DESIGN OF COMPOSITE BRIDGE BY USING STAAD PRO

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ABSTRACT

A bridge structure is a means by which a road, railway and many other services is carried over an obstacles such as a valley, river and other road or railway line, either with few number of supports at various locations or with no intermediate support. While finalization of any types of bridge ; Economy , Strength , Safety are the basic key features that cannot be neglected before construction of any bridge.

The scope of this project includes modelling of deck bridge in STAAD .Pro v8i software and testing for various live load conditions such as for Class A loading , 70R tracked and 70R wheeled vehicle. Structural steels have high strength, ductility and strength to the weight ratio. Thus it has become the choice for long span bridges as steel is more efficient and economic. As compared to the various types of bridges plate girder bridges, truss bridges and box girder bridges are more commonly used. As the cost of steel is rising we have to reduce the amount of steel used without affecting the strength of section.

In this thesis a plate girder bridge is designed as per the Limit state method using the IS 800:2007, IRC: 24-2000, IRC : 6-2017 and analysed in STAAD .Pro v8i software. However the Indian standards are basically derived from the British Standards only, but the basic concept behind that is same. Only the values of various parameters varies according to the design and fabrication/ erection practices which exist in India. Design calculations are carried out forsimply supported single span. Seismic and wind effect is not taken into account at the design stage.. Based on the design results, conclusions are arrived at to know the behaviour of plate girder bridges when it is designed by using Indian code

INTRODUCTION

A girder bridge is a bridge which uses girders as the means of supporting its deck. The two most commonly used types of modern steel girder bridge are box and plate. The term "girder" is often used interchangeably with "beam" in reference to design of bridge. A girder can be made up of concrete or steel. Many shorter bridges, especially in the rural areas where they may be exposed to water overtopping and corrosion, utilize concrete box girder . The term "girder" is basically used to refer to a steel beam. In a beam or girder bridge, the beams themselves acts as the primary support for the deck, and are responsible for transferring the load down from superstructure to thefoundation level. Shape, weight and Material type that all can affect how much weight a beam can hold. Due to the properties of inertia, the height of a girder is the most significant factor that affectits load bearing capacity. Wider spacing ,Longer spans or more traffic, will directly results into a deeper beam. In arch-style bridges and truss , the girders are still the main support to the deck however the load is transferred with the help of the arch or truss to the foundation. These designs in directly allows the bridges to spanlarger distances without increasing the depth of beam to beyond what is practical. However, with the inclusion of a arch or truss the bridge is no longer a true girder bridge.

COMPONENTSOFPLATEGIRDER:-

A. AVAILABLE SIZES OF PLATES :- Readily available thicknesses and lengths of steelplates need to be used so as to minimize the costs. Standard tables have been published by the various steel mills of standard sizes of plates and it should be used for the guidance purpose. These tables are available from the online or steel specialist. In general, an individual plate should not exceed 12′-6″ feet in width, including the camber requirements, or a length nearly about 60 feet. If any one or both of these dimensions are exceeded then butt splice is must require and it should be shown or must be specified on the plans. Some of the plates are available in lengths over 90 feet, so for that web splice locations should be considered optional. Plate thicknesses less than size of 5/16 inches should not be used for bridge applications. When the metric units is used then all the steel thickness , dimensions must be converted.

2 OBJECTIVE OFTHETHESIS

This study mainly aims at design and analysis of composite steel girder for road bridge. This Project includes :-

1. Design of Steel Girder, Deck slab, Shear Connector, Splice plates, Stiffeners.
2. Analysis of Deck Span in STAAD pro v8i for various load conditions such as (Dead load ,Class A loading , 70 R Tracked Vehicle , 70 R Wheeled Vehicle).

LITERATUREREVIEW

Minh-Tung Tran, Vuong Nguyen Van Do, Tuan-Anh Nguyen [2018] , The paper presented an experimental program based on the application of bolts as a shear connectors for the steel-composite beams. Four steel- concrete composite beams were made as well as a reference steel beam and it is tested.

