Experimental investigation of Mineral Admixtures in Pervious Concrete: A Review

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Abstract- This review paper includes literature reviews related to pervious concrete and effects of mineral admixtures (Fly ash and silica fume) on properties of concrete. Various research papers, articles and thesis have been referred to understand various aspects of the pervious concrete, viz., basic behaviour, advantages, limitations, effects & mechanical properties. Various research papers published till date on different aspects of pervious concrete.

Index Terms- Pervious concrete, Porous material, mineral admixtures.

I. INTRODUCTION

1.1 Pervious Concrete

Conventional normal cement concrete is generally used as construction material of buildings. The impervious nature of concrete contributes to the increased water runoff into drainage system, over-burdening the infrastructure and causing excessive flooding in built-up areas. Pervious concrete has become significantly popular during recent decades, because of its potential contribution in solving environmental issues.

Pervious concrete is a high performance concrete which has relatively high water permeability compare to conventional concrete due to interconnected pore structure. Pervious concrete is also termed as porous concrete and permeable concrete. It can be produced using conventional concrete-making materials, namely cement, cement supplementary materials, all types of coarse and no fine or less fine aggregates, and water. Pervious concrete is a type of concrete with significantly high water permeability compared to normal weight concrete.it has been mainly developed for draining water from ground surface, so that stormwater runoff is reduced. Due to high water permeability then normal concrete, pervious concrete has very low compressive strength.

1.2 Mineral admixtures

Mineral admixtures are finally divided siliceous materials, which can be added to concrete in relatively large amounts, generally in the range of 15 to 60% by weight of cement. They may be pozzolanic or cementitious or both. Benefits of using mineral admixtures in concrete are improvements in high ultimate strength, resistance to thermal cracking and chemicals effects, better durability and economy.in this review paper, effects of fly ash and silica fume on concrete are referred.

II. LITERATURE REVIEW

a) Pervious Concrete

Sanket Sharma(2012)[1] determined the effect of percentage of fine aggregates and cement to coarse aggregate ratio to study the mechanical properties of pervious concrete. Tests and results concluded that with addition of 5% fine aggregates in pervious concrete, it increased the compressive strength but also strength decreased with further increment of percentage of fine aggregates. And compared to no fine aggregates in concrete , flexural strength of pervious concrete increased by 50% with addition of 10% fine aggregates.

Jing yang(2012)[2] investigated the effect of smaller sized aggregates, silica fume and super plasticizer to increase the pervious concrete strength greatly. Based on results, they concluded that with use of smaller sized aggregates it helped to improve the significance strength of pervious concrete. SF and SP also enhanced the strength of pervious concrete. Also compressive strength of composition of these materials can be reach up to 50 MPa and it can be applied to footpath and also the low traffic vehicle road.

Rui zhong(2015)[3] dealt with silica fume and ultra-fine silica powder to improve the ultra high performance pervious concrete matrix. To achieve the goal of an ultra-high performance cement based matrix with compressive strength in excess of 150 MPa and high durability properties designed and applied to the mixture design concept of pervious concrete. They concluded from the results that Based on enhanced mechanical properties as well as improved durability, high performance pervious concrete potentially allows extending the application of pervious concrete and thus carries a vital potential in effectively counteracting the growth of impervious urban areas.

Baoshan huang(2009)[4] carried out the experiment on pervious concrete with use of latex polymer to improve the strength properties. With use of latex, natural sand and fibre they evaluated the effect of polymer modification on mechanical and physical properties of PMPC. Based on results , it was possible to produce pervious concrete mixture with acceptable permeability and strength through the combination of latex and sand.

Anthony torres(2015)[5] presented the use of thick cementitious paste on performance of pervious concrete and carried out the significance change in mechanical properties of pervious concrete. To thicken the cementitious paste, they used limestone with sizes of 9.54 mm and 6.35 mm. and for improving thickness of cement paste, they minimized the other variables

such as cement types, w/c ratios, sample size, admixtures etc. based on tests and results they concluded that porosity of pervious concrete decreased with an increase of cementitious paste thickness. And also permeability of concrete decreased with increase of cementitious past thickness in pervious concrete. And surely decrement in porosity and permeability, compressive strength and split tensile strength increased but it can defeat the purpose of pervious concrete if paste thickness becomes too thick.

b) **Mineral admixtures in Concrete : Fly Ash**

J.m.khatib(2007)[8] investigated the influence of fly ash on self compacting concrete properties. Portland cement was partially replaced with fly ash from 0-80%. Properties included workability, compressive strength, absorption and shrinkage were checked out. Based on experiments and results they concluded that High percentage of FA can be used to produce SCC with an adequate strength. Using of up to 60% FA as PC replacement can produce SCC with a strength as high as 40N/mm2 and also water absorption increases with increase of FA content. Replacing cement with 80% FA can reduce the shrinkage by two third.

Amitava sil(2015)[9] presented the effect of local power plant's fly ash in making of HVFA concrete with using of 5 to 10% silica fume as admixture to improve the strength parameters of HVFA concrete. based on results, it showed that with replacement of 50% cement to fly ash, workability of concrete improves. And also some replacement of sand to fly ash can use to make lower grade concrete.

