Formulation of Artificial Neural Network Model for Correlating the Factors Responsible for Industrial Accidents with Severity of Accidents and Man Days Lost by using MATLAB

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Abstract

The safety and protection of people, equipment and the environment is a serious concern in the Engineering industries. Many industries have recognized the advantages of Safe Work Environments and are progressively adopting Safety Management System to prevent hazardous events, avoid production & manpower losses and other fallouts associated with industrial accidents. Safety Management is an organizational function which ensures that all the safety risks have been identified, assessed and satisfactorily mitigated. Thus the safety of the workers is the most important factor in dealing with the industrial safety. The present work utilizes artificial neural network (ANN) modelling technique for modelling. The proposed paper work envisages minimizing industrial accidents by identifying the various factors responsible for industrial accidents and developing the approximate model to correlate the causes of accidents with the severity and the man days lost.

Keywords: Artificial Neural Network (ANN), ANN Parameters, MATLAB, Safety

I. INTRODUCTION

Safety Management system is a proactive and systematic approach for identification, evaluation, mitigation, prevention and control of hazards that could occur as a result of failures in process, procedures, or equipment. Increasing industrial accidents, loss of life & property, public scrutiny, statutory requirements, aging facilities and intense industrial processes, all contribute to a growing need for Safety Management Program to ensure safety and risk management.

In accordance with the specific provisions for ensuring Occupational Safety and Health (OSH) for working population in the Constitution of India, several legislations have been framed dealing with the safely, health and welfare of the workers employed in the organised sector.

The Working Group report has made incisive observations regarding the present Occupational Safety and Health (OSH) scenario and offered insightful recommendations for legislative measures and other pragmatic interventions to make sustainable changes and to make significant difference in OSH status in the country by the end of 2017.

At present, comprehensive safety and health statutes for regulating OSH at workplaces exist only in respect of the four sectors namely, mining, factories, ports, and construction etc.

The main objective of the study is to suggest improvement in industrial safety and reducing industrial accidents.

Work-related accidents or diseases are very costly and can have many serious direct and indirect effects on the lives of workers and their families. For workers some of the direct costs of an injury or illness are the pain and suffering of the injury or illness, the loss of income, the possible loss of a job, health-care costs. It has been estimated that the indirect costs of an accident or illness can be four to ten times greater than the direct costs, or even more. The costs to employers of occupational accidents or illnesses are also estimated to be enormous.

A. Identification of Factors Responsible for Industrial Accidents and Data Formulation:

The factors responsible for industrial accidents were identified by referring to various text on industrial safety, research papers as given below. A 10-point scale is created for the various factors in consultation with the Industrial Safety Managers/professionals, Industry Personnel and Experts and others and their average is taken as a pointer for the factor.

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A. Agency associated with injury (causing accident) (x1)

This is the important factors which are taken to be in to consideration for causing accidents. The agency is the object, substance or exposure which is most closely associated with the injury and which could have been made safer.

Table - 1
Factors for agency associated with injury.

Sr. No	*Agency*	*Pointer*
1	*Hand tools.*	*8.4*
2	*Boilers, Pipe and Pressure apparatus, furnace.*	*8.0*
3	*Machine, Pump, Prime mover.*	*7.2*
4	*Elevator and hoisting apparatus.*	*6.8*
5	*Handling apparatus.*	*5.0*
6	*Conveyor's.*	*4.6*
7	*Electrical apparatus.*	*4.2*
8	*Other working substances.*	*3.6*
9	*Mechanical power transmission apparatus.*	*3.0*

B. Unsafe act (violation of a commonly accepted safe procedure) (x2)

This is also an important factor which is violation of commonly accepted safe procedure which resulted in selected accident type.

Table - 2
Factors associated with unsafe act.

Sr. No	*Unsafe act*	*Pointer*
1	*Failure to use safe attire or personal protective devices.*	*8.4*
2	*Using unsafe equipment, hands instead of equipment or equipment unsafe.*	*7.8*
3	*Taking unsafe position or posture.*	*6.6*
4	*Unsafe loading, placing.*	*6.4*
5	*Working on moving or dangerous equipment.*	*6.0*
6	*Operating without authority, failure to secure or warn.*	*5.6*
7	*Making safety device inoperative.*	*5.2*
8	*Operating as working at unsafe speed.*	*4.4*
9	*Distracting, teasing, abusing, startling and so on.*	*3.1*

C. Personal causes (x3)

These are also called as behavioristic causes that is the mental and boldly characteristics which permitted or occasioned the selected unsafe act.

Table - 3
Factors associated with personal.

