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EFFECT OF DOLOMITE POWDER WITH PARTIAL REPLACEMENTOF CEMENT ON PROPERTIES OF SELF - COMPACTING CONCRETE AS A GOAL FOR SUSTAINABLE DEVELOPMENT

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Abstract: - This study focuses on conducting experiments to investigate the characteristics of self-compacting concrete (SCC). In this research, dolomite powder was utilized as a replacement of port land pozzolana cement. This research examined the impact of incorporating a mineral admixture on the workability, compressive strength, Flexural strength, and ultra pulse velocity of self-compacting concrete (SCC). the replacement level of dolomite powder increased (12%, 24%, and 36%), there were consistent reductions in compressive strength, flexural strength, and slight decreases in ultrasonic pulse velocity (UPV). Specifically, at 28 days, the compressive strength decreased by 21.88%, 30.98%, and 40% for the respective replacement levels. Flexural strength also exhibited continuous reductions with higher dolomite powder replacement. Additionally, while water permeability met the specified range at 12% replacement.

Key Words: Self compacting concrete, dolomite powder, workability, compressive strength,

I. INTRODUCTION

The concept of self-compacting concrete (SCC) originated in Japan during the late 1980s. It was designed as a material that could effortlessly flow through densely packed reinforcement bars without requiring extra consolidation and without experiencing notable segregation due to its own weight [1,2,3,4,5]. SCC offers several advantages, including enhanced productivity resulting in shorter construction time, simplified construction of heavily congested structural elements and inaccessible areas, improved quality of in situ concrete during casting, reduced injuries caused by noise and vibration, and the ability to achieve higher surface quality. A drawback of using self-compacting concrete (SCC) is its cost, which can be attributed to the high volumes of Portland Pozzolana Cement (PPC) and chemical admixtures required. To address this issue, an alternative approach is to incorporate mineral admixtures like dolomite powder. These finely divided materials are added to the concrete mixture during the mixing process.

By replacing a portion of the PPC with mineral admixtures, the cost of SCC can be significantly reduced, especially if these admixtures are waste or industrial by-products. Additionally, the utilization of mineral admixtures in SCC production not only offers economic advantages but also helps in reducing the heat generated during hydration [6]. The reduced water content in the concrete contributes to enhanced durability and improved mechanical integrity of the structure. Additionally, certain mineral admixtures have been found to enhance the rheological properties of concrete and reduce thermally-induced cracking. This is achieved by reducing the overall heat of hydration and improving the workability and long-term characteristics of the concrete [7].

Scientists and researchers have conducted studies on the characteristics of self-compacting concrete (SCC) by incorporating various pozzolanic materials. These materials include fly ash, dolomite powder, blast furnace slag, and silica fume, which are used as partial replacements for Portland cement. Additionally, limestone powder has been utilized to manage the potential for segregation and enhance the deformability of fresh SCC [8,9,10].

Dolomite powder, being a waste material, can be utilized to decrease the cost of SCC while offering these benefits [11]. The aim of this study is to analyze the impact of mineral admixtures on the properties of fresh and hardened self-compacting concrete (SCC). The performance of the mineral admixture in SCC is evaluated through various tests on fresh concrete, including slump flow, T50 time, V-funnel time, and L-box ratio. Hardened concrete tests are conducted to assess parameters such as compressive strength, flexural strength, ultra pulse velocity, and rebound hammer readings. Several specific test methods have been developed to assess the key properties of fresh self-compacting concrete (SCC)

2. Materials used

Pozzolana Portland cement was utilized as the cementitious material in the study. The sand employed was natural river sand, graded between the 600 µm and 150 µm sieve sizes. Coarse aggregate was obtained from crushed sources, with fractions of 20 mm and 10 mm being prepared. The physical characteristics of the fine and coarse aggregates are provided in Table 1. The dosage of admixture was adjusted based on the changes in the mix proportions of dolomite powder to maintain similar fresh properties to those observed in self-compacting concrete (SCC).

