Design And Simulation of Hydraulically Operated Steel Truss Bridge

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Abstract **- In this paper the concept is to design and simulation of a one way steel truss bridge of short span, which is operated by hydraulic energy using some hydraulic cylinders and power pack for safe movement of desired traffic volume for an acceptable level of service which accomplish the social, economic and environmental goals. In order to achieve higher efficiency in terms of load bearing capacity, an optimistic design of bridge structure is needed by optimizing the bridge material and self-weight, subject to suitable hydraulic arrangement. Bridge is a structure which covers a gap. The structure has to perform in an outdoor environment with relatively large temperature changes, subjected to excessive cyclic live loading and is often exposed to corrosive environments. The Truss Bridge having a moving end with respect to other end gives flexibility to make operations convenient as per the requirement and control the traffic accordingly. It was resolved that a Howe connect offers the most minimal, most significant pressure on any pillar when contrasted with the Pratt connect. The expense didn't increment because the corner-to-corner individuals just exchanged positions, and no additional material was required. The historical backdrop of steel truss spans traces back to the 1800s, and pre-assembled steel support spans, back to the 1930s when particular frameworks were produced for military purposes. A truss steel support connect has demonstrated over and over to be a practical, appealing and monetary answer for connecting locales that have troublesome designing difficulties. Indicating an advanced steel truss bridge can be rearranged with the assistance of a bridge maker with the assets and experience to lead the way.**

Keyword: Hydraulic jack, hydraulic power, truss, bridge, young modulus, stress, strain, steel, hydraulic cylinders, beams, support

1. INTRODUCTION

Bridges have an uncommon destination in transportation foundation because of their direct bonding with different areas and rail lines in the country and are relied upon to proceed as planned all through their practical life. Well we have mathematically factor of considering the bridge retrospective like distance, freedom, traffic streamed accessible materials, there are multiple alternatives of bridges to pick reason to carry these designs are traffic heaps of highways crossing any hindrance and play out a compelling opposite side issues.

Planning, designing and construction measurement of any bridge study coherent and essential proofs, found appropriate conduct of the design during any traffic load or opposing flood or seismic occasions. Notwithstanding, support measures ensure the construction, which applied exact, will stay away from any closure of the bridge and traffic issues.

Using pressurized Hydraulically Assisted Bridges (HAB) is another idea in the connecting design that connects an incorporated pressure driven framework into the bridge to carry and handle more weight. The framework is generally reasonable for curve based bridges in which the principle powers are coordinated a level sideways way. Hydraulic powered structure is included in the primary load bearing person from the bridge that may be negligibly constrained by the PC's. In any case whenever, properly aligned and developed the framework has opportunities for non electronics autonomous self – transformation, including lower support costs and less anger in the event of a power breakdown.

Truss bridges are probably the most established sort of current bridges. Truss spans are among an assortment of bridge plans that are being utilized for street traffic. Truss spans comprise triangles that hold up the street and are set on two wharves for help. Truss connect are solid and are hefty support burdens. The triangle point is utilized because they are unbending and are steady. Pressure follows up on the upper-level individuals from the truss structure and the docks that help the bridge. Pressure follows up on the base level individuals. The precise individuals share both of the power.

A truss bridge framework comprises essential individuals that can uphold a lot of weight, and these bridges can be extensively long. Hypothetically, the individuals in a straightforward truss framework are oppressed distinctly to hub power (strain or pressure) instead of bowing. Be that as it may, the actual conduct of truss bridges could be altogether more perplexing and may include hub powers and minutes (both in-plane and out-of-plane).

Principle of a Hydraulically Operated Steel Truss Bridge

The guideline behind hydraulic-driven bridge working is Pascal's law, and for activities, this bridge utilizes petrol-based pressure-driven liquids. Fueling the bridge with hydraulic power, pressure driven engines and hydraulic powered chambers are two significant segments used. The measure of outfitting required is reliant upon the kind of pressure-driven engine for a bridge activity.

