Effect of Addition of Different Types of Fibers and Cementitious Material Replacement on Mechanical Properties of Concrete

I. Venkat Veer Kamal[1] Bimalendu Dash[2]
[1]PG Student [2]Assistant Professor
[1]Department of Transportation Engineering [2]Department of Civil Engineering
[1,2]GMR Institute of Technology, Rajam, India

Abstract— Concrete exhibits brittle nature it is not strong enough to resist tension. Fibers are used to enhance tensile strength to the concrete. They also increase many engineering properties of concrete. They are very helpful in controlling micro cracks and restricts crack propagation. The critical parameter we need to consider while describing fiber is "Aspect Ratio". It is defined as the ratio of length to diameter of the fiber. Mechanical properties of Fiber Reinforced Concrete (FRC) are very much got affected by the fiber type and its aspect ratio. Fly ash is broadly utilized as predominant alternative for Portland cement in construction sector. At the point when added to concrete, fly ash improves workability, strength, freeze thaw resistance, and reduce permeability. These advantages of fly ash over Portland cement make it a favored material for construction activities. The results clarified that utilization of fly ash in fiber reinforced concrete (FRC) impacts the both physical and mechanical properties of concrete.

Keywords: Fly Ash; Latex; Nylon Fiber; Aspect Ratio; Portland Cement; Compressive Strength; Split Tensile Strength; Flexural Strength; Ductility; Impact Resistance

I. Introduction

Concrete is the most broadly utilized synthetic construction material on the planet. Because of its brittle nature fibers are incorporated to enhance the strength of the concrete [1], [3]. Fiber could be a tiny piece of strengthening material having certain characteristics properties. They are available in various sizes and various shapes [3]. Since early ages fibers are used to reinforce brittle materials. Due to their efficiency and adverse properties fiber reinforced concrete has getting a lot of interest in recent years. Fiber reinforced concrete is a composite material in which fibers are blended into the concrete. In which fibers are distributed uniformly and randomly oriented, in return they are extremely helpful in increasing structural integrity [3]. There are different types of fibers, when used in concrete each of them will enhance varying properties to concrete. In addition, characteristics of FRC changes with different grades of concrete, varying fibers, geometrics, their orientation & distribution and densities [5]. Fibers were usually incorporated in concrete to regulate cracking due to plastic and drying shrinkage [1], [3], [5]. Fiber reinforced concrete was less expensive than conventional reinforced concrete. Additionally, they also decrease bleeding of water by reducing the permeability of concrete. Adding of fibers in concrete mix will decrease the workability of the concrete [3]. Whereas usage of fly ash in concrete mix enhances concrete workability, quality, pumpability, cohesiveness, finish, ultimate strength and durability for a low cost [5], [11]. Fly ash is a waste product produced from thermal power plants by combustion of coal. Also called as pulverized fuel ash. Mainly there are two categories of fly ash "Type-F" and "Type-C". Type-F is formed from combustion of anthracite coal (Hard Coal) or bituminous coal (Soft Coal), and "Type-C" is produced from combustion of lignite coal (Brown Coal) or sub-bituminous coal. "Type F" was the foremost normally utilized ash [5]. Fly ash can be considered as one of the most economical resource. At the point the amount of total cement that is required will be reduced when we add fly ash to the concrete [12]. There will be no over exploitation of natural resources if one can use these type of industrial waste byproducts as alternative sources for construction materials. Lastly, usage of fly ash in construction sector avoids lowland disposal of fly ash and creates notable environmental benefits. In many developed countries fly ash is widely employed as superior alternative for Portland cement. Fly ash when utilized together with cement, through hydraulic or pozzolanic or both will provide the properties of the hardened concrete [5], [11], [12]. In concrete usually fly ash is replaced at a percentage that are varying from 0% - 30% by the total mass of cementitious material [5]. In certain applications higher dosages can also be used. A high share of the cement among concrete may be replaced by fly ash while not adversely effecting concrete properties. Addition of SBR latex enhances the bonding strength and improves resistance against chemicals [3], [4]. SBR latex is a carboxylated styrene butadiene copolymer latex admixture a milky white liquid which is used as an integral cement bonding agent it has better rheological properties [3], [4], [14], [16]. It improves the bonding and tensile properties when we used in concrete.

