DESIGN, ANALYSIS AND OPTIMIZATION OF 10 TON CAPACITY WEIGHING SCALE FRAME STRUCTURE

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ABSTRACT

In the present edge it is the need of time to explore more and more optimize product needed, which save money and material. The weighing scale small to large scale may be used to accomplish the need of logistic, dairy and heavy industries. Base structure frame, checker plate the main parts of weighing scale. 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. The ORBITRON ENTERPRISE is solving this problem by adding of frame structure rectangular cross section in existing frame .But this solution makes structure self-weight increased. This problem solving by the FEA analysis indifferent CAD software and optimize the weighing frame.

1. Introduction

1.1 Weighing Scale

Although records dating to the 1700s refer to spring scales for measuring weight, the earliest design for such a device dates to 1770 and credits Richard Salter, an early scale-maker. Spring scales came into wide usage in the United Kingdom after 1840 when R. W. Winfield developed the candlestick scale for weighing letters and packages, required after the introduction of the Uniform Penny Post. Postal workers could work more quickly with spring scales than balance scales because they could be read instantaneously and did not have to be carefully balanced with each measurement. By the 1940s various electronic devices were being attached to these designs to make readings more accurate. Strain gauges, small nodes that convert pressure (or force) to a digital signal, have their beginnings as early as the late nineteenth century, but it was not until the late twentieth century that they became accurate enough for widespread usage.

1.2 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.

Spring scales have two sources of error that balances do not: the measured weight varies with the strength of the local gravitational force (by as much as 0.5% at different locations on Earth), and the elasticity of the measurement spring can vary slightly with temperature. With proper manufacturing and setup, however, spring scales can be rated as legal for commerce. To remove the temperature error, a commerce-legal spring scale must either have temperature-compensated springs or be used at a fairly constant temperature. To eliminate the effect of gravity variations, a commerce-legal spring scale must be calibrated where it is used.

Figure1: Inside weighing scale

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.

1.4 Parts of weighing scale

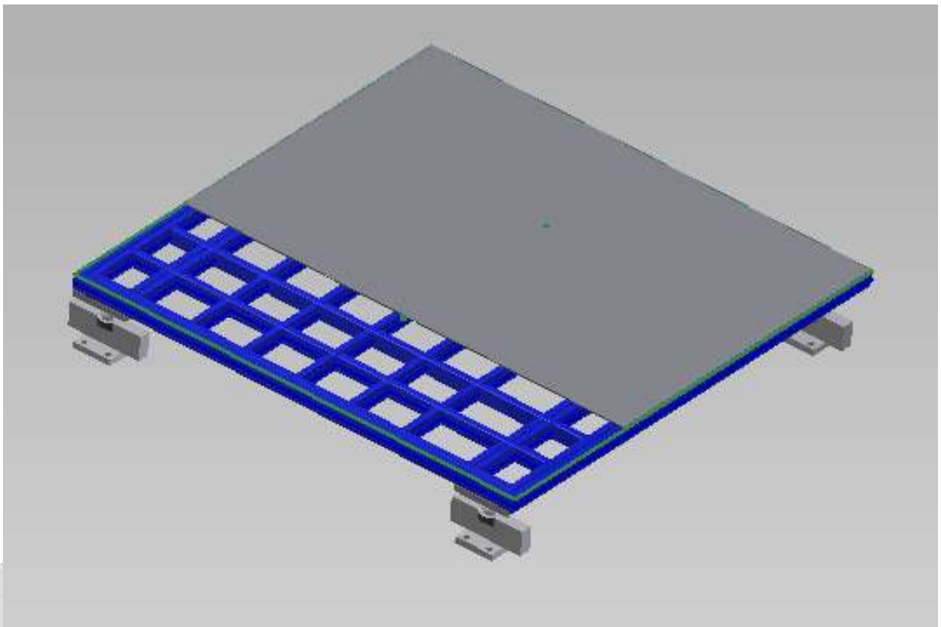

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Figure 2: Breakout view Weighing Scale

Following are some of the main components of the weighing scale.

a) Frame structure

In the frame structure of weighing scale different types of sections are used like rectangular hollow pipe section, angle section, c channel section in different thickness as per loading conditions generally they used. Material in this frame structure is different like as Mild steel, Stainless steel grades as per requirement in which condition scale is used.

