Engineering Bulletin 032

RE: Cable Proof Loading and Pre-Tensioning to Ensure Lasting Performance

Wire rope or mechanical cable is widely used for its capability to carry large tension loads. Formed from wires twisted into a helix, the basic unit of composite rope, wire rope evolved from wrought iron chains that had a history of failure. Since wire rope is made from many parallel strands of wire, a flaw in one wire is compensated for by the other wires. Versatility, cost-effectiveness, flexibility, high strength-to-weight ratio, and wide availability are primary reasons why mechanical cables are ubiquitous in structures, machinery, marine and aerospace, mines, and manufacturing facilities.

Although surprising, mechanical cables do stretch, which must be considered when designing a system that relies on cables. The load-carrying capacity of fabric structures is reliant on properly addressing the cable stretch. Two different kinds of stretches that designers anticipate are **constructional stretch** and **elastic stretch**.

When mechanical cable is manufactured, small gaps form between the wires as they are twisted together. The initial load that is applied to the cable causes the wires to close those gaps and nest together. The resulting elongation from this initial load is called **constructional stretch**, and it is a permanent elongation. The amount of permanent elongation depends on the diameter of the cable, construction method, and lay-length.

Elastic stretch is fundamental to ductile materials such as steel and stainless steel, which wire rope is typically made from. As cables are put under increasing tension loads, there is a linear region where the cable elongation is linearly related to the load – this is called the linear elastic region, and in this region when the load is removed the material returns to its initial length. If cables are loaded beyond the elastic region, the steel stretches plastically and this portion of the elongation will be permanent.

Because the constructional stretch does not deform the material at all (since it arises as the individual strands move to their intended position in the composite structure of the cable) it is sometimes referred to as the “inelastic stretch” or “initial stretch”.

Practical Procedures for Cable Use

Since fabric-covered structures draw their strength from tension, engineers must predict how much the cable will stretch under the expected loads (gravity, snow, wind) to validate the reliability of the structure. Two installation procedures – proof loading and pre-tensioning – are employed to ensure that the cable assemblies perform as required.

Proof Loading

This operation puts significant tension on the cable to take out the constructional stretch before any fittings are attached to the ends. Proof loading involves putting a tension load on the cable of about 60% of the cable's rated breaking strength. This proof loading forces the individual strands to fit together tightly. After the proof loading is completed, it is important not to re-coil the cable, bending or rolling the cable can allow some of the gaps between the strands to reappear. If a cable is re-coiled, it must be proof loaded again once re-installed.

Proof Loading Process

Once the cables are installed in the structure, a prescribed number of turns of the turnbuckle are installed. The thread pitch of the turnbuckle is used the compute the resulting stretch in the cable which corresponds to ~60% of the cable strength. After completing the proof loading, the cable is returned to slack and then pre-tensioned in a similar fashion.

Pre-tensioning

In pre-tensioning, the cable is loaded just above the expected maximum working load of the cable to ensure that it stays under tension during service. A specified number of turns on the turnbuckle is prescribed to achieve the required pre-tension.

Benefits for Fabric-Covered Structures

Due to the fact that the fabric structures rely on tension-only bracing for stability, the pre-tension in the cables and removal of the initial inelastic stretch (constructional stretch) is critical to the performance of the structure.

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