A Final Paper on Enhancing Traffic Flow with Safety by Providing a Flyover Bridge

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Abstract

Transportation plays a vital role in the development of a nation. In India, rapid urbanization and population growth have led to a significant increase in vehicular density, making efficient transportation infrastructure essential for urban expansion. Traffic congestion is a common challenge, particularly in high-density urban areas. Different countries adopt tailored approaches to address transportation challenges based on their population dynamics and available resources. Major cities worldwide, including those in Maharashtra, experience severe traffic congestion, especially at entry points due to inadequate road design and vehicle misalignment. To mitigate these issues, to fallows different methodologies such as extensive surveys are conducted to analyse peak-hour traffic condition. As a strategic solution, the proposed flyover bridge and their components are design by IS Codes, IRC Codes which expected to redirect approximately 30–35% of the total traffic, thereby improving flow efficiency and road safety. Developed the model using "REVIT" as well as physical prospective model. This study focuses on urban traffic management strategies and emphasizing their significance in enhancing mobility. Additionally, it examines the current traffic conditions in Yavatmal and explores the role of the flyover bridge in alleviating congestion and optimizing transportation infrastructure.

Keywords: Traffic flow, Traffic monitoring, Traffic congestion, Safety, Planning, Flyover bridge

1. Introduction

In case of Yavatmal city there is major traffic issues arises at the entry point of the city road due to triangular obstruction which causes major traffic congestion as well as increases the accident rate. The vehicles from the City Road, Nagpur Road and Arni road arises collision at the junction and faces noise pollution in this area. Therefore, an alternative solution proposing flyover bridge with the help of different methodologies, such as traffic analysis, location survey, soil test as well as planning and design with the help guidelines of IS codes, IRC codes for the solution of this problem.

A flyover, often referred to as an overpass, serves as a dedicated elevated roadway designed to facilitate vehicular movement over obstacles such as intersections, railway lines, or other roads. These structures not only serve a functional purpose but also enhance the visual aesthetics of an urban environment, acting as architectural elements that establish seamless connectivity between distinct areas. This paper predominantly centre on the extensive design of an RCC footbridge manually and then creating a 3D model using AutoCAD. A physical prospective model is also developed. The design aims to connect the first floors of these two
buildings effectively.

2. Objectives

- To proposed a fly-over reduce traffic congestion, enhance smooth traffic flow in two separate ways.
- To make an alternative solution to minimize travel time and low fuel consumption.
- To avoid vehicles collision and allocate safe efficient access.
- To provide a direct route without taking any long turn.

3. Scope

- To achieve efficient and rapid flow of traffic at intersection.
- To decreases the accident rate and reduced the fuel consumption.
- To growth of economy of Yavatmal City.

