Centre of Excellence
for Decarbonising Roads

MILES MACADAM HARDIPAVE LIVE TRIAL EVALUATION REPORT

Live Labs 2 North Campus

This report presents the findings of a live trial evaluating HardiPave, a macadam surfacing material that is sealed in with a resin-cementitious grout, as a sustainable alternative to Hot Rolled Asphalt (HRA). HardiPave demonstrated overall higher carbon emissions (A1-A5) than HRA. However, HardiPave has the potential to offset these emissions over-time due to its high resistance claims. Recommendations drawn from this trial include Miles Macadam gaining an Environmental Product Declaration for HardiPave to further verify the materials low carbon claims.

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STATUS/AMENDMENT	PREPARED	REVIEWED	APPROVED
1.0	Name: Annabelle Farrington Signature: Date: 24/10/2025	Name: Aditi Subramanian Signature: Date: 20/02/2026	Name: Matthew Wall Signature: Date:12/03/2026

Executive Summary

This report evaluates a live trial conducted as part of the Live Labs 2 project, which aims to test innovative highway solutions to reduce carbon emissions, improve road performance, reduce maintenance needs, and enhance safety. This trial concerns HardiPave, described by the manufacturer as an open-graded cementitious grouted macadam surface course that claims to deliver a jointless, high resistance wearing surface layer for heavily trafficked and industrial applications. For this trial, HardiPave was supplied and manufactured by Miles Macadam, with Holcim handling mixing and site delivery at their nearby Duntilland quarry and then installation was performed by Miles Macadam.

The manufacturer, Miles Macadam, claim that HardiPave achieves carbon savings due to its cementitious sealing grout that increases surface durability and reduces frequency of maintenance and stone replacement, reducing cumulative emissions over the design life of the surface course.

HardiPave was trialled as part of the Supersite Trial (a single stretch of highway trialling several materials and techniques) along Hirst Road in North Lanarkshire. HardiPave was trialled as a surface course along Junction 1 (B7057) of the supersite at a depth of 40mm. A control section of Hot-Rolled Asphalt (HRA) surface course was also applied to the Supersite at 50mm to allow for direct comparisons to the business as usual (BAU) approach to surfacing for North Lanarkshire Council. The findings, limitations, and recommendations presented in this report aim to inform the potential wider rollout of HardiPave across UK local councils.

This report assesses carbon emissions across material extraction to construction lifecycle stages in accordance with EN 15804, covering product stages A1-A3 of this standard (raw material extraction, transportation to processing facilities and manufacturing) and construction stages A4 to A5 (transportation of the finished material to site and installation). EN 15804 classifies carbon and establishes a modular, transparent approach to lifecycle assessment that assigns emissions to defined stages. Using EN 15804 ensures that this live trial is in line with the recognised European standard, follows accepted boundaries and allocation rules, and enables results that are comparable, auditable and consistent across products and projects.

The findings from the trial show that HardiPave recorded higher A1-A5 emissions when benchmarked against HRA, producing a 52.67% higher embodied carbon figure per square metre than conventional HRA in this trial. The trial indicated significantly higher A4 contributions per square meter, however this can be attributed to the higher transport mileage required to deliver the material to the North Lanarkshire site. These A4 emissions can therefore be considered as site specific emissions and therefore it holds potential to reduce carbon in locations in closer proximity to suppliers. The trail also demonstrated higher A5 emissions per square metre when compared with HRA however, the materials grout-sealant and high durability surface may have potential to reduce frequency of maintenance and stone replenishment, lowering cumulative emissions over the service lifecycle.

It is important to highlight that carbon emission factors for this trial are supplier-sourced and an independent third-party verified Environmental Product Declaration (EPD) for HardiPave was not available at the time of this trial. This limits independent verification, direct comparability and reduces the overall confidence of this carbon analysis.

Introduction

This Evaluation Report provides a high-level assessment of Miles Macdam's HardiPave, an emerging sustainable material in highways, construction and maintenance, focusing on its environmental impact, product viability, and alignment with future infrastructure needs.

This product is being trialled as part of Live Labs 2, a three-year UK-wide programme funded by the Department of Transport (DfT), with a five-year monitoring and evaluation period, focusing on how to decarbonise local highways infrastructure and assets. As part of this initiative, North Lanarkshire Council (NLC) are working alongside Transport for the West Midlands (TfWM), to establish the UK Centre of Excellence for Materials Decarbonisation in Local Roads.

The Centre of Excellence will act as a central hub within Live Labs 2, supporting research, innovation, and best practices to accelerate low-carbon solutions in road construction and maintenance. By integrating findings from Live Labs 2 trials, the Centre will drive sustainable advancements, enabling Local Authority Highway sectors across the UK to adopt more efficient and environmentally responsible materials and methodologies.

The purpose of these reports is to present key findings from a comprehensive evaluation of sustainable materials, including their carbon intensity, potential application, and overall benefits by examining carbon appraisals, lifecycle benchmarks, and various factors such as scalability, compliance, durability and supply chain viability. The report aims to provide decision-makers with valuable insights into the material's capacity to meet sustainability goals while maintaining construction quality and durability. The evaluation will inform ongoing efforts to balance environmental considerations with operational efficiency in infrastructure development.

The carbon profiles of materials have been calculated using the Future Highways Research Group (FHRG) Carbon Leadership Profiler Toolkit (previously known as Carbon Analyser), a excel-based tool developed in collaboration with local highway authorities to provide a simple, standardised method for quantifying carbon emissions associated with transport and highways activities, and the OneClickLCA database where embodied carbon data is otherwise unavailable. All carbon profiles have incorporated a local and sector-wide baseline material to benchmark carbon savings. The HardiPave trial has been evaluated against conventional HRA. For this trial, Miles Macadam supplied and laid the HardiPave, while Holcim mixed and delivered it from their nearby Duntilland quarry.

The carbon evaluations for HardiPave incorporate whole lifecycle assessments which consider:

- Embodied Carbon;
- Transportation emissions of materials and people;
- Operation of plant and equipment during construction period;
- Operational electricity, fuel and water emissions;
- End of life emissions including deconstruction and waste processing.

Feature	Description	Carbon Intensity	Product Prospects
Material Summary	**Description of material**	**Specific emissions data (CO_2e per unit of material)**	**Brief product potential overview**
HardiPave – Miles Macadam	HardiPave is a grouted macadam material comprising an open-graded aggregate mix which is sealed in with a resin-cementitious grout. This grout helps to increase resistance to deformation, fuel and contaminant exposure and heavy traffic loads. HardiPave is applied to create a jointless and impermeable surface course and is ideal for areas under heavy use on highways, subject to high levels of traffic and/or significant HGV use. HardiPave's high resistance reduces maintenance requirements, reducing lifecycle costs.	This product produced 23.22 $kgCO_2e/m^2$. When applied on the same stretch of road conventional HRA produced 9.19 $kgCO_2e/m^2$. HardiPave surface course was applied at a depth of 40mm whilst the control HRA surface course was applied at a depth of 50mm. Comparative carbon analysis in this trial showed a 52.67% increase in A1-A5 lifecycle stage carbon emissions per square metre. A key benefit of the cementitious grout sealant is the improved durability it offers. Scenario carbon modelling extending service life by 20 years compared with conventional HRA demonstrated a 40% reduction in carbon emissions. This modelling is consistent with manufacturer claims for the surfacing product.	It is considered that this product has a potential in the road construction and maintenance industry, particularly in projects prioritising high durability. HardiPave has not shown material stage carbon savings when compared to HRA within this trial, however scenario-based carbon modelling highlights that it does have potential to reduced-carbon surfacing in live environments by extending the useful life of the asset. These results indicate that HardiPave's claimed durability could deliver substantial carbon savings across local-authority networks when assessed on a whole-life basis. A monitoring programme of at least five years is required to validate long-term performance and to quantify any additional carbon reductions from an extended asset service life.

