

Experimental Study On Self Curing Concrete Using Sodium Lignosulfonate As Admixture By Partially Replacement Of Fine Aggregate By M Sand And Cement By Eggshell Powder

Nitin kodle¹, Devaraj², Abhishek Hadpad³, Bhagyashree⁴, Adarsh⁵

¹Professor, Department of Civil Engineering, PDA College of Engineering, Kalaburagi, India

^{2,3,4,5}Student, Department of Civil Engineering, PDA College of Engineering, Kalaburagi, India

ABSTRACT

Concrete is the most widely used construction material, and the demand for natural river sand has led to environmental concerns and material scarcity. This project investigates the effect of partial replacement of natural sand with Manufactured Sand (M-Sand) and the use of sodium lignosulfonate as a chemical admixture on the properties of concrete. The study focuses on M20 grade concrete with 10% replacement of fine aggregate by M-Sand and 0.5% sodium lignosulfonate by weight of cement. Concrete specimens were prepared, cast, and cured as per standard procedures. The workability characteristics and compressive strength of concrete cubes of size 150 mm × 150 mm × 150 mm were evaluated at different curing periods. The results obtained were compared with conventional concrete to assess performance improvement. The inclusion of M-Sand enhanced particle packing, while sodium lignosulfonate improved workability and strength due to its water-reducing properties. The experimental results indicate that the combined use of M-Sand and sodium lignosulfonate improves compressive strength and overall performance of concrete without compromising quality. This study concludes that partial replacement of natural sand with M Sand along with suitable admixtures is a sustainable and economical alternative for modern concrete construction.

Keywords: SCC, Sodium Lignosulfonate, Eggshell Powder

INTRODUCTION

1.1.1 Concrete and composition of concrete:

Concrete has been the most versatile material used in the construction industry. It is the second most consumed material in the world due to high compressive strength and durability, which is the mixture of cement, aggregates, water and with or without suitable admixtures, needs curing to achieve required strength. When cement is added to water, hydration reaction takes place and this hydration process is necessary for hardening of concrete.

1.1.3 SELF CURING CONCRETE:

A self-curing concrete is one which the cement hydrates from a source other than the mixing water. Self-curing concrete is a type of concrete with a special ability to reduce autogenous shrinkage responsible for early stage cracking. Using self-curing concrete will lead to an escalation in this strength of concrete. Self-curing is beneficial in a low water cement ratio concrete because of the chemical shrinkage that accompanies Portland cement hydration and low permeability of these material. Since the water incorporated into and absorbed by the cement hydration products has a specific volume less than that of bulk water a hydrating cement paste will imbibe water from available source. While in higher water cement ratio concrete this water can be and after his supplied by external curing.

1.1.4 SELF CURING CONCRETE WITH SUPERPLASTICIZER

(SODIUM LIGNOSULPHONATE):

When making concrete, superplasticizers (SP) are often utilized as dispersing agents during the hydration of Portland cement. These SP can be either naturally occurring or synthesized polymers that are water-soluble. Super-water reducers, Superfluidizers, and high-range water reducers are all names for the same class of chemicals. Concrete made with SP has a higher workability, making it easier to move, position, and compact; it also has a higher strength and polymers that are water-soluble. Super-water reducers, Superfluidizers, and high-range water reducers are all names for the same class of chemicals. Concrete made with SP has a higher

workability, making it easier to move, position, and compact; it also has a higher strength and requires less water, which are all advantages. This chemical is used to improve the aesthetics and physicochemical properties of the concrete's surface. Additives are mixed into cement and concrete to promote fluidity, avoid segregation, and lower viscosity. The dispersive effect also allows more of the cement's surface area to come into contact with the water, which speeds up the hydration process, yielding more strength with a shorter setting time. In order to provide a denser and less permeable matrix, SP allows a 30% reduction in the water-to-cement (w/c) ratio by increasing the fluidity of the wet cement. The SP's dispersive activity may result from the polymer chain adsorbing to the cement particle surface during the earliest stages of hydration, because of this there will be more negative charges on the surface. The interactions between sodium lignosulfonate and the hydrating cement particles significantly affect the hydration reaction. This study provides conclusive evidence that the hydration of Portland cement is inhibited by chemical forces rather than physical events when superplasticizers are present. Lignosulfonate derived from sulphite pulping spent liquor, or alkali lignin sulphonation can be utilized as a water reducer in the building industry at a reasonable cost. But its modest water reduction capabilities (often approximately 8 per cent) inhibit its widespread deployment. Therefore, it is essential to boost the effectiveness of concrete plasticizers made from lignin. It has been found that the water-reducing capacities of the resulting SLS are significantly determined by the distribution of molecular weight and the presence of strong hydrophilic groups.

LITERATURE REVIEW

T. SHANMUGAPRIYA¹ , R. N. UMA² ¹ASSISTANT PROFESSOR, ² PROFESSOR & HOD, DEPARTMENT OF CIVIL ENGG., SRI RAMAKRISHNA INSTITUTE OF TECHNOLOGY, COIMBATORE, INDIA.

