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A Comparative Study Between Fly Ash and Silica Fume to Increase Strength of Recycled Concrete Aggregates- A Literature Review

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Abstract

Construction and demolition waste disposal have been under notice globally due to the disposal issue that frequently has a negative impact on the environment. Many initiatives are being made to recycle and manage these wastes so they can be used in the creation of various building materials. It is becoming more and more acceptable to handle the extensive amount of recycled aggregate as a whole or in part replacement for natural aggregate in cement concrete. Construction and demolition waste is made up of a wide range of materials that can be produced via several various operations, including building, remodeling, demolishing, clearing land, and even responding to natural disasters. Recycled concrete aggregate is obtained by crushing. Recycled aggregate has a higher propensity to absorb water than the natural aggregate, which limits the range of uses for recycled aggregate and lowers its workability, compressive strength, flexural strength, elastic modulus, and durability. To determine whether pozzolans have a greater influence on recycled concrete aggregates, a comparison between pozzolans (Fly Ash and Silica Fume) and their effect on recycled concrete aggregate are done. To maximize the performance of recycled concrete aggregate, this paper suggests an economic and environmentally friendly strategy.

Keywords: *Recycled concrete aggregates; pozzolans; strength; economic; environment.*

1 Introduction

Crushed remaining concrete from the production of new concrete is known as recycled aggregate. Concrete is a composite material made up of a variety of different ingredients, including aggregates, water, binding materials, and admixtures. Between 60 and 75 percent of the total volume of concrete is comprised of aggregate, and this material has a key role in the composition of concrete (Behera et al., 2014). Waste concrete originates from a variety of sources, including building materials from demolished structures, concrete road sides, precast concrete components that were rejected, wasted concrete in mixing technology, and laboratory test items (Mistri et al., 2020).Both reuse and recycling the steady depletion of natural resources and greater awareness of sustainable waste management in developed and developing countries have led to a growth in the importance of construction and demolition waste in civil engineering projects (Tam et al., 2018). Comparatively speaking, recycled concrete aggregate is less strong than natural aggregate concrete. Because of its reduced compressive strength and higher water absorption, the employed concrete composition results in an extremely unstable construction. To make the recycled aggregate more useful and the construction stronger than it was before, we must treat the surface of the recycled aggregate. Recycling unused concrete aggregate may reduce pollution in the environment and boost the economy. By treating the surface of recycled aggregate, artificial pozzolans such as Fly ash, Silica Fume can play a significant role. Fly ash is used as a concrete admixture to improve the technical properties of concrete while also lowering environmental pollutants. Cement serves as the cornerstone of infrastructure development worldwide. Cement production globally was estimated to be over 1.3 billion tons in 1996. During the manufacture of cement, 0.87 tons of carbon dioxide are released. The production of Portland cement accounts for 7% of global carbon dioxide emissions, to put it another way. Due to our significant impact on environmental degradation and our extensive use of natural resources like limestone, etc., we cannot keep producing more and more cement. Less cement must be used, and this is necessary. One of the practical ways to utilize less cement is to employ other cementitious materials, like fly ash and slag, in addition to cement. High fineness, low carbon content, and strong reactivity are the three main characteristics of good fly ash. Molten ash is quickly cooled and solidified to create fly ash, which leaves the majority of its component parts in good shape. Another substance utilized as a synthetic pozzolanic additive is condensed silica fume, often known as microsilica. It results from the reduction of high-quality quartz and coal in an electric arc furnace to make silicon or ferrosilicon alloy. Silica fume rises as an oxidized vapour. It cools, condenses, and is gathered in cotton bags. To get rid of contaminants and regulate particle size, it undergoes additional processing. More than 90% of condensed silica fume is silicon dioxide in its noncrystalline state. It is a spherical substance that is airborne, similar to fly ash. It is extremely fine and nearly 100 times smaller than ordinary cement particles, with an average diameter of about 0.1 micron and a particle size less than 1 micron. Modern high performance concrete has been created using silica fume and superplasticizer (Shetty Be, n.d.). (Artificial pozzolans can play a key role by modifying the surface of recycled aggregate and acting as a partial substitute for cement.

