

+ Pixel[®] Paver System

Technical Manual - Permeable / Pervious



+ Table of Contents

Introduction	3
Terminology	5
System Choices	6
Basecourse Thickness	10
Formation Level	10
Aggregate and Sand Gradings	11
Permeable Subbase Installation	12
Aggregate Subbase Installation	13
Maintenance	13
Paving on Slopes and Next to Buildings	14
Soil and Grass Details	16

INTRODUCTION

WITH GROWING URBANISATION THERE IS AN INCREASE IN HARD PAVED AREAS, BUILDINGS, AND OTHER IMPERVIOUS STRUCTURES. THESE STRUCTURES DISRUPT THE NATURAL FLOW OF STORMWATER RUNOFF AND CREATE HEAT SINKS THAT NEED TO BE MANAGED. THE PIXEL® PAVER SYSTEM PROVIDES A VISUALLY FLEXIBLE AND ATTRACTIVE SOLUTION TO INCREASING THE PERMEABILITY OF URBAN AREAS.

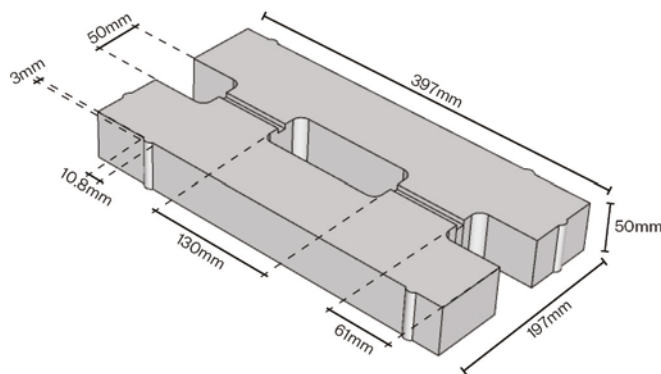
The Pixel paver system was developed to allow the integration of grassed, planted or decorative chip surfaces into paved areas, improving the permeability of urban areas and reducing heat build-up. The ability for stormwater to be easily absorbed by the ground surface reduces surface flow and subsequent flooding risk and helps to restore natural ground water.

The system enables a wide range of visually attractive arrangements to be achieved, creating graphic forms, textures, and pixelated interfaces between hard and soft surfaces in domestic and public areas.

The Pixel paver can be used in 2 ways:

1. As a permeable system on a permeable basecourse, requiring a 50/50 square metre design ratio of Pixel paver and Firth PaveWare® range mix to enable stormwater to be stored and to pass through to the natural aquifers or storage in the base.
2. As a pervious system on a GAP basecourse, enabling storage of the first 5mm of rain. This system will enable more flexibility with the arrangement and visual appearance of the Pixel pavers and PaveWare range and not restricted to a 50/50 design ratio.

FIGURE 1: Schematic of a Pixel Paver (dimensions 400mmL x 200mmD x 50mmH)



WHAT IS THE PIXEL PAVER SYSTEM?

An integral part of the system is the Pixel paver. Figure 1 illustrates the Pixel paver. The Pixel paver is 400mmL x 200mmW with penetrations to allow the vertical passage of water and roots. The 50mm thickness allows a 30mm covering of soil when combined with 80mm thick Firth PaveWare range. The use of the Pixel paver allows the maintenance of frictional interlock between pavers therefore minimising movement when the surface course is trafficked.

DESIGN FLEXIBILITY

The Pixel paver has been designed to be used as a system with the Firth PaveWare range that includes Firth Holland® 80, Holland® 80 Set, Piazza® 80 and Forum® 80 pavers. The structural performance of the paving system is dependent on 3 main considerations:

1. The laying pattern that influences the effectiveness of frictional “lock up” for segmental pavers, especially in trafficked areas.
2. The thickness of the paver that influences the structural strength of trafficked surfaces and increases frictional interlock for segmental pavers.
3. The depth and composition of the underlying granular materials that influences the strength of trafficked areas and the ability for stormwater to move vertically through the system.

Design for segmental and flagstone pavements is prescribed in NZS3116. When designing a pavement incorporating Pixel pavers, the following principles should be followed:

1. The Pixel paver (grass or ground cover filled) should not be on surfaces where traffic will traverse frequently as this will result in compaction of the soil in the Pixel paver void and the subsequent failure of the grass/planted surface.
2. Light traffic areas (refer definitions) can be designed with or a mix of Firth Holland 80, Holland 80 Set, Piazza 80 and Forum 80 pavers. The laying pattern should be Herringbone where possible.

