Palm Oil Fuel Ash (POFA) As Partial Sand Replacement in Concrete: A Review

Devesh Kumar Khare[1], Shailendra Tiwari[2], Rakesh Patel[3]
[1]Student of M.Tech (Construction Technology & Management),[2]Professer,[3]HOD,
Department of Civil Engineering, SIRT-E, Bhopal (M.P), India
****Corresponding Author***
Email Id: deveshkhare127@gmail.com

ABSTRACT

This study reviews the characteristics of Concrete incorporated with Palm Oil Fuel Ash as partial replacement for fine aggregates, with a main focus on the mechanical properties such as Compressive strength, splitting tensile strength, flexural strength etc. A lots of different research papers are reviewed. The practical use of Palm Oil Fuel ash shows a great contribution to waste minimization as well as resources conservation.

Keywords*: Bottom Ash, Compressive Strength, Flexural Strength, Splitting Tensile Strength, Workability.*

INTRODUCTION

Concrete is a manmade building material and it is the most widely applied in various building material in construction industry. There has been so much demand on construction materials in many countries around the world. Therefore, the requirement of alternative building material that should be cheaper and accessible becomes a highly critical issue. Nowadays, the use of waste material as concrete ingredient is gaining popularity. One such material is palm oil fuel ash (POFA). POFA is an agro-waste generated in palm oil industry. It is obtained from the combustion of palm fruit residues of oil palm tree [1].

Generally the wastage of palm oil from palm oil industry was increasing eventually. It is become a major problem to palm oil power plants because this waste is not reused and recycled in any works. Therefore, POFA whose chemical composition contains a large amount of silica in form of oxide can be used in sand replacement. POFA had been used as cementitious material in concrete and as lightweight material in production of lightweight concrete. Recently, the use of POFA in concrete has been reviewed by. Some highlights have been addressed. They found that the POFA is able to react well with the other constituent materials and hence able to produce stronger concrete. At the same time, the silica (SiO_2) content in Palm Oil Fuel Ash is able to increase the compressive strength of concrete and able to reduce the water absorption [1].

Moreover, the comparison the use of POFA and sand has been done. From the review they found that the 5 to 10 % of POFA as filler in lightweight foamed concrete improves the compressive strength, flexural strength and tensile strength compared to foamed concrete containing sand only. From the review indicates that the POFA can be used extensively as partially or fully sand replacement to the concrete stated that the SiO_2 composition in POFA is 49.20 % [2].

A. Need for the Use of Coal Ash in Construction

POFA is categorized as mineral admixture. POFA is agricultural by-products which has

pozzolanic properties due to its chemical composition which is high in silica. POFA is the solid waste produced from husk fibre and shell of palm oil burning by generation plant boiler which produces energy to be used in palm oil mill in order to extract palm oil. Generally, after combustion about 5% palm oil fuel ash by weight of solid wastes is produced.

Utilization palm oil fuel ash (POFA) as partial fine aggregate replacement in concrete is seen as one of the steps to reduce the use of natural sand in concrete production. Replacing of fine aggregates with palm oil fuel ash increases fineness in concrete because Palm Oil Fuel Ash contains more number of fine particle in the concrete thus also provide the lubricating effect in the concrete hence the desire workability can also be attain.

B. Palm Oil Fuel Ash

Palm oil fuel ash (POFA) is a waste-product from biomass power plants, in which palm oil residues such as fibers, shells, and empty fruit bunches are burned to produce electricity. In 2013, approximately 6.25 million tons of palm oil residues were produced in world. After combustion, approximately 312,000tonnes of POFA were obtained or approximately 5% by weight of palm oilresidue.

The main chemical composition of palm oil fuel ash is silicon dioxide (SiO2), and previous studies have shown that POFA in its original size is not suitable as a good pozzolan due to its bigsize particle and high porosity. More ever, high fineness POFA is a good pozzolanic material. Therefore, the Palm Oil Fuel Ash should be ground to higher fineness before it is used to partiallyreplace Ordinary Portland Cement in concrete.

