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Dr. M. S. Nataraja
Engineering Branch
Division of Waste Management
U.S. Nuclear Regulatory Commission
7915 Eastern Avenue
Silver Spring, Md 20910

Dear Dr. Nataraja:

Enclosed is a report for Krishan Wahi's trip to the annual technical conference of the Institute of Shaft Drilling Technology held May 22-24, 1985 in Las Vegas, Nevada. We apologize for the delay in forwarding this report to NRC and hope that it did not cause any inconveniences. If you have any questions, please contact Krishan Wahi or myself.

Sincerely,

E. J. Bonano
Waste Management Systems
Division 6431

EJB:6431:mg

Enclosure

2242

TRIP REPORT

At NRC's request, Krishan Wahi recently attended the annual technical conference of the Institute of Shaft Drilling Technology (ISDT) held in Las Vegas, Nevada. The meeting dates were May 22 through May 24, 1985.

Introductory remarks were made by Paul Richardson, the current ISDT President. A copy of the agenda is attached at the back of this report. Also attached are copies of selected papers; not all speakers made copies of their papers available.

The first paper dealt with the concepts and programs for a proposed two-phased repository in basalt. H. B. Dietz of Rockwell presented an overview of the program. Under the two-phase concept, the DOE intends to provide an interim Phase I repository by 1998, with the Phase II (full scale) repository completed in 2001. The analysis assumes truck shipments only. A "new" waste package design is required for the two-phase concept. Two exploratory shafts, each one 6-ft in diameter, are planned to be constructed using blind drilling. The two shafts will be separated by 500 ft and the underground drift excavation during site characterization will be approximately 1700 ft. A total of nine shafts are proposed for the repository; two with 6-ft diameter, three with 12-ft diameter and four with 8.75-ft diameter. The stated conclusion was that the two-phase concept was viable and would enable a timely completion in compliance with NWPA. Two questions, that are relevant from NRC's perspective, were posed to the speaker: 1. Will the final EA contain more comprehensive analyses of the two-phase concept? and 2. Has there been previous large-hole drilling experience in a high-stress environment? The answer given to the first question was a "no"; DOE views it as a programmatic change that does not impact the determinations given in the Draft EA. The answer to the second question was that they were not aware of any previous experience, but did not anticipate problems (because of small exploratory hole drilling experience). However, C. T. Webster qualified that answer by saying that there has been previous experience at Amchitka.

The second presentation was by C. T. Webster of Rockwell Hanford Operations concerning "Exploratory Drilling in Basalt at Hanford". Mr. Webster is the Principal Engineer on the project. The following comments paraphrase selected parts of his talk. The Columbia Plateau contains the world's second largest basalt formation. The brittle nature of this basalt gives it good drillability with tungsten carbide drill bits. The drilling of DC-1 was a typical learning experience. In coring and core-recovery, the oil-field type of equipment (with diamond-bit drilling) failed to perform. Inflatable packers worked extremely well in the core holes. Lost circulation is a major problem with core drilling; this problem is minimized with rotary drilling. Attempts were made to measure stress in these holes using hydrofracture techniques. There are at present 17 holes with depths between 1000 ft and 2000 ft; and 70 holes that are less than 1000 ft deep. For medium-hard formations with high compressive strength, the J44 bits work well giving drilling rates of 6 ft/hr. Pumping tests of 60- to 90-day duration are envisioned for the RRL-2 nest of holes. Rockwell has acquired two unique drill rigs. At the Hanford site these rigs will be run on electricity only. One of these rigs has been used to drill more than 30,000 ft on two occasions. The most important statement made by the speaker was that he does not believe that the presence of repository-quality basalt can be confirmed without drilling an exploratory shaft.

The next paper was on "Key Factors in Determining Rig and Equipment Requirements versus Shaft Size to be Drilled" by C. Presely (private consultant). Based on his experience and simple analyses, he identified important parameters and dimensions that are of practical value in carrying out drilling programs. He feels that rotary tables are the weakest link in the chain of large-hole drilling equipment because they are not designed for low-r.p.m./high torque operations. The torque is a function of number of cutters, rolling resistance, and radial location of the cutters. Disc cutters outperform any other cutter type, but must be loaded to the rock-failure load. Barrel-type cutters will cut at almost any load. It is possible to comfortably drill 15-ft dia. holes with tapered bottom bit and 19-ft dia. holes with flat bottom bit. Tapered bottom aids bottom hole cleaning which is essential as holes get larger.

