International Journal of Scientific Engineering and Research (IJSER)
ISSN (Online): 2347-3878
Impact Factor (2018): 5.426

Analysis of Grade Separator - A Case Study

Sakshi Kirar[1], Monika Dagliya[2], Rewa Bochare[3]

[1]Prestige Institute of Engineering, Management and Research Indore, Department of Civil Engineering
skirar[at]piemr.edu.in

[2]Prestige Institute of Engineering, Management and Research Indore, Department of Civil Engineering

[3]Prestige Institute of Engineering, Management and Research Indore, Department of Civil Engineering

Abstract: ***Grade Separators provide an important transportation connection and overhead at an important location of the city. Its significance cannot be over-stated as it will meet the immediate and future needs of the growing and progressive area communities for many decades to come. This paper attempts at exploring features like analysis of grade separator, like geotechnical investigations and calculation of bending moments associated with the design of grade separator in accordance with IRC standard code of practice, specifying the various loading possibilities and incorporating various design parameters.***

Keywords: Grade Separators, transportation, connection, overhead, geotechnical, bending moments, design

1. Introduction

Traffic Congestion is one of the major and growing concerns in a developing country like India. Owing to urbanization, this problem has surfaced in a severe form in the past decade.

One of the solutions proposed by traffic engineers and stakeholders is the provision of grade separators.

Grade separator is a form of interaction in which one or more conflicting movements or intersecting ground transport facility such as road, rail, pedestrian way or cycle path are segregated in space. Flyover, railway over bridges, under bridges, subways and underpasses both for vehicular pedestrian traffics are all grade separators.

1.1 Types of Grade Separators:

Fully separated

These junctions connect two freeways:

• Stack interchange (two-level, three-level, or four-level stack, depending on how many levels cross at the central point)
• Cloverleaf interchange

Partially separated

These junctions connect two roads, but only one is fully grade-separated, i.e. traffic on one road does not have to stop at yield lines or signals on one road, but may have to do so when switching to the other:

• Diamond interchange
• Partial cloverleaf interchange
• Single-point urban interchange
• Roundabout interchange

• Compact grade-separation, whereby the two roads are linked by a compact "connector road", with major-minor priority junctions at each of its ends; usually a variant of the cloverleaf type interchange, but only involving two quadrants.

Other variants

These junctions connect three or more roads:

• Various incarnations of Spaghetti Junction

These junctions terminate one road into another:

• Trumpet interchange
• Directional-T interchange

- Roads with grade separation generally allow traffic to move freely, with fewer interruptions, and at higher overall speeds; this is why speed limits are typically higher for grade-separated roads. In addition, less trouble between traffic movements reduces the risk of accidents. However, • Grade-separated road junctions are typically space-intensive, complicated, and costly, due to the need for large physical structures such as tunnels, ramps, and bridges. Their height can be obtrusive, and this, combined with the large traffic volumes that grade-separated roads attract, tends to make them unpopular to nearby landowners and residents. For these reasons, proposals for new grade-separated roads can receive significant public opposition.

2. Case Study

2.1 Location

Due to traffic congestion, development of Nagda-Dhar-Gujri Road section of SH-31 to two lane from km 68 + 800 to km 138 + 300, a grade separator at Ch. 88+638 has been provided.

2.2 Geotechnical Analysis

Geo Engineering Services, Dahod carried out the Geotechnical Investigation, which covers field sampling and tests, necessary tests and finally analysing the subsoil characteristics and behaviour of the proposed site. • The objective of the geotechnical investigation was to explore the sub soil profile up to predetermined depth and work out the design capacity of the soil beneath at a required foundation depth for the proposed type of foundation. Following samples were collected from the site:

- Disturbed soil samples
- Undisturbed soil samples
- Standard Penetration Test in accordance with IS: 2131-1981

In conducting laboratory testing, procedures applied were in accordance with Indian Standards. Following tests were conducted:

- Field Dry Density & Field Moisture Content
- Atterberg's Limit
- Particle Size Distribution
- Specific Gravity
- Direct Shear Test

Calculation for the Safe Bearing Capacity (SBC) and Safe Bearing Pressure (SBP) were carried out considering shear parameters and consolidation characteristics of the sub strata values of SBC & SBP. Based on the field and laboratory test data allowable bearing capacity was derived for open Footing. The bearing capacity was derived based on the minimum achieved value from shear failure and settlement analysis. The same has been shown in Table1.

Table 1: Safe Bearing Capacity

Type	Size in m	Depth in m	Safe Bearing Capacity, T/m2
Pile foundation	5.0 m wide	2.5 m Below EGL	19.96
	7.5 m wide		23.22
	10.0 m wide		26.62

Following were the Recommendations:

- The net safe bearing capacity of soil at a depth of 2.5m shall be considered as 19.5T/m^2.
- The Sub Soil can be used for backfilling but with proper compaction.
- The excavation of foundation of foundation pit shall be carried out with a side slope of about 15°with vertical.

3. Analysis for Grade Separator

3.1 Load Calculations

Table 2 summarizes the basic data available on site before starting the design.

