Analysis of Reinforced Concrete Chimney Using Artificial Neural Network

By

Pandya Pragnesh G.
(04MCL008)

DEPARTMENT OF CIVIL ENGINEERING
Ahmedabad- 382 481
May 2006

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Major Project

Submitted in partial fulfillment of the requirements

For the degree of

Master of Technology in Civil Engineering
(Computer Aided Structural Analysis & Design)

By

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Guide:
Prof. V R. Shah

NIRMA UNIVERSITY
INSTITUTE OF TECHNOLOGY

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CERTIFICATE

This is to certify that the Major Project entitled "**Analysis of Reinforced Concrete Chimney using Artificial Neural Network**" submitted by **Mr. Pragnesh G.Pandya (04MCL008)**, towards the partial fulfillment of the requirements for the degree of **Master of Technology in Civil Engineering** (**Computer Aided Structural Analysis and Design**) of Nirma University of Science and Technology, Ahmedabad is the record of work carried out by him under my supervision and guidance. In my opinion, the submitted work has reached a level required for being accepted for examination. The results embodied in this major project, to the best of my knowledge, haven't been submitted to any other university or institution for award of any degree or diploma.

Prof. V.R. Shah
Guide,
Assistant Professor,
Department of Civil Engineering,
School of Architecture,
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Date: 26th April 2006

Pragnesh G. Pandya
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ABSTRACT

The present major project work deals with the utility value of Artificial Neural Network for the Reinforced Concrete Chimney. In the field of engineering, the present day scenario due to paucity of time needs one to arrive at solution with minimal input. To reach the desired solution with accuracy using conventional technique, some validation is needed by an expert or an experienced person. In such circumstances some artificial intelligence tool can accomplish this task in absence of an expert or an experienced being. A chimney as a structure is a tall slender stack like structure, behaves as a free cantilevered structure. It is not the complete solution for pollution control but it is to be provided for the purpose to reduce the concentration of flue particles that are harmful to mankind. The analysis of R.C.Chimney is very time-consuming process as far as dynamic and modal analysis is concerned. It requires a clumsy computation, as it requires to follow the standard guidelines. Herein, the value of A.N.N. has been utilized for the analysis purpose.

In present work, as far as analytical solution is concerned, the separate spreadsheets have been developed after having studied the proper and related literature from various sources. In spreadsheet calculation, the calculation of dynamic properties likes Mass at various sections, Moment of Inertia about an axis, Area of cross section, Eigen Value, Eigen Vector, Time Period etc… have been calculated as per the vital requirement of A.N.N. like as input vector and target vector. Based on that, as per codal provisions in IS 4998-1992(PART 1), due to vortex shedding, due to drag and gust factor force, the calculation of wind force has been carried out for along wind load as well as for across wind load of simplified approach as well as for Random Response approach. Aforesaid cases gives the amplitude which is tip deflection of chimney, Critical Wind Speed, Sectional Shear Forces and Sectional Bending Moments for Simplified as well as for Random Response approaches related to the aforesaid cases of Wind Load. As per IS 1893-1984 criteria for earthquake analysis, the modal analysis has been carried out with reference to concern literature and the modified acceleration have been found out. It depends upon damping factor, soil condition, modal values, time period, importance factor, and zone factor. Using the value of modified acceleration, reliably the sectional shear forces and bending moments have been calculated up to desired no. of modes. Finally, the Design shear force and Design Bending Moments have been carried out using the method of combination the modes is SRSS (Square Roots of Summation of Squares).

As far as utility value of Artificial Neural Network for the analysis of R.C.Chimney is concerned, reliable and sufficient amount of data needs to be provided for the training purpose. As A.N.N. operates like human brain, where learning takes place with real life experiences becoming input data, more the experiences better is learning and better response to the similar situation. Herein, for the study purpose, total no. of data for training as well as for testing purpose is 44 cases, with different configuration of Reinforced Concrete Chimney such as height of chimney, top diameter, bottom diameter, top thickness, bottom thickness, basic wind speed as per its location (V_b), earthquake zone etc… have been gathered from the actual practice. Out of 44 cases, for the training purpose, 30 cases have been chosen. And after stack the proper training, the remaining data have been tested and its robustness, sensitivity could be measured with analytical solution. There are no. of Neural Network model used for real complex structure but out of that, herein, the Feed Forward Back Propagation Neural Network Model has been fully utilized for the analysis of reinforced concrete chimney. The present study could show the value of A.N.N. in to relevant chapter in form of graphical representation.

The outline of relevant Chapters is given in to the specific chapter called as synopsis.

SYNOPSIS

Topic: **ANALYSIS OF REINFORCED CONCRETE CHIMNEY USING ARTIFICIAL NEURAL NETWORK.**

In the present study, the whole documentation with chapter wise herewith covered to understand the work very easily in brief.

Chapter 1

Chapter gives the outline of the selection of the topic and the scope of work.

Chapter 2

Chapter focuses on the view of history of R.C.Chimney and its functional as well as its structural aspect.

Chapter 3

Chapter gives a detail review of literature from various sources have been sort listed in a proper manner like from Books, from Journals etc….

Chapter 4

Chapter gives the overall idea about Artificial Neural Network, its mechanism, functionality etc… in connection with Feed Forward Back Propagation N.N. Model that is adopted for the concern topic to the study purpose.

Chapter 5

Chapter describes in brief about the procedure adopted for the Wind Analysis as well as for Earthquake Analysis as per IS 4998-1992, IS 1893-1984 is to be discussed and validity of the results with some effective parameters is to be shown.

Chapter 6

This Chapter is the heart of major project work. Particularly, It deals with main concept of the concern topic and it gives the real strength of A.N.N.

model, which would be adopted for the analysis of R.C.Chimney. It also describes in detail with formulation of charts about the results obtained by A.N.N. and obtained by Analytically.

Chapter 7

Chapter gives the Summary of Work, Conclusion, and Future scope of work in the context of Artificial Neural Network.

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It gives the detail of typical Flow Chart Diagram of Design Program of Reinforced Concrete Chimney using TURBO C- Language. And at the end of Flow Chart Diagram, the input file and its desire output of a Program is to be elucidated.

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ABBREVIATION AND NOTATION

Abbreviation:

A.N.N.	Artificial Neural Network
FFBPN	Feed Forward Back Propagation Neural Network
R.C.	Reinforced Concrete
NNs	Neural Networks
N.A.	Neutral Axis
IS	Indian Standard
BIS	Bureau of Indian Standard
ACI	American Concrete Institute
ICJ	Indian Concrete Journal
SRSS	Square Roots of Summation of Squares
RMS	Root mean square
HMW	Hourly Mean Wind

Notation:

The Following Notation is used unless stated otherwise in the text.

W_{ij}	Strength of Connection Height between i^{th} neuron of input or Hidden layer to the j^{th} neuron in the adjacent forward layer and referred as weight matrix
h_i	Output of Summation function
X_j	Input Layer
h_j	Hidden Layer
o_j	Output Layer
H_i	Activation function
Y_j	Target output
δ_{2j}	Error of the units in the output layer
δ_{-1j}	Error of the units in the hidden layer
ΔW_{2ij}	Adjust weights between hidden layer and output layer
η	Learning Rate
ΔW_{1ij}	Adjust weights between input layer and hidden layer
F_z	Along Wind load or Drag Force at any level of z

$þ_z$	Design Wind pressure (N/m^2) obtained in accordance with IS 875 (Part 3): 1987
z	Height of any section of the chimney in m measured from the top of foundation
C_D	Drag Co-efficient of the chimney to be taken as 0.8
d_z	Diameter of chimney at height z in m
V_{cri}	Critical Wind Speed for ith mode of vibration in m/sec
f1	Natural Frequency of the chimney in the ith mode of vibration in Hz
d_{eff}	Effective Diameter taken as average diameter over the top 1/3 height of chimney in m
S_n	Strouhal number to be taken as 0.2
η_{oi}	Peak Tip deflection due to vortex shedding in the ith mode of vibration in m
$\cap$	Equivalent Aspect Ratio= H/d_{eff}
Φ_{zi}	Mode Shape Function normalized with respect to the dynamic amplitude at top of the chimney in the ith mode of vibration
C_L	Peak Oscillatory lift co-efficient to be taken as 0.16
$\overline{C}_L$	RMS oscillatory lift co-efficient to be taken as 0.12
α	Power Law Exponent
β	Structural damping as a fraction of critical damping to be taken as 0.016 (This is for Wind analysis)
δ_s	Logarithmic decrement of structural damping= $2\Pi\beta$
σ	Density of air to be taken as 1.2 kg/m^3
$\overline{V}_{10}$	Hourly mean wind speed in m/sec at 10 m above ground level $= V_b.\ \overline{K}_2$ Where V_b , Regional Basic Wind Speed $\overline{K}_2$ multiplying factor, see IS 875: 1987 (Part 3)
Π	Mathematical Constant to be taken as 3.14718
K_{si}	Mass damping parameter for the ith mode of vibration
L	Correlation length in diameters to be taken as 1.0 in the absence of adequate field data
m_e	Equivalent mass per unit length in the first mode of vibration in kg/m

m_{ei}	Equivalent mass per unit length in the i^{th} mode of vibration in kg/m
m_z	Mass per unit length of the chimney at section z in kg/m
$\bar{p}_z$	Design pressure at height z, due to hourly mean wind, obtained as 0.6 V^2_z in N/m^2
E	A measure of the available energy in the wind at the natural frequency of chimney
e	Distance between central line of the shell and the center of gravity of the local load in m
G	Gust factor
g_f	Peak factor defined as the ratio of the expected peak value to the RMS value of the fluctuating load
k_a	Aerodynamic damping co-efficient to be taken as 0.5
B	Background factor indicating the slowly varying component of wind load fluctuation
H	Height of chimney in m
r	Twice the turbulence intensity
S	Size reduction factor
t_s	Thickness of shell at the section under consideration in m
F_{zm}	The wind load in N/m height due to HMW at height z
F_{zf}	The wind load in N/m height due to fluctuating component of wind at height z
I	Importance factor usually taken as 1.5
g	acceleration due to gravity to be taken as 9.81 m /sec^2
S_a	Average acceleration as per IS 1893-1984
F_0	Seismic zone factor as per IS 1893-1984
β	A coefficient whose value depends upon the soil foundation system=1.0 (This is for Earthquake analysis)
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1. SELECTION OF THE TOPIC AND SCOPE OF WORK

1.1 SELECTION OF THE TOPIC:

Analysis of R.C.Chimney is really a time-consuming and a long procedural methodology, which involves difficult computations and solutions of number of formulas. Number of parameters are required be evaluated and then the configuration of chimney is finalized. It has been felt necessary to provide an easy way to consider a fair picture of solution of this problem without going into much complicated procedures.

