

Experimental Study on Self Curing Concrete Using Sodium Lignosulfonate as a admixture by partially Replacement of Fine Aggregate By M Sand

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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 – Self curing concrete, M sand, compressive strength

I. INTRODUCTION

1.1 GENERAL:

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.

1.1.2 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.

1.1.3 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.

II. LITERATURE REVIEW

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“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.

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“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,

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“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 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.

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"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 concrese increases, In construction of hilly topography lany carrying of concrete it required, In remote location providing of concrete from inner mixing place, in construc tion of road, in lengthy tunneling work, manoal 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 nged 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 con crete like flove, water alsorption, 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

"PREPARATION OF CONCRETE SUPERPLASTICIZER BY OXIDATION-SULFOMETHYLATION OF SODIUM LIGNOSULFONATE".

GUANG YU BIN LI HAI SONG WANG CHAO LIU

This study investigates the enhancement of sodium lignosulfonate (SLS) as a concrete superplasticizer through a two-step modification involving peroxyacetic acid oxidation followed by sulfomethylation. The oxidation process improved the reactivity of SLS, facilitating the introduction of sulfonic groups during sulfomethylation. The modified SLS exhibited significantly increased molecular weight and sulfonation degree, leading to improved cement paste fluidity—achieving up to 185 mm at a 0.3% dosage, comparable to commercial naphthalene-based superplasticizers. Optimal reaction conditions were identified, and structural changes were confirmed through FTIR and NMR analyses. The findings suggest that this method offers an effective, bio-based alternative to conventional petroleum-derived plasticizers.

III. LITERATURE GAP

Sodium lignosulfonate (SLS) is a promising admixture for self-curing concrete due to its water-reducing and moisture-retaining properties. While existing research highlights its benefits in improving workability, strength, and reducing shrinkage, there are still several literature gaps that warrant further investigation:

1. Long-Term Durability and Performance:

* Extended Curing Period Effects: Most studies focus on short-term (7, 14, 28-day) strength and shrinkage. A significant gap exists in understanding the long-term effectiveness of SLS as a self-curing agent, particularly regarding its influence on concrete durability parameters such as resistance to sulfate attack, chloride penetration, carbonation, and freeze-thaw cycles over several years.

* Performance in Various Environmental Conditions: Research often tests SLS in controlled lab environments. There's a need for more studies on its performance in real-world applications under diverse climatic conditions (e.g., extremely hot and dry, cold, humid), which can significantly impact moisture retention and hydration.

* Interaction with Other Admixtures/Supplementary Cementitious Materials (SCMs): While some studies explore the use of SLS with a more comprehensive understanding of its compatibility and synergistic or antagonistic effects with a wider range of SCMs (e.g., silica fume, metakaolin, fly ash from different sources) and other common admixtures (e.g., air-entraining agents, accelerators) is crucial for practical applications.

2. Optimized Dosage and Mechanism:

* Precise Dosage Optimization for Specific Mix Designs: While some studies suggest optimal dosages (e.g., 0.25% to 0.5% by weight of cement), the ideal amount of SLS can vary significantly depending on the concrete mix design, water-cement ratio, type of cement, and desired properties. A more detailed exploration of dosage sensitivity for various concrete grades and applications is needed.

* Fundamental Mechanism of Moisture Retention: Although it's understood that SLS forms an insoluble calcium lignosulfonate barrier and aids in water retention, a deeper, more detailed understanding of the

microscopic and chemical mechanisms by which it precisely retains moisture within the concrete matrix is still developing. Advanced analytical techniques could be employed to visualize and quantify this mechanism.

* Influence on Pore Structure: How SLS specifically modifies the pore structure of concrete (e.g., pore size distribution, connectivity) to enhance self-curing is an area that could benefit from more in-depth research. This could provide insights into how it impacts long-term permeability and durability.

