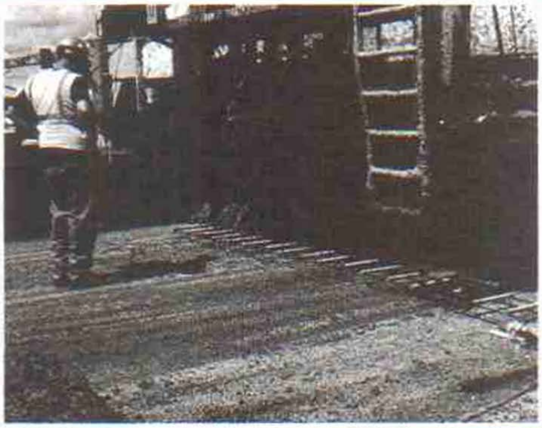
NATIONAL CONCRETE CONSORTIUM

Guide to Dowel Load Transfer Systems for Jointed Concrete Roadway Pavements

National Concrete Pavement Technology Center

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Appendix C - Use of FWD Measurements in Measuring Dowel Effectiveness

The most common way to evaluate joint load transfer efficiency is through the use of a Falling Weight Deflectometer (FWD), which simulates the passage of vehicle loads on the pavement. The FWD load plate is placed at the point of interest (in this case, directly over the critical dowel, which is usually the one closest to the pavement edge, on one side of the joint), operating the FWD to simulate the passage of the design wheel load (typically 9,000 lb for highway pavements), and measuring the resulting deflections on each side of the pavement joint, as shown in Figure C1.

Deflection-based load transfer efficiency (LTE) is most commonly computed as:

$$LTE(\%) = 100\,\frac{\Delta_{UL}}{\Delta_L}$$

where Δ_{UL} is the deflection of the unloaded side of the joint and Δ_L is the deflection of the loaded side of the joint. In theory, LTE values can range from 0 to 100 (where 0 represents complete isolation of the two sides of the joint and 100 represents equal movements on both sides of the joint); however, variability in test measurements sometimes results in LTE values that are slightly greater than 100. Slab bending correction factors are sometimes applied to the LTE equation above to account for the fact that the measured deflections would not be expected to be exactly equal, even if there were no joint present, because the sensor in the load plate should always be at the deepest point in the deflection basin.

Deflection values (and, therefore, computed load transfer values) are affected by many factors, including pavement structural parameters (such as slab dimensions, foundation support, joint opening, and dowel design) and environ tal conditions (such as average slab temperature and perature and moisture gradients in the slab), which can v hourly, daily, and seasonally. Therefore, deflection testing and load transfer evaluation should be performed under conditions that result in a realistic assessment of load tr fer capability. It is generally accepted that concrete pavement joint load transfer testing should be conducted only when the slab temperature is 70°F or less to avoid conditi where thermal expansion results in joint closure and unu ally high LTE values. Similarly, testing should not be done during times when the slab is significantly curled upward (especially on stabilized foundation layers), because measured deflections may be unusually high at these times.

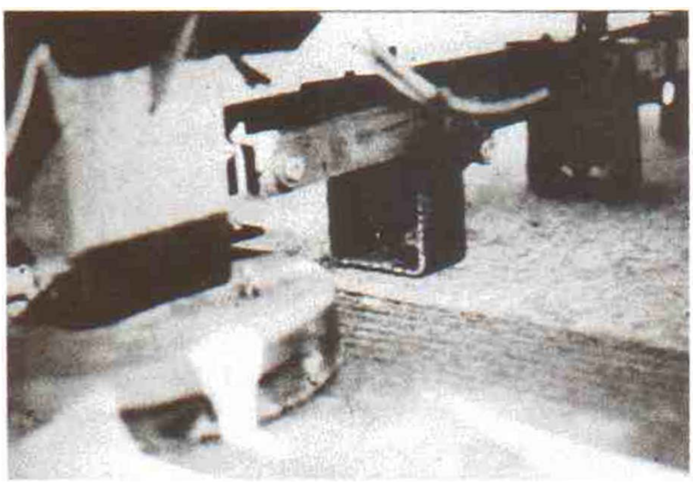

Figure C1 Placement of FWD load plate and first sensor on opposite sides of a transverse joint for the evaluation of LTE (photo source: NHI 1993

LTE has often been used as the sole measure of the effecti ness of the joint load transfer system and of the need for restoration activities, such as load transfer restoration (do bar retrofit), undersealing, and joint replacement (patching). Typical "action" thresholds range from 50 to 70 percent LTE. Unfortunately, LTE alone does not tell the whole story.

