DESIGN, STRESS ANALYSIS OF 10 TON CAPACITY WEIGHING SCALE FRAME STRUCTURE

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ABSTRACT

The weighing scale small to large scale may be used to accomplish the need of logistic, dairy and heavy industries. In weighing scale, frame structure is base of the scale, the function of frame structure is to remain weighing stable and transfer load to the strain gauge. During weighing heavy component frame structure bending, in result of weighing is non-linear. Solving this problem by adding of frame structure rectangular cross section in existing frame .But this solution makes structure self-weight and cost of fabrication increased. This problem solving by the Finite element stress analysis in CAD software and optimize the weighing frame. The need of time to explore more and more optimize product needed, which save money and material.

1. Introduction

1.1 Mechanical scales-Spring scales

Spring scale measures weight by reporting the distance that a spring deflects under a load. This contrasts to a balance, which compares the torque on the arm due to a sample weight to the torque on the arm due to a standard reference weight using a horizontal lever. Spring scales measure force, which is the tension force of constraint acting on an object, opposing the local force of gravity. They are usually calibrated so that measured force translates to mass at earth's gravity. The object to be weighed can be simply hung from the spring or set on a pivot and bearing platform. In a spring scale, the spring either stretches (as in a hanging scale in the produce department of a grocery store) or compresses (as in a simple bathroom scale). By Hooke's law, every spring has a proportionality constant that relates how hard it is pulled to how far it stretches. Weighing scales use a spring with a known spring constant (see Hooke's law) and measure the displacement of the spring by any variety of mechanisms to produce an estimate of the gravitational force applied by the object. Rack and pinion mechanisms are often used to convert the linear spring motion to a dial reading.

1.3Digital Strain gauge scale

In electronic versions of spring scales, the deflection of a beam supporting the unknown weight is measured using a strain gauge, which is a length-sensitive electrical resistance. The capacity of such devices is only limited by the resistance of the beam to deflection. The results from several supporting locations may be added electronically, so this technique is suitable for determining the weight of very heavy objects, such as trucks and rail cars, and is used in a modern weighbridge. Main components of Weighing Scale are checker plate, frame structure, indicator and strain gauge.

Fig-1 weighing scale platform

2. Literature Survey

Plastic optimization of 3D steel frames under fixed or repeated loading: Reduction formulation

Hoang Van Long Nguyen Dang Hung Faculty of Applied Sciences, University of Liege, Chemin des Chevreuils 1, 4000 Liege, Belgium21 January 2010

This paper present a new algorithm of plastic optimization for 3D steel frames under fixed loading (limit optimization) or repeated loading (shakedown optimization). The weights of the frames are minimized under constraints of plastic collapse (instantaneous mechanics/alternating plasticity). A 3D plastic-hinge considering two bending moments and axial force is taken into account by 16-facet polyhedrons. The static theorem of limit analysis is adopted and the formulations are written under a linear programming problem that is solved by using the simplex method. Several useful techniques of reducing the problem sizes are proposed. Some numerical examples are presented to demonstrate the efficiency of the proposed algorithm.

Tailoring static deformation of frame structures based on a non-parametric shape–size optimization method

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In this study, a non-parametric shape–size optimization method is developed for tailoring the static deformation of large-scale frame structures. This deformation control design is one of the important problems in the stiffness design of frame structures, and enables us to create a smart or a high performance structure for a specific ability of deformation. As the objective functional, we introduce the sum of squared error norms for achieving the desired displacements on specified members, and assume that each frame member varies in the off-axis direction with changing cross sections. The shape gradient function, the size gradient function, and the optimality conditions for this problem are theoretically derived with the Lagrange multiplier method, the material derivative method, and the ad joint variable method. The optimal shape–size variations that minimize the objective functional are determined by using the Hent method for frame structures. With the proposed method, the optimal arbitrarily formed frame structures with the optimal cross sections can be obtained without any shape and size parameterization while maintaining their smoothness. The validity and practical utility of this method for tailoring the static deformation of frame structures are varied through design examples.

Analysis of the thickness effect in thin steel welded structures under uniaxial Fatigue loading

Livieri, P., Tovo, R., Analysis of the thickness effect in thin steel welded structures under uniaxial fatigue loading, International Journal of Fatigue (2017)
This paper investigates the scale effect in relatively thin welded joints subjected tofatigue loading made of steel. In the scientific literature, the fatigue behaviour of arc-welded joints is usually divided into two groups: thick and thin joints. A cut-off thickness, typically in the range of 13 mm to 22 mm, was introduced; under such cut-off value, the design fatigue strength does not increase when the thickness is decreased. Despite this common approach, in this paper, the concept of cut-off thickness is revised and a numerical procedure is proposed, regardless of the Thickness of the joint, by means of the implicit gradient method. Classical non-load carrying and load-carrying cruciform joints made of steel are considered in the three-dimensional numerical analysis. Finally, the fatigue behaviour of joints two millimetres thick with a longitudinal or transversal stiffener was also analysed by means of the implicit gradient approach. The Woehler curve was evaluated in terms of the nominal stress of such a series and a good correlation was found with experimental data by using the numerical procedure optimised for thick welded joints.