“Optimization of Partial Replacement of M-Sand by Natural Sand in High Performance Concrete with Silica Fume”

The huge quantity of concrete is consumed by construction industry all over the world. In India, the conventional concrete is produced using natural sand from river beds as fine aggregate. Decreasing natural resources poses the environmental problem and hence government restriction on sand quarrying resulted in scarcity and significant increase in its cost. This paper presents the optimization of partial replacement of manufactured sand by natural sand with silica fume in High Performance Concrete (HPC). Concrete mixes were evaluated for compressive strength and flexural strength. The ordinary portland cement was partially replaced with silica fume by 1.5%, 2.5 %, and 5% and natural sand was replaced with manufactured sand by four proportions (ie 10%, 30%, 50%, 70%). The results indicated that there is an increase in the compressive and flexural strength of HPC nearly 20% and 15% respectively with the increase of manufactured sand percentage. Addition of up to 50% of manufactured sand as sand replacement yielded comparable strength with that of the control mix. However, further additions of manufactured sand caused reduction in the strength.

DAMIEN BREILLY, ^{1,2} SAMI FADLALLAH, VINCENT FROIDEVAUX, ANTOINE COLAS, FLORENT ALLAISURD AGRO-BIOTECHNOLOGIES INDUSTRIELLES (ABI), CEBB, AGROPARISTECH, 51110, POMACLE, FRANCECHRYSO, 7 RUE DE L'EUROPE, Z.I. 45300 SERMAISES DU LOIRET

“Origin And Industrial Applications Of Lignosulfonates With A Focus On Their Use As Superplasticizers In Concrete”

Abstract

In concrete technology, superplasticizers (SPs) are commonly used to reduce water content in concrete admixtures. Although most of them are fossil fuel-based, some derive from lignosulfonates (LS), that are sustainable and environmentally-friendly polyphenolic crosslinked polymers. Indeed, LS are an inexpensive and abundant raw material that contains a variety of functional groups including hydroxyls which can be involved in a wide range of chemical modifications to finely tune the physico-chemical properties of the material. This review presents: (1) the current SPs and their mechanism of adsorption and dispersion as admixtures to improve the properties of fresh concrete (e.g., workability, fluidity,

SHREYAS. K AAST PROFESSOR, DEPT OF CIVIL ENGINEERING. DON BOSCO INSTITUTE OF TECHNOLOGY, BANGALORE, INDIA

“Characteristics Of M-Sand As A Partial Replacement With Fine Aggregate In Mix Design”

Abstract: There is a great demand of both coarse & fine aggregates for the construction of infrastructural facilities, rather than using a conventional river sand as a fine aggregate in concrete mix as one of the construction material which has led to the scarcity of the material an alternative material such as manufactured sand can be used for the construction purposes. A replacement of finer aggregates by a manufactured sand by varying proportions leads to the increase in both engineering & physical properties of concrete constituents

which are to be considered in recent trends. In the present study manufactured sand with varying proportions from 0 to 40% by its weight are mixed with concrete materials as a partial replacement with fine aggregates & analysed for physical and engineering properties, with the further analysis an introduction of manufactured sand in a proper proportions will lead to increase in the compressive strength by 15 to 20% for the concrete cubes which are being tested for 7 days, 14 days & 28 days strength.

KIRAN M. MANE, ABHAY M. JOSHI", D.K. KULKARNI", K.B. PRAKASH

“Influence Of Retempering On Properties Of Concrete Made With Manufactured Sand And Industrial Waste”

The construction industry is currently dealing with a number of major issues. These include of shortage of river sand and large amount of energy required for manufacturing of cement prates free Co, le air, accordingly me of manufactured sand and industrial waste in concrete increases, In construction of hilly topography lany carrying of concrete it required, In remote location providing of concrete from inner mixing place, in construction of road, in lengthy tunneling work, manual transportation of concrete by labor, directly affect the flow property property and concrete get stiff at the time of casting on real site work and in several condilonsent nected by engineers. The paper discusses effects of replacing cerunt with 20% of industrial waste silici fume and partially replacing natural sand with manufactured sand in the context of properties of re-tempered concrete like flove, water alsortion, soqxivity, hesile, compressive, flexural, shear, impact strengths and chloride permeability. The work demonstrates that the low property inversely proposition with re-tempering time. Water absorption, sorptivity and chloride permeability for retempered

OBJECTIVES

- Encourage sustainable water usage: minimize the dependency on external water for curing, promoting resource - efficient construction methods.
- To decrease the water content of a concrete mix by using sodium lignosulphonate.
- To determine the characteristics of self-curing concrete such as compressive strength by adding self-curing agent in varying percentage.
- To compare the strength between conventional and self-curing concrete.
- To reduce cement consumption and environmental impact by partially replacing cement with eco-friendly eggshell powder while maintaining concrete strength.

MATERIALS AND METHODOLOGY

5.1 MATERIALS PROPERTIES:

Following is the list of materials used in the present study. Preliminary tests were conducted for physical properties of these materials and their tests results are presented in section.

