



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 6, June 2022

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.118



9940 572 462



6381 907 438



ijirset@gmail.com



www.ijirset.com

Analysis of Box Culvert under Cushion Loading

Tanmay Deshmukh, Vishwajeet Kadlag

P.G. Student, Department of Structural Engineering, Dr. D.Y. Patil School of Engineering & Technology, Pune, India

Assistant Professor, Dr. D.Y. Patil School of Engineering & Technology, Pune, India

ABSTRACT :- Box Culverts Are The Monolithic Structure Made To Pass Across A Roadway, Railway Lines Etc. Embankments Are Used To Balance The Flood Water On Both Sides. Box Takes Various Types Of Loads Generated By Water, Traffic, Cushion, Soil Etc. This Work Deals With Complete Design Of Box Culvert Manually And Study The Design Parameters Such As Effect Of Earth Pressure, Depth Of Cushion At The Top Slab Of Culvert, Factor Such As Braking Force, Impact Load, Live Load, Dispersal Of Load Through Tracked Or Wheeled Vehicle, Effective Width Etc. In This Work, Study Of Culvert With And Without Cushion Analyzed For Different Classes Of Irc Loadings And Conclusions Made On The Basis Of Bending Moments And Shear Forces With And Without Cushioning Cases. This Paper Provides Full Discussion Of Provisions Provided By Indian Standards, Their Justifications And Considerations Are Taken Into The Account For Design Purpose.

I. INTRODUCTION

Box Culverts Are Low Rise Bridge Or Structure Which Is Used To Discharge Water In The Proper Channel In Crossing Of Railway, Flyover, Roads Etc. And Is Used Where The Bearing Capacity Of Soil Is Low. Culverts Are Always Economical Than Bridge Where The Discharge In The Opening Is 18 M² It Depends On The Number Of Cells Which Is Generally Used Where Roadway Crosses The High Embankment. Box Culverts Are Generally Cast In Situ In India, But In Other Countries The Box Culverts Are Preferred Due To Low Cost And Economically With Having Fast Workmanship. The Box Is Just Name Given For Its Shape, Can Be Found In Various Types Of Shapes And Also It Can Be Act As Minor Bridge When The Number Of Cells Increases And Span Greater Than 6m In Length. Its Height Depends On Span. It Can Control All Water Coming From Irrigation, Surface Water, River And Canals They Control All The Storm Water And Flood Water During Rainy Season.

II. TYPES OF BOX CULVERTS

1) According To The Classification By Materials

- 1.1) Concrete
- 1.2) Steel
- 1.3) Aluminum
- 1.4) Plastic

2) According To The Classification By Loading As Per Irc

- 2.1) Irc-Class-70 R
- 2.2) Irc-Class-A
- 2.3) Irc-Class-B

2.1) Irc-Class-70 R: - It Is A Loading Which Used By The Municipality Which Includes Industrial Areas Along With Major Highways, Bridges Culverts Etc. For Military Heavy Loads Vehicles, The Bridge, Culverts Designed For Class-

A And Also For Class-B. It Should Be Checked For Class-A Loading Because There Will Be Heavy Stresses Created Under Class-A Loadings. As Per Irc 6, The Value For Class 70 R Provided Is 350 Kn For Tracked Vehicle.

2.2) Irc-Class-A: - This Loading Is Preferred On Each And Every Roads On Which Permanent Structures Are Made Such As Bridges, Culverts Etc. As Per Irc 6, The Value For Class A Provided Is 114 Kn For Wheeled Vehicle.

2.3) Irc-Class-B: - This Loading Is Preferred On Each And Every Road On Which Temporary Structures Are Made And For Bridges The Different Materials Are Used Respect To Situations. As Per Irc 6, The Value For Class B Provided Is 68 Kn For Wheeled Vehicle.

III. COMBINATION OF LIVE LOAD:-

Table 01: Combination Of Live Load

S. No	Carriageway Width	Number Of Lanes For Design Purposes	Load Combination
1	9.6m And Above But Less Than 16.6m	3	One Lane Of Class 70r For Every Two Lanes With One Lane Of Class A On The Remaining Lane Or 3 Lanes Of Class A

IV. METHODOLOGY & PROBLEM SOLVING STATEMENT

1. Fixing Of Dimensions Based On Hydraulic Report.
2. Calculation Of Dead Load And Superimposed Dead Load
3. Calculation Of Live Load From Vehicles As Per Lane Consideration For Various Cases Which Will Act On Top Slab
4. Calculation Of Braking Force(As Per Cl.No.211.2-Irc-6-2016)
5. Calculation Of Earth Pressure:- At Rest And Sliding Condition.
6. Calculation Of Loads Acting On Bottom Slab.
7. Calculation Of Modulus Of Subgrade Reaction For Allowable Safe Bearing Capacity Of 15t/M3.
8. Calculation Of Uls, Sls & Qpc Moments At Section 1,2,3,4,5,6,7,8,13 & 14 By Using Staad Pro Software.
9. Calculation Of Shear Force At Sections 1,2,3 & 4 Sections.
10. Rcc Design Of Box Culvert By Ultimate Limit State Method (Irc-112-2011).
11. Verification Of Structural Strength Under Imposed Ultimate Shear(Ved).
12. Checking Stresses Under Serviceability Limit State
13. Calculation Of Stresses For Quasi Permanent Combination.
14. Checking Crack Width Under Serviceability Limit State.

