Interpave

Initial Construction Costs For Various Pavement and Drainage Options

Final

CONTENTS

APPENDICES

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1. OVERVIEW

Scott Wilson have been engaged on behalf of Interpave, The Precast Concrete Paving and Kerb Association, to investigate and compare pavement and drainage construction requirements of a variety of pavement types and their initial construction costs. The extent of pavements under consideration ranged from pedestrian pavements to aircraft pavements, using different surfacing materials and pavement structures for different subgrade conditions. See Table A for a summary of the pavement types and applications.

The next stage of this project is to develop Whole Life Costs for these cases.

Where possible Scott Wilson have used projects that they were originally appointed as the designers. This approach was chosen to give more realistic and accurate designs taking into account typical topography and local drainage requirements.

As these pavement and drainage designs were specific to the original project and based upon certain subgrade soil conditions it was necessary to redesign these pavements in the various pavement types under review within a range of various CBR values. Over 250 different cases were considered in this exercise. Designs and re-designs were undertaken in accordance with current British Standards and/or appropriate design guides. See Appendix 1 for a summary of the design methods and guide documents used.

Appendix 2 details the pavement types and construction requirements over a range of CBR values, for ease of use the costs as detailed in Appendix 3 are reproduced in Appendix 2, alongside the appropriate pavement construction.

The redesigns, in most cases, considers the alternative of using concrete block permeable paving instead of the conventional impermeable pavement and associated surface water drainage system originally used. This includes concrete block paving, concrete flags, and bituminous and concrete construction. In these particular projects the drainage and other associated details have been redesigned to reflect the use of concrete block permeable paving.

2. SUMMARY OF PAVEMENT TYPES AND APPLICATIONS

TABLE A - PAVEMENT TYPE (SURFACING)

Pavement application	Concrete Block Paving	Concrete Flags	Asphalt	RC Concrete	PQC	Permeable Pavements		
						System A*	System B*	System C*
Pedestrian Footpath	✓	✓	✓	✓		✓	✓	✓
Domestic Driveway	✓	✓	✓	✓		✓	✓	✓
Municipal Mall/Plaza	✓	✓	✓	✓		✓	✓	✓
Supermarkets and other Car Parks	✓	✓	✓	✓	✓	✓	✓	✓
Estate Road - Housing	✓		✓	✓	✓	✓	✓	✓
Estate Road - Industrial	✓		✓	✓	✓	✓	✓	✓
Parking for Warehouses	✓		✓	✓	✓	✓	✓	✓
Container Yards	✓		✓	✓	✓			
Airport Airside Pavements	✓		✓	✓	✓			

Note: * System A for subgrade CBR values only greater than 10% * System B for subgrade CBR values only greater than 6%
* System C for subgrade CBR values from 2 to 6%

A summary of the pavement types and layer thicknesses required for each application is contained in Appendix 2

It should be noted that the costs associated with impervious pavements detailed in the Appendices are based upon the use of conventional drainage, the same drainage design being used for all of the impervious pavements, regardless of the pavement type. System A permeable pavements rely wholly on infiltration, so consequently the cost of construction does not include any drainage costs. System B and C permeable pavements require the use of perforated ‘collector’ pipes or Geocomposite fin drains, to collect the water, and carrier drains to remove storm water from the sub-base. These pipes are considerably smaller than would be necessary with a conventional drainage system, as the storage capacity within the sub-base removes the usual drainage requirement to discharge storm water as quickly as possible.

3. THE SCHEMES

1. Small Car Parking scheme – 0.35ha
2. Housing/Light Industrial Access Road scheme – 0.5ha
3. 'Outlet' Retail Car Parking scheme – 5ha
4. Car Storage Compound scheme – 10ha
5. Airport Airside Apron scheme – 2.5ha
6. Dockside container terminal – 26ha

As was stated in the overview, all of the above schemes except scheme 1 were originally designed as conventional impermeable pavements. As one of the fundamental requirements of an impermeable pavement is to shed storm water from the surface of the pavement, the main difference between the redesigned and original pavement reflects the fact that permeable pavements offer optimum performance when laid as flat as possible. As impermeable pavements formed the basis of the original designs, it is probable that rather different designs could have resulted from the use of permeable pavements at the initial design stage. Whilst the topography of a development area has a bearing on the design levels of a site, the creation of suitable falls to large areas of carriageway, parking, or storage plays a major part in determining the ground profile adopted. This then dictates the amount of excavation or imported material necessary. The use of permeable paving is therefore best considered at the earliest stage of any design, as this will be the time when the maximum cost benefits will be derived.

The drainage of large areas of impermeable surface – which in the case of estate roads, for example, could include not only the carriageway, but also any footpaths or domestic driveways – can cause major problems for the designer and developer of new projects, particularly concerning the matter of satisfying the design criteria set out by the Local Authorities and regulators, such as agreeing storm water discharge rates. Again, early consideration should be given to the use of concrete block permeable paving, to minimise the additional measures necessary to comply with these requirements, whether simply discharging to a watercourse or undertaking further surface water management using Sustainable Drainage Systems (SUDS).

There is a possibility that the use of interceptors may not be required for concrete block permeable paving. It is generally agreed that the relatively low levels of contamination arising from vehicles in low speed, car park situations, is of such a level that biodegradation within the sub-base of concrete block permeable paving, by naturally occurring bacteria, will take place well before there is any risk of pollution at the point of discharge. Alternatively there are grounds to propose the use of considerably smaller interceptor units, as the rates of discharge from the sub-base storm water storage areas are significantly lower than those of a normal drainage system. However, it will, be necessary to approach the relevant Local Authorities, and environmental and water authorities on a scheme specific basis, to establish whether they would be in agreement to either proposal.

Scheme 1 - Small Car Parking scheme. This is a project to provide additional car parking, within an existing development in the South West. As a result of increased parking demand, an area that was originally landscaped is now to be paved. The main storm water outfall was already installed as part of the original development. Therefore the additional pavement area could have necessitated the replacement of the outfall. As an alternative, concrete block permeable pavement was used. This removed the requirement to increase the outfall pipe diameter, due to the storm water storage capacity of the permeable pavement construction.

As this scheme was originally designed to be constructed using concrete block permeable paving (System C), the new design details the drainage requirements of impermeable pavements. On this particular project the drainage outfall dimensions remain the same for both permeable and impermeable designs. This is solely due to the fact that steep falls are present within the discharge pipeline. In more normal circumstances the increased area of impermeable pavement drainage system would usually require installation of a larger diameter discharge.

Scheme 2 – Housing/Light Industrial Access Road scheme. In common with a large number of similar developments the original proposed design requires the impermeable asphalt pavement to be shaped to provide satisfactory long-falls for adequate surface water drainage. This results in the forming of summits and valleys along the length of the roads. Gully spacing is, amongst other things, dependant upon the carriageway long-fall, the flatter the fall the greater the number – and hence cost. The use of concrete block permeable pavement not only eliminates potential large numbers of gullies, but also enables the designer to adopt a flat vertical alignment, in many cases reducing the complexity and amount of earthworks necessary. The comments elsewhere concerning discharge pipe diameter and interceptor requirements could also apply in this situation.

The scheme is located in the East Midlands and was originally of impermeable construction, that would also be suitable for use as a design for a light industrial estate road. The vertical alignment as originally designed would require the use of additional pipes, as detailed on drawings HIARD/01/PERM and 02/Perm, for a permeable pavement, as the summits and valleys of the original alignment prevent the use of a single perforated pipe, and dictate the use of an additional carrier drain, albeit of a significantly smaller diameter than the original impermeable design.

HIARD/01/PERM/Alt and 02/PERM/Alt and HIARD/03/PERM details a basic design that would be more suitable for a Permeable Pavement, it replaces the summits and valleys of the original design with a simple straight grade, between the existing carriageway and the proposed outfall, thereby removing the requirement for the additional carrier drain.

The apparent improvements in cost that would result from the more idealistic vertical alignment have not been taken into account in the costing analysis. However, the consequential savings made in the more simple drainage arrangements have.

Scheme 3 – 'Outlet' Retail Car Parking scheme. This is the design of a car park attached to a large retail 'Designer Shopping Mall' in the Northeast of England. The original surface water drainage design collected storm water from the impermeable car park via a linear drainage system and gullies. The access and service roads used gullies and Kerb/Drainage

Units. The retail area pedestrian pavements and the roof water from the premises were also connected to this system.

Whilst the discharge treatment it not considered within the design examples, the cost implications need to be fully considered at an early stage within the design phase. If the storm water that is collected discharges to a public sewer or a watercourse it may be necessary to construct and incorporate within the site limits a storm water storage tank or other facility such as balancing ponds etc, to enable the discharge rate to be regulated to the requirements of the Local Authority and environmental and water authorities. Current thinking suggests that discharge consents may more frequently require that further surface water management using Sustainable Drainage Systems (SUDS) is undertaken prior to discharge. Permeable paving systems have obvious distinct advantages in achieving these aspirations.

The permeable design as detailed on drawings ORCPD/01/PERM to 03 /PERM uses the original vertical alignment for the scheme, and hence requires the use of a large number of collector pipes. This is due to the 'summit and valley' design that is inherent in the original impermeable design to suit a surface water drainage system that relies upon surface gradients to avoid ponding, and to direct surface water to drainage receptors. Additionally a separate system to deal with the roof water may be required. However on the above drawings the roof water is directed into the permeable pavement drainage collector system.

Drawing ORCPD /02/PERM/1 details a more rationalised system that would reflect a drainage design that was geared to permeable paving with a level paved area. For this design the roof/pedestrian area drainage is directed into the permeable paving drainage system. Consequently, the roof water will almost double the water storage requirements of the permeable pavement due to the greater catchment and run off generated. However, due to the inherent water retaining capacity of the graded crushed rock sub-base used in the construction of this type of pavement, it will only be necessary to increase the depth of this layer by a nominal 20mm to give the capacity required for storage. The benefits of this can be seen in the reduced level of drainage infrastructure necessary for this alternative.

