VERTICAL MOVING BRIDGE BY WATER AND COUNTERWEIGHT MECHANISM

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ABSTRACT

The history of lifting heavy objects vertically goes back to the five thousand years ago, at the time of great pyramid of chops at Giza. This research is based on Kattwyk Bridge, and it has been attempted to show that movable bridges can work with water and counterweights and their energy consumption can be reduced because of water pump usage instead of powerful gear mechanism. Water, a tank, counterweights and water pump operates this bridge prototype In this type, an interior span of bridge that remains horizontal s it is raised up and down like an elevator, allowing river traffic to pass beneath the bridge structure. The Bridge mechanism has been divided in three sections. The central section lifts above, while the two side parts remain intact with the bridge supporting frame. The lift mechanism used for the bridge is based on the balance beam with pulley system involving four pulleys and counter weight arrangements. Movable part of bridge section is connected to counter weight on each side using a wire rope string passing over pulley mounted above fixed structure. Track guides wheels mounted on movable section of bridge restrict the motion of central section allowing only the motion only in vertical direction to occur and provide the stability to the bridge structure. The mechanism used to lift the central section by difference of weight is due to the constraint of not using any electric motor or gears but using water for lifting the bridge. In real case situation, the power can be given by electric motors and cables can be used.

Keyword: - *Vertical Bridge lifting, counterweight mass, energy saver, omitted gear mechanism; water and D.C. Water pump etc….*

1. INTRODUCTION

Movable bridges have proved to be an economical solution to the problem of how to carry a rail line or highway across an active waterway. In most instances, marine craft have priority, and the movable span must open to marine traffic upon demand. This precedence is reflected in the terms closed and open, used to describe the position of the movable span. A ‘closed’ movable bridge has closed the waterway to marine traffic, while an ‘open’ bridge has opened the waterway to marine traffic. Highway bridges are typically designed to remain in the closed position and only to be opened when required by marine traffic. However, movable railroad bridges can be designed to remain in either the open or closed position, depending on how frequently they are used by train traffic. They cost less to build for longer moveable spans. The counterweights in a vertical lift are only required to be greater the weight of the deck. Thus heavier materials can be used in the deck, and so this type of bridge is especially suited for heavy railroad use. It is also more energy efficient, requiring comparatively less power to lift the bridge. The project is a prototype of such a bridge and utilizes a rope drive mechanism to lift the middle span of the bridge. Modern bascule bridges use powerful gear motor and gear to lift the movable span. So they use a large amount of energy to rotate the gears, which causes the operation of bridge. In the present research it has been attempted to show that water and counterweight operated bridge could have low energy consumption because of water pump usage instead of the powerful gear motors of the present day movable bridge which has more energy consumption. Hence we can diminish the power by using water pumps instead of an electric motor in the movable bridges. The discussion of this study explains fully the dynamic simulation and physics of this movable bridge.

1.1 Problem Statement

Movable bridges are unique structures from the perspective that they represent the integration of conventional structural components with mechanical systems and electrical power and control systems. These structures are also different from most highway bridges in that they actively facilitate the flow of both vehicular and waterborne traffic. The operation of a movable bridge, and hence its serviceability, can be disrupted or completely compromised by performance problems and failures with any of the mechanical and electrical systems or the structural components. Movable bridges are advantageous in that the vertical clearance requirement for these structures is minimal; however, there are several drawbacks associated with this bridge type. Firstly, movable bridges are located over navigable waterways that are often situated in coastal areas. Coastal areas represent especially harsh environments for bridges, and this increases the risk of corrosion damage to the different bridge components. Secondly, the repetitive movements associated with opening and closing of the structure leads to wearing and deterioration of the bridge's various mechanical systems. The repeated motions involved in opening and closing of the bridge can also lead to large stress cycles and stress reversals, which in turn can lead to fatigue problems. Maintenance and performance monitoring of movable bridges is often more essential and justified than for fixed bridges given their dual service role and the potential for deterioration and other problems with the integrated systems that are essential for ensuring their operation and safety

1.2 Scope of the work

It is attempt to show that water operated bridge mechanism could have low energy consumption instead of powerful gear mechanism of the present days conventional movable bridges which has more energy consumption. The project was undertaken to reduce large capital cost of construction of movable bridges and the large maintenance cost. They cost less to build for longer movable span .The counter weights in vertical lift are only required to be greater the weight of deck .Thus heavier materials can be used in deck, and so this type of bridge is especially suited for heavy rail road and highway use. This attempt is applied where, we face Natural River while travelling, therefore from both point view i. e waterway and roadway transportation can easily achieved. As working mechanism of model is mostly based upon on non-conventional energy resource i. e water hence, beside power consumption there is less use of conventional sources**.**

2. COMPONENTS USED

The components used are given below. They are:

Table-2.1: components and its specifications

COMPONENTS	SPECIFICATION
BRIDGE FRAME	● GCI15, ● Tensile strength -150N/mm^2
WIRE-ROPE	● Nylon Modulus of elasticity = 3.9 x 103 Mpa ● Density = 1140 Kg/m3 ● Ultimate tensile strength = 616 Mpa
PULLEY	● Teflon ● Wear resistant, unreactive, ● Melting point-327°c.
WATER TANK	● Polypropylene ● Melting temperature-164°c. ● Low density, heat resistant, chemical inertness
WATER PUMP	D.C. Pump

