The SOURCE
IGSHPA Newsletter

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Foreign Exchange

by Robert Jones

IGSHPA, long the home of GeoExchange training and research, played host recently to a different kind of exchange — an exchange of information.

A delegation of six energy technology professionals from Japan visited the United States this November to learn about the latest developments and practices in GeoExchange. They were Professor Kunihisa Katsuyama, National Institute of Resources and Environment; Mr. Yoshihiro Tanaka and Mr. Hutoshi Ooki, Engineering Advancement Association of Japan; Mr. Kisuke Yamazaki, Heat Pump and Thermal Storage Technology Center of Japan; Mr. Susumu Yasue, Obayashi Corporation; and Mr. Yasuharu Kayama, Maeda Corporation.

Following a visit to Washington, D.C., they travelled to Stillwater, Oklahoma, to learn about installation methods and to talk about the state of the industry in Japan.

Through informal seminar and question-and-answer sessions, the delegates talked about their current and planned projects, and they learned about state of the art methods being used in the US for GeoExchange installations. IGSHPA Director Dr. Jim Bose and Oklahoma State University's Dr. Marvin Smith spoke about current research as well as what works and what does not work when installing GeoExchange systems. The delegates were particularly interested in ground heat exchanger design methods and tools, drilling, and pipe joining methods.

The group then took to the field for a visit to

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Dr. Smith greets Mr. Susumu Yasue. Also pictured: Mr. Hutoshi Ooki and Professor Kunihisa Katsuyama.

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Bulletin Board

GLHEPRO V. 3.0 Ground Loop Heat Exchanger Design Software for Commercial Applications

Commercial buildings are substantially different from residential buildings in that their loads are more likely to be driven by internal heat gains such as lighting, equipment, and occupants. This wide variation in internal heat gains among different types of commercial buildings demands that the heat exchanger be sized with great care.

GLHEPRO V.3.0 operates with a standard Windows user interface that the user will find easy to understand and simple to use. Users enter information pertaining to one portion of the design process, such as the borehole configuration, or selection of circulation fluid properties, in dialog boxes. The building monthly peak cooling and heating loads are an important input to GLHEPRO.

An interface is provided to read the loads directly from several building energy analysis programs, including BLAST, Trane System Analyzer, and HVAC Load Calculations for Windows.

New features for Version 3.0 include:

- Infinitely adjustable borehole spacing.
- A large number of new borehole configurations.
- User-editable libraries for ground thermal properties, fluids, and heat pumps.
- A built-in borehole resistance calculator.
- Cut-and-paste transfer of loads between GLHEPRO and Microsoft Excel.

GLHEPRO allows the user to perform a simulation of the ground loop heat exchanger to determine peak fluid temperature entering the heat pump, as well as monthly average fluid temperatures, and the power consumed by the heat pump. Secondly, GLHEPRO can determine the required depth of the boreholes that will meet a user-specified minimum or maximum temperature entering the heat pump. The software comes on CD-ROM and runs under Window 95/98/NT.
GLHEPRO V.3.0 #32010 $525.00

GLHEPRO V.3.0 Demonstration Disk #32020 $50.00

Conference CD Available

For the first time, IGSHPA has produced a conference program on CD-ROM. The CD is both PC and Macintosh compatible. It includes the speakers' full presentations. For a quick review of the topics covered at the Sacramento conference, the abstracts are also included. A roster of attendees, web site links, and e-mail links are provided for your convenience. Copies of the CD have already been mailed to attendees.

If you were unable to join us for this meeting, you still have an opportunity to review the technical papers given by leaders in the geothermal industry. Call the IGSHPA office today to order your CD copy for only $19.95 (U.S. postage included).

New Enhanced Grout Being Developed at BNL

By Marita Allan, PhD

Thermally Conductive Cementitious Grout Solves Regulatory Concerns Regarding Geothermal Heat Pumps and Enhances Performance

Increasing the thermal conductivity of grout used to complete boreholes offers potential savings in required bore length and improved performance. Dr. Marita Allan and Dr. A.J. Philippacopoulos at Brookhaven National Laboratory (BNL) are conducting research on thermally conductive cementitious grouts for use with GHPs. BNLs research covers experimental characterization of a wide range of grout properties, numerical modeling of grout behavior under thermal loads, field demonstrations and technology transfer to industry.

