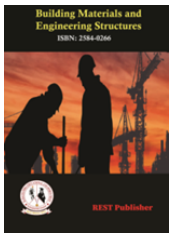
Building Materials and Engineering Structures
Vol: 3(1), March 2025
REST Publisher; ISSN: 2584-0266
Website: https://restpublisher.com/journals/bmes/
DOI: http://doi.org/10.46632/bmes/3/1/3



Influence of Barites on Strength of Internally Cured Concrete by Use of PEG 400

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Abstract: *This study investigates the effects of partial replacement of cement with barites on the compressive and tensile strength of self-curing concrete. The primary goal is to evaluate the feasibility of incorporating barites, a heavy mineral with significant density, into concrete mixtures as a partial cement substitute and PEG 400 curing agent for internal curing to determine its impact on the mechanical properties of the resulting concrete. In this research, various proportions (0%, 2.5%, 5%,7.5% & 10%) of barites and constant 1% PEG 400 to the weight of cement are introduced into M30 Concrete mixtures. By replacing percentage of the cement content with barites, the concrete specimens will be subjected to both compressive and tensile strength tests at different curing periods (7 & 28 days) to assess the influence of barites on these properties. Experimental results revealed that the addition of barites powder influence the workability of concrete due to its low water absorption properties, here PEG helped us for better workability of concrete. The compressive and tensile strengths showed significant improvement, particularly at 7.5% replacement of cement for both 28 days internally and externally cured concrete. These findings indicate that barites powder is sustainable alternative for cement replacement for either internally or externally cured concrete while reducing environmental impact and cost.*

Keywords: *Internal curing, Barite powder, Polyethylene Glycol 400, Compressive Strength, Tensile Strength.*

1. INTRODUCTION

Concrete, the most widely used construction material globally, consists of cement, aggregates, and water. To improve sustainability, researchers are incorporating supplementary cementitious materials, like barites powder ($BaSO_4$). Known for its high density, non-toxic nature, and gamma-ray attenuation capabilities, barites powder enhances concrete properties, including workability, compressive strength, weight density, and durability. It also reduces the environmental impact by partially replacing cement, improving hydration and microstructure. Polyethylene Glycol 400 (PEG 400), a low-molecular-weight polymer, promotes internal curing by retaining moisture in concrete. This self-curing method enhances hydration, compressive and tensile strength while minimizing early-age cracking and shrinkage, making it an effective solution for improving concrete performance.

2. RESEARCH OBJECTIVES

1. Investigate the impact of barites on the compressive strength of the self-curing concrete
2. Assess the effect of barites on the tensile strength of the self-curing concrete, crucial for its structural integrity.
3. Identify the ideal barite percentages for maximizing strength by analyzing the strength results, while maintaining workability.

3. LITERATURE REVIEW

Rajendran, A. S. Ramesh, M. Mahalakshmi, and A. Mohanraj (October 2014), from the Department of Civil Engineering and Structural Engineering, Bannari Amman Institute of Technology, Sathiamangalam, India, published a paper in an international journal on October 2, 2014. They observed the use of 0.3% Polyethylene Glycol 400 (PEG 400) in different grades like M20, M30, and M40. For compressive strength tests, NDT and

HEICO compressive testing machines were used. They found that self-curing concrete exhibits higher compressive strength compared to sprinkler-cured and conventional concrete. Similarly, for tensile tests, self-curing concrete also showed better performance. Furthermore, self-curing concrete was found to have lower water absorption compared to other types of concrete.

Thrinath and P. Sundara Kumar (2017), from the Department of Civil Engineering and Structural Engineering, KL University, Guntur, Andhra Pradesh, India, published a paper in an international journal on April 4, 2017. Their results were based on M30 grade concrete, where they utilized PEG 400 in different dosages with respect to the weight of cement (0.5%, 1%, 1.5%, and 2%). They concluded that the optimum dosage for better compressive and tensile strength is 1% with respect to the weight of cement, while 0.5% is optimum for better flexural strength.

Meenakshi (2017), from the Department of Civil Engineering, SCSVMV University, Kanchipuram, India, published a paper in an international journal in 2017. They used partial replacement of cement with barites and lime powder in M30 grade concrete. The cement was replaced with barites and lime powder at percentages of 0%, 5%, 10%, and 15%. It was observed that the initial strength of the concrete was good; however, later it decreased. They concluded that replacing cement with both barites and lime is not successful.

