RECONSTRUCTION OF A PAVEMENT GEOTHERMAL DEICING SYSTEM

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HISTORICAL BACKGROUND

In 1948, US 97 in Klamath Falls, Oregon was routed over Esplanade Street to Main Street and through the downtown area. In order to widen the bridge across the U.S. Bureau of Reclamation "A" Canal and to have the road cross under the Southern Pacific Railroad main north-south line, a new bridge and roadway were constructed at the beginning of this urban route. Because the approach and stop where this roadway intersected Alameda Ave (now Hwy 50 - Eastside Bypass) caused problems with traffic getting traction in the winter on an adverse 8% grade, a geothermal experiment in pavement de-icing was incorporated into the project.

A grid system within the pavement was connected to a nearby geothermal well using a downhole heat exchanger (DHE). The 419-foot well provided heat to a 50-50 ethylene glycol-water solution that ran through the grid system at about 50 gpm. This energy could provide a relatively snow free pavement at an outside temperature of -10°F and snowfall up to 3 inches per hour, at a heat requirement of 41 Btu/hr/ft^2. The grid was composed of 3/4-inch diameter iron pipes place 3 inches below the surface on 18-inch centers. The pipes were field wrapped in what appears to be an asphalt impregnated material to protect them from external corrosion.

The temperature drop in the grid was approximately 30 to 35°F with the supply temperature varying from 100 to 130°F and the return temperature 70 to 10°F. This was estimated to supply a maximum of 3.5 x 10^5 Btu/hr to the grid at the original artesian flow of 20 gpm, and 9.0 x 10^5 Btu/hr at the pumped rate of 50 gpm. (Lund, 1976).

REHABILITATION OF THE ODOT WELL

Over time, the well temperature drop from 143 to 98°F at the surface. In order to maintain the downhole heat exchanger temperature, a pump was added to the well which pumped and discharged approximately 10 gpm of geothermal water into the storm system to increase the heat flow. However, in 1985, the City of Klamath Falls adopted the Geothermal Resource Act which required all sewer or surface discharge from geothermal wells be eliminated. Since discharge from the well to the sewer was not longer permitted, the well was modified in 1992 by deepening it to about 1000 feet and casing it to 900 feet. The greater depth increased the temperature of the entering water. In addition, the Schedule 40 black iron pipe with malleable couplings was changed to Schedule 80 steel in the top leg of the DHE, the U-trap at the bottom constructed of Schedule 80, and the balance of the DHE fitted with Schedule 40 pipe. The DHE was extended to 900 feet to provide additional energy and to be exposed to more of the hotter water. Several section of Roscoe Moss standard louvre-type screen was installed and a lower seal added. The total cost of the modifications was about $115,000. The net result was that the "new" well produced approximately the same temperature in the grid loop as the "old" well with the pump discharging geothermal fluid to the sewer (Thurston, et al., 1995).

RECONSTRUCTION OF THE BRIDGE AND PAVEMENT SURFACE

At the time of the well rehabilitation, a study by the Bridge Section of the Oregon Department of Transportation (ODOT) recommended that the roadway and the geothermal heat distribution system be reconstructed in six years. This recommendation was based upon the age and condition of the existing portland cement concrete (PCC) surface, leaks in the heating grid, and the annual maintenance costs. The wrought iron tubing cast into the bridge deck and pavement leaked so badly from corrosion that the deicing system was approaching complete failure. Annual maintenance costs were estimated at $9,000 to $10,000 a year, increasing approximately $2,000 a year due to the deterioration (Thurston, et al., 1995).

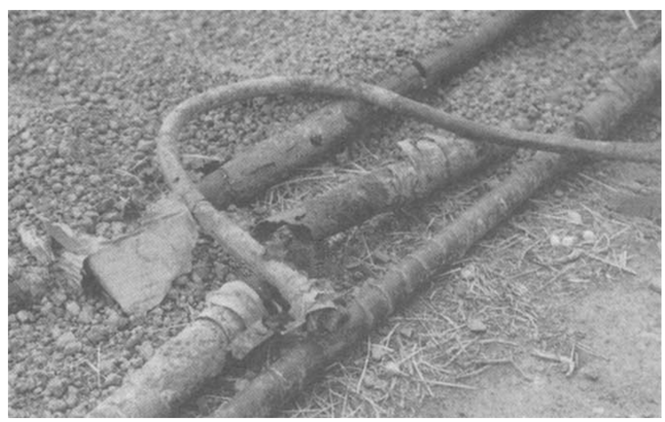

Figure 1. Original iron header pipe showing external corrosion at a break on the protective mastic covering.

