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Evaluating the Effect of Particle Gradation on Concrete's Permeability, Absorption, and Ultrasonic Properties

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Abstract
This research investigates the effects of utilizing dune sand from the Algerian Sahara, a widely available material, as a partial replacement for traditional construction sand on essential physical properties that influence concrete durability. To evaluate the concrete's performance, physical properties such as permeability, capillary absorption, and sound velocity were measured. Construction sand from the Sidi Slimane area was combined with dune sand from the Taibet region in varying proportions (0%, 5%, 10%, 15%, and 20%). Findings revealed that higher dune sand percentages positively affected dynamic acoustic test results by filling void spaces with fine particles, thereby enhancing concrete density and impermeability, which restricts water movement. Permeability tests showed reduced water infiltration with increased dune sand content, reflecting a decrease in void presence. However, capillary absorption rose with higher dune sand levels due to its capillary behavior. The influence of increasing dune sand content on absorption rates was evident, with increments of around 5.38%, 11.21%, 18.38%, and 25.11% relative to CSD0 concrete, after 48 hours of testing for CSD5, CSD10, CSD15, and CSD20, respectively. Consequently, each 5% addition of dune sand resulted in an approximate increase in absorbed water mass by 5.38%, 5.83%, 7.17%, and 6.72%, respectively. Overall, the mixture containing 20% dune sand significantly improved the acoustic and permeability properties, contributing to concrete durability, while formulations without dune sand displayed favorable capillary absorption results due to existing voids.
Keywords: Concrete, Dune Sand, Permeability, Capillary Absorption, Ultrasonic.

1. Introduction

In civil engineering, selecting suitable construction materials is essential for ensuring the durability, strength, and longevity of structures. Among various materials explored, dune sand has garnered interest due to its abundance in arid regions and potential as an eco-friendly alternative in construction (Abu Seif *et al*., 2016). Over the last two decades, dune sand has been widely studied across multiple countries (Liu & Jiang., 2020; Kaab *et al.*, 2023). In Algeria, numerous research projects have been initiated to address the depletion of natural resources by promoting the use of dune sand in the construction sector (Abadou *et al*., 2016; Mokhtari *et al.*, 2015), positioning it as a promising material for the future. Utilizing local materials that are underused or unused has become a necessary response to economic challenges, especially in developing countries (Bederina et *et al.*; Ofori, 2019).

The effects of high temperatures on building materials and structures, as well as solutions to improve fire resistance, have been examined. The mechanical and physical properties of high-performance concrete containing fibers (polypropylene and date palm fibers) revealed their ability to reduce mass loss and mitigate thermal failures. The thermo-mechanical analysis of reinforced concrete walls highlighted the risk of delayed collapse due to the cooling phase and emphasized the importance of realistic models to assess fire resistance. Lastly, post-fire reinforcement with steel structures significantly increased the resistance of reinforced concrete columns under eccentric loads (Dimia *et al.,* 2023; Cherif *et al.,* 2024; Hamda *et al.,* 2023)

As the demand for building construction increases, so do the need for concrete and its constituents (Dawood & Jaber, 2022). Sand, in particular, is increasingly reused, raising environmental concerns and incurring preparation costs (Čajka & Marcalíková, 2021). Concrete structures often encounter significant durability challenges (Yucel, 2021; Kurtoglu *et al*., 2018), with permeability and capillary absorption being key factors (Al-Goody *et al.*, 2015). Water transport properties in concrete indicate the amount of water that can pass through its structure (Öz, 2018; Gesoğlu *et al*., 2014). Concrete’s permeability is closely related to its capacity for capillary absorption, which provides essential data on its durability (Wang *et al.*, 2022; Zerig *et al.*, 2023). Capillary absorption describes the movement of liquid through the concrete structure due to capillary suction (Ho & Chirgwin, 1996). Water saturation in concrete evolves with changing air humidity, which can adversely affect structural longevity (Liu, 2011). Porosity also significantly influences the rate of moisture transfer within concrete (Rabehi, 2014).

With ongoing infrastructure development, cement-based materials are being used in more challenging environments, increasing demands for durability. Water is a primary fluid that can penetrate concrete (Medina *et al*., 2013; Wang & Bao, 2015), with its movement in the pore network playing a key role in various types of ion erosion (Zhang *et al.*, 2021).

Numerous studies have examined concrete made with standardized sand versus dune sand, often highlighting the lower fineness modulus of dune sand (Tafraoui, 2009; Belferrag *et al.*, 2016). Research on using dune sand in concrete reveals its viability as a construction material, achieving satisfactory compressive strength and effective shear stress resistance in deep beams when properly reinforced. Additionally, dune sand enhances concrete workability, mechanical strength, and durability (Mohammed *et al.*, Guo *et al.*, 2023). Work has examined the use of dune sand as an alternative material for concrete, highlighting its effects on key properties such as slump, compressive strength, and durability. It finds that dune sand can be used up to 40% in concrete without significant negative impacts, although issues such as poor grading limit complete substitution. It shows that replacing fine aggregate with dune sand improves workability, increasing slump with higher content, but decreases strength, with a maximum reduction of less than 25% at complete replacement. In addition, absorption characteristics generally increase with more dune sand (Ahmad *et al.*, 2022; Al-Harthy *et al.*, 2007). When fine dune sand is adequately mixed, it can produce high-quality, durable concrete by reducing voids, closing pores, and aiding water absorption during mixing. Improving the physical properties of concrete by incorporating dune sand was done by a group of researchers. Sand is an abundant resource available in southern regions (Melais *et al.*, 2021).

