ANALYSIS AND DESIGN OF BOX CULVERT

Submitted in partial fulfilment of the requirements of the award of the degree of

Master of Technology

In

Civil Engineering

By

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CERTIFICATE

This is to certify that the project work entitled "**Analysis and design of box culvert**" submitted by **Kuldeep Parashar(18SOCE2010017)** to the School of Civil Engineering, Galgotias University, Greater Noida, for the award of the degree of **Master of Technology in Civil Engineering** is a bonafide work carried out by him/her under my supervision and guidance. The present work, in my opinion, has reached the requisite standard, fulfilling the requirements for the said degree.

The results contained in this report have not been submitted, in part or full, to any other university or institute for the award of any degree or diploma.

(Mr Sushil k. Singh)

Asst. Professor

Guide

(Prof. (Dr) Manju Dominic)

Dean,

School of Civil Engineering

External Examiner

DECLARATION

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Date: 10/05/2020 **(Kuldeep Parashar)**
Place: AGRA **18SOCE2020004**

ABSTRACT

Box Culverts are required to be provided under earth embankment for crossing of water course like streams, Nallas across the embankment as road embankment cannot be allowed to obstruct the natural water way. The culverts are also required to balance the flood water on both sides of earth embankment to reduce flood level on one side of road thereby decreasing the water head consequently reducing the flood menace. Culverts can be of different shapes such as arch, slab and box, etc. These can be constructed with different material such as masonry (brick, stone etc.) or reinforced cement concrete. Since culvert pass through the earthen embankment, these are subjected to same traffic loads as the road carries and therefore, required to be designed for such loads. 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 structural design involves consideration of load cases (box empty, full, surcharge loads etc.) and factors like live load, effective width, braking force, dispersal of load through fill, impact factor, co-efficient of earth pressure etc. Relevant IRC Codes are required to be referred in the analysis and design of box culverts. The aim of this project is to model and analyse the box culvert using STAAD PRO software. This software is an effective and user friendly tool for three dimensional model generation, analysis and multi material design. The structural elements of box culvert are designed to withstand maximum bending moment and shear force. The results found from STAAD PRO are used for safe design of the box.

ACRONYMS & ABBREVIATION

IRC- Indian road congress

Ka - Active earth pressure co-efficient

K_{ah} -Active earth pressure co-efficient (Horizontal)

K_{av} - Active earth pressure co-efficient (vertical)

K_0-Earth pressure coefficient (at rest)

γ - density of concrete

Φ-Angle of friction

α-Angle which earth face of the wall makes with the vertical

β-Slope of earth fill

δ-Angle of friction between the earth and the earth fill

γ_{sub}- Submerged density of earth

P1- Earth- pressure at the center of the top slab

P2- Earth- pressure at the center of the bottom slab

HFL-High flood level

H_{eq}-Equivalent height for the live load surcharge.

H_1-Clear height between FRL & Top of box

H_2-height between the FRL & Soffit of top slab.

H_3-Height between the FRL & center of the Bottom slab

W/C-Thickness of the wearing coat

EP-Earth pressure

SBC-Safe bearing capacity of the soil (Box)

SLS-Serviceability Limit state

1-INTRODUCTION

1.1-GENERAL

Culvert is a tunnel carrying a stream under a road or railway. A culvert may act as a bridge for traffic to pass on it. They are typically found in a natural flow of water and serves the purpose of a bridge or a current flow controller.

Culverts are available in many and shape like round, elliptical, flat-bottomed, pear-shaped, and box-like constructions. Culverts are by their load and water flow capacities, lifespan and installation of bedding and backfill. The type is based on a number of factors including hydraulic, upstream elevation, and roadway height and other conditions.

1.2-TYPES OF CULVERT:

- Pipe culvert (single or multiple)
- Pipe-Arch culvert (single or multiple)
- Box culvert (single or multiple)
- Arch culvert
- Bridge culvert
- Metal box culvert

1.2.1-PIPE CULVERT

Pipe culverts are the most common types of culverts due to competitive price and easy installation. They are found in different shapes such as circular, elliptical and pipe arch. Generally, their shapes depend on site conditions and constraints. Pipe culverts on a small scale represent normal pipes like concrete pipes.

ADVANTAGES OF PIPE CULVERT

The main features of pipe culverts are:

- It can be constructed of any desired strength by proper mix design, thickness, and reinforcement.
- They are economical.
- These pipes can withhold any tensile stresses and compressive stresses.
- The crossing of water is under the structure.

DISADVANTAGES OF PIPE CULVERT

The main disadvantage of pipe culvert is that it can be easily corroded at the crown because of bacteria‘s organic matter and release of harmful gas, which is known as Crown corrosion.

1.2.2-PIPE ARCH CULVERT (SINGLE OR MULTIPLE)

Arch culverts are suitable for large waterway opening where fishes can be provided with a greater hydraulic advantage. Moreover, they provide low clearance and are definitely, much artistic. Pipe arches are particularly useful for sites where headroom is limited and also have a hydraulic advantage at low flows.

ADVANTAGES OF PIPE ARCH CULVERT

The features of pipe arch culverts are:

- Limited headroom condition
- Improved hydraulic capacity at a low flow
- Aesthetic shape and appearance
- Lightweight
- Easy to install

1.2.3-BOX CULVERT

Box culverts are made up of concrete and especially, RCC (Reinforced Concrete). The most challenging part in constructing a box culvert is that dry surface is needed for installing it. However, due to the strength of the concrete floor, water direction can be changed when a large amount of water is expected. This feature makes box culverts, one of the most commonly found types of the culvert.

ADVANTAGES OF BOX CULVERT

Box Culverts are economical for the reasons mentioned below:

- The box culvert is a rigid frame structure and very simple in construction
- It is Suitable for non-perennial streams where scrub depth is not significant but the soil is weak.
- The bottom slab of the box culvert reduces pressure on the soil.
- Box culverts are economical due to their rigidity and monolithic action and separate foundations are not required.
- It is used in special cases, weak foundation.

1.2.4-ARCH CULVERT

An arch culvert is made up of metal, stone masonry, concrete, RCC etc. Construction does not take a lot of time and unlike box culvert, water diversion is not necessary, as it can be installed without disturbing the water current. Thus, it can be termed as a Low Profile Culvert. This type of culvert maintains the natural integrity of the wash bed.

The advantages of using arch culverts over traditional box culverts and pipe culverts are as follows:

- Cost savings
- Accelerated construction schedule
- Greater hydraulic efficiency
- Pleasing aesthetics
- Design-build advantage

1.2.5-BRIDGE CULVERT

Bridge culverts serve a dual purpose. It acts both as a bridge and a culvert. Generally, rectangular in shape, bridge culverts are constructed on rivers and canals. A foundation is laid under the ground level and pavement surface is laid on top of the series of culverts. Generally, we can term it as a Multi-Purpose culvert.

ADVANTAGES OF BRIDGE CULVERT

Following are the main features of bridge culvert:

- Extension of the network by acting as a repeater
- Very strong
- Allows traffic to pass on it
- Highly strong foundation
- Most expensive river crossings

1.2.6-METAL BOX CULVERT

The metal box culvert is the economic alternative of the bridge. These bridges are manufactured from a standard structural plate or deep-corrugated structural plate. They are the perfect bridge replacement maintaining the same road grade level.

ADVANTAGES OF METAL BOX CULVERT

The advantages are as follows:

- Durability
- Shorter construction period and easy installation
- Deformation ability
- Long service life

2-<u>LITERATURE REVIEW</u>

2.1-Junsuk Kang, Frazier Parker, Young J. Kang, and Chai H. Yoo published a paper in 2007 **" Effects of frictional forces acting on sidewalls of buried box culverts "**. They showed the results of the effects of frictional forces acting on the sidewalls of buried box culverts with the help of finite element method and detailed soil modelling. The possibility of reducing earth pressure on deeply buried concrete box culverts by the imperfect trench installation (ITI) method has been contemplated during the last several decades. The soil–structure interaction at the box culvert–soil interface was found to have a significant effect on total earth pressure acting on the bottom slab. Predictor equations for earth load reduction rates were formulated for ITIs incorporating the optimum soft zone geometry based on the finite element method. The analysis results indicated that modulus of elasticity of the lightweight material is a major parameter affecting the earth load reduction rate. In addition, the soil–structure interaction at the box culvert–soil interface was also found to have a significant effect on the total earth pressure at the bottom slab depending upon the coefficient of friction assumed. Hence, interface conditions were incorporated in the proposed equations of the earth load reduction rate.

2.2-T.M. Elshimi, A.C. Mak, R.W.I. Brachman & I.D. Moore published a paper in 2011 on the topic "**Behaviour of a deep-corrugated large-span box culvert during backfilling**". In this paper he presented results from a full-scale experiment of a 10-m-span deep-corrugated metal box culvert. The culvert was instrumented and backfilled with compacted Granular A material under controlled laboratory conditions to a cover depth of 1.5 m. Two and three-dimensional finite element analyses were performed to model its behaviour during backfilling. The effect of soil compaction on the culvert's response during backfilling was also considered in the model. The results showed that the maximum upward displacement during side backfilling of the structure to a height of 1.8 m was only 3.2 mm and the maximum deformation measured in a single lift occurred when the first lift of soil was placed over the crown. The three-dimensional finite element analysis was able to calculate central deflections and maximum bending moments within 5 and 6% of the measured values. The behaviour of a 10-m span deep-corrugated metal box culvert measured in the laboratory during backfilling with well-graded sand and gravel was reported. The box culvert deformations and bending moments were calculated using two and three-dimensional finite element analysis and compared to the measured values. For the particular conditions examined, the following can be concluded:

1. The behaviour of the box culvert during backfilling was successfully predicted using the three-dimensional finite element analysis. Two-dimensional finite element analysis successfully predicted the deformed shape and overestimated the bending moment of the box culvert at the shoulder by about 20% of the average measured values.

2. Modelling the increase in lateral stresses due to soil compaction has a minor effect on the response of long-span deep-corrugated metal box culvert during backfilling. The change in the crown displacement due to compaction was less than 4% of the displacement calculated without modelling compaction. The changes in the bending moment values at the crown and the shoulder due to compaction were less than 7% of the moment calculated without modelling compaction effects on lateral stresses.

3. The Canadian Highway Bridge Design Code moment equation overestimates the moment of long-span metal box culverts especially for deep soil cover. At a soil cover of 1.5 m, The Canadian Highway Bridge Design Code moment equation for the 10 m span test culvert overestimated the measured moment by about 73%.

The results and conclusions are for the particular conditions, materials and construction methods examined. Since backfilling was conducted without using a light weight dozer as permitted by the manufacturer's specifications, the potential effects of loading from permitted construction equipment during backfilling should be considered.

2.3-M.G. Kalyanshetti, S.A. Gosavi published a paper in 2014 "**Analysis of box culvert - cost optimization for different aspect ratios of cell**". In this paper he presented about Reinforced concrete box culvert that consists of top slab, bottom slab and two vertical side walls built monolithically which form a closed rectangular or square single cell. By using one or more intermediate vertical walls multiple cell box culverts is obtained. Multiple cell reinforced box culverts are ideal bridge structure if the discharge in a drain crossing the road is large and if the bearing capacity of the soil is low the single box culvert becomes uneconomical because of the higher thickness of the slab and walls. In such cases, more than one box can be constructed side by side monolithically. In conventional method thickness of box culvert is assumed and later on check for thickness is taken. But this may leads to uneconomical design therefore an attempt is made to evaluate optimum thicknesses for economical design. In the present work 12 m channel length is consider for analysis with 2m to 6m height variation which is again divided into single cell, double cell and triple cell. IRC class AA tracked live load is considered. The analysis is done by using stiffness matrix method and a computer program in C language is developed for the cost evaluation. Study is carried out related to variation in bending moment; subsequently cost comparison is made for different aspect ratios. The percentage reduction in cost of single cell, double cell and triple cell based on optimum thicknesses are presented. The optimum thicknesses presented over here are used to achieve the economical design of box culvert. Based on these optimum thicknesses optimum cost per meter width of single cell, double cell and triple cell is evaluated. The study reveals that the cost of box culvert reduces if the optimum thicknesses which are presented in this study are considered.

From which he conclude that:-

- Top slab of box culvert is critical member which carries maximum bending moment.
- The bending moments of different members of box culvert are determined for various aspect ratios and are presented in the form of charts. Using these charts bending moment can be calculated for intermediate aspect ratios also. The charts can be used as a readily reference for obtaining the bending moment for any different aspect ratio.
- In the conventional method of analysis thickness is approximately consider as L/20. However the optimum thickness are different for different aspect ratios for 12m channel length which is divided into single cell, double cell and triple cell they are in the range of L/17 to L/18.5 for 12 m span, L/17.6 to L/21.5 for 6 m span & L/10 to L/20 for 4 m span.
- Based on the optimum thicknesses evaluated for 12m channel length average percentage cost reduction per meter width for single cell is 1.84%, for double cell 4.18% and for triple cell 2.78%.

2.4-Mr. Afzal Hanif Sharif published his review report on "**Analysis and design of railway Box Bridge**". In which he analyse the railway box bridge with the help of staad pro software then and designed all structural elements of box bridge. Then he checked the safety of the bridge.

From this he concluded that Box Bridge is structurally very strong, rigid & safe. Box Bridge does not need any elaborate foundation and can easily be placed over soft foundation by increasing base slab projection to retain base pressure within safe bearing capacity of ground soil. Box Bridge is easy to construct, practically no maintenance. It can have multi cell to match discharge within smaller height of embankment. The designer has option to select the number of cells with desired span to depth ratio suiting to hydraulic conditions at site.

2.5-Vasu Shekhar Tanwar, M. P. Verma and Sagar Jamle published a paper in 2018 on the topic "**Analytic Study of Box Culvert to Reduce Bending Moment and Displacement Values**". In this work they tried to reduce the Bending Moment values and displacement values in order to make structure more safe and reliable to construct and use. These are the following cases of different types of loads which are acting on the box culvert.

Case-1: Dead load, live load, earth pressure acting from outside, no water pressure acting from inside.
Case-2: Dead load, live load, earth pressure acting from outside, water pressure acting from inside.
Case-3: Dead load, earth pressure acting from outside, no water pressure reacting from inside without live load.

After the analysis they concluded that:-

- Displacement values and Bending moment values declined and gave a positive response for structural change.
- Displacement declined in case 1 by 93.89% as the minimum value of displacement is taken.
- Displacement declined in case 2 by 93.61% as the minimum value of displacement
- Displacement declined in case 3 by 92.56% as the minimum value of displacement
- Bending Moment declined in case 1 by 84.23% as the minimum value of Bending Moment.
- Bending Moment declined in case 2 by 90.22% as the minimum value of Bending Moment.

- Bending Moment declined in case 3 by 97.84% as the minimum value of Bending Moment.

2.6-Neha Kolate1, Molly Mathew and Snehal Mali published a paper in 2014 on the topic "**Analysis and Design of RCC Box Culvert**". In this paper they analyse a box of 3m*3m. Various load cases are calculated for the box and the box is checked for shear and shear reinforcement provided on the site. Basically, there is no difference in design of single cell and multi cell box having two, three or more cells. The bending moment is obtained by moment distribution considering all the cells together for different combination of loading and design of section accomplished for final bending moments for that member. Shear force and resulting shear stress have to be checked for members independently.

After analysis and design they conclude that:-

- Box for cross drainage works across high embankments has many advantages compared to slab culvert.
- Box culvert is easy to add length in the event of widening of the road.
- Box is structurally very strong, rigid & safe.
- Box does not need any elaborate foundation and can easily be placed over soft foundation by increasing base slab projection to retain base pressure within safe bearing capacity of ground soil.
- Box of required size can be placed within the embankment at any elevation by varying cushion. This is not possible in case of slab culvert.
- Easy to construct, practically no maintenance, can have multi cell to match discharge within smaller height of embankment.
- Small variation in co-efficient of earth pressure has little influence on the design of box particularly without cushion.
- For culverts without cushion taking effective width corresponding to α for continuous slab shall not be correct. It is likely to provide design moments and shear on lower side hence not safe.
- For box without cushion braking force is required to be considered particularly for smaller span culverts. Further for distribution of braking force effects the same effective width as applicable for vertical application of live load shall be considered. If braking force is not considered or distributed over the whole length of box (not restricted within the effective width) shall be unsafe.

- 10. For box without cushion having low design moments and shear stress as compared to the box having cushion. So steel required is less in the box with no cushion as compared to cushion.

2.7-B.N. Sinha and R.P. Sharma published a paper in 2009 on the topic "**RCC box culvert - methodology and Designs including computer method**". In this paper they 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 Paper has been further restricted to the structural design of box. The structural design involves consideration of load cases (box empty, full, surcharge loads etc.) and factors like live load, effective width, braking force, dispersal of load through fill, impact factor, co-efficient of earth pressure etc. Relevant IRC Codes are required to be referred. The structural elements are required to be designed to withstand maximum bending moment and shear force.