3. SELECTION OF MATERIALS

3.1 Bridge Frame

3.1.1 Design parameters

- Area of frame = 900×300 mm^2
- Total load on frame is about 20kg

- $F = 20 \times 9.81$
- $= 196.2$ N

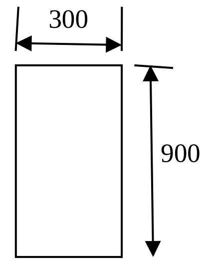


Fig. 3.1 Bridge Frame

This load is applied at the Centre as shown in fig 3.2.

The force is resolved in two reactions R1 and R2

$R1 + R2 = F$ ………………………….(1)

Taking moment at R1

$\Sigma M_{R1} = 0$

$F \times 450 - R2 \times 900 = 0$

$196.2 \times 450 - R2 \times 900 = 0$

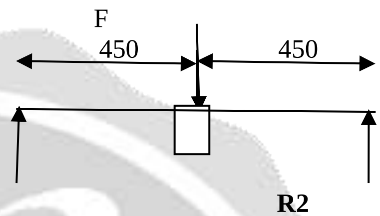


Fig. 3.2 Load Diagram

$R2 = 98.1$ N

Substituting the R2 value in equation (1)

$R1 + 98.1 = 196.1$

$R1 = 98.1$ N

Taking moment at b,

$M_b = 98.1 \times 450$

$M_b = 44145$ N-mm

Distance of extreme fibre,

$Y = b/2$ ……………………..(b = width of angle or pipe use for frame)

$= 25/2$

$= 12.5$ mm

Moment of Inertia

$I = bd^3 / 12$

$= d^4 / 12$

$= (25)^4 / 12$

$= 32552$ mm^4

Stress on frame,

$\sigma = M_b\, y / I$

$\sigma = (44145 \times 12.5) / 32552$

$\sigma = 16$ N / mm^2

$\sigma = S_{yt}$ / F.O.S

Therefore,

$S_{yt} = \sigma \times$ F.O.S

$= 16 \times 5$ …………… (Assuming F.O.S = 5)

$= 80$ N / mm^2

Selecting material GCI 15 having Tensile strength (min) = 150 N / mm^2

3.2 Wire-ropes

When power is to be transmitted over long distances then belts cannot be used due to the heavy losses in power. In such cases ropes can be used. Ropes are used in elevators, mine hoists, cranes, oil well drilling, aerial conveyors, tramways, haulage devices, lifts and suspension bridges etc. two types of ropes are commonly used. They are fiber ropes and metallic ropes. Fiber ropes are made of Manila, hemp, cotton, jute, nylon, coir etc., and are normally used for transmitting power.

3.3 Pulley

A pulley is also called a sheave or a drum, is a mechanism composed of a wheel on as axle or shaft that may have a groove between two flanges around its circumference. A rope, belt, cable, or chain usually runs over the wheel and inside the groove, if present. Pulleys are used to change the direction of an applied force, transmit rotational motion, or realized a mechanical advantage in either a linear or rotational system of motion. Two or more pulleys together called a block or tackle. The pulley systems are the only simple machines in which the possible values of mechanical advantages are the limited to whole numbers

3.4 Water tank

Polypropylene tanks offers exceptional chemical corrosion resistance, is strong, durable and lightweight. It is compatible with both high and low temperatures and has excellent thermal insulating properties. Polypropylene is also mechanically resilient and ideally suited to environments where accidental impacts can occur from parts handling device.

3.5 Water pump

Taking,

3.5.1 Pump Discharge, for water to be filled water tank

Q = 0.2 liters/s

$Q = 0.2 \times 10^{-3}\ m^3/s$

3.5.2 Power required to operate The Pump:

$P = F \times V$

Where,

V=Velocity of pump

V = Q/A(Pipe)

$V = [0.2 \times 10^{-3} / 11.03 \times 10^{-3}]$

V = 0.018 m/s

3.5.3 Power required to lift water,

$Power = F \times V$

$P = 735.75\ N \times 0.018$

P =14 Watt

This is the power required to lift water

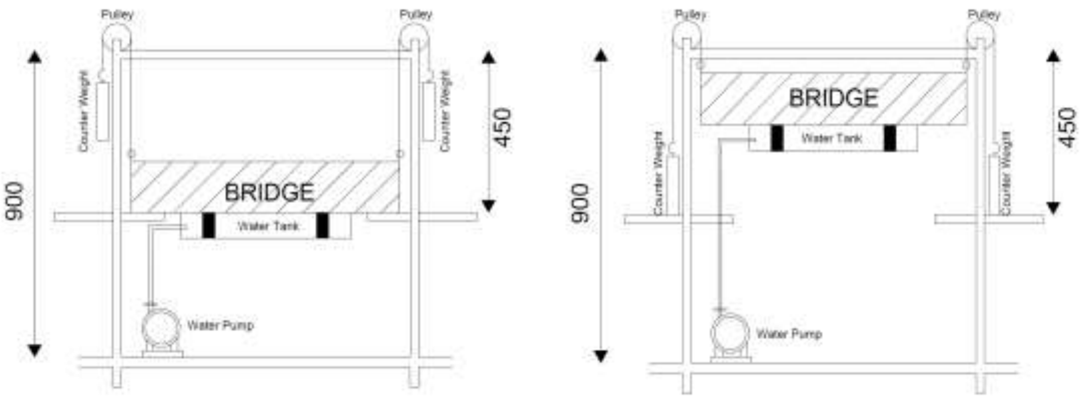
Hence we choose the motor for spring is 12volts 1.2Amp = 15Watt

