

# Design and Analysis of Suspension Bridge

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## Abstract

*A suspension bridge is a kind of bridge wherein the deck i.e. the load bearing element is hold beneath on vertical suspenders. This bridge has cables suspended among towers plus vertical suspender cables that carry the weight of the deck underneath upon which traffic crosses. Cable stayed suspension bridge requires the design of the components namely Deck slab, Cables, Stiffening girder, Suspenders, Cable anchorage etc using IS-1873-1976. The main objective of our project is to study about suspension bridge and its components also designs are carried out. Suspension bridge plan should be prepared using Autocad and analysis will be done using SAP software. The details of Deck slab, Cables, Supporting details of tower, Abutment design details, arrangements and sections are included.*

**Keywords:** Bridge, Deck, Cables and Deck Slab.

## 1. INTRODUCTION

This bridge dates from the early nineteenth century, even as bridges without vertical suspenders have an extended history in lots of mountainous components of the world. This arrangement permits the deck to be degree or to be upward for extra clearance. Like other suspension bridge kinds, this type often is constructed without fake work. The suspension cables ought to be anchored at each quit of the bridge. Since any load carried out to the bridge is converted into a anxiety in these main cables.

### 1.1 Advantages

- Longer essential spans are workable than with every other kind of bridge.
- Less fabric can be required than different bridge types, even at spans they can obtain, leading to a reduced construction fee.
- Can be higher able to resist earthquake actions than heavier and extra inflexible bridges.

### 1.2 Main Cable Protection in Suspended Bridges

The main cables in suspension bridges carry very high tension. Since any failure would endanger the structure, special attention should be taken to prevent corrosion. A very elaborate and protective technique has been developed to provide the main cables in suspended bridges the highest protection possible. It consists of applying different layers of corrosive protective material around the cable after installation. An example of different consecutive layers used is :

- A covering with polyester film
- Initial coating with acrylic resin
- A layer of non-woven glass mat pressed into place
- A second coating with acrylic resin

## 2. METHODOLOGY

Figure 1 shows the methodology of the study.

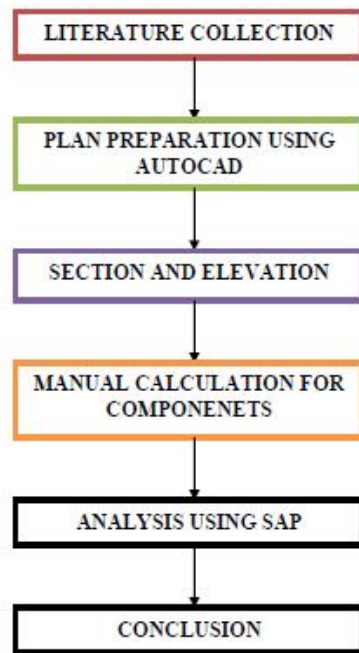


Figure 1 Methodology

**3. MANUAL DESIGN**

*3.1 Design of Deck Slab*

- Carriage way = Two lane 8 m wide
- Materials = M 40 & Fe 415
- Kerbs = 1.5 m wide
- Clear span = 20 m
- Width of slab = 8 m
- Depth of kerb slab = 1.05 m (0.75 + 0.3)
- Wearing coat = 80 mm
- Width of bearing = 400 mm
- Loading = IRC. Class AA

The design should conform to the specification of the bridge code IRC: 21 – 1987

*3.2 Allowable Stress*

$$\begin{aligned}
 f_{ck} &= 40 \text{ N / mm}^2 \\
 f_y &= 415 \text{ N / mm}^2 \\
 \sigma_{cb} &= 13.33 \text{ N/mm}^2 \\
 \sigma_{st} &= 200 \text{ N / mm}^2 \\
 m &= \frac{3\sigma_{cbc}^3}{k}; \\
 j &= 1 - \frac{33}{m}; \\
 Q &= \frac{1}{2} j.k.\sigma_{cbc} \\
 m &= 7 \\
 j &= 0.89 \\
 Q &= 1.86 \\
 b_e &= k.x(1 - x/l_e)l_e + b_w
 \end{aligned}$$