Thermal conductivities up to three times higher than bentonite and neat cement grouts were achieved through appropriate selection of grout ingredients and mix design. The new BNL grout is termed Mix 111 and basically consists of cement, water, silica sand and small amounts of superplasticizer and bentonite. It is simple to mix, cost-competitive and retains thermally conductive properties in the dry state whereas conventional grouts undergo dramatic decline in conductivity. The thermal conductivity in the saturated state is 2.4 W / m.K (1.4 Btu / hr.ft.°F). When dried out the conductivity is 2.1 W / m.K (1.2 Btu / hr.ft.°F). Reductions in bore length can be calculated using design software. While control of initial costs is important, long-term performance of the grout is essential. Mix 111 grout has been designed to provide better thermal coupling throughout the service life of a GHP and thus decrease the life cycle cost.

Field tests performed by Oklahoma State University and Sandia National Laboratories in two different climates and geologies have confirmed the enhanced performance provided by BNLs Mix 111 grout. Initial results are displayed in Figures 1 and 2 and show that thermal resistance decreased by 29 and 35% compared with bentonite grout for the two sites, respectively. Further testing is in progress.

Mix 111 grout had several other advantages besides thermal conductivity that ultimately resulted in resolution of environmental regulatory concerns in New Jersey. The New Jersey Heat Pump Council (NJHPC) contacted BNL in search of an alternative to neat cement grout since permission to use this material had been denied by the New Jersey Department of Environmental Protection (NJDEP). This situation arose due to questionable bond integrity between neat cement grout and U-loop and the possibility of aquifer contamination if channeling occurred at the interfaces. As a result of the

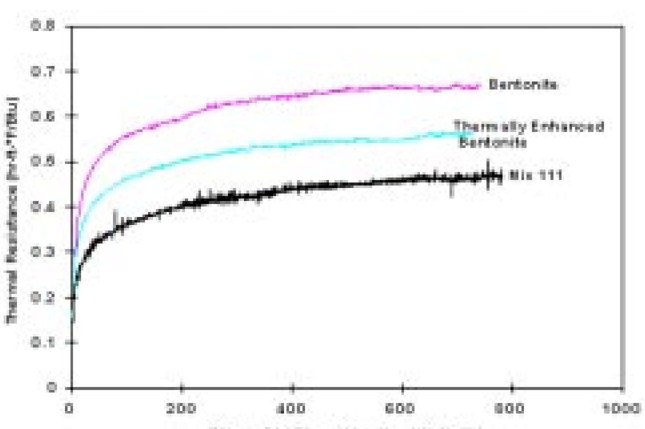

Figure 1. Results of field tests conducted by Oklahoma State University. (OSU)

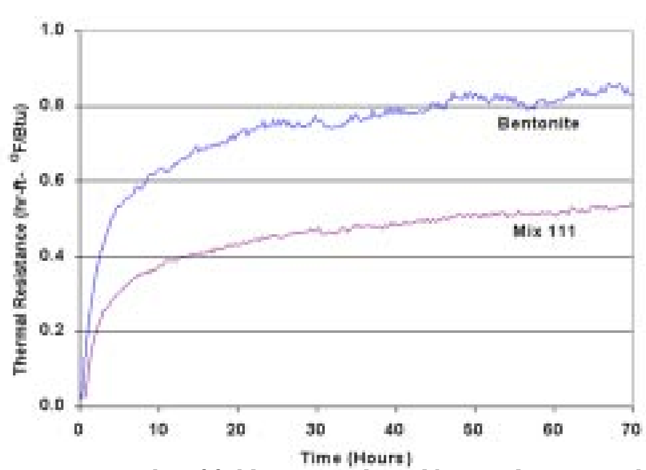

Figure 2. Results of field tests conducted by Sandia National Laboratories. (SNL)

injunction, installation of GHPs in consolidated formations in that state halted and loss of business was estimated to be $3 million in less than one year. The superior performance of Mix 111, including reduced coefficient of permeability, lower infiltration rate, shrinkage resistance and better bond strength to U-loop, convinced the NJDEP that the environmental risk would be minimized by using Mix 111 rather than neat cement. Finite element analysis of thermal stresses developed in the grouted borehole was used to alleviate concerns of cracking induced by expansion of the U-loop (see Figure 3). The grout was approved for use in both consolidated and unconsolidated formations in November 1998. The New Jersey state permit conditions now include specifications for mixing and pumping Mix 111 grout.