The basic aim of the testing program was to examine which type of the steel bolts can be used effectively for steel-composite beams. The four types of the bolts includes: Type 1 the bolt having nut at the end; Type 2 the bolt bending at 90 degree hook;
Mr. Shivraj D. Kopare , Prof. K. S. Upase [2015] , The paper presents the design of a plate girder bridge as per the Limit state method using the codes such as IS 800:2007, IRC: 24-2000 and it is analysed by SAP-2000 software. It is concluded that the Steel is being used on railway and highway bridges successfully all over the world because of its better strength , inherent quality, resistance against fracture toughness, weld ability and a very good resistance against weathering / corrosion.

(3) **Amer f. Izzet , Aymen r. Mohammed [2018]** , In this study an Experimental programme was carried out to investigate the flexural behaviour of horizontally curved composite I-girder decks which is subjected to Iraqi Standard bridge live loads. This paper includes fabricating and testingfive scaled down, curved bridge models ,simply supported, 3 m in central span length. Each model includes four steel girders, with 175 mm girder spacing for the first two models, which had the curvature (L/R) ratio of 0.2 and 0.3 respectively while the other three models had 200 mm girder spacing, with the curvature ratio of 0.1, 0.2 and 0.3, respectively. The applied loads were equivalent to the superimposed dead load and self-weight to achieve that of the full scale designed bridge

(4) **Pawan Patidar, Sunil Harne [2017]**, In this study, mainly 16 different bridge span lengths of 15m,20m,25 m and 30 m were considered and studied. In this study the thickness of web was kept constant while other parameters varies. Following were the conclusions that has been made from this study: - 1. Depth of the web varies linearly with the span for the constant web thickness. 2. With the depth of web to the thickness of web ratio remains the same.

(5) **Ichiro sugimoto ,Yoshinori yoshida , Akira tanikaga [2013]** , In this study, a method is proposed for the structural improvement of existing railway steel bridge through installing concrete slab on the existing steel girders. This method improved the load bearing capacity of the bridge, extends its serviceable life, and reduces the noise emissions. The Feasibility studies for ease of application of composite girder were made and the proposed method was verified to ensure that it could be completed within the allocated time schedules.

(6) **Jaroslav Odrobinak , Josef vican , Jan Bujnak [2013]** , The paper presents conclusion of the experimental verification of highway composite steel concrete bridge behaviour. After experimenting the standard proof-load test, the more detailed verification of stress and deformation state of two girder continuous bridge structure was accomplished. The location of strain and deflection measurement and testing procedure are described.

MATERIALSMETHODS

A) FORDEADLOAD:-

For the dead load model, load calculations are done manually and then the intensity of loads are assigned on specific members for those the loads are calculated. Maximum bending moment and its bending moment diagram for girder 3 are shown in figure 3.5 and 3.6, while figure 3.7 & 3.8 shows the maximum shear force and shear force diagram for girder 3. Similarly for all the girders maximum bending moment and shear force for dead load, superimposed dead load, SSDL, footpath live load are calculated and computed in table format as shown in table 4.4.1.

