ISBN 978-93-84422-63-9
Proceeding of 2016 International Conference on Advances in Software, Control and Mechanical Engineering (ICSCME'16)
Kyoto (Japan) April 12-13, 2016 pp.41-46

The Strength Analysis of an Agriculture Truck Pick-up using Finite Element Method

Jakkree Wichairahad[1*], Poonyapat Thablakhorn[1] and Nattawut Tonglor[1]

[1] Department of Production Engineering, Faculty of Engineering, Chaiyaphum Rajabhat University, Chaiyaphum, Thailand, 36000

***Abstract*:** *The objective of this research was to analyze structural strength of agriculture truck pick-up based on basic global load case using finite element (FE) analysis software. The pick-up of an agriculture truck made from Anan Karn Chang Agriculture Truck in Chatturat district, Chaiyaphum province, Thailand, was chosen for the study. The three-dimensional beam element type was applied in the study. The analysis was simplified based on static load and linear elastic material behavior assumption. There are three types of basic load behavior consisted of bending, longitudinal, and lateral loads considered. The results of maximum stress and deformations including construction stiffness were used as main parameters to evaluate the structural strength among load case. Regarding the results, it was found that the maximum stress occurred in longitudinal load was 208.96 MPa. The stress of bending load and lateral load was 197.60 MPa and 125.18 MPa, respectively. Furthermore, the bending stiffness of pick-up was 8,354 N/mm.*

Keywords: *Agriculture Truck, Pick-up, Structural Strength Analysis, Finite Element Analysis*

1. Introduction

Agriculture transportation using agriculture truck plays a key role in Thailand. According to statistic, number of the agriculture truck has been continuously increased [1]. The truck consists of two axles with 6 meters of length, 2 meters of width, and 1,600 kilograms of weight [2]. Entrepreneurs were required to take into consideration on strength of structure when design and manufacture. Generally, the truck structure is divided into two parts: chassis and pick-up as shown in Figure 1. The chassis carries weight of other parts such as engine, driver, and payload whereas the pick-up placed on chassis serves for carrying agriculture products. In case of basic global load on automotive structure, it was classified into 3 forms [3, 4]: bending loads, longitudinal loads and lateral loads.

Currently, computer aided design, manufacturing and engineering analysis was widely employed in automotive industrial especially design and structure strength analysis before making prototype. So that, while FE accuracy improvement was performed, time consuming for trial and error also were reduced.

According to computer aided engineering process using finite element analysis, there are some advantages and drawbacks when each element type was used. Moreover, there are three popular elements for structure analysis which are surface, beam, and mix-beam surface elements. Thus, strong point of the surface element is analysis accuracy. From previous studies, M.M.K Lee [5] found out that surface element was more accurate than volume element by using simulation of thin-hollow square pipe. Besides, L.P. Pet et al. [6] also showed that time consuming of the volume element process was more 10 times than surface. Structure analysis of thin-hollow square pipe with over 10 times length of cross section, there was another alternative which was beam element because time consuming had been lowered 1000 times compared to the volume [7]. Furthermore, model was more easily adjusted and modified compared to the surface. In case of the accuracy, it was presented that results of the surface element were closely the fact [8].

(a) (b)

Fig. 1: Agriculture truck superstructure; (a) Chassis frame, (b) Pick-up structure

After having literature review, the number of researches related to strength stiffness and stability of truck structure was found that there was maximum stress especially when braking and cornering. Chinnaraj et al., [9] using quasi-static method and analyzed by software named Ansys instead of dynamics method was conducted and stress from experimental was compared. The obtained results showed that the stress using computer analysis was more than experimental with strain gage.

In 2011, Ingole and Bhope [10] investigated strength of 4-wheel and 8-ton truck using CAD 3-D Pro-E and Ansys software. The results showed that maximum stress was 75 Mpa when using static analysis. While maximum stress was 150 Mpa using dynamics, safety factor was 1.66.

