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Swing Bridge: A Movable Bridge

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***Abstract* - This study deals with the basic concepts and steps involved within the design and analysis of a swing bridge. There are different types of movable bridges used worldwide in field of bridge construction, while Swing Bridge can be a better alternative from the point of view of safety as well as economy. As we all know now day's waterway transportation is quite famous and very useful to shorten the distances. Generally when we talk about water way transportation we assume about a ship crossing the river or a bridge over it for vehicular traffic, but assume if both can be achieve at a same time and same location. Main purpose of this study is to provide information about the swing bridge and promote its use in construction of bridges.**

Keywords: swing bridge, type, centre bearing, rim bearing, design, calculation, load, rotation, construction.

I. INTRODUCTION

A swing bridge is a movable bridge that has as its primary structural support a vertical locating pin and support ring, usually at or near to its center of gravity, about which the turning span can then pivot horizontally as shown in the animated illustration to the right. Small swings bridges as found over canals may be pivoted only at one end, opening as would a gate, but require substantial underground structure to support the pivot. In its closed position, a swing bridge carrying a road or railway over a river or canal, for example, allows traffic to cross.

When a water vessel needs to pass the bridge, road traffic is stopped (usually by traffic signals and barriers), and then motors rotate the bridge horizontally about its pivot point. The typical swing bridge will rotate approximately 90 degrees, or one-quarter turn; however, a bridge which intersects the navigation channel at an oblique angle may be built to rotate only 45 degrees, or one-eighth turn, in order to clear the channel.

Swing span bridges are provided with a central pier and rotating machinery, the span of bridge rotates around the central pier. When normal road traffic has to cross the bridge, it is positioned on its close position and act like as a fixed bridge and allow them to pass over it and when a ship or any vessel has to pass the bridge is kept at 90 degree angle from its fixed position and hence allows the vessel to pass. Generally a clearance of 70m to 90m is required.

There can be two types of Swing Bridge on the basis of its working mechanism:

1. Centre bearing Swing Bridge
2. Rim bearing bridge

II. LITERATURE REVIEW

Berger found that (march 2015) : The history of swing bridges in New South Wales most likely commenced in Sydney, with it being noted that the earliest swing bridges in the colony were those erected at Wentworth Park, Pyrmont and Glebe Island in 1850, 1857 and 1862 respectively.

D. Healy (march 2015) :The next development in swing bridge design was apparent on the Hay Bridge completed in 1873. The design consisted of lattice girder span supporting timber decking and the bridge was operated by hand. The drum was a composite of cast and wrought iron that was finally founded on a centre pier. It was noted by Mr G. S. Mullen, past Resident Engineer, that the Hay Bridge was operating satisfactorily with the frequency of openings being over times per annum in the 1880s (Main Roads, 1973). The swing span was locked shut in 1937 and the bridge was demolished in 1973 with the turntable relocated to Lions Park, Hay.

M. Tilley found that: In 1885 a different type of Swing Bridge was constructed on the Fig Tree Bridge over the Lane Cove River (Fig.7) the swing span was a bob-tailed design which consisted of a shortened rear span. This type of bridge is usually adopted due to limited land availability. In order to balance the resultant differential in span masses a counterweight is mounted on the shorter span. There are some minor consequences for this type of design, namely the asymmetric wind loads that are experienced, however these can be catered for by strengthening the bridge where necessary (Waddell, 1916).

In 1892, John MacDonald He prepared a design for a swing bridge to be built on the North Coast, over Cold stream River a tributary of the Clarence River near Maclean. The intention was that it would provide access for the tugs and barges associated with the sugar industry between the farms

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and the mill at Harwood (Fraser 1985).Only a small line drawing survives in MacDonald's calculation books; the design is unusual in that it consists of a lattice trussed central pivoting span with what appear to be plate girder approaches. It would have been similar in some regards to the Sale Bridge in Victoria built in 1883.

III. TYPES OF MOVABLE BRIDGES

Various types of movable bridge are available, but three of them are significantly desirable and practical are discussed in the following sections and number of special types of movable bridge will be discussed as well:

- Bascule Bridge
- Swing Bridge
- Vertical lifting Bridge
- Special types of movable Bridge

Bascule Bridge: Bascule bridge, which is also called as drawbridge, is fixed and supported on an axis which is perpendicular to the bridge longitudinal centerline axis. The horizontal line on which the bridge is pivoted is commonly located at the center of gravity of the bridge to create a balance between the weight of the bridge on either side of the horizontal pivotal axis.

