

50 Years of Form Finding by the Force Density Method

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Abstract:

2022 was the year of the fiftieth anniversary of the Olympic Games in Munich and the completion of the famous free-form cable net roof spanning the sports venues. It was one of the greatest engineering achievements in recent history. Among the many people responsible for the design and construction of the roof, to name just Schlaich, Otto, Leonhardt, Argyris, Isler, Behnisch, were Klaus Linkwitz and Hans-Jörg Schek, the inventors of the force density method. At the time, it was a revolutionary new computer-aided technique for determining the shape of prestressed, freely formed spatial cable nets. Its invention was prompted by the fact that manual techniques based on physical experiments and models had reached the end of their capabilities and alternatives urgently needed to be found. In fact, the 1972 Olympic Games were the occasion for the invention and the first major implementation of the force density method on the supercomputers of the time. Today, the force density method is a well established form finding method, recognized worldwide and in daily use. The talk will outline the time and spirit of its creation, tracing the arc from the original basic formulation for tensile cables to the current state of the art. This includes comments on advances in theory, the resulting practical benefits, and the implementation of generalized linear and nonlinear versions considering consistent extensions for the 2D stress state, the shape finding of textile membranes, lattice shells in compression, or hybrid structures in tension and compression such as tensegrities, and all under additional geometric constraints.