Analysis on Composite Steel Tubes using Genetic Algorithm

Chaithrashree R
PG Student, M Tech
Dept of Civil Engineering
Ghousia College of Engineering
Ramanagaram

Dr. N S Kumar
Professor & Director (R&D)
Dept of Civil Engineering
Ghousia College of Engineering
Ramanagaram

***Abstract*: - In this research investigation on the behaviour of Self Compacting Concrete Filled steel tube (CFST) is carried out. Composite Circular hallow steel tubes with infill of different grades of Self Compacting Concrete are tested for ultimate load capacity. The Obtained results were compared with American Concrete Institute (ACI), Euro Code-4(EC-4) and modelling is carried out using GA (Genetic Algorithm) technique which is a soft tool in Matlab-R2018b. GAs technique is based on natural evolution where provides a robust solution for a given problem. The developed GA model has been verified with the experimental results conducted on composite steel columns. In that way, an alternative efficient method is aimed to develop for the solution of the present problem, which provides avoiding loss of time for computing some necessary parameters.**

Keywords: Genetic Algorithm, MATLAB, VBA, Composite steel Column.

1. INTRODUCTION

Column occupies a vital place in any civil engineering structural system. Weakness or failure of a column destabilizes the entire structure. Strength and ductility of steel columns need to be ensured through adequate strengthening, repair and rehabilitation techniques to maintain adequate structural performance. In India reinforced concrete members are mostly used in the framing system for most of the buildings since this is the most convenient & economic system for low-rise buildings. However, for medium to high rise buildings this type of structure is no longer economic because of increased dead load, high stiffness, span restriction and hazardous formwork.

Recently, composite columns are finding a lot of usage for seismic résistance. Composite members combine both steel and concrete, resulting in a member that has the beneficial qualities for both the materials. Steel members have the advantages of high tensile strength and ductility, while concrete members have the advantages of high compressive strength and stiffness. In order to prevent shear failure of RC column resulting in storey collapse of building, it is necessary to make ductility of column larger, recently, most of building utilizes this Concrete Filled Steel tubes (CFST) concept as primary for lateral load resisting frames. The concrete used for encasing the structural steel section not only enhances its strength & stiffness, but also protects it from fire damages.

1.1 GENETIC ALGORITHM

Genetic Algorithm (GA) on the other hand is a stochastic global searching and optimization algorithm that based on Darwin's biological theory of evolution and the Mendel's Genetic principle of genes.GA is used to solve complicated problems by simulating the evolutionary course of natural selection and natural inheritance of biological circles, featured by many advantages such as simple searching method, strong robustness, global parallel searching and is suitable to solve the complex problems of large scale. GA optimize the encoding which composed by parameters, according to a certain fitness function and genetic operations (selection, cross over and mutation) on the individual implementations of the evolution, so that high fitness value individual has been preserved and form a new group. While the individual of a new group is evolving, fitness value is increasing continually until the limit meets certain conditions. At this point the highest fitness value of the individual shall be the optimum solution. However GA also has its own shortages such as lower local convergence speed inkling to premature convergence etc.

