenance.

7.2 Design requirements.

- a. If it is permitted to use this design method then design and construction specifications will be agreed on a case specific basis with approving officers. Advice from specialists is likely to be required.
- b. Design and construction approaches that might be explored include:
 - Using sawn side units (to the dimensional tolerances for precast concrete blocks) with base and side faces texturised to increase friction with jointing aggregate and permit laying broadly as section 5.
 - As per section 5 but with plastic or neoprene nib spacers applied to the side of units (rather than these being texturised).
 - As per section 5 but with 'X' or 'T' shaped plastic spacers used at joints between units to prevent rotation and loss of interlock. The units themselves might be sawn to all sides or texturised as section 5.
 - Using larger cropped side/base units (to

tight dimensional tolerances) laid by expert masons broadly to the method provided in BS 7533-Part 101:2021 (only using stabilised granular jointing materials like [J-X1] or [J-X2]). Correctly sorting and selecting units to maintain consistent joint widths and adhering to proper compaction procedures (including re-topping of joints and further compaction after initial trafficking) are likely to be crucial. Using intermediary restraints is also likely to be necessary.

- Using smaller cube units laid as per section 3, only in arc patterns that provide greater interlock.

8 Bituminous mixture surfaced carriageway pavements



8.1 Use requirements

8.1.1 Flexible pavements (e.g. with bituminous mixture base course)

- a. This is the preferred method of pavement design for carriageways and commercial Vehicle Crossings and should be used in all circumstances.

8.1.2 Flexible-Composite pavements (e.g. with HBM base course)

- a. In existing streets and spaces, using Flexible-Composite design is restricted to minor maintenance and repair works to existing such pavements. However, if the extent of that repair or reinstatement is significant then replacing the pavement with a Flexible design as section 8.1.1 should be evaluated.
- b. In new streets and spaces, Flexible-Composite pavement design should not be used. Flexible pavement design as section 8.1.1 should be used instead.

8.1.3 Rigid-Composite design (e.g. pavement quality concrete CRCB base course with minimum 100mm bituminous mixture overlay)

- a. In existing streets and spaces using Rigid-Composite design may be permitted by level 1 departure for minor maintenance and repair/reinstate works to existing such pavements. However, if the extent of that repair or reinstatement is significant then replacing the pavement with a Flexible design as section 8.1.1 should be evaluated.
- b. In new streets and spaces Rigid-Composite design should not be used to carriageway pavements. Flexible pavement design as section 8.1.1 should be used instead.

Commuted sums

- c. Where using this method of design is exceptionally permitted for purposes other than minor maintenance and reinstatement of existing such pavements, then the Highway Authority shall require commuted sums.

8.1.4 Rigid design (e.g. pavement quality concrete CRCP with or without 30mm bituminous mixture overlay)

- a. In existing streets and spaces, using Rigid pavement design may be permitted by level 1 departure for minor maintenance and repair/reinstate works to existing such pavements (see note). However, if the extent of that repair or reinstatement is significant then replacing the pavement with a Flexible design as section 8.1.1 should be evaluated.

NOTE: One relatively frequent instance where existing rigid pavements are likely to be encountered is at Inset Bays for buses (bus lay-bys). Rigid concrete will frequently have been used as the restricted working space makes laying and compacting stiff bituminous mixtures impractical.

- b. In new streets and spaces using Rigid pavement design is not permitted. This applies whether or not an asphalt surface overlay is provided.

Commuted sums

- c. Rigid pavement design is not to Highway Authority adoptable standards. If using this method is exceptionally permitted then commuted sums are required.

8.2 Design requirements

8.2.1 Design methodology (including determination of layer thicknesses)

- a. Except where otherwise stated in this design standard, pavement design and layer thickness selection should be carried out in accordance with Highways Agency 'Design Manual for Roads and Bridges' HD 26. Either HD 26/01 or the newer HD 26/06 may be used (see note 1). However:
 - i. It must be expressly stated in Pavement Design Statements which version of HD 26 is being used for a given section of carriageway pavement.
 - ii. If HD 26/01 is used then standard asphalt materials included in nomograph design lines will need correcting owing to changes in the stiffness of surface course materials in recent specifications. See note 2 for further information.
 - iii. If HD 26/06 is used then designs should assume a Class 2 Foundation.
 - iv. For the purposes of establishing the minimum overall thickness of asphalt (e.g. base, binder and surface course), if HD 26/01 is being used this may be reduced beneath the standard 200mm thickness indicated in nomographs (see note 3) by downwards extrapolation using the underpinning information upon which these are based (see note 4). However, the absolute minimum thickness may not be less than 110mm or that dictated for laying purposes for any proposed material. Extrapolation calculations should be included in Pavement Design Statements (see section 2.1).

NOTE 1: Though HD 26/01 is no longer available from the Highways Agency website. The continued use of the superseded HD 26/01 reflects guidance from ADEPT.

NOTE 2: The thicknesses for the materials included in figure 2.2 of HD 26/01 (one of the two key nomographs) assume certain minimum design stiffness values for the overlaying surface course materials. However, recent editions of the SHW have revised these surface course material stiffness values downwards. These same changes are reflected in Southwark Highway Specification clauses. Consequently, in order to use the nomographs in figure 2.2 with confidence it is necessary to use corrected underpinning minimum

stiffness values for binder and base course. These should be as follows (derived from HD 26/06, para 4.13): DBM/HRA – $S_{min}1100$, DBM50 – $S_{min}1800$, HDM – $S_{min}2500$, HMB35 – $S_{min}5200$.

NOTE 3: DMRB HD 26 is aimed primarily at motorways and other trunk roads. Appropriate to these conditions they assume a minimum overall thickness of asphalt (e.g. base, binder and surface course) of 200mm. In HD26/01, nomograph lines artificially flat-line for all levels of trafficking beneath this thickness. Depending upon the material stiffness this typically occurs between 1.7 and 4.4msa. Many roads in Southwark carry significantly less traffic than these associated minimum values for trunk roads. Consequently the standardised use of a 200mm minimum thickness represents a potential wasteful use of resources. Application of the underpinning information to extrapolate further downwards allows lesser thicknesses to be used at lower levels of traffic, thus making more economic and sustainable use of resources.

NOTE 4: This information can be found in 'TRL report LR1132 (Powell W.D et al., 1984)' for HD26/01, 'TRL Report TRL 615 (Nunn M)' for HD 26/06 and associated later research references in both version of the HD.

- b. When using HD 26 as 'a' to design a pavement then:
 - i. The assumed serviceability design life for the pavement should be 20 years as section 2.6.
 - ii. The assumed level of cumulative serviceability design life standard axle trafficking as section 2.4 and Table 3.

8.2.2 Milling, transportation, laying and compaction

- a. All bituminous mixture pavement materials should be transported, laid and compacted in accordance with BS 594987. Note in particular the following requirements of that document.
 - i. Tack coats and/or bond coats should be provided between all courses and to interfaces with edge restraints.
 - ii. Thickness limitations for laying purposes are specified for different materials. These may constrain choices of materials, require a greater thickness of

material to be provided than is needed for structural purposes, or require materials to be installed in more than one layer. Note also that only nominal thicknesses should be used.

