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Mortar damage to stone built heritage

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Stone built heritage in conflict areas is increasingly at risk of accelerated deterioration, as explosive and ballistic damage not only create damage to the surface, but also inherently change the mineral fabric of the stone to deep within the structure. In particular, remotely detonated high-power explosive ordnance has become more accurate and economically viable for state forces, especially given the availability of remote-controlled military aircraft. Concurrently, armed non-state groups engaged in asymmetric warfare rely on (improvised) ground-based explosive devices, seen to devastating effect at high-profile sites like Palmyra.

Stone in historic buildings is pre-weakened through centuries/millennia of exposure to weathering, and may be particularly vulnerable to subsequent heat and shock waves generated by explosives. Whilst appearing unaltered externally, exposure to high-pressure explosive force can result in the growth of microfractures and loss of cohesion within the cement matrix of stone, potentially leading to fracturing and crumbling, particularly if such stones are load-bearing within a rebuilt structure. The loss of density associated with explosive damage is particularly problematic. We show that our preliminary testing of the effect of an 81 mm HE mortar bomb blast in the vicinity of sandstone structures indicates changes in rock surface hardness as well as complex fracturing of the surface. Both visible and non-visible damage were recorded using high speed cameras, rock surface hardness surveys pre- and post-detonation, and photogrammetry. We conclude that even if not directly exposed to an explosive blast, stonework can be inherently altered.