Industrial Engineering Journal
ISSN: 0970-2555
Volume: 52, Issue 11, November: 2023

UTILIZATION OF DOLOMITE POWDER AS PARTIAL REPLACEMENT TO THE CEMENT IN SELF-HEALING CONCRETE

D MOHAMMED MUSTAFA[1], M SRAVANTHI[2], C SASHIDHAR[3]
[1]M.Tech Student, JNTUA College of Engineering, Anantapur, AP, India.
[2]Research Scholar, JNTUA College of Engineering, Anantapur, AP, India.
[3]Professor, JNTUACollege of Engineering, Anantapur, AP, India.

ABSTRACT

Concrete is major role in construction, but its strength depends upon many factors like environmental conditions, more stress than required of weaken structures leads to crack formation where the structures allows harmful reactants into it which leads to decrease in strength concrete structures .To overcome this, problem self-healing mechanism is introduced. Dolomite powder is used as partial replacement of cement in concrete which has similar properties of cement. The technology of self healing concrete combines with there placement of cement with dolomite powder using sodium silicate solution as a healing agent in M40 grade concrete. In addition steel fibers are added to control cracking due to shrinkage in concrete. Controlled cracks are induced in cube specimens for water immersion, water contact and exposures conditions, and compressive strength is tested after 28 and 56 days to assess recovery rates and healing efficiency is studied.
Keywords: Self-Healing concrete, dolomite powder ,Sodium silicate solution.

1.INTRODUCTION

1.1. General

Concrete is main source of construction and which always stands as a main material in construction even though it has a number of advantages like high strength, long life and susceptibility to overload still a major drawback was emission of carbon dioxide from cement which is the ingredients of concrete .Dolomite powder was best material which is studied for self healing which was high advantage and act as filler material for leftover empty voids in concrete also well distributed nano size particles acts as a crystalline centres of hydrated products there by increasing hydration rates improving the structure of transition joint present in between the aggregate and paste assist towards the formation of C-S-H crystals. Due to this calcium leaching enhancing strength which leads to increment in strength and durability even after attending the greater strength replacement of various mineral admixtures yet the concrete was reasonable to formation of cracks with respect the time and various chemicals and chlorides will be penetrate inside the cracks and make the Concrete weaker as one cannot keep money and time for various continuous inspection an alternative solution for the problem named self healing was introduced and which was started in this era. Autonomous healing is a natural healing in which process will take place with the help of impurities present in water heat of hydration between leftover particles at the initial stage is calcium carbonate or calcium hydroxide formation of final expansion of C-S-

H gel autonomous healing was will require human help an act of active modes and passive modes there is no activation required for passive mode but active more will require it.

