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A STUDY ON SUGAR WASTE'S FEASIBILITY FOR USE IN CONCRETE

Onkar Yadav[1], David Kumar[2]

[1]Assistant Professor, Department of Civil Engineering, Sandip University, Madhubani, Bihar, India.
Email: onkary8@gmail.com
[2]Research Scholar, Department of Civil Engineering, Sandip University, Madhubani, Bihar, India

Abstract:

This literature survey focuses on exploring the potential of sugar waste as a sustainable alternative in concrete production, considering the environmental impact associated with conventional manufacturing processes. Concrete production is recognized for its substantial energy consumption and carbon emissions, which contribute to environmental degradation. The aim of this study is to examine existing research articles, journals, and reports to assess the feasibility of incorporating sugar waste into concrete and evaluate its effects on concrete properties. By reviewing the available literature, this survey aims to provide insights into the impact of sugar waste on concrete properties and its potential benefits for the construction industry. The analysis will consider various aspects such as compressive strength, workability, durability, and setting time. These properties play a crucial role in determining the overall performance and applicability of concrete in different construction applications. Additionally, this literature survey will explore the different methods of incorporating sugar waste into concrete, including direct replacement, partial substitution, and pre-treatment techniques. It will also investigate the optimal dosage of sugar waste to achieve desired concrete performance while ensuring the preservation of its structural integrity and long-term durability. Furthermore, this survey will address the environmental benefits and sustainability aspects associated with using sugar waste in concrete production. It will examine the potential reduction in carbon emissions and the opportunities for waste diversion and sustainable waste management practices. By critically analyzing the available literature and identifying research gaps, this study aims to provide a comprehensive understanding of the feasibility and potential of utilizing sugar waste in concrete production. The findings will be valuable for researchers, engineers, and policymakers, aiding them in making informed decisions and promoting sustainable practices within the construction industry.

Keywords — **Sugar waste, Sustainable alternative, Concrete, Environmental impact, Waste management, Strength and Durability.**

1. INTRODUCTION

In the context of reducing the carbon footprint in construction, the utilization of waste materials from various industries is gaining traction. The production of approximately 16 billion tons of recyclable or alternative waste materials in 2009 highlights the potential for their application. As urbanization continues to increase and the demand for robust structures rises, the focus on constructing solid and high-strength buildings becomes crucial. However, achieving both high strength and workability in concrete mixes can be challenging, as low water-cement ratios often result in reduced workability. To overcome this issue, chemical admixtures are commonly employed to enhance workability while maintaining the desired strength. However, an alternative to these admixtures could potentially be found in waste materials generated by specific industries. One such waste material is molasses, a by product of sugar mills.

2. CHALLENGES AND SCOPE OF USE OF MOLASSES

Molasses, a dense and viscous liquid, is the primary by-product of the raw sugar production process. It cannot be further processed to extract additional sugar through simple means. On average, up to 8 gallons of molasses can be obtained per ton of cane processed. Molasses consists of approximately 50 to 60% total sugars, with sucrose accounting for 16-17% and the remaining sugars being glucose and fructose. Despite its potential, the utilization of molasses in concrete is currently limited. Several factors contribute to this limitation:

- Lack of knowledge and standardized guidelines regarding the use of molasses in concrete.
- Prevalent use of molasses in other industries, diverting its availability and potential application in the construction sector.
- Variations in the behavior of molasses based on regional factors, making its performance uncertain.
- Insufficient research conducted on the use of molasses in concrete, leading to a lack of comprehensive understanding.

Technical challenges associated with incorporating molasses in concrete include weak interfacial zones between cement paste and mortar, the presence of high levels of sucrose, elevated sulphate levels, impurities, and significant variations in quality. Due to these reasons, the current utilization of molasses in concrete remains limited, and further research and development are necessary to address the technical challenges and establish proper guidelines for its effective and reliable use in the construction industry.