Where  $x = 3.88$  m  
 Where  $K = 1.75$  (based on B/L ratio - for simply supported slabs)  
 $b_w = 1.01$  m  
 $b_e = 1.75 \times 3.88 (1 - 3.88 / 20.4) + 1.01$

Allowing a factor of safety of 1.5

Allowable stress in one set of cab  
 $= 1570/1.5$   
 $= 1046.67$  N/mm<sup>2</sup>  
 $= 1046.67 \times 10 = 10466.7$

Area of one set of cable  $= 12360/10466.7$   
 $= 11.8$  cm<sup>2</sup>

Area provided 50 mm dia wire rope area  
 $= 11.8 > 7.31$  cm<sup>2</sup> (Safe)

Hence provide 50 mm dia steel cables on both sides, each set contains ropes with a steel core, strands made of 1mm and wire with a minimum tensile strength of 1570 N/mm<sup>2</sup>

**3.2 Design Of Abutment For Suspension Bridge**

**3.2.1 Design data:**

Bearing capacity of the foundation soil = 145 kN/m<sup>3</sup>  
 Friction angle between footing and soil = 30 degrees

**3.2.2 Load calculations:**

Dead load from the super structure (DL) = 49.76 kN/m  
 Live load from the super structure (LL) = 226 kN/m  
 Wind load on structure (W) = 3 kN/m  
 Wind load on live load (WL) = 0.5 kN/m<sup>2</sup> (assume)  
 Breaking force (LF) = 3 kN/m<sup>2</sup> (assume)  
 Shrinkage and temperature force = 10% of DL  
 Surcharge load (LL) ,  $W_L W_L = 10$  kN/m<sup>2</sup> (assume)  
 $W_D W_D = 7$  kN/m<sup>2</sup> (assume)  
 $P_E P_E = 35$  kN/m (assume)  
 $H_L H_L = 14$  kN/m (assume)  
 $H_D H_D = 8.5$  kN/m (assume)  
 $V_L V_L = 4.3$  kN/m (assume)  
 $V_D V_D = 2.7$  kN/m (assume)

Table 1 shows the Vertical load calculations of abutment

**Table 1: Vertical load calculations of Abutment**

Item	Unfactored (V) kN/m	Arm (m)	Moment (M <sub>0</sub> M <sub>0</sub> )
P-1(2*0.5*25)	25	1	25
P-2 (0.7*2.5*25)	43.75	1.15	50.31
P-3 (0.2*1*25)	5	1.4	7
P-4 (0.5*3.2*18)	28.8	1.75	50.4

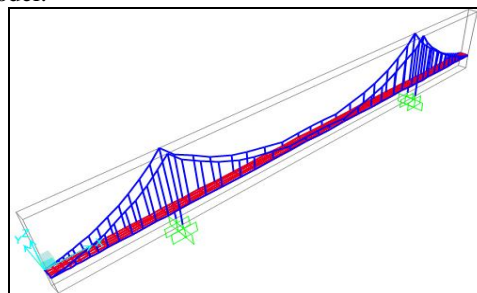
<b>DL</b>	49.76	1.05	52.24
<b>LL</b>	226	1.05	237.3
<b><math>V_L</math></b>	4.3	1.75	7.525
<b><math>V_D</math></b>	2.7	1.75	4.725

#### 4. ABOUT SOFTWARE

SAP 2000 has proven to be the maximum incorporated, productive and sensible wellknown purpose structural program in the marketplace these days. complicated models may be generated and meshed with effective constructed in templates. incorporated layout code capabilities can automatically generate wind, wave, bridge, and seismic hundreds with comprehensive automated metal and urban layout code assessments per US, Canadian and international layout standards.

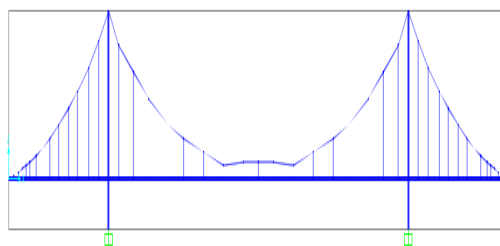
#### 5. ANALYSIS RESULTS

Figure 2 shows the Finite element model.