3. Practical Considerations and Scalability:

* Cost-Benefit Analysis and Economic Viability: While SLS is a relatively low-cost admixture, a thorough economic analysis comparing the overall cost savings (e.g., reduced labor for external curing, less water consumption) against its inclusion cost for various project scales is often lacking.

* Applicability in Mass Concrete and Large Structures: The performance of SLS in large pours or mass concrete where heat of hydration management is critical needs further investigation. Its retarding effect could be beneficial, but its long-term implications for large structures need to be fully understood.

* Standardization and Quality Control: As the use of self-curing concrete grows, there's a need for standardized testing methods and quality control protocols specifically tailored for concrete containing SLS, ensuring consistent performance and reliability in the field.

4. Environmental Impact and Sustainability:

* Life Cycle Assessment (LCA): While SLS is a by-product, a full LCA of self-curing concrete with SLS, considering its production, transportation, and overall environmental impact compared to conventional concrete, could provide valuable insights for sustainable construction.

* Source Variation of Lignosulfonate: Lignosulfonates can vary in composition depending on the wood pulping process and raw materials. Research on how these variations impact the performance of SLS as a self-curing agent would be beneficial for ensuring consistent results and optimizing its use. Addressing these literature gaps through further rigorous research will contribute significantly to the widespread adoption and optimized application of self-curing concrete with sodium lignosulfonate, making concrete construction more sustainable and efficient.

IV.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.

V. 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)

5.1.1CEMENT: 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 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 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 3 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%

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: 2 M Sand
VI. 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

Steps in making cement blocks

1. Batching:

Batching refers to the process of measuring and combining the required quantities of materials such as cement, sand, partially replacement of m sand, water, and other additives to prepare the mix for masonry block production. Accurate batching is crucial to ensure uniformity, consistency, and strength in the final product. Batching can be done in two ways

Volume Batching:

- Materials are measured by volume (e.g., using boxes or containers).
- Common in small-scale or on-site production.
- Less accurate and can lead to inconsistency in block quality.

Weight Batching:

- Materials are weighed using digital or manual scales.
- Preferred for large-scale or industrial production.
- Ensures precise proportions, leading to better quality control.

2. Mixing:

Mixing is the process of thoroughly combining all batched materials-cement, sand, partially replacement of m sand, water, and any admixtures-to form a uniform and workable mix suitable for block casting. The quality of mixing directly affects the strength, durability, and homogeneity of the cement masonry blocks.

3. Moulding:

Moulding is the process of shaping the mixed material into masonry blocks using specific forms or moulds. It gives the blocks their desired size, shape, and surface finish. Moulding ensures dimensional uniformity, which is crucial for construction accuracy and structural stability.

4. Demoulding:

Demoulding is the process of removing the freshly moulded cement masonry blocks from the mould or machine once they have acquired enough shape and stiffness to retain their form without damage.

5. Curing:

Curing is the process of maintaining adequate moisture, temperature, and time conditions after demoulding to allow the cementitious materials in masonry blocks to properly hydrate and gain strength. Cure by sprinkling water or submerging in water. It is a vital step to ensure the durability, strength, and quality of the blocks.

VII. 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

1. The mould for the slump test is a frustum of a cone, 300 mm (12 in) of height. The base is 200 mm (8in) in diameter and it has a smaller opening at the top of 100 mm in).
2. The base is placed on a smooth surface and the container is filled with three layers, whose workability is to be tested.
3. Each layer is tamped 25 times with a standard 16 mm (5/8 in) diameter steel rod. rounded at the end.
4. When the mould is completely filled with concrete, the top surface is struck off (levelled with mould top opening) by means of screening and rolling motion of the tamping rod.
5. The mould must be firmly held against its base during the entire operation so that it could not move due to the pouring of concrete and this can be done by means of handles or footrests brazed to the mould.
6. Immediately after filling is completed and the concrete is levelled, the cone is slowly and carefully lifted vertically, an unsupported concrete will now slump.
7. The decrease in the height of the centre of the slumped concrete is called slump.
8. The slump is measured by placing the cone just besides the slump concrete and the tamping rod is placed over the cone so that it should also come over the area of slumped concrete.
9. The decrease in height of concrete to that of mould is noted with scale. (usually measured to the nearest 5 mm (1/4 in).