Sr. No	*Personal causes*	*Pointer*
1	*Neglecting safety procedures*	*8.4*
2	*Lack of safety awareness*	*6.8*
3	*Inexperience in work (unskilled)*	*6.2*
4	*Improper attitude*	*5.8*
5	*Lack of knowledge or skill*	*5.4*
6	*Physical or mental defect*	*3.1*

D. Environmental causes (x4)

It is a condition of selected agency, which could and could have been guarded and corrected.

Table - 4
Factors associated with Environment.

Sr. No	*Environmental causes*	*Pointer*
1	*Unsafe procedure*	*8.0*
2	*Improper guarding*	*7.6*
3	*Substance or equipment defective through use or warn out*	*6.4*
4	*Substance or equipment defective through design or construction*	*5.0*
5	*Improper dress or apparel (Labour Negligence)*	*4.8*
6	*Unsafe housekeeping facilities*	*4.4*
7	*Improper dress or apparel (Management failure to provide)*	*4.2*

E. Nature of Injuries (x5)

These are the type of injury which has been caused due to accident to the personal.

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Table - 5
Factors associated with nature of injury.

Sr. No	*Nature of injuries*	*Pointer*
1	*Cut*	*8.4*
2	*Wound*	*7.8*
3	*Burn*	*5.8*
4	*Strain*	*5.6*
5	*Fracture*	*5.4*
6	*Eye affected*	*5.0*
7	*Miscellaneous*	*4.4*
8	*Nausea*	*3.1*

F. Dependent variable

1) Severity of accident (y1)

The severity of the accident depends upon the impact of the injury caused due to the accident.

Table - 6
Severity of accident

Sr. No	*Severity of accident*	*Pointer*
1	*Fatal*	*10*
2	*Major with permanent disability*	*9*
3	*Major with temporary disability*	*8*
4	*Minor with hospitalization*	*7*
5	*Minor without hospitalization*	*6*
6	*Minor without a day off.(First aid injury)*	*5*

2) Man house lost (y2)

The data for man hours lost is gathered from the Indian standards manual for accident severity, the nature of injury caused with reference to the number of man hours lost has been depicted in the table of their report and with information from consultation with doctors and industry personal. The scale has been formed as follows.

Table – 7
Man days lost.

Sr. No	*Man days lost*	*Pointer*
1	*2401-6000 days*	*10*
2	*1201-2400 days*	*9*
3	*361-1200 days*	*8*
4	*181-360 days*	*7*
5	*91-180 days*	*6*
6	*31 - 90 days*	*5*
7	*8 - 30 days*	*4*
8	*2-7 days*	*3*
9	*Less than a day*	*2*

a) Data collections

The authenticated data of the industrial accidents has been gathered from various government agencies responsible for handling industrial accidents such as About 173 number of accidents which are recorded by the above are been taken for formulation of the model.

On the basis of the accident reports and other supporting documents and information the factors responsible for industrial accident along with the severity of the accidents and the man days lost are entered in the excel work sheet. The procedure of assigning the pointers to the factors responsible for industrial accident along with the severity of the accidents and the man days lost are explained in the analysis of data.

II. MODEL FORMULATION

The proposed research work attempts to establish the correlation between the causes of accident (X1,X2,X3,X4,X5) with severity of the accident(Y1) and man days lost (Y2).

The correlation between the independent variable i.e causes of accidents and the dependent variables i.e. severity and man days lost can be established by formulating.

Artificial Neural Network (ANN) using MATLAB Software.

A. Artificial Neural Network (ANN) using MATLAB Software

The artificial neural network is composed of many neurons like biological neuron in a structured way and tries to perform the same function as biological neuron. The input vectors are provided to the network and output of the network is compared with the desired target vectors. The applications of Artificial Neural Networks are widely spread. Those can be basically classified in

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three categories as Classification: Pattern recognition, feature extraction, image matching, clustering data. Noise Reduction: Recognize patterns in the inputs and produce noiseless outputs. Prediction: Extrapolation based on historical data like fitting function or time series prediction

B. The Neural Network Fitting Tool in MATLAB

The Neural Network Fitting Tool helps in selecting the data, create and train the network and evaluate its performance using mean square error and regression analysis.

C. Result Analysis

ANNs are considered as predicting and analytical models that are used extensively in research fields. They are helpful in predicting the severity of the injury and the man days lost in relation to the factors causes the industrial accidents. The back propagation technique is used and the number of neurons has been changed to observe the significance if any on the results obtained.

