TECHNICAL GUIDELINES

HBM AND STABILISATION

1 The design and specification of PARKING AREAS AND HARDSTANDINGS

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The British In-situ Concrete Paving Association

This publication provides design and specification guidelines for clients, designers and contractors wishing to use hydraulically bound mixtures for parking areas and hardstandings.

Britpave, the British In-situ Concrete Paving Association, was formed in 1991. It is active in all areas of transport infrastructure including roads, airfields, light and heavy rail, guided bus, safety barriers and drainage channels, soil stabilisation and recycling.

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HBM and stabilisation 1

The design and specification of parking areas and hardstandings

Contents

Glossary

Surface course	previously known as wearing course
Binder course	previously known as basecourse
Surfacing	surface course or combination of surface and binder courses
Base	previously known as roadbase
Subbase	previously hyphenated i.e. sub-base
HBM	hydraulically bound mixture; a mixture that hardens through the hydraulic reaction between the constituents and water
CBM	cement bound mixture (previously cement bound material); an HBM that hardens through hydration of cement
CBGM	cement bound granular mixture; a type of CBM
FABM	fly ash bound mixture; an HBM that relies on the pozzolanic/hydraulic combination of coal fly ash (also known in the UK as pfa, the acronym for pulverized fuel ash) with quick or hydrated lime, or cement
SBM	slag bound mixture; an HBM that relies on the hydraulic/sulfatic combination of granulated blast furnace slag (GBS) with other slags and or with quick or hydrated lime
HRB	hydraulic road binder – a factory blended hydraulic binder, typically made from GBS and or fly ash, lime and gypsum, specifically formulated to be slow setting for road and stabilisation use
HRBBM	HRB-bound mixture; an HBM that uses HRB as the binder
CBGM A	graded aggregate mixture which includes sandy mixtures (ref. SHW 821)
CBGM B	well graded aggregate mixture (ref. SHW 822)
FABM 1, SBM B1-2 & HRBBM 1	0/31.5 mm graded mixtures (ref. SHW 830)
FABM 3, SBM B3 & HRBBM 3	0/6.3 mm mixtures (ref. SHW 831)
msa	millions of standard axles
sa	standard axles
SC	soil (treated by) cement (ref. SHW 840)
SFA	soil (treated by) fly ash (ref. SHW 840)
SS	soil (treated by) slag (usually ggbs, which is ground GBS) (ref. SHW 840)
SHRB	soil (treated by) HRB (ref. SHW 840)
SHW	*Specification for Highway Works*

1 Introduction

These guidelines provide thickness design, specification and construction advice for the use of hydraulically bound mixtures (HBM) including cement bound mixtures (CBM) for parking and hardstanding areas for cars, vans and lorries of weight permitted for use on public roads.

The guidelines are applicable to:

- The use of hydraulically bound mixtures (HBM) mixed in central plants where the aggregate may comprise natural, artificial or recycled material.
- In-situ stabilisation of indigenous granular soils, also referred to here as HBM.
- Binders or hydraulic combinations based on Portland cement, quicklime (CaO) or hydrated lime [$Ca(OH)_2$], ground granulated blast-furnace slag (ggbs) and coal fly ash (also known as pulverized fuel ash or pfa).

Thickness design advice is based on data from well-established and proven pavement design documentation [1, 2, 3]. Specified strengths are in accordance with the European standards for HBM introduced as a British Standard in the UK in 2004 and 2006 [4, 5]. HBM specification recommendations are based on the Highways Agency's *Specification for Highway Works* (SHW)[6].

2 Design parameters

2.1 General

In order to design a paved area, the primary input parameters are:

- Long-term or equilibrium subgrade strength.
- Traffic to be carried during the design life.

In addition, the following issues should be considered:

- Subgrade strength during construction.
- Trafficking during construction.
- Durability.
- Drainage.
- Sulfates.
- Client expectations.

