



Local Government Engineering Department (LGED)

Local Government Division (LGD)

Ministry of Local Government, Rural Development and Co-operatives.

Government of the People's Republic of Bangladesh

Development and validation of a Low-Cost Field Device for Prime Coat Bond Strength Evaluation in Pavement

INCEPTION REPORT

May 2026



Department of Civil and Environmental Engineering,
Islamic University of Technology (IUT),
Gazipur, Bangladesh

CONTENTS

1 INTRODUCTION	1
1.1 Background	1
1.2 Work Objective and Scope	1
1.3 Client: LGED and Relevance to the Assignment.....	2
1.4 Service Provider:	2
1.5 Project Implementation Arrangement	3
1.6 Institutional and Organization Arrangements	3
2 LITERATURE REVIEW	4
2.1 Strategic Importance of Prime Coat Bond Performance.....	4
2.2 Literature Review and State of Knowledge.....	4
2.2.1 Studies on Prime Coat Materials	4
2.2.2 Interlayer Bond Strength	5
2.2.4 Factors Identified in the Literature.....	8
2.2.4 Identified Research Gap	8
3 APPROACH AND METHODOLOGY	10
3.1 Overall Approach.....	10
3.2 Approach to Mobilization and Inception Activities	10
3.3 Technical Methodology: Device Development and Validation	11
3.4 Field Testing Strategy and Test Matrix	12
3.5 Data Analysis, Benchmark Development and Acceptance Logic.....	13
3.6 SOP, Field Handbook and Institutionalization	13
3.7 Capacity Building and Dissemination	14
4 TRAINING AND STAKEHOLDER ENGAGEMENT	16
5 Work Plan	17
5.3 Working Schedule.....	18
6 CONCLUSIONS.....	19
6.1 Work Done.....	19
6.2 Work to be Done	19
7 References.....	20

TABLE OF FIGURES

Figure 1 Project Coordination Framework	3
Figure 2 Weak prime coating can lead to debonding at low stress	4
Figure 3 Technology Gap and Present Issues.....	9
Figure 4 Diagram of Change: Broad Project Outcome	10
Figure 5 Planned Pull-Off (Tensile) Setup on Left and Shear Device on Right	12
Figure 6 Project Workflow.....	15
Figure 7 Training Program Process Flow	16

TABLE OF TABLES

Table 1 Quantity of Bitumen Emulsion as Primer for Various Surface Types (IRC: 16-2008)	5
Table 2 Type and Quantity of Cutback Bitumen Primer (IRC: 16-2008)	6
Table 3 Existing Bond Strength Measuring Device	7
Table 4 Indicative Schedule	17
Table 5 Key report deliverables	17
Table 6 Working Schedule	18

1 INTRODUCTION

1.1 Background

The Local Government Engineering Department (LGED) plays a crucial role in the development of infrastructure in Bangladesh. With its mandate to plan, design, construct, and maintain various infrastructure projects, LGED strives to ensure the sustainable and efficient delivery of essential services to the people. LGED is responsible for a vast network of roads that serve as a lifeline for rural and urban communities. The Local Government Engineering Department (LGED) has recognized the significant challenges posed by inadequate bond strength between the prime coat and the base layer in flexible pavement construction. Prime coat serves as a vital bonding agent between the Wet Mix Macadam (WMM) base and the subsequent bituminous layers, enhancing the adhesion and durability of the pavement structure. However, inconsistencies in the quality of prime coat application and bonding often lead to premature failures such as slippage, pothole formation, and delamination, particularly under Bangladesh's high rainfall, temperature variations, and fluctuating groundwater levels. Currently, prime coat bond strength assessment relies on subjective visual inspections and material compliance checks, which do not provide an objective or quantifiable measure of performance. This gap in reliable testing tools necessitates the development of a practical, field-ready device capable of evaluating bond strength in real construction conditions. The goal of this project is to fill this gap by designing and validating a low-cost, portable device for measuring prime coat bond strength in the field.

The device will be accompanied by a complete tailored testing regimen with high repeatability that is easy to use also by LGED engineers and contractors so users of both data can make data-driven decisions in tendering and construction. The effort will also include target strengths, acceptable thresholds and guidance on the application of prime coat, curing and evaluation. This will at some point be field tested to push this device into LGED's state quality control process which ultimately ensures better performance of the pavement and prevents premature life failings. This document will be prepared to capture the mobilization phase of the first portion of the project and design for this inception report. This inception report, the first project deliverable, is based on decisions made at the meeting and contains a detailed approach to how the consultant will work with the team as well as methodology and step by step implementation plan for ensuring its successful implementation.

1.2 Work Objective and Scope

Objectives of the study are following:

- Design and fabricate portable shear and pull-off (tensile) testers suitable for field use on WMM-prime coat interfaces.
- Evaluate prime coat performance across representative environmental and construction conditions in LGED works, including variation in base moisture, dustiness, curing duration and temperature.
- Establish benchmark strength values and minimum acceptable thresholds, and develop application recommendations (material type, application rate band and curing window) suitable for LGED specifications.
- Develop a Standard Operating Procedure (SOP) and a concise field handbook, including data sheets, decision rules and troubleshooting guidance.

- Train LGED engineers and contractors through workshops and on-site demonstrations, and support dissemination of the invention to professional and research communities.

The Consultant shall carry out the following tasks:

- Conduct a detailed literature review and gap analysis of existing prime coat bonding techniques.
- Identify commonly used prime coat materials in LGED roads (e.g., MC-30, SS-1h).
- Design a viable test matrix with aim to criteria establishment with identification of well-performing and poorly performing prime coats.
- Develop and field-test hand-held shear and pull-off devices.
- Implement testing on selected LGED road projects in at least two regions.
- Analyze data to identify minimum acceptable strength thresholds.
- Develop a Standard Operating Procedure (SOP) and field handbook.
- Organize capacity-building workshops and on-site demonstrations for LGED staff.
- Disseminate findings in national and international platforms

1.3 Client: LGED and Relevance to the Assignment

The Local Government Engineering Department (LGED) is a major public infrastructure agency responsible for rural and peri-urban road networks and connectivity that underpin economic activity and access to essential services. A large share of LGED pavements are flexible pavements constructed on granular bases (including WMM), where prime coats are widely used before bituminous surfacing. A field-quantified prime coat bond evaluation system will directly support improved construction quality control, reduce early-life failures, and improve value-for-money by lowering the frequency and severity of maintenance interventions.

The outputs of this assignment will be actionable for LGED:

- A device set that can be procured, replicated or locally fabricated;
- A standardized SOP/handbook and data formats;
- Benchmark strength values and practical acceptance logic; and
- Trained LGED engineers and contractors capable of deploying the protocol during routine site supervision records.

1.4 Service Provider:

The Islamic University of Technology (IUT), Gazipur, is an international university under the Organization of Islamic Cooperation (OIC), with a focus on engineering education, applied research, and professional capacity development. The university is equipped with laboratory and research facilities to support both academic and consultancy activities. The Department of Civil and Environmental Engineering (CEE) at IUT has established expertise in transportation and pavement engineering, including materials testing, field evaluation, and performance analysis. The Department regularly undertakes research, training, and consultancy for infrastructure agencies. For this assignment, the Department provides the required technical and institutional capacity to support the development, testing, and validation of a low-cost field device for evaluating prime coat bond strength in pavements.

