Centre of Excellence
for Decarbonising Roads

Centre Of Excellence For Decarbonising Roads (CEDR)

South Campus: End Of Project Report

Department for Transport
ADEPT LIVE LABS 2 Decarbonising Local Roads
North Lanarkshire Council
Transport for West Midlands
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Contents

Executive Summary

The Centre of Excellence for Decarbonising Roads (CEDR) is a programme established to accelerate the identification, testing, adoption and dissemination of lower carbon approaches to local roads maintenance. This report summarises the activities and findings of CEDR South Campus, covering the period April 2023 to March 2026, and is intended to inform funders and delivery partners, as well as support local highway authorities to make more evidence-led choices in highways maintenance.

Over the programme period, the South Campus focused primarily on lower carbon materials and treatments used in local roads maintenance, while also investigating the carbon and operational characteristics of pothole repair, where emissions can be strongly influenced by plant, equipment and delivery practices. The programme's core delivery model combined (i) a structured innovation pipeline, (ii) a targeted programme of demonstrator trials across pothole repair, surface treatments and resurfacing, (iii) development and refinement of approaches to carbon assessment, and (iv) creation of an online knowledge bank to support knowledge-sharing and behavioural change across the sector.

Key achievements included:

- Investigating lower carbon pothole repair techniques across multiple authorities and delivery contexts.
- Evaluating asphalt rejuvenation and preservation treatments across different pavement ages and surface types.
- Trialling lower carbon resurfacing innovations, including bio-binders, graphene- and lignin-related approaches and polymer-modified binder variants.
- Comparing and positioning carbon calculation tools for different use cases (installation data capture, product carbon reporting, and operational baselining).
- Developing an online knowledge bank, in collaboration with CEDR North Campus, to improve sector access to evidence and implementation learning.

Headline results and quantified carbon impacts are provided where available, with additional results pending final test completion and data assurance at the time of publication. Where required, this report includes placeholders for final values and signposts the appendices and online knowledge bank for supporting detail.

Introduction

Purpose of this report

This end-of-project report documents what CEDR South Campus set out to deliver, what has been delivered, and the evidence gathered to support future decision-making. The report is intended to:

- Provide accountability and transparency to funders and partners;
- Summarise the delivery and emerging findings of the South Campus demonstrator programme;
- Capture learning and evidence gaps to inform future work; and
- Support local authorities and practitioners to adopt lower carbon maintenance solutions appropriately.

Scope and coverage

This report covers the activities of CEDR South Campus in the West Midlands Combined Authority area from April 2023 to March 2026. CEDR North Campus (North Lanarkshire, Scotland) has separate reporting; this document focuses on South Campus delivery and evidence, while recognising the cross-campus collaboration for shared systems and the knowledge bank.

Programme Overview

What is CEDR?

CEDR (Centre of Excellence for Decarbonising Roads) is a programme designed to support the local roads sector to decarbonise highways maintenance by combining structured innovation identification with evidence generation and knowledge-sharing. For the South Campus, this has included:

- Identifying and prioritising innovations with decarbonisation potential.
- Deploying and monitoring selected innovations through demonstrator trials.
- Capturing and communicating learning through accessible formats and an online knowledge bank, and
- Supporting behavioural change by improving access to “what works”, where and why.

Objectives

CEDR South Campus aligned its work to the following programme objectives:

A. Identify, deploy, and monitor low carbon highways maintenance solutions.
B. Publicise low carbon highways maintenance solutions.
C. Become the “go-to place” to manage know-how about decarbonising highways.
D. Develop robust methods for trials at demonstrator sites and enhance understanding of the effectiveness of carbon calculator tools, including the FHRG Carbon Calculation and Accounting Standard.
E. Develop systems and processes to scan and unlock new decarbonised technologies, enable continuous improvement, and embed learning as business-as-usual (BAU).
F. Develop a carbon-based behavioural change initiative.

South Campus focus

The South Campus focused primarily on the materials used in highways maintenance, including treatments for preservation and resurfacing. The main deviation from a material only focus was in pothole repair, where both material choice and the delivery approach (plant and equipment, logistics, and work methods) can drive emissions and outcomes.

The Case for Change

Local highway authorities must deliver safe, resilient road networks while responding to decarbonisation targets and increasing expectations on environmental performance. Decarbonising roads maintenance is challenging because:

- Maintenance interventions must perform reliably under varied traffic and weather conditions.

- Procurement and standards requirements can constrain adoption of new approaches.

- Carbon impacts depend on both product embodied carbon and operational factors such as logistics, plant, laying methods, traffic management and rework, and

- Evidence is often fragmented across suppliers, trials, and local case studies, making it hard for practitioners to determine which approaches are appropriate for their networks.

CEDR was established to address these challenges by providing a structured, sector-led mechanism for identifying innovations, testing them in the real world, and sharing evidence in a way that supports confident adoption and learning across the local roads community.

CEDR's principal legacy and main mechanism for driving sector change is the online knowledge bank, which enables public-sector knowledge sharing to reduce silos between local highway authorities. The evidence presented in this report, and in future reports, will not in itself solely deliver change and represents only one part of the solution. Meaningful sector wide improvement depends on local highway authorities reflecting on what has worked well, what has been trialled, what has not worked, and the conditions in which different approaches have succeeded or failed, and then sharing that learning through the knowledge bank so that the wider sector can benefit from a community built by the public sector for the public sector.

The online knowledge bank can be accessed via kb.decarbonisingroads.co.uk.

Geography, Partners and Participants

Geography and road classes

CEDR South Campus operated across the West Midlands Combined Authority area. Trials and evidence gathering considered all road classes (where possible), subject to local authority participation, site suitability and availability.

Local Highway Authorities

The South Campus engaged with the seven local highway authorities within the WMCA geography. Not all authorities hosted demonstrator trials; trial locations were selected based on suitability, availability and the ability to support monitoring requirements.

The West Midlands Combined Authority area consists of:

- Birmingham City Council
- Coventry City Council
- Dudley Metropolitan Borough Council
- Sandwell Metropolitan Borough Council
- Solihull Metropolitan Borough Council
- Walsall Metropolitan Borough Council
- City of Wolverhampton Council.

Delivery partners and roles

CEDR South Campus worked with partners to provide testing, technical assurance, delivery capacity and knowledge mobilisation. These included:

- Colas - key delivery partner providing project management and carbon analysis
- Connected Places Catapult (CPC) - support for global innovation scanning, development of the industry playbook, and amplification activities.
- Future Highways Research Group (FHRG) and Asphalt IQ - provision of carbon calculation tools and supporting methodologies.
- North Lanarkshire Council and Amey - North Campus partners supporting cross-campus collaboration and alignment.
- Transport Research Laboratory (TRL) - specified testing, including coring and Falling Weight Deflectometer (FWD) surveys.
- University of Nottingham and Aston University - testing and technical support partners.
- Highway maintenance contractors supporting participating local highway authorities:
    - Balfour Beatty (Coventry CC and Solihull MBC)
    - J A Bates (Sandwell MBC); and
    - Tarmac (Walsall MBC).
- Material suppliers and solution providers
    - ASI Solutions (Rhinophalt) – delivered by Velocity Roads and Allied Infrastructure
    - CNRG Technologies (Everphalt) – delivered by Velocity Roads
    - Colas Denmark (Colas Active Sealing)
    - Colas Ltd (Colpatch)
    - Degafloor (Degafill)
    - FM Conway (Greenpatch)
    - Holcim (surface and binder course solutions)
    - Meon (Permafyx)
    - MQP (HRA 45/10)
    - Red Stag (EZ Street asphalt)
    - Roadmender (Elastomac)
    - Roadtechs (Reclamite and Roadpatch)
    - Tarmac (surface course, binder course and pothole repair solutions)
    - Thermal Road Repairs
    - Velocity Roads (Spray Injection Patching)
      Viatec UK (Viafix)

Governance and Delivery Model

Leadership and programme roles

Programme oversight was provided through a defined leadership and delivery structure comprising:

- **Senior Responsible Owner (SRO):** Director of Network Resilience, Transport for West Midlands (TfWM)
- **Programme Lead:** Regional Highway Infrastructure Manager, TfWM
- **Delivery team:** Project Manager, Carbon Analyst, Project Coordinator Apprentice, with support from a TfWM Corridor Manager, Project Accountant and WMCA Communications Team.

Cross-campus decision making

A joint North and South Campus steering group was established to support cross-campus decision-making and alignment, particularly in relation to shared systems and the development of the knowledge bank. Membership included senior representatives from Transport for West Midlands, North Lanarkshire Council, Amey and Colas.

Delivery Pathway

Most delivery activity was undertaken through participating local highway authorities' existing highways maintenance contracts and supply chains, enabling integration with planned works programmes and established delivery mechanisms.

Workstreams and Outputs

Innovation Pipeline

The South and North Campuses used a structured innovation pipeline to translate innovation scanning into evidence generation and practical sector learning:

Horizon scan → shortlist → supplier engagement → feasibility → trial design → delivery → monitoring → evaluation → publish

Innovations in the South Campus were primarily prioritised by:

1. Decarbonisation potential, and
2. Procurement feasibility, including the ability to obtain and deploy solutions within local authority delivery constraints.

Other considerations, including cost, operational practicality and delivery feedback, were also taken into account where relevant. An innovation log was maintained throughout the programme and contains 361 entries. From this wider pipeline, South Campus progressed more than 20 materials and solutions into live trials. The innovation log is available to download from the CEDR website.

Demonstrator Trials Programme

CEDR South Campus delivered demonstrator activity across:

- **Pothole repair** (Phase 1 and Phase 2),
- **Surface treatments** (Phase 1 and Phase 2), and
- **Resurfacing** (Phases 1–4).

A trials register is provided in Appendix A.

Carbon assessment capability

CEDR South Campus reviewed and used multiple tools to support carbon assessment and carbon decision-making:

- Asphalt IQ: which was best suited to the structured capture of delivery, material and installation data at the point of application by operational teams on site;
- asPECT: which was primarily used by suppliers to calculate the embodied carbon of asphalt products and mixtures, supporting product-level reporting and comparison
- FHRG carbon tool / standard: which were better suited to wider baselining and accounting across highway maintenance activities, supporting a more consistent organisational or programme-level view of carbon.

Across product assessments, carbon was typically considered within an A1-A5 boundary. The programme also recognised that carbon should not be interpreted in isolation from performance and service life, and that decision-making should increasingly consider whole-life questions such as the carbon impact per year of service or per maintenance outcome delivered.

Knowledge bank and dissemination

A key output of CEDR was the development of an online knowledge bank in collaboration with North Campus, intended to become the primary sector-facing repository for evidence on lower carbon maintenance materials and approaches.

Outputs included:

- Knowledge bank case studies and product pages;
- CPC-led industry playbook and amplification activities

Demonstrator Trials: Common Methods and Monitoring

Overview of monitoring approach

CEDR South Campus applied monitoring techniques appropriate to each intervention type and the evidence questions being addressed.

- Pothole repair trials: primarily monitored via visual inspections.
- Surface treatment trials: monitored using coring, SCANNER surveys, in-situ hydraulic conductivity, and visual inspections. SCANNER data included assessment of cracking (where applicable) and surface texture.
- Resurfacing trials: monitored using coring, Falling Weight Deflectometer (FWD) and visual inspections, supporting residual life calculations.

Baseline and comparison strategy

- Pothole repair: Phase 1 focused on longevity and performance of repairs over time on real world defects; Phase 2 used a controlled approach including baseline comparison.
- Surface treatments: products were compared to untreated control sections and, where appropriate, compared across products.
- Resurfacing: trial materials were compared to a baseline section laid at the same time, whilst isolating binder and surface course innovations to maximise comparability

Site selection principles

Site selection was conducted through partner local authorities, based on agreed criteria and suitability:

- Pothole Phase 1: real on-network defects requiring repair;
- Pothole Phase 2: a location suitable for creating artificial potholes to support controlled comparison;
- Surface treatments Phase 1: sites up to 10 years old with minimal defects;
- Surface treatments Phase 2: sites ranging approximately 1-15 years old to assess treatments across varying pavement ages;
- Resurfacing: sites requiring resurfacing that could accommodate the materials and approach being trialled.

