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Analysis and Design of Box Culvert using STAAD-Pro Software

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Abstract: The project will focus on a study of the design features of culvert boxes such as live load distribution angle, the effect of co-efficient ground pressure applied to the culvert walls and the depth of the cushion provided over slab culverts. Depth of pillow, lateral pressure on walls, width or angle of live load spread in pillow box and outside pillow crippling structure are also important factors where designer ideas vary and need to be considered in detail. The structural designing involves consideration of load cases (empty and full box, additional loads etc.) and other factors such as live load, width, braking force, load dissipation by filling, impact factor, ground compression interaction etc. IRC codes are . The purpose of this project is to design and analyze the culvert box using STAAD PRO software. This software is an effective and easy-to-use tool for three-dimensional models, analysis and multi-sector design. The results obtained from STAAD PRO are comparable to manual calculations with precision. The elements of the culvert box are designed to withstand large lengths of bending and cutting force. The project will provide a comprehensive discussion of the provisions provided in the Codes, the consideration and adjustment of all of the above aspects regarding design.

Key Words: Culvert, Stadd Pro Software, IS Code, Base Pressure, Wheel Loads.

I. Introduction

1.1 Overview

It is well-known that roads are often constructed on the embankment that come with the natural flow of floodwaters. As the flow cannot be prevented hence, some type of pumping operations needs to be provided to allow water to pass over the embankment and to take the electrical or other cables from one side to the other. The structures to achieve such a flow across the street are called culverts, small bridges and large bridges depending on the spans and also on the on the discharges.

1.2 purpose of box culvert
Box Culverts are used for **drainage purposes**. They are also used to make tunnels and used for storage as well as material handling. Some culverts act as bridges. They easily accommodate both pedestrian and vehicular traffic.

1.3 Uses of Box Culvert:
Box Culverts are used for drainage purposes. They are also used to make tunnels and used for storage as well as material handling. Some culverts act as bridges. They easily accommodate both pedestrian and vehicular traffic. We can choose the kind of culvert in accordance with our specific needs. With precast box culverts, factors such as rain, site condition, temperature, etc do not matter.

Advantages of Box Culverts:
Box Culverts are very cost-effective as:

- The box culvert has a firm frame structure.
- The construction of the box culvert is very simple
- It is ideal for non-perennial streams where there is lesser significance of scrub depth and the soil is not very strong.
- The bottom slab of the box culvert puts less pressure on soil.
- Box culverts are affordable because of their rigidity as well as monolithic action.

- Prevent Erosion
- Prevent Flooding
- Allow Water to Flow Unobstructed
- Divert Water for Farming/Engineering Purposes

Double cell Box Culvert

Single Cell Box Culvert

1.5 Objective

i. The principal objectives of the project are to investigate basic parameters like shear force and bending moments for culvert with and without cushion.
ii. To study the effect of cushion in RCC culvert by analysis for different cases like traffic condition, soil condition, hydrological condition.
iii. Structural designing of RCC culvert considering various load cases including factors like effective live loads, effective width, and coefficient of earth pressure.

1.6 Aim of Study

i. Structural designing of RCC culvert considering various load cases including factors like effective live loads, effective width, and coefficient of earth pressure.
ii. Net ultimate bearing capacity, Earth pressure on walls, Deck slab Axial forces, Side Wall Axial forces, Deck slab Shear forces, Side wall Shear forces, Base slab Shear forces, Deck slab Bending moments.
iii. Modeling and analysis of Box Culvert with and without cushion by STAAD Pro.

2.0 LITERATURE SURVEY

1. L. A. Chandrakant and P. V. Malgonda (2014), developed an excel system for analysis and comparison of software results. The study concluded that the case for high-end loading is when the culvert box is empty, with a live loading charge over the top slab of the box and the burden of additional charges in the world.

2. M.G. Kalyanshetti and S.A. Gosavi (2014), analyzed a channel length of 12 m with a range of lengths 2m to 6m, divided into single cell, double cell, and triple cell. The analysis was performed using a robust matrix method and a computer program in language C designed to assess costs. Research conducted related to bending minute variability; after that, a cost comparison was made at different rates.

14. N. Kolate, et al. (2014), studied the parameters of the design of the clove boxes such as the scattering angle, the impact of the ground pressure and the depth of the cushion given on the top slab of the clove boxes. The study concluded that a box without a pillow has lower design times and shear pressure compared to a box with a pillow.

15. Muthanna Abbu, Talha Ekmekyapar, Mustafa Özakça (May-2013), proved that although three-dimensional Finite Element (FE) modelling is probably the most critical and time consuming, it is still the most comprehensive and effective technique for static as well as dynamic analyses, which captures all aspects affecting the structural response. The other methods proved their adequacy but are limited in scope and applicability. In this study, three-dimensional solid FE model was created using ANSYS for the study of thermal loadings. By taking into consideration, longitudinal strains, modal analysis, and deformations, this model simulated a three span, 220-meter concrete bridge which is built to replace an existing six span concrete bridge across the Kealakehe Stream. A major interest in this paper is to perform three-dimensional FE analyses of composite box girder bridge to replicate the actual bridge behaviour. In this, attention is focused on development of representative numerical models for a composite box girder bridge. To achieve this purpose several FE models of a laboratory specimen are developed using different approaches available within ANSYS software.