3. Medium trafficked areas (refer definitions) can be designed with or a mix of Firth Holland 80, Holland 80 Set, Piazza 80 pavers. The laying pattern should be Herringbone, preferably laid at 45 degrees to traffic flow. Refer NZS3116 for details.
4. In pedestrian only areas any of the listed pavers can be used and laying pattern can also include Stack Bond, Stretcher Bond, Basketweave and Herringbone.
5. The surface permeability of the system is a function of the area of Pixel pavers to other pavers. Generally, a 50/50 square metre design ratio of Pixel paver and Firth PaveWare® range will satisfy permeability requirements of Council.
6. The permeability and water storage of the system can be fine-tuned to the end need. Consult with your local Council where the system needs to comply with a regulatory requirement. For systems designed for maximum permeability and water retention, a higher Pixel paver/PaveWare square metre design ratio should be combined with a fully designed permeable aggregate base.
7. When using maximum permeability, the system is designed to allow water to pass through the surface. In areas that are trafficked it is important that the granular materials used are suitable for supporting loads when saturated. Normal roading aggregate as defined in NZS3116 is not suitable. Details are provided in this document.
8. In areas where modest permeability is required, and the system is not trafficked, the system can be laid on a more traditional method using a GAP base as per NZS 3116.

The Pixel paver system can be used in the following applications:

- Driveway and parking applications for residential and light commercial vehicles with low traffic volumes.
- Pedestrian areas (i.e., pathways and patios) in a residential area.
- Commercial pathways, public parks, and surfaces with light – medium traffic volumes.

TERMINOLOGY

Permeable – Water accepted around the paver and into the permeable basecourse.

Pervious – Accepts the water into the wearing course but not into the impervious aggregate basecourse.

Porous - Allows water through the paver and into the permeable basecourse.

Paving layer/wearing course - The pavers that sit on top of the prepared base are often referred to as the wearing course.

Bedding layer – This is traditionally a 20-30mm sand layer the pavers on the wearing course are laid directly on to.

Filter cloth – Normally a nonwoven geotextile which allows water to pass through it and prevents the bedding sand from washing into the permeable base course. It also assists in preventing contamination from the sub grade pushing into the permeable basecourse.

Permeable basecourse – The structural drainage layer underneath the bedding layer in a permeable system. This can be made up of permeable aggregate or a no fines concrete. This is sometimes referred as the storage medium as it can act as storage tank detaining the stormwater whilst it dissipates naturally.

Aggregate basecourse – A GAP 40 or GAP 65, this aggregate has clay fines in it and smaller stones that bind up to create a structural base as per NZS 3116.

Sub grade – The undisturbed soil at the bottom of the pavement system, the

strength of this is often referenced as its CBR (California Bearing Ratio), which determines the thickness of the basecourse required to support the pavement

Sub surface drain – A drainage system installed under a permeable base which allows water to enter and conveys it to the storm water network. The drainage system is in place to manage stormwater volumes that exceed the sub grades infiltration rates.

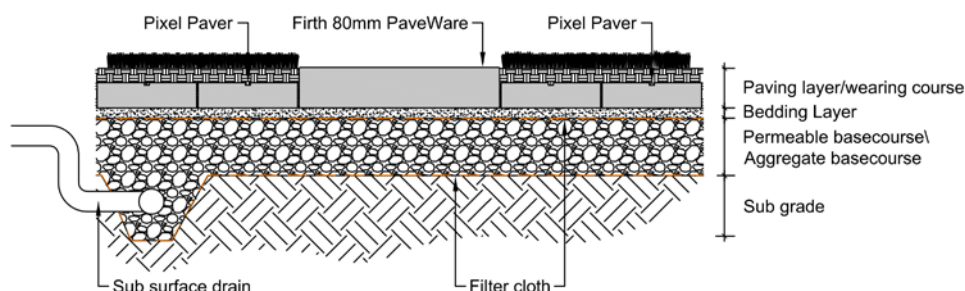
Light traffic – Operation of vehicles with a maximum gross mass not exceeding 3 tonnes.

Medium traffic – Operation of vehicles with a maximum gross mass exceeding 3 tonnes but not exceeding 10 tonnes.

Pixel paver – the Pixel paver is a 50mm unit with a void. An open graded aggregate, grass or groundcover is placed on top of the Pixel paver to create a softer landscape. Pixel paver is laid in conjunction with Firth 80mm PavWare. The 80mm PavWare creates hard zones to assist in spreading the loads.

PavWare range - Firth Paveware is a contemporary range suitable for urban , commercial or streetscape application that include Firth Holland 80, Holland 80 Set, Piazza 80 and Forum 80 pavers.

Holland® PorousPave - Firth Holland PorousPave can be used as a wearing course to enhance permeability across the design.



SYSTEM CHOICES

The Pixel paver system is designed for light - medium duty traffic loadings that includes intermittent parking or occasional access for residential vehicles and light trucks. The Pixel paver system is not designed for use in high volume trafficked areas.

It is important to understand what requirements are to be satisfied and choose the installation method accordingly.