Fig: 3 Slump apparatus

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

VIII. HARD CONCRETE TEST

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.

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.

Procedure:

Remove the specimen from water after specified curing time and wipe out excess water from the surface.

Take the dimension of the specimen to the nearest 0.2m

Clean the bearing surface of the testing machine

Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.

Align the specimen centrally on the base plate of the machine.

Rotate the movable portion gently by hand so that it touches the top surface of the specimen.

Apply the load gradually without shock and continuously at the rate of 140 kg/cm³/minute till the specimen fails

Record the maximum load and note any unusual features in the type of failure.



Fig: 4 Compressive testing machine

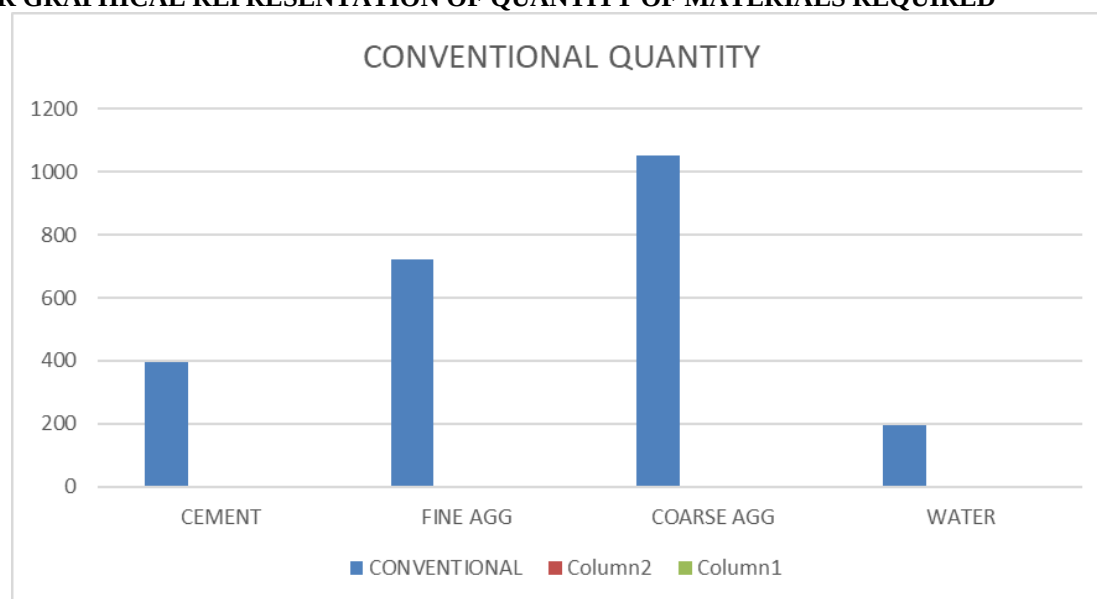
IX. PREPARATION OF TEST SPECIMENS

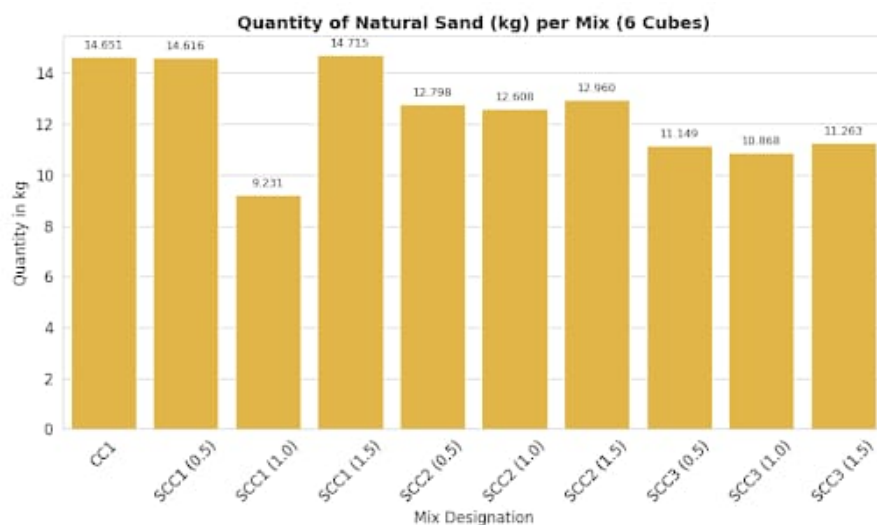
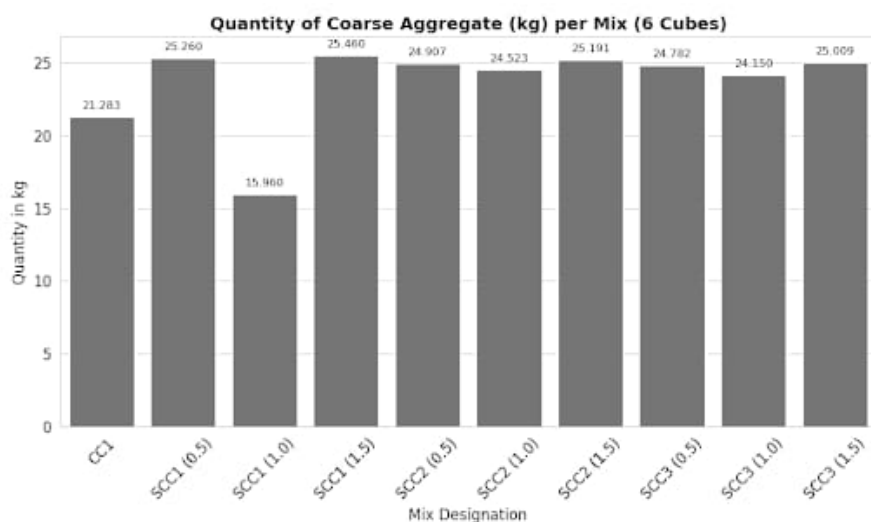
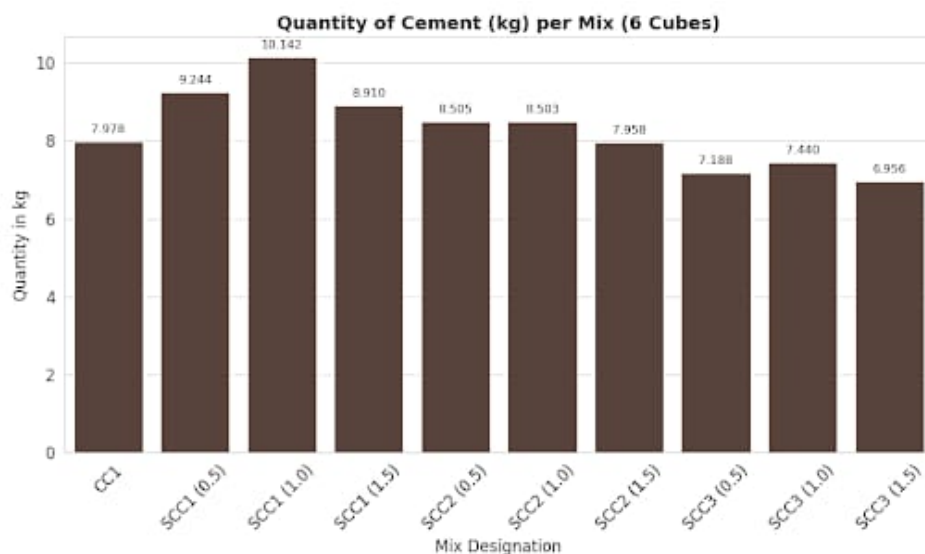
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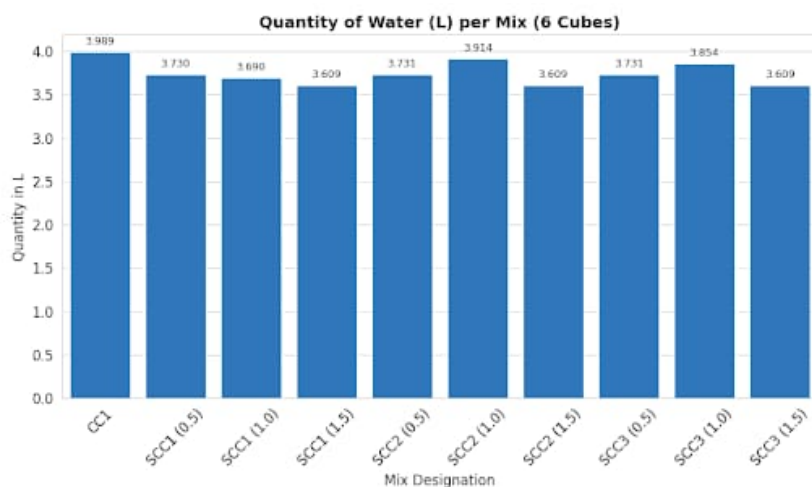
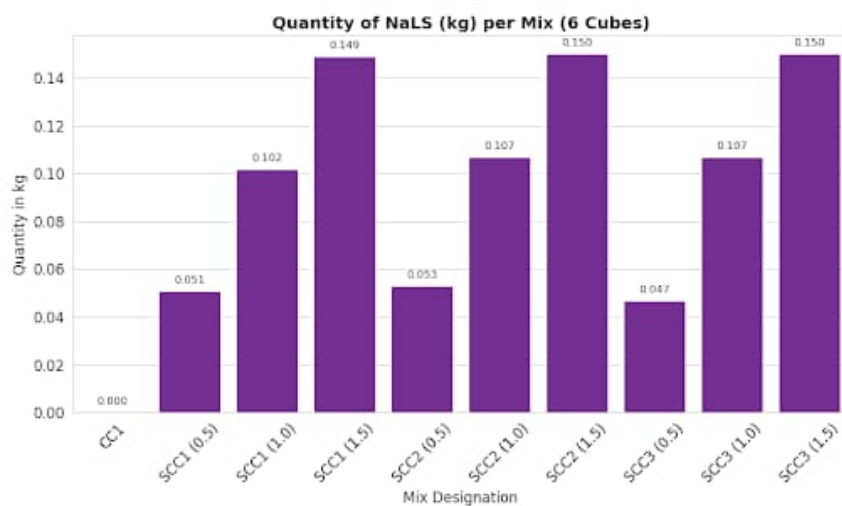
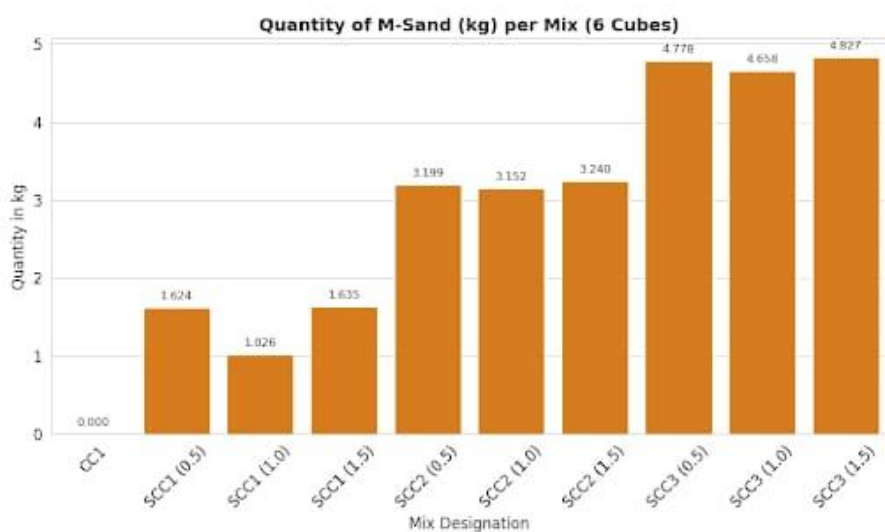
Table: 4 Quantity of materials required for different concrete mixes

