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Effect of Addition of Granite Powder and Polypropylene Fibers on Concrete - A Review

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Abstract: ***Fiber reinforcement in concrete can increase many of the engineering properties (fracture toughness, flexural strength and resistance to fatigue, impact, thermal shock and spalling) of the normal materials. River sand is the most commonly used fine aggregate in making concrete. But extensive use of this natural resource gives rise to its large scale depletion and therefore to cut down the cost of sand, granite powder shall be used as a substitution of fine aggregate. Granite powder is an industrial waste which is available in abundance. The main objective to use Granite Powder in concrete is to determine alternate source of excellent quality of fine aggregates which is reducing day by day due to the fast pace of construction activities all over the world. Many additives are used for enhancing the properties of concrete, but Polypropylene Fibers are preferred material. PP (Polypropylene) is a thermoplastic polymer used in a extensive variety of applications which include packaging and labeling, textiles. Polypropylene fiber is mainly used for reinforcement of concrete to improve the tensile strength. Extensive research in past showed that it can also be used in order to avoid explosive spalling at elevated temperature, thus making it fire resistant. The partial substitution of fine aggregate with the granite powder along with the PP fibers in the conventional mix gives better results in terms of strength, tensile and flexural properties of concrete***
Key Words: granite powder, polypropylene fiber, split tensile, flexure strength.

I. INTRODUCTION

Concrete is without any doubt a prominent construction material. In last three decades, a lot of research has been carried out throughout the globe to improve the strength and durability properties of concrete [1]. Consequently concrete is no more a construction material consisting of aggregate, water and cement, but has evolved as a well proportioned mix blended with several novel materials that meet the varied needs of different regions. In latest years, a lot of research has been carried out throughout the world to improve the performance of concrete i.e. strength and durability. Concrete technology has undergone from macro to micro level study in the improvement of strength and durability properties [2]. Fibers play an integral role in reinforcing the cement based matrices because they are easily available and its consumption of energy is low.

The problem of identifying alternative materials to dampen the demand on river sand is much aggravated in developed countries. Of late, industrial wastes have largely been adopted as alternative material in the construction industry. Aggregates that are artificially manufactured from waste by-products of industrial wastes are also used to reduce the ever increasing demand on river sand. For instance fly ash, slag, or quarry wastes are among some of the most popular industrial waste materials that are often used as a substitute of sand, even though in minor percentages. On the same lines, granite powder can also be used as a partial replacement of natural sand (fine aggregate) in concrete.

Commonly, granite powder waste is used in levelling up the low lying landfill areas. Granite waste which is generated during stone crushing process in industrial plants is largely dumped leading to environmental degradation. Moreover, only inconsequential quantity has been utilized in the construction industry as a replacement of natural fine aggregate. A substantial quantity is dumped in open yards which constitutes of 25% of the total area of industry. Open dumping of such large amounts is tantamount to willful degradation of environment. Granite is kind of signature rock of the earth that is found in abundance throughout the world [1]. Reinforcement of randomly distributed short fibers into the concrete is a good approach to stabilize the cracks, thus making concrete more ductile and with increased tensile strength. PP (Polypropylene) fiber reinforcement is examined as an efficient method that helps in improving the toughness, characteristic shrinkage cracking, and fire resistance of concrete materials. Many research scholars have recommended the use of PP fiber as it results in the reduction of risk of spalling at elevated temperatures.

A. Granite Powder

Granite comes from the Igneous Rock family. One of the major sources of granite powder is industrial polishing units. The density of granite ranges from 2.65 to 2.76 g/cm^3. The specific gravity of the granite powder is 2.59 [2].

B. Polypropylene Fiber

Polypropylene is chosen, because it is not expensive, inert in high pH cementious environment and easy to disperse. The polypropylene fibers increase concrete resistance to fire temperatures. Polypropylene fibers are mainly used to prevent formation of shrinkage cracks or, more precisely, to reduce micro cracking in a new concrete. Specific gravity of Polypropylene was found to be 0.91[2].

II. REVIEW OF RESEARCH WORK CARRIED OUT BY DIFFERENT RESEARCHERS

T. Felixkala and P. Partheeban, in 2010 [3] studied Granite powder concrete F.A (Sand) was substituted with granite powder in varying proportion of 25%, 50%, 75% and 100% in concrete mix. At the same time cement was substituted with 7.5% of silica fume, 10% of slag and 10% of fly ash in the presence of 1% super-plasticizer. Of all these mixes mentioned above, concrete with 25% granite powder mix was found better for all working conditions.