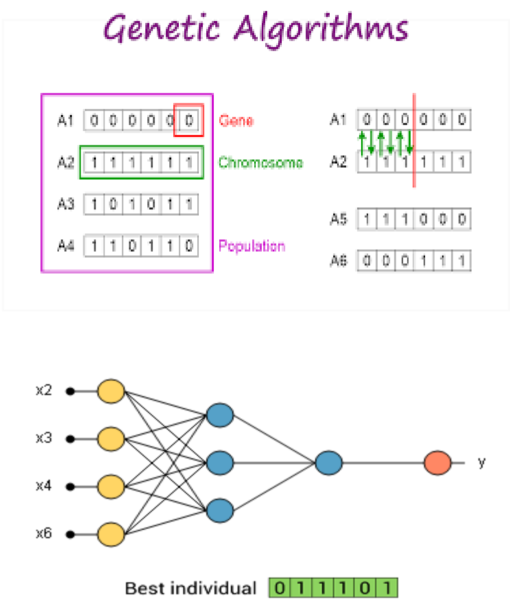

Fig.1. Genetic Algorithm sample

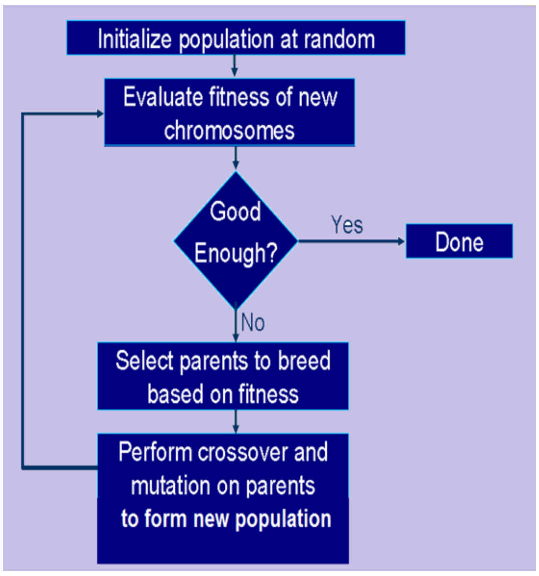

Fig .2.Flow Chart

BENEFITS OF GA:

The concept of Genetic Algorithms is

- Easy to understand,
- Good for noisy Environment.
- We always get an answer and the answer gets better with time
- Inherently parallel and easily distributed.
- Easy to exploit for previous or alternate solutions.
- Flexible in forming building blocks for hybrid applications.

1.2 Composite Steel Column:

A steel-concrete composite column is conventionally a compression member in which the steel element is a structural steel section. There are three types of composite columns used in practice which are Concrete Encased, Concrete filled, Battered Section.

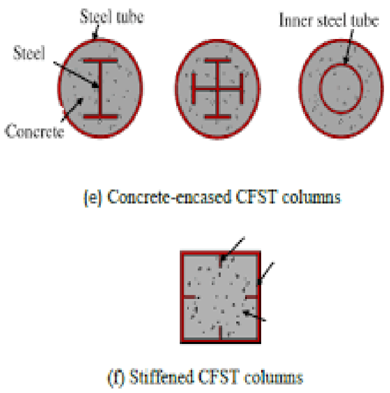

Fig.3.Types of CFST

Advantages of composite structure:

1. Most effective utilization of materials viz. concrete in compression and steel in tension.
2. Steel can be deformed in a ductile manner without premature failure and can withstand numerous loading cycles before fracture. Such high ductility of steel leads to better seismic resistance of the composite section.
3. Steel component has the ability to absorb the energy released due to seismic forces.
4. Ability to cover large column free area. This leads to more usable space. Area occupied by composite column is less than the area occupied by RCC column.
5. Quality of steel is assured since it is produced under Control environment in the factory. Larger use of Steel in composite construction compare to RCC
Option ensures better quality for the major part of the structure.

1.3 Self-compacting concrete:

Self-compacting concrete is a high-performance concrete which is highly flow able or self-levelling cohesive concrete that can be easily placed in the tight reinforcement. It is also known as super workable concrete. As the name suggest, this concrete compacts by itself without the use of external vibrators. Some admixtures are used to reduce the yield stress in SCC such as HRWR (high range water-reducing admixture), and the viscosity is increased by using VMA (viscosity modifying admixture).

Advantages of SCC
1. Faster construction and requires less manpower reduce the overall cost of production.
2. SCC can be placed easily in complicated formwork and dense reinforcement.
3. It is super workable due to its low water-cement ratio, which gives rapid strength development, more durability, and best quality.
4. As it is self-compacted there are no needs to use any vibrator.
5. Bleeding and segregation problems are almost nil.

2. Material Properties:

STEEL

a) Material: Structural Steel Fe 415
b) Young’s Modulus E=210000Mpa
c) Poison’s ratio =0.3
d) Density =7860kg/m3.

CONCRETEPROPERTIES

a) Grade of Concrete: M30
b) Young’s Modulus E=25000Mpa
c) Poison’s ratio = 0.16
d) Density=2400kg/m3

WORK FLOW

- Defining Structural problem.
- Determination of Objective Function, Design Variables and Constraints.
- Development of VBA (visual basic application) code for design.
- Development of MATLAB programme.
- Solving problem Using Optimization Technique.

