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Engineering and Design
BOREHOLE VIEWING SYSTEMS

1. Purpose. The purpose of this pamphlet is to identify the types of data that can be obtained from borehole viewing systems, describe the equipment that is presently available for use, and list where the equipment is available.

2. Applicability. This pamphlet applies to all field operating activities having civil works and military responsibilities.

3. Background. Borehole television and camera systems provide an extra dimension in obtaining borehole information and determining in situ rock conditions. Advantages for television systems are direct viewing, immediate analysis, variable focusing, and concurrent records. Borehole camera surveys can provide color photography, 360 degree viewing area, portable equipment, and high resolution images. The Corps of Engineers pioneered development and use of the NX borehole camera and is currently believed to be the only source for the 360 degree radial-view camera. Television cameras and other systems are more recent developments.

4. Description of Equipment. Characteristics of different viewing systems are listed in Table 1 for comparison of critical features and possible limitations.

a. Television Systems. The television system uses a closed circuit television camera and the image of the borehole sidewall is viewed on a television monitor. Most borehole television systems are composed of a probe containing television electronics or camera equipment, a combination lowering device and cable drum, and a control console. Television systems currently available for FOA's use are listed in paragraph 8. Features of most television systems include the alternative use of an axial (downhole) or radial (sidewall) lens. Some systems have the capability of direct viewing, on the monitor, of a compass-clinometer. Views may be transferred to a videotape for future interpretations. The videotape can also be used to record voice comments as the boring walls are viewed. In addition, a depth indicator located on the console may be programmed to appear on tape, providing continuous location of the probe in the borehole.

TABLE 1

CHARACTERISTICS OF SYSTEMS

SYSTEM	PROBE		HOLE DIAMETER		VIEW ORIENTATION	INCLINOMETER	RADIAL VIEWING	FOCUSING	RECORD
	DIAMETER	LENGTH	MINIMUM	MAXIMUM					
TV Systems	$1\frac{3}{4}$" – $4\frac{3}{4}$"	12"-32"	2"-5"	13"-20" *	Magnetic Compass/or None	Bubble/or None	Rotatable/ or Fixed Mirror	Remote	Video Tape
NX Camera	$2\frac{3}{4}$"	30"	3"	4"	Magnetic Compass	Floating Arrow	360 Degree Conical Mirror	Fixed	16MM Color Film
Borescope	2"	-	$2\frac{1}{2}$"	4"	None	None	Rotatable	None	Photograph
Televiewer	2"	22"	3" **	-	Magnetic North	None	360 Degree Sweep	None	Photograph

* Some systems have an effective distance of 20 feet with telephoto lens.

** Requires centering device.

b. Camera Systems. The Republic NX camera is designed to provide continuous, overlapping, 360 degree coverage (radial view) of the borehole walls. The camera is contained in a stainless steel, waterproof cylinder. A magazine containing 25 feet of film will permit photographing about 75 feet of the boring. A photograph can be taken every 3/4 inch, thereby producing continuous pictures of the borehole sidewall. A conical mirror located at the quartz window is truncated at the top to expose the hollow interior of the cone. The opening permits the camera to photograph, on each exposure, the orientation of a floating magnetic compass and tilt indicator. By this means, a departure from vertical of any section of the borehole is photographed simultaneously with the compass orientation of the photograph. Film interpretation of the NX system can be otained by two methods with the use of a special projector. One method recreates (by means of a conical mirror) the cylindrical geometry of the borehole. The mirror projects each photograph onto the interior surface of a frosted glass cylinder. From outside this cylindrical glass screen, the interpreter sees a projection that resembles a rock core in true perspective, permitting a continuous borehole log to be developed. The second method projects, by means of a plain mirror, a distorted, flat, doughnut-shaped image onto the projector's screen. The image is then analyzed and interpreted with the aid of various types of overlays, depending upon the information desired. At the present time, there is no known supplier of new NX camera equipment.

c. Borescope. The borescope is basically a tubular periscope with optical magnification and a light source. The equipment is sectional, and is lowered into the boring by hand, or by use of a simple lowering mechanism on a tripod. Optical fittings on the ends of the tube can be selected for either radial or axial viewing and a camera attachment for photographing the borehole can be fitted. The depth to which the borescope may be used is limited by the ability of the system to transmit adequate light to the hole. Not all borescope systems are waterproof.

