

Setting Time of Fresh Concrete using P-Wave (PUNDIT SET)

Definitions

Setting of concrete is the change that occurs when the concrete changes from a plastic state to a solid state. In general, it refers to change from a fluid state to a solid state. When water is added to the dry concrete mix, cement paste is formed and remains pliable and plastic for a short time. As the reaction between water and cement particles continue, the paste loses its plasticity. This early period in the hardening of cement is referred to as 'setting' of the concrete. The initial set point is when the cement paste loses its plasticity and stiffens considerably. The final set point is when the paste hardens and can sustain some minor load.

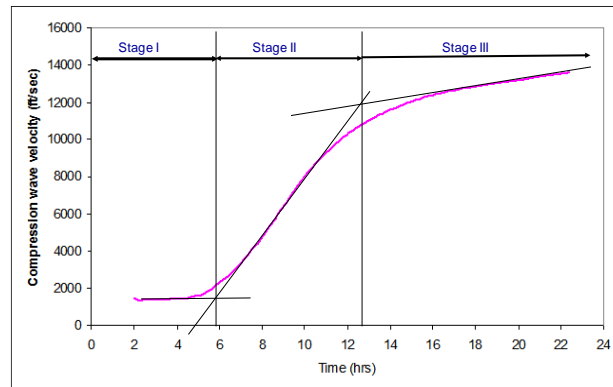
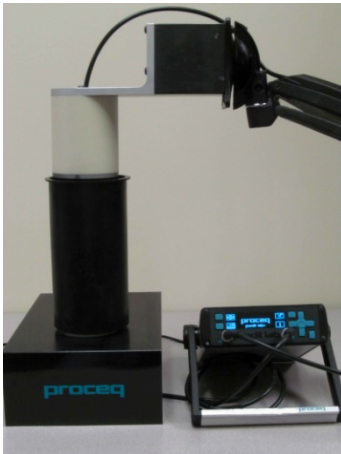
Knowing when the concrete sets is important because there can be variation between batches which may result in scheduling or material compatibility issues.

Theory

The Ultrasonic Pulse Velocity (UPV) method has been used in the construction rehabilitation industry for over fifty years. The UPV method is a stress wave propagation method which measures the travel time of propagating waves pulsed over a known path length. A piezoelectric transmitter and receiver are used to generate the signal. The time the pulses take to travel from the transmitter-transducer to the receiver-transducer is recorded electronically. Once this time is recorded, the concrete pulse velocity V can be calculated by dividing the distance L between transducers by the transit time t .

$$V = \frac{L}{t}$$

The pulse velocity of concrete has been used to measure the elastic modulus (dynamic) of concrete and record the change over a period of time.



Typical Wave Velocity vs Time Plot

Procedure

A concrete cylinder is prepared with fresh concrete, according to ASTM C31, the concrete cylinder is then coupled and positioned onto the bottom holder. The top transducer holder is then lowered onto the surface of the concrete. Once the cylinder and top transducer is positioned, the settings are adjusted on the computer. When all the test parameters are set, the program then controls the duration and strength of each wave form and records the travel time of each wave form. Data logging time intervals of one to two minutes is typical. The program can run indefinitely, capturing data until the test duration is complete.

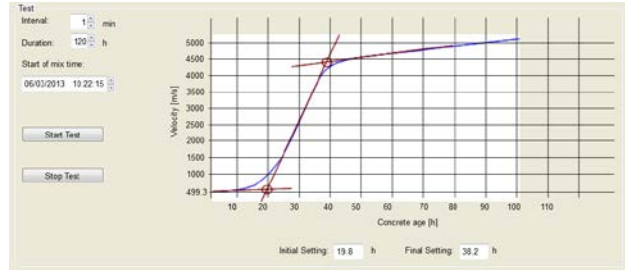
Compression Wave Velocity Trend (Typical Wave Velocity vs. Time Plot)

As the data is acquired by the unit, the system records the data and the plot of Velocity vs. Time Plot is generated. The typical “S” shape curve is recorded. The “S” shape curve can depicts the different stages of ongoing hydration and the mechanical property changes in the concrete.

