

Evaluation of admixture effect on strength and durability properties of concrete - a critical review

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Abstract

The present paper is focused on the study of admixture effect on strength and durability properties of concrete. In this study selected admixtures bentonite clay, coconut shell, cow dung ash, crushed rubber, egg shell, glass powder, groundnut shells, rich husk, stone dust, sugar bagasse etc., research papers has been reviewed. In spite of several usage of waste, presently millions of tons are produced every year and remain unused all around the world and causes serious environment problems. Utilization of waste products all over the world has become challenging task for civil engineers. High costs of cements are not economical for all the types of construction works. Therefore, it is necessary to utilize the locally available materials for improving the properties of concrete in the field of construction industry. The usage of different waste material for the improvement of concrete properties has drawn much attention to the researchers. Moreover, several researchers were made an investigation on laboratory tests on partial and fully replacement of cement, sand, aggregate in concrete and various properties like workability, compressive strength, and density are studied. Based on the research work carried out several researchers we can conclude that the utilization of different usage of waste material as resources and prevents environmental pollution. It is also observed that waste materials can be used as an alternate material for the better improvement of strength and durability properties of concrete.

Keywords: Admixture; Cement; Compressive Strength; Concrete; Durability.

1. Introduction

Concrete is most widely used as a construction material due to its specialty of being cast in any desirable shape; it has almost replaced stone and brick masonry. Concrete is the important construction material in the construction other than steel and timber. Its main constituents are cement, sand, fine aggregates and coarse aggregates, and water. Various properties of concrete and their behavioral plays a pivotal role in the designing of construction of a specific structure. Some of the concrete properties includes compression, tension, shrinkage, thermal expansion, creep, durability, elastic modulus etc. Concrete is perhaps the most extensively used construction material in the world and in the case of conventional concrete Portland cement is one of most the important ingredient. Now-a-days the overall cost of these materials are increasing gradually so, we need to look at a way to reduce the cost of building materials particularly cement. For the last few decades the construction techniques have been modernized with focus on high strength, dense and uniform surface texture, more reliable quality, improved durability, and faster construction. One of the recent advancement in construction industry is replacement of materials in concrete. The amount of cement production emits approximately equal amount of carbon dioxide into the atmosphere. Natural resources are slowly decreasing because continuous production of huge quantity of cement on daily basis. Therefore

additional burden has create an opportunity to utilize the supplementary materials. As there are different wastes coming from the industries and these waste becoming problem to dispose. Hence, we can use those wastes as the constituents of concrete by replacing or partially replacing the cement, sand or aggregates which makes cost reduction, energy savings and protection of environment, economical and finally conserves the natural resources. Sustainability in Concrete Production can be achieved by innovations in substitutions of materials used in the constructions. In the present study an attempt has been made on the Utilization of Different Waste Materials and its effect on Concrete Properties. In the present paper the selected waste materials (when cement is partially replaced by waste materials) are chosen and their importance in the concrete are only discussed. The selected waste materials such as waste marble powder, fly ash, metakaolin, steel fibers etc.

2. Utilization of different waste materials and its effect on concrete properties

Every year from the thermal power plant lot by product are produced and by product of the combustion of pulverised coal is known as Fly ash. Usually it is in spherical in shape and the particle diameter ranges between 1 μ m to 150 μ m. Moreover, the chemical composition of fly can be easily determined by using the unburnt matter in the coal. Based in the percentage of elements such

iron, calcium magnesium, silicon aluminium the different percentage of chemical compounds will exist. Generally, sub-bituminous has additional calcium and iron content will exist while compared to bituminous coal. Fly ash was successfully applied in the electrical power plant industry in 1930's on other hand the comprehensive data on fly ash can be found in detail manner [4], [12].

Construction of highway pavements or airport runways are always busy with traffics and its construction can be completed within a short period of time. In such situations the High-Performance Fiber Reinforced Concrete (HPFRC) are most suitable alternate methods for construction of busy highway pavements or runways. On the other hand the HPFRC are more expensive when compared to conventional concrete. [1].

In order to ensure the strength and stability of a selected construction, some of the basic test of concrete will be carried out before the construction of any pavements or runways. The basic tests includes compressive strength, tensile strength and elastic modulus etc. From the literature review it is observed that very little research works are available on HPFRC. In another case study it observed that an attempt was made on HPFRC with mineral admixtures as a partial replacement of cement to increase the strength of concrete properties. The different percentages of admixture has significant affect the properties of concrete. [1].

In their research work they pointed out that despite quite optimistic levels of utilization of fly ash in India; only less than 25% of the total fly ash produced is being utilized. They were also enlightened the areas in which fly ash usage has potential in India. [3]. Fly ash is considered as one of the hazardous waste due to leaching of toxic substances into the ground water and soil when it is disposed into ponds, lagoons etc. or used as a land fill and the Major constituents of Fly ash include, silicon dioxide (SiO₂) and calcium oxide (CaO), Al₂O₃, Fe₂O₃. However, broadly the fly ashes are classified into two classes of fly ash as defined by ASTM C618 such as Class F fly ash and Class C.

