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STUDYING DYNAMIC EFFECTS FOR THE CASE OF FORWARD MOTION ON CRAWLER CRANES DURING THE DIFFERENT TERRAIN CONFIGURATIONS

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ABSTRACT
This is the third work on dynamic effects on Crawler cranes for different cases of motion of the crane or its parts. In this case we are going to study the dynamic effects on the crawler crane for the case of traveling forward. This motion is another type of motion which creates lots of dynamic stresses, particularly when that motion is done with workload hanging. Traveling is categorized in the group of translational motions. The difficulties in implementing this activity come from the type of terrain as a ground where crane travels. Terrain could be flat, horizontal and strong which is preferable, or could be inclined (towards x or y axes), humped or soft, which makes movement difficult. Also, taking care of motion speed is very important. There are many cases when cranes overturned due to difficulties of terrain. In this work, we are going to simulate the work of crawler crane while moving forward. The aim is to see the effects of dynamic forces (or moments) in the crane's construction during this activity, particularly when the working load is hanged and swings. Reasons for doing this study are to research crane's dynamic stability. We will study the effects of terrain configuration, load weight and swinging, and speed in the overall crane stability. By using the modeling applications and applying simulations, we consider that we will have better view of occasions for this case of motion and give some conclusions for enforcing stability against overturning, security in work and design considerations. To do this we designed "virtual crawler crane" using model design and simulation applications and did simulations [3].
Keywords: Crawler crane, dynamic, translational motion, torque, cables, tension, simulation.

1. CRANE PROPERTIES

Crane will be studied for the case of translational motion (moving forward) while the workload hangs in constant height. Movement will be studied for the case of forward motion in flat ground, moving up, moving down and moving in inclined ground. Workload has the mass equal to max carrying weight: Q = 27 t = 27000 kg. Position of the load above the flat ground is 14 m. Distance from the pulley and boom top is 10 m. Crane will be studied when fully engaged, by analyzing the dynamic momentum in the platform and tension in luffing cables [1]. Properties of the crawler crane: Length of the Boom - 42 m. Mass of the boom – 100 t. Mass of the platform with tracks – 100 t.

2. DYNAMIC MOMENTUM IN THE PLATFORM AND TENSION IN LUFFING CABLES

Dynamic momentum represents the torque on the platform, as shown in Fig.1; it has three components towards axes of coordinate system T_x , T_y , T_z [2]. We consider that studying this parameter is important for overall dynamic response. Simulations will be done with the traveling speed of v_1 = 0.5 m/s and v_2 = 1 m/s. Results are also compared with static torque.

Tension in the luffing cables (Figure 8) is studied for all cases of traveling. These cables undergo heavy tension (axial force in cables, measured in N) due to traveling and swinging of workload [2].

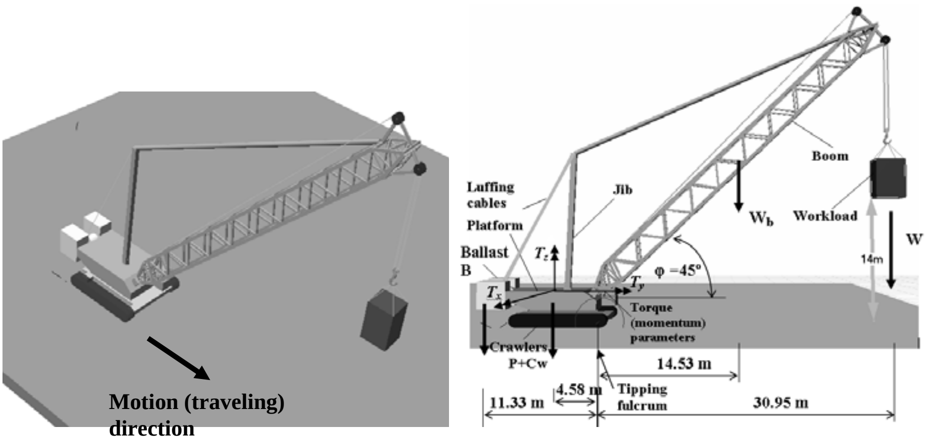


Figure 1. Virtual model of the crawler crane with key elements

2.1. Traveling on Flat Horizontal ground

This is the case when basement is horizontal, and results of traveling forward are given graphically with torque on platform and tension in luffing ropes, measured in time. Simulation is processed for these cycles: for the case 0<t<0.5 s - crane is in relative rest with no movement. For 0.5<t<14 s crane travels forward. On t <=14 crane is stopped, but workload still swings.

