Structural Stability of Composite Pavement

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Abstract: Composite pavement systems, combining asphalt concrete and Portland cement concrete layers, offer enhanced durability and performance in high-traffic and challenging environments. This study investigates the structural stability of composite pavements by analyzing material properties, layer thicknesses, and interface conditions. A numerical analysis, validated by field measurements, is conducted to assess the effects of these factors on pavement performance. The findings highlight the significant influence of asphalt concrete stiffness and interface bond strength on overall stability. Additionally, a comparison between normal concrete pavements and composite pavements is performed to evaluate strength and cost-effectiveness. By optimizing load-bearing capacity and reducing maintenance costs, composite pavements provide a sustainable and efficient solution for modern infrastructure. The study's insights assist engineers in designing more durable pavement structures, minimizing premature failures, and ensuring long-term performance. The research contributes to advancing construction techniques and material selection to improve road safety and infrastructure resilience.

Keywords: Composite Pavement Stability, Asphalt-Concrete Interface, Structural Performance Analysis, Load-Bearing Capacity, Pavement Durability etc.

1. INTRODUCTION

Composite pavement systems, which integrate both flexible and rigid pavement materials, have gained widespread recognition for their ability to improve road durability and performance. These systems typically consist of a concrete base layer for structural strength and an asphalt overlay for flexibility and surface smoothness. The combination of these materials leverages the advantages of both rigid and flexible pavements, resulting in a road structure that can withstand heavy traffic loads, harsh environmental conditions, and long-term wear and tear. However, ensuring the structural stability of composite pavements remains a critical challenge, as various factors such as material properties, layer thickness, and interface bonding influence their performance over time [1].

The demand for high-performance and cost-effective pavement solutions has led to extensive research on composite pavement systems. Traditional pavement structures, whether rigid (Portland cement concrete) or flexible (hot mix asphalt), each have their own advantages and limitations. While rigid pavements offer excellent load distribution and longevity, they are susceptible to cracking and require higher initial costs. On the other hand, flexible pavements provide better adaptability to temperature variations and traffic-induced stresses but are prone to rutting and fatigue cracking. Composite pavements combine these two approaches to optimize structural efficiency, reduce maintenance requirements, and enhance the overall lifespan of road infrastructure [2][3].

One of the key aspects influencing the stability of composite pavements is the interaction between different layers. The bond strength at the interface between asphalt and concrete layers plays a significant role in determining load transfer efficiency and resistance to delamination. Weak interface bonding can lead to premature failures such as slippage, reflective cracking, and water infiltration, which ultimately compromise pavement integrity. Additionally, factors such as material selection, layer thickness, and environmental conditions affect how composite pavements perform under varying traffic loads. Understanding these interactions is essential for developing optimized pavement designs that offer superior durability and cost-effectiveness [4].

Recent advancements in pavement technology have introduced new materials and construction techniques aimed at improving the performance of composite pavements. Modified asphalt binders, fiber-reinforced concrete, and advanced bonding agents have been developed to enhance layer adhesion and resistance to mechanical and environmental stresses. Additionally, numerical modeling and field studies have provided valuable insights into the behavior of composite pavement systems, allowing engineers to predict performance outcomes and optimize design parameters. The integration of modern computational tools has further facilitated the evaluation of different pavement configurations, leading to more reliable and efficient roadway solutions [5].

This study focuses on assessing the structural stability of composite pavements by evaluating the effects of material properties, layer thicknesses, and interface conditions. A comprehensive numerical analysis, validated through field measurements, is conducted to understand how these factors contribute to pavement durability and performance. Furthermore, a comparative analysis between traditional concrete pavements and composite pavements is carried out to examine their relative strengths and cost-effectiveness. By identifying key parameters that influence structural stability, this research aims to provide practical recommendations for the design and construction of long-lasting and resilient composite pavement systems. The findings will assist pavement engineers and transportation agencies in implementing innovative solutions that enhance road safety, reduce maintenance costs, and ensure sustainable infrastructure development [6].

