Review Paper on the use of Artificial Intelligent tools in the Prediction of Structural Response

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***Abstract*— Artificial intelligence is 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 RCC frames filled with masonry, predicting the structural response of multi-storied reinforced concrete buildings for ground acceleration, and anticipating 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 behavior. 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 testing in the field or in the lab to find out the parameters of the design.**

***Keywords*— AI, ANN, Predicting response, Steel shed**

I. INTRODUCTION

A sub-field of computer science known as artificial intelligence (AI) deals with the creation of software and machines that are effective at carrying out tasks that frequently require human intelligence. Artificial intelligence is growing as an effective elective way over conventional methods. In contrast to conventional approaches, AI provides a more effective aid in resolving complex issues and offers a more effective approach to dealing with issues related to unpredictability.

When testing is not possible, AI-based responses are proving to be a superior alternative to knowing engineering design parameters, resulting in significant cost and testing time savings. Additionally, AI has the potential to speed up decision-making, reduce error rates, and increase the efficiency of computation.

There are a lot of problems in civil engineering that can be solved using traditional computational methods. However, an expert with the appropriate training typically has the ability to resolve these issues. Computerized reasoning (simulated intelligence) has designated this sort of trouble by catching the substance of human perception at the most elevated level. AI, a computational method, is an attempt to replicate human intelligence capabilities through databases with symbols for organization and symbol manipulation to solve engineering problems that derive solutions using conventional methods.

Uncertainty has an impact on a lot of problems in structural engineering, such as construction management, monitoring of conditions, design, analysis, and decision-making. These problems necessitate calculations in physics, mathematics, and mechanics, and the practitioner's experience may play a role in their resolution. It is also true that computers are not yet used to their full potential for many tasks. This is because the analysis and design process require the use of prior experiences, constraints on feasibility, logical reasoning, and typically unique problems.

Nonetheless, computer-based intelligence methods can be effectively used to better these endeavours and can likewise be considered to approve lab or field test results.

II. LITERATURE REVIEW

Tanja K. [1] crafted a neural networking process tool for anticipating the seismic response of RCC frames filled with masonry in order to verify the accuracy of neural networks.

The information base of trial tests directed on one-story single bay masonry filled RCC outlines were gathered, and from that data set of neural networks was planned. Based on the findings, it was concluded that these networks were suitable for predicting base shear and inter-story drift ratios. The evaluation of the expression's applicability to multi-bay frames of the same length allowed the obtained result for one-story, one-bay masonry-filled RCC frames to be extended to multi-bay-filled frames. With only a mean relative error of 4.5 per cent, it was determined that the proposed equation was acceptable for the multi-bay frame.

In their study, Reni S. and colleagues [2] employed Artificial Neural Network (ANN) technology to anticipate the dynamic behavior of multi-storied concrete structures under the influence of ground seismic acceleration. To facilitate the training of the ANN, they utilized modal response spectrum analysis to simulate ground acceleration and generate structural response data. A significant dataset of 6345 instances was employed to train the ANN model thoroughly. The achieved Mean-Squared Errors (MSE) were impressively low, reaching as low as 1.2 x 10^-4. This indicates the model's strong ability to accurately predict structural responses based on ground acceleration. The study's results highlighted the remarkable predictive capability of the trained neural network, achieving an impressive prediction rate of 96 percent when estimating structural responses influenced by ground seismic acceleration. This suggests that the ANN model holds promising potential for efficiently forecasting the behavior of multi-storied concrete structures in seismic conditions.

In their work, Alessio C. and colleagues [3] introduced an analytical Artificial Neural Network (ANN) model designed to predict the strength of Fiber Reinforced Polymer (FRP)-confined concrete. The model was developed based on an extensive experimental database, which allowed them to identify the relevant variables for the circular columns in their equations. The study demonstrated that the proposed model exhibited consistency with the mechanical trends observed in laboratory tests.

A. Cascardi et al. [4] predicted the shear strength of Fibre Reinforced Mortar-strengthened masonry using an analytical model based on ANN. Utilizing an info data set of research facility results for masonry, ANN was created. The created data set and the ensuing examination gave a successful model for foreseeing the in-plane shear strength of brickwork boards fortified by FRM frameworks. Regardless of the extraordinary variety of information boundaries, the proposed model was found to introduce great accuracy and exactness; the heartiness and responsiveness of the model were additionally assessed through a broad parametric review.

