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Dynamic Triaxial Test on Sand

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ABSTRACT
Triaxial experiments are a common method for measuring shear strength. Usually the loading in the shear phase in these experiments are done at a quasi-static rate but in many real instances the loading is dynamic in nature. Therefore, a triaxial setup has been developed based on a Kolsky bar experimental technique to characterize the shear response of the material at high rates. Using this setup, a systematic investigation of the undrained behavior of sand at high pressures has been performed to study the rate effects on the stress-strain behavior. The dynamic experiment results show that the stress-strain response of the sand specimens is only sensitive to pressure levels while it is insensitive to loading rates.

INTRODUCTION

Historically, triaxial experiments involve low and/or intermediate rate of loadings. But in many cases, the stress environments of the soil are dynamic in nature. Therefore, it is necessary to perform high rate triaxial experiments on sand to quantify the sand response at these stress environments. To explore the high rate response, Kolsky bar has been modified in the past where the radial confinement to sand was applied using rigid jackets around the sand specimen [1-2]. However, the rigid jacket does not provide a controllable confining pressure throughout the experiment. Other group of researchers [3, 4] has used a combination of confined fluid media and servo-hydraulic load frames in modified Kolsky bar apparatuses to obtain a hydrostatic state of stress in a test sample. A dynamic triaxial experimental setup has been recently developed based on Christensen work [5]. In this setup, two pressure chambers are integrated with a Kolsky bar to apply a triaxial stress state. The isotropic pressure loading on the specimen is still applied quasi-statically; however, the specimen experiences a stress-wave loading from the Kolsky bar in the shear phase of the experiment. In the following sections, the experimental setup, specimen preparation, and measurement techniques for high-rate triaxial experiments on dry sand have been described.

EXPERIMENT

Two hydraulic pressure cells are incorporated with the Kolsky bar. One cell is located at the end of the transmission bar and other one is surrounding the specimen. In the hydrostatic phase of the experiment the pressure cell at the end of the transmission bar applies the axial load on the specimen, while the pressure cell surrounding the specimen applies the radial load. Quikrete #1961® fine grain sand has been used as sample materials. All specimens have a diameter of 19 mm and length of 9.3 mm. The small specimen length is required to ensure stress equilibrium within the specimen. All specimens are confined by a polyolefin heat shrink tube. A heat gun is used to shrink the tube to the desired diameter. Two steel discs are used to hold the sand. The specimen thickness was checked through verification of alignments between the edges of the tube and the marked lines on the transmission bar. The measurement techniques for load and deformation have been described elsewhere [6]

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RESULTS

The stress-strain response of the specimen is plotted in Figure 1 at strain-rates of 1000 and 500 s^{-1}, respectively. The stress-strain response indicates that, this material is pressure dependent.

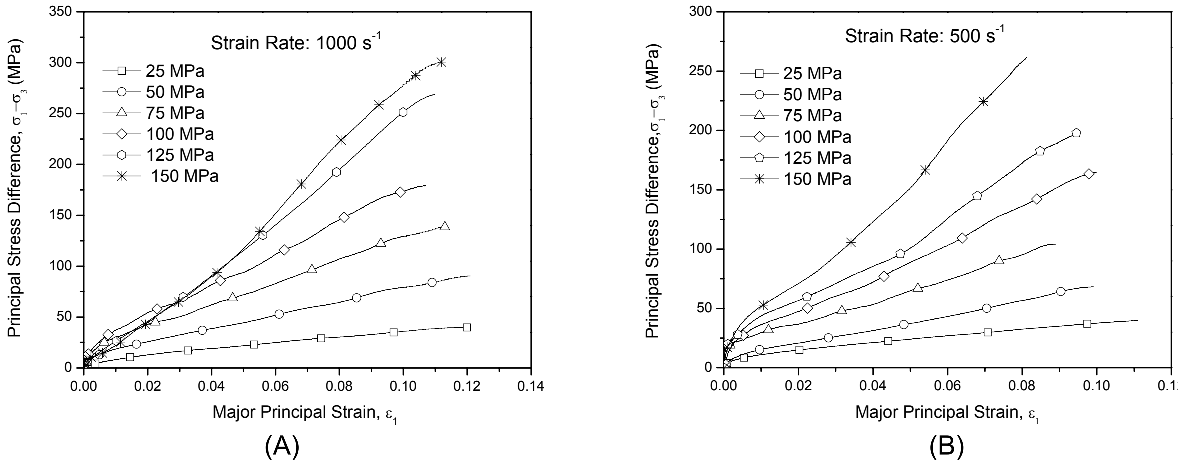

Fig. 1: Stress-strain response for high rate triaxial experiments at strain-rate of (A) 1000 s^{-1} strain-rate (B) 500 s^{-1}

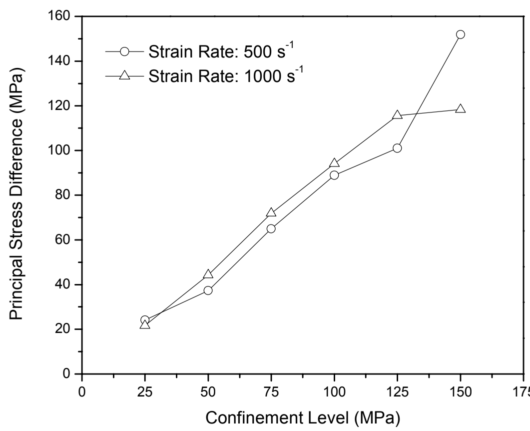

Fig. 2: Principle stress difference at 5% axial strain as a function of confining pressure

To compare the strain rate effects, principal stress difference at 5% axial strain is plotted for different confinement levels in Figure 2. This clearly indicates that there in no significant strain-rate effect for the shear property of sand at these strain rate levels.

CONCLUSION

The results show that the stress-strain response of the sand specimens is only sensitive to pressure levels while it is insensitive to high loading rates.

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