The two options available in the Pixel paver system are:

- Permeable basecourse
- Aggregate basecourse

The difference in these is the permeability of the basecourse material. The wearing course remains the same.

It is important to check Council and regional acceptance of what constitutes a permeable system, i.e. the Auckland Unitary Plan does not recognise an aggregate basecourse as permeable, even though the wearing course accepts water.

TABLE 1: Overview of difference between permeable and aggregate uses

	Traffic ¹	Pixel infill	Basecourse	Permeability
Permeable basecourse	Pedestrian Light - medium traffic loadings	Grass, ground cover or chip	Permeable aggregates or No fines concrete	High
Aggregate basecourse	Pedestrian	Grass, ground cover or chip	GAP	Low
	Light traffic	Grass or ground cover	GAP	

1. Note the traffic column refers to the loading the pavement system is subjected not just the Pixel pavers.

Schematic 50/50 square metre design ratio design ratio Pixel Paver System/PaveWare light vehicle traffic



LIGHT TRAFFIC DRIVING AND PARKING AREAS PAVEWARE HOLLAND 80MM, HOLLAND SET 80MM AND POROUS 80MM. PEDESTRIAN AREAS PIXEL PAVER AND PAVEWARE PIAZZA 80MM, FORUM 80MM, HOLLAND 80MM, HOLLAND SET 80MM AND POROUS 80MM.

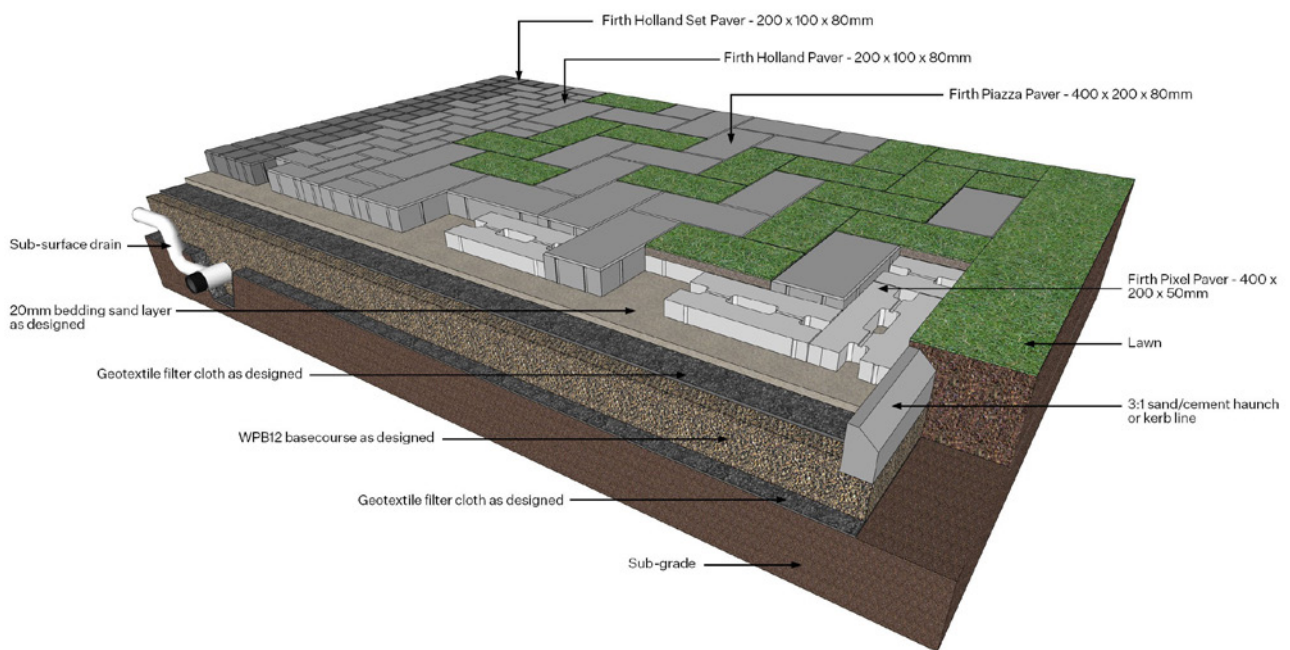
PERMEABLE BASECOURSE SYSTEM

A permeable system has an open graded basecourse, typically WPB12 or similar, see aggregate and sand grading section. This allows moisture from a rain event to pass easily from the wearing course into the basecourse where it can either be infiltrated

into the sub grade or released in a managed fashion into the stormwater network, reducing the pressures on our storm drains and receiving streams and rivers.

The voids in the Pixel paver can be filled with a soil and grass or ground covers or a variety of aggregates such as clean drainage chip or a decorative pebble.

