ISSN:2348-2079

Volume-6 Issue-2

International Journal of Intellectual Advancements and Research in Engineering Computations

# Optimal design of R.C beams using neural network

Mrs.Karthiga.N [#1], Mohanraj A [#2]
karthis47@gmail.com
[1]*Assistant Professor , Bannari Amman Institute of Technology, Sathyamangalam, Erode District, TamilNadu,India*
drnarunachalam@yahoo.co.in
[2 1]*Assistant Professor, Bannari Amman Institute of Technology, Sathyamangalam, Erode District, TamilNadu,India*

*Abstract –Beam elements are designed and the total cost of each of these has been estimated. The grade of concrete has been varied from M20 to M40 and grade of steel varied from Fe 250 to Fe 550. The singly reinforced beams have been designed for various values of live loads and adopting the ratio of b/D from 0.4 to 0.9. In this paper, it is shown that how the decision variables like b, D, Fck, Fy, Asprov, Mu, Vu etc contribute in the optimal design of structural elements, the Main Objective of this paper has been finalized Minimizing Beam Element Total Cost (BETC). Material and labor and formwork costs are also found out. This paper deals with designing a low cost of RCC beam in MATLAB. The results from the software and the results from manual design are compared and finally the optimal design of the beams is explained in detail from the various graphs obtained from both the sources.*

***Key Words – Decision Variables, Objective function, MATLAB, beams.***

## 1.INTRODUCTION

RCC Beam Designs involves - based upon the Preliminary Sizing and subjected loads, - the calculation Design Forces from Analysis (Mu, Vu etc) (i). Thereupon evaluation of various decision variables such as formwork fcross section sizes – b, D, grade of concrete & reinforcement steel material respectively - $f_{ck}$, $f_y$ respectively, Area of steel - $A_s$ & its length, position & arrangement of reinforcement for various steel such – Longitudinal and Transverse Steel are made such that resultant strength & serviceability requirements are satisfied.

Optimization means making things the best. Thus, structural optimization is the subject of making an assemblage of materials sustains loads in the best way. We want to find the structure that performs this task in the best possible way. However, to make any sense out of that objective we need to specify the term “best.” The specification that comes to mind may be to make the structure as minimizing total cost.

## 2. OBJECTIVES

The following objectives are defined to achieve the research goal:

- Development of computer models to automate the design process of reinforced beams according to IS 456 Code.
- Development of TAGUCHI models using MINITAB software
- Development neural network optimization models using MATLAB software.
- To find the factors which influence the total cost.
- To fond the optimal solution.

## 3. SCOPE

Six hundred R.C beams are designed for moments in the range of 100kN-m to 300 kN-m and b/D in the range of 0.4 to 0.9. bending moment about minor axis in the range of 50kN-m to 350kN-m.The grades of concrete considered are M20, M25, M30, M35 and M40.The grades of steel adopted – Fe 250, Fe415 and Fe 500.Computer programs have been developed using C language for the design of all the above mentioned structural components and MS - Excel has been made use of it. The estimated costs of each of the designed structural elements have been determined. Factors which influenced the cost have been determined by using Minitab software. A set of neural network have been made use of to predict the cost of elements.Results of this neural network have been compared with the results obtained by hand calculation.

## 4. DESIGN OPTIMIZATION PROBLEM FORMULATION

In this section, the model of the RC beam is described, showing the fixed parameters, the design variables, the design variables' bounds, the design constraints and the objective function. A typical simply supported rectangular RC beam has a span of L m and may be carrying a Moment kN-m. The grades of concrete considered are M20, M25, M30, M35 and M40.The grades of steel adopted – Fe 250, Fe415, Fe 500 and Fe550. It is intended to optimize the design of the beam according to the provisions of the IS-456 Code.

### 4.2.1 THE FIXED PARAMETERS

The fixed parameters for this RC simple beam model are taken as the span of the beam, the cost/m3 of concrete, the cost/Kg of steel, the modulus of elasticity of concrete, the compressive strength of concrete, the yield strength of reinforcement and the value of the Moments.

