# Subject Index

A	C 230-80, 199(ftn, table)
Absorption (See also Initial rate of absorp-	C 246, 206
tion)	C 270, 8, 42, 44, 49, 50, 52(table), 193-194,
brick	199, 220
boiling water, 186(fig)	C 270-82, 32
cold-water 185(figs)	C 270-84 (also, UBC 24-20), 7-17, 21,
initial rate, 11, 186-187(figs)	22(ftn, tables), 148(table)
statistical methods for testing, 182-192	C 476-83, 21
tests on terra-cotta, 235	C 1072, 43, 45, 49, 51, 52(tables)
ACI (See American Concrete Institute)	C 1072-86, 8
Acrylic clear coating, 224	E 447-84, 23, 148(table)
Adhesion, terra cotta, 235	E 514, 43, 44(fig), 45, 46, 51-52, 53(fig),
Air content	54-55, 220-221, 234
extended plastic life mortar, 196	Avongard calibrated crack monitor, 276
Air content of mortar	
influence on bond strength, 9-11(fig),	В
22(tables), 32, 33	D
Air-cured cube strengths	BIA (See Brick Institute of America)
cement only extended plastic life mortars,	Binary operations, 179, 182
200(table)	Biological growth as a cause of glaze spalling,
Air content	231-232(fig)
extended plastic life mortar, 196	Bisque—failure between glaze, 228
Algae, 231	Bisque faults, 229, 231
Alkaline gel, 251	Block (concrete), literature review of masonry
Alkyl trialkoxy silane clear coating, 224	cracks, 257
Aluminum stearate clear coating, 223	Block pier specimens—materials, 20, 22(ta-
American Concrete Institute	bles)
ACI 318, Section 11.6—flexural shear and	BOCA (See Building Official Conference of
torsional shear, 120-121	America)  Rolling water absorbtion, brief 186(fig)
ASTM Special technical publications STP 589, 1	Boiling water absorption—brick, 186(fig) Bond, masonry, 33, 41-56
STP 778, 1	Bond strength
STP 871, 1	brick and mortar, 7, 8-9(figs), 14-15(figs),
ASTM Standards	33-34, 46-47, 52
C 67, 43, 46(table), 51, 52(table), 201	Bond wrench testing techniques, 33, 45(fig),
C 67-83, 169	46
C 67-85, 147	Brick
C 90, 263	masonry, 41, 42-43(figs), 169
C 109, 8	properties
C 109-86, 147	applied statistical methods, 185-192
C 110, 199(ftn, table)	(figs)
C 140-75, 21	Brick and mortar properties
C 144, 45, 223	bond strength, 7, 8(fig), 33-34
C 144-84, 149(table)	boiling water absorption, 186(fig)
C 150, 222	cold-water absorption, 185(figs)
C 185-80, 199(ftn, table)	compressive strength, 151(table), 187(fig)
C 207, 222-223	expansion, 189-190
C 216, 42, 46, 220, 263	initial rate of absorption (IRA), 11, 12(fig),
C 216-85a, 147	186-187(figs)

