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STUDY OF COMBINED EFFECT OF METAKAOLIN AND STEEL FIBER IN CONCRETE - A CRITICAL REVIEW

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ABSTRACT
The motivation of writing this paper is to investigate the research which has been done so far in which metakaolin and steel fiber has been utilized increase concrete property which is utilized in the structural engineering industry. For this, papers have been chosen after several days of reviewing by the authors which have been displayed below. This can eventually help in a superior comprehension of research in this area and so more work can be done in this regard to the preparation of better concrete mixtures. It will further improve the concrete properties. This can be used in different aspect ratios in different percentages. Subsequent to perusing each the studies that have been explored by various researchers, it is indicated that the metakaolin and steel fiber can be successfully utilized as an admixture in concrete.

KEYWORDS:
Metakaolin, steel fiber, and industrial waste

INTRODUCTION

Concrete is used as construction material all over the world. Almost two billion tons of concrete are used all over the world in one year (Zerbino et al., 2011). The application of concrete is wide-ranging from the construction of bridges to buildings and many more (Wagner, 2013). With such a wide application of this material, every single application of concrete requires some special properties. Nowadays, cement concrete is generally used. As the use of concrete is rising day by day, the use of cement is also growing rapidly (Shaaban et al., 2020). According to research by the Central Pollution Control Board, India's cement sector is one of the most polluting industries in the world. A huge amount of polluting substances like dust, carbon dioxide, nitrogen oxide, sulphur oxide pollutes the environment (Mohanta & Samantaray, 2019). These substances are very hazardous to the environment.

Figure 1: Metakaolin

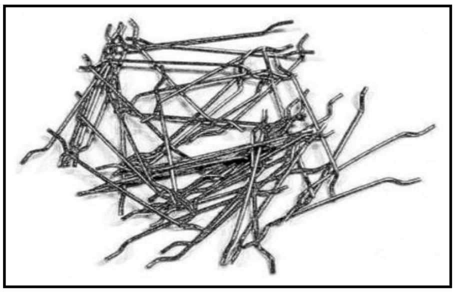

Figure 2: Steel fiber

Research is underway to minimize the use of cement in concrete. They are trying to use a waste product that can be used to replace cement in making concrete and can give better results than cement concrete. There are harmful materials present in the atmosphere that are released from industries. Research is going on in various materials such as fly ash, groundnut shell ash, sugarcane husk ash, etc (Sharma & Akhai, 2019). In this paper, the matter is briefly explained about the research that has been done on the Metakaolin and steel fiber so that

iJETRM
International Journal of Engineering Technology Research & Management

more experiments are done in this direction and a concrete mixture is developed which will provide better properties but at the same time will be eco-friendly for the environment.

LITERATURE REVIEW

A literature review is a summary of the work which has been done in past years by the researchers. So improvise the properties of concrete. The researches that have been done so far in which steel fiber and Metakaolin are utilized are shown below:

Usage of steel fiber in concrete

This section of the literature review has been poured into the research by the researchers on steel fiber that has been used to elevate concrete properties. That may give authors the clarity and direction to work with steel fibers. So that it can give better properties than ordinary concrete.

Zhang et al., (2015) in this paper entitled "Low-velocity flexural impact response of steel fiber reinforced concrete subjected to freeze-thaw cycles in NaCl solution" from researchers of china, used steel fiber as an admixture. As per the result of this paper, if 1.5% by volume steel fiber has been added, it has a very low effect on the weight loss concrete but also depends on the freeze-thaw cycles which have a 3.0 % NaCl solution. SFRC subjected to 0,100, 150, 200 freeze-thaw cycles. However, the initial Impact Strength Decrees for SFRC specimen is subjected to 250 freeze-thaw cycles.

Meng et al., (2016) presented their findings in a paper entitled "Experimental investigation of the mechanical behavior of the steel fiber reinforced concrete tunnel segment". The author utilized Steel fiber along with Steel rebar as an admixture material. The study's experimental research shows that the enhancement effect is caused by the steel fiber and steel rebar by delaying the cracking impact and increasing the proportionality of the segments. Cracking load, cracking resistance and rigid improves due to the addition of the steel fiber in the concrete.

Raczkiewicz, (2017) in his paper "The effect of micro-reinforcement steel fibers addition on the size of the shrinkage of concrete and corrosion process of the main reinforcement bars" showed that steel-fiber as an admixture can be successfully utilized in concrete. The result of this paper shows that 1% of steel fibers if poured into concrete, corrosion to a cut in illuminating up to 33% of the main reinforcement bars. If a 33 % micro-reinforcement steel fiber is inserted into concrete, the shrinkage of the concrete specification is reduced.

