ANALYSIS AND DESIGNING OF BOX CULVERT FOR HEAVY LOAD CONDITIONS USING STAAD PRO

PROJECT REPORT

Submitted in partial fulfillment of the requirements for the award of the degree
Of
BACHELOR OF TECHNOLOGY
IN
CIVIL ENGINEERING

Under the supervision
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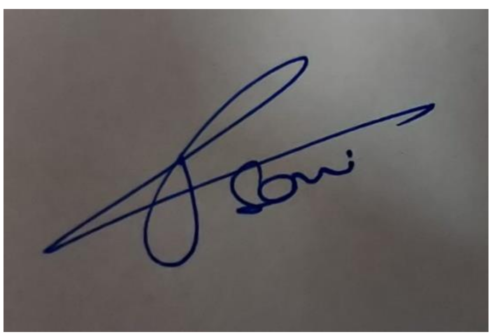
May -2021

STUDENT'S DECLARATION

I hereby declare that the work presented in the Project report entitled **"Analysis and designing of box culvert for heavy load conditions using STAAD pro"** submitted for the partial fulfillment of requirements for the degree of Bachelor of Technology in Civil Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of our work carried out under the supervision of **Dr Saurav.** This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.

Signature of Students



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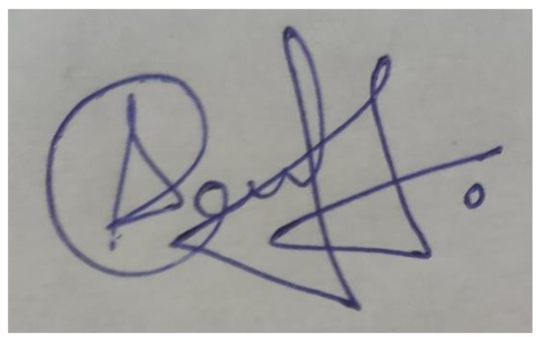

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"Analysis and designing of box culvert for heavy load conditions using STAAD pro"** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Pawas Soni(171608) and Sameep Aggarwal (171629)** during a period from August, 2020 to May, 2021 under the supervision of **Dr Saurav.**

The above statement made is correct to the best of our knowledge.

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ABSTRACT

Box culverts are the structures under the bridges, railway crossings and flyovers so as to properly channelize the discharge flow of water, such that above structures should not be affected by the flow. The deep study of DFC is very important in the developing era of our country. This study demonstrates the design of box culvert using STAAD pro using IRS- CBS codes. The following structural elements such as top slab, bottom slab, side wall were designed to withstand Ultimate Load criteria that is maximum bending moment and shear force due to various loads like Dead Load, Live Load, SIDL, LL surcharge, DL surcharge and serviceability criteria that is calculated by Crack width.

Key words: Box culvert, STAAD pro, DFC

LIST OF FIGURES

LIST OF TABLES

TABLE OF CONTENT

CHAPTER 3: Methodology

CHAPTER 4: RESULTS AND DISCUSSION

CHAPTER 1

INTRODUCTION

1.1 General

In this report we have covered the basic information on Box Culvert. The low rising bridges or structures used to drain water from the appropriate station at the crossing of the railway, flyer, roads etc. and is used when the force carries low ground is known as Box culvert. It is a reinforced concrete frame / shape that can be square or rectangular, with open spaces on both sides of the clove.

They are also efficient for the construction for railway bridges because they reduce weight, while increasing flexibility and strength of the structure. It is generally used for span of 4m and height less than 3m. In box culvert generally dead load, live load and moving load is to be taken. Load act on the slab of culvert, sidewalls resists the earth pressure coming from earth soil.

A detailed literature review as well as a summary of the same has been included in this report.

The main objective of our project is to provide a clear vision about the analysis and design of box-type road bridges and railway bridges. We are designing box culvert using STAAD Pro for heavy load conditions

1.2 Culverts

Culvert is a small cross-sectional structure constructed or placed to allow discharge of water to flow under road, railway tracks, flyovers etc from one side to the other. Culverts are surrounded by the earth (soil). These are generally used both as for drainage of ditches crossing drains are constructed from the sewerage that is at the roadside and natural drainages to allow the passing of water under a road and stream crossing as in Fig 1.2 and 1.3. Culverts are also bridge-like structures that are designed to allow vehicles or pedestrian ways to cross over the waterway along with allowing the passage of water. The material used for the construction of culverts is pipe, reinforced concrete or other material. It could be cast-in-situ or precast concrete, galvanized steel, aluminum or high density plastic. Composite structures are constructed by the combination of two or more materials.

Culverts can be of different shapes and sizes according to many factors like soil conditions, the requirements of the pressure work, the limitations of rising water levels, and the height of the road, working conditions, purpose of construction, finance etc. Culverts could be round, flat-bottomed, elliptical, open-bottom, centered and shaped square or rectangular box like as shown in Fig1.1.

Fig 1.1: Concrete Box Culvert [1]

Fig 1.2: Steel Culvert with a plunge pool below[2]

Fig 1.3: Culvert under a natural surface[3]

1.3 Box Culverts

Box Culverts consisting of horizontal and two vertical slabs constructed in the same way allowing an opening for waterways. This type of culverts is suitable for crossing a railway and a bridge having road or track on it with major barriers crossing the river boundary flow. Suitable for a small exit route across the bottom ditch or medium traffic density and for the soils having low bearing capacity. The overall dimensions of box culvert are kept within 4m*4m.

Box culvert could be "Single celled box culvert" or "Multi-celled box culvert". If for the purpose of work only one box is constructed then it is known as Single celled box culvert and for more than one box it is known as Multi celled box culvert. Box culvert could be rectangular or square depending upon different conditions.

1.3.1 Types of box culvert

1. Box culverts:

Box culverts are the naturally buried structures where pipes cannot be an appropriate solution. These structures are having large openings as shown in Fig 1.4, so it is also helpful in providing sufficient capacity to press them. Box culverts are widely used various activities like it is used by pedestrians, cattle underpass, vehicular movements etc. Either, welded wire fabric or conventional bar reinforcements can be used in RCC box culverts.

Note: Welded wire fabric has yield strength slightly larger than conventional bar reinforcement.

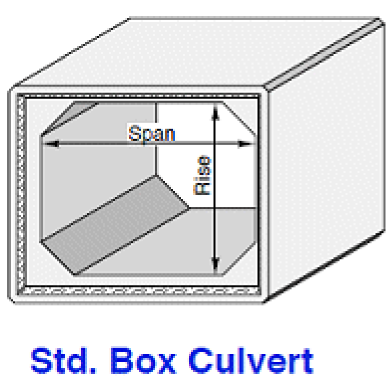


Fig 1.4: A typical box culvert[4]

2. Precast concrete box culverts:

In Sp-20, there are standard designs for the construction of precast concrete boxes are available in spaces from 2 to 5 m and rise from 1.5 to 4m as shown in Fig 1.5. Typical concrete box culverts are built in sections of 2 m; but large boxes are made with 1.5 m sections to reduce the weight of the section. Designs using concrete strengths should be filled with heights ranging from less than 0.6 m to 7.5 m. Box culverts outside the standard size range should be customized.

Fig 1.5: Pre-cast box culvert[5]

3. *Cast-In-Place Concrete Box Culverts:*

These are the culverts that are constructed from starting to end on site as shown in Fig 1.6. The works like scaffolding, bar binding and concreting all are done at site. This type gives good strength over the time used less because of more time consumption in this as compared to precast concrete box culverts.

Fig 1.6: Cast in place concrete [6]

4. *Buried structures:*

They are typically used for conveying water. There is a variety of structure and- types of materials are used. They are used to provide separate pedestrian crossings other times. Buried structures with horizontal dimensions less than 3 m are not classified as bridges. These smaller buried structures are typically selected from standard designed tables. Buried structures that are with horizontal dimensions greater than or equal to 3 m are considered bridges as shown in Fig 1.7. Pipes and box culverts, precast concrete arches, precast three-sided structures, and long-span corrugated steel structures in addition are used as buried structures.

Fig 1.7: Railway bridge

1.3.2 Loads on Box Culvert

There are various types of loads acting on Box Culvert during its service period. These loads may or may not remain constant with time. For the calculations of the load on culverts, there are several factors such as design parameters involving angle of dispersion of live load, coefficient of earth pressure, depth of cushion etc for critical loads. Any structure subjected to multiple types of loads must be analyzed as per the critical combination of the loads.

Box culvert is subjected to various loads:

- Dead load of top and side slabs
- Live loads
- Impact loads
- Water pressure from inside
- Earth pressure from outside
- Earth up-thrust

1.3.3 Advantages of Box Culvert

A box culvert has many of the design and various advantages of installation.

- No separate foundation is needed to be laid on.
- For minimizing the pressure on soil the bottom slab serves as a raft foundation.
- Strength: Due to high strength it is useful to support pedestrian, livestock, automobiles, railway etc.
- Economical

1.4 Dedicated Freight Corridor (DFC)

Government of India along with Ministry of Railways, has planned to construct a Dedicated Freight Corridor (DFC) covering about 3325 Km on the two corridors, Eastern and Western freight Corridors. The Western Corridor is constructing from the Jawaharlal Nehru Port, Mumbai to Tughlakabad/ Dadri near Delhi. The Western corridor covers a length of 1,483 Km (JNPT – Ahmadabad – Palanpur – Rewari – Asaoti - Dadri).
The construction of DFC will be having double track electrified railway lines that will be able to withstand axle load of 32.5 ton. The bridges and other structures will be designed for 32.5 ton axle load and track will be designed for 25 ton--axle load. It will operate at a train speed 100km/hr.

1.5 Need of study

As we know it takes a lot of time while analyzing any structure. Box culvert is very advantageous as it do not require separate foundation and is economical. Due to development in highways and railways, ROB’s (Road over bridges) and RUB’s (Road under bridges) are getting prominent. Dedicated freight corridor is going to boost our railway sector, so there is a need of research and having thorough knowledge about box bridges for taking heavy loads.

CHAPTER 2

LITERATURE REVIEW

2.1 General

This chapter presents a summary of different studies by researchers on the design and analysis of box culvert. It includes various studies to design and analysis of the box culvert using STAAD pro and other manual or computerized methods. It also tells about the comparison of the results of manual calculations with computerized calculations. This also tells about the safety measures to be taken care during designing of box culvert.

2.2 Reviews on research papers

I. Siva Rama Krishna and Ch. Hanumantha Rao, Study on Box Culvert Soil Interaction. ***International Journal of Civil Engineering and Technology*****, 8(1), 2017, pp. 734-738**.

This paper concentrates mainly on the behavior of box culvert with or without soil contact . They analyzed soil interaction using finite element method and for without soil interaction they used stiffness method. The box culvert was analyzed for maximum shear force and bending moment's values along with taking care of external conditions like weather conditions and accordingly the loads forcing on box culvert.

Conclusion: From the following study they concluded that the shear force and bending moment values on top slab, side walls and bottom slab of box culvert are increased in without soil interaction as compared to with soil interaction.

II. Zaman Abbas Kazmi, Ashhad Imam and Vikaas Srivastavaa, Analysis and Design of the Box Types Minor Railway Bridges, International Journals of Civil Engineering and Technologies, 8(7), 2017, pp. 295–306

This paper concentrates mainly on the structural analysis and design of the structural analysis and design of RCC box type minor bridge using manual approach (i.e. MDM method) and by computational approach (STAAD-pro) using IRS - CBC codes. They designed the box culvert members (top slab, side walls, bottom slab) to withstand the ultimate load criteria using both approaches. After that they compared the results of manual approach to the STAAD pro results. They first done manual analysis of RCC box has been done using Moment Distribution Method (MDM). After that they manually designed using working stress method (WSM). Then thecomputational analysis has been done using STAAD Pro. After that computational design for flexural behavior has been done using Ultimate limit State (ULS) and crack check has been done using Serviceability limit State.

Conclusion: From the following study they concluded that-

- The studies show that the greatest design strength is due to the loading condition when the top slab is under a dead load and the live load and the inner wall are subjected to ground pressure and surcharges, and when the culvert is empty.
- It was observed that Computational method (STAAD Pro) was much more better than Moment Distribution Method (MDM) in term of efficiency of result and time consumption for analysis.
- The size of the bridge plays a dominant role in the involvement of the various loads and there are cases of design purpose.

III. Saurav, Ishaan Pandey, Economic design of RCC box culvert through comparative study of conventional and finite element method, International Journal of Civil Engineering and Technology, 9(3),2017,pp. 1707-1713.

This paper concentrates mainly on the economic and effective design of box culvert using finite element analysis. By this study they wanted to give an approach which could be used for the designing of large structures. They tested for all the possible load conditions that could be faced during its serviceability period. They also analyzed the structure using STAAD pro for the computation. Then they compared the results of FEM using ANSYS with the STAAD pro results.

Conclusion: From the following study they concluded that-

- The study results clearly infer that the culvert if designed through finite element method rather than conventional, this method will not only save equipment and money but will also make the design safer.
- The application of FEM through ANSYS software can save large amount of money and effort in design and implementation of box culvert and other structures.

IV. K.Rajasekhar, P.Leela Krishna, Analysis and design of box culvert, International Journal of Civil Engineering and Technology, (10),2018,pp. 141-156.

This paper concentrates mainly on to modeling and analysis the box culvert using STAAD PRO software. The results obtained from STAAD pro are compared with the manual calculations obtained using MATLAB. The structural elements of box culvert are designed to bear maximum bending moment and shear force. Then they analyzed various components and members at different positions of a box culvert. They observed the values both manually and with STAAD pro. After that the result were compared.

Conclusion: From the following study they concluded that-

- The designing is take care by using three load cases. The values of design moments etc are marginally more close to the values given by manual calculations for the three load cases.
- The Box culverts with more research cells can significantly save larger spaces compared to a single single-cell box as on paper the maximum bending moment and shear strength values in the test are much lower, so smaller sections are required.

V. K. S. Patil, Pavan S. Dandge, Vaibhav V. Gund, Shubham S. Tilekar, Prathamesh R. Awhale, Jayesh G. Jadhav, RCC Box Culvert – Design and Analysis by STAAD Pro, Journal of Advances and Scholarly Researches in Allied Education, 15(2),2018,pp. 717-719.

This paper mainly deals with box culverts made of RCC, with and without cushion. The size, invert level, layout etc. are decided by hydraulic considerations and site conditions. The cushion depends on road profile at the culvert location. The scope of this work has been further restricted to the structural design of box. By taking the loads on box culvert they used FEM for analysis. After that they designed the culvert on STAAD pro and calculated for different values of bending moment and shear forces.

Conclusion: From the following study they concluded that-

- Results obtained from analysis of box culvert in STAAD Pro are almost same as results obtained from manual analysis.
- The 3D modeling of the Box culvert with the symmetry in STAAD Pro proves a good research option.
- The size of the members is initially thought to indicate that a thinner member can be used in a short span box culvert. So it will save money.

VI. Mr. Afzal Hanif Sharif, Analysis and design of railway box bridge and comparison between STAAD software and MDM results, IJSDR 1(8),2016,pp. 1-8.

This paper mainly concentrates on Box Bridges that are required for the movement of trains and locomotives efficiently and under earth embankment for the crossing of water course like streams across the embankment. The structural elements are designed to withstand maximum bending moment and shear force. This paper provides discussions on the provisions in the Codes, considerations and justification of all aspects of design.

Conclusion: From the following study they concluded that-

- The dimension of a bridge plays a very important role for involvement of various loads and there cases for designing purpose.
- It is found that for designing any railway bridge, relevant IRS codes to be very meticulously followed.

VII. Zaman Abbas Kazmi, Ashhad Imam, Vikas Srivastava, Analysis and design of box type minor railway bridge, International Journal of Civil Engineering and Technology (IJCIET) 8(7), 2017.pp. 395-306

This paper mainly concentrates on the analysis of design and construction of an RCC box type bridge using a manual method and by computational approach using IRS - CBC codes. What the results found was that manual calculations used were very tedious and difficult in a complex structure, so it was a difficult task to do the calculations manually. The main purpose of this paper was to study the operation of a small railway bridge when it is fitted to a different combination of loads depending on the bending moment and the shear strength variation.

Conclusion: From the following study they concluded that-

- Great design capability is designed for loading conditions where the culvert is empty, the top slab is under live load and dead load and the side wall is subjected to ground pressure and overhead costs.
- Dimension of a bridge plays a very important role for the involvement of various loads for designing purpose.

2.3 Objective of current paper

To design and analyze the box culvert using STAAD pro for railway (Heavy tracked vehicles) and road for various load conditions.

2.4 Scope of the work

In this growing era of development, we need everything perfect along with saving our time. We are making and using software for our works instead of doing it manually. Also the chances of mistake also decrease. Work precision increases.

CHAPTER 3

METHODOLOGY

3.1 General

The following chapter contracts with the designing and analysis of a box culvert using STAAD Pro. Box culvert is a hydraulic structure which allows water to flow under a road or a rail road. It is economical because of its rigidity and the monolithic action. A separate foundation is not required since bottom slab rest directly on the soil. This methodology displays the sequential method and steps involved in the designing of the box culvert using various types of loads and surcharge according to the Indian Standard codes. After the designing of the structure, the design is checked and analyzed through the software itself through run analysis command and a brief report is made which carries all the necessary reactions and movements along with displacements.

3.2 Components of Culvert

Table 3.1: Shows the components of culvert

TOP SLAB
BOTTOM SLAB (RAFT SLAB)
SIDE SLABS

3.3 Geometry of Culvert

Table 3.2: Shows the geometry of designed culvert for **ROAD**. [7]

Span	4 m
Clear height	4 m
Top slab thickness	0.45 m
Bottom slab thickness	0.45 m
Side slab thickness	0.45 m

Unit weight of concrete	25 kN/m^3
Unit weight of earth	18 kN/m^3
Modulus of sub grade soil	250000 kN/m^2/m
Co-efficient of earth pressure at rest	0.5
Total cushion on top	0.0 m
Thickness of wearing coat	0.065 m
Carriageway	2 lane

Table 3.3: Shows the geometry of designed culvert for **RAILWAYS.**

Span	5 m
Clear height	5 m
Top slab thickness	0.5 m
Bottom slab thickness	0.5 m
Side slab thickness	0.5 m
Unit weight of concrete	25 kN/m^3
Unit weight of earth	18 kN/m^3
Modulus of sub grade soil	250000 kN/m^2/m
Co-efficient of earth pressure at rest	0.5
Total cushion on top	0 m
Thickness of wearing coat	0.065 m
Carriageway	1

Table 3.4: Shows the geometry of designed culvert for **DFC (DEDICATED FRIEGHT CORRIDOR)**

Span	5.5 m
Clear height	5.5 m
Top slab thickness	1.60 m
Bottom slab thickness	1.60 m
Side slab thickness	1.40 m
Unit weight of concrete	25 kN/m^3
Depth of Ballast	0.3 m
Density of saturated soil	20 kN/m^3
Centre-line distance (Width)	11.9 m
Centre-line distance (Depth)	7.1 m
Weight of rails + ballast + sleepers	18.3 kN/m^2
Carriageway	2

3.4 Load calculation

3.4.1 Dead load

For box culvert of road

Dead load in our design will be a combination of two loads i.e. self weight plus weight of the wearing coat. Taking values from Table 3.2.

1) Self weight will be calculated by the software itself.
2) Weight of the wearing coat = thickness of wearing coat × 22 (as per I.R.C CODE)

= 0.065×22

= 1.43 kN/m^2

(Taking 2 kN/m^2 as per most specification)

For box culvert of DFC

Base Pressure

SIDL

Ballast + rail +sleepers = 18.3 kN/m^2

3.4.2 Surcharge load

- Taking pressure of earth with surcharge equivalent along with live load to 1.2m height on the filling sides of the structure.
- Pressure of earth at base of the culvert due to live load and surcharge
  = 1.2×18×0.5 = 10.8 kN/m^2

3.4.3. Live load

Live Load + Vertical reaction+ Curvature due to wind load = 67.96 kN/m^2

Load factors for Serviceability limit state

1 for Dead Load+ Live Load+ 1.2 for SIDL

1*110 + 1.2*18.312 + 1*67.97 = 223.9 kN/m^2

Minimum SBC taken as= 225 kN/m^2

3.5 The following chart displays the sequential steps or commands with a pictorial description that are used in STAAD Pro for the designing.

3.5.1 For box culvert of ROAD

Step 1- A point is taken as the reference point and a beam is drawn vertical through it and accordingly a box is made with the help of transitional repeat command and taking 5 m as the span as shown in Fig 3.1.

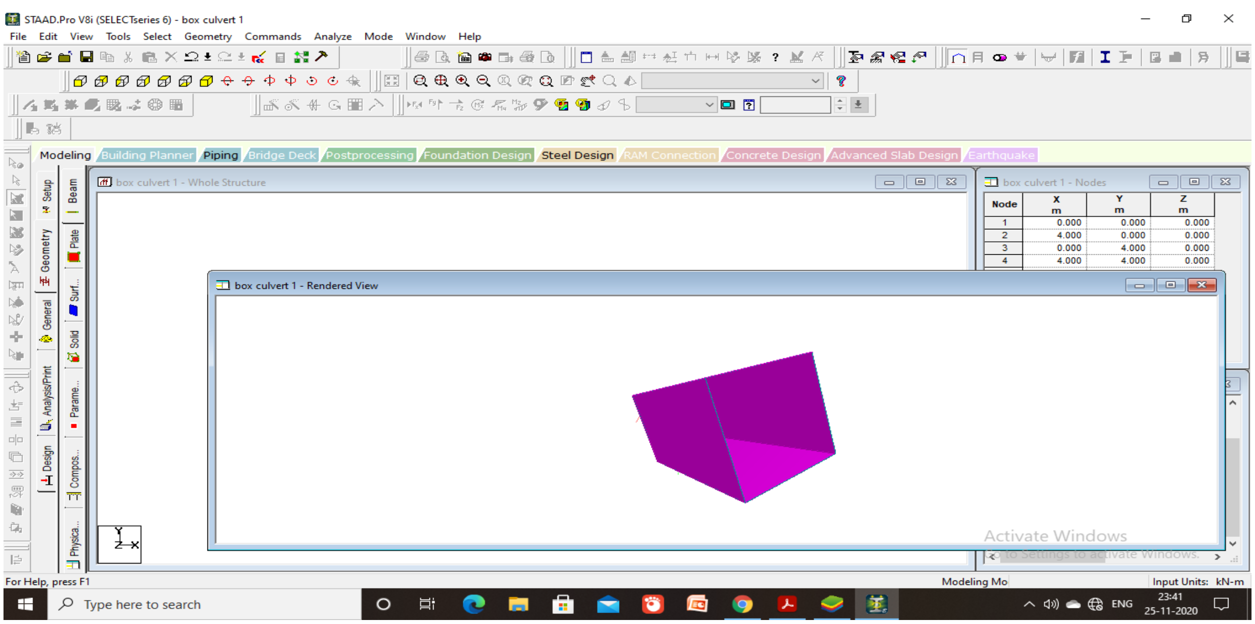


Fig 3.1: Output of step 1(Road)

(The above picture shows a 3-d rendering view of the box made, so if any flow is present in the structure can be fixed).

