

Self Compacting Concrete Incorporating Foundry Sand

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Abstract

This paper presents an investigation on innovative optimum, Self-compacting concrete (SCC) can produce much higher fluidity with no occurrence of segregation, thanks to its lower yield value and higher viscosity than conventional concrete. Increased productivity and improved working environment have had high priority in the development of concrete construction over the last decade. The casting process creates a significant amount of waste foundry sand (WFS). Using WFS as a concrete ingredient reduces the problems associated with the dumping process of these types of wastes, removes/reduces carbon dioxide, and is also considered economical in terms of overall concrete production cost. . Hence, predicting the behavior of concrete using the development of models based on artificial intelligence (AI) algorithms derived from the laboratory data can remarkably improve the project's efficiency in terms of cost and time. This paper assessed the performance of artificial neural networks (ANNs) to predict the strength parameters of concrete containing WFS (CCWFS). In this regard, a comprehensive laboratory database consisting of 102, 397, 146, 346, and 169 data for the slump, compressive strength, elasticity modulus, splitting tensile strength, and flexural strength of CCWFS were collected from literature, respectively.

Keywords: - Waste foundry sand, Aritifical Neural Networks (ANNs), Multiple linear regression (MLR).

INTRODUCTION

General

It was first developed in Japan in late 80's to increase the concrete quality. It is an innovative concrete which flows under its own weight. Concrete, being the most extensively used construction material in the world, and it is the backbone of all the structures and development activities around the world. Self compacting concrete is highly engineered concrete with much higher fluidity without segregation and is capable of filling every corner of formwork under its self weight. Self-Compacting concrete (SCC) it is considered to be one of the most successful innovation in industry of construction.

The development of a more fluid concrete brought many advantages such as improvements in productivity, energy consumption, working environment, quality. In a short time self-compacting concrete has developed in different areas of construction industry; so it can be used for in situ application as well as for precast production. Self-compacting concrete is not only an alternative material to normal vibrated concrete it also opens the possibility for radical changes in whole construction process.

It has three essential fresh concrete properties filling ability, passing ability and segregation resistance. SCC can save labour, eliminate consolidation noise and lead to innovative construction methods. The demand of Self Compacting Concrete (SCC) is growing rapidly due to the shortage of skilled labours; it is also proved to be more economical, durable and termed as high performance concrete. The quality of concrete construction is of utmost importance in order to have a durable concrete structure and one of the reasons to make a durable structure is proper compaction which requires skilled labors but due to shortage of skilled labors full compaction. The solution to this is the use of self-compacting concrete which compacts in every corner of formwork. The use of SCC is rising steadily over the years because of their advantages and many scientists and organizations carried out research on properties of SCC.

It is the concrete which is fully compacted without segregation without external energy. SCC has economic, social and environmental benefits over conventionally vibrated concrete. SCC is made from the same basic constituents as conventional concrete but with the addition of a viscosity modifying admixture and high levels of super-

plasticizing admixtures to impart high workability. Fresh SCC must possess at required levels the three key properties related to workability. Filling ability is the ability of the SCC to flow, spread and fill into all spaces within the formwork under its own weight. Passing ability is the ability of the SCC to flow through tight openings such as spaces between steel reinforcing bars, under its own weight without blocking them. Resistance to segregation is the property in which SCC must meet the required levels of properties and its composition remains uniform throughout the process of transport and placing that is keeps the sand and aggregate in suspension.

Foundry sand is high quality silica sand used as a moulding material by ferrous and non-ferrous metal casting industries. It can be reused several times in foundries but, after a certain period, cannot be used further and becomes waste material, referred to as used or spent foundry sand (UFS or SFS). The majority of spent moulding sands are classified as nonhazardous waste. Foundries use high quality size-specific silica sands for use in their moulding and casting operations.

