

## DESIGN AND APPLICATIONS OF SULFONATED MELAMINE FORMALDEHYDE SUPERPLASTICIZER IN HIGH PERFORMANCE CONCRETE STRUCTURE

Nimra<sup>1</sup>, Shaukat Ali<sup>2</sup>, Asif Hanif Chaudhry<sup>3</sup>, Nosheen Sial<sup>4</sup>, Muhammad Aslam<sup>5</sup>,  
Saliha Sommaie<sup>1</sup>, Iqra Amin<sup>1</sup>, Isra Ghafoor<sup>1</sup>

<sup>1</sup>Department of Chemistry, The Superior University, Lahore

<sup>2</sup>Building Research Station, Lahore, Communications and Works Department, Government of Punjab, Lahore

<sup>3</sup>Department of Chemistry, Geological Survey of Pakistan, Lahore

<sup>4</sup>Department of Chemistry, Government Graduate College for Women, Gulberg, Lahore

<sup>5</sup>Department of Chemistry, University of Education, Lahore

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Corresponding Author: \*

Asif Hanif Chaudhry

### Abstract

The purpose of this study was to create sulfonated melamine formaldehyde using a condensation process as a superplasticizer for high-performance concrete. The NMR spectra confirmed that the newly synthesized chemical was produced in a satisfactory yield (85%). Seven batches of various concrete composite compositions with SMF in quantities ranging from 0.5% to 3.5% were created in order to assess the compound's performance and investigate the effect of sulfonated melamine formaldehyde on the concrete's compressive strength. In order to create more robust and long-lasting concrete structures, the mechanical strength of concrete specimens incorporating SMF was examined. A total of forty-two concrete cube specimens were produced. After seven and twenty-eight days, the samples' compressive strength was measured using a CTM. The results demonstrated that using SMF as a superplasticizer greatly increased the concrete specimens' compressive strength. After 28 days, concrete samples with 3% SMF had an impressive average compressive strength of 3258 psi, which was around 5.4% higher than the compressive strength of reference samples (2716 psi). Scanning electron microscopy was used to perform morphological examination. Additionally, SEM images showed that the interfacial transition zone between cement particles was significantly enhanced when SMF was added to the concrete.

### INTRODUCTION

The process of erecting tall structures—generally defined as those with more than seven stories or an elevation of 75 feet, or around 23 meters—is known as high-rise construction. These buildings provide mixed-use, residential, or commercial purposes and are typically found in urban areas with limited space. The structure of a high-rise building often has a more obvious effect on the overall cost and design than that of a low-rise one. Therefore, those who are creating large structures

for the first time need to be aware of concepts that are not given priority in low-rise architecture. High-rise design becomes important when a structure's thinness makes it naturally susceptible to lateral stresses and its lateral system development is viewed more highly [1]. Construction materials are the many chemicals or compounds used in the building and construction industry to make buildings, structures, and infrastructure. These materials, which may be synthetic, natural, or composite, are selected based

on their special attributes, affordability, environmental impact, and suitability for the intended function. Inorganic materials (such as steel, concrete, and bricks), organic materials (such as wood), composites, polymers, and plastics, and sustainable or ecologically friendly materials are the broad types of building materials. Each type of material has unique characteristics that make it suitable for specific applications during the construction process. Inorganic materials are a significant type of building materials that are widely used in the building and construction industry. These materials are characterized by their mineral composition and lack of carbon-hydrogen (C-H) bonds. They originate from non-living, natural sources and undergo several processes to become building-grade materials [2]. Inorganic building materials are non-carbon-based materials derived from the Earth's crust, such as metals, glass, and ceramics. These materials are vital building materials because of their strength, durability, and resistance to various factors. Examples include steel, gypsum, cement, lime, and other alloys [3]. Often called bio-based materials, organic building materials come from renewable biological sources including microbes, plants, and animals. These materials are becoming more and more popular in sustainable building because of their potential to lower greenhouse gas emissions, minimal environmental impact, and renewability. Examples include Hempcrete, Straw Bale, Wood and timber and Superplasticizers [4].

Superplasticizers have recently proved crucial in improving concrete's mechanical qualities in the building industry. One superplasticizer that has been used in the building industry in recent years is sulfonated melamine formaldehyde [5]. By improving the fluidity, the inclusion of these superplasticizers in place of additional water shortened the concrete's hardening time and did not merely weaken the material like water does. However, higher slumping values and improved concrete adhesion to reinforce bars were also greatly attained [6]. Melamine and sulfite have a molar ratio of 0.5–1.2 in synthesis processes. In this case, the SMF is produced in a ratio greater than 1.2. Melamine formaldehyde is dissolved by a sulfonate group, which gives the resin an

electronegative charge that blocks multiple propagation centers. Condensation conditions and resin characteristics are significantly impacted by the S/M molar ratio [5].