Our work is important in promoting sustainable construction practices by using dune sand, an abundant resource in desert regions, as a substitute for non-renewable sands from valleys and seas, which are ecologically challenging. Key objectives include evaluating optimal dune sand substitution ratios to improve concrete properties such as strength, durability, and permeability while maintaining performance standards. By conducting detailed analyses of how different proportions of dune sand affect ultrasonic velocity, permeability, and water absorption, your research provides valuable information to civil engineering. In addition, you propose practical solutions, such as the use of special additives and adjustment of mix compositions, to mitigate potential negative effects, making your work a vital advancement in the field of concrete technology and resource optimization.

2. Methodologies

2.1.Material characteristics

2.1.1. Cement

The cement used in our study is CPJ CEM II/A 42.5, sourced from Ain Touta, Algeria. Known for its strength and adaptability, this cement is well suited for a range of construction applications. Key characteristics including chemical composition, fineness, setting time and compressive strength significantly influence the overall performance of the concrete mix. Detailed specifications of these properties, as described in the data sheet, are presented in Table 1. This information is essential to understand how cement improves the workability, strength and durability of the produced concrete.

Table 1 - Physical result tests on used cement (Bedadi &Bentebba, 2017**)**

Physical properties (kg/m^3)	Value	Chemical properties	Value
Specific gravity (g/cm^3)	3.08	Loss on ignition	8.0 ± 2.0
Blaine fineness (cm²/g)	3700-5200	Insolube residue	1.35 ± 0.65
Normal consistency (%)	26.5 ± 2.0	Sulphate content SO_3 (%)	2.5 ± 0.5
Expansion (mm)	≤3.0	Magnesium oxide content MgO (%)	1.7 ± 0.5
Shrinkage at 28 days (µm/m)	<1000	Chloride content (%)	0.02 - 0.05
Initial setting time (min)	150 ± 30	C3S	60 ± 3.0
Final setting time (min)	230 ± 50	C2S	15 ± 3.0
Compressive strength at 2 days (MPa)	≥ 10	C3A	7.5 ± 1.0
Compressive strength at 28 days (MPa)	≥ 42.5	C4AF	11 ± 1.0

2.1.2. Gravel

The gravel used in this study was sourced from the Haoud El-Hamra gravel pit. Two types of gravel were utilized: Gravel G1 (3/8) and Gravel G2 (8/15). Both types exhibit the same characteristics, which were applied consistently in the control samples.

2.1.3. Sand

Two types of sand were incorporated in this research: dune sand and alluvial sand. The dune sand (SD) originated from the El-Oued region, while the alluvial sand (SA) was obtained from the Sidi Slimane Touggourt sand pit in El-Oued Province. The study involved mixing these two sand types, with dune sand added in gradually increasing proportions of 0% (C0), 5% (C5), 10% (C10), 15% (C15), and 20% (C20). Table 2 summarizes the physical properties of these sands.

Table 2 - Physical Properties of Sands at Various Percentages

	S0	S5	S10	S15	S20	SD
Apparent density (g/cm^3)	1.81	1.8	1.79	1.78	1.77	1.63
Absolute density (g/cm^3)	2.5	2.5	2.5	2.5	2.5	2.5
Fineness modulus	2.33	2.27	2.21	2.16	2.09	1.11
Sand Equivalent (%)	74.07	75.19	76.25	77.33	78.42	95.83
Water absorption (%)	1.48	1.61	1.70	1.76	1.81	2.42

2.1.4. Water

For mixing this concrete, tap water sourced from the civil engineering laboratory at El-Oued University was utilized. This water is free from harmful and aggressive substances, as detailed in Table 3.

Table 3 - Chemical Characteristics of Water Used in the Sand Concrete Mixture (Mani *et al.*, 2021**)**

Salinity	PH	HCO_3^-	SO_4^{2-}	NO_3^-	Cl^-	Na^{2+}	K^{2+}	Mg^{2+}	Ca^{2+}
2799	7.75	124	755	14.5	755	536	31	125	242

2.2.Grading analysis

The grading analysis by sieving is a method used to evaluate aggregate size distribution, which involves passing the aggregate through a series of square-hole sieves arranged in descending order of size (Pham *et al.*, 2021). After sieving, grading curves are plotted to illustrate the cumulative weight percentages of grains that pass through each sieve (Elhag, 2020). The particle size distribution curves for the sands used in this study are shown in Figure 1. The grading analysis of the sand from Sidi Slimane indicates that the particle sizes are well distributed, with a fineness modulus of approximately 2.33. This sand falls within the granular classification, specifically limited to a range between 2.2 and 2.8, which is considered preferable (Bedadi, 2019). From the gradation curve, it is evident that all categories analyzed are positioned within the granular zones. In our study, we utilized five types of concrete, differentiated by their dune sand content:

- Concrete (CSD0): Free from dune sand.
- Concrete (CSD5): Contains 5% dune sand.
- Concrete (CSD10): Contains 10% dune sand.
- Concrete (CSD15): Contains 15% dune sand.
- Concrete (CSD20): Contains 20% dune sand.