2. LITERATUREREVIEW

To determine if utilising dolomite powder as a cement substitute is feasible, it is combined with other materials in various ways. In addition to replacing cement by 0%, 5%, 10%, 15%, and 20% by weight of cement, dolomite powder replacement for cement is maintained at 10% by weight of cement. The addition of 10% dolomite powder resulted in a greater compressive strength of 41.6 N/mm2, according to the compressive strength data. Bala Yarramsetty Balaji and Dudekula Rafi. [1] The engineering cementitious composites (ECC) had capsules that held the sodium silicate solution. The ECC specimens were precracked at 14 days of age using three-point bending tests. In order to encourage self-healing, the healing ingredient was let go into the fissures. With the use of environmental scanning electron microscopy (ESEM), the self-healing phenomena was discovered. Additionally, the chemical components of the healing products were ascertained by the use of X-ray microanalysis (EDS). Si, O, Ca, and Na are the primary chemical components of the healing products, according to the EDS data. The composites of CSH and sodium silicate are the healing products that develop in the cracks, according to the examination of the Ca/Si and Na/Si ratios. Therefore, the reactivity of calcium cations with the dissolved sodium silicate and the crystallisation of the sodium silicate constitute the primary process of sodium silicate solution self-healing. Using sodium monofluorophosphate (Na2PO3F) in 4mm-diameter EC capsules, HaoliangHuang and Guang Ye [2] showed that sodium on fluorophosphates healed the samples and markedly enhanced the quality of concrete in the carbonation zone. Light aggregate capsules filled with sodium silicate were employed by Alghamri et al. [3]. Comparing the cracking test sample to a control sample showed an 80% recovery in load-bearing capability. Additionally, there was an improvement in capillary water absorption, suggesting less cracking and an anticipated longer material durability. UlgerBulutin [4] In addition to being strong, SFRC has significant residual strengths even after the first fracture appears. This article examines the function of variously configured steel fibres in conjunction with steel bar reinforcement. It presents the findings of an experimental study programme that examined the effects of different kinds and quantities of steel fibre on the flexural tensile strength, fracture behaviour, and workability of high-strength concrete beams reinforced with steel bars. Several bar reinforcements (about 6 mm and 12 mm) and three distinct fibre designs (two straight with end hooks that varied in ultimate tensile strength and one corrugated) were employed in the study framework. There were three distinct fibre contents used. Experiments demonstrate that greater load values in the post-cracking region and a more ductile behaviour were achieved for all specified fibre contents.[5] investigated the use of granular self-healing chemicals to enhance the protection of water leaks via fractures. Granulation enhanced the delay of recession and prevented water leaks. In mortar specimens, Stuckrath et al. [6] investigated a variety of self-healing agents (chemical, biological, and hybrid). Chemical agents performed better in the healing process, and combinations of agents produced the best outcomes. Concrete's mechanical qualities were investigated and ash substitution was experimented with by Foust et al.

[7]. The ideal replacement of ash was discovered to be 25%, which improved the self-healing properties of concrete. Plain concrete is fragile and needs reinforcing to handle typical stresses and impact loads, according to Dr. K. Vidhya and colleagues [8]. They discovered that by adding fibres, which increase flexural and tensile strength, the occurrence of microcracks in concrete constructions may be reduced. Their investigation evaluated the compressive strength, tensile strength, and flexural behaviour of concrete beams using M40 grade concrete with different amounts of steel fibre. The impact of dolomite powder on the characteristics of C30 and C50 cements was reported by S. Bakhitiyari [9].Concretes containing dolomite powder had their microstructure, splitting tensile strength, compressive strength, and fracture toughness evaluated using mercury intrusion porosimetry (MIP), pressure testing equipment, and universal testing equipment. An increase in dolomite powder dose within 90 days was associated with higher splitting tensile strength, compressive strength, and fracture toughness of concretes. Da-we-wang, Xhangzhou, [10] The study that looked at using dolomite powder (DP) as the SCC filler component produced some intriguing findings as well. Thus, it became evident from the experimental observation that the SCC with a blended combination of fly ash and DP (as opposed to the conventional limestone powder) in a 3:1 ratio demonstrated the engineering qualities that mostly met the criteria for research practise.

3. OBJECTIVES

3.1 Objectives of research

1. The main objective is to replace cement with dolomite powder in M40 grade concrete.
2. To investigate the self-healing capacity of M40 grade concrete containing dolomite powder under three distinct environmental conditions: Water Immersion(WI), Water Contact(WC), and Air Exposure(AE).
3. In this study most appropriate combinations of dolomite powder with and with out crystalline admixture to be integrated into the M40 grade concrete mix which leads to the concrete blend for superior performance and sustainability.

4. MATERIALS AND METHODOLOGY

The blends are casted with the goal of giving concrete its maximum strength. The mix proportions of the different materials used in the concrete mixes reconsidered based on the IS:10262-2019 Code approach.

4.1. MATERIALSUSED

4.1.1. Ordinary Portland cement(grade53)

The type of cement used in the study is OPC 53 grade cement from JSW PVT Ltd. The individualproperties of the cement were determined to ensure that they met the limits specified in the IS: 12269-1987standard.The specific gravity of cement is obtained as3.15.

4.1.2. Coarse aggregate

The coarse aggregates originate from a combination of naturally existing rock fragments and crushed granite. Concrete strength qualities may also be affected by the coarse aggregate form.

As per IS:383-1970,in the study coarse aggregate is used as 20 mm size aggregate. The specific gravity of the aggregate is obtained as 2.74.

