Standard Method of Test for

Vibrating Kelly Ball (VKelly) Penetration in Fresh Portland Cement Concrete

AASHTO Designation: TP 129-18 (2020)[1,2]

Technical Subcommittee: 3c, Hardened Concrete

Release: Group 1 (April)

AASHTO

American Association of State Highway and Transportation Officials
555 12th Street NW, Suite 1000
Washington, DC 20004

Standard Method of Test for

Vibrating Kelly Ball (VKelly) Penetration in Fresh Portland Cement Concrete

AASHTO Designation: TP 129-18 (2020)[1,2]

AASHTO

Technical Subcommittee: 3c, Hardened Concrete

Release: Group 1 (April)

1. SCOPE

1.1. This test method describes the procedure for determining the consistency of fresh concrete by measuring the depth of penetration of a metal mass into plastic concrete under the force of gravity and quantitatively assessing the responsiveness to vibration of dry concrete mixtures, as is desired of a mixture suitable for slipform paving.

1.2. The values stated in either SI units or inch-pound units are to be regarded separately as the standard. Within the text, the inch-pound units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.3. *The standard does not purport to address all the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.*

1.4. The text of this standard references notes and footnotes that provide explanatory information. These notes and footnotes shall not be considered as requirements of this standard.

2. REFERENCED STANDARDS

2.1. *AASHTO Standard*:
- R 60, Sampling Freshly Mixed Concrete

2.2. *California Test Standard*:
- CTM 533, Method of Test for Ball Penetration in Fresh Portland Cement Concrete

2.3. *Other Documents*:
- Koehler, E., and Fowler, D. *Summary of Concrete Workability Test Methods*. ICAR Report 105.1. University of Texas at Austin, Austin, TX, 2003.
- Wang, X., P. Taylor, and X. Wang. A Novel Test to Determine the Workability of Slipform Concrete Mixtures. *Magazine of Concrete Research*, Vol. 69, No. 6, 2017, pp. 292–305.

3. SUMMARY OF TEST METHOD

3.1. This test method comprises a two-part measurement to assess static and dynamic behavior of plastic concrete mixtures.

3.2. First, the consistency of fresh concrete is assessed by measuring the depth of penetration of a metal mass into concrete under the force of gravity.

3.3. Second, the rate of penetration of the metal mass under vibration energy of 98 J (72 lbf) at 8,000 vibrations per minute (vpm) is measured and recorded for up to 36 s. The rate of penetration in $cm/s^{1/2}$ ($in./s^{1/2}$) is determined and reported as the VKelly index. This parameter indicates the responsiveness of a mixture to vibration.

4. SIGNIFICANCE AND USE

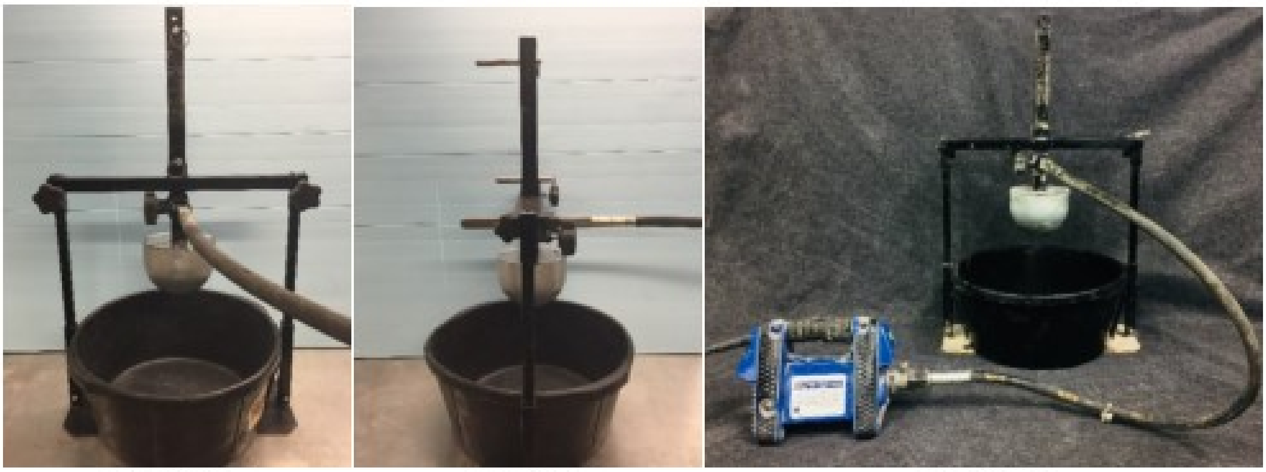
4.1. This test method is intended to assess consistency and responsiveness to vibration of low slump concrete mixtures for applications such as slipform paving. Such a mixture should be mobile while under vibration, making it easy to move the mixture through a paving machine and to achieve full consolidation, but static and resistant to edge slump after the paver has moved on. The slump test only addresses the latter parameter. The approach here is to take the Kelly Ball test and modify it by adding vibration energy.