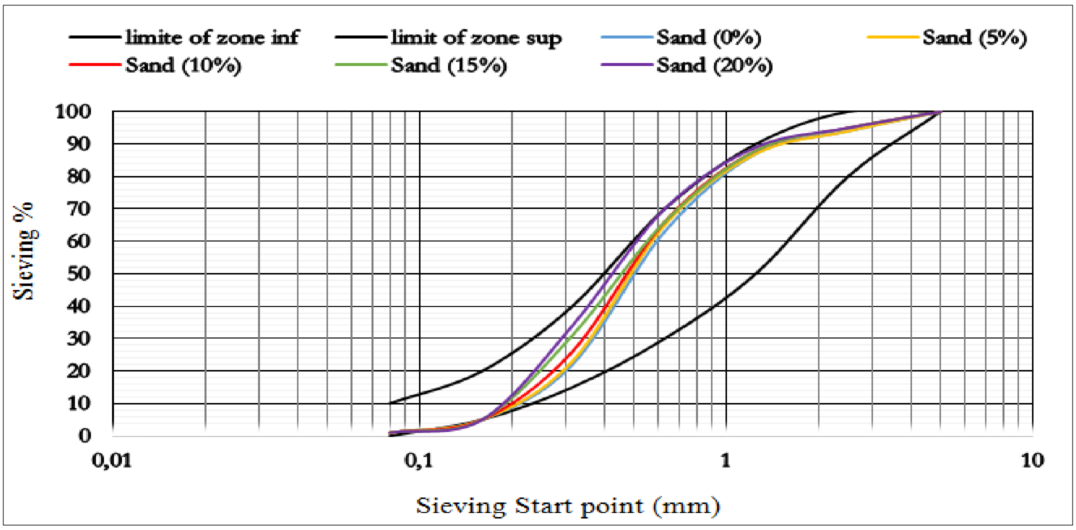

Figure 1 - Grading Curves for Different Types of Sand

2.3.Formulation of concrete

This method is primarily used for reinforced concrete structures. Since specifications usually define the cement quantity, the Faury method allows for the calculation of the appropriate amounts of aggregates and water (Vieira, *et al.*, 2011). The calculated values are shown in Table 4. The consistency of different concrete compositions was assessed using the Slump Test with Abrams' cone, adhering to the NF European standard (Norme Européenne, 2019). In this study, the superplasticizer percentage was adjusted to ensure that the slump cone drop remained consistent across all mixtures, with an evaluated drop of 10.5 cm. This adjustment was necessary because variations in the fineness modulus of the different sand formulations, caused by changes in the number of fines, led to a reduction in concrete slump (ASTM International, 2004).

Table 4 - Percentages of Materials Utilized in Each Type of Concrete

Types of Concrete	Quantity of Cement (kg)	Dune Sand (kg)	Building sand (kg)	gravel 3/8 (kg)	Gravel 8/15 (kg)	Quantity of Water (l)	W/C	Superplasticizer (%)	Slump (cm)
CSD0	350	0	711.87	198.3	912	171.5	0.49	0.36	10.5
CSD5	350	35.59	676.28	198.3	912	171.5	0.49	0.39	10.5
CSD10	350	71.19	640.75	198.3	912	171.5	0.49	0.42	10.5
CSD15	350	106.78	605.09	198.3	912	171.5	0.49	0.44	10.5
CSD20	350	138.27	553.10	220.38	912	171.5	0.49	0.49	10.5

3. Results and discussion

In this study, based on the nature of the tests to be performed, we utilized the following molds: 15×15×15 cm cube molds for the permeability test, 10×10×10 cm cube molds for the capillary absorption test, and 16×32 cm cylindrical molds for the ultrasound test.

3.1.Permeability

This test evaluates the depth of water penetration in 15×15×15 cm cubic specimens under a pressure gradient of 5 bars over a period of (72 ± 2) hours, as illustrated in Figure 2. The test was performed on specimens that were cured in air for 28 days. Pressure is applied to the center of the lower surface of the specimen. After 72 hours of pressure application, the specimens are split using the splitting tensile test, and the depth of water penetration is measured with a Vernier caliper.

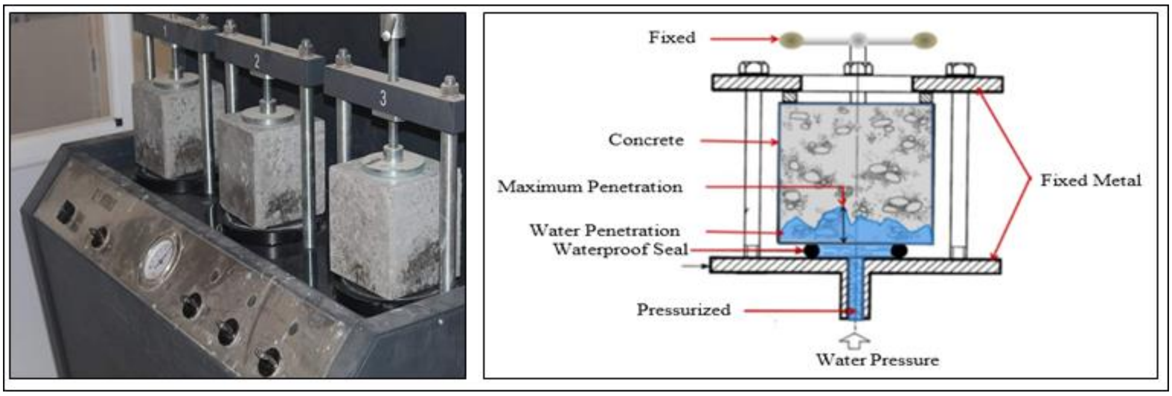

Figure 2 - Setup of the Sample in the Testing Apparatus

Permeability is characterized by Darcy's Law, as proposed by Henry Darcy (Eq 1). This law applies to incompressible fluids, like water, to describe unidirectional flow through a homogeneous porous medium. While concrete does not entirely meet the criteria for a homogeneous material at a microscopic level, it is still acceptable to treat it as homogeneous on a macroscopic level, thus allowing the application of Darcy's Law (Chen *et al.*, 2021).

$$K = \frac{Q.L}{A.\Delta h} \quad (1)$$

where Q is the rate of water flow (m^3/s); K is the hydraulic conductivity (m/s); A is the column cross section area (m^2); Δ his Pressure difference between the upstream and downstream of the specimen (m) and L Flow length (m).

