Analysis and Optimization of Water Treatment Plant Rotating Truss

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Abstract - *In any industry a manufacturing or fabrication is the process which gives final product. In order to get the required function from the final product, it should be well designed. The product should be analyzed in each and every possible ways. In this* ***study a "Water Treatment Plant Rotating Truss" also called as "Water Treatment Plant Bridge" or "Clariflocculator Rotating Truss" is analysed for the*** *identification of possible failure situations, finding unnecessary material sections, stresses in different length of truss, channels and finding factor of safety. At last the truss bridge was optimised without affecting strength at important locations. Over the years a lot of work has been done and is still continuing to save weight and cost. The current trend is to provide weight/cost effective products which meet the standard requirements. Due to the increase in the population and health consciousness among the people, there is more demand for Water Treatment Plant. Thus it becomes necessary that each parts of water treatment plant should be properly designed and optimally utilised. In order to achieve this, an effort has been made to carry* ***out the analysis of "Water Treatmen****t Plant Rotating* ***Truss" with different cross sectional areas. The*** *Rotating Truss is statically analysed considering live loads, dead loads and self-weight of it. Length of truss is depended upon size of clariflocculator. In this study, truss is analysed which is of 9500 mm in length which is taken as standard case. A critical load case is considered for a structure analysis. Finite Element Analysis method is performed to obtain the variation of stress magnitude along the length of truss. Finite element analysis was carried out with help of FEA Software (Hypermesh)). The results were compared with theoretical calculations obtained from Method of Joints an elastic method. An effort has been made to study existing truss structure which weighs more, optimise the critical parts and to minimize the overall weight of structure. The C-channel (ISMC), I-section (ISMB) and L-sections (ISA) were used for construction of the truss bridge. At the end the truss structure was optimised using combinations of above section depending upon their size and yield strength which reduced the mass of truss to great extent.*

Key Words: *Rotating Truss, C-channel, I-Beam and L-section, Optimise the weight.*

1. INTRODUCTION

Water treatment is the industrial-scale process that makes water more acceptable for an end use. It should remove existing contaminant and reduce their concentration. The physical infrastructure used for water treatment is called Water Treatment Plant (WTP). The process is carried out by using mechanical tool or machine, cement structure and chemicals. Clariflocculator are widely used for primary treatment of water by using chemicals. In this process floc settling time is decreased. It is a combination of both flocculation and clarification in a single tank. It is consists of concentric circular compartments. The inner compartment is for the flocculation chamber and outer is clarifier. The chemically dosed water is uniformly distributed over the surface of the flocculation chamber. The specially designed flocculation paddles enhance flocculation of the feed solids. Heavy particles settle to the bottom and these are collected at central area using scraper. In the flash mixer, coagulant chemicals are added to the water and the water is mixed quickly and violently. After flash mixing, coagulation occurs. In final step the compartmentalized chamber allows increasingly large floc to form without being broken apart by the mixing blades and is called as flocculation. Throughout this process, mixing blades (Agitator), Scraper, And Rotating Truss play important role. These important components should be carefully designed considering all constraints and optimally utilised. In order to meet this, Rotating Truss is analysed using different sectional areas for greater weight reduction and better utilization. In this study, analysis is carried out for truss length 9500mm.Typical clariflocculator has a capacity of 2 to 4 Million Liters per Day (MLD) and in general the capacity is referred as capacity of the WTP. Depending upon this all parameters of parts are decided. The breadth and height are decided based on standards.

The scope of present study includes, the Structural Analysis and Optimization of the water treatment plant

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rotating truss by using different sections like C-channel, I-beam & L-section or combination of all three sections. The stresses and deflections in critical elements are noted to reduce the weight and cost of the rotating truss.

1.1 Parts of WTP Clariflocculator

The use of bridge in WTP Clariflocculator is explained in following points in short.

- It is rotating element runs at 1 revolution per hour
- Agitator and scraper is attached to it
- Helps to monitor all parts regularly as person can walk on it.

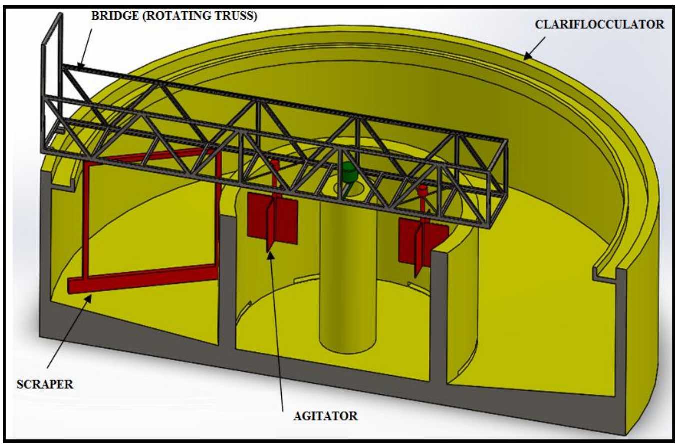

Fig -1: Parts of Water Treatment Plant Clariflocculator.

