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STUDY OF STRENGTH AND WORKABILITY OF HIGH VOLUME FLY ASH CONCRETE

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Abstract - *The utilization of High Volume of Fly Ash in concrete is gaining significance and is considered as a sustainable option for many concrete constructions. According to various test conducted the results show that, HVFA concrete has lower strength at early ages but at later age HVFA concrete shows continuous increase in strength properties. HVFA Concrete exhibits comparable costs, increased strengths and enhanced workability. Thus, the HVFA concrete is more suitable for warm weather sand where early strength is not essential. This project shows workability and strength properties of High Volume Fly Ash Concrete.*

The construction techniques are progressive with specialise in high strength, dense and uniform surface texture, additional reliable quality, improved sturdiness and quicker construction. This project shows the development of High Volume Fly Ash concrete for construction with reference to its predecessors like High Strength Concrete (HSC) and High Performance Concrete (HPC).

It was observed that HVFA concrete developed the strength at lower rate as compare to normal concrete. At age of 56 days the strength of HVFA concrete is at par with the strength of normal concrete.

Key Words: High Volume Fly Ash Concrete, Water cement ratio, Strength and Workability.

1. INTRODUCTION

The application of concrete in construction is as recent because the days of Greek and roman civilization. except for varied reasons, the concrete housing industry isn't sustainable. It consumes a lot of virgin materials and the principle raw material of concrete i.e. cement is responsible for greenhouse gas emissions causing a threat to environment through global warming. The production of Portland cement releases large amounts of CO_2 into the atmosphere, and because this gas is a major contributor to the greenhouse effect and the global warming of the planet, the developed countries are considering very severe regulations and limitations on the CO_2 emissions. In view of the global sustainable development, it is imperative that supplementary cementing materials be used to replace large proportions of cement in the concrete industry, and the most available supplementary cementing material worldwide is fly ash, a by-product of thermal power stations. To significantly increase the employment of ash that's otherwise being wasted, and to own a major impact on the assembly of cement, it's necessary to advocate the utilization of concrete which will incorporate massive amounts of ash as a replacement for cement. Therefore, the trade has seen numerous varieties of concrete in search of an answer to sustainable development. Infrastructural growth has witnessed many forms of concrete like High Strength Concrete, High Performance Concrete, Self Compacting Concrete and the latest in the series is High Volume Fly Ash (HVFA) Concrete. The paradigm has shifted from one property to other of concrete with advancement in technology.

Cement is a main ingredient of concrete or mortar. The excess cement content in concrete leads to cracking due to drying shrinkage or early age thermal cracking and increased risk of damage due to alkali silica reaction. Increased cement does not add value to concrete. High the cement content, higher is the strength, is not true. In fact most of the concrete structure constructed around the world uses decreased quantity of cement by replacing a part of cement with fly ash cement concrete to enhance the properties of concrete such as reduction in heat of hydration, increasing strength, durability etc. High Volume fly ash Concrete mix contains lower quantities of cement and better volumes of fly ash (up to 60%). From the literature available, it is found that the proportions of Fly Ash in concrete can vary from 30% - 80% for various grades of concrete.

In this project HVFA concrete was produced for 3 grades which are M20, M30 and M40. Mix designed was carried out as per IS method (IS 10262:2009). To increase workability of HVFA concrete superplasticizer (SNF based) was used. compressive strength, Split Tensile Strength, workability test were carried out.

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2. LITERATURE REVIEW

T. Ch.Madhavi, L. Swamy Raju, Deepak Mathur studied Fly ash, is one of the residues generated during combustion of coal and comprises of the fine particles that rise with the flow gases. Major components of Fly ash include, silicon dioxide (SiO) and calcium oxide (CaO) Al_2O_3, Fe_2O_3. However, the parts of fly ash vary significantly, relying upon the coal being burned. fly ash acts as a pozzolona when used as a supplementary binding material in concrete. Pozzolon as are those materials which in itself do not possess any cementitious value but in its finely divided form exhibits cementitious properties when combined with Calcium Hydroxide in the presence of moisture. The Pozzolon chemically react with Calcium Hydroxide at room Temperature to form cementitious compounds. Similar to OPC, pozzolanic hydrate in water but do not produce the required strength as OPC and gains strength over longer period of time. Fly ash which is a finely divided amorphous alumino-silicate powder reacts with the calcium hydroxide released by hydration of cement and produces various calcium–silicate hydrates (C-S-H) and calcium aluminum hydrates.

