WAVE VELOCITY IN YOUNG CONCRETE

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1. Introduction

In the sonic echo method of integrity testing, the pile head is hit with a hammer and reflected waves are monitored by suitable equipment. In order to obtain a good estimate for the pile length (and for the depth of any existing defects), the longitudinal wave velocity in the pile material c has to be assumed. A typical value of 4,000 m/sec for hardened, good-quality concrete is often quoted (Fleming et al. 1985).

Due to tight construction schedules, testing firms are often under pressure to test cast-in-situ piles a few days after casting. At this stage, the concrete is still hardening, and wave velocity should be strongly dependent on its age. The following discussion presents a method to determinte the wave velocity in young concrete.

2. Wave velocity - basic relationships

The function relating wave velocity to concrete strength and age is based on the following equations:

(1) $$c = (E/\rho)^{1/2} = k_1 E^{1/2}$$

where E is Young's Modulus of the concrete and ρ its mass density (Richart et al. 1970),

(2) $$E = k_2(f_c)^{1/3}$$

where f_c is the cylinder crushing strength of the concrete (Lacroix et al. 1982) and

(3) $$f_c = k_3.\log(t + 1)$$

where t is the concrete age in days (Lacroix et al. 1982). Combining eqs. (1), (2) and (3), it results that the relationship between wave velocity and concrete age is of the form:

(4) $$c = K\ [\log(t + 1)]^{1/6}$$

where $K = k_1.(k_2)^{1/2}.(k_3)^{1/3}$ is an empirical dimensional constant.

3. Experimental determination of wave velocity

The 64 piles included in this study were all tremied with 30 MPa concrete under bentonite slurry. The piles were tested by TNO sonic equipment at ages

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of between four and 44 days, and wave velocity adjusted so that the lengths obtained fitted those measured in the boreholes before casting. a linear regression of the results yielded the following relationship:

(5) $$c_{30}(m/sec) = 3946.[\log(t+1)]^{1/6}$$

With a coefficient of correlation 0.78 and a standard deviation of 160 m/sec. For different grades of concrete, eq. (2) and (4) may be combined to give:

(6) $$c = c_{30}.(f_c/30)^{1/6}$$

The results are graphically represented in Fig. 1.

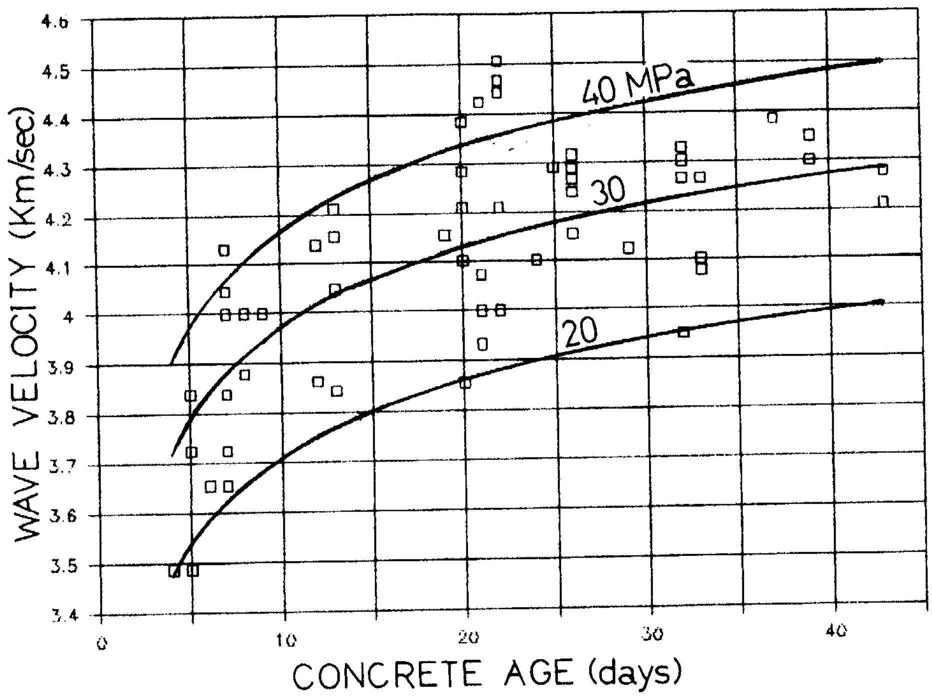

Fig. 1 - Wave velocity as a function of concrete grade and age

3. Conclusions

Based on theoretical considerations, semi-empirical equations and testing results, a convenient method to estimate the wave velocity in young concrete is presented.

4. References

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