Thor Helical Wire Design Brief (European Patent No. EP 1307303B1)

There are three behavioral characteristics which, in combination, are inherently unique to helically finned wire fixings. These characteristics are torsional elasticity/yield, surface friction and the mechanical interaction with various compositions of substrate.

In order to fully understand the anchorage it is necessary to appreciate how the tie is manufactured, how it is installed and how it behaves under load.

1. Manufacturing Process.

Thor Helical wire is formed from round stainless steel wire, which is passed through a series of rolling processes to progressively alter the cross sectional shape into a substantially cruciform profile with large work- hardened fins that extend from its core (Fig 1).

The profiled wire is then forced through a twisting die such that the fins are wound around the core in a precise helical path (Fig 2). During the twisting process the wire shortens by about 5% as the core becomes compressively stressed, whilst the fins, which run both along and around the core, are stressed into tension.

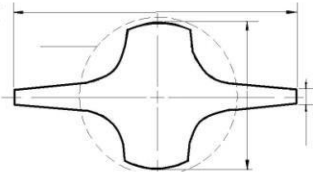

Fig 1

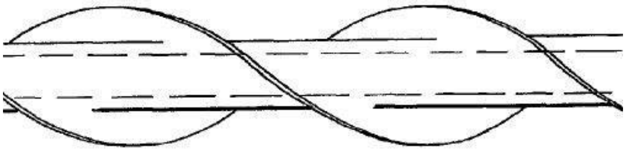

Fig 2

The process delivers a pre-stressed wire having a nominal ultimate tensile strength around twice that of conventional stainless steel wire (Heli-Tie wire = circa 160 Kips/I^2 - rebar = circa 75 Kips/I^2), with a consistently high level of flexural capacity.

2. Installation.

The Thor Helical 9mm “CDTies™” are essentially a hammer driven self-tapping screw anchor for use in base construction materials such as timber, concrete and masonry. When subjected to a series of axially applied hammer blows, the faces of angular helical fins react against the host material, initiating self-rotation of the fixing as it cuts a precise helically threaded penetrative path.

The anchorage is achieved by virtue of the peaks and troughs of the helix being mechanically interlocked with the host material and acting upon the hosts cylindrical shear resistance at the notional circumscribed periphery of the helical fins. The interlocking mechanical connection exerts no expansion forces and efficiently transfers the loads to the base material along the entire embedded length of the anchorage. The resulting stress-free connection compliments the ties high-performance spring-like characteristics to provide consistent load capacity and vibration failure resistance**.**

3. Behavioral Characteristics.

2.1 Torsional Elasticity.

Conventional self-tapping anchors have a rigid thread angle of 25 degrees or less and are installed via rotary power. They achieve relatively high load with little yield, failure being characterized by sudden shear of the base material.

The Thor Helical 9mm tie has a twin start thread, each with a nominal angle of 57.85 degrees (+/- 0.7) such that provides optimum angle of deflection to permit hammered installation. This angle optimises the balance of shear between the tie fin and that of the base material within the helical trough (Fig 11).

If the tie is fixed into a single building element it can simply be withdrawn, subject to the amount of frictional resistance, by unscrewing it from its helical seating. However when two separate elements are helically connected both ends of the tie become locked against rotation, as the construction elements are themselves not free to rotate, thereby resolving all torsional tendencies in equal and opposite fashion.

When the tied elements are subjected to an axial load the angular interface connections transmit the axial load as torsional stress, (Fig 4), which depending on whether the axial load is compressive or tensile attempts to tighten or loosen the pitch of the helix.

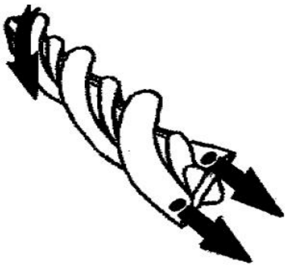

Fig 4

The torsional behavior enables the helical fixing to progressively accumulate the load, acting in effect like a high strength torsional spring, to accommodate natural building movements and provide high and consistent service load capacity. This torsional elasticity provides Thor Helical 9mm ties with an inherent capacity to load share from one anchor to another.