Limitations and assumptions

The demonstrator trials were undertaken on live highway networks and were designed to balance research objectives with operational delivery. As a result, the degree of control and standardisation varied by trial type. In particular, Phase 1 pothole trials were based on real defects and did not include direct like-for-like product comparisons, as such, product performance could only be evaluated in isolation, whereas later phases adopted more structured approach focusing on side-by-side comparison. Site selection was constrained by the locations made operationally available by partner local authorities, meaning that trial sites were not drawn from a fully controlled sample. Although the best available sites were selected and variables were minimised where practicable, differences in pavement age, condition, traffic loading, environment, contractor practices and construction history may have influenced performance outcomes.

Baseline information and monitoring coverage also varied between sites and intervention types. Control sections were used where practicable, but these should be regarded as practical comparators rather than fully experimental controls in all cases. Some historical construction and maintenance records were incomplete, and coring data were not available for every site. Visual inspections formed part of the monitoring approach and therefore involved an element of professional judgement, with inspection personnel varying by location. Coring, SCANNER, hydraulic conductivity and FWD testing were applied according to the needs of each trial, but sampling locations and frequencies were influenced by safety, access and logistical constraints. For resurfacing trials, residual life assessment remains ongoing and is inherently dependent on assumptions regarding pavement structure, material properties, traffic loading and prior deterioration.

The monitoring period captured performance to date, but for a number of treatments it is too early to draw firm conclusions on long-term durability or whole-life outcomes. Some products were installed later in the programme and are being monitored beyond the formal end of the project. The findings should therefore be interpreted as site-specific evidence and proof of concept under West Midlands conditions, rather than as universally transferable performance values. They nevertheless provide a valuable real-world evidence base for practitioners considering similar materials or treatments in comparable contexts.

Pothole Repair Trials

Phase 1 – Multi site deployment

CEDR South Campus undertook Phase 1 of the pothole repair trials in March 2024 to evaluate a range of repair materials and techniques under live operational conditions across the West Midlands. The purpose of the trial was to assess the carbon, cost, longevity and operational feasibility of innovative pothole repair solutions, with the longer-term aim of identifying approaches that could be scaled into local authority business as usual where appropriate. The Phase 1 trial was delivered across five local highway authorities and included a broad range of road types, reflecting the variability typically encountered in day-to-day highway maintenance.

Trial design and methodology

Phase 1 was designed as a real-world, multi-site deployment rather than a tightly controlled like-for-like laboratory comparison. Products were installed on potholes requiring typical reactive repair across a mix of urban roads, residential streets and A roads, enabling the trial to capture how the innovations performed in representative operational contexts. Roads were categorised by road type, local authority network hierarchy, SROH type and road classification. Across the trial programme, the sites included 22 residential new roads, 12 residential old roads, 7 A/B roads and 15 C/link roads. By classification, the trial covered 45 unclassified roads, 10 A roads, 5 B roads and 11 C roads.

To reduce variation in weather and environmental conditions, the main trial activity was completed within three days, with the exception of Thermal Road Repairs, which was delivered separately. Each repair solution was installed in accordance with the relevant manufacturer’s guidance and under typical operational constraints, with the intention of replicating normal delivery conditions rather than creating an artificial test environment.

A structured data collection process was used throughout the trial. At least one data collector attended each site to observe the repair process, gather operator feedback and record quantitative information. Data collected included pothole dimensions, cut patch size where applicable, road type, USRN, network hierarchy, What3Words location, road class, average depth, material quantities used, start and finish times, machinery and equipment used, vehicles on site, transportation distances and fuel usage. Data was recorded using either clipboards or mobile devices, with videography also used to support accuracy and provide a visual record of the installations.

In addition to field deployment, supporting testing and validation work was initiated. Core samples were taken from selected trial locations to identify any underlying pavement conditions that might influence performance outcomes. CEDR also worked with the University of Nottingham to develop pothole repair slabs for accelerated laboratory testing, including water jetting, immersion wheel tracking, scuffing tests and indirect tensile stiffness and fracture testing. This work was intended to complement the field trials by helping assess likely relative durability under more controlled conditions.

A range of factors could influence repair performance, including weather conditions, ground temperature, road condition and age, pothole size and depth, and the skill and approach of the installation team. Phase 1 should therefore be understood primarily as a practical field trial designed to generate applied learning under operational conditions, rather than as a definitive direct comparison between products.

Products and sites trialled in March 2024 (Phase 1):

- **Coventry:**
    - Langdale Avenue – Degafill (Degafloor)
    - Winding House Lane – Degafill (Degafloor)
    - Chingford Road – Degafill (Degafloor)
    - Shilton Lane – Degafill (Degafloor)
    - Villiers Street – Roadpatch (Roadtechs)
    - Richardson Way – Roadpatch (Roadtechs)
    - Bennetts Road – Roadpatch (Roadtechs)
- **Dudley:**
    - Castle Mill Road – Elastomac (Roadmender)
    - Highland Road – Elastomac (Roadmender)
    - Catholic Lane – Elastomac (Roadmender)
    - Blenheim Way – Greenpatch (FM Conway)
    - Dibdale Road – Greenpatch (FM Conway)
    - Langstone Road – Greenpatch (FM Conway)
- **Sandwell:**
    - High Street West Bromwich – Colpatch (Colas)
    - Europa Avenue – Colpatch (Colas)
    - Forster Street – Permafyx (Meon)
    - Rolfe Street – Permafyx (Meon)
    - Buttress Way – Permafyx (Meon)
    - Holly Lane – Permafyx (Meon)
    - Adkins Lane – Thermal Road Repairs (TRR)
    - Bearwood Road – Thermal Road Repairs (TRR)
    - Newtown Road Layby – Thermal Road Repairs (TRR)
- **Walsall:**

  - Wood Lane – Spray Injection Patching (Velocity)
  - Somerfield Road – Spray Injection Patching (Velocity)
  - Gwendolyn Way – Spray Injection Patching (Velocity)

- **Wolverhampton:**
  - Willenhall Road – Viafix (Viatec)
  - Parkfield Road – Viafix (Viatec)
  - Strawberry Lane – Viafix (Viatec)
  - Winster Road – Viafix (Viatec)
  - Cavendish Road – Viafix (Viatec)

Monitoring approach

Phase 1 monitoring focused primarily on visual inspections to observe the condition of repairs over time. Inspections were undertaken at 3, 6 and 12 months+, with further inspections continuing beyond this period. Photographs were taken at each visit to improve consistency and provide a reference point for comparison over time. While this strengthened the review process, assessment of deterioration remained partly subjective.

This report summarises the trial design, deployment and monitoring approach. Detailed findings on repair performance over time, including longer-term longevity observations, will be published separately through the CEDR knowledge bank, where they can be presented alongside supporting technical detail and any subsequent updates.

Carbon and cost

A1-A3 carbon results were obtained for most products trialled in Phase 1, although the availability, quality and completeness of source data varied between solutions. The reported total A1–A3 carbon associated with the Phase 1 trial was 838.81 $kgCO_2e$. Carbon calculations were completed in Excel using site-collected data, together with a combination of Environmental Product Declarations (EPDs) and supplier-provided carbon information.

However, a direct like-for-like comparison of product carbon performance was not possible. Repairs were undertaken across different local highway authorities, on different road types, and in potholes that varied in size, depth and geometry. In addition, carbon factor data was derived from a mix of sources and units, which further limited comparability. The carbon factor inputs used for Phase 1 are summarised in Table 1.

Product	A1-A3 KgCO2e	Carbon Factor Unit	Carbon factor data source
Degafill	3.59	/kg	EPD for similar product from supplier, Degaroute
Elastomac	.09293	/kg	Supplier provided figures, updated with Eurobitume carbon factor for Bitumen
Greenpatch	0.0638	/kg	Supplier provided figures
HRA(Baseline)	0.0687	/kg	MPA EPD for HRA
Thermal Road Repairs	0.0603	/kg	MPA EPD for SMA
Permafyx	0.911	/kg	EPD in progress
Viafix	0.025	/kg	Supplier provided carbon factor
Colpatch	0.02	/kg	Supplier provided carbon factor-Winter grade Colpatch
Roadpatch	6.6	/m2	Supplier provided carbon factor

Table 1: A1-3 kgCO2e for phase 1 pothole trial materials

Cost data was also collected. However, variation in use case, productivity, material quantities, site conditions and time on site meant that Phase 1 did not provide a sufficiently consistent basis for robust cost comparison between products.

Lessons learned

Phase 1 generated a number of practical lessons that informed the design of subsequent trials. These included the need for stronger communication arrangements between data collectors, local authorities, repair gangs and traffic management teams; improved advance site selection and validation; clearer briefing of all parties before works commenced; and a more robust and defensible trial methodology overall.

The trial also highlighted that having only one data collector on site could make it difficult to capture all relevant information while also responding to operational questions or site issues. In response, later work considered the provision of additional data collection support and supplementary video capture. It also became clear that the data collection sheet should better reflect the chronological flow of on-site activity, so that information could be recorded more efficiently and with less risk of omission.

More broadly, Phase 1 demonstrated the value of treating the initial deployment as a learning stage, allowing improvements to be built into the methodology for later phases.

Limitations

Phase 1 was subject to a number of important limitations. Site identification proved challenging because potholes are often repaired soon after they are identified, leaving only a limited window in which to coordinate suppliers, traffic management and data collection. Some proposed locations were unsuitable on the day due to site conditions, access constraints or traffic management arrangements. One supplier also withdrew because they were not comfortable with the methodology being used, resulting in the loss of potentially useful evidence.

The potholes themselves varied considerably in size, depth and shape, which limited direct comparability between products. In some cases, only one data collector was present, increasing the risk of incomplete or inconsistent data capture. Data collection activity also interrupted repair gangs at times, meaning observed outputs may not have fully reflected normal operational productivity. Longer-term monitoring was further constrained at some sites where subsequent maintenance activity, such as surface dressing, prevented continued inspection.

Finally, while the programme generated useful carbon and operational evidence, there were still limitations in the completeness and consistency of the dataset. Carbon information was not available in the same form for every innovation, direct cost comparison was not sufficiently robust, and condition monitoring remained partly subjective despite the use of photographs and a common scoring approach. Detailed findings on repair performance over time will therefore be published separately through the CEDR knowledge bank, where they can be presented alongside supporting technical context and any subsequent updates.

Overall interpretation

Phase 1 of the pothole repair trials provided a valuable first-stage evidence base on how a range of innovative repair materials and techniques can be deployed under live highway maintenance conditions. The trial demonstrated that it is possible to gather carbon and operational data across multiple authorities and road types, while also highlighting the practical difficulties of doing so within reactive maintenance environments.

The results should therefore be viewed less as a definitive comparison between products and more as a structured learning exercise. Its principal value was in generating applied evidence, identifying methodological limitations, and informing the development of a more robust and controlled Phase 2 approach.

Phase 2 – Controlled comparison (Thimblemill Road, Sandwell)

Phase 2 of the pothole repair trials was undertaken in July 2025 and was designed to provide a more controlled and comparable assessment of pothole repair materials than had been possible in Phase 1. Whereas the first phase focused on live operational deployment across multiple authorities and a wide range of naturally occurring defects, Phase 2 adopted a standardised trial format to improve comparability between products. The objective was to evaluate the carbon, cost, longevity and operational characteristics of a range of pothole repair materials under closely aligned conditions, with the longer-term aim of identifying solutions that could support local authority business as usual.

Figure 1 – Image of Thimblemill Lane – Potholes Phase 2.

The Phase 2 trial was carried out on Thimblemill Road, Sandwell, a B-class residential road on the live highway network. A total of seven pothole repair products were assessed through 28 uniform patch repairs. To maximise consistency, each defect was artificially created rather than selected from naturally occurring potholes. The defects were formed using a Multihog, which in theory would enable each patch to be produced to a consistent width and depth. All repairs were located on the same road and arranged side by side, thereby reducing many of the variables that affected Phase 1 and allowing a more robust product comparison.

Figure 2 – Image of artificial potholes being marked up on Thimblemill Road.

Trial design and methodology

The operational approach centred on controlling the key factors most likely to influence repair performance and carbon measurement. By using a single site, creating uniform defects, and trialling all products within the same road environment, the Phase 2 methodology substantially reduced variation associated with road type, traffic environment, pothole geometry and background pavement condition. This created a more defensible basis for comparing material performance.

The principal controlled variables were:

- Defect size and geometry - 28 artificial potholes were created to a consistent size and depth to improve comparability between products.
- Material quantity – the quantity of material used in each repair was weighed so that carbon calculations could be based on actual usage rather than assumptions.
- Fuel and power consumption – the project team recorded the fuel used by vehicles and tools, together with the duration for which vehicles and equipment were active, to improve the accuracy of installation-stage carbon calculations.