In engineering problems, iterative process, assumption, analysis, design, validation of assumption and modification and so on - is the conventional approach. The first stage of assumption includes decision regarding preliminary dimensions and design parameters. It also includes consideration of some feasible alternatives. In the stage of analysis not all but only few are dealt with since analysis is a strenuous process. Therefore some selection mechanism is needed. Thereafter the best of selected configurations is worked out in detail.

In this context, two major points draw a special attention, though they are unnoticed.

1) Generally, in the initial stage, preliminary dimensions and design parameters are decided on the basis of the past experience or of some references of the solution of some problem of the same nature or sometimes even randomly. If the preliminary dimensions and design parameters are well chosen, the analysis and design requires less efforts, requires no revision and can be made economical. Therefore a guiding mechanism for selection of initial data is very much essential.
2) After analysis and design, some validation mechanism or at least some index that could lead to a reasonably fair picture of solution is necessary.

There are a no. of techniques for both of the aforesaid stages, but are different for different types of problems are not general purpose and many of them are based on intuitive approach. Many techniques based on direct approach for working in exploratory stage are available, out of which Artificial Neural Network is one which has not been applied that widely in the actual practice even though it is very much suitable, efficient, robust and general purpose. Perhaps because of efforts required for development of simulator, people do not prefer it. But once the simulator is developed, it can be applied to any problem. Advances in computer hardware and philosophy of computer science have made it possible to apply such difficult looking tool very easily.

The Artificial Neural Network provides a direct technique to learn from the past experiences and apply this knowledge in the future problems. It leads to estimated results without going in to much detail. To get estimated results directly, with little efforts and that, too, in no time feels awesome but that is the very function of Artificial Neural Network. But, it takes some time in learning and the reliability of its results depends on extent to which it has learnt. At the same time it provides an index of comparison of results of analysis. Thus, both of the points, above discussed, are dealt with satisfactorily in a single tool – Artificial Neural Network.

Predominantly out of no. of technique of expert system in the field of Artificial Intelligence, here Artificial Neural Network has been applied and to square its strength after the whole study done. Therefore here it was thought to study it.

1.2 SCOPE OF WORK:

Analysis of R.C.Chimney involves clumsy calculations particularly because of its being prone to large oscillations under lateral loads. Lateral loads usually dominate the design. Therefore it is always important to know various parameters like shear forces and bending moments at various points and other parameters like frequencies under modes of vibrations. All these computations fall in the very scope of dynamic analysis which itself is a complex procedure. If Artificial Neural Network can be developed for such complex calculations, it can be useful not only for preliminary design but for cross checking also. Keeping in view the matter, following points may be considered to be in the scope of work.

- Defining the Analysis procedure
- Clustering actual case studies
- Preparing Analysis of required number of chimneys with all required computations
- Selection of ready made software for Artificial Neural Network
- Designing Architecture of Artificial Neural Network and required parameters
- Training of Artificial Neural Network with selected data
- Testing of Artificial Neural Network for data collected aforesaid
- Analyzing results and deriving conclusion thereupon
- Documentation of the whole study and suggesting the further scope of study as well.

In short, in the present study, Artificial Neural Network as a selection mechanism that can be useful in exploratory stage and an index of relationship has been studied.

2. AN INTRODUCTION- A REINFORCED CONCRETE CHIMNEY

2.1 ANCIENT CIRCUMSTANCES:

Man has always been in search of an effective system to dispose off undesirable gaseous products of combustion. The concept of stack has come through the small vent in a house a very earliest form to exhaust the smoke after combustion of fuel.

Meanwhile the development of power plants for the production of electricity at thermal station as well as at industrial plants, the brick as well as the steel chimneys have been built. Afterwards, as the volume of gases is increased, the Reinforced Concrete Chimneys have been built in to early 1900s.Brick Chimneys replaced with steel and steel chimneys replaced with Reinforced Concrete Chimneys. First Concrete chimney has been built in Germany in 1876 with a uniform section. Meanwhile the tapered chimneys have been constructed in Japan and UK countries in the middle of 1900s.

A Reinforced Concrete Chimney is a powerful ingredient of thermal power station. It is to be used with the purpose of to exhaust the undesirable gases at a higher elevation. Reinforced Concrete Chimney is a tall slender structure as well. Generally, in plan, it is in circular but it may vary with plan. Mostly, it is well defined in tapered section, varies along the height of the chimney. It is to be provided only for discharging the undesirable gaseous form at a higher elevation and it is called as stack like industrial structure.

2.2 SELECTION CRITERIA:

For the selection of chimneys, following features of chimneys of different construction materials are considered.

1) Generally, steel chimneys are preferred for process work, where heat up period is short and where thermal capacity required is low, while it is not

suitable where there are chances of acid condensation and corrosion, which results in smutting and reduction in the life of chimneys.

2) Guyed steel chimneys are best suited where the supporting capacity of the soil is low while it is not suitable where it is difficult to find suitable anchor points of guys at ground, Guyed steel chimneys involved regular maintenance of guy wires, anchor points and other fittings.
3) Reinforced Concrete chimneys are to preferred mostly where the height to diameter ration has become critical as well as volume of gases are very high across the section of the chimneys. In short, where the height of chimney is above 45 m then the reinforced concrete chimneys proves to be economical

And other parameters are also affect the selection criteria of chimneys like the atmospheric condition, ambient temperature, soil bearing capacity, volume of gases, type of construction, purpose of project, type of fuel, etc….

2.3 FUNCTIONAL ASPECT:

A Chimney is a means by which waste gases are discharged at a high enough elevation so that after dilution due to atmospheric turbulence, their concentration and that of their entrained solid particulates is within acceptable limits on reaching the ground. A chimney achieves simultaneous reduction in concentration of number of pollutants like SO_2, fly ash, etc. and being highly reliable it does not require stand by.
Merely, here it is noticed that the Chimney is not the complete solution to the problem of pollution control.

2.4 STRUCTURAL ASPECT:

A Chimney is a tall slender structure and it behaves as a free-cantilevered structure. In general, as the chimney is very tall as dynamic wind eddies would be governing except the high seismic zone. By considering the static as well as dynamic effect of wind, chimney requires dynamic properties as well as inherent properties from its elements. When one needs to analyze the R.C.Chimney that is a stack like structure. For this some guidelines are available in Bureau of Indian Standard, IS 4998-1992 (Part 1) Design Criteria for R.C.Chimney for assessments of loads like Wind, earthquake, temperature etc…. And for squaring the stresses at various sections along the part of chimney BIS has been published IS 4998-1975 (Part 1).

When the wind flows over as well as across the chimneys and with a very high amount of peak ground acceleration due to high intensity of earthquake, at that time the cross-section properties of chimneys are very important to resist those forces. But the finalization of cross-section properties like diameter, thickness, height, size of opening, etc… require quite a long time as cumbersome analysis procedure as per IS 4998-1992 (Part 1). Is to be carried out.

From the standard mechanism, assessment of loads like self-weight, temperature, wind, earthquake, live load at particular level would likely to be assess from the inventor. And finally to predict the real behavior of chimney under lateral load effect. When two or more cluster of chimneys is available at location, at that time, due to its tallness the vortex excitation, down draught and down wash should also be consider in to the structural aspect.

Actual study of Reinforced Concrete Chimney using the aforesaid aspects would be clearer in to the relevant chapter. Thus, the analysis of R.C.Chimney deprived of A.N.N., the inventor should know the basic aspect like ancient features, functional, structural aspects as well as to measure the painstaking efforts requires to predict the performance of the structure.

3. LITERATURE REVIEW

3.1 REVIEW FROM BOOKS:

[1] **Title:** Tall Chimneys- Design and Construction [1]

Author: S N. Manohar, Mc-Graw Hill publication, 1985

Abstract:

In this literature, the author has mainly pointed out with relation of Reinforced Concrete Chimneys. The topics that are to be discussed comprehensively ar Chimney Sizing, Dynamic analysis of chimney, Modal analysis, Design of chimney etc…. Literature explains the fundamentals aspect in detail like as structural, environmental and construction of tall R.C.Chimney. Author had done the work very spontaneous with consideration of static as well as dynamic effect due to wind. And due to earthquake, author adopted the response spectrum as well as modal analysis too. Also author had done the formulation of equation and given the pictorial graphs that would be helped in the actual practice of design of reinforced concrete chimney.

In this particular literature, the author had given the suitable piece of examples with consideration of all aspects along with concern topic too.

[2] **Title:** Reinforced Concrete Chimneys and Towers [2]

Author: G M. Pinfold, View point publication, 1975

Abstract:

In this literature study, the author had tried out in detail to study the philosophy of Reinforced Concrete Chimney. The typical example of R.C.Chimney with consideration of dynamic effect, temperature effect, and considered the effect of sway or deflection due to steady pressure too. Author had found of the empirical solution of analysis of annular section subjected to compression and bending. Also he had suggested two approaches of design like one is the elastic and second one is the limit state design. Model testing is also included like wind tunnel testing. In respective appendices, author had given the calculation of mode shapes, frequencies by stiffness matrix method. Finally, the construction and advanced technology in pre cast technology and suggested the appropriate material for the construction for safety intention. Some decent pictorial had been also included.

[3] **Title:** Reinforced Concrete Chimneys [3]
Author: C P. Taylor and L Turner, Concrete publications Ltd., 1960

Abstract:

The analysis of Reinforced Concrete Chimney is done through out the literature with the use of ACI code standard. In general, the all dimension of integer value would be in FPS unit system. The author had investigated the actual temperature in to the chimneys and reaches at a level where the results can be proven that it is used frequently in to the design practice straightforwardly. Author had shown the graphs for the design process which quite cumbersome and lot of assumption are put up in to derivation.

Author had published his second edition also. In the second edition, author had invented the new method for analyzing the annular raft sections. Author had done the work on squared the stresses at various sections due to self-weight as well as with wind, both of are considered in the design process.

Literature Review

[4] **Title:** Structure Dynamics [4]

Author: Mario Paz, CBS publication, 1980

Abstract:

Particularly, herein this publication had been studied only for the derivation of the dynamic properties like mode shape value and frequency in form of Eigen vector and Eigen value. As the chimney is a free-cantilevered structure by consider as a single degree of freedom system. In this book, author had given the number of mathematical solution for finding the Eigen value and Eigen vector for single degree freedom system as well for the multi degree freedom systems.