Drawing ORCPD /02/PERM/2 again details a rationalised system, geared to permeable paving and a level paved area. On this alternative design the roof/pedestrian area drainage has not been incorporated into the permeable paving drainage system levels and is therefore connected in to a separate carrier drain. As the roof water would be considered 'clean' it should be possible to discharge the pipe without having to connect to an oil interceptor, enabling a smaller interceptor capacity to be used solely for the car park discharge.

Scheme 4 – Car Storage Compound scheme. This is a major Car Manufacturers car storage compound, based in the Midlands. The volume of runoff generated by an impermeable pavement would, as in the original design, require the construction of a suitable storm water collection and storage system. This would then require a suitable outfall; a watercourse, sewer or suitable SUDS surface water management scheme. The use of concrete block permeable paving would eliminate the need for storm water storage – beyond that provided within the sub-base – and where the use of System A or B permeable pavement was permitted, would maintain at least the same level of groundwater replenishment. Arguably, the storage of the storm water within the sub-base would decrease the amount of surface runoff, thereby reducing the surface flow and increasing the flow to groundwater.

The original surface water drainage design collected storm water from the car park via a large capacity linear drainage system and carrier drains. A large diameter pipe that replaces an

existing ditch that runs from the north to the south will be required whichever type of construction is used. The original vertical alignment has been used for the permeable pavement, as the proposed finished vertical profile of the storage areas is equally acceptable for both an impermeable and permeable paving system. Laying the permeable paving system with a flat vertical profile would though, in all probability, make further cost savings in plant, labour and materials.

Scheme 5 – Airport Airside Apron scheme. This is the design of an airside apron at a regional airport in the North West of England. The loading on this area exceeds the maximum currently acceptable for concrete block permeable paving and as a consequence this scheme will not consider this application to this pavement option. SWPE have detailed which construction types are suitable for this type of location, along with pavement designs.

Scheme 6 – Dockside container terminal. This is a Dockside container terminal, in Asia. The loading on this area exceeds the maximum currently acceptable for concrete block permeable paving and as a consequence this scheme will not consider this application to this pavement option. SWPE have detailed which construction types are suitable for this type of location, along with pavement designs.

4. CONSTRUCTION AND BILLING BASIS

Carriageway Construction
The original designs do not include carriageway construction details; these are to be obtained from the appropriate SWPE table. For comparative cost purposes the above schemes are to be considered for the construction types applicable to the pavement application, at a range of CBR values – 2%, 3%, 6%, 10% and 15% - the suitability of a particular pavement construction at a given CBR and/or traffic loading is given in Appendix 2.

Drainage
The drainage system detailed on the original designs, (except scheme 1), is based upon impermeable carriageway construction. This system is to be used on all impermeable construction pavement types without any changes to the design levels.

The three concrete block permeable paving designs, where their use is defined as acceptable in Table 1, are to be used on the alternative designs – drawings labelled 'PERM'. The need for any further drainage is not required on System A, as this design relies on 100% infiltration.

The impermeable drainage design depths, (invert levels), are given on the design drawings along with the drain diameter.

Use of drainage pipes with less than 900mm cover is not normal practice for pavements that carry vehicles. As such it will be necessary to construct perforated pipes at this depth with each permeable pavement option where required. Alternatively a geocomposite fin drain can be used, laid either directly on the prepared formation for System B, or directly on the impermeable membrane for System C.

Gullies detailed on the impermeable pavement shall comply with the requirements of HCD F13.

Kerb Drainage Units shall be as detailed on the scheme drawings.

Catchpits are to be used on all chambers connected to perforated pipes, and are to be constructed as detailed on HCD drawing F11. Carrier Drains are to be provided with Manholes, the construction details of which are to be as HCD drawings F3 to F7, dependant upon depth and pipe diameter.

Pipes are to be Group 15 structured wall thermoplastic perforated pipes and group 14 PVCu carrier drains (Type S bedding – all depths), up to and including 300mm diameter – and medium duty concrete pipes above this diameter. Concrete carrier drain to be System B, granular bed and haunch, up to 2.5m depth of cover, or System A, concrete bed where depth of cover exceeds 2.5m.

Geocomposite Fin Drains for use in System B and C permeable systems shall be Sanddrain 25S, 250mm width, manufactured by ABG Ltd of Meltham, Yorkshire.

Kerbing and Edging
Kerbs are to be provided where the carriageway/parking area abuts a footway or a verge, except where a kerb drainage unit is detailed. Edgings are to be laid to the perimeter of any area of construction not restrained by a kerb or other suitable edge constraint.

Linear Drainage Units shall be as detailed on the scheme drawings

Factors affecting the use of Permeable Pavement

The use of concrete block permeable paving is restricted due to a number of factors, these are primarily; traffic loading, proposed use, subgrade strength and permeability, and topography of the site.

As the maximum approved loading is 5,000kg axle load, use is restricted to sites where this loading will not be exceeded. The Interpave document; 'guide to the design construction and maintenance of concrete block permeable pavements', describes three types of permeable pavements. These are known as Systems A, B and C. This document gives specific guidance on the suitability of different permeable pavement types for given applications.

The subgrade strength is generally linked to the permeability of the subgrade, in that the lower the CBR value the greater the likelihood of a cohesive subgrade. Again System C is the only permissible type of construction when the CBR and permeability is low, System A is only appropriate for use with high CBR and permeability values and System B can be used when the permeability is not sufficient to enable full infiltration, but the subgrade strength and composition is such that it will not be reduced due to the effects of infiltration. The vertical alignment of the original designs relies on long fall and crossfall to channel storm water to the drainage system, whereas the concrete block permeable paving system requires finished levels to be as flat as possible, to maximise storage capacity. The concrete block permeable paving designs assume that the use of the system in these 'non-flat' areas does not have any significant effect on the storage capacity of the system, since if a detailed design was undertaken, the finished levels would reflect this requirement.

5. RESULTS OF COSTING ANALYSIS

1. All rates are net in £ sterling and no allowance has been made for overheads and profit.

2. The rates are for comparative purposes and include an allowance for kerbing and drainage, except for pavement types 8 and 9.

3. No drainage has been allowed for pavement type 2, except for the permeable pavement options Systems B and C

4. The manholes have been measured in accordance with the HCD details. Namely only chamber type 4, 5 and 6 have concrete surround

5. Oil interceptors have been measured for the System B and C permeable pavements for pavement Types 7 and 10. If they were omitted then the rate per square metre for the System B and C permeable payments for pavement type 7 could be reduced by £ 0.26p per square metre and for pavement type 10 by £0.52p per square metre. If a smaller interceptor was used then the rate for payments for pavement type 7 could be reduced by £ 0.22p per square metre and for pavement type 10 by £ 0.45p per square metre.

6. The works have been priced as at 4th quarter 2004.

7. The two permeable options for the Retail Park have been added.

6. LIST OF DRAWINGS

1. Small Car Parking scheme

SCPD/001/PERM	Original Scheme, Drainage Layout
SCPD/001/IMP	Impermeable Pavement, Drainage Layout

2. Housing/Light Industrial Access Road scheme

HIARD/01/IMP	Original Scheme, Drainage Layout 1 of 2
HIARD/02/IMP	Original Scheme, Drainage Layout 2 of 2
HIARD/01/PERM	Permeable Pavement, Drainage Layout 1 of 2
HIARD/02/PERM	Permeable Pavement, Drainage Layout 2 of 2
HIARD/01/PERM/Alt	Permeable Pavement, Drainage Layout 1 of 2
HIARD/02/PERM/Alt	Permeable Pavement, Drainage Layout 2 of 2
HIARD/03/PERM	Alternative Vertical Alignment Long section

3. 'Outlet' Retail Car Parking Scheme

ORCPD/01/IMP	Original Scheme, Drainage Layout 1 of 3
ORCPD /02/IMP	Original Scheme, Drainage Layout 2 of 3
ORCPD /03/IMP	Original Scheme, Drainage Layout 3of 3
ORCPD /01/PERM	Permeable Pavement, Drainage Layout 1 of 3
ORCPD /02/ PERM	Permeable Pavement, Drainage Layout 2 of 3
ORCPD /03/ PERM	Permeable Pavement, Drainage Layout 3 of 3
ORCPD /02/PERM/1	Permeable Pavement, Drainage Layout 2
ORCPD /02/PERM/2	Permeable Pavement, Drainage Layout 3

4. Car Storage Compound Scheme

CSCD/IMP	Original Scheme, Drainage Layout
CSCD/PERM	Permeable Pavement, Drainage Layout

5. Airport Airside Apron scheme

AAAD/IMP	Original Scheme, Drainage Layout

6. Dockside container terminal

PORTD/IMP	Original Scheme, Drainage Layout

7. Standard Details / HA HCD's

F1 to F7, F11 and F13

8. ABG Sanddrain 25S Product sheet

APPENDIX 1 DESIGN REFERENCES – Table 1

TABLE 1
UK DESIGNS FOR TEN PAVEMENT TYPES AND NINE APPLICATIONS
SUMMARY OF DESIGN REFERENCES
(SEE TABLES 2-6 FOR DESIGNS FOUNDED ON SUBGRADE EXHIBITING EQUILIBRIUM CBR VALUES OF 2%, 3%, 6%, 10% & 15%)