Same Pump has been used to remove the water from tank.

4. DESIGN

Design consists of application of scientific principle, technical information, and imagination for development of new mechanism to perform specific function with maximum economy and efficiency. Hence careful design approach has to be adopted. The total design work has been split into two parts.

1. System design
2. Mechanical design



(A) Unlifted Bridge **(B) Lifted Bridge**

Source- Author

Fig. 3 Basic Line Diagram of Bridge

4.1 System design

System design is mainly concerns the various physical constraints and ergonomics, space requirements, arrangement of various components on frame at system, man-machine interaction, no. of controls, position of controls, working environments, of maintenance, scope of improvement, weight if machine from ground level, total weight of machine and a lot more. In system design we mainly concentrated on the following parameter:-

4.1.1. System selection based on constraints: - Our machine is used in small-scale so space is major constrain. The system is to be very compact so that it can be adjusted in small space.

4.1.2. Arrangement of various components: - Keeping into view the space restrictions all components should be laid such that their easy removal or servicing is possible. Every possible space is utilized in component arrangements.

4.1.3 Man machine interaction:-Friendliness of machine with the operated that is operating is an important criterion of design.

4.1.4. Chances of failure: - Losses incurred by owner in case of any failure are important criterion of design. Factor of safety while doing design should be kept high so that there are less chances of failure. Moreover periodic maintenance is required to keep unit healthy.

4.1.5. Servicing facility: - Layout of components should be such that easy servicing is possible. Those which require frequent servicing can be easily disassembled.

4.1.6. Scope of future improvement:-Arrangement should be provided in such way that if any changes have to be done for future scope for improving efficiency of machine.

4.1.7. Height of machine elements from ground:- All the elements of the machine should be arranged to the height from where it is simple to operate by operator. Machine should be slightly higher than the waist level, also enough clearance should be provided from the ground for cleaning purpose.

4.1.8Weight of machine:- Total weight depends on the selection of material of all components as well as their dimensions. Higher weight will result in difficulty in transportation; it is difficult to take it to workshop because of more weight.

4.2 Mechanical design:

In mechanical design the components are listed down and stored on the basis of their procurement, design in two categories namely.
1. Designed parts
2. Parts to be purchased

Mechanical design phase is very important from the view of designer as whole success of project depends on the correct design analysis of the problem.

Many preliminary alternatives are eliminated during this phase. Designer should have adequate knowledge about physical properties of material, load stresses and failure. He should identify all internal and external forces acting on machine parts.

These forces may be classified as,
- Dead weight forces
- Friction forces
- Inertia forces
- Centrifugal forces
- Forces generated during power transmission etc.

Designer should estimate these forces very accurately by using design equations. If he does not have sufficient information to estimate them he should make certain practical assumptions based on similar conditions which will almost satisfy the functional needs. Assumptions must always be on the safer side. Selection of factors of safety to find working or design stress is another important step in design of working dimensions of machine elements. The correction in the theoretical stress values are to be made according in the kind of loads, shape of parts & service requirements. Selection of material should be made according to the condition of loading shapes of products environment conditions & desirable properties of material provision should be made to minimize nearly adopting proper lubrications method.

5. CONCLUSIONS

Water operated vertical bridge lifting acquires less consumption of power than that of the conventional type of bridges. It not only eliminates the complicated gear mechanism but also eliminates highly rated electric motors. While transporting, naturally rivers are to be faced, therefore from both point of view i.e. ship and automobile transport bridge to be constructed is as per our project, which would be best solution as power saving. We are confident that our project will not only add a feather to our cap but also it will raise the bar of our knowledge of various sections which are including in the syllabus of our course. It will also enable to the junior friends to carry out experiment successfully.

6. ACKNOWLEDGEMENT

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7. REFERENCES

[1]. Referen I. Berger, D. Healy and M. Tilley. "Movable span bridges study" Volume (2).Page no. (10-22) ce 1

[2].Malvern, L. E., S. Y. Lu and D. A. Jenkins (1982). Handbook of Bascule Bridge Balance.
[3]. Procedures. Project No. 99700-7247, Report submitted to Florida Department of Transportation.
[4]. Saul, R. and Humpf, K. - (Double balance beam bridge – Pro-posal of a new type of bascule bridge). Stahlbau 76 (2007), pp. 559 – 564.
[5] http://bridges.transportation.org/Documents/2015