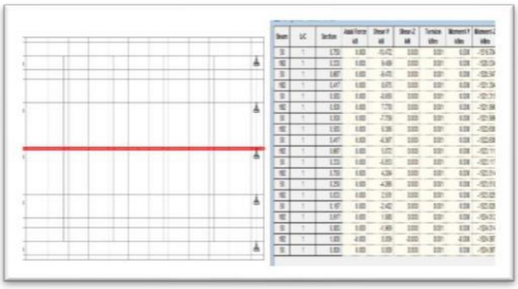


Fig3.5: Maxbendingmoment forG3

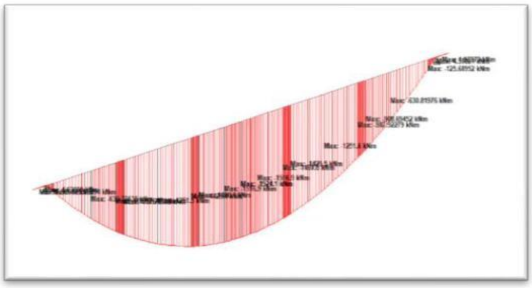


Fig3.6:Deadload B.M.D

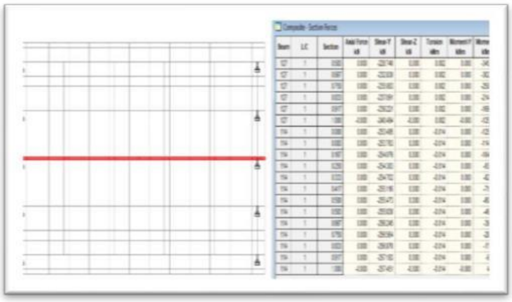


Fig3.7:MaxShearForceforG3

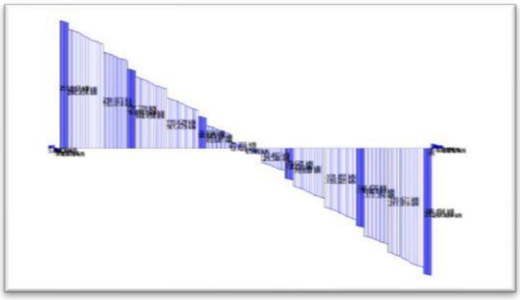


Fig3.8:Deadload S.F.D

B) FOR2CLASSALOADING:-

According to IRC 6:2017 if the carriageway width is between 5.3m to 9.6m then one lane of class 70R or two lanes for class A has to be designed. Following figure 3.9 & 3.10 shows the Two Class A loading and the moving load. while figure 3.11 & 3.12 shows the maximum bending moment diagram and shear force and shear force diagram for girder 1. Similarly for all the girders maximum bending moment and shear force are calculated and computed in table format as shown in table 4.4.2.

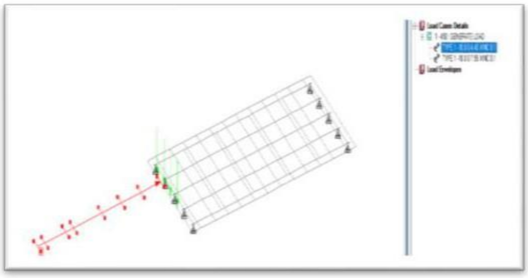


Fig3.9:ClassAloading

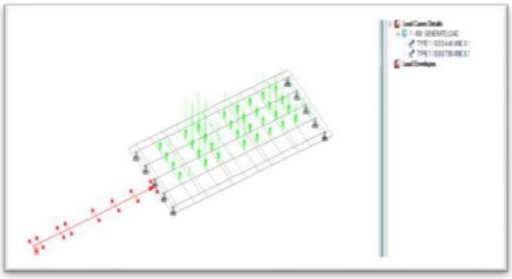


Fig3.10: ClassAmovingload

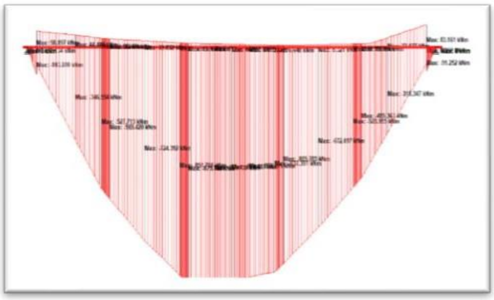


Fig3.11:BendingMomentdia.For G1

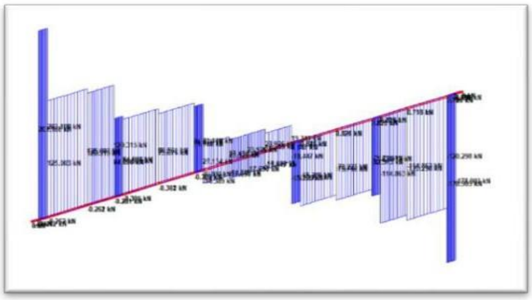


Fig3.12: ShearForcedia. ForG1

C) FOR70RTRACKEDVEHICLE:

Following Figures 3.13 & 3.14 shows 70R Tracked Vehicle model and moving load , while figure 3.15 & 3.16 shows maximum bending moment diagram and shear force diagram for girder 1. Similarly for all the girders maximum bending moment and shear force are calculated and computed in table formats as shown in table 4.4.2.