- b. When milling existing bituminous mixture courses either:
 - i. A complete layer should be removed plus a further 5mm of the next layer.
 - ii. Milling should not take place within 15mm of a layer interface.

8.2.3 Joints and Transition details

- a. At transitions between different types of bituminous mixture carriageway pavement (e.g. Flexible, Flexible Composite, Rigid or Rigid-Composite) transition details should be used as per Highways Agency' MCHW Volume 3 details.
- b. Where lengths of new and existing bituminous mixture pavement meet, the new section should be benched into the existing as Figure 2.2 in Highways Agency 'Design Manual for Roads and Bridges' DMRB HD 27/04.

8.2.4 General requirements for base course

- a. All Polymer Modified Binders (PMB) used in bituminous mixture should be Highway Authorities' Product Approval Scheme (HAPAS) approved and certified.
- b. Where cold-mix bituminous mixture options are permitted for use then the grade and indirect tensile stiffness modulus should be as permitted in Table 10.
- c. In new streets and spaces all bituminous base course mixtures should be subject to Saturated Ageing Tensile (SATs) testing to determine the moisture sensitivity of the mixture and binder adhesion to the aggregate. Refer to the Southwark Highway Specification for further details of testing procedures.

| Cold mix grade (see note 1) | Is use permitted in existing street for road category (see Table 3) 3 or 4 | Is use permitted in existing street for road category (see Table 3) 1 or 2 | Is use permitted in new street for road category (see Table 3) 3 or 4 | Is use permitted in new street for road category (see Table 3) 1 or 2 |
|-----------------------------|--|--|---|---|
| SVE storage grade | Yes | No | Yes | No |
| QVE structural grade | Without departure | No | No | No |
| QVE structural grade | Subject to level 1 departure (see note 2) | Yes | No | Yes |
| QH/SH | No | No | No | No |

NOTES

- 1) The indirect tensile stiffness modulus (ITSM) as Southwark Highway Specification Clause 948, Table 9/14 of either grade of cold mix shall be either Class B3 or B4. For the purposes of design nomographs in HD 26/01 and HD 26/06, Class B4 QVE material may be used to an equivalent thickness to DBM 50 (see also note 2 to '8.2.1a'). Class B3 QVE material will need to be used at an appreciably greater thickness. Class B4 SVE material can be used assuming a 0.75 equivalence factor compared with DBM/HRA (e.g. laid approximately a third thicker). Class B3 SVE material will again need to be used at a significantly increased thickness.
- 2) Use will normally only be permitted owing to the need for a faster setting mixture to avoid delays to traffic during works in critical situations.

Table 10. Requirements for cold mix base course materials.

8.2.5 General requirements for binder course

- a. When constructing new Flexible and Flexible-Composite pavements:
 - i. A separate binder course should be provided unless a Hot Rolled Asphalt (HRA) surface course is used wherein it may optionally be omitted if permitted as HD 26/01.
 - ii. If a Thin Surface Course System (TSCS) surface course is used then a Stone Mastic Asphalt (SMA) binder course should be used. This may be substituted for an HRA binder by level 1 departure (see note 1).
 - iii. If the surface course is not a TSCS then the binder course may be either an SMA or an HRA.

- iv. As HD 37/06, the nominal thickness of binder course should be $\geq 50\text{mm}$ for all mixtures other than SMA which may be $\geq 30\text{mm}$ (see note 2).

NOTE 1: Use of SMA binder course is important because of the pervious nature of TSCS. The SMA and bond coat seal the base course, preventing the damaging ingress of air and moisture. Use of HRA as an alternative (which is typically more expensive) may be appropriate where the risk of surface water ingress is significant (e.g. in areas prone to flooding).

NOTE 2: The attention of designers is drawn to the fact that HD 26/01 nomographs assume that the stiffness of the binder course is at least equal to that of the base course. If the binder course is less stiff then its thickness will need to be increased slightly using the underlying formulas (see note 2 to '8.2.1a') to provide equivalent performance. However, for the purposes of this design standard, where the stiffness is greater than that of the base course then no reduction in thickness may be made.

- b. When rehabilitating existing Flexible or Flexible-Composite carriageway pavements, a separate binder course should be provided wherever possible. Omitting the binder course requires level 1 departure. It must be demonstrated both that:
 - i. Omitting it will provide greater long term value for money without compromising structural integrity.
 - ii. The level tolerances necessary for laying the surface course can be achieved using the base course mixture that is proposed.
 However, if TSCS surfacing is used then, because of the risk of air and surface water penetration, omitting binder courses is only acceptable if:
 - iii. The base course is an HRA, and
 - iv. It can be demonstrated through site investigations and surveys that the existing surface is sound and reasonable strong – that is exhibiting a deflection under wheel load of not more than 0.65mm and having a reasonable surface profile so that the TSCS thickness is always within the permitted (see note).

NOTE: If the carriageway has a pronounced camber then planning works should be undertaken to correct this and so facilitate laying of the TSCS by pavers to accurate thicknesses.

- c. If an SMA binder course is used on a street with a Road Category of 3B or busier (see Table 3) either:
 - i. At or in the vicinity of a bus cage.
 - ii. In any other circumstances where it will be trafficked by heavy, slow moving traffic (e.g. a narrow slow moving high street or Classified Road).

Then it must achieve deformation resistance equivalent to half the value permitted for Wheel Track 2 as PD 6691, Table D.2 when tested at 60° C (e.g. max rut rate of 2.5mm/hour and max rut depth of 3.5mm).

8.2.6 General requirements for surface

- a. Surface course materials should achieve an overall neutral to dark grey appearance that endures for the majority of the design life of the pavement. Surfaces should not contain exposed coloured binder, aggregate or surface chippings.
- b. If they are not generic materials to BS EN 13108 then all materials should be Highway Authorities' Product Approval Scheme (HAPAS) approved and certified.
- c. See section 2.8 about the potential use of slurry surfacing, micro surfacing and micro asphalt. See standard DS.107 about the use of High Friction Surfacing. Other surface dressings (e.g. resin bonded aggregate) should not be used.
- d. The minimum average surface macro-texture depth should be to SHW clause 921 and Table 9/3 'Road Type: Lower speed roads'. Actual values should be as close to the minimums as possible and should not exceed these by more than 0.2. Use of elevated macro-texture depths is generally unnecessary for lower speed roads. Where used in areas with heavy turning

movements this may result in loss of surface aggregate. See also additional requirements for TSCS after two years of trafficking.

- e. Minimum Polished Stone Values (PSV) to BS EN 1097-8:2000 for bituminous mixture surfaced carriageways in new streets and spaces with a 20mph speed limit or which form part of a 20mph zone (other than those forming part of the principal road network) should be as Table 11. If existing 20mph signed carriageways are resurfaced then PSV values should be brought into accordance with these requirements. Notwithstanding these minimums, necessary skid resistance values should always be reviewed by designers and considered in Pavement Design Statements. Where the need for increased values can be demonstrated or is apparent then this may be permitted by level 1 departure else instructed by approving officers (see note 1). For minimum carriageway surface PSV values for 30mph streets and streets forming part of the Principal Road Network, see standard DS.107. Also see standard DS.107 about using high friction surfaces with PSVs of 70+ (and alternatives) in locations with a history of incidents.

