



MARSHALLS LANDSCAPE PRODUCTS

Priora Permeable Paving Design

26 Ilex Way, Worthing

Prepared for: Pope Stevens Architecture Ltd

Project Number: 5949020

Design Number: DRQ0000606

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CONTENTS

1	DESIGN SUMMARY	2
1.1	Design Parameters	2
1.2	Pavement Design.....	2
1.3	Quantities	3
2	DESIGN RESPONSIBILITY	4
3	DESIGN METHODOLOGY	5
3.1	Hydraulic Design	5
3.2	Structural Design	6
4	ADDITIONAL INFORMATION.....	8
4.1	Installation	8
4.1.1	Compaction of the Subbase	8
4.1.2	Edge restraints.....	8
4.1.3	Base Installation	8
4.1.4	Site Traffic.....	8
4.2	Water Quality	9
4.3	Jointing Information	9
4.4	Block Thickness Guidance	10
5	MATERIAL SPECIFICATION	11
5.1	MM380 Tanking Membrane	11
5.2	MT120 Filtration Membrane	11
5.3	HX165 Geogrid.....	12
5.4	Aggregates.....	12
5.4.1	Laying Course	13
5.4.2	Sub-base Course.....	13
6	CONTACT DETAILS.....	14
7	DESIGN WARRANTY	15

1 DESIGN SUMMARY

A permeable paving design has been undertaken for the site at 26 Ilex Way, Worthing. In association with this design document, External Layout Drawing Number DRQ0000606 shows the site layout and areas of pavement.

Information has been provided by Pope Stevens Architecture Ltd. It is the customers' responsibility to check the validity and accuracy of the information provided and of the resulting proposals. The design parameters considered for each area are summarised in the table below. If any changes are made to the design parameters, it is imperative that Marshalls be made aware and changes be made accordingly.

1.1 Design Parameters

Hydraulic Design Factors		
Parameter	Value	Source
Design Storm	1 in 100 years + 45% climate change	Assumed typical value
M5-60	20	Interpave FSR map
R	0.4	Interpave FSR map
Infiltration/Outflow Rate	1.8×10^{-6} m/s	GI report
Structural Design Factors		
Anticipated Vehicular Loading	CAT 2 – Cars and Light Vans (3500kg Gross vehicle weight)	Assumed typical value
Design CBR%	5%	Assumed typical value

1.2 Pavement Design

	Depth (mm)	Specification
Priora Blocks	60	Installed in line with BS7533-101
Laying Course	50	2/6.3mm OGCR, Grading/Tolerance Gc 80/20, GTc 20/15, to BS EN 12620
Optional MT120 Filtration Membrane	-	Installed in line with SHW 609
Sub-base (OGCR)	330	4/20mm (preferred) or 4/40mm, Grading/Tolerance GC 85-15, GTc 20/17.5 to BS EN 13242 or BS 12620
MT120 Filtration Textile	-	
Total Construction Depth (mm)	440	

Please refer to drawing DRQ0000606 for full construction detail.

1.3 Quantities

Components		Areas Considered
	Units	Total
MT120 Filtration Textile	Rolls	1
4/20 OGCR Sub-base	Tonnes	35
2/6.3 OGCR Laying Course	Tonnes	6
Pavement Area	m ²	58

2 DESIGN RESPONSIBILITY

Marshalls are warranting the design of the pavement in the areas specified by Marshalls, based on the design information supplied. If design information is incorrect or exceeds the conditions as stated and approved by the Principle Designers, this would result in the warranty being invalid. Any sections of the pavement which are not specified by Marshalls fall outside of the design warranty.

As Marshalls are not involved in the overall design, management and supervision of the project, or the selection of materials or contractors, we cannot be liable for the performance of our products on site and in use. This does not detract from the customer's rights under common law for claims made against the quality of our products, should the situation arise.

As the scheme's designer retains overall control of the project, it must remain their responsibility to check our proposals ensuring that all design and statutory requirements are met. Marshalls are not able to accept any responsibility for failure to check our proposals.

All advice given assumes the use of Marshalls products in your project specification. If you use any other manufacturer's products, Marshalls can accept no responsibility whatsoever for the performance of those products, or generally for the advice we have given. Areas are only estimates and are provided in good faith, but must be checked by the customer prior to ordering. No responsibility can be accepted for shortfall or excess of materials

3 DESIGN METHODOLOGY

3.1 Hydraulic Design

The hydraulic design of the pavement has been calculated using Causeway Flow.

