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Use of Grog Fines in Flowable Fill

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ABSTRACT: Flowable fill or Controlled Low Strength Material (CLSM) is a mixture of soil or any byproduct, cement, water and sometimes admixtures that hardens into a material with a little higher compressive strength than soil. In applications where it is normally difficult to obtain the required degree of compaction using the conventional compaction equipments, CLSM is considered as an effective alternative. The present study intends to investigate the feasibility of using Grog Fines (GF), the refractory byproduct generated from the production line of refractory in Saint Gobain India Pvt. Ltd. Based on the basic properties, GF could be used to replace major proportion of cement in the conventional flowable fill. Fresh and hardened properties including flowability, compressive strength, bleeding, hardening time, etc. are evaluated. The study may pave the way for other potential uses of this waste material in the construction industry, targeting more environmentally sustainable concrete industry. In this study it was found that the compressive strength of the flowable fill decreases with increase in the amount of grog fines but lies within the required range of compressive strength for flowable fill.

Keywords: *Flowable fill; Controlled Low Strength Material; Grog Fines*

1 INTRODUCTION

Flowable fill or Controlled low strength material (CLSM) is a low compressive strength, self-compacting, self-levelling and highly flowable cementing materialthat satisfy American Concrete Institute (ACI 229) recommendations. Owing to these unique characteristics, flowable fills are used in many applications including backfills against retaining wall, structural fills, insulating and isolation fills, thermal-insulation- conductivity fills, erosion control, void filling,conduit bedding for pipe, electrical, telephone; at nuclear facilities for waste stabilization, encapsulation of decommissioned pipelines and tanks, encapsulation of waste disposal sites, new landfill construction; and pavement bases, sub bases and subgrades (Ghanad et al., 2020). The compressive strength suggested by ACI committee for flowable fill is less than 8300 kPa (8.3 MPa) which is necessary to allow for future excavation and the flowability in its fresh state is in between 200 mm to 300mm for easy filling and self-compaction (Dueramae et al., 2021). Additionally, bleeding and hardening time are also determined in flowable fill. Cement, fine aggregate, water, and other chemical admixtures constitutes the common CLSM mixture. Even a mixture of cement and fine aggregate with high level of water content to adjust flowability can be considered as the simplest form of CLSM. The low mechanical requirements compared with concrete enable the use of industrial wastes or by-products and recycled materials.

The main objective of the study is the effective utilization of Grog fines, the waste generated from Saint Gobain India Pvt Ltd, Kanjikode, Palakkad, toevaluate the feasibility of incorporating it as a partial replacement for cement into a flowable fill that can be used for various purposes. Findings from the study will pave the way for other potential uses of industrial wastes in the construction industry, targeting a more sustainable technique.

2 PROPERTIES OF MATERIALS

GROG FINES

Grog fines, the by-product are collected from Saint Gobain India Pvt. Ltd.,Kanjikode, Palakkad. Grog fines called as Alumino silicate which is used as insulating grains in the process of AZS (Alumina, Zirconia, Silica) refractory making to insulate the casted blocks for achieving a predefined cooling gradient.General physical properties of Grog fines are:

- Fine powder - + 200 mesh size
- Sound thermal insulation property
- Odor less
- Highly abrasive in nature
- Insoluble in water
- Chemically inert

CEMENT

Ordinary Portland Cement (OPC) of grade 33 was used. The cement binds the aggregate into a solid mass, fills up voids present in the aggregate and gives strength to fill during setting and hardening when mixed with water.

FINE AGGREATE

Fine aggregates are small size filler materials used in construction. It is an essential ingredient in concrete and mortar. It reduces shrinking, cracking and helps in hardening of cement. In this study ordinary river sand was used.

WATER

Water is essential for hydration process to take place. It ensures workability andhelps in spreading of the mix. Potable water with pH value around 7.2 was used.

3 MIX PROPORTION OF FLOWABLE FILL

It is necessary to select a mix ratio before going into preparation of flowable fillso that there is uniformity in all mixes prepared and hence it will be easier to compare the results of various tests performed. The mix ratio selected in this study is 1:3 (cement: sand) with a water content that allows a flow diameter of 23cm. We arrived in this mix by referring various journals that was available to us and practically performing flow test for various mixes. We prepared mixes of ratios 1:2, 1:3, 1:4, 1:5 and 1:6. It was found out that every mixes apart from the mix 1:3 which is prepared with cement, sand, grog fines and water, did not satisfy the flow requirement which should be between 20-30 cm as per ASTM standards provided for flowable fill. With this mix proportion 9 samples were prepared for each proportion of grog fines. After setting the specimen is taken out of the mould and cured for 7, 14 and 28 days.

4 TESTS ON FLOWABLE FILL

FLOWABILITY: Flowable fills should flow easily without segregation. Watercontent governs the flowability which can be determined as per ASTM D 6103. Flowability recommended for a CLSM is between 200 and 300 mm. Table 1 shows the test results of flowability.

Table 1: Flow consistency of Flowable fill

Description	Amount of Cement Replacedby Grog Fines (%)	Average Flow (cm)
A	0	22
A1	10	23
A2	20	23
A3	30	23
A4	40	23
A5	50	22

BLEEDING: Bleeding is defined as the segregation of water from the cementitious materials and thereby water rises to the surface of the mix. This may led to inefficient hardening of the mix. The bleeding property of the mix is determined as per ASTM C 232. Table 2 shows the test results of bleeding.

