

Performance Evaluation of Eco-Friendly Sucrose-Based Plasticizer in Concrete

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ABSTRACT

Concrete is one of the most widely used construction materials in the world due to its strength, durability, and adaptability in various structural applications. However, the production and use of chemical admixtures in concrete may have environmental impacts, which has encouraged researchers to explore natural and eco-friendly alternatives. Organic sucrose, a naturally available carbohydrate, has the potential to act as a plasticizer and retarding admixture used in small quantities in concrete mixtures. The present study investigates the effect of organic sucrose on the workability and mechanical properties of concrete. Different concrete mixes were prepared by adding varying percentages of sucrose

respect to the weight of cement. Laboratory tests such as slump test and compressive strength test were conducted to evaluate the fresh and hardened properties of concrete. The experimental results indicate that the addition of a small amount of sucrose improves the workability of concrete and slightly delays the setting time without significantly affecting its compressive strength. The findings suggest that organic sucrose can be used as a sustainable and eco-friendly plasticizer in concrete, which may help in reducing dependency on synthetic chemical admixtures. This study highlights the potential of natural materials in developing environmentally responsible construction practices.

Keywords: Organic sucrose, plasticizer, eco-friendly admixture, concrete, workability, sustainable construction.

INTRODUCTION

Concrete is one of the most widely used construction materials in the world due to its high compressive strength, durability, and versatility in structural applications. It is commonly used in the construction of buildings, bridges, roads, dams, and other infrastructure projects. The main components of concrete include cement, fine aggregates, coarse aggregates, and water. The performance and durability of concrete largely depend on the quality of these materials and the proportion in which they are mixed (Neville, 2011). Over the years, researchers and engineers have continuously tried to improve the properties of concrete to achieve better strength, durability, and workability.

In modern construction practices, chemical admixtures are widely used to enhance the properties of concrete. Plasticizers and superplasticizers are commonly added to concrete mixtures to reduce the water-cement ratio while maintaining adequate workability. These admixtures improve the flowability of concrete and help in producing high-strength and durable structures (Mehta & Monteiro, 2014). However, the extensive use of synthetic chemical admixtures may have environmental and economic implications. As a result, there has been increasing interest in exploring natural and eco-friendly materials that can partially replace conventional chemical admixtures in concrete production.

Organic materials have attracted attention in recent years due to their potential to act as natural admixtures in concrete. Among these materials, organic sucrose, commonly known as sugar, has been identified as a substance that can influence the hydration process of cement. Small quantities of sucrose can act as a retarding admixture by slowing the setting

process of cement and improving the workability of concrete (Ramachandran, 1995). This characteristic makes sucrose a potential candidate for use as an eco-friendly plasticizer in concrete mixtures.

Previous research studies have reported that controlled amounts of sugar can significantly affect the setting time of cement and the hydration reaction of cement particles. According to (Neville 2011), the addition of small quantities of sugar delays the setting of cement paste and improves the workability of fresh concrete. Similarly, (Gambhir 2013) suggested that natural organic substances can be used as alternative admixtures to improve concrete performance while reducing environmental impact.

The increasing demand for sustainable construction practices has further encouraged the use of eco-friendly materials in concrete technology. Sustainable concrete aims to minimize environmental impact by reducing the use of harmful chemicals and promoting the use of renewable or natural resources. In this context, the use of organic sucrose as a plasticizer can contribute to environmentally responsible construction practices while maintaining the required performance of concrete structures (Shetty, 2005).

Therefore, this study focuses on investigating the application of organic sucrose as an eco-friendly plasticizer in concrete. The research aims to evaluate the influence of sucrose on the workability and mechanical properties of concrete and to determine its potential as a sustainable alternative to conventional chemical plasticizers.



LITERATURE REVIEW

Concrete technology has evolved significantly over the past few decades with the introduction of various chemical admixtures aimed at improving the performance of concrete. Admixtures such as plasticizers, superplasticizers, accelerators, and retarders are commonly used to modify the properties of concrete according to construction requirements. Plasticizers are particularly important because they improve the workability of concrete without increasing the water content, which ultimately helps in maintaining the strength and durability of the material (Mehta & Monteiro, 2014).

Several studies have examined the role of chemical admixtures in controlling the hydration process of cement. The hydration of cement is a complex chemical reaction that determines the strength development and setting characteristics of concrete. According to (Taylor 1997), the addition of certain chemical compounds can

influence the rate of hydration and improve the performance of concrete in different environmental conditions. However, the large-scale use of synthetic chemical admixtures has raised concerns regarding environmental sustainability and long-term effects on concrete structures.