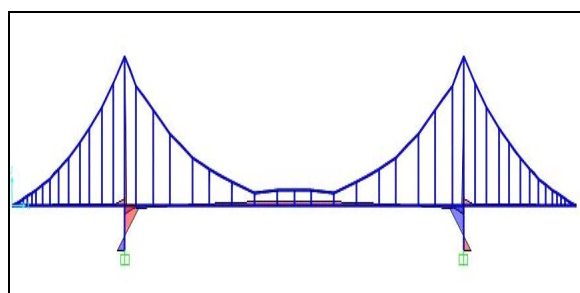
**Figure 2** Finite element model

Figure 3 shows the suspension bridge Elevation.



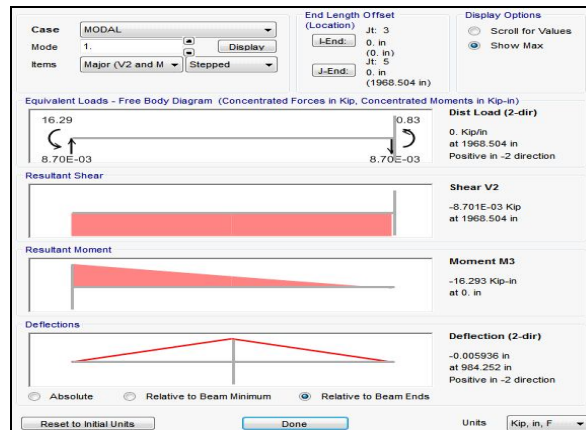
**Figure 3** Suspension bridge Elevation

Figure 4 shows the bending moment diagram.



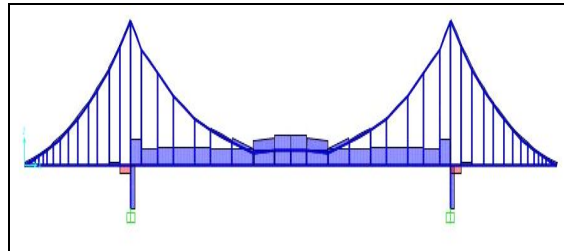
**Figure 4** Bending moment diagram

Figure 5 shows the BM and SF Diagram window.



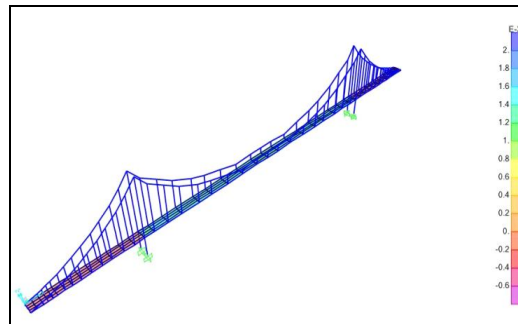
**Figure 5** BM and SF Diagram window

Figure 6 shows the Axial Force diagram.



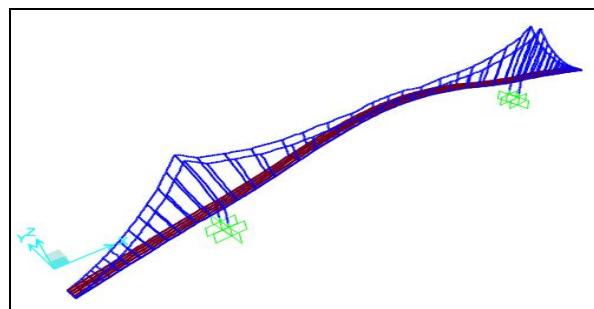
**Figure 6** Axial Force diagram

Figure 7 shows the stress diagram.



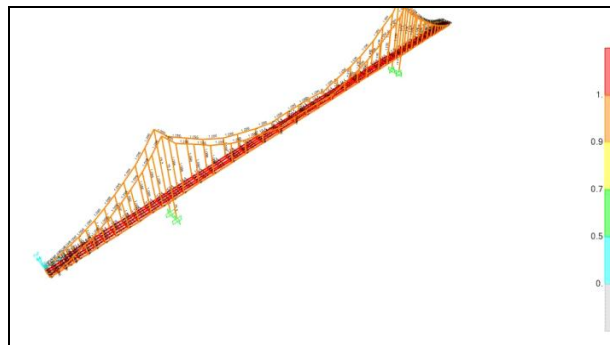
**Figure 7** Stress Diagram

Figure 8 shows the Deformed Shape.



