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Pervious Concrete for Urban Heat Island

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Abstract– This research explores the effectiveness of permeable pavements in reducing urban heat island effects and enhancing urban energy use. The impact of key factors such as reflectivity, thermal characteristics, and evaporation cooling on permeable pavements' performance was evaluated through laboratory investigations. Additionally, a comparative analysis of different pervious concrete mixtures was conducted to identify the most effective combination of materials for mitigating urban heat island effects. The findings highlight the potential of permeable pavements as a sustainable solution for managing urban temperatures and promoting energy resilience in cities.

Keywords—concrete, pervious, pavement, mixture, urban, heat island.

I. Introduction

The most widely used construction material is concrete. Modern concrete is more than simply a mixture of cement, water, and aggregates; it contains more often mineral components, chemical admixtures, fibers, and other. Pervious concrete, a revolutionary material in contemporary construction, embodies a paradigm shift in the domain of sustainable urban development. Engineered with meticulous precision, this specialized variant of traditional concrete boasts remarkable porosity, allowing water to permeate effortlessly, rainfall can be captured and percolate into the ground, recharging groundwater, supporting sustainable construction, reducing storm-water runoff, and providing a solution for construction that is sensitive to environmental concerns [1]. Its significance lies not only in its functional efficacy but also in its role as a pivotal solution for stormwater management, endorsed by regulatory bodies such as the U.S. Environmental Protection Agency. Characterized by a unique composition that balances aggregates and cementitious paste to create a highly interconnected void structure, pervious concrete stands as a beacon of innovation in the quest for eco-friendly building materials.

Beyond its utilitarian applications, pervious concrete harbors ecological benefits that resonate profoundly in the contemporary urban landscape. By curbing runoff and filtering pollutants, it fosters the preservation of water bodies while facilitating the replenishment of groundwater reserves. Furthermore, its permeable nature creates an environment conducive to vegetation growth, mitigating the adverse impacts of urbanization on green spaces. In essence, pervious concrete represents a holistic approach to sustainable development, where functionality seamlessly integrates with environmental stewardship to shape a greener, more resilient future.

With a unique composition that balances aggregates and cementitious paste to create a structure of highly interconnected voids, permeable concrete stands as an example of innovation in the search for eco-friendly building materials.

In terms of sustainability, permeable concrete not only helps in stormwater management, but also simplifies drainage systems and reduces costs, in addition to awarding points in certifications for sustainable constructions. However, its use is not recommended in areas with impermeable soils, regions with permanent freeze-thaw cycles, arid regions or regions with high wind erosion content, and areas of high traffic.

For other hands, Rapid urbanization puts pressure on cities, engineers, and researchers to explore different ways to reduce the Impervious surfaces and to deal with storm-water management in a sustainable and environment friendly way [2].

This research aims to determine the effectiveness of permeable pavements in reducing urban heat island effects by analyzing the impact of key factors such as reflectivity, thermal characteristics, and evaporation cooling.

II. BACKGROUND

In urban areas, the extensive use of impermeable surfaces like asphalt and concrete for streets, parking lots, and sidewalks exacerbates the phenomenon known as the urban heat island effect. These surfaces absorb a significant amount of solar radiation during the day, causing them to heat up and retain that heat well into the evening, leading to elevated temperatures in urban environments compared to their rural surroundings. This increase in temperature can have various detrimental effects, including heightened energy consumption for cooling, compromised air quality, and discomfort for residents [3].

To combat the urban heat island effect, researchers and urban planners have been exploring innovative solutions, one of which is the development and implementation of "cool pavements." Cool pavements are engineered using specialized materials that possess high solar reflectance and infrared emittance properties [4]. Unlike traditional pavement materials that absorb sunlight and convert it into heat, cool pavements reflect a significant portion of the incoming solar radiation back into the atmosphere, thereby reducing the amount of heat absorbed by the surface.

