

10,000-ton, world's largest tunnel digger built with ancient swordsmith skill

The load of a tunnel boring machine is borne by the bearing which is not more than 0.4 inches thick.

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A large diameter TBM from CRCHI

Charlie Chen/ CRCHI

Engineers at the China Railway Construction Heavy Industry Corporation (CRCHI) have turned to a 2,500-year-old blacksmithing approach to help build the world's largest tunnel-boring machine (TBM). Weighing 10,000 tonnes, the TBM is as heavy as the Eiffel Tower and establishes China's dominance in yet another area of high-end engineering structure.

For a manufacturing giant, China was until recently dependent on the West for heavy tunneling equipment that was not only expensive to procure but also to maintain. It was only in 2008 that the country domestically manufactured a TBM, but in the following decade, it improved its technological capabilities to become a global leader in TBM supply.

TBM machines are critical components of underground construction machinery, allowing engineers to tunnel through a wide variety of terrains. However, the equipment is not only a feat of engineering but also combines high-end technology from electronics, information technology, and even artificial intelligence.

As engineers at CRCHI looked to build the world's largest TBM, they dug back into their ancient roots to overcome a major hurdle they faced.

Bringing back 2,500-year-old tech

Liebherr held the previous record for the world's largest TBM, boasting a diameter of 26 feet (eight meters). With increased size, the machine's weight also increases, increasing the load borne by the surface layer of the bearing, which is no more than 0.4 inches (one cm) thick.

As the temperatures of the main bearing change during the tunneling process, the structure can become weak. CRCHI engineers used an ancient [sword-making](#) technique to strengthen the steel and overcome this issue.

The intricate and sharp design of the Sword of Goujian, made of bronze for the King of Yue, who lived between 496 BC and 465 BC, was influenced by the engineers' research into techniques for hardening the steel on their TBM.



The Sword of Goujian made two and half millennia ago. Image credit: [Windmemories/Wikimedia Commons](#)

Conventionally, blacksmiths use a quenching process, where they harden the sword using high temperatures and then rapidly cool it down in water. However, with the Sword of Goujian, blacksmiths covered the sword with clay during quenching to ensure that the temperature changed uniformly.

By applying the same approach, CRCHI engineers solved the problem of uneven quenching temperatures and built the world's largest TBM.

From importer to world leader

The CRCHI TBM has a diameter of 28 feet (8.61 m) and is approximately three stories tall. The bearing that drives the machine weighs over 10,000 tonnes or is as heavy as the [Eiffel Tower](#), and is also composed of more than 30,000 parts.

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Its successful completion also made China a world leader in manufacturing extra-large-diameter-wide bearings, but the achievement took time.

Even after becoming the major supplier of TBMs, China continued to invest in improving the main bearing design and set up a research and design institute for this specific issue in 2019. Teaming up with the Chinese Academy of Sciences, CRCHI also worked on research and development projects for manufacturing the bearings, the [South China Morning Post](#) reported.

The achievement announced now has been in the works through experiments with materials and processes over many years.