Table 1: Collection of data and comparison

Year	Grade	Diameter	Length	Thickness	D/t	L/D	Pu(Exp)	Pu(Ec-4)	Pu(Aci)
		mm	mm	mm			Kn	Kn	Kn
2007	Hallow	160	750.4	2.5	64	4.69	361.4	367.275	367.275
2007	M20	160	750.4	2.5	64	4.69	491.3	624.468	646.3244
2007	M30	160	750.4	2.5	64	4.69	693.3	713.1	738.0585
2010	Hallow	139.6	800	4	34.9	5.73	453.3	450.63	450.63
2010	M20	139.6	800	4	34.9	5.73	598.6	612.53	633.9686
2010	M30	139.6	800	4	34.9	5.73	712.4	748.5	774.6975
2010	Hallow	139.6	2000	4	34.9	14.32	470.5	460.63	460.63
2010	M20	139.6	2000	4	34.9	14.32	610.3	612.53	633.9686
2010	M30	139.6	2000	4	34.9	14.32	739	748.478	774.6747
2011	Hallow	111.25	750.4	2.5	44.5	6.75	267.3	270.7	270.7
2011	M20	111.25	750.4	2.5	44.5	6.75	331.3	347.9	360.0765
2011	M30	111.25	750.4	2.5	44.5	6.75	427.3	436.6	451.881
2013	Hallow	160	400	2.8	57.14	2.5	261.3	276.42	276.42
2013	M20	160	400	2.8	57.14	2.5	297.5	302.54	313.1289
2013	M30	160	400	2.8	57.14	2.5	371	398	411.93
2013	Hallow	160	1000	2.8	57.142	6.25	283.3	276.42	276.42
2013	M20	160	1000	2.8	57.142	6.25	643	650.7	673.4745
2013	M30	160	1000	2.8	57.142	6.25	687	707.8	732.573
2014	Hallow	60.3	301.5	2.9	20.79	5	99.5	104.53	104.53
2014	M20	60.3	301.5	2.9	20.79	5	153.7	151.1	156.3885
2014	M30	60.3	301.5	2.9	20.79	5	182.1	174.4	180.504
2014	Hallow	60.3	422.1	3.6	16.75	7	112.6	128.2	128.2
2014	M20	60.3	422.1	3.6	16.75	7	168.2	172.8	178.848
2014	M30	60.3	422.1	3.6	16.75	7	195.6	194.6	201.411
2016	Hallow	26.9	215.8	3.2	8.4	8	70	77.7	77.7
2016	M20	26.9	215.8	3.2	8.4	8	80	84.3	87.2505
2016	M30	26.9	215.8	3.2	8.4	8	90	94.3	97.6005
2016	Hallow	26.9	404.8	3.2	8.4	15	75	77.7	77.7
2016	M20	26.9	404.8	3.2	8.4	15	88.3	84.3	87.2505
2016	M30	26.9	404.8	3.2	8.4	15	93.7	94.3	97.6005
2016	Hallow	33.7	215.8	3.2	10.53	6.4	84	81.3	8103
2016	M20	33.7	215.8	3.2	10.53	6.4	101.7	103	106.605
2016	M30	33.7	215.8	3.2	10.53	6.4	112.3	109	112.815
2016	Hallow	33.7	404.8	3.2	10.53	12	90	81.3	81.3
2016	M20	33.7	404.8	3.2	10.53	12	110	103	106.605
2016	M30	33.7	404.8	3.2	10.53	12	120	109	112.815

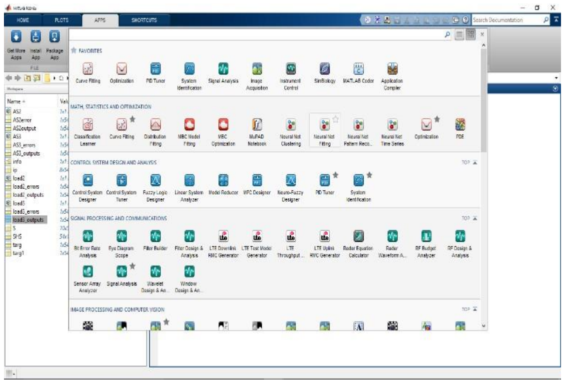

Fig-4 Different Tools in Matlab

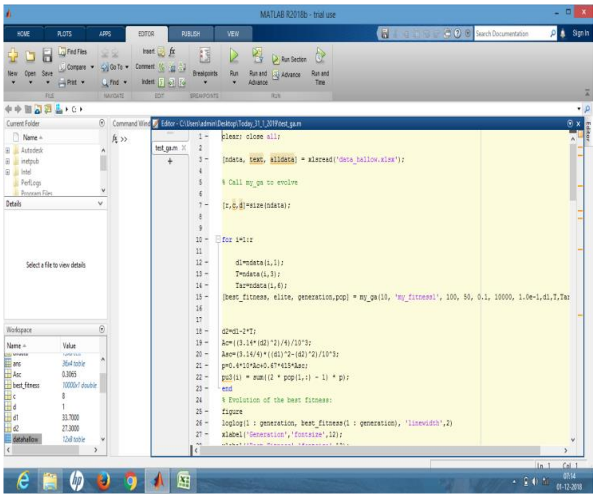

Fig-5 GA Programming

4. Predicted and experimental results:

After collecting the data from experimented conducted by previous researches and creating the model using GA soft-tool to train the the input data to predict the ultimate axial load capacity of the CFST tubes, The below table shows the values obtained from the analysis from different Iterations.