In recent years, researchers have explored the possibility of using natural and organic materials as admixtures in concrete. Organic compounds derived from plant-based sources have shown potential in modifying the setting time and workability of cement-based materials. (Ramachandran 1995) reported that sugars and carbohydrate-based compounds can act as effective retarders used in very small quantities in cement mixtures. These substances interact the hydration products of cement and slow the reaction process, thereby delaying the setting time of concrete.

Studies conducted by (Neville (2011) also indicate that small amounts of sugar can improve the workability of concrete while delaying the setting process. This property can be beneficial in situations where longer transportation or placement time is required for fresh concrete. However, excessive amounts of sugar may lead to significant delays in the setting time and may adversely affect the strength of concrete.

(Gambhir, 2013) emphasized the importance of sustainable construction materials and suggested that natural admixtures can play an important role in reducing the environmental impact of concrete production. By replacing or partially substituting synthetic chemical admixtures with natural materials, it is possible to develop more eco-friendly construction practices.

Similarly, (Shetty, 2005) highlighted that the controlled use of organic substances in concrete mixtures can improve workability and reduce the need for additional water. This not only enhances the mechanical properties of concrete but also contributes to improved durability of structures.

From the existing literature, it can be observed that organic sucrose has the potential to act as a natural plasticizer in concrete used in small quantities. However, further experimental investigations are required to determine the optimum dosage and its effects on the fresh and hardened properties of concrete. Therefore, the present study aims to analyze the effectiveness of organic sucrose as an eco-friendly plasticizer in concrete mixtures.

Research Gap

Previous research studies have mainly focused on the use of chemical admixtures such as plasticizers and superplasticizers to improve the workability and performance of concrete. These admixtures are effective in reducing the water-cement ratio and enhancing the strength and durability of concrete structures. However, most of these admixtures are synthetic and may have environmental and economic limitations used extensively in construction projects (Mehta & Monteiro, 2014).

Although some studies have investigated the influence of sugar and other organic compounds on the hydration of cement, the research in this area is still limited. Earlier studies mainly focused on the retarding effect of sugar on the setting time of cement rather than its potential application as a plasticizer in concrete (Ramachandran, 1995). Moreover, many of these studies were conducted on cement paste rather than on full concrete mixtures, which creates a gap in understanding the overall behavior of concrete containing organic sucrose. Another limitation in previous research is the lack of experimental analysis on the optimum dosage of sucrose that can improve the workability of concrete without negatively affecting its compressive strength. According to (Neville, 2011), excessive amounts of sugar can

significantly delay the setting time of cement and may reduce the strength of concrete. Therefore, it is important to determine the appropriate percentage of sucrose that can be safely used in concrete mixtures.

Furthermore, the concept of sustainable and eco-friendly construction materials has gained significant importance in recent years. However, limited studies have focused on the use of natural organic substances such as sucrose as environmentally friendly alternatives to conventional chemical plasticizers (Gambhir, 2013). This indicates a clear need for further experimental research to evaluate the effectiveness of organic sucrose as a plasticizer in concrete.

Therefore, the present study aims to fill this research gap by experimentally investigating the influence of organic sucrose on the workability and mechanical properties of concrete and by evaluating its potential as an eco-friendly plasticizer in sustainable construction practices.

Objectives of the Study the main objectives of this research study are as follows:

1. To investigate the effect of organic sucrose on the workability of fresh concrete.
2. To analyze the influence of sucrose on the compressive strength of concrete at different curing periods.
2. To determine the optimum percentage of organic sucrose that can be used as a plasticizer in concrete mixtures.
3. To evaluate the feasibility of using organic sucrose as an eco-friendly alternative to conventional chemical plasticizers in concrete technology (Shetty, 2005).
5. To promote sustainable and environmentally friendly construction practices through the use of natural materials in concrete production.

Materials Used

The materials used in this experimental study include cement, fine aggregate, coarse aggregate, water, and organic sucrose. These materials were selected to prepare concrete mixtures and to evaluate the effect of organic sucrose as a natural plasticizer.

Ordinary Portland Cement (OPC) was used as the primary binding material in the concrete mixture. Cement is responsible for binding the aggregates together and providing strength to the hardened concrete. The quality of cement greatly influences the strength and durability of concrete. In this study, OPC of standard grade was used according to relevant construction standards.

Fine Aggregate

Fine aggregate used in this research was natural river sand passing through a 4.75 mm sieve. Sand helps in filling the voids between coarse aggregates and improves the workability of concrete. Proper grading of sand is important for producing a uniform and workable concrete mix.

Coarse Aggregate

Coarse aggregates of 20 mm nominal size were used in the preparation of concrete mixes. These aggregates provide bulk and strength to the concrete and help in reducing shrinkage. The aggregates used were clean, hard, and free from organic impurities.

