International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 8 Aug. 2022, pp: 1505-1512 www.ijaem.net ISSN: 2395-5252

Effects of Natural Fibre on Fly Ash Concrete

Vignesh, M.E, M.Anand
Department of Civil engineering, Maha bharathi engineering College, Anna University , Villupuram, India
post graduate student, Department of Civil engineering, Maha bharathi engineering College
Anna University, Villupuram, India

Submitted: 15-08-2022 Revised: 27-08-2022 Accepted: 30-08-2022

ABSTRACT—
Nowadays the tendency to realize environment-friendly products is becoming more widespread to ensure sustainable and smart development. The synthetic fibers, frequently used, are harmful to the environment because they are non-degradable and non-renewable. Therefore, the possibility of replacing them with natural fibers is very essential. Another major environmental issue in current scenario is reducing the environmental defects due to cement production, disposal of industrial waste materials like fly ash and copper slag. This project is to utilize the industrially produced waste which attributing the pozzolanic action, for the purpose of partially replacing the cement with fly ash, lime and partial replacement of fine aggregate by copper slag. In this work lime fly ash concrete specimens are prepared and analyzed to evaluate the influence on their performance of different fibers used as reinforcement. A testing campaign for determination of porosity, impact strength test, shear test, fracture toughness test, scanning electron microscope test, and sorpitivity test were evaluated of all the mixes of lime fly ash concrete to be carried out. Following the obtained results, application of lime, fly ash in replacement of cement and copper slag in replacement of sand, as a sustainable alternative, is discussed. Thus, the effects of natural fibers on lime fly ash concrete are investigated.
Keywords—Concrete, Lime, fly ash, copper slag, sisal fibre, coir fibre, SEM

I. INTRODUCTION

Initially, cement was used for mortars in construction which later extended in making of concrete, an important building material now a day. Concrete has become a most utilized material in the earth than any other material or resources, which come next to water. With the increase in industrialization, the usage of cement for concrete has increased. The production of cement requires fusing of calcareous and argillaceous materials at high temperatures. To produce such high temperature the combustion process results in the emission of CO_2 , which is of a great consequence in greenhouse gas effect. Cement manufacturing is responsible for about 10% of the global carbon dioxide emission. Similarly, with the increased industrialization and development, the generation of industrial by-products has increased significantly.

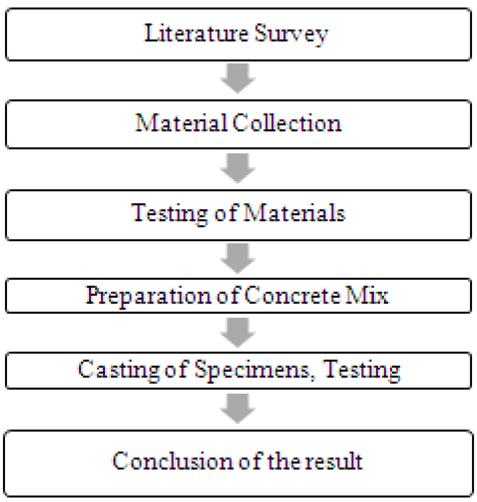
The objective of the project is,
To manufacture an eco-friendly cement mixture
To reduce the overall cost of production
To reduce overall annual cement production causing CO2 emission which affects the global warming
Effective utilization of industrial waste materials as construction material blended along with cement
To reduce the usage of fine aggregate (. i.e.) river sand
Utilization of natural wastes like fibers (Sisal, Coir)

INFERENCE
1.Workability decreased, and fresh density increased slightly due to inclusion of fly ash and lime.
2.Replacement of OPC by fly ash alone has negative impact on compressive strength, whereas fly ash along with lime has positive impact.
3.The combined effect of fly ash and lime on compressive strength development is found significant at early age, comparable at 28 days and appreciable at late age.
4.The flexural and bond strength of concrete containing fly ash and lime, replacing OPC up to 47% improved significantly at all ages.
5.Inclusion of fly ash and lime has positive impact on abrasion resistance of concrete.
6.Sorpitivity of concrete mixes containing fly ash and lime found less than control mix at all ages.
7.The lime plasters reinforced with natural fibers showed lower weight loss than those reinforced with to polymeric ones. This behavior is due to hydrophilic nature of natural fibers.
8.The use of natural fibers such as coir and sisal is functional to the reduction of tensions due to the plastic shrinkage that determine the occurrence of cracks on the surface of the structures exposed to water evaporation.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 8 Aug. 2022, pp: 1505-1512 www.ijaem.net ISSN: 2395-5252