1. Cement (43 grade OPC)
2. Fine aggregate
3. Coarse aggregate
4. Water
5. Super plasticizer (Sodium Lignosulphonate)

5.1.1 CEMENT: The cement used was ordinary Portland cement of 43 grade conforming to IS 12269- 1987. The cement was checked for its freshness and consistency. It was found dry, pure, without any lumps. Tests were conducted for physical properties of cement and results are given in

Table 5.1.1 Properties of Cement

Sl. No	Properties	Test results	IS-values 10262-2009
1	Specific gravity	3.15	3.15
2	Normal consistency	33%	25%-35%
3	Initial setting time	30 minutes	30-60 minutes
4	Final setting of cement	2hours 38min	10 hours(max)
5	Fineness of cement	2%	10%(max)

5.1.2 FINE AGGREGATE:

Natural and conforming to Zone II, fine aggregate is used. The sand was sieved with 4.75 mm. It was free from clay, silt and organic impurities. The aggregate was tested for its physical requirements such as fineness modulus, specific gravity and bulk density.

Table 5.1.2 physical properties of fine aggregate

Sl. No	Properties	Fine aggregate
1	Bulk density	1.64gm/cm ³
2	Specific gravity	2.68
3	Water absorption	4.16%

5.1.3 COARSE AGGREGATE:

The Coarse aggregate using in this present study was 20mm size locally available crushed stone obtained from local quarries. The physical properties have been determined as per IS: 2386-1963. The specific gravity of coarse aggregate was found to be 2.78. The water absorption was 0.25%.

5.1.4 WATER:

Potable water was fit for mixing concrete as well as for curing of concrete. So, it was made confirm that the water is covering all the requirements of its purity and use in concrete mix. Mixing water should not contain undesirable organic substances or inorganic constituents in excessive proportions. In this project clean potable water is used and curing as per IS: 456-2000

5.1.5 Sodium lignosulphonate:

Sodium Lignosulphonate are mainly for concrete mixture as water-reducing additive.



Fig:1 Sodium lignosulphonate

Table 5.1.5 properties of sodium lignosulphonate

S.NO	INDEX ITEMS	STANDARD VALUES
1	Appearance	Dark brown
2	Lignosulphonate	50%
3	Dry matter	92%
4	Moisture contents	7.0%
5	PH value	7-11
6	Inorganic Salts (Na,So)	5.0%
7	Total reducing matter	4.0%

5.1.6 Eggshell Powder

Eggshell Powder is mainly used to reduce quantity of cement used.



Fig 2 Eggshell Powder

M.SAND:

M sand, or manufactured sand, is a sustainable alternative to river sand. It is produced by crushing hard granite stones and rocks, which are then grounded into a fine powder. The process involves employing advanced machinery and technology, resulting in a consistent and high-quality product. The resulting product is cubical in shape and possesses similar properties to natural river sand. M sand is often preferred for construction projects due to its consistent quality, availability, and minimal impurities.



Fig: 4 M Sand

METHODOLOGY

Materials Required

Material	Description
Cement:	Ordinary Portland Cement (OPC) 33/ 43/53 grade
M sand:	Granite crushed or rock crushed having zone of (I,II,III,IV)
Superplasticizer:	To improve workability
Eggshell powder:	To reduce cement quantity

MIX PROPORTION

6.1 DESIGN MIX PROPORTION

Below is the mix design calculation for M20 grade concrete with using 0.5% of Superplasticizer. Mix design is done as per IS : 10262-2019.

- Grade designation : M20
- Type of cement and grade of cement : OPC 43 grade
- Max nominal size of aggregate : 20 mm
- Exposure condition : Severe (IS 456-2016, table-3)
- Minimum Cement Content : 320kg/m³ (IS 456-2016)
- Workability in terms of slump : 100mm (IS 456-2016, Cl 7.1)
- Type of Coarse aggregate : Crushed angular aggregate
- Eggshell powder : 5% of weight of cement
- Maximum Cement Content : 450 kg/m³ (IS 456-2016 Cl:8.2.4.2)

Test data for materials

- Cement used : OPC 43 grade
- Specific gravity of cement : 3.15
- Specific gravity of
 - 1. Coarse aggregate : 2.78
 - 2. Fine aggregate : 2.68
- Water absorption
 - 1. Coarse aggregate : 0.45%
 - 2. Fine aggregate : 1.0%
- Sieve analysis
 - 1. Coarse aggregate : Confirming to Table 8(IV) of IS 383-2016
 - 2. Fine aggregate : Confirming to Zone-I of IS 383-2016

A. Target strength for mix proportioning:

$$f'_{ck} = f_{ck} + k_s$$

From IS 10262-2019 of table-1, standard deviation, (S) = 4 N/mm²

$$\text{Therefore target strength} = 20 + [4 \times 1.65] = 26.6 \text{ N/mm}^2$$

B. Selection of w/c ratio:

From table 5 of IS 456:2000,

Maximum water cement ratio = 0.45

Adopt water cement ratio as 0.45 which is less than 0.55, hence O.K.