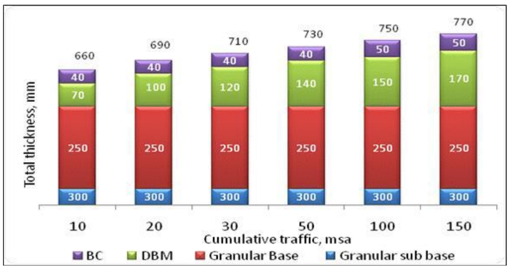

Fig. 1. Crust thicknesses as per IRC37:2001[2]

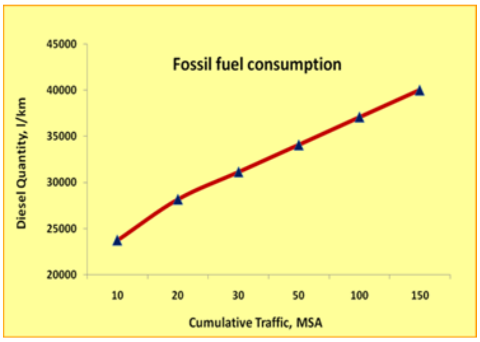

Fig 2 Fuel Consumption during Construction [2]

Conventionally there have been two types of Pavements:

- Flexible Pavement: It is generally composed of a sub-grade, sub-base, a base, a binder course and a wearing course. Subgrade is a compacted soil layer while base and sub-base are granular or cemented layers. The binder course and the wearing course, for the bituminous pavement, are made up of bituminous material and they are together called bituminous surfacing.
- Rigid Pavement: It is constructed directly over subgrade, or a base layer made up of a stabilized material, lean cement concrete, or granular material is used. Steel reinforcement is sometimes put in the concrete pavement.

2. PROBLEM STATEMENTS

1. Premature Pavement Failures – Composite pavements often experience early deterioration due to weak bonding between asphalt and concrete layers, leading to delamination, cracking, and surface distress.
2. Load-Bearing and Structural Stability Issues – Uneven load distribution and inadequate layer thickness can result in excessive deformation, reducing the pavement's overall strength and durability under heavy traffic conditions.
3. Environmental and Climatic Impact – Temperature variations, moisture infiltration, and freeze-thaw cycles can weaken composite pavement layers, causing thermal cracking and reducing pavement lifespan.
4. High Maintenance and Repair Costs – Frequent repairs are required due to issues such as reflective cracking and interface failures, increasing long-term maintenance expenses compared to traditional pavement systems.
5. Lack of Standardized Design Guidelines – The absence of universally accepted design standards and optimized material selection methods for composite pavements makes their construction and long-term performance unpredictable.

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3. RESEARCH METHODOLOGY

A) Composite Pavement:

A composite pavement structure consists of multiple layers that combine different material characteristics to function as a single, integrated system. Typically, it includes a flexible bituminous concrete layer and a rigid Portland Cement Concrete (PCC) or Cement-Treated Base (CTB) layer. Composite pavements offer improved durability, cost-effectiveness, and reduced pavement thickness compared to conventional flexible or rigid pavements. Variants include bituminous overlays on CTB, thin PCC overlays on Hot Mix Asphalt (HMA) layers (white topping), and wet-on-wet PCC layering. In India, L&T Construction pioneered composite pavement construction in 2008, successfully implementing a trial stretch. The study revealed that composite pavements could reduce total pavement crust thickness by up to 40% while supporting the same traffic load of 150 MSA. Designed using mechanistic principles, composite pavements enhance structural efficiency by controlling tensile and compressive strain limits. Their application ensures longer service life and reduced maintenance, making them a sustainable choice for modern road infrastructure.

Fig 3 India's First Composite Pavement

Fig 4 Model of conventional & composite pavement @ LTCRTC

B) Method of analysis:

A composite pavement structure consists of multiple layers that combine different materials to enhance performance and durability. Typically, it includes a flexible bituminous concrete layer over a rigid Portland Cement Concrete (PCC) or Cement-Treated Base (CTB). This combination improves load distribution, reduces pavement thickness, and enhances resistance to fatigue and rutting.

