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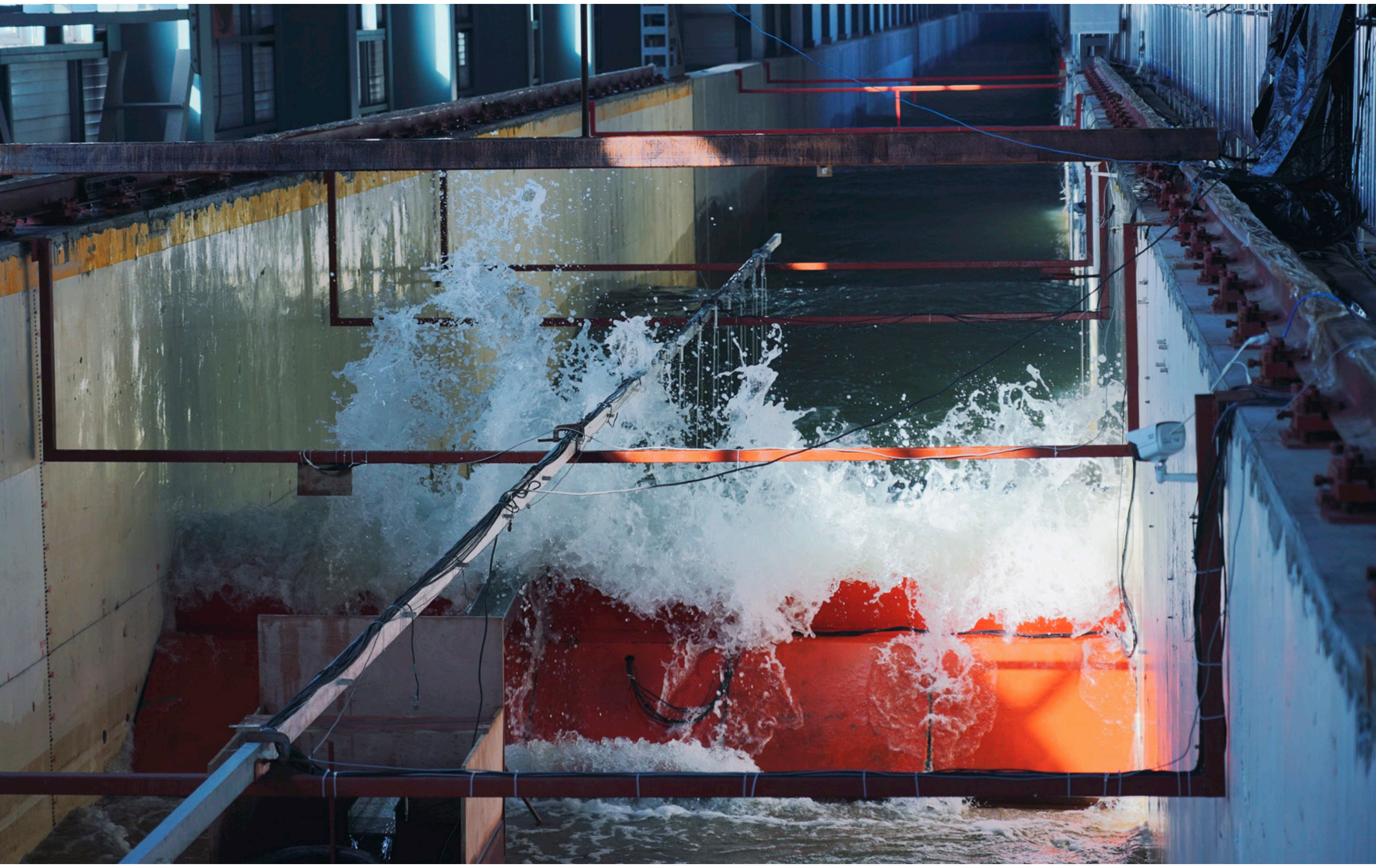

PRECISION UNDER WATER

TIWTE uses a Kistler dynamometer to measure wave impact loads on offshore structures

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Offshore structures test: Dr. Hu Jielong of TIWTE inspects the installation of Kistler's waterproof dynamometer under the platform for a photovoltaic system installed at sea.

A customized measuring instrument from Kistler is playing a key part in work at the Tianjin Research Institute for Water Transport Engineering (TIWTE) in northeastern China. Developed in Kistler's Custom Product Lane (CPL) to meet the Institute's specific requirements, this dynamometer withstands extreme conditions in the world's largest wave-current flume to supply precise data for hydrodynamic studies of wave impact loads on offshore structures.