C. Selection of water content:

From table 4 of IS 10262-2019, maximum water content = 186 liters [for 25 -50 mm slump range]

[For workability other than 25 mm - 50 mm range the required water content may be increased by about 3 percent for every additional 25 mm slump].

$$\text{Final water content} = 186 + 6/100 \times 186 = 197 \text{ litres}$$

Based on trials with superplasticizer (0.5%), water content reduction of 15% has been achieved.

$$\text{Therefore, Water content} = 197 \times 0.80 = 158 \text{ litres.}$$

D. Calculation of Cement

$$W/C \text{ ratio} = 0.45$$

$$\text{Cement material} = 158 / 0.45 = 351 \text{ kg/m}^3$$

From the table-5 of IS 456-2000 the cement content for severe condition is 320 kg/m³

$\therefore 352 > 320 \text{ kg/m}^3$, Hence OK.

Consider the increase of 10% cement material content = $352 \times 1.10 = 388 \text{ Kg/m}^3$

Cement content = $388 \times 0.9 = 350 \text{ Kg/m}^3$

E. Volume of M-sand:

W/C ratio = 0.45

Volume of M-sand = 0.680 times 0.45 = 0.306 m^3

Mass of M-sand

M-sand = 0.306 times 2.68 times 1000

M-sand kg/m^3

(Per 1 m^3 Concrete)

M-sand required = $\sim 820.08 \text{ kg/m}^3$

E. Determination of volume of coarse aggregate and fine aggregate content:

(From the table-3 of IS 10262-2019 volume of coarse aggregate corresponding to 20mm size aggregate of zone-II is 0.62. In the present case w/c ratio is 0.45, therefore volume of coarse aggregate is required to decrease the fine aggregate content: As the w/c ratio is lowered by 0.45, the proportion of volume of coarse aggregate is increased by 0.01)

Therefore, volume of coarse aggregate = 0.61

Volume of fine aggregate = $1 - 0.6 = 0.39$

Mix Calculation:-

a) Volume of concrete = 1 m^3

b) Volume of cement = (mass of cement / specific gravity of cement $\times 1 / 1000$)
 $= (352 / 3.15 \times 1 / 1000) = 0.1117 \text{ m}^3$

c) Volume of M Sand = $(751.28 / 2.2 \times 1 / 1000) = 0.341 \text{ m}^3$

d) Volume of water = mass of water / 1000
 $= 158 / 1 \times 1 / 1000 = 0.158 \text{ m}^3$

e) Volume of chemical admixture {Superplasticizer i.e. Sodium Lignosulphonate} at 0.5% by mass of Cement material = $1.76 / 1.145 \times 1 / 1000 = 0.0015 \text{ m}^3$

f) Volume of all in aggregate = $a - (b + c + d + e)$
 $= 1 - [0.1117 + 0.158 + 0.0015 + 0.01] = 0.7188 \text{ m}^3$

g) Mass of coarse aggregate = (f) $\times$ Vol of CA $\times$ S.G of CA $\times 1000$
 $= 0.718 \times 0.61 \times 2.78 \times 1000$
 $= 1217 \text{ kg}$

h) Mass of fine aggregate = (f) $\times$ Vol of FA $\times$ SP.GR. of FA $\times 1000$
 $= 0.7188 \times 0.39 \times 2.68 \times 1000 = 751.28 \text{ Kg}$

Summary:

Cement	= 352 kg/m^3
M Sand	= 820.08 Kg/m^3
Water	= 158 kg/m^3

FA	= 752 kg/m ³
CA	= 1217 kg/m ³
Chemical Admixture (Super plasticizer)	= 2.31 kg/m ³
Water content ratio	= 0.45
Eggshell powder	= 17.6 kg/m ³

FRESH CONCRETE TEST -WORKABILITY TEST

7.1 Slump Test:

The concrete slump test is an empirical test that measures the workability of fresh concrete. More specifically, it measures the consistency of the concrete in that specific batch. This test is performed to check the consistency of freshly made concrete. Consistency is a term very closely related to workability. It is a term which describes the state of fresh concrete. It refers to the ease with which the concrete flows. It is used to indicate the degree of wetness. Workability of concrete is mainly affected by consistency i.e. wetter mixes will be more workable than drier mixes, but concrete of the same consistency may vary in workability. It is also used to determine consistency between individual batches. Test is popular due to the simplicity of apparatus used and simple procedure. The test is conducted as per IS specification as follows



Fig: 5 Slump apparatus

The result got from this test is: 95mm for conventional concrete and 100mm for self-curing concrete.

HARD CONCRETE TEST

8.1 Compressive Strength

The compressive force applied per unit area on the specimen is termed as the compressive strength. In simple words the compressive force is the pushing force that acts on the specimen. This is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, and quality control during production of concrete etc. Test for compressive strength is carried out on cubes.

The cube specimens of dimension 150 x 150 x 150 mm were cast for M20 grade of concrete. The compressive strength test was carried out for 7,14 and 28 days curing. After their respective days of curing, these cubes were removed from water tank and surface dried by wiping with dry cloths, then compression test was conducted on it.

PREPARATION OF TEST SPECIMENS

Mixing was done in a laboratory by hand mixing. While preparation of concrete specimens, aggregates, cement and mineral admixtures were mixed with the shovel and trowels. After proper mixing, mixture of water and plasticizer were added. The mixing was continued until a uniform mix was obtained. The concrete was then placed into the moulds which were properly oiled. After placing of concrete in moulds proper compaction was given using the tamping rods. Specimens were demoulded after 24 hours of casting and were kept in a curing tank for curing till the age of test.