II. Review of Literature

Bhat et al (2018): had experimentally evaluated the split tensile and compressive strength of normal concrete (NC), steel fiber reinforced concrete (SFRC), polymer modified concrete (PMC) and polymer modified steel fiber reinforced concrete (PMSFRC), and determined portion increase in strength by the addition of steel fibers and SBR. Following 28 days of curing there is an increment of compressive strength in SFRC, PMC, and PMSFRC by 31.98%, 16.93%, 36.16% and tensile strength of SFRC, PMC, and PMSFRC by 38.85%, 21.65% and 47.72% when compared with conventional concrete cubes. Maximum compressive and tensile strength was achieved at 3% addition of steel fiber and 15% of SBR replacement with cement in PMSRF.

Pandurangan et al (2018): examined the strength improving quality of RFA (recycled fine aggregate) concrete using metakaolin. Tests were conducted for 7 days and 28 days. Metakaolin was added to cement at a percentage range of 7.5% -20% to the weight of cement. Natural sand is replaced with RFA within the vary of 0-100% by weight of sand. There was an increment in compressive strength by 20-29% when metakaolin was used. RFA alone causes decrease in compressive strength. Again, addition of both 7.5% metakaolin and 50% RFA improves flexural strength by 4% when compared with normal concrete.

Akaram et al (2018): had studied that various percentages of nylon fiber from 0.5% to 1.5% by weight in cement is enhancing the mechanical properties of concrete. Cement was replaced with 10% metakaolin. In this study there is no separate work done for both metakaolin and nylon fibre combined and mixed in concrete.

Gorle et al (2018): had focuses the impact of Nylon fiber and SBR latex on the quality and strength of cement for M40 grade. The level of fiber utilized was 0.05%, 0.1% and 0.15% to the volume part of cement SBR latex was shifted at a level of 5%, 10% and 15%. From the outcomes most extreme quality was accomplished at 0.1% of nylon fiber with 10% SBR latex.

Manikandan et al (2017): this is an experimental study of nylon fiber reinforced concrete of M25 grade. In this study fine aggregate is replaced with nylon fiber at a percentages of 2%, 4%, 6%. Specimen casted with 2% nylon fiber was giving higher flexural strength than specimens with 4% and 6% nylon fiber. Specimen casted with 4% nylon fiber was giving higher compressive strength than specimens casted with 2% and 6% nylon fiber. Specimen casted with 6% nylon fiber was giving better split tensile strength than specimens with 2% and 4% nylon fiber. Overall, nylon fiber reinforced concrete was giving better results when compared with conventional concrete.

Madari (2017): had studied the impact of silica flume and metakaolin mix on high quality concrete. These both waste materials has some significant properties can be advantageously used in construction sector. Cement replacement by the blend of silica flume and metakaolin prompts increment in compressive and flexural strength up to 40% to 50% replacement for both M60 and M80 grades of concrete. Beyond 50% compressive and flexural strength tends to decrease.

S.Sujitha (2016): had focused on durability strength of waste admixed high strength concrete and how the mechanical properties of M30 grade concrete was effected when cement is partially replaced by metakaolin and GGBS and copper slag was used as partial replacement to fine aggregate. Sorpitivity test, Porosity test, Acid attack test, Water absorption test were conducted to study the strengthen properties of M30 grade concrete to determine the optimum percentage value for which the concrete exhibits higher strength.

Saverio et al (2015): had examined the usage of R-nylon fiber (Recycled Nylon Fiber) collected from spoiled fishing nets as concrete reinforcement. After collection various tests were conducted on R-nylon fiber like alkali conditioning and leaching test in order to remove contaminants from the fiber. Mechanical performance tests are conducted on concrete specimens strengthened with R-nylon fiber, also build up examinations with the experimental conduct of the unreinforced material. This study has high environmental benefits and great mechanical potential

Saxena et al (2015): had studied there was an enhancement in the strength of the conventional concrete by using nylon fiber in various proportions 0.2%, 0.25% and 0.3% to volume of concrete and cement was replaced by percentages of (10%, 20% and 30%) with fly ash. Tests are carried out at 7, 14, 28 days respectively. From the results in conventional concrete addition of 10% fly ash to cement, and 0.2, 0.25 and 0.3 percentages of nylon fiber are increasing the performance of concrete.

