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A PATH FOR HORIZING YOUR INNOVATIVE WORK

FORETELLING THE STRENGTH OF CONCRETE USING ARTIFICIAL INTELLIGENCE PLATFORM

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Abstract: The field of artificial intelligence, attempts to understand intelligent entities as well as construct them. The constructed intelligent entities are interesting and useful in their own right. AI has produced many significant and impressive products so far. Although no one can predict the future in detail, it is clear that computers with human-level intelligence would have a huge impact on our everyday lives and on the future course of civilization. Calculators are not intelligent. Since the earliest days of computing, few machines have been envisioned that could go beyond our own ability to solve problems i.e. intelligent machines. The dream of the intelligent machine is the vision of creating something that does not depend on having people pre-program its problem solving behavior. Put another way, artificial intelligence should not seek to merely solve problems, but should rather seek to solve the problem of how to solve problems. This paper represents the importance and methodology to forecast the strength of concrete by using AI. The strength of concrete is getting changed by modifying the composition, such as, cement, sand, metal & admixtures while mixing. In order to predict the future strength and achieving the economy, this AI tool will be very helpful in judging the strength of concrete after few hours of casting the members. For example, one can predict the 28 days strength of concrete just after casting the cubes or members without waiting for long tenure.

Keywords: Lateral loading capacity, Lateral deflection, Pile, Slope

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INTRODUCTION

As we know, Concrete is the basic engineering material and traditionally used for the civil engineering structures. It is the most widely adopted construction material because of its flowability and workability in most complicated form i.e. its ability to take any shape while wet, and its strength development characteristics when it hardens. Generally concrete is used to build protective structures, which are subjected to several extreme stress conditions. Concrete is the most widely used construction material manufactured at the site. This composite material is obtained by mixing cement, water and aggregates. Its production involves a number of operations according to prevailing site conditions. The ingredients of widely varying characteristics can be used to produce concrete of acceptable quality. The strength, durability and other characteristics of concrete depend upon the properties of its ingredients, the proportions of the mix, the method of compaction and other controls. The popularity of concrete as a construction material is due to the fact that it is made from commonly available ingredients and can be used as per the functional requirements in a particular situation.

Among the various properties of concrete, its compressive strength is considered to be the most important. However, workability of concrete plays an important role in the mix design. Other factors such as W/C ratio, Fineness modulus of aggregate and specific gravity of cement have their own importance in concrete mix design.

IMPORTANCE OF STUDY

Concrete cube strength tests are usually performed 7–28 days after pouring the concrete. The 28-day waiting period required to perform such a test may delay the construction process, but neglecting the test would limit quality control in large construction sites. Therefore, the rapid and reliable prediction of concrete strength is essential for pre-design or quality control. It would enable the adjustment of the mix proportion if the concrete does not meet the required design level, which would save time and construction costs. The early prediction of concrete strength is essential for estimating the time needed for concrete form removal, project scheduling and quality control.

Artificial Intelligence techniques open new possibilities in classifying and generalization of the available experimental results, by the way of learning by examples to predict strength from the relative contents of mix components. If such a mapping can be effectively modeled in a neural system, in spite of data complexity, incompleteness, and coherence, it might be useful for a concrete mix designer as a new tool that supports the decision process and improves its efficiency.

OBJECTIVE

The objectives of the proposed study is,

1. To understand the existing methods of determining Strength of Concrete Mix.
2. To study the factors responsible for the development of Strength of Concrete.
3. To develop the methodology based on Artificial Intelligence in the prediction of Concrete Mix Strength.

SCOPE

The scope of the study is confined to Quality Assurance program of the construction industry. The scope of the study is to figure out the existing concrete strength testing methods in the construction industry and to explore new methods such as artificial neural networks in the field of construction industry. Further the scope extends to develop a model based on artificial neural networks to predict strength of the concrete mix.

CONCRETE MIX DESIGN

Concrete mix design is the science of deciding relative proportions of ingredients of concrete, to achieve the desired properties in the most economical way. With advent of high-rise buildings and pre-stressed concrete, use of higher grades of concrete is becoming more common. Even the revised IS 456-2000 & IS 10262-2009 advocate's use of higher grade of concrete for more severe conditions of exposure, for durability considerations. With advent of new generation admixtures, it is possible to achieve higher grades of concrete with high workability levels economically. Uses of mineral admixture like fly ash have revolutionized the concrete technology by increasing strength and durability of concrete by many folds.

PROCEDURE OF MIX DESIGN (IS-10262-2007)

1. Determine the mean target strength 'ft' from the specified characteristic compressive strength at 28-day fck and the level of quality control.

ft = fck + 1.65 S

Where,

S is the standard deviation obtained from the Table 1 of approximate contents given after the design mix.

Table 1: Assumed standard deviation (IS 456:2000)

Grade of Concrete	Assumed Standard Deviation N/mm²
M 10, M 15	3.5
M 20, M 25	4.0
M 30, M 35, M 40, M 45, M 50	5.0

NOTE—The above values correspond to the site control having proper storage of cement; weigh batching of all materials; controlled addition of water; regular checking of all materials, aggregate gradings and moisture content; and periodical checking of workability and strength. Where there is deviation from the above the values given in the above table shall be increased by 1N/mm².

