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Preloaded High-Rate Tension Techniques

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Engineering parts are usually assembled together with joint units. For example, bolts are very common components to connect parts together. During assembly, a certain amount of torque is applied to the bolts, producing a pre-tension load in the bolts, to maintain the structural integrity under various loading conditions in applications. One should be very careful of the amplitude of the preload applied to the bolts as either over-loaded or under-loaded bolts may result in unexpected failure or malfunction of the engineering structures. The effect of preload on the mechanical response including failure and fracture of the bolts in tension is desired to be thoroughly understood. Particularly, for the cases where the bolts are subject to impact loading, the dynamic tensile response of the preloaded bolts is necessary to be determined. This requires the development of new preloaded high-rate tension techniques. In this study, we properly modified the current Kolsky tension bar to characterize the high-rate tensile properties of bolts under various amount of preload.

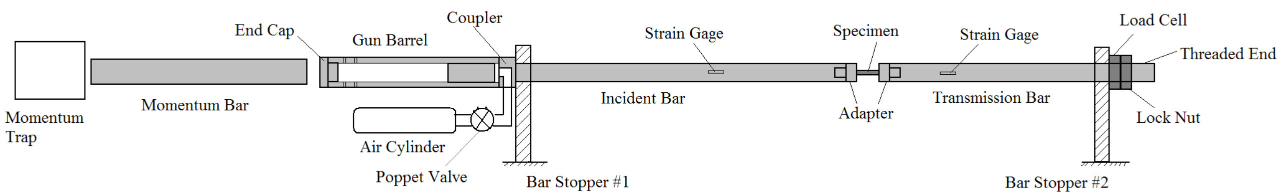

Fig. 1. Schematic of preloaded Kolsky tension bar.

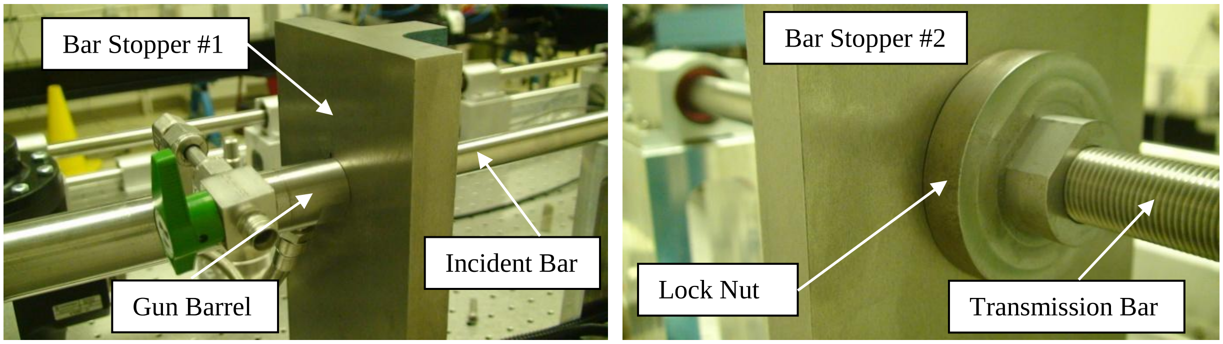

Fig. 2. Photographs of bar stoppers

Figure 1 shows the schematic of the modified Kolsky tension bar with preload capability. As shown in Fig. 2, two bar stoppers were installed on the ends of the incident and transmission bars, respectively. The first bar stopper (#1) is used to prevent the bar system from moving when the bar system is preloaded in tension. The threaded far end of the transmission bar passes through the second bar stopper (#2). Tightening the lock nut against the bar stopper #2 provides a tension load in the bar system. The preload can be controlled and measured with the load cell installed between the lock nut and the bar stopper (#2). Alternatively, the preload can be measured with the strain gages on the incident bar or the transmission bar, which is the case described in this paper. Figure 2 shows actual photographs of both bar stoppers.

