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Study and Design of Fly-Over Bridge on Major Road Junction in Yavatamal

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ABSTRACT: Our project deals with the study and design of flyover bridge on major road junction in yavatmal. The project area is having very high density of traffic flow. The common public felt inconvenient to cross the junction. The location of this project is at four road junction at "Old bus stand square, yavatmal and there is a heavy traffic problem and therefore the fly-over bridge is essentially required at the junction for easy traffic flow, fly-over helps to streamline the traffic flow by helping to reduce traffic congestion problems.

In this project we are planning & designing the fly-over of 4.5m width. It is an single lane fly-over which starts from arni road towards the state bank road & it get further devided towards Nagpur road from main junction. In this project we did traffic volume survey of that area. Then designed all the structural parts of the fly-over by taking reference from IRC, and then prepared a model of this fly-over bridge.

1. INTRODUCTION

Our project deals with the study on design of flyover bridge on major road junction in yavatmal. Flyover bridge is a bridge that carries on road or highway line above another, for easy communication between two sides, or to increase capacity of traffic flow and reduce the traffic congestion in both the direction.

According to guidelines for controlling traffic at an intersection, it used traffic volume as criteria to choose a type of junction, for traffic volume about 25,000 to 45,000 vehicles/day, two levels of control should be used.

Flyover may refer to overpass, a high level road bridge that crosses over a highway interchange or intersection. Flyover is basically a same thing as bridge. There are mainly three types of flyover i.e.

1) Composite flyover
2) Steel flyover
3) Concrete flyover.

Fig. (3D View of Flyover Bridge)

OBJECTIVE

The objectives of this study are as the following:

- The main objective of designing of Fly-over Bridge on major junction in Yavatmal is to avoid excessive traffic.
- To study and to make the suggestion and improvement in transportation by providing fly-over bridge for excessive traffic.
- To study traffic and road safety issue at the fly-over.
- To assess the economic evaluation of fly-over.
- To Minimize the traffic delay due to heavy traffic.
- To suggest the fly-over with good Aesthetic and Architectural view.
- For easy transportation of agricultural goods and industrial goods with ease.

LITERATURE REVIEW

T. Patel, K. Dave: Observed that the number of accident occur due to high speed of vehicle, traffic delay, risk of pedestrian life, lack of proper facility like symbol, signals and markings. Fly-over suggest for the traffic flow at this intersection and during the construction of flyover minimize traffic delay by the road safety audit and using the rapid construction of the fly over at intersection. Conclude the final that the fly over bridge will carry the future traffic safely next 30year. Construction of flyover is an accelerated by the prefabricated bridge element. Minimise the accident by construct flyover and smooth traffic flow in both direction. And in himmatnagar number of ceramics so it can ceramic waste use in construction to minimise the pollution.

T. PRAMOD KUMAR: Deals with the analysis and design of super structure of road cum railway bridge across Krishna river proposed and downstream side of existing bridge between

Mahandu road of Sithangaram and P.N. Bus station, Vijayawada. The bridge is made of through type steel truss which carries two railway tracks at lower level and a roadway of three lane carriage way in the upper level. The span length matches with that of existing nearby railway bridge. Analyses of top floor members, truss members and bottom floor members are done using STAAD Pro. The design of structural members of the truss, top floor and bottom floor members done as per Indian railway standard code and Indian roads congress code. In which they concluded that Road cum railway bridge reduce the construction cost by providing single bridge for both railway traffic road traffic instead of providing two separate bridges. It meets the increased railway and road traffic needs across the river Krishna. It reduces the land acquisition problem by providing single bridge.

PARTHKUMAR K. PATEL, ARVIND M. JAIN: In this paper the author has works on the briefly study on the construction of the over bridge. And check the present ground condition. Evaluate the over bridge performance and impact on traffic condition. Various surveys are carried out and finally conclude that the total number of vehicle benefitted by an over bridge, average Delay time and saving in travel time and fuel consumption. These saving are calculated in terms of rupee. Calculate that the bridge is appropriate and its yearly benefits are 24.5% and it is more than assumed direction 22.5%.