2. Obtain the water cement ratio for the desired mean target using the empirical relationship between compressive strength and water cement ratio so chosen is checked against the limiting water cement ratio given in Table 4 of IS 456:2000 for respective environment exposure condition. The water cement ratio so chosen is checked against the limiting water cement ratio for the requirements of durability given in table and adopts the lower of the two values.

Table 2: Minimum Cement Content, Minimum Water Cement Ratio and Minimum Grade of Concrete for Different Exposure with Normal Weight Aggregate of 20mm Nominal Maximum Size (IS 456:2000)

Sl No.	Exposure	Plain Concrete			Reinforced Concrete		
		Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete
1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Mild	220	0.60	–	300	0.55	M 20
iii)	Moderate	240	0.60	M 15	300	0.50	M 25
iii)	Severe	250	0.50	M 20	320	0.45	M 30
iv)	Very severe	260	0.45	M 20	340	0.45	M 35
v)	Extreme	280	0.40	M 25	360	0.40	M 40

NOTES

1 Cement content prescribed in this table is irrespective of the grades of cement and it is inclusive of additions mentioned in 5.2. The additions such as fly ash or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water-cement ratio if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolona and slag specified in IS 1489 (Part 1) and IS 455 respectively.

2 Minimum grade for plain concrete under mild exposure condition is not specified.

1) Select the water content, for the required workability and maximum size of aggregates (for aggregates in saturated surface dry condition) from Table 5

Table 3: Maximum Water Content per Cubic Metre of Concrete for Nominal Size of Aggregate (IS 10262:2007)

Nominal maximum Size of Aggregate	Maximum Water Content
10	208
20	186
40	165

Water content corresponding to saturated surface dry aggregate

The quantity of maximum mixing water per unit volume of concrete may be determined from Table 5. The water content in Table 5 is for angular coarse aggregate and for 25mm to 50mm slump range. For other than 25mm to 50mm slump range required water content may be established trial or increase by about 3 % additional for every additional 50 mm slump.

2) Calculate the cement content from the water-cement ratio and the final water content as arrived after adjustment. Check the cement against the minimum cement content from the requirements of the durability, and greater of the two values is adopted.

3) The approximate value for the coarse aggregate volume is given in Table 6.

Table 4: Volume of Coarse Aggregate per Unit Volume of Concrete for Different Zone Of Fine Aggregate (IS 10262: 2007)

Nominal maximum Volume of coarse aggregate per unit volume of concrete for different zone of fine aggregate

Size of aggregate	Zone IV	Zone II	Zone II	Zone I
10	0.50	0.48	0.46	0.44
20	0.66	0.64	0.62	0.60
40	0.75	0.73	0.71	0.69

Volumes are based on the aggregate in saturated surface dry condition.

4) All the ingredients have been estimated except the coarse and fine aggregate content. These quantities are determined by finding out the absolute volume cementitious material and water. By dividing their mass by their respective specific gravity, multiplying by 1/100 and subtracting the result of their summation from unit volume. Values so obtained are divided into coarse and fine arrogate fraction by the volume in accordance with coarse aggregate proportion already determined. The coarse and fine aggregate content are then determined by multiplying with their respective specific gravities and multiplying by 1000.

5) Determine the concrete mix proportions for the first trial mix.

6) Prepare the concrete using the calculated proportions and cast three cubes of 150 mm size.

7) Prepare trial mixes with suitable adjustments till the final mix proportions are arrived at.

METHODOLOGY

In view and ever changing conditions in the construction industry there must be an effective approach towards quality management no matter how small and large a construction project is to be handled. Quality must be considered as an integral part of the planning of construction program. Quality must be maintained at each stage and at each level of the project by prudent anticipation and must be looked upon as an essential component of the work.

Methodology involves interaction with various personnel's involved in concrete mix design. Based on the interaction and the literature review factors responsible for the strength of concrete are identified. Data is collected regarding mix design for different grades of concrete and their characteristic cube compressive strength.

The data was divided in 8 sets, namely 3 Days characteristic cube compressive strength, 7 days characteristic cube compressive strength, 14 days characteristic cube compressive strength, 28 days characteristic cube compressive strength, 56 days characteristic cube compressive strength, 90 days characteristic cube compressive strength, 100 120 and 180 days characteristic cube compressive strength, 270 360 and 365 days characteristic cube compressive strength.

All input and output data have been normalized by maximum value for each parameter so that the values lie between 0 to 1 for better comparison and avoiding influence of greater parameter. The output of the network is obtained in the form of normalized output which is then de-normalized to actual values by multiplying each value by corresponding normalizing factor as used for preparing the training set.

Data set is obtained from a University of California, Irvine (UCI) repository of data (Yeh 1998) regarding mix design for different grades of concrete and their characteristic cube compressive strength. Data set often contains unexpected inaccuracies. For example, the class of fly ash may not be indicated. Another problem is that the super plasticizers may be produced by different manufacturers and have different chemical compositions. Concrete compressive strength is not only determined by the water to concrete ratio but also by the other materials used in the mix.

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