Affordable and energy efficient fiber reinforced earth masonry for high wind regions

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Stabilized earth masonry (SEM), built with compressed stabilized earth blocks (CSEB) and mortar, is rising as a construction system for affordable, sustainable and high-quality dwellings. SEM is extremely appealing for the construction of affordable housing in rural areas and farmlands, where underrepresented and underprivileged groups often are found. However, lack of affordable housing is an issue across the United States, where low-income families are most affected, expending half of their income on housing. In addition, the low-income population is more susceptible to the impact of hazard events because of the lack of resources to cope with them. Annually in the US, high wind events, such as tornadoes in the so-called “Tornado Alley” and hurricanes in the south-east, cause material and human losses. Although, SEM has been widely used around the world for the construction of modest and high-end housing; the non-engineered nature of its material and structures limits its use as a mainstream construction system. Bridging the knowledge gap related with the structural behavior of the SEM is important to increase the confidence and acceptance of this extremely affordable masonry system, which could help to reduce housing insecurity and thus homelessness. Recently, Matta et al. (2015) demonstrated the feasibility of using SEM in low-rise dwellings to withstand high wind loads using a structural analysis framework. However, this study pointed out the need for an experimentally characterized masonry prototype, where the strength and failure modes are verified.

The research goal of the present study is to provide an affordable and green masonry prototype with well-defined mechanical and structural properties for high wind resistance. Using a silty loam soil, which is locally available in South Carolina and well dispersed throughout the “Tornado Alley”, the earth blocks are designed. The blocks are stabilized with small amounts of ordinary Portland cement (OPC) and reinforced with randomly distributed non-biodegradable recyclable plastic fibers. The brittle CSEBs were transformed into earth blocks with significant post-cracking deformability and residual strength due to the bridging effect of the plastic fibers. This makes the earth blocks a viable option for a masonry system that provides resistance against the impact of flying debris. Then, two SEM prototypes that are engineered for high wind resistance are presented. The salient mechanical properties, obtained by load-testing masonry subassemblies, were used for the prototyping process and characterization of SEM. First, a prototype built with unreinforced compressed earth blocks and mortar that meets the strength requirements for high wind resistance is given. As proof of concept, the experimental strengths obtained from the unreinforced SEM are used for the structural analysis of a realistic EF3 tornado-resistant dwelling. The second prototype, made with the plastic fiber reinforced CSEBs and a mortar reinforced with low-cost plastic fibers; aims to radically enhance the SEM damage tolerance and resist the impact of wind borne debris. The plastic fibers radically modified the behavior at the block mortar interface and the toughness of the earth masonry. Finally, the results of a high velocity impact test are presented as preliminary evidence of the SEM and SREM behavior against flying debris.