### 4.2.2 DESIGN VARIABLES

**INDEPENDENT DECISION VARIABLES**

b : Discr. Beam width (mm), (ex-200, 250, 300, 400 ..mm etc)
*(bLL< = b < = bUL, i.e b- Lower and Upper Bound Value)*
D : Discr. Beam Overall Depth (mm),(ex-300, 450, 600, 750 ..mm etc)
*(DLL< = D < = DUL, i.e D- Lower and Upper Bound Value)*
Fck : Grade of Concrete (N/mm2),(ex- Fck 20, 25, 30,35,40.N/mm2 etc)
Fy : Grade of Reinforcement Steel (N/mm2),(ex- Fy 250, 415, 500,550 N/mm2 etc).

**INDEPENDENT PREASSIGNED DESIGN DECISION PARAMETERS**

Lclr :Clear Length of the beam between support
Mu: Fact.Bending Moment (KN.M).
Vu : Factored Shear force (KN)
pAsmax : 4% or Even lesser User Defined (Max. Percentage Steel)

**DEPENDENT PREASSIGNED DESIGN DECISION PARAMETERS**

Q : Limiting Moment of resistance Factor.=0.36* (Xumax /deff)*(1-0.42*Xumax/deff)*Fck (1)
pAsmin : 0.85/ Fy *100 (Min. Percentage Steel) (2)

**CONCRETE COST**

Cost of M20 concrete = Rs 4394 /$m^3$
Cost of M25 concrete = Rs 4440 /$m^3$
Cost of M30 concrete = Rs 4637 /$m^3$
Cost of M35concrete = Rs 4933 /$m^3$
Cost of M40 concrete = Rs 5327 /$m^3$

**STEEL COST**

Cost of Fe250 steel = Rs 46 /kg
Cost of Fe415 steel = Rs 52 /kg
Cost of Fe500 steel = Rs 55 /kg
Cost of Fe550 steel = Rs 57 /kg

**FORMWORK COST**

Cost of Formwork = Rs 320 /$m^2$

**DEPENDENT DESIGN DECISION VARIABLES**

Asmin : pAstmin * b *deff /100 (Min. Area of Steel) (3)
Asmax : pAsmax * b *D /100 (Max. Area of Steel) (4)
Mulim : Q * b * $deff^2$ (Limiting Moment) (5)

**Singly reinforced design :**

MuMax <= Mulim , Then Tension Steel Area reqd
Astreqd = 0.5 *Fck/Fy*[ 1 – Sqrt (1-4.6*MuMax / (Fck*b*deff2) ) ] *b*deff

**Shear Design:**

v = Vu / b * deff → (6)
*(Nominal shear Stress)*
Pt=100Ast/ b*d → (7)
*c = Depending upon Astprov (Area of Steel Tension provided) and Grade of Concrete Fck.*
*C > v (hence safe)*
Vus = Vu –(c * b *deff) → (8)
*Transverse Steel Shear resistance Required.*
Vus_pr = 0.87 *Fy * Asv_pr *deff / Sv_pr (9)

### 4.2.3DESIGN CONSTRAINTS

A)Bending Strength Related Constraints :
1) MuMax < = MOR_pr
B) Steel Constraints :
2) Astreqd < = Astprov
3) Astprov < = Asmax
4) Asmin < = Astprov
5) deff< = deff_pr
C) Side Face Steel Constraints :
7) AS_SF_reqd < = AS_SF_prov
8) SFRdistprov < = SFRdistmax

D) Upper and Lower Bound Constr. on Beam Sizes:
9) b< = bUL
10) bLL< = b
11) D < = DUL
12) DLL < = D

**4.2.4 OBJECTIVE FUNCTION**

The chief task of the optimization process is to select the values of variables in a way that satisfies the provisions of the code regarding safety and serviceability within the least cost possible, the function below defines the total cost of the RC simple beam model in terms of the cost of the concrete and reinforcement and form work used.