In 2012, H. Kamal et al. [11] carries out structure of 6-wheel truck using static analysis in terms of 2 cases: bending loads when 1-front wheel climbing speed hump and torsion loads when 2-front wheel climbing speed hump. It was described that there was maximum stress occurred in case of 1-front wheel climbing speed hump due to torsion stress.

R. Chandra et al. [12] analyzed strength of TATA truck model 2515EX aiming to reduce cost by comparing strength of 3 composite materials which were Carbon/Epoxy, E-glass/Epoxy and S-glass /Epoxy. It was found that all material could decrease weight and lower cost under strength regulation of mentioned truck.

Hemant Patil et al. [13] carried out structure of 6-wheel truck using C channel structure steel as chassis focusing on thickness and chassis transverse beam location then computer analysis was employed. It was found that thickness adjustment of C channel structure steel was more decreased maximum stress than chassis transverse beam location adjustment.

Hence, the objective of the study was to analyze strength of agriculture truck pick-up starting up with CAD 3 D creation, defined payload and acceleration as the input while strength analysis was performed using finite element method under 3 basic global load cases with computer aided engineering software. The researcher aims this study will be beneficial for the agriculturist in safety and the truck manufacturer in structure design and development procedure.

2. Material and Method

The model was designed and analyzed by researchers using computer software as followed:

2.1. Computer Modeling

Pick-up finite element model of Jumbo Elephant agriculture truck with 2,000 mm. width, 3,800 mm. Length and 1,500 mm. high, manufactured by Anan Karn Chang Agriculture Truck in Chatturat district, Chaiyaphum province, Thailand, was made using computer aided design and engineering whereas the model was used by 3 D beam element and was specified pick-up cross section as shown in Figure 2

2.2. Material Properties

Linear elastic homogeneous material behavior assumption was considered and available material properties were from standard testing. For C channel steel 150x75 mm, yield stress was 245 MPa, Young modulus was 199 GPa, and Poisson ratio was 0.3. For square hollow steel 75x38 mm, yield stress was 314 MPa, Young modulus was 200 GPa, and Poisson ratio was 0.28 and for plate steel 75x12 mm, yield stress was 314 MPa, Young modulus was 199 GPa, and Poisson ratio was 0.26

