To Study Fresh and Hardened Property of Self-Curing Cement Mortar Incorporating Agricultural Waste

P. Vijayavendhaan[1], P. Nirmal[2]
[1]*PG student Department of Civil Engineering, GCT Coimbatore*
[2]*Assistant Professor Department of Civil Engineering, GCT Coimbatore*

Abstract— The advantages and uses of self-curing mortar are the main subjects of the study. Because cement mortar made with mineral admixtures is denser in nature, it is observed that typical curing techniques are inefficient for curing this type of mortar. This led to the development of the self-curing concept, which involves supplying water internally to improve product hydration. Concrete that can hold onto water to increase strength is known as self-curing mortar. PEG was utilised as an additive in this study, and its impact on the performance of cement mortar with a POFA (Palm Oil Fuel Ash) source was investigated. POFA is utilised in this work to partially replace cement mortar. Physical qualities of POFA, fine aggregates, and ordinary Portland cement were tested in compliance with BIS requirements. In this study, 10, 15, 20, and 25% of self-curing cement mortar with a constant W/c of 0.5 of self-curing cement are substituted for cement, and the fresh and hardening properties of the cement are also investigated for 0, 0.5, and 1% of self-curing agent. The purpose of the study was to assess novel qualities such as the flow mortar test and mechanical properties using compressive strength. In order to evaluate concrete's performance under various curing conditions, its fresh and hardened properties were examined. Following 7- and 28-days various ratios of polyethylene glycol 400 and palm oil fuel ash, the mean compressive strength is ascertained. A comparison is made between the compressive strength and the conventional self-curing mortar cube. The study found that concrete mixtures containing up to 1% polyethylene glycol 400 and 20% palm oil fuel ash had better compressive strengths than other combinations.

Keywords— POFA, SCM, PEG

I. INTRODUCTION

Adequate curing is crucial for concrete structures to meet durability and performance standards. In conventional curing, after combining, putting, and finishing, external curing is applied to achieve this. Self-curing, also known as internal curing, is a technique for increasing the moisture content of concrete in order to promote cement hydration and reduce self-desiccation. Concrete can now be internally cured using two primary methods. Using saturated porous lightweight aggregate (LWA), the first method creates an internal water supply to replace the water lost to chemical shrinkage during cement hydration. By decreasing water evaporation, poly-ethylene glycol (PEG) is utilised in the second approach to help retain water on the concrete surface.

A. Self-curing concrete.

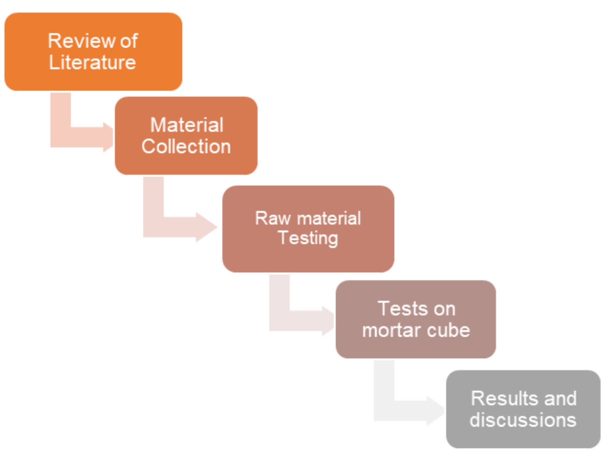
The disparity in chemical potential between the liquid and vapour phases causes a constant loss of moisture from the outer surface of concrete. By making hydrogen bonds with the water molecules in the concrete mixture, the inclusion of polymers essentially lowers the chemical potential of the molecules. Water evaporates from the surface more slowly as a result of the vapour pressure being lowered.