4.1.3. Fine aggregate

Sand is a naturally occurring substance composed of minuscule fragments of rock and mineral. Quartz's chemical inertness and substantial hardness make it the most prevalent material that can withstand harsh weathering. In concrete, it serves as a fine aggregate. To do this task, in this study the river sand found locally is used, which was passing through a 4.75mm IS sieve and conforming to grading zoneIIofIS:383.The specific gravity of fine aggregate is obtained as 2.65.

4.1.4. Dolomite powder

Dolomite is used as a source of magnesium metal and of magnesia (MgO), which is a constituent of refractory bricks. Dolostone is often used instead of limestone as an aggregate for both cement and bitumen mixes and also as a flux in blast furnaces which is imported locally whose specific gravity was found to is 2.85.

Fig.1

4.1.5. Steel fibers

Fibers are normally used in concrete to control cracking due to plastic shrinkage and to drying shrinkage .They also reduce the permeability of concrete and for this reason minimize bleeding of water.Some types of fibers produce greater impact, abrasion, and shatter–resistance in concrete.

As concrete was weak in the tension zone the steel fibers incorporated in the concrete would nicely handle the tensile stresses. The weight of steel fibers is chosen as 2% by weight of cement. The length of fiber is 10mm and the diameter is 0.12mm.

4.1.6. Water

The primary ingredient in making concrete is water. Concrete was mixed and cured using drinkablewater. Oils, acids, alkalis, salts, biological matter, and other pollutants that might harm concrete should not be present in the water used to mix concrete, including the free water on the aggregates. The pH of water is maintained in range of 6.7-7.3

4.1.7. Super Plasticizer

In order to make high-strength concrete, super plasticizers (SP) are added to fresh concrete to enhance its workability and enable the water content to be dropped. Conplast SP 430 DIS is the Superplasticizer utilized in this investigation. The specific gravity of superplasticizer is obtained as 1.08.

4.1.8. Sodium silicate solution

Sodium silicate solution, commonly referred to as water glass, is a versatile healing agent used in self-healing concrete. When incorporated into concrete mixes, sodium silicate reacts with calcium ions

Industrial Engineering Journal
ISSN: 0970-2555
Volume: 52, Issue 11, November: 2023

in the presence of moisture to form calcium silicate hydrate (C-S-H) gel. This reaction effectively seals microcracks that developin concrete over time, enhancing the material's self-healing capabilities. Sodium silicate has proven effective in improving concrete durability and minimizing the ingress of harmful substances, making it a valuable component in the development of more resilient and long-lasting concrete structures. Its non-toxic nature and compatibility with existing concrete technology further contribute to it attractiveness as a healing agent in the construction industry. The specific gravity of Sodium silicate obtained as 1.91.

4.2. METHODOLOGY

The four steps that make up this study's evaluation of dolomite powder's potential as a partial cement substitute are listed below.

1. Calculating the compressive strength of dolomite powder in lieu of concrete without crystalline admixture (DP5, DP10, DP15, and DP20) and concrete with crystalline admixture (CDP5, CDP10, CDP15, and CDP20).
2. The specimens are given controlled harm.
3. Emulation of the different environmental exposures required to improve healing outcomes.
4. Measuring the specimens' recoverable compressive strength after being exposed to various exposure settings for 28 and 56 days to controlled cracking and sodium silicate as a self-healing agent.

Table1.Mix proportions

Dolomite powder as partial replacement to cement in kg/m3									
Name of mix	**Percentage Replacement**	**Cement**	**Dolomite powder**	**Fine aggregate**	**Coarse aggregate**	**Water content**	**Super plasticizer**	**Steel fibres**	**Healing agent**
RM	0	411	0.00	667	1274	148	4.11	8.22	0
DP5	5	390.45	20.55	667	1274	148	4.11	8.22	0
DP10	10	369.9	41.1	667	1274	148	4.11	8.22	0
DP15	15	349.35	61.65	667	1274	148	4.11	8.22	0
DP20	20	328.8	82.2	667	1274	148	4.11	8.22	0
CRM	0	411	0.00	667	1274	148	4.11	8.22	20.55
CDP5	5	390.45	20.55	667	1274	148	4.11	8.22	20.55
CDP10	10	369.9	41.1	667	1274	148	4.11	8.22	20.55
CDP15	15	349.35	61.65	667	1274	148	4.11	8.22	20.55
CDP20	20	328.8	82.2	667	1274	148	4.11	8.22	20.55

