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Wave mixing in a heat-damaged concrete slab

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Characterizing the nonlinear mechanical properties of a superficial layer in a material using ultrasounds has applications in nondestructive evaluation. Among others, nonlinear ultrasonics has proven highly sensitive to heat damage in concrete. The common approach to achieve detection is to use the second harmonic generation effect, with Rayleigh waves. This effect is however of limited use if the medium if very attenuative or if there is significant scattering, which is the case of concrete at relevant scale of inspection.

We here choose to resort to the wave mixing phenomenon that converts two Rayleigh waves into a P-wave as a favorable alternative [1]. We propose to go beyond mere detection by looking for the signature of the depth scale of the damage –a preliminary step for inversion of a full depth distribution. For this purpose, we examine the frequency dependency of the effect, first numerically on a model distribution on Murnaghan's parameters, and then experimentally. Our specimens are concrete and mortar slabs that have been exposed to elevated temperatures during a short time in order to generate controlled gradients of damage. By comparing with control specimens, we show that we do achieve detection of frequency dependence of the effect due to the damage gradient. Finally, we also demonstrate the effect and its frequency dependence on heat exposed steel plates.

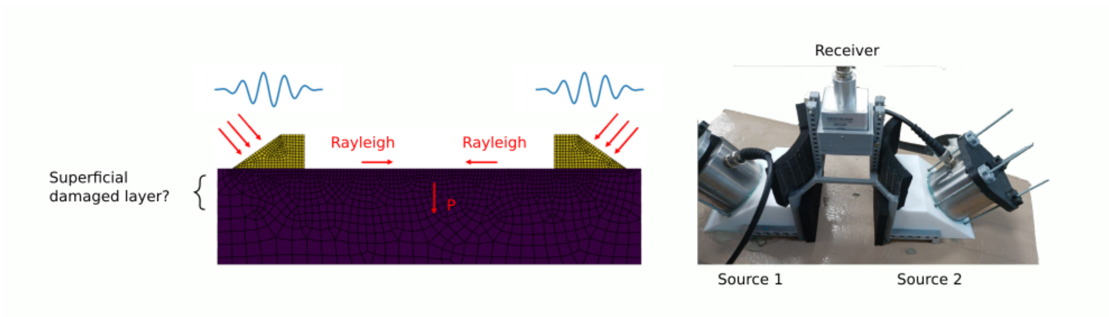

Figure 1: Rayleigh to P wave mixing setup. The experimental implementation involves piezoelectric wedge emitters and an air coupled receiver.

[1] Gartsev, S., Zuo, P., Rjelka, M., Mayer, A., & Köhler, B. (2022). Nonlinear interaction of Rayleigh waves in isotropic materials: Numerical and experimental investigation. Ultrasonics, 122, 106664.

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