The oceans have always presented us humans with opportunities as well as threats: on the one hand, they offer immense resources that can help solve problems such as meeting the energy needs of the world's ever-growing population. But on the other, they harbor risks that are becoming even more severe due to climate change: storm surges and tsunamis are just two examples. These issues are the focus of work at the Tianjin Research Institute for Water Transport Engineering (TIWTE) – a bureau-level institution directly under China's Ministry of Transport, located in the port city of Tianjin. Since 1974, researchers here have undertaken a vast and diverse range of projects on topics related to port construction and waterborne goods transportation. One of TIWTE's fifteen institutes is the Marine Hydrodynamics Research Center, which partners with all China's major ports as well as overseeing more than 200 projects in over 30 countries. Research topics here include wave impact loads on critical infrastructure elements – for example, dikes, dams, and offshore structures such as wind farms and solar farms operated at sea. "We also offer services including site selection and advisory support for infrastructure projects such as port facilities," says Dr. Chen Songgui, who heads the Flow Laboratory at TIWTE. "Our solutions help to overcome challenges in design and construction."

TIWTE's site in Tianjin houses the world's largest wave-current flume: it measures 456 meters in length and has water depths ranging from eight to twelve meters. This facility can even simulate tsunamis with the help of waves up to 3.5 meters high and a suitable scale ratio (between 1:1 and 1:5). Submarine cables are also tested here, flow tests are conducted on offshore structures, and wave impact loads on sea bridges are investigated. The advanced hydrodynamic measuring equipment at TIWTE includes a six-component dynamometer from Kistler, added in 2023. This instrument – the outcome of close Swiss-Chinese collaboration – was developed in Kistler's Custom Product Lane (CPL), an in-house department dedicated to complex customized measurement technology projects.

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>
> **Dr. Chen Songgui, Head of Flow Laboratory at TIWTE**

Water-resistant dynamometer tailored to individual customer needs

When the hydrodynamic experiments are in progress, the dynamometer has to meet several requirements such as water and corrosion resistance, adaptability, and immunity to interference – and, crucially, it must deliver exceptional measurement accuracy. "Water resistance, in particular, is a

Hu Bin, an expert in force measurement technology at Kistler China, assisted TIWTE researchers with hydrodynamic studies on offshore structures using the new dynamometer.

A dynamometer developed by Kistler for hydrodynamic tests provides researchers at TIWTE with precise measurement data – even under extreme conditions.

challenge not to be underestimated," according to Hu Bin, an expert in force measurement technology and testing at Kistler in China. "Ensuring stable operation at water depths of up to 20 meters goes far beyond conventional requirements." Moreover, the dynamometer was designed with the maximum possible resistance to interference from the facility's powerful wave generators and circulation pumps. Hu Bin adds: "Our task is to enable our customers to obtain high-quality measurement data, even under extremely complex testing conditions."

To achieve this goal, the CPL team at Kistler developed water-resistant cables and connectors; they then conducted an underwater test at 2 bar for the entire measurement chain, over a period of one week (168 hours). The six-component dynamometer – which measures all forces and moments in the three spatial axes – was also factory-calibrated to ensure optimal measurement accuracy under the specific operating conditions during hydrodynamic tests at TIWTE: these included measurements of wave impact loads on offshore structures. The customer was therefore highly satisfied when the dynamometer was delivered in late summer 2023.
Dr. Chen is enthusiastic: "The greatest advantage for us is that Kistler's sensors deliver data very reliably – even in underwater applications and over long periods. This makes it substantially easier for us to carry out our hydrodynamic experiments." Thanks to excellent performance across the entire measurement chain, TIWTE researchers save considerable time on the design, layout and installation of their tests. Reliable raw data can be obtained more directly and efficiently with no need for complex processing.

Wave impact loads: testing offshore structures

In a project at TIWTE led by Dr. Duan Zihao, the new dynamometer is used for hydrodynamic tests to measure the wave impact loads on onshore and offshore structures. One of the aims here is to understand how wave patterns and currents behave during sudden changes in coastal areas. The goal is to optimize the future design of breakwaters and related infrastructure. As an added benefit, the results may help to improve and supplement engineering standards in hydrodynamics. The dynamometer is embedded directly into the structures under test, thus ensuring the reliability and accuracy of hydrodynamic measurements over extended periods. "The critical factors here are the wide measurement range, high dynamic measuring capability with high resolution, and outstanding immunity to interference," Dr. Duan reports.

In a second research field led by Dr. Hu Jielong, the dynamometer was mounted under the platform of a photovoltaic system to be installed above the sea's surface. In this case, the total load acting on the offshore structure under extreme conditions is measured: this includes the loads due to wave impact as well as those caused by strong winds – during a typhoon, for instance. The measurement results allow step-by-step validation of the system to ensure the safety and efficiency of projects such as these. Thanks to the new customized and application-specific dynamometer from Kistler's CPL, the overall aerodynamic and hydrodynamic forces can be captured directly and accurately – even in a highly dynamic, rapidly changing environment. "With the help of Kistler's measurement technology, we can replicate the real situation as accurately as possible, so we effectively avoid potential errors caused by generalizations and complex calculations," Dr. Hu emphasizes.

Scientific research at TIWTE (the Tianjin Research Institute for Water Transport Engineering) began back in 1974 – and Kistler has been supporting TIWTE's work since 2023.

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