



Centre of Excellence
for Decarbonising Roads

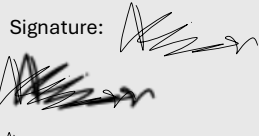


COLAS IN-SITU RECYCLING LIVE TRIAL EVALUATION REPORT

Live Labs 2 North Campus

This report presents the findings of a live trial evaluating Colas Regen In-situ Recycling with a bitumen emulsion binder. Trial results produced $9.15 \text{ kgCO}_2\text{e/m}^2$. Overall, the trial demonstrated that in-situ recycling shows high potential for decarbonising the local road network. Recommendations from this trial include further research into the long-term recyclability of in-situ recycled road layers, as well as exploring opportunities to replace the bitumen emulsion with a recycled or lower-carbon alternative.

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Executive Summary

This report evaluates a live trial conducted as part of the wider Live Labs 2 project, which aims to test innovative highway solutions to improve road performance, reduce maintenance needs, and enhance safety. This specific trial concerns medium in-situ recycling undertaken by Colas. In-situ recycling is the process of recovering the materials in the existing carriageway, breaking them up and mixing with an emulsion to create a new sub-base upon which a new surface course can be laid. Colas delivered Regen, a cold in-situ recycling at a depth of 110mm along sections one to four of the Supersite (a single stretch of highway trialling several materials and techniques) located on Hirst Road, North Lanarkshire, Scotland.

Colas claims that carbon savings are achieved due to the process's cold, on-site recycling method, which avoids the need for a hot-mix plant, cutting plant fuel use and carbon emissions compared with full-depth hot-mix reconstruction. By reusing existing material and requiring minimal emulsion binder addition, in-situ recycling reduces the use of virgin material associated with conventional binder course reconstruction.

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 A1-A3 emission factor for Colas Regen emulsion is currently undergoing third-party verification by the University of Nottingham, therefore the results of carbon analysis should be treated as provisional until it can be academically verified.

The findings from the trial demonstrate potential for high carbon savings by use of cold in-situ recycling when compared with conventional binder replacement methods. Trial results produced 9.15 kgCO₂e/m² for cold in-situ recycling with a bitumen emulsion. The primary driver of carbon savings can be attributed to the minimal use of virgin material when employing in-situ recycling as the process reuses the existing carriageway structure.

Introduction

This Evaluation Report provides a high-level assessment of Regen in-situ recycling completed by Colas, an emerging sustainable method 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), followed by 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 for Live Labs 2, supporting research, innovation, and best practices to accelerate low-carbon solutions in road construction and maintenance. By disseminating 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 aim is 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) tool Carbon Leadership Profiler Toolkit (previously known as Carbon Analyser), an 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. In-situ recycling trials have been evaluated against conventional practices used as part of a traditional binder replacement programme.

The carbon evaluation for Colas Regen in-situ recycling method considers cradle-to-construction lifecycle stages (A1–A5) which includes:

- Embodied Carbon;
- Transportation emissions of materials and people;
- Operation of plant and equipment during construction including 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 (CO₂e per unit of material)	Brief product potential overview
In-situ Recycling (Regen) – Colas	<p>Colas offer a variety of in-situ recycling options. On the Supersite trials Regen was trialled using bitumen emulsion binder.</p> <p>To complete the trial process the existing surface is milled on-site, stabilised with the addition of an emulsion binder, compacted and then re-laid. This process recycles up to 100% of the existing binder course material.</p>	<p>Colas Regen medium cold in-situ recycling during the live trial produced 9.15 kgCO₂e/m².</p> <p>Results from this trial demonstrate a 63.09% reduction in material extraction to construction carbon emissions when compared to traditional asphalt re-construction.</p> <p>Most of these carbon savings can be attributed to the reduced use of virgin materials and instead the re-use of the existing carriageway.</p>	<p>It is considered that this product has demonstrated potential to reduce emissions and materials use in the road construction and maintenance industry, particularly in projects prioritising sustainability.</p> <p>The trial has demonstrated that a bitumen-based emulsion used for in-situ recycling results in measurable carbon reductions when compared with conventional practices.</p>

Methodology

Trial Design

The Colas Regen in-situ recycling trial was designed to evaluate the performance, durability, and environmental impact of the method. 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. Colas’s bitumen emulsion binder in-situ recycling method was used along sections 1, 2, 3 and 4 of the Supersite trial.

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 rules and reporting format for Environmental Product Declarations (EPD) for construction products, providing a consistent, auditable framework for quantifying carbon impacts across a product’s 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.

