Co-Processing of Waste Sludge in Construction Industry: A Review

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Abstract— Many attempts have been made to incorporate wastes into production of building material. It is a practical solution to reduce cost expenditure on waste management and its effects on environment. The sewage treatment process as well as many industries which using effluent treatment plant generates a sludge, that must be disposed in environmentally sound manner among all disposal options. The use of sludge in producing constructional elements is considered to be the most economic and environmentally sound option. Advancing solid waste management results in alternative construction material like, brick, block, aggregate and cement to safe guard environment. This study reviews various attempts that have been made to use sludge from different plants in construction industry.

Key words: Industrial Sludge, Blocks, Bricks, Ceramic, Compressive Strength, Concrete, Material, Water Absorption

I. INTRODUCTION

Rapid Industrialization and Urbanization is causing serious environmental problems. One of the major concerns amongst these is safe and sound disposal of solid wastes. There is a strong demand for environmentally safe reuse and effective disposal methods for sludge due to the increasing amount of sludge generated by the industries. While sanitary landfills are commonly used for disposal or sewage sludge, rapid urbanization has made it increasingly difficult to find suitable landfill sites. Therefore Co-processing of industrial sludge is great alternative.

Co-processing is the use of waste as raw material, or as a source of energy, or both to replace natural resources. Co-processing is proven sustainable development concept that reduces demands on natural resources, reduces pollution and landfill space. Storing the waste materials and the resulting global environmental hazard has increased the demand and development of sustainable alternatives. For this reason, industrial attention has focus on developing environmentally friendly, low cost and lightweight construction materials obtain from waste.

Researchers have attempted reuse and recycle waste to enhance a sustainable environment. Attempts have been made to incorporate industrial sludge in the production of bricks; for instance, the use of paper processing residues, cigarette butts, flu ash, textile effluent treatment plant sludge, polystyrene foam, plastic fibre, straw, polystyrene fabric, cotton waste, dried sludge collected from an industrial wastewater treatment plant, rice husk ash, granulated blast furnace slag, rubber, Kraft pulp production residue, limestone dust and wood sawdust, processed waste tea, petroleum effluent treatment plant sludge, welding flux slag and waste paper pulp.

Co-Processing, Reuse or recycling such waste to develop sustainable construction materials as proved to be a practical solution to disposal and environmental problem.

II. LITERATURE REVIEW

The following gives the details on materials and methods used in the study so far conducted.

Bricks were developed using mixture of sludge with clay and shale, called bio brick. It was discovered that conventional clay and shale ingredients could be partially supplemented with wastewater sludge has solid content 15-25% to produce bio bricks. The bio brick had the look, feel and smell of regular bricks. [1]

Brick developed using dried waste water sludge and clay, samples with varied sludge percentage was produced and fired in a kiln, the results on the mechanical and physical properties shows that dry sludge can be used with clay at percentage ranges of 0-40 of brick weight and the compressive strength decreases with increase in sludge content. Due to the burnt off organic content of sludge during firing process, uneven texture surface and porosity arises. This problem was solved by introducing or replacing dry sludge with sludge ash which has zero organic content and it was determined that the maximum sludge percentage that can be used is 50% and results showed that the bricks containing pulverized sludge ash had a higher strength than bricks containing sewage sludge. Bricks containing 10% of sludge ash have strength as high as normal clay bricks. [7]

The potential use of dry pulverized sludge in brick production was performed. Dry pulverized sludge was introduced in the production of prefabricated bricks using 2% into the prepared samples and the properties of the specimen were tested, the results shows a significant increase in compressive strength, decrease in porosity and water absorption compare to bricks without sludge. [8]

The utilization potential of Sludge and co-generation ashes generated by the paper industry in producing bricks; bricks were fired at 1000°C. The products made from the material have exhibit some good properties in term of water absorption and compressive strength, which met the required standards though the bricks are only recommended for use as non-load bearing spacing construction material. [9]

The potential use of dried sludge from water treatment plant with agricultural waste and rice husk ash in production of novel light weight bricks was performed. The results for the mechanical properties show that bricks with 40% by weight rice husk heated at 1100ºC exhibit a high strength required for lightweight bricks, use in future green building in accordance with Taiwan standards. Results of Toxic Characteristic Leaching Procedure (TCLP), shows that the concentrations of Cu, Zn, Cr, Cd and Pb in the products were lower than allowable level in the standard regulation. [10]

Bricks produced from industrial waste water treatment plant sludge, all necessary properties test were performed. Results show that the quality of the product depends on sludge proportion and the firing temperature.