From this work they conclude that:-

- Box for cross drainage works across high embankments has many advantages compared to a slab culvert.
- It is easy to add length in the event of widening of the road.
- Box is structurally very strong, rigid and safe.
- Box does not need any elaborate foundation and can easily be placed over soft foundation by increasing base slab projection to retain base pressure within safe bearing capacity of ground soil.
- Box of required size can be placed within the embankment at any elevation by varying cushion. This is not possible in case of slab culvert.
- Right box can be used for flow of water in skew direction by increasing length or providing edge beam around the box and it is not necessary to design skew box.
- Easy to construct, practically no maintenance, can have multi-cell to match discharge within smaller height of embankment.
- Small variation in co-efficient of earth pressure has little influence on the design of box particularly without cushion.

- For culverts without cushion (or little cushion) taking effective width as per provision in IRC: 21-2000 corresponding to α for continuous slab shall not be correct. It is likely to provide design moments and shear on lower side hence not safe.
- For box without cushion braking force is required to be considered particularly for smaller span culverts. Further for distribution of braking force effects the same effective width as applicable for vertical application of live load shall be considered. If braking force is not considered or distributed over the whole length of box (not restricted within the effective width) the design shall be unsafe.
- It may be seen that α affects effective width, mainly applicable for the top slab (particularly for box without cushion) and braking force. As regards bottom slab and top and bottom slabs of box with cushion due to dispersal of loads either through walls or through fills effective width loses its applicability.
- The design of box is covered by three load cases dealt in this paper. The forth situation when whole box is submerged under water, provide design moments etc. less than given by the three load cases hence need not be considered.
- The design of box with cushion done by STAAD. Pro computer software compares very close to manual design.

3-MATERIAL AND ITS PROPERTIES

3.1-SOIL

Soil is a material composed of five ingredients — minerals, soil organic matter, living organisms, gas, and water. Soil minerals are divided into three size classes — clay, silt, and sand. The percentages of particles in these size classes is called soil texture. The mineralogy of soils is diverse. A clay mineral called smectite can shrink and swell so much upon wetting and drying that it can knock over buildings. The most common mineral in soils is quartz. We are using here dry soil. Physical properties of soil include colour, texture, structure, porosity, density, consistence, temperature, and air. Colours of soils vary widely and indicate such important properties as organic matter, water, and redox conditions. Soil texture, structure, porosity, density, and consistence are related with types of soil particles and their arrangement. There are two types of soil particles—primary and secondary. Primary particles include sand, silt, and clay, categorized on the basis of their effective diameter. There are important differences in physical, chemical, and mineralogical properties of these fractions. Their relative proportion in a soil is called soil texture. It is a fundamental property of soil. It is not easily altered. There are 12 textural classes ranging from sand to clay. Soil structure is the arrangement of soil particles into different geometric patterns. It is classified into different types on shape, classes on size, and grades on stability. Soil structure is amenable. Soil texture and structure together regulate porosity, density, compactness, retention, and movement of water and air in soil. Soil temperature is slightly higher than air temperature in a place.

3.2-CEMENT

Cement, one of the most important building materials, is a binding agent that sets and hardens to adhere to building units such as stones, bricks, tiles, etc. Cement generally refers to a very fine powdery substance chiefly made up of limestone (calcium), sand or clay (silicon), bauxite (aluminium) and iron ore, and may include shells, chalk, marl, shale, clay, blast furnace slag, slate. The raw ingredients are processed in cement manufacturing plants and heated to form a rock-hard substance, which is then ground into a fine powder to be sold. Cement mixed with water causes a chemical reaction and forms a paste that sets and hardens to bind individual structures of building materials.

Cement is an integral part of the urban infrastructure. It is used to make concrete as well as mortar, and to secure the infrastructure by binding the building blocks. Concrete is made of cement, water, sand, and gravel mixed in definite proportions, whereas mortar consists of cement, water, and lime aggregate. These are both used to bind rocks, stones, bricks, and other building units, fill or seal any gaps, and to make decorative patterns. Cement mixed with water silicates and aluminates, making a water repellent hardened mass that is used for water-proofing.

3.3-WATER

Water as a raw material to make any kind of cementitious paste (be it plain cement concrete/reinforced/or with additives/simple mortar paste). It is what helps initiate the hydration reaction of the cement to turn that slurry of the mix to act as a binder between all its constituents (bulk matter).Water in soil preparation in carious structures. Be it to help compact soil to its densest underneath a road, or on the back side of a retaining wall, foundations etc. Water as a curing compound. Water as a raw material during manufacture of various civil materials. Say during quenching in TMT process of the reinforcements etc. Or in standardised testing (as various test are performed under some or the other water requirements. Water as a weathering action (opposing) force needs to be considered as well. Say to estimate the damage to a steel structure in a heavy rainfall area, so we can better judge the structures durability and take counter-measures. Or to say ground water table rising up and compromising the strength of soil base and others.

3.4-STEEL

Steel is the most commonly used structural metal, due to its various properties like great strength, good ductility and high strength, allowing easy fabrication. Due to its high strength members of light sections can be used to carry a heavy load, which means there is considerable reduction in dead load.

It is due to this reason, steel becomes an affordable material for making very long span structures like auditoriums, sport halls etc. Due to their stiffness, steel members deflect to very small extents often not needing special consideration. Steel allows itself to be worked easily in the fabricating shop in various ways like, drilling, sawing, flame cutting etc. It allows joining easily by welding. Steel is also comparatively cheaper to other metals. For instance, Aluminium may cost 3 to 4 times more than the usual grades of steel. Steel allows easy erections and may not need form work. Considerable part of the steel structure can be prefabricated accurately in the workshop, away from the construction site.

Due to its relatively lower weight, steel allows making large span structures. It is worthy to note that construction is fast with steel. For example, constructing a bridge over a busy road or railway line can be done in the shortest duration of time, considerably minimizing the period of obstruction. Steel also allows any later modifications like extensions easily.

Tensile Strength:
The stress applied to cause failure of the material is considerably greater than the yield stress.

Ductility:
Steel has this important property to undergo substantial deformation without fracture. At the stage of failure, the strain may be 0.25 for mild steel, whereas this strain at failure will be less in the case of high carbon steels. It may also be noted that the range of elastic strain is just a small part of the total strain occurring as the material reaches the fracture stage.

3.5-AGGREGATES

Aggregates are inert granular materials such as sand, gravel, or crushed stone that, along with water and Portland cement, are an essential ingredient in concrete. For a good concrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of concrete. Aggregates, which account for 60 to 75 percent of the total volume of concrete, are divided into two distinct categories--fine and coarse. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 3/8-inch sieve. Coarse aggregates are any particles greater than 0.19 inch, but generally range between 3/8 and 1.5 inches in diameter. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder. Natural gravel and sand are usually dug or dredged from a pit, river, lake, or seabed. Crushed aggregate is produced by crushing quarry rock, boulders, cobbles, or large-size gravel. Recycled concrete is a viable source of aggregate and has been satisfactorily used in granular subbases, soil-cement, and in new concrete. After harvesting, aggregate is processed: crushed, screened, and washed to obtain proper cleanliness and gradation. If necessary, a benefaction process such as jigging or heavy media separation can be used to upgrade the quality. Once processed, the aggregates are handled and stored to minimize segregation and degradation and prevent contamination. Aggregates strongly influence concrete's freshly mixed and hardened properties, mixture proportions, and economy. Consequently, selection of aggregates is an important process. Although some variation in aggregate properties is expected, characteristics that are considered include:

- grading
- durability
- particle shape and surface texture
- abrasion and skid resistance
- unit weights and voids
- absorption and surface moisture

Grading refers to the determination of the particle-size distribution for aggregate. Grading limits and maximum aggregate size are specified because these properties affect the amount of aggregate used as well as cement and water requirements, workability, pumpability, and durability of concrete. In general, if the water-cement ratio is chosen correctly, a wide range in grading can be used without a major effect on strength. When gap-graded aggregate are specified, certain particle sizes of aggregate are omitted from the size continuum. Gap-graded aggregate are used to obtain uniform textures in exposed aggregate concrete. Close control of mix proportions is necessary to avoid segregation.

DESIGN OF SINGLE CELL BOX CULVERT

4.1 GENERAL:-

These calculations pertain to design of RCC Box culvert. The clear opening inside the box has been kept as 6X3 m. The box section has been idealised as plane frame of unit width and analysed using STAADPRO software. Effect of Live Load on deck slab has been computed as per Anexure B-3 of IRC:112

4.2 IS CODES:-

All the elements of the bridge shall be designed as per provisions of IRC codes. Following codes shall be used.

IRC - 5	Standard Specifications and code of practice for road bridges, Section I - General Features
IRC - 6	Standard Specifications and code of practice for road bridges, Section II - Load & Stresses
IRC - 112	Code of Practice for Concrete Road Bridges

Other codes (BIS, BS etc.) and specilist literature will also be refered as and when required.

4.3 MATERIAL :-

Concrete grade box	M25
Reiforcement	Fe 500 confirming to IS 1786

4.4 CALCULATION OF ACTIVE EARTH PRESSURE COEFFICIENT:-

Ka = Sin^2 (a+f)/ [Sin^2 a sin (a-d) {1+ sqrt ((Sin(f+d).Sin (f-i))/(Sin (a-d).Sin(a+i)))} ^{2}]

Angle of internal Friction f	30	deg
Angle of Friction between soil and concrete d	20	deg
Surcharge angle i	0	deg
Angle of wall face with horizontal, a	90	deg
Bulk Density of earth g	2	t/m^3
Submerged Density of Earth g_{sub}	1	t/m^3

a+f	2.09	rad	Sin^2(a+f)=	0.75
a	1.57	rad	Sin^2(a)=	1.00
a-d	1.22	rad	Sin(a-d)=	0.94
f+d	0.87	rad	Sin(f+d)=	0.77
f-i	0.52	rad	Sin(f-i)=	0.50
a+i	1.57	rad	Sin(a+i)=	1.00
d	0.35	rad	Sin(d)=	0.34
			Cos(d)=	0.94

Ka-	0.297
Ka horizontal-	0.279
Ka vertical-	0.102

DESIGN OF SINGLE CELL BOX

4.5 DESIGN OF BOX :-

4.5.1 BASIC DESIGN DATA:-

Clear Span	6	m
Min ht at entrance	3	m
Max clear ht at exit of box	3	m
skew angle	0	degrees
GL	272.311	m
Effective span of box	6.35	m
Total clear ht at entrance	3	m
FRL	276.351	m
Top of box	275.325	m
Foundation lvl	271.625	m
Clear height	3.000	m
Wall Thickness (Assumed)	0.35	m
Effective span of box	6.35	m
Dry Density of fill/soil	20	kN/m^3
Submerged Density of fill/soil	10	kN/m^3
Density of water	10	kN/m^3

4.5.2 LOAD CALCULATIONS:-

1 SELF-WEIGHT:-

Self weight command has been applied in stad pro & resective bending moment and shear force has ben tabulated in the table below:-

2 SUPER IMPOSED DEAD LOAD:-

2)a- Cushion weight:-

Cushion height	1.026	m
Avg density of cushion	22	kN/m^3
Wt of cushion	22.572	kN/m

3 LIVE LOAD CALCULATIONS:-

Type of loading considered:- 40t bogie load/70R tracked vehicle

The above mentioned loading on the effective width in Staad pro & their respective bending moment n shear force has been tabulated below

Effective width of the live load (refer Annexure-A)

4 EARTH PRESSURE CALCULATIONS:-

4)a- Active earth pressure :- clause 214.1.1.1 of IRC-06

Maximum water level is considered upto Sofffit of top flange of box. It is proposed to design the box for earth pressure only. Pressure diagram is shown below.

Active Earth Pr Coeff. (Ka)		0.279		
Active Earth pressure at P1=	= (0.279 * 22 * 1.201	$\boxed{7.37}$	kN/m^2	(Pressure due dry soil at center of top slab)
Active Earth pressure at P2=	(Pressure due dry soil abv HFL)	+	(Pressure due submerged soil below HFL)	
Active Earth pressure at P2=	= (0.279 * 22 * 1.376	+	=0.279*10*(3.175)	
Active Earth pressure at P2=	8.45	+	8.86	
Active Earth pressure at P2=	= 8.45+ 8.86 = 17.31 Kn/m2			

4)b- <u>Earth Pressure at rest :-</u> (Refer, cl 214.1.3 of IRC-06-2017)

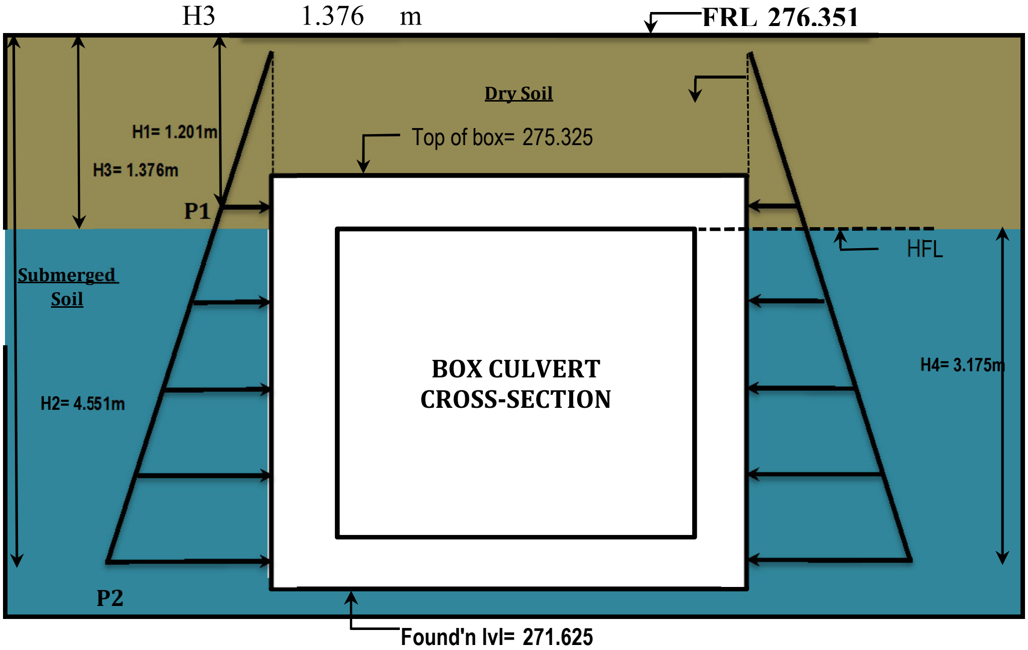
Earth Pr Coeff. At Rest(Ko)		0.500		
Earth pressure at rest P1=	= (0.5 * 22 * 1.201)	$\boxed{13.21}$	kN/m^2	(Pressure due dry soil at center of top slab)
Earth pressure at rest P2=	(Pressure due dry soil abv HFL)	+	(Pressure due submerged soil below HFL)	
Earth pressure at rest P2=	= (0.5 * 10 * 1.376)	+	=0.5*10*(3.175)	
Earth pressure at rest P2=	15.14	+	15.88	
Earth pressure at rest P2=	= 15.14+ 15.88 = 31.02 Kn/m2			

5 <u>LIVE LOAD SURCHARGE CALCULATIONS:-</u>

<u>Earth pressure due to live load surcharge</u> (Refer, cl 214.1.1.3 of IRC-06-2017)

Equival'nt height of soil for vehicular loadin		1.2	m	cl.214.1.1.3 ,IRC 06-2017
Active EP due to live load surcha	=0.279 * 20 * Heq	6.7	kN/m^2	
EP due to live load surcharge at r	=0.5 * 20 * Heq	12	kN/m^2	

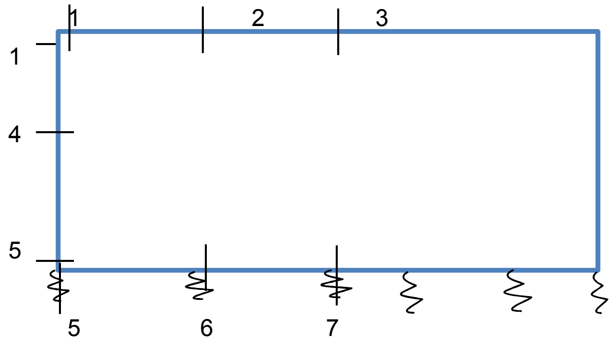
	H1	1.201	m
Where:-	H2	4.551	m
	H3	1.376	m



4.5.3 COMPUTAION OF BENDING MOMENTS :-

Box-Structure is idealised as plane frame using STAADPRO for computing Bending Moments. Bottom slab is assumed to be supported on no. of springs.

4.5.4 BM AT CRITCAL SECTIONS AND REINF. CALCULATION :-



+VE BM Tension outside

-VE BM Tension inside

Sections	Description
1	(At L=0) i.e Top slab-wall support
2	(At L/4) of Top slab
3	(At L/2) i.e Mid of Top slab
4	(At H/2) i.e Mid of Vertical wall
5	(At L=0) i.e Bottom slab-wall support
6	(At L/4) of Bottom slab
7	(At L/2) i.e Mid of Bottom slab

Moments in **KNM** are tablated below for 7 critical sections shown in sketch.