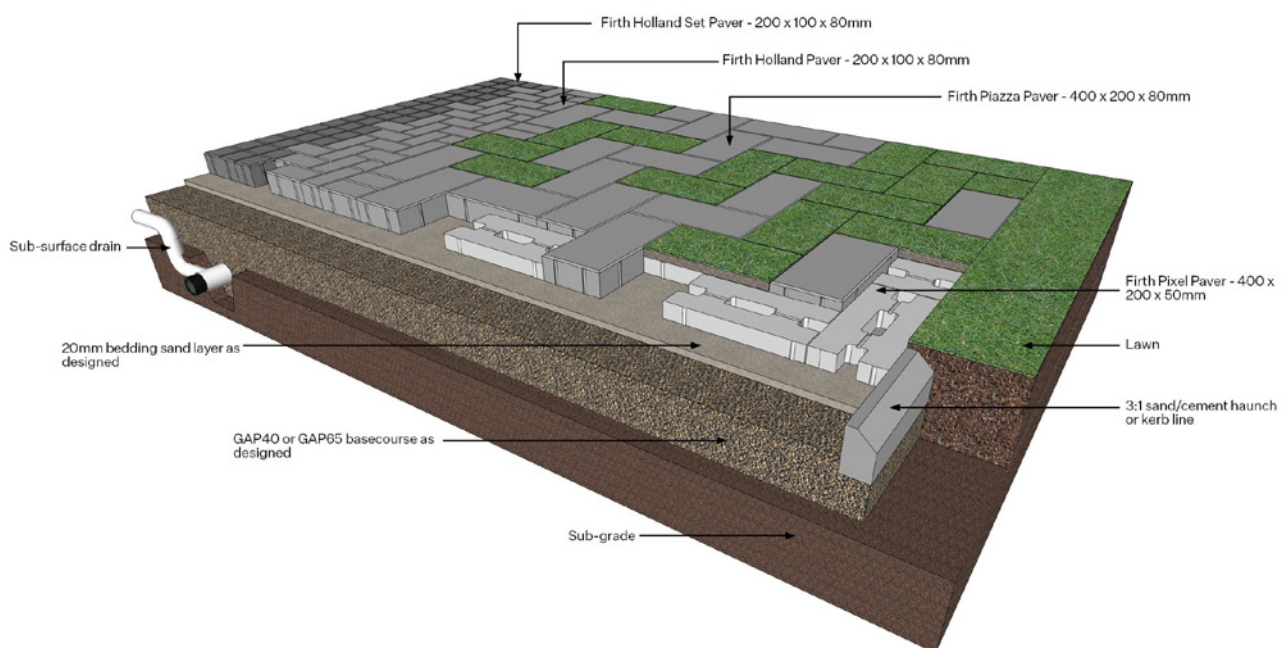
FIGURE 2: Permeable basecourse system



AGGREGATE BASECOURSE SYSTEM

Where modest surface permeability is required, and the traffic is light and infrequent, the system can be laid on a traditional (GAP) aggregate basecourse. If the system is trafficked, the Pixel pavers should be filled with a grass system as the soil in the wearing course can absorb the first 5mm of rain fall and limit the infiltration of water into the basecourse. The performance of GAP materials deteriorates with saturation, hence the need to limit traffic and infiltration for this option.

FIGURE 3: Aggregate base





LIGHT VEHICLE TRAFFIC AND FOOTPATH



MEDIUM TRAFFIC

BASECOURSE THICKNESS

The basecourse can have a structural and water storage function. The table below

relates only to the minimum thickness from a structural perspective.

TABLE 2: Basecourse thickness from a structure perspective

Function	Type of aggregate	Basecourse depth, mm		
		CBR 5 to 6.9	CBR 7 to10	CBR>10
Patio/footpath	Permeable ¹	150	150	150
	GAP aggregate	100	100	100
Light traffic	Permeable ¹	175	150	150
	Gap aggregate	150	125	100
Medium traffic	Permeable ¹	200	150	150

1. Greater depth maybe required to increase the desired amount of water storage.

Basecourse depths are indicative only and are provided to give an example of typical construction depths. This does not replace specific engineering advice.

CBR

NZS 3116.2002 section C303.2 allows for small residential jobs following sub grade assessment. The test should be carried out on damp or wet conditions:

- Weak CBR <5 - walking leaves a strong imprint in the soil
- Medium CBR 5-10 - heel pressure leaves an imprint
- Strong CBR >10 - no imprint in walking.

FORMATION LEVEL

The formation level to excavate to equals the finished surface level minus:

1. The required basecourse thickness in Table 2.
2. 30mm for the bedding sand.
3. 80mm for the thickness of the PaveWare segmental paving.

Additional excavation for pipes and perimeter haunching (edge restraint) may be required.

Ensure that the excavation is uniform, falls in the right direction and is free of detritus and other debris.

If the base of the excavation does not meet the design assumption CBR in table 2 the system will require further excavation to achieve a stable base.