As with Phase 1, the trial was delivered under live highway conditions and supported by an on-site data collection team. The information recorded included:

- fuel consumed,
- fuel type,
- pothole dimensions,
- road class,
- start and finish time, and
- quantity of materials used.

Data collection was supported through the use of data sheets, stopwatches, industrial scales, infrared thermometers, photography and videography, helping to provide a complete operational record of the trial process.

A videographer was present on the day of the trials. A YouTube video can be viewed at: https://youtu.be/bbQvqDdpLw0?si=-JnHaj44RxwaFZHd via the Centre of Excellence for Decarbonising Roads YouTube channel.

Products trialled

The following materials were included in the Phase 2 controlled comparison:

- Viafix (Viatec)
- Ultipatch Bio (Tarmac)
- EZ Street (Red Stag)
- Degafill (Degafloor)
- Thermal Road Repairs (TRR)
- Elastomac (Roadmender)
- Baseline comparator: HRA 45/10 (MQP)

The inclusion of HRA 45/10 (Sandwell’s BAU at the time) as a baseline reference material was particularly important, as it introduced a conventional comparator against which the innovative products could be assessed. This strengthened the trial design and improved the value of the results for local authority decision-making.

Monitoring approach

As with Phase 1, the principal method for monitoring in-service performance was visual inspection. The intention was to assess the operational longevity of each repair through inspections at 3, 6 and 12 months+, with further inspections continuing thereafter where possible. Photography and videography were used at each stage to improve consistency, support comparison over time, and create a record that could also be used within the knowledge bank.

This monitoring approach was intended to identify changes in repair condition over time, including any signs of fretting, cracking, settlement, debonding, material loss or redevelopment of the defect. Although visual assessment remains partly subjective, the controlled nature of the trial layout improves confidence in comparative observations because all repairs are exposed to the same general road, traffic and environmental conditions.

A basic five-point scoring system was also developed to help with consistency of visual inspections as per Table 2 below.

Score	Status	Description
1	Repair performing well	Repair remains intact and flush with the surrounding surface. No visible cracking, fretting, settlement, loss of material, or water ingress. Ride quality unaffected.
2	Minor deterioration	Slight signs of wear or early ageing are visible, such as minor edge fretting, slight texture loss, or very small gaps at the interface with the existing surface. Repair is still functioning as intended.
3	Moderate deterioration	Repair shows clear signs of deterioration, such as noticeable edge breakdown, shallow depressions, minor cracking, or limited loss of repair material. Defect is beginning to redevelop but has not yet significantly affected serviceability or safety.
4	Significant deterioration	Repair has deteriorated substantially. There may be pronounced settlement, extensive cracking, debonding, material loss, or a clear reappearance of the pothole. Ride quality is affected and further deterioration is likely if untreated.
5	Repair failure	Repair has failed. The pothole has reformed, or the repaired area has broken down to the extent that it no longer performs its intended function. Defect may present a safety risk or require urgent attention.

Table 2: five point scoring system for phase 2 pothole trials.

Visual findings - as of February 2026

As of February 2026, visual inspection of the Phase 2 pothole repair sites indicated that all repairs remained in place and broadly functional at the six-month stage, although their apparent condition varied. Most repairs were assessed as showing either good performance or minor deterioration, with common observations including slight edge definition, minor texture change and limited localised fretting. HRA 45/10 showed the highest level of visible deterioration within the group and appeared to warrant closer ongoing observation. These findings provide an initial indication of in-service condition only and should be interpreted as part of a wider evidence base rather than as a definitive measure of long-term performance.

Repair Name	**Score (1-5)**	**Status**	**Feb 2026 Description**
Elastomac 6 month	1	Repair performing well	Repair appears intact, well bonded and broadly flush with the surrounding surface. No obvious cracking, fretting, settlement, edge breakdown or material loss is visible. Texture is uniform and the patch appears to be performing as intended.
Degafill 6 Month	2	Minor deterioration	Repair remains intact and serviceable. There is slight texture variation and a small visible interface around parts of the perimeter, particularly on the left-hand side, but no clear evidence of significant breakdown, settlement or loss of function.
EZ Street 6 month	2	Minor deterioration	Repair is still intact and appears to be carrying traffic adequately. A narrow interface band is visible around the patch and there are early signs of slight edge wear or minor fretting, but no substantial defect redevelopment is evident.
Ulitpatch Bio 6 month	2	Minor deterioration	Repair remains in place with no obvious major cracking or pothole reformation. The patch shows slight edge definition and minor surface texture wear, but overall, it still appears to be functioning satisfactorily.
Viafix 6 month	2	Minor deterioration	Repair appears generally sound and intact. Some slight edge visibility and minor localised wear at the patch boundary can be seen, but there is no clear indication of pronounced settlement, debonding or material loss.
Thermal Road Repairs 6 month	2	Minor deterioration	Repair is still performing its function, but the surface appears slightly open and uneven in texture relative to the better-performing patches. Some early ageing or minor fretting is visible, though there is not yet clear evidence of substantial breakdown or pothole redevelopment. The slightly open surface could be a result of the use of HRA 45/10.

HRA 45/10 6 month	3	Moderate deterioration	This repair shows the greatest visible deterioration of the group. The surface appears rougher and less uniform, with noticeable localised material loss or fretting and a more evident patch perimeter. While it is still in place, the repair is beginning to show signs of breakdown and would warrant monitoring.

Figure 3 - Phase 2 Pothole Repair Image 1 - Viafix (Viatec) – 6 months - Minor deterioration.

Figure 4 - Phase 2 Pothole Repair Image 2 – Ultipatch Bio (Tarmac) – 6 months - Minor deterioration.

Figure 5 - Phase 2 Pothole Repair Image 3 – EZ Street (Red Stag) – 6 months - Minor deterioration.

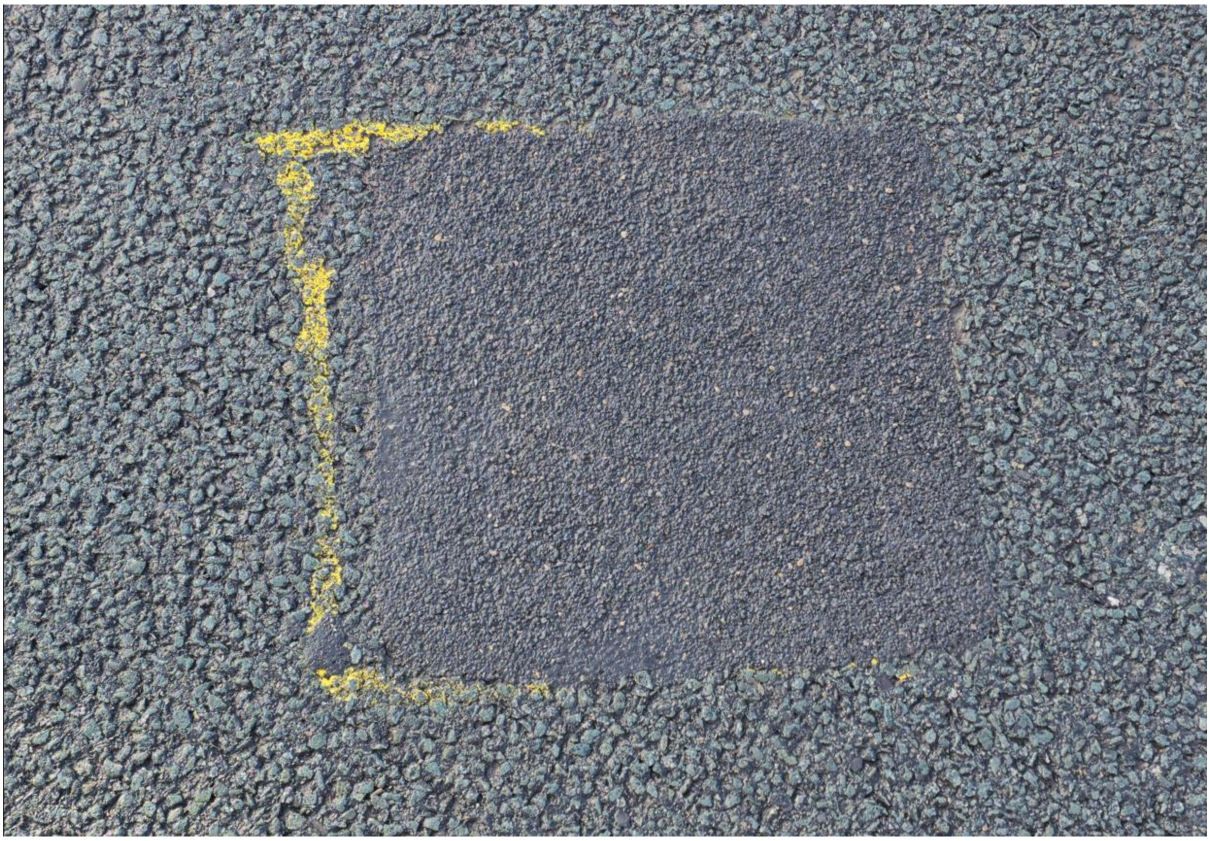

Figure 6 - Phase 2 Pothole Repair Image 4 – Degafill (Degafloor) – 6 months - Minor deterioration.

Figure 7 - Phase 2 Pothole Repair Image 5 – Thermal Road Repairs (TRR)– 6 months - Minor deterioration.

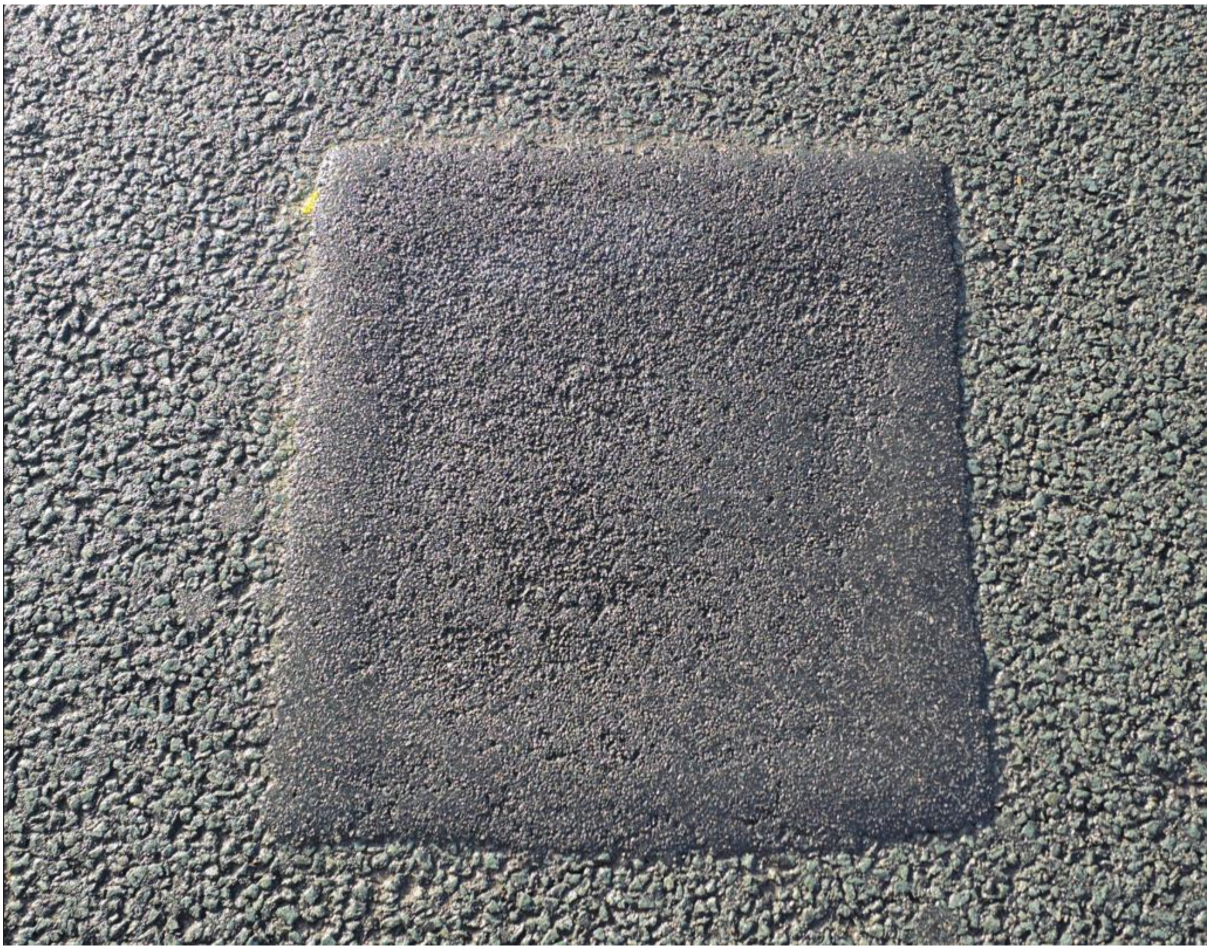

Figure 8 - Phase 2 Pothole Repair Image 6 – Elastomac (Roadmender) – 6 months – Repair performing well.

