Abstract. Taking a certain large crawler crane boom as research object, the local buckling critical load is calculated by finite element analysis, and a full-range analysis for the boom structure is conducted. The analysis method of boom structure instability propagation process is established, and the true load response of actual structure is reconstructed. The results show that the dynamic effect is obvious after the occurrence of local instability accompanied with dynamic hopping. The research results of this paper have certain reference value to make measures for preventing the instability propagation, and also have guiding significance for the large boom structure design.

Keywords: Large crawler crane boom structure, eigenvalue analysis, structural instability, nonlinear analysis.

1 Introduction

Engineering structure or component will be in a balanced state under certain loads, constraints and the influence of other factors. However it will deviate from its equilibrium position under the effect of any small external disturbance. The balanced state is stable if it can automatically revert to the initial equilibrium position after the disturbance is removed. Otherwise, the initial equilibrium state is unstable. The behavior that the engineering structure or component changed from an equilibrium position to another equilibrium position because of the instable balance form is called buckling, or known as the instability [1].

For a structure system subjected to external effect, we not only concern its critical load when the local buckling occurring, but also concern the instability behavior when the load exceeds the critical load, which is post-buckling behavior. The dynamic effect is very obvious when the local instability accompanied with dynamic hopping happens, so it is necessary and important to make a full-range analysis for the structure. However, the traditional static analysis can not represent the true load response of the actual structure because it greatly simplifies the whole analysis process. Many scholars and researchers have done a lot of work on the buckling analysis of large span arch bridge, and shell structures [2-4]. The paper adopts this
method in the construction machinery field, considering the dynamic response; we put forward the analytical method of instability propagation process for large crawler crane boom structure, and use the international common finite element software- ANSYS to analyze the loading patterns, local instability form’s influence on the instability propagation process.

2 Eigenvalue Buckling Analysis of Large Crawler Crane Boom Structure

Eigenvalue buckling analysis as one kind of linear analysis is generally used for predicting the theoretic buckling strength (that is, bifurcation point) of the ideal elastic structure. Because it doesn’t consider any non-linear and initial defects, the calculation speed is particularly fast. Prior to conducting the non-linear buckling analysis, eigenvalue buckling analysis can be used for obtaining the buckling shape quickly.

We define the structure stress stiffness matrix $[K_\sigma]$ as stress stiffness matrix under unit external load, and the load multiplier is $\lambda$, the external load is $[R]$, the displacement matrix is $[D]$. Under linear conditions, $[K_\sigma]$ and usual stiffness matrix $[K]$ aren’t displacement function. Under baseline conditions, the mechanical balance equation of the structure is defined as follow:

\[
[K] + \lambda [K_\sigma] [D] = [R] \tag{1}
\]

The structure will reach a new equilibrium state with the effect of external load. Defining the virtual displacement matrix as $[\overline{D}]$, we can get the new mechanical balance equation:

\[
([K] + \lambda [K_\sigma])[D + \overline{D}] = [R] \tag{2}
\]

According to the above two equation, we obtain the following equation:

\[
([K] + \lambda [K_\sigma]) [\overline{D}] = 0 \tag{3}
\]

Equation (3) is used for solving the structure’s eigenvalue $\lambda$ and the displacement eigenvalue vector $[\overline{D}]$. Bifurcation point critical load $P_o$ can be obtained from $\lambda$ multiplying load. If the initial load is unit load, we know that the $\lambda$ is $P_o$. The displacement eigenvalue vector $[\overline{D}]$ denotes buckling shape which also is called buckling mode. In common buckling analysis, the first eigenvalue and eigenvalue vector are important.

We take a certain large crawler crane boom shown in Fig.1 as study object. The bottom is under hinged constraints, and the top is supported by two steel wire ropes. It can withstand the maximum load $10e6$kg under working conditions.