

Nondestructive Test Methods for Determining Material Properties of Hardened Concrete in Existing Construction

Property/ Condition	Method		Comment
	Primary	Secondary	
Compressive strength	Cores for compression testing (ASTM C42 and C39)	Penetration resistance (ASTM C803): Pullout testing (drilled-in)	Strength of in-place concrete; comparison of strength in different locations. Drilled-in pullout test not standardized by ASTM
Relative compressive strength	Rebound number (ASTM C 805); Ultrasonic pulse velocity (UPV) (ASTM C 597)		Rebound number influenced by near surface properties; UPV gives “average” result through the thickness.
Tensile strength	Splitting tensile strength of core (ASTM C 496)	In-place pulloff test (ACI 503R; BS 1881: Part 207)	Assess tensile strength of concrete.
Density	Specific gravity of samples (ASTM C 642)	Nuclear gage	
Moisture content	Moisture meters	Nuclear gage	
Static modulus of elasticity	Compression test of cores (ASTM C 469)		
Dynamic modulus of elasticity	Resonant frequency testing of sawed specimens (ASTM C 469)	Ultrasonic pulse velocity (ASTM C 597); impact-echo; spectral analysis of surface waves (SASW)	Requires knowledge of density and poisson’s ratio (except C215); dynamic elastic modulus is typically greater than the static elastic modulus
Shrinkage/expansion	Length change of drilled or sawed specimens (ASTM C 341)		Measure of incremental potential length change.
Resistance to chloride penetration	90-day ponding test (AASHTO T 259)	Electrical indication of concrete’s ability to resist chloride ion penetration (ASTM C 1201)	Establish relative susceptibility of concrete to chloride ion intrusion; assess effectiveness of chemical sealers, membranes, and overlays

Property/ Condition	Method		Comment
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Air content; cement content; and aggregate properties (scaling; alkali silica reactivity; freeze/thaw susceptibility)	Petrographic examination of concrete samples removed from structure (ASTM C 856 and ASTM C 457); cement content (ASTM C 1084)	Petrographic examination of aggregates (ASTM C 294, C 295)	Assist in determination of cause(s) of distress; degree of damage; quality of concrete when originally cast and current.
Alkali-silica reactivity (ASR)	Cornell/SHRP rapid test (SHRP-C-315)		Establish in field if observed deterioration is due to ASR
Carbonation, pH	Phenolphthalein (qualitative indication); pH meter	Other pH indicators (e.g., litmus paper)	Assess corrosion protection value of concrete with depth and susceptibility of steel reinforcement to corrosion; depth of carbonation
Fire damage	Petrography; rebound number (ASTM C 805)	SASW; UPV; Impact-echo; Impulse-response	Rebound number permits demarcation of damaged surface
Freezing and thawing damage	Petrography	SASW; Impulse-response	
Chloride ion content	Acid-soluble (ASTM C 1152) and water-soluble (ASTM C 1218)	Specific ion probe (SHRP-S-328)	Chloride ingress increases susceptibility of steel reinforcement to corrosion
Air permeability	SHRP surface airflow method (SHRP-S-329)		Measures in-place permeability index of the near-surface concrete (15mm)
Electrical resistance of concrete	AC resistance using 4-probe resistance meter	SHRP surface resistance test (SHRP-S-327)	AC resistance useful for evaluating effectiveness of admixtures and cementitious additions; SHRP method useful for evaluating effectiveness of sealers.
Air content; cement content; and aggregate properties (scaling; alkali silica reactivity; freeze/thaw susceptibility)	Petrographic examination of concrete samples removed from structure (ASTM C 856 and ASTM C 457); cement content (ASTM C 1084)	Petrographic examination of aggregates (ASTM C 294, C 295)	Assist in determination of cause(s) of distress; degree of damage; quality of concrete when originally cast and current.

Nondestructive Test Methods To Determine Structural Properties And Assess Conditions Of Concrete

Property/ Condition	Method		Comment
	Primary	Secondary	
Reinforcement location	Covermeter; Ground penetrating radar (GPR) (ASTM 4748)	X-ray and Y-ray radiography	Steel location and distribution; concrete cover
Concrete component thickness	Impact-echo (I-E); GPR (ASTM D 4748)	Intrusive probing	Verify thickness of concrete; provide more certainty in structural capacity calculations; I-E requires knowledge of wave speed and GPR of dielectric constant
Steel area reduction	Ultrasonic thickness gage (requires direct contact with steel)	Intrusive probing; radiography	Observe and measure rust and area reduction in steel; observe corrosion of embedded post-tensioning components; verify location and extent of deterioration; provide more certainty in structural capacity calculations.
Local or global strength and behavior	Load test, deflection or strain measurements	Acceleration, strain, and displacement measurements	Ascertain acceptability without repair or strengthening; determine accurate load rating
Corrosion potentials	Half-cell potential (ASTM C 876)		Identification of location of active reinforcement corrosion
Corrosion rate	Linear polarization (SHRP-S-324 and S-330)		Corrosion rate of embedded steel; rate influenced by environmental conditions
Location of delaminations, voids, and other hidden defects	Impact-echo; Infrared thermography (ASTM D4788); Impulse-response; Radiography; GPR	Sounding (ASTM D 4580); pulse echo; SASW; intrusive drilling and borescope	Assessment of reduced structural properties; extent and location of internal damage and defects; sounding limited to shallow delaminations.

Nondestructive Test Methods For Evaluating Repairs

Property/ Condition	Method		Comment
	Primary	Secondary	
Bond strength	Pulloff test(ACI 503R), CAN/CSA A23.2-6B;BS 1881: Part 207		
Bond quality (absence of voids at interface)	Pulloff test(ACI 503R), CAN/CSA A23.2-6B;BS 1881: Part 207	Impact-echo; SASW; Impulse-response	SASW good for layered systems
Injection of cracks or voids	Ultrasonic pulse velocity; Impact-echo	SASW	Proper geometry required for reliability of UPV