Strength of bricks with up to 20% sludge content at temperature ranges of 960-1000°C met the required standards. The leaching result on the product shows a low metal leaching level. [11]

Bricks developed using sewage sludge as a raw material. The bricks were tested for physical and mechanical properties. Results show that the products met the required standard, though the use of sludge content more than 30% was not recommended for it high brittleness. [12]

The use of Municipal Solid Waste Incineration fly ash slag (MSWI) on fired clay bricks, bricks were fired at 1000°C. The mechanical properties and environmental effect of the leachate from the products were tested. Results indicate that the mechanical properties satisfy the Chinese National Standard code for second-class brick and leachate were within acceptable level. Result also shows that increase in the MSWI content leads to increase in the compressive strength though will decreased the water absorption of the sintered bricks. [15]

Bricks are produced from the mixture of clay and recycled industrial wastes. The result shows that compressive strength increased with the increase of sintering temperature. The products satisfy standard requirement for the water absorption and compressive strength. [16]

Lightweight bricks manufactured by sintering mixes of dried water treatment sludge and rice husk. Bricks products with up to 20% by weight of rice husk were fired to obtain effective organic burn-out. Addition of rice husk increased the porosity of sintered samples and increase in sintering temperatures leads to increased compressive strengths. Materials containing 15% by weight of rice husk sintered at 1100°C produced low bulk-density and higher compressive strength that were compliant with relevant Taiwan building code standards for use as lightweight bricks. [17]

The production of bricks using textile laundry wastewater, sludge and clay was performed. Bricks were produced with different quantities of the sludge, dried at 100°C then firing was done at 900°C and the mechanical properties were determined. Mechanical properties of ceramics as flexural strength and water absorption were satisfactory within the Brazilian legislation. The obtained results showed that bricks with 20% sludge content give the best mechanical properties and the leaching test conducted show that the product is safe without any adverse health effect on the user. [18]

The environmental effect of the use of bricks manufactured from sewage sludge examined, considering the leach ability and toxicity the results show that the sludge can be successfully incorporated into bricks with sludge additions ranging from 5 to 25% in weight (and even more if we do not consider mechanical properties), Without any significant adverse effect on the health of the user and the environment. [19]

The replacement of clay brick using sludge, agricultural and industrial wastes (such as Rice Husk Ash (RHA) and Silica Fume (SF)) was developed. Bricks samples were fired at different temperatures. The properties of the product were investigated and compare with conventional brick in accordance with Egyptian standard specification. Products with 25% SF and 50% sludge showed superiority over the conventional bricks. [20]

III. Materials and Methods

Brick is one of the most common masonry units as a building material due to its properties. It has the widest range of products, with its unlimited assortment of patterns, textures and colours. Many attempts were made to incorporate wastes into the production of bricks, for examples, cement, flyash, and sludge. Recycling such wastes by incorporating them into building materials is a practical solution for pollution problem.

Bricks were made using cement, flyash, and sludge (obtained from UPL, Ankleshwar). The raw materials used for casting of bricks were soil, clay, fine sand and waste materials (fly ash and sludge).The sludge used for casting of bricks were collected from UPL, Ankleshwar.

A. Mix Design for Bricks

Different Percentage of sludge	Soil	Sand	Fly Ash	water
10%	52%	26%	12%	40 lit.
20%	45%	23%	12%	42 lit.
30%	38%	20%	12%	44 lit.
40%	31%	17%	12%	42 lit.
50%	24%	14%	12%	45 lit.

(Table: Mix Design for Bricks)

The raw materials soil, clay, fine sand and waste materials were collected in a tray in the required amounts. They were mixed, as per the given proportion. The amount of water to be added depends on the nature of the clays and their plasticity. This water is removed during drying and firing.

The mix is placed in the mould to form the size unit desired. To keep the clay from sticking, the moulds were lubricated with grease; after they are filled, excess clay is struck from the top of the mould. After the bricks are formed, they were sun dried to remove the free water. Bricks were fired and cooled in a muffle furnace, an oven-type chamber at temperature of 1000 °C for 4 hours.

Fig. 1: lab scale model of brick using 40% sludge

Fig. 2: Muffle Furnace setup

IV. CONCLUSION

This review study demonstrated that usage of sludge as a raw material in construction industry is clearly feasible without compromising the material requirements according to available standard. It can be concluded that the potential use of sludge in construction industry is an alternative to the treatment and disposal of sludge considering the huge cost and complexity involved in the treatment. Considering the economic and environmental factors a technical application of various type of sludge in construction industry would provide a complete solution to the waste problem and promote eco-friendly environment with a reduced or low-cost raw material.

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