Methodology

Trial Design

The HardiPave trail was undertaken to evaluate the performance, durability, and environmental impact of this material. The trial was conducted as part of the larger Supersite trial (a single stretch of highway trialling several materials and techniques) which focussed on testing innovative low-carbon surfacing materials and in-situ recycling techniques to evaluate their carbon savings and long-term performance under real-life road conditions. HardiPave was chosen to be applied to the Junction B7057 site along Hirst Road to assess the materials high durability claims.

Carbon emissions have been assessed based on the whole lifecycle stages A1-A5 (material extraction to construction) in accordance with EN 15804. EN 15804 is the European standard that defines the standards and reporting format for Environmental Product Declarations (EPD) for construction products, providing a consistent, audible framework for quantifying carbon impacts across a products lifecycle. These stages cover raw material extraction, transport to and manufacture at the factory, delivery to site and on-site installation, see Figure 1. This clear separation of stages enables precise attribution of emissions to each segment of the supply chain, helping to identify areas for potential reduction measures and ensuring comparability across all trials.

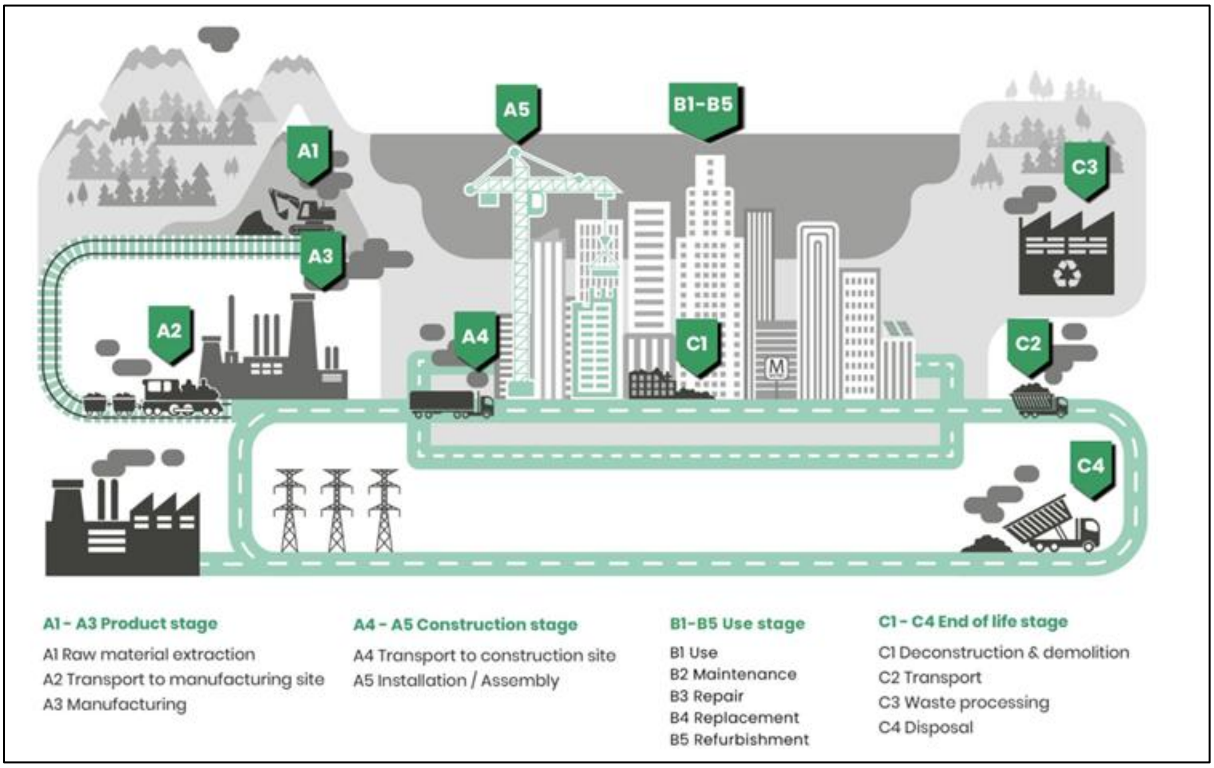

Figure 1: Carbon Lifecycle Stages[1]

[1] Life Cycle Stages | One Click LCA

Site Selection

The trial sites were chosen based on the following criteria:

- **Traffic Volume:** The site was chosen as it experiences high volumes of both light and heavy vehicles allowing for assessment of material performance under differing stress conditions.
- **Environmental Conditions:** The Supersite site was selected due to its varying weather conditions (e.g., temperature, humidity) to evaluate the surfacing material's resilience.
- **Surface Type:** Sites were all originally with hot-rolled asphalt (HRA) and had severely deteriorated with time and use, requiring urgent maintenance.

Data Collection Plan

The following data items were collected to ensure a thorough evaluation of HardiPave during site trials:

DATA ITEM	UNIT(S)	RESPONSIBLE	LOCATION OF DATA	PURPOSE
Trial Location	Road name, Road Type (A, B, C), Coordinates of location of HardiPave	Operational Staff	Site Diary	Technical comparisons
Conditions at the time of lay	Temperature (°C) Conditions (rain, dry, etc)	Operational Staff	Site Diary	Operational considerations and technical comparisons
Coring	Pen Softening Point DSR	University of Nottingham	Site Diary	Technical Evaluation
Road Surface Temperature	Temperature (°C)	Inspector	Site Diary	Technical Evaluation
Quantity	m^2 of HardiPave used	Operational staff & Carbon Lead	Site Diary	Cost and Carbon Evaluations
Cost	£ for HardiPave £ for conventional resurfacing	Amey Procurement and Suppliers	SAP	Purchase cost and whole lifecycle cost evaluation
Line Characteristics	Length and Width (cm)	Carbon and/or Technical Lead	Site Diary	Technical and Carbon Evaluation
Operational Experience – ease of installation	Subjective – any concerns or benefits experienced by Operations Team	Project Manager to collect on-site data with Operations Team	Case Study in knowledge bank	Scalability Evaluation
Health & Safety	Ease of installation on-site Temperature required for installation	Operational staff and supplier information	Site Diary	Health and Safety Assessment
Operational Data	Time to complete (hh:mm)	Operational Staff	Site Diary	Operational considerations and carbon evaluation
Fuel Usage	Litres of petrol used Type of plant/fleet used (electric, diesel, model)	Operational Staff	Site Diary	Carbon evaluation

Table 1: Data collection plan

Trial Location Plan

The primary aim of the Supersite trials is to undertake a comparison analysis of surface courses with the current benchmark used by North Lanarkshire Council, traditional HRA. There were a total of eight trial sections along one site (Hirst Road), with six surface courses and two binder courses on the main straight stretch of carriageway and a further two surface course sections at junctions – HardiPave was tested on junction B7057. All trial sites were completed on one B classification of road (Hirst Road).

