Review Paper on Experimental Study of High Performance by Replacing Cement and Natural River Sand with Industrial Waste and By-Products

Vipulkumar N. Tailor[1] Chintan. D. Pate[2] Bansal. R. Patel[3]
[1]PG Student [2,3]Assistant Professor
[1,2,3]Department of Applied Mechanics
[1,2,3]L.D. College of engineering, Ahmedabad, India

Abstract— Concrete is one of the most widely used constructional material in the world. Along with this, the utilization of natural resources has been increased. This is leading to vanishing of them. Also due to ever increasing quantities of waste materials and industrial by-products, solid waste management is one of the prime concern in the world. There are several types of industrial by-products and waste materials. The utilization of such materials in concrete not only makes it economical but also helps in reducing disposal concerns. Therefore the main aim of this paper is to review some of the research papers which uses industrial by-products and waste materials to produce high performance concrete by replacing fine aggregate and cement. Further study of this research papers will lead to economical and sustainable construction.

Key words: High Performance Concrete, Quarry Dust, Silica Fume, Fine Aggregate, Cement, Replacement

I. INTRODUCTION

Reinforced-concrete (RC) structures constitute about 70% of today's infrastructures and for economic reasons structural engineers are under tremendous pressure to design smaller and shallower reinforced- concrete members. Such practice usually leads to heavily reinforced elements especially in beam-column joints and in structures located in highly seismic regions.

Steel, cement, glass, aluminium, plastics, bricks, etc. are energy-intensive materials, commonly used for building construction. Generally these materials are transported over great distances. Extensive use of these materials can drain the energy resources and adversely affect the environment. On the other hand, it is difficult to meet the ever-growing demand for buildings by adopting only energy efficient traditional materials (like mud, thatch, timber, etc.) and construction methods. Hence, there is a need for optimum utilization of available energy resources and raw materials to produce simple, energy efficient, environment friendly and sustainable building alternatives and techniques to satisfy the increasing demand for buildings.

Fine aggregate is an essential component of concrete. The most commonly used fine aggregate is natural river or pit sand. The global consumption of natural sand is very high due to the extensive use of concrete owing to rapid infrastructural growth. In this situation, the construction industries of developing countries are in stress to identify alternative materials to lessen or eliminate the demand for natural sand. So, quarry waste fine aggregate could be an alternative of natural sand. It is a byproduct generated from quarrying activities involved in the production of crushed coarse aggregates. Quarry waste fine aggregate, which is generally considered as a waste material after the extraction and processing of rocks to form fine particles less than 4.75mm, causes an environmental load due to disposal problem. Hence, the use of quarry waste fine aggregate in concrete mixtures will reduce not only the demand for natural sand but also the environmental burden. Moreover, the incorporation of quarry waste fine aggregate will offset the production cost of concrete. In brief, the successful utilization of quarry waste fine aggregate will turn this waste material into a valuable resource.

It was realized that the high strength alone will not be an effective method for achieving high performance and that the durability of these materials in various environments needs a better understanding to achieve an appropriate solution. These necessitated the utilization of industrial wastes having pozzolanic property in concrete and showed the possibility of obtaining improvements in durability, besides attaining HSC composites. The improvement milestone of these works is probably the introduction of silica fume.

II. LITERATURE REVIEW

M. Fauzi M. Zain, Md. Safiuddin, T. K. Song, H.B.Mahmud and Y. Matsufuji(1) investigated the effects of chemical admixtures and quarry dust on the physical properties of freshly mixed high performance concrete. Normal Portland cement (NPC), silica fume (SF) and fly ash (FA) concretes were prepared with the water-cement ratios of 35% and 50%. Quarry dust (QD) was also used with normal Portland cement, silica fume and fly ash to prepare six types of concrete mixes. NPC concrete was considered as the control concrete. Quarry dust was used to replace 20% and 40% of sand respectively in preparing the concrete mixes containing quarry dust. Silica fume and fly ash were used as 10% replacement of cement in the concrete mixes containing silica fume and fly ash respectively.

The mixes with 35% water-binder ratio produced lower slump, slump flow and V-funnel flow than the mixes with 50% water-binder ratio. The mixes with 35% water-binder ratio possess higher volume concentration of cementitious materials but lower volume concentration of aggregates. The concrete mixes containing silica fume required higher dosage of super-plasticizer than the mixes with normal Portland cement and fly ash.

It was concluded that addition of chemical admixtures provides higher slump and slump flow in fresh mixes of high performance concrete. Silica fume with super-plasticizer produces higher slump and slump flow than fly ash in fresh concrete mixes. The partial replacement of sand by quarry dust increases the slump and slump flow of fresh concrete mixes.

Ahmed Ibrahim, Hassan El-Chabib and Ahmed Eisa(2) studied the development of ultrastrength high-performance flowable concretes made with a high content of supplementary cementitious materials. Supplementary cementitious materials such as class C(FAC) or class F fly-ash(FAF), granulated blast furnace slag(SL), and silica fume(SF) were used to prepare 27 concrete mixtures.

A total of 27 concrete mixtures were prepared and tested, three of which were 100% portland cement and with w/c of 0.30, 0.33, and 0.37 respectively. These mixtures were prepared using the SCM materials like 100% of C, 40%C + 60%FAC, 40%C + 50%FAC + 10%SF, 30%C + 30%FAC + 30%SL + 10%SF, 30%C + 70%SL, 30%C + 60%SL + 10%SF, 40%C + 60%FAF, 40%C +50%FAF +10%SF, 30%C +30%FAF + 30%SL + 10%SF. All of the mixtures were prepared with w/c of 0.30, 0.33, and 0.37 respectively.

