

# Effect of Over Weight Vehicle on RCC T Girder Bridge

**R. Prateek**

Assistant Professor  
Department of Civil Engineering  
Rungta College of Engineering and Technology  
Bhilai, Chhattisgarh, India  
Email: r.prateek24@gmail.com

**Abstract:** A large number of infrastructure projects have been undertaken in Taiwan in recent years because it is a developing country. These large-scale constructions have caused rapid growth in the number of heavy vehicles in service, as well as a dramatic increase in the size and weight of heavy vehicles. A very serious truck overloading problem has resulted, which significantly affects pavement performance and bridge safety. Overload attributable to increased vehicle loads is becoming an increasingly serious issue in highway transportation. Overload results in damages to bridge structures, degradation of their load-carrying capacities, and even collapse of bridges, which may cause loss of lives and properties. Hence, the actual load-carrying capacity of existing bridges with many years of service and obvious damages is becoming an important concern for researchers and engineers.

The paper presents a method for comparing the mechanical effects of overweight and design load vehicles on bridges. There is no restriction on the arrangement of the axles and on the size of the axle loads. The bridge may be a simple span bridge, a continuous girder. Even for a very complex bridge structure the only required parameter of the bridge is the span length. The presented method is a robust and reliable tool for the permitting process of overweight vehicles, which is verified by several thousand comparisons. A software program, SAP-2000, assists authorities in this task. It is based on a comparison of internal forces (bending moments and shear forces) under design-code loads and loads induced by special transport. For this purpose the bridge structure is numerically simplified into a sequence of simply supported beams. By virtue of this simplification the application SAP-2000 is both fast and easy to use. Development of the SAP-2000 program was based on object-oriented methodology. The system model resulting from requirement analysis is shown and shortly discussed.

The result of the average weight vehicles of GVW (surveyed by CRR) by SAP analysis was made comparison with

governing load of (16.2t, 25t, 40.2t) whose bending moment and shear force was found more than governing load.

This shows that overloaded vehicles having effects on bridges which causes wear and tear on bridge structures and also damages, vehicle accidents etc. We should take authorized steps to overcome this problems. So many technologies have been developed by an European countries. In India this steps should be taken seriously by I.R.C, C.R.R.I and NCHRP to overcome this problems.

**Keywords:** Axle load, Bending moment, Bridge design, clearance, GVW, SAP, Shear force, Span length, Speed limits.

## I. INTRODUCTION

The effect of live load on the existing road infrastructure under currently plying vehicle is evoking great interest all over the world. Highway infrastructure protection has been an important consideration in determining the parameters of truck size and weight (TS and W) limits. The wear in pavement increases with axle weight, number of axle loadings and the spacing between the axles within the axle groups, such as a tandem or tridem. Truck weight also affects the design and fatigue life of bridges. Also, the distribution of weight over the distance between truck axles also affects bridge design and fatigue life. Truck dimensions influence roadway design and vice versa: truck width affects lane widths, trailer or load height affects bridge and other overhead clearances, and length affects the degree of curvature and intersection design in a road network.

## II. NEED OF STUDY

Liberalization and globalization of Indian economy has brought unprecedented industrial, trade and commercial developments in our country during the last one decade which in turn has led to many fold increase in road traffic in terms of volume and axle loads. Majority of heavy commercial vehicles plying on Indian

highways are 2 axle/3 axle/5axle rigid body trucks as observed in several studies, that the extend of axle loads and gross vehicle weight (GVW) carried by these trucks are very much higher than that of legally permissible load limits. The truck industry can get more carrying capacity by increasing truck weight while bridge owner need to control the loading on the bridges to limit the deterioration of the existing bridge infrastructures in India and to keep the structure in safe condition. Even though, the Motor Vehicle Act (MVA 1988) introduced a legislation related to the truck weight which prescribes the gross vehicle weights (GVW) and prescribes weight per vehicle axle and axle groups, the overloading in currently plying trucks continues to exist.

### III. METHODOLOGY OF THE STUDY

To achieve the above objectives, a detailed literature survey was carried out. Analysis of the axle load data of trucks plying in specific routes have been carried out to understand the extent of overloading especially in 2-axle, 3-axle and 5-axle trucks. Subsequently, two R. C. T-girder bridges of 21m and 25m span respectively were analysed using the commercially SAP 2000 for different loads such as (i) loads specified for bridge design in IRC: 6 (ii) GVW of 2 –axle truck, 3-axle truck and 5-axle truck (iii) loads carried by excessively loaded 2-axle, 3-axle and 5-axle truck observed in specific routes, in eastern part of the country. Also, the analysis of the bridges has been extended to understand the effect of extremely heavy vehicles.

