Department of Civil Engineering and Engineering Mechanics
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THE MINDLIN LECTURE

Identifying The Unique Ground Motion Signatures of Supershear Earthquakes: The One-Two Punch Effect on High-Rise Buildings

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Directly studying earthquakes presents a host of insurmountable difficulties, the least of which is our inability to trigger earthquakes of various magnitudes at will and the lack of means of scrutinizing the behavior at depth while the quake propagates. We have developed techniques to produce miniature (or surrogate) laboratory earthquakes and follow their progress with high-speed imaging tools. Our laboratory quakes mimic actual ones, and have allowed us to demonstrate the existence of ruptures of "super-shear" or "intersonic" rupture speeds. The propagating fronts of such supershear ruptures feature a Mach-cone of shear “shock waves” similar to that of supersonic aircraft. For earthquake ruptures transitioning from sub-Rayleigh to supershear rupture speeds, this unusual “shear” Mach cone feature is also followed by a trailing Rayleigh disturbance which is all that remains of the old sub-Rayleigh rupture after transition is complete. Each propagating disturbance contributes to the unique ground motion signature in the near field. We refer to this as a “one-two punch” scenario. In particular, ground motion associated with passage of the shear Mach features a dominant fault-parallel velocity component while ground motion from the trailing Rayleigh field is characterized by a dominant fault-normal velocity component (characteristic of common, sub-shear earthquake ruptures). Appropriate scaling of the laboratory ground velocity measurements are used to shake 3-D numerical models of high-rise buildings (located in near fault locations) with hypothetical supershear and sub-Rayleigh earthquakes with unexpected implication to building safety and seismic hazard analysis.