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WARREN
TRUSS BRIDGE

ANALYSIS USING SAP2000

What is a Warren Truss Bridge?

- A **truss bridge** is a bridge whose load-bearing superstructure is composed of a truss, a structure of connected elements, usually forming triangular units.
- **Warren truss** is a type of truss employing a weight-saving design based upon equilateral triangles named after the British engineer James Warren, who patented it in 1846.
- The Warren truss consists of longitudinal members joined only by angled cross-members, forming alternately inverted Equilateral triangle-shaped spaces along its length. This gives a pure truss: each individual strut, beam, or tie is only subjected to tension or compression forces. There are no bending or torsional forces on them.

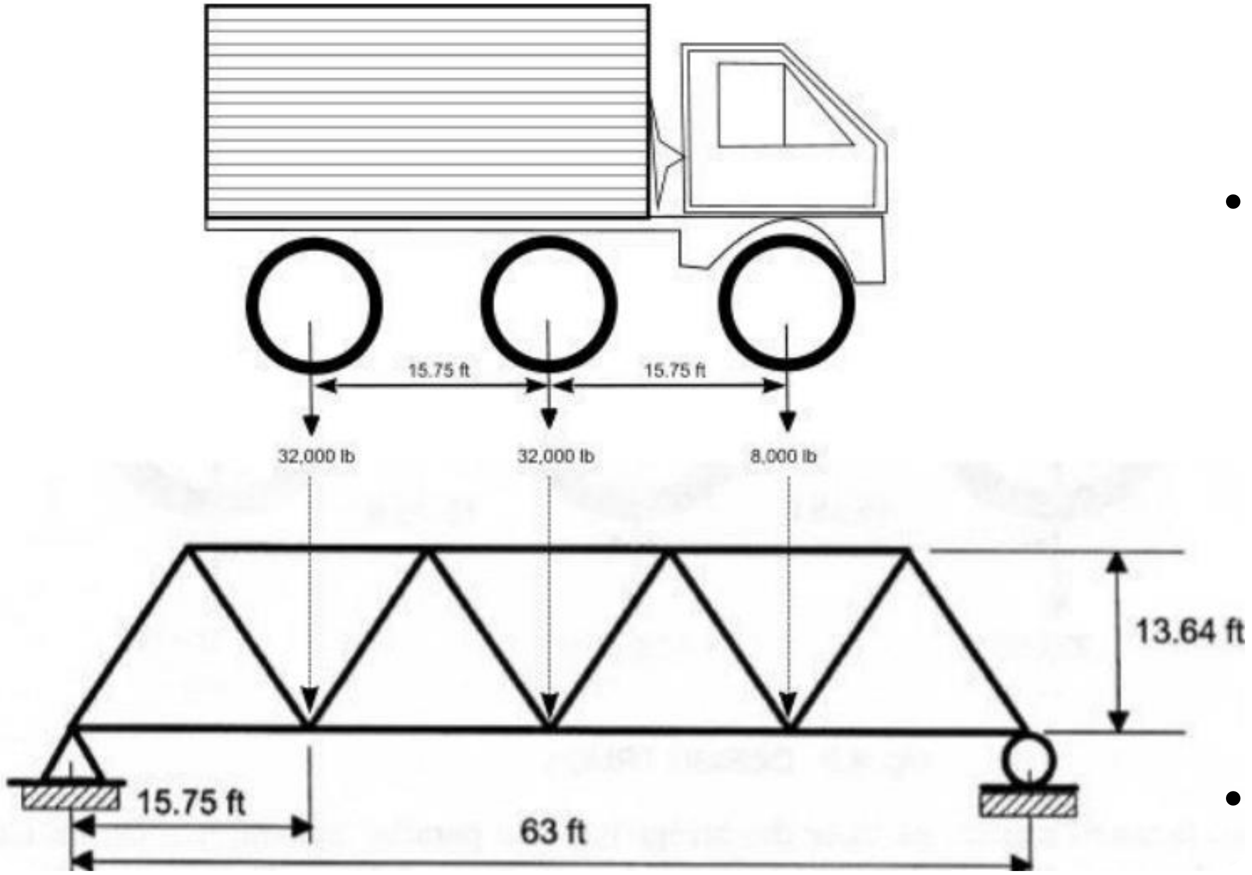
Advantages of a Truss Bridge

- **Strong Load-Bearing Capacity:** The structure of interconnecting triangles means that the load-bearing capacity of truss bridges is huge. The structure effectively manages both compression and tension, by spreading out the load from the roadway throughout its intricate structure. This means that no one part of the structure is carrying a disproportionate amount of weight.
- **Effective Use of Materials:** The building of a large truss bridge can be a very economical option, when compared to other bridge designs. These bridges are more relevant these days due to their effective use of materials even when it consists of many linked parts. Materials such as wood, iron and steel are all utilized to their highest potential, and every piece plays a role. Thus, the construction and use of each steel piece are perfect for the bridge.
- **Affordable To Construct:** Because of the simplicity of truss bridge designs, they are often a great fit for accelerated bridge construction. In order to improve construction time, each steel piece can be quickly pieced together. Less use of materials means easier construction and less money spent. Thus, the entire cost of material and labor for the bridges saves builders capital .
