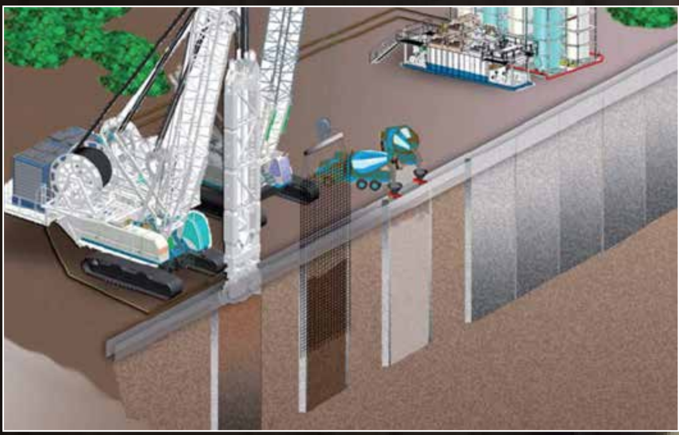
TECHNOLOGY

TTMJ
Tension Track Milled Joint

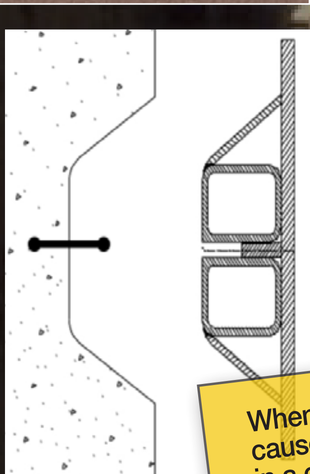
How to ensure good quality joints in embedded retaining walls?

Embedded retaining walls, such as diaphragm walls and secant pile walls, are installed from the surface down into the ground. They support the soil and allow excavation for structures such as basements and subway stations to take place. These walls can also be used as impervious barriers to prevent ground water inflow and/or movement.

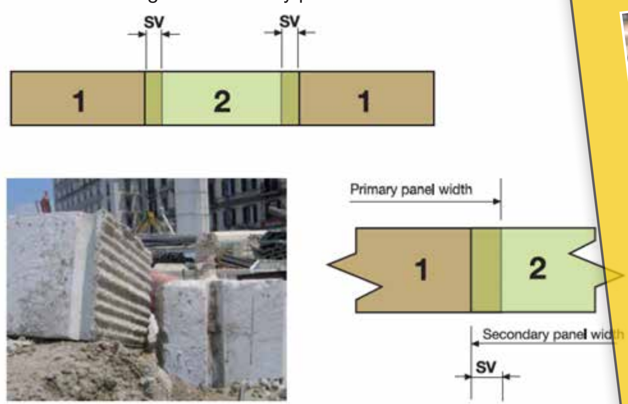
The selection of the type of embedded retaining wall, for any project, depends on many factors: such as the required wall depth, the nature of the soils, the groundwater level and the type of structure to be built. An assessment of these factors will help decide the type of wall to use and the accuracy with which it needs to be installed.



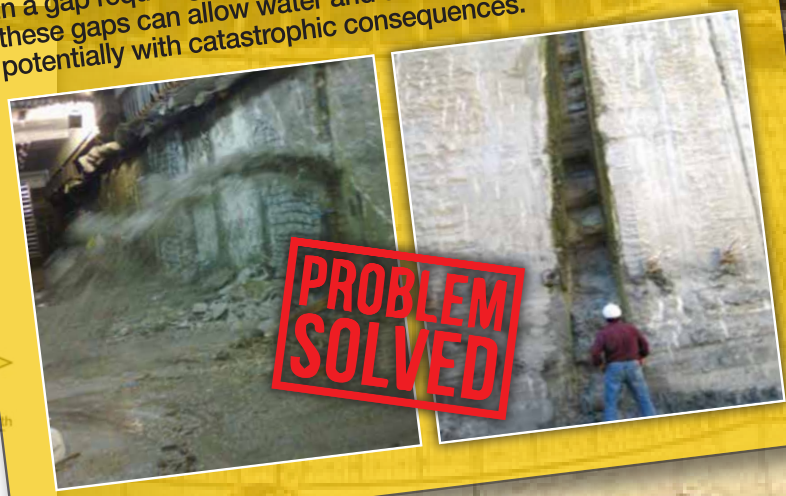
Diaphragm walls, which are the most popular system for deep embedded retaining walls, are formed from rectangular reinforced elements or panels. Typically, once a panel is excavated steel joint formers are installed, a prefabricated steel reinforcement cage is lowered into the excavation, and the panel is concreted. The panels are installed one at a time to form quasi-continuous wall. When hydro-mills are used to excavate the diaphragm wall they can also be used to overcut.



