Impact Factor (SJIF): 4.542

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444

Volume 4, Issue 4, April-2017

Optimization of Beam- Column using Harmony Search Algorithm

Gunjan R. Chauhan[#1,3], Vishal B. Patel[#2,4], Vishal A. Arekar[#2,5]

[#]Structural Engineering Department, BVM engineering college
V V Nagar, Anand, India.

[1]Research Scholar, [2]Assistant Professor

Abstract — *In the present paper a research work for optimization of beam column section has been described using a newly developed meta heuristic algorithm which is the harmony search algorithm. In structural design of building the designer comes across to design the column which is subjected to combined axial force and biaxial moment. There is many design software available for such purposes like STAAD.PRO, ETABS, and SAP etc. But this software is not a reliable source for designing the building. A beam column section has been optimized using STAAD design tool. The research on the design results given by STAAD shows that the given steel section does not satisfy the requirement given by the Indian Standard Code 800:2007. Hence the given section cannot be used as a building member while construction. To overcome this a Visual Basic program is developed by the author to give the optimized steel section. The optimization method used for developing the program is Harmony Search Algorithm with adaptive pitch adjustment rate. The program uses the input data entered by user and gives optimized section for given conditions. The results show that the program is reliable and satisfies all Indian code requirements as compared to other software.*

Keywords-structural optimization, harmony search method, Beam column.

I. INTRODUCTION

The harmony search method is a modern invention in the field of optimization, developed by Geem in 2001. Optimization using this algorithm is analogues to the improvisation of jazz music. In case of jazz music musician try to find a perfect state of harmony through repetitive practice on the instruments. Similarly, through number of iterations algorithm finds the best acceptable solution. This algorithm is very simple to understand and to code it in preferred coding language. Due to this reason it has been gaining popularities year after year in the field of optimization. In the present work a program has been developed for optimization of beam column with programing tool visual basics.

II. HARMONY SEARCH ALGORITHM

The harmony search algorithm is a newly developed optimization algorithm developed by Geem, Kim and Loganathan in 2001. It is based on an analogy to musical improvisation of jazz, where musicians try to find, through repeated iterations, the aesthetically pleasant harmony given (optimum solution to a problem). Iterations are called improvisations or practice. Variables analogues to musical instruments. Values for variables are the notes of instruments. Every solution is called harmony. Through repetitive random search technique, a new harmony vector is generated which replaces worst harmony in harmony memory. The analogy between harmony search and optimization problem is shown in table 1.

TABLE I: ANALOGY BETWEEN HARMONY SEARCH AND OPTIMIZATION PROBLEM

Harmony search	**Optimization problem**
Instruments	Components of the system being optimized
Notes: sets of possible tones to be played by musicians	design variables: set of possible design values for system components
Chord: specific collection of notes	design: specific collection of design variables
Harmony: synthesis of all notes	objective function: synthesis of all design variables
Goal: maximize harmony	goal: extremize objective function
Process: trial and error, improvise new harmonies and try them out	process: improvise on designs by trial and error

In general, mathematical optimization problems, harmony search uses the harmony memory (HM) to store the solutions, and the harmony memory size (HMS) gives the number of solutions stored in the harmony memory. The harmony memory is initialized by assigning random values to every design variable from its possible range of values. With the help of initial HM, the value of the objective function for every harmony is calculated and the harmony with the worst objective function value is determined. In each iteration a new harmony is improvised and its objective function is calculated, if it gives a better objective function value, it replaces the worst harmony in the harmony memory and the harmony memory is updated. The previous procedure is again repeated till a termination criterion is met which is normally maximum number of iterations or until no further improvement of harmony or design performance can be achieved. The following figure (fig.1) shows the flowchart of harmony search algorithm.

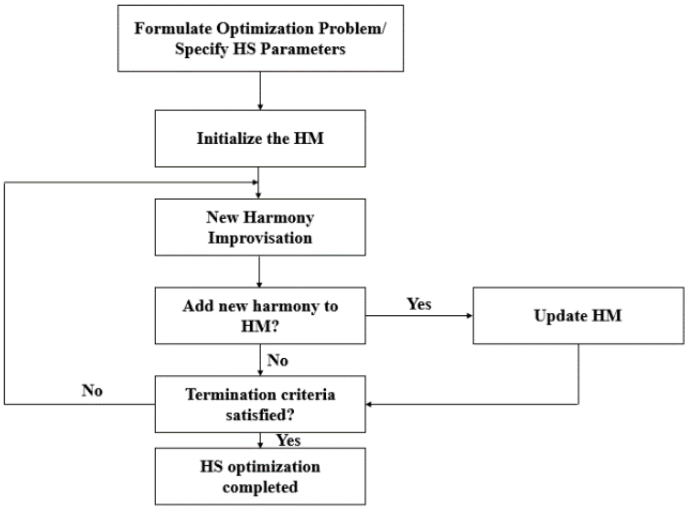

Figure 1: Flow chart of harmony search algorithm

In the Improved Harmony Search (IHS), Mahdavi suggested that 'par' increase linearly and 'bw' decrease exponentially with iterations. Therefore, mathematic expressions were adapted into these parameters to follow the iteration change:

par = parmin + (parmax – parmin) * (t/ NI)

c = Log ((bwmin / bwmax)) / NI

bw = bwmax * Exp(c * t)