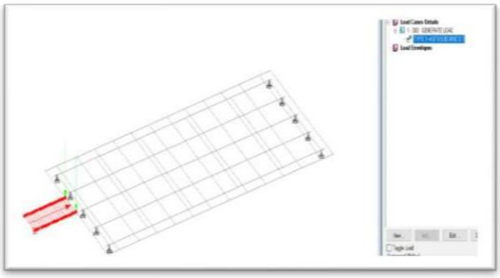


Fig3.13: 70RTrackedVehicle

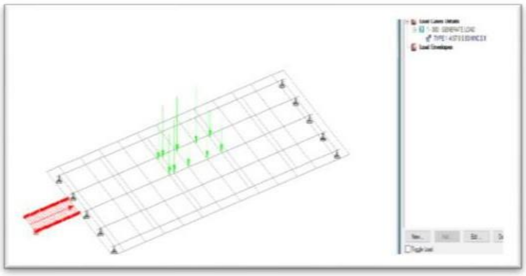
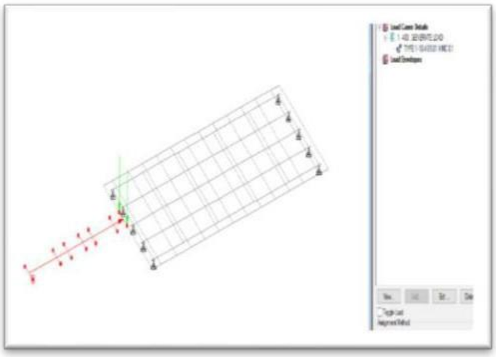


Fig3.14: 70RTrackedVehiclemovingload



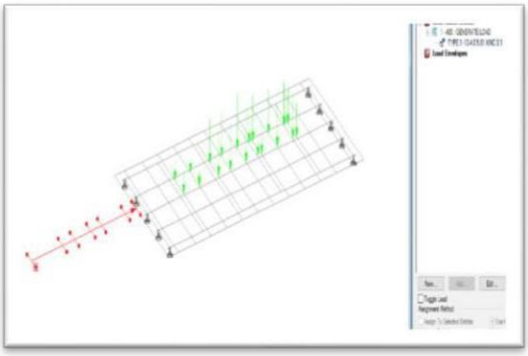


Fig3.15: BendingMomentdia.ForG1Fig3.16:ShearForcedia.ForG1

D) FOR70RWHEELEDVEHICLE:

Following Figures 3.17 & 3.18 shows 70R Wheeled Vehicle model and moving load , while figure 3.19 & 3.20 shows maximum bending moment diagram and shear force diagram for girder 1. Summery for bending moment and shear force which is obtained from STAAD software for all the live load conditions such as class A loading , 70R tracked and 70R wheeled vehicle for all the girders are computed in table format as shown in table.