There are three types of bascule bridge designs:

- **Fixed trunnion or heel trunnion:** Rotates around a large axle that raises the span.
- **Rolling lift trunnion:** Raises the span by rolling on track resembling a rocking chair base.
- **Rall type:** Combines rolling lift with longitudinal motion on trunnion when opening.

Figure 1: Bascule Bridge

Vertical Lifting Bridge: It is one of the most widely constructed and used type of movable bridge.

It is composed of a span commonly truss type span which is supported by towers at the end of the span or at each corner of the span. Counterweight is usually used to balance the weight of the span. Ropes, which travel over counterweight rotating sheaves fixed on towers, are utilized to connect the end of the span to the counter weight. Added to that, waterway is opened by moving the span up exactly in vertical direction.

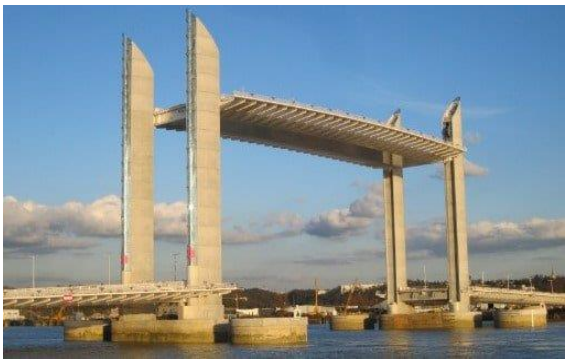

Figure 2: Vertical Lifting Bridge

Swing Bridge: Swing Bridge is fixed on horizontal plane that turns around vertical axis to provide ways for vessels and ships to travel through the bridge. The horizontal plane is on a bearing Installed on a pier which is termed as pivotal pier. When the swing bridge is closed, the end of the span should be supported by resting piers or abutments if the total length of the bridge span is not very long. Machineries used to open and close swing bridge is more complicated compared to other types of movable bridges. The end of its span should be free during opening and closing that is why retractable rollers, wedges, shoe or jacks are introduced to lift the end of swing span. Therefore, swing bridge moves horizontally around vertical axis to provide water way and vertical movement is not involved whereas other types of movable bridges need to move vertically to provide passage spaces for vessels.

Special Types of Movable Bridge: Bridges that fall into this category are rarely constructed and uncommon. The decline in the application of such movable bridges is due to some factors such as the increase of applied loads, newly developed materials and safety precautions and concerns.

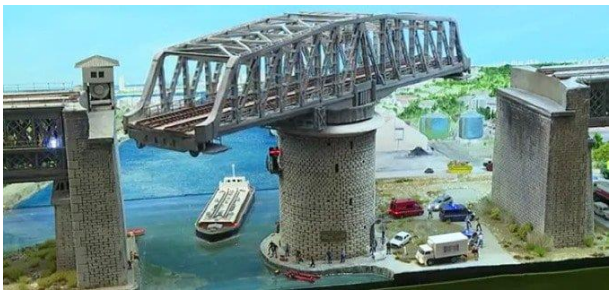

Figure 3: Swing Bridge

Retractile, pontoon retractile, pontoon swing, shear pole swing, Folding, Curling, removable spans, Submersible Bridge, Tilt bridge, Transporter bridge, Jet bridge etc. are the special types of movable bridges.

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Figure 4: Special Types of Movable Bridge

IV. METHODOLOGY

It is necessary to swing the bridge at a certain angle to connect railway tracks. So, as above explanation the main challenge is to swing the bridge at certain angle and that problem of swing the bridge can be solving by two major mechanisms to swing the bridge, one is Rack and pinion method, and second one is hydraulic system.

Rack and pinion method: In Rack and pinion method, the linear motion of rack is converted into circular motion of pinion, which helps to swing the bridge. The whole assembly of rack and pinion system is placed on the pier, which is at the center of the bridge. It's the most suitable system of power transfer. As there are no any difficulties so this system is very economical. The mechanism is very simple, so the maintenance cost of this system is very low.

But the power requirement for this system is more, which is not suitable as point of economical view.