In the fall of 1998, a contract was issued for the reconstruction of the bridge deck and highway pavement along with replacing the grid heating system. In addition to replacing the surface and tubing, the circulating pump was upgraded and electronic monitoring and control system added. Except for landscaping, the project was completed by early December, 1998 and is now in operation and is proving effective at keeping the bridge free of ice and snow. The deicing portion of the pavement is 442.5 feet long and 53.5 feet wide with about a 160-foot by 10-foot section removed for the piers supporting the railroad bridge and for landscaping.

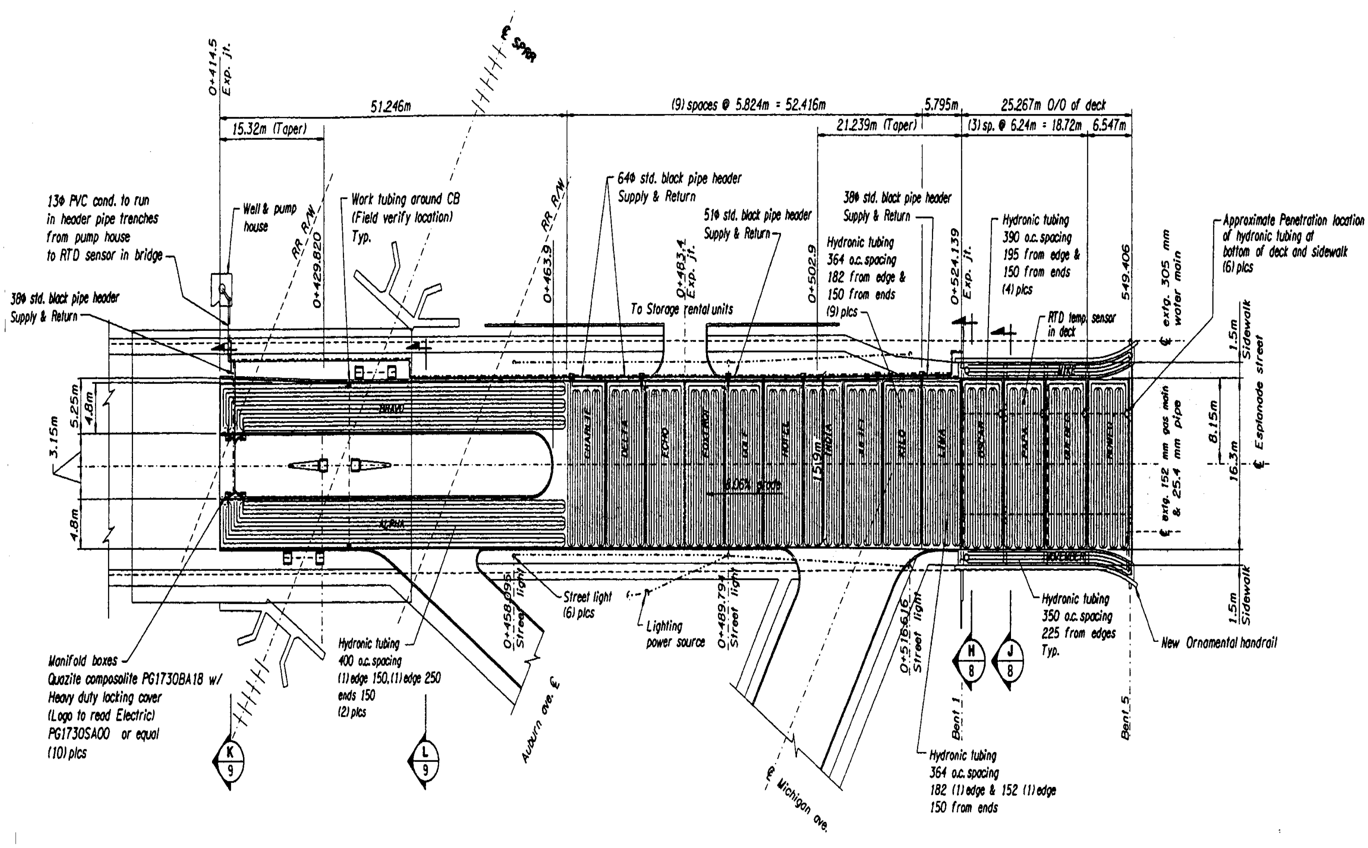

Figure 2. Overall project design.