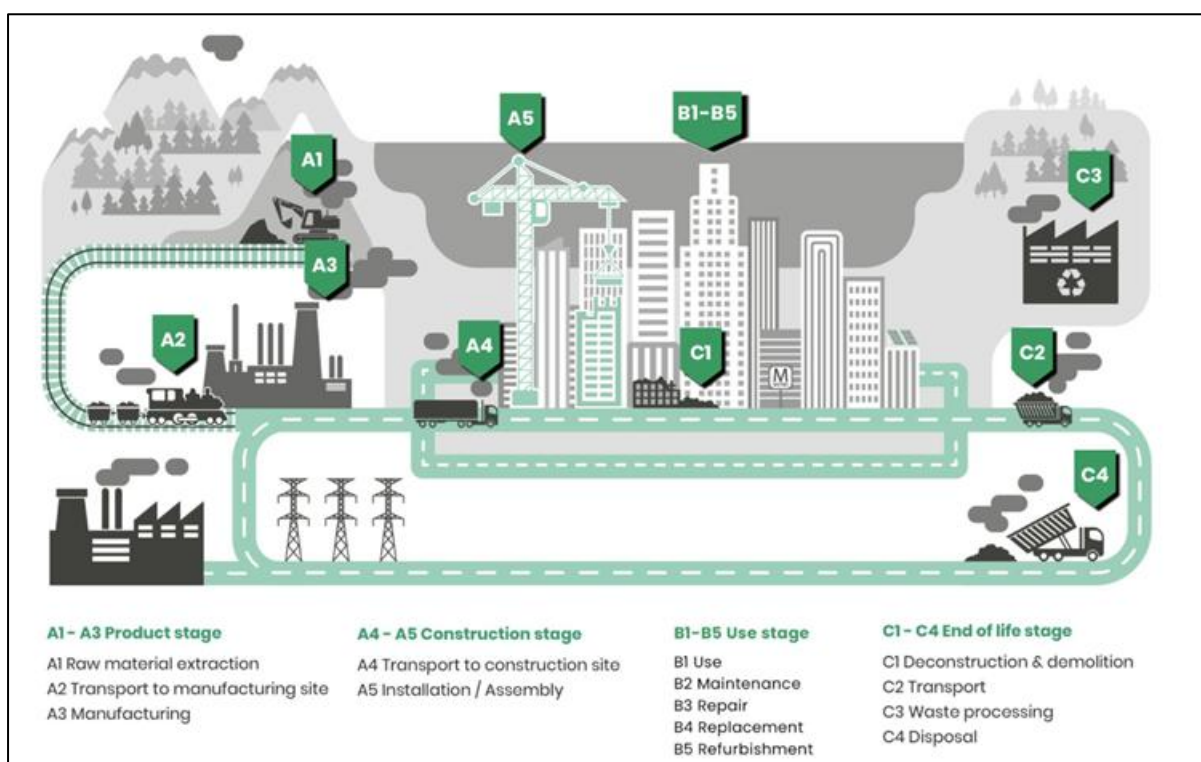


Figure 1: Carbon Lifecycle Stages¹

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 the assessment of the material's 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 laid with hot-rolled asphalt (HRA) and asphalt concrete (AC20) binder course that had deteriorated with use and age to the point where they required maintenance..

Data Collection Plan

The following data items were collected to ensure a thorough evaluation of Colas emulsion binder in-situ recycling 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 Colas Regen In-situ Recycling	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 Colas Regen In-situ Recycling	Operational staff & Carbon Lead	Site Diary	Cost and Carbon Evaluations
Cost	£ for Colas Regen In-situ Recycling £ 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

DATA ITEM	UNIT(S)	RESPONSIBLE	LOCATION OF DATA	PURPOSE
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 NLC, 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 the carriageway and a further two surface course sections at junctions. Colas's in-situ recycling methods were tested on sections 1, 2, 3 and 4. All trial sites were completed on one B classification of road (Hirst Road).

TRIAL SECTION	BINDER COURSE			SURFACE COURSE			
	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 trial. Loose debris and water were removed to ensure proper adhesion.

Material Application: Roads were prepped as per manufacturer's instructions prior to the products application. All materials are applied in accordance with manufacturer's instructions and specifications. The in-situ recycling binder was completed by Colas employees who were trained to install the material.

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

Performance analysis: The performance of Colas's in-situ recycling was evaluated based on criteria such as durability, resistance to traffic stress, and environmental impact. Comparisons were made versus traditional binder resurfacing to benchmark performance.

Data Analysis

The collected data was analysed to determine the effectiveness of Colas Regen as an in-situ recycling method acting as an alternative to conventional asphalt binder course replacement. Statistical methods were used to evaluate the performance of Colas's in-situ recycling methods versus a control section (traditional binder course replacement) 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 in-situ recycling, including material, application, and maintenance costs.

The embodied carbon factors for trialled materials have been developed based on supplier product data and supported by carbon factors sourced from OneClick LCA where required. Carbon emission factor for the bitumen emulsion used by Colas in Regen in-situ recycling has been sourced from Colas Ltd and is currently undergoing academic verification by the University of Nottingham. This verification process will be in line with the European standard for Environmental Product Declarations, EN 15804.

Carbon Appraisal

Drawing on data collected through trials, a carbon assessment has been undertaken. Table 3 establishes the parameters of the model, defines assumptions and outlines product specifications.