Dave Becker of Rockwell-Hanford made the next presentation on "Large Diameter Shaft Steel Liner Design Concerns". He categorized the liner design concerns into three areas: fabrication and delivery, field preparation and installation, and outfitting and operations. The fabrication and delivery factors include liner weight, constructability, shipment to site, quality assurance/quality control and inspection, and cost. Field preparation and installation factors include liner weight, handling, lifting methods, hole mis-alignment etc. Weight curves for ring-stiffened steel casing for a 3900-ft shaft were presented. These curves (for different yield strength) present liner weight as a function of inside diameter. Alternate reinforcing ring designs were shown. Arc time versus liner thickness curves for different welding techniques were given. Reinforcement rings can be placed inside the liner instead of outside, which would reduce welding requirements. However, higher section thicknesses would be required when inside reinforcement rings are used.

Casing port hole drilling in a high pressure environment was discussed by D. Moak of Rockwell-Hanford. A copy of Moak's paper is attached. The first Exploratory shaft (ES-1) will provide access to the repository horizon. In-situ testing will take place from both shafts prior to breakout. Every borehole drilled will be continuously bored. The breakout is planned at a depth of 3150 ft. The temperature and water pressure near that depth are expected to be 124 degrees Fahrenheit and 1300 psi. Additional safety margins are planned to satisfy DOE and NRC concerns. A multi-level work deck will be built and E/H powered drill will be used for quiet operation. Six-hour work shifts will be used. A total of ninety-eight portholes, varying in length from 40 ft to 130 ft, are planned with 42 in flow tops and interbeds and 56 in flow interiors. Some of the holes will be inclined.

The remaining papers were unrelated to the BWIP project and are described very briefly in the following paragraphs. Wendell Mansel of Fenix and Scisson presented a paper on controlled bit tests. A copy of his paper is included. Two important conclusions were: 1. Increasing the circulation rate results in an increase of the rate of penetration; 2. When re-tipped cutters are used (instead of new cutters) both the penetration rate and the bit-wear increase. The increased penetration rate is speculated to be due to the re-tipping material. A presentation on "Big Hole Measurement While Drilling" was given by Karl Hahn of Reynolds Electrical and Engineering. They have used different kinds of drill bits and found polishing patterns on the bit paints. Different off-bottom distances of the pick-up tube, and various sizes of mudline and rotary hose have been tried to study their effect on penetrarion rates. Significant fuel savings resulted when larger diameter mudline and rotary hose were used. They hope to make real time MWD (measurement while drilling) using EPR (wire), mud pulse, acoustics and electromagnetics. The parameters of interest are the pressure and temperature in the bit region. J. R. Benjamin from the Wirth Company gave a talk on rotary drilling machines for shaft construction. They are manufacturers of drilling equipment, and his talk concentrated on drilling machines made by Wirth. A sequential raise boring machine and a box holing machine were described.

The Thursday, May 23, morning session started with a status report on ISDT membership. Two items of interest are a blind-drilling short course and a symposium on raise boring. The first talk of the day was given by T. Wilson from the Los Alamos National Laboratory (LASL). The subject of this talk was a numerical simulation of fluid flow and chip transport beneath a drill bit. A copy of this paper is attached. Based on the analysis, some possibilities for improved bottom-hole cleaning were suggested. These are: lower mouth of pickup tube, a shroud (i.e., false bottom), jets near hole wall, and experimentation with jet orientation. Alternate chip-removal methods were propo[illegible]d for assessment; namely, [illegible]eep pick ups, wipers and conveyors. Computer simulations were promoted as a relatively inexpensive tool for understanding and improving drilling performance.

Robert Parker, Jr., of Parker Drilling Company made a presentation titled, "A large Diameter Drilling Rig Design". According to Mr. Parker, his company has drilled the world's largest/deepest hole, which is 6200 ft deep with 7.5 ft diameter. The Parker Co. designed a new rig in mid-1982 for the BWIP project. This rig (Parker 221) is capable of drilling large diameter shafts and can handle 80-ft casing sections of 110" diameter. It has a static load capacity of 2 million pounds with a 3000-4000 h.p. (electric) draw-works. The substructure is 7 to 8 ft high, the drilling line is 2" dia. and the leg-span is 40 ft. The rotary table has 2000 h.p. motors and a diameter of 37.5 in. The largest drill rig owned by Parker is currently at a site in Oklahoma to drill a 33,000-ft deep hole; its rotary table has a diameter of 49.5 inches.

A presentation on understanding the tension-torque diagram was given by G. Alther of LOR, Inc. A copy of this paper is enclosed. The tension-torque curve is typically elliptical for tubular pipe without connections. A factor of safety is used such that the maximum operational limit is 75% of the material yield limit. When rotary shouldered connections are present, other considerations enter into the construction and interpretation of the tension-torque diagram.

