Paper on Experimental Analysis of Pressure Vessel Support Frame

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Abstract

A structure refers to a system with connected parts used to support a load. Some examples related to civil engineering are buildings, bridges and towers. At first, we will consider simple examples of structures and parts of structures like beams, trusses, frames etc. There are many types of structures all around us. Each structure has a specific purpose or function. They must be capable of carrying the loads that they are designed for without collapsing. They must support the various parts of the external load in the correct relative position. The frame discussed in this paper is designed with conventional CAD design practices and then analyzed experimentally by FFT analyzer. The experimental analysis is carried out to determine the induced stresses and the deflections at various locations on proposed frame. The structure was optimized to reduce weight. In this paper the experimental Analysis of skid Frame for Rigidity is been carried out. The base frame is analyzed using FFT analyzer, impact hammer and accelerometer test. The static loads are applied on the frame and analysis is carried out. The test is carried out to check the conformance of the existing design. The skid base frame is modified for making a stiffer design within the allowable stress limits.

Keywords: Experimental, Pressure Vessels, Support Frame, FFT

I. INTRODUCTION

There are numbers of structures all around us. Each structure has a some specific purpose or function. Some structures are simple, while others are complex; however there are two basic principles of composing structures.

However there are two basic principles of composing structures. They must be capable of carrying the load for which they are designed without collapsing and they must support the components of the external load in the correct relative position applied on various parts of the application they are supporting.

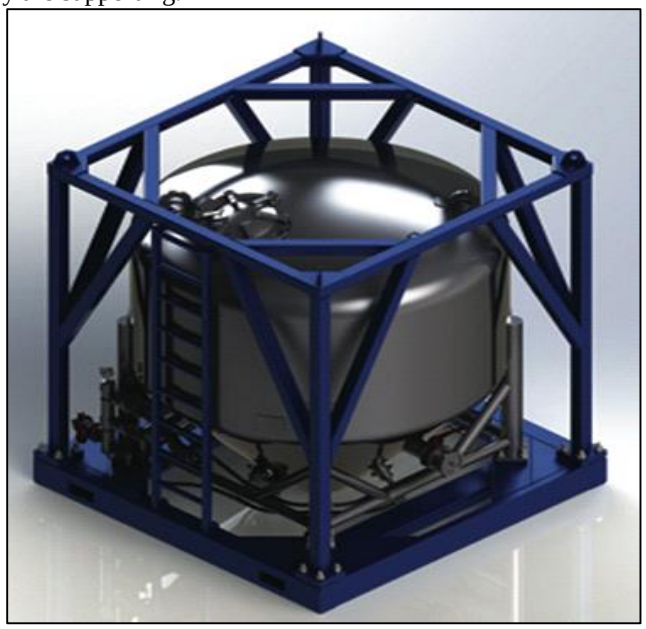

Fig. 1: Pressure vessel support frame

The pressure vessel support frame is fabricated with 1: 10 scaling factor of actual dimensions of a frame with reference of CAD model and structural drawing.