Table 1 physical properties of fine and coarse aggregate

Physical properties	Bulk specific gravity (SSD)	Absorption (%)	Fineness modulus
Fine aggregate	2.6	3.02	2.33
Coarse aggregate	2.65	0.56	6.57

The dolomite powder utilized in this study was sourced from an industrial rock crushing plant situated at Azadpur Flyover, New Delhi. The physical properties of the dolomite powder, as well as Portland cement, are presented in Table 2

Table 2 Physical properties of powders

Properties	PPC	Dolomite powder
Specific gravity	2.9	2.6
Initial setting time	140min	-

Table 3. Designation of specimens

Mix designations	Proportions of PPC and dolomite powder
Mix 1	100% PPC
Mix 2	88% PPC +12% DP
Mix 3	76% PPC +24% DP
Mix 4	64% PPC +36% DP

Table 4. Mix proportions

Mix	w/c	Cement (kg/m3)	Dolomite powder (kg/m3)	Aggregate (kg/m3)		Super plasticizer(kg)
				Fine	coarse	
Mix 1	0.43	446.51	-	891.5	750	3.57
Mix 2	0.48	392.93	53.58	891.5	750	3.57
Mix 3	0.56	339.35	107.16	891.5	750	3.57
Mix 4	0.67	285.54	160.61	891.5	750	3.57

2.1. Mix proportions

The mix design for self-compacting concrete (SCC) has been formulated in accordance with the guidelines specified in IS 10262 and IS 456 [12,13,14]. In this study, four concrete mixes were examined, each containing varying proportions of dolomite powder. Additionally, different water cement ratios were utilized for each mix. The dosage of superplasticizer was kept consistent to maintain similar self-compactibility among the mixes. The designations of the specimens and the corresponding mix proportions can be found in Table 3 and Table 4, respectively.

2.2. Manufacture and curing of test specimens

To determine the compressive strength and ultrasonic pulse velocity (UPV), cubic molds measuring 100 mm x 100 mm x 100 mm were utilized. For the evaluation of static and dynamic elastic moduli, prism molds measuring 100 mm x 100 mm x 500 mm were employed. Nine cubes and three beams were prepared for each concrete mixture.

2.3. Testing of specimens

Numerous test methods have been developed to evaluate the properties of self-compacting concrete (SCC). However, there is no universally accepted single method or combination of methods. Each mix design should be assessed using multiple test methods to evaluate various workability parameters. In this study, the filling ability of SCC was determined using the slump flow test with Abrams Cone. The passing ability was evaluated using the L-box test, while the segregation resistance was assessed through the V-funnel at T5 minutes test. Brief descriptions of these tests are provided in the following paragraphs.

2.5. V-funnel at T5minutes test

The interior surface of the V-funnel apparatus was wet, and it was securely placed on a flat surface. A bucket was positioned beneath the 'trap door' after it was shut. Concrete was poured into the device to its full capacity without being compacted or tamped. The trap door was opened and the concrete was allowed to exit by gravity after 10 seconds of filling. When the trap door was opened, a stopwatch was set in motion, and the discharge's completion time was noted. When light was visible through the funnel from above, this picture was captured. The entire test was finished in 5 minutes. The V-funnel was immediately refilled after monitoring the flow time in order to measure the flow time at T5minutes. It was a trap door.*Figure 1*

2.4. L-Box test

The sliding gate may open and close freely because the L-box test apparatus, which has three smooth bars with a gap of 41 mm and three smooth bars of 12 mm diameter, was placed on a levelled, firm surface. The apparatus's interior surface was wet. Concrete was poured into the device' vertical section, which was then given a minute to rest. The sliding gate was then raised, allowing the concrete to pour out into the horizontal part. The distances 'H1' and 'H2' were measured when the concrete stopped flowing. The blocking ratio was called 'H2/H1'. The entire test was finished in 5 minutes.Figure *2*

