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PERFORMANCE EVALUATION OF HYDROPHOBIC CONCRETE USING SILICONE OIL EMULSION

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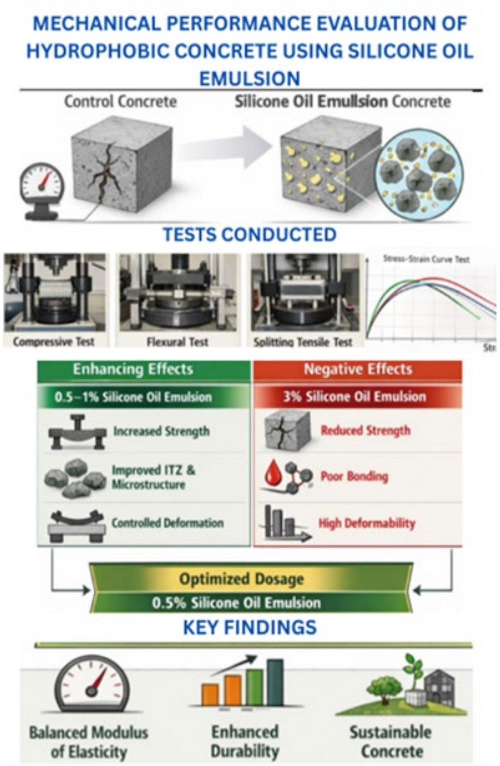
Graphical abstract



Abstract

The hydrophobic modification of concrete using internal admixtures has attracted considerable research interest, as such treatments can influence the internal characteristics of concrete and consequently affect its mechanical performance. In this study, the mechanical behaviour of hydrophobic concrete incorporating silicone oil emulsion as an admixture was experimentally evaluated. M30 grade concrete mixes were prepared with different dosages of silicone oil emulsion (0%, 0.5%, 1%, and 3% by weight of cement). The influence of silicone oil emulsion on workability, compressive strength, split tensile strength, flexural strength, and stress–strain behaviour was investigated at different curing ages. Stress–strain analysis was carried out to evaluate stiffness, peak stress, deformation characteristics, and elastic response. Compared with the control mix, the incorporation of silicone oil emulsion at moderate dosages (0.5–1%) improved the overall mechanical performance of concrete, resulting in higher strength and a favorable stress–strain response. Among the investigated mixtures, the 0.5% silicone oil emulsion mix exhibited the most balanced performance, with higher strength, controlled deformation, and satisfactory stiffness characteristics. However, the 3% dosage resulted in a reduction in strength and stiffness compared with the lower dosages. The results indicate that silicone oil emulsion can be used as a functional admixture to enhance the mechanical performance of concrete while supporting the development of more durable and sustainable construction materials.

Keywords: Hydrophobic concrete, Silicone oil emulsion, Mechanical properties, Modulus of elasticity, Stress-strain behavior, Sustainable concrete.

1.0 INTRODUCTION

Concrete is the most used building material in construction because of its adaptability, affordability, and capacity to satisfy a wide range of structural needs. However, the heterogeneous and porous microstructure of ordinary concrete, which controls stress transfer, crack initiation, and deformation behavior under load, has a significant impact on its mechanical performance [1,2]. Microstructural alteration is a key strategy for enhancing concrete performance since the existence of capillary pores and weak interfacial transition zones (ITZ) influences stiffness and post-elastic response in addition to strength development [18].
The internal structure of cementitious materials has been investigated in recent years by the addition of chemical and polymer-based admixtures. Among these, hydrophobic agents especially silicone-based materials have gained interest because of their capacity to modify pore surface properties and moisture interaction within the cement matrix[3,4]. When utilized as internal admixtures, silicone oil emulsions change internal pore surfaces without creating a continuous polymer film by

dispersing throughout the concrete matrix and partially fixing onto hydration products [5]. Silicone oil emulsions are different from regular polymer coatings and surface treatments due to their internal mechanism of action.

Prior research on cementitious materials treated with silicone oil has primarily focused on durability related performance, such as water absorption, permeability, carbonation resistance, and shrinkage behavior [3,6,7]. According to these investigations, silicone oil modifies internal moisture distribution and decreases capillary suction, which affects moisture transport within the matrix and modifies hydration behavior and pore structure. However, it has also been noted that adding too much silicone oil could negatively impact mechanical behavior by decreasing matrix bonding and interfering with cement hydration[6,8].

