EXPERIMENTAL INVESTIGATION ON PLASTIC WASTE REPLACEMENT OF COARSE AGGREGATE IN CONCRETE

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Abstract - *One of the most pressing environmental challenges currently confronting our nation is the effective management of solid waste. Researchers are actively investigating the potential of recycled plastics as a feasible substitute for traditional coarse particles in the production of concrete. The primary aim of the study is to assess the impact of incorporating polymers into concrete on its mechanical properties. Moreover, the research delves into the thermal characteristics of the concrete in addition to its mechanical behavior. The results of the study suggest that the inclusion of plastic aggregates in concrete results in the creation of lightweight concrete. Nevertheless, it is essential to recognize that plastics have an adverse effect on the compressive and tensile strength of the concrete. Despite this drawback, a significant benefit of using plastics in concrete is the decrease in heat conductivity of the material. This revelation indicates that recycled plastics could potentially function as an efficient insulating material for building interiors, thereby offering a sustainable solution to enhance energy efficiency. By exploring the innovative application of recycled plastics in concrete production, we may have the opportunity to tackle the urgent issue of solid waste management while simultaneously promoting environmental sustainability in construction practices.*

Key Words: Concrete, Plastic waste, Coarse aggregate replacement, Sustainability, Environmental impact.

1.CONCRETE

Concrete, comprised of a robust amalgamation of cement, aggregates, and water, stands as the foundational element of modern construction endeavors. This adaptable substance can be fashioned into a diverse array of edifices, exemplifying the innovative prowess and technical acumen of mankind. Whether it be the imposing skyscrapers that grace urban skylines or the unassuming walkways that facilitate pedestrian flow, concrete assumes a crucial role in shaping the architectural landscape. Nevertheless, the significance of concrete transcends its mere physicality. It functions as a representation of fortitude, permanence, and the enduring heritage of bygone civilizations. Within its unyielding sturdiness, concrete embodies the aspirations and triumphs of societies endeavoring to erect enduring monuments that will withstand the trials of time.

Figure-1: Concrete

1.1.Cement

Cement, often mistaken for being synonymous with concrete, is merely one constituent of this widespread building material. Originating from limestone and other substances through a sophisticated process of heating and grinding, cement acts as the adhesive that binds the aggregates in concrete, allowing it to harden into a robust structure. Its significance lies in its capacity to create a powerful bonding agent, fostering unity among the diverse components of a concrete blend. Beyond its pragmatic function in construction, cement carries a deep historical legacy dating back millennia, with ancient societies like the Romans utilizing similar materials in their architectural marvels. Presently, cement production constitutes a substantial sector, propelling economic advancement while also sparking debates concerning environmental sustainability due to its carbon emissions. As we navigate the intricacies of contemporary infrastructure and progress, cement remains a fundamental element, both literally and metaphorically, shaping the cityscapes and the course of our civilizations.

1.1.1.Grade of Cement

The classification of cement pertains to its robustness and quality attributes, which play a crucial role in determining its appropriateness for diverse construction purposes. Typically categorized according to its compressive strength, cement grades signify the level of pressure a sample of cement can endure before it collapses or fractures. Common classifications encompass ordinary

Portland cement (OPC), a widespread choice for general construction undertakings, as well as higher strength variations like Portland Pozzolana cement (PPC) and Portland slag cement (PSC), which boast improved durability and resilience against specific environmental elements. Each classification undergoes meticulous examination and quality assurance protocols to ensure uniformity and dependability in its performance. The selection of a cement grade hinges on the particular requisites of a project, taking into account factors such as load-bearing capacity, exposure to harsh conditions, and desired longevity. By opting for the appropriate cement grade, engineers and builders can optimize the structural soundness and lifespan of their constructions, thereby contributing to the creation of safer, more durable infrastructure.

1.2.Fine Aggregate

Fine aggregate, a vital constituent of concrete, plays a pivotal role in determining its strength, workability, and durability. Comprised of particles smaller than 4.75 millimeters, fine aggregate typically consists of sand, crushed stone, or gravel. Its primary purpose is to occupy the voids between coarse aggregates and cement paste, forming a dense matrix that enhances the overall compactness and strength of the concrete mixture. Apart from its structural contributions, fine aggregate also influences the workability of concrete, impacting its ability to be shaped, positioned, and completed during construction. Furthermore, fine aggregate can affect the visual appeal of concrete surfaces, with variations in color, texture, and grain size adding unique aesthetic characteristics to finished structures. Due to its importance in concrete production, the quality and characteristics of fine aggregate are held to rigorous standards and testing procedures to ensure optimal performance and longevity of constructed elements. Serving as a fundamental component in concrete compositions, fine aggregate underscores the delicate equilibrium between materials engineering and construction practices, shaping the built environment in which we reside and operate.