Ali Behnood, Masoud (J. Mater. Civil. Eng.), in 2009 [4] "Comparison of compressive and splitting tensile strength of high-strength concrete with and without polypropylene fibers heated to high temperatures" proposed four mixes of concrete i.e. Mix(1) comprises of OPC-M40, Mix(2) comprises of OPC-M40 with 6% of silica flume as a replacement to the cement, Mix(3) comprises of OPC-M30 and Mix(4) comprises of OPC-M30 with 10 % of silica flume as a replacement to the cement. Now the irregular shaped polypropylene fibers of 12mm length were added in Mix [4] with the proportion of 1kg/m^3, 2kg/m^3, 3kg/m^3 in order to prepare Mix(5), Mix(6), and Mix(7). The outcomes of the above study led us to the following conclusions:

Concrete mixes containing polypropylene fibers were found out to be much superior to concrete mixes without any PP fiber.

Above 200^{0}C, compressive strength was largely affected by the presence of PP fibers as compared to splitting tensile strength.

A.Arivumangai and T. Felixkala, in 2016 [5] "Experimental Investigation on Fire Resistance of Granite Powder Concrete". In this research, M30 grade concrete is used. The fine aggregate is replaced by granite powder with the proportion of 0%sssss, 25% and 50%. The cement is partiallyreplaced with slag (10%), fly ash (10%), silica fume (0.5%) and 1% superplasticizer is added. Tests conducted in the study indicated that granite powder when used with control proportions of admixtures not only improved the concrete strength but also improved its durability. From all the three mixes, GP25 was found to be the most superior one. For all the ages of concrete, compressive strength was recorded to be higher than normal concrete mix.

Oyekan G.L and Kamiyo O.M, in(2008) [6] in this experimental study, structural and hygrothermal properties of hollow concrete sand blocks constituting of sharp sand, cement, and granite fines in varying amounts. Granite fine volume was varied from 5% to 30% in subsequential steps in terms of volume of total fine aggregates. Tests results indicate that addition of granite fines in the sand cement mix has a very important outcome on the parameters of sand concrete blocks (compressive strength). The best optimized structural performance was obtained at 15% granite fine proportion.

Kanmalai Williams C et al in (2008), [7] replaced fine aggregates with granite powder and observed the performance of concrete mix for compressive strength. Granite powder was added step-wise with varying percentages of 0%, 25%, 50%, 75%, and 100%. Silica fume was replaced with cement having fixed proportions of 7.5% silica fume, 10% slag, and 10% fly ash. To improve workability conditions, 1% super plasticizer was added in the concrete mix. With curing temperature set at 32^{0}C, water absorption and drying shrinkage were recorded along with compressive and split tensile strength for 7, 16, 28, 56, and 90 days. In this study, it is observed that if there is an increase in percentage of granite powder then compressive strength of concrete reduces. A compressive strength of 47.35KPa with 25% granite powder percentage was recorded as the highest among all the mixes after 90 days. It was concluded that granite powder could be a good partial substitution of fine aggregates in high performance concrete mixes.

Shirulea P.A et al in (2012), [8] determined the split tensile strength and compressive strength of concrete when the cement was substituted with varying percentage of powder of marble dust (0%, 5%, 10%, 15%, and 20%). For a fixed proportion of marble powder added as a replacement with respect to weight of cement it was recorded that the value of compressive strength increases in the beginning and then it decreases gradually. Replacement of marble dust powder up to 10%, the compressive strength was found to be increasing and from this point on the addition of marble powder only results in decrease of compressive strength.

Hanifi Binici et al in (2007), [9] experimented with the mechanical properties of concrete by mixing it with varying limestone dust (LD) and marble dust (MD) percentages. 7 concrete samples were formed in three sequences with 400 kg cement content. F.A (sand) replaced with marble dust and limestone dust. Marble dust was added with the varying proportion of 5% and 10%. Limestone

dust content was kept fixed at 15%. The concrete samples compressive strength was found on 7th, 28th, 90th and 360th day. The concrete mix was also tested for sodium sulphate resistance after a period of 12 months. Investigative studies for water absorption and abrasion resistance of concrete were also carried out. Results indicated that concrete having marble dust and limestone dust shows good workability and abrasion resistance. Increase in limestone dust and marble dust percentage, increases both the properties i.e. sulphate resistance and workability of the concrete mix along with compressive strength.