Concrete's strength development, stiffness, and deformation behavior can all be greatly impacted by the use of hydrophobic admixtures from a mechanical perspective. Optimal admixture dosages can preserve or improve compressive, tensile, and flexural strengths through better particle dispersion and decreased microcrack initiation within the cement matrix, according to research on concretes treated with polymers and organosilicon. The poor aggregate-paste bonding and partial hydration inhibition with higher dosages will show reduced strength and stiffness [8,10]. These results indicates that mechanical performance of hydrophobic concrete is mostly dosage dependent.

However, systematic research on the mechanical performance based on criteria such as stress-strain behavior and modulus of elasticity are rare in literature, despite an increasing number of studies focused towards hydrophobic concrete. This discrepancy has been demonstrated in studies incorporating silicone oil emulsion as an internal additive into concrete [19]. Despite the importance of such properties to structural design and performance, they are routinely excised without consideration for stiffness, ductility, peak stress or failure behavior in comparison with durability. It provides a complete knowledge of the elastic and post-elastic behavior of concrete under load, stress-strain analysis is important to capture strength properties [20].

Furthermore, from the point of view of mechanical efficiency, the application of silicone oil emulsion as an internal admixture can provide some prospect for sustainability. This in turn contributes towards economy of effort in concrete. Mix design by increasing the strength and ductility of concrete when less cement is used. Internal hydrophobic additives are added to the mix, to provide a one-time effect without needing additional materials and long-term maintenance, compared to surface applied treatments that either need extra material or occasionally some kind of renewal [4,7].

From the above review, it is evident that there is limited research on mechanical properties and stress-strain behavior of silicone oil emulsion hydrophobic concrete. To fill this knowledge gap, the present study is intended to analyze the impact of different doses of silicone oil emulsion on all these properties like compressive strength, split tensile strength, flexural strength and stress–strain behavior etc., of M30 grade concrete. Optimization of silicone oil emulsification in thermoset matrices to improve mechanical properties though maintaining an imposed level of stiffness and ductility is generally the focus here which is suitable for civil structures.

2.0 OBJECTIVE OF THE STUDY

This research aims to investigate if silicone oil emulsion is an appropriate internal hydrophobic additive for structural concrete applications and the influence of silicone oil emulsion on mechanical behavior of M30 grade concrete. The research in particular investigates the impact of different contents of silicone oil emulsions on concrete flexural, split tensile and compressive strengths. The stress-strain behavior of hydrophobic concrete is also examined in order to understand changes in stiffness, peak stress, deformation characteristics, and modulus of elasticity under compressive loading. The research also intends to validate the role of silicone oil emulsion in enhancing concrete performance through decreased material-related inefficiencies and improved microstructural efficiency, thereby contributing to sustainable concrete, by enabling improved mechanical efficiency without increasing cement content or resource consumption.

3.0 NOVELTY OF THE STUDY

Hydrophobic concrete has gained attention in recent years because of its durability improvement and less water ingression. Most of the existing studies have mainly focused on durability properties like carbonation resistance, moisture related deterioration and permeability of concrete. Even though these researches have proved the efficiency of silicone-based materials in enhancing durability, their influence on the mechanical response of concrete has not been explored to the same level. In particular, information on stress–strain behavior, stiffness characteristics, and modulus of elasticity remain inadequate when silicone oil emulsion is used as an internal admixture. Since these properties are vital in structural applications, a better knowledge of the mechanical behavior of hydrophobic concrete is required. Therefore, this study inspected the effect of different silicone oil emulsion dosages on the strength and stress–strain characteristics of M30 grade concrete and recognizes the dosage that provides a balance between hydrophobic performance and mechanical efficacy.

4.0 EXPERIMENTAL INVESTIGATION

4.1. Materials

In the present study, to generate a hydrophobic concrete mix (HM) OPC 53 grade conforming to IS: 12269-2013 was used as the main binder [11]. The chemical and physical properties of the cement are mentioned in Table 1 and Table 2. The fine aggregate used was natural river sand from Zone II according to IS: 383-2016 [12], which had satisfactory grading and density appropriate for structural concrete. Coarse aggregates consisted of 12 mm and 20 mm crushed angular granite in standard proportions to provide improved packing density and strength characteristics. The potable tap water was used for mixing as well as curing and meets the requirements of concrete preparation according to IS: 456-2000 [13].