TABLE I: CLASSIFICATION OF BRIDGES BASED ON SPAN LENGTH

Span Range	Type of Construction
< 6m	Culverts
>6m <10m	Solid RCC Slabs
>10m <20m	Precast / Pretensioned or Post tensioned RCC beams
>20m<25m	RCC voided slab
>25m<30m	PSC Voided slab
>30m<35m	RCC Box
>35m<40m	PSC Beams
>40m<55m	PSC box
>55m<120m	Cantilever / Segmental Construction
>120m<1000m	Cable stayed
>800m <2000m	Suspension Bridge

TABLE II: MINIMUM CLEARANCE BETWEEN THE ROAD FACE OF THE KERB AND THE OUTER EDGE OF THE WHEEL OR TRACK C

Carriageway width		Min value of C
3.8 m and above	Single lane bridge	0.3m
Less than 5.5 m	Multi-Lane bridges	0.6m
5.5 m or above		1.2m

### IV. AXLE LOAD AND SPEED LIMITS IN INDIA

The legal axle load limit in India is 10.2 tonnes, as amended by Central Government in 1996 under the Section 58 of the Motor Vehicles Act 1988. The maximum permissible load limits for different types of trucks in India are given below in Table III. The standard 2-axle truck and 3-axle trucks are shown in Fig. 1 and Fig. 2. The dimensions of some of the popular 2-axle and 3-axle trucks are shown in Table II. The pictorial view of typical 2-axle and multi-axle trucks and heavy commercial trucks are shown in Fig. 3, Fig. 4 and Fig. 5.

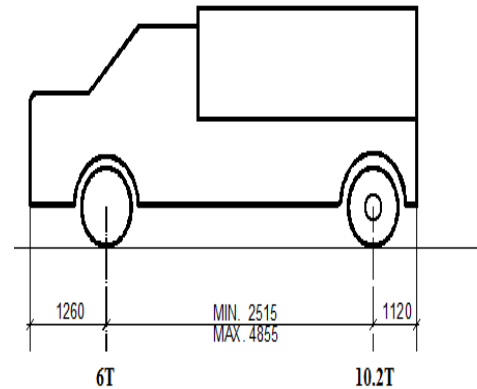


Fig. 1: Standard 2-axle truck

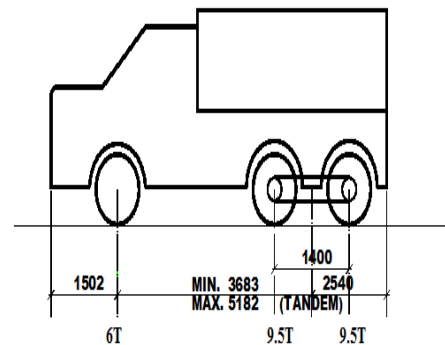


Fig. 2: Typical 3-axle truck



Fig. 3: Typical 2-axle truck



Fig. 4: Typical multi-axle truck



Fig. 5: Heavy commercial vehicle

TABLE III: MAXIMUM PERMISSIBLE LOADS FOR DIFFERENT TYPES OF TRUCKS IN INDIA

Vehicle Type	Legal Load limits(Tonnes)
Trucks - 2 axle	16.2
Truck – Semi Trailer	25.0
Truck –Trailer	35.0
Truck -3 axle (rear tandem)	25.0
Truck – Multi axle (rear tandem)	35.0
Truck – multi axle (both rear tandem)	45.0

### V. SPEED LIMITS IN INDIA

The general speed limits on National and State Highways as defined by MVA for various types of vehicles are given below. For the full list reference may be made to MVA.

- a) Medium / heavy goods vehicle (Rigid): 65 Km/hr.
- b) Medium goods vehicle with not more than one: 50 Km/hr trailer or heavy articulated goods vehicle.
- c) Heavy goods vehicle with not more than one trailer: 40 Km/hr.

