# Study on Prefabricated Geosynthetic-Reinforced Asphalt Slabs for Emergency Road Repairs

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**Abstract**
*The application of geosynthetic-reinforced asphalt in pavement engineering has gained attention for its potential to improve durability, reduce material usage, and enhance resistance to pavement distresses such as fatigue cracking and rutting. This study explores the feasibility of using prefabricated geosynthetic-reinforced asphalt (PGRA) slabs as a solution for pothole repairs. Eight slabs were fabricated in a laboratory using a bituminous concrete mix of Grade 1 and installed to repair a pothole. Four months after installation, the performance of the repaired section was evaluated through visual inspections and light weight deflectometer (LWD) tests to assess structural response. The findings provide insights into the practicality and effectiveness of PGRA slabs for localized pavement repairs, contributing to the ongoing development of durable and efficient maintenance techniques.*

**Key words:**
*Pothole repair, Prefabricated geosynthetic-reinforced asphalt (PGRA), Light weight deflectometer (LWD)*

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## 1.0 Introduction

Geosynthetic-reinforced asphalt is being studied as a potential advancement in pavement engineering, with the aim of enhancing road performance and durability. By incorporating geosynthetics into asphalt layers, it is expected that these materials may improve structural stability and resistance to common pavement distresses such as fatigue cracking and rutting. Additionally, this approach could optimize material usage, potentially reducing the thickness of pavement layers.

Several researchers have explored the potential of geosynthetics in asphalt applications. Studies have demonstrated improvements in the fatigue life of asphalt layers reinforced with geosynthetics [1, 2, 3 4] and enhanced rutting resistance based on field trials [5]. The importance of selecting appropriate geosynthetic materials for maximizing performance has also been highlighted [6].Prefabricated slabs can dramatically reduce construction time compared to conventional cast-in-place methods. Panels are manufactured in controlled environments and are ready to be installed, minimizing delays due to curing time. In some cases, roads can be reopened to traffic within hours of installation.Since slabs are produced in a controlled setting, they have consistent material properties and reduced risks of defects.The enhanced durability and precision manufacturing of prefabricated slabs lead to longer service life and lower overall maintenance costs. They also resist cracking and deformation better than traditional pavements [7]. These studies provide a foundation for exploring geosynthetic-reinforced asphalt in localized repairs, such as pothole remediation, where durable and efficient solutions are crucial.

Prefabricated geosynthetic-reinforced asphalt (PGRA) slabs were fabricated in the laboratory using bituminous concrete of Grade 1. Eight such slabs were installed to repair a pothole, providing an opportunity to evaluate their performance under real-world conditions. The evaluation was conducted four months after installation using visual inspections to assess surface conditions and a light weight deflectometer (LWD) to measure the structural response of the repaired section.

## 2. Materials and Methodology

### *2.1. Material Selection*

#### *2.1.1. Geosynthetic Reinforcement*

In this study, uniaxial geogrid is used, which is supplied from the local manufacturer and physical properties of the geogrid are shown in Table 1.

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*Table 1. Physical properties of the geogrid*

| Property | Value | Standard |
|---|---|---|
| Ultimate Strength (MD) | 250 kN/m | ASTM D6637 method B |
| Tensile strength at 5 % strain | 155.2 kN/m | ASTM D6637 method B |
| Creep reduction factor | 1.55 | ASTM D6692 |
| Reduction Factor ($RF_{ID}$) | 1.15 | ASTM D5818 |

*2.1.2. Tack coat*

Tack coat plays a critical role in ensuring proper bonding between layers in pavement construction and maintenance [8,9]. In this study, two types of emulsions were used for specific interfaces, considering their properties and compatibility with the materials involved:

- **Slow-Setting (SS) Emulsion**

The SS emulsion was applied between the prefabricated geosynthetic-reinforced asphalt (PGRA) slab and the underlying pavement layer. This choice was made due to its ability to penetrate and adhere effectively to the existing surface, particularly in cases where the base layer was slightly porous or uneven. The slower curing time allowed for thorough absorption into the lower surface, creating a strong and durable bond.

- **Rapid-Setting (RS) Emulsion**

The RS emulsion was used between the two layers of the asphalt slab during the fabrication of the PGRA. This emulsion was chosen for its quick curing properties, which facilitated a strong and immediate bond between the layers of asphalt. This ensured that the slab maintained its structural integrity and performed as a cohesive unit during installation and under load conditions.