Dry matter	80%
Total sugar	52-58%
Sucrose	16-17%
Reducing sugars	34-38%
Total nitrogen	2-3%
Organic acids	3%
Gums (insoluble in alcohol)	2%
pH value	5-6
Ash	12-18%

Table 1: Typical composition of Molasses (Source: ASI molasses survey (2000)

3. TYPES OF MOLASSES

Molasses is a by product obtained during the purging or spinning of a massecuite in centrifugals within the sugar production process. It is categorized into different types, namely A, B, and C, based on its characteristics. The discharge obtained before the washing process is referred to as heavy molasses, while the diluted form with wash water is known as light molasses. The molasses that is ultimately extracted from the process is considered waste or final molasses. Although the sugar industry aims to produce final molasses with low purity and total sugar content, it still emerges as waste from the sugar production process. Final molasses exhibits variations in its brix (sugar concentration) and total sugar content, lacking uniformity. Consequently, based on their respective brix and total sugar content, the final molasses are classified into three different grades, as illustrated in Table 2.

S.No.	Grade of final molasses	Degree Brix	Total sugar Content (%)
1.	A	100° to 110°	55 - 60
2.	B	90° to 100°	45 – 55
3.	C	80° to 90°	40 – 45

Table 2 : Types of Molasses. (Gmbh, 2006)

4. MISCELLANEOUS APPLICATIONS OF MOLASSES

In addition to its potential use in cement mortar and concrete, molasses finds application in various other areas, including:

- Alcohol production: Molasses can be utilized in the production of alcohol.
- Glycerine production: A portion of the sugar content in molasses can be converted to glycerine.
- Rum production: Beet molasses can be used in the preparation of rum.
- Citric acid production: Molasses can serve as a raw material for the production of citric acid.
- Itaconic acid production: Itaconic acid can be produced from molasses.
- Production of butane, acetone, and dextran: Molasses can be used in the production of these substances.
- Butanediol production: Molasses can be utilized in the production of butanediol.
- Distillation of gases by carbonization: Molasses can be subjected to carbonization for the distillation of gases.
- Biological utilization as Vinasse: Molasses can be employed as Vinasse in biological processes.
- Cattle feed and other feed products: Molasses is rich in carbohydrates and minerals, making it suitable as feed for livestock. It has shown positive effects on the general health of horses when used as part of their diet.

These diverse applications highlight the versatility of molasses beyond its potential use in construction materials, making it a valuable resource in various industries.

5. LITERATURE REVIEW

This study aims to investigate the impact of molasses on the properties of cement, cement mortar, and cement concrete. In this chapter, a literature review is presented, focusing on the application of molasses in cement concrete and examining its effects on both the fresh stage properties and hardened properties of specimens. By reviewing the existing research conducted in this field over the past few years, this chapter provides an overview of the studies conducted in this area. The literature review serves to provide valuable insights and a foundation for the current study, shedding light on the advancements and findings related to the utilization of molasses in cement concrete.

Yildrim & Altun (2012) This study aimed to compare the water-reducing and retarding effects of molasses with a lignosulphonate-based water reducer admixture. For the experimental investigation, a lignosulphonate-based water reducer admixture conforming to ASTM C 494 Type A specifications was utilized. Additionally, three different types of molasses, namely Konya, Susurluk, and Bor, were employed as plasticizer admixtures. In total, fourteen different concrete mix designs were prepared for the study.

Giridhar et al. (2013) The objective of this study was to compare the effects of sugar and molasses on the properties of cement concrete. The target mix design strength was set at M20. Three different proportions (0%, 0.05%, and 0.1%) were used for each molasses and sugar, respectively, as admixtures in the concrete mix. The test results revealed that the addition of both molasses and sugar led to an increase in the slump value of the concrete. However, it was observed that the slump value was relatively higher when sugar was used compared to molasses. Furthermore, the compressive strength of the concrete improved as the dosage of the admixtures increased. Concrete with molasses as an admixture exhibited better strength values compared to concrete with sugar. The usage of these admixtures also contributed to reduced segregation and bleeding of the concrete mixture. In terms of setting time, it was observed that the concrete's setting time increased more rapidly as the dosage of sugar was increased, indicating a retarding effect. However, specific details regarding the extent of the setting time increase were not provided in the given information. Overall, the study concluded that both molasses and sugar admixtures had a positive impact on the properties of cement concrete, enhancing slump, compressive strength, and minimizing segregation and bleeding. However, molasses showed better strength performance compared to sugar, and sugar exhibited a more pronounced effect on extending the concrete's setting time.

