ISSN: 2581-4311
DOI: doi.org/10.30967/IJCRSET/Onur-Irgat/209

URF PUBLISHERS
connect with research world

International Journal of Current Research in Science, Engineering & Technology

https://urfpublishers.com/journal/ijcrset

Vol: 8 & **Iss:** 4

Research Article

Investigation of the Use of Emulsion and Epoxy as an Interlayer in Composite Pavements

Onur Irgat* **and Salih Bektaş**

Aksaray University, Engineering Faculty, Civil Engineering Department, Aksaray, Turkey

Citation: Irgat O, Bektas S. Investigation of the Use of Emulsion and Epoxy as an Interlayer in Composite Pavements. *Int J Cur Res Sci Eng Tech* 2025; 8(4), 498-502. DOI: doi.org/10.30967/IJCRSET/Onur-Irgat/209

Received: 26 December, 2025; **Accepted:** 31 December, 2025; **Published:** 01 January, 2026

*__Corresponding author:__ Onur Irgat, Aksaray University, Engineering Faculty, Civil Engineering Department, Aksaray, Turkey

A B S T R A C T

A composite pavement is a pavement system in which a hot-mix asphalt concrete layer is placed over a rigid (concrete) base layer and it is widely used in road construction and rehabilitation applications. The concrete layer provides high structural load-bearing capacity, while the asphalt layer ensures the required functional performance. The interfacial bonding between the concrete and asphalt layers plays a critical role in the overall performance of composite pavements. Due to the significant difference in elastic moduli, deformation compatibility between the concrete and asphalt layers is limited; therefore, the interlayer bond is more susceptible to shear damage under the combined effects of traffic loading and environmental conditions. Inadequate interlayer bonding results in increased stresses and deflections within the composite pavement structure, leading to premature surface distresses. These distresses are particularly pronounced at intersections as a result of braking and acceleration forces. Consequently, ensuring a strong bond between the concrete and asphalt layers is essential for achieving satisfactory performance in composite asphalt pavements.

In this study, an inclined rigid laboratory test setup was developed to simulate both static and dynamic vehicle loads. The objective was to evaluate the stresses induced by braking loads as vehicles approach intersections and to investigate the mechanical behaviour of composite pavement layers. Furthermore, the performance of different interlayer types was compared with each other and with findings reported in previous studies in order to identify the most effective interlayer configuration. Composite test specimens were prepared using C25-grade cylindrical concrete samples with no interlayer and with a smooth interlayer, as well as specimens incorporating an MC-30 emulsion with a roughened interface and an epoxy interlayer. The results indicated that the highest bond strength and overall performance were achieved on surfaces treated with emulsion-coated rough aggregates and epoxy-applied interfaces.

Keywords: Composite Pavement; Emulsion; Epoxy; Interlayer; Tack Coat

Introduction

Road pavements are generally constructed in three forms: rigid, flexible and composite. Pavements constructed with cement concrete are termed "rigid pavements"[1]. Rigid pavements typically consist of a concrete slab constructed over a base layer. Flexible pavements are multilayered structures. They consist of sub-layers made of granular material with high drainage capability and upper layers made of bituminous mixtures that offer high stability and comfortable driving conditions. Flexible pavements consist of sub-base, base and surface course layers[2].

Composite pavement, also referred to as flexible-rigid superstructure, is a pavement type consisting of two main structural layers (a flexible asphalt surface and a rigid base, typically composed of cement concrete, roller-compacted concrete (RCC), continuously reinforced concrete pavement[3,4]. The performance of the pavement structure is of great importance in highways with a high percentage of heavy vehicles, heavy-duty areas such as ports and container terminals, cargo distribution centers and organized industrial zones. In such cases, the performance of traditional flexible pavements is often insufficient. Therefore, composite pavement designs come to the forefront. However, in composite pavements, the performance of the interlayers significantly affects the quality of service. This is because, during braking, a horizontal load approximately equal to half of the vertical load acts on the pavement layer alongside the vertical load[5].

In the experimental studies to be conducted; a design mode that ensures the composite layers work together (composite action) will be determined by testing different materials and additives for these interlayers, which affect the performance of composite pavements. The mechanical properties and performance of flexible, rigid and intermediate layers will be tested together using the prepared inclined test setup.