Step 2- The walls grid is filled with plates by using (fill floor grid with plates command) and a mesh is generated through (generate plate mesh command in the form of quadrilateral meshing) as shown in Fig 3.2

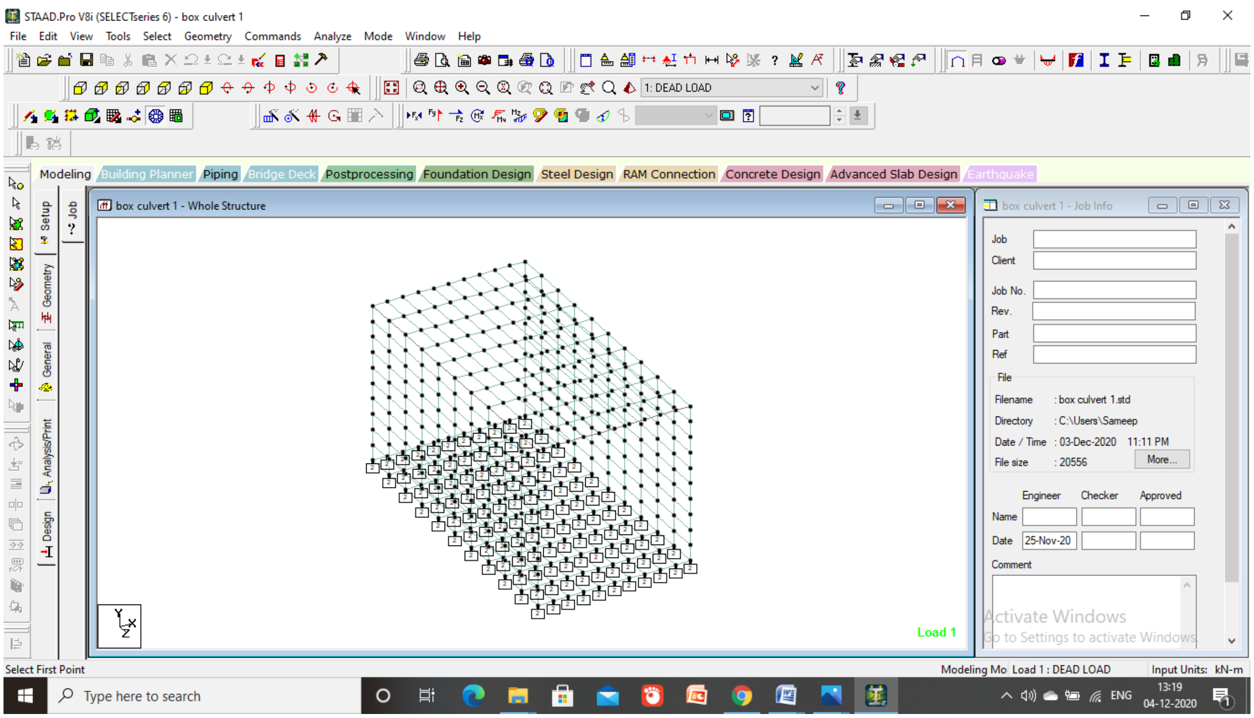


Fig 3.2: Output of step 2(Road)

Step 3- Design a plate mat support through generate support command and assign it at the bottom slab with taking modulus of sub grade soil as (250000 kN/m^2/m) under the command of compression only as shown in Fig 3.3

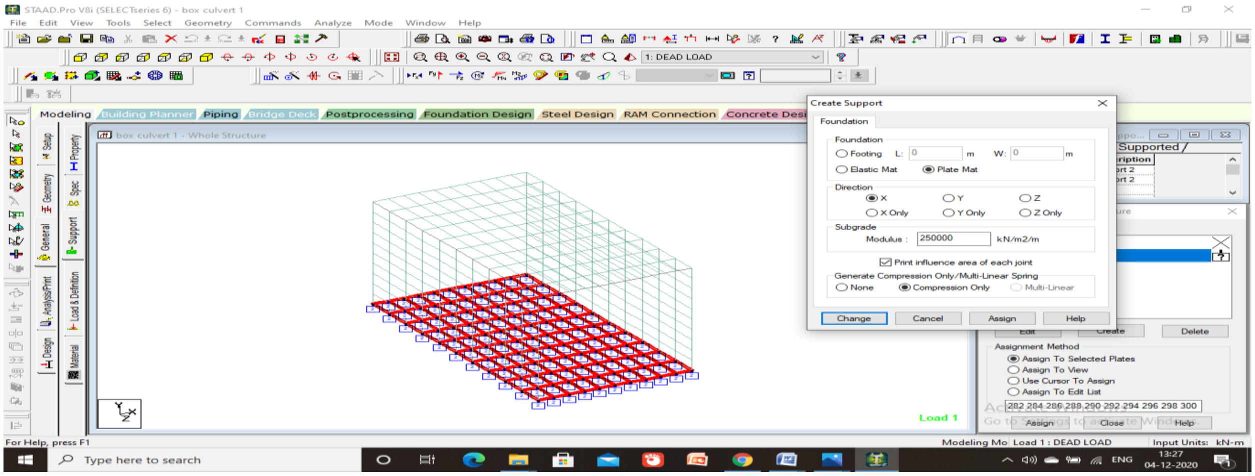


Fig 3.3: Output of step 3(Road)

Step 4- The property is assigned by taking thickness 0.45 m and the side beams is deleted because the culvert is only consist of shear walls , we assigned the beams before just for taking references as shown in Fig 3.4.

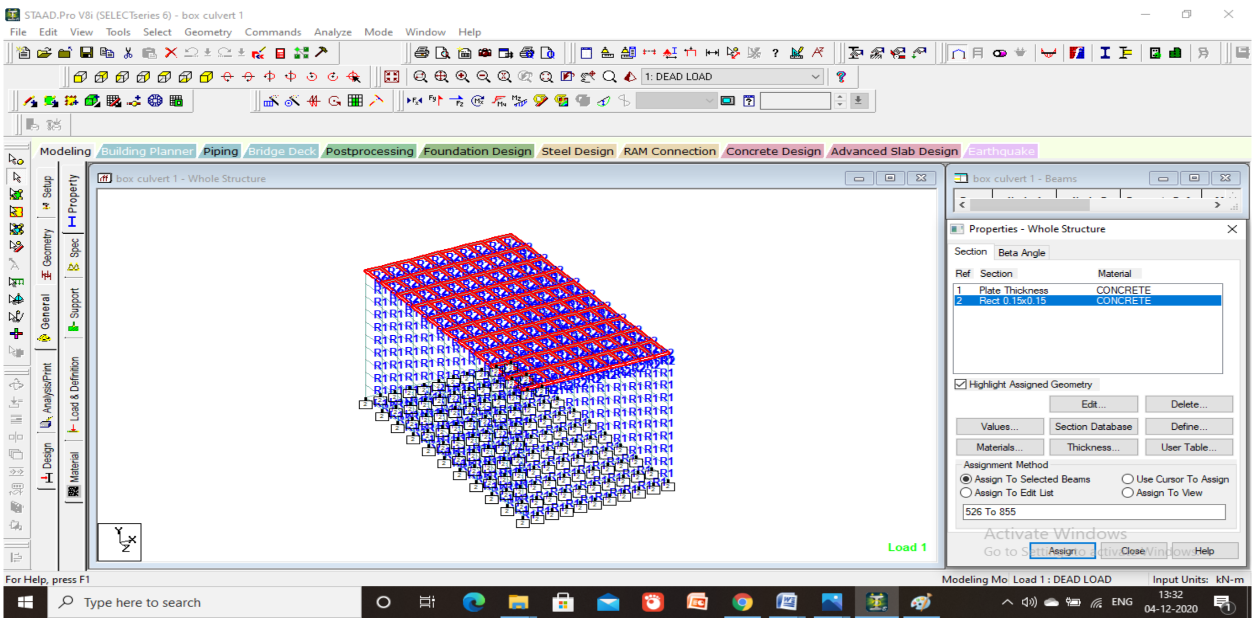


Fig 3.4: Output of step 4(Road)

Step 5- We have to add some hidden beams at the upper slab or at the top slab so that it can take the vehicle load , so here we will design the rectangular beams of 0.15 to 0.15 dimensions and will assign them at the top slab along (x) and (z) axis as shown in Fig 3.5.

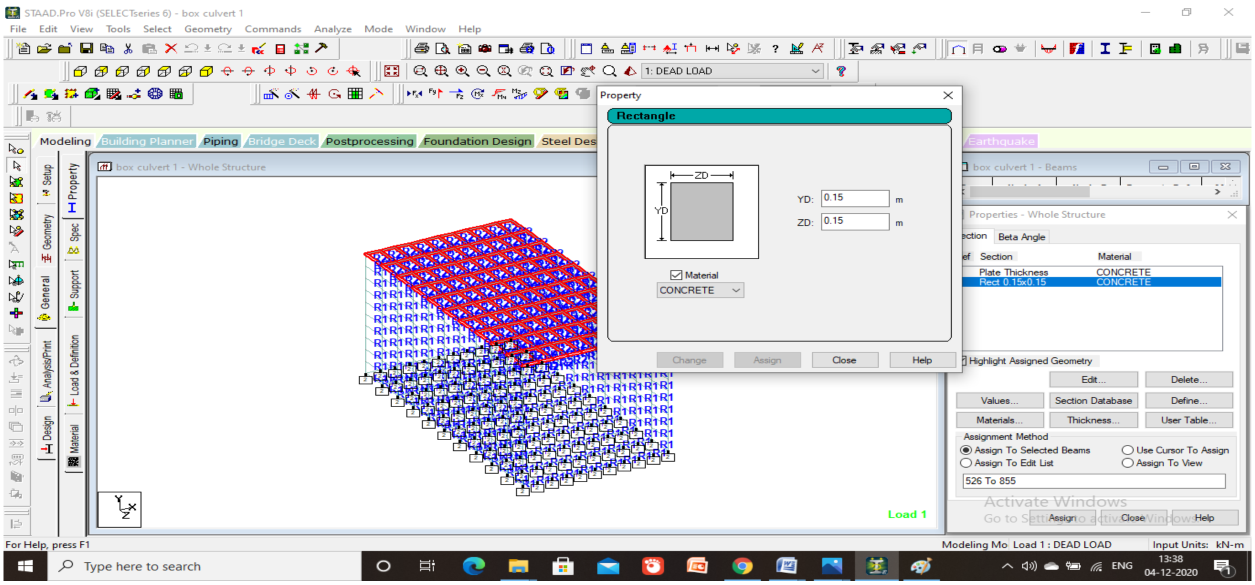


Fig 3.5: Output of step 5(Road)

Step 6- Assigning loads now- dead load it consist of self weight and the wearing coat at the upper slab for road construction. Here we will design loads by using load and definition command and taking at global y axis only as shown in Fig 3.6 and 3.7.

1st - self weight

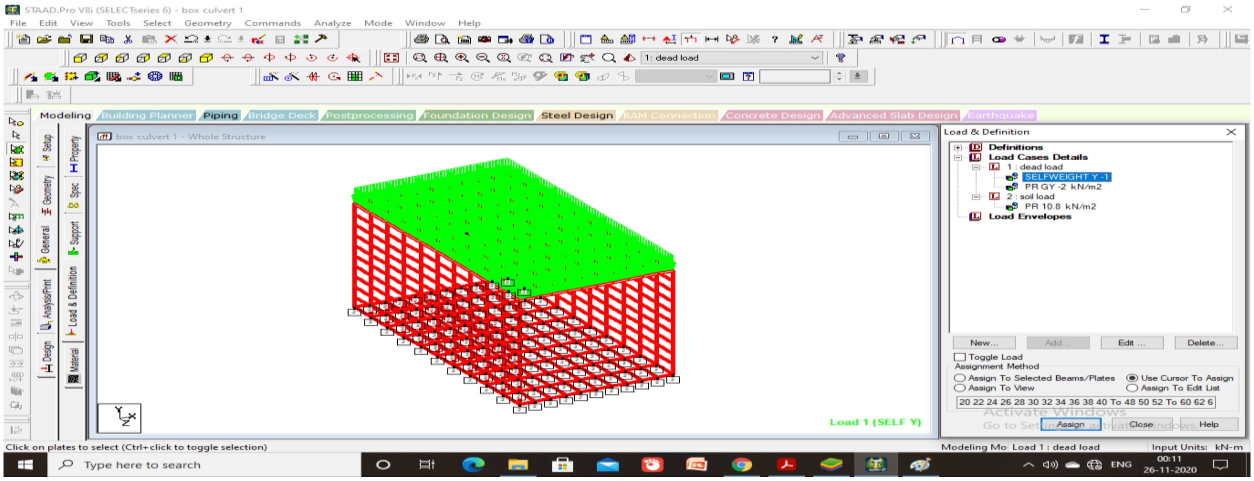


Fig 3.6: Output of step 6 self weight(Road)

2nd – Wearing Coat

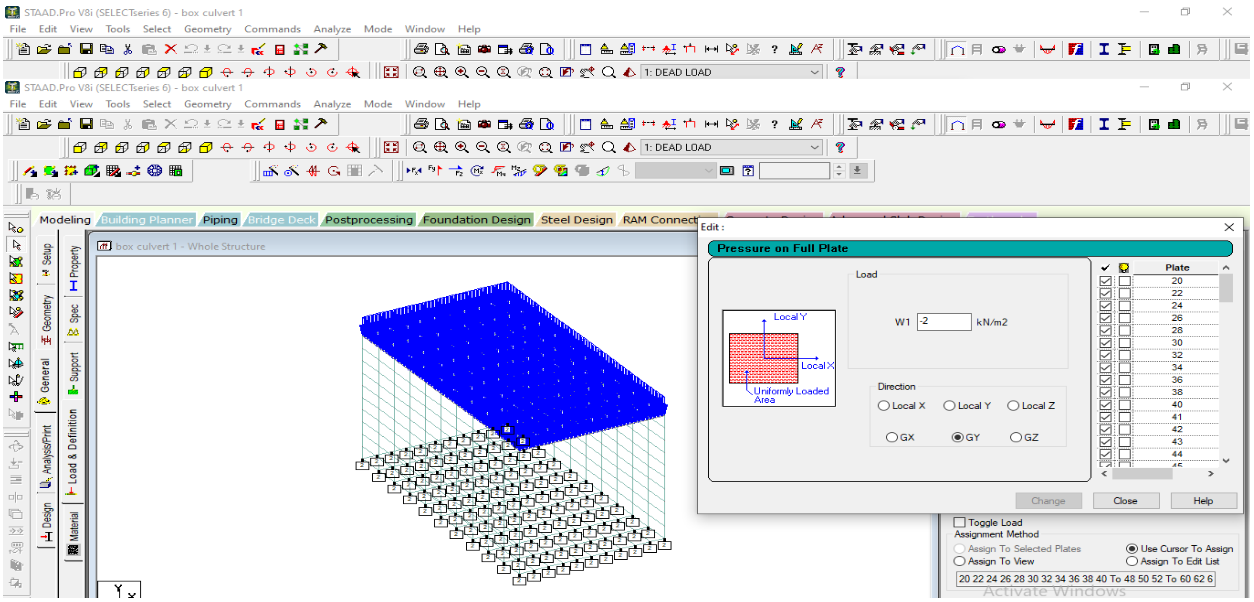


Fig 3.7: Output of step 6 wearing coat(Road)

Step 7 – Soil load or surcharge load is assigned according to IRC -6. By using load and definition command design a soil load of 10.8 kN/ m^2 towards local z axis as shown in Fig 3.8.

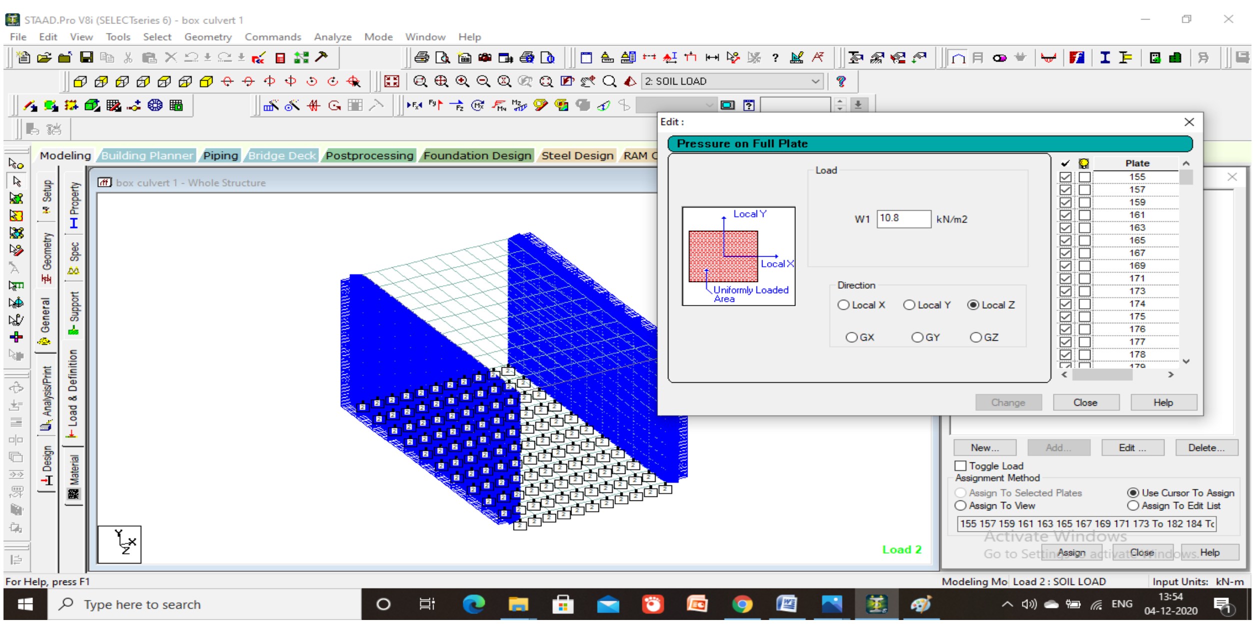


Fig 3.8: Output of step 7(Road)

Step 8- Assign vehicle loading at the top slab according to the IRC AA loading. Through vehicle load definition command design vehicle load for two times as the road taken are two lane roads.

as shown in Fig 3.9 and 3.10

For 1st vehicle

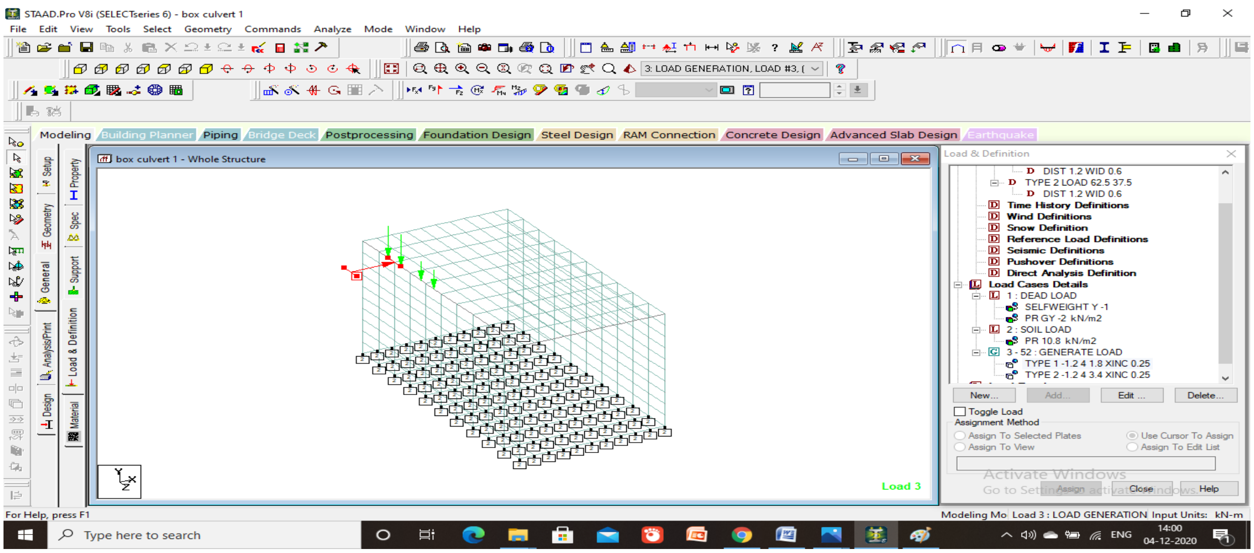


Fig 3.9: Output of step 8 1st vehicle(Road)

For 2nd vehicle

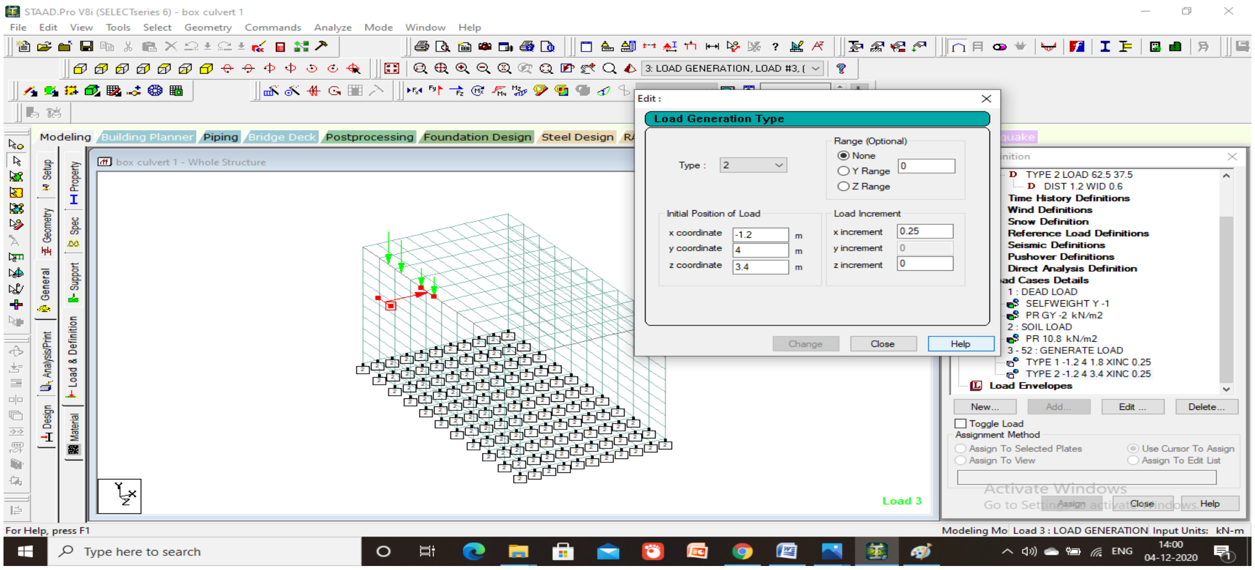


Fig 3.10: Output of step 8 2nd vehicle(Road)

Step 9-Analyse the structure through run analysis command to check whether the design is correct or contains any errors, so that they can be resolved through individual approach to each and every faulty member as shown in Fig 3.11.