For example, cities like Los Angeles and Phoenix have been experimenting with reflective sealants on asphalt roadways to reduce heat absorption. These cool pavements can also improve water quality by reducing the temperature of stormwater runoff and enhance safety by improving nighttime visibility.[5]

Phoenix has more than 5,000 mi of city streets over a 520 sq mi area. Because paved surfaces account for 30% to 40% of urbanized areas, a lot of surfaces would need to be covered with cool pavement to significantly reduce the heat island effect for the entire city. However, even with a 1-degree reduction in average temperature in the city, residents would save $15 million per year in avoided air conditioning costs alone, according to David Sailor, the director of the Urban Climate Research Center. [5]

Furthermore, advancements in cool pavement technology have led to the incorporation of additional features aimed at enhancing their cooling capabilities. For instance, some cool pavements are designed to allow water to permeate through the surface, either through small pores or channels, enabling water to infiltrate the pavement structure. These permeable pavements promote evapotranspiration, where water evaporates from the pavement surface, absorbing heat in the process and cooling the surrounding air. Other cool pavements are engineered with porous structures that retain water within the pavement matrix, acting as a reservoir for evaporative cooling.

By deploying cool pavements in urban environments, cities can effectively mitigate the urban heat island effect and its associated challenges. Not only do these pavements help to reduce surface temperatures and improve thermal comfort for residents, but they also contribute to energy savings by reducing the need for excessive air conditioning. Additionally, cool pavements have the potential to enhance overall urban resilience by mitigating the impacts of heat waves and contributing to sustainable urban development efforts. As cities continue to grapple with the challenges of climate change and urbanization, the adoption of cool pavement technologies presents a promising strategy for creating more livable, resilient, and sustainable urban environments.

III. Properties and Characteristics

Pervious concrete (PC) offers a multitude of benefits that contribute significantly to reducing energy consumption and fostering environmental sustainability. Here's how PC achieves this:

Mitigating Urban Heat Island (UHI) Effects: By decreasing surface temperatures, PC helps counteract the urban heat island effect, making urban environments cooler and more comfortable for inhabitants.

Lower Energy Storage: Compared to traditional concrete pavements, PC systems store less thermal energy due to their lower conductivity, thereby reducing the overall heat retention in urban areas.

Enhanced Heat and Moisture Exchange: The interconnectedness of soil and air facilitated by PC allows for efficient exchange of heat and moisture, aiding in the regulation of the Earth's temperature and humidity levels.

Reduced Potential for Thermal Shock: Unlike impervious concrete, PC exhibits greater resilience to temperature fluctuations, minimizing the risk of material damage due to thermal shock.

Lower Surface Temperatures: Permeable pavements, a type of PC, maintain lower surface temperatures compared to asphalt pavements, contributing to a cooler urban environment.

Evaporative Cooling: By keeping the pavement surface moist, PC enhances the cooling effect through evaporation, further reducing ambient temperatures.

Stormwater Management: PC eliminates the need for separate stormwater control devices by allowing water to permeate through its surface, thus mitigating runoff and conserving energy associated with conventional drainage systems.

When formulating PC mixtures, several key parameters are considered to achieve optimal performance. Common Mixture Design Parameters:

Cement Paste Composition: PC mixtures typically consist of a blend of pure water and Portland cement, ensuring adequate binding and structural integrity.
Coarse Aggregates: PC incorporates coarse aggregates ranging from 6 to 20mm in size, providing stability and permeability to the pavement structure.
Water-to-Cement (W/C) Ratio: The W/C ratio typically ranges from 0.3 to 0.45, striking a balance between workability and strength while minimizing water consumption.
Void Ratio: PC mixtures are designed to have a void ratio of approximately 38% to 42%, facilitating water permeability and drainage.
Additives: The judicious use of additives is considered to enhance specific properties of PC, such as durability, permeability, and resistance to environmental factors.
By optimizing these mixture design parameters, PC achieves its objectives of reducing energy consumption, promoting sustainability, and improving the overall environmental performance of urban infrastructure.

IV. Design

In an exploration of preliminary PC mix designs, two distinct formulations have been developed, each tailored to specific project requirements and objectives. The decision to create two designs stems from the recognition of diverse application scenarios and the need to address varying performance criteria.