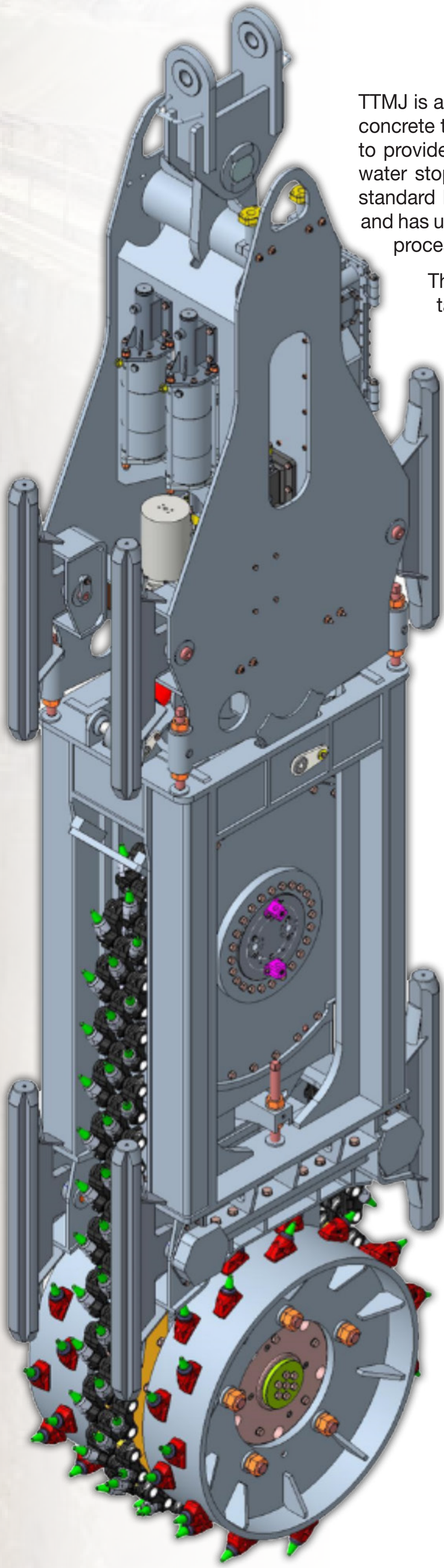
SV = concrete overcut in the primary panel when excavating the secondary panel



When using the conventional methods, the defects are mostly caused by misalignment between adjacent panels resulting in a gap requiring costly remediation work. Sometimes these gaps can allow water and soil to flow through the wall potentially with catastrophic consequences.



The new TTMJ System



TTMJ is a new diaphragm wall joint system, providing full width concrete to concrete joint contact to any depth, with the facility to provide a tension connection across the joints, an effective water stop and a shear key, none of which is possible with a standard hydromill. The system is covered by several patents, and has undergone several tests to allow full control of the entire process.

The TTMJ System provides concrete to concrete contact between panels, without requiring the use of joint formers, both with grab and hydromill excavation.

The system involves the use of a special trimming machine (the TTMJ trimmer) running in, and guided by, tracks cast into the primary panels. If a shear key is required, this is created simply by switching to a larger diameter sprocket for the cutting chain. The teeth on the chain will then cut deeper into the central portion of the joint producing a shear key.

