GROUP FCL
YOUR HIGHWAY & RUNWAY MAINTENANCE SPECIALIST

FOSTER CONTRACTING LIMITED

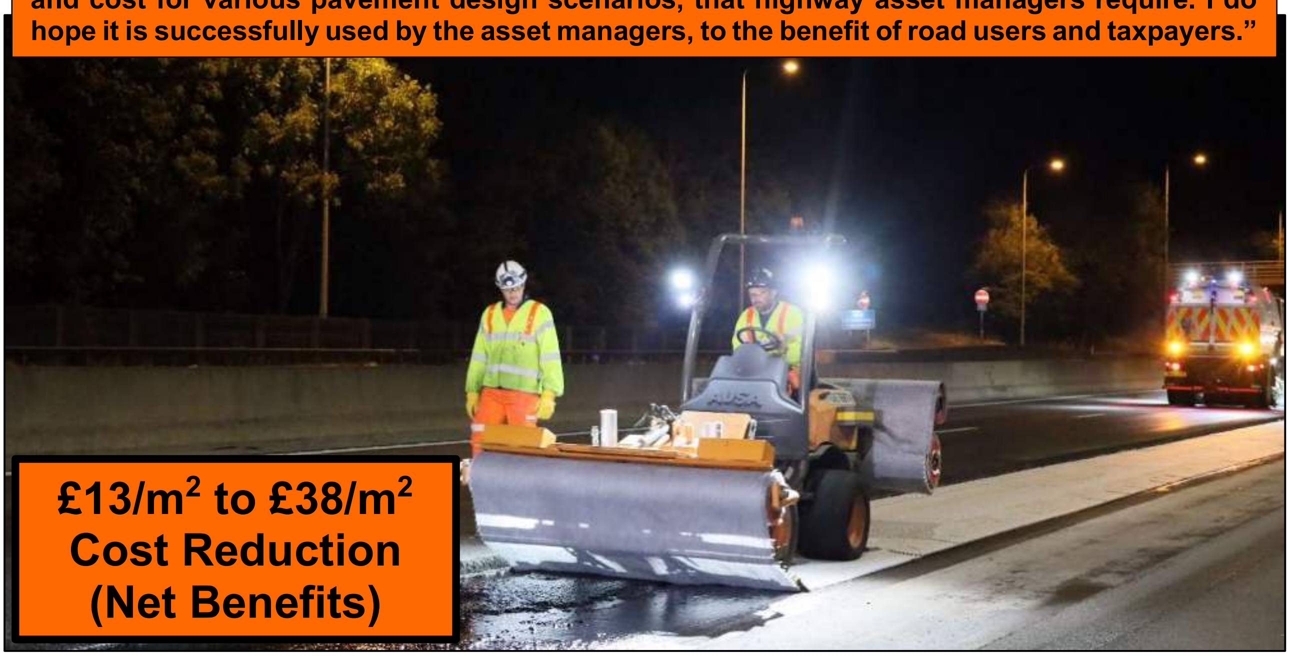
FCL Information Doc. Ref. CA-ID-02-11-23-v11

Carbon & Cost Benefits of FCL's Geosynthetic Interlayers

29% to 93% Carbon Reduction (Net Benefits)

Paul Boss, CEO of the Road Surface Treatments Association stated, "FCL's Information Document successfully demonstrates the carbon and cost benefits of using Geosynthetic Interlayers in highways / road maintenance construction, as part of the implementation of a sustainable and efficient asset management strategy."

Directed at FCL, Paul also wrote "May I congratulate you on an excellent piece of work with your Carbon and Cost Benefits document. As a local authority / Amey asset manager for the period 2005 – 2020, this is exactly the type of document, setting out comparisons of carbon and cost for various pavement design scenarios, that highway asset managers require. I do hope it is successfully used by the asset managers, to the benefit of road users and taxpayers."



£13/m^2 to £38/m^2 Cost Reduction (Net Benefits)

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FCL Information Doc. Reference: CA-ID-02-11-23-v011 (30/01/24)	Dated
Review of the beneficial impact on carbon and cost, when utilising a pavement solution which incorporates a geosynthetic interlayer, having all 3 functions, in accordance with BS EN 15381, as manufactured by Tensar International, and installed by FCL, a NHSS13 certified maintenance specialist contractor.	**v11 30/01/24**

Cracking in asphalt pavements is recognised as one of the biggest problems faced by highway authorities. Interlayers are a proven approach for maintaining or extending the life of pavements. One of the best treatments used over the past 30 years in the UK, is a geosynthetic interlayer which is installed within the bound layers, to intercept the path of crack propagation and dissipate / absorb stress. These systems have a track record of successful use, with over 1.82 million m^2 used annually in the UK (2021 RSTA data), however this figure has decreased by a third since 2017 (2.7M m^2). A lack of funding is now reflected in the increased number of cracked and failing roads that we see on our highway networks.