Figure 5 represents an exaggerated friction-free behavioral model to highlight the conditions under which extreme axial load could overcome elastic torsional resistance and induce excessive deflection, (uncoiling of the unrestrained portion).

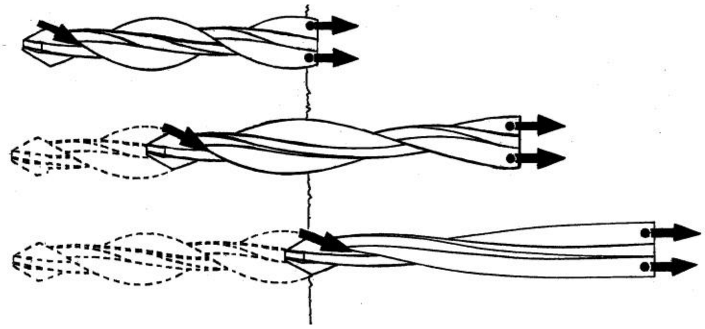

Fig 5

Torsional capacity has a significant bearing upon performance and in real circumstance, under service load conditions, such deflections are miniscule and within elastic limits. As the strain is relieved the embedded portion of the helix will regain and maintain load capacity. This unique torsional yield characteristic avoids catastrophic or sudden in-service failure.

The Thor Helical 9mm tie is designed with an optimum cross sectional profile to maximize torsional strength. Figure 6 shows the cross section of the Thor Helical 9mm tie, with its strong central mass (core/web) to lever arm (fin) ratio. Figure 7 and Figure 8 show the cross sections of competing alternatives in less robust 8mm and

10mm profiles respectively. These competing ties have a disproportionate central mass to lever-arm ratios, even from one size to the next, the reduced material content providing less torsional capacity.

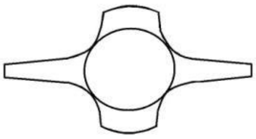

Fig 6

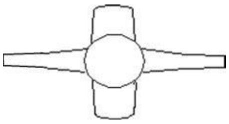

Fig 7

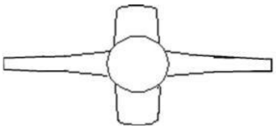

Fig 8

2.2 Friction.

Friction takes place on primarily upon the contact faces of the helical fins, (tension on one side and compression on other), and is a function of the force that presses objects together and the roughness of the interfacing surfaces.

The helical tie will give higher load performance in dense concretes having an aggregate matrix containing sharp and hard flint-like elements than in a more consistent material such as aerated concrete. This is due to the dense concrete having a much rougher surface that provides a higher coefficient of static friction, offering greater resistance to rotational unscrewing of the tie.

2.3 Mechanical Interaction with Substrate.

Performance reliability is a function of the tie, in terms of pitch consistency, torsion and elasticity, and the base material, in terms of stress capacity, static coefficients of friction and consistency of composition.

The anchorage relies upon intimate contact at the thread periphery with the hosting base material. The helical form provides an even contribution of load upon its full embedment depth, distributing the cone of influence upon a narrowed angle (Fig 9) and allowing the tie to be used at close edge-distance.

The most frictionally consistent building material is aerated concrete, followed by wood, clay brick and finally concrete, which, being made up of relatively large aggregates provides a course pilot hole wall, such that contact points with the tie are potentially courser though less consistent.

Under load one face of the torsionally stressed tie will bed tightly against the irregular matrix of large aggregate particles, creating a narrow angled band of mechanical interlock (Fig 10) and inducing high levels of friction.
If the granular aggregate particles are dislodged by the strain or if the static frictional resistance is overcome locally, there is a temporary drop of load and a local relaxation of torsional stress.

Fig 9.