V-funnel

J-ring

L-box

Slump flow test

3. Results and discussions

Properties of fresh SCC and **Error! Reference source not found.**The results depicting the properties of fresh self-compacting concrete (SCC) are illustrated in It is observed that the slump flow values for all SCC mixtures ranged between 550 and 650 mm, which indicates good deformability. These values fall within the range of 550-650 mm, which is specified as Slump flow class SF1 according to the EFNARC guide [14]. The SCC mixtures also demonstrated favorable stability, as evidenced by V-funnel flow times of less than 8 seconds. Therefore, the viscosity classification of the SCCs can be assigned as VF1 based on their performance in this regard. The L-box ratios for all the concrete mixes exceeded the minimum requirements outlined in the EFNARC guide

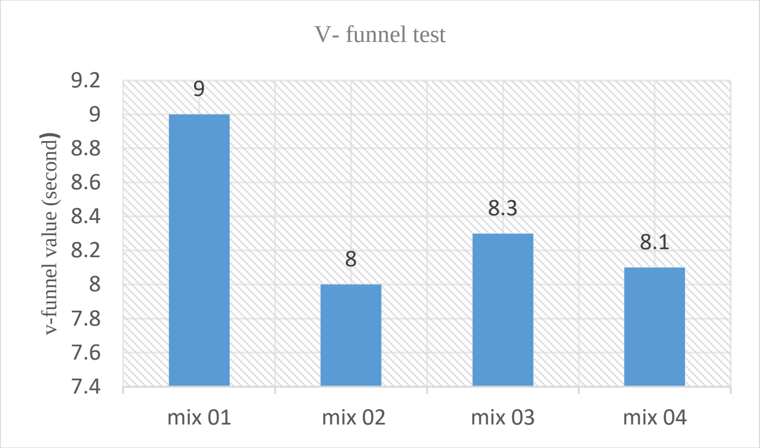


Figure 1 V-funnel test

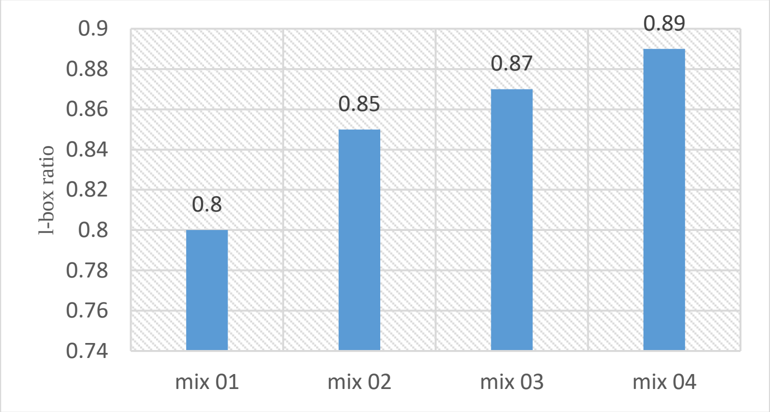


Figure 2 L-box test

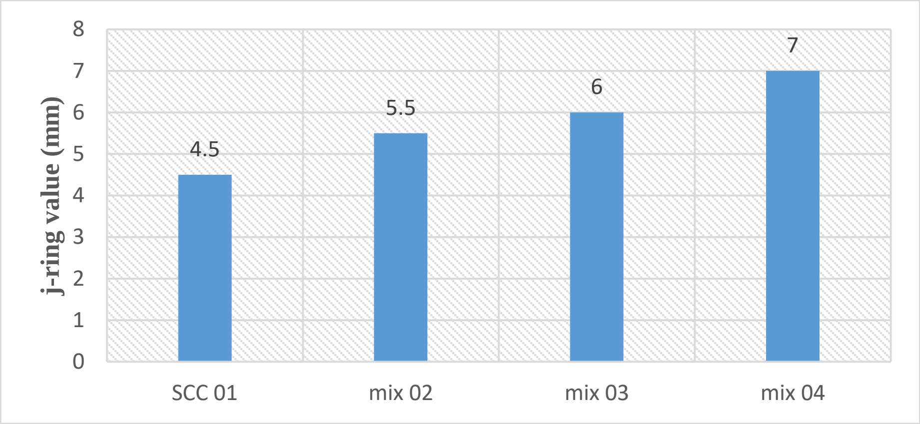


Figure 3 J-ring test

It is crucial to acknowledge that the properties of dolomite powder, being waste materials, are likely to change over time. Therefore, it is necessary to conduct studies on the effects of chloride penetration and sulfate attack when incorporating these materials into Self-Consolidating Concretes (SCCs).

Furthermore, it is important to note that SCC, similar to traditional concrete, cannot be associated with a specific composition or performance. In fact, the variations in composition of SCC are even more pronounced compared to traditional concretes due to the reliance on local materials. The performance of SCC is influenced by specific process requirements and the intended application. Consequently, it is challenging to compare different SCC materials in terms of both composition and performance.

