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Review

Waste foundry sand in concrete: A review

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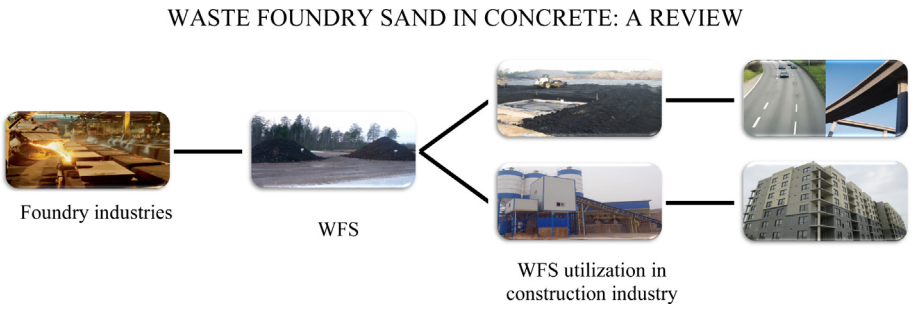
HIGHLIGHTS

- Need of use of waste foundry sand (WFS) in concrete.
- Material properties of WFS.
- WFS shows enhanced mechanical performance of concrete.
- Durability of concrete enhanced with incorporation of WFS up to an optimum level.

GRAPHICAL ABSTRACT



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ABSTRACT

Concrete is the most extensively used construction material in the world, second to water. Increasing rate of urbanization and industrialization has lead to over exploitation of natural resources such as river sand and gravels, which is giving rise to sustainability issues. It has now become imperative to look for alternatives of constituent materials of concrete. Waste foundry sand, a by-product of ferrous and non ferrous metal casting industries is one such promising material which can be used as an alternative to natural sand in concrete. In last few decades, several studies have been conducted to investigate the effect of addition of waste foundry sand as partial and complete replacement of regular sand in concrete. It has been found suitable to be used as partial replacement of sand in structural grade concrete. A number of properties have been reviewed in the current paper, the results observed from the various studies depict that replacement of foundry sand to a certain extent enhance the durability as well as strength properties of the concrete but simultaneously decreases the slump value with the increase of replacement level of waste foundry sand.

Contents

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1. Introduction

Concrete, being the most extensively used construction material in the world, is the backbone of all the construction and development activities around the world. Each of the primary constituent of concrete has an environmental impact, to a different extent. Being used in enormous quantity around the world, it gives rise to different sustainability issues.

There is rising concern about over-exploitation of natural sand and gravels, constituents of concrete. The massive use of concrete due to boom in urbanization and industrialization has resulted in the over-extraction of river sand from the river bed. This has called for several harmful consequences, including increased river bed depth, lowering of the water table, exposure of bridge substructures, major impact on rivers, deltas and coastal and marine ecosystems, loss of land through river or coastal erosion and decrease in the amount of sediment supply. Furthermore, the subsistence of construction industry has been severely affected due to the restrictions in the extraction of sand from the river resulting in rise of the price of sand [1]. Thus, it has become imperative to look for alternative to natural river sand.

Increasing population and advancements in technology have led to increase in waste production. Thus, many researchers and scientists all over the world are finding new ways to reduce these wastes or as a better alternative to use them as resources with added values. Since past several decades, various industrial wastes are being studied extensively as a substitute/replacement material for fine aggregate. Substitution of alternative materials in concrete has been found to improve both the mechanical and durability properties, and this practice can lead to the sustainable concrete development.

Waste foundry sand (WFS) is one such promising material which needs to be studied extensively as substitute of fine aggregates in concrete. It is a by-product from the ferrous and non ferrous metal casting industries with ferrous foundries producing the most sand. It is characteristically sub-angular to round in shape and has high thermal conductivity which makes it suitable for moulding, casting operations. Moulding sands are recycled and reused multiple times during casting process. In due course, the recycled sand degrades to the state that it can no longer be reused in the casting process. Then, the old sand is dismissed as by-product, and new sand is introduced into the cycle.

Metal alloy casting industries only produce several million tons of by-product in the world and waste foundry sand (WFS) is the major by-product. It has been successfully used as a land filling material since many years, but due to rising disposal costs, land filling is also becoming a problem. United States has about 3000 foundries which annually utilizes 100 million tons of sand for its production and about 6–10 million metric tons of waste foundry sand is discarded per year, which goes into landfills [2,3]. With high national average tipping fee of foundry by-products landfilling has also not remained a feasible option. Indian foundry industry is the third largest casting manufacturer in the world after China and USA. With approximately 5000 foundries and installed capacity of 15 Million metric tons/annum the annual production of nearly 9.3 Million Metric tons is reported for 2012–13. The installed capacity and output could be actually higher than estimate since the sector is majorly (around 85%) unorganized that does not reports in public [4]. Waste produced (WFS) from these foundries is approximately 1,710,000 tons (1.71 MT) per annum [5].

In an effort to use the waste foundry sand in large volume, research is being carried out for its possible substantial utilization as partial replacement of fine aggregate in concrete. Also, foundries use high quality size-specific silica sands for use in their moulding and casting operations. Usually raw sand is of a higher quality than the typical bank run or natural sands used in fill construction sites [6]. Therefore, this can be a very competent material for sand replacement.

2. Foundry sand

Foundry sand is high quality silica sand that is a by-product from the production of both ferrous and non-ferrous metal casting

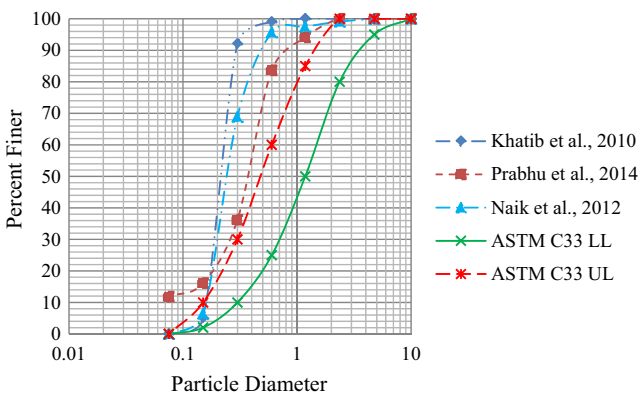

Fig. 1. Sieve analysis results of WFS with respect to ASTM C33 limits for fine aggregate.