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Study and Analysis on Behavioral change of Temperature on Rigid pavement using Sensors

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Abstract: The analysis of the behavioral change of temperature on rigid pavement is a critical aspect of understanding the performance and durability of concrete roadways. Temperature fluctuations significantly impact the rigid pavement, leading to distresses such as cracking, deformation, and reduced service life. This experimental study aims to investigate the effects of temperature variations on the behavior of rigid pavement and develop strategies to mitigate potential issues. The objective of this research is to analyze the behavioral response of rigid pavement under controlled temperature changes. To achieve this objective, a representative section of rigid pavement was selected for testing. The pavement sample was constructed according to standard specifications, ensuring it accurately represents real-world conditions. The sample consisted of typical layers found in a rigid pavement structure, including the concrete slab, base, and sub base layers. The collected data was analyzed to understand the effects of temperature changes on the rigid pavement. Statistical analysis and visualization techniques were employed to identify patterns, trends, and correlations between temperature variations and the observed behavioral changes. The analysis provided insights into the susceptibility of rigid pavements to temperature-induced distress, such as thermal cracking and differential expansion.

Keywords: LM 35sensor, Arduino, Temperature variation, Rigid pavement

1. Introduction

Due to their longer service lives, lower maintenance needs, and smoother riding surface, cement concrete pavements are increasingly being used in new road constructions in India. The analysis of the behavioral change of temperature on rigid pavement is of utmost importance for understanding the performance and durability of concrete roadways. Temperature fluctuations significantly impact the rigid pavement, leading to various distresses and deformations. Conducting experimental analyses allows researchers and engineers to gain valuable insights into the effects of temperature changes on the pavement structure and develop strategies to mitigate potential issue

However, the currently available thermoelectric generators cannot yet produce a large amount of electricity.

The study employs a comprehensive methodology that encompasses material preparation, casting, curing, and temperature monitoring. The material preparation involves the proper dispersion and integration the concrete mixture used for constructing the rigid pavement. Through optimized mixing techniques, is uniformly distributed within the concrete matrix to maximize its thermal conductivity and interfacial contact.

2. Literature Review

Wang, X. et al (2020)[1]. Experimental Investigation of Graphene-Modified Asphalt Mixtures for Heat Dissipation. Construction and Building Materials, 235, 117418. This study examined the heat dissipation capabilities of asphalt mixtures modified. The results showed that the incorporation of improved the thermal conductivity of the asphalt, leading to enhanced heat dissipation from the pavement surface. The study concluded -modified asphalt mixtures could effectively reduce pavement temperatures and mitigate thermal-induced distress.

Liu, J et.al (2019)[2]. Enhancing the Thermal Conductivity of Asphalt Concrete by Graphene Oxide. Construction and Building Materials, 217, 301-308. In this study, graphene oxide was added to asphalt concrete to improve its thermal conductivity. The findings revealed that the introduction of significantly enhanced the thermal properties of the asphalt mixture, resulting in improved heat dissipation.

Gandomi, A. H. et al (2017)[3]. A Comprehensive Study on Thermal Properties of Graphene Oxide-

Modified Asphalt Binders and Mixtures. Journal of Materials in Civil Engineering, 29(2), 04016234. This comprehensive study investigated the thermal properties of asphalt binders and mixtures modified with oxide. The alt. The study concluded that oxide modification could enhance the thermal performance and durability of asphalt pavements

3. Materials and Methods

3.1. Cement

Cement is a thin amorphous substance which can join separate pieces or masses of solid matter to create a mechanically strong material when combined with water and allowed to set and solidify. Ordinary Portland cement of grade 53, according to IS:12269, is the most frequently used type of cement. Ordinary Portland cement represents a portion of overall production.

3.2. Water

Water addition is a critical process in concrete preparation, involving the incorporation of water into the mixture of cement, aggregates, and other admixtures. It is essential for achieving the desired workability, strength, and durability and long life of the concrete. The right amount of water is crucial to ensure proper hydration of cement particles, facilitating the formation of strong and durable cementitious compound.