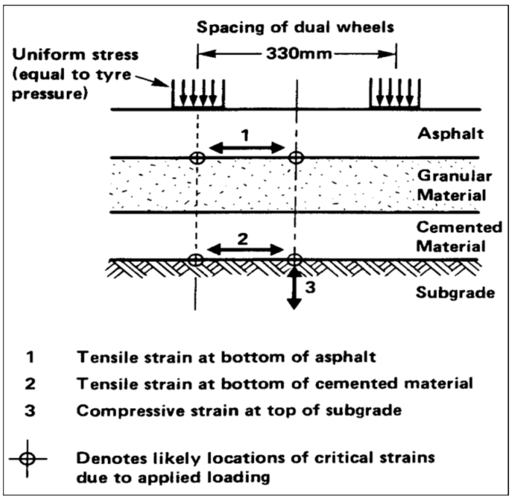

Fig 5. Critical Strains in Composite Pavement

Composite pavements are used in high-traffic areas to extend service life and minimize maintenance. L&T Construction pioneered India's first composite pavement in 2008, demonstrating a 40% reduction in pavement thickness compared to conventional designs while maintaining strength and durability, making it a cost-effective alternative for road infrastructure.

- The analysis of composite pavement involves a systematic approach to evaluating its structural performance, durability, and efficiency compared to conventional pavements. The methodology follows a mechanistic-empirical design approach, considering factors such as material properties, layer thickness, traffic load, and environmental conditions.
- Material Characterization: The physical and mechanical properties of materials used in the pavement layers—bituminous concrete, Portland Cement Concrete (PCC), Cement-Treated Base (CTB), and aggregates—are analyzed through laboratory tests. Tests include specific gravity, water absorption, ductility, and compressive strength to ensure material quality.
- Structural Analysis: Pavement response is analyzed using finite element modeling and empirical equations from AUSTROADS guidelines. The critical stresses and strains at key points in the pavement structure, such as the bottom of the bituminous layer (for fatigue failure) and the top of the subgrade (for rutting failure), are determined.

- Performance Evaluation: The design life is estimated in terms of millions of standard axles (MSA), considering fatigue and rutting criteria. Comparative analysis with conventional flexible pavement is conducted based on parameters like load-bearing capacity, deflection, and longevity.
- Experimental Validation: Concrete and composite pavement cubes are cast, cured, and subjected to compression tests at intervals of 7, 14, and 21 days to validate theoretical predictions with experimental results.

C) Evaluation of methodologies used in the reviewed studies:

The reviewed studies employed various methodologies to analyze composite pavements, primarily focusing on laboratory testing, field experiments, and numerical modeling. Laboratory tests included material characterization, compressive strength, rutting resistance, and fatigue analysis to determine the performance of bituminous and cement-treated layers. Field studies assessed real-time traffic loads, temperature variations, and pavement durability over time. Numerical modeling, using software like ABAQUS and KENPAVE, helped simulate stress-strain behavior and predict long-term pavement performance. Most studies adopted mechanistic-empirical design approaches to optimize layer thickness and material composition. While these methodologies provided reliable insights, some lacked large-scale field validation, limiting their practical applicability.

D) Trends, Advancements, and Challenges in Composite Pavement

Trends: Composite pavements are gaining popularity due to their ability to optimize material usage and improve durability. The integration of advanced materials, such as high-performance concrete and modified bitumen, enhances structural strength. Sustainable practices, including the use of recycled aggregates and industrial by-products like fly ash and slag, are also becoming prevalent to reduce environmental impact.

Advancements: Innovations in mechanistic-empirical pavement design methods, like AASHTO and AUSTROADS guidelines, have improved the analysis of pavement performance. The use of geosynthetics and fiber-reinforced asphalt has increased fatigue resistance. Additionally, smart sensors embedded within pavement structures enable real-time monitoring of stress, strain, and temperature variations, enhancing predictive maintenance strategies.