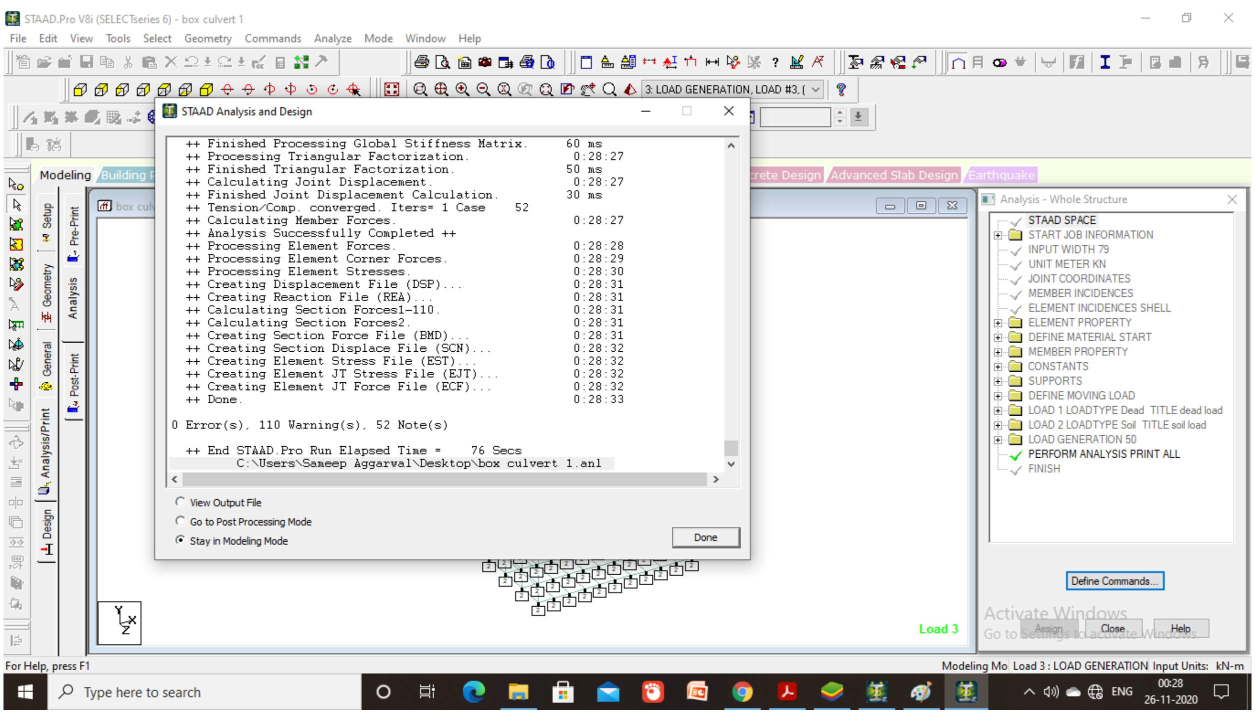


Fig 3.11: Output of step 9(Road)

3.5.2 For box culvert of RAILWAYS (Heavy tracked vehicles)

STEP 1- A cubical structure is designed by using transitional repeat command (taking x=0) as the reference node as shown in Fig 3.12.

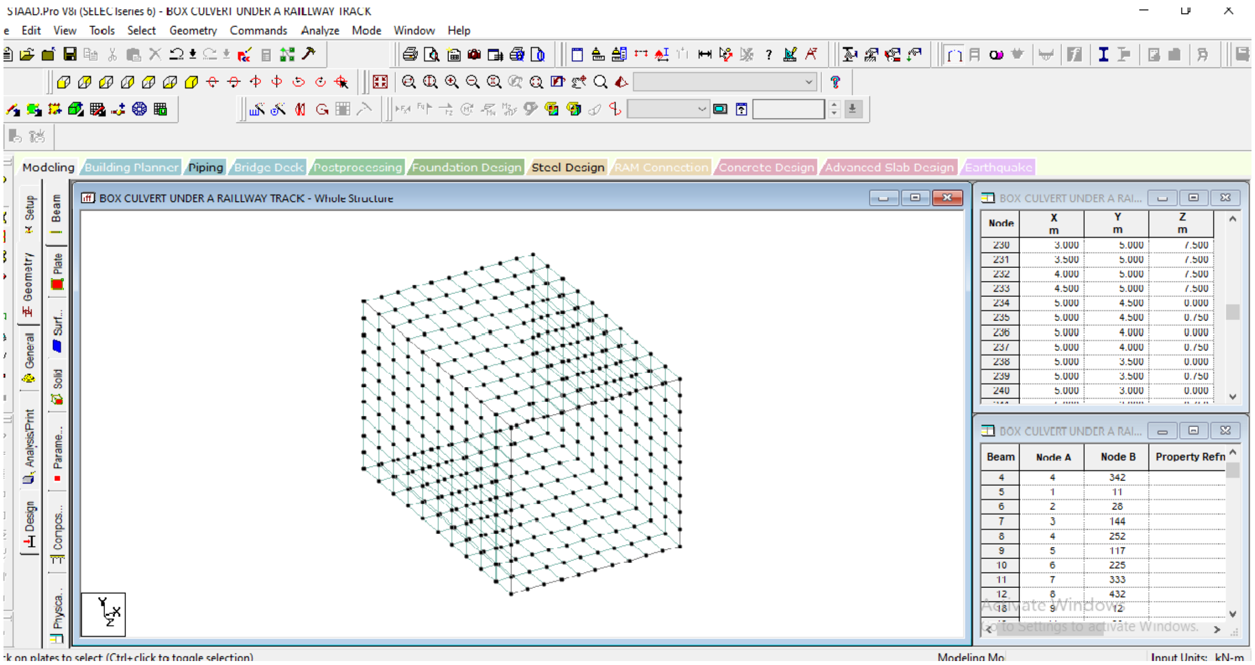


Fig 3.12: Output of step 1 (Railways)

STEP 2- Plates are installed at the sides of the structure and then a plate mesh is generated (quadrilateral plate mesh) as shown in Fig 3.13.

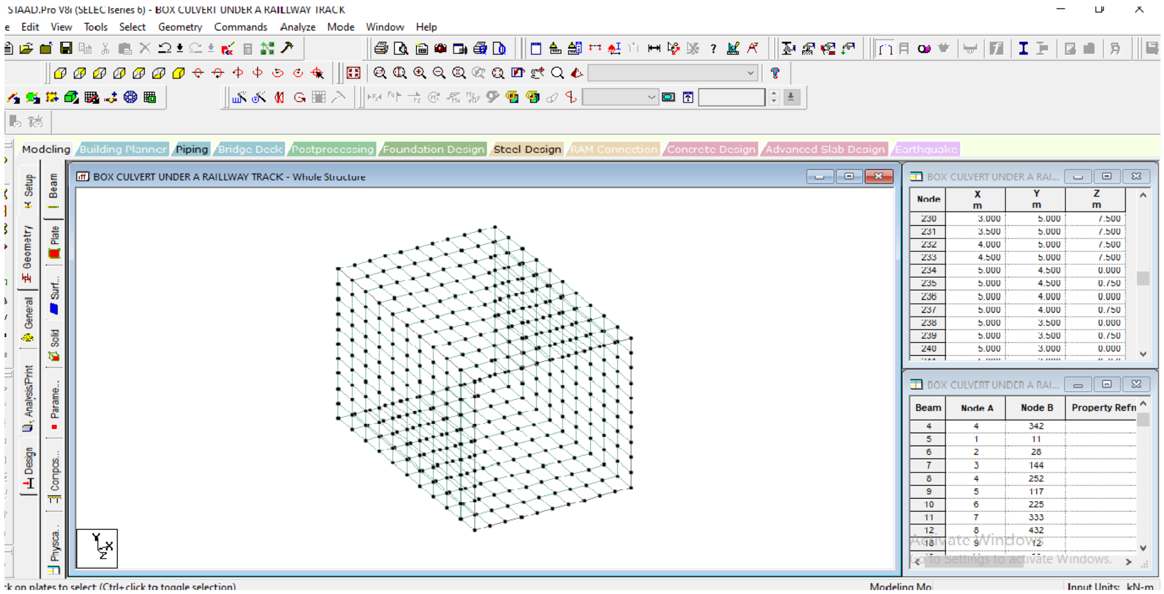


Fig 3.13: Output of step 2 (Railways)

STEP 3- The extra beams were deleted from the structure because the box culvert is only consist of shear walls, top and a bottom slab which is also settled on the ground itself and does not require any specific foundation as shown in Fig 3.14 (the support that we have provided in the structure through the software is just to compensate the up thrust force i.e. compression through sub grade.

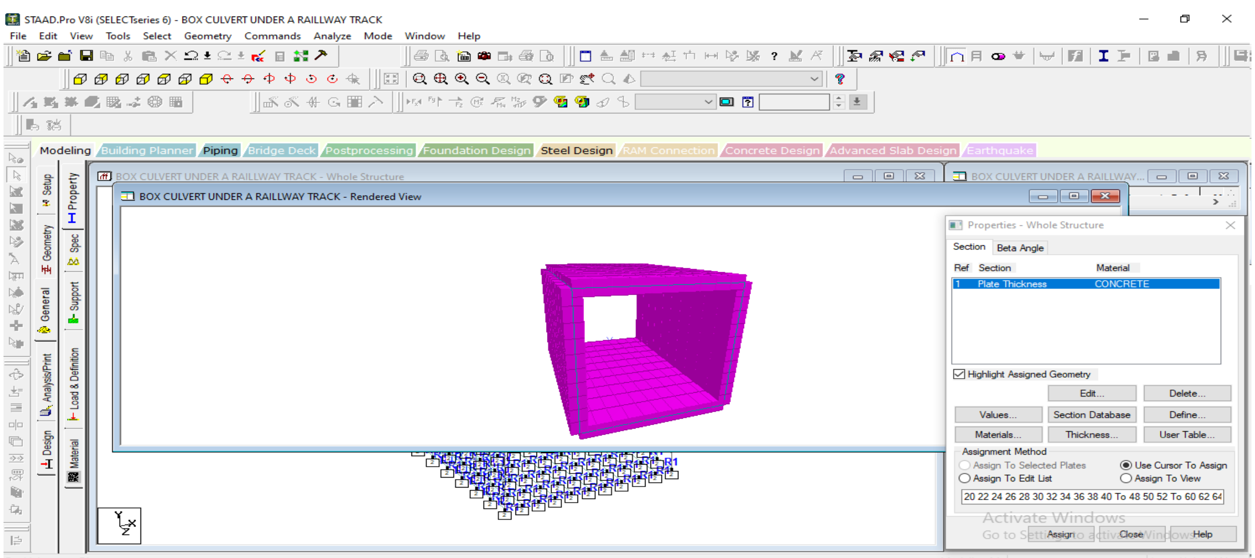


Fig 3.14: Output of step 3 (Railways)

STEP 4- Checking the structure in 3-D rendering view, to check for any flow in the structure as shown in Fig 3.15.

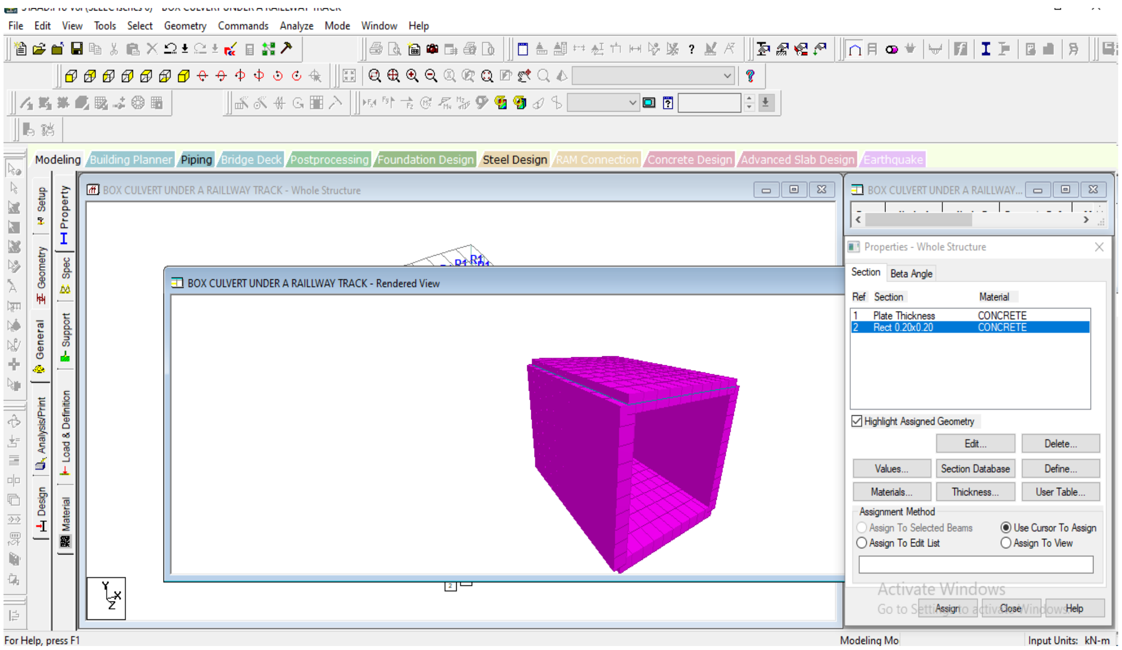


Fig 3.15: Output of step 4 (Railways)

- **STEP 5-** Dead loads are applied which include self weight, load of the wearing coat at the top slab and surcharge load at the side walls as shown in Fig 3.16 and 3.17.

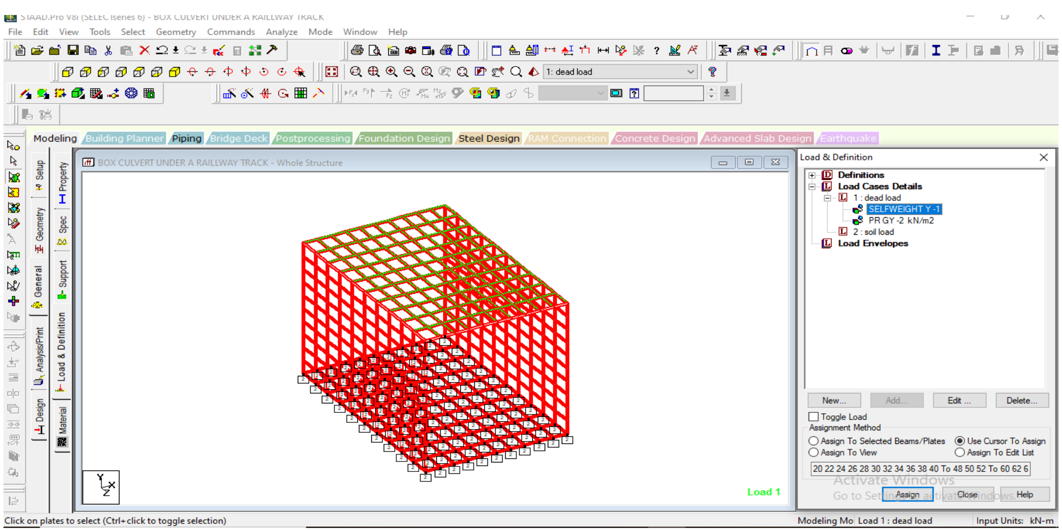


Fig 3.16: Output of step 5 top slab (Railways)

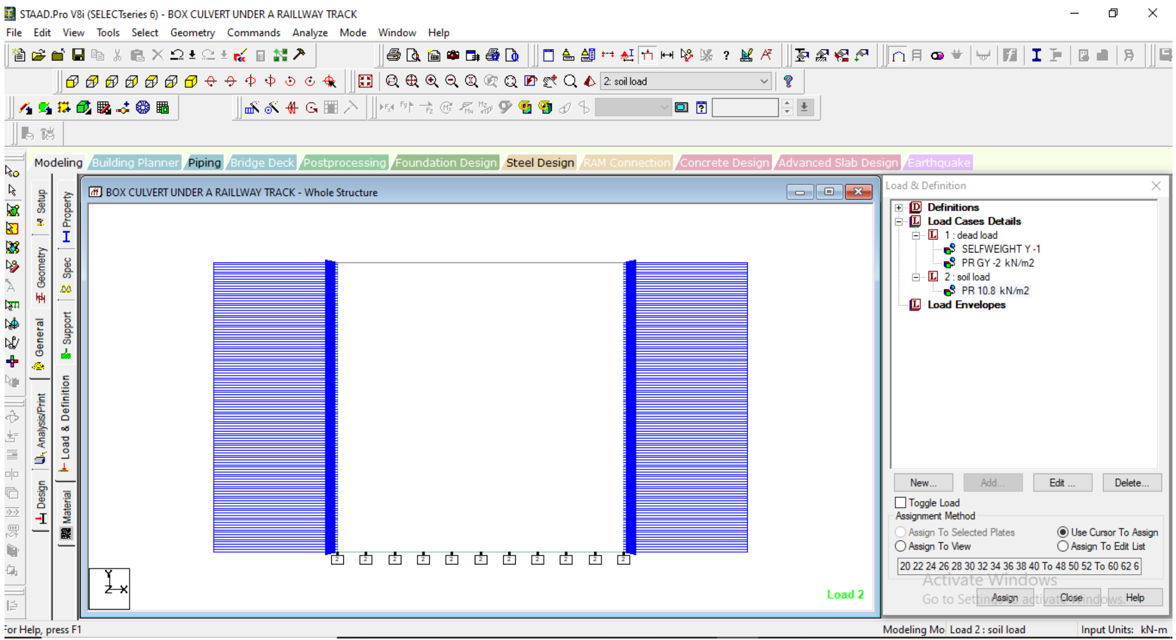


Fig 3.17: Output of step 5 side walls (Railways)

Fig - this figure shows the surcharge load at the side walls, this load is considered according to the (IRC-6).

STEP 6- Vehicle load is applied on the designed structure of the culvert with 50 load combinations for continues moving load condition. The value here is taken from IRC AA loading (track vehicle section) as shown in Fig 3.18.

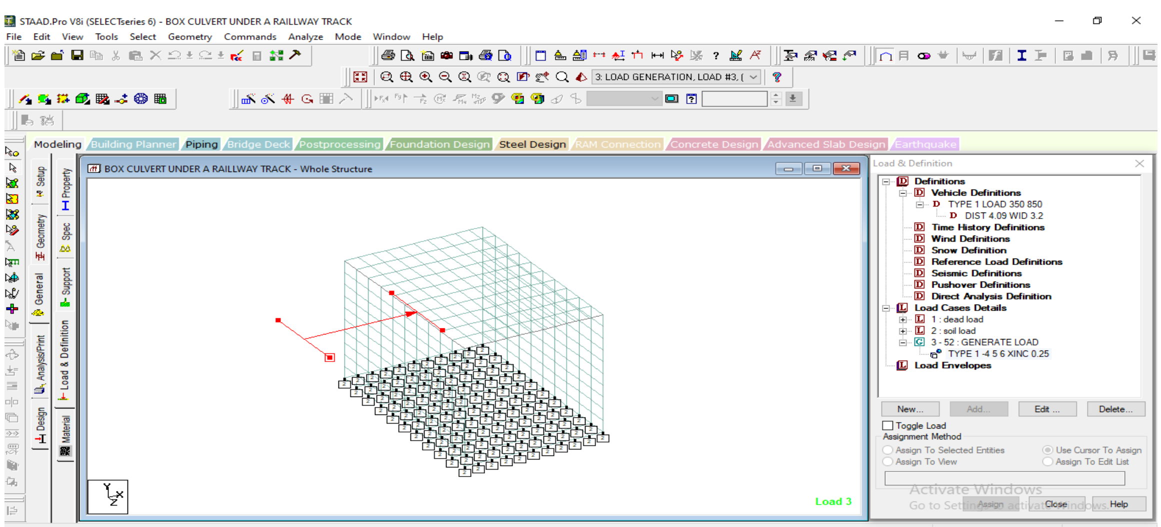


Fig 3.18: Output of step 6 (Railways)

3.5.3 For box culvert of DFC

Step1 - Basic structure has been designed by using transitional repeat command and after the modelling a quadrilateral type of mesh has been generated by using mesh generation command to each plate as shown in Fig 3.19.

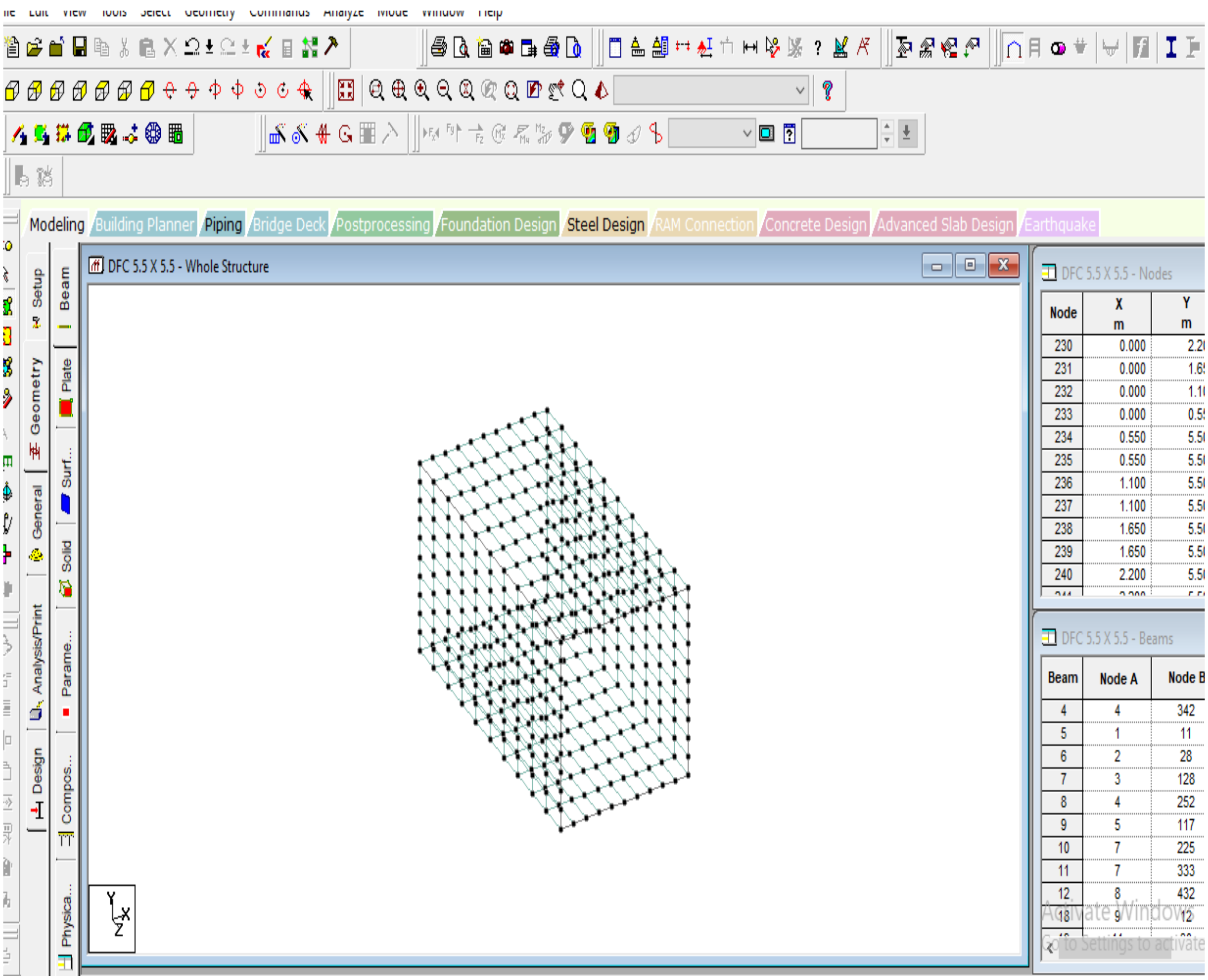


Fig 3.19: Output of step 1 (DFC)

Step2- A plate mesh is generated under foundation generation command as shown in Fig 3.20.

