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SELF CURED CEMENT - LESS CONCRETE IN CANAL LINING WORKS USING INDUSTRIAL WASTE- A CASE STUDY

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ABSTRACT
Cement is the most widely utilized building material, second only to water. The process of making ordinary Portland cement (OPC) is extremely harmful to the environment since it emits a significant amount of CO2. In an effort to reduce the production of greenhouse gases, geopolymer—an alumino-silicate-based binding substance comprised of fly ash, an industrial waste product, and alkaline liquids that react with the fly ash to create geopolymer—has been used as an alternative to cement. Cement-free binder created from alkali activated industrial waste such as fly ash and slag has emerged as the best low-carbon emission alternative to OPC in the cement industry. In this paper the strength and durability of such a one-of-a-kind self-cured concrete must be investigated in order to determine its long-term viability in the field. The fly ash based geo-polymer concrete (GPC) has been designed after verifying the fresh and mechanical properties by replacing fly ash and ground granulated blast furnace slag (GGBFS) with 10 molar concentration of sodium hydroxide solution in self curing under ambient conditions. The outside performance in field operations such as canal lining construction was then studied using this proportion. At 7 days of maturation, the parts of the structure having larger percentages of GGBFS had the greatest strength. The strength of the canal lining improvements were measured using rebound hammer tests at 7, 14, and 28 days, and the results were compared to the strength of laboratory cube tests.

Key words: Self curing, GPC, GGBFS, field work, mechanical strength, rebound hammer test

INTRODUCTION:
190 million tonnes of cement are produced globally each year to meet the 260 million tonnes of demand. Carbon dioxide emissions and energy use during cement manufacture both contribute to global warming [5,13]. Currently, 7% of all emissions of greenhouse gases come from the cement sector. If the current upward trend in emissions continues, cement production may soon represent half of all emissions. [1,2,3,4,12,13]. The primary raw material of cement is lime stone, and it is a limited-resource natural resource. Around two tonnes of lime stone and shale are required as raw materials to create one tonne of OPC. Natural resources such as lime stone may be depleted from the earth's surface as a result of regular consumption. In the next twenty-five to fifty years, geologists think that the world's available lime stones will be depleted. [7,8,12,13]. Therefore, it is now necessary to look into the most economical use of these natural resources. Although a concrete construction should last for at least fifty years, corrosive surroundings cause it to deteriorate in twenty to thirty years [13]. The need for long-term durability and the growing environmental hazard posed by the cement industry have made it imperative to find a method for producing concrete without cement. The goal of this research is to provide a long-lasting, ecologically friendly substitute for OPC.
Geo-polymer, developed in the 1970s by Prof. J. Davidovits, may be the best cement substitute. Fly ash and alkali activator mix to form an alumina-silicate material that is high in silica (50%) and alumina (30%) and is three-dimensionally networked. The resulting geo-polymer materials exhibit good mechanical properties. Additionally, geo-polymer has outstanding chemical and heat resistance, indicating greater durability. Carbon dioxide emissions can be cut by 80% by switching to geo-polymer concrete from conventional OPC concrete. [5,6,13].

As manufacturing waste, over 450 million tonnes of fly ash and 350 million tonnes of GGBFS are produced annually. Only 7% of this industrial waste is used in the production of cement or as a cement substitute for making concrete. The remaining fly ash and slag are typically dumped on open fields, using a lot of space and polluting the atmosphere. These industrial wastes' storage has recently come under scrutiny. Negative environmental effects and the price of producing concrete will both be decreased if these waste items can be utilised to create useful materials like concrete. [10,11,13].

In this research, different percentages of fly ash and GGBFS with 10M sodium hydroxide and sodium silicate mix were casted for the purpose of canal lining works, and their strength parameters were compared at the site using rebound hammer test apparatus and collected cube samples from site at laboratory.