Table 1 Chemical Composition of cement

Oxides	Cement
CaO	65.66
SiO_2	21.23
Al_2O_3	5.31
MgO	0.94
LOI	1.62
SO_3	2.61
Fe_2O_3	4.68
Na_2O	0.16
K_2O	0.64

Table 2 Physical properties of cement

Parameters	Cement
Relative density	3.13
Initial setting time (min)	68
Final setting time (mm)	220
Consistency (%)	32

A commercial Silicone Oil Emulsion 30 obtained from DRP Silicone Pvt. Ltd., Mumbai, was used as the hydrophobic admixture. Silicone-based waterproofing agents are known for their strong chemical stability and internal hydrophobic modification capability in cementitious composites. Four different hydrophobic concrete Mix (HM) are under investigation using silicone oil emulsion at 0%,0.5%,1% and 3% by weight of cement. The properties of the silicone oil emulsion are provided in Table 3.

Table 3 Physical properties of silicone emulsion

Properties	Silicone emulsion
Chemical Nature	Dimethyl poly-siloxane
Specific gravity	0.98
Nature	Non-ionic
PH	6-8
Diluents	Water
Solids	30%

A naphthalene-based superplasticizer sourced from a local supplier in Vijayawada. It was used to improve the workability for achieving required slump without adding more water content. Previous studies have shown the use and scope of high-range water reducers within hydrophobic concrete systems.

4.2. Mix Design

The mix design for M30 grade concrete was carried out as per IS 10262:2019 guidelines [14]. A target water-cement ratio of 0.45 was adopted to achieve a medium workability of about 75 mm slump. The quantities of materials were proportioned to 448 kg/m³ of cement and 197 kg/m³ of total mixing water. Four different mixtures were prepared, one control mix without hydrophobic agent (0%) and three hydrophobic concrete mixes (HM) containing 0.5%, 1% and 3% silicone oil emulsion 30 by weight of cement. Since the silicone oil emulsion 30 consists of 30% active silicone content and 70% water, the total water content was adjusted in each hydrophobic mix by considering extra water contributed due to the emulsion so that the effective water–cement ratio remains constant as 0.45 for all mixes. All the other material quantities such as fine aggregate, coarse aggregate and superplasticizer were kept constant for all the mix combinations (Table 4).

Table 4 Mix proportions of Control mix and Hydrophobic Concrete Mix

Materials	Control mix	HM-0.5%	HM-1%	HM-3%
Cement	447.74	447.74	447.74	447.74
Fine aggregate	798.81	798.81	798.81	798.81
12mm Coarse aggregate	403.36	403.36	403.36	403.36
20mm Coarse aggregate	604.04	604.04	604.04	604.04
Water	197	195	192.52	183.56
Super plasticizer	2.23	2.23	2.23	2.23
Silicone emulsion	-	2.23	4.47	13.43

5.0 METHODS

5.1. Workability

In compliance with IS 1199:1959, the slump cone test was used to evaluate the workability of fresh concrete [15]. For every concrete mix, the test was carried out right away after mixing. Fresh concrete was poured into the slump cone in three layers, each of which was evenly tamped to guarantee adequate compaction. The slump was calculated as the difference between the height of the concrete specimen and the cone after the cone was raised vertically. By varying the dosage of the naphthalene-based superplasticizer while maintaining a constant effective water-cement ratio, a goal slump of roughly 100 mm was achieved for all mixes. The impact of silicone oil emulsion on the fresh characteristics of concrete was evaluated using the workability data.

5.2. Compression Strength Test

The compressive strength test of the concrete is conducted using 150 mmx150 mmx 150 mm cube specimens in compliance with IS 516:1959 [16] (Figure 1). Cube specimens were cast for each combination, compacted using a vibrator and then demolded a day later. The specimens were cured in water at 27 ± 2°C until they reached testing age. A calibrated compression testing apparatus was used to perform compression strength at 7 and 28 days. Before conducting the test surface area of the concrete is wiped clean. Up to failure, the load was applied consistently and uniformly. For every mix and testing age, the provided compression strength values are the mean of three specimens.

