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Use of Artificial Neural Network in Wind Response of Tall Buildings

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***Abstract:*— India is the second largest country in the world with about 1,336,087,445 population as on today. In present scenario, population density in our country reaches approximately 455 per square kilometers and in a way to grow at higher side. As we all know the basic requirement for an individual is food, shelter and water to survive. A civil engineer plays an important role in providing shelter to each and every citizen of India. Presently population growth is a main hurdle for an engineer to come across and space in big cities is one of the big task for civil engineers. With the lack of space engineers find their way in designing the slender, taller structures. With the increase in height of building, the study of wind induced building motion becomes very important. Wind tunnel experiments are the basic source to study these motions for taller buildings. But use of wind tunnel is not feasible every time and it is must to find alternate solutions. I.S. 875 (Part - 3): 1987 describes along wind response by gust factor method by considering the effects of change in terrain category. A new code reaffirmed in 2013 is also available to calculate along and across response of buildings. This paper discusses the method for calculating along wind response with use of Indian standard codes and Artificial Neural Network to save the time and money required in wind tunnel experiments.**

Index Terms **:-- along wind Response, Indian Standard Codes, Artificial Neural Network.**

I. INTRODUCTION

Tall buildings are commonly featuring today in both developed and developing economies and with the increase population and lack of open spaces. Multistoried buildings are increasingly becoming popular instead of single storied constructions. With this special consideration, need to be given for the analysis of tall structures by considering the dynamic nature of wind.

Tall buildings are slender flexible structures. Such structures be investigated to ascertain the importance of wind induced along and across oscillations. The Indian code of practice, IS 875 Part 3: 1987gives a procedure to determine along wind response of tall structures, while the across wind response and interference effects are not included in the code at present. The code is due for revision and Bureau of Indian Standards has recently finalized circulated a draft for the revised code based on IITK – GSDMA document, and will become operative very soon. The procedure is modified to obtain along wind response of tall buildings with simplified making use of formulae and procedure to obtain across wind response for buildings using figures and expressions for selected (h: b: d) ratios based on extensive wind tunnel experimentation also included.

Detailed wind tunnel experimentation remains the main source for determination of wind loads on buildings and structures. Other than this Artificial Neural Networks (ANN) have the ability to learn by training examples and generalize the problem. ANN can be applied to generalize the results obtained from expensive, tedious, time consuming wind tunnel testing. ANN has been chosen because of its good generalization capability when trained with limited data. In addition solutions from ANN models are obtained easily and rapid.

II. REVIEW OF PAPERS

Artificial Neural Network has been applied many ways in civil engineering. Flood Ian and Kartan Nabil (1994), uses Neural Networks in solvinga simple problem of cantilever beam.

Rafiq M. Y., Bugmann G., Easterbrook D. J., (2001), presented practical guidelines for designing ANN for engineering applications. Major aspects of three types of NN, multi-layer perception (MLP) radial basis network (RBF) (NRBF) are discussed. New methods for selection and normalization of training data are introduced and a practical example of reinforced concrete slab design is presented.

Rao M. M. and Datta T. K. (2006), presented an Artificial Neural Network based control scheme for reduction of the seismic response of a multistoried building frame considering first three modes for the response analysis of the

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10 storey building frame and Acceleration feedback measurements are taken form first, third, fifth, seventh and 10th stories.

Abdalla Jamel A, Elsanosi A, Abdelwahab A. (2005), presented application of ANN for predicting the shear resistance of beams, mainly shear-span to depth ratio, concrete strength, longitudinal reinforcement, shear reinforcement, beam depth and beam width, are used as input for the ANN. A back propagation neural network (BPNN) with different activation functions is used and their results are compared.

Agrawal Vinay, Nagar, Dr. Ravindra and Chandwani Vinay (2007), highlights the capabilities of neural networks for predicting slab deflections.Otherwise quite difficult to calculate using the traditional methods of computing, which is not possible at conceptual stage.

J.Y. Fu, Q.S. Li, Z.N. Xie (2006), given the use of FNN in simultaneous pressure measurements made on a large flat roof model in a boundary layer wind tunnel. An FNN approach is developed for prediction of mean pressure distributions on the roof model, and wind tunnel test results are used as the training sets for the FNN to recognize the pressure distribution patterns.