It can be stated as Total Beam Element Cost (BE_TC)

i.e. Total of all cost components (Concrete Reinforcement Steel and Formwork) :

**BE_TC = BE_CC + BE_FC + BE_RC (10)**

**4.2.5 R.C MEMBER**

Six hundred R.C beams are designed for moments in the range of 100kN-m to 300 kN-m and b/D in the range of 0.4 to 0.9.The grades of concrete considered are M20, M25, M30, M35 and M40.The grades of steel adopted – Fe 250, Fe415,Fe 500 and Fe550 .for example,(only given b/D=0.4)

**5.2 COST INFLUENCING FACTORS FOR SINGLY REINFORCED BEAM**

Six hundred R.C singly reinforced beams have been designed for bending moment of 100kN-m to 300kN-m with b/D ratio 0.4 to 0.9. The grades of concrete considered are $M_{20}$, $M_{25}$, $M_{30}$, $M_{35}$ and $M_{40}$.The grades of steel adopted are $Fe_{250}$, $Fe_{415}$, $Fe_{500}$ and $Fe_{550}$.The program have been developed using C language for the design of all the above mentioned structural components and MS -Excel has been made use of it. The estimation of cost of each of the designed structural element has been determined by using Excel sheets.

| Parameters | | Levels | | | | Parameters | Levels | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | | | 1 | 2 | 3 | 4 |
| A | Moment | 100 | 150 | 200 | 250 | C | Fy | 250 | 415 | 500 | 550 |
| B | Fck | 20 | 25 | 30 | 35 | D | b/D | 0.4 | 0.5 | 0.6 | 0.7 |

**Table1. Parameters and their values corresponding to their levels are studied from design for singly reinforced beam**

The orthogonal array $L_{16}$ is selected for the design to get the optimum input for obtaining minimum total cost. In this design the major input parameters are Moment, Fck, Fy and b/D are varied for four levels of the values are shown in table 5.3.

| SI.no | Moment kN-m | Fck N/mm^2 | Fy N/mm^2 | b/D Ratio | SI.no | Moment kN-m | Fck N/mm^2 | Fy N/mm^2 | b/D Ratio |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 100 | 20 | 250 | 0.4 | 9 | 200 | 20 | 500 | 0.7 |
| 2 | 100 | 25 | 415 | 0.5 | 10 | 200 | 25 | 550 | 0.6 |
| 3 | 100 | 30 | 500 | 0.6 | 11 | 200 | 30 | 250 | 0.5 |
| 4 | 100 | 35 | 550 | 0.7 | 12 | 200 | 35 | 415 | 0.4 |
| 5 | 150 | 20 | 415 | 0.6 | 13 | 250 | 20 | 550 | 0.5 |
| 6 | 150 | 25 | 250 | 0.7 | 14 | 250 | 25 | 500 | 0.4 |
| 7 | 150 | 30 | 550 | 0.4 | 15 | 250 | 30 | 415 | 0.7 |
| 8 | 150 | 35 | 500 | 0.5 | 16 | 250 | 35 | 250 | 0.6 |

**Table2 Input data arrangement $L_{16}$ Orthogonal array for singly reinforced beam**

**RESULT AND DISCUSSION**

Taguchi technique is used as a time consumption and to give accurate results. The main objective of using taguchi is to identify the optimal operating condition to obtain the minimum cost. For $L_{16}$ ($4^4$) has 16 trails has been carried out and repeated the trail four times to reduce the uncontrollable external factors that affects the design. The total cost for the trail is shown in the table 5.6.

| SI.no | Moment kN-m | Fck N/mm^2 | Fy N/mm^2 | b/D Ratio | Total Cost(Rs) | SI.no | Moment kN-m | Fck N/mm^2 | Fy N/mm^2 | b/D Ratio | Total Cost(Rs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 100 | 20 | 250 | 0.4 | 1195 | 9 | 200 | 20 | 500 | 0.7 | 2038 |
| 2 | 100 | 25 | 415 | 0.5 | 1098 | 10 | 200 | 25 | 550 | 0.6 | 2167 |
| 3 | 100 | 30 | 500 | 0.6 | 1198 | 11 | 200 | 30 | 250 | 0.5 | 1517 |
| 4 | 100 | 35 | 550 | 0.7 | 1265 | 12 | 200 | 35 | 415 | 0.4 | 1165 |
| 5 | 150 | 20 | 415 | 0.6 | 1592 | 13 | 250 | 20 | 550 | 0.5 | 2898 |
| 6 | 150 | 25 | 250 | 0.7 | 1958 | 14 | 250 | 25 | 500 | 0.4 | 1488 |
| 7 | 150 | 30 | 550 | 0.4 | 1178 | 15 | 250 | 30 | 415 | 0.7 | 2130 |
| 8 | 150 | 35 | 500 | 0.5 | 1337 | 16 | 250 | 35 | 250 | 0.6 | 2574 |

**Table 3 Designed Data for $L_{16}$ combination for singly reinforced beam**

The Minitab software was used to analyze the collected data. In this experiment for obtaining the minimum total cost performance characteristic select shorter the better. The formula to find the signal to noise ratio for larger is better.

