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Analysis and Design of A Flyover Using Civil Engineering Softwares

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***Abstract*—paper is focussed on the analysis and design of a flyover. Flyover is a grade separated structure connects road at different levels for the purpose of reducing vehicle congestion. The grade separator is of 100 m length with 10 spans, 10m per span. It consists of a deck slab, longitudinal girders, cross girders, pier and foundation. The structure is subjected to different loadings namely Dead load, Super Imposed Dead Loads, Carriageway Live loads etc., For the analysis, different live load cases namely IRC Class A, IRC Class 70R wheeled & tracked are considered. Also, the braking load, impact load, wind load, longitudinal forces are to be considered in the analysis. Here the structural analysis is carried out by using STAAD Pro V8i software. Structural design of one span was made for all the above components. Slab is designed by working stress method as per the recommendation of IRC: 21-2000, Clause 304.2.1. Cantilever slab is designed for maximum moment due to cantilever action. Longitudinal girders are designed by Courbon's method. Cross girders are designed mainly for stiffness to longitudinal girders. The deck beam is designed as a cantilever on a pier. The Pier is designed for the axial dead load and live load from the slab, girders, deck beam. Foundation designed as footing for the safe load bearing in the soil. All the elements are designed by using M25 grade concrete and Fe415grade steel. Designs are based on Working stress and Limit state method as per IRC: 21-2000 and IS: 456-2000.**

***Index Terms*—Design, Flyover, IRC Codes, STAAD Pro, Sub-Structures, Super structure.**

I. INTRODUCTION

The flyover-bridge intersection is an intersection that has a special bridge constructed over an at-grade intersection to allow for the free flow in two directions on one of the main roads – to increase capacity of traffic flow and reduce the traffic congestion in both of these directions, but underneath of the bridge, the existing traffic signalization is still used to control traffic as the situation before. This model is used for increasing traffic capacity at a bigger intersection in suburb area. According to the 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. The flyover only facilitates traffic flows in the directions of the bridge, but the infrastructure cannot fully solve all the problems especially on the secondary road. The design is considered for class 1 type structure in which there are no tensile stresses under the service load. The loads are considered as per IRC class AA tracked vehicle. This code is treated as heavy loading and to be used for bridge construction in certain industrial area and other specified areas and highways. The main objective of our project is to know the various design aspects of planning, analysis and design. The planning is done as per the requirements and regulations given by the Indian Road Congress (IRC).

1. Objective

The main objective of this project is to plan and design the structural elements of a flyover.
In order to fulfil the aim, the following specific objective are formulated.

- To draft the plan of the flyover in Auto CAD
- Creating model using REVIT
- Analysis in STAAD PRO
- Designing all the structural components as per IS codes.

2. Components of Flyover

The important components to analyse and design a flyover are described in detail. The following elements are designed as per the codal provision, and the analysis is carried out in Staad pro.

A. Deck slab:

Deck slab is the part of super structure of bridge which is constructed over the Girder that transfer the live load of vehicles to the sub structure and substructure further transfer the load to the foundation.

B. Longitudinal girder:

The structure is thus named because of the foremost longitudinal girders are designed as T-beams integral with an area of the deck block, that is formed monolithically with the girders. Simply supported T-beam span of over thirty Meter are rare because the loading then becomes too serious.

Cross girder:

A girder /cross girder is a support beam used in construction. It is the main horizontal support of a structure which supports smaller beams. Girders often have an I-beam cross section composed of two load-bearing flanges separated by a stabilizing web, but may also have a box shape, Z shape and other forms.

C. Deck beam:

A beam deck is one where the deck and any supporting structure act together as a single beam.

Pier:

The Piers are the vertical support structures of bridges. They are the intermediate supports whose function is to transmit the forces they receive from the load-beaing elements to the foundations.

D. Foundation:

A bridge foundation is the part built under the pier or abutment and over the fundamental soil or rock. The loads sent by the foundations to the subordinate soil should not cause soil shear failure or harming settlement of the superstructure.

E. Pile Foundation Bridge:

Pile foundation is the types of bridge foundation that is utilized in conditions where there is extremely delicate soil and hard strata are not accessible at a sensible profundity. It is likewise utilized where scouring of a river as to be done and an enormous, concentrated load is to be taken by the foundation.

Abutment:

A bridge abutment is a structure which connects the deck of a bridge to the ground, at the ends of a bridge span, helping support its weight both horizontally and vertically.

3. Review of literature

Review of literature plays a vital role in arriving the data required, methodology to be followed and specifications to be followed in any project. Previous works carried by the other researchers are collected from journal papers, books and online resources are given below.

H.R.Nikhade, A.L.Dandge, A.R.Nikhade (2014): The paper gives us idea about various classes of bridges also according to the specified class describes loading calculations. According to the Standard specification and code of practice for road bridges (section: I) Load and stresses (IRC:6-2000) the design is given. This paper gives case study that how the height of web behaves in The prestressed box girder with the span and grade of concrete. Generally, load moment decreases with increase in the grade of concrete in RCC bridges.

B. K. Vishwanath, S. Sudheer (2017): The paper deals with design of pier cap and pier. The pier is designed as a cantilever portion. Pier is designed for 2 lane road bridge loaded with IRC Class AA tracked vehicle. Designs are based on working stress method and limit state method as per IRC: 21-2000 and IS: 456-200

M Siva (2018): The paper facilitates us to solve the various difficulties arriving the bending moment coefficient calculation. Paper gives solution for this problem by pigeaud chart. After analysis of slab panels bending moment for various IRC loading are found that IRC class AA tracked vehicle cause maximum value as the load intensity is maximum as compared to all IRC loading. Hence for the design of national highway and express way class AA tracked vehicle as the base.

G.Narender, C.Manikanta Reddy, M.Shiva koti Reddy (2018): This paper deals with construction of a composite bridge. Slab is designed by working stress method as per the recommendation of IRC: 21-2000, Clause 304.2.1. Cantilever slab is designed for maximum moment due to cantilever action. Longitudinal girders are designed by Courbon's method. Cross girders are designed mainly for stiffness to longitudinal girders. Elastomeric reinforced bearing plate is used.

Y. Kamala Raju, R.Mehar Babu,Mohd. Husssain(2018): This paper deals about the case study of Reinforced Cement Concrete Bridge Deck Design of a Flyover with Analysis for Dynamic Response Due To Moving Loads for Urban Development in Transportation Systems.

Dandawate Ajinkya, Anantrao Dakhane, Yogesh Dattu, Janjire Akshay Satish Dhadge, Shivaji Vishwanath (2019): This paper gives us a clear idea about the design of prestressed box girders. The design is considered for class 1 type structure in which there are no tensile stresses under the service load. The loads are considered as per IRC class AA tracked vehicle. This code is treated as heavy loading and to be used for bridge construction in certain industrial area and other specified areas and highways.

Bismi M Buhari, Abhijith S, Aparna B Lal, Joseph Samuel, Sarath (2021): This deals with design and analysis of flyover. The manual design of flyover consists of deck slab, longitudinal girder, cross girder, pier, pier cap, abutment, pile cap and pile based on code such as IS: 456-2000 and IRC: 21- 2000. Here the structural analysis is carried out by using STAAD Pro V8i software.

Allan Pereira, Faizan Inamdar, Nawnath Rathod, Feroj Shaikh, Aparna Nikumbh (2022): This paper deals with analysis and design of deck slab using Staad Pro. The deck of bridge is to be constructed using Prestressed concrete. The calculation of loads was dynamic load included weight of passenger vehicle; dead load included self-weight of deck.