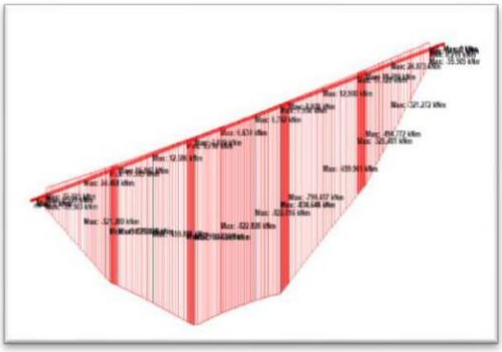


Fig3.17: 70RWheeledVehicle

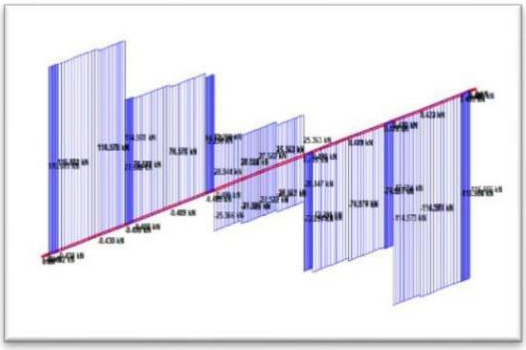


Fig3.18:70RWheeledVehiclemovingload

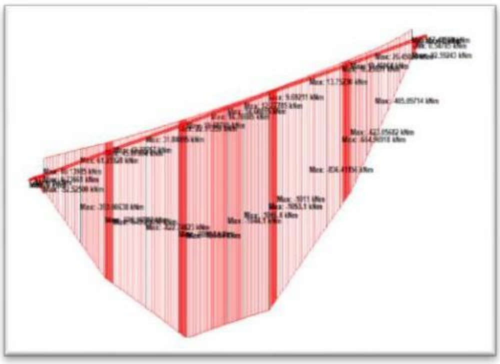


Fig3.19:BendingMomentdia.For G1

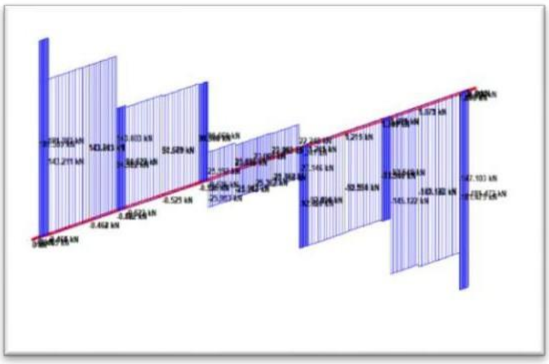


Fig3.20 :ShearForcedia. ForG1

RESULTSAND DISCUSSION

TABLE4.2.1:Sectionpropertiesoflongitudinal–girderalone,nocomposite action :-

Sr. No.	Description of section	Section dimensions in mm		No. of section	Area W x H A	CG Dist. from base Y	AxY	CG of memto sec. CG dist.	l-self	Ix-x= Iself + 2	Iyy
		W	H	Nos.		mm		mm			

					2		3		4	4	4
1	Top Flange Plate	400	28	1	11200	1550	1.74E+07	941	731733	9.92E+09	1.49E+08
2	Bottom Flange Plate	720	36	1	25920	18	4.67E+05	591.0	2.80E+06	9.06E+09	1.12E+09
3	Web Plate	18	1500	1	2700	786	2.12E+07	177.0	5.06E+09	5.91E+09	7.29E+05
			1564	ΣA=	64120		3.90E+07		Σlx-x=	2.49E+10	1.27E+09

	Over all Depth	C/S Area	CG from Top	CG from Bottom	Ixx	Iyy	Zxx Top	ZxxBot.	
	mm	2	mm	mm	4	4	3	3	mm
Summery OfSection. Property	1564	64120	955	609	2.49E+10	1.27E+09	2.61E+07	4.09E+07	140.73

Accordingto**IRC:22-2015Clause604.3**,forcalculatingstressesanddeflection,the Value of modular ratio , m shall be taken as ,

m= Es/Ecm≥ 7.5Forshortterm effectorloading
m=Es/KcxEcm≥15.0ForPermanent orlongtermloads(Kc=Creepfactor=0.5)
where,

Es=Modulusofelasticityforsteel=2.0x10^5

N/mm^2 Ecm=Modulus of elasticity of cast in situ concrete .

TABLE 4.2.2 : Section properties of longitudinal girder under composite action for DL & SIDL (For ‘m’ for Permanent Loads = 15.00) .

Sr. No.	Description of section	Section dimensions IN MM		No. ofsection	Area WxHA	CG Dist. from base Y	AxY	CG of mem tosec. CG dist.	l-self	lx-x= Iself+2	Iyy
		W	H	Nos.	2	mm	3	mm	4	4	4
1	Deckslab forPerm. Load	2500	16.67	1	41666.7	1579.0	6.58E+07	567	9.65E+05	1.34E+10	2.17E+10
2	Haunch	600	6.67	1	4000.0	1567.3	6.27E+06	555	1.48E+04	1.23E+09	1.20E+08
3	Top flange Plate	400	28	1	11200	1550	1.74E+07	538	7.32E+05	3.24E+09	1.49E+08
4	Bottom	720	36	1	25920	18	4.67E+05	994	2.80E+0	25615252095	1.12E+0

	Flange Plate								6		9
5	Web Plate	18	1500	1	2700	786	2.12E+07	226	5.06E+09	6.44E+09	7.29E+05
			1587.3	ΣA=	64120		1.11E+08		Σlx-x=	4.99E+10	2.31E+10

	Overall Depth	C/SArea	CG from Top	CG from Bottom	lxx	Iyy	ZxxTop	ZxxBot.	
	mm	2	mm	mm	4	4	3	3	mm
Summary of Section . Property	1587.33	109786.67	575	1012	4.99E+10	2.31E+10	8.68E+07	4.93E+07	4.58.62
	ExcludingDeckSlab		559		4.99E+10				

TABLE 4.2.3 : Section Properties of Longitudinal girder under composite action for LL(For 'm' for Live Loads = 7.50) .