**Figure 8** Deformed shape

Figure 9 shows the Design window.



**Figure 9** Design window

## 6. CONCLUSION

The suspension cable bridge are may furnish quarters and facilities for assemblage of human beings for social business or leisure functions and might have interaction inside the preserving portion of its premises for shops and organizations whose continuity is call for suitable to a suspension cable bridge. Special consideration during design should be taken into account since cables are very slender elements that are affected by external conditions. Cable vibration is a common phenomenon in cables. To prevent the excessive vibration amplitudes from affecting the integrity of the structure, damping devices are being implemented. In this project deals with 240m span length x 7.5m carriage width suspension bridge with basic bridge components such as Deck slab, Cable design, Suspenders and Pile foundation, abutments they are designed both Manual and Analysis using Sap, Results are shown in this Document.

## References

- [1] T.Subramani., A.Arul, "Design And Analysis Of Hybrid Composite Lap Joint Using Fem" International Journal of Engineering Research and Applications, Volume. 4, Issue. 6 (Version 5), pp 289- 295, 2014.
- [2] T.Subramani, D.Sakthi Kumar S.Badrinarayanan "Fem Modelling And Analysis Of Reinforced Concrete Section With Light Weight Blocks Infill " International Journal of Engineering Research and Applications, Volume. 4, Issue. 6 (Version 6), pp 142 - 149, 2014.
- [3] T.Subramani, S.Poongothai, S.Priyanka , " Analytical Study Of T Beam Column Joint Using FEM Software " , International Journal of Emerging Trends & Technology in Computer Science (IJETTCS), Volume 6, Issue 3, May - June 2017 , pp. 148-156 , ISSN 2278-6856
- [4] T.Subramani, P.Babu, S.Priyanka , " Strength Study On Fibre Reinforced Concrete Using Palmyra Palm Fibre Using Fem Software " , International Journal of Emerging Trends & Technology in Computer Science (IJETTCS), Volume 6, Issue 3, May - June 2017 , pp. 198-207 , ISSN 2278-6856.
- [5] T.Subramani, S.Chitra, S.Priyanka & J.Karthick Rajan, Modeling And Analysis Of Concrete Filled Steel Tubular Beams Using Finite Element Analysis, International Journal Of Mechanical And Production Engineering Research And Development (IJMPERD), Vol. 8, Special Issue 2, Pp 429-436, Nov 2018, ISSN (P): 2249-6890; ISSN (E): 2249-8001
- [6] T.Subramani, S.Vishnupriya, "Finite Element Analysis of a Natural Fiber (Maize) Composite Beam", International Journal of Modern Engineering Research, Volume. 4, Issue. 6 (Version 1), pp 1 – 7, 2014,
- [7] T.Subramani and M.Kavitha, "Analysis Of Reliability Of Steel Frame Systems With Semi-Rigid Connections Using Numerical Method And Finite Element Analysis", International Journal of Applied Engineering Research (IJAER), Volume 10, Number 38,Special Issues, pp.28240-28246, 2015.
- [8] T.Subramani, A.Mohammed Ali, R.Karthikeyan, E.Panner Selvan , K.Periyasamy , " Analytical Study Of T-Beam Using ANSYS " , International Journal of Emerging Trends & Technology in Computer Science (IJETTCS), Volume 6, Issue 3, May - June 2017 , pp. 259-266 , ISSN 2278-6856.
- [9] T.Subramani, Periasamy, "A. Study on Behaviour of Stud Type Shear Connector in Composite Beam Using ANSYS". **International Journal of Engineering & Technology**, [S.l.], v. 7, n. 3.10, p. 54-58, july 2018. ISSN 2227-524X.