TABLE IV: DIMENSIONS OF SOME OF THE POPULAR 2-AXLE AND 3-AXLE TRUCKS

	Eicher 30.25	Telco 2515 EX	Telco 2515C	ALL 2214 Tusker super	Eicher 20.16	T1613 EX	T1613TC	T1613 (697) TC	Al tipper Tarus
MAX. GVW (T)	25.0	25.0	25.0	25.0	16.20	16.20	16.20	16.20	25.0
Calculated pay load (T)	17.15	16.5	16.50	16.50	10.30	9.70	9.70	9.70	15.25
Wheel base (m)	5.26	4.88	4.88	4.572	4.80	4.225	4.225	4.225	3.810

### VI. TYPES OF AXLE

- 2-axle(16.2T)
- 3-axle(25T)
- 5-axle(40.2T)
- 6-axle(49T)
- 7-axle upto 16-axle or more(147.4T to 335T or more)

#### A. Truck characteristics on load carrying capacity of bridge

- a) When the span of the bridge < than length of the truck-
  - 1) Length of axle as comparison to the span.
  - 2) Axle weight and axle spacing
  - 3) Spreading axle in an axle group is a beneficial.

- b) When the span of the bridge > than the length of the truck-
  - 1) GVW
  - 2) Spread of axles-bending stress is more sensitive than no. of axles.

#### B. ASTHO Formulas used for permitting legal weight vehicles in U.S.A

- $W=500(LN/N-1 +12N + 36)$
- Where W is the allowable gross weight in pounds on any group of two or more consecutive axles.
- L is the distance in feet between the extreme of any group of two or more consecutive axles.

N is the number of axles included in the group under consideration.

TABLE V: ESTIMATION OF ALLOWABLE GVW IN 2 AXLE TRUCK

Type of vehicles	Wheel base(m)	Overall length(m)	No. of axle	GVW(t)	Allowable vehicle weight(t) as per AASTHO
Tata SE 1210B/32	3.225	5.370	2	15.66	18.11
Tata SE1210B/36	3.625	6.100	2	16.2	18.70
Tata SE1210B/42	4.225	6.970	2	16.2	19.5
AL comet ALCO 3/1	4.470	7.264	2	15.54	19.93
AL Tusker 13 C 42	4.216	7.264	2	16.20	19.95

TABLE VI: ALLOWABLE AXLE WEIGHTS BY USING AASTHO

Type of vehicle	Wheel base(m)	Overall length(m)	No. of axle	GVW(t)	Allowable axle weight(t) vehicle as per AASTHO
2 axle truck	3.20	5.58	2	16.2	14.8
3 axle truck	5.972	10.014	3	25	22.63
4 axle truck	8.703	10.16	4	35.2	27.24
5 axle truck	11.71	13.167	5	44	32.14

## VII. ANALYSIS OF AXLE LOAD DATA

Damaging effects of vehicles, specially of the commercial vehicles, depends largely upon their numbers and magnitude of axle loads passing over the road. Knowledge of magnitude of axle loads and vehicle numbers, which are mainly responsible for causing damage to the road, is imperative for proper designing and rehabilitating the bridge structures. Bridge design is done on the basis of number of commercial vehicles. Design of bridge should, therefore, be based on the number of standard axle loads that are expected. Therefore a assignment was taken by CRRRI , a survey was conducted on axle load through this following routes in October, 2009.

- A. Dohrightat to Azamgarh (down)\_Azamgarh to Dohrightat (up)

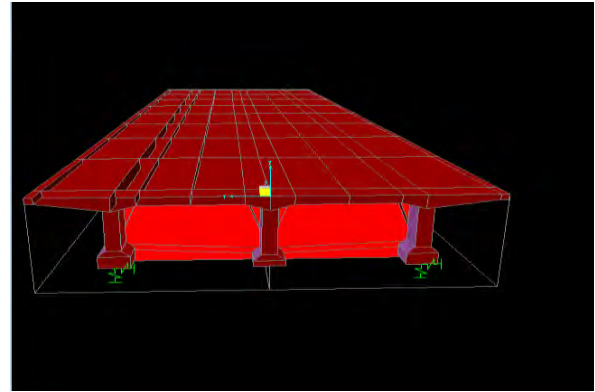


Fig. 6: RCC-T girder bridge

- B. Gazipur to Azamgarh(down)-Azamgarh to Gazipur(up)  
C. Varanasi to Azamgarh(down)-Azamgarh to Gazipur(up)

Evaluation of R.C.C T Girder Bridge by SAP-2000

Example project

The example bridge is of R.C.C-T girder bridge with the following features:

- Span- Two bridges with span of 21m and 25 m each.
- Material property-
  - Concrete-35
  - Weight per unit volume- Nmm
  - Mass per unit volume- Nmm
  - Modulus of elasticity-30000 Nmm
  - Poisson's Ratio-0.2
- Deck sections-
  - Number of girders -3
  - Total width-8700 mm
  - Total depth-1800 mm
  - Slab thickness-210 mm
- Cross diaphragms-5 cross diaphragms are provided in RCC-T girder bridge with thickness of 250 mm.

