KTH Mekanik

Göran Karlsson

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5C1106 Tillämpad fysik, mekanik, 4 poäng (6 ECTS)

Projekt: Lyftkranar

Cranes have long been used to assist humans in building structures. For example, the Ancient Egyptians, Greeks, and Romans created cranes with which to build bridges and statues. The first mobile cranes, made of wood and iron, were invented so that military personnel could get over large walls without having to climb them, as shown in Fig. 1(*a*).

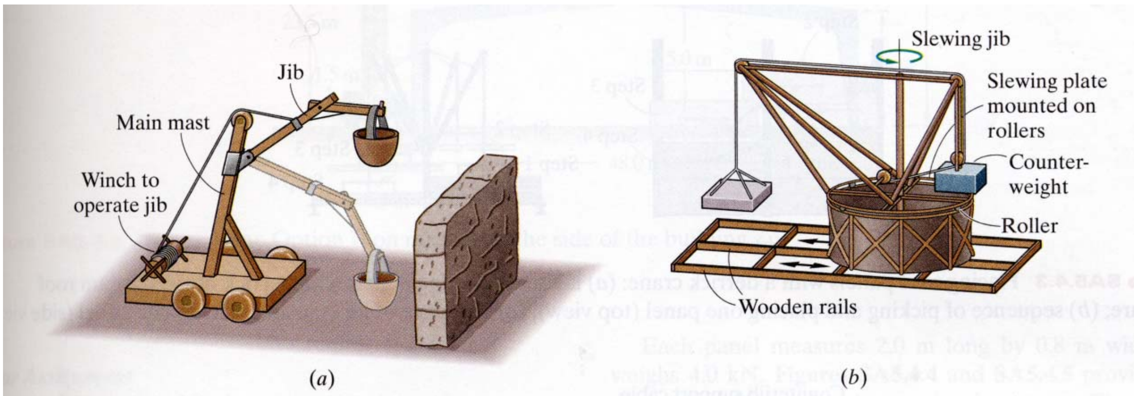

Fig. 1. Early engineered cranes for military construction made of wood and iron: (*a*) first mobile cranes in 15th century; (*b*) da Vinci's firs real slowing crane with counterweight.

The Italian Leonardo da Vinci (1452-1519) was extremely interested in cranes and helped advance the technology from simple tower cranes to large semi-mobile slewing cranes, all still built out of lumber and iron, as shown in Fig. 1(*b*). The rollers on which the slewing plane moved increased the productivity of those types of cranes dramatically – the cycle time for one lift was shortened due to the easy rotation of the jib around the main mast (=slewing).

The invention of steel, wire rope, and steam engines during the middle of the 19th century did much to advance transportation systems (*e.g.* canals, railways, harbors) and the construction technologies used to create these systems. In particular, the invention of wire rope in 1834 (also known as cable) and steam engines enabled the design of cranes with larger load capacities and increased mobility.

Reynolds Coliseum is a 12,400-seat multi-purpose arena in Raleigh, North Carolina. The arena opened in 1949. It is home to the North Carolina State University Wolfpack women's basketball team. At the time Reynolds Coliseum was constructed in 1949, derrick cranes were in use. The roof of the building includes heavy precast concrete panels placed on top of the steel beams that span the large open interior space, as shown in Fig. 2.

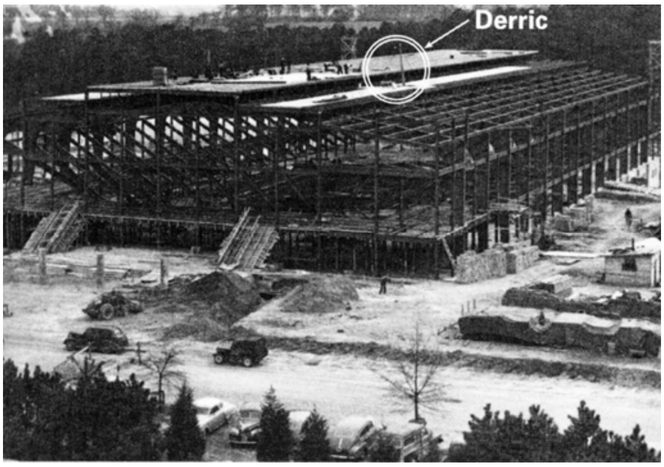

Fig. 2. Placement on concrete panels with help of two derricks on March 17, 1949.

