**Experiment 1: STATICS LAB**

**STATIC EQUILIBRIUM AT A POINT: THE WALL JIB CRANE**

**BACKGROUND:** A crane is a type of machine, generally equipped with a hoist rope, wire ropes or chains, and sheaves, that can be used both to lift and lower materials and to move them horizontally. It is mainly used for lifting heavy things and transporting them to other places. The device uses one or more simple machines to create mechanical advantage and thus move loads beyond the normal capability of a human. Cranes are commonly employed in the transport industry for the loading and unloading of freight, in the construction industry for the movement of materials, and in the manufacturing industry for the assembling of heavy equipment.

The first known construction cranes were invented by the Ancient Greeks and were powered by men or beasts of burden, such as donkeys. These cranes were used for the construction of tall buildings. Larger cranes were later developed, employing the use of human treadwheels, permitting the lifting of heavier weights. In the High Middle Ages, harbor cranes were introduced to load and unload ships and assist with their construction – some were built into stone towers for extra strength and stability. The earliest cranes were constructed from wood, but cast iron, iron and steel took over with the coming of the Industrial Revolution.

For many centuries, power was supplied by the physical exertion of men or animals, although hoists in watermills and windmills could be driven by the harnessed natural power. The first 'mechanical' power was provided by steam engines, the earliest steam crane being introduced in the 18th or 19th century, with many remaining in use well into the late 20th century. Modern cranes usually use internal combustion engines or electric motors and hydraulic systems to provide a much greater lifting capability than was previously possible, although manual cranes are still utilized where the provision of power would be uneconomic.

Cranes exist in an enormous variety of forms – each tailored to a specific use. Sizes range from the smallest jib cranes, used inside workshops, to the tallest tower cranes, used for constructing high buildings. Mini-cranes are also used for constructing high buildings, in order to facilitate constructions by reaching tight spaces. Finally, we can find larger floating cranes, generally used to build oil rigs and salvage sunken ships.

Some lifting machines do not strictly fit the above definition of a crane, but are generally known as cranes, such as stacker cranes and loader cranes.

**Types of Crane:** Jib- A jib crane is a type of crane where a horizontal member (jib or boom), supporting a moveable hoist, is fixed to a wall or to a floor-mounted pillar. Jib cranes are used in industrial premises and on military vehicles. The jib may swing through an arc, to give additional lateral movement, or be fixed. Similar cranes, often known simply as hoists, were fitted on the top floor of warehouse buildings to enable goods to be lifted to all floors.

Bulk-Handling Crane- Bulk-handling cranes are designed from the outset to carry a shell grab or bucket, rather than using a hook and a sling. They are used for bulk cargoes, such as coal, minerals, scrap metal etc.

Loader Crane Using A Jib Extension- A loader crane (also called a knuckle-boom crane or articulating crane) is an electrically powered articulated arm fitted to a truck or trailer, and is used for loading/unloading the vehicle.

Stacker Crane- A crane with a forklift type mechanism used in automated (computer controlled) warehouses (known as an automated storage and retrieval system (AS/RS)).

**Components:** Tower cranes are used extensively in construction and other industry to hoist and move materials. There are many types of tower cranes. Although they are different in type, the main parts are the same, as follows:

Mast: the main supporting tower of the crane. It is made of steel trussed sections that are connected together during installation (same purpose with the wall frame used in this experiment).

Slewing unit: the slewing unit sits at the top of the mast. This is the engine that enables the crane to rotate.

Operating cabin: on most tower cranes the operating cabin sits just above the slewing unit. It contains the operating controls, load-movement indicator system (LMI), scale, anemometer, etc.

Jib: the jib, or operating arm, extends horizontally from the crane. A "luffing" jib is able to move up and down; a fixed jib has a rolling trolley that runs along the underside to move goods horizontally.

Counter jib (The same with the tie used in this experiment): holds counterweights, hoist motor, hoist drum and the electronics.

Hoist winch: the hoist winch assembly consists of the hoist winch itself (motor, gearbox, hoist drum, hoist rope, and brakes), the hoist motor controller, and supporting components such as the platform. Many tower cranes have transmissions with two or more speeds.

Hook (or Hanger): the hook (or Hanger) is used to connect the material (Load) to the crane. It is suspended from the hoist rope either at the tip, for luffing jib cranes, or in the hoist rope belly underneath the trolley for hammerhead cranes.

Hoist rope (String): holds the Hook (or Hanger) that connects the material (Load) to the crane.

Weights: Large concrete counterweights are mounted toward the rear of the counter deck, to compensate for the weight of the goods lifted (the tie has a spring balance which is fixed at fixed to the wall frame and measure the force acting on the tie).

**Mechanical Principles:** There are three major considerations in the design of cranes. First, the crane must be able to lift the weight of the load; second, the crane must not topple; third, the crane must not rupture.

STABILITY: For stability, the sum of all moments about the base of the crane must be close to zero so that the crane does not overturn. In practice, the magnitude of load that is permitted to be lifted (called the "rated load" in the US) is some value less than the load that will cause the crane to tip, thus providing a safety margin. For stationary pedestal or kingpost mounted cranes, the moment created by the boom, jib, and load is resisted by the pedestal base or kingpost. Stress within the base must be less than the yield stress of the material or the crane will fail.