V. BOX CULVERT DISTRIBUTED INTO SECTIONS

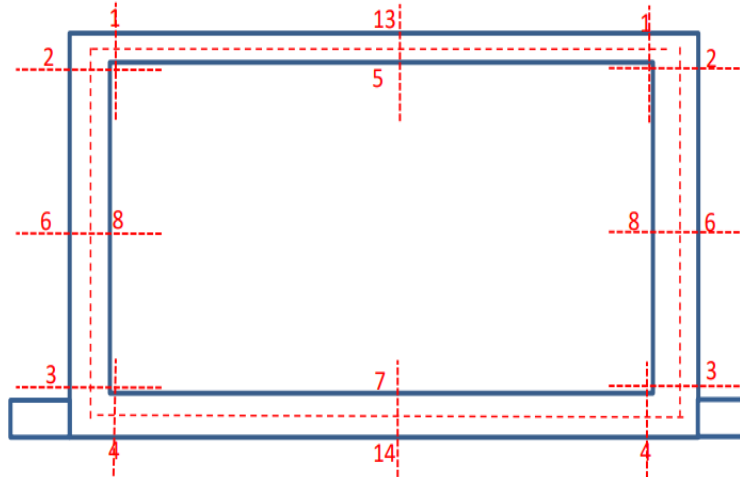


Figure 01: Box Culvert Divided Into Sections

VI. DESIGN OF TOP SLAB

1. Calculation Of Dead Load And Super Imposed Dead Load

Table 02: Calculation Of Dead Load

Dead Load-

Self Weight Of Slab	$0.3 \times 2.5 \times 1 = 0.75 \text{ t/M}$
Weight Of Top Slab-	
Weight Of Overburden Excluding Road Crust	$3.794 \times 2 = 7.948 \text{ t/M}$
Weight Of 4 Haunch Portion	$0.011 \times 2.5 = 0.113 \text{ t/M}$

Table 03: Calculation Of Super Imposed Dead Load

Superimposed Dead Load-

Dead Load Of One Crash Barrier	$0.285 \times 1.1 \times 2.5 = 0.785 \text{ t/M}$
Dead Load Due To Two Crash Barrier	1.570 t/M
Dead Load Due To Road Crust	$0.610 \times 2.2 \times 1.00 = 1.342 \text{ t/M}$

2. Live Loading Calculations-

Case 1: Class-A-3 lane

Effective Length Of Dispersion Of One Wheel (Lef)

$L_{ef} = \text{Contact Length Of Wheel} + 2 \times (\text{Overburden})$

$$0.25 + 9.168 = 9.418 \text{ m}$$

Effective Width Of Dispersion Of One Wheel (B1)

$B1 = \text{Contact Length Of Wheel} + 2 \times (\text{Overburden})$

$$0.5 + 9.168 = 9.668 \text{ m}$$

Calculation Of α

$$(B/Le)=13/2.3=5.61$$

When Maximum Loading Axle Placed At Centre For Maximum Bending Moment

Table 04: Calculation Of Live Load For Class-A Vehicle

No.Of Axle	Axle	Axle Load(T)	Axle Spacing (M)	A (M)	Le (M)	Lef (M)	Bef (M)	Bef (M)	Impact Factor	Load Intensity T.M ² /M	Bmmax T.M
3	1st	34.2	0	0.55	2.3	9.418	10.76	14.578	1.542	1.57	
3	2nd	34.2	1.2	1.75	2.3	9.418	10.76	14.578	1.542	1.57	8.15

2).LI-2 Maximum Axle Load Of 70r(Wheel) Vehicle+Maximum Axle Load Of Class-A Vehicle

1.Class A

Table 05:Table 04: Calculation Of Live Load For Class-A Vehicle

No.Of Axle	Axle	Axle Load(T)	Axle Spacing (M)	A (M)	Le (M)	Lef (M)	Bef (M)	Bef (M)	Impact Factor	Load Intensity T.M ² /M	Bmmax T.M
1	1st	11.4	0	0.55	2.30	9.42	10.76	7.578	1.54	1.01	
1	2nd	11.4	1.2	1.75	2.30	9.42	10.76	7.578	1.54	1.01	5.22