Design #1 prioritizes the utilization of smaller aggregates and incorporates two additives, resulting in a lower water-to-cement (w/c) ratio. By employing finer aggregates and carefully selected additives, this approach aims to enhance the overall strength and durability of the concrete mixture while minimizing potential shrinkage and improving workability. This design will have an aggregate size ranging from 9.5 to 12.5 mm, utilizing two additives: Silica Fume and Superplasticizer, with a targeted w/c ratio of 0.25 to 0.35

Differentiating Factors:

1. Aggregate Size: Smaller aggregates limestone (9.5 to 12.5 mm) is utilized to enhance the compactness and cohesion of the concrete mixture, contributing to improved strength and durability.
2. Additives: Incorporation of Silica Fume and Superplasticizer additives enhances the properties of the concrete, including increased strength, reduced permeability, and improved workability.
3. Water-to-Cement (w/c) Ratio: The lower w/c ratio (0.25 to 0.35) minimizes the amount of water required for hydration, optimizing the strength and durability of the concrete while reducing the risk of shrinkage.

In contrast, **Design #2** emphasizes the use of larger aggregates without additives, coupled with a relatively higher water-to-cement (w/c) ratio. This approach is geared towards achieving specific structural requirements or desired aesthetic qualities. While foregoing additives, the increased w/c ratio facilitates greater flowability during placement, albeit with potential trade-offs in terms of long-term durability and shrinkage characteristics. This design will utilize larger aggregates ranging from 15 to 20 mm, no additives, and a targeted w/c ratio of 0.35 to 0.45

Differentiating Factors:

1. Aggregate Size: Basalt Larger aggregates (15 to 20 mm) are selected to enhance the visual appearance and structural integrity of the concrete pavement, catering to specific design requirements or aesthetic preferences.
2. Additives: Design #2 does not incorporate additives, opting for a simpler mixture composition that may be suitable for applications where enhanced performance properties are not required.
3. Water-to-Cement (w/c) Ratio: The relatively higher w/c ratio (0.35 to 0.45) provides greater flowability during placement, facilitating ease of construction, although it may result in slightly lower strength and increased shrinkage compared to Design #1.

Properties of Limestone aggregate

Physical and Mechanical Properties:

- Strength: Limestone is tough, making it suitable for structural applications such as concrete and pavements
- Low Possibility of Alkali-Silica Reaction: This reduces the risk of uncontrolled expansion in concrete, improving its durability.
- Decreased Drying Shrinkage: Helps minimize problems related to concrete shrinkage when drying.
- Low Thermal Expansion: This property contributes to greater dimensional stability under thermal changes [8].

Environmental and Economic Properties:

- Sustainability: The production of limestone aggregates requires less energy than other materials, reducing their environmental footprint. In addition, the waste can be recycled as aggregates for new projects.
- Durability and Minimal Maintenance: Its use prolongs the useful life of construction surfaces by being resistant to wear and requiring little maintenance [8].

Properties of Basalt Gravel aggregate

Physical and Mechanical Properties

- Strength: Basaltic gravel is very strong, making it suitable for structural applications such as pavements and road foundations.
- Density: It has a real density between 3.00 and 3.15 g/cm³, which contributes to its stability under heavy loads.
- Water Absorption: It has a low water absorption (0.1 - 0.3%), which reduces the risk of expansion due to humidity.
- Thermal Expansion: Its coefficient of thermal expansion is moderate (around 0.90 mm/m at 100°C), helping to maintain structural integrity under thermal changes.

Environmental and Economic Properties

- Sustainability: Being an abundant natural material, its use can be more sustainable compared to other synthetic materials.
- Durability and Minimal Maintenance: High wear resistance reduces costs associated with maintenance.

V. Pervious Concrete Mixture

For the designs in this research all the materials of the pervious concrete were considered, these being the cement, water, aggregates, water-cement ratio, and additives. All these ingredients mentioned are used to make the pervious concrete and need to be precisely measured before mixing. A water-cement ratio of approximately 0.2-0.4 was considered in mixture design; this approximation was not used only when additives were involved. The additives used were the Glenium 3030 which is a water-reducer that helps to maintain strength while still having good workability; the other additive was the MasterMatrix VMA which is a viscosity-modifier that simply does just that, modifies the mixture viscosity to ensure good quality (Figure 1)

Figure 1. Basalt Gravel Pervious Concrete Molding in Cylinder

Below is the mixture measurement for the first sample of pervious concrete cylinders. In this sample there is a control mixture where the mixture does not have any additive which is used to compare with the other designs that do from this first sampling.