The water permeability results of the different types of concrete are shown in Figure 3.

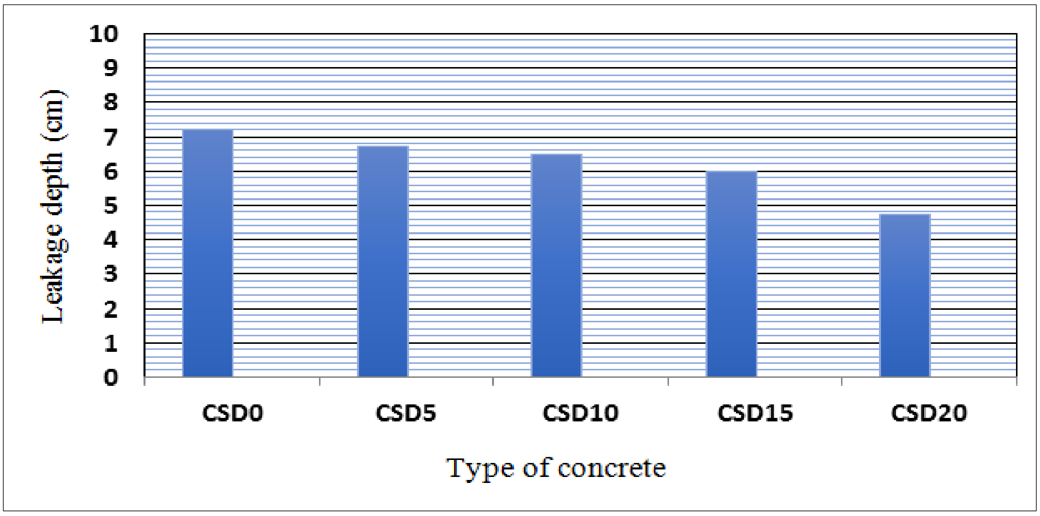

Figure 3 - Results of Water Permeability for Various Concrete Types

From Figure 3, we can see a consistent decline in the depth of water penetration in the samples as the proportion of dune sand increases. The outcomes of the water permeability tests indicate the concrete's effectiveness in resisting water intrusion, a phenomenon influenced by the concrete's gradation. The gradation plays a crucial role in determining the voids and pores present within the concrete, subsequently affecting its capacity for water absorption. For instance, concrete with larger aggregates tends to have bigger voids, facilitating easier water penetration, while a finer gradation with smaller aggregates leads to numerous tiny pores that reduce water absorption capacity. Furthermore, the water-to-cement ratio is a critical factor in determining water permeability; a higher ratio typically results in increased pore formation and permeability. In our research, we maintained a consistent water-to-cement ratio and standardized operational conditions across all mixtures by adjusting the proportions of superplasticizer, as detailed in Table 3, to mitigate the impact of the W/C ratio on the results. Following the application of Darcy's law to the concrete samples, the permeability coefficients for each were calculated, as shown in Table 5 and Figure 4.

The observed reduction in water permeability of concrete with higher fine sand content can be attributed to several factors:

- **Decrease in voids and pores:** Fine sand fills the gaps between larger aggregates more effectively than coarse sand, thereby minimizing the likelihood of water leakage.
- **Enhanced aggregate packing:** Fine sand improves the interaction with cement and water, creating a denser concrete mix and reducing water permeability.
- **Influence on cement paste properties:** The addition of fine sand can enhance the qualities of the cement paste, resulting in increased concrete strength and improved resistance to leakage.

Overall, the incorporation of fine sand leads to a denser concrete formulation with diminished water permeability, thereby enhancing the concrete's ability to prevent water infiltration.

Table 5 - Permeability Coefficient Values for Each Type of Concrete

	CSD0	CSD5	CSD10	CSD15	CSD20
hydraulic conductivity (m/s)	$3.547\ 10^{-11}$	$2.949\ 10^{-11}$	$2.385\ 10^{-11}$	$1.782\ 10^{-11}$	$8.3\ 10^{-12}$