Figure-2: Fine Aggregate

1.3.Coarse Aggregate

Large aggregate, a vital element of concrete mixtures, plays a crucial role in the stability and overall functionality of concrete. Comprised of particles exceeding 4.75 millimeters in size, large aggregate typically consists of crushed stone, gravel, or recycled concrete materials. Its main purpose is to provide volume and support to the concrete framework, thereby enhancing its ability to bear loads and withstand stress. By integrating with cement paste and fine aggregate, large aggregate establishes a sturdy structure within the concrete blend, adding toughness and endurance to the final product. In addition to its structural function, large aggregate also impacts the workability, drainage capabilities, and thermal properties of concrete. The choice of large aggregate is influenced by various factors, such as the specific needs of the construction project, the availability of materials in the region, and the desired visual outcomes. Through proper grading, sizing, and quality assurance practices, large aggregate guarantees the dependable performance and longevity of concrete structures, promoting the safety, sustainability, and resilience of constructed environments worldwide.

Figure-3: Coarse Aggregate

1.4.Water

Water plays a pivotal role in concrete as a fundamental element and a vital component of the hydration process. When combined with cement, water sets off a chemical reaction called hydration, which causes the cement particles to intertwine and create a solid structure. This reaction leads to the solidification and solidification of concrete, changing it from a liquid blend to a sturdy mass capable of withstanding structural loads. Furthermore, water aids in the malleability and flexibility of concrete, enabling it to be effortlessly mixed, positioned, and compressed into desired forms and configurations during construction. Nonetheless, it is crucial to achieve the optimal water-to-cement ratio, as an excess of water can undermine the strength and endurance of concrete, resulting in heightened porosity, shrinkage, and fractures.

Therefore, the precise regulation and supervision of water content are key elements of concrete mix design, guaranteeing that the resulting blend attains the desired attributes and operational features. To sum up, water in concrete serves a dual function of instigating hydration and improving workability, playing a crucial part in the creation of long-lasting and structurally sound construction materials.

2.PLASTIC WASTE IN THE CONCRETE

The incorporation of plastic waste into concrete presents a promising strategy for tackling two significant global issues: plastic pollution and sustainable construction. By adding shredded plastic particles or fibers to concrete mixtures, engineers and researchers seek to lessen the environmental impact of plastic waste while enhancing the properties of concrete. Plastic waste acts as a partial substitute for traditional aggregates, aiding in the preservation of natural resources and the decrease of landfill waste. Furthermore, the introduction of plastic fibers can improve the ductility, toughness, and durability of concrete, thereby reducing cracking and enhancing its resistance to impact and fatigue. Nevertheless, challenges such as ensuring sufficient adhesion between plastic and cementitious materials, preserving the structural integrity of the concrete, and addressing potential leaching of harmful substances from plastic additives necessitate thoughtful consideration and further investigation. Despite these obstacles, the integration of plastic waste in concrete holds considerable promise for promoting circular economy principles, lowering carbon emissions linked to conventional concrete manufacturing, and propelling sustainable practices within the construction sector. Through ongoing innovation and collaboration, harnessing plastic waste in concrete provides a concrete path towards a more eco-friendly and resource-efficient built environment.

3.PLASTIC WASTE AS A COARSE AGGREGATE IN THE CONCRETE

The incorporation of plastic waste as a substitute for conventional coarse aggregates in concrete offers a unique and encouraging solution to combat both plastic pollution and promote sustainable construction practices. By replacing traditional coarse aggregates with shredded or granulated plastic particles, engineers and researchers aim to diminish the environmental impact of plastic waste while simultaneously enhancing the properties of concrete. Plastic waste emerges as a feasible alternative to natural aggregates, providing an opportunity to lessen the depletion of finite natural resources and divert substantial amounts of plastic from landfills and oceans. Furthermore, integrating plastic waste into concrete mixtures can enhance the material's thermal and acoustic insulation characteristics, reduce its overall density, and result in structures that are lighter and more energy-efficient. Nonetheless, challenges like ensuring proper adhesion between plastic particles and cementitious materials, optimizing mix designs to uphold structural integrity and durability, and addressing potential concerns regarding long-term performance and environmental impact necessitate comprehensive investigation and technological refinement. Despite these obstacles, the incorporation of plastic waste as a coarse aggregate in concrete signifies a promising path for promoting circular economy principles in the construction sector, fostering innovation, and advancing sustainable development objectives. Through collaborative research, innovation, and responsible implementation, utilizing plastic waste in concrete construction has the potential to contribute to a cleaner environment, conservation of resources, and the development of more resilient and environmentally friendly built environments.