Table 2.Ultimate Load values in GA

Diameter (mm)	Length (mm)	Thickness (mm)	D/t	L/d	p_u(GA) KN For M20	p_u(GA) KN For M30
160	750.4	2.5	64	4.69	606.99	702.3
139.6	800	4	34.9	5.73	611.608	721.4
	2000	4	34.9	14.32	622.3	748.9
111.25	750.4	2.5	44.5	6.75	346.3	434.29
160	400	2.8	57.17	2.5	304.49	376.99
	1000	2.8	57.14	6.25	652	701.99
60.3	301.5	2.9	20.79	5	164.69	196.1
	422.1	3.6	16.75	7	180.20	208.59
26.9	215.8	3.2	8.4	8	90.99	96.99
	404.8	3.2	8.4	15	101.30	108.69
33.7	215.8	3.2	10.53	6.4	116.70	127.29
	404.8	3.2	10.53	12	116	132

5.Graphical Representation of GA Results

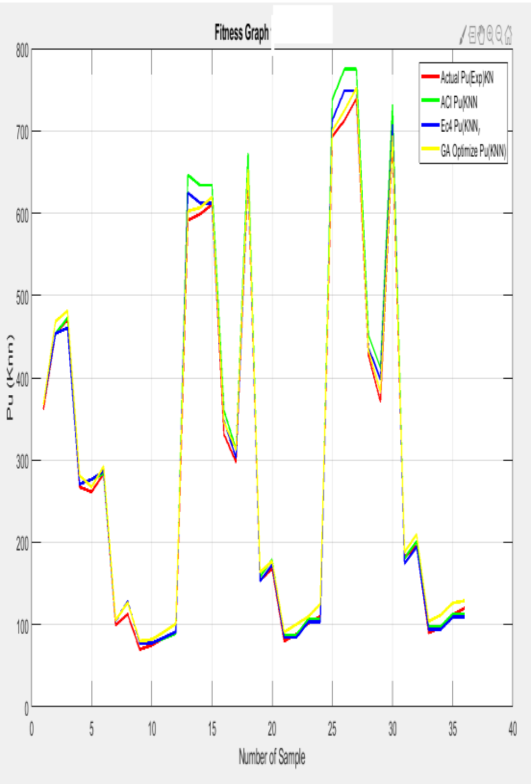

Fig 6. Fitness Graph

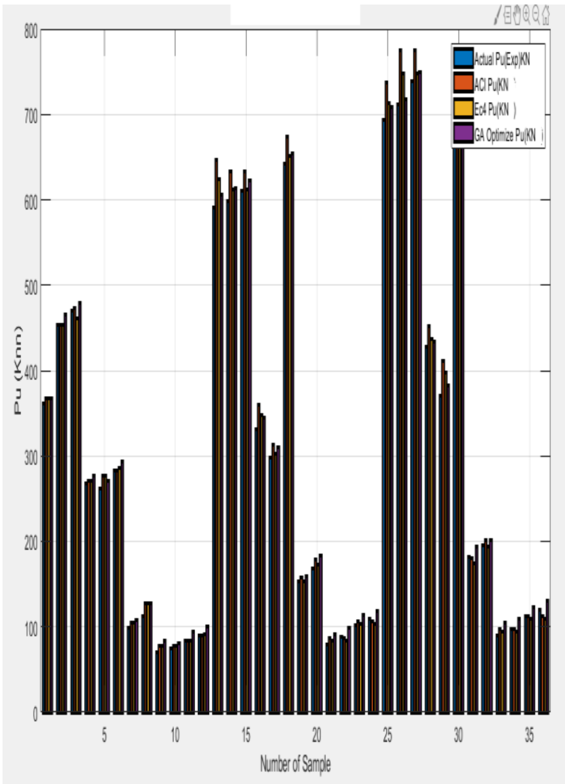

Fig7.Ultimate Axial Load

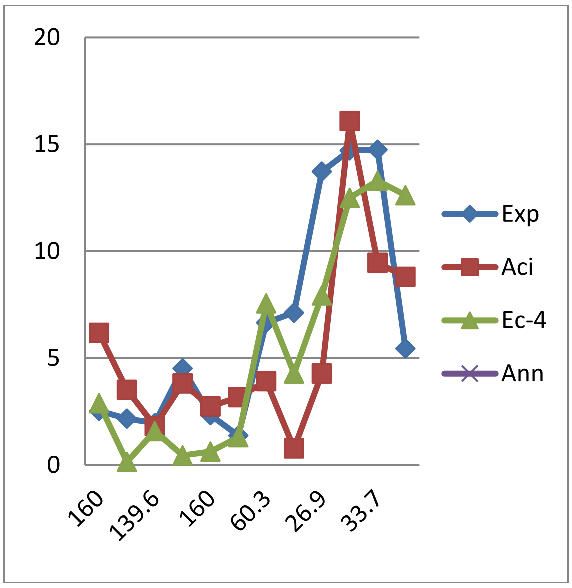

Fig.8, % error for M-20

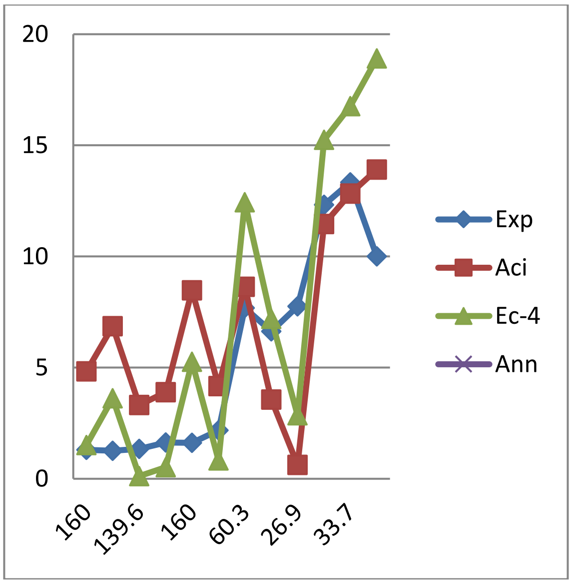

Fig.9 % error for M-30

4. *Results and discussion:*

The GA is a soft-tool in MATLAB R2018b Software (matrices laboratory) is one way of including specimen irregularities in the model using the results of the behavior of SCC infilled composite tubes subjected to different loadings.

The Genetic Algorithm Programming has been shown to successfully predict the ultimate load of the composite steel tubes. In which input layer consists of 6 parameters like grade, dia, length, thickness, D/t and L/D and one target value i.e., exp P_u. GA shows good results with less error.

7. CONCLUSION

- Percentage variation of Ultimate load values GA programming with Experimental values obtained from Previous Researches (International journal and from R&D work from civil engineering PG students) were found to be vary from 2% to 15%.
- It is observed that % of error is inversely proportional to Ultimate load values from Experiment.
- Percentage variation of Pu reduces using GA programming in comparison with ACI and EC4.
