Design, Analysis and Validation of Conceptual Bricks Handling Trailer

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Abstract

Nowadays, construction industry is on a boom. Almost everywhere one can find some kind of construction work in progress. At every construction site bricks are required. For normal wall construction bricks are must have. Bricks are of vital importance in construction. To provide bricks in time at the construction site and that too without damage is still a challenge in India. But manually handling these bricks cause workers to suffer from back injury and long-term pain if regularly lifting/carrying heavy or awkward objects. So, the palletizing and mechanization of the bricks is suggested so as to reduce the human injury and to increase the productivity and profitability.

Keywords: Bricks, Construction Site, Palletizing, Mechanization

I. INTRODUCTION

Expressed in simple language, materials handling is loading, moving and unloading of materials, i.e. raw material, semi/finished good, etc. To do it safely and economically, different types of tackles, gadgets and equipment are used, for mechanical handling of materials. Since primitive times men discovered the use of wheels and levers, they have been moving materials mechanically. Any human activity involving materials need materials handling. However, in the field of engineering and technology, the term materials handling is used with reference to industrial activity. In any industry, be it big or small, involving manufacturing or construction type work, materials have to be handled as raw materials, intermediate goods or finished products from the point of receipt and storage of raw materials, through production processes and up to finished goods storage and dispatch points. A material handling as such is not a production process and hence does not add to the value of the product. It also costs money; therefore it should be eliminated or at least reduced as much as possible. However, the important point in favor of materials handling is that it helps production. Depending on the weight, volume and through put of materials, mechanical handling of materials may become unavoidable. In many cases, mechanical handling reduces the cost of manual handling of materials, where such materials handling are highly desirable. All these facts indicate that the type and extent of use of materials handling should be carefully designed to suit the application and which becomes cost effective.

Overhead cranes are commonly employed in the transport industry for the loading and unloading of freight, in the construction industry for the movement of materials and in the manufacturing industry for the assembling of heavy equipment, because they can move loads far beyond the normal capability of a human. Thus in this project a detailed design and analysis of the overhead hoist system is undertaken to handle construction bricks.

II. LITERATURE REVIEW

A.D. Anjikar [1] Handling of raw material, semi-finished, finished product & other material is ever concern & cost in an industry. With increasing cost of labour & its scare city the manual work or operation in industries are now replaced by semi-automatic or automatic system. These low cost systems are not only cost efficient but also enhance productivity & address the issues related to labour problem. Conventionally in micro or small scale industries which are labour intrinsic transportation of raw material, semi finished product is always an expensive & problematic issue. After visiting Waghmare food products, Nagpur & after discussion with the concern the shifting of raw material from store to the work place was a costly labour activity. Presently it is done manually. The industry was interested to identifying some optional material handling system to encounter their problems After carefully survey of factory layout, discussing with management, concern exhaustively literature search it was preferred to design & develop a overhead monorail for handling of raw material The main aims to design cost efficient, overhead monorail material handling system. The detailed drawings will also drawn using the software’s like CATIA/ PRO-E. The cost estimation along with economical feasibility and pay back will also be calculated.

Du-Ming Tsai [2] Material handling pallets are the most common tool used in warehousing industries. Nearly every warehouse uses them to some extent. Pallets have become an almost universal warehouse operations tool. They provide a convenient, simple way to transport, stack, and store materials. Traditional palletizing methods load only boxes of the same size on one pallet. For retail business such as grocery distribution or manufacturers that produce many products of small quantities, a wide product mix of different box sizes must be loaded onto the same pallet. The traditional palletizing method may not optimize
the utilization of the pallet cube. Manual palletizing is an extremely tedious and fatiguing task. Automatic palletization is, therefore, a potentially attractive alternative. Commercially available palletizers handle only one box size at a time. They cannot meet the requirements of palletizing applications with mixed box sizes. Industrial robots have always been a viable solution to complex loading operations due to their flexibility and programming capability.

Sourabh R. Dinde, Rajashekhar S. Talikoti [3] According to the structural point of view Industrial Pallet rack structure can be considered typical steel framed structure. This work presents a general analysis of an industrial pallet rack structure, evaluating the influence of each of the components on the global stability. An analytical study for the sensitivity of pallet rack configuration in linear static equivalent lateral loads. The aim is to braced/unbraced frames were design and their analytical models are to be built in software. The finite element analysis is used to determine axial forces in beam and column, maximum storey displacement and buckling loads on braced/unbraced pallet rack structure. Bracing systems are mostly provided to enhance the stiffness factor of the structures with the seismic loads. Unbraced systems have mostly translational modes of failure and are very flexible due to excessive loads.