NOTE 1: Where there is a considerable risk of skidding then, in general, introducing speed reduction measures is preferable to increasing aggregate PSV values.

- f. Maximum Aggregate Abrasion Values (AAV) to BS EN 1097-8:2000 should be as Highways Agency DMRB HD 36/06. The same levels of AAV and PSV should be used on different traffic lanes across the carriageway except that - where aggregates are used for demarcation - a maximum difference of 5 PSV points may be permitted by level 1 departure.

| Site Category | Minimum PSV value for a Two-way or one-way street with contra-flow with a 7am-7pm 12 hour average weekday flow (see note 1) ≤2250 | Minimum PSV value for a Two-way or one-way street with contra-flow with a 7am-7pm 12 hour average weekday flow (see note 1) >2250 | Minimum PSV value for a One-way street without a contra-flow with a 7am-7pm 12 hour average weekday flow (see note 1) ≤1000 | Minimum PSV value for a One-way street without a contra-flow with a 7am-7pm 12 hour average weekday flow (see note 1) >1000 |
|---|---|---|---|---|
| Within 23m of any Controlled Crossing or Signalised Junction | 65 | 65 | 65 | 65 |
| Within 40m of any pedestrian entrance used by pupils of a school, nursery or similar facility | 60 | 65 | 60 | 65 |
| Any carriageway with a longitudinal gradient >10% | 60 | 65 | 60 | 65 |
| Carriageways with a bend <25m radius | 60 | 65 | 60 | 60 |
| All other instances | 60 | 60 | 60 | 60 |

NOTES

- 1) This value is the sum of all PCUs using the street in all lanes over the period. In existing streets this should be based on the average value across surveys on a number of different days.
- 2) Where a Raised Table spans the entire junction space or any approach and the ramp face for this is both within 15m of the junction space or giveway line and has a gradient equal to or steeper than 1:12 then the PSV value may be reduced by 5 down to a minimum of 55.

Table 11. PSV values for bituminous mixture surfaced carriageways on streets with a 20mph speed limit

Thin Surface Course Systems (TSCS)

- g. If use of a TSCS surface is permitted then:
- i. Surface applied grit (SAG) must be applied to the surface and rolled in before final compaction if the pavement:
 - Has a gradient steeper than 5%
 - Is located within the following distance of the limits of a controlled Formal Crossing or Signalised Junction:
 - 25m if it is a 20mph street.
 - 33m if it is a 30mph street.
 - ii. The TCSC should be a Highway Authorities' Product Approval Scheme (HAPAS) certified product. Generic Stone Mastic Asphalts should not be used.
 - iii. The PSV of course and fine aggregate should always be the same.
 - iv. Macrotexture should be to HAPAS Level 1 unless agreed otherwise. The guarantee period for this must be 5 years.
 - v. The TCSC should have a toughness of ≥ 30 N/mm² as measured by the tensile bending test at 0°C (see note 2).
 - vi. If it is used on a street with a Road Category of 3B or busier (see Table 3)

either:

- At or in the vicinity of a bus cage.
- In any other circumstances where it will be trafficked by heavy, slow moving traffic (e.g. a narrow slow moving high street or Classified Road) then the deformation resistance (as reported on the HAPAS certificate) should be equivalent to half the value permitted for Wheel Track 2 as PD 6691 Table D.2 when tested at 60° C (e.g. max rut rate of 2.5mm/hour and max rut depth of 3.5mm). Approving officers have discretion to require even greater deformation resistance in extreme circumstances.

- viii. With respect to aggregate size, notwithstanding the aggregate sizes permitted as Appendix B, Pavement Design Statements (see section 2.1) should always expressly evaluate the appropriate aggregate size for the site given expected trafficking conditions (see note 3). This should make reference to the table in section 4.7.1 of the 'Londonwide Asphalt Specification, 3rd Edition (Road Consultants, 2013)'.

Greater or lesser aggregate sizes than allowed as Table 13, Table 14 and Table 15 of Appendix B may be permitted by level 1 departure or instructed by approving officers on the basis of that evaluation.

- ix. It is of utmost importance that a consistent thickness surface course is achieved. To aid this, where existing barrelled roads are to be overlaid with a TCSC then the existing receiving pavement should be planed and regulating materials used to create a new planar cross-fall profile (usually with a central crown).

Hot Rolled Asphalt surfacing (HRA)

- h. If it is permitted to an HRA surface then:
 - i. Pre-coated chippings (PCC) should be provided to cover the surface. The rate of spread should be as BS 594987, clause 7.2. The size of chippings should be selected from one of the following to obtain the required PSV, AAV and macro texture (see note).
 - 6.3/10, Gc85/20 (*generally preferable for visual reasons*).
 - 8/14, Gc85/15.
 - 14/20, Gc85/20.
 - ii. The binder for the PCC should be as BS EN 13108-4:2006 (see in particular clause C.3).

8.2.7 Selecting materials for different types of pavement

Flexible pavements (e.g. with bituminous mixture base course)

- a. Materials for base, binder and surface course layers should be selected from Appendix B, appropriate to the NRSWA Road Category and environment. See section 8.2.1 about determining layer thicknesses for the various courses.
- b. See standard DS.602 for requirements about thickness and materials for subbase and (where required) capping layer.

All other types of pavement

- c. In exceptional circumstances where it is permitted to use Flexible-Composite, Rigid or Rigid- Composite pavement designs, requirements will be agreed on a case specific basis with approving officers.

9 Bituminous mixture surfaced footway and cycleway pavements



9.1 Use requirements

- a. Bituminous mixture surfaces may only be used if either:
 - i. It is identified as an acceptable material in the SSDM surfacing palette(s) for the relevant SSDM/RP designation(s).
 - ii. It is instructed by approving officers around mature trees.
- b. This design method may not be used to bituminous mixture surfaced commercial Vehicle Crossings. These should be design using the method in section 8 instead.

Commuted sums

- c. Except where permitted or instructed as 'a', this method of design is outside Highway Authority adoptable standards. Commuted sums will be required owing to under-standard design.

9.2 Design requirements

- a. Design is to a bespoke local specification based on Highways Agency 'Design Manual for Roads and Bridges' CD 239 revision 1, 'Footway and Cycleway Pavement Design' (March 2020).
- b. When milling existing bituminous mixture base courses either:
 - i. A complete layer should be removed plus a further 5mm of the next layer.
 - ii. Milling should not take place within a 15mm thickness of a layer interface.
- c. All bituminous mixture pavement materials should be transported, laid and compacted in accordance with BS 594987:2010. Note in

particular the following requirements of that document.

- i. Tack coats and/or bond coats should be provided between all courses and to interfaces with edge restraints and iron work.
- ii. Thickness limitations for laying purposes are specified for different materials. These may constrain choices of materials, require a greater thickness of material than required for structural purposes to be provided to meet minimum requirements, or require materials to be installed in more than one layer. Only nominal thicknesses should be used. Minimum thicknesses are to allow for variation on site and should not be used for design purposes.

| Layer | Ped. Only footways & cycle ways | Light vehicle footways & cycle ways | Heavy vehicle footways & cycle ways | Heavy vehicle footways & cycle ways |
|-----------|---------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| Surfacing | 20mm | 20mm | 25mm | 25mm |
| Binder | 50mm | 50mm | - | - |
| Base | - | - | 90mm | dense AC |
| Subbase | 100mm | 225mm | 320 mm | 210 mm |
| Sub-grade | ≥2.5% CBR | ≥2.5% CBR | 2.5% ≥CBR≥4 % | CBR >4% |

NOTES:

Refer to Material palette for information about materials.