- **Versatile and Adaptable Design:** While truss bridges are great for short spans, what makes them versatile is their ability to go long distances and still support large loads. With the polygonal design of the truss, it is possible to cover long distances. Despite the harsh weather, with great structural engineering, our truss bridges are prepared to last even the worst storms for decades to come, where other bridges such as beam and arch bridges may not be a viable.

PROBLEM STATEMENT

- **There is a warren steel truss bridge that spans a total distance of 63 ft.** The Warren truss bridge consists of two parallel trusses. The lower chords of the trusses support the roadway which in turn carries the car and truck traffic. **We need to calculate the internal forces in each member of the bridge under the effect of the weight of the bridge and roadway (the dead load) and the weight of the vehicles (the live loads) that are likely to cross the bridge**. It is herein assumed that the bridge carries two lanes of vehicle traffic.

ASSUMPTIONS



- The bridge is supposed to carry its dead load (that is, the weight of the steel members and the weight of the roadway), as well as the live load (that is, the weight of the cars and trucks) that will cross over it. **In order to simplify the analysis process, it is assumed that the live load can be represented by the truck configuration.**
- The effect of this truck is assumed to model the effect of the heaviest trucks that are expected to cross the bridge in its lifetime

ASSUMPTIONS

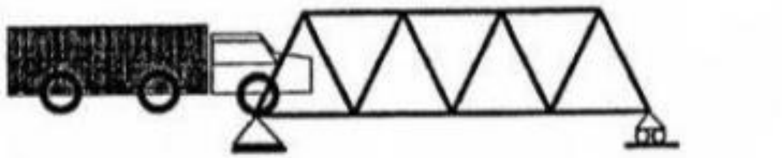
Assumed that the bridge is 26 ft wide with and that the roadway carries two lanes of traffic.

Assumed that the total load applied on the bridge is divided equally to each truss. That is, each truss will carry the weight of its members, half the weight of the roadway and one lane of traffic

Assumed that it is formed by one concrete deck with an 8-inch thickness. Concrete weighs 150 lb/ft3 and the weight of concrete must be counted as part of the applied load.

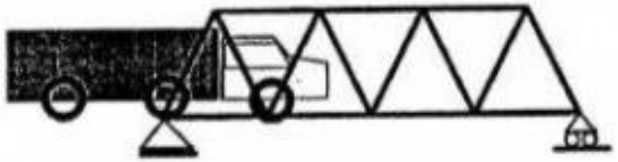
Assumed that each of the steel truss members has cross-sectional area A = 0.5 in2 and the modulus of elasticity of the steel is E = 29,000,000 lb/in2. Steel weighs 490 lb/ft3. The weight of each member will be assumed to be equally divided between the two joints at each end of the member

