Proceedings of the SEM Annual Conference
June 7-10, 2010 Indianapolis, Indiana USA

Measurement of Stresses and Strains in High Rate Triaxial Experiments

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ABSTRACT
Triaxial experiments are widely used for finding the shear properties of geo-materials such as sand, clay and rock. In many instances, these materials undergo dynamic loading where the material is subjected to high rate of deformation. To observe the material response in such condition, a high rate triaxial experimental setup has been developed recently. In the current phase of the work, novel experimental techniques are developed to measure the specimen dimensions and stresses during dynamic triaxial experiments.

INTRODUCTION
Triaxial experiments are conducted in two steps. In the first step, the specimen is loaded isotropically. The specimen is then axially loaded to generate shear. Typical triaxial test specimen is cylindrical in shape. Thus there are only two principal directions: axial and radial, which simplifies the load-deformation measurement. Specimen length and axial load in the shear phase are typically recorded outside the pressure chamber but the diameter change and pressure variation is recorded locally. The frequency response of such devices is typically only up to 20 Hz, which is in the quasi-static region of deformation rates. The shear phase of the dynamic triaxial experiment has duration of 200 μs. Most of the quasi-static measurement techniques do not have sufficient frequency response to measure the load and specimen dimensions at this rate. Therefore, new methods have been developed to accurately measure the loads and displacements in both phases. In the following sections, the new load and deformation measurement techniques are described briefly. The details of the techniques can be found elsewhere [1].

MEASUREMENT TECHNIQUE
To conduct dynamic triaxial experiments, two pressure chambers are integrated with a Kolsky bar [2]. One chamber is installed around the specimen, which is called radial chamber. The other one is at the far end of the transmission bar, called longitudinal chamber. In the isotropic pressure phase, a desired hydrostatic pressure is applied using high pressure fluid. In the shear phase, a dynamic axial load is applied by the impact of the striker on to the incident bar.

The loading in isotropic consolidation phase is quasi-static in nature. Therefore, conventional pressure and length change measurement outside the pressure chamber are sufficient to use. A line pressure gage is used for hydrostatic load measurement and an LVDT (linear variable differential transformer) to measure the length change. Strain gages are mounted on the incident and transmission bars to record the incident, reflected, and transmitted signals which analyzed using one-dimensional wave theory to measure the axial load and deformation during the shear phase [3-4].

During the dynamic phase the radial stress is measured by a manganin gage. The radial deformation in both phases of the experiment is measured by a novel capacitive transducer. The capacitive transducer is

T. Proulx (ed.), *Dynamic Behavior of Materials, Volume 1*, Conference Proceedings of the Society for Experimental Mechanics Series,
DOI 10.1007/978-1-4419-8228-5_62, © The Society for Experimental Mechanics, Inc. 2011

fabricated by placing a coiled spring around the specimen followed by a small copper tube mounted on the transmission bar specimen end. A Schering Bridge along and lock-in amplifier are used as the null detector to balance the bridge [5].

To demonstrate the feasibility of the measurement technique dynamic triaxial experiments were conducted on Quikrete #1961® sand. The specimen diameter was 19 mm with a length of 9.3 mm. The specimens are initially contained in polyolefin heat shrink tubes. The specimen is pressurized to 100 MPa, it is then dynamically compressed along the axial direction at a strain rate of 1000/s. The shear dilation of the specimen is shown in Fig. 1.

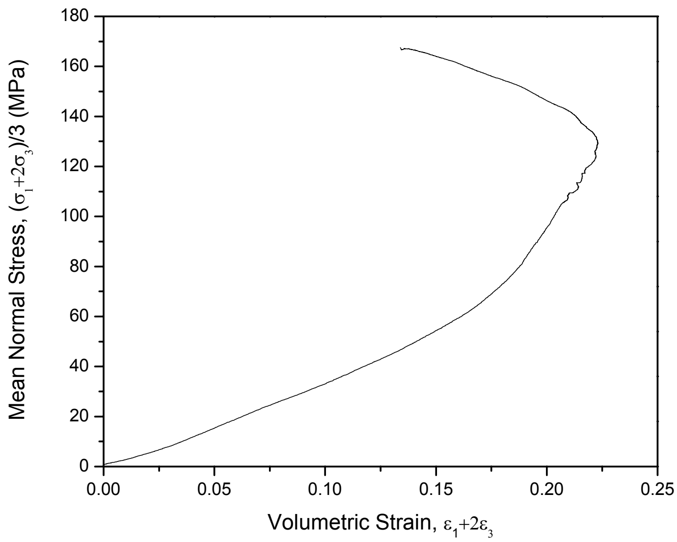

Fig. 1: Total shear dilation plot for 100 MPa and 1000 s^{-1} strain rate

This particular plot includes both the phases and requires all stresses and strains to be measured. Then all these stress-strains are converted to true forms. It is seen from the figure that the behavior of the sand resembles that of the quasi-static triaxial experiment.

ACKNOWLEDGEMENT
This research is sponsored by the Sandia National Laboratories, which is operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under Contract DE-AC04-94AL85000.

CONCLUSION
Measurement technique for the stresses and strains the dynamic triaxial experiment has been developed and demonstrated for the dynamic triaxial experiment on sand.

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