- As grade of concrete increases from M 20 to M 30 values % of error in the values of Pu w.r.t Experiment and EC4 found to be decreasing than from ACI and ANN.
- Values of Pu increases as diameter of steel tube increases with increase in grade of concrete as observed from GA model.
- As infill Grade of concrete increases for the same diameter of steel tube, Percentage of Pu values obtained from Pu(EXPT) varies by 2% GA values.
- As when the diameter increases and decrease in length the load carrying capacity of CFST columns increases.
- The results are compared with EURO CODE-4, ACI and are proved to be with ANN values.
- It can be concluded that the application of NNs in concrete field is more user-friendly and more precise model.

REFERENCES

[1] Rajashekharan S &Vijaylakshmi Pai G A,*Neutal networks,Fuzzy logic and Genetic Algorithms*(Prentice Hall of India, New Delhi),2003.
[2] Chee Kiong Soh[1] and Yaowen Yang[2] "Genetic programming-based approach for Structural Optimization"
[3] Malleshappa Malapur M[1], Prateek Cholappanavar[2], R.J.Fernandes[3]
[4] "OPTIMIZATION OF RC COLUMN AND FOOTINGS USING GENETIC
[5] ALGORITHM" IRJET vol.5, issue-8,Aug 2018.
[6] Sharad Man Shrestha[1] and Jamshid Ghaboussi[2] "Evolution of optimum Structural shapes using Genetic Algorithm"
[7] G. S. Wang [1] F. K. Huang [2] and H. H. Lin [3] " Application of Genetic Algorithm to Structural Dynamic Parameter Identification"
[8] Ayaho Miyamoto[1]; Hideaki Nakamura[2]; and Leopold Kruszka[3] "Application of the Improved Immune Algorithm to Structural Design Support System"
[9] Eurocode 4. Design of composite steel and concrete structures, part 1.1:general rules for buildings. Commission ofEuropean communities, British standards institution;1994.
[10] ACI 318-99. Building code requirements for structural concrete and commentary. Farmington Hills(MI), American Concrete Institute, Detroit, USA, 1999.