Table 1. Basalt Gravel Control Cylinder Mixture Measures for First Sample

Basalt Gravel Control	
Water	239.9 g
Cement	593.4 g
Aggregates	2,865.1 g
W/C	0.404

Table 2. Limestone Control Cylinder Mixture Measures for First Sample

Limestone Control	
Water	250.2 g
Cement	599.7 g
Aggregates	2,723.4 g
W/C	0.417

Table 3. Basalt Gravel with Additive Cylinder Mixture Measures for First Sample

Basalt Gravel with Additives	
Water	178.2 g
Cement	867.7 g
W/C	0.205
Glenium	5 ml
VMA	4 ml

Table 4. Limestone with Additive Cylinder Mixture Measures for First Sample

Limestone with Additive	
Water	250.2 g
Cement	862.6 g
W/C	0.290
Glenium	5 ml
VMA	4 ml

Continuing are the next mixture measurements designs for the second sampling of pervious concrete cylinders, which as well as the first sampling, have a control mixture for comparison.

Table 5. Basalt Gravel Control Cylinder Mixture Measures for Second Sample

Basalt Gravel Control	
Water	407.7 g
Cement	1,017.7 g
Aggregates	5,017.7 g
W/C	0.4

Table 6. Limestone Control Cylinder Mixture Measures for Second Sample

Limestone Control	
Water	383 g
Cement	887.7 g
Aggregates	4,498 g
W/C	0.43

Table 7. Basalt Gravel with Additive Cylinder Mixture Measures for Second Sample

Basalt Gravel with Additives	
Water	337.2 g
Cement	992.1 g
W/C	0.34
Glenium	2 ml
VMA	2 ml

Table 8. Limestone with Additive Cylinder Mixture Measures for Second Sample

Limestone with Additive	
Water	434.1 g
Cement	991.6 g
W/C	0.437
Glenium	2 ml
VMA	2 ml

Further, the mixture measurements designed for the pervious concrete slab are used to determine its infiltration rate. This represents a varied percentage, as the permeability of pervious concrete, although dependent on the aggregate particle size, is also influenced by compaction and setting segregation that can occur during the moulding process (Figure 2).

Figure 2. Pervious Concrete Slabs

The water/cement (w/c) ratio was set at 0.24 because, among the examined research, it yields the greatest outcomes when combined with the number of aggregates. Ratios set at 0.45 are excessive, resulting in an excess of fluid paste that clogs the pores, which are a crucial component of the investigation.

Table 9. Basalt Gravel with Additive Slab Mixture Measurements

Basalt Gravel with Additives	
Water	1,745.5 g
Cement	4,061.9 g
Aggregates	18,856.8 g
W/C	0.43
Glenium	4 ml
VMA	6 ml

Table 10. Limestone with Additive Slab Mixture Measurements

Limestone with Additives	
Water	1,340.4 g
Cement	3,644.8 g
Aggregates	17,057.6 g
W/C	0.37
Glenium	3 ml
VMA	6 ml