Pavement Application	Pavement Types									Assumed Design Traffic / Loading Appropriate to Given Pavement Application (Colour Coded)			
	Concrete Block Paving*	Concrete Flags**		Asphalt	Reinforced Concrete		Pavement Quality Concrete	Permeable Pavements*****					
		On Bedding Sand	On Bedding Mortar		Bars	Fibres		Type A[a] (Total Infiltration)	Type B[b] (Partial Infiltration)	Type C (No Infiltration)				
1) Pedestrian Only Footpaths	BS7533-2 (2001): (Cat IV) - Table 4/5.	BS7533-8: fig 1-3, Table 2.	As no BS exists on Mortared Flag design, guides (DMRB Volume 7 HD39/01) assume no difference between mortar and sand constructions, but a nominal 25mm reduction in sub-base thickness (subject to 100mm minimum) has been allowed here.	DMRB Volume7 HD39/01-Table 3.1.	☒	☒	☒	Interpave(2003) - Guide to Permeable Concrete Block Paving Design p9-16,20.			Given light loading, design based on water retention requirements only. Minimum 150mm Base, increasing to 225mm dependent on rainfall	Assumed pedestrian traffic only i.e. 0msa, 0cv/day, minimum constructions in all designs.		
2) Domestic Driveway (cars only)	BS7533-2 (2001): (Cat IV) - Table 4.	BS7533-8: fig 1-3, Table 2.		Asphalt Information Service - 'Construction and Surfacing of Car Parking Areas including Private Drives' - Table.	No Design Guidance is available, so utilised practical minimum concrete thickness of 125mm (reinforced with polymer mesh) over lowest Sub-base thickness from Asphalt Drive & Reinforced Concrete Car park.	☒	☒	Interpave(2003) - Guide to Permeable Concrete Block Paving Design p9-16,20.			Given light loading, design based on water retention requirements only. Minimum 150mm Base, increasing to 225mm dependent on rainfall	Category IV - 'Private Drives' - assumes no cv. traffic.	Design for 0-0.0002msa is same, private drives would be unlikely to experience greater than 0.0002msa in their design life.	Assumes 'light usage e.g. private drives'
3) Municipal Mall / Plaza (Light Vehicle Overrun Only)	BS7533-2 (2001): (Cat IIIb) - Table 4.	BS7533-8: fig 1-3, Table 2.		DMRB Volume7 HD39/01-Table 3.3.	☒	☒	☒	Interpave(2003) - Guide to Permeable Concrete Block Paving Design p9-16,20.			Assumes Factored Load of 1400kg	Category IIIb - 'Footways to be over-ridden by no more than occasional vehicular traffic'	From Table 2 assume 'Small shopping areas' (5CV/day) =0.045msa	Table 3.3 -'light vehicle design with only occasional Vehicle overrun'
4) Car Parks (Cars Only)	BS7533-2 (2001): (Cat IIIb) - Table 4.	☒	☒	Asphalt Information Service - 'Construction and Surfacing of Car Parking Areas including Private Drives'.	Road Note 29 (1970) - Figure 6 & 8	☒	Road Note 29 (1970) - Figure 6 & 8	Interpave(2003) - Guide to Permeable Concrete Block Paving Design p9-16,20.			Assumes Factored Load of 2000kg	Category IIIb - 'Car parks receiving no heavy traffic'	Assumes Failure Traffic <=0.01msa****	Public car parks ... with stray use of heavier vehicles'
5) Estate Roads (Housing)	BS7533-2 (2001): (Cat II) - Table 4.	☒	☒	Road Note 29 (1970) - Figure 6 & 8	Road Note 29 (1970) - Figure 6 & 8	☒	Road Note 29 (1970) - Figure 6 & 8	Interpave(2003) - 'Guide to Permeable Concrete Block Paving Design' - p9-16,20.			Assumes Factored Load of 7000kg	Category II - 'Roads less than 0.5msa'	Assumes Failure Traffic of 0.1msa****	
6) Estate Roads (Commercial / Light Industrial)	BS7533-1 (2001): (Cat I) Figure2-3.	☒	☒	DMRB Volume7 HD26/01-Figure 2.2.	DMRB Volume7 HD26/01-Figure 2.4.	☒	DMRB Volume7 HD26/01-Figure 2.4.	Interpave(2003) - Guide to Permeable Concrete Block Paving Design p9-16,20.			Assumes Factored Load of 8000kg	Category I - 'Roads between 0.5 and 12msa' (assuming 5000m² commercial / 500sa construction traffic)	Assumes Minimum Highway design (1.0msa to 'Intervention' Criteria)****	
7) Car Parks (Subject to Commercial Vehicle Trafficking)	BS7533-2 (2001): (Cat II) - Table 4.	☒	☒	Asphalt Information Service - 'Construction and Surfacing of Parking Areas for Medium and Heavyweight Vehicles'. Tables 1-2	Road Note 29 (1970) - Figure 6 & 8	☒	Road Note 29 (1970) - Figure 6 & 8	Interpave(2003) - Guide to Permeable Concrete Block Paving Design p9-16,20.			Assumes Factored Load of 10000kg	Category II - 'Car parks receiving occasional heavy traffic'	Assumes Failure traffic of 0.5msa****	'Medium weight lorries'
8) Container Yards (Trucks, Container Moving Equipment)	Interpave(1996) - 'The Structural Design of Heavy Duty Pavements for Ports And Other Industries' - Table 10,19 & figs. Surfacing reduces calculated C10 base thickness in accordance with Table 4.2 of 2nd Edition.	☒	☒	Interpave(1996) - 'The Structural Design of Heavy Duty Pavements for Ports And Other Industries' - Table 10,19 & figs. Surfacing reduces calculated C10 base thickness in accordance with Table 4.2 of 2nd Edition.	Interpave(1996) - 'The Structural Design of Heavy Duty Pavements for Ports And Other Industries' - Table 10,19 & figs.	Interpave(1996) - 'The Structural Design of Heavy Duty Pavements for Ports And Other Industries' - Table 10,19 & figs. (Fibres detailed for C30 or C40 concrete only)	Interpave(1996) - 'The Structural Design of Heavy Duty Pavements for Ports And Other Industries' - Table 10,19 & figs.	☒	☒	☒	Assumes 20 year design incorporating 4.7million movements of Linde Lansing straddle carrier (C4130TL/5 - Design Load 592kN) with 20 ton Containers stacked up to 5 high. Surfacing considered to contribute to the pavement strength.			
9) Airport Airside Pavements	CAA Paper 96001- 'The Use of Pavers for Aircraft Pavements' - Chapter 3, PSA Guide(1989) - Chart 4 (for 2%CBR design see also PSA Guide fig5-6a)	☒	☒	CAA Paper 96001- 'PSA Guide to Airfield Pavement Design and Evaluation' - Chapter 4,6 & Chart 4 (for 2%CBR design see also PSA Guide fig5-6a)	CAA Paper 96001- 'PSA Guide to Airfield Pavement Design and Evaluation' - Chapter 4-5 & Chart 2- *** (for 2%CBR design see also PSA Guide fig5-6a)	☒	CAA Paper 96001- 'PSA Guide to Airfield Pavement Design and Evaluation' - Chapter 4-5 & Chart 2- As (See Design Extracts Appendix p15,17,19***) (for 2%CBR design see also PSA Guide fig5-6a)	☒	☒	☒	Assumes (medium trafficking) 20 year design incorporating up to 100,000 coverages of Airbus A320 with dual gear			

KEY:-
*- Blocks are specified to BS6717:2001
**-Designs Assume Designation 'G' (300x300x60)mm slabs as per BS7263-1:2001. Use of thicker slabs may allow a slight reduction in sub-base thickness.
***- PSA rigid airport pavement design specifies Modulus of Subgrade Reaction (k) for rigid pavements instead of CBR as a measure of subgrade quality. There is no fixed relationship between k and CBR, so it has been assumed that the rigid and flexible ACN bandings for high, medium, low and very low quality subgrade are approximately equivalent (Ref: PSA table 2.1)
i.e. 15%CBR=Ultra High, 10%=Medium, 6%=Low, 3%=Ultra Low
****- Road Note 29 designs are based on end 'failure' criteria of extensive cracking and / or rutting >20mm, DMRB volume 7 designs are based on 'investigatory' criteria described as the onset of cracking and / or rutting >10mm for flexible designs and failure of 30% of bays for rigid designs. Foundation design in accordance with volume 7 HD25/94 (appropriate for an equivalent of 1000 passes of an 8 tonne construction vehicle axle load before significant structural rutting).
*****- Interpave Guide advises to "seek details from member companies regarding permeable paving blocks". The current thinking is that 80mm blocks should be used.
a- Type A (Total infiltration) designs only available for CBRs of 10%+ as a result of relationship between CBR and k value.
b- Type B (Partial infiltration) designs only available for CBRs of 6%+ as a result of relationship between CBR and k value.
☒ - Inappropriate Pavement Type for given Applications and / or no widely accepted UK design guidance.