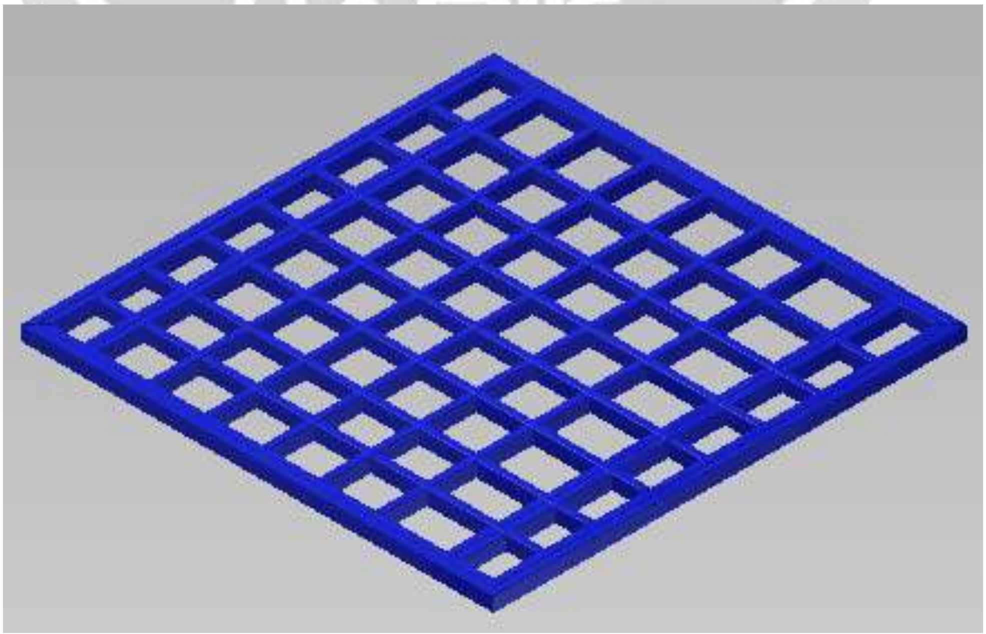

Figure 3: Frame of Weighing Scale

b) Checker plate

Checker plate is assembling on top surface of frame structure. Checker plate construct from harden surface thick sheet metal. Load for weighing put on the checker plate.

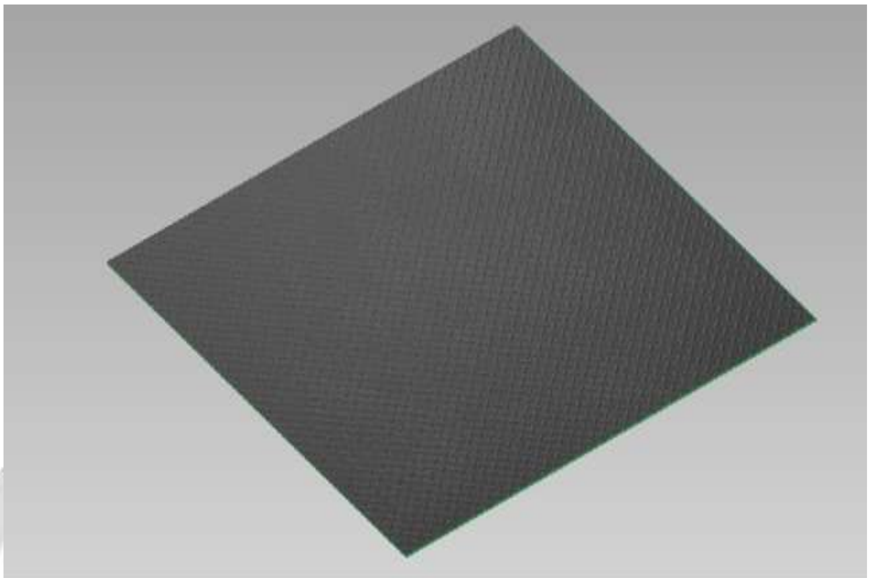

Figure 4: Checker plate of Weighing Scale

c) Strain gauge

A strain gauge is a device used to measure strain on an object. Invented by Edward E. Simmons and Arthur C. Ruge in 1938, the most common type of strain gauge consists of an insulating flexible backing which supports a metallic foil pattern. The gauge is attached to the object by a suitable adhesive, such as cyanoacrylate. As the object is deformed, the foil is deformed, causing its electrical resistance to change. This resistance change, usually measured using a Wheatstone bridge, is related to the strain by the quantity known as the gauge factor.

Through a mechanical construction, the force being sensed deforms a strain gauge. The strain gauge measures the deformation (strain) as a change in electrical resistance, which is a measure of the strain and hence the applied forces. A load cell usually consists of four strain gauges in a Wheatstone bridge configuration. Load cells of one strain gauge (Quarter Bridge) or two strain gauges (half bridge) are also available. The electrical signal output is typically in the order of a few milli volts and requires amplification by an instrumentation amplifier before it can be used. The output of the transducer can be scaled to calculate the force applied to the transducer. Sometimes a high resolution ADC, typically 24-bit, can be used directly.

