International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 9
September 2017

A Software for Optimization of Fan Type Stay Cable Profiles in Cable Stayed Bridges

H.R.Dhananjaya[1], Somesh Gajera[2], Rutvi Jogani[3], Hardik Bhervia[4]
[1,2,3,4]Dept of Civil Engineering, School of Technology,
Pandit Deendayal Petroleum University, Gandhinagar, India

ABSTRACT:
This paper presents a software for optimization of fan type stay cable profiles in cable stayed bridges. Objective function is expressed for the minimum cost of cables considering their profiles. Each cable profile is optimized with respect to its position and inclination so that its full strength is utilized to carry the bridge deck load. Computer program for optimizing the fan type stay cable profiles has been written in Fortran 90. And a corresponding flow chart is included in the paper. Cost of cables obtained from manual design for an example problem is compared with cost of cables obtained in optimized design using the software. It is shown that at least 30 percent economy can be achieved in optimized fan type stay cable profiles compare to manual design.

Keywords: Cable stayed bridge, fan type stay cables, optimization, Cable profiles.

1. INTRODUCTION:

In general, manual design of the structure either leads to over-safe or under-safe. Both are undesirable as former becomes uneconomical while later becomes unsafe. But optimum design of structures becomes economical and safe. Carrying out optimum design manually is a laborious and tedious process, some times it becomes impossible. But these days with the advent of the computers, optimum design is made possible in the design of engineering structures. Design of iteration kind can be carried out easily using the computer by writing appropriate computer code for optimum design. For example, optimum design of post tensioned pre-stressed concrete T beam is given in the reference[1]. Laborious and tedious process involved in the concrete mix design can also be avoided by using the software developed for concrete mix design given in the reference[2]. The optimum design using the computer is always economical, safe and least time consuming. The optimum design of cable stay bridge deck can be seen the references [3-6]. Luis et al, have gone for discrete optimum design of cable-stayed bridges[7]

While designing cable stayed bridges manually, stay cables are spaced at regular intervals. In such situations most of the stay cables will not be utilized for their full strength in carrying bridge deck loads. Hence providing the stay cables at regular intervals becomes uneconomical. Providing different diameter cables and maintaining regular intervals also proves to be uneconomical as getting different diameter for stay cables is not feasible and not advisable. Alternatively stay cables can be made economical by spacing them at suitable positions (not at equal interval spacing) with suitable inclinations so that strength of each stay cable is effectively utilized in carrying the bridge deck load. Carrying out this kind work manually is highly laborious and tedious many a times it becomes impossible. Considering these points, in this paper a software has been developed using Fortran – 90 programming language for optimization of fan type stay cable profiles i.e., positioning the stay cables and their inclinations optimally so that each stay cable will be utilized effectively to carry the bridge deck loads. A flow chart corresponding this software is also included.

2. OPTIMIZATION OF FAN TYPE STAY CABLE PROFILES:

Objective function considered here is minimization of the cost of fan type stay cables accounting their profiles. This can be achieved by minimizing the number of stay cables and their profiles so that each stay

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 9
September 2017

cable will be effectively utilized in carrying the bridge deck load which comprises dead load and imposed uniformly distributed live load.