16. S. Shreedhar and R Shreedhar (2013) examined the coefficients of the second-bending design, shear strength and normal thrust of various loading cases with different L / H = 1.0, 1.25, 1.5, 1.75 and 2.0 counts on the culvert of three-cell boxes. This study concluded that the critical sections considered are the center span of the upper and lower slabs as well as the supporting sections and in the middle of the vertical walls.

18. Sujata Shreedhar and R. Shreedhar (2013): Introduced the paper Coefficients for Designing Couples in a two-cell box. The box culvert should be analyzed for times, shear strength and thrust improved due to various loading conditions for any of the old methods such as short-term distribution method, slope deviation method etc. It becomes very difficult for a designer to come up with a variety of design capabilities. loading conditions. Research has therefore been conducted to achieve the intermediate coefficients, shear strength and axial thrust of different loading cases and different measurements of length and length.

19. Zakia Begum, MS, (2010) explained that the box girders offer better resistance to torsion, which is particularly of benefit if the bridge deck is curved in plan. Due to the high torsional stiffness of the box girders as the cross section is closed, it often ranges from 100 to 1000 times larger than the torsional stiffness of comparable I-shaped sections, the torsional moment induced by the curvature of the girder can be resisted by the I-shaped girders with much more transverse bracing than that of the box girder. The fabrication of the I-shaped girder is more economical as compared to the Box shaped girder, but this additional cost in box girder is usually balanced by the reduction in substructure that need to construct. This study is to develop the three-dimensional finite element beam and shell models of curved and straight box girders using the commercially available finite element computer program "ANSYS"

20. H. Maximos, et al., (2010) summarize the evaluation process to assess the effects of fatigue on rigid concrete box (RC) and resultant recommendations made (AASHTO). The test results show a good distribution of load resistance between the two reinforcing strips in the culvert section of the box.

21. B.N. Sinha and R.P. Sharma (2009) provided a comprehensive discussion of the provisions in Coding, consideration, and modification of design elements. Research has concluded that cross drainage box operating at higher altitudes has many advantages compared to slab culvert.

22. H. Chanson (2000) Review the hydraulic structure of the culvert. This paper introduces a new approach to teaching hydraulic design to students of civil and environmental engineering in the degree curriculum. The hydraulic design of the culvert was introduced as part of the complete design approach. The paper outlines engineering design techniques where individual innovation and innovation are required.

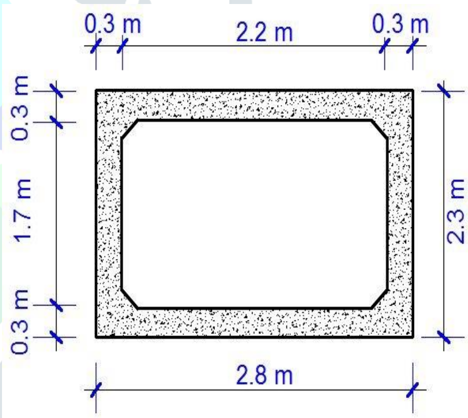
23. Shivanand Tenagi and R. Shreedhar conducted research on the RCC slab culvert using the codes IRC 112 - 2011 and IRC 21-2000. The RCC slab enclosure was analyzed and designed for IRC uploads as standard specifications and L / S savings rates. d was found in both the moderate condition and the functional stress method. The study concluded that the required concrete capacity is below the boundary condition method and a L / d rating equal to 20 for the boundary condition method and 13 for the operating pressure method may be acceptable for design.

3.0 METHODOLOGY

Three Load cases which are adopted and mainly govern the design:
Case 1: Box empty, Dead load and live load acting from outside as well as earth pressure.
Case 2: Box full, Dead load and live load acting from outside as well as earth pressure.
Case 3: Box full, Dead load and live load acting from outside no earth pressure.
These load cases are to be examined for box culvert with cushion and without cushion.

Geometry and material Properties of Box Culvert

Total Length of Culvert = 8 m
Width of Culvert c/c of side wall = 205 m
Height of Culvert = 2.0 m
Length of Wing wall = 2.12 m
Thickness of all Elements= 300 mm
Thickness of Asphalt layer = 70 mm

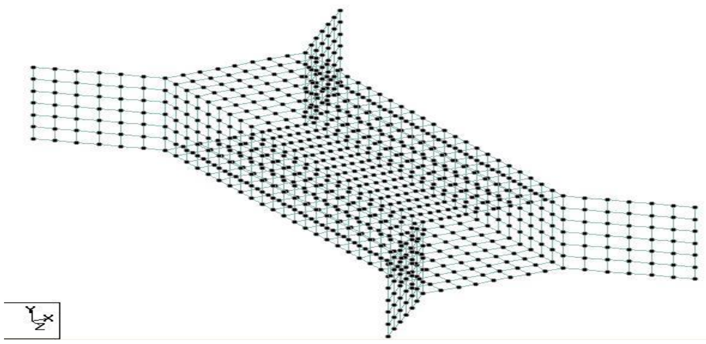


Material Properties

Angle of internal friction= 30 Degree
Unit weight of water = 9.81 KN/m^3
Unit weight of backfill soil = 19 KN/m^3
Unit weight of Concrete = 25 KN/m^3
Unit weight of Asphalt Concrete = 22.5 KN/m^3
F_{ck} = 30 Mpa
F_y = 500 Mpa
Concrete Cover = 50 mm

