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Partial Replacement of Cement Using Palm Oil Fuel Ash (POFA)

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ABSTRACT:-

Amongst the potential solutions to a cleaner environment is to minimize the consumption of non-biodegradable materials and to reduce wastes. Palm oil fuel ash (POFA) is a waste material generated in power plants as a result of the combustion of palm oil industry waste for the generation of electricity. They are generally disposed to open fields causing traffic hazards besides potential of health hazards and environmental pollution problems. The utilization of solid waste in the sustainable constructions has concerned much attention due to the lower cost of wastes along with saving a necessary place of landfills. Due to its abundance and high pozzolanic characteristics, many researchers have evaluated its potential as a construction material; it can be utilized to partially replace cement in a concrete mix.

Many studies have shown that concrete containing POFA has better compressive strength, durability and other properties than concrete containing Ordinary Portland Cement (OPC). This study focuses over the applications and effects of POFA on cement mortar properties as reported by previous studies that have been conducted to find out POFA properties and its effects under various conditions. Chemical and physical properties have been illustrated by carrying out various standard tests on the POFA samples according to IS 1727-1967(Methods for test of Pozzolanic Material) depending on the POFA characteristics

A total of 45 mortar cubes of dimension (70.6 mm x 70.6 mm x 70.6 mm) and 24 concrete cubes of dimension (150 mm x 150 mm x 150 mm) will be casted at various percentage OPC replacement with POFA from 5% and 20%. Initially mortar cubes will be tested for compressive strength determination and selected the appropriate replacement percentage in concrete (i.e., 5%). The workability of fresh concrete properties will be tested by the slump test and the compressive strength of the hardened concrete will be tested. However, will check concrete with 5% POFA gives better results or not. The results will indicate that if there is a great potential to using POFA as cement replacement because of its ability to improve compressive strength, reduce hydration heat of cement mortar and positively affect other fresh and hardened concrete properties.

INTRODUCTION:-

1.1 Introduction to POFA:

Palm oil fuel ash (POFA) is a by-product from biomass power plants, in which palm oil residues such as fibers, shells, and empty fruit bunches are burned to generate electricity. In 2013, approximately 6.25 million tons of palm oil residues were produced in Thailand. After combustion, approximately 312,500 tons of POFA were obtained or approximately 5% by weight of palm oil residue. Since the palm oil is the main material in the production of biodiesel, the by-product of palm oil fuel ash is tended to increase annually, whereas the application of POFA remains to be very limited. Thus, most POFA is disposed as waste in landfills, which causes many environmental problems. The main chemical composition of palm oil fuel ash is silicon dioxide (SiO_2), and previous studies have shown that POFA in its original size is not suitable as a good pozzolana, due to its large particle and high porosity. However, high fineness POFA is a good pozzolanic material. Therefore, the POFA should be ground to higher fineness before it is used to partially replace OPC in concrete.

A B C

A- Palm Oil Seed, B- Kernel Seed (Dry), C- Ash (POFA)

Fig 1: Introduction of POFA.

1.2 Need of Study:

Sustainability has widely emerged in recent years to resist climate change and pollution caused by ineffective waste management. The cement industry, as one of the fundamental materials industries, plays a very important role in the social and economic development as well as imposes a great challenge in terms of its large consumption of natural resources and energy and the emission of greenhouse gases. Cement is one of the main constituents in concrete and is thus one of most utilized commodities in the world.

From an environmental perspective, the production of 1 tonne of cement directly generates about 1 tonne of CO2. Cement production is therefore responsible for 7-10% of the world's total CO2 emissions; compare this to the aviation industry, which is 2.8%, three times less than the production that comes from cement industry.

The world's growing demand for energy has pushed the prices of the non-renewable resources such as Petro-chemicals, natural gases and coal. As these fuels emit toxic gases, they are huge contributors towards global warming. Also, several studies indicated that the current reserves of petroleum and natural gases are depleting day by day. Alternative renewable energy sources include the solar, wind, hydro, nuclear etc.

Concrete, the second highest consumed material after water in the world, plays a very important role in the construction field because of the adaptability in its use. It is a composite construction material consists of aggregate, cement and water. Cement and water together form the binding paste that binds the aggregates and fills the voids within. Cement is the major manufactured, most utilized important ingredients and heavy contributor of the CO_2 emission of construction industry contributing Global Warming, climate change, and ozone layer depletion. Due to heavy CO_2 emission and a large contribution to global warming of the construction industry, there has been a growing emphasis on the utilization of waste materials and by-products in construction materials.

