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A REVIEW PAPER ON PRODUCTION OF ENVIRONMENT FRIENDLY CONCRETE BY USING SEWAGE WATER

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ABSTRACT

The study focuses on investigating the potential of using recycled wastewater from various sources in the mixing and curing processes of concrete, aiming to address the environmental issues related to clean water availability and wastewater disposal. The researchers collected wastewater from four different sources, namely the sewage treatment plant industry (food-based industry), acid-containing aluminium industry, acid-free aluminium industry, and sewage treatment plant. For comparison, normal tap water was used as a control sample.

Concrete mixes were prepared using both wastewater and tap water, and the curing process was carried out using the same water source. The performance of the concrete mixes was assessed based on parameters such as compressive strength, split tensile strength, water absorption, and corrosion current density. The microstructure of the concrete mixes was examined using scanning electron microscopy (SEM) and X-ray diffraction (XRD). The properties of different water sources were also compared.

The results indicated that concrete mixed and cured with wastewater exhibited lower compressive strength compared to the control mix prepared with tap water. Additionally, the water absorption of the wastewater mixes was higher than that of the control mixes. The study also explored the microstructure of the concrete mixes through SEM and XRD analyses. The keywords associated with this study include wastewater, concrete, compressive strength, and corrosion.

Keywords: Water reuse, Sustainable construction, Recycled water, Environmental impact, Concrete durability, Water quality.

1. INTRODUCTION

Water scarcity has become a pressing issue as only a small fraction of the Earth's water is easily accessible. As the demand for resources continues to grow, it is essential to balance environmental concerns with development. The construction industry, driven by advancements in science and technology, is expanding rapidly, making concrete the second most consumed substance after water. The production of concrete requires a significant amount of water, with approximately 186 liters needed for every cubic meter of concrete.

Moreover, the construction industry is the largest consumer of water globally, utilizing around one trillion gallons for the production and curing of concrete. To address this water consumption and inefficiency, finding alternatives to fresh water in the construction industry can lead to substantial water savings. In this research, the focus is on reusing wastewater from various sources in concrete production. The wastewater is used in both the mixing and curing processes of concrete, and the resulting waste effluent concrete is evaluated for its properties. By exploring the reuse of wastewater in concrete, this study aims to mitigate water scarcity and promote efficient water usage.

2. ROLE OF WATER IN CONCRETE

Water is a crucial component of concrete, playing a vital role in various stages of its production and performance. Its importance lies in its ability to facilitate the mixing, laying, compaction, setting, and hardening of the concrete matrix. When water is added to the mixture of binding materials (such as cement, fly ash) and inert materials (such as aggregates, sand), it initiates the hydration process of cement. In the hydration process, water chemically reacts with cement, resulting in the formation of a binding paste. This paste binds the aggregates together and contributes to the overall strength and durability of the concrete. The quantity of water required for proper hydration is typically around 30% of the mass of cement, giving rise to a minimum water-to-cement (w/c) ratio of 0.3. However, using this minimum amount of water would produce a rough and difficult-to-place concrete mix. To address this, additional water is necessary to improve the workability of the concrete mixture. Water acts as a lubricant for the aggregates, allowing for better distribution and easier compaction. It wets the surface of aggregates, enhancing the adhesive quality between the cement paste and the aggregates. Water also dampens the aggregate surface, preventing them from absorbing water that is crucial for the chemical reactions to occur effectively. Furthermore, water imparts plasticity to the various ingredients of the concrete mix, ensuring that it has the desired workability for easy transportation, handling, and placement into molds or formwork. It enables the smooth flow of the concrete mix, facilitating its proper placement. Ultimately, water plays a crucial role in achieving the desired properties of concrete by chemically reacting with cement, enhancing workability, and ensuring proper binding, strength, and durability.

3. QUALITY OF MIXING WATER IN CONCRETE

The quality and quantity of water used in concrete significantly impact its properties. The strength of concrete is greatly influenced by the properties of the water used in the mixture. Typically, water used in construction should meet the same quality standards as drinking water to ensure it is free from impurities such as suspended solids, organic matter, and dissolved salts. These impurities can have adverse effects on the fresh, hardened, and durability properties of concrete. While it is generally accepted that potable water can be used for concrete production, it is advisable to test the water if potable water is unavailable. Testing helps identify the presence of any potentially harmful substances in the water and appropriate measures can be taken to minimize their adverse effects, especially if they are present in excessive amounts. If water of poor quality is used for concrete mixing without proper consideration, it can have detrimental effects on the structural properties, including strength and durability. Excessive presence of salts in water can adversely affect early-age strength and lead to the corrosion of reinforced bars in reinforced concrete structures. Oils such as vegetable oil, linseed oil, or mineral oil in water, when present above 2%, can reduce the strength of the concrete matrix by about 25%. While slightly acidic water has no serious impact on concrete, highly acidic or alkaline water should be avoided as it can adversely affect the hardening process. Water mixed with algae should also be avoided as it can cause entrainments, resulting in a loss of strength. Seawater has been found to reduce the long-term strength of concrete, although the reduction is typically limited to around 15%.