The result obtained for the severity of accidents (Y1) is as shown:

By using the feed forward back proposition network type with Tranlm as training function with performance function as MSE (mean square error)and number of neurons 20 with transfer function as Tansig. There are five input parameters and one output, the following model is validated, trained and tested as follows with R=0.89649.

The best validation performance is 0.047874 at epoch eleven as shown in the figures. The three plots represent the training, validation, and testing data. The dashed line in each plot represents the perfect result – outputs = targets. The solid line represents the best fit linear regression line between outputs and targets. The R value is an indication of the relationship between the outputs and targets. If R = 1, this indicates that there is an exact linear relationship between outputs and targets. If R is close to zero, then there is no linear relationship between outputs and targets.

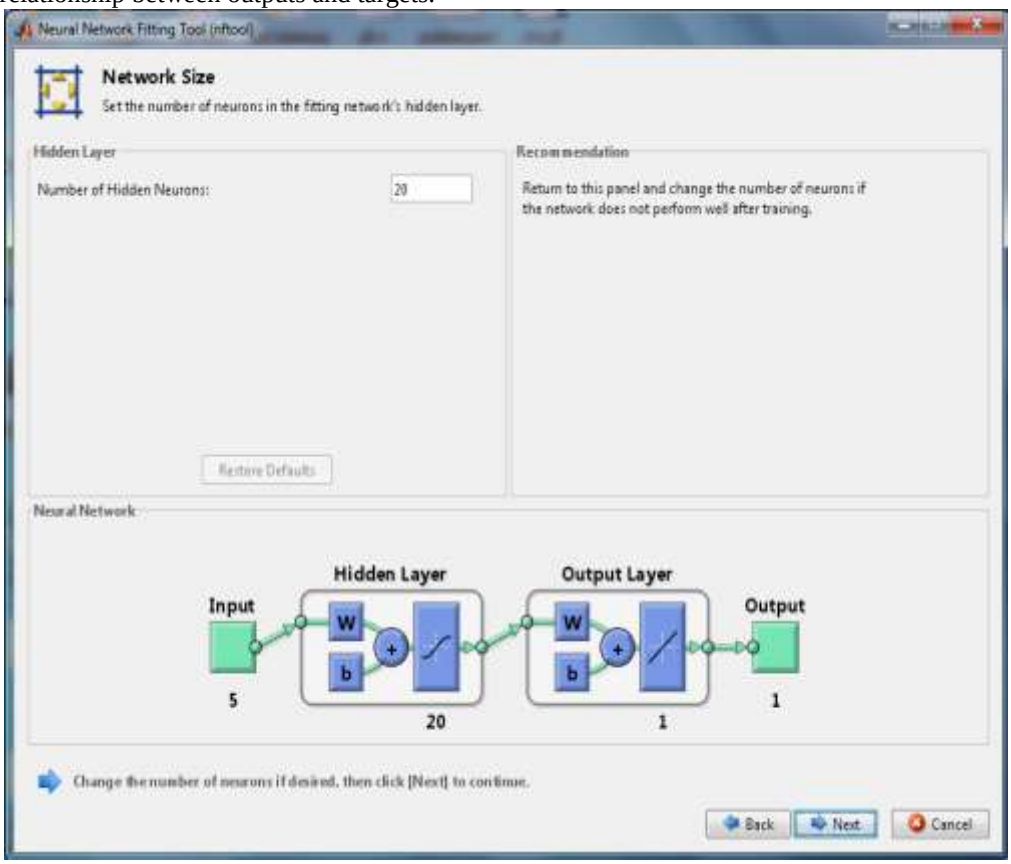

Fig. 1: Neural Network Tool

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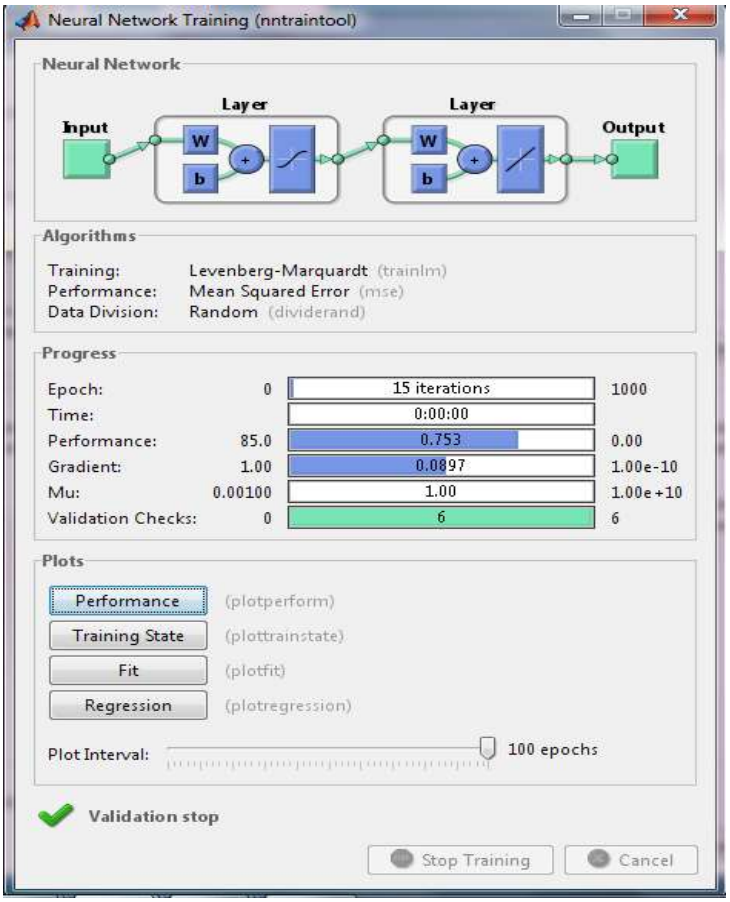

Fig. 2: Neural network train Tool for Y1

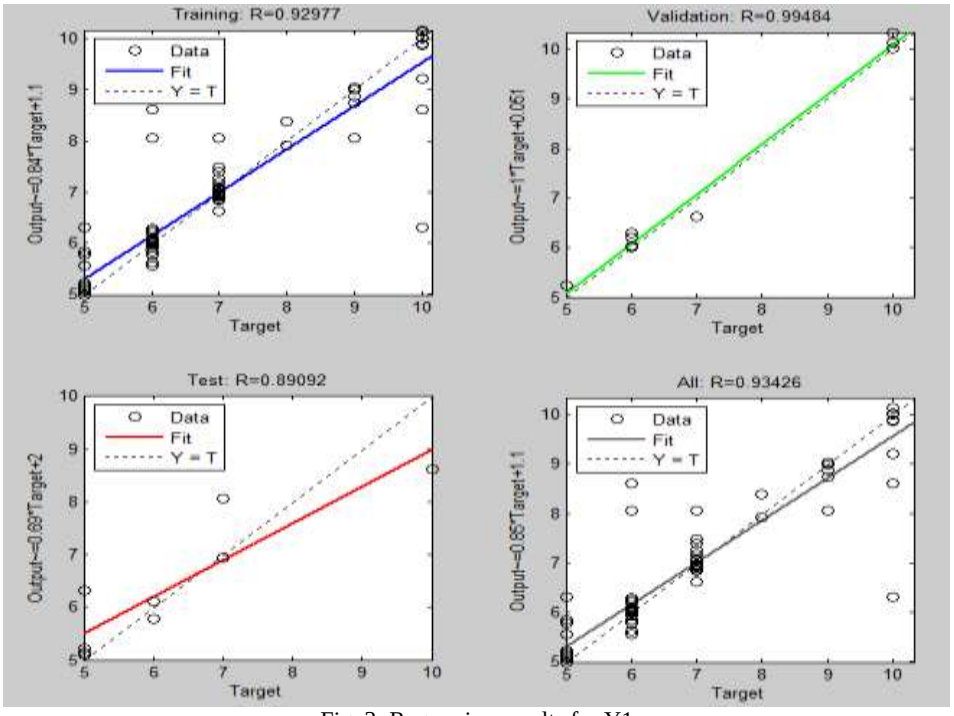

Fig. 3: Regression results for Y1

The best validation performance is 0.047874 at epoch eleven one as shown in the figure

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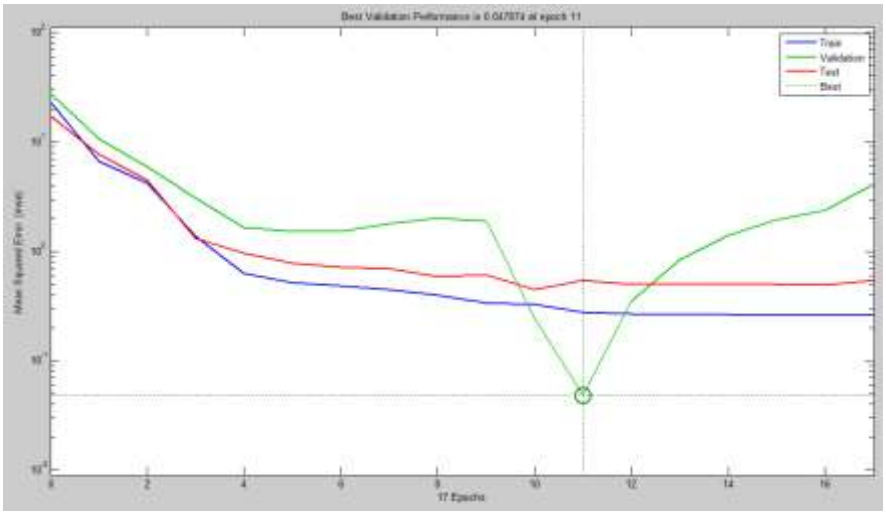