Figure 1 compression testing of cube specimen

5.3. Split Tensile Strength Test

In compliance with IS 5816:1999, cylindrical specimens of 150 mm in diameter and 300 mm in height were used to calculate the split tensile strength of concrete [17](Figure 2). After being appropriately compacted and cast in molds, the specimens were demolded after a day. The specimens were then cured in water at 27 ± 2°C until they reached the testing age. A compression testing machine was used to perform the test at 7 and 28 days. Every cylinder was positioned horizontally between the loading platens, and the force was applied consistently along the specimen's length until it failed. The maximum applied load was used to compute the split tensile strength. For each concrete mix, the stated values are the mean of three specimens.

2(a)

2(b)

Figure 2(a) & 2(b) Split tensile strength test and behavior of specimen after testing

5.4. Flexural Strength Test

In compliance with IS 516:1959, the flexural strength of concrete was assessed using prism specimens measuring 100 mm x 100 mm x 500 mm (Figure 3). After being cast in molds and sufficiently compacted, the specimens were demolded after a day [16]. Until they reached testing age, all specimens were cured in water at 27 ± 2°C. A flexural testing equipment was used to perform flexural strength tests under two-point loading at 7 and 28 days. Up until failure, the load was introduced progressively. The specimen's maximum load was used to calculate the flexural strength. For every concrete mix, the reported flexural strength values are the mean of three tested specimens.

3(a)

3(b)

Figure 3(a) & 3(b) Flexural strength test and behavior of specimen after testing

5.5. Stress Strain Behavior Test

Concrete's stress-strain behavior was examined after 28 days using cylindrical specimens measuring 150 mm in diameter and 300 mm in height that were exposed to uniaxial compressive pressure (Figure 4). A calibrated compression testing apparatus was used to conduct the test. A compressometer was used to measure axial deformation, and the recorded deformation was used to compute the appropriate strain values. The applied load was divided by the specimen's cross-sectional area to determine the stress values. To assess the impact of silicone oil emulsion 30 on concrete stiffness, peak stress, and deformation behavior, stress-strain curves were drawn for the hydrophobic and control concrete mixes.

Figure 4 Behavior of specimen after testing under UTM

6.0RESULTS AND DISCUSSIONS

6.1. Workability

A slump test is conducted to fresh concrete to gauge its workability, with the findings set out in Table 5. Mixtures were designed for a medium to high level of workability, as is needed for casting and compaction in the lab. The control mix gave us a slump of 115 mm. Due to the inclusion of silicone oil emulsion there was little change in the slump figures; the HM-0.5 and HM-1 mixtures came in at 117 and 119 mm respectively. That describes that the emulsion does not create any harm to the workability of the concrete at these moderate dosages. Even the HM-3 mixture, which showed a small drop to 110 mm, was well within what is acceptable for placing and compacting the concrete. The small differences in slump from one mixture to another would suggest the fresh properties were effectively maintained throughout the research. To ensure comparable workability conditions, the superplasticizer at a constant range of 0.5% of the cement weight was used across the board. This way we could judge the effect of the silicone oil emulsion on performance without workability being a confounding factor. All in all, the numbers show that the emulsion has but a limited impact on the behavior of the fresh concrete and the workability of every mixture was satisfactory.

Table 5 Slump Test Results

MIX	SLUMP (mm)
Control mix	115
HM-0.5%	117
HM-1%	119
HM- 3%	110

6.2. Compression Strength Test

Table 6 displays the findings of the control and hydrophobic concrete mixes compressive strengths. The control mix showed a compressive strength of 26.5 MPa after 7 days. Improved early-age strength was achieved by adding silicone oil emulsion; the 0.5% mix had the greatest value of 30.0 MPa, followed by the 1% mix (28.5 MPa).