Sulfonated melamine formaldehyde's structure contains nitrogen, oxygen, and sulfur, which may be absorbed on metal surfaces to provide a protective coating. Because of its affordability, it is a viable option for use as a corrosion inhibitor [7]. Melamine formaldehyde, or MFR, is one of the effective thermoset polymers used in SMF as a solid acid polymer-based catalyst. Unlike other polymer-based solid acid catalysts, MFR can be synthesized from inexpensive and accessible monomers and uses irreversible covalent bonds rather than weak coordination or reversible covalent bonds to connect the building units [8]. For UHPC applications to give the essential strength and rheological properties, superplasticizers are required. A study on nano-engineered UHPC found that superplasticizers improved workability and allowed for greater particle packing, which boosted compressive strength. Based on study conducted in Pakistan, processed versions of locally available superplasticizers improved the workability and compressive strength of M15 grade concrete [9].

MFs are well renowned for their excellent ability to improve concrete's surface finish and reduce water. They disperse cement particles by electrostatic repulsion, much like SNFs. Perfect for applications requiring great early strength and perfect surface finishes, such as architectural precast pieces. Studies show that MFs increase workability and decrease porosity to increase durability [10].

According to Garzón-Agudelo et al. (2021), the extensive use of concrete in civil works and building projects necessitates consideration of criteria, technical specifications, and advancements that provide the durability required by builders and material manufacturers. Concrete is consequently treated with plasticizers to enhance its mechanical properties and physical characteristics. A combination of quantitative and qualitative methods was used to examine thoroughly verified sources that contained information pertinent to the study's topic in order

to highlight the significance of additives in the essential characteristics of building materials used in construction as well as the optimal conditions for their use. It was possible to demonstrate noticeably favorable results when plasticizers were used as water reducers that increase mechanical strength, provided that they are used in a suitable quantity to improve the physical properties of concrete [11].

According to Colleparidi et al. (1998), plasticizing and superplasticizing admixtures can improve the laying properties of concrete without changing the ratio of water to cement in comparison to the plain mixture. The main ingredients of superplasticizers are sulfonated melamine formaldehyde (SMF) condensate, or SNF. A new range of products based on acrylic polymers (AP) was released recently. Due to their reduced slump loss and base water-to-cement ratio at a given slump, these polymers are more effective than those based on SMF or SNF. Furthermore, the mode of addition has no effect on the effectiveness of AP-based superplasticizers, however the slump level of concrete mixes including SMF and SNF-based additives is much greater when a superplasticizer is introduced later than when water is combined. As demonstrated using SMF and SNF-based additions, the dispersion of cement particles that causes the mobility increase brought on by the addition of a superplasticizer is not always connected to the attraction of electrostatic charges related to zeta potential measurements. AP-based superplasticizers greatly improve the fluidity of cement mixtures by breaking up big cement particle agglomerates into smaller ones by polymer adsorption rather than electrostatic rejection [12].

According to Aruntaş et al. (2008), this study looked at how curing conditions and superplasticizer (SP) affected the characteristics of concrete with and without fibers. The concrete compositions included Portland cement, steel fibers, SP, and artificial aggregate. Superplasticizer was added to concrete mixtures at ratios of 1.0%, 1.5%, and 2.0% by weight of cement to produce C25 fiber-containing and fiber-free concrete. Two distinct therapies are available. Both continuous wet treatment and outdoor treatment were applied

to the samples. Fiber-containing and fiber-free concrete, as well as Portland cement concrete, were compared. The highest compressive and flexural strengths were attained using 1.0% and 1.5% SP fiber reinforced concrete, respectively [13].

According to Bediako et al. (2024), superplasticizers are infrequently utilized in many developing countries. Conversely, adding it to concrete enhances its mechanical properties and durability. The efficiency of Sulfonated Naphthalene Formaldehyde (SNF) superplasticizers in concrete has received very little investigation. One batch was made without the SNF superplasticizer as a control, and the superplasticizer was added to the second batch. The results showed that cement's functionality improved and its ion mobility decreased when SNF superplasticizers were added. This was explained by a decrease in the number of connected pores, which led to notable increases in mechanical properties including elastic and dynamic moduli and strength. Furthermore, concrete with SNF superplasticizer has a considerably higher resistance to acid attack than concrete without it [14].

Labalh et al. 1988 have reported that the impact of sulfonated-melamine formaldehyde superplasticizers' polymerization conditions on the functionality, mechanical characteristics, and settling of mortar and concrete was examined. A new process was used to create more than twenty super-plasticizers. The characteristics of the superplasticizers and how they interact with concrete were discovered to be significantly impacted by the reaction circumstances. The performance of the four-step reaction products was 30-40% better than that of the three-step procedure. The stability of the products is impacted by the fourth step parameters of temperature and time, although workability is not much impacted. Using molecular theory, the impact of reaction conditions on the functionality of melamine-based superplasticizers is examined [15].

