Polymer bonded explosives (PBX) are a class of granular composites with a high-volume fraction of solid. Typically, they contain 80-95% explosive crystals and 5-20% soft polymer binder. The primary function of the soft binder is to reduce the impact sensitivity of the explosive and prevent an accidental explosion. However, there have been inadvertent detonations in these materials during transportation and handling. The main reason that causes such unintentional explosion is not well understood. However, it is commonly accepted that the formation of local high-temperature regions, called ‘hot spots’, is the primary cause of these accidental explosions.

Apart from this generalized argument, there is a significant knowledge gap in the research community about the main failure mechanisms that causes such localized heating. The primary focus of the present work is to understand the local deformation mechanisms in polymer bonded explosives subjected to high rate and impact loadings. An experimental method is developed based on high-speed photography and digital image correlation (DIC). The experimental setup helps to observe and quantify the deformation mechanisms in-situ at a spatial and temporal resolution of 10.66 µm/pixel and 200 ns, respectively. The capability of the experimental setup is validated in two heterogeneous materials system subjected to loading at strain rates varying from 150-1000s⁻¹.

For the current investigation, polymer bonded sugar (PBS), a mechanical simulant of PBX is used. The PBS contains sugar as the filler and plasticized hydroxyl-terminated polybutadiene (HTPB) as the soft binder. Two different dynamic loading configurations are studied, simulating intermediate strain rate and high impact loading conditions.

The first loading configuration involves the dynamic loading of PBS specimens at strain rates ranging from 150 to 1000 s⁻¹. From these experiments, global and local deformation mechanisms and failure behavior are studied in detail. The effects of strain rate and particle volume fraction on the deformation mechanisms are studied for a comprehensive understanding of the material behavior. These experiments revealed the link between the macroscale shear band formation and its microscopic origin.

The second case involves a direct impact loading scenario utilizing a gas-gun with impact velocity varying from 50 to 100 m/s. From the images captured during loading, a quantitative analysis of the compaction wave dynamics is performed at two length scales. The particle velocity, compaction wave velocity, and wave thickness are calculated from the macroscale experiments. In addition, spatial stress distribution is determined from the equilibrium equations using the full displacement data obtained from DIC. From stress and strain rates, the total energy dissipated during compaction wave propagation is estimated. Finally, mesoscale experimental observations are used to identify the main local failure and deformation mechanisms associated with the energy dissipation.