- [10] T.Subramani, V. Sukumar, "Castellated Beam with and without Stiffeners Using ANSYS". **International Journal of Engineering & Technology**, [S.l.], v. 7, n. 3.10, p. 94-97, July 2018. ISSN 2227-524X.
- [11] T.Subramani, M.Piruntha, "Behaviour of CRP- Geopolymer Concrete Columns under Axial Loading using ANSYS", *International Journal of Engineering & Technology*, S.l.], v. 7,n (3.10), 203-206, July 2018. ISSN 2227-524X.
- [12] T. Subramani, J. Balakrishnan, S. Priyanka & J. Karthick Rajan, Design And Analysis Of Stiffened Plate With And Without Stiffener Using ANSYS, *International Journal Of Mechanical And Production Engineering Research And Development (IJMPERD)*, Vol. 8, Special Issue 2, Pp 461-468, Nov 2018, ISSN (P): 2249-6890; ISSN (E): 2249-8001.
- [13] T.Subramani, S.Subithabi, S.Priyanka & J.Karthick Rajan, Analysis Of Composite Shear Wall Using ANSYS, *International Journal Of Mechanical And Production Engineering Research And Development (IJMPERD)*, Vol. 8, Special Issue 2, pp 477-484, Nov 2018, ISSN (P): 2249-6890; ISSN (E): 2249-8001.
- [14] T.Subramani and Athulya Sugathan, "Finite Element Analysis of Thin Walled- Shell Structures by ANSYS and LS-DYNA", *International Journal of Modern Engineering Research*, Vol.2, No.4, pp 1576-1587, 2012.
- [15] T.Subramani, A.Kumaresan., " Advanced Cable Stayed Bridge Construction Process Analysis with ANSYS", *International Journal of Modern Engineering Research*, Volume. 4, Issue.6 (Version 1), pp 28-33, 2014,
- [16] T.Subramani, R.Senthil Kumar, "Modelling and Analysis of Hybrid Composite Joint Using Fem in ANSYS", *International Journal of Modern Engineering Research*, Volume 4, Issue 6 (Version 1), pp 41- 46, 2014.
- [17] T.Subramani., R.Manivannan, M.Kavitha, "Crack Identification In Reinforced Concrete Beams Using Ansys Software" ,*International Journal of Engineering Research and Applications*, Volume. 4, Issue. 6 (Version 6), pp 133 - 141, 2014.
- [18] T.Subramani, M.Subramani, K.Prasath,"Analysis Of Three Dimensional Horizontal Reinforced Concrete Curved Beam Using Ansys" *International Journal of Engineering Research and Applications*, Volume. 4, Issue. 6 (Version 6), pp 156 - 161, 2014.
- [19] T.Subramani, K.Bharathi Devi, M.S.Saravanan , Suboth Thomas<sup>4</sup>, Analysis Of RC Structures Subject To Vibration By Using Ansys," *International Journal of Engineering Research and Applications* Vol. 4, Issue 12(Version 5), pp.45-54, 2014
- [20] T.Subramani, T.Krishnan, M.S.Saravanan , Suboth Thomas, "Finite Element Modeling On Behaviour Of Reinforced Concrete Beam Column Joints Retrofitted With CFRP Sheets Using Ansys" *International Journal of Engineering Research and Applications* Vol. 4, Issue 12(Version 5), pp.69 -76, 2014
- [21] T.Subramani, S.Krishnan, Saravanan.M.S, Suboth Thomas "Analysis Of Retrofitting Non-Linear Finite Element Of RCC Beam And Column Using Ansys" *International Journal of Engineering Research and Applications* ,Vol. 4, Issue 12(Version 5), pp.77-87, 2014.
- [22] T.Subramani, J.Jayalakshmi , " Analytical Investigation Of Bonded Glass Fibre Reinforced Polymer Sheets With Reinforced Concrete Beam Using Ansys" , *International Journal of Application or Innovation in Engineering & Management (IJAEM)* , Volume 4, Issue 5, pp. 105-112 , 2015
- [23] T.Subramani, M.S.Saravanan, "Analysis Of Non Linear Reinforced And Post Tensioned Concrete Beams Using ANSYS", *International Journal of Applied Engineering Research (IJAER)* *International Journal of Applied Engineering Research (IJAER)*, Volume 10, Number 38 Special Issues, pp.28247-28252, 2015
- [24] T.Subramani, K.Balamurugan , " Finite Element Anaylsis Of Composite Element For FRP Reinforced Concrete Slab By Using ANSYS" , *International Journal of Application or Innovation in Engineering & Management (IJAEM)* , Volume 5, Issue 5, pp. 076-084 , 2016 .
- [25] T.Subramani, A.Kumaravel , " Analysis Of Polymer Fibre Reinforced Concrete Pavements By Using ANSYS" , *International Journal of Application or Innovation in Engineering & Management (IJAEM)* , Volume 5, Issue 5, pp. 132-139 , 2016 .
- [26] T.Subramani, M.Senthilkumar , " Finite Element Anaylsis Of RC Beams With Externally Bonded Simcon Laminates By Using ANSYS" , *International Journal of Application or Innovation in Engineering & Management (IJAEM)* , Volume 5, Issue 5, pp. 148-155 , 2016 .
- [27] T.Subramani, A.Selvam , " Studies On Economical Configuration Of RCC And Prestressed Shell Roofs By Using ANSYS " , *International Journal of Application or Innovation in Engineering & Management (IJAEM)* , Volume 5, Issue 5, pp. 182-191 , 2016 .
- [28] T.Subramani, S.Sharmila, "Prediction of Deflection and Stresses of Laminated Composite Plate with Artificial Neural Network Aid", *International Journal of Modern Engineering Research*, Volume 4, Issue 6 (Version 1), pp 51 -58, 2014.