Load Case	Description	Section						
		1	2	3	4	5	6	7
1	Self-weight	16	-17	-28	29	40.80	-26	-48.07
2	W/C +cushion	50	-36	-65	49	47.80	-36	-63.55
3	Live load	52	-37	-67	51	49.70	-38	-66.10
4	Active EP	4	4	4	-14	4.28	4	4.07
5	At Rest EP	7	7	7	-24	7.68	7	7.29
	EP (LL Sur.)							
6	Active EP	2	2	2	-7	2.21	2	2.10
7	At Rest EP	4	4	4	-13	3.96	4	3.76

4.5.5 CHECK FOR BASE PRESSURE:-

Length of the member in staad	0.79	m
Width of the member in staad	1	m
Area of the member in staad	0.79	m^2

Calculation of maximum downward pressur

Load case	P(kn)	Max. pr- P/A(kn/m2)
Self-weight +Cushion weight	20.1	25.44
Due Live load	19.2	24.3
Due fill above bottom slab	5	6.33

Max downward pressure due critical load cases	56	Kn/m^2
Max Alowwable base pressure (SBC)	120	Kn/m^2
Hence ,Base pressure on bottom slab deemed to be	**SAFE**	

4.5.6 LOAD FACTORS FOR ULS CHECK

Load Case	Description	Load Factors in combination				
		1	2	3	4	5
1	Self-weight	1.35	1.35	1.35	1.35	1.35
2	W/C +cushion	1.75	1.75	1.75	1.75	1.75
3	Live load	1.50	1.15	1.50	1.15	1.50
4	Active EP	0.00	0.00	1.00	1.50	1.00
5	At Rest EP	1.00	1.50			
	EP (LL Sur.)					
6	Active EP	0.00	0.00	1.00	1.50	
7	At Rest EP	1.00	1.50			

4.5.7 FACTORED ULS LOADS AND REINFORCEMENT:-

SECTION	1	2	3	4	5	6	7
COMB 1	198	-129	-240	163	225	-144	-264
COMB 2	186	-111	-211	127	213	-125	-236
COMB 3	194	-134	-245	180	220	-149	-269
COMB 4	178	-118	-219	152	206	-133	-243
COMB 5	191	-136	-247	187	218	-151	-271
DESIGN BM	**198**	**-136**	**-247**	**187**	**225**	**-151**	**-271**
D	350	350	350	350	350	350	350
Cover	50	50	50	50	50	50	50
effective depth	290	290	290	290	290	288	288
Lever arm=0.9 deff	261	261	261	261	261	259	259
STATUS	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**
Ast	1747	1199	2178	1645	1981	1341	2409
Bar size type 1	20	20	20	20	20	25	25
Bar size type 2	16		16	16	16		16
Spc Prov. Type 1	220	220	220	220	220	220	220
Spc Prov. Type 2	450		220	220	220		220
Ast provided	1875	1428	2342	2342	2342	2231	3145
STATUS	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**	**OK**

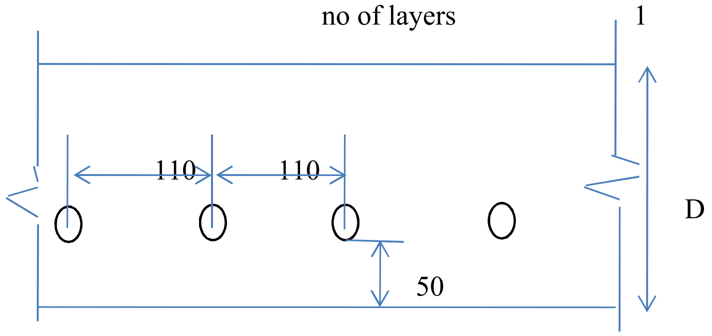
LOAD FACTORS FOR SLS CHECK:-

Load Case	Description	Load Factors in combination				
		Rare1	Rare2	Quasi P		
1	Self-weight	1.00	1.00	1.00		
2	W/C +cushion	1.20	1.20	1.20		
3	Live load	1.00	0.75	0.00		
4	Active EP	1.00	1.00	1.00		
5	At Rest EP	0.00	0.00			
	EP (LL Sur.)					
6	Active EP	1.00	1.00	1.00		
7	At Rest EP	0.00	0.00			
8	Temp Rise/Fall	0.60	1.00	0.50		

4.5.8 FACTORED SLS LOADS AND REINFORCEMENT:-

SECTION	1	2	3	4	5	6	7
COMB 1	134	-90	-166	117	154	-101	-184
COMB 2	121	-81	-150	105	142	-92	-168
COMB 3 (QuasiP)	82	-53	-100	67	105	-63	-118
DESIGN BM (Rare)	134	-90	-166	117	154	-101	-184

Reinforcement Provided	9.09	BARS OF	16	mm diameter
SPACING OF DIA	16.00	@	110	MM
	no of layers		1	



CONDITION		Rare	Quasi P	
DESIGN B.M (SLS)		18.43	11.82	**tn-m**
Modulus of Steel Es		2.00E+05	2.0E+05	mpa
Concrete grade		25	25	mpa
Modulus of Concrete Ec	(Refer TABLE 6.5)	32000.0	32000.0	mpa
Modular ratio 'a_e' = Es/Ec	200000/32000=	6.3	6.3	
Steel Yield stress 'fy'		500	500	mpa
permissible comp stress in concrete s_c =		12	9	mpa
permissible tensile stress in steel s_{st} =		400	400	mpa
Depth of neutral axis x =	1/(1+400/(6.25*12.00))=	0.16	0.12	times 'd'

Leve arm j=	1-0.16/3=	0.95	0.96	times 'd'
Thickness 'h' =		350	350	mm
fct,eff		2.2	2.2	
bt		1000	1000	
Cmin' min cover to tension steel		50	50	mm
Es		200	200	kN/sqm
Ec		32	32	kN/sqm
m=		6.250	6.250	
Effective Depth 'd'	350-50-16/2	292	292	mm
As	9.09*pi*(16^2/4)	1828	1828	sqmm/m
Depth of neutral axis 'dc'	0.16*292	46.72	35.04	mm
Second moment of area of section				
Due to concrete above neutral axis				
	1000*46.72^3/12+1000*46.72*(46.72/2)^2	3.40E+07	1.4E+07	mm^4
Due to steel below neutral axis				
	6.25*1,828.00*(292-46.72)^2	6.87E+08	7.5E+08	mm^4
Total moment of area	3,39,92,824+68,73,54,031=	7.21E+08	7.7E+08	mm^4
stress in steel s_{sc} =	18.43*10000000*(292-46.72)/72,13,46,855*6.3	**392.0**	**247.0**	mpa
stress in concret s_{cb} =	18.43*10000000*(46.72)/72,13,46,855	**11.9**	**5.4**	mpa

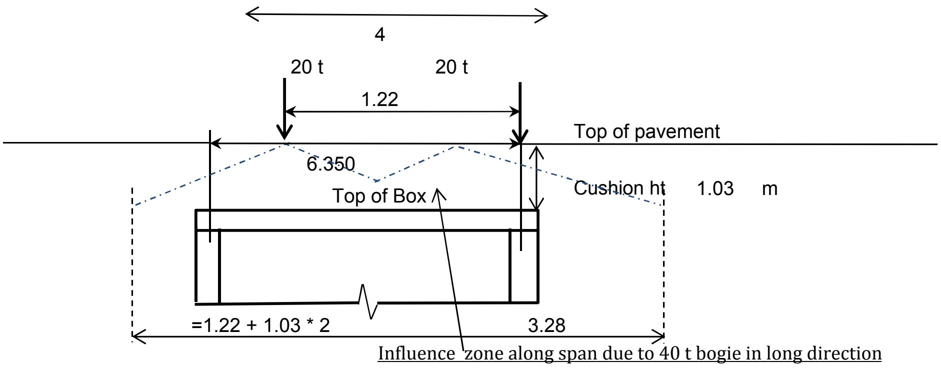
As per Table 12.3 of IRC 112:2011, max spacing for stress of 247 mpa	Spacing requried:-	191.3	mm
	ctual spacing provided	>110.0	mm
As, 191.25 mm > 110 mm Hence, Crack control deemed to be	**Satisfied**		

DESIGN OF SINGLE CELL BOX

4.6 COMPUTATION OF LIVE LOAD EFFECT FOR BOX PORTION:-

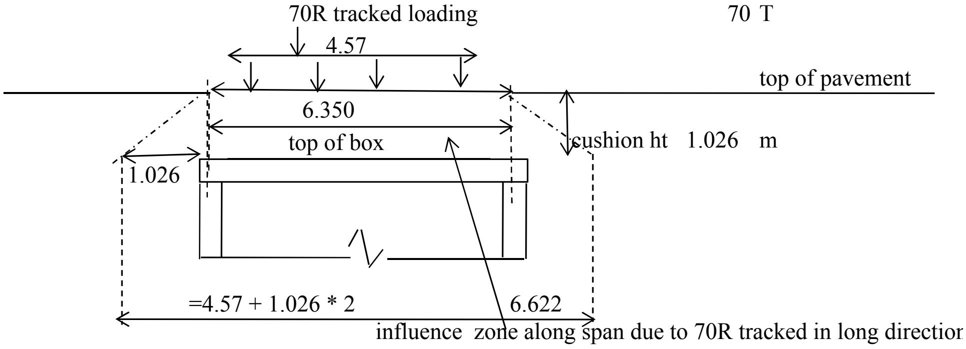
As explained earlier, The effect of Live Load on deck slab as well as whole box has been computed as per Annexure B-3 of IRC:112-2011. Maximum loading out of 40t bogie and 70R tracked has been considered.

4.6.1 EFFECTIVE LOADING FOR Bogie load of 40 tn:-



Width of 40t boggie			2.79	m
Width of wheel in trans direction	Refer Irc:6 annex A	= 0.41-0.05	0.36	m
Total dispersion width in transverse direction		= 2.79 + 1.03 *2	4.85	m
Tyre pressure	Refer IRC:6 Annexure A clause 201.1		52.73	t/m^2
Tryre contact width in long direction		= 5/52.73/0.36	0.263	m
Total dispersion length in long direction		= 3.28 + 0.263*2	3.543	m
Area		= 3.543*4.85	17.184	m^2
Impact factor	Refer cl 208.3(a) & 208.6 of IRC:6		1.100	
UDL per metre width of slab due to LL of 40 t inc. impact		= 4/17.184	0.256	t/m

4.6.2 EFFECTIVE LOADING FOR 70R TRACKED VEHICLE :-



*here we have cushion of height 1.04m and angle of dispersion of live load is 45 degrees as per B.3.4 of IRC:112. Therefore it is considered as UDL over span lengtl

Width of 70R tracked vehicle			2.9	m
Total dispersion width in transverse direction		=2.9+1.026*2	4.952	m
Total dispersion length in long direction		=4.57+1.026*2	6.622	m
Area		=4.952*6.622	32.8	m^2
Impact factor	Refer cl 208.3(a) & 208.6 of IRC:6		1.100	
UDL per metre width of slab due to LL of 70R inc. im		=70/32.792	2.348	t/m

Its clear from above calculation that loading due to 40 t boggie is less than 70R tracked as UDL due to 70R covers the entire span, so 70R tracked loading is adopted for Live Load calculations.

Job Information

	Engineer	Checked	Approved
Name:			
Date:	05-05-20		

Structure Type	PLANE FRAME

Number of Nodes	11	Highest Node	11
Number of Elements	11	Highest Beam	11

Number of Basic Load Cases	6
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	SELFWEIGHT
Primary	2	SIDL
Primary	3	ACT EARTH PRESSURE
Primary	4	LL SURCHARGE(ACTIVE)
Primary	5	AT REST EARTH PRESSURE
Primary	6	LL SURCHARGE(AT REST)

Nodes

Node	X (m)	Y (m)	Z (m)
1	0.000	0.000	0.000
2	0.794	0.000	0.000
3	1.587	0.000	0.000
4	2.381	0.000	0.000
5	3.175	0.000	0.000
6	3.969	0.000	0.000
7	4.762	0.000	0.000
8	5.556	0.000	0.000
9	6.350	0.000	0.000
10	0.000	3.350	0.000
11	6.350	3.350	0.000

Beams

Beam	Node A	Node B	Length (m)	Property	β (degrees)
1	1	2	0.794	1	0
2	2	3	0.794	1	0
3	3	4	0.794	1	0
4	4	5	0.794	1	0
5	5	6	0.794	1	0
6	6	7	0.794	1	0
7	7	8	0.794	1	0
8	8	9	0.794	1	0
9	10	1	3.350	1	0
10	9	11	3.350	1	0
11	10	11	6.350	1	0

Section Properties

Prop	Section	Area (cm^2)	I_{yy} (cm^4)	I_{zz} (cm^4)	J (cm^4)	Material
1	Prismatic General	3.5E+3	0.000	360E+3	0.000	MATERIAL1

Materials

Mat	Name	E (kN/mm^2)	ν	Density (kg/m^3)	α (/°C)
1	STEEL	205.000	0.300	7.83E+3	12E -6
2	STAINLESSSTEEL	197.930	0.300	7.83E+3	18E -6
3	ALUMINUM	68.948	0.330	2.71E+3	23E -6
4	MATERIAL1	32.000	0.170	2.55E+3	0.000
5	CONCRETE	21.718	0.170	2.4E+3	10E -6

Releases

There is no data of this type.

Supports

Node	X (kN/mm)	Y (kN/mm)	Z (kN/mm)	rX (kN·m/deg)	rY (kN·m/deg)	rZ (kN·m/deg)
1	0.000	0.500	Fixed	Fixed	Fixed	0.010
2	0.000	1.000	Fixed	Fixed	Fixed	0.010
3	0.000	1.000	Fixed	Fixed	Fixed	0.010
4	0.000	1.000	Fixed	Fixed	Fixed	0.010
5	0.000	1.000	Fixed	Fixed	Fixed	0.010
6	0.000	1.000	Fixed	Fixed	Fixed	0.010
7	0.000	1.000	Fixed	Fixed	Fixed	0.010
8	0.000	1.000	Fixed	Fixed	Fixed	0.010
9	20.000	0.500	Fixed	Fixed	Fixed	0.010

Primary Load Cases

Number	Name	Type
1	SELFWEIGHT	None
2	SIDL	None
3	ACT EARTH PRESSURE	None
4	LL SURCHARGE(ACTIVE)	None
5	AT REST EARTH PRESSURE	None
6	LL SURCHARGE(AT REST)	None

1 SELFWEIGHT : Selfweight

Direction	Factor	Assigned Geometry
Y	-1.000	ALL

2 SIDL : Beam Loads

Beam	Type		Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
11	UNI	kN/m	GY	-22.572	-	-	-	-

3 ACT EARTH PRESSURE : Beam Loads

Beam	Type		Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
9	TRAP	kN/m	Y	7.372	0.000	8.446	0.175	-
	TRAP	kN/m	Y	8.446	0.175	17.304	3.350	-
10	TRAP	kN/m	Y	17.304	0.000	8.446	3.175	-
	TRAP	kN/m	Y	8.446	3.175	7.372	3.350	-

4 LL SURCHARGE(ACTIVE) : Beam Loads

Beam	Type		Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
9	UNI	kN/m	GX	6.696	-	-	-	-
10	UNI	kN/m	GX	-6.696	-	-	-	-

5 AT REST EARTH PRESSURE : Beam Loads

Beam	Type		Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
9	TRAP	kN/m	Y	13.211	0.000	15.136	0.175	-
	TRAP	kN/m	Y	15.136	0.175	31.011	3.350	-
10	TRAP	kN/m	Y	31.011	0.000	15.136	3.175	-
	TRAP	kN/m	Y	15.136	3.175	13.211	3.350	-

6 LL SURCHARGE(AT REST) : Beam Loads

Beam	Type		Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
9	UNI	kN/m	GX	12.000	-	-	-	-
10	UNI	kN/m	GX	-12.000	-	-	-	-

Beam End Forces

Sign convention is as the action of the joint on the beam.