	BINDER COURSE			SURFACE COURSE			
TRIAL SECTION	MATERIAL / METHOD	DEPTH (MM)	SUPPLIER	PRIMARY MATERIAL	INNOVATION	DEPTH (MM)	SUPPLIER
1	In-situ Recycling	110	Colas	HRA	GiPave	50	Iterchemica/ Holcim
2	In-situ Recycling	110	Colas	HRA	Styrelf bio-PMB	50	Total /Holcim
3	In-situ Recycling	110	Colas	HRA (warm mix)	Traditional Surface HRA 35/14	50	Holcim
4	In-situ Recycling	110	Colas	HRA	HRA 35/14 Warm Mix	50	Holcim
5	In-situ Recycling	4% CEM II and 4% calcined clay binder (150mm HBM recycled layer)	SPL	HRA	UltiPave Bio	50	Tarmac/ Holcim
6	In-situ Recycling	4% CEM II and 4% calcined clay binder (150mm HBM recycled layer)	SPL	HRA (warm mix)	HRA 35/14 Warm Mix	50	Holcim
Junction 1	Traditional Binder	60	Hochtief	14mm HardiPave	HardiPave	40	Miles Macadam
Junction 2	Traditional Binder	60	Hochtief	14mm MilePave PMB	MilePave	50	Miles Macadam

Table 2: Supersite trial information

Procedure

Site Preparation: The selected sites were cleaned, prepared and planed for the application of HardiPave. Loose debris and water were removed to ensure proper adhesion.

Material Application: Roads were prepped as per manufacturer's instructions prior to product application. All materials were applied in accordance with manufacturer's instructions and specifications. HardiPave was applied via a paver using conventional HRA processes. It was applied by Miles Macadam employees who were trained to install the material.

Monitoring and Data Collection: The trial sites will be monitored over a period of 12 months. Data on surface condition, material performance, and environmental impact were collected at regular intervals.

Performance analysis: The performance of HardiPave was evaluated based on criteria such as durability, resistance to traffic stress, and environmental impact. Comparisons were made versus traditional resurfacing to benchmark performance.

Data Analysis

The collected data were analysed to determine the effectiveness of HardiPave as an alternative surfacing material to conventional HRA. Statistical methods were used to evaluate the performance of HardiPave versus a control section (HRA) along the same road. The analysis focused on:

- **Durability**: Assessing the longevity of the treated site and resistance to traffic and environmental stress;
- **Environmental Impact:** Evaluating the reduction in carbon emissions and use of recycled materials; and
- **Cost- Effectiveness:** Comparing the costs associated with HardiPave, including material, application, and maintenance costs.

For this trial, HardiPave was supplied by the manufacturers Miles Macadam, with Holcim handling mixing and site delivery at their nearby Duntilland quarry. Holcim were responsible for material mixing prior to installation by Miles Macadam. The embodied carbon factors for the trialled materials have been built based on Holcim product area, supplier product data and supported from carbon factors sourced from OneClick LCA where required. An Environmental Product Declaration (EPD) had not been produced for HardiPave at the time of this carbon evaluation.

Holcim have provided A1-A3 carbon values for the mixing of HardiPave at Duntilland Quarry. Holcim's internal carbon tool was used to calculate these values. This tool follows the principles of EN 15804 and has been third party verified by Circular Ecology Ltd. The tool uses primary activity data from Holcim operations, secondary data coming primarily from the UK Government GHG emission factors and Inventory of Carbon and Energy v4.0 by Circular Ecology and University of Bath, with additional data supplied by Carbon Trust.

The reliance on supplier provided carbon emission factors raises possible confidence issues due to limited transparency within the supplier's methodology however, the best available data has been used to ensure consistency across trial materials.

Carbon Appraisal

Drawing on data collected through trials; a carbon assessment has been undertaken. This establishes the parameters of the model, defines assumptions and outlines product specifications. Table 3 presents assumptions for all the materials used in the trial on site, including those employed by Holcim during the mixing process as well as the HardiPave supplied by Miles Macadam.

ASSUMPTIONS	JUSTIFICATION
All transportation is undertaken via diesel HGV.	Based on standard modelling assumptions from similar schemes.
Design life of pavement surface is 40 years.	Based on PAS 2080 guidance[2]. At 40 years the binder course of HRA requires replacing.
Unit of measurement used is ‘$kgCO_2e/ m^2$’.	Based on the best available data used to conduct carbon appraisals.
Assuming fuel usage is based on an 8-hour shift.	Based on the best available data provided by the supplier to conduct this assessment.
Traffic management activities were not included within this carbon assessment.	Traffic management differs between sites and local authorities so requires separate capturing, as part of standard practice
Government emission factor transport, HGV, diesel 2025 was used to calculate A5 for plant when a specific emission factor is unknown.	Based on the best available data at the time of this carbon appraisal.
This carbon analysis does not incorporate planing out activities within this assessment.	This is a BAU activity therefore is not influenced by this innovative process.
Where specific emission factors are unavailable OneClick LCA machine hours is used.	Based on the best available data at the time of this carbon appraisal.
Bondcoat application rate 1.2 kg/m^2	Based on application records from the Hirst Road Supersite trial.
Machinery hours have been pulled from site diary records	Based on the best available data at the time of this carbon appraisal.
Bondcoat application time based of time to apply for MilePave per m^2	Based on the best available data provided by contractors at the time of this carbon appraisal.
The comparative carbon modelling for HardiPave and HRA assumes a standard 20-year service life for HRA and models scenarios in which HardiPave extends the surface material’s service life by an additional five years and an additional 20 years. Modelling assumes every 20 years HRA requires planing and re-installing.	Based on PAS 2080 guidance.
The service-life scenario modelling does not include emissions or impacts from lifecycle stages B1–B9.	This information was not available at the time of this carbon analysis. Therefore, these stages have been excluded to ensure service-life scenario modelling to maintain a clear, auditable scope focused on construction-phase and embodied impacts where robust, project-specific data are available.
To calculate the CO_2e emissions per tonne of aggregate from each quarry, Holcim utilised the total energy consumption for each quarry (Duntilland) over the previous 12 months. The quarry’s energy use was converted to an equivalent CO_2 emission value then divided by the total tonnage of aggregate sold in that same period.	Based on the most up to date information the contractor, Holcim, had available at the time of this carbon analysis.
Holcim utilised Eurobitume’s 2025 carbon emission factor for bitumen, 530$kgCO_2e$/ tonne.	This figure is the most recent bitumen emission factor and is considered the industry standard.
Fuel consumption of dryers has been calculated by the amount of fuel used divided by the tonnage of asphalt supplied. Giving the CO_2e value per tonne of asphalt mixed can vary plant to plant based on tonnage supplied, fuel type, efficiency etc.	Based on the best available data at the time of this carbon appraisal.