Application of horizontal tunneling machines to vertical drilling was discussed by Milton Head of Head Development, Inc. The title of his talk was "Cutter on Casing Shaft Sinking Method". Torque capacities of 13 million ft-lb have been achieved with these tunneling machines. He showed many slides of tunneling machines and equipment and different types of liner design. Segmented, prefabricated reinforced concrete liner with wooden pins was cited as a very successful design. An application was shown where a 9-ft dia. shaft was drilled in shale/alluvium using tunneling equipment. The conclusion was that there is a lot of potential for using tunnel boring technology to shaft drilling and lining.

Euclid Worden from Drilco Industrial talked about developments in raise boring bit bodies. "Flat-bottomed" bodies are used for cutting in one plane. The term "flat" does not necessarily imply complete flatness or horizontal cutting plane. Frequent failure of threaded joint or drill stem has led to the development of replaceable stems. Although roller stablizers were popular in the past, they are no longer favored in raise boring.

Case histories of large diameter raise boring were presented by W. Harrison of Frontier-Kemper. One example was of a 20-ft diameter shaft for the Monterey Coal Project. Frontier-Kemper has a total of 3.5 miles of raise drilling experience and has a very large inventory of drills for raise boring. B. Kirkpatrick, owner of Raisebor, Inc. gave a report on angle raise boring methods. Holes that are 75 to 85 degrees with respect to the horizontal plane are relatively free of complications. "Flatter" holes have several unique problems. Poor surveying of a project site can sometimes lead to a need for angled holes. Raisbor, Inc. has been involved in a number of 45-degree hole drilling jobs. Problems with angled holes that are not drilling related have to do with mechanical aspects of rig design, poor lubrication, increased bearing-wear, combined state-of-stress on load-bearing members, and bolt loosening. Some of the drilling related problems are the drill-bit wear and hole-direction deviation. Operator skill is extremely important in angled hole raise drilling.

The Friday morning session started with a talk by V. Valencia, President of International Ground Support Systems, on "Remote Shotcrete Linings". Mr. Valencia also runs a shotcrete training school. He had many practical tips on shotcreting. One warning was not to use shotcreting after everything else has failed. A pre-construction testing procedure that is followed by his company was shown. The water/cement ratio controls the strength of shotcrete; most of the mixes use the ASTM specifications. Ideal water/cement ratios fall in the 0.27-0.35 range. High strength should be achieved early on (i.e., quickly after application) without the use of "accelerators". On an NTS job, 8-in thick (average) shotcrete was placed remotely and an average compressive strength of 6200 psi was achieved. A video film of the whole operation was shown toward the end of the talk.

J. Neudecker of LASL discussed the application of water-jet cutting to shaft drilling. In water-jet cutting, pressures of 15,000 psi are considered moderate. Cutting rates are proportional to the ratio of water jet pressure and rock strength. Plots of drill rate versus jet pressure were shown for small diameter holes. There are advantages to using higher water jet pressure on the guage cutters. Additional power of about 400 h. p. is needed to provide extra jet pressure of approximately 10,000 psi. Some planned laboratory experiments were mentioned to perform parametric studies.

The use of a combination blind-raise drill in a gold mine operation in South Africa was described by J. Friant of the Robbins Co. The expected benefit of using raise-drilling technology was to reduce the amount of waste rock in the enlargement of a hole. The machine was a Robbins drill (Box Hole Drill Model 52R). It has a torque of 95,000 ft-lb and a thrust of 300,000 lb. Some problems were encountered that required an abnormal amount of interruption and maintenance. The main lesson was that a better cutter design is necessary for a rock of such high compressive strength.

The last presentation of the meeting was given by a team of speakers from Santa Fe Joint Venture on the AOSTRA (Alberta Oil Sands Technology and Research Authority) Project. Due to unfavorable ground and underground conditions it was thought necessary to resort to blind drilling. An estimated 160 billion cubic meters of oil sands exist in Alberta. A shaft and Tunnel Access Concept (SATAC) has been developed to exploit this energy source. The initial shaft dimensions are 13 ft diameter and 722 ft depth for an underground test facility. Some drilling problems were encountered in the limestone formation. Specifically, the penetration rates were very low and no satisfactory explanation could be developed to explain these penetration difficulties. Efforts to log the hole were also not productive. On the positive side, the mud program was very successful and the surveying data were reliable. A second hole of the same dimensions is in the process of being completed. Although it is only 50m away from the first hole, the conditions are quite different. This observation has significant implications with respect to the spatial variability issues that are of concern to the NRC.