3.1. Compressive strength of SCC

Figure *4* presents data on the compressive strength of different mixtures, specifically focusing on self-compacting concrete (SCC) with dolomite powders. The results indicate that the compressive strengths ranged from 15.5 to 23.1 MPa at 7 days and 25.56 to 42.5 MPa at 28 days. Among all the mixes, Mix 1, which solely used 100% Portland Pozzolana Cement (PPC), exhibited the highest compressive strength at different ages, suggesting that SCC with only PPC as the binder resulted in the strongest concrete. However, as the dolomite powder content increased in the mixes, a decrease in compressive strength was observed for all ages. This implies that the addition of dolomite powder had a detrimental effect on the strength of the concrete.

At the 7th day, the addition of 12% dolomite powder resulted in a decrease in compressive strength of approximately 15.38%. Similarly, replacing natural coarse aggregates (NCA) with 24% dolomite powder led to a reduction of approximately 3.9%, while substituting NCA with 36% dolomite powder resulted in a decrease of approximately 37.78%.

On the 28th day, the reduction in compressive strength was lower compared to the 7th day. Replacing NCA with 12% dolomite powder resulted in a decrease of approximately 21.88%. The addition of 24% dolomite powder led to a reduction of around 30.98%, and substituting NCA with 36% dolomite powder resulted in a decrease of approximately 40%.