**Experimental****CHEMICALS**

Melamine AR grade (sigma aldrich), distilled water, sodium lignosulfonate AR grade (sigma aldrich), formaldehyde AR grade (sigma aldrich) and concentrated sulfuric acid.

**APPARATUS**

1000 mL three-necked round bottom flasks, condenser, thermometer, magnetic stirrer, heating mantle, pH meter, filter funnel and vacuum oven.

**PROCEDURE**

SMF was prepared using a three-stage process that included hydroxymethylation, sulfonation, neutralization, and condensation. The F/M ratio for the hydroxymethylation was 3.0-5.0. The following methods were used to carry out these steps: The first stage included heating 150 ml of a 37% concentrated formaldehyde aqueous solution to 55°C after diluting it with 50 ml of water. After adding 2.25 milliliters of 1 N solution of sodium hydroxide to bring the formalin solution's pH down to 8.5, 56.9 g of melamine was added. Automatically, the reaction mixture's temperature rose as the melamine dissolved, reaching 59–60°C when the solution turned clear. Ten minutes were then spent heating the reaction mixture to 60°C. The sulfonation of melamine formaldehyde was caused by the addition of sodium lignosulfonate in the second stage. In the third step, neutralization and condensation was accomplished using H<sub>2</sub>SO<sub>4</sub> and NaOH. Using NMR spectroscopy, the newly produced chemical was characterized.

**Sodium(4,6-bis(methoxymethylamino)-1,3,5-triazin-2-ylamino)methanesulfonate**

Found as white solid (85%), 343°C-354°C; <sup>1</sup>H-NMR (D<sub>2</sub>O): δ = 5.12(s, 2H-methylene), 4.72(s, 4H-2methylene), 3.96(s, 3H-amine), 3.27(s, 6H-2methyl). <sup>13</sup>C-NMR (DT2): = 56.7, 62.2, 83.7, 162.5, 165.7, 176.0.

**Procedure to determine compressive strength test****MATERIALS**

Cement, coarse aggregates, fine aggregates, water, sulfonated melamine formaldehyde

**APPARATUS**

Followings apparatus was being used during performing experiment which are mentioned below:-

- (1) Iron moulds having dimension 6X6X6
- (2) Mechanical full load mixture machine
- (3) Water curing tank
- (4) Compression Testing machine
- (5) Weighing Balance

**PROCEDURE FOR PREPARATION OF CONCRETE CUBES**

Stepwise procedure for preparation of concrete cube is described as below.

The concrete cubes and cylinder were prepared according to literature protocol like ASTM C39 and British Standard BS 1881: Part 225. Seven concrete combinations were made, each combination contain 3 cubes, and all based on the same control mixtures, in order to fulfill the objectives. As a percentage of the total cementitious material content sulfonated melamine formaldehyde was added. Various percentages of SMF were tested and compared to the reference mixture to see how they affected both fresh and cured concrete qualities. The prepared samples were tested after three distinct ages like 7, 28 days.

**PREPARATION OF MIXTURE**

All components used in this investigation, including regular Portland cement, fine and coarse aggregates, water, and sulfonated melamine formaldehyde, were mixed automatically using a mechanical full-load mixer. The seven concrete mixtures were created as follows: Mixture No. 1, which served as the reference, had 50 kg of cement, 100 kg of fine aggregate, and 200 kg of coarse aggregate. Mixture No. 2 had 50 kilogram of cement, 100 kg of fine aggregate, 200 kg of coarse aggregate, and 50g of sulfonated melamine formaldehyde. Mixture No. 3 contained 50 kg of

cement, 100 kg of fine aggregate, 200 kg of coarse aggregate, and 100g of sulfonated melamine formaldehyde. Mixture No. 4 was created using 50 kg of cement, 100 kg of fine aggregate, and 200 kg of coarse aggregate and 150g of sulfonated melamine formaldehyde. Mixture No. 5 consisted of 50 kg cement, 100 kg fine aggregate, 200 kg coarse aggregate, and 200g sulfonated melamine formaldehyde.

#### CASTING OF CONCRETE CUBES

36 No iron mould of sizes 6X6X6 were used to cast concrete cubes. 21 No of concrete cubes were casted from each freshly prepared mixture. For this purpose, iron moulds were filled with reference concrete mixture and blended sulfonated melamine formaldehyde concrete mixture in the laboratory. The poured concrete cube in iron mould were left at room temperature for 24 hours for early setting.

#### CURING OF CONCRETE CUBES

All the casted concrete cubes and cylinders were separated from iron mould after passing the 24 hours and soaked them with fresh water. Curing tank for 7 and 28 days. Curing was carried out by using normal curing method at room temperature

#### COLLECTION OF CONCRETE

From water curing tank, the cured concrete cubes and cylinders were collected after specified time period. In order to avoid any damage that could affect the test results, extra care was taken to handle them.