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Contingent upon the development, the pressure-driven chambers can be separated into tie bar and welded. Forgiving life span to the bridge, the welded hydraulic-powered chamber is reasonable.

To convey changing burdens and stand firm on the bridge solidly in any situation, offset valves utilized in the construction will help. By the relative valve operated, smooth and exact speed increase and deceleration are given.

INFRASTRUCTURE

A steady test among our country's framework chiefs and their designing accomplices is to decide the most financially savvy, dependable structure of the bridge that will fit the numerous imperatives of the current bridge substitution project. Numerous insufficient bridges found across the America can be rustic, decrease-capacity streets appropriate for pre-assembled steel truss spans.

These requirements may incorporate ecologically delicate stream intersections, or costly railroad level partition projects, blending public info and backing, or activities where the need for speed is essential. A considerable lot of these raise the expense of the task with no substantial advantage. A long, clear range is demonstrated to tackle significant maximum issues. By ethicalness an incredible range to-weight proportion, steel truss bridges can kill wharves, improve hydraulic power and lessen establishment valuation of other bridges types can't.

Further, a regularly rehashed justification indicating steel support spans banks on how individuals like them; they improve the scene and make a mark impersonation to the voyaging citizen.

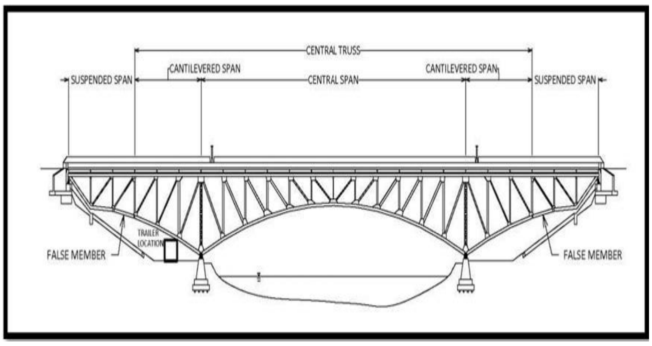

Figure 1: Truss Layout

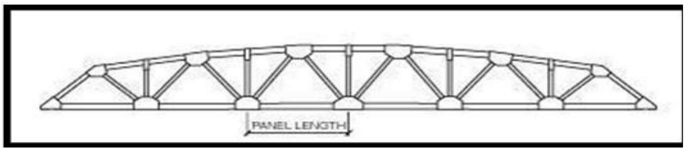

Figure 2: Warren Truss Configuration

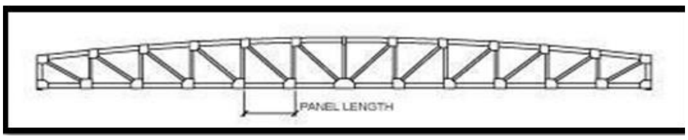

Figure 3: Pratt Truss Configuration

Specifying span and configuration

The normal latitude for pre-assembled steel support spans is 75 to 250 feet and is characterized by the arrangement measurement between the forward and back centerline of all bearing projections. The measurement, in some cases, is mistaken for "connect length." all in all, general bridge distance can be considered as the hole that should be crossed or filled; or the opening between the projection's back dividers. The contrast among range and length requires a comprehension of the finish of bridge subtleties that portray the augmentation of the design past its bearing focuses as it compasses to the foundation. This is resolved during the projection plan and is impacted by the prerequisites of any called-for bridge connect. Support bridges might be arranged in a slanted way, implying that the starting station of the left-side truss isn't equivalent to one side truss, as in a fantastic design. Some adaptability exists in orchestrating the floor, outlining a slanted support length as it might follow the slanted arrangement or be organized symmetrically to the truss. Every one of these properties is intrinsic to steel and significantly improves the adaptability of the bridge to adjust to the site math while keeping a monetary game plan.

Specifying a steel protection system

The life span of bridge and standard upkeep exercises are significant worries for a bridge proprietor. Accordingly, steel spans require plane insurance against forceful conditions. Like other steel spans, pre-assembled bridges might be fabricated utilizing enduring steel; defensive hot-plunge electrifies steel or a layered paint framework. Each All its benefits and impediments and ought to determined cautiously.

