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By Kevin Wilcox

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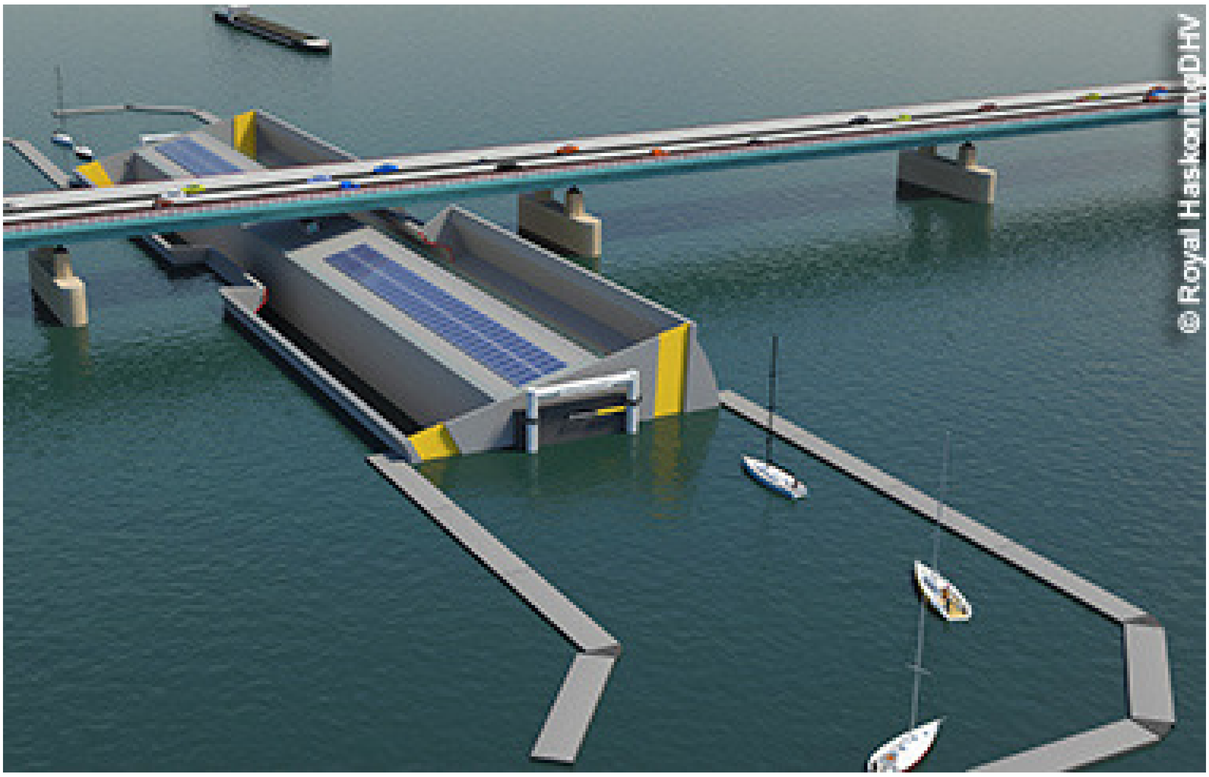

As boats enter the lock, it is tilted up approximately 16 degrees. Once the boats are inside and the watertight doors are closed, the lock tilts down 32 degrees, adding 8 m of clearance. © Royal HaskoningDHV

A pivoting, floating lock would add 8 m of clearance to drawbridges, greatly reducing the number of inconvenient openings required for boaters.

September 16, 2014—What if a sailboat could somehow duck under a low bridge?

That was a question that occurred to engineers at Royal HaskoningDHV, an engineering and architecture firm based in the Dutch city of Rotterdam. It was prompted by the familiar summer sight of sailboats awaiting the opening of a movable span bridge, along with the subsequent traffic jam as vehicles wait for the bridge to close again.

"It starts off [with that]. Followed by all sorts of sketches that may work but that fail on energy use, or building costs, et cetera. Slowly a tilting structure develops," said Carolus Poldervaart, an infrastructure project manager with Royal HaskoningDHV. Poldervaart provided written answers to questions posed by Civil Engineering online.

The concept that the team has developed to address the problem is effectively a large, circular floating pontoon having channels on either side that are 9 m wide and 3.5 m deep when the pontoon is level. This 190 m long steel structure, called the Tilting Lock, would be moored via two large steel anchoring structures referred to as spud poles.

Each channel has watertight doors on each end. Boaters who want to cross under the bridge approach the side of the lock that tilts upward by approximately 16 degrees.

"The door opens and the yacht sails into the channel, where it moors against a floating structure. After closing the door, the lock will tilt 32 degrees, which lowers the channel and the boat by 8 metres. Then the floating mooring device moves with the boat to the other end of the lock, thus passing underneath the bridge. Then the lock tilts back 32 degrees, opens the door, and the yacht departs," Poldervaart said.

Poldervaart said the biggest engineering challenges of the design were developing a cross section that would maintain the center of gravity at the center of the lock and finding a way to permit as much vertical movement as possible.

"The left- and right-hand sides of the lock are equal. That provides a center of gravity somewhere on the vertical line through the center of the lock," Poldervaart explained. "From there on, you add ballast at the right height in order to move the center of gravity just to the center of the circle formed by the hull." Ballast would be required in any event to obtain a sufficient draft on the lock, he said.

Solar photovoltaic panels provide power to tilt the lock, which moves slowly and displaces no water. © Royal HaskoningDHV.

There would be no connection between the two channels, Poldervaart explained. "Each channel keeps its own water," he said. "But it stays horizontal during tilting and hence disturbs the center of gravity. This disturbance can easily be accommodated by a slight modification of the hull shape above the neutral waterline."

The lock tilts via hydraulic arms on each spud pole structure. These hydraulic cylinders would use just 0.04 kWh of energy, which would be supplied by solar panels. Poldervaart explained that energy requirements are minimal because the tilt is accomplished slowly—six seconds per degree—and the lock is in balance throughout the process, displacing no water.

The spud pole assemblies, which embody technology similar to that employed to anchor workboats, are still in the design phase. They will transfer horizontal forces to the bottom of the river and anchor directly into the soils.

"The idea behind using spud poles is that every now and then you may want to move the lock in order to maintain the bottom of the river underneath the lock to ensure enough depth for the lock," he explained. "So just order a tugboat or two, pull up the spud poles, and move the lock a few hundred meters."

The preliminary design of the Tilting Lock has been conceptualized for use on the Haringvliet Bridge, a bascule crossing in Cromstrijen, the Netherlands. This application would accommodate most sailboats with an air draft of 21 m or less, adding 8 m to the bridge's 13 m clearance. The lock can accommodate five sailboats at a time, alternating direction with each tilt.

The system would eliminate the majority of bridge openings for pleasure craft and reduce the economic effects of stopping traffic that come from lost time, wasted fuel, and delayed freight shipments. An economic analysis by Royal HaskoningDHV projects that the Tilting Lock could cost €60 million (U.S.$76.7 million) to build but would save €100 million (U.S.$129 million) over 25 years. And while the design team currently envisions the Tilting Lock being used in conjunction with movable bridges, it could be used in lieu of one if the conditions were right.

And while building a new movable bridge with the Tilting Lock system would probably be more expensive than building a conventional bridge high enough to allow all ships to pass beneath, aesthetic and land use concerns often preclude the construction of such bridges in the picturesque areas frequented by boaters.

The Royal HaskoningDHV team is proceeding with structural design of the lock, Poldervaart said. "Decisions have to be made on all sorts of detail questions, such as the influence of strong winds on energy use and the balance of the system."