Abstract - Fly-overs have been constructed since early seventies. They are mainly constructed for the purpose of traffic congestion elimination. However planning, design, construction, and erection of fly-over consume great span of time. The same have been the case with the emerging fly-over over NH By-pass, Palarivattom, and spanning 600m with a width of 6.6m. Greater seismic resistance, life span, and lesser life cycle cost nullify the excess cost of construction of steel flyover. India has a rich history of steel bridges. Steel bridges are ideal solutions for long spans, construction in hilly areas or in the difficult terrain conditions. For the short and medium span bridges and flyovers Steel – concrete composite construction is gaining popularity. But Kerala lacks such steel bridges. Kerala is a small state, with high population density. Most of the cities are saturated and traffic congestion is one of the major problems faced by these cities. Construction of flyovers is a solution to this problem. But construction of flyovers using R.C.C is time consuming, and will affect existing traffic and it has low seismic resistance. Construction of flyovers using steel sections can overcome these disadvantages, even though its initial cost is high.

The project involves study of planning, and design of Palarivattom- Vytilla flyover and further design, and analysis of steel flyover for the same span.

1.1 Objective

The project area is having very high density of traffic flow. The public felt inconvenient to cross the busy palarivattom - vytilla highway & therefore the flyover is essentially required at the junction.

For easy traffic flow of vehicles without traffic congestion flyover or over bridges is essential to overcome the traffic congestion required. Our project deals with the Design of a steel flyover in the intersection. The location is at four roads junction at pipeline junction, which is facing major traffic problems due to the construction.

We have designed the longitudinal girder, cross girder and deck slab for this grade separator.

2. STRUCTURAL DETAILS OF THE PALARIVATTO- VYTILLA RCC FLYOVER

The total span of the flyover is divided mainly into three sections:
(1) First trestle portion with 9 spans of each of 22.20m
(2) Middle obligatory span of 35m
(3) Second trestle portion with 8 spans each of 21.50m

A minimum vertical clearance of 6.00m is allotted for the obligatory span. Flyover has been designed as bi-directional (each two lane) with a design speed of 85kmph. Cast-in-situ RC girder and deck slab of grade M35 concrete is being used for the standard spans (the two trestle portions), whereas cast-in-situ prestressed concrete post tensioned girders and deck slab of grade M40 is being used for the obligatory span. Grade of concrete used for the sub structural components like pier, pier cap, and piles is M35. All the necessary reinforcement is provided using Fe500 confirming to IS: 1786. A solid ramp portion with slope of
1in 30 is provided on either sides of the flyover. An initial valley curve (100.00m), followed by a 1 in 30 slope (116.40m), a summit curve (280.00m), another 1 in 30 slope (135.441m), another valley curve (100.00m), and a 1 in 150.37m slope together comprises the entire section of flyover. Elastomeric bearings separate the superstructure from substructure.

3. DESCRIPTION OF THE MATERIALS

3.1 Concrete

Concrete of grade M35 is adopted in the design of RC deck slab and isolated footing.

3.2 Steel

Steel of grade Fe 415 is adopted for the reinforcement and E250 Steel is adopted for the girder design.

4. LOADS ON THE STRUCTURE

4.1 Dead Loads

The dead loads of the structure consists of the self-weight of the various components such as deck slab, intermediate girders, cross girders, crash barriers, hand rails, wearing coat.

- D.L due to self-weight of the structure which is incorporated by SAP software
- D.L due to crash barriers and hand rails = 7.5 kN/m
- D.L due to wearing coat = 1.76kN/m

4.2 Live Loads

In SAP, the bridge loads can be assigned in the form of moving loads and impact loads. IRC: 6-2014 is used to verify all values. The governing loading types are:

- i. Class AA wheeled type vehicle
- ii. Class AA Tracked type vehicle

4.3 Vehicles

Vehicles are defined for Class AA wheeled and tracked in accordance to IRC 6, 2014

5. DESIGN OF OBLIGATORY SPAN (35m)

Obligatory span is the central most portion of the fly-over. A minimum vertical clearance of 6.00m is allotted for the obligatory span.

5.1 Design of Deck Slab

Spacing of cross girders (c/c) = 4.25m
Width of cross girder = 700mm
Spacing of Longitudinal girder = 2.06m
Width of Longitudinal girder (c/c)= 700mm
Thickness of slab = 250mm
Thickness of wearing coat = 80mm
Effective span in transverse direction = 1.36m
Effective span in longitudinal direction = 3.55m

5.1.1 Maximum Bending Moment Due to Dead Load

Weight of deck slab = 6.25kN/m²
Weight of wearing coat = 1.76kN/m²
Total weight = 8.01kN/m²
Total dead load = 38.67kN
Moment along short span = 1.74kNm
Moment along long span = 0.413kNm

