International Journal of Research in Engineering, Science and Management
Volume-3, Issue-6, June-2020
www.ijresm.com | ISSN (Online): 2581-5792

Design and Development of Automotive Material Handling Trolley

Sachin P. Dhavane[1], Priyanka D. Suryavanshi[2], Rahul B. Kamble[3], Renuka K. Gaikwad[4*], Shital P. Matte[5]

[1]*Professor, Department of Mechanical Engineering, MIT Academy of Engineering, Pune, India*

[2,3,4,5]*Student, Department of Mechanical Engineering, MIT Academy of Engineering, Pune, India*

*Corresponding author: rkgaikwad@mitaoe.ac.in

***Abstract*: Transportation of automotive parts within the plant and from one industry to another or from the manufacturing industry to OEMS industries is the basic need of each company. The Timely Delivery and lesser Defective parts during the transport play a major role in controlling the inventory which in turn results in the profitability of the industry. The transported parts are to be used in an assembly line or to be stored as per the future requirements. Therefore, that storage of such parts safely and for the specified duration is done by using different trolleys. The theme of the paper is to showcase the design and manufacturing of material handling trolley used in the automotive industry. In this paper, mainly focusing on a case study involving trolley which is used for storing and transporting the HVC front panels. The main motive is to design trolley with given specific load conditions, to reduce clutter and allow for streamlined picking and handling. The Modeling design is carried out by using Solid Works 2014*64 edition software and analysis of the trolley is performed using Hypermesh 2017 software. The Desired design parameters of the trolley are checked by Analytical Calculations and the Results from the software Analysis. Finally, the Paper empathizes the selection of optimum material, Dimensions, and safety conditions for the Trolley to be manufactured.**

***Keywords*: Heavy commercial vehicle front panel, Loading conditions, Hypermesh, Obtistruct, Selection of material.**

1. Introduction

In the automotive industry, material handling trollies are required for various purpose, they are used for handling components within plants or departments. Transportation of components from one industry to another industry. A wide range of automated, semi-automated equipment is used to store and handling of this material almost every item during manufacturing within the industry is transported by using types of equipment like conveyor, Forklift, truck, and trolleys. Mostly transportation of trollies is taking place with the help of a forklift. A forklift is selected as per the trolley dimensions.

A trolley is a mechanical device used to store and handling of material within industry or transport purpose at various points. For different kind of application one has to select a specific type of trolley. Trolley has to be designed by considering different aspects like the component to be stored, its dimensions, weight, and quantity to be stored and concerning this material and dimensions of trolley get selected. In this paper, the trolley is designed for the front panel of the car. This trolley is a special purpose trolley this is only used for storing and transportation of front panel.

While designing consider the payload capacity of the trolley which is 160 kg, material used for manufacturing, the height of trolley and ergonomics of human. Trolley is designed for 16 components mounted at a time on the trolley with 160 kg load. The Modelling design is carried out by using Solid Works 2014*64 edition software and analysis of the trolley is performed using Hypermesh 2017 software.

2. Problem Statement

To design the Pallet Trolley for automotive part transportation and storing purpose. The part is a hood panel of Heavy Commercial Vehicle having weight 10 kg and the material is sheet metal of mild steel which 0.8 mm thick. The 16 parts are to be placed in trolley. The Payload Capacity of the Trolley is 160kg. The acceptable aspect ratio criteria that are H/L is 0.73 and L/W is 2.1. Develop trolley by analysing points of failure caused by stresses created because of load applied.

3. Literature Review

Ramkumar R, Krishnaraju A et.al (2016) have done work on "Optimization of Material Handling Trolley using Finite Element Analysis". In this research paper, they want to reduce the weight of the trolley used in the automotive industry especially in the car body and panel for that purpose they use CREO and ANSYS. They change material and mass reduction and at the last got the best results for the second case which has 15 mm thickness with pad and material is Mild steel [1].

Maher Ali Hussein[1] et.al (2013) made research on problems encountered i.e. office trolley have a low load-carrying capacity. They modified an existing design that loads effective and more lighten. The simulation of office trolley shows that the Alloy Steel (stainless steel) office trolley gives the best result in terms of a load carried lighten body weight, and higher safety factor contributes by this product [2].

