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PHASE Ia – REPORT NO. 2

AREA OF TECHNOLOGY:

BOTTOM BREAKOUT FORCES

BY: H. J. Lee

DECEMBER 1974

CIVIL ENGINEERING LABORATORY
NAVAL CONSTRUCTION BATTALION CENTER
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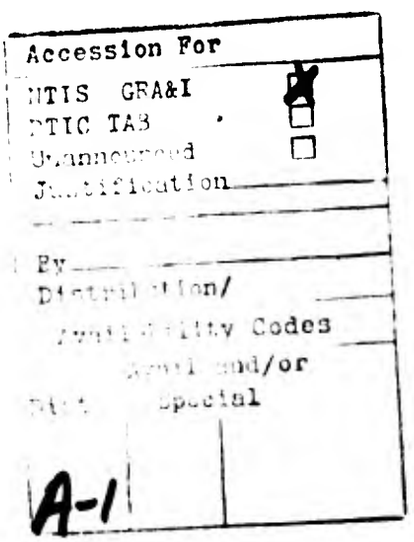
The report includes a discussion of the impact of breakout-force technology on other areas of technology within the field of ocean facilities engineering, and, also, the impact of other technologies breakout technology.



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AREA OF TECHNOLOGY: BOTTOM BREAKOUT FORCES

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December 1974

Prepared for
OCEAN ENGINEERING AND CONSTRUCTION PROJECT OFFICE
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ABSTRACT

This report describes the processes for extracting an object from a state of embedment in the seafloor. A comprehensive breakdown of breakout-force parameters is given in terms of all possible classes and subclasses of importance in ocean facilities engineering. Each class and subclass is described by relatively terse non-quantitative verbal statements. The report is not an engineering manual, but rather a tutorial exposition for managers and program planners in ocean engineering and construction. A specific objective of this report is presentation of minimal background information to be used in establishment of methods and criteria for the Navy's ocean facilities engineering efforts.

The report includes a discussion of the impact of breakout-force technology on other areas of technology within the field of ocean facilities engineering, and, also, the impact of other technologies on breakout technology.

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INTRODUCTION

During fiscal year, 1974, the Naval Facilities Engineering Command (NAVFAC) initiated a program for the establishment of standards and criteria applicable to the needs of ocean engineering and construction (OE/C). Management of the program was assigned to the OE/C Project Office, Chesapeake Division, NAVFACENGCOM. The original title of the program was OE/C Standards and Criteria Program. In FY 75, the title was changed to Ocean Facilities Engineering Criteria and Methods (C/M) Program. The document ''Program Guidelines''* of 25 Jan 1974 outlines the instructions for conducting Phase I of the C/M Program.

Phase Ia of the C/M Program has been the preparation of a set of documents which describe the areas of technology (AT's) within the field of Ocean Facilities Engineering. Included in the assigned areas of technology (AAT's) is Bottom Breakout Forces. This AT was assigned to the Civil Engineering Laboratory (CEL), Port Hueneme, California. A description of Bottom Breakout Forces is presented in this report, and is broken down as follows:

1. Technology Breakdown Structure (TBS) for hardware and equipment.
2. TBS for parametric descriptors.
3. Technology Interface Requirements (TIR) for AAT's.
4. Glossary
5. References

The TBS's and TIR are presented in the form of block diagrams with supporting narratives. The term, parametric descriptors, covers performance characteristics of the hardware and equipment as well as parameters which describe the media in contact with or affected by the hardware and equipment. Technology interface requirements describe the relations between one AAT, in this case, Bottom Breakout Forces, and other AAT's (as well as unassigned AT's) which impact or are dependent on the central AAT.

The scope of the AAT, Bottom Breakout Forces, covers only parametric descriptors, specifically, object parameters, placement parameters, and characteristics of the operations for breaking an object out of the seafloor. The term, object, refers to any structure, structural component, or vessel, associated with or part of a fixed ocean facility (FOF) or the system used to install, maintain, etc., the FOF. Topics which are not included in this AAT, but are treated elsewhere or in the TIR, are: breakout systems and seafloor soil properties.

