

NATURE OF HIGH-PERFORMANCE CONCRETE FOR HIGHWAY PAVEMENT USING ALCCOFINE AND FLYASH

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ABSTRACT

Concrete is an important material in the construction industry. Currently, stone is recognized as one of the best building materials. However, the progress in the stone industry has brought with it many natural problems such as pollution, waste disposal, greenhouse gas (CO₂) emissions, vegetation and depletion of natural resources. Today, ordinary portland cement (OPC), cementitious materials and other materials are cheap. This improves the properties of the concrete.

However, for every ton of cement produced, approximately one ton of carbon dioxide is produced. Therefore, cement production plays an important role in the production of carbon monoxide, which accounts for about 5% of all CO₂ emissions. Developed countries such as the US and the UK are aware of these conditions and are also taxing climate change to reduce their carbon emissions. Therefore, the concept of sustainable development was introduced, which aims to use waste products to improve performance. These waste industries or products play an important role in the sustainable development of the concrete industry, providing the most suitable, economical and practical solutions for waste disposal, thus reducing the harm to the body.

Keywords: High performance computing, Alccofine, effectiveness, compressive strength

1. INTRODUCTION

HPC is used to protect heavy traffic on highways and roads due to its high strength, durability and low wear. HPCs are great tools for protecting the products they are designed for throughout their lifetime. Less fiber breakage can be observed with HPC mixes, but still requires good control. An early combination of strength is also used to reduce due to closure. A stone of high early power reaches a special power of 17.

it reaches 5 to 21 MPa in 24 hours or less compared to regular concrete. The additional cost of early-stage high-strength concrete is often offset by reusing old formwork, removing supports, and using precast structures. HPC is very popular around the world, especially in North America and Europe. The use of HPC in India started in the early 1990s. Kaiga Power Project, Konkan Railway Project, Mumbai Municipal Corporation Roads are examples of HPC implementation in India.

ADDITIVES USED IN HPC

Admixtures are ingredients other than water, aggregate, hydraulic cement, and fibers that are added to the concrete mix just before or during mixing.

There are two types of additives, chemical additives and mineral additives. When used correctly, they provide some of the advantages of concrete, such as improving the quality of concrete during the stages of mixing, handling, pouring and curing in adverse weather conditions, reducing the cost of building a house, avoiding certain situations during the mixing process and using certain products. A study by the National Ready Mixed Concrete Association reports that 39% of ready-mixed concrete manufacturers use fly ash and that at least 70% of the concrete produced contains reduced water.

Although the chemical composition of additives varies, it is important that all additives used in the mixture meet the requirements and that the necessary tests are carried out to evaluate the composition, as some additives have more than one function. Goods. The advantages of concrete admixtures are due to the following properties:

- Protection against freeze-thaw cycles that increases lifespan
- Reducing the water content in the mixture • Increasing the strength of the concrete
- Corrosion protection
- Set acceleration
- Increase in strength
- Setting retardation

- Crack control (shrinkage reduction)
- Liquidity
- Complete the upgrade

Mineral admixtures

Mineral admixtures are usually added to concrete in large quantities to improve its workability, improve its resistance to thermal cracking, alkali aggregate expansion and sulfate attack, reduce permeability, increase strength, and allow a reduction in cement content, thereby improving properties concrete mixes.

Mineral admixtures influence the character of hardened concrete by hydraulic or pozzolanic action. Pozzolans are cementitious materials and include natural pozzolans (such as volcanic ash used in Roman concrete), fly ash and Alccofine.

Ashes

Fly ash is a finely ground residue mixed with ground or powdered coal. It is usually thinner than cement and is usually a spherical glass containing remnants of hematite and magnetite, coal and some crystalline phases formed during cooling. Alkali-aggregate reaction to improve sulfate resistance. Because Portland cement concrete pavements are dependent on a large amount of cement, it is necessary to use fly ash as an economically important additive

Alccofine

Alccofine is a new generation Ultra Fine Low Calcium Silicate product made in India. Improves stone properties in new and hard phases. It is a product obtained by a controlled granulation process that creates a small gap between electronic products. Alccofine has beautiful vitreous properties that make it an excellent pozzolanic material. Alccofine has been shown to increase compressive strength, bond strength and damage, reduce permeability and help protect fittings from corrosion. Therefore, the use of Alccofine together with fly ash offers an interesting alternative, which can be called concrete strength and high performance. Alccofine can be used as a water softener to increase compressive strength by reducing the water required or as a performance material to improve flow.