The most of the rotating trusses are over-hanged with truss elements as shown in above Fig-1.

Clariflocculator: It is well type structure, which are widely used for primary treatment of water by using chemicals. In this process floc settling time is decreased. It is a combination process of both flocculation and clarification in a single tank. This well consists of two concentric circular compartments. The inner compartment is for the flocculation and outer is clarifier compartment. The water which is dosed with chemical is uniformly distributed over the surface of the flocculation chamber. The specially designed flocculation paddles enhance flocculation of the feed solids. Heavy particles settle to the bottom.
Agitator: It is rotating element, which helps to increase the flocculation of impurities. It rotates at 4 revolutions per minute. The speed is designed in such a way that it helps to floc the solid particles.
Scraper: When water after flocculation enters into clarification chamber, Heavy particles goes down and settles on bottom floor. Scraper sweeps the mud collected in outside chamber. It is attached to the bridge. The bottom part of scraper is always in contact with mud & guides it towards inside wall.
Rotating Truss or Bridge: It is structure, to which agitator & scraper is attached. It is like bridge which facilitates for regular maintenance and observation of process. It rotates at very low velocity. It rotates at velocity nearer to 1 revolution per hour, such that it shouldn't disturb water steadiness.

1.2 Different Types of Structures (Truss):

There are different types of truss structures depending upon their shape and pattern. The names of different truss structures are:

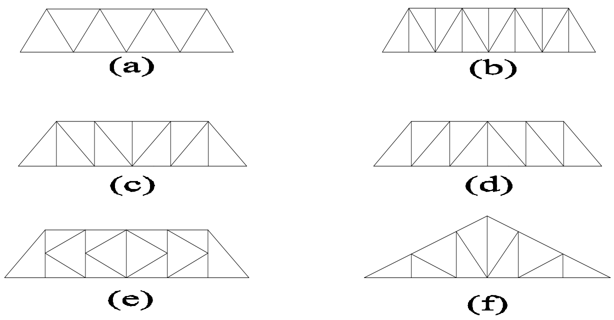

Fig -2: Different Types of Truss, a) Warren Truss b) Warren Truss with Verticals c) Pratt Truss d) Howe Truss e) K Truss f) Roof Truss.

1.3 Different Parts of Truss.

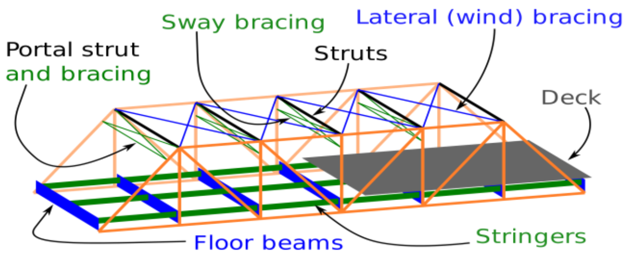

Fig -2: Different Parts of Truss Bridge.

2. LOADING OF TRUSS BRIDGE

For anaysing the WTP truss bridge, first the loading and constraints of the bridge were understood. The bridge is like overhanging beam. Agitator, Scraper, Operator & its dead weight is considered for loading. Also it is mandatory to follow certain constraints and those are as follows:

- Weight of truss bridge should be around 500 kg,
- Bottom chord and floor beam should be of ISMC100 & remaining elements can be built by various sizes of ISMC, ISA and ISMB.
- Length, Breadth & Height should be 9500 mm, 1250mm & 1330mm respectively

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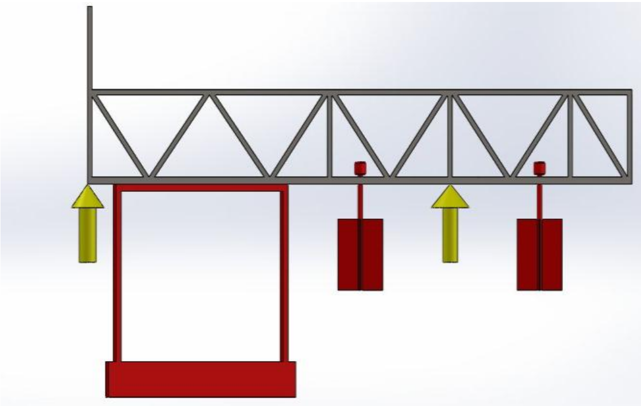

