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Comparative Analysis of Mechanical Properties of Fly-Ash Concrete with Conventional Concrete

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Abstract

Objective: To analyze and study various mechanical properties of fly ash concrete with that of convention concrete and also to check at what percentage of fly-ash gives better and economic result. **Methods:** The cubes were being tested for their compressive strength using a compression testing machine as per the mix design. USPV is a recognized non-destructive test which is done to evaluate the quality of given concrete sample. It allows us to assess the condition of the ancient structures as well as maintain the quality of new structures. Fire test is carried out to check how concrete withstands all the different types of loads even with the increase in the temperature. **Findings:** The compressive strength of concrete will increase up to 25% replacement of fly ash and then will subsequently decrease. The compressive strength also reduces if the cement used is old. The workability of the mix increases with the increase in fly ash content even when the water cement ratio is kept constant. USPV Test analysis shows us that there is a better orientation of concrete mix particles with the increase in fly ash content. The packing of lime-fly-ash concrete cubes was found to be best for the ratio of 60% cement and 20% of lime and fly-ash each. **Improvement:** The use of fly ash in concrete is not a new practice and though much work has already been done in this field, it is a field of continuing research. Also to study the use of other chemicals as a binder material in fly ash concrete, for e.g. sodium silicate, sodium hydroxide etc. We can also study the effect of the addition of various admixtures in fly ash concrete. And also, study the effect of the addition of rice husk in fly ash concrete.

Keywords: Analysis, Comparison, Conventional Concrete, Fly-ash Concrete, Mechanical Properties

1. Introduction

As we all know construction industry is growing at a very fast rate and has grown in multi folds in past few decades with more and more powerful and efficient building tools and methods. With the growing demand and consumption of cement comes one of the major global problems that are global warming. The studies have shown that cement industry contributes a considerable amount of release of Carbon-di-oxide (CO_2) in the atmosphere which approximately adds 7% of the world total carbon-di-oxide emission. Researchers have also demonstrated that high dosage levels (40% to 60%) fly-ash can be used in structural applications and to produce concrete which will be having durability and good mechanical properties[1]. Adapted from a recent paper by Malhotra[2], typical component materials for different higher performance level in structure by controlling the water content which is most essential because the quantity of water is being varied within a narrow range between 100-130 kg/m^3 and by combining of more tools like super plasticizing admixture, fly ash of higher quality, and well-graded aggregate. The main focus is on some of the macroscopic properties such as the behaviour of concrete when a compressive load is applied, Ultra Sonic Pulse Velocity (USPV) Test and Fire Test.

2. Materials and Methods

2.1 Materials

Ordinary Portland Cement which is being mentioned in IS 12269-1987 was used. Clean, well-graded, natural river

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sand which is locally available and having fineness modulus of 2.89 which is mentioned in IS 383-1970 was used as fine aggregate.

2.2 Fly-ash

Fly-ash bears a close resemblance to volcanic ashes. These volcanic ashes were used in the production of hydraulic cement. Nowadays, instead of volcanoes, the fly-ash primarily comes from the blast furnace or coal-fired thermal power plants. Fly ash is a very fine, grey powder with glassy particles. It is produced as a waste material in the process of generating electricity in coal-fired power stations. The properties of fly-ash depend on various conditions such as Nature of parent coal, Method of combustion, Type of Storage and Type of a method for handling.

2.3 Lime

Lime generally pertains to the products which have been derived from burning of limestone. For example, quicklime and hydrated lime. Quicklime is obtained from burning of limestone whereas hydrated lime is obtained when water is added to this quicklime. It is a sedimentary rock which is naturally occurring in abundance. It is usually obtained from mines and quarries.

Lime was used as the primary binder for mortars and plasters since thousands of years. But the examples of damage to historic buildings due to modern plasters and cement mortars which have led to its resuscitation. The major consumption of limestone is in cement and steel industry comprising a total of 92 percent. Its usage is dependent on the deposit quality of the limestone. Limestone is being quarried to fulfill the needs of the construction industry.

2.4 Tests

2.4.1 Compressive Strength Test

The cubes were then tested for their compressive strength using a compression testing machine. As the mix design are checked to give us the desired results for the 7 days strength of the cubes so the same mix design are taken for the other cubes. Now the cubes with different proportion of cement, lime and fly-ash are cast. Due to the temperature conditions and presence of lime these cubes took about 48 hours to get dried off and are then taken are being out of the moulds[3]. These cubes are to be also cured for 7 days and then tested in the compression testing machine for their 7 days compressive strength. The weight and internal packing of the all the cubes are also to be noted before their compressive strength is being checked[4].

2.4.2 Ultra Sonic Pulse Velocity (USPV) Test

USPV is a recognized non-destructive test which is done to evaluate the quality of given concrete sample. It allows us to assess the condition of the ancient structures as well as maintain the quality of new structures. It is used to assess the integrity of the concrete and also helps in detecting the depth of cracks which are present on the surface of the concrete.