Figure 9 - Phase 2 Pothole Repair Image 7 – HRA 45/10 (MQP) – 6 months – Moderate deterioration.

Carbon and operational data

A1-A3 carbon results for the Phase 2 trial, together with carbon factors for each product, were obtained for all seven materials trialled. The reported figures are summarised in Table 3.

Product	Total A1-3 carbon for trial	Unit	A1–A3 per kg of product	Unit	Carbon factor data source
Degafill	76.11	$kgCO_2e$/pothole	3.59	$kgCO_2e$/kg	EPD for similar product from supplier, Degaroute
Elastomac	1.52	$kgCO_2e$/pothole	0.093	$kgCO_2e$/kg	Supplier provided figures, updated with Eurobitume carbon factor for Bitumen
EZ Street	0.78	$kgCO_2e$/pothole	0.06	$kgCO_2e$/kg	Supplier provided figures
HRA 45/10	1.51	$kgCO_2e$/pothole	0.0687	$kgCO_2e$/kg	MPA EPD
Thermal Road Repairs	1.61	$kgCO_2e$/pothole	0.0687	$kgCO_2e$/kg	MPA EPD
Ultipatch Bio	-0.12	$kgCO_2e$/pothole	-0.009	$kgCO_2e$/kg	Supplier provided figures
Viafix	0.318	$kgCO_2e$/pothole	0.025	$kgCO_2e$/kg	Supplier provided figures

Table 3: A1-3 carbon data for phase 2 pothole trials.

These results provide an initial indication of material-stage carbon performance. However, they should be interpreted with caution and considered alongside wider operational observations and longer-term in-service performance. Carbon is only one part of the assessment, and material-stage results alone do not indicate overall value or suitability in practice. Further detail on the remaining carbon analysis and longevity findings will be provided in a more detailed report to be published through the CEDR online knowledge bank.

Headline position at time of reporting

At the time of reporting, longitudinal performance monitoring is ongoing, and no final longevity conclusions are yet drawn. However, the principal value of Phase 2 lies not only in the data collected, but also in the improved trial design. By moving from a dispersed, real-world deployment of variable potholes in Phase 1 to a single-site, standardised, side-by-side comparison in Phase 2, the programme created a much stronger basis for assessing relative product performance.

This represents a significant methodological improvement over Phase 1. The use of uniform defects, a common road environment, measured material quantities and tracked fuel use means that Phase 2 is better placed to support a fairer comparison of carbon, operational inputs and in-service durability. It therefore provides a more robust evidence base for future decision-making, even though the longer-term performance findings are still emerging.

Overall interpretation

Phase 2 was designed to address several of the limitations identified in the earlier pothole trials, particularly the difficulty of comparing products tested on different roads, under different conditions, and in potholes of varying size and geometry. The use of artificial, standardised defects and a baseline comparator material has strengthened the quality of the trial evidence and improved the potential to draw more meaningful conclusions about the relative merits of different pothole repair approaches.

While the longevity findings remain under development, Phase 2 has already demonstrated the value of a more controlled trial format for evaluating highway maintenance innovations. The results from ongoing inspections will be important in determining which products not only offer lower carbon potential but also provide durable and operationally practical repairs in a local authority setting.

Surface Treatment Trials

Surface treatment trials were undertaken to evaluate the potential for asphalt preservation and rejuvenation treatments to extend pavement life, reduce permeability, and offer a lower-carbon alternative to more intervention-heavy maintenance activities. The programme focused on products intended to preserve or restore the condition of early to mid-life flexible pavements by reducing moisture ingress, slowing oxidation, and improving binder performance. Across the programme, monitoring included visual inspections, SCANNER surveys, in-situ hydraulic conductivity testing, Falling Weight Deflectometer (FWD) surveys for baseline structural context, and coring for laboratory analysis of mixture and binder properties.

Figure 10 – comparison between untreated section (left) and section sprayed with asphalt rejuvenator during curing period (right).

The trial programme was delivered in two phases. Phase 1, undertaken in August 2024, focused on pavements generally around ten years old or older, representing assets approaching mid-life condition. Phase 2, undertaken in August to September 2025, expanded the scope to sites ranging from approximately one to over fifteen years since resurfacing, enabling assessment of product suitability across a broader asset age range and under differing traffic and operational conditions.

Phase 1 (August 2024)

Phase 1 trialled three preservation products across sites in Coventry and Solihull. The products assessed were Rhinophalt (ASI), Colas Active Sealing (referred to earlier in the programme as PenTack), and Reclamite (Roadtechs). Treatments were applied to a range of surfacing types including Stone Mastic Asphalt (SMA), Hot Rolled Asphalt (HRA) and Asphalt Concrete (AC).

Rhinophalt is a cold spray-applied penetrative asphalt preservative fortified with gilsonite, intended for preventative maintenance by helping to protect the binder against oxidation and delay surface deterioration. Colas Active Sealing / PenTack is a cold-applied bitumen emulsion-based preservation treatment that combines regenerating and modified bitumen emulsions with fine aggregate to restore lost surface mortar and extend pavement life. Reclamite is a spray-applied maltene-based asphalt rejuvenator designed to penetrate the surface and chemically restore components lost through ageing and oxidation, thereby helping to delay cracking and other forms of deterioration.

The Phase 1 sites and treatments were as follows:

- Pickford Way, Coventry: Rhinophalt and Colas Active Sealing
- Stivichall & Cheylesmore Bypass, Coventry: Rhinophalt and Colas Active Sealing
- Auckland Drive, Solihull: Reclamite and Colas Active Sealing
- A452 Collector Road, Solihull: Reclamite and Colas Active Sealing

These sites were selected in partnership with local highway authorities based on criteria including pavement age, traffic conditions, surface type, operational feasibility, and their representativeness of typical UK local road assets. The Phase 1 portfolio included both higher-speed dual carriageway environments and lower-speed urban or residential routes, providing a useful spread of live network conditions.

Where practicable, products were installed in adjacent sections with untreated control areas (see *Figure 11*) to support comparison between treatments and against a counterfactual no-treatment condition. Prior to installation, sites were reviewed through visual assessment, mapping, video review, and structural screening using FWD. SCANNER data and site observations were used to understand pre-treatment condition, including evidence of surface ageing, cracking and texture-related characteristics. Treatment extents and control sections were marked in advance to support consistent monitoring.

All products were installed in accordance with supplier method statements and under operational supervision. Site preparation included sweeping and removal of debris to provide a clean surface. A key learning from Phase 1 was that, at some locations, coring and treatment took place on the same shift, introducing excess surface moisture that may have affected curing and performance. This informed a revised approach in Phase 2, where coring and installation activities were separated.

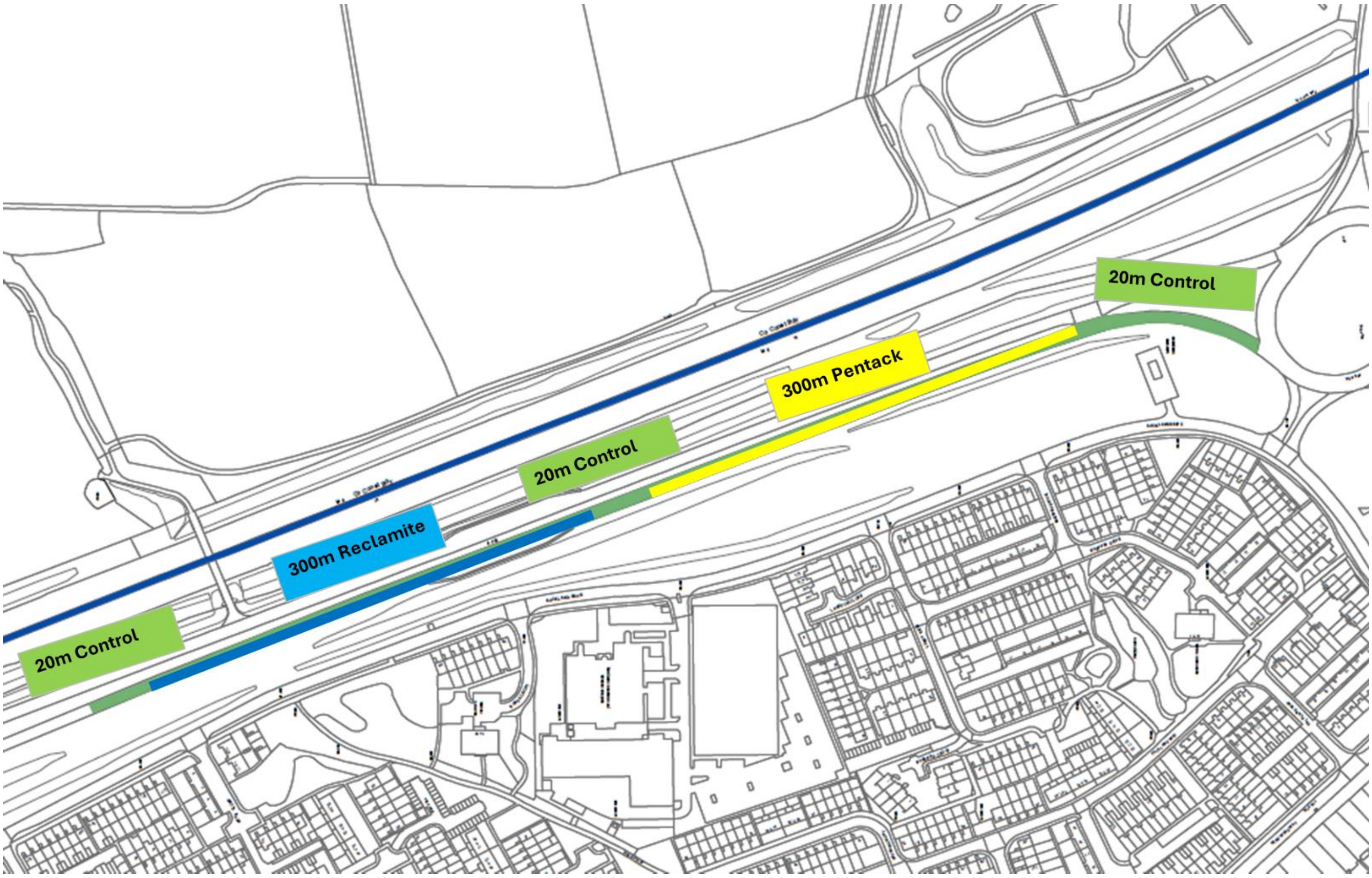

Figure 11 - Example of products installed in adjacent sections with untreated control areas on A452 Collector Road.

Monitoring and testing

The monitoring regime for the surface treatment trials combined field observation with laboratory investigation to provide both practical and mechanistic evidence of performance. This included:

- Visual inspections immediately after application and at planned intervals thereafter to assess coverage, finish, cracking, fretting, ravelling, bleeding and other signs of distress;
- SCANNER surveys to provide repeatable network-level condition data, particularly in relation to cracking and other surface defects;
- In-situ hydraulic conductivity testing to assess changes in surface permeability and moisture ingress potential;
- Core sampling and laboratory testing, including bulk density, stiffness modulus, water uptake, binder extraction and recovery, Dynamic Shear Rheometer analysis, and SARA fractionation;

- FWD surveys to establish baseline structural condition and help distinguish surface treatment performance from any underlying structural weaknesses.