In High Volume Fly Ash (HVFA) Concrete, increase in the quantity of cementitious C-S-H phase and calcium aluminum hydrates improves the long term Production of Portland cement produces large amounts of carbon dioxide. About one ton of carbon dioxide is released into the environment during the production of 1 ton of clinker besides SO_2 and NO_2 emissions.

Aires Camões, Rui Miguel Ferreira found that in order to guage the chance of manufacturing high performance-low value concrete, laboratory tests were performed on specimen of concrete with increasing binder contents and cement replacements by ash. The compressive strength tests indicate that concrete with 65 MPa strength at 56 days will be created victimization B500 with up to 20% cement replacement and B600 with up to 40% cement replacement. This strength was obtained with the specimens cured in water till 56 days. If these set conditions weren't maintained during now, certainly the strength would decrease. the opposite mixes studied didn't achieve this level of strength at this age. it's noted that the potency of the binder, i.e. the amount required for every 1 MPa increase in strength compared to B400, will increase with increasing set time. Moreover, it absolutely was noted that the optimum quantity of cement replacement will increase with set time and binder content. The addition of FA = 60% permits the getting of concrete with significantly lower mechanical characteristics, as compared of the others. However, regarding the low quantities of cement existing within the combine, those could also be thought-about as concrete with an honest economic performance.

Harsha G Sri, Binimol Babu says the utilization of fly ash in concrete as partial replacement of cement is gaining immense importance today, mainly on account of the improvement in the long run sturdiness of concrete combined with ecological edges. Technological enhancements in thermal power station operations and fly ash assortment systems have resulted in up the consistency of ash.

N. G. Patoliya, Dr. Anurag Misra learned that percentage of water absorption of concrete mix falls with decrease in water cement ratio. An increase in the amount of fly ash in the mix also decreases its water absorption. Up to 50% fly ash replacement indicated approximately same compressive strength as that of control mix, but the water absorption was substantially lower. The increase in compressive strength with lower water content is visible in 28 days. Though the early strength of fly ash concrete was lower. However, compressive strength of fly ash concrete is almost equal or little less than that of the control mix but it can be expected that by 90 days after casting it will be higher than the compressive strength of the control mix.From all the results obtained it can be concluded that 0.475 water cement ratio and 40% fly ash is the optimum dose for the concrete mix under observation, given other conditions remain the same.

Antoni, Antoni & Widianto, Alvin & Wiranegara concluded that variation in ash quality affects the contemporary and hardened properties of mortar or concrete. Higher workability and longer setting time was found at higher ash replacement ratios. However, because of content variation, the optimum magnitude relation has to be determined for every cargo. The optimum vary of ash replacement magnitude relation was found to be around 20–40%. Some mortar specimens incorporating ash might have higher compressive strength than those of the management specimens with none ash, at replacement ratios of 30% and 40%, and mortar compressive strength of 42 MPa was still possible with replacement magnitude relation of 50%.

Yoo, Sung-won & Choi, Young & Choi, Wonchang say that the elastic modulus values of the HVFC combine were under those of the OPC combine. This outcome was because of the various water-to-binder quantitative relation and low unit weight of the HVFC mixture that's caused by the low relative density of its inherent ash compared to the burden of cement. Meanwhile, the compressive behavior of the HVFC and OPC columns was similar with relevancy crack morphology and crack progression. the most load-carrying capability of the columns with HVFA tented decrease up to 14 % compared to the columns with OPC. The RC column parts created with HVFA behaved equally, for sure, supported the equation wont to predict OPC column behavior. Existing style standards can guardedly predict the last word capability of HVFC columns.

