Design of Cable Stayed Pedestrian Bridge

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Abstract : Chennai is a business city which gives opportunity for pedestrian by using a way of platform, roadways. The development of population, we need to construct a Cable Bridge Structure, which can full fill the requirements of crossing roads and also restrict accidents etc. The project work deals with the Design of a Cable Strain Pedestrian Bridge. It is a typical reinforced framed structure. In this ground axis are by using roadways. The floor way consists of pedestrian. This structure is designed by limit state method for main girder and cross girder frame, slab, beam and column also. All the designs are in accordance with IS: 456-2000 & IS: 800-2007, Design aids (sp-16) is used for the design. The concrete mix used for slabs, beams, columns, footing and various other structural members are of M20 grade of concrete and Fe415 grade steel. The typical span length of cable stayed bridges range from 34.87m. The longest cable stayed bridge in the world is presently the cable bridge with a main span of 30m. Total area of the bridge structure is 179.01 sq.m.

IndexTerms **- Cable, Slab, Beam, Staircase, Girders and Footing.**

I. INTRODUCTION

The increase of commuters in metro cities been very high. People travel with different and complex reasons. Increasing growth of traffic volume shortly caused that some factors which play important role in this area to be taken into consideration. Many people around the world getting accidents while crossing the high traffic road. To avoid such accidents the bridges and underway are been constructed in big cities. In this project we have took an idea of building a cable stayed bridge for pedestrians. By this idea the place can get a good appearance with the peoples care to avoid accidents.

The need of bridge is useful for commuters to cross the natural or artificial obstacles. Same way the pedestrian bridge is used to cross the busy traffic areas. This is useful for public to minimize the accident risks. This paper also focussed on the busy location in Chennai city where the accident also occurs due to the problem of no proper crossings. So here we planned to take the location in the city of N4 beach, Royapuram, Chennai. In this paper the design components for every structural members and plan, detailing are carried. That this project is developed in the aim of restricting accidents high risky areas by providing a suitable cross bridges. Here the cable stayed bridge of length 34.87m is provided. The design are carried with accordance of suitable Indian standard codes.

II. OBJECTIVE

1. To avoid fatal accidents.
2. To efficiently convey the traffic.
3. To avoid traffic congestion.
4. To feed a continuous flow of traffic.

III. SCOPE

1. The project included the Preliminary Design of Pedestrian Footbridge.
2. The development of the scheme shall be undertaken by any kind of Bridge companies, NHAI, IRC or any other private firms which so ever is economic to both the public and private sectors.

IV. LITERATURE REVIEW

Partha Pratim Roy made an report “Cable-Stayed bridge” as a part of International Journal of Science and Advanced Technology explains the various features and working of a stayed cable bridge. It also clearly states the advantage that a cable stayed bridge has over a normal suspension bridge.

Ishita Arora, in “A Review on The Study of Cable Stayed Bridges” explains about Cable Stayed Bridges have much greater stiffness since the cables can handle more pressure. They are also much more resistant to environmental changes such as the frequent occurrences of earthquakes.

Renen Constantino, “Design of Bridges” The Indian standard codes do not have a provision for pedestrian loading and thus the values of forces developed in a pedestrian bridge were obtained from its report.

Manjeet, “A Study of Various types of Bridges in India with Historical Perspective” concluded that It may be well appreciated that India has constructed numerous medium to large span bridges across the country. Perhaps the needs are more, but due to various economic and planning reasons, demand has not been fulfilled.

Madhuri Yadav 2018, Behavior Analysis of Stayed Bridge With Different Cable Arrangement Using Staad Pro, resulted that all these study the pylons (i.e. one axial layer of stay and two lateral of stays) the circular and the H shape with harp and the fan shape configuration is the best configuration.