Fig. 4: Best validation Function for Y1

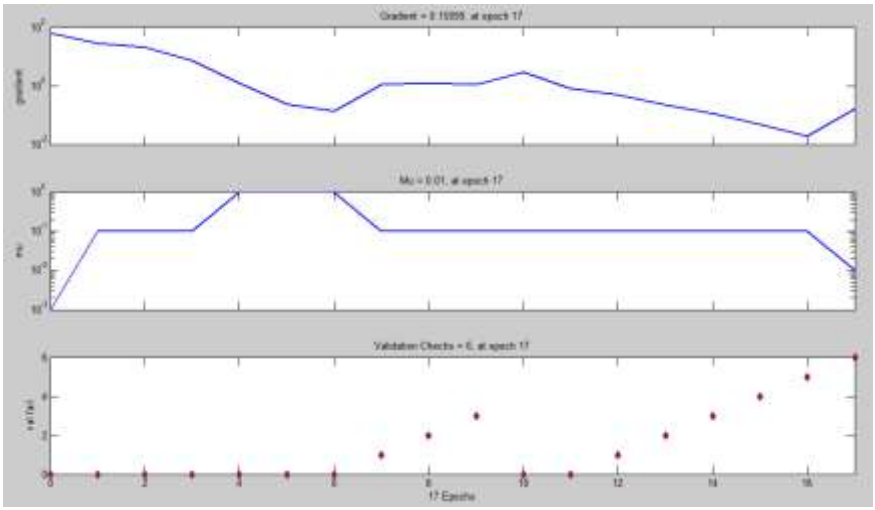

Fig. 5: Gradient, Mu and validation checks for Y1

The Input data i.e. the various causes/factors responsible for the accidents are tested with the severity of the accident and the regression value is found to be R=0.9327.

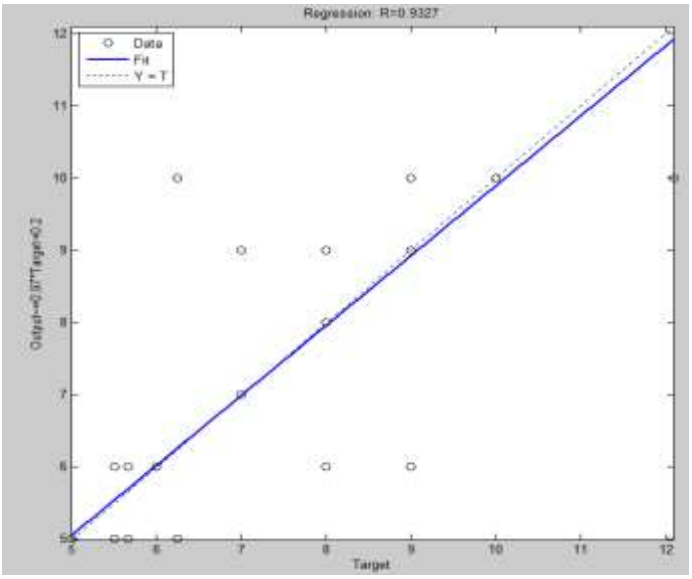

Fig. 6: Testing regression Plot for Y1

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The following value of the mean square error for training is obtained as 0.2856.