Compound lever loading system, 118

Brick and mortar properties (cont.) Compression pier specimens, materials, 20-21, 22(tabrick masonry prisms, 186-187(figs) bles) cracks, 63-67(figs), 158(fig), 186(figs) cube, extended plastic life mortar, 197prism, 45(fig), 147, 151(table) tests, 147 198(figs) Brick Institute of America (BIA) literature review on masonry cracks, 258 prism testing, 205(figs), 206, 207-210(figs) shear reinforcement and torsional shearing Compressive load as cause of tensile splitting, stresses, 120-121 Standard: Recommended practice for engi-62(fig) Compressive strength neered brick masonry, 120 brick masonry, 100, 169, 186-187 Technical note 28B, 96-97 Brick National Testing Program, 97-98 concrete masonry block, 21 **Brick prisms** mortar, 7-8(fig), 12-13, 33, 100, 151(table) terra-cotta, 237-243, 249 bond wrench test, 33, 45(fig), 46 compressive strengths, 100(fig) Compressive stresses of terra-cotta in-situ evaluation, 237-246 Brick spandrel panel, prefabricated, 118-145 Brick suction, log-normal fit, 184(table) Compressive tests, 145-147 Brick surface texture, 34-35(table, figs) Computer analysis, 103, 107, 116 Brick testing and evaluation, 42-44, 47-Concrete masonry, 21, 41, 58 Concrete masonry shrinkage 55(figs, tables), 97-98 Brick veneer construction, 41, 96, 103literature review on cracks, 260 Construction materials 109(figs), 116 specifications and standards, 167 **Bricks** Construction procedures literature review on masonry cracks, 263preconstruction testing program, 41 Construction Technology Laboratories(CTL) Brittle behavior, 28 research on masonry mortars, 33 BV/MS construction (See Brick veneer) Building Official Conference of America Cope, 46, 50-54 Corrosion (BOCA code), 120 Burnham and Root's Rookery Building, Chiextended plastic life mortar, 214, 218cago, 251 219(figs) literature review on masonry cracks, 257 masonry buildings, 57-95 Corrosion of embedded metals C terra-cotta glaze spalling, 230 Carbonation shrinkage, Crack classification, literature review on maliterature review on masonry cracks, 258 sonry cracks, 257 Crack repair methods, literature review on Cavity wall, 41 Cement content in extended plastic life mormasonry cracks, 276-280 tars, 199, 200(table) Cracking and spalling, 232(fig) Cement shrinkage, literature review on macorrosion induced, 91-95 (discussion) sonry cracks, 258 Chemicals, environmental masonry buildings, 28, 57-95(figs) terra-cotta glaze spalling, 231 Cracks, masonry compression, 63-67(figs), 69, 74-75(figs), Chimneys historic preservation and restoration repair, 158, 169, 186 literature review, 258-280 254, 256 literature review on masonry cracks, 275 repair methods, 276-280 Cladding Crazing, 229, 237 CTL (See Construction Technology Laboratoterra-cotta glaze spalling, 227, 230, 237 Clay brick masonry units ries) extended plastic life mortar testing, 201 Curtain walls, 60-61(figs), 63-90(figs), discussion, 91-95 Clay-masonry prisms, 34 Coatings-waterproofing, 220 Cyclic loading, 23-24, 145-147 Cold water absorption of brick, 185(figs) masonry piers, 23-24 Combined wind and gravity force, 118-144 slow-rate, 152

tests, 145-147(fig), 152, 156, 157(figs)

Deflections, 59(table), 70(fig), 140-143 Density functions, probability statistical methods applied to masonry, 184-192(figs) Design (See Seismic design) Deterioration, 92, 169, 227 Differential movement, 59-60 Displacements cracks, shear, 67, 75(figs) Distress, masonry buildings, 57-95 Distribution, statistical methods applied to masonry, 169-192 (equations, figs, tables) Dynamic analysis, tests of model masonry single-pier, 145-147 Dynamic response, 158-163(figs, tables) Dynamic shaking test, 152, 155(figs), 161 (fig), 162

# $\mathbf{E}$

Earthquake resistance, 145-147 Efflorescence, 211, 215(figs) Elasticity modulus, 189(fig), 206, 243 brick veneer testing program, 99 End-boundary condition, 96 Envelope curves, 147 Envelope of hysteresis, 147, 156 Environmental chemicals terra-cotta glaze barrier, 231 EPL (See Extended plastic life) Epoxy coating damage to terra-cotta, 233 Expansion, brick elasticity and compressive strength, 189(fig) freezing, 189(fig) literature review on masonry cracks, 265 moisture, 169, 190(fig) thermal, 190(fig) Expansion joints on curtain walls, 60-61(figs) Extended plastic life (EPL) mortars air content, 196 air-cured cube strengths, 200(table) cement content, 199, 200(table) clay brick masonry units, 201 compression cube, 197-198(figs) flexural bond test, 202, 203(fig) flow test, 195(fig) masonry units, 202(table) performance criteria, 193-194 physical properties, 202 strength retrogression, 198 suction effect, 197(fig) testing, 195-198(figs), 199-200 type M, N, S mortars, 199 water retention, 196(fig)