Unless otherwise stated default source control parameters are used for simulation purposes. Downstream effects are not considered during the hydraulic design.

- We have used FSR m5-60 and R for the location
- A void ratio of 32% has been used to calculate available storage in the subbase.

A total catchment area of 58 m² has been considered. The paved area is 58 m². DRQ0000606 shows each area.

An Infiltration rate of xxx has been used. This should be tested at formation level using the method presented in BRE Digest 365, in which each test is repeated 3 times. A suitable number of tests should be completed in different areas throughout the site in accordance with BRE Digest 365.

As a result of these factors the hydraulic depth is given by the peak water level occurring during the critical storm, this is calculated to be: 184 mm

Calculations are available upon request.

3.2 Structural Design

Marshalls uses its own design methodology which has been developed alongside Professor John Knapton at Newcastle University. The design methodology is based on FEA modelling which reveals the critical stresses and strains occurring in each layer of the pavement. Transfer equations were used to calculate the maximum stress and/or strain for a number of coverages. The thicknesses of each layer were optimised such that the maximum stress and strain matched that of the transfer functions for each layer. The method was validated following Marshalls decades of experience and testing at Newcastle University's Rolling Load Facility (NUROLF).

The following table shows the loading categories as a result of the above. One standard axle is based on a 40kN wheel load or 8200kg axle load.

Loading Category	Typical Traffic Application	Critical Loading
1	Domestic	2000kg (Gross Vehicle Weight)
2	Cars & Light Vans	3500kg (GVW)
3	Light Commercial	7500kg (GVW)
4	Emergency Large Goods Vehicles	100 standard axles (sa)
5	1 HGV per week	0.015 million standard axles (msa)
6	10 HGV per week	0.15 msa
7	100 HGV per week	1.5 msa
8	1000 HGV per week	15 msa
9*	Heavy Duty Applications and Ports	15msa +

*Refer to the Heavy Duty Paving Manual for design guidance

Loading Category 2 was selected as being the most appropriate anticipated vehicular overrun for the site. If the anticipated loading is different from the above, Marshalls should be made aware and the design should be amended.

Proposed Design CBR at the formation level is 5% and above. Prior to construction a CBR test in accordance with BS1377-4:1990+A2:2002, Clause 7 should be undertaken. This should be at formation level and using long term moisture content of the soil. If it is likely that the subgrade at formation level will become saturated during part or all of the life of the pavement the method employing the soaking procedure should be used. If the results show a lower CBR%, the design may need amending to include additional capping material.

Typically additional 4/20 OGCR material is added to the subbase depth for subgrades less than 5%. Our HX165 geogrid may also be used at formation level which has the effect of increasing the ground CBR by 1%. Depending on material availability for tanked type C systems customers may opt to use 6F1, 6F2 and MOT Type 1 class capping material below the membrane. This is shown in the table below. Please seek guidance from Marshalls for any other suggested materials.

Subgrade CBR Value	Capping Layer Thickness Type A & B Systems (mm)		Capping Layer Thickness Type C (mm)			
	OGCR		OGCR or MOT Type 1		Capping Material	
	Without HX165 Grid	With HX165 Grid	Without HX165 Grid	With HX165 Grid	Without HX165 Grid	With HX165 Grid
5%	-	-	-	-	-	-
4%	100	-	100	-	150	-
3%	125	75	125	75	225	150
2%	175	110	175	110	350	225
1%	300	210	300	210	600	400

For OGCR specification please refer to section 5.4 of this document.

Capping material 6F1 and 6F2 to SHW 613.

Subbase material MOT Type 1 when used as capping material to SHW 803

Additional non-frost susceptible material may be required to prevent frost penetration. If the MAFI of the site is below 50, the total build-up should be at least 350mm, and if the MAFI is above 50, this should be increased to 450mm minimum.

4 ADDITIONAL INFORMATION

4.1 Installation

4.1.1 Compaction of the Subbase

Install as per BS7533-3 and Interpave Permeable Design guide

All materials should be compacted in layers not exceeding 150mm in thickness. All conventional rollers can be used for compaction but these should not be vibrating. This avoids over compaction as it is important to retain a void ratio of 32%. As all sites and materials differ it is recommended that a trial be conducted. Installers should aim to achieve a tolerance of +20mm to -30mm from specified levels when installing the capping layer.