C. Use of Palm oil fuel ash

Using this material is more endurable and environmentally amicable and eludes the use ofnatural resources such as sand and gravel. POFA ash is used in following activities:

1) Reinforced cement concrete block
2) Light weight concrete in partition wall and wall lining
3) Impermeable construction work
4) Precast concrete block
5) Foundation work of low-rise buildings

LITERATURE REVIEW

G A Jokhio, H M Hamada

Research shows advantages of POFA as a partial replacement of cement in concrete production, especially cement mortar. Report collection has been done from the literature review related to the use of POFA as partial cement replacement in the production of cement concrete and mortar. Therefore, this research paper can potentially become a guide for researchers and manufacturers to use POFA in various mixtures to replace the ordinary Portlandcement (OPC) in cement concrete.

POFA has good properties to enhance and improve the concrete durability especially with finer particles which is called ultrafine POFA, due to having high content of silica thus showing high pozzolanic behavior. In order to benefit from the POFA advantages in the concrete manufacturing, further experimental studies should be conducted to show the potential benefitsof the incorporation of POFA in concrete mixtures [3].

N.M Altwair, Shahid Kabir
Studies conducted on the use of POFA as a pozzolanic material to improve the mechanical properties and durability of concrete has obtained satisfactory results. Consequently, POFA can be considered an environmentally-friendly substitute for cement when employed as a supplemental cementitious material in concrete.

The results suggest that ground POFA is an excellent pozzolanic material and can be used as a good pozzolana to replace part of Portland cement in making mortar, concrete with relatively high strength, low drying shrinkage and water permeability. It reduces expansion due to alkali-silica reaction and increases carbonation, chloride and sulfate resistance. The hydration reaction and pozzolanic activity can be enhanced by the incorporation of FPOA. It is recommended that the optimum replacement levels of POFA to Portland cement are up to 30%. The ground POFA with high fineness (up to 20 μm) is a reactive pozzolanic material and can be used to produce high-strength concrete [3].

Brabha Hari Nagaratnam, Muhammad Abdul Mannan
This paper evaluates the feasibility of utilizing palm oil fuel ash (POFA) and fly ash (FA) as an Ordinary Portland Cement (OPC) replacement in self-compacting concretes (SCC). The level of OPC replacement is up to 40% based on a 540 kg/m3 mix design. All concrete mixtures were restricted to the following consistency parameter; slump flow of 750 ± 100 mm, T500 of 1.5s to 4.0s, J-Ring diameter of 650 ± 100 mm, step height of 5 to 15mm and sieve segregation resistance of less than 20%. The ternary SCC (TNY) consists of POFA and FA in equal portions. Compressive strength of SCC was determined at 7, 28 and 90 days using both cubes and cylinders.

The utilisation of POFA and FA, at higher percentages of replacement, could have great benefit in terms of generating cost savings for the construction industry by reducing the high volume of OPC [4].

W A. Saffuan, Khairunisa Muthusamy, N. A. Mohd Salleh
The present research investigates the effect of ground palm oil fuel ash as partial fine aggregate replacement on workability, compressive and flexural strength of concrete. The cube and beam specimens were casted and water cured up to 28 days before subjected to compressive strength and flexural strength testing respectively.

It can be concluded that inclusion of suitable percentage of ground POFA as fine aggregate replacement successfully enhances both the compressive strength and flexural strength performance. This finding encourages the use of palm oil waste materials as fine aggregate replacement in concrete, which saves the use of natural sand mined from the river [4].

Jonida Pone, Ahmed Ash
This study investigates the effectiveness of agro waste ash by-product Palm Oil Fuel Ash (POFA) as an alternative material to replace Portland cement (OPC). Experiments were carried out by supplementing CEM I cement by weight in concrete mixes with POFA at 2.5%, 5%, 10%, 15% and 20% steps at the point of need, with water to cement ratio of 0.5. Results were compared with a control specimen, which was made with 100% cement.