In their research, S. Chakraverty et al. [5] devised Artificial Neural Network (ANN) models to analyze the fundamental response of a single degree of freedom system subjected to Indian earthquake data from Chamoli and Uttarkashi ground movements. The ANN models were trained initially using data from a single real earthquake dataset. The ANN architecture was put to the test by simulating earthquakes at different intensities. Remarkably, the results showed that the ANN model's predicted responses aligned accurately with practical observations. This suggests that the developed ANN models hold great promise for effectively predicting the behavior of single degree of freedom systems under various seismic conditions, utilizing ground movement data from Chamoli and Uttarkashi earthquakes.

Recent AI-based algorithms have important applications in the field of structural engineering, according to Hadi S. et al. [6]. The application of Machine Learning (ML), Deep Learning (DL), and Pattern Recognition (PR), was also discussed in relation to the significance of AI in structural engineering.

III. SCOPE, METHODOLOGY, PURPOSE

a. Scope

The construction of gable roof steel structures is the need of the industry. Artificial intelligence is not commonly utilized in the field of design for computing the physical behaviour of gable roof sheds.

There are a couple of studies that have investigated this point so this exploration region should be additionally examined.

The extensive knowledge and experimental data of steel shed can be used to train ANNs and a strong network can be built.

b. Methodology

1. Selecting a structure to study response.
2. Collecting experimental data based on the response of a structure.
3. Creating a neural network for predicting the response of the similar structure.
4. Feeding collected experimental data in a neural network for structural prediction.
5. Verifying results.

c. Purpose

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

IV. WIND PRESSURE

The symmetric portal frame models with symmetric shows better performance for the external and internal wind pressure distribution. The scaled model with the ratio of 1:35 model having wind attack angles 0°, 45°, and 90° was studied.. The windward wall experiences peak external pressure at A2 on the eave joint at 86.8 mm of H_2O in the wind direction normal to the roof ridge. The highest internal pressure occurs at C1 of 65.7 mm of H_2O on the leeward roof ridge. Compared to the wind direction of 0°, the 45° wind direction, namely the wind direction oblique to the roof ridge, produces higher external pressure on the windward wall. The formation of a conical vortex on two sides of the region results in higher pressure generation near the roof corner, and the corresponding maximum pressure is up to 114 mm of H_2O. In the 90° wind direction, namely, the wind direction parallel to the roof ridge, the sidewalls experience high internal pressure due to the separation airflow from the leading edges of walls, and the corresponding maximum internal pressure is up to 76.6 mm of H2O. High internal pressure appears in the ridge joint of the leeward roof resulting from the sudden change in slope of the roof.

V. COMPARISON WITH PUBLISHED LITERATURE

For windward sidewall, the consistent trends show that Tap A2 i.e., the tap placed at 30mm from the eaves end faced a higher external pressure than that of tap A1 which is placed at the bottom end of the wall. Holmes (6) commented that flow separates at the top of the windward wall and again reattaches at a region further downside of the roof, leading to high-pressure generation at top of the wall and bottom end of the roof. The peak external pressure of 103.2 mm of H2O was noted at a 90º wind attack angle at tap A2. Out of all the orientations, 90º wind attack angle consistently showed the maximum pressure distribution for most pressure measuring taps. For roof-ceiling near fire exit, Tap C1 i.e., tap placed at 42.5mm from the roof ridge faced the external peak pressure of 121 mm of H2O at an attack angle of 90 degrees i.e., the wind direction parallel to the roof ridge. The separation of airflow from the leading edge of the roof causes the creation of a conical vertex on two sides of the ridge, which leads to increased pressure generation towards the ridge end.[5] For roof-ceiling away from fire exit, Tap B3 i.e., tap placed at 42.5mm from ridge end faced the maximum internal pressure of 91.8 mm of H2O at an attack angle of 90°. A sudden change of roof slopes creates wind rotation at the ridge, leading to high-pressure generation on both sides of the roof. For roof-ceiling near fire exit, Tap C1 i.e., tap placed at 42.5mm from the roof ridge faced the internal peak pressure of 108.1 mm of H2O at an attack angle of 90°. As expected, the tap near the ridge end faced maximum pressure due to wind rotation. A sudden drop in internal pressure at tap C2 and C3 can be observed because after hitting the ridge, wind flows in the downward direction instead of flowing forward in the leeward direction of the shed.

VI. PRACTICAL SUGGESTIONS FOR IMPROVING SAFETY OF STRUCTURE UNDER HIGH PRESSURE

1. Providing pressure release valve near-critical section to release the extreme internal pressure.
2. Providing material having high elasticity in the high-pressure zones.
3. Making connections stiffer near high-pressure zones.
4. Similar to wood roofing, curves near ridge & eaves in steel roofing can be provided to dissipate extreme external air gusts safely.
5. Providing more opening area near high pressure zones.

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