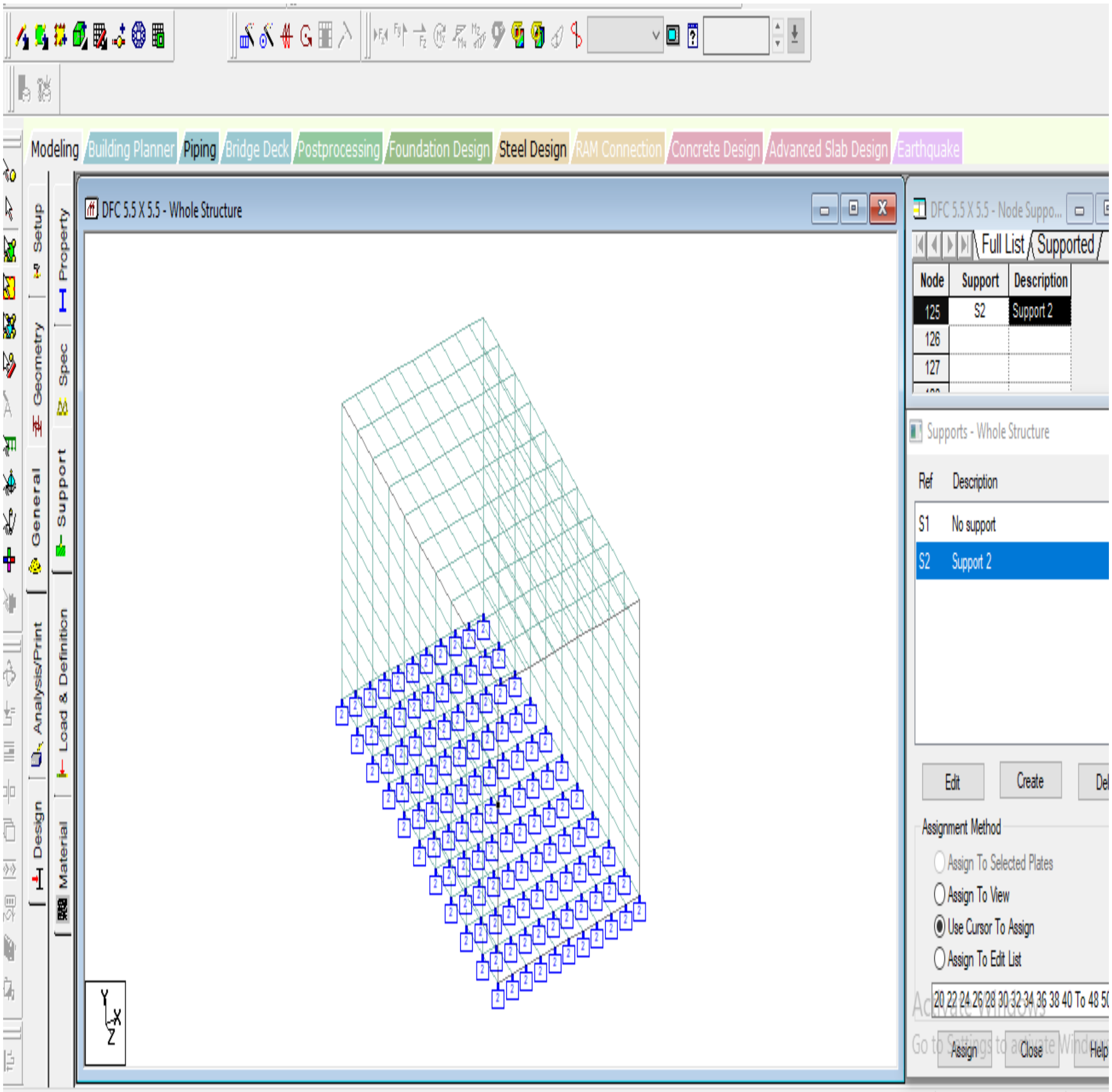


Fig 3.20: Output of step 2 (DFC)

<u>Step3</u> –After casting of basic structure the beams were deleted as the culvert is only consist of walls and slabs, so plates are designed for slab and walls and their properties were assigned as shown in Fig 3.21.

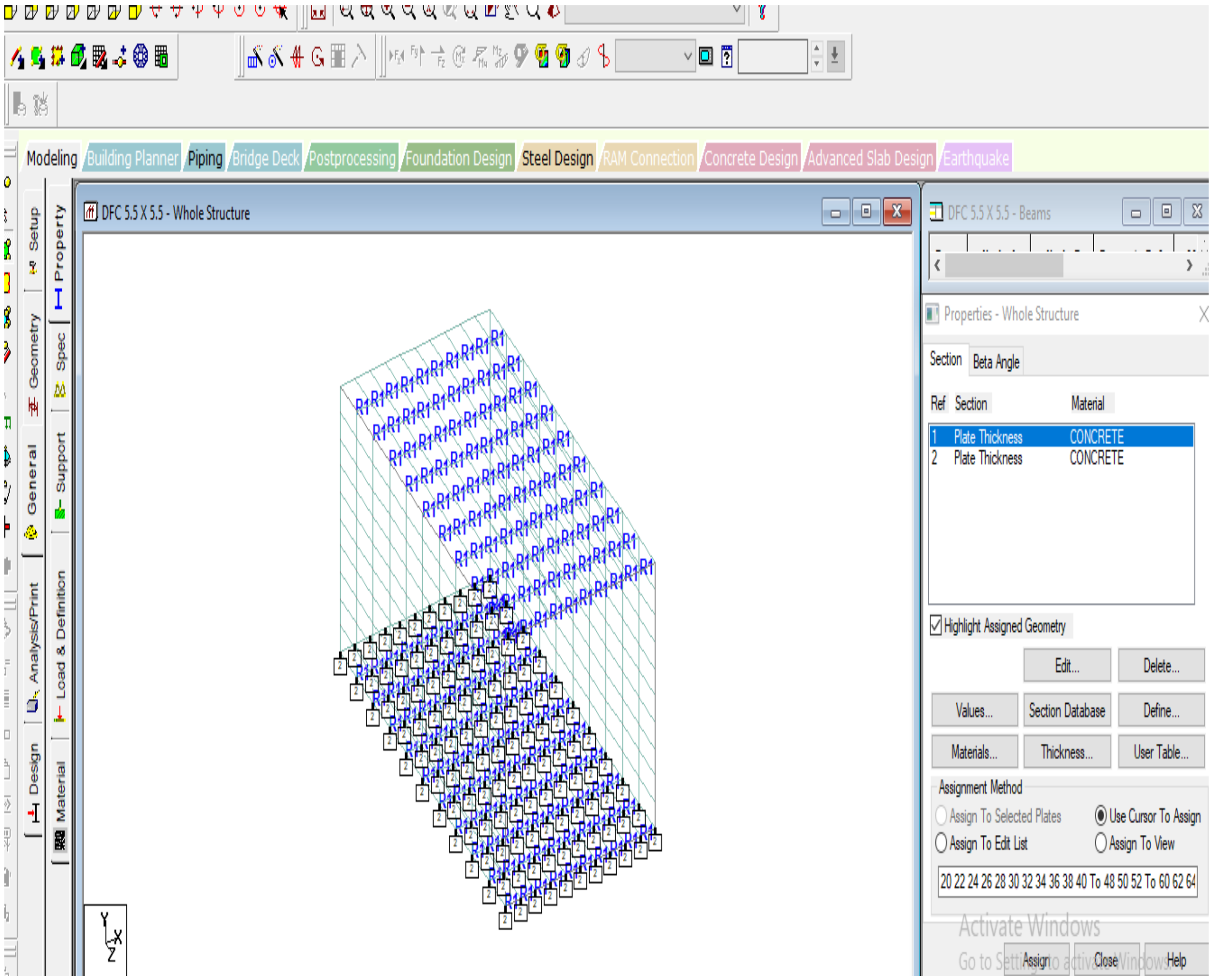


Fig 3.21: Output of step 3 (DFC)

<u>STEP 4</u> – The properties are assigned individually for slabs and walls. Hence they were designed according to the different dimensional factors as shown in Fig 3.22.

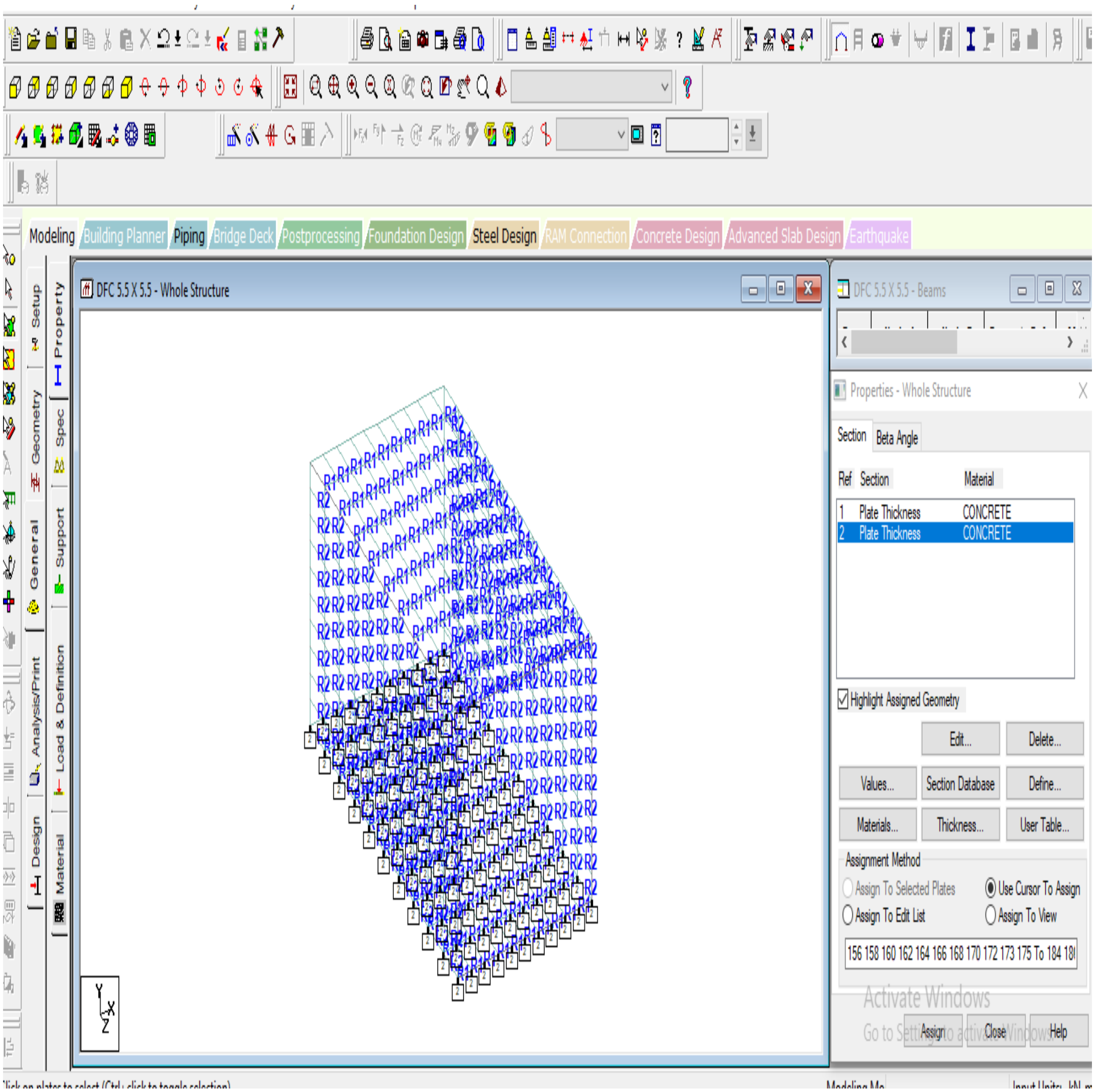


Fig 3.22: Output of step 4 (DFC)

Step 5 – The structure were viewed in 3D rendering view to check for any flow in the walls or slabs as shown in Fig 3.23.

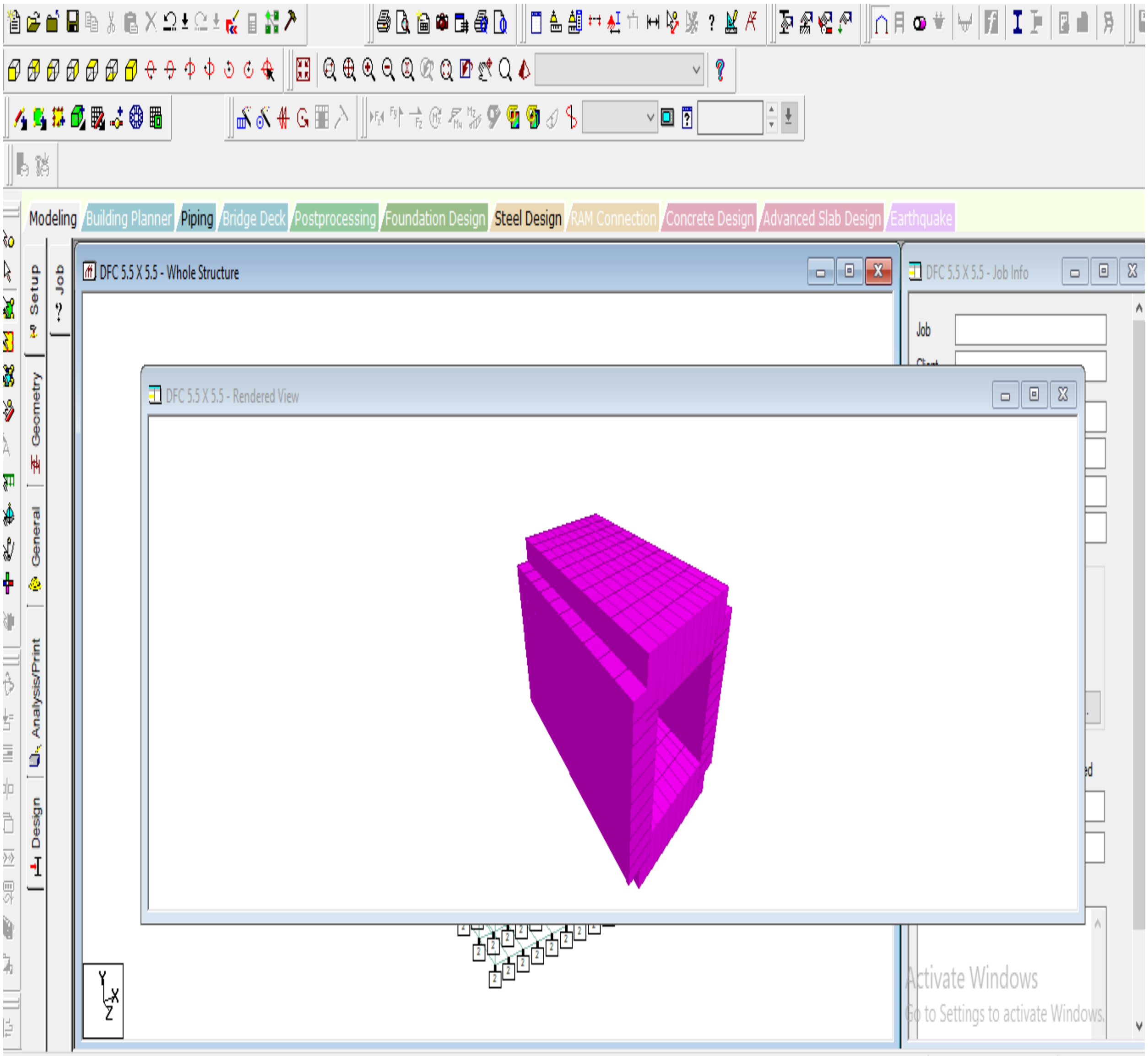


Fig 3.23: Output of step 5 (DFC)

<u>STEP 6</u> – Various loads were applied according to the loading conditions under the phenomenon of dead, live and surcharge load.

1- Self-weight as shown in Fig 3.24.

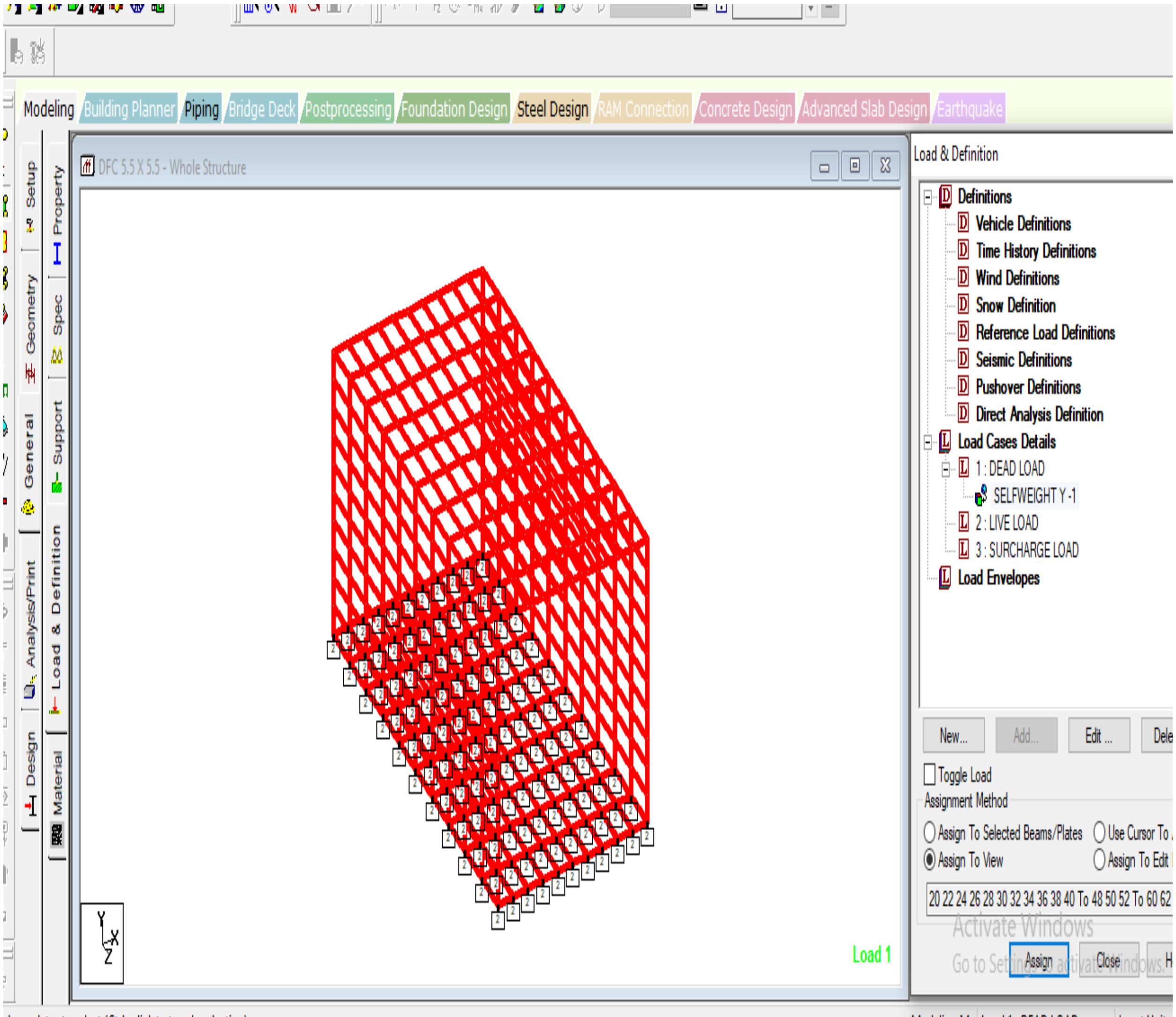


Fig 3.24: Output of step 6 self weight (DFC)

2 - Load of ballast+ rail+ sleepers as shown in Fig 3.25.