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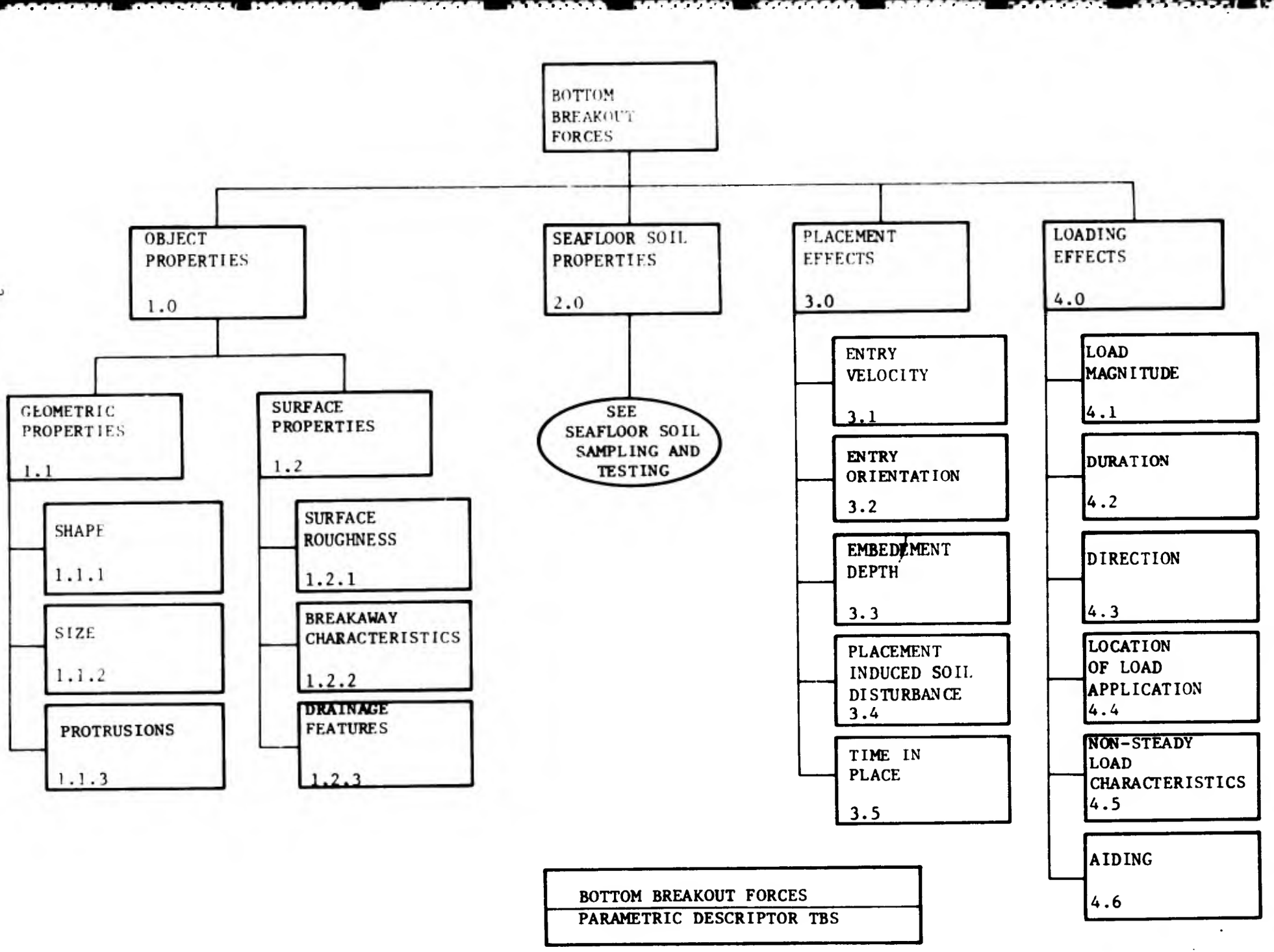
* Ocean Engineering and Construction Standards and Criteria Program, ''Guidelines for Conducting the Phase I Study,'' Ocean Engineering and Construction Project Office, Chesapeake Division, Naval Facilities Engineering Command, Washington, D.C., 25 Jan 1974.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BOTTOM BREAKOUT FORCES
PARAMETRIC DESCRIPTOR TBS