Fig -2: Loading of Truss Bridge

2.1 Loads

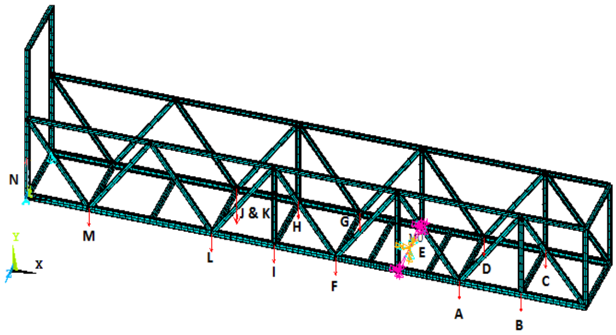

Fig -4: Loading of Bridge in Detail

The alphabets have been used to represent the loading system systematically.
Load of Agitator 1(right side of Fig-4) is connected to four points to a set of nodes at each points as shown in Fig-1.
A, B, C, D. i.e.
A + B + C + D = 200 Kg × 9.81 = 1962 N
Thus
A = B = C = D = (1962/4) = 490.5 N

Load of Agitator 2 (left side of Fig-4) is distributed to points F, G, H, I. i.e.
F + G + H + I = 200 Kg × 9.81 = 1962 N
Thus
F = G = H = I = (1962/4) = 1962
Load of Scraper is distributed to points.
M & J
M + J = 100 Kg × 9.81 = 981 N
Thus
M = J = (981/2) = 490.5 N.
Load of operator is considered in area where it gives maximum deflection.

Operator weight acts at section K and L i.e.
K + L = 100 Kg × 9.81 = 981
Thus,
K = L = (981/2) = 491 N

The truss bridge rotates at 1 to 2 revolutions per hour. Since in this field the bridge doesn't incur dynamic parameter. Hence this study is based on static theory. Only static loads are applied at specified points.

2.2 Constraints:

At point N – Displacement is restricted in Y direction.
At point E – Displacement is restricted in All direction.

3. SOLVING IN FEA SOFTWARE:

The IGS model was imported as model geometry. First it was 2-D meshed the outer surface of model using tria element, and then it was 3-D meshed using tetra element. Material and Properties were assigned to meshed model. Steel having young's modulus as 2.1×10^5 N/mm2, poissions ratio as 0.3 and density as 7860×10^{-9} kg/mm3 are given as inputs to the model. Above all mentioned loads and boundary conditions are applied with gravity. Gravity is added to account self-weight of bridge, then it was solved with solver package.

4. RESULTS AND OPTIMISATION.

Stress values for different models are plotted for 9500 mm length truss bride.

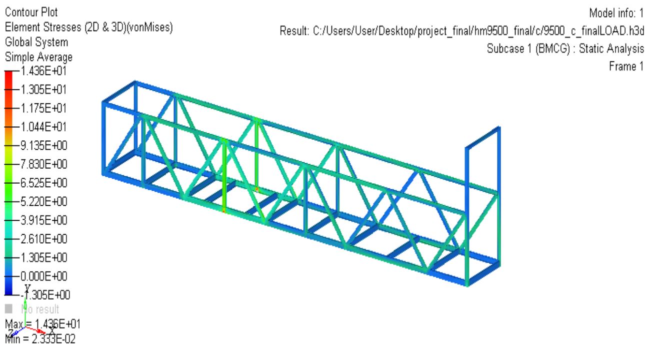

Fig -5: Stress for model made from C-Channel.

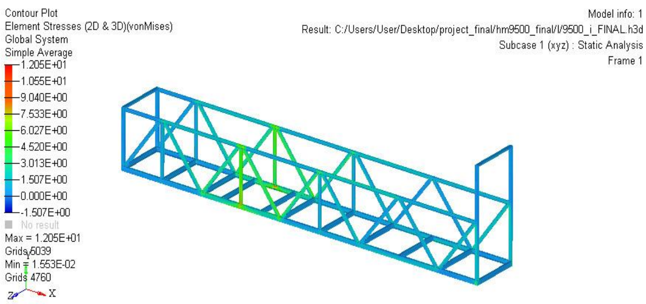

Fig -6: Stress for model made from I-Beam.

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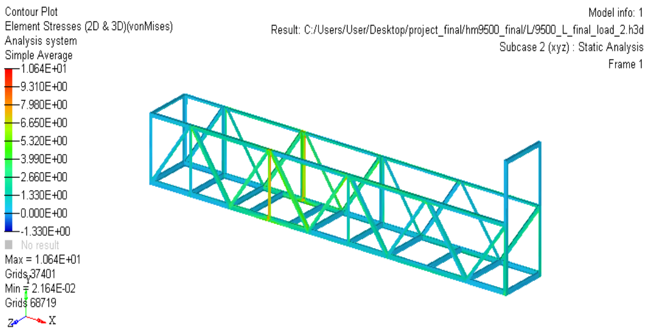

Fig -7: Stress for model made from L-Section.