Sr. No.	Description of section	Section dimensions INMM		No. of section	Area WxH A	CG Dist. from base Y	AxY	CGof mem tosec. CG dist.	l-self	lx-x= Iself+	Iyy
		W	H	Nos.		mm		mm			

1	Deckslab forPerm. Load	2500	33.33	1	83333	1594.0	1.33E+08	544.00	7.72E+06	2.47E+10	4.34E+10
2	Haunch	600	13.33	1	8000	1570.7	1.26E+07 +06	520.67	1.19E+05	2.17E+09	2.40E+08
3	Top flange Plate	400	28	1	11200	1550	1.74E+07	500	7.32E+05	2.88E+09	1.49E+08
4	Bottom Flange Plate	720	36	1	25920	18	4.67E+05	1032.00	2.80E+06	2.76E+10	1.12E+09
5	Web Plate	18	1500	1	2700	786	1.63E+08	264.00	5.06E+09	6.44E+09	7.29E+05
			1610.7		155453.3		3.04E+07			6.40E+10	4.49E+10

	Over all Depth	C/S Area	CG from Top	CG from Bottom	lxx	Iyy	ZxxTop	ZxxBot.	
	mm		mm	mm					mm
Summery	1610.667	155453.33	5607	1050.0	6.404E+10	4.49E+10	1.14E+08	60988251.95	537.51

TABLE4.3.1:Section properties of cross girder

Sr. No.	Descripti on of section	Section dimensions IN mm	No. of Section	Area A	CG dist. From basey	AxY	CG of memto sec. CG dist.	I-self	lx-x= Iself + AY²	Iyy

		W	H	Nos.	mm²	mm	mm³	mm	mm⁴	mm⁴	mm⁴
1	Top flange plate	300	16	1	4800	1274	6.12E+06	633.00	102400	1.92E+09	3.60E+07
2	Bottom Flange Plate	300	16	1	4800	8	3.84E+04	633.00	1.02E+05	1.92E+09	3.60E+07
3	Web Plate	12	1250	1	15000	641	9.62E+06	0.00	1.95E+09	1.95E+09	1.80E+05
			1282		24600		1.58E+07			5.80E+9	7.22E+07

	Over all Depth	C/S Area	CG from Top	CG from Bottom	Ixx	Iyy	ZxxTop	ZxxBot	Rmin
	mm	mm²	mm	mm	mm⁴	mm⁴	mm³	mm³	mm
Summery of Section. Property	1282	24600	641.00	641	5.80E+10	7.22E+07	9.05E+06	9.05E+06	54.17

Table4.4.1:-SummeryforB.M.&S.F.(DeadLoad,SIDL,SSDL,FootpathLive Load)

Maximum Bending Moment and Shear Force DeadLoad,SIDL,SSDL,FootpathLiveLoad								
S.N.	DeadLoad(Slab, LongGirder,Cross Girder		SIDL(Crash Barrier)		SSDL(Wearing CoatPaver Blocks)		FootpathLive Load	
	B.M.	S.F.	B.M.	S.F.	B.M.	S.F.	B.M.	S.F.
	KNm	KN	KNm	KN	KNm	KN	KNm	KN
G1	1511.61	256.87	487.70	106.42	309.11	57.03	196.65	43.72
G2	1520.74	255.09	426.66	65.31	297.87	47.57	166.42	23.01
G3	1524.07	257.45	401.32	52.83	294.01	47.34	155.45	19.60
G4	1520.59	256.94	426.68	64.08	297.88	47.33	166.42	22.71
G5	1511.26	255.89	487.72	104.44	309.11	56.31	196.65	42.88

Table4.4.2:-:- Summery for B.M.&S.F.(For70RTracked&Wheeled,TwoClassA)