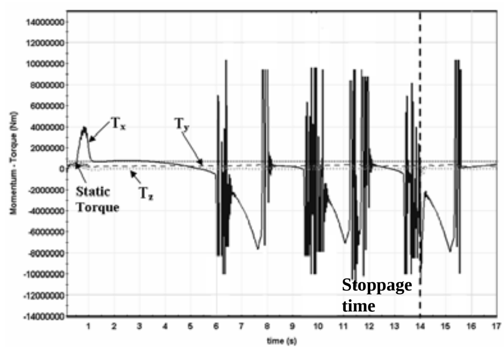


Figure 2. Torque – with speed of v_1 = 0.5 m/s

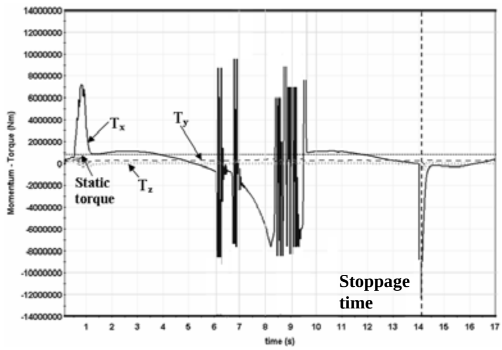


Figure 3. Torque – with speed of v_2 = 1 m/s

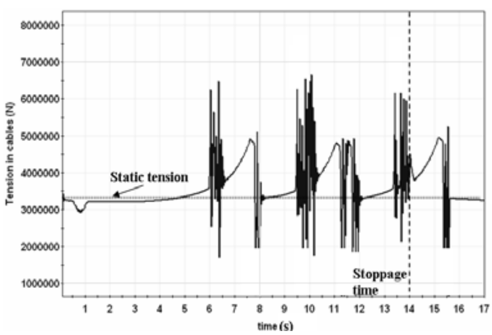


Figure 4. Tension in cables –speed v_1 = 0.5 m/s

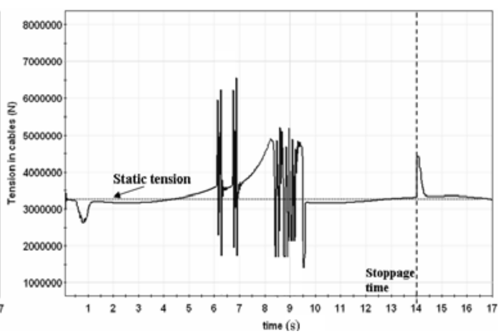
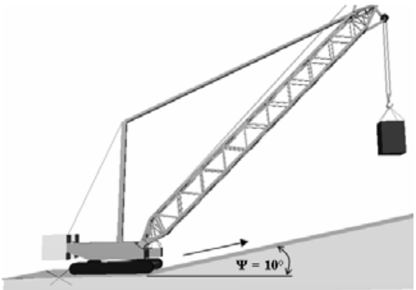


Figure 5. Tension in cables –speed v_2 = 1 m/s

Figure 2 shows the case for speed v_1 = 0.5 m/s, with heavy dynamic process in period beetwen 6<t<14 s. In Figure 3, for the case of speed v_2 = 1 m/s, there is similar dynamic process with less periods of oscillations, before and after stoppage time. Noticeable is the curve in the moment of stoppage, where we see heavy fall and increase of momentum. Similar conclusions can be given for the graphs of tension in cables, where these cables undergo heavy tension (Figure 4 and Figure 5).

2.2. Traveling upwards

This is motion when crane climbs, as shown in Figure 6. Angle of inclination is $\psi = 10°$. Results show higher dynamic process then in 2.1. Oscillations of torque in platform are heavier and more intense, even after the stoppage time. Same conclusion can be given for luffing cables.



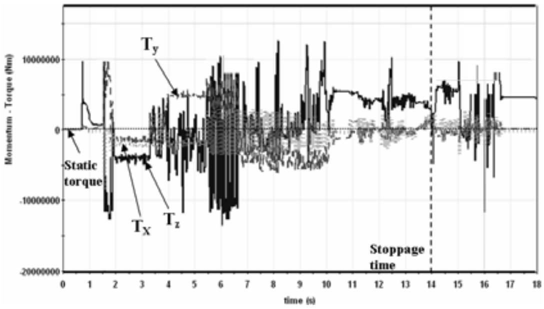
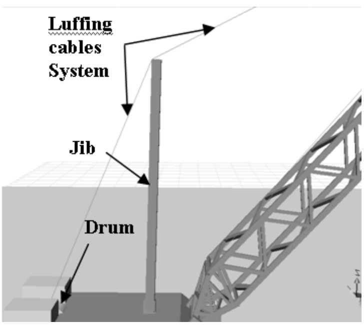


Figure 6. Traveling upwards, angle $\psi = 10°$

Figure 7. Torque – with speed of $v = 0.5$ m/s



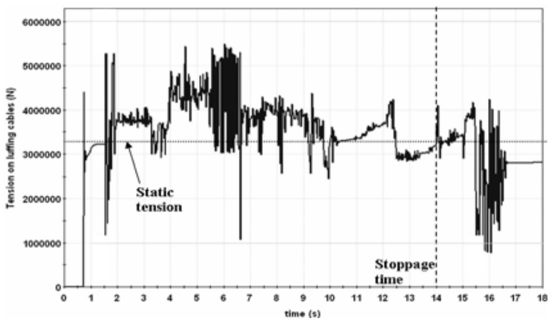
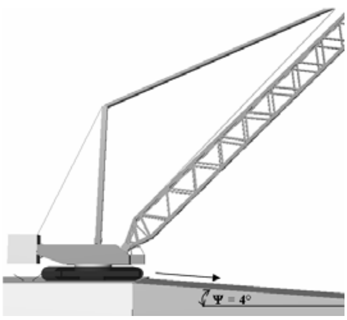


