Environmental Challenges

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Correspondence Date	Letter	Recipient	Manuscript Number	Article Title
08/04/2021 03:26:49	Reviewer Notification of Reject Decision	Astrilia Damayanti	ENVC-D-21-00713	Characterisation and application of synthetic flyash aggregate as a highway construction material in India
08/03/2021 20:37:27	Reviewer Thank You	Astrilia Damayanti	ENVC-D-21-00713	Characterisation and application of synthetic flyash aggregate as a highway construction material in India
07/30/2021 02:17:56	Reviewer Instructions and Due Date	Astrilia Damayanti	ENVC-D-21-00713	Characterisation and application of synthetic flyash aggregate as a highway construction material in India
07/30/2021 02:11:55	Reviewer Reminder - Before Agree or Decline	Astrilia Damayanti	ENVC-D-21-00713	Characterisation and application of synthetic flyash aggregate as a highway construction material in India
07/25/2021 16:54:38	Reviewer Invitation	Astrilia Damayanti	ENVC-D-21-00713	Characterisation and application of synthetic flyash aggregate as a highway construction material in India
07/25/2021 16:52:30	Proxy Registration Notice to Registrant	Astrilia Damayanti		

Date:	Aug 04, 2021
To:	"Astrilia Damayanti" astrilia.damayanti@mail.unnes.ac.id
From:	"ENVIRONMENTAL CHALLENGES" support@elsevier.com
Subject:	Review for Environmental Challenges - manuscript rejected

Manuscript Number: ENVC-D-21-00713
Characterisation and application of synthetic flyash aggregate as a highway construction material in India

Dear Damayanti,

Thank you for reviewing the above referenced manuscript. With your help, I have reached a reject decision on this manuscript.

The anonymised comments to author, from all reviewers, are included below. You can also access this information by logging into Editorial Manager as a reviewer.

Thank you for your contribution and time in reviewing this manuscript, which not only assisted me in reaching my decision, but also enables the author(s) to disseminate their work at the highest possible quality.

I am grateful to you for your assistance as a reviewer for Environmental Challenges.

Kind regards,

Berrin Tansel
Editor-in-Chief
Environmental Challenges

Comments to author:

Reviewer #1: The paper presents selected results of synthetic fly-ash aggregate (SFA) and concretes with its addition.
I have a few criticisms of the article:
1. It is difficult to understand what the main goal of the research was for the authors. The title shows that the SFA aggregate in question should be used in road concrete. However, the research carried out by the authors does not confirm this.
2. The authors of the literature review relied on publications up to 2012. In the last 10 years, several dozen works relevant to this issue have been published in this area in the world.
3. In the described research, there is no information to what extent the composition of the fly ash used to produce the fly ash is repeatable, as it determines the industrial application of the product. The very chemical composition of fly ash should not be presented graphically but in a table.
4. Why did the authors use the research methodology from the last century when examining the properties of the SFA aggregate (the standards come from 1959, 1963 and 1983).
5. The methodology of testing the properties of concretes with SFA has not been described.
6. The obtained results of the compressive strength tests raise great doubts. If, after 28 days, the tested concretes reached 28 and 35 Pa, respectively, for cubic samples with a side of 150 mm, it is a very low concrete strength. Normal structural concrete should have a minimum of 20 MPa.
7. The article does not provide the composition of the tested concretes or the grain size of the SFA aggregate for the execution of these concretes.
8. Figure 6 compares the properties of SFA aggregate and natural aggregate. It was not described what natural aggregate was selected for comparison and what parameters it had to be considered representative for use in ordinary concretes. Please justify the term "conventional aggregates concrete".
There are no units of measured quantities.
9. Provide the values obtained from the tests that were used to prepare graphs 4 and 5. How many test samples were there and what was the standard deviation.
Due to serious deficiencies and inaccuracies in the described research, the paper in the presented form is not suitable for publication.