			Axial	Shear		Torsion	Bending	
Beam	Node	L/C	Fx (kN)	Fy (kN)	Fz (kN)	Mx (kNm)	My (kNm)	Mz (kNm)
1	1	1:SELFWEIGH	7.259	-46.064	0.000	0.000	0.000	-40.796
		2:SIDL	-0.624	-62.124	0.000	0.000	0.000	-47.799
		3:ACT EARTH	23.865	-0.059	0.000	0.000	0.000	-4.284
		4:LL SURCHA	11.231	-0.031	0.000	0.000	0.000	-2.208
		5:AT REST EA	42.768	-0.106	0.000	0.000	0.000	-7.678
		6:LL SURCHA	20.128	-0.055	0.000	0.000	0.000	-3.957
	2	1:SELFWEIGH	-7.259	53.009	0.000	0.000	0.000	1.477
		2:SIDL	0.624	62.124	0.000	0.000	0.000	-1.512
		3:ACT EARTH	-23.865	0.059	0.000	0.000	0.000	4.237
		4:LL SURCHA	-11.231	0.031	0.000	0.000	0.000	2.184
		5:AT REST EA	-42.768	0.106	0.000	0.000	0.000	7.594
		6:LL SURCHA	-20.128	0.055	0.000	0.000	0.000	3.914
2	2	1:SELFWEIGH	7.259	-31.404	0.000	0.000	0.000	-1.477
		2:SIDL	-0.624	-43.687	0.000	0.000	0.000	1.512
		3:ACT EARTH	23.865	-0.099	0.000	0.000	0.000	-4.237
		4:LL SURCHA	11.231	-0.051	0.000	0.000	0.000	-2.184
		5:AT REST EA	42.768	-0.177	0.000	0.000	0.000	-7.594
		6:LL SURCHA	20.128	-0.091	0.000	0.000	0.000	-3.914
	3	1:SELFWEIGH	-7.259	38.349	0.000	0.000	0.000	-26.206
		2:SIDL	0.624	43.687	0.000	0.000	0.000	-36.188
		3:ACT EARTH	-23.865	0.099	0.000	0.000	0.000	4.159
		4:LL SURCHA	-11.231	0.051	0.000	0.000	0.000	2.144
		5:AT REST EA	-42.768	0.177	0.000	0.000	0.000	7.453
		6:LL SURCHA	-20.128	0.091	0.000	0.000	0.000	3.841
3	3	1:SELFWEIGH	7.259	-17.221	0.000	0.000	0.000	26.206
		2:SIDL	-0.624	-25.899	0.000	0.000	0.000	36.188
		3:ACT EARTH	23.865	-0.082	0.000	0.000	0.000	-4.159
		4:LL SURCHA	11.231	-0.042	0.000	0.000	0.000	-2.144
		5:AT REST EA	42.768	-0.146	0.000	0.000	0.000	-7.453
		6:LL SURCHA	20.128	-0.075	0.000	0.000	0.000	-3.841
	4	1:SELFWEIGH	-7.259	24.166	0.000	0.000	0.000	-42.631
		2:SIDL	0.624	25.899	0.000	0.000	0.000	-56.745
		3:ACT EARTH	-23.865	0.082	0.000	0.000	0.000	4.094
		4:LL SURCHA	-11.231	0.042	0.000	0.000	0.000	2.110
		5:AT REST EA	-42.768	0.146	0.000	0.000	0.000	7.337
		6:LL SURCHA	-20.128	0.075	0.000	0.000	0.000	3.782
4	4	1:SELFWEIGH	7.259	-3.383	0.000	0.000	0.000	42.631
		2:SIDL	-0.624	-8.577	0.000	0.000	0.000	56.745
		3:ACT EARTH	23.865	-0.031	0.000	0.000	0.000	-4.094
		4:LL SURCHA	11.231	-0.016	0.000	0.000	0.000	-2.110

Beam End Forces Cont...

Beam	Node	L/C	Axial Fx (kN)	Shear Fy (kN)	Shear Fz (kN)	Torsion Mx (kNm)	Bending My (kNm)	Bending Mz (kNm)
		5:AT REST EA	42.768	-0.055	0.000	0.000	0.000	-7.337
		6:LL SURCHA	20.128	-0.029	0.000	0.000	0.000	-3.782
	5	1:SELFWEIGH	-7.259	10.329	0.000	0.000	0.000	-48.073
		2:SIDL	0.624	8.577	0.000	0.000	0.000	-63.553
		3:ACT EARTH	-23.865	0.031	0.000	0.000	0.000	4.070
		4:LL SURCHA	-11.231	0.016	0.000	0.000	0.000	2.098
		5:AT REST EA	-42.768	0.055	0.000	0.000	0.000	7.293
		6:LL SURCHA	-20.128	0.029	0.000	0.000	0.000	3.759
5	5	1:SELFWEIGH	7.259	10.329	0.000	0.000	0.000	48.073
		2:SIDL	-0.624	8.577	0.000	0.000	0.000	63.553
		3:ACT EARTH	23.865	0.031	0.000	0.000	0.000	-4.070
		4:LL SURCHA	11.231	0.016	0.000	0.000	0.000	-2.098
		5:AT REST EA	42.768	0.055	0.000	0.000	0.000	-7.293
		6:LL SURCHA	20.128	0.029	0.000	0.000	0.000	-3.759
	6	1:SELFWEIGH	-7.259	-3.383	0.000	0.000	0.000	-42.631
		2:SIDL	0.624	-8.577	0.000	0.000	0.000	-56.745
		3:ACT EARTH	-23.865	-0.031	0.000	0.000	0.000	4.094
		4:LL SURCHA	-11.231	-0.016	0.000	0.000	0.000	2.110
		5:AT REST EA	-42.768	-0.055	0.000	0.000	0.000	7.337
		6:LL SURCHA	-20.128	-0.029	0.000	0.000	0.000	3.782
6	6	1:SELFWEIGH	7.259	24.166	0.000	0.000	0.000	42.631
		2:SIDL	-0.624	25.899	0.000	0.000	0.000	56.745
		3:ACT EARTH	23.865	0.082	0.000	0.000	0.000	-4.094
		4:LL SURCHA	11.231	0.042	0.000	0.000	0.000	-2.110
		5:AT REST EA	42.768	0.146	0.000	0.000	0.000	-7.337
		6:LL SURCHA	20.128	0.075	0.000	0.000	0.000	-3.782
	7	1:SELFWEIGH	-7.259	-17.221	0.000	0.000	0.000	-26.206
		2:SIDL	0.624	-25.899	0.000	0.000	0.000	-36.188
		3:ACT EARTH	-23.865	-0.082	0.000	0.000	0.000	4.159
		4:LL SURCHA	-11.231	-0.042	0.000	0.000	0.000	2.144
		5:AT REST EA	-42.768	-0.146	0.000	0.000	0.000	7.453
		6:LL SURCHA	-20.128	-0.075	0.000	0.000	0.000	3.841
7	7	1:SELFWEIGH	7.259	38.349	0.000	0.000	0.000	26.206
		2:SIDL	-0.624	43.687	0.000	0.000	0.000	36.188
		3:ACT EARTH	23.865	0.099	0.000	0.000	0.000	-4.159
		4:LL SURCHA	11.231	0.051	0.000	0.000	0.000	-2.144
		5:AT REST EA	42.768	0.177	0.000	0.000	0.000	-7.453
		6:LL SURCHA	20.128	0.091	0.000	0.000	0.000	-3.841
	8	1:SELFWEIGH	-7.259	-31.404	0.000	0.000	0.000	1.477
		2:SIDL	0.624	-43.687	0.000	0.000	0.000	-1.512
		3:ACT EARTH	-23.865	-0.099	0.000	0.000	0.000	4.237
		4:LL SURCHA	-11.231	-0.051	0.000	0.000	0.000	2.184
		5:AT REST EA	-42.768	-0.177	0.000	0.000	0.000	7.594
		6:LL SURCHA	-20.128	-0.091	0.000	0.000	0.000	3.914
8	8	1:SELFWEIGH	7.259	53.009	0.000	0.000	0.000	-1.477
		2:SIDL	-0.624	62.125	0.000	0.000	0.000	1.512
		3:ACT EARTH	23.865	0.059	0.000	0.000	0.000	-4.237
		4:LL SURCHA	11.231	0.031	0.000	0.000	0.000	-2.184

Beam End Forces Cont...

			Axial	Shear		Torsion	Bending	
Beam	Node	L/C	Fx (kN)	Fy (kN)	Fz (kN)	Mx (kNm)	My (kNm)	Mz (kNm)
		5:AT REST EA	42.768	0.106	0.000	0.000	0.000	-7.594
		6:LL SURCHA	20.128	0.055	0.000	0.000	0.000	-3.914
	9	1:SELFWEIGH	-7.259	-46.064	0.000	0.000	0.000	40.796
		2:SIDL	0.624	-62.125	0.000	0.000	0.000	47.799
		3:ACT EARTH	-23.865	-0.059	0.000	0.000	0.000	4.284
		4:LL SURCHA	-11.231	-0.031	0.000	0.000	0.000	2.208
		5:AT REST EA	-42.768	-0.106	0.000	0.000	0.000	7.678
		6:LL SURCHA	-20.128	-0.055	0.000	0.000	0.000	3.957
9	10	1:SELFWEIGH	27.781	7.259	0.000	0.000	0.000	-16.477
		2:SIDL	71.666	-0.624	0.000	0.000	0.000	-49.890
		3:ACT EARTH	0.000	-18.398	0.000	0.000	0.000	-3.951
		4:LL SURCHA	-0.000	-11.200	0.000	0.000	0.000	-2.157
		5:AT REST EA	-0.000	-32.970	0.000	0.000	0.000	-7.080
		6:LL SURCHA	0.000	-20.073	0.000	0.000	0.000	-3.865
	1	1:SELFWEIGH	-57.094	-7.259	0.000	0.000	0.000	40.796
		2:SIDL	-71.666	0.624	0.000	0.000	0.000	47.799
		3:ACT EARTH	-0.000	-23.865	0.000	0.000	0.000	4.284
		4:LL SURCHA	0.000	-11.231	0.000	0.000	0.000	2.208
		5:AT REST EA	0.000	-42.768	0.000	0.000	0.000	7.678
		6:LL SURCHA	-0.000	-20.128	0.000	0.000	0.000	3.957
10	9	1:SELFWEIGH	57.094	-7.259	0.000	0.000	0.000	-40.796
		2:SIDL	71.666	0.624	0.000	0.000	0.000	-47.799
		3:ACT EARTH	-0.000	-23.865	0.000	0.000	0.000	-4.284
		4:LL SURCHA	-0.000	-11.231	0.000	0.000	0.000	-2.208
		5:AT REST EA	0.000	-42.768	0.000	0.000	0.000	-7.678
		6:LL SURCHA	-0.000	-20.128	0.000	0.000	0.000	-3.957
	11	1:SELFWEIGH	-27.781	7.259	0.000	0.000	0.000	16.477
		2:SIDL	-71.666	-0.624	0.000	0.000	0.000	49.890
		3:ACT EARTH	0.000	-18.398	0.000	0.000	0.000	3.951
		4:LL SURCHA	0.000	-11.200	0.000	0.000	0.000	2.157
		5:AT REST EA	-0.000	-32.970	0.000	0.000	0.000	7.080
		6:LL SURCHA	0.000	-20.073	0.000	0.000	0.000	3.865
11	10	1:SELFWEIGH	-7.259	27.781	0.000	0.000	0.000	16.477
		2:SIDL	0.624	71.666	0.000	0.000	0.000	49.890
		3:ACT EARTH	18.398	0.000	0.000	0.000	0.000	3.951
		4:LL SURCHA	11.200	-0.000	0.000	0.000	0.000	2.157
		5:AT REST EA	32.970	-0.000	0.000	0.000	0.000	7.080
		6:LL SURCHA	20.073	0.000	0.000	0.000	0.000	3.865
	11	1:SELFWEIGH	7.259	27.781	0.000	0.000	0.000	-16.477
		2:SIDL	-0.624	71.666	0.000	0.000	0.000	-49.890
		3:ACT EARTH	-18.398	-0.000	0.000	0.000	0.000	-3.951
		4:LL SURCHA	-11.200	0.000	0.000	0.000	0.000	-2.157
		5:AT REST EA	-32.970	0.000	0.000	0.000	0.000	-7.080
		6:LL SURCHA	-20.073	-0.000	0.000	0.000	0.000	-3.865

Beam Maximum Moments

Distances to maxima are given from beam end A.

Beam	Node A	Length (m)	L/C		d (m)	Max My (kNm)	d (m)	Max Mz (kNm)
1	1	0.794	1:SELFWEIGH	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-40.796
			2:SIDL	Max +ve	0.000	0.000	0.794	1.512
				Max -ve	0.000	0.000	0.000	-47.799
			3:ACT EARTH	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-4.284
			4:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-2.208
			5:AT REST EA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-7.678
			6:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-3.957
2	2	0.794	1:SELFWEIGH	Max +ve	0.000	0.000	0.794	26.206
				Max -ve	0.000	0.000	0.000	-1.477
			2:SIDL	Max +ve	0.000	0.000	0.794	36.188
				Max -ve	0.000	0.000		
			3:ACT EARTH	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-4.237
			4:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-2.184
			5:AT REST EA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-7.594
			6:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-3.914
3	3	0.794	1:SELFWEIGH	Max +ve	0.000	0.000	0.794	42.631
				Max -ve	0.000	0.000		
			2:SIDL	Max +ve	0.000	0.000	0.794	56.745
				Max -ve	0.000	0.000		
			3:ACT EARTH	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-4.159
			4:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-2.144
			5:AT REST EA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-7.453
			6:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-3.841
4	4	0.794	1:SELFWEIGH	Max +ve	0.000	0.000	0.794	48.073
				Max -ve	0.000	0.000		
			2:SIDL	Max +ve	0.000	0.000	0.794	63.553
				Max -ve	0.000	0.000		
			3:ACT EARTH	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-4.094
			4:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-2.110
			5:AT REST EA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-7.337
			6:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-3.782

Beam Maximum Moments Cont...

Beam	Node A	Length (m)	L/C		d (m)	Max My (kNm)	d (m)	Max Mz (kNm)
5	5	0.794	1:SELFWEIGH	Max +ve	0.000	0.000	0.000	48.073
				Max -ve	0.000	0.000		
			2:SIDL	Max +ve	0.000	0.000	0.000	63.553
				Max -ve	0.000	0.000		
			3:ACT EARTH	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-4.094
			4:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-2.110
			5:AT REST EA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-7.337
			6:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-3.782
6	6	0.794	1:SELFWEIGH	Max +ve	0.000	0.000	0.000	42.631
				Max -ve	0.000	0.000		
			2:SIDL	Max +ve	0.000	0.000	0.000	56.745
				Max -ve	0.000	0.000		
			3:ACT EARTH	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-4.159
			4:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-2.144
			5:AT REST EA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-7.453
			6:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-3.841
7	7	0.794	1:SELFWEIGH	Max +ve	0.000	0.000	0.000	26.206
				Max -ve	0.000	0.000	0.794	-1.477
			2:SIDL	Max +ve	0.000	0.000	0.000	36.188
				Max -ve	0.000	0.000		
			3:ACT EARTH	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-4.237
			4:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-2.184
			5:AT REST EA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-7.594
			6:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-3.914
8	8	0.794	1:SELFWEIGH	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-40.796
			2:SIDL	Max +ve	0.000	0.000	0.000	1.512
				Max -ve	0.000	0.000	0.794	-47.799
			3:ACT EARTH	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-4.284
			4:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-2.208
			5:AT REST EA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-7.678
			6:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-3.957
9	10	3.350	1:SELFWEIGH	Max +ve	0.000	0.000		

Beam Maximum Moments Cont...

Beam	Node A	Length (m)	L/C		d (m)	Max My (kNm)	d (m)	Max Mz (kNm)
				Max -ve	0.000	0.000	3.350	-40.796
			2:SIDL	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-49.890
			3:ACT EARTH	Max +ve	0.000	0.000	1.675	13.600
				Max -ve	0.000	0.000	3.350	-4.284
			4:LL SURCHA	Max +ve	0.000	0.000	1.675	7.211
				Max -ve	0.000	0.000	3.350	-2.208
			5:AT REST EA	Max +ve	0.000	0.000	1.675	24.372
				Max -ve	0.000	0.000	3.350	-7.678
			6:LL SURCHA	Max +ve	0.000	0.000	1.675	12.922
				Max -ve	0.000	0.000	3.350	-3.957
10	9	3.350	1:SELFWEIGH	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-40.796
			2:SIDL	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	3.350	-49.890
			3:ACT EARTH	Max +ve	0.000	0.000	1.675	13.600
				Max -ve	0.000	0.000	0.000	-4.284
			4:LL SURCHA	Max +ve	0.000	0.000	1.675	7.211
				Max -ve	0.000	0.000	0.000	-2.208
			5:AT REST EA	Max +ve	0.000	0.000	1.675	24.372
				Max -ve	0.000	0.000	0.000	-7.678
			6:LL SURCHA	Max +ve	0.000	0.000	1.675	12.922
				Max -ve	0.000	0.000	0.000	-3.957
11	10	6.350	1:SELFWEIGH	Max +ve	0.000	0.000	0.000	16.477
				Max -ve	0.000	0.000	3.175	-27.626
			2:SIDL	Max +ve	0.000	0.000	6.350	49.890
				Max -ve	0.000	0.000	3.175	-63.879
			3:ACT EARTH	Max +ve	0.000	0.000	0.000	3.951
				Max -ve	0.000	0.000		
			4:LL SURCHA	Max +ve	0.000	0.000	0.000	2.157
				Max -ve	0.000	0.000		
			5:AT REST EA	Max +ve	0.000	0.000	6.350	7.080
				Max -ve	0.000	0.000		
			6:LL SURCHA	Max +ve	0.000	0.000	0.000	3.865
				Max -ve	0.000	0.000		

Beam Maximum Shear Forces

Distances to maxima are given from beam end A.