2 Literature Review

Shi Cong Kou, Chi Sun Poon, and Dixon Chan concentrated on the characteristics of recycled aggregate concrete under the impact of fly ash as a cement substitute. They focused on strength, creep, shrinkage, aggregates, and recycling. Cement, fly ash, aggregates, and superplasticizers are the components utilized in this study. They discovered through study that the use of a reduced W/B ratio effectively compensated for the decline in compressive strength, tensile splitting strength, and static modulus of elasticity as the recycled aggregate content rose. Drying shrinkage of concrete can be reduced by using fly ash as partial replacement of cement(Cong Kou et al., n.d.).

Focus was placed on recycled aggregates, self-compacting concrete, mechanical qualities, nano-SiO2, and sustainable development by Aref Sadeghi-Nik, Javad Berenjian, Sahar Alimohammadi, Omid Lotfi-Omran, Adel Sadeghi-Nik, and Mahmood Karimaei. They learned that the manufacture of the SCC may utilise fine aggregates. Metakaolin, an additive, has a beneficial impact on lowering water absorption.(Sadeghi-Nik et al., 2019).

Researchers Haleh Rasekh, Ali Toghroli, Peyman Mehrabi, Mahdi Shariati, Nguyen Thoi Trung, and Soheil Jahandari evaluated the use of pozzolanic additives and recycled concrete aggregate in fiber-reinforced pervious concrete with industrial and recycled fibers. They discovered that using 100% RCA together with 2% STF and 2% NC results in pervious concrete that is appropriate for structural purposes (Toghroli et al., 2020).

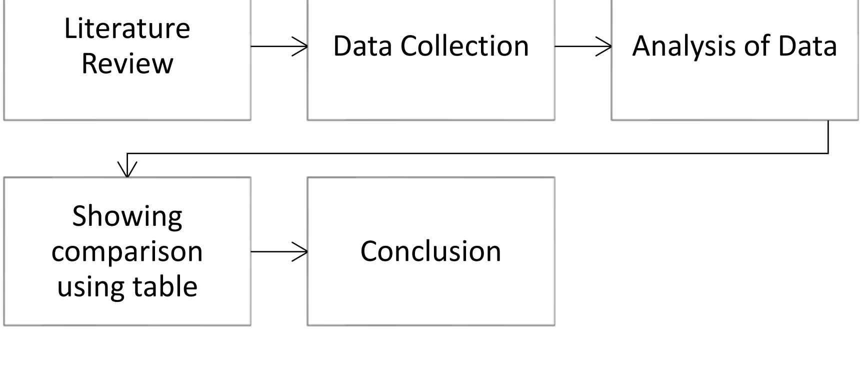
Jianhe Xie, Liang Huang, Yongchang Guo, Zhijian Li, Chi Fang Lijuan Li, and Junjie Wang examined the compressive and flexural properties of recycled aggregate concrete treated with silica fume and fibers. Based on a synthetical analysis of performance improvement and financial cost, they demonstrated that a 10% silica fume content by the same amount substitution of cement is suitable for the compressive and flexural strength of steel-fiber-reinforced RAC (Xie et al., 2018).

Research on the synergistic effects of fly ash and hooked steel fibers on the strength and durability attributes of high-strength recycled aggregate concrete was conducted by Babar Ali, Syed Safdar Raza, Rawaz Kurda, and Rayed Alyousef. They discovered that the combined effects of 1% steel fiber and 15% fly ash increased recycled concrete's flexural, splitting-tensile, and compressive strengths by 73–78%, 39–50%, and 13-23%, respectively (Ali et al., 2021).