Reviewer #2: General
1. Flyash writing is inconsistent.
2. There are still many that have not been included in each sentence.
3. The latest references (last 10 years) used are only 2 and too few so that this study does not show novelty and the scientific explanation is still lacking 4. Measurement of pH is not because it does not use a pH meter
5. Basis of conclusion
6. The variables used in Table 1 do not appear in all discussion charts

Abstract
1. Researchers have not mentioned the variables used
2. The aggregate standard used has not been mentioned yet
3. There is no conclusion regarding the research results

UNNES UNIVERSITAS NEGERI SEMARANG

Astrilia Damayanti <astrilia.damayanti@mail.unnes.ac.id>

Invitation to review for Environmental Challenges

1 message

ENVIRONMENTAL CHALLENGES <em@editorialmanager.com> Mon, Jul 26, 2021 at 3:54 AM
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To: Astrilia Damayanti <astrilia.damayanti@mail.unnes.ac.id>

Manuscript Number: ENVC-D-21-00713
Characterisation and application of synthetic flyash aggregate as a highway construction material in India

Dear Damayanti,

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Abstract:

The study presented herein provides an insight into manufacturing process and properties of synthetic fly-ash aggregate (SFA). SFAs were formed by mixing fly ash, cement, bentonite, coal dust and water varying the fly-ash and cement content. Other ingredients such as bentonite and coal dust were kept fixed. The aggregates were sun-dried for one day followed by drying in muffle furnace for 12 hour at 1000 OC. The properties of the synthetic fly ash

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Characterisation and application of synthetic flyash aggregate as a highway construction material in India

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Characterisation and application of synthetic flyash aggregate as a highway construction material in India

--Manuscript Draft--

Manuscript Number:	ENVC-D-21-00713
Full Title:	Characterisation and application of synthetic flyash aggregate as a highway construction material in India
Article Type:	Full Length Article
Keywords:	Fly ash; Synthetic fly ash aggregate; Impact value; Crushing value; Abrasion value.

Abstract:	The study presented herein provides an insight into manufacturing process and properties of synthetic fly-ash aggregate (SFA). SFAs were formed by mixing fly ash, cement, bentonite, coal dust and water varying the fly-ash and cement content. Other ingredients such as bentonite and coal dust were kept fixed. The aggregates were sun-dried for one day followed by drying in muffle furnace for 12 hour at 1000 OC. The properties of the synthetic fly ash aggregates were analysed and compared with natural aggregates. The study showed that the aggregate with cement to fly ash ratio (10:80) yielded significant result compared to natural aggregates in respect of the crushing, impact and abrasion value which were found to be 27%, 16% and 29% respectively. These values satisfy the requirements for the aggregates to be used in road construction and other construction purposes. The compressive strength of concrete made out of SFA found to be 36.8 MPa in 28 days and 25.6 MPa in 7 days which satisfy the target strength of M20 concrete mix. The 28-day compressive strength of SFA concrete mix was 13.23% higher than natural aggregates concrete.

Characterisation and application of synthetic flyash aggregate as a highway construction material in India

ABSTRACT

The study presented herein provides an insight into manufacturing process and properties of synthetic fly-ash aggregate (SFA). SFAs were formed by mixing fly ash, cement, bentonite, coal dust and water varying the fly-ash and cement content. Other ingredients such as bentonite and coal dust were kept fixed. The aggregates were sun-dried for one day followed by drying in muffle furnace for 12 hour at 1000 ^{O}C. The properties of the synthetic fly ash aggregates were analysed and compared with natural aggregates. The study showed that the aggregate with cement to fly ash ratio (10:80) yielded significant result compared to natural aggregates in respect of the crushing, impact and abrasion value which were found to be 27 %, 16 % and 29 % respectively. These values satisfy the requirements for the aggregates to be used in road construction and other construction purposes. The compressive strength of concrete made out of SFA found to be 36.8 MPa in 28 days and 25.6 MPa in 7 days which satisfy the target strength of M_{20} concrete mix. The 28-day compressive strength of SFA concrete mix was 13.23 % higher than natural aggregates concrete.

Keywords: Fly ash; Synthetic fly ash aggregate; Impact value; Crushing value; Abrasion value.