Ismail et al. (2014) In this study, molasses was incorporated into cement paste containing Effective Microorganism (EM). Effective Microorganism is a branch of horticulture that focuses on cultivating beneficial microorganisms to improve soil quality and enhance crop yield. The research involved the introduction of five different ratios of molasses blended with a constant content of EM.No-1 (5%) in the cement paste. Various tests were conducted to evaluate the consistency, setting time, and soundness of the microbed cement paste with different molasses contents. Additionally, the chemical phases and oxide composition of the microbed cement, both with and without molasses, were analyzed using X-Ray Fluorescence (XRF) to investigate their properties.

Karthik et al. (2015) The objective of this study was to examine the effects of molasses on the setting time, workability, and strength of concrete. The target mix design for the concrete was set at 20 MPa. Molasses was introduced in various proportions, including 0.2%, 0.4%, 0.6%, 0.8%, and 1.0% by weight of the cement content. The findings of the study demonstrated that the addition of molasses significantly increased both the initial and final setting times of the concrete. This indicates that molasses acted as a time retarding agent, prolonging the setting process. Furthermore, the workability of the concrete was improved with the inclusion of molasses. The compacting factor and slump value increased as the content of molasses increased, indicating enhanced workability and ease of placement. Overall, the results indicated that molasses could be effectively utilized as a time-retarding plasticizer in concrete mixtures. It offered the advantage of extending the setting time while improving the workability of the concrete, thereby facilitating better construction practices.

Kashyap et al. (2015) This study investigated the combined effect of rice husk ash (RHA) and molasses on the compressive strength of concrete. The concrete grade chosen for the mix design was M30, with a water-cement ratio of 0.45. Two sets of specimens were prepared using a design mix approach. In the first set, the specimens were cast by varying the percentage of cement replacement with RHA, ranging from 0% to 20% with increments of 5% by weight of the cement. These replacements were represented as 5%, 10%, 15%, and 20%, respectively. In the second set, the same procedure was followed, but one of the samples from the first set, which yielded the optimum strength, was selected. Then, the sugar molasses content was varied at 0.4%, 0.8%, 1.2%, 1.6%, and 2% by weight of the cementitious material. The test results showed that the optimum compressive strength at 28 days was achieved when 10% of the cement was replaced with RHA. It was observed that the addition of sugar molasses at 0.8% by weight of the cementitious material further increased the strength at 28 days. The strength of the concrete varied depending on the amount of RHA and the admixture used. Overall, the study concluded that the use of sugar molasses as an admixture, along with RHA, effectively enhanced the strength of the concrete. The combination of 10% RHA replacement and 0.8% sugar molasses content yielded the optimum results in terms of compressive strength at 28 days.

Aalm and Singh (2016) In this study, the researchers examined the impact of molasses on the properties of cement and concrete. The effects of different dosages of molasses, measured as a percentage of the weight of cement, were investigated for standard consistency and setting time in fresh concrete. Additionally, the tensile strength and flexural strength of the concrete were evaluated at the 28-day mark for dosages of 0%, 0.10%, 0.25%, and 0.50% of molasses by weight of cement. The test results, as depicted in Figure 3.13, revealed that molasses acted as an accelerator up to a dosage of 0.50% and subsequently exhibited retarding properties. Furthermore, the flexural strength and tensile strength of the concrete displayed an increase when incorporating molasses at dosages ranging from 0% to 0.50%. Overall, the findings indicate that the use of molasses in concrete can have a significant impact on its properties. At lower dosages, molasses acted as an accelerator, enhancing the strength characteristics of the concrete. However, at higher dosages, it transitioned into a retarder. The study provides valuable insights into the dosage-dependent effects of molasses on cement and concrete, offering potential opportunities for optimizing concrete mix designs and achieving desirable strength properties.