Headline findings from Phase 1

Phase 1 testing indicated that all three surface preservation products produced a measurable preservation effect, particularly through reducing water ingress and altering binder behaviour within the surface course. Across the treated sections, laboratory analysis suggested that the treatments generally increased mixture density and reduced water uptake relative to untreated controls, indicating that the products penetrated and/or sealed the surface void structure to differing degrees. This is important because reduced permeability can help limit moisture-related deterioration and slow further ageing of the surfacing.

The laboratory findings also showed clear differences in how the products appeared to act. Colas Active Sealing and Reclamite behaved primarily as rejuvenating treatments, restoring lighter binder fractions and reducing stiffness in a number of the SMA sections. In practical terms, this suggests that they were effective in softening aged binder and improving flexibility. Rheological testing indicated that both products could move aged binders away from more brittle behaviour and towards a more flexible condition, while chemical analysis suggested that this was associated largely with replenishment of the saturates fraction. Rhinophalt, by contrast, behaved more as a preservative and stabilising treatment than as a strong softening agent. Its effect on stiffness was generally more moderate and more uniform through the depth of the cores. Chemical analysis suggested a different mechanism of action, with a relative increase in aromatic content and a more chemically balanced binder state, pointing towards preservation through stabilisation and surface reinforcement rather than deeper softening.

The findings also suggested differences in penetration behaviour. Colas Active Sealing showed a stronger reduction in binder stiffness in the lower part of the cores, indicating deeper penetration of lighter components, whereas Rhinophalt appeared to have a more even but shallower effect. These findings should, however, be treated as headline observations only. The full laboratory methodology, detailed results, interpretation and supporting analysis will be published in a dedicated technical report via the CEDR online knowledge bank, produced in collaboration with the University of Nottingham. That report will provide the fuller technical evidence base for Phase 1, including the detailed testing outcomes that sit behind the summary conclusions presented here.

Overall, the Phase 1 results indicate that all three treatments showed potential as lower-carbon surface preservation options, but with different performance characteristics. Colas Active Sealing and Reclamite appeared most suited to situations where restoring binder flexibility and reducing permeability were key objectives, while Rhinophalt appeared to offer a more stabilising preservation effect with less risk of over-softening. These early findings informed refinement of the Phase 2 trial design and added to the wider evidence base on how different preservation products may be matched to pavement condition and network context. Full technical substantiation of these findings will be set out in the forthcoming detailed laboratory report to be released through the online knowledge bank in collaboration with the University of Nottingham.

Carbon data for Modules A1–A3, A4 and A5 for the Phase 1 surface treatment trials are summarised in Table 4.

Product	**A1 -A3(Raw material extraction, transport to plant and manufacturing of materials)**	**A4(Transport to site)**	**A5(Construction and installation)**	**Unit**
Colas Active Sealing	0.260443701	0.095175792	0.000726797	KgCO2/m2
Reclamite	0.039109876	0.149218607	0.000685205	KgCO2/m2
Rhinophalt	0.2458	0.193630978	0.00076271	KgCO2/m2

Table 4: KgCO2e/m2 for the Phase 1 surface treatment materials.

NB: A1-A3 for Colas Active Sealing is to be updated once verified data is available from supplier

Total carbon for each treatment across all Phase 1 sites treated is summarised in Table 5.

Product	**Area (m²)**	**Total kgCO$_2$e**
Colas Active Sealing	14,762	3,181.5
Reclamite	6,731	1,788.6
Rhinophalt	9,571.5	4,000.5

Table 5: total carbon for each treatment across all phase 1 sites.

These carbon results provide an initial indication of the relative scale of material, transport and installation impacts for the products trialled. However, they should be interpreted with caution and not in isolation. Differences in treatment area, site context, product function and expected performance period mean that carbon figures alone do not provide a complete basis for comparison or decision-making. Further detail on the carbon analysis, together with the full laboratory findings and their interpretation, will be provided in the dedicated Phase 1 technical report to be published through the CEDR online knowledge bank.

Phase 2 (September 2025)

Phase 2 built on the learning from Phase 1 by broadening the range of trial sites, pavement ages and operating conditions, while refining the delivery approach to improve consistency and reliability. Whereas Phase 1 focused mainly on pavements around ten years old or older, Phase 2 included sites ranging from approximately one to over fifteen years since resurfacing. This enabled the programme to examine how preservation treatments may perform across a wider asset lifecycle window, including relatively younger surfaces where early intervention may help delay deterioration, and older surfaces where preservation may still offer value if structural condition remains sound.

Phase 2 also reflected operational learning from the earlier trials. In particular, coring and treatment installation were separated to avoid excess surface moisture at the point of application, reducing the risk of compromised curing conditions. Works were predominantly delivered under overnight closures, which better reflected the operational conditions likely to apply on busier parts of the network and reduced disruption to road users. As in Phase 1, treatment extents and control areas were identified in advance, and installation was undertaken in accordance with supplier method statements and risk assessments.

Three products were trialled during Phase 2: Colas Active Sealing, Rhinophalt, and Everphalt. Unfortunately, Reclamite couldn’t be used in Phase 2 due to availability.

Sites were selected with partner authorities in Walsall, Sandwell and Coventry, based on pavement age, road hierarchy, traffic loading, surface type, and operational feasibility. The Phase 2 sites and treatments were as follows:

Sites and products:

- A41 The Expressway, Sandwell – Colas Active Sealing (Colas Denmark)
- A4123 Wolverhampton Road, Sandwell – Colas Active Sealing (Colas Denmark)
- A444 Jimmy Hill Way, Coventry – Colas Active Sealing (Colas Denmark)
- A4053 Ring Road Junction 2–4, Coventry – Rhinophalt (ASI)
- A4053 Ring Road Junction 2–4, Coventry – Everphalt (CNRG)
- Aldridge Road, Walsall – Colas Active Sealing (Colas Denmark)
- A41 Black Country New Road, Walsall – Rhinophalt (ASI)
- A41 Black Country New Road, Walsall – Everphalt (CNRG)
- B4155 Lichfield Road, Walsall – Rhinophalt (ASI)
- Longwood Lane, Walsall – Colas Active Sealing (Colas Denmark)
- A4124 Lichfield Road, Walsall – Everphalt (CNRG)
- A4124 Lichfield Road / Sneyd Lane – Rhinophalt (ASI)
- A34 Stafford Road, Walsall – Everphalt (CNRG)
- Reedswood Way, Walsall – Everphalt (CNRG)

These locations provided a broad spread of live network conditions, including high speed dual carriageways, strategic urban corridors, suburban roads and residential streets. This wider spread strengthened the evidence base by assessing preservation treatments under more varied traffic and environmental conditions than in Phase 1.

Figure 12 – Image of A41 The Expressway during curing period of Colas Active Sealing.

Monitoring remained consistent with the overall trial methodology and included visual inspections, SCANNER surveys, in-situ hydraulic conductivity testing, core sampling and laboratory analysis, with Falling Weight Deflectometer data used to provide baseline structural context where available. As with Phase 1, the intention was not only to observe visible condition change, but also to understand how the products influenced permeability, binder behaviour and the likely mechanisms through which they may extend service life.

At the time of reporting, the Phase 2 programme had generated strong evidence on operational delivery and carbon performance, with technical performance monitoring continuing. The carbon assessment showed that all three treatments delivered substantial reductions in A1-A5 carbon when compared with conventional resurfacing. Across the Phase 2 sites, Colas Active Sealing, Everphalt and Rhinophalt each achieved carbon savings of approximately 95% to 97% relative to a resurfacing counterfactual, and 66% to 75% relative to double racked in surface dressing. This confirms that, from an embodied and installation carbon perspective, preservation treatments can offer a materially lower-carbon alternative to more intervention-heavy maintenance options.

Although direct comparison between products should be treated with caution due to differences in site characteristics, area covered and supply logistics, the overall pattern was consistent with Phase 1: preservation treatments required significantly less material and energy input than resurfacing and therefore produced far lower upfront carbon emissions.

Pentack (Colas Active Sealing) – Phase 2 Totals

Site	Area (m²)	Total Carbon ($kgCO_2e$)
A41 Expressway	7,120.4	2,089.4
Longwood Lane	2,681.8	672.8
Aldridge Road	8,117.7	2,138.84
Jimmy Hill Way – SMA	6,159.0	1,603.80
Jimmy Hill Way – HRA	4,281.4	1,114.88
TOTAL	**28,360.3 m²**	**7,619.72 $kgCO_2e$**

Table 6: Colas Active Sealing Phase 2 totals

Everphalt – Phase 2 Totals

Site	Area (m²)	Total Carbon ($kgCO_2e$)
Black Country New Road	6,662	1,637.52
Lichfield Road	3,166	778.20
Reedswood Way	6,270	1,541.17
Stafford Road	6,252	1,536.74
Ring Road (A4053)	2,842	698.56
TOTAL	**25,192 m²**	**6,192.19 $kgCO_2e$**

Table 7: Everphalt Phase 2 totals

Rhinophalt – Phase 2 Totals

Site	Area (m²)	Total Carbon ($kgCO_2e$)
B4155 Lichfield Road	3,192	1,157.4
A4124 Lichfield Road	4,367	1,450.6
Black Country Road	6,514.5	2,025.4
TOTAL	**14,073.5 m²**	**4,633.4 $kgCO_2e$**

Table 8: Rhinophalt Phase 2 totals

Phase 2 therefore reinforced the central conclusion emerging from the surface treatment trials: where pavement structure remains fundamentally sound, asphalt preservation can provide a practical, scalable and lower-carbon intervention that may help delay more intensive maintenance. The Phase 2 programme also broadened the evidence base by testing preservation treatments across a wider range of road types and pavement ages, while improving the robustness of the trial process through lessons learned from Phase 1.

Longer-term monitoring will remain important in determining how these products perform over time and in identifying the most appropriate treatment type and timing for different asset and network conditions.

Further Phase 2 findings, including the results of Phase 2 laboratory testing, will be published following completion through the CEDR online knowledge bank.

Resurfacing Trials

CEDR South Campus undertook four phases of resurfacing trials to evaluate lower-carbon asphalt mixtures and binder innovations within live resurfacing schemes. The overall aim was to test whether these materials could reduce embodied carbon while maintaining, or potentially improving, long-term pavement performance. Across the programme, the trials moved from lower-trafficked residential roads to more heavily trafficked urban corridors and bus routes, allowing assessment under a range of loading conditions and use cases. Monitoring included coring, Falling Weight Deflectometer (FWD) testing and ongoing visual inspections, with FWD data intended to support residual life estimation and help determine whether the lower-carbon materials can perform at least as well as conventional alternatives over time.

Phase 1 – Pauls Coppice, Walsall

The first resurfacing trial was delivered with Tarmac on Pauls Coppice, Walsall, a Carriageway Type 4 road carrying up to 0.5 msa. The purpose of this phase was to investigate lower-carbon resurfacing options for residential roads by comparing a small conventional control section with biogenic binder and surface course alternatives.

The baseline treatment comprised a Warm AC 20 Dense Bin 100/150 DES binder course laid at 60 mm, with a Warm AC 10 Close Surf 70/100 PSV 60 surface course laid at 40 mm. This was compared with a lower-carbon biogenic solution consisting of BIO AC 20 Dense Bin 100/150 DES at 60 mm and BIO AC 10 Close Surf 70/100 PSV 60 at 40 mm. The total trial area was 1,378 m², of which 280 m² was laid using the conventional binder course as a control section. The remaining area used the biogenic binder course, with the majority of the site also surfaced using the biogenic surface course. All materials were supplied from the same Birmingham asphalt plant, helping to reduce variability associated with plant location.

The reported A1-A3 carbon figures for the materials were as follows:

Material	**Asphalt plant**	**A1-A3 kgCO$_2$e/tonne**	**Tonnes**
Warm AC 10 Close Surf 70/100 PSV 60	Birmingham	57.7	38.62
Warm AC 20 Dense Bin 100/150 DES	Birmingham	48.3	38.88
BIO AC 10 Close Surf 70/100 PSV 60	Birmingham	49.6	156.38
BIO AC 20 Dense Bin 100/150 DES	Birmingham	41.2	156.38

Table 9: Supplier provided A1-3 figures for Pauls Coppice asphalt mixes using asPECT.

Residual life assessment is being undertaken by TRL using FWD testing, although results were not yet available at the time of drafting. The additional cost of the biogenic materials on this site was reported as only circa £2,000. If performance proves comparable to or better than the conventional materials, this suggests that biogenic mixes could represent a practical lower-carbon option for lightly trafficked local roads. The materials were laid by Tarmac. A full trial report for Pauls Coppice will be published on the online knowledge bank.