[2] 2023-03-29-pas_2080_guidance_document_april_2023.pdf

The emission factor used for fibre pellets used as part of conventional asphalt production was sourced from ASPECT.	Based on the most recent emission factors available to the contractor, Holcim, for emission factor calculation. Holcim's internal carbon calculation tool has been externally verified by Circular Ecology and follow the principles EN 15804.
The default emission factor used for RAP (reclaimed asphalt pavement) was sourced from ASPECT.	Based on the most recent emission factors available to the contractor, Holcim, for emission factor calculation. Holcim's internal carbon calculation tool has been externally verified by Circular Ecology and follow EN 15804 principles.
The emission factor used for limestone filler was sourced from ICE v.3 2020.	Based on the most recent emission factors available to the contractor, Holcim, for emission factor calculation. Holcim's internal carbon calculation tool has been externally verified by Circular Ecology and follow the principles EN 15804.

Table 3: Carbon appraisal matrix

Carbon Modelling

The carbon modelling for the trials was conducted using the Future Highways Research Group (FHRG) Carbon Leadership Profiler Toolkit to collect and analyse primary carbon data from the trials, detailing emissions from materials, transport, construction activities and equipment use. Using this information the tool generated carbon profiles that identified emission hotspots and using the toolkit's emission database providing verified emissions factors to improve data accuracy.

One Click LCA was also utilised in modelling to support the FHRG Carbon Leadership Profiler Toolkit due to its large database of emission factors supported by Environmental Product Declaration (EPD). The carbon emission factor for HardiPave is supplier sourced and lacks third-party verification or EPD at the time of this carbon analysis.

Indicative results from carbon modelling for the HardiPave works at the Junction B7057 site along Hirst Road are presented graphically in Figure 2:

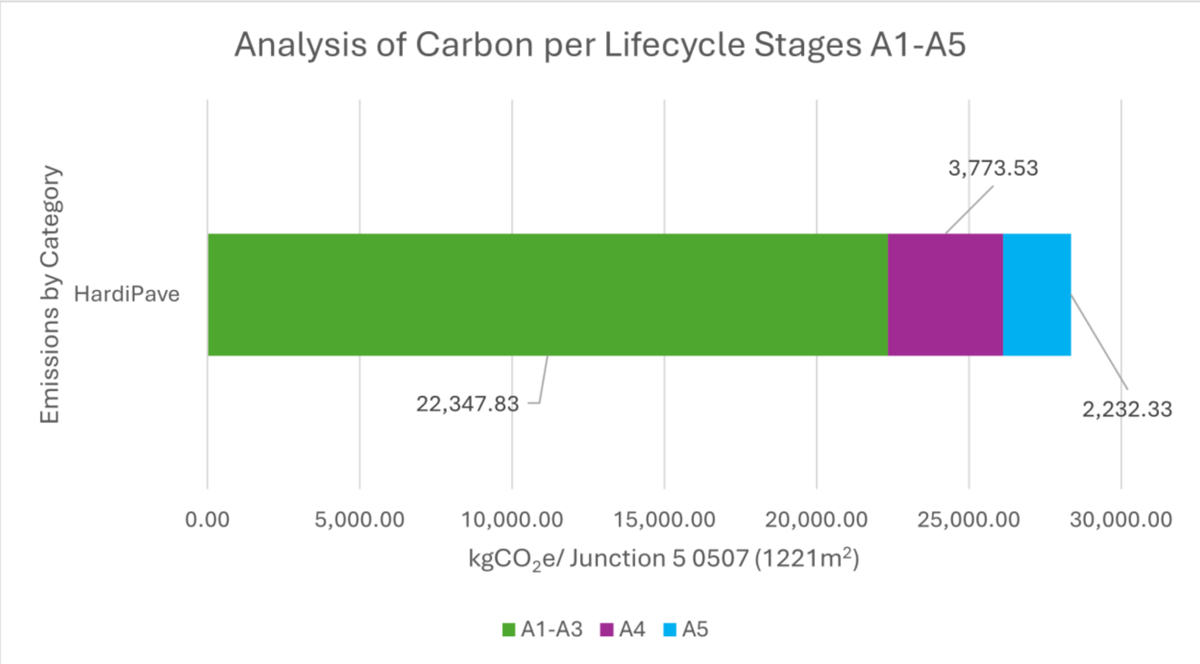

Figure 2: Carbon Analysis of HardiPave per lifecycle stages A1-A5

The following graphs illustrate the live trial results, expressed in $kgCO_2e/m^2$. This presentation of emissions enables direct comparison across different surfacing materials, to highlight carbon-efficient options and support data-driven decision making for reduction strategies. See **Error! Reference source not found.** and Figure 3:

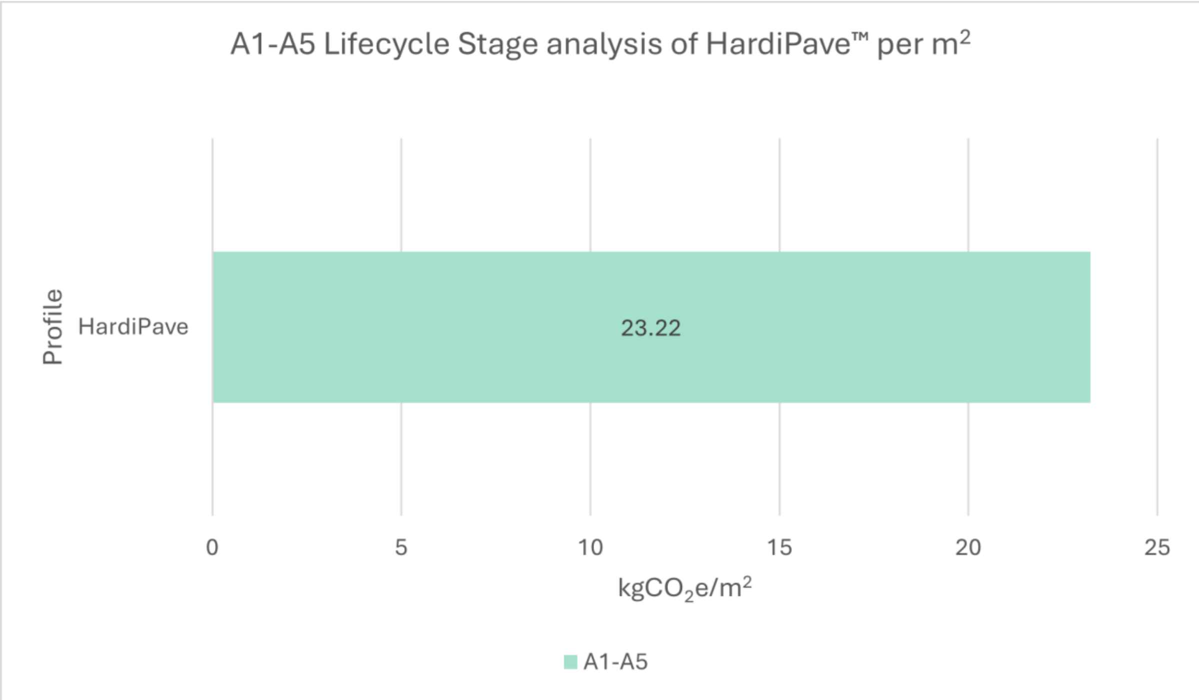

Figure 3: Carbon analysis of HardiPave per m² (40mm depth)

