International Journal of Scientific Research in Civil Engineering
© 2022 | IJSRCE | Volume 6 | Issue 5 | ISSN : 2456-6667

Analysis of Suspension Bridge with different Types of Anchoring Considering Vehicular Loading using SAP2000

Jyotiprakash Sahu[1], Radeep Ku. Nirmal[2], Okesh Singh[3]
P.G. Scholar[1], Asst. Prof.[2], Assoc. Prof.[3]
Department of Civil Engineering, R. S. R Rungta, Chhattisgarh, India

Article Info
September-October-2022
Publication Issue :
Volume 6, Issue 5
Page Number : 98-112
Article History
Accepted : 08 Sep 2022
Published : 20 Sep 2022

ABSTRACT

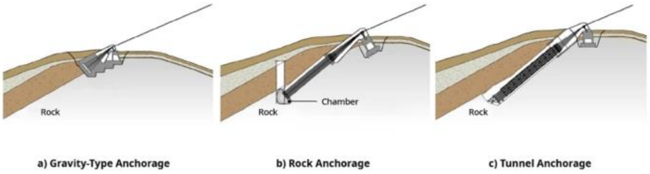
Cable-stayed and suspension bridges are two types of cable-supported bridges. One of the most common styles of long-span bridges, suspension bridges offer a number of advantages in terms of the stiffening girders' height-span ratio and material qualities. The main cables of a suspension bridge are held in place by the anchorages, which are also made up of main beams, tower piers, cables, and anchorages. Based on the main cable anchoring method, suspension bridges are classified into self-anchored or earth-anchored. In a self-anchored bridge type, the main cable is directly attached to the stiffening girder, whereas in the earth-anchored type, the main cable is directly attached to the bridge via anchorages at the beginning and end locations.

Keywords : Bridge, Concrete, Anchorage, Analysis, Force, Stress.

I. INTRODUCTION

An engineered overpass is alluded to a sort span upheld by links. This sort of scaffold has been with humanity since old times. The present huge and sublime engineered overpasses were made conceivable through the foundation of primary investigation techniques, material turns of events, development strategies, and PC innovation advancements. Engineered overpasses are quite possibly of the most gorgeous unique extension, and are viewed as one of the kinds of scaffolds numerous primary architects dream to plan.

Ports are significant designs that communicate the flat and vertical powers of the fundamental link to the establishments. The kinds of harbors are arranged into gravity-type ports, burrow type moorings, and rock safe havens. Gravity-type mooring comprises of a strategy for opposing the heaps from the links with oneself load of the establishment and anchor outline. Numerous engineered overpasses use gravity-type ports. Burrow type dock is a strategy for opposing the heaps of the links by utilizing the shear powers of the external outline of the steel outline and the tension of the fitting body. Rock dock is a strategy for opposing the heaps of the link by utilizing the weight, grip, and frictional obstruction of rock wedges. This strategy is utilized in regions with great stone arrangements.



a) Gravity-Type Anchorage b) Rock Anchorage c) Tunnel Anchorage

Fig 1 Anchorage types

II. Literature Review

Xiangong Zhou et.al (2022) the exploration and examination strategy for underlying delicacy of three-tower self-secured engineered overpass was introduced exhaustively founded on reasonable designing cases.

Under the activity of seismic waves along the extension, the harm exceedance likelihood of the damped association framework is lower than that of the completely drifting design framework. Simultaneously, the distinction in harm exceedance likelihood of the two frameworks under a similar harm level keeps on extending. It demonstrates the way that the expansion of a damper gadget can essentially work on the seismic execution of the design, and the decrease impact of a damper gadget for an extreme focus tremor is more clear than that for a low-power quake. The likelihood of slight and moderate harm to the wharfs and heading of the drifting arrangement of the threetower self-secured engineered overpass is high, while the likelihood of harm to the extension tower is generally little. This plan is in accordance with the plan thought of accepting the handily fixed parts as auxiliary parts in the seismic plan.

Zhijin Shen et.al (2022) research paper directed a field-scale examination to concentrate on the north side passage of Wujiagang Scaffold in Yichang, China. As per the closeness standard, the 1:12 passage anchor scale model was laid out. The passage anchor scale model was chosen in the space neighboring the real task site to guarantee the closeness of stratigraphic conditions. Using a removal meter, inclinometer opening, strain measure, micrometers, and other extensive checking strategies, the plan load test, over-burden test, over-burden rheological test, and extreme bearing limit disappointment test were completed. Through the primary deformity perception and stress perception of the port body and encompassing stone, the pressure misshapening attributes and rheological qualities of the harbor body and encompassing stone in the field-scale try were dissected. The twisting disappointment system, deformity disappointment process, potential disappointment mode, and over-burden limit of strong passage anchor were explored.

In view of the cutoff harmony examination aftereffects of the model, the security and objectivity of the passage safe haven structure plan of the real engineered overpass were assessed. As indicated by the model trial results, under the plan heap of 1P, the distortion of the stone mass at the highest point of the anchor burrow is the biggest, which is 0.005 mm followed by the disfigurement of the stone mass at the front anchor surface, and the misshapening of the stone mass at the back anchor surface is the littlest, which is 0.001 mm. As per the comparability rule, it is hypothesized that the greatest twisting of the front anchor surface of the strong anchor is around 1.2 mm under 1P burden. Rheological experimental outcomes show that the drawn out rheological qualities of passage port are not clear under the activity of configuration burden and bit by bit over-burden load, and the mooring can be in a drawn out stable state under rheological burden. The plan of passage mooring on the north side of Wujiagang Yangtze Waterway Scaffold in Yichang can meet the designing necessities.

Objectives of the Research

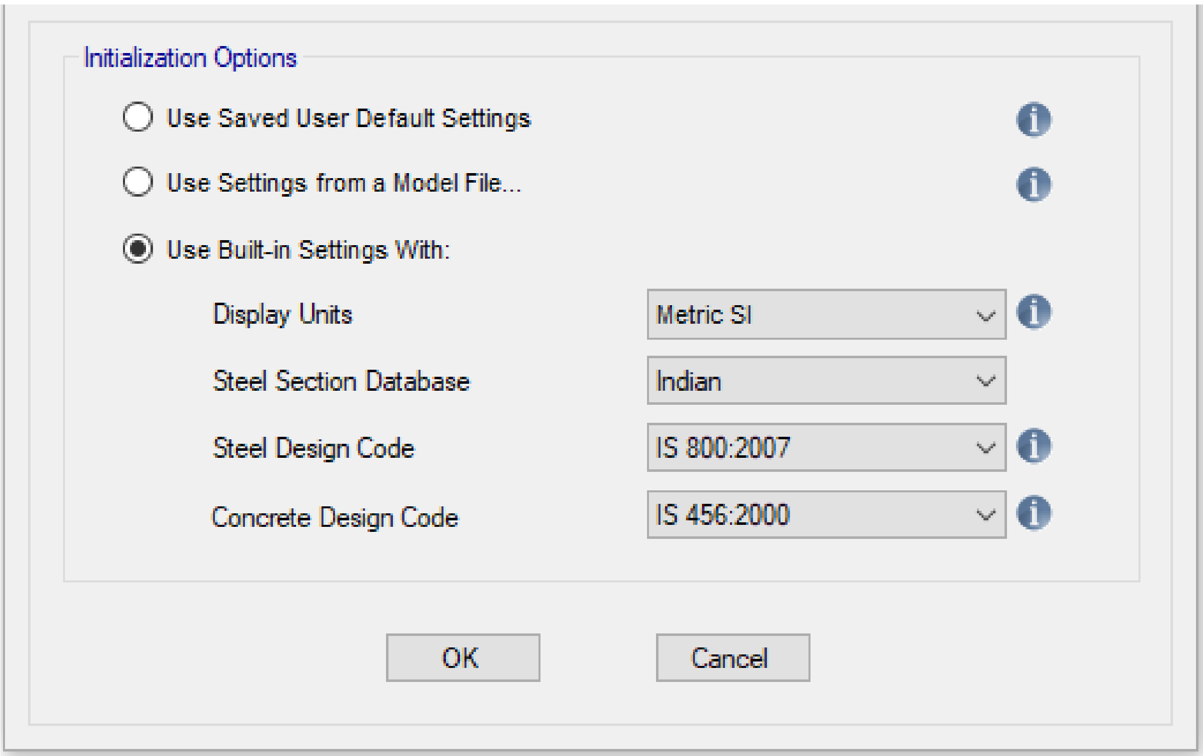
The primary goals of the current examination are as per the following:-

1. To decide the take out conduct of the passage type dock and gravity type in light of rock joint.
2. To examination the heap bearing limit of the dock span with two different condition.
3. To decide limited component examination of harbor based span utilizing investigation instrument SAP2000.
4. To decide the most appropriate sort of jetty in examination.

