Form-finding of lightweight tension-compression structures with equilibrium-based graphical methods

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The ability to work with both form and forces in the structural design process is crucial, especially in the early design phase, as these are key parameters that influence the static behavior of a structure. In this context, graphical methods such as graphic statics provide a powerful framework for the conceptual design of structures in static equilibrium. Graphic statics is a geometry-based method that relates the form of a loaded structure to its internal force distribution. To this end, graphic statics uses form and force diagrams, where the form diagram represents the discrete geometry of a structure along with the applied external forces, and the force diagram depicts the equilibrium of each node of the structure. By simultaneously transforming form and force diagrams, graphic statics can be effectively used to generate and explore visually different design solutions in the early design phase. The first part of the talk will focus on two recently developed computational methods for the design of lightweight structures based on graphic statics: Vector-based Graphic Statics (VGS) and Combinatorial Equilibrium Modeling (CEM). VGS includes a general procedure for constructing a vector-based force diagram from a given form diagram of a spatial network in static equilibrium. The interdependence of form and force diagrams in VGS enables direct evaluation of diagram transformations and supports rapid, visual and interactive exploration of equilibrium solutions in early design stages. CEM, built on vector-based graphic statics and graph theory, is a form-finding approach that allows the design and transformation of mixed tension-compression structures. CEM translates user-defined topologies and metric inputs as well as geometric constraints into an equilibrium model represented in the form diagram. The second part of the talk will present several projects created using the VGS and CEM methods in combination with different materials and construction technologies.