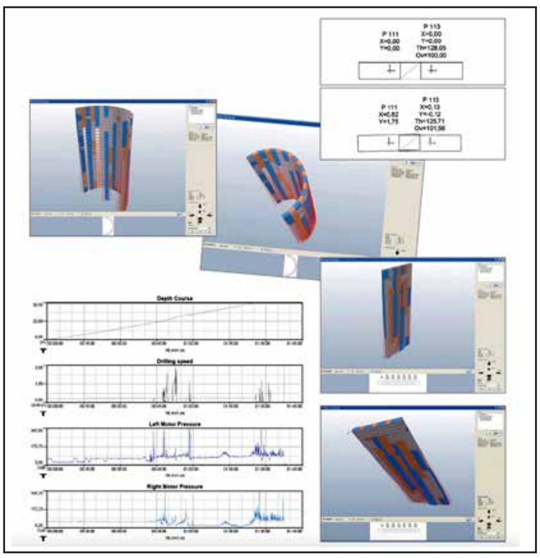
The trimmer can be replaced by a hydromill fitted with the bespoke guides. Each track is formed by a glass fibre reinforced polymer (GFRP) pultruded section, and a separate sacrificial profile on the front of the track, which is removed, as the trimmer cuts down the concrete.

Technology: equipment and tools

The plane of trimmed surface is controlled by the position of the two tracks in the primary panels

The system can trim the concrete of primary panels, regardless of the shape of the concrete at the end of the panel, by maintaining a pre-determined distance from the position of the GFRP tracks.

By surveying the position of the TTMJ tracks in combination with the onboard instrumentation, the position of each panel can be plotted in 3D.

