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Design and analysis of skid frame for pumping station

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Abstract – Skid frame is a structural assembly consisting of beams of various cross sections and dimensions. This frame is to designed for flow control pumping station which is used to regulate the flow & pressure for fluids. The base frame is subjected to the gravitational loading of all components mounted viz. pump with motor, duplex strainer, control valves, instruments & piping etc. The flow control application mainly required for process industries like cement plants, power plants etc. This frame is designed with conventional CAD design Practice and the analyzed statically with FEA software. All the design standards are based on IS standards.

Keywords – Pumping Station, Skid Frame, Static Analysis.

I. Introduction

Steel is commonly used structural metal in engineering due to its greater strength, good ductility and easy to fabricate. Due to its high strength and relatively light weight (less dead weight) it can carry heavy loads. The section used may be equal dimensions and cross sections, or a combination can be used for optimum weight. Different type of sections is used for designing skid frame, the sections selected for this project is of Indian Standards (IS). Depending on the type of loading, design is made considering material properties and steel members can be joined easily by welding, riveting and bolting. The skid frame is required to support various components that have been designed by conventional design procedure. The weight of components mounted on the frame are considered as static loads for desinging.3D model is carried out Autodesk Inventor & analysis is carried out by Ansys Work Bench 16 software package. These pumping systems are locally operated & hence their elevation should be designed in such a way that will reduce the hardship of the operator.

Static & Dynamic Analysis

A **static analysis** calculates the effect of steady loading on a structure while ignoring inertia and damping effects, such as those caused by time varying loads. A static analysis can however include steady inertia loads – such as gravity & rotational velocity and time varying loads that can be approximated as static equivalent – Wind & seismic loads commonly defined. Static analysis is used to determine the displacement, stress, strains and forces in structure components caused by loads that do not include significant inertia and damping effects.

A **Dynamic analysis** can be used to determine the vibration characteristics of structures or machine components while it is being designed. It also can be starting point for another, more detailed dynamic analysis such as transient analysis, a harmonic analysis or a spectrum analysis. Dynamic analysis is the study of the dynamic properties of structures under vibration excitation.

II. Methodology& Material

Methodology – This study involves modelling of skid frame & analysis of stress and deformation under loading condition. CAD model of skid frame were developed in Autodesk Inventor 2015 and stress analysis and deformation of models are then obtained in ANSYS WORKBENCH 15.0.

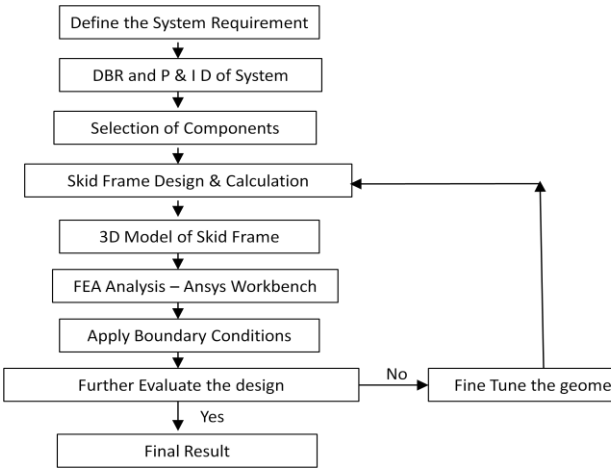

Figure 1.1 Design Methodology Flow chart

Design Basis Report

- Defines the Design Consideration of Pumping Systems & Calculation.
- Finalizing the, Pipe Size & Valve Size, Pump Capacity (Flow & Head) and Motorrating.