### F

Fabricated masonry assemblies for preconstruction testing, 41 Facade replacement program, 118 Facing brick performance standards, 42-43 Failure, 28, 153 Failure literature review on masonry cracks, 257 FEM (See Finite method analysis) Field survey of glaze spalling, 233-234(fig) Field tests for water infiltration of glaze spalling, 234(fig) Finite method analysis(FEM), 122 Flexural bond stress masonry walls, 97-98(fig), 107 ordinary vs computer analysis, 109, 112 (fig), 116 Flexural bond test extended plastic life mortar, 202, 203(fig) Flexural shear, 120 Flexural strength of brick masonry, 169, 187 Flexural tensile strength of masonry bonds, 233-234(figs) Flexural tension of brick, 52, 98(fig) Flow test, extended plastic life mortars, 195(fig) Foundation wall, literature review on masonry cracks, 267-271(figs) Fracture mechanics, literature review on masonry cracks, 258 Freeze/thaw damage to terra-cotta, 233 deterioration, 92, 169 resistance, 211, 214-215(figs, table) tests on brick and mortar, 46 Freezing expansion of brick, 189(fig) Frequency distribution, 170(table) Full-scale testing, 118-144

# G

Glaze spalling, terra-cotta
adhesion, 235
biological growth, 232(fig)
epoxy coatings, 233
failure between bisque, 228-229(figs)
preventive measures, 235
tests, 235
Glessner House, John J.
history, 251
restoration, 251-256
Granite restoration, 253-254
Gravity and wind force, combined, 118-144
Gravity loading, 120, 122
Grout conditions, 120

discussion, 91-95

Grout mixture for pier testing, ASTM C476cement-based mortar, 18, 19(table), 34 83, 21 cracks, literature review, 257-280 Grouting, 223 distress, 57-90—discussion, 91-95 literature review on cracks, 257-280 mortars, 33, 148-149(tables) H performance failure, literature review on cracks, 257 Histagram—sampling, 170 performance standards, 37, 41 Historic structure preservation and restoration, 251-256 piers, 18, 23-24, 145, 147 prisms, 21-23 (tables) Hystereses loops, 147, 156 properties coefficients of variation, 171(table) I vs reinforced concrete masonry, 58(table) Inertia force, 153 vs structural steel, 58(table) Initial rate of absorption-brick IRA, 11, 12restoration, 251 13(figs), 33, 186-187 shrinkage, 206, 211-217 standards, inadequacy of ASTM C 270, 7-In-situ evaluation of compressive stress on terra-cotta, 237-243 seismic design, 147 Inspection, literature review on masonry cracks, 257 terra-cotta, 227 Interaction, 57 testing and evaluation program, 21, 41 Masonry assemblage shrinkage, 206 IRA (See Initial rate of absorption) Masonry buildings, distress, 60-90(figs) 94-L Masonry units, extended plastic life mortars Leakage, water (See Water leakage) physical properties, 202(table) Lichen, 231 Masonry walls Literature review on masonry cracks, 257-280 flexural bond stress of brick veneer/metal Load stress distribution on brick spandrel stud, 97 panels, 126-131(figs) flexural strength of brick panels, 187(fig) performance, 41, 52(table), 97-99(fig, ta-Load factors (See also Dynamic loading, Cyclic loading) deflection, 140-143(figs) preconstruction testing, brick veneer, 41, failure, 153 Material properties, 97-98, 147, 148(table) rotation, 141(fig), 143-144(figs) testing, 152-153 Material properties of brick, 149 Materials, strength, 97 Load in tie, 108(fig) Loading bents, elevation, 134-139(figs) Materials testing, 20, 22, 169-192 Maximum and minimum properties Loading, gravity, 120, 122 Loading mechanisms and procedures, test statistical methods for brick masonry samplan, 132, 133(fig) pling and testing, 178-179 Loading test, 152(table), 156, 157(figs) Mean and variance, 170-175(equations, ta-Log-normal distribution, 183-185(figs, tables) Mechanical properties of materials, 147 bles) Metal Lath/Steel Framing Association (ML/ SFA), 96-97 M Metal studs, 103, 110-116(figs, tables) Maintenance of terra-cotta, 233 Metal tie flexibility, 103 Malaysia Pavilion buildings, 96 ML/SFA (See Metal Lathe Steel Framing As-Marshall Field Warehouse, Chicago, 251 sociation) Masonry Model masonry piers bond strength, 33-34 structural behavior, 145-147, 148(table) brick and mortar, 220-224 test results, 156, 157(figs), 158-165 buildings Modulus of elasticity in compression, 99, 189, 206, 243 corrosion, 57-95 curtain walls, 57-60 Model prisms

stress-strain curves, 149(fig)