A. Fabrication Drawings

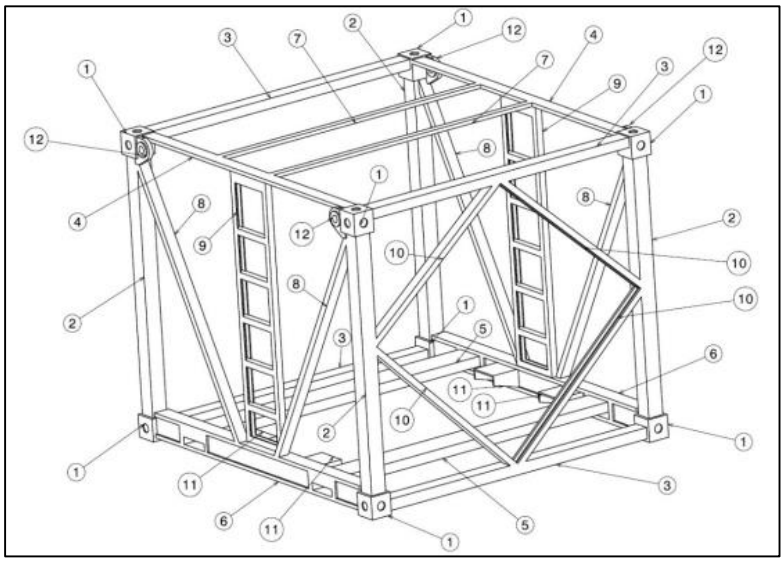

Fig. 2: Schematic diagram of pressure vessel support Frame

Table - 1
Bill of material

Sr. No.	*Part Name*	*Qty*
1	*Square solid section*	*8*
2	*Vertical square bar*	*4*
3	*Horizontal square bar*	*4*
4	*Horizontal bar*	*2*
5	*Horizontal bar bottom*	*2*
6	*Horizontal bar bottom side*	*2*
7	*Horizontal bar top side*	*2*
8	*Solid rectangular bar cross*	*4*
9	*Ladder*	*2*
10	*Side cross bar*	*4*
11	*Bottom extruded feature*	*4*
12	*Top end feature*	*4*

B. Detail Drawings

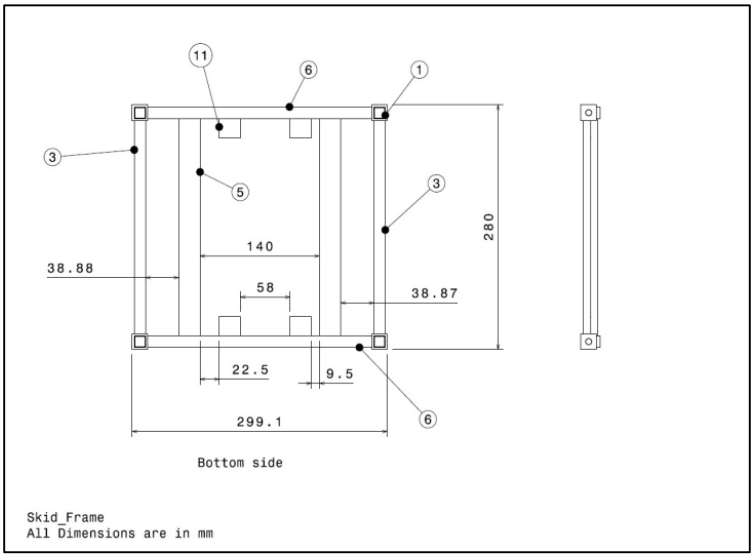

Fig. 3: Detail Drawings

C. Experimentation

The experimental investigation will be performed on fabricated prototype on universal testing machine at Praj Metallurgical Lab, Kothrud, Pune. Compression test will be performed on the prototype produced. The input conditions are recreated in the lab while the component is being tested. The loading and the boundary conditions are matching the practical working conditions under which the specimen is expected to perform. The loading conditions are applied as per the scaling proportions on the prototype for testing purpose.

D. Scaling of load from prototype to scale model

Experimental analysis using huge structure calls for larger laboratory space, higher loading capacity, huge test structure and high cost. Scaled down models are widely used for experimental investigations of huge structures due to limitation in the capacities of testing facilities and moreover the experimentation on scaled models is less expensive. Scaling principle provides a powerful tool for engineers and scientists to replicate the behavior of the prototype (full model) using an appropriate scaled model. For a prototype, a scaled replica can be built to duplicate the behavior of the full-scale system. The experimental results on the model (scaled down model) can be utilized to predict the behavior of the prototype. The scaling down concept is thus very useful, especially, for problems with either a complex domain for which numerical solutions are not sufficiently accurate. If the prototype is perfectly replicated, the experiment results on the model can be scaled to predict the behavior of the prototype with sufficient accuracy.

The main objective of conducting experiments on structures at reduced scales is to reduce the cost of experimentation. Sufficient care should be taken on how far the model behaves similar to the prototype. The modeling accuracy depends upon the material property of model, fabrication accuracy, loading technique, measurement method and interpretation of results.

For scaled down model load should be reduced by S2 times the actual model. The deflection in the scaled model will be S times less than the actual model.

Where, S = geometrical scale factor.

Skid frame is scaled down to a ratio of 1:10, Therefore, S is 10.

As per given data:

Operating load = 18650 Kg (approx.)

