Appendix U.8.3 – UPV

Generic Name of Test	*Sound Pulses* NDT : Abrasion / Non Destructive Test
Principle of Test	Sound waves pass through the specimen at a measured rate
Historic Development of Test	Concrete has been tested using ultrasonic pulse techniques from as early as 1955. The first British Standard BS 4408 : Part 5 : 1974 was superseded by a revised version *BS 1881 : Part 203 : 1986 Recommendations for measurement of velocity of ultrasonic pulses in concrete* [Sadegzadeh (1986)]
Apparatus	The PUNDIT (see figure U.8.3.1) transmits and receives ultrasonic pulses (i.e. longitudinal ultrasonic vibrations) generated by electrical impulses at a frequency of 50 kHz, and measures the time delay. The apparatus consists of an electrical pulse generator, a pair of transducers (see figure U.8.3.2), an amplifier and an electronic timing device capable of measuring the time interval between the sending and receiving of a pulse. Petroleum jelly or grease is used to obtain acoustical coupling between the concrete and the face of each transducer. [BS 1881 : Part 203 : 1986]

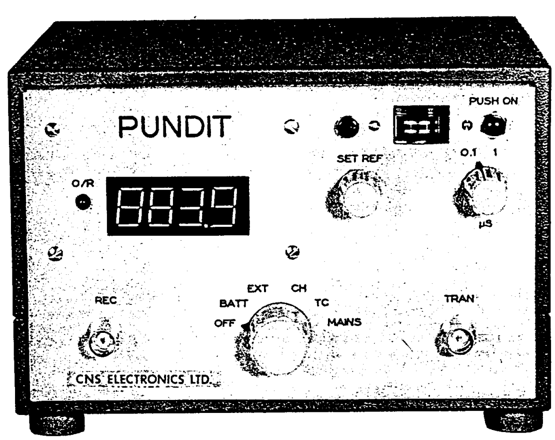

Figure U.8.3.1 The **P**ortable **U**ltrasonic **N**on destructive **D**igital **I**ndicating **T**ester [C.N.S. Electronics LTD]

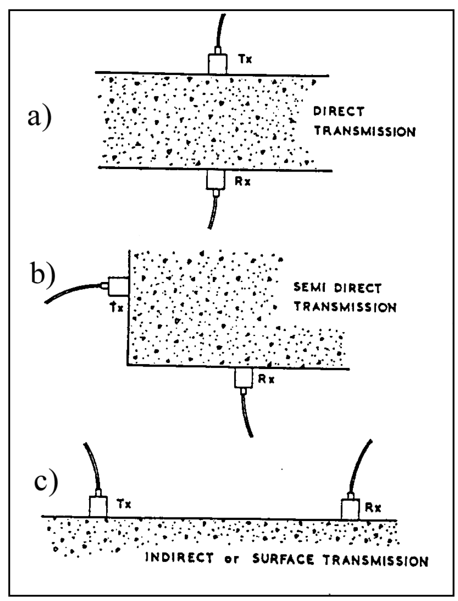

Figure U.8.3.2 Methods of propagating ultrasonic pulses [C.N.S. Electronics LTD]

Test Method	After the apparatus has been accurately calibrated (by using a reference bar of known transit time to eliminate the effects of time delay due to the transducer material and their cables), the 2 transducers are placed on the concrete in any one of the configurations shown in figure U.8.3.2 with a small amount of couplant. A minimum distance of 150mm between the 2 transducers is required for direct transmission and 400mm for indirect transmission. [BS 1881 : Part 203 : 1986]
Abrasion Wear	No abrasion takes place. The results of the test are reported as the pulse velocity (km/s) through the concrete. The time between transmission and reception is measured and the velocity calculated from: $\text{Velocity (km/sec)} = \frac{\text{Path length(mm)}}{\text{Time}(\mu s)}$. [BS 1881 : Part 203 : 1986]

APPENDIX U.8.3

Mechanisms according to Authors

No wear takes place in this non-destructive test
(i) BS 1881 : Part 201 : 1986: The pulse velocity depends on the dynamic Young's modulus, dynamic Poisson's ratio and density of the concrete. [The velocity of longitudinal ultrasonic vibrations travelling in the elastic solid is given by $V = \sqrt{\frac{E(1-\nu)}{\rho(1+\nu)(1-2\nu)}}$ where:

E is the dynamic elastic modulus
ρ is the density and
ν is Poisson's ratio]

(ii) BS 1881 : Part 203 : 1986: The indirect transmission arrangement gives pulse velocity measurements which are influenced by the core and the surface of the concrete [The indirect method (see figure U.8.3.2c) *must* be used when testing a concrete floor on the ground]
(iii) Sadegzadeh (1986): The ultrasonic pulse technique was not sensitive to variations in mix design (and thus the abrasion resistance) which may have been caused by the indirect method of transmission (see figure U.8.3.2c) and the rough contact surfaces.
(iv) Dr. Steinkamp (1989): The ultrasonic beam of energy is scattered by discontinuities within the material under test. However the amplitude of the signal received by the receiving transducer may be as low as 1 to 2% for the indirect method relative to the direct method. Roughly speaking, the higher the quality and compressive strength of concrete, the higher will be the pulse velocities, and it is possible to correlate compressive strength with pulse velocity for carefully considered conditions as shown in figure U.8.3.3
(v) Visual Effects: None

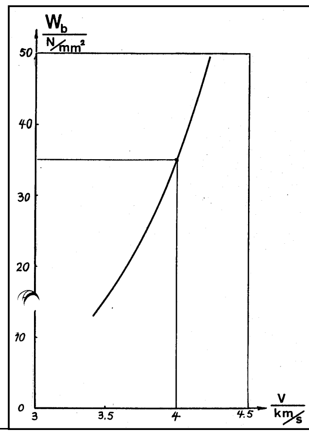

Figure U.8.3.3 Correlation betwen pulse velocity and stength of concrete [Steinkamp (1989)

Mechanisms according to writer [R0 S0 I0]
No wear takes place in this non-destructive test.

The velocity of sound waves (ultrasonic pulses) travelling through a solid material depends on the density and elastic properties of that material [C&CI notes NDT (1997)]. Therefore variation in the velocity of the pulse may indicate variations in the quality of the concrete including compressive strength and abrasion resistance. There are however some problems with using UPV as a means of measuring abrasion resistance:

- The correlation between density and strength is not always a given, and may vary as much as +/- 20% depending on a number of factors.
- Abrasion resistance is related to *surface* density, and will therefore only correlate with the UPV in as far as the surface density corresponds with that of the core concrete.
- Note that according to the formula for V given above, an increase in density will result in a decrease in pulse velocity, unless there is a greater increase in E. ν must also be considered.

	Author	Comment
References	BS 1881 : Part 203 : 1986	Source document
	Sadegzadeh (1986)	Source document
	C&CI level 4 Notes: NDT (1997)	Source document
	Steinkamp (1986)	Source document