$S=-10 \log 10\{(1/r)\sum_{i=1}^{r}(y)\}$

Where ,

r is the number of trial for the levels of the noise factors

$Y_i$= values of average total cost

The factors are classified into control factors and noise factors. The DOE for obtaining graph for the obtained results. In the response table for the ranking for each input parameters are obtained as follows.

| level | Moment kN-m | Fck N/mm^2 | Fy N/mm^2 | b/D Ratio |
|---|---|---|---|---|
| 1 | 1189 | 1931 | 1811 | 1257 |
| 2 | 1516 | 1678 | 1496 | 1713 |
| 3 | 1722 | 1506 | 1515 | 1883 |
| 4 | 2273 | 1585 | 1877 | 1848 |
| Delta | 1084 | 425 | 381 | 626 |
| Rank | 1 | 3 | 4 | 2 |

Table 4 Response Table for singly reinforced beam

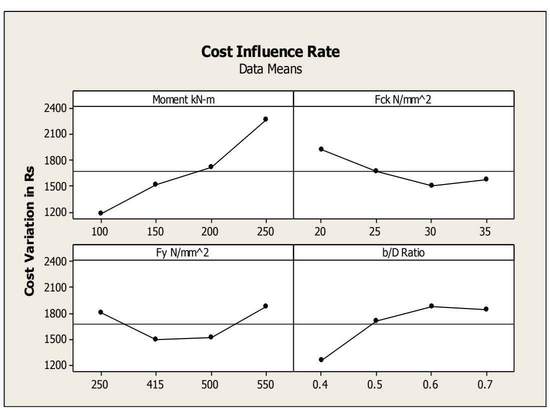


**Fig 1 Cost influence factors for singly reinforced beam**

ANNOVA is a method used to identify the contribution of each input parameter. From the result of ANNOVA operating moment has the large effect on the cost of element. In the weight level made the confidence level as 92.87%. The moment is the primary significant factor on the cost of element and the percentage of contribution for moment is 52.23%.

| FACTOR | DOF | Sum of square | Variance | Contribution (% ) |
|---|---|---|---|---|
| A | 2 | 2482357 | 1241179 | 52.23847911 |
| B | 2 | 408464.8 | 204232.4 | 8.856545674 |
| C | 2 | 467086.3 | 233543.1 | 10.1276076 |
| D | 2 | 998204.3 | 499102.1 | 21.64358499 |
| ERR | 7 | 255897.3 | 36556.75 | 7.13378262 |
| TOTAL | 15 | | | 92.873 |