SACHIN KULKARNI(2014): Carry out a seismic evaluation case study for an existing RC bridge using nonlinear static (pushover) analysis. In the present study a 4 Span RC Bridge existed in SH-12 in Karnataka, India, was selected and by defining FEMA 356 Auto hinges conducted Nonlinear Static (Pushover)Analysis using (ATC r40) Capacity Spectrum Method and software SAP2000 was used to analyze the Bridge. The evaluation results presented here shows that the selected bridge does not have the capacity to meet the desired performance level and it requires retrofitting. From the Pushover Analysis the performance levels of bridge are studied. From the Analysis it is evident that Spectral Displacement Demand is more than the Spectral Displacement Capacity in the analyze Bridge. So the analyzed bridge requires retrofitting.

N. D. Chhatbar, Pa. Shinkar: In these papers the author was undertaken to determine effects of fly over undertaken to determine effects of fly over construction to the way of life of the motorists and commuters and general travelling public. Use various methods like benefit/cost ratio and net Present value (NPV) method are used for economic assessment. And conclude that in terms of rupee an installation of flyover at a cost and vehicle delay time in terms of cost are calculated and assess the fly over bridge.

A.V.ARJUN: "Economic Feasibility & Efficient Project Scheduling of Fly Over in VISAKHAPATTANAM (INDIA) between MADDAILAPALEM and satyam junction is carried out. The benefits acquired the construction cost of flyover,feasibility study has been done. The fly over construction is scheduling is carried out through different stages of construction manger to decide between economy and duration of the project. Finally conclude that the peak our traffic at MADILAPALEM junction toward NAD() at various times is calculate in PCU. And studied the benefits and cost concluded that the construction of the single lane flyover thoroughly feasible between NAD.

2. METHODOLOGY

General

DESIGN DATA FOR STRUCTURE:-

1. Carriageway
    - Carriageway width:- clear carriage of 4.5m

- Width of crash barrier:- 0.25m
- Height of crash barrier above wearing coat:- 1.00m
- Overall width of fly-over:- 4.5m

2. Seismic effects
(Taking reference from fly-over constructed at Amravati under PWD)
- Seismic zone:-zone Ⅲ
- Importance factor:- 1.0

3. Speed of vehicles: - 80kmph/40kmph on curves.
4. Exposure condition: - moderate.
5. Temperature range:-10^0 to 50^0C.
6. Maximum temperature (t):- 50^0C.
7. Live load for viaduct for 4m of clear carriage-way: - As per IRC: 6(2014) one lane of class A.
8. The impact factor shall be applied as per IRC-6.
9. Bearing type:- POT-PTFE as per IRC-83(Ⅲ)
10. Expansion joint:- Modular strip sed types
11. Wearing covers:- 50mm thick dense bitumen or RCC M30.
12. Minimum grade of concrete
- Foundation – M30
- Piers & pier caps – M35
- Pedestals – M45
- Superstructure – M40
- Seismic arrester – M30
- Annular filling – M15
- Leveling cover PCC – M15

13. Minimum covers to be provided
- Superstructure – 40mm
- Substructure – 40mm
- Foundation – 75mm
- Pre-stressing cable duct – 75mm
- Pre cast element – 35mm

14. Minimum diameter of bar
- Diameter of any reinforcing bar including transverse ties, stirrups, etc. will not be less than 10mm.
- Diameter of any longitudinal reinforcement bars in columns / vertical member will not be less than 12mm.
- However, diameter of the reinforcing bars will not exceed 25mm in slab & 32mm in other member.

15. Slope of flyover
- A slope of 30^0 (1.73H: 1V) shall be generally considered.
- Slope is provided on first 30m of flyover and then 20m in piers.

16. Span
- Total length of flyover is 820m.
- No. of span – 82 span [Each of 10m span].

17. No. of piers
- Providing piers at every 10m.

Clear span = 640m
= 640/10
No. of pier = 64 NOS.

- No. of piers provided in slope = 60/10 = 6 NOS.
- One single circular pier is provided at the center of junction which is to be design for 15m span.
- Total no. of circular shape pier for 10m span = 70 piers
- Total no. of circular shape pier for 15m span = 1 pier.

