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Importance of Admixtures for Manufacturing of Concrete for Road Pavement

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***Abstract:* -- Road pavements are relentlessly exposed to high traffic loads and high temperatures which imparts negative effects on the durability of the concrete. To restore the weakened concrete properties and further to enhance the performance of the pavement an effective multifunctional material is obligatory. Admixtures are widely used for this purpose. Using fly ash in concrete may both provide economic advantages and better properties in the production of concrete. Use of polypropylene fiber in concrete has been researched in recent days. Besides in addition of fiber provide better performance for the concrete while fly ash in the mixture may adjust the workability and strength losses caused by fibers and improve strength gain, durability, density, corrosion resistance, etc. Combination of fly ash and fibers has given better performance when tested. Fly ash increases 50– 60% of compressive strength and 80 – 90% of tensile strength and fiber decreases shrinkage up to 30-40%.**

I. INTRODUCTION

Concrete is the most widely used construction material after water which is often crack ridden connected to plastic and hardened states, drying shrinkage. More than 11.4 billion tons of concrete consumed annually worldwide. The production of concrete has reached a value of more than one ton concrete per capita globally. Concrete made with Portland cement are relative strong in compression, weak in tension and are brittle in nature. The poor nature of concrete can be overcome by adding steel reinforcement in different tension zones. The brittle nature of concrete can be overcome by using discrete fiber. Providing reinforcement in concrete effective and economical of converting cementitious material tough and brittle. The tensile strength of concrete is only about 10% of its compressive strength, and concrete cracks when subjected to tensile stresses. Crack control plays a crucial role in the performance life of concrete in construction. This is because the settlement and plastic shrinkage cracks may pass through fresh concrete, thus forming planes of weakness and lowering the integrity of the structure of concrete. The requirement of cement increases with time and it was estimated that each ton of cement produced generates an equal amount of carbon dioxide. The production of cement is responsible for 5% of global greenhouse gas emission created by human activities. Therefore, incorporating sustainability concerns into the design of civil engineering materials is urgently needed.

II. ADMIXTURE

Admixtures are anything other than Portland cement, water, and aggregates that are added to a concrete mix to modify its properties. Included in this definition are chemical admixtures (superplasticizer), and mineral admixtures such as fly ash, silica fume, corrosion inhibitors, colors and fibers. Many concrete admixtures are available to modify, improve, or give special properties to concrete mixtures. Admixtures should be used only when they offer a needed improvement not economically attainable by adjusting the basic mixture

MINERAL ADMIXTURE

• FLY ASH

Fly ash is a by-product of coal burning power plants which possess good pozzolanic properties and is usually considered a waste material. These are generally finer than cement and spherical in shape. It is cost effective. More than 1000 million tons of fly ash is generated each year worldwide out pf which 80% is disposed of in landfills and it is likely to exceed 2000 million tons in 21st century. With pozzolanic and cementitious properties, it has been used as a substitute for cement in concrete. The use of fly ash in concrete is found to affect strength characteristics adversely. One of the ways to compensate for the early-age strength loss associated with the usage of fly ash is by incorporating fibers, which have been proved very efficient in enhancing the strength characteristics of concrete.

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Traditionally, the replacement of cement by fly ash is limited to approximately 10 to 30% of the total cementitious materials. Fly ash can be used as additive or by replacing a fraction of cement in concrete. The use of fly ash enhances the term strength and durability. With the progress in water-reducing chemical additives, high volume fly ash (HVFA) structural concrete with reasonable compressive strength and workability was introduced. The term HVFA concrete is used to recognize a concrete material that has more fly ash than cement. It has been reported that concrete incorporating HVFA has significant improvement in mechanical properties and durability. Specifically, HVFA concrete has higher elastic modulus, lower shrinkage and creep, lower water permeability and also increase workability, strength, durability and reduces the heat of hydration of concrete. The use of fly ash in concrete as a construction material has following technical advantages such as

- Reduced bleeding and segregation
- Improved finished ability and flow properties
- Reduced heat oh hydration
- Increase cracking resistant
- Increase durability

Table I Chemical Composition of Fly Ash

Oxides	Percentages
SiO_2	40-50
Al_2O_3	18-28
Fe_2O_3	3-8
CaO	3-20
MgO	1-4
SO_3	1-2
others	8