III. METHODOLOGY

Steps of the Analysis

Step 1 First step is to study different research papers from authors all across the globe to understand the research done in the same field and this gave our study base and scope for further research.
Step 2 this step includes defining the unit to design the model initialization where the units is measured as Metric SI. Steel code and concrete design code is locked as IS 800:2007 and IS 456:2000.



Initialization Options

○ Use Saved User Default Settings

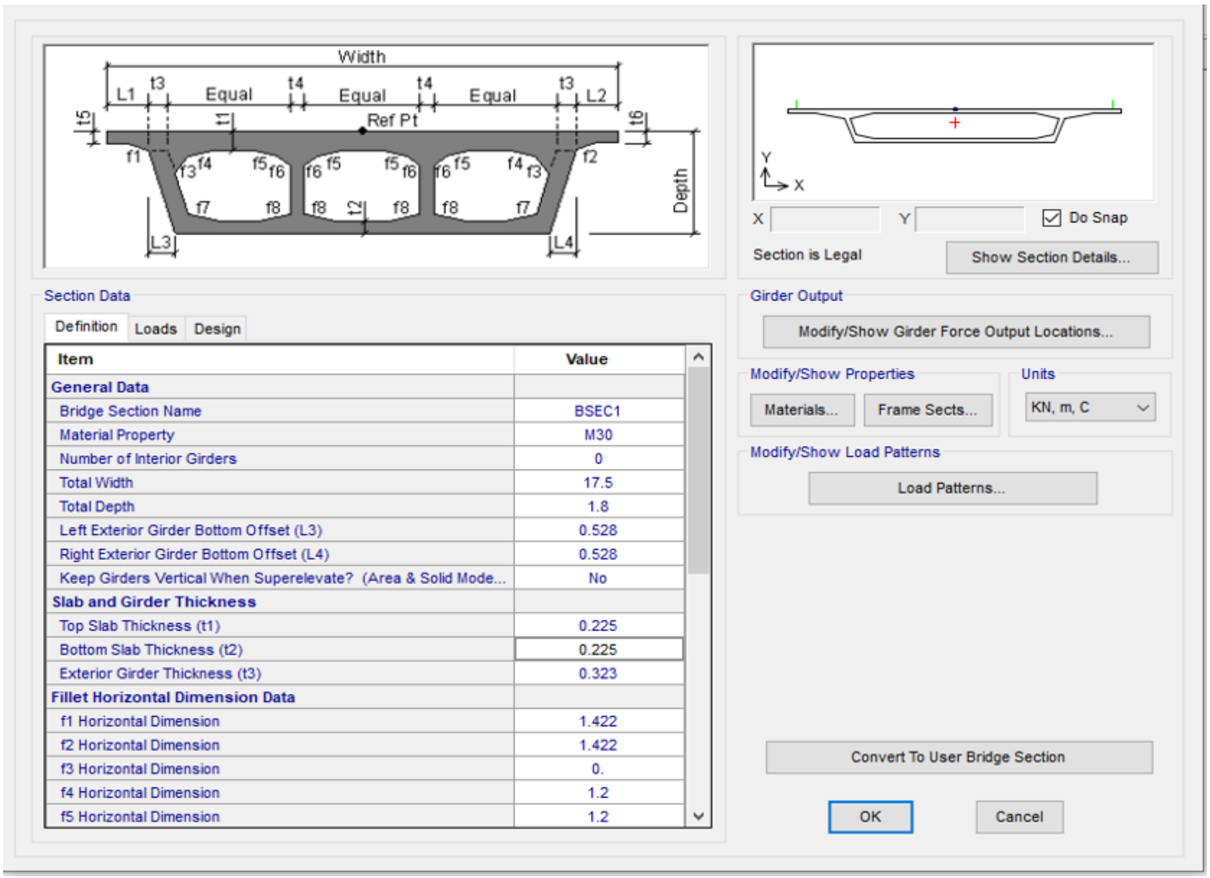
○ Use Settings from a Model File...

● Use Built-in Settings With:

Display Units	Metric SI
Steel Section Database	Indian
Steel Design Code	IS 800:2007
Concrete Design Code	IS 456:2000

Fig 2 Initialization of Model

Step 3: Modelling of the section a working drawing



Section is Legal

Units: KN, m, C

Item	Value
General Data	
Bridge Section Name	BSEC1
Material Property	M30
Number of Interior Girders	0
Total Width	17.5
Total Depth	1.8
Left Exterior Girder Bottom Offset (L3)	0.528
Right Exterior Girder Bottom Offset (L4)	0.528
Keep Girders Vertical When Superelevate? (Area & Solid Mode...	No
Slab and Girder Thickness	
Top Slab Thickness (t1)	0.225
Bottom Slab Thickness (t2)	0.225
Exterior Girder Thickness (t3)	0.323
Fillet Horizontal Dimension Data	
f1 Horizontal Dimension	1.422
f2 Horizontal Dimension	1.422
f3 Horizontal Dimension	0.
f4 Horizontal Dimension	1.2
f5 Horizontal Dimension	1.2

Fig 3 Modeling of Sectional Drawing

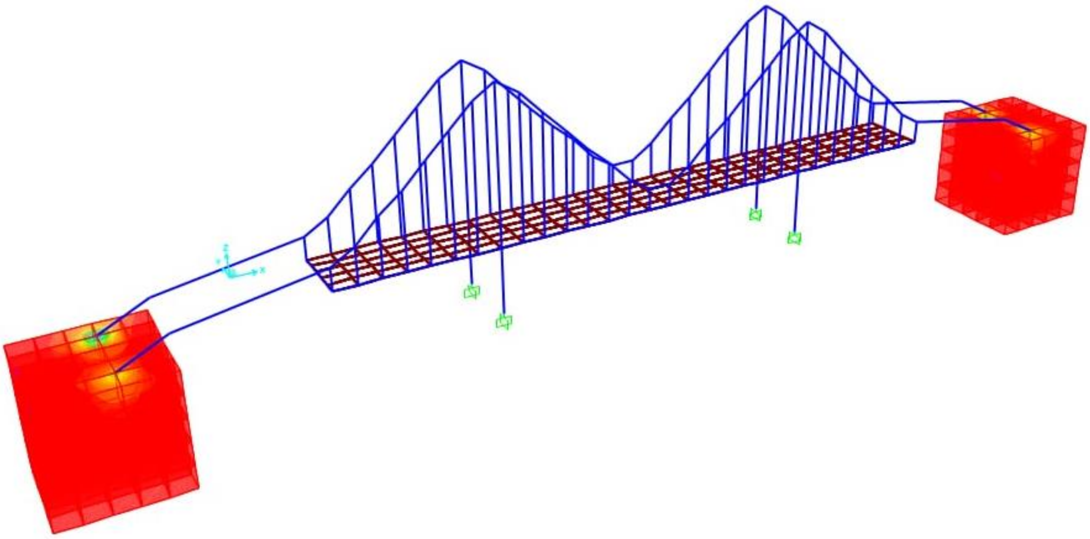
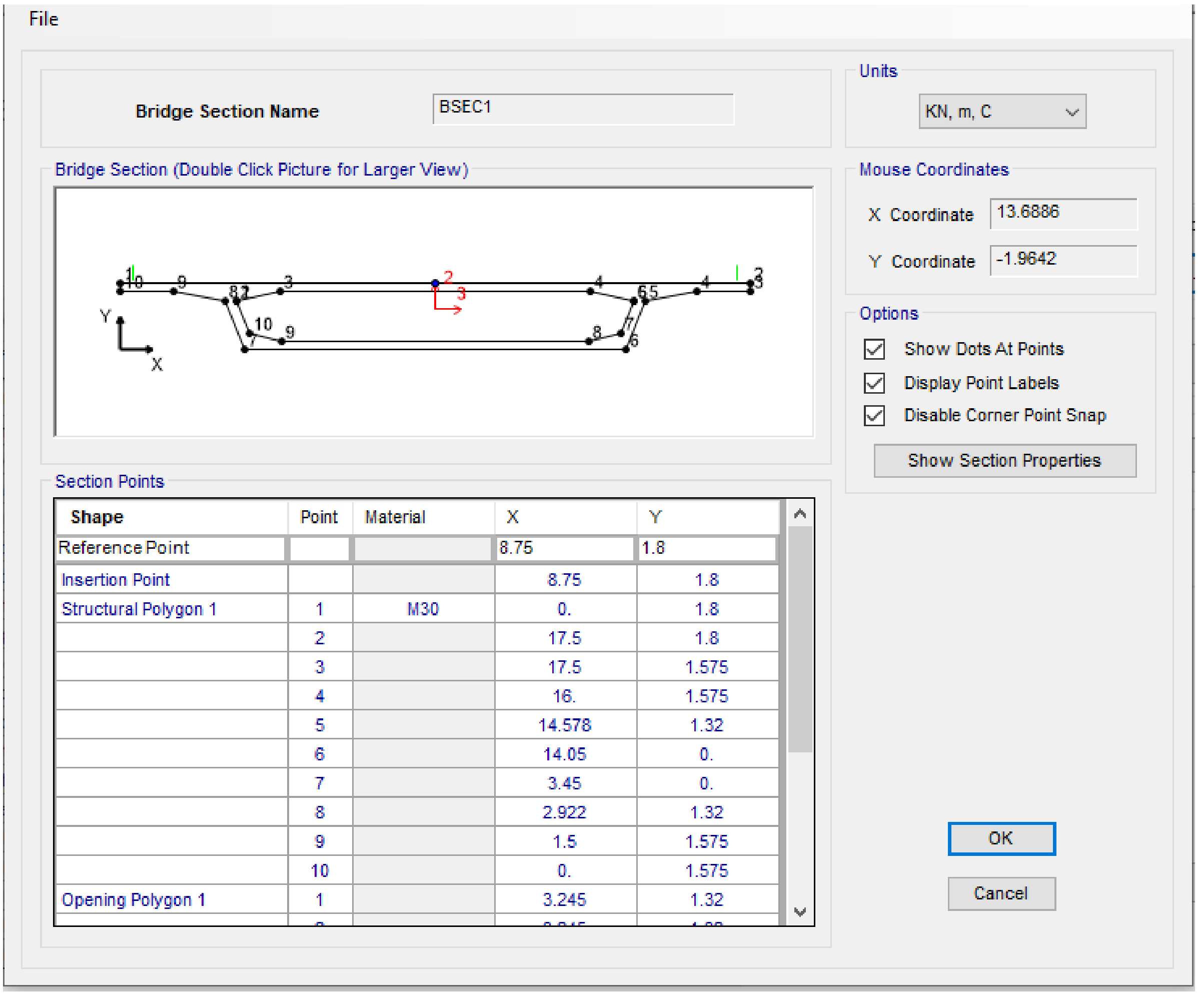