Jang et al., (2018) in their paper titled "Use of steel fibers as transverse reinforcement in diagonally reinforced coupling beams with normal - and high-strength concrete" presented research utilizing steel fiber as an admixture material where the test results show that in the coupling beam the shear strength increases with the amplify in compressive strength while the energy dissipation ability for the normal and elevated strength reinforced concrete (RC) coupling beam. Further studies have revealed that the inclusion of steel fiber leads to the prevention of buckling diagonal steel rebar and also provides additional transverse reinforcement.

Tang, (2019) in his paper titled "Corrosion of steel fiber reinforced concrete (SFRC) subjected to simulated stray direct (DC) interference" presented results reflecting is that use of steel elevates inherent corrosion resistance to stray DC interference condition in a chlorate free-condition and if a tiny amount of NaCl is present, that can also result in enhancement of the stray DC-induced corrosion.

Liu et al., (2020) in their paper entitled "Experimental investigation on flexural properties of directional steel fiber reinforced rubberized concrete" conducted an experimental investigation on flexural properties of directional steel fiber reinforced rubberized concrete utilized rubber and steel fibers in concrete for investigation. The use of rubber causes the strength to increase to 128.8% and it is used in steel fiber reinforced concrete (SFRC), but it has better effects on flexural strength. Further, steel fibers and the orientation of steel fiber promote the flexural strength in which Crack resistance and flexural toughness of SFRRC is dropped due to the strain value of cracks. One can increase the tensile strength of rubberized concrete by using steel fiber. The result shows a 34.23% increase in splitting tensile strength. The flexural strength gets increases by 86.96%.

Usage of metakaolin in concrete

This section of the literature review has been poured into the research by the researchers on metakaolin has been used to elevate concrete properties. That may give authors the clarity and direction to work with steel fibers. So that it can give better properties than ordinary concrete.

Barbhuiya et al., (2015) in their paper entitled "Microstructure, hydration and nanomechanical properties of concrete containing metakaolin" found that when metakaolin is used as an admixture the study revealed

iJETRM
International Journal of Engineering Technology Research & Management

enhancement in the properties of concrete. The experimental research shows that the modification shows in four various ways in which metakaolin is mixed in cement. Portlandite is transformed in C–S–H gel with the help of a pozzolanic reaction.

Tafraoui et al., (2016) in their paper entitled "Durability of the Ultra High Performances Concrete containing Metakaolin" presented that Ultra high-performance concrete (UHPC) can be perfectly manufactured through the metakaolin. A remarkable method to measure métakaolin is based on technical and economic levels. Such substances can be used to make different types of components of structure such as can be used for bridges and beams.

Shen et al., (2017) in their paper entitled "Efficiency of metakaolin in steam cured high strength concrete" study is carried out on the effect of metakaolin on hydration, microstructure, and volume stability of steam cured high strength concrete. It is done at 800^0C by combining water to binder ratio of 0.25. The conclusion derived is that hydration of cement is accelerated by the presence of metakaolin. The volume of metakaolin decreases when steam cured high strength concrete, which is formed through heat treatment, in addition to drying shrinkage, which leads to much better stability of the volume. The application of aluminum results in the modification of layer stacking. It also results in a reduction of porosity. This, in turn, improves the strength, microstructure, and volume stability of steam cured HSC.

Al Menhosh et al., (2018) in their paper entitled "Long term durability properties of concrete modified with metakaolin and polymer admixture" presented observations through this study that the mechanical strength and durability of concrete can be significantly improved by using metakaolin and polymer admixtures. Both materials act as complementing materials when mixed in concrete. The application of these materials in concrete by using them in extreme conditions like off-shore, bridge structures, and sewage systems is under study. The conclusion derived is that by using Portland cement with 15% metakaolin and 5% polymer provides optimum levels of improvement for Portland cement concrete.

Muduli & Mukharjee, (2019) in their paper entitled "Effect of incorporation of metakaolin and recycled coarse aggregates on properties of concrete", presented that the usage of metakaolin in improving the physical and mechanical properties of concrete. The main purpose of doing the study is to improve recycled coarse aggregates properties which are obtained from construction and demolition waste, to improve the metakaolin is used so that concrete is created with good and improved properties. It is also observed that by using metakaolin in RAC, the water absorption is reduced. The use of 15% of RAC improves performance and shows the best results.