1.5 Project Implementation Arrangement

The assignment will be managed through LGED's Research, Innovation and Knowledge Management (RIKM) Cell under the Planning and Research Unit. The Consultant will work under the direct supervision of the relevant LGED authority and will coordinate closely with field offices to access selected project sites, obtain construction records, and schedule field trials without disrupting project progress. A structured governance approach will be followed, including an inception meeting to confirm scope and sites; milestone-based review of prototype designs and test procedures; mid-term progress review workshop; and final validation and dissemination arrangements. The consultant shall work under the direct supervision of the chief engineer and the Superintending Engineer (Planning and Research) of LGED. An organogram for Executing Agency, the LGED, for the implementation of this Project is shown in Figure 1.

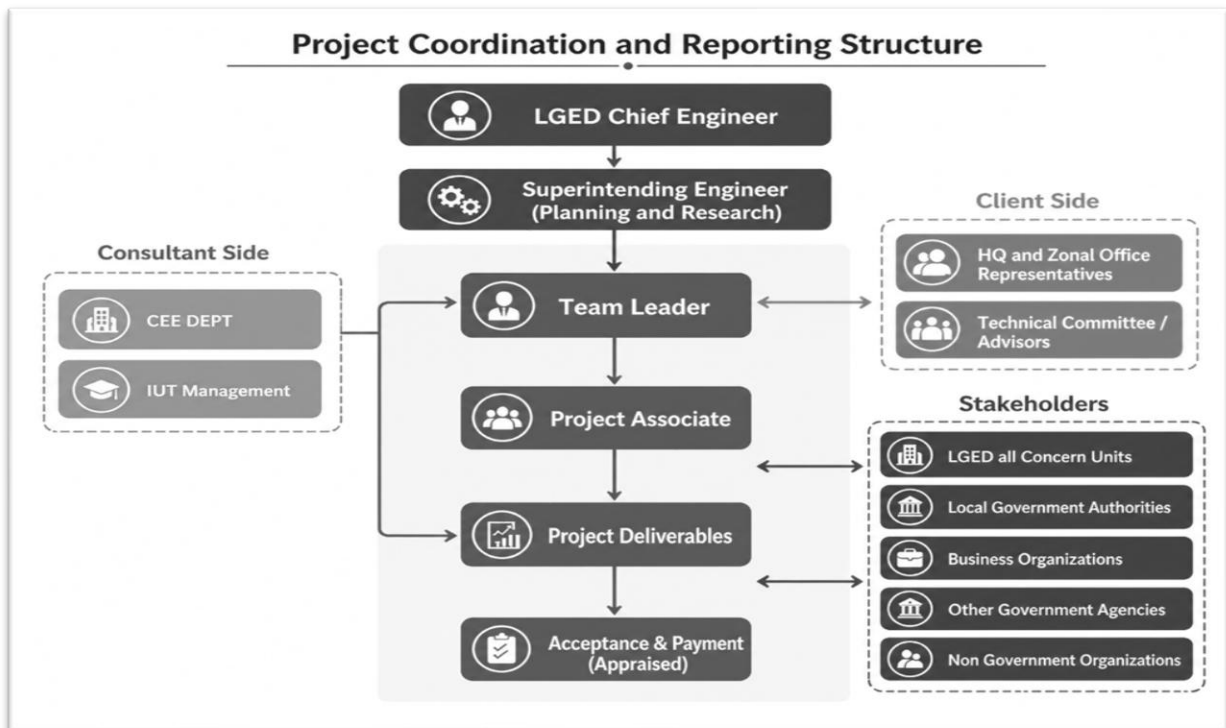


Figure 1 Project Coordination Framework

1.6 Institutional and Organization Arrangements

The Research, Innovation and Knowledge Management (RIKM) Cell operates under the Planning and Research Unit of LGED. The Superintending Engineer (Planning and Research), as the head of the unit, will serve as the overall head of the RIKM Cell and will provide strategic oversight for this research work.

The Executive Engineer (RIKM), as the head of the Cell, will guide and assist the study team as necessary - particularly in areas related to technology gap analysis, identification of opportunities, formulation of the technology roadmap and implementation plan, as well as assessment, monitoring, and evaluation activities.

LGED shall provide related data, services, and facilities aligned to this research work to the Consultants. Besides, during field survey and data collection work, if necessary relevant LGED personnel would accompany the study team.

2 LITERATURE REVIEW

2.1 Strategic Importance of Prime Coat Bond Performance

Prime coat is a critical interface treatment in flexible pavement construction. It is applied over the prepared granular base to penetrate surface voids, stabilize loose fines, reduce short-term moisture ingress, and promote adhesion between the granular layer and the overlying bituminous surfacing. Prime coat is a sprayed bituminous application on untreated subgrade or base that fills surface voids, protects the base from weather, stabilizes fines, and promotes bonding to subsequent pavement layers.

For LGED roads, this issue is especially important because a large share of the network is built on granular bases, including WMM, and prime coat quality is strongly influenced by field conditions such as moisture, dust, application rate, curing time, and traffic opening. The project documents identify inadequate or inconsistent bonding at the WMM–prime coat–asphalt interface as a recurring cause of premature failures such as slippage, potholes, stripping, and delamination. They also note that current quality control is still dominated by material compliance and visual judgment, which does not directly measure bond performance.



Figure 2 Weak prime coating can lead to debonding at low stress

This makes the proposed study highly relevant. The project aims to develop and validate a practical, low-cost, field-ready device and protocol so that LGED can move from subjective inspection to objective, quantifiable acceptance of prime coat performance. It is therefore not just a device-development exercise; it is a quality assurance intervention that can improve construction reliability, reduce early-life pavement distress, and strengthen routine site supervision.

2.2 Literature Review and State of Knowledge

2.2.1 Studies on Prime Coat Materials

The direct literature on prime coat shows that prime-treated granular bases influence permeability, cohesion, penetration depth, and the stability of the pavement system. Mohan and Yildirim evaluated multiple prime coat materials, including MC-30, CSS-1H, and SS-1H, on granular base systems and reported that the engineering properties of the prime-coated base play an important role in pavement stability (Mohan & Yildirim, 2013). Texas Transportation Institute work likewise emphasized that prime coats seal surface pores, reduce moisture migration, strengthen the upper part of the granular base by binding finer particles, protect the base before surfacing, and promote adhesion between the granular base and the subsequent bituminous layer (Freeman et al., 2010).