1. Introduction

Electricity is an indispensable need of any industrial society for economic and social development and no nation can progress without adequate supply of power. All the developed and developing countries in the world meet their energy requirement mostly from coal based thermal power plants. In this process, all thermal power plants produce a combustion waste product called as fly-ash or coal ash. In developing countries like India, the installed capacity for power generation has been increased from 1,362 MW to 4,48,110 MW from the year 1947 to 2020. Out of total power generation, 2,34,000 MW is coal/lignite based thermal power which generate nearly 226 million tons of fly ash per year. In 13th Five Year Plan, the Planning Commission has planned to generate 100,000 MW from Coal/Lignite based thermal power plants. By the end of year 2020, the fly ash generation reached about 300 million tons per year and likely to increase with same pace for next one to two decades.

The flyash generated from coal based thermal power plants is considered as a waste material and its disposal (dry or wet process) has posed numerous environmental and ecological threats to the society. The potential use of such huge quantity of flyash is in fact a herculean task for all power plants. Therefore, effective use of flyash is inevitable. Although several methods have been attempted for use of flyash for different purposes, converting a waste into low cost, eco-friendly, highly efficient product as a substitute of natural resources is generally considered to be a promising method. Recent researches have revealed its use as an invaluable ingredient in concrete and cement within the prescribed specifications. Now-a-days, it is being widely used as partial or full replacement of fine aggregate in concrete, replacement for clay in brick manufacturing and supplementary cementitious material etc (Manikandan and Ramamurthy, 2007). However, present research studies have highlighted the depletion of natural coarse aggregates and suggested to find an alternative as a substitute to natural aggregates (Kayali, 2008). Replacing the natural coarse aggregates such as granite, pumice, scoria etc. by manufacturing artificial aggregates using flyash and other waste materials etc having suitable mechanical characteristics for structural applications is need of the time (Amato et al., 2012). In addition, the normal weight of natural aggregate concrete turns to be not economical for engineering applications compared to lightweight aggregate concrete. The actual benefits of using lightweight aggregate concrete can result in reducing the self weight of the structural members; thus an increase in the number of floors can be realized (Shanmugasundaram et al., 2010). Extensive studies have been carried out in order to use different industrial waste materials for production of aggregate using various methods. The close examination of slag based light weight aggregates demonstrated higher percentage of external porosity having pore diameter more than 100 μm (Yogini and Hiller, 2011). Sintering and cold-bonded are two major processes of manufacturing the artificial aggregates. The manufacturing of synthetic aggregate has shown that the moisture content, pelletizer speed and binder dosage affects the formation of pellet (Bijen, 1986; Yang and Huang, 1998; Harikrishnan and Ramamurthy, 2006; Gesoglu et al., 2012). The past study also revealed the poor performance of cold-bonded fly ash aggregate concrete due to the presence of large voids in the aggregate (Niyazi and Turan, 2010). It was reported that there are many drawbacks in the manufacturing process due to time-consuming synthesis process, thus creating problems in practical application. Still researchers are in the process of searching new methodologies for transforming the flyash into a usable product. Scanty literature is available for production of synthetic aggregate using flyash by hot sintering processes. The abundance availability of flyash in many parts of the India and converting this waste into a saleable product by value addition has motivated the investigators to make a feasibility study of manufacturing synthetic flyash aggregates by hot bonding agglomeration process and characterize the aggregates in order to check its suitability for utilization as a highway construction material leading to conservation of natural resources.

2. Materials and Methods

2.1. Materials

In the present study, fly ash generated from a local captive power plant was used . The samples were available without any cost. The flyash samples were made ready by sieving and sun drying for a day. Portland cement of 53grade with specific gravity 3.15 was used as a binder. Locally available coal dust (500μm) and bentonite was used in the process. Portable drinking water was used for making of fly ash aggregate (IS 456, 2000).

2.2. Preparation of synthetic flyash aggregate (SFA)

Fly ash aggregates were prepared by mixing fly ash, cement, coal dust and bentonite in different proportion by weight which is presented in Table 1. Coal dust and bentonite were kept fixed in the mix. The contents were thoroughly mixed and aggregates were prepared of 10 to 12 mm size approximately. Once the aggregate were formed, the same were allowed to dry for a day in the sunlight and 12 hour in the furnace at 1000 ^{O}C. Then the aggregate were cured for 7 days in normal tap water and taken out to conduct different tests to ascertain the properties of aggregates.