Amer S.,Van Der Veen ,C., Wallarven , J. C.5: Paper gives information about study of bridges constructed more than 50 years ago in Netherland. Designer are found out the bridge is safe for modern traffic. Various type of loads is used, and the effect of prestressed level was studied. Resulting when loaded directly above the prestressing bridge deck slab show the higher punching stress.

4. Plan of flyover

The plan of the flyover is drawn using the software Auto CAD.

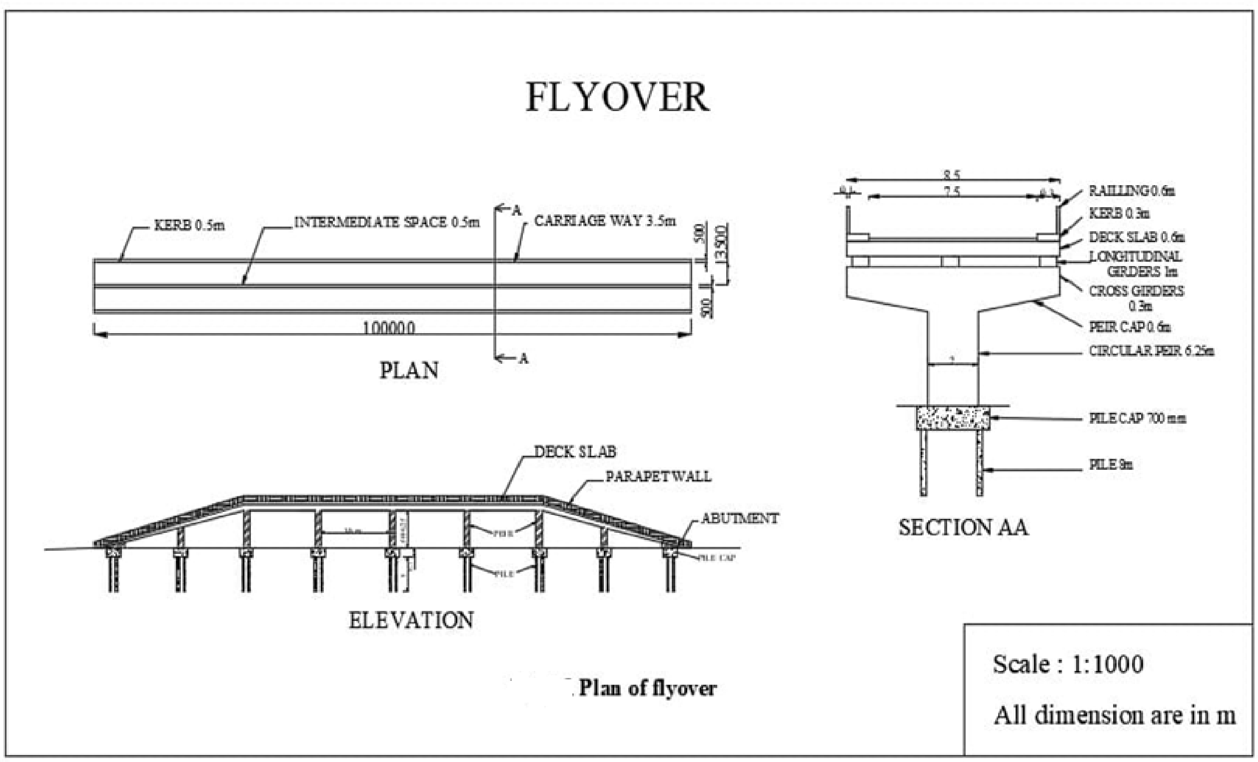


Fig – 1: Plan of flyover

5. Analysis of structural load

The analysis is carried out in Staad pro, and the results are as shown in the Fig.no2,3,4,5

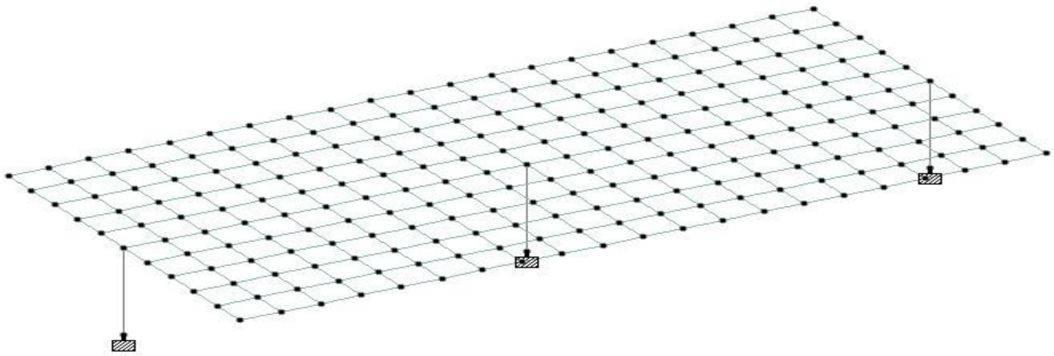
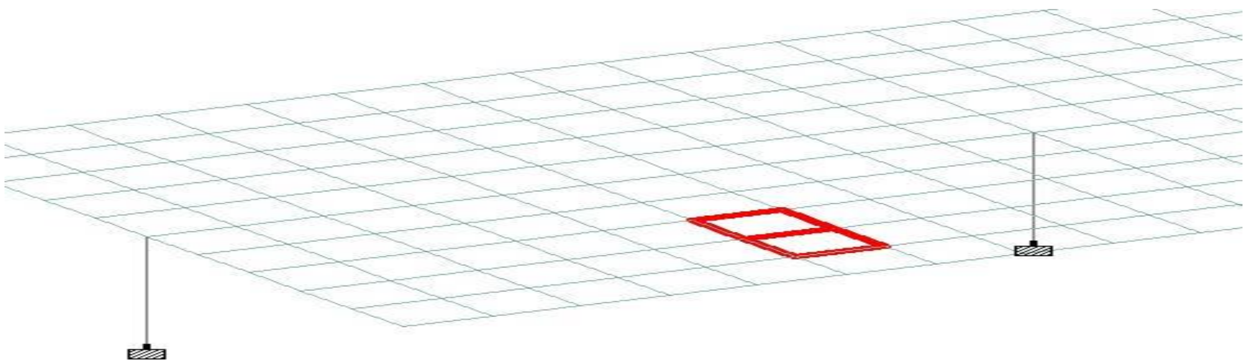


Fig – 2: Flyover drawing in staad



		Shear (Local)		Membrane (Local)			Bending Moment (Local)		
Plate	L/C	SQX N/mm2	SQY N/mm2	SX N/mm2	SY N/mm2	SXY N/mm2	MX kN-m/m	MY kN-m/m	MXY kN-m/m
109	1 LOAD CAS	0.048	0.056	-0.026	-0.010	-0.020	190.772	-73.102	57.752
	2 LOAD GENE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	3 LOAD GENE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	4 LOAD GENE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
110	1 LOAD CAS	0.021	0.040	-0.044	-0.003	-0.026	246.548	-86.136	35.250
	2 LOAD GENE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	3 LOAD GENE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	4 LOAD GENE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Fig – 3: B.M results on plate