4.1.2 Edge restraints

Pavement needs to be framed either by a building line or a suitable edge restrained to stop lateral spread of the pavement elements. Example edge restraint details included within drawing.

4.1.3 Base Installation

The roadbase is to be DBM 50 per SHW clause 929 laid to SHW clause 903 with 75mm diam. at 750mm centres filled with laying course material. Other material specifications are listed below.

4.1.4 Site Traffic

The design does not consider site traffic therefore, the subbase should not be trafficked directly, a DBM can be included for construction traffic purposes. Advice can be sought from Marshalls if this is required. Alternatively, the surface may be covered with a sacrificial layer to protect the subbase. Furthermore, a geotextile can be included over the subbase to protect the layer from detritus and carefully removed on completion so as to not cause clogging to the subbase.

4.2 Water Quality

Concrete Block Permeable paving is particularly good at dealing with low-medium polluted run-off. CBPP is effective at removing heavy metals, oils, sediments, grease and some nutrients and therefore significantly reduce pollutant load to receiving water courses. These pollutants are removed by the following mechanisms:

- Filtration, the majority of silt is trapped within the laying course, this effect can be increased by including a MT120 Filtration Textile.
- Biodegradation of organics and oils.
- Adsorption of pollutants to the surface of aggregate
- Settlement and retention of solids

Due to these reasons CBPP has been allocated the following risk mitigation indices which can be used for treatment design as per the CIRIA SUDS Manual C753:

Pollutants	Risk Mitigation Indices
Total Suspended Solids	0.7
Metals	0.6
Hydrocarbons	0.7

4.3 Jointing Information

Joints between the blocks are created by the Piora nib and should be filled with laying course material. Only certain patterns are allowable due to the interlocking nibs included on a Piora block.

General advice on bond patterns should be in accordance with the table below:

Loading Category	Bond Pattern
1	Stretcher/Herringbone*
2	Stretcher/Herringbone*
3	Stretcher/Herringbone*
4	Stretcher/Herringbone*
5	Herringbone
6	Herringbone
7	Herringbone
8	Herringbone
9	Herringbone

*Stretcher bond patterns must be laid perpendicular to the direction of traffic. Site specific conditions needs to be taken into consideration, contact Marshalls Design Team for further advice.

4.4 Block Thickness Guidance

General advice on block thickness should be in accordance with the table below:

Loading Category	Block Thickness (mm)
1	60
2	60
3	80
4	80
5	80
6	80
7	80
8	80
9	80

Site specific conditions needs to be taken into consideration, contact Marshalls Design Team for further advice.

5 MATERIAL SPECIFICATION

5.1 MM380 Tanking Membrane

Characteristic	Value or Statement	Units	Compliance Criteria	Test Method
Length	20	m	-0%/+10%	EN 1848-2
Width	4	m	+/- 2.5%	EN 1848-2
Thickness	0.38	mm	+/- 10%	EN 1849-2
Mass	395	g/m ²	+/- 12%	EN 1849-2
Resistance to Impact	30	mm/diameter	>MLV	EN 12691
Resistance to Tearing	185 185	N	MDV	EN 12310-1
Tensile Strength	24.2 20.7	N/50mm	MDV	EN 12311-1

Product	Dimensions	Item Code
MM380 Tanking Membrane (roll)	20m x 4m (80m ²)	DYPV9701000
Top Hat (including clip)	110mm	DYPV9701100
Top Hat (including clip)	160mm	DYPV9701200
Jointing Tape (roll)	15m x 100mm	DYPV9701300

5.2 MT120 Filtration Membrane

Characteristic	Value	Units	Test Method
Length	100	m	For Guidance
Width	5.4	m	For Guidance
Roll Weight	65	kg	For Guidance
Thickness	1.0	mm	BS EN ISO 12956
Static Puncture Strength (CBR)	1800	N	BS EN ISO 12236
Tensile Elongation	45	%	BS EN ISO 10319
Mass per Unit Area	120	GSM	BS EN ISO 9864
Water Flow	120	l/sm ²	BS EN ISO 11058
Air Permeability	719	l/sm ²	ISO 9237:1995

Product	Dimensions	Item Code
MT120 Textile (roll)	5.4m x 100m (540m ²)	PV9702500

5.3 HX165 Geogrid

Property	Value
Base Raw Material	PP Polypropylene
Rib Shape	Rectangular
Aperture Shape	Hexagonal, Trapezoidal & Triangular
Continuous Rib Pitch (mm)	80
Rib Aspect Ratio	>1.0
Node Thickness (mm)	3.25
Radial Secant Stiffness at 2% Strain	165kN/m with a tolerance of -65kN/m