Research was conducted by Kyuhun Kim, Myoungsu Shin, and Soowon Cha on the combined impacts of recycled aggregate and fly ash on the sustainability of concrete as well as on the amount of fly ash in recycled aggregates and the moisture level of recycled aggregates. They discovered that adding fly ash to recycled aggregate concrete increased its flowability, and the results of their strength tests revealed that using more recycled aggregate typically resulted in weaker concrete's compressive and tensile strengths. Aggregates made up of 30% recycled material only slightly decreased compressive strength(Kim et al., 2013).

The effects of fly ash as a cement additive on the hardened qualities of recycled aggregate concrete were studied by Shi Cong Kou, Chi Sun Poon, and Dixon Chan. They discovered that the detrimental impact on concrete's mechanical characteristics might be reduced by mixing fly ash with recycled aggregate concrete. Additionally, the inclusion of fly ash decreased the drying shrinkage and improved the resistance of concrete made with recycled aggregate to chloride ion penetration (Kou et al., 2008).

3 Methodology



4 Table

Name of the pozzolans	Percentage	Outcomes
Fly Ash	15% fly ash, 1% steel fibre	Upgraded the flexural, splitting-tensile, and compressive strength of recycled concrete by 73–78%, 39–50%, and 13–23%, respectively.
	fly ash (30% of cement), RA (30% of total weight)	Improved the flowability of recycled aggregate concrete; slight compressive strength reduction, higher resistance to chloride penetration.
	25% fly ash (partial replacement of cement)	Reduced the compressive and tensile splitting strengths of concrete; Reduced w/c ratio from 0.55 to 0.40 which mitigate the drying shrinkage of concrete, minimized chloride ion penetration.
	20-25% FA, 30% RCA	Better performance of compressive strength
	25% FA, 50% RCA	Increases compressive strength
	30-33% FA, 50% RCA	Increases compressive strength
	50% FA, 50% RCA	Strength lower than conventional concrete
Silica Fume	10% Silica fume (partial replacement of cement), 2% steel fibre, 2% nano silica, 100% recycled aggregate.	The 28-day compressive and flexural strengths are reduced by 56% and 64%, respectively, when NCA is completely replaced by RCA.
	10% silica fume, 100% recycled aggregate.	Improves the compressive properties of recycled aggregate concrete,
	10% silica fume, 50% RCA	Compressive strength is improved.

5 Benefits of using artificial pozzolans in Recycle Aggregate

- These can be used for the partial replacement of cement.
- Provided for increasing the compressive and tensile strength of the recycled aggregate.
- These improve flowability of recycled aggregate.
- Resistance to chloride penetration.
- Cost effective.
- Pollution free.
- Cheaper.
- Low rate than Portland cement.
- Improves flexural strength.

6 Limitations of Using Recycle Aggregate

- Compared to natural aggregate, it is weaker.
- Inadequately processed aggregate and concrete might lead to major problems including cracks and uneven surfaces.
- It is not always available.
- To ensure quality, the material must be inspected

7 Conclusion

Fly ash is the most effective and economical artificial pozzolan in comparison to the others, and it is also the most ecologically friendly. Because fly ash damages the environment by creating carbon dioxide when improperly handled. If the coal's byproducts are used appropriately, they won't have the same negative effects on the environment whereas in manufacturing of cement produce a huge amount of carbon dioxide which is harmful to the environment. The use of pozzolans like fly ash can decrease the use of cement which is economically and environmentally helpful. The combination of fly ash(up to 40%) and recycled concrete aggregates give better performance than conventional concrete aggregates. If the percentage of fly ash is increased by more than 50 with 50% RCA, it gives lower compressive strength than conventional concrete aggregates. Silica fume is also an effective pozzolan but it is more costly than fly ash and it's manufacturing process is also difficult compared with fly ash. Silica fume is added 5-20% of replacement of cement with RCA, it increases the compressive strength of the concrete. About 10% of silica fume used in replacement of cement, gives the best performance. But when it is used more than 20%, it does not give the same feedback. It gradually decreases the compressive strength. Comparing both of them, we can say that fly ash is better than silica fume concerning compressive strength and the percentage of using FA and SF in replacement of cement. With the help of fly ash, we can reduce the use of cement at higher levels.

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