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A COMPARATIVE STUDY ON THE COMPRESSIVE STRENGTH PREDICTION FOR NANOMATERIALS BY USING ARTIFICIAL NEURAL NETWORK AND SUPPORT VECTOR MACHINE

A REVIEW

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Abstract : Today's concrete constructions require structural members with higher mechanical properties and longer service life. This can be done by incorporating nanostructured elements into concrete to increase its mechanical qualities and reduce maintenance costs and eliminate the need for immediate replacement. The main objective was to study how microstructural changes affect the effectiveness of the compressive strength of concrete. New materials can be used to improve the mechanical properties of concrete and other materials. The improvement rate depends on the type and percentage of the nanomaterial.Another approach can be used, the Artificial Neural Network (ANN), which has recently gained popularity in the civil engineering field. ANN is a soft computer technique that simulates the characteristics of the human brain, learns from previous situations and adapts to new environments without any constraints. In this study, compressive strength (CS) of concrete containing nanomaterials, data collected in previous experimental surveys was used for ANN model. was developed with 5 input parameters as nanoSiO2, nanoAl2O3, nanoFe2O3, nanoTiO2, nanoZnO to predict CS of concrete nanomaterials; hidden layer knots as well as weights and biases are established through trial and error to achieve the best performing model.The correlation coefficient for training and testing data is suggesting that ANN can be used to predict CS of nanomaterials of specific strength is superior compared with support vector machine (SVM) .In the near future, understand A better understanding of the properties of nanomaterials will help define a better approach to creating innovative, livelihood-improving materials. Using specific nanostructured materials can help concrete structures perform better and last longer.

IndexTerms-Nano-materials(nano-SiO2,nano-Al2O3,nano-Fe2O3,nano-TiO2,nano-ZnO),Compressive strength, ANN, SVM(Support Vector Machine),MATLAB.

I. INTRODUCTION

Modern concrete infrastructure requires structural components with higher mechanical strength and greater durability.the construction industry should be considered not only for enhancing material properties and functions but also in the context of energy conservation. This is a particularly important prospect since a high percentage of all energy used (e.g., 41% in the United States) is consumed by commercial buildings and residential houses by applications such as heating, lighting, and air conditioning.

Concrete is one of the oldest materials in the construction industry, being a mixture of lacquer and aggregate. Concrete production is a complex process that involves the impact of several processing parameters on the quality control of concrete with regards to workability, strength, etc. All these settings effectively to produce a single amount of compressive strength. Therefore, to improve the mechanical properties of cement-based composites for modern concrete infrastructure. Based on the statistics, it was assumed (in the UK Delphi Survey 1990) that the construction industry would benefit the most from nanotechnology. However, the construction industry is lagging behind other industries. in terms of attractive investments from key business areas. on a smaller scale.A nanometer is one billionth of a meter.

A nanoparticle is defined as a particle with at least one dimension less than 100 nm. The size of the grain is very important because at the nanometer length scale, i.109 m, the particles' physical properties are actually affected.
For example, the compressive, tensile and flexural strengths of a concrete structure need improved.To do this, nanomaterials can be mixed with a cement-based matrix to create concrete with high mechanical strength
. ; are core elements of construction and these materials can be developed using nanotechnology.

This technology was first introduced by physicist Richard P. Feynman in his famous lecture at the American Physical Society meeting at the California Institute of Technology in 1959.However, after two decades, it was defined by Drexler as producing materials using dimensions and accuracy between 0.1 and 100 nm. So it's not a new science or technology, but has been a hot research topic for over two decades. The National Science Foundation estimates that the annual market for nanotechnology components will reach $1 trillion by 2015.

In civil engineering, major developments have been achieved through the production of whether with new functionality or by improving the performance of existing materials. Such potential is seen today through many current applications involving surface coatings, self-cleaning and fire resistance .

Granular particles with high surface area to volume ratio .In this way, the nanoparticles with a diameter of 4 nm have more than 50% of their atoms on the surface and are therefore very reactive. Some of these nanomaterials include nanosilica (nanoSiO2), nanoalumina (nanoAl2O3), nanoferric oxide (nanoFe2O3), nanotitanium oxide (nanoTiO2), Zinc oxide (nanoZnO). The use of these nanomaterials can improve the performance and life cycle of concrete infrastructure. This review presents recent research on the key performance impacts of cementitious composites induced by nanomaterial incorporation. Nanomaterials can reduce the porosity of cement, creating a denser surface transition zone.Additionally, nanomaterial-reinforced cement can enable the construction of high-strength concrete structures with greater durability, reducing the need for maintenance or early replacement.