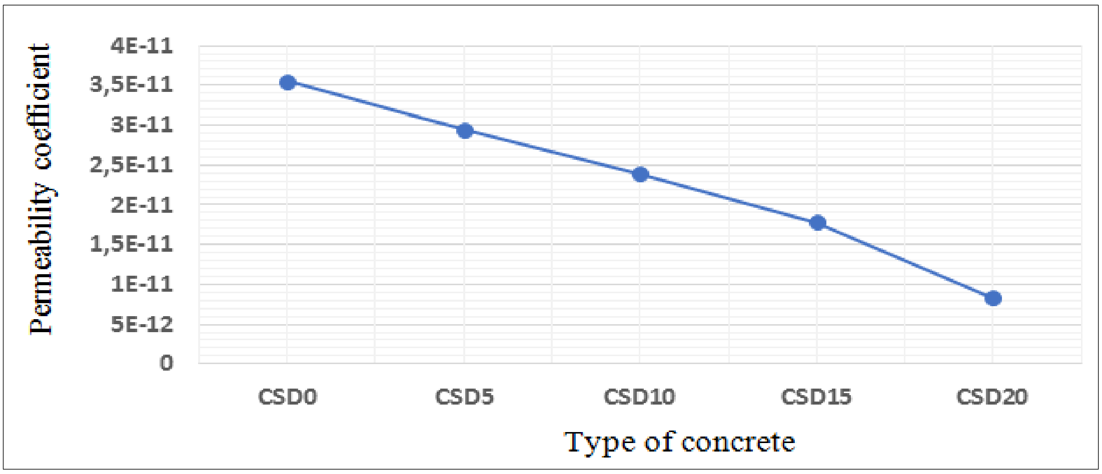

Figure 4 - Permeability Coefficient Values for Each Type of Concrete

3.2.Capillary Water Absorption

Capillary water absorption, also known as sorptivity, describes the process by which water penetrates through small pores in concrete composites due to surface interaction. This property provides critical insights into the microstructure and durability of cement-based materials. To determine the sorptivity coefficient of concrete specimens, a capillary water absorption test was performed in accordance with the standards set by TS EN 13057 and ASTM C1585-04.

Prior to conducting the absorbency measurements, the specimens, which were cubic in shape (10×10×10 cm), were preconditioned following the ASTM C1585-11 recommendations. This involved submerging the base of the specimens in a water layer 0.5 cm deep and tracking the changes in mass over time. To maintain a constant water level, an overflow system was used (as illustrated in Figure 5). The lateral surfaces of the specimens were waterproofed with a plastic film (adhesive tape), directing the water flow in a uniaxial manner and preventing evaporation from these faces. The mass of absorbed water was determined through successive weighings of the samples, ensuring that any residual water film on the underside of the specimen was removed using absorbent paper before each weighing.

The amount of water absorbed per unit surface area after one hour serves as a representative measure of the volume of the largest capillaries in the surface layer, as these capillaries are the most effective in water absorption. All tests were conducted under controlled laboratory conditions (temperature: (20 ± 20)°C and relative humidity: (45 ± 10%). Specimens were periodically removed from the testing apparatus at intervals of 5, 10, 15, 30, 45, 60, 120, 240, 480, 1440, and 2880 minutes, and each was weighed with precision to determine the quantity of absorbed water. The sorptivity index or coefficient for each concrete specimen was calculated according to established equations (Assié, 2004).

$$\mathrm{Cat} = \frac{\mathrm{Mt} - \mathrm{M0}}{\mathrm{A}} \tag{2}$$

$$\mathrm{S} = \frac{\mathrm{Ca2} - \mathrm{Ca1}}{\sqrt{\mathrm{t2}} - \sqrt{\mathrm{t1}}} \tag{3}$$

where;

Cat is the absorption coefficient at time t (kg/m^2); Mt is the mass of the specimen at a given time (kg); M0 is the initial mass of the specimen (kg), A is the surface area in contact with water (m^2) ; S is the sorptivity (capillary water absorption) ($kg\ m^{-2}s^{-1/2}$) and t is the time (h).

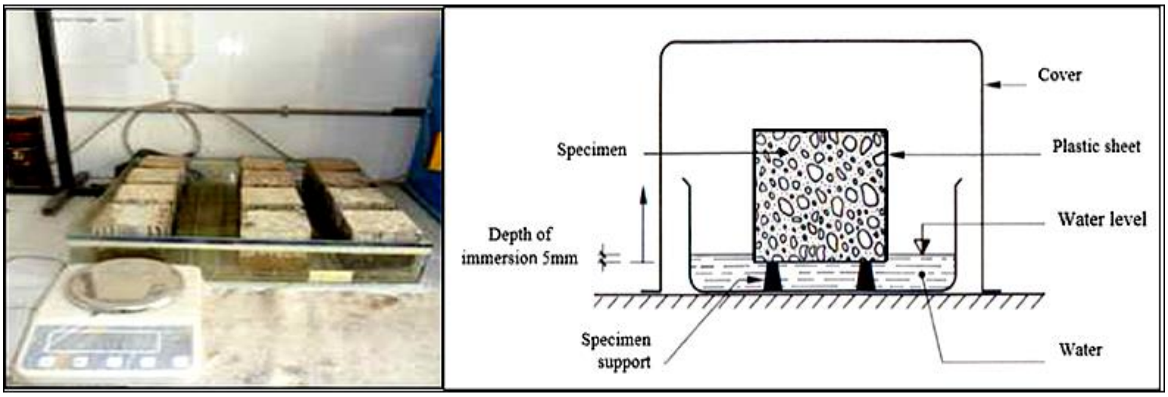

Figure 5 - Diagram of the capillary water absorption test

Two primary parameters influence water absorption in dry concrete: the effective porosity of the concrete and the rate of capillary rise absorption, commonly referred to as absorptivity.

The tests are conducted over duration of 48 hours. The frequency of measurements is higher during the initial hour, as this period exhibits the most significant water absorption. The kinetics of absorption is characterized by variations in the amount of water absorbed over time, as well as the square root of time. The water absorption kinetics for the different types of concrete studied are illustrated in Figures 6 and 7.