Moisture expansion, 169 Performance standards of extended plastic Moisture expansion, terra-cotta tests, 235 life mortars, testing, 193-199(figs) Performance standard, mortar Mortar batch properties, 199(table) inadequacy of ASTM C 270, 7-17 bed joint—evaluation testing, 42 Permeability of water, 44-46 bond strength, 7-9, 46-47, 52 Permeability of water in terra-cotta glaze, 231 brick prisms, 34, 147 Permeance testing, 222(fig), 223 (table), 224 compressive strength, 34, 100(fig), 151 Physical properties of extended plastic life mortars, 202 (See also Mortars, Ex-(table) cyclic loading, 145, 149(table) tended plastic life mortars) joints, preservation of Glessner house, 251-Pier specimens, 20-21(figs) Pier testing, 153-155(figs) Piers, masonry, 18-32, 145, 147 literature review on masonry cracks, 258 model masonry and model brick properties, Plastic life mortars, extended, 189-194 148-149(tables) Portland cement-based mortar, 18, 19(table) extended plastic life, 194 performance standards, 37, 41 testing, 21, 41-56, 194 Preconstruction testing of masonry materials, prisms, 45, 147, 151 41. 54-55 shaking, 145, 149(table) Prefabricated brick panels, 118 shrinkage, literature review, 260 Prefabricated panels, 62, 68-70 Preservation, historic, 252 terra-cotta, effect of water infiltration, 235 Prisms Mortar standards brick masonry compressive strength, 188inadequacy of ASTM C 270, 7-17 189(figs), 202, 205(figs), 219 Mortars cement-based, 18-19, 34 clay-masonry, 34 compressive strength, 100, 101(figs), 219 extended plastic life, 193-194 masonry, 21-23(tables), 145-147 masonry, 33, 148-149 mortar-brick, 34, 45-46, 147, 151 types M and S, 19(table), 21, 22(tables), 32, Probability density functions, 171-185 (equations, figs, tables) type N, 147—compared to extended plastic life mortar, 199 Profilometer, surface, 34 Moss, 231 Property specifications Movement joints, 57-95 inadequacy of ASTM C 270, 7-17 Movement (structural) in masonry buildings, 57-60, 94-95 Q literature review on masonry cracks, 257-Quasistatic cyclic loading, model masonry 258, 259(figs), 273-274 pier, 145-165 R

National Historic Preservation Act of 1966, 252

Ordinary conventional analysis strength of materials, 97 Ordinary vs computer analysis, flexural bond stress, 109

Penetrometer test, extended plastic life mortar, 196(fig) Performance failure of masonry literature review on cracks, 257

Ready mix, 193

Reinforced concrete masonry properties compared to masonry and structural steel, 58(table) Reinforced structural masonry, 118-144 Reliability, 182 Repair, literature review on masonry cracks, Residual compressive stresses, 237 Resistance, 193, 211, 214-215 Restoration of terra-cotta glaze, 235, 250 Restoration—Glessner House, 251-256 Retarded strength, 193 Richardson, Henry Hobson-design architect, 251 Rigid connections, 57

Strain measurements, 242, 243(table)

