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

The Analysis of Shell Structures Using T-spline Finite Element Method

***Tae-Kyoung Uhm[1] and Sung-Kie Youn[2]**

[1] Department Mechanical Engineering, Korea Advanced Institute of Science and Technology
373-1 Guseong-dong, Yuseong-gu, Daejeon 305-701, Republic of Korea
espoir@kaist.ac.kr

[2] Department Mechanical Engineering, Korea Advanced Institute of Science and Technology
373-1 Guseong-dong, Yuseong-gu, Daejeon 305-701, Republic of Korea
skyoun@kaist.ac.kr

Key Words: *T-splines, NURBS, Local Refinement, Shell.*

ABSTRACT

In conventional design process, the communication between CAD and CAE is necessary and frequently happens. In this communication, there exist many difficulties because the same functions are not used to describe geometry in CAD and CAE. This is the primary factor for time-consuming works such as the meshing of CAE models. Recently, the new finite element method using NURBS was proposed [1-2]. It is very promising because it can directly use CAD data to describe geometry and field variables. It can greatly reduce CAE costs in that CAD models can be directly used for analysis and the meshing is not needed. Using the NURBS-based finite element method, the communication between CAD and CAE is very easy and mutual interaction is possible. In this analysis framework, geometries are not approximated but exactly represented. Therefore, it can also contribute to the accuracy of simulation results. But in spite of these advantages, the method using NURBS have limitations on mesh refinement. NURBS surface cannot be refined locally. Therefore, in order to refine some local areas, global refinement must be performed. It makes superfluous control points, which not only interfere with the design process but also cause excessive computational costs. T-splines are recently developed surface modelling technique [3]. A T-spline surface is a NURBS surface with T-junctions and is defined by a control grid called T-mesh. The T-mesh is similar to a NURBS control mesh except that in a T-mesh, a row or column of control points is permitted to terminate in the inner parametric space. The final control point in a partial row or column is a T-junction. The T-junctions enable T-spline surfaces to be refined locally. That is, it is possible to add a single control point to a T-spline control grid without propagation of an entire row or column of control points. In addition, the merging of several T-spline patches can be easily accomplished without the addition of control points. In this research, shell formulation based on the T-spline finite element method is presented. Although the spline-based finite element method has many merits, it cannot be directly employed for the analysis of shell structures. Shell formulation based on NURBS or T-splines has fundamental limitations because rotational d.o.f., which are necessary in the shell formulation, cannot be directly defined on control points. Various approaches have been attempted to apply spline-based finite element method to the analysis of shell structures [1,4]. They need some special

techniques. In our research, the idea for interpolating normal vectors and their rotation using T-spline shape functions is proposed. Using this concept, T-spline finite element method can be easily extended for shell analysis. The proposed shell formulation will be verified through various benchmarking problems.

REFERENCES

[1] H. Y. Roh and M. Cho, "The application of geometrically exact shell elements to B-spline surfaces", *Comput. Methods Appl. Mech. Engrg.*, Vol. **193**, pp. 2261-2299, (2004).

[2] T. J. R. Hughes, J. A. Cottrell, and Y. Bazilevs, "Isogeometric analysis: CAD, finite elements, NURBS, exact geometry and mesh refinement", *Comput. Methods Appl. Mech. Engrg.*, Vol. **194**, pp. 4135-4195, (2005).

[3] T. W. Sederberg, J. Zheng, A. Bakenov and A. Nasri, "T-splines and T-NURCCs," *ACM T. Graphic.*, Vol. **22**, pp. 477-484, (2003).

[4] K. Inoue, Y. Kikuchi, and T. Masuyama, "A NURBS finite element method for product shape design," *J. Eng. Design*, Vol. **16**, pp. 157-174, (2005)