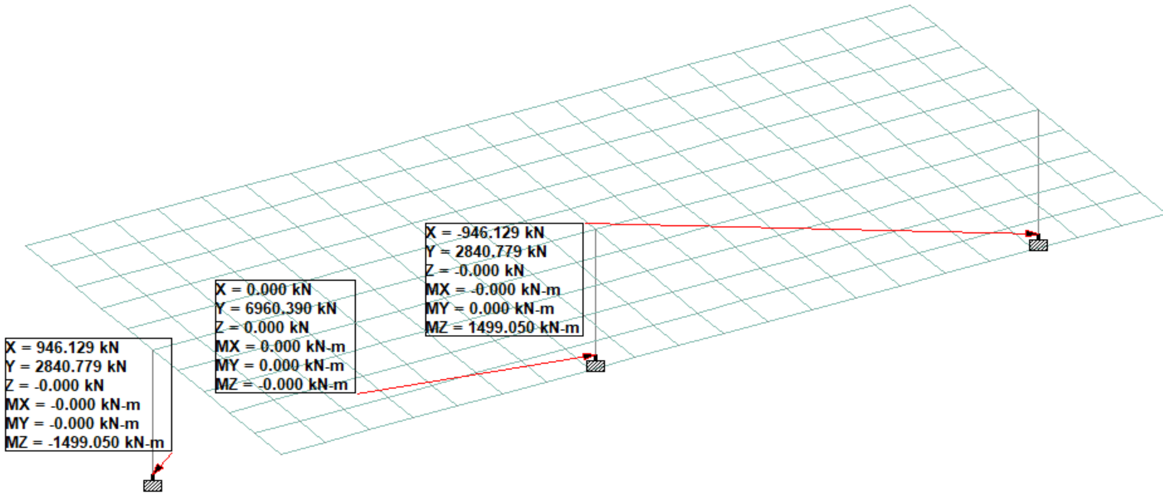


Fig – 4: Reactions on pier

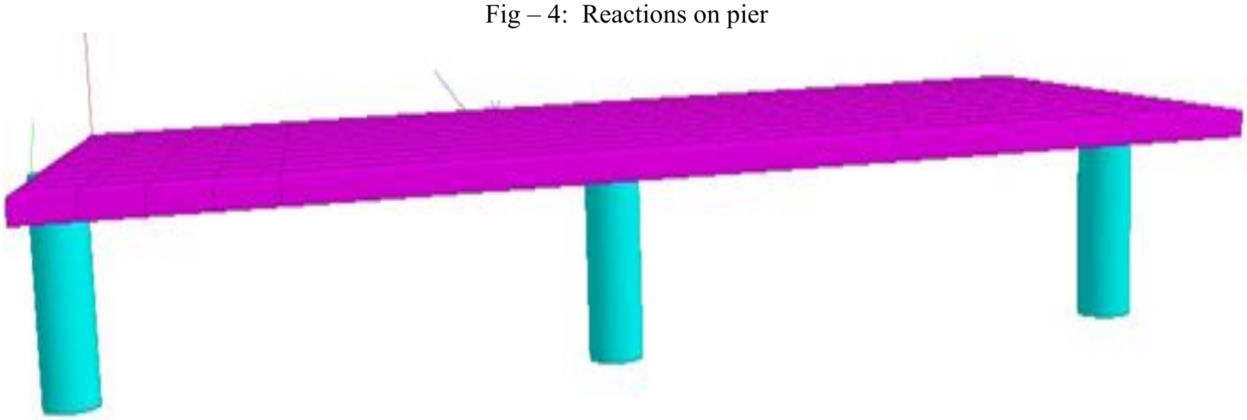


Fig – 5: 3D rendering of flyover using STAAD

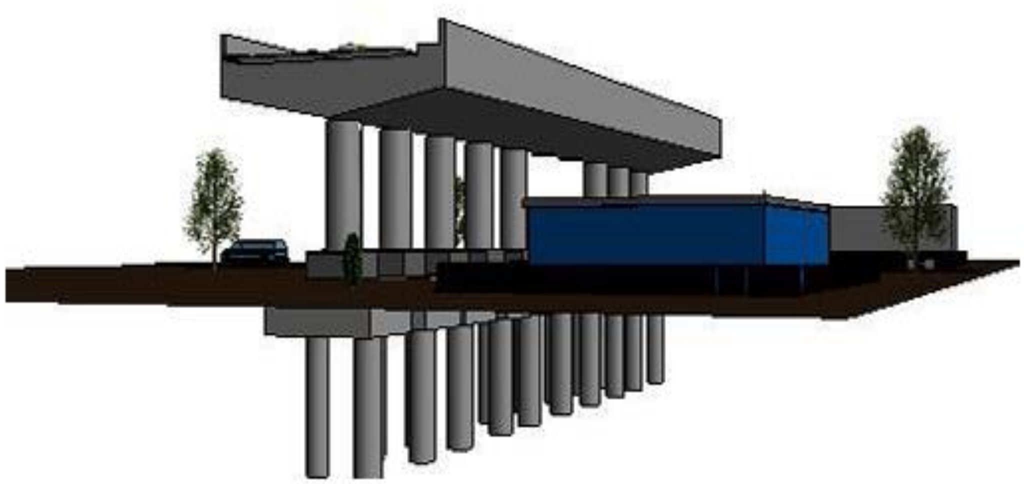


Fig – 6: Full view of a flyover using revit

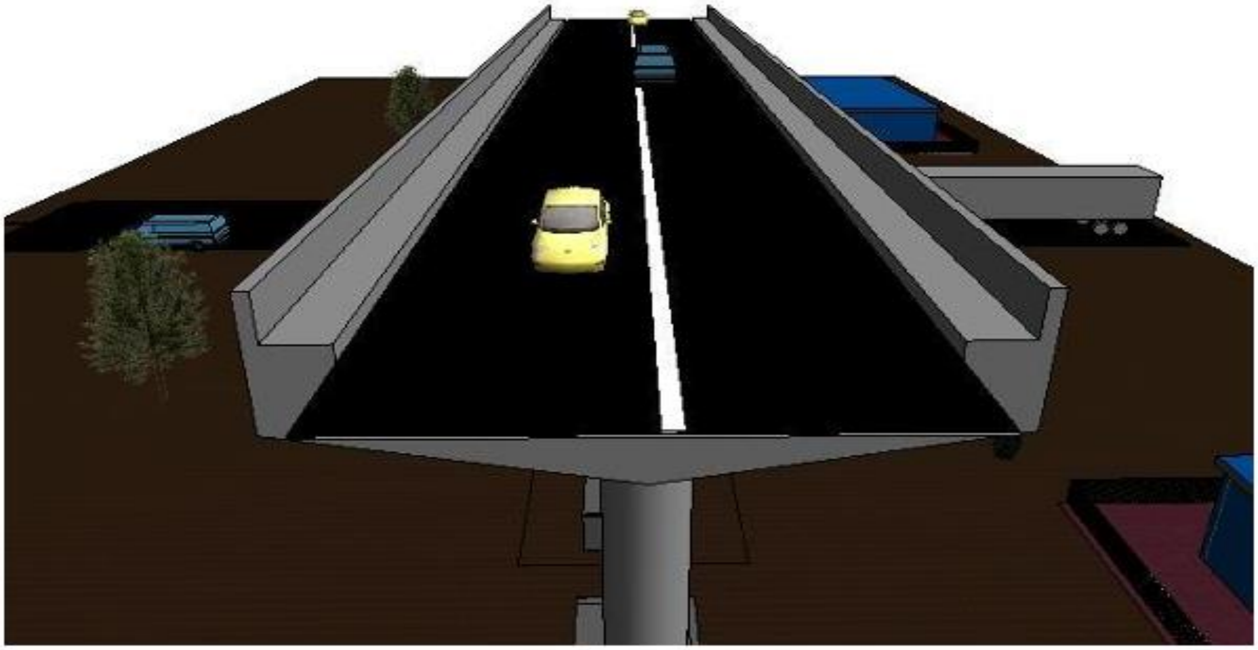


Fig – 7: Top view of the flyover

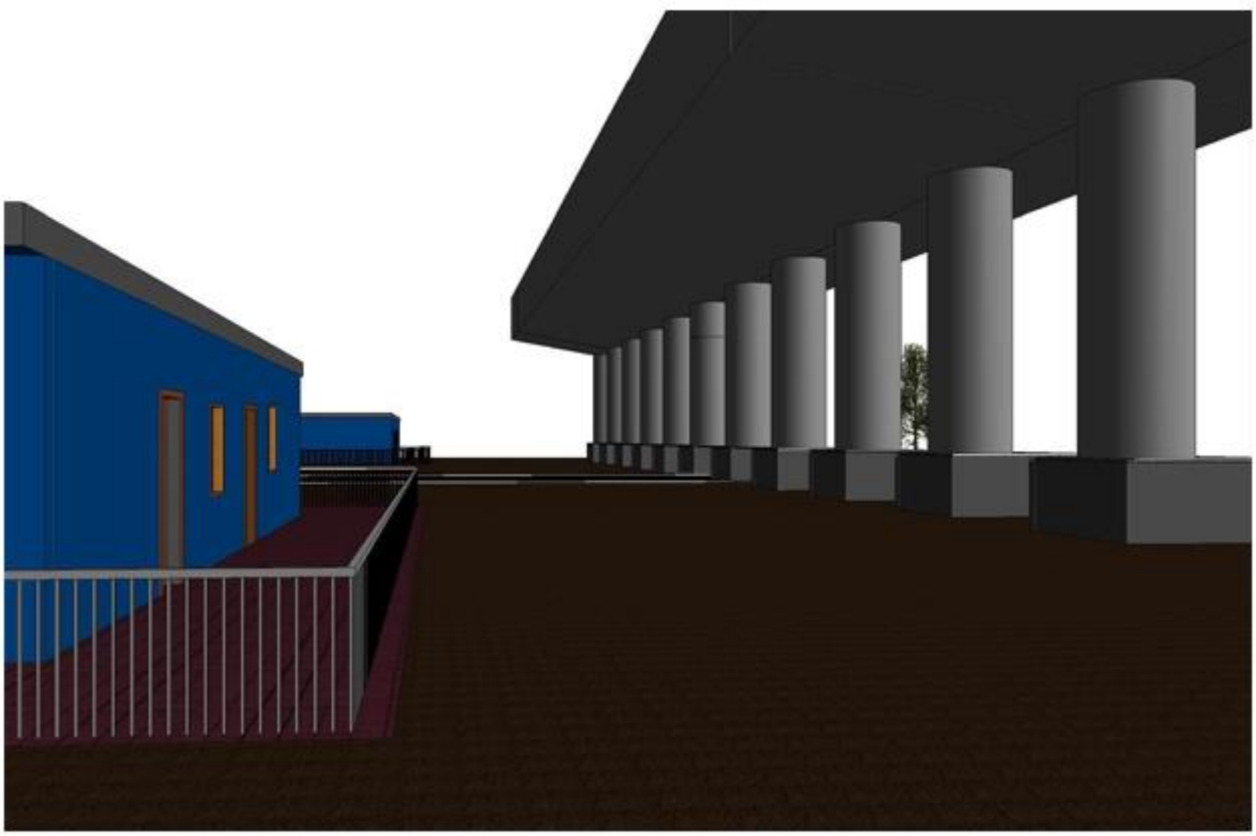


Fig – 8: Bottom view of the flyover

6. Structural design of flyover components Design of deck slab