Hydraulic System: The second method is a hydraulic system. By using the hydraulic power the bridge can be swing. The Swing Bridge has two identical hydraulic systems, one in each pivot pie. The two systems can operate independently or simultaneously .The operator has independent control of each system. Each hydraulic system consists of lift and slew actuators, fluid Transmission lines, savior and a power pack which contains pumps and control valves. The hydraulic system is used by various accumulators, which are as follows: Hydraulic Accumulator Towers Raised weight Air-filled accumulator Compressed gas (or gas-charged) closed accumulator Spring type Metal bellows type.

Functions of accumulator

- In the case of piston-type pumps accumulator to absorb pulsations of energy from the multi-piston pump.
- Accumulator helps protect the system from fluid hammer.
- Accumulator protects system components, particularly pipe work, from both potentially destructive.
- The additional energy that can be stored while the pump is subject to low demand so, the designer can use a smaller capacity pump.
- Accumulator can maintain the pressure in a system for periods when there are slight leaks without the pump being cycled on and off constantly
- Accumulator helps to maintain change in pressure due to the temperature changes.

Centre bearing Swing Bridge

- In this type, span of the bridge is totally dependent on central pivoting pier.
- To prevent the bridge span from failure under unbalanced loads i.e. wind load, balance wheels are provided which rolls on a large-diameter circular track concentric with the pivot bearing.
- The design is based on the fact that the centre bearing supports all of the dead load when the span is in its open position. The live load is usually supported by centre and end lift devices which are
- Actuated when the span is returned to the closed position.
- Rotation of the span is provided with the help of machines which are operated manually.

Rim bearing Swing Bridge

- In rim bearing swing bridges, a minimum of two longitudinal spanning members are required to support the super structure.
- Tapered rollers are also provided because the distance travelled by the outer end is longer than that travelled by the inner end of the roller, for the provided angle of bridge rotation.
- In case of rim bearing mechanism when the bridge is fixed or in its closed position, it supports both dead load and live load. Rim bearings are quite handful for wide and heavily-loaded swing bridges.
- Load is transferred by the drum girder to a tapered tread plate which is supported by tapered rollers. Rotation of the span is achieved in the same manner as it was for the centre-bearing & swing bridge.

V. MACHINERIES IN SWING BRIDGE

It's important in Swing Bridge to select proper machines to swinging the bridge. Some of the swing bridge machineries may operate fast such as rim bearing.

When standing on moving span or under it one the pier, its need to avoid the crush between a moving and stationary pivot of the bridge. The swing bridge is divided into three classes

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according to machinery on center pier of the bridge. They are as follows,

- Center bearing
- Rim bearing
- Combination of both

A) Center bearing: This type of bearing required less power for working. It has smaller number of parts and is also less expensive to construct and maintain. Most important advantage of this type of bearing is that, it is not affected by irregular settlements of pier. They are mostly adopted for single span and single track bridges.

B) Rim bearing: On the other hand the rim-bearing type gives a greater turning surface and balancing the bridge better while turning. It gives a better distribution of loads, and hence a less wear of turning parts. Rim bearing required additional power in turning as compared with the center-bearing type. They are mostly adapted to long single-track, and all double, or four-track bridges.

C) Combination of both: By combining the two types of the machines it is possible to overcome the limitations of each of them. Combination of these two machines can improve the working of bridge. The opening of a swing bridge involves four operations as follows, Turning or opening the bridge. When brought back the ends must be "set up" or raised. The bridge must be locked. The rails must be aligned with those on the fixed track. The bridge is "set up" and locked by hydraulic power, while the rotation of the bridge is carried out by electric power. It is largely used, especially in America and is said to be simpler and to assure more certainty of operation.

VI. CONSLUSION

Swing Bridge is more convenient for two different ways of transportation like railway and roadway. Construction of two conventional bridges required large area as compared to rail-cum-road Swing Bridge. The analysis and design required less time as compared time required for design and analysis of conventional bridges. This bridge also swing in particular angle hence it can be also convenient for waterways transportation. At last it is concluded that Swing Bridge is the best alternative for the short span rivers and canals and also suitable for large spans if carefully designed. It is more preferable than that of Bascule Bridge. Accidents and many failures caused in these types of bridges are because of the improper operation and functioning and also improper designing. If during the time of construction and designing proper designing is done also if material chosen for the bridge serves all properties there is no chance of failure for a long duration.

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