TECHNOLOGY BREAKDOWN STRUCTURE (PARAMETRIC DESCRIPTORS)

DEFN - Forces or other activities required to remove an object from a state of embedment in the seafloor. The object may have been placed on the seafloor (e.g., a bottom sitting platform) or may have inadvertently collided with the seafloor (e. g., a sunken vessel). Usually the breakout force is taken as the force required beyond the buoyant weight of the object. The force develops as a result of interactions with the bottom soil.

1.0 OBJECT PROPERTIES

DEFN - Those characteristics of the embedded object which might affect the forces required to remove the object from its state of embedment.

1.1 Geometric Properties

DEFN - The characteristics of the object shape and size which might affect the required breakout forces.

1.1.1 Shape

DEFN - The overall form of the object, e.g., sphere, flat plate, cube, cylinder.

APPLICATION - In general, breakout forces appear to be slightly less if the object is curved in the vertical plane rather than being a flat plate, cube, or rectangular solid.

1.1.2 Size

DEFN - The overall magnitude of the object dimensions.

APPLICATION - breakout forces appear to increase with object size, possibly greater than linearly.

1.1.3 Protrusions

DEFN - Small scale attachments to the object surface.

APPLICATION - Breakout forces increase with number of protrusions. Protrusions cause the object to become more intimately attached to the seafloor.

1.2 Surface Properties

DEFN - Characteristics of the object surface which may affect the required breakout forces

1.2.1 Surface Roughness

DEFN - Small-scale surface irregularities.

APPLICATION - Breakout forces will generally be slightly greater if the surface is rough.

1.2.2 Breakaway Characteristics

DEFN - The ability of the portion of the object in contact with soil to disconnect itself from the object during breakout. This portion would be considered expendable.

APPLICATION - The breakout force could be reduced almost entirely with breakaway surface elements. It is important that a means be provided for venting the space between the breakaway element and the object.

1.2.3 Drainage Features

DEFN - The ability of the portion of the object in contact with soil to allow water flow.

APPLICATION - The major cause of breakout force generation is the difficulty water experiences in flowing into a space beneath the object. If a means is provided (tubes, grooves, or porous surface) to allow water flow, the breakout force can be substantially reduced.

2.0 SEAFLOOR SOIL PROPERTIES

DEFN - Those characteristics of the seafloor itself which influence breakout forces.

APPLICATION - Fine grained, cohesive soils (clays) can produce substantial breakout forces while coarse grained soils (sands) generally do not cause breakout problems. The most important cohesive soil property is the short-term undrained shear strength as determined, for example, in the vane shear test. In long-term breakout, consolidation, creep, and permeability probably play a role although it is difficult to identify this role specifically. The determination of soil properties is covered by the AAT, "Seafloor Soil Sampling and Testing."

3.0 PLACEMENT EFFECTS

DEFN - Those characteristics of the object's collision with the seafloor and its history following collision which may influence the required breakout force.

3.1 Entry Velocity

DEFN - The velocity of the object at the time it meets the seafloor.

APPLICATION - Faster moving objects will generally penetrate farther and, thereby, be more difficult to dislodge.

3.2 Entry Orientation

DEFN - The orientation of the object relative to the seafloor and to the direction of motion at the time of collision.