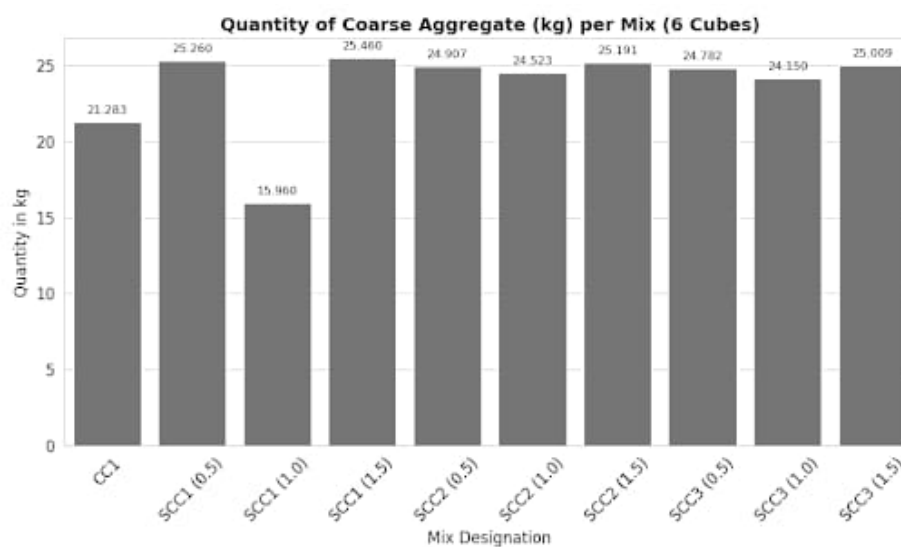
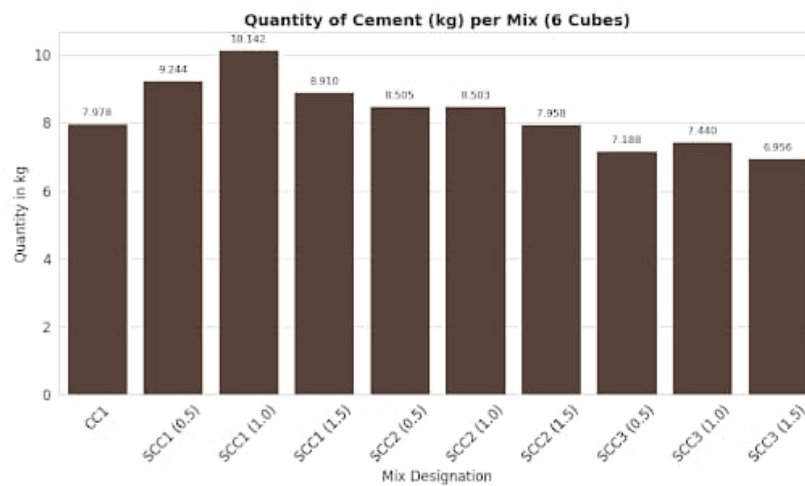
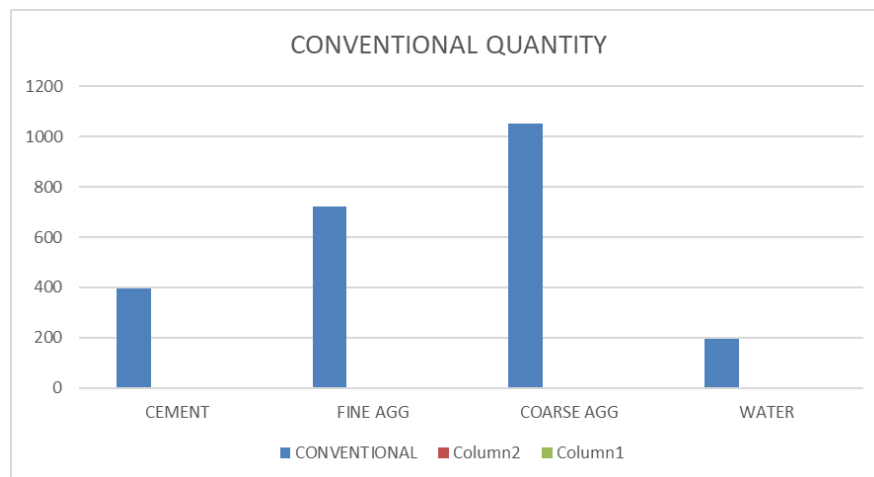


