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Factors Contributing to Damage in Port-au-Prince from the 12 January 2010 M7.0 Haiti Earthquake

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The catastrophic extent of damage and the high death toll from the 12 January 2010 Mw7.0 Haiti earthquake was primarily a consequence of high population density and poor construction. First-person eye-witness surveys reveal extreme structural vulnerability, suggesting that many structures sustaining serious damage or collapse in shaking that did not exceed modified Mercalli Intensity V-VI (JMA 5-lower to 5-upper). To explore the extent to which local geological site conditions contributed to the damage, we deployed strong-motion instruments in Port-au-Prince. A total of nine stations were deployed between late January and mid-April, 2010. Analysis of M3.5-4.5 aftershocks events recorded across the urban array reveals, as expected, amplification of ground motions at sites within the Cul de Sac Valley, which underlies most of the city. The strongest amplifications, however, are observed at two sites along a foothill ridge in the Petionville District. The steepness of the topography as well as direct estimates from surface-wave techniques (Cox et al., in review, 2010) indicate that the ridge is characterized by higher shallow impedance than the surrounding region. The observed amplifications, which reach factors of 4-5 relative to a hard-rock reference site for frequencies ranging from a few to 10 Hz, thus cannot be explained by traditional near-surface sediment-induced amplification. We show that the amplification factors and predominant periods are consistent with predicted amplification associated with SH-wave diffraction within a narrow ridge. We also consider the distribution of damage. The overall damage pattern throughout Port-au-Prince is complex, and reflects a number of factors including structural vulnerability and distance from the mainshock rupture. In the relatively affluent Petionville region, however, damage was generally not as severe as in other parts of the city. Considering the distribution of damage interpreted by DLR (German Remote Sensing Data Center) from optical imagery, we show that a swath of unusually high damage corresponds with the extent of the ridge where high amplifications are observed. We further use ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer)-based global Digital Elevation Models and automated terrain classification methods to map geological and topographic structure, including a delineation of the small-scale topographic features that correspond to zones of concentrated damage. Our results suggest that, in general, amplified damage is associated with especially steep small-scale topographic features. Damage does not correlate with steepness per se: damage was not amplified on steep slopes in the larger hills to the south. A microzonation map for Port-au-Prince will thus need to incorporate topographic effects as well as traditional site response.