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Water Operated Vertical Bridge Lifting

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Abstract— This project is a model and a simplified version of Kattwyk Bridge and has been made under the constraints of space, time and resources available. Although good approximations can be made in the development of analytical models. For existing structures, construction tolerances, deterioration of seals, and wear at support points are factors that further alter loading and structural conditions. To ensure that a safe structural design is produced assumptions on loading and structural characteristics can generally be conservative. So that a reliable assessment can be made, it is desirable to identify the unknown quantities (loading, boundary conditions, etc.) with sufficient accuracy. Experimental systems can measure the actual response of a structure subjected to various loading. However, with most systems only a few selected points on a structure can be monitored. An optimum evaluation system would incorporate both analytical and experimental techniques. An analytical model of such a system can be systematically modified until it simulates structural behaviour observed under experimental conditions. We considered the deck and truss of the bridge for analysis because to eliminate the complexity of the project. We considered the bridge as a fixed beam and the load to be a uniformly distributed load and calculated total deformation, maximum stresses and strains.

Index Terms — Vertical lift bridge, Rope drive, Recouvrance, Bascule bridge, Span, Sheave, Teflon, D.C. Pump.

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1 INTRODUCTION

Movable bridges have been an integral part of the U.S. tranportation system, their development being in concert with that of:
(1) The development of the railroads.
(2) The development of our highway system.
While sometimes referred to as draw bridges, 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. It is not surprising to learn that movable bridges are found most commonly in states that have low coastal zones such as California, Florida, Louisiana, and New Jersey, or a large number of inland waterways such as Michigan, Illinois, and Wisconsin Jurisdiction for movable bridges currently lies with the U.S. Coast Guard. 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(s). A “closed” movable bridge has closed the waterway to marine traffic, while an “open” bridge has opened the wterway to marine traffic. Highway bridges are typically dsigned 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. The difference is important as different wind and seismic load design conditions are used to design for a bridge that is usually open vs. one that is usually closed. The first specification for the design of movable bridges was published by the American Railway Engineering Association (AREA) in its 1922 Manual of Railway Engineering.

A vertical-lift bridge or lift bridge is a type of movable bridge in which a span rises vertically while remaining parallel with the deck which ensures passing of ships underneath. 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 mterials can be used in the deck, and so this type of bridge is epcialy suited for heavy railroad use. It is also more energy effcient, requiring comparatively less power to lift the bridge. The prject is a prototype of such a bridge and utilizes a rope drive mechanism to lift the middle span of the bridge.
Among mobile bridges, lifts ones appear as the right answer when relatively long spans are needed. Bascule bridges or rtaing ones are more limited, because of their overhanging decks. In France the existing lift bridge with the longest span is “Recouvrance” Bridge in Brest, with an 87.5 meters lifting span. But most large bridges of this kind are located in New Jersey, USA where many water ways allow maritime traffic. The longest lifting span in the world belongs to Arthur Kill Bridge with 170 meters, no longer in operation.
As it is complicated for complete bridge analysis we consiered the movable section (i.e. deck with truss structure). A subset of the pertinent design specifications that will be needed for this part of the design are given here.
- Length of the movable section: 0.25 m
- Width of the movable section: 0.225m

2 LITERATURE REVIEW

An engineering project is systematic combination of numerous activities carried out by entrepreneurs, organizers, developers, planners, engineers, technicians, workers and many other agencies related with such activities. It is a time bound activty. An engineer plays a very important role in the success of evry project. The success of project depends upon the engineer’s ability, intelligence, hard work and technical knowledge.
P = Planning before carrying out the work.
R = Raw material required for the work.
O = Organization of work.

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J = Joint efforts put together in the work.
E = Estimation of the work.
C = Costing of the work.
T = Techniques used in performing the work.

The first vertical lift bridge designed. This bridge type locates the power on top of the lift truss span. The actual lifting is accomplished using "up-haul and down-haul ropes" where turning drums wind the up-haul (lifting) ropes as they simultaneously unwind the down-haul ropes. Vertical lift bridge machinery is located on top of the lift truss span, and the operating drums rotate to wind the up-haul (lifting) ropes as they simultaneously unwind the down-haul ropes. A variation of this type provides drive pinions at both ends of the lift span which engage racks on the towers. Electronic material submitted is crucial since the content is not recreated, but rather converted into the final published version. [1]

The motive force was supplied by a gasoline engine, which was replaced by a 25-horsepower electric motor. The control machinery is sheltered in a welded framework at mid-span on the north (upstream) side. Reduction gears and winding drums for the cables are located beneath the house. [2]

William Scherzer 1895 (Chicago) - The first rolling lift bridge was designed. The entire moving leaf, including the front arm with the roadway over the channel and the rear arm with the counterweight, rolls away from the channel while the moving leaf rotates open. On this type of bridge, curved tracks are atached to each side of the tail end of the leaf. The horizontal tracks have lugs (or teeth) to mesh with the holes preventing slippage as the leaf rolls back on circular castings whose cetreline of roll is also the centre of gravity of the moving leaf. [3]