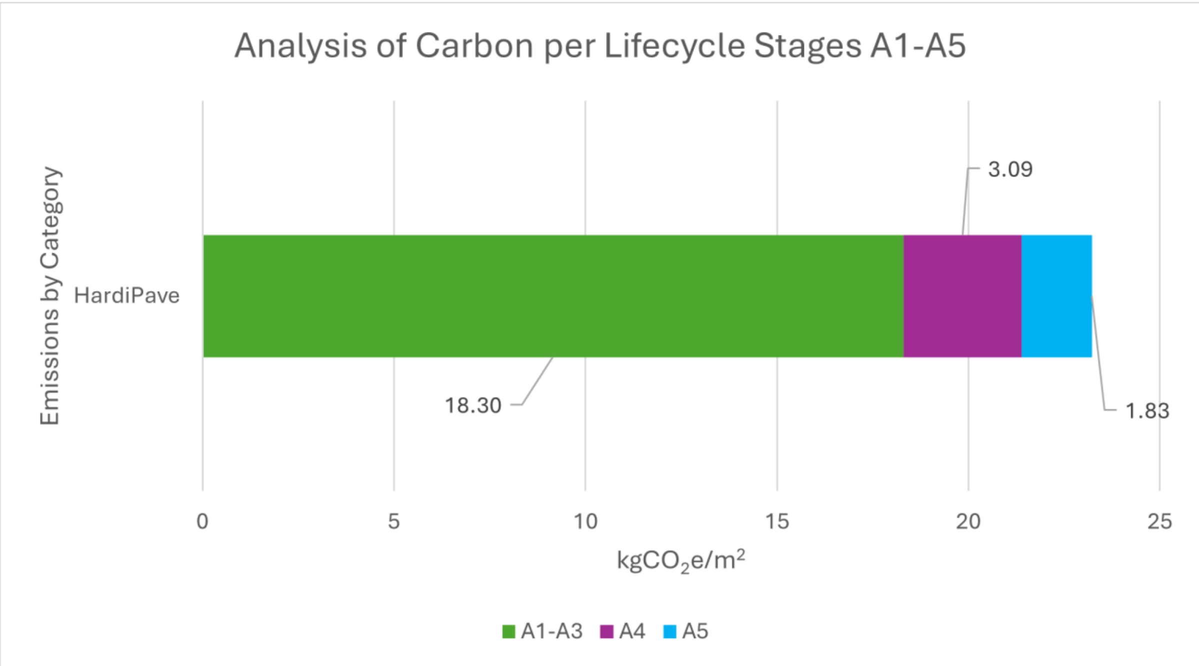

Figure 4: Carbon analysis of HardiPave per lifecycle stages A1-A5 per m² (40mm depth)

Benchmarking

HardiPave is yet to be used as business as usual (BAU) on North Lanarkshire Highways. These trials allow for an analysis of the performance of HardiPave in comparison to conventional HRA on the same road of the same traffic loads. This would be the traditional option for re-surfacing if HardiPave were not used and allows for comparative carbon analysis between HardiPave and BAU HRA surfacing.

Comparative analysis results are presented graphically in Figure 5 and Figure 6:

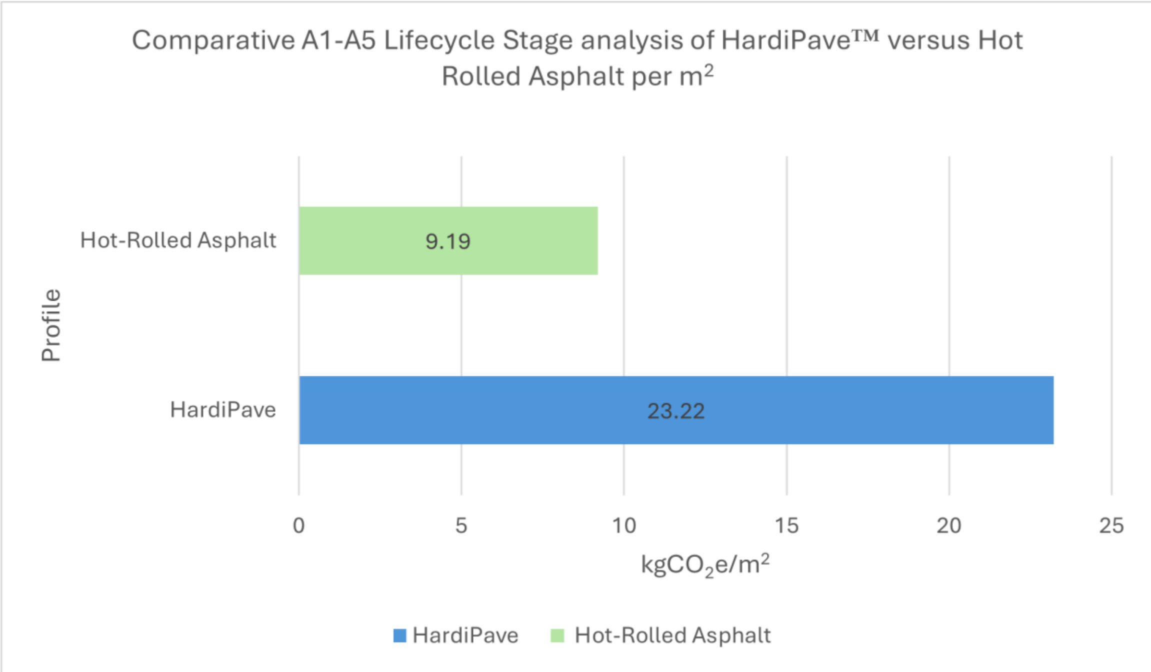

Figure 5: Comparative carbon analysis HardiPave versus HRA per m² (40mm depth HardiPave, 50mm depth HRA).