AGGREGATE AND SAND GRADINGS

PERMEABLE BASECOURSE SYSTEM

(A) BASECOURSE

The grading, strength and broken faces requirements for open grade permeable aggregates is provided below.

Winstone Aggregates Base Course Drainage Aggregate “WPB12” 2-12mm

TABLE 3: “WPB12” grading envelope

SIEVE SIZE (MM)	WPB12	
	UPPER LIMIT	LOWER LIMIT
19.0mm	100	100
13.2mm	95	100
9.5mm	75	90
6.7mm	50	75
4.75mm	30	50
2.36mm	0	10

WPB12 will store approximately 300litres/m³, or when laid 100mm thick, will store approximately 30litres/m²

SPECIFIC REQUIREMENTS

- > The material shall produce less than 10% fines under a load of 120kN when tested in accordance with NZS 4407:1991 Test 3.10.
- > The material shall contain no deleterious material such as organic or clay material.
- > The broken face content shall be not less than 70% by weight and have 2 or more broken faces when tested in accordance with NZS 4407:1991 Test 3.14.

(B) BEDDING SAND

The bedding sand shall comply with NZS3116:2002 Table 4 Sand category III residential, residential driveways and public footpaths.

TABLE 4: Grading limits for bedding sand

BS SIEVE SIZE	PERCENTAGE BY MASS PASSING		
	SAND CATEGORY I	SAND CATEGORY II	SAND CATEGORY III
5.00 mm	90 to 100	89 to 100	89 to 100
2.36 mm	75 to 100	65 to 100	65 to 100
1.18 mm	55 to 90	45 to 100	45 to 100
600 Qm	35 to 65	25 to 80	25 to 80
300 Qm	10 to 45	5 to 48	5 to 48
150 Qm	0 to 10	0 to 15	0 to 15
75 Qm	0 to 1.5	0 to 3	0 to 5 (1)

Note: (1) F or residential pedestrian applications a 0 - 10% range can be used.

© Copyright Standards New Zealand 2011. Content from NZS 3116:2002 has been reproduced with permission from Standards New Zealand under Copyright License 000890. For full details, please refer to NZS 3116:2002, available to purchase from the Standards New Zealand website.

SPECIFIC REQUIREMENTS

- > The material shall contain no deleterious materials such as clay or organic material, nor contain more than 2.5% of light weight particles as determined by NZS 3111:1986.

(C) JOINTING SAND

SIEVE SIZE (MM)	Roads and Industrial Pavements Percent Passing	Other Percent Passing
2.36mm	100	100
1.18mm	75 - 90	75 - 100
600um	55 - 80	55 - 100
300um	20 - 40	15 - 60
150um	5 - 15	3 - 30
75um	0 - 5	0 - 5

Note: Joint sand shall be free of all soluble deleterious salts and other contaminants. The clay index of the fraction of sand passing the 75um sieve shall not be greater than 3 when the sand is tested according to NZS 4407.3.5. The sand shall have not more than 2.5% by weight of lightweight particles as determined by NZS 3111, section 9. Joint sand shall not have a water soluble chloride content in excess of 0.05% by its mass where aesthetics of the finished paving are of importance.

AGGREGATE BASECOURSE SYSTEM

(A) BASECOURSE

The specification for basecourse for the GAP aggregate basecourse option shall comply with NZS3116.

(B) BEDDING SAND

The specification for bedding sand for the GAP aggregate basecourse option shall comply with NZS3116.

(C) JOINTING SAND

The specification for jointing sand to comply with NZS3116.

PERMEABLE INSTALLATION

1. Excavate to the required formation level.
2. Install pipework if specified.
3. Lay the geotextile on the bottom of the excavation, ensure that there is sufficient geotextile available to go up each side of the excavation and approximately 300mm over the top once installed.
4. Lay impermeable membranes adjacent to building if specified and baffles for sloping sites.
5. Install the permeable basecourse (i.e. Winstone WPB12 or Firth No Fines 19mm concrete) on top of the geotextile. Compact the permeable aggregate with a plate compactor. One pass North and South and one pass East and West is usually sufficient.
6. Lay the geotextile fabric over the top of the permeable base and lap with the fabric coming up the sides.
7. Place the bedding sand and screed off to the correct heights. Compact the bedding sand then add a 5mm spread of bedding sand over the top.
8. Lay the 50mm Pixel paver and the 80mm PaveWare as per design. Once cut in and haunched, fill the voids created by the Pixel paver with aggregate, decorative pebble, or soils with ground cover or grass (turf grass recommended as per Appendix A). Once the voids are filled sweep a jointing sand into the joints of the PaveWare.