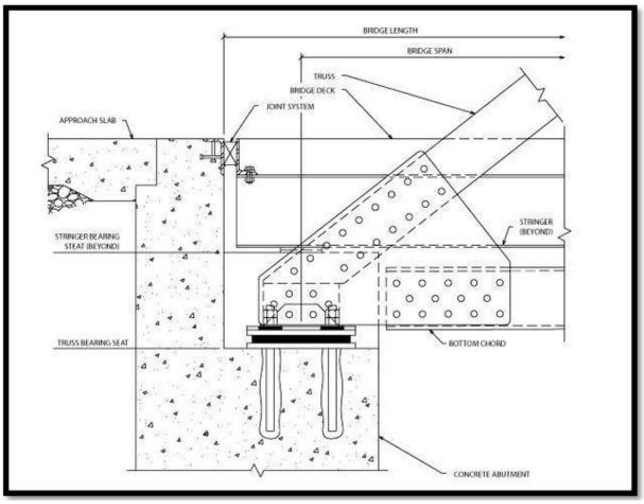

Figure 4: Simulation of Hydraulically operated steel Truss bridge

Enduring steel has a rustic nature. Every day, we see fits picturesque settings. Since it has fewer tasks to act in the assembling interaction, it is viewed as the most affordable for the most part. It's essential constraint is that of nearness to vast hydraulic, yet it is hard to obtain on a short timetable once in a while.

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Hot-plunge arousing offers unrivalled erosion security and is indicated the most. Arousing has a silver to-dark appearance and mixes into a foundation understand well overall. A few producers offers 35-years of guarantee through their electrify that guarantees a period to "Ist upkeep" (you can see different learning assets from the given references.).
Indicating a painting framework likewise is feasible and regularly utilized assurance technique. It gives quality assurance an appearance that, in any case, can't be accomplished. Producers ought to be AISC supported and have broad high practiced painting span constructions to guarantee a quality application that will last. Paint coated designs ordinarily are utilized to feel it is significant, and the bridge is imagined as a point of convergence.

Consumption security frameworks may even be consolidated unexpectedly, for example, covering up electrifying, or halfway composition of enduring steel regions, or even connecting an electrified floor outlining with enduring steel truss individuals. The determination of consolidated frameworks should improve a specific benefit from one of these individual frameworks.

DESIGN PROCESS

We can divide structural project into the three basic phases, i.e. planning, design and construction.

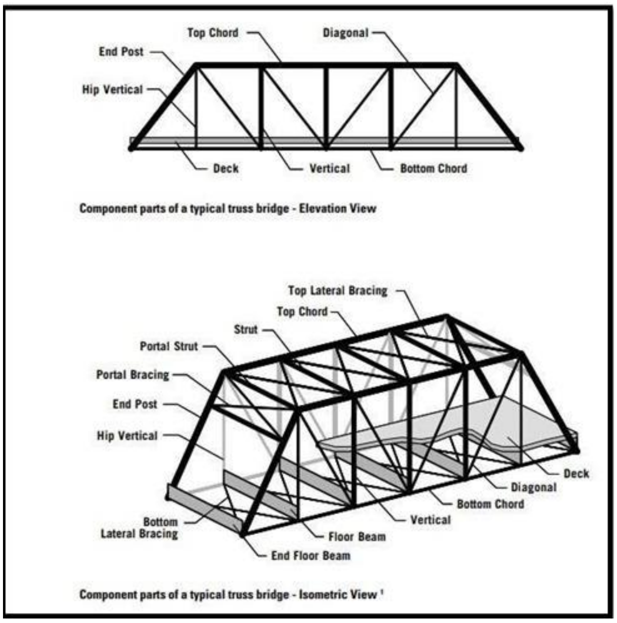


Figure 5: Components of Truss bridge

Planning: This stage having the different prerequisites and variables influencing the overall design and metrology of the construction and results comes in one or maybe a few elective sorts of creation, which provide best arrangement board. The fundamental thought is the capacity of the structure. Auxiliary contemplations like style, law, financial aspects, human science and the climate may likewise be considered. Moreover, there are underlying and constructional pre-requisites and constraints, which may influence the kind of construction to be planned.