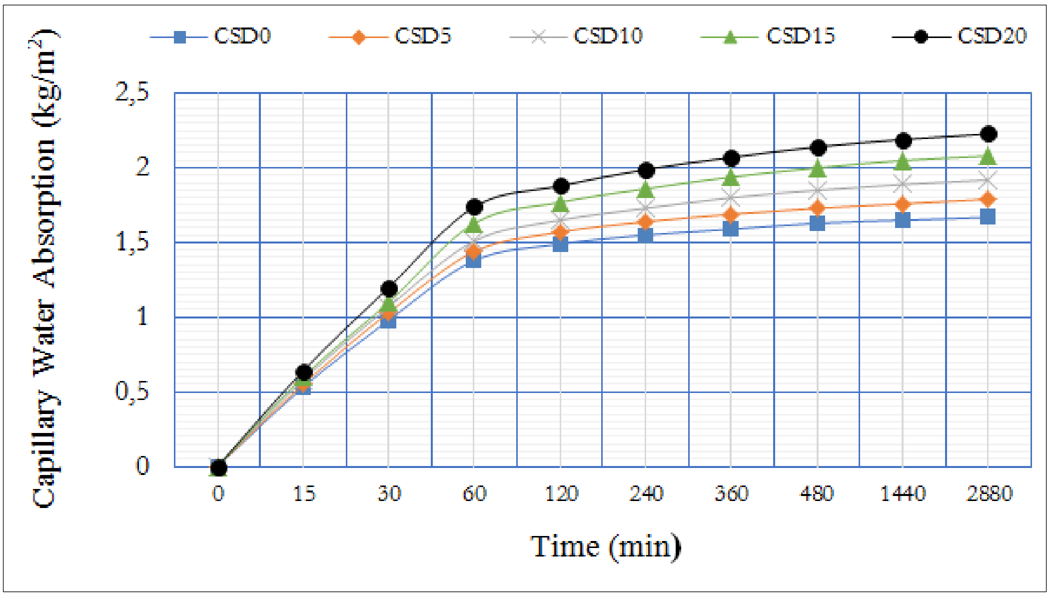

Figure 6 - Water absorption by capillary action for different types of concrete

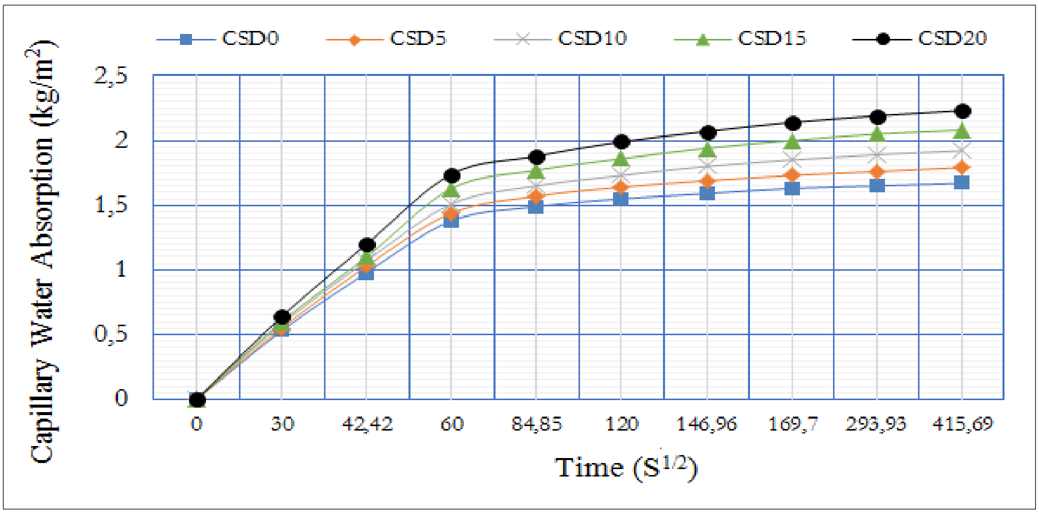

Figure 7 - Water absorption by capillary action

The downward slope indicates that, as the test progresses, increasingly finer capillaries are involved in the water absorption process. The results of the capillary water absorption tests suggest potential changes in the microstructure of the samples, which significantly impact water transport within the concrete.

The findings from the water absorption coefficient tests over time reveal a continuous progression in the curve for concrete. The absorption kinetics, expressed as the mass of water absorbed per unit surface area against the square root of time for different types of concrete, are clearly evident. From the first hour of the test, it is observed that the capillary absorption kinetics of all concrete types increase rapidly. This implies that a higher percentage of dune sand in the sample correlates with a higher initial absorption rate.

The increased quantity of fine grains contributes to a rise in the mixing water, which subsequently leads to greater evaporation and increased volumes of internal pores, ultimately resulting in a higher water absorption coefficient. Absorptivity, which refers to the rate of absorption by capillary rise, is calculated using Equation 3, derived from the curve by determining the slope of the line. The first absorption phase is recorded during the initial hour of the test, while the second phase assesses absorptivity between 1 hour and 48 hours.

In Table 6, it can be observed that the capillary absorptivity of all types of concrete is similar. The phenomenon of water absorption by capillarity is very significant from the first hour of the test. The increase in fine grains leads to an increase in the absorptivity coefficients S. It is concluded that the capillary absorption phenomenon is governed by the capillary pores (diameter, distribution, and quantity) and several characteristics influence water absorption in concrete, such as grain size, porosity, etc.

Table 6 - Water absorptivity (S) obtained for the different types of concrete

	Sorptivity (kg/m^2/s$^{1/2}$)				
	CSD0	CSD5	CSD10	CSD15	CSD20
First phase (0-1 hour)	0.023	0.024	0.025	0.027	0.029
Second phase (1-48 hours)	0.0008	0.00098	0.00115	0.00126	0.00137

The impact of increasing dune sand percentages on the absorption rate is evident in Figure 8. After 48 hours of testing, the absorption rates for concrete types CSD5, CSD10, CSD15, and CSD20 increased by 5.38%, 11.21%, 18.38%, and 25.11%, respectively, compared to CSD0. This indicates that for every 5% increase in dune sand, the mass of absorbed water rises by approximately 5.38%, 5.83%, 7.17%, and 6.72%.

