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SEEWAGE SLUDGE ASH (SSA) IN PRECAST CONCRETE BLOCKS

K.Nagarjuna*, I.Prasanth Aryabhat
Department Of Civil Engineering, R.V.R & J.C College Of Engineering,Guntur, A.P, India.

ABSTRACT

The present study explored the technological feasibility of re-using sewage sludge ash (SSA) as a Portland cement replacement in commercially manufactured pre cast concrete blocks. The blocks analysed were made to the guidelines laid down in Waste Water Treatment Plant Sludge, and Indian specifications (CE marking) for such products. Performance was compared in three families of blocks, with 0, 10 and 20% SSA. The findings proved that SSA is apt for pre cast concrete block manufacture and that, in addition to the economic and environmental benefits afforded, its use would improve certain of the properties of conventional block.

KEYWORDS: SSA,precast blocks,concrete.

INTRODUCTION

The composition of the sewage sludge (SS) generated in waste water treatment plants depends on the pollution contained in the initial waste water and the treatment procedures used. Since water treatment concentrates the pollution present in sewage, the resulting SS contains a wide variety of suspended or dissolved matter, some of which is of agricultural value (organic matter, nitrogen (N), phosphorus (P) and potassium (K) and in smaller proportions, calcium (Ca), magnesium (Mg) and other essential plant micronutrients), while other components, such as heavy metals, pathogens and organic compounds, are potentially polluting. This waste must be managed in accordance with principles and policies geared to protecting the environment and human health, which include prioritising prevention over recycling and other types of valorisation, including energy, and establishing the deposit of these materials in sanitary landfills as a last resort (1). SS is normally used in agriculture. The respective legal framework lays down ceiling values for heavy metals and requirements for bio-logical, chemical or thermal treatment, long-term storage or other suitable procedures to significantly reduce the fermentation power in sludge and any health hazards involved in its use in the soil. The legislation further stipulates that plants' nutrition needs must be determined to define fertiliser dosages to prevent any alteration of water or soil quality (2). The most widespread treatment processes for SS, often used in combination, are: mesophilic anaerobic digestion; composting; thermal drying; aerobic stabilisation; chemical stabilisation (with mineral reagents such as iron chloride or lime); dehydration; incineration; and co-incineration in cement plants. Some of these treatments entail drawbacks such as high initial investment and maintenance costs, the need for odour control or very large sites, or the risk of explosion in processes that generate gas.

According to a 2010 study, India produces approximately 2800 tonnes of sludge yearly, measured as dry matter. Such waste commonly ends up in fertilisers (65–80%), sanitary landfills (8–20%) or incinerators to reduce its volume. Around 4–10% of the total sludge is incinerated, but the trend is to raise European mean of 20–25%. In sludge with a 25–30% solids content, incineration reduces the volume by 90%, greatly facilitating management of this waste. A certain fraction of the energy consumed in combustion or to heat the air to partially dry the sludge is "recovered" in the form of exhaust gases. Some plants have boilers and tur-bines that generate electric power from those gases.

Although the power output is fairly small unless the solids content in the sludge is significantly higher than 30%. Prior studies showed that SSA can be used in brick manufacture, as fines mortars, to prepare synthetic aggregate (14–17) and as aggregate in hot mix asphalt (18). SSA has likewise been used to produce phosphoric acid (19). Nonetheless, one of its most promising applications is as an admixture in construction mortars or concretes. Previous studies have shown that mortars made with SSA exhibit good mechanical properties. The improvement observed can be attributed to the pozzolanic activity of SSA, although recent research on re-used material showed that, compared to other known pozzolans, its pozzolanicity is weak at best. SSA fineness has been observed to have a significant effect on both the mechanical strength and workability of concrete.SSA has also been applied as a lightweight material in thermal and acoustic insulation. Studies on its compatibility with a variety of types of cement in connection with mechanical strength concluded that given its physical properties, it is apt for inclusion in the preparation of portland cement based materials. Lastly, environmental questions must also be borne in mind, for sludge ash may contain hazardous compounds. in

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EXPERIMENTAL METHODOLOGY

The components of the pre cast concrete blocks analysed in this study were tap water, limestone fine and coarse aggregate and portland cement. The SSA used was produced by a fluidised bed incinerator in a waste water treatment plant The maximum temperature reached at the plant is 800 ° C. Table 1 gives the chemical composition of the SSA, obtained with X-ray fluorescence (XRF), while Table 2 lists crystalline compounds of sewage sludge ash. The SSA was a fine brown powder with a mean particle diameter ranging from 63 to 110 microns. Although X-ray diffraction (XRD) identified a number of crystalline compounds, the SSA was primarily amorphous due to the high temperatures reached during the incineration of the original sewage sludge, which induced thermal activation of its clay content. Ash particles were irregularly shaped a These properties were indicative of the existence of the pozzolanicity that essential to the objectives proposed and to the potential use of the ash as a cement replacement.

maximum dry density of 20.1kN/m^3, optimum moisture content of 9.4% and having a silt size of 16%. The gravel size is 3% and sand size is 81%. As per Indian standards the stone dust from its properties of particle size comes under SM.

PROCEDURES

The application and the CE marking to construction materials and other products is advancing steadily in India. To obtain the CE marking, without which products cannot be brought to market, certain minimum safety and quality standards must be met. Consequently, contrary to past practice, no product-specific requirements are established. Rather, manufacturers must guarantee the characteristics of their products, in the case of concrete masonry units, as per Indian standard. According to these provisions, prior to the introduction of a new product on the Indian market, a series of initial trials must be run to ensure that its properties meet the manufacturer's specifications and quality and safety standards. The methodology used in the present study was designed along the guidelines set out in those provisions. For pre cast concrete blocks and the Indian standards describing the procedures for each that were followed in this study.