A. Test Results From Various Experimental Programmes

Important details such as the material used and the resultsobtained from various experimental programs carriedout by different researchers has been summarized in Table 1.

Table 1: Comparison of various Experimental studies

S. No	Researcher/Title	Material Used	Result	Temperature
1.	A.Arivumangai And T. Felixkala, [5]. Experimental Investigation on Fire Resistance of Granite Powder Concrete	• OPC 53 grade. • Granite powder is replaced with sand by 25% and 50%. • Cement is partially replaced by silica fume, fly ash, slag. • Super plasticizer by 2-4% of cement.	• Among the four mixtures considered, Granite Powder (GP25) has the most superior Compressive strength. • The result shows the percentage decrease in weight, fire resistance depends upon the substitution of granite powder.	70°C, 140°C, 210°C and 280°C
2.	T. Felixkala and P. Partheeban, [3]. Granite Powder Concrete	• OPC 43 grade. • Granite powder is added by weight (25%, 50%, 75% and 100%) as a replacement of sand used in concrete. • Super plasticizer (1%), silica fume (7.5%), fly ash (10%), slag (10%) replaced with cement.	• Among the six mixes, concrete having 25% granite powder was found better for all working conditions.	Not defined
3.	Farhad Aslani and Bijan Samali, [10]. High Strength Polypropylene Fiber Reinforcement Concrete at High Temperature	• OPC 43 grade • Polypropylene fiber content in various between 0.11% and 0.6% in Polypropylene Fiber Reinforcement Concrete.	• From the results, it is observed that other tests at different temperatures are necessary to examine the role of compressive and tensile stresses on the polypropylene fiber reinforcement concrete compressive strength, modulus of elasticity, creep strain, transient strain, and fire spalling.	20^0 C to 900^0 C.

4.	Ali Behnood, Masoud Ghandehari, [4]. Comparison of compressive and splitting tensile strength of high-strength concrete with and without polypropylene fibers heated to high temperatures	• OPC 43 grade. • River sand with water absorption (0.8%) and specific gravity (2.70) was used as fine aggregate. • Limestone coarse aggregate having nominal maximum size of 12.5mm, water absorption (0.6%) and specific gravity (2.65) was used. • Polypropylene fibrillated fibers, 12mm in length, were used with the varying proportion of 1, 2, and 3kg/m^3.	• Above 200^0C, compressive strength was largely affected with the presence of Polypropylene fibers as compared to splitting tensile strength. • From all the test results, it is observed that the addition of 2kg/m^3 Polypropylene fiber can promote the residual Mechanical properties of High strength concrete during heating.	100^0 C to 600^0 C.
5.	Kanmalai Williams C. ,Partheeban P. , Felix Kala T, [7]. Mechanical properties of high performance concrete Incorporating granite powder as fine aggregate	• OPC 43 grade • Fine aggregate replaced with granite powder by varying percentage of 25%, 50%, 75% and 100%. • Silica fume was replaced with cement with fixed proportions of 7.5% silica fume, 10% slag, and 10% fly ash. • 1% super plasticizer was added	• In this study, increase in percentage of granite powder lead to reduction in compressive strength of concrete. • Compressive strength of 47.35KPa with 25% granite powder percentage was recorded as the highest among all the mixes after 90 days.	Not defined
6.	Shirulea P.A, Ataur Rahmanb and Rakesh D. Gupta, [8]. Partial Replacement of Cement with Marble Dust Powder	• OPC 43 grade. • Marble dust powder with varying percentage (5%, 10%, 15%, and 20%) was replaced with cement.	• Up to a value of 10%, the compressive strength was found to be increasing where subsequent addition of marble powder only resulted in decrease of compressive strength.	Not defined
7.	By Hanifi Binici, Hasan Kaplan and Salih Yilmaz, [9]. Influence of Marble and limestone dusts as additives on some mechanical Properties of concrete	• OPC 53 grade. • F.A was replaced with marble dust and limestone dust. • The percentage of marble dust was 5 and 10%. • The percentage of limestone dust was 15%.	• Water penetration and Abrasion resistance of concrete were researched. • Results indicated that concrete having marble dust and limestone dust shows good workability and abrasion resistance. • Increase in Marble dust and limestone dust percentage increased both the sulphate resistance and workability of the concrete mix along with compressive strength.	Not defined

III. CONCLUSION

According to studies, use of waste as a partial substitution of sand in concrete has a great prospective. Industrial wastes are capable of improving the physical properties. Following conclusions has been derived after reviewing various experimental programs:

A. When the proportion of granite powder exceeds 25 % as the replacement to sand, there is a reduction in the compressive strength of concrete.