Palm Oil Fuel Ash is an effective pozzolan to replace cement at low percentages with the optimum level is at 2.5%. Specimens made with 2.5% and 5% POFA replacement had higher

strengths compared to the control at 7 and 28 days; very similar behaviour to silica fume. Workability decreases with increased amount of POFA unlike with PFA and GGBS concrete; like silica fume POFA has a high-water demand [3,4].

Liyana Ahmad Sofri, Zulham Affendi
The use of waste oil palm ash can overcome the problem of solid waste. POFA is a pozzolanic material and it can act as a replacement of cement (OPC) to produce concrete with higher strength and low cost. POFA quality will increase as the range made up to a medium levelof fineness in the size of 50 microns.

Compressive strength obtained from POFA is more and less on a percentage of the compressive strength of control, but still able to bear the load and can be used more effectivelyif the selected mix ratio is appropriate. Flexural strength obtained from POFA is more and less ona percentage of the compressive strength of control, but still able to bear the load and can be used more effectively if the selected mix ratio is appropriate [4].

Wenny Arminda and Hanizam binti Awang
Many researchers investigated the POFA as an alternative binder to mitigate the cement usage in producing concrete. A foamed concrete mixes have been prepared having a density of 900kg/m3 with a filler to binder ratio of 1:1.5 and three levels of POFA replacement.

The high POFA content as cement replacement reduces the workability; hence need to increase the dosage of superplasticizer to achieve the sufficient workability, b) Replacing 30% cement content with POFA gained a higher compressive strength compared to the normal foamed concrete (without POFA and superplasticizer) [5].

Hyung-Min Lee, Mohamed Ismail, Han-seung Lee
This paper presents experimentally investigated the effects of pozzolan made from various by-Product materials on mechanical properties of mortar. Ground Blast furnace slag (BFS), ground fly ash (FA), and palm oil fuel ash (POFA) were partially used to replace Portland cement.

The FA, POFA, BFS are very reactive pozzolanic materials. On the 28 days curing age, FA, POFA, BFS show lower compressive strength than that of OPC. In case of the accelerate curing for 7 days, the result was similar to 28-days strength. Some study shows that accelerate curing have an effect on the strength of mortar because it promotes pozzolanic reaction. The activity index reveals high in the when the cement replacement rate is 11%. Since the amount of OPC is relatively high the strength reached the peak in the early age [6].

Hasfalina, C.M, Corolin, M. Rashid
This study investigated the effects of Palm Oil Fuel Ash (POFA) on engineering properties in terms of compressive strength, flexural strength and splitting tensile strength. 3 types of concrete cubes were prepared, lightweight concrete with 100 % sand as control mix (CM), lightweight concrete with 10 % Palm Oil Fuel Ash replacement as part of filler (POFA10), and lightweight concrete with 20 % Palm Oil Fuel Ash replacement as part of filler (POFA20).

This can be concluded that the incorporation of POFA into lightweight concrete as sand replacement plays important part in enhancing the engineering properties of lightweight

concretein terms of compressive strength, splitting tensile and flexural strength [7].

CONCLUSIONS

1) The work ability of POFA ash concrete reduces with the increase in bottom ash content due tothe increase in water demand.
2) The density of POFA Ash concrete decreases with the increase in POFA ash content due to thelow specific gravity of POFA ash as compared to fine aggregates.
3) Compressive strength of sand replaced POFA ash concrete will be little higher than normalconcrete specimens at all the ages.
4) Splitting Tensile strength of sand replaced bottom ash concrete will be lower than normalconcrete specimens at all the ages.
5) Flexural strength of fine aggregate replaced POFA ash concrete will be lesser than normal concrete specimens at all the ages.

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