AGGREGATE (PERVIOUS) INSTALLATION

1. Excavate to the required formation level.
2. Install the aggregate basecourse (ie GAP40 or GAP65). Compact the aggregate with a plate compactor until compaction is achieved.
3. Place the bedding sand and screed off to the correct heights. Compact the bedding sand then add a 5mm spread of bedding sand over the top.
4. Lay the 50mm Pixel paver and the 80mm PaveWare as per design. Once cut in and haunched, fill the voids created by the Pixel paver with soils (as specified)

as per Appendix A and ground cover or grass (turf grass recommended) as per Appendix A. Once the voids are filled sweep a jointing sand into the joints of the PaveWare.

NB. When installing on a GAP base, clean aggregate or decorative pebble is not recommended to fill the Pixel paver voids as the rain water will flow through the wearing course to the GAP materials. GAP materials lose cohesion under load in a saturated state.

MAINTENANCE

The grassed areas require mowing and weeding as required.

Annually check for laterals and control if required.

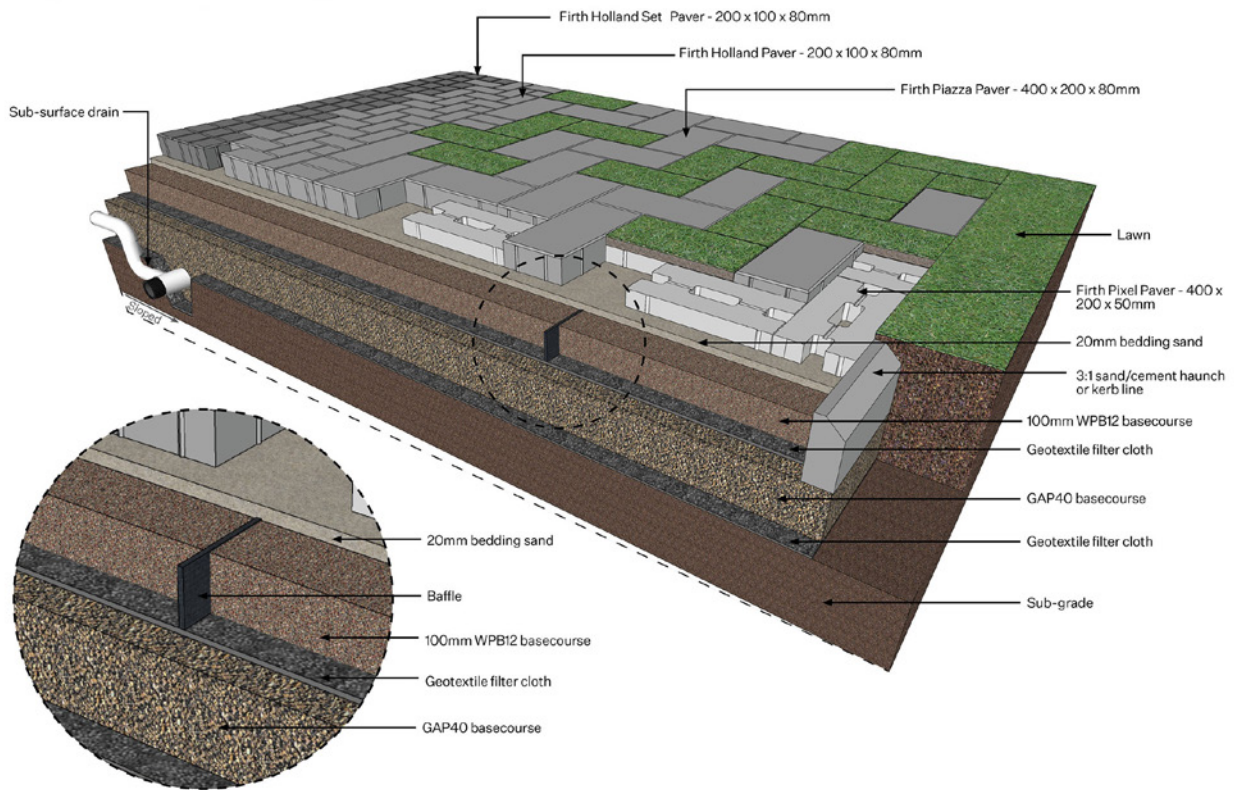
Check paver joints for laterals and jointing sand , clean and top up as required.