Fig 4 Model Structure

Step 4: Defining materials as per Indian Standards and assigning to the structural members



Bridge Section Name: BSEC1

Units: KN, m, C

X Coordinate: 13.6886

Y Coordinate: -1.9642

☑ Show Dots At Points

☑ Display Point Labels

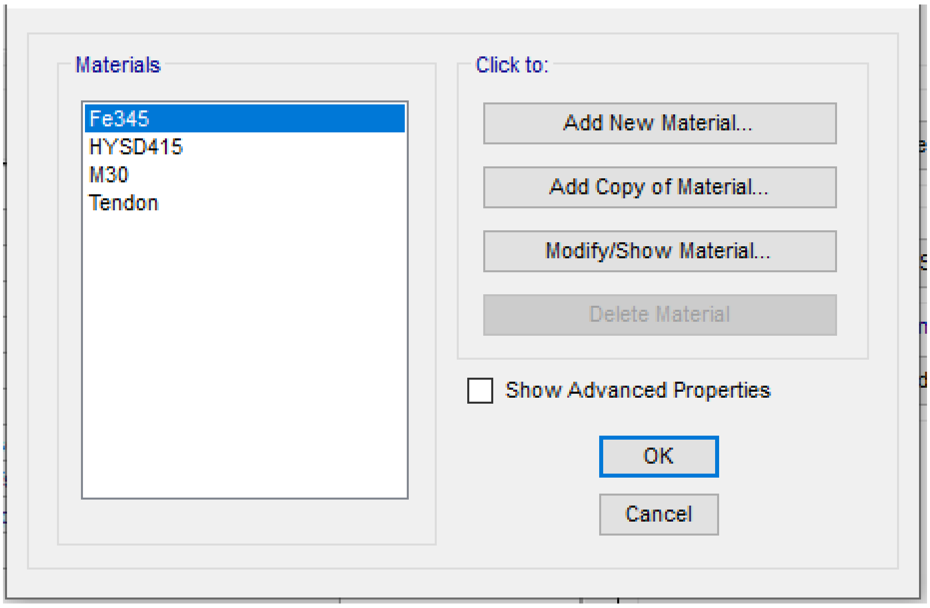
☑ Disable Corner Point Snap

Section Points

Shape	Point	Material	X	Y
Reference Point			8.75	1.8
Insertion Point			8.75	1.8
Structural Polygon 1	1	M30	0.	1.8
	2		17.5	1.8
	3		17.5	1.575
	4		16.	1.575
	5		14.578	1.32
	6		14.05	0.
	7		3.45	0.
	8		2.922	1.32
	9		1.5	1.575
	10		0.	1.575
Opening Polygon 1	1		3.245	1.32

Fig 5 Defining Bridge Section

Step 5: Defining Properties of Material



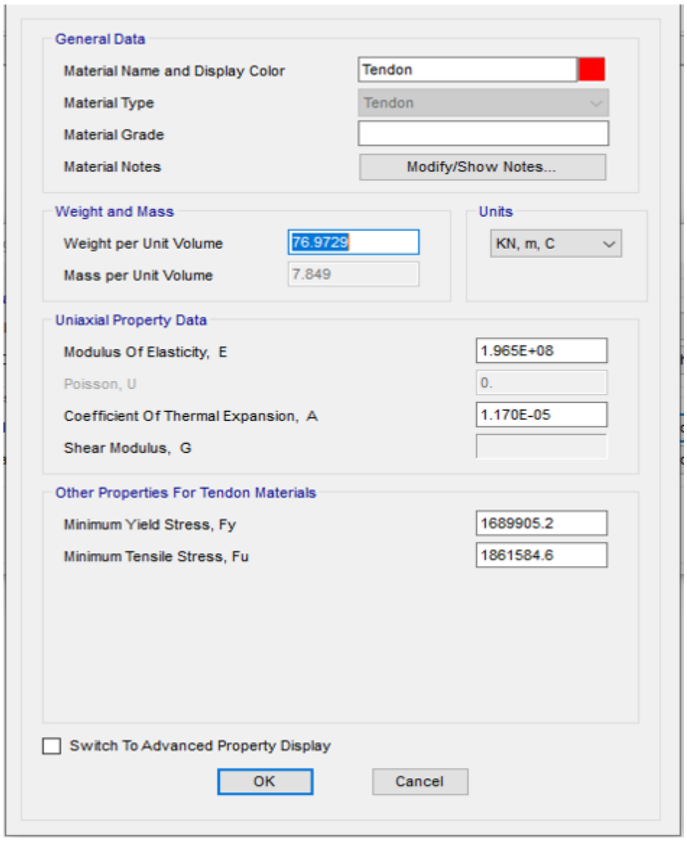
Materials:

- Fe345
- HYSD415
- M30
- Tendon

☐ Show Advanced Properties

Fig 6 Defining Properties of Material

Step 6: Assigning tendons to precast segmental beam.



General Data

Material Name and Display Color: Tendon 🟥

Material Type: Tendon

Material Grade:

Material Notes: Modify/Show Notes...

Weight and Mass

Weight per Unit Volume: 76.9729

Mass per Unit Volume: 7.849

Units: KN, m, C

Uniaxial Property Data

Modulus Of Elasticity, E: 1.965E+08

Poisson, U: 0.