Design: This phase involves point by point consideration of the alternative arrangements described in the arrangement phase and as a result assures the most appropriate details, measurements and fine turning of primary components and associations to develop each underlying choice course of action.

Construction: Thus phase include assembly of faculty, receiving materials and gear including their transportation to site and actual on location construction. During this phase, if unforeseen challenges occurs such as inability to determine the materials or installation issues, some overhaul may be required.

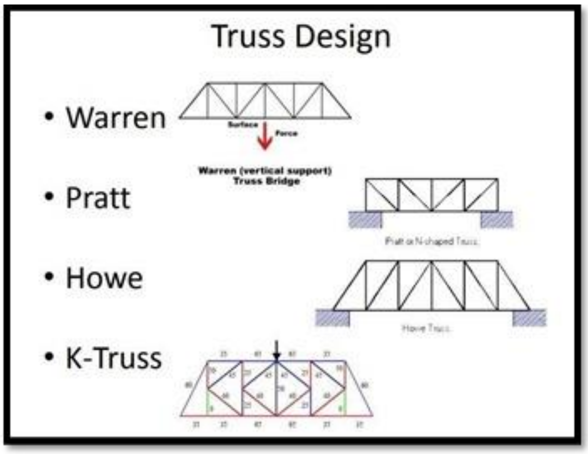


Figure 6: Truss designs

All detailed information for this essential bridge design, such as its, material properties, geometric properties, and assumptions made during the design process and enclosed in **Annexure I**.

The Summary of the same is given in below table:

Parameters	Values
Yield Strength, N/m^2	2.21E+08
FOS	4
Total Weight (Approx), N	342043.19
Permissible Bending Stress, N/m^2	5.51E+07
Maximum Bending Stress, N/m^2	5.44E+07
Permissible Shear Stress, N/m^2	2.76E+07
Maximum Shear Stress , N/m^2	6.50E+06
Deflection of Structure under load, mm	9.00

FABRICATION AND INSTALLATION

Two tools that empower span prefabrication to expand usefulness and quality are Computer Numerically Controlled (CNC) hardware and Bridge Information Modeling (BrIM) programming.
Bridge primary parts handled on CNC gear are first modified by programming that characterizes the activities, tooling and amounts for each piece. Bridge

Information Modeling (BrIM) takes into consideration a consistent trade of plan information to the machines. Determining that steel be handled with CNC hardware and customized with a total 3D Bridge Information Model will abbreviate creation times and increment the nature of the manufactured bridge. After the steel is gotten from the factories, it is prepared in steel manufacturing shops utilizing gear and labor to bore, cut and bend the segments, then, at that point, weld or bolt the shippable congregations together. Different things for development that may be requested for the undertaking, for example, wood floor, guardrail, and direction and light-gauge concrete structures, are obtained and prepared for transportation to the site.

Quality control measures are utilized to confirm that parts are manufactured precisely and collected by determining norms. These principles ought to incorporate the American Institute of Steel Construction (AISC) Steel Construction Manual, AASHTO/NSBA's S2.1 Steel Bridge Fabrication Guide Specifications, the American Welding Society (AWS) D1.5 Bridge Welding Code and the Research Council on Structural Connections (RCSC) Specifications for Structural Connects Using A325 or A490 Bolts. Contingent upon the size of the bridge, individuals, will be shop collected into erectable units to speed development. The size and weight of these units will be displayed in the development drawings to help the worker for hire in arranging the establishment. Together alongside other individual parts, these units will show up on the site on a progression of trucks. The segments are set apart as per the drawings, which are then used to direct the hire's establishment.

Specialized help from the prefabricator's staff, who is knowledgeable about raising steel spans, is prescribed during assurance of the particulars to guarantee a smooth establishment.

