Test Results: Evaluation of The Humboldt GeoGauge™ On Soil-Fly Ash-Cement Mixtures

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Patent Pending

Two days of testing were conducted during 14 and 15 March with the GeoGauge for the Maryland State Highway Administration (SHA) on US 113 re-construction near Berlin, MD. This testing was a precursor to the development of a method to evaluate if not control the quality of soil-fly ash-cement mixtures and the installation of these mixtures as a highway base. In attendance were representatives of the SHA, the contractors and Johns Hopkins University. Bob Kochen, Director of Central & District Laboratory & Field Measurements, directed the testing. SHA and Humboldt personnel made the measurements.

The objectives of the test were to 1) confirm the relationship between the modulus derived from FWD and GeoGauge measurements; and, 2) begin to evaluate the variability in the strength of pavement, soil-fly ash-cement base and soil subgrade so as to understand the limitations of the construction process and materials.

Six locations were tested per the 1/14/00 plan developed for the SHA by Humboldt. These locations represented silty sand subgrade, several months old soil-fly ash-cement base (two 8" lifts), one lift of base that was 5 days old, one lift of base that was a few hours old, ~ 4" of Superpave 19mm asphalt over base & subgrade and ~ 4" of Superpave 19mm asphalt over subgrade only (ramp). The tests on the few hours old base were repeated after 24 hours to gauge its rate of cure. Thirty (30) GeoGauge measurements and 10 FWD measurements were made at each location. FWD measurements were made with a 13", serrated, rubber coated plate. FWD stress on the surface was 60 psi and typical deflection was 0.060". FWD measurements left virtually no depressions on the subgrade or base! Nuclear density measurements were made on the few hours old base, the subgrade and the several months old base. The stiffness measurements are summarized in Table 1.

GeoGauge measurements on the subgrade were relatively uniform. The mean stiffness was 12.2 MN/m with a standard deviation of 3.4 and a coefficient of variation of 27.9%. Measurements at any location were repeatable within a few percent of the mean. Additional measurements outlying the planned pattern revealed gross non-uniformities in compaction.

The GeoGauge measurements on the several month old base revealed a problem. Measurements varied from 3 to 48 MN/m! The mean stiffness was 27.7 MN/m with a standard deviation of 12.0 and a coefficient of variation of 43.3%. Over more than 70% of the locations the top 0.5" to 1" of base had delaminated. Tapping on the delaminated areas produced a hollow sound. The delaminated layers were relatively easy to chip away with a shovel or pick. This discovery caused concern among the SHA personnel. They knew that such delamination of the base would locally weaken pavement support and cause premature pavement failures. The SHA thought that an uncontrolled process was the cause. The lack of maintaining a moist surface, poor sequencing of construction operations or insufficient preparation of the surface after the winter shut-down were the most likely causes. Again, GeoGauge measurements at any location repeated within a few percent of the mean. Measurements on all base material required the periodic use of moist sand to seat the gauge, as the surface was often hard and smooth.

The GeoGauge measurements on the 5-day old base revealed no delaminations and relative uniformity. The mean stiffness was 17.4 MN/m with a standard deviation of 3.7 and a coefficient of variation of 21.3%. This location had been watered regularly since its installation.

The GeoGauge measurements on the few hours old base revealed no delaminations and excellent uniformity. The mean stiffness was 10.4 MN/m with a standard deviation of 1.7 and a coefficient of variation of 16.3%. This location had been watered regularly since its installation. After 24 hours, the mean stiffness was 14.9 MN/m with a standard deviation of 4.5 and a coefficient of variation of 30.2%. Stiffness increased an average of 43% in 24 hours. The increase in standard deviation was apparently due to locations that were not curing (setting up) and poor subgrade compaction in the area of pipe related back fills. SHA personnel were impressed with the ability of the GeoGauge to detect these structural nonuniformities. Again, GeoGauge measurements at any location repeated within a few percent of the mean.

The GeoGauge measurements on the Superpave 19mm asphalt over base & subgrade were very uniform. The mean stiffness was 64.4 MN/m with a standard deviation of 7.6 and a coefficient of variation of 11.8%. Seating the gauge on this surface was a little difficult because of the high stiffness of the material. Seating with moist sand was a necessity for every measurement. About 10 minutes was required to refine the seating technique to assure consistent and repeatable measurements. GeoGauge measurements at any location still repeated within a few percent of the mean.

The GeoGauge measurements on the Superpave 19mm asphalt over subgrade only (full depth pavement) were very uniform, except in an area of a buried pipe. Excluding the area of the pipe crossing, the mean stiffness was 28.7 MN/m with a standard deviation of 4.3 and a coefficient of variation of 15.0%. Seating the gauge on this surface was easy, but required moist sand in every location. In the area of the pipe, stiffness was as low as 6.4 MN/m! Again, the SHA was impressed with the diagnostic value of the GeoGauge.

It was interesting to note that the density of the base material did not change, regardless of its age (several hours or several months).

According to Bob Kochen, the second objective of the test plan was achieved. If only for the diagnostic value, he thought the GeoGauge would be of value to the SHA. He said that Johns Hopkins would be tasked with developing the specifications and test methods needed to evaluate if not control the quality of soil-fly ash-cement mixtures and the installation of these mixtures as a highway base. Hopkins' field methods would center on the GeoGauge and are hoped to be available for the next construction season. Hopkins' work will begin with correlating the unconfined compressive strength of the base material with its modulus. There is significant precedent for this with other soil-cement mixtures. He asked for my help in guiding if not assisting Hopkin

Table 1
Summary: Stiffness Test Results

Location (Station)	Material	Date	~ Time	Mean Stiffness (MN/m)	Standard Deviation (MN/m)	Coefficient of Variation (%)	Mean Resilient Modulus MPa	kpsi
Spur A	Subgrade A24, Silty Sand	3/14	8:30 AM	12.2	3.4	27.9	105.8	15.3
2008+75	Base Several Months Old	3/14	11:15AM	27.7	12.0	43.3	134.4	19.5
2043+25	Base 5 Day Old, 1st Lift	3/14	3:45 PM	17.4	3.7	21.3	150.9	21.9
2041+00	Base < 24 hr. Old	3/14	2:10 PM	10.4	1.7	16.3	90.2	13.1
2058+00	Pavement Superpave 19mm ~ 4" Thick	3/15	9:00 AM	64.4	7.6	11.8	558.6	81.0
2041+00	Base ~ 1 Day Old	3/15	2:30 PM	14.9	4.5	30.2	129.2	18.7
2+25 South Bound Ramp to 90E	Full Depth Pavement Superpave 19mm ~ 4" Thick	3/15	1:15 PM	28.7	4.3	15.0	249.0	36.1

Note:

The current thinking at the FHWA, Office of Pavement Design is that if highways could be constructed to the design parameters of structural stiffness and material modulus, then typical tolerances of $\pm$ 25% on these parameters would provide for highways of acceptable life.

The value of Poisson's Ratio used to determine the Resilient Modulus is 0.35.