PILOT STUDY:

A pilot study was carried out in the distributary No. 0 of Kendrapada Canal, which included canal lining of 10m length trapezoidal sections and 20m length trough sections under Mahanadi North Division, Jagatpur-1, Cuttack, Odisha. The details of plan and section of the structures are mentioned in fig. 2.

Materials used:

The materials used for cementless concrete are as follows and also mentioned in fig. 1.

- Fly ash used here is collected from National Thermal Power Corporation, Kaniha, Odisha
- GGBFS: Slag is a bi-product of iron and steel making industry and is obtained from TSPL, Kalinga Nagar in the Jajpur district of Odisha in the form of flakes and ground it in the laboratory of the KIIT Civil Engineering to get ground granulated blast furnace slag (GGBFS).
- Alkaline Solution: The alkali activated liquid is prepared by mixing different molarities of NaOH (10M) solution with Na_2SiO_3 solution in the proportion of 1:2. Sodium hydroxide (NaOH) :Pellets of NaOH of 97%-98% purity was purchased from a local supplier in bags of 50kg. Sodium silicate solution: Na_2SiO_3 solution (bulk density - 1.41 kg/L, Na_2O= 13.7 % , SiO_2=29.4%, and water=55.9% by mass) was purchased from a local supplier.
- Fine aggregate: Standard Sand conforming IS- 650:1991
- Coarse aggregate: Crushed hard granite coarse aggregate conforming to IS 383(1987) was used.