4. Literature Review

1. **D. Firmansyah (2024):** have focused on the progression of motorcycle-related studies in Asia and categorized studies such as accidents and human factors, traffic and policy, air pollution, motorcycle engineering and performance, and roads and technological innovation, demonstrates a clear evolution in the scope of research as the issues surrounding motorcycles have expanded beyond safety concerns to include environmental impacts, technological advances, and also urban sustainability. provide insights into the geographical distribution of research, noting that China (including Taiwan) has contributed the most to the field. Furthermore, the study suggests several emerging areas of interest for future research, such as eco-friendly fuels, diverse motorcyclist behaviours, and technology-based safety improvements.
2. **S. V Yadav et al. (2024):** have accentuated multiple causes of accidents, including road defects, human errors, and vehicle engineering flaws. They focus on reducing accident severity using geodetic techniques to improve traffic signals and road safety devices.
3. **Habibullah et al. (2024):** have amplified the role of a cyber-physical framework that connects physical structures with digital systems, enhancing immediate data gathering and traffic management in rapidly urbanizing cities.
4. **Ezzati Amini et al. (2024):** have measured the increasing popularity of motorcycles in Asia, highlighting accident risks due to affordability and flexibility. They identify future research directions focusing on eco-friendly fuels and technology-based safety solutions.
5. **A. Bhardwaj et al. (2023):** have deconstructed that such jams can occur in extremely brief periods, which is why they are referred to as sudden traffic jams. They have attributed traffic jams in developing cities, linking them to poor traffic management and suggesting infrastructure improvements and better road system management.
6. **Mishra et al. (2023):** have pointed the need for improved traffic management strategies, including redesigning the intersection and implementing advanced signalizing systems to enhance safety and efficiency. They provide a comprehensive analysis of traffic patterns and accident data. The study offers actionable recommendations to reduce conflicts and optimize traffic flow; they underscored the importance of proactive management to ensure safer transportation at the LIC Square intersection.
7. **Wallenstein-Betech, et al. (2023):** have evaluated lane reversal strategies under asymmetric demand, such as during evacuations or large events. Their study showed that travel time reductions could reach up to 60%, offering insights for optimizing traffic flow through lane management.
8. **Pang et al. (2023):** have focused on optimizing biofuel blends for improved combustion efficiency, suggesting that more efficient engines reduce fuel consumption and can indirectly alleviate traffic congestion over time. These advancements align with sustainable mobility goals.
9. **Sun et al. (2022):** have analysed how governance policy changes and socioeconomic variations affect traffic congestion. They evaluated various time scenarios and identified the most detrimental factors, providing insights for regional policy development.
10. **Mahajan (2022):** has signified the rising demand for transportation in India due to economic and infrastructural development, population growth, and significant issues, particularly in metropolitan areas like Pune. They analysed the causes of congestion to propose solutions for better planning, design, and cost-efficient systems.
11. **Roopa Ravish, et al. (2021):** have studied the administration of increasing vehicle flow as a challenge worldwide. How ITS (Intelligent Transportation Systems) technology is used for traffic management in flyover bridges. It categorizes the solutions into four groups. The first one is traffic information solutions, traffic oversight solutions, congestion mitigation solutions, and travel time forecasting solutions.
12. **Rose Mary Xavier et al. (2021):** studied to analyse and compare the peak value of the three intersections, which took the highest. The peak value selected for traffic volume data collection has been chosen to ensure accurate and reliable analysis, which implements the present and future demands of the traffic may be satisfied.
13. **Shaik Zia Ur Rahman et al. (2020):** have described Hyderabad city, which is facing major traffic problems at peak hours. In this study, the outcome will be the flyover constructed to reduce horizontal curvature and reduce the risk of accidents and road crashes.
14. **A. P. S. Gawande et al. (2020):** have observed the skew intersection at Lohara M.I.D.C. in Yavatmal City and highlighted the necessity for a comprehensive survey and design of an effective traffic system. Traffic signals are recognized as a flexible and beneficial method for controlling traffic. There was less congestion and accidents while enhancing traffic flow.
15. **Vencataya, et al. (2018):** have recommended that policymakers adopt better management strategies and invest in infrastructure and implementing policies that can alleviate congestion and improve overall travel conditions. Their study in Mauritius analysed the effects of congestion on worker productivity in which the Congestion leads to longer commuting times, which reduces overall productivity, Economic growth health in which increased traffic delays can negatively impact the economy by reducing the efficiency of the labour force and hindering business operations, and also providing insights for urban planning.

5. Methodology

5.1 Planning and modelling of flyover
5.2 Design concept of flyover bridge

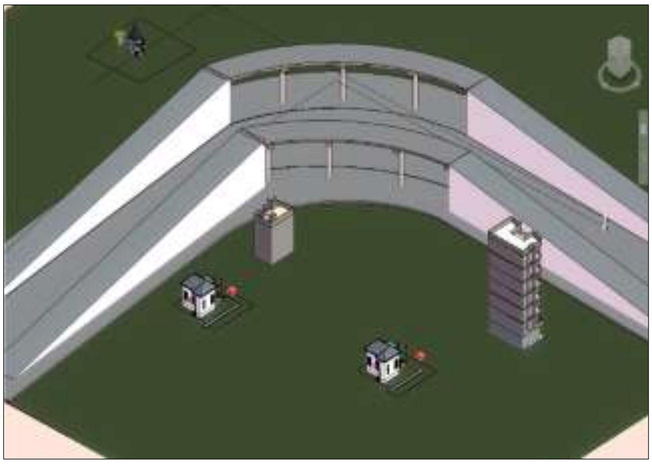
5.1 Planning and modelling of flyover

Figure 1: 3D model of flyover bridge by using REVIT SOFTWARE

6 Design concept of flyover bridge

1. Carriageway
Carriageway width :- Clear carriage of 3.5m
Width of crash barrier :- 0.25m
Height of crash barrier above wearing coat :-1.00m
Overall width of fly-over :- 12m
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° to 50°C.
6. Maximum temperature (t) :- 50°C.
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 :- 65mm thick dense bitumen or RCC M30.
12. Grade of concrete