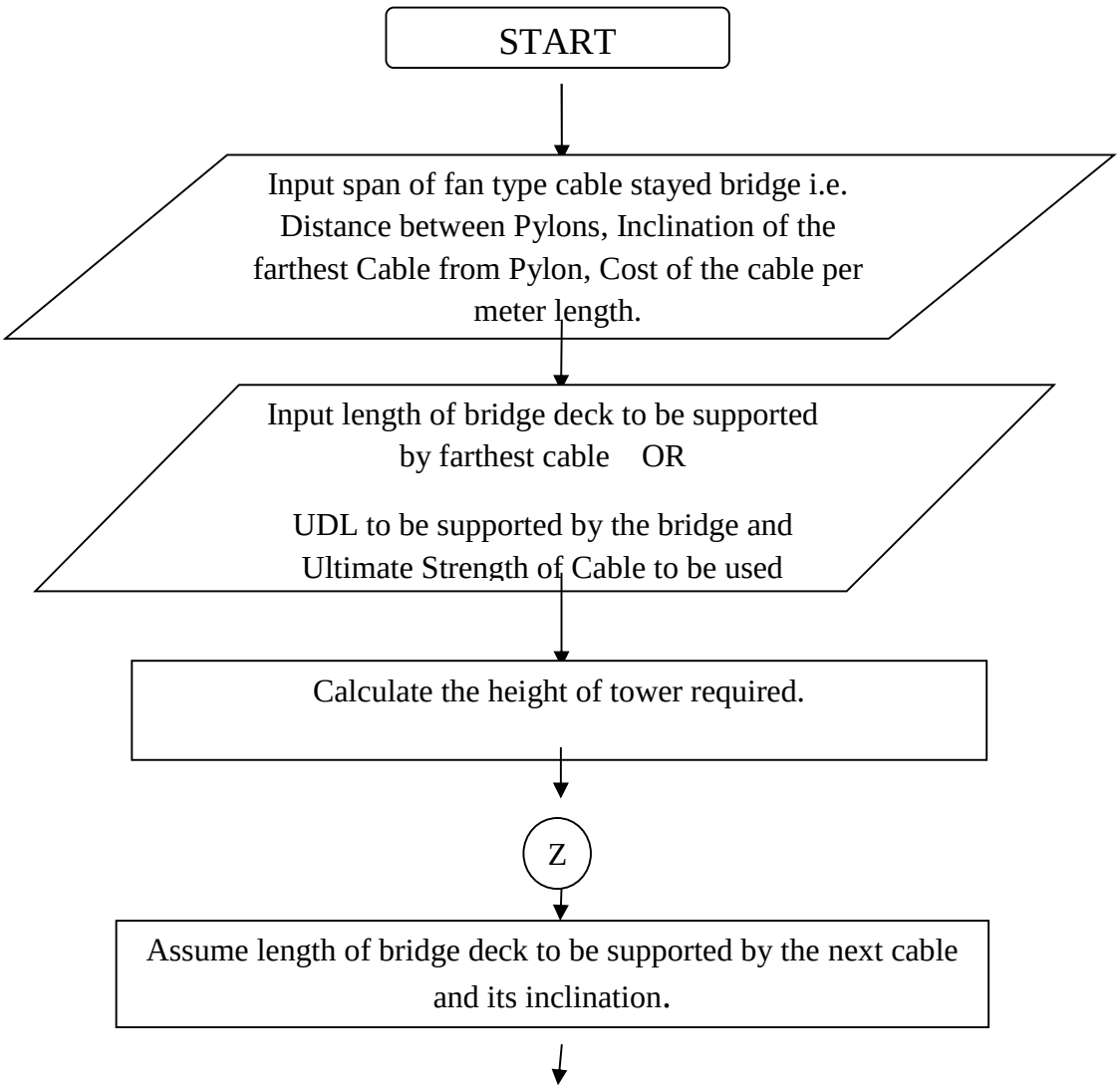
A program in Fortran-90 has been written for optimizing the fan type stay cable profiles to utilize the each cable strength fully to carry the bridge deck load. Corresponding flow chart is given in Fig. 1.

3. DESIGN EXAMPLE PROBLEM AND RESULT DISCUSSION

Design example problem considered here is given below:

A cable stay bridge has been designed[8-14] for the river of width 600m. Data considered for the problem are:

- Three towers (Pylons) are spaced at 200 m center to center as shown in the Fig. 2.
- Width of bridge deck = 10 m (two lane + footpath on either side)
- Bridge deck comprises slab and stiffened girders on either side
- Load (Dead load and imposed load) acting on each stiffened girder = 1000 kN/m
- Distance of farthest stay cable from Pylon = 97 m
- Inclination of the farthest stay cable = 22.12^0



International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 9
September 2017