Depth of slab: D = 600 mm and Effective Span: = 8.00 m

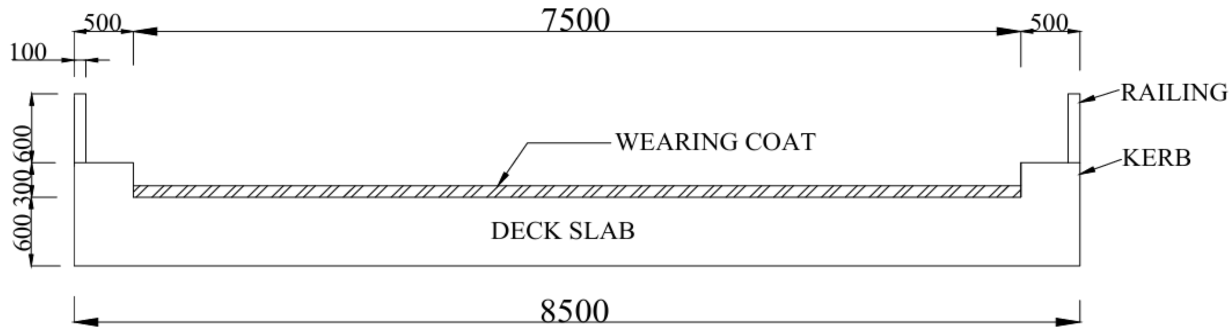


Fig – 9: Cross section of deck slab

Bending Moment calculation
Find the impact factor for different types of loading [Refer IRC 6 2000 Pg: 22-25]. For span less than 9m: for class AA tracked vehicle 25% for 5m linearly reducing to 10% for span 9m. For 7.9m span, the dispersion of loads due to IRC class A-A, Dispersion of loads and the position of loads are shown in the following figures.