APPENDIX 2 PAVEMENT THICKNESS CHARTS – Table 2 to 6

TABLE 2

UK DESIGNS FOR TEN PAVEMENT TYPES AND NINE APPLICATIONS
SUBGRADE CBR = 2%[6] (ASSUMES DESIGN PERMEABILITY 'k' VALUE OF 10^{-9}m/s FOR PERMEABLE PAVEMENTS)

Pavement Application[1]	Pavement Types									
	Concrete Block Paving	Concrete Flags		Asphalt	Reinforced Concrete		Pavement Quality Concrete	Permeable Pavements[4]		
		On Bedding Sand	On Bedding Mortar		Bars	Fibres		Type A (Total Infiltration)	Type B (Partial Infiltration)	Type C (No Infiltration)
1) Pedestrian Only Footpaths	50mm Pavers 50mm Bedding Sand 200mm Sub-base[2*]	60mm Flags 30mm Bedding Sand 100mm Sub-base	60mm Flags 30mm Bedding Sand 100mm Sub-base	20mm Surface Course 40mm Base Course 100mm Sub-base						80mm Permeable Pavers 50mm Bedding Aggregate 150-225mm Open Graded Crushed Rock Impervious Membrane
2) Domestic Driveway (cars only)	50mm Pavers 50mm Bedding Sand 200mm Sub-base[2*] GSM	60mm Flags 30mm Bedding Sand 100mm Sub-base	60mm Flags 30mm Bedding Sand 100mm Sub-base	20mm Surface Course 60mm Base Course 150mm Sub-base	125mm Reinforced (Polymer grid) Pavement Quality Concrete 150mm Sub-base					80mm Permeable Pavers 50mm Bedding Aggregate 150-225mm Open Graded Crushed Rock Impervious Membrane
3) Municipal Mall / Plaza (Light Vehicle Overrun Only)	50mm Pavers 50mm Bedding Sand 300mm Sub-base GSM	60mm Flags 30mm Bedding Sand 400mm Sub-base	60mm Flags 30mm Bedding Sand 375mm Sub-base	20mm Surface Course 50mm Base Course 225mm Sub-base						80mm Permeable Pavers 50mm Bedding Aggregate 550mm Open Graded Crushed Rock Impervious Membrane
4) Car Parks (Cars Only)	50mm Pavers 50mm Bedding Sand 300mm Sub-base GSM			30mm Surface Course 60mm Basecourse 350mm Sub-base [7]	125mm Jointed (15m bays), Reinforced (2.61kg/m^3) Pavement Quality Concrete 350mm Sub-base [7]		150mm Jointed (5m bays), Unreinforced Pavement Quality Concrete 350mm Sub-base [7]			80mm Permeable Pavers 50mm Bedding Aggregate 600mm Open Graded Crushed Rock Impervious Membrane
5) Estate Roads (Housing)	60mm Pavers 30mm Bedding Sand 125mm CBM 2 Base[3] 400mm Sub-base GSM			40mm Surface course 80mm Basecourse 350mm Sub-base [7]	140mm Jointed (15m bays), Reinforced (2.61kg/m^3) Pavement Quality Concrete 350mm Sub-base [7]		160mm Jointed (5m bays), Unreinforced Pavement Quality Concrete 350mm Sub-base [7]			80mm Permeable Pavers 50mm Bedding Aggregate 125mm Cement Stabilised Crushed Rock 500mm Open Graded Crushed Rock Impervious Membrane
6) Estate Roads (Commercial / Light Industrial)***	50mm Pavers 30mm Bedding Sand 130mm CBM 2 Base[3] 150mm Sub-base GSM 470mm Capping			30mm Surface Course 50mm Basecourse 70mm Roadbase 350mm Sub-base [7]	150mm Jointed (25m bays), Reinforced (500mm^2/m), Pavement Quality Concrete 350mm Sub-base [7]		150mm Jointed** (5m bays), Unreinforced Pavement Quality Concrete 350mm Sub-base [7]			80mm Permeable Pavers 50mm Bedding Aggregate 150mm Cement Stabilised Crushed Rock 500mm Open Graded Crushed Rock Impervious Membrane
7) Car Parks (Subject to Commercial Vehicle Trafficking)***	60mm Pavers 30mm Bedding Sand 125mm CBM 2 Base[3] 400mm Sub-base GSM			30mm Surface Course 60mm Basecourse 100mm Roadbase 350mm Sub-base [7]	160mm Jointed (15m bays), Reinforced (2.61kg/m^3) Pavement Quality Concrete 350mm Sub-base [7] laid in 15x5m Bays		170mm Jointed (5m bays), Unreinforced Pavement Quality Concrete 350mm Sub-base [7]			80mm Permeable Pavers 50mm Bedding Aggregate 200mm Cement Stabilised Crushed Rock 500mm Open Graded Crushed Rock Impervious Membrane
8) Container Yards (Trucks, Container Moving Equipment)	80mm Pavers 30mm Bedding Sand 560mm C10 base[8] 150mm Sub-base 350mm Capping			40mm Surface Course[5] 60mm Basecourse 580mm C10 base[9] 150mm Sub-base 350mm Capping	Thicknesses as shown for 'Pavement Quality Concrete', with A393 mesh reinforcement at the top and bottom of the slab (C40 bays 6m x 15m)		440mm C40 base 150mm Sub-base 350mm Capping (C40 bays 6m x 6m)			
9) Airport Airside Pavements	80mm Pavers 30mm Bedding Sand 725mm BBM 400mm 15%CBR Capping			Interpave(1996) - 'The Structural Design of Heavy Duty Pavements for Ports And Other Industries' - Table 10,19 & figs. Surfacing reduces calculated C10 base thickness in accordance with Table 4.2 of 2nd Edition.	Thicknesses as unreinforced, with minimum 163mm^2 of steel / m cross-section of concrete. No increase in bay size permitted by PSA Guide.		325mm C40 Concrete 150mm Rolled Drylean Concrete 400mm 15%CBR Capping Laid in 6x6m bays			

Definitions:-
Capping- e.g. graded material other than unburnt colliery spoil argillaceous rock or chalk.
Sub-base- TYPE 1 granular sub-base material.
Open Graded Crushed Rock - Sub-base material with grading as defined in Interpave - 'Guide to Permeable Concrete Block Paving Design' - Table 9.
Surface Course- SMA type surface course. 30mm surface course can be replaced by 40mm surface course and vice versa, provided the overall asphalt thickness shown does not change (i.e. increase or reduce the base course or base layer by 10mm in compensation respectively).
BBM - Bound Base Material (typically 1/3 Bituminous Material aver 2/3 Lean Concrete with an assumed effective stiffness of 1200MPa.)
C10 - Grade 10 Concrete
C40 - Grade 40 Concrete
Basecourse - 50pen Dense Bitumen Macadam base layer
Roadbase - 50pen Dense Bitumen Macadam base layer
GSM - Geotextile Separating Membrane.

Notes:-
1- Pavements constructed over frost-susceptible soils or capping should (typically in UK) have an overall thickness of non frost-susceptible material of not less than 450mm.
2- '1' condition does not apply.
3- CBM 2 base can be replaced with similar thickness of CBM1a or DBM100. If DBM50 is used, thicknesses can be reduced by 15%.
4- Manufacture controls can be assumed to be tight, so material safety factor of 1.1 for open graded crushed rock has been removed; Where variability is permitted in base material thickness, it is a function of regional precipitation levels. (see 'Guide to permeable Concrete Block Paving Design' - Table 4.)
5- Flexible surfacing materials should be chosen with caution with respect to their deformation resistance properties.
6- There may be long term settlement issues for soils with very low bearing capacities, particularly with pavements subject to static loading
7- 350mm sub-base can be replaced by 150mm sub-base and 450mm capping
8- Pavers and Sand allow a reduction in the C10 base thickness from 680mm to 560mm.
9- Asphalt surfacing allows a reduction in the C10 base thickness from 680mm to 580mm.

Anomalies:-
*- Sub-base thickness specified by BS7533 can differ considerably from thicknesses specified for other pavement types. Sub-base thickness for BS design does vary with CBR however, unlike other pavement types.
**- Decrease in Concrete thickness for Application 6 as a result of change in design guidance. In order to create an increase in construction thickness here, an unfeasible (in the context of other pavement types) traffic level of >8msa would have to be adopted.
***- Non-increase in Concrete Block Paving construction thickness between Applications 6 and 7 is not easily resolvable as a result of comparing different design approaches. Changing trafficking category would have a knock-on effect, and would cause discontinuities with designs in other pavement types.

TABLE 3

UK DESIGNS FOR TEN PAVEMENT TYPES AND NINE APPLICATIONS

SUBGRADE CBR = 3% (ASSUMES DESIGN PERMEABILITY 'k' VALUE OF 10^{-8}m/s FOR PERMEABLE PAVEMENTS)