2. OBJECTIVE OF THE RESEARCH

As explained in the introduction, one of the goals of this investigation is to conduct a comprehensive investigation to contribute to the development of HPC. The goal is to prepare a design mix of M60 for HPC. The following objectives would be achieved during this investigation:-

- To study the physical, chemical and structural properties of fly ash, Alccofine, cement and aggregates used in this study.
- Identify the behavior of HPC mechanical characteristics using additional fly ash and Alccofine cementitious material.
- Investigate the optimal dosage of fly ash and Alccofine by increasing the mechanical strength of the HPC mixture as a partial replacement for cement.
- Checking the rheological properties of fresh concrete.
- Design the thickness of rigid pavement using different strength of concrete using fly ash and alccofine.
- To study the possible advantages of using fly ash and alccofine in concrete for rigid roads.

3. LITERATURE REVIEW

In order to explain the purpose of the research project, a comprehensive literature review of relevant research projects, both experimental and theoretical, was conducted.

Zubair SM(2) examines the use of various fly ash, Alccofine and silica fumes. The fresh and hardened condition of the concrete was examined and strength tests were carried out on the cast at a certain date and the results of the analyzes showed that the compressive strength of the mixture containing Alccofine and fly ash was higher. Due to the small size of the microsilica powder, machinability was reduced, to achieve the same working strength, it is necessary to increase the amount of superplasticizer.

Tsai CT (3) Research on Cement Concrete Pavement Construction Using HPC and High-Performance Steel Fiber Reinforced Concrete (HPSFRC) on Taipei City Bus Lane Investigated the compressive and flexural strength behavior of HPC and HPSFRC at 3, 28 and 56 days of age.

This successful research laid the foundation for the creation of a transportation policy in Taipei City, which proposes to replace the asphalt road system on the bus line near the bus station with a cement concrete road. P.Muthupriya(4) Effectiveness of concrete behavior investigated by partial replacement of portland cement with metakaolin and fly ash.

The authors concluded that the increase in concrete strength was due to the pozzolanic reaction and the addition of metakaolin. Replacement with metakaolin and fly ash results in greater cohesion and less segregation and a denser microstructure of the concrete matrix that improves stability. It can also be seen that the water absorption of the tested samples is lower than that of normal building samples.

Reddy MVS (5) studied the HPC properties of M80 and M90 grades with and without the use of secondary cementitious materials (SCM). Good plastics should be used to check the work. Higher percentages of superplasticizer are required to improve performance, increase the level of minerals in the mix to achieve the desired mix and strength. Percentage of fly ash and metakaolin, HPC grades M80 and M90 have a very low total cost. Compared to conventional concrete, the SCM pozzolanic reaction improves the concrete pore structure and results in lower permeability compared to conventional concrete, again providing greater resistance to chloride ion penetration at high exchange rates.

Patil BB (6) presented a study using metakaolin with some suitable plastics by weight of cement and investigated various properties of M60 grade concrete such as workability, compressive strength and durability.

Using highly reactive metakaolin (HRM) improves performance and strength and increases chemical resistance. When the HRM content increased to 7.5%, the compressive strength increased slightly, but the excess content decreased the w/b ratio, thus retarding the pozzolanic activity, which caused a slight decrease in the compressive strength. The increase in compressive strength is due to the ability of sufficient HRM to react with calcium hydroxide, thereby increasing the hydration of the cement and forming a C-S-H gel.

Patel V and Shah N (7) provided detailed information on the development of high performance concrete in recent years, including the effects of minerals and chemicals used to improve properties. The paper also lists the product and related terms, including price, life and durability. It was concluded that the strength of concrete work depends on proper concrete mix design, production, casting and processing. In addition, Patil Shreekedar (8) investigated the compressive strength and workability of concrete mixes containing fly ash and microsilica and also processed microsilica and fly ash to M60 strength. Concrete containing microsilica and fly ash has been shown to have higher compressive strength, better stability and lower workability. The small size reduces gaps, which does not directly increase strength.