Syed Sajid Ahmad Syed Nisar, K. I. Ahmad, and M. Sohail

Pervez et.al (2016) - In this project undertaking a detailed investigation of existing industrial pallets (metal) used in a forklift truck.

After that, they will analyze the existing design and modify it to reduce the weight or cost. The modified design will be further analyzed and validated to confirm that it can take the design loads [3].

Abdullah Waseem, Ahmad Nawaz, Nauman Munir, Bilal Islam[4], and Sahar Noor[5] et.al from these results, PVC is considered based on minimum deflection out of 4 plastic materials. It can easily withstand 45000 N or 45KN. PVC recyclable in for usage in other applications. PVC can withstand high tensile loads (evident from simulation results). Finally, mass production is possible using PVC material [4].

Bhavin J Shah, Virag A Timbadia, Rahul Bhat, Dhruvi N Panchal, Karan Dave et.al (2017) in this they design a trolley which is used for multipurpose, the trolley can be used at the airport and shopping mall. They choose stainless steel of grade SS 202 and for wheel Polyurethane (PU). The design is simple and easy to handle. Design is rigid and robust and capable to carry a load [5].

4. Constructions

Design of trolley is completed by using Solidworks 2014*64 edition software. Following is the Assembly model of trolley.

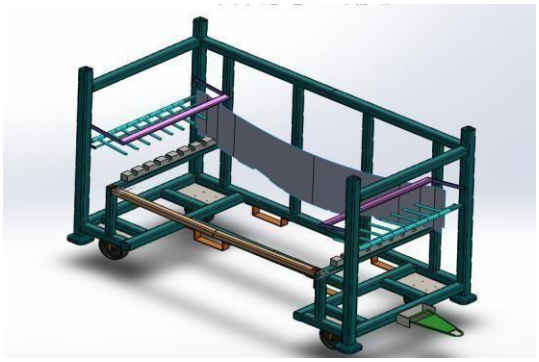

Fig. 1. Trolley for HVC front hood panel

A. Design of Trolley

Dimensions of a trolley are fixed with reference to the HVC hood panel. The requirement to design trolley is panel orientation, a number of panels in one slot of PP block to place (for space optimization), the capacity of trolley should be 16 number of panels, and trolley should have to withstand in stacking conditions. The distance between square tubes which is below the PP block to the ground is to be 547mm is required. Fig. 2. HCV Hood Panel

As the Panel Length is given, considering dimensions of square tube and clearance from both sides of the panel length of a trolley is 1700mm fixed. And according to length of the trolley. The company has a standard aspect ratio which they follow i.e. the acceptable aspect ratio criteria is H/L is 0.73 and L/W is 2.1. With reference to the aspect ratio, Width, and Height also defines which is 800mm and 1100mm. According to the Number of panels and to avoid material contact dimension of PP block is fixed.

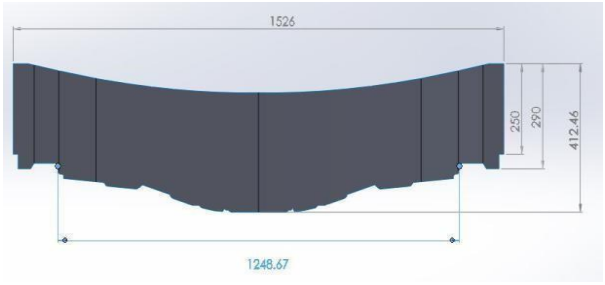

Fig. 2. HVC front hood panel

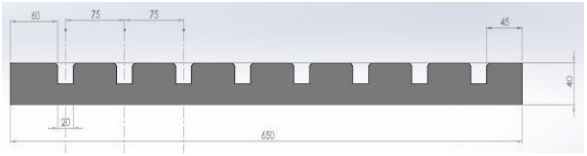

Fig. 3. PP Block

To avoid slippage and material contact due to external vibration or sudden jerk movable Separator is designed. And from upper side locker is attached which is also movable in rotary movement. To move or transport trolley from one location to another at the bottom side of the trolley fork guide is used. Caster wheels are used that are made up of nylon and wheels are selected from the catalogue. Wheels are selected by using weight acting on the wheel and the height of the wheel, diameter is 150mm.