BS EN 15381 'Geotextiles and Geotextile Related Products – characteristics required for use in pavements and asphalt overlays', sets the standard for manufacturers to produce geosynthetic interlayers with CE marking. By combining all three well defined functions*, pavement design life / capacity can be maintained, by mitigating the effect of failures due to reflective cracking / fatigue, or pavement design life / capacity can be extended, by enhancing the structural 'whole life' of a sound pavement, and/or pavement thickness can be reduced, whilst still achieving the site-specific pavement design life / capacity.

***Functions:**
Reinforcement function (R) - Increasing pavement stiffness / strength, to mitigate reflection cracking.
Stress Relief function (STR) - Reducing pavement fatigue and/or the mitigation of reflection cracking.
Interlayer Barrier function (IB) - Prevention of moisture ingress into underlying pavement / foundation.

To achieve all three functions, the paving grade backing fabric adopted in the Tensar manufacturing process (for all of their geosynthetic interlayers) has a mean mass of 130g/m^2. This fabric is manufactured to absorb / retain a mean residual spray rate of 1.1kg/m^2 of straight run bitumen. In the UK, a 160/220 pen grade bitumen is common for colder conditions, with a 100/150 pen grade adopted for warmer conditions.

All geosynthetic interlayer products utilised in pavement layers should be in accordance with the Code of Practice for Geosynthetics (and Steel Mesh) for Asphalt Reinforcement Interlayers 2018, independently prepared by the Road Surface Treatments Association (RSTA). This document has been peer reviewed by ADEPT. It provides highway authorities, designers and principal contractors with a thorough understanding of asphalt interlayers, their use, laying techniques and applications. The Code of Practice is intended to represent industry best practice. The 2018 edition anticipated the publication of the DMRB CD227 'Design for pavement maintenance' document and the SHW Cl. 936, which includes a requirement for Product Assessment. The most recent edition has also been written and may be used with reference to the ADEPT document "Guidance on the use of paving fabrics and grids as asphalt reinforcement".

All installers of geosynthetic interlayers shall have National Highway Sector Scheme (NHSS) 13 certification / accreditation. NHSSs are integrated quality management schemes, bespoke to individual highways specialisms. Certification of suppliers is carried out by certification bodies, which in turn are accredited by the United Kingdom Accreditation Service (UKAS). They aim to make sure that work is carried out to the highest standards of professionalism, using properly trained and competent staff.

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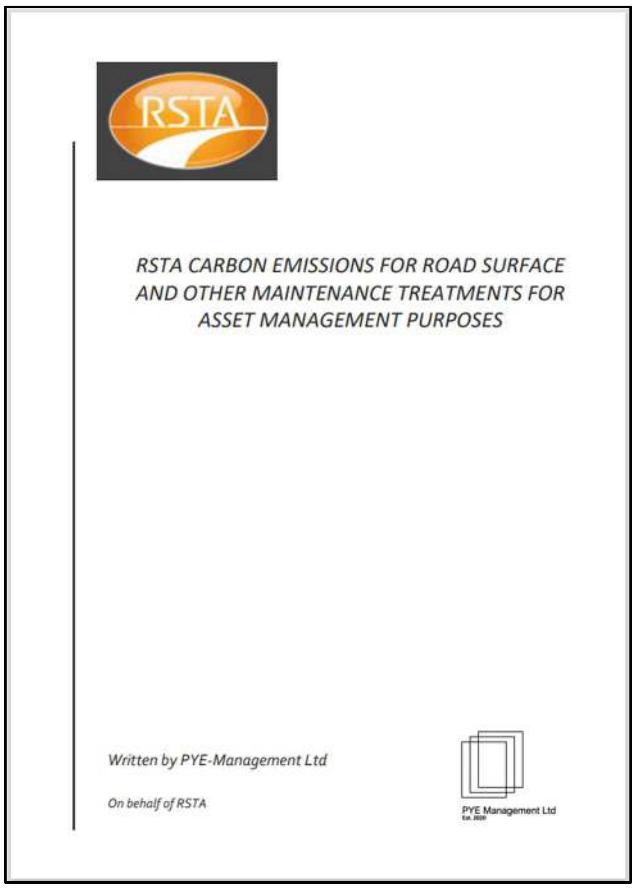
Carbon & Cost Benefits of FCL’s Geosynthetic Interlayers

In April 2023, PYE Management Ltd produced a document for the RSTA, ‘RSTA Carbon Emissions for Road Surface and Other Maintenance Treatments for Asset Management Purposes’. It states that road surface treatments are methods or materials for extending the lifetime of road pavements, delaying the need for major maintenance or rehabilitation. This process means that surface treatment contractors believe the treatment processes against conventional methods have a lower impact on the Greenhouse Gas (GHG) emissions produced.