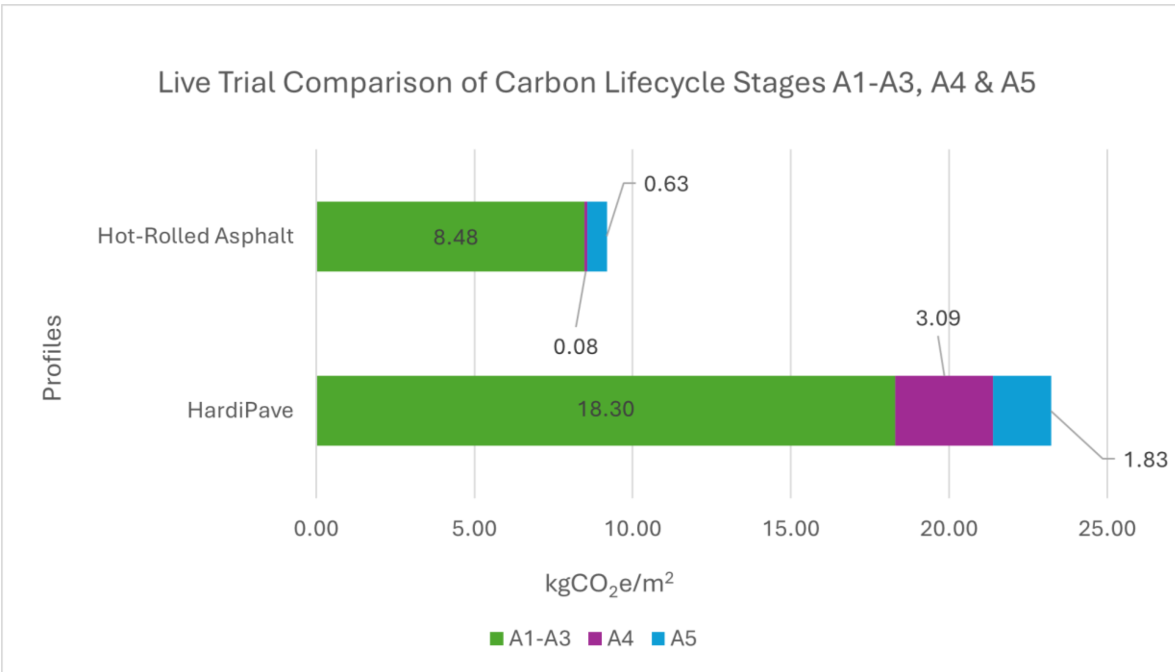

Figure 6: Comparative carbon analysis of HardiPave versus HRA, lifecycle stages A1-A5.

The following shows comparative carbon modelling of HardiPave under the scenario that the cementitious grout extends the pavement's service life by 5 years. This analysis accounts for the planing off, single re-application and disposal of the HRA surface course that would be required over the same assessment period. This analysis assumes the standard service life for conventional HRA is 20 years and does not include emissions associated with the surfaces use (B1-B9). Results from this modelling is represented graphically below in Figure 7:

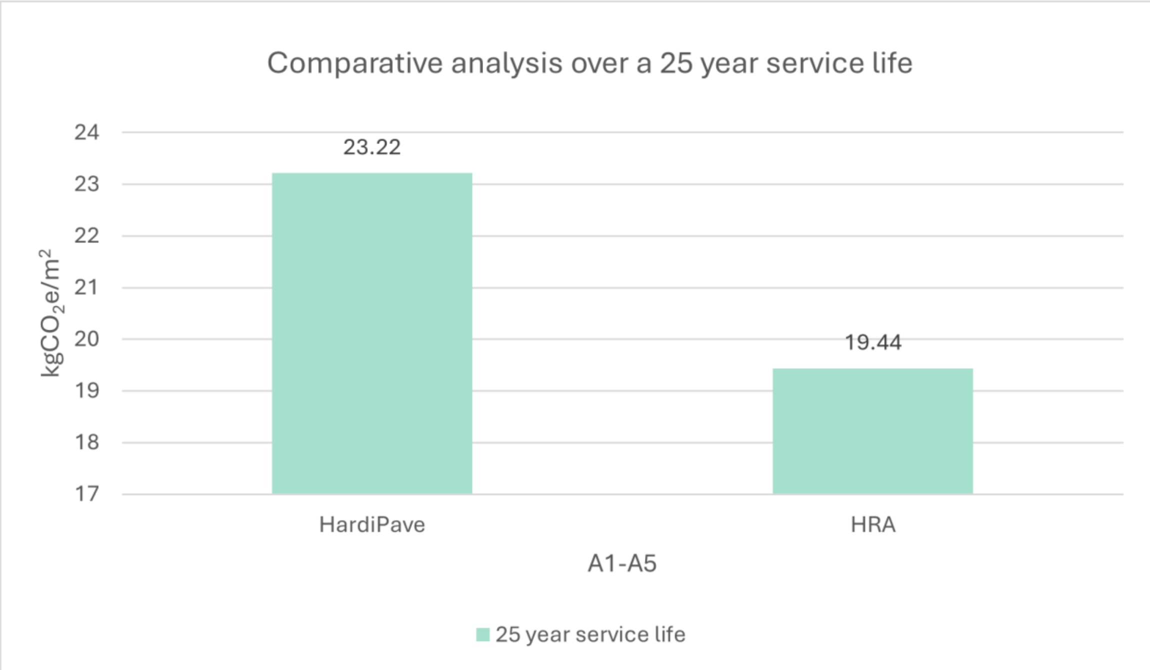

Figure 7:Comparative carbon analysis HardiPave versus HRA per m^2 (40mm depth) over a service life of 25 years

The following shows comparative carbon modelling of HardiPave under the scenario that the cementitious grout extends the pavement's service life by 20 years. This analysis accounts for the planing off, single re-application and disposal of the HRA surface course that would be required over the same assessment period. This analysis assumes the standard service life for conventional HRA is 20 years and does not include emissions associated with the surfaces use (B1-B9). Results from this modelling is represented graphically below in Figure 8:

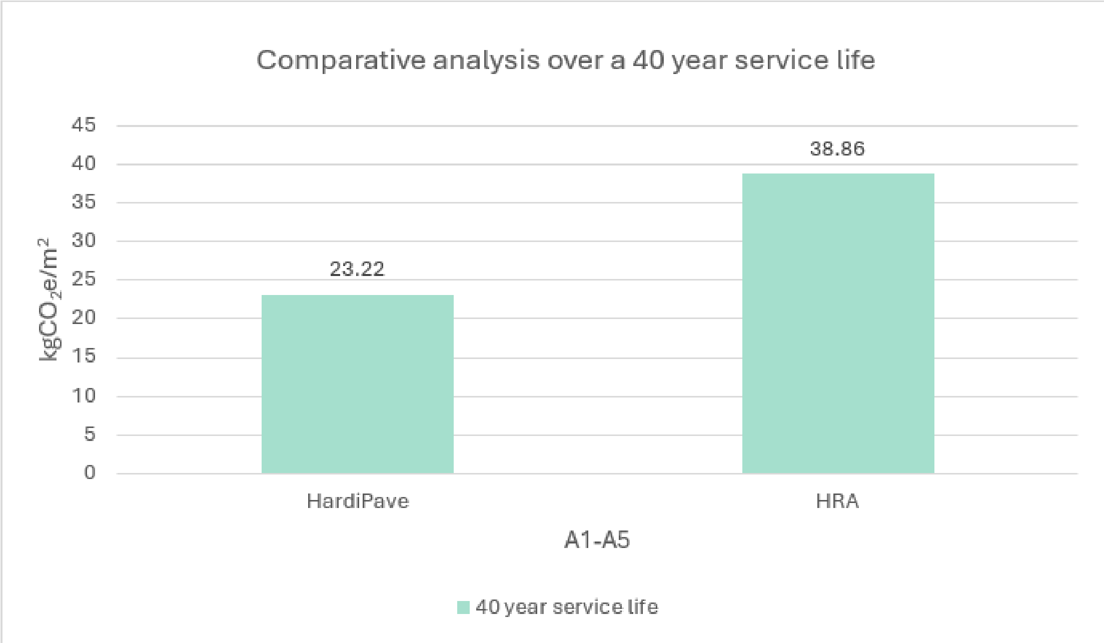

Figure 8: Comparative carbon analysis HardiPave versus HRA per m² (40mm depth) over a service life of 40 years

