Dansk Stålinstitut

STEEL *CASES*

Juni 2015

Odin’s Bridge

The Longest Twin Swing Bridge in Northern Europe

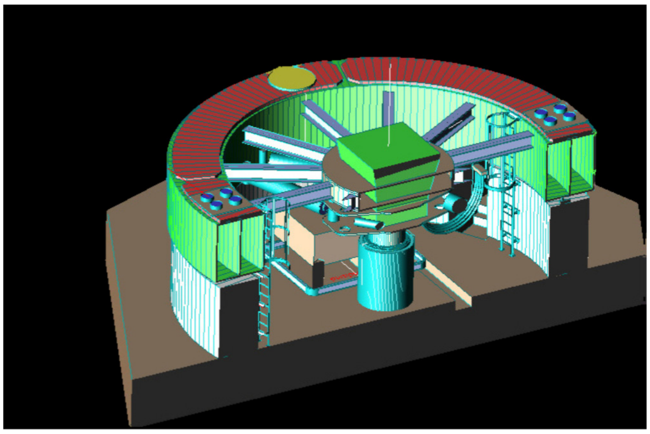
Odin´s Bridge is a 900 m long bridge closing a gap in a circular road being an integral part of the infrastructure of the city of Odense, Denmark.

The bridge comprises a 194 m swing bridge crossing the 80 m wide navigation canal. The swing bridge consists of two equal rotating parts designed as monoplane structures in steel. The outstanding part of the swing bridge is a new concept for the 10.5 m diameter sliding bearings on which the swing bridge sections rotate.

The detailed design started in 2009 and all contracts with the contractors were entered in December 2010. The construction on site started on February 1st 2011. The bridge was handed over to the client for service in June 2014.

The Twin Swing Bridge

The canal crossing of the bridge connection is designed as a twin swing bridge with a total span of 194 m, a center span of 120 m and two side spans of 37 m. A special feature with this bridge connection is that the bridge part rotates on a new developed bearing system which has, as far as we know, not been applied before in this type of swing bridges.



Isometrics of rotating bearing Ø 10.5 m center bearing containing the hydraulic system and the 1.8 m high box girder beam with the polished stainless steel top welded on and the 4 neotoph bearings which slides in rotating mode.

The bridge design is the result of an international competition in 2008 according to the EU service directive. Six consulting groups were pre-qualified and participated in this competition. On September 9th 2009 the mayor of Odense city declared during the inauguration of an exhibition for the competitions proposals, that the bridge design carried out by ISC Consulting Engineers A/S was the winner of the competition as the technical and economical best solution.

The Evaluation committee highlighted following as factors for selecting the proposal from ISC:

• That the bridge design did not cause any disturbance to the canal traffic of any kind.

• That the embankment and the pedestrian-and bike roads along the canal were undisturbed.

• That the overall design would provide the harbor's entrance to Odense with a characteristic landmark.

• That there will be environmental benefits due to a non-water blocking effect, as no foundations are arranged in the canal.

• That the main foundations supporting the rotating bearings, are located so far from the embankments, that the bridge sections in the open positions will be inside the shore, thus preventing any ship impacts.

The two almost identical bridge sections are designed as twin steel box girders with a 3 m light opening between the box girders. These box girders are structurally connected with a number of cross beams, also designed as box girders, placed above the circular supports at the center span and at the end supports and in two intermediate positions.

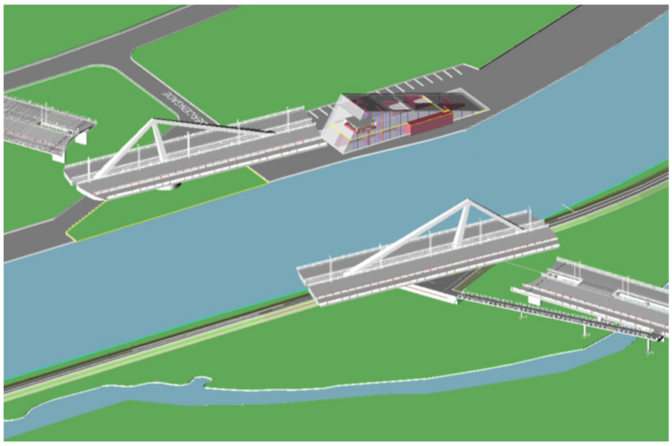
The triangular superstructure is a monoplane structure, which carries the two box girder sections on either side of the monoplane structure. The triangular structure is designed in box sections and has a height of 20 m above the roadway surface. The bridge carries two roadway bicycle path has been added to the northern box girder. The total width of the bridge is 28.14 m.

The two box girders separated by the monoplane structure are all welded and has a height of 2 m. The roadway floor is designed as orthotropic steel floor, stiffened by trapezoid steel stiffeners. Transverse bulkheads are arranges pr. 3.4 m for support of the trapezoid formed orthotropic deck stiffeners.

The circular main foundations, which carry bearings for the bridge sections in the permanent service situation as well as in the rotating situation, have an outer diameter of 12 m. The foundations are designed in reinforced concrete.

Approach spans

The western part of the total bridge connection comprises a 280 m long dam including a tunnel for fauna passing along the Stavids creek. From the dam towards the swing bridge the connection continues with a 280 m long continuous pre-stressed concrete bridge over a lower laying environmentally protected area.