2.2 Subgrade strength (long-term and during construction)

Limited guidance on typical subgrade strengths for a range of soil types is given in Table 1. For further information, reference should be made to Appendix C in LR1132 from TRL [7], which provides more detailed advice on both short and long-term (equilibrium) subgrade strength for high and low water tables under differing construction conditions.

For in-situ stabilisation it should be noted that the subgrade, which underlies the stabilised layer, is usually never directly exposed to the elements or trafficking. Thus the subgrade strength during in-situ stabilisation is a lesser issue than when imported HBM is used.

2.3 Traffic (in-service and during construction)

Design traffic loading, particularly for parking areas for commercial vehicles, is difficult to assess because it is a function of design life, the type of commercial vehicle and client expectations, all of which can sometimes be difficult to quantify. To simplify the issue, the parking and hardstanding areas covered by these guidelines have been broadly categorized into three types catering for:

- Cars only.
- Vans (including cars).
- Legal road lorries.

In arriving at the design thicknesses recommended in these guidelines, a traffic design band in millions of standard axles (msa) has been assigned to each of these three categories as follows:

- < 0.5 msa.
- 0.5 to <1.5 msa.
- 1.5 to < 2.5 msa.

These categories are broadly in accord with reference 1, which addresses the issue of design traffic loading for these pavements. They are also consistent with references 2 and 3.

The latter references use similar msa bands in defining Type 3 (0.5 to 2.5 msa) and Type 4 (< 0.5 msa) public roads where:

- Type 3 roads would describe roads carrying up to, say, 100 commercial and or public service vehicles per day.
- Type 4 roads would be typical of country lanes subject to very little commercial traffic.

It seems reasonable therefore to use the traffic levels covered by Type 3 and 4 roads, and the associated design approach in references 2 and 3, to produce the recommendations in this publication for parking and hardstanding areas for cars, vans and lorries.

This somewhat simplistic approach has the advantage of incorporating a degree of conservativeness into the recommendations, particularly for car and van parking areas, which will accommodate the occasional lorry and, within reason, lorries associated with construction.

2.4 Drainage

With regard to surface water drainage, it is imperative that surface water is not allowed to stand on pavements. This may cause saturation of stabilised layers or the upper part of a layer that could, if subject to freezing temperatures, suffer damage. Adequate cross falls must be employed to prevent the possibility of standing water. Surfacing or the first course of surfacing should be placed as soon as possible to provide a weather-proof seal.

Provision for the collection of surface water and the prevention of the ingress of ground water shall, as with all large area paving works, be provided at the edges of the pavement and elsewhere where necessary.

2.5 Client expectations and surfacing

In-service life expectations and serviceability requirements will vary.

As a rule-of-thumb, thicker surfaces are more durable, improving the life and serviceability of pavements. Minimum surfacing recommendations are given in Table 1 for asphalt, concrete block or clay paver solutions. It is stressed that these are minimum values.

Clearly in-situ concrete is a pavement solution offering inherent structural benefits as well as durable, rutting- and abrasion-resistant running surfaces. However, as the focus of this document is the design of pavements where the main structural contribution is provided by HBMs, concrete options are not included in Table 1. Further guidance on these pavements types is available elsewhere [8].

The fuel resistant properties of surfacing layers are also important, since oil, diesel and petrol spillage will be an inevitable occurrence, particularly with hardstandings for lorries. Where such spillage is identified as a problem, consideration should be given to the use of ‘cementitious’ grouted macadam or block paving surfacing.

3 Design

3.1 Recommendations

Design recommendations are given in Table 1 and the notes to the table, with:

- Rows D & E applicable, but not exclusively, to in-situ stabilisation of granular subgrades
- Rows F & G applicable, but not exclusively, to the use of imported HBM.

3.2 Design basis for Table 1

TRL 386 [2] has been the main design and specification reference over the last few years for the strengthening of failed highway pavements using in-situ recycling. There have been no reported problems with recycling carried out in accordance with TRL 386. The recommendations given for in-situ recycling using cement (particularly those in Table 6 of TRL 386), form the basis of the recommendations given in these guidelines, but with some minor modifications reflecting recent changes in strength classification and age of strength determination. These are discussed below.