Figure 8. System of luffing Cables

Figure 9. Tension in luffing cables –speed $v = 0.5$ m/s

2.3. Traveling downwards



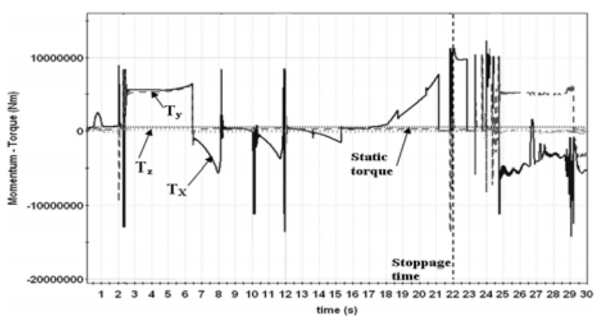


Figure 10. Traveling downwards, angle $\psi = 4°$

Figure 11. Torque – with speed of $v = 0.3$ m/s

This type of motion is very complex for study. Going from horizontal to downwards is risky with instability and chances for overturning. Not every speed and angle is appropriate for crane. After many simulations, we came to conclusion that, for this type of crane, traveling downwards is best with the speed v ≤ 0.3 m/s, and inclination of $\psi \leq 4°$, as shown in Figure 12. Looking at Figure 11 and 13, we conclude that this process is also with heavy oscillations, even after stoppage time. Simulation is processed for longer stoppage time t = 22 s (6.6 m travel) for better view of process.

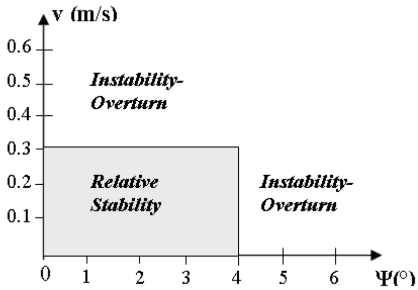


Figure 12. Graph of stability

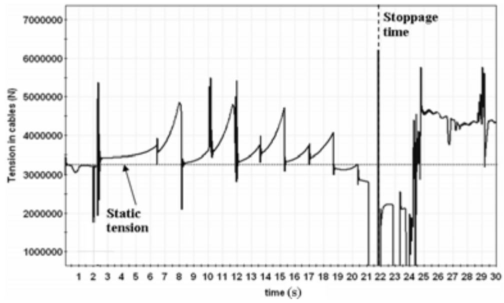


Figure 13. Tension in luffing cables –speed v = 0.3 m/s

2.4. Traveling on inclined basement

Inclined basement is shown in Figure 14. This was the most complex for studying and simulating. In this case, besides heavy dynamic processes, another process occurred – slipping of crane. Instability occurs even in lower angles. We concluded that speeds higher than v = 0.5 m/s and angle of basement $\theta > 9°$ are limits for instability and overturning for this type of crane. Also, friction between crawlers and basement should be considered [1]. Figure 15 shows that T_y momentum has highest values.

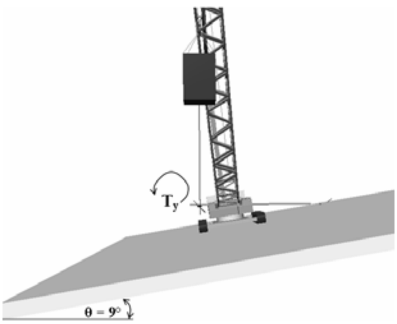


Figure 14. Traveling inclined, angle θ = 9°

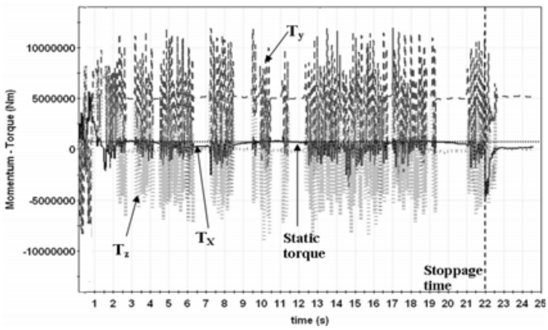


Figure 15. Torque – with speed of v = 0.5 m/s

3. CONCLUSIONS

Studying translational motion proved that during this working process crawler crane undergoes intensive dynamic processes and should be considered in calculations. We studied several cases of basement configurations and different speeds of crane. We gave some important conclusions about the angles of basement inclination and limits of speed which affects the functionality and work safety of these types of cranes.

4. REFERENCES

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[2] Ing. J. Verschoof: Cranes – Design, Practice, and Maintenance, London 2002.
[3] MSC VisualNastran 4D User Guide, MacNeal-Shwendler Corporation, Santa Ana, 2003.