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Star-Shaped Testing with a Falling Weight Deflectometer

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Motivation & Methodology

Introduction

Tests with Falling Weight Deflectometers (FWD) are used for the evaluation of the state of pavement roads and of the subgrade beneath them. Geophones measure deflections along the driving direction. These measured deflections are translated into effective moduli of the subgrade assuming symmetry with respect to the axis of the falling weight.

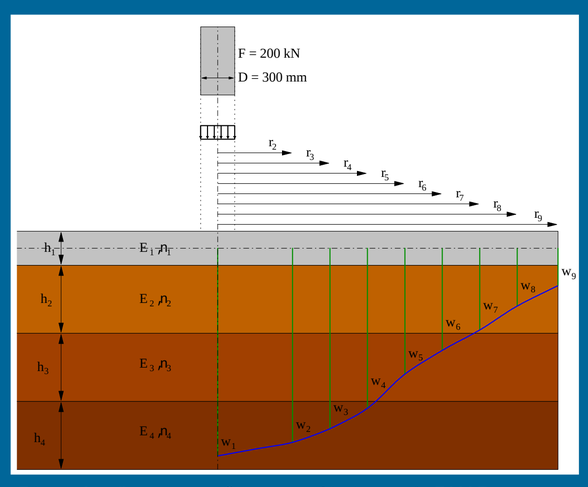

Fig. 1. Setup of a traditional FWD test. Taken from [1].

New Star-Shaped FWD Measurements

Star-shaped tests were carried out in eight radial directions described by a local cardinal system. Nine geophones captured the deflection history along each direction. Three tests were performed along each direction in order to be able to assess the quality of test repeatability. After the eight directions were investigated, another set of three tests were performed in the N direction.

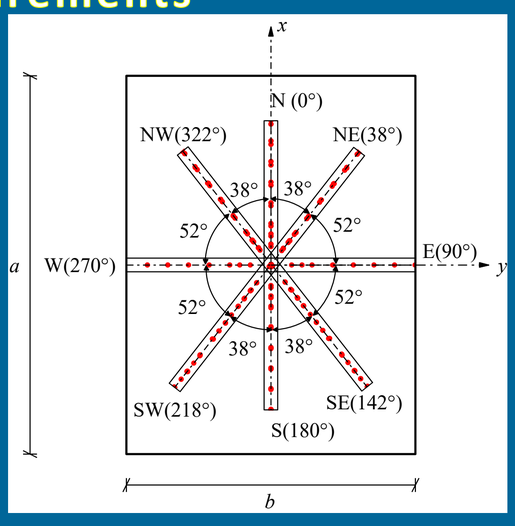

Fig. 2. Novel star-shaped FWD and local cardinal system. Taken from [1].

Experimental Data

Experimental Data of the New Plate #33.360

Test location: Kilometer 33.360 of the highway “A1”, near the junction “Steinhäusl” in Lower Austria, Austria. Since the plate was only a few weeks old, so that it represented ideal conditions for the evaluation of the state of the plate and the subgrade beneath it.

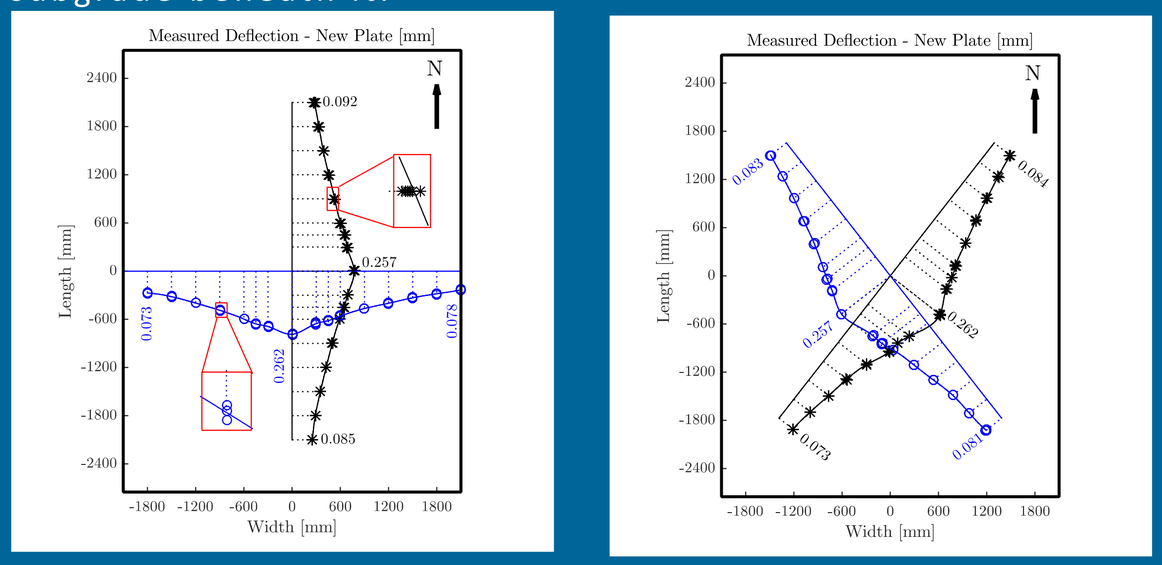

Fig. 3. Results from star-shaped FWD testing on the new plate. Taken from [1].