Further benchmarking has been undertaken as the HRA control section on the supersite contained 15% RAP, which is higher than that conventionally used. RAP content varies by HRA mix and by Local Authority due to specification and design. To provide an alternative like-for-like comparison, HardiPave has been modelled against an HRA baseline with no RAP. Previous scenario modelling used the figure for HRA 15% RAP, as used on the supersite. Results from this modelling are represented graphically below in Figure 9:

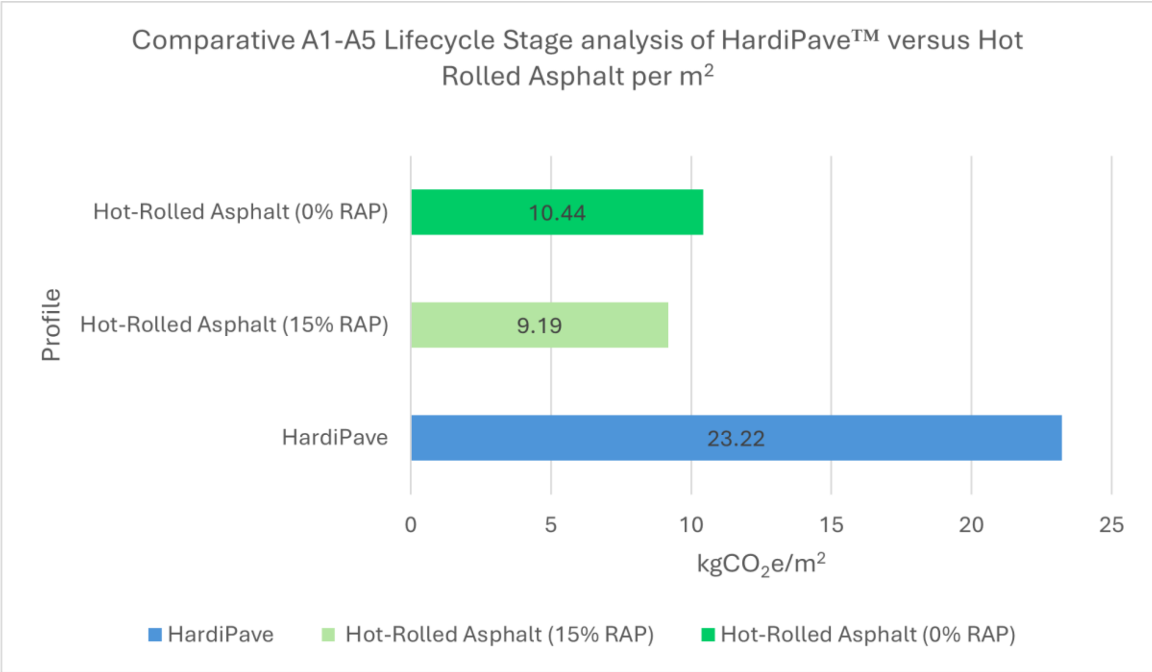

Figure 9: Comparative carbon analysis HardiPave versus HRA with no RAP content per m²

MATERIAL	COMPOSITION	APPLICATIONS	PERFORMANCE	INSTALLATION	SUSTAINABILITY
HRA	HRA is a gap-graded bituminous mix comprising of a mortar of fine aggregate. It is hot applied via a paver. Immediately after paving, the pre-coated high-PSV chippings are rolled into the hot mix to lock in a positive texture for skid resistance.	HRA is predominately intended for use on high-speed and heavily trafficked roads such as motorways, A-roads, bus lanes, roundabouts etc.	The densely mortared matrix makes HRA impermeable and resistant to rutting and deformation under heavy loads. Its sharp chippings protrude from the surface to maximise adhesion and increases skid resistance, even at speed.	HRA is supplied and laid on site at approximately 160-180 degrees. After initial compaction, pre-coated chippings are spread at a controlled rate and rolled in immediately to embed them into the mortar.	Traditional HRA can incorporate reclaimed asphalt pavement (RAP) percentages, though high fines and virgin bitumen grades often limit RAP rates to maintain mortar cohesion.
HardiPave	HardiPave is a cementitious grouted macadam surface course. The open-graded surface source controls void content by applying a cementitious grout resin over the receiving course. It is hot applied via paver following conventional HRA practices.	HardiPave is produced for heavy industrial environments such as waste and distribution and heavily trafficked highway networks such as bus lanes, junctions and roundabouts.	The cementitious grout resin helps to increase the surfaces resistance to deformation and rutting. This also creates high resistance to fuel/leachate contamination.	HardiPave is laid using traditional paving machinery as HRA. After compaction, the cementitious grout resin is applied over the receiving course when it's cold, to fill any voids. The material has a short curing time allowing quick reopening to traffic.	HardiPave's increased durability reduces the requirements for maintenance, minimising future traffic disruption and traffic management requirements. This minimises air and noise pollution due to the absence of heavy machinery and personnel.

Table 4 HardiPave Appraisal

Life Cycle Stage	Baseline Carbon Emissions (HRA) ($kgCO_2e$)	HardiPave Carbon Emissions ($kgCO_2e$)	Difference (%) (Increase/ Reduction)
A1 – A3	17,799.73	22,347.83	25.55%
A4	163.98	3,773.53	2,201.21%
A5	1,326.71	2,232.33	6,826%

Table 5: Comparison of lifecycle stages per instance.

Carbon Benefits and Considerations (Matrix)

Table 6 presents the findings of the carbon benefits and considerations matrix for HardiPave application on a HRA and SMA laid road. **All scoring is bold and underlined.**

Technical data used during benchmarking and the carbon benefits and considerations matrix were supplied by the manufacturer and are not derived from the Supersite live trial in North Lanarkshire. While reliance on supplier-provided information may introduce uncertainty in confidence levels, the information and data represent the best available evidence at the time of the appraisal. Data quality has been considered when selecting supplier information and, where possible, supplier values were chosen from manufacturers' standard test reports, specifications and product datasheets that reference recognised test methods and certification.

BENEFIT/LOAD UNDER REVIEW	CONSIDERATIONS	SCORING SYSTEM	JUSTIFICATION
Costs	Transport, operational, material procurement	1 - Significant additional costs **2 - Costs approximate baseline** 3 - Costs significantly lower than baseline	HardiPave is typically more expensive than conventional HRA due to the two-stage application of the cementitious grout resin. However, HardiPave's increased durability has potential to reduce maintenance associated costs.
Maintenance	Design life, maintenance burden, on-time for plant	1 – Significantly more maintenance/lower longevity 2- Approximately same maintenance/similar longevity **3 – Significantly less maintenance/higher longevity**	HardiPave is produced for heavily trafficked highways – the cementitious grout resin fills voids to increase durability, reducing the requirement for maintenance as it is resistant to deformation and rutting.
Scalability	Manufacturing facilities	1 - Lab testing only 2 - In process of commercialisation w. small scale manufacture **3 - Already has market presence with developed supply chain**	Miles Macadam already has market presence within the UK and has a variety of case studies highlighting the durability and suitability of HardiPave for heavily trafficked areas.
Compliance with specifications	Requirements for standards departures	1 - Requires significant departure(s) from standard and has not been used before by end client 2 - Requires some departure from standard, but has been used before by end client **3- Already has market presence with developed supply chain**	HardiPave holds HAPAS certification.
Environmental	Nature-based solution	1 - Would have significant net disbenefit for environmental factors (noise, AQ, biodiversity, landscape etc) **2 - Would have negligible net benefit/disbenefit or no**	HardiPave reduces the frequency of maintenance, minimising traffic disruptions and traffic management requirements. This minimises air and noise pollution due to the absence of heavy machinery and personnel.