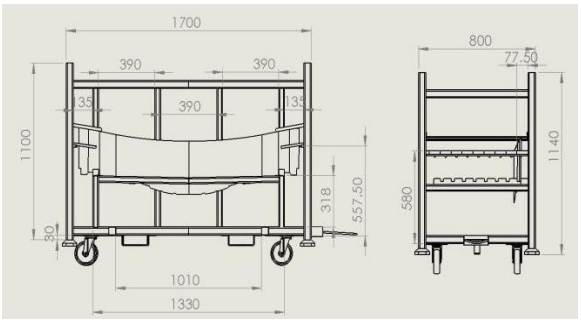

Fig. 4. Front and Side View of Trolley

5. Material Selection

As the trolley carries 160 kg weight of panels and its own weight so that while designing the parts of trolley should have considered parameter like strength, tensile strength, hardness, and toughness, young's modulus etc. The load which the trolley would bear will affect the other parts like wheels and PP blocks, Hence the part of trolley must be made from hard material so it can support large payload and material should have properties of light-weight which will reduce the overall weight of trolley. By considering all this aspect chooses the mild still material as it is strong and tough also.

A. Material used for trolley

IS 2062 (2011): Hot Rolled Medium and High Tensile Structural Steel [MTD 4: Wrought Steel Products] [7].

This standard of material covers the requirements of steel including micro alloyed steel plates, strips, shapes and section (angles, tees, beams, channels, etc.), flats, bars, etc., for use in structure work

Table 1
Chemical Composition of IS2062

Grade Designation (1)	Quality (2)	Ladle Analysis, Percent, Max. C (3)	Mn (4)	S (5)	P (6)	Si (7)	Carbon Equivalent
E 250	A	0.23	1.50	0.045	0.045	0.40	0.42
	BR B0	0.22	1.50	0.045	0.045	0.40	0.41
	C	0.20	1.50	0.040	0.040	0.40	0.39

Steels of qualities A, BR, B0 and C are generally suitable for welding processes. The weldability increases from quality A to C for grade designation E250 and E275. Steel quality used is A.

The steel, if required, may be treated with calcium based compound or rare earth element for better formability. Lower limits for carbon equivalent and closer limits for other elements may be mutually agreed to between the purchaser and the manufacturer. As mention by Indian Standards. [7]

Table 2
Mechanical Properties of E 250

Grade Designation	Quality	Tensile Strength R_m, Min MPa	Yield Stress R_{eH}, Min MPa <20	20-40	>40	Percentage Elongation A, Min At Gauge Length, L_o=5.65	Internal Bend Diameter Min ≤ 25	>25	Charpy Impact Test Temp °C	Min J
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
E 250	A	410	250	240	230	23	2t	3t	-	-
	BR								RT	27
	B0								0	27
	C								(-) 20	27

6. Methodology of the Work

Trolley is often the last part of a system to be considered and is usually seen as a simple piece of the puzzle. However, there are actually a multitude of different aspects that must be considered when designing and ordering material handling trolley to ensure a proper fit for a material to be stored. This is why it is important to allow ample time for industry experts to analyse the many aspects of a proper designing.

A. The methodology used for design of trolley can be broken down into three major elements as follows:

1) Details of the product being stored. 2) Physical site variables. 3) Trolley design variables

B. Product Being Stored

1) Size and weight of the Product

This is the most important aspect of designing material handling trolley. Since trolleys are designed with a built-in safety factor, it is important not to inflate the weight of the product, which will increase the cost of the trolley components.

2) Storage of Product on Trolley

If product overhangs the trolley, the trolley may need to increase in width or depth to accommodate the overhang.

C. Physical Site Considerations

1) Seismic Classification

The government classifies each site location by potential ground motion in the event of an earthquake. All site locations have a seismic classification, even if the potential for an earthquake is low. This is why the building address is so important.

2) Concrete Floor Specifications

This is used to determine if the concrete slab can support the weight of the pallet rack and the product being stored. Depending on the strength of the concrete, larger foot plates may be required to spread the load of your pallet racking.

3) Nearby Environment

It is also to be taken into consideration because it is necessary to avoid the accidental situation if occurs any.

4) Separation Requirement

This is a measure of the minimum distance between the trolley and any building elements, mainly the building columns. This requirement can significantly impact the layout, especially the quantity and width of the drive aisles.