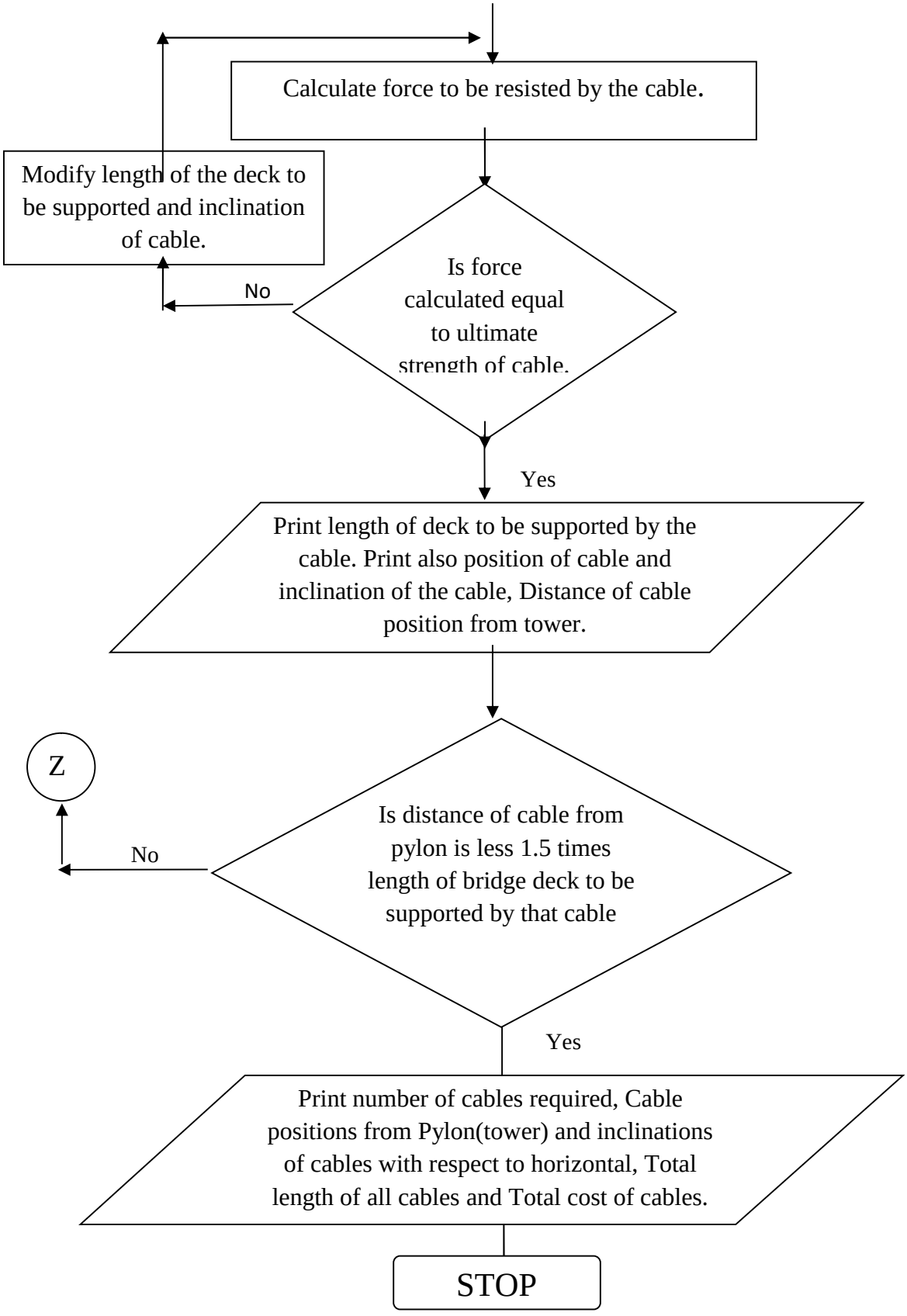


Fig.1 A flow chart for optimum design of fan type stay cable profiles

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 9
September 2017

Manual design of stay cable profiles:

In the manual design, fan type stay cables profiles are provided as shown in the Fig. 2.

All cables are spaced 6 m c/c

No of cables required on each side = 16 (Fig. 2 and Fig. 3)

No of cables required on both sides = 32

Total length of all cables considering one sides= 1084.375 m

Total length of all cables considering both sides = 2x1084.375= 2168.75 m

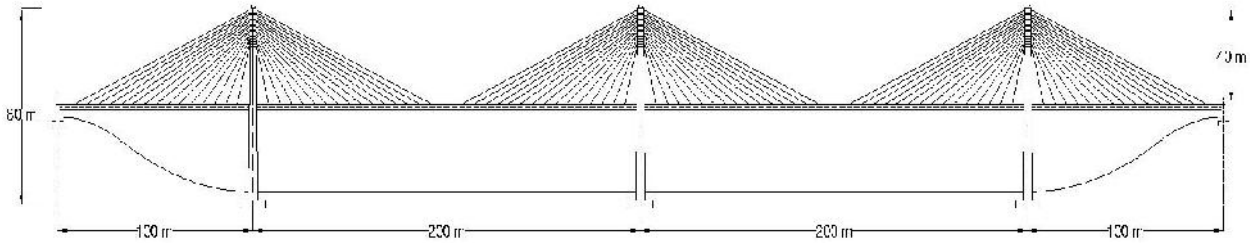


Fig 2. Fan type stay cable profiles used in manually design of cable stayed bridge