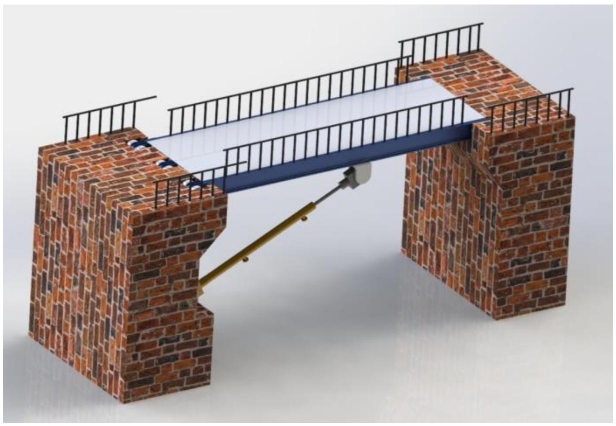


Fig- Isometric view of bridge

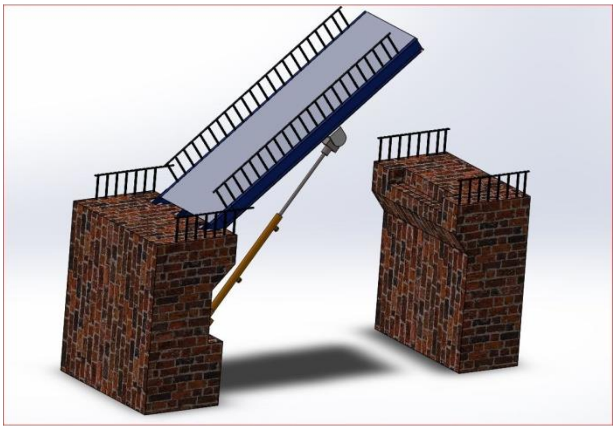


Fig- Isometric view of bridge

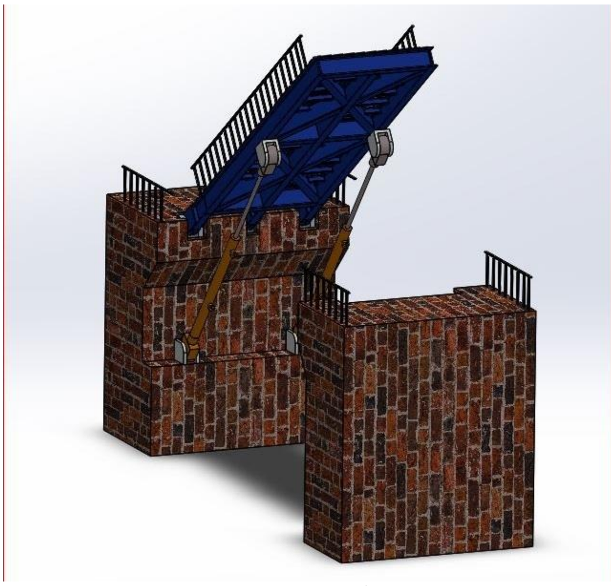
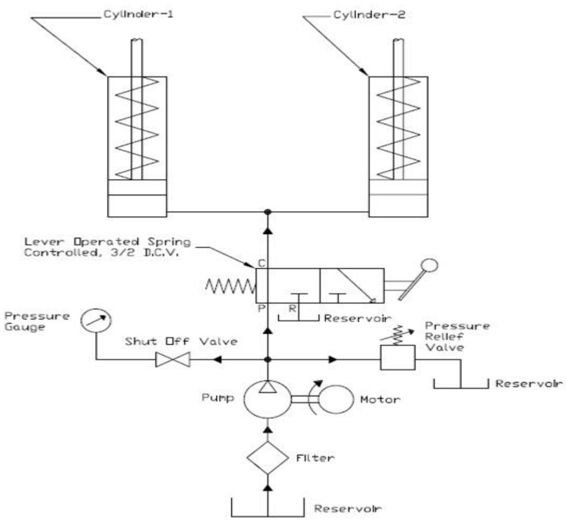


Fig- Isometric view of bridge

Hydraulic System and Circuit Diagram

The hydraulic system is in such a way to disconnect the bridge from use using 3/2 DCV as shown in diagram.