Coefficient Of Thermal Expansion, A: 1.170E-05

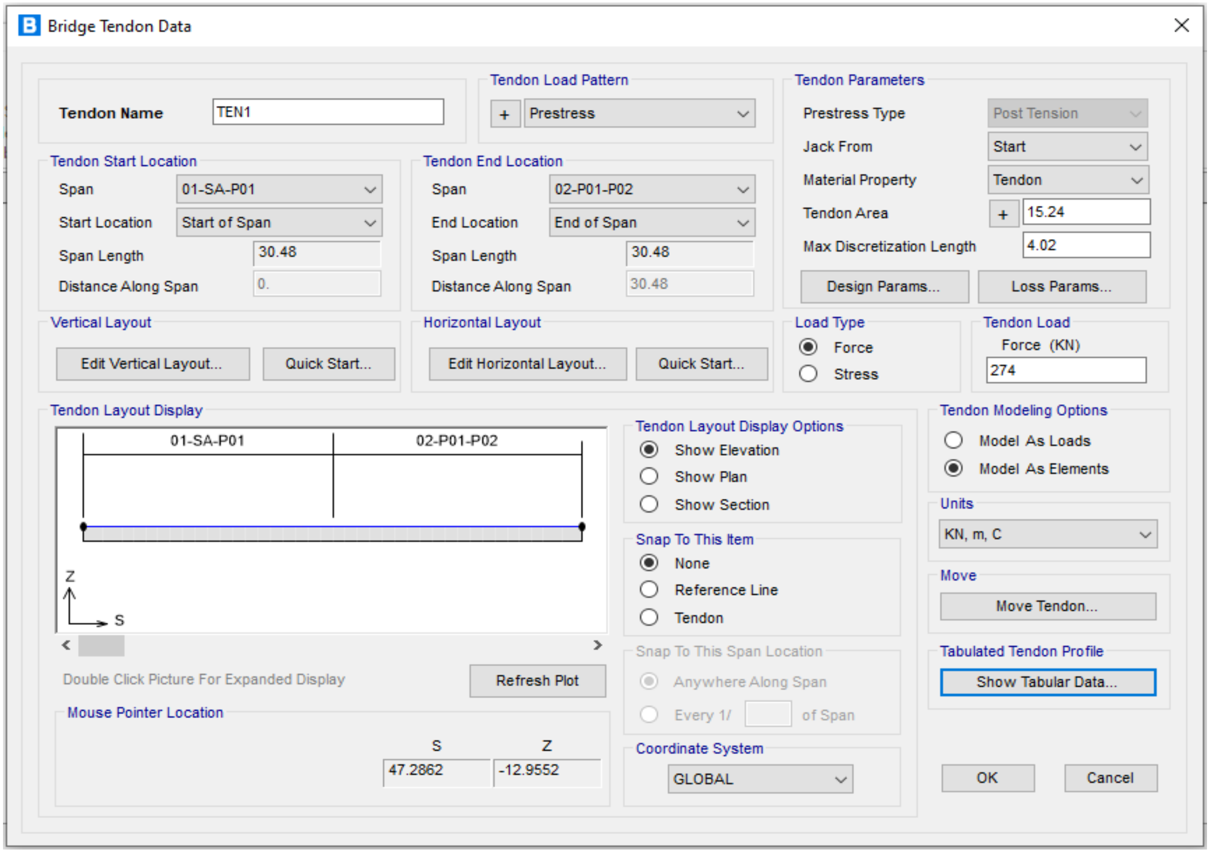
Shear Modulus, G:

Other Properties For Tendon Materials

Minimum Yield Stress, Fy: 1689905.2

Minimum Tensile Stress, Fu: 1861584.6

☐ Switch To Advanced Property Display



Bridge Tendon Data

Tendon Name: TEN1

Tendon Load Pattern: Prestress

Tendon Parameters

Prestress Type: Post Tension

Jack From: Start

Material Property: Tendon

Tendon Area: 15.24

Max Discretization Length: 4.02

Tendon Start Location

Span: 01-SA-P01

Start Location: Start of Span

Span Length: 30.48

Distance Along Span: 0.

Tendon End Location

Span: 02-P01-P02

End Location: End of Span

Span Length: 30.48

Distance Along Span: 30.48

Load Type: ● Force ○ Stress

Tendon Load: Force (KN) 274

Tendon Layout Display Options: ● Show Elevation ○ Show Plan ○ Show Section

Snap To This Item: ● None ○ Reference Line ○ Tendon

Snap To This Span Location: ● Anywhere Along Span ○ Every 1/ of Span

Coordinate System: GLOBAL

Tendon Modeling Options: ○ Model As Loads ● Model As Elements

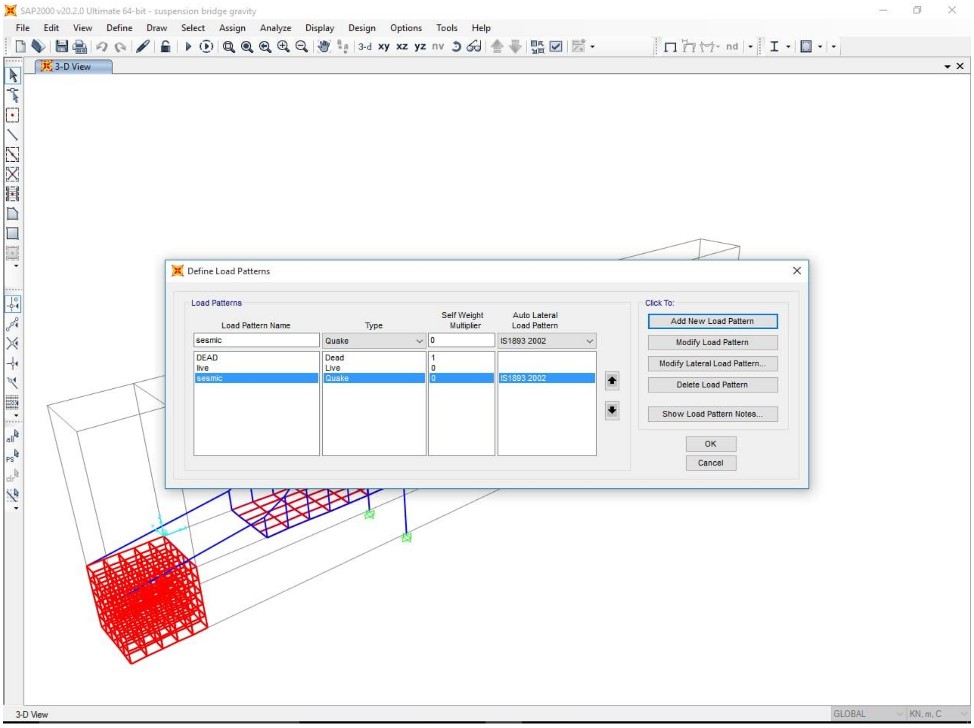
Units: KN, m, C

Mouse Pointer Location: S 47.2862, Z -12.9552

Double Click Picture For Expanded Display

Fig 7 Defining and Assigning Bridge Tendons

Step 7: Assigning Loading conditions to the model Precast Segmental beam with tendons.

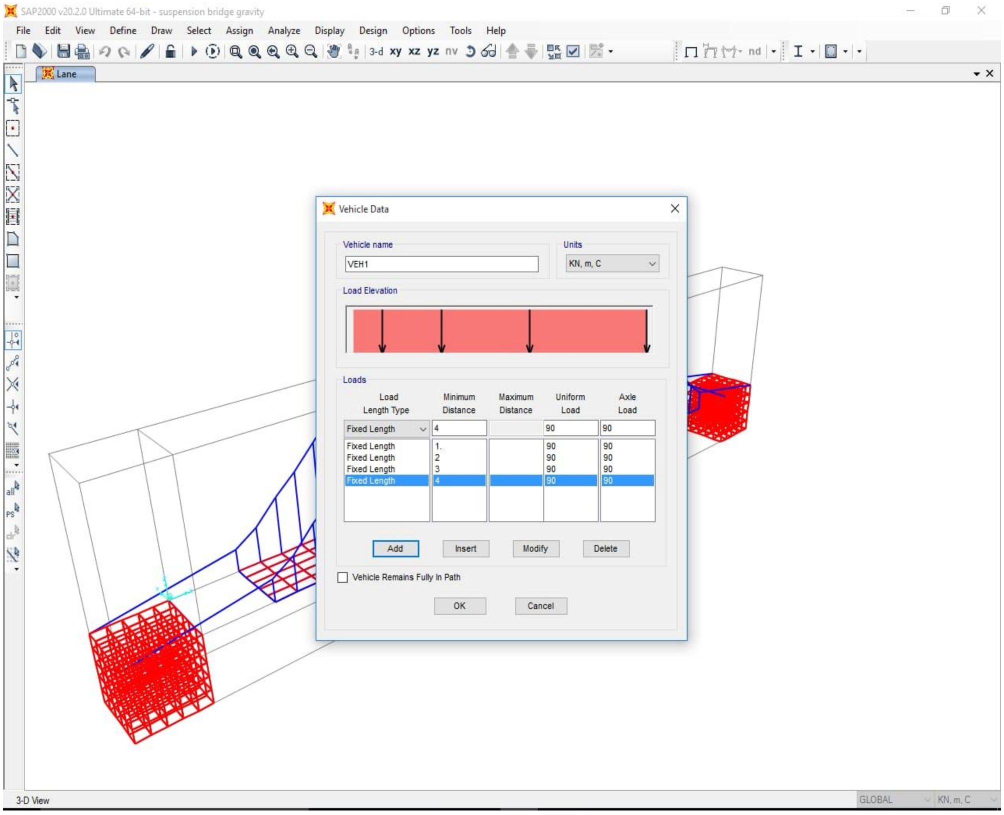


Load Patterns

Load Pattern Name	Type	Self Weight Multiplier	Auto Lateral Load Pattern
sesmic	Quake	0	IS1893 2002
DEAD	Dead	1	
live	Live	0	
sesmic	Quake	0	IS1893 2002