Ten groups of three cubes each were used to cast the specimens. For the purpose of improving strength qualities, ten groups are used. These are two types of concrete: one with crystalline admixture (CRM,CDP5,CDP10,CDP15& CDP20) and the other with dolomite powder substituted (RM,DP5,DP10,DP15& DP20). Ten groups are utilised in the research of structural fractures that self-heals under the three environmental exposure conditions of air exposure (AE), water immersion (WI), and water contact (WC).

1. To measure the compressive strength of both plain concrete and concrete mixed with dolomite powder, two cube specimens of 150 x 150 x 150 mm were made, one with crystalline admixture and the other without.
2. Damage creation (pre-cracking procedure): cube specimens (150 x 150 x 150 mm) were pre-cracked using a compression test for structural cracks at the age of 28 days. Controlled damage refers to the crack's breadth, which is set to a target value by controlled loading.
3. Exposure simulation: By contrasting reference concrete with dolomite powder and with and without crystalline admixture concrete, three environmental exposure conditions were taken into consideration in order to ascertain the influence of water availability and its temperature on the self-healing capability of the tested specimens. Every specimen was given 28 or 56 days to recuperate.
4. At 28 and 56 days, ascertain the concrete specimens' restored compressive strength following the healing of fractures in them under various environmental exposure circumstances.

1. MECHANISM

Silica based healing agent sodium silicate solution are considered as excellent mineral agent for self-healing of cementatious materials. Sodium silicate reacts with calcium hydroxide (CH) in the presence of water to form a calcium silicate hydrate(CSH) gel which is the main product of cement hydration.

The reaction between sodium silicate and calcium hydroxide in the presence of water is given as:

$$Na_2SiO_3 + Ca(OH)_2 + H_2O \longrightarrow (CaO.SiO_2)\,2H_2O + Na_2O$$

As Sodium silicate solution has silica in addition to the silica present in cement, leads to the formation of additional CSH gel, which is the primary strength contribution in concrete. This

Industrial Engineering Journal
ISSN: 0970-2555
Volume: 52, Issue 11, November: 2023

additional silica may react with calcium hydroxide reducing the formation of Ca(OH)2 which is beneficial as excessive calcium hydroxide may affect durability of concrete.

2. RESULTS & DISCUSSIONS

Regained compressive strength was analyzed for both with and without crystalline admixture conditions for all the exposure conditions over a time period of 28 & 56days.The results obtained were plotted in the graphs for all the exposure conditions with respect to 28 & 56 days and represented below.

The Regained compressive strength for 28 & 56 days are depicted in the fig.2-3below. It was found from fig 3 that the compressive strength obtained for the mix containing 15% of dolomite powder replacement without crystalline admixture reached the maximum value in all the exposure conditions. At 28 days & 56 days it was found that the compressive strength obtained for the mix containing 15% of dolomite powder replacement addition was higher among the all the mixes and found to be 30.41 N/mm^2 & 32.70 N/mm^2 respectively for Water Immersion exposure.