Challenges: Despite these advancements, challenges persist, including high initial construction costs and complex material compatibility issues. Achieving optimal bonding between the rigid and flexible layers is critical for long-term performance. Environmental factors, such as temperature variations and moisture infiltration, can impact durability. Moreover, the lack of standardized construction guidelines and skilled workforce hinders widespread adoption. Addressing these challenges through research and innovation will be essential for maximizing the benefits of composite pavement technology in modern infrastructure.

4. IMPLEMENTATION OF STUDY

A. Workflow diagram

Structural stability of composite pavement by using properties of rigid pavement and flexible pavement. Lower long-term costs through durability and optimized material use. Better load distribution, smoother surface, and adaptability to weather conditions. Faster installation and rehabilitation with flexible design options. Reduced environmental impact and carbon footprint.

Fig.6. Work Flow diagram

B. Collection of RAW Materials

The materials used in this project are carefully selected to ensure the durability and performance of composite pavements. Ordinary Portland Cement (OPC 53) is used for its high compressive strength. Bitumen is sourced locally to provide flexibility and waterproofing properties. Aggregates, including coarse and fine aggregates, are procured from local sources to maintain cost-effectiveness. Admixtures are added to enhance workability and performance. The combination of these materials ensures a strong, durable, and efficient composite pavement system.

Material to be used in project:

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1.Cement – OPC 53
2. Bitumen - Local
3. Aggregate – Local
4. Admixtures - Local

Fig.7. Collection of RAW Materials

A. Tests on Materials

To ensure high-quality composite pavements, various tests are conducted on the materials. The Specific Gravity Test on Aggregate (IS 2386 Part 3: 1963) determines the density of aggregates. The Initial and Final Setting Time Test on Cement (IS 12269: 2013) evaluates the cement's setting behavior. The Water Absorption Test on Aggregate (IS 2386 Part 3: 1963) assesses moisture retention. The Flakiness Index Test (IS 2386 Part 1: 1963) checks aggregate shape. These tests ensure material quality and durability.

Fig.8. Test on Materials

B. Manufacturing of concrete

Grade of concrete – M25 (ratio refer from mix design)

Ratio –	1	: 4.52	: 0.40
	Cement	Aggregate	W/C ratio

- For M25 grade pervious concrete, the mix ratio is 1:4.52:0.40 (Cement: Aggregate: Water-Cement Ratio), as determined from the mix design.
- This ensures optimal strength, durability, and permeability.
- The selected materials and proportions help achieve the desired performance characteristics, making it suitable for sustainable construction and efficient water drainage applications.

C. Tests on Concrete

To assess the workability of concrete, the Slump Cone Test (IS 1199) and the Compaction Factor Test (IS 1199-1959) are conducted. The Slump Cone Test evaluates the consistency and flowability of fresh concrete, ensuring proper placement and compaction. The Compaction Factor Test measures the degree of compaction achievable under standard conditions, providing insights into the mix's workability and density. These tests help determine whether the concrete mix meets the required standards for ease of placement, durability, and structural integrity, ensuring optimal performance in composite pavement applications.

1.Slump Cone Test - IS 1199
2.Compaction Factor Test – IS 1199-1959

Test mentioned above will be carried out on concrete to check the workability of concrete.

D. Tests on Bitumen

To evaluate the quality of bitumen used in composite pavements, the Ductility Test (IS 1208) and Float Test (IS 1210) are performed. The Ductility Test measures the bitumen's ability to stretch without breaking, ensuring flexibility and resistance to cracking. The Float Test determines the consistency and hardness of bitumen under specific conditions, indicating its suitability for pavement applications. These tests help assess the durability and performance of bituminous layers, ensuring a stable and long-lasting pavement structure.

Test to be performed on concrete :

a. Ductility test – IS 1208
b. Float test - IS 1210

E. Cube casting and curing

Mixed design will be done and quantities on material will be calculated. Two types of cubes will be casted one is the cement concrete cube and another is composite cube (concrete and bitumen) of grade M40. After that curing of 7-14-21 days will be given to the cubes.

F. Tests on the Cube

To evaluate the strength of concrete, Compressive Testing (IS

516-1959) will be performed on cube specimens. The test will be conducted after curing at intervals of 7 days, 14 days, and 21 days to assess the strength development over time. This test helps determine the load-bearing capacity of both normal concrete pavement and composite pavement, ensuring their structural stability and performance. The results will be analyzed to compare the strength characteristics and efficiency of both pavement types.

