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# A simulation of fatigue crack propagation in structures under variable amplitude loading

## -Development of an automatic analysis system of crack propagation combined with the crack opening/closing model-

Teppei Okawa and Yoichi Sumi

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**Summary:** In a design stage of marine structures, the S-N approach is commonly used for fatigue strength evaluation, where fatigue failure is often considered as the penetration of the plate-thickness of structural members. It is sometimes observed that the cracks having penetrated the plate-thickness of ship structural members exhibit relatively slow growth rates, which may be due to the high structural redundancy and/or the compressive residual stress. Therefore, it is important to predict the crack propagation when it is detected during in-service inspections, which can give us the proper maintenance schedules of marine structures. From the viewpoint of such aspects, the authors have developed a simulation program, "CP-System", for multiple cracks propagating in a three-dimensional stiffened panel structure. It can predict fatigue crack lives and paths, where through-the-thickness crack propagation is formulated as a two-dimensional in-plane problem, and the crack propagation behavior is simulated by step-by-step finite element analyses. In order to accurately evaluate the fatigue lives of ship structures, it is necessary to take into account wave-induced load histories, which are generally a kind of clustered loading with variable stress range. In the present paper, a new crack opening/closing simulation method is developed utilizing the crack tip stress field parameters evaluated by finite element analyses, and the effective stress intensity range, $\Delta K_{RP}$, which precisely correspond to the tensile plastic deformation ahead of the crack tip, is obtained by taking into account of the plastic wake induced by fatigue crack propagation. The usefulness of the developed method is demonstrated by the simulation of fatigue crack propagation in a ship structure under a wave load sequence.