- Foundation-M35
- Pier/Abutment Column-M40



- Pedestals and crash barrier- M40
- Superstructure-M35
- Seismic arrester-M30
- Deck slab-M35
- Approach slab- M30
- Annular filling-M15
- Leveling course-M15

13. Minimum covers to be provided.

- Superstructure 30mm
- Substructure 40mm
- Foundation 75mm
- Pre-stressing cable duct - 75mm
- Pre cast element-35mm

15. Slope of flyover

- A slope of 30° (1.73H: IV) shall be generally considered.
- Slope is provided on first 30km of flyover.
- Total length of flyover is 80km.
- No. of span-4 spans [End span 30km and middle span 25km].

18. Height

- Minimum height of flyover deck slab from ground surface or road way should be 8.4m.
- More than 7m or 7m of overall height of flyover to be provided.

19. Span of flyover

- Total length of flyover is 80m
- No. of span three middle span 30m and other two are 25m

4.5. Structural Design of components:

1.Design of deck slab:-

Clear span = 3.8m
No. of lanes = Single Lane
Loading = IRC Class A
Concrete = M-35
Avg. thickness of Wearing coat = 75mm
Depth of Slab is to be assumed = 240mm
Width of Girder = 800mm

Step 1 :- Effective Span (S)

S = min. (c/c span, c/c span−width of girder + effective depth))
S = min. (3.8, 3.8-0.8+0.24)
S = min. (3.8m, 3.24m)
S = 3.24m

Minimum Thickness Check:

$t_{min} = 1.2(S+10)/30$
$t_{min} = 1.2(3.24+10)/30$
$t_{min} = 0.52$ ft.
$t_{min} = 15.84\text{cm} < 20$
Hence ok

Step 2 :- Dead Load Calculation

Wd_{slab} = Thickness × Unit weight of concrete
= 0.24×24
$Wd_{slab} = 5.76\text{kN/m}^2$

$Wd_{surfacing}$=Thickness×Unit wt. of wearing coat
= 0.075*22
= 1.65kN/m^2
Wd = $Wd_{surfacing}$ + Wd_{slab}
Wd = 7.41kN/m^2

Dead Load Moment (M_{DL}):

∴ M_{DL} = 1/10× wd ×wd×S^2
= 1/10×7.41×(3.24)^2
M_{DL} = 7.77 kN.m/m

Step 3:- Live Load Moment (M_{LL})

M_{LL} = 0.8×3.28S+2/32×P
For IRC Class A load
= 0.8×3.28×3.24+2/32×72
M_{LL} = 22.72 kN.m/m

Where,

- **MLL** = Live Load Moment (kN·m/m)
- **Wd** = Service (un-factored) Dead Load
- **S** = Span (m), given 0.6<S<7.30.6 < S < 7.30.6<S<7.3
- **P** = Wheel Load (kN)
- **For HS-20 (AASHTO):** P=72 kN
- **For Military (Iraqi Specification):** P=90.74 kN

HS-20 = Highway Semi-Trailer 20-Ton Weight of the tractor

Step 4:- Impact Load Moment (MI)

I = 15.24/S+38.1
= 15.24/3.24+38.1
I = 0.36>0.3
Use I =0.3
MI = I* M_{LL}
= 0.3* 22.72
MI = 6.81 KN.m/m

Step 5:- Total Moment (M_{Total})

M_{Total} = M_{DL}+ M_{LL} + MI
= 7.77+22.72+6.81
M_{Total} = 37.3 KN.m/m

Step 6:- Depth of Slab

$$D_{min} = \sqrt{\frac{2M}{fckjb}}$$

$$= \sqrt{\frac{2\times37.3\times10^6}{14\times\frac{3}{8}\times\frac{7}{8}\times1000}}$$

D_{min} = 127.43mm ≈ 128 mm

Where,

D_{min} = Minimum effective depth (slab thickness) for strength requirements

f_c = Allowable Compressive Strength of Concrete = 0.4 f_c' (MPa)

k = Neutral axis depth coefficient ≈ 3/8

j = Internal resisting moment arm coefficient ≈ 7/8

b = Strip width = 1000 mm

$D_{provided}$ = t – cover - $\frac{\emptyset}{2}$
= 240- 50 – 16/2
$D_{provided}$ = 182mm >128mm…..ok