2.70r

Table 06: Calculation Of Live Load For 70-R Vehicle

No.Of Axle	Axle	Axle Load(T)	Axle Spacing (M)	A (M)	Le (M)	Lef (M)	Bef (M)	Bef (M)	Impact Factor	Load Intensity T.M ² /M	Bmmax T.M
1	1st	17	0	2.3	0.47	9.778	10.993	12.923	1.25	0.71	
1	2nd	17	1.37	2.3	1.84	9.778	10.993	12.923	1.25	0.71	3.65

3. Maximum Bogie Load(70r(W))

Table 07: Calculation Of Live Load For 70-R Vehicle With Bogie Load

No.Of Axle	Axle	Axle Load(T)	Axle Spacing (M)	A (M)	Le (M)	Lef (M)	Bef (M)	Bef (M)	Impact Factor	Load Intensity T.M ² /M	Bmmax T.M
1	1st	20	1.22	2.3	0.54	9.778	11.102	13.032	1.25	0.83	
1	2nd	20	1.22	2.3	1.76	9.778	11.102	13.032	1.25	0.83	5.00

VII. LOAD COMBINATIONS FOR VERIFICATION OF ULTIMATE LIMIT STATE (ULS)

Load Cases Considered:

- Dead Load (Dl)
- Wearing Coat (Wc)
- Active Earth Pressure (Aep)
- Surcharge On One Side (Sos)
- Surcharge On Both Side (Sbs)
- Breaking Force (Bp)
- Temperature Uniform Rise (Tur)
- Temperature Uniform Fall (Tuf)
- Temperature Gradient Rise (Tgr)
- Temperature Gradient Fall (Tgf)
- Earth Pressure At Rest (Ep)

Dry ConditionUls1: $1.35dl + 1.75wc + 1.5ll + 1.2sos + 1.5aep$ Uls2: $1.35dl + 1.75wc + 1.5epr$ Uls3: $1.35dl + 1.75wc + 1.5ll + 1.2sbs + 1.5aep$ **Wet Condition**Uls4: $1.35dl + 1.75wc + 1.5ll + 1.2sos + 1.5aep + Wp$ Uls5: $1.35dl + 1.75wc + 1.5epr + Wp$ Uls6: $1.35dl + 1.75wc + 1.5ll + 1.2sbs + 1.5aep + Wp$ **Results-****Table 08- Moments For Uls****Section 1**

Combination	Factored Moments
Uls1	25
Uls2	16
Uls3	20
Uls4	23
Uls5	15
Uls6	18
Governing Moments	25

for Section 2

Combination	Factored Moments
Uls1	51
Uls2	36
Uls3	44
Uls4	50
Uls5	35
Uls6	43
Governing Moments	51

For Section 3

Combination	Factored Moments
Uls1	31
Uls2	18
Uls3	22
Uls4	30
Uls5	18
Uls6	22
Governing Moments	31

For Section 4

Combination	Factored Moments
Uls1	17
Uls2	18
Uls3	18
Uls4	15
Uls5	5
Uls6	6
Governing Moments	18

For Section 5

Combination	Factored Moments
Uls1	72
Uls2	57
Uls3	70
Uls4	74
Uls5	59
Uls6	72
Governing Moments	74

For Section 13

Combination	Factored Moments
Uls1	0
Uls2	0
Uls3	0
Uls4	0
Uls5	0
Uls6	0
Governing Moments	0

For Section 7

Combination	Factored Moments
Uls1	46
Uls2	36
Uls3	45
Uls4	49
Uls5	39
Uls6	47
Governing Moments	49

For Section 14

Combination	Factored Moments
Uls1	0
Uls2	0
Uls3	0
Uls4	0
Uls5	0
Uls6	0
Governing Moments	0

For Section 6

Combination	Factored Moments
Uls1	35
Uls2	23
Uls3	28
Uls4	28
Uls5	26
Uls6	31
Governing Moments	35

For Section 8

Combination	Factored Moments
Uls1	0
Uls2	0
Uls3	0
Uls4	0
Uls5	0
Uls6	0
Governing Moments	0

VIII. CONCLUSION

Hogging Moment Takes Place At Section 1, 2, 3 & 4 Respectively, Sagging Moment Takes Place At Section 5, 6, 7, 8, 13 & 14 Respectively. Maximum Sagging Moment Was Found At Section 5 Since Super Imposed Dead Load Is Acting Maximum At Section 5. Maximum Hogging Moment Was Found At Section 2 Due To Live Load Surcharge.