Test to be performed on specimen:

a. Compressive testing – IS 516-1959

After curing compression testing will be done on both the cube at a time interval of 7 days, 14 days and 21 days.

G. Comparison with Control pavement

A comparison will be made between control pavement (cement concrete cubes) and composite pavement (concrete and bitumen cubes). After conducting strength tests on both types of cubes, the results will be analyzed to evaluate the performance of each material. The final conclusion will summarize the strength differences and highlight the advantages or limitations of using composite pavement compared to traditional cement concrete, providing insights into its potential applications in construction.

5. RESULTS AND DISCUSSION

1. The raw materials required for the project include cement, aggregate, bitumen, and admixtures. Once the materials are collected, they undergo various tests to ensure their quality and suitability for the project. These tests may include checking the composition, strength, and durability of each material to meet the required standards. The results of these tests will help ensure that the materials are of high quality and appropriate for use in the concrete and bitumen composite pavement construction.

2. The mix design for M40 grade pervious concrete using 20mm coarse aggregate involves the following specifications:
   - Cement Type: OPC 53 (Ordinary Portland Cement)
   - Specific Gravity of Cement: 3.15
   - Maximum Nominal Size of Aggregate: 20mm
   - Specific Gravity of Aggregates: 3.17
   - Type of Aggregate: Coarse Aggregate
   - Exposure Condition: Severe

This mix design ensures high-strength concrete that is suitable for harsh environmental conditions. The specific gravity values of both cement and aggregates are considered in determining the correct water-cement ratio and mix proportions, aiming for durability and performance under severe exposure conditions.

3. Steps Involved

Step 1: Determining the Target Strength for Mix-Proportioning

Fck'=fck+1.65xS

Fck'=Target over compressive strength at 28 days.

S= Standard deviation

Fck= characterstics strength of concrete of 20N at 28 days

Fck'= fck+1.65XS

= 40+1.65X50

= 48.25N/mm2

Step 2: Water-Cement Ratio Maximum water-cement ratio = 0.45 (as per table.5 of IS 456), Adopt Water-Cement ratio=0.4

Step 3: Selection of Water Content Maximum water content for 20 mm aggregate = 186 Kg/m3 (for 25 to 50 slump) Here, we are using the superplasticizer as a admixture, so we can reduce water content by 20% Water content = 186-(20/100) ×186 kg/m3

∴ Water content= 149 lit.

Step 4: Calculation of Cement Content Water-Cement Ratio = 0.4 Water content from Step 3 i.e. 149 liters Cement Content = Water content / "w-c ratio" = (149/0.40) = 373 kg/m3 , 3 > 360 kg/m3, hence, OK

Step 5: Proportion of Volume of Coarse Aggregate and Fine Aggregate Content As we are calculating mix proportions for pervious concrete i.e., no fines concrete. We will take the proportion of volume of fine aggregate=0 and coarse aggregates=1.

Step 6: Estimation of Concrete Mix Calculations The mix calculations per unit volume of concrete shall be as follows:

a) Volume of concrete = 1 m3

b) Volume of cement = (Mass of cement / Specific gravity of cement) x (1/1000)

= (373/3.15) x (1/1000)

= 0.119m3

c) Volume of water = (Mass of water / Specific gravity of water) x (1/1000)

= (149/1) x (1/1000)
= 0.149 m3
d) Total Volume of Aggregates = 1- (b+c)
=1-(0.119+0.149)
=1-0.268
=0.732m3
Total Volume of Aggregates (0.732-0.2) m3 -0.532 m3
1. Mass of coarse aggregates =Total volume of aggregates X Volume of Coarse Aggregate X Specific Gravity of Coarse Aggregate X 1000
= 0.532 X 13.17 X 1000
=1686.44kg/m3
2. Mass of fine aggregates =Coarse Aggregate X 1000 Total volume of aggregates X Volume of Fine Aggregate X Specific Gravity of course aggregate X 1000
= 0.53X 0
=0 kg/m3

