

Purpose – Why Do This Test?

Determining the set time of a concrete mixture during the mixture design and mixture verification phases enables comparison of the mixture's early strength development characteristics. Such a comparison may reveal changes in the mixture's behavior and properties as compared to what was observed during the mixture design stage. Early identification of strength development trends may be helpful in preventing uncontrolled cracking in the pavement.

Principle – What is the Theory?

The hydration process for a given concrete mixture is complex and dependent on the interaction of many factors (materials and processes). Set time testing identifies two points on the hydration curve: initial set and final set. Initial set occurs at 500 lb/in² (penetration resistance) and final set is defined to occur at 4,000 lb/in² (penetration resistance). Even though the initial and final set values are arbitrary and may not have any connection to field behavior of the pavement, these test values provide an objective measure of the concrete mixture's early strength development characteristics.

Test Procedure – How is the Test Run?

ASTM C 403, the *Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance*, determines the penetration resistance (expressed in lb/in²) of a mortar sample over time. Penetration resistance is a function of the force required for a needle of known bearing area to penetrate a curing mortar sample to a depth of 1 in. A penetrometer with varying size needles is used to determine the penetration resistance.

Test Apparatus (figure 1)

- Container for mortar specimen(s).
- Penetration needles with the following bearing areas (in²): 1.00, 0.50, 0.25, 0.05, 0.025.
- Penetrometer.
- Tamping rod.
- Pipet.
- Thermometer.
- Vibratory mortar sampler (suggested for field sampling).

Test Method

1. Prepare a lab mortar sample or obtain a mortar sample from a field-mixed batch.
2. Record the time at which cementitious materials first come into contact with water.

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Figure 1. Set time testing equipment

3. Record the temperature of the fresh mortar sample, place in a container, consolidate, and level the top surface of the mortar.
4. Maintain the ambient test conditions at 68°F to 77°F (lab and field tests).
5. Begin penetration testing approximately 3 to 4 hours after initial contact between the cement and water. Continue penetration testing at 30 to 60 minute intervals, decreasing the needle bearing area as necessary, until final set of 4,000 lb/in² occurs.
6. For each penetration, record the ambient temperature, mortar temperature, force, and bearing area.
7. Calculate the penetration resistance by dividing the force by the penetration area.
8. Plot the results.

Output – How Do I Interpret the Results?

Plot the set time for mixture design and mixture verification tests together (figure 2). Compare the results and note whether the field-mixed concrete has significantly different set time characteristics than the mixture design.

Construction Issues – What Should I Look For?

Delays in normal setting may lead to uncontrolled cracking as stresses build up in the pavement before it has time to gain enough strength for sawcutting operations. This is especially critical in hot and/or dry weather conditions. Accelerated set will require earlier sawcutting operations.

Penetration Resistance ASTM C 403

Project: I-35 Payne Co.
 Test description: Mixture verification
 Date: 29-May-08
 Time: 9:10 AM
 Operator: BZ

Time	Air/mortar temperature (°F)	Elapsed time	Needle #	Reading (lb)	Penetration resistance (lb/in ²)	Log (PR)	Log (f)
12:50 PM	69.0/73.2	220	1	112	112	2.05	2.34
1:50 PM	69.4/74.3	280	2	175	350	2.54	2.45
2:20 PM	69.5/74.8	310	4	198	792	2.90	2.49
2:50 PM	70.3/76.7	340	10	120	1,200	3.08	2.53
3:20 PM	71.1/78.8	370	20	75	1,500	3.18	2.57
3:40 PM	71.6/79.9	390	40	55	2,200	3.34	2.59
4:10 PM	72.3/80.2	420	40	80	3,200	3.51	2.62
4:40 PM	72.1/81.6	450	40	115	4,600	3.66	2.65
Initial set (at 500 lb/in²)		estimated times based on test data	290 min		4.84 h		
Final set (at 4,000 lb/in²)			452 min		7.53 h		

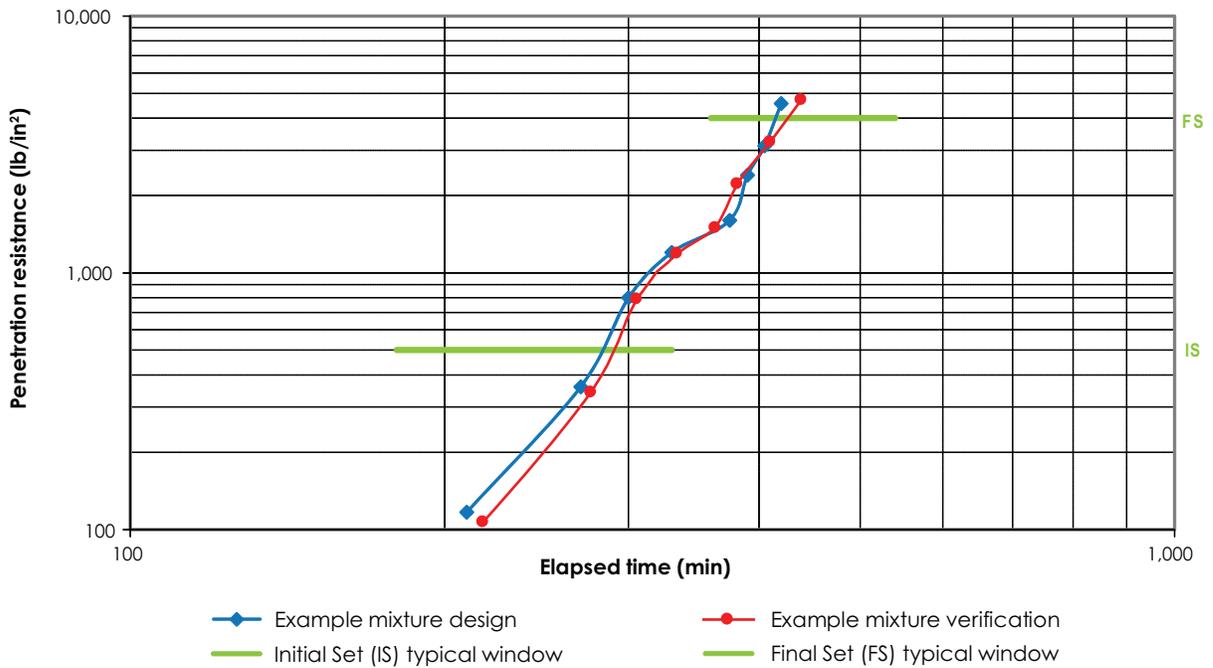


Figure 2. Plotting set time for mixture design and mixture verification

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