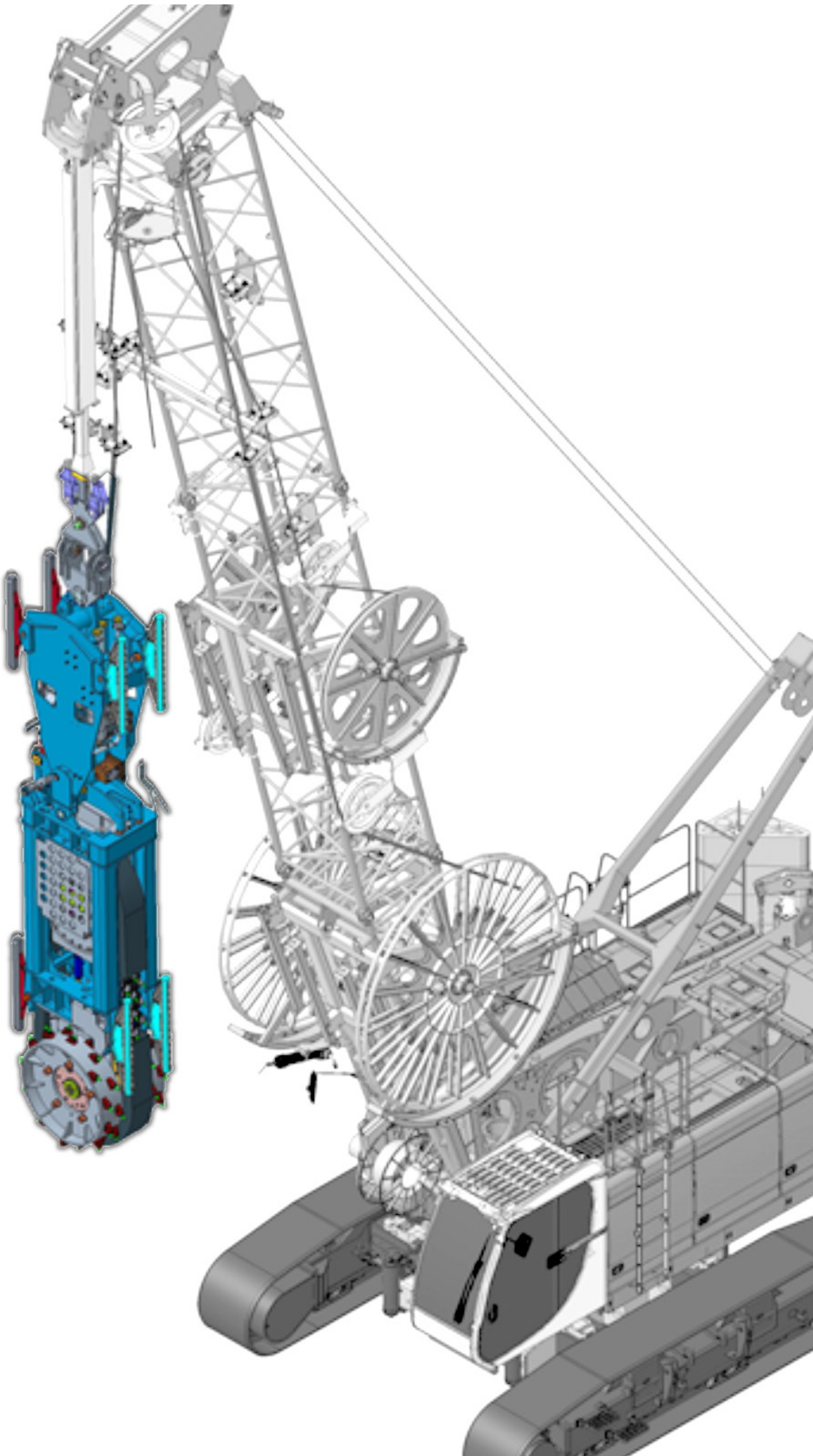


The basic TTMJ trimmer has a 1m wide cutting wheel.

Greater widths can be trimmed by simply changing the size of the cutting wheel.

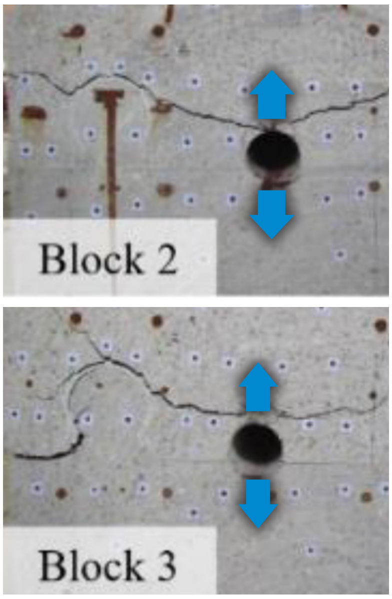
A special kit can be fitted to the crane, normally used for excavating with a hydraulic grab, so that it can also operate the TTMJ trimmer.

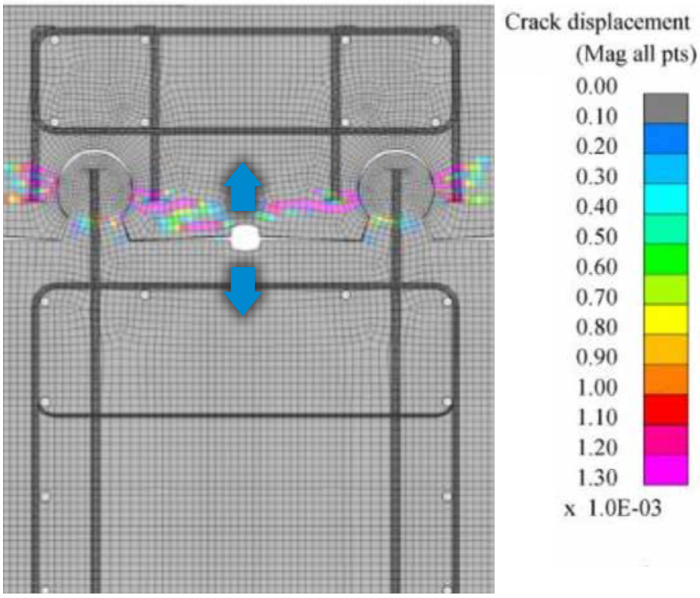
Alternatively, a hydromill can be fitted with the guides that fit into the TTMJ tracks.



Experimental splitting tests were conducted on three samples and compared with a LS-DYNA finite element model.

The model was adjusted to minimize the differences in terms of boundary conditions and prescribed loads with respect to the real test.





The crack pattern and the maximum tension forces observed in the model have been in very good agreement with LS-DYNA predictions, confirming the capability to estimate such capacity at design stage.

Main advantages

Programme and costs

• Minimization of the overcut: as little as 4 cm of concrete needs to be trimmed, thus increasing productivity and reducing contamination of the stabilizing fluid and costs for concrete

• The hydromill is no longer necessary in soil conditions where the use of the clamshell is more productive.

• Significant reduction of the programme on some diaphragm wall projects.

The above improvements can give potential cost savings of up to 20% on diaphragm wall projects.

Risk control

• Constant concrete-to-concrete contact between panels regardless of the depth, and regardless of the verticality tolerances.