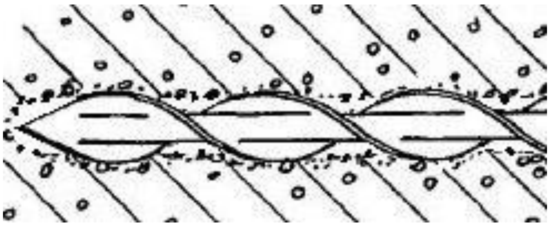

Fig 10.

Under microscopic drop-off movement the forces are redistributed as the helix flexes to re-bed itself locally and regain mechanical and frictional interface, thus permitting the re-accumulation of load, often to a higher level, despite the displacement encountered.

It should be remembered that on thin walled blocks loads are concentrated over a relatively shallow embedment depth and shortened interface connection. The microscopic cycle of relaxation and recovery is, in this instance, likely to be more scattered than for deeper embedment, due to the shallow aggregate matrix.

3. Summary.

In understanding the role of torsion, friction and the mechanical interaction between the Thor Helical 9mm tie and a range of base materials it becomes easier to comprehend the behavioral characteristics of helical anchorages, to interpret test results and to establish design specifications.

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5 Features and Benefits of Helical Ties.

Features	Benefits
One Piece Anchor.	No multiple components or moving parts.
	Economic.
Stainless Steel Construction.	Corrosion Resistant, (Austenitic 316 Grade).
Helical Design.	Permits Rapid Hammer-Action Installation.
	No high point loading.
	Multi-drip points to prevent water transfer.
Undercutting Fins.	Non expansive stress.
	Close edge-distancing.
Rolled from Round Wire.	Extraordinary Tensile Strength.
Flexible.	Accommodates normal & cyclic building movements.
Versatile.	Effective in Concrete, Brick, Hard Mortar and Timber.
	Usable in all climates.
	Excellent interlock with grouts, mortars and resins in other applications.

6 Thor Helical Tie Advantages over other Helical Ties.

The Ollises earlier original patented profiles, (known as **Helifix**, Brutt and Target Fixings (U.K), are still being formed from long lengths of profiled wire, (7-10 metres), which are twisted by spinning the wire between two centres such as to provide a defined number of revolutions (pitches) over the length. The resulting length of helical wire has a pitch that is invariably progressively tighter at one end than at its centre.

The upper portion of Fig. 11 represents an exaggerated behavioral model of an inaccurately twisted helical tie that highlights the deficiencies of pitch variance whereby the angle of the leading end undercut is widened by the trailing threads, to the detriment of the interfacing connection. The lower portion represents the correct interface connection as provided by the precise pitch twisting die technology, (***European Patent No. EP 1307303B1***), of Thor Helical ties and wires.

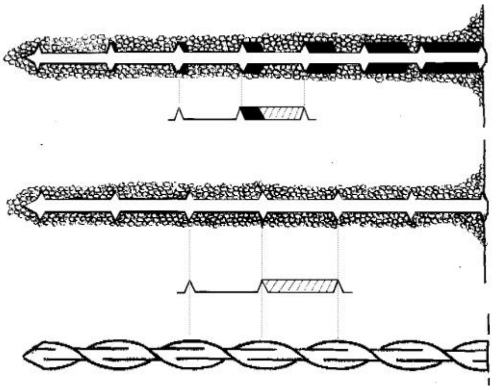

Fig. 11
Top: - Inaccurate Undercut.
Bottom: - Precise Pitch Technology.

Features	Benefits
Precise Pitch Technology (***EP 1307303B1***).	Stronger, Reliable Helical Consistency
	Easier, Faster Installation
	Accurate Tracking Across Wide Cavities
Balanced Robust Profile.	Greater Torsional Strength
	Increased Compression Resistance (Reduces Buckling Tendencies)
Manufacturing	Innovative Design - Precise Engineering
Full In House Control	Continuous Improvement over 30 years.