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A Comprehensive Study of Effect on Increasing the Wire Rope Diameter in Crawler Crane

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Abstract

Metro rail project have the lowest carbon emission among the various modes of mass transfer. The construction works are generally done with the help of various machineries such as cranes and piling equipment .A case study was conducted at metro tunneling project at southern part of India. The influence of wire rope diameter over load carrying capacity in crawler cranes was analyzed using design calculations. The results reveal that increase in wire rope diameter will increase the load carrying capacity.

Keywords: Wire rope;Cranes; Material handling.

1. Introduction

A metro rail project ensures enhanced mobility and reduces congestion roads. It uses clean technology and energy efficient. It provides high passenger capacity and requires 1/5 th of energy per passenger compared to a road based system. It reduces road accident thereby saving human life. From the point of view of application modality, the material handling equipment can be classified into the following groups as conveying systems; industrial trucks; cranes and hoists; auxiliary equipment (Chakraborty and Banik, 2007). Very little attention has been paid for selecting accurate material handling equipment (Deb et al,2002). A crane is a machine for lifting and lowering a load and moving it horizontally, with the hoisting mechanism and integral part of the machine. A "crawler crane" consists of a rotating superstructure with power plant, operating machinery, and boom, mounted on a base, equipped with crawler treads for travel. Its function is to hoist and swing loads at various radii

.Cranes, like all machines, obey the principle of conservation of energy. This means that the energy delivered to the load cannot exceed the energy put into the machine. For example, if a pulley system multiplies the applied force by ten, then the load moves only one tenth as far as the applied force. Since energy is proportional to force multiplied by distance, the output energy is kept roughly equal to the input energy. Crawler cranes have both advantages and disadvantages depending on their use. Their main advantage is that they can move around on site and perform each lift with little set-up. Cranes can also get in chain reactions; the rupture of one crane may in turn take out nearby cranes. Hence cranes are monitored and watched carefully.

2. Stability of Crane

For stability, the sum of all moments about any point such as the base of the crane must be equal to zero. The magnitude of load that is permitted to be lifted is less than the load that will cause the crane to tip. The principle of the lever allows a heavy load attached to the shorter end of the beam to be lifted by a smaller force applied in the opposite direction to the longer end of the beam. The ratio of the load's weight to the applied force is equal to the ratio of the lengths of the longer arm and the shorter arm is called as the mechanical advantage. The hydraulic cylinder is used directly to lift the load or indirectly to move the jib or beam. Stress within the base must be less than the yield stress of the material or the crane will fail

3. Wire Rope Terminology

Wire rope is an essential element in crane. Wire rope is a rope which consists of several strands of metal wire twisted into a helix. Initially wrought iron wires were used, but today steel is the main material used for wire ropes. Steel wires for wire ropes are normally made of non-alloy carbon steel with a carbon content of 0.4 to 0.95%. The endurance of wire ropes with the parallel strand is always much greater than of those with cross lay strands. There are technical regulations for the rope drives of cranes, elevators, rope ways and mining installations not exceeding a given tensile force and not falling short of a given diameter ratio D/d of sheave and rope diameters. The wire ropes are stressed by fluctuating forces, by wear, by corrosion and by extreme forces. The rope lifespan is fixed and the safety is only given by inspection for the detection of wire breaks on a reference rope length, of cross-section loss as well as other failures so that the wire rope can be replaced before a dangerous situation occurs. Ropeways must be permanently supervised by a responsible manager and the rope has to be inspected by a magnetic method capable of detecting inner wire breaks.

4. Design of Wire Rope

For Cranes and Hoists, 6×37 Wire rope is selected.

1. Breaking strength of the wire rope For wire rope diameter, d = 24 mm, Breaking strength = 31 tonnes = 310kN
2. Diameter of the pulley
   Take Sheave or Pulley diameter , $D = 30d$= 30×24 = 720 mm

3. Cross sectional area of the rope
   Cross sectional area, $A = \pi/4 \times d^2 \times 0.4 = \pi/4 \times (24)^2 \times 0.4 = 180.956$ mm^2
4. Diameter of wire Wire diameter, $d_w = d / (1.5 \times \sqrt{i})$ =24 / (1.5×√6×37) =1.07385 mm
5. Weight of the wire rope W_r = 2.1 kgf/m = 21N/m
   Considering the height to be lifted = 50 m
   W_r = 21×50 = 1050 N = 1.05kN
6. Direct load , $W_d = W + W_r$ = 120+1.05 = 121.05 kN
7. Bending load , $W_b = \sigma_b \times A = (E \times d_w / D \times A$
   W_b = (0.8 ×10^5×1.07385) / 720 × 180.956 = 21591.067 N =21.59 kN
8. Acceleration load , $W_a = \{ (W+W_r) / g \} \times a$ = { (120+1.05) / 10} × 1 = 12.105 kN
9. Effective load , $We = W_d+W_b+W_a$ = 121.05+21.59+12.105 = 154.745 kN
10. Working Factor of safety, *(FOS) = Breaking load / Effective load* = 310 / 154.745 = 2.003

Table 1 Shows the effect of varying diameters in order to increase the different loads carrying capacity of the wire rope.

Table 1: Various load values corresponding to different diameters.

Sl. No	Wire rope dia, d (mm)	Breaking Strength (kN)	Wiredia, dw (mm)	Wd (kN)	Wb (kN)	Wa (kN)	We (kN)	FOS
1	24	310	1.0738	121.05	21.59	12.11	154.75	2.003
2	25	356	1.1186	121.19	23.43	12.12	156.73	2.27
3	29	447	1.298	121.5	31.54	12.15	165.18	2.706
4	32	554	1.432	121.85	38.39	12.19	172.42	3.21
5	35	671	1.566	121.57	45.92	12.16	179.64	3.74
6	38	798	1.7	121.7	54.12	12.17	187.99	4.25

If the diameter of the rope increases, as direct load, bending load, acceleration load and effective load also increases. For example, if we increase the diameter of the rope from 24 mm to 25 mm, then the load capacities will be increased slightly. In that way, we analyze how the different loads are varied when the wire rope diameters increases and the results are presented in Fig. 1.

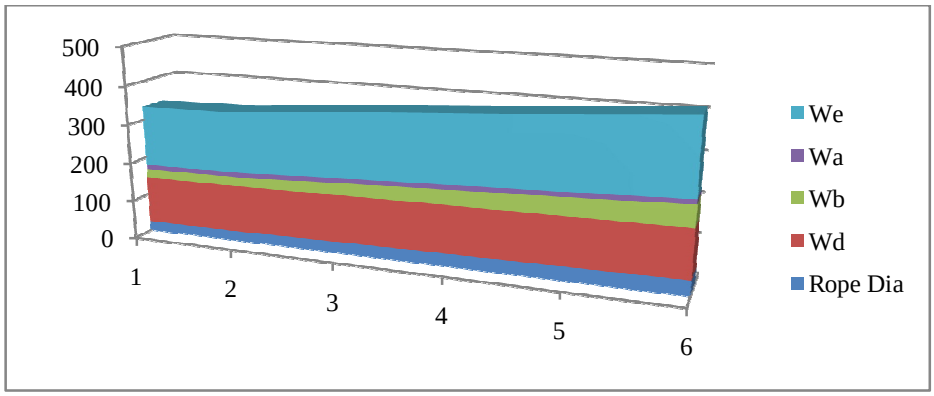

Figure 1: Influence of diameter on different load.

5. Conclusion

The design calculation show that the load carrying capacity of the crane increases when the diameter of the wire rope increases. Hence it is clear that the dimensions of the wire rope influence the load carrying capacity of the crane.

Reference

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