A World First in Engineering Design

A unique wheel-like structure will transfer boats between two canals in Central Scotland, thus connecting a vertical gap of about 32 metres, and is a world first in construction and engineering design.

The Stg£78 million wheel measures 35 metres in diameter, with an axle length of 28 metres. It will simultaneously lift and lower two 22 metre long caissons which each holds a payload of 300 tonnes, comprising water and up to four boats. The ÒFalkirk WheelÓ, which will be located close to the Scottish town after which it is named, is a new giant rotating boat lift and will be the only structure of its kind in the world.

It is the centrepiece of the Millennium Link, a Stg£78 million project led by British Waterways, which reopens and reconnects the Forth and Clyde Canal, and the Union Canal between Glasgow and Edinburgh. The wheel measures 35 metres in diameter, with an axle length of 28 metres, and will transfer boats between the two canals, over a vertical gap equivalent to the height of eight London buses.

The idea of connecting the canals via a rotating boat lift was put forward and was originally conceived as a giant Ferris wheel with suspended gondolas. For this design, SKF, the world's leading bearing solution supplier, proposed large, double row, spherical roller bearings and specially designed bearing housings to support the wheel. The final design has, however, evolved over the years of planning into the radical concept that is now a reality.

To many in Scotland, the Falkirk Wheel is expected to become a new national landmark. The new design came from the successful collaboration of several designers led by the Morrison Bachy Soletanche Joint Venture. It follows on from the much-acclaimed initial design by Dundee Architects Nicoll Russell Studios and the exemplar designs by Engineers Binnie Black and Veatch. Situated in a natural amphitheatre, the wheel takes the shape of a Celtic-inspired, double headed axe, in which two axe-shaped arms rotate in a continuous circle, 180 degrees at a time. It will simultaneously lift and lower two 22 metre long caissons which each hold a payload of 300 tonnes, comprising of water and up to four boats, and uses a series of synchronous gears to positively keep the caissons in the horizontal plane.

Butterley Engineering, of Ripley, Derbyshire, won the contract to build the wheel and its engineering design consultant, Bennett Associates, of Rotherham, Yorkshire, invited SKF to provide a new bearing solution. To support the wheel, SKF developed a solution which uses a pair of purpose-designed, four metre diameter, three row, slewing bearings, one positioned at either end of the wheel, with outer rings bolted to the support structure and inner rings bolted to the arms. The inner ring of one of the bearings is equipped with gear teeth to transmit the drive to the wheel. The use of the slewing bearings was an unusual solution, as these bearings are normally used in applications with heavy axial loads, such as those encountered in the rotational movement of large cranes.

However, SKF specially designed these slewing bearings to be positioned on a horizontal axis and to cope with the specified combination of radial and axial loads. When the wheel is fully loaded,

it weighs 1800 tonnes, which results in a radial load of 9095 kNewtons per bearing. Each slewing bearing has three rows of cylindrical rollers, one for the radial load and two with smaller rollers for the axial loads. The wheel is rotated by ten hydraulically driven gearboxes, via the geared slewing bearing. It turns at a rate of around 0.125 rpm, which sees it lift and lower boats at an average rate of 4 metres per minute. With consideration given to the time taken for loading boats, the wheel is expected to complete a half turn about once every 15 minutes.

In operation, the wheel will be maintained close to perfect balance. With the caisson and the canal watertight doors open for loading and unloading, the water levels in the caissons will depend on the level in the canals to which they are then open. Any vessel which enters a caisson will automatically displace its own weight of water back into the canal and therefore has no net effect. When the caisson and canal watertight doors are closed, a pump system will be brought into action to equalize the water levels in the two caissons to establish near perfect balance.

The wheel drive system has, of course, been designed to handle a degree of imbalance due to differing water levels in the caissons. However, even allowing for this potential imbalance, the very low friction torque of the SKF antifriction bearings means that a rated torque of only 2972 kNm is required to rotate the wheel. Although the bearings come with their own integral seals and have been designed to have a life expectancy of 120 years, SKF is also supplying extra CR seals of 4 metre and 2.5 metre diameters.

This type of seal is specifically designed to withstand the conditions found in heavy-duty applications and, in this instance, will virtually guarantee the prevention of any ingress of water. SKF has also provided bearings, in the form of SKF cross roller bearings, to support the idler gears, which will keep the caissons level at all times. The caissons themselves will run on a wheel arrangement on circular rails, with each wheel mounted on two SKF sealed spherical roller bearings.

As the centrepiece of the Millennium Link project the Falkirk Wheel is part of the largest canal restoration project currently underway in any part of the UK.

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