Currently Palm Oil Fuel Ash is one of the least recycled materials in the majority of countries and requires the consumption of relatively large amounts of energy for the processing of the raw constituents. Theoretically, ash can be recycled many times without a change in its chemical properties, although due to high levels of impurity, colour and so ash has a low recycling rate**.** The recent situation of discarding waste ash to landfills is also not offering an environmental friendly management, due to the non-biodegradable form. The waste ash represents an urgent environmental challenge all over the world because of the non-biodegradable nature, resulting in serious environmental pollutions**.** Therefore, various attempts have been made in order to utilize such waste ash in building materials, especially cement-based composites. In addition, the chemical composition and the pozzolanic properties of ash are encouraging for the use in the cement and concrete industries and to provide an environmental friendly solution to the cement industries.

As a result, the use of supplementary cementing materials (SCMs), like pulverized fuel ash (PFA) and ground granulated blast furnace slag (GGBS) have been established over the past 30 years as they not only reduce the embodied CO2 of concrete, the long-term strength and durability is improved.

The shortage of space is a growing issue nowadays due to increase in population for this there is a need of having column free space.The main reason floating column came into existence is to keep the groundstorey open and is a peculiar part of modern multi storey buildings in India.On the other hand,A soft story building is a multi-story building in which one or more floors have windows, wide doors, large unobstructed commercial spaces, or other openings in places where a shear wall would normally be required for stability as a matter of earthquake engineering design.Both this feature adds structural load on the buildingwhich may lead to structural failure especially in the earthquake prone areas. Open ground storeys arepoor systems because of the strength discontinuity along the height of column in building. If columns are weak they'll show severe damage which may lead to building collapse which is very dangerous and at times fatal to mankind.

LITERATURE REVIEW:-

1.Siti Shahara, Binti Zakaria(2013)

Study on geopolymer characteristic properties of Palm Oil Fuel Ash (POFA) and its effects as geopolymer cement materials. The main objective is to determine the relationship between compressive strength with curing time and other effecting factor.

The additions of additives and other type of blended ashes may help in increasing the compressive strength of the cement. The curing time is also giving impact to the compressive strength. It is observed that, the longer the curing time, the higher the compressive strength.

2Wachilakorn Sanawung, Tieng Cheewakaet, Weerachart Tangchirapat, Chai Jaturapitakkul1(2017)

This research studies the effects of W/B ratios and palm oil fuel ash (POFA) on compressive strength, water permeability, and chloride resistance of concrete.

The effects of W/B ratios on the compressive strengths of the POFA concrete were similar to those of conventional concrete; that is, the compressive strength of POFA concrete increased as the W/B ratio was decreased. From the results of the rapid chloride ion penetration test, ground POFA can be used very effectively to reduce chloride ion penetration in concrete.

3.Hussein M. Hamada, Gul Ahmed Jokhio, Fadzil Mat Yahaya, Ali M. Humada, Yasmeen Gul(2017)

Study on applications and effects of POFA on concrete properties as reported by previous studies that have been conducted to find out POFA properties and its effects under various conditions.The microstructure composition of POFA is weak and highly porous. Reducing the particle size to micro and nano, however, significantly improves the performance of POFA. The finer varieties of POFA react well with the other constituent materials and produce stronger concrete. POFA satisfies the ASTM C618 requirements to be used as a binder pozzolanic material in concrete production.

4.Hassnen Jafer,William Atherton, Monower Sadique, Felicite Ruddock, Edward Loffill(2018)

This paper reports the results of experimental work for the optimization of a Binary Blended Cementitious Binder (BBCB) using two types of fly ash as an alternative for use in soft soil stabilization. As well as the effect of palm oil fuel ash (POFA) pozzolanic reactivity on the engineering properties of soft soil.

HCFA was found to be very effective in improving the consistency limits of the stabilised soil, where the PI decreased from 20.2 for the untreated soil, to 13.38 by using 12% mechanically activated HCFA. No significant effect was observed using POFA in the binary mixtures, but the PI continued to decrease, dropping to 11.73 for the soil treated with BM4. This reduction in PI will substantially improve the resistance of stabilized soil against swelling and shrinkage stresses.

5.Rayed AL YousefHossein, MohammadHossein, Mahmood Md. Tahir,Hisham Abdul-Jabbar(2019)

In this paper, the feasibility of metalized plastic waste (MPW) fibers and palm oil fuel ash (POFA) in the production of concrete composites was investigated by assessing the mechanical properties.

By adding MPW fibers into concrete mixes, concrete was harsher, and the workability decreased. At the early ages, cube compressive strength diminished slightly with the adding of MPW fibers and POFA. However, for POFA mixes, the compressive strength was higher than that of OPC mixes.

