論 文 の 内 容 の 要 旨

Thesis Summary

論文題目　ELASTIC STABILITY OF ARCHES WITH BUCKLING CONSTRAINT COMPONENTS AND THEIR APPLICATIONS
（座屈補剛されたアーチの弾性安定性とその応用に関する研究）

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In this thesis, circular arches with symmetric closed cross section are taken as research objects, the elastic stability problems of circular arches with straight components and flexible components are mainly studied. The elastic stiffnesses of straight components play an important role in providing stiffening effects. In another aspect, for flexible components, if there are directly loads applied on flexible components, generating internal forces of flexible components may provide a type of stiffness (so-called stiffness of pseudo-spring) to stiffen arches.

The research work is done mainly in following aspects:

In Chapter 1, the background, the research purpose, the past researches and outline of this thesis are introduced.

In Chapter 2, according to two categorizing rules, one is the position of reaction force of braces, and the other one is the spatial relationship of the arch and braces, the stiffening patterns of single arch and cross arch are classified.

In Chapter 3, formulations of elements in finite element method are mainly discussed. Linear buckling analysis method by using FE approach to obtain the critical load and buckling mode for the bifurcation point is introduced. In order to treat the buckling problems of the circular arches and rings under uniform compression as linear buckling problems, modified matrixes considering the follower force effects of uniform compression are stated. Furthermore, formulations of linear beam element and linear truss element, formulations of geometric nonlinear beam element and geometric nonlinear truss element in FE approach are given.

In Chapter 4, theoretical approaches to analyze in-plane and out-of-plane elastic stability problems of circular arches under uniform compression are discussed. The static equilibrium differential equations built on the isolated infinitesimal body may be divided for in-plane stability and out-of-plane stability separately. Then related general solutions of displacements for in-plane stability and out-of-plane stability are given in explicit expressions. Buckling control equations for calculating the critical loads are also obtained, and specific numerical examples and FE method are used to verify these buckling control equations.

In Chapter 5, arch-spring models are proposed to simplify arches stiffened with straight braces. By using general solutions of displacements, the relationship of internal forces and these displacements on isolated infinitesimal body can be built, then the theoretical procedures for deducing the buckling control equations for in-plane stability and out-of-plane stability are given respectively. In addition, no matter in-plane stability or out-of-plane stability, spring ratios of the stiffnesses of the braces and arches are proved to be existing. Furthermore, stability problems of several stiffening patterns of single arch and cross arch, as well as hoop-rings stiffened with spokes, are analyzed.

In Chapter 6, the stiffening principle of flexible components is studied. Study work shows that the stiffening effects of elastic stiffnesses of flexible components can be ignored, and then the generating internal tension aroused by external loads mainly contributes to stiffening structures. Through an example of specific curved cables, explicit expressions of so-called stiffnesses of pseudo-springs are given. Validities of these stiffnesses of pseudo-springs are proved through comparison of the results obtained by theoretical analysis and by nonlinear FE method on a numerical example of a column model featuring with curved cables. And as applications, the stability problems of a guyed mast and a circular arch featuring with curved cables are analyzed. The variations of critical loads in these two structure systems show that the stiffening effects of curved cables are very similar to the one in the example involving column. A typical characteristic of the stiffening effect of curved cables is that there are optimal external loads on curved cables to obtain maximum critical loads. Oversize external loads on cables will decrease the critical loads, and they will also make the curved cables provide stiffening effect analogous to hinged ended.

In Chapter 7, three negatively pressured pneumatic structures utilized as first-aid shelters are constructed. During the experiments, stiffening pattern in setting ropes along the peripheral direction of multiple-arch skeleton can stop rotational buckling behavior and greatly increase the critical loads of the skeleton. Light-weight infrastructures are also verified available in the practice. Furthermore, arch model with pseudo-springs is proposed to simulate the stiffening effect of curved membrane in negatively pressured pneumatic structure in numerical analysis, and vertical load pattern and radical load pattern in numerical analysis are compared. Finally, through a load test experiment processed in a column structure featuring with curved cables, the changing of buckling shapes of the column is observed when the loads on curved cables are increasing, and the stiffnesses of pseudo-springs are proved to be existing in curved cables.

In Chapter 8, the conclusions of this thesis and future work are discussed.