Product	Dimensions
HX165 Grid (roll)	50m x 3.8m (190m ²)

5.4 Aggregates

Properties	Category to BS EN 13242 or BS 12620
Grading	40/20 (preferred) or 4/40, GC 85-15, GTc 20/17.5
Fines Content	f ₄
Shape	Fl ₂₀
Resistance to Fragmentation	LA ₃₀
Internal Angle of Friction	40°
Durability	
Water Absorption to BS EN 1097-6:2000+A1:2005, Clause 7 for WA>2%	WA ₂₄ 2
Magnesium Sulphate Soundness	MS ₁₈
Resistance to Wear	MS _{DE} 20
Acid Soluable Sulphate Content	
Aggregates other than Air Cooled Blast Furnace Slag	AS _{0.2}
Air Cooled Blast Furnace Slag	AS _{0.1}
Total Sulphur	
Aggregates other than Air Cooled Blast Furnace Slag	<1% by mass
Air Cooled Blast Furnace Slag	<2% by mass
Volume Stability of Blast Furnace and Steel Slags	
Air Cooled Blast Furnace Slag	Free from dicalcium silicate and iron disintegration in accordance with BS EN 13242:2002+A1:2007, 6.4.2.2. Vs
Steel Slag	
Leaching of Contaminants	
Blast furnace slag and other recycled materials should meet the requirements of the environment agency "waste acceptance Criteria" A) for inert waste when tested in accordance with BS EN 12457-3	

5.4.1 Laying Course

Laying Course Grading Requirements	
Recommended BS EN 12620 Aggregate (mm)	2/6.3
Recommended BS EN 12620 Grading/Tolerance Category	Gc 80/20, GTc 20/15

Laying Course Grading Details	
Sieve Size (mm)	Percentage by Mass Passing ISO 565 Sieve
31.5	
20	
14	100
10	98-100
6.3	80-99
4	
2	0-20
1	0-5
0.0063	0-2

5.4.2 Sub-base Course

Sub-base Grading Requirements	
Recommended BS EN 12620 Aggregate (mm)	4/20
Recommended BS EN 12620 Grading/Tolerance Category	Gc 80/20, GTc 20/15
Porosity	0.32

Sub-base Grading Details	
Sieve Size (mm)	Percentage by Mass Passing ISO 565 Sieve
31.5	98-100
20	90-99
14	
10	25-70
6.3	
4	0-15
3.15	
2	0-5

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6 CONTACT DETAILS

Should you have any queries or require any clarification regarding any aspect of this document or require on-site technical support and advice please do not hesitate to contact the following:

Design Team	
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For further information on products please visit our website:
<http://www.marshalls.co.uk/commercial/water-management>

Marshalls Design Warranty



“Marshalls” means Marshalls Mono Limited, its direct and indirect holding companies and any subsidiary of it or of such holding companies.

1. Copyright in our designs

- 1.1 This Design has been produced specifically for the site stated in the design. All design advice is specific to your Project. The finished Design together with all drawings, plans, specifications and other preparatory material and advice produced by or on behalf of Marshalls is subject to the law of copyright and Marshalls asserts its exclusive copyright in such material and retains all copyright and other intellectual property rights in such materials. This Design and/or design advice may not be copied or used for other projects without the express prior written approval of Marshalls.
- 1.2 For these purposes “Design” means the design attached to these conditions, any design included in the specification and/or any other design or technical advice provided by Marshalls in writing in connection with the Project, including any revisions, amendments and updates made by Marshalls to these designs and/or design advice, and “Project” means the customer’s specified project (where “customer” includes any contractor, architect, specifier or agent who is identified as the customer) in connection with which the Design is supplied.