The test usually consists of the time taken by the ultrasonic pulse to travel through the concrete being tested. When the quality of concrete is good, a higher value of velocity is obtained[5].

2.4.3 Fire Test

One of the major advantages of concrete over other building materials is its fire-resistance property. However, the design of concrete structures for fire effects is still required. They should still be able to bear and withstand all the different types of loads even with the increase in the temperature. It has been noted that with the increase in temperature, the modulus of elasticity for both steel and concrete decreases along with the strength which is a major factor in the design of structures.

Change in the properties of concrete corresponding to high temperatures which are dependent on the type of coarse aggregates to be used in the mix[6]. The types of aggregates which are commonly used are as given below:

Table 1. Giving values of compressive strength for cubes of different ratio

Composition	**M25**	**70:15:!5**	**60:20:20**	**50:25:25**	**34:33:33**
Not Heated Cube	16.32	10.2	16.32	11.22	9.18
Heated Cube 1	14.29	8.16	15.3	10.2	7.14
Heated cube 2	14.29	9.18	15.3	9.18	7.14

Carbonate aggregates- including dolomite and limestone. The strength of concrete with carbonate aggregates retain most of their strength at about 1100-1200^{0}F. Siliceous aggregates- including sandstone and granite[7]. The strength of concrete with siliceous aggregates is reduced to half at around 100-1200^{0}F. Lightweight aggregates- including clay and slate. This type of concrete has insulating properties and has better fire resistance properties.

3. Result and Discussions

There are 10 samples; with two each of 100% cement, 70% cement, 60% cement, 50% cement and 33% cement were tested. The difference in the compressive strengths before and after the fire test was formed the basis of their degree and extent of fire resistance. The early strength gain of the concrete increases when the cement content in reduced to 60 % of original cement content of M25 and 40% cement is replaced by 20% lime and 20% fly-ash. This variation is strength could be due to the formation of more C-S-H gel formed at his specific percentage of the mix. It is assumed that when the content of cement is 60%, the free lime formed and lime added are in the right proportion with the fly-ash that they combine to the maximum extent and form maximum C-S-H gel and hence better strength is noted (Table 1). The fire test results show almost the same variation in all the cubes irrespective of the ratios. There was a decrease in strength of about; 1.5 to 2 N/mm^2 in the compressive strength, for an exposure time of 30 minutes (Figure 1). The USPV test showed better-packed cubes better compressive strength results. The packing of lime-fly-ash concrete cubes was found to be best for the ratio of 60% cement and 20% of lime and fly-ash each (Table 2–6).

Table 2. USPV Test Table for M25

Cube Number	Path Length(in mm)	Time(micro Sec)	Velocity
1	150	34.2	4.38
2	150	33.6	4.46
3	150	34.1	4.39

Table 3. USPV Test Table for ratio 34:33:33

Cube Number	Path Length(in mm)	Time(micro Sec)	Velocity
1	150	35.5	4.22
2	150	34.4	4.36
3	150	34.6	4.33

Table 4. USPV Test Table for ratio 50:25:25

Cube Number	Path Length(in mm)	Time(micro Sec)	Velocity
1	150	35.2	4.26
2	150	35.2	4.26
3	150	33.8	4.43

Table 5. USPV Test Table for ratio 60:20:20

Cube Number	Path Length(in mm)	Time(micro Sec)	Velocity
1	150	32.5	4.61
2	150	31.4	4.77
3	150	32.9	4.56

Table 6. USPV Test Table for ratio 70:15:15

Cube Number	Path Length(in mm)	Time(micro Sec)	Velocity
1	150	33.7	4.45
2	150	32.3	4.64
3	150	33.9	4.42

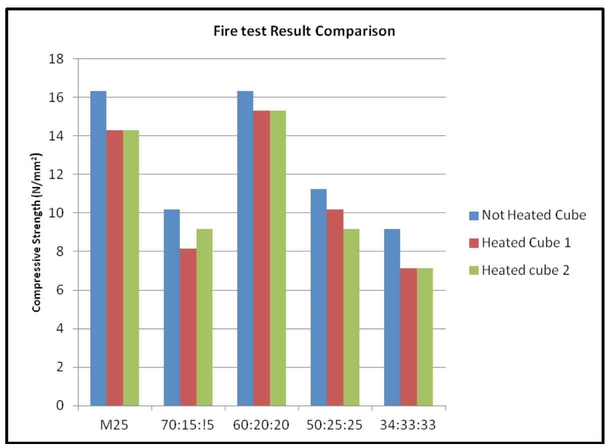

Figure 1. Fire test comparison.

4. Conclusion

The following conclusions can be drawn:

i) The compressive strength of concrete will increase up to 25% replacement of fly ash and then will subsequently decrease.

ii) The compressive strength also reduces if the cement used is old.

iii) The workability of the mix increases with the increase in fly ash content even when the water cement ratio is kept constant.

iv) USPV Test analysis shows us that there is better orientation of concrete mix particles with the increase in fly ash content.

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