18. Height

- Minimum height of flyover deck slab from ground surface or road way should be 7m.
- More than 7m or 7m of overall height of flyover to be provided.

19. Other related insufficient data to be assumed from IRC codes

STRUCTURAL DESIGN:-

1. DECK SLAB WITH GIRDER:-

Clean Span between pier= 10m
No. Of lanes = Single Lane
Loading = IRC Class A
Concrete M-40
Wearing coat = 50mm
Depth of Slab is to be assumed = 300mm
Effective span = 3.2m

1. **Dead load calculations:-**

Self -weight of deck Slab = 24x0.3 = 7.2 KN/M²
Self- weight of wearing coat = 22X0.05 = 1.1KN/M²
Total dead load = 7.2+1.1 = 8.3 KN/M²
Max. Dead load of shear force = $\frac{WL}{2}$ = 8.3x$\frac{3.2}{2}$ = 13.28 KN
Max. Dead load for bending moment = $\frac{WL^2}{8}$= 8.3x $\frac{3.2^2}{8}$= 10.624 KN.M²

2. **Live load calculation:**

Impact factor (IRC 6:2016 clause 20.6.8)
Impact factor = $25 - \frac{25-10}{95}$ = 1.197
Effective width load
$b = \propto xa\left(1 - \frac{a}{Lo}\right) + b1$
Lo = 3.2m
$a = \frac{10}{2} = \frac{8.2}{2} = 1.6m$
$b1 = 0.85 + 2\ X\ 0.005 = 0.95mm$
By interpolation, $\propto = 2.728$
$b = 2.728x1.6\left(1 - \frac{1.6}{3.2}\right) + 0.95$
$b_{eff.} = 3.132m$
Effective width of dispersion including overlap
= 0.5+0.3+1.3+0.3+0.5+0.3+1.3+0.3+ $\frac{3.132}{2}$
= 6.86m

Width of dispersion $= 0.5 + \frac{0.3}{2} + 2(0.3 + 0.1)$

$= 1.45\text{m}$

Impact factor from IRC-6

For Span < 5m – 25%

For Span < 9m – 10%

Impact factor = 1.197

Intensity of loading $= \frac{4\text{x}114\text{x}1.197}{6.86\text{x}1.6} = 49.72\text{KN.M}$

$\text{Mx} = \left(49.72\text{x}\frac{1.6}{2}\text{x}\frac{1.6}{2}\right) - \left(\frac{49.72\text{x}1.6}{2}\text{x}\frac{4.5^2}{4}\right)$

Mx =18.52KN.M

Total moment $(\text{Mu}) = 1.35(\text{D.L}) + 1.5(\text{L.L})$

$= 1.35(10.624) + 1.5(18.52)$

$= 42.12\text{KN/M}$

Shear force $(\text{V}) = 49.72\text{x}1.6\text{x}\left(\frac{1.6-\frac{1.6}{2}}{45}\right)$

$\text{V} = 14.14\text{KN}$

3. **Flexure: -**

$\text{Mu} = 0.36\ \text{Fck.b.Xumax.}(\text{d} - 0.12\text{Xumax.})$

$\text{Mu} = 0.36\text{x}30\text{x}3132(500 - 0.42\text{x}500)$

$\text{Mu} = 9.80\text{x}10^6\text{N.MM}$

CalculatingAst:-

$$\text{L} = 0.87\text{xbyxAstxd}\left(1 - \frac{\text{Fy.Ast}}{\text{Fck.b.d}}\right)$$

$$9.80\text{x}10^6 = 0.87\text{x}500\text{xAstx}3132\left(1 - \frac{500\text{xAst}}{30\text{x}3132\text{x}300}\right)$$

Ast = 720.13mm²

$\text{Ast}_{\text{min.}} = 0.12\%\ \text{ofbD}$

$= \frac{0.2}{100}\text{x}1000\text{x}300$

$= 360\text{mm}^2$

∅ of bars = 20mm

∴provide 4 bars of 20mm ∅

1. **PIER: -**

Design for 64 piers of height 7m.