We take, Operating load = 187000 N

Scale down operating load = 187000/ (10) ˆ2

So, scale down operating load = 1870 N

E. Fabricated Model

Fig. 4: (Image Fabricated Prototype frame model)

F. Experimental Set Up

The experimental set up consists of following, components,

Table - 2
Experimental set up components

Sr. No.	*Components*	*Use*
1	*Test component*	*Pressure vessel support frame.*
2	*Load frame*	*Usually consisting of two strong supports for the machine.*
3	*Load cell*	*A force transducer or other means of measuring the load.*

4	*Cross head*	*A movable cross head (crosshead) is controlled to move up or down. Usually this is at a constant speed, sometimes called a constant rate of extension (CRE) machine.*
5	*Means of measuring extension or deformation*	*Many tests require a measure of the response of the test specimen to the movement of the cross head. Extensometers are sometimes used.*
6	*Output device*	*A means of providing the test result is needed. Some older machines have dial or digital displays and chart recorders.*
7	*Conditioning*	*The machine can be in a controlled room or a special environmental chamber can be placed around the test specimen for the test.*
8	*Test fixture*	*Specimen holding jaws, and related sample making equipment.*

G. Experimental Results

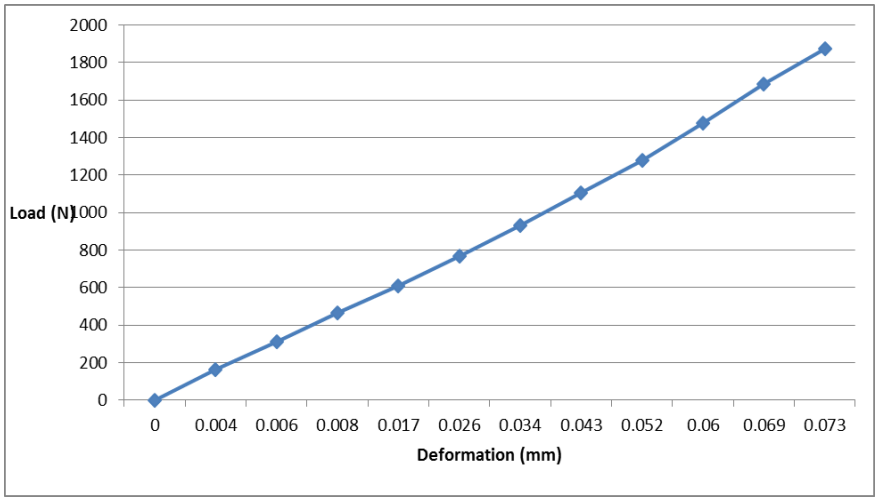

Fig. 5: Experimental Results

From testing results, deformation value is 0.073mm

Table - 3
(Stress variation from ANSYS)

Sr No.	*Parameters of results*	*Min value*	*Max value*	*Deformation*
1	*Stresses in Iteration No.1*	*0.0632*	*79.91*	*0.56*
2	*Stresses in Iteration No.2*	*0.0632*	*82.28*	*0.50*
3	*Stresses in Iteration No.3*	*0.0765*	*86.89*	*0.68*
4	*Stresses in Iteration No.4*	*0.0755*	*87.47*	*0.67*

Stress and deformation variation from ANSYS analysis on actual frame (at load = 187000N)

H. Experimental Results

Table - 4
Experimental Results

Sr. No.	*Load (in N)*	*Deformation*
1	*1870*	*0.073*

From experimental results and FEA results,
(Note: we take scale down deformation value of FEA results, i.e. 0.067)
Percentage Error = (Experimental - FEA) / Experimental = (0. 073- 0.067) / 0.073 = 6.84 %.

I. Weight Reduction

Table - 5
Weight Reduction

Sr. No.	*Skid Frame*	*Weight (kg)*
1	*Existing*	*3536.33*
2	*Iteration- 1*	*3165.01*
3	*Iteration- 2*	*3084.69*
4	*Iteration- 3*	*3067.93*
5	*Iteration- 4*	*3008.38*
6	*Scaled Model*	*3*

Weight is reduced by 527.95 Kg
Percentage Reduction = (Existing -Iteration_4) / Existing = (3536.33 - 3008.38)/3536.33 = 14.92 %

J. Material Cost reduction

M.S. cost per kg.150 Rs /kg

Table - 6
Material cost reduction

Existing	*530499 Rs*
Optimized	*451257 Rs*

II. CONCLUSION

- Fabrication of skid frame was done with 1:10 scaling factor and testing of the same are performed.
- It can be concluded that the weight reduction of 14.9% is observed in optimized model of skid frame without compromising over its strength hence the objective is achieved.
- From experimental results it is observed that for pressure vessel support frame deformation is 0.073mm.

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