Nagaraj et al.(2019) The primary objective of this research was to evaluate the effectiveness of a new concrete shear box instrument in measuring the rheological properties of Conventional Vibrated Concrete (CVC) and Self-Compacted Concrete (SCC). The focus was on determining the yield stress and plastic viscosity, which are crucial parameters for assessing the workability requirements of CVC with varying levels of workability and the flowability of SCC. The study aimed to provide a scientific and quantitative approach to characterizing fresh concrete, as opposed to relying solely on empirical tests that have limitations and can yield misleading results.Concrete rheology, based on established fluid rheology principles, emerged as a promising technology for scientifically describing the flow properties of concrete. The experimental study demonstrated the feasibility of using the new concrete shear box instrument to determine the rheological properties of both CVC and SCC. The unique aspect of the study was the procedure adopted to calculate the rheological properties, which involved determining the peak shear stress, shear stress at zero normal stress, and zero displacement rates before obtaining the yield stress and plastic viscosity. The results and observations confirmed the utility of the concrete shear box as an additional instrument for effectively determining the rheological properties using the Bingham model. The static test with a low shear rate applied to the specimen closely mimics the conditions experienced by concrete in real-world applications. The study emphasized the need for a quantitative fundamental science approach in characterizing fresh concrete, highlighting the advantages of using concrete rheology as a scientific method for evaluating flow properties.

Azad et al.(2020) Based on this study, several important findings can be derived. Firstly, it was observed that up to a sugar concentration of 0.08%, both the initial and final setting times of cement gradually increased. However, beyond this threshold, the setting times experienced a significant increase due to the retardant effect of sugar in the cement paste. Secondly, the compressive strength of the concrete exhibited satisfactory improvement when 0.08% sugar was used, regardless of the curing period. This concentration yielded the highest strength compared to other sugar percentages tested. Thirdly, the initial setting time for 0.08% sugar was determined to be 105 minutes, which falls within the acceptable limits set by ASTM (120 minutes). Moreover, no detrimental effects were observed on the concrete or cement paste at this sugar concentration. Lastly, the delay in concrete setting provided by 0.08% sugar could prove beneficial in preventing cold joints and reducing premature cement setting during hot weather concreting.

Dulawat et al.(2020) The effects of incorporating SBA (Silica-Based Admixture) in concrete mix were examined in this study. It was observed that as the replacement percentage of sand with SBA increased from 0% to 40%, there was a reduction in slump value by 25% and compaction factor by 9%. Initially, the compressive strength of the concrete decreased with the inclusion of SBA. At 7 days, 14 days, and 28 days, the compressive strength of concrete cubes decreased by 20%, 19%, and 18%, respectively, when 40% SBA was used as a replacement for cement. Similarly, the flexural strength at 14 days and 28 days decreased by 6% and 5%, respectively, with the same 40% SBA replacement. However, the incorporation of SBA and polymer in the concrete mix resulted in a reduction in material cost while maintaining the same strength of concrete. This cost reduction was possible because SBA was obtained as a waste material at no cost from the factory, and the addition of polymers aided in enhancing the concrete mix's strength.

Shiv et al. (2021) This investigation focused on examining the impact of molasses, a type of sugar waste, on cement concrete. The study involved analyzing cement paste, various mortar mixes, and five different concrete mixes with and without the addition of molasses. Molasses, which contains 40-60 percent total sugar content depending on its type, was collected from a sugar mill for this research. Different dosage levels of molasses (ranging from 0.1 to 5.00 percent by weight of cement) were investigated for their effects on standard consistency, setting time, water-reduction behavior, and air-entrainment in fresh concrete. The study also evaluated the compressive strength of mortar at 7-day and 28-day intervals, compressive strength of concrete at 7-day, 28-day, 56-day, and 91-day intervals, and the tensile strength and flexural strength of concrete at 14-day intervals. The test results demonstrated that molasses acts as an accelerator up to a 0.50 percent dosage and then becomes a retarder. It also exhibits slight water-reducing and air-entraining properties. The use of molasses at dosages between 0 and 0.50 percent resulted in increased compressive strength of mortar and concrete, as well as improved flexural and tensile strength of concrete. The most favorable dosage was found to be 0.25 percent of molasses by weight of cement.