The raw sand is normally of a higher quality than the typical bank run or natural

sands used in fill construction sites. In the casting process, moulding sands are recycled and reused multiple times. Eventually, however, the recycled sand degrades to the point that it can no longer be reused in the casting process. When it is not possible to further reuse sand in the foundry, it is removed from the foundry and is termed as spent foundry sand. Spent Foundry sand is high quality silica sand that is a byproduct from the production of both ferrous and non-ferrous metal castings. Foundries use high quality size-specific silica sands for use in their molding and casting operations. The raw sand is normally of a higher quality than the typical bank run or natural sands used in fill construction sites. In the casting process, molding sands are recycled and reused multiple times.

Eventually, however, the recycled sand degrades to the point that it can no longer be reused in the casting process. When it is not possible to further reuse sand in the foundry, it is removed from the foundry and is termed as spent foundry sand. The physical and chemical characteristics of foundry sand will depend in great part on the type of casting process and the industry sector from which it originates.



Figure: - 1

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 industries. It is used for the centuries as a moulding casting material because of its high thermal conductivity. For various foundry operations, raw sand is used and several binders and additives are added into it to enhance its properties. Based on binder system used, foundry sand is classified into two categories i.e. clay-bonded (green) sand and chemically bonded sand.

As evident from the names, clay-bonded or green sand consists of clay as binder whereas in chemically bonded sand chemicals are used as binders. Green foundry sand is generally composed of 85–95% silica sand, 4–10% of bentonite clay

as binder then 2–10% of carbonaceous Additive, to improve finishing of casting surface. It also contains traces of oxides such as MgO, K₂O, TiO₂. Whereas, chemically bonded sand or chemical foundry sand, consists of 93–99% silica sand and about 1–3% chemical binder [5].

The silica sand and chemicals are thoroughly mixed and then a catalyst initiates the reaction that cures and hardens the mould mass. Most commonly used chemical binder are- epoxy resins, sodium silicates, furyl alcohol, phenolic urethanes etc. Presence of carbonaceous additives imparts black colour to green foundry sand whereas chemical foundry sand is light in colour. Green foundry sand is preferred for moulding operations whereas chemical foundry sand is used for both mould making and core making operations, which

require higher strengths to withstand the heat of molten metal.

A. Physical Properties and Chemical Properties

Foundry sand is sub-angular to round in shape. Alike regular sand, WFS also mainly consists of silica but its silica content has been found lower than regular sand.

Depending upon the industry sector from which it originates, type of casting process, type of additives used for moulding, number of times the sand is recycled and type and amount of binder used, its physical and chemical characteristics may vary. About 85–90% of its particles are smaller than 100 mm. It is principally made up of sand which is evident from the particle size (0.05–2 mm) of WFS, obtained from 39 foundries, ranging from 76.6% to 100%, with a median of 90.3%. Since it is basically fine aggregate so it can be expected to be used in many applications as substitute of natural sand.

Depending upon type of metal, type of binder and combustible used, the chemical composition of waste foundry sand may vary and it further influences its performance. Sands obtained from a single

foundry, however, may not likely show significant variation over time; besides, blended sands produced by consortia of foundries often produce sands with consistently same composition. Waste foundry sand is rich in silica content and is coated with thin film of burnt carbon, dust and residual binder such as betonies, sea coal or chemicals.

Importance

- a. Self-compacting concrete doesn't required vibration which is necessary during the placement of concrete into form work which makes placement of concrete easier and faster.
- b. Foundry sand is likely to constitute as raw material for the manufacture of cement or concrete at low cost.
- c. Incorporating industrial byproduct like foundry sand in self compacting concrete reduces environmental.

LITERATURE REVIEW

General

Following papers highlight about the utilization, Effects, Study on performance enhancement, Evaluation of concrete used by Foundry sand. With ever increasing quantities of industrial by-products and waste materials, solid waste management

has become the principal environmental concerns in the world. Scarcity of land-filling space and due to its ever increasing cost, utilization recycling of byproducts waste has become an attractive alternative to disposal. Several types of by products and waste materials are generated. Each of these waste products has specific effects on the properties of cement based materials (CLS Mand Concrete).

The utilization of such materials in concrete/ CLS Monotony makes it economical, but also do help introducing disposal problems. Reuse of bulk wastes is considered the best environment alternative for solving the problem of disposal.

