CHAPTER II

LITERATURE REVIEW

2.1. Tower Crane Productivity

The erection of a high-rise building usually involves tower cranes to lift various components, including prefabricated elements, steel beams, ready-mixed concrete, and large-panel formwork. The selection of tower cranes and their appropriate positioning can significantly affect the costs and overall productivity of the construction operation (Hasan et al. 2013; Tam and Tong 2003).

A great deal of research has been centered on identifying the optimal location of tower cranes and material supply points on the construction site to minimize the costs of lifting operations (Lien and Cheng 2014; Tam et al. 2001; Huang et al. 2011). The demand points on a construction site are usually dictated by the location and shape of the building. The tower crane location determines the travel time of materials between the supply and demand points and thus the operating costs.

However, apart from the horizontal movement of materials considered, the tower crane and material-supply-point location optimization problem should additionally account for the vertical displacement due to vertical hook movement (Lien and Cheng 2014). Minimizing the operation time of the tower crane, which directly affects its operating costs, has been extensively studied in the literature. Zhang et al. developed an analytical model that considered tower crane hooks' travel

time and adopted a Monte Carlo simulation to optimize tower crane location (Zhang et al. 1999).

Moussavi et al. have researched Location Optimization of Tower Crane with a developed model on a residential project. Come out with the result, a 31.9% reduction in the total costs (Moussavi et al. 2017).

2.2. Tower Crane Location Model

Crane lift capacity is determined from a radius-load curve where the greater the load, the smaller the crane's operating radius. Assuming a load at the supply point (S), its corresponding crane radius is r. Therefore, a crane is unable to lift a load unless it is located within a circle with radius r [Picture 2.1(a)]. To deliver a load from (S) to demand point (D), the crane has to be positioned within an elliptical area enclosed by two circles, shown in [Picture 2.1(b)]. This is called a feasible task area. The area's size is related to the distance between S and D, the weight of the load, and crane capacity. The larger the feasible area, the more easily the task can be handled (Zhang et al. 1999).

Three geometric relationships exist for any two feasible task areas, as illustrated in Picture 2.2; namely, (a) one fully enclosed by another (tasks 1 and 2); (b) two areas partly intersected (tasks 1 and 3); (c) two areas separated (tasks 2 and 3). As indicated in cases (a) and (b), by being located in area A, a crane can handle both tasks 1 and 2, and similarly, within B, tasks 1 and 3. However, case (c) shows that tasks 2 and 3 are so far from each other that a single tower crane is unable to handle both without moving location, so more than one crane or greater lifting

capacity is required. The closeness of tasks can be measured by the size of the overlapping area, e.g., task 2 is closer to task 1 than task 3 because the overlapping area between tasks 1 and 2 is larger than that for 1 and 3. This concept can be extended to measure the closeness of a task to a task group. For example, area C in picture 2..2(b) is a feasible area of a task group consisting of three tasks, where task 5 is said to be closer to the task group than task 4 since the overlapping area between C and D is larger than that between C and E. If task 5 is added to the group, the feasible area of the new group would be D, shown in Figure 2.2.(c). (Zhang et al. 1999)