B. Palm Oil Fuel Ash.

Based on roughly 15 million hectares of agriculture, 60 million tonnes of palm oil were produced worldwide. Roughly speaking, 4 kg of dry biomass are produced for every kilogramme of palm oil produced, or roughly 240 million tonnes of biomass overall. Approximately 5% of the biomass is converted to ash, which is dumped in open fields because it has insufficient nutritious value to be used as fertiliser. Therefore, it is projected that the globe produces 12 million tonnes of palm oil fuel ash annually. The tropical nations of Nigeria, Malaysia, and Indonesia are home to palm oil misspenders. Rather than accumulating these waste products in these nations.

This by-product material is what remains after palm oil waste (palm kernel shell, fibre, bunches, and oil palm husk) is burned in palm oil mills to generate the necessary energy. POFA is frequently dumped in landfills and open spaces, resulting in waste accumulation and environmental problems. Thus, innovative approaches to maximise the potential benefits and reduce the risks associated with these by-products are desirable. produced high replacement level self-compacting concrete using the treated POFA. studied POFA's qualities as a limited substitute for cement, ranging from 10% to 50%, in order to create a concrete that is sustainable. That was observed. The concrete samples' compressive strength narrowed when the replacement level was between 20 and 50%. Conducted a thorough analysis on the uses of POFA in the concrete sector, covering the durability of POFA concrete. utilised POFA with nanoparticle sizes varying from 0% to 30% to create lightweight aggregate concrete (LWAC). The findings showed that substituting up to 30% of the cement with NPOFA improved the workability, compressive strength, and UPV on a regular basis and reduced the amount of CO2 released into the atmosphere. The POFA plays a significant role in mitigating and averting sulphate assaults. Used ground POFA (GPOFA) in place of some of the cement (10, 20, 30, and 40%), and found that as the fineness of the cement paste and concrete mixtures rises, so does the POFA output.

II. METHODOLOGY



III. MATERIALS

A. Cement

In order to ensure compliance with IS 1489-part 1, Ordinary Portland Cement (OPC) was tested and used in accordance with Indian Standards IS 4031-1988.

B. Palm Oil Fuel Ash.

Fuel ash from palm fruit extraction is used as fuel in cogeneration boilers of palm oil factories. The residue's leftover ash is collected as a byproduct from burning the residue using a bag-house filter and dumped on the nearest land. The present investigation involved collecting Palm Oil Fuel Ash from Oil Palm Industry, Kollam, Kerala, India. The raw Palm oil fuel ash was dried at 105–110ºC for 24 hours to remove any evaporable water content. The dried palm oil fuel ash was then sieved again using a 300 µm sieve to achieve improved reactive materials and remove significant unburnt fibrous fractions.

In order to create mixed concrete using palm oil fuel ash, sieved POFA was used. According to IS 1727-2004, the specific gravity of fuel ash derived from palm oil was found to be 1.89. Using X-ray technology, the oxide composition of palm oil fuel ash (raw material) is determined. Based on the data, it can be concluded that palm oil fuel ash is pozzolanic material since it contains 75.654% silicon.

C.Fine aggregate

As a result, fine aggregate was produced in compliance with IS 383-1970 Specifications, with specific gravity of 2.65 and fineness modulus of 2.11, matching the grading curve zone II.

D. Polyethylene glycol 400

Tiny molecular weight Under PEG, PEG-400 is the name. The liquid is translucent, thick, and colorless. In part because of its low toxicity, PEG 400 is widely used in a wide variety of pharmaceutical compositions. It is soluble in glycerin, water, acetone, benzene, and aromatic hydrocarbons; it is only weakly soluble in aliphatic hydrocarbons. 2nH4n+2On+1 is the chemical formula for PEG-400. 128 g/cm3 is its density, while 4 to 8ºC (39 to 46ºF; 277 to 281K) is its melting temperature.

IV. PREPARATION OF SPECIMENS

Fifteen mortar cube mixes were made with binary and control cementitious systems in a 1:3 ratio. To partially replace the weight of OPC, these mixes incorporated varying volumes of polyethylene glycol 400 and Palm Oil Fuel ash. In self-curing cement mortar, POFA is used in place of cement at the following percentages: 0, 10, 15, 20, and 25%. Additionally, for each percentage of Palm Oil Fuel ash, 0.5 and 1% of polyethylene glycol 400 are added.

