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CALCULATIONS, MODELING AND ANALYSIS WITH FINITE ELEMENT METHOD OF RUBBER TYRED CONTAINER STACKING CRANE

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ABSTRACT
This paper presents the modeling, calculations and analysis using Finite Element Method (FEM)of the rubber tyred container stacking crane in ports. All elements of the rubber tyred container stacking crane was modeled and made its calculations. Although stress and deformation analysis of crane bridge girder and buckling analysis of the crane legs are performed. ANSYS Workbench program has been used to perform the finite element method. In addition, rubber tyred container stacking crane has been modeled by using Autodesk INVENTOR 2010 program. Stress, deformation and buckling analysis have been compared with calculations. The aim of this work is to consider the new possibilities and the gains of finite element method over conventional calculation methods on rubber tyred container stacking crane design. When we examine the results, deformation formed on crane system is not significant when considering geometric dimensions of model and it was observed that the stress values remain under the yield strength of the steel which is used for crane brigde and legs.
Keywords: Finite Element Method (FEM), ANSYS Workbench, Autodesk INVENTOR 2010, Stress and Deformation Analysis, Buckling Analysis, Rubber Tyred Container Stacking Crane

1. INTRODUCTION

Lifting and transporting machines are used for moving from place to another place and storing processes of the raw materials, semi finished and finished products in industrial plants. Cranes are a type of lifting machinery. Cranes also participate in production processes and serve to transfer loads from one place to another. The principal parameter of their operation is thus in the final analysis the cost transferring loads under given conditions. The operating conditions of a crane depend on the king and weight of loads to be transferred, the coordinates of the points of the pickup and discharge, the intensity of the flow of the loads, location of the crane and also the effect of the environment (temperature, wind, snow, humidity, dust content etc..). [1]This type of lifting machinery, but all loads lifting or lowering, they also allow for horizontal movement. Movement of the loads along three axes can be obtained as spatial. Therefore, cranes which are placed in workshops, factories, ports, warehouse etc. are very useful and effective lifting machinery. In industrial and commerce field, lifting and moving of the heavy loads in various way is required. In order to overcome these works, many types of crane were developed. One of these types of cranes is rubber tyred container stacking crane. Rubber tyred container stacking crane, containers to be loaded on ships taken from vehicles and stacking neatly to stacked block and eliminating this intensity at ports, plays a leading role. Rubber tyred container stacking crane is a type of portal crane.

This crane is capable of stacking six ISO standard type containers which have maximum total weight of 40 t over and over. Leg clearance of the crane was sized in order to stack also six containers. So we can stack the containers six by six via this crane.

2. CALCULATION OF STRESSES,DEFORMATION AND BUCKLING LOAD

Properties of the rubber tyred container stacking crane will be needed for calculations are as follows ;

Table 1. Main properties of the rubber tyred container stacking crane

Rubber Tyred Container Stacking Crane Properties	
Lifting Load	40 t
Weight of Trolley	27 t
Crane Bridge Clearance (L_K)	23830 mm
Crane Tyre Clearance	23000 mm
Lifting Velocity	20 m/min
Trolley Velocity	70 m/min
Crane Velocity	80 m/min
Spreader Weight	11.5 t

The material St52-3 is used for the construction of the bridge girder and crane legs. Therefore elasticity of modulus, poisson's ratio and density are taken as 210 GPa, 0.3 and 7850 kg/mm^3, respectively.

3. STRESS, DEFORMATION AND BUCKLING ANALYSIS WITH FINITE ELEMENT METHOD

Stresses and deformation (displacement) are occurred on the bridge girder of the rubber tyred container stacking cranes due to the lifting load, trolley weight, bridge girder weight and the platform weight, the spreader weight. Crane legs are also subjected to buckling due to these loads. It has been made deformation and stress analysis for bridge girder, buckling analysis for legs with finite element method by using ANSYS Workbench program.

When considered the stress and deformation analysis, it has been used St 52-3 material for the construction of bridge girder. Therefore material properties are such as material density is 7850 kg/m^3, modulus of elasticity 210 GPa, poisson's ratio 0.3.

After modeling the bridge girder, it has been imported to Workbench, select the static structural section for analysis and then defined the material properties mentioned above. Then we assigned the mesh by using Mesh/sizing. Until getting the best value, mesh size is reduced. After that two ends of the bridge girder are fixed (constraints defined) and applied the loads. One of the loads is caused by the lifting load, trolley weight and the spreader weight. The other load is caused by the bridge girder and platforms weight. After applying the loads, defined values that required the results such as total deformation and von-misses stresses. Finally it is solved and showed the results. The results of the stress and deformation analysis are as following. Figure 1 shows the stress and deformation result of the bridge girder or the rubber tyred container stacking crane.

