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A development of crack growth simulator for plated structure using damage mechanics

Dae Suk Han[1a], Myung Hyun Kim[1b], Min Sung Chun[1c], Tak Kee Lee[2d] and Jae Myung Lee[1e]*,

[1] Department of Naval Architecture and Ocean Engineering, Pusan National University
30 Jangjeon-dong, Geomjung-gu, Busan, Korea 609-735
[b] kimm@pusan.ac.kr [c] chmsung@empal.com

[2] Korea Institute of machinery & Materials
104 Sinsung-ro, Yusung-gu, Daejeon, Korea 305-343
[a] hds619@pusan.ac.kr
[d] tklee@kimm.re.kr [e] jaemlee@pusan.ac.kr

*Corresponding author

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ABSTRACT

The objective of this research is to develop a simulation technique for the assessment of collapse of plated structures, such as ship structures, damaged by fatigue crack, stranding or collision. There is a close correlation between the state of damage and the external load in ship structures. For instance, when external load is relatively large for the case of harsh sea state, the breakdown of hull girder may occur due to damages as well as gradual propagation of cracks. On the contrary, ship survival capability can not be threatened when sea state is moderate and ship stability is sufficient, even the case that the middle parallel part of hull has serious damage. In order to evaluate the residual strength of ship structures, a systematic methodology is required for the assessment that can estimate crack growths. In the perspective, a previous attempt to resolve these problems was carried on by D.S. Han et al (2007).

In general, structural safety assessment on damaged hull can be classified into two methods: simplified analytical methods and direct nonlinear analysis method. The former has been mainly developed upon calculation of residual hull girder strength on two-dimensional mid-ship section. That is to say, it is comparative method by calculating ultimate hull girder strength of the damaged ship except damaged members using progressive collapse analysis under vertical bending moment. Recently, these methods have been developed to reflect transverse pressure and hydraulic pressure including inundation and slope. An effect of transverse members under torsion load and the interaction of structural member in damage expansion, however, are not considered yet. The latter is performing nonlinear-finite element analysis reflecting state of various loads over damaged ship structure, after structure of damaged ship is modeled by finite element method in three-dimension. This method can achieve reliable simulations. J.M. Lee and Y. Toi (2002) developed fully coupled nonlinear FE program to solve damage expansion of steel structures. Based on these studies, it is known that fully coupled damage calculation is uneconomical method due to excessive calculation time as the corresponding FE model is massive. In addition, it requires extensive experience of

analysis for various damage cases, and the result can be turned out different because the results are highly dependent on input parameters.

Therefore, in this study, it is attempted to perform finite element analysis and damage analysis for damaged plated structures to acquire resultant damage values based on the coupled elasto-plasticity in damage mechanics framework. Based on this method, an expansion of damage crack propagation of damaged plated structures is effectively predicted. Moreover, the results are verified by experimental data.

DAMS (Damage Simulator): Program for damage caculation including crack propagation. Regarding user friendly environment, C++ programming is carried out for construction of visulaization of damage level. Damage per structural element (Finite element) is calculated according to damage model based on continuum damage mechanics. The developed simulator can perfom damage analysis using resultant strain field and show the results graphically.

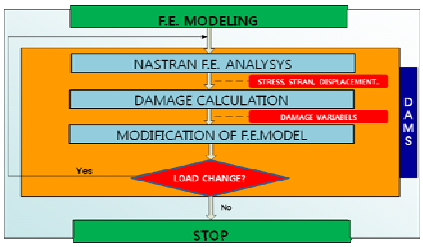

Figure 1: A scheme of DAMS

Figure 1 represents the flowchart of DAMS. In order to calculate damage variables of a continuum, NASTRAN analysis is required to determine damage variables. Then internal damage calculation module estimates the magnitude of element damage value using the information based on each element. DAMS perform element removing process, corresponding to calculated damages. If there are another loading conditions, user can input the changed loading conditions and boundary conditions with accumulated damage values.

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