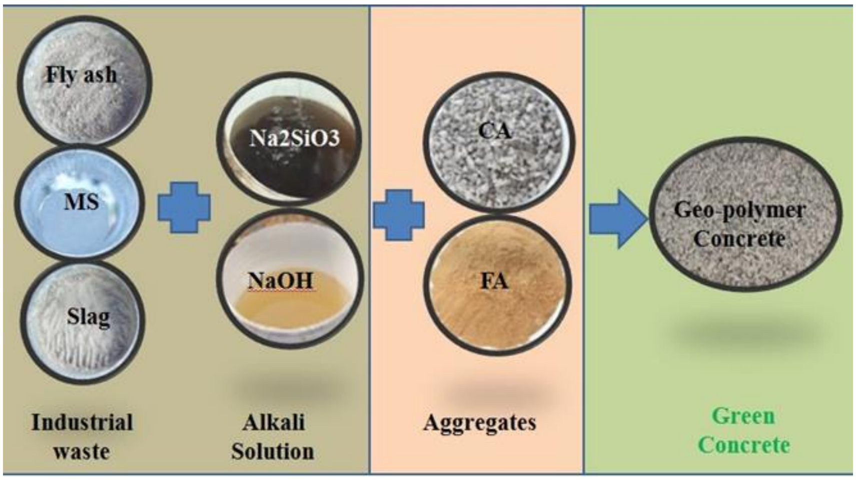

Fig.1 Materials used for cement-less concrete

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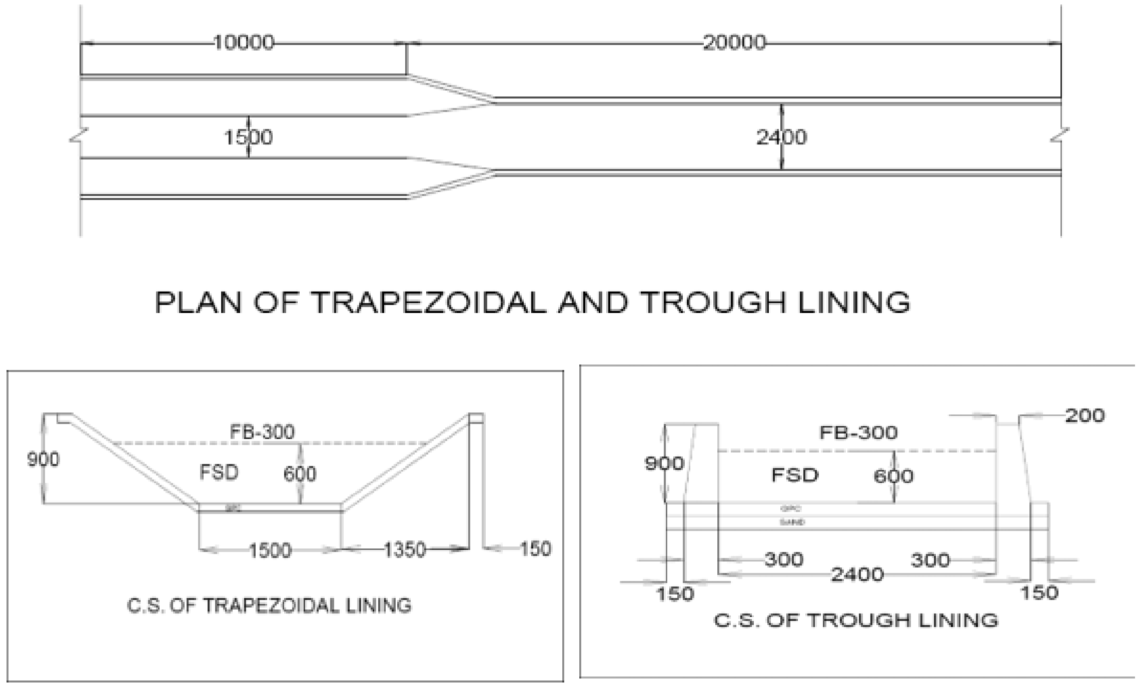

Fig. 2 Plan and cross section of canal lining

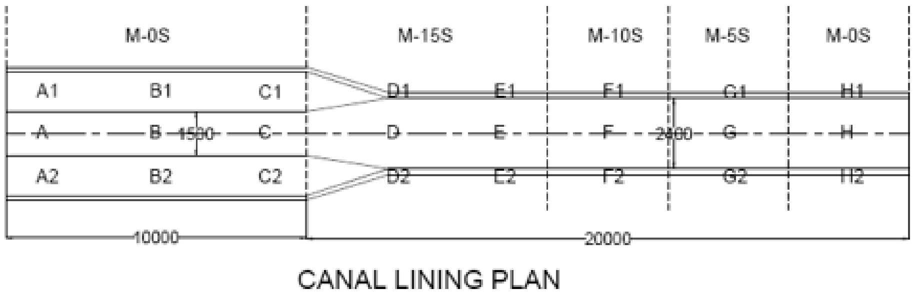

Fig. 3 Location of mix proportions and numbering of RH testing

Mix Design for Pilot Project:

In this work, GPC was considering M-15 grade concrete for canal lining and alkali solution to fly ash ratio was taken as 0.4, NaOH concentration 10M solution for canal lining works, ratio of sodium hydroxide to sodium silicate solution - 1:2. To study the behavior of strength in canal lining works, four types of mixtures were used: M-0S (0 % GGBFS), M-5S (5 % GGBFS), M-10S (10 % GGBFS), and M-15S (15 % GGBFS).

Table.1 Mix design for construction of canal lining (kg/ m³)- M-15 grade

MIX	Fly ash	Alkali solution	Slag	Fine aggregate	Coarse aggregate
M-0S	431.2	176	0	792	1320
M-5S	409.2	176	22	792	1320
M-10S	387.2	176	44	792	1320
M-15S	365.2	176	66	792	1320

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Mixing and Casting:

- One day prior to casting NaOH solution of 10M conc. were prepared at site for canal construction.
- Fly ash, slag and aggregates in required quantities were mixed in a mechanical mixer machine for 2-3 minutes thoroughly and then measured quantity of alkali solution, plasticizer and some quantity of water were added gradually for getting a good workability and mixed further for 2 minutes till a uniform mix was obtained.
- After mixing, the concrete mix was transported to the required place as quickly as possible by manual/ wheel based trolleys. During placing care was taken that no contamination, segregation for loss of its constituent materials or ingress of foreign matters to place and the required workability was maintained.
- The slump test was carried out using slump cone test apparatus. The average slump value was seen 40 mm.
- After placing of concrete of required thickness, compaction was done by plate and needle vibrator before the initial setting time of concrete and surface was leveled and finishes smooth by straight edge. Care was taken to avoid displacement of form work.
- Cube samples were casted at site and delivered to the laboratory for 7, 28 days strength tests.