Cross-sectional optimization of cold-formed steel channels to Eurocode 3

Weixin Ma, Jurgen Becque, Iman Hajirasouliha, Jun Ye Department of Civil and Structural Engineering, The University of Sheffield, Sheffield, UK July 2015

Cold-formed steel structural systems are widely used in modern construction. However, identifying optimal cross section geometries for cold-formed steel elements is a complex problem, since the strength of these members is controlled by combinations of local, distortional, and global buckling. This paper presents a procedure to obtain optimized steel channel cross-sections for use in compression or bending. A simple lipped C-shape is taken as a starting point, but the optimization process allows for the addition of double-fold (return) lips, inclined lips and triangular web stiffeners. The cross-sections are optimized with respect to their structural capacity, determined according to the relevant Euro code (EN1993-1-3), using genetic algorithms. All plate slenderness limit values and all limits on the relative dimensions of the cross-sectional components, set by the Eurocode, are thereby taken into account as constraints on the optimization problem. The optimization for compression is carried out for different column lengths and includes the effects of the shift of the effective centroid induced by local buckling. Detailed finite element models are used to confirm the relative gains in capacity obtained through the optimization process.

Experimental analysis of the effect of frame spacing variation on the ultimate bending moment of box girders

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An experimental study is presented of three box girders made of mild steel subjected to pure bending moment, with different spacing between frames. The moment curvature curves are presented, allowing for the analysis of elastic–plastic behaviour until collapse and the evaluation of the ultimate bending moment and post collapse behaviour for each experiment. The residual stress relief during loading and unloading path is also analysed. The effect of the span between transverse frames on the ultimate bending moment of the box girder is studied and thus its dependence on the column slenderness of the panel under compression can be established. The energy dissipated by internal friction during each load cycle is evaluated and compared with elastic potential energy.

Experimental study of stainless steel angles and channels in bending

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Substantial research has been conducted in recent years into the structural response of stainless steel components, with the focus being primarily on doubly symmetric cross-sections. Limited experimental data exist on non-doubly symmetric stainless steel sections in compression, while there is an absence of such data in bending, despite these sections being widely used in the construction industry as wind posts, lintels and so on. To address this limitation, and to bring an improved understanding of the behaviour of these sections, an experimental study into the flexural response of stainless steel channels bent about their minor axis and angles bent about their stronger geometric axis is described herein. In total, 16 bending tests on austenitic stainless steel beams have been conducted and the obtained results, including the full load-deformation history and observed failure modes have been described. Auxiliary tests on tensile coupons extracted fromthe tested sections and initial geometric imperfection measurements have also been performed and are reported in detail. The influence of the spread of plasticity and strain hardening on the shift of the neutral axis and the ultimate load carrying capacity is also examined. Based on the obtained test results, the current design provisions of EN 1993-1-4 [1] for these types of cross-sections were assessed and found to be unduly conservative. The effect of strain hardening on the structural response of stocky stainless steel sections and the need to account for it in design has been highlighted.

2.1 Research Gap

In study of the existing literature some gaps have been observed. Literature Review rivals that the researcher have carried out most of work on shape, size of different loading structure development monitoring and optimization of material optimization on Shape, thickness, distance of frame member. There is lack of research on the different type’s cross section of material not used for frames structure load distribution.

3.1 Problem definition

The weighing frame structure is the backbone of weighing scale. Since the weighing frame structure is a major component in the weighing scale, it must be strong enough to resist the impact load, twist, vibration and other stresses so it is often identified for refinement.

As per the literature survey Maximum stress and maximum deflection are important criteria for design of the frame structure. The objective of present work is to determine the maximum stress, maximum deflection and to recognize critical regions under static loading condition. Static structural analysis of the frame structure is carried out by FEA Method. The structural weighing frame 10 ton load capacity weighing scale is modeled and analyzed by using the Inventor 2015. As per the result of analysis required modifications will be considered.

This study is stiffness improvements can also be realised by modifications to the geometry of the frame structure arrangement. An important part is the frame structure, optimum material used for frame fabrication so the weight of weighing frame itself decrease and chances of self weight bending will be solved.

3.2 Research Objectives

To prepare the 3D CAD model and 2D drawing for present frame structure.

To perform static structural analysis of frame structure.

To find how much deflection in present weighing scale frame structure.

To validate analysis results with experimental readings.