Step 7:- Calculation of area of reinforcement

$$As = \frac{M}{fs}.j.d$$

$$= \frac{37.3\times10^6}{170\times\frac{7}{8}\times240}$$

As = 1044.818mm^2/m

Where,

f_s = Allowable Tensile Strength of Steel Reinforcement

f_s = 140Mpa if fy <350 Mpa
f_s = 170Mpa if fy≥ 350 Mpa

Step 8 :-

Distribution Reinforcement (Longitudinal Reinforcement)

An AASHTO specification requires an amount as the percentage of the main reinforcement for
(M^+): For Reinforcement ⊥ traffic;
We use the AASHTO formula:

$$As_{Dist.} = \frac{2.2AS}{\sqrt{3.28S}} = \frac{2.2\times1044.81}{\sqrt{3.28\times3.24}}$$

Where,

- AS=1044.81mm²/m (Main reinforcement area calculated in Step 7)
- S=3.24m (Effective span)

Now, calculating,

$$As_{Dist.} = \frac{2.2\times1044.81}{\sqrt{3.28\times3.24}}$$

$As_{Dist.}$ = 705.09≈710 mm²/m.

The distribution reinforcement area is 710 mm²/m.
Since, 710 mm²/m>0.67 As , It is satisfy the requirement.

- **For bottom longitudinal reinforcement**

Required area ($As_{Dist.}$) = 710mm^2/m
Assume, 32 mm @ 250 mm for bottom longitudinal reinforcement.
As = $\pi/4 \times 32^2 \times \frac{1000}{250}$
As = 3216.99mm²/m
Since, 3216.99 mm²/m > 710 mm²/m, 32 mm $\emptyset$ $bars$ @ 250 mm is safe.

For top longitudinal reinforcement

Calculation of Temperature & Shrinkage Reinforcement (Astemp)
AStemp = 0.002×b×t
= 0.002×1000×240
AStemp =480 mm²/m

Where,

- b=1000 mm (width per meter)
- t=240 mm (total slab thickness)
- 0.002 is the standard AASHTO factor for shrinkage reinforcement.

Required area AStemp = 480 mm²/m

Assume, 16 mm @ 250 mm for top longitudinal reinforcement

As = $\pi/4 \times 16^2 \times \frac{1000}{250}$

As = 804.25 mm²/m >480 mm²/m, 16 mm $\emptyset$ $bars$ @ 250 mm is safe.

Shear and Bond

The AASHTO specification says that designed for moment will be says that slabs designed for moment will be considered safe in shear in shear and bond (i.e. No need to check shear and bond).

2. Design of column footing: -

Given Data: -

Size of column = 8800×9200mm

Factored axial Load (Pu) = 2470 (Assume)

Safe bearing capacity = 350 KN/m²

Use M35 grade concrete

Ultimate sate bearing capacity (Su) = 1.5×SBC

=1.5×350

(Su) = 525 KN/m²

Step1: - Size of footing

calculate AF = Area of footing

(pu) footi = (Pu) c + (10% column Load)

= 2470 +

Footing (Pu) = 2417 KN

Area of footing = 8.8 x 9.2

Area of footing = 80.96 m²

$\frac{\pi}{4} \times Df^2$ = 80.96

Df = $\sqrt{\frac{80.96\times4}{\pi}}$

Df = 10.15m

Step 2 :- Check for diameter based on SBC.

(Su) = Column factored load / Area of tooting

Area of footing = $\frac{\pi \times (Df)^2}{4}$

= $\frac{\pi\times(10.15)^2}{4}$

Area of footing = 80.91 m²

Hence ok.

= $\frac{2475}{80.91}$

(Su) check = 30.58 <525 kN/m²

Hence check diameter is adequate

Step 3 :- Ultimate moment & S.F .

Mu= Wu.e

Df = outerØ = Dc = columnØ

Af (Hollow) = $\frac{\pi}{4}$ × Df²- Dc²)

Af (Hollow) = $\frac{\pi}{4}$(10.15²-0.800²)

Af = 80.41m²

Wu = Su * Af

= 30.58 × 80.41

Wu = 2458.93KN

For $\frac{1}{4}$ Quadrant = 1/4 * (wu)