Strain gauge load cells are the most common in industry. These load cells are particularly stiff, have very good resonance values, and tend to have long life cycles in application. Strain gauge load cells work on the principle that the strain gauge (a planar resistor) deforms/stretches/contracts when the material of the load cells deforms appropriately. These values are extremely small and are relational to the stress and/or strain that the material load cell is undergoing at the time. The change in resistance of the strain gauge provides an electrical value change that is calibrated to the load placed on the load cell.

Figure5: Strain gauge load cell transducers of Weighing Scale.

d) Weighing indicator

Weighing indicator is a digital instruments, it shows the weight in digital form. On the construction of indicator electronic circuits are fitted in the metal or palstic enclose. Use of strain gauge output electronic circuit display weight.

Figure 6: Weighing indicator of Weighing Scale

2Literature Survey

Journal Mekanikal December 2008, No. 26, 76 - 85Roslan Abd Rahman, Mohd Nasir Tamin, Ojo Kurdi*Faculty of Mechanical Engineering, Universiti Teknologi Malaysia,81310 UTM, Skudai, Johor Bahru

This paper presents the stress analysis of heavy duty truck chassis. The stress analysis is important in fatigue study and life prediction of components to determine the critical point which has the highest stress. The analysis was done for a truck model by utilizing a commercial finite element packaged ABAQUS. The model has a length of 12.35 m and width of 2.45 m. The material of chassis is ASTM Low Alloy Steel A 710 C (Class 3) with 552 MPa of yield strength and 620MPa of tensile strength.

The result shows that the critical point of stress occurred
At the opening of chassis which is in contact with the bolt. The stress magnitude of critical point is 386.9 MPa. This critical point is an initial to probable failure since fatigue failure started from the highest stress point.

Comparativeexperimentalstudy ofhot-formed,hot-noshed andcold-formedrectangularhollowsections

Xing-Zhao Zhang (Exchange PhD Candidate) ,Su Liu (Professor of Architecture) , Ming-Shan Zhao (Research Fellow),Sing-Ping Chiew (Professor of Civil Engineering) This paper presents a comparative experimental study on the physical, chemical and mechanical properties of indirectly formed hot-formed, hot-finished and cold-formed structural steel rectangular hollow sections. Characteristic geometrical parameters and chemical compositions are examined to investigate the physical and chemical differences. Tensile test and charpy V-notch impact test are employed to evaluate the difference in strength, ductility and toughness. Further, the residual stress distributions in both transverse and longitudinal directions are measured using the sectioning method and hole- drilling technique. It is found out that although the geometrical parameters and chemical composition of the tested hollow sections are similar, the mechanical properties are signifi- cantly different, especially for strength, ductility and residual stress distribution. While the hot-finished and hot-formed sections are often treated equally in design, their mechanical properties and residual stresses distribution are actually different.

Stress analysis of tractor trailer chassis for self weight reduction

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Ebrahim Ebrahimi, Alimohamad Borghei, Morteza Almasi,"Design, Fabrication, and Testing of a Hay Bale Trailer", ResearchJournal of Applied Sciences, Engineering and Technology, Maxwell Scientific Organization, 2010

Tractor Trailers are very popular and cheaper mode of goods transport in rural as well as urban area. But these trailers are manufactured in small scale to moderate scale industry; due to which design of chassis is at primary level. In Present work finite element method has been implemented to modify existing chassis of tractor trailer which ultimately results in reduction of weight and manufacturing cost. For analysis, a 8 ton 4 wheeler trailer manufactured by Awachat Industries. Ltd.Wardha is selected. The finite element analysis of existing chassis revealed the stresses distribution on chassis members. So, an effort is made to modify the structure of existing chassis so that advantage of weight reduction along with safe stress can be obtained.

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 types of alloy and composites material used for framestructure load distribution.

