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A Study - Design and Analysis of A Swing 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 days waterway transportation is quite famous and very useful to shorten the d
istances. 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.

1. INTRODUCTION

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

There is also a third type of swing bridge which is termed as bobtail swing bridge but that is not used for construction any more because it is not symmetric in structure and can be a cause of failure.

1.1 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
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- 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.

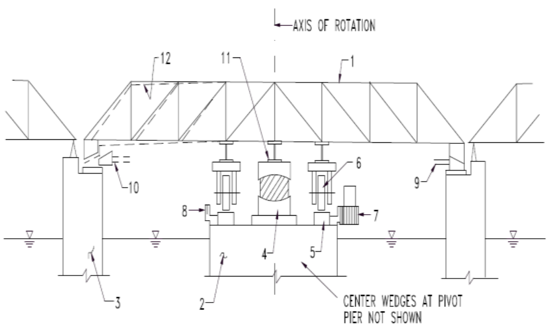


Figure. 1 Centre bearing swing bridge

1.2 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.

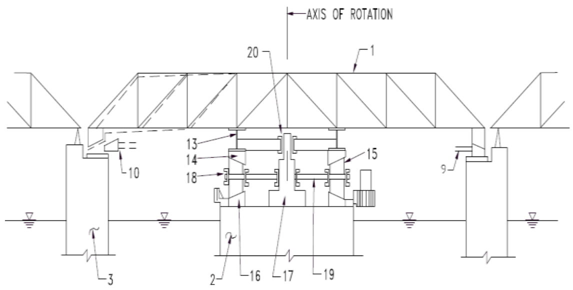


Figure. 2 Rim bearing swing bridge

2. LITERATURE SURVEY

I.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 (Dare 1896, *Main Roads* 1973). The Pyrmont design consisted of a lattice deck which pivoted about a central pier and the Glebe Island design consisted of a single opening swing span mounted on the bridge abutment (Fig.4)

According to 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.

This type of bridge design was also adopted for the swing span on the Gladesville Bridge over Parramatta River completed in 1881, with reports that the operation was also satisfactory. Figure 8.8 is an elevation of this type of swing bridge design.

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). Dual plate web girders are the main components of the bridge superstructure and they taper from 6 ft. at the abutment to 2 ft. at the pier. It is noteworthy that this design was also manually operated by a handle on deck level which passed through a number of gears before transferring rotation to the structure.

In 1892, John MacDonald 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 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.

Possibly as a result of the considerable expense involved, or potentially due to a lowering of demand from river traffic, this bridge was never built; a single lane timber beam bridge was erected at the crossing instead.

The completion of the Pyrmont Bridge in 1902 and the Glebe Island Bridge in 1903 represented a significant milestone in the Australian swing bridge design evolution. The designs are often cited in engineering literature as being at the forefront in the world for swing bridges at their time due to their electrical operation and large size (*Main Roads* 1953, Allan 1924, Fraser 1985)

Other Swing Bridges in Australia

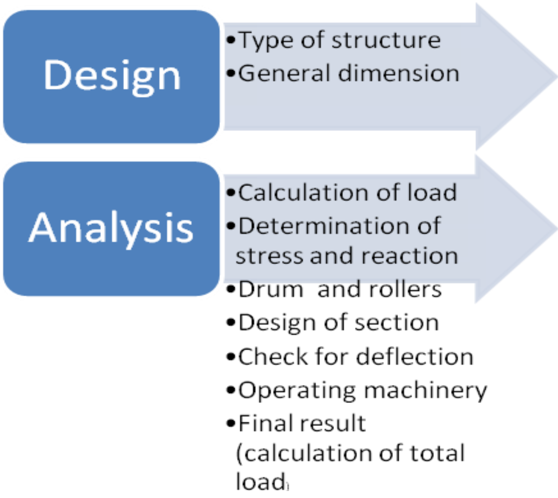
There have been at least ten sites in Australia where swing bridges have been erected. In Sydney Harbour there are two; Pyrmont and Glebe Island Bridges, four in Tasmania, two in Port Adelaide and one each in Queensland and Victoria. In several cases, when an early swing bridge reached the end of its service life, it was replaced by another.

The 1874 Bridgewater Bridge carried the Tasmanian Main Line Railway across the Derwent River. The swing span was supported off-centre to maximise the width of the navigation channel. A separate road bridge was opened in 1892 with a swing span designed for conversion to railway use. This was later converted to dual road and rail use in 1908 because the turntable of the road bridge was supported on timber piles and gave endless trouble. The existing bridge was opened in 1942 and carries both road and rail in separate corridors and has a lift span. The Institution of Engineers Australia placed a Historic Engineering marker on the remnants of the Jervois Swing Bridge which carried road vehicles, rail, trams and pedestrians across the Port River in Port Adelaide. It was built in 1878 and demolished in 1969.