For decades, researchers have been involved in the development of various computational and mathematical prediction models to fill gaps in empirical investigation. Many mathematical regression models are developed and used when the prediction accuracy is not satisfactory for the experimentally predicted values.) has attracted attention for applications in the field of civil construction. resolve

new data without any constraints.Recent findings have shown the applicability of ANN to predict the CS of concrete with different substitute materials (5). Literature review work is underway on the application of soft computational techniques in concrete strength prediction. The use of ANN is suggested by many researchers to model the complex relationship between the composition of concrete and its strength. (5).A neural network is a giant parallel distributed processor that naturally tends to store experiential knowledge and make it usable. It resembles the brain in two ways: The knowledge network is acquired by a learning process. They are used to store knowledge.

In this study, compressive strength (CS) of concrete containing nanomaterials, data collected from previous experimental investigations was used for the ANN model. was developed with 5 input parameters as nanoSiO2, nanoAl2O3, nanoFe2O3, nanoTiO2, nanoZnO to predict CS of concrete nanomaterials; hidden layer nodes as well as weights and biases are corrected by trial and error to get the best performing model. Coefficients of correlation for train and test data are shows that ANN could be used for predicting the CS of nanomaterial concrete strengths as compare with Support Vector Machine (SVM)
Through the use of nanotechnology in concrete buildings, it has been demonstrated that it is possible to increase service life, tensile stability and mechanical strength, reduce maintenance costs and eliminate the need for immediate replacement. instantly. In the near future, a better understanding of the properties of nanomaterials will help identify better approaches to creating innovative materials that improve livelihoods. making nanoparticles on a commercial basis so that these materials can be fabricated more simply and at a lower cost.

II. LITERATURE REVIEW

Jingge Ren, Xiaoxiao Luo, Ruiqiang Bai, Chonggen Pan, Jun Zhang, "Pore characteristics of different phase in nano-modified concrete and their influences on the compressive strength",(2022).
They fully understood the influence of nanoparticles on the pore characteristics of concrete; Vacuum saturation, mercury infiltration moisture measurement and scanning electron microscopy were used to analyze the pore characteristics of the concrete block, mortar phase and ITZ phase, respectively. The results show that with the best dosage nanoSiO 2 and nanoTiO 2 can reduce the porosity of concrete blocks by 15.6% and 3.5%, respectively, the porosity of cement mortar is 34.7% and 16.6%, and the porosity of ITZ is 92. 0% and 65.6% respectively. In addition, nanoparticles can also reduce the most probable pore openings and critical openings in the mortar phase, and can reduce the number of pores in the ITZ phase. . Then, the effect of these voids on the compressive strength was analyzed using gray theory

Yasmin Murad, "Compressive strength prediction for concrete modified with nanomaterials", (2021).
Gene expression programming (GEP) was used in this study to develop a predictive model that can estimate the compressive strength of concrete modified with carbon nanotubes (CNT), nanosilica (NS), nano clay (NC) and nano aluminum (NA). A total of 94 data points were collected from several tests found in the literature to develop the GEP model. Two GEP models have been developed where the first one ignores the influence of NC and NA while the second GEP model considers their influence. The models were then verified using statistical evaluation. The GEP models had high R2 values of 94% and 92.5% and low mean absolute errors of 4.6% and 2.9% of all data for the first and second GEP models, respectively. , corresponding. The compressive strength of concrete predicted using the GEP model increases with the addition of CNT, NS and NC, while it decreases with NA. This confirms the accuracy of the GEP. Models.

L. Senff a,⇑, D.M. Tobaldi b, P. Lemes-Rachadel c, J.A. Labrincha b, D. Hotza c. "The influence of TiO2 and ZnO powder mixtures on photocatalytic activity and rheological behavior of cement pastes", (2014).

A pure mixture containing nT or mT and a tertiary mixture of 0.67mT: 0.17nT: 0.17mZ obtained the best comparative performance in terms of photocatalytic activity. DoE is a mathematical method used. to determine the individual effects and interactions of independent factors (in our case nT, mT and mZ) on a particular response. Such methodology was used as a criterion for making mortar. The photocatalytic activity results showed different trends, indicating a certain correlation between the powders used. Such results can be explained by the distinct nature of the photocatalyst powders, as well as their own physical characteristics. corresponding. Compared with sample REF, 100% nT shortened hibernation time. In contrast, the changes induced by 100% nT and 0.67 mT: 0.17 nT: 0.17 mZ were as small as 0.

S.S. Lucas a,⁎, V.M. Ferreira a, J.L. Barroso de Aguiar b , "Incorporation of titanium dioxide nanoparticles in mortars — Influence of microstructure in the hardened state properties and photocatalytic activity", (2013).