Table 11a. Required layer thicknesses for bituminous mixture surfaced footways.

Combined base and binder course

- d. Materials and thicknesses should be as Table 12 for the relevant circumstance and location.

Surface course

- e. [B-SFA] should be used to a 30mm thickness.

NOTE: Decorative surface dressings may not be used.

- f. Surface course materials should achieve an overall neutral to dark grey appearance that endures for the majority of the design life of the pavement.

- g. See section 2.8 about the potential use of slurry surfacing, micro-surfacing and micro-asphalt surfaces. Other surface dressings (e.g. resin bonded aggregate) should not be used.

| Material | Is material permitted in new street of space | Is material permitted in existing street of space | Required thickness (mm) in Heavy Overrun Area | Required thickness (mm) in Light Overrun Area |
|--|--|---|---|---|
| [B-BiFC] cold mix asphalt QVE (structural grade), ITSM Class B4 (see note 1) | No | Yes | 80 | 50 |
| [B-BiFC] cold mix asphalt SVE (storage grade), ITSM Class B4 (see note 1) | Yes | Yes | 120 | 70 |
| [B-BiFA] dense asphalt concrete | No | Subject to level 1 departure | 100 | 60 |

NOTES

- 1) Refer to Table 10 for further information about cold-mix asphalts, including indirect tensile stiffness modulus (ITSM) classes. Whilst other lower classes of ITSM may also be used, the thickness values in this Table will then need to be substantially increased to provide equivalent performance.

Table 12. Required thickness for base course materials to bituminous mixture surfaced footways.

10 Self binding gravel surfacing to existing pavements disturbed by tree roots



10.1 Discussion

- a. See standard DS.501 for a full discussion about using self-binding gravel surfaces around existing mature street trees.
- b. The permeability of different types of self-binding gravel products varies significantly and this will have a major impact on the suitable design specification – particularly where the surface is being applied to an existing pavement construction.

10.2 Use requirements



- a. Self-binding gravel surfaces should only be used in existing footways (or other non-carriageway pavements) and only then to areas around mature trees that have been disturbed by root heave.

NOTE: Using self-binding gravel in other circumstances may be appropriate where 'orchard' style spaces are proposed that would involve a significant grouping of trees in close proximity to one another. However, these must be protected from vehicle overrun and should also not be subject to heavy pedestrian traffic.

- b. See standard DS.501 about using self-binding gravel to provide surface infill to new pavement openings for trees.
- c. Any self-binding gravel surfaced areas around trees should be inspected twice annually for deflection, rutting or de-compaction of the surface as this is likely to result in drainage

issues. Inspections should be timed to occur during wet months in the spring and winter when ponding is likely to be most critical. The surface should be re-rolled at least once per year to maintain compaction of the surface. A greater frequency of rolling may be required where pavements are little trafficked. At this time, any weeds or other vegetation evident should be removed from the pavement and soft spots or ruts excavated and re-laid to design levels. If ponding is evident upon inspection at other times of the year (or ruts that may result in this are identified) further rolling and resurfacing should be undertaken.

10.3 Design requirements

Base course

- a. Pavements of this type do not require a base course and should be laid directly onto subbase foundation layers.

Surface course

- b. The surface course should be a minimum 50mm compacted thickness of [BG-SB1] self-binding- gravel. Within busier *Town Centre – Zone A* and *World Centre* SSDM/RP Specification Areas, using a harder wearing [BG-R1] or [BG-R2] resin bound gravel surface may be permitted as an alternative by level 1 departure or instructed by approving officers (see notes). It must be demonstrated or thought that pedestrian traffic will be heavy and therefore risk damaging vulnerable roots.

*NOTE 1: See standard DS.208 for confirmation of the extents of *Town Centre – Zone A*.*

NOTE 2: Resin bound gravel is a far from ideal surface. In addition to being very expensive it isn't flexible enough to move with on-going root heave and cracks quickly instead. However, it is a much harder wearing surface than self-binding-gravel and this quality may outweigh these negatives in heavily trafficked areas.

- c. Special care must be taken to lay the surface course (and grade the top of the underlying subbase) to falls towards a drainage outlet as the structural integrity of the surface will be undermined if it becomes saturated. Introducing un-filled weep joints between kerb units at the edge of carriageway may be appropriate if other solutions cannot be identified. All other requirements as standards DS.601, DS.602 and DS.603 continue to apply.

Appendix A - Background discussion

1 General introduction to pavements

1.1 The function of pavements

- a. In structural terms the main role of a pavement is to provide a stable, level surface for people, vehicles and other loads to move across or rest on. This is achieved by using a construction that can distribute any loads to the extent that they are within the tolerances that the natural ground (subgrade) below is able to support without distorting. In the case of modular unit surfaced pavements (e.g. slabs, flags, blocks or setts) the construction must also provide enough support to prevent the surface units from breaking when overrun by vehicles or when other loads are applied.

1.2 Basic design considerations

- a. Very broadly, there are two main structural approaches used when designing pavements, though combinations (composite) versions of both are common in practice.
 - i. Rigid construction - This aims to make the upper layers as stiff as possible so that they won't bow and so that forces are transmitted to the underlying foundations layers. Typically (though not necessarily) this is achieved by binding all the various pavement upper layers and the materials in these to one another to create a stiff composite plate that can distribute loads over a very wide area.
 - ii. Flexible construction - This allows for a greater degree of movement in the upper layers. The various materials making up the pavement layers are left unbound else only lightly bound so as to be less stiff than those used in rigid constructions. Because of this, imposed loads are not distributed as widely and can pass down through the entire depth of the pavement through grain to grain contact between the aggregates or units making up the layers.
- b. The materials used for the layers beneath the surface are typically carefully graded aggregate mixtures. These aggregates may be left unbound or can be bound together with cement, bitumen or other binders.

Increasingly special modular plastic crates (geo-cellular units) are also used to foundation layers. Either way, the stiffest materials tend to be used closer to the surface where loads are more significant. As loads are distributed by the layers and reduced, successively weaker and cheaper materials can be used with depth. This helps make efficient use of resources. Surface layers can be made up of bituminous mixtures (e.g. blacktop) or other similar mixtures that can be rolled out, or modular paving units (e.g. flags, slabs, blocks, setts or pavers). Where modular paving units are used these might be bound to one another and the layer immediately beneath using mortar (rigid construction) else left unbound on a sand or gravel laying course and jointed with similar material (flexible construction). Occasionally, high strength in-situ cast concrete might also be used for surface courses, though this is uncommon in London.

- c. In all instances effective compaction of the materials making up the various layers is important when they are being installed in order to minimise future movement that could undermine support for other layers. Preventing water getting into the pavement else carefully draining this from within to prevent saturation and gradual washing out of materials (and potential related frost and pore pressure damage that might follow) is also important to long term performance. It might seem that this would be more of a concern for unbound construction. However, it is also very important for bound constructions where water may seep in through tiny cracks and often has no means of escape. Since water expands when it freezes this can result in considerable damage. Again, it might seem like this might be more of a concern in colder countries and climates (such as Scandinavia or the Alps). However in reality the climate in the UK can be far more challenging since temperatures often fluctuate around freezing during winter months and so water can freeze and thaw often within a single night.