The simulation of the 20 data sets is been carried out on Simulink function on NN tool MATLAB and the results are thus obtained:

For Severity of Accident (Y1)

Table – 9
Test Results for Y1

Sr. no.	*Y1*	*Y1 pred.*	*ERROR*	*ERROR SQUARE*
1	*7*	*7.2825*	*-0.2825*	*0.07980625*
2	*7*	*7.2825*	*-0.2825*	*0.07980625*
3	*8*	*8.2618*	*-0.2618*	*0.06853924*
4	*7*	*7.2618*	*-0.2618*	*0.06853924*
5	*9*	*9.2618*	*-0.2618*	*0.06853924*
6	*8*	*8.2346*	*-0.2346*	*0.05503716*
7	*10*	*9.9743*	*0.0257*	*0.00066049*
8	*10*	*9.5908*	*0.4092*	*0.16744464*
9	*7*	*7.2618*	*-0.2618*	*0.06853924*
10	*10*	*9.974*	*0.026*	*0.000676*
11	*9*	*8.9782*	*0.0218*	*0.00047524*
12	*10*	*9.9059*	*0.0941*	*0.00885481*
13	*6*	*6.1872*	*-0.1872*	*0.03504384*
14	*5*	*5.1319*	*-0.1319*	*0.01739761*
15	*6*	*6.3098*	*-0.3098*	*0.09597604*
16	*8*	*8.3924*	*-0.3924*	*0.15397776*
17	*5*	*5.1452*	*-0.1452*	*0.02108304*
18	*7*	*6.912*	*0.088*	*0.007744*
19	*7*	*7.2825*	*-0.2825*	*0.07980625*
20	*6*	*6.1872*	*-0.1872*	*0.03504384*

The Mean Square error is calculated for the above as 0.0556.

The result obtained for the Man days lost(Y2) is as shown :By using the feed forward back proposition network type with Tranlm as training function with performance function as MSE(mean square error)and number of neurons 20 with transfer function as Tansig, the following model is validated, trained and tested as follows with R=0.940.