Table 1
Composition of aggregate

Material used	Percentage by mass			
	Sample-1	Sample-2	Sample -3	Sample -4
Fly ash	75%	80%	85%	90%
Cement	15%	10%	5%	0%
Coal dust	8%	8%	8%	8%
Bentonite	2%	2%	2%	2%

2.3. Preparation of synthetic flyash aggregates concrete (SFAC)

Concrete mixture for M_{20} grade concrete were designed and tested as per IS 10262:2009. Uniform mixing of concrete in concrete mixer was ensured to get correct results of the specimen of 150 mm x 150 mm x 150 mm size. The slump test was conducted to measure the degree of workability for M_{20} grade with natural aggregates and flyash aggregates (IS: 1199, 1959). The concrete cube specimens were completely immersed in curing tank for curing.

2.2. Analysis procedure

The physical properties such as bulk density and specific gravity of fly ash samples were determined by water pycnometer (IS: 2386, 1963). The coefficient of permeability was determined by a constant-head permeameter (ASTM D-2434). The particle morphology of the fly ash samples was analyzed from the micrograph obtained with a JEOL JSM-5800 Scanning Electron Microscope (SEM). Mineralogical characteristics were determined by X-ray diffraction using Cu-Kα radiation, where a properly dried sample were crushed with the help of motor pastel kept in a glass slide which was exposed to X ray in XRD instrument.

Water absorption, impact value, crushing value and abrasion value of the synthetic flyash aggregates were determined following standard laboratory procedures (IS: 2386 (Part IV), 1963). The compressive strength of concrete was measured in compression testing machine.

3. Results and Discussions

3.1. Physical properties and mineralogical compositions of flyash

It was found that fly ash was having a mean particle diameter of 36.8 μm. Table 2 shows physical properties of the fly ash samples. The coefficient of permeability of ash samples was found to be very low. The average bulk density of fly ash was found in the range of 1.05 to 1.08 g/cc.

Table 2

Physical properties of the fly ash samples

Parameters	**Color**	**Specific Gravity**	**Bulk density, g/cc**	**Porosity,%**	**Coefficient of permeability, k x 10^{-4} cm/s**
Fly ash	Gray	1.95- 2.26	1.05 - 1.08	50-54	1.58 - 1.77

The scanning electron micrograph (SEM) fly ash at X1000 magnification is shown in Fig. 1. The micrograph revealed that the fly ash samples were mostly spherical particles. The chemical composition (element oxides) of ash sample is presented in Fig. 2. The results of the chemical composition showed that the ash samples were primarily enriched with alumina (Al_2O_3) and silica (SiO_2) having little amounts of TiO_2, Fe_2O_3, K_2O, MgO and CaO. Other compounds in the ash samples were of negligible concentrations. The sum of SiO_2, Fe_2O_3 and Al_2O_3 accounted for more than 90% of the total composition in flyash samples. The reactive silica content in fly ash was found to be in the range 16-18%.

3.*2 Variation of pH of flyash-water mixture*

The pH of the fly ash was determined in 1:5 solutions (1flyash: 5water). The variation of pH with time is presented in Fig. 3. The pH value of fly ash was acidic in nature after one hour of measurement and the value increased with passage of the time. This behaviour of fly ash may be mainly due to presence of alumina (in form of Al_2O_3) which exhibits amphoteric character. When fly ash was mixed with water, alumina present in fly ash initially slowered pH of the slurry as alumina has 56% basic constituents and 44% acidic constituents. As acidic constituents were generally more soluble in water, pH of the sample decreased immediately after mixing with water. As the time passed, basic constituents neutralised the acidic fraction and pH of the sample gradually increased and equilibrium was attained at the final pH value of the samples observed as 6.67.

3.3. Effect of fly ash content in fly ash aggregates

It may be observed from the fig. 4 that with increase in fly-ash content, the aggregate crushing value, impact value and abrasion value increased indicating reduction in strength/quality of aggregate. The samples (Sample 1 & 2) having cement content ≥ 10 % showed a crushing value below 30 % and less than 10% signified a crushing value below 45 %. The percentage increase in crushing value with increase in fly-ash content in aggregates from 75 % to 80 % increased by 3.85. However subsequent increase in fly ash content from 80 % to 85 % and 85 % to 90 % increased the crushing value by 26 % and 23.5 % respectively.