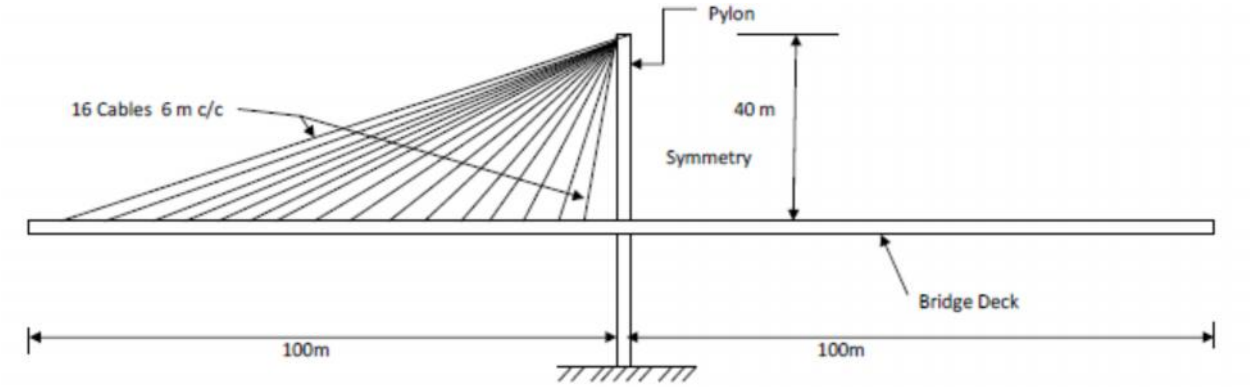


Fig. 3 Details of fan type stay cable profiles used in manually design

Optimum design of fan type stay cable profiles using software

Using the program developed, the optimization of profiles of stay cables has been done considering above data and the output is given below.

Output of the software:

Span of the cable stayed bridge (Distance between pylons) = 200.00 m

Inclination of farthest stay cable from Pylon = 22.12 Deg

Length of bridge deck to be supported by farthest stay cable = 6.00 m

Height of Tower (Pylon) = 39.43m (.≈ 40 m)

Number of cables required on each side = 10

Total length of all cables each side = 750.77m

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 9
September 2017

Total length of all cables on both sides = 1501.54 m

Optimized fan type stay cable profiles obtained from the software are given in the Table 1.

Table 1. Optimized fan type stay cable profiles for the given problem

Cable No	Deck length to be supported(m)	Inclination of the Cable (θ) in Degrees	Cable Position from Pylon (m)	Fan type stay cable length (m)
1	6.00	22.12	97.00	104.71
2	6.44	23.84	90.78	98.97
3	6.87	25.56	84.12	92.90
4	7.30	27.28	77.03	86.54
5	7.87	29.59	69.45	79.86
6	8.63	32.79	61.20	72.80
7	9.62	37.13	52.08	65.32
8	10.93	43.32	41.80	57.46
9	12.68	52.74	30.00	49.54
10	14.73	67.55	16.29	42.66

The optimized fan type stay cable profiles obtained using the software are shown in the Fig. 4.