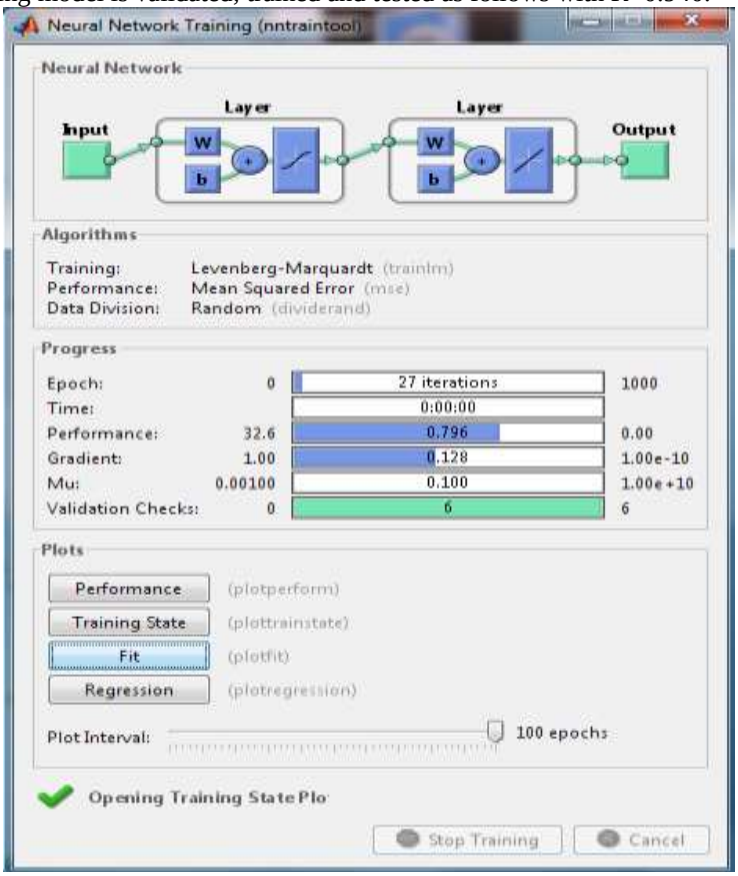

Fig. 7: Neural network train Tool for Y2

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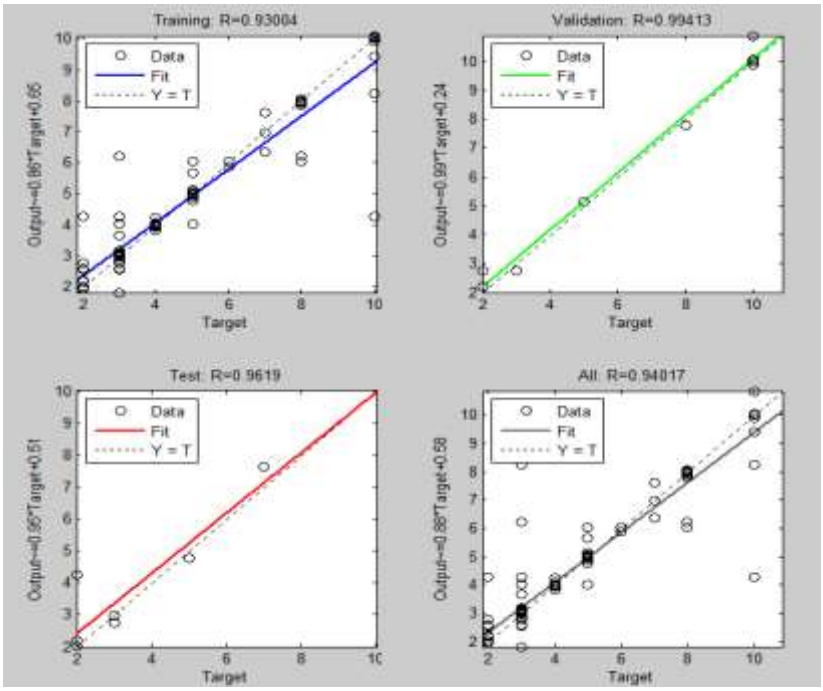

Fig. 8: Regression results for Y2

The best validation performance is 0.16421 at epoch twenty one as shown in the figure.