In LGED rural road construction, prime coat is applied on the prepared granular base before placing bituminous carpeting. LGED’s Road Design Standards for Rural Roads specify that the prime coat material should be cutback bitumen conforming to ASTM/AASHTO requirements. The standard further states that cutback bitumen may be prepared by blending 60/70 or 80/100 penetration-grade straight-run bitumen with kerosene or diesel, generally at a ratio of 100 parts bitumen to 40–60 parts kerosene/diesel, depending on surface porosity and field trial results. The correct application quantity is described as the amount fully absorbed within 24 hours (Local Government Engineering Department [LGED], 2005). The same LGED standard recommends that prime coat be applied by a mechanical distributor or manually at about 1.20 L/m², with spraying temperature between 100°C and 120°C. It also requires surface cleaning before application, field trial approval where necessary, and a curing period of 48 hours or more before opening to traffic or placing the next bituminous layer (LGED, 2005).

Based on these requirements, cutback bitumen, particularly MC-30, may be considered the most common conventional prime coat material for LGED-type rural roads. MC-30 is a medium-curing cutback asphalt with low viscosity, suitable for penetrating granular or crushed-stone bases before bituminous surfacing. ASTM D2027 covers medium-curing cutback petroleum asphalts for pavement construction and treatment, which supports the use of MC-type cutback binders for such applications (ASTM International, 2024). A second material increasingly considered in pavement practice is SS-1h bitumen emulsion. SS-1h is an anionic slow-setting asphalt emulsion composed mainly of asphalt, water, emulsifier, and surfactants. ASTM D977 covers emulsified asphalt grades used in pavement construction, and product specifications state that SS-1h meets ASTM D977 and AASHTO M140 requirements (ASTM International, 2020; SealMaster, 2007). Although SS-1h is more commonly described as a tack/prime coat or adhesion promoter between bituminous layers, some emulsion suppliers also specify SS-1h for prime coat use, with typical application rates around 0.50–1.00 L/m² depending on surface condition. Therefore, in a prime-coat bonding-strength study for LGED roads, MC-30 should be treated as the conventional reference material, while SS-1h may be included as an alternative emulsion-based material for comparison, especially where lower-temperature application, safer handling, or reduced solvent use is desired (Raha Oil Company, n.d.; RG Incorporated, 2025; SealMaster, 2007).

2.2.2 Interlayer Bond Strength

Because the published literature on portable field devices for prime coat bond over WMM is still limited, the wider interlayer-bond literature for asphalt pavements is highly relevant. Wang et al. reviewed tack coat performance and concluded that interlayer bonding is jointly influenced by tack coat type, application rate, curing time, and application conditions including temperature, moisture, and surface texture (Wang et al., 2017). Yang and Li similarly showed that interlayer bond characterization is commonly approached through shear, pull-off, and torsion testing, and that bond performance is affected by tack coat properties, temperature, asphalt aging, and surface condition (Yang & Li, 2021).

Table 1 Quantity of Bitumen Emulsion as Primer for Various Surface Types (IRC: 16-2008)

Type of Surface	Rate of Spray (kg/m ²)
WMM/WBM	0.7 – 1.0
Mechanically stabilized soil base, lime/cement stabilized soil and lime cement base	0.9 – 1.2

Type of Surface	Rate of Spray (kg/m ²)
Gravel Base, Crusher Run Macadam and Crushed Rock base	1.2 – 1.5

Table 2 Type and Quantity of Cutback Bitumen Primer (IRC: 16-2008)

Type of Surface	Type of Cutback	Rate of Spray (kg/m ²)
WMM/WBM	MC 30	0.6 – 0.9
Mechanically stabilized soil base, lime stabilized soil, soil cement and lime cement base	MC 70	0.9 – 1.2
Gravel Base, Crusher Run Macadam and Crushed Rock base	MC 250	1.2 – 1.5

Pull-off testing measures the tensile adhesion between the primed base and the overlying layer. In pavement interlayer research, tensile and pull-off-based methods are commonly used to evaluate adhesion, and the broader literature recognizes pull-off testing as one of the principal approaches for interface-bond evaluation. (Yang & Li, 2021). Common tensile methods include the UTEP pull-off test, the Swiss pull-off test, and the Louisiana Tack Coat Quality Test. These methods are widely used in interlayer-bond studies, although not all of them were developed specifically for prime coats. (Mohammad et al., 2009; Yang & Li, 2021). For prime-coat-specific materials, one useful study is the MDPI paper on high-permeability emulsified asphalt for cement-stabilized macadam base. It reported pull-off strengths from 0.17 to 0.53 MPa depending on material type and spray rate. (Zhang et al., 2022). At the optimum rates, the reported pull-off strengths were 0.32 MPa for traditional emulsified asphalt at 1.1 L/m², 0.27 MPa for high-permeability emulsified asphalt at 1.3 L/m², and 0.53 MPa for modified high-permeability emulsified asphalt at 1.1 L/m². (Zhang et al., 2022). Another strong prime-coat result comes from the waste-oil cutback asphalt study on cement-stabilized macadam base. The article reported a pull-out strength of 0.235 MPa at an optimum application condition of 1.1 L/m², which was higher than the values for the conventional PC-2 emulsified asphalt and kerosene cutback asphalt used in that comparison. (Ren et al., 2023). A practical caution comes from the recent TxDOT prime-coat report.

Shear testing is the most common and more practically useful bond test for pavement interfaces because traffic-induced interlayer distress is dominated by sliding or slip shear. The broader interlayer-bond literature classifies common bond-strength tests into shear, pull-off, and torsion categories, and several shear-based devices are discussed in the literature. (Yang & Li, 2021; Kim & Mun, 2021). Common shear methods mentioned in the literature include Leutner, LISST, LTRC direct shear, Florida direct shear, ASTRA, and related interface shear devices. (Yang & Li, 2021). For prime-coat-specific shear results, an application rate of 1.5 kg/m² gave the best overall outcome, with cohesion increased to 43 kPa, in one of the studies. That is relatively low value compared with asphalt-over-asphalt tack-coat interfaces, but it is directly relevant because the

study dealt with prime coat on base material, not a dense asphalt-asphalt interface. (El-Gabry et al., 2025).


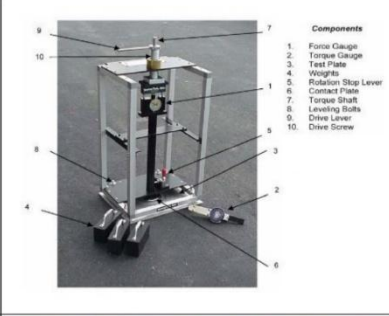


Device/method name	Figure	Loading principle	Use
UTEP Pull-Off Test / UTEP Pull-Off Device (UPOD)		<p>A metal plate/dolly is bonded to the tack-coated surface and pulled vertically until failure.</p>	<p>Measures tensile adhesion strength of tack coat between pavement layers.</p>
ATAcker / Tack Coat Evaluation Device (TCED)		<p>Uses a field device to evaluate tensile and torque-shear strength of tack coat materials.</p>	<p>Developed for field evaluation of tack coat materials such as SS-1, CSS-1, CRS-2, and PG binder.</p>
Portable pull-off adhesion tester		<p>A loading fixture is attached to the surface and pulled normal to the surface. The test is performed according to ASTM D 4541</p>	<p>General adhesion measurement method; concept can be adapted for pavement surface bonding.</p>
FDOT Shear Tester		<p>Horizontal shear load is applied along the interface between two asphalt layers.</p>	<p>Measures bond strength between existing HMA and new HMA overlay.</p>

Table 3 Existing Bond Strength Measuring Device

2.2.4 Factors Identified in the Literature

The literature consistently identifies several major factors that influence prime-coat performance, including surface cleanliness, base porosity, material type, application rate, penetration, curing time, and weather condition. In LGED rural road construction, the granular base surface must be properly cleaned before applying the prime coat, because dust, loose particles, and excess moisture can reduce penetration and bonding. Application rates are one of the most important factors. If the amount of prime coat is too low, it may not adequately bind the base surface or support proper adhesion with the bituminous carpeting layer. On the other hand, excessive prime coat may remain on the surface and create a weak or slippery interface, reducing bonding strength. Previous studies on low-volume roads also emphasize that prime coat should not exceed the amount that can be absorbed by the base, as excess binder can negatively affect pavement performance (Cross et al., 2005).