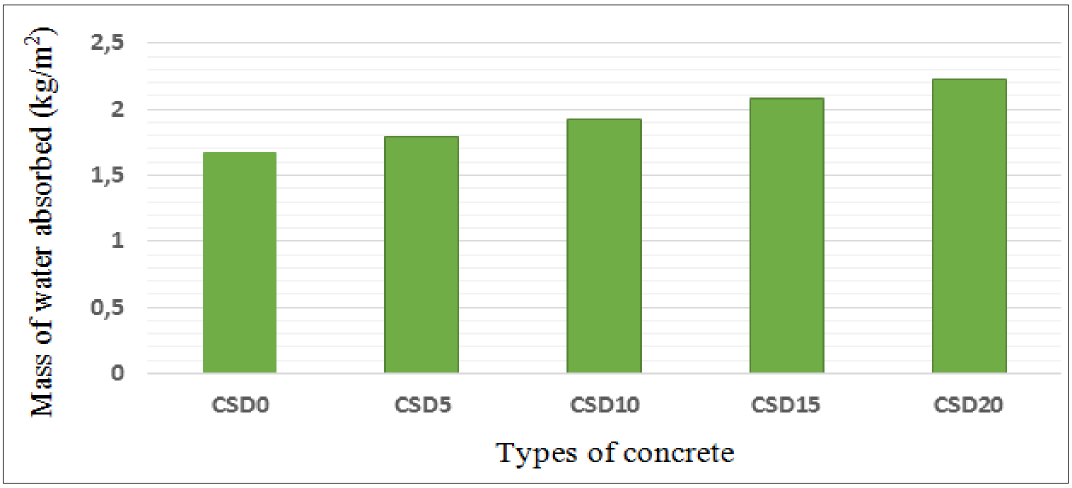

Figure 8 - Water absorption by capillarity after 48 hours for different types of concrete

3.3.Ultrasonic

The ultrasound non-destructive technique (NDT) is employed for assessing material strength, calculating the modulus of elasticity of concrete, and detecting internal defects such as cracks, voids, and gaps. This method also evaluates the homogeneity of concrete; measures the depth of concrete layers, and determines overall concrete quality by measuring ultrasonic velocity through the material as shown in Figure 9.

For this examination, cylindrical concrete specimens measuring 16 × 32 cm and aged 28 days are tested before being subjected to a compression test. The testing is conducted using a Pundit ultrasonic instrument, which generates ultrasonic pulses transmitted to the area under evaluation. The time taken for the pulses to propagate through the concrete is displayed digitally.

According to the specifications of BS1881, 1983, Part 116, a sound speed greater than 4400 m/s indicates that the concrete is of good quality and homogeneous. The surface wave velocity is measured using an ultrasonic pulse generator paired with two transducers (transmitter and receiver) operating at a frequency of 54 kHz. Velocities are calculated by measuring the time taken for a pulse to traverse the concrete surface.

This testing can be performed on laboratory samples or existing structures, with several factors influencing the results, including the surface condition and maturity of the concrete, the distance the wave travels, and the presence of reinforcement bars.

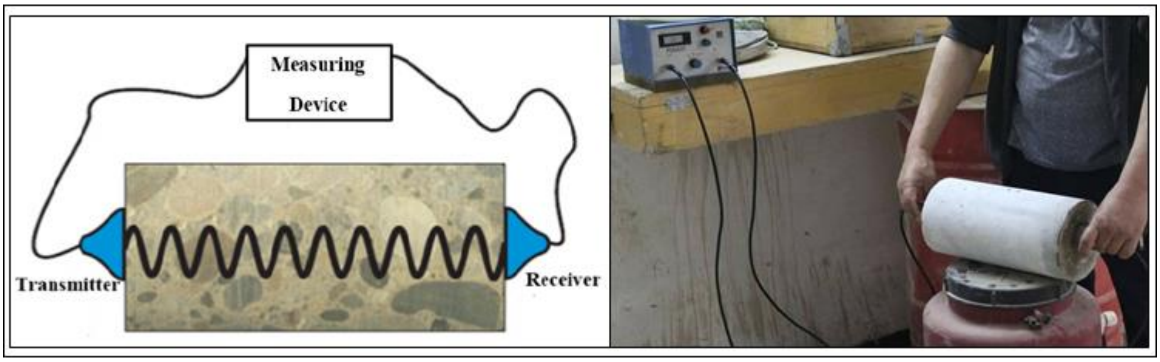

Figure 9 - Measure the speed of sound

Based on Figures 10 and 11, all concrete mixes demonstrated pulse velocities exceeding 4400 m/s in various tests, indicating excellent and homogeneous quality. Among these, the CSD20 mix exhibited the best results, while CSD0 showed the weakest performance. The curves illustrate a consistent increase in sound speed relative to the fineness modulus and over time, confirming the good quality of all concrete types.

Notably, sound speed for all samples decreases significantly before 28 days, but from 28 to 90 days, the decline is minimal, suggesting stabilization. This initial decrease is attributed to water evaporation, which creates internal pores that contribute to sound refraction. Figure 11 highlights an increase in sound speed with a higher proportion of dune sand. The presence of fine particles in the concrete mix positively influences sound speed by increasing mixture density; as fine particles fill voids, the samples become more compact.

Consequently, this densification enhances the concrete's hardness and resistance to external forces such as pressure and vibrations, thereby increasing strength and durability. Non-destructive testing methods facilitate quality control during construction and enable the indirect assessment of material characteristics, including strength, homogeneity, porosity, and durability. However, it is important to consider that higher mix density may also increase the concrete's final weight, potentially impacting the supporting structure and necessitating a more robust engineering design.