V. EXPERIMENTAL RESULTS AND DISCUSSION

A.Flow table test

The cement mortar flow table test is used to determine the consistency of the mortar mix. The procedure is outlined in the Indian Standard (IS) code IS: 4031 (Part 5) "Methods of Physical Tests for Hydraulic Cement". Below is a general explanation of the procedure: consists of a round steel table with a raised lip around its circumference, measuring around 70.6 cm. A round mould measuring 10 cm in diameter and 15 cm in height. for mixing and filling the mould with mortar. A balance that is able to identify a single gramme. To calculate the water's volume.

Fig.1 Flow table

TABLE I. FLOW TABLE TEST ON MORTAR

Replacement of OPC by POFA (%)	Flow (%)
0%	109
10%	108
15%	106
20%	107
25%	108

A.compressive test of mortar cube.

The compressive strength of the mortar cubes is expressed in N/mm^2 and is calculated by dividing the maximum force applied to the cubes during the test by the cross-sectional area, using the section mean dimensions.

Fig.2 Compressive strength of motar cube

COMPRESSIVE STRENGTH OF THE CEMENT MORTAR FOR 7 AND 28TH DAYS

MIX ID	Compressive strength (N/mm²)			
	7th day	Remarks	28th day	Remarks
OPC100	37	As per IS 269:2015 should be greater than 37 N/mm^2	53	As per IS 269:2015 should be greater than 53 N/mm^2
POFA 10	38		55	
POFA 15	42		59	
POFA 20	36		53	
POFA 25	34		50	

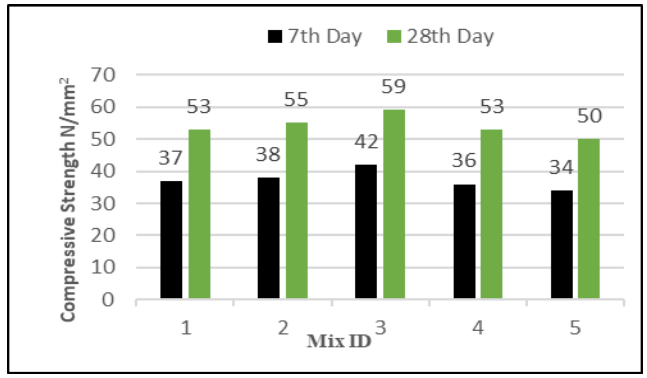


Fig.3 Compressive Strength of the Cement Mortar for 7th and 28th Day

TABLE III.
OMPRESSIVE STRENGTH OF THE CEMENT MORTAR WITH PEG400 0.5% IN FOR 7 AND 28TH DAYS

MIX ID	Compressive strength (N/mm²)			
	7th day	Remarks	28th day	Remarks
OPC100	38	As per IS 269:2015 should be greater than 37 N/mm^2	54	As per IS 269:2015 should be greater than 53 N/mm^2
POFA10	42		58	
POFA 15	44		61	
POFA 20	42		57	
POFA 25	37		53	

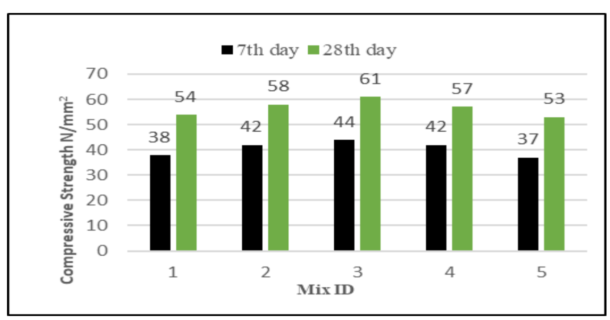


Fig.4 Compressive Strength of the Cement Mortar with PEG 400 0.5% for 7th and 28th Day.