These claims are not usually made based on robust, standard led assessments as there is currently a lack of standardisation and consistency in producing carbon footprints. The purpose of this document is to follow a required methodology for producing a carbon footprint in accordance with the current International Standards, (BS EN 15804, modules A1-A5), and apply this to the different treatments as well as the conventional methods of resurfacing or patching, to determine which approach has a lower carbon footprint.

A carbon footprint is a calculation of the amount of GHG produced from using resources to make products or provide services, expressed as a carbon dioxide equivalent (CO2e). A conversion factor is applied to the activity data, which enables the emissions to be converted to a common unit of KgCO2e (kilogram of carbon dioxide equivalent). (Gov, 2022)

Extracts from the RSTA Carbon Emissions report:



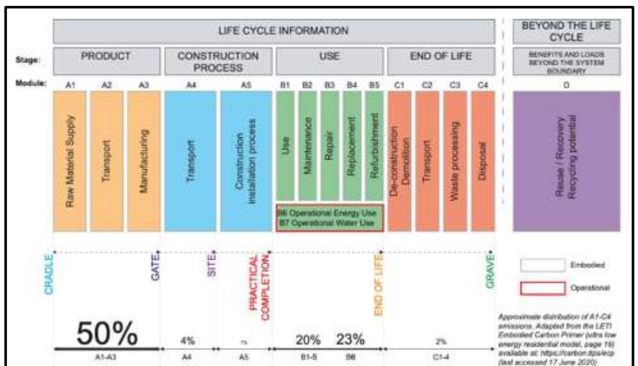
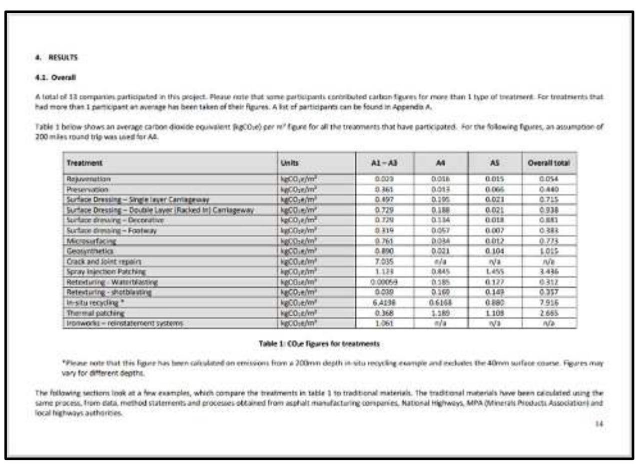


Figure 2: Lifecycle stages and modules (thestructuralengineer.org,2020)



4. RESULTS

4.1. Overall

A total of 13 companies participated in this project. Please note that some participants contributed carbon figures for more than 1 type of treatment. For treatments that had more than 1 participant an average has been taken of their figures. A list of participants can be found in Appendix A.

Table 1 below shows an average carbon dioxide equivalent (kgCO₂e) per m² figure for all the treatments that have participated. For the following figures, an assumption of 200 miles round trip was used for A4.

Treatment	Units	A1 – A3	A4	A5	Overall total
Rejuvenation	$kgCO_2e/m^2$	0.023	0.016	0.015	0.054
Preservation	$kgCO_2e/m^2$	0.361	0.013	0.066	0.440
Surface Dressing – Single layer Carriageway	$kgCO_2e/m^2$	0.497	0.195	0.023	0.715
Surface Dressing – Double Layer (Racked In) Carriageway	$kgCO_2e/m^2$	0.729	0.188	0.021	0.938
Surface dressing – Decorative	$kgCO_2e/m^2$	0.729	0.134	0.018	0.881
Surface dressing – Footway	$kgCO_2e/m^2$	0.319	0.057	0.007	0.383
Microsurfacing	$kgCO_2e/m^2$	0.761	0.034	0.012	0.773
Geosynthetics	$kgCO_2e/m^2$	0.890	0.021	0.104	1.015
Crack and Joint repairs	$kgCO_2e/m^2$	7.035	n/a	n/a	n/a
Spray Injection Patching	$kgCO_2e/m^2$	1.123	0.845	1.455	3.436
Retexturing - Waterblasting	$kgCO_2e/m^2$	0.00059	0.185	0.127	0.312
Retexturing - shotblasting	$kgCO_2e/m^2$	0.039	0.169	0.149	0.357
In-situ recycling *	$kgCO_2e/m^2$	6.4138	0.6168	0.880	7.916
Thermal patching	$kgCO_2e/m^2$	0.368	1.189	1.108	2.665
Ironworks – reinstatement systems	$kgCO_2e/m^2$	1.061	n/a	n/a	n/a

Table 1: CO₂e figures for treatments

*Please note that this figure has been calculated on emissions from a 200mm depth in-situ recycling example and excludes the 40mm surface course. Figures may vary for different depths.