Murkute U.T in “Design and Analysis of Cable Stayed Bridge”, tells about the Design of cable stayed pedestrian bridge is done manually, various check for the allowable and maximum deflection. Shear force, bending moment, bearing stresses and shearing stresses in case of rivets are applied and found satisfactory and analyze the same bridge from computer aided software.

V. SITE LOCATION AND LAYOUT

The city of Chennai has always had a keen eye on promoting its city. It has lot of significant tourist places in the city many of which are civil related Chennai created the first ever piped water supply system in the early 1940s. It's holding the oldest shipping harbor, N4 beach, Royapuram, Chennai, Tamilnadu. An integral part of this park is the artificially created in beach, over which the Cable Stayed Pedestrian Bridge.

Fig.1. Site Location

A Cable Stayed Bridge is a structure with several points in each span between the towers supported upward in a slanting direction with inclined cables and consist of main tower cable stays and main girders, as shown in fig 2.

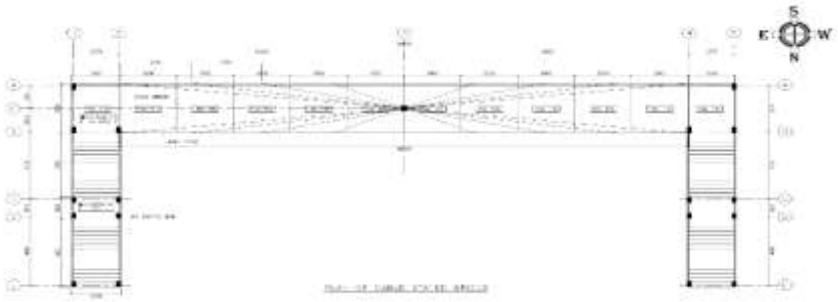

Fig.2. Plan of Bridge

The Cable Stayed Bridge is optimal for spans longer than cantilever bridges and shorter than suspension bridges. This is the range with in which cantilever bridges would rapidly grow heavier, and suspension bridge cabling would be more costly, shown in fig 3.

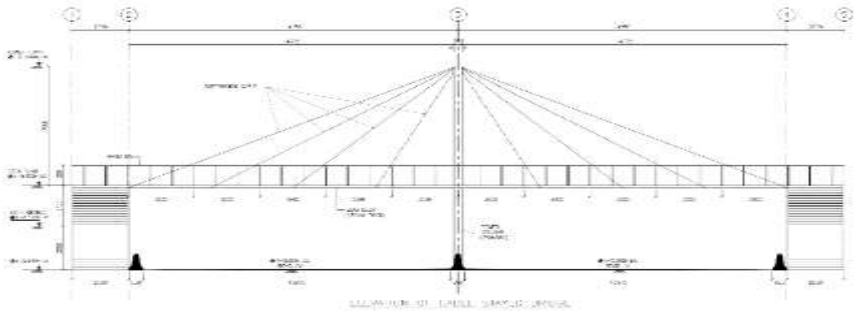

Fig.3. Elevation of Bridge

VI. STRUCTURAL DESIGN AND RESULTS

In every structure Load calculation and Load distribution is main part of the structures. To give proper dimensions to the structural components and load carrying capacity need to carry proper design of structural members. Here we have discussed about the structural members of slab, girder, beam, tower, connection and cable of the bridge.

6.1. Design of Slab

Input data

Lx = 3m (Shorter Span)

Ly = 3.5m (Longer Span)