• FIBER

Fiber is a natural or synthetic substance that is significantly longer than it is wide. Fibers are often used in the working many years. These fibers are used as in concrete as a three-dimensional secondary reinforcement. Due to adhesion between polypropylene fiber and bitumen the strengthening mechanism in asphalt concrete is somehow different. Polypropylene fiber are new generation chemical fibers. About 4 million tons of polypropylene fibers are produced in the world. Polypropylene fiber is manufactured using conventional melt spinning. The commonly used fibers are steel, glass, polymeric, asbestos and natural fibers. Polypropylene fibers are used in construction which mitigate plastic and early drying shrinkage by increasing the tensile property of concrete and bridging the forming cracks. The polypropylene fiber has a low Young's modulus so they cannot prevent the formation and propagation of cracks at high stress level but they can bridge large cracks.

Shrinkage especially the drying shrinkage influences the performance of structural concrete which could induce cracking and thus reduces the durability. Polypropylene fiber is introduced in the mix to minimize brittleness of the matrix thereby reducing the susceptibility to cracking of a concrete. The use of polypropylene fiber has increased tremendously in construction because its improves toughness, flexural strength, tensile strength as well as failure modes of concrete. For effective performance the dosage rate of polypropylene fiber is 0.9kg/m3.

Advantages of Polypropylene fiber are

- Polypropylene fiber is non-magnetic
- Polypropylene fiber is compatible with concrete chemical admixture.
- Polypropylene fiber is fire resistance material
- Polypropylene fiber is crack resistance

CHEMICAL ADMIXTURE

• SUPERPLASTICIZER

Superplasticizer also known as high range water reducers are chemical admixtures used were well dispersed particle suspension is required. These polymers are used as dispersants to avoid particle segregation (gravel, coarse and fine sand), and to improve the flow characteristics of suspension such as in concrete application. Their addition to concrete or mortar allows the reduction of the water to cement ratio, not affecting the workability of th mixture and enables the production of self-consolidating concrete and high-performance concrete. This effect drastically improves the performance of the hardening fresh paste. The strength of concrete increases when the water to cement ratio decreases. However, their working mechanisms lack a full understanding revealing in certain cases cement-superplasticizer incompatibilities.

III. LITERATURE REVIEW

1. Tatyana Boikava, et. al. (MAY 2017)

To create a high-performance road concrete, it is advisable to use two complex additives simultaneously with the aim of increasing concrete density, strength, hardness, corrosion resistance and durability. To increase crack resistance and tensile strength in bending and to decrease abrasion another complex admixture on the basis of

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sparingly soluble salts of magnesium modified by silica with different particle sizes was developed too. Concrete with these two additives used in rational quantities is characterized by 55-60% increase of compressive strength and 85-90% increase of tensile strength in bending, with coefficient of crack resistance rising by 17-20%. The concrete abrasion corresponds to the G1grade of concrete and the concrete freeze resistance – to F 2600 grade. The concrete water absorption is reduced by 40%. This increases the concrete density. Corrosion resistance of the modified concrete at the age of 360 days is raised more than 15%. The amount of sparingly soluble hydrated compounds is increased when these two additives are applied together. The concrete designed with given additives is recommended for creation of an effective pavement.

2. Marcela Guirola, et. al. (2017)

In this paper the combined effect of fly ash and fiber on properties of cement concrete was studied. Different dosage of cement was replaced by fly ash and also glass fiber or polyester fiber were added. The compressive strength, flexural strength and split tensile strength were experimentally determined. According to the above test result the concrete with 10% replacement of cement with fly ash and fiber presents better results of compressive strength than the concrete without fiber. Higher
dosage of fly ash decreased the mechanical strength and small dosage of fly ash increases flexural strength by using glass fiber. Polyester fiber had increased the values of all flexural strength of fly ash cement concrete.

3. Rahul Bansal (2015)

They studied the basic replacement of cement to fly ash. It was practically found that 10% replacement of fly ash decreases the compressive strength by 20% and 50% at the age of 7 and 28 days. In 20% replacement, 7% and 11% increase in compressive strength was observed at the age of 7 and 28 days respectively. In 30% replacement 23% and 19% increase in the compressive strength was observed at the age of 7 and 28 days respectively. They concluded that as the fly ash content increases there was increase as well as decrease in the strength of concrete. It was also observed that with increase in age the compressive strength also increased for fly ash replaced concrete.