4. LITERATURE REVIEW

Several researchers have conducted investigations to explore the impact of waste effluent on the fresh properties of cement, such as setting time, and the workability of concrete, measured by slump. Their findings indicate that the use of waste effluent in cement mixing can lead to variations in setting time, with some instances of both shorter and longer setting times compared to control samples mixed with fresh water. The workability of concrete, as indicated by slump values, can also be influenced by the incorporation of waste effluent, with changes in slump values observed depending on the specific composition of the waste effluent. These studies highlight the importance of considering the characteristics of waste effluents when using them in cement mixing, as different effluents can have varying effects on the fresh properties of cement and concrete.

Al-jabri et al. (2011) In the study, wastewater from a car wash station was utilized for both the mixing and curing processes of the concrete matrix. The compressive strength of the concrete was tested after 7 and 28 days, using 150 mm cubes. The results showed that the strength of the waste effluent specimens was lower compared to the specimens mixed with tap water. Specifically, the 7-day and 28-day strength of the tap water concrete were 66 MPa and 77 MPa respectively, which were higher than the corresponding strengths of 63.8 MPa and 72 MPa for the wastewater concrete.

Noruzman et al. (2012) The researcher utilized wastewater from three different sources, specifically the effluent from a sewage treatment plant, the effluent from a palm oil mill, and the effluent from a heavy industry. The study revealed a consistent increase in the setting time of all concrete mixes incorporating these wastewater sources. Notably, the mix containing palm oil treated effluent exhibited the longest setting time, which was attributed to the presence of organic impurities in the effluent. Similarly, the mixes made with treated effluent from the heavy industry and domestic sewage also exhibited prolonged setting times compared to the mix made with potable water.

Swami et al. (2015) In the research, the researcher investigated the use of treated domestic sewage effluent for the purpose of mixing concrete and subsequently tested the compressive strength of the resulting concrete. It was observed that the inclusion of effluent in the concrete led to an increase in strength, specifically a 7% increase in compressive strength at 28 days. This improvement in strength can be attributed to the filling of pores by the suspended solids present in the effluent, which contributed to the enhanced strength of the concrete.

Assadolahfardi et al., (2016) In one study, treated domestic sewage effluent was employed for producing concrete, and it was observed that the setting time of the effluent mix was 165 minutes, which was 15 minutes longer than the setting time of the control mix prepared using drinking water. Similarly, the final setting time also exhibited a similar trend, with the effluent mix taking longer to reach its final setting time.

In another study conducted by Ghrair et al. in 2016, primary treated and secondary treated waste effluents were used in concrete. The results indicated an increase in setting time for the concrete mixes incorporating these effluents. Specifically, a 30-minute and 5-minute increase in setting time were observed when using primarily treated and secondary treated effluents, respectively, compared to the control mix prepared with potable water. The presence of sulfates in the effluents was identified as a factor contributing to the hydration process retardation of C_3S, thus causing a delay in the initial setting of the cement.

Ghrair et al., (2016) In the investigation, primary treated and secondary treated wastewater were incorporated into concrete mixes. To assess the workability of the concrete, a slump test was performed, revealing a reduction in the slump value when wastewater was used. Specifically, a decrease of 25 mm and 15 mm was observed for primary treated wastewater and secondary treated wastewater, respectively. The higher total solid content present in the wastewater was identified as the underlying cause for this decrease in workability.