The literature also shows that penetration and curing are essential for effective bonding. Proper penetration helps stabilize the upper portion of the granular base, seal surface voids, and improve adhesion between the base and asphalt layer. However, curing time depends on material type, temperature, humidity, and field conditions. Cutback bitumen may require longer curing time than emulsion-based materials, while rainy or cold weather can delay curing and reduce bonding effectiveness. Although several laboratory methods are available to evaluate pavement layer bonding, such as shear, pull-off, and torque tests, many of these methods require costly equipment and controlled laboratory conditions.

2.2.4 Identified Research Gap

The literature shows that prime coat performance depends on material type, surface cleanliness, application rate, penetration, curing time, and base porosity. Existing guidelines explain how prime coats should be applied and cured, and LGED also provides practical requirements for material selection, application rate, surface preparation, and curing period. However, these guidelines mainly describe construction procedures and do not provide a simple field method to directly measure whether the prime coat has achieved sufficient bonding strength before bituminous carpeting is placed.

Most available bond-strength testing methods in pavement literature are developed for tack coat or asphalt-to-asphalt interlayer bonding. These methods commonly include shear, pull-off, and torsion tests, but many of them require laboratory equipment, field cores, skilled operators, or expensive testing arrangements (Tashman et al., 2021). Therefore, they are not always suitable for routine quality control in rural road projects, especially at LGED field sites where testing facilities and project budgets may be limited.

This creates a clear knowledge gap: there is limited research on a low-cost, portable, and easy-to-use device for checking prime-coat bonding strength directly in the field. For LGED rural roads, such a device would be useful to identify weak bonding caused by dust, poor penetration, insufficient curing, excessive binder, or improper application before the asphalt carpeting layer is placed. Therefore, this project focuses on developing a simple low-cost bonding-strength check device that can support field-level quality control and help reduce early pavement failures related to poor prime-coat performance.

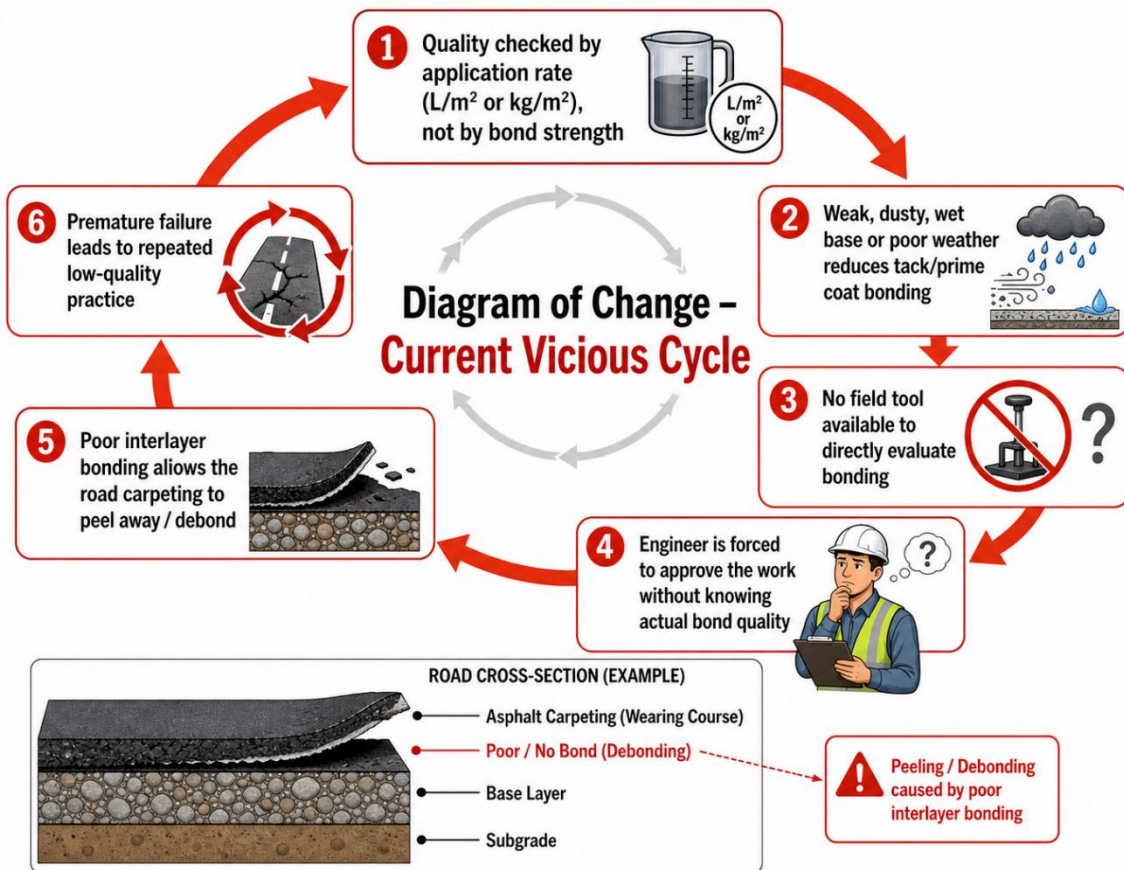


Figure 3 Technology Gap and Present Issues

3 APPROACH AND METHODOLOGY

3.1 Overall Approach

The Consultant will apply a stepwise development and validation pathway that balances engineering rigor with field practicality: concept development -> prototype fabrication -> calibration and controlled validation -> field validation on live projects -> benchmarking and decision rule development -> institutionalization through SOP, handbook and training. Throughout the assignment, a quality assurance plan will be maintained for device calibration, measurement uncertainty control, and data integrity (replicates, operator effects and environmental metadata).