9.There was an almost 22% reduction in the water demand at 100% copper slag replacement in comparison with the control mixture with 100% sand at the same workability.
10.At the same workability, there was general increase in the compressive strength as copper slag proportion increases.
11.There was more than 20% improvement in the compressive strength of concrete with 100% copper slag substitution in comparison with the control mixture at the same workability.
12.For cement mortars, all mixtures with different copper slag proportions yielded comparable or higher compressive strength than the strength of the control mixture.
13.There was more than 70% improvement in the compressive strength of mortars with 50% copper slag substitution in comparison with the control mixture.
14.There is almost 5% increase in the concrete density, when copper slag was used as a sand replacement, whereas the workability increased substantially with an increase in copper slag content. This was attributed to the low water absorption and glassy surface of copper slag.
15.The compressive, tensile and flexural strength of concrete were comparable to the control mix using up to 50% copper slag substitution for sand, but they decreased with a further increase in copper slag contents.
16.The surface water absorption of concrete was reduced with up to 40% copper slag replacement for sand.
17.The volume of permeable voids decreased with the replacement of up to 50% copper slag.
18.Copper slag, in the range of 40–50%, could potentially replace sand in concrete mixtures.

METHODOLOGY



II. THE MATERIAL DESCRIPTION

2.1 LIME

Lime isa calcium-containing inorganic material in which carbonates, oxides, and hydroxides predominate. In the strict sense of the term, lime is calcium oxide or calcium hydroxide. It is also the name of the natural mineral (native lime) Cao which occurs as a product of coal seam fires and in altered limestone xenoliths in volcanic ejector. A white caustic alkaline substance consisting of calcium oxide, which is obtained by heating limestone, and which combines with water with the production of much heat. The rocks and minerals from which these materials are derived, typically limestone or chalk, are composed primarily of calcium carbonate. They may be cut, crushed or pulverized and chemically altered. "Burning" (calcination) converts them into the highly caustic material "quicklime" (calcium oxide, Cao) and, through subsequent addition of water, into the less caustic (but still strongly alkaline) "slaked lime" or "hydrated lime" (calcium hydroxide, Ca(OH)2), the process of which is called "slaking of lime". Lime kilns are the kilns used for lime burning and slaking.

Fig. 2.1Lime powder

2.2 FLY ASH

According to the American Concrete Institute (ACI) Committee 116R, fly ash is a finely divided residue that results from the combustion of ground or powdered coal and that is transported by flue gasses from the combustion zone to the particle removal system" (ACI Committee 232 2004). Fly ash is removed from the combustion gases by the dust collection system, either mechanically or by using electrostatic precipitators, before they are discharged to the atmosphere. Fly ash particles are typically spherical, finer than Portland cement and lime, ranging in diameter from less than 1 µm to no more than 150 µm. The major influence on the fly ash chemical composition comes from the type of coal. The physical and chemical characteristics depend on the combustion methods, coal source and particle shape

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 8 Aug. 2022, pp: 1505-1512 www.ijaem.net ISSN: 2395-5252

Fig. 2.2 Fly Ash

2.3COPPER SLAG

Copper slag is a by-product created during the copper smelting and refining process. During the refinery process the copper ore leaves back some large Vol. of rock, ore soot and non-metallic dust metals, which collectively called as Copper Slag. Copper slag has a high strength-to-weight ratio, making it an effective option in concrete, or as a fill material under the roadway. The copper slag in the concrete provides good density and abrasive property to the concrete. The copper slag can be effectively used as fine aggregate in the concrete which helps in reducing the damage to the environment, by preserving the natural resource.