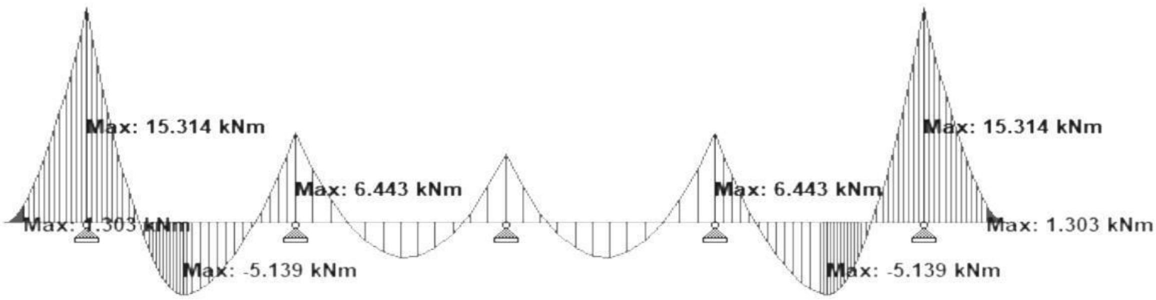
Maximum Bending Moment and Shear Force LIVELOAD						
S.N.	70RTRACK		70R WHEELED		2CLASSA	
	B.M.	S.F.	B.M.	S.F.	B.M.	S.F.
	KNm	KN	KNm	KN	KNm	KN
G1	834.65	116.66	1053.07	181.47	875.71	178.90
G2	1007.32	237.33	1112.86	263.65	925.62	169.51
G3	942.24	255.59	1001.84	266.75	876.88	175.79
G4	605.15	95.56	703.38	108.51	710.94	120.55
G5	324.69	41.62	400.46	67.83	509.41	104.23

DESIGNOFDECKSLAB

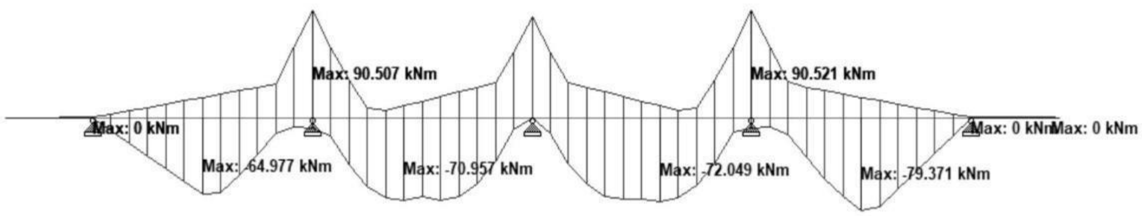
VehicleData: Cantilever Panel Intermediate Panel

		ClassA	Class70R	BogieLoad	
Maximum Wheel Load	=	57.0	85.0	100.0	KN
Total Length of vehicle	=	18.8	18.8		m
Max Tyre pressure	=		527.30	527.30	KN/^{2}
Area of Tyre	=		0.1612	0.1896	m^2
Width of wheelW	=	0.5000	0.8100	0.8100	m
Width along traffic B	=	0.2500	0.1990	0.2340	m
Clearance from kerb edge	=	0.1500	1.2000	1.2000	m
Distance between two wheels	=	1.8000	1.9300	1.9300	m
Axle Spacing along traffic direction	=	1.2000	1.3700	1.2200	m
Impact Factor	=	1.5000	1.2500	1.2500	m

STAADRESULT



1.35*DL+1.35*SIDL+ 1.75*SSDL+ 1.75*FootpathLoad+1.5*FootpathLL



Live Load

CONCLUSION

It is concluded that the Steel is being used on highway and railway bridges successfully all over the world because of its high strength, resistance against fracture toughness, weld ability and a good resistance against weathering / corrosion action.

1. The STAAD analysis results indicate that the designed plate girder bridge is stable in bending moment, shear force, and deflection forvarious live load conditions such as for Class A loading , Class 70R tracked and wheeled vehicle .
2. 70R wheeled vehicle gives maximum value of Bending moment and Shear force as compared to 2 Class A loading and 70 R Tracked vehicle.

SCOPEFORFUTUREWORK

The study presented in this thesis should be extended beyond 25m span. Since we have considered composite bridge but Frame bridges, Steel truss bridge and Continuous bridges must be considered for designing in future.

A comparison can be made between the continuous span and simply supported bridge keeping constant parameters.

This study includes concrete deck slab but Composite deck slab can also be considered for designing in future.

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