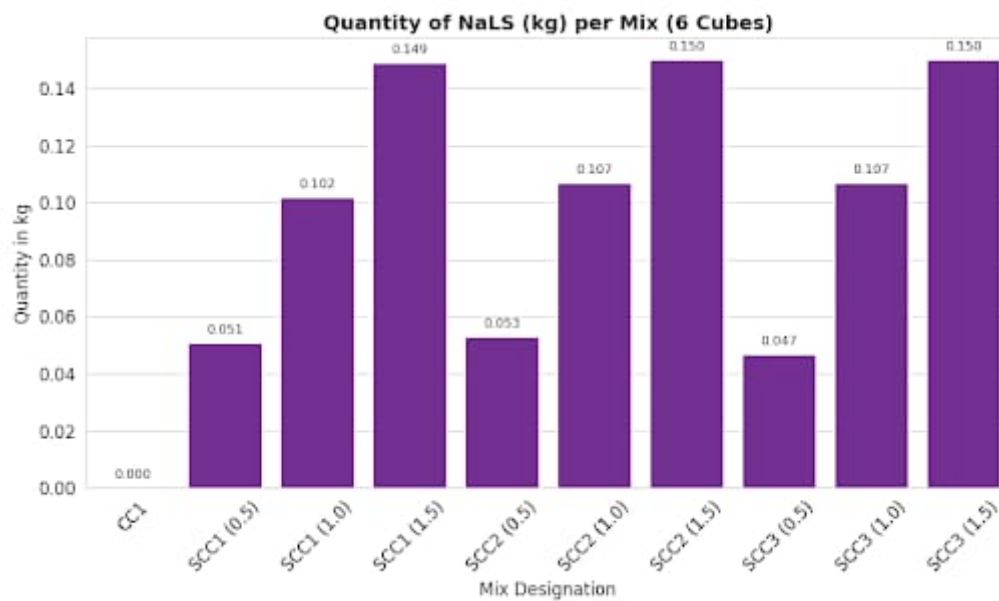
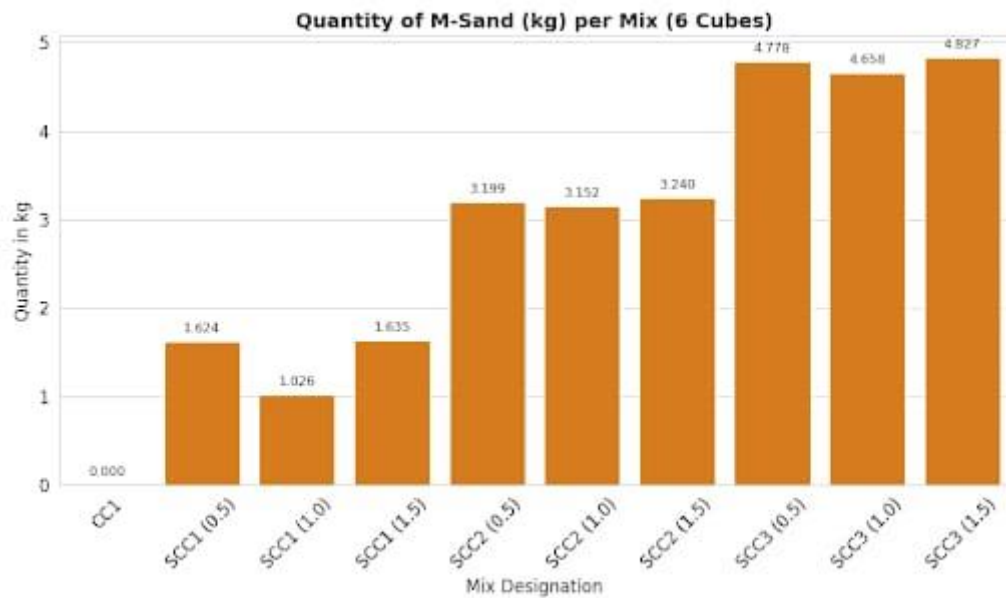
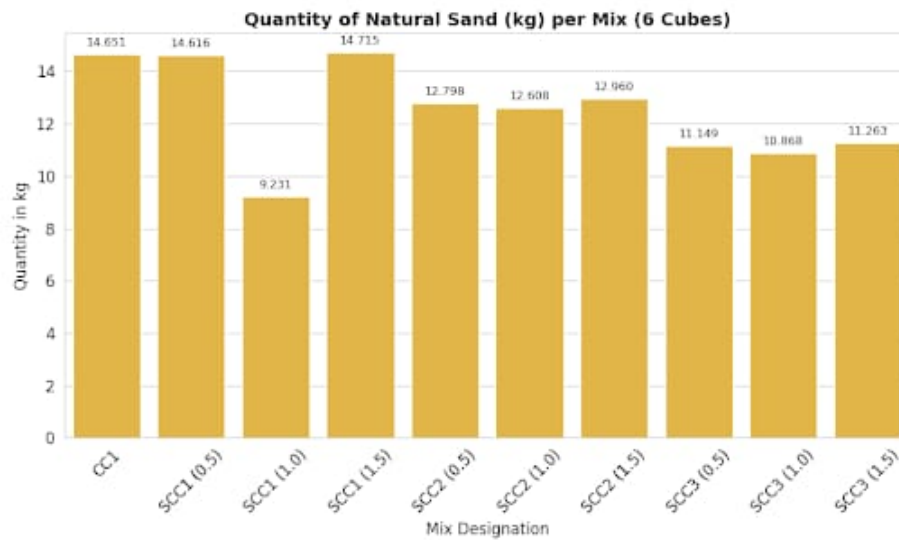
Fig: 7 Mixing of materials