Fig 8 Defining Load Pattern

Step 8: Defining Vehicular Loading



Vehicle name: VEH1

Units: KN, m, C

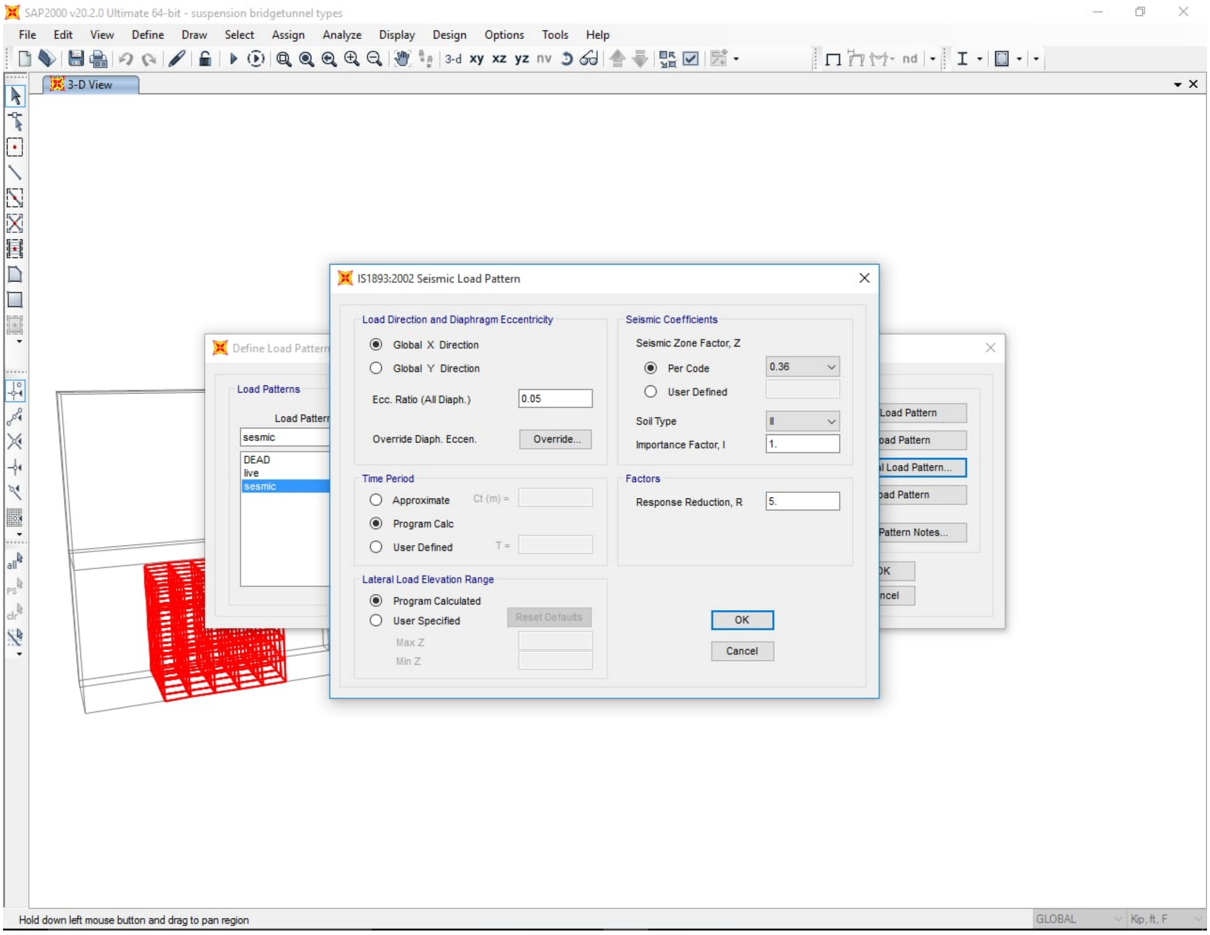
Loads

Load Length Type	Minimum Distance	Maximum Distance	Uniform Load	Axle Load
Fixed Length	4		90	90
Fixed Length	1.		90	90
Fixed Length	2		90	90
Fixed Length	3		90	90
Fixed Length	4		90	90

☐ Vehicle Remains Fully In Path

Fig 9 Vehicular Loading

Step 9: Defining Seismic loading as per IS 1893:2016 Part I



Load Patterns: sesmic, DEAD, live, sesmic

IS1893:2002 Seismic Load Pattern

Load Direction and Diaphragm Eccentricity
● Global X Direction
○ Global Y Direction
Ecc. Ratio (All Diaph.) 0.05
Override Diaph. Eccen. Override...

Seismic Coefficients
Seismic Zone Factor, Z
● Per Code 0.36
○ User Defined
Soil Type II
Importance Factor, I 1.

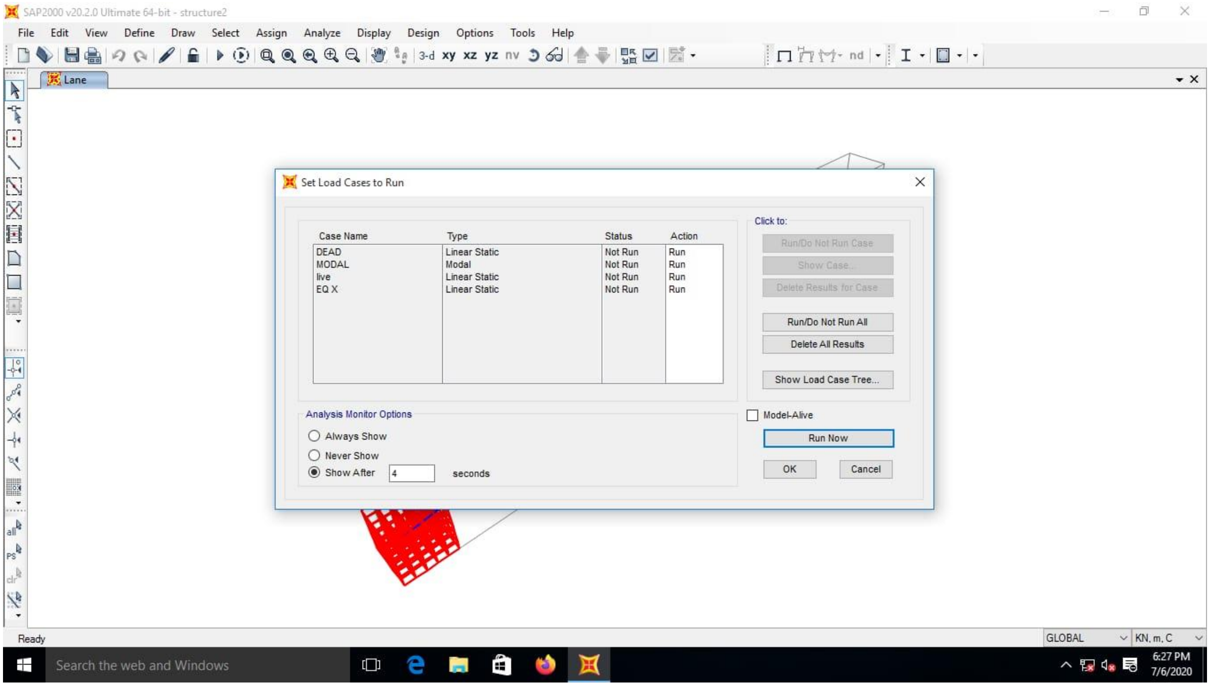
Time Period
○ Approximate Ct (m) =
● Program Calc
○ User Defined T =

Factors
Response Reduction, R 5.