VI. Testing Conducted

1. ASTM-C1701 (Infiltration Rate): Serves as a crucial tool for evaluating the performance of pervious concrete over time. By conducting tests at consistent locations across multiple years, potential reductions in infiltration rate can be detected, signaling the need for remediation measures. It's important to note that the infiltration rate obtained through this method is applicable only to the specific area of the pavement where the test is conducted. To ascertain the infiltration rate of the entire pervious pavement, testing must be conducted at multiple locations, with results averaged accordingly. The field infiltration rate is typically determined by the design engineer, considering the anticipated precipitation event as per the project's design specifications. However, it's worth mentioning that this test method does not directly measure the impact of void sealing near the bottom of the pervious concrete slab on the in-place infiltration rate. For assessing void sealing, visual inspection of concrete cores remains the preferred approach, providing valuable insights into the condition of the pavement structure.
2. ASTM-C1549 (Solar Reflectance): Method to measure how much sunlight bounces off a flat, solid surface (solar reflectance). This matters because solar reflectance affects how hot the surface gets. A surface that reflects a lot of sunlight (high reflectance) will stay cooler than one that absorbs most of the sunlight (low reflectance). The test uses a portable device and is useful for both new materials and checking how a surface's reflectance changes over time due to wear and tear.
3. ASTM-C39 (Compressive Strength): Delineates a test method for determining the compressive strength of cylindrical concrete specimens. It underscores caution in interpreting results, noting that strength is influenced by various factors including specimen size and shape, mixing procedures, curing conditions, and more. The method is applicable to specimens prepared and cured according to specific practices and test methods. Results are utilized for quality

control, compliance assessment, evaluation of admixture effectiveness, and similar purposes. Personnel conducting acceptance testing must meet certification requirements outlined in Practice C1077. The scope is limited to concrete with a density exceeding 800 kg/m3. Measurement units can be either SI or inch-pound, with safety considerations emphasized, especially concerning concrete fragments during specimen rupture. As with any standard, safety practices and regulatory compliance should be observed.

4. ASTM D2434-68 Permeability Granular Soils (Head): Outlines a method for determining the coefficient of permeability in granular soils through a constant-head technique, focusing on laminar water flow. Its goal is to provide representative values for the permeability coefficient of granular soils commonly found in natural deposits and used in engineering projects like embankments and pavements. The standard details of the apparatus required, specimen preparation procedures, and testing protocols. It emphasizes limiting consolidation effects by restricting the soil types tested to those with less than 10% passing the 75-m (No. 200) sieve. Users are reminded to establish appropriate safety measures and regulatory compliance before applying this standard.
5. ASTM-C1688 (Density and Void Content): Outlines a procedure for assessing the density and void content of freshly mixed pervious concrete, particularly useful for verifying mixture proportions. It is applicable to mixtures with coarse aggregate sizes up to 25 mm. The test involves a standard consolidation process to measure fresh density and void content. Notably, results should not be construed as representing in-place characteristics of pervious concrete. Additionally, it emphasizes the importance of consistent application procedures.
6. ASTM C-136 - Sieve Analysis: Method for conducting sieve analysis on fine and coarse aggregates, crucial for determining their grading and compliance with specifications. The results aid in controlling aggregate production and developing relationships related to porosity and packing. However, it's noted that for materials finer than the 75-µm sieve, Test Method C 117 should be utilized. Additionally, the standard includes instructions for aggregates with both coarse and fine fractions. It's important to note that while SI units are the standard, inch units are provided for reference. As with any standard, safety considerations should be observed by users.
7. ASTM C127 - Specific Gravity and Absorption of Coarse Aggregate: Specifies a method for determining the relative density (specific gravity) and absorption characteristics of coarse aggregates. Relative density is crucial for calculating the volume occupied by aggregates in various mixtures, while absorption values indicate the change in mass due to water absorbed in the pore spaces within the particles. The standard distinguishes between oven-dry (OD) relative density, saturated-surface-dry (SSD) relative density, and apparent relative density. It's noted that the absorption values obtained may vary based on conditioning methods, such as boiling water or vacuum saturation. The scope excludes lightweight aggregates meeting specific criteria. SI units are standard for measurement. As with any standard, safety precautions should be observed.

VII. Analysis and Results

Before designing the pervious concrete mixtures, quality control tests should be conducted on the aggregates to be used. In this case, the aggregates are two types: Basalt Gravel and Limestone (Figure 3).

The first analysis conducted on the aggregates mentioned above was the Sieve Analysis (ASTM C-136). In this test, the aggregate is passed through four sieves of different sizes to determine the amount in grams and the percentage of aggregates of each size. This information is then used to select the appropriate particle sizes for the design specifications.