Mix 111 has been used on five residential projects in New Jersey to date by Geothermal Services Inc. and a test bore was grouted for a future Hilton Hotel project. Several other commercial projects in New Jersey and other states are pending. The grout has also been used in prepackaged form on the Gallatin Middle School project in Tennessee involving 130 boreholes 300 ft deep by Enlink Geoenergy Services and Ted Wynne Engineering. Project engineers were extremely satisfied with the high thermal conductivity, consistency from hole to hole of the grout conductivity, independence of performance from the depth of water table and aquifer protection afforded by Mix 111. Marked improvement in reproducible heat transfer compared with backfilling the boreholes with soil cuttings resulted from appropriate grouting techniques and materials.

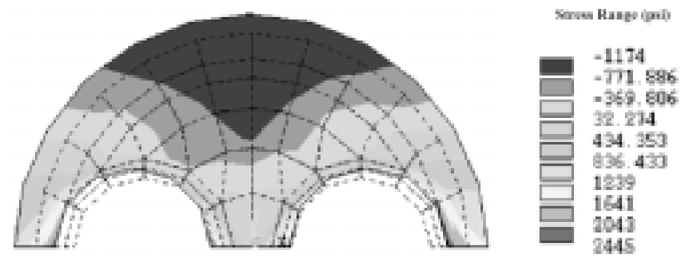

Figure 3. Finite element analysis of thermal stresses in grouted borehole operating in cooling mode. (BNL)

For further information contact Dr. Marita Allan, BNL, (516) 344 3060, allan@bnl.gov.

Energy Buyers Program Offers Opportunity

It almost goes without saying — GeoExchange and electricity go hand-in-hand. Developments in the GeoExchange industry can affect utilities, and changes in the utility industry certainly affect GeoExchange.

Deregulation is one change that holds great potential for affecting the GeoExchange industry. With deregulation, new and creative ways to lower utility bills are being developed, such as the energy buyer program offered by Affiliated Power Purchasers Inc. (APPI) of Salisbury, Maryland. This program, sponsored by the American Society of Association Executives (ASAE), reduces utility-related expenses by aggregating an organization's purchasing power with other national trade organizations. The result is lower utility costs through greater-volume purchasing.

APPI uses the leverage of its large and highly diversified buyer pool to shop for the best combination of price and reliability from competing suppliers. APPI's statewide energy pools are attractive to energy providers because APPI segments its client companies into different load profiles in order to create the homogeneous, high-volume demand that energy providers prefer. By managing the energy contracts of these buyer pools, APPI is able to do what one association alone could never do for itself.

APPI primarily markets their services to professional associations interested in offering lower utility rates as a recruitment or retention tool. APPI designed their services to be hassle-free and easily administered, including a toll-free number members can call for support. The association receives a small percentage of the savings, as does APPI, and the rest goes to the member. So in addition to helping an

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Shallow Heat Exchangers Show Promise: Part 2

Part 1 of this article (see last month's issue) gave a little background into the Shallow Heat Rejection project at Oklahoma State University. Over the past year, the five experimental systems have displayed great potential for balancing the load of a vertical bore field by rejecting excess heat in various weather conditions.

In order to demonstrate the viability of this system using real-world conditions, Dr. Smith and his colleagues have arranged with a local entrepreneur to install an experimental shallow loop system under the parking lot and walkway of a new restaurant in Stillwater, Oklahoma. The building is 12,500 square feet, and the parking area is about 35,100 square feet.

Dr. Smith and Fred Schroeder discuss installation of the header pipes.

The main loop field consists of sixty horizontal loops at 250 feet long each, and fifteen 250-foot vertical boreholes. All of these are attached via two-inch lines to a header box that feeds a four-inch supply and return line to the heat pump systems. There are seven heat pumps for the building providing a total heating and cooling capacity of fifty-five tons.

The vertical and horizontal loops together serve as the main heat exchanger for the system. Since the shallow heat exchanger system for Joseppi's restaurant is experimental in nature, the main loop field was designed to handle the entire peak cooling load of the building without assistance from the surface units. The design also incorporates special valving and Pete's ports for monitoring loop performance. Once complete, the system will have the ability to use any combination of vertical, horizontal, and surface loops desired.