[5] **Title:** Programming with C++ and Neural Network[5]

Author: Dr. A.S.Pandya, Jan-1997

Abstract:

In this literature, author had given the basic fundamentals of Neural Networks, which is through C++ programming language. Especially, how to create a node, random weights, target vector etc… with the help of C++ has been studied. Author had tried out in given the detail such as Feed forward back propagation model, input layer, hidden layer, output layer, understanding of biological neural network and artificial neural network with the help of C++ coding. In this literature, the complete algorithm of FFBPN is given and how to convert in to coding form is also given in brief.

Literature Review

3.2 REVIEW FROM PERIODICALS:

[1] **Title:** Design of Circular R.C.Chimney section subjected to axial load and bending moment [6]

Author: Prem Chand, The Indian Concrete Journal, July 1994

Abstract:

In the process of designing the Reinforced Concrete Chimneys, one of the most important requirements is to find the position of neutral axis. From the position of neutral axis, the inventor should give his comment on typical structure like how much amount of sectional area lies on tension side and compression side? However, the position of the neutral axis depends upon many factors such as – Modular ratio, eccentricity ratio, Percentage of reinforcement in vertical direction and type of section like with opening or the without opening. Author had assumed the chimney shell is thin as compared to its diameter so that there is no such variation in stresses across thickness. Finding of the neutral axis is the process of trial and error based. So that, to eliminate such tedious work the author has derived the expression in terms of graphical form by charts of typical four cases. Author had prepared the seven design charts that would be very helpful to the designer in actual practice. At last, Author had given the suitable example with the use of charts. The design would be based on working stress principle.

[2] **Title:** Wind- induced loads on Reinforced Concrete Chimneys [7]

Author: B J.Vickery, National seminar on tall chimneys, April 1985, New Delhi

Abstract:

Author had considered the effect of wind on Reinforced Concrete Chimneys. Due to wind effect, chimneys are predominantly behaves under the effect of along wind load as well as across wind load. Author had considered both the sides of wind induced and suggested that some valuable and useful formulas by model testing of R.C.Chimney. Author had taken some basic ideas from ACI code, in this paper, author had described the simplified approaches for both the sides of wind and those approaches developed for ACI committee and for CICIND to estimate both along as well as across wind loads.

Author had taken the five-no. of chimneys for measure the strength of those formula and check with the draft code format of ACI code with CICIND. The paper has been reviewed that the simplified approaches that have been employed in the preparation of a new draft code ACI 307 (Reinforced Concrete Chimneys) This paper is reached up to a level of evaluated the wind loads only not considered the effect of Random Response and also not to squared with stresses. In along wind load criteria, author had developed the formula for calculating gust factor and in the across wind load criteria, author had done the experimental study. In this paper, from the review itself, the author is very silence with the proximity effect of closely spaced chimneys.

[3] **Title:** Model Study of 275 m Tall Chimney[8]

Author: N. Nagaraja, Tata Consulting Engineers, Bangalore, 1990, Wind load on structures handbook

Abstract:

A modeled 275 m tall chimney had taken for an experimental study. And this model would be reflected in the real sense after its complete study. Author had taken the aero elastic model of chimney. It was made for a length scale of 1/150 and velocity ratio of 1.22. The scale were so chosen that the Reynolds number for the along wind is greater than 200,000 and that of crosswind greater than 80,000. The main objective of the studies was to study or to determine experimentally the winds induced moments and shears and compare them with analytical values. The models were welded steel sheet of variable thickness, and mechanism was such that the mass is gradually distributed along its height.

Literature Review

Author had taken the three models for actual study for different stages of construction.

After done the study, author had found that the No significant interference on the earlier same height with different stage were observed. So that the experimental study gave a clear spectrum of the interference effects thereby dispelling all apprehensions of possible amplifications of wind induced forces due to close proximity of the structures. The analytical analysis was validated by the experimental results.

[4] **Title:** A note on codal gust factor provisions for Concrete Chimneys[9]

Author: Ushnish basu and V K. Gupta, The Indian Conc. Journal

Abstract:

As specified in the recommendation that the analysis procedure for R.C.Chimney as per criteria of reinforced concrete chimneys-IS 4998 (PART 1)-1992. A gust factor method is very popular when the wind forces are to be estimated along wind response as well. As per code provision, Random response method includes the gust factor to picked up the exact fluctuating moment at typical section of chimney. Author had taken the four different kind of chimney with different height. In that case, modification of F_{zf} factor leads to on a very conservative side, whereas the bending moments at various sections concerned. The wind environment provided for the gust factor as per IS 875(part 3) -1987 and compared with the IS 4998-1992 (Part 1) for the fluctuating moments due to both wind environments like along wind as well as across wind.

Literature Review

[5] **Title:** Seismic/ Wind analysis of a Reinforced Concrete Chimney- A Comparative Study of ACI and IS codes [10]

Author: V S. Phani, R C. Jain and S Ramanujam, SEC-2003

Abstract:

Chimneys are fall in to category of special tall structure so that both forces like wind and the earthquake affects it as well. Those forces are not acting simultaneously at the same time but it has to be required to check with those predominant forces whether the chimney is safe or not against the worst effect of lateral loading. As the time period of a structure is long, the acceleration experienced by it is comparatively smaller where as the displacement are high.

In this paper, author has taken a 100 m tall chimney has been analyzed using different methods like in earthquake analysis is (1) simplified method as given in IS 1893-1984 (2) Modal analysis as per W.S.Rumman and (3) detailed dynamic analysis. In addition, wind analysis is carried out by (1) Simplified approach (2) Random response method as per IS 4998(part 1)-1992.and ACI 307-95.

Finally their results are compared. Results are shown that the design shear forces and bending moments are governed by wind analysis at the base of the stack or chimney. Critical wind velocity producing the resonant vibrations in the transverse direction in the first two modes is within the basic wind speed limits. So that for the first two modes, it is necessary to calculate the forces across wind as per IS 4998 (part 1) -1992.However their effects in the higher modes need not be considered.

Literature Review

3.3 REVIEW FROM IS CODES:

[1] **Title:** IS 4998-1975 (Part 1) Criteria for Design of R.C.Chimney[11]

[2] **Title:** IS 4998-1992 (Part 1) Criteria for Design of R.C.Chimney

Author: Bureau of Indian Standard, New Delhi [12]

Abstract:

Codal Provision would always been helpful guide to all who are the real designer in actual practice. For those people, particularly for R.C.Chimney BIS has provided a standard formulization after done the lot of experimental study on it.

In the aforesaid standard, the complete analysis procedure has given for Reinforced Concrete Chimneys with uniform sections as well as significant tapered sections also. How to find out dynamic properties of the chimneys? And how many nos. of modes to be considered in to the analysis procedure? That is mentioned very specifically in this standard. Herein, it is an exceptional case that aforesaid both the codes are in practice. In 1975 revision, only checking the stresses with worst loading combination is to be given. And in 1992 revision, only the load calculation of a chimney is to be given more specifically than 1975 revision.

The study of literature cannot pause but here out of many literatures the foremost literature is included with purpose of comprehension nothing else.

4. AN ARTIFICIAL NEURAL NETWORK- AN ABRIDGEMENT

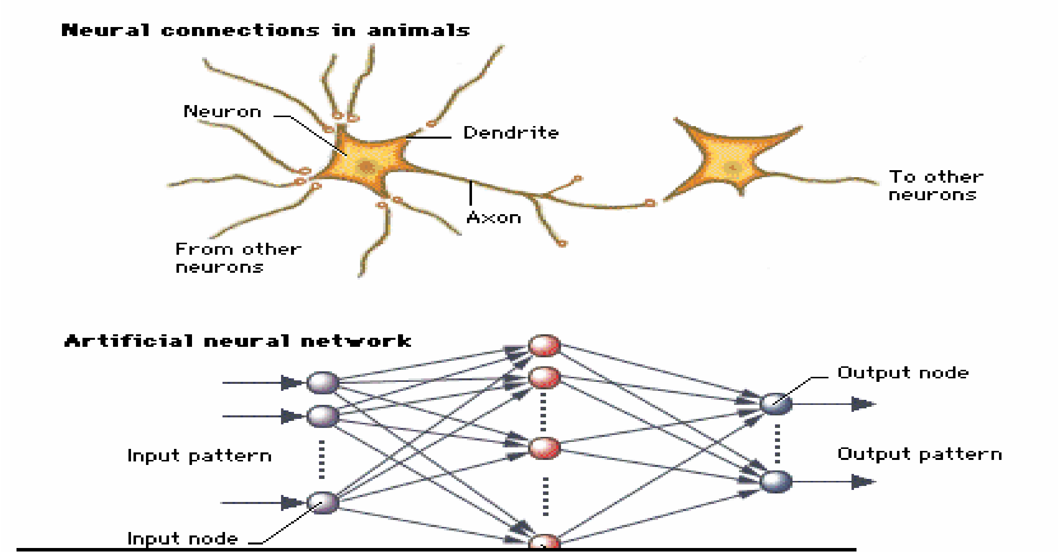
4.1 CONCEPT AND TERMINOLOGY OF A.N.N.:

Artificial Neural Network is an extension of Artificial Intelligence. Where A.I. is a study in which one models the system in such a way that machine or computer are made to learn and do new things based on their learning rather than simply doing the sequential activity. A.N.N is a computational structure inspired by the Biological Neural Network.

Neural Network, in computer science is highly interconnected network of information-processing elements that mimics the connectivity and functioning of the human brain. Neural networks address problems that are often difficult for traditional computers to solve, such as speech and pattern recognition. They also provide some insight into the way the human brain works. One of the most significant strengths of neural networks is their ability to learn from a limited set of examples. It is well proposed in 1943 by McCulloch & Pitls as an alternative computing display. And in 1986, Rumathart proposed a Back Propagation scheme to train multi layer preceptor.