ASSUMPTIONS	JUSTIFICATION
All transportation is undertaken via diesel HGV.	Based on standard modelling assumptions from similar schemes.
Unit of measurement used is 'kgCO ₂ e/ m ² '.	Based on the best available data used to conduct carbon appraisals.
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.
Carbon analysis incorporates emissions associated with the planning of the carriageway prior to Colas's in-situ recycling activities.	This follows BAU approach required prior to in-situ recycling.
Additional resources required solely to facilitate this Live Labs trial have been excluded from this analysis, as they do not represent Colas's business-as-usual approach.	Live Labs 2 is a nationally significant programme, which necessitated additional on-site resources. However, this analysis focuses on business-as-usual carbon performance to ensure the findings are applicable and meaningful for local authorities across the UK.
Comparative analysis assumes that planings from the benchmark binder course were used in asphalt RAP production.	Evidence supplied by the site teams demonstrates that the planings were used for the purpose of RAP production. It has been confirmed that 100% of the planings were used.
Planing data has had a multiplier of two applied to represent a two-day programme for traditional binder-course resurfacing.	This ensures the analysis aligns with the realistic operational practice on site and provides a representative estimate of planning-related carbon emissions.
Vehicles transporting materials are assumed to travel fully laden to site and return empty.	The assumption that vehicles travel fully laden to site and return empty reflects standard haulage practice for material deliveries. Applying this assumption ensures carbon calculations accurately represent typical operational behaviour and avoid artificially reducing transport-related emissions.
Carbon emission factor for the bitumen emulsion used by Colas in Regen in-situ recycling has been sourced from Colas Ltd and is currently undergoing academic verification by the University of Nottingham.	This emission factor is in the process of obtaining third-party verification. This figure is being treated as a provisional emission factor and will be updated once independent academic verification is gained.
Emission factor for Asphalt Concrete has been sourced from Holcim (the main contractor) from a different CEDR trial in North Lanarkshire.	It can be assumed that similar production methodology, energy consumption and fuel use were used.
The baseline AC20 binder course was applied at a depth of 60mm while Colas in-situ recycling was completed at a depth of 110mm.	A depth of around 60mm is typical for an AC20 binder course in UK local road maintenance, making it an appropriate and realistic baseline for comparison. In-situ recycling requires further depth to ensure the restructure and to stabilise the full treatment layer.

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. The toolkit's emission database was also used to provide verified emission factors and 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 the bitumen emulsion used in Colas's Regen in-situ recycling is currently undergoing third-party verification in accordance with EN 15804 by the University of Nottingham. The current figure provided by Colas is being treated as a provisional emission factor which will require updating once verification is gained.

Indicative results from carbon modelling for the Colas Regen in-situ recycling works at Hirst Road have been expressed in $\text{kgCO}_2\text{e}/\text{m}^2$. This presentation of emissions enables direct comparison across low-carbon innovations, to highlight carbon-efficient options and support data driven decision making.

Results are presented graphically in Figure 2 and Figure 3:

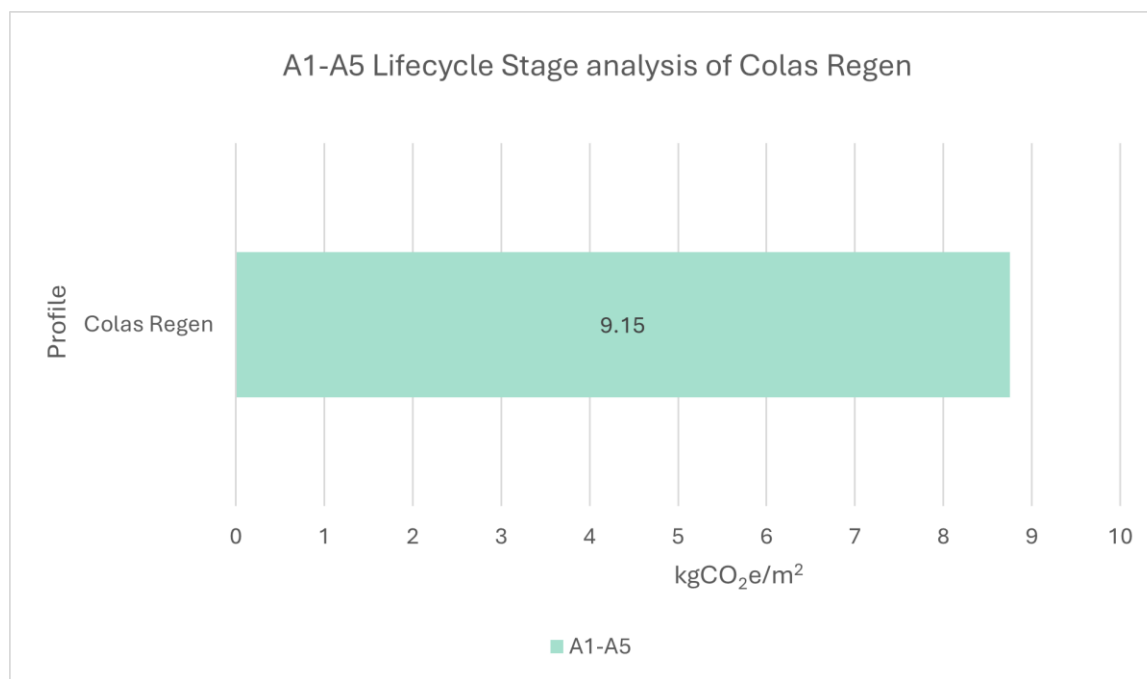


Figure 2: Carbon analysis of the total Colas in-situ recycling Hirst Road, North Lanarkshire per m²