4.FACTOR AFFECTING THE STRENGTH OF THE COARSE AGGREGATE IN THE CONCRETE

Numerous factors play a role in determining the robustness of coarse aggregate within concrete, ultimately affecting the overall efficacy and longevity of the concrete blend.

4.1.Quality and Composition

The strength of the coarse aggregate is greatly impacted by its quality and composition. Elements like the hardness, morphology, and texture of the aggregate particles, along with the existence of impurities, can influence its capacity to withstand compressive and tensile forces.

4.2.Gradation

The gradation, or distribution of particle sizes, within the coarse aggregate plays a crucial role in determining the strength of the concrete. Well-graded aggregates with a balanced distribution of particle sizes provide better interlocking and packing, resulting in higher concrete strength.

4.3.Absorption and Moisture Content

The absorption and moisture levels of the coarse aggregate play a crucial role in determining the water-cement ratio in the concrete mixture. Excessive absorption may result in an increased water requirement, thereby compromising the strength of the concrete, whereas insufficient moisture content can impede the hydration process and diminish bond strength.

4.4.Surface Texture

The surface morphology of coarse aggregate particles plays a crucial role in determining the adhesion between the aggregate and the cement paste. Irregular surfaces facilitate superior mechanical interlocking, thereby bolstering the structural integrity of the concrete, whereas sleek surfaces can lead to diminished bond strength.

4.5.Presence of Fines

The inclusion of fines (fine particles) in the coarse aggregate can have a significant impact on both the strength and workability of the concrete. An excess of fines can result in higher water requirements, diminished cohesion, and a decrease in the overall strength of the concrete mixture.

4.6.Porosity and Density

The permeability and strength of coarse aggregate are influenced by its porosity and density. Increased porosity can result in higher permeability and lower strength, whereas aggregates with higher density generally demonstrate superior strength and durability.

4.7.Aggregate-Cement Ratio

The proportion of coarse aggregate to cement in the concrete mixture significantly impacts its strength. A well-balanced aggregate-cement ratio promotes effective packing and dispersion of aggregate particles, ultimately enhancing the strength and longevity of the concrete.

5.ADVANTAGE FOR USE OF PLASTIC WASTE AS COARSE AGGREGATE IN THE CONCRETE

The incorporation of plastic waste as a coarse aggregate in concrete presents numerous benefits, enhancing both environmental sustainability and the properties of the concrete.

5.1.Environmental Impact

The integration of plastic waste into concrete serves to alleviate the environmental repercussions of plastic pollution by diverting substantial quantities of plastic from landfills and oceans. This method advocates for the recycling and repurposing of plastic materials, thereby diminishing the necessity for virgin aggregates and preserving natural resources.

5.2.Waste Reduction

By replacing conventional coarse aggregates with plastic waste, the construction sector has the potential to make a significant impact in diminishing the build-up of plastic waste in the environment. This not only tackles the urgent problem of plastic pollution but also aligns with endeavors to promote circular economy principles by reutilizing waste materials in meaningful applications.

5.3.Resource Conservation

The utilization of plastic waste as a coarse aggregate helps decrease the reliance on natural aggregates, like sand and gravel, which are limited resources frequently obtained through environmentally harmful mining procedures. By preserving natural resources, this method advocates for sustainable construction practices and lessens the ecological disruptions linked with aggregate extraction.

5.4.Lightweight Properties

Plastic waste aggregates generally exhibit lower densities in comparison to conventional aggregates, leading to the creation of lighter concrete mixtures. This characteristic can prove beneficial in scenarios requiring weight reduction, such as in precast concrete elements or structures where considerations regarding dead load are crucial.

5.5.Improved Thermal and Acoustic Insulation

Plastic aggregates have the potential to augment the thermal and acoustic insulation characteristics of concrete. By incorporating plastic particles or fibers into concrete blends, the conductivity of heat and the propagation of sound can be diminished, thereby fostering energy conservation and enhancing the well-being of individuals within structures and civil works.

5.6.Enhanced Durability and Performance

Accumulations of plastic waste can enhance specific characteristics of concrete, including its ability to resist chemical corrosion, abrasion, and shrinkage cracking. Moreover, the integration of plastic fibers into concrete blends can bolster ductility and toughness, thereby augmenting the resilience and lifespan of concrete structures.