The panels were hoisted from the ground and then stored on the center section of the roof before being placed one by one onto the beams by one of the two derrick cranes. Fig. 3 illustrates the basic elements and operation of the derrick crane. The placing sequence of each of the 4.0 kN precast concrete panels consisted of the following four steps: (1) hooking the panel to the spreader bar of the crane, (2) hoisting to the proper height and the start of slewing, (3) slewing and (4) luffing of the jib (changing the boom angle) and placing the panel at the proper location..

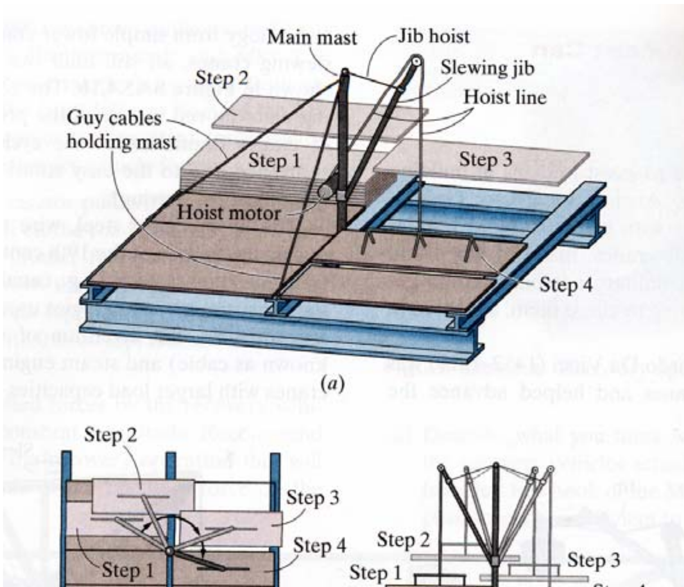

Fig. 3. Placing roof panels with a derrick crane:
(*a*) layout of placing panels with derrick onto coliseum roof structure;
(*b*) sequence of picking and placing one panel (top view);
(*c*) sequence of picking and placing one panel (side view).

Construction technology has further evolved since 1949. One example is the emergence of the tower crane presented in Fig. 4.

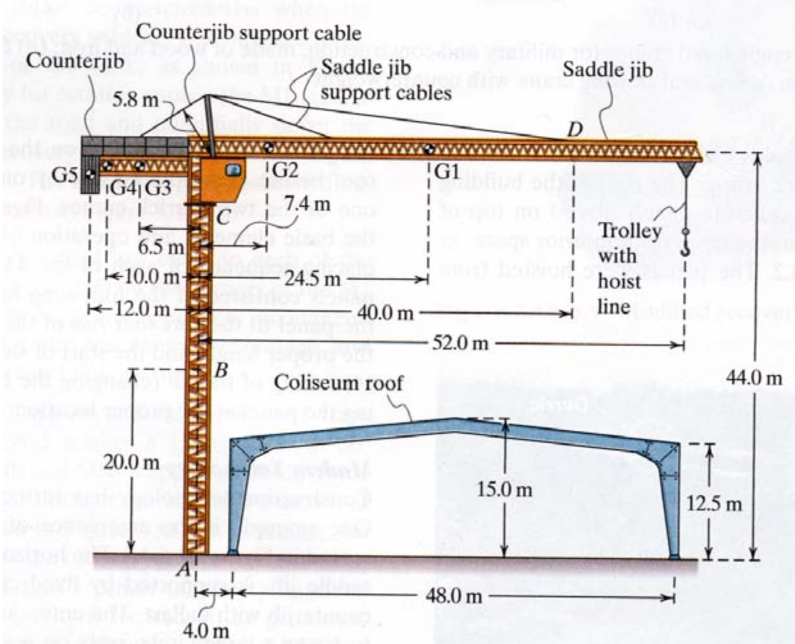

Fig. 4. Layout for placing concrete panels with fixed tower crane (Option A).