**Table 5 Result of ANNOVA for $L_{16}$ design for singly reinforced beam**

**6.2 SINGLY REINFORCED BEAM**

INPUT DATA FOR NEURAL NETWORK

| SI.NO | Fck | Fy | b/D Ratio | Moment | Total cost | SI.NO | Fck | Fy | b/D Ratio | Moment | Total cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | N/mm^2 | N/mm^2 | | kN-m | Rs | | | | | | |
| 1 | 20 | 250 | 0.4 | 100 | 1195 | 76 | 20 | 250 | 0.6 | 150 | 1952 |
| 2 | 25 | 250 | 0.4 | 100 | 1154 | 77 | 25 | 250 | 0.6 | 150 | 1832 |
| 3 | 30 | 250 | 0.4 | 100 | 1139 | 78 | 30 | 250 | 0.6 | 150 | 1899 |
| 4 | 35 | 250 | 0.4 | 100 | 1138 | 79 | 35 | 250 | 0.6 | 150 | 1850 |
| 5 | 40 | 250 | 0.4 | 100 | 1145 | 80 | 40 | 250 | 0.6 | 150 | 1920 |
| 6 | 20 | 415 | 0.4 | 100 | 988 | 81 | 20 | 415 | 0.6 | 150 | 1593 |
| 7 | 25 | 415 | 0.4 | 100 | 933 | 82 | 25 | 415 | 0.6 | 150 | 1475 |
| 8 | 30 | 415 | 0.4 | 100 | 906 | 83 | 30 | 415 | 0.6 | 150 | 1513 |
| 9 | 35 | 415 | 0.4 | 100 | 895 | 84 | 35 | 415 | 0.6 | 150 | 1466 |
| 10 | 40 | 415 | 0.4 | 100 | 893 | 85 | 40 | 415 | 0.6 | 150 | 1422 |
| 11 | 20 | 500 | 0.4 | 100 | 976 | 86 | 20 | 500 | 0.6 | 150 | 1698 |
| 12 | 25 | 500 | 0.4 | 100 | 920 | 87 | 25 | 500 | 0.6 | 150 | 1578 |
| 13 | 30 | 500 | 0.4 | 100 | 892 | 88 | 30 | 500 | 0.6 | 150 | 1505 |
| 14 | 35 | 500 | 0.4 | 100 | 879 | 89 | 35 | 500 | 0.6 | 150 | 1458 |
| 15 | 40 | 500 | 0.4 | 100 | 872 | 90 | 40 | 500 | 0.6 | 150 | 1426 |
| 16 | 20 | 250 | 0.4 | 150 | 1526 | 91 | 20 | 250 | 0.7 | 200 | 2112 |
| 17 | 25 | 250 | 0.4 | 150 | 1474 | 92 | 25 | 250 | 0.7 | 200 | 2088 |
| 18 | 30 | 250 | 0.4 | 150 | 1455 | 93 | 30 | 250 | 0.7 | 200 | 2054 |
| 19 | 35 | 250 | 0.4 | 150 | 1454 | 94 | 35 | 250 | 0.7 | 200 | 2112 |
| 20 | 40 | 250 | 0.4 | 150 | 1464 | 95 | 40 | 250 | 0.7 | 200 | 2172 |
| 21 | 20 | 415 | 0.4 | 150 | 1259 | 96 | 20 | 415 | 0.7 | 200 | 1683 |
| 22 | 25 | 415 | 0.4 | 150 | 1188 | 97 | 25 | 415 | 0.7 | 200 | 1710 |
| 23 | 30 | 415 | 0.4 | 150 | 1155 | 98 | 30 | 415 | 0.7 | 200 | 1639 |
| 24 | 35 | 415 | 0.4 | 150 | 1140 | 99 | 35 | 415 | 0.7 | 200 | 1596 |
| 25 | 40 | 415 | 0.4 | 150 | 1138 | 100 | 40 | 415 | 0.7 | 200 | 1569 |
| 26 | 20 | 500 | 0.4 | 150 | 1240 | 101 | 20 | 500 | 0.7 | 200 | 1802 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 27 | 25 | 500 | 0.4 | 150 | 1167 | 102 | 25 | 500 | 0.7 | 200 | 1675 |
| 28 | 30 | 500 | 0.4 | 150 | 1132 | 103 | 30 | 500 | 0.7 | 200 | 1583 |
| 29 | 35 | 500 | 0.4 | 150 | 1116 | 104 | 35 | 500 | 0.7 | 200 | 1589 |
| 30 | 40 | 500 | 0.4 | 150 | 1030 | 105 | 40 | 500 | 0.7 | 200 | 1722 |
| 31 | 20 | 250 | 0.5 | 200 | 1988 | 106 | 20 | 250 | 0.7 | 200 | 2584 |
| 32 | 25 | 250 | 0.5 | 200 | 2002 | 107 | 25 | 250 | 0.7 | 200 | 2417 |
| 33 | 30 | 250 | 0.5 | 200 | 1926 | 108 | 30 | 250 | 0.7 | 200 | 2436 |
| 34 | 35 | 250 | 0.5 | 200 | 1981 | 109 | 35 | 250 | 0.7 | 200 | 2384 |
| 35 | 40 | 250 | 0.5 | 200 | 2028 | 110 | 40 | 250 | 0.7 | 200 | 2374 |