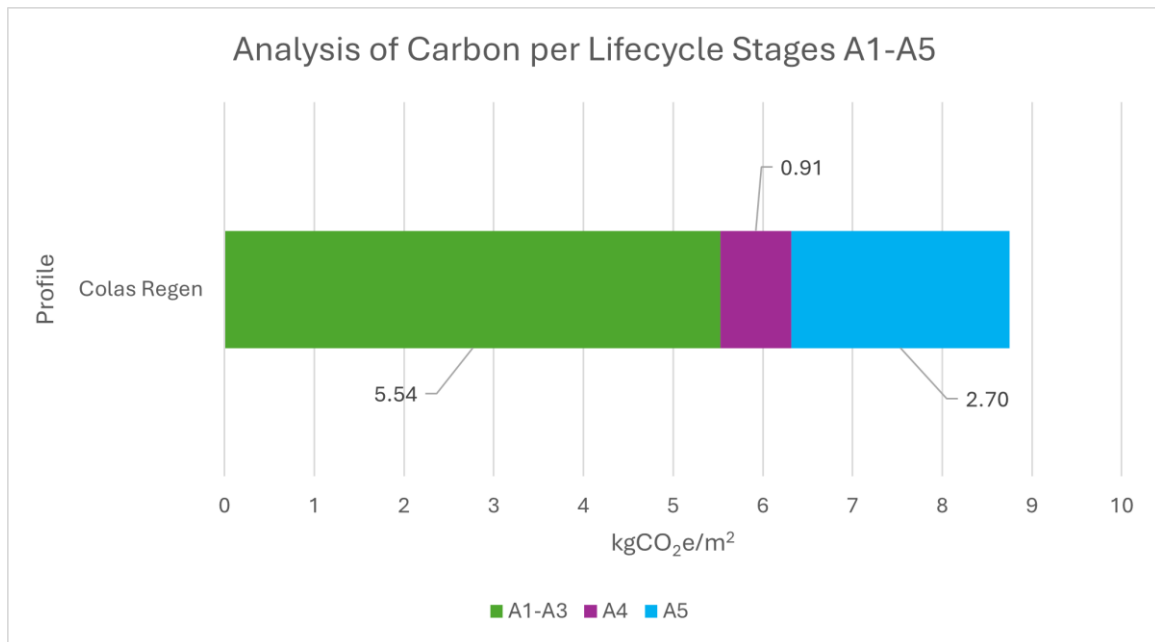


Figure 3: Carbon analysis of the total Colas in-situ recycling lifecycle stages A1-3, A4, A5 per m²

Carbon analysis has included the activities involved with milling the existing surface and binder course of the carriageway as this is required to enable in-situ recycling to take place. The following modelling excludes these emissions to demonstrate purely emissions associated with in-situ recycling. Modelling is presented graphically in Figure 4:

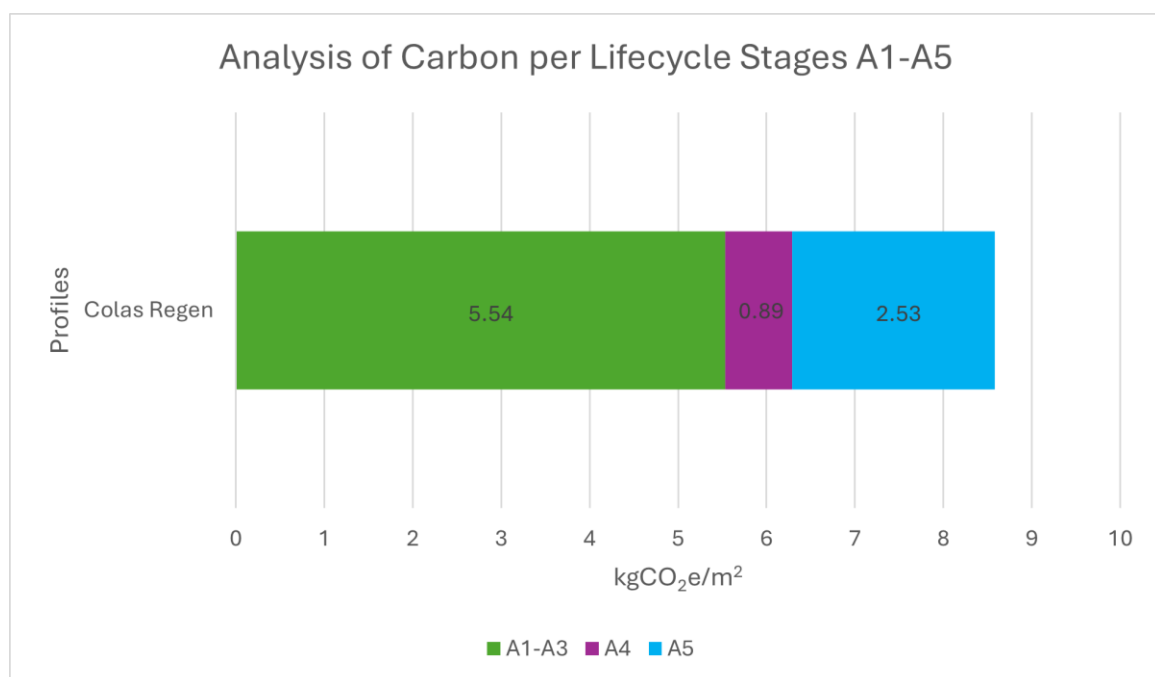


Figure 4: Carbon analysis of Colas in-situ recycling lifecycle stages A1-A3, A4, A5 (no planing) Hirst Road, North Lanarkshire per m²

Benchmarking

In-situ recycling was yet to be used in North Lanarkshire prior to this trial. These trials are to allow for an analysis of the performance of different types of in-situ recycling in comparison to conventional asphalt binder course replacement on the same road of the same traffic loads. This would be the traditional option for binder resurfacing if in-situ recycling was not used. This allows for comparisons between Colas's Regen in-situ recycling methods versus BAU binder resurfacing within the carbon analysis.