Pavement Application[1]	Pavement Types									
	Concrete Block Paving	Concrete Flags		Asphalt	Reinforced Concrete		Pavement Quality Concrete	Permeable Pavements[4]		
		On Bedding Sand	On Bedding Mortar		Bars	Fibres		Type A	Type B	Type C
1) Pedestrian Only Footpaths	50mm Pavers 50mm Bedding Sand 150mm Sub-base[2]	60mm Flags 30mm Bedding Sand 100mm sub-base	60mm Flags 30mm Bedding Sand 100mm sub-base	20mm Surface Course 40mm Basecourse 100mm Sub-base						80mm Permeable Pavers 50mm Bedding Aggregate 150-225mm Open Graded Crushed Rock Impervious Membrane
2) Domestic Driveway (cars only)	50mm Pavers 50mm Bedding Sand 150mm Sub-base[2]	60mm Flags 30mm Bedding Sand 100mm sub-base	60mm Flags 30mm Bedding Sand 100mm sub-base	20mm Surface Course 60mm Base Course 150mm Sub-base	125mm Reinforced (Polymer grid) Pavement Quality Concrete 150mm Sub-base					80mm Permeable Pavers 50mm Bedding Aggregate 150-225mm Open Graded Crushed Rock Impervious Membrane
3) Municipal Mall / Plaza (Light Vehicle Overrun Only)	50mm Pavers 50mm Bedding Sand 250mm Sub-base	60mm Flags 30mm Bedding Sand 325mm sub-base	60mm Flags 30mm Bedding Sand 300mm sub-base	20mm Surface Course 50mm Basecourse 150mm Sub-base						80mm Permeable Pavers 50mm Bedding Aggregate 450mm Open Graded Crushed Rock Impervious Membrane
4) Car Parks (Cars Only)	50mm Pavers 50mm Bedding Sand 250mm Sub-base			30mm Surface Course 60mm Basecourse 300mm Sub-base[6]	125mm Jointed (15x15m bays), Reinforced (2.61kg/m^3) Pavement Quality Concrete 300mm Sub-base[6]		150mm Jointed (5m bays), Unreinforced Pavement Quality Concrete 300mm Sub-base[6]			80mm Permeable Pavers 50mm Bedding Aggregate 500mm Open Graded Crushed Rock Impervious Membrane
5) Estate Roads (Housing)	60mm Pavers 30mm Bedding Sand 125mm CBM 2 Base[3] 350mm Sub-base			40mm Surface course 80mm Basecourse 300mm Sub-base[6]	140mm Jointed (15x15m bays), Reinforced (2.61kg/m3) Pavement Quality Concrete 300mm Sub-base[6]		160mm Jointed (5m bays), Unreinforced Pavement Quality Concrete 300mm Sub-base[6]			80mm Permeable Pavers 50mm Bedding Aggregate 125mm Cement Stabilised Crushed Rock 400mm Open Graded Crushed Rock Impervious Membrane
6) Estate Roads (Commercial / Light Industrial)***	50mm Pavers 30mm Bedding Sand 130mm CBM 2 Base[3] 270mm Sub-base GSM			30mm Surface Course 50mm Basecourse 70mm Roadbase 300mm Sub-base[6]	150mm Jointed (25m bays), Reinforced (500mm^2/m), Concrete 300mm Sub-base[6]		150mm Jointed** (5m bays), Unreinforced Pavement Quality Concrete 300mm Sub-base[6]			80mm Permeable Pavers 50mm Bedding Aggregate 150mm Cement Stabilised Crushed Rock 400mm Open Graded Crushed Rock Impervious Membrane
7) Car Parks (Subject to Commercial Vehicle Trafficking)***	60mm Pavers 30mm Bedding Sand 125mm CBM 2 Base[3] 350mm Sub-base			30mm Surface Course 60mm Basecourse 100mm Roadbase 300mm Sub-base[6]	160mm Jointed (15m bays), Reinforced (2.61kg/m^3) Pavement Quality Concrete 300mm Sub-base[6]		170mm Pavement Quality Concrete 300mm Sub-base[6] placed in 5m bays			80mm Permeable Pavers 50mm Bedding Aggregate 200mm Cement Stabilised Crushed Rock 400mm Open Graded Crushed Rock Impervious Membrane
8) Container Yards (Trucks, Container Moving Equipment)	80mm Pavers 30mm Bedding Sand 560mm C10 base[8] 150mm Sub-base 250mm Capping			40mm Surface Course[5] 60mm Basecourse 580mm C10 base[9] 150mm Sub-base 250mm Capping	Thicknesses as shown for 'Pavement Quality Concrete', with A393 mesh reinforcement at the top and bottom of the slab (C40 bays 6m x 15m)		440mm C40 base 150mm Sub-base 250mm Capping (C40 bays 6m x 6m)			
9) Airport Airside Pavements	80mm Pavers 30mm Bedding Sand 725mm Basecourse			Interpave(1996) - 'The Structural Design of Heavy Duty Pavements for Ports And Other Industries' - Table 10,19 & figs. Surfacing reduces calculated C10 base thickness in accordance with Table 4.2 of 2nd Edition.	Thicknesses as unreinforced, with minimum 163mm^2 of steel / m cross-section of concrete. No increase in bay size permitted by PSA Guide.		325mm C40 Concrete 150mm Rolled Drylean Concrete Laid in 6x6m bays			

Definitions:-

Capping- e.g. graded material other than unburnt colliery spoil argillaceous rock or chalk.
Sub-base- TYPE 1 granular sub-base material.
Open Graded Crushed Rock - Sub-base material with grading as defined in Interpave - 'Guide to Permeable Concrete Block Paving Design' - Table 9.
Surface Course- SMA- type surface course. 30mm surface course can be replaced by 40mm surface course and vice versa, provided the overall asphalt thickness shown does not change (i.e. increase or reduce the base course or base layer by 10mm in compensation respectively).
BBM - Bound Base Material (typically 1/3 Bituminous Material aver 2/3 Lean Concrete with an assumed effective stiffness of 1200MPa.)
C10 - Grade 10 Concrete
C40 - Grade 40 Concrete
Basecourse - 50pen Dense Bitumen Macadam base layer
Roadbase - 50pen Dense Bitumen Macadam base layer
GSM - Geotextile Separating Membrane.

Notes:-

1- Pavements constructed over frost-susceptible soils or capping should (typically in UK)have an overall thickness of non frost-susceptible material of not less than 450mm.
2- '1' condition does not apply.
3- CBM 2 base can be replaced with similar thickness of CBM1a or DBM100. If DBM50 is used, thicknesses can be reduced by 15%.
4- Manufacture controls can be assumed to be tight, so material safety factor of 1.1 for open graded crushed rock has been removed; Where variability is permitted in base material thickness, it is a function of regional precipitation levels. (see 'Guide to permeable Concrete Block Paving Design' - Table 4.)
5- Flexible surfacing materials should be chosen with caution with respect to their deformation resistance properties.
6- 300mm sub-base can be replaced by 150mm sub-base and 350mm capping.
7- Not used
8- Pavers and Sand allow a reduction in the C10 base thickness from 680mm to 560mm.
9- Asphalt surfacing allows a reduction in the C10 base thickness from 680mm to 580mm.

Anomalies:-

*- Sub-base thickness specified by BS7533 can differ considerably from thicknesses specified for other pavement types. Sub-base thickness for BS design does vary with CBR however, unlike other pavement types.
**- Decrease in construction thickness as a result of change in design guidance. In order to create an increase in construction thickness here, an unfeasible (in the context of other pavement types) traffic level of >8msa would have to be adopted.
***- Non-increase in Concrete Block Paving construction thickness between Applications 6 and 7 is not easily resolvable as a result of comparing different design approaches. Changing trafficking category would have a knock-on effect, and would cause discontinuities with designs in other pavement types.

TABLE 4

UK DESIGNS FOR TEN PAVEMENT TYPES AND NINE APPLICATIONS
SUBGRADE CBR = 6% (ASSUMES DESIGN PERMEABILITY 'k' VALUE OF 10^{-7}m/s FOR PERMEABLE PAVEMENTS)

Pavement Application[1]	Pavement Types									
	Concrete Block Paving	Concrete Flags		Asphalt	Reinforced Concrete		Pavement Quality Concrete	Permeable Pavements[4]		
		On Bedding Sand	On Bedding Mortar		Bars	Fibres		Type A	Type B	Type C
1) Pedestrian Only Footpaths	50mm Pavers 50mm Bedding Sand[2]	60mm Flags 30mm Bedding Sand 100mm sub-base	60mm Flags 30mm Bedding Sand 100mm sub-base	20mm Surface Course 40mm Base Course 100mm Sub-base					80mm Permeable Pavers 50mm Bedding Aggregate 150-225mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 150-225mm Open Graded Crushed Rock Impervious Membrane
2) Domestic Driveway (cars only)	50mm Pavers 50mm Bedding Sand[2]	60mm Flags 30mm Bedding Sand 100mm sub-base	60mm Flags 30mm Bedding Sand 100mm sub-base	20mm Surface Course 60mm Base Course 150mm Sub-base	125mm Reinforced (Polymer grid) Pavement Quality Concrete 120mm Sub-base				80mm Permeable Pavers 50mm Bedding Aggregate 150-225mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 150-225mm Open Graded Crushed Rock Impervious Membrane
3) Municipal Mall / Plaza (Light Vehicle Overrun Only)	50mm Pavers 50mm Bedding Sand 100mm Sub-base	60mm Flags 30mm Bedding Sand 175mm sub-base	60mm Flags 30mm Bedding Sand 150mm sub-base	20mm Surface Course 50mm Base Course 150mm Sub-base					80mm Permeable Pavers 50mm Bedding Aggregate 200-225mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 200-225mm Open Graded Crushed Rock Impervious Membrane
4) Car Parks (Cars Only)	50mm Pavers 50mm Bedding Sand 100mm Sub-base			30mm Surface Course 60mm Basecourse 200mm Sub-base	125mm Jointed (15m bays), Reinforced (2.61kg/m^3) Pavement Quality Concrete 210mm Sub-base		150mm Jointed (5m bays), Unreinforced Pavement Quality Concrete 210mm Sub-base		80mm Permeable Pavers 50mm Bedding Aggregate 250mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 250mm Open Graded Crushed Rock Impervious Membrane
5) Estate Roads (Housing)	60mm Pavers 30mm Bedding Sand 125mm CBM 2 Base[3] 150mm Sub-base			40mm Surface course 80mm Basecourse 210mm Sub-base	140mm Jointed (15m bays), Reinforced (2.61kg/m^3) Pavement Quality Concrete 210mm Sub-base		160mm Jointed (5m bays), Unreinforced Pavement Quality Concrete 210mm Sub-base		80mm Permeable Pavers 50mm Bedding Aggregate 125mm Cement Stabilised Crushed Rock 50-100mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 125mm Cement Stabilised Crushed Rock 50-100mm Open Graded Crushed Rock Impervious Membrane
6) Estate Roads (Commercial / Light Industrial)***	50mm Pavers 30mm Bedding Sand 130mm CBM 2 Base[3] 200mm Sub-base			30mm Surface Course 50mm Basecourse 70mm Roadbase 210mm Sub-base	150mm Jointed (25m bays), Reinforced (500mm2/m), Concrete 210mm Sub-base		150mm Jointed** (5m bays), Unreinforced Pavement Quality Concrete 210mm Sub-base		80mm Permeable Pavers 50mm Bedding Aggregate 150mm Cement Stabilised Crushed Rock 50-75mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 150mm Cement Stabilised Crushed Rock 50-75mm Open Graded Crushed Rock Impervious Membrane
7) Car Parks (Subject to Commercial Vehicle Trafficking)***	60mm Pavers 30mm Bedding Sand 125mm CBM 2 Base[3] 150mm Sub-base			30mm Surface Course 60mm Basecourse 100mm Roadbase 210mm Sub-base	160mm Jointed (15m bays), Reinforced (2.61kg/m^3) Pavement Quality Concrete 210mm Sub-base		170mm Pavement Quality Concrete 210mm Sub-base Placed in 5m bays		80mm Permeable Pavers 50mm Bedding Aggregate 220mm Cement Stabilised Crushed Rock 50-75mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 220mm Cement Stabilised Crushed Rock 50-75mm Open Graded Crushed Rock Impervious Membrane
8) Container Yards (Trucks, Container Moving Equipment)	80mm Pavers 30mm Bedding Sand 560mm C10 base[8] 225mm Sub-base			40mm Surface Course[5] 60mm Basecourse 580mm C10 base[9] 225mm Sub-base	Thicknesses as shown for 'Pavement Quality Concrete', with A393 mesh reinforcement at the top and bottom of the slab (C40 bays 6m x 15m)		440mm C40 base 225mm Sub-base (C40 bays 6m x 6m)			
9) Airport Airside Pavements	80mm Pavers 30mm Bedding Sand 525mm BBM			Interpave(1996) - 'The Structural Design of Heavy Duty Pavements for Ports And Other Industries' - Table 10,19 & figs. Surfacing reduces calculated C10 base thickness in accordance with Table 4.2 of 2nd Edition.	Thicknesses as unreinforced, with minimum 163mm^2 of steel / m cross-section of concrete. No increase in bay size permitted by PSA Guide.		325mm C40 Concrete 150mm Rolled Drylean Concrete Laid in 6x6m bays			