LOADING CONDITIONS



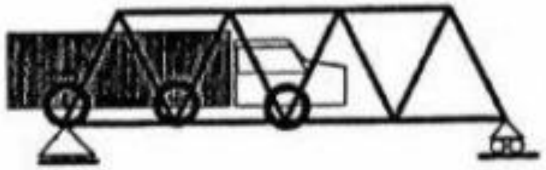
LOADING CONDITION - 1

LOADING CONDITION - 4

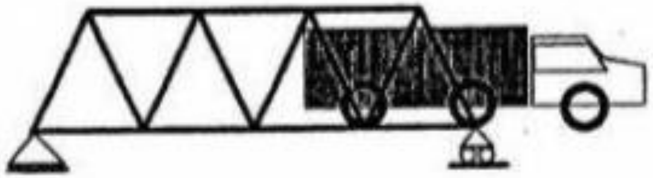


LOADING CONDITION - 2

LOADING CONDITION - 5



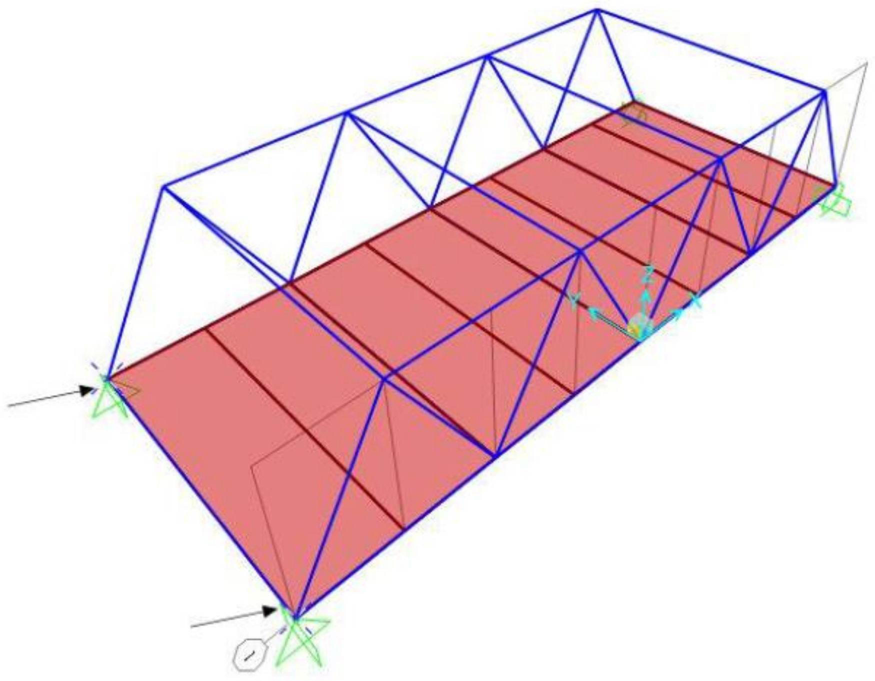
LOADING CONDITION - 3



LOADING CONDITION - 6

LOADING CONDITION - 7

SAP MODEL:

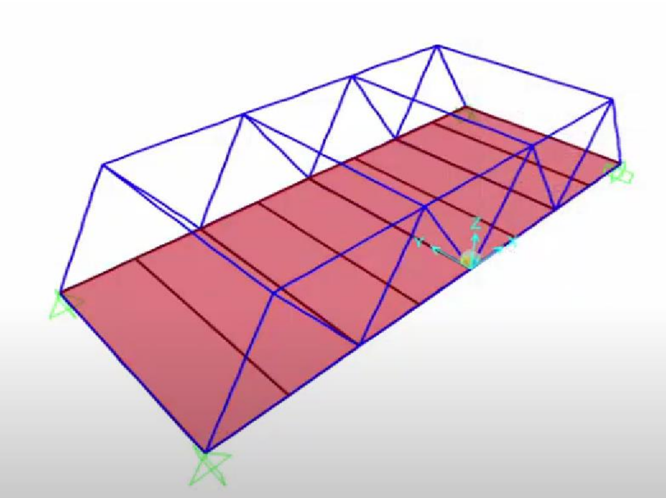


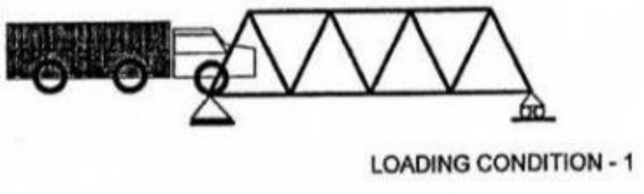
- To analyze the structural components of the modeled Warren Truss Bridge, SAP 2000 was used.
- Depending on the loading conditions in the course of a truck traversing the bridge, 7 cases are formed.
- In each of these cases, the maximum compressive and the tensile forces are evaluated.
- Furthermore, to support the explanations axial forces diagrams are developed.

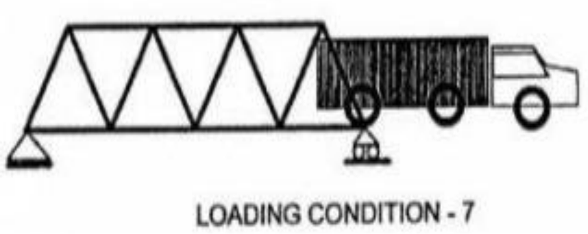
ANALYSIS RESULT:

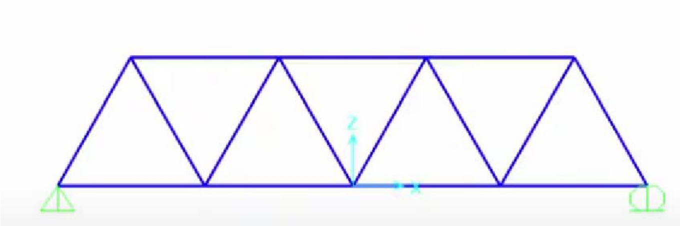
The results are as per shown in the subsequent slides:

CASE 1: & # Case 7:





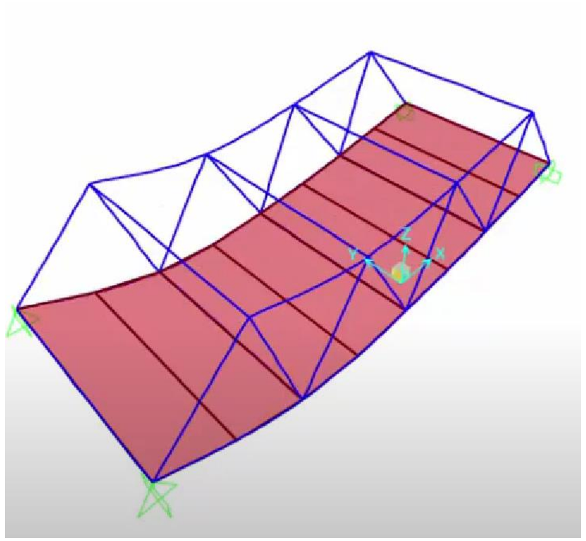


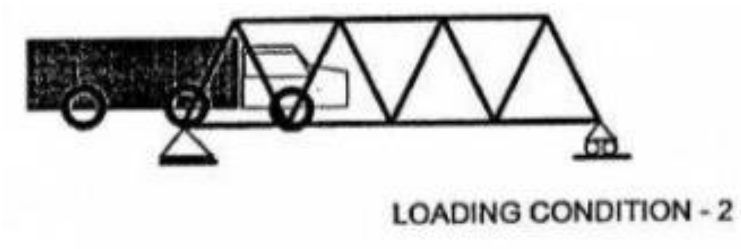


NO AXIAL FORCES

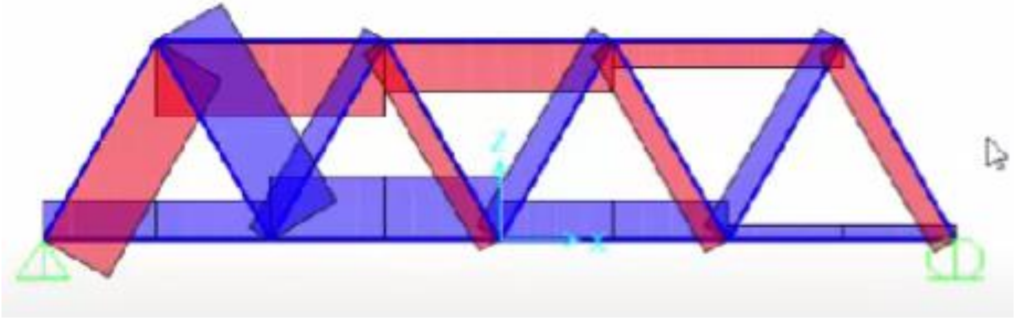
It's worth noting that these two cases are identical due to similar positions of truck on the bridge. Hence loadings are identical.

Case 2:



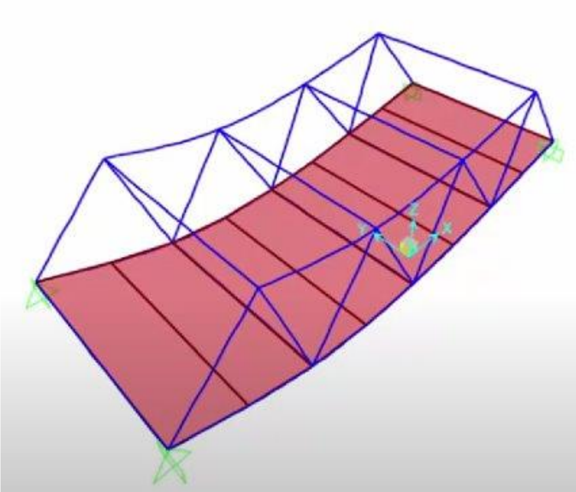


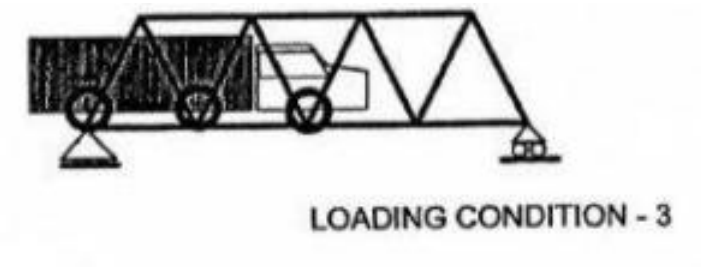
MAX COMPRESSIVE FORCE =153.9kN
MAX TENSILE FORCE=128kN



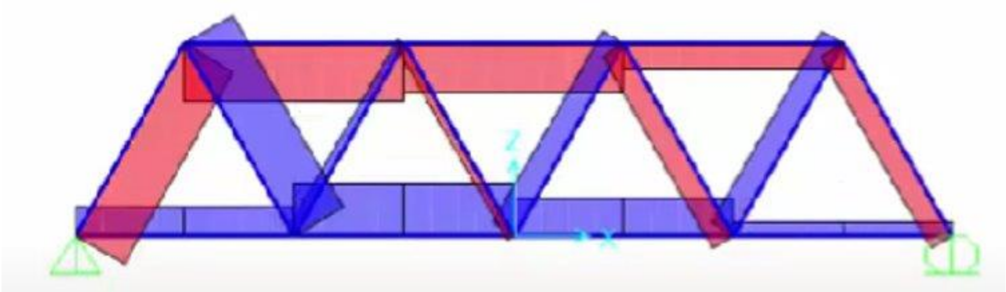
AXIAL FORCE DIAGRAM
-RED REPRESNT COMPRESSIVE FORCES
-BLUE REPRESENT TENSILE FORCES

Case 3:



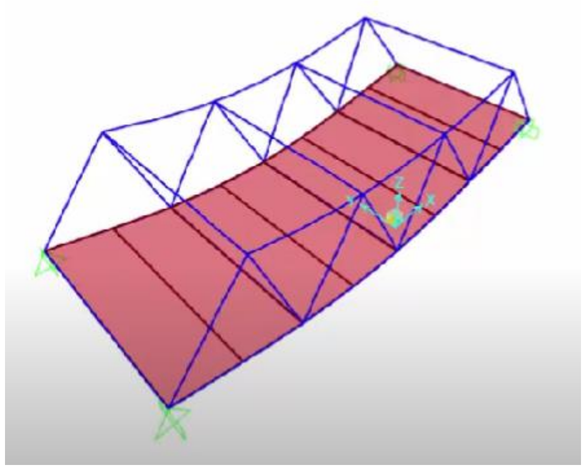


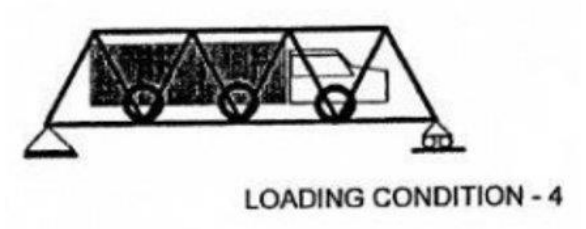
MAX COMPRESSIVE FORCE =299kN
MAX TENSILE FORCE=231kN



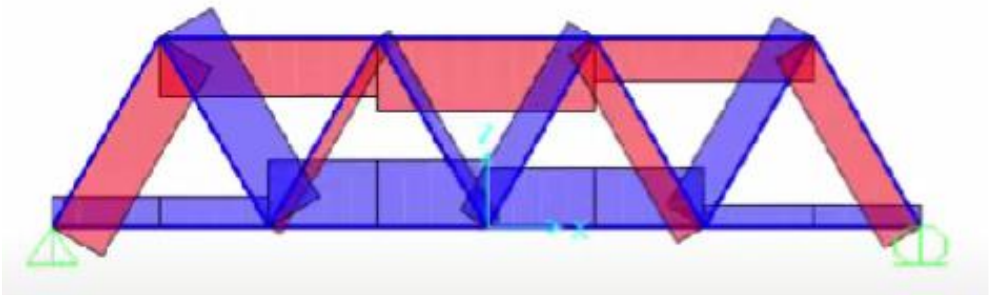
AXIAL FORCE DIAGRAM
-RED REPRESNT COMPRESSIVE FORCES
-BLUE REPRESENT TENSILE FORCES

Case4:



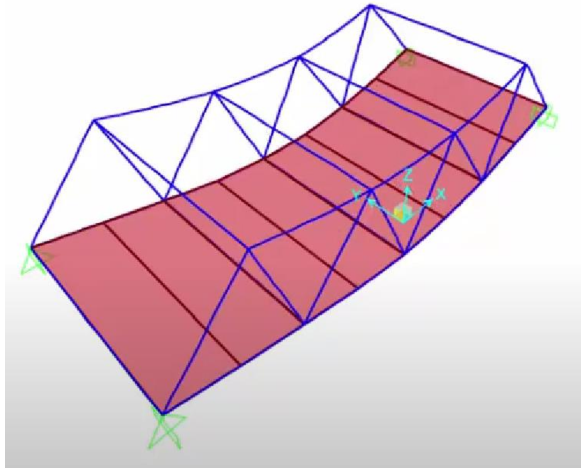


MAX COMPRESSIVE FORCE =334.93kN
MAX TENSILE FORCE=228kN

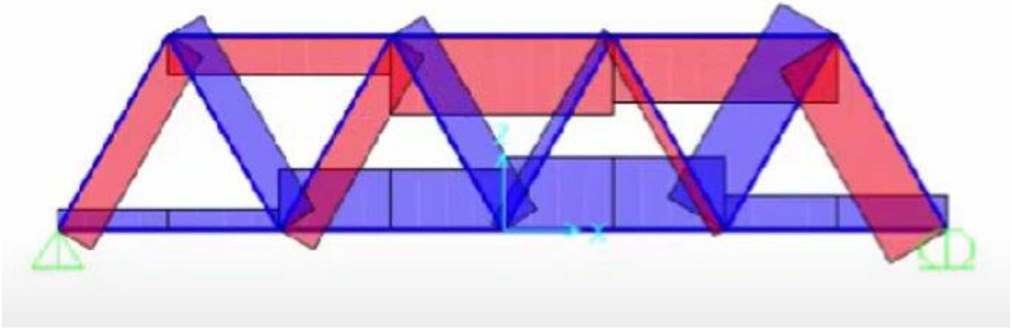


AXIAL FORCE DIAGRAM
-RED REPRESNT COMPRESSIVE FORCES
-BLUE REPRESENT TENSILE FORCES

Case 5:

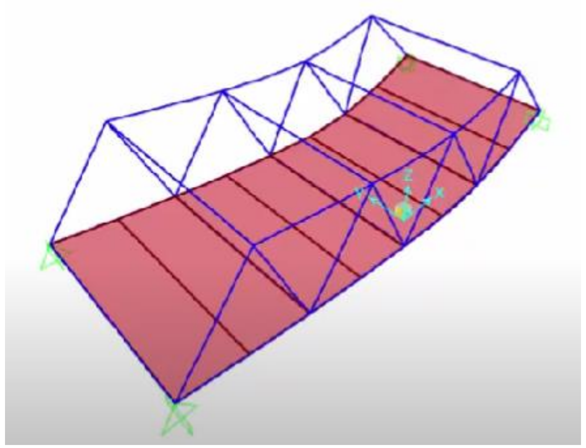


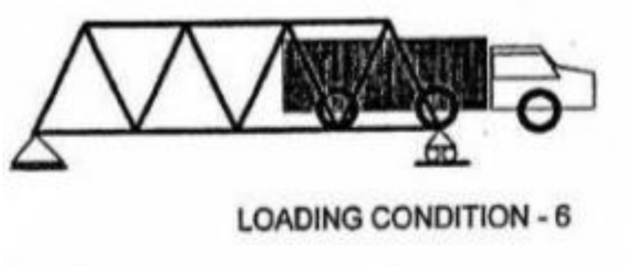
MAX COMPRESSIVE FORCE =153.9kN
MAX TENSILE FORCE=128kN

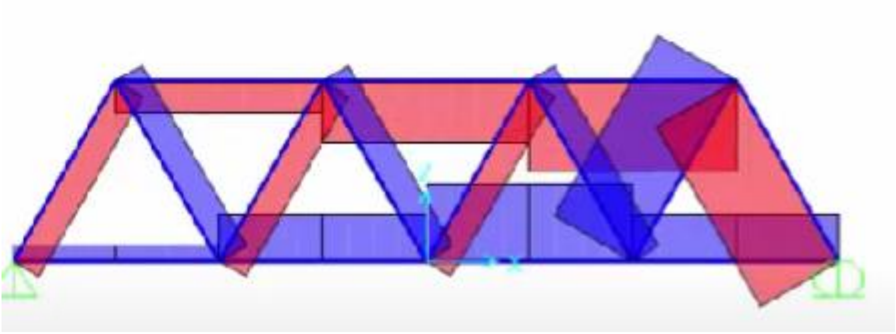


AXIAL FORCE DIAGRAM
-RED REPRESNT COMPRESSIVE FORCES
-BLUE REPRESENT TENSILE FORCES

Case 6:







MAX COMPRESSIVE FORCE =153.9kN
MAX TENSILE FORCE=128kN

AXIAL FORCE DIAGRAM
-RED REPRESNT COMPRESSIVE FORCES
-BLUE REPRESENT TENSILE FORCES

Conclusions:

1. Thus, a Warren Truss Bridge model has been analyzed in good detail and results have been closely observed.
2. Warren Truss Bridge is widely used in modern-day traversing over a river or a valley.
3. It forms the basis of many other advanced bridges which have been developed of late.
4. The information gathered while designing the model virtually, will help in understanding the structural analysis of complex structures.

References:

- SAP 2000
- Yuan Y. H., Elementary Theory of Structures, 3rd Edition, Prentice Hall, 1987.
- Norris C. H., Wilbur J. B., Uktu S., Elementary Structural Analysis, 3rd Edition, McGraw-Hill Education, Chennai, 2016.


THANK YOU!