- The strength requirements used here reflect the new European HBM compressive strength classes and change in age of strength testing from 7 to 28 days, now adopted in the SHW. Thus the old CBM 1 (7 day compressive strength 4.5 MPa) and CBM 2 (7 day compressive strength 7 MPa) used in TRL 386 for Type 4 and Type 3 roads respectively, are replaced here with HBM C5/6 (tested at 28 days) and HBM C6/8 (tested at 28 days).
- For CBM1, the change to HBM C5/6 has negligible effect. For CBM2, the change to HBM C6/8 represents a slight strength reduction of, say, 15%. This reduction, however, has been more than compensated for by the increase in specified thickness advocated here in Table 1, compared with that in Table 6 in TRL 386.
- As described in TRL 611 [3], the replacement for TRL 386, the recommendations in these guidelines can also be used for other hydraulic binder combinations including:
  - Cement with either fly ash or ggbs.
  - Quicklime or hydrated lime with either fly ash or ggbs.

Key elements of mix-in-place stabilisation

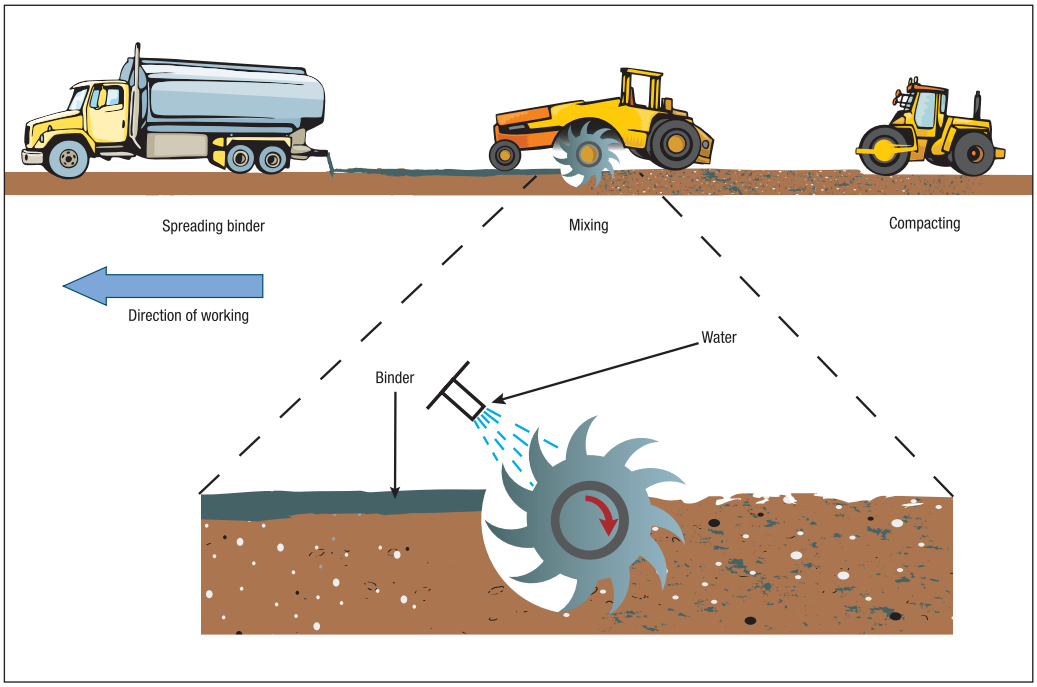

Table 1: Surfacing and HBM thickness and strength recommendations for parking areas and hardstandings

(note that entrance/exit areas may need to be considered separately)