Fig. 2.3 COPPER SLAG

2.4 SISAL FIBER

Sisal fiber (agave sisalana) is commercially produced in east Africa and Brazil. The global demand for sisal fiber and its products is predicted to degrease 1998 to 2000 and (2010 by a yearly date of 2.3%) as agricultural twine their traditional market continues to decline by substation of synthetic substitute and implementation of harvesting technology that uses small amount of no twine

Common name : Sisal
Scientific name : agave sisalana
Fiber : hard (leaf)
Family : Agavaceae

Fig. 2.4 COPPER SLAG

2.5 COIR FIBER

Coir fiber is extracted from the outer shell of a coconut. It is the natural fiber of the coconut husk where it is a thick and coarse but durable fiber. The common name, scientific name and plant family of coconut fiber is Coir, Cocosnucifera and Arecaceae (Palm), respectively. There are two types of coconut fibers, brown fiber extracted from matured coconuts and white fibers extracted from immature coconuts. Brown fibers are thick, strong and have high abrasion resistance.

In this project the brown fiber is used. Both brown and white coir consist of fibers ranging in length from 4-12 inch (10-30 cm). Those that at least 8 inch (20 cm) long are called bristle fiber. The coir fibers are used as matting for soil stabilization.

Fig. 2.5 COIR FIBRE

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 8 Aug. 2022, pp: 1505-1512 www.ijaem.net ISSN: 2395-5252

III. EXPERIMENAL WORKS

3.1 Mix proportions

Mix	Cement	Lime	Fly Ash	FA	Copper slag	CA	Water
GM1	384	-	-	546.05	-	1188.1	192
GM2	230.4	76.8	76.8	273.02	273.02	1188.1	192
GM3	230.4	76.8	76.8	273.02	273.02	1188.1	192
GM4	230.4	76.8	76.8	273.02	273.02	1188.1	192
GM5	230.4	76.8	76.8	273.02	273.02	1188.1	192

TABLE. 3.1MIX PROPORTIONS

3.2 FRACTURE TOUGHNESS TEST

Toughness is the measurement of a material's resistance to break, fracture or rupture. It is usually measured in units of energy or work. Typical graph showing a toughness test: We provide force measurement instruments and materials testing machines for toughness testing.

For fracture toughness test, beams of size 250mm ×50mm × 50mm are used. Notch ratios of 0.1, 0.2,0.3 and 0.4are used for the beams. The width of notch is kept as 3mm. The steel plate of 3 mm thickness is used to produce precast crack in concrete. Three-point and four-point bending tests must be conducted to measure the fracture parameters.

Fig. 3.1FRACTURE TEST SPECIMEN

Fig. 3.2FRACTURE TOUGHNESS TEST SPECIMEN

3.3 THREE POINT BENDING TEST

The three-point bending test is performed on a flexural testing machine. The specimen was placed on two supports that are 200 mm apart. The beam was supported on steel rollers which are placed on steel plates. Loading for all beams is given by means of hydraulic jack. The jack is manually operated for loading and unloading. The applied load is measured by means of pre-calibrated proving ring of 100 KN capacity. In three-point bending test, the loading is given at center that is exactly above the notch of the specimen

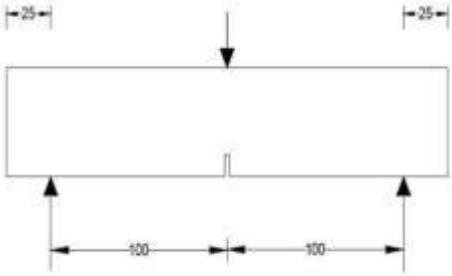


Fig. 3.3THREE POINT TEST

3.4 FOUR POINT BENDING TEST

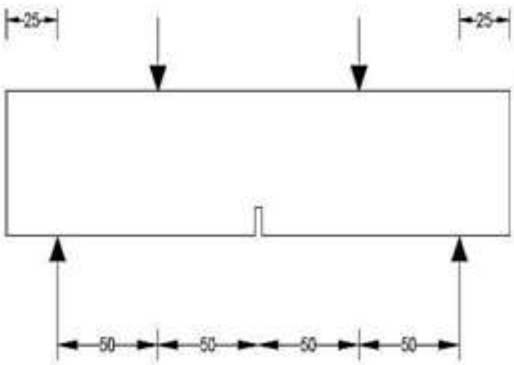


Fig. 3.4FOUR POINT TEST

The four-point bending test is performed on a flexural testing machine. The specimen was placed

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 8 Aug. 2022, pp: 1505-1512 www.ijaem.net ISSN: 2395-5252

on two supports that are 200 mm apart. The beam was supported on steel rollers which are placed on steel blocks. Loading for all the beams is given by means of hydraulic jack. The jack is manually operated for loading and unloading. The applied load is measured by means of pre-calibrated proving ring of 100 KNcapacities. In three-point bending test, the loading is given at the distance of 1/4thspan length of specimen from each support. This loading is chosen to obtain pure bending at the middle half portion of the beam where the crack is present.