They concluded that using up to 70% of slag as partial replacement of cement in concrete mixtures slightly increased the mechanical properties of concrete and significantly reduced concrete permeability. Also, using a combination of 50% FAF and 10% SF to replace cement reduces concrete permeability by more than 85%.

M. Mazloom, A.A. Ramezanianpour and J.J. Brooks(3) has done the experimental work on mechanical properties of high-strength concrete containing different levels of silica fume. The study was about to investigate the effects of binder systems containing different levels of silica fume on fresh and mechanical properties of concrete. The percentages of silica fume that replaced cement in this research were: 0%, 6%, 10% and 15%. Apart from measuring the workability of fresh concrete, the mechanical properties like development of compressive strength, strain due to creep, shrinkage and swelling were also evaluated

The results 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 was increased. Moreover, the basic creep of concrete decreased at higher silica fume replacement levels. The results of swelling tests after shrinkage and creep indicated that increasing the proportion of silica fume lowered the amount of expansion.

Marijana Serdar, Ivan Biljecki, and Dubravka Bjegovi(4) have studied the importance of the locally available industrial by-products. By-products generated by locally available industries like steel plant, thermal power plant, aluminum plant, and stone quarry (slag, fly ash, red mud, and quarry dust) were used to form four concrete mixes. The heat of hydration and the autogenously shrinkage were monitored on the fresh concrete mixes. The chloride migration and electrical resistivity of the concrete were measured at different concrete ages over 91 days. Compressive strength was tested after 28 and 91 days.

The results indicated that concrete prepared with a high volume of fly ash, slag, red mud, and quarry dust had very low chloride migration coefficients compared to concrete prepared with ordinary cement.

Souradeep Gupta(5) looked into the possibility of development of UHPC with high amount of cement replacement (around 70%) by two supplementary cementitous materials, slag and silica fume. The scope of this paper also covered the effect of curing method on strength development of the proposed UHPC mix and concludes that choice of curing medium and method highly influence strength development.

GGBS (up to 80 %) and silica fume (up to 20%) was used to replace the concrete with 3 different water cement ratio and using 3 different curing methods.

He concluded that Silica fume of around 10% when added to GGBS as a means of high amount cement replacement improved compressive and flexural strength. Even, early strength which was lower when only GGBS was used can be raised through usage of silica fume along with it by around 6%.

S.Azhagarsamy(6) determined the feasibility of the usage of quarry dust as 60:40 proportion of substitution of natural sand i.e. (quarry dust replaces 60% of natural sand) in concrete was determined. Silica fume was added as mineral admixture by 15% of weight of cement and steel fibre used in different percentage (0.5%, 1.0%, and 1.5%) to increase the tensile strength. Tests were conducted for 3, 7 and 28 days to study the compressive, tensile, flexural strength and durability test of concrete also conducted.

Results stated that the addition of the steel fibre up to 1% improved the compressive strength of M60 concrete. Tensile strength and flexural strength was also achieved optimum at 1 % of steel fibre. It was concluded that it is possible to prepare the high performance concrete using quarry dust and steel fibre.

V.Priyadharshini(7) describes the experimental study of High-Performance concrete with quarry dust as fine aggregate in addition of steel fibre. Cement was replaced with 10% of silica fume. Fine aggregate was fully replaced by quarry dust in the experimental program. The M60 grade concrete used was designed by using a modified ACI method. Volume fraction of the fibres used in this study as 0%, 0.5%, 1%, 1.5%. Specimens were casted and compression, split tensile and flexure test were conducted for 7 and 28 days.
It was seen in the results that Combination of quarry dust and silica fume exhibiting good performance due to efficient micro filling ability and pozzolanic action of silica fume. From the experimental investigation it was found that the optimum fibre content is 1%. When adding more fibre in concrete, bonding between the fibres will increase and accumulate of fibre will occur.

III. CONCLUSION

As the demand of high performance concrete in this present scenario of construction industry and environmental conditions, the utilization of cement and other natural resources are increased, leading to vanishing of them in nearby future. Also, lands are being used by the disposal of industrial waste and by-products, creating another major problem to the survival of human being. Therefore it is necessary to produce high performance concrete that have a minimum cement content and natural resources which also include industrial by-products in it so that both the problems can be minimize at a greater level. After referring to the research papers, we can conclude that further more research is needed in the development of high performance concrete that includes the replacement of both the natural river sand and cement at the same time with industrial waste and by-products without losing the quality of the same.

References

[1] M. Fauzi M. Zain, Md. Safiuddin, T. K. Song, H.B.Mahmud and Y. Matsufuji "Influence of Admixtures and Quarry Dust on the Physical Properties of Freshly Mixed High Performance Concrete" ELSEVIER, 2001
[2] Ahmed Ibrahim, Hassan El-Chabib and Ahmed Eisa "Ultrastrength Flowable Concrete Made with High Volumes of Supplementary Cementitious Materials" ASCE 2013
[3] M. Mazloom, A.A. Ramezanianpour, J.J. Brooks "Effect of Silica Fume on Mechanical Properties of High-Strength Concrete" ELSEVIER 2004
[4] Marijana Serdar, Ivan Biljecki, and Dubravka Bjegovi´ "High-Performance Concrete Incorporating Locally Available Industrial By-Products" ASCE 2016
[5] Souradeep Gupta "Development Of Ultra High Performance Concrete Incorporating Blend Of Slag And Silica Fume As Cement Replacement" IJCSER 2014
[6] S.Azhagarsamy "Effect of Quarry Dust on High Performance Concrete" IRJET 2017
[7] V.Priyadharshini "High Performance Concrete using Quarry dust as Fine aggregate" IJARC 2014