UTILISATION OF INDUSTRIAL SLUDGE IN MUD CONCRETE: INVESTIGATION OF MECHANICAL PROPERTIES

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Turning wastes into building materials is a successful method of producing building materials while promoting sustainability in every aspect. There are many attempts and remarkable products around the world that show promising results of utilisation of waste-based construction materials in small- and large-scale infrastructure developments. Mud Concrete (MC) is a such innovation where the fine and coarse aggregates, which give the enduringness to a typical cement-based concrete, are replaced with soil. Replacing cement in MC with pozzolanic waste materials, preferably fly ash, is a continuation of the study on MC. Recent advancement of this same study is the geo-polymerisation of fly ash in MC using caustic soda thereby developing the strength. Aiming further waste utilisation in mud concrete and reducing energy use, replacing caustic soda with an alkaline waste, and reproducing the mixture is a potential study area, identified. This paper is advanced to investigate the behaviour of geo-polymerisation of fly ash in MC using alkaline industrial wastewater instead of caustic soda and, to assess the mechanical properties and optimise the mix proportions. The study begins with a literature review on soil-based construction, waste utilisation methods, and mud concrete chemistry. The geo-polymerisation process, which requires an alkaline environment, is separately explored as a potential strategy to utilise industrial waste in MC. Industrial wastes which are annually generated in massive amounts and, have a challenging time to dispose of, are considered. Out of those, waste types with high alkalinity are compared and, textile wastewater, the phase before it is turned into sludge, and having pH 13 is selected for further experimentation. The trial mixes are arranged by changing the mix proportions and curing temperature to assess the strength development of MC against critical parameters and, then the results are compared with existing literature findings. As the main outcome of this study, Unconfined Compressive Strength (UCS) is analysed to assess the effectiveness of sludge waste in forming geo-polymers and replacing caustic soda. It could be observed that under the same conditions, both samples with caustic soda mixed and wastewater mixed have the same UCS strength levels. This strength is 33% higher compared to that of the controlling sample with water. This leads to predicting the effect of geo-polymerisation. Further, the influence of soil type, curing temperature, and moisture content on compressive strength development are studied to identify how these key factors are affecting on strength development of MC. The observed optimum moisture content is 0.14 and, the maximum strength gain after maintaining the obtained optimum conditions is 1 MPa. A graph is developed to estimate the amount of waste, namely fly ash and textile wastewater concentration, required to achieve desired strength levels. Recommendations for further analysis include microstructure analysis expanding the study to other industrial sludge waste types and assessing how far this can be generalised. Future work involves investigating factors such as moisture content and fly ash properties to enhance MC strength. Additional tests on leachate, durability, and toxicity are suggested to further convince the use of industrial sludge waste in MC.

Keywords: Mud concrete, Alternative stabiliser, Alkali activation, Geo-polymerisation

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Utilization of Industrial Sludge in Mud Concrete: Investigation of Mechanical Properties

Thirty three percent strength increase in wastewater-based mud concrete compared to the control conditions, lead to predict the positive effect on the substitution of alkaline textile wastewater to caustic soda in geo-polymerization.

Mud Concrete

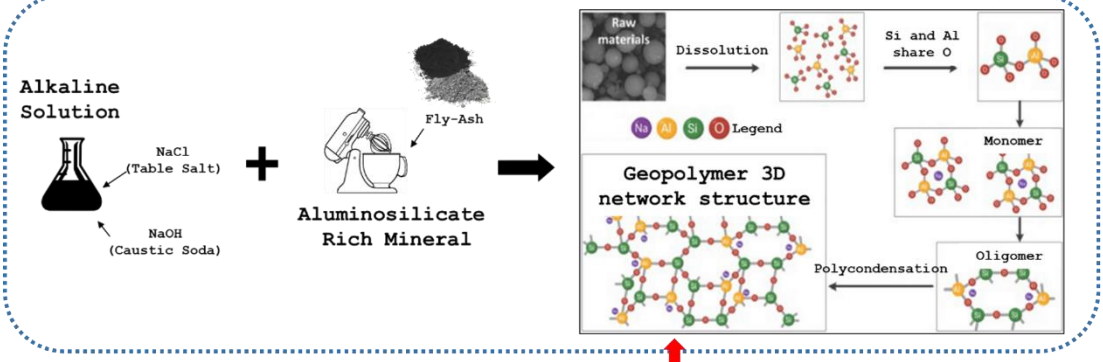
Soil:
- Fine Particles → 10%
- Fine Aggregate → (55 – 60)%
- Coarse Aggregate → (30 – 35)%

Main binder: Cement – Minimum 4%
Moisture Content: (0.80 – 0.20)

Geo-Polymerized Mud Concrete

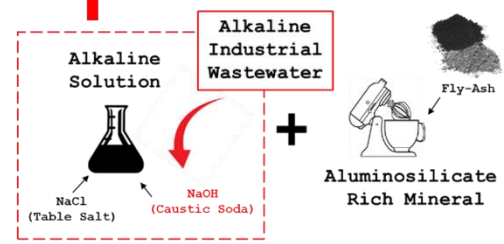
Soil:
- Fine Particles → 5%
- Fine Aggregate → 60%
- Coarse Aggregate → 35%

Main binder: Geo-polymers
Moisture Content: (0.80 – 0.20)



METHODOLOGY

- **Experiment 1**: pH testing of the sludge types and assessing the potential use
- **Experiment 2**: Checking the selected soil is capable of giving the required proportions of different particle sizes; Casting mud concrete by altering NaOH with industrial sludge in ambient temperature and elevated temperature and comparing the strength
- **Experiment 3**: Testing the influence of moisture content on strength development
- **Experiment 4**: Finding out the optimum fly-ash and waste contents to gain the maximum strength under controlled conditions



Alternative Approach to geo-polymerization by Waste Utilization

MAIN FINDINGS

- Optimum moisture content = 0.14
- Development of Compressive strength versus wastewater concentration and fly-ash content graph