III. IDENTIFIED GAPS IN LITERATURE

Bricks are of vital importance in construction. To provide bricks in time at the construction site and that too without damage is still a challenge in India. But manually handling these bricks cause workers to suffer from back injury and long-term pain if regularly lifting/carrying heavy or awkward objects. So, the palletizing and mechanization of the bricks is suggested so as to reduce the human injury and to increase the productivity and profitability. After closely monitoring the brick handling process for a Heavy commercial vehicle, following problem were identified,

A. Labor Force is More
In current material handling system the number of labor required for carrying material from intake zone to delivery zone is more.

B. Cost is More
Due to large labor force the cost of material handling is increases.

C. Efficiency is Less
The input provided to the system in terms of labor effort is more but output obtained in terms of material delivered to the unloading zone is less.

D. Flexibility in System is Less
There is no other option than the manual conveying system for conveying material which makes the system less flexible to suit changing atmosphere within industry.

E. Material Conveying Time is More
Due to manual conveying system time required to deliver material is more as compare to other conveying system

F. Human Safety is Less
Instead of motor or other driving mechanism humans are used to lift the bricks which create unsafe environment for them, also it may cause back injuries.

IV. PROBLEM FORMULATION

Design of conceptual trailer which would help in loading and unloading of bricks with much ease with the assistance of mechanical machine mounted on the trailer. Design a frame with some mechanical movement which would assist in the movement of the hoist mounted on it. The hoist can slide on the guide rail along the length of truck. It can also move perpendicular to it on sliding rail. The hoist can be manually operated, electrically or pneumatically driven and may use chain, fiber or wire ropes as its lifting medium.

V. OBJECTIVE

- Design of conceptual trailer which would help in loading and unloading of bricks with much ease with the assistance of mechanical machine mounted on the trailer.
- Design a frame with some mechanical movement which would assist in the movement of the hoist mounted on it.
- The hoist can slide on the guide rail along the length of truck.
- It can also move perpendicular to it on sliding rail.
- The hoist can be manually operated which is electrically or pneumatically driven and may use chain, fiber or wire ropes as its lifting medium.
Essential boundary conditions in mechanical problems involve displacements (but not strain-type displacement derivatives). Support conditions for a building or bridge problem furnish a particularly simple example. But there are more general boundary conditions that occur in practice. A structural engineer must be familiar with displacement B.C. of the following types.

1) **Ground or Support Constraints**
   Directly restraint, the structure against rigid body motions.

2) **Symmetry Conditions**
   To impose symmetry or anti-symmetry restraints at certain points, lines or planes of structural symmetry. This allows the discretization to proceed only over part of the structure with a consequent savings in modeling effort and number of equations to be solved.

3) **Ignorable Freedoms**
   To suppress displacements those are irrelevant to the problem. Even experience users of finite element programs are sometimes baffled by this kind. Examples are rotational degrees of freedom normal to smooth shell surfaces.

**A. Connection Constraints**

To provide connectivity to adjoining structures or substructures, or to specify relations between degrees of freedom.
The analysis of brick handling system has to carry out for the weight of 750 kg. Thus total force acting on the chassis will be 750*9.81 = 7.357 KN.

To carry out the analysis, it is difficult to show the uniform distribution of load over the entire span, so the total load acting on the chassis is distributed over 15 points on the chassis as shown figure 4, the intensity of load at each point is 0.49 KN.

As the solution is defined the software is allow to solve the entire problem and generate the results. As soon as the results are generated, it can be saved with their graphical representations figures or graphs. At this point, the Finite element model with all the necessary information is exported for solution in Finite element Solver - NASTRAN.

**B. Displacement Counter Plot**

The result of counterplot for the displacement is shown in fig below.

![Max. Displacement = 1.56mm](image)

**C. Vonmisses Stress**

Vonmisses stresses is used to check whether the design will withstand the given load condition or not. Using this information it is checked whether the maximum vonmisses stress induced in the material is more than strength of the material. It works mostly well for most of the cases especially for ductile material. It is used for the distortion energy theory which is most preferred failure theory in industry.