It is widely accepted that typical pavement distresses such as bottom-up fatigue cracking and rutting can be effectively eliminated in composite pavements. However, it has been argued that reflective cracking, top-down cracking and delamination can occur. Furthermore, the large modulus difference between the asphalt surface and the concrete base may cause high shear stresses, leading to pavement damage and reduced service life[6,7].

Studies have been conducted to improve the interlayer between the asphalt cement flexible surface and the rigid base[8,9]. However, few studies focusing on the performance of the asphalt layer have been reported. Due to the high modulus and elasticity of the underlying rigid base, the mechanical responses of the asphalt layer differ significantly from those of a flexible pavement and require careful examination.

Traffic loads transmitted to the pavement by moving vehicles are complex: one is the vertical load due to gravity and the other is the horizontal load due to the relative motion between the wheel and the pavement surface[10,11]. The horizontal load is influenced by various conditions such as temperature, load level, emergency braking, acceleration and deceleration and pavement alignment. Numerous studies have reported that horizontal load is a significant factor affecting the service level and fatigue life of the pavement structure[12,13].

Although horizontal load can be numerically modelled or simulated in full-scale pavement facilities, it remains difficult to simulate real traffic loads characterizing both vertical and horizontal loads in a laboratory setting. The planned study aims to extend the service life of the pavement. An inclined loading test device was developed to simulate the compressive shear strength of the asphalt pavement under moving traffic loads in a laboratory environment. With this test method, the mechanical properties of the pavement under both horizontal and vertical loads have been examined. Different designs for interlayers and the performance of these designs will be investigated in the laboratory. The study aims to enhance the performance of composite highway pavement designs. Additionally, the experimental setup will provide a more realistic simulation of loads originating from highway vehicular traffic.

Methodology

C25 class concrete was used as the sub-base in the composite pavement. The properties of the concrete class are shown in **(Table 1)**. Ready-mix concrete was procured from the plant and poured into 10 cm diameter plastic pipes as seen in **(Figure 1)**. The concrete was allowed to cure for the full 28-day period and was then removed from the molds. Since an asphalt layer would be applied on top after removal from the Molds, iron Molds of 10 cm diameter were also fabricated **(Figure 2)**.

Figure 1: Pouring concrete into Molds.

Figure 2: Iron Molds and concrete specimens.

Figure 3: Aggregate samples.

The aggregate sizes to be used in the experiment were determined as 0-5 mm, 5-12 mm and 12-19 mm. As seen in **(Figures 3 and 4)**, a sieve analysis test was applied to the aggregates and a gradation curve was plotted.

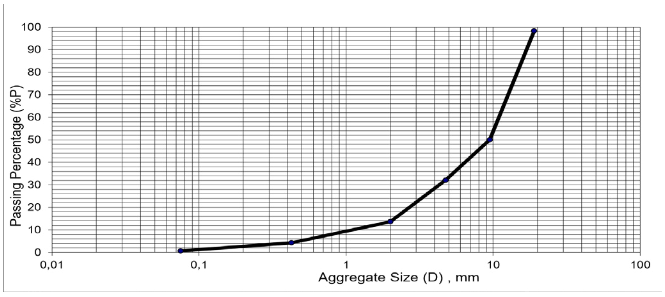

Figure 4: Gradation curve.

After the sieve analysis, the mixture ratios of the samples were determined using the arithmetic method and compliance was verified according to the specifications. The sample weight was determined as 750 g and it was decided to use 0.65 (65%) of 0-5 mm aggregate, 0.20 (20%) of 5-12 mm aggregate and 0.15 (15%) of 12-19 mm aggregate. The bitumen content was taken as 5.5% of the mixture. Aggregates and bituminous materials were heated in an oven at 160°C. As seen in **(Figures 5 and 6)**, the heated mixture was weighed on a scale and reheated to 160°C in a pan. It was poured into molds and compacted by applying 75 blows with a Marshall hammer (compactor). This is shown in **(Figures 7 and 8)**.

Figures 5 and 6: Weighing and heating of aggregate and bitumen materials.

Figure 7: Compaction with Marshall hammer.

Figure 8: Loading the inclined device.