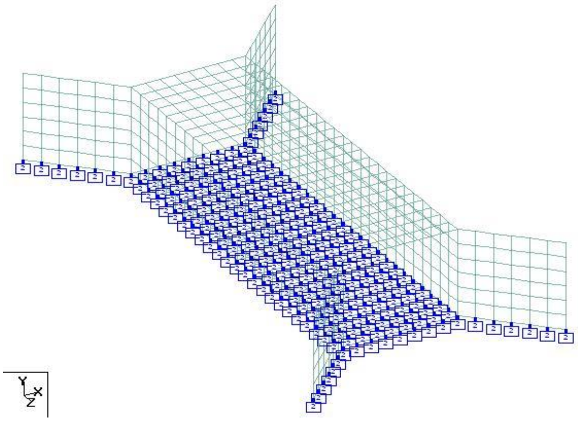
Steps followed in Modelling:

(1) Meshing: The meshing process can be completed by adding plate thickness of 300 mm to all the elements.

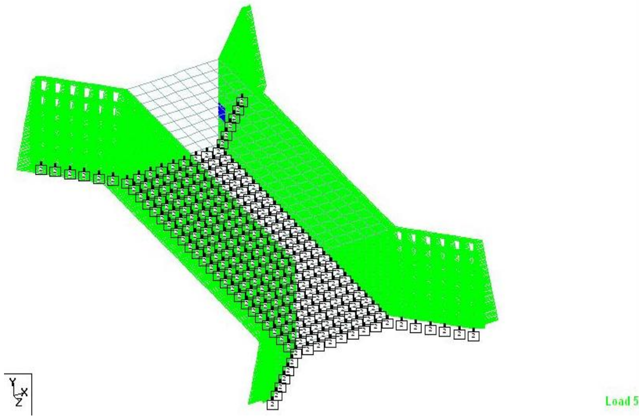


Meshing

2. Assigning of support conditions/foundations: If we assume that the supporting soil and the backfill are of the same material, then we can maintain the same angle of internal friction of 30°. Angle of internal friction of 30° can suggest a loose - medium dense sand in its undisturbed state, therefore we can take a modulus of subgrade reaction of 50,000 kN/m²/m for a well compacted sand. For a slightly compacted sand, you can take a value of 30,000 kN/m²/m.



Assigning of support conditions/foundations



Loading

(3) Loading: we considered two construction cases.

(A) where the culvert is buried under the soil, and (B) where is there no earth fill on top of the culvert.

(B) When there is no earth fill on the culvert, the traffic load is directly on the top slab of the culvert as tandem loads and as UDL, but when there is earth fill, traffic load is dispersed in the ratio of 2:1 as UDL on the culvert. We are going to consider 5 load cases in in this model.

(1) Self-weight and other superimposed actions

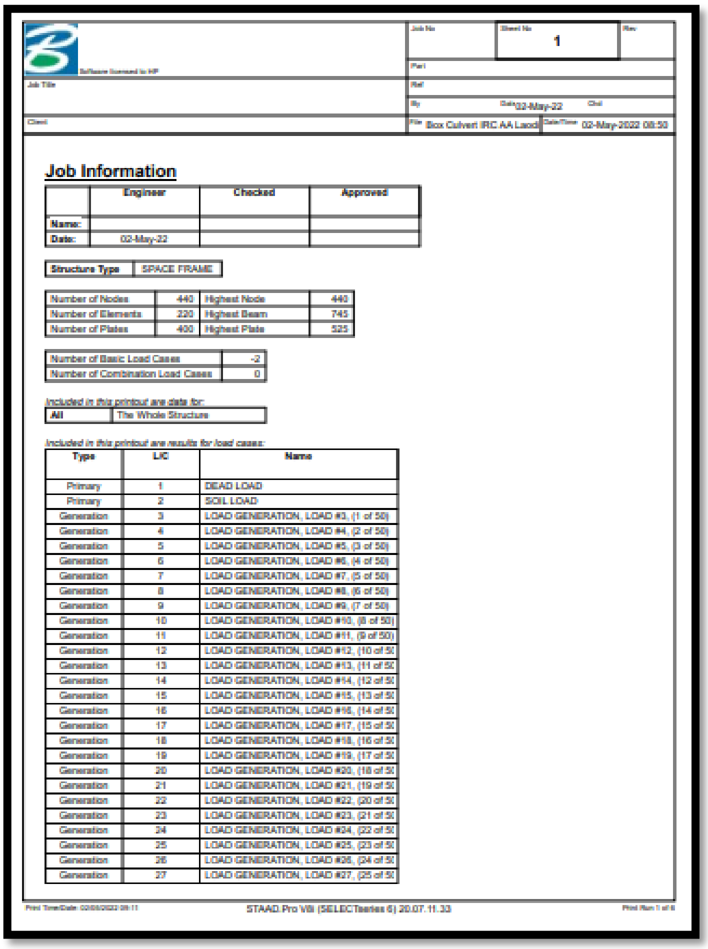
(2) Vertical earth load

(3) Traffic load

(4) Surcharge load

(5) Horizontal earth pressure load

4.0 Analysis & Modelling: Analysis and modelling were performed by Stadd Pro software, following are the outputs:



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Sheet No 1

Date 02-May-22

File Box Culvert IRC AA Laodi Date/Time 02-May-2022 08:50

Job Information

	Engineer	Checked	Approved
Name:			
Date:	02-May-22		

Structure Type	SPACE FRAME

Number of Nodes	440	Highest Node	440
Number of Elements	220	Highest Beam	745
Number of Plates	400	Highest Plate	525