Wu et al.(2022) This study focused on the utilization of sugar cane bagasse ash (SCBA), the final waste material in sugar production, as a cement replacement in the development of eco-friendly ultra-high performance concrete (UHPC). The research aimed to analyze the effects of SCBA on various properties of UHPC, including fluidity, setting time, compressive strength, flexural strength, and autogenous shrinkage. To assess the impact of SCBA on cement hydration, hydration products, and pore structure, hydration heat evaluation, X-ray diffraction (XRD), thermogravimetric (TG) analysis, and mercury injection (MIP) techniques were employed. The findings demonstrated that incorporating SCBA in UHPC as a cement replacement not only maintained compressive strength but also improved workability and reduced autogenous shrinkage in UHPC paste. Compared to the control group, UHPC with a 40% replacement rate of SCBA exhibited favorable overall performance, with a 24.48% reduction in autogenous shrinkage and comparable compressive strength. This study confirms the technical feasibility of utilizing SCBA as a cement replacement in UHPC, thereby promoting the utilization of agricultural byproducts in cementitious materials.

Kumar et al.(2023) Through an experimental investigation conducted on bituminous mixes, specifically Stone Matrix Asphalt (SMA) and Bituminous Concrete (BC), several key findings were observed. All three types of fillers used in BC met the necessary specifications, demonstrating their suitability for application. Among these fillers, BC with cement filler exhibited the highest stability, while alternatives such as fly ash and stone dust fillers proved to be viable and cost-effective options. The addition of fibers up to 0.3% showed improvements in the stability of BC, although further incorporation of fibers did not lead to significant enhancements compared to SMA. The inclusion of fibers resulted in a decrease in the flow value of BC, but interestingly, when 0.5% of fibers were added, the flow value increased. SMA exhibited superior tensile strength when compared to BC, and the incorporation of fibers reduced deformation in both types of mixes. Particularly, SMA with sisal fiber exhibited excellent performance for flexible pavement applications, indicating its potential in various construction projects.

Jiang et al.(2023) Concrete structures often suffer from cracking, and researchers have been exploring the use of microbially induced calcite precipitation (MICP) for crack repair. Previous studies have proposed the feasibility of preparing a microbial self-healing agent coated with sugar. However, the impact of external environmental conditions on the effectiveness of crack healing in concrete remains unknown. Therefore, this study comprehensively investigates the influence of various external factors such as curing conditions, external temperature, cracking time, and freeze-thaw cycles on the repair of microbial concrete cracks. The evaluation of the self-healing effect of microbial concrete is conducted using methods based on crack width healing percentage and average repair width. The findings reveal that concrete exhibits better crack healing under dry-wet cycle or immersion curing, with average repair widths of 0.376 mm and 0.340 mm respectively at 28 days. Bacteria are more susceptible to low temperatures than high temperatures, and at 30°C, the percentage of completely repaired cracks reaches 82.1%. At low temperatures (10-25°C), only cracks with widths less than 0.25 mm can be effectively repaired. Remarkably, even concrete that is 180 days old can undergo successful self-healing under appropriate conditions, with the percentage of completely repaired cracks reaching 66.7%. The number of freeze-thaw cycles does not affect the crack-healing effectiveness of concrete. Under dry-wet cycle curing at 30°C, the percentage of completely repaired cracks (with widths <0.4 mm) in self-healing concrete reaches 89.4%, affirming the suitability of the "sugar-coating" method for preparing microbial self-healing agents. This study provides valuable methods and suggestions for the advancement of microbial concrete development.

Kumar et al.(2023) The incorporation of manufactured sand in concrete offers several advantageous effects on its overall performance. Both M40 and M50 grade concretes exhibit a notable reduction in water absorption when manufactured sand is utilized, as compared to conventional sand concrete. This reduction is achieved by employing a lower water-binder ratio, resulting in concrete that is impermeable and exhibits enhanced resistance to water penetration. Moreover, the inclusion of manufactured sand results in a decrease in chloride ion penetrability, indicating improved durability and lower permeability of the concrete. Another benefit of using manufactured sand is its increased resistance to acid and alkaline attacks, leading to reduced weight loss when compared to concrete made with traditional sand. Additionally, concrete mixes incorporating synthetic sand demonstrate enhanced resilience against impact and abrasion, making them more durable in challenging conditions. Overall, the utilization of manufactured sand positively impacts various aspects of concrete performance.

