**Update on CC9 GPR Data Analysis**

***Cart-Mounted System (900 MHz Ground-Coupled Antenna)***

1. Re-visit of Ground-Truth Elevation

* On CC9 as-built, the depth of instrumentation (e.g., PC) was taken from the pavement surface to the middle of the sensor.
* The thickness of sensor was measured at 1-inch for PC and 0.25-inch for LSG/TSG.
* Exact depth of PC (*h*) = as-built Z – 0.5xPC thickness, and the depth of LSG/TSG reported on as-built was correct.

1. Re-analysis of GPR Ground-Truth Data

* During the baseline survey, additional GPR testing was conducted on the instrumented locations (i.e., on PC and LSG/TSG) that provided the ‘Ground-Truth’ data file(s), which were re-visited for advanced analysis to determine the signal velocity in asphalt layer.
* The steps in this analysis were: (a) Apply filter (High Pass: 600 MHz and Low Pass: 2500 MHz for test items ‘Fatigue Model’ through ‘Cement-Treated Permeable Base’; and High Pass: 1500 MHz and Low Pass: 2500 for ‘Overload’ test item) to reduce noise level, enhance resolution in case of thin asphalt layer, and track the ‘Ground-Truth’ as well as layer interfaces; (b) Apply ‘Migration’ technique to locate the apex of the hyperbolic reflection that corresponds to the exact location of ‘Ground-Truth’; (c) Track the pavement surface and exact location of ‘Ground-Truth’ to determine the 2-way travel time (*t*) in asphalt layer, i.e., P-401MR + P-403MR; and (d) Determine the signal velocity: , where depth of ‘Ground-Truth’ as obtained in Step: A.

1. Prediction of Layer Thickness

* The previous CC9 baseline GPR data analysis showed close match between as-built and predicted asphalt thickness, i.e., P-401MR + P-403MR, for test items LFS-1N and -2N, whereas the remaining test items showed asphalt thickness difference at varying degree. Therefore, GPR data from LFS-1N and -2N were excluded from the scope of this re-analysis.
* GPR data files for the re-analysis were: (a) Sta: 0+15 (LFS-1S); (b) Sta: 0+75 (LFS-2S); (c) Sta: 1+35 (LFC-3N and -3S); (d) Sta: 1+95 (LFC-4N and -4S); and (e) Sta: 2+55 (LFC-5N and -5S). Note that no GPR data (image) re-processing was needed and the 2-way travel time in asphalt layer was obtained from the baseline processing.
* Predicted asphalt layer thickness incorporating the revised signal velocities are summarized in Table 1. Prediction improvement was evident at some degree, but conclusive observations will depend on the completion of the remaining stations under the CC9 test items (i.e., Sta. 0+30, 0+90, 1+50, 2+10, and 2+70).

***Van-Mounted System (2 GHz Air-Coupled Antenna)***

A metal plate re-calibration test was conducted at higher sampling rate such as 512 and 1024 samples/scan, which will be integrated to the analysis of 2 GHz air-coupled antenna data for thickness prediction. Advanced analysis including filtering may be required.

Table 1. Summary of Layer Thickness (900 MHz Ground-Coupled Antenna)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Test item | Station | Layer | Signal Velocity, in/ns | As-built Thickness, inch | Ground-Truth (PC and/or LSG/TSG), inch | Predicted Thickness, inch | | (%) Difference in Thickness (Re-Analysis vs As-built) | |
| Re-Analysis | Baseline | Re-Analysis | Baseline |
| LFS-1S | 0+15 | P-401MR+P403MR | 4.80 | 8.9 | 9 | 8.9 | 9.2 | 0.0 | 3.4 |
| LFS-2S | 0+76 | P-401MR+P403MR | 4.81 | 8.7 | 9 | 8.7 | 9.1 | 0.0 | 4.6 |
| LFC-3N | 1+35 | P-401MR | 4.83 | 5.1 | 5 | 5.0 | 6.5 | 2.0 | 27.5 |
| LFC-3S | 1+35 | P-401MR | 4.83 | 5.2 | 5 | 5.0 | 6.6 | 3.8 | 26.9 |
| LFC-4N | 1+95 | P-401MR | 4.63 | 5.1 | 5 | 4.8 | 6.4 | 5.9 | 25.5 |
| LFC-4S | 1+95 | P-401MR | 4.63 | 5.2 | 5 | 5.1 | 6.9 | 1.9 | 32.7 |
| LFC-5N | 2+55 | P-401MR | 3.82 | 3.3 | 3 | 3.1 | 5 | 6.1 | 51.5 |
| LFC-5S | 2+55 | P-401MR | 3.82 | 3.3 | 3 | 3.1 | 5.1 | 6.1 | 54.5 |