5.1.2 Live Load Bending Moment Due to IRC Class AA Tracked Vehicle

Size of one panel of deck slab= 4.25m x 2.06m
One track of the tracked vehicle is placed symmetrically on the panel. Track contact length taken from IRC: 6-2010
Impact factor fraction = 10%
Total load per track including impact = 385kN
Effective load on the span = 363.497kN
Moment along short span = 20.99kNm
Moment along long span = 4.925kNm

5.1.3 Live Load Bending Moment Due To IRC Class AA Wheeled Vehicle

- i) Bending moment due to wheel 1
  Load, W = 62.5kN
  Moment along short span= 12.56kNm
  Moment along long span= 10.44kNm

- ii) Bending moment due to wheel 2
  Equivalent load, W = 546.37kN
  Moment along short span = 52.71kNm
  Moment along long span = 13.14kNm

  Bending moment due to middle portion,
  Equivalent load, W = 421.37kN
  Moment along short span = 47.11kNm
  Moment along long span = 12.01kNm

  Net bending moment along short span = 2.795kNm
  Net bending moment along long span = 0.535kNm

  Total short span bending moment, M₁ = 15.355kNm
  Total long span bending moment, M₂ = 10.975kNm

  Impact factor = 19%

  Therefore, \( M₁ = 1.19 \times 15.355 = 17.29\) kNm
  \( M₂ = 1.19 \times 10.975 = 11.45\) kNm

  Absolute maximum bending moments,
  \( M₁ = 20.99\) kNm (tracked)
5.1.4 Reinforcement

Use 12mm diameter at 200mm c/c as main reinforcement along short span and 8mm diameter bars at 170mm c/c as longitudinal reinforcement.

5.2 Design of Longitudinal Girder

The design of longitudinal girders is done as I plate girder. Hence it is necessary to determine minimum depth required which is further used for determination of moment capacity.

5.2.1 Preliminary Dimensioning

5.2.1.1 Depth of girder

Adopted girder depth is 1800 mm.

5.2.1.2 Web thickness

Adopted web thickness is 20mm.

5.2.1.3 Flanges

Adopted $b_f = 700$mm and $t_f = 70$mm

5.2.2 Optimum Girder Depth and Thickness of Web

The maximum bending moment obtained from analysis is $M_{1}=22.73$ kNm $M_{2}=11.86$ kNm

Thus, $M_{1}=18.184$ kNm

$M_2 = 11.86 \times 0.8 = 9.489$ kNm

5.3 Design of Cross Girder

The girder is designed as I plate girder. Hence it is necessary to determine the minimum depth required which is further used for the determination of moment capacity.

5.3.1 Preliminary Dimensioning

5.3.1.1 Depth of the girder

Adopted girder depth is 2000mm.

5.3.1.2 Web thickness

Adopted web thickness is 20mm.

5.3.1.3 Flanges

Flange width adopted is 700mm and the thickness of flange is 70mm, so $b_f/t_f = 10 < 13.6$

5.3.2 Optimum Girder Depth

Maximum bending moment obtained from analysis is $4100.3$ kNm.

The optimum value of depth is obtained as $d = 1133.89$ mm

5.3.3 Design of End Bearing Stiffeners

As per clause 8.7.5.2, IS 800-2007

$F_{psd} = \frac{A_q \times f_y q}{.8 \times \gamma_m}$

$A_q > 7139.62$ mm$^2$

Thus provide two flats of size 200 x 40 mm on each side.

Area provided $= 16000$ mm$^2$ > $7139.62$ mm$^2$

6. DESIGN OF TRESTLE SPAN (22.2m)

Trestle spans are the portion of the fly-over on either side of the obligatory span. Design of trestle portions is similar to that of the obligatory span.

6.1 Design Of Deck Slab

Spacing of cross girders $(c/c)=4.04$ m

Width of cross girder $= 700$mm

Spacing of Longitudinal girder $= 3.6$ m

Width of Longitudinal girder $(c/c)=700$mm

Thickness of slab $= 250$mm

Thickness of wearing coat $= 80$mm

Effective span in transverse direction $= 2.9$ m

Effective span in longitudinal direction $= 3.34$ m
6.1.1 Maximum Bending Moment Due to Dead Load

Weight of deck slab = 6.25 kN/m²
Weight of wearing coat = 1.76 kN/m²
Total weight = 8.01 kN/m²
Total weight = 77.58 kN
Moment along short span = 3.68 kNm
Moment along long span = 2.83 kNm

6.1.2 Live Load Bending Moment Due to IRC Class AA Tracked Vehicle

Size of one panel of deck slab = 4.04m x 3.6m
One track of the tracked vehicle is placed symmetrically on the panel.
Total load per track including impact = 385kN
Effective load on the span = 341.99 kN
Moment along short span = 29.97 kNm
Moment along long span = 23.72 kNm