Where,

t = iteration number

NI = maximum no. of iterations

For the purpose of study of harmony search method, a visual basic macro program was developed in excel and a mathematical optimization problem was solved using the developed program. The problem is shown below:

Minimize,

$$f(X) = 5.358547 * (x3)^2 + 0.8356891 * x1 * x5 + 37.293239 * x1 - 40792.141$$

Subject to,

$$g1 = 85.334407 + 0.0056858 * x2 * x5 + 0.0006262 * x1 * x4 - 0.0022053 * x3 * x5$$

$$g2 = 80.51249 + 0.0071317 * x2 * x5 + 0.0029955 * x1 * x2 + 0.0021813 * (x3)^2$$

$$g3 = 9.300961 + 0.0047026 * x3 * x5 + 0.0012547 * x1 * x3 + 0.0019085 * x3 * x4$$

where,

$$0 \le g1 \le 92;\ 90 \le g2 \le 110;\ 20 \le g3 \le 25$$

and,

$78 \leq x1 \leq 102$; $33 \leq x2 \leq 45$; $27 \leq x3, x4, x5 \leq 45$

The results are tabulated below:

TABLE II: COMPARISON BETWEEN PRESENT WORK AND LITERATURE

Particular	Present work	Literature
x1	78.073	78.000
x2	34.545	33.000
x3	30.114	29.995
x4	44.009	45.000
x5	33.828	36.775
F	-30814.0	-30664.9
g1	91.883	91.999
g2	98.903	98.840
g3	19.571	19.991

By comparing the results, it is seen that harmony search method is an effective method in finding out optimum solution of a given mathematical problem.

III. OPTIMIZATION OF BEAM COLUMN

This section contains a description of the process involved in the design of beam- column steel section subjected to combined axial load and biaxial bending. Steel sections used in the design are the Indian Standard Rolled section. The program gives the steel section with minimum cross section area and which satisfies all the constraints of IS 800, 2007. The problem consists of finding optimum steel section of a given column. The data regarding length of column, location of column, axial load and moment (both major axis and minor axis moment) are the input data for the problem.

The program designs the beam column such that the cross sectional area is minimum. The program uses section 9 of IS: 800, 2007 (member subjected to combined forces) for design of beam column. The objective function is to find the steel section with minimum cross sectional area.

The formulation of optimization problem is as follows:

Minimize f = area

Subject to,

A. cl. 9.3.1 section strength:

$$fx \leq fy/\gamma m$$

$$\frac{N}{Ag} + \frac{My}{Zey} + \frac{Mz}{Zez} \leq 1.0$$

B. Cl. 9.3.2.2 bending and axial compression:

$$\frac{P}{Pdy} + Ky\frac{Cmy\,.My}{Mdy} + KLT\frac{Mz}{Mdz} \leq 1.0$$

$$\frac{P}{Pdz} + 0.6\,Ky\frac{Cmy\,.My}{Mdy} + Kz\frac{Cmz\,.Mz}{Mdz} \leq 1.0$$

IV. COMPARISON BETWEEN STADD AND DEVELOPED PROGRAM

This section describes the comparison between the design output of staad and the developed program. A common problem of finding the optimum section for beam column is the input data for both the software and the program the program consists of following.

Design a column section located at ground story with 3.6 m height. The column is subjected to axial load of 300 kN. The moment data is described as below:

Moment @ major axis:

At top = 50 kNm
At bottom = 25 kNm

Moment @ minor axis:

At top = 10 kNm
At bottom = 5 kNm

After running the program, the optimum section obtained is ISHB 250. While for the same data, STAAD gives the optimum section as ISLBP 300.

Hence, the program developed is more reliable than the stadd output.

IV. CONCLUSION

This paper describes the use of harmony search algorithm in structural optimization. The developed program is checked with the software available. The results show that the program is effective in optimum design of beam column section than the software. The section given by program is lighter and satisfies all the IS 800, 2007 requirements. Further, the harmony search algorithm is very useful in structural optimization problems. One can develop program for different structural optimization problems using harmony search method.

REFERENCES

[1] Engineering optimization: theory and practice, fourth Edison by S. S. Rao, John willy and sons , INC.
[2] IS 800, 2007.
[3] Klarbring, A. (2008). An introduction to structural optimization (Vol. 153). Springer
[4] Yang X.S., "Harmony Search as a Metaheuristic Algorithm", in: Music-Inspired Harmony Search Algorithm: Theory and Applications (Editor Z. W. Geem), Studies in Computational Intelligence, Springer Berlin, vol. 191, pp. 1-14.
[5] Hasancebi O, Erdal F, Saka MP, "An adaptive harmony search method for structural optimization". J Struct Eng 1:72.
[6] Lee KS, Geem ZW. A new meta-heuristic algorithm for continuous engineering optimization: harmony search theory and practice, Computer Methods in Applied Mechanical Engineering, 2005, Vol. 194(36-38), pp. 3902-3933.
[7] INTERNATIONAL JOURNAL OF OPTIMIZATION IN CIVIL ENGINEERING Int. J. Optim. Civil Eng., 2011; 3:485-494