A study on natural frequency-based crack detection for skeletal structures

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A crack decreases structural stiffness and leads to a drop in natural frequencies. This is the underlying logic of frequency-based crack detection methods. To examine the feasibility of crack detection based on frequency measurement, the 'chronological order' between the critical crack severity causing crack propagation or brittle fracture and the crack severity resulting in a measurable frequency drop is studied. Natural frequencies are computed using the Rayleigh-Ritz method incorporating the penalty method, and the critical crack severity is determined using fracture mechanics.

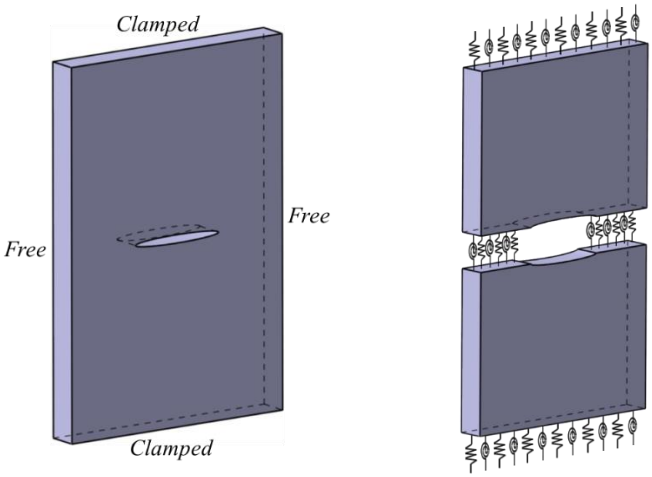


Fig. (a). A centre-crack plate and (b). the application of the penalty method

The effect of a surface crack on a skeletal structure is approximated by springs. Previous research has shown that a natural frequency shift is caused when a rigidly connected roving mass with rotary inertia passes the crack location. Potentially this phenomenon can be utilized in crack detection as whenever a frequency shift is observed, there might be a crack in the position where the frequency shift occurs. The current research aims to explore the possibility of this crack detection method.

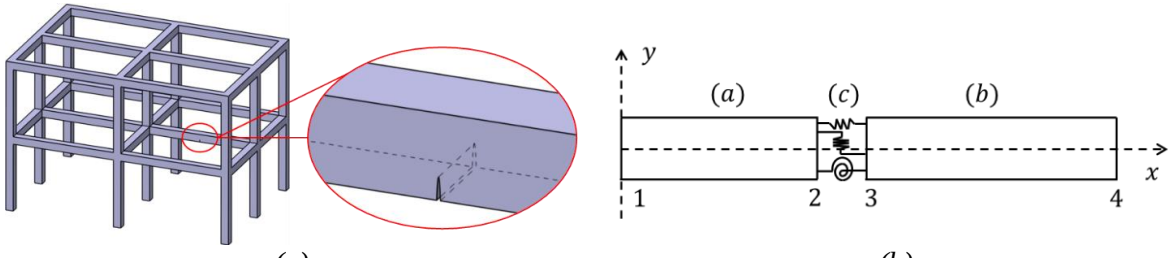
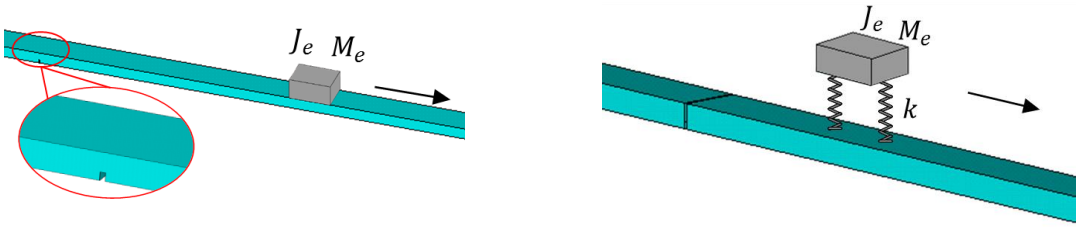


Fig. (a). A cracked frame and (b). modelling the crack using zero-length massless springs

Instead of using a rigidly connected roving mass which only exists under ideal conditions, a roving spring-mass system with rotary inertia is applied to a cracked beam or

frame. Timoshenko beam theory incorporating Rayleigh bar theory is used to model the structural behaviour. The dynamic stiffness matrix of the spring-mass system is integrated into the global dynamic stiffness matrix using the dynamic stiffness method, and the resulting transcendental determinant is solved using the Wittrick-Williams algorithm. An experiment will be conducted to find out whether the frequency shift is measurable.



(a) *(b)*

Fig. (a). A roving mass with rotary inertia and (b). a roving spring-mass system