Build the simple trunnion bascule bridge in 1902. This type of Bascule Bridge consists of a forward cantilever arm out over the channel and a rear counterweight arm. The leaf rotates about the trunnions. Each trunnion is supported on two bearings, which in turn, are supported on the fixed portion of the bridge such as trunnion cross-girder, steel coumns, or on the pier itself. Forward bearing supports locaed in front of the trunnions are engaged when the leaf reaches the fully closed position. [4]

The first multi-trunnion bascule bridge was designed. The trunnion supports the couterweight, and two link pins are used to form the four coers of a parallelogram-shaped frame. The counterweight link keeps the counterweight hanging vertically from the counterweight trunnions while the moving leaf rotates about the main trunnions. [5]

The design for the new bridge was completed in the year 2001.Construction took place in 2010 and 2011. The project is unusual because it is a vertical lift span replacing a shorter vertical lift span. McHugh Construction at the time of the bid opening and needed to perform further research to learn of their extensive experience and capabilities. The span was successfully launched across the main river channel to a temporary rceiing structure using hydraulic skid shoes. The span was then jacked up and rolled into position. The design of the launch won an award from the American Council of Engineering Companies. The project was planned to have duration of 720 days, with an 84-hour shutdown of both the railroad and the Illinois River to remove the old vertical lift span and to set the new vertical lift span. Construction officially began on October 19, 2009 with the Notice to Proceed. CN forces first reported the contractor's activity at the site in the second week of Feruary, 2010. A short delay was taken prior to contract award as the Coast Guard attempted to find a way to accelerate the schedule and get the money into the U.S. economy faster. Maintaining the schedule was challenging due to unseasonably high water levels in the Illinois River, a strike by several labour unions, and the winter weather of 2011, which included both excessive snow and cold temperatures. The highlight of the schedule was the 84-hour shutdown from July 8 through July 11, 2011, to install the new span. [6]

The Pont Bacalan-Bastide is the latest modern vertical lift bridge being constructed in France. The team developed a vertical lift bridge with four independent pylons for its dramatic character. The four pylons were formed out of concrete and each house one of the four counterweights that balance the bridge. [7]

3 MATERIALS AND METHODS

3.1 DESIGN

An object's gravitational energy depends on how high it is, and also on its weight. Specifically, the gravitational energy is the product of weight time's height:

Gravitational energy = (weight) x (height)

To calculate the energy required to lift the bridge to know the force produces by the bridge on down word direction.

Weight of the bridge with empty water tank and valve is 6.2kg

Force = weight x Gravitational Acceleration

$$F = m \times g \qquad (1)$$
$$= 6.2 \times 9.8$$
$$= 60.76 \text{ N}$$

Gravitational energy required to lift the bridge around 1ft. i.e. 0.25m

Gravitational energy = (weight) X (height)

$$E = F \times h \qquad (2)$$
$$E = m \times g \times h$$
$$= 60.76 \times 0.25$$
$$= 15.19 \text{ Nm}$$

So, to lift the bridge we have to arrange weight over pulley rope which exert the energy more than 15.29 Nm

Suppose we have to use the same weight as the bridge weight i.e. 6.2kg the both side are at equilibrium and the weight is balances that's why we have to add more weight to lift the bridge.

Considering friction losses the pulley system is not 100% efficient due to friction 1.2% of energy lost and convert into heat energy. So we used 4.5 kg weight to each side means 9 kg weight to lift the bridge. But to get the bridge its original road side place we have to balances or more energy is required it is

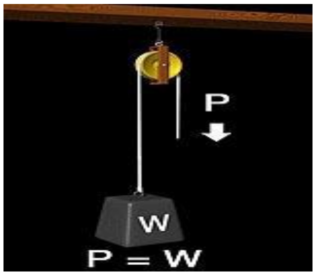


Fig 1 Rope and pulley

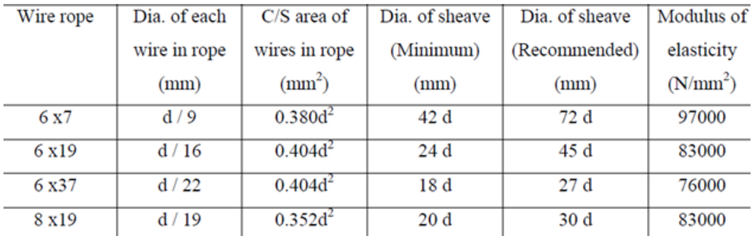
E = mgh
= 8 x 9.8 x 0.25
= 19.62 Nm or J
To add this amount of energy i.e. =19.62 –15.19
= 4.43 Nm
E = mgh
4.43 = m x 9.8 x 0.25
m = 4.43/2.4525
m = 1.8 kg
So to get the bridge to its original position we have to add the water of 1.8 kg.
We are using the water the specific gravity of water is 1
So the 1kg of water = 1liter
We have to pump 1.8liters of water into tank to get the bridge its original position.