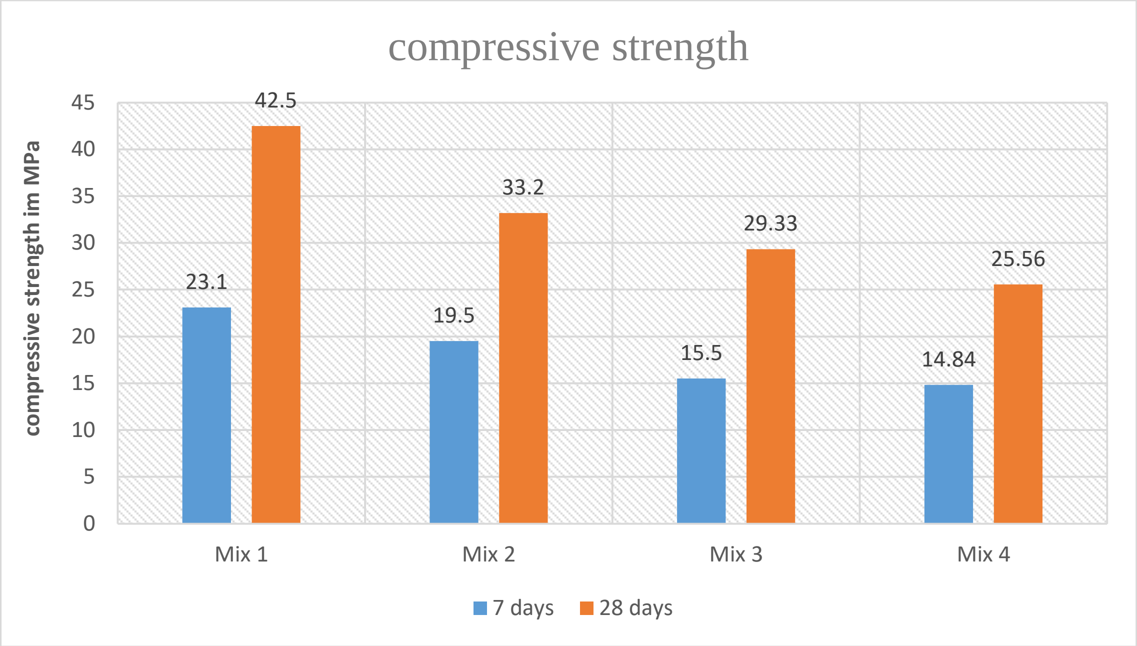


Figure 4 Compressive strength test

3.2. Flexural strength

Figure 5 presents the results of flexural strength testing conducted on prism specimens with varying water-to-cement ratios (w/c) at 28 days. The data examines the impact of replacing dolomite powder with different percentages of

cement on the flexural strength of the concrete. Replacing 12% of cement with dolomite powder resulted in a reduction in flexural strength of approximately 7.74% compared to the control specimens. Increasing the dolomite powder replacement to 24% led to a slightly higher decrease in flexural strength, approximately 15.66%. Further increasing the dolomite powder replacement to 36% resulted in a more significant reduction in flexural strength, with an approximate decrease of 30.29% compared to the control specimens.

These findings clearly indicate that as the percentage of dolomite powder in the concrete mix increases, the flexural strength decreases. This highlights the importance of carefully evaluating the effects of incorporating dolomite powder on the flexural behavior of concrete. It is crucial to adjust the mix design accordingly and consider the structural implications when utilizing dolomite powder in concrete applications, particularly when maintaining sufficient flexural strength is critical.