Number of Basic Load Cases	-2
Number of Combination Load Cases	0

Included in this printout are data for:

All	The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	DEAD LOAD
Primary	2	SOIL LOAD
Generation	3	LOAD GENERATION, LOAD #3, (1 of 50)
Generation	4	LOAD GENERATION, LOAD #4, (2 of 50)
Generation	5	LOAD GENERATION, LOAD #5, (3 of 50)
Generation	6	LOAD GENERATION, LOAD #6, (4 of 50)
Generation	7	LOAD GENERATION, LOAD #7, (5 of 50)
Generation	8	LOAD GENERATION, LOAD #8, (6 of 50)
Generation	9	LOAD GENERATION, LOAD #9, (7 of 50)
Generation	10	LOAD GENERATION, LOAD #10, (8 of 50)
Generation	11	LOAD GENERATION, LOAD #11, (9 of 50)
Generation	12	LOAD GENERATION, LOAD #12, (10 of 5
Generation	13	LOAD GENERATION, LOAD #13, (11 of 5
Generation	14	LOAD GENERATION, LOAD #14, (12 of 5
Generation	15	LOAD GENERATION, LOAD #15, (13 of 5
Generation	16	LOAD GENERATION, LOAD #16, (14 of 5
Generation	17	LOAD GENERATION, LOAD #17, (15 of 5
Generation	18	LOAD GENERATION, LOAD #18, (16 of 5
Generation	19	LOAD GENERATION, LOAD #19, (17 of 5
Generation	20	LOAD GENERATION, LOAD #20, (18 of 5
Generation	21	LOAD GENERATION, LOAD #21, (19 of 5
Generation	22	LOAD GENERATION, LOAD #22, (20 of 5
Generation	23	LOAD GENERATION, LOAD #23, (21 of 5
Generation	24	LOAD GENERATION, LOAD #24, (22 of 5
Generation	25	LOAD GENERATION, LOAD #25, (23 of 5
Generation	26	LOAD GENERATION, LOAD #26, (24 of 5
Generation	27	LOAD GENERATION, LOAD #27, (25 of 5

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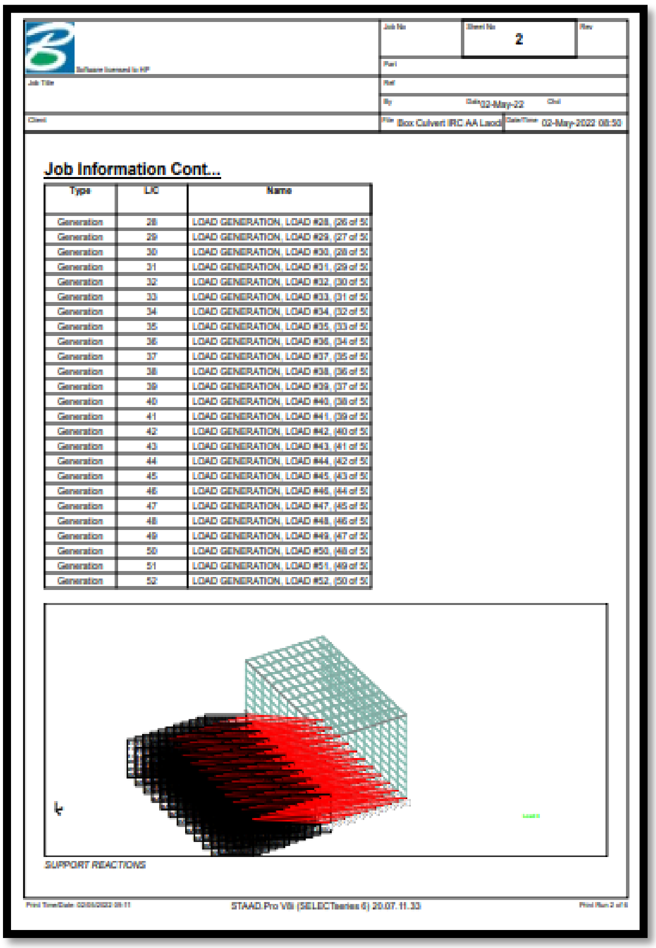

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Sheet No 2

Date 02-May-22

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Job Information Cont...