4.1.1 A Biological Neural Network:

4.1.2 An Artificial Neural Network:



Courtesy: www.encarta.com

FIGURE 4.1 A BIOLOGICAL NEURON AND AN ARTIFICIAL PERCEPTRON

The neural networks that are increasingly being used in computing mimic those systems found in the nervous systems of vertebrates. The main characteristic of **a biological neural network**, top, Fig. 4.1 is that each neuron, or nerve cell, receives signals from many other neurons through its branching dendrites. The neuron produces an output signal that depends on the values of all the input signals and passes this output on to many other neurons along a branching fiber called an axon. In **an artificial neural network**, bottom Fig.4.1, input signals, such as signals from a television camera's image, or may be input parameters of chimneys such as top dia., Bottom dia., height, top thickness, bottom thickness etc. fall on a layer of input nodes, or computing units. Each of these nodes is linked to several other "hidden' nodes between the input and output nodes of the network. There may be several layers of hidden nodes, though for simplicity only one is shown here. Each hidden node performs a calculation on the signals reaching it and sends a corresponding output signal to other nodes. The final output is a highly processed version of the input.

4.2 WHY MAPPING AND ARTIFICIAL NEURAL NETWORK?

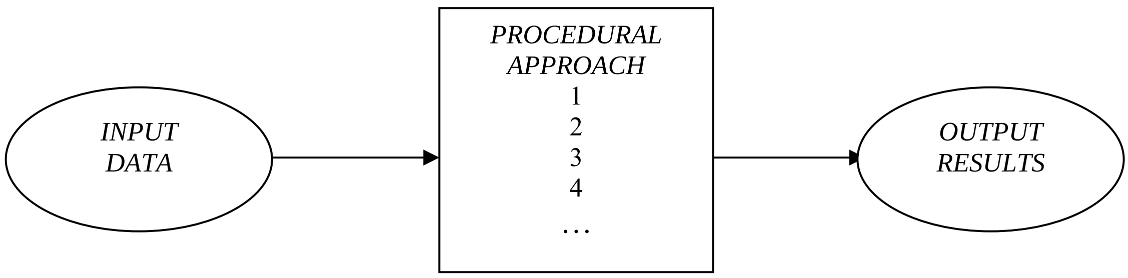


FIGURE 4.2 CONVENTIONAL PROCEDURAL APPROACH

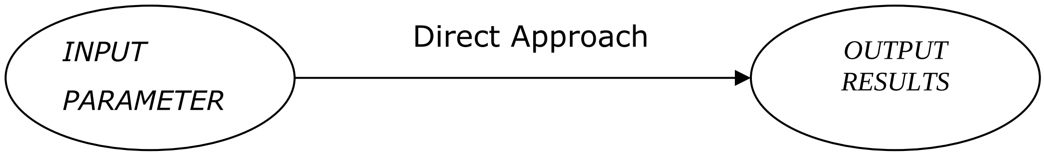


FIGURE 4.3 MAPPING APPROACH

MAPPING CONCEPT:

Any design problem in engineering has to pass through an iterative process, assumption, analysis, design, modification in assumption and so on. Better the assumption less the efforts and more economical the design. Thus, in the stage of logical explanation needs either experience or explorations. Actually this is a stage in which logical explanation is not at all included anywhere and therefore only configuration of the problem is taken for consideration, the validity of which is obviously to be tested subsequently. For the type of exploratory work, procedural approach is not generally resorted.

In some special circumstance, step-by-step procedure is not available or is more important or is available but not advisable to implement because of some constraint like non-availability of time or high cost of efforts are involved. Sometimes, the estimation of the results is more important than accurate results. An aforesaid point gives transparency that procedural approach must be replaced by an approach, which may lead one to close to the actual results of the problem; Mapping is one such technique that exactly does this work.

ARTIFICIAL NEURAL NETWORK -AN ABRIDGEMENT:

Mapping is the technique where the output surface can be obtained from the known input surface. Evidently, in such cases, Human Brain does this excellently. A neuron considers number of relevant parameters as input, process them together and on the basis of that find a value of process, creates an electrical spike in the sense of right or wrong or even some gray value. Many electrical spikes from many neurons are taken as an input by some neuron and are processed by it. This complex chain of activities continues till the final decision is reached. Here, the concept of process inevitably includes weitage to various parameters. This complex process is modeled in many mathematical models to form a set of the concepts behind the complexities of the working of the human brain. In different problems, different modes are used.

Artificial Neural Networks are well known since long back, but advancement in computer hardware in terms of their memory and speed are to be facilitated by their use.

CHARACTERISTICS OF ARTIFICIAL NEURAL NETWORK:

- The Neural Networks exhibit mapping capabilities, that is, they can map input patterns to their associated output patterns.
- The NNs learn by examples. Thus, NNs architectures can be 'trained' with known examples of a problem before they are tested for their 'inference' capability on unknown instances of the problem. They can, therefore, identify new objects previously untrained.
- The NNs possess the capability to generalize. Thus, they can predict new outcomes from past trends
- The NNs are robust system and are fault tolerant. They can, therefore, recall full patterns from incomplete, partial or noisy patterns.
- The NNs can process information in parallel, at high speed, and in a distributed manner.

Human brain generally makes judgment instead of going through analytical procedures. This judgment is based on past experiences it has gone through. The relationship between input and output is always of intuitive nature. Which are the governing parameters and what is relationship amongst the parameters is not known to anybody. This type of subtle process takes place in human brain while arriving at some judgment. Going through more experiences modifies the process of coming to the judgment, which is generally known as learning. And key point is that the establishment of relationship between two domains is generally known as mapping. There is no procedural or logical sequence to derive the output vector from over the input vector; rather, obtaining the output vector directly using some relationship amongst the elements of input and output vectors is the technique resorted too.

Some special characteristics of mapping have goaded many engineers on resorting to it as an alternative methodology. They are-

- Saving of effort
- Absence of divergence owing to error in some part of computational work
- Requirement of minimum data
- Operational ease
- Possibility of further learning
- Generality and versatility

4.3 BASIC CONCEPT OF F.F.BPN MODEL of A.N.N.:

The abbreviation of FFBPN is Feed Forward Back Propagation Model. Out of the various types of Artificial Neural Network models, the features and performance of two well known models i.e. Back Propagation (BPN) and Counter Propagation Model (CPN). Each model has own merits, demerits and also limitations. Herein for the satisfaction of the scope of study, by taking an advantage of Feed Forward Back Propagation model, has been chosen because of no. of reasons which are as follows:

1. One the training is done using Back Propagation output vector is calculated with Feed Forward technique very easily.
2. After training, the same input vector generates identical output vector even if many times the feed forward technique is used. Further training is possible at later stage.
3. In difficult applications where the input/output relationships are nonlinear, and/or involve high order corrections among the input variables; Back Propagation has produced surprisingly accurate results.

See fig. 4.4, Feed Forward Neural Network.

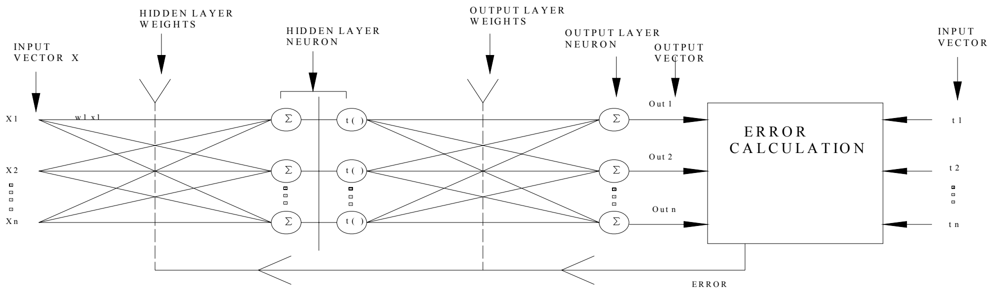


FIGURE 4.4 FEED FORWARD NEURAL NETWROKS

A typical model of multi layer feed forward neural network architecture and an artificial neural network is shown in fig. 4.4 and fig. 4.5.

An Artificial neuron is characterized by a summation function and a transfer function. Summation function combines all inputs for hidden layers nodes after multiplying each input value by corresponding weight. Output of summation function hi is computed as

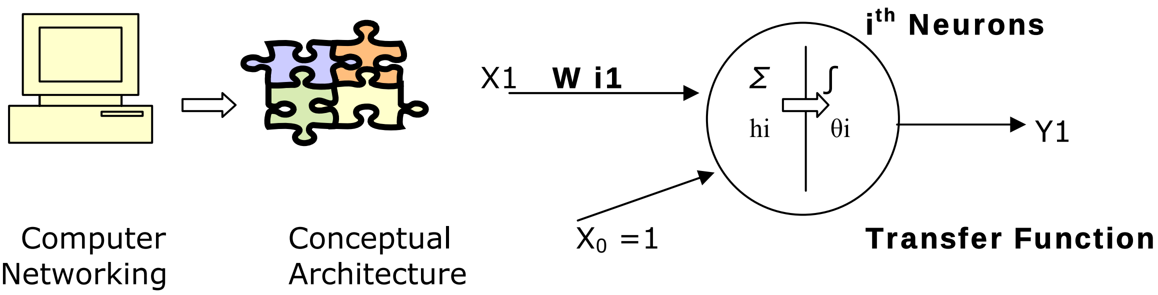


FIGURE 4.5 A TYPICAL ARTIFICIAL NEURON

$$hi = \sum_{i=1}^{n} Wij * Xj \qquad \textbf{4.1}$$

Where,

Wij = Strength of connection height between i^{th} neuron of input or hidden layer to the j^{th} neuron in the adjacent forward layer and referred as weight matrix.

Value zero represent no connection, while value greater than zero increases the potential of neurons and value less than zero reduces the neuron where in x_0 = 1. Output of summation function (hi) is then received by the transfer function as an argument and gives out its output.

4.4 STEPS IN FEED FORWARD BACK PROPAGATION MODEL: AN ALGORITHM

Given: A set of input- output vector pairs.

Compute: A set of weights for three-layer network that maps inputs on to corresponding outputs.

1. Let A is the number of units in the input layer, as determined by the length of the training input vectors. Let C is the number of units in the output layers. Now choose, B the number of units in the hidden layers. As shown in fig 4.6. The input and hidden layers each have an extra unit used for thresholding; the ranges (0 will sometimes index the units in these layers… A) And (0, ….B). We denote the activation levels will of the units in the input layer by X_j, in the hidden layer by $h_{j,}$ and in the output layer by O_j. Weights connecting the input layer to the hidden layer are denoted by W 1_{ij}, where the subscript i indexes the input units and j indexes the hidden units. Likewise, weights connecting the hidden layer to the output layer are denoted by W 2_{ij}, with I indexes to hidden units and j indexes output units.