TABLE IV. COMPRESSIVE STRENGTH OF THE CEMEN T MORTAR WITH PEG 400 1% IN FOR 7 AND 28TH DAYS

MIX ID	Compressive strength (N/mm²)			
	7th day	Remarks	28th day	Remarks
OPC100	39	As per IS 269:2015 should be greater than 37 N/mm²	55	As per IS 269:2015 should be greater than 53 N/mm²
POFA 10	41		58	
POFA 15	43		60	
POFA 20	38		55	
POFA 25	37		53	

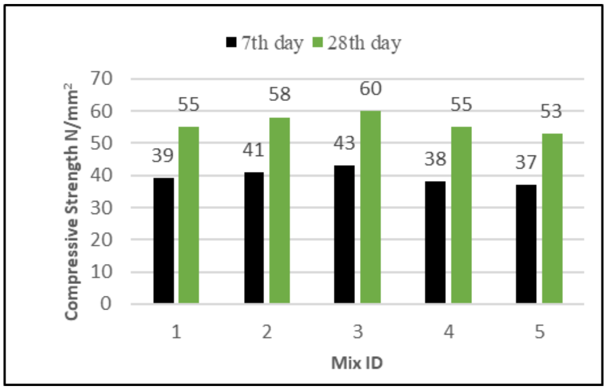


Fig.5 Compressive Strength of the Cement Mortar with PEG 400 1% for 7th and 28th Day.

C.Results and discussion

The investigation of the effects of adding different concentrations of palm Oil Fuel ash and polyethylene glycol to self-curing mortar cubes.

1. Workability Assessment:

The flow table test was used to determine the workability of the cement mortar. The results of the test indicated that the flow percentage dropped as the mixture's POFA content increased. Workability is a crucial aspect of construction, and this discovery suggests that higher POFA levels may have a negative impact on the handling and laying of mortar.

2. Compressive Strength Tests:

Compressive strength tests were performed 7 and 28 days after the self-curing mortar cubes were manufactured. The data showed that the mortar cubes' compressive strength increased with the addition of POFA and PEG. The ratios of 0.5% for PEG and 15% for POFA replacement resulted in the highest levels of compressive strength, indicating that these combinations were the most effective in strengthening the mortar. 15% replacement for POFA and 0.5% replacement for PEG, indicating that the mortar was best fortified at these specific ratios.

VI. CONCLUSION

- This study's main goal was to investigate the mechanical effects of self-curing mortar made of ordinary Portland cement (OPC) and palm oil fuel ash (POFA). Although the research findings were summarized in each chapter's conclusion, the main conclusions of this study are provided below as a thorough summary.
- The mixture became less workable as the amount of Palm Oil Fuel Ash substituted for Ordinary Portland Cement increased. POFA's pozzolanic qualities are related to this phenomenon. According to the study, the best replacement rate to achieve the required workability attributes is 15%
- On the seventh day, it was discovered that the 20% POFA substitution had a lower compressive strength than the OPC (Control mix). This suggests that when POFA is used as a partial replacement, the cement might not hydrate completely. It is observed, therefore, that the binary self-curing mortar cubes have greater compressive strengths than the traditional self-curing mortar cubes.
- According to the study, adding palm oil fuel ash to the cement mixture improves its pozzolanic activity and hydration response.
- It has been established that up to 15% of palm oil fuel ash should be replaced in cement, and 0.5% polyethylene glycol 400 should also be included. Past this point, the mortar's compressive strength decreases as additional POFA is added.

REFERENCE

[1] El-Dieb, AS 2007, 'Self-curing concrete: Water retention, hydration and moisture transport', Construction and Building Materials, vol. 21, pp. 1282-1287.

[2] Mousa, MI, Mahdy, MG, Abdel-Reheem, AH & Yehia, AZ 2015a, 'Mechanical properties of self-curing concrete (SCUC)', HBRC Journal, vol. 11, pp. 311-320.