5) Building Specific Elements

These elements include size and type of building columns; location of roof drains or other obstructions on building columns; or presence of wind bracing

D. Design calculation

The following table shows the weight, capacity, material and dimensions of trolleys and methodology for analytical calculation is:

Weight of Single Part = 10 Kg,

Load of single part is distributed at two points which is Polypropylene Blocks Load on one pp block in each slot is 5Kg. and No. of Total Doors is 16.

Table 3
Specification of pallet trolley

Material	Mild steel, Steel
Weight of part	10KG
Payload Capacity	160KG
No. Doors fitted in each slot of PP Block	02
Aspect ratio	Height to length - 0.73 Length to width - 2.1 Acceptable when less than or equal to 1.5
Dimensions of parts	Length of trolley is 1600mm Width of trolley is 800mm Height of trolley is 1100mm

Considering, Length of pp block as distance between two supports

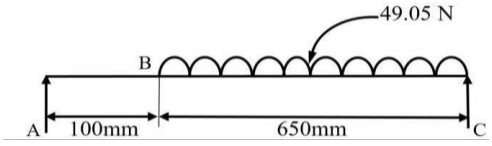

Fig. 5. Uniformly distributed load diagram

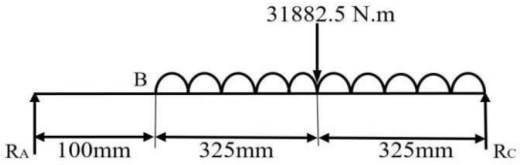

Fig. 6. Free body diagram

Applying the conditions of equilibrium,
$\sum F_y = 0$ (↑ +ve, ↓ -ve)

$\therefore RA + RB - 3188.25 = 0$
$\therefore RA + RB = 3188.25$ N..... (i)

$\sum M = 0$

Taking moments about A,
$- R_B \times 650 + 3188.25 \times 325 = 0$
$\therefore R_B \times 650 = 3188.25 \times 325$
$\therefore R_B = 1594.12$ N

From equation (i),
$R_A = 3188.25 - R_B$
$R_A = 3188.25 - 1594.12$ $R_A = 1594.12$ N

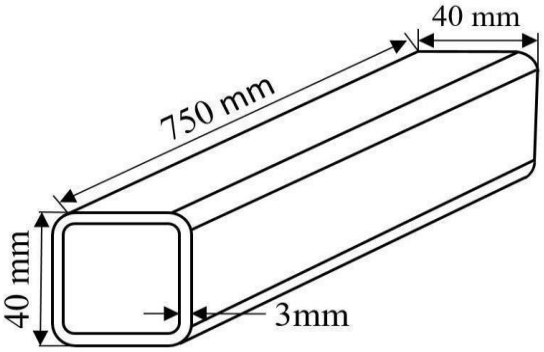

Fig. 7. Square tube dimensions below the pp block

Surface Area of Square tube,
Area (A) = (Length$_1$ × Breadth$_1$) – (Length$_2$ × Breadth$_2$)
= (750 ×40) – (744 × 34)
= 4704 mm^2

Total force acting on square tube by car front panels = 31882.5 N.

Induced Stress (σ) = $\frac{\text{Force}}{\text{Area}}$
$= \frac{31882.5}{470}$

$\therefore \sigma = 6777.7423$ N/m^2 or 6.777 N/mm^2
$\therefore \sigma = 6.777$ MPa

Static Failure Theories:
Ductile

- Von-Mises Theory/ Maximum Distortion-Energy

Trolley material is mild steel which is a ductile material. Ductile materials typically have the same tensile strength and compressive strength. Also, yielding is the criterion of failure in ductile materials. In maximum shear stress theory and distortion energy theory, it is assumed that the yield strength in tension (S_{yt}) is equal to the yield strength in compression (S_{yc}). Also, the criterion of failure is yielding. Therefore, maximum shear stress theory and distortion energy theory are used for ductile materials.

Distortion energy theory is used when the factor of safety is to be held in close limits and the cause of failure of the component is being investigated. This theory predicts the failure most accurately

As,
Yield Shear Strength (S_{sy}) = 0.577S_{yt}

Permissible stress = $\frac{0.577 S_{yt}}{FOS}$
Induced stress value (σ) =6.77 Where,
FOS=2.1
And S_{yt} =250MPa …. (For mild steel) [7]

Condition,
Induced stress value < Permissible stress value
Therefore,
Permissible stress = 0.577 × 215/2.1
= 68.70 N/mm^2
Induced stress value < Permissible stress value Hence, Design is safe.