Figure 3. Pouring Basalt Gravel Aggregate into Sieves for Particle Size Analysis

Table 11. Sieve Analysis for the Basalt Gravel Aggregate

Sieve (mm)	Retained (g)	Cumulative Ret.	Cum. (%)	Passing (%)
19 (3/4in)	631.1	631.1	18.53	81.46
9.5 (3/8in)	1875.5	2506.6	73.60	26.39
6.3 (1/4in)	677	3183.6	93.48	6.51
4.75 (No.4)	157.9	3341.5	98.12	1.87
Pan	63.8	3405.3	100	0

Table 12. Sieve Analysis for the Limestone Aggregate

Sieve (mm)	Retained (g)	Cumulative Ret.	Cum. (%)	Passing (%)
19 (3/4in)	0	0	0	100
9.5 (3/8in)	5.9	5.9	0.39	99.60
6.3 (1/4in)	481.4	487.3	32.89	67.10
4.75 (No.4)	555.4	1042.7	70.39	29060
Pan	438.6	1481.3	100	0

The second quality control test conducted for the coarse aggregates used in the research was the Specific Gravity and Absorption Test (ASTM C127), which measures the water absorption capabilities of the aggregates. This test involves completely saturating the aggregates by submerging them in water for at least 24 hours, then weighing them. Afterward, the aggregates are dried completely in an oven at around 110-120°C for at least 24 hours or until dry and weighed again. The aggregates are also weighed in their natural state

Figure 4. Aggregates in Oven for Drying

Table 13. Specific Gravity and Absorption Test Results for Both Aggregates Used

	Basalt Gravel	Limestone
A= Mass of Oven-Dry Sample in Air	1533.4	805.6
B= Mass of Saturated Surface-Dry Sample in Air	1586.5	852.8
C= Mass of Saturated Sample in Water	1159	654.2
Bulk Specific Gravity = A/(B-C)	3.58	4.05
Bulk Specific Gravity (SSD) = B/(B-C)	3.71	4.29
Apparent Specific Gravity = A/(A-C)	4.09	5.32
Absorption % =((B-A)/A) X 100	3.46	5.85

Third and final quality control test done for both aggregates used in this research was the Bulk Density “Unit Weight” and Voids Test (ASTM C-29) which determines the density of the aggregate to know the strength of the aggregates since the coarse aggregate is the biggest source of strength in the pervious concrete, the results shown the average for this test was 1800 kg/m3 See Figure 5.

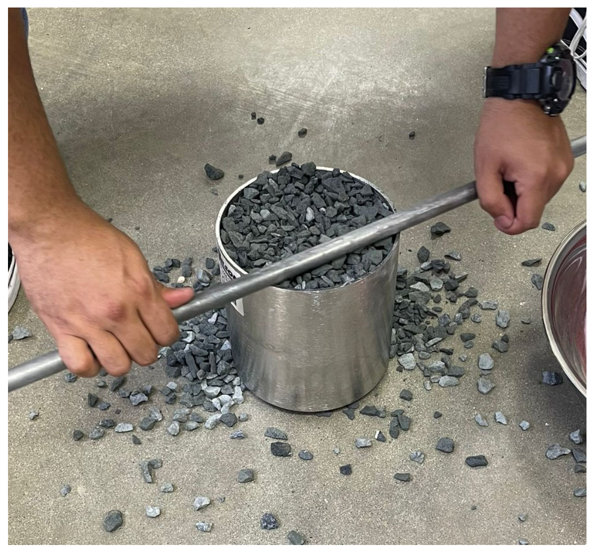

Figure 5. Basalt Gravel being Compacted by Rod in Cylinder Mold for the Bulk Unit Weight Test

The compressive strength of concrete without fines for porous concrete without additives ranges from 1550 to 2300 PSI with a water/cement (w/c) ratio of 0.36. The compression test was conducted on the pervious concrete cylinders, and the results are shown below. The basalt gravel presented better results compared to limestone.