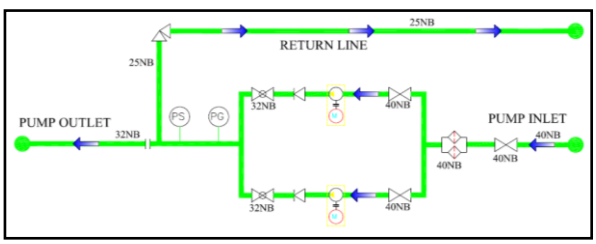

Figure 1.2 Piping & instrumentation Diagram

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Table 1.1 Weights of Systems Components

Sl. No.	Items	Size	QtyNos	Weight
1	Motor	9.3kW	2	2356 N
2	Duplex Strainer	40NB	1	884 N
3	Pump – 7m^3/hr,	155m	2	
4	Gate Valve	40NB	3	
5	Check Valve	32NB	2	
6	Globe Valve	32NB	2	
7	Pressure Switch	¼" BSP	1	
8	Pressure Gauge	½" BSP	1	
9	Pressure Relief	25NB	1	
10	Pipe, MS	40NB	6 M	
11		32NB	6 M	
12		25NB	6 M	4150 N
13	Flange, MS	40NB	4	
14		32NB	2	
15		25NB	2	
16	Elbow, MS	40NB	2	
17		32NB	2	
18		25NB	2	
19	Tee, MS	40NB	2	
20		32NB	2	
21		25NB	2	
Total				**7390 N**

Material properties – For application of skid frame, structural steel are used.

Table 1.2 Material Properties of Skid Frame

Sl. No.	Physical Properties	Values	SI Units
1	Density (ρ)	7850	Kg/m^3
2	Young's Modulus (E)	210x10^3	Mpa
3	Tensile Strength	510	Mpa
4	Yield Strength	355	Mpa
5	Shear Modulus (G)	80x10^3	Mpa
6	Poisson's Ratio	0.3	

Table 1.3 Chemical Compositions

Chemical Composition IS : 2062/2011					
Grade	C	Mn	S	P	Si
E250A	0.23	1.50	0.045	0.045	0.40

Selected Structural Steel – ISMC 100

Yield Strength = 327 Mpa

Tensile Strength = 480 Mpa

% of Elongation = 32

Calculation:-

Factor of safety = 1.2 for static load case.

Allowable Stress = Yield Strength / FOS

Channel Sections – Channel are the most critical members in structures, therefore their design should not be economical but also safe. Its difficult task for designer to select a channel size for a given span & load that will satisfy all the conditions. A number of rolled steel structures are used in construction. However L angles & T-sections are inherently weak in bending while channels can only be used for light / heavy loads. If we take a circular beam max cross sectional area would be at the centre of beam where no bending stress occurs. If we take a square beam it will have more cross sectional area at the top & bottom. Hence I Beam / C Channel / Square hollow section is most efficient and economical, as it has excellent strength affordable cost and most commonly used for skid frames.

Indian Standard Medium Weight Channels (ISMC)

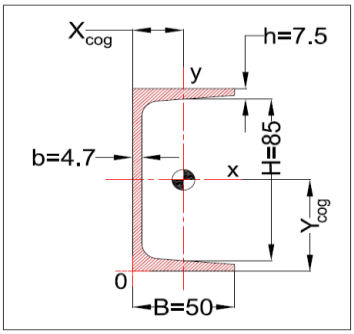

Figure 1.3 Diagram of ISMC

Table 1.4 Formulas for Section Properties

Sl. No.	Parameter	Symbol	Equation
1	Cross section Area	A	A = 2Bh + Hb
2	Area of Moment of inertia	I_{xx}	$I_{xx}=\frac{H^3b}{12}+2\left(\frac{h^3B}{12}+hB\left[\frac{h+H}{4}\right]^2\right)$
3	Area of Moment of inertia	I_{yy}	$I_{yy}=\frac{b^3H}{12}+bH\left(x_{cog}-\frac{b}{2}\right)^2+2\frac{B^3h}{12}+2Bh\left(x_{cog}-\frac{B}{2}\right.$
4	Section Modulus	S_{xx}	$S_{xx}=\frac{I_{xx}}{Y_{cog}}$
5	Minimum Section Modulus	S_{yy}	$S_{yy}=\frac{I_{yy}}{(B-X_{cog})}$
6	Center of Gravity	X_{cog}	$X_{cog}=\left(\frac{2hB^2}{2}+\frac{b^2H}{2}\right)A$
7	Center of Gravity	Y_{cog}	$Y_{cog}=\left(\frac{2hB^2}{2}+\frac{b^2H}{2}\right)A$
8	Mass	M	$M=Al\rho$
9	Radius of Gyration	r	$r=\left(\frac{1}{A}\right)^{0.5}$
10	Polar Moment of Inertia	J	$J=I_{xx}+I_{yy}$