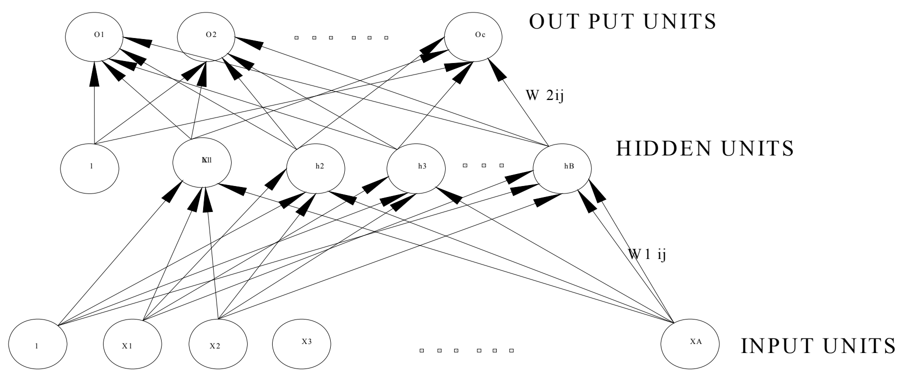


FIGURE 4.6 A MULTILAYER NETWORK

2. Initialize the weights in the network. Each weight should be set randomly to a number between –0.1 to +0.1

   $W\,1_{ij}$ = Random (-0.1, +0.1) for all i= 0 ……. A, j= 1 ….B
   $W\,2_{ij}$ = Random (-0.1, +0.1) for all i= 0 ……. B, j= 1 ….C

3. Initialize the activation of thresholding units. The values of these thresholding units should never change.

   $X_0=1.0$, $h_0=1.0$

4. Choose an input –output pair. Suppose the input vector is Xi and the target output vector is Yi. Assign activation levels to the input units.
5. Propagate the activation from the units in the input layer to the units in the hidden layer using the activation function of

$$Hj = \frac{1}{1+ e^{-\Sigma w2_{ij} h_i}} \quad \text{for all } j= 1\ldots B \qquad \textbf{4.2}$$

Note that i ranges from 0 to A. W_{1oj} is the thresholding weight for hidden unit j (it propensity to the irrespective of its inputs.) Xo is always 1.0

6. Propagate the activation from the units in the hidden layer to the units in the output layer.

$$Oj = \frac{1}{1+ e^{-\Sigma w2_{ij} h_i}} \quad \text{for all } j= 1,\ldots, C \qquad \textbf{4.3}$$

Again, the thresholding weight W 2 oj for out put unit j plays a role in the weighted summation, ho is always 1.0

7. Compute the errors of the units in the output layer, denoted δ 2j. Errors are based on the network's actual output (oj) and the target output (yj)

$$\delta\ 2j = Oj\ (1- Oj)\ (Yj- Oj) \text{ for all } j = 1\ldots.C \qquad \textbf{4.4}$$

8. Compute the errors of the units the hidden layer denoted –1 j.

$$\delta\ \text{-}1j = h_j\ (1- h)_j\ \Sigma\ \delta\ 2_j\ w2_{ij\ for} \text{ all } j = 1\ldots B \qquad \textbf{4.5}$$

9. Adjust the weights between the hidden layer and output layer. The learning rate is denoted η; its function is the same is in Perceptron learning. A reasonable value of η is in between 0 to 1.

$$\Delta\ w\ 2_{ij} = \eta\ \delta\ 2_j\ h_i \quad \text{for all } i = 0, \ldots.B,\ j= 1, \ldots\ldots C \qquad \textbf{4.6}$$

10. Adjust the weights between the input layer and the hidden layer.

$$\Delta\ w\ 1_{ij} = \eta\ \delta\ \text{-}1_j\ x_i \quad \text{for all } i = 0, \ldots.A,\ j= 1, \ldots\ldots B \qquad \textbf{4.7}$$

11. Go to step 4 and repeat. When all the input –output pairs have been presented toe the network, one epoch has been completed. Repeat steps 4 to 10 as many epochs as desired.

Following important considerations are to be observed while using feed forward backpropagation, neural network approach.

- For a given problem and architecture, the error surface in the multi-dimensional space of weights may be hilly and may have many local minima. The objective is to reach global minimum.

- If the global minimum is shallow, convergence may be slow.

- Final state is very sensitive to initial random weights.

- If the weights are large, the output of neurons may have high or low limiting value, where the slope is zero and hence no weight changes are possible. So it is advisable to use small initial weights.

- Learning rate should not be too large, otherwise solution may jump from one minima to other.

- Convergence rate often depends on learning rate, momentum term, initial weights and even transfer function.

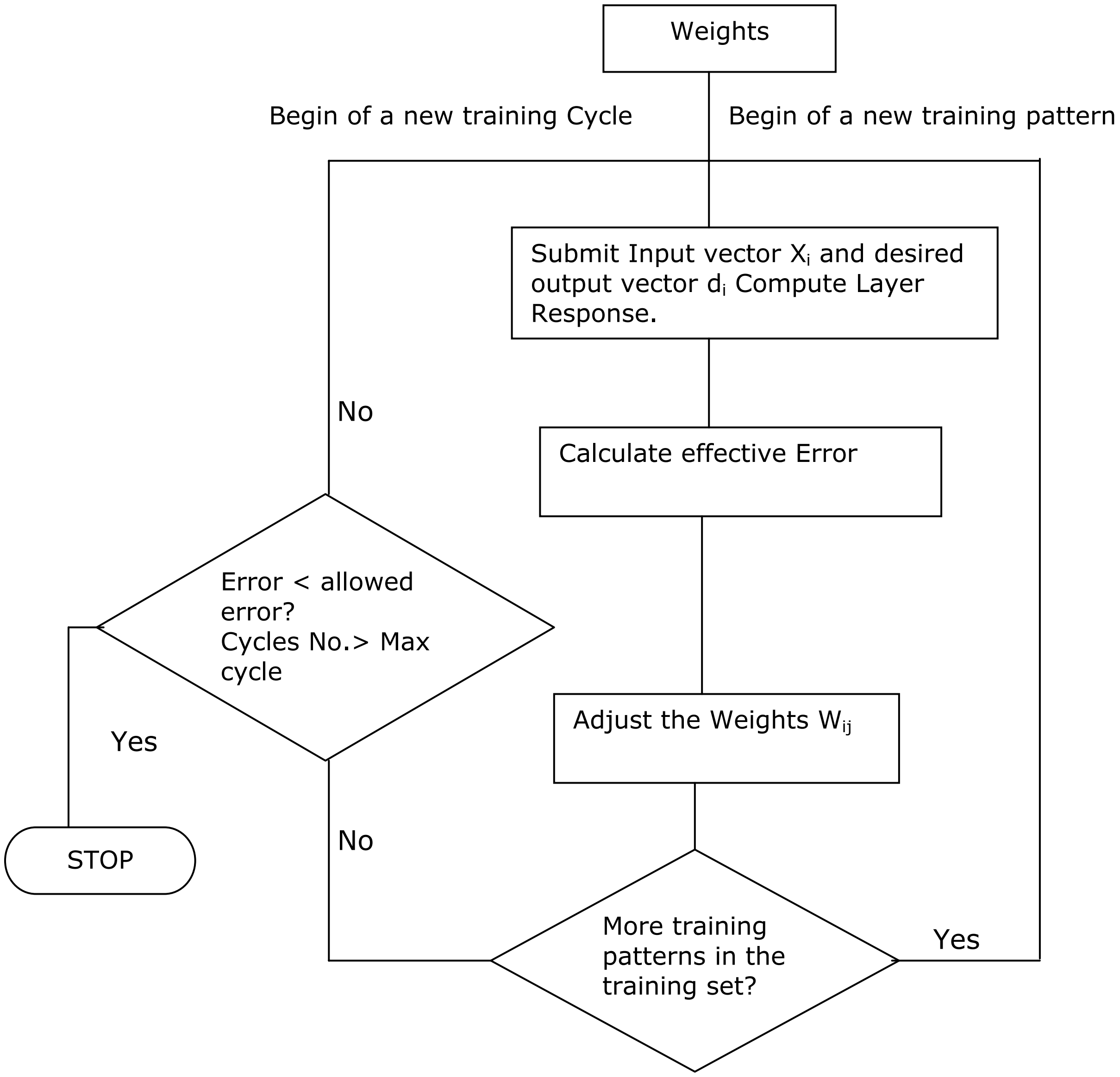
- There are two schemes of modifying weights:
    - Incremental update: Present one pattern; modify the weights before presenting other pattern.
    - Batch update: Present all patterns and then modify the weights.

- Often the patterns are presented in random fashion.

- The input and target vectors may need some transformation so that variation within them is smooth. Sharply failing or rising curve can not be learned properly by the A.N.N.

- Training set should be comprehensive and should represent fully the dynamics to be learned.

- From the given input-output pairs, 80% is used as training set, 20% is for last set to assess the capability of Generalization.



FIFURE 4.7 BASIC FLOW CHART DIAGRAM OF F.F.BPN MODEL

- It is necessary to ensure that the network is not over fitted. Number of weight parameters to be determined should be substantially smaller than the number of data points available.

- It has been shown that 3-Layer network or 4-Layer network can represent any complex function. In other words, network with one or two layers can also give good convergence.

- Number of neurons in the hidden layer is judiciously to be chosen so that network may not loose the ability of generalization.

Basic Flow Chart of back propagation algorithm is shown in Fig.4.6. Training is stopped at either error reduction below specified limit or at user specified number of cycles (Whichever is occur first) in BPNNs. The Algorithm is already explained in aforesaid section.

5. VALIDATION METHODOLOGY:

In the Analysis of Reinforced Concrete Chimney, some validation methodology would be adopted and then the preliminary configuration of chimney would be finalized. So that, as per IS 4998-1992 (Part – 1) Load Assessment for Reinforced Concrete Chimney has been stipulated and herein discussed with an abridgement.

5.1 WIND ANALYSIS (SIMPLIFIED APPROACH):

Following steps are adopted for the Wind Analysis with the effect of static as well as dynamic. Both the effect would be understood with two approaches like one are the simplified and another one is Random Response as per IS 4998-1992 (Part 1).