1.3 New demands on pavements

- a. Increasingly environmental concerns are leading to new approaches to pavement design that allow surface water to permeate constructions. This can help recharge ground water, slow down water surges in drainage

infrastructure after heavy rainfall events and control water quality closer to source. Another new approach allows trees to grow more successfully under paved trafficked surfaces. However, both approaches rely on specialist materials and designs that are very different to those used historically. These are not easily retrofitted to existing pavements and are much more complicated than simply replacing the surface paving units with ‘pervious’ blocks. Broadly, the pavement must be redesigned to the entire depth of the construction.

1.4 Empirical vs. analytical design approaches

- a. Sometimes for carriageway pavements on very busy roads (e.g. trunk roads and motorways) an ‘analytical’ approach to design is taken. This involves assessing the appropriate construction from first theoretical engineering principles using mathematical models. Significant trial lengths of the resulting proposed design are then constructed and tested to see if they perform structurally as was theoretically predicted.
- b. However, analytical design is seldom cost effective for less busy roads or footways where the level of trafficking, the loads imposed, and the consequences of closures are far less onerous (not to mention the impracticality of constructing significant trial lengths for testing in urban areas). Instead, design traditionally takes an ‘empirical’ approach following national or international standards. Broadly, these recommend summary constructions for different loading categories based on many years of live experience and testing of different materials in different combinations – so saving engineers and designers the time and effort of developing and testing bespoke constructions. An analytical approach is only likely to be used where:
 - i. Special engineering constraints exist (for instance, where a basement exists beneath a pavement or where it is proposed to include geo-cellular units or other similar structures within the pavement construction).
 - ii. There is a wish to include new and unfamiliar materials about which little is currently known.

1.5 Wider design considerations

- a. Pavements in London are subjected to regular disturbance by works carried out by Statutory Undertakers (public utility companies). They have a statutory right to construct, lay and maintain pipes, sewers, cables, ducts and associated chambers (e.g. manholes) within any Highway. Highway Authorities’ have only very loose powers to control this. The age of central London streets (many of which are quite narrow) and the much greater density of buildings and properties needing connections mean that there are likely to be many utilities in streets. Rigid pavements with bound surface courses are more likely to be damaged or visually scarred by such works than are flexible pavements with unbound surfaces. There is also the concern that utility companies may not accurately reinstall layers deep in the pavement and that unseen imperfections in these will ‘reflect’ through to the surface over time leading to eventual failure.
- b. Footways are also often subject to greater vehicle overrun than in other parts of the country. This influences choices about the form and robustness of construction. Cost must also be born in mind. Though the whole life costs for longer lived rigid pavements may be lower, initial construction costs may be higher, an important consideration in times of stretched budgets. In addition, the assumptions that rigid constructions provide ‘longer life’ may not always apply due to the gradual wear and damage caused by frequent interventions made by Statutory Undertakers. Wherever underground services are present these tend to enforce a finite life of around 20 years for almost all construction types.
- c. Finally - except where entirely new streets are being created - pavement design in London (or indeed elsewhere) seldom involves constructing or reconstructing the whole depth of the pavement. This would be very expensive indeed, not least because of the impact upon the economy from the lengthy road closures required and the sheer number of utilities that may need to be moved or worked around. This explains why introducing special pavement constructions that allow surface water to be stored or stored or infiltrate or which provide rooting zones for trees is so difficult in existing streets. More likely the

pavement upper layers will be only partly replaced (sometimes by recycling the materials in place) else - for certain forms of construction) - new upper layers will be installed on top of the existing as 'overlays', so gradually increasing the level of the street. In either instance, the structural performance of the retained existing pavement (and all the various materials within this) are factored into the new design, standing in for the lower levels and prescribed materials that would be required were a full new pavement constructed. Reusing parts of the existing pavement in this way helps reduce the carbon footprint of construction works. Consequently, whilst design standards such as this one give fairly neat design specifications for pavements (with different layers of specified thicknesses and materials) the reality of most existing pavements in London is much messier – each being composed of a jumble of successive overlays of various historic materials. This will be further complicated by reinstatement works by Statutory Undertakers who may use different backfill materials when they reinstate over their utilities. The only way for designers to know what they are dealing is to carry out intrusive investigations, and even then the construction may vary considerably within a couple of metres.

2 Precast concrete and natural stone flag and slab surfaced pavements (unbound surface)

- a. Slabs and flags can be laid unbound on a sand or crushed rock laying course directly over foundation layers if they have an appropriate breaking load and levels of heavy vehicle overrun are relatively low. No base course is required.
- b. The bending strength of units (and their ultimate breaking load) is influenced by various factors. The smaller and squarer the unit is (relative to thickness) then the higher its strength will be. The properties of the material used also play a part. Units don't need to be capable of holding all the weight of vehicles and other loads alone as they will be supported by the underlying foundation layers (providing these are properly installed). However, this form of construction is only appropriate for lightly trafficked footways. It will only be appropriate for carriageways and other heavily trafficked pavements where the

thickness/strength of the slabs and flags is increased significantly. Whilst using very thick units in the carriageway is common place in some parts of Europe, it is not in the UK where most available units tend to be quite thin.

- c. This form of construction is relatively simple and easy to reinstate since the entire construction can be unbound. This makes it very sustainable. However, various points should be borne in mind.
- d. Loads will not be distributed between the surface units – only through the subbase. This is because, - unlike say flexible precast concrete block surfaces as section 4 of this appendix – there is insufficient joint shear between the units for distribution to occur.
- e. The long term integrity of the pavement relies heavily on compacting and preparing the laying course and subbase well. Designers must also be aware of the breaking load of the surface slabs and flags.
- f. As with any form of unbound modular construction, draining the laying course during service to prevent it becoming saturated by any water that may succeed in penetrating the surface is critical to the stability of the surface units and the long-term durability of the whole construction. Historically in London, concerns about the stability of unbound granular laying course mixtures (due to surface water getting in through the joints and washing out fines) has led designers to use weak mortars instead. These are also quick and easy to install. Unfortunately they have proven too brittle and have often broken up under occasional vehicle overrun, letting in water and undermining support for the surface units nonetheless. This issue is behind many of the rocking and damaged slabs seen in London's streets. Consequently, national standards no longer provide for weak mortar to be used with this form of construction. A certain degree of surface water penetration must be accepted and designers must use other methods to drain the laying course. This is best achieved by ensuring that both the laying course and the underlying subbase are sufficiently permeable so that moisture can infiltrate down to be dispersed within foundation layers by sub-drains or other measures. This should not be confused with attempting to create 'pervious' pavement constructions as part of a surface

water management strategy. Whereas that involves attempting to maximise the penetration of surface water into pavements, the strategy here is to continue to minimise penetration whilst providing for easy dispersal from the construction of any that does occur.