[3] Mousa, MI, Mahdy, MG, Abdel-Reheem, AH & Yehia, AZ 2015b, 'Physical properties of self-curing concrete (SCUC)', HBRC Journal, vol. 11, pp. 167-175.
[4] Mousa, MI, Mahdy, MG, Abdel-Reheem, AH & Yehia, AZ 2015c, 'Self-curing concrete types; water retention and durability', Alexandria Engineering Journal, vol. 54, pp. 565-575.
[5] Li, Z, Liu, J, Xiao, J & Zhong, P 2020, 'Internal curing effect of saturated recycled fine aggregates in early-age mortar', Cement and Concrete Composites vol. 108, no. 103444, pp. 1-10.
[6] India Construction Materials Database of Embodied Energy and Global Warming Potential Methodology Report, 2017, International Finance Corporation, World Bank Group, USA.
[7] M.O. Yusuf, M.A.M. Johari, Z.A. Ahmad, M. Maslehuddin, Strength and microstructure of alkali-activated binary blended binder containing palm oil fuel ash and ground blast-furnace slag, Construct. Build. Mater. 52 (2014) 504–510.
[8] S. Hesami, S. Ahmadi, M. Nematzadeh, Effects of rice husk ash and fiber on mechanical properties of pervious concrete pavement, Construct. Build. Mater. 53 (2014) 680–691.
[9] E. Khankhaje, M. Rafieizonooz, M.R. Salim, R. Khan, J. Mirza, H.C. Siong, Sustainable clean pervious concrete pavement production incorporating palm oil fuel ash as cement replacement, J. Clean. Prod. 172 (2018) 1476–1485.
[10] B.S. Thomas, S. Kumar, H.S. Arel, Sustainable concrete containing palm oil fuel ash as a supplementary cementitious material–A review, Renew. Sustain. Energy Rev. 80 (2017) 550–561. [11] A.A. Awal, M.W. Hussin, Effect of palm oil fuel ash in controlling heat of hydration of concrete, Procedia Engineering 14 (2011) 2650–2657.
[11] P. Chindaprasirt, S. Homwuttiwong, C. Jaturapitakkul, Strength and water permeability of concrete containing palm oil fuel ash and rice husk–bark ash, Construct. Build. Mater. 21 (2007) 1492–1499.
[12] B. Alsubari, P. Shafigh, M.Z. Jumaat, Utilization of high-volume treated palm oil fuel ash to produce sustainable self-compacting concrete, J. Clean. Prod. 137 (2016) 982–996.
[13] J.-H. Tay, Ash from oil-palm waste as a concrete material, J. Mater. Civ. Eng. 2 (1990) 94–105.
[14] H.M. Hamada, F.M. Yahaya, K. Muthusamy, G.A. Jokhio, A.M. Humada, Fresh and hardened properties of palm oil clinker lightweight aggregate concrete incorporating Nano-palm oil fuel ash, Construct. Build. Mater. 214 (2019) 344–354.
[15] A.A. Awal, M.W. Hussin, The effectiveness of palm oil fuel ash in preventing expansion due to alkali-silica reaction, Cement Concr. Compos. 19 (1997) 367–372.
[16] W. Kroehong, T. Sinsiri, C. Jaturapitakkul, P. Chindaprasirt, Effect of palm oil fuel ash fineness on the microstructure of blended cement paste, Construct. Build. Mater. 25 (2011) 4095–4104.
[17] G.F. Huseien, M. Ismail, M.M. Tahir, J. Mirza, N.H.A. Khalid, M.A. Asaad, et al., Synergism between palm oil fuel ash and slag: production of environmentally friendly alkali activated mortars with enhanced properties, Construct. Build. Mater. 170 (2018) 235–244.
[18] G.F. Huseien, M.M. Tahir, J. Mirza, M. Ismail, K.W. Shah, M.A. Asaad, Effects of POFA replaced with FA on durability properties of GBFS included alkali activated mortars, Construct. Build. Mater. 175 (2018) 174–186.
[19] A.M. Zeyad, B.A. Tayeh, A.M. Saba, M. Johari, Workability, setting time and strength of high-strength concrete containing high volume of palm oil fuel ash, Open Civ. Eng. J. 12 (2018)