Baert, Gert & Belie, Nele & Poppe stated that fly ash has a positive effect on chemical aggression. Concrete with high-volume fly ash performed better in lactic/acetic and sulphuric acid during accelerated experiments. The chloride migration coefficients during CTH tests were significantly lower for concrete with cement replacement by fly ash than for the control concrete, except for the mixture with 60% replacement of the cement (which used a different type of fly ash). Not only the level of cement replacement, but also the type of fly ash determines the performance of concrete in these tests. The good results can be explained by the dense structure of these concrete types. The resistance to frost– thaw cycles was similar for fly ash and reference concrete all without the use of air entrainment agents.The carbonation depth after 9 weeks in a 10% CO2 environment increased with fly ash content. High volumes of fly ash also decreased significantly the resistance against the combined action of frost and de-icing salts (3% NaCl solution).

Kumar, Binod & Tike, G. & Nanda state at 90 days and beyond, the compressive strength of the mixtures with 20, 30, and 40% fly ash was more, whereas the strength of mixtures with 50 and 60% fly ash was less than that of control mixtures at each w–cm ratio. The maximum strength developed in the mixture containing 60% cement and 40% fly ash. A similar trend was observed for flexural strength of the mixtures. The percentage increase in the compressive strength of all the mixtures containing fly ash, at the age of 90 days and more with respect to the strength at 28 days, was higher than that of control mixtures. The maximum increase was observed in the mixture containing equal amounts of cement and fly ash. The percent increase in the strength decreased with decreasing w–cm ratio of the mixture.The abrasion resistance of all the fly-ash-admixed mixtures was less than that of the control mixtures at each w–cm ratio. It decreased with increasing fly-ash content and increased with decreasing w–cm ratio of the mixture. In general, the abrasion resistance of concrete increased with increasing compressive strength.

Atiş, Cengiz studied that HVFA concrete attained satisfactory or higher compressive and tensile strength compared to OPC concrete. HVFA concrete mixtures created with optimum water content showed considerably lower shrinkage values compared to OPC concrete. Concrete created with superplasticizer showed higher shrinkage than concrete created while not superplasticizer ,with its high strength and low shrinkage properties, HVFA concrete becomes a attainable different to OPC concrete used for road pavements applications and huge industrial floors.

According to Mochmad Solikin and Budi Setiawan concrete is by far the most widely used construction material worldwide. Concrete consumes a large amount of virgin materials. Second, the principal binder in concrete is cement, by these production the greenhouse gas is increased which causes effects the global warming and climatic changes. The supplementary cementing materials like natural materials, by-products or industrial wastes are used. The compressive strength test to be conducted to justify the strength properties of HVFA concrete.

The present study is carried out to determine the effect of high volume fly ash concrete mechanical properties. Different types of concrete mixes were prepare that consist of 40%, 50%, 60% and 70% of class F fly ash by weight of cement which where compare with plain concrete. The mechanical properties of high volume fly ash concrete are evaluated for 7, 28 and 56 days.

3. MATERIALS REQUIRED

3.1 Cement

It was made with Ordinary Portland Cement of grade 53.

3.2 Fine Aggregate

According to 383:1970 the fine aggregate is classified into four different zone, that is Zone-I, Zone-II, Zone-III, Zone-IV. The fine aggregate used in this project is belongs to Zone –II.

3.3 Coarse Aggregate

In this project work the coarse aggregate (crushed basalt) passing from 12.5mm, retained on 10 mm has been used.

3.4 Admixture

Maserrheobuild 825GJ obtained from BASF chemicals, is a high performance superplasticizer intended for applications where high water reduction and long workability retention are required , and it has been developed for use in self compacted concrete, pumped concrete , concrete requiring long workability retention and high performance concrete. This superplasticizer is Sulphonated naphthalene Formaldehyde condensates (SNF).

3.5 Fly Ash

In this research, class F fly ash was obtained.