*2.1.3. Asphalt Mix*

The bituminous concrete (BC) Grade 1 mix used for this study was designed as per the Marshall method of mix design. The mix design followed the specifications outlined in the Ministry of Road Transport and Highways (MoRTH) 5th revision guidelines.Natural granite from the road construction company from hot bin batches and VG 40 bitumen are used for the mix design [10, 11]. The properties of aggregates and bitumen used are given in the table2 and table 3 respectively.

Aggregates were blended in proportions (20 mm: 36%, 12 mm: 21%, 10 mm: 18%, stone dust: 25%) to achieve the desired gradation for BC-1. Five binder contents (3.5%, 4.0%, 4.5%, 5.0%, and 5.5%) were evaluated for volumetric and strength properties.The OBC was obtained as 4.2 % by the weight of the mixture and the mix properties are shown in table 4.

*Table 2. Properties of VG 40 Bitumen*

| Property | Value | Test Method |
|---|---|---|
| Softening point (R &B) (°C) | 53 | IS 1205 |
| Absolute Viscosity @ 60 °C poise | 4145 | IS 1206 Part 1 |
| Penetration at 25 °C, 100g, 5s | 52.1 | IS 1203 |
| Flash Point COC, °C | 232 | IS 1209 |
| Kinematic Viscosity @135°C, cSt | 475 | IS 1206 Part 3 |
| Solubility in Trichloroethylene, % | 99.3 | IS 1216 |
| Tests on residue<br>· Ductility @ 25 °C<br>· Viscosity @ 60 °C, Poises | <br>58<br>3.16 | <br>IS1208<br>IS 1206 Part 2 |

*Table 3. Physical Properties of aggregate*

| Property | Value | Test Method |
|---|---|---|
| Grain size analysis (cleanliness)%<br>· 20 mm<br>· 12 mm | <br>0.67<br>1.14 | IS 2386 Part 1 |
| Combined Flakiness and Elongation Indices (%) | 31 | IS 2386 Part 1 |
| Los Angeles Abrasion (%) | 13.34 | IS 2386 Part 4 |
| Aggregate Impact value (%) | 10.73 | IS 2386 Part 4 |
| Stripping value (%) | 100 | IS:6241 |
| Specific Gravity<br>· 20 mm<br>· 12 mm<br>· 10 mm below<br>· Filler | <br>2.945<br>2.986<br>2.918<br>2.908 | IS 2386 Part 3 |

*Table 4. Properties of the bituminous concrete Grade-1*

| Property | Value | Test Method |
|---|---|---|
| Bulk specific gravity ($G_{mb}$) | 2.667 | ASTM D2726 |
| Maximum theoretical specific gravity ($G_{mm}$) | 2.770 | ASTM D2041 |
| Air Voids (Va) | 3.69 % | - |
| Optimum Bitumen content (OBC) | 4.2 % | - |
| VMA | 13.05% | - |
| VFA | 71.75 % | - |
| Marshall Stability (MS) | 16.86 kN | ASTM D6927 |
| Flow Value (FV) | 3.78 | ASTM D6927 |
| TSR | 81.22 % | AASHTO T283 |

### 2.2. Fabrication Process

Using the established BC Grade 1 mix design, eight prefabricated geosynthetic-reinforced asphalt (PGRA) slabs were fabricated.The PGRA slab was cast in two distinct layers to reinforce geogrid in between the layers. Aggregates were first heated to the mixing temperature of 155–165°C, and the VG-40 binder was added at the determined optimum binder content (OBC). This mix was then compacted using a slab compactor. After the initial layer was compacted and allowed to cool slightly, a rapid-setting tack coat was applied evenly over its surface to facilitate a strong adhesive bond. Following this, a geogrid was carefully placed on the tack-coated surface to serve as reinforcement. The second asphalt layer was then laid over the geogridensuring proper encapsulation and bonding between the layers. Figure 1 illustrates the process of slab casting using the slab compactor.

*Figure 1:Casting slab using the slab compactor*

### *2.3. Site Preparation and Installation*

The pothole and surrounding damaged area were cut to create a clean and stable repair site. This step ensures the edges are well-defined for proper slab placement.The exposed area was compacted to provide a stable foundation for the PGRA slabs.A bonding tack coat slow setting emulsion was applied to the compacted base to enhance adhesion between the base and the prefabricated slab.The PGRA slabs were installed and compacted into place to create a smooth, seamless surface. The site preparation and installation process are shown in Figure2

*a)Compacting the exposed layer after cutting the distressed area*

*b) Applying tack coat*

*c)Installing the PGRA slabs*

*Figure 2: Site preparation and installation*

### *2.4. Performance Evaluation*

The performance of the prefabricated geosynthetic-reinforced asphalt (PGRA) slabs was evaluated through a combination of visual inspections and light weight deflectometer testing. Visual inspections were conducted to assess surface conditions, including the presence of cracks, deformation, or other signs of distress. These inspections were carried out immediately after installation and again after four months to monitor changes over time. Additionally, a lightweight deflectometer was used to measure the dynamic modulus.The dynamic modulus is a critical parameter that reflects the stiffness and structural capacity of pavement materials under load. Dynamic modulus tests were conducted on the distressed pavement sections at three critical stages: prior to the installation of the PGRA slabs, immediately after their installation, and four months post-installation. These tests provided a comprehensive assessment of the pavement's structural behaviour and stiffness over time, offering valuable insights into the effectiveness and durability of the PGRA slabs under real-world conditions.