Result

Therefore, provide main reinforcement 10mm dia bars of 300mmC/C @ Longer Span

Provide secondary reinforcement 10mm dia at 200mm C/C @ Shorter Span

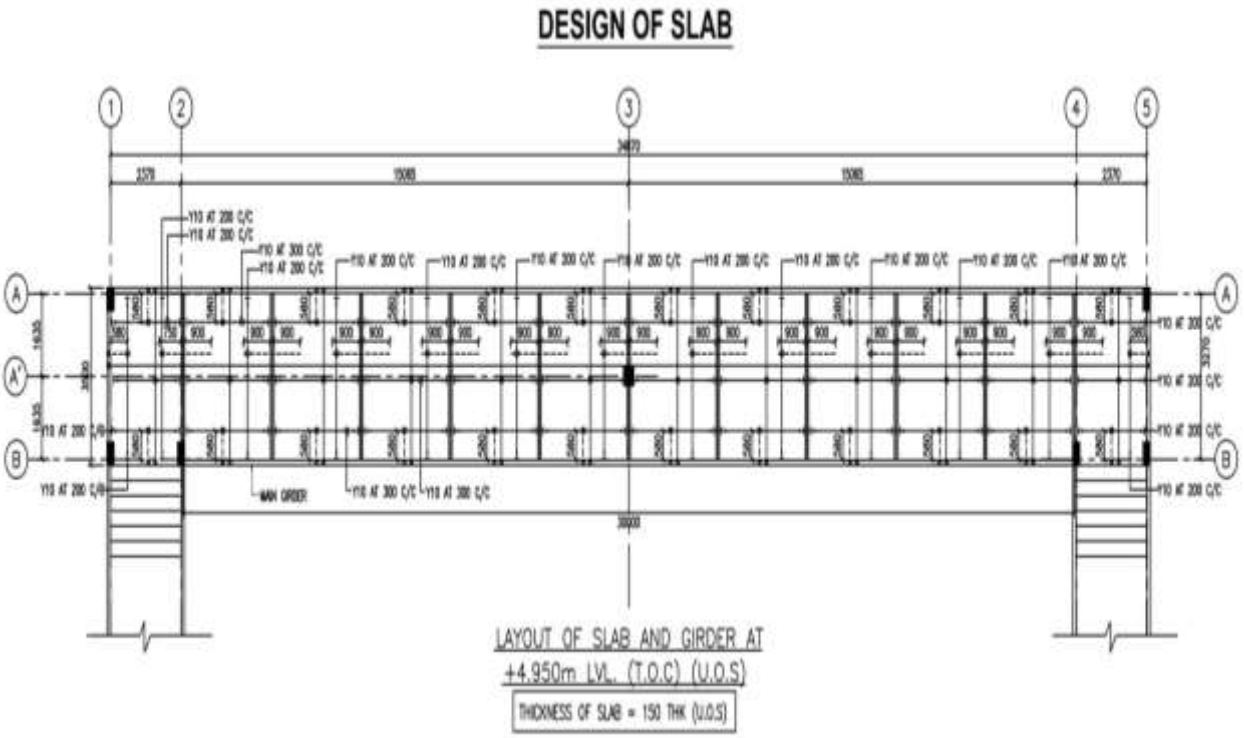

Fig.4. Design of Slab

6.2. Design of Cross Girder

Input data

Total load acting on cross girder = 45.58 KN

Result

From Annex H of IS 800:2007

Choosing ISWB 225

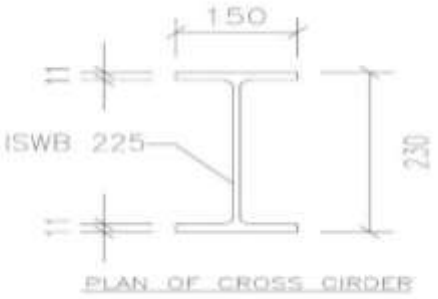

Fig.5. Cross Girder

6.3. Design of Main Girder

Input data

Total load acting on main girder = 47.682KN

Result

Choosing ISMB 600

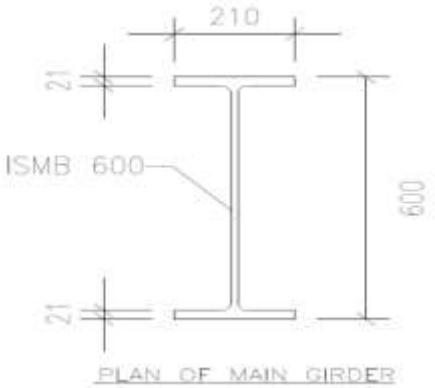

Fig.6. Main Girder

6.4. Design of Tower

Input data

Load due to slab = 9 x 3.5 x 30 = 945KN

Load due to cross girder = 0.288 x 3.5 x 11

= 11.088KN

Load due to main girder = 1.226 x 30.x 2

= 73.56KN

Total load acting in tower = 1027.63KN

Result

Therefore, provide a section of ISMB 350 @ 52.4

Provide 1 bolt of 20mm dia of 4.6 grade

6.5. Design of Splice Plate

At 4m from the top and bottom, 50% of load is transferred to splice

Load on splice plate = $\frac{772.5}{2}$ = 386.25KN

Load on splice plate = 386.25KN

Load on single splice plate = $\frac{386.25}{2}$ = 193.12KN

Area of splice plate = $\frac{193.12x10^6}{250}$ = $772.48mm^2$

Width of the splice plate = bf + bf + d

= 140 + 140 + 279.77

= 559.77mm

Thickness = $\frac{\text{Area of the splice plate}}{width\ of\ the\ splice\ plate}$

= $\frac{772.48}{559.77}$

= 1.379

It should not be less than 6mm

Therefore thickness = 6mm

6.6 Design of Slab Base

The compound section of 2 x ISMB 350 column is resting on concrete pedestal of M20 grade using slab base plate

Properties of ISMB 350

D = 350mm

bf = 140mm

tf = 14.2mm

tw = 8.1mm

Provide an equal projection of 100mm on all four edges of column

Therefore, provide a base plate of 12mm thickness.

6.7. Design of Connection

Result

The connections to various elements are made by bolted connections

Provide 2 bolts in each direction, therefore to connect the cross girder with the main girder 4 nos of bolts with 25mm dia of 4.6 grade is used and to connect the Main Girder to Tower Connections requires number of bolts is 6 numbers.

6.8. Design of Staircase

Input data

Total load = 2788 N/m

Result

Therefore, provide 8mm dia bar of 300mm C/C reinforcement in staircase.