APPLICATION - An object moving with its smallest cross-sectional area perpendicular to the direction of motion will penetrate farthest and become most difficult to dislodge. Other orientations will produce smaller breakout forces.

3.3 Embedment Depth

DEFN - The average depth to which an object has become embedded at the time breakout operations are begun. Includes the initial penetration depth achieved during collision plus any additional longer term settlements.

APPLICATION - The more deeply an object is embedded, the greater will be the required breakout force.

3.4 Placement Induced Soil Disturbance

DEFN - Changes in soil properties (especially shear strength) produced by placing an object on the seafloor.

APPLICATION - Object placement, particularly if the object is moving rapidly, can remold the soil through which it passes and cause a lower shear strength. This could produce a lower breakout force than would be expected if the soil were not remolded.

3.5 Time in Place

DEFN - The length of time between object placement and initiation of breakout operations.

APPLICATION - As an object remains in place on the seafloor the strength of the soil surrounding it is slowly regained. The object can settle farther and become more intimately attached to the soil. The overall effect is an increase in breakout force with time in place.

4.0 LOADING EFFECTS

DEFN - The characteristics of the loads applied and other activities performed in conjunction with breaking an object out of the seafloor.

4.1 Load Magnitude

DEFN - The size of the load applied (generally by a line) at the object. The breakout force is generally taken as this load minus the buoyant weight of the object.

APPLICATION - At least three types of breakout are possible: (1) immediate or short-term breakout in which the line load is increased rapidly until breakout occurs, (2) long-term breakout in which a line load less than the immediate load is applied until breakout occurs after some time has passed, and (3) aided breakout in which activities other than direct line pulling are conducted to reduce the breakout force.

4.2 Duration

DEFN - The length of time during which the line force is applied.

APPLICATION - Generally the longer a line force can be applied, the smaller it needs to be to achieve breakout.

4.3 Direction

DEFN - The orientation of the line load relative to the seafloor.

APPLICATION - Complex; it is necessary to analyze the individual situation to determine whether a vertical or non-vertical pull is best. In some cases pulling the object along the bottom may reduce the breakout force.

4.4 Location of Load Application

DEFN - The point on the object through which the line load is applied.

APPLICATION - The breakout force is probably greatest if it passes through the object center of mass. Lifting from one end may substantially reduce the required force.

4.5 Non-Steady Load Characteristics

DEFN - Deviations from a constant line pull.

APPLICATION - In many instances a non-steady (cyclic or series of jerks) line pull will probably produce breakout at a lower force level than a steady line load. An exception might be medium to very long-term breakout.