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

BAR GRAPHICAL REPRESENTATION OF QUANTITY OF MATERIALS REQUIRED







X. RESULTS AND CONCLUSION

10.1.1 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

10.1.2.1 COMPRESSIVE STRENGTH TEST RESULTS:

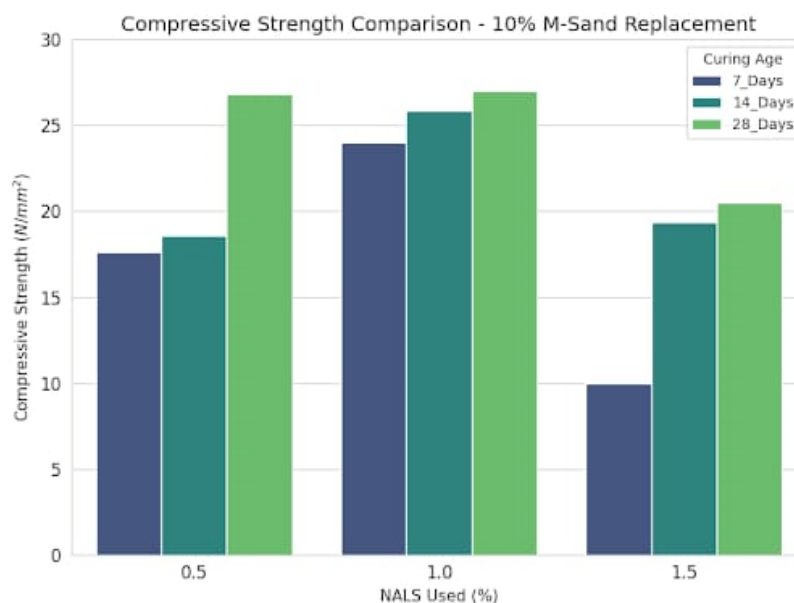
Table.5 Compressive strength test results for conventional concrete