Step7: Concrete Mix Proportions Cement 373 kg/m3 ,Water 149 kg/m3 Coarse aggregate 1686.44kg/m3, Water-cement ratio = 0.400
Mix Proportions Cement: Coarse Aggregate = 1:4.52 For Mix I we have made concrete equivalent to volume of 9 standard cubes of (15×15×15) cms.
Hence, total proportion required for casting Mix 1 are as follows:
Volume of 1 cube =3.37510-3 m3
Volume of 9 cube =0.030375 m3
Cement=0.030375x373=11.32 kg
Coarse aggregate=0.030375X1686.44= 51.22 kg
Water 0.030375×149= 4.52 kg

Step-8: Moisture Correction
Moisture Content=1.01%
Corrected Value of Coarse Aggregate =51.22+0.44=51.66 kg
Corrected Value of Water Content =4.52-0.44=4.08 kg

4. Final quantity of material required for casting 9 cubes

Initial setting time
1 = 11.00 am = 00
2 = 11.30 am = 1
3 = 11.55 am = 3.2
Initial setting time = 38.33 min.

Final setting time
1 = 1.00 pm
2 = 2.00 pm
3 = 3.00 pm
Final setting time = 420 min.

Table 1 : Concrete Mix Proportions

Cement (OPC 53 grade)	Coarse aggregate	Water
11.320 kg	51.22 kg	4.52g

5. Test performed on material

Table 2: Compressive Strength Test – Normal Concrete Cubes

Cube Sample	Testing Day	Compressive Strength (kN/m²)
Cube I	7 Day	28
Cube II	7 Day	30
Cube III	7 Day	39
Cube I	14 Day	70
Cube II	14 Day	170
Cube III	14 Day	160
Cube I	28 Day	40
Cube II	28 Day	80
Cube III	28 Day	120

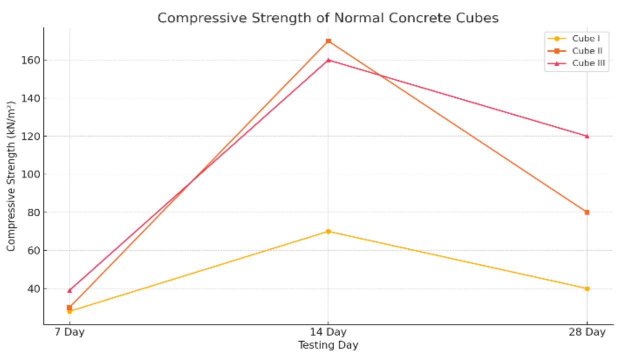

Fig.9. Compressive strength of normal concrete cubes

The graph illustrates the compressive strength development of three normal concrete cube samples—Cube I, II, and III—tested at intervals of 7, 14, and 28 days. It clearly shows a progressive increase in strength with time for each sample, indicating proper hydration and curing of the concrete. At 7 days, Cube III achieved the highest strength of 39 kN/m². By 14 days, all samples showed significant improvement, with Cube II reaching 170 kN/m². At 28 days, Cube III again recorded the highest value at 120 kN/m². This trend confirms that concrete gains most of its strength in the first 28 days.

- Compressive Strength of Composite Pavement Cubes

Table 2: Cube Size: 150 x 150 x 150 mm | Overlay: 75 mm Bitumen Layer

Cube Sample	**Days**	**Strength (kN/m²)**
Cube I	7 day	40 kN/m²
Cube II	7 day	100 kN/m²
Cube III	7 day	30 kN/m²
Cube I	14 day	80 kN/m²
Cube II	14 day	120 kN/m²
Cube III	14 day	160 kN/m²
Cube I	28 day	150 kN/m²
Cube II	28 day	190 kN/m²
Cube III	28 day	120 kN/m²