Table 6 Compression Strength Test Results

MIX	7 Days	28 Days
Control mix	26.5	40.0
HM-0.5	30	43.5
HM-1	28.5	42.1
HM-3	25	38.4

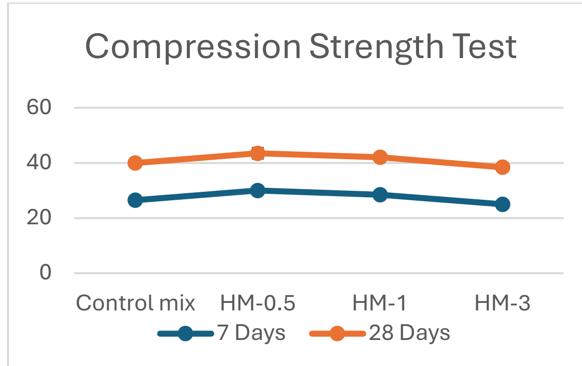


Figure 5 Development of compression strength of concrete mixes

Better particle dispersion and a lower effective water-cement ratio as a result of the combined effects of silicone emulsion and superplasticizer might be responsible for the improvement in early strength. The 3% mix, however, had a reduced strength (25.0 MPa), suggesting that early hydration may be hampered by an excessive hydrophobic admixture. At 28 days, a similar trend was noticed (Figure 5). The control mix attained the strength required for M30 grade concrete by recording compression strength of 40 Mpa. With a high value of 43.5 MPa, the silicone oil emulsion at 0.5% addition of silicone oil produced an apparent rise with 42.0 MPa, the 1% silicone oil mix showed greater strength than the control. The concrete with a 3% silicone oil emulsion dose, on the other hand, demonstrated a decrease in strength and reached a compressive strength of 38.5 MPa. Higher silicone emulsion dosages may partially delay cement hydration and enhance hydrophobicity, which may restrict the amount of effective bonding between hydration products and aggregates. Overall, the findings show that while high dose negatively impacts strength development, moderate silicone oil emulsion integration (0.5–1%) improves compressive strength. An optimum dosage of HM-0.5% was identified for attaining maximum compressive strength in hydrophobic concrete.

Table 7 Mean compressive strength, standard deviation and coefficient of variation of concrete mixtures

MIX	Mean ± SD (CV%)	
	7 Days	28 Days
Control	26.5 ± 1.30 (4.92%)	40 ± 0.81 (2.01%)
HM-0.5	30 ± 0.95 (3.18%)	43.5 ± 1.97 (4.54%)
HM-1	28.5 ± 0.84 (2.95%)	42.1 ± 1.16 (2.75%)
HM-3	25 ± 0.87 (3.46%)	38.4 ± 1.04 (2.68%)

For the statistical reliability of compressive strength data to the test, standard deviation and coefficient of variation for each mix were calculated with three specimens being run through the tests (Table 7). The coefficient of variation came in between 2.01 and 4.92%, a sign of good consistency and little variability from one specimen to the next. Then there are the standard deviation figures, which are quite modest; they confirm the repeatability of experimental results and the reliability of the strength trends were observed.

6.3. Split Tensile Strength Test

The split tensile strength data show how silicone oil emulsion affects the formation and spread of cracks in concrete (Table 8). The control mix showed a split tensile strength of about 2.2 MPa after 7 days. The mixtures with 0.5% and 1% silicone oil emulsion had higher values 2.4 MPa and 2.3 MPa, respectively. A possible explanation may be the better particle dispersion and fewer micro-voids as a result of the silicone emulsion's lubricating action.

Table 8 Split Tensile Strength Test Results

MIX	7 Days	28 Days
Control mix	2.2	3.3
HM-0.5	2.4	3.5
HM-1	2.3	3.4
HM-3	2.0	3.0

On the other hand, the early-age tensile strength of the 3% silicone emulsion mix was lower (~1.9 MPa). After 28 days of curing, the trend in split tensile strength was also similar (Figure 6). The tensile-split strengths of concrete mixtures with 0.5% and 1% silicone oil emulsion were greater than the control mixture, whose strength was at 3.3 MPa. As opposed to that, mix with 3% silicone oil emulsion possessed a decrease of split tensile strength of about 3.0 MPa. Similar trends have been noticed in previous studies, these findings explains that excessive hydrophobic content may lead to the dominate matrix behavior and lower tensile strength, moderate inclusion of silicone oil emulsion improves crack resistance.