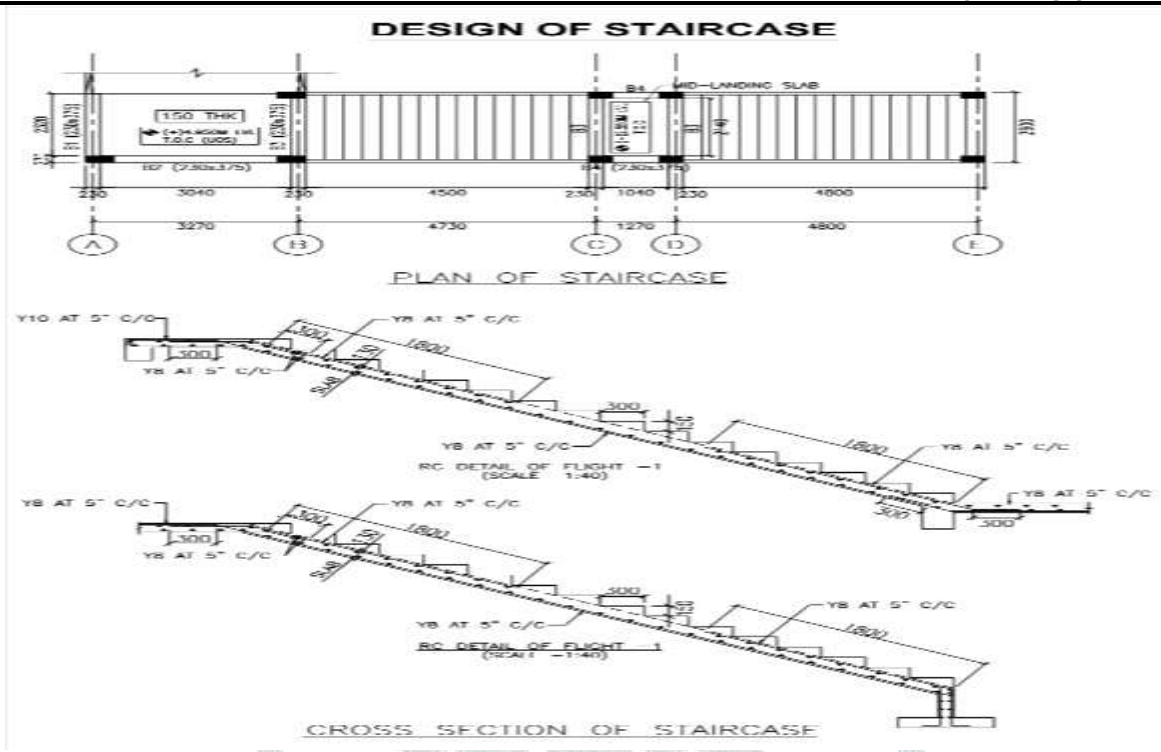

Fig.7. Design of Staircase

6.9. Design of Tie Beam

Result

Provide 6mm dia bar of 2 legged stirrups @ 250mmC/C reinforcement.

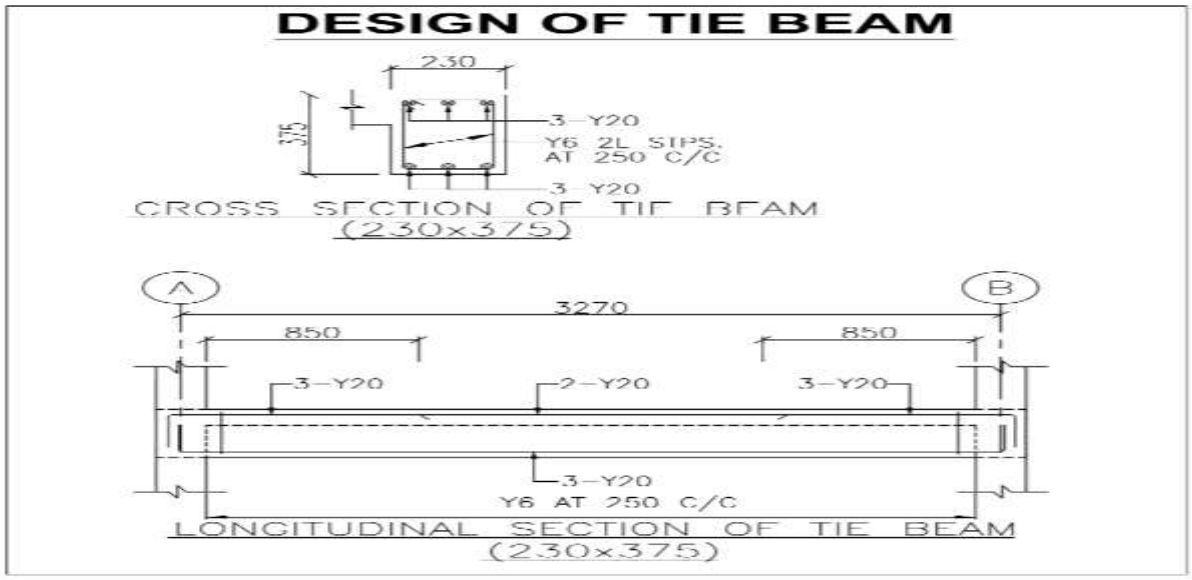

Fig.8. Design of Tie Beam

6.10. Design of Column Footing

Input data

P = 2000KN

Size of column = 230 x 450mm

Result

Therefore, provide minimum steel of 10 bar of 16mm dia bars.

Therefore, provide 8mm dia bar of 300mm C/C reinforcement in footing.