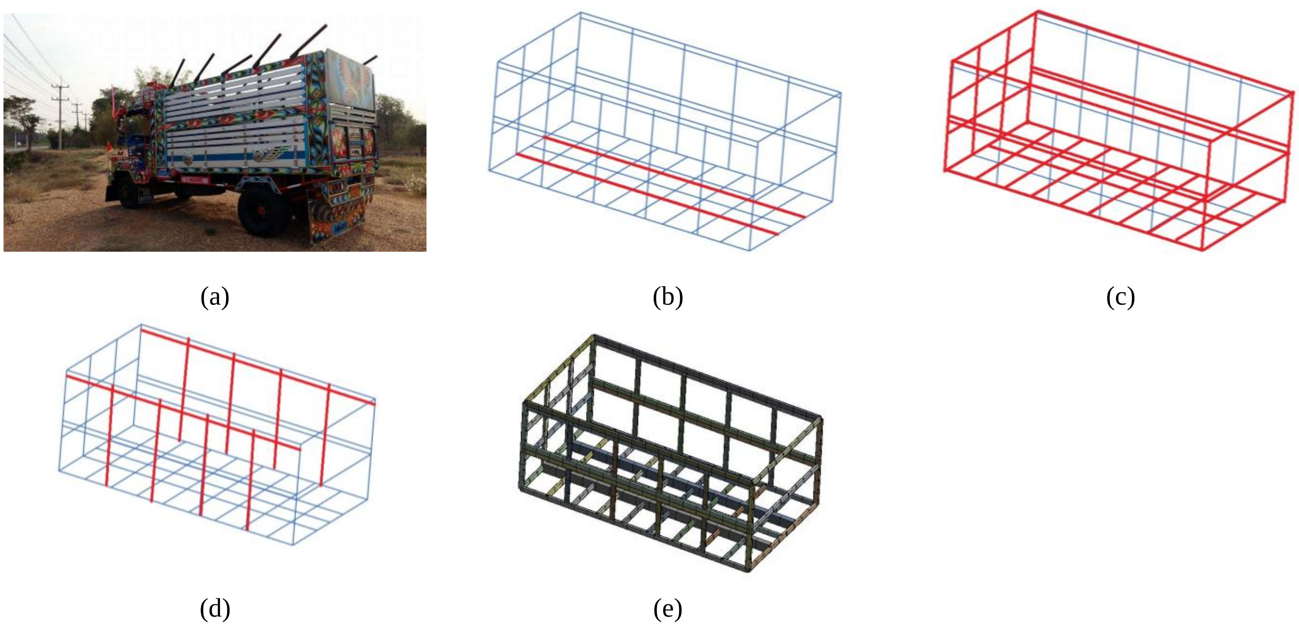


Fig. 2: Agriculture truck CAD model and cross section of pick-up. (a) Real agriculture truck, (b) C channel 150x75 mm. steel, (c) Square hollow 75x38 mm. steel, (d) Plate 75x12 mm. steel and (e) FE model of pick-up.

2.3. Boundary Condition

Regarding to the boundary condition and the total of 3 global load cases, they were performed as following;

Bending load case; a total of 2 components consisted of the payload of 98,100 N. and the construction weight of 6,576.7 N. (from CAD simulation), was considered as a vehicle at rest with the simply support. [3, 4]

Longitudinal load case; the acceleration or deceleration responds were carried out in longitudinal direction. From the previous studies, the severe acceleration load of 0.75g was recommended for this case. [3, 4]

Lateral load case; a lateral acceleration was used to simulate the cornering maneuver. For a severe drive, a lateral acceleration of 0.35g was employed to obtain both sides of a turning response. [3, 4]

2.4. Pick-up Maximum Stress and Stiffness

While the strength analysis was considered maximum combine stress in terms of load cases, structure stiffness was focused on bending stiffness (K_B) as displayed in Figure 3 from ratio of load and deformation as shown in Equation 1

$$K_B = W / \delta \tag{1}$$

Where: W –total load (N)
δ –deformation (mm)

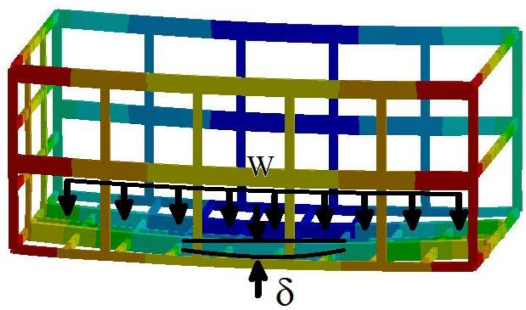


Fig. 3: Bending Stiffness

3. Results and Discussions

The results were categorized into 2 parts as followed:

3.1. Pick-up Maximum Stress

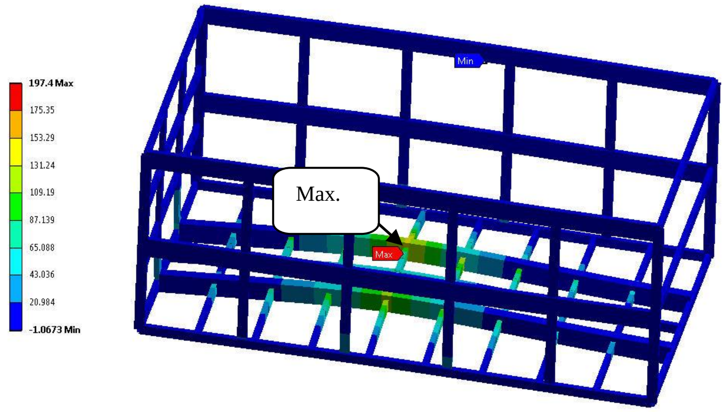
The results of simulation were shown that maximum stress of bending, longitudinal and lateral loads was 197.60 MPa, 208.96 MPa, and 125.18 MPa respectively. The maximum stress occurred at the pick-up in position of maximum moment applied as shown in Figure 4. In addition, safety factor of structure in 3 basic global load cases, it was found that the safety factor of bending, longitudinal and lateral loads was 1.59, 1.50 and 2.50 respectively. However, safety factor was required to consider dynamics factor included which safety factor of truck structure from previous studies could be more than 1.5 [14, 15].