The carbon analysis accounts for the planing of the original binder course, resurfacing of an AC20 binder course and the processing of the planings into Reclaimed Asphalt Pavement (RAP). Accounting for these activities provides a complete and conservative representation of construction stage emissions and any material substitution benefits. This ensures the appraisal captures both the additional operational burden of removal and the emissions associated with producing and re-using planings for RAP rather than employing in-situ recycling.

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

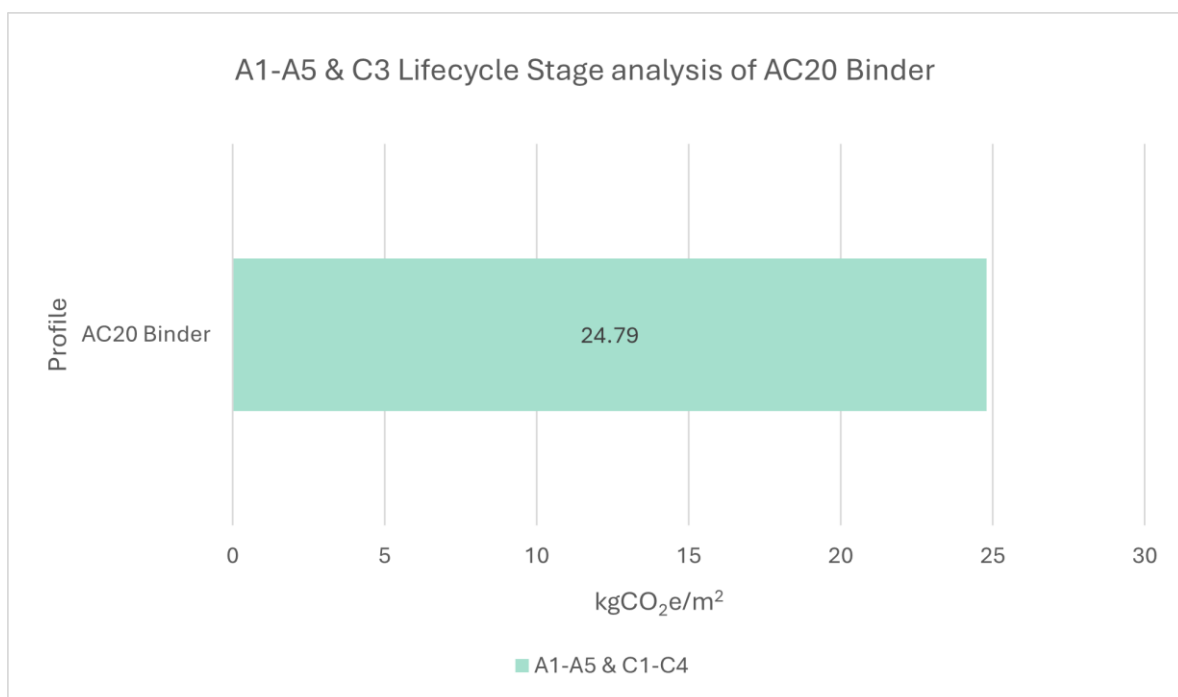


Figure 5: Carbon analysis of AC20 Binder lifecycle stages A1-A5 & C1-C4 per m²

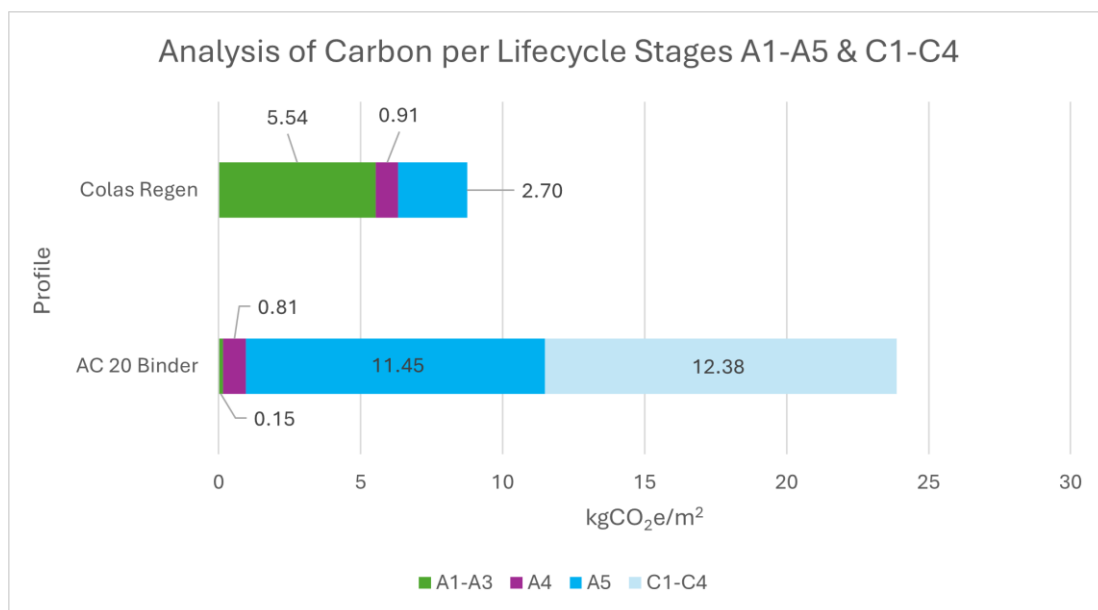


Figure 6: Comparative carbon analysis A1-A5 & C1-C4 per m²

A comparative analysis excluding transportation emissions was also performed to isolate the construction-stage benefits of in-situ recycling. This adjustment was necessary as these activities cannot currently be supplied locally, with plant and personnel travelling long distances by necessity, whereas planing and installation of an AC binder course represent business-as-usual (BAU) activities that can be delivered locally within North Lanarkshire.

Transportation can dominate A4 emissions when materials or specialist crews travel long distances; removing it from the comparison prevents those external logistics factors from obscuring the merits of in-situ recycling versus conventional resurfacing. Analysis removing transport emissions is presented graphically in Figure 7:

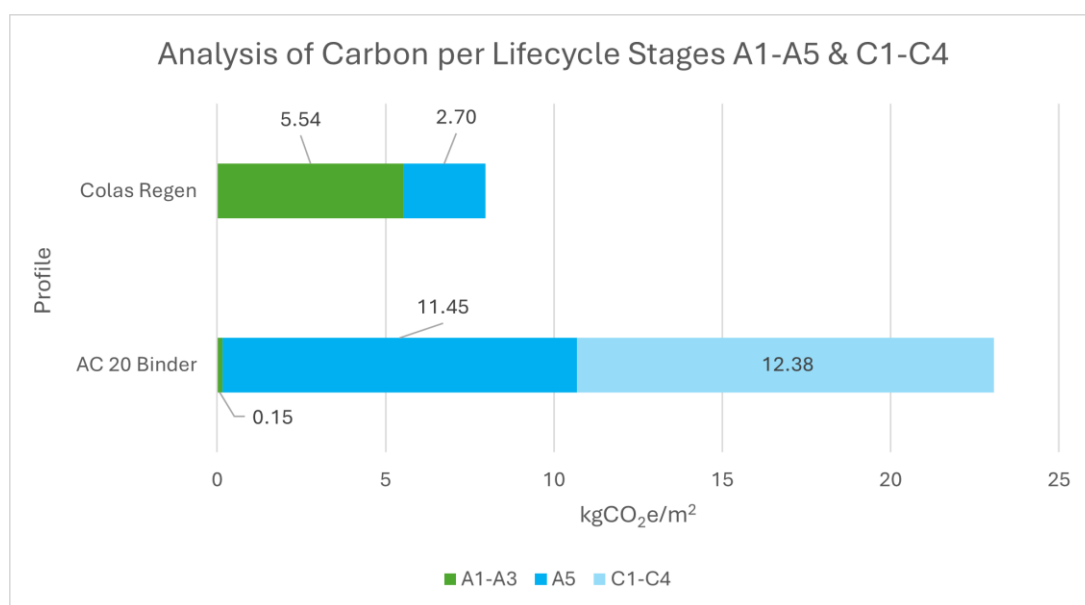


Figure 7: Comparative carbon analysis A4 values removed per m²

MATERIAL	COMPOSITION	APPLICATIONS	PERFORMANCE	INSTALLATION	SUSTAINABILITY
Asphalt binder course (AC20)	<p>This does not involve in-situ recycling. Instead the planings of the original binder and course are replaced</p> <p>Conventional AC20 binder course is composed of bitumen binder with a mixture of aggregates like stone, sand and gravel.</p> <p>The proportions of binder and aggregate differ depending on gradation and specification but is usually 5-7% binder by mass.</p>	<p>The conventional structural binder layer beneath surfacing on roads.</p> <p>Usually used beneath high-stress carriageways, motorways and urban roads.</p> <p>It suitable for most road types.