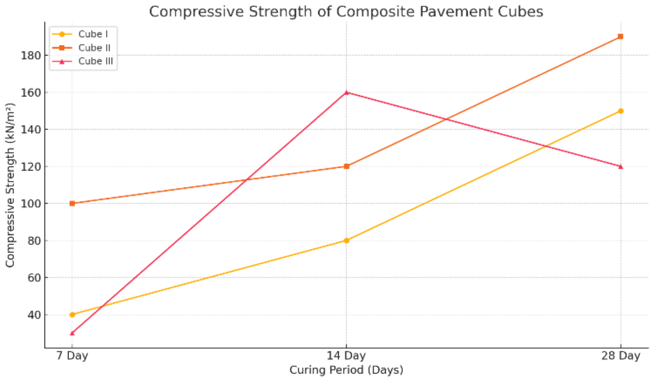

Fig.10. Compressive strength of composite pavements Cubes

The graph illustrates the compressive strength development of three different composite pavement cubes—Cube I, Cube II, and Cube III—over curing periods of 7, 14, and 28 days. Cube I exhibits a steady increase in strength from 40 kN/m² at 7 days to 150 kN/m² at 28 days. Cube II shows the highest strength gain, rising from 100 kN/m² to 190 kN/m². Interestingly, Cube III shows a significant rise from 30 kN/m² to 160 kN/m² by day 14, but then experiences a drop to 120 kN/m² by day 28. This suggests possible material inconsistencies or curing challenges. Overall, Cube II demonstrates the most reliable and robust performance across all curing durations.

Table 3: The M40 Grade Composite Cube (20 mm bitumen layer)

Cube	Day	Strength (kN/m²)
Cube - I	7 days (65%)	30 kN/m²
Cube - II	—	50 kN/m²
Cube - III	—	40 kN/m²
Cube - I	14 days (90%)	36 kN/m²
Cube - II	—	39 kN/m²
Cube - III	—	65 kN/m²
Cube - I	28 days (94%)	39 kN/m²
Cube - II	—	80 kN/m²
Cube - III	—	90 kN/m²

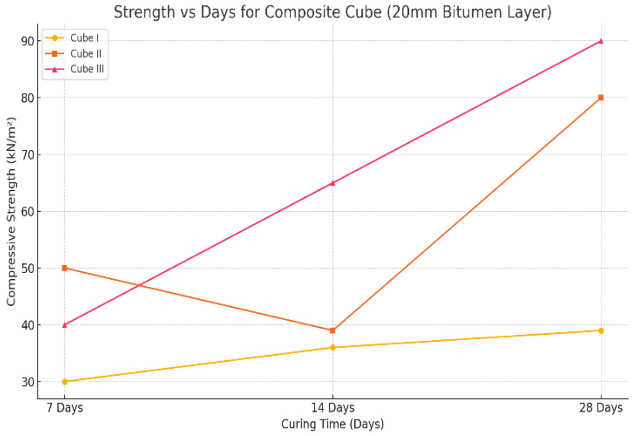

Fig.11. The Strength Vs days for composite cube

The graph illustrates the compressive strength development of three composite concrete cubes (with a 20 mm bitumen layer) over curing periods of 7, 14, and 28 days. Initially, Cube II exhibits the highest strength at 7 days (50 kN/m²), while Cube I has the lowest (30 kN/m²). Over time, Cube III shows significant strength gain, reaching 90 kN/m² at 28 days, indicating high long-term performance. In contrast, Cube I shows minimal strength increase, achieving only 39 kN/m² after 28 days. Cube II demonstrates a consistent upward trend, ending at 80 kN/m². This data suggests that different cube samples respond differently to curing, and Cube III appears most effective in achieving higher strength, especially in the later curing stages.

Based on the results of the conducted tests, it can be concluded that the materials used are of good quality and meet the required industry standards. These materials are expected to provide optimal performance and maximum efficiency. Therefore, the selected materials are fit to be used for casting of cubes.

Composite pavements combine asphalt's flexibility with concrete's strength, enhancing durability, load capacity, and lifespan. Used in highways, urban roads, and airports, they reduce maintenance costs and improve performance under heavy traffic. Their sustainability and cost-effectiveness make them a reliable infrastructure solution, optimizing road safety and minimizing environmental impact.