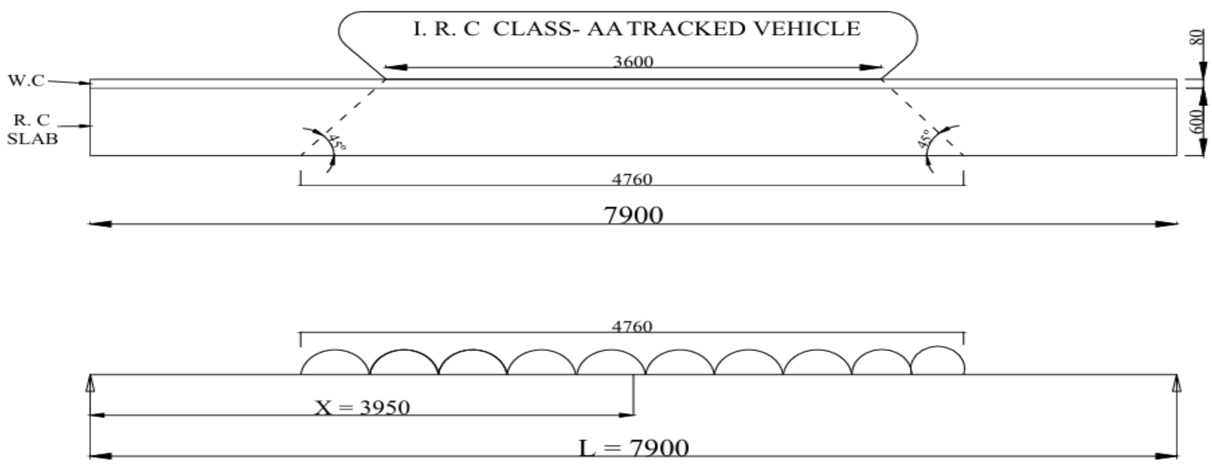


Fig – 10: Dispersion of loads due to IRC class- AA vehicle

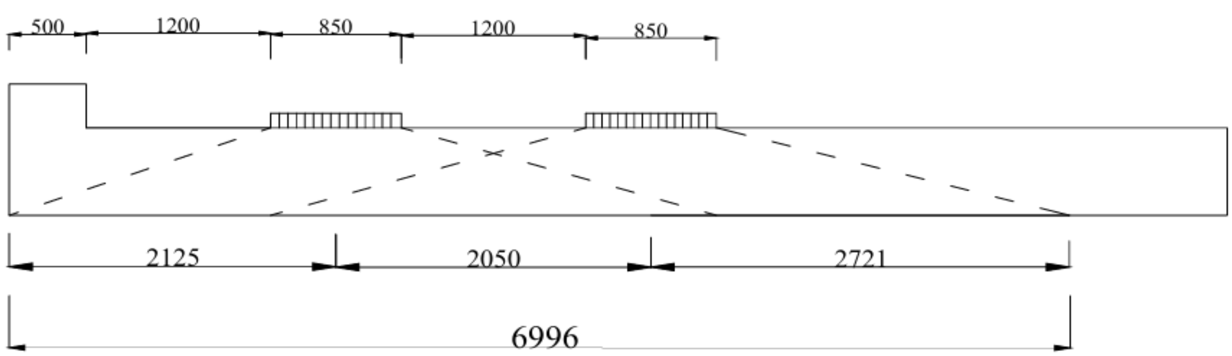


Fig – 11: Effective width of dispersion

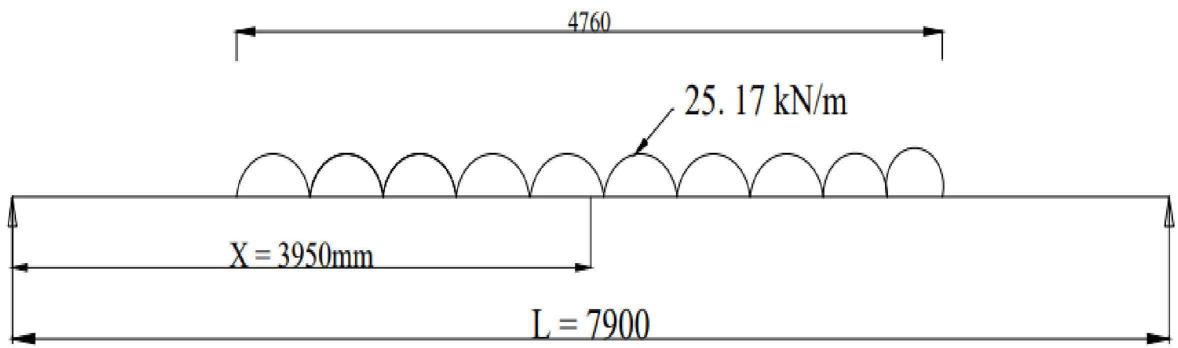


Fig – 12: Position of load for maximum BM

Dead load Bending Moment – 16.16 kN/m & 126.06 kN.m

Live load Bending Moment: B.M of LL = 152.48 kN.m

Total B.M = DL B.M +LL B.M = 126.06 + 152.48 = 278.54 kN.m

Shear due to type of vehicle:

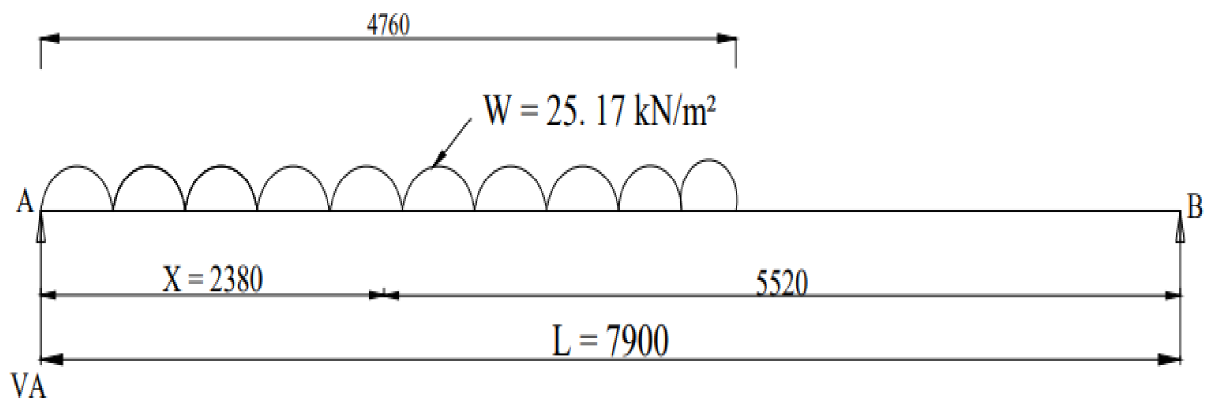


Fig – 13: Position for maximum shear

Total SF = LL SF + DL SF = 120.31 kN

Reinforcement Details

a) Main Reinforcement: Provide 25mm dia bars@ 200 mm c/c spacing.

b) Distribution Reinforcement: Provide 12mm dia bars @ 180 mm c/c spacing.

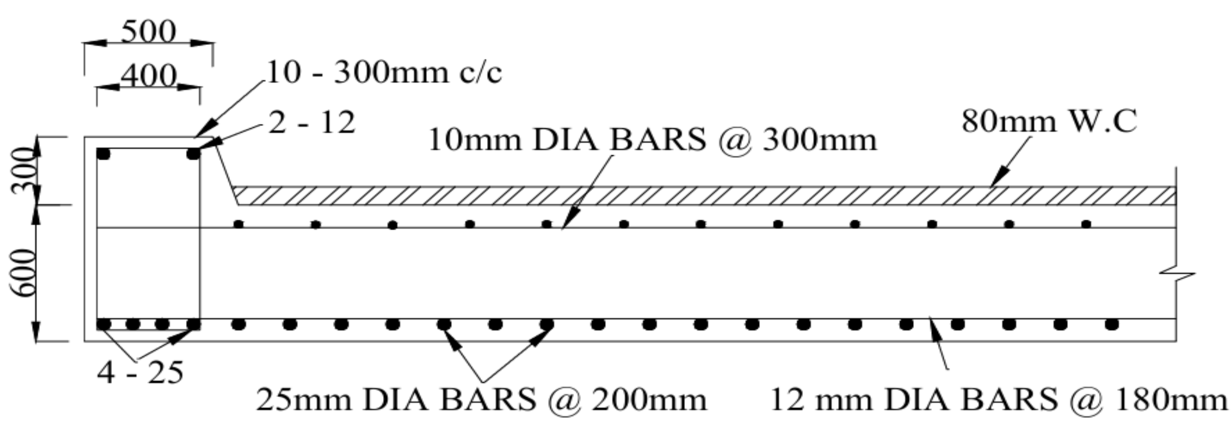


Fig – 14: Cross section of deck slab

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7. Design of longitudinal girders
Using courbon's method
The reaction factor for the outer girder is = 0.52w
The reaction factor for the inner girder is = 0.33W