Table 1 Conclusions made after literature survey

SN	Title of Paper	Authors	Conclusions
1	Neural Networks in Civil Engineering. I: Principles and Understanding	Flood Ian and Kartan Nabil (1994)	ANN in solving simple problem of cantilever beam.
2	Neural Network Design for Engineering Application	Rafiq M. Y., Bugmann G., Easterbrook D. J., (2001)	ANN in solving example of reinforced concrete slab.
3	Modal Seismic Control of Building Frames by Artificial Neural Network	Rao M. M. and Datta T. K. (2006)	ANN in seismic response of a 10 storey multistoried building frame.
4	Modeling and Simulation of shear resistance of R/C beams using Artificial Neural Network	Abdalla Jamel A, Elsanosi A, Abdelwahab A. (2005)	Used BPNN for predicting the shear resistance of beams.
5	Application of Neural Networks in predicting slab deflection at conceptual stage	Agrawal Vinay, Nagar, Dr. Ravindra and Chandwani Vinay (2007)	Recognition of the deflection pattern of the slab for different live load intensities, depth edge beams and the thickness of the slab with ANN.
6	Prediction of wind loads on a large flat roof using fuzzy neural networks	J.Y. Fu, Q.S. Li, Z.N. Xie (2006)	Fuzzy neural networks (FNN) in predicting wind loads on buildings for the data obtained from wind tunnels.

III. ARTIFICIAL NEURAL NETWORK

A structure of ANN composed of number of interconnected units termed as artificial neurons. Each unit has input / output and implements a local function. The output of any unit is determined by input parameters, interconnections to other units and external inputs. ANN adopts the brain metaphor, which suggests the intelligence emerges through large number of processing elements connected together. A human has as many neurons as 10 – 500 billion. These neurons are interconnected forming the networks like working of a human brain.

A human brain stores the experiences and incorporates that in a well manner. A brain is able to make own prediction depending upon the several past self organized experiences. This implicates the generalization capabilities.

Figure 1 show the biological neuron which consists of a central cell body, an axon, and a multilayer of dendrites.

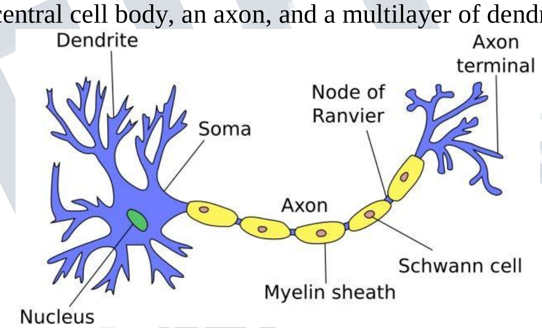

Figure 1 Biological Neuron

IV. COMPUTER PROGRAM

IS 875 (Part 3) – 1987 provides procedure for Dynamic Analysis of Building. The code includes number of Tables and Cumbersome Charts for calculating parameters comes under complete wind analysis of any tall structure. With the use of charts and Tables it is very difficult to develop a Computer Program. Manual analysis is very time consuming as well as tiresome.

A new code CED 37 (7792) reaffirmed in 2013 which is under Circulation is available for estimating along and across wind load. The code is revised with number of formulae instead of Tables and Charts. This code makes analysis much simpler and rapid. Using the formulae from new draft code we can easily develop a Computer Program in any suitable computer programming language.

A FORTRAN based computer program proposed and developed as per the procedure given in revised code (Draft under Circulation) CED 37 (7792) for obtaining the along wind response and which can be used to generate data to be used for the Artificial Neural Network development.

I have decided the input parameters as H, B, D, DH, CF,

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VB and TC. Take output as Shear Force and Bending
Moment at each level in which building is divided.
Where,
H – Total Height of Building
B – Dimension of building taken normal to wind
D – Dimension of building taken parallel to wind
DH – distance between two consecutive parts in which building is to be divided
CF – Drag Force Coefficient (Refer Cl. 4.1.6)
VB – Basic Wind Speed in m/s as per Indian code of practice.
TC – Terrain Category as per Indian code of practice.

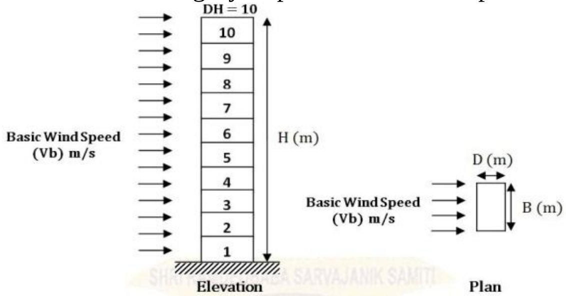

Figure 2 Building Model for Dynamic Analysis

V. EXAMPLE

Table 2 gives the problem statement whose manual solution prepared as per present code of practice IS 875 (Part 3): 1987 and validated the results using computer program output.

Table 2 Problem Statement for validation of computer program

Building Parameters	
Height (m)	100
Breadth (m)	30
Length (m)	20
Drag Force Coefficient (Cf)	1.30
Basic Wind Speed (m/s)	50
Terrain Category	1

All the parameters shown in table 2 will be taken as input in computer program.

Table 3 gives the shear force and bending moment variation at various levels of building as a output of computer program.