Fig. 3.5FRACTURE TEST SPECIMEN LOADING

3.5 SHEAR STRENGTH TEST

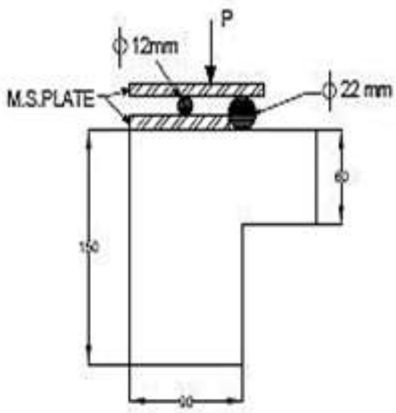


Fig. 3.6SHEAR STRENGTH TEST SPECIMEN

The specimens are placed as shown in Figure 4.3 on compression testing machine. A 150 × 85 × 10 mm size MS plate was placed on left side portion of 90 mm face. A mild steel bar of 12 mm diameter is placed over the center of the plate. Another MS bar of 22 mm diameter is placed at the edge of the plate. Over these bars, another MS plate of size 150 × 110 × 10 mm was placed. Load was applied on the top plate which forms shear plane below the center of 22 mm diameter bar. The loading was continued until the specimen failure. The shear strength was obtained using the relation,

Shear strength, fs = P/A
were
fs – Shear strength
P – Applied compression load
A – Shearing area (150mm × 60mm)

Fig. 3.7SHEAR STRENGH TEST SPECIMEN

Fig. 3.8SHEAR STRENGTH TEST SPECIMEN

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 8 Aug. 2022, pp: 1505-1512 www.ijaem.net ISSN: 2395-5252

Fig. 3.9SHEAR STRENGTH TEST LOADING

3.6 IMPACT STRENGTH TEST

The impact resistance of the specimen was determined by using drop weight method of Impact test recommended by ACI committee 544. The size of the specimen recommended by ACI committee is 152 mm diameter and 63.5 mm thickness and the weight of hammer is 4.54 Kg with a drop of 457mm.

For each mix, three numbers of specimens were used to determine the Impact resistance of concrete for 28 days. Hollow tubular mould of 152 mm with a height of 63.5 mm was made from a commercially available PVC pipes. The moulds were placed over a hardened platform and it was filled in the mould with proper compaction. After 24 hours, the cylindrical specimens were demolded and they were kept in a curing tank for 28 days. After 28 days curing, the specimens were air dried.

The energy consumption was evaluated as below
Energy = N×Mass (kg) ×Height (m) × g (m/sec2)
Where,
N= Number of blows to initiate the crack

Fig. 3.10IMPACT STRENGTH TEST LOADING

Fig. 3.11IMPACT TEST SPECIMEN

Fig. 3.12IMPACT STRENGTH TEST SPECIMEN

3.7 POROSITY TEST

`The saturated water absorption of concrete is a measure of the pore Vol. or porosity in hardened concrete which is occupied by water in saturated condition. It denotes the quantity of water which can be removed on drying a saturated specimen. The porosity obtained from absorption tests is designated as effective porosity.

The Vol. of voids is obtained from the Vol. of water absorbed by an oven dried specimen or the Vol. of water lost on oven drying water saturated specimen at 105^0 C to constant mass. The bulk Vol. of the specimen is given by the difference in mass of the specimen in air and its mass under submerged condition in water.

Effective Porosity = (Mw –Md) / (Mw –Msub)
Where,
Mw - Weight of specimen at fully saturated condition. Md - Weight of oven dried specimen
Msub - weight of specimen submerged in water.