Consider the case of a well-supported pavement structure, where FWD testing results in only 5 mils of deflection under the load and 2 mils on the unloaded side of the joint. The resulting LTE is 100*2/5 = 40%, which would be considered a failure using the LTE criteria described previously, even though the deflections are very small, so load-related slab stresses should also be small and the difference in defl across the joint is probably not enough to cause significant pumping problems.

Conversely, consider the case of a poorly supported pavement structure, where FWD testing results in 30 mils of deflection under the load and 21 mils on the unloaded side of the joint. The resulting LTE is 100x21/30 = 70%, which w be considered acceptable under the LTE criteria described previously. In this case, however, total deflections are very high (due to the weak pavement support or voids under the joint) and the difference in deflections across the joint is (and may be a source of the loss of support if pumping is taking place).

Clearly, joint evaluation cannot be based on LTE values alone. The additional consideration of maximum deflection or differential deflection (DD = Δ_L - Δ_{UL}) is probably appropriate. For example, Larson and Smith (2005) suggest that "doweled joints with LTE of 85 percent or less and/or a different deflection greater than 0.13 mm (5 mils) in five years or less are unlikely to performance. The maximum differential deflection criteria of 0.13 mm (5 mm) may help evaluate dowel looseness or the possibility of delaminations in the concrete at the dowel bar level." Some states have adopted similar (but less stringent) criteria. For example, the Pennsylvania DOT specification for slab stabilization (Section 679) requires patching and stabilization of any joint or crack having a corner deflection of more than 20 mils and LTE of 65 percent or less (PennDOT 2007).

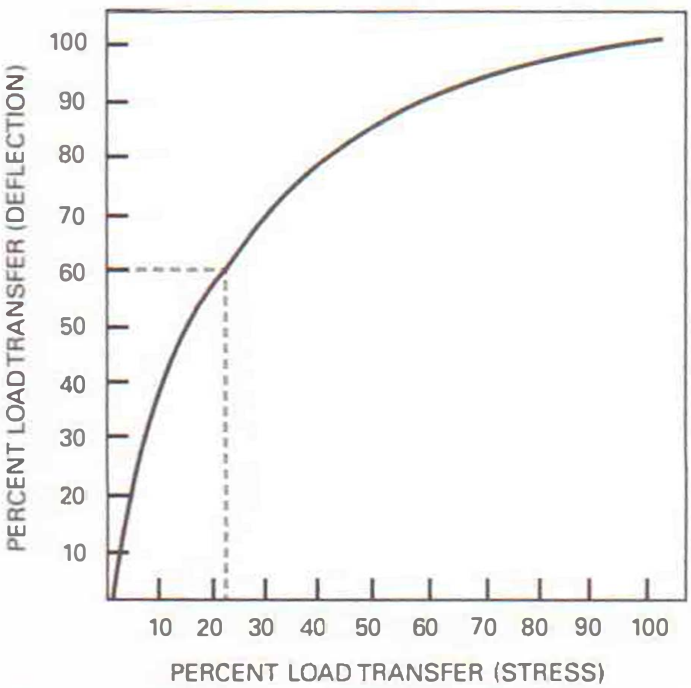

Figure C2. Example of the relationship between deflection and stress load transfer efficiencies for a particular pavement design thickness and support condition (source: FHWA 1997).

In establishing a limiting LTE standard, consideration should be given to the fact that concrete slab edge stresses change at a much different rate than do deflections. Stress transfer efficiency (STE) can be computed using an equation similar to the LTE equation presented previously:

$$STE(\%) = 100\frac{\sigma_{UL}}{\sigma_L}$$

where σ_{UL} is the stress in the unloaded side of the joint and σ_L is the stress in the loaded side of the joint. Figure C2 presents an example of an approximate relationship between deflection and stress load transfer efficiencies and shows that for the typical threshold deflection LTE value of 60 percent, stress transfer efficiency is only approximately 20 percent. Thus, it may be appropriate to consider the adoption of deflection LTE criteria that are 80 percent or higher to achieve stress transfer efficiencies of at least 50 percent.

References

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