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AN OVERVIEW ON A STUDY ON HIGH PERFORMANCE REINFORCED CONCRETE USING PYPROPHYLITE

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Abstract: This project explores the use of pyrophyllite, a natural clay mineral, as a partial replacement for fine aggregates in high-performance fiber-reinforced concrete (HPFRC). The aim is to assess the effect of pyrophyllite on the mechanical properties and durability of the concrete when combined with different types of fibers, such as steel and synthetic fibers. Various replacement levels of pyrophyllite (7.5%, 10%, and 12.5%) were tested for their impact on workability, compressive strength, flexural strength, tensile strength, and durability characteristics, such as water absorption and freeze-thaw resistance.

I. INTRODUCTION

High-performance concrete (HPC) is an advanced type of concrete designed to possess superior mechanical and durability properties compared to traditional concrete mixes. It isformulated with special ingredients and optimized proportions to achieve enhanced strength, durability, and other performance characteristics. The development of high- performance concrete is driven by the need for construction materials that can meet the demands of modern infrastructure and building projects.

Pyrophyllite

Pyrophyllite is a phyllosilicate mineral that belongs to the aluminium silicate hydroxide group. It is composed of aluminium, silicon, oxygen, and hydrogen. The mineral has a distinctively dense, foliated structure, and its name is derived from the Greek words "pyro,"meaning fire, and "phyllon," meaning leaf, due to its tendency to exfoliate into thin, flexible sheets when heated. Pyrophyllite has several notable properties and applications, making itvaluable in various industries. Here's an introduction to pyrophyllite:

- Chemical Composition

Pyrophyllite has the chemical formula $Al_2Si_4O_{10}(OH)_2$, indicating its composition of aluminium, silicon, oxygen, and hydrogen. It belongs to the kaolinite-serpentine group of minerals.

- Physical Properties

The mineral typically occurs in white, green, grey or brown in colour. It has a pearly or greasy luster and hardness ranging from 1 to 1.5 on the Mohs scale. Pyrophyllite is known for its excellent cleavage in one direction, allowing it to be easily split into thin, flexible sheets.

➢ Formation and Occurrence

Pyrophyllite forms in low-temperature hydrothermal environments, often in association with other aluminium silicate minerals. It is commonly found in metamorphic rocks, such as schist and slate, and is associated with minerals like talc, serpentine, and kaolinite.

Cement concrete

Cement concrete is a crucial building material used in construction projects worldwide. It's made by mixing cement, water, sand, and crushed stone or gravel. When these ingredients combine, they form a paste that binds the aggregates (sand and stone) together, creating a solid and durable material known as concrete.

Concrete has many advantages, including its strength, versatility and durability. It's used in various construction applications such as building foundations, roads, bridges, dams and sidewalks. Additionally concrete can be moulded into different shapes and sizes, making it suitable for a wide range of architectural designs.

Overall, cement concrete is a fundamental component of modern construction playing a vital role in creating stable and long-lasting structures.

Problem statement

The construction industry is continually seeking sustainable and eco-friendly alternatives to traditional construction materials to mitigate the environmental impact associated with conventional practices. In this context, the exploration of pyrophyllite, a naturally occurring mineral, as a potential replacement material in cement concrete presents a promising avenue. Pyrophyllite possesses unique physical and chemical properties that may contributeto the improvement of concrete performance, but the feasibility, effectiveness, and potential challenges associated with its incorporation remain largely unexplored.

The use of pyrophyllite as a partial substitute for traditional constituents in concrete raisesquestions related to its impact on the structural, mechanical, and durability properties of the resulting composite material. Furthermore, considerations must be given to the sourcing, processing and overall environmental sustainability of pyrophyllite, ensuring that any advantages gained in the concrete mixture are not offset by negative ecological consequences.

The cement industry is a major contributor to greenhouse gas emissions, prompting the need for sustainable alternatives. Pyrophyllite, a naturally occurring mineral, exhibits properties that make it a potential candidate for partial replacement in cement. This study aims to investigate the feasibility and impact of incorporating pyrophyllite as a partial replacement material in cement for concrete production.

The present study aims to address these critical knowledge gaps and uncertainties surrounding the utilization of pyrophyllite in cement concrete by systematically investigating its effects on concrete properties and understanding the economic and environmental implications of its production and application, we seek to note valuable insights that could guide the construction industry toward more sustainable practices.
The specific objectives of this study include:

1.Assessing the mechanical strength and durability of concrete incorporating pyrophylliteas a partial replace cement for traditional materials.