Lateral Load Elevation Range
● Program Calculated
○ User Specified
Max Z
Min Z

Fig 10 Defining Seismic Loading

Step 10: Analyzing the stress on the structure



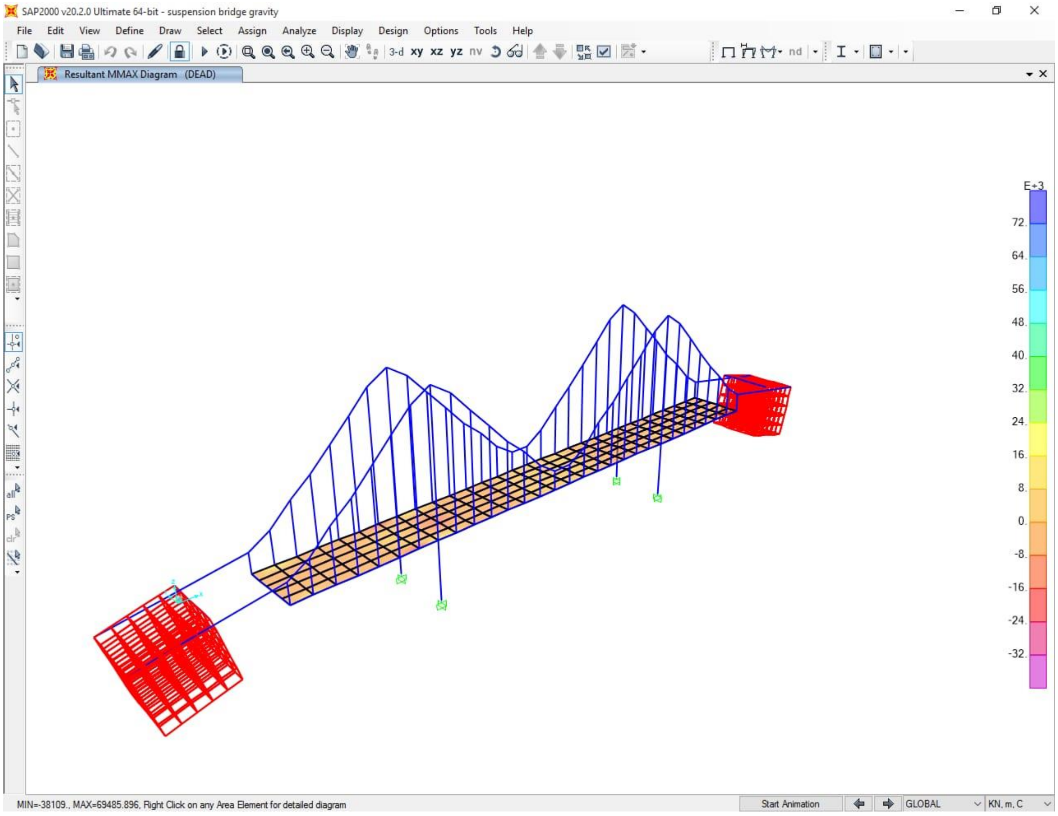
Set Load Cases to Run

Case Name	Type	Status	Action
DEAD	Linear Static	Not Run	Run
MODAL	Modal	Not Run	Run
live	Linear Static	Not Run	Run
EQ X	Linear Static	Not Run	Run

Analysis Monitor Options
○ Always Show
○ Never Show
● Show After 4 seconds

☐ Model-Alive

Fig 11 Running Load Cases



MIN=-38109., MAX=69485.896, Right Click on any Area Element for detailed diagram

Fig 12 Stress Analysis

Flow Chart of the Study

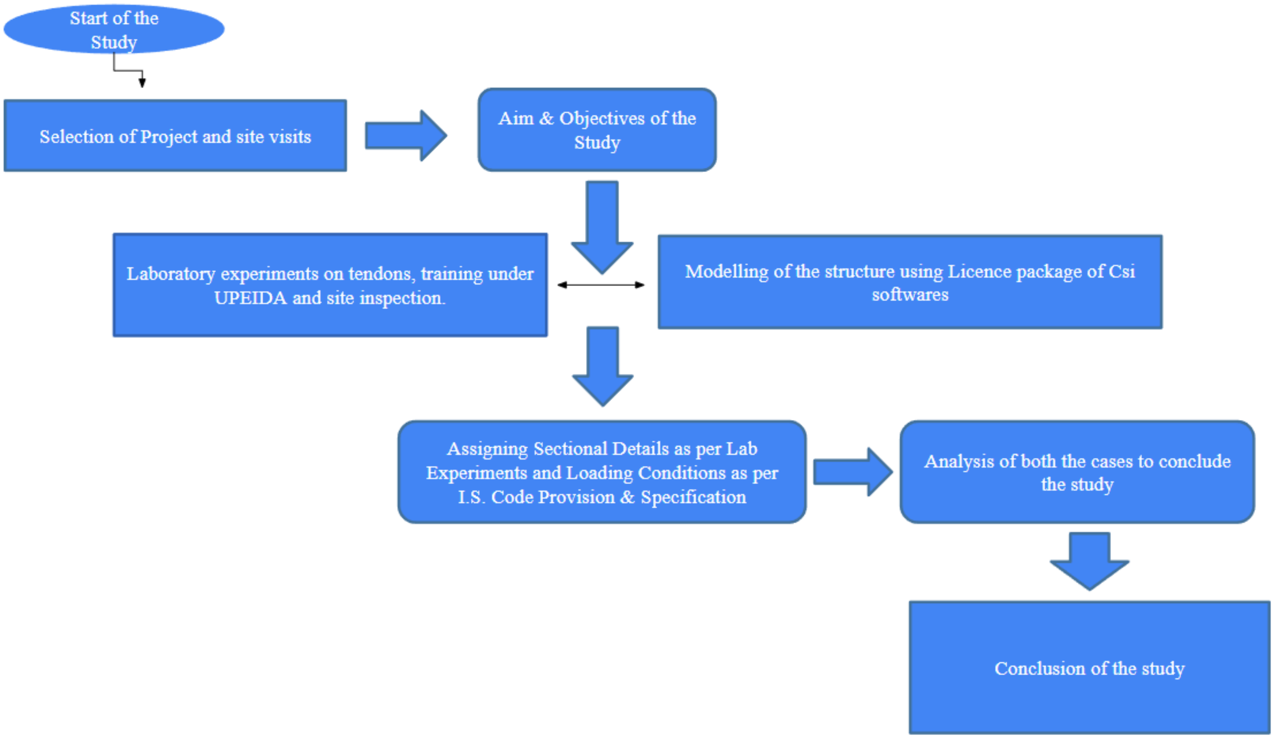


Fig 13 Flow Chart of the Study

Table 1 Geometrical Description

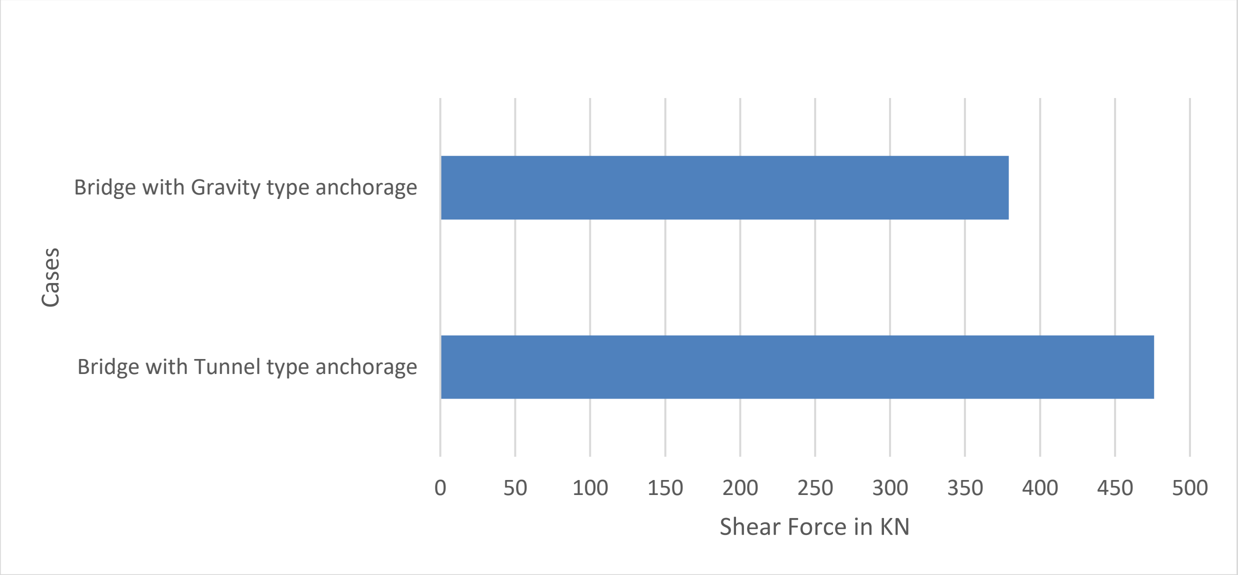
Dimension of the model	
Length	17500 mm
Height	3400 mm
Web thickness	300 mm
Construction joint for crash barrier portion	3000 mm
Opening	800 x 900 mm
Anchorage	Tunnel and Gravity
Haunch	100 x 100 mm

Analysis Result

Shear Force in kN

Table 2 Shear Force in kN

Shear force in kN	
Bridge with Tunnel type anchorage	476.098
Bridge with Gravity type anchorage	379.207