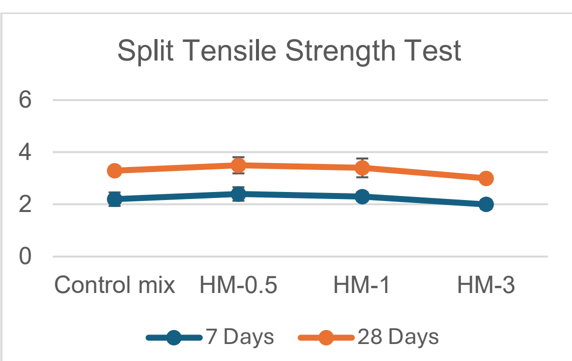


Figure 6 Development of split tensile strength of concrete mixes

Table 9 Mean split tensile strength, standard deviation and coefficent of variation of concrete mixtures

MIX	Mean±SD (CV%)	
	7 Days	28 Days
Control	2.20 ± 0.26(11.82%)	3.37 ± 0.15 (4.54%)
HM-0.5	2.40 ± 0.26 (10.83%)	3.63 ± 0.31 (8.50%)
HM-1	2.30 ± 0.17 (7.53%)	3.40 ± 0.36 (10.70%)
HM-3	2.00 ±0.17 (8.66%)	3.00 ± 0.10 (3.33%)

To place the split tensile strength results in a statistical context, the standard deviation and coefficient of variation (CV) from three specimens for every mix and curing age were noted (Table 9). The CVs came in between 3.33 and 11.82 %, which is a sign of acceptable consistency. The variability in the split tensile measurements is slightly higher than in the compressive ones given due to the sensitive tensile failure of initiation and propagation of cracks, and that was indeed the case. But with the standard deviation figures being on the low side, the repeatability of our work is confirmed and the trends we have noted in tensile strength as the silicone oil emulsion is added are well supported.

6.4. Flexural Strength Test

The flexural behavior of concrete explains that the inclusion of silicone oil emulsion influences the concrete's bending performance at early ages (Table 10). After 7 days of curing the flexural strength of control mix was around 3.5 MPa. The flexural strength increased to about 3.9 MPa and 3.7 MPa by adding silicone oil emulsion of 0.5% and 1%, respectively (Figure 7). The same tendency was evident after 28-day curing. In the case of the control mix, the flexural strength attained to 5.1 MPa, whereas for the mixtures HM-0.5 and HM-1, their flexural strengths were 5.7 MPa and 5.5 MPa, respectively.

Table 10 Flexural Strength Test Results

MIX	7 Days	28 Days
Control mix	3.5	5.1
HM-0.5	3.9	5.7
HM-1	3.7	5.5
HM-3	3.3	4.9

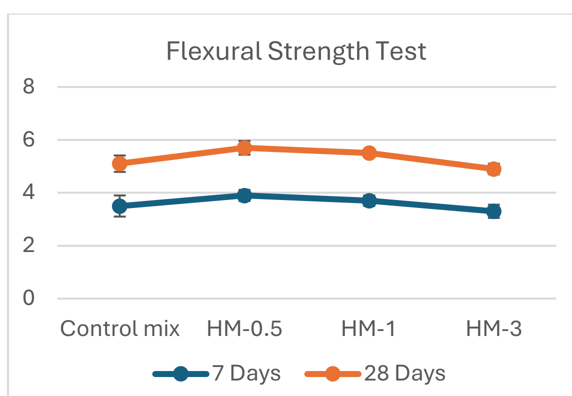


Figure 7 Development of flexural strength of concrete mixes

The mixture HM-3 demonstrated the lowest flexural strength of 4.9 MPa. It can be assumed that silicone oil emulsion in lower dosages may positively affect flexural strength; however, the flexural strength decreased in the case of higher dosages (in comparison to the control mixture). Thus, it can be concluded that the influence of silicone oil emulsion on flexural strength is dependent on its dosages. The mixture HM-0.5 demonstrated the highest values of flexural strength after both periods of curing.