- State I: Inactive stage
- Stage II: Initial Phase Transition Stage
- Stage III: Final Phase Transition Stage

Setting Time of Concrete With Ultrasonic Wave Software

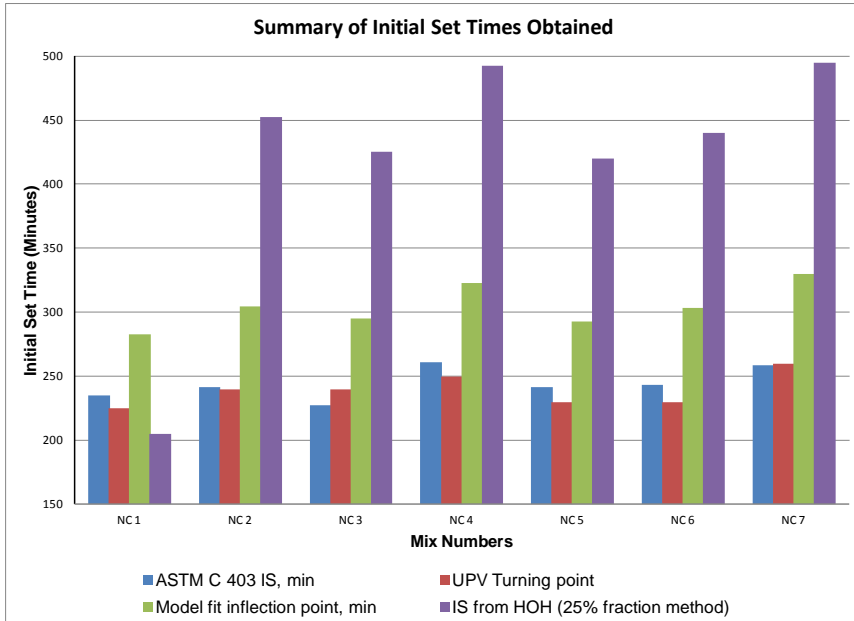
The Time of Set Software is designed to record the time of travel of the wave and generate a Velocity vs. Time plot. Once the test is complete the software automatically calculates the initial and final set based upon the intersection on the “S” Curves. The software will continue to collect data until the preset duration is achieved.



Test Results

Work performed at Iowa State University** (2013) has shown good correlation between ASTM C403 and the UPV results.

Mix	CA, lbs	FA, lbs	Cement, lbs	Slag, lbs	Slag type	Dosage	Water	w/c	AEA, ml	WR, ml	Slump, in./t weight	Air, %	
NC 1	1909	2157	733	0	X	0%	308	0.420103	195	1943	4	149.0	6
NC 2	1909	2157	587	147	Grade 100	20%	308	0.420103	234	1943	7	147.8	6
NC 3	1909	2157	477	257	Grade 100	35%	308	0.420103	234	1943	5.5	145.7	6
NC 4	1909	2157	367	367	Grade 100	50%	308	0.420103	234	1943	6.5	144.3	7
NC 5	1909	2157	587	147	Grade 120	20%	308	0.420103	234	1943	3	145.5	6
NC 6	1909	2157	477	257	Grade 120	35%	308	0.420103	234	1943	5.5	144.3	7
NC 7	1909	2157	367	367	Grade 120	50%	308	0.420103	234	1943	6	145.7	Ult



** Data Contribution: Mr. XuHao Wang and Dr. Kejin Wang (Iowa State University), Dr. Peter Taylor (CP Tech Center) and Mr. Malcolm Lim (Proceq Technical and Application Services).

Vendor

Proceq, 117 Corporation Drive, Aliquippa, PA 15001
800-839-7016