Definitions:-
Sub-base- TYPE 1 granular sub-base material.
Open Graded Crushed Rock - Sub-base material with grading as defined in Interpave - 'Guide to Permeable Concrete Block Paving Design' - Table 9.
Surface Course- SMA- type surface course. 30mm surface course can be replaced by 40mm surface course and vice versa, provided the overall asphalt thickness shown does not change (i.e. increase or reduce the base course or base layer by 10mm in compensation respectively).
BBM - Bound Base Material (typically 1/3 Bituminous Material aver 2/3 Lean Concrete with an assumed effective stiffness of 1200MPa.)
C10 - Grade 10 Concrete
C40 - Grade 40 Concrete
Basecourse - 50pen Dense Bitumen Macadam base layer
Roadbase - 50pen Dense Bitumen Macadam base layer
GSM - Geotextile Separating Membrane.

Notes:-
1- Pavements constructed over frost-susceptible soils or capping should (typically in UK) have an overall thickness of non frost-susceptible material of not less than 450mm.
2- '1' condition does not apply.
3- CBM 2 base can be replaced with similar thickness of CBM1a or DBM100. If DBM50 is used, thicknesses can be reduced by 15%.
4- Manufacture controls can be assumed to be tight, so material safety factor of 1.1 for open graded crushed rock has been removed; Where variability is permitted in base material thickness, it is a function of regional precipitation levels. (see 'Guide to permeable Concrete Block Paving Design' - Table 4.)
5- Flexible surfacing materials should be chosen with caution with respect to their deformation resistance properties.
6- Not used
7- Not used
8- Pavers and Sand allow a reduction in the C10 base thickness from 680mm to 560mm.
9- Asphalt surfacing allows a reduction in the C10 base thickness from 680mm to 580mm.

Anomalies:-
*- Sub-base thickness specified by BS7533 can differ considerably from thicknesses specified for other pavement types. Sub-base thickness for BS design does vary with CBR however, unlike other pavement types.
**- Decrease in construction thickness as a result of change in design guidance. In order to create an increase in construction thickness here, an unfeasible (in the context of other pavement types) traffic level of >8msa would have to be adopted.
***- Non-increase in Concrete Block Paving construction thickness between Applications 6 and 7 is not easily resolvable as a result of comparing different design approaches. Changing trafficking category would have a knock-on effect, and would cause discontinuities with designs in other pavement types.

TABLE 5

UK DESIGNS FOR TEN PAVEMENT TYPES AND NINE APPLICATIONS
SUBGRADE CBR = 10% (ASSUMES DESIGN PERMEABILITY 'k' VALUE OF 10^{-6}m/s FOR PERMEABLE PAVEMENTS)

Pavement Application[1]	Pavement Types									
	Concrete Block Paving	Concrete Flags		Asphalt	Reinforced Concrete		Pavement Quality Concrete	Permeable Pavements[4]		
		On Bedding Sand	On Bedding Mortar		Bars	Fibres		Type A	Type B	Type C
1) Pedestrian Only Footpaths	50mm Pavers 50mm Bedding Sand[2]	60mm Flags 30mm Bedding Sand 100mm sub-base	60mm Flags 30mm Bedding Sand 100mm sub-base	20mm Surface Course 40mm Basecourse 100mm Sub-base				80mm Permeable Pavers 50mm Bedding Aggregate 150-225mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 150-225mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 150-225mm Open Graded Crushed Rock Impervious Membrane
2) Domestic Driveway (cars only)	50mm Pavers 50mm Bedding Sand[2]	60mm Flags 30mm Bedding Sand 100mm sub-base	60mm Flags 30mm Bedding Sand 100mm sub-base	20mm Surface Course 60mm Base Course 150mm Sub-base	125mm Reinforced (Polymer grid) Pavement Quality Concrete 80mm Sub-base			80mm Permeable Pavers 50mm Bedding Aggregate 150-225mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 150-225mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 150-225mm Open Graded Crushed Rock Impervious Membrane
3) Municipal Mall / Plaza (Light Vehicle Overrun Only)	50mm Pavers 50mm Bedding Sand 100mm Sub-base	60mm Flags 30mm Bedding Sand 150mm sub-base	60mm Flags 30mm Bedding Sand 125mm sub-base	20mm Surface Course 50mm Basecourse 150mm Sub-base				80mm Permeable Pavers 50mm Bedding Aggregate 200-225mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 200-225mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 200-225mm Open Graded Crushed Rock Impervious Membrane
4) Car Parks (Cars Only)	50mm Pavers 50mm Bedding Sand 100mm Sub-base			40mm Surface Course 60mm Basecourse 170mm Sub-base	125mm Jointed (15m bays), Reinforced (2.61kg/m^3) Pavement Quality Concrete 170mm Sub-base		150mm Jointed (5m bays), Unreinforced Pavement Quality Concrete 170mm Sub-base	80mm Permeable Pavers 50mm Bedding Aggregate 250mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 250mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 250mm Open Graded Crushed Rock Impervious Membrane
5) Estate Roads (Housing)	60mm Pavers 30mm Bedding Sand 125mm CBM 2 Base[3] 150mm Sub-base			40mm Surface course 80mm Basecourse 170mm Sub-base	140mm Jointed (15m bays), Reinforced (2.61kg/m3) Pavement Quality Concrete 170mm Sub-base		160mm Jointed (5m bays), Unreinforced Pavement Quality Concrete 170mm Sub-base	80mm Permeable Pavers 50mm Bedding Aggregate 125mm Cement Stabilised Crushed Rock 50-100mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 125mm Cement Stabilised Crushed Rock 50-100mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 125mm Cement Stabilised Crushed Rock 50-100mm Open Graded Crushed Rock Impervious Membrane
6) Estate Roads (Commercial / Light Industrial)***	50mm Pavers 30mm Bedding Sand 130mm CBM 2 Base[3] 160mm Sub-base			30mm Surface Course 50mm Basecourse 70mm Roadbase 170mm Sub-base	150mm Jointed (25m bays), Reinforced (500mm^2/m), Concrete 170mm Sub-base		150mm Jointed** (5m bays), Unreinforced Pavement Quality Concrete 170mm Sub-base	80mm Permeable Pavers 50mm Bedding Aggregate 150mm Cement Stabilised Crushed Rock 50-75mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 150mm Cement Stabilised Crushed Rock 50-75mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 150mm Cement Stabilised Crushed Rock 50-75mm Open Graded Crushed Rock Impervious Membrane
7) Car Parks (Subject to Commercial Vehicle Trafficking)***	60mm Pavers 30mm Bedding Sand 125mm CBM 2 Base[3] 150mm Sub-base			30mm Surface Course 60mm Basecourse 100mm Roadbase 170mm Sub-base	160mm Jointed (15m bays), Reinforced (2.61kg/m^3) Pavement Quality Concrete 170mm Sub-base		170mm Pavement Quality Concrete 170mm Sub-base Placed in 5m bays	80mm Permeable Pavers 50mm Bedding Aggregate 220mm Cement Stabilised Crushed Rock 50-75mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 220mm Cement Stabilised Crushed Rock 50-75mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 220mm Cement Stabilised Crushed Rock 50-75mm Open Graded Crushed Rock Impervious Membrane
8) Container Yards (Trucks, Container Moving Equipment)	80mm Pavers 30mm Bedding Sand 560mm C10 base[6] 150mm Sub-base			40mm Surface Course[5] 60mm Basecourse 580mm C10 base[9] 150mm Sub-base	Thicknesses as shown for 'Pavement Quality Concrete', with A393 mesh reinforcement at the top and bottom of the slab (C40 bays 6m x 15m)		440mm C40 base 150mm Sub-base (C40 bays 6m x 6m)			
9) Airport Airside Pavements	80mm Pavers 30mm Bedding Sand 400mm BBM			Interpave(1996) - 'The Structural Design of Heavy Duty Pavements for Ports And Other Industries' - Table 10,19 & figs. Surfacing reduces calculated C10 base thickness in accordance with Table 4.2 of 2nd Edition.	Thicknesses as unreinforced, with minimum 150mm^2 of steel / m cross-section of concrete. No increase in bay size permitted by PSA Guide.		300mm C40 Concrete 100mm Rolled Drylean Concrete Laid in 6x6m bays			

Definitions:-

Sub-base- TYPE 1 granular sub-base material.
Open Graded Crushed Rock - Sub-base material with grading as defined in Interpave - 'Guide to Permeable Concrete Block Paving Design' - Table 9.
Surface Course- SMA- type surface course. 30mm surface course can be replaced by 40mm surface course and vice versa, provided the overall asphalt thickness shown does not change (i.e. increase or reduce the base course or base layer by 10mm in compensation respectively).
BBM - Bound Base Material (typically 1/3 Bituminous Material aver 2/3 Lean Concrete with an assumed effective stiffness of 1200MPa.)
C10 - Grade 10 Concrete
C40 - Grade 40 Concrete
Basecourse - 50pen Dense Bitumen Macadam base layer
Roadbase - 50pen Dense Bitumen Macadam base layer
GSM - Geotextile Separating Membrane.