3.3. Fine Aggregate

River sand that is readily available nearby is processed into fine aggregate by 4.75mm sieve. According to IS383:1970, the FA is being classified into four different zones, thatis Zone- I, Zone-II, Zone-III, Zone-IV. The fine aggregate used in this study is under zone II. It is typically composed of sand, crushed stone, or gravel particles with a size ranging from 0.075mm (No. 200 sieve) to 4.75mm (No. 4 sieve). The main function of fine aggregate inconcrete is to fill the voids between the coarse aggregate particles and provide a workableand cohesive mixture

3.4. Coarse Aggregate

Coarse aggregates are irregular broken stone or naturally-occurring rounded gravel used for making concrete. Materials which are large to be retained on 4.7 mm sieve size are called coarse aggregates, and its maximum size can be up to 63 mm. 20 mm coarse aggregate, conforming to IS: 383 -1970 was used. The properties of coarse aggregates such as specific gravity and water absorption were obtained

3.5. Temperature Testing

To check the temperature of the top most layer of a rigid pavement using Arduino Uno. It requires the following components

3.5.1. Arduino Uno board: This is the microcontroller board that will receive temperature readings from the sensor and process the data.

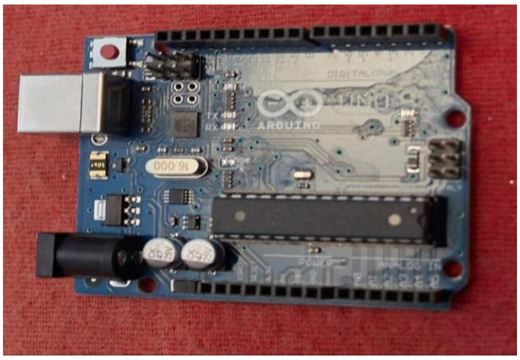

Fig 1: Arduino Board used

3.5.2. Temperature sensor: Choose a suitable temperature measuring sensor that is in compatible with Arduino, such as a thermistor or a digitally temperature sensor.

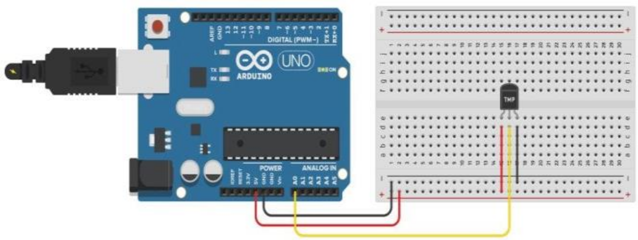

Fig 2: Temperature Sensor arrangement

3.5.3. Connecting wires: Use jumper wires to establish the connections between the Arduinoboard and the temperature sensor.

Fig 3: Connecting wires

3.5.4 LM35

The LM35 is a widely used temperature sensor that offers high precision and accuracy in measuring temperature. Developed by Texas Instruments, the LM35 sensor provides an analog output voltage proportional to the temperature being measured. It is commonly employed in various applications where temperature monitoring and control are crucial, such as environmental monitoring systems, industrial processes, and electronic devices.

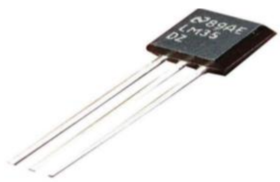

Fig 4: L M 35

4. CC pavement Mould Preparation

4.1 Rigid Pavement Mix:

- Select the appropriate mixture proportions for the rigid pavement, including cement, aggregates, and other necessary components.
- Determine the desired percentage of graphene to be incorporated into the pavement mix. Thiscan vary based on research objectives and the desired level of heat extraction enhancement.
- Use standard testing procedures to determine the properties of the base pavement mix, such as compressive strength, flexural strength, and workability.