Divide the chimney in 20 equal sections along its height and derived the properties like outside diameter, thickness, Mass (kg/m). Also calculate the area of the cross section and Moment of inertia of each section, which is useful for finding out the frequency and mode shape.
Calculate the wind pressure as per specified wind speed, terrain category, and class of structure.
Depending upon codal provision, Drag co-efficient must be taken as 0.8 only.
Calculate the wind shear force along the height of chimney would be like this:

Reference: IS 4998-1992 (Part 1) clause no. 4.3.2 and 4.4

5.1.1 ALONG WIND LOAD OR DRAG FORCE

The along wind load or drag force per unit length of the chimney at any level shall be calculated from the equation 5.1

$$F_z = p_z * C_D * d_z \qquad \textbf{5.1}$$

Where,

p_z = Design wind Pressure obtained in accordance with IS 875 (PART 3): 1987

z = Height of any section of the chimney in m measured from the top of the foundation

C_D = drag co-efficient of the chimney to be taken as 0.8

d_z = diameter of chimney at height z in m

The moments are calculated from the sectional forces treating the chimney as a freestanding structure.

5.1.2 ACROSS WIND LOADS:

Whether the across wind analysis are prerequisite or not, it is to be verified with the help of critical wind speed criteria as per code provision

5.1.2.1 FREQUENCY, MODE SHAPE, CRITICAL WIND SPEED:

Calculation of critical wind speed (V_{cri})

$$V_{cri} = f_1 \, d_{eff} / S_n \qquad \textbf{5.2}$$

Where,

d_{eff} = effective diameter at top $1/3^{rd}$ height of chimney in m

S_n = strouhal number is to be taken as 0.2

f_1 = natural frequency of i^{th} mode in Hz

The critical wind speeds for exciting the fundamental and higher modes of vibration of the chimney shall be calculated by substituting the relevant frequencies in the Eq 5.2. All the modes, which can be excited up to wind speeds 10 percent above the maximum expected at the height of the effective diameter, shall be considered for subsequent analysis. If the critical wind speed calculated for any mode of oscillation exceeds the limits specified earlier, it is permissible to assume that problem of vortex excited resonance will not be a design criterion for that and the higher modes. In such cases across wind analysis are not presumed. The amplitude of vortex excited oscillation perpendicular to direction of wind for any mode of oscillation shall be calculated by the equation 5.3

5.1.2.1 AMPLITUDE OR TRANSEVERSE OSCILLATION:

$$\eta_{oi} = \left\{ \frac{\int_0^H d_z \phi_{zi} d_z}{\int_0^H \phi^2{}_{zi} d_z} \right\} \frac{C_L}{4 * \Pi * S^2{}_n * K_{si}} \qquad \textbf{5.3}$$

Where,

η_{oi}	=	peak tip deflection due to vortex shedding in the i^{th} mode of vibration in m
C_L	=	peak oscillatory lift coefficient to be taken as 0.16
H	=	height of chimney in m
K_{si}	=	mass damping parameter for the i^{th} mode of vibration
Φ_{zi}	=	mode shape function normalized with respect to the dynamic Amplitude at top of the chimney in the i^{th} mode of vibration.

The recommended value of the peak oscillatory lift co-efficient accounts for the Reynolds number, partial correlation of vortex shedding over the height of the chimney, effect of amplitude of oscillation and typical value of surface roughness. Calculations based on this value are acceptable for oscillatory amplitudes of up to 4 percent of the effective diameter. If oscillation η_{oi} exceeds 4 percent of the effective diameter, the amplitude of oscillation shall be increased as follows:

Amplitude of oscillation η_{oi} (for computed value of $\eta_{oi} > 0.04$ d) = (Computed value of $\eta_{oi})^3 / (0.4\ d)^2$.

Calculation of mass damping parameter is given as below:

$$K_{si} = \frac{2\ m_{ei}\ \delta_s}{\sigma * d^2} \qquad \textbf{5.4}$$

Where,

m_{ei} = equivalent mass per unit length in kg/m in the i^{th} mode of vibration, as defined Equation 5.4

δ_s = logarithmic decrement of structural damping = *2Πβ*

β = structural damping as a fraction of critical damping to be taken as 0.016

σ = mass density of air to be taken as 1.2 kg/m^3

d = effective diameter taken as average diameter over the top 1.3^{rd} height of chimney in m

$$m_{ei} = \frac{\int_0^H m_z * \phi^2{}_{zi} * d_z}{\int \phi^2{}_{zi} * d_z} \qquad \textbf{5.5}$$

When the mass per unit length has to be used in a numerical method of integration, it is recommended that the mass of the segment above the section considered be added to the mass of the segment below the section and the total mass so obtained divided by the total length of the two segments.

5.2 WIND ANALYSIS (RANDOM RESPONSE APPROACH):

Pollution regulations have forced a steep increase in chimney heights, as the increase in demand of high grade of concrete has permitted a reduction in the shell diameter, thereby increasing a chimney's slenderness and sensitivity to wind induced vibrations. As a result, dynamic analysis plays an important role in the design of modern tall chimneys.

5.2.1 ALONG WIND LOAD

As per IS 4998-1992, clause no. A-5 herein, the discussion in a very brief manner is given below:

Along wind response of a chimney shall also be calculated by the Gust factor method as also described below. The use of the chimney Gust factor method requires a comprehension of Hourly Mean Speed (HMW). Hourly mean wind speed at any height (z) shall be obtained as per IS 875-1987 (Part –3).

The along wind load per unit height at any height z on a chimney shall be calculated from the equation 5.5

F_z = $F_{zm} + F_{zf}$ **5.6**

Where,

F_{zm} = wind load in N/m height due to HMW at height z and is given by

F_{zm} = $\bar{p}_z\ C_D\ d_z$ **5.7**

Where,

$\bar{p}_z$ = design wind pressure at 0.6 * $\bar{V}^2_z$ as per IS 875- 1987 (Part 3) in N/m^2

F_{zf} = Wind load in N/m height due to the fluctuating component of wind at height z and is given by equation 5.7:

F_{zf} = $3*(G-1) / H^2 * (z/H) \int_0^H F_{zm} * z * d_z$ **5.8**

Where,

G = Gust factor which shall be calculated from the equation.

G = $1 + g_f \cdot r \sqrt{\{B + SE/\beta\}}$

g_f = peak factor defined as the ratio of the expected peak value to RMS value of the fluctuating load

= $\sqrt{(2 \log_e vT)} + 0.577 / \sqrt{(2 \log_e vT)}$

vT = $3600\, f_1 / (1 + B\,\beta / SE)^{1/2}$

r = twice the turbulence intensity

= $0.622 - 0.178 \log_{10} H$

B = background factor indicating the slowly varying component of wind load fluctuation

= $[1+ (H / 265)^{0.63}]^{-0.88}$

E = a measure of the available energy in the wind at the natural frequency of Chimney

= $[123 (f_1 / \overline{V}_{10}) H^{0.21}] / [1+ (330 f_1 / \overline{V}_{10})^2 * H^{0.42}]^{0.83}$

S = size reduction factor

= $[1+ 5.78 (f1 / \overline{V}_{10})^{1.14} H^{0.98}]^{-0.88}$

$\overline{V}_{10}$ = hourly mean wind speed in m/sec at 10 m above ground level

= $\overline{V}_b * K_2$

$\overline{V}_b$ = Basic wind speed as per specified wind zone and V_b and K_2 as defined in IS 875-1987 (Part 3)

f_1 = natural frequency of chimney in the first mode of vibration in Hz

CRITICAL WIND SPEED CALCULATION:

As mentioned earlier in section 5.1, the wind velocity can transverse oscillation is initially determined using equation 5.2. However, due to transverse motion the effective chimney diameter is larger than its physical diameter by a factor

$$[1+ 1.54\, ys / D_{co}] \qquad \textbf{5.9}$$

Where, ys = initial displacement due to vortex shedding effects.

D_{co} = outside diameter of chimney in m

This effective diameter is then used to evaluate the revised critical velocity, which will be larger than the one initially calculated. The wind velocity must increase correspondingly increase otherwise the oscillation may not start or will decay if they have already started. This amplification is self-limiting.

Calculation of critical wind speed = V_{cri} = $f_1 \, d_{zei} / S_n$ **5.10**

Where,

d_{zei} = effective diameter at top 1/3rd height of chimney in m

S_n = strouhal number is to be taken as 0.2

f_1 = natural frequency of i^{th} mode in Hz

5.2.2 ACROSS WIND LOAD

Calculation of across-wind load is made by first calculating the peak amplitude at the specified mode of vibration (usually the first or second). The relevant expressions for chimneys with taper less than or equal to 1 in 50 and those with taper more than 1 in 50 are given in equation 5.11 and 5.12 below respectively. Taper is defined as

$\{2\,(d_{av} - d_{top}) / H\}$

Where, d_{av} = average outer diameter over the top half of chimney

d_{top} = outer diameter at top of the chimney

5.2.2.1 FREQUENCY, MODE SHAPE, CRITICAL WIND SPEED:

1. For Chimneys with Little or no Taper (That is, If the Average Taper Over the top One Third Height is Less Than or Equal to 1 in 50) – The modal response, at a critical wind speed $V_{cri} = f_1 \, d / S_n$ shall be Calculated by the formula:

5.2.2.2 AMPLITUDE FOR LITTLE TAPER OR NO TAPER:

$$\eta_{oi} = \frac{\dfrac{1.25 * \bar{C}_L * d * \phi H_1}{\pi^2 * S^2 n} * \dfrac{\sigma * d^2 * \sqrt{\{(\pi L)/2\ (\cap + 2)}}{mei}}{[1/H \int_0^H \phi^2{}_{zi} d_z]^{1/2} \qquad (\beta - k_a * \sigma * d^2 / m_{ei})^{1/2}} \qquad \mathbf{5.11}$$

Where,

$\cap$ = equivalent aspect ratio = H/d

$\bar{C}_L$ = RMS lift coefficient to be taken as 0.12

L = correlation length in diameters, which may be taken as 1.0 in the absence of field data

k_a = aerodynamic damping coefficient to be taken as 0.5

2. Chimneys which are Significantly Tapered (That is, If the Average Taper Over the Top One Third Height is More Than 1 in 50) – The modal Response shall be calculated by the formula:

5.2.2.3 AMPLITUDE FOR SIGNIFICANT TAPER:

$$\eta_{oi} = \frac{\sigma * \bar{C}_L * d^4 * \phi_{zei} * \phi H1 * (\pi * L / 2 * t)^{1/2}}{2 * \pi^2 * s^2{}_n * m_{ei} \int \phi^2{}_{zi} dz * (\beta - ka * \sigma * d^2 / m_{ei})^{1/2}} \qquad \mathbf{5.12}$$

Where,

Zei = height in m at which $d^4_z\ \Phi_{zi} / \sqrt{t}$ is a maximum in the i^{th} mode of vibration

$$t = \left\{ \frac{-\delta}{\delta_s} \quad \frac{d_z + \alpha\, d_z}{z} \right\}_{z=z_{ei}}$$

α = Power law exponent shall be taken as given below for each terrain category as defined in IS 875 –1987 (Part 3)

Terrain category	α
1	0.10
2	0.14
3	0.18
4	0.34
3 km from above sea shore	0.12

The value of α does not exactly match the variation of k_2 factors of IS 875 –1987 (Part 3). However, they have been chosen to be slightly conservative and should be used only in equation 5.12. And mean while the critical wind speed as per equation5.9 would be calculated.

