KTMR-16 TESTING OF DOWEL BARS PLACED IN CONCRETE FOR RESISTANCE TO REMOVAL (PULL OUT) (Kansas Central Lab Test KT-MR-16)

a. SCOPE

The procedure described herein governs the method for determining the pull out resistance from cured concrete of epoxy coated dowel bars. This resistive force is primarily due to the static coefficient of friction between the bar surface and the concrete. Bars are to be tested dry and with a lubricant. The purpose of the test is to provide a relative comparison of the effectiveness of various lubricants in reducing the static coefficient of friction. The dry bar test is for the establishment of a reference datum and is to be conducted at the frequency stated in the following discussion.

Note: Unless otherwise specified, the tolerance on parameters stated herein is $\pm$2.5 % of their value. Conduct all procedures at the concrete cure temperature stated in c.6.

b. EQUIPMENT REQUIRED

b.1. Epoxy coated 1 1/8-inch (29 mm) diameter #9 smooth dowel bars of sufficient length to provide for an insertion depth of 9 inches (230 mm) and effective grip length. Current KDOT equipment requires 24 inch dowel bars for test samples.

b.2. Cylindrical containers of approximately 12 inch (300 mm) in diameter and 15 inches (380 mm) in depth. Note: 5 gal. (20 L) plastic buckets are acceptable.

b.3. Concrete produced according to the following mix design utilized for the Class I evaluation of aggregate at the M & R Center:

Monarch Cement, Type II	
25%	-3/4" +1/2" (-19.0 mm +12.5 mm) [Dry Aggregate]
25%	-1/2" +3/8" (-12.5 mm + 9.5 mm) [Dry Aggregate]
50%	FA-A
Y.C.F.	601.60 lbs/yd^3 (356.92 kg/m^3)
w/c	0.4431 to 0.4874
Air	5 to 7%
Slump	1-1/2" to 2-1/2" (38.0 mm to 63.5 mm)

b.4. A hollow ram hydraulic cylinder with an effective inside ram diameter (I.D.) of 2 1/8 inches (54 mm), height of approximately 10 inches (250 mm), loading capacity of 30 tons (270 kN) (minimum) and compatible hydraulic pump. The pump may be either powered or operated manually (manual operation preferred). If powered, the pump must be controllable to the extent that the load can be applied slowly or in incremental steps so that the pull out resistance can be determined at various levels of bar removal. An Enerpac (Butler, WI) P-80 manual pump and RCH-603 hollow ram cylinder 60-ton (530 kN) jack are acceptable. Both are rated at 10,000 psi (70 MPa). The jack has a relieved circular base area, 3 1/4-inch (80 mm) I.D., surrounding the ram.

Note: If a cylinder jack other than the one specifically referenced previously is utilized, a 1/2 inch (13 mm) thick steel annular ring, 3 1/4 inch (80 mm) I.D. and outside diameter

(O.D.) of 6 1/4 inch (160 mm), is to be placed between the jack base and concrete surface. This plate is necessary to provide the free concrete surface confinement imposed by the RCH-603 cylinder jack.

b.5. An applied load-indicating device such as a pressure gage incorporated into the ram and pump assembly, load cell with digital display, etc. This device must be capable of indicating a minimum applied load of 1,000 lbf (4 kN) and have a resolution on the order of 250 lbf (1 kN) or finer. This applies to indirect (psig or kPa) or direct load (lbf or kN) indicating devices. The equipment specifically referenced in **b.4.** utilizes a 0 to 10,000 psig (70 MPa) analog gage with incremental divisions of 200 psi (1,400 kPa) resolvable to 50 psi (350 kPa).

b.6. Access to a system for calibration of the applied load indicating device such as a universal test machine (UTM) that is certified accurate according to ASTM E 4 within $\pm$ 1 % over a load range of 1,000 to 60,000 lbf (4 to 270 kN) as a minimum.

b.7. A collar with tapered serrated wedge insert(s) for gripping the dowel bar is required. The collar diameter must at least equal the outside diameter of the hollow ram. An R-9 collar with inserts as provided by Fox-Howlett (Berkley, CA) is acceptable.

b.8. Equipment for removing the epoxy from the dowel bar in the grip area, e.g., engine lathe.

c. PROCEDURE

c.1. Prepare the dowel bars by legibly and uniquely identifying each dowel bar in a test group. A test group of three bars will be required for each lubricant to be evaluated. One dowel bar will be required for the dry bar test.

c.2. Place a legible mark at a distance of 9 inches (230 mm) from one end of each test bar. At the opposite end of the dowel bar, remove epoxy to the extent that the insert(s) of the gripping collar contacts only the steel surface of the bar. The extent of epoxy removal required can be determined by preassembling the bar, cylinder and collar group to the final dimensions as when placed in the concrete.

c.3. Apply the lubricant to be evaluated to each bar in the test group according to the lubricant manufacturer's instructions. The lubricant is to be applied to the 9 inch (230-mm) marked bar end. If prelubricated bars are being evaluated, it is the responsibility of the prelubricated bar vendor to provide the appropriate test samples as specified.

c.4. Prepare the concrete according to the mix design and place in the containers. One container of concrete is required for each test dowel bar. Placement of the concrete is to be according to the procedures specified for the production of concrete test cylinders. Vibratory consolidation is acceptable.