Anju and R. Nikhil (2023), from the Department of Civil Engineering and Structural Engineering, Universal Engineering College, Thrissur, Kerala, India, published a paper in an international journal on April 4, 2023. In their study, cement was partially replaced by 0%, 5%, 10%, 15%, 20%, and 25% barites powder, combined with silica fume at one-fourth of the barites powder quantity. They conducted compressive strength and split tensile strength tests using M30 grade concrete for self-compacting concrete. They concluded that self-compacting concrete with 15% replacement of barites powder and silica fume achieved higher compressive and split tensile strength.

4. MATERIALS

Portland Pozzolana Cement (Ultra-Tech Brand) cement was used. Natural sand was used as a fine aggregate, obtained from Penna River, locally available Coarse aggregate of size 20mm was used, Barites powder was collected from madhavi micro minerals pvt ltd. PEG 400 was bought from Tharun Scientifics, a local supplier

5. EXPERIMENTAL METHODOLOGY

Concrete mix design was made for M30 grade concrete as per IS 456 :2000 for different mix proportions 0%, 2.5%, 5%, 7.5%, and 10% of barites powder and PEG 400 with the dosage fixed at 1% of the cement weight. A total of 100 specimens, including cubes and cylinders, 60 cubes of size 150 mm $\times$ 150 mm $\times$ 150 mm and 40 cylinders are of size 150mm dia and 300mm height were cast,the specimen with PEG were internally cured and specimen without PEG were externally cured for 7 and 28 days and after there designated curing periods Tests for compressive strength and tensile strength were conducted systematically. The results obtained provided insights into the mechanical performance of concrete under varying dosages of barites powder for both internally and externally cured concretes when helps to obtain obtimum barite ratio.

6. MIX CALCULATIONS

- Cement = 440 kg/m^3
- Water = 198 kg/m^3
- Fine aggregate = 635.715 kg/m^3
- Coarse aggregate = 1086.265 kg/m^3
- W/C ratio = 0.45

Cement	Fine aggregate	Coarse aggregate	Water
440 kg/m^3	635.715 kg/m^3	1086.265 kg/m^3	198 kg/m^3

Therefore, the mix proportion of Cement, F.A , C.A and Water is as shown below:

Cement	Fine aggregate	Coarse aggregate	Water
1	1.44	2.46	0.45

7. RESULTS AND DISCUSSIONS

7.1 VEE-BEE Test On Concrete Mix

The primary goal of the Vee Bee Consistometer test is to assess the workability of freshly mixed concrete. This test measures the time it takes for a concrete sample to reach a certain degree of consistency under specific vibration conditions. The remoulding effort, measured in seconds, indicates the amount of work involved in transforming the concrete from a conical shape to a cylindrical shape through vibration. The time taken for complete remoulding, expressed in Vee-Bee seconds, is a quantitative measure of workability.

TABLE 1. Workability of concrete

s.no	% of Replacement	Workability of concrete without PEG (sec))	Workability of concrete with PEG (sec)
1	0%	5.85	5.01
2	2.5%	6.23	3.1
3	5%	6.1	2.85
4	7.5%	5.91	2.5
5	10%	4.34	2.1