B. The strength properties of the concrete enhance with the granite powder obtained from the crusher units in the place of river sand.

C. The usage of Polypropylene fiber was more efficient for compressive strength than splitting tensile strength at high temperature.

D. The compressive strength of concretes containing Polypropylene fibers was superior to those of mixes without Polypropylene fibers.

Hence, Polypropylene fiber and granite powder could be very conveniently used in concrete as a replacement for fine aggregates thereby reducing load on natural sand.

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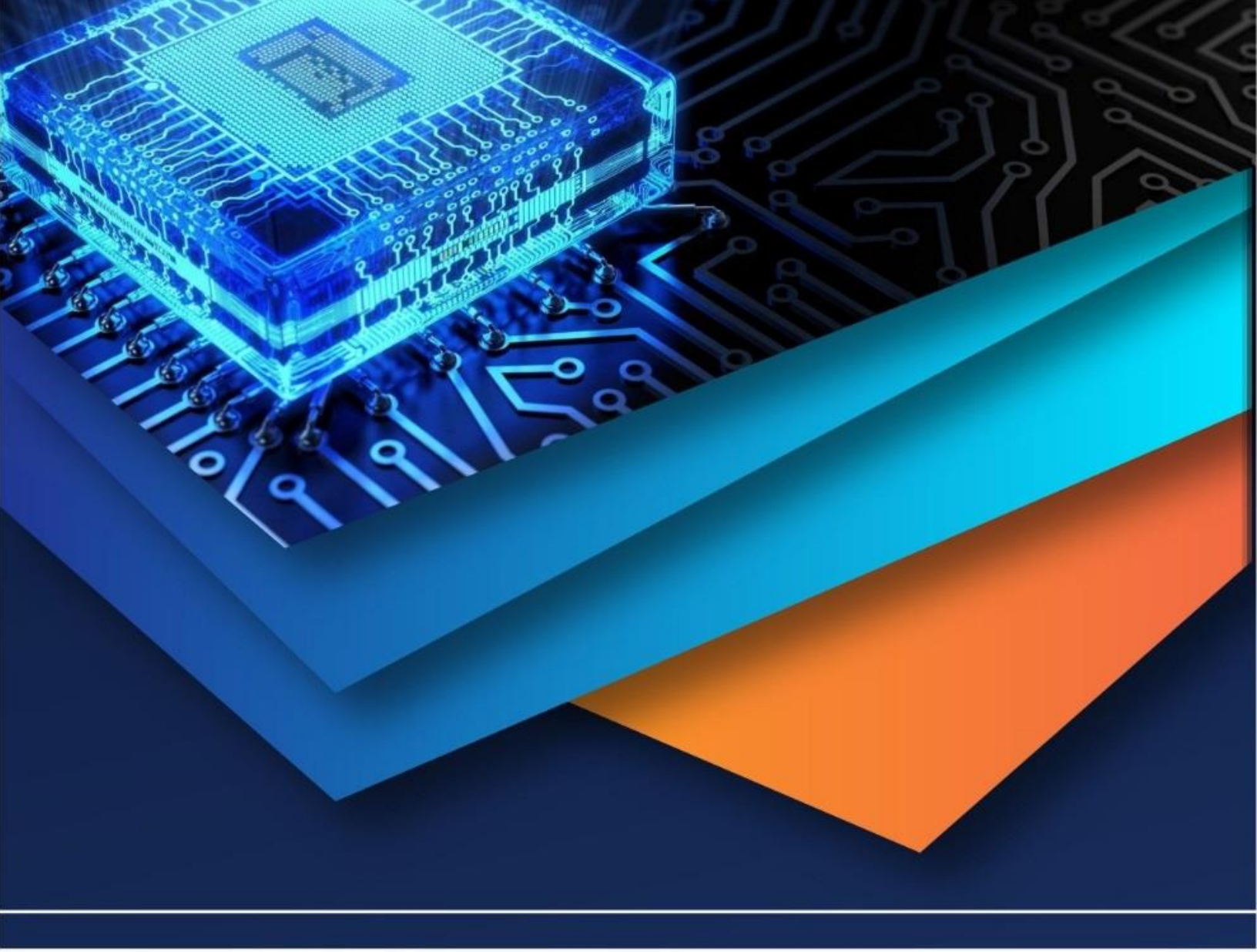

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