2.Investigating the influence of varying pyrophyllite percentages on the workability and rheological properties of the concrete mix.

3.Evaluating the environmental impact of pyrophyllite production and its incorporationinto concrete.

This research is crucial in fostering the feasibility and potential benefits of using pyrophyllite in cement concrete. Ultimately, the outcomes of this study could contribute to the development of more sustainable construction practices and promote the adoption of alternative materials in the quest for a greener and more environmentally responsible builtenvironment.

RESEARCH METHODOLOGY

B. Das and J.K. Mohanty.- Mineralogical and chemical analyses of three textural varieties of pyrophyllite samples collected from Baliadihi mine of Keonjhar district, Orissa, India are investigated. Mineralogically, they consist of quartz, pyrophyllite, altered feldspar as major minerals and muscovite, chlorite, tourmaline, hematite etc. as minor minerals. The samples exhibit compositional variation of SiO_2 65.56 - 71.66%, Al_2O_3 18.79- 22.94%, FeO 1.13- 1.68% and alkalis 3.24 to 6 %. Beneficiation studies using flotation technique has indicated that silica can be reduced with concomitant increase in alumina and brightness from a raw pyrophyllite sample which can be suitable for refractory purposes

M. Mansour Sabria Malika- The current trend of industrial concrete leans more towards the use of self-compacting concrete. These must have fresh properties well defined as fluidity, filling ability and resistance to segregation. However, to ensure the rheological stability, use mineral fines is required. In this work, powder of calcined pyrophyllite (CP) was used as cement substitution at level of 10% and 20% by weight. The interest is focused on the role played by the calcined pyrophyllite to produce SCC with reduced impact environmental. Calcination of pyrophyllite powder was carried out at 750 °C. Its effect on the workabilityand mechanical properties of self-compacting concrete is analyzed. The results show that the properties of workability of SCC containing 10% of calcined pyrophyllite tested at fresh state (Slump Flow, T50, passing ability and segregation resistance) are almost identical to those of the control SCC. Furthermore, the calcined pyrophyllite increases the compressive strength, tensile and flexural strength of SCC approaching without exceeding those of the control SCC. It seems that 10 % of calcined pyrophyllite is the optimum replacement rate which improves mechanical strength compared to 20%. Replacing cement with the calcined pyrophyllite aims to save cement and reduce the CO_2 emissions released during the manufacture of cement.

M s. Mansour[1], r. Chaid[2]-. The combination of pyrophyllite as mineral admixture, synthetic fibers and binder creates an unusual fiber reinforced concrete; new composite, which offers a wide field of possible use in construction industry. The Polypropylene fiber reinforced concrete containingpyrophyllite represents a new step forward for concrete construction as it offers many advantages both economically and ecologically. The experimental results showed that: The use of pyrophyllite as substitution to cement slows down the hardening process of PFRC concrete, consequently producing lower strengths concretes at early ages approaching without exceeding those that the reference reinforced concrete. It seems that the rate of 10 % of pyrophyllite gives the reinforced concrete, the best physical- mechanical performances compared to 20% Pyr and 30% Pyr.The application of this composite material is ensured by the synthetic fibers, which along with the other components constitutes the tough structure of the composite favorable especially under tensile loading due to its high ductility.