</p>	<p>An AC20 binder course has high stiffness, high bearing capacity and is designed to resist permanent deformation and rutting under repeated axle loads when designed correctly.</p> <p>Has a long service life – typically designed for 20years plus.</p> <p>When surfaced with HRA, provides high skid resistance.</p>	<p>Produced at the asphalt plant and delivered to site hot in insulated trucks.</p> <p>Laid hot via asphalt paver and compacted by rollers. Maintaining a high temperature control is critical in ensuring correct installation.</p> <p>Requires high amount of traffic management, usually full or partial road closure.</p> <p>Has a limited laydown window for compaction and is weather sensitive, increasing the likelihood of waste.</p>	<p>High carbon emissions due to bitumen production and high temperature requirements during production and installation.</p> <p>Reclaimed asphalt pavement (RAP) can be incorporated.</p> <p>Has an established supply chain nationally that reduces transport emissions, and sourcing aggregates locally can further lower carbon emissions.</p> <p>Potential for the materials long design life to offset higher upfront carbon per year of service. However, only if maintenance is limited.</p>
Colas Regen – emulsion binder	<p>The cold in-situ recycling process requires mixing a bitumen emulsion onsite with the existing asphalt material that has previously been planed off.</p> <p>The process can recycle up to 100% of the binder course back into the road. Helping reduce the use of virgin bitumen and aggregates.</p>	<p>The traditional binder for cold in-situ recycling, is bound into the original binder course layer for road rehabilitation.</p> <p>May not be suitable for all road types, with preference being given to rural B and C classification roads.</p>	<p>The supplier claims that the performance and durability of the binder course is equal to that of conventional binder course asphalt.</p>	<p>The original surface needs to be planed off. This material then is mixed with the emulsion via a recycler using dosage control. Following this the installation process follows conventional grading and compaction processes.</p> <p>This process allows for the road to be reopened and trafficked quickly.</p>	<p>The process of in-situ recycling minimises the creation of waste and the usage of virgin materials.</p> <p>Whilst the emulsion is still a virgin material, the process significantly reduces the overall quantity of virgin material than that used in the baseline approach.</p>