BENEFIT/LOAD UNDER REVIEW	CONSIDERATIONS	SCORING SYSTEM	JUSTIFICATION
		overall change regarding environmental factors 3 - Would have significant net benefit/disbenefit for environmental factors.	
	Road noise	1 - Would have significant net disbenefit **2 - Would have negligible net benefit/disbenefit or no overall change regarding** 3 - Would have a significant net benefit	There is potential that the cementitious grout resin will increase operational road noise when compared to conventional HRA.
	Climate resilience/future proofing	1 - Would have significant net disbenefit **2 - Would have negligible net benefit/disbenefit or no overall change regarding** 3 - Would have a significant net benefit	HardiPave offers high durability, reducing the requirement for maintenance activities on the road surface and associated emissions.
Risk and safety	H&S impacts, safety testing data	1 - Would present increased risk or safety versus BAU option **2 - Would present no overall risk increase or safety impact versus BAU option** 3 - Would present lower risk or safety impact versus BAU option.	Miles Macadam are an established company within the UK market. Practices follow conventional asphalt laying practices and when laid according to design do not present any increase risks to health and safety. .
Technology Readiness Level	Is it commercially available, is there enough R&D?	1 - Not yet commercially available 2 - Commercially available from worldwide suppliers 3 - Commercially available from European suppliers **4 - Commercially available from UK suppliers** 5 - Commercially available from local suppliers	HardiPave is commercially available from the UK, with the head office of Miles Macadam located within Cheshire, UK. Has the readiness for widespread adoption for maintaining road infrastructure within the UK.
Constructability	How easy is it to handle on site, install, recover, curing time, specialist equipment/training, storage?	1 - Specialist contractors, time on site and/or equipment required **2 - No considerations required above and beyond baseline solution** 3 - Significant benefits to on-site activity / ease of installation	The two-stage application (lay and grout resin) adds complexity compared to single-pass asphalt. It relies on the co-ordination of plant, materials and curing windows. On site there was some concerned raised over constructability with some voids experienced from foreign bodies.

BENEFIT/LOAD UNDER REVIEW	CONSIDERATIONS	SCORING SYSTEM	JUSTIFICATION
Supply Chain	Material availability	1 - Novel materials used with limited supply **2 - Materials are available with some supply restrictions** 3 - Materials are readily available	Miles Macadam has a high presence within the UK market. However, they do not have local depots within Scotland, Miles Macadam employees had to travel from Malpas, Cheshire to install HardiPave in North Lanarkshire.
Circular Economy	Recycled content	**1 - Virgin materials are used with little or no recycled content** 2 - Materials contain a level of recycled content 3 - Materials are predominantly recycled and/or use novel sources of recycled content that would otherwise be discarded as waste	Miles Macadam make no claims to include recycled content within HardiPave's composition. HardiPave does not include any bio-derived aggregates or binders – instead uses polymer and bitumen.
	Ease of recycling	**1 - Minimal recycling of material possible upon removal** 2 - Limited recycling is possible and/or significant reprocessing required 3 - Reuse/recycling is easy and convenient	Miles Macadam make no claims over the recyclability of HardiPave.

Table 6: Carbon benefits and considerations matrix

Long-Term Performance Analysis

The carbon analysis within this report does not contain analysis of longevity. This will be finalised dependent upon the publishing of longer term test results in partnership with the University of Nottingham.

These tests will focus on the following:

- Durability and Aging Resistance,
- Skid Resistance and Surface Integrity,
- Lifecycle Carbon Savings,
- Traffic and Environmental Stress Testing,
- Optimal Reapplication Intervals.

Conclusion & Recommendations

Conclusions

The live trial of HardiPave has demonstrated some promising results for sustainable road surfacing practices when compared to conventional Hot Rolled Asphalt (HRA). HardiPave 40mm depth recorded 23.22 $kgCO_2e/m^2$ compared with 9.19 $kgCO_2e/m^2$ for HRA at 50mm depth. However, a proportion of this increase can be attributed to the high transport emissions of Miles Macadam transporting personnel and plant from Malpas, Cheshire, England.

Transportation and construction stage emissions (A4-A5 lifecycle stages) increased in this trial due to installer logistics and site-specific transportation factors, partially off-setting material-stage gains (though insufficient to completely offset the net benefits at the trial site in North Lanarkshire). If HardiPave were to be deployed nationwide, transport-related emissions may well be lower due to increased local availability.

HardiPave is claimed to have potential for strong operational performance and durability, characteristics highly relevant to Local Authority use. In scenario-based modelling HardiPave did not exhibit potential carbon savings when service life is increased by 5 years. However, if service life is increased by 20 years carbon savings were 63%, demonstrating HardiPave still has potential to produce carbon savings over the whole life of the surface. While HardiPave and HRA are closer. carbon emissions over a period of 25 years, HRA still has higher emissions. Greater benefit emerges when assessed over approximately 40 years. Accordingly, the recommendations following this trial should be interpreted over a minimum 30-year and preferably 40 year timescale to better account for whole-life performance.

It must be considered that A1-A3 modelling inputs have been produced based on supplier and contractor (Miles Macadam and Holcim) delivered data, this and the absence of a third-party EPD reduces independent confidence in reported embodied carbon values and limits direct comparability across authorities.

Overall, the trial of HardiPave has demonstrated credible potential to deliver meaningful carbon savings when compared to HRA. The material’s durability makes it a strong candidate for local authority resurfacing where supply chains and logistics are optimised. To translate trial-level gains into dependable, scalable benefits, Miles Macadam should prioritise a third-party EPD, pursue regional manufacturing or installer capacity, and commit to a multi-year performance monitoring to refine whole-life carbon modelling and prove potential carbon reductions demonstrated in modelling.

Recommendations

It is advised that robust long-term monitoring (over 5+ years) be undertaken at the trial sites to comprehensively evaluate performance and verify lifecycle carbon savings. This further long-term monitoring will allow for more expansive carbon modelling to assess end-of-life scenarios to provide a more comprehensive understanding of whole life carbon emissions.

It is recommended that Miles Macadam prioritise obtaining a third-party Environmental Product Declaration (EPD) for the surfacing material. This should be a priority to verify their carbon saving claims. If an EPD is obtained, HardiPave will be in the position for integration into preventative maintenance strategies within North Lanarkshire and the wider UK. This would involve the investment in training programmes for contractors to enable broader deployment of HardiPave without reliance on Miles Macadam personnel.