Type	L/C	Name
Generation	28	LOAD GENERATION, LOAD #28, (26 of 5
Generation	29	LOAD GENERATION, LOAD #29, (27 of 5
Generation	30	LOAD GENERATION, LOAD #30, (28 of 5
Generation	31	LOAD GENERATION, LOAD #31, (29 of 5
Generation	32	LOAD GENERATION, LOAD #32, (30 of 5
Generation	33	LOAD GENERATION, LOAD #33, (31 of 5
Generation	34	LOAD GENERATION, LOAD #34, (32 of 5
Generation	35	LOAD GENERATION, LOAD #35, (33 of 5
Generation	36	LOAD GENERATION, LOAD #36, (34 of 5
Generation	37	LOAD GENERATION, LOAD #37, (35 of 5
Generation	38	LOAD GENERATION, LOAD #38, (36 of 5
Generation	39	LOAD GENERATION, LOAD #39, (37 of 5
Generation	40	LOAD GENERATION, LOAD #40, (38 of 5
Generation	41	LOAD GENERATION, LOAD #41, (39 of 5
Generation	42	LOAD GENERATION, LOAD #42, (40 of 5
Generation	43	LOAD GENERATION, LOAD #43, (41 of 5
Generation	44	LOAD GENERATION, LOAD #44, (42 of 5
Generation	45	LOAD GENERATION, LOAD #45, (43 of 5
Generation	46	LOAD GENERATION, LOAD #46, (44 of 5
Generation	47	LOAD GENERATION, LOAD #47, (45 of 5
Generation	48	LOAD GENERATION, LOAD #48, (46 of 5
Generation	49	LOAD GENERATION, LOAD #49, (47 of 5
Generation	50	LOAD GENERATION, LOAD #50, (48 of 5
Generation	51	LOAD GENERATION, LOAD #51, (49 of 5
Generation	52	LOAD GENERATION, LOAD #52, (50 of 5

SUPPORT REACTIONS

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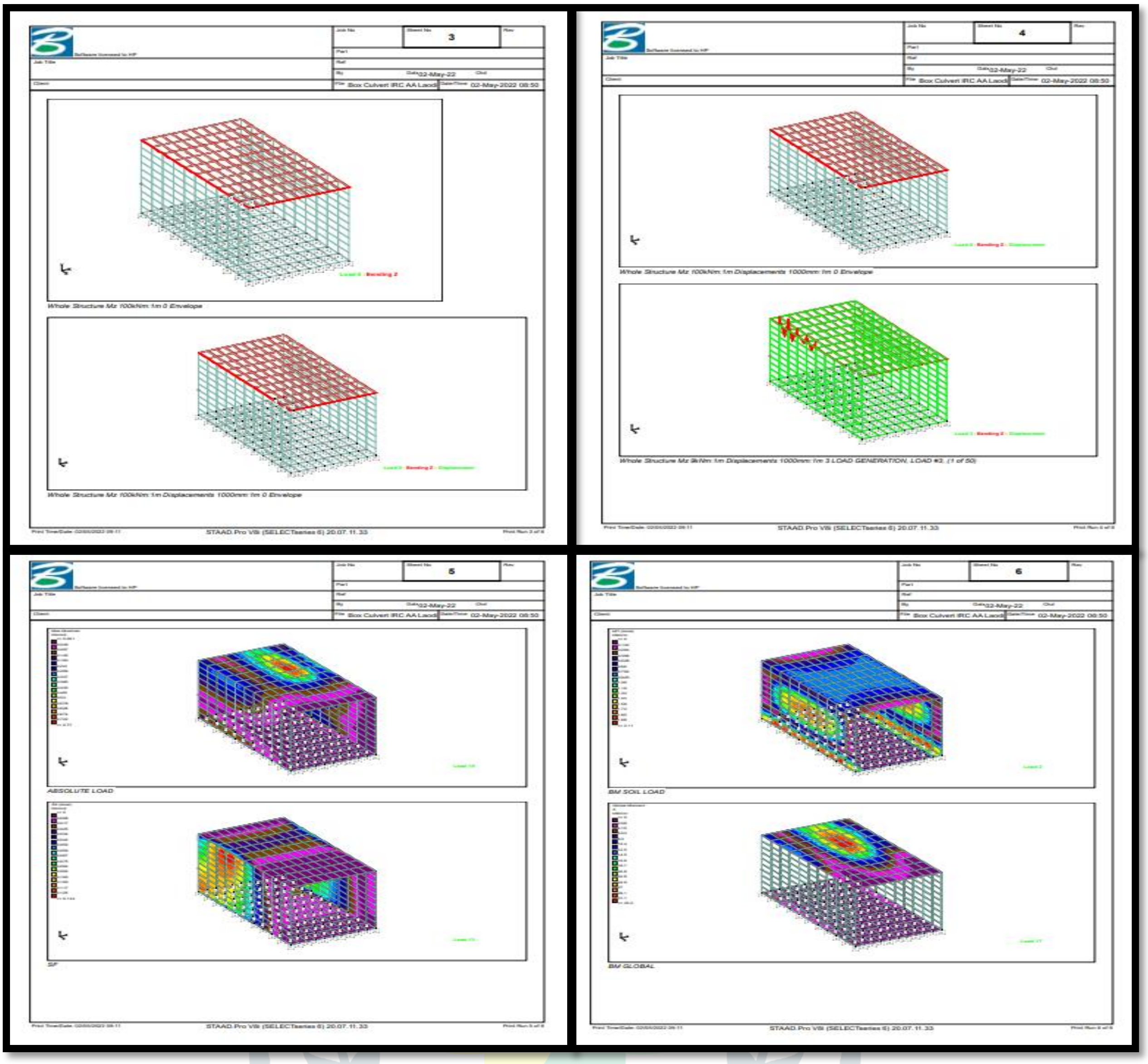

5.0 Results & Discussions: The analysis of the box culvert using Stadd pro software were performed and various parameters are being evaluated under the loading conditions. The obtained outcomes are discussed below:

1.0 Base Pressure Summary

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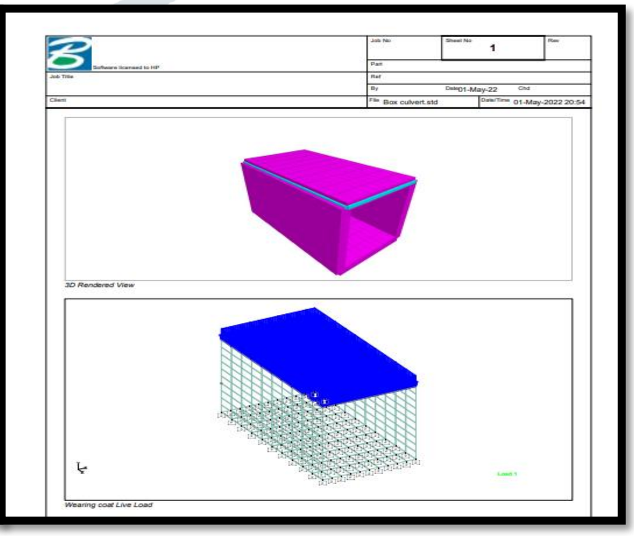
Job No	Sheet No 1	Rev
Job Title	Part	
	Ref	
	By Date 01-May-22	Chd
Client	File Structure1.std	Date/Time 01-May-2022 17:22

Base Pressure Summary

	Node	L/C	FX (N/mm²)	FY (N/mm²)	FZ (N/mm²)
Max FX	1	1:DEAD LOAD	**0.000**	0.057	0.000
Min FX	1	1:DEAD LOAD	**0.000**	0.057	0.000
Max FY	296	3:LOAD CASE	0.000	**0.341**	0.000
Min FY	125	3:LOAD CASE	0.000	**-0.192**	0.000
Max FZ	1	1:DEAD LOAD	0.000	0.057	**0.000**
Min FZ	1	1:DEAD LOAD	0.000	0.057	**0.000**

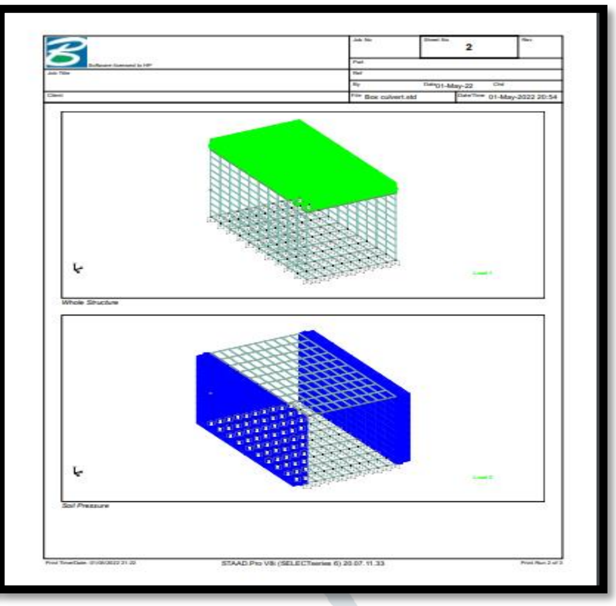


2.0 Beam End Force Summary

Beam End Force Summary

The signs of the forces at end B of each beam have been reversed. For example: this means that the Min Fx entry gives the largest tension value for an beam.

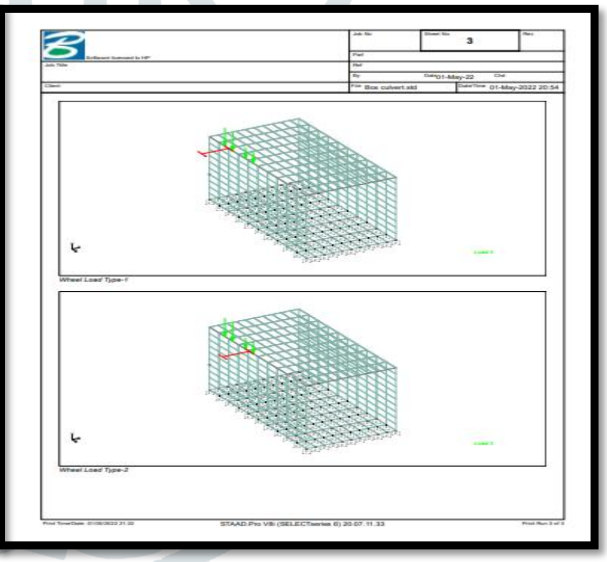
	Beam	Node	L/C	Axial Fx (kN)	Shear Fy (kN)	Shear Fz (kN)	Torsion Mx (kNm)	Bending My (kNm)	Bending Mz (kNm)
Max Fx	3	1	1:LOAD CASE	**37.187**	-47.191	0.000	0.000	0.000	-27.151
Min Fx	2	3	1:LOAD CASE	**-0.044**	37.187	0.000	0.000	0.000	14.622
Max Fy	2	3	1:LOAD CASE	-0.044	**37.187**	0.000	0.000	0.000	14.622
Min Fy	4	2	1:LOAD CASE	8.209	**-47.279**	0.000	0.000	0.000	-23.417
Max Fz	1	1	1:LOAD CASE	0.000	-10.948	**0.000**	0.000	0.000	-2.555
Min Fz	1	1	1:LOAD CASE	0.000	-10.948	**0.000**	0.000	0.000	-2.555
Max Mx	1	1	1:LOAD CASE	0.000	-10.948	0.000	**0.000**	0.000	-2.555
Min Mx	1	1	1:LOAD CASE	0.000	-10.948	0.000	**0.000**	0.000	-2.555
Max My	1	1	1:LOAD CASE	0.000	-10.948	0.000	0.000	**0.000**	-2.555
Min My	1	1	1:LOAD CASE	0.000	-10.948	0.000	0.000	**0.000**	-2.555
Max Mz	2	3	1:LOAD CASE	-0.044	37.187	0.000	0.000	0.000	**14.622**
Min Mz	3	1	1:LOAD CASE	37.187	-47.191	0.000	0.000	0.000	**-27.151**