Hydraulic Circuit Diagram for single acting cylinders using 3/2 D.C.V.

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ADVANTAGES

If precisely adjusted, there is no requirement for PCs to control the pressure-driven actuators. The hydraulic-powered rams can be moving simply by the stacking applied to them. In other words, if a specific burden is used on the bridge, the hydraulic driven smash applies a proper power upwards to balance any avoidance. This infers that there is almost no support concerning robotized frameworks, and in the circumstances like power outages or glitches, the bridge won't be in any quick worry for disappointment. Because of applying a power upwards, reliant upon the heap and relocation of the bridge, the amount of material needed to develop the bridge is diminished. The material alone doesn't need to deal with all forced stacking; the heap is conveyed onto the hydraulic-powered rams. Subsequently, less cash can be utilized in buying materials, and the undertaking cost is decreased (apparently, the money might be spent on the hydraulic-powered frameworks).

Beautiful bridges might be developed with more slender underlying individuals, building its tasteful and social effect on the local area around it. What is more is that if the heap becomes too extraordinary and makes the mid-range cylinder go down, then, at that point, the help cylinders will push inwards, bringing about the curve heading upwards; thus, they look after harmony. The truss supports that length the hole can be sizable, profound support individuals. Still, since they are past the street, the project over the road considers a little profundity from the street surface to the underside of the least outlining part. This saves costs because of less dike material, less asphalt development, fewer effects on close by landowners and more accessible allowing.

CONCLUSION

Bridges are perhaps the most significant and exorbitant designing undertakings, including broad plan contemplations that attempt to limit costs while guaranteeing the bridge won't come up short. Various bridges were developed to perform tests that figured out which pillars were in pressure and how much power was knowledgeable about the shaft's the point at which a static burden was applied. PC recreations were likewise performed to decide the heaps on the various bars. The re-enactment and determined outcomes were contrasted with the guaranteed exactness of the end-product. It was resolved that a Howe connect offers the most minimal, most significant pressure on any pillar when contrasted with the Pratt connect. The expense didn't increment because the corner to corner individuals just exchanged positions, and no additional material was required. The historical backdrop of steel truss spans traces back to the 1800s, and pre-assembled steel support spans, back to the 1930s when particular frameworks were produced for military purposes. A truss steel support connect has demonstrated over and over to be a practical, appealing and monetary answer for connecting locales that have troublesome designing difficulties. Indicating an advanced steel truss bridge can be rearranged with the assistance of a bridge maker with the assets and experience to lead the way.

REFERENCES

[1] AR, H. N. HISTORIC AMERICAN ENGINEERING RECORD BUFFALO RIVER BRIDGE.

[2] Tinkov, D. V., & Safonov, A. A. (2017). Design optimization of truss bridge structures of composite materials. Journal of Machinery Manufacture and Reliability, 46(1), 46-52.

[3] Catbas, F. N., Susoy, M., & Frangopol, D. M. (2008). Structural health monitoring and reliability estimation: Long span truss bridge application with environmental monitoring data. Engineering Structures, 30(9), 2347-2359.

[4] Swati, A. K., & Gaurang, V. (2014). Study of steel moment connection with and without reduced beam section. Case Studies in Structural Engineering, 1, 26-31.

[5] Chauhan, A. D. M., Soni, B. P. S., & Gohil, A. M. (2011). Parametric Optimization of Hydraulic Modular Trailer Frame using ANSYS (APDL). In 2nd International Conference on Current Trends in Technology (NUiCONE 2011) (No. 12, pp. 480-483).

[6] Annexure I - Structure Suitability Result Cross Verification with Manual Calculation.