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Energy Buyers, continued

association gain and retain members, the program also generates revenue for its member associations.

Not only does APPI contract low-cost power for their clients, they also offer a full range of analysis and support services. For example, at the member's request, APPI will audit utility bills to catch discrepancies that can lead to refunds.

To find out more about this unique opportunity, contact McKinley Marketing at (301) 961-0022 or visit their web site at http://www.mckinleymarketing.com.

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Initially, the surface heat exchanger design called for 70,000 feet of _-inch HDPE pipe. This pipe was to be formed into ten-inch pitch loop heat exchangers with 700 feet of pipe each. There would be 100 of these loops, with one two-inch supply and return header for every ten loops. The reverse return headers were to be routed to a covered header pit. As in the main system, there are two four-inch header pipes going to the building. The loops themselves were to be imbedded in fill sand on the sub-grade, then covered with concrete four to six inches thick to form the parking lot.

This design was presented to the owner and architect, who rejected it because it would require placing sand under the parking lot. They were concerned that the sand would migrate over time and cause the pavement to crack. However, all parties concerned agreed that laying the loops directly on the sub-grade and pouring four to six inches of concrete over them would not provide the structural integrity desired. The design concept had to be re-worked.

The new design uses _-inch U-bend loops with a spacing of five inches, a configuration designed to approximate loop performance. The U-bend loop system has about 50,000 feet of pipe. The north section loops are in an elongated spiral configuration in order to fit the desired loop length of 500 feet within the parking and drive area to be covered.

An additional change in design had to be made when the local authorities would not allow the header vault to be buried where the design placed it. Another spot has been identified to the west of the original location in the corner between parking areas. The vault has been installed.

Because of the construction schedule and the heavy vehicles working in the area above the header trenches, the system will make use of flowable fill and will be rugged enough to handle heavy traffic.

Shortly before the construction schedule calls for a section of the parking and drive area to be poured, U-bends will be placed under the forms on a sub-grade below the designated parking and drive sub-grade. The spaces between the pipes will then be filled with screenings.

After that, the drive will be poured over the new sub-grade formed by the pipes and fill. The ends of the U-bend loops exposed on the north of the forms will be kept rolled and confined, minimizing

interference with the pouring of the drive.

The pins and rebar have already been installed for the U-bend subgrade, and workers are waiting for enough dry weather to install and backfill the shallow heat exchanger loops. Meanwhile, with the horizontal and vertical loops installed, workers are continuing construction on the building.

Look for articles in upcoming issues of The Source that will chronicle the progress of this installation and the data gathered from this project.

The two header assemblies for the shallow heat exchangers will be used to control and monitor the system.

Foreign Exchange continued

the experimental shallow heat exchanger installation now in progress at the Joseppi's restaurant in Stillwater, where they were treated to a demonstration of heat fusion joining of HDPE pipe. After that, it was back to the classroom for a presentation by Mr. Phil Albertson of Ditch Witch, more questions and answers, and an instructional video on grout installation.

The next day, the group hopped onto a van to Oklahoma City for a tour of the Oklahoma State Capitol building led by Mr. Roger Power, who is part of the Capitol maintenance team. The Capitol has one of the largest GeoExchange installations in the state.

Randy Perry answers questions about pipe joining methods at the Joseppi's Restaurant site.

This hybrid system uses a combination of 370 vertical bores and a cooling tower connected to 460 ClimateMaster water-to-water heat pumps to provide 843 tons of heating and cooling for the building. The system is computer-controlled and highly configurable. At the time of the tour, the system was using the bore field for 40% of the cooling capacity, with the cooling tower providing the remaining 60%.

Following a culturally enlightening Tex-Mex lunch, the group toured the ClimateMaster manufacturing facility that produced the water-to-water heat pumps used in the State Capitol and other GeoExchange installations.

And since no trip outside your own country is complete without souvenirs, our visitors wrapped up their stay with a stop at Shepler's Western Wear.

IGSHPA would like to thank Mr. Kamal Ulaby of ClimateMaster, Mr. Roger Power with the Oklahoma State Capitol, and Mr. Phil Albertson of Ditch Witch for their hospitality and for the insight and information they provided.