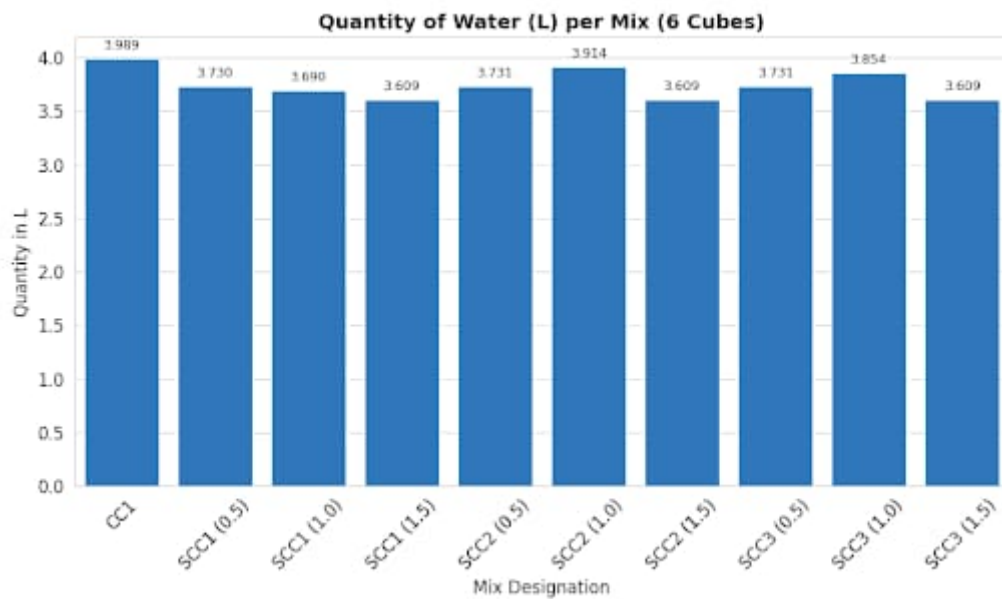
Table: 1 Quantity of materials required for different concrete mixes

MIX DESIGNATION	NATURAL SAND PARTIALLY REPLACEMENT WITH M SAND	NaL S USED IN %	ESP in %	CEMENT USED IN % (KG/m ³)	FINE AGGREGATE (KG/m ³)	COARSE AGGREGATE (KG/m ³)	NaL S (KG/m ³)	WATER (liters)	TO TEST SPECIMENS (no of cubes)
CC1				394	723.5	1051.03		197	6
SCC1	10%	0.5	5	456.5	802	1247.4	2.54	184.2	18
		1.0	5	500.85	506.52	788.13	5.02	182.2	
		1.5	5	440	807.4	1257.3	7.34	178.2	
SCC2	20%	0.5	5	420	790	1230	2.6	184.25	18
		1.0	5	419.9	778.25	1211	5.26	193.3	
		1.5	5	393	800	1244	7.4	178.2	
SCC3	30%	0.5	5	354.97	786.5	1223.8	2.30	184.25	18
		1.0	5	367.4	766.7	1192.6	5.26	190.3	
		1.5	5	343.5	794.6	1235	7.4	178.2	

BAR GRAPHICAL REPRESENTATION OF QUANTITY OF MATERIALS REQUIRED







10. RESULTS AND CONCLUSION

This chapter presents that the results obtained based on the experiments conducted and their inferences.

10.1.FRESH CONCRETE TEST RESULT – WORKABILITY OF CONCRETE

Slump test results: 95mm for conventional concrete and 100mm for self-curing concrete