The following sections look at a few examples, which compare the treatments in table 1 to traditional materials. The traditional materials have been calculated using the same process, from data, method statements and processes obtained from asphalt manufacturing companies, National Highways, MPA (Minerals Products Association) and local highways authorities.

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Road surface treatments are methods or materials for extending the lifetime of road pavements when they deteriorate, delaying the need for major maintenance or rehabilitation.

Geosynthetics are industry recognised for extending the life of pavements. When placed between bituminous bound layers these products retard the initiation and/or the propagation of reflective cracking which leads to premature pavement failures (Highways Magazine, 2014).

The LCA (Life cycle assessment) approach was originally developed in the 1960s and 1970s as an approach to quantify environmental sustainability against specific criteria for a product's full life cycle or from "cradle-to-grave."

The LCA process can be used to look at a number of different criteria including greenhouse gas emissions, energy use, etc. The LCA approach, therefore, lends itself to quantifiable environmental sustainability comparison between widely different techniques to achieve the same ends.

ISO 14040:2006 describes the principles and framework for LCA including: definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, the relationship between the LCA phases, and conditions for use of value choices and optional elements (ISO, 2023).

BS ISO 14025 helps users present quantified environmental information on the life cycle of a product to enable comparisons between products fulfilling the same function, paying due attention to the level of awareness of the target audience (ISOa, 2023).

Environmental product Declarations (EPD) are defined by ISO 14025 as "providing quantified environmental data using predetermined parameters and, where relevant, additional environmental information" (BSI, 2010). The EPD is a summary of the LCA and Product Category Rules (PCR) activities that enable simple comparisons of environmental impacts. Once a company has produced an EPD this should be made publicly available.

The European Standard for the generation of EPD for construction products, EN 15804, was published in 2012. EPDs are generated based on data obtained through an LCA, which is performed using a peer reviewed PCR in line with EN 15804, ISO 14025, and other related international standards.

PCRs are defined in ISO 14025 as a "set of specific rules, requirements, and guidelines for developing Type III environmental product declarations for one or more product categories" (BSI, 2010). In simpler terms, the PCR defines how the EPD will be created for a specific product, such as an asphalt binder.

This includes how system boundaries are chosen, what impact categories will be included and what methodology will be used. By developing a PCR, an industry can align itself on the methodology to be used to ensure consistent application of best practices and guiding principles for LCA development to demonstrate the industry's commitment to sustainability.

PCR PN514 is a PCR document for the assessment of the environmental performance of construction products. The PCR requires A1-A3 to be included as minimum, however stages A4, A5, B, C and D are optional for inclusion. Therefore, some EPDs could include more stages than others. (BRE, 2014).

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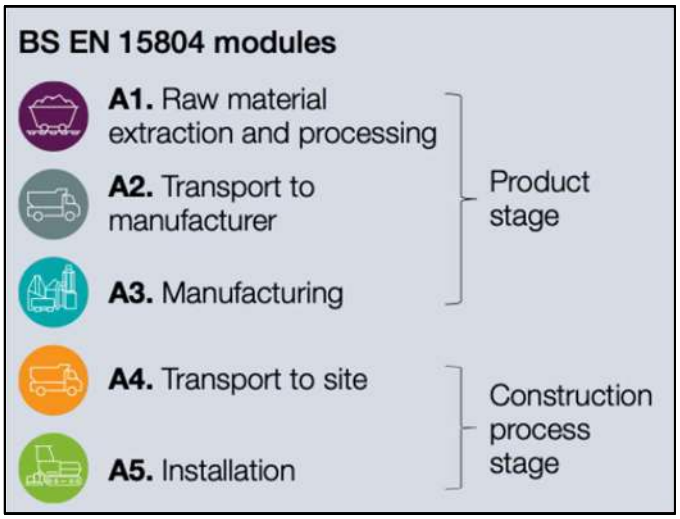
In 2021, National Highways set out their Net zero plan for highways with a commitment to have net zero emissions from construction and maintenance activity by 2040. In 2022, National Highways launched their Net Zero plan for concrete, steel and asphalt. The roadmaps describe how emissions can be reduced through decarbonising the raw materials, the manufacture of the materials, transport and construction emissions. The process aligns with the A1 to A5 modules defined by EN15804: Sustainability of Construction Works. (National Highways, 2023).



<u>A1 to A5 "CRADLE TO LAY"</u>

National Highways states that "every tonne of asphalt that we lay emits an average of 70 kg CO2e" and carbon assessments have now been completed for the different types of asphalt in accordance with A1-A5.