One of such industrial by-products is Spent Foundry sand (SFS). Spent foundry sand is a byproduct of ferrous and

nonferrous metal casting industries. Foundries successfully recycle clean dry use the sand many times in a foundry. When the sand can no longer be reused in the foundry, it is removed from the foundry and is termed as spent foundry sand. Published literature has shown that SFS could be possibly used in manufacturing Controlled Low Strength Materials (CLSM) and concrete. This paper presents an overview of some of there search published on the use of SFS in controlled low strength material sand concrete.

Effect of SFS on CLSM characteristics like plastic properties, compressive strength, permeability, and leach ate analysis, and concrete properties such as compressive strength, splitting tensile strength, modulus of elasticity, freezing–thawing resistance, and shrinkage are presented.



Figure: - 2

Feed Forward-Back Propagation Algorithm

- Inspired from the learning process of a neuron.
- Initial value are assigned on weight and biases and gradually change during the training of the network.
- Correlates the input and output

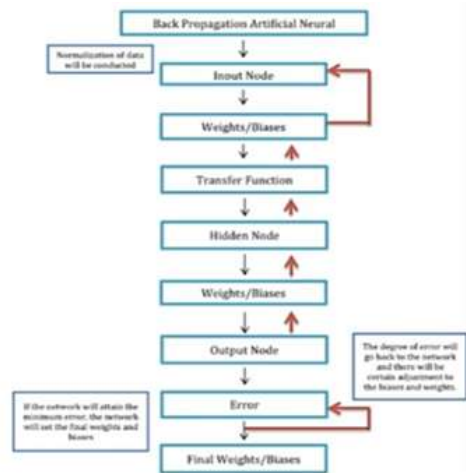


Figure:-3

Network

- Network Name
- Network Type
- Input and Target Data
- Training Function
- Performance Indicator
- Number of Layers
- Number of Neurons
- Transfer Function

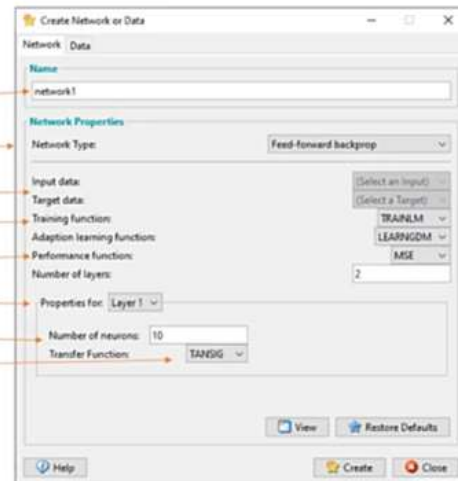


Figure: - 4

Motivation towards Proposed Work

- Foundry sand is the solid waste generated from the metal casting industries, since scarcity of the land disposal of the foundry sand is the major problem.
- Since self compacting concrete is costlier than conventional concrete, by incorporating industrial rejects, it is possible to make it economical.

OBJECTIVES

1. Study the effect of foundry sand on fresh properties of self compacting concrete.
2. Influence of waste foundry sand on mechanical properties of self compacting concrete.
3. To produce economical self compacting concrete.