3 Purpose and Work

3.1Purpose and Scope of Investigation

So many areas of the economy are affected by weights and measures that the program It needs to be pervasive. The importance to a community of adequate weights and Measures supervision cannot be overestimated. Next to the personal safety and health of the people, one of the most important of the fundamental obligations of the state or Municipality to its citizens is the regulation of commercial weighing and measuring Instruments and the exercise of a reasonable control over the users there of. The commercial measurement system is huge, and the market segments that should be inspected by weights and measures officials are almost unlimited. Weights and measures directors must determine which areas are going to be inspected and where the inspection resources can best be utilized. When businesses adopt a culture of honesty and make the commitment to comply with weights and measures laws and regulations, the work of the weights and measures regulatory official becomes much easier. It is believed that a much higher compliance rate can be achieved through voluntary compliance than through enforcement actions to force the businesses to comply. Fortunately, most businesses operate ethically with the goal of complying with all applicable laws and regulations. Weights and measures officials must remember that they serve both businesses and consumers. The goals of providing consumer protection, ensuring fair competition among businesses and facilitating interstate commerce and international trade require that the weights and measures program maintain a balance of interests of industry, consumers and officials. To be competitive and increase customer values, industry is always searching for better products at reduced design cycles and costs. For Weighing Scale companies, Optimization improvements of weighing scale are of interest due to economical and safety aspects. New demands on the deregulated energy market make it also attractive to improve the frame structure over a wide range of operating conditions.

4.Basic Concepts FEM

The finite element method (FEM) is a computational technique used to obtain approximate solutions of boundary value problems in engineering. Simply stated, a boundary value problem is a mathematical problem in which one or more dependent variables must satisfy a differential equation everywhere within a known domain of independent variables and satisfy specific conditions on the boundary of the domain .An unsophisticated description of the FE method is that it involves cutting a structure into several elements (pieces of structure), describing the behaviour of each element in a simple way, then reconnecting elements at nodes as if nodes were pins or drops of glue that hold elements together. This process results in a set of simultaneous algebraic equations. In stress analysis these equation are equilibrium equations of the nodes. There may be several hundred or several thousand such equations, which mean that computer implementation is mandatory.

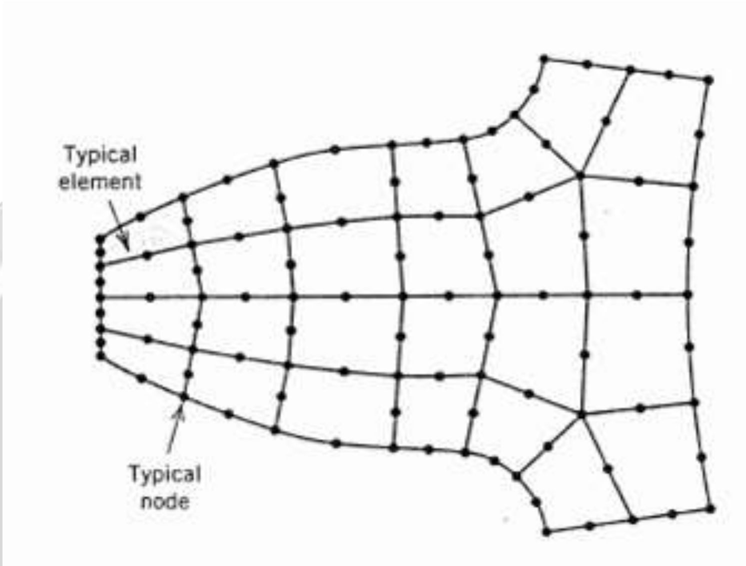

Figure 7: A course –mesh, two-dimensional model of gear tooth. All nodes elements lie in plane of the paper

Modulus Elasticity E(Pa)	Density ρ (kg/m3)	Poisson Ratio	Yield Strength (MPa)	Tensile Strength (MPa)
207 x 109	7800	0.3	550	620

Table 1: Properties of truck chassis material

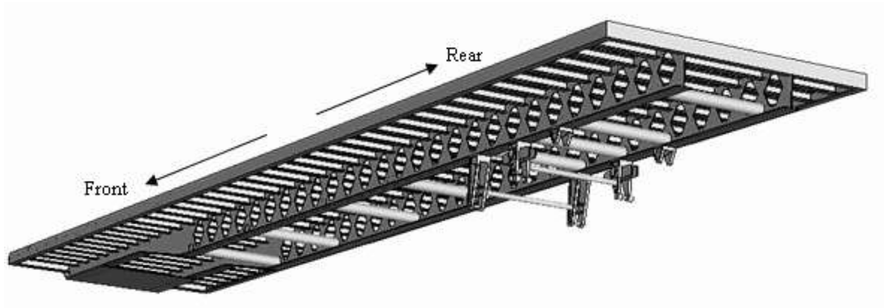

Figure 7: Model of truck chassis

The truck chassis model is loaded by static forces from the truck body and cargo. For this model, the maximum loaded weight of truck plus cargo is 36.000 kg. The load is assumed as a uniform pressure obtained from the maximum loaded weight divided by the total contact area between cargo and upper surface of chassis. Detail loading of model is shown. The magnitude of pressure on the upper side of chassis is calculated as 67564.6 N/m2.