Similarly to Pyrmont Bridge, several other swing bridges have been refurbished or restored and remain in existence. The 1883 road bridge at Sale, Victoria is restricted to foot traffic but is swung regularly at advertised times. The Victoria Bridge in Townsville built in 1889 was returned to use as a major community asset after restoration in 2001 by the Townsville City Council.

3. METHOD

Method is a way of providing solutions for the problems. While designing a swing bridge the method consists of the following steps as describe below in the flow chart:



3.1 Design

Whenever it comes to design any structure general dimension such as basic length and width are firstly calculated or assumed.

In case of swing bridge the dimension the bridge are calculated on the basis of existing bridge on the same river.

3.1.1 Type of structure

For the designing purpose the most common type of swing bridges may be divided into three classes :

a. Two span continuous
b. Three span continuous
c. Three span partially continuous

Chosen structure depends upon the length of the track to be designed.

3.1.2 General dimension:

The width of the bridge is fixed by the width of the track and side clearance is also considered in addition in width. It usually varies from seven to eight feet from the centre of track to the nearest inner part of the truss.

The depth of the floor system is taken between twenty-eight to swing bridges. The height of the bridge is calculated with the help of required clearance.

3.2 Analysis

3.2.1 Load calculation

Load (self weight) can be calculated using the following formula :

$$w = 6L + 350$$

where L = length of span in feet,

w = weight of bridge per linear foot of span in pounds. (1 pounds = 4.448 Newton).

3.2.2 Determination of reaction:

Reactions formulas are given by professor:
P.E. Turnesure (3dec.1896) at **"ROSE POLYTECHNIC INSTITUTION"**

$$R_1 = P(1-K) - \frac{P}{4+6n}(K-K^3)$$

$$R_2 = PK + \frac{P}{4+6n}(K-K^3)$$

$$R_3 = -R_4 = \frac{P}{4+6n}(K-K^3)$$

Where,

P = the load at a point

n = the ratio of the length of the centre to the end span, and

K= the ratio of the distance of the load P from the end of the span, to the length of the span.

$$n = \frac{16}{175}$$
$$= 0.091$$

3.2.3 Calculation of stresses:

Following stresses are calculated
1. Dead load bridge swinging,
2. Dead load bridge continuous,
3. Full line load bridge continuous,
4. Each arm as simple span for line
5. Line load on one arm, approaching on other.

3.2.4 Drum and Roller

The swing bridge is divided into three classes:
1. Rim bearing sing bridge.
2. Centre-rim bearing swing bridge.
3. Combination of the two.

The centre-bearing type requires less power to turn, has a smaller number of moving parts, is less expensive to construct and maintain, and is not so materially affected by irregular settlement of the pier. They are best adapted to short span, single-track bridges. The additional power required in turning, when compare with the centre-bearing type, is comparatively small if power is used. They are better adapted to long single-track, and all double, or four-track bridges

3.2.5 Design of section :

From the maximum and minimum stresses the section of the member are calculated.
Following sections are designed according to their required numbers:
1. Diagonal.
1. Upper chord section.
3. Lower chord section.
4. Section of post.
5. Transverse and lateral bracings.

3.2.6 Deflections:
Section should be checked for Following given deflections :
1. Dead load deflection
2. Camber deflection
3. Deflection due to temperature
4. Inelastic deflection
5. Combined deflection
6. Amount of lift

3.2.7 Operating machinery:
The operating machinery of a swing bridge involves four operations. First, turning or opening the bridge. Second, when brought back the ends must be "set up" or raised. Third, the bridge must be locked. Fourth, the rails must be aligned with those on the fixed track.

The bridge is "set up" and locked by hydraulic power, whilst the rotation of the bridge is carried out by electric power. This combined system has been selected in preference to using electric power exclusively, since it is largely used, especially in America, and is said to be simpler and to assure more certainty of operation.

3.2.8 Final result:
At last all the total weight due to each member is calculated and this estimate for load per unit length can be used for the cost estimation.

Table 1. Estimation of total weight

Member	weight
Top laterals	...
Bottom laterals	…
Intermediate bracing	…
Track	…
Stringer	…
Intermediate floor beams	…
End floor beams	…
Total	…
Total for main members	+…
Total weight on drum	…
Weight per linear foot	…
Assumed weight per linear foot	…

4. CONCLUSION
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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