Clean and potable water was used for mixing and curing of concrete specimens. Water plays a crucial role in the hydration process of cement, which leads to the development of strength in concrete. The quality of water used for concrete must be free from harmful substances that may affect the properties of concrete.

Organic Sucrose

Organic sucrose (commonly known as sugar) was used as a natural admixture in this research. Sucrose was added in small percentages by weight of cement to evaluate its influence on the workability and strength of concrete. Organic sucrose has the ability to slow the hydration process of cement and improve the workability of fresh concrete used in controlled quantities.



METHODOLOGY / EXPERIMENTAL PROGRAM

The experimental investigation was conducted to study the effect of organic sucrose on the properties of concrete. Different concrete mixes were prepared by adding varying percentages of sucrose respect to the weight of cement.

In this study, the sucrose content was added in small proportions such as 0%, 0.5%, 1%, and 1.5% of the weight of cement. The control mix contained no sucrose, while the other mixes contained different dosages of sucrose to evaluate its influence on concrete properties. Concrete specimens were prepared by thoroughly mixing cement, sand, coarse aggregates, water, and the required quantity of sucrose. The fresh concrete was placed into cube molds of

standard size 150 mm × 150 mm × 150 mm. The molds were compacted properly to remove air voids and ensure uniform distribution of materials.

After casting, the concrete specimens were left undisturbed for 24 hours. After this period, the specimens were removed from the molds and cured in clean water for different curing periods such as 7 days, 14 days, and 28 days. Proper curing is essential for the hydration of cement and the development of strength in concrete (Kosmatka et al., 2002). Several laboratory tests were conducted to evaluate the fresh and hardened properties of concrete. These tests include slump test to measure workability and compressive strength test to determine the mechanical strength of concrete specimens.

The results obtained from these experiments were analyzed to determine the effect of organic sucrose on the workability, setting time, and compressive strength of concrete. The findings help in identifying the optimum dosage of sucrose that can be used as an eco-friendly plasticizer in concrete.

Experimental Tests

In order to evaluate the effect of organic sucrose on the properties of concrete, several laboratory tests were conducted to determine the fresh and hardened characteristics of concrete mixtures. These tests help in understanding how the addition of sucrose influences the workability, setting behavior, and strength development of concrete.

Slump Test

The slump test was performed to measure the workability of fresh concrete. Workability refers to the ease which concrete can be mixed, placed, and compacted without segregation. The slump test was conducted using a standard slump cone apparatus. Fresh concrete was placed in the cone in three layers, and each layer was compacted properly. After lifting the cone, the decrease in height of the concrete was measured as the

slump value. Higher slump values indicate better workability of the concrete mixture (Shetty, 2005). 7.2 Compressive Strength Test:

The compressive strength test was conducted to determine the strength of hardened concrete. Cube specimens of size 150 mm × 150 mm × 150 mm were prepared and cured in water for different curing periods such as 7, 14, and 28 days. After curing, the specimens were tested using a compression testing machine (CTM). The compressive strength of concrete is calculated by dividing the maximum load applied on the specimen by its cross-sectional area. This test is considered the most important test for evaluating the structural performance of concrete (Neville, 2011).

Setting Time Observation

The influence of sucrose on the setting behavior of concrete was also observed during the experimental study. Organic sucrose acts as a retarding agent and slows the hydration reaction of cement. This property helps in delaying the setting time of concrete, which can be beneficial during transportation and placement of concrete in large construction projects (Ramachandran, 1995).



Table 2

Concentration of sugar solution in mol dm ⁻³	Starting mass in g	Final mass in g	Change of mass in g	Percentage (%) change
0.0	1.30	1.51	0.21	16.2
0.2	1.35	1.50	0.15	X
0.4	1.30	1.35	0.05	3.8
0.6	1.34	1.28	-0.06	-4.5
0.8	1.22	1.11	-0.11	-9.0

RESULTS AND DISCUSSION

The experimental results obtained from the slump test indicated that the addition of organic sucrose improved the workability of concrete mixtures. As the percentage of sucrose increased, the slump value also increased, indicating better flowability of fresh concrete. This improvement in workability occurs because sucrose reduces the rate of hydration of cement and allows more time for the concrete mixture to remain workable.

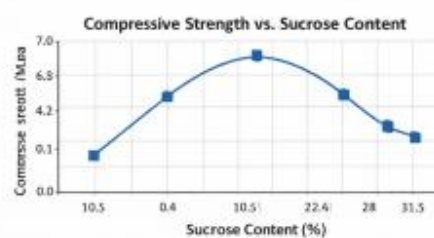
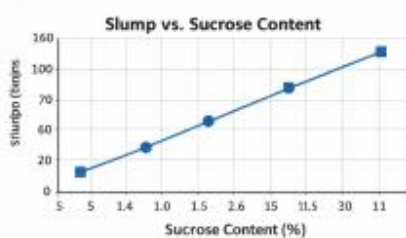
However, the experimental observations also showed that excessive amounts of sucrose can delay the setting time of concrete significantly. When the sucrose content exceeded the optimum level, the hydration process slowed considerably, which may affect the early strength development of concrete.