Experimental Data of the Old Plate #33.354

Test location: Kilometer 33.354 of the highway “A1”, near the junction “Steinhäusl” in Lower Austria, Austria. The plate was 22 years old at the time of testing and was scheduled to be repaired soon. Traffic had passed mainly along the Eastern edge of the plate.

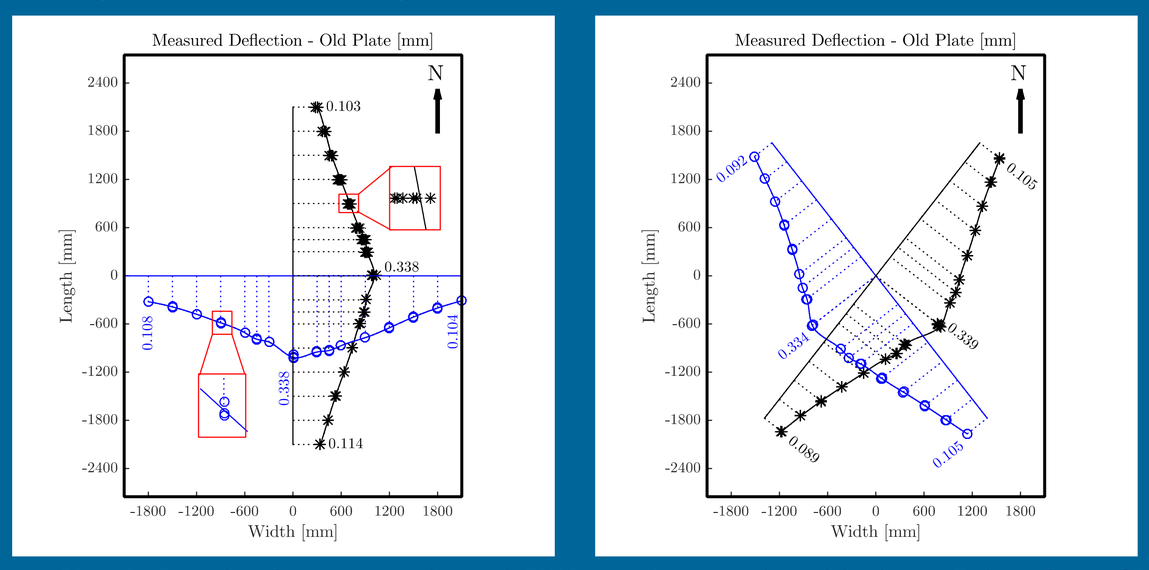

Fig. 4. Results from star-shaped FWD testing on the old plate. Taken from [1].

Results & Conclusions

Asymmetries of the structural behavior

Development of a suitable index, $A_{d,\delta}$, for the quantification of the asymmetry of the structural behavior of the plate in the d and δ directions, as

$$A_{d,\delta} = \sqrt{\frac{1}{2.1\ m}\int_{r=0}^{2.1\ m}\left[\frac{w_d(r)}{w_d(0)} - \frac{w_\delta(r)}{w_\delta(0)}\right]^2 dr}\ ,$$

where w_d refers to the spline in d direction, as presented by the local cardinal system from Fig. 2, and $r \geq 0$ denotes the radial direction.

- If the dowels and tie bars had an influence in the structural behavior of the plate, then deflections could be expected to be symmetric with respect to the E-W axis.
- If the dowels did not have an influence in the structural behavior of the plate, its deflections are expected to be doubly symmetrical with respect to the E-W as well as the N-S axis.

New Plate	Old Plate
$A_{N,S}$ = 3.98%	$A_{N,S}$ = 4.94%%
$A_{NE,SE}$ = 3.09%	$A_{NE,SE}$ = 4.98%%
$A_{SW,NW}$ = 2.79%	$A_{SW,NW}$ = 5.05%
mean value = 3.29%	**mean value = 4.99%**
$A_{E,W}$ = 3.49%	$A_{E,W}$ = 12.00%
$A_{NE,NW}$ = 2.55%	$A_{NE,NW}$ = 7.47%
$A_{SW,SE}$ = 2.43%	$A_{SW,SE}$ = 7.34%
$A_{NE,SW}$ = 4.44%	$A_{NE,SW}$ = 3.01%
$A_{NW,SE}$ = 1.24%	$A_{NW,SE}$ = 12.19%
mean value = 2.83%	**mean value = 8.40%**

Conclusions

- The new plate behaves in a virtually double symmetric fashion: structural analysis may be performed assuming free edge boundary conditions.
- The old plate behaved in a significantly asymmetric fashion due to long-term service degradation. If the plate had not already been scheduled for replacement, the asymmetry indicators evaluated would suggest such a necessity.
- Star-shaped FWD tests allow for a more detailed assessment of the state of a plate and its directional behavior.

Acknowledgments

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Reference

[1] Díaz Flores, R., Aminbaghai, M., Eberhardsteiner, L., Blab, R., Pichler, B. (2021). Multi-Directional Falling Weight Deflectometer (FWD) Testing and Quantification of the Effective Modulus of Subgrade Reaction for Concrete Roads. *Submitted to International Journal of Pavement Engineering.*