Live load: IRC Class AA tracked vehicle

Materials: M-35 grade concrete and Fe-415 steel

Data:

Effective span of girder = 10m

Clear width of roadway = 4.0m

Live load on bridge class AA

Height of piers = 7m

Height of flood level = 2m

Assume Weight of bearing plate as 10kn

- **Dead load at pier cap:**

  The pier cap is divided into two cantilevers and are of rectangular section

  Wight (moment) of two trapezoidal sections

  = Area X Unit weight of circular pier

  = 322. 56KN.m

- **Stress due to live load:**
  Reaction due to live load class AA loading including impact
  = 1.197 X 70
  = 83.79KN.m
  Maximum bending moment = 83.79X 0.5
  = 41.895KN.m
  Maximum and Minimum stresses at the base due to this load will be
  σ_c= 5.74 KN/m^2 and 0.916 KN/m^2
- **Stresses due to longitudinal force:**

Maximum longitudinal force will occur due to class AA Loading = 14Kn
Moment at base of piers dur to this force = 100 X 14 = 140Kn

Stress at base = $\frac{(140\ X14)}{IXX}$
= 12.100KN/m^2
Assume coefficient of friction as 0.25 at is bearing and 0.22 at other bearing
Total resistance at one set of bearing with D.L and L.L
= 0.25 (166.85+1.197X700)
= 234.212 KN
Total resistance at other set of bearings due to DL only,
= 0.22 X 166.85
= 36.707KN

- **Stresses due to wind load:**
  Exposed height of the structure
  = depth of girder + thickness of slab + height of railing
  = 1.4 + 0.30 + 1.0
  = 2.7m
  Ratio = $(\frac{d}{D}) = (\frac{40}{750}) = 0.053$
  Where,
  'D' is the diameter of circular pier = 750mm
  'd' is the clear cover = 40mm
- **Reinforcement:**
  Percentage of steel reinforcement
  P = 0.01 X 7.5
  = 0.075

Area of steel = 0.075X$\frac{\pi}{4}$ X750^2
= 33133.99 mm^2
Use 25mm diameter bar
Ast = $\frac{3.14X25^2}{4}$
Ast= 490.87 mm^2
No. of bars =$\frac{33133.99}{490.87}$
= 68 No.

However, provide 68 no. of 25mm diameter bars assumed the circular piers and use 10mm diameter bars of lateral ties.
Similarly for 2 piers that is to be provided in slope of fly-over,
Height to be provided is 5.5m and 6m respectively, as per above design.

For one single circular pier located at the center of junction which is to be design for span 15m of size 1000m in diameter.

2. **PIER CAP**: -

Design of hammer head portion over circular pier for the following details Live load: IRC class AA Tracked vehicle.
Materials: - M35 grade concrete and Fe-415 steel.
Live Load is the IRC class AA tracked vehicle

- permissible stresses (IRC-21)

For M35 grade concrete &Fe 415 steel.
σ_{cb} = 11.67 N/mm, m=10, σ_{st}=200N/mm

- Calculating moments: -
  Total dead load moment= 1166. 752kN.m

Live load moment = The live load is IRC class AA tracked vehicle.
Effective width of dispersion perpendicular to spans given by
$b_e = 1.2x + b_w$
x = 0.1m
b_w = [0.85m +2x0.075] + 1
= 1m
∴Live load perimeter width including impact = 2110. 6KN.m
Design moment: -
M = 1166.752 + 2110.6
= 3277. 352KN.m
Factored moment = 4916. 028KN.m

Reinforcements: -

Effective depth required
2Qbd = Maximum bending moment

$$d = \frac{(4916.028X10^6)}{(1.93X1000)X0.5}$$

= 1595.98mm

Effective depth required is = 2150mm
∴ 2150mm > 1595.98mm
Hence Adopted depth is adequate

$$Ast = \frac{(4916.028X10^6)}{(200X0.9X2150)}$$

$= 12702mm^2$
Use 32mm ϕ bars

$$Ast = \frac{(3.14X32^6)}{4}$$

$= 804.24mm^2$

$$\therefore \text{No. of bars} = \frac{12702}{804.24}$$

= 16

However, provide more effective reinforcement then required

3. **Design of column footing: -**

Data: -
Size of Column = 750mm
Factored axial load (Pu) = 2400KN (assume)
Safe bearing capacity = 200 KN/M²
Use M-30 grade concrete