- g. Despite the importance of sub-drainage and permeability to this method of construction, in London concerns that Statutory Undertakers (public utility companies) may reinstate unbound subbase materials inadequately has tended to encourage designers to use impermeable bound materials instead (e.g. wet lean concretes). British Standards permit this. However, in addition to frustrating drainage of laying courses (see 'f'), using conventional bound subbase materials undermines the various maintenance benefits of this method of construction. Recent improvements in how works by Statutory Undertakers are regulated mean that inadequate reinstatement is now less of a concern than in the past. Never the less, many existing pavements in the borough include concrete foundations. Where removing these is not possible then it is likely to be necessary to retro fit sub-drainage measures to disperse and water that has succeeded in penetrating the surface course.

3 Precast concrete and natural stone slab and flag surfaced pavements (bound surface)

- a. Pavements with large or very thin slab or flag surface courses rely on rigid plate construction methods. This requires the slabs or flags to be bound as a laminate to the laying course and base course beneath (using very strong mortar) to create a stiff composite plate that is capable of flexing as a whole. This serves to spread loads over a very wide area – rather than just that of each individual surface slab or flag. The base course is normally a steel reinforced pavement quality concrete (PQC) slab.
- b. Because it allows wider mortar filled joints to be used, this method of design is sometimes favoured for visual reasons where designers consider that narrow joints (often required in the past for unbound construction as described in section 2 of this appendix) and are inappropriate to local character. This is often the case where natural stone slabs are

used within conservation areas. However, new stabilised unbound jointing materials which permit wider joints have now been introduced and these invalidate this concern in many circumstances. Whereas in the past weak cement-sand mortar was often used, experience has shown that these mixtures are too brittle to adequately support flags/slabs outside of fully pedestrianised areas. Consequently, where mortar joints are required modern standards now require much stronger and more adhesive 'high-performance' mortars to be used. The extent to which these will shrink whilst they cure (harden) is very important to success.

- c. The overall design with tightly mortar bonded laminate surface units and a stiff base slab results in an extremely robust construction. Providing this is not overloaded it can have a near indeterminate design life. In fact, the composite slab is so stiff that the surface slabs/flags can be made relatively thin - like a true laminate. They only really need to be thick enough to sustain their own weight during laying. Designers keen to conserve expensive surface course materials may therefore prefer this method.
- d. Whilst it is still possible to create surface water infiltration or attenuation reservoirs within the foundation layers of pavements of this type, it is not possible for surface water to percolate directly through the upper layer construction in order to reach these. Any conveyance to the reservoir must be via other means (typically a conventional carrier drainage system else via swales or other green features adjacent to the pavement). Notwithstanding this, some limited unintended surface water penetration will always occur and, consistent with most other forms of construction, it remains important for the pavement courses beneath to be at least lightly draining so as to allow this to escape.
- e. In general, despite it being extremely robust and highly recommendable elsewhere, this form of construction is problematic within the Highway. This is largely because of the Pavement Quality Concrete (PQC) base slab and the almost certain presence of pipes, cables etc. owned by Statutory Undertakers (public utility companies) beneath the pavement.
 - i. Steel fabric included in the PQC base slab can interfere with cable detection tools,

making it difficult to locate Statutory Undertakers apparatus. This can pose a safety hazard for those carrying out construction works

- ii. Manholes and other larger access chambers associated with services are likely to need to be 'isolated' from the PQC base slab to prevent damage when thermal expansion and contraction occurs
 - iii. Because of the robustness of the PQC base slab and high adhesive strength of the jointing and laying course mortar, any maintenance and reinstatement works by Statutory Undertakers will be inevitably destructive and likely involve the damage beyond reuse of many of the expensive, tightly bonded surface units. In addition, reinstatement is likely to be expensive, time consuming and complex.
- f. Given the above, unbound flag or slab pavements as section 2 of this appendix are generally significantly preferable within the Highway. If bound construction is unavoidable then – as a calculated risk - weaker cement bound materials tend to be substituted for the PQC base slab. This simplifies design by avoiding the need for joints and steel reinforcement. Providing this approach is not taken in a carriageway then it is unlikely to result in significant failures. However, surface slabs/flags must still be tightly bonded to the base and so still risk damage beyond reuse in the event of future maintenance and/or reinstatement.
- g. Notwithstanding the above, in rare instances when underground services can be relocated away from the area of construction, or where new streets and spaces can be designed to constrain services to other areas of the street, this method of design (including potentially using a PQC base slab) should be strongly favoured owing to its robustness. If not disturbed then it is unlikely to require any maintenance for its design life.

4 Precast concrete block and imitation clay paver surfaced pavements (unbound surface)

- a. Unbound surfaces with small modular units involve placing closely spaced precast concrete blocks or imitation clay pavers on a compacted sand or crushed rock laying course. The joints between the units must be

kept to controlled widths and are tightly packed with special sand or crushed rock. This allows loads to be distributed between units when traffic passes over them.

- b. This form of construction has a number of advantages compared to alternatives. The most obvious is that the surface units can be easily lifted and relaid if it becomes necessary to excavate the pavement to access buried utilities (or to correct general defects). This reduces asset management, sustainability and visual quality concerns associated with having to source and purchase matching replacement units. In addition, the individual units themselves are at less risk of breaking when loaded than are larger flags or slabs as they have a comparatively high depth to plan size ratio. This means that they can be safely laid in carriageways within certain limits. Lastly, any maintenance to the surface that is necessary is relatively simple and easy to carry out and typically requires nothing more than occasional resetting of any units that have come loose or re-screed small areas of the underlying sand or crushed rock laying course. This is all very different to modern bound/rigid methods of modular surface construction.
- c. On the continent, precast concrete blocks and clay pavers are typically quite deep, being at least as thick as they are wide when used to more heavily trafficked areas. Because of the depth of joints between units and the overall unit size, turning moments are less in both the horizontal and vertical plane and joint support greater. In the UK however, only relatively shallow units are generally available which makes units more prone to tipping and twisting. This can compromise joints and raises several issues. Firstly, it means that a slightly thicker base course is required in most instances to support the surface than would otherwise be the case. Secondly, it makes correctly specifying and installing jointing and laying course material very important in order to achieve effective load transfer between units. Lastly, it makes the selecting the laying pattern for the units important to ensure that these do not work loose with trafficking and compromise the joints. Laying patterns that provide greater interlock tend not to be to visual preferences.