3.2. Pick-up Bending Stiffness

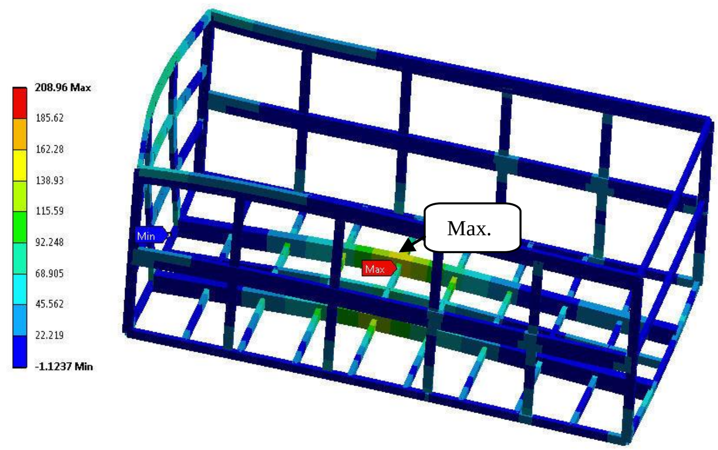
It was found that maximum deformation of bending loads was 11.74 mm. Bending load deformation was computed bending stiffness as shown in Equation 1 and the result was 8,354 N/mm. From previous studies, more than 3,000 N/mm. was recommended results [16]. Meanwhile bending stiffness was shown deformation resistance on bending load including payload [3].

4. Conclusions

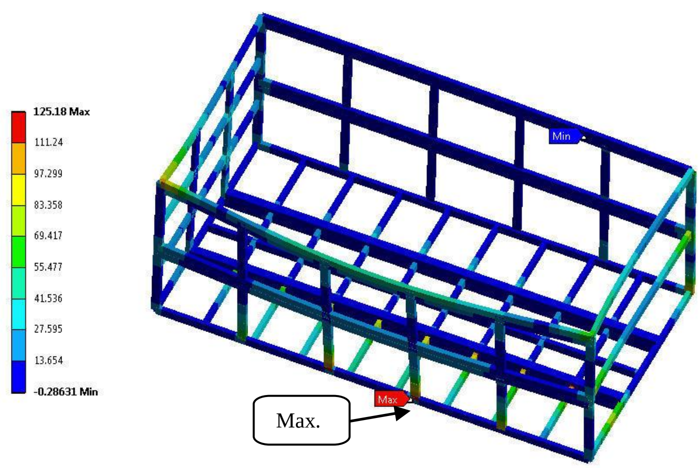
This study was strength analysis of Jumbo Elephant agriculture truck pick-up manufactured by Anan Karn Chang Agriculture Truck in Chatturat district, Chaiyaphum province, Thailand, using finite element analysis with computer aided engineering software. The 3 D beam element was used under linear elastic homogeneous material behavior assumption with 3 basic global loads including bending, longitudinal and lateral loads. It was found that maximum stress on pick-up under longitudinal load was 208.96 MPa and safety factor was 1.50. Considering pick-up deformation, maximum deformation on bending load was 11.74 mm. In terms of bending stiffness was found 8,354 N/mm. So that, the results was consistent with the recommended results from previous studies which could be more than 3,000 N/mm for bending stiffness. The researcher aims this study will be beneficial for the agriculturist in safety and the truck manufacturer in structure design and development procedure.



(a)



(b)



(c)

Fig. 4: Stress distribution (a) Bending load, (b) Longitudinal load and (c) lateral load

5. Acknowledgements

The research fund was supported from Chaiyaphum Rajabhat University and the researchers would like to thank Anan Karn Chang Agriculture Truck in Chatturat district, Chaiyaphum province, Thailand for kind cooperation and providing information related to agriculture truck and sincerely thank Assistant Professor

Dr.Supakit Rooppakhun from School of Mechanical Engineering, Institute of Engineering, Suranaree University of Technology for any suggestion on using finite element analysis.