**Efficiency Increase Of Cranes:** Lifetime of existing cranes made of welded metal structures can often be extended for many years by after-treatment of welding. During development of cranes, load level (lifting load) can be significantly increased by taking into account the IIW recommendations (the International Institute of Welding Technology IIW published the Guideline "Recommendations for the HFMI Treatment" in 2016) leads in most cases to an increase of the permissible lifting load and thus to an efficiency increase.

**AIM OF STUDY**: To validate the law of static equilibrium at a point.

**LABORATORY EQUIPMENT:** The experimental wall jib crane is as annotated. Changing the load in the hanger changes the static condition of the wall jib crane. The static conditions are read from the balances. The loads are known.

**EXPERIMENTAL PROCEDURE:** The top of the wall frame is marked OT, THE BOTTOM of the wall frame is marked OB and the attachment of the string to the frame is marked OS then OSOT = 24.50cm and OTOB = 44.60cm. Various loads are placed on the hanger, the forces on the jib and tie were recorded at each loading and the lengths of the jib, tie, and string are measured at each loading.

**RESULTS AND CALCULATIONS:** OSOT = 24.50cm and OTOB = 44.60cm

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| FW (g) | FJ, exp (N) | FT,exp (g) | LJ (cm) | LT (cm) | LS (cm) | θJ  (°) | θT  (°) | θS  (°) | FJ,theo [N] | FT,theo [N] |
| 0 | 0 | 0 | 53.4 | 59.5 | 52.0 | 75.11 | 60.48 | 97.05 | 0 | 0 |
| 300 | 6.0 | 350 | 52.2 | 60.0 | 52.2 | 78.89 | 59.87 | 101.09 | 5.3187 | 4.3933 |
| 500 | 10.0 | 550 | 52.0 | 60.2 | 52.3 | 79.72 | 59.68 | 101.94 | 8.8844 | 7.1993 |
| 700 | 12.0 | 700 | 51.9 | 60.5 | 52.3 | 79.99 | 59.03 | 102.23 | 12.3450 | 9.9081 |
| 900 | 16.0 | 850 | 51.8 | 60.7 | 52.3 | 80.26 | 58.60 | 102.51 | 15.8032 | 12.5805 |
| 1400 | 24.0 | 1300 | 51.3 | 61.3 | 52.4 | 81.91 | 57.53 | 104.22 | 24.4390 | 18.6596 |
| 1900 | 32.0 | 1700 | 51.0 | 62.0 | 52.5 | 83.02 | 56.24 | 105.35 | 32.7701 | 24.1958 |
| 2400 | 40.0 | 2150 | 50.5 | 62.7 | 52.7 | 84.99 | 55.17 | 107.32 | 41.2319 | 28.7805 |
| 2900 | 48.0 | 2600 | 50.0 | 63.3 | 52.8 | 86.68 | 54.08 | 109.01 | 49.5130 | 32.7425 |
| 3400 | 54.0 | 3000 | 49.7 | 64.0 | 53.0 | 88.12 | 52.99 | 110.39 | 57.6298 | 36.2388 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| FW (N) | FJ, exp (N) | FJ,theo [N] | FT,exp (N) | FT,theo [N] | %Error J [%] | %ErrorT [%] | %J[%] | %T [%] |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2.94 | 6.0 | 5.3187 | 3.4342 | 4.3933 | -12.81 | 21.83 | 12.81 | 21.83 |
| 4.91 | 10.0 | 8.8844 | 5.3966 | 7.1993 | -12.56 | 25.04 | 12.56 | 25.04 |
| 6.87 | 12.0 | 12.3450 | 6.8684 | 9.9081 | 2.79 | 30.68 | 2.79 | 30.68 |
| 8.83 | 16.0 | 15.8032 | 8.3402 | 12.5805 | -1.25 | 33.71 | 1.25 | 33.71 |
| 13.74 | 24.0 | 24.4390 | 12.7556 | 18.6596 | 1.80 | 31.64 | 1.80 | 31.64 |
| 18.64 | 32.0 | 32.7701 | 16.6804 | 24.1958 | 2.35 | 31.06 | 2.35 | 31.06 |
| 23.55 | 40.0 | 41.2319 | 21.0958 | 28.7805 | 2.99 | 26.70 | 2.99 | 26.70 |
| 28.45 | 48.0 | 49.5130 | 25.5112 | 32.7425 | 3.06 | 22.09 | 3.06 | 22.09 |
| 33.35 | 54.0 | 57.6298 | 29.4360 | 36.2388 | 6.30 | 18.77 | 6.30 | 18.77 |
|  |  |  |  | MPE = | -0.733 | 24.152 | ------ | ------ |
|  |  |  |  | |MPE| = | ------ | ------ | 4.591 | 24.152 |

**OBSERVATIONS:**

**Reason for Inconsistency:**

**PRECAUTIONS:**

1. I ensured that the wall jib crane apparatus is in good working condition.
2. I avoided error due to parallax when taking my readings from the meter rule and spring balance.
3. I avoided air resistance while carrying out the experiment.

**CONCLUSION**