Table 2: Basic Data on Site

1	Total width of superstructure	12.00m
2	Width of carriageway	11.10m
3	Width of crash barrier	0.500m
4	Thickness of deck slab at centre	0.210m
5	Thickness of deck slab at ends (cantilever)	0.210m
6	Thickness of wearing coat	0.065m
7	No. of longitudinal girder	4
8	C/C spacing of longitudinal girders	3.00m
9	Web width of girder at span	0.300m
10	Top flange of girder at span	0.850m
11	Grade of concrete of superstructure	M40
12	Dry weight of concrete	25KN/m^3
13	Dry weight of wearing coat	22KN/m^3

3.2 Calculations

As per clause 211.2 & 211.3 IRC 6-2014, Impact factor for design of slab:

(i)For class A Loading;

IF = 0.5

(ii) For class 70R loading;

IF = 0.25

Design B.M. of Cantilever portion: -

(i) Due to Live Load-

Check for Class 70R loading:
Clearance = 1.2m from C.B also Width of one tyre of road = 0.84m but available roadway = 0.575m.
So the cantilever portion will not get affected from 70R loading.
Load position for maximum moment in cantilever portion:
For Class A loading: -
Distance of CG of load from cantilever edge = 0.6 – 0.425, x = 0.176m.
Effective width (transverse) A/c to IRC-112;
beff = 1.2x+bw 1.2*0.175+ [0.25+2(0.065)] = 0.59m
Load/m width of slab = 57/0.59= 96.61KN/m
Dispersion width along span. (Longitudinal) = 0.5 + 2(0.21+0.065)= 1.05m
Dispersion width in cantilever portion = (1.05/2) + 0.175= 0.70m
Load in cantilever portion (i) for 1.05m = 96.61KN/m
(ii) for 0.7m = 96.61*0.7/1.05 = 64.40KN/m
Now UDL/m of load = 64.40/0.7= 92KN/m
Maximum B.M. (at A) = 92*(0.7) ^{2}/2 = 22.54KN-m (hogging)
If 'x' is taken from centre of girder = x = 0.6m
Effective width (transverse) A/c to IRC-112 = beff = 1.2X+bw = 1.2(0.6) + 0.3= 1.10m
Load/m width of slab = 57/1.10 = 51.81KN/m
Dispersion width along span (longitudinal) = 0.5 + 2(0.21+0.065)= 1.05m
Now UDL/m of load = 51.81/1.05= 49.34KN/m
UDL/m including impact = 1.50*49.34= 74.03KN/m
Now Maximum B.M. (at A) = 74.03*(1.05) ^{2}/2= 46.67KN-m (hogging)

Due to Dead Load-
Self-weight = 0.21*1.5*25* = 7.875KN/m width of slab
Load/m run = 7.875/1.5 = 5.25KN/m
DL B.M. = 5.25*1.5^2/2 = 5.9KNm
Wearing Coat = 0.065*1.5*22 = 2.145KN/m width of slab

Load/m = 2.145/1.5= 1.43KN/m
DL BM due to wearing coat = $1.43*1.5^2/2$= 1.6KN-m
Due to Crash Barrier-
Self-weight = 0.5*0.7*25*1 = 9KN/m width of slab
Load/m run = 9/0.50 = 18KN/m
DL B.M. = 18*0.5*1.25 = 11.30KN-m
Total B.M. = 65.40KN-m
Bending Moment including combination: -
Basic Combination –
B.M. = (5.9*1.35) + (1.75*1.6) + (11.3*1.35) + (1.5*46.67) = 95.9KN-m
Rare combination –
B.M. = 5.9 + 1.6 + 11.3 + 46.6 = 65.40KN-m
Quasi. Combination –
B.M. = (5.9*1) + (11.3*1) + (1.6*1) + 0 = 19 KN-m
So, the max. B.M. = 95.9KN-m.

4. Results

Upon execution of detailed calculations, the bending moments at various points were calculated and their values are as given in Table 3 below.

Table 3: Summary of Bending Moment

Max BM at nodes	A(KNm)	B(KNm)	Mid between A and B(KNm)
Self weight	5.9	3.5	1.2
SIDL CB	11.3	2.4	4.4
SIDL wearing	1.6	1	0.3
LL	46.6	36.8	21.5

5. Conclusions

- Factor of Safety considered is 2.5.
- Ground water was not found during the exploration work.
- The foundation shall in no means rest on Filled up Soil or Black Cotton Soil.
- If in the course of excavation, if sub soil strata differ from the bore log strata the same shall be reported for necessary steps.
- For Intermediate footing size the value of SBC shall be interpolated. No Extrapolation is allowed.
- Ultimate Limit State check was applied and found satisfactory.

References

[1] Samyak S, Manoj TP, Santhi AS. A Parametric Study of Integral Bridges Subjected To Thermal Loading. International Journal of Civil Engineering and Technology. 2017 Apr; 8(4).
[2] Dash KP, Lohani TK, Senapati DR, Ojha BK. Analysis & Design of T-Beam Bridge over Rangiya Nala. International Journal of Structural Engineering and Analysis. 2015 Nov 11; 1(2):13-29.
[3] Patel R, Kadia BN, Mistry P. Comparative Study of Live Load Condition on RCC Girder Span Bridge using IRC and AASHTO.
[4] Plain IS. Reinforced Concrete Code of Practice. Bureau of Indian Standard. 2000.
[5] Vazirani VN, Ratwani MM. Concrete Structures: Analysis, Design and Details of Structures in SI Units According to New IS Code 456, 1978: Vol. IV. Khanna Publishers; 1983.
[6] Punmia BC, Jain AK, Jain AK. Reinforced Concrete Structures Vol. II. Firewall Media; 1992.
[7] Datta BN. Estimating and costing.
[8] Detailed Design And Detailing Report of GRADE SEPARATOR AT CH. 88+638 OF NAGDA-DHAR-GUJRI ROAD SECTION OF SH-31 TO TWO LANE FROM KM. 68+800 TO KM.138+300