Table 4 Colas in-situ recycling Appraisal*

*All factors assessed as part of the appraisal of Colas in-situ recycling has been built on supplier provided material and are not drawn from the live trial.

Life Cycle Stage	Baseline Carbon Emissions (Asphalt Concrete Binder Course) (kgCO ₂ e/m ²)	Colas Regen Carbon Emissions (kgCO ₂ e/m ²)	Difference from Baseline (%) (Increase/Reduction)
A1 – A3	0.15	5.54	3,593%
A4	0.81	0.91	12%
A5	11.45	2.70	76%
C1-C4	12.38	0	100%

Table 5: Lifecycle Stage Comparison to BAU

Carbon Benefits and Considerations (Matrix)

Table 6 presents the findings of the carbon benefits and considerations matrix for Colas in-situ recycling. **All scoring is bold and underlined.**

Technical data used for the benchmark comparator were supplied by the manufacturer and are not derived from site trials. 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 <u>2 - Costs approximate baseline</u> 3 - Costs significantly lower than baseline	Emulsion based in-situ recycling reduces transport and material import costs but requires specialist plant and emulsion supply.
Maintenance	Design life, maintenance burden, on-time for plant	1 – Significantly more maintenance/lower longevity <u>2 - Approximately same maintenance/similar longevity</u> 3 – Significantly less maintenance/higher longevity	Supplier claims the durability is comparable to traditional base courses when designed correctly.
Scalability	Manufacturing facilities	1 - Lab testing only 2 - In process of commercialisation w. small scale manufacture <u>3 - Already has market presence with developed supply chain</u>	Colas is a global company and operates a network of in-situ recycling team across the UK. Colas manufactures a variety of bitumen emulsions across the UK and globally.
Compliance with specifications	Requirements for standards departures	1 - Requires significant departure(s) from standard and has not been used before by end client <u>2 - Requires some departure from standard, but has been used before by end client</u> 3- Already has market presence with developed supply chain	May require specification departures depending on the road class and local authority requirements.
Environmental	Nature-based solution	1 - Would have significant net disbenefit for environmental factors (noise, AQ, biodiversity, landscape etc) <u>2 - Would have negligible net benefit/disbenefit or no overall change</u>	The process reduces the use of virgin materials, waste generated, fuel consumption and site vehicle movements. Reducing the likelihood of disturbance to surrounding protected species and habitats. However, the emulsion still used virgin materials (bitumen), so a level of disturbance during extraction is still required.

BENEFIT/LOAD UNDER REVIEW	CONSIDERATIONS	SCORING SYSTEM	JUSTIFICATION
		<p>regarding environmental factors</p> <p>3 - Would have significant net benefit/disbenefit for environmental factors.</p>	In-situ recycling produces volumes of dust which has potential to affect local biodiversity and therefore is not suitable for areas designated for protected species and habitats as works may result in disturbance.
	Road noise	<p>1 - Would have significant net disbenefit</p> <p>2 - Would have negligible net benefit/disbenefit or no overall change regarding</p> <p>3 - Would have a significant net benefit</p>	No expected change to noise characteristics versus the benchmark.
	Climate resilience/future proofing	<p>1 - Would have significant net disbenefit</p> <p>2 - Would have negligible net benefit/disbenefit or no overall change regarding</p> <p>3 - Would have a significant net benefit</p>	<p>Reusing the existing surface reduces the reliance on virgin materials in road construction.</p> <p>The emulsion remains a virgin material (bitumen) however uses significantly less virgin material than the baseline.</p>
Risk and safety	H&S impacts, safety testing data	<p>1 - Would present increased risk or safety versus BAU option</p> <p>2 - Would present no overall risk increase or safety impact versus BAU option</p> <p>3 - Would present lower risk or safety impact versus BAU option.</p>	In-situ recycling requires the use of a Recycler, which is not required in conventional asphalt laying. However, if all H&S controls are taken, no additional safety risks beyond the BAU are expected.
Technology Readiness Level	Is it commercially available, is there enough R&D?	<p>1 - Not yet commercially available</p> <p>2 - Commercially available from worldwide suppliers</p> <p>3 - Commercially available from European suppliers</p> <p>4 - Commercially available from UK suppliers</p> <p>5 - Commercially available from local suppliers</p>	Colas operates emulsion plants and delivers regen in-situ recycling in the UK market. However, a solely Scotland based team does not currently exist.
Constructability	How easy is it to handle on site, install, recover, curing time, specialist equipment/training, storage?	<p>1 - Specialist contractors, time on site and/or equipment required</p> <p>2 - No considerations required above and beyond baseline solution</p> <p>3 - Significant benefits to on-site activity / ease of installation</p>	Requires a recycler, emulsion dosing controls and trained crews. However, after recycling, installation follows typical grading and rolling procedures.