One of the recent advancement in construction industry is replacement of materials in concrete. In their work they studied the fresh and hardened properties of concrete when cement is partially replaced by waste marble powder. The waste marble powder 0%, 5%, 10%, 15% and 20% were replacement and the Workability, compressive strength, split tensile strength, and flexural strength test were conducted for 7, 28 days. Their obtained experimental results reveals that the workability and compressive strength, flexural, and split tensile strengths of concrete are increased with partial replacement of cement by waste marble powder between 10% to 15%. [2], in their experimental investigation were carried out on M20, M30, M40 grades of concrete, it is found that the optimum percentage for replacement of marble powder with cement ranges from 10% to 15%. Therefore, upto 15% replacement of waste marble powder is acceptable for improving the performance of hardened concrete.

Similarly in the another study the concrete mixes of different percentages 0%, 5%, 10%, 15% and 20% replacement of cement by metakaolin and fly ash are studied. Again 0.32 and 0.25%, 0.5%, 0.75% and 1% of constant w/c ratio are also considered by volume of crimped fibers to enhance the properties of concrete. In their study it is observed that the strength properties are gradually increasing for the long period of curing (after 28days).from their research work it is proved that the 10% replacement of metakaolin can be considered as the optimum percentage to enhance the compressive strength of concrete. [5].

[6], Studied the compressive strength performance of the blended concrete containing different percentage of silica fume and Fly Ash and steel fiber as a partial replacement of OPC. The cement in concrete is replaced accordingly with Silica fume content was use from 0% to 10% in the interval of 2% in weight basis and also fly ash content was use from 10% in weight basis. So to improve the strength of concrete steel fibers were added 0.5%, 1%, 1.5% and 2% by weight of steel fiber. Therefore, their results shows that the optimum replacement Fly ash and silica fume to cement and steel fiber without changing much the compressive strength is 10% -8 % & 1.5 % respectively for M25 grade Concrete.

Based on the earlier studies the fly ashes have been limited mainly to high strength concrete in the past as structural applications of concrete. One of the reasons is different curing conditions, setting times, strength characteristics and durability of normal strength fly ash concrete information not available to the concerned resident engineer.

In another case study the research was carried out on coconut shell with various percentages in the concrete. They reported that coconut shell concrete is showing 65% of compressive strength to that of normal concrete. However, their study was only at the initial stage and further it requires need to explore coconut shells as coarse aggregates in concrete in future. [13].

Though there were boundless research were done with the marble powder by-product as a substitute material in concrete production in the past, still there is need of the hour to widespread granite powder (GP) waste as a filler material in concrete production and in construction industry. [11]. the details of the utilization of Different Waste Materials and its effect on Concrete Properties are presented in Table 1.

3. Summary and conclusions

All The Construction cost can be minimized with usage of marble powder which is freely or cheaply available and the environmental pollution can be reduced by using waste marble powder as replacement of cement in concrete. Hence their test results shows that waste marble powder is capable of improving hardened concrete performance up to 15% replacement. [2].

The flexural strength and split tensile strength furthers any addition of waste marble powder there was slight decrease in strength as compared to conventional concrete because this may be due to its filling effect and growth of hydration products in concrete. [2]. Metakaolin is an effective pozzolona and results in enhanced early strength and ultimate strength of concrete. The construction cost is slightly reduced to addition fly ash in the mix and these fly ash is locally available low cost material.

Usually addition of fibers to all the mixes in improvements of all the properties such as compressive strength, split tensile strength, and most importantly increased flexural strength, this property is very useful in arresting the cracks to a large extent. [5]. Due to the effectiveness of minerals admixtures such as fly ash, and silica fume not only improve properties of concrete and also to increase the resistance [5], [6].

Usage of fly ash in concrete imparts several environmental benefits and it is eco-friendly. It saves the cement requirement for the same strength which reduces the raw materials such as limestone, coal etc required for manufacture of cement. However, Fly ash is fine powder of pozzolanic material & it improving the properties of concrete like compressive strength & Durability. [7].

Waste marble powder can be used as one of the replacement of cement in concrete to increase performance of the concrete because it is freely or cheaply available. Therefore, the construction cost can be reduced upto certain extent and the environmental pollution can be minimized [2].

Inspite of available of different admixtures like bentonite clay, coconut shell, cow dung ash, crushed rubber, egg shell, glass powder, groundnut shells, rich husk, stone dust, sugar bagasse etc. Fly ash is used in most of the research studies to improve the strength and durability of properties of concrete but still there is a need of the hour to focus on the detailed study of all the additive and admixtures.