In this study, applied to pre cast concrete blocks in which the cement was partially replaced with SSA. The findings were compared to the results for control materials, namely concrete blocks containing no SSA.

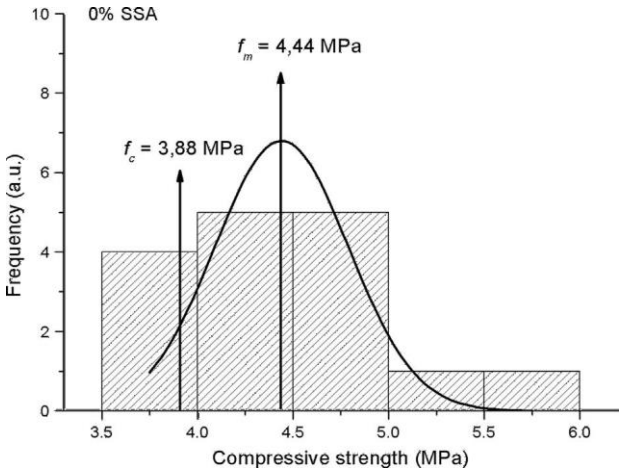
EXPERIMENTAL DATA

Table1: chemical composition of sewage sludge ash

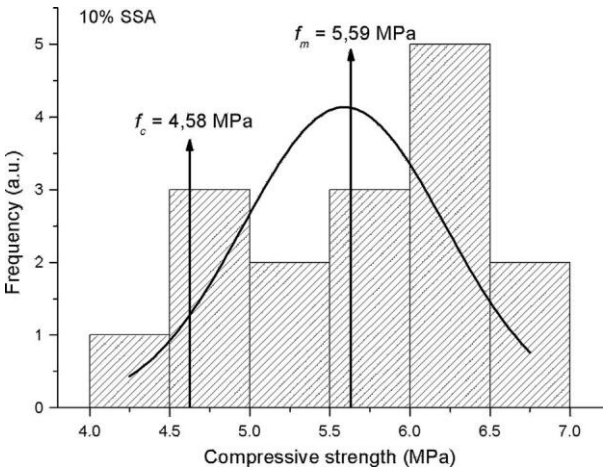
S NO	Composition	Wt %
1	**Al_2O_3**	8.9
2	**CaO**	30.6
3	**Fe_2O_3**	10.0
4	**SO_3**	11.1
5	**Na_2O**	0.8
6	**MgO**	2.7
7	**H_2O**	0.5

Table 2: crystalline components in sewage sludge ash

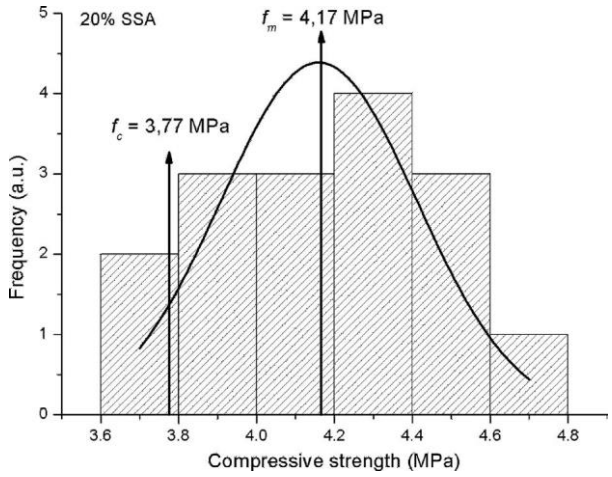
S.No	MINERAL	FORMULA
1	Quartz	SiO_2
2	Anhydrite	$CaSO_4$
3	Calcite	$CaCO_3$
4	Magnetite	$FeO{\cdot}Fe_2O_3$
5	Free lime	CaO

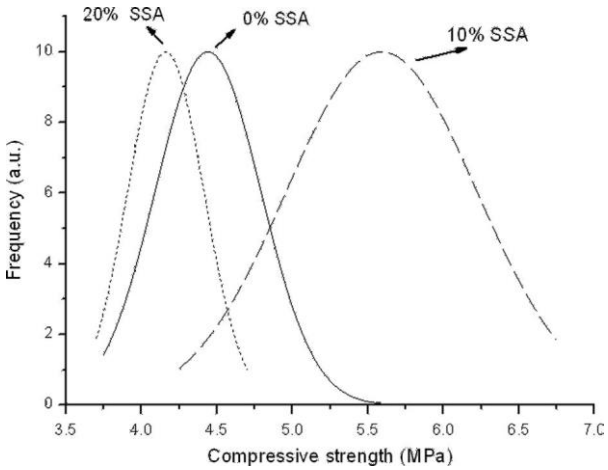


Analysis of compressive strength data for pre cast concrete blocks with no SSA.



Analysis of compressive strength data for pre cast concrete blocks with 10% SSA





CONCLUSIONS

- The manufacture of pre cast concrete blocks in which the cement was replaced by up to 20 wt% SSA proved to be a suitable method for reducing the environmental impact of this waste material. The manufacture of blocks containing SSA to CE mark-ing standards is commercially viable. This solution is also in keeping with the sustainability guidelines set out for Waste Water Treatment Plant Sludge.

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