	1	2	3	4
A		Cars	Vans	Lorries
Surfacing layer guidance (Note 1)				
B	Minimum asphalt surfacing	Surface dressing	40 mm single course	80 mm 2-courses (Note 1)
C	Concrete block or clay paver surfacing	60/65 mm pavers on 30 mm bedding sand layer		80 mm pavers on 30 mm bedding sand layer
Base layer guidance				
D	HBM strength class (Note 2) in MPa [1st number relates to 2:1 cylinders, the 2nd to cubes or 1:1 cylinders]	C5/6	C5/6	C6/8
E	HBM thickness for sand & gravel subgrade (design CBR ≥ 15%)	200 mm	200 mm	230 mm
F	HBM thickness for sandy subgrade (design CBR 8% – 14%)	200 mm	200 mm	250 mm
G	HBM thickness for subgrade design CBR 5% – 7% (typically chalk or low plasticity subgrades with average to good construction conditions and low water table assumed, otherwise use row below)	220 mm	220 mm	A suitable depth (not less than 200 mm) of frost-resistant granular material or subgrade treatment should be provided between the subgrade and HBM layer and then design based on row E. If the granular import option is employed, then extra depth could be placed to permit production of the HBM by in-situ stabilisation of the upper part of the granular layer.
H	HBM thickness for subgrade design CBR 2% – 4% (typically clay subgrade)	Depending on CBR, a suitable depth (not less than 300 mm) of frost resistant granular material or subgrade treatment should be provided between the subgrade and HBM layer and then design based on row F. If the granular import option is employed, then extra depth could be placed to permit production of the HBM by in-situ stabilisation of the upper part of the granular layer.		

Notes

1 *The surfacing or first course of surfacing should be laid as soon as possible to provide a weather-proof seal. Grouted macadam or concrete block paving should be given particular consideration where fuel and oil resistance is required. Refer to specification in Annex A.*

2. *The HBM and strength classes shown are compatible with the European standards for cement bound granular mixtures (BS EN 14227–1), other hydraulically bound mixtures (BS EN 14227–2, 3 & 5) and the 800 series of the SHW. The first number of each class relates to the compressive strength of cylindrical specimens with a slenderness ratio of 2 and the second number to a slenderness ratio of 1 or to cubes. Refer to specification in Annex A.*

3.3 Durability to weather

Provided standing water is prevented, the strength levels recommended in Table 1, whatever the material treated, can be considered capable of providing a durable water and frost resistant construction. It is advisable to place the surfacing as quickly as possible to provide a weather-proof seal.

Frost resistance of subgrade material beneath the stabilised layers and the frost index for the area should also be considered because the depth of stabilisation and surfacing and thus insulation of the subgrade to frost could be as thin as 200 mm. Potential for frost heave depends on the nature of the subgrade material, the severity of the weather and, most importantly, the position of the water table. If the water table is deep relative to the subgrade, then there is unlikely to be a problem. If the overall cover thickness is at least 300 mm, there is also unlikely to be a problem since frost penetrations greater than this have not occurred, at least in the southern half of the UK, since the mid-1980s.

3.4 Sulfates

The existence of sulfates, sulfides and other materials capable of causing volume instability in the stabilised layer should be explored at the site investigation stage and, if applicable, at the mixture design stage using immersion and/or swell testing. Advice on this is found in references 6 and 9.

4 Specification

The HBM classes C5/6 and C6/8 recommended in Table 1 should conform to the specification framework included in Annex A.

The use of Table 1 and the specification framework is illustrated in Annex B.

5 Mixture design, construction and control testing

Mixture design, construction and control testing are covered by the *Specification for Highway Works* [6], but further advice and understanding can be found in publications from The Concrete Centre [10] and Britpave [11].

Because of the nature of mix-in-place construction, it is not uncommon for depths of treatment to exceed (or fall short of) the target depth by up to 50 mm. To compensate for this variation, it is advised that the powder-spread rate be increased accordingly but keeping the target depth for construction to that required by the design. This is particularly relevant where materials such as clays and chalks are being treated; here durability performance is more a function of the sealing effect of binders rather than the absolute strength achieved.

ANNEX A: Specification framework for HBM for parking areas and hardstandings

For ease of use, the design table in the main text is reproduced here but with the **HBM thickness recommendations removed and replaced with specification recommendations**, which are in accordance with the European standards for HBM and the SHW 800 series.