According to studies, it has been determined that when a vehicle brakes or accelerates, the horizontal force is 50% of the vertical load. In this sense, when the horizontal force is 50% of the vertical load ($f_h = 0.5f_v$), the inclination angle α = arctan (0.5) ≈ 26.6° corresponding to the most unfavorable condition of emergency braking[14-16].

Accordingly, a large alloy steel platform with the same inclination angle was manufactured to provide support to the specimen as shown in **(Figure 8)**. Different materials were used to improve the bonding performance between asphalt and concrete. First, asphalt was poured onto the smooth, flat side of the concrete removed from the mold without applying any interface material. Subsequently, it was applied to the rough surface. To obtain a rough surface, aggregates were added to the interface. Smooth and rough surfaces are shown in **(Figure 9)**. Additionally, aggregates were added to both smooth and rough surfaces as shown in **(Figure 10)**.

Bitumen emulsion was applied as an interlayer material to smooth and rough surfaces for testing. Finally, epoxy was applied to the smooth surface **(Figures 10 and 11)**.

Figure 9: Placed aggregates after application of emulsion.

Figure 10: Aggregates added to surfaces with emulsion application / Application of epoxy to concrete surface.

Figure 11: Experiment setup for measuring specimen strength.

Results and Discussions

The average of the three test results was calculated and the performance comparison of the interlayers is presented in **(Figure 12)**.

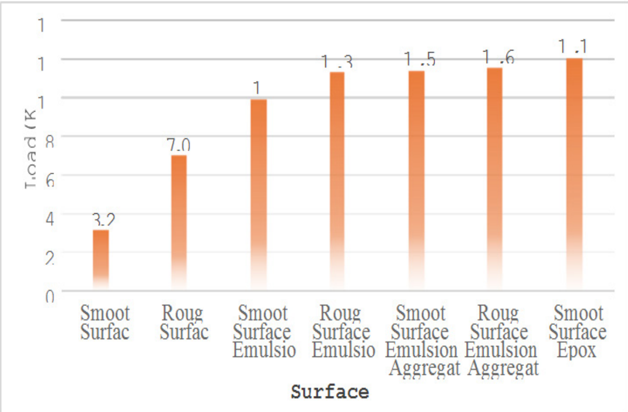

Figure 12: Average strengths of specimens in interlayer tests

As shown in **(Figure 12)**, the average test results of various interlayers were compared. The measured average shear strengths are summarized as follows: smooth surface (3.20 kN), rough surface (7.06 kN), smooth surface with emulsion (10.00 kN), rough surface with emulsion (11.36 kN), smooth surface with emulsion and aggregate (11.50 kN), rough surface with emulsion and aggregate (11.60 kN) and smooth surface with epoxy (12.16 kN). To determine whether the observed differences among the test groups were statistically significant, a oneway analysis of variance (ANOVA) was performed.

Test Measurements

Table 1: Test measurements and group averages.

Group	Test 1 (kN)	Test 2 (kN)	Test 3 (kN)	Group Mean
G1	3.0	2.8	3.8	3.20
G2	6.5	5.6	9.1	7.07
G3	7.8	9.8	12.4	10.00
G4	9.85	11.5	12.7	11.35
G5	10.0	12.45	12.0	11.48
G6	12.8	11.0	11.2	11.67
G7	11.5	12.0	13.0	12.17

Each group consisted of $n = 3$ specimens, which resulting in a total number of observations of $N = 21$. The grand mean of all measurements was calculated as $X^{-} = 9.85$ kN.

ANOVA calculations

The sum of squares between groups was calculated as:

$$SSbetween = Xn(Xi - X^{-})2 = 194.99 \quad (1)$$

The sum of squares within groups was calculated as:

$$SSwithin = X(Xij - Xi)2 = 28.42 \quad (2)$$

The total sum of squares was obtained as:

$$SStotal = 223.40 \quad (3)$$

One-way ANOVA results

Table 2: One-way ANOVA test table.

Source of Variance	SS	df	MS	F
Between Groups	194.99	6	32.50	16.01
Within Groups (Error)	28.42	14	2.03	–
Total	223.40	20	–	–

ANOVA Decision

The calculated F-value was $F_{calculated} = 16.01$. The critical F-value for a significance level of $\alpha = 0.05$ with $df_1 = 6$ and $df_2 = 14$ is approximately $F_{table} = 2.85$.

