Evaluation of Light Weight Deflectometer (LWD) for Characterization of Subgrade Soil Modulus

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Introduction

- Nondestructive tests (NDT) are widely used for structural evaluation and characterization of pavement layers' moduli for flexible and rigid pavements.
- Falling weight deflectometer (FWD) is a NDT, commonly used for pavement structural evaluation. However, FWD equipment is costly, thereby its availability is limited across the province.
- Light weight deflectometer (LWD) is an emerging NDT, which functions based on similar principles as FWD. LWD has several advantages over FWD, including lower initial cost, lower operational time and cost and a simplified testing procedure.
- This study will evaluate the applicability of LWD for characterization of subgrade soil modulus.

Field test program

- Integrated Road Research Facility (IRRF) is a 500-m access road to Edmonton Waste Management Center (EWMC), located on the eastern edge of Edmonton, Alberta.
- IRRF in one section (Stationing 130+80 to 130+140) is built on a fill embankment made of Tire Derived Aggregate (TDA) (Figure 1). Other sections of the road (130+40 to 130+80 and 130+140 to 130+250) are built on normal existing ground.
- FWD and LWD tests were performed on the test road after the construction of the subgrade.

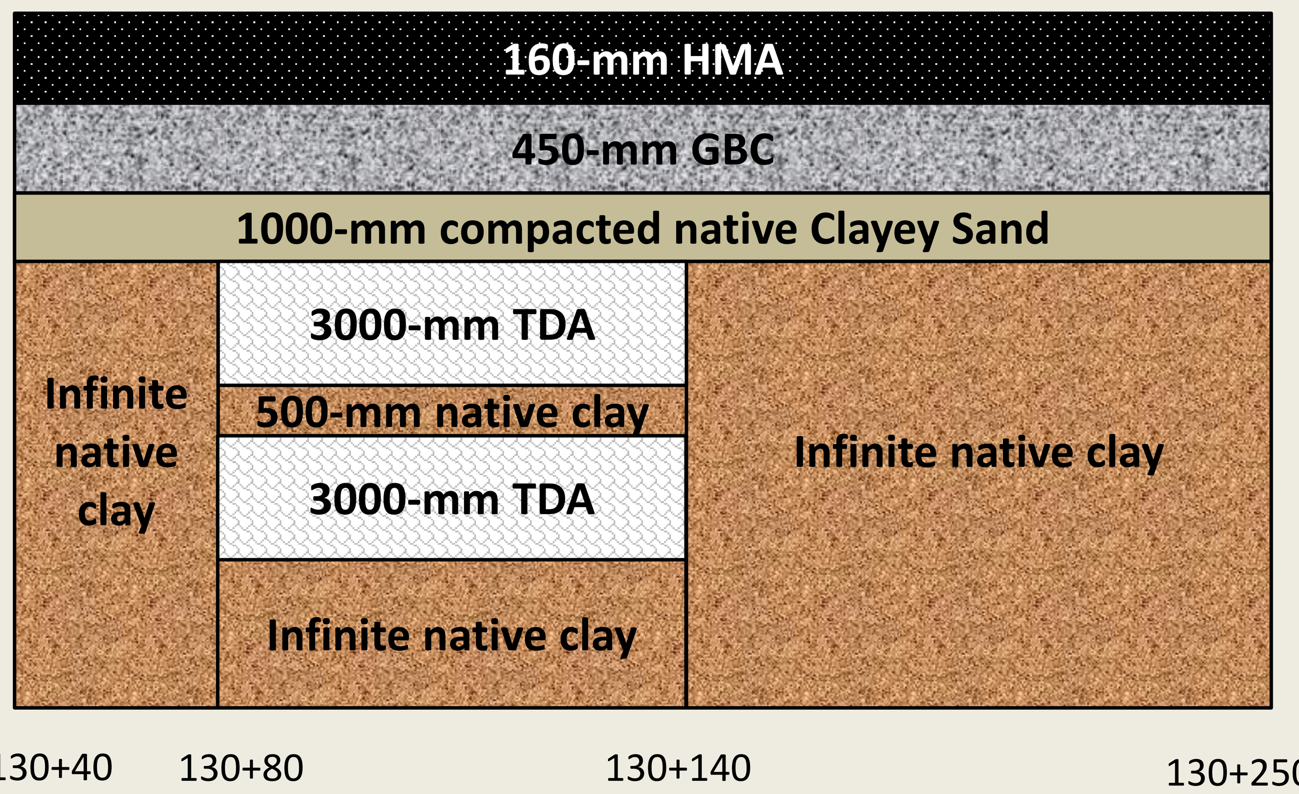

Figure 1. Schematic cross section of the test road.

Research approach

- FWD and LWD tests were conducted on July 11th, 2012 from Stationing 130+35 to 130+255 on top of the 1-m soil cover in the northbound lane.
- The drops were performed at 5-m intervals along the TDA fill section and at 10-m intervals at sections with normal subgrade along both the outer wheelpath and the centerline.
- The Dynatest FWD device was used to apply four drops resulting in target load magnitudes of 5.8, 8.1, 10.0 and 12.4 kN on a 300-mm diameter load plate.
- LWD tests were also carried out at the same locations immediately after FWD applications using a ZFG 3.0 LWD.

LWD device and backcalculation

- Zorn® ZFG 3.0 utilizes a 10-kg falling weight, which is dropped on a 30-cm diameter load plate from a 70-cm height.
- 15-kg loading device as well as 5-kg load plate allows for portability of LWD device.
- Each drop produces a 7.07 kN dynamic load with a 18 ms duration on top of the material under testing.

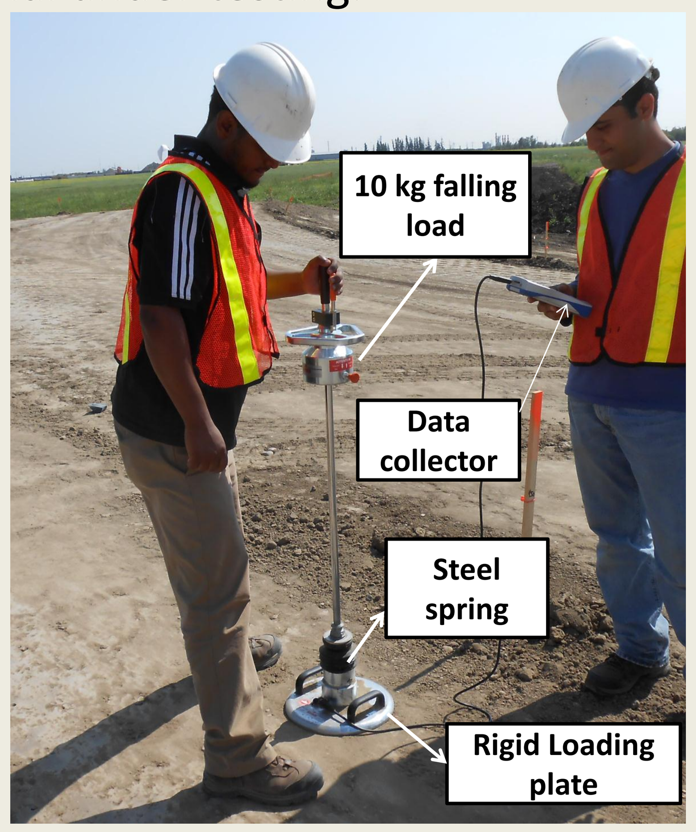

Figure 2. Different components of the LWD used in the study.