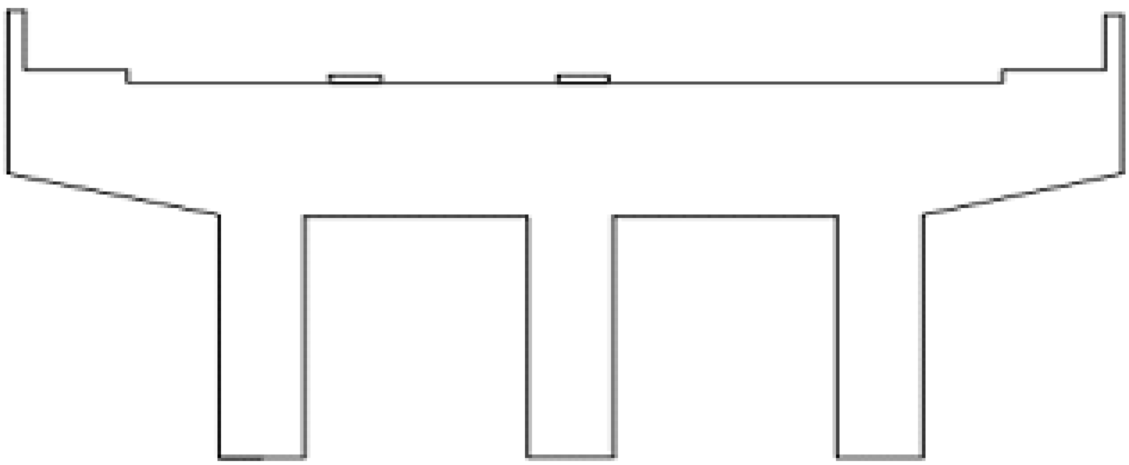

Fig – 15: Placement of wheels of IRC class AA loading

8. Live load bending moment
The maximum live load bending moment will occur when IRC class AA vehicle is centrally placed on the girder

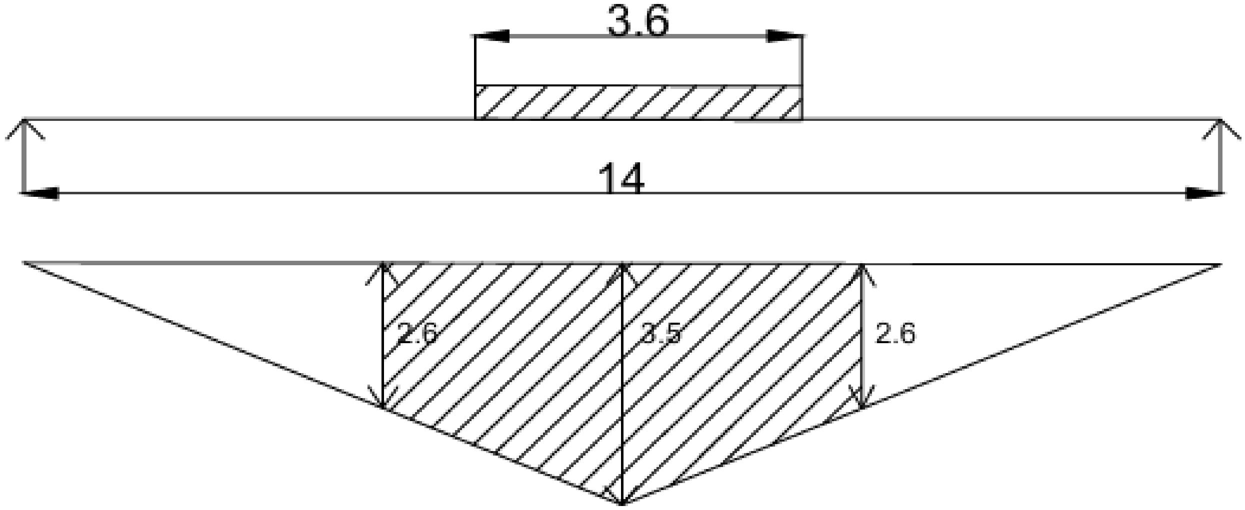

Fig – 16: I.L.D for maximum live load bending moment

Bending moments including impact factor (10%) and reaction factor are:

For inner girder = 1.1 x 0.333 x 2135 = 782.05 kN.m

For outer girder = 1.1 x 0.52 x 2135 = 1221.22 kN.m

Live load shear force

Maximum shear force will be developed in the girder when the live load is near the girder. This load is to be placed between the support and the exterior girder. Shear force will be found as a reaction developed by longitudinal girders. The placement of the wheels for maximum shear force is as shown in the figure.

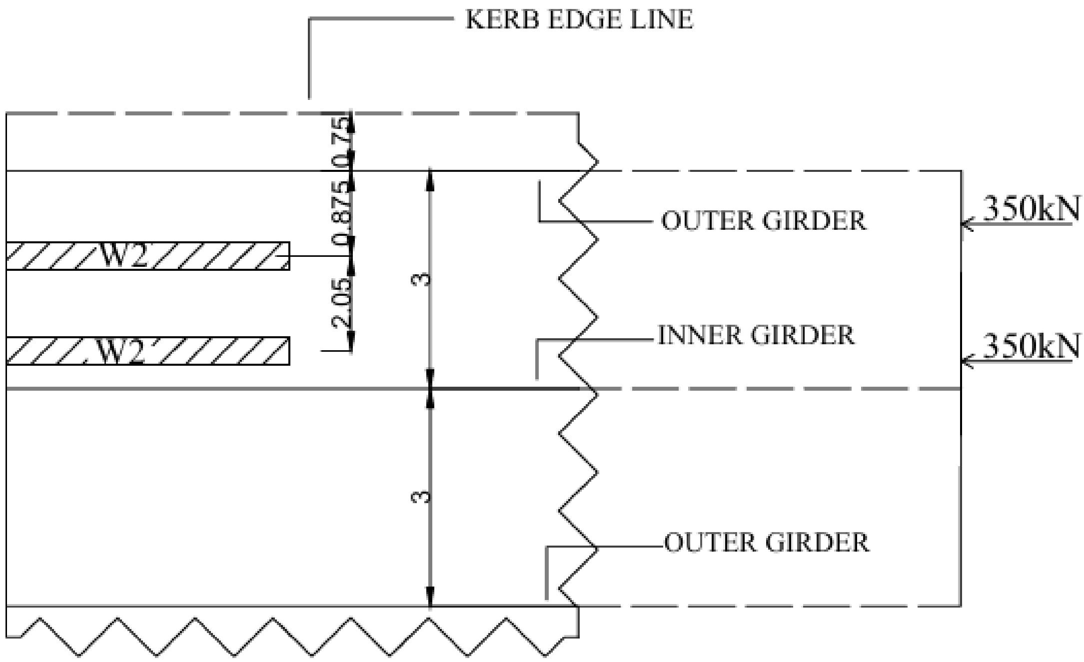

Fig – 17: Placement of wheels for maximum shear force

Maximum shear force on the outer girder = 225.28 kN, Maximum shear force on the inner girder = 389.84 kN, Maximum live load bending moment = 1221.22, Maximum dead load bending moment = 567.91, Total BM = 1789.1 kN.m

Maximum live load shear force = 389. 84, Maximum Dead load shear force = 245.04

Total SF = 634.8 kN

Design of section

Main reinforcement – 11 numbers of 36mm diameter are provided in three rows, 3 numbers of 36mm bars are bent at supports to take up shear stress at supports.