4. Tomas U, et. al. (2013)

This experiment study aimed to investigate the physical, chemical and mechanical properties of fly ash cement concrete for road construction. Study has shown that 30% of fly ash and 70% of cement has a better performance as compared to the standard requirements. Use of fly ash in concrete reduces the cost of materials in construction and greenhouse gas emission. High strength of concrete can be made and the incorporation of admixture or substitute to improve the properties of concrete. The method used for proportioning permits the use of a wide range of fly ash, it has been found that the quality of fly ash is not that important but the variation of that quality is more. The advantage of the use of fly ash in concrete is the flexibility that allows the selection of the mix proportions. By Using fly ash in concrete, it is possible to choose the low-cost mixture or easiest to place or most durable. Fly ash has a lower unit weight which shows that the greater will be percentage of fly ash in the paste, better lubricated the aggregates are and better will concrete flows. They continue to combine with the lime in cement, increasing compressive strength over time. It helps the concrete mixture achieve its maximum strength faster. Thus, it is concluded that fly ash can be used effectively as material in concrete road pavement.

5. Okan Karahan, et. al. (JULY 2010)

This report shows a comprehensive study on durability properties of concrete containing polypropylene fiber and fly ash. Different properties are studied including unit weight, workability of fresh concrete and compressive strength, modulus of elasticity, porosity, water absorption, sorptivity coefficient, drying shrinkage of hardened concrete .Fly ash is replaced 0%, 15% and 30% in mass basis and fiber as 0%, 0.05%, 0.10% and 0.20% in volume basis .Test results shows that of fly ash improves workability of concrete and polypropylene fiber decreases the workability of concrete .Addition of polypropylene fiber into cement concrete or fly ash concrete has no effect on compressive strength and elastic modulus .The relation between polypropylene fibers and fly ash guide to the lowest drying shrinkage of concrete with fly ash .Freeze–thaw resistance of polypropylene fiber concrete shows slight increase as compared to concrete without fibers .Fly ash increased the freeze–thaw resistance than the polypropylene fibers.

6. Don L Ivey, et. al. (1967)

This paper report shows various physical effects of chemical admixture on concrete and cement mortar and also compares the different test on mortar with various methods in concrete tests and correlate these tests with tests on concrete. The available data gives a detail idea about utilization or standard mortar for quality control test of chemical admixture. Basic concentration is given on compressive strength, shrinkage and setting time. The solution for shrinkage crack spacing is developed and is

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compared with available test data. Concrete 60-day shrinkage varies from 450mm to 650mm for four lignosulphonates, 350mm to 500mm for three organic acids and 420mm to 480mm for two polymers. The result obtained from shrinkage test shows some difference in the effect of different chemicals types in both concrete and mortar. The tests results show some correlation with theoretical solution for shrinkage cracking. Thus, it is concluded that as shrinkage increase of
41%. There is a decrease of average crack spacing by 76%. This indicates that as percentage of shrinkage increases there will be effect on concrete cracking.

7. C.Marthong, et. al. (2010)

In this report the various effect of concrete properties when OPC of varying grades replaced by fly ash in variation of 10%, 20%, 30% and 40%. From the above variation in concrete it is concluded that the use of fly ash improves the workability and concrete and workability increases with the decrease in the grade of cement.

8. V.M. Sounthararaajan, et al., (2010)

In the above paper the author investigated the replacement level of fly ash at 25% and 50% with addition of polypropylene fiber from 0% to 0.3%.it was concluded that the split tensile strength improved with addition of 0.1% of polypropylene fiber. However, with the higher dosage of polypropylene fiber showed a slight reduction in the split tensile strength.

IV. CONCLUSIONS ON LITERATURE REVIEW$

From the above literature review the following conclusions could be drawn:

(1) Addition of polypropylene fiber and fly ash reduce the unit weight. While inclusion of fly ash improves, polypropylene fiber decreases the workability of concrete.

(2) Compressive strength decreased with the increase of fly ash content.

(3) Porosity, water absorption values increased with the increase of fly ash and fiber contents for all concrete mixtures.

(4) Influence of addition of fly ash on compressive strength is found to be more than the addition of polypropylene fibers in concrete.

(5) Presence of polypropylene fiber and fly ash in concrete reduces drying shrinkage of concrete.

(6) Fiber being added to the cement as an admixture gave efficient characteristic on the performance of the concrete with respect to its properties as to better strength, durability, elasticity and shrinkage.

(7) The presence of fly ash in concrete reduces the compressive strength at early ages but there is a drastic increase in compressive strength at later stage.

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