Approach:

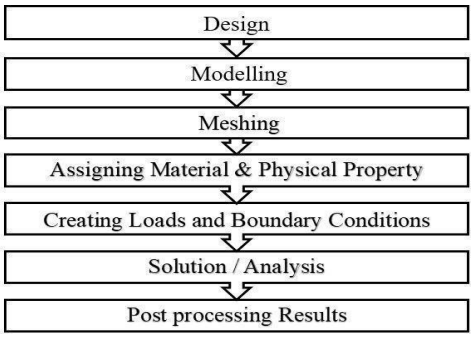

Fig. 8. Workflow for Linear Static Analysis

7. Software Results

The finite element analysis is a numerical method for solving engineering problems. Linear static analysis for Pallet Trolley is carried out by using OPTISTRUCT software. For this first created 3D model in SOLID WORKS 2014 x 64, then it goes for meshing by using Hypermesh. Results come from linear static analysis for variants are shown below.

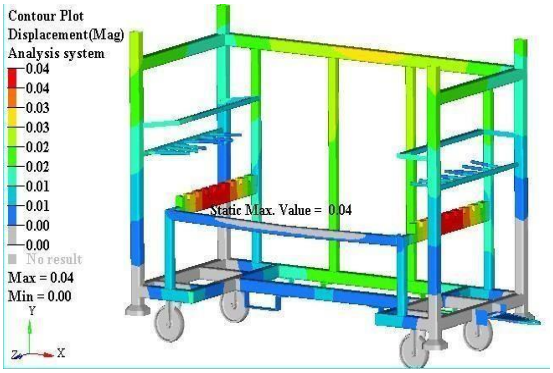

Fig. 9. Static Maximum Displacement in mm

Maximum stress at the beam and the beam supports is 8.09 MPa.

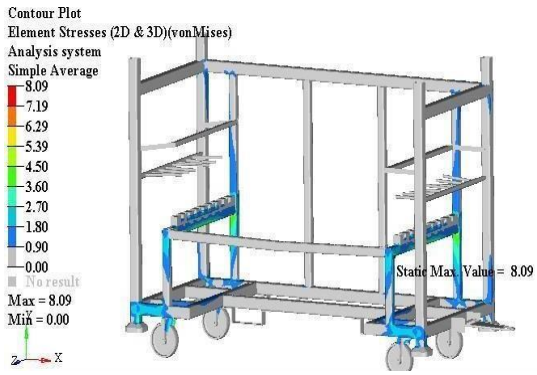

Fig. 10. Maximum Stress

Maximum displacement that is 0.04 occurs at the Centre of the beam so there are more chances of failure and the minimum displacement that is 0.00 occurs at the supports of the trolley.

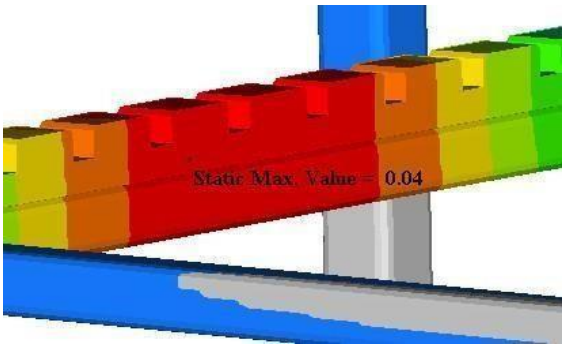

Fig. 11. Location of Maximum Displacement

This is the location of beam at which maximum displacement occurs and the chances of failure are more, so to avoid failure we have to add material on this point

This is the location at which maximum stress i.e. 8.09 MPa occurs. Trolley having their self-weight and its design for a safe working load which is 160 Kg. To determine the maximum stress and displacement value and location, assembly is analyse in OPTISTRUCT. And as per that, by applying the loading conditions and aspect ratios. The location will got at maximum stress and maximum displacement is occurring.