3.8 SORPITIVITY TEST

According to the ASTM draft standard all that is required is a scale, a stopwatch and a shallow pan of water. The sample is preconditioned to a certain moisture condition, either by drying for four hours at 50 degrees Celsius and then allowed to cool in a sealed container for three days. The sides of the concrete samples are sealed, typically with electrician's tape. The initial mass of the sample is taken and at time is 0 is immersed to a depth of 5-10 mm in the water. At selected times (typically 5,10,15,20,25 and 30 minutes) the sample is removed from the water, the stopwatch stopped, excess water blotted off with a damp paper towel and the sample weighed. It is then replaced in the water and stopwatch started again. The gain in mass per unit area over the density of water is plotted versus the square root of the elapsed time. The slope of the line of best fit of these points (ignoring the origin) is reported as the sorpitivity.

The Sorpitivity is determined by following formula

S = (M / √T) / (A x d)

Where,
S = Sorpitivity in mm/s
M = change in specimen mass in grams over a time interval.
A = the exposed area of the specimen in cm2 d = density of the water in g/cc.

IV. RESULTS AND DISCUSSION

5.1 FRACTURE TOUGHNESS TEST

The fracture toughness of the notched beams is determined by using three point and four-point bending test and the results are tabulated below.

The comparison of fracture toughness results obtained by three-point bending and four points bending for different notch-depth ratios 0.1, 0.2, 0.3 and 0.4 are tabulated in Table No.5.1.

The above table indicates that the mix GM2 containing 60% cement, 20 % lime, 20% flyash,50% copper slag and 1% of sisal fiber shows 14%increase in fracture toughness in three point bending test and 10 % increase of values in four point bending test when compared to GM1 (control mix).Mix GM3 containing 60% cement, 20 % lime, 20% flyash,50% copper slag and 1% of coir fiber shows 6%increase in fracture toughness in three point bending test at 0.1notch to beam depth ratio and 5 % increase of values in four point bending test 0.1notch to beam depth ratio when compared to GM1 (control mix).

Mix GM4 containing 60% cement, 20 % lime, 20% flyash,50% copper slag, 0.5% sisal fiber and 0.5% of coir fiber shows 7%decrease in fracture toughness in three point bending test at 0.1notch to beam depth ratio and 1% decrease of values in four point bending test 0.1notch to beam depth ratio when compared to GM1 (control mix).Mix GM5 containing 60% cement, 20 % lime, 20% flyash,50% copper slag, 1% sisal fiber and 1% of coir fiber shows 18% decrease in fracture toughness in three point bending test at 0.1notch to beam depth ratio and 16 % decrease of values in four point bending test 0.1notch to beam depth ratio when compared to GM1 (control mix).It shows that the fracture toughness decreases when the fiber content increases more than 1%.

5.2 SHEAR STRENGTH TEST

The mix GM3 shows greater shear strength value in 28 days shear strength test. The shear strength of the control mix GM1 is found to be 4.80 Mpa and 6.98 Mpa at 7days and 28 days respectively. The maximum shear strength of8.28 MPa is obtained in mix GM3 at 28 days which is about 19% greater than that of control mix GM1at 28 days which is 6.98 Mpa. The shear strength value of mix GM2 and GM3 is similar at 7 days is 5.23Mpa. Further curing the shear strength value of mix GM3 is increased as 8.28 Mpa when compare to the mix GM2 at 28 days which is 7.85 Mpa. The mix GM5 containing 60% cement, 20 % lime, 20% fly ash, 50% copper slag, 1% sisal fiber and 1% of coir fiber gives the minimum value of 3.2 MPa. It shows that the shear strength value decreases when the fiber content increases more than 1%.

5.3 IMPACT STRENGTH TEST

The mix GM2 containing 60% cement, 20 % lime, 20% fly ash,50% copper slag and 1% of sisal fiber shows 12.5% increase in impact strength at 7 days test and 9% increase of values in 28 days test when compared to GM1 (control mix).