Note: The sequence order of **c.3.** and **c.4.** may vary, depending on the requirements for application of a specific lubricant.

c.5. Center the bar in the exposed surface of the concrete and insert the lubricated end to the marked depth of 9 inches (230 mm). Minimize the disruption of the concrete during this process. Finish the disturbed concrete surface around the point of bar insertion. The bar must be maintained perpendicular to the concrete surface and at the 9-inch (230-mm) depth until the initial set of the concrete has occurred. This

may be accomplished by various means. A suggested technique is to utilize lengths of wooden '2 X 4's' (51 X 102 mm) that span the top of the container and are predrilled in the center to slightly clear the dowel bar. The bars can be held to the depth mark by placing a stiff 'O' ring, spiral screw (hose) clamp, etc. on the bar at the exposed top surface of the wooden support.

c.6. Allow the concrete to cure 14 days at 25 ± 5° C (77 ± 9° F), with other conditions ambient, before initiating the pull out testing.

c.7. Before initiating testing, the pull out equipment must be calibrated. The equipment referenced in **b.6.** is required for this operation. The load application equipment referenced in **b.4.** and **b.5.** must be assembled and calibrated as a system regardless of the type of load indicating device (direct or indirect) utilized. The first check point should be as close as possible to 2,000 lbf (9 kN). Increment by approximately 2,500 lbf (11 kN) to each successive point until a total of five points have been checked within the range of approximately 2,000 to 12,000 lbf (9 to 53 kN). Each of these points should be verified three times in an ascending load application. If a load cell with a digital display is being utilized, the display equipment can be adjusted so that each point can be located with a high degree of precision, if not, the cell or signal conditioning equipment is most probably defective.

If an indirect indicating device, such as a pressure gage, is present, the applied load vs. the gage indication at each checkpoint should be plotted on rectangular coordinates. Linear regression analysis should be performed to determine the load vs. pressure relationship. The graphical presentation can be used for approximating the load at a given pressure, however, the final load values are to be calculated from the regression equation. The preceding constitutes calibration of the load application system for low range testing.

For the high range calibration relationship, check applied load vs. indicated load (or pressure) at approximately 25, 35, 45, and 55 kips (100, 150, 200, and 250 kN). Verify each point three times in the ascending mode. For an indirect indicating device such as the pressure gage, incorporate these additional points into the graphical and linear regression representations previously discussed. The resultant relationships should be used for high range testing or from above 10 kips to 60 kips (45 to 270 kN) applied load.

c.8. Note: A test series will consist of an initial dry bar test followed by five test groups (total of 16 bars). The reference datum will be established from the average maximum peak load value (re: discussion to follow) of the last three (one and two for the first two series) dry dowel bar pull out tests. This sequence is to repeat after every 16 pull out tests. A significant change in this average value may indicate an unknown variable introduced into the test procedure and that corrective action is required.

After the 14-day cure, removal of the dowel bar supports, and calibration of the load application system, proceed with the pull out testing. Place the hollow ram of the hydraulic cylinder over the dowel bar and center the bar within the I.D. of the ram. The ram should be fully depressed to obtain maximum travel during testing. If a ram with an I.D. greater than 2 1/8 inches (54 mm) is utilized, the annular ring must be installed over the bar and centered before the cylinder is set in place. Install the gripping collar and wedge insert(s) over the exposed end of the dowel bar and lightly tap the insert(s) in place.

Slowly apply hydraulic pressure to the cylinder and carefully observe the bar for movement and the pressure (or load) level. Typically, if the load required to initiate bar movement exceeds approximately 2,200 lbf (10 kN), the energy release will be audible with a corresponding and noticeable drop in the indicated load and slight movement of the bar. Record this initial peak load or pressure, depending on the indicating device,

and continue to apply load. Typically, the energy release will again be audible and the second peak will be higher than the initial value. Continue to slowly load the bar, it will be observed that this process of 'lock and release' of the bar will repeat several times with each successive peak load value higher than the previous. After several repetitions, the observed peak value will begin to decrease significantly relative to the previous value. A decrease in the audible level of the energy release and a greater incremental movement of the bar will also be observed. Record each observed peak value. Continue loading and removing the bar until the observed peak load value has dropped 20 % below the maximum-recorded peak load value. The test may be terminated at this point or, if observation of the embedded dowel end is required, the bar may be removed.

When the applied force required to initiate bar movement is at or below approximately 2,200 lbf (10 kN), it has been observed that the initial energy release may or may not be audible and that each successive peak value will be less than the initial peak load value. When this occurs, continue to slowly load the bar until a 20 % decrease in the peak load relative to the initial value occurs. Record all peak load values. The test may then be terminated or the bar removed if desired. **Note: If pressure values were recorded, utilize the regression equations developed through c.7. to convert these values to applied loads before the final data reduction.**

c.9. Report the identification, type of lubricant (if any) and application method, and the maximum peak load value observed during the pull out test for each dowel bar tested. Also report the average of the maximum peak load values for a test group, their extreme spread, and the ratio of this average to the most recent dry bar pull out test maximum peak load value (or running average thereof).

(MTU - Physical Test Section)