4.2 Mix Design

Table 1: Material Quantity

Material	Quantity/Percentage	Purpose/Description
Cement	504 kg	Binder for pavement mixture
Fine Aggregate	750 kg	Provides stability and strength
Coarse Aggregate	1512 kg	Enhances structural integrity
Water	250 kg	Provides workability and hydration

Fig 5: Rigid Pavement Prototype (Mould Casting)

5. Temperature Measurement

5.1 Checking Temperature using Arduino Uno

The LM35 device is rated to operate over a −55°C to 150°C temperature range.

Step 1: Connections:

The data sheet for the utilized lm35, which has the ground pin and the Vs pin switched, is often available. Connect the Vs pin to the Arduino's 5v pin and one of the power rail's two ground pins to the Vs pin. Connect one of the analog pins—A0 in this instance—to the V out pin.

Step 2: Program

Program is written and executed for the measurement of Temperature

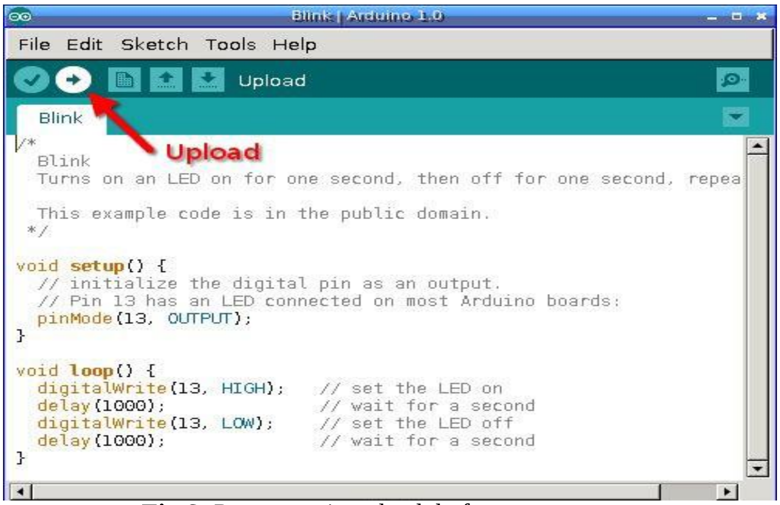

Fig 6: Programming check before run

Step 3: Temperature Measurement

After running the program, the program and LM35 sesnor is ready for the temperature measurement. The Arduino along with LM 35 is placed on the prepared Rigid pavement mould. The variation in temperature in recorded as shown in the Fig7 and Fig 8. The process is repeated for different time of the day, different day of the week.