d. Televiewer or Seisviewer. The borehole televiewer is a cable-mounted downhole tool which transmits acoustic pulses to the borehole wall and records the reflected energy. This energy is converted and displayed on an oscilloscope, and can be photographed. The transmitter of the acoustic signal sweeps the hole in a 360 degree arc oriented to magnetic north. Because fractures, soft seams, cavities, and other discontinuities will attenuate the acoustic reflection, these features will be distinguished on the oscilloscope image. Changes in lithology and porosity may also be distinguished by changes in the image intensity. A major advantage to this system is that the log image does not require clear fluid in the borehole, and therefore it can be conducted in a mud filled boring. It does require use of a fluid to transmit the acoustic pulse. Usual logging speed is 15 feet per minute.

e. Impression Packer. The impression packer can be used to obtain fracture and "washout" data for limited sections of borehole. The procedure for use consists of coating an inflatable formation packer with a slow curing rubber compound, inserting it into the boring to the depth of interest, and inflating the packer. When the rubber has cured, the packer is deflated and withdrawn. The rubber membrane will contain an impression of the fracture traces.

5. Applications. Borehole television and camera systems provide easy to reproduce records for future reference, are easily portable, can provide 360 degree borehole sidewall photographs, and produce good pictures either in clear water-filled or dry holes. Also, the systems may be used in well screen condition surveys, to ascertain grout distribution and effectiveness in boreholes, and in borehole casing assessments. Borehole drift angle and direction can be determined with the NX borehole camera and with the use of a directional gyroscope in conjunction with certain television systems. Specific applications of borehole viewing systems for geotechnical data collection include:

a. Location of zones of core loss or "washout".

b. Assessment of zones of core losses due to badly fractured zones and very soft zones.

c. Determine geometry, spacing, and dimensions of rock joints, fractures, bedding, and other discontinuities.

d. Determine dip direction of bedding, foliation, and shear and fault zones.

e. Determine condition of rock-concrete contacts.

f. Evaluate openings along joints, fractures, and bedding.

g. Evaluate cavities.

h. For drill holes where no core has been obtained, viewing systems may be able to provide data on:

(1) lithologic characteristics
(2) stratigraphic sequence
(3) bed thickness
(4) establishing horizon markers
(5) zones of oxidation and deterioration
(6) joints and rock cleavage
(7) fractures--width of shear zone--strike and dip
(8) fault clay and gouge
(9) brecciated and crushed zones
(10) stylolites
(11) cross bedding
(12) unconformities

6. Discussion. The television camera is easy to use and provides an immediate image which can be stored on videotape. The resolution of the TV image is not as good as that of a film camera. The television system can record an entire hole in one operation, whereas the film camera can only record about 75 feet of the hole before it must be withdrawn and the film changed. The borehole camera can take color or black and white photographs, but color may not be available for TV images in the smaller sizes. The film camera images cannot be evaluated until the film is processed and projected. Holes must be free of mud or muddy water to provide optimum results. The borehole can be flushed and/or "wiped", and flocculants added to settle suspended sediments. The seisviewer can be used in holes filled with drilling mud. Special uses of viewing systems could be to obtain additional data on the extent of solution cavities or mines and to assess the success of mine and cavity backfilling. The camera can also be used to examine well screens and casings or to monitor holes specially drilled for the purpose of observing cracks in concrete or stress relief in foundations or excavations. Where hydrofracturing is performed to determine in-situ stress, cameras can be used to measure the fracture orientation (stress direction). They may also be used for orientation purposes where obtaining oriented core is not possible or feasible. Borehole viewing systems should not be used as a substitute for obtaining cores. However, these systems can provide valuable data in holes where coring has not been done, such as drains, NX grout holes, wells, instrument borings, etc.

8. Availability. Corps of Engineers owned viewing equipment and services are available as listed below: (Point of contact in parentheses)

a. Waterways Experiment Station (Engineering Geology and Rock Mechanics Division).
- NX camera
- TV cameras; for NX hole, for 5 inch hole
- televiewer
- borescope

b. US Army Engineer Division Laboratory, Southwestern (Director, SWD Laboratory).
- NX camera

c. US Army Engineer District, Walla Walla (Foundation and Materials Branch).
- NX camera
- TV camera, for 4-1/2 inch hole

d. US Army Engineer District, Mobile (Geotechnical Branch).
- TV camera, for 3 inch hole

e. Other government agencies have developed their own camera and TV systems for special uses. For special or limited purposes, consideration may be given to fabrication of an inexpensive camera system such as described in "Development of System for Photography of Underground Openings Through Drilled Holes," Missouri Highway and Transportation Department, Report No. 80-2, March 1981.

FOR THE COMMANDER:

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