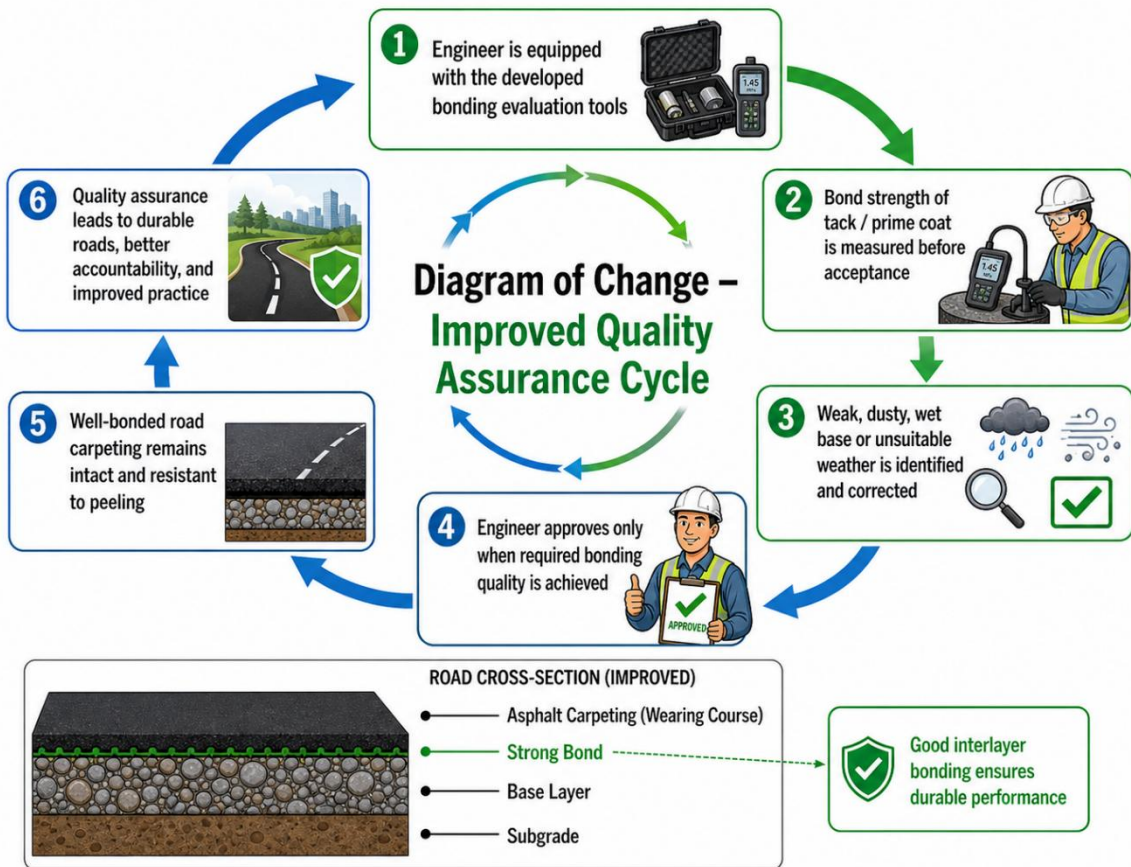


Figure 4 Diagram of Change: Broad Project Outcome

The methodology is intentionally designed to capture real-world variability. Rather than testing only ideal conditions, the test matrix will include typical site variability in base moisture and dust, material type and rate, and curing durations. This will allow LGED to identify which conditions consistently produce acceptable bond strength and which conditions present high risk of early failure.

3.2 Approach to Mobilization and Inception Activities

Within the first weeks of commencement, the Consultant will mobilize the core team, finalize a detailed implementation plan with LGED, and confirm pilot regions and candidate projects. An inception workshop will be organized to agree on selection criteria for sites, material types to be

included (e.g., MC-30 and SS-1h), data to be recorded from construction (application rate, curing time, base condition), and the validation strategy for the field devices. The Inception Report will present the finalized methodology, risk and safety plan, QA plan for calibration, and the proposed test matrix framework.

3.3 Technical Methodology: Device Development and Validation

The field device set will consist of two complementary testers to capture interface performance under different stress states; One will be finalized after evaluation. The device design will prioritize ruggedness, portability, fast setup, operator safety, and low-cost replication using locally available components. The proposed devices will be developed in line with the findings of the literature review, where pull-off/tensile and shear-based testing methods are commonly used to evaluate pavement layer bonding. Therefore, the device set will be designed to reflect these established testing principles while adapting them for practical field application in prime coat bonding strength evaluation on LGED rural roads. This approach will help ensure that the proposed low-cost device is technically relevant, field-friendly, and suitable for routine quality-control use before bituminous carpeting is placed.

Shear bond strength tester: A portable device that applies a controlled horizontal shear load to a standardized fixture seated on the primed WMM surface. The design will accommodate surface irregularity, control alignment to minimize eccentricity, and provide a direct readout of peak load. The method will report peak shear force, calculated shear bond strength (normalized by contact area), and observed failure mode. The detailed design, components, and testing arrangement of the device will be included in the Interim Report.

Pull-off (tensile) adhesion tester: A portable pull-off device using a standardized dolly/fixture bonded to the surface to apply a perpendicular tensile load. The procedure will define fixture preparation, bonding time, alignment control, loading rate, and failure mode logging. The method will report peak pull-off force and calculated tensile adhesion strength. The detailed design, components, and testing arrangement of the device will be included in the Interim Report.

A central challenge in developing an acceptable test regime arises from the viscoelastic nature of bitumen. Unlike materials such as concrete, where simple monotonic loading can provide reliable strength measurements, bitumen’s response is highly sensitive to loading rate, temperature, and the aspect ratio of the test specimen. As a result, the test protocol must carefully account for these variables to ensure meaningful and reproducible results. Establishing such a regime that balances laboratory rigor with field practicality is a complex and demanding task. Before extensive field deployment, both testers will be calibrated using known loads to verify accuracy and repeatability. Controlled validation will assess sensitivity within expected strength ranges, repeatability under the same operator, and reproducibility across operators. Where issues are found, fixture geometry, loading mechanisms, or procedural steps will be refined.

