A REVIEW PAPER ON THE USE OF ARTIFICIAL INTELLIGENT TOOLS IN THE PREDICTION OF STRUCTURAL RESPONSE

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Abstract: Artificial intelligence is a machine/software intelligence as opposed to intelligence shown by animals. AI when used makes a wide term, of which Artificial Neural Network is a sub-part. ANN even though not a new concept but its popularity in the structural engineering field is quite new. Its application in predicting the seismic response of masonry-infilled RCC frames, predicting the structural response of multi-storied reinforced concrete buildings for ground acceleration, predicting the shear strength of Fibre Reinforced Mortar strengthened masonry are recent examples of it. The aim and scope of this project is to identify the use of ANN in predicting structural behaviour. If ANN is better understood, it can be more efficiently used in the construction field. This study is carried out based on a literature review. The objective of this study is to aid in minimizing or probably avoiding prolonged laboratory or field tests to determine design parameters.

1. Introduction

Artificial intelligence (AI) is a branch of computer science related to developing software/machines which are efficient in carrying out tasks that often require human intelligence. AI is popularising as an efficient alternative approach to traditional techniques. Parting to traditional methods, AI offers a more efficient way to deal with issues associated with unpredictability and is an effective help to solve such complex problems.

AI-based answers are proving a better alternative to knowing engineering design parameters when testing is not possible, thus ensuing in significant savings of efforts and testing time spent in experiments. AI also has the potential of reducing error rates, decision-making faster, and increase computational efficiency.

Civil engineering is filled with problems that derive solutions through traditional computational techniques. However, these problems can usually be solved by an expert having the right training. Artificial intelligence (AI) has targeted this kind of difficulty by capturing the essence of human cognition at the highest level. To solve engineering problems that derive solutions using conventional methods, AI (a computational method) is an attempt to replicate human cognition capabilities through symbol manipulation and symbolically structured knowledge bases.

In the field related to structural engineering, numerous problems are influenced by uncertainties, e.g., those related to construction management, condition monitoring, design, analysis decision making, etc. Such problems need mathematics, physics, and mechanics calculations to be solved, and their solution to an extent depends on the practitioner's

experience. It can further be said that computers are still to be fully utilized for many tasks. This is due to the need for problems that tend to be unique, logical reasoning, feasibility constraints, and the need to use prior experiences in the analysis and design process.

However, AI techniques can be efficiently used to better these efforts and can also be considered to validate laboratory or field test results.

2. Literature Review

Title - Prediction of the Seismic Response of Multi-Storey Multi-Bay Masonry Infilled Frames Using Artificial Neural Networks and a Bilinear Approximation

Author - Tanja Kalman Sipos and Kristina Strukar

Developed a neural networking process tool for predicting the seismic response of masonry-infilled RCC frames so that they can check the reliability of neural networks. The database of experimental tests conducted on one-story one-bay masonry infilled RCC frames were collected, and from that database neural networks were designed. From the obtained results it was found that these networks were acceptable for predicting inter-story drift ratios and base shear. The obtained result for one-story one-bay masonry infilled RCC frames was then extended to multi-bay infilled frames by evaluating the applicability of the expression to multi-bay frames of different and same lengths. For the multi-bay frame, it was concluded that the proposed equation showed sufficient acceptability with only 4.5% means relative error.

Title - Prediction of structural response based on ground acceleration using artificial neural network

Author - Reni Suryanita, Harnedi Maizir, Hendra Jingga

Used Artificial Neural Network (ANN) to predict the structural response of multi-storied reinforced concrete buildings when facing ground acceleration. Modal response spectrum analysis was performed to simulate ground acceleration so as to produce structural response data for further use in ANN.6345 data sets were used to train the ANN. The trained ANN was found to be capable of predicting structural responses based on ground acceleration at a (96%) rate of prediction and the calculated Mean-Squared Errors (MSE) were as low as 1.2×10^{-4}.