Thanoon et al.(2023) This study focuses on addressing the challenge of cement setting time and workability in hot weather conditions, specifically in the Sultanate of Oman. To achieve retardation, a combination of sugar and gypsum was used as retarders. The objective was to investigate the impact of these retarders on the consistency and setting time of ordinary Portland cement (OPC) paste, as well as the compressive strength of concrete cubes after a 7-day curing period. OPC paste was prepared by mixing 500 grams of ordinary Portland cement, a fixed amount of sugar (0.02% by weight of cement), and varying proportions of gypsum (1%, 2%, 3%, 4%, and 5% by weight of cement) with water, maintaining a water-cement ratio of 0.4 to 0.5. It was observed that sugar exhibited a significant retarding effect, but this effect could be controlled by the addition of gypsum, which helped reduce the prolonged setting time caused by sugar. The addition of gypsum resulted in a reduction in the setting time of cement paste from 5.5 hours to 3 hours while maintaining a fixed amount of sugar. Furthermore, increasing the gypsum content, while keeping the sugar content constant, led to a slight decrease in compressive strength from 31.5 MPa to 30.92 MPa.

6. SUMMARY

The review paper focuses on assessing the feasibility of utilizing sugar waste in concrete applications. It summarizes the findings and insights obtained from various studies conducted in this area. Sugar waste, such as molasses and sugar cane bagasse ash (SCBA), have been explored as potential materials for incorporation in concrete mixtures. The paper highlights that SCBA, as the final waste product in sugar production, exhibits pozzolanic characteristics and is abundantly available. Researchers have investigated its use as a cement replacement in eco-friendly ultra-high performance concrete (UHPC). The study examines the effects of SCBA on fluidity, setting time, compressive strength, flexural strength, and autogenous shrinkage of UHPC. Results indicate that incorporating SCBA in UHPC not only maintains compressive strength but also improves workability and reduces autogenous shrinkage. The review also discusses the influence of external environmental conditions, such as curing conditions, temperature, cracking time, and freeze-thaw cycles, on the self-healing effect of microbial concrete using sugar-coated microbial self-healing agents. The crack-healing effectiveness is observed to be better under dry-wet cycling or immersion curing, and the method of sugar-coating is deemed feasible. Overall, the review paper provides valuable insights into the potential utilization of sugar waste in concrete, highlighting its beneficial effects on concrete properties and promoting the utilization of agricultural byproducts in cementitious materials.

REFERENCES

1. Giridhar.V, Gnaneswar . K and Kishore Kumar Reddy. P (2013); *Effect of Sugar and Molasses on Strength Properties of Concrete,* The International Journal Of Engineering And Science (IJES),Volume 2, Issue 10, Pages 01-06, 2013, ISSN (e):2319 – 1813 ISSN (p): 2319 – 1805.
2. Noorli Ismail, Hamidah Mohd.Saman, Hanis Jelani, Hasyidah Mansor and Mohd Faizal Md Jaafar (2014) *The Studies on the Effect of Molasses in Effective Microbed Cement Paste* International Conference on Agriculture, Environment and Biological Sciences (ICFAE'14) June 4-5, 2014 Antalya (Turkey).
3. S. Karthik, T. Suresh, E. Ashok kumar, N. Bharath kumar, R. Umashankar, K. Muthu kumar (2015). *Experimental Study on Strength and Setting Time of Concrete After Modifying Workability by Using Molasses as Time Retarding and Plasticizing Agent;* Journal of Structural Engineering and Management ISSN: 2393-8773(online)Volume 2, Issue 2 www.stmjournals.com.
4. Kumar, Ajay & Yadav, Onkar & Kumar, Sagar. (2023). AN OVERVIEW ARTICLE ON INCORPORATING HUMAN HAIR AS FIBRE REINFORCEMENT IN CONCRETE. 11. 967-975.
5. Rishabh Kashyap, R.D.Patel (2015); *Studies on Compressive Strength of Cement Concrete by use of Rice Husk Ash with Sugar Molasses Waste*; IJSRD - International Journal for Scientific Research & Development| Vol. 3, Issue 06, 2015 | ISSN (online): 2321-0613.
6. Aftab Aalm, Parveen Singh (2016); *Experimental Study on Strength Characteristics of Cement Concrete by Adding Sugar Waste;* International Journal of Enhanced Research in Science, Technology & Engineering ISSN: 2319-7463, Vol. 5 Issue 7, July-2016.
7. Kumar, A., Yadav, O. and Kumar, A.N., A REVIEW PAPER ON PRODUCTION OF ENVIRONMENT FRIENDLY CONCRETE BY USING SEWAGE WATER.
8. Nagaraj, Ajay. (2019). FEASIBILITY STUDIES ON THE USE OF CONCRETE SHEAR BOX FOR MEASUREMENT OF RHEOLOGICAL PROPERTIES OF SCC MIXES.
9. Azad, Muhammad Abul & Rahman, Sajedur & Chowdhury, Reyadul. (2020). Effect of Sugar on Setting Time of Cement and Compressive Strength of Concrete.
10. Kumar, A., Yadav, O. and Shukla, R., 2023. A COMPREHENSIVE REVIEW PAPER ON