Industrial wastes are competent to improve the physical and chemical properties of concrete and also it reveals that there was a great performance due to the efficient micro filling ability in the past research work.

Table 1:

Author (s) and year	Area/ Type of Concrete	Name of waste material	Percentage of Replacement of admixtures	Other Constituents Ratio	Age/ Curing Period	Comparing Criteria	Concluding Remarks
Tehmina Ayuba. et al 2014, [1].	Conventional Concrete	Basalt Fibers	1, 2 and 3% Basalt fiber	10% cement content with silica fume and locally produced met kaolin	28 days	Plain concrete containing no mineral admixture	Basalt fibre volume was found to be higher, whereas at 3% fibre volume compressive strength reduced probably due to the presence of voids caused by the use of higher fibre volume of Basalt fibres
T. Ch. Madhavi et al., 2014 [4].	Conventional Concrete	Fly ash	50% of fly ash	High volume fly ash concrete (HVFAC) – w/c – 0.30, 0.33, 0.35, PCC – 0.39, 0.45, 0.46	28, 91 days	Plain concrete containing no mineral admixture	Fly ash contents of up to 50% may be suitable for most elements provided the early-age strength requirements of the project can be met and provided that adequate moist-curing can be ensured
G.Latha et al., 2015 [2].	Conventional Concrete	Marble Powder	Waste marble powder of 0%,5%,10%, 15% and 20%	M20, M30, M40	7, 28 days	Plain concrete containing no mineral admixture	The workability, flexural strength and split tensile strength for M20, M30, M40 grades of concrete increased with increase in % of waste marble powder up to 20%, 15% and 10% replacement by cement respectively., The enhancement of compressive strength of concrete can be achieved with 10% replacement with metakaolin.
Mohammed Saifuddin and Mohd Majiduddin (2015). [5].	Conventional Concrete	Metakaolin and Fly ash	Concrete mixes 0%, 5%, 10%, 15% and 20% metakaolin and fly ash with constant w/c ratio of 0.32 and 0.25%, 0.5%, 0.75% and 1%	---	7, 28 days	Plain concrete containing no mineral admixture	Partial replacements of OPC by metakaolin in the range up to 10% by weight, and was at the 20% level still maintained. The highest 28-days strength improvement of concrete can be expected at partial replacements in the 10-15% range.
Madheswaran et al., (2014) [6].	Conventional Concrete	Steel Fibers with Mineral admixture	Steel fibres were added 0.5%, 1%, 1.5%, 2% by weight of steel fibre	---	3, 7, 28 days	Plain concrete containing no mineral admixture	The optimum dosage for partial replacement of cement by fly ash and silica fume is (10% and 8%) for the addition of steel fibre is 1.5%.
Shriram et al., (2014) [8].	Self Compacting Concrete	Fly Ash	0%, 10%, 20%, 30%	The admixture CONPLAST SP 430 G8 was used a super plasticizer with a density of 1.2 kg/l	7, 28, 91 days	Plain concrete containing no mineral admixture	Addition of 20% Fly ash gave an optimum strength for M30 grade (SCC mixes). The compressive strength, split tensile strength and flexural strength of M30 up to 91 days and increased 1 to 2% and 2 to 3% over its 28 day strength respectively.
Nitisha Sharma and Ravi Kumar (2015), [10].	Industrial Waste	Marble Powder	0%, 5%, 10%, 15%, 20%, 30% and 50 % by weight	----	7, 28 days	Plain concrete containing no mineral admixture	Waste marble powder has some cementitious properties and it can be used for fillings and reduces the economical and environmental problems.
C.G. Kona-pure and V.S Dasari (2015) [9].	Steel Fibre Reinforced Concrete	Silica Fume	Silica Fume & C.A (0% & 1%, 5% & 0.5% , %&1% , 5% & 1.5%, 10% & 1.5%, 15% & 1.5%)	----	7, 28	Plain concrete containing no mineral admixture	Usually weight of the concrete decreases as the percentage of content silica fume increase. In their case study both compressive and flexural strength increases at 15% of silica fume.
M. Vijayalakshmi (et al), 2013. [11].	Industry Waste	Granite powder	Concrete mixtures were prepared by 0%,5%,10%, 15%, 20% and 25% by granite powder	Slump cone test, Electrical resistivity test,	After 28 days, 180 days, 365 days	Compressive strength, Splitting tensile strength, Flexural strength	The significant losses were observed in slump in addition the workability of the concrete decreases with the increases in the substitution rate due to high surface specific area and rough and angular texture of the GP waste. The denser matrix of the GP by-product and the better dispersion of the cement grains the early age (i.e. 7 days) compressive strength of the mixtures CGP 5%, CGP 10%, CGP 15% showed better gain in strength when compared to the CM.

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