Beam	Node A	Length (m)	L/C		d (m)	Max Fz (kN)	d (m)	Max Fy (kN)
1	1	0.794	1:SELFWEIGH	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-53.009
			2:SIDL	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-62.124
			3:ACT EARTH	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-0.059
			4:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-0.031
			5:AT REST EA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-0.106
			6:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-0.055
2	2	0.794	1:SELFWEIGH	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-38.349
			2:SIDL	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-43.687
			3:ACT EARTH	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-0.099
			4:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-0.051
			5:AT REST EA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-0.177
			6:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-0.091
3	3	0.794	1:SELFWEIGH	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-24.166
			2:SIDL	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-25.899
			3:ACT EARTH	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-0.082
			4:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-0.042
			5:AT REST EA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-0.146
			6:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-0.075
4	4	0.794	1:SELFWEIGH	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.794	-10.329
			2:SIDL	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-8.577
			3:ACT EARTH	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-0.031
			4:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-0.016
			5:AT REST EA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-0.055
			6:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-0.029

Beam Maximum Shear Forces Cont...

Beam	Node A	Length (m)	L/C		d (m)	Max Fz (kN)	d (m)	Max Fy (kN)
5	5	0.794	1:SELFWEIGH	Max +ve	0.000	0.000	0.000	10.329
				Max -ve	0.000	0.000		
			2:SIDL	Max +ve	0.000	0.000	0.000	8.577
				Max -ve	0.000	0.000		
			3:ACT EARTH	Max +ve	0.000	0.000	0.000	0.031
				Max -ve	0.000	0.000		
			4:LL SURCHA	Max +ve	0.000	0.000	0.000	0.016
				Max -ve	0.000	0.000		
			5:AT REST EA	Max +ve	0.000	0.000	0.000	0.055
				Max -ve	0.000	0.000		
			6:LL SURCHA	Max +ve	0.000	0.000	0.000	0.029
				Max -ve	0.000	0.000		
6	6	0.794	1:SELFWEIGH	Max +ve	0.000	0.000	0.000	24.166
				Max -ve	0.000	0.000		
			2:SIDL	Max +ve	0.000	0.000	0.000	25.899
				Max -ve	0.000	0.000		
			3:ACT EARTH	Max +ve	0.000	0.000	0.000	0.082
				Max -ve	0.000	0.000		
			4:LL SURCHA	Max +ve	0.000	0.000	0.000	0.042
				Max -ve	0.000	0.000		
			5:AT REST EA	Max +ve	0.000	0.000	0.000	0.146
				Max -ve	0.000	0.000		
			6:LL SURCHA	Max +ve	0.000	0.000	0.000	0.075
				Max -ve	0.000	0.000		
7	7	0.794	1:SELFWEIGH	Max +ve	0.000	0.000	0.000	38.349
				Max -ve	0.000	0.000		
			2:SIDL	Max +ve	0.000	0.000	0.000	43.687
				Max -ve	0.000	0.000		
			3:ACT EARTH	Max +ve	0.000	0.000	0.000	0.099
				Max -ve	0.000	0.000		
			4:LL SURCHA	Max +ve	0.000	0.000	0.000	0.051
				Max -ve	0.000	0.000		
			5:AT REST EA	Max +ve	0.000	0.000	0.000	0.177
				Max -ve	0.000	0.000		
			6:LL SURCHA	Max +ve	0.000	0.000	0.000	0.091
				Max -ve	0.000	0.000		
8	8	0.794	1:SELFWEIGH	Max +ve	0.000	0.000	0.000	53.009
				Max -ve	0.000	0.000		
			2:SIDL	Max +ve	0.000	0.000	0.000	62.125
				Max -ve	0.000	0.000		
			3:ACT EARTH	Max +ve	0.000	0.000	0.000	0.059
				Max -ve	0.000	0.000		
			4:LL SURCHA	Max +ve	0.000	0.000	0.000	0.031
				Max -ve	0.000	0.000		
			5:AT REST EA	Max +ve	0.000	0.000	0.000	0.106
				Max -ve	0.000	0.000		
			6:LL SURCHA	Max +ve	0.000	0.000	0.000	0.055
				Max -ve	0.000	0.000		
9	10	3.350	1:SELFWEIGH	Max +ve	0.000	0.000	0.000	7.259

Beam Maximum Shear Forces Cont...

Beam	Node A	Length (m)	L/C		d (m)	Max Fz (kN)	d (m)	Max Fy (kN)
				Max -ve	0.000	0.000		
			2:SIDL	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-0.624
			3:ACT EARTH	Max +ve	0.000	0.000	3.350	23.865
				Max -ve	0.000	0.000	0.000	-18.398
			4:LL SURCHA	Max +ve	0.000	0.000	3.350	11.231
				Max -ve	0.000	0.000	0.000	-11.200
			5:AT REST EA	Max +ve	0.000	0.000	3.350	42.768
				Max -ve	0.000	0.000	0.000	-32.970
			6:LL SURCHA	Max +ve	0.000	0.000	3.350	20.128
				Max -ve	0.000	0.000	0.000	-20.073
10	9	3.350	1:SELFWEIGH	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-7.259
			2:SIDL	Max +ve	0.000	0.000	0.000	0.624
				Max -ve	0.000	0.000		
			3:ACT EARTH	Max +ve	0.000	0.000	3.350	18.398
				Max -ve	0.000	0.000	0.000	-23.865
			4:LL SURCHA	Max +ve	0.000	0.000	3.350	11.200
				Max -ve	0.000	0.000	0.000	-11.231
			5:AT REST EA	Max +ve	0.000	0.000	3.350	32.970
				Max -ve	0.000	0.000	0.000	-42.768
			6:LL SURCHA	Max +ve	0.000	0.000	3.350	20.073
				Max -ve	0.000	0.000	0.000	-20.128
11	10	6.350	1:SELFWEIGH	Max +ve	0.000	0.000	0.000	27.781
				Max -ve	0.000	0.000	6.350	-27.781
			2:SIDL	Max +ve	0.000	0.000	0.000	71.666
				Max -ve	0.000	0.000	6.350	-71.666
			3:ACT EARTH	Max +ve	0.000	0.000	0.000	0.000
				Max -ve	0.000	0.000		
			4:LL SURCHA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-0.000
			5:AT REST EA	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-0.000
			6:LL SURCHA	Max +ve	0.000	0.000	0.000	0.000
				Max -ve	0.000	0.000		

Beam Maximum Axial Forces

Distances to maxima are given from beam end A.

Beam	Node A	Length (m)	L/C		d (m)	Max Fx (kN)
1	1	0.794	1:SELFWEIGH	Max +ve	0.000	7.259
				Max -ve		
			2:SIDL	Max +ve		
				Max -ve	0.000	-0.624
			3:ACT EARTH	Max +ve	0.000	23.865
				Max -ve		
			4:LL SURCHA	Max +ve	0.000	11.231
				Max -ve		
			5:AT REST EA	Max +ve	0.000	42.768
				Max -ve		
			6:LL SURCHA	Max +ve	0.000	20.128
				Max -ve		
2	2	0.794	1:SELFWEIGH	Max +ve	0.000	7.259
				Max -ve		
			2:SIDL	Max +ve		
				Max -ve	0.000	-0.624
			3:ACT EARTH	Max +ve	0.000	23.865
				Max -ve		
			4:LL SURCHA	Max +ve	0.000	11.231
				Max -ve		
			5:AT REST EA	Max +ve	0.000	42.768
				Max -ve		
			6:LL SURCHA	Max +ve	0.000	20.128
				Max -ve		
3	3	0.794	1:SELFWEIGH	Max +ve	0.000	7.259
				Max -ve		
			2:SIDL	Max +ve		
				Max -ve	0.000	-0.624
			3:ACT EARTH	Max +ve	0.000	23.865
				Max -ve		
			4:LL SURCHA	Max +ve	0.000	11.231
				Max -ve		
			5:AT REST EA	Max +ve	0.000	42.768
				Max -ve		
			6:LL SURCHA	Max +ve	0.000	20.128
				Max -ve		
4	4	0.794	1:SELFWEIGH	Max +ve	0.000	7.259
				Max -ve		
			2:SIDL	Max +ve		
				Max -ve	0.000	-0.624
			3:ACT EARTH	Max +ve	0.000	23.865
				Max -ve		
			4:LL SURCHA	Max +ve	0.000	11.231
				Max -ve		
			5:AT REST EA	Max +ve	0.000	42.768
				Max -ve		
			6:LL SURCHA	Max +ve	0.000	20.128
				Max -ve		

Beam Maximum Axial Forces Cont...

Beam	Node A	Length (m)	L/C		d (m)	Max Fx (kN)
5	5	0.794	1:SELFWEIGH	Max +ve	0.000	7.259
				Max -ve		
			2:SIDL	Max +ve		
				Max -ve	0.000	-0.624
			3:ACT EARTH	Max +ve	0.000	23.865
				Max -ve		
			4:LL SURCHA	Max +ve	0.000	11.231
				Max -ve		
			5:AT REST EA	Max +ve	0.000	42.768
				Max -ve		
			6:LL SURCHA	Max +ve	0.000	20.128
				Max -ve		
6	6	0.794	1:SELFWEIGH	Max +ve	0.000	7.259
				Max -ve		
			2:SIDL	Max +ve		
				Max -ve	0.000	-0.624
			3:ACT EARTH	Max +ve	0.000	23.865
				Max -ve		
			4:LL SURCHA	Max +ve	0.000	11.231
				Max -ve		
			5:AT REST EA	Max +ve	0.000	42.768
				Max -ve		
			6:LL SURCHA	Max +ve	0.000	20.128
				Max -ve		
7	7	0.794	1:SELFWEIGH	Max +ve	0.000	7.259
				Max -ve		
			2:SIDL	Max +ve		
				Max -ve	0.000	-0.624
			3:ACT EARTH	Max +ve	0.000	23.865
				Max -ve		
			4:LL SURCHA	Max +ve	0.000	11.231
				Max -ve		
			5:AT REST EA	Max +ve	0.000	42.768
				Max -ve		
			6:LL SURCHA	Max +ve	0.000	20.128
				Max -ve		
8	8	0.794	1:SELFWEIGH	Max +ve	0.000	7.259
				Max -ve		
			2:SIDL	Max +ve		
				Max -ve	0.000	-0.624
			3:ACT EARTH	Max +ve	0.000	23.865
				Max -ve		
			4:LL SURCHA	Max +ve	0.000	11.231
				Max -ve		
			5:AT REST EA	Max +ve	0.000	42.768
				Max -ve		
			6:LL SURCHA	Max +ve	0.000	20.128
				Max -ve		
9	10	3.350	1:SELFWEIGH	Max +ve	3.350	57.094

Beam Maximum Axial Forces Cont...

Beam	Node A	Length (m)	L/C		d (m)	Max Fx (kN)
				Max -ve		
			2:SIDL	Max +ve	0.000	71.666
				Max -ve		
			3:ACT EARTH	Max +ve	0.000	0.000
				Max -ve		
			4:LL SURCHA	Max +ve		
				Max -ve	0.000	-0.000
			5:AT REST EA	Max +ve		
				Max -ve	0.000	-0.000
			6:LL SURCHA	Max +ve	0.000	0.000
				Max -ve		
10	9	3.350	1:SELFWEIGH	Max +ve	0.000	57.094
				Max -ve		
			2:SIDL	Max +ve	0.000	71.666
				Max -ve		
			3:ACT EARTH	Max +ve		
				Max -ve	0.000	-0.000
			4:LL SURCHA	Max +ve		
				Max -ve	0.000	-0.000
			5:AT REST EA	Max +ve	0.000	0.000
				Max -ve		
			6:LL SURCHA	Max +ve		
				Max -ve	0.000	-0.000
11	10	6.350	1:SELFWEIGH	Max +ve		
				Max -ve	0.000	-7.259
			2:SIDL	Max +ve	0.000	0.624
				Max -ve		
			3:ACT EARTH	Max +ve	0.000	18.398
				Max -ve		
			4:LL SURCHA	Max +ve	0.000	11.200
				Max -ve		
			5:AT REST EA	Max +ve	0.000	32.970
				Max -ve		
			6:LL SURCHA	Max +ve	0.000	20.073
				Max -ve		

Node Displacements

Node	L/C	X (mm)	Y (mm)	Z (mm)	Resultant (mm)	rX (rad)	rY (rad)	rZ (rad)
1	1:SELFWEIGH	0.004	-22.060	0.000	22.060	0.000	0.000	0.000
	2:SIDL	-0.000	-19.083	0.000	19.083	0.000	0.000	0.001
	3:ACT EARTH	0.014	0.119	0.000	0.120	0.000	0.000	-0.000
	4:LL SURCHA	0.006	0.061	0.000	0.062	0.000	0.000	-0.000
	5:AT REST EA	0.024	0.213	0.000	0.214	0.000	0.000	-0.000
	6:LL SURCHA	0.011	0.110	0.000	0.110	0.000	0.000	-0.000
2	1:SELFWEIGH	0.004	-21.605	0.000	21.605	0.000	0.000	0.001
	2:SIDL	-0.000	-18.438	0.000	18.438	0.000	0.000	0.001
	3:ACT EARTH	0.012	0.039	0.000	0.041	0.000	0.000	-0.000
	4:LL SURCHA	0.006	0.020	0.000	0.021	0.000	0.000	-0.000
	5:AT REST EA	0.021	0.070	0.000	0.073	0.000	0.000	-0.000
	6:LL SURCHA	0.010	0.036	0.000	0.038	0.000	0.000	-0.000
3	1:SELFWEIGH	0.003	-21.129	0.000	21.129	0.000	0.000	0.001
	2:SIDL	-0.000	-17.787	0.000	17.787	0.000	0.000	0.001
	3:ACT EARTH	0.010	-0.017	0.000	0.020	0.000	0.000	-0.000
	4:LL SURCHA	0.005	-0.009	0.000	0.010	0.000	0.000	-0.000
	5:AT REST EA	0.018	-0.031	0.000	0.036	0.000	0.000	-0.000
	6:LL SURCHA	0.009	-0.016	0.000	0.018	0.000	0.000	-0.000
4	1:SELFWEIGH	0.003	-20.783	0.000	20.783	0.000	0.000	0.000
	2:SIDL	-0.000	-17.322	0.000	17.322	0.000	0.000	0.000
	3:ACT EARTH	0.008	-0.051	0.000	0.051	0.000	0.000	-0.000
	4:LL SURCHA	0.004	-0.026	0.000	0.026	0.000	0.000	-0.000
	5:AT REST EA	0.015	-0.091	0.000	0.092	0.000	0.000	-0.000
	6:LL SURCHA	0.007	-0.047	0.000	0.047	0.000	0.000	-0.000
5	1:SELFWEIGH	0.002	-20.657	0.000	20.657	0.000	0.000	0.000
	2:SIDL	-0.000	-17.154	0.000	17.154	0.000	0.000	-0.000
	3:ACT EARTH	0.007	-0.062	0.000	0.062	0.000	0.000	0.000
	4:LL SURCHA	0.003	-0.032	0.000	0.032	0.000	0.000	-0.000
	5:AT REST EA	0.012	-0.111	0.000	0.111	0.000	0.000	-0.000
	6:LL SURCHA	0.006	-0.057	0.000	0.057	0.000	0.000	0.000
6	1:SELFWEIGH	0.002	-20.783	0.000	20.783	0.000	0.000	-0.000
	2:SIDL	-0.000	-17.322	0.000	17.322	0.000	0.000	-0.000
	3:ACT EARTH	0.005	-0.051	0.000	0.051	0.000	0.000	0.000
	4:LL SURCHA	0.002	-0.026	0.000	0.026	0.000	0.000	0.000
	5:AT REST EA	0.009	-0.091	0.000	0.091	0.000	0.000	0.000
	6:LL SURCHA	0.004	-0.047	0.000	0.047	0.000	0.000	0.000
7	1:SELFWEIGH	0.001	-21.129	0.000	21.129	0.000	0.000	-0.001
	2:SIDL	-0.000	-17.787	0.000	17.787	0.000	0.000	-0.001
	3:ACT EARTH	0.003	-0.017	0.000	0.017	0.000	0.000	0.000
	4:LL SURCHA	0.002	-0.009	0.000	0.009	0.000	0.000	0.000
	5:AT REST EA	0.006	-0.031	0.000	0.031	0.000	0.000	0.000
	6:LL SURCHA	0.003	-0.016	0.000	0.016	0.000	0.000	0.000
8	1:SELFWEIGH	0.001	-21.605	0.000	21.605	0.000	0.000	-0.001
	2:SIDL	-0.000	-18.438	0.000	18.438	0.000	0.000	-0.001
	3:ACT EARTH	0.002	0.039	0.000	0.039	0.000	0.000	0.000
	4:LL SURCHA	0.001	0.020	0.000	0.020	0.000	0.000	0.000
	5:AT REST EA	0.003	0.070	0.000	0.070	0.000	0.000	0.000
	6:LL SURCHA	0.001	0.036	0.000	0.036	0.000	0.000	0.000
9	1:SELFWEIGH	-0.000	-22.060	0.000	22.060	0.000	0.000	-0.000

Node Displacements Cont...