Table 14. Compression Capacity of Basalt Gravel Pervious Concrete Mixture Designs

Basalt Gravel	Maximum Load
No Additives	1900 lb/in2
With Additives	1975 lb/in2

Table 15. Compression Capacity of Limestone Pervious Concrete Mixture Designs

Limestone Gravel	Maximum Load
No Additives	1800 lb/in2
With Additives	1850 lb/in2

Thermographic Analysis (Empirical Test) revealed a significant difference in heat absorption between the permeable concrete cylinders. This difference could play a role in mitigating the urban heat island effect, suggesting potential environmental benefits.

Thermographic test on the Limestone Cylinder Sample present in Figure 6 the central object in the image is emitting heat, as indicated by the color gradient from purple (cooler) to yellow and white (hotter). The temperature readings show approximately 102°F in the top left corner and 99.9°F in the bottom right corner. There is also a value of 0.60 displayed near the top left corner, and the number "120" is visible in the top right corner.
Remember that the key factors contributing to urban heat islands include :Buildings and Infrastructure: Materials like concrete and asphalt absorb and re-emit heat, contributing to higher temperatures, other one is lack of Vegetation: Trees and plants provide shade and cooling through evapotranspiration, which is often missing in urban areas, and the other important is human Activities: Activities such as transportation, industrial processes, and air conditioning release additional heat into the environment

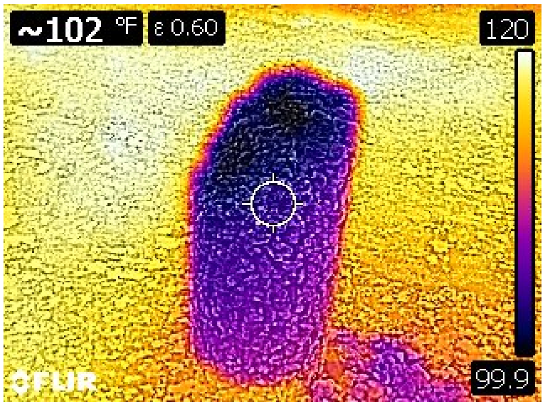

Figure 6. Thermographic test on the Limestone Cylinder Sample

Figure 7 shown, top left corner: approximately 107°F, top right corner: 125°F, and bottom right corner: 106°F.
Emissivity (ε): The value of 0.60 indicates the surface's ability to emit thermal radiation.

The thermal image shows temperature variations on the pervious concrete surface. The cooler central area (dark spot) indicates lower temperatures, possibly due to water infiltration, which cools the surface. The surrounding warmer areas (yellow and orange) suggest higher temperatures, typical of urban heat islands where surfaces like concrete absorb and retain heat.
High Porosity: Pervious concrete is made with large aggregates and little to no fine aggregates, creating a network of voids that allow water to flow through.
Environmental Benefits: It helps manage stormwater, reduces the need for drainage systems, and minimizes the risk of flooding. It also helps filter pollutants from runoff water.

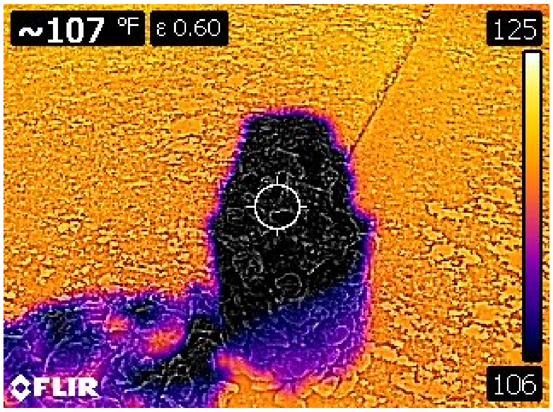

Figure 7. Thermographic test on the Basalt Gravel Cylinder Sample

In the testing of the pervious concrete, two tests were conducted: the compression test and the infiltration test.
For the permeability test, a volume of 4,000 mL of water was used. In the first cylinder, containing limestone aggregate, it took 18 seconds for the water to fully pass through. For basalt aggregate, the permeability test showed that 4,000 mL of water passed through in 50 seconds.

According to the results, the samples analyzed meet the permeability requirements, as the precipitated water percolated efficiently in both samples in a short period of time. The samples' high permeability is attributed to their short vibration period of only 15 seconds. According to the literature, reduced vibration inhibits paste segregation because this type of mixture has few binders [6].