## VIII. GRAPHICAL DISPLAYS

When a bridge model is developed using the SAP2000/Bridge module, the Display menu > Show Bridge Forces/Stresses command can be used to display force and stress results, an example of which is shown in Fig. (7-12)

Shear force and Bending moment diagrams for 21m span

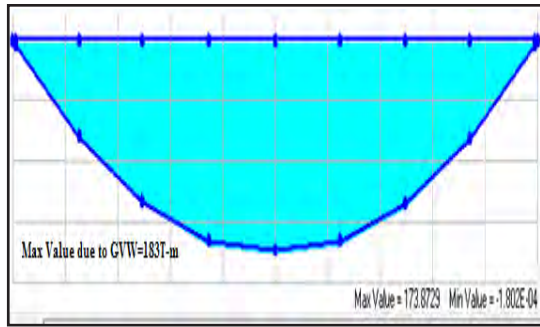


Fig. 7: Bending moment (live load) of 16.2T (2 axle) [min. distance] for 21m span

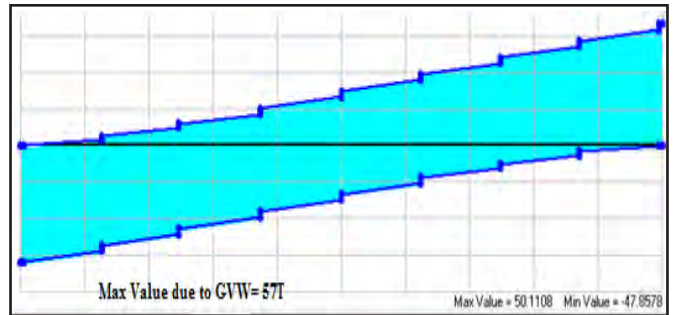


Fig. 10: Shear force (live load) of 25T (2 axle) [max. distance] for 21m span

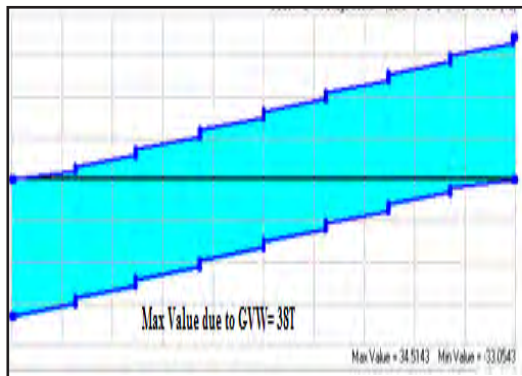


Fig. 8: Shear force (live load) of 16.2T (2 axle) [min. distance] for 21m span

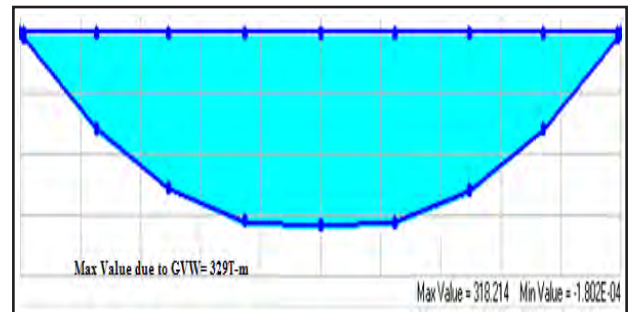


Fig. 11: Bending moment of 40.2T (5 axle) [min. distance] for 21m span

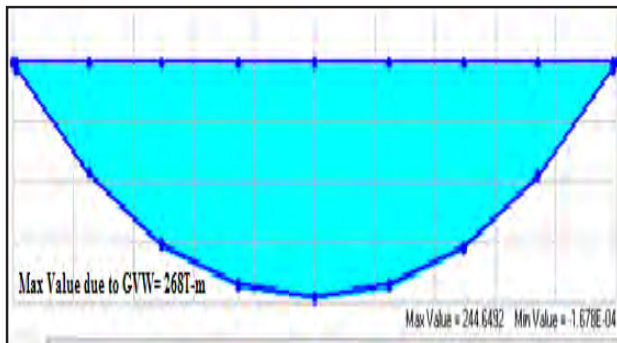


Fig. 9: Bending moment (live load) of 25T (3 axle) [max. distance] for 21m span

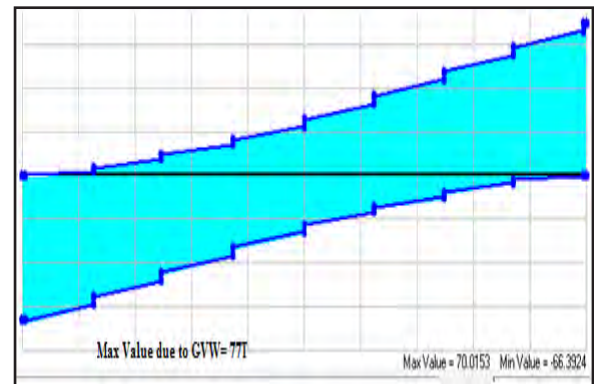


Fig. 12: Shear force (live load) of 40.2T (5 axle) [min. distance] for 21m span

### IX. INTERPRETATION OF RESULTS

#### A. Bending moment and shear force for 21m span

TABLE VII: BENDING MOMENT AND SHEAR FORCE FOR 21M SPAN

Loads(t)	Bm(t-m)[max/min-distance]	If(tm) [max/min-distance]	Sf(tm) [max/min-distance]	If(tm) [max/min-distance]	Comparison-Bm(t-m) [GVW]	Comparison-S.F(t-m) [GVW]
16.2t	173/158	209/191	34/33	41/39	183	38
25t	254/244	307/295	51/50	61/60	268	57
40.2t	318/316	384/382	70/69	84/83	329	77
26.031t	281/256	340/309	55/53	66/64		
49.031t	499/479	603/579	100/98	121/118		

72.76t	572/569	692/688	126/125	152/151		
I.R.C-70R	406	491	84	101	422	93
335T	549	-	110	-		

### B. Bending moment and shear force for 25m span

TABLE VIII: BENDING MOMENT AND SHEAR FORCE FOR 25M SPAN