2. Exclusion of Liability

- 2.1 This Design and any advice provided to you by Marshalls in connection with this design are specific to your Project. You acknowledge that in preparing the Design and providing the advice we have relied upon information supplied by you and/or your professional advisers, agents and/or contractors relating to the Project site and we take no responsibility for any failure or defect arising directly or indirectly from incomplete, inaccurate or misleading information provided to us, or arising as a consequence of any act, omission or failure by you or any third party contractor, engineer, quantity surveyor, architect or other professional adviser engaged in relation to the Project.
- 2.2 This Design and any advice provided by Marshalls have been prepared and delivered on the basis that Marshalls products are explicitly specified and will be used. If you use any other manufacturer’s products, Marshalls can accept no responsibility whatsoever for the performance of those products, nor can we give any assurance that this Design and/or advice provided by Marshalls will be suitable for use with those products.
- 2.3 As Marshalls is not involved in the overall management and supervision or the selection of materials or contractors on site we will not be liable for any failure in our products caused by the actions or omissions of third parties or the treatment of our products on site and in use. This does not affect your statutory rights.
- 2.4 Marshalls will have no liability for loss of profit, loss of use, loss of contract and/or any indirect or consequential loss or for any liquidated damages that may arise in respect of the Project. Our total liability to you arising in connection with the Project in any event will not exceed the lower of the aggregated value of materials supplied by Marshalls to the Project or £500,000.
- 2.5 To the extent permitted by law, the warranties and remedies set out in this document relating to the Design and any advice provided by Marshalls in relation to the Project are exclusive and in lieu of all warranties and remedies and contract terms, express or implied by law, including any contract terms implied by law as to quality or fitness for any particular purpose provided that this clause does not exclude liability for death, personal injury or fraudulent misrepresentation to the extent such exclusion would be prohibited by law.

3. Design warranty

- 3.1 In providing this Design and any written advice in relation to the Project Marshalls has used the standard of skill and care which would reasonably be expected from an experienced manufacturer of paving and drainage products of the type supplied by Marshalls to the Project.
- 3.2 To maintain best practice and in keeping with the BS EN ISO 9001 quality management system, Marshalls has its own internal checking procedure in place which involves a design verification process for work carried out by members of Marshalls’ Marshalls Design Warranty engineering teams. It is essential that the qualified individual appointed by the customer agrees with the design data inputs and outputs particular to their Project before installation, as project requirements can change during the lifespan of the Project prior to commencement of the installation stage.
- 3.3 Marshalls warrants that it will repair or replace or provide a refund (at Marshalls’ discretion) in respect of any failure of the Design or of any Marshalls product installed in accordance with the Design to conform to the stated standard within 10 years of installation up to a total aggregated cost of £50,000, provided that:

Marshalls Design Warranty



- 3.3.1 Marshalls' specification and guidance (as provided by Marshalls in writing) has been followed diligently including our recommendation for all component materials that form part of the Design.
- 3.3.2 Only Marshalls paving products have been used.
- 3.3.3 The relevant Design has been checked and signed off prior to the installation stage by a qualified individual associated with the Project acting on behalf of the customer, such as a project/design manager.
- 3.3.4 The finished Project incorporating the products in the Design must have been installed and maintained at all times in accordance with Marshalls' guidance.
- 3.3.5 Any claims are submitted to Marshalls in writing within 10 years of the Project having completed (or such part of the Project that includes the Design) and in any event within 2 calendar months of the date on which the claimant became aware or should have become aware of the event or circumstance giving rise to the claim.

If any of the above conditions (3.3.1) to (3.3.5) inclusive have not been met, the above warranty will be invalid and Marshalls shall have no liability in respect of the Design and/or the products installed in accordance with the Design.

- 3.4. The above warranty will cover the performance of a sub-base incorporated into the Design. It expressly excludes any liability of Marshalls in respect of workmanship in relation to the sub-base and/or any installation whatsoever, including installation of any Product and/or the sub-base, and/or any defects or damage which occurs as a result of ground conditions (including but not limited to hydrological, climatic natural and/or physical conditions and man-made and other physical obstructions and pollutants).
- 3.5. The above warranty is for the exclusive benefit of the customer and may not be assigned or otherwise transferred to any other party without the written consent of Marshalls in its absolute discretion.

4. Insurance

Marshalls carries public and products liability insurance to a level of at least £10m and professional indemnity insurance to a level of £5m in respect of its designs.

5. Terms and Conditions

These conditions are in addition to and do not exclude the standard terms and conditions of Marshalls applicable to the sale of products to the Project from time to time. To the extent that any provisions of these design terms conflict with Marshalls' standard terms and conditions of sale, these provisions shall prevail insofar as they apply to the Design and any advice in connection with the Design. These conditions will also prevail over any terms and conditions which any contractor, architect, specifier and/or other customer may seek to impose on Marshalls in relation to the Project.

These conditions will be governed by English law.