| 36 | 20 | 415 | 0.5 | 200 | 1740 | 111 | 20 | 415 | 0.7 | 200 | 2008 |
| 37 | 25 | 415 | 0.5 | 200 | 1593 | 112 | 25 | 415 | 0.7 | 200 | 1864 |
| 38 | 30 | 415 | 0.5 | 200 | 1518 | 113 | 30 | 415 | 0.7 | 200 | 1913 |
| 39 | 35 | 415 | 0.5 | 200 | 1643 | 114 | 35 | 415 | 0.7 | 200 | 1843 |
| 40 | 40 | 415 | 0.5 | 200 | 1495 | 115 | 40 | 415 | 0.7 | 200 | 1794 |
| 41 | 20 | 500 | 0.5 | 200 | 1703 | 116 | 20 | 500 | 0.7 | 200 | 1935 |
| 42 | 25 | 500 | 0.5 | 200 | 1575 | 117 | 25 | 500 | 0.7 | 200 | 1943 |
| 43 | 30 | 500 | 0.5 | 200 | 1635 | 118 | 30 | 500 | 0.7 | 200 | 1908 |
| 44 | 35 | 500 | 0.5 | 200 | 1588 | 119 | 35 | 500 | 0.7 | 200 | 1839 |
| 45 | 40 | 500 | 0.5 | 200 | 1560 | 120 | 40 | 500 | 0.7 | 200 | 1812 |
| 46 | 20 | 250 | 0.5 | 250 | 2311 | 121 | 20 | 250 | 0.8 | 100 | 1490 |
| 47 | 25 | 250 | 0.5 | 250 | 2290 | 122 | 25 | 250 | 0.8 | 100 | 1455 |
| 48 | 30 | 250 | 0.5 | 250 | 2183 | 123 | 30 | 250 | 0.8 | 100 | 1390 |
| 49 | 35 | 250 | 0.5 | 250 | 2290 | 124 | 35 | 250 | 0.8 | 100 | 1425 |
| 50 | 40 | 250 | 0.5 | 250 | 2255 | 125 | 40 | 250 | 0.8 | 100 | 1406 |
| 51 | 20 | 415 | 0.5 | 250 | 1893 | 126 | 20 | 415 | 0.8 | 100 | 1180 |
| 52 | 25 | 415 | 0.5 | 250 | 1921 | 127 | 25 | 415 | 0.8 | 100 | 1166 |
| 53 | 30 | 415 | 0.5 | 250 | 1814 | 128 | 30 | 415 | 0.8 | 100 | 1102 |
| 54 | 35 | 415 | 0.5 | 250 | 1760 | 129 | 35 | 415 | 0.8 | 100 | 1072 |
| 55 | 40 | 415 | 0.5 | 250 | 1728 | 130 | 40 | 415 | 0.8 | 100 | 1126 |
| 56 | 20 | 500 | 0.5 | 250 | 1995 | 131 | 20 | 500 | 0.8 | 100 | 1170 |
| 57 | 25 | 500 | 0.5 | 250 | 1848 | 132 | 25 | 500 | 0.8 | 100 | 1168 |
| 58 | 30 | 500 | 0.5 | 250 | 1760 | 133 | 30 | 500 | 0.8 | 100 | 1118 |
| 59 | 35 | 500 | 0.5 | 250 | 1686 | 134 | 35 | 500 | 0.8 | 100 | 1073 |
| 60 | 40 | 500 | 0.5 | 250 | 1807 | 135 | 40 | 500 | 0.8 | 100 | 1057 |
| 61 | 20 | 250 | 0.6 | 100 | 1511 | 136 | 20 | 250 | 0.8 | 150 | 1919 |
| 62 | 25 | 250 | 0.6 | 100 | 1486 | 137 | 25 | 250 | 0.8 | 150 | 1829 |
| 63 | 30 | 250 | 0.6 | 100 | 1496 | 138 | 30 | 250 | 0.8 | 150 | 1866 |
| 64 | 35 | 250 | 0.6 | 100 | 1458 | 139 | 35 | 250 | 0.8 | 150 | 1809 |
| 65 | 40 | 250 | 0.6 | 100 | 1500 | 140 | 40 | 250 | 0.8 | 150 | 1887 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 66 | 20 | 415 | 0.6 | 100 | 1338 | 141 | 20 | 415 | 0.8 | 150 | 1582 |
| 67 | 25 | 415 | 0.6 | 100 | 1196 | 142 | 25 | 415 | 0.8 | 150 | 1453 |
| 68 | 30 | 415 | 0.6 | 100 | 1210 | 143 | 30 | 415 | 0.8 | 150 | 1390 |
| 69 | 35 | 415 | 0.6 | 100 | 1174 | 144 | 35 | 415 | 0.8 | 150 | 1352 |
| 70 | 40 | 415 | 0.6 | 100 | 1137 | 145 | 40 | 415 | 0.8 | 150 | 1481 |
| 71 | 20 | 500 | 0.6 | 100 | 1296 | 146 | 20 | 500 | 0.8 | 150 | 1557 |
| 72 | 25 | 500 | 0.6 | 100 | 1170 | 147 | 25 | 500 | 0.8 | 150 | 1427 |
| 73 | 30 | 500 | 0.6 | 100 | 1198 | 148 | 30 | 500 | 0.8 | 150 | 1364 |
| 74 | 35 | 500 | 0.6 | 100 | 1162 | 149 | 35 | 500 | 0.8 | 150 | 1326 |
| 75 | 40 | 500 | 0.6 | 100 | 1140 | 150 | 40 | 500 | 0.8 | 150 | 1287 |