Mix GM3 containing 60% cement, 20 % lime, 20% fly ash,50% copper slag and 1% of coir fiber shows2.5% decrease in impact strength at 7 days test but7% increase of values in 28 days test when compared to GM1 (control mix).Mix GM4 containing 60% cement, 20 % lime, 20% fly ash,50% copper slag, 0.5% sisal fiber and 0.5% of coir fiber shows 7.5% increase in impact strength at 7 days test and 6% increase of values in 28 days test when compared to GM1 (control mix).Mix GM5 containing 60% cement, 20 % lime, 20% fly ash,50% copper slag, 1% sisal fiber and 1% of coir fiber shows 18% decrease in impact strength at 7 days test and13% decrease of values in 28 days test when compared to GM1 (control mix).It shows that the fracture toughness decreases when the fiber content increases more than 1%.Mix GM-2 (60% cement,20 % lime, 20% fly ash and 1% of sisal fiber) gives more impact resistance value than other mixes.

5.4 POROSITY TEST

Mix Id	Md	Msub	Mw	% Loss in weight
GM1	2.705	2.765	2.855	1.66
GM2	2.690	2.760	2.880	1.58
GM3	2.425	2.500	2.600	1.75
GM4	2.384	2.470	2.565	1.90
GM5	2.170	2.328	2.478	2.05

Mix GM-2 (60% cement, 20 % lime, 20% fly ash and 1% of sisal fiber) gives low porosity value than other mixes. Mix GM5 containing 60% cement, 20 % lime, 20% fly ash,50% copper slag, 1% sisal fiber and 1% of coir fiber shows 23% increase of porosity value when compared to GM1 (control mix). It shows that the porosity increases when the fiber content increases.

5.5 SORPITIVITY TEST

The test specimens were immersed in calcium hydroxide solution and the sorpitivity values are found out for 15minutes and 30 minutes. The tests results were shown below.

Mix GM-1 (control mix) gives low sorpitivity value than other mixes at both 15 minutes and 30 minutes test. Mix GM5 containing 60% cement, 20 % lime, 20% fly ash,50% copper slag, 1% sisal fiber and 1% of coir fiber shows 19% increase of sorpitivity value at 15 minutes and 13% increase in 30 minutes test when compared to GM1 (control mix). It shows that the porosity increases when the fiber content increases more than 1%.

V.CONCLUSION

The experimental investigation on durability strength of concrete having various proportions of natural fibers with lime, fly ash and copper slag were reported. The above test results show more durability prospective than the control mix. Fly ash, the byproduct of coal obtained from thermal power plant. It contributes to environmental protection because it minimizes the use of cement during the production of concrete. Copper slag is also a by-product of metallurgical operations in Sterlite industries. Lime is used as a partial replacement substance for cement to increase the strength of concrete.

Among all the mix combinations mix GM-2 (20 % lime, 20% fly ash and 1% of sisal fiber) gives more fracture toughness value than other mixes. The notch to beam depth ratio plays key role in fracture toughness. The fracture toughness of all the mixes with a/w ratio 0.1 shows higher values when compared with other notch depth ratios. Mix GM-3 which has 20% lime, 20% fly ash and 1% of coir fiber shows more shear strength values than others. Mix GM-2 (20 % lime, 20% fly ash and 1% of sisal fiber) gives more impact resistance value than other mixes. Mix GM-5 which contains 20% Lime, 20% fly ash, 50% copper slag and 1% of sisal fiber and 1 % coir fiber gives more sorpitivity values on both 15 minutes and 30 minutes results and it gives high porosity values.

It is finally concluded that cement replacement and fiber percentage should be varied to attain good strength. It is observed that Mix GM-2 (20 % lime, 20% fly ash and 1% of sisal fiber) offers good strength and Mix GM5 which has more fibers offers higher porosity and sorpitivity values.

REFERENCES

[1]. Al-Jabri, Abdullah H. Al-Saidy, Ramzi Taha (2011), “Effect of copper slag as a fine aggregate on the properties of cement mortars and concrete.”, Construction and Building Materials, Vol.25, Issue 2, pp. 933–938.

[2]. Al-Oraimi (2009), “Performance of high strength concrete made with copper slag as a fine aggregate”, Construction and Building Materials, Vol.23, pp. 2132–2140.

[3]. Bhanumathidas N and Kalidas N., (2002), “Fly Ash for Sustainable Development”, Institute for Solid Waste Research and Ecological Balance (INSWAREB).

[4]. Barryman, Zhu , Jensen and Tadros, M. (2005), “High Percentage Replacement of Cement with Fly Ash for Reinforced Concrete Pipe”, Cement and Concrete Research, Vol.35, pp. -1088-1091.