Loads(t)	Bm(t-m) [max/min-distance]	If(tm) [max/min-distance]	Sf(tm) [max/min-distance]	If(tm) [max/min-distance]	Comparison-Bm(t-m)[GVW]	Comparison-S.F(t-m) [GVW]
16.2t	229/212	274/254	37/36	44/43	231	40
25t	339/328	406/393	55/54	66/64	341	57
40.2t	445/443	534/531	78/77	93/92	449	80
26.031t	371/343	445/411	60/58	72/69		
49.031t	664/643	796/771	109/107	130/128		
72.76t	801/798	961/957	141/140	169/168		
I.R.C-70R	566	679	94	112	571	98
335T	758	-	123	-		

## X. CONCLUSION

This report also provides information on the extent to which axle group overloading within

GVW limits occurs. This information will support us in investigations required in considering whether an axle group overloading defence might be appropriate when GVW limits have not been exceeded.

The analysis for two-axle rigid vehicles in India, from Azamgarh\_Dohrighat showed that 52.2% of the drive axles were overloaded, from Dohrighat\_Azamgarh showed that 74% of the drive axles were overloaded, from Azamgarh\_Gazipur showed that 33% of the drive axles were overloaded, from Gazipur\_Azamgarh showed that 48.4% of the drive axles were overloaded, from Azamgarh\_Varanasih showed that 6% of the drive axles were overloaded, from Varanasih\_Azamgarh showed that 6% of the drive axles were overloaded.

The analysis for three-axle rigid vehicles in India, from Azamgarh\_Dohrighat showed that 98.5% of the drive axles were overloaded, from Dohrighat\_Azmagarh showed that 15.7% of the drive axles were overloaded, from Azamgarh\_Gazipur showed that 33% of the drive axles were overloaded, from Gazipur\_Azamgarh showed that 61% of the drive axles were overloaded, from Azamgarh\_Varanasih showed that 22% of the drive axles were overloaded, from Varanasih\_Azamgarh showed that 99% of the drive axles were overloaded.

