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Application of Artificial Neural Network in Wind Response of Tall Buildings

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Abstract: **-- As per World Population Prospects 2017, India is having about 1.3 billion population and ranks second in the world. Due to the continuous increase in population, lack of open spaces plays a very vital role in growing economies. With the lack of open spaces, tall buildings are featuring well in developed as well as developing countries. With the increase in demand of tall buildings, it is a basic need to do the analysis of the tall buildings considering the dynamic response of a tall structure subjected to wind. The Indian code of practice IS 875 (Part-3):2015 gives the procedure to determine along and across wind response of tall structures. Artificial Neural Network approach in wind response of tall buildings is very useful and rapid method where availability of major data is critical.**

***.Key Words*: - Along wind response, IS 875 (Part-3):2015, Computer program, Artificial Neural Network, etc.**

I. INTRODUCTION

An old Indian Standard code for Wind Loads on Buildings and Structures [IS 875 (Part – 3) – 1987] recommends Gust Factor (GF) or Gust Effectiveness Factor (GEF) for calculating along wind load on flexible slender tall structures. The Gust Factor calculations are based on hourly mean wind speed and tiresome charts. A present modified Indian Standard code for Wind Loads on Buildings and Structures [IS 875 (Part – 3) – 2015] shows many modifications particularly in the procedure to obtain along wind response of tall buildings. The present code has been simplified making use of formulae. Across wind response for building is also included in the present code. Wind tunnel modelling remains the primary source of knowledge on wind loads on tall structures. The detailed tunnel modelling studies are implemented in the form of formulae, figures and charts. Artificial Neural Networks have the ability to learn by training examples and generalize the problem. With this property of ANN, it can be used to generalize the outcomes obtained from tiresome, expensive, and time consuming wind tunnel experimentations.

II. ARTEFICIAL NEURAL NETWORK

Artificial Neural Network includes number of interconnected artificial neurons. Each neuron performs local function with input value and gives output. The output is determined by provided input parameters as well as their interconnections to other units. Artificial Neural Network provides a good platform which works over the terminology of human brain metaphor. A human has as many neurons as 10 – 500 billion. These neurons are interconnected forming the networks and gives output on specific provided input parameters..

III. DEVELOPMENT OF COMPUTER PROGRAM

Present Indian Code IS 875 (Part 3) – 2015 provides simplified procedure for Dynamic Analysis of tall structures. The code includes number of simplified formulae which makes analysis simple and rapid. By using Present Indian Code of practice IS 875 (Part 3) – 2015, we can easily develop a Computer Program in any suitable computer programming language. A FORTRAN based computer program has been developed as per the procedure given in present code of practice to obtain the along wind response. This data can be used to generate data to be used for the ANN network.

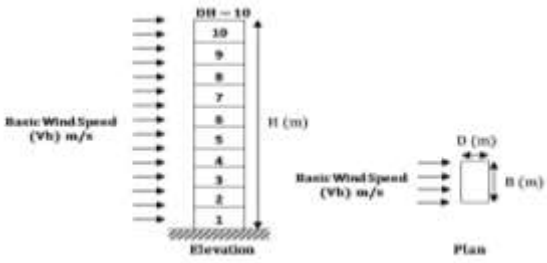

Fig. 3.1 Structural Parameters for Dynamic Analysis

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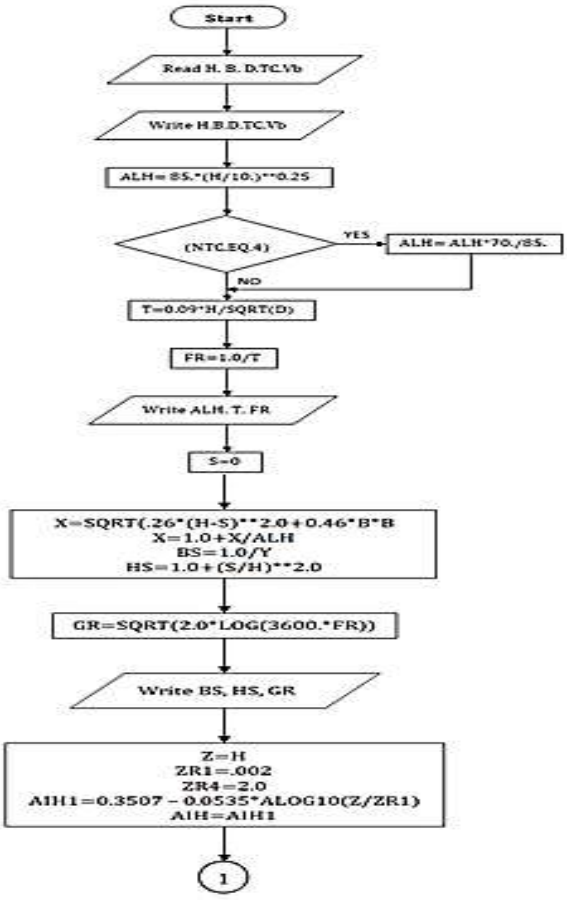
The input and output details, are given below: -

Input Parameters:
H, B, D, TC, VB, DH, and CF are the input parameters.