The top portion of the bridge deck was hydro-blasted to remove six to seven inches of the PCC pavement. Holes were drilled through the deck to the header pipes hung underneath. Wirsbo 5/8-inch ID hePEX (a cross-linked polyethylene) tubing was placed in a double overlap pattern at 14-inch on center spacing across the deck on top of a mat of reinforcing steel. These tubes were then covered with a fresh layer of PCC. An RTD temperature sensor was placed in the bridge deck and an ambient sensor on an adjacent power pole.

The pavement section from the edge of the bridge deck, through the railroad underpass and to a point opposite the well building was completely removed. The subgrade was excavated to make room for about six inches of gravel base. Forms were installed and a steel mesh placed on top of the compacted subgrade within the forms. Geothermal black iron header pipes (supply and return) varying from 1.25 to 2.5 inches in diameter were placed outside the forms along the north side of the roadway. These header pipe had a brass manifold placed at about 40-foot intervals, to allow for four supply and return PEX pipes to be attached. The 3/4-inch PEX grid system pipes where then attached by wire to the reinforcing steel at 14-inch on center transverse to the roadway. Under the railroad underpass, the tubing was placed longitudinally at about 16 inches on center, due to the narrowness of the pavement at this point. Concrete (PCC) was then placed which provided for a cover over the pipes of about 3 inches. The header pipes, were insulated with about one inch of Armstrong Armflex pipe insulation and then covered with an aluminum foil vapor barrier. The manifolds were placed in concrete boxes for easy access for future maintenance. The header pipes, provided with two expansion loops and a concrete anchor, were covered with earth and then had concrete slope paving placed on top for protection.

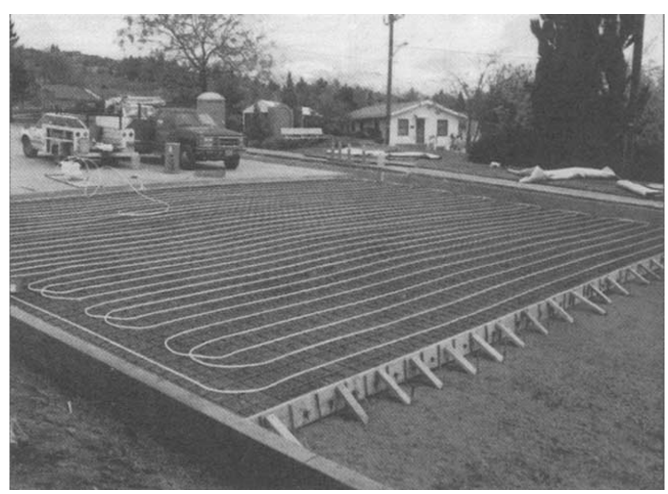

Figure 3. A four-loop section ready for concrete placement.

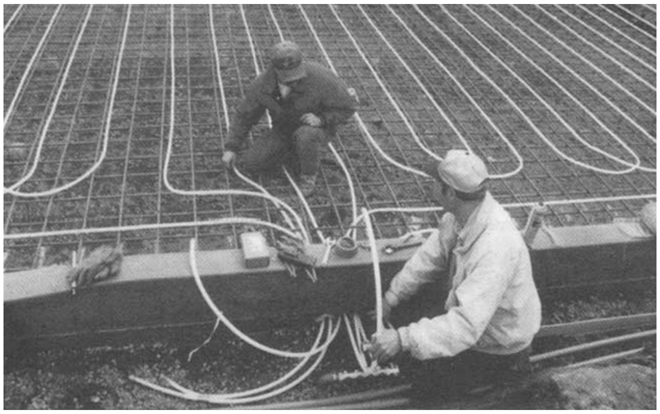

Figure 4. Attaching the loop pipes to the manifold.

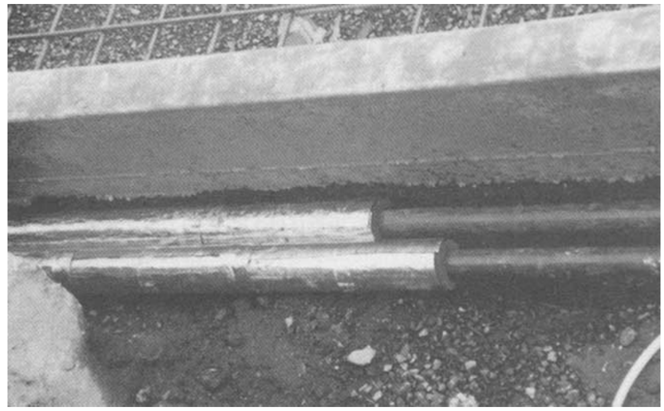

Figure 6. Iron header pipe with insulation.