- LWD test at each location starts with a minimum of three seating drops. The test continues with three consecutive test runs (load drops) at 100 Kpa stress, where the resulting deflections are recorded.
- Both LWD and FWD subgrade resilient moduli (Mr) were backcalculated based on elastic half-space (Boussinesq's) theory using a rigid plate (equation shown below).

$$E = \frac{\pi(1-v^2)a\,\sigma_0}{2d_1}$$

- $v = Subgrade\ poisson\ ratio (defined\ as$
- $0.35\ for\ the\ subgrade\ soil),$
- $a = Plate\ radius,$
- $\sigma_0 = Applied\ stress,$
- $d_1 = Deflection\ under\ plate\ center.$

Analysis of results

- Subgrade Mr along the outer wheelpath is relatively consistent , with average values ranging between 47-60 Mpa for Drops 1 to 4. An abrupt increase to 86 Mpa at Stationing +145 is seen. This point is the end of the fill section and the start of the normal existing ground. Also, the sudden increase at 130+220 is perhaps due to change in the natural soil profile.
- Average subgrade Mr of 24 Mpa was found for the three LWD drops, showing consistent LWD Mr along the road.

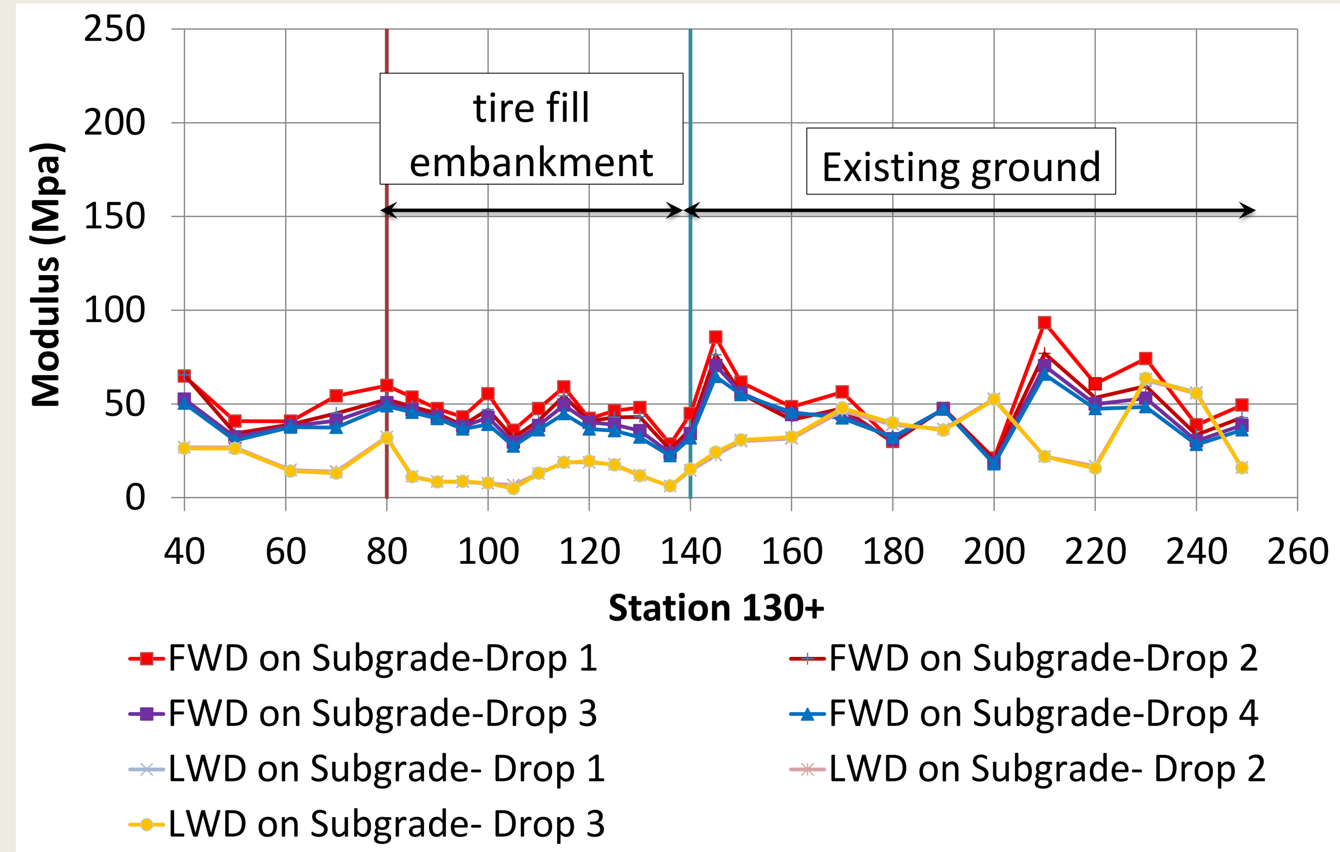

Figure 3. Backcalculated FWD and LWD subgrade Mr along the outer wheelpath.

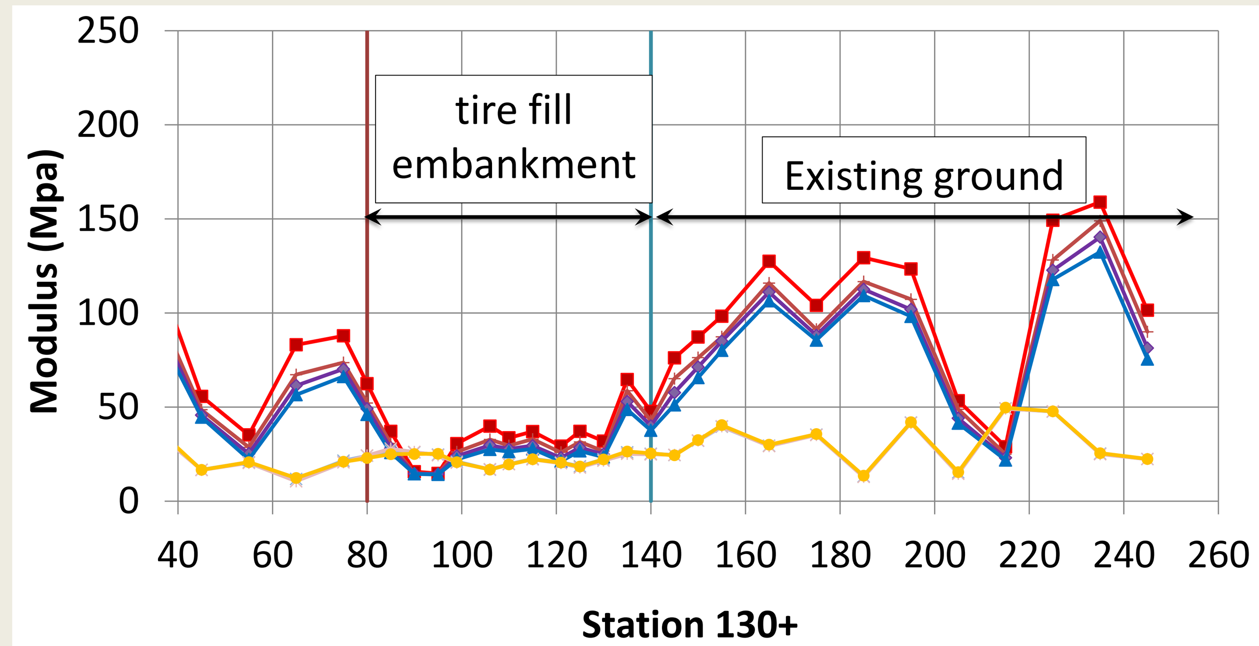

Figure 4. Backcalculated FWD and LWD subgrade Mr along the centerline.

- Average subgrade Mr along the centerline ranges between 54-70 Mpa for Drops 1 to 4. This range is higher than those obtained for the tests performed in the outer wheelpath. Mr drops at the edge of the tire fill embankment (Stationing +80) and remains as low as 32 Mpa over the fill section.
- Average LWD modulus of 30 Mpa was obtained over the entire centerline.
- LWD modulus shows a drop over the tire fill sections with respect to the normal sections.