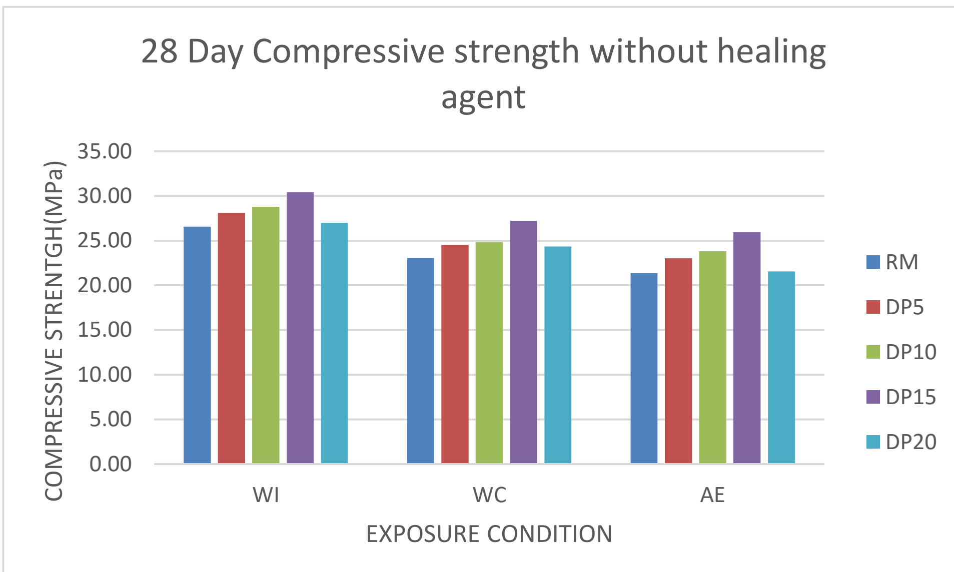


Fig.2 - 28 Days regained strength without healing agent for different exposure conditions in N/mm2

Industrial Engineering Journal
ISSN: 0970-2555
Volume: 52, Issue 11, November: 2023

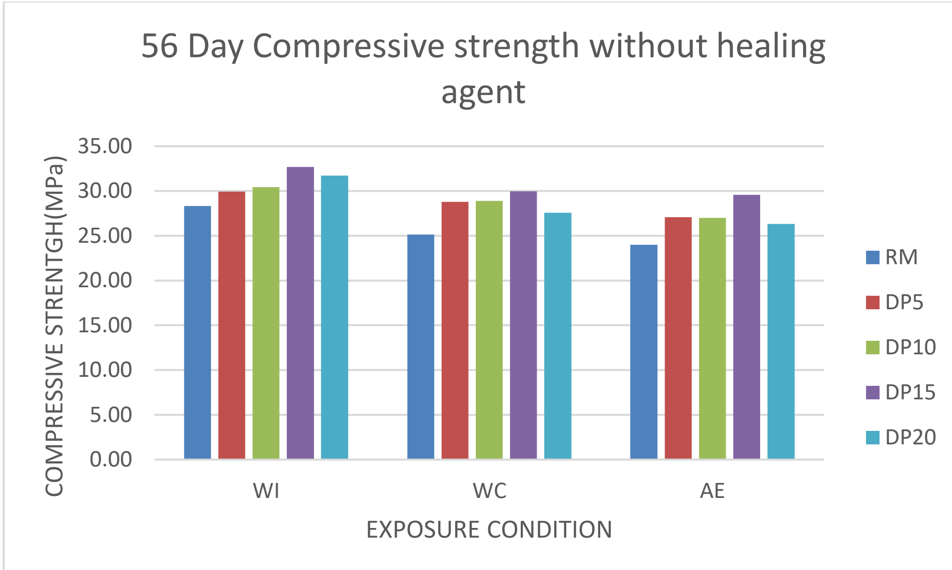
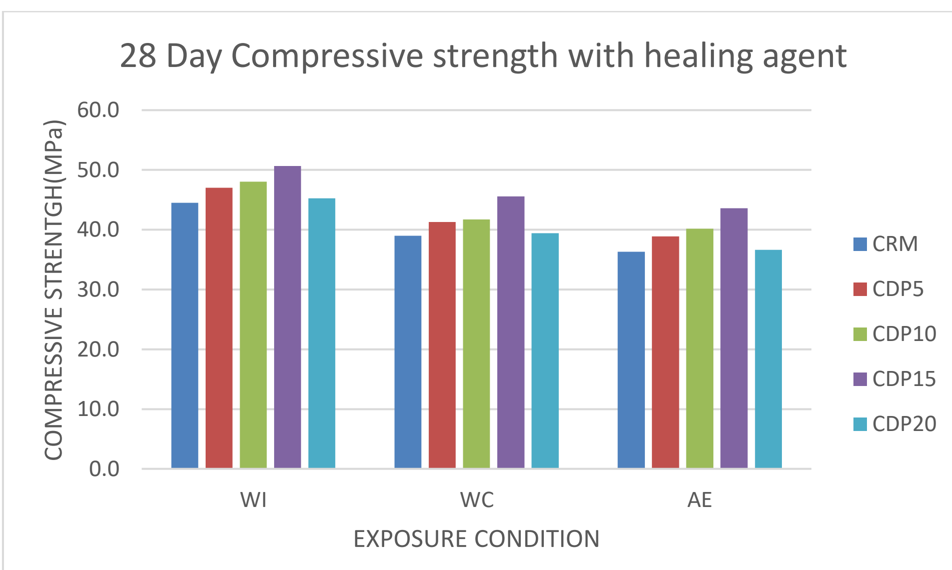