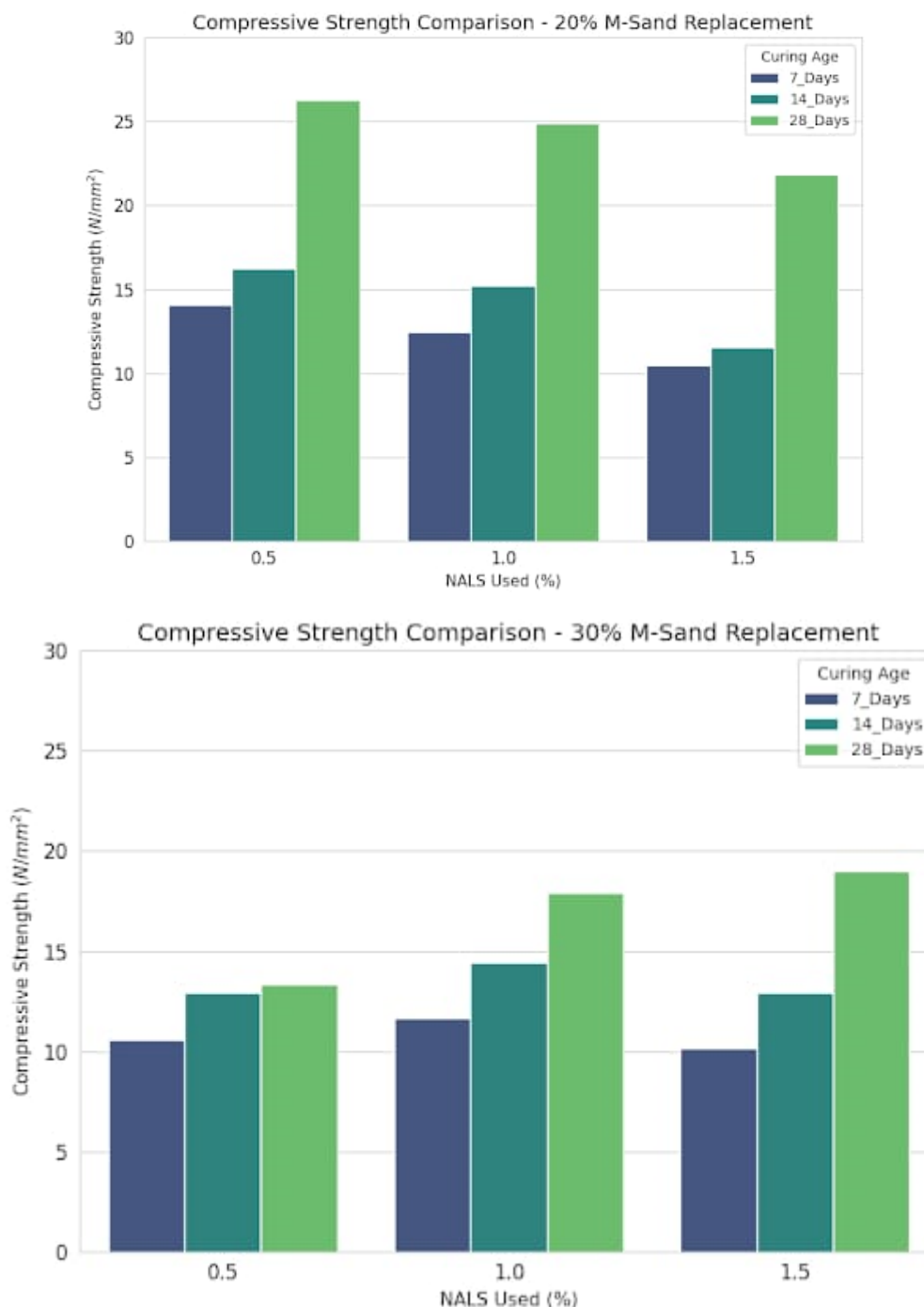
SL.NO	COMPRESSIVE STRENGTH IN N/mm ²		
	7 days	14 days	28 days
1	12.5	14.9	13.25

Table: 6 Compressive strength test results for self- cured concrete

SL NO	NATURAL SAND PARTIALLY REPLACEMENT WITH M SAND	% OF NALS USED	COMPRESSIVE STRENGTH IN N/mm ²		
			7 DAYS	14 DAYS	28 DAYS
1	10	0.5	17.60	18.58	26.8
		1.0	24	25.87	27
		1.5	10	19.38	20.53
2	20	0.5	14.04	16.26	26.3
		1.0	12.44	15.2	24.9
		1.5	10.48	11.55	21.86
3	30	0.5	10.58	12.9	13.33
		1.0	11.64	14.4	17.95
		1.5	10.13	12.9	19.02

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





10.2 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 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 achieves satisfactory compressive strength while maintaining good durability and consistency.

The study also highlights that controlled replacement levels improve material efficiency and reduce dependency on natural resources, thereby contributing to sustainable construction practices. 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 and chemical admixtures in conventional concrete can be recommended for economical, durable, and eco-friendly construction.

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