Node	L/C	X (mm)	Y (mm)	Z (mm)	Resultant (mm)	rX (rad)	rY (rad)	rZ (rad)
	2:SIDL	-0.000	-19.083	0.000	19.083	0.000	0.000	-0.001
	3:ACT EARTH	-0.000	0.119	0.000	0.119	0.000	0.000	0.000
	4:LL SURCHA	0.000	0.061	0.000	0.061	0.000	0.000	0.000
	5:AT REST EA	0.000	0.213	0.000	0.213	0.000	0.000	0.000
	6:LL SURCHA	-0.000	0.110	0.000	0.110	0.000	0.000	0.000
10	1:SELFWEIGH	-0.000	-22.073	0.000	22.073	0.000	0.000	-0.000
	2:SIDL	0.000	-19.105	0.000	19.105	0.000	0.000	-0.001
	3:ACT EARTH	0.012	0.119	0.000	0.119	0.000	0.000	0.000
	4:LL SURCHA	0.006	0.061	0.000	0.062	0.000	0.000	0.000
	5:AT REST EA	0.021	0.213	0.000	0.214	0.000	0.000	0.000
	6:LL SURCHA	0.011	0.110	0.000	0.110	0.000	0.000	0.000
11	1:SELFWEIGH	0.004	-22.073	0.000	22.073	0.000	0.000	0.000
	2:SIDL	-0.000	-19.105	0.000	19.105	0.000	0.000	0.001
	3:ACT EARTH	0.002	0.119	0.000	0.119	0.000	0.000	-0.000
	4:LL SURCHA	0.000	0.061	0.000	0.061	0.000	0.000	-0.000
	5:AT REST EA	0.003	0.213	0.000	0.213	0.000	0.000	-0.000
	6:LL SURCHA	0.000	0.110	0.000	0.110	0.000	0.000	-0.000

Job Information

	Engineer	Checked	Approved
Name:			
Date:	10-MAY-20		

Structure Type	PLANE FRAME

Number of Nodes	11	Highest Node	11
Number of Elements	11	Highest Beam	11

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	

Nodes

Node	X (m)	Y (m)	Z (m)
1	0.000	0.000	0.000
2	0.794	0.000	0.000
3	1.587	0.000	0.000
4	2.381	0.000	0.000
5	3.175	0.000	0.000
6	3.969	0.000	0.000
7	4.762	0.000	0.000
8	5.556	0.000	0.000
9	6.350	0.000	0.000
10	0.000	3.361	0.000
11	6.350	3.361	0.000

Beams

Beam	Node A	Node B	Length (m)	Property	β (degrees)
1	1	2	0.794	1	0
2	2	3	0.794	1	0
3	3	4	0.794	1	0
4	4	5	0.794	1	0
5	5	6	0.794	1	0
6	6	7	0.794	1	0
7	7	8	0.794	1	0
8	8	9	0.794	1	0
9	10	1	3.361	1	0
10	9	11	3.361	1	0
11	10	11	6.350	1	0

Section Properties

Prop	Section	Area (cm^2)	I_{yy} (cm^4)	I_{zz} (cm^4)	J (cm^4)	Material
1	Prismatic General	3.5E+3	0.000	360E+3	0.000	MATERIAL1

Materials

Mat	Name	E (kN/mm^2)	ν	Density (kg/m^3)	α (/°C)
1	STEEL	205.000	0.300	7.83E+3	12E -6
2	STAINLESSSTEEL	197.930	0.300	7.83E+3	18E -6
3	ALUMINUM	68.948	0.330	2.71E+3	23E -6
4	MATERIAL1	32.000	0.170	2.55E+3	0.000
5	CONCRETE	21.718	0.170	2.4E+3	10E -6

Supports

Node	X (kN/mm)	Y (kN/mm)	Z (kN/mm)	rX (kN·m/deg)	rY (kN·m/deg)	rZ (kN·m/deg)
1	0.000	0.500	Fixed	Fixed	Fixed	0.010
2	0.000	1.000	Fixed	Fixed	Fixed	0.010
3	0.000	1.000	Fixed	Fixed	Fixed	0.010
4	0.000	1.000	Fixed	Fixed	Fixed	0.010
5	0.000	1.000	Fixed	Fixed	Fixed	0.010
6	0.000	1.000	Fixed	Fixed	Fixed	0.010
7	0.000	1.000	Fixed	Fixed	Fixed	0.010
8	0.000	1.000	Fixed	Fixed	Fixed	0.010
9	2.000	0.500	Fixed	Fixed	Fixed	0.010

Load Generators

There is no data of this type.

1 : Beam Loads

Beam	Type		Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
11	UNI	kN/m	GY	-22.435	1.264	-	5.087	-

Node Displacements

Node	L/C	X (mm)	Y (mm)	Z (mm)	Resultant (mm)	rX (rad)	rY (rad)	rZ (rad)
1	1:	-0.002	-11.456	0.000	11.456	0.000	0.000	0.000
2	1:	-0.002	-11.043	0.000	11.043	0.000	0.000	0.001
3	1:	-0.002	-10.635	0.000	10.635	0.000	0.000	0.000
4	1:	-0.001	-10.346	0.000	10.346	0.000	0.000	0.000
5	1:	-0.001	-10.243	0.000	10.243	0.000	0.000	-0.000
6	1:	-0.001	-10.347	0.000	10.347	0.000	0.000	-0.000
7	1:	-0.001	-10.638	0.000	10.638	0.000	0.000	-0.000
8	1:	-0.000	-11.047	0.000	11.047	0.000	0.000	-0.001
9	1:	0.000	-11.461	0.000	11.461	0.000	0.000	-0.000
10	1:	0.003	-11.469	0.000	11.469	0.000	0.000	-0.001
11	1:	0.000	-11.474	0.000	11.474	0.000	0.000	0.001

Beam End Forces

Sign convention is as the action of the joint on the beam.

			Axial	Shear		Torsion	Bending	
Beam	Node	L/C	Fx (kN)	Fy (kN)	Fz (kN)	Mx (kNm)	My (kNm)	Mz (kNm)
1	1	1:	-4.030	-37.147	0.000	0.000	0.000	-27.135
	2	1:	4.030	37.147	0.000	0.000	0.000	-2.351
2	2	1:	-4.030	-26.104	0.000	0.000	0.000	2.350
	3	1:	4.030	26.104	0.000	0.000	0.000	-23.070
3	3	1:	-4.030	-15.469	0.000	0.000	0.000	23.070
	4	1:	4.030	15.469	0.000	0.000	0.000	-35.348
4	4	1:	-4.030	-5.123	0.000	0.000	0.000	35.348
	5	1:	4.030	5.123	0.000	0.000	0.000	-39.414
5	5	1:	-4.030	5.120	0.000	0.000	0.000	39.414
	6	1:	4.030	-5.120	0.000	0.000	0.000	-35.350
6	6	1:	-4.030	15.467	0.000	0.000	0.000	35.350
	7	1:	4.030	-15.467	0.000	0.000	0.000	-23.073
7	7	1:	-4.030	26.105	0.000	0.000	0.000	23.073
	8	1:	4.030	-26.105	0.000	0.000	0.000	-2.352
8	8	1:	-4.030	37.152	0.000	0.000	0.000	2.352
	9	1:	4.030	-37.152	0.000	0.000	0.000	27.137
9	10	1:	42.875	-4.030	0.000	0.000	0.000	-40.680
	1	1:	-42.875	4.030	0.000	0.000	0.000	27.135
10	9	1:	42.883	4.030	0.000	0.000	0.000	-27.137
	11	1:	-42.883	-4.030	0.000	0.000	0.000	40.682
11	10	1:	4.030	42.875	0.000	0.000	0.000	40.680
	11	1:	-4.030	42.883	0.000	0.000	0.000	-40.682

Beam Maximum Moments

Distances to maxima are given from beam end A.

Beam	Node A	Length (m)	L/C		d (m)	Max My (kNm)	d (m)	Max Mz (kNm)
1	1	0.794	1:	Max +ve	0.000	0.000	0.794	2.351
				Max -ve	0.000	0.000	0.000	-27.135
2	2	0.794	1:	Max +ve	0.000	0.000	0.794	23.070
				Max -ve	0.000	0.000		
3	3	0.794	1:	Max +ve	0.000	0.000	0.794	35.348
				Max -ve	0.000	0.000		
4	4	0.794	1:	Max +ve	0.000	0.000	0.794	39.414
				Max -ve	0.000	0.000		
5	5	0.794	1:	Max +ve	0.000	0.000	0.000	39.414
				Max -ve	0.000	0.000		
6	6	0.794	1:	Max +ve	0.000	0.000	0.000	35.350
				Max -ve	0.000	0.000		
7	7	0.794	1:	Max +ve	0.000	0.000	0.000	23.073
				Max -ve	0.000	0.000		
8	8	0.794	1:	Max +ve	0.000	0.000	0.000	2.352
				Max -ve	0.000	0.000	0.794	-27.137
9	10	3.361	1:	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-40.680
10	9	3.361	1:	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	3.361	-40.682
11	10	6.350	1:	Max +ve	0.000	0.000	6.350	40.682
				Max -ve	0.000	0.000	3.175	-54.483

Beam Maximum Shear Forces

Distances to maxima are given from beam end A.

Beam	Node A	Length (m)	L/C		d (m)	Max Fz (kN)	d (m)	Max Fy (kN)
1	1	0.794	1:	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-37.147
2	2	0.794	1:	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-26.104
3	3	0.794	1:	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-15.469
4	4	0.794	1:	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-5.123
5	5	0.794	1:	Max +ve	0.000	0.000	0.000	5.120
				Max -ve	0.000	0.000		
6	6	0.794	1:	Max +ve	0.000	0.000	0.000	15.467
				Max -ve	0.000	0.000		
7	7	0.794	1:	Max +ve	0.000	0.000	0.000	26.105
				Max -ve	0.000	0.000		
8	8	0.794	1:	Max +ve	0.000	0.000	0.000	37.152
				Max -ve	0.000	0.000		
9	10	3.361	1:	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-4.030
10	9	3.361	1:	Max +ve	0.000	0.000	0.000	4.030
				Max -ve	0.000	0.000		

Beam Maximum Shear Forces Cont...

Beam	Node A	Length (m)	L/C		d (m)	Max Fz (kN)	d (m)	Max Fy (kN)
11	10	6.350	1:	Max +ve	0.000	0.000	0.000	42.875
				Max -ve	0.000	0.000	5.292	-42.883

Beam Maximum Axial Forces

Distances to maxima are given from beam end A.

Beam	Node A	Length (m)	L/C		d (m)	Max Fx (kN)
1	1	0.794	1:	Max +ve		
				Max -ve	0.000	-4.030
2	2	0.794	1:	Max +ve		
				Max -ve	0.000	-4.030
3	3	0.794	1:	Max +ve		
				Max -ve	0.000	-4.030
4	4	0.794	1:	Max +ve		
				Max -ve	0.000	-4.030
5	5	0.794	1:	Max +ve		
				Max -ve	0.000	-4.030
6	6	0.794	1:	Max +ve		
				Max -ve	0.000	-4.030
7	7	0.794	1:	Max +ve		
				Max -ve	0.000	-4.030
8	8	0.794	1:	Max +ve		
				Max -ve	0.000	-4.030
9	10	3.361	1:	Max +ve	0.000	42.875
				Max -ve		
10	9	3.361	1:	Max +ve	0.000	42.883
				Max -ve		
11	10	6.350	1:	Max +ve	0.000	4.030
				Max -ve		

Reactions

		Horizontal	Vertical	Horizontal	Moment		
Node	L/C	FX (kN)	FY (kN)	FZ (kN)	MX (kNm)	MY (kNm)	MZ (kNm)
1	1:	0.000	5.728	0.000	0.000	0.000	-0.000
2	1:	0.000	11.043	0.000	0.000	0.000	-0.000
3	1:	0.000	10.635	0.000	0.000	0.000	-0.000
4	1:	0.000	10.346	0.000	0.000	0.000	-0.000
5	1:	0.000	10.243	0.000	0.000	0.000	0.000
6	1:	0.000	10.347	0.000	0.000	0.000	0.000
7	1:	0.000	10.638	0.000	0.000	0.000	0.000
8	1:	0.000	11.047	0.000	0.000	0.000	0.000
9	1:	-0.000	5.730	0.000	0.000	0.000	0.000

Job Information

	Engineer	Checked	Approved
Name:			
Date:	10-MAY-20		

Structure Type	PLANE FRAME

Number of Nodes	11	Highest Node	11
Number of Elements	11	Highest Beam	11

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	

Nodes

Node	X (m)	Y (m)	Z (m)
1	0.000	0.000	0.000
2	0.794	0.000	0.000
3	1.587	0.000	0.000
4	2.381	0.000	0.000
5	3.175	0.000	0.000
6	3.969	0.000	0.000
7	4.762	0.000	0.000
8	5.556	0.000	0.000
9	6.350	0.000	0.000
10	0.000	3.350	0.000
11	6.350	3.350	0.000

Beams

Beam	Node A	Node B	Length (m)	Property	β (degrees)
1	1	2	0.794	1	0
2	2	3	0.794	1	0
3	3	4	0.794	1	0
4	4	5	0.794	1	0
5	5	6	0.794	1	0
6	6	7	0.794	1	0
7	7	8	0.794	1	0
8	8	9	0.794	1	0
9	10	1	3.350	1	0
10	9	11	3.350	1	0
11	10	11	6.350	1	0

Section Properties

Prop	Section	Area (cm^2)	I_{yy} (cm^4)	I_{zz} (cm^4)	J (cm^4)	Material
1	Prismatic General	3.5E+3	0.000	360E+3	0.000	MATERIAL1

Materials

Mat	Name	E (kN/mm^2)	ν	Density (kg/m^3)	α (/°C)
1	STEEL	205.000	0.300	7.83E+3	12E -6
2	STAINLESSSTEEL	197.930	0.300	7.83E+3	18E -6
3	ALUMINUM	68.948	0.330	2.71E+3	23E -6
4	MATERIAL1	32.000	0.170	2.55E+3	0.000
5	CONCRETE	21.718	0.170	2.4E+3	10E -6

Supports

Node	X (kN/mm)	Y (kN/mm)	Z (kN/mm)	rX (kN·m/deg)	rY (kN·m/deg)	rZ (kN·m/deg)
1	0.000	0.500	Fixed	Fixed	Fixed	0.010
2	0.000	1.000	Fixed	Fixed	Fixed	0.010
3	0.000	1.000	Fixed	Fixed	Fixed	0.010
4	0.000	1.000	Fixed	Fixed	Fixed	0.010
5	0.000	1.000	Fixed	Fixed	Fixed	0.010
6	0.000	1.000	Fixed	Fixed	Fixed	0.010
7	0.000	1.000	Fixed	Fixed	Fixed	0.010
8	0.000	1.000	Fixed	Fixed	Fixed	0.010
9	20.000	0.500	Fixed	Fixed	Fixed	0.010

Releases

There is no data of this type.

Load Generators

There is no data of this type.

1 : Beam Loads

Beam	Type		Direction	Fa	Da (m)	Fb	Db	Ecc. (m)
11	UNI	kN/m	GY	-23.481	0.000	-	-	-

Node Displacements

Node	L/C	X (mm)	Y (mm)	Z (mm)	Resultant (mm)	rX (rad)	rY (rad)	rZ (rad)
1	1:	-0.000	-19.852	0.000	19.852	0.000	0.000	0.001
2	1:	-0.000	-19.180	0.000	19.180	0.000	0.000	0.001
3	1:	-0.000	-18.504	0.000	18.504	0.000	0.000	0.001
4	1:	-0.000	-18.020	0.000	18.020	0.000	0.000	0.000
5	1:	-0.000	-17.845	0.000	17.845	0.000	0.000	-0.000
6	1:	-0.000	-18.020	0.000	18.020	0.000	0.000	-0.000
7	1:	-0.000	-18.504	0.000	18.504	0.000	0.000	-0.001
8	1:	-0.000	-19.180	0.000	19.180	0.000	0.000	-0.001
9	1:	-0.000	-19.852	0.000	19.852	0.000	0.000	-0.001
10	1:	0.000	-19.874	0.000	19.874	0.000	0.000	-0.001
11	1:	-0.000	-19.874	0.000	19.874	0.000	0.000	0.001

Beam End Forces

Sign convention is as the action of the joint on the beam.

