Numerical Study on the Mechanism of Interface Debonding Detection for CFST with PZT

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Abstract

Introduction
In order to understand the detection mechanism of the PZT based nondestructive testing (NDT) technology for interface debonding of CFSTs, numerical simulation on a multi-physical model composed of surface-mounted PZT patches and CFST structural member is established in COMSOL Multiphysics®. The stress propagation process and the electrical signal output of an embedded PZT patch as a sensor in the coupled multi-physical model under different excitation signal is simulated with finite element method (FEM). The PZT sensor response of the CFST member with and without interfacial debonding defects under continuous sinusoidal and sweep excitations with different types, frequencies, amplitudes is simulated and the effect of the size of interfacial defects on the output voltage signals is studied. Numerical results show that the interfacial debonding defect changes the stress wave propagation path, travel time and the amplitude of the output of sensors. Similar to results of experiments carried out by the authors, when the propagation of stress wave encounters interface debonding, scattering and energy attenuation occur and the amplitude of the output signal decays. The simulation results validate the observation of the experimental study on interface debonding detection of CFST structural members.

Use of COMSOL Multiphysics®
In order to explain the experimental study findings for the interfacial debonding detection, in this paper, a multi-physics coupling model composed of PZT patches and CFST section is made considering the piezoelectric effect of the PZT patches and the stress wave propagation is simulated with finite element method in COMSOL (Figure 1). Numerical simulation on the stress wave propagation and the attenuation characteristics of stress waves due to the interfacial debonding defects under different excitation signals are carried out. The output voltage signal of the sensors and the influence of the interfacial debonding defect on the stress wave propagation are investigated.

Results
The modelling with COMSOL Multiphysics® makes it possible to see clearly that the existing of the debonding defects will directly affect the propagation of stress waves. It can be seen that as the propagation distance increasing, the amplitude of the wave decreases gradually (Figure 2). It is indicated that the interfacial debonding defect changes the propagation path, traveling time

and the amplitude of the stress wave.The increase of defect area extends the propagation path of stress wave, so the time domain signal of the PZT sensor measurement changes significantly (Figure 3 and Figure 4).

Conclusion
Numerical simulation with FFEM on multi-physics coupling models composed of surface mounted and embedded PZT patches and CFST member is carried out for the purpose of understanding the change in stress wave propagation characteristics due to the existence of interface debonding between steel tubular and concrete core. The COMSOL Multiphysics® model make it clear that comparing the stress wave fields of CFST specimens under healthy and damaged specimens, the propagation process of the stress wave in CFST is clearly demonstrated.

Figures used in the abstract

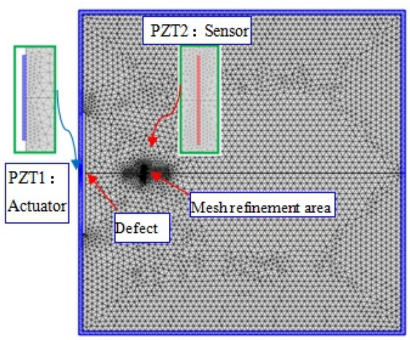

Figure 1: Meshing of the PZT patch and CFST coupled model in COMSOL

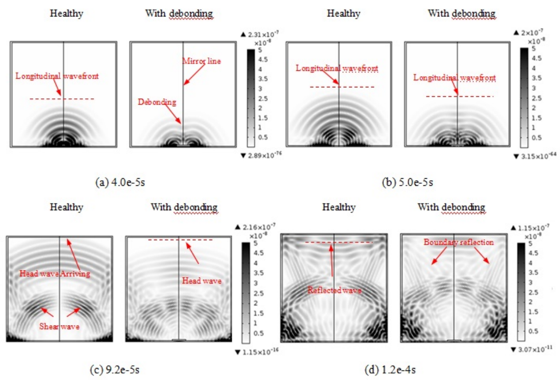

Figure 2: Wave field snapshots at different time instant under pulse signal(unit: mm)

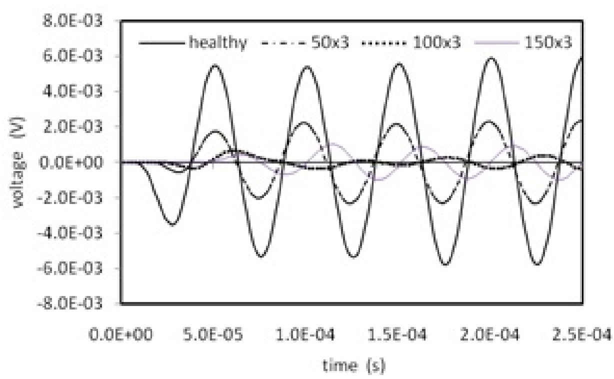

Figure 3: Output voltages when damage area changes (sine)

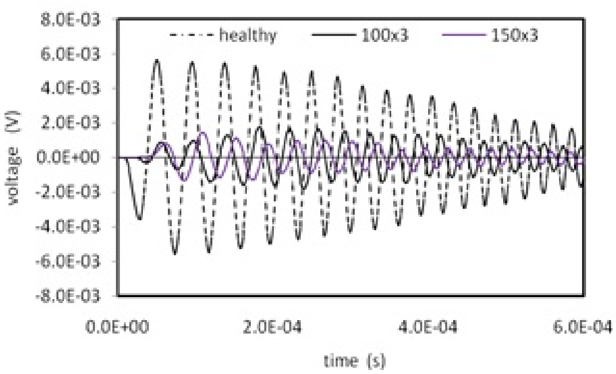

Figure 4: Output voltages when damage area changes (sweep)