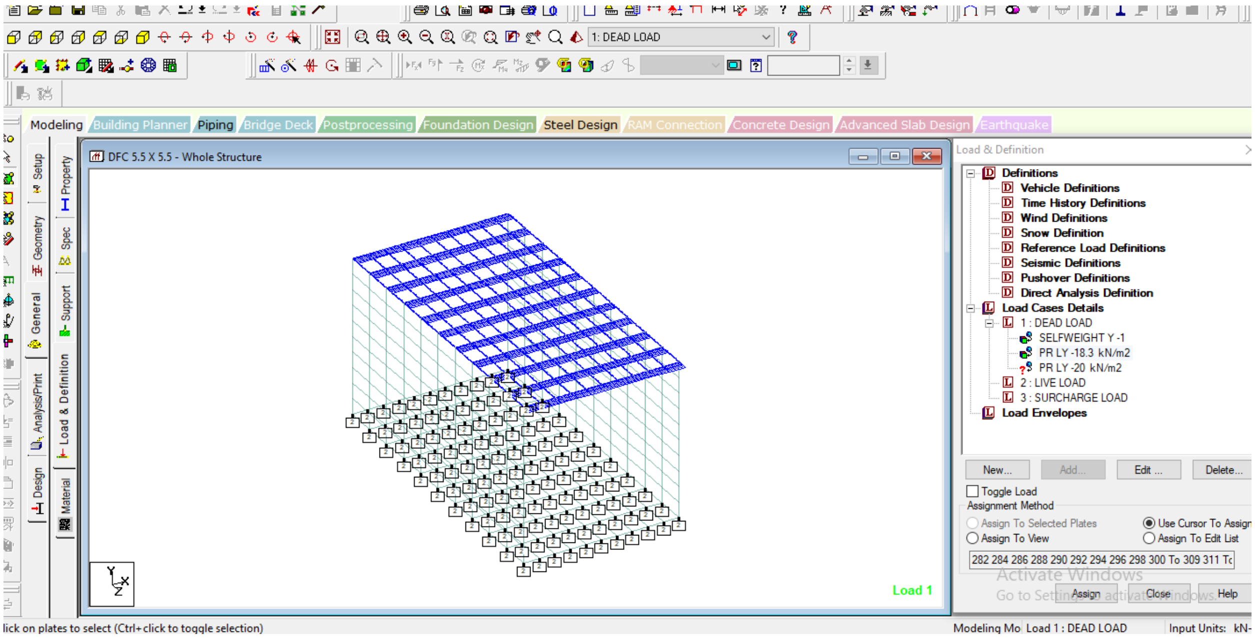


Fig 3.25: Output of step 6 B+R+S (DFC)

3 – Load of **o**verburden saturated soil as shown in Fig 3.26.

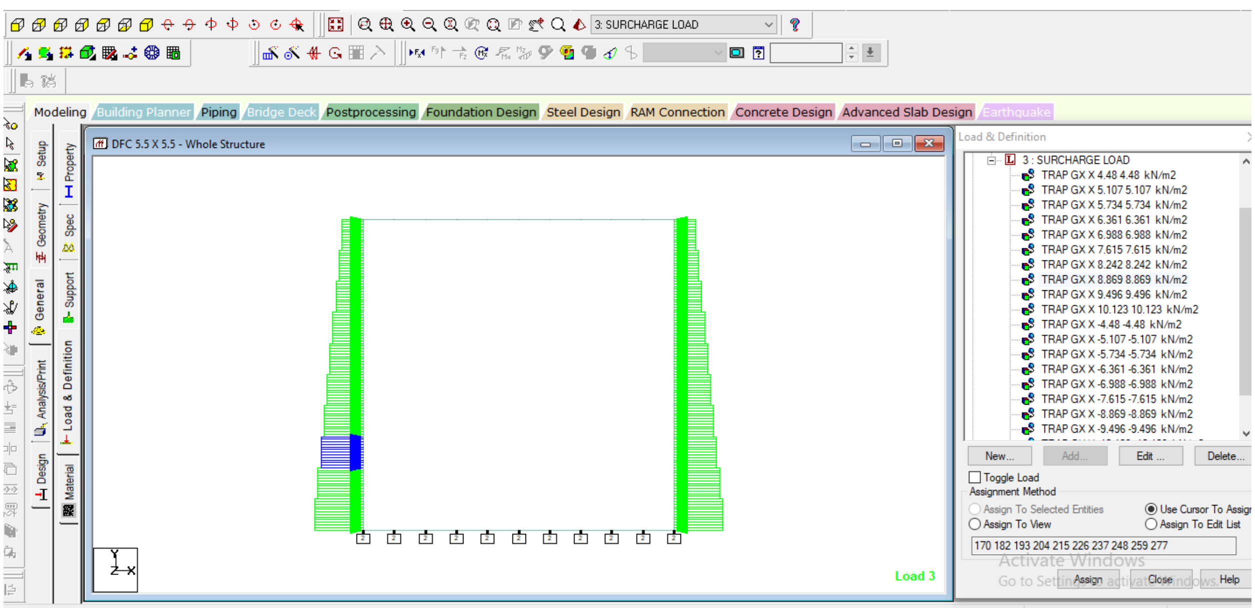


Fig 3.26: Output of step 6 OSS (DFC)

4 – Live load + curvature +vertical reaction due to wind as shown in Fig 3.27.

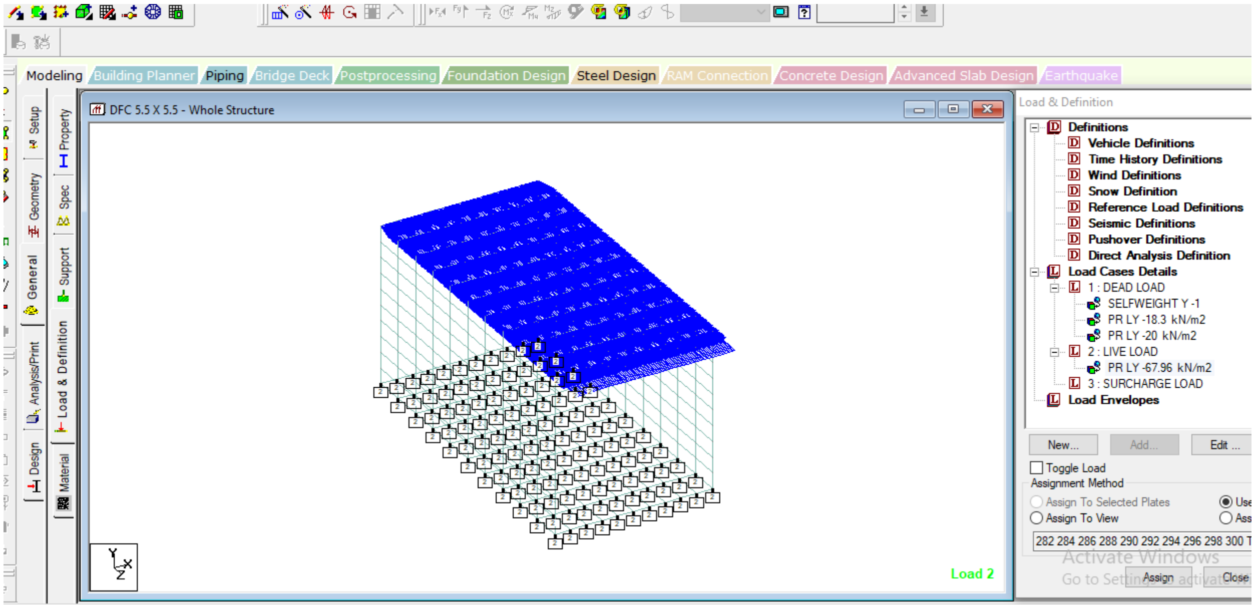


Fig 3.27: Output of step 6 LL+C+V (DFC)

5 – Load factor for SLS (serviceability limit state of floor) as shown in Fig 3.28.

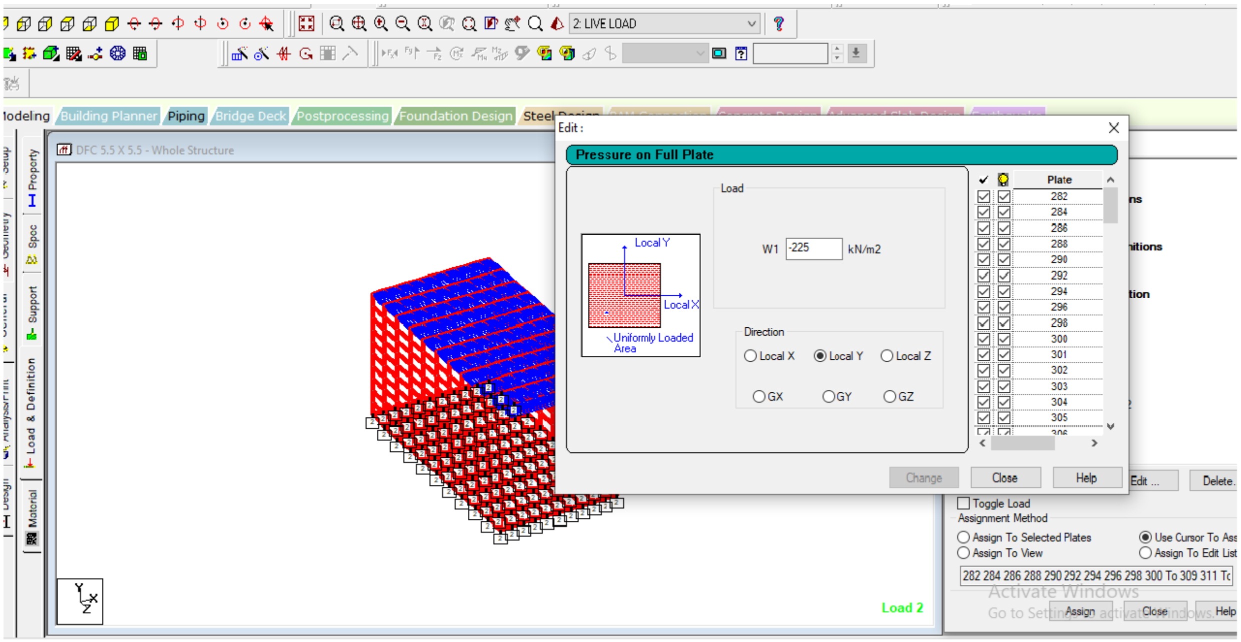


Fig 3.28: Output of step 6 SLS (DFC)

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 General

The following chapter displays the results and its interpretations obtained with the help of tables and pictorial description, the chapter also display the **shear forces**, **bending moment** and the **axial forces** acting on the designed structure. The following data has been taken from the report summary that is been made through the STAAD Pro software after analysis of the designed structure.

4.2 ROADWAYS

4.2.1 Reaction on Nodes

Reactions are shown in Fig 4.1 and Fig 4.2.

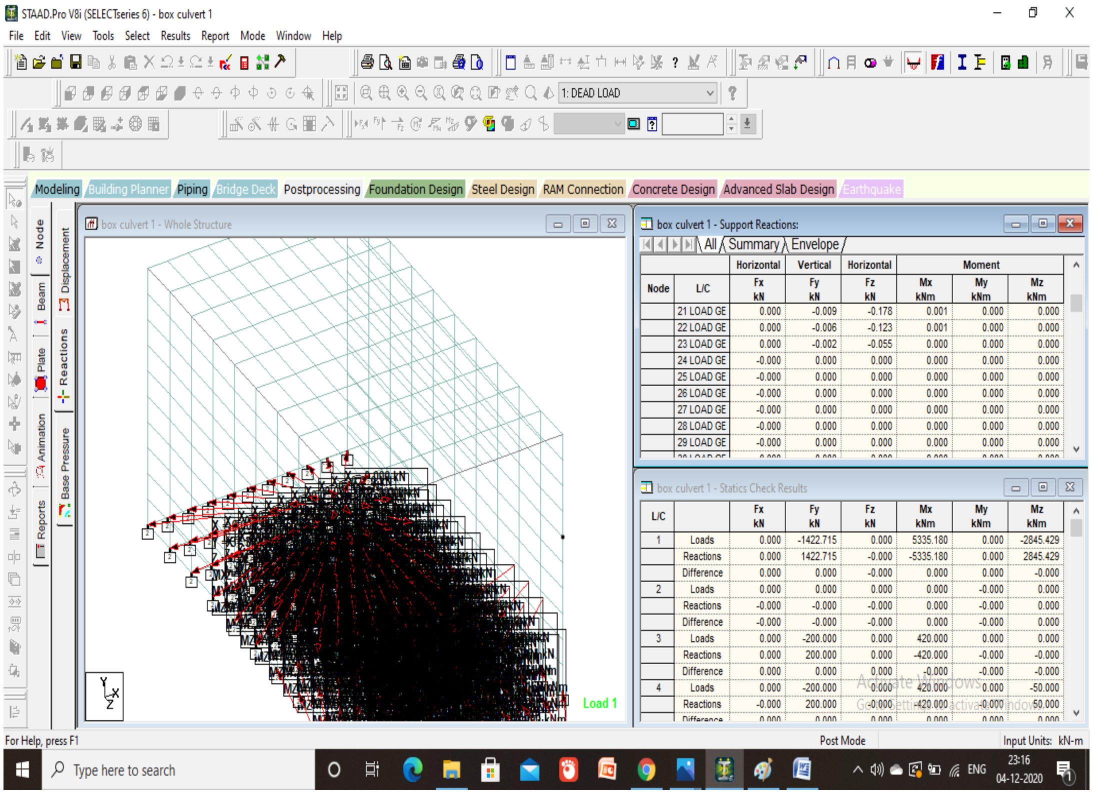


Fig 4.1: This picture shows the stress at the nodes along with the direction of the stress

	Node	L/C	Horizontal Fx kN	Vertical Fy kN	Horizontal Fz kN	Moment Mx kNm	My kNm	Mz kNm
Max Fx	322	21 LOAD GE	0.000	4.825	-0.670	0.053	0.000	0.000
Min Fx	312	21 LOAD GE	-0.000	5.946	-0.618	0.061	0.000	0.000
Max Fy	144	19 LOAD GE	0.000	68.453	8.181	0.696	0.000	0.000
Min Fy	144	2 SOIL LOAD	0.000	-28.257	0.786	-0.009	0.000	0.000
Max Fz	144	19 LOAD GE	0.000	68.453	8.181	0.696	0.000	0.000
Min Fz	312	8 LOAD GEN	0.000	19.434	-5.922	0.664	0.000	0.000
Max Mx	6	1 DEAD LOA	0.000	37.384	-5.304	4.162	0.000	0.000
Min Mx	1	8 LOAD GEN	0.000	42.471	7.492	-4.744	0.000	0.000
Max My	1	1 DEAD LOA	0.000	37.383	5.304	-4.162	0.000	0.000
Min My	1	1 DEAD LOA	0.000	37.383	5.304	-4.162	0.000	0.000
Max Mz	1	1 DEAD LOA	0.000	37.383	5.304	-4.162	0.000	0.000
Min Mz	1	1 DEAD LOA	0.000	37.383	5.304	-4.162	0.000	0.000

Fig 4.2: The highlighted row shows the maximum stress value in the Fy direction clearly and other major reaction values can also be seen

4.2.2 Reaction on Beams

Reactions are shown in Fig 4.3, 4.4, 4.5, 4.6.

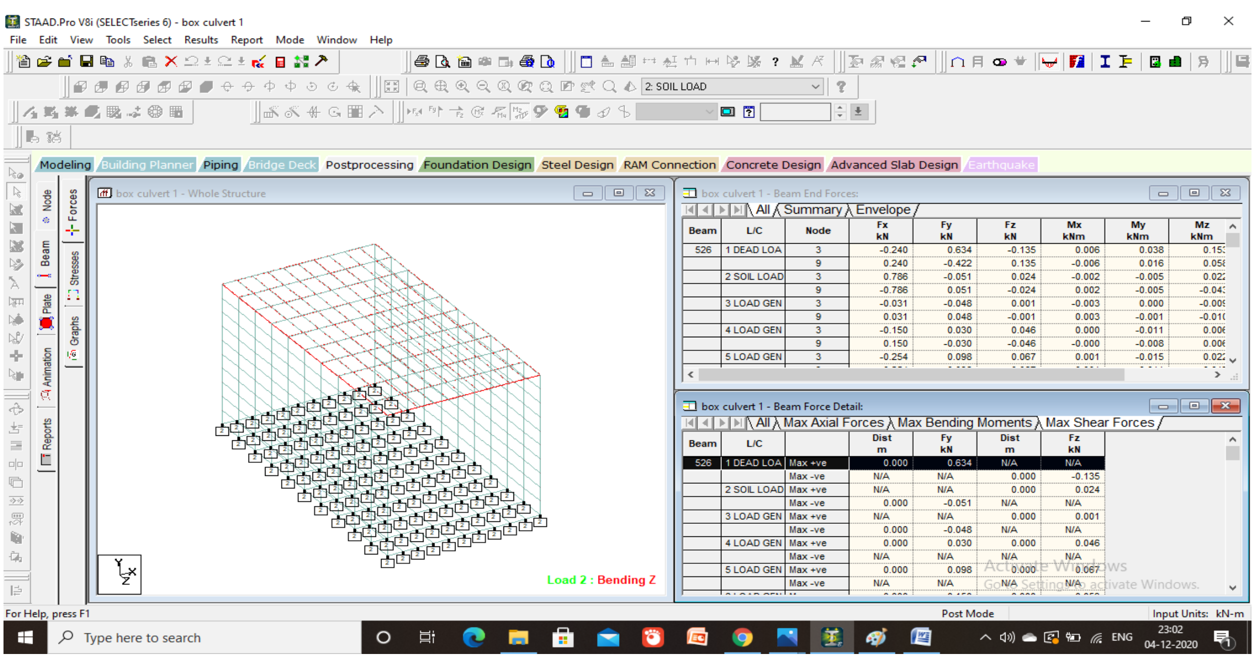


Fig 4.3: The red lines shows the positions of beams at the top slabs along with the brief reactions results in the side tables

Beam	L/C		Dist m	Fy kN	Dist m	Fz kN
526	1 DEAD LOA	Max +ve	0.000	0.634	N/A	N/A
		Max -ve	N/A	N/A	0.000	-0.135
	2 SOIL LOAD	Max +ve	N/A	N/A	0.000	0.024
		Max -ve	0.000	-0.051	N/A	N/A
	3 LOAD GEN	Max +ve	N/A	N/A	0.000	0.001
		Max -ve	0.000	-0.048	N/A	N/A
	4 LOAD GEN	Max +ve	0.000	0.030	0.000	0.046
		Max -ve	N/A	N/A	N/A	N/A
	5 LOAD GEN	Max +ve	0.000	0.098	0.000	0.067
		Max -ve	N/A	N/A	N/A	N/A
	6 LOAD GEN	Max +ve	0.000	0.150	0.000	0.053
		Max -ve	N/A	N/A	N/A	N/A
	7 LOAD GEN	Max +ve	0.000	0.178	0.000	0.028
		Max -ve	N/A	N/A	N/A	N/A
	8 LOAD GEN	Max +ve	0.000	0.172	0.000	0.009
		Max -ve	N/A	N/A	N/A	N/A
	9 LOAD GEN	Max +ve	0.000	0.216	0.000	0.029
		Max -ve	N/A	N/A	N/A	N/A
	10 LOAD GE	Max +ve	0.000	0.240	0.000	0.032
		Max -ve	N/A	N/A	N/A	N/A
	11 LOAD GE	Max +ve	0.000	0.253	0.000	0.021
		Max -ve	N/A	N/A	N/A	N/A
	12 LOAD GE	Max +ve	0.000	0.239	0.000	0.005
		Max -ve	N/A	N/A	N/A	N/A
	13 LOAD GE	Max +ve	0.000	0.220	N/A	N/A
		Max -ve	N/A	N/A	0.000	-0.008

Fig 4.4: The table shows the maximum shear force value due to dead load and soil load

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	750	8 LOAD GEN	52	**1.113**	24.789	-0.085	-0.017	0.033	4.814
Min Fx	535	14 LOAD GE	26	**-0.665**	-0.246	0.000	0.008	0.007	0.009
Max Fy	748	3 LOAD GEN	30	0.761	**40.430**	0.008	0.005	-0.002	6.712
Min Fy	779	11 LOAD GE	53	0.108	**-51.355**	-0.010	-0.018	-0.003	6.616
Max Fz	595	16 LOAD GE	71	0.344	-0.632	**0.291**	-0.021	-0.045	-0.073
Min Fz	586	10 LOAD GE	63	0.310	0.814	**-0.315**	0.026	0.076	0.196
Max Mx	587	11 LOAD GE	62	0.341	0.693	-0.073	**0.054**	0.018	0.087
Min Mx	771	11 LOAD GE	62	0.084	-0.044	-0.049	**-0.048**	0.018	-0.008
Max My	586	11 LOAD GE	63	0.376	0.738	-0.315	0.025	**0.077**	0.200
Min My	751	11 LOAD GE	74	-0.022	0.263	-0.166	-0.037	**-0.063**	-0.096
Max Mz	757	19 LOAD GE	39	1.025	-40.519	-0.026	-0.006	-0.012	**6.742**
Min Mz	561	11 LOAD GE	34	0.475	-0.864	-0.007	0.007	0.002	**-0.367**

Fig 4.5: This table consist of maximum stress in the beam according to the member number in Fx and Fy directions

Beam	L/C		Dist m	Mz kNm	Dist m	My kNm
526	1 DEAD LOA	Max +ve	0.000	0.153	0.000	0.038
		Max -ve	0.400	-0.058	0.400	-0.016
	2 SOIL LOAD	Max +ve	0.400	0.043	0.400	0.005
		Max -ve	N/A	N/A	0.000	-0.005
	3 LOAD GEN	Max +ve	0.400	0.010	0.400	0.001
		Max -ve	0.000	-0.009	N/A	N/A
	4 LOAD GEN	Max +ve	0.000	0.006	0.400	0.008
		Max -ve	0.400	-0.006	0.000	-0.011
	5 LOAD GEN	Max +ve	0.000	0.022	0.400	0.011
		Max -ve	0.400	-0.017	0.000	-0.015
	6 LOAD GEN	Max +ve	0.000	0.038	0.400	0.010
		Max -ve	0.400	-0.022	0.000	-0.011
	7 LOAD GEN	Max +ve	0.000	0.052	0.400	0.007
		Max -ve	0.400	-0.019	0.000	-0.004
	8 LOAD GEN	Max +ve	0.000	0.061	0.400	0.005
		Max -ve	0.400	-0.008	N/A	N/A
	9 LOAD GEN	Max +ve	0.000	0.077	0.400	0.009
		Max -ve	0.400	-0.010	0.000	-0.003
	10 LOAD GE	Max +ve	0.000	0.089	0.400	0.010
		Max -ve	0.400	-0.007	0.000	-0.003
	11 LOAD GE	Max +ve	0.000	0.099	0.400	0.009
		Max -ve	0.400	-0.002	N/A	N/A
	12 LOAD GE	Max +ve	0.000	0.103	0.400	0.007
		Max -ve	N/A	N/A	N/A	N/A

Fig 4.6: This table shows the maximum bending moment values on the beam members specially due to dead and soil load

4.2.3 Reaction on Plates

Reactions are shown in Fig 4.7,4.8,4.9,4.10.