PAVING ON SLOPES AND NEXT TO BUILDINGS

When using the permeable system, it is important that the water entering the permeable base is managed. When constructed on a slope, the water will infiltrate the pavement then naturally follow

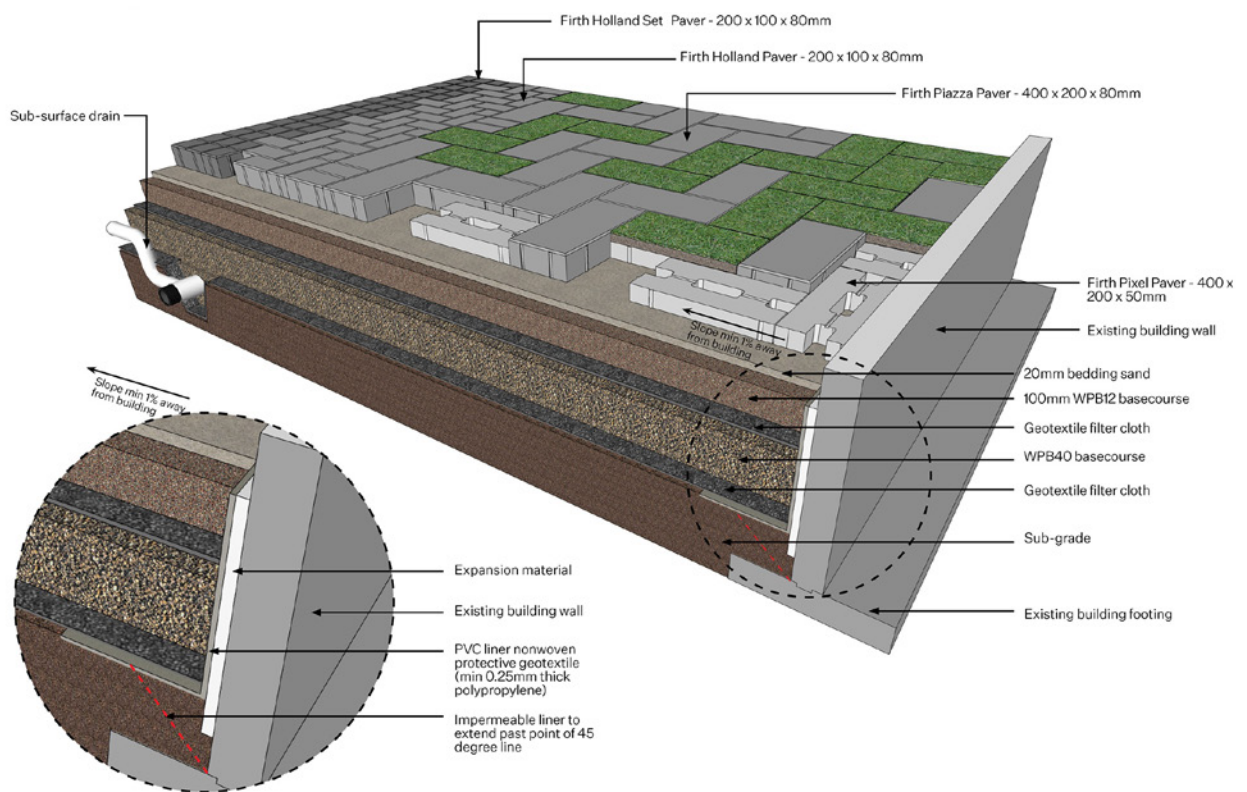
the slope of the subgrade. This can result in the stormwater collecting at the foot of the slope. For slopes greater than 5% it is recommended baffles are installed every 15 meters to mitigate the flow.

FIGURE 4: Paving on slopes



When installing adjacent to a building, it needs to be recognised that the basecourse may contain water and an impermeable liner is recommended to prevent moisture moving under the building. Refer figure 5.

FIGURE 5: Paving next to buildings



SOIL AND GRASS DETAIL

New Zealand Turf Management Solutions (NZTMS) conducted an independent field trial of the Pixel paver system laid on a permeable basecourse. The overall objective of this trial was to identify and measure the key performance characteristics of the Pixel paver system in conjunction with a range of turf grass varieties and simulated light traffic use. The trial was conducted over the period of one year 2019/2020.

The trial focused on warm and cool season turf varieties suitable for use in the top half of the North Island: Kikuyu, Tall Fescue, Couch and Kerbside Persist (ryegrass multi-blend). The trial focused on identifying which varieties and method of application would be most suitable for high care through to low care situations, assuming installation is likely to occur outside optimal seasons and will receive a wide range in quality of installation and aftercare. Consideration was given to factors including initial material

costs and availability, ease of installation and establishment, species resilience, vulnerability to wear and other environmental factors within the upper North Island climatic zone.

Both seeded and turf formats were trialled, with turf proving superior. The initial trial identified seeding is not a desirable option for installation, establishment, and growth as the seeded application resulted in over-spill and wash-out, spreading seed into paving gaps whilst also requiring a high input of maintenance to gain establishment.

Two separate levels of care were provided with one half being frequently watered and mown and the other left to establish with minimum care.

Whilst all species established well, key findings were the on-going need to trim back the lateral growth (stolon) of the warm season turf species.