Environmental pollution in urban areas is one of the causes of poor indoor air quality of buildings, especially in suburban areas. The development of photocatalyst building materials could help purify the air and improve sustainability. In this study, a photocatalyst additive (titanium dioxide) was added to the mortar prepared with lime, cement and aerial gypsum binder.Laboratory results showed that all The tested compositions all showed high photocatalytic efficiency. It has been demonstrated that photocatalyst mortars can be applied in new and old buildings, as nano-admixtures do not affect the curing properties of the mortar.

Sakshi Gupta "Using Artificial Neural Network to Predict the Compressive Strength of Concrete containing Nano-silica",(2013).

This paper presents the application of artificial neural network to develop a model to predict the 28-day compressive strength of concrete with partial replacement of cement by nanosilica whose data is extracted from the different documents. The performance of the model can be evaluated by the correlation coefficient, the mean absolute error and the mean square error are used as measures to compare with the experimental results obtained from the literature.

III. SYNTHESIS AND CHARACTERIZATION OF MATERIALS AND MODEL USED

3.1:-Artificial Neural Network

- Artificial Neural Networks (ANNs), as their name suggests, are inspired by the biology of brain neurons. Even a fairly simple ANN, which is small in size compared to the human brain, has strong characteristics of knowledge and information processing due to its similarity to the human brain. ANNs can learn from examples and can deal with non-linear problems.(4)
- One of the distinguishing characteristics of ANNs is their ability to learn from experience and examples, and then adapt to situations. change situation. The main building blocks of ANNs are neurons or nodes, and the links that connect them. An artificial neuron consists of five main parts: input, weight, sum function, activation function, and output, (4)as shown in Figure (1) .

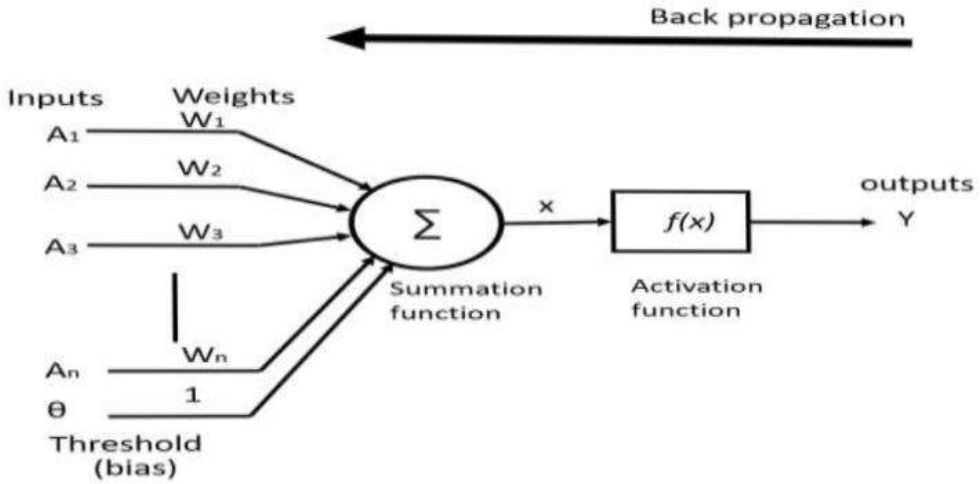

Figure 1: Show Artificial Neural Network

Inputs (Ai)are information that enters the cell from other cells or from external world. Weights (Wi) are values that express the effect of an input set or another process element in the previous layer on this process element. Sum function ∑ is a function that calculates the effect of inputs and weights totally on this process element. This function calculates the net input (X) that comes to a cell [4]. The weighted sums of the input components are calculated by using Eq. (1) as follows

$$X = {}_{\theta+}\sum_{i}^{n} Ai\ Wi \qquad \ldots\ldots (1)$$

Where

(Ɵ): The bias which employs the result as the argument for a singular valued function
(Ai): The value of input i.
(Wi): the weight of input i.
(n): the number of neuron inputs.
(X): is the net input that comes to a cell.