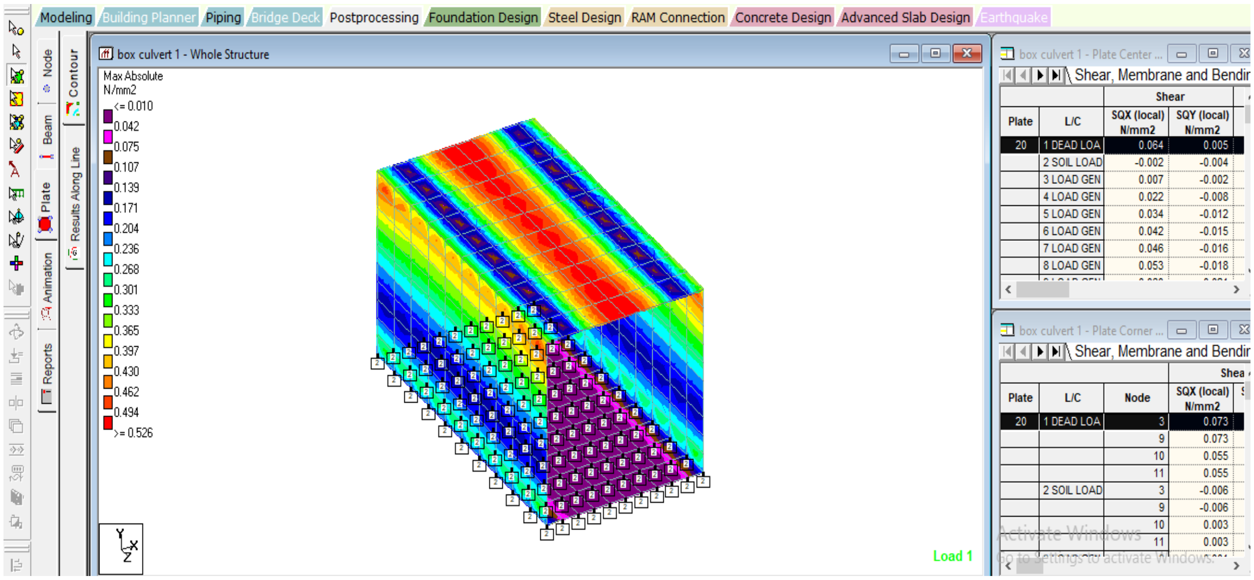


Fig 4.7: The above picture shows the absolute maximum pressure on the plates due to dead load. The red portion is the place where the pressure is maximum

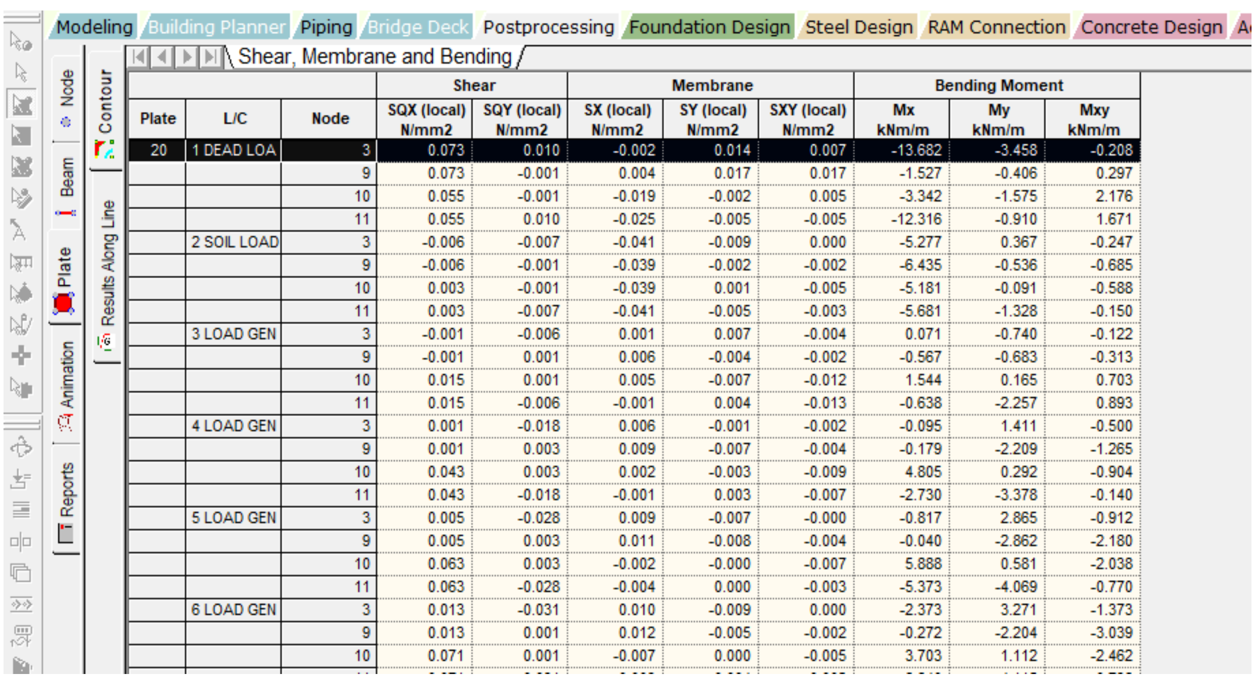


Plate	L/C	Node	Shear SQX (local) N/mm2	Shear SQY (local) N/mm2	Membrane SX (local) N/mm2	Membrane SY (local) N/mm2	Membrane SXY (local) N/mm2	Bending Moment Mx kNm/m	Bending Moment My kNm/m	Bending Moment Mxy kNm/m
20	1 DEAD LOA	3	0.073	0.010	-0.002	0.014	0.007	-13.682	-3.458	-0.208
		9	0.073	-0.001	0.004	0.017	0.017	-1.527	-0.406	0.297
		10	0.055	-0.001	-0.019	-0.002	0.005	-3.342	-1.575	2.176
		11	0.055	0.010	-0.025	-0.005	-0.005	-12.316	-0.910	1.671
	2 SOIL LOAD	3	-0.006	-0.007	-0.041	-0.009	0.000	-5.277	0.367	-0.247
		9	-0.006	-0.001	-0.039	-0.002	-0.002	-6.435	-0.536	-0.685
		10	0.003	-0.001	-0.039	0.001	-0.005	-5.181	-0.091	-0.588
		11	0.003	-0.007	-0.041	-0.005	-0.003	-5.681	-1.328	-0.150
	3 LOAD GEN	3	-0.001	-0.006	0.001	0.007	-0.004	0.071	-0.740	-0.122
		9	-0.001	0.001	0.006	-0.004	-0.002	-0.567	-0.683	-0.313
		10	0.015	0.001	0.005	-0.007	-0.012	1.544	0.165	0.703
		11	0.015	-0.006	-0.001	0.004	-0.013	-0.638	-2.257	0.893
	4 LOAD GEN	3	0.001	-0.018	0.006	-0.001	-0.002	-0.095	1.411	-0.500
		9	0.001	0.003	0.009	-0.007	-0.004	-0.179	-2.209	-1.265
		10	0.043	0.003	0.002	-0.003	-0.009	4.805	0.292	-0.904
		11	0.043	-0.018	-0.001	0.003	-0.007	-2.730	-3.378	-0.140
	5 LOAD GEN	3	0.005	-0.028	0.009	-0.007	-0.000	-0.817	2.865	-0.912
		9	0.005	0.003	0.011	-0.008	-0.004	-0.040	-2.862	-2.180
		10	0.063	0.003	-0.002	-0.000	-0.007	5.888	0.581	-2.038
		11	0.063	-0.028	-0.004	0.000	-0.003	-5.373	-4.069	-0.770
	6 LOAD GEN	3	0.013	-0.031	0.010	-0.009	0.000	-2.373	3.271	-1.373
		9	0.013	0.001	0.012	-0.005	-0.002	-0.272	-2.204	-3.039
		10	0.071	0.001	-0.007	0.000	-0.005	3.703	1.112	-2.462

Fig 4.8: The highlighted row shows the value of different reaction on the plate due to dead load

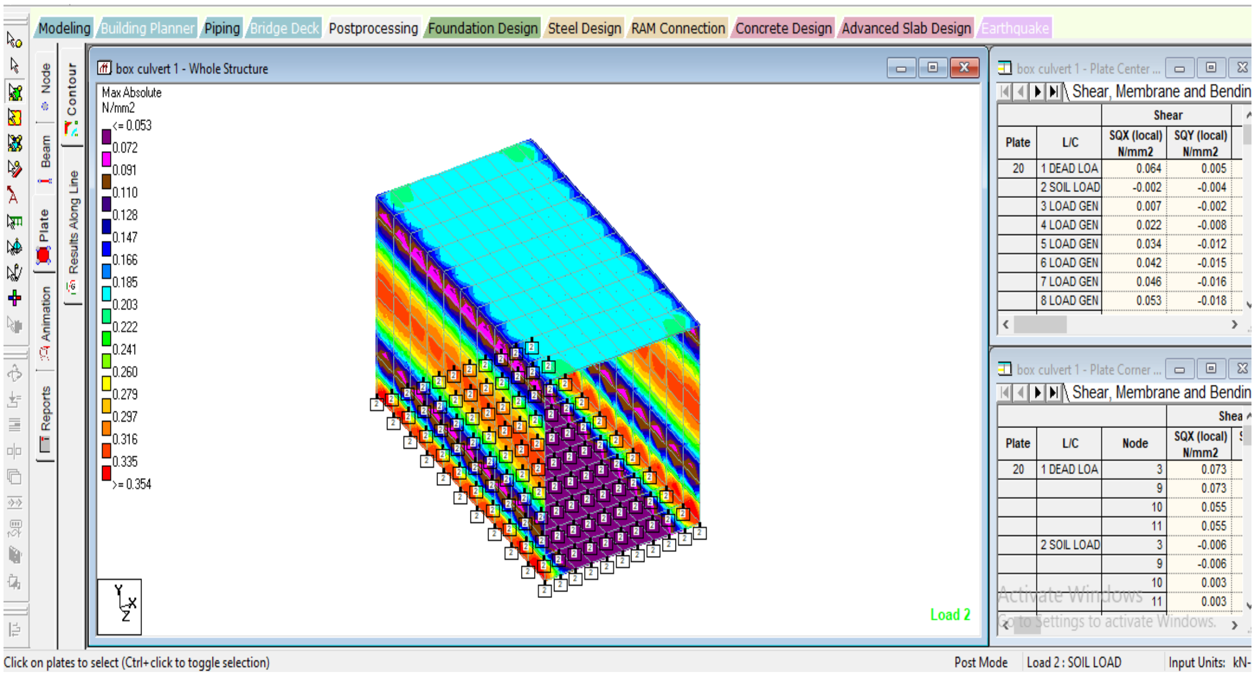


Fig 4.9: This picture shows the pressure on the plates due to soil load on the walls of the culvert

		Shear		Membrane			Bending Moment		
Plate	L/C	SQX (local) N/mm2	SQY (local) N/mm2	SX (local) N/mm2	SY (local) N/mm2	SXY (local) N/mm2	Mx kNm/m	My kNm/m	Mxy kNm/m
20	1 DEAD LOA	0.064	0.005	-0.010	0.006	0.006	-7.717	-1.587	0.984
	2 SOIL LOAD	-0.002	-0.004	-0.040	-0.004	-0.002	-5.644	-0.397	-0.417
	3 LOAD GEN	0.007	-0.002	0.003	0.000	-0.008	0.102	-0.879	0.290
	4 LOAD GEN	0.022	-0.008	0.004	-0.002	-0.006	0.450	-0.971	-0.702
	5 LOAD GEN	0.034	-0.012	0.003	-0.004	-0.004	-0.085	-0.871	-1.475
	6 LOAD GEN	0.042	-0.015	0.002	-0.005	-0.002	-1.946	-0.484	-1.918
	7 LOAD GEN	0.046	-0.016	-0.000	-0.004	-0.001	-3.940	-0.365	-1.867
	8 LOAD GEN	0.053	-0.018	0.000	-0.004	-0.005	-5.747	-0.943	-1.678
	9 LOAD GEN	0.060	-0.021	-0.001	-0.005	-0.004	-6.796	-1.114	-2.106
	10 LOAD GE	0.063	-0.023	-0.002	-0.005	-0.003	-8.309	-1.109	-2.369
	11 LOAD GE	0.065	-0.025	-0.004	-0.005	-0.002	-10.132	-0.986	-2.522
	12 LOAD GE	0.062	-0.024	-0.005	-0.005	-0.001	-11.459	-0.976	-2.343
	13 LOAD GE	0.058	-0.023	-0.007	-0.005	-0.001	-12.408	-0.976	-2.134
	14 LOAD GE	0.052	-0.021	-0.007	-0.005	-0.001	-12.791	-0.990	-1.876
	15 LOAD GE	0.045	-0.019	-0.007	-0.004	-0.001	-12.384	-0.951	-1.630
	16 LOAD GE	0.037	-0.017	-0.007	-0.004	-0.001	-11.605	-0.885	-1.392
	17 LOAD GE	0.030	-0.014	-0.007	-0.003	-0.001	-10.129	-0.763	-1.175
	18 LOAD GE	0.022	-0.012	-0.005	-0.003	-0.001	-8.238	-0.608	-0.972
	19 LOAD GE	0.015	-0.009	-0.004	-0.002	-0.001	-6.071	-0.432	-0.780
	20 LOAD GE	0.011	-0.007	-0.003	-0.002	-0.001	-4.876	-0.354	-0.565
	21 LOAD GE	0.008	-0.005	-0.003	-0.001	-0.001	-3.891	-0.281	-0.421
	22 LOAD GE	0.005	-0.003	-0.002	-0.001	-0.001	-2.707	-0.193	-0.287
	23 LOAD GE	0.002	-0.002	-0.001	-0.000	-0.001	-1.331	-0.089	-0.173
	24 LOAD GE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	25 LOAD GE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	26 LOAD GE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	27 LOAD GE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	28 LOAD GE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Fig 4.10: The highlighted row shows the absolute maximum pressure values due to soil load

4.3 RAILWAY

4.3.1 Reaction on Nodes

Displacement Reactions are shown in Fig 4.11

	Node	L/C	Horizontal X mm	Vertical Y mm	Horizontal Z mm	Resultant mm	Rotational rX rad	Rotational rY rad	Rotational rZ rad
Max X	335	9 LOAD GEN	0.605	-0.030	0.009	0.606	0.000	0.000	-0.000
Min X	123	16 LOAD GE	-0.592	-0.032	0.010	0.593	0.000	-0.000	0.000
Max Y	134	2 SOIL LOAD	0.007	0.122	-0.001	0.122	0.000	-0.000	0.000
Min Y	209	13 LOAD GE	-0.031	-1.769	0.020	1.769	0.000	-0.000	-0.000
Max Z	164	22 LOAD GE	0.078	-0.105	0.044	0.138	0.000	-0.000	0.000
Min Z	246	22 LOAD GE	0.061	-0.015	-0.008	0.064	0.000	0.000	-0.000
Max rX	159	13 LOAD GE	-0.030	-1.301	0.017	1.301	0.000	-0.000	-0.000
Min rX	221	18 LOAD GE	-0.408	-1.007	0.024	1.086	-0.000	-0.000	0.000
Max rY	334	13 LOAD GE	0.415	-0.058	0.019	0.420	0.000	0.000	0.000
Min rY	124	12 LOAD GE	-0.381	-0.060	0.020	0.386	0.000	-0.000	-0.000
Max rZ	213	15 LOAD GE	-0.240	-0.502	0.023	0.557	0.000	0.000	0.001
Min rZ	205	10 LOAD GE	0.277	-0.506	0.024	0.577	0.000	-0.000	-0.001
Max Rs	209	13 LOAD GE	-0.031	-1.769	0.020	1.769	0.000	-0.000	-0.000

Fig 4.11: The highlighted row shows the maximum Displacement value in the X direction clearly and other major reaction values can also be seen

Moment at nodes Reactions are shown in Fig 4.12

	Node	L/C	Horizontal Fx kN	Vertical Fy kN	Horizontal Fz kN	Moment Mx kNm	Moment My kNm	Moment Mz kNm
Max Fx	107	34 LOAD GE	0.000	46.335	-1.820	-0.205	0.000	0.000
Min Fx	96	34 LOAD GE	-0.000	43.912	-1.162	-0.094	0.000	0.000
Max Fy	332	22 LOAD GE	0.000	264.506	-25.341	-2.381	0.000	0.000
Min Fy	423	11 LOAD GE	0.000	-68.407	1.525	0.042	0.000	0.000
Max Fz	252	22 LOAD GE	0.000	116.989	23.060	-0.229	0.000	0.000
Min Fz	8	22 LOAD GE	0.000	162.510	-29.036	17.947	0.000	0.000
Max Mx	8	22 LOAD GE	0.000	162.510	-29.036	17.947	0.000	0.000
Min Mx	4	22 LOAD GE	0.000	67.903	17.168	-7.467	0.000	0.000
Max My	1	1 DEAD LOA	0.000	52.579	8.276	-5.863	0.000	0.000
Min My	1	1 DEAD LOA	0.000	52.579	8.276	-5.863	0.000	0.000
Max Mz	1	1 DEAD LOA	0.000	52.579	8.276	-5.863	0.000	0.000
Min Mz	1	1 DEAD LOA	0.000	52.579	8.276	-5.863	0.000	0.000

Fig 4.12: The highlighted row shows the maximum moment value in the Fy direction clearly and other major reaction values can also be seen

4.3.2 Plate loads

1-Dead load Reactions are shown in Fig 4.13 and 4.14.

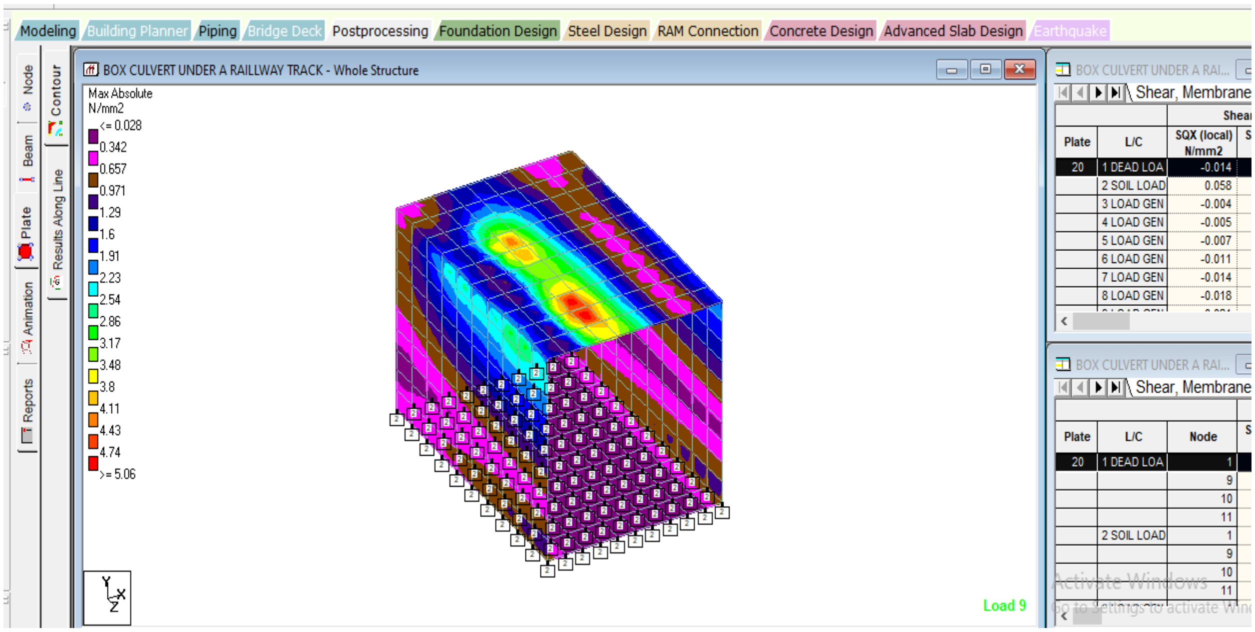


Fig 4.13: The above picture shows the absolute maximum pressure on the plates due to dead load. The red portion is the place where the pressure is maximum

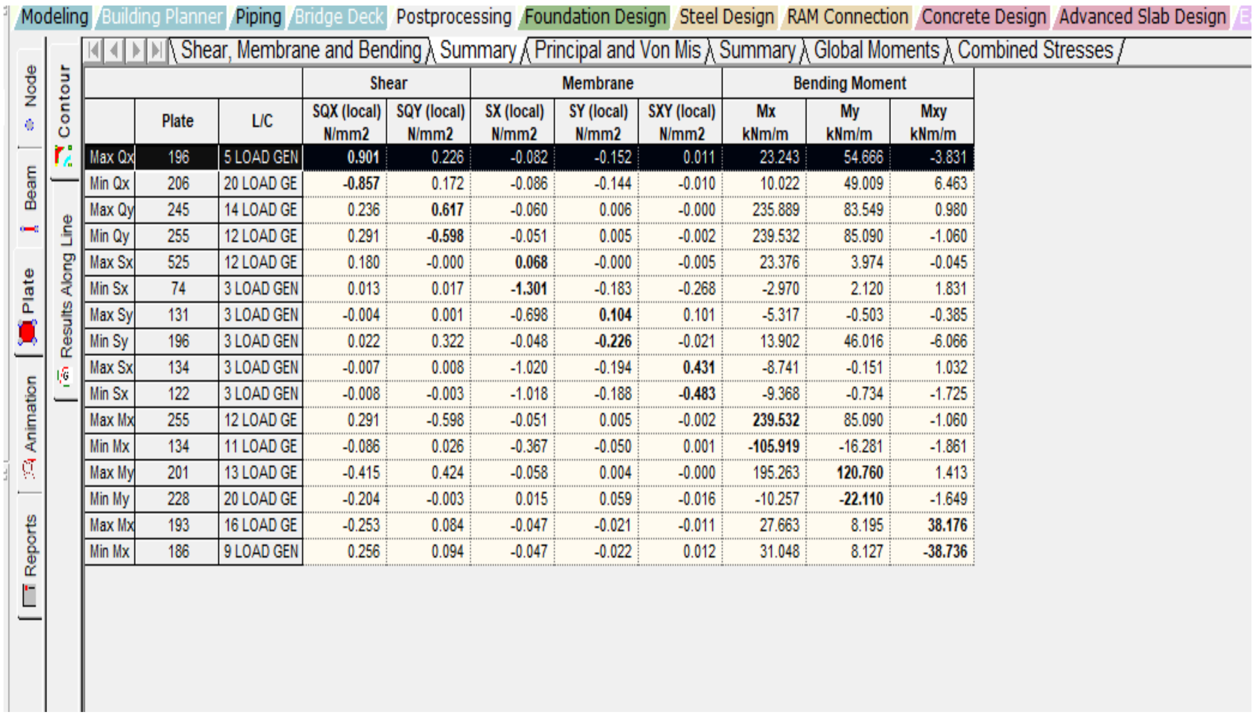


	Plate	L/C	Shear SQX (local) N/mm2	Shear SQY (local) N/mm2	Membrane SX (local) N/mm2	Membrane SY (local) N/mm2	Membrane SXY (local) N/mm2	Bending Moment Mx kNm/m	Bending Moment My kNm/m	Bending Moment Mxy kNm/m
Max Qx	196	5 LOAD GEN	0.901	0.226	-0.082	-0.152	0.011	23.243	54.666	-3.831
Min Qx	206	20 LOAD GE	-0.857	0.172	-0.086	-0.144	-0.010	10.022	49.009	6.463
Max Qy	245	14 LOAD GE	0.236	0.617	-0.060	0.006	-0.000	235.889	83.549	0.980
Min Qy	255	12 LOAD GE	0.291	-0.598	-0.051	0.005	-0.002	239.532	85.090	-1.060
Max Sx	525	12 LOAD GE	0.180	-0.000	0.068	-0.000	-0.005	23.376	3.974	-0.045
Min Sx	74	3 LOAD GEN	0.013	0.017	-1.301	-0.183	-0.268	-2.970	2.120	1.831
Max Sy	131	3 LOAD GEN	-0.004	0.001	-0.698	0.104	0.101	-5.317	-0.503	-0.385
Min Sy	196	3 LOAD GEN	0.022	0.322	-0.048	-0.226	-0.021	13.902	46.016	-6.066
Max Sx	134	3 LOAD GEN	-0.007	0.008	-1.020	-0.194	0.431	-8.741	-0.151	1.032
Min Sx	122	3 LOAD GEN	-0.008	-0.003	-1.018	-0.188	-0.483	-9.368	-0.734	-1.725
Max Mx	255	12 LOAD GE	0.291	-0.598	-0.051	0.005	-0.002	239.532	85.090	-1.060
Min Mx	134	11 LOAD GE	-0.086	0.026	-0.367	-0.050	0.001	-105.919	-16.281	-1.861
Max My	201	13 LOAD GE	-0.415	0.424	-0.058	0.004	-0.000	195.263	120.760	1.413
Min My	228	20 LOAD GE	-0.204	-0.003	0.015	0.059	-0.016	-10.257	-22.110	-1.649
Max Mx	193	16 LOAD GE	-0.253	0.084	-0.047	-0.021	-0.011	27.663	8.195	38.176
Min Mx	186	9 LOAD GEN	0.256	0.094	-0.047	-0.022	0.012	31.048	8.127	-38.736

Fig 4.14: The highlighted row shows the value of different reaction on the plate due to dead load

Soil loading Reactions are shown in Fig 4.15 and 4.16.