PROCEDURE FOR STATIC ANALYSIS

There are 3 main steps involve in Static Analysis

1. Construct the Model
2. Apply Load and find Solution
3. Review the results.

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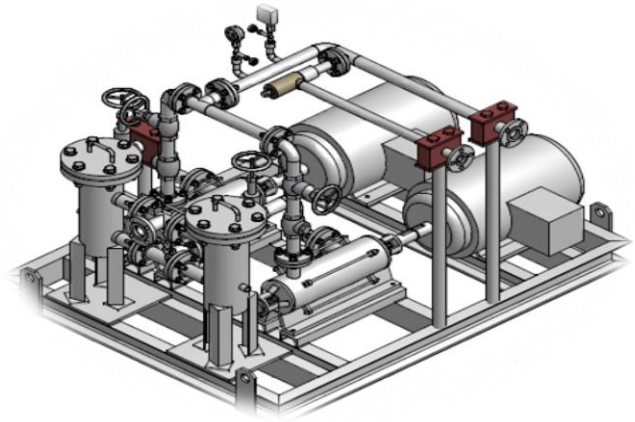


Figure 1.43D Model of Pumping Station.

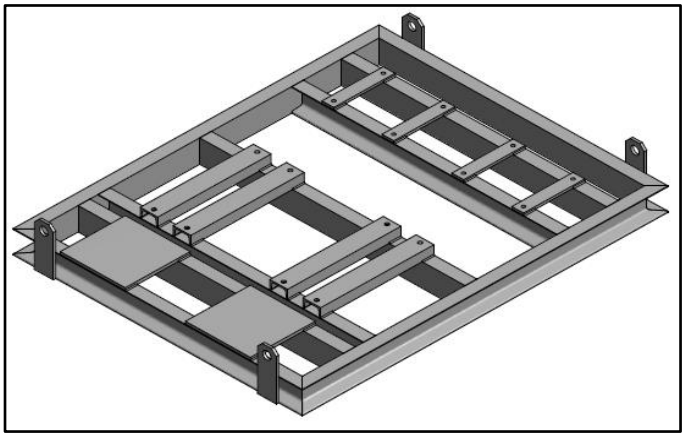


Figure 1.5 3D Model of Skid Frame.

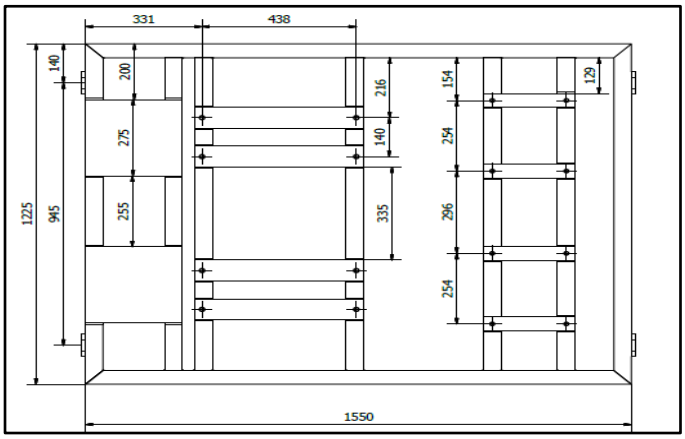
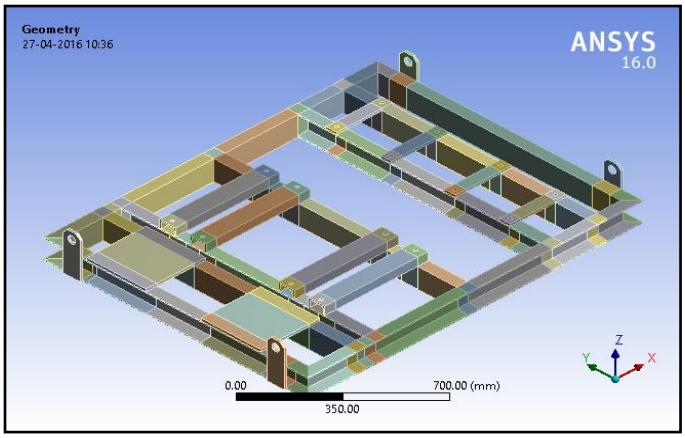


