T5 – Cable structure

Background

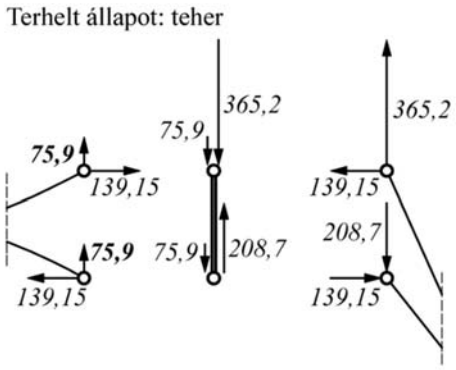
In case of high-span structures – as in the beginning of the semester – the cross section of an element can be utilized the most if pure tension applies in the structure. In this case no buckling has to be considered, the element can be loaded until its strength limit. However, for cable structures the shape must be maintained in order to avoid deformation for different loads.

In case of pre-tensioned structures, the effect of pre-tensioning is usually of same scale as the internal forces caused by external loads. However, it is possible to design such a truss structure that contains only compressed elements.

The pre-tensioning is a permanent effect on the structure, but its magnitude can change over time (relaxation of the material), thus post-tensioning may be necessary. In case of tensioning two different safety factors are to be applied: favorable case: $\gamma_{P,fav}=1,0$; unfavorable case: $\gamma_{P,unfav}=1,3$.

Currently no Eurocode standard is available for cable structures.

Aim of the practical



In this lesson the internal forces in a cable structure are presented. In these cable-truss structures the "compressed" (upper) cord is able to performs its task because of pre-tensioning. The "compression" caused by the external load defines the minimum value of pre-tensioning.

The behaviour of the structure is presented separately for each case (external load only / pre-tensioning only), that the internal forces are combined based on linear superposition. At both sides tensioned binding cables are necessary to support the structure. These cables apply tension to the foundation.

The tensioned foundation is verified in two cases: First, the self-weighted foundation, that transmits the loads to the soil, which is a plastic material without tensile strength. This balances the foundation against the normal forces and moment caused by the columns and cables. In the second case long enough soil anchors are applied that transmit the tension to the lower layers of the soil.

During the practical a simple approximation is presented to calculate the required cross section of a wire cable. This helps the specification of the cable thickness in a pre-design phase. To define the exact cross-sections and products it is adviced to visit the webpage of producers: Pfeifer, FUX, furthermore we recommend the webpage membranedetail.

In connection with previous courses

Superposition of effects (*Statics*)
Assessing Load-combinations (*Design of load bearing structures*)
Principle of distributed safety *(Introduction, Design of l.b.s)*
Equilibrium of plastic behavior cross section without tensile strength *(Strength. 1.)*
Estimation of tensioned and compressed steel elements *(Design of load bearing structures)*

T6 – Simplified calculation of tent structure

Background

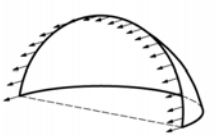
Tent structures are in close relation with cable structures: like cable structures tents can only bear tension, thus similar constructions can be established. The tent structure is made of textile, from which a surface can be formed, so they are close to the one-layer cable-web structures. The principles of the two structures are similar, the main difference is that the surface and the wire elements have different connection possibilities and thus different network structure is used. The strength of the tent textiles is much more limited than of the high-strength steel cables.

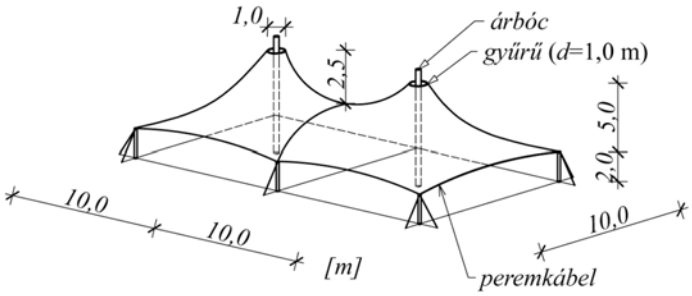
At the beginning of the semester we discussed reinforced concrete shells that could bear tension, compression as well as shear force in its plane. Choosing the right geometry, masonry arches can even work as moment-free shell, but they bear the internal moment caused by the changing load, thanks to their thickness.

On the other hand, tent structures are moment- and shear-free shells, they only bear tension because of the thin textile material. To maintain the shape of the structure – as for cable structures – pre-tensioning is necessary.

Aim of the practical

In this practical two different kinds of tent structures are assessed. The internal forces are calculated based on basic mechanics and simple calculations. In case of the pneumatical tent, the definition of the load case for verifying the tent material is of major importance.





The second exercise presents another possibility for pre-tensioning: the usage of hyperbolic surface. The internal forces of the two-mast-supported tent structure can be exactly determined only by nonlinear finite element method, however, the discussed simplifications and considerations make the manual calculations suitable. The tent structure is tensioned by the edge cables. The critical locations on the tent surface are identified, the internal forces caused by wind and snow load are calculated, and additional (supporting and binding) elements are also verified in this lesson. The design of the tensioned foundation is similar to the cable-truss structure.

In connection with previous courses

Principal curvatures – using the Barlow's formula *(Introduction)*

Load combinations *(Design of load bearing structures)*

Definition of the statical model *(Design of load bearing structures)*