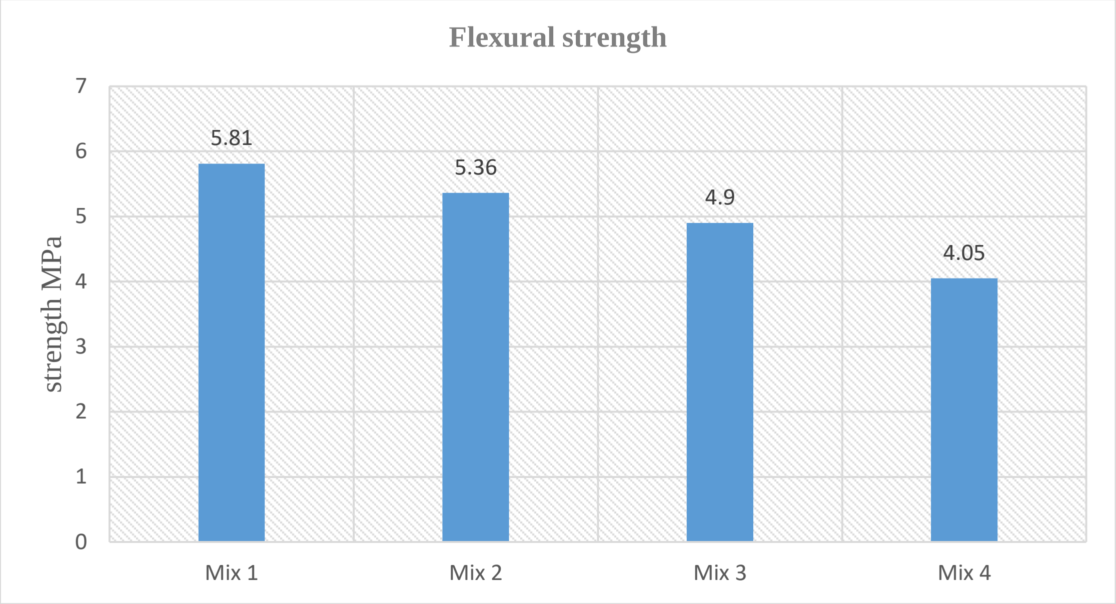


Figure 5 flexural strength

3.3. Ultrasonic pulse velocity (UPV)

Figure 6 The addition of dolomite powder to concrete mixtures has been found to have a minor adverse impact on the ultrasonic pulse velocity (UPV). Experimental studies have shown that as the percentage of dolomite powder in the mix increases, there is a corresponding increase in UPV values at 7 days. For example, when 12% of the cement was replaced with dolomite powder, the UPV increased by approximately 3.98%. Increasing the dolomite powder replacement to 24% resulted in a slightly higher increase of around 4.28%. However, when the dolomite powder content was further increased to 36%, there was a slight decrease in UPV, with an approximate decrease of 1.26% at 7 days. Similarly, after 28 days of testing, increasing the percentage of dolomite powder led to a reduction in UPV.

These findings indicate that incorporating dolomite powder into concrete mixtures can have a slight adverse impact on the UPV. It is important to note that UPV is commonly used as an indicator of concrete quality and can be related

to various properties such as density, homogeneity, and internal flaws. Therefore, when considering the use of dolomite powder, it is essential to evaluate its effects on the overall quality and durability of the concrete, beyond just the UPV. Proper adjustments in mix design and implementation of quality control measures should be undertaken to ensure that the desired performance characteristics are achieved when utilizing dolomite powder in concrete applications.

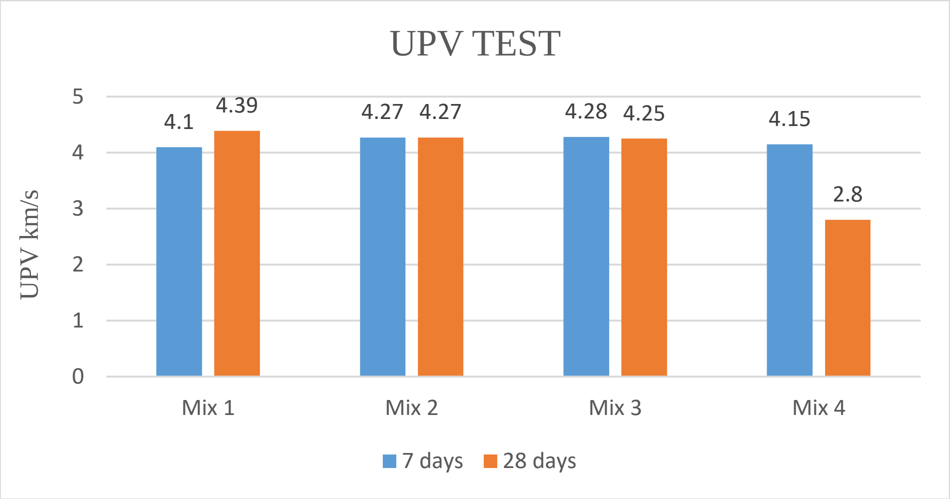


Figure 6 Ultra sonic pulse velocity

3.4. water permeability

Figure 7 The water permeability of concrete with a 12% replacement of dolomite powder adheres to the specified range of 25mm, as stated in Section 1700 of MORTH 5th Revision, Clause 1717.7.5. However, when the dolomite powder replacement increases to 24% and 36%, the water permeability exceeds the 25mm range. This implies that higher percentages of dolomite powder in the mix lead to greater permeability, potentially compromising the concrete's ability to resist water penetration. It is crucial to carefully consider the inclusion of higher amounts of dolomite powder in concrete mixes, especially when maintaining water-tightness is crucial. Adjustments in mix design and additional measures should be employed to mitigate the increased permeability associated with higher dolomite powder replacements, ensuring that the resulting concrete meets the desired water-tightness requirements.