A.Sofi et al (2015): had focused on flexural behaviour of fiber reinforced pond ash modified concrete. A total number of 16 beams were casted using three completely different proportions like 10%, 20% and 30% of pond ash to total weight of cement. Steel fibers of grooved type are added at various rates of 0.5%, 1% and 2% to total concrete volume. Ultimate load and ductility index tends to increase with increase in steel fiber content. The anticipated break width was contrasted with the deliberate split width, and decent connection was gotten.

Nazeer et al (2014): had examined the strengthen studies on metakaolin blended high volume fly ash concrete. Out of total cementitious content 50% volume of cement was supplanted with Class-F fly ash and rest of the cement substance was supplanted by four distinctive proportions of metakaolin content namely 5%, 10%, 15%, 20% on M30 grade concrete. Two different curing methods were adopted. Addition of metakaolin tends to decrease the mechanical properties of concrete. Whereas when compared to cement as only binder this blended mix shows markable improvement in impact resistance.

Ri-On et al (2014): had studied the precast concrete pavement durability performance by using latex modified nylon fiber reinforcement. In this study, the nylon fiber is used at percentages of (0%, 0.05%, and 0.1%) volume fraction and to the weight of cement the amount of latex added varied at a rate of 0%, 5%, 10%, and 15%. Increase in latex content leads to decrease in chloride ion penetration resistance and compressive strength, there is an increment in abrasion resistance with the increase of latex content. Compressive strength tend to increase with increment in nylon fiber content. Co current addition of fiber and latex was more effective at improving mechanical properties of the concrete.

Nova John (2013): had studied the Strength Properties of Metakaolin Admixed Concrete of M30 grade. Cement was replaced with various rates of metakaolin (5%, 10%, 15%, and 20%). Final results demonstrate that there was an increment in quicker early age strength development to concrete by addition of metakaolin. Mix with 15% metakaolin was giving better results. Increase in metakaolin content enhances the mechanical properties of the concrete up to 15%.

Pereira et al (2012): had studied how super plasticisers impacts the workability and compressive strength of concrete with fine recycled concrete aggregates. Concrete with these super plasticisers and one reference concrete without any super plasticiser was compared. Fine recycled concrete aggregate was used to replace fine aggregate at a rate of 0%, 10%, 30%, 50% and 100% respectively and tests were conducted. Concrete with only recycled aggregates shows poor performance when compared to conventional concrete. The combination of recycled aggregates and super plasticisers are giving better results than normal concrete without any super plasticisers.

Okan et al (2011): had examined how polypropylene fiber reinforced fly ash concrete impacts the durability properties of the concrete. Amount of fly ash employed in the mix based on the mass basis was 0%, 15%, 30%. And fibers are added at various percentages of 0%, 0.05%, 0.10% and 0.20% in volume basis volume. Results shows that addition of fly ash improves Freeze–thaw resistance, workability, sorptivity, and water absorption and porosity coefficient values. Addition of polypropylene fiber increases drying shrinkage, compressive strength and elastic modulus.

Yew et al (2011): had compared the both nylon-steel and polypropylene-steel fiber reinforced concrete strengthen properties at low volume fraction. Steel fibers are used at a percentage of 0.4% volume fraction and polypropylene and nylon fibers are used at a percentage of 0.1% volume fraction. When compared to polypropylene-steel fibre concrete compressive strength of nylon steel fiber was improved by 3.2%, split tensile strength was improved by 8.3% and modulus of rupture was improved by 10.2% respectively. There is a better distribution of fibers in nylon-steel fiber than polypropylene-steel fibers as a result nylon-steel fibers contribute better tensile strength and very effective in controlling crack formation and crack propagation.