3.0 Node Displacement Summary:

Node Displacement Summary

	Node	L/C	X (mm)	Y (mm)	Z (mm)	Resultant (mm)	rX (rad)	rY (rad)	rZ (rad)
Max X	12	3:LOAD CASE	**113.904**	18.014	113.398	161.734	-0.002	0.036	-0.001
Min X	10	1:DEAD LOAD	**-0.165**	-0.715	-0.085	0.738	-0.000	0.000	-0.000
Max Y	12	3:LOAD CASE	113.904	**18.014**	113.398	161.734	-0.002	0.036	-0.001
Min Y	11	3:LOAD CASE	113.426	**-20.162**	-113.155	161.481	0.003	0.036	-0.002
Max Z	12	3:LOAD CASE	113.904	18.014	**113.398**	161.734	-0.002	0.036	-0.001
Min Z	9	3:LOAD CASE	113.884	18.000	**-113.360**	161.691	0.002	-0.036	-0.001
Max rX	508	3:LOAD CASE	85.199	-16.311	-83.011	120.066	**0.003**	0.036	-0.002
Min rX	539	3:LOAD CASE	85.275	-16.302	83.079	120.165	**-0.003**	-0.036	-0.001
Max rY	12	3:LOAD CASE	113.904	18.014	113.398	161.734	-0.002	**0.036**	-0.001
Min rY	9	3:LOAD CASE	113.884	18.000	-113.360	161.691	0.002	**-0.036**	-0.001
Max rZ	138	3:LOAD CASE	8.821	-0.747	-0.017	8.853	-0.000	-0.000	**0.001**
Min rZ	495	3:LOAD CASE	3.223	-3.027	-2.984	5.334	-0.001	0.013	**-0.006**
Max Rst	12	3:LOAD CASE	113.904	18.014	113.398	**161.734**	-0.002	0.036	-0.001



4.0 Reaction & Plate Centre Principal Stress Summary:

Reaction Summary

	Node	L/C	Horizontal FX (kN)	Vertical FY (kN)	Horizontal FZ (kN)	Moment MX (kNm)	Moment MY (kNm)	Moment MZ (kNm)
Max FX	74	20:LOAD GENI	**0.000**	9.140	-0.724	0.087	0.000	0.000
Min FX	85	20:LOAD GENI	**-0.000**	7.440	-0.880	0.088	0.000	0.000
Max FY	252	19:LOAD GENI	0.000	**68.471**	8.181	0.695	0.000	0.000
Min FY	252	2:SOIL LOAD	0.000	**-28.276**	0.784	-0.008	0.000	0.000
Max FZ	252	19:LOAD GENI	0.000	68.471	**8.181**	0.695	0.000	0.000
Min FZ	85	8:LOAD GENE	0.000	19.429	**-5.925**	0.665	0.000	0.000
Max MX	8	1:DEAD LOAD	0.000	36.425	-5.188	**4.042**	0.000	0.000
Min MX	1	8:LOAD GENE	0.000	42.488	7.491	**-4.747**	0.000	0.000
Max MY	1	1:DEAD LOAD	0.000	36.425	5.188	-4.042	**0.000**	0.000
Min MY	1	1:DEAD LOAD	0.000	36.425	5.188	-4.042	**0.000**	0.000
Max MZ	1	1:DEAD LOAD	0.000	36.425	5.188	-4.042	0.000	**0.000**
Min MZ	1	1:DEAD LOAD	0.000	36.425	5.188	-4.042	0.000	**0.000**

Plate Center Principal Stress Summary

	Plate	L/C	Principal Top (N/mm^2)	Principal Bottom (N/mm^2)	Von Mis Top (N/mm^2)	Von Mis Bottom (N/mm^2)	Tresca Top (N/mm^2)	Tresca Bottom (N/mm^2)
Max (t)	189	11:LOAD GENI	**1.146**	-0.484	0.996	1.040	1.146	1.194
Max (b)	312	15:LOAD GENI	-0.189	**0.636**	0.883	0.585	0.962	0.636
Max VM (t)	189	11:LOAD GENI	1.146	-0.484	**0.996**	1.040	1.146	1.194
Max VM (b)	190	13:LOAD GENI	1.144	-0.490	0.994	**1.041**	1.144	1.195
Tresca (t)	189	11:LOAD GENI	1.146	-0.484	0.996	1.040	**1.146**	1.194
Tresca (b)	190	13:LOAD GENI	1.144	-0.490	0.994	1.041	1.144	**1.195**

5.0 Moving Load & Beam minimum force summary:

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Job No | Sheet No 1 | Rev
Job Title | Part | Ref
By | Date 02-May-22 | Chd
Client | File Box Culvert IRC AA Laodi | Date/Time 02-May-2022 08:50

