DESCRIPTION FOR THE GENERAL PUBLIC

A classical problem to be solved by a structural engineer is to cover a large area by a stiff and light structure, without any supporting columns or additional supports apart from the boundary stiffening. Since allowance for bending results in very heavy structures, a sound idea is to propose a thin-walled shell structure, of appropriate rise and shape, in which almost no bending takes place, to transmit the dead load, as well as other possible lateral loads to the supporting edge. Shortly speaking, the task of the engineer is to design the best path linking the load with the support. This task resembles either the transportation problem, or the problem of flow. The role of the engineer is to design the material ways of this flow of the load towards the supports. On the other hand the engineering structures are made of usually homogeneous and isotropic material, hence no clear transport lines of the load to the support are distinguished. In the traditional books on structural design one can find hints of how to find the stress trajectories within the isotropic structure and then construct the ribs along them, to make this flow of the load towards the support possibly smooth. Yet this method is not optimal. The recent results of the Free Material Design (FMD), and of the Topology Optimization in general, teach how to make this idea fully scientific and how to extend it towards more complicated problems.

We shall apply the methods in which the requirement of the maximal stiffness is assured by solving the problem of minimization of the overall compliance. If augmented with a natural cost of the design assumption concerning the material to be used, the FMD method of the compliance minimization is formally rearranged to a completely different problem of the mathematical structure known of the same kind as the mass transportation problem of Monge and Kantorovich. This rearrangement has proved that the attempts of the old masters of civil engineering to treat the structure as the system of canals along which the stresses flow as e.g. the blood flows in the arteries has found its rational justification. The FMD approach we shall use in the project shows how to create these canals for the stress flow – the first step is to solve an auxiliary problem to form the ideal net of lines of the best stress flows. Let it be emphasized: this net is different than those used in the past – it does not refer to the stress trajectories in the isotropic body, but is designed independently of any material-type assumptions. This ideal net is constructed on the data on the load, on the feasible domain and on the support. The result is thus material independent, as it should be. Having this net we obtain further information of how the material should be placed and which anisotropy should be used for the best stiffness. This algorithm of FMD has never been applied to plates in bending and to thin shells design. The aim of the project is to develop the theory of such problems and to implement this concept into numerical codes. The method to be proposed will be capable of performing the cutting out of the material domain from the given design domain, with no a priori assumptions concerning the topological characteristics, like the number of openings or folds of the possible thin shells.