Durability is also increased due to strong compactness. The maximum amount of fly ash is 10% and modified microsilica cement 15%. Similarly, the resistance of magnesium sulfate and the effects of chemical problems are reduced. All this is due to its rich mineral composition. Therefore, M60 concrete with high values of compressive strength can be obtained. Patel YH (9) investigated the behavior of the concrete mixture by evaluating the compressive strength test (9) chloride strength, seawater tests and accelerated corrosion tests at 28 and 56 days. Studies showed that concrete mixed with Alccofine and fly ash is more compressive, while Alccofine makes the concrete stronger and reduces the effect of chloride diffusion. Compressive strength applied with Alccofine (8%) + fly ash (20%) reached 54.89 MPa and 72.97 MPa after 28 and 56 days. With the addition of Alccofine, there is lower weight and compressive strength in the chloride solution and seawater test. The effect of chloride attack is reduced due to the denser and less uniform concrete. The leachable calcium hydroxide is converted to an insoluble, non-filterable gel product. The impermeability of the rock is caused by the action of volcanic ash. In addition, the removal of $\text{Ca}(\text{OH})_2$ reduces the chloride concentration.

Filling pores with particles reduces the rapid chloride penetration rate (RCPT) of concrete. One coat is sufficient to protect the metal from corrosion, as weight loss in the electrolytic corrosion test is rapid due to pore filling and tight grain. Concrete with an RCPT value of 500 coulombs can now be produced. SonyD et al. (10) performed an experiment on HPC mixing Alccofine and fly ash. First, M80 grade concrete was prepared using local materials, then the effect of the difference between Alccofine and fly ash in the mixture was investigated, and the amount of Alccofine and fly ash in the mixture was well made, and the stone material was tested at different ages. especially. Different doses of Alccofine and PFA may alter efficacy. Alccofine was found to be superior to other slag materials in helping to increase compressive strength and flexural strength to some extent.

GENERAL

This section describes the equipment used in the experimental studies. Concrete is a simple homogeneous mixture of two components, aggregate (gravel or crushed stone) and cement (cement, water and entrapped or intentionally entrained air). Cement slurry usually makes up about 25% - 40% of the total volume of concrete and aggregate makes up 60% - 75% of the total volume of concrete. When the paste is mixed with aggregate, the chemical reaction of the ingredients binds the aggregate as it solidifies into a rock-like mass. This material is called rock. The quality of concrete depends on the quality of slurry and the quality of hard concrete on the ratio of water and cement. Using less water will make the concrete better if it can be properly reinforced. Although little water makes it difficult to mix, this mixture is more economical and can be used with good vibrations to solve problems. The materials used to produce research are cement, aggregate, fly ash, Alccofine, superplasticizer, water, etc.

4. HIGH PERFORMANCE CONCRETE AND ITS COMPONENTS

As already mentioned in the definition of HPC, it exhibits better properties than normal concrete. According to the Federal Highway Administration (FHWA), HPC is defined as concrete that exhibits improved impermeability, increased durability, and accelerated strength gain over conventional concrete. HPC can be divided into different parts based on strength, which is described in Table below.

Table:1 Classification of HPC on Strength Basis

Compressive Strength (MPa)	High Performance Class
50	I
75	II
100	III
125	IV
150	V

CEMENT

There are generally three types of cement available in the market (33,43,53). JK Lakshmi Grade 43 Ordinary Portland Cement is used in HPC as per IS:8112-1987(41). The physical and chemical properties of cement are shown in Table below.

Table:2 Physical Properties of OPC43 Grade Cement

S.No.	Properties	Values
1	Sp. Gravity	3.15
2	Consistency	31%
3	Initial setting time	75 min
4	Final setting time	165 min
5	Compressive strength (MPa) at 3 days	26.3
	Compressive strength (MPa) at 7 days	34.9

Table:3 Chemical Properties of Cement

S.No.	Chemical Properties	Value (%)
1	SiO ₂	23
2	Al ₂ O ₃	4.2
3	MgO	0.20
4	Fe ₂ O ₃	1.2
5	CaO	63

FLY ASH

Fly Ash is the industrial by-product produced by electrostatic process from flue gases of power station furnaces fired with coal. According to ASTM C 618-99(41), FA is classified into 2 classes i.e. Class F and Class C. The characteristic of Fly ash showing pozzolanic property similar to cement has motivated the use of Fly Ash as partial replacement of cement in concrete. The specific gravity of locally available flyash used in this study is 2.24.

ALCCOFINE

Alccofine is new generation product with ultrafine size having less calcium silicate content, easily available in India. It has characteristics to improve the performance of concrete in both fresh and hardened phases. Alccofine shows better properties than other admixtures used in India. Alccofine forms C-S-H gel by consuming calcium hydroxide which results in denser structure and gain strength. The specific gravity of Alccofine is 2.86 and is used to increase workability. Various properties of Alccofine is presented in Table. The Alccofine 1203 is used in the experiment from Ambuja cement outlet as shown in Figure.

