Abstract— The objective of this research was to compare the structural strength results of agriculture truck pick-up based on basic global load case using finite element analysis (FEA) 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 two element type, three-dimensional beam element and solid element were applied in the study for compared of FEA result. The analysis was simplified based on static load and linear elastic homogeneous 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, for three-dimensional beam element 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. The bending stiffness of pick-up was 8,354 N/mm. for three-dimensional solid element it was found that the maximum stress occurred in longitudinal load was 210.04 MPa. The stress of bending load and lateral load was 184.05 MPa and 125.53 MPa, respectively. Furthermore, the bending stiffness of pick-up was 13,962 N/mm. However, the safety factor of two analyzed case were more than 1.5.

Keywords— Agriculture Truck, Pick-up, Structural Strength Analysis, Finite Element Analysis.

I. 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 beam, surface and elements. Thus, beam element was less time consuming than solid element in CAD modeling and CAE process but less accuracy than solid element. [5]

![Fig.1. Agriculture truck superstructure; (a) Chassis frame, (b) Pick-up structure](image-url)
Ingle and Bhope [7] 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. [8] 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. [9] 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. [10] 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 compare the structural strength results between beam and solid element of agriculture truck pick-up using finite element analysis. 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.

II. 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 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 3 D solid element were 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.

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 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

$$K_B = \frac{W}{\delta}$$

Where: $W$ – total load (N), $\delta$ – deformation (mm)
III. RESULTS AND DISCUSSION

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 for beam element analysis and 184.05 MPa, 210.04 MPa, and 125.53 MPa respectively for solid element. The maximum stress occurred at the pick-up in position of maximum moment applied as shown in Figure 4 and 5. The tiny difference of stress results between beam and solid element because beam element analyzed only the combination of tensile or compression stress and bending stress from moment applied, but solid element Von-Mises stress including analyzed shear stress. 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 for beam element analysis and 1.70, 1.50 and 2.50 respectively for solid element analysis. 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 [11, 12].

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 for beam analysis and maximum deformation of bending loads was 7.02 mm. bending stiffness was 13,962 N/mm for solid element analysis. From previous studies, more than 3,000 N/mm was recommended results [13]. Meanwhile bending stiffness was shown deformation resistance on bending load including payload [3]. The difference of deformation and bending stiffness due to the difference of contact method of structure member joint on CAD modeling process, in case of beam element, member was contact by two lines with one point but in case of solid element, member was contact by two surface.

CONCLUSIONS

This study was the comparison of strength analysis results of agriculture truck pick-up manufactured by Anan Karn Chang Agriculture Truck in Chatturat district, Chaiyapum province, Thailand, using finite element analysis with computer aided engineering software. The 3D beam and solid element was used for compare the analysis results under linear elastic homogeneous material behavior assumption with 3 basic global loads including bending, longitudinal and lateral loads. It was found that in case of beam element analysis, the maximum stress on pick-up under longitudinal load was 208.96 MPa and safety factor was 1.50, in case of solid element analysis, the maximum stress on pick-up under longitudinal load was 210.04 MPa and safety factor was 1.50. Considering pick-up deformation, in case of beam

Fig.3. Bending Stiffness

Fig.4. Stress distribution, in case of beam element analysis (a) Bending load, (b) Longitudinal load and (c) lateral load
element analysis, the maximum deformation on bending load was 11.74 mm. In terms of bending stiffness, was found 8,354 N/mm., in case of solid element analysis, maximum deformation on bending load was 7.02 mm. and bending stiffness was found 13,962 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.

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