EVALUATION OF THE MODIFIED STRESS INTENSITY FACTORS OF THE VIBRATING COMPOSITE PLATES WITH CRACK ALONG THE CLAMPED END BY AMPLITUDE-FLUCTUATION ESPI METHOD

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ABSTRACT

In this paper, an optical interferometery method named as amplitude fluctuation (AF) electronic speckle pattern interferometry (ESPI), as shown in Fig. 1, which is a kind of time-averaged ESPI based on the fluctuation of vibration driving force, was implemented to perform the measurement of dynamic properties of a crack existed cantilever composite plate. The crack was manufactured perpendicular to the vertical edge of the composite plate and then clamped by a vise to simulate a crack generated along the clamped edge where the geometric defect is most likely introduced by bending moment.

Two composite plates with $[0]_{16}$ stacking sequence but different crack lengths were used for the study. The crack was created and clamped as mentioned to simulate the crack locates along the clamped edge. Two crack lengths were selected, i.e. 20 mm and 40 mm. The composite plate was produced from the 250 mm x 250 mm unidirectional CFRP prepreg and then cured by the vacuum bag method. The cured CFRP plate was cut into several 190 mm x 90 mm sheets, as shown in Fig.2, by using a diamond wheel. To produce the crack, a screw slotting cutter of 0.35 mm thick was used.

In this paper, the mode shapes and the modified SIFs are two vibration characteristics for discussions. The composite plate was excited by a shaker at different frequencies. Thanks to the whole field measurement capability of the AF ESPI method, , the vibration modes at different resonant frequencies can be determined. A typical AF ESPI fringe pattern is shown in Fig. 3. The displacement across the crack at different resonant frequencies was determined by interpreting the fringe order with fringe formula. In this study, sub-fringe order on the crack was evaluated by linear interpolation between adjacent fringes to provide better resolution. Then based on the relationship between the crack opening displacement (COD) and the stress intensity factor (SIF), the modified-SIF values of different resonant frequencies of the crack-contained composite plate were evaluated. Different from the conclusions of early numerical and theoretical studies on crack subjected to the dynamic

periodic loads, the values of the modified SIFs are upper-bound values instead of becoming infinite in spite of the crack contained plate is subjected to resonant vibration force.

In this study, while the cracked structure subjected to a resonant loading, two failure criteria need to be evaluated to investigate the reliability of the structure. They are the displacement criterion and the stress criterion. Different from the traditional dynamic structure design, particular a defect-free structure, large displacement instead of stress is always first considered to dominant the structural failure. In this study, the modified SIFs of the first six modes were determined by the displacement on the upper surface of the crack. Based on Δw-$\sqrt{r}$ plot, the magnitude of modified SIFs can be then be compared, where Δw is the displacement difference between crack surfaces and r is the radial distance from the crack tip. The plot provides very important results that if there is a crack exists in the structure, the stress failure criterion must also be considered, especially for higher frequency vibration.

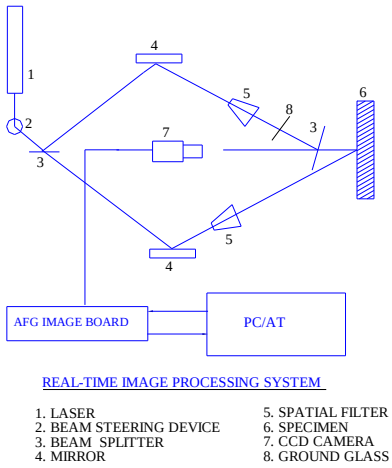

Fig. 1 Schematic of the assembled experimental setup

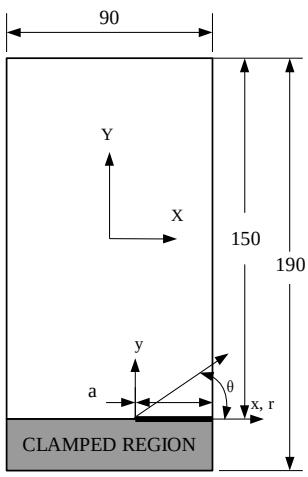

Fig. 2 The edge cracked specimen with $[0]_{16}$ stacking sequence

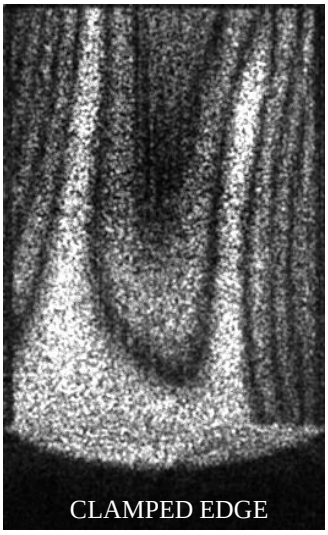

Fig. 3 Typical ESPI fringe pattern of a $[0]_{16}$ composite plate with 20mm crack length on the clamped edge