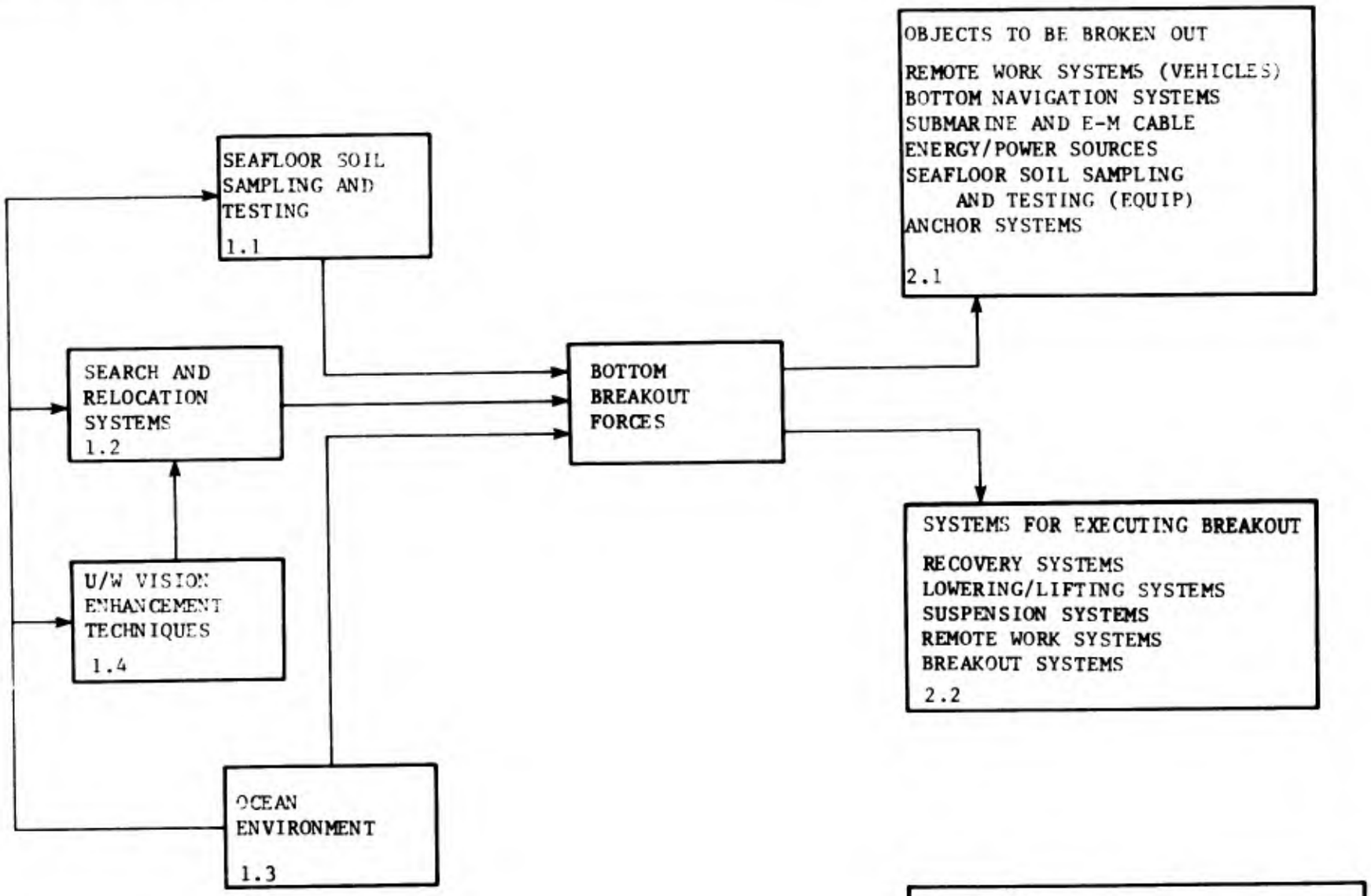
4.6 Aiding

DEFN - Activities other than direct line pulling conducted to expedite breakout.

APPLICATION - Numerous breakout aides have been proposed. Included are jetting, pumping, inserting tubes, rolling, and items discussed previously (e.g., expendable surface elements). Each of these has the potential to greatly reduce the breakout force.

1.0 INPUT/DEPENDENCIES

2.0 APPLICATIONS



BOTTOM BREAKOUT FORCES
TECHNOLOGY INTERFACE REQUIREMENTS

TECHNOLOGY INTERFACE REQUIREMENTS

1.0 INPUT/DEPENDENCE

1.1 SEAFLOOR SOIL SAMPLING AND TESTING

DEFN - Sampling of bottom sediments and subsequent laboratory testing to obtain engineering properties. Also in-situ testing to obtain engineering properties directly.

IMPACT - Sediment engineering properties are used to predict the forces necessary to extract objects embedded a known distance in the seafloor. The properties could also be used to estimate how far an object might have penetrated or will penetrate under certain entry velocities and orientations. The specific property needed to predict immediate breakout is the short-term or undrained shearing strength as measured by a laboratory or in-situ vane shear test, a triaxial compression test, or a direct shear test. In long-term breakout other parameters (permeability, consolidation parameters, and drained shearing strength) are probably involved. However, none of the existing prediction procedures use them. Rather, empirical procedures based on the undrained shearing strength have been developed.