3.2 DESIGN OF WIRE-ROPE

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 fibre ropes and metallic ropes. Fibre ropes are made of Manila, hemp, cotton, jute, nylon, coir etc., and are normally used for transmitting power. Metallic ropes are made of steel, aluminium. alloys, copper, bronze or stainless steel and are mainly used in elevator, mine hoists, cranes, oil well drilling, aerial conveyors, haulage devices and suspension bridges.

Material: Nylon
Properties:
Modulus of elasticity = 3.9 x 103 Mpa
Density = 1140 Kg/m3
Ultimate tensile strength = 616 Mpa
Specific gravity = 1.13 M/s2
Maximum temperature = 99°c
Minimum temperature = -70°c
Mass of span (without water) = 6.2 Kg
Weight of span (without water) = 60.822 N
Weight of span (with water) = (Weight of span (without wter)) + Weight of water
= 78.48 N = 80 N
Mass of counter weight = 9 Kg
Weight of counter weight = 88.29 N
Total Weight (acting on frame) = Weight of span (with water) + Weight of counter
= 80 + 88.29
= 168.29 N
So, we are using 4 numbers of pulley's and wire-rope for lifing the span.
Load on the single rope
= 42.07 N

TABLE 1 DIMENSIONAL DATA FOR WIRE-ROPE



Wire rope	Dia. of each wire in rope (mm)	C/S area of wires in rope (mm^2)	Dia. of sheave (Minimum) (mm)	Dia. of sheave (Recommended) (mm)	Modulus of elasticity (N/mm^2)
6 x7	d / 9	$0.380d^2$	42 d	72 d	97000
6 x19	d / 16	$0.404d^2$	24 d	45 d	83000
6 x37	d / 22	$0.404d^2$	18 d	27 d	76000
8 x19	d / 19	$0.352d^2$	20 d	30 d	83000

From Table,
Wire rope 6 x19 is suitable for hoisting application.

3.3 SELECTION OF 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 realised a mchanical 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.

Material: Teflon.
Properties:
1. Teflon consists of lowest coefficient of friction.
2. Teflon is very unreactive.
3. High melting point at 327°c.
4. High wear resistant.

3.4 STEPS FOR ANALYSING A FRAME

Draw the FBD of the entire frame or machine and its members, as necessary.
a) Identify any two-force members,
b) Where there is an internal hinge, forces common to two members act with equal magnitudes but opposite senses on respective members.
c) If a load is applied at a joint (on a hinge), place the load on only one of the members at that joint. But definitely you should put the internal forces due to the hinge.

4 RESULT

4.1 TESTING PROCEDURE

1. First, collect the standard data of set up like volume of tank and flow rate of pump

2. Switch on the main switch, cut the infrared proximity sensor while arrival of ship.
3. Calculate the bridge down time by stop-watch.
4. After completing the downward movement of bridge, calclate the bridge up time.
5. Calculate actual power requirement.

4.2 TESTING CALCULATION

We performs the testing on prototype model of water operated vertical bridge lifting and it's cycle time is,
Bridge down time = 85 sec.
Bridge up time = 75 sec.
So, power required for down the lifting span is calculated as,
Power = Pp x Down time
Theoretical Power = Pp x t
Discharge of pump (Q) = 1.75 LPM
Volume of tank (V) = 1.8 Litre

TABLE 2
TESTING RESULT TABLE

PARAMETER	THEORETICAL	PRACTICAL
1. Power	892.85 J	1224 J
2. Time	62 Sec	85 sec

4.3 POWER COMPARISON

4.3.1 KATTWYK BRIDGE

1. Weight = 100 ton
2. Electric Motor = 150 Hp
3. Total no. of motor = 04

Electric power required for operating Kattwyk Bridge
= [Total no. of motor] x [power required for operating each motor] x 735.5
= 441300 Watt

4.3.2 PROTOTYPE

1. Weight = 10 Kg
2. D.C.Pump = 12 V, 1.2 amp

Electric power required for operating Prototype Bridge
= V x I
= 12 x 1.2
= 14.4 W

Hence, if we actually implement this bridge for 100 tonn, then power to be required will be,
(Wp / Wa) = (Pp / Pa)
Where,
Wp = Weight of Prototype = 10 Kg
Wa = Weight of actual bridge = 100 ton
Pp = Operating power for Prototype = 14.4 W
Pa = Operating power for actual bridge
= [100000 / 10] x [14.4]
= 144000 W

4.3.3 TOTAL POWER SAVING

Total power save = Pkattwyk – Pactual
= 441300 – 144000
Total power save = 297300 W

4.3.4 PERCENTAGE OF POWER SAVING

Percentage of power saving = [Save power] / [Operating power of Kattwyk Bridge]
= 67.36 %

4.4 RESULT

When Water Operated Vertical Bridge Lifting is actually implemented it consumes 144000 W powers, which is 297300 W less than that of Kattwyk Bridge. Hence, project is 67.36 % efficient than that of Kattwyk Bridge.

4.5 CONCLUSION

According to the results, 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 travelling, 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 rise the bar of our knowledge of various sections which are include in the syllabus of course. It will also enable to the junior friends to carry out experiment successfully.

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