6.11. Design of Foundation

Input data

Load of structure (P) = 75KN/m^2

Density of soil (W) = 16KN/m^3

Angle of repose (Θ) = 19.2˚

D = 1.19m.

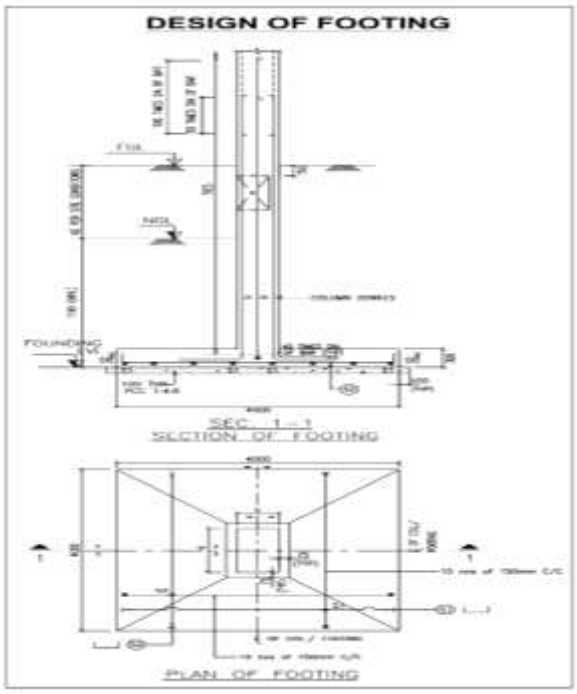

Fig.9. Design of Foundation

6.12. Design of Beam

Input data

Slab Thickness = 150mm

Total Load = 22.68KN/m

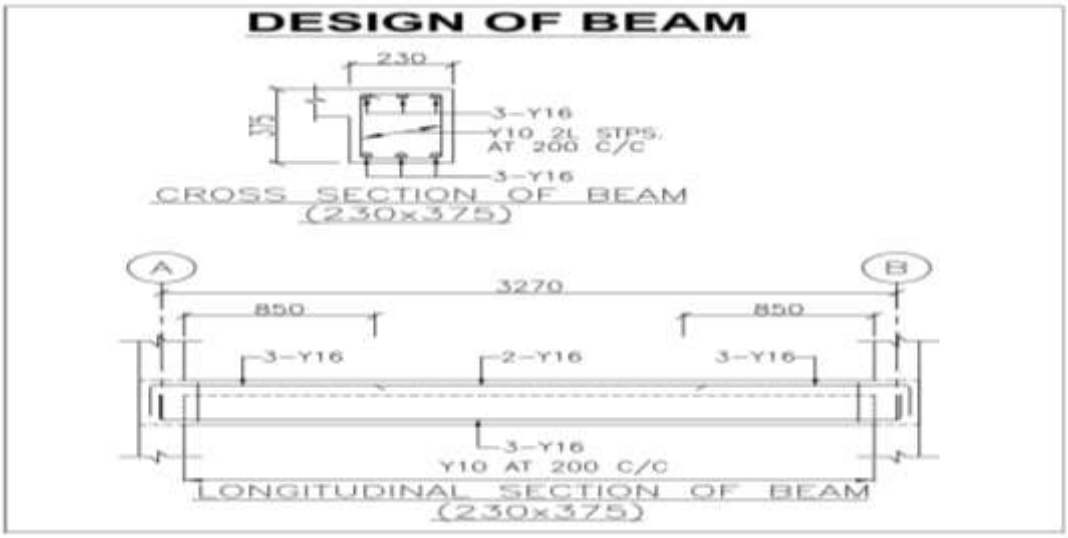

Fig.10. Design of Beam

6.13. Design of Column

Input data

Axial Load = 60KN

Design Load = $60 \times 1.5 = 90 \times 10^3$ N

Fck = 20 N/mm^2

Fy = 415 N/mm^2

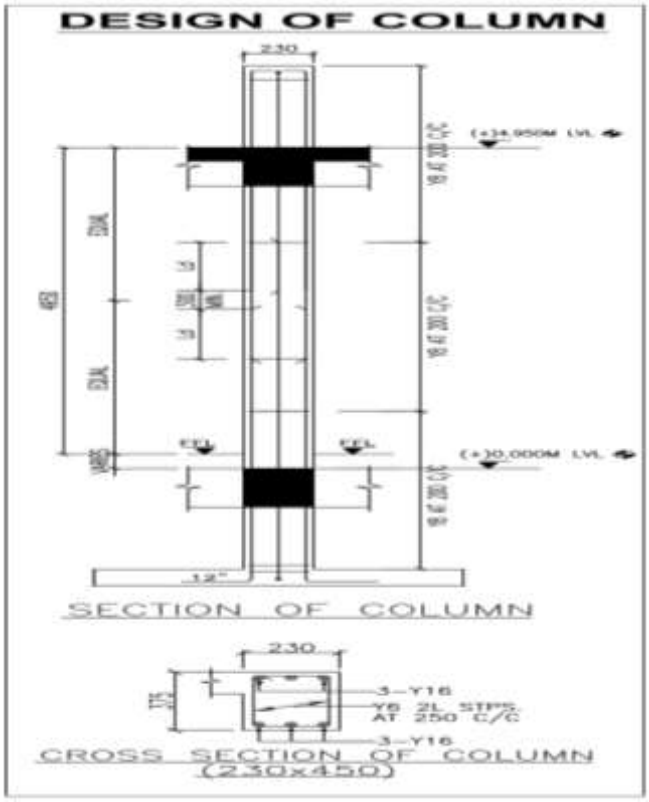

Fig.11. Design of Column

6.14. Design of Cables

Result

12 numbers of cables are used with 6 cables in each of span. The cables is attached to the tower a interval 250mm and therefore the cable design is semi harp type.

Each cable carries a tensile force of 128.453 KN.

Table. 1 Nominal Ultimate & Allowable Tensile Strength for Cables

Type	Nominal Tensile Strength (fpu)	Allowable Tensile Strength
Bars, ASTM A722 Type II	150	0.45 fpu = 67.5
Locked coil strand	210	0.33 fpu = 70
Structural strand ASTM A586*	220	0.33 fpu = 72.6
Structural rope ASTM A603*	220	0.33 fpu = 73.3
Parallel wire	225	0.40 fpu = 90
Parallel wire ASTM A421*	240	0.45 fpu = 108
Parallel strand ASTM A416*	270	0.45 fpu = 121.5

VII. CONCLUSION

Due to the rapid increase of population in urban areas results in concrete jungles in cities. That creates a congested living in cities which makes less area more population. That huge population results to increase the city areas. Though the improvement of city area happens on National Highway roads due to easy connection with near towns. That rarely make the people to cross in between the roads. That results in accidental impacts in every cities and nearby places. To minimize the accidents and improve development activities we need this type of bridges in the city areas where people can cross from one side to another side of the road easily it also not disturbs the vehicle in peak hours. So we have a made selection of cable stayed bridge and we had took the accident risky zone in Chennai, tamilnadu. Based on the road width we have planned in such way the dimensions and detailing. The complete load calculation of the cable stayed bridges been carried as per IS codes and the design of structural members slab, girder, splice plate, tower, beam, column, staircase, footing and cables been designed. Based on the values got from the design we have chosen the steel sections and grade of concrete is chosen on the consideration factor of bridge. Cables are selected based on ASTM.

The safety and comfort way to cross the roads been suggested here. Hence it has been observed that the development of Cable Bridge for boding and lodging is essential. In proposed with modern style of pedestrian way. So the design and consideration of Cable bridge building aids is very essential for Civil Engineers. This design has offered to us learn and expressing our ideas on the topics like Planning, Designing.

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