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Influence of Backfill Properties on the Collapse of Pipes Under Dynamic Loads
One of the most severe problems in laboratory or field studies of ground shock in soils is the measurement of earth pressures, since measured results are often erratic. These erratic results may result from the way the gage is placed in the soil rather than from the gage itself. This study is an investigation of the effect of several arbitrarily chosen placement methods on the static response of SE (steel-epoxy) soil stress gages in dense sand and stiff clay. It illustrates that the way the gage is placed has a significant influence on both the overregistration ratio and the scatter of the data about the mean. Results of this study indicate that, for placement methods similar to those used, measurement of stress magnitude with a single gage is a practical impossibility and that, if accuracy within plus or minus 20 percent of the true stress is desired, the average of at least three measurements (corrected for over- and underregistration) should be used. A further result of this study is a proposed calibration method to determine statistically the overregistration ratio and confidence interval on the mean for a given gage in a given soil using a particular placement procedure in order that these parameters may be used to predict the over- or underregistration of the buried gage in a virgin loaded test specimen. Although not directly applicable to the main objective of this study, information was also obtained on the effect of placement method on response during repetitive loading. The data, presented in an appendix, indicate that overregistration ratio and confidence interval for sand tests decrease with repetitive loading. (Author).

Cratering in Greenland Icecap Snow
The objective of this investigation was to study the failure of statically loaded steel circular arches buried in sand as affected by three variables; footing width, arch flexibility, and depth of burial. Static tests were performed on 16 arches with 18-inch outside diameters. The

parameters varied were wall thickness, depth of burial, and footing area. The maximum static overpressure available was 100 psi. Strain measurements were made at various locations on the arch so that thrusts and moments could be computed. (The computer program developed for these computations is described in Appendix B.) Measurements of crown deflection and footing settlement were also made. Three modes of failure were observed in the various tests. Buckling of the crown of the arch and punching of the footings into the supporting soil were the two dominant failure modes, but buckling of the arch haunches also occurred in the case of the thin arch with large footings. Generally, it was observed that the thin arches with large footings exhibited arch failure while the thick arches with small footings exhibited footing failure. Based on the test results, a method was proposed for predicting the type of failure occurring for arches with various footing and arch stiffness configuration combinations. Support investigations were conducted to determine the properties of the sand and steel used in the test. Sand properties are described in Appendix A. (Author).

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This was an experimental investigation into the response of small, shallow-buried (in dense, dry sand and stiff clay), aluminum cylinders to static (15-min rise time), rapid (13 msec), and dynamic (0.3 msec) plane-wave loading up to 500 psi. The cylinders had identical outside diameters of 3.5 in. and two thicknesses, 0.022 and 0.065 in. Hence, the cylinder stiffnesses, EI/CuR, were 1.7 and 45 (d/t = 159 and 54), respectively. In stiff clay, the overpressure required to cause collapse increased very slowly with increasing depth of burial from zero to the deepest burial, three-quarters of the diameter. The hydrostatic buckling equation, Pcr = 3 EI/CuR, was applicable for the cylinders tested. In the dense sand, the overpressure required to cause collapse increased greatly with increasing depth of burial from zero to one-eighth of the diameter. Below this depth it was not possible to collapse even the most flexible cylinders under the available 500-psi pressure. The hoop compression theory was verified. A ductility factor of about 7 was found to be conservative for cylinders buried at depths greater than one-eighth their diameter in the dense sand. The recorded strains were nonelastic in amny cases and it was shown that large yielding does not necessarily define collapse. Stress and moment were found to be nonlinear functions of overpressure, whereas thrust was generally found to be a linear function of overpressure. The differences between static and rapid loading in the elastic response of the cylinder were found to be small.

Development of a Dynamic High-pressure Triaxial Test Device

The investigation reported herein was undertaken to develop an approach to modeling displacements of surface and shallow-buried footings on dry sand subject to high-intensity, single-pulse loads. A hypothetical shallow-bured structure with an isolated footing loaded by airblast overpressure produced by detonation of a nuclear weapon was assumed for design of load pulses on nine model footings used: footing widths of 4.5, 6.0, and 7.5 in. and depth-of-burial to footing

width ratios of 0, 0.5, and 1.0. The principles of similitude were used to scale length, force, and time in the models. The models were placed in mobile test bins of uniform, fine, dry sand (90 percent relative density) and subjected to dynamic and static loading. Nondimensional load-displacement relations dependent only on depth-of-burial ratio were developed relating maximum displacement to peak dynamic load, footing width, and soil shear strength gradient. When the dynamic response of the footings in the form of reaction-displacement curves was compared with static response, an increase in initial stiffness and ultimate strength was observed for dynamic loading. However, these dynamic increases were greatest when the static shear strength was lowest, i.e. footings on the surface, and were least for footings buried at a depth equal to its width where the static overburden produced a substantial increase in shear strength. (Author).