Figure 13 – Pauls Coppice

Phase 2 – Croxstalls Road, Walsall

The second resurfacing phase was also delivered with Tarmac, this time on Croxstalls Road, Walsall, a Carriageway Type 3 road carrying 0.5 to 2.5 msa. In contrast with Pauls Coppice, the focus here was on the use of graphene as an additive to reduce the carbon impact of asphalt while maintaining suitable performance for a more heavily trafficked industrial estate road.

The trial compared a conventional polymer-modified surface course, ULTILAYER S 10 SURF PMB PSV 60 at 40 mm, with a graphene-modified surface course, ULTIPAVE D 10 SURF 40/60 + GRAPHENE PSV 65, also at 40 mm. To reduce the number of variables, the binder course was kept consistent throughout the site using ULTILAYER SINGLE 20 PMB H/S at 60 mm thickness. The total area resurfaced was 2,631 m². The graphene-modified material was laid between two conventional Ultilayer surface course sections, creating a direct in-scheme comparison.

The reported A1-A3 carbon figures were:

Material	**Asphalt plant**	**A1-A3 kgCO$_2$e/tonne**	**Tonnes**
ULTIPAVE D 10 SURF 40/60 + GRAPHENE PSV 65	Bayston Hill	67.8	97.52
ULTILAYER S 10 SURF PMB PSV 60	Mountsorrel	83.8	147.9
ULTILAYER SINGLE 20 PMB H/S	Birmingham	68.7	193.58
ULTILAYER SINGLE 20 PMB H/S	Bayston Hill	61.7	193.68

Table 10: Supplier provided A1-3 figures for Croxstalls Road asphalt mixes using asPECT.

This phase was intended to examine whether a graphene-modified surface course could last as long as, or longer than, a conventional PMB surface course while also offering carbon and potentially cost benefits. It also highlighted an important methodological point: even for nominally similar materials, asphalt plant location can materially influence A1-A3 carbon values. Residual life estimation is again being undertaken by TRL using FWD data, with results to be published separately. The materials were laid by Tarmac.

Phase 3 – Broad Lane and Willenhall Lane, Coventry

The third phase moved to Coventry and broadened the trial design by separately testing lower-carbon options in the binder course and the surface course. The aim was to allow Holcim to propose the lowest-carbon solutions it could offer for each layer, while retaining control sections specified by the local highway authority.

Broad Lane

Broad Lane is a Carriageway Type 1 road carrying 10 to 30 msa. The trial on this site focused on binder course comparison, while maintaining a consistent surface course to reduce variables. Broad Lane received five different binder course materials, one of which was a conventional control specified by the local highway authority. The surface course was the same across the site.

The binder course options were:

- AC 20mm HDM WMA 1680S (control)
- AC 20 HDM 40/60 + Graphene 1680G (graphene-modified)
- AC 20 HDM SuperLow Carbon PMB 1686Z (biogenic PMB mix)
- Foamix ECO with ACLA (using carbon-negative aggregate)
- Foamix ECO with E20 Lignin (lignin-based)

On Broad Lane, the binder course was laid at 100 mm and the surface course at 50 mm. This was the first time these materials had been trialled together on one site.

The reported A1-A3 values are as per Table 11 below.

Location	**Material**	**Asphalt plant**	**A1-A3 kgCO$_2$e/tonne**
Broad Lane	AC 20mm HDM WMA 1680S	Croft	42.2
Broad Lane	SuperCurve 10mm 80U26F	Croft	66.54
Broad Lane	AC 20 HDM 40/60 + Graphene 1680G	Croft	38.99
Broad Lane	Foamix ACLA	OCL Croft	0
Broad Lane	Foamix Lignin E20	OCL Croft	0
Broad Lane	AC 20 HDM SuperLow Carbon PMB 1686Z	Croft	41.73

Table 11: Supplier provided A1-3 figures for Broad Lane asphalt mixes using asPECT.

Figure 14 – Broad Lane post resurfacing.

Willenhall Lane

Willenhall Lane is a Carriageway Type 2 road carrying 2.5 to 10 msa. Here the focus shifted to surface course comparison, with one consistent binder course used throughout. The binder course was AC 20mm HDM WMA 1680S, while the surface courses compared were:

- SuperCurve 10mm 80U26F (control)
- SuperCurve 10mm SuperLow Carbon PMB 80U26Z (biogenic PMB mix)
- SuperCurve 10mm PMB + BioCarb ME50 80U24B (lignin-based PMB mix)
- SuperCurve 10mm PMB + Graphene 80U26GF (graphene-based PMB mix)

As at Broad Lane, the binder course was laid at 100 mm and the surface course at 50 mm.

The reported A1-A3 figures are as per Table 12 below.

Location	Material	Asphalt plant	A1-A3 kgCO$_2$e/tonne
Willenhall Lane	SuperCurve 10mm SuperLow Carbon PMB 80U26Z	Croft	64.7
Willenhall Lane	AC 20mm HDM WMA 1680S	Bardon	35.39
Willenhall Lane	SuperCurve 10mm PMB + BioCarb ME50 80U24B (Lignin)	Croft	52.19
Willenhall Lane	SuperCurve 10mm PMB + Graphene 80U26GF	Croft	65.54
Willenhall Lane	SuperCurve 10mm 80U26F (Control)	Bardon	77.64

Table 12: Supplier provided A1-3 figures for Willenhall Lane asphalt mixes using asPECT.

For both Broad Lane and Willenhall Lane, the University of Nottingham undertook laboratory testing including IT-CY stiffness, wheel tracking (Proc. B), fatigue testing (4PB-PR) and stiffness testing (4PB-PR). These results were not yet available at the time of drafting. Residual life estimation is also being supported through FWD testing by TRL. All materials were laid by CR Macdonald as Balfour Beatty's surfacing contractor. Full technical reports will be published once available via the online knowledge bank, which can be accessed at kb.decarbonisingroads.co.uk.

Phase 4 – Walsgrave Road, Coventry

The fourth resurfacing phase was delivered on Walsgrave Road, Coventry, and brought together multiple suppliers to propose lower-carbon solutions with a focus not only on embodied carbon, but also on longevity as a decarbonisation strategy. The rationale was that if pavements last longer, fewer maintenance interventions are required over time, thereby reducing whole-life carbon.

This phase compared approaches from Holcim and Tarmac on a heavily trafficked route including an electric bus corridor. All binder course materials were laid at 100 mm, and all surface course materials at 50 mm. The site was split into three sections:

- Section 1: conventional Holcim materials representing what Coventry would normally specify.
- Section 2: Holcim lower carbon / long-life proposal
- Section 3: Tarmac lower carbon / long-life proposal

Section 1 used a conventional AC 20 HDM bin 40/60 binder course with SuperCurve SMA 10 surf PMB - 80U26H as the surface course. Section 2 used Supreme AC20 Bin PMB in the binder course, paired with the same Holcim surface course from section 1. Section 3 used a Biogenic AC 20 HDM 40/60 pen binder course with Ultilayer S10 Surf PMB (AGESAFE) PSV 60 as the surface course. An overlap between Sections 2 and 3 allows direct comparison between the Holcim and Tarmac long-life solutions.

Holcim's Supreme binder course was selected as a highly compactable, very strong and durable asphalt intended for heavily loaded areas such as bus lanes, junctions and industrial yards. Tarmac's solution combined a lower-carbon biogenic binder course with a surface course using Shell's Agesafe PMB, which is designed to reduce oxidation and delay binder embrittlement, thereby extending surface life.

The reported A1-A3 figures are as per Table 13 below.

Location	**Material**	**Asphalt plant**	**A1-A3 kgCO$_2$e/tonne**	**Supplier**
Walsgrave Road	AC 20 HDM bin 40/60 CL929 des - 1920A	Bardon Hill	42.16	Holcim
Walsgrave Road	Supreme AC20 Bin PMB - 24G4D1	Bardon Hill	56.89	Holcim
Walsgrave Road	SuperCurve SMA 10 surf PMB - 80U26H	Bardon Hill	71.74	Holcim
Walsgrave Road	Supreme AC20 Bin PMB - 14G4D1	Bardon Hill	56.89	Holcim
Walsgrave Road	AC 20 HDM bin 40/60 - 1680S	Bardon Hill	28.62	Holcim
Walsgrave Road	AC 20 HDM bin 40/60 CL929 des - 1920A	Bardon Hill	31.12	Holcim
Walsgrave Road	Ultilayer S10 Surf PMB (AGESAFE) PSV 60	Mountsorrel	64.5	Tarmac
Walsgrave Road	Biogenic AC 20 HDM 40/60 pen	Birmingham	42.2	Tarmac

Table 13: Supplier provided A1-3 figures for Walsgrave Road asphalt mixes using asPECT.

Figure 15 – Walsgrave Road Section 3

Residual life estimation is again being undertaken by TRL using FWD data, and the site will also be monitored over time in line with the wider resurfacing trial programme. As with the earlier phases, materials were laid by CR Macdonald as Balfour Beatty's surfacing contractor, providing consistency of delivery across the competing materials. A full technical report will be available via the online knowledge bank for Walsgrave Road once testing is complete.

Overall position at time of reporting

At the time of reporting, detailed performance and residual life findings from the resurfacing trials were still being developed, with FWD interpretation and laboratory testing ongoing. However, the trials have already established an important practical evidence base by showing how different lower-carbon solutions can be incorporated into live resurfacing schemes across a range of road types and traffic environments.

Taken together, the four phases explored a broad spectrum of decarbonisation approaches, including biogenic binders, graphene-modified mixes, lignin-based solutions, carbon-negative aggregate concepts, and long-life binder and PMB systems. The programme has therefore not treated decarbonisation as a single product question, but as a broader investigation into how carbon can potentially be reduced through material substitution, mix design innovation, and improved durability.

The long-term value of these trials will depend on whether the lower-carbon and long-life materials perform as well as, or better than, the conventional alternatives. For that reason, ongoing monitoring and publication of the residual life and laboratory test results will be critical in determining which of these resurfacing solutions offer the strongest case for wider adoption.

Assessment of Pothole Repair Enabling Plant and Equipment

CEDR South Campus also assessed the carbon performance of small plant and enabling equipment commonly used to support pothole repairs and minor carriageway maintenance. While much of the programme focused on repair materials themselves, the equipment used to cut, break, compact and clear defects also contributes to the overall carbon impact of reactive maintenance. This work was therefore undertaken to better understand the operational carbon implications of commonly used petrol and diesel tools, and to compare these against electric alternatives.

The assessment was designed to generate a transparent and repeatable evidence base for local authorities and contractors considering the selective or wider adoption of electric small plant. The key objectives were to generate primary measured fuel-use data for combustion-powered tools, convert audited whole-life carbon data for electric equivalents into directly comparable operational intensities, compare emissions across tool types, quantify indicative annual carbon savings, and establish a methodology that could be reused in future trials.

Methodology

Physical testing of combustion-powered equipment was undertaken at the Colas National Highways Area 9 Coleshill Depot within a controlled test environment. Petrol and diesel tools were hired through GAP Hire Solutions to provide a consistent equipment standard and reliable fuel measurement. The tools assessed were a circular saw, road breaker, whacker plate and blower.

Electric tools were not physically tested on site. Instead, the assessment used audited whole-life carbon data from Speedy Hire's Whole-Life Carbon dataset, which provided total kgCO_2e values, daily operating hours, and equipment identifiers. These data were converted into kgCO_2e per minute so that the electric tools could be compared directly with the measured petrol and diesel results.

To maintain consistency during the physical testing, each combustion-powered tool was assessed in two operating modes: free-spinning and under resistance, such as cutting, breaking or compacting. The same two operatives were used throughout the trial to reduce variability in handling, loading and working technique. A full RAMS process was completed in advance, and testing durations were aligned with safe continuous-use periods as instructed by the Colas SHE Manager.

For the petrol and diesel tools, the method involved filling the fuel tank to 100 per cent using calibrated two-litre pitchers, operating the tool for ten minutes and/or over approximately 0.5 m^2 of test area where safe, and then refilling the tank to determine fuel consumed. From this, litres per minute and kgCO_2e per minute were calculated using UK Government GHG Factors (2025). For cutting and breaking tasks, $kgCO_2e$ per m² values were also derived.

For the electric tools, Speedy Hire's whole-life carbon figures were normalised using expected daily operating hours to produce $kgCO_2e$ per hour and $kgCO_2e$ per minute values. This allowed a like-for-like comparison with the measured fuel-based data.