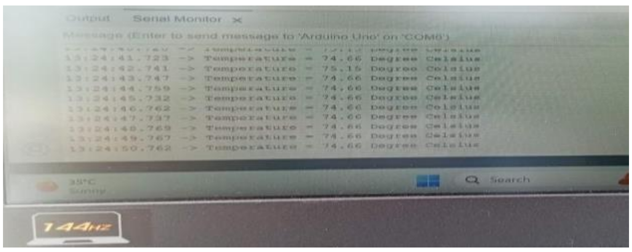

Fig 7: Temperature Measurement

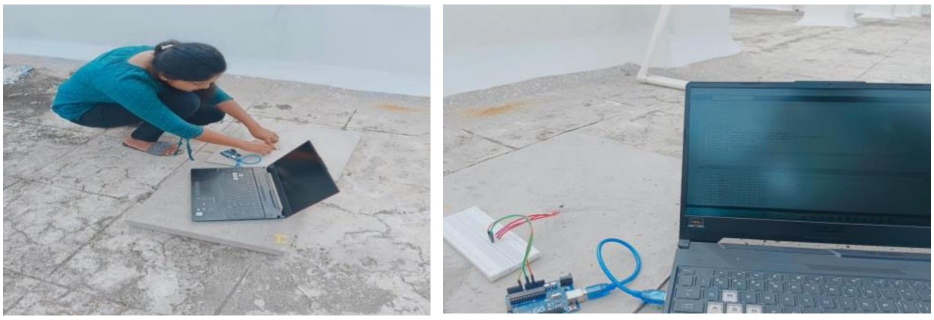

Fig 8: Temperature Testing on Rigid pavement mould

6. Results, Data Analysis and Discussion

6.1 Materials Strength

Table 2: Basic test results

MATERIALS	CONDUCTED EXPERIMENTS	RESULTS
Cement	Specific gravity test	3.15
	Standard consistency test	31%
	Setting time (Initial and final)	Initial=43minutes Final=600minutes
Coarse aggregates	Specific gravity test	2.65
	Impact Test	32.66%
	Abrasion Test	34%

6. Data analysis of CC Pavement: Temperature variation measurement for different time of the day

Observation 1:(3 days curing)

Table 3: Temperature variation observed between 2 Moulds for 3 days Curing

Time	Room Temperature	Mould 1 Temperature	Mould 2 Temperature
Day 1			
11.00AM	31°C	40.2°C	41.5°C
12.00PM	33°C	42.5°C	44.8°C
1.00PM	35°C	45.3°C	46.3°C
DAY 2			
11.00AM	31°C	42.2°C	43.5°C
12.00AM	32°C	44.5°C	46.8°C
1.00PM	35°C	47.3°C	48.3°C
DAY 3			
11.00AM	35°C	45.3°C	47.7°C
12.00AM	37°C	49.5°C	51.2°C
1.00PM	37°C	50.2°C	53.9°C
DAY 4			
11.00AM	29°C	38.0°C	37.5°C
12.00AM	31°C	42.7°C	41.3°C
1.00PM	34°C	45.6°C	43.2°C

Observation 2: Mould 1(7 days curing)

Table 3: Temperature variation observed between 2 Moulds for 7 days Curing

Time	Room Temperature	Mould 1 Temperature	Mould 2 Temperature
Day 1			
11.00AM	31°C	47.1°C	45.5°C
12.00PM	33°C	49.2°C	50.1°C
1.00PM	35°C	52°C	51.9°C
DAY 2			
11.00AM	32°C	49.6°C	48°C
12.00AM	32°C	51.4°C	50.7°C
1.00PM	35°C	55.5°C	53.9°C
DAY 3			
11.00AM	33°C	51.3°C	52.7°C
12.00AM	34°C	52.5°C	54.1°C
1.00PM	35°C	57.2°C	55.2°C
DAY 4			
11.00AM	31°C	47.5°C	46.5°C
12.00AM	34°C	50.8°C	49.8°C
1.00PM	37°C	54°C	52.5°C

Observation 2: Mould 1(14 days curing)

Table 3: Temperature variation observed between 2 Moulds for 14 days Curing

Time	Rooom Temperature	Mould 1 Temperature	Mould 2 Temperature
Day 1			
11.00AM	31°C	51°C	52.8°C
12.00PM	33°C	54°C	52°C
1.00PM	30°C	56°C	56°C
DAY 2			
11.00AM	31°C	53.2°C	52°C
12.00AM	32°C	55.2°C	53°C
1.00PM	35°C	56.8°C	59°C
DAY 3			
11.00AM	38°C	55.3°C	54.7°C
12.00AM	37°C	56.5°C	55°C
1.00PM	37°C	57.2°C	55.2°C
DAY 4			
11.00AM	31°C	47.5°C	44.5°C
12.00AM	32°C	50.8°C	49.8°C
1.00PM	37°C	54°C	52.5°C

7. Conclusion

- This experimental analysis shows that Rigid pavement's performance and behavior are noticeably impacted by temperature variations.
- When designing and analyzing the pavement for this experiment, local meteorological variables must be taken into account.
- The surface of the stiff pavement is used to measure heat.
- This experimental approach shows that temperature changes have a considerable impact on the behavior of rigid pavement, emphasizing the significance of taking the local climate variables into account while designing and maintaining pavement.
- In this experiment, we extracted the heat from Rigid pavement's surface.

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