			Axial	Shear		Torsion	Bending	
Beam	Node	L/C	Fx (kN)	Fy (kN)	Fz (kN)	Mx (kNm)	My (kNm)	Mz (kNm)
1	1	1:	-0.650	-64.626	0.000	0.000	0.000	-49.724
	2	1:	0.650	64.626	0.000	0.000	0.000	-1.573
2	2	1:	-0.650	-45.446	0.000	0.000	0.000	1.573
	3	1:	0.650	45.446	0.000	0.000	0.000	-37.645
3	3	1:	-0.650	-26.942	0.000	0.000	0.000	37.645
	4	1:	0.650	26.942	0.000	0.000	0.000	-59.030
4	4	1:	-0.650	-8.923	0.000	0.000	0.000	59.030
	5	1:	0.650	8.923	0.000	0.000	0.000	-66.113
5	5	1:	-0.650	8.923	0.000	0.000	0.000	66.113
	6	1:	0.650	-8.923	0.000	0.000	0.000	-59.030
6	6	1:	-0.650	26.942	0.000	0.000	0.000	59.030
	7	1:	0.650	-26.942	0.000	0.000	0.000	-37.645
7	7	1:	-0.650	45.446	0.000	0.000	0.000	37.646
	8	1:	0.650	-45.446	0.000	0.000	0.000	-1.573
8	8	1:	-0.650	64.626	0.000	0.000	0.000	1.573
	9	1:	0.650	-64.626	0.000	0.000	0.000	49.724
9	10	1:	74.552	-0.650	0.000	0.000	0.000	-51.900
	1	1:	-74.552	0.650	0.000	0.000	0.000	49.723
10	9	1:	74.552	0.650	0.000	0.000	0.000	-49.723
	11	1:	-74.552	-0.650	0.000	0.000	0.000	51.900

Beam End Forces Cont...

			Axial	Shear		Torsion	Bending	
Beam	Node	L/C	Fx (kN)	Fy (kN)	Fz (kN)	Mx (kNm)	My (kNm)	Mz (kNm)
11	10	1:	0.650	74.552	0.000	0.000	0.000	51.900
	11	1:	-0.650	74.552	0.000	0.000	0.000	-51.900

Beam Maximum Moments

Distances to maxima are given from beam end A.

Beam	Node A	Length (m)	L/C		d (m)	Max My (kNm)	d (m)	Max Mz (kNm)
1	1	0.794	1:	Max +ve	0.000	0.000	0.794	1.573
				Max -ve	0.000	0.000	0.000	-49.724
2	2	0.794	1:	Max +ve	0.000	0.000	0.794	37.645
				Max -ve	0.000	0.000		
3	3	0.794	1:	Max +ve	0.000	0.000	0.794	59.030
				Max -ve	0.000	0.000		
4	4	0.794	1:	Max +ve	0.000	0.000	0.794	66.113
				Max -ve	0.000	0.000		
5	5	0.794	1:	Max +ve	0.000	0.000	0.000	66.113
				Max -ve	0.000	0.000		
6	6	0.794	1:	Max +ve	0.000	0.000	0.000	59.030
				Max -ve	0.000	0.000		
7	7	0.794	1:	Max +ve	0.000	0.000	0.000	37.646
				Max -ve	0.000	0.000		
8	8	0.794	1:	Max +ve	0.000	0.000	0.000	1.573
				Max -ve	0.000	0.000	0.794	-49.724
9	10	3.350	1:	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-51.900
10	9	3.350	1:	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	3.350	-51.900
11	10	6.350	1:	Max +ve	0.000	0.000	6.350	51.900
				Max -ve	0.000	0.000	3.175	-66.452

Beam Maximum Shear Forces

Distances to maxima are given from beam end A.

Beam	Node A	Length (m)	L/C		d (m)	Max Fz (kN)	d (m)	Max Fy (kN)
1	1	0.794	1:	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-64.626
2	2	0.794	1:	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-45.446
3	3	0.794	1:	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-26.942
4	4	0.794	1:	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-8.923
5	5	0.794	1:	Max +ve	0.000	0.000	0.000	8.923
				Max -ve	0.000	0.000		
6	6	0.794	1:	Max +ve	0.000	0.000	0.000	26.942

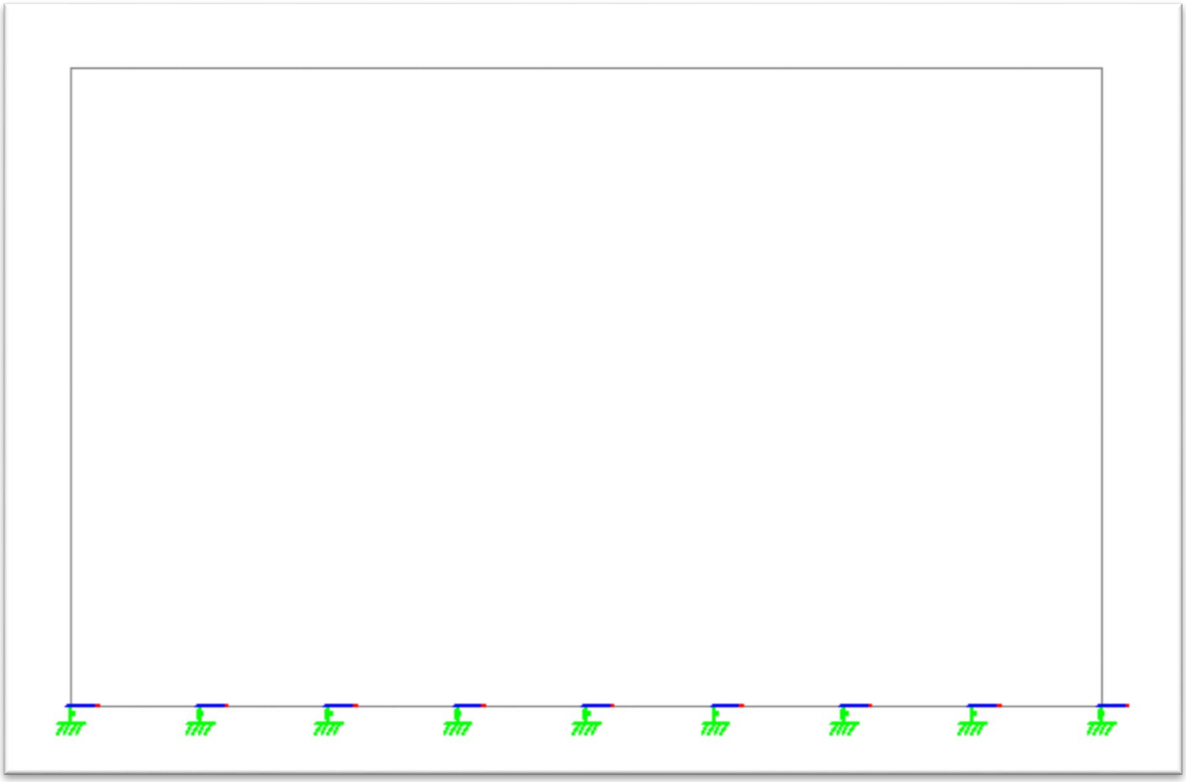
Beam Maximum Shear Forces Cont...

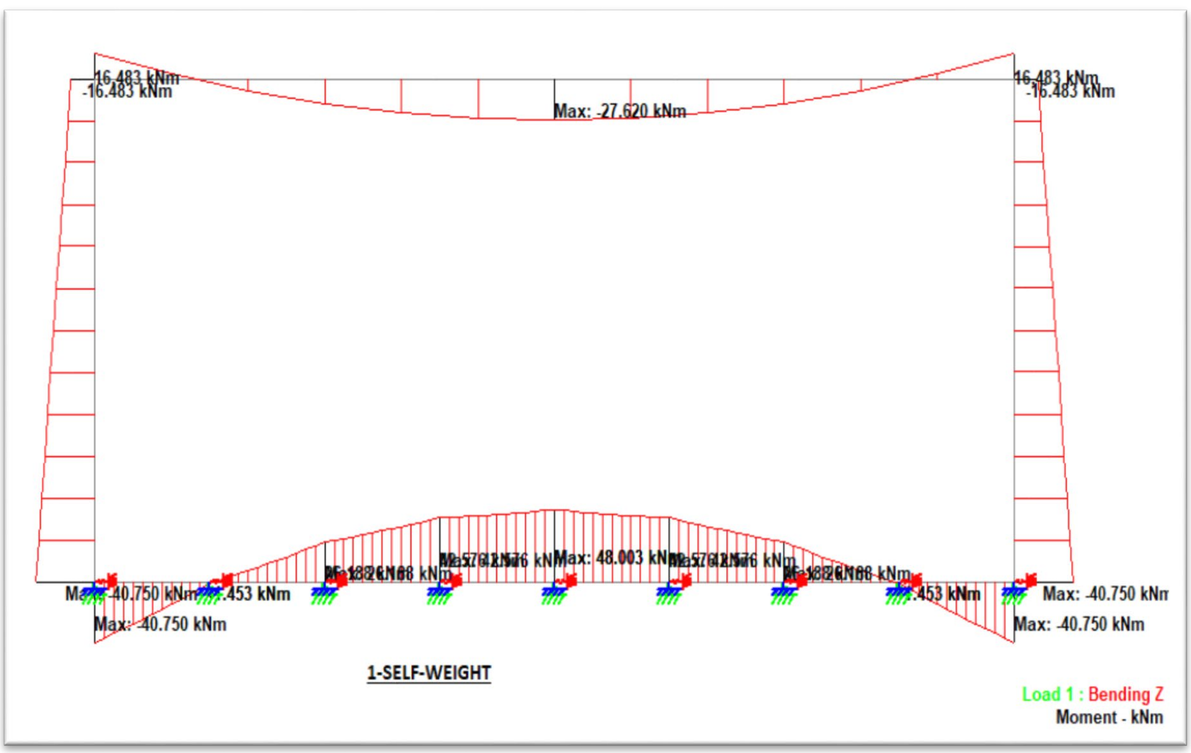
Beam	Node A	Length (m)	L/C		d (m)	Max Fz (kN)	d (m)	Max Fy (kN)
				Max -ve	0.000	0.000		
7	7	0.794	1:	Max +ve	0.000	0.000	0.000	45.446
				Max -ve	0.000	0.000		
8	8	0.794	1:	Max +ve	0.000	0.000	0.000	64.626
				Max -ve	0.000	0.000		
9	10	3.350	1:	Max +ve	0.000	0.000		
				Max -ve	0.000	0.000	0.000	-0.650
10	9	3.350	1:	Max +ve	0.000	0.000	0.000	0.650
				Max -ve	0.000	0.000		
11	10	6.350	1:	Max +ve	0.000	0.000	0.000	74.552
				Max -ve	0.000	0.000	6.350	-74.552

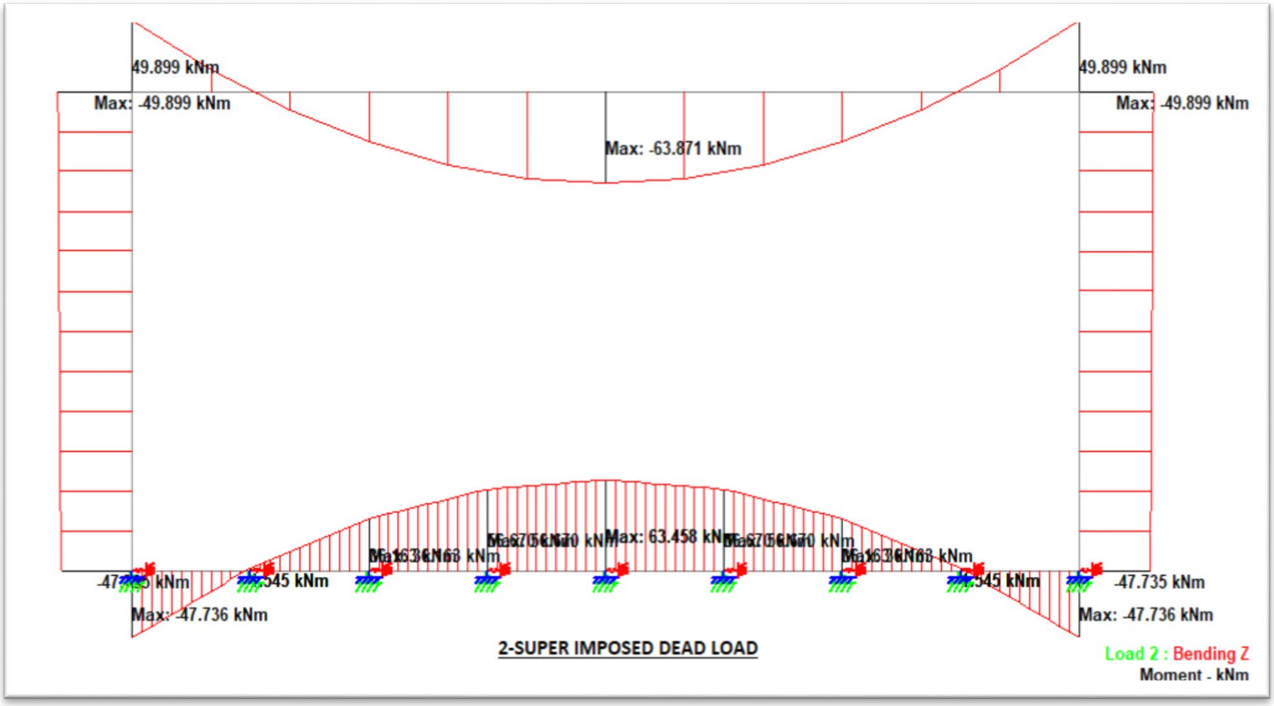
Beam Maximum Axial Forces

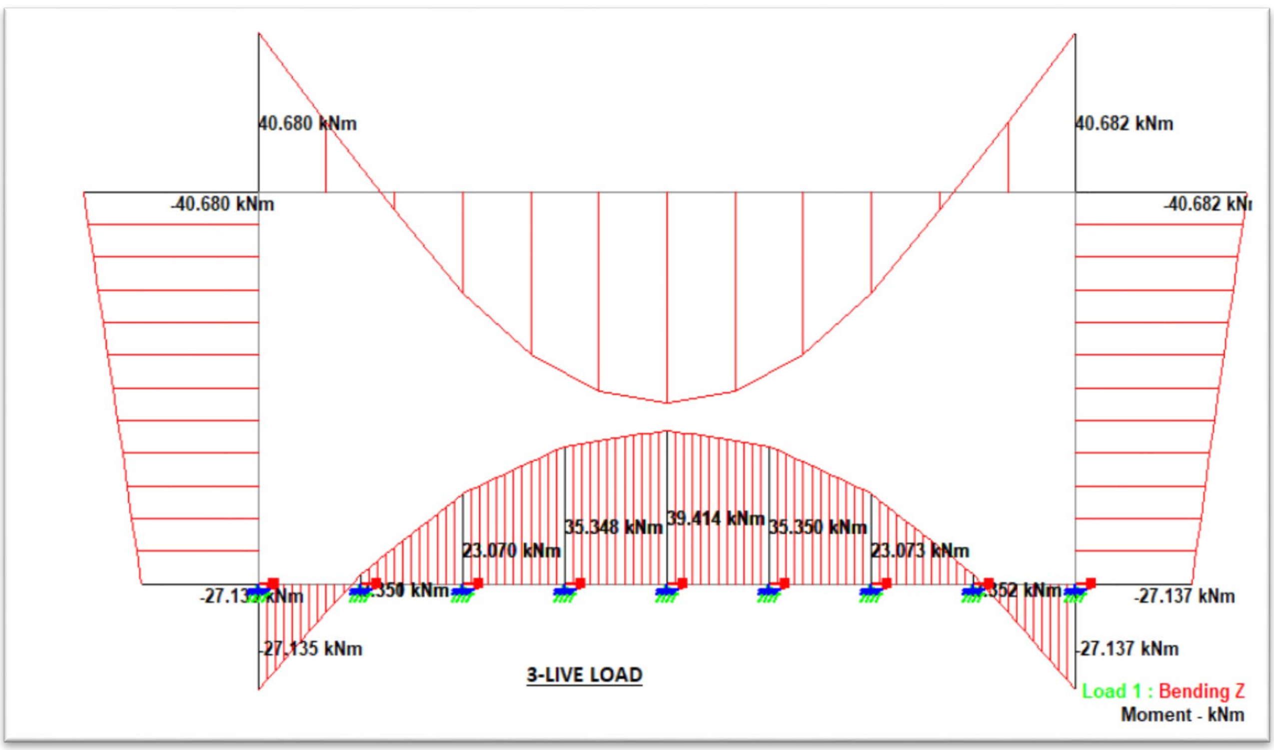
Distances to maxima are given from beam end A.