6.Taha Mehmannavaz, Mohammad Ismail,Salihuddin Radin Sumadi.(University Technology Malaysia)(2014)

Binary Effect of Fly Ash and Palm Oil Fuel Ash on Heat of Hydration Aerated Concrete (2014)

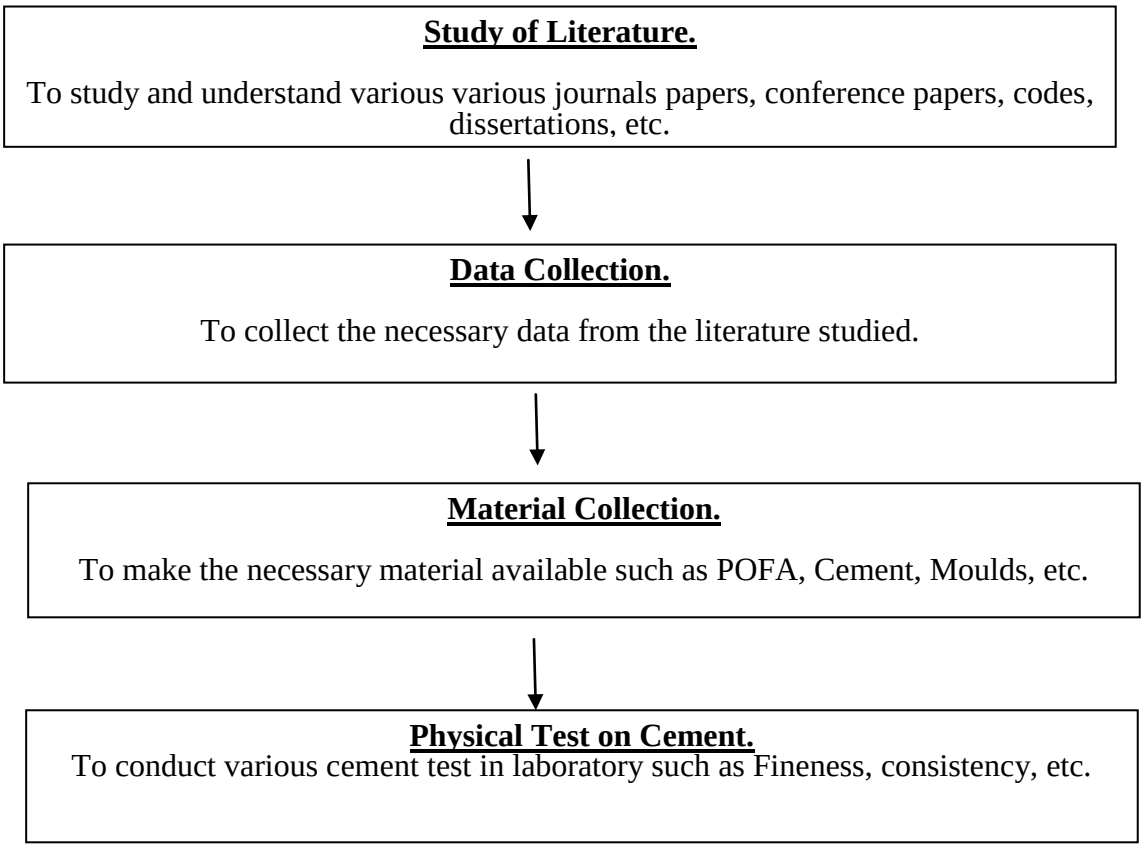
The quantity of heat developed upon complete hydration of a certain amount of unhydrated cement at a given temperature is defined as heat of hydration . The significance of heat of hydration in concrete technology is manifold.

OBJECTIVES:-

- To replace cement with Palm Oil Fuel Ash (POFA).
- TodeterminetheeffectofPOFA replacing cement partially.
- Tocompare results of samples with POFA and without POFA

METHODOLOGY:-

Stage 1:-



Physical Test on POFA.

To conduct various cement test in laboratory such as Fineness, Chemical Analysis, etc.

Analysis of Results.

(For determination of Pozzolonic Characteristics)

Determination of Mix Design for Cement Mortar.

Stage 2:

Casting of Mortar Cubes.

Casting of total 45 cubes of cement mortar (70.6 mm x 70.6 mm x 70.6mm) replaced with different percentage of POFA. (i.e. 5% to 20%)

Testing of Cubes.

After the specified interval of 3days, 7days, 28days of curing, testing the mortar cubes for compressive strength.

Result Analysis.

Analysing the results obtained from the cement mortar cubes to determine appropriate replacement ratio for concrete cubes.

Selection of mix ratio for concrete cubes.

For the casting if concrete cubes it is essential to determine the mix ratio of concrete.

Casting of Concrete Cubes.

Casting of total 24 cubes of cement concrete (150 mm x 150 mm x 150 mm)replaced with specific percentage of POFA.

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Testing of concrete Cubes.

After the specified interval of 7days, 28days of curing, testing the concrete cubes for compressive strength.

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Conclusion.

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