Abdultaha Demez, Mehmet Burhan Karakoc - As temperature increased, compressive strength of concrete mixtures decreased. The reduction in compressive strength, however, was more prominent in all concrete mixtures exposed to temperatures higher than 600°C. Cooling in water has more harmful effects compared to cooling in air. Under identical temperatures, air-cooling maintains relatively higher values of residual compressive strength. When subjected to the peak temperature of750°C, the residual compressive strength of mixtures with 0 and 100% PA dropped to approximately 37 and 42% of the original values after air-cooling regime and 33 and 38% after water-cooling regime, respectively. The weight of the concrete specimens reduced significantly as the temperature increased. As the temperature increased, the weight loss of the concrete increased. Compared to five different mixtures used in the study, mixture containing 100% PA showed better performance. In visual observation of concrete samples subjected to elevated temperatures, it was noticed that the surface cracks became visible when the temperature reached 600°C. The cracks were very pronounced at 750°C. These results were supported by SEM studies. As will be seen from the studies, the PA can be used especially in concretes that can be exposed to high temperature.
Anja Terzić, Milica V. Vasić : Pyrophyllite was successfully employed as a 50 % replacement resource in the refractory, ceramic, and carbonate raw clay composites, as well as up to 30 % replacement in mortars based on andalusite, ordinary Portland cement, and high aluminate cement. Theinvestigation proved the efficiency and suitability of pyrophyllite as a resource for producing high-temperature processed building materials. In ceramics, pyrophyllite reduced the firing shrinkage, but the optimal firing regime and percent of addition must be further tested to avoid undesired cracking. The recommended firing temperature is 1200°C.The composites with the best performances were pyrophyllite with either refractory or ceramic clay to manufacture floor tiles fired at 1200°C. Pyrophyllite can solely be used in wall tiles production. In

mortars, pyrophyllite contributed to the hydration of ordinary Portland cement as it propagated the additional quantity of mineral phases (alite, belite, wollastonite, and gehlenite), which influenced the increase in compressive strength and refractoriness of Portland cement-based mortars. This influence was less notable in high aluminate cement mortars, while in blended cement mortars, the result was moderate. Crystalline folia, characteristic of pyrophyllite, was detected, forming the micro- reinforcement within the mortar's microstructure. Pyrophyllite addition of up to 20 % can be used in building or refractory mortars (fired at 1000°C) without deteriorationof their performances.

IV. RESULTS AND DISCUSSION

Compressive strength test on cubes

- Compressive Strength of Nominal Concrete Cubes

Table 7.1.1. : Compressive Strength of Nominal Concrete cubes in 7 days curing

No. of Blocks	Compressive strength N/mm^2	Avg N/mm^2
Cube 1	16.22	18.35
Cube 2	20.35	
Cube 3	18.48	

Table:7.1.2 Compressive Strength of Nominal Concrete cubes in 28 days curing

No. of Blocks	Compressive strength N/mm^2	Avg N/mm^2
Cube 1	27.42	23.68
Cube 2	21.06	
Cube 3	22.56	

- Compressive Strength of Partial Replacement by 7.5% of Pyrophyllite inConcrete Cubes

Table 7.1.3 : Compressive Strength of reinforced Concrete cubes in 7 days curing for7.5%

No. of Blocks	Compressive strength N/mm^2	Avg N/mm^2
Cube 1	18.88	17.68
Cube 2	18.22	
Cube 3	15.96	

Table 7.1.4: Compressive Strength of reinforced Concrete cubes in 28 days curing for7.5%

No. of Blocks	Compressive strength N/mm^2	Avg N/mm^2
Cube 1	22.56	25.33
Cube 2	24.80	
Cube 3	28.64	

- Compressive Strength of Partial Replacement by 10% of Pyrophyllite inConcrete Cubes

Table 7.1.5 : Compressive Strength of reinforced Concrete cubes in 7 days curing for10%

No. of Blocks	Compressive strength N/mm^2	Avg N/mm^2
Cube 1	22.62	22.95
Cube 2	24.22	
Cube 3	22.02	

Table 7.1.6 : Compressive Strength of reinforced Concrete cubes in 28 days curing for10%

No. of Blocks	Compressive strength N/mm^2	Avg N/mm^2
Cube 1	26.46	23.20
Cube 2	21	
Cube 3	22.14	

- Compressive Strength of Partial Replacement by 12.5% of Pyrophyllite inConcrete Cubes

Table 7.1.7 : Compressive Strength of reinforced Concrete cubes in 7 days curing for12.5%