10.1.2 HARD CONCRETE TEST RESULTS

9.1.2.1 COMPRESSIVE STRENGTH TEST RESULTS:

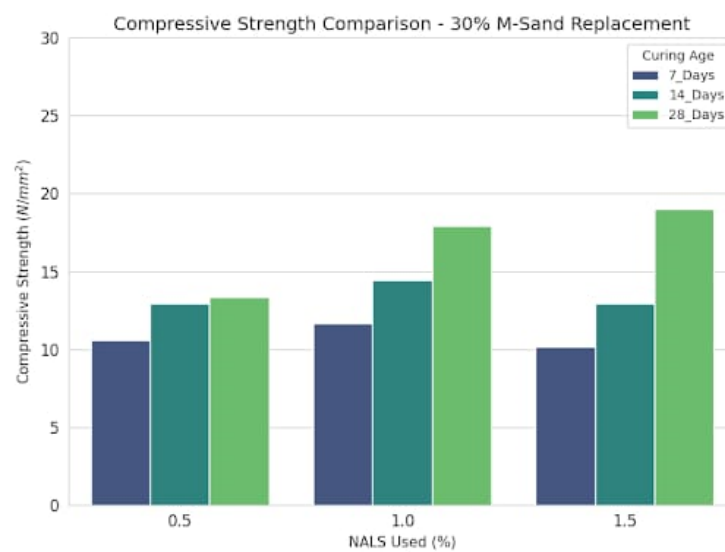
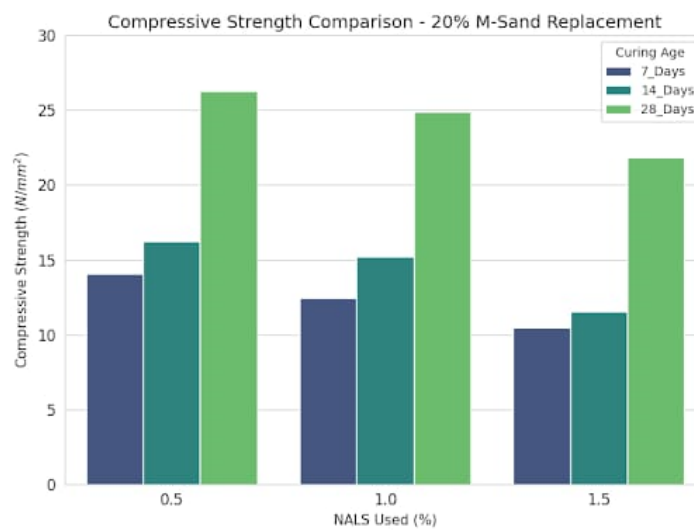
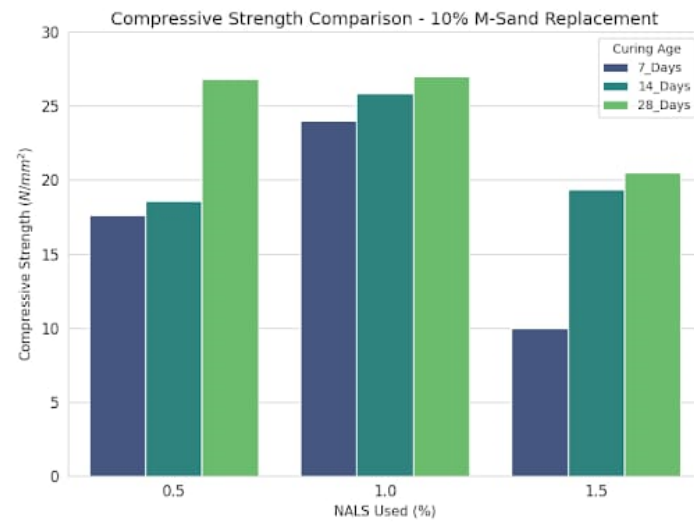
Table.1 Compressive strength test results for conventional concrete

SL.NO	COMPRESSIVE STRENGTH IN N/mm ²		
	7 days	14 days	28 days
1	12.5	14.9	13.25

Table: 2 Compressive strength test results for self- cured concrete

SL NO	NATURAL SAND PARTIALLY REPLACEMENT WITH M SAND	% OF NALS USED	% of ESP used	COMPRESSIVE STRENGTH IN N/mm ²		
				7 DAYS	14 DAYS	28 DAYS
1	10	0.5	5	17.60	19.58	27.8
		1.0	5	24	26.87	27.6
		1.5	5	10	21.38	22.53
2	20	0.5	5	14.04	17.26	27.3
		1.0	5	12.44	16.2	26.9
		1.5	5	10.48	12.55	22.86
3	30	0.5	5	10.58	13.9	14.33
		1.0	5	11.64	15.4	19.95
		1.5	5	10.13	14.9	20.02

BAR GRAPHICAL REPRESENTATION OF COMPRESSIVE STRENGTH TEST RESULT FOR SELF CURED CONCRETE



SCOPE AND STUDIES

- Self-curing concrete, particularly using sodium lignosulfonate and M-sand (manufactured sand), is a growing area of research focused on improving concrete's durability and reducing external curing needs. Studies explore how sodium lignosulfonate, acting as a plasticizer and self-curing agent, affects strength, workability, and durability of concrete, especially when combined with M-sand.
- Strength and Durability: Research focuses on how sodium lignosulfonate and M-sand affect compressive strength, split tensile strength, flexural strength, and durability of self-curing concrete.
- Workability: Studies examine the impact of sodium lignosulfonate on concrete workability, including slump values and ease of placement.
- Reduced Curing Needs: Self-curing agents like sodium lignosulfonate can significantly reduce the need for external curing, leading to cost savings and environmental benefits.
- Potential for Sustainability: Using M-sand and incorporating self-curing agents can contribute to more sustainable concrete production by reducing material consumption and energy requirements.

CONCLUSION

From the present experimental investigation, it can be concluded that the use of alternative materials in concrete is both technically feasible and environmentally beneficial. The partial replacement of natural sand with M-sand, the incorporation of 5% egg shell powder as a supplementary cementitious material, and the use of sodium lignosulfonate as an admixture have shown a positive influence on the workability and strength characteristics of M20 grade concrete. The test results indicate that the modified concrete mix with 5% egg shell powder achieves satisfactory compressive strength while maintaining good durability and consistency, since finely ground egg shell provides additional calcium compounds that participate in the hydration process and strength development at low replacement levels .

The study also highlights that controlled replacement levels improve material efficiency and reduce dependency on natural resources, while the use of egg shell powder further enhances sustainability by utilizing agro-waste that would otherwise contribute to solid waste disposal issues . Overall, the results demonstrate that the proposed mix proportions are suitable for practical applications in structural and non-structural works. Hence, the use of M-sand, 5% egg shell powder, and chemical admixtures in conventional concrete can be recommended for economical, durable, and eco-friendly construction

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