Warm season turf varieties Kikuyu, Couch and Kerbside Persist grass trial



A further trial was undertaken in 2020 to determine if the Tall Fescue (*Festuca arundinacea* var. *lagertha*) grass species would establish with minimum maintenance. Tall Fescue has a naturally dense growth habit. The newest variety (*Lagertha*) is quicker to establish and provides a dark green turf sward. Best mown at 25mm - 30mm height for optimum plant health. The Tall Fescue turf significantly reduced the need to trim as it remains in the Pixel paver void and does not spread laterally like the Kikuyu and Couch varieties.

For best results fertilising twice a year with a fertiliser like Andersons 28-3-10 (50%) or similar was recommended by the report. Fertilisers that are high in trace elements including Fe (Iron) are to be avoided, as they create orange flecking on the exposed pavers.

Once established, watering is required during periods of hot dry weather to sustain optimum growth performance.

Other plants in the “grass trial” such as Thyme were trailed in the voids, which needed more time to establish than the trial ran for. Table 5 provides a list of hardy ground cover plants that are suitable for planting in the Pixel paver voids.

The Turf Mix TM180 has been engineered specifically for turf, the ability of this product to sustain a variable ground moisture percentage whilst also having the required infiltration performance to satisfy permeability made it the preferred soil choice. See report for product specifications.

TABLE 5 : Summary of Recommended Products

Element	Product
Soil	Premium Lawn Soil TM180, or similar
Turf	Tall Fescue
Ground Covers	<i>Acaena inermis</i> “Purpurea” <i>Selliera radicans</i> <i>Dichondra repens</i> <i>Thymus praecox</i> <i>Thymus serpyllum</i> <i>Mentha requienii</i> <i>Origanum marjorana</i>
Aggregates	Any clean aggregate or pebble in the range of 2mm-19mm , similar but not limited to : SC6 or WPB products McCallum Chip or similar Waikato Fleck 3-7mm & 7-16mm or similar River pebble 7-13mm or similar
Fertiliser	Andersons 28-3-10 or similar <i>Note. Iron (fe) based fertilizers may stain the paving units</i>

Beneficial to bees and other insects ground covers established after the trial was completed.



Image supplied by NZTMS.

THERMO PERFORMANCE

Dark and light-coloured paving surrounding the Pixel paver can affect the growth performance of the grass due to heat retention of the paver. Darker shades adsorb more heat, especially in summer. This should be a consideration in pavement colour choice, warm season varieties coped better in the darker paving.

Refer New Zealand Turf Management System 0 – study on grass types.
Contact us on 0800 FIRTH 1 to get this report.

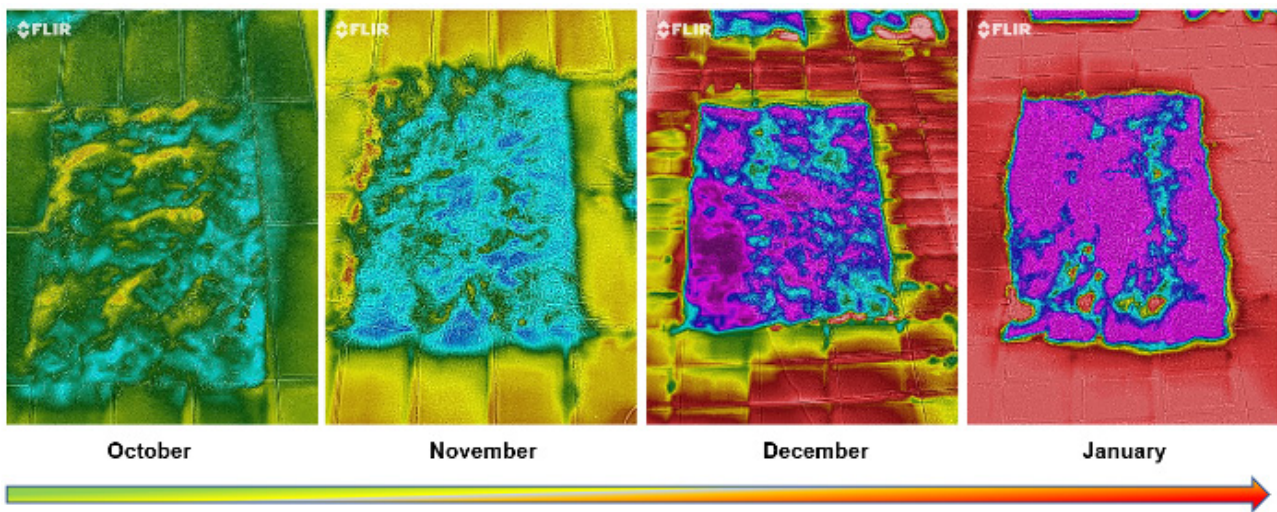


Figure 9: Monthly increase in temperature of system during peak daytime hours (12 – 2 pm).



FOR MORE INFORMATION VISIT FIRTH.CO.NZ OR CALL 0800 FIRTH 1