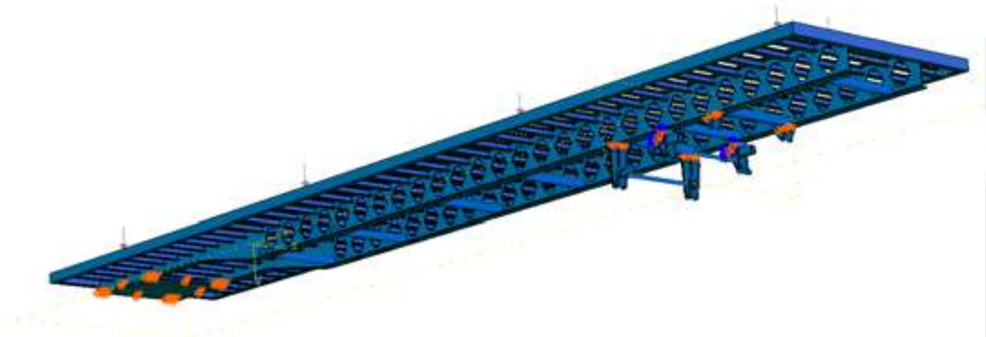

Figure 3: Static load (pressure=67564.5N/m2)

5 Design of Frame structure

5.1 Introduction

Structural design is the methodical investigation of the stability, strength and rigidity of structures. The basic objective in structural analysis and design is to produce a structure capable of resisting all applied loads without failure during its intended life. The primary purpose of a structure is to transmit or support loads. If the structure is improperly designed or fabricated, or if the actual applied loads exceed the design specifications, the device will probably fail to perform its intended function, with possible serious consequences. A well- engineered structure greatly minimizes the possibility of costly failures.

5.2 Structural design process

A structural design project may be divided into three phases, i.e. planning, design and construction Planning: This phase involves consideration of the various requirements and factors affecting the general layout and dimensions of the structure and results in the choice of one or perhaps several alternative types of structure, which offer the best general solution. The primary consideration is the function of the structure. Secondary considerations such as aesthetics, sociology, law, economics and the environment may also be taken into account. In addition there are structural and constructional requirements and limitations, which may affect the type of structure to be designed.
Design: This phase involves a detailed consideration of the alternative solutions defined in the planning phase and results in the determination of the most suitable proportions, dimensions and details of the structural elements and connections for constructing each alternative structural arrangement being considered.

Construction: This phase involves mobilization of personnel; procurement of materials and equipment, including their transportation to the site, and actual on-site erection. During this phase, some redesign may be required if unforeseen difficulties occur, such as unavailability of specified materials or foundation problems.

5.3 Philosophy of designing

The structural design of any structure first involves establishing the loading and other design conditions, which must be supported by the structure and therefore must be considered in its design. This is followed by the analysis and computation of internal gross forces, (i.e. thrust, shear, bending moments and twisting moments), as well as stress intensities, strain, deflection and reactions produced by loads, changes in temperature, shrinkage, creep and other design conditions. Finally comes the proportioning and selection of materials for the members and connections to respond adequately to the effects produced by the design conditions.
The criteria used to judge whether particular proportions will result in the desired behaviour reflect accumulated knowledge based on field and model tests, and practical experience. Intuition and judgment are also important to this process.

The traditional basis of design called elastic design is based on allowable stress intensities which are chosen in accordance with the concept that stress or strain corresponds to the yield point of the material and should not be exceeded at the most highly stressed points of the structure, the selection of failure due to fatigue, buckling or brittle fracture or by consideration of the permissible deflection of the structure. The allowable stress method has the important disadvantage in that it does not provide a uniform overload capacity for all parts and all types of structures.

The newer approach of design is called the strength design in reinforced concrete literature and plastic design in steel-design literature. The anticipated service loading is first multiplied by a suitable load factor, the magnitude of which depends upon uncertainty of the loading, the possibility of it changing during the life of the structure and for a combination of loadings, the likelihood, frequency, and duration of the particular combination. In this approach for reinforced-concrete design, theoretical capacity of a structural element is reduced by a capacity- reduction factor to provide for small adverse variations in material strengths, workmanship and dimensions. The structure is then proportioned so that depending on the governing conditions, the increased load cause fatigue or buckling or a brittle-facture or just produce yielding at one internal section or sections or cause elastic-plastic displacement of the structure or cause the entire structure to be on the point of collapse.

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.

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