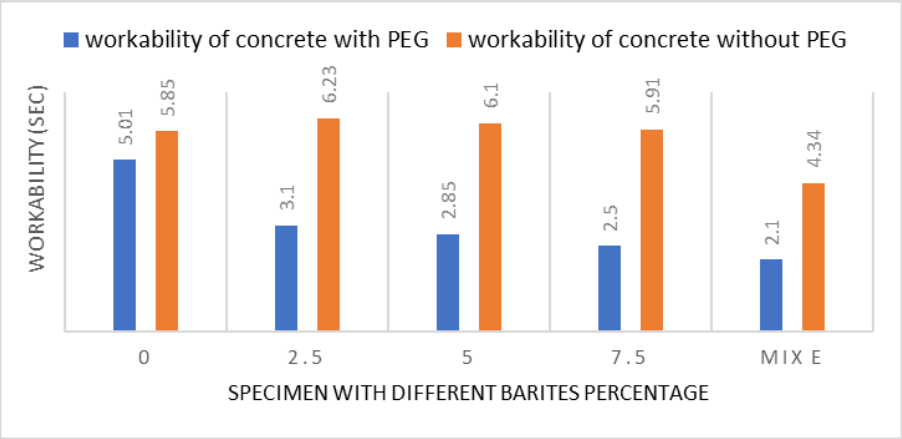

FIGURE 1. Workability of concrete with & without PEG 400

7.2 Compressive Strength Test

Conducting compressive strength tests on concrete specimens is an essential part of your project to analyze the influence of barites and PEG 400 on concrete strength.

To conduct compressive strength tests on concrete specimens, ensure both externally and internally cured cube samples (150×150×150 mm) are cured for 7 and 28 days. After curing, remove the externally cured specimens from the tank and dry any surface moisture. Place the cube centrally on the lower platen of the compression testing machine. Apply a uniform load gradually at a constant rate until failure. Record the maximum load applied at the point of failure.After testing,

- calculate the compressive strength of the concrete specimen using the Formula:

$$CompressiveStrength = \frac{MaximumLoad}{Cross-sectionalArea} \quad (1)$$

TABLE 2. Compressive strength of concrete specimen for 7 days curing

S.NO	% of Replacement	Compressive strength of concrete without PEG (N/mm^2)	Compressive strength of concrete with PEG
1.	0	21.55	19.629
2	2.5	22.14	20.29
3	5	22.815	22.44
4	7.5	24	23.33
5	10	22.29	21.55

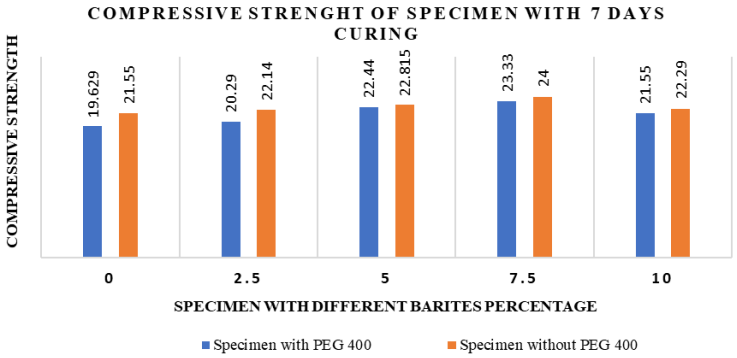

FIGURE 2. Compressive strength of concrete specimen for 7 days curing

TABLE 3. Compressive strength of concrete specimen for 28 days curing

S.NO	% of Replacement	Compressive strength of concrete with out PEG (N/mm^2)	Compressive strength of concrete with PEG (N/mm^2)
1.	0	39.11	38.44
2	2.5	40.296	39.629
3	5	41.33	40.44
4	7.5	42.96	41.11
5	10	40.66	39.037

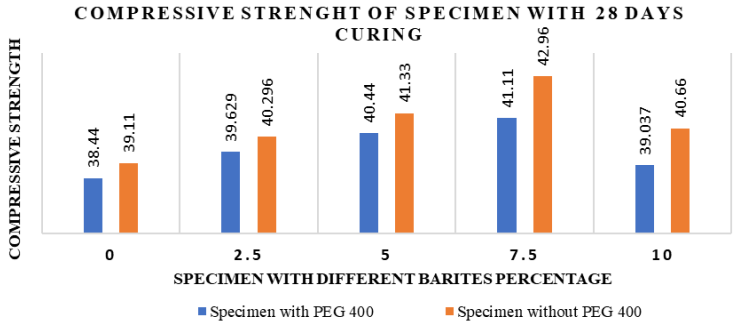

FIGURE 3. Compressive strength of concrete specimen for 28 days curing

8. TENSILE STRENGTH TEST

- To determine the tensile strength of concrete, conduct the split tensile strength test. Ensure cylindrical specimens are cured for 7 and 28 days. After curing, dry surface moisture from externally cured specimens. Place the specimen horizontally between the loading platens of a universal testing machine, aligned along its central axis. Use thin plywood strips for uniform load distribution. Gradually apply a constant load until failure and record the maximum load applied at failure.