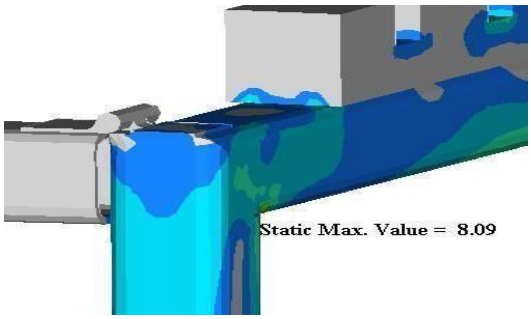

Fig. 12. Location of Maximum Stress

8. Results and Discussion

Table 4
Software and Analytical Results

Parameters	Analytical Stress in MPa	Simulated stress in MPa	Permissible stress in MPa
1	6.67	8.09	68.70

By the analytical method, Maximum stress is 6.67 MPa by using a uniformly distributed simply supported beam diagram. The software method by OPTISTRUCT solver maximum stress is 8.09MPa. That induced stress is less than the permissible stress which is 68.70 MPa. That permissible stress value is calculated by using the material properties. As the Factor of safety is considered as 2.1, the need for a factor of safety is to ensure that when the object is withstand with mechanical load and if it exceeds permissible stress object will withstand and not rupture. And as on in analytical calculations permissible stress is exceeded from induced stress. Hence our design is safe.

The maximum displacement in the beam/square tube is 0.04 mm from the software. In values of analytically calculated and analysed value by software, there is a difference of 1.42MPa which is a calculation error. The design of the trolley is safe means the material selected for the trolley that can withstand with the given payload and environmental conditions and the stress at a point which is located by the software can minimize the stress to avoid the failure of the structure at loading condition.

9. Conclusion

As per the problem statement, the material handling trolley is designed and analysed by Solidworks and hypermesh software. Results are calculated analytically and from the design model, can address that design is safe as induced stress is greater than permissible stress. By analysing the model it can be possible to locate the maximum stresses and maximum displacement. The obtained results full fill the customer requirements as well as given conditions get satisfied.

Acknowledgement

This research was supported by Mr. Anil Shete, CEO of

Shree Om Techno Services. Address: Gat No.183, Ganesh Nagar, Near Appa Bhanuse School, Talawade, Pune 412114.

We thank for their great support and guidance. We thank Mr. Rajeev Sir (Design Engineer) and Mr. Deepak Sir (Design Engineer) for assistance with Design of Trolley and their standard methodologies.

We would also like to show our gratitude to the Mr. Sachin P. Dhavane, Assistance Professor, of MIT Academy of Engineering. For sharing their pearls of wisdom with us during the course of this research.

References

[1] Ramkumar R. And Krishnaraju A. (2016) "Optimization of Material Handaling Trolley Using Finite Element Analysis" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 13, Issue 6, pp. 137-148,

[2] Maher Ali Hussein (2013) "Design and Analysis of Office Trolley."

[3] Syed Sajid Ahmad Syed Nisar, K. I. Ahmad and M. Sohil Pervez (2016) "Design and Optimization of Industrial Pallets for Handling Engine Blocks of Mahindra Scorpio" International Journal for Innovative Research in Science & Technology (IJIRST), Volume 3, Issue 01, pp. 281-283.

[4] Abdullah Waseem, Ahmad Nawaz, Nauman Munir Bilal Islam and Sahar Noor (2013) "Comparative Analysis of Different Materials for Pallet Design Using ANSYS" International Journal of Mechanical & Mechatronics Engineering IJMME-IJENS, Vol. 13, N. 2, pp. 26-32.

[5] Bhavin J. Shah, Virag A. Timbadia, Rahul Bhat, Dhruvi N. Panchal, Karan Dave (2018), "Development of Multi- Purpose Trolley" International Journal of Advance Research in Science and Engineering (IJARSE), Volume 6, Special issue No. 4, pp. 185-192, (ICETCAME 17).

[6] V. B. Bhandari, "Design against static loading", Design of Machine Elements, Third edition, Tata McGrawHill Education (2010), pp. 112-116.

[7] "IS 2062:2011 Hot Rolled Medium and High Tensile Structural Steel – Specification", Bureau of Indian Standards, Seventh Revision, (2011) Wrought Steel Products Sectional Committee, pp. 1- 4.

[8] Bingen Yang (University of Southern California), "Stress Analysis in Two-Dimensional Problems", Stress, Strain and Structural Dynamics, An Interactive Handbook of Formulas, Solutions, And MATLAB Toolboxes, Elsevier Academic Press, (2005), pp. 135-156.