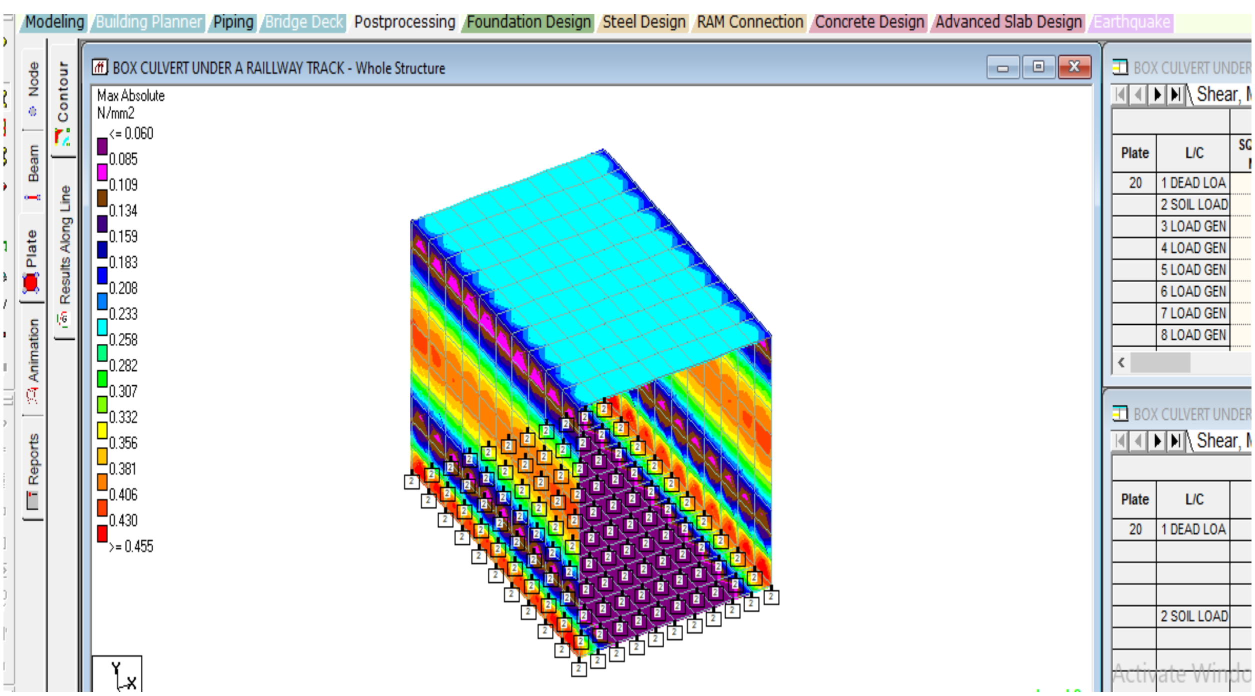


Fig 4.15: This picture shows the pressure on the plates due to soil load on the walls of the culvert

	Plate	L/C	Shear		Membrane			Bending Moment		
			SQX (local) N/mm2	SQY (local) N/mm2	SX (local) N/mm2	SY (local) N/mm2	SXY (local) N/mm2	Mx kNm/m	My kNm/m	Mxy kNm/m
Max Qx	196	5 LOAD GEN	**0.901**	0.226	-0.082	-0.152	0.011	23.243	54.666	-3.831
Min Qx	206	20 LOAD GE	**-0.857**	0.172	-0.086	-0.144	-0.010	10.022	49.009	6.463
Max Qy	245	14 LOAD GE	0.236	**0.617**	-0.060	0.006	-0.000	235.889	83.549	0.980
Min Qy	255	12 LOAD GE	0.291	**-0.598**	-0.051	0.005	-0.002	239.532	85.090	-1.060
Max Sx	525	12 LOAD GE	0.180	-0.000	**0.068**	-0.000	-0.005	23.376	3.974	-0.045
Min Sx	74	3 LOAD GEN	0.013	0.017	**-1.301**	-0.183	-0.268	-2.970	2.120	1.831
Max Sy	131	3 LOAD GEN	-0.004	0.001	-0.698	**0.104**	0.101	-5.317	-0.503	-0.385
Min Sy	196	3 LOAD GEN	0.022	0.322	-0.048	**-0.226**	-0.021	13.902	46.016	-6.066
Max Sx	134	3 LOAD GEN	-0.007	0.008	-1.020	-0.194	**0.431**	-8.741	-0.151	1.032
Min Sx	122	3 LOAD GEN	-0.008	-0.003	-1.018	-0.188	**-0.483**	-9.368	-0.734	-1.725
Max Mx	255	12 LOAD GE	0.291	-0.598	-0.051	0.005	-0.002	**239.532**	85.090	-1.060
Min Mx	134	11 LOAD GE	-0.086	0.026	-0.367	-0.050	0.001	**-105.919**	-16.281	-1.861
Max My	201	13 LOAD GE	-0.415	0.424	-0.058	0.004	-0.000	195.263	**120.760**	1.413
Min My	228	20 LOAD GE	-0.204	-0.003	0.015	0.059	-0.016	-10.257	**-22.110**	-1.649
Max Mx	193	16 LOAD GE	-0.253	0.084	-0.047	-0.021	-0.011	27.663	8.195	**38.176**
Min Mx	186	9 LOAD GEN	0.256	0.094	-0.047	-0.022	0.012	31.048	8.127	**-38.736**

Fig 4.16: The highlighted row shows the absolute maximum pressure values due to soil load

4.3.3 Vehicle load with different load generations

Reactions are shown in Fig 4.17 and 4.18.

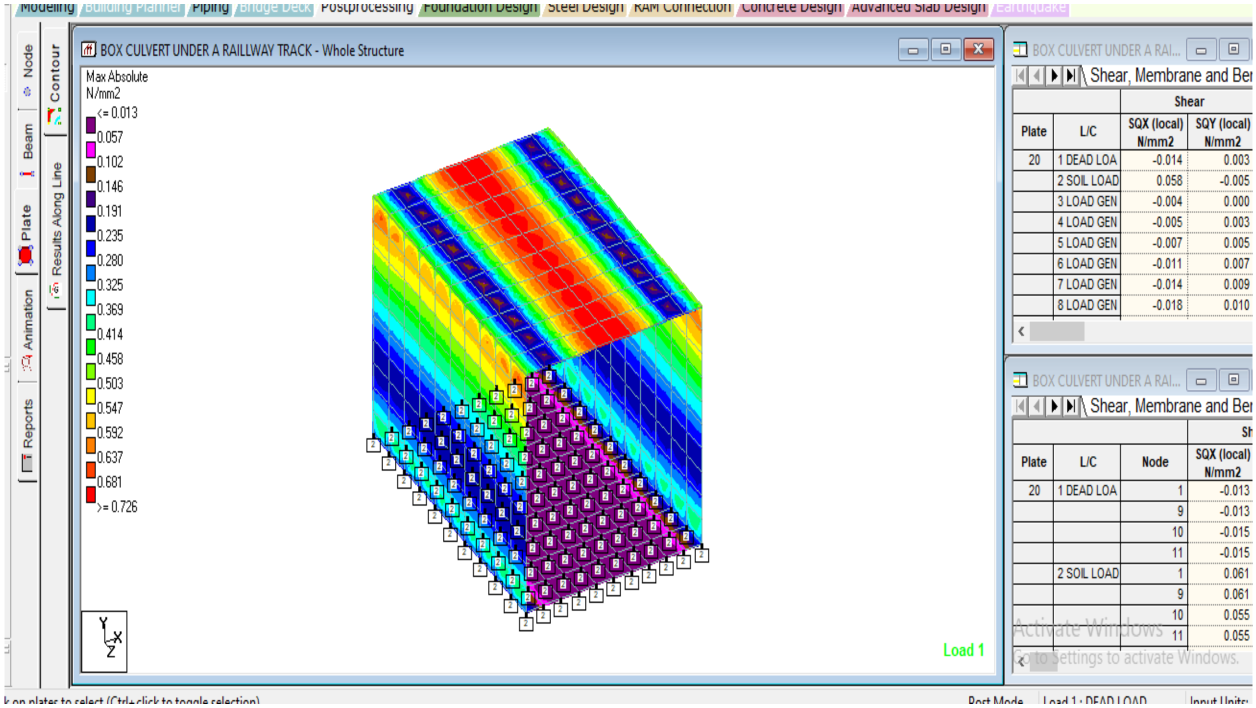


Fig. 4.17 The above picture shows the absolute maximum pressure on the plates due to vehicle load. The red portion is the place where the pressure is maximum.

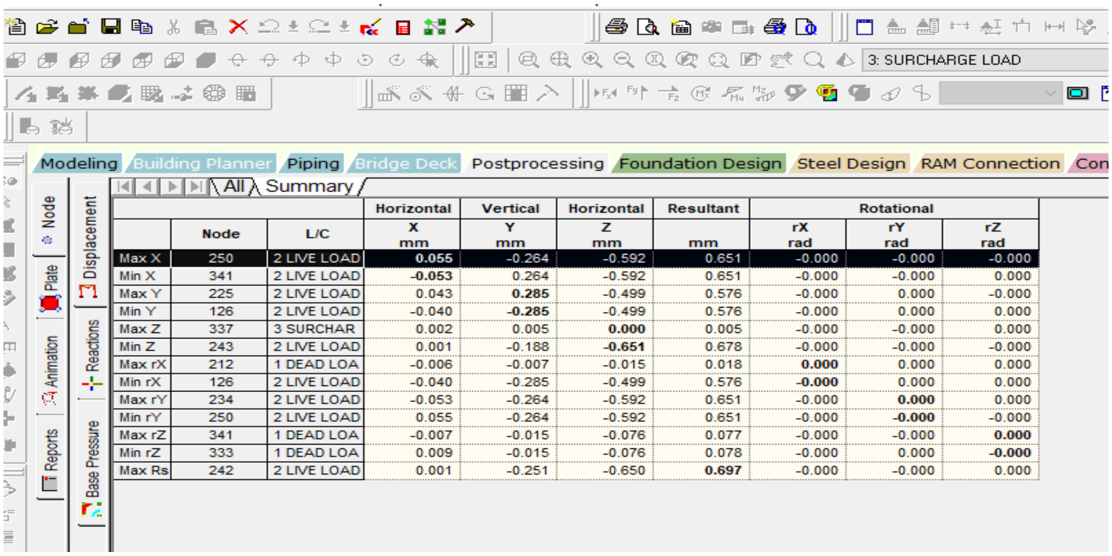
	Plate	L/C	Shear		Membrane			Bending Moment		
			SQX (local) N/mm2	SQY (local) N/mm2	SX (local) N/mm2	SY (local) N/mm2	SXY (local) N/mm2	Mx kNm/m	My kNm/m	Mxy kNm/m
Max Qx	196	5 LOAD GEN	**0.901**	0.226	-0.082	-0.152	0.011	23.243	54.666	-3.831
Min Qx	206	20 LOAD GE	**-0.857**	0.172	-0.086	-0.144	-0.010	10.022	49.009	6.463
Max Qy	245	14 LOAD GE	0.236	**0.617**	-0.060	0.006	-0.000	235.889	83.549	0.980
Min Qy	255	12 LOAD GE	0.291	**-0.598**	-0.051	0.005	-0.002	239.532	85.090	-1.060
Max Sx	525	12 LOAD GE	0.180	-0.000	**0.068**	-0.000	-0.005	23.376	3.974	-0.045
Min Sx	74	3 LOAD GEN	0.013	0.017	**-1.301**	-0.183	-0.268	-2.970	2.120	1.831
Max Sy	131	3 LOAD GEN	-0.004	0.001	-0.698	**0.104**	0.101	-5.317	-0.503	-0.385
Min Sy	196	3 LOAD GEN	0.022	0.322	-0.048	**-0.226**	-0.021	13.902	46.016	-6.066
Max Sx	134	3 LOAD GEN	-0.007	0.008	-1.020	-0.194	**0.431**	-8.741	-0.151	1.032
Min Sx	122	3 LOAD GEN	-0.008	-0.003	-1.018	-0.188	**-0.483**	-9.368	-0.734	-1.725
Max Mx	255	12 LOAD GE	0.291	-0.598	-0.051	0.005	-0.002	**239.532**	85.090	-1.060
Min Mx	134	11 LOAD GE	-0.086	0.026	-0.367	-0.050	0.001	**-105.919**	-16.281	-1.861
Max My	201	13 LOAD GE	-0.415	0.424	-0.058	0.004	-0.000	195.263	**120.760**	1.413
Min My	228	20 LOAD GE	-0.204	-0.003	0.015	0.059	-0.016	-10.257	**-22.110**	-1.649
Max Mx	193	16 LOAD GE	-0.253	0.084	-0.047	-0.021	-0.011	27.663	8.195	**38.176**
Min Mx	186	9 LOAD GEN	0.256	0.094	-0.047	-0.022	0.012	31.048	8.127	**-38.736**

Fig 4.18: The highlighted row shows the absolute maximum pressure values due to vehicle load

4.4 DFC (DEDICATED FREIGHT CORRIDOR)

4.4.1 Reaction on Nodes

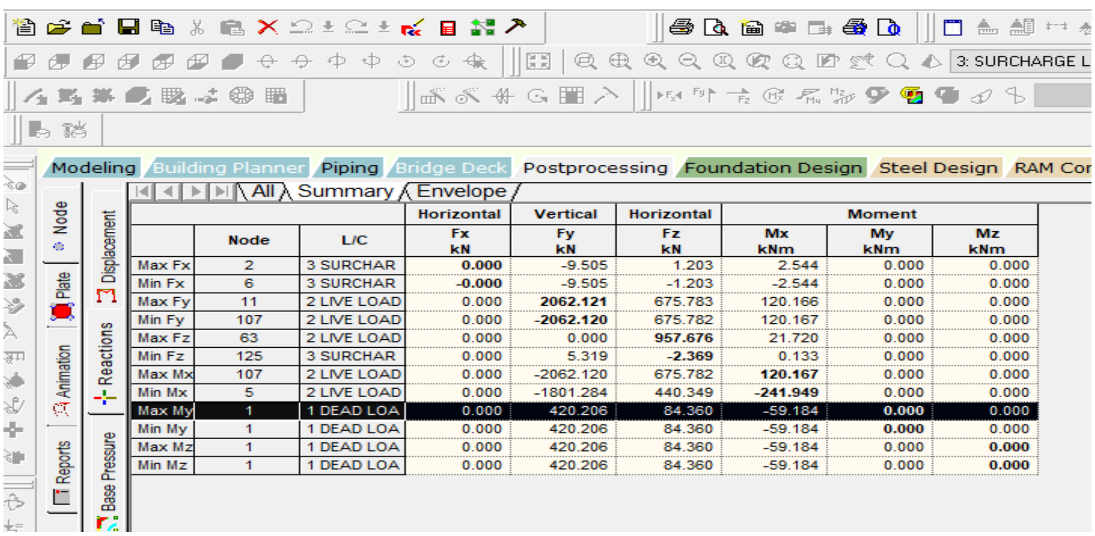
Displacement is shown in Fig 4.19.



	Node	L/C	Horizontal X mm	Vertical Y mm	Horizontal Z mm	Resultant mm	Rotational rX rad	rY rad	rZ rad
Max X	250	2 LIVE LOAD	0.055	-0.264	-0.592	0.651	-0.000	-0.000	-0.000
Min X	341	2 LIVE LOAD	-0.053	0.264	-0.592	0.651	-0.000	-0.000	0.000
Max Y	225	2 LIVE LOAD	0.043	0.285	-0.499	0.576	-0.000	0.000	-0.000
Min Y	126	2 LIVE LOAD	-0.040	-0.285	-0.499	0.576	-0.000	0.000	0.000
Max Z	337	3 SURCHAR	0.002	0.005	0.000	0.005	-0.000	-0.000	0.000
Min Z	243	2 LIVE LOAD	0.001	-0.188	-0.651	0.678	-0.000	-0.000	-0.000
Max rX	212	1 DEAD LOA	-0.006	-0.007	-0.015	0.018	0.000	0.000	0.000
Min rX	126	2 LIVE LOAD	-0.040	-0.285	-0.499	0.576	-0.000	0.000	0.000
Max rY	234	2 LIVE LOAD	-0.053	-0.264	-0.592	0.651	-0.000	0.000	-0.000
Min rY	250	2 LIVE LOAD	0.055	-0.264	-0.592	0.651	-0.000	-0.000	-0.000
Max rZ	341	1 DEAD LOA	-0.007	-0.015	-0.076	0.077	-0.000	-0.000	0.000
Min rZ	333	1 DEAD LOA	0.009	-0.015	-0.076	0.078	-0.000	0.000	-0.000
Max Rs	242	2 LIVE LOAD	0.001	-0.251	-0.650	0.697	-0.000	-0.000	0.000

Fig 4.19: The highlighted row shows the maximum Displacement value in the X direction clearly and other major reaction values can also be seen

Moment at nodes as shown in Fig 4.20.



	Node	L/C	Horizontal Fx kN	Vertical Fy kN	Horizontal Fz kN	Moment Mx kNm	My kNm	Mz kNm
Max Fx	2	3 SURCHAR	0.000	-9.505	1.203	2.544	0.000	0.000
Min Fx	6	3 SURCHAR	-0.000	-9.505	-1.203	-2.544	0.000	0.000
Max Fy	11	2 LIVE LOAD	0.000	2062.121	675.783	120.166	0.000	0.000
Min Fy	107	2 LIVE LOAD	0.000	-2062.120	675.782	120.167	0.000	0.000
Max Fz	63	2 LIVE LOAD	0.000	0.000	957.676	21.720	0.000	0.000
Min Fz	125	3 SURCHAR	0.000	5.319	-2.369	0.133	0.000	0.000
Max Mx	107	2 LIVE LOAD	0.000	-2062.120	675.782	120.167	0.000	0.000
Min Mx	5	2 LIVE LOAD	0.000	-1801.284	440.349	-241.949	0.000	0.000
Max My	1	1 DEAD LOA	0.000	420.206	84.360	-59.184	0.000	0.000
Min My	1	1 DEAD LOA	0.000	420.206	84.360	-59.184	0.000	0.000
Max Mz	1	1 DEAD LOA	0.000	420.206	84.360	-59.184	0.000	0.000
Min Mz	1	1 DEAD LOA	0.000	420.206	84.360	-59.184	0.000	0.000

Fig 4.20: The highlighted row shows the maximum moment value in the Fy direction clearly and other major reaction values can also be seen

4.4.2 Reaction on Plate Loads

Dead load Reactions are shown in Fig 4.21 and Fig 4.22.

