RMD KWIKFORM

ALTRAD

Bringing structures to life

ON-SITE | INSIGHT

GROUND SHORING AND THERMAL LOAD

THERMAL LOADING:

All you need to know

The new Tubeshor
Active Thermal Compensator

Ground breaking
innovations

Introduction

Underground construction projects have a critical role in creating modern infrastructure. Whether it's creating basements, transport tunnels, or underground storage facilities, projects are often highly complex, bringing significant technical challenges and costs.

The global underground construction equipment market size was valued at $19.4 billion in 2021, and is projected to reach $31.3 billion by 2031[1], and a vast range of solutions are available to assist with creating underground spaces and structures.

When it comes to ground support, the use of proprietary props to support deep excavations has become increasingly popular, with contractors moving away from using structural steel due to supply chain issues and price fluctuations.

As well as the usual excavation sequence and geotechnical factors that need to be taken into consideration during the design of a scheme, vital seasonal and environmental factors also need to be considered as they give rise to thermal loading.

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[1]https://www.alliedmarketresearch.com/underground-construction-equipment-market-A53682

What is thermal load?

Props used for ground support are confined between the relatively stiff walls of an excavation. This means that they are not able to freely change their length when subjected to daily and seasonal air temperature variations.

The confined nature of the props means that temperature changes bring about changes in the axial prop load with axial loads increasing with higher temperature and decreasing with lower temperature.

Historically thermal loading has not been such an issue in the UK due to the relatively even climate. However, Consulting Engineers are now interpreting industry standards differently, meaning an increased contribution from solar gain also has to be taken into account, which, when combined with seasonal and daily variations can produce a design thermal range in excess of 35˚C.

An increased contribution from solar gain can produce a design thermal range in excess of

35°C

How does this affect ground shoring equipment?

Using this temperature range, thermal loading can account for 50% of the axial load capacity of the props, so half of the steel in the excavation is there purely to take account of thermal loading.

The resulting need for larger or more props can sap scheme efficiency, push up the equipment cost, and take up valuable excavation space.

What's more, installation may require heavier plant and more labour to assemble the equipment, incur greater costs for transportation and result in a larger carbon footprint.

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THERMAL LOAD CRITERIA

There are five variables that influence the thermal loading within a propping system:

1. The cross-sectional area of the Steel tube from which the prop body is made
2. The bore and extended length of any in-line (not mechanically locked) hydraulic system
3. The compressibility of the hydraulic fluids therein
4. The stiffness of the supported structure
5. The change in the temperature of the propping components from installation, resulting from daily and seasonal temperature changes together with solar gain.

In-prop hydraulics can reduce induced thermal loading as the bulk modulus (volumetric stiffness) of the hydraulic oil is significantly lower than the Young's modulus (uni-axial stiffness) of the prop steelwork. Therefore, a prop with an in-line hydraulic cylinder has a lower axial stiffness than an equivalent prop made from structural steel. There are though some negative factors in the use of existing in-line hydraulic solutions:

- The prop allowable working load is restricted to the maximum load capacity of the hydraulic cylinder, which is often 2-3 times lower than the load capacity of the prop steelwork.
- The reduction in prop axial stiffness due to the presence of the hydraulic oil is partially offset by the fact that the coefficient of thermal expansion for the oil is 58 times more than that of the steelwork, which renders the effect less useful, especially when considering longer term temperature variations.
- The maximum stroke of internal hydraulic systems is 800-1,000mm and application engineers typically target mid-range ram extension (circa 450mm) to provide maximum leeway to deal with variations in the excavation size on site. Therefore, a hydraulic seal failure resulting in loss of pressure from the hydraulic system could result in very significant prop shortening that is likely to significantly compromise the safety of the excavation and surrounding infrastructure.
- Altrad RMD Kwikform hydraulic units incorporate RamLock screw collars that can be wound down onto the prop steelwork, thus isolating the hydraulics from the structure and eliminating any risk associated with hydraulic cylinder leakage. This produces a much stiffer prop, which can be desirable in some applications, but does significantly increase the induced thermal load.
- A mid-way solution with Altrad RMDK RamLock units that better satisfies all constraints, is to leave the RamLock screw collar raised just 25mm, so the thermal load is reduced by the hydraulics, and any oil leakage will result in minimal prop shortening. Which should protect the excavation whilst remedial measures are put in place ; allowing a lower (hydraulic) thermal load range to be used without compromising on safety.

Mitigating risks from **thermal load** variations

There are currently several methods used to mitigate risks from thermal load variations and the reduction in solar gain:

Higher yield steel:

Using high yield grade S460 steel minimises steel area and reduces thermal loading.