The horizontal jib, is supported by fixed cables that tie into the counterjib with ballast. The entire saddle jib, which is able to cover a large circle, rests on a slewing ring, located at *C*, sits atop a fixed tower that has the capabilities to climb higher as the building grows. This economical design became very popular in the 1960s in Europe for the construction of apartment building in tight spaces. This tower crane design has since spread all over the world.

<u>Assignment</u>

Assume now that you are hired as a summer intern by a company that won a contract to replace all the concrete panels on the Reynolds Coliseum. Your knowledge of moments is critical for the assignment. Your boss needs your help in deciding which crane arrangement he should select. He wants you to compare two crane setups, Option A (Fig. 4) and Option B (Fig. 5).

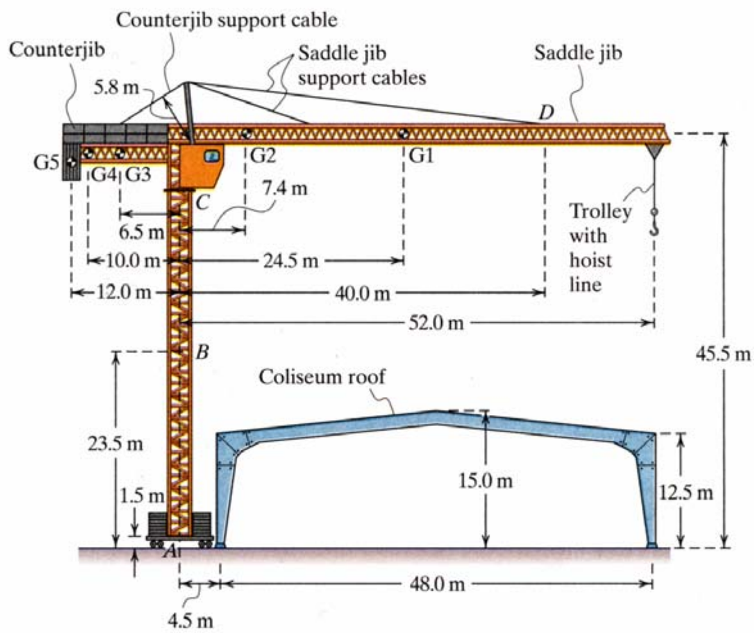

Fig. 5. Tower crane Option B on rails along the side of the building.

Each panel measures 2,0 m long by 0,8 m wide and weighs 4,0 kN. Figs. 4 and 5 provide the dimensions for each crane option in meters. The allowable, or rated, loading is smaller than the theoretical lifting capacity by a safety factor to allow for unforeseen conditions and imperfections in real-world components and materials. The rated loadings at 52.0 m (end of the saddle jib) are 6.0 kN for Option A and 4.0 kN for Option B. Additional data for both cranes can be found in the Table below.

		Option A Rated 6,0 kN at 52,0 m	Option B Rated 4,0 kN at 52,0 m
Label	Crane Element	Weight of Element (kN)	Weight of Element (kN)
G1	Saddle jib center of gravity	18,0	12,0
G2	Jib support cables center of gravity	9,4	6,3
G3	Counterjib center of gravity	17,1	11,3
G4	Counterjib winches and cables center of gravity	6,5	4,3
G5	Ballast center of gravity	45,0	30

Your boss would like to know which crane option he should use, considering that the building is approximately 98,0 m long. Since you are new to this job he promises that he can provide you with a step-by-step guideline on how to tackle this kind of problem. However, at present he does not have time to give you this guideline, but expects you to start on your own and then turn to him when you need the it.

(Problem and figures from Sheppard-Tongue: Statics. Analysis and Design of Systems in Equilibrium. John Wiley Sons, Inc., 2005.)