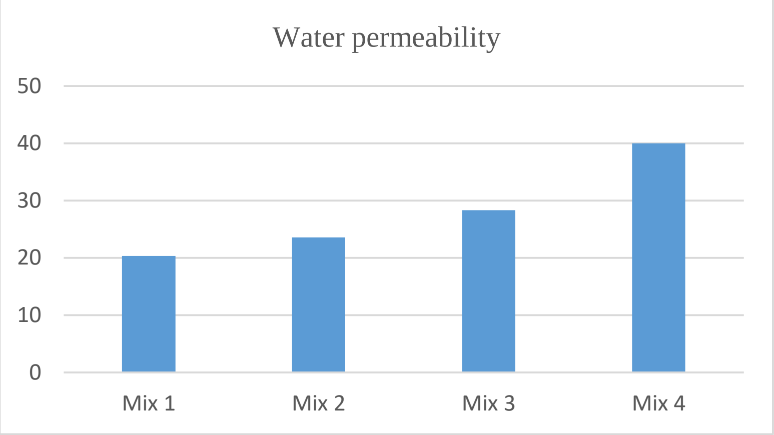
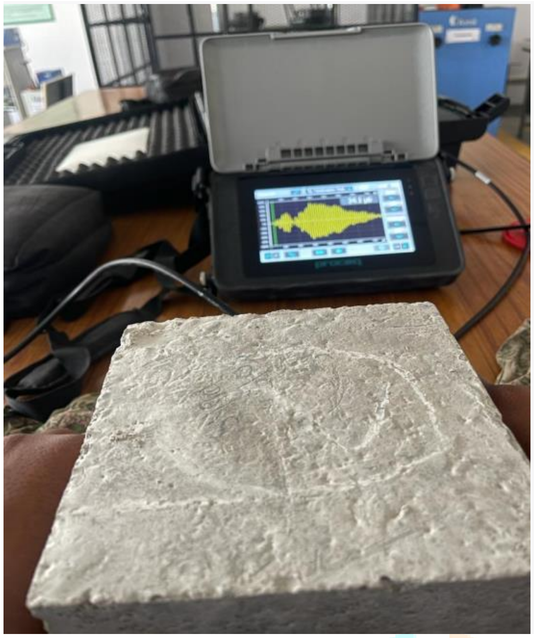


Figure 7 water permeability test

Compressive strength test

Flexural strength test



Ultra sonic pulse velocity

Water permeability test

4. Conclusions

It can be concluded that the addition of dolomite powder to self-compacting concrete (scc) mixtures has a detrimental effect on the compressive strength, flexural strength, and ultrasonic pulse velocity (upv) of the concrete.

Regarding compressive strength, it was observed that as the dolomite powder content increased, there was a decrease in compressive strength at both 7 days and 28 days. The highest compressive strength was obtained when using 100% portland pozzolana cement (ppc) as the binder, indicating that scc with only ppc resulted in the strongest concrete.

The flexural strength of the concrete also decreased as the dolomite powder content increased. Increasing the dolomite powder replacement led to a gradual reduction in flexural strength, indicating that the inclusion of dolomite powder negatively affected the ability of the concrete to resist bending and cracking forces.

In terms of ultrasonic pulse velocity (upv), the addition of dolomite powder had a minor adverse impact. At 7 days, increasing the dolomite powder content resulted in an increase in upv, except when the dolomite powder content reached 36%, which led to a slight decrease. After 28 days, the upv values decreased as the dolomite powder content increased.

These findings highlight the importance of carefully evaluating the effects of incorporating dolomite powder in concrete mixtures. Adjustments in mix design and quality control measures should be considered to ensure the desired performance characteristics, such as compressive strength, flexural strength, and upv, are achieved when utilizing dolomite powder in concrete applications.

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