6. References

[1] Transportation Statistics Group, Planning Division, Department of Land Transport (2557). Statistics of registered vehicles across the country until December31, 2014, http://apps.dlt.go.th/statistics_web/vehicle.html access on 19 February, 2015.

[2] Ministerial Regulation Issue 1 (B.E.2525) under Vehicles Act B.E. 2522 (2525, 11 May). Government Gazette Issue 99, Article 65, Page 72-75.

[3] J. C. Brown, A. J. Robertson and S. T. Serpento. (2002). Motor Vehicle Structures: Concepts and Fundamentals, ISBN: 07506-5134-2, Butterworth-Heinemann, Oxford.

[4] J. H. Smith. (2002). An Introduction to Modern Vehicle Design. ISBN: 07506-5044-3, Butterworth-Heinemann, Oxford.

[5] M.M.K. Lee. (1999). Strength Stress and Fracture Analyses of Offshore Tubular Joints using Finite Elements. Journal of Constructional Steel Research, 51: 265-286, DOI:10.1016/S0143-974X(99)00025-5.

http://dx.doi.org/10.1016/S0143-974X(99)00025-5

[6] L.P. Pey, A.K. Soh and C.K. Soh. (1995). Partial implementation of compatibility conditions in modeling tubular joints using brick and shell elements. Finite Elements in Analysis and Design, 20: 127-138.

http://dx.doi.org/10.1016/0168-874X(95)00020-T

[7] G. Stigliano, D. Mundo, S. Donders snd T. Tamarozzi. (2010). Advanced Vehicle Body Concept Modeling Approach Using Reduced Models of Beams and Joints. Proceedings of International Conference on Noise and Vibration Engineering 2010. :4179-4190

[8] E. Alcala, F. Badea, A. Martin and F. Aparicio. (2013). Methodology for the accuracy improvement of FEM beam type T-junctions of buses and coaches structures. International Journal of Automotive Technology. 14(5): 817-827.

http://dx.doi.org/10.1007/s12239-013-0090-3

[9] K. Chinnaraj, M. Sathya Prasad and C. Lakshmana Rao. (2008). Experimental Analysis and Quasi-Static Numerical Idealization of Dynamic Stresses on a Heavy Truck Chassis Frame Assembly. Applied Mechanics and Materials. (13-14): 271-280.

[10] N. K. Ingole and D.V. Bhope. (2011). Stress analysis of tractor trailer chassis for self weight reduction. International Journal of Engineering Science and Technology. 3(9): 7218-7225.

[11] H. Kamal Asker, T. Salih Dawood, A. Fawzi Said. (2012). Stress Analysis of standard Truck Chassis during ramping on Block using Finite Element Method. ARPN Journal of Engineering and Applied Sciences. 7(6): 641-648.

[12] M. Ravi Chandra, S. Sreenivasulu, and S. Altaf Hussain. (2012). Modeling and Structural analysis of heavy vehicle chassis made of polymeric composite material by three different cross sections. International Journal of Modern Engineering Research. 2(4): 2594-2600.

[13] B. H. Patil, S. D. Kachave and E. R. Deore. (2013). Stress Analysis of Automotive Chassis with Various Thicknesse. IOSR Journal of Mechanical and Civil Engineering. 6(1): 44-49.

http://dx.doi.org/10.9790/1684-0614449

[14] J. P. Vidosic. (1957). Machine Design Project. Ronald Press, New York.

[15] O. Kurdi, R. Rahman and M. N. Tamin. (2008). Stress analysis of heavy duty truck chassis using finite element method. 2n d Regional Conference on Vehicle Engineering & Technology. Kuala Lumpur, 15-17 July 2008

[16] G. Murali, B. Subramanyam and D. Naveen. (2013). Design Improvement of a Truck Chassis based on Thickness. Proceedings of Altair Technology Conference. India.