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The formulation of constitutive relations for use in computerized analyses of free-field ground shock phenomena is based primarily on laboratory-determined material properties. These properties, as described by stress-strain relations, are not directly determined in the laboratory, but are derived through interpretation of load and deformation data measured by the experimenter. Throughout this paper, one laboratory test, the triaxial shear test, is used to illustrate the extent of interpretation required on raw data and the influence of this interpretation on recommended constitutive properties. Various techniques that have been developed to obtain stress-strain data from the triaxial test are reviewed along with current advances in measurement systems. Typical raw data are presented and calculations of axial, lateral, and volumetric strains are made based on a variety of empirical and theoretical approaches. (Author).

Dynamic Tests of Large Reinforcing Bar Splices

A limited laboratory testing program was conducted on materials cored from two tunnels at the Nevada Test Site, Mercury, Nevada. The materials were grouped into three different tuffs. The purposes of the study were to investigate the loading-rate effects and the response characteristics of the materials from the two tunnels. Both static (rise time of approximately 1 minute) and dynamic (rise time of 2 to 50 msec) hydrostatic and triaxial shear tests were conducted in the U.S. Army Engineer Waterways Experiment Station's new dynamic high-pressure triaxial test device. Although the test program was very limited, the test data to provide some insight into the hydrostatic and shear response of the tuff materials tested. (Author).

Design and Evaluation of a Device for Determining the One-dimensional Compression Characteristics of Soils Subjected to Impulse-type Loads

A parametric study was conducted to determine the effect of using various nonlinear elastic-plastic constitutive model formulations to fit a given set of soil property data in calculating high-explosive (HE), airblast-induced, superseismic ground shock. The code used was a modified version of the 2D axisymmetric LAYER code developed by the Paul Weidlinger firm. A constant shear modulus model, a constant Poisson's ratio model, and a hybrid-type model were employed. Two series of calculations were performed. In the first, the effect of an HE-type airblast on a deep highly compressible layer of soil was investigated for the three different models. In the second series, a two-layer soil profile comprising a shallow layer of highly compressible soil over a deep highly incompressible material was used. The study showed that the radial stress-, velocity-, and displacement-time histories at shallow depths were strongly influenced by the type of constitutive model used to represent the soils' mechanical behavior. Relatively large differences in maximum and final radial displacement were observed for the different models. (Author).

Effects of Relative Density and Pulse Duration on Dynamic Response of Footings Buried in Sand

The report documents a study conducted on the Gulf Radiation Technology (GRT) piezoelectric stress gage in support of the Diamond Mine Event at the Nevada Test Site (NTS). The gage was first calibrated in oil and then embedded in an NTS grout and tested under conditions of uniaxial strain. The results of these tests indicated a slightly nonlinear output of the gage under hydrostatic loadings and an under registration of the gage when embedded in the grout. Limited uniaxial strain tests were concurrently conducted on the grout mix. The property information from these tests was used as input to the WESTES finite element code in which the test boundary conditions were simulated to analytically investigate behavior of the grout specimen with and without an embedded inclusion or gage. The calculated results indicated that the contact interface between the gage and the grout had the greatest effect on gage performance. (Author).

In-structure Motion Measurements, Project LN315, Operation Prairie Flat

A general-purpose test facility for determining the one-dimensional compression characteristics of soils subjected to impulse-type loads has been developed in order to help satisfy the ever-increasing demand for reliable soil-property data required in support of a wide variety of nuc lear-weapons-effects-related problems. The design, fabrication, installation, and evaluation of the various elements which together comprise the test facility were accomplished. The various considerations involved in the design and evaluation of the newly developed test facility are discussed in detail, thus providing some insight into the types of factors which affect the experimental-accuracy capability of a one-dimensional compression test facility and thereby the reliability of the data obtained under any particular set of conditions. (Author).