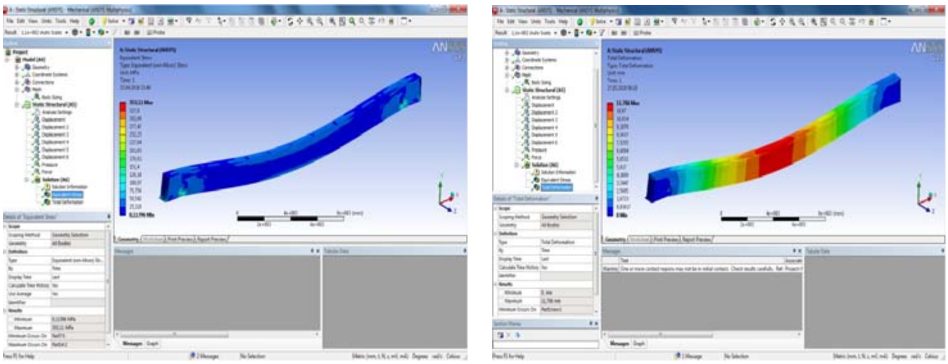

Figure 1. Stress and Deformation analysis result of the bridge girder

However considered the buckling analysis, it must be pre-stressed. Buckling analysis contains two section. First section is pre-stressed section, the other is buckling analysis. After selecting static structural analysis, firstly leg model imported the Workbench then make meshing. In the pre-stressed section after defining the materials properties mentioned above, two ends of the leg are fixed. Then applied the loads 1 N to these ends. After that choose normal stress and deformation that required results then solve it. After this section passing the other section called as buckling analysis. It had been defined model, meshing and material properties etc. at the previous section. Therefore only define the deformation and then solve it. After solving the problem, get an load multiplier. For getting the critical load, multiply these multiplier by load applied at the first section. For example if applied 1 N load at the pre-stressed section and get a load multiplier from the program 150, the critical load is equal to 150 N (1*150=150). Buckling analysis result of the crane leg is as shown in Figure 2.

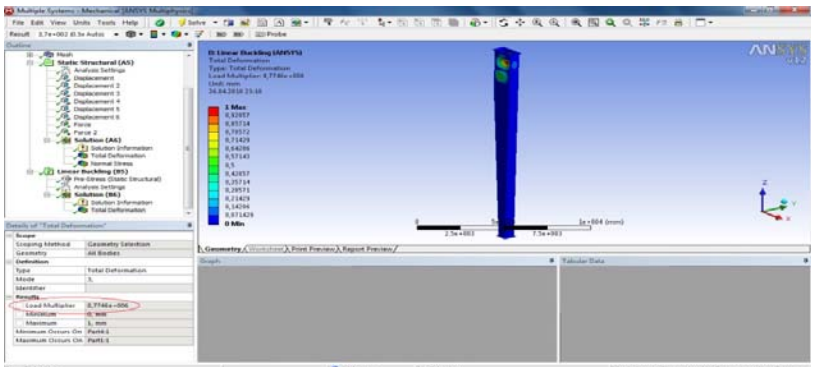

Figure 2. Buckling analysis result of the crane leg.

4. RESULTS

This paper presents modeling, calculation and stress, deformation and buckling analysis of the rubber tyred container stacking crane. As a result compare calculation and analysis. For comparing the stress and deformation analysis and the calculation show in Table 2. Examining the results the stress value is 201.83 N/mm^2 (Figure 3.) for the analysis but stress value is equal to 204.56 N/mm^2 from the calculation. If compare the deformation results between analysis and calculation, the analysis result is 11.706 mm and the calculation result is 15.27 mm(Figure 3). There is no significant difference between the analysis and calculation result for the stresses and deformations. Therefore analysis result can be taken into consideration.

Table 2. Comparison of the calculation and analysis for stress and deformation

	Calculation Results	Analysis Results
Stress Values	204.56 N/mm^2	201.83 N/mm^2
Deformation (Displacement) Values	15.27 mm	11.706 mm

When considering the buckling analysis get a load multiplier which has a value of 8774600 and multiply this value by applied load 1 N at the pre-stressed section. Then critical load is equal to 8774600 N. From the calculation the critical load is 8674038 N. The comparison of the calculation and the analysis for the buckling analysis (critical load) is as shown in Table 3. For the buckling analysis, results can be taken into consideration. Because there is no big difference between calculation and analysis.

Table 3. Comparison of the calculation and analysis for buckling analysis

	Calculation Results	Analysis Results
Critical Load Values	8674038 N	8774600 N

5. CONCLUSION

Finally, gains and the benefits of finite element method (FEM) has been observed as following ;

- ✓ Reaches solution faster (save time)
- ✓ Resolve the complex problems easily
- ✓ It is less costly than experimental studies (cost profit)
- ✓ Gives more precise and accurate results.

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