The Sectional Shear Forces and Bending Moment would be calculated as follows for both aforesaid approaches: as per IS 4998-1992 clause no A-4.2.1.

- Calculate the shear force and Bending Moments for both along as well as across wind case as per specified approaches.
- Calculate final shear and bending moments would be well chosen by SRSS (square root of summation of squares) method for both approaches.

5.3 EARTHQUAKE ANALYSIS (MODAL ANALYSIS):

As per IS 1893-1984, the chimneys are vulnerable to earthquakes because they are tall, slender structures. Therefore, such structures have to be very carefully designed to safely withstand the forces likely to be imposed on them by ground motion. Herein, the earthquake analysis procedure should be well specified using modal analysis. The stepwise procedure is as follows:

5.3.1 MODIFIED HORIZONTAL SEISMIC CO-EFFICIENT:

5.3.2 FREQUENCY, TIME PERIOD, MODE SHPAE

- Divide the chimney in 20 equal sections along the height of chimney and derived the properties like outside diameter, thickness, mass. Also calculate the area and Moment of inertia at each section, which is useful for finding out frequency and mode shape.

- Calculate the frequencies, mode shapes at each section. In all the problems taken in this study, Frequency and Mode shapes are calculated by problems taken chimney as Single Degree of freedom system and analysis is carried out in STAAD- (pro. 2004). After getting the frequency, calculate factor Sa/g as per graph given in IS 1893-1984.

- Calculate modified horizontal seismic coefficient by the following equation 5.12 for each mode of vibration.

$$\varphi = \left[\frac{\int m_{ei} * \Phi i * d_z}{\int m_{ei} * \Phi^2_i * d_z} \right] * (Sa/g * \beta * I * F_0) \qquad \textbf{5.13}$$

Where,

Sa/g	=	Average acceleration corresponding to time as per IS 1893-1984
mei	=	mass per unit length in kg/m
Φ_i	=	modal shape for i^{th} mode of vibration
β	=	Soil foundation factor is to be taken as 1.0
I	=	Importance factor is equal to 1.5]
F_0	=	Design seismic coefficient corresponding to different zone

- Calculate the shear forces and Bending Moments by considering single degree freedom system for each mode of vibration.

- Calculate final shear and Bending Moment by SRSS method.

5.4 VALIDATION OF RESULTS:

Since there is more number of parameter, it is not possible to compare all the results. Following table 5.1 shows the results between in actual practice and results obtained by spreadsheet calculations. For validation purpose, here, the problem has been taken from (VMS Consultants) of 95 m height of chimney.

TABLE 5.1 INPUT DATA OF 95 m HEIGHT OF CHIMNEY FOR VALIDATION OF RESULTS

INPUT DATA:	
Height of Chimney (m)	**95.0**
Top Diameter (m)	**3.3**
Bottom Diameter (m)	**6.0**
Top Thickness (m)	**0.2**
Bottom Thickness (m)	**0.4**
Basic Wind Speed (m/s)	**47.0**
Earthquake zone	**3.0**

TABLE 5.2 COMPARISON OF NATURAL FREQUENCY (CYCLE/SEC)

Natural Frequency	**Mode 1**	**Mode 6**
Actual Results	0.56	27.21
Results Obtained	0.57	27.33

TABLE 5.3 COMPARISON OF CRITICAL WIND SPEED BY SIMPLIFIED METHOD (m/Sec)

Critical Wind Speed	**Mode 1**	**Mode 6**
Actual Results	9.21	445.39
Results Obtained	9.42	452.50

TABLE 5.4 COMPARISON OF SHEAR FORCE BY SIMPLIFIED ALONG WIND LOAD (kN)

Along Wind-Shear Force	**At Base**
Actual Results	461.00
Results Obtained	484.00

TABLE 5.5 COMPARISON OF BENDING MOMENT BY SIMPLIFIED ALONG WIND LOAD (kN-m)

Along Wind- B.M.	**At Base**
Actual Results	23394
Results Obtained	23540

TABLE 5.6 COMPARISON OF AMPLITUDE BY SIMPLIFIED ACROSS WIND LOAD (m)

Amplitude (m)	**Mode 1**
Actual Results	0.019433
Results Obtained	0.018943

6. RESULTS AND DISCUSSION

6.1 INTRODUCTION:

Results, an inevitable part of any work, must be reliable, precise, logical, and lucid so that it should depict a clear picture of activities carried out by the A.N.N. An effort is made in this work to achieve above objectives with as much perfection as possible.

Analysis of reinforced concrete chimney includes consideration of lateral loads such as wind load as well as an earthquake load. Their dynamic effects are also required to be studied. Therefore, modal analysis becomes important. Various parameters related to dynamic analysis and other computation based on them are following:

ANALYSIS OF REINFORCED CONCRETE CHIMNEY:

- Natural Frequency of a chimney
- Critical wind speed by Simplified Method
- Critical Wind Speed by Random Response Method
- Amplitude by Simplified approach
- Amplitude By Random Response approach
- Mode shape values up to 6 modes of vibration
- Design Shear Force
- Design Bending Moment

Architecture of Artificial Neural Network for each parameter differs and is mentioned with the title of that chart.

Chimneys of different height are taken for training and testing and the discussion is done for each parameter. For training and testing the data available from various sources of actual practice has been taken. And identify the testing data for measure the sensitivity in terms of height as well as variation in earthquake zone, wind speed too has been chosen. Their results have been compared with spreadsheets calculation and STAAD so that performance of the Neural Network can be judged.

6.2 TRAINING DATA:

Generally, more the training data, the more knowledgeable the Neural Network. It can be made act like an experienced person.

Training data is selected in such a manner that various chimneys with different height are selected with different parameters like top diameter, bottom diameter, top thickness, bottom thickness, basic wind speed, earthquake zone, etc. in order to have sufficient variety of data. This has enabled the ANN to learn variety of data and hence produces good results in many cases. However, in variety of data, certain intermediate configurations are not taken in the training data since this is an academic exercise and the purpose of study is to test the strength of ANN and effect of missing training on final results. Therefore, minimum number of chimneys is taken in training set and still good results are produced.

6.3 TESTING DATA:

In general, to check the strength or grade of performance on the basis of training the data is called as testing the data. Effect of training has been reflected in to the results of testing data.

Testing data is taken in such a way that strength of ANN could be ascertained for worst cases, i.e. no chimney close to a particular configuration is taken in training. Therefore, it may give an impression that results are not that good, but the fact is that one of the purposes of study is to test the efficacy of ANN and effect of missing data in training data set on final results. If the same chimneys are added to the training data set and ANN is trained again, the results are bound to be close to accurate even in these cases.

6.4 NORMALIZATION FORMULA:

The Neural Network applied here requires having the inputs and outputs ranging between 0 and 1. Our actual values are large positive and large negative, which need to be converted in to a form in which the aforesaid requirement is satisfied. The process of normalization does this.

There are number of technique of normalization. For different parameters different formulas are used which are mentioned along with the corresponding charts.

Success of neural network essentially depends on the normalization and hence, an effort has also been made in this direction.

6.5 ARCHITECTURE OF ARTIFICIAL NEURAL NETWORK:

Only one hidden layer has been taken to avoid complexity for Mode shape values and for Design Shear forces and Design Bending Moments. But two hidden layer has been chosen to measure the robustness of the Network for Natural frequency, Critical wind Speed by simplified Method ,Critical Wind Speed by Random Response Method, Amplitude By Simplified ,Amplitude By Random Response. Due to changes in number of outputs for different parameters, architecture of the neural network is also changed. Architecture of the neural network for different parameters has been mentioned with the charts.

Learning rate has been chosen, as a 0.5 for study of all parameters and number of cycles are 25000. Learning rate has been taken very high compared conventional application so as to expedite the learning process, since the number of parameters to be studied is quite large and the size of work is also considerably large.

Moreover, problem of local minima has been eliminated during training by making number of trials and hence the neural network applied here is highly reliable.

6.6 CHARACTERISTICS OF SIMULATOR:

Simulator is generalized to a great extent and can be applied for some another purpose with some another architecture.

Following are some advantages of this simulator.

- Number of hidden layers can be up to three, which can be selected at the run -time.
- Learning rate, rate of precision and number of cycles can be given at the run time.
- Any number of input and output nodes can be taken at the run time.
- Output is very easily understandable to even a common man and stored in an ASCII file.
- Training and testing are done for any number of data.

6.7 INTERPRETATION OF RESULTS:

Chart no- represent the comparison of results obtained through analytical approach and results obtained from A.N.N.

6.7.1 NATURAL FREQUENCY:

In chimney no-2, 11 and 43, error of the size of 4.11%, 6.52% and 4.92% respectively has been recorded. It is interesting to note that natural frequency increases with mode number as a basic principal of dynamics. In mode 5 only, some error is noticed, in all other modes error is negligible and the A.N.N is in general reliable for all chimneys up to 6 modes.

6.7.2 CRITICAL WIND VELOCITY-SIMPLIFIED METHOD:

In chimney no-11, 11-A and 13 error of the size of 12.13%, 19.53% and 19.68% respectively has been recorded. It is interesting to note that critical wind velocity increases with mode number as a basic principal of dynamics In mode 1 only, some error is noticed, in all other modes error is negligible and the A.N.N. is quite reliable in general for all other modes error is negligible and the A.N.N is quite reliable in general for all chimney up to 6 modes.

6.7.3 CRITICAL WIND VELOCITY-RANDOM RESPONSE METHOD:

In chimney no-17, 20 and 22, error of the size of 13.59%, 9.15% and 13.51% respectively has been recorded. It is interesting to note that critical wind velocity increases with mode number as basic principal of dynamics. In mode 1 only, some error is noticed, in all other modes error is negligible and the A.N.N. is quite reliable in general for all chimneys up to 6 modes.