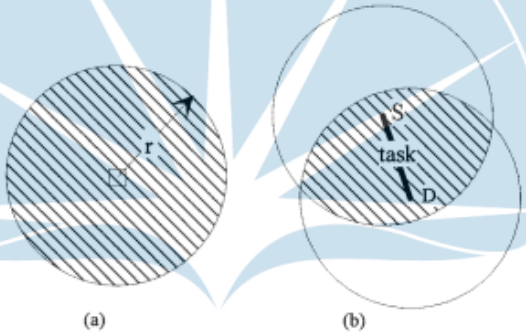

Figure 2.1 Feasible Area of Crane Location for Task

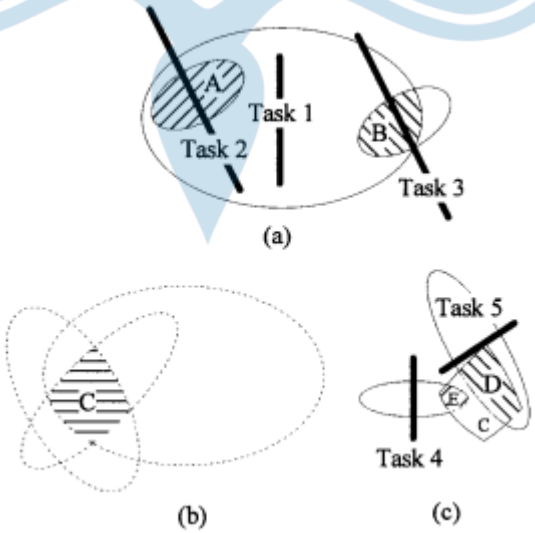

Figure 2.2 Task “Closeness”

2.3. Type of Tower Crane

Tower Crane has many models that are adapted to the conditions project. There are four types of Tower Crane (Chudley, 2004) :

1. Self Supporting Static Tower Crane

These cranes generally have a greater lifting capacity than other types of crane. The mast of the self-supporting tower crane must be firmly anchored at ground level to a concrete base with holding-down bolts or a special mast base section cast into a foundation. They are particularly suitable for confined sites and should be positioned in front or to one side of the proposed building with a jib of sufficient length to give overall coverage of the new structure. Generally, these cranes have a static tower, but types with a rotating or slewing tower and luffing jib are also available. The details and overview of this crane can be seen in figure 2.3.

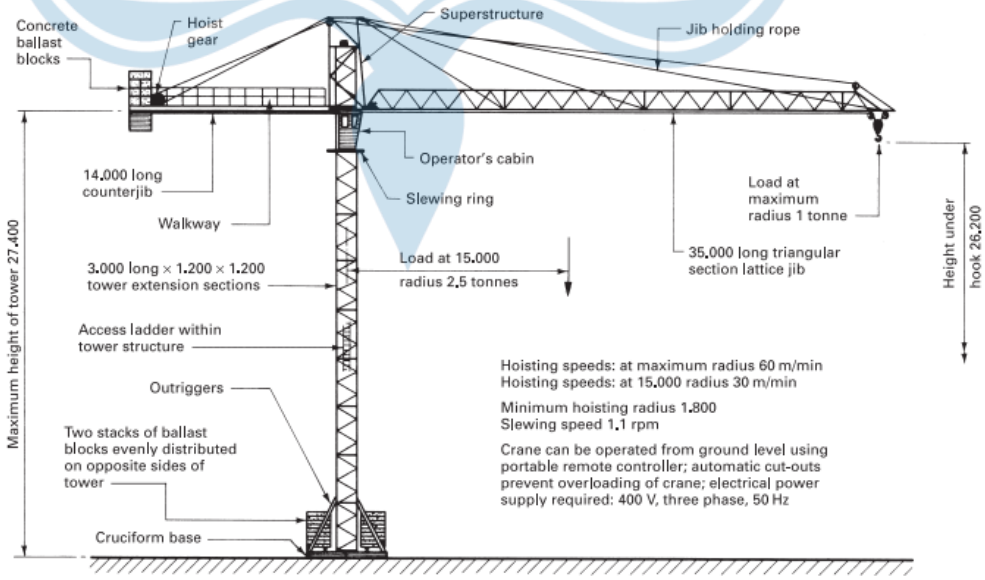

Figure 2.3 Self Supporting Static Tower Crane

(source: Chudley, 2004)

2. Supported Static Tower Crane

These are similar in construction to self-supporting tower cranes but are used for lifting to a height over that possible with self-supporting or traveling tower cranes. The tower or mast is fixed or tied to the structure using single or double steel stays to provide the required stability. This tying back will induce stresses in the supporting structure, which must therefore be of adequate strength. Supported tower cranes usually have horizontal jibs because a luffing jib mast's rotation renders it unsuitable for this application. The details are as shown in figure 2.4 completely.