4.2. This test method is not considered applicable to non-cohesive concrete and maximum aggregate size greater than 37.5 mm (1.5 in.) or for mixtures with a slump greater than 75 mm (3 in.).

5. APPARATUS

5.1. *Equipment*:

5.1.1. VKelly test apparatus is shown in Figure 1. The test apparatus is available in a kit from the National Concrete Pavement Technology Center. Alternatively, a Kelly Ball is commercially available. It will have to be modified to clamp the vibrator onto it, to add a graduated shaft, and to allow for the mass of the vibrator head. A frame is desirable to hold the system vertically during the test and to facilitate depth measurement.



(a) Front View (b) Side View (c) Final Set-Up

Figure 1—Assembled Apparatus (*Source: National CP Tech Center*)

5.1.1.1. *Rubber Tub*—With a 25-L (6.5-gal) capacity, approximately 430-mm (17-in.) diameter (top) by 380-mm (15-in.) diameter (bottom) by 200 mm (8-in.) depth.

5.1.1.2. *Four Frame Pieces for Stabilizing the Kelly Ball*—One base plate, two side bars, and one top bar.

5.1.1.3. *Pin*—To hold the graduated shaft up before testing starts.

5.1.1.4. *Steel Kelly Ball*—Mounted on a graduated shaft with a total weight of 13.6 ± 0.05 kg (30 ± 0.1 lb).

5.1.1.5. *WYCO Square Vibrator Head*—21-mm^2 ($^{13}/_{16}$-in.^{2}) width by 330-mm (13-in.) length (Part #W877-520), 1.5-m (5-ft) cable, with "quick disconnect" adaptor (Part #423500).

5.1.1.6. *Vibration Motor*—One that can provide 98 J (72 lbf) energy at a constant 8,000 vpm (i.e., Wyco Sure Speed, Model WVG1). A 15-A and 120-V (approximately 2000-W) power source is required.

6. SAMPLING, TEST SPECIMENS, AND TEST UNITS

6.1. Sample concrete in accordance with R 60.

6.2. Gently place fresh, unconsolidated concrete in the tub to a depth of at least 150 mm (6 in.) for 25-mm (1-in.) aggregate or smaller and 200 mm (8 in.) for larger aggregate.

6.3. Use a float to create a level area on the concrete surface of about 0.14 m^2 (1.5 ft^2) without tamping, vibrating, or consolidating the concrete. Do not overwork the surface.

7. PROCEDURE

7.1. *Static Test*:

7.1.1. Pull out the pin holding the graduated shaft while holding the shaft to prevent it from dropping.

7.1.2. Gently lower the ball until it touches the surface of the concrete.

7.1.3. Record the initial reading on the graduated scale (R_i) to the nearest 2.5 mm (0.1 in.).

7.1.4. Let the ball sink under its own weight so that penetration is due to the dead load of the ball only and not to any force generated by acceleration of the mass (CTM 533). Record the reading on the graduated scale where the ball comes to rest (R_s).

7.1.5. When the ball comes to rest, record the static depth to the nearest 2.5 mm (0.1 in.) as shown in Figure 2.

7.1.6. Complete the static test within 30 s.

Figure 2—Depth of Penetration under Static Load (*Source: National CP Tech Center*)

7.2. *Dynamic Test*:

7.2.1. As soon as static test is completed, turn on the vibrator motor and set it to 8,000 vpm, and simultaneously start the timer.

7.2.2. Record the depth readings on the graduated shaft every 6 s up to 36 s (R_t). Stop the test if the top of the ball reaches the surface of the concrete.

Note 1—One means to collect data is to use a video recorder to monitor the graduated scale for the duration of the test. Alternatively, a digital laser measurer (Bosch Professional GLM 40 or similar) can be installed on the top bar to help record the ball penetration depth during vibration.

7.2.3. In the laboratory, dump the testing concrete back into the mixer and remix it for about 30 s then repeat the test on a fresh, leveled concrete surface in accordance with Sections 6.1 to 7.2.2.

7.2.4. In the field, repeat the test using fresh concrete from the same composite sample.

7.2.5. Take a minimum of three individual sets of readings. Individual readings should agree within 12.5 mm (0.5 in.) of penetration at any given time.