Table 6:

RESULTS AND CONCLUSION:

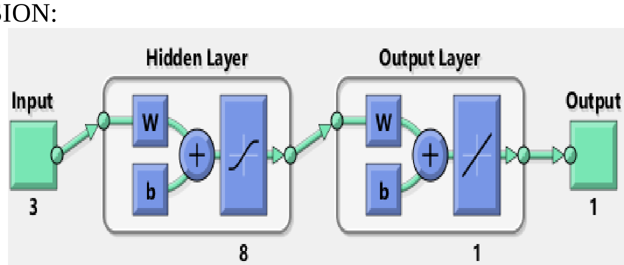


**Fig 2 Artificial neural network arrangement for singly reinforced beam**

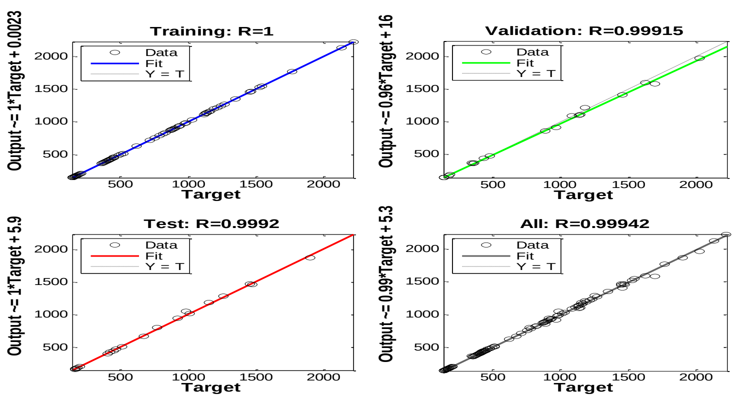


**Fig 3 Graph showing accuracy of result for singly reinforced beam**

| SI.no | Fck N/mm^2 | Fy N/mm^2 | b/D Ratio | Moment kN-m | Neural network result Total cost Rs | Obtained result Total cost Rs | percentage |
|---|---|---|---|---|---|---|---|
| 1 | 20 | 250 | 0.4 | 300 | 2094 | 2155 | 0.418183 |
| 2 | 25 | 250 | 0.4 | 300 | 1998 | 2060 | 0.530152 |
| 3 | 30 | 250 | 0.4 | 300 | 2073 | 2020 | 0.279355 |
| 4 | 35 | 250 | 0.4 | 300 | 1953 | 2008 | 0.595195 |
| 5 | 40 | 250 | 0.4 | 300 | 2067 | 2015 | 0.793499 |
| 6 | 20 | 415 | 0.4 | 300 | 1754 | 1809 | 0.812473 |
| 7 | 40 | 415 | 0.5 | 100 | 2223 | 2189 | 0.450567 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 8 | 20 | 500 | 0.5 | 100 | 3496 | 3562 | 0.377053 |
| 9 | 25 | 500 | 0.5 | 100 | 3142 | 3070 | 0.457049 |
| 10 | 30 | 500 | 0.5 | 100 | 2648 | 2719 | 0.726416 |
| 11 | 35 | 500 | 0.5 | 100 | 2394 | 2453 | 0.578064 |
| 12 | 40 | 500 | 0.5 | 100 | 2195 | 2244 | 0.634968 |
| 13 | 20 | 500 | 0.6 | 300 | 2356 | 2311 | 0.452037 |
| 14 | 25 | 500 | 0.6 | 300 | 2286 | 2332 | 0.249636 |
| 15 | 30 | 500 | 0.6 | 300 | 2186 | 2224 | 0.70809 |
| 16 | 35 | 500 | 0.6 | 300 | 2193 | 2155 | 0.610928 |
| 17 | 40 | 500 | 0.6 | 300 | 2069 | 2114 | 0.220687 |