PARTIAL CEMENT SUBSTITUTION IN CEMENT MORTAR WITH WOOD ASH. *Research in Multidisciplinary Subjects (Volume-1)*, p.26.

11. Dulawat, Shashivendra & Bais, Tekram. (2020). Use of Locally Available Sugarcane Bagasse Ash & Latex Polymer for the Partial Replacement of Cement & Fine Aggregate in Concrete [1]. Solid State Technology. 63. 3134-3143.

12. Kumar, Shiv. (2021). Effect of Sugar Waste on Cement Concrete. International Journal for Research in Applied Science and Engineering Technology. 9. 1353-1360. 10.22214/ijraset.2021.38124.

13. Wu, Nengsen & Ji, Tao & Huang, Ping & Fu, Tengfei & Zheng, Xiaoyan & Xu, Qing. (2022). Use of sugar cane bagasse ash in ultra-high performance concrete (UHPC) as cement replacement. Construction and Building Materials. 317. 125881. 10.1016/j.conbuildmat.2021.125881.

14. Kumar, A., & Yadav, O. (2023). Concrete Durability Characteristics as a Result of Manufactured Sand. Central Asian Journal of Theoretical and Applied Science, 4(3), 120-127. https://doi.org/10.17605/OSF.IO/8P5HE.

15. Jiang, Lu & Han, Qiangqiang & Wang, Wenjing & Zhang, Yu & Lu, Wei & Li, Zhu. (2023). A sugar-coated microbial agent for self-healing cracks in concrete. Journal of Building Engineering. 66. 105890. 10.1016/j.jobe.2023.105890.

16. Kumar, N. ., Kumar , P. ., Kumar, A. ., & Kumar, R. . (2023). An Investigation of Asphalt Mixtures Using a Naturally Occurring Fibre. AMERICAN JOURNAL OF SCIENCE AND LEARNING FOR DEVELOPMENT, 2(6), 80–87. Retrieved from http://inter-publishing.com/index.php/AJSLD/article/view/1977.

17. Thanoon, Khaldoon & Ali, Subhi & Reddy, Sreedhar & Unilorin, Njtd. (2023). Effect of Using Sugar and Gypsum as a Retarder on Concrete Properties in Omani Weather. Nigerian Journal of Technological Development. 20. 10.4314/njtd.v20i1.1264.

18. Kumar, A., 2023. WEB OF SYNERGY: International Interdisciplinary Research Journal.

19. Faiyaz Alam, Ajay Kumar, & Rambilash Kumar. (2023). Review of Literature for Utilizing Guided Waves for Monitoring the Corrosion Protection of Reinforced Concrete Structures with Active FRP Wrapping. *American Journal of Engineering , Mechanics and Architecture (2993-2637)*, *1*(6), 18–26. Retrieved from https://grnjournal.us/index.php/AJEMA/article/view/468

20. Ajay Kumar and Sujeet Kumar (2023) “Review Paper on Assessment of Deterioration in Concrete Filled with Steel Tubular Section via Guided Waves”, *World of Science: Journal on Modern Research Methodologies*, 2(8), pp. 12–19. Available at: https://univerpubl.com/index.php/woscience/article/view/2444 (Accessed: 8 August 2023).

21. IS 9103: 1999, “Indian Standard Concrete Admixture Specification”, Bureau of Indian Standard, New Delhi.

22. IS 456: 2000, “Indian Standard Code of Practice for Plain and Reinforced Concrete”, Bureau of Indian Standard, New Delhi.

23. IS 10262: 1982, “Recommended Guidelines for Concrete Mix design”, Bureau of Indian Standard, New Delhi.