All the samples having cement content ≥ 5 % showed the impact value less than 30% (Fig. 5). The aggregates samples having no cement content showed the impact value 32 %. It was again observed that percentage increase in impact value with increase in fly-ash content from 75% to 80% was marginal (6.67%). But further increase in fly ash content increased the impact value significantly. The aggregates with fly ash: cement ratio (75:15 and 80:10) showed a high quality aggregate with very tough properties. Hence the quality of synthetic aggregates reduced with increase in fly ash content. The specific gravity and water absorption capacity of synthetic fly-ash aggregate increased with increase in cement content suggesting increase in amount of void present. Further, the abrasion value of aggregate increased with decrease in cement content. The abrasion value which was found to be 24.8 % at 15 % cement content increased to 41 % without any cement content. It means the quality of the aggregates reduced rapidly with decrease in cement content below 10%.

It was concluded that the aggregate crushing value of the synthetic fly-ash aggregates below 30% can be used for cement concrete pavement at surface and aggregate below 45% can be used for concrete other than for wearing surface (IS: 2386, 1963). The synthetic aggregates samples having abrasion value with 40% can be used in surface coarse as water bound macadam (WBM), bituminous macadam (BM), bituminous penetration macadam. The flyash aggregates with abrasion value 35% can be used for bituminous carpet, bituminous dressing, single or two coats, cement concrete surface coarse etc.

3.4. Comparison between natural aggregate (NA) and synthetic fly-ash aggregate (SFA)

The strength parameters between synthetic fly-ash aggregates and natural aggregates is compared and presented in Fig. 6. It may be observed that the impact value of SFA was almost at par with natural aggregate indicating the toughness of both SFA and NA. The crushing strength and abrasion value of SFA is more than NA. The water absorption value of both is almost same. The specific gravity of SFA is less compared to the NA. The strength parameters of synthetic fly ash aggregate showed that the properties of aggregate depended on the type of binder and its dosage. There was considerable gain in strength and reduction in water absorption of SFA with increase in cement content in aggregates. Although the binder did not modify the chemical composition, however it influenced the structure of the aggregate at micro level resulting in improvement in the properties of aggregate. The addition of bentonite having organic matters increased the quality of gases evolved during sintering; thus reduced the density of the aggregate. The study indicated that cement and bentonite improved the binding ability whereas coal dust helped in the sintering and strengthened the properties of synthetic flyash aggregate. Since the strength parameters of SFA having cement content up to 10 % illustrated the best result, flyash (max) to cement (min) ratio as 80:10 was therefore considered as an optimum value without compromising the qualitative aspects of SFA.

3.5. Comparison of properties of SFA concrete and CA concrete

Fig. 7 shows the comparison of compressive strength of concrete mix made out of synthetic aggregates (flyash to cement ratio as 80:10) and natural aggregates. It may be viewed that the compressive strength of SFA concrete was higher than that of the corresponding mix made out of natural aggregates (NA). At the age of 28 days, the compressive strength of SFA concrete and NA concrete was 36.8 MPa and 32.5 MPa respectively. SFA concrete was 13.23% higher in 28 days compressive strength than the common natural aggregate.

The strength of SFA concrete was clearly understood when a closer look was given to the nature of the individual aggregate. Some of the aggregate were angular and some were rounded shape with a smooth texture. The surface of the SFA aggregates appeared to have tiny bubbles which looked like craters. These crater-like formations were resulted from the sintering of the aggregates. This formation improved the bonding of aggregates with the cement paste resulting in increase in compressive strength. In natural aggregate concrete, the interfacial zone being the weakest area was the first to fail and acted as a crack propagator. The failure line was an extension of the de-bonded aggregate-matrix interface. In contrast, the bond between the SFA and the cement paste matrix was strong. The interface zone was evidently in tight and cracking was not initiated in the interface but rather was arrested at the interfacial zone.