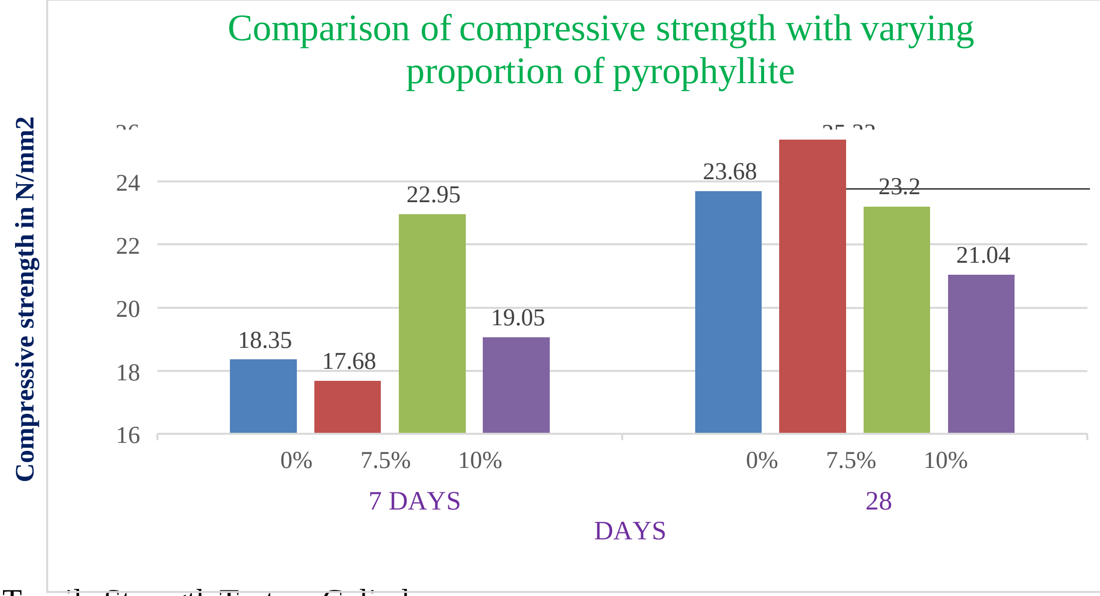
No. of Blocks	Compressive strength N/mm^2	Avg N/mm^2
Cube 1	22.18	19.05
Cube 2	18.57	
Cube 3	16.41	

Table 7.1.8 : Compressive Strength of reinforced Concrete cubes in 28 days curing for12.5%

No. `of Blocks	Compressive strength N/mm^2	Avg N/mm^2
Cube 1	23.14	21.04
Cube 2	22.48	
Cube 3	17.14	

Table 7.1.9 Average Compressive Strength N/mm^2

SL NO	% Of Pyrophyllite Added	Compressive Strength of 7 days curing in N/mm^2	Compressive Strength of 28 days curing inN/mm^2
1	0	18.35	23.68
2	7.5	17.68	25.33
3	10	22.95	23.20
4	12.5	19.05	21.04



7.2. Split Tensile Strength Test on Cylinder

➢ Split tensile Strength of Nominal concrete Cylinder

Table 7.2.1: Split tensile Strength of Nominal Concrete cylinder in 7 days curing

No. Of Blocks	Split tensile strength N/mm^2	Avg N/mm^2
Cylinder 1	2.28	2.24
Cylinder 2	2.43	
Cylinder 3	2.02	

Table 7.2.2: Compressive Strength of Nominal Concrete cylinder in 28 days curing

No. Of Blocks	Split tensile strength N/mm^2	Avg N/mm^2
Cylinder 1	2.7	2.56
Cylinder 2	2.72	
Cylinder 3	2.26	

➢ Split tensile Strength of Partial Replacement by 7.5% of Pyrophyllite inConcrete Cylinder

Table 7.2.3 : Split tensile Strength of Partial Replacement by 7.5% of Pyrophyllite inConcrete Cylinder in 7 days curing

No. Of Blocks	Split tensile strength N/mm^2	Avg N/mm^2
Cylinder 1	1.56	1.77
Cylinder 2	2.04	
Cylinder 3	1.73	

Table 7.2.4 Split tensile Strength of Partial Replacement by 7.5% of Pyrophyllite inConcrete Cylinder in 28 days curing

No. Of Blocks	Split tensile strength N/mm^2	Avg N/mm^2
Cylinder 1	2.72	2.47
Cylinder 2	2.20	
Cylinder 3	2.41	

➢ Split tensile Strength of Partial Replacement by 10% of Pyrophyllite inConcrete Cylinder

Table 7.2.5 Split tensile Strength of Partial Replacement by 10% of Pyrophyllite inConcrete Cylinder in 7 days curing

No. Of Blocks	Split tensile strength N/mm^2	Avg N/mm^2
Cylinder 1	1.40	1.59
Cylinder 2	1.55	
Cylinder 3	1.83	