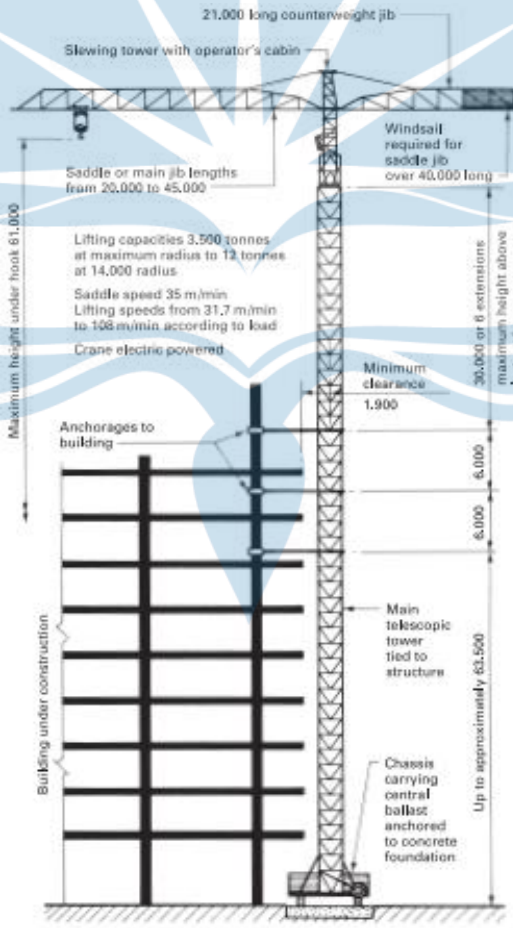

Figure 2.4 Supported Static Tower Crane

(source: Chudley, 2004)

3. Traveling Tower Crane

To obtain better site coverage with a tower crane, a rail-mounted or traveling crane could be used. The crane travels on heavy wheeled bogies mounted on a wide-gauge (4.200 m) rail track with gradients not exceeding 1 in 200 and curves not less than 11.000 m radius depending on mast height. The base for the railway track sleepers must be accurately prepared, well-drained, regularly inspected, and maintained if the stability of the crane is to be ensured. The motive power is electricity, the supply of which should be attached to a spring-loaded drum, which will draw in the cable as the crane reverses to reduce the risk of the cable becoming cut or trapped by the wheeled bogies. Traveling cranes can be supplied with similar lifting capacities and jib arrangements as given for static cranes. The complete details and overview of this crane can be seen in figure 2.5.