Meena and Luhar. (2019) In the study, three different waste effluents were used for mixing and curing concrete: tertiary treated waste effluent (TTWE), secondary treated waste effluent (STWE), and normal tap water (TW) as a control. The workability of the concrete mixes was evaluated using a slump test following the guidelines of IS 1199-1959. It was observed that the slump value was lower for the concrete cast with waste effluents compared to the conventional tap water matrix. The decrease in workability was attributed to the presence of solid content in the waste effluents, which had a spongy nature and high water absorption capacity. In the study, CC refers to control samples, TWW refers to tertiary treated water, and SWW refers to secondarily treated water. In the study, three types of waste effluents were employed for the mixing and curing of the concrete mix: tertiary treated waste effluent (TTWE), secondary treated waste effluent (STWE), and normal tap water (TW) as a control. The compressive strength of the samples was evaluated after curing for 7, 28, and 90 days. The findings revealed that the compressive strength of the waste effluent samples was lower compared to the samples mixed with potable water. This decrease in strength was attributed to the presence of ettringites, which converted into compounds such as mono sulfate aluminates that dissolved during hydration. The reported decrease in compressive strength was 29% at 7 days, 20.64% at 28 days, and 14.5% at 90 days when TTWE was used in the concrete mix. Similarly, the decrease in strength was 32.24% at 7 days, 29% at 28 days, and 16.6% at 90 days when STWE was used. Additionally, the impurities present in the effluents were responsible for the reduced strength as they formed a duplex layer between the cement paste and aggregates, resulting in a weaker bond.

Zinad et al.(2022) This study proposes a sustainable construction approach by replacing environmentally weak cement with recycled construction waste-based materials such as WCP, BFS, or NGB. This substitution not only reduces the need for raw materials but also lowers the cost of concrete, aligning with the principles of sustainable and green construction. In terms of mechanical properties, sustainable concrete performs just as well as normal concrete (Dawood et al., 2020), but it offers the advantage of being around 40% cheaper. Therefore, sustainable concrete is not only cost-effective but also environmentally friendly, while maintaining comparable mechanical properties.

Qaidi et al. (2023) The rapid development of modern societies has led to increased construction and infrastructure projects, creating a high demand for concrete, a versatile and widely used construction material. However, the production of traditional Portland cement, a key component of concrete, is costly and depletes natural resources while also contributing to carbon dioxide emissions and global warming. The extraction of raw materials for concrete production also has significant environmental impacts. In response to these challenges, researchers have focused on finding sustainable alternatives by incorporating waste materials into cement and concrete production. By utilizing industrial waste such as silica fume, slag, and fly ash, as well as agricultural by-products like rice husk ash and wood ash, and construction and demolition waste, it is possible to reduce pollution, greenhouse gas emissions, and energy consumption while creating durable and eco-friendly concrete. These waste materials can be used to replace cement or serve as aggregates and fillers in concrete production. By adopting these practices, significant progress can be made towards achieving sustainability goals, including reducing CO2 emissions, increasing the durability of concrete structures, conserving energy, and effectively managing waste. The utilization of waste materials to produce sustainable concrete is a viable, beneficial, and cost-effective approach to energy conservation and infrastructure development, and contributions to further research in this area are highly encouraged.

Bostanci et al. (2023) The concrete industry is striving to minimize its environmental impact and promote sustainable development. Utilizing waste materials in concrete production can be a promising approach to achieve these sustainability goals. However, there is a lack of clear quantitative evaluation regarding the performance of waste-incorporated concrete, which limits its widespread use. In this study, locally obtained waste coal ash (WCA) was used as a replacement for both CEM I and CEM II/B-S cements at 10% and 20% replacement levels to produce sustainable concrete. The concrete mixes were evaluated for various engineering properties, such as slump, density, compressive strength, water permeability, and porosity, as well as sustainability characteristics encompassing social, environmental, and economic aspects. A balanced scoring system was employed to assess the overall performance of the laboratory mixes. The results indicated that the use of WCA resulted in comparable slump values but reduced fresh density. The compressive strength of the WCA mixes was lower, but they exhibited improved absorption characteristics. The environmental and economic sustainability indicators showed significant reductions, while social sustainability indicators, such as sound permeability and thermal conductivity, demonstrated enhanced performance in the WCA mixes, suggesting their potential for sustainable construction applications. The overall performance analysis indicated that WCA mixes could improve performance by 11% and 15.5% at 10% and 20% replacement levels, respectively.

Kumar et al.(2023) Concrete grades M40 and M50, made with manufactured sand, demonstrate lower water absorption compared to concrete made with conventional sand. Additionally, when a lower water-binder ratio is utilized, the concrete becomes impermeable. The chloride ion penetrability of concrete made with manufactured sand is also reduced compared to concrete made with ordinary sand, indicating lower permeability. Furthermore, mixes incorporating synthetic sand exhibit improved resistance to acid and alkaline attacks, resulting in less weight loss compared to traditional sand concrete. Finally, manufactured sand concrete shows enhanced resistance to impact and abrasion compared to conventional sand concrete. Overall, the use of manufactured sand in concrete enhances its performance in various aspects.