Table 11 Mean flexural strength, standard deviation and coefficent of variation of concrete mixtures

MIX	Mean±SD (CV%)	
	7 Days	28 Days
Control	3.53 ± 0.40 (11.32%)	5.17 ± 0.31 (5.96%)
HM-0.5	3.93 ± 0.21 (5.31%)	5.70 ± 0.26 (4.56%)
HM-1	3.70 ± 0.20 (5.39%)	5.53 ± 0.12 (2.09%)
HM-3	3.33 ± 0.25 (7.50%)	4.90 ± 0.20 (4.08%)

The accuracy of flexural strength measurements was checked by using the standard deviation and coefficient of variation (CV) (Table 11). The minimum and maximum coefficients of variation were within 2.09% and 11.32%, respectively, showing that the test results are consistent and repeatable. More than 75% of the investigated mixtures have CV values below 8%. It clearly shows that there is very little variation among the tested specimens. The low standard deviation values indicate accurate measurement of the flexural strength of the mixtures due to the influence of silicone oil emulsion on concrete flexure.

6.5. Stress-Strain Behavior Test Results

Concrete's stiffness, load-carrying capacity, deformation properties, and modulus of elasticity under compressive loading are all revealed by its stress-strain behavior (Table 12). The stress-strain curves of the control mix and hydrophobic concrete mixes with varying silicone oil emulsion dosages at 7 and 28 days are shown in the graphs below. The findings show that silicone oil emulsion has a major impact on concrete's elastic and post-elastic response. The control mix had the steepest slope in the first elastic part of the stress-strain curve, suggesting a higher modulus of elasticity and reduced deformability. The curves for the 0.5% and 1% silicone oil emulsion mixes on the other hand were slightly less steep implying a slight reduction in modulus of elasticity relative to that of control mix. Such a behavior might be attributed to the better internal lubrication and the improved dispersion of the particles in the silicone emulsion, which influence elastic stiffness without however inhibiting effective stress transfer throughout the matrix.

In this study, we put the control and hydrophobic concrete mixtures through their paces to see how silicone oil emulsion would affect strength, stiffness and deformation under compression. The stress-strain data showed that the concrete's behavior is highly dependent on the dosage of the emulsion.

Table 12 Quantitative Analysis of Stress-Strain Curve

Mix	Peak Stress (Mpa)	Peak Strain	Ultimate Strain	Relative Stiffness
Control mix	25	0.0043	0.0043	High
HM-0.5	24.8	0.0060	0.0070	Moderate
HM-1	35	0.0019	0.0019	Very High
HM-3	31	0.0045	0.0045	Moderate-High

By 28 days the control mix had reached a peak stress of 25 MPa with a strain of 0.0043 (Figure 8). The HM-0.5 was not far behind in terms of stress at 24.8 MPa, but its peak strain was up to 0.0060, which speaks to a higher capacity for deformation before maxing out (Figure 9). Then there is the HM-1, which posted the highest peak stress of all at 35 MPa, although at a lower strain of 0.0019; this points to a stiffer kind of response than you would see in the control or other hydrophobic types (Figure 10). As for the HM-3, 31 MPa (strain 0.0045) is achieved, offering more strength compared to control while keeping a strain level in line with conventional concrete (Figure 11).

By observing the early part of the curves, the differences in stiffness are plain to see. The HM-1 has the steepest initial slope by some margin, making it the stiffest of the bunch. The HM-0.5 is more gradual in its stress build-up, and the HM-3 falls somewhere in between.