To propose design concepts for frame structure to achieve maximum stiffness and material optimum use for fabrication.

To select most stiff design of frame structure based on static structural analysis.

6.1 Modelling of Weighing Frame

Finite Element Modeling of The Weighing Frame was modeled using commercial software and all the specifications were accordingly followed the relevant drawing standard. As a preliminary study here, several assumptions have been made i.e. the chosen material was homogeneous, the frictional effect has not been taken into account, shackle, to reduce the complexity of simulation. The whole assembly is pre-processed. The iges file is imported to hyper mesh, wherein finite element modeling is executed. A finite element model is the complete idealization of the entire structural problem including the node location, the element, physical and material properties, loads and boundary conditions. The purpose of the finite element modeling is to make a model that behaves mathematically as being modeled and creates appropriate input files for different finite element solve.

6.2 Specification of the Problem and analyze

The objective of the present work is to design, analysis, and optimization of 10 Ton weighing frame structure,

- Modelling of frame Existing structure
- Analysis of frame structure
- Material definition
- Boundary condition
- Force apply
- Meshing
- Take graphical result
- Deflection on specific region.
- Stress generation report.

In this problem here i am modelling existing weighing frame which is modified by ORBITON ENTERPRISE, and analyse in CAD software. Here show some data of analysis.

6.4 Data of Analysis for weighing frame

Mass	229.831 kg
Area	14959100 mm^2
Volume	29325600 mm^3
Center of Gravity	x=8.55763 mm y=4.35343 mm z=14.1214 mm

Mass Density	7.85 g/cm^3
Yield Strength	207 MPa
Ultimate Tensile Strength	345 MPa
Young's Modulus	220 GPa
Poisson's Ratio	0.275 ul
Shear Modulus	86.2745 GPa

Load Type	Force
Magnitude	98000.000 N
Vector X	0.000 N
Vector Y	0.000 N
Vector Z	98000.000 N

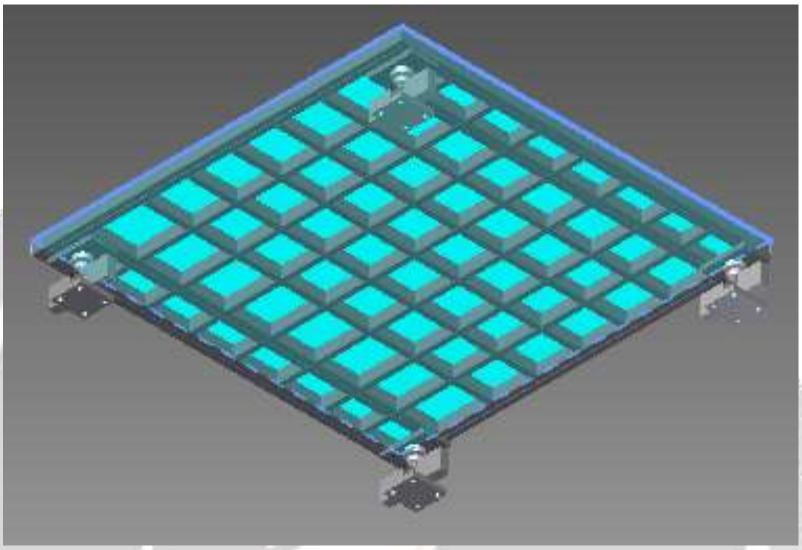

Fig-2 Fixed constrained area

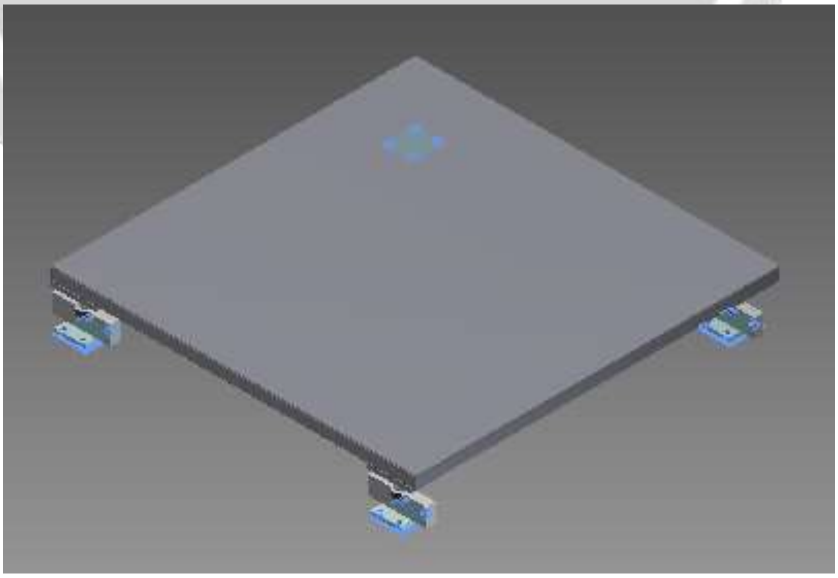

Fig-3 load applying area

Reaction Force and Moment on Constraints

Constraint Name	Reaction Force		Reaction Moment
	Magnitude	Component (X,Y,Z)	Component (X,Y,Z)
Fixed Constraint:1	98000 N	0 N	979.198 N m
		0 N	-2194.57 N m
		-98000 N	0 N m