6.7.4 MODE SHAPES:

- In mode shape-1, error of the size of 9.42% is located in chimney no-22, which very low. In all other chimneys almost exact are the results given by A.N.N., which suggest high-level accuracy and precision of A.N.N. Graphs are the proof of the said fact.
- In mode shape-2 and 3, for all chimneys analytical values and results obtained through A.N.N. coincide with each other suggesting very high-level accuracy offered by A.N.N.
- In mode shape-4, error of the size of 7.92% and 2.36% respectively is located in chimney no-40 and 43,which is very low. In all other chimneys almost exact are the results given by A.N.N., which suggest high-level accuracy and precision of A.N.N. Graphs are the proof of the said fact.
- In mode shape-5, error of the size of 12.96%, 8.64% and 8.84% respectively is located in chimney no- 11-A, 40 and 43. In all other

chimneys almost exact are the results given by A.N.N., which suggest high-level accuracy and precision of A.N.N Graphs are proof of the said fact.

- In mode shape-6, error of the size of 13.22% is located in chimney no-43. In all other chimneys almost exact are the results given by A.N.N., which suggest high-level accuracy and precision of A.N.N. Graphs are the proof of the said fact.
- Actually, higher mode of vibration means greater number of apex points and higher the complexity of profile to be learnt by the A.N.N. leading higher probability of spread error with higher magnitude. But fortunately in this case, the A.N.N. designed and trained has attained enough strength of learning complex surfaces and the aforesaid general weakness of A.N.N. has been got rid of, which can be proven with the help of all the charts for 6 mode shapes.

6.7.5 AMPLITUDE BY SIMPLIFIED METHOD:

Error of the size of 6.28%, 5.19% and 7.715% respectively is located in chimney no-11, 20 and 22, which is very low. In all other chimneys almost exact are the results given by A.N.N., which is suggest high level accuracy and precision of A.N.N. Graphs are the proof of the said fact. Though the target surface is highly complicated, the A.N.N has successfully learnt it.

6.7.6 AMPLITUDE BY RANDOM RESPONSE METHOD:

Error of the size of 5.55%, 7.56%, 2.67% and 4.85% respectively is located in chimney no- 11, 11-A, 13 and 43, which is very low. In all other chimneys almost exact are the results given by A.N.N., which suggest high-level accuracy and precision of A.N.N. Graphs are the proof of the said fact. The target surface is very simple in nature and hence the A.N.N. has successfully learnt it without any difficulty.

6.7.7 DESIGN SHEAR FORCE:

In chimney no- 11-A, 13 and 25, significant error level is found. In all other chimneys very low error level is found in results obtained through A.N.N.

It is important to note the fact that the surface to be learnt is complicated. However, the line-by-line fragmentation of the same looks quite regular in the shape, i.e. Linear, which is very easy to understand on the basis of S.F.diagram of a stack structure. This surface has been simplified with the help of reversed normalization formula and hence error level in normalized form is negligible (Table No-6.4). When demoralization is done, error is magnified but the error trend has been regular. Magnification of error in order to simplify the surface configuration which when converted in to original one leads to multiplication with a high number. Both the curves- analytical results and results obtained through A.N.N. are Linear straight line. Had conventional normalization formula been banked up on, quality of results might have been inferior owing to much higher error levels for smaller magnitudes of Shear Forces. Such precision for high values of phenomenon under study. This phenomenon is observed particularly when the target surface is straight-line.

6.7.8 DESIGN BENDING MOMENT:

In chimney no-20, 22, and 25, significant error level is found. In all other chimneys very low error level is found in results obtained though A.N.N.

It is important to note the fact that the surface to be learnt is complicated. However, the line-by-line fragmentation of the same looks quite regular in the shape, i.e. parabolic, which is very easy to understand on the basis of B.M.diagram of a stack structure. This surface has been simplified with the help of reversed normalization formula and hence error level in normalized form is negligible (Table No-6.5). When demoralization is done, error is magnified but the error trend has been regular. Magnification of error in order to simplify the surface configuration which when converted in to original one leads to multiplication with a high number. Both the curves- analytical results and results obtained through A.N.N. are parabolic. Had conventional normalization formula been banked up on, quality of results might have been inferior owing to much higher error levels for smaller magnitudes of Bending Moments. Such precision for high values of phenomenon under study. This phenomenon is observed particularly when the target surface is curved.

7. SUMMARY, CONCLUSION AND FUTURE SCOPE OF WORK

7.1 SUMMARY, CONCLUSION:

- Neural Network can be trained to estimate the results using non-procedural approach.
- With the help of proper training, sensitivity and robustness of the neural network can be achieved in the results obtained in a testing stage. Here, the natural frequency, mode shape value, critical wind speed by both approaches, amplitude by both approaches prove this. And to some extent Design shear force and Design Bending Moment prove the efficacy of A.N.N. due to very high denominator compared to lower results of low height of chimney. But at the same time the normalized error level in S.F and B.M. is very negligible.
- Relationship between input and results may increase or decrease. Both the types of relationships can be sensed and reflected if training data is selected properly. In the case of calculation of natural frequency, mode shape value, critical wind speed by both approaches, amplitude by both approaches, it is nicely observed.
- In all architecture of A.N.N., the learning rate and no. of cycles, error precision at run time plays an important role for training data. Therefore, in the present study such values have been taken as a 0.5, 25000, and 0.001. But it can be changed at the run-time. Lower learning rate, more number of cycles, and higher level of error precision will improve the resulting A.N.N.
- Multi-apex surfaces can also be estimated with reasonable error limits. This needs appropriate normalization formula to augment sensitivity to the neural network. This is a fascinating characteristic of the neural network, which is observed in the Natural frequency, mode shape value, and Critical wind speed by both approaches, and amplitude by both approaches. However, in design shear forces and design bending moments at some point, due to limitation of normalization formula have been encountered.

- Magnitude of training data and appropriate variation in training data play very crucial role in obtaining sensitivity and robustness of neural network.
- When very large variation between minimum and maximum values of results are there, errors can be noticeable for smaller values. This is observed in Bending Moments and Shear forces.
- Configuration and architecture of neural network is also important factor.

7.2 FUTURE SCOPE OF WORK:

The contemporary analysis work has been carried out using the worth of Artificial Neural Network to the Reinforced Concrete Chimney. But it can be applied to any complex engineering problem. Herein, for academic purpose only A.N.N. has been utilized to the analysis of R.C.Chimney. The work will be spread out in form its future scope of work such as follows:

- In this Major Project, Neural Network has been simply applied and tested it. It has proven as an efficient tool just like as an experienced person.
- Effect of different normalization formulas on data of various ranges and kinds is also worth studying. It may enhance the performance of neural network.
- Out of number of architectures of artificial Neural Networks, herein Feed forward back Propagation algorithm has been applied but some other architecture may useful in some other way.
- In present study, different stages are dealt with separately. For different parameters different sets of input vector, hidden layer and output vector and weights are derived. A preprocessor to integrate the work, which would be user-friendly also, is really needed for a common man to directly use it.
- Here, the A.N.N has been compared with analytical solution, which is through spreadsheets, but the analysis of R.C.Chimney can be possible by using readily available finite-element structural analysis software or any

- other standard results that is compiled by experimentally or from standard references.
- With the little change of material properties, and A.N.N performance can be judged for steel chimneys also.
- A.N.N is an area of Artificial Intelligence, so other useful and efficient technique can be utilized for the structure-engineering problem such as genetic algorithm, Fuzzy logic.
- For finding of the Neutral axis of the cross section of chimney is very tedious process whether the entire section is in tension or in compression in availability of different kind of openings, so using the concept of mapping within the fraction of time, for any kind of opening at any level, the exact position of N.A. can be obtained by A.N.N. It is also worth studying to locate the exact position of N.A. for R.C.Chimney.
- With use of A.N.N., separate component of analysis of R.C.Chimney like dynamic properties, dynamic behavior of chimney under the action of lateral loads can be studied individually.
- A single stage model with different architecture in which all inputs are given and all output for different parameters are obtained at a time may be changed.

BIBLIOGRAPHY:

List of Books:

1. S N. Manohar, "*Tall Chimneys –Design and Construction*" Mc-Graw Hill publication, 1985
2. G M.Pinfold, *"Reinforced Concrete Chimneys and Towers"*, View point publication1, 1975.
3. C P.Taylor and L. Turner, *"Reinforced Concrete Chimneys"*, Concrete publication Ltd., 1960
4. Mario Paz, *"Structure Dynamics" –Theory and construction*, CBS
5. Dr. A S. Pandya, *"Programming with C++ and Neural Network"*, International conference on NNs using OOPs language, Jan 1997, A' Bad.

List of Periodicals:

6. Prem Chand, *"Design of circular R.C.Chimney sections subjected to axial load and bending moments"* July 1994, Vol 76, The Indian Concrete Journal.
7. B J.Vickery, "*Wind – Induced loads Reinforced Concrete Chimneys"*, National seminar on tall chimneys, April 1985, New Delhi.
8. N. Nagaraja, *"Model Study of 275 m Tall Chimney",* Tata Consulting Engineers, Bangalore, 1990, Wind Load on structures hand book
9. Ushnish Basu and Vinay K. Gupta, "*A note on the codal gust factor provisions for concrete chimneys"*, May 1998, Vol. 73, The Indian Concrete Journal
10. V S.Phani, Kanth, R C.Jain, and S Ramanujam *"Seismic / Wind Analysis of a Reinforced concrete chimney comparative study of ACI and IS codes"*, SEC-2003, December, Architecture & Civil engineering Division, -BARC, Trombay, Mumbai, India.

List of useful codes:

11. IS 4998 (PART 1): 1975, *"Criteria for Design of Reinforced Concrete Chimneys",* BIS, New Delhi.
12. IS 4998 (PART 1): 1992, *"Criteria for Design of Reinforced Concrete Chimneys"*, second edition, BIS, New Delhi.

REFERENCES:

List of literature to be reviewed

13. Dr. C V R Murthy, "*Hand Book on Reinforced Concrete Chimneys",* SERC-Chennai, 1986.
14. Dr. Rajshekhran *"Neural Networks, Fuzzy logic, Genetic Algorithm",* CBS publication.
15. Doris M. Mehta, Atul K. Desai, *"Seismic Design of Tall Chimneys using IS 1893-1984 and IS: 1893-Draft (Part 4) Code",* ICEE, Feb. 2006,SASTRA, Thanjavur.
16. C S. Krishnamurthy, *"Artificial Intelligence and knowledge-based engineering expert system for civil engineering",* Indian Conc. Journal- Dec 2000.
17. B.Yegnarayana, *"Artificial Neural Network",* Prentice-Hall of Indian Pvt. Limited, New Delhi, 1999.