Where,
H – Total Height of Building
B – Plan dimension of building (Refer fig. 3.1)
D – Plan dimension of building (Refer fig. 3.1)
TC – Terrain Categories
VB – Basic Wind Speed in m/s.
DH – distance between two consecutive parts when building is divided in number of parts.
CF – Drag Force Coefficient

Output Parameters:
Gust Factor, Wind Pressure, Wind load, shear force and bending moment at each mentioned level.

IV. COMPUTER PROGRAM FLOW CHART



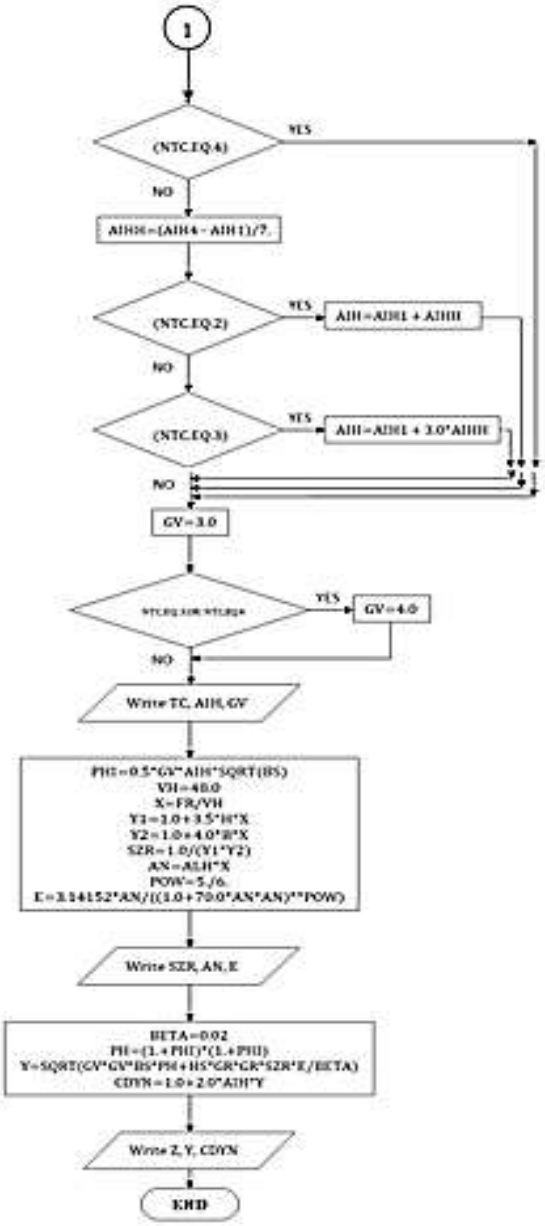


Fig. 4.1 Computer Program Flow Chart

V. VALIDATION OF COMPUTER PROGRAM

Building with following particulars analyzed for validation purpose.

Table 5.1 Building Particulars

Building Parameters	Values
Height (m)	100

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Breadth (m)	30
Length (m)	20
Basic Wind Speed (m/s)	50
Terrain Category	1, 2, 3, 4
Drag Force Coefficient (Cf)	1.30

Note: Breadth considered normal to the wind direction and k1, k3 and k4 taken as 1.0.

Table 5.2 and 5.3 gives Max Shear Force and Bending Moment variation for a given Building in all terrain categories by old code and the revised present code.

Table 5.2 Maximum Shear Force (kN) Variation

Terrain Category	IS 875 (Part-3):2015 (Computer Program)	IS 875 (Part-3):1987 (Manual Calculation)
1	8282	8932
2	7321	8092
3	6627	5971
4	4079	2944

Table 5.3 Maximum Bending Moment (kNm) Variation

Terrain Category	IS 875 (Part-3):2015 (Computer Program)	IS 875 (Part-3):1987 (Manual Calculation)
1	465090	488754
2	418580	454737
3	390980	341459
4	257440	164135

V. DISCUSSIONS

The revised code [IS 875 (Part-3):2015] gives a set of formulae to determine along and across wind response of tall buildings. The procedure is systematic and convenient for computer programming.

On the basis of analysis of number of buildings using old Code and revised Code, it is seen that the results for bending moment and shear force are very close for Terrain Category 1, 2 and 3 while for category 4 the revised gives higher value for Shear Force and Bending Moment as compared to old Code.

It is found that the use of ANN is most useful tool for predicting the wind response by reviewing many research papers.

The use of ANN in calculation of wind response of tall buildings plays vital role in the analysis where the data availability is critical.

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