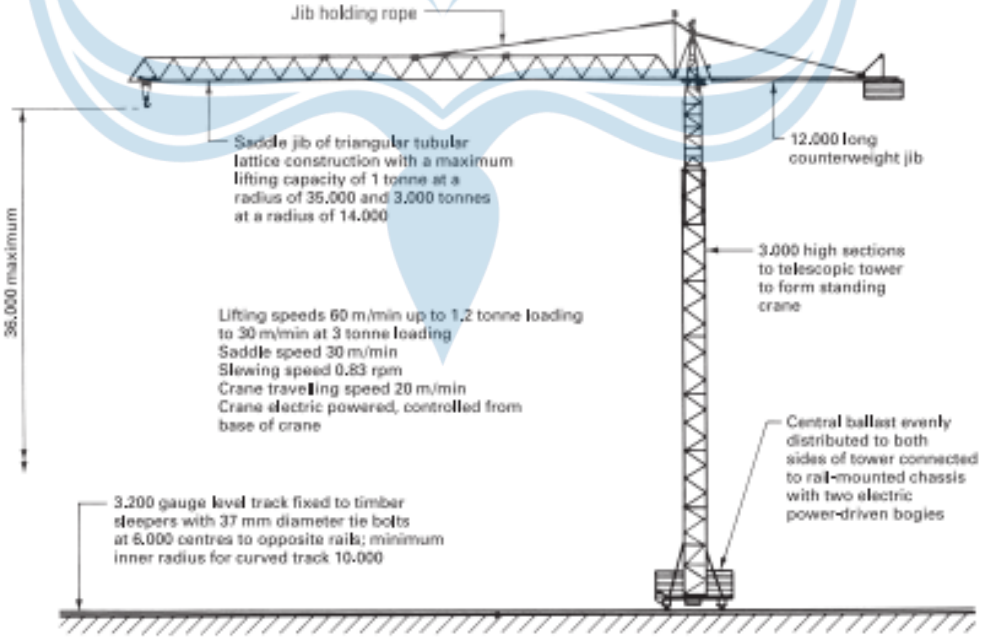

Figure 2.5 Traveling Tower Crane

(source: Chudley, 2004)

4. Climbing Cranes

These are designed for tall buildings, being located within and supported by the structure under construction. The mast, which extends down through several stories, requires only a small (1.500 to 2.000 m square) opening on each floor. Support is given at floor levels by special steel collars, frames, and wedges. The raising of the static mast is carried out using a winch that is an integral part of the system. Generally, this form of the crane requires a smaller horizontal or luffing jib to cover the construction area than a static or similar tower crane. The jib is made from small, easy-to-handle sections, which are lowered down the face of the building, when the crane is no longer required, through a special winch attached to one section of the crane. The winch is finally lowered to ground level by hand when the crane has been dismantled. Figure 2.6 show the details and overview about this crane completely.

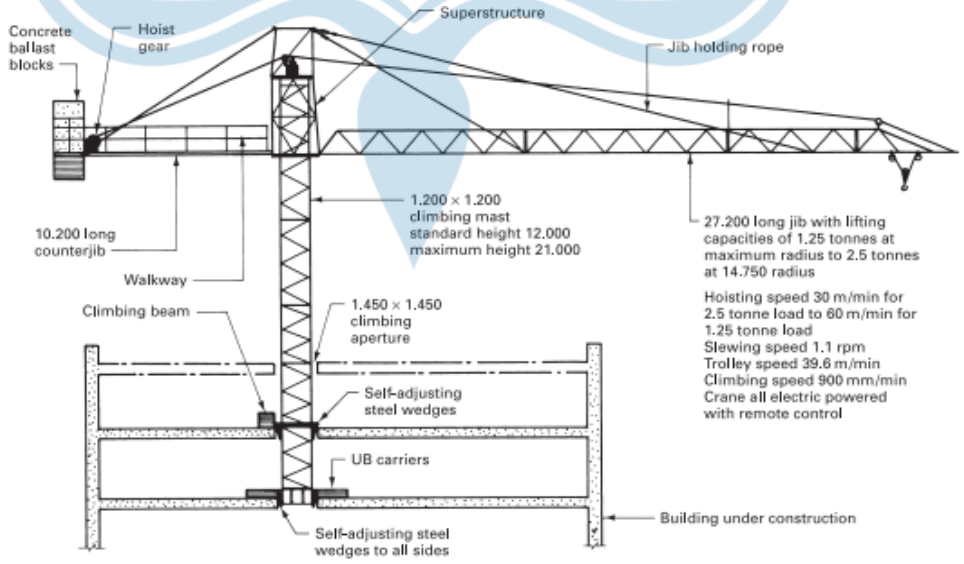

Figure 2.6 Climbing Tower Cranes

(source: Chudley, 2004)

2.4. Part of Tower Crane

The parts of tower crane are shown in picture 2.7, the detail as follows:

1. Jib

A jib is the longest part and can rotate by 360 ° with a function to lift the material.

2. Counter Jib

The extension part of the jib to maintain the jib stay balance, usually installed with the counterweight.

3. Counter Weight

Made of concrete installed on the counter jib to maintain jib balance.