Table:4 Physical and Chemical Properties of Alccofine

Chemical Analysis	Mass%	Physical Analysis	Values
CaO	32-34	Bulk density	600-700kg/m ³ 12000cm ² /gm
Al ₂ O ₃	18-20	Surface area	120000cm ² /gm
Fe ₂ O ₃	1.8-2	Particle shape	Irregular
SO ₃	.3-.7	Particle size, d ₁₀	<2 μ
MgO	8-10	d ₅₀	<5 μ
SiO ₂	33-35	d ₉₀	<9 μ



Figure:1 Alccofine from Ambuja Cement

AGGREGATE

Concrete consists of aggregates mixed with cement paste produced from hydration of cement. Some admixtures are used to enhance the concrete properties e.g. workability, to retard setting time, to achieve greater compressive strength, and to resist from unwanted materials.

Two types of aggregate used in concrete are coarse aggregate and fine aggregate.

FINE AGGREGATE

Material passing through an IS sieve 4.75mm is called as fine aggregate.

The locally available materials confirming to Zone-II grade IS 383-1970(42) is used as fine aggregate as shown in Figure. Tests of materials have been according to IS Codes and the results are as discussed in Table.

Table:5 Physical Properties of Fine Aggregates

Sieve analysis for F.A(sample=2kg)			
IS Sieve size(mm)	Retained aggregate(gm)	% retained	Cumulative % retained
4.75	162	8.1	8.1
2.36	252	12.6	20.7
1.18	432	21.6	42.3
0.6	378	18.9	61.2
0.3	290	19.5	80.7
0.15	278	13.9	94.6
Fineness modulus		3.076	
Grade Zone		II	
Specific gravity		2.646	



Figure: 2 Locally available fine aggregate

COARSE AGGREGATE

Materials retained on IS sieve 4.75mm is called as coarse aggregate. To produce high strength concrete, it is very important to select proper material. This is investigated from previous research that the use of small coarse aggregate leads to the increase of concrete strength in comparison to the larger aggregate as smaller aggregate is stronger than the larger ones. So, locally available aggregates of maximum 10mm size is used. Testing of materials is done according to IS Codes procedures and the results are shown in the Table. Figure above shows coarse aggregate used in experimental work.

Table:6 Physical Properties of Coarse Aggregates

Sieve analysis for C.A(sample=2kg)			
IS Sieve size(mm)	Retained Aggregate (Kg)	% retained	Cumulative % retained
10	0.192	9.9	9.9
4.75	1.54	56.73	86.63
2.36	0.267	13.37	100
Fineness modulus		5.96	
Specific gravity		2.69	
Water absorption(%)		0.905	
Crushing value (%)		19.1	
Impact value (%)		12.02	
Los Angeles abrasion value (%)		21.58	



Figure:3 Locally available coarse aggregate of 10 mm size

SUPERPLASTICIZER

Non-toxic conplast- SP430 PQC, a concrete superplasticizer based on Sulphonated Naphthalene Polymer is used as a water-reducing admixture and to improve the workability of admixed concrete as shown in Figure. Conplast SP430A1 (QCDA-579) has been specially formulated to give high water reductions up to 25% without loss of workability or to produce high quality concrete of reduced permeability. Specific gravity of superplasticizer is 1.23 as reported by manufacturer.



Figure: 4 Conplast SP430 from FOSROC brand

WATER

Water is an important ingredient in preparation of concrete. Potable water free from deleterious materials, odorless, normal appearance oils, salts with normal temperature is used mixing and curing in this experiment.

MIX DESIGN FOR HPC

This research study depends upon two factors to produce HSC, i.e. the use of SCMs and variation in W/C ratio in HPC. This research study is commenced by identifying the optimum concrete mix design of HPC using SCM. Proportioning of mix is carried out as per guidelines given in ACI 211.4R-08(46) given in Table. The water binder ratio for these mixes used are taken low. The final amount of materials (kg/m³) taken after several controlled mixed trials in the concrete and results of these samples are given in following Table. Six cube samples each for 7 days and 28 days testing are casted and designated M1 to M6. The slump value of this control mix is found to be 32 mm. the compressive strength at 7 days and 28 days are given in Table and graph is plotted as shown in Figure.