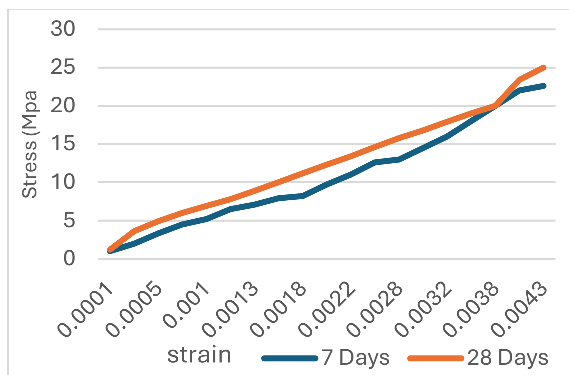


Figure 8 Compressive stress-strain curve of control mix

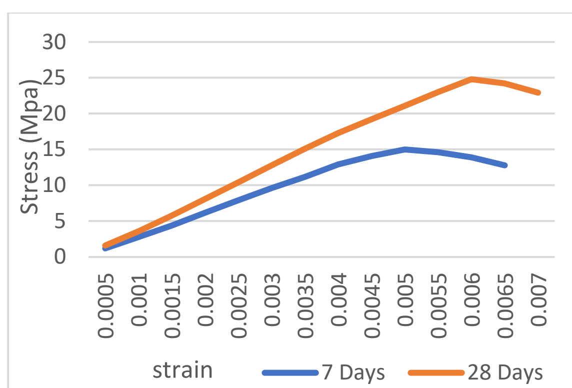


Figure 9 Compressive stress-strain curve of HM-0.5

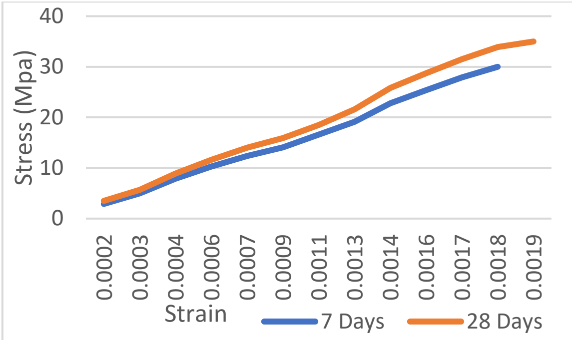


Figure 10 Compressive stress-strain curve of HM-1

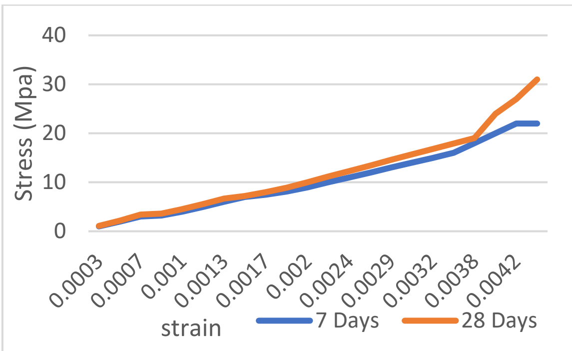


Figure 11 Compressive stress-strain curve of HM-3

In short, the HM-1 is your best bet for compressive resistance and stiffness, whereas the HM-0.5 will give you the most in the way of strain. The HM-3 mix provided a good balance. All in all, the numbers bear out that adding silicone oil emulsion has an effect on both the elastic and post-elastic behavior of the concrete, and exactly what that effect is will depend on how much dosage is used. The hydrophobic blends were more deformable than the control blend, which behaved in a relatively brittle manner with lower strain at failure. At maximum strain for 3% silicone emulsion system, ductility is higher but decreased stiffness and modulus of elasticity.

On analysis of all of these, it can be observed that the stress-strain relationship indicates a desirable combination of strength, ductility, and elasticity for 0.5 to 1% silicone oil emulsion dose addition to concrete. With higher amounts of addition, it can be observed that there is a greater ability to withstand deformation, but this accompanied a noticeable reduction in stiffness and elasticity. This evidence can be interpreted to state that silicone oil emulsion has a distinct influence on the elasticity and post-elastic region of concrete, and it has a desirable dose for which it can improve its strength without deteriorating its integrity.

7.0 CONCLUSION

- Mechanical properties and stress-strain curves for hydrophobic concrete appear to be dependent on the silicone oil emulsion.
- A mix with moderate concentrations of silicone oil emulsion (0.5–1%) possessed superior flexural strength, split tensile strength, and compressive strength compared to the control mix.
- The combination containing 0.5% silicone oil emulsion resulted in a higher peak stress value with the same regulated deformation and a respectable modulus of elasticity, based on stress-strain plots.
- Strength, stiffness, and elastic modulus tended to diminish as the dosage of the silicone oil emulsion increased above 3%. The reason might have been interference with hydration and bonding in the matrix.
- Sustainable concrete construction is made possible by the use of silicone oil emulsion, which allows increased mechanical efficiency without the need for additional cement.
- For M30 grade hydrophobic concrete, the optimal dosage of the silicone oil emulsion was determined to be 0.5%, which led to favorable mechanical and deformation properties.

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Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper

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