4. Conclusion

The present characterization study of synthetic flyash aggregates showed that the strength parameters of aggregates primarily depended on the dosages of binder. Further it was observed that increasing the fly ash content in SFA increased the crushing, abrasion and impact value of the aggregates. The strength parameters of SFA at flyash to cement ratio (80:10) were better compared to conventional aggregates. The compressive strength of concrete made out of flyash aggregates found to be 36.8 Pa in 28 days and 25.6 Pa in 7 days which satisfy the target strength of M_{20} concrete mix. The 28 days compressive strength of concrete mix made out of flyash aggregates was 13.23 % higher than conventional aggregates concrete. It is concluded from the present work that the SFA can be used as an alternative to conventional aggregates to accomplish more environment friendly and sustainable concrete products. Also, using of synthetic aggregates in concrete may diminish the negative environmental impacts of coal based thermal power plants and helps in protecting the natural resources.

Declaration of Interest

None.

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List of Figures

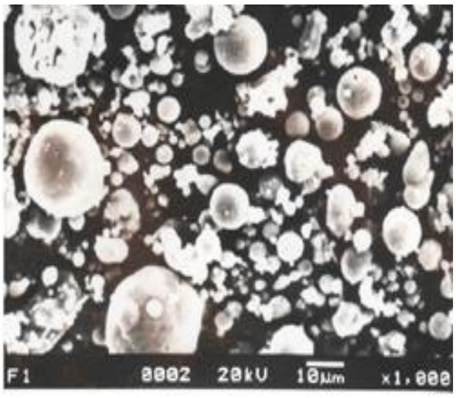

Fig. 1. SEM of flyash sample.

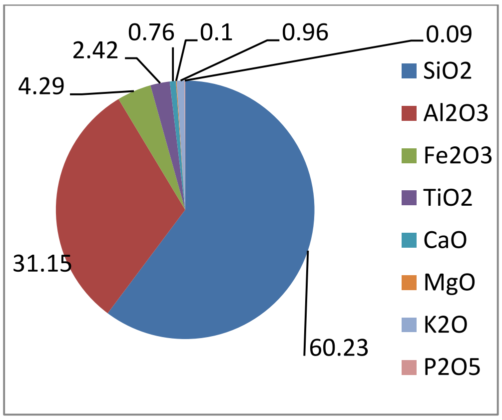

Fig. 2. Element oxides composition of flyash.

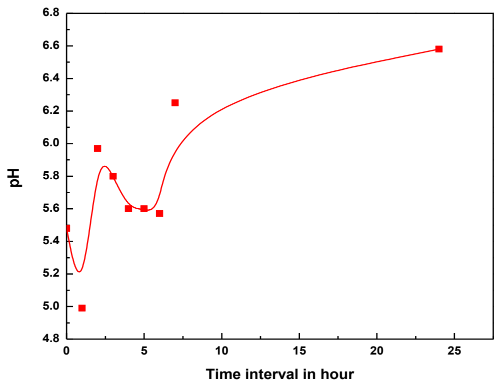

Fig. 3. Variation of pH with time.

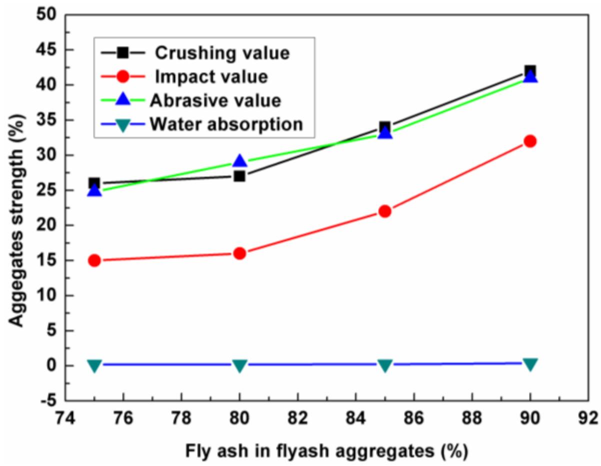

Fig. 4. Effect of flyash content on the strength parameters of flyash aggregates.

