

A Study on Temperature Sensitivity of Stress Intensity Factor Using Finite Element Method

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Abstract: When a structure is subjected to any sort of damage such as loadings cracks will be developed. When those structure continuously subjected to repeated loading it leads to catastrophic failure of the structure. In this study, it is investigated that the effect of the temperature on stress intensity factor. Finite element analysis (Ansys 12.0) is used to investigate the temperature effect on stress intensity factor. A plate with both ends fixed at the top and bottom with an edge crack is tested for a temperature gradient zero at mid thickness to $T^{\circ}C$ at the edges. The temperature tested in this study are $20^{\circ}C$, $25^{\circ}C$, $30^{\circ}C$, $35^{\circ}C$, $40^{\circ}C$, $45^{\circ}C$ and $50^{\circ}C$. The stress intensity factor for each rise of temperature are noted. Finally it is found that the stress intensity factor is sensitive to the temperature and it is linear with increase in temperature.

Index Terms: Stress Intensity Factor, Temperature

I. INTRODUCTION

Finite element method (FEM) is a numerical method for solving a differential or integral equation. It has been applied to a number of physical problems, where the governing differential equations are available. The method essentially consists of assuming the piecewise continuous function for the solution and obtaining the parameters of the functions in a manner that reduces the error in the solution. In this article, a brief introduction to finite element method is provided. The method is illustrated with the help of the plane stress and plane strain formulation. There for in this investigation it is amid that the stress intensity factor is related to the temperature sensitivity by using Finite element Package Ansys 12.0

II. REVIEW OF LITERATURE

investigated on “Fundamental principles of structural behavior under thermal effects” and concluded that It is

now well recognized that contrary to popular belief, composite steel framed structures possess a much larger inherent fire resistance than that apparent from testing single steel members in fire furnaces. It is also accepted that the current prescriptive approaches of designing such structures are overly conservative and not based on rational principles. It is therefore possible to construct these structures much more economically, without any loss of fire resistance, by removing or drastically reducing the fire protection of steel members. However, to fully exploit the considerable reserves of strength, it is imperative that the mechanics of whole steel frame structure behavior in fire is understood well. The ideas presented in this paper are a step in this direction. The fundamental principles presented in this paper provide a means of estimating forces and displacements in real structures with appropriate idealisations. Such estimates can be of considerable use in assessing the results from more rigorous numerical analyses or they can be used in design calculations. There are however a considerable number of very important issues that remain to be investigated as mentioned in the previous section. Considerable effort is required to address these issues to satisfaction before a complete set of principles can be developed.

B.V.D.Wakchaure, A.A.V. Deokar^[4] investigated on “Experimental Investigation of Crack Detection in Cantilever Beam Using Natural Frequency as Basic Criterion” and concluded that detailed experimental investigations of the effects of crack on the first three modes of vibrating cantilever beams have been presented in this paper. From the results it is evident that the vibration behavior of the beams is very sensitive to the crack location, crack depth and mode number. A simple method for predicting the location and depth of the crack based on changes in the natural frequencies of the beam is also presented, and discussed. This procedure becomes feasible due to the fact that under robust test and measurement conditions, the measured parameters of frequencies are unique values, which will remain the same (within a tolerance level), wherever similar beams are tested and responses measured. The experimental identification of crack location and crack depth is very close to the actual crack size and location on the corresponding test specimen. Crack identification technique by using frequency contours of the first three modes of beam (mode 1, normalized frequency (0.9398); mode 2, normalized frequency (0.9663); and 3: mode 3, normalized frequency (0.9334).

Revised Manuscript Received on 30 October 2012

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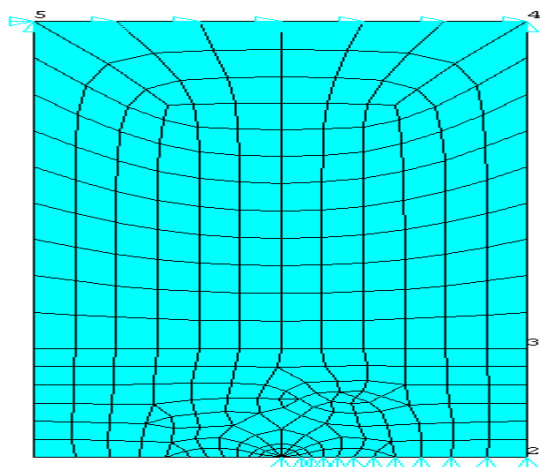


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Blue Eyes Intelligence Engineering
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Dr. S. Welch, Dr.Martin Gillie and Mian Zhou^[12] investigated on “Spalling Behaviour of HSC Beam Subject to High Temperatures ” and concluded that maximum thermal gradient provides good indication on the initiation time point of spalling. In addition, compressive plastic strain (PE33) contour could be utilised as an indicator on spalling region prediction.

III. FINITE ELEMENT MODELLING

The modeled plate consisted of testing of plate of size 4m x2m with an edge crack length of 1m. The top and bottom of the plate is fixed and 20°C, 25°C, 30°C, 35°C, 40°C, 45°C and 50°C applied individually for every case .The stress intensity factor obtained using finite element analysis are noted and Temperature Vs Stress intensity factor curve was plotted using finite element analysis. The material properties are taken as Youngs Modulus E=10X10⁵ N/mm² and Poissons ration 0.0.3.FEA software ANSYS 12.0 is adopted for predicting the Temperature Vs Stress intensity factor. An edge crack of 1m is modeled using fracture mechanics approach as shown in the figure .PLANE 182 elements are used in modeling the plate and CINT command is used to determine the stress intensity factor.

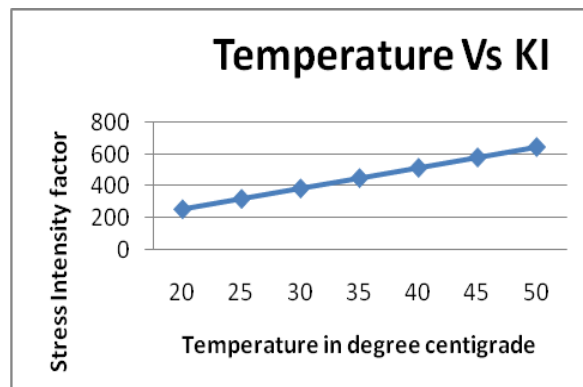


IV. FEA ANALYSIS AND RESULTS

The results obtained using FEM are tabulated as shown below.

S.No	Temp (°C)	KI (ansys)	KI (calculated)
1	20	257.265941	253.207989
2	25	321.582426	316.509986
3	30	385.898911	379.811984
4	35	450.215396	443.113981
5	40	514.531881	506.415978
6	45	578.848366	569.717975
7	50	643.164851	633.019973

The above results are plotted as shown below.



From the above graph it is observed that the temperature is linear with the stress intensity factor.

V. CONCLUSIONS

Based on the results obtained from FEM, and theoretical analysis, the following conclusions are drawn.

1. In this investigation, presence of a crack reduced the strength of the plate.
2. Results obtained for the plate using finite element analysis are in good correlation with the theoretical values.
3. It is found that the rise of the temperature gradient is linear with respect to the stress intensity factor.

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