6.1.3 Live Load Bending Moment Due To IRC Class AA Wheeled Vehicle

i) Bending moment due to wheel 1
   Moment along short span = 15.09 kNm
   Net bending moment along short span = 3.77 kNm
   Net bending moment along long span = 3.485 kNm

ii) Bending moment due to wheel 2
   Moment along short span = 15.09 kNm
   Net bending moment along short span = 1.401 kNm
   Net bending moment along long span = 1.62 kNm

iii) Bending moment due to wheel 3
   Moment along short span = 15.09 kNm
   Net bending moment along short span = 5.52 kNm
   Net bending moment along long span = 1.59 kNm

iv) Bending moment due to wheel 4
   Moment along short span = 15.09 kNm
   Net bending moment along short span = 3.77 kNm
   Net bending moment along long span = 3.485 kNm

v) Bending moment due to wheel 5
   Moment along short span = 15.09 kNm
   Net bending moment along short span = 1.401 kNm
   Net bending moment along long span = 1.62 kNm

vi) Bending moment due to wheel 6
   Moment along short span = 15.09 kNm
   Net bending moment along short span = 3.77 kNm
   Net bending moment along long span = 3.485 kNm

Total short span bending moment, \( M_1 = 30.95 kNm \)
Total long span bending moment, \( M_2 = 26.89 kNm \)

Impact factor = 25%
Therefore, \( M_1 = 1.25 \times 30.95 = 38.69 kNm \)
\( M_2 = 1.25 \times 26.89 = 33.61 kNm \)

Absolute maximum bending moments,
\( M_1 = 38.69 kNm \) (wheeled)
\( M_2 = 33.61 kNm \) (wheeled)

Total design bending moments, \( M_1 = 33.89 kNm \)
\( M_2 = 23.77 kNm \)

6.2 Design of Longitudinal Girder

The design of longitudinal girders is done as I plate girder. Hence it is necessary to determine minimum depth required which is further used for determination of moment capacity.

6.2.1 Preliminary Dimensioning

6.2.1.1 Depth of girder

Adopted girder depth is 1800 mm.

6.2.1.2 Web thickness

Adopted web thickness is 20 mm.

6.2.1.3 Flanges

Adopted \( b_f = 700 mm \) and \( t_f = 70 \)
\( \frac{b_f}{t_f} = \frac{10 mm}{13.6} \)

6.2.2 Optimum Girder Depth

The optimum value of depth is obtained as
\( d = \left( \frac{M k}{f_y} \right)^{0.33} \)
Maximum bending moment obtained from analysis is 14070.907 kNm.
\( d = 1228.26 mm \)
t\( w = 19.12 mm \)
Thus a web thickness of 20 mm is adopted.

6.2.3 Design of End Bearing Stiffeners

As per Clause 8.7.5.2, IS 800-2007
\( F_{psd} = \frac{A_q \times f_y \times q}{0.8 \times \gamma_{nto}} \)
\( A_q > 8668.63 mm^2 \)
Thus provide two flats of size 200 x 40 mm on each side
Area provided = 16000 mm² > 8668.63 mm²

6.3 Design of Cross Girder

The girder is designed as I plate girder. Hence it is necessary to determine the minimum depth required which is further used for the determination of moment capacity.

6.3.1 Preliminary Dimensioning

6.3.1.1 Depth of the girder

Adopted girder depth is 2000 mm.

6.3.1.2 Web thickness

Adopted web thickness is 20 mm.
6.3.1.3 Flanges

The flange width adopted is 700mm and the thickness of flange is 70mm, so \( b_f/t_f = 10 < 13.6 \)

6.3.2 Optimum Girder Depth

Maximum bending moment obtained from analysis is 7463.3 kNm. The optimum value of depth is obtained as \( d = 1381.67 \) mm

6.3.3 Design of End Bearing Stiffeners

As per Clause 8.7.5.2, IS 800-2007

\[
F_{psd} = \frac{A_d \times f_y q}{0.8 \times Y_{mc}}
\]

\( A_d > 7297.31 \text{mm}^2 \)

Thus provide two flats of size 200 x 40 mm on each side

Area provided \( = 16000 \text{mm}^2 > 7297.31 \text{mm}^2 \)

3. CONCLUSIONS

Construction of flyovers using R.C.C is time consuming, and will affect existing traffic. Construction of flyovers using steel sections can overcome these disadvantages, even though its initial cost is high. Steel bridges offer a wide range of solutions to choose from based on the design/site requirements. Truss type or girder type, deck type or through type, arch type or frame type, simple or continuous span type, all-steel or composite construction options are only a few examples. Some of the advantages of steel intensive bridges and flyovers are:

1. Fast - track construction
2. Prefabrication possibility and minimum disruption to public life in urban areas
3. Cost competitiveness, easy construction, maintenance and up-gradation
4. Sleek, strong and long span structures, lighter foundation
5. Durable structures, longer life and improved life cycle performance
6. Ensured quality of material and construction

REFERENCES