#### TESTING AND ANALYZING

##### COMPRESSIVE STRENGTH TEST

The concrete specimens and cylinders were examined after 7 and 28 days curing by using two steel bearing plates covering the specimens' top and lower bearing areas to determine their compressive strength.

#### RESULTS

Table 1 Determined compressive strength of concrete Cubes against specified compressive strength 2000 psi after 07 days as BS 1881: Part 225



Cube No.	Mix Ratio Cement:Sand: Aggregate	Use of additive in %age	Area in inches	Age in Day	Load applied in lbs.	Determined compressive strength in psi
1	1:2:4	-	36	7	66780	1855
2	1:2:4	-	36	7	70775	1966
3	1:2:4	-	36	7	64260	1785
4	1:2:4	1%	36	7	66760	1910
5	1:2:4	1%	36	7	65700	1825
6	1:2:4	1%	36	7	64620	1795
7	1:2:4	1.5%	36	7	69155	1921
8	1:2:4	1.5%	36	7	66060	1835
9	1:2:4	1.5%	36	7	68255	1896
10	1:2:4	2%	36	7	69625	1934
11	1:2:4	2%	36	7	70380	1955
12	1:2:4	2%	36	7	72035	2001
13	1:2:4	2.5%	36	7	73655	2046
14	1:2:4	2.5%	36	7	75205	2089
15	1:2:4	2.5%	36	7	74195	2061
16	1:2:4	3%	36	7	77615	2156

17	1:2:4	3%	36	7	82585	2294
18	1:2:4	3%	36	7	78625	2184
19	1:2:4	3.5%	36	7	73295	2036
20	1:2:4	3.5%	36	7	73045	2029
21	1:2:4	3.5%	36	7	75.96	2086

Table 2 Determined compressive strength of concrete Cubes against specified compressive strength 3000 psi after 28 days as BS 1881: Part 225

Cube No	Mix ratio Cement:Sand:Aggrega te	Use of additive in %age	Area in inches	Age in Days	Load applied in lbs.	Determined compressive strength in psi
1	1:2:4	-	36	28	97775	2716
2	1:2:4	-	36	28	103535	2876
3	1:2:4	-	36	28	98425	2734
4	1:2:4	1%	36	28	102815	2856
5	1:2:4	1%	36	28	101556	2821
6	1:2:4	1%	36	28	100620	2795
7	1:2:4	1.5%	36	28	104112	2892
8	1:2:4	1.5%	36	28	104690	2908
9	1:2:4	1.5%	36	28	105660	2935
10	1:2:4	2%	36	28	106164	2949
11	1:2:4	2%	36	28	107460	2985
12	1:2:4	2%	36	28	108180	3005
13	1:2:4	2.5%	36	28	110376	3066
14	1:2:4	2.5%	36	28	109405	3039
15	1:2:4	2.5%	36	28	111565	3099
16	1:2:4	3%	36	28	114445	3179
17	1:2:4	3%	36	28	119665	3324
18	1:2:4	3%	36	28	117288	3258
19	1:2:4	3.5%	36	28	111275	3091
20	1:2:4	3.5%	36	28	109295	3036
21	1:2:4	3.5%	36	28	112932	3137

## Discussion

This chapter, which is divided into two sections, discusses newly synthesized compounds and evaluates the performance of concrete that contains sulfonated melamine formaldehyde as a super plasticizer.

- i. Synthesis
- ii. Performance evaluation of concrete

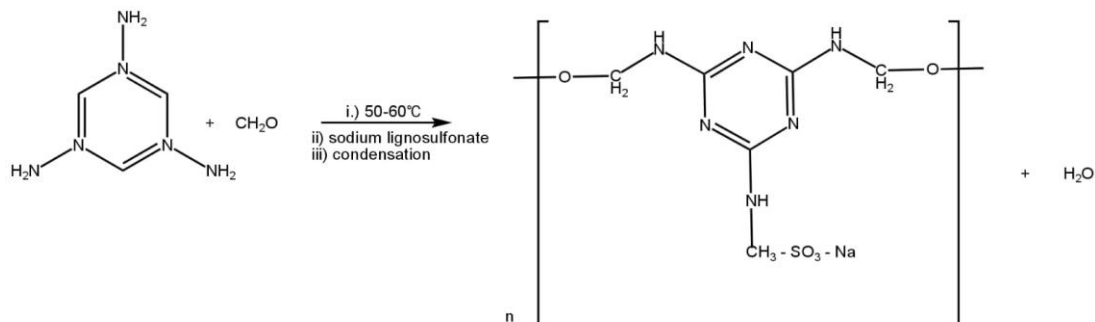
## 5.1 Synthesis

Formalin solution was initially created in the synthetic section by diluting the concentrated formaldehyde solution with 50 milliliters of water. After that, melamine was added to the mixture and the pH was adjusted to 8.5 using NaOH to create melamine formaldehyde. After that, the reaction mixture was heated to 59–60°C for ten