Figure 1.6.2D Model of Skid Frame



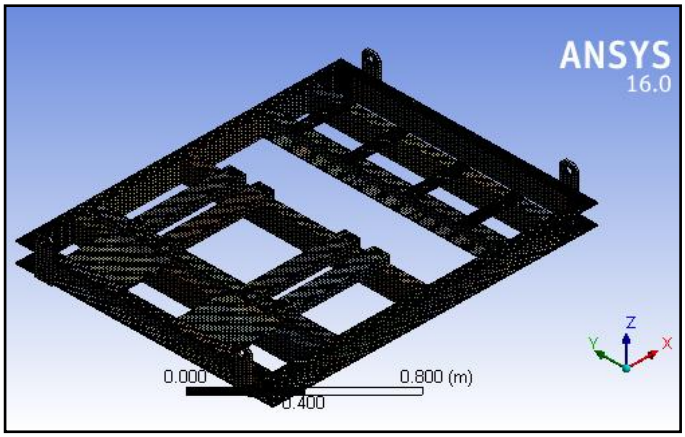


Figure 1.8 Meshed Model of Skid Frame.

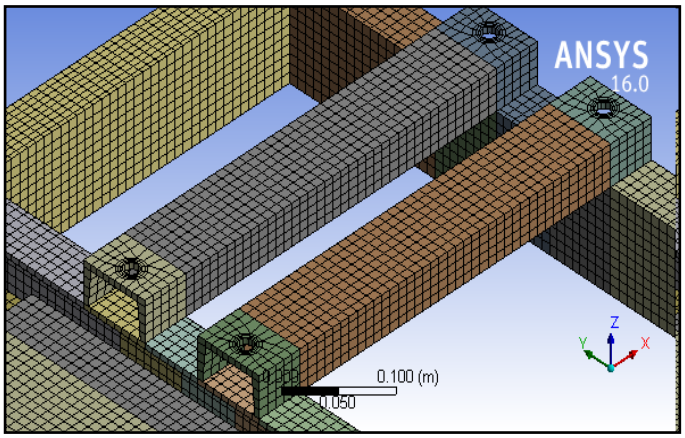


Figure 1.9 Zoomed view of Meshed Model of Skid Frame.

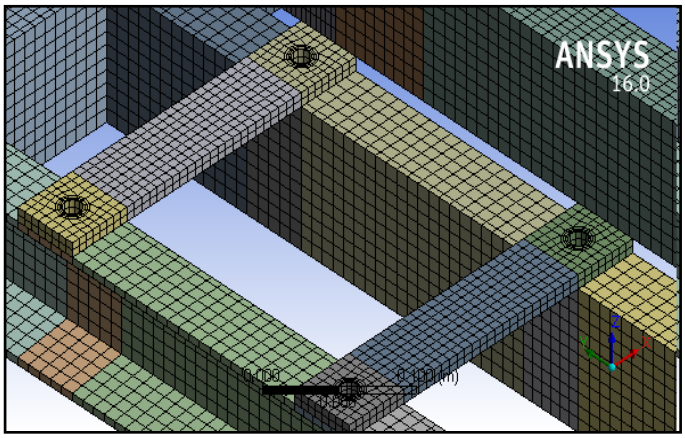


Figure 1.10 Zoomed view of Meshed Model of Skid Frame.