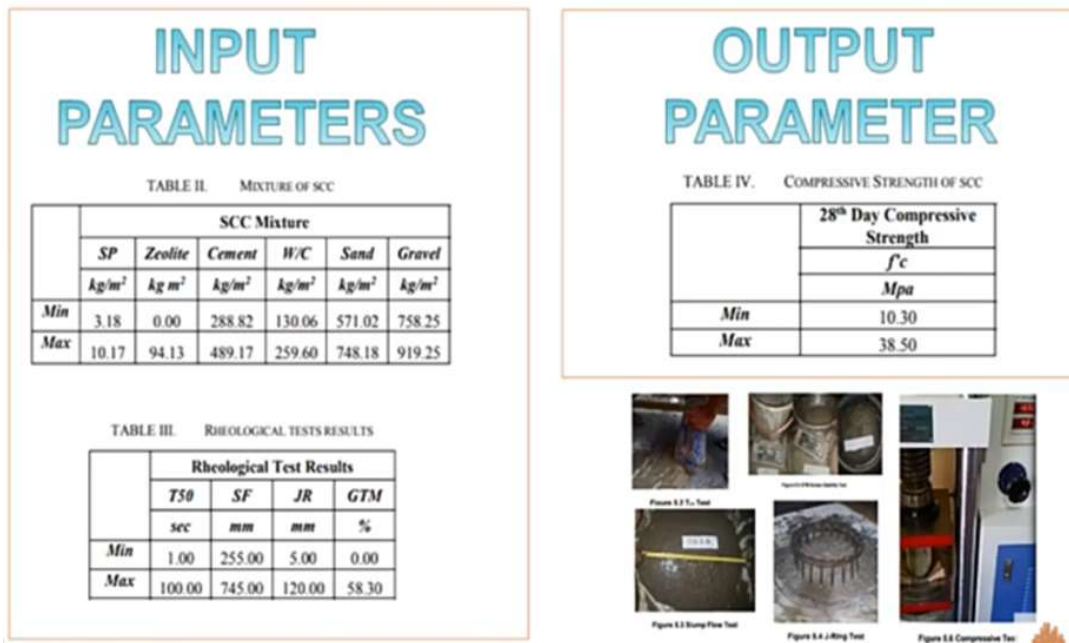


Figure:-5

METHODOLOGY

ANN Method

Applied Deep Learning Tutorial Series

In this method of analyzing the several deep learning techniques starting with Article neural network called as ANN method in particular feed forward neural network. What exactly separates this tutorial from the rest we can find online is that well takes a hand-on- approach with plenty of codes examples and visualization. Here some of contents where I will overview step by step methods

An Overview ANN Method

Artifices neural network are multi layer fully connected neural nets that looks like the figure below. They consist of an input

layer, multiple hidden layers, and a output layer. Every node layer we make the network deeper by increasing the number of hidden layer. If we zoom into one of the hidden or output nodes, what we will encounter in the figure below- A given nodes takes the weighted sum of its inputs and passes it through a non linear activation function. This is the output of the node, which then becomes the input of another node in the next layer. The signals flow from left to right and the final output is calculated by performing this producer foe all the nodes. Training this deep neural network means learning the weights associated with all the edges.

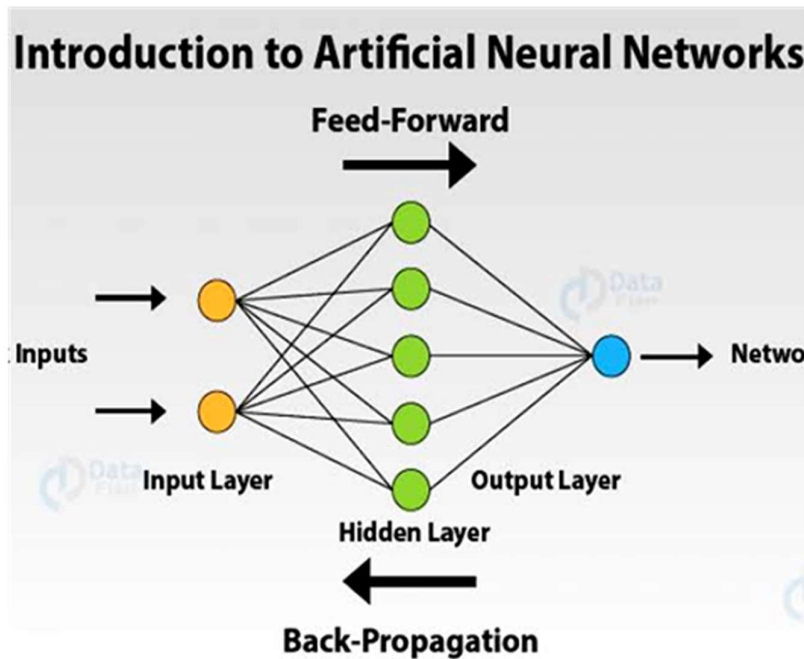
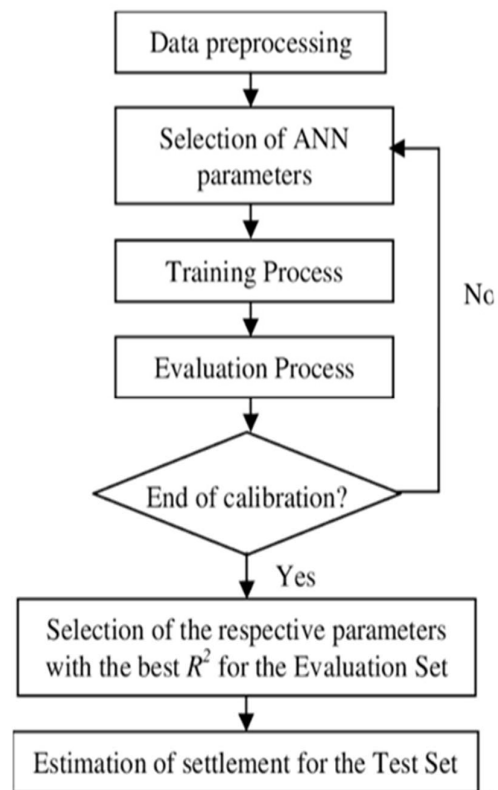