Operational carbon results

The measured petrol baseline demonstrated the following operational carbon intensities:

Equipment	**Fuel use per minute (L)**	**$kgCO_2e$ per minute**	**$kgCO_2e$ per m2**
Circular saw	0.056	0.165	0.959
Road breaker	0.029	0.087	1.486
Whacker plate	0.035	0.103	1.162
Blower	0.008	0.021	N/A

Table 14: Operational carbon intensities for measured petrol baseline of tools.

The normalised electric values derived from the Speedy Hire dataset were as follows:

Equipment	**Total $kgCO_2e$**	**Daily operating hours**	**$kgCO_2e$ per hour**	**$kgCO_2e$ per minute**
Electric road breaker	5.5054	2.4	2.2939	0.03823
Electric circular saw	5.5054	2.4	2.2939	0.03823
Electric plate compactor	13.3780	2.5	5.3512	0.08919
Electric handheld blower	1.5771	3.3	0.4779	0.00797

Table 15: Operational carbon intensities for electric tools.

These results show that electric equipment produced lower operational carbon emissions across all tool categories assessed.

Annualised carbon savings

To illustrate the practical significance of the results, annual carbon outputs were estimated using the assumption of 150 working days per year. Annual minutes were calculated from the expected daily operating hours for each tool. On this basis, the indicative annual savings from switching from petrol to electric equipment were as follows:

Tool	**Annual petrol CO_2e (kg)**	**Annual electric CO_2e (kg)**	**Saving ($kgCO_2e$)**	**Saving (tCO_2e)**
Circular saw	3,564.0	825.7	2,738.3	2.74
Road breaker	1,879.2	825.7	1,053.5	1.05
Plate compactor	2,317.5	2,006.8	310.7	0.31
Handheld blower	623.7	236.7	387.0	0.39

Table 16: Annualised carbon savings from electric tool use.

The greatest annual carbon saving was associated with the circular saw, followed by the road breaker, handheld blower and plate compactor.

Carbon savings and operational implications

The assessment demonstrated a clear and measurable carbon benefit from replacing petrol-powered enabling tools with electric alternatives. Although electric tools are not carbon-free when electricity generation and charging are considered, they consistently emitted less operational carbon per minute than their combustion-powered equivalents.

For the road breaker, the electric alternative emitted 0.038 $kgCO_2e$ per minute, compared with 0.087 $kgCO_2e$ per minute for the petrol breaker. This equates to an approximate 51 per cent reduction and an annual saving of just over 1 tonne of CO_2e per tool. The reduction is attributable largely to the removal of direct fuel combustion and the avoidance of idle-burn losses.

For the circular saw, the electric version emitted 0.038 $kgCO_2e$ per minute, compared with 0.165 $kgCO_2e$ per minute for the petrol saw. This represents the largest reduction of all tools assessed and makes the cut-off saw the strongest case for electrification in carbon terms. On the assumptions used, each electric saw could save around 2.74 tCO_2e per year.

For the plate compactor, the electric version emitted 0.089 $kgCO_2e$ per minute, compared with 0.103 $kgCO_2e$ per minute for the petrol equivalent. The reduction was smaller than for other tools, which is unsurprising given the sustained mechanical effort and higher power demand associated with compaction. Even so, the electric compactor still delivered a measurable annual saving and may offer other practical benefits.

For the handheld blower, the electric alternative emitted 0.00797 $kgCO_2e$ per minute, compared with 0.021 $kgCO_2e$ per minute for the petrol model. This equates to a reduction of around 62 per cent. Because blowers tend to be used for relatively long daily periods, the annual saving remained significant despite the tool's comparatively low per-minute emissions.

Wider operational observations

In addition to carbon savings, electric tools offer a number of wider operational advantages. These include lower noise, reduced vibration, zero exhaust fumes, lower idle losses, and in many cases improved operator comfort. Feedback from operatives indicated that the electric saw and blower in particular provided smoother handling and reduced vibration compared with petrol equivalents. The electric breaker was also reported to provide consistent performance for pothole enabling works.

These wider benefits are relevant to local authority operations, particularly in urban and residential settings where noise, air quality and operator welfare are increasingly important considerations alongside carbon reduction.

Overall findings

Across all categories assessed, electric enabling plant demonstrated lower operational carbon emissions than the petrol equivalents used as the benchmark. The findings therefore support a wider shift towards electric small plant as part of a lower-carbon maintenance approach. While embodied carbon associated with batteries and manufacture remains a consideration, the operational savings identified in this assessment indicate that electrification of frequently used small tools can deliver clear environmental benefit.

This work strengthens the overall evidence base developed through CEDR by showing that decarbonisation opportunities exist not only in repair materials and treatment choice, but also in the tools and equipment used to deliver maintenance. For local authorities seeking practical carbon reductions in pothole repair operations, electrification of small plant appears to represent a credible and scalable opportunity.

Conclusion

The assessment shows that electric enabling plant can reduce the operational carbon footprint of pothole repair activities while also offering practical advantages in use. Depending on tool type and duty cycle, annual savings were estimated to range from 0.31 to 2.74 tCO_2e per tool per year, with the most compelling cases for substitution being the circular saw, road breaker and handheld blower.

Taken together, the results suggest that selective or wider electrification of small plant fleets could make a meaningful contribution to reducing emissions from local highway maintenance, while also improving site conditions for operatives and reducing nuisance in the surrounding environment.

Carbon Assessment Methods and Tools

CEDR South Campus used carbon assessment to support consistent decision-making and to strengthen the evidence base for adoption.

Use cases and tool roles

- **Asphalt IQ** supported structured capture of project data at the point of installation, improving consistency and auditability of inputs.
- **Manual Data Collection** was facilitated where appropriate by the project's carbon analyst as an alternative to Asphalt IQ.
- **asPECT** supported product-level embodied carbon estimates typically provided and used by suppliers for asphalt products and mixes.
- **FHRG carbon tool / standard** supported baselining and accounting across the broader highways maintenance operation, enabling a more organisational or programme-wide perspective.

Boundary and interpretation

For products, assessment focused on A1–A5 (product and construction stages). The programme recognises that carbon decision-making should also consider implications of service life and performance, translating A1–A5 results into outcome-based interpretation (e.g., carbon per year of service, carbon per prevented failure).

Conclusions and recommendations on carbon tools

The UK highways sector operates within a diverse carbon-tool ecosystem because no single tool covers all lifecycle stages, organisational needs, or PAS 2080 requirements. Instead, tools specialise by purpose:

- **Strategic optioneering (A–D):** FHRG CPT provides the most robust whole-life, network-level carbon modelling for early decisions and net-zero pathways.

- **Materials and design LCAs:** asPECT v5.0 gives sector-standard asphalt mixture assessment, while One Click LCA supports full-scheme LCAs with extensive EPD data and BIM integrations.

- **Construction and maintenance data capture:** CarbonIQ fills the long-standing data gap in real-time A4–A5 emissions from site activities.

- **Client-mandated reporting:** FHRG CFA enables consistent LHA-wide Scope 1–3 accounting, while the National Highways Carbon Tool standardises supplier returns.

- **Supply chain readiness:** The SCSS Carbon Calculator supports supplier-level carbon literacy and consistent Scope 1–3 reporting.
- **Materials and plant comparisons:** SEVE supports detailed eco-comparisons of asphalt mixes and construction scenarios.

The strongest outcomes arise when these tools are combined into a coherent workflow from option development through design and delivery to annual reporting supported by a single, governed factor library.

Recommendations

For Local Highway Authorities (LHAs)

- Use FHRG CFA annually to track Scope 1–3 emissions with consistent data and factor governance.
- Apply FHRG CPT to quantify whole-life impacts and develop credible net-zero roadmaps.
- Require asPECT v5.0 for asphalt-related decisions and encourage low-carbon options (WMA, RAP).
- Pilot CarbonIQ to replace generic A5 estimates with real operational data and feed these into CFA.
- For major schemes, request One Click LCA outputs aligned with PAS 2080 and CEEQUAL.

For Tier 1 Contractors and Delivery Partners

- Deploy CarbonIQ routinely to drive reductions in plant use, haulage, and construction operations.
- Provide asPECT v5.0 outputs for asphalt and propose quantified mix optimisations.
- Ensure compliance with NH Carbon Tool data structures and reporting cycles.
- Encourage subcontractors to use the SCSS Carbon Calculator to build supply chain consistency.

For Consultants and Designers

- Begin optioneering with FHRG CPT to identify low-carbon strategic options early.
- Use One Click LCA for full-scheme LCAs, integrating asPECT v5.0 where asphalt is significant.

- Provide clear, procurement-focused recommendations (e.g., EPD requirements, logistics strategies).

Key Findings and Cross-Cutting Insights

This section summarises the principal insights emerging across the CEDR South Campus programme, bringing together findings from the pothole repair trials, surface treatment trials, resurfacing trials, carbon assessment work and implementation learning. At this stage, some laboratory and residual life outputs remain in progress, so the conclusions below should be read as the strongest evidence currently available rather than a final statement on long-term performance.

A consistent finding across the programme is that meaningful carbon reduction is possible within routine highway maintenance, but the most appropriate solution depends heavily on the asset type, traffic environment, pavement condition and intervention timing. The trials do not support the idea of a single “best” low-carbon product or material for all circumstances. Instead, they point towards a more nuanced asset management approach in which lower-carbon interventions are selected according to site need, expected life, operational constraints and whole-life value.

Across the surface treatment trials, the evidence indicates that preservation treatments can offer a credible lower-carbon alternative to more intervention-heavy maintenance where pavement structure remains fundamentally sound. The Phase 1 and Phase 2 trials showed that products such as Colas Active Sealing, Reclamite, Rhinophalt and Everphalt can be applied within live network conditions across a range of road types and pavement ages, with substantial reductions in A1-A5 carbon when compared with resurfacing. In Phase 1, the treatments achieved reductions of approximately 94 to 97 per cent relative to a resurfacing counterfactual, and in Phase 2 the savings were of a similar order, around 95 to 97 per cent. Even against a lower-carbon double racked in surface dressing counterfactual, the preservation products still showed materially lower carbon impacts. This strongly suggests that where a road is still structurally sound, earlier intervention through preservation has considerable decarbonisation potential.

The technical findings from the surface treatment work also point to different preservation mechanisms rather than a single common effect. Colas Active Sealing and Reclamite generally behaved as rejuvenating treatments, reducing stiffness in a number of the SMA sections, replenishing lighter binder fractions and reducing water uptake. Rhinophalt behaved more as a preserving and stabilising treatment, with a more moderate and generally more uniform effect through the depth of the core. Across all product’s, reduced permeability was a recurring positive outcome, which is important because limiting water ingress should help slow subsequent deterioration. The implication is that product selection should be based not only on carbon, but also on what the site requires: deeper rejuvenation and increased flexibility, or a more stabilising preservation effect.

The pothole repair trials reinforce the importance of trial design in generating useful evidence. Phase 1 provided valuable operational learning by deploying a wide range of materials across five authorities and many live sites, but it also demonstrated the limitations of comparing products installed in potholes of differing size, depth, shape, traffic environment and underlying pavement condition. Even so, the long-term visual inspections suggest that many of the repairs remained serviceable over the monitoring period, with most products generally falling into the minor to moderate deterioration range rather than complete failure. This indicates that several lower-carbon or alternative repair materials are capable of performing credibly in live conditions, although Phase 1 does not support robust direct ranking between them.

Phase 2 of the pothole trials improved significantly on this by moving to a controlled, side-by-side comparison on Thimblemill Road, where artificial potholes were created to uniform dimensions on the same road. This was a major methodological step forward. It reduced many of the variables that affected Phase 1 and created a stronger basis for comparing carbon, material use, operational inputs and longer-term durability. Although the longevity findings are still ongoing, the Phase 2 approach provides a much more defensible template for future comparative trials. One of the clearest cross-cutting insights from the pothole work is therefore that controlled trial design matters if evidence is to support decision-making with confidence.

The programme's work on pothole repair enabling plant and equipment adds an important further dimension to the decarbonisation evidence base. It shows that carbon savings can be achieved not only through the repair material chosen, but also through the tools used to undertake the repair. Across all categories assessed, electric small plant produced lower operational carbon emissions than the petrol equivalents. The most compelling case was the electric circular saw, followed by the road breaker and handheld blower, while the plate compactor still showed a smaller but positive carbon benefit. Estimated annual savings ranged from around 0.31 to 2.74 tCO_2e per tool per year, depending on use. This suggests that local authorities seeking practical carbon reduction in reactive maintenance should consider fleet electrification alongside material innovation, especially for frequently used enabling plant.