Table 3 Shear Force and Bending Moment Variation

Sr. No.	Height (z) m	Gust Factor (G)	Along Wind Load ($\bar{F}_z$) kN	Shear Force (kN)	B.M. (kNm)
1	0	1.7421	0	8570	488084
2	10	1.7496	625.03	8570	402383
3	20	1.7603	735.26	7945	322933
4	30	1.7740	807.40	7209	250836
5	40	1.7902	864.34	6402	186812
6	50	1.8091	913.68	5538	131432
7	60	1.8301	957.84	4624	85188
8	70	1.8530	998.73	3666	48524
9	80	1.8772	1038.13	2667	21846
10	90	1.9017	1074.67	1629	5549
11	100	1.9256	554.97	554	0

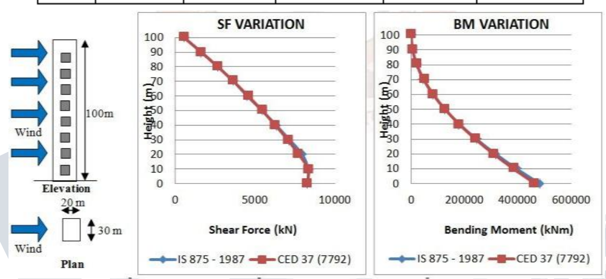

Figure 2 Shear Force & Bending Moment Variation for Terrain Category 1

VI. DISCUSSIONS

1) After reviewing several papers it is found that an artificial neural network is a very important tool in predicting the wind response.
2) Also ANN can be used in many civil engineering structural analysis problems where complete data is not available.
3) ANN in calculation of wind response of tall buildings plays an important role in the analysis where the data is incomplete.
4) The code reaffirmed in 2013, CED 37 (7792) gives a set of formulae to determine along wind response of tall buildings making the procedure is systematic and convenient for hand calculations.
5) This code also provides most favorable exposure to create computer program as there is no need to refer any graphs or table.
6) The procedure suggested in present code of Indian practice, IS 875 (Part 3):1987 for the calculation of along wind response is not easy as number of Tables and Figures needed to be referred.
7) The programming is also difficult using IS 875 (Part 3):1987. Hence it is a need to develop new techniques to All the parameters shown in table 2 will be taken as inputpredict the wind response and ANN is a useful tool other in computer program. than the computer program.

REFERENCES

[1] Flood Ian and Kartam Nabil, Neural Networks in Civil Engineering. I: Principles and understanding, Journal of Computing in Civil Engineering, 8(2), 1994, pp 131 – 147.

[2] Girma T. and Godbole P. N. , Application of Cascade Correlation Learning Network for Determining Wind Pressure Distribution on Building, Proceedings 10 ICWE, Copenhegan, Denmark, June 21 – 24, 1991, pp 1491 – 1496.

[3] James L. Rogers, Simulating Analysis with Neural Network, Journal of Computing in Civil Engineering, 8(2), 1994, Paper No. 5286.

[4] Khanduri A.C., Bedard C., Stathopouls T., Neural Network Modeling of Wind Induced Interference Effects, Proceedings 9 ICWE, New Delhi, India, 1995, pp 1341 – 1352.

[5] Kwatra N., Godbole P. N., Premkrishna, Application of ANN for Determination of Wind Induced Pressure on Gable Roof, International Journal of Wind and Strustures, 5(1), 2002, pp 1–14.

[6] Prem Krishna, Krishen Kumar, N. M. Bhandari, IS: 1987 (Part 3): Wind Loads on Buildings and Structures – Proposed Draft & Commentary Diocument No. IITK – GSDMA – Wind 02 – V5.0, 2004, IITK – GSDMA project on building codes, Department of Civil Engineering, IIT Kanpur, India.

[7] Rao M. M. and Datta T. K., Modal Seismic Control of Building Frames by Artificial Neural Network, Journal of Computing in Civil Engineering, 20(1), 2006, pp 69 – 73.

[8] Bodhisatta Hazra, Along Wind Response of Tall Buildings, M. Tech. Project, Department of Applied Mechanics, 2007, VNIT, Nagpur.

[9] Suyog U. Dhote, P. N. Godbole (2012), "Wind Response of Tall Multistoried Buildings", M. Tech. Thesis, RCOEM, Nagpur.

[10] http://www.marekrei.com/blog/wp-content/uploads/2014/01/n euron.png

[11] P. N. Godbole, Application of Neural Network For Assessing Wind Loads on Buildings – An Approach to Disaster Mitigation, 2001, Research Project, Department of Civil Engineering, IIT Roorkee (U.P.).

[12] Suyog U. Dhote, P. N. Godbole (2012), Application of Neural Networks in Predicting Wind Response of Tall Buildings, International Conference on Disaster management, YCCE, Nagpur.

[13] Suyog U. Dhote (2015), Computational Techniques in WindResponse of Tall Buildings, International Journal of Research in Advent Technology (E-ISSN: 2321-9637) Special Issue, pp150-154.