Result Summary

Name	Minimum	Maximu
Volume	29075600 mm^3	
Mass	228.967 kg	
Von Mises	0.107954	756.421
1st Principal	-510.054 MPa	816.162
3rd Principal	-1008.65 MPa	374.279
Displacement	0 mm	3.98731
Safety Factor	0.283582 ul	15 ul
Stress XX	-681.114 MPa	453.643
Stress XY	-212.136 MPa	197.997
Stress XZ	-294.351 MPa	281.614
Stress YY	-561.178 MPa	480.957
Stress YZ	-365.381 MPa	347.263
Stress ZZ	-982.935 MPa	795.435
X	-0.246092	0.241042
Y	-0.212589	0.20818
Z	-0.465139	3.98731
Equivalent	0.0000005181	0.0035889
1st Principal	-0.000225121	0.0030974

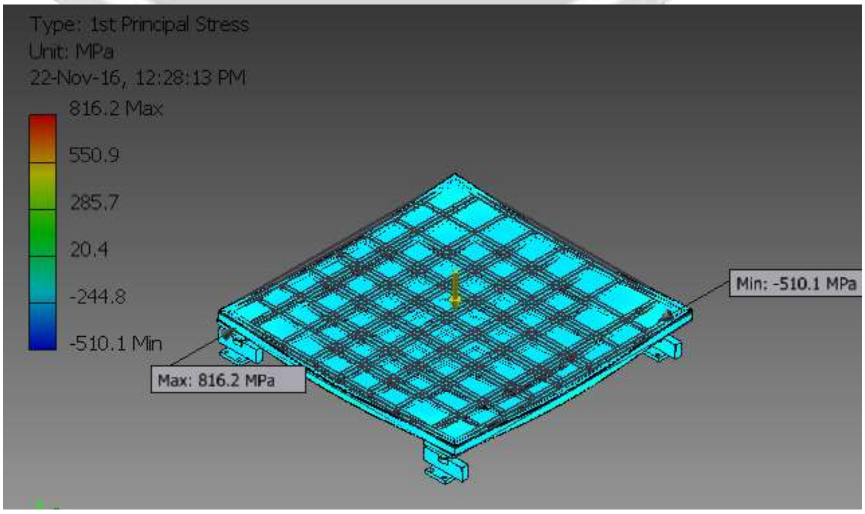

Fig-3 Principal stress

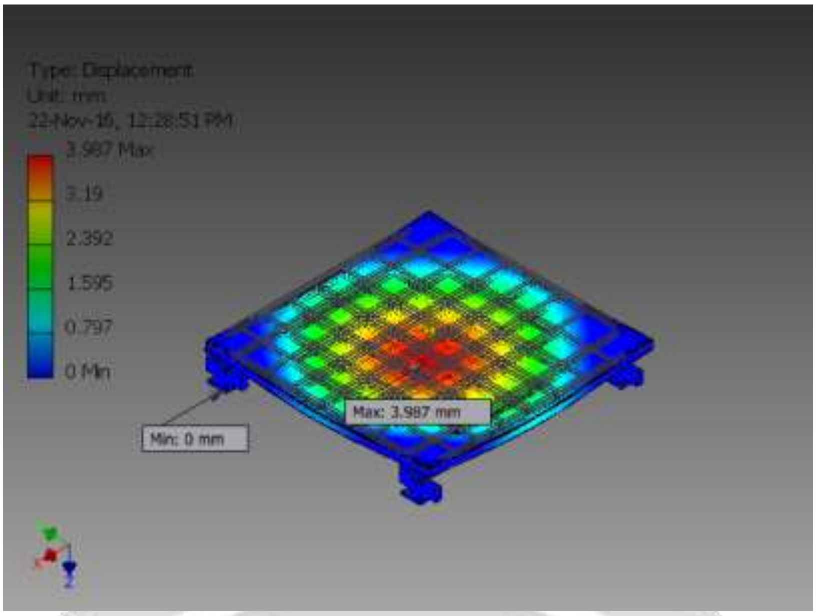

Fig-4 Displacement

6. CONCLUSION

The main objective of having this new design is to improve the stiffness of structure and also optimize the material usage in weighing frame. We will compare the results and find out the best suited design.

7. REFERENCES

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