National Highways Asphalt Net Zero Plan sets out the following actions:

- Embedding whole life carbon reduction into pavement asset management.
- More durable asphalt materials will deliver longer service life.
- Best practice pavement construction will reduce maintenance and operational carbon.
- Building less new road infrastructure will directly reduce demand for asphalt.

Publicly Available Specification (PAS) 2080 is a global standard for managing infrastructure carbon and has been authored to meet World Trade Organisation requirements. The framework looks at the whole value chain, aiming to reduce carbon and reduce cost through more intelligent design, construction and use (Carbon Trust, 2023).

PAS 2080 looks at the whole life cycle of the carbon used on projects and promotes reduced carbon, reduced cost infrastructure delivery and a culture of challenge in the infrastructure value chain where innovation can be fostered. Clients applying this standard will require information from their value chain of their carbon emissions.

National Highways have launched their Net zero highways: our zero carbon roadmap for concrete, steel and asphalt plan in which they have an action that requires Tier 1 and 2 suppliers to be PAS2080 certified by the end of 2025. National Highways (National Highways, 2023). National Highways obtained verification to PAS 2080:2016 in 2022.

More details (and the full PYE Management Ltd – RSTA document) are available on the RSTA website: [Home - RSTA (rsta-uk.org)]

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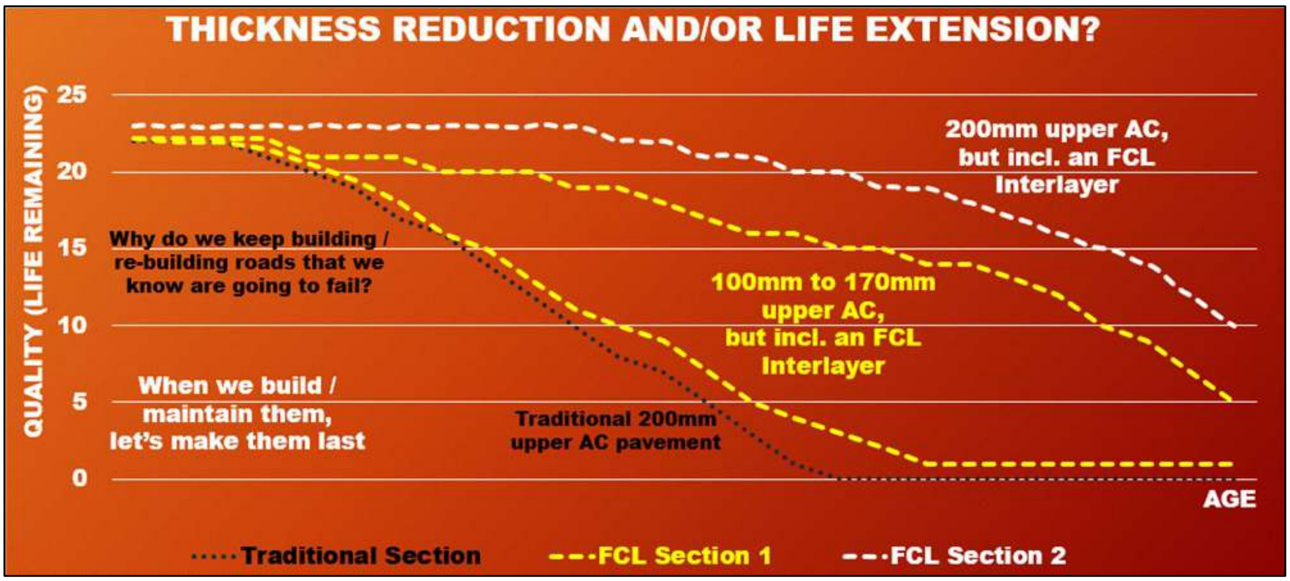
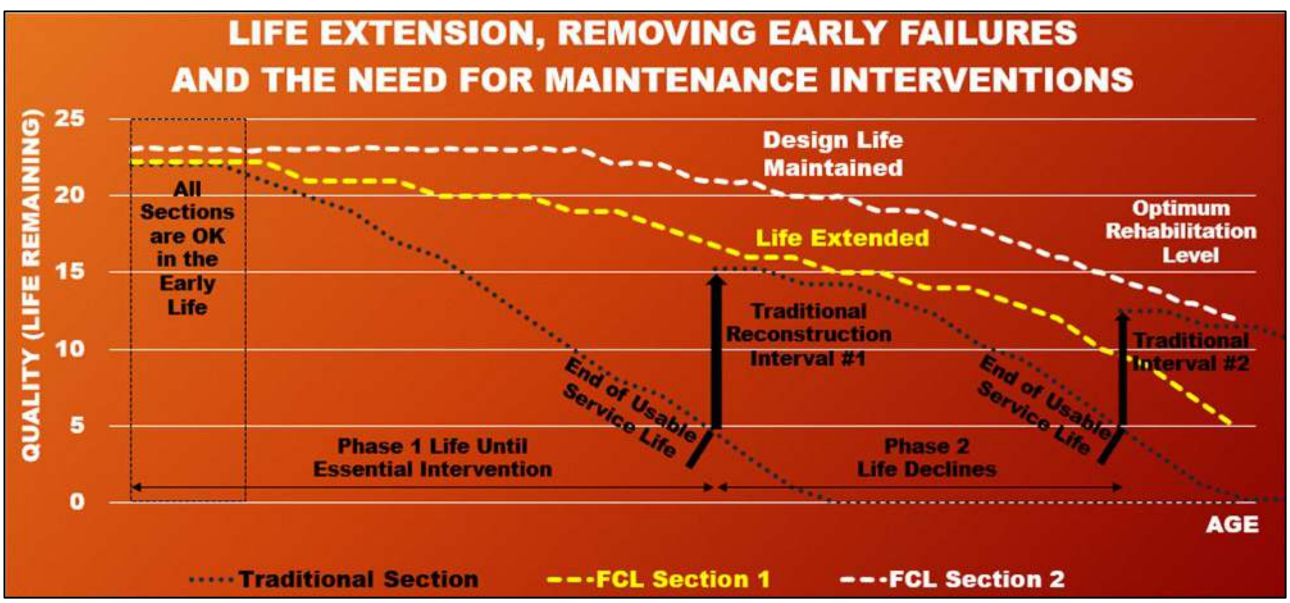
Carbon & Cost Benefits of FCL's Geosynthetic Interlayers