Ergal yasar(2003)[10] presented the strength properties of light weight concrete made with basaltic pumice and fly ash.in this research they made light weight concrete with replacement of 20% cement to fly ash on weigh basis. The compressive and flexural tensile strengths of hardened concrete, the properties of fresh concrete including density, and slump workability were measured. They concluded that the use of fly ash, which will reduce the cost and environmental pollution, seems to be possible in SLWC mixture. It is possible to produce a lightweight concrete with 25MPa cylinder compressive strength by the use of fly ash.

Rafat siddique(2013)[13] was carried out to study the properties of self-compacting concrete (SCC) made with coal bottom ash. The mixes were prepared with three percentages (0, 10, 20 and 30) of coal bottom ash as partial replacement of fine aggregates. tests were conducted up to the age of 28 days & results indicated that SCC mixes developed 28-day compressive strength between 25.8 and 35.2 MPa. Abrasion resistance and water absorption of SCC mixes increased with the increase in bottom ash content at a particular age, however, it decreased with increase in age.

Fereshteh sabet(2013)[12] used mineral admixtures discusses the effect of natural zeolite, silica fume and fly ash on the properties of fresh and hardened concrete. Slump flow, super plasticizer demand, compressive strength, electrical resistivity, water absorption and chloride permeability were measured for all mixes. The test results indicated that incorporation of mineral admixtures generally improve mechanical and durability characteristics of the mixes. However, silica fume is slightly more effective than natural zeolite or fly ash in improving durability Properties of self-consolidating high performance concrete, while natural are much more cost effective.

P.Nath(2011)[15] determined the durability properties of high strength concrete utilizing high volume Class F fly ash sourced from Western Australia have been investigated. Concrete mixtures with fly ash as 30% and 40% of total binder were used to cast the test specimens. The 28-day compressive strength of the concrete mixtures varied from 65 to 85 MPa. The fly ash concrete samples showed less drying shrinkage than the control concrete samples when designed for the same 28-day compressive strength of the control concrete. In general, incorporation of fly ash as partial replacement of cement improved the durability properties of concrete.

Rahul bansal(2015)[19] studied the basic replacement of cement to fly ash. It was observed that 10% replacement of fly ash was 20% and 50% decrease the compressive strength at the age of 7 and 28 days respectively. 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 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.

c) Effects of silica fume on concrete

M.Mazloom(2003).[21] studied the effect of silica fume on mechanical properties of high strength concrete. The aim of the study was to investigate the effects of binder systems containing different levels of silica fume on fresh and mechanical properties of concrete. The results of this research indicated that as the proportion of silica fume increased, the workability of concrete decreased but its short-term mechanical properties such as 28-day compressive strength and secant modulus improved. Also the percentages of silica fume replacement did not have a significant influence on total shrinkage; however, the autogenous shrinkage of concrete increased as the amount of silica fume increased. Moreover, the basic creep of concrete decreased at higher silica fume replacement levels.

V.T.Giner(2011)[23] studied the influence of SF additions in quantities ranging from 0% to 15% of cement mass on the dynamic and static mechanical properties of concrete. The results proved that SF additions or replacements reduce both the dynamic modulus of elasticity and damping ratio of concrete. The dynamic elastic properties of concrete, with and without SF, present higher values than their static counterparts. These differences are smaller in concretes containing SF.

N.K.Amudhavali(2012)[24] investigated the partial replacement of cement with silica fume at various percentage and studied about compressive strength, flexural strength and split tensile strength in M35 grade concrete. The results concluded that increment in compressive strength of concrete obtained in range of 10-15% of replacement of silica fume. But with other mixes, the loss in weight and compressive strength percentage was found to be reduced by 2.23 and 7.69 when 10% cement replaced by silica fume.

➢ **Critical remarks from above observations:**

- Pervious concrete has void content range from 15% to 35% of total volume of concrete which gives higher permeability as purpose of this concrete. but other hand, higher porosity decrease the amount of compressive strength of pervious concrete than conventional concrete.[1-4].
- Use of fine sand at limit from 5% to 10% can give enough structural strength in pervious concrete. But further increment of sand can control the strength properties of pervious concrete [2].
- The compressive strength of conventional pervious is lower than 15 to 20 MPa [4]. But with use of modifications in coarse aggregates can increase strength in range of 12 to 14% than conventional compressive strength [6],[7].
- Replacement of fly ash with cement upto 40% gives increment in compressive strength of concrete[8]. Fly Ash particles provide a greater workability with replacement upto 50% of cement[9] of the powder portion of the concrete mixture which results in greater workability of the concrete and a lowering of water requirement for the same concrete consistency.
- Generally replacement of fly ash with cement gives compressive strength in ranges of 25 to 35MPa.but with modified design of concrete with fly ash can gives strength upto 80-100MPa.[11,12,15]
- Use of silica fume in concrete gives earlier high strength but with higher replacement of cement with this material gives strength loss and also loss in workability of concrete[21-23].
- Mix of fly ash and silica fume give increment up to 145% when mixes with fly ash without mixing of silica fume but it also decreases the workability of concrete [14]
- Fly ash is cheaper than silica fume. So for strength increment purpose, fly ash can be used as cheaper admixture with higher effects on strength of concrete.

III. Final Conclusion

For achievement of higher strength and workability in pervious concrete, it is not possible to get higher strength with conventional concrete mix. Modification is necessary in design. With use of fly ash and silica fume, it can be possible to increment in strength of pervious concrete.

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