= 1/4 * 2458.93

Wu = 614.73KN

Mu = 0.138 fck bd²

= 0.138 * 35 * 8.8 * (9.2)²

Mu = 3597.53 KN.m

Step 4: - Check for depth of footing

Mu = 3597.53 kN.m

d = $\sqrt{\frac{Mu}{0.138\ Fck\ b}}$

= 3597.53×10⁶/ 0.138 × 35 ×8.800

d = 9199.98 mm≈ $\mathbf{9200\ mm}$

3. Design of Short Column: -

Step 1 :- Given Data

p = 2775.77 KN ≈ $2776\ KN$

F_{ck} = 40 N/m²

F_y = 550 N/m²

d = 2000 mm

L = 8.4 m

P_u = 1.5 × 2770

P_u = 4164 KN

Step 2 :- Effective length (L_{eff})

[From IS 800 – 2007 Table no.11]

L_{eff} = 1 × L

= 1 × 8.4

= 8.4 m

L_{eff} = 8400 mm

Step 3 :- Slenderness ratio

$\frac{L_{eff}}{d} = \frac{8400}{2000}$ = 4.2 < 12

Hence, It is short column

Step 4 :- To Find the e_{min}

E_{min} = [$\frac{L}{500} + \frac{d}{300}$] = [$\frac{8400}{500} + \frac{2000}{30}$]………(Page no.42 IS 456 – 2000)

E_{min} = 83.47

$\frac{E_{min}}{d} = \frac{83.47}{2000}$ < 0.05

0.041 < 0.05

Hence , Axial loaded member

When eccentricity does not exceed 0.05D

0.05 × D = 0.05 ×2000

= 100 mm

E_{min} = 83.47 < 100 mm

Hence design is ok.

Step 5 :- Area of reinforcement (Asc)

[From IS 456 – 2007, page no.71 clause no. 39.4]

Pu = 1.05 × Pu (lateral tie)

Pu = 1.05 × (0.4 Fck Ac + 0.67 Fy Asc)

Ag = Ac +Asc

Provide 32 mm $\emptyset$ *bars*

Overall diameter (D) = d + 2 t

t = Clear cover + No. of bars

20 + 32

t = 82 mm

Overall diameter (D) = diameter (d) +2×t

= 2000 +2 ×82

Overall diameter (D) = 2164 mm

$Ag = \frac{\pi}{4} \times D^2$

$= \frac{\pi}{4} \times 2164^2$

$Ag = 3677937.92\ mm^2$

Ac = 3677937.92 --- Asc

$4164 \times 10^3 = 1.05 \times (0.4 \times 40 \times (3677938 - Asc) + 0.67 \times 550 \times Asc$

$Asc = 163848.05\ mm^2$

Percentage of steel $= \frac{Asc}{Ag} \times 100$

$\frac{163848.05}{3677938} \times 100$

Percentage of steel = 4.45%

[According IS 456 – 2000 Page no. 48]

Area of steel lies in between 0.8% to 6%

Percentage of steel = 4.45 %

Hence ok.

Provide 32 mm of $\emptyset$ *bars*

Ast = 0.01 × Ag

= 0.01 ×3677938

$Ast = 36779.98\ mm^2$

No. of bars $= \frac{Ast}{\frac{\pi}{4} \times d^2} = \frac{36779.38}{\frac{\pi}{4} \times 32^2}$

No. of bars = 45.73 ≈ 46 Nos of bars

Provide 20 mm – 32 mm $\emptyset$ *bars*

[According IS 456 – 2000 Page no.49]

Design of lateral ties $> \frac{1}{4} \times 20$

6 mm > 5 mm

6 mm $\emptyset$ lateral ties diameter.

Spacing of ties [According IS 456 – 2000-page no.49]

Spacing should not be more than

1] Least lateral dimension:-

$$A = \frac{\pi}{4} \times D^2$$

$$163848.05 = \frac{\pi}{4} \times D^2$$

$$D = 456.74\ mm$$

Least lateral dimension = 456.74 ≈ 460 *mm*

2] 16 $\emptyset$ = 16 ×20 = 320 mm

3] 300 mm

Provide 46 Nos of bars @ 300 mm spacing c/c.

7. Conclusion

The main aim of our project is to manage traffic and reduce collisions at the intersection of Nagpur Road, Arni Road, and City Road in Yavatmal. We propose a four-lane flyover bridge as the best solution to ensure safe and smooth movement for both vehicles and pedestrians. To check the need and feasibility of the flyover, we conducted traffic surveys, soil tests, and site inspections. These studies showed that current traffic conditions cause delays, accidents, and problems for emergency vehicles. The flyover will solve these issues by offering a separate, safer route. It will also reduce noise, improve connectivity, support city growth, and regulate vehicle speeds to lower the accident rate.

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