- [29] T.Subramani, K.Udhaya Kumar, "Damping Of Composite Material Structures with Riveted Joints", International Journal of Modern Engineering Research, Volume. 4, Issue. 6 (Version 2), pp 1 – 5, 2014.
- [30] T.Subramani, S.Sundar, M.Senthilkumar, "Investigation of the Behaviour for Reinforced Concrete Beam Using Non Linear Three Dimensional Finite Elements", International Journal of Modern Engineering Research, Volume. 4, Issue. 6 (Version 2), pp 13 -18, 2014,
- [31] T.Subramani, and P.Shanmugam, "Seismic Analysis and Design of Industrial Chimneys By Using STAAD PRO" International Journal of Engineering Research and Applications, Vol.2, Issue.4, pp 154-161, 2012.
- [32] T.Subramani and D.Ponnuvel, "Seismic and stability Analysis of Gravity Dams Using STAAD Pro" International Journal Of Engineering Research and Development, Vol.1, No.5, pp 44- 54, 2012.
- [33] T.Subramani, B.Saravanan, J.Jayalakshmi, "Dynamic Analysis Of Flanged Shear Wall Using STAAD Pro", International Journal of Engineering Research and Applications, Volume. 4, Issue. 6 (Version 6), pp 150 - 155, 2014.
- [34] T.Subramani, K.Bharathi Devi, M.S.Saravanan, Suboth Thomas, "Analysis Of Seismic Performance Of Rock Block Structures With STAAD Pro International Journal of Engineering Research and Applications Vol. 4, Issue 12(Version 5), pp.55- 68, 2014.
- [35] T.Subramani, V.Kanian Poonkundran , " Prefabricated Multistory Structure Exposure To Engineering Seismicity By Using SAP" , International Journal of Application or Innovation in Engineering & Management (IJAEM) , Volume 5, Issue 5, pp. 123-131 , 2016 .
- [36] T.Subramani, R.Praburaj , " Pushover Anaylsis Of Retrofitted Reinforced Concrete Buildings By Using SAP" , International Journal of Application or Innovation in Engineering & Management (IJAEM) , Volume 5, Issue 5, pp. 140-147 , 2016 .
- [37] T.Subramani, R.Vasanthi , " Earth Quake Resistant Building Using SAP" , International Journal of Application or Innovation in Engineering & Management (IJAEM) , Volume 5, Issue 5, pp. 173-181 , 2016 .
- [38] T.Subramani., J.Jothi, M.Kavitha "Earthquake Analysis Of Structure By Base Isolation Technique In SAP", International Journal of Engineering Research and Applications, Volume. 4, Issue. 6 (Version 5), pp 296 - 305, 2014.
- [39] T.Subramani., Reni Kuruvilla, J.Jayalakshmi, "Nonlinear Analysis Of Reinforced Concrete Column With Fiber Reinforced Polymer Bars" International Journal of Engineering Research and Applications Volume. 4, Issue. 6 (Version 5), pp 306- 316, 2014.

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