minutes. Following that, sulfonated melamine formaldehyde was created by sulfonation using sodium lignosulfonate. Finally, sulfonated melamine formaldehyde condensate was created by heating the mixture between 50 and 80 degrees Celsius. TLC on a silica plate and a solution of ethyl acetate and n-hexane were used to track the reaction. The purity of the freshly made chemical

was demonstrated by the solitary spot that the newly synthesized product showed on TLC in the solvent solution. NMR spectra were then used to describe the chemical and help identify its structure. The following provides the essential explanation, analysis, and characterisation of the newly synthesized compound:

### Scheme



Scheme 5.1 Synthesis of sulfonated melamine formaldehyde via condensate reaction using melamine, formaldehyde and sodium lignosulfonate.

### Reagent and condition for synthesis of sulfonated melamine formaldehyde

(i) Melamine (ii) Formaldehyde (iii) 50-60 C (iv) Sodium lignosulfoante

As stated in the scheme, sulfonated melamine formaldehyde was produced using a traditional approach as described in the literature protocol (48). This strategy's main goal was to get the super plasticizer ready. In the presence of a sulfonating agent and base (NaOH), the amino hydrogen bonded to C-1, C-3, and C-5 in the melamine was substituted with  $-\text{CH}_2\text{-O}-$ . A satisfactory product yield of 85% was attained. The  $^1\text{H-NMR}$  spectrum revealed a singlet signal at 5.12 ppm, which was caused by two methylene protons. Three more singlet peaks were found at 4.72 ppm, 3.96 ppm, and 3.27 ppm, which were caused by four methylene group protons, three amine group protons, and six H of the  $2\text{CH}_3$ -bond, respectively. The six carbon atoms in the reagent from 56.1 ppm, 63.1 ppm, 83.5 ppm, 161.0 ppm, 165.2 ppm, and 175.5 ppm are likewise confirmed by the  $\text{C-13}$  spectra of the newly created molecule.

### 5.2 Performance evaluation of concrete

A total of 42 concrete specimens were created in order to evaluate the impact of SMF on the concrete's compressive strength. As a result, several batches of concrete composites were created by combining SMF content varying from 1% to 3.5% with cement, sand, and gravel in a 1:2:4 ratio. After seven and twenty-eight days, concrete cubes and cylinders were created to assess their compressive strength. Twelve specimens, comprising twenty-one concrete cubes, were tested for compressive strength after seven days. The findings are displayed in Table 4.1. Concrete cubes 4–21 were test examples, whereas cubes 1, 2, and 3 were reference specimens. The test specimens' compressive strengths were contrasted with the reference specimens'.

In contrast to the 2000 psi compressive strength required by BS:1881 (part 225), three reference concrete cubes, numbers 1, 2, and 3, showed compressive strengths of 1855 psi, 1966 psi, and 1785 psi, respectively. The concrete cubes for 4, 5, and 6 showed compressive strengths of 1910 psi, 1825 psi, and 1795 psi, respectively, when 1% by weight SMF was added. Additionally, constructed

concrete cubes 7, 8, and 9 with 1.5% SMF displayed corresponding pressures of 1921, 1835, and 1896. Additionally, the compressive strength of cube No. 10-12 with 2% SMF was 1934 psi, 1955 psi, and 2001 psi, respectively. Conversely, the compressive strength of 2.5% SMF mixed concrete cubes 13, 14, and 15 was 2046 psi, 2089 psi, and 2061 psi, respectively. Concrete cubes 16,

17, and 18 with a 3% SMF addition had compressive strengths of 2156, 2294, and 2184 psi, respectively. Conversely, the compressive strength of 3.5% SMF mixed concrete cubes 19, 20, and 21 was 2036 psi, 2029 psi, and 2086 psi, as seen in figures 1 and 2.