Since $16.01 > 2.85$, the null hypothesis (H_0) was rejected. Therefore, a statistically significant difference exists between the test groups.

Conclusions

In this study, the performance of various interlayers in composite pavements was evaluated. For the control specimens, no interlayer material was applied and tests were conducted on both smooth and rough surfaces.

The smooth surface specimens exhibited shear strengths of 2.8 kN, 3.0 kN and 3.8 kN, whereas the rough surface specimens showed values of 6.5 kN, 5.6 kN and 9.1 kN.

For specimens with emulsion application, the smooth surfaces yielded results of 7.8 kN, 9.8 kN and 12.4 kN, while the rough surfaces produced 9.85 kN, 11.5 kN and 12.7 kN. The addition of aggregate to the emulsion layer resulted in shear strengths of 10.0 kN, 12.45 kN and 12.0 kN for smooth surfaces and 12.7 kN, 11.0 kN and 11.2 kN for rough surfaces.

Finally, specimens with epoxy application on smooth surfaces achieved shear strengths of 11.5 kN, 12.0 kN and 13.0 kN.Based on the experimental results, it was observed that shear strength increases with increasing surface roughness and interlayer treatment. Among all tested interlayers, epoxy resin exhibited the highest shear strength performance, indicating its superior bonding capability.

Conflict of Interest

The authors declare no conflict of interest.

References

1. Liu Z, Zheng J, Hua Z. Rigid-flexible composite asphalt pavement of CRC+AC structure and its engineering application. J Highway and Transportation Research and Development 2008;25(12):59-64.
2. Rith M, Kim YK, Hong SJ, Lee SW. Behavior of RCC-base composite pavement for heavy duty area. Constr Build Mater 2018;175:144-151.
3. Llopis-Castell´o D, García-Segura T, Montalb´an-Domingo L, Sanz-Benlloch A, Pellicer E. Influence of pavement structure, traffic and weather on urban flexible pavement deterioration. Sustainability 2020;12(22):9717.
4. Perez-Acebo H, Gonzalo-Orden H, Findley DJ, Rojí E. Modelling the international roughness index performance on semirigid pavements in single carriageway roads. Construction and Building Materials 2021;272:121665.
5. Zhaoa Q, Fu Q, Zhang H, Wang J. Performance improvement model of cement pavement in seasonal- frost regions, Magazine of Civil Engineering 2022;111(3):11108.
6. Aashto, Mechanistic-Empirical Pavement Design Guide-A Manual of Practice, 3rd ed., Washington, DC, USA, American Association of State Highway and Transportation Officials 2020.
7. Sun L. Mechanics of behaviour for asphalt pavements. Tongji University Press 2021.
8. Zhu J, Sun L, Wang Y, Li H, Liu L. Development and calibration of shear-based rutting model for asphalt concrete layers. Int J Pavement Eng 2016;18(10):1-8.

9. Li S, Huang Y, Liu ZH. Experimental evaluation of asphalt material for interlayer in rigid flexible composite pavement. Constr Build Mater 2016;102:699-705.
10. Liu L, Liu Z, Liu JY, Li S. Fatigue performance of interlaminar anti cracking material for rigid-flexible composite pavement. J Mater Civ Eng 2016:06016012.
11. Song W, Shu X, Huang B, Woods M. Laboratory investigation of interlayer shear fatigue performance between open-graded friction course and underlying layer. Construction & Building Materials 2016;115:1381-389.
12. Hun M, Chabot A, Hammoum F. 7th RILEM international Conference on Cracking in Pavements. Springer Netherlands 2012:51-60.
13. Li S, Liu Z, Li Y, Zhou T. Experimental study on interlaminar shear fatigue of rigid flexible composite pavement. China Civil Eng J 2013;46(7)151-156.
14. Huang Y, Liu Z, Liu J, Yan D, Yu H. Laboratory study on mechanical properties of composite pavement under partial compression-shear load. Construction & Building Materials 2022:356-129240.
15. Rith M, Kim YK, Hong SJ, Lee SW. Effect of horizontal loading on RCC-base composite pavement performance at heavy duty area. Constr Build Mater 2017;131:741-745.
16. Al-Qadi IL, Yoo PJ. Effect of surface tangential contact stress on flexible pavement response. J Assoc. Asphalt Paving Technol 2007;76:558-582.