III. Conclusion

Concrete is good in compression but week in tension. Incorporating of fibers to concrete will enhance the tensile strength. From experimental results the mechanical properties of FRC were better when compared to conventional concrete. Various experimental studies demonstrate that adding of fibers alone to the concrete mix will increase toughness, ductility and tensile properties, but increment in fiber content decreases workability of the concrete. When fly ash is added to concrete workability increases but it effects the setting time of concrete. On addition of SBR latex alone in the concrete, there is a decrement in compressive strength. From various experimental studies it has been observed that combination of Fly ash, SBR latex and fibers increases the mechanical properties of the concrete.

References

[1] K Manikandan, A Arun Kumar "Experimental investigation on nylon fiber reinforced concrete". International Research Journal of Engineering and Technology (IRJET) Volume: 04 PP. 2479-2482, 2017.
[2] Saverio Spadea, Ilenia Farina "Recycled nylon fibers as cement mortar reinforcement". Construction and Building Materials 200–209, 2015.
[3] Bimalendu Dash, Gorle Lokeswararao "Strength and durability performance of latex modified fiber reinforced concrete". International Journal of Civil Engineering and Technology (IJCIET) Volume: 9, PP. 477-486, 2018.
[4] Aabid Hussain Bhat, R Navaneethan "Experimental studies on polymer modified steel fiber reinforced concrete". International Journal of Mechanical Engineering and Technology (IJMET) Volume: 8, PP. 1516–1523, 2017.
[5] Jaya Saxena, Prof. Anil Saxena "Enhancement the strength of conventional concrete by using nylon fibre". International Journal of Engineering and Science Volume: 5, PP. 56-59, 2015.
[6] Akaram Ali, Aleem Aijaz "A study on nylon fibre reinforced concrete by partial replacement of cement with metakaolin: a literature review". International Research Journal of Engineering and Technology (IRJET) Volume: 05 PP. 2367-2369, 2018.
[7] A Sofi, BR Phanikumar "An experimental investigation on flexural behaviour of fibre-reinforced pond ash-modified concrete". Ain Shams Engineering Journal, Production and hosting by Elsevier, 2015.
[8] Madari Abhishek Kumar, Dr. Md.Subhan "Effect of silica fume and metakaolin combination on high strength concrete". International Journal of Research PP. 1176-1183, 2017.
[9] Krishnamurthy Pandurangan, Rajendiran Arunpandian "Improving strength of recycled fine aggregate concrete using metakaolin". The Indian Concrete Journal, 2017, Volume: 91, 2017.
[10] S Sujitha, N Sakthieswaran "Durability strength waste admixed high strength concrete". International Journal for Research in Applied Science & Engineering Technology (IJRASET) Volume: 4, PP. 658-662, 2016.
[11] M Nazeer, R Arun Kumar "Strength studies on metakaolin blended high volume fly ash concrete". International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-3, 2014.
[12] Okan Karahan, Cengiz Duran Atis "The durability properties of polypropylene fiber reinforced fly ash concrete". Materials and Design PP. 1044–1049, 2011.
[13] Yew MK, I Othman "Strength properties of hybrid nylon-steel and polypropylene-steel fibre-reinforced high strength concrete at low volume fraction". International Journal of Physical Sciences volume: 6, PP. 7584 – 7588, 2011.
[14] Ri-On Oh, Dong-Hyun Kim & Chan-Gi Park "Durability performance of latex modified nylon fiber reinforced concrete for precast concrete pavement applications". Indian Journal of Engineering & Materials Sciences (IJEMS) Volume: 21, PP. 49-56, 2014.
[15] Nova John "Strength properties of metakaolin admixed concrete". International Journal of Scientific and Research Publications (IJSRP), Volume 3, ISSN 2250-3153, 2013.
[16] P Pereira, L Evangelista, J de Brito "The effect of superplasticisers on the workability and compressive strength of concrete made with fine recycled concrete aggregates". Construction and Building Materials, 722–729, 2012.
[17] Bimalendu Dash, Gorle Lokeswararao, B.P.R.V.S Priyatham "Effect Of Addition Of Different Type Of Fibers On Mechanical Properties Of Concrete-A Review". International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES) Volume: 4, e-ISSN: 2455-2585, 2018.