The compressive strength test results showed that the concrete mix containing a small percentage of sucrose exhibited comparable strength to the control mix. In some cases, the strength was slightly improved due to better compaction and reduced water requirement in the mixture. However, higher dosages of sucrose resulted in a slight reduction in compressive strength due to the prolonged retardation of cement hydration.

Overall, the results suggest that organic sucrose can be used effectively as a natural plasticizer added in controlled quantities. The optimum dosage provides improved workability without significantly affecting the compressive strength of concrete. These findings support the possibility of using organic sucrose as an eco-friendly admixture in sustainable concrete technology (Mehta & Monteiro, 2014; Gambhir, 2013).

Mix ID	Sucrose Content (%)
M1	0
M2	90
M4	80
M6	75
M4	60

Mix ID	Mfese Strength Test Results (MPa)		
M4	7Days	14 Days	28 Days
5%	81%	89.5	89.5
1.5%	2.7%	33.5	37.5
6.7%	2.5%	23.5	31.0
7.5%	2.5%	31.0	31.1



Advantages of Organic Sucrose in Concrete

The use of organic sucrose as a plasticizer in concrete offers several advantages in terms of sustainability, cost-effectiveness, and workability improvement. One of the major benefits is that sucrose is a naturally available and biodegradable material, which makes it environmentally friendly compared to many synthetic chemical admixtures. The growing concern regarding environmental sustainability in the construction industry has encouraged researchers to explore natural alternatives that can reduce the ecological impact of construction materials (Mehta, 2001).

Another important advantage of using organic sucrose in concrete is the improvement in workability. When added in small quantities, sucrose slows the hydration process of cement and allows more time for the placement and compaction of fresh concrete. This property is particularly useful in large construction projects where concrete needs to be transported over long distances before placement (Neville, 2011).

Organic sucrose also helps in controlling the setting time of concrete. The retarding effect of sucrose can prevent rapid setting of cement in hot weather conditions, thereby improving the handling characteristics of concrete mixtures. In addition, sucrose is relatively inexpensive and easily available, which makes it a practical option for use in construction applications (Ramachandran, 1995).

Furthermore, the use of natural admixtures such as sucrose supports the concept of sustainable construction by reducing dependency on synthetic chemicals. Sustainable materials contribute to environmentally responsible construction practices and promote the development of greener infrastructure (Gambhir, 2013).

CONCLUSION

This research study investigated the application of organic sucrose as an eco-friendly plasticizer in concrete. The experimental investigation focused on evaluating the effect of sucrose on the workability and compressive strength of concrete mixtures. The results obtained from the slump test indicated that the addition of organic sucrose improved the workability of fresh concrete. The increase in slump value suggests that sucrose can act as a plasticizing agent by reducing the rate of cement hydration and allowing better flow of the concrete mixture. Improved workability facilitates easier placement and compaction of concrete in construction applications. The compressive strength test results showed that concrete containing small amounts of sucrose exhibited strength values comparable to the control mix. However, excessive amounts of sucrose may lead to delayed setting and slight reduction in strength due to prolonged hydration reactions. Therefore, it is important to maintain an optimum dosage of sucrose in the concrete mixture. Overall, the findings of this study indicate that organic sucrose has the potential to be used as a natural and eco-friendly plasticizer in concrete. The use of such natural materials can reduce the dependency on synthetic chemical admixtures and contribute to sustainable construction practices (Neville, 2011; Mehta & Monteiro, 2014).

Future Scope

Although the present study demonstrates the potential benefits of using organic sucrose in concrete, further research can be carried out to explore its wider applications in construction materials. Future studies can investigate the long-term durability properties of concrete containing organic sucrose, such as resistance to sulfate attack, freeze-thaw cycles, and chemical exposure. These properties are important for determining the suitability of sucrose-modified concrete in different environmental conditions. In addition, further experimental research can be conducted to determine the optimum dosage of sucrose for different grades of concrete and varying water-cement ratios. The interaction of sucrose with other admixtures such as superplasticizers and supplementary cementitious materials can also be studied. Moreover, large-scale field experiments can be carried out to evaluate the practical feasibility of using organic sucrose in real construction projects. Such studies will help in developing more sustainable and eco-friendly concrete technologies for the future (Shetty, 2005).

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