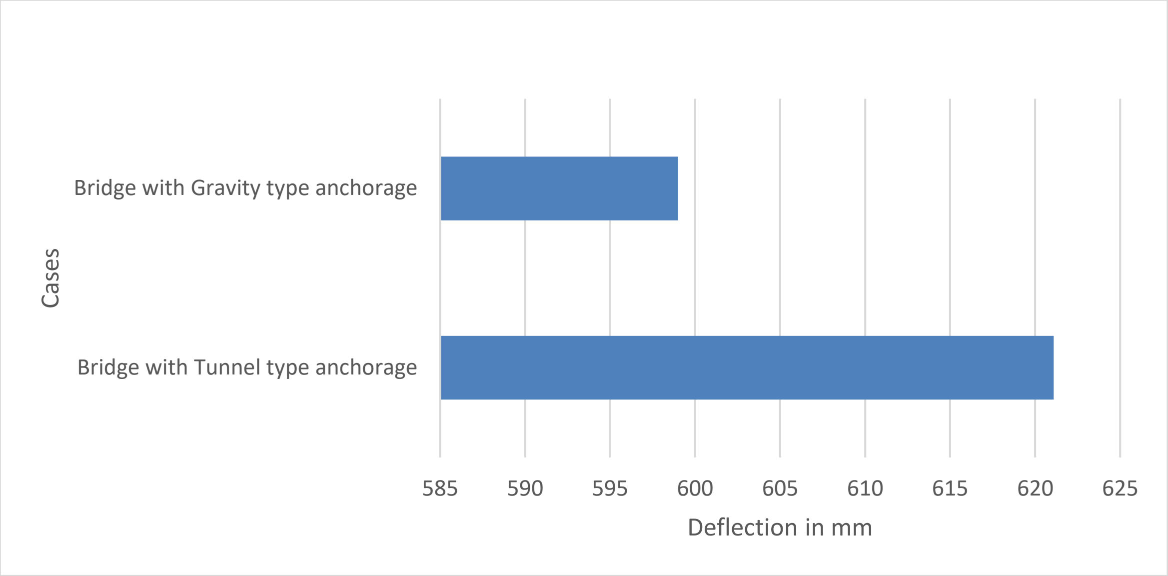


Discussion: As the above graph stated shear force was least found in bridge with gravity type anchorage as shear force for bridges with Gravity type anchorage was 379.207 kN whereas shear force for bridge with Tunnel type anchorage was 476.098 kN.

Maximum Deflection in mm

Table 3 Maximum Deflection in mm

Maximum Deflection in mm	
Bridge with Tunnel type anchorage	621.098
Bridge with Gravity type anchorage	598.992

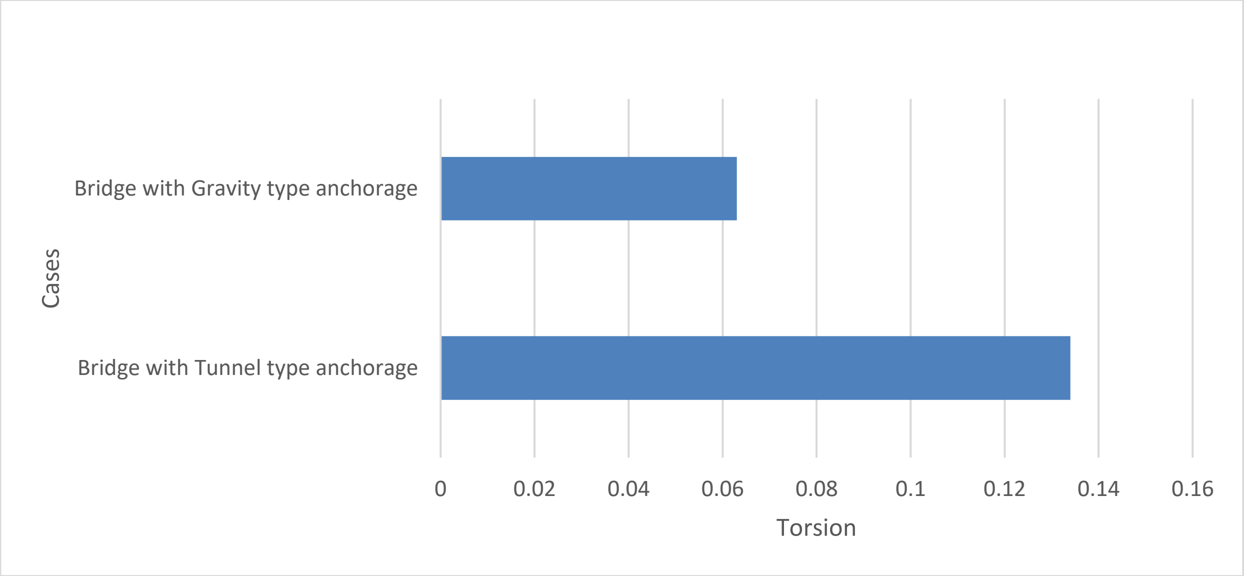


Discussion: The structure was fragmental in segments to evaluate maximum deflection as minor gap was seen in both the cases as of 9% difference.

Torsional Values in kN-m

Table 4 Torsional Values in kN-m

Torsional Values in KNm	
Bridge with Tunnel type anchorage	0.134
Bridge with Gravity type anchorage	0.063

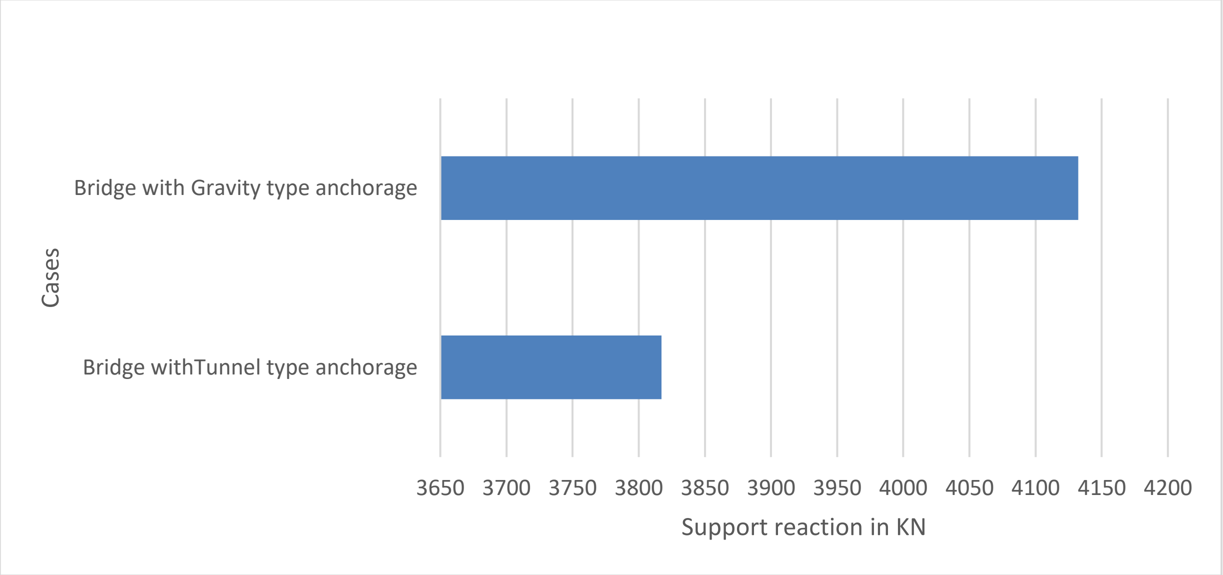


Discussion: Torsion is the state of strain in a material that has been twisted by an applied torque. Something happens when a structural member is subjected to a twisting force. Torsion is the state of strain that has deformed the rectangles, and it is made up entirely of pure shear. The torsion values for bridge with tunnel anchorage was 0.134 kn-m and bridge with gravity anchorage was 0.063 kN-m.