4. Pendant/Tie rod

The wire that hold the jib in a 90^{o} condition with the tower.

5. Cat Head

Center of cable ties from jib and counter jib. It is located on the top of the TC.

6. Trolley

Horizontal movement machine along the jib.

7. Hook

Transported material is attached to the hook.

8. Operator Cabin

The control room of Tower Crane.

9. Slewing Ring

Provide the slewing ability for TC

10. Hydraulic Climbing Cage

It will be used during the mast installation.

11. Mast

Part of TC tower to increase the TC height.

12. Base

The reinforcement of the tower crane foundation made of large concrete.

2.5. Tower Crane Mechanism Movement

The Mechanism movement can be seen in figure 2.7, with the detail as follows.

1. Hoisting

Hoisting is a horizontal movement mechanism used when lifting and lowering the material load.

2. Trolleying

Trolleying is the horizontal movement mechanism of the trolley along the jib.

3. Slewing

Slewing is the rotation movement mechanism of the tower crane.

4. Traveling

Traveling is a Movement mechanism of a tower crane on fixed rail, especially on Travelling Tower Crane.

5. Luffing

Luffing is a horizontal jib movement. The jib can move more than 90^{o}.

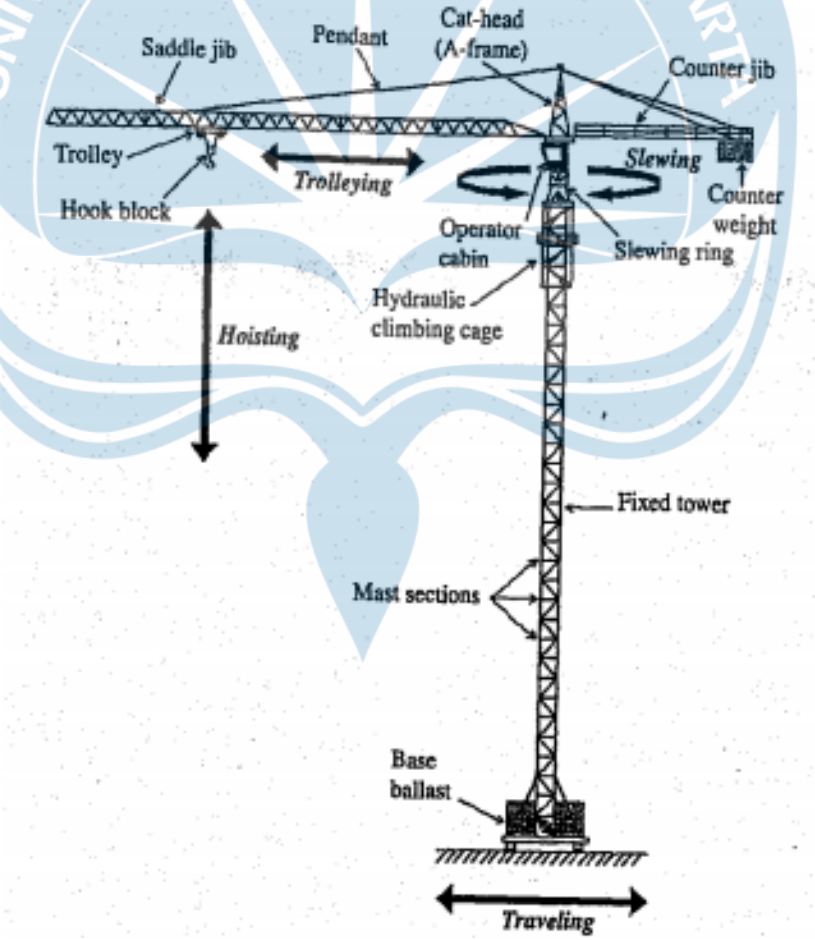

Figure 2.7 Tower Crane Mechanics

(Source: Peurifoy, 2006)