### 3. Results and Discussions

Visual inspections were conducted to evaluate the performance of the repaired pavement over a four-month period. These inspections focused on identifying any signs of distress, such as cracks, deformations, or other surface irregularities. Remarkably, no visible issues were observed throughout the monitoring period.Figure 3 illustrates the pavement condition at three critical stages: before the repair, immediately after the installation of the PGRA slabs, and four months post-repair..

*a)Before the repair*

*b)Immediately after the installation*

*Figure 3: Pavement condition at three stages*

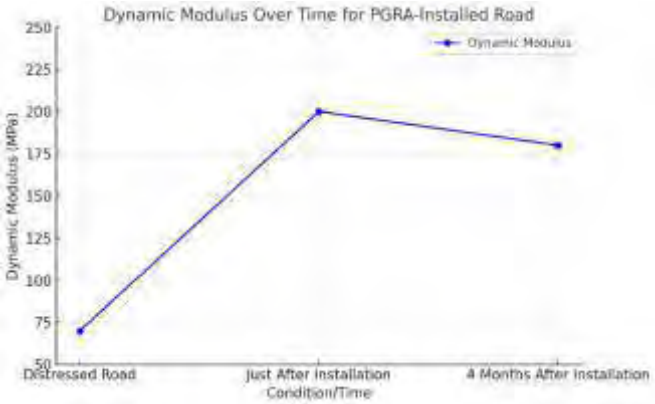


*Figure 4: Dynamic modulus of the road under different conditions*

Light weight deflectometer is used to measure the dynamic modulus atdifferent points and the average values obtained are presented in the Figure 4. For the distressed road, the average modulus was low (70 MPa). Immediately after the installation of PGRA slabs, the modulus improved significantly to an average of 200 MPa, reflecting the enhanced stiffness and load-bearing capacity. Four months after installation, the modulus showed a slight decrease to an average of 180 MPa but remained considerably higher than the initial condition.

The results indicate a substantial improvement in the structural capacity of the pavement following the installation of PGRA slabs. The initial low modulus (70 MPa) confirmed the presence of significant structural deficiencies in the distressed road section. The immediate post-repair improvement to 200 MPa reflects the effectiveness of the PGRA slabs in restoring pavement stiffness and enhancing load-bearing capacity.The slight decrease in the modulus after four months (to 180 MPa) is likely due to the natural settlement of the slabs and minor adjustments in the pavement structure under traffic loading. However, the values remaining significantly above the pre-repair condition demonstrate the durability and long-term stability of the repair method. The absence of visible surface distress further reinforces the efficacy of the repair technique, suggesting it provides both structural and surface integrity.

### 4.Conclusions

The implementation of PGRA slabs has proven to be an effective method for rehabilitating distressed pavements, as demonstrated by significant improvements in the dynamic modulus and the absence of visible surface distress over a four-month monitoring period. Although a slight decrease in modulus was observed, the repaired pavement maintained a much higher structural capacity than its initial condition. These findings affirm the suitability of this repair approach for extending the service life of pavements.

Further studies are recommended to assess the long-term performance of PGRA slabs under diverse conditions, paving the way for broader adoption and optimization of this technique in pavement rehabilitation practices.

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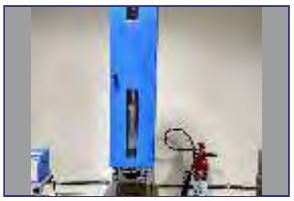
## Installation Damage of Geosynthetics

The geosynthetics are prone to some amount of damage during their installation. To assess the quantity of the installation damage, a standard method was initially developed by Watts and Brady of the Transport Research Laboratory in the United Kingdom. The procedure has also discussed in the ASTM D 5818 with similar requirements. We are at BTRA doing the test following same ASTM D 5818 method followed by respective tensile strength. For the time being we are using the construction site for the sample preparation. If customer will agree, BTRA will collect the sample from site after standard procedure and provide the report.



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