Ultimate safe bearing capacity (S_u) = 1.5x200 = 300 KN/M²

(S1) Size of footing

Calculate A_f = Area of footing

(Pu) footing = (Pu) c + (10% column load)

$= 2400 + \frac{2400}{100} \times 10$

(Pu) footing = 2640KN

Area = $\frac{2640}{750}$

$A_f = 35.2m^2$

$\frac{\pi}{4} \times D_f^2 = 35.2$

$D_f = \sqrt{\frac{35.2x4}{\pi}} \cong 6m$

D_f = 6m

Check for diameter based on SBC. = (S_u) check = $\frac{\text{column factored load}}{\text{Area of footing}}$

Area of footing = $\frac{\pi x(DF)^2}{4} = \frac{\pi x(6)^2}{4}$

Area = 28.27m²

$= \frac{2400}{28.27}$

(S_u) check = 191.08 KN/m² < 300 KN/m²

Hence check diameter is adequate

(S_u) adopt. < (S_u) given.

Ultimate moment &S.f.:-

Mu = Wu.e d_f = outer ϕ =D_c = Colum ϕ = 0.750

Wu =$S_u.A_f$. (Hollow)

A_f(Hollow) = $\frac{\pi}{4}x(DF^2-Dc^2)$

A_f(Hollow) = $\frac{\pi}{4}(6^2-0.75^2)$

$A_f = 27.83\ m^2$

Wu = 191.08 x27.83= 5317.75KN

For $\frac{1}{4}$ Quadrant = $\frac{1}{4}$ x (Wu) = $\frac{1}{4}$ x 5317.75

Wu = 1329.43KN.

Length l = 611-150 = 461

Mu = 1329.43x0.461

Mu = 612.86 KN.M.

Check for depth of footing:-

Mu = 0.138 Fck. bd²

$d = \sqrt{\frac{Mu}{0.138xFckxb}} = \sqrt{\frac{612.86x10^6}{0.138x30x250}}$

d = 769mm

d ≅800 mm

Depth required for shear consideration will be nearby 1.5 times that for moment consideration

b = $\frac{1}{4}$ x (circumference length)

b =$\frac{1}{4}$ x π x 750

b = 589mm ≅ 600mm

Reinforcement for footing:

$$Mu = 0.87\ Fy.\ Ast.\ d\ (1 - \frac{Fy.Ast}{Fck.b.d})$$

$$612.86 \times 10^6 = 0.87 \times 415 \times Ast \times 800(1 - \frac{415\ xAst}{30 \times 600 \times 800})$$

$A_{st} = 2270.34mm^2$

Provide 12mm diameter of bars

$a_{st} = \frac{\pi}{4} \times 12^2$

$a_{st} = 113.097\ mm^2$

$$\text{No. of bars} = \frac{\text{Total area of steel(Ast)}}{Area\ of\ one\ steel\ bar(ast)}$$

$$= \frac{2270.34}{113.097} = 20.07 \cong 21 \text{ Nos.}$$

$$Sv = \frac{ast}{Ast} \times 1000$$

$$Sv = \frac{113.097}{2270.34} \times 1000$$

$Sv = 115.73$

$Sv \cong 120mm$

Provide 21 no. of 12mm diameter of bars (Sv) @ 120mm c/c.

For all types of Fly-over Bridge structure generally most suitable footing to be provided is column footing.

3. CONCLUSION

This project concludes the planning and study of Flyover Bridge on major junction in Yavatmal. This structure help in reduction of traffic flow on main road and enhance the safe driving. This fly-over bridge is an early solution to the problem of traffic jam that may occurs in few years as per future consideration because of the daily incrementation in traffic.

We have designed a single lane-one way flyover bridge of 4.5 m width having total span of 820m and totally 71 number of piers are their in the structure and are designed as per IRC standards. We have designed this whole structure as per the IRC standards.

This project helps to minimize the road accident, traffic jams, it also reduces the impact of sound pollution as well as air pollution on environment. It also increases the traffic capacity of the roads and reduces the travel time as well as fuel consumption of vehicles.

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