Areal view of the bridge and the administration building. The foundations are placed in a position so that the open bridge lies within the shoreline of the canal, giving maximum width of the canal to ship traffic thus eliminating risk of collision.

The bridge was given its shape and was visualized. The administration building on the right was created in harmony with the bridge´s girder.

The cross section of the bridge has been designed as an open girder deck design preferred by the client to facilitate eventual later suspension of pipe ducts under the bridge deck. The continuous concrete bridge structure is constructed with in-situ casting and post tensioning of cables. The west approach bridge has 9 spans of 26 m and a smaller span at the connection to the swing bridge of 25 m and 18 m respectively.

The eastern side´s approach to the bridge comprises only three spans carried out in pre-stressed concrete. These spans are curved to join the continuing dam in land and the spans are 21 and 26 m.

Bearing system

The concept for the bearing system has - as far as we know - not been used before in twin swing bridges like the present. The permanent supports for the bridge in service consist of two neotof bearings with a diameter of 1.4 m. These bearing rests on the circular gliding face of corrosion resistant steel with a diameter of 10.5 m. Before activating the opening of the bridge, further two bearings are activated, located on the circular bearing ring in the bridge direction. These bearings are jacked up under the bridge until they reach the same load as the permanent two bearings.

The total load is thereby distributed on four bearings. To reduce friction on the circular sliding face, further release is introduced with jack-up of 1000 tons on the central vertical bearing. Thereby the hydraulic machinery used to rotate the bridge is reduced in capacity due to less frictional resistance.

The horizontal stability and support of the bridge section during rotation, is secured by means of a circular spherical bearing inserted between the central support structure and a diaphragm arranged to a circular steel box girder mounted on top of the concrete foundation. The sliding surface of corrosion resistant steel is mounted on this steel box girder. The steel box girder is introduced to provide possibility for adjusting the swing bridge to the exact position in the final stage. In the permanent service situation the structure will act as a continuous girder with a charnier in the center of the span and a simple supports at the bridge ends.

At the abutments the box girders are supported by means of a hydraulic operated bearing system which are pushed into the steel girder arranged at the concrete abutment. In the center of the swing bridge two hydraulically operated dowels are activated in a way so that the box girders in the center are interconnected with a charnier and they are further torsional rigidly connected.

The centrally placed neoptof bearings are provided with a lining in the actual bearing which consists of PEHD 1000 sliding blocks. The system is in comparison with traditional ball bearing- or roller bearing systems much simpler and less expensive.

Client:
Odense Kommune
Turnkey consultant:
ISC Rådgivende Ingeniører A/S
Architect consultants:
Bystrup Arkitekter
Contractors – swing bridge
MT Højgaard A/S
Contractors - concrete bridges and foundations:
Per Aarsleff A/S

Mechanical system

All movable elements, bearings and main structures required for allowing the opening of the bridge, are activated by means of hydraulic systems. This applies for the dowel connection in the bridge´s center, the rotation of the bridge sections and the bearings connecting the bridge ends with the end supports.

The same applies for the two bearings which are activated in the bridge longitudinal in the direction. Four hydraulic jacks in each bearing activate the supports to achieve that all four supports with equal loads are active during rotation.

The hydraulic system is designed with the capacity to work with a maximum friction coefficient of up to 0.15 % and with maximum wind load. The expected frictions in the bearings have been tested to be approximately 5 times of working load.

Bridge opening/closing

The operation of the opening and closing functions for the bridge is managed from a control room located nearby in the newly built office building housing the harbour administration staff. The total time consumption for the opening of the bridge, activation of signals and clearing the bridge from traffic etc. is estimated to 7 minutes. The rotation of the bridge alone is carried out in 2 minutes.

Foundation

Due to poor soil conditions foundations for the bridge are founded on seventy 40x40 cm and 30 m long concrete piles. Due to expected minor settlements even with the pile foundations, a 0.8 m high and 1.5 m wide steel box girder was introduced on top of the cylindrical concrete foundation to provide an adjustment facility in case of minor settlements and also for flexibility in adjusting the bridge to its final position on the bearings. It is possible to install hydraulic jacks under this circular steel box girder for adjustment of the heights during lifting of those box girders.

To be highlighted

For the longest twin span swing bridge in Northern Europe called Odins Bridge, which crosses the 80 m wide Odense navigation Canal the following should be highlighted:

1. The 194 m long bridge is the longest twin span bridge in Northern Europe.

2. The structural system is characterized with a triangular monoplane centrally located structure, supporting a four lane road. The monoplane structure provides an esthetical clean structure in all opening angles for the bridge.

3. The support system for the permanent in service situation and in the rotating situation consists of four sliding bearings instead of traditional roller bearings. This leads to low cost solution with adequate adjustment possibilities for the bridge and for the replacement of bearings.

4. An elegant transition from the two point support in the service condition to a four point support in the rotation situation by means of two hydraulic activated supplementary bearings.

5. The bridge was evaluated between six proposals from international consulting firms as the most functional and economical sound solution and the most attractive solution from an international point of view.

The gate to the sea into Odense is now open to all ships -and the ring around the city has been linked.

STEELcases informerer om anvendelsern af stål i byggeri og anlæg.

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