Painting props white:

Heat input via solar gain is affected by the colour of the paint finish to the props, with white reflective paint resulting in lower solar gain than matt black paint. Orange, yellow, red, and cyan props are classed as being a light colour and attract a medium rating. However, painting props white has been shown to reduce solar gain by only 10%.

Insulating props:

Insulating prop wrapping has been shown to reduce total daily thermal variation (including air temperature changes and solar gain) by about 45%, but cannot compensate for seasonal temperature shift. Taking into account seasonal changes, the maximum reduction in thermal effect by use of these simpler means is estimated to be 35%.

Thermal load monitoring / e-Pins:

High-capacity load cells - e-Pins provide real time load data with alert notifications against pre-determined trigger levels for thermal load variations.

RamLock units:

The Altrad RMDK RamLock units feature a unique mechanical screw collar that can be left raised by around 25mm and act as a fail-safe in the event of a hydraulic seal failure.

TUBESHOR ACTIVE THERMAL COMPENSATOR

With this in mind, above and below ground temporary works specialist, Altrad RMD Kwikform has recently developed a revolutionary new solution to reduce the effects of thermal loading - the Tubeshor Active Thermal Compensator (ATC).

Quick overview of Tubeshor

The Tubeshor hybrid hydraulic tubular shoring system is used for propping waler beams or capping beams of large excavations. It comes in a range of diameters to cater for all heavy-duty shoring requirements.

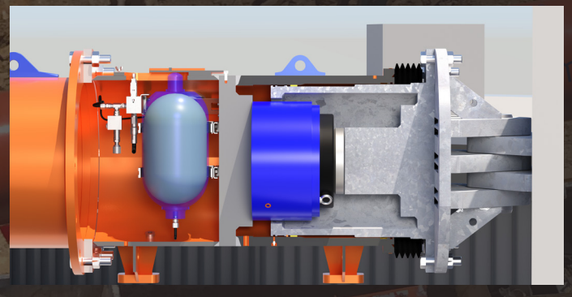
What is the ATC?

An evolution of Tubeshor, the Tubeshor Active Thermal Compensator (ATC), is a Tubeshor accessory that can reduce thermal loading by up to 90% compared to a mechanically locked off prop.

How is it installed?

Prop installation and pre-loading on site is carried out in the same way as for any standard proprietary prop, so no special operative skills are needed.

What's more, as Tubeshor ATC Units are assembled directly into the prop makeup at the end, standard prop end-fittings such as Swivel Units and Spherical Bearers can be used, and props can be installed into the excavation in the usual manner.



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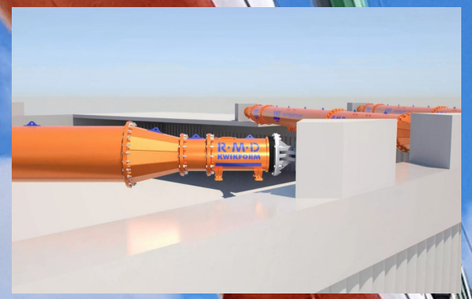
How does it work?

The Tubeshor ATC contains a 450tonne load capacity hydraulic cylinder coupled to a bladder accumulator which is pressurised to suit the individual prop and design geo-load before dispatch. Most of the time, the pressure of the hydraulic cylinder will be less than the pressure in the accumulator - which results in normal/static performance of the prop.

When higher temperature forces excessive prop thermal expansion which causes the pressure in the hydraulic cylinder to be greater than the accumulator, the gas within the accumulator will automatically compress to balance out the pressures. This means that a further increase in prop length resulting from thermal expansion does not result in nearly the usual increase in prop load.

FEATURES AND BENEFITS



Reduction in props:

Up to 90% reduction in thermal loading reduces prop loads, enables less and/or smaller props with wider prop spacings.

Reduced cost:

With less space taken up within the excavation, savings can be made on equipment, labour, transport, and plant cost, as smaller plant can be used to install and remove the equipment.

More economical permanent works design:

Loads imposed on the permanent wall from the temporary props are reduced, enabling a lower cost wall design using less material and potentially reduce the volume of excavated soil, minimising project cost, and further decreasing the carbon footprint.

Quick and easy installation and use:

Prop installation and pre-loading on site is carried out in the same way as for any standard proprietary prop, so no special operative skills are needed with quick installation.

Autonomous mitigation:

Mitigation of thermal load is autonomous with no need for external pumps or electrical power, which reduces complexity, the chance of malfunction and improves on-site safety.

Innovative monitoring:

The prop load can be read by direct inspection on site, with the option to use e-Pins and Wireless Nodes to provide continuous prop load monitoring and data logging via a smartphone, tablet or laptop offering total peace of mind.

Inherently safe:

Tubeshor ATC is CE certified and compliant with the European Pressure Directive.

Reduced CO2:

Less material, transport, waste & smaller plant, lowers carbon footprint.

