【Grant-in-Aid for Young Scientists(S)】
Science and Engineering (Engineering Ⅱ)

Title of Project : Improvement of the Fatigue Life Estimation for Large Welded Built-up Structures Based on the Estimation of Fatigue Crack Growth Histories

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Research Area : Engineering (Integrated Engineering)

Keyword : Fatigue, Material/Structural mechanics, Maintenance/Management, Steel structure

【Purpose and Background of the Research】

Many accidents are caused by fatigue in welded built-up steel structures, e.g. cars, ships, offshore structures, bridges, towers, railroad vehicle etc. As a result, it is important to estimate the fatigue lives of such structures quantitatively for safety reasons.

An example of fatigue crack occurred in steel structures (Photo credit; Metropolitan Expressway Company Ltd.)

Fatigue accidents occur not only due to the carelessness of designers or manufactures in the production stages, but also to the insufficient ability of the conventional fatigue life estimation procedures based on the conventional S-N curves approach. The S-N curves approach is, however, powerless in the evaluation of fatigue integrity for new type structural designs. The only reliable enhanced method of fatigue lives is to reduce the working stress for structures through a trial and error process. A theoretical method to identify the amount of reduction of working stress has not been proposed yet.

Our research group has been conducting research based on the fracture mechanics approach; because this approach makes fatigue life estimation for large welded built-up structures more accurate.

In this research, two representative objectives for practical fatigue life estimation will be achieved: the establishment of a quantitative fatigue crack growth estimation procedure both for surface or embedded cracks, and for multiaxial working stress conditions in these structures.

【Research Methods】

1. Fatigue tests using standard small fatigue specimens as well as large built-up test pieces and specimens with surface or embedded cracks will be conducted to investigate fatigue crack growth behaviours. Fatigue tests with large specimens will be performed by applying the special test systems of the National Maritime Research Institute (NMRI).

2. Numerical fatigue crack growth simulation will be developed in this research. Fatigue crack opening/closing behavior, which corresponds to the governing factor of fatigue crack growth, must be considered for this simulation. Numerical simulation code FLARP [1], which enables this characteristic behavior and estimation of the fatigue crack growth curves with a good accuracy for a through thickness crack problems to consider, are highlighted as a starting theories of our developing simulation code.

【Expected Research Achievements and Scientific Significance】

1. The research findings will significantly improve the fatigue life evaluation method based on the fracture mechanics approach. In particular, the fatigue life of small specimens in an experimental laboratory will be associated quantitatively with in-service large structures.

2. The findings will expand the application of the comprehensive preventive maintenance in order to improve the estimates of the expiration life of infrastructures throughout the in-service period.

3. Weight saving of infrastructures will be achieved by applying the combination of the research findings and the current design procedures of the structures.

【Publications Relevant to the Project】

[1] Toyosada,M., Gotoh,K. and Niwa,T., Int. J. Fatigue, Vol.26, No.9, 2004, pp.983-992

[2] Gotoh,K. et al., Proc. ISOPE 2007, Vol.4, 2007, pp.3343-3347

[3] Nagata,Y., Gotoh,K. and Toyosada,M., J. Marin Sci. and Tech., Vol.14, No.1, 2009, pp. 104-114

【Term of Project】 FY2009 - 2013

【Budget Allocation】 80,600 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.nams.kyushu-u.ac.jp/common/production/