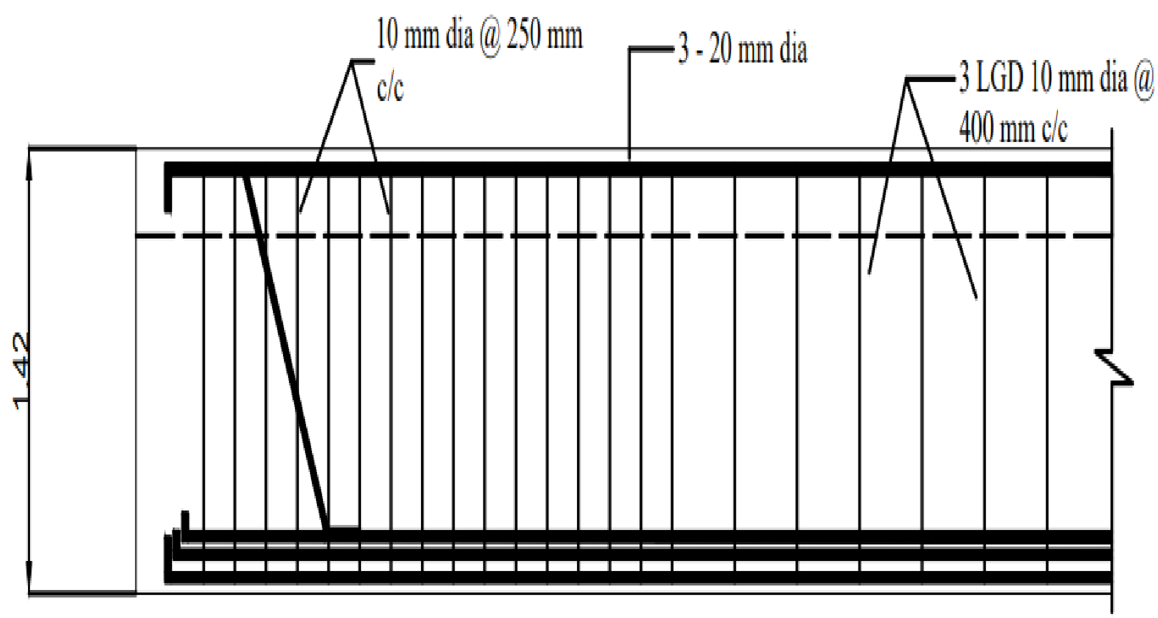

Fig – 18: Longitudinal section of girder

9. Design of cross girders
Cross- sectional dimension of the cross girders are maintained the same as those of the longitudinal girders. Effective depth = 1000 – 100 = 900mm, Breadth 300 mm

Main reinforcement 6 bars of 32mm Dia bars
Using 10mm diameter 2 - legged stirrups, a spacing of 250mm is adopted near the supports and the spacing is made 400mm near the centre.

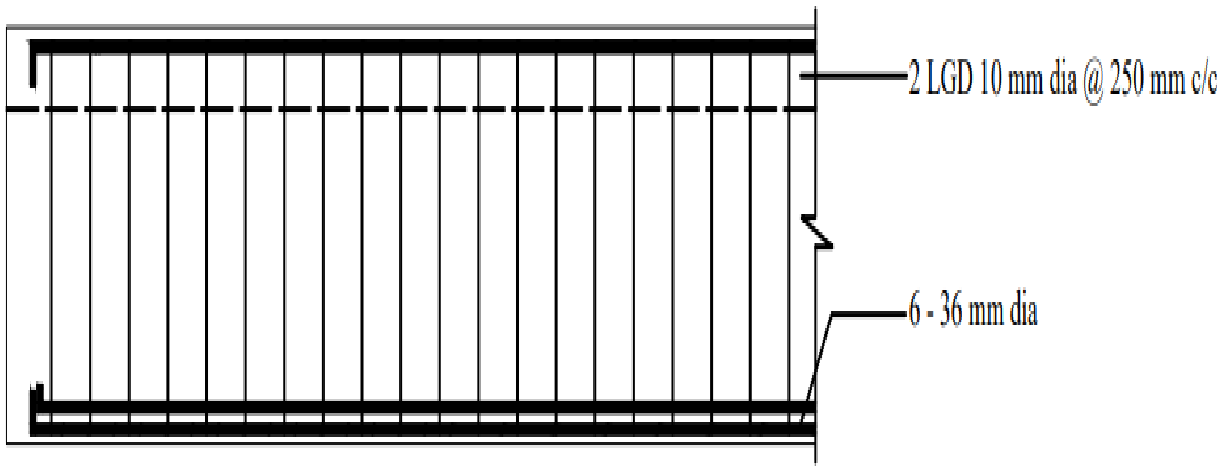

Fig – 19: Longitudinal section of cross girder

10. Design of pier cap
Live load: IRC Class AA Tracked vehicle

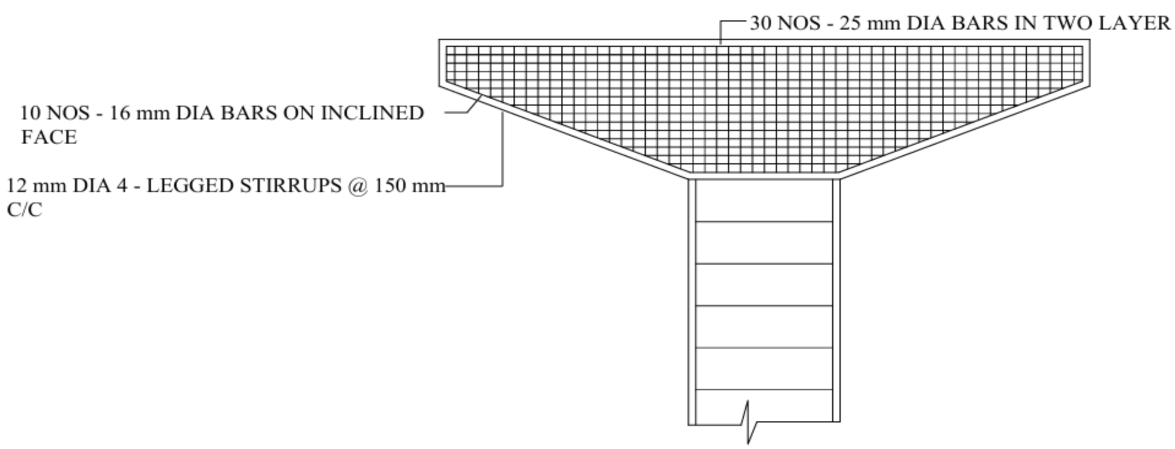

Fig – 20: Reinforcement details of pier cap

11. Design of pier
Provide 32 nos of 25 mm bars around the circular pier
Provide 10 mm dia bars of lateral ties @ 300 mm c/c
DESIGN OF PILE
Longitudinal reinforcement – provide 4 nos of 20mm dia with clear cover of 50mm

Lateral reinforcement – provide 8 mm dia ties @ 150 mm c/c
Lateral reinforcement near pile head – Provide 8mm diameter spiral at a pitch of 45mm for a length of 90mm near the pile head. The spiral is enclosed inside of the main reinforcements.