Table A1: Specification with relevant SHW clause numbers

	1	2	3	4
A		Cars	Vans	Lorries
Surfacing layer guidance (Note 1)				
B	Minimum asphalt surfacing	Surface dressing	40 mm single course	80 mm two courses
C	Concrete block or clay paver surfacing	60/65 mm pavers on 30 mm bedding sand layer		80 mm pavers on 30 mm bedding sand layer
Base layer guidance				
D	HBM Strength class (Note 2) in MPa [1st number relates to 2:1 cylinders, the 2nd to cubes or 1:1 cylinders]	C5/6 (Note 3)	C5/6 (Note 3)	C6/8 (Note 3)
E	HBM specification for sand & gravel subgrade (design CBR ≥ 15%)	SC, SS, SHRB or SFA to SHW clause 840		See 1 to 4 below
F	HBM specification for sandy subgrade (design CBR 8% – 14%)			
G	HBM specification for subgrade design CBR 5% – 7% (typically chalk or low plasticity subgrade with average to good construction conditions and low water table assumed, otherwise use row below)	1. CBGM A to SHW clause 821 2. SBM B1, FABM 1, HRBBM1 to SHW clause 830 3. SBM B3, FABM 3, HRBBM 3 to SHW clause 832 4. SBM B4, FABM 4, HRBBM 4. Although not in the SHW, can be used to SHW clause 832.		
H	HBM specification for subgrade design CBR 2% – 4% (typically clay subgrade)			

Notes

1. *The surfacing or first course of surfacing should be laid as soon as possible to provide a weather-proof seal. 80 mm asphalt will normally be laid in two courses of, say, a 30 mm thin surface course on a 50 mm binder course. Where fuel and oil resistance is required, consideration should be given to using grouted macadam as the surface course or substituting the whole of the asphalt surfacing with 80 mm concrete blocks on a 30 mm sand laying course.*
2. *The strength classes shown are compatible with the European standards for cement bound granular mixtures (BS EN 14227–1), hydraulicIly-bound mixtures (BS EN 14227–2, 3 & 5) and the 800 series of the SHW. Strengths shall be assessed at 28 days using sealed curing at 20°C for mixtures employing at least 3% CEM I cement by dry mass. For mixtures based on fly ash or ggbs (or GBS) containing less than 3% CEM I cement by dry mass, or activated by lime, 28 day testing shall also be used but after sealed curing at 40°C. In all cases, the specified strength shall mean the minimum based on the average of five specimens every 1000 m^2 with no individual result less than 70% of the minimum average requirement.*
3. *Minimum binder contents should be in accordance with Table 8/10 in the SHW. Where treatment is carried out using mix-in-place stabilisation, the quantity of stabiliser should be calculated assuming 50 mm additional depth but keeping the target depth for construction as that required by the design.*

Annex B: Example of the use of Table 1 and specification framework

Requirement

Lorry-park on a sandy subgrade. Fuel spillage is likely.

Options

Surfacing

80 mm concrete blocks on bedding sand or 80 mm two-course asphalt using cementitious grouted macadam for the top course.

Stabilised/HBM thickness and strength

250 mm HBM C6/8.

HBM types

SC, SS, SHRB or SFA to SHW clause 840.

Construction

SHW clause 814, 815 or 816.

Strength testing

Testing shall be carried out at 28 days after sealed curing at 20°C for mixtures employing at least 3% by mass CEM I cement. For other mixtures based on fly ash or ggbs (or GBS) containing less than 3% CEM I by dry mass, or activated by lime, 28 day testing shall also apply but sealed curing at 40°C shall be used. In all cases, the specified strength shall mean the minimum based on the average of five specimens every 1000 m^2 with no individual result less than 70% of the minimum average requirement.

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– Part 5: *Hydraulic road binder bound mixtures (HRBBM).*
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– Part 11: *Soil treated by lime (SL).*
– Part 12: *Soil treated by slag (SS).*
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