Support Reaction in kN

Table 5 Support Reaction in kN

Support Reaction in kN	
Bridge withTunnel type anchorage	3817.098
Bridge with Gravity type anchorage	4132.276

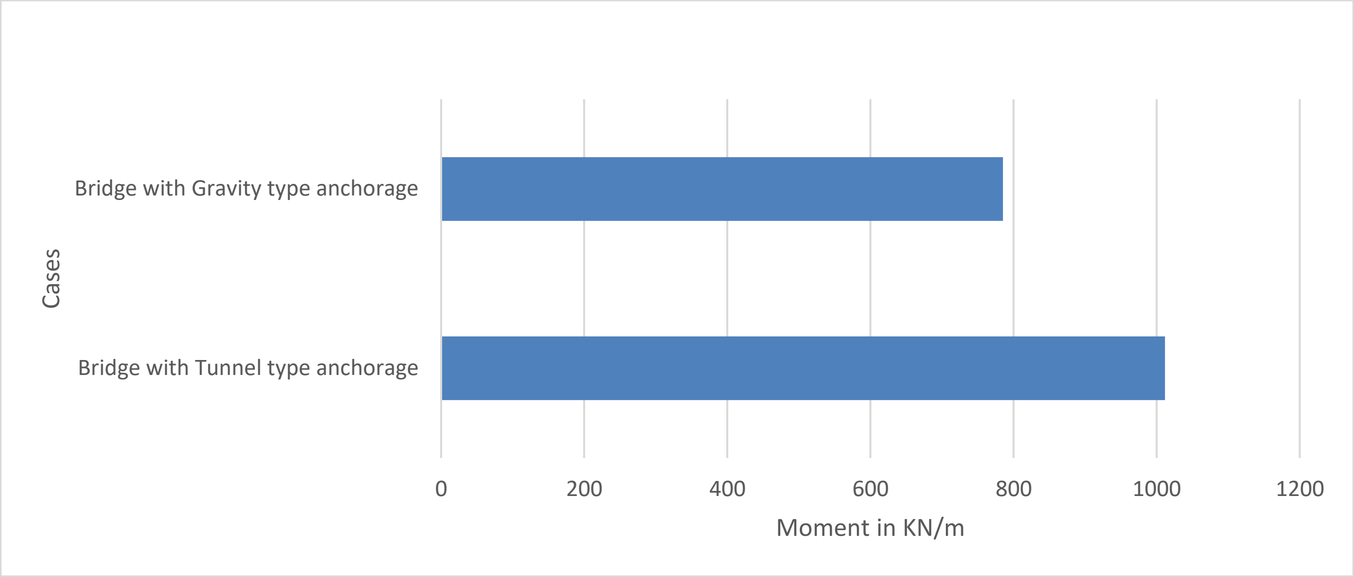


Discussion: A support reaction is a force that is applied to a support or a resultant restraining end moment that occurs as a result of the inability to move. Support responses in structural systems are in balance with external forces operating on the structure. Here the support reaction was maximum with a bridge with gravity anchorage in comparison to a bridge with tunnel anchorage.

Maximum Moment in kN-m

Table 6 Maximum Moment in kN-m

Maximum Moment in kN-m	
Bridge with Tunnel type anchorage	1011.88
Bridge with Gravity type anchorage	785.007



Discussion: The maximum bending moment in a girder occurs when the shear force at that section is zero or changes sign because the bending moment is zero at the point of contra flexure. A sagging bending moment, also known as a positive bending moment, is one such bending moment. Here the bending moment was 785.007 kN-m for bridge with gravity anchorage whereas 1011.88 kN-m for bridge with tunnel anchorage.

IV. CONCLSION

Shear Force in kN

Shear force was least found in bridges with Gravity anchorage as shear force for bridges was 379.207 kN whereas shear force for bridges with tunnel anchorage was 476.098 kN.

Maximum Deflection

The structure was fragmental in segments to evaluate maximum displacement as a minor gap was seen in both the cases of 9% difference.

Torsional Values

The state of strain in a material that has been twisted by an applied torque is known as torsion. When a structural element is subjected to a twisting force, something happens. Torsion is the state of strain that has deformed the rectangles, and it is made up entirely of pure shear. The torsion values for bridge with tunnel anchorage was 0.134 kn-m and bridge with gravity anchorage was 0.063 kn-m.

Support Reaction

A support reaction is a force that is applied to a support or a resultant restraining end moment that occurs as a result of the inability to move. Support responses in structural systems are in balance with external forces operating on the structure. Here the support reaction was maximum with a bridge with gravity anchorage in comparison to a bridge with tunnel anchorage.

Maximum Moment

The maximum bending moment in a girder occurs when the shear force at that section is zero or changes sign because the bending moment is zero at the point of contra flexure. A sagging bending moment, also known as a positive bending moment, is one such bending moment. Here the bending moment was 785.007 kN-m for bridge with gravity anchorage whereas 1011.88 kN-m for bridge with tunnel anchorage.

Summary: As per our comparative results stated above it can be said that Gravity type anchorage is comparatively more suitable in comparison to tunnel type thus it can be said that gravity type anchorage can result in more reliable type of anchorages.

V. REFERENCES

[1]. Chang-ke Jiao, Xin Dong, Ai-qun Li, Guang-dong Zhou, and Xiao-ping Wu, [Seismic Response of Long-Span Triple-Tower Suspension Bridge under Random Ground Motion], Hindawi Mathematical Problems in Engineering Volume 2017, Article ID 3457452, 16 pages.

[2]. Xiangong Zhou, Lei Cao, Heng Han, Xiaobo Zheng , Hanhao Zhang and Zhiqing Zhang, [Seismic Fragility Analysis of Self-Anchored Suspension Bridge Considering Damping Effect], Hindawi Advances in Civil Engineering Volume 2022, Article ID 6980221, 12 pages.

[3]. Nana Li, Yongqiang Zhou, Yanqiang Zhao and Guiju Li, [Analysis of suspension bridge tunnel-type anchorage construction on the stability of surrounding rock], E3S Web of Conferences, 2020.

[4]. Wen Lina, Cheng Qiangong, Cheng Qiang and Guo Xifeng, [Stabilitation Research of the Tunnel Anchorage of Dadu River Bridge in Luding in Yaan to Kangding Expressway], American Journal of Civil Engineering 2017; 5(4): 196-204.

[5]. Serap Altın, Kubilay Kaptan and Semih S. Tezcan, [Dynamic Analysis of Suspension Bridges and Full Scale Testing], Open Journal of Civil Engineering, 2012, 2, 58-67.

[6]. Farhan Farid Reshi, Priyanka Singh, Shivangi, Ravinder Kumar Tomar and S K Singh, [Analysis and Design of Cable Stayed and Suspension Bridge Subjected to Wind Loading], IOP Conf. Series: Earth and Environmental Science 889 (2021) 012059.

[7]. Hyunsung Lim, Seunghwan Seo, Sungjune Lee and Moonkyung Chung, [Analysis of the passive earth pressure on a gravity-type anchorage for a suspension bridge], Lim et al. Geo-Engineering, 2020.

[8]. Feifei Shao, Zhijun Chen and Hanbin Ge, [Parametric analysis of the dynamic characteristics of a long-span three-tower self-anchored suspension bridge with a composite girder], Advances in Bridge Engineering (2020) 1:10.

[9]. Wen-Liang Qiu, Chang-Huan Kou, Chin-Sheng Kao, Shih-Wei Ma, and Jiun Yang, [STUDY ON THE SEISMIC BEHAVIOR OF SELF-ANCHORED SUSPENSION BRIDGES], Journal of Marine Science and Technology, Vol. 20, No. 4, pp. 384-391 (2012).

[10]. Zhijin Shen, Jianhong Jia, Nan Jiang, Bin Zhu and Wenchang Sun, [Field-Scale Experiment on Deformation Characteristics and Bearing Capacity of Tunnel-Type Anchorage of Suspension Bridge], Energies 2022, 15, 4772.

[11]. T.Subramani, J.Karthick rajan, V.R.Perumal, A.Palani and P.Kesavan, [Design and Analysis of Suspension Bridge], International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 8, Issue 3, March 2019, ISSN 2319 - 4847.

[12]. G. M. Savaliya, A. K. Desai and S. A. Vasanwala, [THE INFLUENCE OF CABLE SAG ON THE DYNAMIC BEHAVIOUR OF CABLE-STAYED SUSPENSION BRIDGE WITH VARIABLE SUSPENSION TO MAIN SPAN RATIO], International Journal of Research in Engineering and Technology eISSN: 2319-1163, Volume: 04 Issue: 11 | Nov-2015.

[13]. Abhishek Pandey and Nitesh Kushwah, [Seismic Analysis and Design of Cable Stayed Bridge with Different Cable Arrangements], International Research Journal of Engineering and Technology (IRJET), Volume: 07 Issue: 12 | Dec 2020.

[14]. Luca Martinellia, Marco Domaneschia and Chunxia Shib, [Submerged Floating Tunnels under Seismic Motion: Vibration Mitigation and Seaquake effects], Procedia Engineering 166 (2016) 229 – 246.
[15]. Neel Shah, Prashant Kanzariya and Bimal Shah, [PARAMETRIC STUDY OF CABLE STAYED BRIDGE USING DIFFERENT PYLON CONFIGUARTION], International Journal of Engineering Applied Sciences and Technology, 2021 Vol. 5, Issue 10, ISSN No. 2455-2143, Pages 342-348.

Cite this article as :

Jyotiprakash Sahu, Radeep Ku. Nirmal, Okesh Singh, "Analysis of Suspension Bridge with different Types of Anchoring Considering Vehicular Loading using SAP2000", International Journal of Scientific Research in Civil Engineering (IJSRCE), ISSN : 2456-6667, Volume 6 Issue 5, pp. 98-112, September-October 2022.
URL : https://ijsrce.com/IJSRCE226513