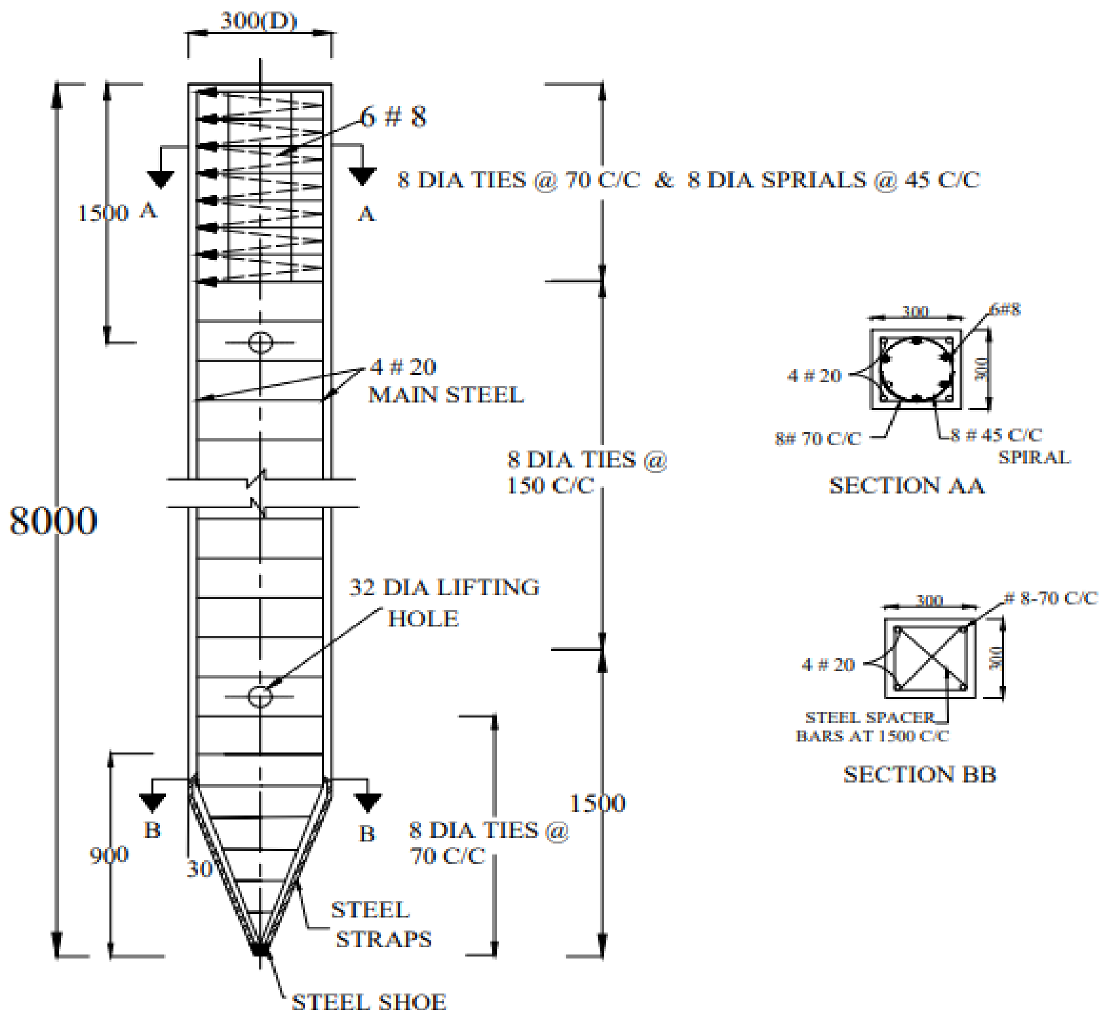

Fig – 21: Reinforcement details of pile

12. Design of pile cap

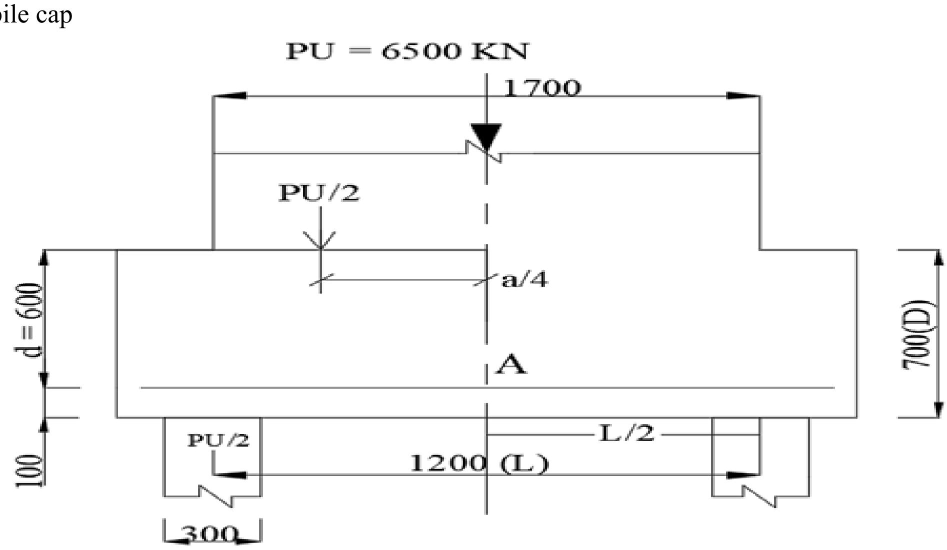

Fig – 22: Plan of pile cap

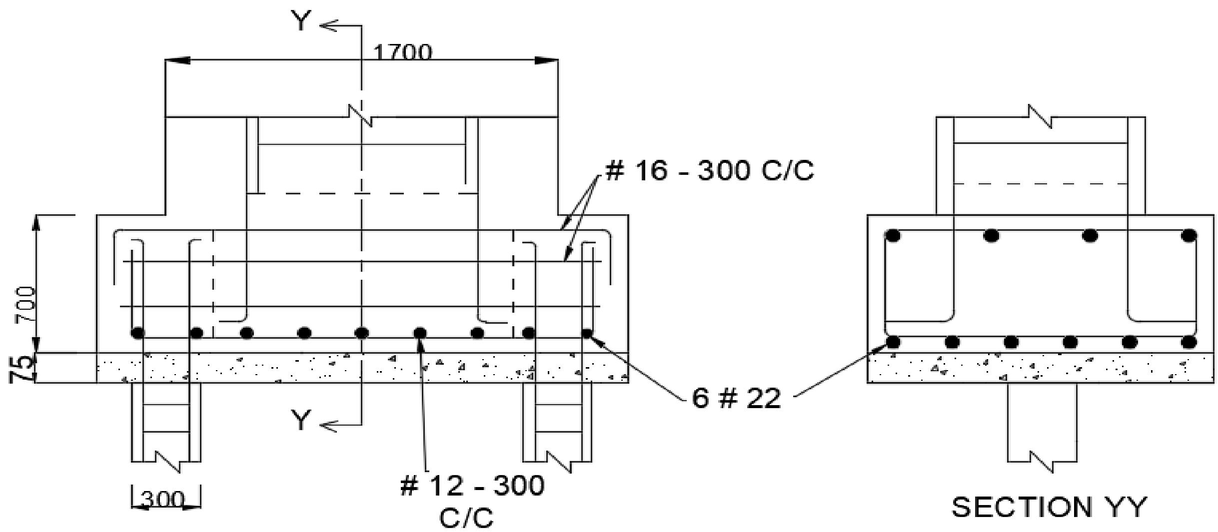

Fig – 23: Reinforcement details

II. CONCLUSION

Planning, Analysis and Design of a flyover using the various softwares in Civil Engineering is carried out in the project. Various load combinations as per IRC class AA loading and other loads are considered for the analysis in Staad pro. The design of the flyover components are carried out as per the Codal provisions. Ultimately, a well-designed flyover enhances transportation efficiency, contributes to urban development, and prioritizes the safety and comfort of users. Continued advancements in technology and materials will further improve the design process, leading to more sustainable and resilient infrastructure.

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