1) **Vonmisses stress in rigid frame with horizontal member**

The value of vonmisses stresses obtained after performing analysis of the component is 139 MPa.
D. FE Results

1) Vonmisses Stress in frame without horizontal member
The value of vonmisses stresses obtained after performing analysis of the component is 76.5 MPa.

Fig. 7: Vonmisses Stress contour plot after analysis for frame without horizontal member (Deploying)

2) Maximum vonmisses stress in horizontal member
The value of vonmisses stresses obtained after performing analysis of the component is 139 MPa.

Fig. 8: Max. vonmisses stress in horizontal member

3) Maximum vonmisses stress in columns
The effect of vonmisses stresses in columns after analysis is shown below.

Fig. 9: Max. von misses stress in column
E. Deploying

1) Maximum displacement of assembly for frame
The value of maximum displacement obtained after performing analysis of the component is 1.51 mm.

Fig. 10: Maximum displacement of assembly for frame (Deploying)

2) Vonmises stress in rigid frame with horizontal member
The value of vonmises stresses obtained after performing analysis of the component is 140 MPa.

Fig. 11: Vonmises stress in rigid frame with horizontal member (Deploying)

3) Maximum vonmises strain in rigid frame with horizontal member
The value of vonmises strain obtained after performing analysis of the component is 1.62e-04 mm.

Fig. 12: Vonmises strain in rigid frame with horizontal member
4) **Maximum vonmises stress in frame without horizontal member**

The value of vonmises stresses obtained after performing analysis of the component is 87 MPa.

![Fig. 13: Vonmises stress in rigid frame without horizontal member](image)

5) **Maximum vonmises stress in horizontal member**

The value of vonmises stresses obtained after performing analysis of the component is 140 MPa.

![Fig. 14: Vonmises stress in horizontal member](image)

**F. Optimization**

Since the stress in the above part was low as 80 MPa, after reducing the thickness of the section was reduced to 3mm & 2mm. Mass applied on the frame.

- Previous: 310kg
- Now: 220kg

![Fig. 15: Reduction in thickness which causes reduction in stress.](image)

1) **Maximum Displacement in Rigid Frame with Horizontal Member**

The value of maximum displacement obtained after performing analysis of the component is 1.74 mm.
2) **Maximum vonmisses stress in rigid frame with horizontal member**

The value of vonmisses stresses obtained after performing analysis of the component is 148 MPa.

3) **Maximum vonmisses strain in rigid frame with horizontal member**

The value of vonmisses strain obtained after performing analysis of the component is 2.60e-04 mm.
4) Vonmises stress in rigid frame without horizontal member
The value of vonmises stresses obtained after performing analysis of the component is 98 MPa.

![Vonmises stress in rigid frame without horizontal member after optimization](image)

5) Maximum Vonmisses stress in columns
The value of vonmises stresses obtained after performing analysis of the component is 89 MPa.

![Vonmises stress in columns after optimization](image)

VII. CALCULATIONS

Area of brick = 97 × 212 = 20564 mm²
Area of pallet = 1000 × 1000
Number of bricks = \( \frac{1000 \times 1000}{20564} \) = 48.62 \( \cong 48 \)

A. Pallet size:

![Size of Pallet](image)

1000mm

![Size of trailer](image)

1000mm
So the truck can load 10 pallets, each pallet can contain 50 bricks. Thus the dimension of each pallet would be 1000 × 1000 mm².

Each pallet has 4 layer of bricks.
Total number of bricks in each pallet = 4×50 = 200 bricks.
Weight of each bricks = 3.5kg (wet)
Weight of bricks in 7 pallets = 3.5×200 = 700 kg
Weight of pallet=50 kg
Total weight = 750 kg
Total force acting = 750×9.81 = 7357.5 N

\[ \Sigma f_y = 0 \]
\[ R_a + R_b = 7357.5 \text{ N} \] (1)

\[ \Sigma M_a = 0 \]
\[ 7357.5 \times 457.55 - R_c \times 1030 = 0 \]
\[ R_c = 3268.37 \text{ N} \]
\[ R_a + R_c = 7357.5 \]
\[ R_a = 7357.5 - 3268.37 \]
\[ R_a = 4089.13 \text{ N} \]
\[ \Sigma M_b = \Sigma M_c = 0 \]
\[ \Sigma M_B = 4089.13 \times 457.55 \]
\[ \Sigma M_B = 1870981.431 \text{N-mm} \]
Now,

\[ \sigma = \frac{M}{I} \]
\[ \sigma = \frac{1870981.431 \times 46}{104881.89} \]
\[ \sigma = 82.059 \text{ N/mm}^2 \]