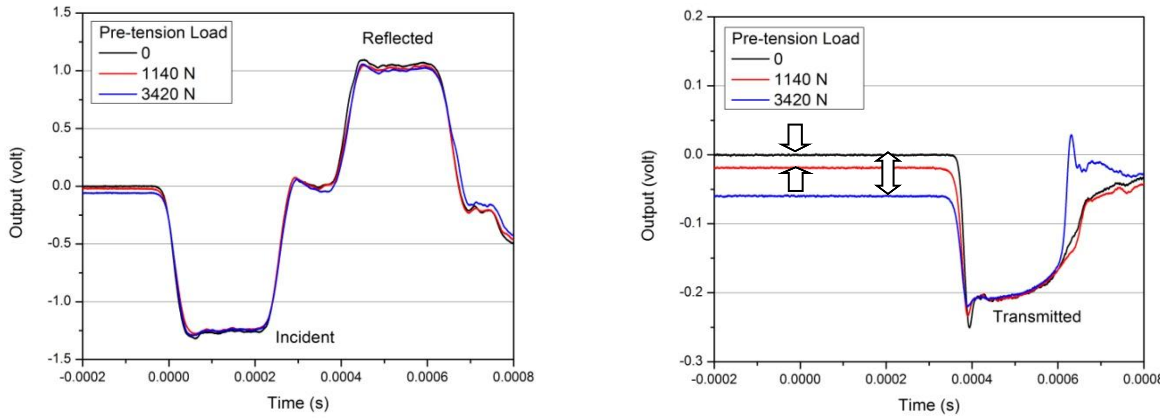

Fig.3 Incident, reflected, and transmitted pulses at different pretension loads

In this study, we employed this preloaded Kolsky tension bar system to characterize brass alloy fully threaded studs. The studs are 1” (25.4 mm) long with ¼”-20 threads. Before dynamic test, the stud specimen was directly threaded into the ends of incident and transmission bars via adapters (Fig. 1), making a gage length of ¼” (6.35 mm). Experimental procedure is the same as the regular Kolsky tension bar experiments [1, 2]. In order to eliminate strain-rate effect from preload effect, the striking speed was changed appropriately to maintain the same strain rate for different pre-tension load experiments. A Ø1/4”x0.02” annealed copper disk was used as the pulse shaper to facilitate constant plastic strain rate and dynamic stress equilibrium [1, 2]. Figure 3 shows oscilloscope records of three experiments with different pre-tension loads: 0, 1140, and 3420 N. The baseline offsets shown in Fig. 3 indicate such different pre-tension loads. In this study, we used a MTI 2000 Fotonic sensor to replace the Micro-Epsilon laser system [2] to directly measure the displacement of the incident bar end. This Fotonic sensor has a sufficiently high resolution in measuring small displacement of the bar end, enabling precise small-strain measurement of the specimen. The strain rates for all three dynamic experiments were maintained identical, which is approximately 1350±50 s^{-1}. The early stress peaks ridden on the stress-strain curves are pseudo due to threads and the amplitudes decreased with increasing pre-tension load [2, 3]. Figure 4 shows the resultant tensile stress-strain curves of the brass threaded studs at different pre-tension loads. The stress-strain curves shown in Fig. 4 have been shifted according to different preloads (1140 and 3420 N). The brass studs exhibit nearly perfectly plastic flow response. With the strain is over 10%, the flow stress then decreases with increasing strain, which is a precursor of failure. The results show the preload does not significantly influence the plastic flow stress. However, the failure responses are quite different for different pre-tension loads. The mechanism of preload effect on the failure behavior is still under study.

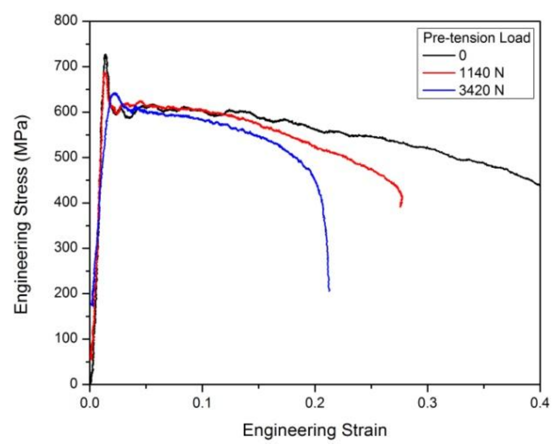

Fig. 4 Tensile stress-strain curves of threaded studs at different pre-tension loads

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REFERENCES

1. Song, B., Antoun, B. R., Connelly, K., Korellis, J., and Lu, W.-Y., 2011, “Improved Kolsky tension bar for high-rate tensile characterization of materials,” Measurement Science and Technology, Vol. 22, 045704(1-7).
2. Song, B., Jin, H., and Antoun, B. R., “Kolsky tension bar techniques for characterization of alloys,” In: Proceedings of 2011 SEM Annual Conference and Exposition on Experimental and Applied Mechanics, Mohegan Sun, Uncasville, CT, June 13-16, 2011.
3. Song, B., and Antoun, B. R., “Pseudo stress response in Kolsky tension bar experiments,” Experimental Mechanics, (in press).