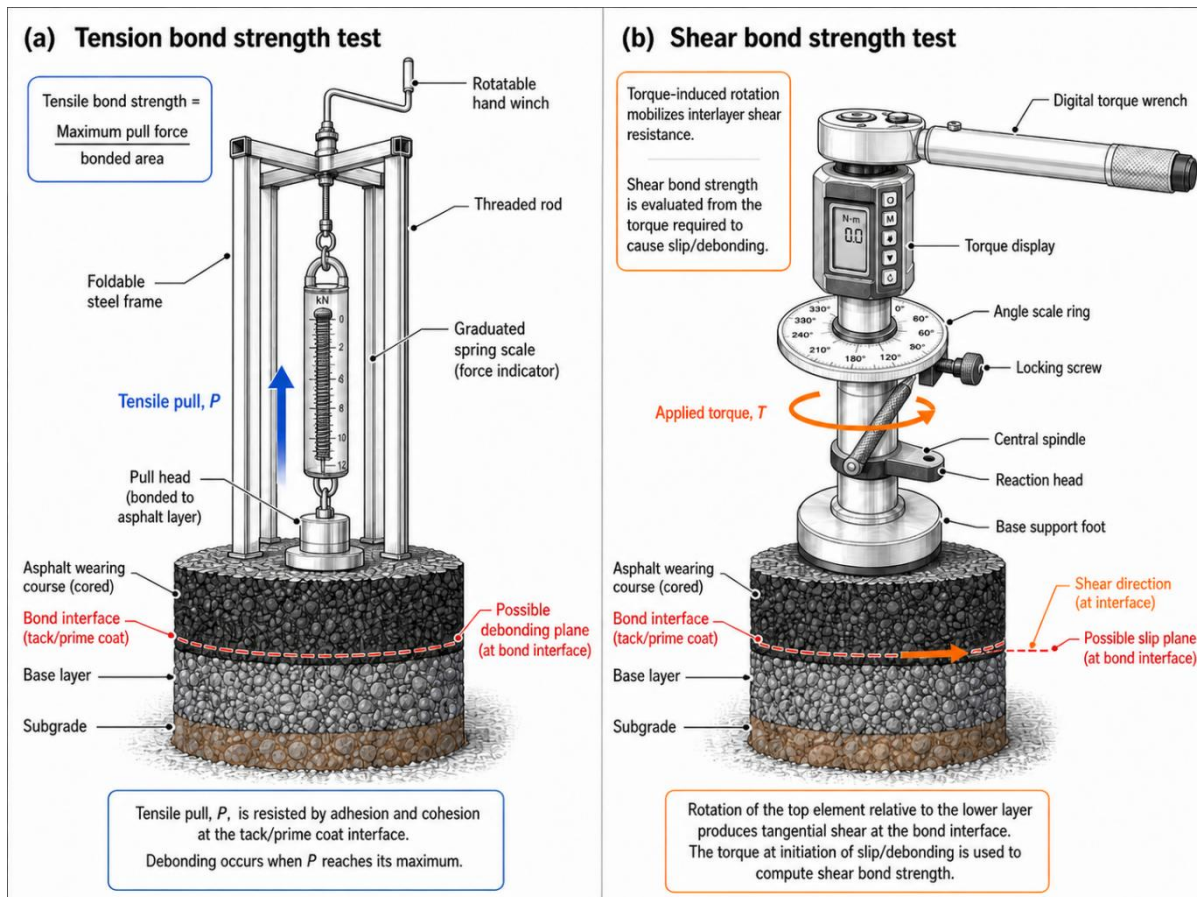


Figure 5 Planned Pull-Off (Tensile) Setup on Left and Shear Device on Right

3.4 Field Testing Strategy and Test Matrix

Field validation will be conducted on selected LGED road projects in at least two regions to capture representative variability in environmental and construction conditions. The final test sites will be selected in consultation with LGED during the inception stage. The proposed site categories will include: (i) a high-traffic rural/peri-urban road section, such as Gazipur or a similar area with frequent construction traffic and higher road-use intensity; and (ii) a moisture-prone or flood-affected road section, such as a haor, low-lying, or floodplain area where base moisture, dust, delayed curing, and water sensitivity may influence prime-coat bonding performance.

The test matrix will be finalized with LGED during inception and will cover variations in material type, application rate, curing time, base surface condition and ambient temperature window.

Key factors to be captured in the test matrix include:

- Prime coat material type (MC-30, SS-1h and other materials identified during inception).
- Ambient temperature, moisture, high/low traffic and time-of-day effects (morning/mid-day/evening), relevant for curing and emulsion break

At each test location, the Consultant will record a standard metadata set (site chainage, GPS, date/time, weather, base moisture rating or measurement where possible, prime coat type, observed/historical application condition, and construction traffic). Multiple replicate tests per condition will be carried out. Failure modes will be classified as adhesive (interface), cohesive (within binder/film) or substrate-related (WMM failure), because acceptance decisions and remedial actions differ by failure type.

3.5 Data Analysis, Benchmark Development and Acceptance Logic

The test results will be analyzed to determine minimum acceptable shear and tensile bond strength thresholds suitable for LGED rural road projects. Benchmark development will consider the strength distribution under good and poor bonding conditions, the influence of curing time, base moisture, material type, application rate, ambient temperature, and measurement uncertainty.

A parallel laboratory testing program will also be carried out for the full test matrix. The same material types, application rate bands, curing periods, base conditions, and moisture conditions considered in the field will be prepared and tested under controlled laboratory conditions. These laboratory results will be used as the reference benchmark. Field test results will then be compared with the laboratory benchmark to identify variations caused by actual site conditions, construction practice, weather, base surface irregularity, and field curing behavior. This comparison will help validate the reliability of the proposed field device and establish correction or interpretation factors where necessary.

The final SOP will translate the benchmark values into a clear acceptance and action framework. For example, it will define when to hold and retest due to insufficient curing, when to proceed because the measured strength meets the threshold with an acceptable failure mode, and when to rework or adjust because the strength remains consistently below the acceptable limit. This logic will be presented as a practical field decision flowchart and checklist for LGED engineers and site personnel.

3.6 SOP, Field Handbook and Institutionalization

A Standard Operating Procedure (SOP) and field handbook will be prepared, tested during pilot deployment, and finalized with LGED feedback. The SOP will include an equipment checklist, calibration verification steps, fixture preparation, test point selection, loading rate guidance, replicate requirements, data sheets, failure mode identification, acceptance thresholds, and troubleshooting. The field handbook will provide quick-reference visuals and reporting formats that can be attached to routine site supervision documents.

3.7 Capacity Building and Dissemination

The Consultant will organize an inception workshop, a mid-term progress review workshop, and a Training of Trainers (ToT) after submission of the Draft Final Report, as required by the ToR. On-site demonstrations will be integrated into field deployments. Upon completion, a National Dissemination Seminar will be held for approximately 100 participants. The Consultant will also prepare materials suitable for submission to national and international professional platforms and journals, subject to LGED approval and schedule feasibility.

This work represents a significant advancement in pavement engineering, and as such, we plan to publish research articles and present our findings at regional and/or international conferences. IUT researchers will join LGED personnel to participate as coauthors and plan joint attendance at these conferences to promote the developed technology, subject to budgetary

availability. This collaborative approach aims to highlight IUT's contributions and enhance LGED and Bangladesh's visibility within the global research community.