5.7.Innovative Solutions

The utilization of plastic waste in concrete presents opportunities for creative exploration and scholarly investigation in the realm of sustainable construction materials. Engineers and researchers are delving into a plethora of methodologies and compositions to enhance the efficacy and characteristics of plastic-infused concrete, resulting in innovative approaches to tackling environmental and structural obstacles.

6.RESULT AND ANALYSIS

The objective of carrying out experiments is to acquire a wide array of results relevant to our investigation of self-curing concrete containing varying ratios of polyethylene glycol-400 and fly ash. These findings will provide insight into the effects of different curing environments on the performance of self-curing concrete. Through a thorough analysis of the results, our goal is to enhance our comprehension of how the interplay between polyethylene glycol-400 and fly ash impacts the self-curing characteristics of concrete under different environmental circumstances.

6.1.Compressive Strength

The cubic specimens underwent compression testing utilizing a 3000KN apparatus. Both the surface of the specimen and the contact surface of the machine were diligently cleansed to eliminate sand or any other debris. The specimen was situated within the apparatus in a manner that the force was evenly distributed to the opposing sides of the cubes, rather than their top and bottom, as they were originally molded. The axis of the specimen was accurately aligned at the center of the loading frame. The applied stress was then gradually augmented in a continuous and consistent manner until the specimen reached its fracture point under the escalating load. The maximum load imposed on the specimen was documented as Fe-P/A, with P denoting the load and A representing the area. The diagram below depicts the fluctuations in compressive strength resulting from the inclusion of plastic chips.

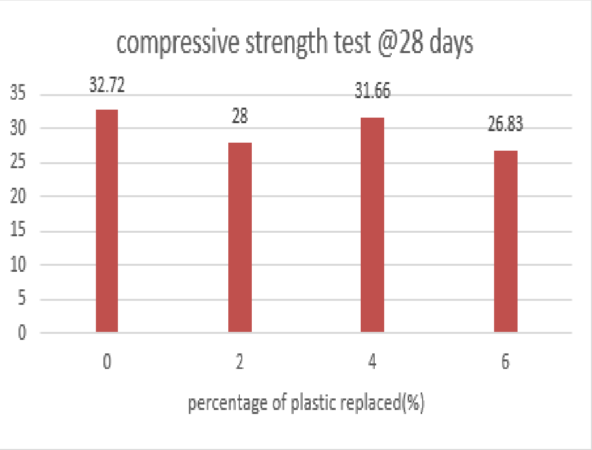

Figure-3: Result of Compressive Strength

6.2.Flexure Tensile Strength

After a duration of 28 days, the split tensile strength of concrete containing plastic additives was compared to that of standard concrete at different water-cement ratios. It was observed that the split tensile strength of plastic aggregate-incorporated concrete was consistently inferior to that of the standard concrete, with water-cement ratios ranging from 0.4 to 0.52. This outcome correlates with the findings of the compressive strength assessment, indicating a substantial 78 percent decrease in the split tensile strength of plastic-infused concrete.

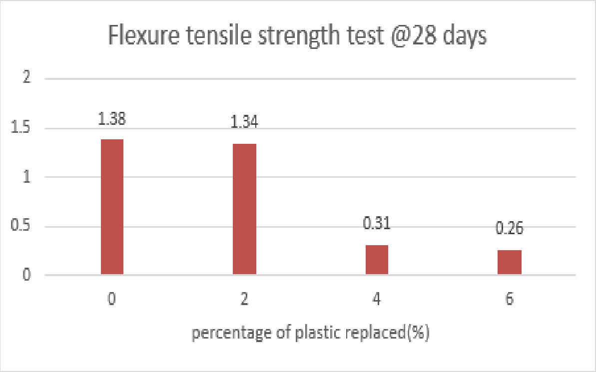

Figure-4: Result of Flexure Tensile Strength

7.CONCLUSION

The consistent findings from the aforementioned empirical study, which bear great significance, elucidate that substituting coarse aggregate with plastic chips by 2%, 4%, and 6% yields the highest average compressive strength and split tensile strength of concrete in the M25 grade. By integrating plastic chips in varying proportions into concrete, one can evaluate its influence on key properties such as strength and workability. To augment the characteristics of concrete and mitigate environmental pollution and waste generation in the construction sector, a comprehensive analysis on the properties of concrete composed of a combination of recycled aggregate and plastic chips in different ratios could be conducted.

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