The resurfacing trials show that lower-carbon asphalt solutions can be incorporated into live resurfacing schemes on roads ranging from low-trafficked residential streets to heavily loaded corridors and bus routes. However, the evidence to date suggests that the "lowest carbon" mix is likely to be site-specific rather than universal. At Pauls Coppice, the biogenic binder and surface course mixes appear promising for a lightly trafficked residential road, particularly given the relatively small extra-over cost. At Croxstalls Road, the graphene-modified surface course showed lower reported cradle-to-gate carbon than the conventional PMB surface course used for comparison, suggesting potential on a somewhat heavier trafficked industrial route. At Broad Lane and Willenhall Lane, the trials demonstrated that graphene, lignin, biogenic and other low-carbon formulations can all be deployed within the same scheme but also highlighted that apparent carbon advantages on paper must be treated cautiously until performance is proven. At Walsgrave Road, the programme moved beyond simple embodied carbon comparison and explicitly explored decarbonisation through longevity, recognising that on heavily loaded routes the optimum solution may not be the material with the lowest upfront carbon, but the one that lasts longest and therefore reduces intervention frequency.

A key cross-cutting lesson from the resurfacing work is that A1-A3 carbon data alone is not sufficient to identify the best material choice. Several materials show lower cradle-to-gate carbon than conventional comparators, but the critical question is whether they last at least as long in service. Until FWD-derived residual life outputs, laboratory performance testing and longer-term field monitoring are available, only provisional conclusions can be drawn. The programme therefore points strongly towards the need for whole-life thinking, rather than decisions based solely on upfront embodied carbon.

Another important insight emerging across the programme is the significance of timing of intervention. The surface treatment work in particular supports the principle that acting earlier, while the pavement remains structurally sound, can offer major carbon benefits by delaying or avoiding more carbon-intensive maintenance. This is a crucial asset management message. The same principle is echoed in the pothole and resurfacing work: the value of an intervention is not only what it costs or emits at the point of delivery, but what it does to the future maintenance trajectory of the asset.

The programme also demonstrated the importance of good quality operational data collection. Carbon assessment was strengthened where material quantities, fuel use, plant hours, transport assumptions and site activity were recorded carefully. Equally, where data collection was incomplete, inconsistent or intrusive to the works, this limited confidence in the results. This was particularly evident in the Phase 1 pothole trials. A further cross-cutting lesson is therefore that future innovation trials should place strong emphasis on pre-planned data collection, clear roles, consistent proformas, and where possible the use of controlled or semi-controlled conditions.

There are also important lessons around implementation and delivery. Site selection, traffic management, communication between trial partners, supplier readiness and consistency of installation all had a material influence on trial quality. In several cases, the practical challenges of trialling innovations on the live network were as significant as the material performance questions. The programme therefore shows that successful innovation adoption requires not just technical performance, but also operational practicality, supply chain confidence and a methodology that can stand up to scrutiny.

Finally, a broader strategic insight from the programme is that decarbonising roads is not only about finding new materials. It is about combining several levers: selecting lower-carbon materials where appropriate; intervening earlier through preservation; improving repair methods; electrifying small plant; considering longevity as a route to carbon reduction; and generating better evidence to support specification and asset management decisions. In that sense, the programme has helped shift the conversation from isolated product claims to a wider evidence-based view of how local road maintenance can reduce carbon while remaining practical and performance-led.

Overall, the evidence developed so far suggests that lower-carbon road maintenance is achievable, but only if authorities move away from one-size-fits-all thinking and instead adopt a site-specific, evidence-led and whole-life approach. Continued monitoring, publication of residual life and laboratory results, and further refinement of trial methods will be essential in turning these promising findings into confident business-as-usual adoption.

Impact and Benefits

CEDR South Campus has contributed to the decarbonisation of local road maintenance primarily by strengthening the evidence available to highway authorities and helping to reduce practical barriers to the adoption of lower-carbon approaches. Through live demonstrator trials, technical testing and carbon assessment, the programme has helped move the conversation beyond product claims towards a more objective understanding of where different interventions may be appropriate. This has included evidence that asphalt preservation treatments can deliver substantial upfront carbon savings compared with resurfacing where pavements remain structurally sound; that lower-carbon resurfacing materials, including biogenic, graphene- and lignin-based solutions, can be incorporated into live schemes on different road types; that a range of pothole repair materials can perform credibly in service; and that electrification of smaller plant and enabling equipment can also make a measurable contribution to reducing maintenance emissions.

A further benefit of CEDR South Campus has been the social value and training activity delivered across the West Midlands. The programme has engaged with schools across the region through careers fairs and assemblies, helping to raise awareness of both CEDR and career opportunities within the highways sector. CEDR has also developed a highways-specific carbon literacy training programme, currently in testing and intended to form part of the project’s legacy. This will support local authorities and regional partners to strengthen knowledge and capability in relation to carbon across highway maintenance and wider highways activity.

A significant benefit for West Midlands local authorities has been the establishment of a service-level carbon baseline. Six authorities became early adopters of the Department for Transport's Carbon Leadership Programme, with three already having received completion certificates. This represented the first time a highways service carbon baseline had been developed across these authorities, providing an important foundation for future measurement, comparison and improvement.

The programme has also generated practical sector learning, not only on carbon and technical performance, but on implementation. The trials highlighted the importance of intervention timing, particularly the value of earlier preservation treatments in delaying more carbon-intensive maintenance. They also reinforced that there is no single best lower-carbon solution for every circumstance: the most appropriate treatment depends on road type, traffic loading, pavement condition, operational constraints and the likely whole-life outcome. In addition, the programme generated important lessons on trial design and delivery, including the need for stronger site selection, clearer communication, better data collection, more controlled comparisons where appropriate, and careful consideration of constructability and supplier readiness. In this respect, South Campus has helped build a more mature evidence base for decision-making in local roads maintenance.

The knowledge bank is intended to extend that impact beyond the live trials by providing a structured platform for sharing trial outcomes, implementation learning, product information and case studies from both South Campus and the wider sector. Its role is not simply to store information, but to support more informed and consistent decision-making by making evidence easier to access, compare and apply. This is particularly important in a sector where innovation adoption can be slowed by fragmented information, limited peer-to-peer learning and uncertainty about what has worked elsewhere. The evidence presented in this report, and in future reports, will not by itself deliver change and represents only one part of the solution. Meaningful sector-wide improvement depends on local highway authorities reflecting on what has worked well, what has been trialled, what has not worked, and the conditions in which different approaches have succeeded or failed, and then sharing that learning through the knowledge bank so that the wider sector can benefit from a community built by the public sector for the public sector.

Taken together, these activities mean that the impact of CEDR South Campus is not limited to the sites trialled. Its wider benefit lies in helping local highway authorities move towards a more evidence-led, site-specific and whole-life approach to maintenance decarbonisation, giving practitioners greater confidence to consider lower-carbon options while keeping performance, durability and operational practicality at the centre of decision-making.

Lessons Learned

Lessons Learned

A number of lessons emerged from the delivery of CEDR South Campus. First, the programme underestimated the scale of testing required to support the trials and the time needed to complete that work. In future, testing requirements, laboratory capacity and associated lead times should be scoped in greater detail at an earlier stage so that they can be better integrated into programme planning.

Secondly, the initial procurement of the main commercial delivery partner, Colas, took longer than anticipated, which had a consequential impact on the overall programme timetable. This contributed to delays in trial delivery, with the first Phase 1 pothole trials taking place around a year after project mobilisation. Future programmes would benefit from earlier procurement planning and mobilisation activity to reduce the risk of delays to core delivery.

The programme also identified opportunities to strengthen trial design and delivery. For example, future surface treatment trials could draw more directly on established international methodologies, including approaches used in the United States where rejuvenation and preservation treatments are applied repeatedly over time alongside untreated control sections to support more consistent comparison. In addition, there was a time lag in receiving testing outputs from partners, indicating that the interface between field delivery, sampling and laboratory analysis could have been managed more efficiently. The administration of trial payments and procurement arrangements with local highway authorities also proved more complex than initially anticipated, highlighting the need for clearer and more streamlined processes. Finally, closer and more regular engagement with participating local authorities would have helped reduce the risk of external activities, such as utility works or other maintenance interventions, affecting trial sites and disrupting monitoring.

Evidence Gaps and Future Research Priorities

While the programme has generated a stronger practical evidence base for lower-carbon road maintenance, several important gaps remain before widespread adoption can be supported with full confidence. The most significant gap is long-term performance evidence. Across the surface treatment and resurfacing trials, the key unresolved question is not simply which materials have lower upfront carbon, but whether they will last as long as, or longer than, conventional alternatives under real traffic and environmental conditions. Residual life outputs, longer-term visual monitoring, and the outstanding laboratory results from TRL and the University of Nottingham will therefore be critical. Without these, it remains difficult to move from promising carbon data to confident whole-life specification decisions.

A second gap concerns whole-life comparability and standardisation of evidence. Much of the current dataset is strongest at A1-A3 or A1-A5 level, but less complete on whole-life carbon, lifecycle cost, maintenance frequency and end-of-life implications. Future research should therefore focus on linking embodied carbon data to verified service life, maintenance demand and intervention frequency so that authorities can compare options on a genuinely whole-life basis. There is also a need for more standardised trial methods, especially where direct comparison is intended. The Phase 2 pothole trial demonstrated the value of controlled, like-for-like conditions, and similar discipline would strengthen future comparative work on maintenance materials, preservation treatments and resurfacing options. Related to this is the need to better understand how results vary by site type: road class, traffic loading, pavement form, existing condition and climate all appear to influence what the “best” option may be.

Finally, the programme highlights a need for further work on implementation, operational practicality and transferability into business as usual. Future research should examine not only whether innovations perform technically, but how easily they can be specified, procured, installed, monitored and repeated at scale by local authorities. This includes better evidence on productivity, cost, workforce implications, supplier readiness, quality control, and the role of enabling measures such as electrification of small plant. In short, the next phase of work should move beyond proving that lower-carbon options are possible and towards identifying which solutions are robust, repeatable and genuinely preferable for different maintenance scenarios across the local road network.

Next Steps and the Future of CEDR

CEDR South Campus recommends that the programme should not end with the close of the current project but should instead be developed into a broader Centre of Excellence for Local Roads, building on the model established through CEDR. One of the clearest lessons from the programme is that innovation and learning within the local roads sector are still too often fragmented across individual authorities, suppliers, trials and short-term projects. Useful evidence frequently exists, but it is dispersed, inconsistently recorded, difficult to compare, and not always easy for practitioners to access or apply. This creates unnecessary duplication, slows adoption of effective approaches, and can lead to authorities repeatedly testing or assessing similar issues in isolation rather than benefiting from collective learning.

The CEDR model has shown that there is value in a sector-led mechanism that identifies innovations, tests them in real-world conditions, captures both technical and operational learning, and makes that information available in a structured and accessible form. There is a strong case for extending this approach beyond decarbonisation and materials alone. Local highway authorities face similar evidence and knowledge-sharing challenges across a much wider set of issues, including asset management, maintenance treatments, resilience, adaptation, performance, value for money and delivery practice. Evolving CEDR into a wider Centre of Excellence for Local Roads would therefore allow the same core model to be applied more broadly: generating evidence, standardising data where possible, reducing silos, and making practical learning readily available to the sector across multiple topics.

This next phase should focus on strengthening and widening the evidence base, deepening the content and functionality of the knowledge bank, improving consistency in data collection and monitoring, and supporting adoption through clearer decision-support frameworks, practitioner guidance and peer-to-peer learning. In doing so, it would build on CEDR's legacy not simply as a project, but as the foundation of a longer-term, public-sector-led resource designed to help local highway authorities make more informed, consistent and effective decisions across the wider local roads agenda.

Website and Communication Channels

Online Knowledge Bank: https://kb.decarbonisingroads.co.uk/

Centre of Excellence for Decarbonising Roads YouTube Channel: https://www.youtube.com/@decarbonisingroads

Linkedin: Centre of Excellence for Decarbonising Roads.

Email: Info@decarbonisingroads.co.uk

Appendices

Appendix A – Trials Register (Excel spreadsheet)