- A Correlation between the backcalculated subgrade Mr using FWD and LWD tests on the sections with normal subgrade soil was performed along the outer wheelpath.
- The correlation established for the tests performed along the outer wheelpath showed FWD modulus was 1.16 times higher than LWD modulus.
- Difference between loading rate and equipment's weights, including the loading plate, have been identified as the sources of variability between FWD and LWD backcalculated subgrade Mr (Fleming et al., 2007)

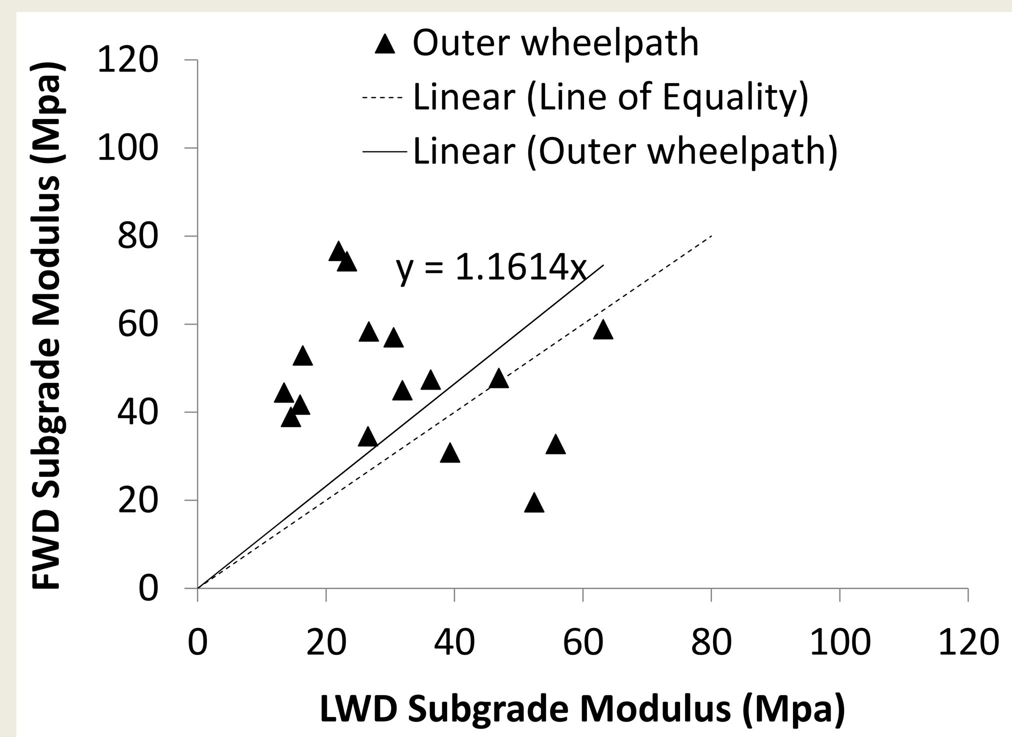

Figure 5. Correlation between LWD and FWD modulus.

Conclusions

- FWD tests performed on the subgrade can be very sensitive to many variables along the road, Including change in the terrain slope, fill versus normal ground or cut and moist versus dry zones.
- The FWD test results showed that special care needs to be taken during compaction at transition zones between cut and fill sections and also where the ground topography varies.
- A linear correlation was established between the backcalculated subgrade Mr from LWD and FWD tests for the sections on the normal ground along the outer wheelpath.
- More testing is planned to study the correlation between LWD and FWD modulus.

Acknowledgement

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Reference: Fleming, P. R., Frost, M. W., & Lambert, J. P. " A review of LWD for routine insitu assessment of pavement material stiffness", 2007 TRB annual meeting CD-ROM, Washington, D.C.