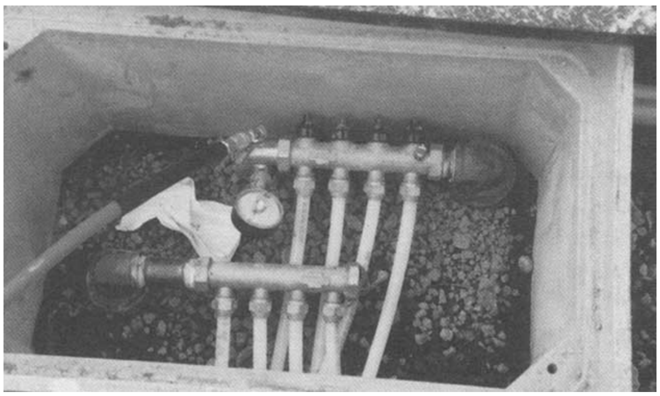

Figure 5. Details of the manifold box.

Each manifold had four supply and return pipes that made four loops for a total length of about 430 feet each. Two loops were staggered on top of each other to balance the temperature loss in each loop - i.e. the hot end of one was placed adjacent to the cold end of the other, since there could be as much as 35°F temperature drop in each loop. The PEX grid pipe is designed for 180°F at 100 psi and 200°F at 80 psi according to ASTM specification F 876. The pipes are filled with an ethylene glycol mixture through an air vent at the high point on the bridge deck.