In Neural Network, the term back-propagation(BP) is one of the most popular learning algorithms. It is used to solve the weight optimization problems of multilayered Artificial Neural Networks. The data sequence is principal factor in achieving a good learning process, especially, in the back-propagation pattern, as is the influence of the training data distribution on all supervised training methods. The back-propagation algorithm attempts to minimize the error function in weighted space, which leads to minimize the error function. To assess the performance of the neural network model, an error measure like mean square error (MSE) or mean absolute percentage error (MAPE) might be utilized (4)

3.2:- Nanomaterials

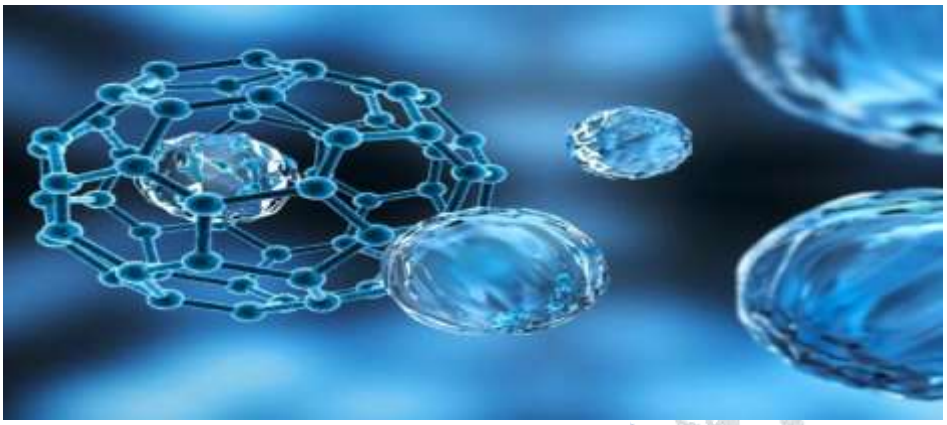

Figure 2: show Nano- material

- Nanotechnology is the use of very small pieces of materials by themselves or their manipulation to create new large scale materials.
- The Nano- scale is the size range from approximately 1nm to 100nm.
- It is an enabling technology that allows us to develop materials with improved or totally new properties.
- Nanotechnology is widely used in construction materials as :-In concrete,steel,wood,glass,coating,photovoltaic.
- Nanotechnology can modify the structure of concrete materials and finally improves in properties of materials as bulk density,mechanical performance,volume stability,durability,sustainability of concrete,improved concrete,compensate for concrete weakness in tension.
- **Nano – silica:** it is the first nano product that replaced the micro silica. Advancement made by the study of concrete at nano scale have proved Nano silica much better than the silica used in concrete.
- **3.3:-Designing Parameters**

  Compressive strength:- The application of artificial neural network (ANN) to predict the compressive strength of concrete in existing structures has been studied. ANN has been systematically used to predict the compressive strength of concrete, using both the ultrasonic pulse velocity and the results of the Schmidt elastic hammer test, available in the literature. The comparison of results obtained from ANN with experimental results is very consistent, proving that ANN is capable of estimating compressive strength of concrete accurately and reliably. Therefore, the (quantitative) values of the weights for the proposed neural network model are provided so that the proposed model can be easily implemented in a spreadsheet and for anyone interested. simulation processes are accessible.

IV. MODELING, ANALYSIS, DESIGN USING MATLAB SOFTWARE

- In this study the Matlab NN toolbox is used for NN applications.To overcome optimization difficulty, a program has been developed in Matlab which handles the trial and error process automatically(11).
- In order to compare the results obtained with the ANN with Support-Vector Machines (SVM) have been carried out on the same data using MATLAB.
- The main goal of this project was to develop an ANN model to predict the compressive strength of concrete using the MATLAB software and to validate the model.

V. PROJECT MANAGEMENT USING MATLAB SOFTWARE

Why Matlab?

- Matlab is meant primarily for Mathematical Computing. Matlab contains an enormous assortment of predefined algorithmic program that is employed for image processing. AN algorithm may be tested directly while not recompiling it again. Matlab provides an interactive atmosphere which helps you to figure innovatively along with your information and helps to stay track of the files and variable and so forth.
- Initially, data was collected through the literature and experimental results were conducted in the laboratory. This data is entered into the MatLab workspace in matrix format with input parameters
- as the input data matrix and experimental data values and collected as the target matrix. The network configuration is done to create the network in the neural network tuning tool. The regulator in the neuron community is used to map between the digital input data set and the digital targets set. The Neural Network Tuning Tool will help select statistics,create and teach a community, and test its overall performance using implicit square root error and regression evaluation. regulation.

VI. CONCLUSION

- The complex non-linear behavior of concrete can be efficiently handled using neural network techniques. In this study, artificial neural networks were developed to predict the compressive strength (CS) of concrete for input parameters nanoSiO2, nanoAl2O3, nanoFe2O3, nanoTiO2, nanoZnO.
- The development of neural network is useful to avoid bias caused by taking certain data to train neural network. The number of hidden neurons and performance measures were studied to get the best performance from each network.
- Neural network represents the main components of the proposed model because of the CS of the inputs. Their outputs are considered as model outputs.
- The Prediction results have been confirmed with certainty that the proposed model can be effectively applied to estimate CS for concrete with particle admixtures.

VII. REFERENCES

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