For reference, the following data has been produced as a theoretical / general guide to the potential carbon and cost reduction benefits, when incorporating one of FCL's geosynthetic interlayers into a pavement section, compared to a more traditional pavement maintenance intervention approach. Each site shall be assessed based on its own condition, and the scope based on the needs of the Client.

In this first theoretical model, we can explore the effects of the thinnest (traditional and engineered) section, a thinner section, and the same thickness of section, whilst incorporating an FCL interlayer:



In the next theoretical model, we can consider the effects of life extension and design life maintenance (whilst incorporating an FCL interlayer) compared to the number of traditional maintenance interventions:



Regardless of scope, an FCL interlayer can provide significant carbon and cost benefits in both models.

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Please note that the following worked examples, do not include for additional carbon and costs associated with the milling and/or break-out of existing materials, removal and disposal of the existing road surfacing, traffic management / road closures and general impact on the road user.

All values have been extracted from the relevant parts of the 'RSTA Carbon Emissions for Road Surface and Other Maintenance Treatments for Asset Management Purposes' document.

Table 1 below shows an average carbon dioxide equivalent ($kgCO_2e$) per m² figure for all the treatments that have participated. For the following figures, an assumption of 200 miles round trip was used for A4.

Treatment	Units	A1 – A3	A4	A5	Overall total
Geosynthetics	$kgCO_2e/m^2$	0.890	0.021	0.104	1.015

Table 1: CO_2e figures for treatments

Example number 1A – FCL's Geosynthetic Interlayer vs 30mm of Asphaltic Materials.

What if the inclusion of one of FCL's Geosynthetic Interlayers is incorporated into the pavement, which prevents the need for an early surface course maintenance intervention, by mitigating failure / cracking in the upper surface, preventing premature failure, targeting the required design life of the surface course layer. Alternatively, FCL's Geosynthetic Interlayer is used instead of 30mm of asphaltic materials. In this case, we simply compare the FCL interlayer to 30mm of asphaltic materials.

Estimated Reduction in kgCO2e/m² (supplied and installed)

FCL's Geosynthetic Interlayer @ 1 kgCO2e/m² (figures rounded)

Vs

30mm Surface Course or AC SAMI @ 5 kgCO2e/m² (figures rounded)

= 4 kgCO2e/m² (80% reduction in kgCO2e/m²), by adopting FCL's Geosynthetic Interlayer.

Estimated Reduction in £/m² (supplied and installed)

FCL's Geosynthetic Interlayer @ £6/m² (mean / rounded)

Vs

30mm Surface Course or AC SAMI @ £19/m² (mean / rounded)

= £13/m² cost reduction (68% reduction in £/m²), by adopting FCL's Geosynthetic Interlayer.

Example number 1B – FCL's Geosynthetic Interlayer prevents the need for a 40mm intervention.