Viii) Load Combinations For Verification Of Serviceability Limit State (Sls)

Load Cases Considered:

1. Dead Load (Dl) 2. Wearing Coat (Wc) 3. Active Earth Pressure (Aep) 4. Surcharge On One Side (Sos) 5. Surcharge On Both Side (Sbs) 6. Breaking Force (Bp) 7. Temperature Uniform Rise (Tur) 8. Temperature Uniform Fall (Tuf) 9. Temperature Gradient Rise (Tgr) 10. Temperature Gradient Fall (Tgf) 11. Earth Pressure At Rest (Ep)

Dry Condition

Sls1: $Dl + 1.2wc + Ll + 0.8 Sos + Aep$

Sls2: $Dl + 1.2 Wc + Epr$

Sls3: $Dl + 1.2 Wc + Ll + 0.8 Sbs + Aep$

Wet Condition

Sls4: $Dl + 1.2wc + Ll + 0.8 Sos + Aep + Wp$

Sls5: $Dl + 1.2 Wc + Epr + Wp$

Sls6: $Dl + 1.2 Wc + Ll + 0.8 Sbs + Aep + Wp$

Results

Table 09: Moments For Sls

Section 1

Combination	Factored Moments
Sls1	17
Sls2	12
Sls3	17
Sls4	16
Sls5	10
Sls6	12
Governing Moments	17

For Section 2

Combination	Factored Moments
Sls1	36
Sls2	26
Sls3	36
Sls4	35
Sls5	26
Sls6	31
Governing Moments	36

For Section 3

Combination	Factored Moments
Sls1	30
Sls2	18
Sls3	22
Sls4	30
Sls5	18
Sls6	22
Governing Moments	30

For Section 4

Combination	Factored Moments
Sls1	11
Sls2	5
Sls3	11
Sls4	9
Sls5	3
Sls6	3
Governing Moments	11

For Section 5

Combination	Factored Moments
Sls1	52
Sls2	42
Sls3	52
Sls4	54
Sls5	44
Sls6	53
Governing Moments	54

For Section 13

Combination	Factored Moments
Sls1	0
Sls2	0
Sls3	0
Sls4	0
Sls5	0
Sls6	0
Governing Moments	0

For Section 7

Combination	Factored Moments
Sls1	34
Sls2	27
Sls3	34
Sls4	36
Sls5	29
Sls6	35
Governing Moments	36

For Section 14

Combination	Factored Moments
Sls1	0
Sls2	0
Sls3	0
Sls4	0
Sls5	0
Sls6	0
Governing Moments	0

For Section 6

Combination	Factored Moments
Sls1	35
Sls2	23
Sls3	28
Sls4	35
Sls5	23
Sls6	28
Governing Moments	

For Section 8

Combination	Factored Moments
Sls1	0
Sls2	0
Sls3	0
Sls4	0
Sls5	0
Sls6	0
Governing Moments	0

IX. CONCLUSION

Hogging Moment Takes Place At Section 1, 2, 3 & 4 Respectively, Sagging Moment Takes Place At Section 5, 6, 7, 8, 13 & 14 Respectively. Maximum Sagging Moment Was Found At Section 5 Since Super Imposed Dead Load Is Acting Maximum At Section 5. Maximum Hogging Moment Was Found At Section 2 Due To Live Load Surcharge.

REFERENCES

1. Codes By Indian Road Congress And Is Code For Design : Irc Sp- 41, Irc 6-2016, Irc 103-2012, Irc 103-1988, Sp – 16 And Is 456:2000.
2. Y.Vinod Kumar And Dr. Chava Srinivas (2015) : Analysis And Design Of Box Culvert By Using Computational Methods, International Journal Of Engineering & Science Research, Vol. 5, No 7, July 2015, Pp. 850-861.
3. [1] Neha Kolate, Molly Mathew And Snehal Mali, —Analysis And Design Of Rcc Box Culvert, International Journal Of Scientific & Engineering Research, Volume 5, Issue 12, December-2014.
4. Mahesh D. Kakade, Rajkuwar A. Dubai (2017), " A Study Of Behavior Of R.C.C. Box Culvert Under The Influence Of Static & Dynamic Loads In Accordance With Irc " International Research Journal Of Engineering And Technology , Issn No.(O) 2395-0056, Issn No.(P) 2395-0072, Vol.04, Issue-10, P.P. 30-35.
5. Afzal Hamif Sharif (2016), "Review Paper On Analysis And Design Of Railway Box Bridge" International Journal Of Scientific Development & Research, Issn No.2455-2631, Vol.01, Issue-07, P.P. 204-207.



INNO SPACE
SJIF Scientific Journal Impact Factor
Impact Factor: 8.118



ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 **9940 572 462**  **6381 907 438**  **ijirset@gmail.com**



www.ijirset.com

Scan to save the contact details