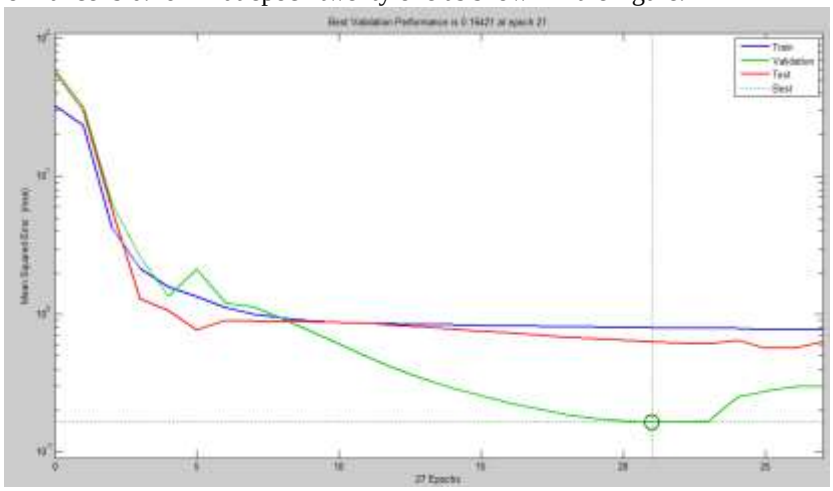

Fig. 9: Best validation Function for Y2

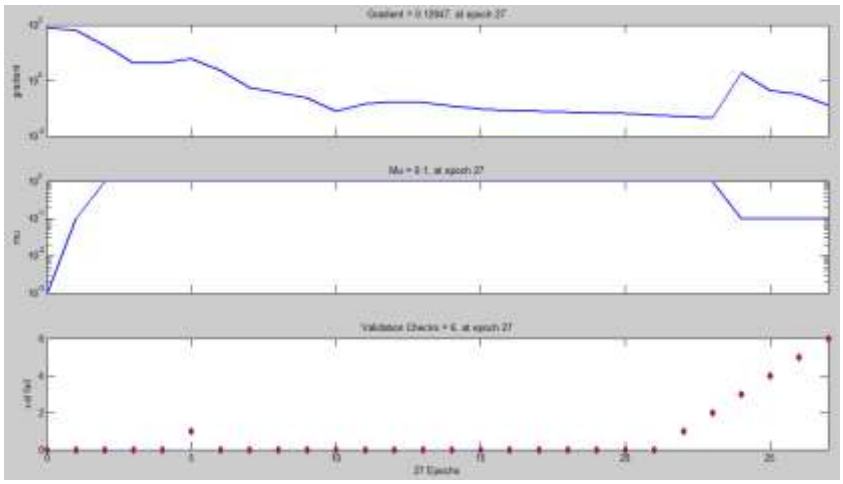

Fig. 10: Gradient, Mu and validation checks for Y2

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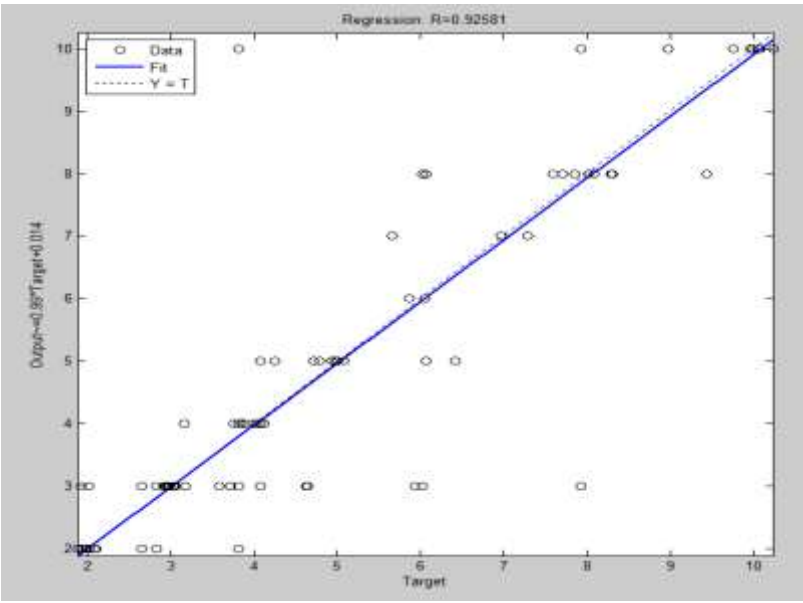

Fig. 11: Testing regression Plot for Y2

The following value of the mean square error for training is obtained as 0.929.

The simulation of the 20 data sets is been carried out on Simulink function on NN tool MATLAB and the results are thus obtained for Man days lost (Y2):

Table – 10
Test Results for Y2

Sr no.	*Y2*	*Y2 pred*	*ERROR*	*ERROR SQUARE*
1	*5*	*4.3047*	*0.6953*	*0.48344209*
2	*5*	*4.3047*	*0.6953*	*0.48344209*
3	*3*	*3.8086*	*-0.8086*	*0.65383396*
4	*3*	*3.8086*	*-0.8086*	*0.65383396*
5	*5*	*4.9576*	*0.0424*	*0.00179776*
6	*10*	*9.83*	*0.17*	*0.0289*
7	*10*	*9.7098*	*0.2902*	*0.08421604*
8	*10*	*9.8063*	*0.1937*	*0.03751969*
9	*10*	*9.83*	*0.17*	*0.0289*
10	*8*	*8.0253*	*-0.0253*	*0.00064009*
11	*8*	*7.8642*	*0.1358*	*0.01844164*
12	*10*	*9.806*	*0.194*	*0.037636*
13	*10*	*9.83*	*0.17*	*0.0289*
14	*8*	*8.0235*	*-0.0235*	*0.00055225*
15	*8*	*7.8042*	*0.1958*	*0.03833764*
16	*3*	*3.5488*	*-0.5488*	*0.30118144*
17	*2*	*2.0133*	*-0.0133*	*0.00017689*
18	*8*	*7.9047*	*0.0953*	*0.00908209*
19	*10*	*9.9179*	*0.0821*	*0.00674041*
20	*5*	*4.878*	*0.122*	*0.014884*

III. CONCLUSION

An Neural Network model is developed using MATLAB to co-relate various causes of accident with severity of accident and man days lost and as the Mean Square Error calculated is less and as the Regression R values are higher this model is accepted for predicting the severity of the injury and the man days lost in relation to the factors causes the industrial accidents.

REFERENCES

[1] R P Blake,(1943), "Industrial Safety", Prentice Hall,Inc, Englewood cliffs. N.J
[2] H.W. Heinrich., "Industrial Accident Prevention", McGraw-Hill Book Company,Inc,New York.
[3] J D Dhande,Dr S M Gulhane, "Design of Classifier using artificial neural network for patients survival analysis",IJESIT,VOL1,NOV 2012
[4] Iraj Mohammadfam,Ahmed Soltanzade,Abbas Moghimbeigi, "Use of artificial neural networks for the analysis and modelling of factors that affect occupational injuries in large construction industries",Electronic Physician,VOL7,2015,1515-1522.

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[5] P A Chandak,A R lende,J P Modak, "A literature review on methodology and fundamentals of development of mathematical model through simulation of artificial neural networks,IJCA,VOL1,2014,63-75.
[6] Jaques de Villier,Etienne Barnard, "backpropogation Neural Nets with one and two Hidden layers",IEEE Transactions on neural networks,Vol 4,No.1,1992,136-141.
[7] Farman A. Moayed,Richard L. Shell, "Application of Artificial neural Network models in Occupational Safety and Health Utilizing Ordinal variables",Ann,Occup.Hyg.,Vol 55,No.2,2011,132-142.
[8] Debika Thakuria, Daisy Sharma,Rajesh kumar, "Continuous System Simulation and Neural network Modelling",IARJS,Vol 2,Issue 4,2015,93-96.

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