Table 2: Bleeding in various mixes

Description	Amount of Cement Replaced by Grog Fines (%)	Bleeding (ml)	Bleeding (%)
A	0	38	4.75
A1	10	28	3.5
A2	20	26	3.2
A3	30	24	3.0
A4	40	22	2.75
A5	50	21	2.625

HARDENING: The time required for the flowable fill to harden from its initial state is referred as hardening time. This property is measured using Kelly Ball apparatus as per ASTM D6024. Table 3 shows the test results of Hardening time.

Table 3: Hardening time of flowable fill

Description	Hardening time in hours
A	6.5
A1	5.75
A2	4.75
A3	4.5
A4	4.3
A5	4.1

COMPRESSIVE STRENGTH TEST: The compressive strength test at water contents corresponding to flowability values obtained are conducted as per ASTM D4832. The samples are prepared in PVC pipe moulds of 50mm diameter and 100mm length. The size of the moulds are selected in such away that the cured sample is suitable for unconfined compressive strength testing to quantify the strength gain of the mixes. The mix with required flowability is carefully poured into the mould avoiding air bubbles entrap and without compaction. The ends of the moulds are covered with plastic sheets [Fig. 1] to avoid evaporation loss. The samples [Fig. 2] are removed from moulds after 24 hrs and are kept for curing. By testing the cured samples in UCC apparatus, it could be observed that the strength gain of the trial mix itself is more than the proving ring's maximum limit. Hence considering the cement properties and strength range, the strength tests are further carried out in compression testing machine (CTM) as given in [Fig. 3].

Fig.1: Casting of the specimen

Fig.2: Specimen removed from the mould after 24 hrs

Fig.3: Specimen kept in CTM for compression testing

Table 4: Compressive strength of flowable fill

Description	Grog fines (%)	Compressive strength (N/mm^2)		
		7 days	14 days	28 days
A	0	5.49	6.49	7.99
A1	10	3.99	5.49	6.99
A2	20	3.49	4.99	6.49
A3	30	2.74	4.49	5.99
A4	40	2.49	3.99	5.49
A5	50	1.74	3.99	4.99

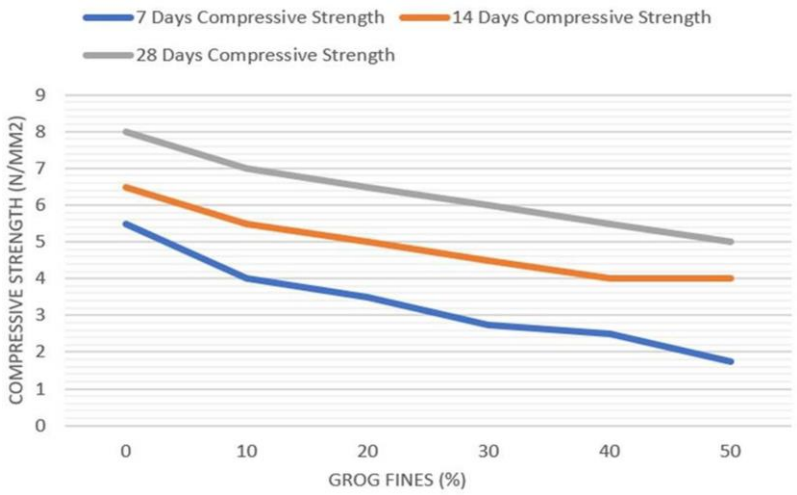

Fig. 4: Variation in compressive strength with increase in the grog fine content

The compressive strength of control mix and the mixes with various proportions of grog fines are obtained as shown in Table 4. As per the ASTM standards the compressive strength should be in the range of 0.3 to 8.3 N/mm^2. From the abovetable the strength obtained for 7, 14, and 28 days is in the required range. It can be observed that when the amount of grog fines increases the strength of the flowable fill decreases as described in Fig.4.

5 CONCLUSIONS

This study intends to investigate the feasibility of using grog fines in flowable fills to perform various applications like filling of underground pipelines and mine shafts, where it is normally difficult to obtain the required degree of compaction using the conventional compaction equipments. In such situations, flowable fill is considered as an effective alternative. Major conclusions drawn from the detailed study on finding the suitability of grog fines as flowable fills are as follows:

- To obtain the preferred flowability for every mixes corresponding to the control mix, the water content is found to be decreasing with the increase in percentage of grog fines in the flowable fill. For each 10 % increase in the grog fines, the amount of water content corresponding to required flowability reduced by 2 to 5 %.

- It is found that the compressive strength of the flowable fill decreases with the increase in the amount of grog fines, but lies within the required range (0.3 to 8.3 N/mm^2) of compressive strength for flowable fill. Since flowable fill isused for various applications, we can effectively use the flowable fill with grogfines for these applications.
- The replacement of cement with grog fines is able to obtain the requiredproperties of flowable fill, thus grog fines can be used effectively in flowable fill there by reusing the byproducts from the refractory lines of Saint Gobain India Pvt. Ltd. will lead to a sustainable alternative.

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