- d. Another difference between UK and continental practice relates to the materials used for base courses. On the continent it is far more common for unbound granular mixtures to be used in carriageways, whereas this is almost unthinkable in the UK. Using unbound granular mixtures in this way requires much greater attention to both how mixtures are installed and to the resulting stiffness values that are achieved (as those values need to be significantly greater than those often achieved in the UK). Attention must also be paid to the permeability of the material. However, in general the continental approach is significantly cheaper and can all but eliminate issues relating to surface water ingress.
- e. As discussed above, whilst any necessary maintenance of precast concrete blocks and clay pavers is quite simple and straight forward (and therefore much lower cost than for other forms of construction) it is likely to be required more regularly where vehicle flows are considerable. This needs to be planned for. Consequently, such surfaces are not something that can be built and left unattended until the end of the planned design life - except where traffic flows are modest. However, provided simple light touch intervention is carried out when required the intended design life can often be considerably exceeded.
- f. Off of the Highway, unbound block and paver surfaces are increasingly specified to allow for the creation of pervious pavement constructions (where surface water percolates into the construction via the joints between surface units, to be stored in reservoirs within the foundation layers). This can be used to address flood risk and water quality issues and has the considerable benefit of all- but eliminating the need for pavements to be set on cambers or slopes (since there is no need to shed surface water towards gullies). However, this all requires a very different form of design to be used. This carries certain maintenance risks that are currently not well understood or easy to overcome. In addition, whilst fine for lesser trafficked private areas (e.g. large car parks and quiet estate roads) there is uncertainty about the durability of the construction within more highly trafficked highways. Given these risks (and the availability of various alternative ways of directing water beneath pavements for storage that allow for a more conventional construction – or otherwise sustainability managing it) there is much debate at present amongst highway designers about whether pervious surface design is the best means of addressing flood risk in existing urban environments. Consequently a conservative approach is advisable for the time being.
- g. Even with conventional design, drainage of surface water within the pavement remains very important to long term performance. The principal concern is preventing saturation by surface water of the sand or crushed rock laying course that immediately supports the surface units and washing out of the ‘fines’ within this - much the same as for unbound flag or slab pavements (though more so given the greater joint area in the surface and hydraulic pressures created by regular overrunning vehicles). Where saturation and suspension/loss of fines from the laying course material occurs this may undermine support for the surface units through various processes and ultimately lead to rutting of the pavement or other types of failure. Irrespective of the width of joints between units, some degree of surface water ingress is always inevitable and crusting of joints due to gradual build-up of detritus should not be relied upon to seal them. Various precautions are important to avoid these risks to the laying course. Firstly, the fines content in the mixture used must be reduced to a very low level (typically a maximum of 1-2% passing depending upon the type of trafficking). This will make the mixture permeable and prevent liquefaction of the remaining larger articles by escaping fines. Next, for more challenging service conditions the selected aggregate for the laying course needs to be very hard to prevent it fragmenting. Almost pure quartz sand (e.g. from crushed quartzite or natural occurring quartz arenite sand) similar to the industrial sand used in the glass making industry is the ideal, though sands from other rocks/minerals may also suffice. Finally, measures must be introduced to allow the inevitable surface water ingress to escape rapidly from the laying course. Ideally this should be achieved by using permeable materials for lower courses so that water can pass through to be dispersed by pavement sub-drains. Alternatively, insufficiently permeable base or subbase materials can be

used whilst employing one of a number of strategies. These include setting the impermeable base course on a slight gradient to shed water laterally through to sub-drains or weep holes at the edge of the pavement (e.g. wider joints between kerb units, though geotextiles will likely be required to retain the laying course); perforating the base course with closely spaced holes or; using special joint sealants to minimise the infiltration of surface water through joints in the first place. However, these alternatives each carry various risks and are far from guaranteed success.

5 Precast concrete block, imitation clay paver or natural stone sett surfaced pavements (bound surface)

- a. Like bound and rigid constructions with slabs or flags this method of design results in a very robust construction. It is often used in preference to unbound block, paver or sett construction as it can allow cheaper surface units to be used (particularly where these are composed of natural stone – e.g. cropped side units), wider joints or particular laying patterns. Any of these may be desirable for visual reasons.
- b. Whilst it is still possible to create surface water infiltration or attenuation reservoirs within the foundation layers of this type of pavement, it is not possible for surface water to percolate directly through the upper layer construction in order to reach this. Any conveyance to the reservoir must be via other means (typically a conventional carrier drainage system else via swales or other green features adjacent to the pavement).
- c. Many of the same maintenance concerns that apply to bound and rigid constructions with slabs or flags also apply to this type of pavement construction as it requires the use of similar high adhesive strength jointing and laying course mortar (e.g. destruction of surface units should it become necessary to excavated the pavement and complexity of later reinstatement). Given this, wherever possible laying units as part of an unbound surface (as sections 4 or 6 of this appendix) is generally preferable. Only where underground services can be located away from the area of construction should this method of design be favoured. However, use may still be

appropriate to small features like ramp faces and rumble strips (for which unbound construction is not always appropriate).

6 Natural stone sett surfaced pavements (unbound surface)

- a. Natural stone setts are typically more expensive than most precast concrete blocks or clay pavers. However, they are often preferred by designers, both for visual reasons and because of their perceived greater durability. Setts can range from very small cubed units of around 70mm to all sides (often referred to on the continent as ‘mosaic’) to much larger units of sizes exceeding 300mm in length and 150mm in width. Where they are to be laid in vehicle trafficked areas then the thickness of units generally needs to be equal to or greater than their width. Because of the implied depth of excavation required and the presence of existing below ground constraints (such as shallow underground utilities) this latter requirement may sometimes make using very large units in existing streets impractical.
- b. Laying natural stone setts unbound means that they can be easily lifted and replaced when maintenance is necessary. This is preferable to laying them bound in mortar since the expensive units are then likely to be damaged beyond reuse.
- c. It is often assumed that natural stone setts and blocks can be laid unbound using the same method as used for precast concrete block and clay pavers. This is not entirely true. Precast concrete blocks and imitation clay pavers can be manufactured from moulds or extrusions to have very straight sides that allow tight uniform joints to be created between units. These tight joints are very important to the success of the construction. The concrete and clay used for the units also provides good friction with jointing materials. However, whilst rougher sedimentary stones like yorkstone can be cut and used in the same way, this is much less easy to achieve with igneous natural stones like granite. Granite tends to be the stone of choice for carriageway areas (yorkstone being too easily stained by tyres and oil spills due to its absorbency). The reason for this difficulty is that when granite is sawn it tends to produce a smooth ‘slippy’ face that does not interlock well with jointing aggregate. By turns, if it is cropped by hand

then it fractures too irregularly to achieve the consistent joint widths needed. Unbound granite natural stone sett surfaced pavements therefore require a subtly different design and construction method.

- d. The correct method is one of the most intensely debated issues in urban design. Whilst unbound construction with granite and other igneous stone setts is common place on the continent (and many landscape architects query why it cannot be achieved in the UK given its apparent advantages) there is considerable nervousness about its appropriateness to the particular conditions and constraints found here. This is in part due to a lack of clarity about certain aspects of continental design, installation and maintenance practice, reflected in the uncertainty of British Standard recommendations. Whilst there have been numerous small scale trials, many of these have failed badly. Given this, a cautious approach must be taken for the time being until greater experience is gained.

7 Bituminous mixture surfaces (bound surface)

- a. Bituminous mixtures (e.g. asphalt, black top, bitmac or tarmac) include a range of materials that consist of a mixture of coarse aggregate, fine aggregate, filler material and a bituminous binder. The relative proportions between these components will vary (as will the strength of the binder) – so imparting different properties to the material. Some common types are Hot Rolled Asphalt, Asphalt Concrete, Stone Mastic Asphalts and Thin Surface Course Systems. The appropriate material to use in different circumstances varies greatly.
- b. Bituminous mixtures can provide a simple, smooth, trafficable surface that is reasonably cost effective. Assuming suitable space and depth exists this can be relatively easily and sustainably rehabilitated by using ‘milling’ machines that ‘plane off’, remix and relay the material else (in certain circumstances) by simply adding a further layer on top of the existing.
- c. However, bituminous mixtures have drawbacks too. These include the facts that:

- i. Being darker they absorb and radiate more heat than other lighter surfaces and so contribute significantly to urban heat island effects and associated impacts on health and comfort for street users.
- ii. Most mixtures (though not all) require heating during mixing and laying and the energy used for this has a sustainability impact.
- iii. As bound granular surfaces they are subject to inevitable visual scarring after reinstatement when it is necessary to dig them up for maintenance reasons. Even where great care is taken the variable wear and composition of the mix means that exact visual matching of surfaces will never be possible.
- iv. Lack of space on footways and the presence of shallow obstructions from tree roots and utilities mean that ‘cold milling’ rehabilitation techniques may not always be possible – even in carriageways. Where this is the case rehabilitation becomes much more complicated and may require several pavement courses to be removed.