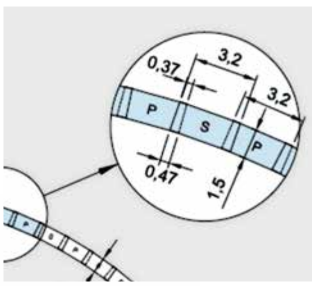
• Option to install a waterbar and option to install a tension connection between adjacent diaphragm wall panels.

• Option to form a shear key in the joint.

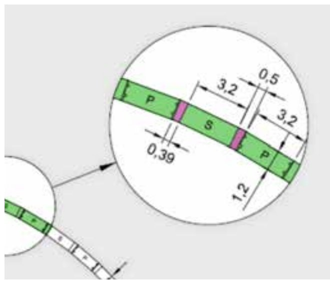
• Simpler joints in corner panels minimizing the need for "L" shaped cages and reducing single pour concrete volumes and slurry storage capacity requirements.

• Opportunity to build smaller-dimensioned square and circular shafts than is possible with current methods.

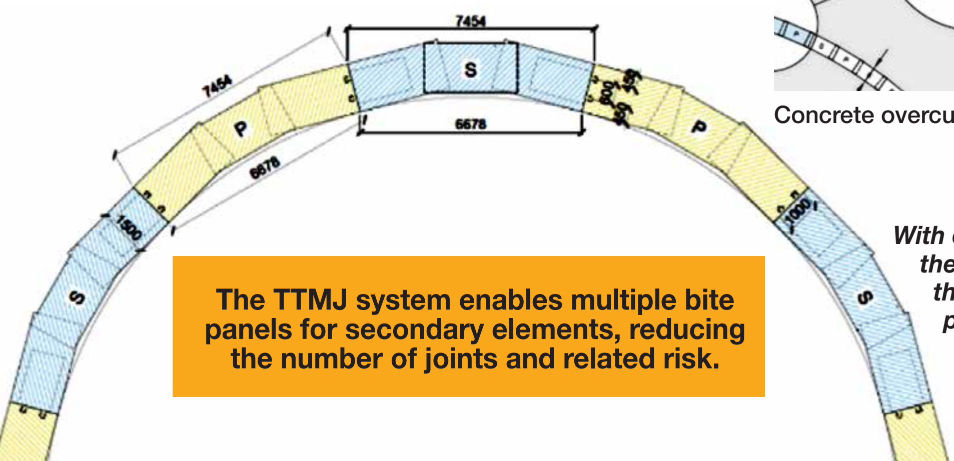
• Improved Health & Safety control of site operations.



Concrete overcut



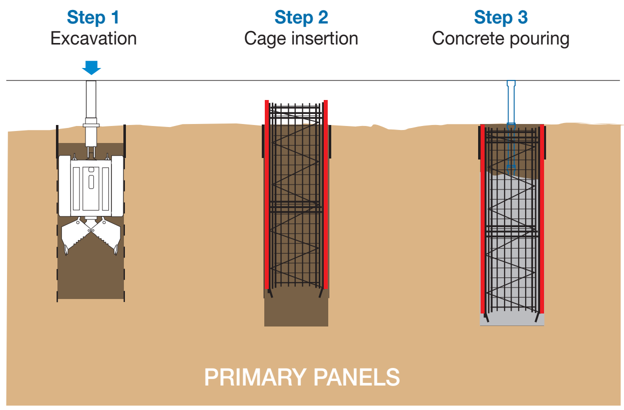
Material to be excavated by the trimmer



The TTMJ system enables multiple bite panels for secondary elements, reducing the number of joints and related risk.

With circular shafts, the TTMJ system reduces the number of panels and can reduce the thickness of the diaphragm wall, as it provides a guaranteed width of contact between adjacent panels.

