CRATERING MOTIONS AND MATERIAL DESCRIPTIONS FOR PRAIRIE FLAT/DIAL PACK SURFACE-BURST EXPLOSION CRATERS IN WET, UNCONSOLIDATED ALLUVIUM, Michael G. Austin, Physics International Co., San Leandro, California 94577

Terrestrial explosion craters which exhibit flat floors and central uplifts or multirings suggest comparison with planetary impact craters or basins having similar morphological and structural features (4). Understanding the dynamic cratering motions of the explosion craters hopefully should improve understanding of the planetary impact structures even though the target materials and scales are dissimilar.

The Prairie-Flat 500-ton tangent sphere TNT charge was detonated in August, 1968 at the Defence Research Establishment Suffield (DRES), Alberta, Canada. It formed a large, shallow crater with a broad central uplift surrounded by a multiring structure on a flat-floor with steep sides. The site stratigraphy consisted of layered alluvial, lacustrine, and glacial till deposits overlaying sandstone bedrock. The water table was at approximately 6.7 meters and the bedrock at 65 m. The apparent crater was 61 m wide and 4.4 m deep. The event was heavily instrumented with velocity gages and sand column marker cans. Detailed geologic cross sections were also made after the event. Dial Pack was an identical 500-ton tangent sphere TNT event over the same geology. Together the Prairie Flat/Dial Pack data provide a detailed picture of a large aspect ratio cratering event with which to compare the results of computer simulations.

The well-documented data and extensive post-shot analysis provide a coherent picture of the crater development and sequence of cratering motions involved. This makes Prairie Flat an ideal event to verify the adequacy of computational techniques and material modelling efforts for cratering applications and specifically to calculate larger aspect ratio craters than has been done previously.

Within the first several seconds Prairie Flat formed a broad flat-floored crater with overturned flap and downfolded rim (5,6). Simulations of Prairie Flat address the cratering motions of large transient uplift of material and rebounding of the crater floor as well as the terminal deformations. Specific features which calculations attempt to simulate are: (i) the sequence of rim deformations and motions resulting in a downturned rim and overturned flap, (ii) the crater shape and large aspect ratio, specifically the formation of the broad, flat floor, (iii) the central uplift and surrounding multiring structure, (iv) the role played by the layering, including the shallow water table and the alluvium-bedrock interface, and (5) the time sequence and mechanisms involved in these. At early times as the large transient cavity expands, a large part of the flow field can be described by a simple modified Z-Model (1). But as the rebound and inward motions occur the flow field description becomes much more complicated and requires resolution into several different phases.

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The basic data needed for the calculations are the compressibility and shear strength of the various layers of material at DRES (3,8). The basic material models are augmented by an effective stress rule (2) which requires an input relation of pore pressure as a function of applied mean stress or volumetric strain. The basic idea of the effective stress rule is based on the observations that if the pore pressure and hydrostatic stress are increased by the same amount, then there is negligible change in the volume of the material; and there is no increase in the shear strength if both the stress and pore pressure are increased by the same amount, but if the applied stress alone is increased there is a large increase in shear strength. To apply effective stress concepts to a material, the material needs to have high porosity, be nearly saturated with a not too viscous fluid, and be permeable. The first order effects of the pore pressure are to make the material less compressible and lower in shear strength than it would otherwise be. But the difference in material behavior introduced by the presence of a nonzero pore pressure are not just quantitative, they are qualitative. When the effective stress replaces the mean stress in the relations for compressibility and shear strength, qualitatively as well as quantitatively new possible stress-strain paths are introduced.

The effective stress model provides a particular kind of strain softening of the fluid saturated material during unloading at constant axial strain (the approximate condition of most of the cratering flow field behind the outgoing shock). In a parameter study in which two cratering calculations were done varying only the material strength in a somewhat arbitray way, it was shown (7) that reduction in the low pressure failure strength of the material after passage of the shock wave leads to larger aspect ratio, larger volume, and longer formation time. Where applicable, a reasonable effective stress model provides just such a real physical mechanism for material strength reduction on unloading. An effective stress material model can thereby lead to the calculation of larger aspect ratio craters.

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