BENEFIT/LOAD UNDER REVIEW	CONSIDERATIONS	SCORING SYSTEM	JUSTIFICATION
Supply Chain	Material availability	<p>1 - Novel materials used with limited supply</p> <p>2 - Materials are available with some supply restrictions</p> <p>3 - Materials are readily available</p>	<p>Bitumen emulsions and recycling equipment are available within the Colas UK network.</p>
Circular Economy	Recycled content	<p>1 - Virgin materials are used with little or no recycled content</p> <p>2 - Materials contain a level of recycled content</p> <p>3 - Materials are predominantly recycled and/or use novel sources of recycled content that would otherwise be discarded as waste</p>	<p>Recycling uses up to 100% of the existing pavement and reduces virgin material use. However, the emulsion itself is not recycled.</p>
	Ease of recycling	<p>1 - Minimal recycling of material possible upon removal</p> <p>2 - Limited recycling is possible and/or significant reprocessing required</p> <p>3 - Reuse/recycling is easy and convenient</p>	<p>Emulsion-bound layers can be reused in future recycling but may require additional crushing or blending into RAP streams.</p> <p>More research is required on final recyclability behaviour and at what point in-situ recycling is no longer a viable option.</p>

Table 6: Carbon benefits and considerations matrix

Long-Term Performance Analysis

The carbon analysis in this report does not include a lifespan analysis. This will be finalised dependent upon the publishing of longevity 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 Re-recycling Intervals.

Conclusion & Recommendations

Conclusions

The live trial of Colas Regen emulsion binder in-situ recycling has demonstrated some promising results for sustainable road surfacing practices when compared to conventional binder course removal and replacement. The trial results show that in-situ recycling can significantly lower lifecycle stage A1-A5 emissions. Significant carbon savings were achieved when using a bitumen-based emulsion binder in the in-situ recycling process. This achieved a 63.09% reduction in carbon emissions relative to the baseline binder course reconstruction process and delivering carbon emissions at 9.15 kgCO₂e/m².

The process of cold in-situ recycling showed operational benefits, including reduced transport demand and reduced reliance on virgin materials. These advantages support the wider objectives of Live Labs 2 by providing evidence that cold, in-situ techniques can play an important role in future decarbonisation strategies for local authorities. However, issues on site related to grading difficulties, requiring re-processing of 840m² of the site, highlighted that the method of in-situ recycling is still developing and may not be suitable for all road classes. In particular, the process of in-situ recycling requires full road closure, which may not be appropriate for 'A' classified roads, urban areas where constant access is required or sites requiring tight geometric control. This suggests the in-situ recycling method is likely not universally applicable and should be used in targeted maintenance only in appropriate scenarios.

The trial also identified several uncertainties that should be addressed before widescale adoption can be unconditionally recommended. In particular, the variability of transportation emissions associated with Colas's current supply chain and operational footprint and lack of a local in-situ recycling team. This is of significance as the in-situ recycling process requires specialist expertise and plant that cannot yet be sourced locally. Furthermore, whilst in-situ recycling used fewer virgin materials and demonstrated a carbon reduction relative to the baseline, caution is required given its reliance on virgin bitumen material.

Overall, the live trial has demonstrated that Colas's in-situ recycling is a viable, lower carbon alternative to conventional binder replacement and has potential to support Local Authority decarbonisation programmes, provided further validation of the method's suitability for all road classifications, scalability and long-term monitoring is undertaken.

Recommendations

It is recommended that robust long-term monitoring (over 5+ years) be implemented at treated 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.

Should North Lanarkshire consider adopting in-situ recycling in maintenance strategies, training for NLC operational teams would be recommended. This would involve the investment in training programmes for the NLC contractors to enable broader deployment of Colas Regen cold in-situ recycling while lowering transport related emissions which are currently a significant contributor to overall carbon emissions.

Furthermore, while in-situ recycling significantly minimises virgin material use, it still requires the use of potentially 100% virgin bitumen. It is recommended that research focuses on reducing the virgin proportion within the emulsion or identifying viable recycled-bitumen alternatives.

An area for further investigation is the long-term recyclability of in-situ recycling layers. The process allows for all the existing binder course to be reused during installation however, it remains unclear at what point in-situ recycling of the existing carriageway is no longer achievable and what the end-of-life pathways for these treated layers would be. This includes determining whether in-situ recycled asphalt can be incorporated into Reclaimed Asphalt Pavement (RAP), whether additional processing would be necessary and whether repeat in-situ recycling is feasible. Clarifying this will help to validate long-term circularity.