What if the inclusion of one of FCL's Geosynthetic Interlayers is incorporated into the pavement, which prevents the need for an early surface course maintenance intervention, by mitigating failure / cracking in the upper surface, preventing premature failure, targeting the required design life of the surface course layer. In this case, we compare the FCL solution under a new 40mm surface course, to 40mm of asphaltic material being required and laid twice (due to premature failure), instead of just once.

Estimated Reduction in kgCO2e/m² (supplied and installed)

FCL's Geosynthetic Interlayer @ 1 kgCO2e/m² (figures rounded)
40mm Surface Course @ 6 kgCO2e/m² (figures rounded) – life extended.

Vs

40mm Surface Course (initial) @ 6 kgCO2e/m² (figures rounded) – failed surface.
40mm Surface Course @ 6 kgCO2e/m² (figures rounded) – replacement layer.

= 5 kgCO2e/m² (29% reduction in kgCO2e/m²), by adopting FCL's Geosynthetic Interlayer.

Estimated Reduction in £/m² (supplied and installed)

FCL's Geosynthetic Interlayer @ £6/m² (mean / rounded)
40mm Surface Course @ £20/m² (mean / rounded) – life extended.

Vs

40mm Surface Course (initial) @ £20/m² (mean / rounded) – failed surface.
40mm Surface Course @ £20/m² (mean / rounded) – replacement layer.

= £14/m² cost reduction (35% reduction in £/m²), by adopting FCL's Geosynthetic Interlayer.

Example number 1C – FCL's Geosynthetic Interlayer prevents the need for 2 SC interventions.

What if the inclusion of one of FCL's Geosynthetic Interlayers is incorporated into the pavement, which prevents the need for an early surface course maintenance intervention, by mitigating failure / cracking in the upper surface, preventing premature failures, and maintaining the required design life of the surface course layer. In this case, we compare the FCL solution under a new 50mm surface course, to 50mm of asphaltic material being required and laid three times (due to premature failures), instead of just once.

Estimated Reduction in kgCO2e/m² (supplied and installed)

FCL's Geosynthetic Interlayer @ 1 kgCO2e/m² (figures rounded)
50mm Surface Course @ 7 kgCO2e/m² (pro rata figures) – full life maintained.

Vs

50mm Surface Course (initial) @ 7 kgCO2e/m² (figures rounded) – failed surface.
2 x 50mm Surface Course @ 14 kgCO2e/m² (pro rata figures) – 2 interventions

= 13 kgCO2e/m² (62% reduction in kgCO2e/m²), by adopting FCL's Geosynthetic Interlayer.

Estimated Reduction in £/m² (supplied and installed)

FCL's Geosynthetic Interlayer @ £6/m² (mean / rounded)
50mm Surface Course @ £22/m² (mean / rounded) – full life maintained.

Vs

50mm Surface Course (initial) @ £22/m² (mean / rounded) – failed surface.
2 x 50mm Surface Course @ £44/m² (mean / rounded) – 2 interventions.

= £38/m² cost reduction (58% reduction in £/m²), by adopting FCL's Geosynthetic Interlayer.

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Example number 2A – FCL's Geosynthetic Interlayer vs 100mm of Asphaltic Materials.

What if the inclusion of one of FCL's Geosynthetic Interlayers is incorporated into the pavement, which prevents the need for an early surface and binder course maintenance intervention, by mitigating failure / cracking, preventing premature failure, and maintaining the required design life of the upper surface and binder course layers. In this case, we simply compare the FCL interlayer to 100mm of asphaltic materials.

Estimated Reduction in $kgCO_2e/m^2$ (supplied and installed)

FCL's Geosynthetic Interlayer @ 1 $kgCO_2e/m^2$ (figures rounded)

Vs

100mm Surface and WM Binder Course @ 14 $kgCO_2e/m^2$ (6+8 figures rounded)

= 13 $kgCO_2e/m^2$ (93% reduction in $kgCO_2e/m^2$), by adopting FCL's Geosynthetic Interlayer.

Estimated Reduction in £/m² (supplied and installed)

FCL's Geosynthetic Interlayer @ £6/m² (mean / rounded)

Vs

100mm Surface and WM Binder Course @ £40/m² (mean / rounded)

= £34/m² cost reduction (85% reduction in £/m²), by adopting FCL's Geosynthetic Interlayer.

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Example number 2B – FCL's Geosynthetic Interlayer prevents the need for a 100mm intervention.

What if the inclusion of one of FCL's Geosynthetic Interlayers is incorporated into the pavement, which prevents the need for an early surface and binder course maintenance intervention, by mitigating failure / cracking, preventing premature failure, and extending the required design life of the 100mm of upper surface and (warm mix) binder course layers.

Estimated Reduction in kgCO2e/m² (supplied and installed)

FCL's Geosynthetic Interlayer	@ 1 kgCO2e/m² (figures rounded)
100mm Surface and WM Binder	@ 14 kgCO2e/m² (6+8 figures rounded) – life extended.