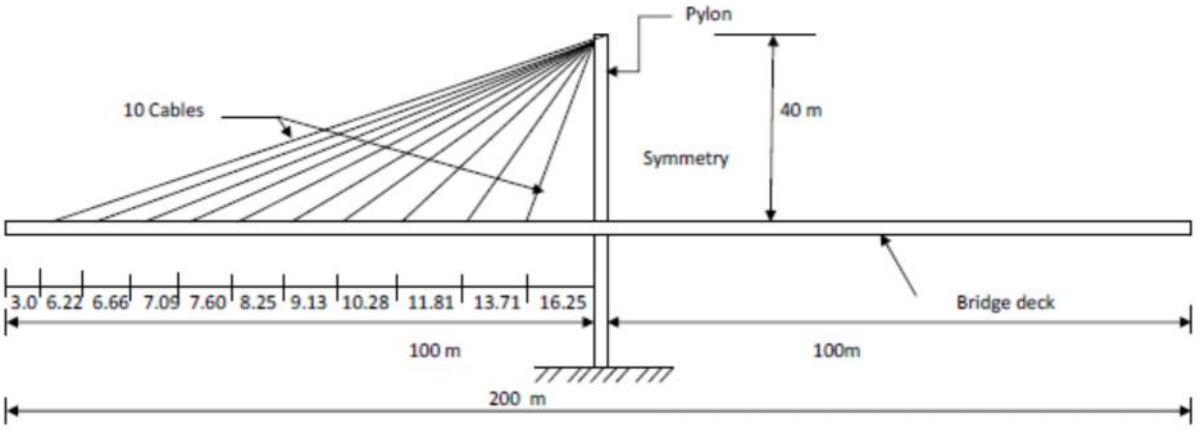


Fig. 4. Optimized fan type stay cable profiles for the problem shown for one Pylon(Tower).

***Results discussion*:**

The given problem for fan type stay cable profiles has been designed manually and optimum design using the developed software. Total length of all cables (16 cables on each side) on both sides of Pylon by manual design = 2x1084.375= 2168.75 m. Total length of all cables(10 cables on each side) on both side of Pylon by optimized design = 2x750.77 =1501.54 m. Using developed software percentage economy achieved is 30.76% compare manual design.

4. CONCLUSIONS:

In this paper, the following conclusions are drawn:-

- A fan type cable stayed bridge considering two lane has been designed for a river of width 600 m placing pylons at 200 m centre to centre using the specifications of IRC and IS codes. The manual design of fan type stay cable profiles has been done for this problem and total length of all stay cables on both sides is found to be 2168.75 m

- A software has been developed in Fotran-90 programming language, for optimization of fan type stay cable profiles and the flowchart is included in the paper. Using this software, optimization of fan type stay cable profiles for this problem has been done and obtained total length of all stay cables of both sides equal to 1501.54 m.
- On comparison, the cost of stay cable obtained using the software is 30.76% economical compared to that obtained from manual design.

REFERENCES:

[1] H R Dhananjaya, "A Software For Optimum Design Of Post-Tensioned Pre-Stressed Concrete T - Beams", *Journal of Structural Engineering*, Vol. 27, No.4, January 2001, pp.293-300.
[2] H R Dhananjaya, "A Software For Concrete Mix Design", *The Indian Concrete Journal*, September, 1996, pp.489-493.
[3] J. H. O. Negrao and L. M. C. Simoes, Optimization of cable-stayed bridges with three-dimensional modelling, *Computers & Structures*, Volume 64, Issues 1-4, July-August 1997, pp. 741-758.
[4] L. M. C. Simoes and J. H. O. Negrao, Optimization of cable-stayed bridges subjected to earthquakes with non-linear behaviour, *Engineering Optimization*, Volume 31, 1999, pp. 457-478.
[5] L. M. C. Simoes and J. H. J. O. Negrao, Optimization of cable-stayed bridges with box-girder decks, *Advances in Engineering Software*, Volume 31, Issue 6, June 2000, pp. 417-423.
[6] J. H. O. Negrao and L. M. C. Simoes, Reliability-based optimum design of cable-stayed bridges, *Structural and Multidisciplinary Optimization*, 28, 2004, pp. 214-220
[7] Luís M. C. Simões1, Alberto M. B. Martins2, Sandra R. S. Monteiro, Discrete Optimum Design of Cable-Stayed Bridges, 8th World Congress on Structural and Multidisciplinary Optimization, June 1 - 5, 2009, Lisbon, Portugal, pp. 1-9
[8] KrishanRaju, N., Pre-stressed Concrete Bridges. CBS Publishers and Distributers, New Delhi, 2014
[9] KrishanRaju, N., Design of bridges, Third Edition. Oxford and IBH Publishing Co, Pvt Ltd, New Delhi, 1998.
[10] IRC 6 – 2000 "Standard Specifications and Code of Practice for Road Bridges, Section II – Loads and Stresses (Fourth Revision) **",** Indian Road Congress, New Delhi
[11] IRC 18 – 2000 " Design criteria for pre-stressed concrete road bridges (post tensioned concrete)", Indian Road Congress, New Delhi
[12] IRC 21 – 2000 " Standard specification and Code of practice for road bridges ", Indian Road Congress, New Delhi
[13] IS :1343-2012, Pre-stressed concrete - Code of practice, Bureau of Indian Standards, New Delhi, India, November 2012.
[14] IS :456-2000, Plain and reinforced concrete - Code of practice, Bureau of Indian Standards, New Delhi, India, July 2000.