2) Case 2
Column analysis
Since, the load acting on above calculation would be the force acting on column (assumption). Compressive stress
\[ \sigma_c = \frac{F}{A} \]
\[ F = Ra = 4089.13 \]
Area of I section column = \(H_d + 2hD\)
\[ = (68.02 \times 4.04) + [2 \times (6.02 \times 40)] \]
Area = 756.4mm\(^2\) \(\cong 767.58\)
\[ \sigma_c = \frac{F}{A} \]
\[ \sigma_c = 5.327N/mm^2 \]
Buckling load (both ends pinned)
\[ P_{cr} = \frac{\pi^2 \times E \times I}{L^2} \]
\[ P_{cr} = \frac{\pi^2 \times 200000 \times 767430}{1809.24^2} \]
\[ P_{cr} = 462312.57N \]
\[ I = 110746.62mm^4 \]
Buckling Load for outside column
\[ l = (1809.24 + 1500) \]
\[ P_{cr} = \frac{\pi^2 \times E \times I}{L^2} \]
\[ P_{cr} = \frac{\pi^2 \times 200000 \times 110746.62}{3309.24^2} \]
\[ P_{cr} = 19941.78 N \]
3) Case 3:
Longitudinal member between two columns.
\[ I = 775549.83 mm^4 \]

\[ \sum f_y = 0 \]
\[ R_a + R_b = 4089.13 \]
\[ \sum M_a = 0 \]
\[ 4089.13 \times 817.66 = R_b \times 1635.33 \]
\[ R_a = R_b = 2044.56N \]
\[ \sum M_c = 2044.56 \times 817.66 \]
\[ \sum M_c = 1671759.017 \]
Now,
\[ \frac{M}{I} = \frac{\sigma}{Y} \]
\[ \sigma_y = \frac{1671759.01 \times 40.3}{775549.83} \]
\[ \sigma_y = 86.869 N/mm^2 \]

**VIII. Research Methodology**

Various steps involved in study of nonstandard design of brick handling system are:
- Data accumulation: Brick and TATA TRUCK2515 body selected for the analysis. From a local manufacturer all design data related to dimensions of truck body and brick is obtained. With the help of vernier caliper measured the thickness of all components and connection between components studied.
- CAD model generation: as per design data obtained. A cad model generated by using CAD software Solidworks.
- Finite Element Model generation: A finite element model of truck body has generated using CAD model in hypermesh. As per geometry dimensions suitable element configurations used for meshing. mesh was generated according to the set criteria. Material and elemental properties was assigned to the mesh.
- Modal analysis of the truck body using FEA: we perform modal analysis, for finding the mode shapes and the different vibrating frequencies. For this purpose we formed two load collectors: spc & eigrl. lay the constraint to the model and process it for solver.
Static analysis of the truck body using FEA: we perform static analysis, for finding stresses and displacement for applied load. For this purpose we form 2 load collectors: 1 spc & force. lay the constraint to the model and process it for solver.

- Altering the design of these areas. Since there was a scope for optimization in the model, we took iterative steps and changed the thickness of the channels and front shaft.
- Results discussion: The comparative study of the result of original model and modified model was carried out. To draw a conclusion.

IX. CONCLUSION

In this project the various activities that are involved are:
- Gathering the functional and structural requirement of brick handling system.
- Making General arrangement drawings.
- Hand Calculations.
- CAD model generation.
- Finite element model generation (Pre-Processing).
- Finite Element Analysis.
- Addressing the change request from customer.
- FEA of the updated design.
- Publishing of drawings of the final design.

To provide bricks in time at the construction site and that too without damage is still a challenge in India. But manually handling these bricks cause workers to suffer from back injury and long-term pain if regularly lifting/carrying heavy or awkward objects. So, the palletizing and mechanization of the bricks is suggested so as to reduce the human injury and to increase the productivity and profitability.

This proposed design of brick handling system in the heavy commercial vehicle can revolutionize the construction industry through significant labour savings and increased productivity.

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REFERENCES

[8] PIP, Material Handling Guide