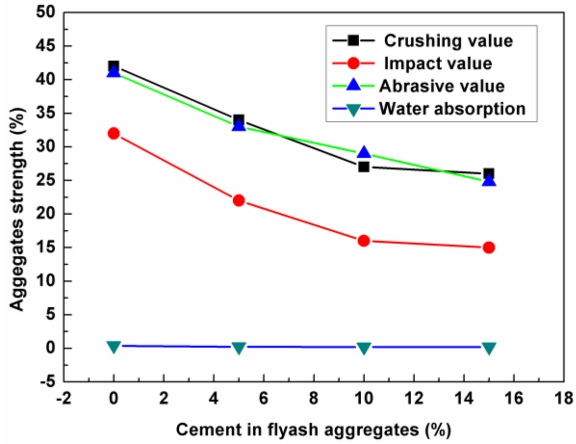

Fig. 5. Effect of cement content on the strength parameters of flyash aggregates.

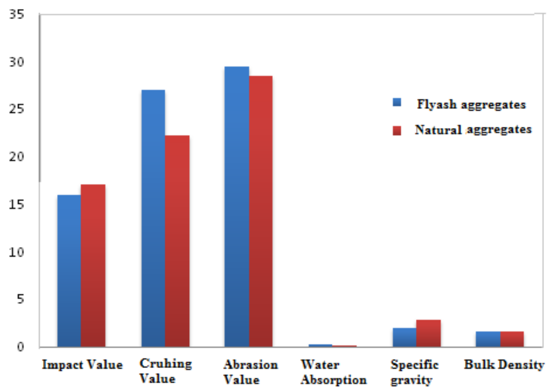

Fig.6. Comparison of parameters between fly ash aggregate and conventional aggregate

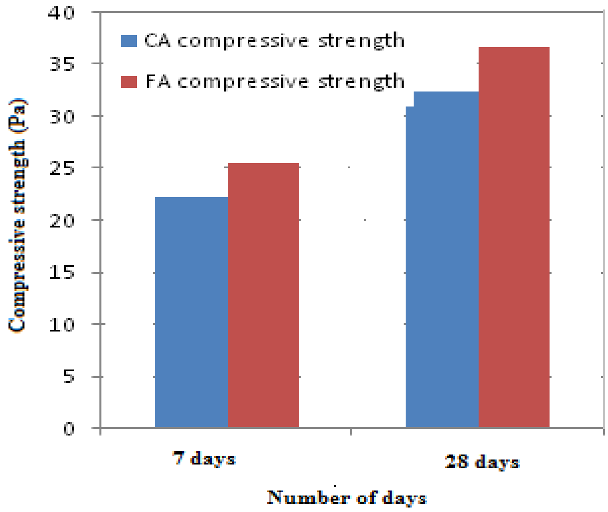

Fig.7. Comparison between compressive strength of SFA concrete and CA concrete

Table 1
Composition of aggregate.

Material used	Percentage by mass			
	Sample-1	Sample-2	Sample -3	Sample -4
Fly ash	75%	80%	85%	90%
Cement	15%	10%	5%	0%
Coal dust	8%	8%	8%	8%
Bentonite	2%	2%	2%	2%

Table 2
Physical properties of the flyash samples.

Parameters	**Color**	**Specific Gravity**	**Bulk density, g/cc**	**Porosity,%**	**Coefficient of permeability, k x 10^{-4} cm/s**
Fly ash	Gray	1.95- 2.26	1.05 - 1.08	50-54	1.58 - 1.77

Highlights

- The flyash generated from coal based thermal power plants may be utilised as synthetic flash aggregates (SFA).
- The characterization of synthetic flyash aggregates showed that the strength parameters of aggregates primarily depended on the dosages of binder.
- The strength parameters of SFA at flyash to cement ratio (80:10) was better compared to conventional aggregates. The 28 days compressive strength of concrete mix made out of flyash aggregates was 13.23 % higher than conventional aggregates concrete.
- SFA can be used as an alternative to conventional aggregates to accomplish more environment friendly and sustainable concrete products. It may reduce the negative environmental impacts of coal based thermal power plants and helps in protecting the natural resources.