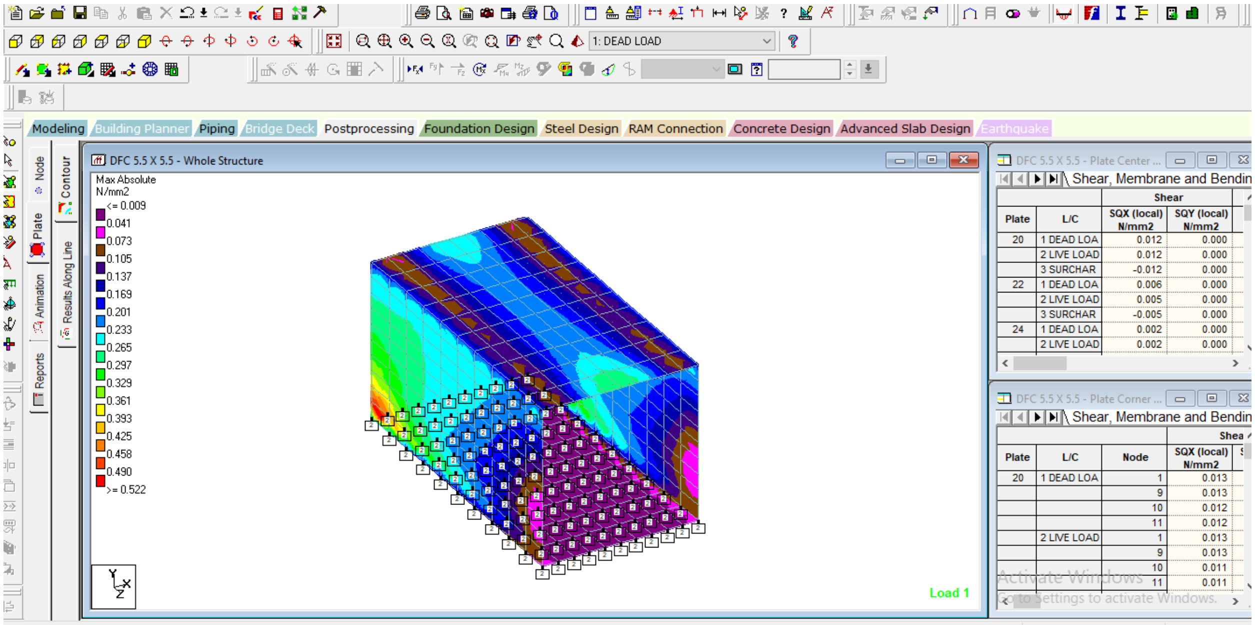


Fig 4.21: The above picture shows the absolute maximum pressure on the plates due to dead load. The red portion is the place where the pressure is maximum

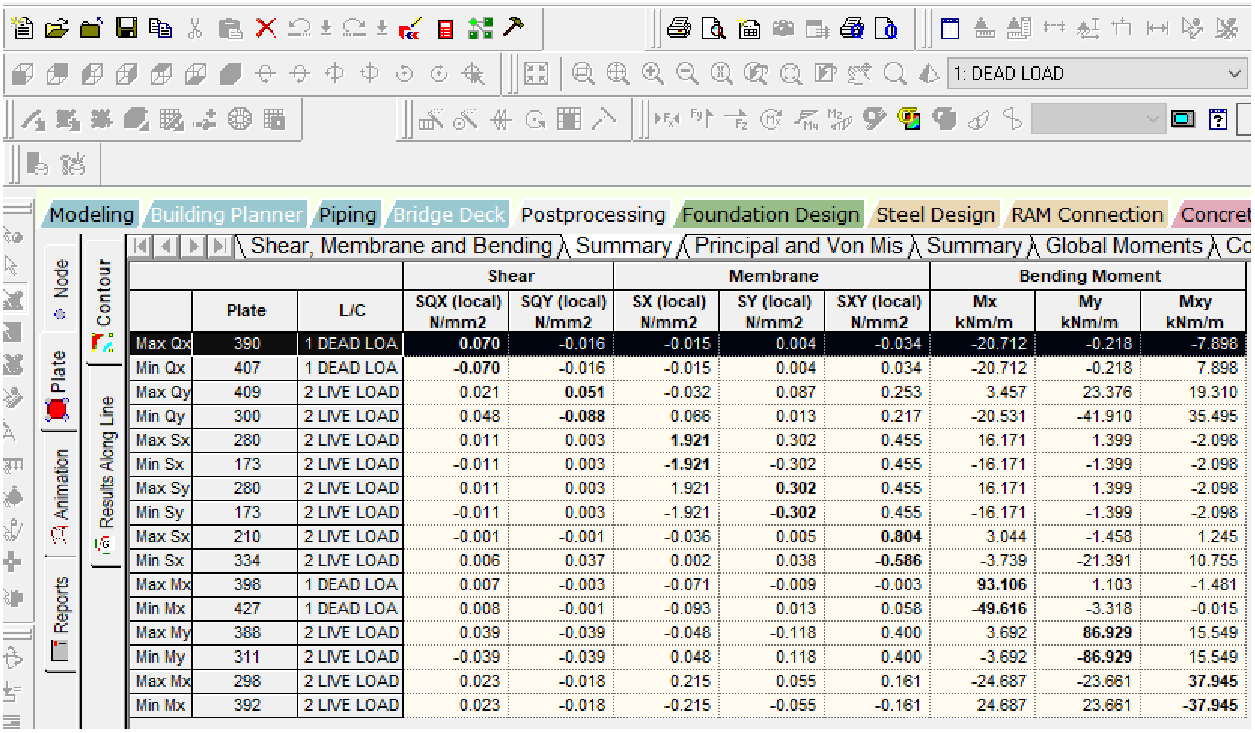


	Plate	L/C	Shear SQX (local) N/mm2	Shear SQY (local) N/mm2	Membrane SX (local) N/mm2	Membrane SY (local) N/mm2	Membrane SXY (local) N/mm2	Bending Moment Mx kNm/m	Bending Moment My kNm/m	Bending Moment Mxy kNm/m
Max Qx	390	1 DEAD LOA	0.070	-0.016	-0.015	0.004	-0.034	-20.712	-0.218	-7.898
Min Qx	407	1 DEAD LOA	-0.070	-0.016	-0.015	0.004	0.034	-20.712	-0.218	7.898
Max Qy	409	2 LIVE LOAD	0.021	0.051	-0.032	0.087	0.253	3.457	23.376	19.310
Min Qy	300	2 LIVE LOAD	0.048	-0.088	0.066	0.013	0.217	-20.531	-41.910	35.495
Max Sx	280	2 LIVE LOAD	0.011	0.003	1.921	0.302	0.455	16.171	1.399	-2.098
Min Sx	173	2 LIVE LOAD	-0.011	0.003	-1.921	-0.302	0.455	-16.171	-1.399	-2.098
Max Sy	280	2 LIVE LOAD	0.011	0.003	1.921	0.302	0.455	16.171	1.399	-2.098
Min Sy	173	2 LIVE LOAD	-0.011	0.003	-1.921	-0.302	0.455	-16.171	-1.399	-2.098
Max Sx	210	2 LIVE LOAD	-0.001	-0.001	-0.036	0.005	0.804	3.044	-1.458	1.245
Min Sx	334	2 LIVE LOAD	0.006	0.037	0.002	0.038	-0.586	-3.739	-21.391	10.755
Max Mx	398	1 DEAD LOA	0.007	-0.003	-0.071	-0.009	-0.003	93.106	1.103	-1.481
Min Mx	427	1 DEAD LOA	0.008	-0.001	-0.093	0.013	0.058	-49.616	-3.318	-0.015
Max My	388	2 LIVE LOAD	0.039	-0.039	-0.048	-0.118	0.400	3.692	86.929	15.549
Min My	311	2 LIVE LOAD	-0.039	-0.039	0.048	0.118	0.400	-3.692	-86.929	15.549
Max Mx	298	2 LIVE LOAD	0.023	-0.018	0.215	0.055	0.161	-24.687	-23.661	37.945
Min Mx	392	2 LIVE LOAD	0.023	-0.018	-0.215	-0.055	-0.161	24.687	23.661	-37.945

Fig 4.22: The highlighted row shows the value of different reaction on the plate due to dead load

4.4.3 Reaction of Soil load

Side wall Reactions are shown in Fig 4.23 and Fig 4.24.

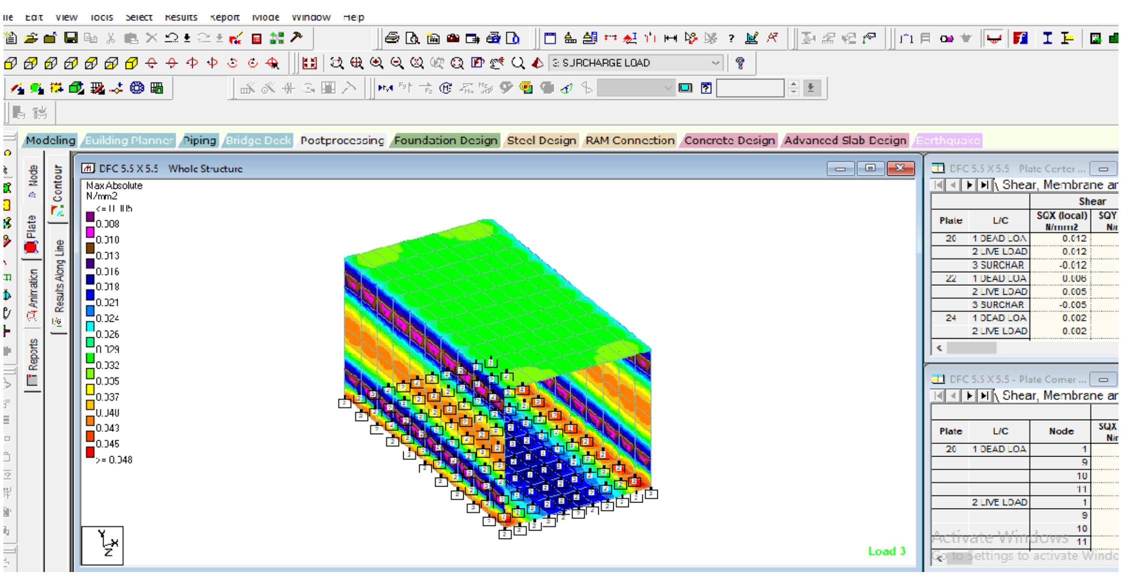
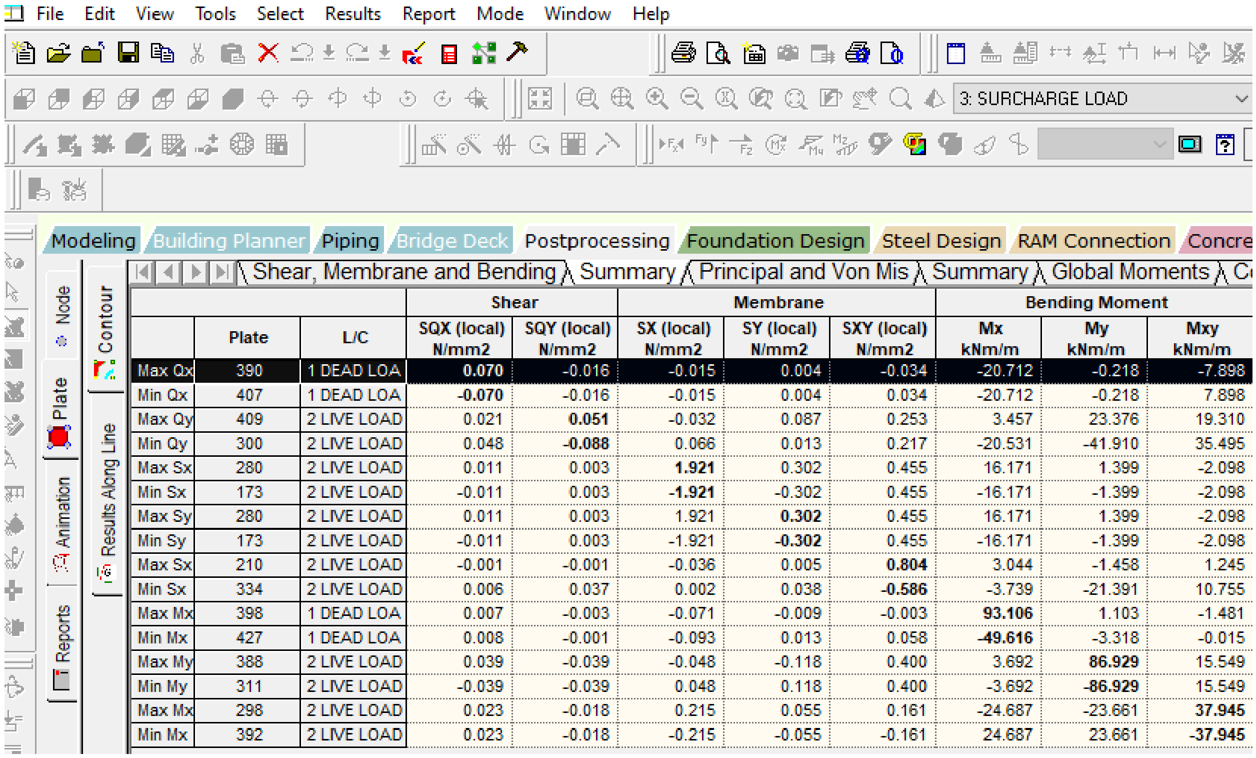


Fig 4.23: This picture shows the pressure on the plates due to soil load on the walls of the culvert



			Shear		Membrane			Bending Moment		
	Plate	L/C	SQX (local) N/mm2	SQY (local) N/mm2	SX (local) N/mm2	SY (local) N/mm2	SXY (local) N/mm2	Mx kNm/m	My kNm/m	Mxy kNm/m
Max Qx	390	1 DEAD LOA	0.070	-0.016	-0.015	0.004	-0.034	-20.712	-0.218	-7.898
Min Qx	407	1 DEAD LOA	-0.070	-0.016	-0.015	0.004	0.034	-20.712	-0.218	7.898
Max Qy	409	2 LIVE LOAD	0.021	0.051	-0.032	0.087	0.253	3.457	23.376	19.310
Min Qy	300	2 LIVE LOAD	0.048	-0.088	0.066	0.013	0.217	-20.531	-41.910	35.495
Max Sx	280	2 LIVE LOAD	0.011	0.003	1.921	0.302	0.455	16.171	1.399	-2.098
Min Sx	173	2 LIVE LOAD	-0.011	0.003	-1.921	-0.302	0.455	-16.171	-1.399	-2.098
Max Sy	280	2 LIVE LOAD	0.011	0.003	1.921	0.302	0.455	16.171	1.399	-2.098
Min Sy	173	2 LIVE LOAD	-0.011	0.003	-1.921	-0.302	0.455	-16.171	-1.399	-2.098
Max Sx	210	2 LIVE LOAD	-0.001	-0.001	-0.036	0.005	0.804	3.044	-1.458	1.245
Min Sx	334	2 LIVE LOAD	0.006	0.037	0.002	0.038	-0.586	-3.739	-21.391	10.755
Max Mx	398	1 DEAD LOA	0.007	-0.003	-0.071	-0.009	-0.003	93.106	1.103	-1.481
Min Mx	427	1 DEAD LOA	0.008	-0.001	-0.093	0.013	0.058	-49.616	-3.318	-0.015
Max My	388	2 LIVE LOAD	0.039	-0.039	-0.048	-0.118	0.400	3.692	86.929	15.549
Min My	311	2 LIVE LOAD	-0.039	-0.039	0.048	0.118	0.400	-3.692	-86.929	15.549
Max Mx	298	2 LIVE LOAD	0.023	-0.018	0.215	0.055	0.161	-24.687	-23.661	37.945
Min Mx	392	2 LIVE LOAD	0.023	-0.018	-0.215	-0.055	-0.161	24.687	23.661	-37.945

Fig 4.24: The highlighted row shows the value of different reaction on the plate due to soil load

Live load

Reactions are shown in Fig 4.25 and Fig 4.26.

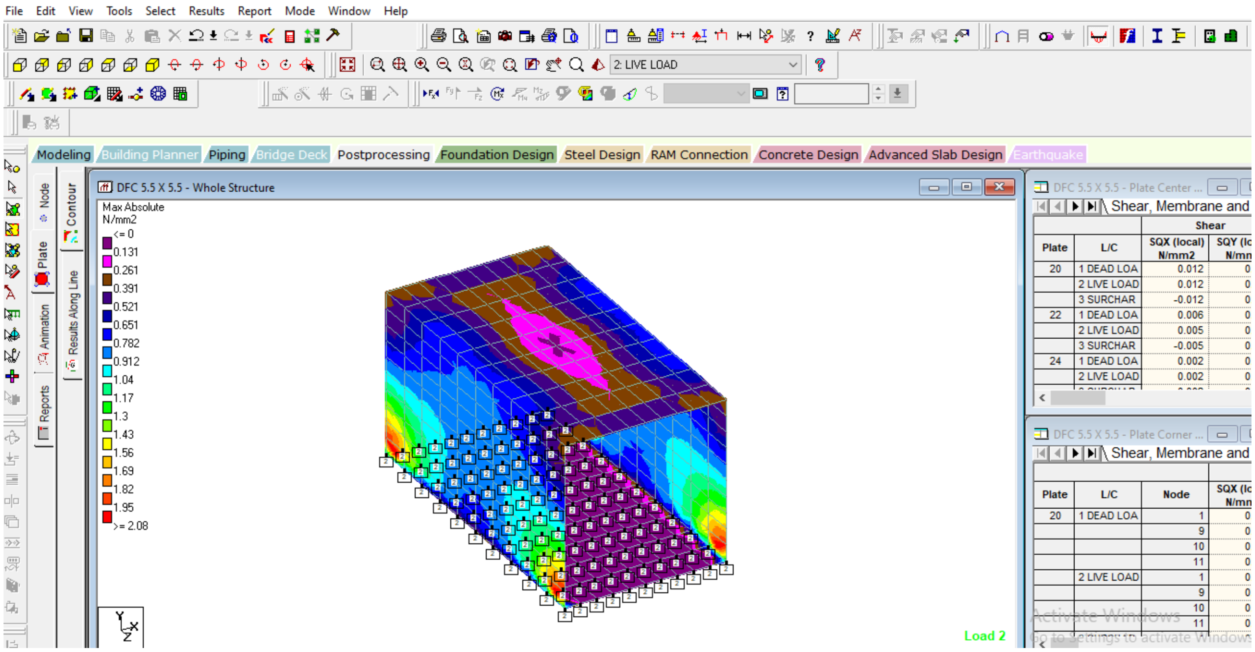


Fig 4.25: The above picture shows the absolute maximum pressure on the plates due to live load. The red portion is the place where the pressure is maximum.

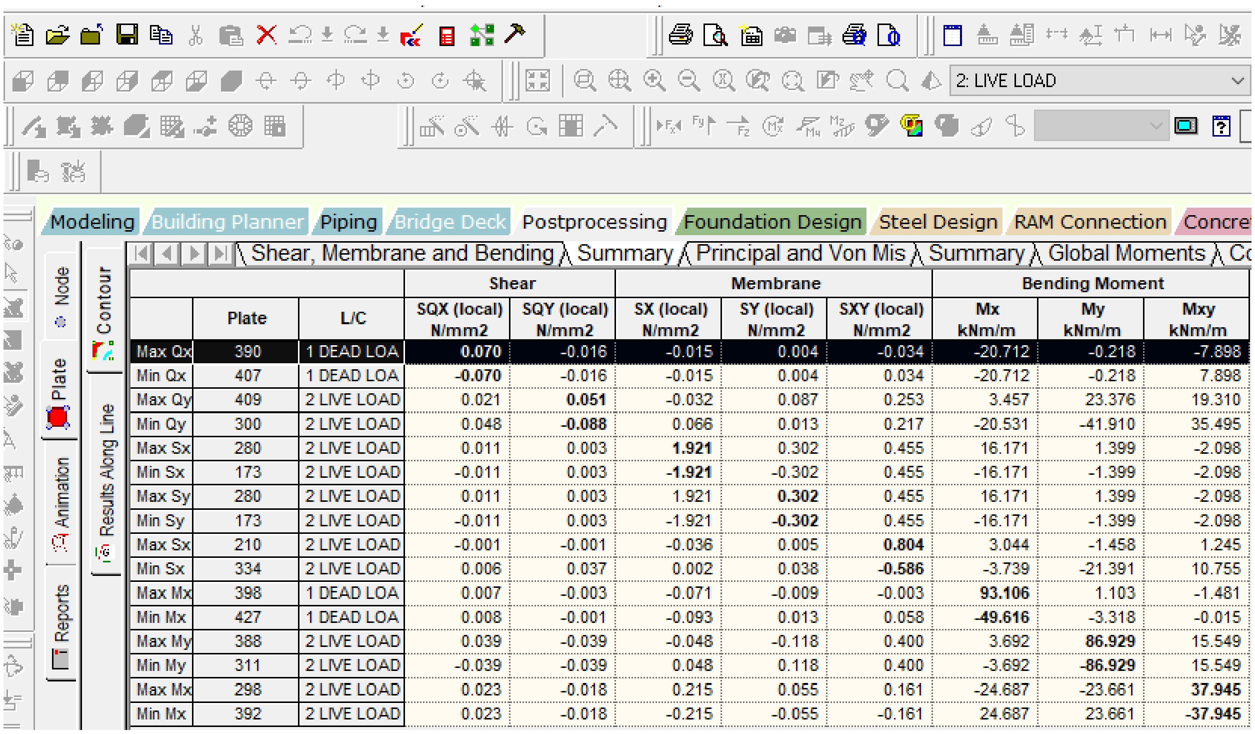


	Plate	L/C	Shear		Membrane			Bending Moment		
			SQX (local) N/mm2	SQY (local) N/mm2	SX (local) N/mm2	SY (local) N/mm2	SXY (local) N/mm2	Mx kNm/m	My kNm/m	Mxy kNm/m
Max Qx	390	1 DEAD LOA	**0.070**	-0.016	-0.015	0.004	-0.034	-20.712	-0.218	-7.898
Min Qx	407	1 DEAD LOA	**-0.070**	-0.016	-0.015	0.004	0.034	-20.712	-0.218	7.898
Max Qy	409	2 LIVE LOAD	0.021	**0.051**	-0.032	0.087	0.253	3.457	23.376	19.310
Min Qy	300	2 LIVE LOAD	0.048	**-0.088**	0.066	0.013	0.217	-20.531	-41.910	35.495
Max Sx	280	2 LIVE LOAD	0.011	0.003	**1.921**	0.302	0.455	16.171	1.399	-2.098
Min Sx	173	2 LIVE LOAD	-0.011	0.003	**-1.921**	-0.302	0.455	-16.171	-1.399	-2.098
Max Sy	280	2 LIVE LOAD	0.011	0.003	1.921	**0.302**	0.455	16.171	1.399	-2.098
Min Sy	173	2 LIVE LOAD	-0.011	0.003	-1.921	**-0.302**	0.455	-16.171	-1.399	-2.098
Max Sx	210	2 LIVE LOAD	-0.001	-0.001	-0.036	0.005	**0.804**	3.044	-1.458	1.245
Min Sx	334	2 LIVE LOAD	0.006	0.037	0.002	0.038	**-0.586**	-3.739	-21.391	10.755
Max Mx	398	1 DEAD LOA	0.007	-0.003	-0.071	-0.009	-0.003	**93.106**	1.103	-1.481
Min Mx	427	1 DEAD LOA	0.008	-0.001	-0.093	0.013	0.058	**-49.616**	-3.318	-0.015
Max My	388	2 LIVE LOAD	0.039	-0.039	-0.048	-0.118	0.400	3.692	**86.929**	15.549
Min My	311	2 LIVE LOAD	-0.039	-0.039	0.048	0.118	0.400	-3.692	**-86.929**	15.549
Max Mx	298	2 LIVE LOAD	0.023	-0.018	0.215	0.055	0.161	-24.687	-23.661	**37.945**
Min Mx	392	2 LIVE LOAD	0.023	-0.018	-0.215	-0.055	-0.161	24.687	23.661	**-37.945**

4.26: The highlighted row shows the absolute maximum pressure values due to live load

Chapter 5

CONCLUSION

This report contains the sequential methods that how we can design a BOX CULVERT in STAAD Pro software under the influence of various loads and parameters according to Indian Standard codes of designing.

The following points are the conclusions that are concluded throughout the designing.

1. Because of the rigidity and monolithic action of the box culvert it becomes very economical.

2. The base slab does not require any separate foundation as it rests on the soil without any support and it serves as raft foundation also known as raft slab.

3. Side walls of the structure face pressure from inside to outside due to flowing water and also from outside to inside due to soil load or due to surcharge load.

4. The top slab contains a wearing coat, whose load is also considered and accompanied with dead load in global y axis direction.

5. Vehicle load is also designed according to IRC AA loading system.

6. The errors are removed after analysis of the design by individual approach to each faulty member of the structure.

7. Dimensions of box culverts for roads and railway are different.

8. Load factors and conditions are to be thoroughly examined before analysis.

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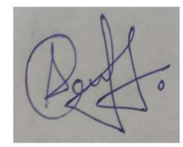
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