Vs

100mm Surface and WM Binder	@ 14 kgCO2e/m² (6+8 figures rounded) – failed due to cracking.
100mm Surface and WM Binder	@ 14 kgCO2e/m² (6+8 figures rounded) – replacement layers.

= 13 kgCO2e/m² (46% reduction in kgCO2e/m²), by adopting FCL's Geosynthetic Interlayer.

Estimated Reduction in £/m² (supplied and installed)

FCL's Geosynthetic Interlayer	@ £6/m² (mean / rounded)
100mm Surface and WM Binder	@ £40/m² (mean / rounded)

Vs

100mm Surface and WM Binder	@ £40/m² (mean / rounded)
100mm Surface and WM Binder	@ £40/m² (mean / rounded)

= £34/m² cost reduction (43% reduction in £/m²), by adopting FCL's Geosynthetic Interlayer.

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Example number 2C – FCL's Interlayer and 100mm Reconstruction vs 200mm Traditional Recon.

The inclusion of one of FCL's Geosynthetic interlayer limits the depth of intervention to surface and binder course layers, by extending the predicted capacity of the 100mm thick surface and binder course recon., meeting the required life with less materials, averting the need to go down to a 200mm depth of pavement reconstruction, which in itself carries additional numerous risks and resourcing issues / constraints.

Calculated Reduction in $kgCO_2e/m^2$ (supplied and installed)

FCL's Geosynthetic Interlayer	@ 1.015 $kgCO_2e/m^2$ (precise figures)	Interlayer Used To
100mm Surface and WM Binder	@ 13.94 $kgCO_2e/m^2$ (precise figures)	Increase Capacity

Vs

200mm Surf / Bin / Base Course @ 24.308 $kgCO_2e/m^2$ (precise figures)

= 9.353 $kgCO_2e/m^2$ (38.4% reduction in $kgCO_2e/m^2$), by adopting FCL's Geosynthetic Interlayer.

Calculated Reduction in £/m² (supplied and installed)

FCL's Geosynthetic Interlayer	@ £6/m² (mean / rounded)
100mm Surface and WM Binder	@ £40/m² (mean / rounded)

Vs

200mm Surf / Bin / Base Course @ £70/m² (estimated figures rounded)

= £24/m² cost reduction (34% reduction in £/m²), by adopting FCL's Geosynthetic Interlayer

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Glossary of Terms

ADEPT	Association of Directors of Environment, Economy, Planning and Transport
CO2	Carbon Dioxide
EPD	Environmental Product Declaration
GHG	Greenhouse Gas
ISO	International Organisation for Standardisation
kgCO2e	Kilogram Carbon dioxide equivalent
LCA / LCIA	Life Cycle Assessment / Life Cycle Impact Assessment
NHSS13	National Highways Sector Scheme 13, for The Supply and Application of Surface Treatments to Road Surfaces (ref. also the NHSS13 Technical Advisory Committee (TAC))
PAS	Publicly Available Specification
PCR	Product Category Rules
RSTA	The Road Surface Treatments Association

Original Text, Queries, Support and Feedback

For any original text, and/or references, please refer back to the original document 'RSTA Carbon Emissions for Road Surface and Other Maintenance Treatments for Asset Management Purposes', written by PYE-Management Ltd, for the RSTA, available on the RSTA website: Home - RSTA (rsta-uk.org). For any feedback, queries or additional technical support, you should communicate direct with the author of this document, whose contact details are illustrated in the footer of each page.

Statement by Emma Pye, Founder and Director of PYE Management Ltd

"FCL's Carbon and Cost Benefits Information Document is an extremely useful and informative document, showing both the potential for whole life carbon and cost savings in using FCL's Geosynthetic Interlayers. FCL have used the RSTA's Carbon Emissions Report exactly as it was intended, to take the base carbon information per m2, to produce detailed calculations for low carbon strategies. Having this information enables customers to make both sustainable and financially efficient decisions when planning highways works, a key tool that is very much needed in the current climate."

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Technical Director | FCL Group
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FOSTER CONTRACTING LIMITED

FCL Information Doc. Ref. CA-ID-02-11-23-v11

Carbon & Cost Benefits of FCL's Geosynthetic Interlayers

Work in Partnership with FCL, by using more / all of our Specialist Contractor Services:

FCL1	Geosynthetic Interlayers	**FCL5**	Crack / Joint Treatments
FCL2	Spray Bond / Tack Coats	**FCL6**	P/L/M for General Civils Works
FCL3	Hydroblasting Treatments	**FCL7**	Maintenance of Plant / Fleet
FCL4	Surface Course Treatments	**FCL8**	Supply Only Sales

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