- Calculate the split tensile strength of the concrete specimen using the formula:

$$SplitTensileStrength = \frac{2p}{\pi LD}$$

1. P is the maximum load applied,
2. L is the length of the specimen,
3. D is the diameter of the specimen.

TABLE 4. Tensile strength of specimen for 7 days curing

S.NO	% of Replacement	Tensile strength Of concrete without PEG (N/mm2)	Tensile strength Of concrete with PEG (N/mm2)
1.	0	2.53	2.41
2	2.5	2.766	2.69
3	5	3.22	3.145
4	7.5	3.59	3.47
5	10	3.41	3.22

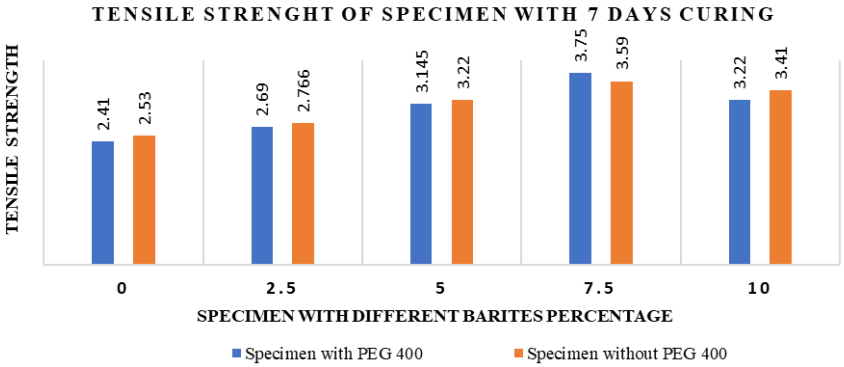

FIGURE 4. Tensile strength of concrete specimen for 7 days curing

TABLE 5. Tensile strength of specimen for 28 days curing

S.NO	% of Replacement	Tensile strength Of concrete without PEG (N/mm2)	Tensile strength Of concrete with PEG (N/mm2)
1.	0	4.54	4.2
2	2.5	5.24	5.1
3	5	5.55	5.41
4	7.5	6.13	5.87
5	10	5.83	5.64

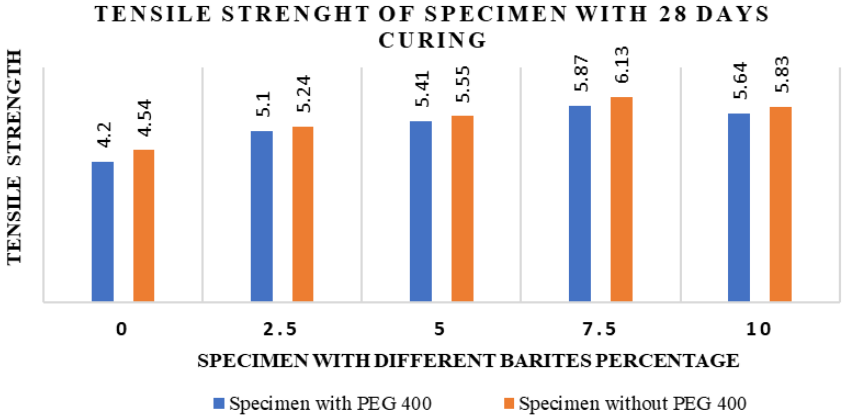

FIGURE 5. Tensile strength of concrete specimen for 28 days curing

9. CONCLUSION

- The highest compressive strength is obtained at MIX D, i.e 7.5% for self curing concrete with a slight difference of 0.89 N/mm2 when compared to fully cured concrete
- The highest tensile strength is obtained at MIX D, i.e 7.5% for self curing concrete with a slight difference of 0.26 N/mm2 when compared to fully cured concrete
- Although self curing concrete has low strength when compared to fully cured concrete the variation of strength between them is low. Therefore , we can use self curing concrete in water scarved areas.
- The addition of barites powder influence the workability of concrete due to its low water absorption properties and high density ,here PEG helped for better workability of concrete
- Economical point of view we can save the cost of cement by replacing barites with cement

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