Table 7.2.6 Split tensile Strength of Partial Replacement by 10% of Pyrophyllite inConcrete Cylinder in 28 days curing

No. Of Blocks	Split tensile strength N/mm^2	Avg N/mm^2
Cylinder 1	2.24	2.12
Cylinder 2	1.85	
Cylinder 3	2.29	

- Split tensile Strength of Partial Replacement by 12.5% of Pyrophyllite inConcrete Cylinder

Table 7.2.7 Split tensile Strength of Partial Replacement by 12.5% of Pyrophyllite inConcrete Cylinder in 7 days curing

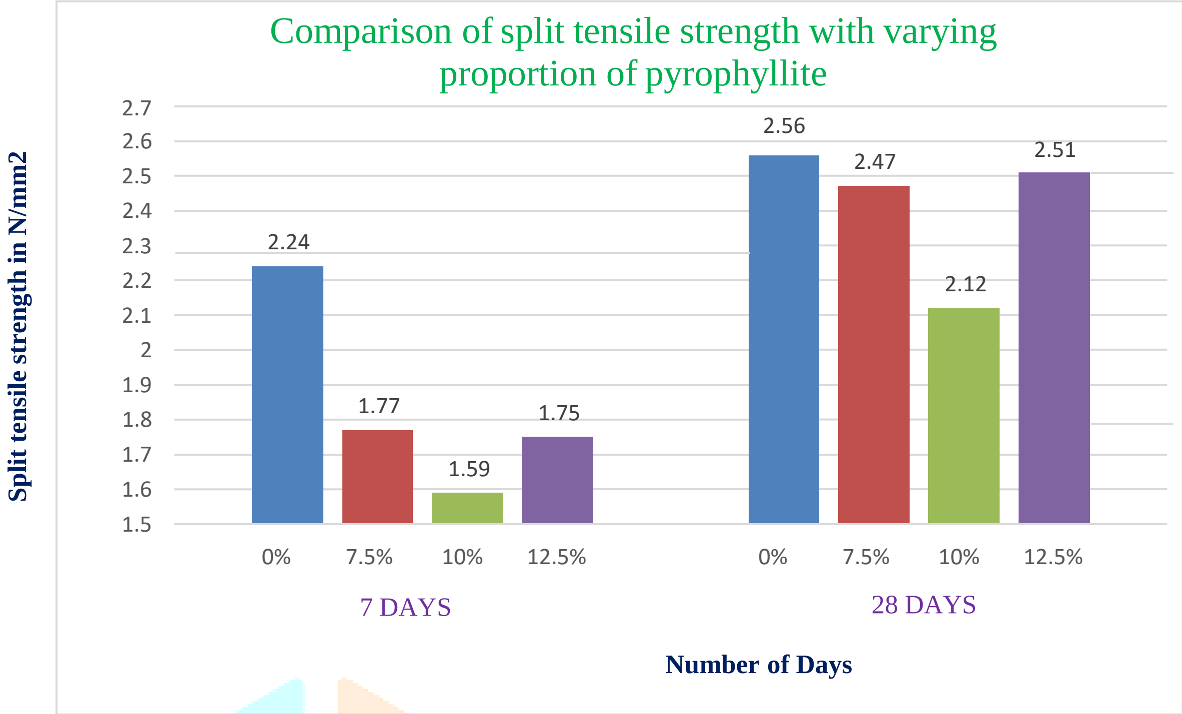
No. Of Blocks	Split tensile strength N/mm^2	Avg N/mm^2
Cylinder 1	1.70	1.75
Cylinder 2	1.54	
Cylinder 3	2.02	

Table 7.2.8 Split tensile Strength of Partial Replacement by 12.5% of Pyrophyllite inConcrete Cylinder in 28 days curing

No. Of Blocks	Split tensile strength N/mm^2	Avg N/mm^2
Cylinder 1	2.80	2.51
Cylinder 2	2.79	
Cylinder 3	2.04	

Table 7.2.9 Average Split tensile Strength in N/mm^2

Sl.no	% Age of pyrophylliteadded	Split tensile strength in 7 days curing in N/mm^2	Split tensile strength in 28 days curing in N/mm^2
1.	0	2.24	2.56
2.	7.5	1.77	2.47
3.	10	1.59	2.12
4.	12.5	1.75	2.51



strength comparison chart of Cylinders

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