Fig.3 - 56Days regained strength without healing agent for different exposure conditions in N/mm2

The Regained compressive strength for 28 & 56 days are depicted below by addition of crystalline admixture in following fig 4-5 below. It was found from fig that the compressive strength obtained for the mix containing 15% of dolomite powder replacement with crystalline admixture reached the maximum value in all the exposure conditions . At 28 days& 56 days it was found that the compressive strength obtained for the mix containing 15% of dolomite powder replacement addition was higher among the all the mixes and found to be 50.6 N/mm^2& 56.3N/mm^{2}respectively for Water Immersion exposure.



Industrial Engineering Journal
ISSN: 0970-2555
Volume: 52, Issue 11, November: 2023

Fig.4 - 28 Days regained strength with healing agent for different exposure conditions in N/mm2

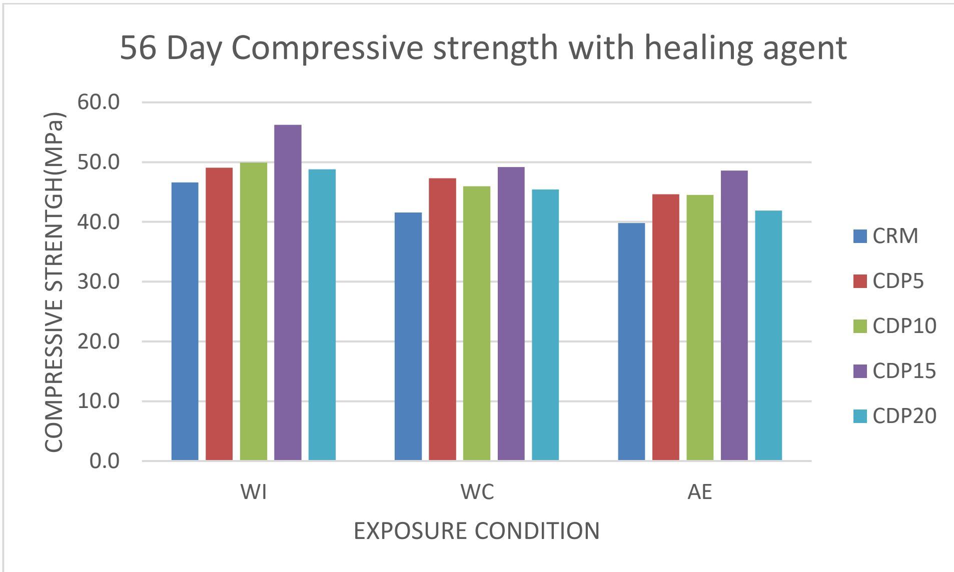


Fig.5 – 56 Days regained strength with healing agent for different exposure conditions in N/mm2

CONCLUSIONS

1. After analyzing the regained compressive strength and crack closure capabilities over the curing period with respect to different environmental exposures the following conclusions are made.
2. The optimum compressive strength for 28and 56 days curing was obtained for the mix containing15% of Dolomite replacement and crystalline admixture addition and it was found to be 50.6 N/mm^2 and 56.3 N/mm^2 respectively.
3. From the crack closures and regained compressive strength values obtained for the mixes with absence of crystalline admixture and presence of Dolomite was found to be 30.41 N/mm^2 for 28 days and 32.70N/mm^2 for 56 days it was proved that Dolomite has contributed partial amount of healing.
4. The mixes which contains both the crystalline admixture and Dolomite has given a good exceptional results for all the exposure conditions. Environmental exposures named Water immersion (WI), Water Contact(WC) and Air Exposure (AE) has the complete crack closure ability and the maximum Regained compressive strength obtained for Water Immersion (WI) was efficient and found to be 50.6N/mm^2 at 28 days and 56.3N/mm^2 at 56 days.