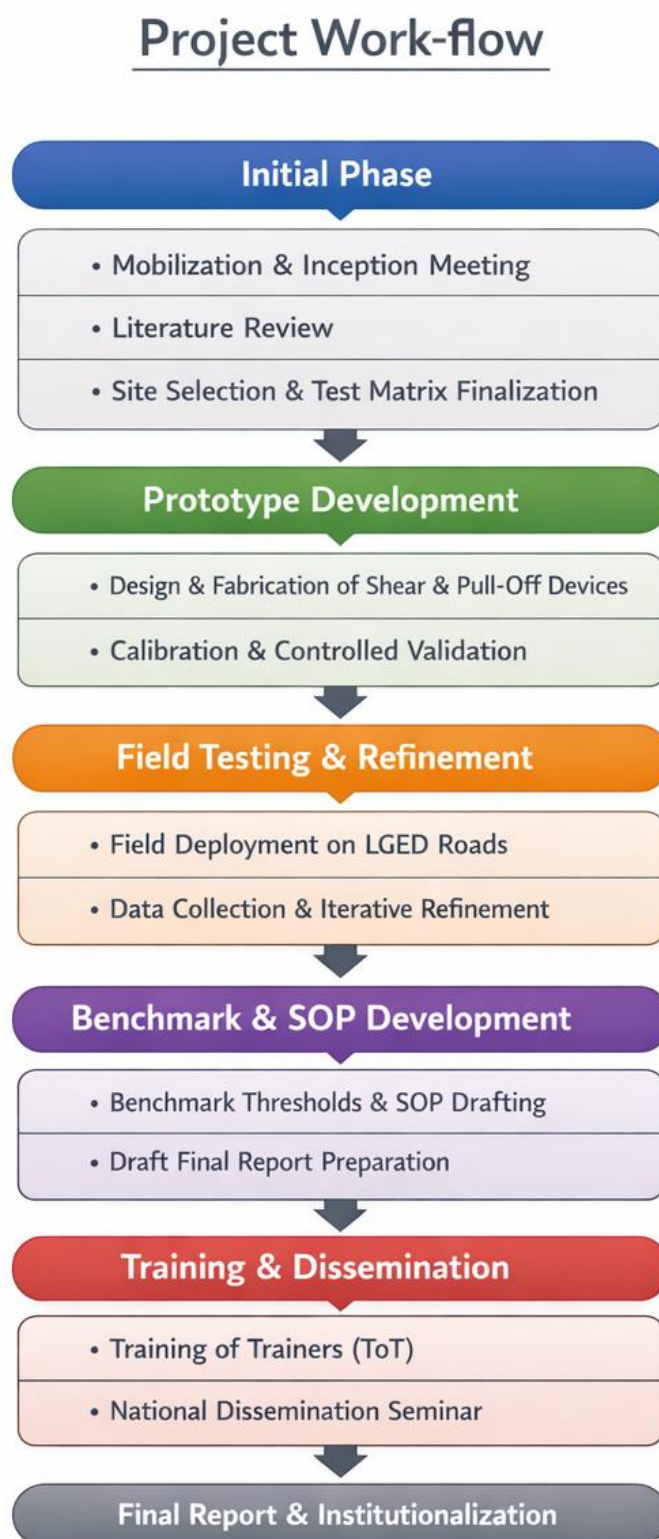


Figure 6 Project Workflow

4 TRAINING AND STAKEHOLDER ENGAGEMENT

The consultant shall organize meetings, trainings, and workshops as and when required to ensure the effective delivery and implementation of the research outputs.

The assignment has four workshops listed as below

- Inception Workshop (within Month 1-2)
- Process Review Workshop (mid-term, during field development, approx. Month 7–12)
- Training of Trainers (after submission of Draft Final Report, during months 13-18)
- National Dissemination Seminar (upon completion)

Upon submission of the draft final report, a Training of Trainers (ToT) program will be organized for about 25 participants at LGED Headquarters or at the consultants' premises. The ToT will aim to build institutional capacity for applying the developed methodologies and tools. The training session will primarily focus on the updated draft Standard Operating Procedure (SOP) and field handbook, reflecting the findings from the pilot implementation of the Prime Coat Bond Strength Device. The pilot results will serve as the key input for updating the SOP, testing procedures, and field documentation. The training will be a daylong session, divided into two parts: a theoretical session covering prime coat bonding, device operation, testing protocols, and interpretation of results, and a practical session involving device setup, calibration, field demonstrations, and data collection procedures.



Figure 7 Training Program Process Flow

At the end of the project (Month 18), a National Dissemination Seminar will be organized. This seminar will present the results, benchmark bond strength values, SOP, and field handbook to approximately 100 participants, including representatives from relevant ministries, agencies, LGED officials, contractors, researchers, professional organizations, and development partners to present and discuss the research findings and policy implications. The seminar will facilitate wider dissemination, awareness, and adoption of the developed methodology and device across relevant stakeholders.

5 WORK PLAN

The total duration of the consulting services is 18 months. In line with the ToR, the first 12 months focus on device development and field validation culminating in the Draft Final Report, followed by consolidation, capacity building, dissemination and post-completion support during the remaining period.

Table 4 Indicative Schedule

Activity / Milestone	Month 1-2	Month 3-6	Month 7-12	Month 13-18
Mobilization, inception meeting, literature review, site selection and test matrix finalization	X			
Prototype design and fabrication (shear and pull-off) plus calibration and controlled validation		X		
Field deployment on LGED roads in at least two regions and iterative refinement			X	
Benchmark development, SOP/handbook drafting and Draft Final Report preparation (end of Month 12)			X	
Training of Trainers, institutionalization support and consolidation into Final Report (end of Month 17)				X
National dissemination seminar and broader dissemination support (Month 18)				X

Reporting will follow the ToR requirements and schedules. Following table summarizes the key report deliverables.

Table 5 Key report deliverables

Deliverable/ No of Reports	Main content	Submission timing	Notes
Inception Report (5)	Detailed methodology, literature review summary, test matrix and pilot plan, QA/calibration plan, risks and mitigation	End of Month 2nd	Includes inception workshop outcomes
Interim Report (5)	Prototype device development, calibration results, controlled trial outputs and refinements for field deployment	End of Month 4 th	Supports technical review
Test Report (5)	Field testing results from LGED projects (at least two regions), metadata, failure mode analysis and preliminary thresholds	End of Month 11 th	Basis for benchmarks
Draft Final Report (10)	Finalized test method, device details, benchmark thresholds, SOP and handbook (draft) and training plan	End of Month 12th	Triggers ToT preparation
Final Report (3)	Consolidation of all reports, finalized SOP/handbook, training outcomes, dissemination materials and implementation guidance	End of Month 17th	Incorporates stakeholder feedback

5.3 Working Schedule

Table 6 Working Schedule

TASK & Subtasks	Month																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Task 1: Mobilization, inception meeting, literature review, site selection and test matrix finalization	√	√																
Task 2: Prototype design and fabrication (shear and pull-off) plus calibration and controlled validation			√	√	√	√												
Task 3: Field deployment on LGED roads in at least two regions and iterative refinement							√	√	√	√	√	√						
Task 4: Benchmark development, SOP/handbook drafting and Draft Final Report preparation (end of Month 12)										√	√	√						
Task 5: Training of Trainers, institutionalization support and consolidation into Final Report (end of Month 17)													√	√	√	√	√	
Task 6: National dissemination seminar and broader dissemination support (Month 18)																		√
Deliverables (Report Submissions)																		
D1: Inception Report	R																	
D2: Interim Report				R														
D3: Test Report											R							
D4: Draft Final Report												R						
D5: Final Report																	R	
Workshops / Key Events																		
Inception / Kick-off Workshop		W																
Progress Review Workshop							W											
Training of Trainers (ToT) + Field Demonstrations													W					
Final Dissemination Seminar																		W

6 CONCLUSIONS

6.1 Work Done

In the context of the Development and Validation of a Low-Cost Field Device for Prime Coat Bond Strength Evaluation in Pavement under LGED, the Inception Report has been completed. This report outlines the project's methodology, schedule, and deliverables, providing a clear foundation for the subsequent phases of the project.