Table: 7 Mix Proportion

Materials	Quantity (Kg/m ³)
Cement	668
Fly ash	135
Coarse aggregate	1044
Fine aggregate	585
Water-binder ratio	0.25
Superplasticizer (% of binder)	3%

Table: 8 Compressive strength of controlled mixes at 7 days

Designation	Compressive Strength Using Rebound Hammer at 7 Days	Compressive strength, fck at 7 Days (MPa)	Compressive strength, fck at 28 days (MPa)
M1	45.8	44.8	62.8
M2	48.4	47.6	65.7
M3	47.1	54.6	60.3
M4	40.8	43.2	64.8
M5	43.8	44.4	67.7
M6	40.4	50.32	61.9

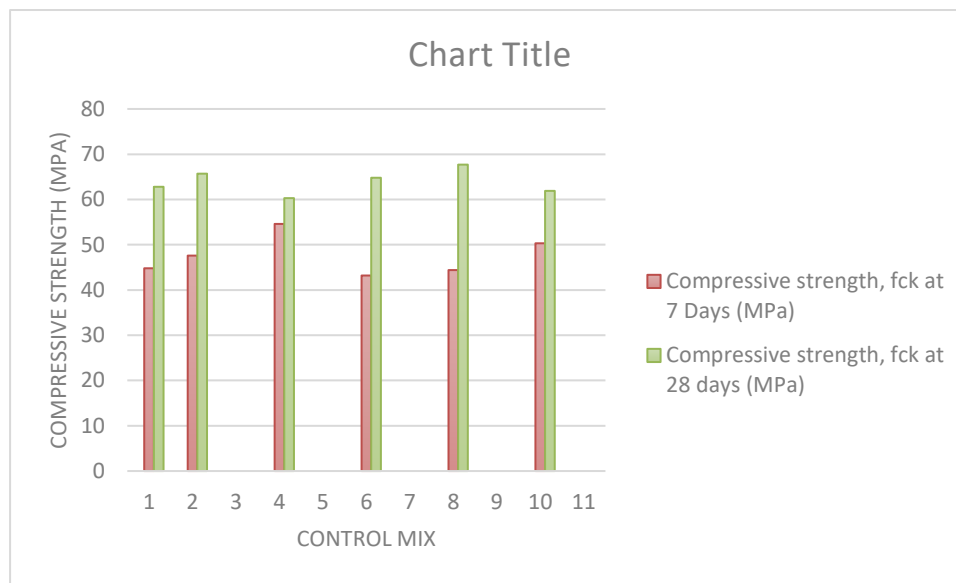


Figure:5 Compressive strength bar chart

5. CONCLUSIONS

The performance of concrete was a step forward in construction technology. Due to its superior performance, the use of HPC has spread worldwide. Due to its performance in new and cured states, it attracts new technology researchers, application engineers and many industries such as cement and composite materials. Increasing productivity, reducing labor requirements and increasing productivity are also important. Due to the recent needs of the construction industry, the demand for HPC development is fast.

The main objective of each design method is to determine a suitable and economical combination of properties that can be used for the initial testing of concrete, approaching a good balance between low cost and the various needs of concrete. . Spreading the mix evenly creates a mix that only needs to be changed more or less to suit the needs of the function. Experimental studies were conducted to check the preparation and acceptance of the composite design. The mix was made according to ACI's material-based mixing method, mixing HPC grade M60 with a percentage of fly ash and Alccofine. Evaluate the rheological properties of the as-new composite design to determine the suitability of the concrete design.

Compressive strength, splitting tensile strength and flexural strength were calculated with different volumes of fly ash and Alccofine at 28 days.

Laboratory tests including HPC mechanical and rheological tests were performed. The main lines of these articles are:

- High performance concrete is treated as SCM by mixing with fly ash and Alccofine. These improvements reduce CO₂ emissions and make it more environmentally friendly.
- Considering all the available SCMs, good results were found for the mixture containing fly ash and Alccofine in terms of the compressive strength of the different mixtures. The minimum and maximum compressive strengths obtained after 28 days of curing were 59.89 N/mm² and 66.53 N/mm².
- With an Alccofine content of up to 12%, the compressive strength of concrete increases. Therefore, based on research, it was determined that it is possible to produce concrete with a compressive strength above 60 MPa by mixing Alccofine and fly ash as SCM in a ratio of 0.25 w/b. The use of fly ash and Alccofine in combination has shown a significant improvement in the strength properties of HPC.
- The combination containing fly ash and Alccofine showed a significant improvement in bending properties. The maximum obtained bending strength is 7.35 MPa.
- It was found that the minimum and maximum separation tensile strength of 3 was achieved at 28 days of curing. 94 N/mm² and 5.55 N/mm². The high strength obtained by using SCM reduces the maintenance costs of the structure.

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