Bladder **Accumulator** explained

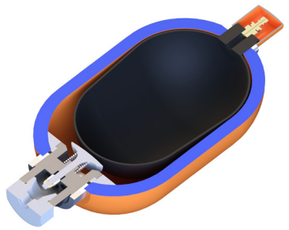
The term fluid encompasses both the liquid and gaseous phases of materials. The volumetric stiffness of a gas is many times lower than that of a liquid, so the optimum way to reduce the stiffness of the hydraulic circuit is to introduce a gas.

This could be directly into a hydraulic cylinder, but this has the potential to result in cavitation damage to cylinders, seals and pumps which is not desirable. The optimum way in which to introduce the gas is thus via connection of a pressurised bladder accumulator.

A bladder accumulator consists of a forged, high-yield steel external capsule containing a flexible Neoprene bladder. The bladder is open at one end where it seals to the capsule, with a valve used to charge the unit with gas to a pre-charge pressure. In the pressurised state the bladder fully fills the steel capsule.

The opposite end of the capsule is connected to the hydraulic circuit. Once the oil pressure in the circuit exceeds the bladder pre-charge pressure, oil enters the capsule partially compressing the bladder until equilibrium is reached. In this state the compressed gas is in-series with the hydraulic system whilst being isolated from it.

Pure, dry nitrogen gas is used to charge accumulators as it is economical, inert and a non-pollutant. Active Thermal Compensator accumulators are supplied to site pre-charged so that there will be no need for adjustment on site. The accumulators used have a safe working pressure of 690bar, which significantly exceeds the 500bar maximum pressure rating for the coupled hydraulic cylinder.



Support and **Collaboration** with **Altrad RMD KWIKFORM**

By collaborating with Altrad RMDK on your project you can benefit from a highly skilled team who understand the ever-increasing complexity of projects, tight timescales, and the need to meet stringent health and safety standards.

Once we have supplied materials, trained Site Demonstrators can be on hand to provide practical guidance on how best to use our equipment in a safe and efficient manner, as well as advising on any design variations required. Our sole objective is to ensure you achieve a successful outcome.

Altrad RMD Kwikform is the only temporary works provider to offer this unique Patented ATC solution, in tandem with comprehensive ongoing support to our customers throughout the initial specification, installation, and throughout the propping cycle.

Ajay Nagah,
Commercial Manager

THE FUTURE OF **GROUND SHORING**

Hydraulic props offer a range of benefits for supporting excavations, such as, quick and easy installation, flexibility and the ability to re-use equipment, as well as being a sustainable and economical solution. Despite this, the adoption of hydraulic propping has been varied across the globe, with varied historical customs and practices in different markets.

While hydraulic propping may not be commonplace in all regions yet, this could change over the next 5-10 years. We are starting to see a shift in perceptions, with more regions appreciating the value in preloading excavations with hydraulics. We believe this is the beginning of a new step change towards widespread adoption of advanced hydraulic propping and the benefits this could offer.

Stage one is material innovation - using higher grade steels and composite materials in the construction of props in the future. Ideally, engineers want to design and develop a solution that reduces weight and thermal load and/or a smaller section size, but to achieve this, higher grades of materials are required.

Stage two is the uptake of not only standard hydraulic props, but the shift towards equipment that boasts intelligent features and technology that makes the solution safer, easier and more cost effective. A great example of this is Tubeshor ATC.

Stage three is all about data collection and utilising it in an intelligent manner to inform decisions on current and future projects. At present we are spending a lot of time collecting data, but what do we do with it? It's about better understanding the behaviour of an excavation during the construction phase and working out how you adapt your engineering judgement based on that data.

Historically, solutions have been designed to code parameters set out in a rigid manner, but when we take load measurements, we may anticipate load X, but we actually get load Y – sometimes that can be up to 60% less than what we designed for. This gap is a consequence of multiple factors of safety, but are we adding unnecessary insurance on top of insurance?

In comparison, we are now at a stage where we can collect data that gives us the ability to have a more observational and economical approach to design. This real-life data enables engineers to challenge methods and parameters laid out in standards that may be proven by monitoring results to be over-conservative. Ultimately, we want to have an accepted code that allows us to make a judgement based on collected data.

An engineering skillset is essential for this type of analysis and judgement, to think outside the box and offer a leaner solution for the customer. At Altrad RMD Kwikform we're not focusing on going big, we're focused on being smart - it's how we design our products, with Finite Element Analysis (FEA) and laboratory testing of our equipment.

We are pushing the envelope of innovation, fine tuning every aspect of what we do to get the maximum performance whilst using unique and innovative manufacturing procedures. We hope to be a catalyst for a shift in the way the industry works and revolutionise hydraulic propping for the better.

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