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Annexure I : Structure Suitability Result Cross Verification with Manual Calculation

Assumptions and Values Taken:

1. Live/moving load is considered as point load on beam.					
2. Maximum moving load considered	=	14.3	Ton	140000	N
3. Maximum wind speed	=	15	miles/hr	6.67	m/sec
4. Factor of safety for structure	=	4			
5. Vehicle Axle Distance (l_1)	=	2	m		
6. Gravitational Acceleration	=	9.81	m/s^2		
7. Air Density (ρ)	=	1.225	Kg/m^3		
8. Unit width of bridge structure considered.					
9. Distance b/w hinge and nearest support (l_2)	=	1.5	m		

Mechanical Properties:

Material	=	Low Carbon Steel	
Yield Strength (S_{YT})	=	2.21E+08	N/m^2
Shear Strength (S_{SY})	=	1.10E+08	N/m^2
Tensile Strength (S_{UT})	=	4.00E+08	N/m^2
Compressive Strength (S_C)	=	2.50E+08	N/m^2
Young Modulus (E)	=	2.1E+11	N/m^2
Poisson Ratio (μ)	=	0.28	
Mass Density	=	7800	Kg/m^3
Thermal Expansion Coefficient	=	0.000013	/K

Reference:

1. IS 808 : 1989 - Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections
2. IS 1730 : 1989 - Steel Plates, Sheets, Strips and Flats for Structural and General Engineering Purposes - Dimensions

Physical Properties:

Length of Bridge	=	11.5	m
Effective Length of Bridge (L)	=	10	m
Width of Bridge (B)	=	3.5	m
Top Surface Area of the Structure (L x B)	=	35	m^2

Masses (M)-

ISMB 600	=	123	Kg/m
ISMB 200	=	24.2	Kg/m

Moment of Inertia (I_{x-x})-

ISMB 600	=	91800	cm^4	0.000918	m^4
ISMB 200	=	2120	cm^4	0.0000212	m^4

Sectional Area (a)-

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ISMB 600	=	156	cm^2	0.0156	m^2
ISMB 200	=	30.8	cm^2	0.00308	m^2

Length of Beams-

ISMB 600	=	68.51	m	Approx.
ISMB 200	=	42	m	Approx.

Total Mass of Beams-

ISMB 600	=	8427.11	Kg	Approx.
ISMB 200	=	1016.40	Kg	Approx.

Mass of 22mm MS Plate	=	173.00	Kg/m^2
Total Mass of 22mm MS Plate	=	6055	Kg

Force/Weight Calculation:

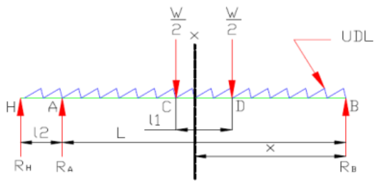
Wind Force (F_w)	=	$1/2 \times \rho \times v^2 \times A$	
	=	952.78	N
Structure Mass	=	20498.51	Kg
Structure Weight	=	201 090.41	N

Note- Taken 5Ton additional for Handrail, Welding, Rivet, Pin etc

Therefore, UDL	=	17568.97	N/m
and Point load (W)	=	140 000.00	N

Bending Stresses-

$R_H + R_{A1}$	=	26 353.5	N
Therefore, R_H	=	13 176.7	N
Therefore, R_{A1}	=	13 176.7	N
$R_{A2} + R_B$	=	315 689.73	N
Therefore, R_B	=	157 844.86	N
Therefore, R_{A2}	=	157 844.86	N
Therefore, $R_A = R_{A1} + R_{A2}$	=	171 021.59	N



Let, a point on beam where the bending moment is maximum. Taking distance x meter from B.

Therefore, bending equation,

$M_{xx} = R_B*x - W/2*(x-4) - UDL*x*x/2$

Differentiating the above equation w.r.t. x.

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R_B - W/2 - UDL*x = 0

Therefore, x = 5 m

Therefore, Maximum bending moment (M_{max}) = 499 612.16 N-m

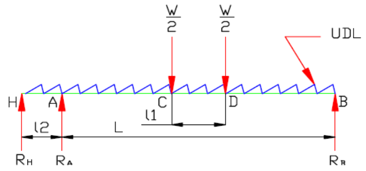
Therefore, maximum bending stress (σ) 5.44E+07 N/m^2

Whereas, permissible bending stress (σ_p) 5.51E+07 N/m^2

Since, $\sigma < \sigma_p$, Beam is Safe.