Figure:-6

The equation for a given node looks as follows. The weighted sum of its input passed through a non linear activation function. It can be represented as a vector dot product, where n is the number of inputs for the node.

$$Z = (f, w) = f(\sum x_i w_i) \quad x \in d_1 * n, w \in d_n * 1, z \in d_1 * 1$$

The bias term for simplicity Bias is an input to all the nodes and always has the value 1. It allows shifting the result of the activation function to left to right. It also helps the model to train when all the input features are zero, if this sounds complicated right now.



You can safely ignore the bias term for completeness, the above equation looks as follows with the bias included. So far we have described the forward pass, meaning given an input and weights how the output is computed. After the training is complete, we only run the forward pass to make the predictions but I first need to train our model to actually learn the weights the training procedure works as follows

Randomly initialize the weights for all the nodes there are smart initialization methods which we will explore in another article. For every training example, perform a forward pass using the current weights and calculate the output of each node going from left to right, the final output is the value of the last node. Compare the final output with the actual target in the training data and measure the error using a loss function.

Model Development

A program was developed in MATLAB version 9.1 (R2016b) software to build and evaluate different ANN models. This program initially divides each data set randomly into two training and testing subsets using 70% and 30% of the data, respectively. Also, external data records, including 15, 60, 22, 52, and 25 records

for slump, CS, E, STS, and FS tests, were used for validation purposes. Clearly, the validation records did not interfere in the training process. It should be mentioned that the performance of each model is hugely affected by its distribution (Gandomi and Roke 2015). The frequency histograms of the selected records of slump, CS, E, STS, and FS of CCWFS for the two training and testing data sets are shown in Fig. 2. The next step is to set the activation functions, the type of training algorithm, and the control parameters. Network processing is usually performed by activation functions. Sigmoid functions are often used by researchers in neural network training to minimize the amount of error due to the simple relationship between the value of the function and the derivative of the function at any desired point. (Ghanizadeh et al. 2018).

There are several activation functions, each with its geometric shape. Although the same choice is not required for all single-layer neurons, the activation function for single-layer neurons is usually chosen the same. In most cases, this function uses the nonlinear function so that multilayer networks have the most nonlinear characteristics.

CONCLUSION

1. This paper explains the behavior of self compacting concret can be suitably produced by partially replacing natural sand with waste foundry sand.
2. Self compacting concrete incorporating waste foundry sand will be economical.
3. Preservation of natural resources like natural sand.
4. ANN models to predict the strength parameters for concrete containing waste foundry sand to facilitate its use in civil engineering designs.

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