Fig.4 Mixing of GPC

Fig.5 Pictures at the time of casting of canal lining cube making, slump cone testing

Testing:

Testing was carried out in two methods: compressive strength was carried out of samples collected from site after 7 &28 days, non destructive test (Rebound hammer Test) was carried out at 7, 14 & 28 days on canal lining construction.

Rebound hammer testing at site:

According to the fig.3 rebound hammer test was carried out at canal lining works portions as per IS 13311: Part 2 : 1992. The rebound hammer numbers of each location were collected at 7, 14 and 28 days maturation of the works. The average numbers of six points of each location are then mapped as per the graph available in the IS code.

RESULTS AND DISCUSSION:

The results of rebound hammer test at different location of canal lining works were collected in 7, 14 & 28 days of maturations and mentioned in the fig. 6. The results of cube casted at site and tested at laboratory in 7 and 28 days also mentioned in fig. 6. Here RH- Rebound Hammer results, Lab- Cube testing at laboratory (Casted at Site).

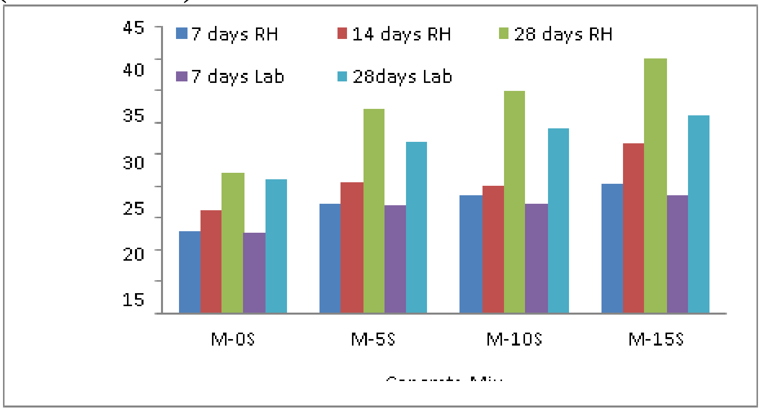

Fig. 6 Results of strength of Canal lining

Because of the sunlight exposure at the site, the compressive strength attained at site is higher than the strength achieved in the laboratory.The compressive strength of the M-0S mix was below the specified strength at 7 days and above the designed strength for the other mixes M-5S, M10S, and M- 15S, however 14 and 28 days strengths were above the designed strength for all mixes. The rebound hammer test of the canal lining at different dates like 7, 14 and 28 days are shown in fig 7, 8 & 9 respectively.

Fig. 7 Rebound hammer testing at canal lining portion on 7 days of maturation

Fig. 8 Rebound hammer testing at canal lining portion on 14 days of maturation

Fig. 9 Rebound hammer testing at canal lining portion on 28 days of maturation

CONCLUSION:

The following conclusions have been arrived from the project works;

The flowability of the GPC reduces as the percentage of GGBFS rises. The compressive strength of GPC increases as the fraction of GGBFS rises. Before the 14-day self-curing period, the Canal Lining works reached their target design strength.The entire drying process was completed outside under natural lighting.The cubes' strength was lesser than that of exterior works since they were kept within the room. Thus, geopolymer concrete is an excellent substitute for OPC concrete in the construction of roads and canal lining, as well as a smart option for engineers looking to lower greenhouse gas emissions. However, more investigation may be done into the usage of other components in a geopolymer concrete mix that are both affordable and have a low carbon footprint.

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