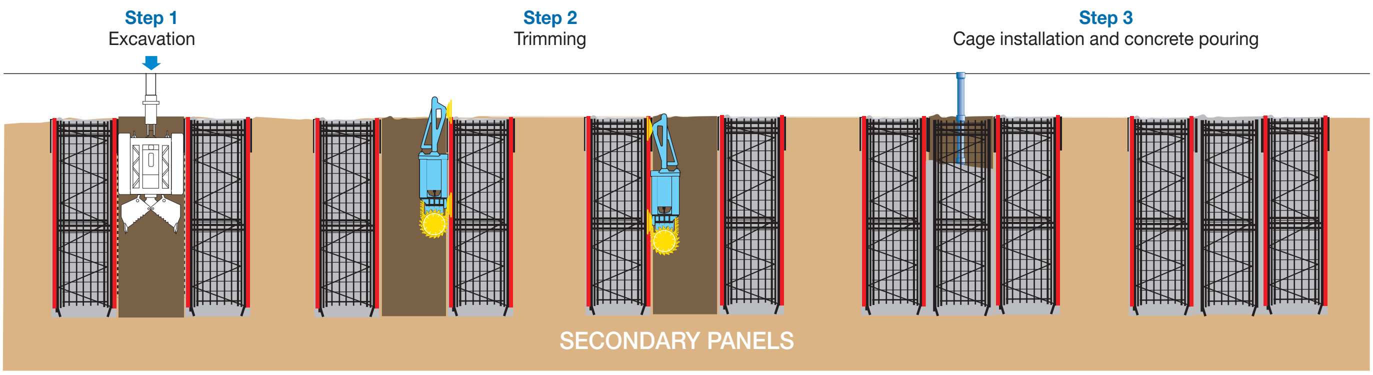
Work sequence



The sequence of installation involves the following steps:

Installation of primary panels:

- Excavation by grab/hydromill to design depth;
- Installation of the prefabricated reinforcement cage which is fitted with a pair of GFRP tracks at each end;
- Pouring concrete to complete the primary panel.

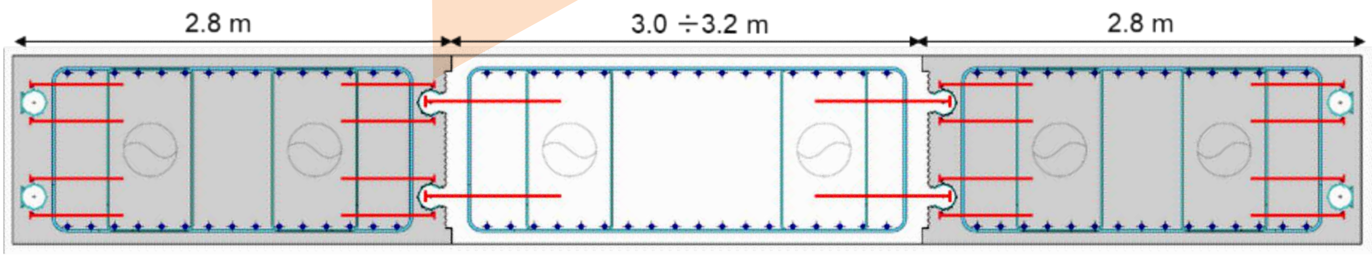


After at least two primary panels are installed, **installation of secondary panels:**

- Excavation of the panel, using one pass or multiple passes; grab or hydromill can be used;
- Trimming of the ends of the adjacent primary panels with TTMJ trimmer or bespoke hydromill;
- Installation of the prefabricated reinforcement cage;
- Pouring concrete to complete the secondary panel.

Tension Joints

The reinforcement cage of the secondary element can be fitted with T-head bars to form the tension connection across the panel joint.



Applications

Experimental splitting tests were conducted on three samples and compared with a LS-DYNA finite element model by Arup. The model was adjusted to minimize the differences in terms of boundary conditions and prescribed loads with respect to the real test.
The crack pattern and the maximum tension forces observed in the model have been in very good agreement with LS-DYNA predictions, confirming the capability to estimate such capacity at design stage.

A typical application for the TTMJ joint is where circular or peanut shafts are used for metro stations, underground basements and similar structures, mine access, fuel storage, etc. This circular geometry is very popular for its' intrinsic stiffness. These types of shafts are becoming preferred more and more by designers, as they reduce settlement by 60%, and require less propping because the structures work in compression.

The TTMJ system allows concrete-to-concrete contact between adjacent panels regardless their depth.

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Trevi is committed to continuous innovation and searching for solutions to complex civil engineering problems worldwide. Experimenting cutting-edge technologies, entrepreneurship and investing in research and human resources are the strengths of a company based in more than 30 countries.

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