6.2 Work to be Done

The project will proceed with several key activities and deliverables. The first phase will involve mobilization, an inception meeting, conducting a literature review and finalizing the site selection and test matrix. Once these are completed, the prototype design (shear and pull-off devices) will be fabricated, followed by calibration and controlled validation. The field deployment on LGED roads in at least two regions will take place in the next phase, with iterative refinement based on field feedback.

By the end of Month 12, benchmark development, SOP/handbook drafting, and the Draft Final Report will be prepared. This will be followed by training of trainers and finalization of the report, with all deliverables consolidated by Month 17. The final stage of the project will include a national dissemination seminar to share the results of the work.

Reporting and deliverables will follow the schedule outlined in the ToR, with key reports submitted throughout the project, including the Inception Report, Interim Report, Test Report, Draft Final Report, and Final Report. These reports will provide updates on the development, field deployment, and results, leading to the completion of the final deliverables and training materials. Workshops will be organized, including the Inception workshop to confirm study design, a Progress Review Workshop to assess prototype performance and refine testing procedures, and a Training of Trainers session to ensure the institutionalization of the new methods for LGED engineers and contractors.

7 REFERENCES

- Mohan, G., & Yildirim, Y. (2013). Engineering properties of prime coats applied to a granular base. *Journal of Testing and Evaluation*, 41(5), 713-718. <https://doi.org/10.1520/JTE20120292>
- El-Gabry, M. A., Soliman, A. A., Morsy, M. S., Mahdy, K., & Soltan, A. (2025). Optimizing prime coat application rates: Integrating penetration, permeability, and shear strength. *Innovative Infrastructure Solutions*, 10, 353. <https://doi.org/10.1007/s41062-025-02146-z>
- Wang, J., Xiao, F., Chen, Z., Li, X., & Amirhanian, S. (2017). Application of tack coat in pavement engineering. *Construction and Building Materials*, 152, 856-871. <https://doi.org/10.1016/j.conbuildmat.2017.07.056>.
- Yang, K., & Li, R. (2021). Characterization of bonding property in asphalt pavement interlayer: A review. *Journal of Traffic and Transportation Engineering (English Edition)*, 8(3), 374-387. <https://doi.org/10.1016/j.jtte.2020.10.005>.
- Kim, D., & Mun, S. (2021). Development of an interface shear strength tester and a model predicting the optimal application rate of tack coat. *Construction Materials*, 1(1), 22-38. <https://doi.org/10.3390/constrmater1010002>
- Sudarsanan, N., Fonte, B. R., & Kim, Y. R. (2020). Application of time-temperature superposition principle to pull-off tensile strength of asphalt tack coats. *Construction and Building Materials*, 262, 120798. <https://doi.org/10.1016/j.conbuildmat.2020.120798>
- Freeman, T. J., Button, J. W., & Estakhri, C. K. (2010). Effective prime coats for compacted pavement bases (Report No. FHWA/TX-10/0-5635-1). Texas Transportation Institute / Texas Department of Transportation.
- El-Gabry, M. A., Soliman, A. A., Morsy, M. S., Mahdy, K., & Soltan, A. (2025). Optimizing prime coat application rates: Integrating penetration, permeability, and shear strength. *Innovative Infrastructure Solutions*, 10, 353. <https://doi.org/10.1007/s41062-025-02146-z>
- Ali, M. H., Khalil, A. H., & Wang, Y. (2023). Experimental study of the effect of tack coats on interlayer bond strength of pavement. *Sustainability*, 15(8), 6600. <https://doi.org/10.3390/su15086600>
- Texas Department of Transportation. (n.d.). Prime coat - flexible pavements. Texas Department of Transportation Pavement Design Manual.
- United Nations. (n.d.-a). Goal 9: Industry, innovation and infrastructure. United Nations Sustainable Development Goals.
- United Nations. (n.d.-b). Goal 12: Responsible consumption and production. United Nations Sustainable Development Goals.
- United Nations. (n.d.-c). Goal 13: Climate action. United Nations Sustainable Development Goals.
- United Nations. (n.d.-d). Goal 3: Good health and well-being. United Nations Sustainable Development Goals.
- United Nations. (n.d.-e). Goal 8: Decent work and economic growth. United Nations Sustainable Development Goals.
- United Nations. (n.d.-f). Goal 11: Sustainable cities and communities. United Nations Sustainable Development Goals.
- Goehl, D., Sebesta, S., Bierman, C., Liu, K.-W., & Hsu, J.-L. (2025). Best practices for the use of prime in Texas pavement structures (Report No. 0-7103-R1). Texas A&M Transportation Institute. https://rosap.nsl.bts.gov/view/dot/80595/dot_80595_DS1.pdf
- Kim, D., & Mun, S. (2021). Development of an interface shear strength tester and a model predicting the optimal application rate of tack coat. *Construction Materials*, 1(1), 22-38. <https://doi.org/10.3390/constrmater1010002>

- Wang, J., Xiao, F., Chen, Z., Li, X., & Amirkhanian, S. (2017). Application of tack coat in pavement engineering. *Construction and Building Materials*, 152, 856-871. <https://doi.org/10.1016/j.conbuildmat.2017.07.056>
- Yang, K., & Li, R. (2021). Characterization of bonding property in asphalt pavement interlayer: A review. *Journal of Traffic and Transportation Engineering (English Edition)*, 8(3), 374-387. <https://doi.org/10.1016/j.jtte.2020.10.005>
- Zhang, X., Xu, J., Cai, Y., & Tang, Y. (2022). Properties and preparation of a new high-permeability emulsified asphalt and its modification. *Applied Sciences*, 12(24), 12730. <https://doi.org/10.3390/app122412730>
- ASTM International. (2024). *D2027/D2027M-19(2024): Standard specification for cutback asphalt (medium-curing type)*. ASTM International.
- ASTM International. (2020). *D977-20: Standard specification for emulsified asphalt*. ASTM International. doi:10.1520/D0977-20.
- Local Government Engineering Department. (2005). *Road design standards: Rural roads*. Local Government Engineering Department.
- Raha Oil. (n.d.). *Bitumen emulsion SS-1h*. Raha Oil Company.
- SealMaster. (2007). *Technical data sheet: SS-1H asphalt binder*. SealMaster.
- SealMaster Hawaii. (n.d.). *SS-1H asphalt binder*. SealMaster Hawaii.
- ASTM International. (2022). *ASTM D4541-22: Standard test method for pull-off strength of coatings using portable adhesion testers*. ASTM International.
- Buchanan, M. S., & Woods, M. E. (2004). *Field tack coat evaluator (ATACKer)* (FHWA/MS-DOT-RD-04-168). Mississippi Department of Transportation.
- Tashman, L., Nam, K., & Papagiannakis, A. T. (2006). *Evaluation of the influence of tack coat construction factors on the bond strength between pavement layers* (WA-RD 645.1). Washington State Department of Transportation.
- UTEP ScholarWorks. (n.d.). *Test set-up to determine quality of tack coat*. University of Texas at El Paso.