After performing complete analysis of rotating truss bridge, Software gives stress value as 14.36 N/mm² for C-section model (Model No: 1), 12.05 N/mm² for I-section model (Model No: 2), & 10.64 N/mm² for L-section model (Model No: 3). von-Mises stress theory is chosen to evaluate stress values. Also deformation figure is plotted & is within 1 mm. The deformation and stress values are well within the yield limit. The stresses are not same at all locations. It has varied from point to point. The place where the loading is more, that element has induced more stress than element without subjected to load. So it was decided to go for material optimization at the elements which has negligible low stress value.
C-channel of grades ISMC100 and ISMC75 were used for first model. Fig-5 shows stress distribution of this model. But it is not feasible to use due to overweight. For optimization, it is necessary to use channels, angles and I-beams in combination with different size at different location.

Fig -6: optimized model using C-channel, I-beam & L-section links.

L-sections have implemented at locations where stress value is too low, I-beam link have been put at vertical position location E, where it is fixed. C-channels have been put as per design criteria. In optimization the bottom chord & floor beam of truss are built by ISMC100. The top chord, portal strut, vertical post and diagonals were built by ISA40.
One vertical post at support is made with ISMB100 beam
And ISA50 was introduced in beside two vertical posts. This Model No: 4 and it is shown in Fig – 6.

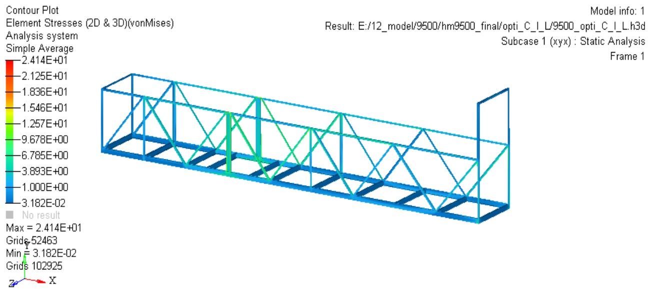

Fig -8: Stress for optimized model made from C-channel, I-beam, L-section.

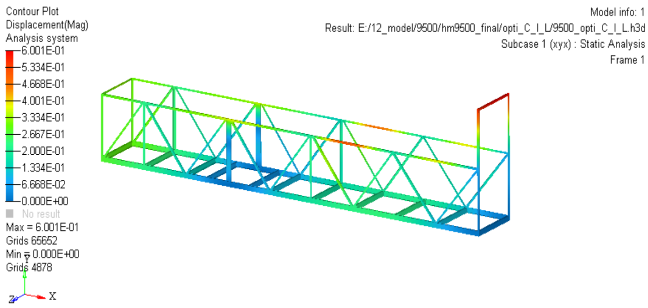

Fig -9: Deflection for optimized model made from C-channel, I-beam and L-section.

5. DISCUSSION & COMPARATIVE STATEMENT.

The results from FEA packages for different models are plotted. Its maximum stresses are show in figures. These results are cross verified from theoretical calculations. Here a method of joints has been used to validate the results. The model is considered as truss problem & from method of joints forces acting at each joint are calculated and the results compared with against software results. The results from both the methods were in good agreement with each other.

Table -1: Comparative Statement

Model No	Descriptions	Stress (N/mm²)	Deflection (mm)	Mass (kg)	Remarks
1	ISMC100 ISMC75	14.36	0.22	749	Over weight
2	ISMC100 ISMB75	12.05	0.23	733	Over weight
3	ISMC100 ISA75	10.64	0.23	762	Over weight
4	ISMC100 ISMB75 ISA50 ISA40	24.14	0.60	537	Chosen

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The results of both the model are interpreted and plotted in table no.1 Model No:1, Model No:2, Model No:3 has stress well within limits but its weight is more and don't fit in required criteria. Model No: 4 gave optimum stress values at most of the locations which are well with in yield strength of steel. And also Model no.4 found to have less mass than rest of the model. This study was done to reduce the weight of the truss bridge, hence model no.4 is chosen.

6. CONCLUSIONS

1).Three dimensional rotating truss model was created and analysed using FEA package. Bridge which is made up of C-channel had more factor of safety, this was experienced same with the bridge made up of I-beam & L-section. Also there are more such link where the stress induced is very less compare to maximum stress in rotating truss bridge.
2).Suitable sections are used for particular links depending on stress value. This leads to minimize the gap between minimum and maximum stress values.
3).The optimized truss bridge were analysed and it was observed that results are satisfactory as the F.O.S greatly reduced. This model weights around 537 kg
4).Ultimately the final model found very close solution to given problem statement, which aims to reduce the weight of truss without compromising its strength.

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