Notes:-

1- Pavements constructed over frost-susceptible soils or capping should (typically in UK)have an overall thickness of non frost-susceptible material of not less than 450mm.
2- '1' condition does not apply.
3- CBM 2 base can be replaced with similar thickness of CBM1a or DBM100. If DBM50 is used, thicknesses can be reduced by 15%.
4- Manufacture controls can be assumed to be tight, so material safety factor of 1.1 for open graded crushed rock has been removed; Where variability is permitted in base material thickness, it is a function of regional precipitation levels. (see 'Guide to permeable Concrete Block Paving Design' - Table 4.)
5- Flexible surfacing materials should be chosen with caution with respect to their deformation resistance properties.
6- Not used
7- Not used
8- Pavers and Sand allow a reduction in the C10 base thickness from 680mm to 560mm.
9- Asphalt surfacing allows a reduction in the C10 base thickness from 680mm to 580mm.

Anomalies:-

*- Sub-base thickness specified by BS7533 can differ considerably from thicknesses specified for other pavement types. Sub-base thickness for BS design does vary with CBR however, unlike other pavement types.
**- Decrease in construction thickness as a result of change in design guidance. In order to create an increase in construction thickness here, an unfeasible (in the context of other pavement types) traffic level of >8msa would have to be adopted.
***- Non-increase in Concrete Block Paving construction thickness between Applications 6 and 7 is not easily resolvable as a result of comparing different design approaches. Changing trafficking category would have a knock-on effect, and would cause discontinuities with designs in other pavement types.

TABLE 6

UK DESIGNS FOR TEN PAVEMENT TYPES AND NINE APPLICATIONS
SUBGRADE CBR = 15% (ASSUMES DESIGN PERMEABILITY 'k' VALUE OF $5x10^{-6}$m/s FOR PERMEABLE PAVEMENTS)

Pavement Application[1]	Pavement Types									
	Concrete Block Paving*	Concrete Flags		Asphalt	Reinforced Concrete		Pavement Quality Concrete	Permeable Pavements[4]		
		On Bedding Sand	On Bedding Mortar		Bars	Fibres		Type A	Type B	Type C
1) Pedestrian Only Footpaths	50mm Pavers 50mm Bedding Sand[2]	60mm Flags 30mm Bedding Sand 100mm sub-base	60mm Flags 30mm Bedding Sand 100mm sub-base	20mm Surface Course 40mm Basecourse 100mm Sub-base				80mm Permeable Pavers 50mm Bedding Aggregate 150-225mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 150-225mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 150-225mm Open Graded Crushed Rock Impervious Membrane
2) Domestic Driveway (cars only)	50mm Pavers 50mm Bedding Sand[2]	60mm Flags 30mm Bedding Sand 100mm sub-base	60mm Flags 30mm Bedding Sand 100mm sub-base	20mm Surface Course 60mm Base Course 150mm Sub-base	125mm Reinforced (Polymer grid) Pavement Quality Concrete 80mm Sub-base			80mm Permeable Pavers 50mm Bedding Aggregate 150-225mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 150-225mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 150-225mm Open Graded Crushed Rock Impervious Membrane
3) Municipal Mall / Plaza (Light Vehicle Overrun Only)	50mm Pavers 50mm Bedding Sand 100mm Sub-base	60mm Flags 30mm Bedding Sand 150mm sub-base	60mm Flags 30mm Bedding Sand 125mm sub-base	20mm Surface Course 50mm Basecourse 150mm Sub-base				80mm Permeable Pavers 50mm Bedding Aggregate 200-225mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 200-225mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 200-225mm Open Graded Crushed Rock Impervious Membrane
4) Car Parks (Cars Only)	50mm Pavers 50mm Bedding Sand 100mm Sub-base			40mm Surface Course 60mm Basecourse 150mm Sub-base	125mm Jointed (15m bays), Reinforced (2.61kg/m^3) Pavement Quality Concrete 150mm Sub-base		150mm Jointed (5m bays), Unreinforced Pavement Quality Concrete 150mm Sub-base	80mm Permeable Pavers 50mm Bedding Aggregate 250mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 250mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 250mm Open Graded Crushed Rock Impervious Membrane
5) Estate Roads (Housing)	60mm Pavers 30mm Bedding Sand 125mm CBM 2 Base[3] 150mm Sub-base			40mm Surface course 80mm Basecourse 150mm Sub-base	140mm Jointed (15m bays), Reinforced (2.61kg/m^3) Pavement Quality Concrete 150mm Sub-base		160mm Jointed (5m bays), Unreinforced Pavement Quality Concrete 150mm Sub-base	80mm Permeable Pavers 50mm Bedding Aggregate 125mm Cement Stabilised Crushed Rock 50-100mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 125mm Cement Stabilised Crushed Rock 50-100mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 125mm Cement Stabilised Crushed Rock 50-100mm Open Graded Crushed Rock Impervious Membrane
6) Estate Roads (Commercial / Light Industrial)	50mm Pavers 30mm Bedding Sand 130mm CBM 2 Base[3] 150mm Sub-base			30mm Surface Course 50mm Basecourse 70mm Roadbase 150mm Sub-base	150mm Jointed (25m bays), Reinforced (500mm^2/m), Concrete 150mm Sub-base		150mm Jointed** (5m bays), Unreinforced Pavement Quality Concrete 150mm Sub-base	80mm Permeable Pavers 50mm Bedding Aggregate 150mm Cement Stabilised Crushed Rock 50-75mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 150mm Cement Stabilised Crushed Rock 50-75mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 150mm Cement Stabilised Crushed Rock 50-75mm Open Graded Crushed Rock Impervious Membrane
7) Car Parks (Subject to Commercial Vehicle Trafficking)	60mm Pavers 30mm Bedding Sand 125mm CBM 2Base[3] 150mm Sub-base			30mm Surface Course 60mm Basecourse 100mm Roadbase 150mm Sub-base	160mm Jointed (15m bays), Reinforced (2.61kg/m^3) Pavement Quality Concrete 150mm Sub-base		170mm Pavement Quality Concrete 150mm Sub-base Placed in 5m bays	80mm Permeable Pavers 50mm Bedding Aggregate 220mm Cement Stabilised Crushed Rock 50-75mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 220mm Cement Stabilised Crushed Rock 50-75mm Open Graded Crushed Rock Separating Geotextile	80mm Permeable Pavers 50mm Bedding Aggregate 220mm Cement Stabilised Crushed Rock 50-75mm Open Graded Crushed Rock Impervious Membrane
8) Container Yards (Trucks, Container Moving Equipment)	80mm Pavers 30mm Bedding Sand 560mm C10 base[8] 150mm Sub-base			40mm Surface Course[5] 60mm Basecourse 580mm C10 base[9] 150mm Sub-base	Thicknesses as shown for 'Pavement Quality Concrete', with A393 mesh reinforcement at the top and bottom of the slab (C40 bays 6m x 15m)		440mm C40 base 150mm Sub-base (C40 bays 6m x 6m)			
9) Airport Airside Pavements	80mm Pavers 30mm Bedding Sand 375mm BBM			Interpave(1996) - 'The Structural Design of Heavy Duty Pavements for Ports And Other Industries' - Table 10,19 & figs. Surfacing reduces calculated C10 base.	Thicknesses as unreinforced, with minimum 150mm^2 of steel / m cross-section of concrete. No increase in bay size permitted by PSA Guide.		300mm C40 Concrete 100mm Rolled Drylean Concrete Laid in 6x6m bays			

Definitions:-

Sub-base- TYPE 1 granular sub-base material.
Open Graded Crushed Rock - Sub-base material with grading as defined in Interpave - 'Guide to Permeable Concrete Block Paving Design' - Table 9.
Surface Course- SMA- type surface course. 30mm surface course can be replaced by 40mm surface course and vice versa, provided the overall asphalt thickness shown does not change (i.e. increase or reduce the base course or base layer by 10mm in compensation respectively).
BBM - Bound Base Material (typically 1/3 Bituminous Material aver 2/3 Lean Concrete with an assumed effective stiffness of 1200MPa.)
C10 - Grade 10 Concrete
C40 - Grade 40 Concrete
Basecourse - 50pen Dense Bitumen Macadam base layer
Roadbase - 50pen Dense Bitumen Macadam base layer
GSM - Geotextile Separating Membrane.

Notes:-

1- Pavements constructed over frost-susceptible soils or capping should (typically in UK)have an overall thickness of non frost-susceptible material of not less than 450mm.
2- '1' condition does not apply.
3- CBM 2 base can be replaced with similar thickness of CBM1a or DBM100. If DBM50 is used, thicknesses can be reduced by 15%.
4- Manufacture controls can be assumed to be tight, so material safety factor of 1.1 for open graded crushed rock has been removed; Where variability is permitted in base material thickness, it is a function of regional precipitation levels. (see 'Guide to permeable Concrete Block Paving Design' - Table 4.)
5- Flexible surfacing materials should be chosen with caution with respect to their deformation resistance properties.
6- Not used
7- Not used
8- Pavers and Sand allow a reduction in the C10 base thickness from 680mm to 560mm.
9- Asphalt surfacing allows a reduction in the C10 base thickness from 680mm to 580mm.

Anomalies:-

*- Sub-base thickness specified by BS7533 can differ considerably from thicknesses specified for other pavement types. Sub-base thickness for BS design does vary with CBR however, unlike other pavement types.
**- Decrease in construction thickness as a result of change in design guidance. In order to create an increase in construction thickness here, an unfeasible (in the context of other pavement types) traffic level of >8msa would have to be adopted.
***- Non-increase in Concrete Block Paving construction thickness between Applications 6 and 7 is not easily resolvable as a result of comparing different design approaches. Changing trafficking category would have a knock-on effect, and would cause discontinuities with designs in other pavement types.