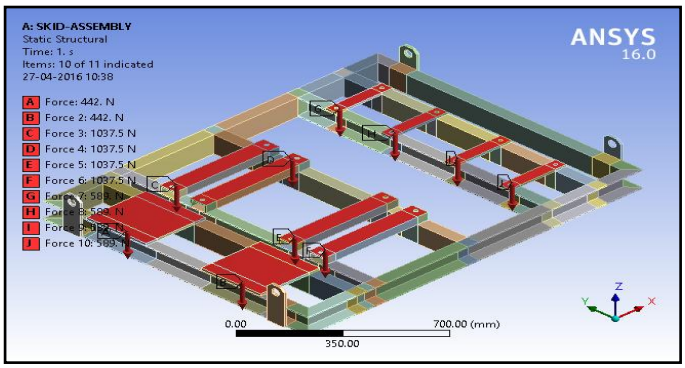


Figure 1.11 Boundary condition of Skid Frame.

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III. Results & Tables

1) Mesh Information

Table 1.5 Nodes and Element of model

Statistics	
Total Nodes	261846
Total Elements	37037
Mesh Type	Hexa
Mesh Size	10mm

2) Stress Distribution

Table 1.6 Von Mises Stress

Name	Type	Minimum	Maximum
Stress	Von Mises Stress	0.40987 N/m^2	$1.52x10^7$ N/m^2

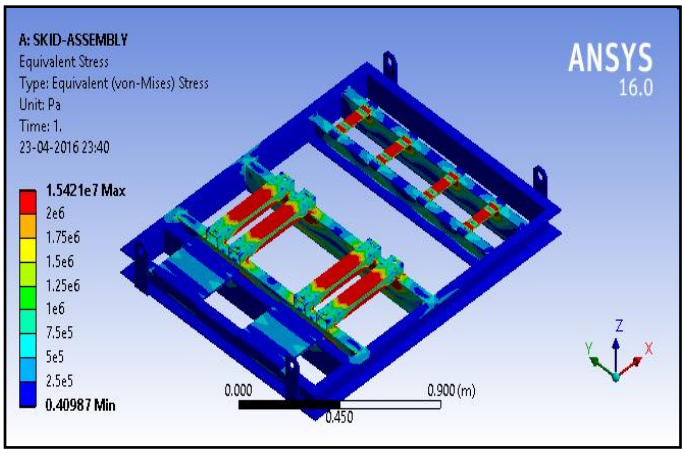

Figure 1.12 Von Mises Stress

3) Total Deformation

Table 1.7 Total Deformations

Name	Type	Minimum	Maximum
Stress	Total Deformation	0	$2.19x10^{-5}$

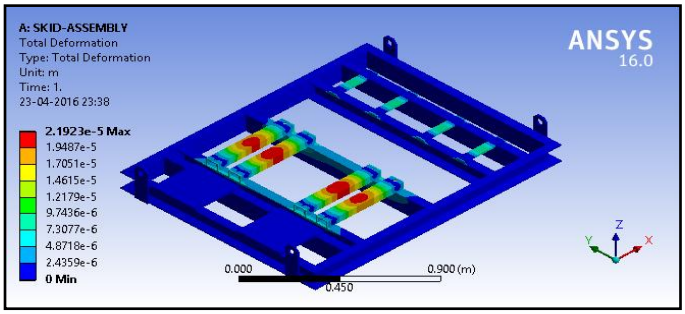

Figure 1.13 Total Deformations

4) Maximum Principal Stress

Table 1.8 Principal Stress

Name	Type	Minimum	Maximum
Stress	Principal Stress	-$1.8x10^6N/m^2$	$6.98x10^6N/m^2$