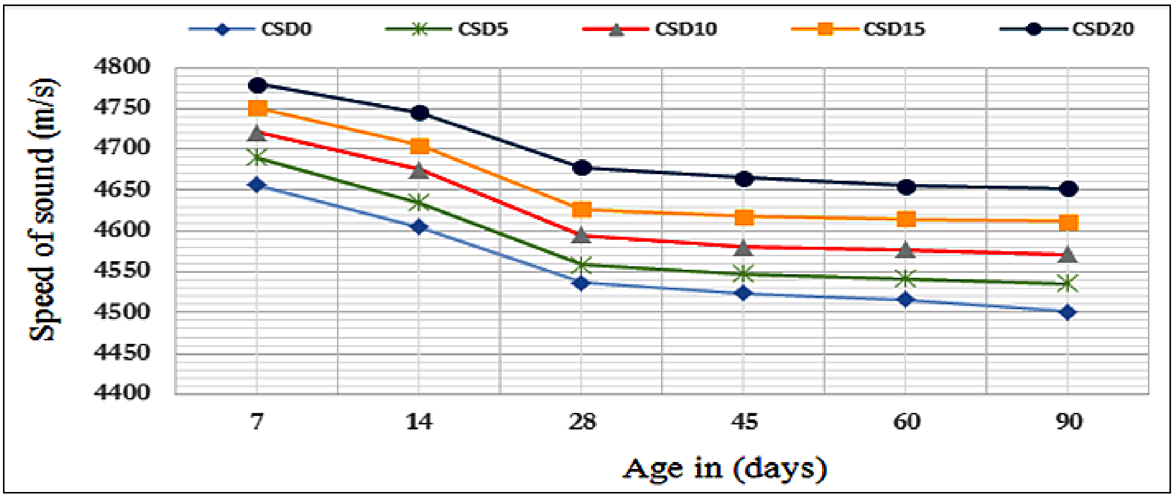

Figure 10 - Variation of the speed of sound as a function of age

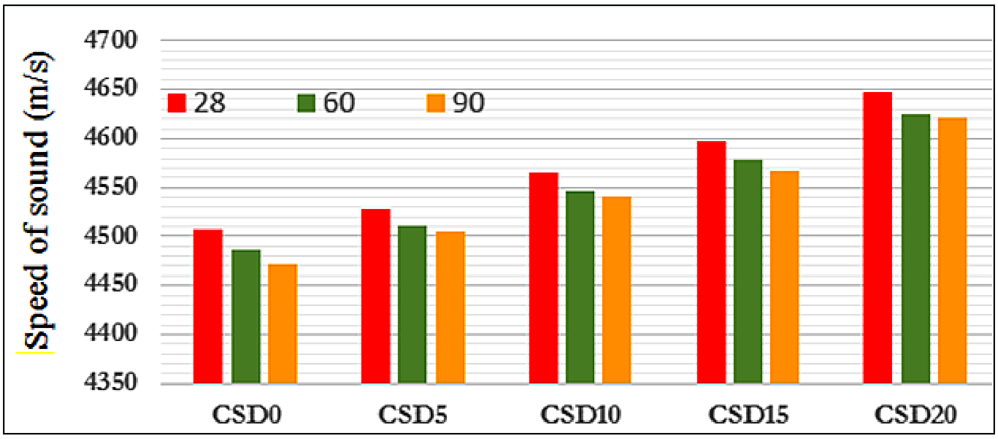

Figure 11 - Variation of the speed of sound function of type of concrete

4. Conclusion

The primary objective of this study was to improve the physical properties of concrete by incorporating the readily available dune sand found in desert regions, considering its potential for construction applications. This was achieved by blending dune sand with construction sand as a substitute for non-renewable valley and sea sands, which present environmental challenges. While utilizing dune sand as a major or complete replacement for natural sand can negatively affect performance, limited incorporation is feasible.

The optimal substitution ratio identified for most properties studied was 20% for ultrasonic and permeability tests. A linear relationship was observed between permeability and surface wave velocity in concrete, which becomes less accurate at lower proportions of dune sand. This relationship indicates that permeability decreases in proportion to ultrasonic velocities. However, in the absorption test, the sample without any dune sand demonstrated the best performance.

Adding dune sand in proportions of 5%, 10%, 15%, and 20% produced satisfactory results in dynamic auditory tests, outperforming the results achieved with 100% construction sand. An increase in the percentage of dune sand also correlated with a rise in sound speed, as the sand fills voids, enhancing the concrete's rigidity and cohesion. Additionally, these proportions showed improved results in permeability tests, with decreased water leakage as the dune sand content increased, attributed to reduced porosity.

Conversely, the absorption test revealed that higher percentages of dune sand led to increased absorption rates, with the mixture completely free of dune sand performing the best. This is likely because a higher quantity of fine sand particles creates additional fine voids, which enhances water absorption capacity. The incorporation of dune sand influences the internal structure of the concrete by increasing the presence of fine voids, resulting in greater water absorption.

To mitigate the effects of increased specific surface area and the presence of fine sand particles in concrete, several solutions can be considered:

- **Incorporating special additives**, such as powders with a fineness of less than 80 micrometers (e.g., brick powder, granite, or ceramic residues), to enhance concrete properties and minimize the negative impact of fine particles.
- **Adjusting the proportions of mix components**, including water, sand, and cement, to achieve the desired properties.
- **Using coarse sand instead of fine river sand** to lessen the impact of fine particles on the final properties of the concrete.

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