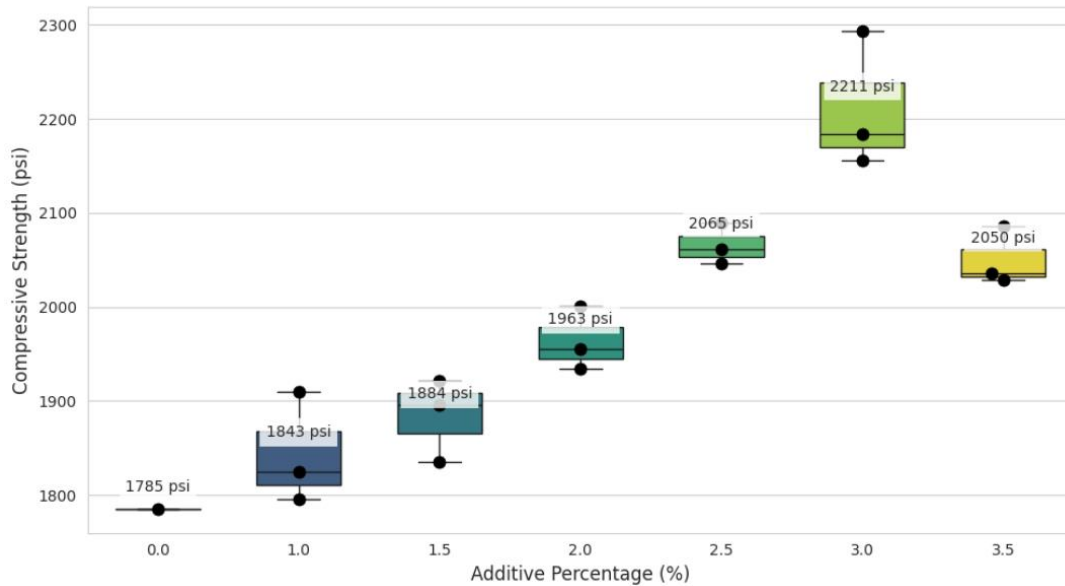


Figure 1: Box plot of compressive strength by additive percentage

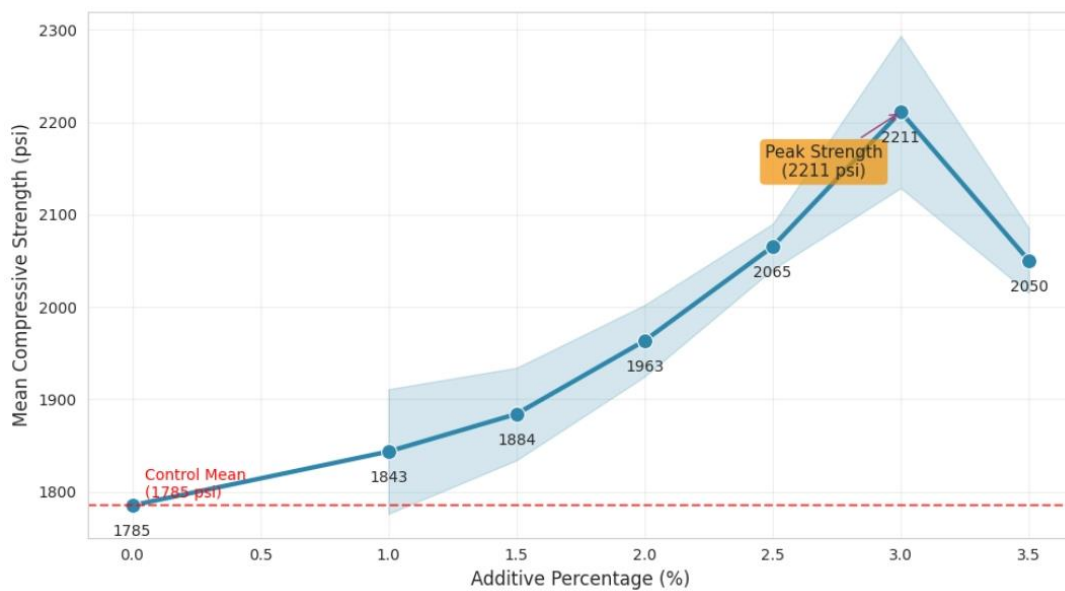


Figure 2: Mean compressive strength vs. additive percentage

In a similar manner, 21 concrete cylinders were tested at 28 days of age to compare their compressive strength to the ASTM C39-specified compressive strength of 3000 psi. Table 4.2 shows the test findings. The compressive strength of nearly all of the concrete cubes was within the range of 1983 psi. Cylinders Nos. 1 through 3 are regarded as reference concrete specimens, whereas cylinders Nos. 4 through 21 are regarded as test concrete specimens, and their calculated compressive strengths are contrasted with those of the reference concrete specimens.

In comparison to the 3000 psi required by BS:1881 (part 225), the reference concrete cubes with the numbers 1, 2, and 3 had compressive strengths of 2716 psi, 2876 psi, and 2734 psi, respectively. Concrete cylinders 4, 5, and 6

demonstrated compressive strengths of 2856 psi, 2521 psi, and 2795 psi, respectively, after adding 0.5% SMF by weight. The compressive strengths of cylinders 7, 8, and 9 with 1% SMF were 2892 psi, 2978 psi, and 2935 psi. Compressive strengths of 2949, 2985, and 3005 psi were attained by cylinders 10, 11, and 12 with 1.5% SMF. The strengths of concrete cylinders 13, 14, and 15 with 2% SMF were 3066 psi, 3039 psi, and 3099 psi, respectively. The compressive strengths of cylinders 16, 17, and 18, which contained 2.5% SMF, were 3179 psi, 3324 psi, and 3258 psi, respectively. Lastly, the compressive strengths of cylinders 19, 20, and 21 with 3% SMF were 3091 psi, 3036 psi, and 3137 psi, respectively as seen in figures 3 and 4.