APPENDIX 3 DETAILED QUANTITY AND COSTING RESULTS

SUBGRADE CBR = 2% 1

Pavement Application	Pavement Types											
	Concrete Block Paving	Concrete Flags		Asphalt	Reinforced Concrete		Pavement Quality Concrete	Permeable Pavements				
		On Bedding Sand	On Bedding Mortar		Bars	Fibres		Type A	Type B	Type B Fin Drain	Type C	Type C Fin Drain
1) Pedestrian Only Footpaths	64.02	54.68	70.22	53.66	--------	--------	--------	--------	--------		55.49	47.52
2) Domestic Delivery (cars only)	38.68	29.34	44.88	32.78	35.75	--------	--------	--------	--------		41.44	38.47
3) Municipal Mall / Plaza (Light Vehicle Overrun Only)	54.97	56.19	70.52	47.90	--------	--------	--------	--------	--------		57.03	54.73
4) Car Parks (Cars Only)	41.84	--------	--------	41.48	50.20	--------	54.22	--------	--------		51.56	50.70
5) Estate Roads (Housing)	68.69	--------	--------	51.95	62.74	--------	66.33	--------	--------		56.99	55.86
6) Estate Roads (Commercial / Light industrial)	72.95	--------	--------	56.47	65.11	--------	63.18	--------	--------		58.16	57.03
7) Car Parks (Subject to Commercial Vehicle Trafficking)	53.19	--------	--------	44.92	50.54	--------	53.12	--------	--------		51.12	50.97
8) Container Yards (Trucks, Container Moving Equipment) assume excavation	79.93	--------	--------	82.02	95.67	0.00	82.08	--------	--------		--------	
8A) Container Yards (Port area) Assuming fill won from dredging	71.55	--------	--------	73.59	89.98	0.00	74.47	--------	--------		--------	
9) Airport Airside Pavements	72.12	--------	--------	76.80	74.90	--------	77.59	--------	--------		--------	

SUBGRADE CBR = 3% 2

Pavement Application	Pavement Types											
	Concrete Block Paving	Concrete Flags		Asphalt	Reinforced Concrete		Pavement Quality Concrete	Permeable Pavements				
		On Bedding Sand	On Bedding Mortar		Bars	Fibres		Type A	Type B	Type B Fin Drain	Type C	Type C Fin Drain
1) Pedestrian Only Footpaths	61.49	54.68	70.22	53.66	--------	--------	--------	--------	--------		55.49	47.52
2) Domestic Delivery (cars only)	34.22	27.41	42.95	30.85	33.82	--------	--------	--------	--------		41.44	38.47
3) Municipal Mall / Plaza (Light Vehicle Overrun Only)	50.43	50.44	64.58	41.13	--------	--------	--------	--------	--------		52.76	50.36
4) Car Parks (Cars Only)	37.80	--------	--------	37.41	46.36	--------	50.08	--------	--------		44.82	43.81
5) Estate Roads (Housing)	64.47	--------	--------	47.87	58.64	--------	62.22	--------	--------		50.62	49.33
6) Estate Roads (Commercial / Light industrial)	65.06	--------	--------	51.68	61.01	--------	59.08	--------	--------		51.78	50.48
7) Car Parks (Subject to Commercial Vehicle Trafficking)	50.00	--------	--------	40.78	46.42	--------	49.00	--------	--------		47.42	47.24
8) Container Yards (Trucks, Container Moving Equipment) assume excavation	76.57	--------	--------	78.64	92.53	0.00	78.94	--------	--------		--------	
8A) Container Yards (Port area) Assuming fill won from dredging	70.29	--------	--------	72.34	88.73	0.00	74.47	--------	--------		--------	
9) Airport Airside Pavements	61.25	--------	--------	59.62	64.38	--------	60.94	--------	--------		--------	

SUBGRADE CBR = 6% 3

Pavement Application	Pavement Types											
	Concrete Block Paving	Concrete Flags		Asphalt	Reinforced Concrete		Pavement Quality Concrete	Permeable Pavements				
		On Bedding Sand	On Bedding Mortar		Bars	Fibres		Type A	Type B	Type B Fin Drain	Type C	Type C Fin Drain
1) Pedestrian Only Footpaths	53.36	54.68	70.22	53.66	--------	--------	--------	--------	50.68	44.47	55.49	47.52
2) Domestic Delivery (cars only)	26.09	27.41	42.95	30.85	32.22	--------	--------	--------	38.37	36.05	41.44	38.47
3) Municipal Mall / Plaza (Light Vehicle Overrun Only)	42.62	42.62	56.77	41.13	--------	--------	--------	--------	40.29	37.59	43.36	40.05
4) Car Parks (Cars Only)	32.31	--------	--------	33.59	42.57	--------	46.55	--------	35.59	34.18	37.52	35.94
5) Estate Roads (Housing)	57.20	--------	--------	44.44	55.20	--------	58.75	--------	39.08	37.04	40.95	38.68
6) Estate Roads (Commercial / Light industrial)	61.94	--------	--------	48.22	57.55	--------	55.62	--------	40.34	38.31	42.11	39.83
7) Car Parks (Subject to Commercial Vehicle Trafficking)	42.74	--------	--------	37.28	42.96	--------	45.52	--------	36.84	36.52	38.22	37.90
8) Container Yards (Trucks, Container Moving Equipment) assume excavation	71.97		--------	74.03	88.14	0.00	74.55	--------	--------		--------	
8A) Container Yards (Port area) Assuming fill won from dredging	68.24		--------	70.28	86.71	0.00	72.42	--------	--------		--------	
9) Airport Airside Pavements	48.26	--------	--------	46.52	63.92	--------	60.48	--------	--------		--------	

SUBGRADE CBR = 10 4

Pavement Application	Pavement Types											
	Concrete Block Paving	Concrete Flags		Asphalt	Reinforced Concrete		Pavement Quality Concrete	Permeable Pavements				
		On Bedding Sand	On Bedding Mortar		Bars	Fibres		Type A	Type B	Type B Fin Drain	Type C	Type C Fin Drain
1) Pedestrian Only Footpaths	53.36	54.68	70.22	53.66	--------	--------	--------	42.03	50.68	44.47	55.49	47.52
2) Domestic Delivery (cars only)	26.09	27.41	42.95	30.85	30.09	--------	--------	35.14	38.37	36.05	41.44	38.47
3) Municipal Mall / Plaza (Light Vehicle Overrun Only)	42.62	41.23	55.56	41.13	---------	---------	--------	36.68	40.29	37.59	43.36	40.05
4) Car Parks (Cars Only)	32.11	--------	--------	32.31	40.91	--------	44.87	30.92	35.22	33.81	37.15	35.58
5) Estate Roads (Housing)	56.84	--------	--------	42.82	53.55	--------	57.09	33.47	38.93	36.89	40.65	38.38
6) Estate Roads (Commercial / Light industrial)	58.66	--------	--------	46.57	55.90	--------	53.97	34.57	40.02	37.99	41.79	39.51
7) Car Parks (Subject to Commercial Vehicle Trafficking)	42.38	---------	--------	35.59	41.29	--------	43.85	35.00	36.45	36.16	37.84	37.51
8) Container Yards (Trucks, Container Moving Equipment) assume excavation	68.65	--------	--------	70.71	85.05	0.00	71.46	---------	---------		--------	
8A) Container Yards (Port area) Assuming fill won from dredging	66.40	---------	---------	68.44	84.84	0.00	70.57	--------	--------		---------	
9) Airport Airside Pavements	39.94	--------	--------	38.33	54.93	--------	53.26	---------	---------		--------	

SUBGRADE CBR = 15 5

Pavement Application	Pavement Types											
	Concrete Block Paving	Concrete Flags		Asphalt	Reinforced Concrete		Pavement Quality Concrete	Permeable Pavements				
		On Bedding Sand	On Bedding Mortar		Bars	Fibres		Type A	Type B	Type B Fin Drain	Type C	Type C Fin Drain
1) Pedestrian Only Footpaths	53.36	54.68	70.22	53.66	--------	--------	--------	42.03	50.68	44.47	55.49	47.52
2) Domestic Delivery (cars only)	26.09	27.41	42.95	30.85	30.09	--------	--------	35.14	38.37	36.05	41.44	38.47
3) Municipal Mall / Plaza (Light Vehicle Overrun Only)	42.62	41.23	55.56	41.13	--------	--------	--------	36.68	40.29	37.59	43.36	40.05
4) Car Parks (Cars Only)	31.92	--------	--------	31.41	39.97	--------	43.92	30.56	34.86	33.44	36.78	35.21
5) Estate Roads (Housing)	56.49	--------	--------	41.91	52.62	--------	56.14	33.17	38.63	36.59	40.35	38.08
6) Estate Roads (Commercial / Light industrial)	57.99	--------	--------	45.63	54.96	--------	53.03	34.25	39.71	37.67	41.47	39.19
7) Car Parks (Subject to Commercial Vehicle Trafficking)	42.02	--------	--------	34.61	40.34	--------	42.89	34.61	36.07	35.78	37.45	37.13
8) Container Yards (Trucks, Container Moving Equipment) assume excavation	67.87	--------	--------	69.91	84.49	0.00	70.90	--------	--------		--------	
8A) Container Yards (Port area) Assuming fill won from dredging	66.40	--------	--------	68.44	84.84	0.00	70.57	--------	--------		--------	
9) Airport Airside Pavements	37.99	--------	--------	36.38	54.55	--------	52.88	--------	--------		--------	

APPENDIX 4 DRAWINGS

Drawings are not included here for reasons of space but are available for inspection at the offices of Interpave, by appointment.