8. CALCULATION AND REPORT

8.1. Calculate the depth of penetration (D_s) under static load ($D_s = R_s - R_i$) for the three repeats, and determine an average. Multiply by 2 (Koehler and Fowler, 2003) to obtain the slump equivalent (VKelly slump) and report to the nearest 5 mm ($^1/_4$ in.).

8.2. Determine the depth of penetration D_t under vibration for times 6 through 36 s every 6 s) ($D_t = R_t - R_s$). Plot the penetration readings in millimeters (inches) (vertical axis) against the square root of time in seconds (horizontal axis) (Figure 3), and determine the slope of the best-fit line through the data (Equation 1) to 3 significant figures.

$$D_t = V\sqrt{t} + c \qquad (1)$$

where:

D_t = penetration depth at time t,

t = elapsed time of vibration (s),

c = constant (not zero), and

V = VKelly Index.

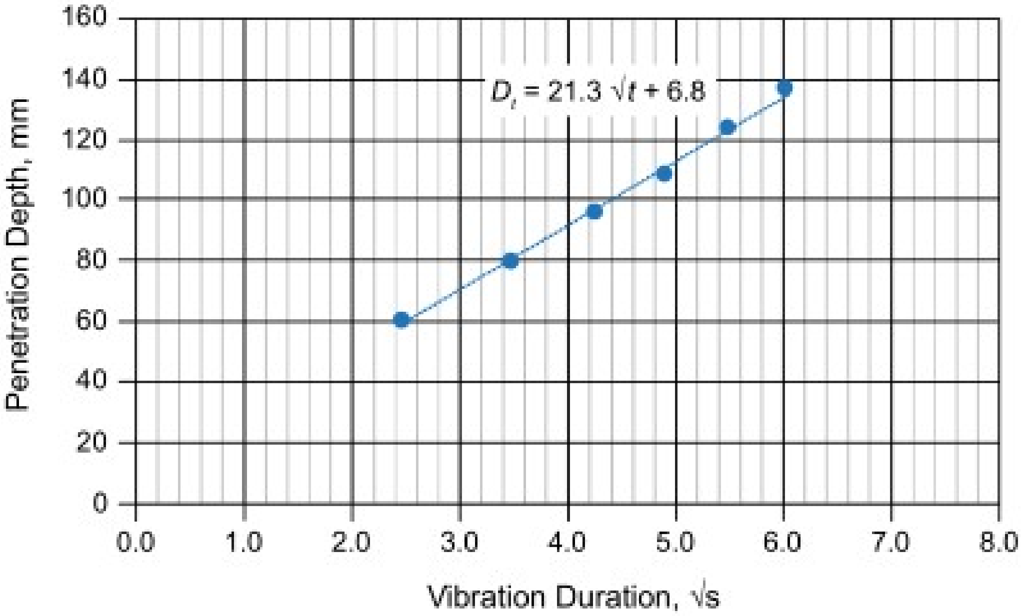


Figure 3—Sample Plot of VKelly Test Data. VKelly Index = 21.3 mm/√*s*

8.3. Report the averaged VKelly slump in mm (in.).

8.4. Report the averaged VKelly Index in mm/√*s* (in./√*s*).

9. PRECISION AND BIAS

9.1. *Precision*:

9.1.1. *Single-Operator Precision*—The repeatability of the VKelly test performed by a single operator is verified (Wang et al., 2017). A mixture was tested four times and the coefficient of variation of the VKelly index for the four mixtures was determined to be 0.6 mm/$s^{1/2}$ (in./√*s*).

9.1.2. *Multi-Operator Precision*—The multi-operator standard deviation is 8.31 percent for over 23 mixtures. The reported results for the replicate readings apply to tests conducted by different operators performing tests on the same mixture less than 10 min apart.

9.2. It is suggested that the VKelly test should be conducted within 45 min after discharging.

10. KEYWORDS

10.1. Fresh concrete consistency; Kelly Ball test; responsiveness; slipform paving concrete; workability test.

11. REFERENCE

11.1. Taylor, P., X. Wang, and X. Wang. (2015). Concrete Pavement Mixture Design and Analysis (MDA): Development and Evaluation of Vibrating Kelly Ball Test (VKelly Test) for the Workability of Concrete. Technical Report TPF-5(205). National Concrete Pavement Technology Center, Iowa State University, Ames, IA.

---

[1] This provisional standard was first published in 2018.
[2] This is a modification of a test method formerly published in T 183 (last published in 1977), and in ASTM C360 (last published in 1999).