**Table 7 Testing Data of ANN for singly reinforced beam**

Table 7 shows the design data chosen for testing purpose using ANN technique in MATLAB. These valves are used to the optimum values. Using this input parameter the optimized valves of total cost is obtained. Trained experimental minimum error is 0.00001254 and tested experimental minimum error is 0.000012123. by comparing experimental valve and ANN 99% of accuracy was obtained.

**RESULT AND CONCLUSIONS**

**1. SINGLY REINFORCED BEAM**

7.1.1Results from Taguchi and Annova technique

- Mainly four factors influence the total cost of singly reinforced beam elements, namely Moment, fck, fy, b/D ratio.
- The optimal solution for singly reinforced beam design was done using M30 grade of concrete and Fe 500 grade of steel and b/D ratio of 0.4.
- In ANNOVA method, it clearly shows that
  - 52% total cost is influenced by moment
  - 21% total cost is influenced by b/D ratio
  - 10% total cost is influenced by fck
  - 8% total cost is influenced by fy.

7.1.2 Results from artificial neural network

- The table 7 shows the design data chosen for testing purpose using ANN technique in MATLAB. These valves are used to the optimum values.
- Using this input parameter the optimized valves of total cost is obtained.
- Trained experimental minimum error is 0.000001254
- Tested experimental minimum error is 0.000001212
- By comparing manual valve and ANN 99% of accuracy was obtained.

Thus it is concluded that the optimization done by Artificial Neural Network is more effective than the manual optimization method.

**REFERENCE**

1. Salim T.Yousif, Ikhlas S.Slsaffar, Saddam M.Ahmed, (2006) "Optimum Design of Singly and Doubly Reinforced Concrete Rectangular Beam Sections: Artificial Neural Networks Application ",Iraqi Journal of Civil Engineering Vol. 6, No. 3, pp. 1-19 , *doi*: 10.12691/ajcea-3-5-2, *ISSN*: 74281992
2. Zubin S. Mehta, ,(2006) "Cost Optimization of Concrete Beam Element - By Direct Exhaustive Search Method", Indian Journal of Engineering & Materials Sciences Vol. 13, pp. 503-511, *DOI*: 10.17706, ISSN: 0975-1017
3. 3.Balachandra.S.A,Adsul.P.K,(2012) "Cost Optimization Of Doubly Reinforced Rectangular" International journal of Modern Engineering Research (IJMER)-Vol 2 Issue 5,pp.3939-3942, *DOI*: 10.5923/j.ijea.20120202.01 ISSN: 2249-6645
4. 4.Sara A. Babiker, Fathelrahman. M. Adam, Abdelrahman E. Mohamed, ,(2012) " DESIGN OPTIMIZATION OF REINFORCED CONCRETE BEAMS USING ARTIFICIAL NEURAL NETWORK" International Journal of Engineering Inventions, Volume 1, Issue 8,PP: 07-13, *DOI*: 10.5120/8522-2485, ISSN: 2278-7461
5. Krishnaraju.N (2009). Advanced Reinforced concrete design, CBS Publishers and Distributors, New Delhi, Bangalore.
6. Krishnaraju.N (2009). Reinforced concrete design, CBS Publishers and Distributors, New Delhi, Bangalore.