The analysis five-axle rigid vehicles in India, from Azamgarh\_Dohrighat showed that 25% of the drive axles were overloaded, from Azamgarh\_Varanasih showed that null% of the drive axles were obtained, from Varanasih\_Azmagarh showed that 100% of the drive axles were overloaded.

This study considers 5 different types of vehicles including average weight of GVW (16.2t, 25t, 40.2t, 335t,) on two different spans (21 m and 25 m) of bridge by using SAP-2000

Software. 8 bending moments and shear force were developed for all 5 different vehicles. Among 5 vehicles 3 vehicles are the average weight of all three GVW (2-axle, 3-axle and 5-axle) calculated. This Sap analysis include all- a) interior and exterior girder b) shear force and bending moment c) multi lane loading. The result of this average weight vehicles of GVW by SAP analysis was made comparison with governing load of (16.2t, 25t, 40.2t) whose bending moment & shear force is more than governing load.

This results shows that overloaded vehicles having effects on bridges which causes wear and tear on bridge structures and also damages, vehicle accidents etc. We should take authorized steps to overcome this problems. So many technologies have been developed by an European countries. In India this steps should be taken seriously by I.R.C and NCHRP to overcome this problems.

The following are recommended for further consideration:

- 1) State the allowable maximum axle loads in terms of single axle, tandem axles, tridem axles and so on, in order not to create confusion on the interpretation of the allowable maximum loads.
- 2) Establish standards, type approval system, and monitoring system for truck modifications, in order to ascertain compliance with safety and stability standards.
- 3) Conduct studies on actual axle loads and GVWs on a more regular basis, say every 5 years, by the I.R.C, C.R.R.I and NCHRP, in order to establish a database from which allowable maximum axle loads and GVWs may be updated in aid of legislation.
- 4) Conduct impact assessments.

The U.S. Department of Transportation (2000) recommendations that may be relevant in the impact assessments include:

- a. Infrastructure costs – including implications on road pavements, bridges and geometrics

- b. Safety impacts – including crash/accident rates, public perception, vehicle stability and control, and vehicle comparisons
- c. Traffic operations – impacts on road capacity and speeds
- d. Energy and environment – impacts on fuel consumption and vehicle emissions

## REFERENCES

### 1) Code of Practices

- [1] “IRC:5-1998 Standard specifications and code of practice for road bridges, Section I - General features of design (7th revision),” Indian Road Congress, 1998.
- [2] “IRC:6-2010 Standard specifications and code of practice for road bridges, Section II - Loads and stresses (5th revision),” Indian Road Congress, 2010.
- [3] “IRC:21-2000 Standard specifications and code of practice for road bridges, Section III – Cement concrete (plain and reinforced),” Indian Road Congress, 2000.
- [4] “IRC:3-1983 Dimensions and weights of road design vehicles (1st revision),” Indian Road Congress, 1983.
- [5] “IRC:SP:37-1991 Guidelines for evaluation of load carrying of bridges,” Indian Road Congress, 1991.

### 2) Hand Books

- [1] M. Dicleli, and M. Bruneau, “Fatigue-based methodology for managing impact of heavy-permit trucks on steel highway bridges,” *Journal of Structural Engineering*, ASCE, vol. 121, no. 11, pp. 1651-1659, Nov. 1995.
- [2] T. Pinkaew, and P. Asnachinda, “Experimental study on the identification of dynamic axle loads of moving vehicles from the bending moments of bridges,” *Engineering Structures*, Elsevier, vol. 29, no. 9, pp. 2282–2293, Sep. 2007.
- [3] L. Deng, “Identification of dynamic vehicular axle loads: Demonstration by a field study,” CSA publications, 1983, p. 432.
- [4] J. Wekezer, “Analytical and experimental evaluation of existing florida dot bridges,” Smith and Sons, New York, 1976, p. 33.
- [5] F. W. Taylor, S. E. Thompson, and E. Smulski, “Reinforced concrete bridges,” John Wiley and Sons, New York, 1955, pp. 1-456.
- [6] T. M. Matson, and W. S. Smith, “*Bridge Engineering*,” McGraw Hill Book Company, Inc. New York.
- [7] M. Rautenbach, “The effect of an increase in the permissible heavy vehicle loads on road bridges,” VKE, Van Wyk and Louw, CSIR, RDAC 91/004, Pretoria, Oct. 1999.