8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

COMPLIANT MECHANISM TOPOLOGICAL OPTIMUM DESIGN BASED ON TRUSS-LIKE CONTINUUM

***Kemin Zhou[1] and Dan Zhao[2]**

Huaqiao University
College of Civil Engineering, Huaqiao University, Fujian 362021, CHINA
[1]zhoukemin@tsinghua.org.cn, [2]zhaodmel@hqu.edu.cn

Key Words: *Compliant Mechanisms, Topology Optimization, Finite Element Method, Truss-like Continuum*

ABSTRACT

Compliant mechanisms can transfer or transform motion, force or energy by deflection of flexible members. Compliant mechanisms need fewer parts, less assemble time and simple manufacturing processes. They have less wear, high precision and reliability. Compliant mechanisms can be designed on the traditional rigid-body kinematics [1] or on the topology optimization method of continuum structures [2].

This paper investigates the design method of compliant mechanisms by topology optimization method of continuum structures. The truss-like anisotropic continuum is adopted as material model [3]. The elastic matrix can be expressed by,

$$\boldsymbol{D}_e = E\sum_{j\in S_e} N_j \sum_{b=1}^{2} t_{bj} \sum_{i=1}^{6} \boldsymbol{T}^{\mathrm{T}}(\varphi_{bj})\mathrm{diag}[1 \quad 0 \quad (1-R_G)/4]\boldsymbol{T}(\varphi_{bj}),$$

where E is elastic modulus; S_e the set of nodes belong element e; N_j the shape function value at node j; $\boldsymbol{T}$ the frame rotation matrix; t_{bj} and φ_{bj} (b=1,2; j=1,2,...,J) the densities and orientations of truss-like material at nodes, which are taken as design variables; J the number of nodes; R_G the shear ratio, which will decrease to zeros in the iteration process. The displacement u_{out} at a given node along a given direction is taken as the objective function. The optimization problem is expressed by,

$$\begin{aligned} &\text{find } t_{bj} \geq 0, \varphi_{bj}, \quad b=1,2; \ \ j=1,2,\ldots,J \\ &\max u_{\mathrm{out}} \\ &\text{s.t.} \quad V \leq V_0 \end{aligned}.$$

where the V is the volume of the structure, V_0 prescribed volume. The stress and strain fields are analyzed by finite element method. The material distribution is optimized by the method of moving asymptotes. From this process the truss-like continuum is established. Truss-like continuum can be approached by discrete truss easily since the material model is designed according to truss-like continuum. To simulate truss-like continuum by isotropic material, the tiny gaps are introduced into continuum along weaken material directions.

Since material is distributed continuously and intermediate densities are not suppressed in the process of topology optimization, the numerical instabilities, such as

checkerboards, mesh-dependence and local minima, commonly occurring in applications of other topology optimization method are avoided completely. Several examples are presented, which are compared with the existed results. Fig 1 shows a displacement converter. The rectangular is design domain. For the symmetry only a half

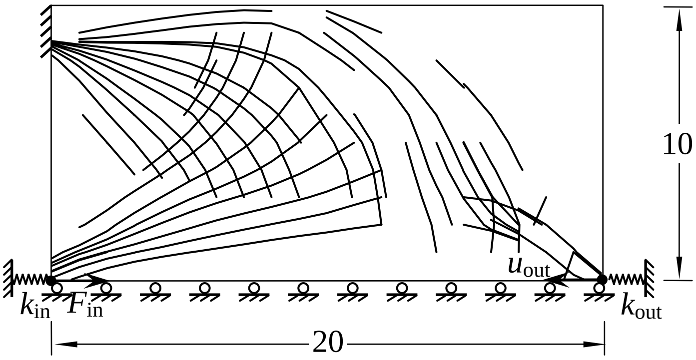

Fig 1 A displacement converter design

is analyzed. The optimum truss-like continuum is drawn inside the rectangular, which can be converted to discrete truss or isotropic continuum.

REFERENCES

[1] L.L. Howell, *Compliant Mechanisms*. John Wiley & Sons, Inc., New York, 2001.

[2] O. Simund. On the design of compliant mechanism using topology optimization. *Mech. Struct. Mach.*, Vol. **25**, pp. 493-524, (1997).

[3] K. Zhou and J Li, "Topology optimization of structures under multiple load cases using fiber-reinforced composite material model", *Comput. Mech.*, Vol. **38**, pp. 163-170, (2005).