1.2 SEARCH/RELOCATION SYSTEMS

DEFN - Search and relocation systems would be used to locate and mark lost objects which might have become embedded in the seafloor.

IMPACT - An important parameter in predicting required breakout forces is the depth to which the object is embedded in the seafloor. Search systems would be used to find the lost object, measure its embedment depth, and determine its orientation.

1.3 OCEAN ENVIRONMENT

DEFN - The physical, chemical, and bilogical characteristics of the seawater, seafloor, and air. The effects of wind, waves, currents, and seafloor soil movements are considered.

IMPACT - Currents will affect the facility with which lines can be attached to objects embedded in the seafloor. Slumping, scour and deposition of sediments can alter the object depth of embedment. Water turbidity can affect the ease with which objects are located and their depths of embedment measured.

1.4 U/W VISION ENHANCEMENT TECHNIQUES

DEFN - Systems and procedures for improving underwater visibility.

IMPACT - It may be necessary to determine object orientation and embedment prior to initiation of breakout operations. This determination can be facilitated through vision enhancement techniques.

1.5 SYSTEMS FOR EXECUTING BREAKOUT

DEFN - The various systems used in reducing breakout forces and exerting uplift forces to overcome the breakout resistance of the sediments. The areas of technology included are remote work systems, recovery systems, lowering/lifting systems, suspension systems, and breakout systems.

2.0 APPLICATIONS

2.1 OBJECTS TO BE BROKEN OUT

DEFN - Ocean engineering structures or other objects which might become embedded in the seafloor and require subsequent recovery. Included are objects represented by the following areas of technology: remote work systems, bottom navigation systems, submarine and E-M cable, energy/power sources, seafloor soil sampling and testing equipment, and anchor systems.

IMPACT - The design of these various ocean engineering devices may depend upon anticipated breakout forces in the event the device becomes embedded in the seafloor. The configuration of the base of the device, the institution of breakaway surfaces, and the installation of breakout aids on the device may all be included. Although holding capacity of anchors is not included in the area of technology "Bottom Breakout Forces" (instead see "Anchor Systems"), knowledge about bottom breakout forces can be used in the design of certain anchors. Included primarily are anchors which derive most of their capacity from dead weight.

2.2 SYSTEMS FOR EXECUTING BREAKOUT

DEFN - The various ocean engineering systems used in reducing breakout forces and in exerting uplift forces to overcome the breakout resistance of the sediments. Remote work systems would be used to attach lines and perform certain breakout aids such as jetting. Recovery systems would be used to expedite attachment of lines to structures. Lowering/lifting systems would be used to perform the actual lifting operation. Suspension systems would be used to transfer the lifting load from a surface vessel to the embedded object.

IMPACT - The design of the overall system for executing breakout will depend upon the magnitude of the anticipated breakout forces, the ability of breakout aids to reduce these forces, and the manner in which these forces are expected to vary with duration of loading.

GLOSSARY

consolidation (soil). Reduction in soil volume accompanied by pore water flow out of the soil. Usually produced by long-term compressive loading.

creep (soil). The gradual deformation of a soil element under a constant load. Applicable to very long-term loading conditions.

drained shearing strength (soil). The soil shearing strength under conditions of water flow sufficient to neutralize pore water pressures set up by loading. Used to analyze relatively long-term loading conditions.

permeability (soil). The parameter which describes the difficulty water experiences in flowing through soil. For example, a highly permeable soil conducts water readily while soil of low permeability effectively reduces water flow.

shear strength (soil). The peak shearing stress that can be applied to a soil element without causing very large strains or rupture. The shear strength is highly dependent upon rate of loading, boundary conditions, and nature of applied stress state.

turbidity. Water cloudiness produced by suspended sediment or biological material.

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