Xie et al., (2020) their paper entitled "Effect of nano metakaolin on compressive strength of recycled concrete" presented that the use of nano metakaolin improves the strength of concrete. The waste aggregate concrete left after construction and building projects, when mixed with nano metakaolin forms nano metakaolin recycled concrete. The strength of recycled aggregate concrete can be improved by adding nano metakaolin at different substitution rates to obtain varied results in an attempt to obtain the best possible result. Furthermore, when the replacement rate of recycled aggregate was 30%, added 5% nano metakaolin could not only fill the micropore and microcrack of the recycled aggregate itself but also improve the contact surface of new and old mortar, but also fill the micropores inside the new mortar so that the compressive strength of recycled concrete exceeded that of ordinary concrete.

Usage of Metakaolin and steel fiber in concrete

This section of the literature review has been poured into the research by the researchers on the combination of metakaolin and steel fiber that has been used to elevate concrete properties. That may give authors the clarity and direction to work with metakaolin and steel fiber together. So that it can give better properties than ordinary concrete.

Ghugal et al., (2017) in their paper entitled "Experimental investigation on high strength steel fiber reinforced concrete with metakaolin" presented an experimental investigation which they performed to study the properties of the structural concrete in which steel fiber (SF) and metakaolin (MK) are mixed in concrete in different proportions. The crimped steel fiber with aspect ratio 85 to be carried out along with and metakaolin has been used. The fiber content used in the ranges from 5% to 10 % by weight of cement and on the other side metakoline that is used in the range of 5% to 20% by weight of cement mixed in the concrete in the various proportions. As the content which is Fiber and metakaolin in concrete increases, the workability and the temperature of green concrete composite reduce, and wet density is following the upside trend. As the fiber

iJETRM
International Journal of Engineering Technology Research & Management

content rises, it also results in the toughness indices being increased. The toughness indices are about to the maximum, it's 10% of the fiber content.

Mohanta & Samantaray, (2019) in their paper entitled "Study of Combined Effect of Metakaolin and Steel Fiber on Mechanical Properties of Concrete" studied the mechanical properties of concrete when Metakaolin is mixed, along with and without steel fiber. Metakaolin is partially substituted from ordinary Portland cement. Metakaolin for substitution mixed in different ranges such as 3%, 6%, 9%, 12%, 15%, and 18% which is according to the weight of the total binder. Steel fiber has been used in this study to produce fiber reinforced concrete with a length of 50 mm and its diameter is 0.70mm. Due to metakaolin and the addition of different types of steel fiber, it has been observed that this showcases a good effect on the mechanical characteristics of concrete.

Mehdipour et al., (2020)) in their paper entitled "Mechanical properties, durability and environmental evaluation of rubberized concrete incorporating steel fiber and metakaolin at elevated temperatures" presented that metakaolin and steel fiber is successfully substituted with Portland cement where metakaolin is used in different ratios such as 0%, 10%, and 20% which should be equal to the weight of cement and steel fiber which is utilized in different percentages such as 0%,0.25%,0.5% and 1% according to the volume of concrete. Several things have been taken into account to analyze it, such as microstructure, mechanical properties, durability, and especially global warming potential (GWP), which Because the crumb rubber is replaced with natural fine aggregate by 25% volume of concrete which is at the prominent temperature. One benefit of using this combination in the making of rubberized concrete is that carbon emissions are also reduced to a great extent which is a great impetus for our ecology.

CONCLUSION

1. After analyzing previous studies being carried out by researchers it is observed that steel fiber can be used and this has shown a positive effect on the properties such as splitting tensile strength that can increase by 34.23% and flexural strength increases by 86.96%.

2. It has been proved that metakaolin which was **used** as an admixture material in the concrete showcases better results in RAC which leads to a reduction in the water absorption and volume of voids.

3. Metakaolin can be used in a proportion of around 15 to 20% and steel fiber can also be substituted by almost 1%. But it is highly dependent on the material used, volume, climatic condition, etc.

4. Metakaolin can be used to enhance properties. Steel fibers can also be used for enhancing properties. It can be used in different aspect ratios in different percentages. One can replace cement with these materials and prepare a concrete that will be much better than the ordinary one.

FUTURE SCOPE

There are still some possibilities which can be explored through further research:

1. The authors who conducted this review paper have analyzed extensively on the present topic at hand. Some ratios are yet to be analyzed by mixing the metakaolin and steel fiber. Maybe the results and conclusions show that better properties can be achieved.
2. More and more studies can be done with different cement grade, for achieving better properties (strength, compressive strength, etc).
3. Different types of waste material can be used for different concrete so that the properties can be improved and analyzed as to which material leads to enhancing and improving the property. Some waste material such as fly ash, rice husk ash, sugarcane husk ash, etc can be very suitable. They are generated in large amounts by factories and are evidently of no much use and application. Adding to that is the fact that they can be potentially dangerous for both the environment and humans.

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iJETRM
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