Shear Stresses-

At Resting Points when load is at centre-



Since, $R_A > R_B$ & R_H

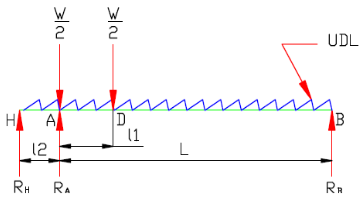
Therefore, Max. Shear Force = R_A = 171 021.59 N

Shear Stress (ζ) = 3.65E+06 N/m^2

Whereas, permissible shear stress (ζ_p) = 2.76E+07 N/m^2

Since, $\zeta < \zeta_p$, Beam is Safe.

At Resting Points (A) when load is acting on same-



$R_H + R_{A1}$ = 96 353.5 N

Therefore, R_H = 13 176.7 N

Therefore, R_{A1} = 83 176.7 N

$R_{A2} + R_B$ = 245 689.73 N

Therefore, R_B = 24 569.0 N

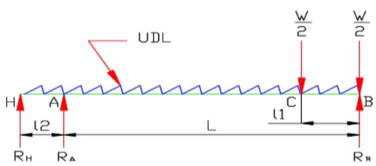
Therefore, R_{A2} = 221 120.76 N

Therefore, $R_A = R_{A1} + R_{A2}$ = 304 297.48 N

Shear Stress (ζ) = 6.50E+06 N/m^2

Since, $\zeta < \zeta_p$, Beam is Safe.

At Resting Points (B) when load is acting on same-



$R_H + R_{A1}$ = 26 353.5 N

Therefore, R_H = 13 176.7 N

Therefore, R_{A1} = 13 176.7 N

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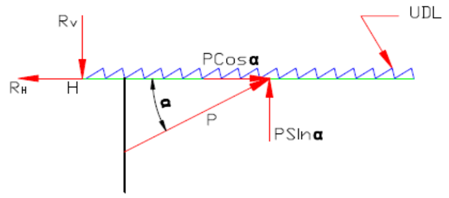
$R_{A2} + R_B$	=	315 689.73	N
Therefore, R_B	=	213 844.86	N
Therefore, R_{A2}	=	101 844.9	N
Therefore, $R_A = R_{A1} + R_{A2}$	=	115 021.59	N
Shear Stress (ζ)	=	4.57E+06	N/m^2

Since, $\zeta < \zeta_p$, Beam is Safe.

Stresses at hinge/fixed point (H) while lifting the structure-



$P \cos\alpha = R_H$

$P \sin\alpha = R_V + UDL$

and $\alpha = 30°$

Moment about H,

$P \sin\alpha * 6.5 = UDL * 11.5 * (11.5/2)$

Therefore, P	=	357 461.02	N
Therefore, R_H	=	309 561.25	N
&, R_V	=	161 161.54	N
Therefore, resultant reaction (R)	=	349 000.30	N
Shear Area at hinges	=	0.5148	m^2
Therefore, Shear Stress (ζ)	=	677 933.75	N/m^2

Since, $\zeta < \zeta_p$, hinge is Safe.

Crushing Area at hinges	=	0.198	m^2
Therefore, Crushing Stress	=	1.76E+06	N/m^2

Which is lower than compressive strength. Therefore safe.

Shear Stress on Pin-

Shear Area of Pin	=	0.1884	m^2
Therefore, Shear Stress (ζ)	=	1.85E+06	N/m^2

Since, $\zeta < \zeta_p$, Pin is Safe.

Deflection of Structure-

Deflection under load-

Deflection due to self-weight (δ_1) = $5WL^4/384EI$	=	3.96	mm
and, deflection due to vehicle weight (δ_2) = $WL^3/48EI$	=	5.04	mm
$\delta_{Max.}$	=	9.00	mm

Deflection while lifting-

Deflection due to self-weight ($\delta_{Max.}$) = $WL^4/8EI$	=	2.37	mm

Here, L = 5m