5. The concrete with 15%Dolomite as a partial replacement to Cement with crystalline admixture Sodium silicate solution gained complete strength that 56 days is 1.04% higher than original strength.
6. From the above study it was clear that the healing rate was in the order of WI>WC>AE.

3. REFERENCES

1. BB Yarramsetty, R Dudekula, [2023] “Experimental study on concrete strength properties by partial replacement of cement with Dolomite Powder & fine aggregate with M sand”
2. R Alghamri, S Rengaraju, A Al-Tabbaa [2023]”Large-scale laboratory trials of smart aggregates for self-healing in concrete under different curing regimes”
3. JagadishaC.E,JeevanM N,LukeshNet al(2023),“An Experimental Study on Partial Replacement of Cement by Dolomite Powder”.
4. D.SreehariRao,GuduguntlaVenkataSaiRithik(2023)“an experimental investigation on strength characteristics of concrete by partial replacement of cement with dolomite and oyster sea shell”
5. Iram Shaikh , B. A Memon ,et al (2023), “Effect of steel fibers on compressive strength of recycled aggregate concrete”
6. Giridhar N. Narule, Yogesh B. Ulape et al (2023), “Performance on steel fiber reinforced concrete using metakaolin”
7. MugahedAmran,1AliM.Onaizi,etal[2022]“Self-Healing Concrete as a Prospective Construction Material: A Review”,Materials(Basel).
8. N.Akhtar,RizwanAhmadKhanetal(2022),“Influence of Natural Zeolite and Mineral additive on Bacterial Self-healing Concrete:AReview”
9. C. Pradeep Kumar, M. Shahul Hameed et al (2022), “Experimental study on the behaviour of steel fibre when used as a secondary reinforcement in reinforced concrete beam”
10. Balamurali Kanagaraj , N. Anand et al (2022), “Performance evaluation on engineering properties of sodium silicate binder as a precursor rmaterial for the development of cement-free concrete”.
11. Mohammad Idris Rasuli et al (2022), “A Study on the Influence of Sodium Silicate Concentration and SiO2:Na2O Ratio on the Properties of Low-Calcium FlyAsh-Based Alkali-Activated Materials Cured at Ambient Condition”,
12. AkyuncuV,SanliturkF(2021)Investigation of physical and mechanical properties of mortars produced by polymer coated perlite aggregate.
13. Álvaro González a, Araceli Parraguez b, Liliana Corvalán c, Néstor Correa c, Javier Castro d, Cl audia Stuckrath a, Marcelo González a [2020] Evaluation of Portland and Pozzolanic cement mortar on the self-healing of mortars with calcium lactate and bacteria
14. S.BAKHTIYARI & A.ALLAHVERDI (2014). A case study on modifying the fire resistance of self-compacting concrete with expanded perilite aggregate and zeolite powder additives.
15. H Huang, G Ye, D Damidot [2013] Characterization and quantification of self-healing behaviors of microcracks due to further hydration in cement paste
16. HAMID H. HUSSAIN (2013). Analysis of temperature gradient for mass concrete units by using polystyrene beads and perilite.

17. S. Bakhtiyari a, A. Allahverdi b, M. Rais Ghasemi c, B.A. Zarrabi d, T. Parhizkar c [2011] Self-compacting concrete containing different powders at elevated temperatures – Mechanical properties and changes in the phase composition of the paste
18. ISCODES
    - Plain and Reinforced Concrete – Code of Practice, Indian Standard Code 456-2000.
    - Guideline for Concrete Mix Proportion, Indian Standard Code 10262-2019.
    - Methods of Test for Aggregates of Concrete, Indian Standard Code 2386-1963.
    - Specification for 53 Grade Ordinary Portland cement, Indian Standard Code12269-1989.
    - Compressive strength test : IS516-1956