COMPUTATIONAL SENSITIVITY ANALYSIS OF RULED_SURFACE

I. Pokorska, M.Grzywinski
Faculty of Civil Engineering, Czestochowa University of Technology, Poland
Akademicka 3, 42-200 Czestochowa, Poland

1. Abstract

The paper deals with some computational aspects of structural sensitivity analysis and its application in the engineering design. The considerations are illustrated by numerical results concerning an industrial thin shell structure modeled as a 3-D structure. Numerical calculations by using the finite element method are performed.

2. Introduction

In the sensitivity analysis a variability of some functionals is investigated and obtained numerical results depend on a number of design variables, for instance the cross-sectional areas and lengths of particular elements, Young's moduli of used material etc. In general, these functional can depend on the current states of displacements and stresses as well as their admissible values called the design constraints [1].

In this paper computational sensitivity analysis of a thin shell structure subjected to static load under the constraints on the nodal displacements is presented. The comprehensive aspects of computer implementation are discussed.

2. Formulation of the problem

The structural response functions is defined as

(1) $$\phi = G\left[q(h), h\right]$$

$h = \{h^e\}$, $e = 1,\dots,E$ is the vector of design variables, $q(h) = \{q_\beta(h)\}$, $\beta = 1,\dots,N$, describes the vector nodal displacements which are calculated using the finite element method

(2) $$K_{\alpha\beta}(h)\, q_\beta(h) = f_\alpha(h)$$

where symbols $K_{\alpha\beta}(h)$ and $f_\alpha(h)$, $\alpha = 1,\dots,N$, denote the stiffness matrix and load vector.
The total derivative of the functional ϕ with respect to *h* gives

(3) $$\frac{dG}{dh} = \frac{\partial G}{\partial h} + \frac{\partial G}{\partial q} K^{-1}_{\alpha\beta}\left(\frac{\partial f_\alpha}{\partial h} - \frac{\partial K_{\alpha\beta}}{\partial h} q_\beta\right)$$

Computer implementation of this formula enables obtaining the values of sensitivity analysis.

3. Computational example of sensitivity analysis

The response of a thin shell structure is considered. Fig.1 shows the half of a cylindrical shell clamped at boundaries under uniformly distributed pressure.
It is seen (Fig. 2) that for the case of the displacement constraint a unit change in thickness of the element 9 has the largest effect on the vertical displacement at node 42. To decrease displacement most effectively at node 42, the thickness of the elements: 1 (-0,0251) and 2 (-0,0246); to increase element 9 (+0,0068) and 4 (+0,0048)

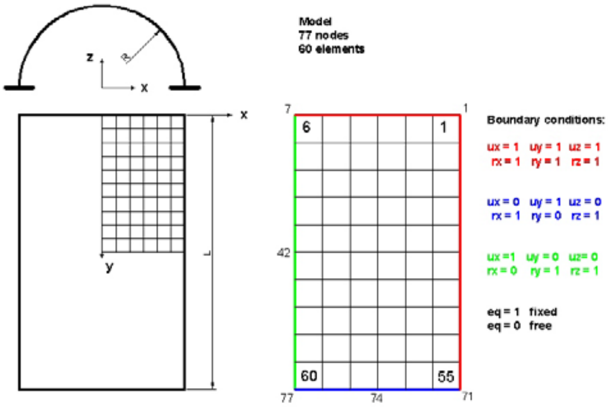

Fig. 1. 60-element shell with mesh grid

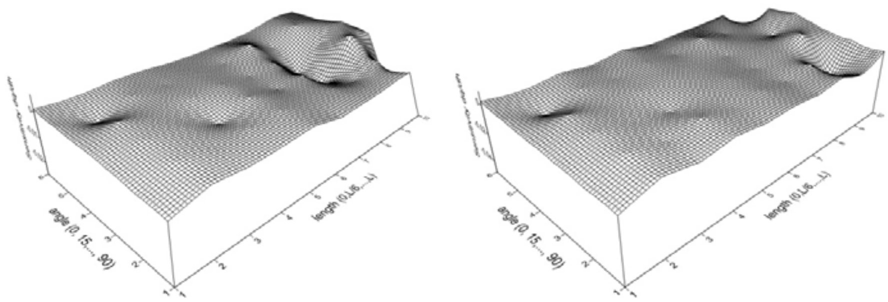

Fig. 2. Displacement sensitivity to variations thickness elements at node number 42 and 77

For the case of the displacement constraint a unit change in thickness of the element 4 has the largest effect on the vertical displacement at node 77. To decrease displacement most effectively at node 77, the thickness of the elements: 6 (-0,0486) and 8 (-0,0216) ; to increase element 4 (+0,0092) and 9 (+0,0060).

4. Conclusions

The conclusions drawn are directed to the practicing structural designer and consulting expert. Thus the classical methods can be supplemented with the computational sensitivity analysis [2]. It has otherwise been treated as a tool in the problem of structural design.

The presented approach is hoped to be useful for the structural designer of real engineering systems.

5. References

[1] E.J. Haug and K.K. Choi and V. Komkov (1986). Design Sensitivity Analysis of Structural Systems. *Academic Press, Inc.,* **381**.

[2] M GrzywiDski and T.D. Hien, Static and dynamic sensitivity analysis of bar structure. *Bulletin of the Koszalin University of Technology, Mechanical Engineering Series*, Koszalin, 2007; Vol. 40, **8**, 113–120.