Title - An Artificial Neural Networks model for the prediction of the compressive strength of FRP-confined concrete circular columns

Author - Alessio Cascardi, Francesco Micelli, Maria Antonietta Aiello

Presented an ANN analytical model to predict the strength of FRP confined concrete. The proposed model was for circular columns for which an extensive experimental database was used to propose the variables of the proposed equations. A parametric analysis was performed in order to verify if the mathematical formula is coherent with the FRP-confined concrete compressive behaviour described in experimental tests, the proposed model did show to be consistent with the mechanical trends that were observed in the laboratory tests. And the proposed model shows satisfying statistical evidence of the predictive performance.

Title - Analytical model based on artificial neural network for masonry shear walls strengthened with FRM systems

Author - A. Cascardi, F. Micelli, and M. A. Aiello

Proposed an analytical model based on ANN to predict the shear strength of Fibre Reinforced Mortar strengthened masonry. Using an input database of laboratory results for masonry, ANN was developed. The developed database and the subsequent analysis provided an effective model for predicting the in-plane shear strength of masonry panels strengthened by FRM

systems. Despite the great diversity of input parameters, the proposed model was found to present good precision and accuracy; the robustness and sensitivity of the model were also evaluated through an extensive parametric study.

Title - Response Prediction of Structural System Subject to Earthquake Motions using Artificial Neural Network

Author - S. Chakraverty, T. Marwala, Pallavi Gupta, and Thando Tettey

Developed Artificial Neural Network (ANN) models to compute the structural response of a single degree of freedom system subjected to Indian earthquakes at Chamoli and Uttarkashi ground motion data. Initially, the system was trained for a single real earthquake data. For simulating earthquakes, the trained ANN architecture was then used with various intensities and it was found that the predicted responses given by the ANN model were accurate for practical purposes.

Title - Emerging artificial intelligence methods in structural engineering

Author - Hadi Salehi, Rigoberto Burgueno

Presented the significance of emerging AI methods for structural engineering applications during the last decade. The importance of AI in structural engineering along with the application of Machine Learning (ML), Pattern Recognition (PR), and Deep Learning (DL) was discussed.

3. Scope, Methodology and Purpose

3.1 Scope

- The use of steel sheds is very prevalent for the construction industry, accordingly, the steel shed behaviour, in general, is known. The use of neural networks in the civil engineering field is already certain however the application of neural networks for the prediction of steel shed behaviour is rare. There are only a few studies that have explored this topic so this research area needs to be further investigated.
- The extensive knowledge and experimental data of steel shed can be used to train ANNs and a strong network can be built.

3.2 Methodology

- Selecting a structure to study response.
- Collecting experimental data based on response of structure.
- Creating neural network for predicting response of similar structure.
- Feeding collected experimental data in neural network for structural prediction.
- Verifying results.

3.3 Purpose

The proposed work will help to predict behaviour of steel shed while resisting wind force. Suggestion and recommendation made through this project will also be useful for the industry people, as precise behaviour of structure will be known ultimately reducing cost on laboratory work.

References

1) Tanja Kalman Sipos and Kristina Strukar, “Prediction of the Seismic Response of Multi-Storey Multi-Bay Masonry Infilled Frames Using Artificial Neural Networks and a Bilinear Approximation”

2) Reni Suryanita, Harnedi Maizir, Hendra Jingga, “Prediction of structural response based on ground acceleration using artificial neural network”

3) Alessio Cascardi, Francesco Micelli, Maria Antonietta Aiello, “An Artificial Neural Networks model for the prediction of the compressive strength of FRP-confined concrete circular columns”

4) Alessio Cascardi, F. Micelli, and M. A. Aiello, “Analytical model based on artificial neural network for masonry shear walls strengthened with FRM systems”

5) S. Chakraverty, T. Marwala, Pallavi Gupta, and Thando Tettey, “Response Prediction of Structural System Subject to Earthquake Motions using Artificial Neural Network”

6) Hadi Salehi, Rigoberto Burgueno, “Emerging artificial intelligence methods in structural engineering”