-

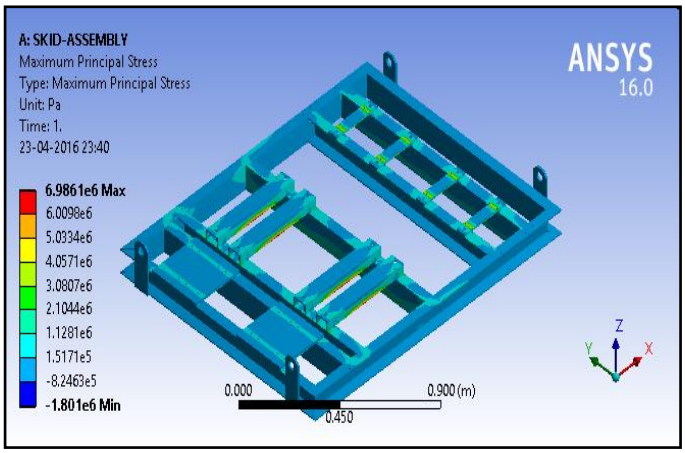

Figure 1.14 Principal Stress

5) Force Reaction

Table 1.9 Force Reactions

Name	Type	Minimum	Maximum
Stress	Force Reaction	246.33N	7390N

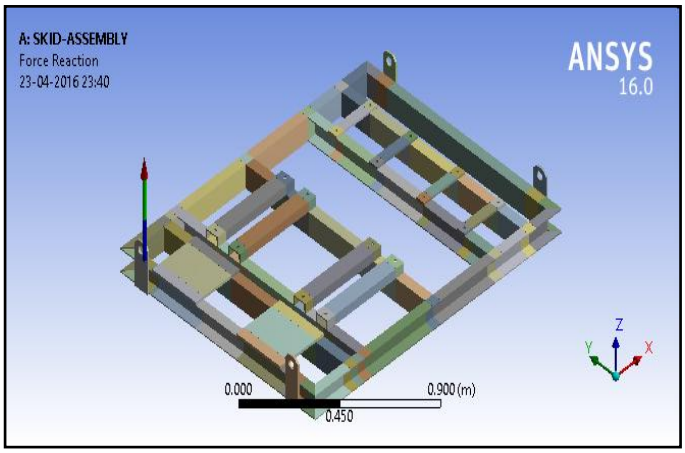

Figure 1.15 Force Reactions

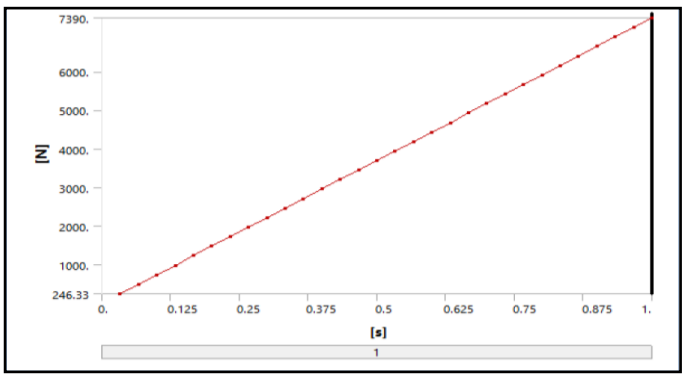

Figure 1.16 Graphs for Forces Vs Time

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IV. Conclusion

The Skid Frame have been modelled &analyzed, various parameter such as nodal displacement and stress distribution are completely studied. The study shows that the area where the Von Mises Stress concentration is within the limit due to applied load and the portions to be considered in the design of skid frame in order to avoid frequent breakdown& to improve its reliability. Stress analysis of skid frame has been done to predict the stability at the give condition, Hence, the Model is safe, qualifies and passes as per specifications for the design, operating conditions.

Acknowledgment

Words in reality start failing at such moments when one starts acknowledging the guidance and help provided by many individuals.

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