Roofs, literature review on masonry cracks, Strength compressive, 169 Rotation, 141, 143-144 flexural, 169 Strength of materials analysis, 99-102(figs), 116, 121 Strength retrogression, extended plastic life Sampling, brick masonry, 169-177 (tables, mortar, 198 Stress distribution, brick spandrel panels, Sampling and testing of concrete masonry 124-131(figs) units, 21 Stress due to stiff masonry, 57 Sarabond mortar additive, 91-95 Stress failures of terra-cotta, 237-240 Scaffolding for historic restoration, 256 Stress in mortar, 108(fig) STRESS program-computer model, 103 Scale factor, 145 Stress relief, 243, 245-248(figs, tables), 249-SCPRF (See Structural Clay Products Research Foundation) Sealant joints, literature review on masonry Stress-strain curves of model prisms, 149(fig), cracks, 261, 263 205-210(figs) Stress-strain data for terra-cotta, 244(fig) Seismic design testing, 147 Seismic zones, use of masonry cement, 18 Structural behavior, 147 Shaking, 147, 153-155(figs), 158-165 Structural Clay Products Research Foundation(SCPRF), 97 Shear behavior of masonry, 18, 25-31(figs), 67, Structural steel properties 147 compared to masonry and reinforced concrete masonry, 58(table) displacement cracks, 75(figs) literature review on masonry cracks, 258 Studs, computer analysis vs ordinary analysis, reinforcement(BIA), 120 96-116 Sheer strength (See Shaar behavior of ma-Studs, metal, 103, 110-116 Suction effect, extended plastic life mortar, sonry) Shear stress, 156, 158(fig) (See also Shear be-197(fig) Surface profilometer, 34 havior of masonry) Shelf angles, literature review on masonry Surface texture parameters of brick, 34 cracks, 274-275 Shrinkage, 206, 211, 212-217(figs) Т Shrinkage, literature review on masonry Temperature changes, effects on masonry cracks, 258-261 buildings, 78(fig) Single piers, 147 Tensile splitting due to compressive load, 62 Slow-rate cyclic loading, 152 Soft joint, 96 Tension due to temperature changes, 78(fig) Spalling of terra-cotta, 227-228, 233, 237 Terra-cotta cladding material, 237 Span-deflection ratios, 103, 111 Spandrel beam masonry piers, testing 23compressive strength, 237-243, 249 facade, 237 25(figs) freeze/thaw damage, 233 Spandrel panel, prefabricated brick analysis and testing, 118, 119(fig) glaze spalling, 227-228 installation, 229-230 Specifications performance standards of masonry maintenance, 233 inadequacy of ASTM C 270, 7-17 moisture expansion, 235 Spring constant, 96 restoration, 227 spalling, 227-231 Square panel, 145 Standard deviation sampling, 171 strain relief tests, 237-243 stress failure, 237-240 Static behavior, 165 Statistical methods for brick masonry thermal coefficient tests, 235 sampling and testing, 169-192 thermal expansion, 229 Steel grout void conditions, 120, 121 water infiltration, 235 Tension tests, 147 Stiffness degradation, 96, 147 Strain in terra-cotta, 230, 237-243 Test results of mortar performance standards, Testing brick masonry, statistical methods for sampling and testing, 169-192 concrete masonry units, ASTM (C 140-75), 21, 41 extended plastic life mortars, 195-200 load factors, 152-153 model masonry, 147, 152(table) water permeability, 44-46, 53, 220-224 Thermal coefficient tests on terra-cotta, 235 Thermal expansion, 190(fig), 229 Tie flexibility, 103, 116 Torsional behavior of brick spandrel panel, 122(fig) Torsional sensitive, C-shaped cross section, 118 Torsional shearing stresses, 120 Tuckpointing, 222-224, 252-254, 256 Type M mortar, 21, 32, 99 Type N mortar, 147 Type S mortar, 21, 32, 97, 99 Type M, N, S—extended plastic life mortars,

# U

UBC (See Uniform Building Code)
Uniform Building Code (UBC)
allowable shear stresses, 18, 32
chapter 30. sect. 304(b), 249
Unique compound lever loading system, 118144

# V

Variance statistical method for brick masonry sampling and testing, 170-175 Variation coefficient masonry properties, 171(table) Veneer, brick, 41, 103 Vertical displacement, 156
Vertical load tests, 120
Vibration, literature review on masonry
cracks, 275

### W

Wall height, 104-106(figs) Wall panels, 187 Wall stress, 104-106(figs) Walls (See also Curtain walls) brick veneer, 103-107(figs) concrete masonry, literature review on masonry cracks, 261-274(figs) exterior performance, 41 masonry buildings, 57, 108-109(figs), 116 Water and salt deposits, effect on terra-cotta, 231, 233 Water infiltration of terra-cotta glaze, 235 Water leakage in mortar-brick combinations, 11, 12(figs), 13-15(figs), 16(table), 46-47, 50-53(figs, table) Water leakage resistance, influence of air content and water flow, 16(table) Water loss shrinkage, literature review on masonry cracks, 258 Water permeability test for brick, 44(fig), 46, 53(fig) Water permeance, 220-224, 258 Water retention of extended plastic life mortars, 196(fig) Water retention of mortar, relation to bond strength, 8-9(fig), 33 Water-to-cement ratio for strength development, 9 Waterproof coatings, 223-224 Wind and gravity force, 118 Wind frames, 70-72(figs) Wind load, 104-106(figs), 120, 122, 123(fig) Wind load stress distribution, 128-131(figs) Window panel, 73(fig)