- d. Given the above, the use of bituminous mixture surfaced pavements in Southwark is generally confined to carriageways. Only within particular SSDM/RP designations where the surfacing is in keeping with established local character (and sufficient canopy cover exists from trees to mitigate its heat absorbing/radiating qualities during summer months) may it be used to footways. See SSDM/SER/Surfacing Material palettes for further details.
- e. It is possible to make bituminous mixture surface courses (and other deeper courses) permeable so that surface water can drain through them. However, at present per the use of permeable bituminous mixture surfaces is not supported. Consequently whilst it is still possible to create surface water infiltration or attenuation reservoirs beneath such pavements, it is not possible for surface water to percolate directly through the upper layer construction in order to reach these. Any conveyance to reservoirs must be therefore be via other means (typically a conventional carrier drainage system else via swales or other green features adjacent to the pavement).

Appendix B - Bituminous pavement upper layer design options for Flexible pavements

| Pavement course/use requirements | Option 1 | Option 2 | Option 3 |
|----------------------------------|--|---|---|
| Surface | [B-ST14] (see note 1) [B-ST10] (see note 1) [B-ST6] (see note 1) | [B-ST14] (see note 1) [B-ST10] (see note 1) [B-ST6] (see note 1) [B-S1H] (see note 1) | [B-ST10] with deformation resistance as '8.2.6g.vi' in the main design standard |
| Binder | [B-Bi1S] | [B-Bi1S] | [B-Bi1E] (see note 2) |
| Base | [B-Ba1A] | [B-Ba1H] | [B-Ba1E] (see note 2) |
| Use Requirements | Preferred option that should be used in most circumstances | May be used by level 1 departure if overlaying/inlaying cracked material or where a risk of surface water ingress exists. Approving officers also have discretion to instruct use in such circumstances. TSCS surface options should generally be used unless the risk of ingress is severe | Should be used to and in the vicinity of bus cages and other lengths of carriageway with severe channelised or slow moving traffic (e.g. congested high streets or signalised junction approaches). Approving Officers have discretion to instruct use where they consider it appropriate |

NOTES

- 1) The appropriate maximum nominal aggregate size for TSCS surface course options will vary with circumstances. See '8.2.6g.vii' in the main design standard for further details.
- 2) If an EME 2 base or binder course is used then a rigid HBM subbase is needed in all instances. See standard DS.602 for further discussion.
- 3) The options in this Table are not applicable for hand-laid Raised Tables, Road Humps and Speed Cushions for which see standard DS.111.
- 4) Unless otherwise stated, materials may be used at any of the pen grades stated within their item specifications.

Table 13. Permitted bituminous mixture upper layer material combination options for flexible pavements in NRSWA Road Category 1 C/ways.

| Pavement course/use requirements | Option 1 | Option 2 | Option 3 |
|----------------------------------|--|---|---|
| Surface | [B-ST14] (see note 1) [B-ST10] (see note 1) [B-ST6] (see note 1) | [B-ST14] (see note 1) [B-ST10] (see note 1) [B-ST6] (see note 1) [B-S2H] (see note 1) | [B-ST10] with deformation resistance as '8.2.6g.vi' in the main design standard |
| Binder | [B-Bi2S] | [B-Bi2H] | [B-Bi2S] with deformation resistance as '8.2.5c' in the main design standard |
| Base | [B-Ba2A] | [B-Ba2H] | [B-Ba2A] with 30/45 pen binder |
| Use Requirement | Preferred option that should be used in most circumstances | May be used by level 1 departure if overlaying/inlaying cracked material or where a risk of surface water ingress exists. Approving officers also have discretion to instruct use in such circumstances. TSCS surface options should generally be used unless the risk of ingress is severe | Should be used to and in the vicinity of bus cages and other lengths of carriageway with severe channelised or slow moving traffic (e.g. congested high streets or signalized junction approaches). Approving Officers have discretion to instruct use where they consider it appropriate |

NOTES

- 1) *The appropriate maximum nominal aggregate size for TSCS surface course options will vary with circumstances. See '8.2.6g.vii' in the main design standard for further details.*
- 2) *The options in this Table are not applicable for hand-laid Raised Tables, Road Humps and Speed Cushions for which see standard DS.111.*
- 3) *Unless otherwise stated, materials may be used at any of the pen grades stated within their item specifications.*

Table 14. Permitted bituminous mixture upper layer material combination options for flexible pavements in NRSWA Road Category 2 C/ways.

| Pavement course/use requirements | Option 1 | Option 2 | Option 3 | Options 4 |
|----------------------------------|--|---|--|--|
| Surface | [B-ST14] (see note 1) [B-ST10] (see note 1) [B-ST6] (see note 1) | [B-ST14] (see note 1) [B-ST10] (see note 1) [B-ST6] (see note 1) [B-S3H] | [B-S3A] | [B-ST10] |
| Binder | [B-Bi3S] | [B-Bi3H] | [B-Bi3A] | [B-Bi2S] |
| Base | [B-Ba3C] | [B-Ba3H] | [B-Ba3C] | [B-Ba2A] |
| Road Category 3 use requirement | Preferred option that should be used in most circumstances | May be used in existing streets and spaces by level 1 departure if overlaying/ inlaying cracked material or where risk of surface water ingress exists. Approving officers also have discretion to instruct use in such circumstances. TSCS surface options should generally be used unless the risk of ingress is severe | Not to be used | Should be used to and in the vicinity of bus cages And other lengths of carriageway with severe channelized or slow Moving traffic (e.g. congested high streets or signalized junction approaches. Approving officers have discretion to instruct use where they consider it appropriate |
| Road Category 4 use requirements | To be used with a [B-ST10] surface at and in the vicinity of bus cages. Approving officers also have discretion to instruct use in other circumstances here increased stress is likely | May be used in existing streets and spaces by level 1 departure if overlaying/ inlaying cracked material or where risk of surface water ingress exists. Approving officers also have discretion to instruct use in such circumstances. TSCS surface options should generally be used unless the risk of ingress is severe | Preferred option In most circumstances for Road Category 4 | Not to be used |

NOTES

- 1) The appropriate maximum nominal aggregate size for TSCS surface course options will vary with circumstances.
- 2) The options in this Table are not applicable for hand-laid Raised Tables, Road Humps and Speed Cushions for which see standard DS.111.
- 3) Unless otherwise stated, materials may be used at any of the pen grades stated within their item specifications.

Table 15. Permitted bituminous mixture upper layer material combination options for flexible pavements in NRSWA Road Category 3 and 4 C/ways