Moving Load Definition : Type 1

Width (m)
0.600

Force (kN)	Distance (m)
37.500	-
62.500	1.200

Moving Load Definition : Type 2

Width (m)
0.600

Force (kN)	Distance (m)
62.500	-
37.500	1.200

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Job No | Sheet No 1 | Rev
Job Title | Part | Ref
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Client | File Box Culvert IRC AA Laodi | Date/Time 02-May-2022 08:50

Beam Maximum Forces by Section Property

		Axial	Shear		Torsion	Bending	
Section		Max Fx (kN)	Max Fy (kN)	Max Fz (kN)	Max Mx (kNm)	Max My (kNm)	Max Mz (kNm)
Rect 0.15x0.15	Max +ve	1.118	40.430	0.316	0.054	0.082	6.742
	Max -ve	-0.841	-51.352	-0.343	-0.048	-0.065	-5.190

6.0 Beam Displacement detail & Plate centre Stress Summary:

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Job Title | Part | Ref
By | Date 02-May-22 | Chd
Client | File Box Culvert IRC AA Laodi | Date/Time 02-May-2022 08:50

Beam Displacement Detail Summary

Displacements shown in italic indicate the presence of an offset

	Beam	L/C	d (m)	X (mm)	Y (mm)	Z (mm)	Resultant (mm)
Max X	637	10:LOAD GENI	0.675	**0.045**	-0.027	-0.007	0.053
Min X	526	17:LOAD GENI	0.000	**-0.044**	-0.007	-0.001	0.045
Max Y	530	2:SOIL LOAD	0.400	0.005	**0.070**	-0.001	0.070
Min Y	698	11:LOAD GENI	0.375	0.037	**-0.442**	-0.006	0.444
Max Z	645	1:DEAD LOAD	0.375	0.002	-0.021	**0.002**	0.021
Min Z	650	19:LOAD GENI	0.675	-0.025	-0.033	**-0.012**	0.043
Max Rst	698	11:LOAD GENI	0.375	0.037	-0.442	-0.006	**0.444**

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Plate Center Stress Summary

			Shear		Membrane			Bending		
	Plate	L/C	Qx (N/mm^2)	Qy (N/mm^2)	Sx (N/mm^2)	Sy (N/mm^2)	Sxy (N/mm^2)	Mx (kNm/m)	My (kNm/m)	Mxy (kNm/m)
Max Qx	196	10:LOAD GENI	**0.187**	0.043	-0.025	-0.035	-0.001	-9.687	1.554	2.191
Min Qx	195	17:LOAD GENI	**-0.200**	-0.024	-0.025	-0.034	0.004	-8.599	2.142	0.252
Max Qy	178	11:LOAD GENI	0.063	**0.055**	-0.017	0.002	0.003	37.451	13.145	0.072
Min Qy	222	14:LOAD GENI	0.003	**-0.053**	-0.013	-0.002	0.000	22.374	1.275	1.315
Max Sx	409	14:LOAD GENI	-0.052	0.000	**0.021**	0.001	-0.001	5.360	0.911	-0.009
Min Sx	312	19:LOAD GENI	0.014	-0.003	**-0.255**	-0.057	-0.030	-12.791	-2.347	0.747
Max Sy	229	8:LOAD GENE	0.012	0.023	0.002	**0.017**	0.004	-1.516	-1.964	2.575
Min Sy	312	19:LOAD GENI	0.014	-0.003	-0.255	**-0.057**	-0.030	-12.791	-2.347	0.747
Max Sxy	301	19:LOAD GENI	0.006	0.001	-0.230	-0.046	**0.049**	-9.666	-1.307	0.584
Min Sxy	50	3:LOAD GENE	0.003	0.001	-0.166	-0.033	**-0.042**	0.940	0.414	0.248
Max Mx	190	13:LOAD GENI	0.029	-0.020	-0.026	0.003	0.001	**39.356**	16.743	1.681
Min Mx	312	14:LOAD GENI	0.032	-0.005	-0.142	-0.028	0.004	**-26.990**	-5.235	-0.402
Max My	200	14:LOAD GENI	-0.026	0.029	-0.026	0.001	0.001	38.116	**16.818**	1.998
Min My	74	12:LOAD GENI	-0.031	-0.008	-0.154	-0.034	-0.002	-26.343	**-5.300**	1.251
Max Mxy	219	12:LOAD GENI	0.061	-0.022	-0.011	-0.005	-0.003	3.981	-0.966	**9.810**
Min Mxy	226	15:LOAD GENI	-0.055	-0.016	-0.010	-0.002	0.002	2.553	-0.871	**-9.123**

5.0 Conclusions:

The total deformations of box full condition are more than box empty conditions (i.e., when no stream passes through the box). The normal stress, maximum principal stress and equivalent stress for box full condition are also more as compared to box empty condition.

1. Box does not need any massive foundation underneath and can easily be placed over soft foundation by increasing base slab projection to retain base pressure within safe bearing capacity of ground soil.
2. Box of required size can be placed within the embankment at any variation in height by varying cushion on which it will be placed, this is not possible in case of slab culvert. They need enough slab projection at bottom to maintain gravitation stability.
3. Easy to construct, practically no maintenance, can have multicell to match discharge within smaller height of embankment.
4. Small variation in co-efficient of earth pressure has little influence on the design of box particularly without cushion.

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