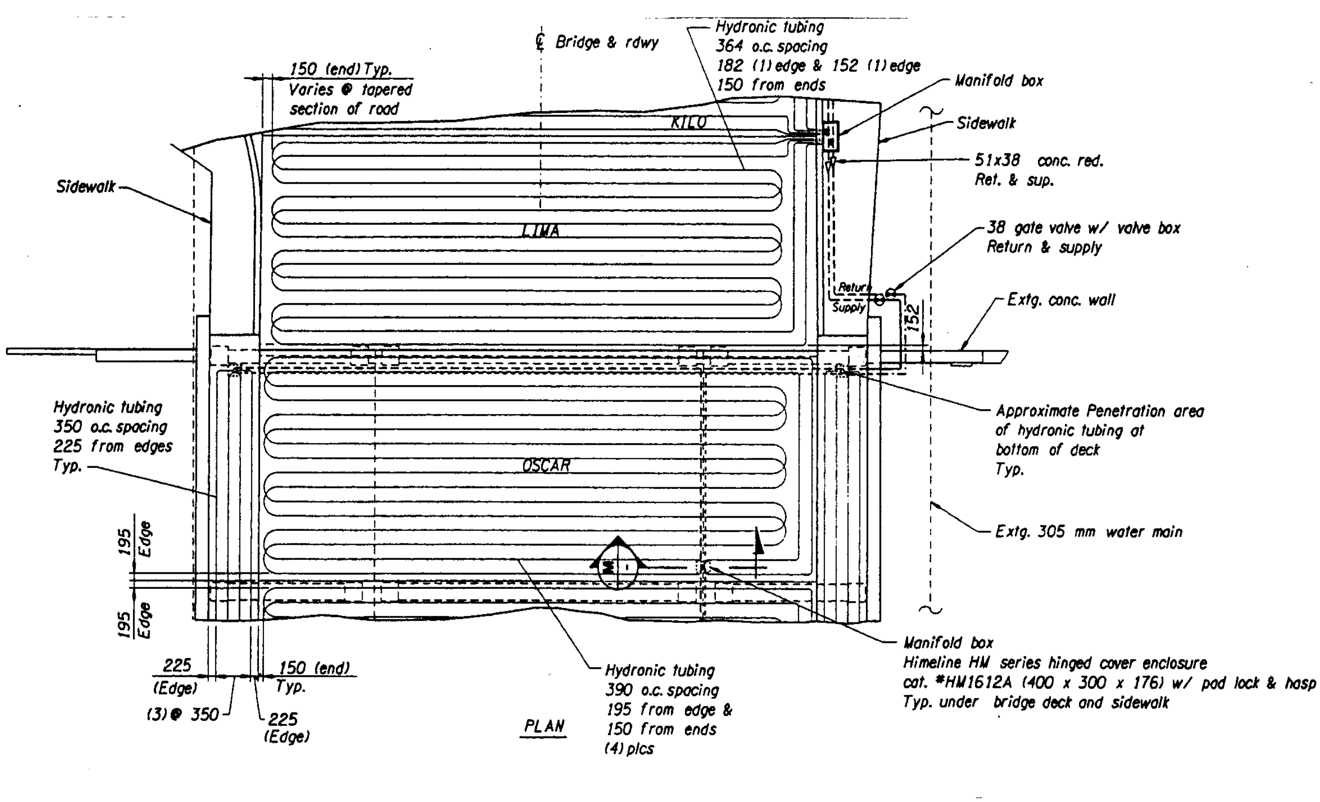

Figure 7. Details of a four-loop section with manifold.

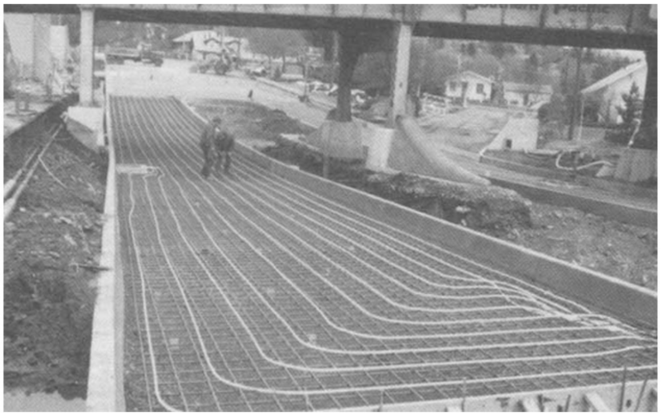

Figure 8. Longitudinal loops under the railroad bridge.

The entire cost of the reconstruction project was approximately $430,000 and the estimated annual maintenance cost will be $500 and the operating cost (for the circulating pump) $3,000. The heated bridge deck covers 22,000 square feet and is designed for a heat output of 50 Btu/sq.ft/hr. This is suppose to keep the deck clear during heavy snowfall down to -10°F. During the first days of operation after a snowfall, the DHE supply temperature was 100°F and the return temperature 76°F for a delta-T of 24°F. Once the ground and concrete temperatures reach equilibrium, it is expected that the supply and return temperatures will increase by as much as 30°F. The renovated deicing system appears to be operating effectively, based on substantial snowfalls in January and February, 1999.

Figure 9. End of project and pump house in background.

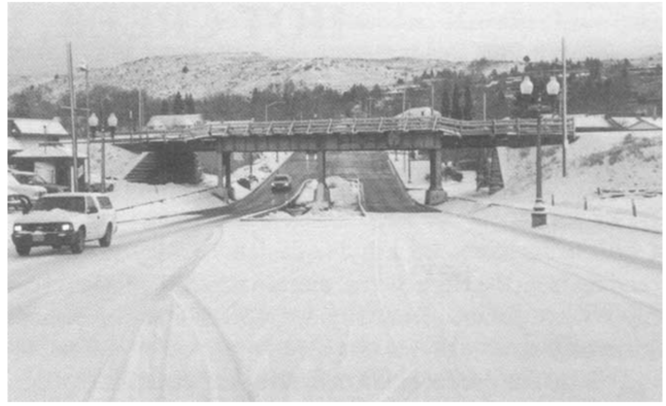

Figure 10. January snowfall looking east

Figure 11. January snowfall looking up the 8% grade to the traffic signal and bridge deck.

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REFERENCES

Lund, John W., 1976. "Geothermal De-Icing of a Highway Pavement." Geo-Heat Center Quarterly Bulletin, January, Vol. 1, No. 3, pp. 7-9.

Lund, John W., 1976. "Geothermal De-Iceing of a Pavement - Part II." Geo-Heat Center Quarterly Bulletin, April, Vol. 1, No. 4, p. 7.

Thurston, Rachel, E.; Culver, Gene and John W. Lund, 1995. "Pavement Snow Melting in Klamath Falls - Rehabilitation of the ODOT Well." Geo-Heat Center Quarterly Bulletin, February, Vol. 16, No. 2, pp. 23-28.