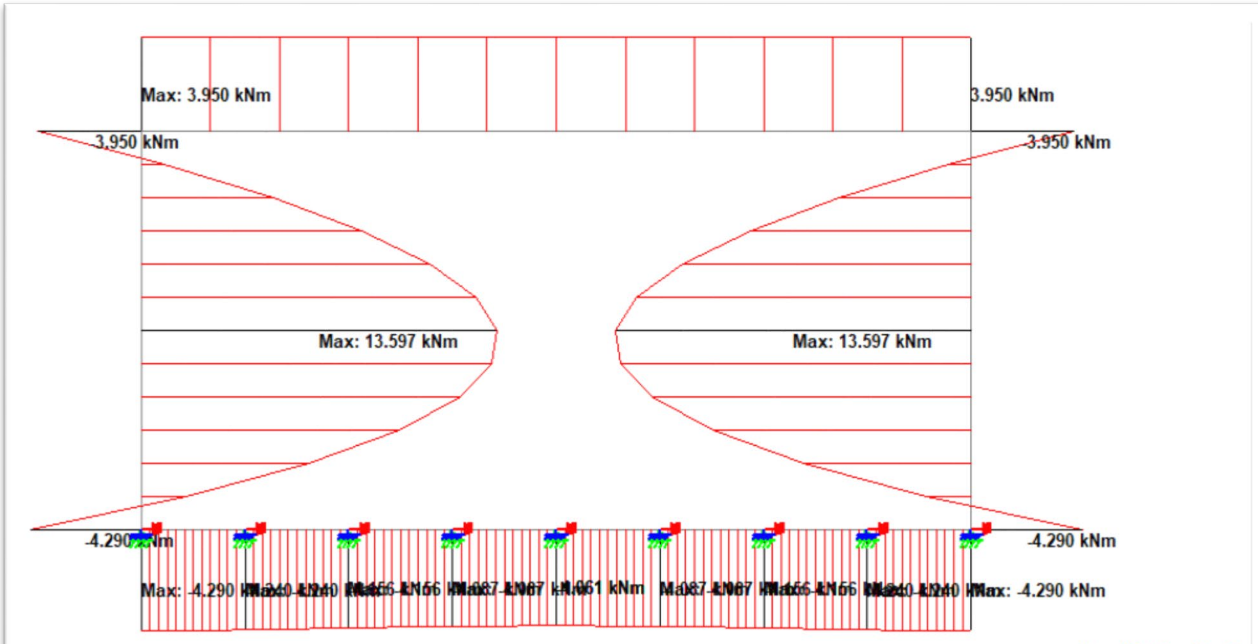
Beam	Node A	Length (m)	L/C		d (m)	Max Fx (kN)
1	1	0.794	1:	Max +ve		
				Max -ve	0.000	-0.650
2	2	0.794	1:	Max +ve		
				Max -ve	0.000	-0.650
3	3	0.794	1:	Max +ve		
				Max -ve	0.000	-0.650
4	4	0.794	1:	Max +ve		
				Max -ve	0.000	-0.650
5	5	0.794	1:	Max +ve		
				Max -ve	0.000	-0.650
6	6	0.794	1:	Max +ve		
				Max -ve	0.000	-0.650
7	7	0.794	1:	Max +ve		
				Max -ve	0.000	-0.650
8	8	0.794	1:	Max +ve		
				Max -ve	0.000	-0.650
9	10	3.350	1:	Max +ve	0.000	74.552
				Max -ve		
10	9	3.350	1:	Max +ve	0.000	74.552
				Max -ve		
11	10	6.350	1:	Max +ve	0.000	0.650
				Max -ve		



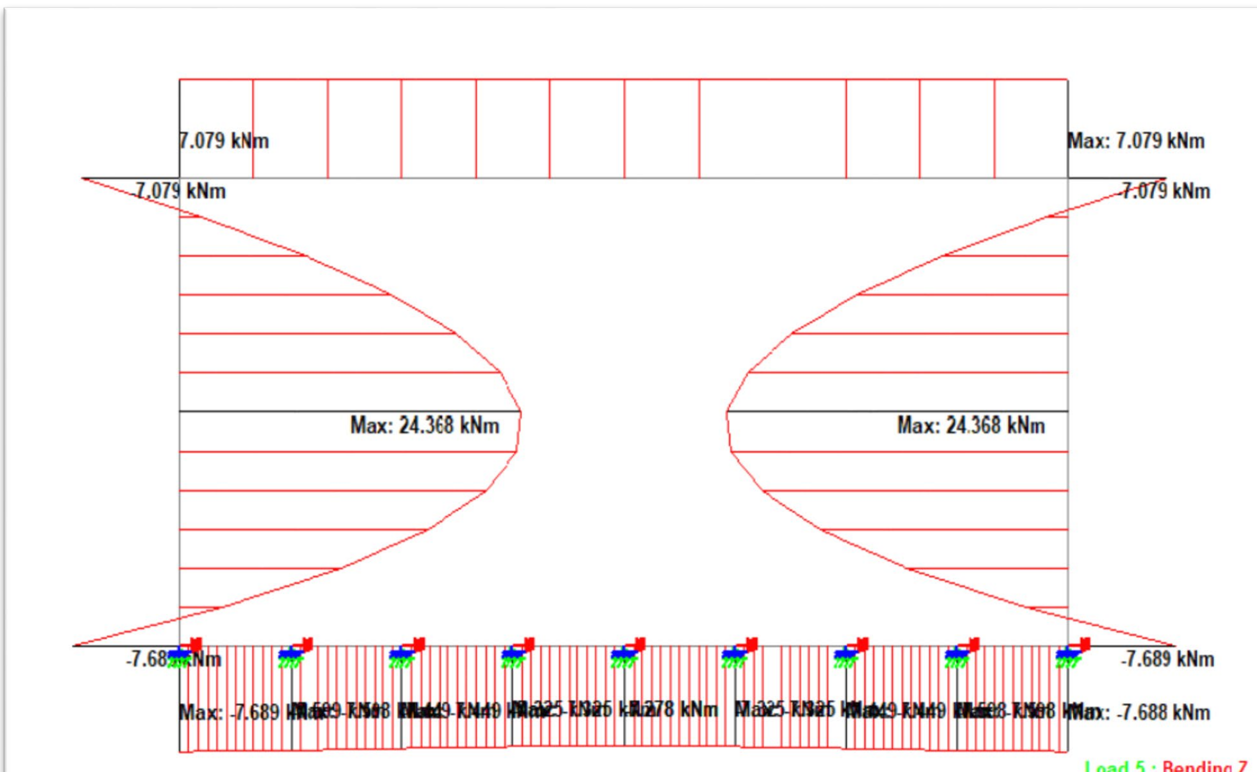

16.483 kNm
-16.483 kNm
Max: -27.620 kNm
16.483 kNm
-16.483 kNm
Max: 48.003 kNm
Max: -40.750 kNm
Max: -40.750 kNm
Max: -40.750 kNm
Max: -40.750 kNm
1-SELF-WEIGHT
Load 1 : Bending Z
Moment - kNm


49.899 kNm
49.899 kNm
Max: -49.899 kNm
Max: -49.899 kNm
Max: -63.871 kNm
Max: 63.458 kNm
-47.735 kNm
Max: -47.736 kNm
Max: -47.736 kNm
2-SUPER IMPOSED DEAD LOAD
Load 2 : Bending Z
Moment - kNm

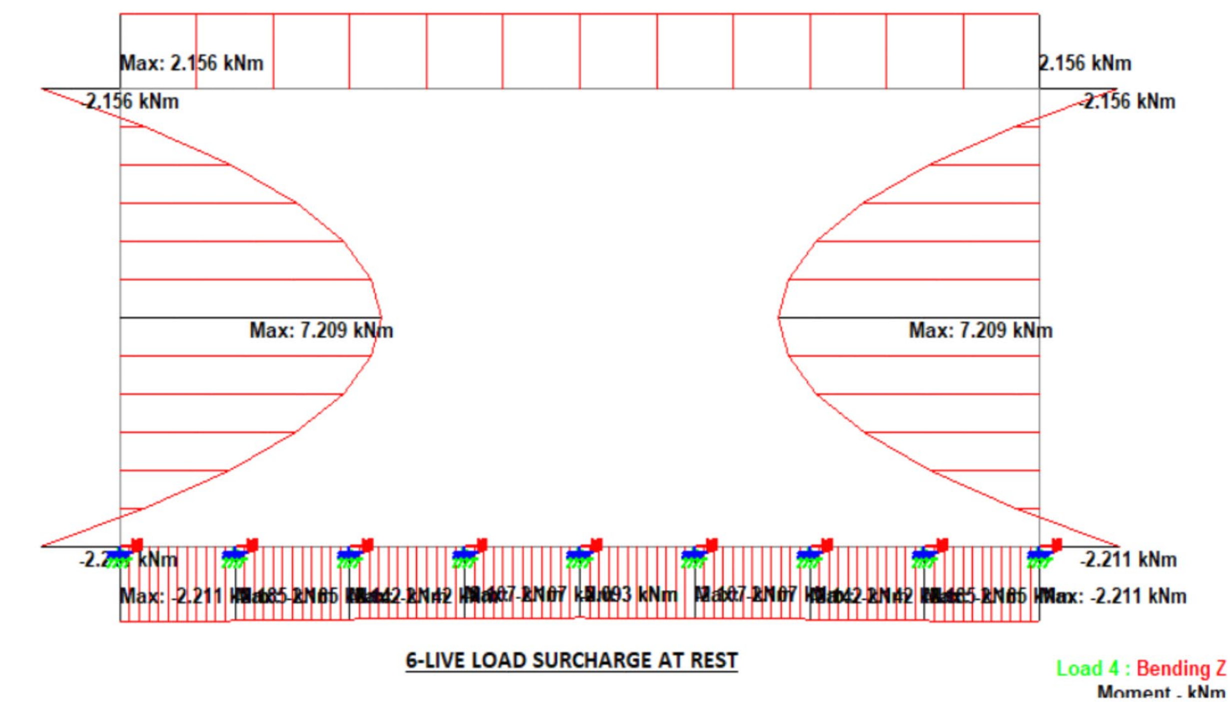

40.680 kNm
40.682 kNm
-40.680 kNm
23.070 kNm
35.348 kNm
39.414 kNm
35.350 kNm
23.073 kNm
-27.137 kNm
-27.135 kNm
-27.137 kNm
3-LIVE LOAD
Load 1 : Bending Z
Moment - kNm



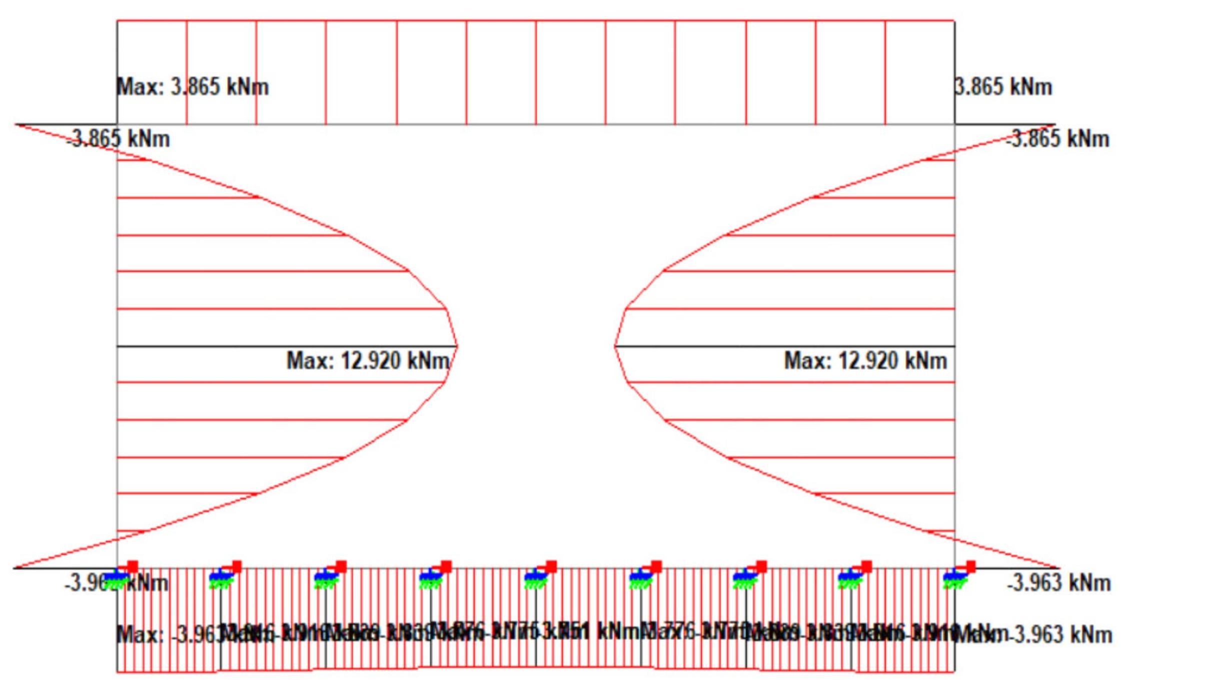
4-ACTIVE EARTH PRESSURE



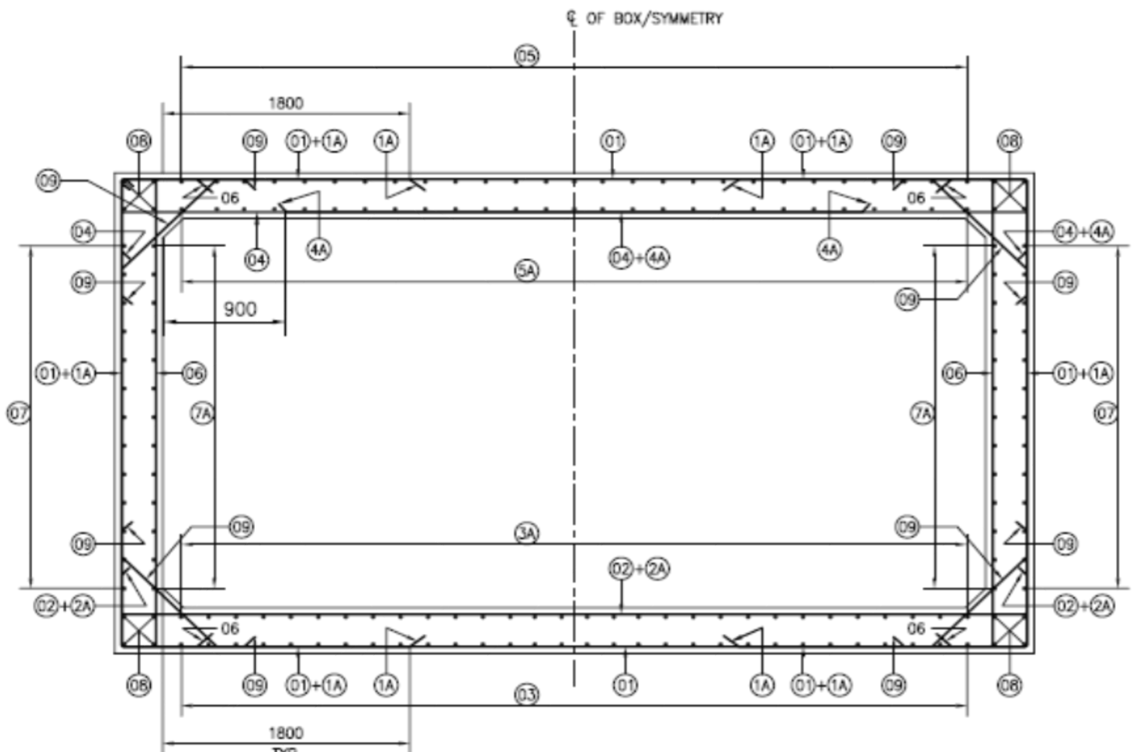
5-EARTH PRESSURE AT REST



6-LIVE LOAD SURCHARGE AT REST



7-LIVE LOAD SURCHARGE AT



REINFORCEMENT OF BOX

(SCALE 1:40)

REINFORCEMENT SCHEDULE

Bar Mark.	Bar Dia	Spacing & No. of bars	Shape	Remark
01	12	200		STP
1A	16	200	2175 2175	E/F
02	16	200	300 300	
2A	16	200	300 300	
03	12	275	200 200	
3A	12	275	200 200	
04	16	200	300 300	
4A	16	200	4200	
05	12	275	200 200	
5A	12	275	200 200	
06	10	200	300 300	
07	12	275	200 200	
7A	10	275	200 200	
08	10	4X4 Nos.	200 200	
09	10	200	20 200	

5-CONCLUSION

- The study shows that the maximum positive moment develop at the centre of top and bottom slab for the condition that the sides of the culvert not carrying the live load and the culvert is running full of water.

- The maximum negative moments develop at the support sections of the bottom slab for the condition that the culvert is empty and the top slab carries the dead load and live load.

- The maximum negative moment develop at the centre of vertical wall when the culvert is running full and when uniform lateral pressure due to superimposed dead load acts only.

- The maximum shear forces develop at the corners of top and bottom slab when the culvert is running full and the top slab carries the dead and live load.

- The study shows that there is significant contribution to positive normal thrust at centre of vertical wall due to superimposed dead load & live load and weight of side walls.

- The study shows that the multi celled box culverts are more economical for larger spans compared to single cell box culvert as the maximum bending moment and shear force values decreases considerably, thus requiring thinner sections.