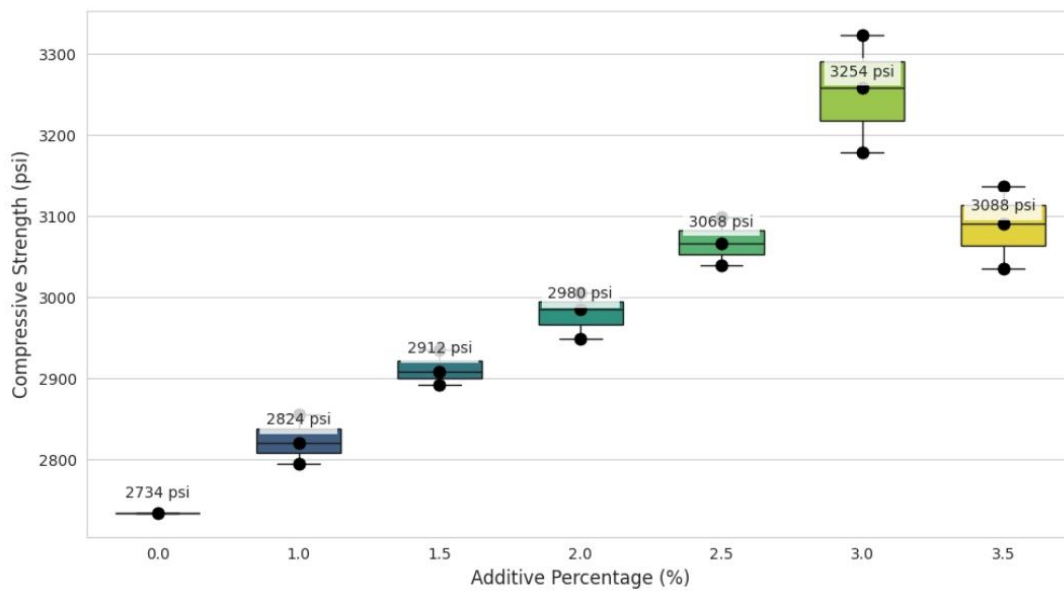


Figure 3: Box plot of compressive strength by additive percentage

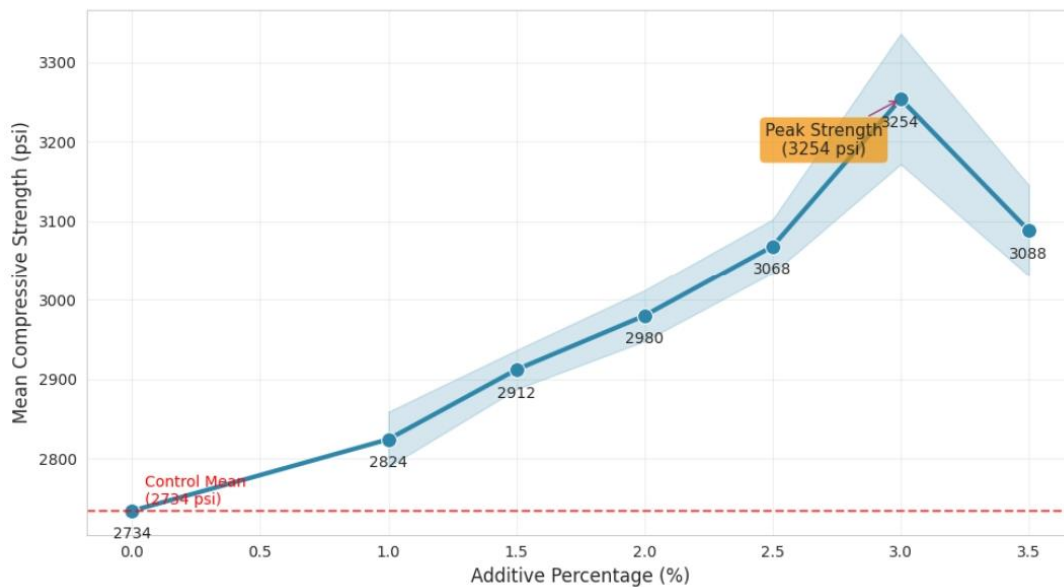


Figure 4: Mean compressive strength vs. additive percentage

### Conclusion

This thesis synthesizes sulfonated melamine formaldehyde condensate via a one-step procedure that involves three phases of sulfonation, condensation, and neutralization. NMR spectroscopy was used to characterize the structural analysis of the synthetic admixture. This additive had an 85% yield, and the building industry took use of its ability to increase concrete's compressive strength. The performance of SMF-containing concrete was assessed for this purpose by contrasting its compressive strength with regular concrete. Seven batches of concrete composites with SMF concentrations ranging from 1% to 3.5% were created by casting 42 concrete cubes with different superplasticizer concentrations. Using a Compression Testing Machine (CTM), the produced concrete specimens' compressive strength was assessed at 7 and 28 days of age.