3.5.1: The chemical and physical properties of class F fly ash

Properties	Unit	IS-3812 Specifications	Pozzocrete 100
Fineness– Specific surface by Blaine's method	M^2/Kg	320	637
ROS # 350 (45 MIC) Max.	%	34	0.03
Moisture Content (Max.)	%	2	0.21
Loss on Ignition (Max.)	%	5	0.77
$Sio_2 + Al_2O_3 + Fe_2O_3$	%	70 Minimum by mass	93.19
SiO_2	%	35 Minimum by mass	58.69
MgO	%	5 Minimum by mass	1.46
SO_3	%	3.00 Maximum by mass	0.50
Na_2O	%	1.5 Maximum by mass	0.43
Total Chlorides	%	0.05 Maximum by mass	0.022

4. MIX DESIGN

Mix Proportion for M20 grade of plain concrete is 1:1.49:2.62.

Trials were conducted on this mix proportion and some changes were made to obtain desired strength and workable concrete. The final mix proportion used was 0.45:1:1.74:3.15 for normal concrete and mix proportions for HVFA concrete use were 0.45:1:2.04:.2.71.

Similarly for M30 grade of normal concrete 0.4:1:1.54:2.76 & mix proportion for HVFA concrete use were 0.4:1:1.51:2.01.

For M40 grade of normal concrete 0.38:1:1.62:2.39 & mix proportion for HVFA concrete use were 0.38:1:1.60:2.11.

5. TESTS ON CONCRETE

5.1 Tests on Fresh Concrete

i. Slump Cone Test
ii. Compaction Factor Test

5.2 Tests on Fresh Concrete

iii. Compressive Strength Test
iv. Split Tensile Strength Test

6. APPLICATIONS ON WORKABILITY OF HIGH VOLUME FLY ASH CONCRETE

With associate optimum replacement level of 40% to 60% ash, the concrete will be employed in large concrete structures to cut back the heat of hydration and thermal cracking. If the items like footings, walls, columns and beams don't need early age strengths, then HVFAC will be used with a minimum of seven days curing. If seven days solidifying can't be provided, lower amount of ash needs to be used.

Fly ash contents of 40% to 50% can be used for slabs that need a mere broom finish, however that for slabs that need trowel finishing the fly ash content needs to be reduced to regarding 25% to 50%, therefore on avoid unwanted delays in finishing.

6.1 PAVEMENT CONSTRUCTION

6.2 DAM CONSTRUCTION

7. RESULT AND DISCUSSION

For M20 grade of HVFA concrete 80.60% compressive strength as that of normal concrete is achieved at 7days curing and after 28 days 86.50% compressive strength is achieved. The maximum compressive strength is achieved in 56 days 96.93% as compared to normal concrete.

For M30 grade of concrete HVFA 75.47% compressive strength as that of normal concrete is achieved at 7days curing and after 28 days 86.79% compressive strength is achieved. The maximum compressive strength is achieved in 56 days 96.46% as compared to normal concrete.

For M40 grade of HVFA concrete 86.67% compressive strength as that of normal concrete is achieved at 7days curing and after 28 days 87.24% compressive strength is achieved. The maximum compressive strength is achieved in 56 days 94.30% as compared to normal concrete.

8. LIMITATIONS ON WORKABILITY OF HIGH VOLUME FLY ASH CONCRETE

i. The setting time is more.
ii. The strength development rate is slow.
iii. The early age strength is less as compared to standard concrete.
iv. The time required for construction is more.
v. In cold weather conditions it is difficult to use.
vi. The resistance to carbonation is low.

9. CONCLUSIONS

- High Volume Fly ash Concrete is more sustainable concrete compared to conventional concrete as it reduces the usage of cement and also reduces environment pollution. HVFA concrete performs well at a later stage than at an early age.
- The compressive strength of HVFA concrete at 7 days is much less than normal concrete. The difference reduces at later ages.
- The split tensile strength of HVFA concrete follows the same trend as that of compressive strength.
- The 60% replacement of cement with fly ash shows good compressive strength for 28 days. At 56 days the strength obtained is at par with normal concrete.
- Fly ash contents of up to 60% 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.
- The fly ash makes concrete more impermeable and denser as compared to Ordinary Portland Cement. The long-term strength (56 days and above) of fly ash concrete is at par with plain concrete. The Pozzolanic material in fly ash react with calcium hydroxide liberated by the hydrating Portland cement and forms cementitious compounds generally known as Calcium Silicate hydrate (C-S-H) gel and hence the development of strength is slower in HVFA concrete.

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