This explains the efficiency of the permeability test, as attention was given to the vibration of the analyzed samples, allowing the concrete to fulfill its principal role of permitting water percolation through its structure. Another component

investigated was the relationship between the proportion of aggregates and the water/cement (w/c) factor. The low cement consumption, with no fines and greater consumption of coarse aggregates, together with decreased water consumption in the mixture, results in a paste with a high void ratio. As a result, the pores in the concrete structure can infiltrate the water that passes through them. Finally, when the three samples were compared, it was discovered that the sample with the largest aggregate diameter (15 to 20 mm) allowed water to precipitate in the shortest time. Furthermore, the shorter the water percolation time, the greater the diameter of the gravel [7].
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VII. CONCLUSION.

This investigation enabled certain conclusions to be drawn regarding what was intended and achieved, which are described more below. Regarding the destructive tests, it was discovered that there is a bigger variety in the findings than what is accomplished in test specimens of porous concrete, and this variation is explained by the high rate of voids, which is a key aspect of this form of concrete. In this regard, the compressive strength findings from this study remained in the region below 2000psi, indicating what is thought to be low resistance. Permeable concrete, on the other hand, falls with strengths ranging from 2.8 to 13 MPa. It is obvious that additional research is required to increase the strength of porous concrete. However, the capacity of these concretes to enable water to percolate through them is the fundamental goal sought after. Given that the findings of the permeability test were positive, it was found that permeable concrete behaved well as a draining medium in the mixes that were studied. As a result, it may be possible to use some additions to increase the mechanical resistance without reducing the permeability factor in the upcoming comprehensive surveys, as well as a specific number of fine particles. Given that the findings of the permeability test were positive, it was found that permeable concrete behaved well as a draining medium in the mixes that were studied. As a result, it may be possible to use some additions to increase the mechanical resistance without reducing the permeability factor in the upcoming comprehensive surveys, as well as a certain quantity of fine particles. Additionally, it should be emphasized that the three combinations utilized in this study did not produce results

that were noticeably variable because they provided values that were almost the same for virtually all the evaluated parameters. Consequently, the qualities of the material are not significantly influenced by the difference in diameter from the greatest to the smallest. Based on all that was said regarding the primary goal of this study, it was determined that permeable concrete is unquestionably an option to floods brought on by the effects of urbanization in Kathmandu Metropolitan City (KMC) because it has attained its primary property, permeability. It should be mentioned that the mechanical qualities of this kind of concrete can be enhanced by the addition of minerals, chemicals, and fibers, enabling it to function well by combining resistance and permeability.
In the study of pervious concrete using two types of aggregates—basalt and limestone—it was found that the size and type of aggregate significantly influence the concrete's properties. Basalt, being the larger aggregate, demonstrated superior performance in terms of permeability and compressive strength compared to limestone.

Permeability: The larger basalt aggregates allowed for better water infiltration, making the concrete more effective in managing stormwater and reducing runoff.

Compressive Strength: Basalt aggregates contributed to higher compressive strength, enhancing the durability and structural integrity of the pervious concrete.
Aggregate Size: The larger size of basalt aggregates (15 to 20 mm) compared to limestone (9.5 to 12.5 mm) played a crucial role in achieving these improved properties.

Overall, the use of larger basalt aggregates in pervious concrete offers significant advantages in terms of both permeability and strength, making it a preferable choice for applications requiring efficient water management and robust structural performance.

Basalt is a durable material that can withstand high temperatures and harsh weather conditions. Its longevity reduces the need for frequent replacements, which can contribute to lower overall heat emissions from construction activities.
Pervious concrete with basalt can be integrated with green infrastructure, such as green roofs and walls, to further mitigate the UHI effect. The combination of reflective surfaces and vegetation can significantly lower urban temperatures

Incorporating basalt into pervious concrete offers significant advantages in mitigating the urban heat island effect. Its permeability, thermal properties, and durability make it an effective material for creating cooler, more sustainable urban environments.

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