Index of Publications

Important to the successful stemming and containment of underground nuclear explosions is the ability of ground shock pressures generated by an explosion to collapse the line-of-sight (LOS) pipe for a significant distance from the zero point. Prior to this study, the influence of the strength and density of the various grouts used to couple the steel LOS pipe to the parent rock on the collapse of the LOS pipe was not known except in general qualitative terms. Dynamic tests were conducted on a copper tube embedded in grouts of various physical properties and explosively loaded by a traveling detonation wave. The grouts were chosen to be representative of those used at the Nevada Test Site and to provide a significant range of strength and density. All tests were conducted underwater to ensure explosive coupling and to facilitate measurement of the dynamic pressures generated by the explosion. A theoretical analysis of a typical test cross section was made assuming the tubing and the grouts to behave as rigid plastic materials and the traveling load to be stationary. (Modified author abstract).

The Effect of Placement Method on the Response of Soil Stress Gages

The report documents the results of a limited number of static and dynamic tests on one tuff from the location of the Diamond Mine Event tunnel at the Nevada Test Site. The tests comprised the first experimental study conducted in the then newly developed dynamic high-pressure triaxial test device. The purpose of the study was to determine loading rate effects on the uniaxial strain, hydrostatic compression, and triaxial shear response of that tuff when loaded statically (approximately 2 minutes to peak stress) and dynamically (approximately 20 msec to peak stress). The results indicated that rate effects were of secondary importance when compared with the effects of variation of water content of specimens. Primary consideration should be given to testing the tuff at its in situ water content. (Author).

Study of Soil Behavior Under High Pressure

The report documents the results of an airblast-induced ground-shock calculation performed at the U.S. Army Engineer Waterways Experiment Station (WES) for the Operation Prairie Flat 500-ton high-explosive (HE) event. A WES-modified version of the 2D axisymmetric LAYER Code developed by the Paul Weidlinger firm was used for the investigation. Each layer of the soil profile was mathematically modeled with a nonlinear elastic-plastic-compacting type constitutive model that provided good fits to the available material property test data. Field airblast measurements were used to develop an airblast routine suitable for code input. The code results, carried to 300 msec of real time, showed good quantitative and qualitative agreement with the field ground-motion measurements in regions outside the crater zone. The calculations reported herein represent initial efforts at WES to conduct comprehensive parametric studies of the effectiveness of contemporary mathematical constitutive models in predicting airblast-induced ground motions for several high-explosive field tests. The overall research program includes study of the influences of computational details such as boundary conditions, grid size, and time step and comparative analyses of the calculated ground motions and those recorded during the field test events. (Author).

Hydrostatic and Shear Responses of Two Tuff Materials Under Various Rates of Stress

A finite element computer code called WESTES was developed to study the influences of laboratory testing equipment on the states of stress and strain induced in cylindrical specimens of earth media. The code can solve general static, axisymmetric, boundary value problems and is programmed to take an incremental, nonlinear constitutive model called the Variable Moduli Model II. Some of the special features of the code include the ability to simulate cyclic (load/unload/reload) laboratory tests using iterative treatments at the load/unload and unload/reload interfaces and special logic to separately handle loading and unloading in the volumetric and deviatoric stress components as dictated by the constitutive model. (Modified author abstract).

Free-field Code Predictions Versus Field Measurements

Three large rock-bolted underground cavities were constructed at the Nevada Test Site. Two of the cavities, approximately 100 feet in diameter and 140 feet high, were constructed at a depth of 1300 feet in a very weak tuff of excellent rock mass quality. The third cavity, approximately 60 feet in diameter and 80 feet high, was constructed at a depth of 350 feet in a jointed granite of high intact strength and fair to good rock mass quality. The stability of the cavities was monitored throughout construction by measuring rock displacements, observing fractures in near-surface rock, and observing the behavior of the rock-bolt support system. Supporting field and laboratory tests were performed in order to evaluate intact and in-situ properties of the rock mass. Radial movement of the cavities was measured using extensometers anchored at various depths in holes drilled from the cavity surface. Displacement versus depth profiles were used to determine the depth at which rock movement was concentrated. By comparing rock movement with excavation and support progress, a continual estimate of the cavity stability was obtained. Large displacements, or large rates of displacement, were indicative of potentially unstable behavior. Displacements were compared with displacements predicted from elastic theory, using a finite element solution and simple closed solutions. (Author).

Facility RequirementsEffects of Relative Density and Pulse Duration on Dynamic Response of Footings Buried in SandTechnical Abstract BulletinMOS Proficiency Test Aid for Construction Draftsman (MOS Code 811)Investigation of Gage-placement Effects on a Stress Gage Embedded in Grout

Failure of Footing-supported Buried Steel Arches Loaded Statically

Facility Requirements

The Combined Effects of Thermal Burns and Whole-body X Irradiation on Survival Time and Mortality

Site Investigations

MOS Proficiency Test Aid for Construction Draftsman (MOS Code 811)