Surprisingly, it was found that adding sulfonated melamine formaldehyde as a superplasticizer significantly boosts concrete's mechanical strength, which ranges from 3179 to 3258 psi after 28 days. The concrete specimen No. with 3%

superplasticizer had exceptional compressive strength, exhibiting 3258 psi, according to the

obtained result. The improvement of the interfacial transition zone by making concrete denser and more compact is responsible for the increase in compressive strength, which was also confirmed by SEM. In contrast, cube No. 1-3 without SMF had an average compressive strength of 2775 psi at 28 days, which is 7% less than the BS-1885 stipulated compressive strength of 3000 psi.

The results showed that SMF-based admixtures may be utilized to increase early compressive strength by enhancing cement hydration management, which also improves concrete durability by lowering microcracks and permeability by giving the concrete the ability to mend itself.

## REFERENCES:

- Zils J, Viis J. An Introduction To High Rise Design. STRUCTURE magazine. 2003 Nov.
- Babu B, Petchikkan M. Overview of construction materials. Nagercoil: Amrita College of Engineering and Technology; 2023 Nov 25.
- Rock M, Murphy JT, Rasiah R, van Seters P, Managi S. A hard slog, not a leap frog: Globalization and sustainability transitions in developing Asia. Technological Forecasting and Social Change. 2009 Feb 1;76(2):241-54.
- Wikipedia contributors. *Hempcrete* [Internet]. Wikipedia; 2024 May 4 [cited 2025 May 7]. Available from: <https://en.wikipedia.org/wiki/Hempcrete>
- Yunchao H, Fansen Z, Hu Y, Chunying L, Zhaoqiang W, Weining L, Shukai Y. Synthesis and properties of high-sulfonated melamine-formaldehyde resin. Journal of applied polymer science. 1995 Jun 20;56(12):1523-6.
- Dupuis M, Spiratos I, Handy Chemicals Limited. Processes for manufacture of sulfonated melamine-formaldehyde, 5424390, Jun 13, 1995.
- Sharifi Z, Pakshir M, Mohamadi S. Investigation of synthesized sulfonated melamine formaldehyde as a novel corrosion inhibitor for mild steel in saline environment. Journal of Materials Engineering and Performance. 2015 Feb;24:664-9.
- Nezhad SM, Pourmousavi SA, Zare EN, Heidari G, Makvandi P. Magnetic sulfonated melamine-Formaldehyde Resin as an efficient catalyst for the synthesis of antioxidant and antimicrobial pyrazolone derivatives. Catalysts. 2022 Jun 7;12(6):626.
- Garzón-Agudelo PA, Palacios-Alvarado W, Medina-Delgado B. Impact of plasticizers on the physical and structural properties of concrete used in constructions. In Journal of Physics: Conference Series 2021 Oct 1 (Vol. 2046, No. 1, p. 012069). IOP Publishing.
- Collepari M. Admixtures used to enhance placing characteristics of concrete. Cement and concrete composites. 1998 Jan 1;20(2-3):103-12.
- Aruntaş HY, Cemalgil S, Şimşek O, Durmuş G, Erdal M. Effects of super plasticizer and curing conditions on properties of concrete with and without fiber. Materials letters. 2008 Jul 15;62(19):3441-3.
- Bediako M, Ametefe TK. Effect of sulphonated naphthalene formaldehyde superplasticizer on the mechanical and durability properties of concrete produced using locally sourced fine aggregate from Ghana. Journal of the Ghana Institution of Engineering. 2024 Mar 8;24(1):41-51.
- Lahallh SM, Absl-Halabi M, Ali AM. Effect of polymerization conditions of sulfonated-melamine formaldehyde superplasticizers on concrete. Cement and Concrete Research. 1988 Jul 1;18(4):513-31.
- Jhatial AA, Sohu S, Lakhia MT, Shahzaib J, Buriro AA. Effectiveness of locally available superplasticizers on the workability and strength of concrete. Civil Engineering Journal. 2018 Dec 23;4(12):2919-25.
- Huang R, Xu L, Xu Z, Zhang Q, Wang J. A Review on Concrete Superplasticizers and Their Potential Applications for Enhancing the Performance of Thermally Activated Recycled Cement. Materials. 2024 Aug 23;17(17):4170.