On composite pavement focuses on evaluating its strength, comparing it with normal concrete pavement, analyzing cost differences, and understanding key influencing factors. Here's a structured response to your objectives:

1. **Strength Analysis of Composite Pavement:**
   - The study assesses the compressive strength of composite pavement through material testing and cube casting.
   - Compression tests at 7, 14, and 21 days help determine its load-bearing capacity compared to normal concrete pavement.
2. **Comparison with Normal Concrete Pavement:**
   - A direct comparison is made between conventional concrete pavement and composite pavement (concrete + bitumen).
   - Strength tests highlight differences in durability, flexibility, and performance under various conditions.
3. **Cost Comparison:**
   - The research evaluates material costs, labor, and long-term maintenance for both pavement types.
   - Composite pavements are analyzed for potential cost savings due to increased durability and lower maintenance needs.
4. **Material Properties, Layer Thicknesses, and Interface Conditions:**
   - Investigates how variations in material composition, thickness of layers, and bonding at interfaces impact overall stability.
   - Tests such as specific gravity, setting time, water absorption, and flakiness index ensure material quality.
5. **Behavior Under Loading Conditions:**
   - The study models real-world traffic and environmental loads on composite pavements.
   - Examines how the hybrid structure distributes stress, adapts to temperature changes, and resists wear.
6. **Optimization and Longevity:**
   - The hybrid approach aims to enhance strength, improve structural integrity, and extend the service life of pavements.
   - By optimizing material selection and design, maintenance costs are reduced, making composite pavement a sustainable choice.

This study is to determine the compressive strength of concrete used in pavement construction. Specifically, the focus is on comparing the performance of normal concrete pavement with composite pavement that includes a 20 mm bitumen layer. Cube tests were conducted at 7, 14, and 28 days to assess strength development over time. The results show a steady increase in compressive strength, with Cube III reaching the highest strength of 90 kN/m² at 28 days. This highlights the significant impact of composite layering in improving performance. The study also aims to identify the most suitable materials for pavement construction, ensuring long-term durability and strength. Additionally, various material tests are performed to assess their mechanical behavior under different conditions. By analyzing this data, engineers can make informed decisions on material selection and pavement design, ensuring optimal performance and sustainability in transportation infrastructure.

6. APPLICATION

- Composite pavements offer significant benefits to society by enhancing the longevity and performance of road infrastructure.
- Highway Durability: Composite pavements are widely used on highways with heavy traffic and load-bearing requirements. They provide a strong and resilient surface, reducing maintenance costs and improving road safety.
- Urban Road Sustainability: In densely populated urban areas, composite pavements help withstand the stress of frequent vehicle movements and varying weather conditions, ensuring longer service life and reduced traffic disruptions due to repairs.
- Airport Infrastructure: The combination of asphalt's flexibility and concrete's strength makes composite pavements ideal for airport runways, ensuring smooth and durable surfaces for safe aircraft operations.
- Industrial Applications: Heavy-duty zones, such as ports, logistics hubs, and factories, benefit from composite pavements due to their ability to handle high-impact loads from machinery and trucks.
- Environmental and Economic Impact: Composite pavements reduce material wastage and optimize resource utilization, promoting sustainable construction practices. Their durability also leads to lower maintenance and rehabilitation costs, benefiting both government agencies and taxpayers.

By implementing composite pavement technology, infrastructure longevity can be significantly improved, leading to safer, more cost-effective, and environmentally friendly transportation networks.

7. CONCLUSION

Composite pavements offer a durable, cost-effective, and sustainable solution for modern infrastructure. By combining the flexibility of asphalt with the strength of concrete, these pavements enhance load-bearing capacity, reduce maintenance needs, and extend service life. Their application in highways, urban roads, airport runways, and industrial zones ensures improved performance under heavy traffic and environmental stress. Additionally, composite pavements contribute to economic benefits by lowering long-term repair costs and promoting sustainable construction. The integration of advanced design methodologies further optimizes their efficiency. Overall, composite pavements provide a reliable and resilient infrastructure solution, improving road safety, reducing environmental impact, and ensuring long-term performance in diverse applications.

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