Baltazar et al.(2023) In terms of carbonation depth, the conventional concrete made with 100% Portland Cement exhibited the lowest depth, with an average of 0.33 cm between the front and posterior sections. The sustainable concretes containing 10% and 20% of SCBA and SF showed average carbonation depths of 0.55 cm and 0.44 cm, respectively, representing an increase of 67% and 33% compared to the conventional concrete. When the substitution of Portland Cement with agro-industrial and industrial waste (SCBA and SF) was increased to 30% and 40%, the sustainable concretes (SC30 and SC40) exhibited carbonation depths of 0.85 cm and 0.76 cm, respectively, representing an increase of over 160% compared to the conventional concrete. The sustainable concrete with 50% substitution of SCBA-SF demonstrated the poorest performance, with an average carbonation depth of 1.48 cm, representing an increase of over 350% compared to the conventional concrete. The resistance to carbonation decreased in the sustainable concretes based on agro-industrial and industrial waste (SCBA and SF) when exposed to the environment of the City of Xalapa, Ver; Mexico for a year, corresponding to the percentage of Portland cement substitution in these concretes.

Alaneme et al.(2023) Agro waste-based geopolymer concrete offers a promising and sustainable alternative to traditional Portland cement-based concrete. Utilizing agricultural byproducts like banana peel ash, rice husk ash, bagasse ash, and sawdust ash as aluminosilicate sources for geopolymerization has shown potential in reducing the carbon footprint of the construction industry. Research indicates that agro waste-based geopolymer concrete demonstrates comparable or enhanced mechanical properties and good resistance to acid and sulfate attacks. Additionally, it helps reduce waste and improves the economic viability of construction. However, challenges such as raw material variability, standardization in mix design and testing, and the long-term durability and environmental impact need to be addressed. Morphological assessments reveal unique microstructural characteristics, including a denser morphology, reduced porosity, and finer pore size distribution, leading to improved mechanical properties and environmental resistance. Further investigation is necessary to fully comprehend the microstructural aspects and optimize the potential of agro waste-based geopolymer concrete for widespread adoption in construction.

Kumar et al.(2023) The experimental research conducted on bituminous mixes, including Stone Matrix Asphalt (SMA) and Bituminous Concrete (BC), yielded the following conclusions. All three types of fillers used in BC met the required specifications, making them suitable for use. While BC with cement filler provided the highest stability, the use of fly ash and stone dust as fillers proved feasible and cost-effective. Adding fibers up to 0.3% increased the stability of BC, but further fiber addition did not significantly improve stability compared to SMA. Incorporating fibers reduced flow value in BC, but 0.5% fiber addition increased flow value. SMA exhibited higher tensile strength than BC, and adding fibers reduced deformation in both mixes. SMA with sisal fiber showed excellent performance for flexible pavement applications, indicating its potential in construction.

5. SUMMARY

Several studies have explored the effects of waste effluents on the properties of cement and concrete. The findings indicate that incorporating waste effluent in cement mixing can lead to variations in setting time and workability of concrete. The setting time can be shorter or longer compared to control samples mixed with fresh water, depending on the specific waste effluent used. The workability, measured by slump values, can also be influenced by the composition of the waste effluent. Research conducted by various authors demonstrates that the strength of concrete mixed with waste effluent can be lower compared to samples mixed with fresh water. Different waste effluents, such as car wash wastewater, sewage treatment plant effluent, and industrial effluent, have been studied, and their impacts on concrete properties have been assessed. Factors such as organic impurities, sulfates, and solid content in the effluents contribute to variations in setting time, strength, and workability. However, some studies have also shown positive effects of waste effluents on concrete properties. For instance, the use of treated domestic sewage effluent resulted in increased compressive strength, attributed to the filling of pores by suspended solids. Additionally, the utilization of waste materials in concrete production, such as silica fume, slag, fly ash, rice husk ash, and wood ash, has been shown to reduce pollution, greenhouse gas emissions, and energy consumption while maintaining comparable mechanical properties. Overall, the incorporation of waste effluents in cement and concrete production offers potential for sustainable development. However, it is crucial to consider the specific characteristics of the effluents and their effects on the desired properties of cement and concrete. Further research is needed to optimize the use of waste effluents and ensure their compatibility with construction requirements.

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