Absorption, tests, 65
Adhesive, 20
Adjacent work, installation tolerances, 53
Allowable-stress design, 4, 24, 31-32
safety factor, 117
Anchorage, 19, 36
brake-formed kerf clip, 98, 100
capacity and effective engagement length test, 125
correct device configuration, 78-86
correction of points of contact, 82-83
slippage, 84-86
design rules, 78
moisture collection or retention, 84
weight support, 81-82
design and installation philosophy, 77
determinacy, 77-78
device limit state, 43
device types, 89-97
erk anchor, 90
rod anchor, 90-93
rod-and-plug anchor, 92-94
tooled-rod anchor, 94-96
wire tie anchor, 95-96
direct attachment, 87
displacement analysis during tests, 74
durability, 78
dependence of end-prying, 75
extruded, 99-101
function, 77
handling stone during installation on, 86-89
indeterminacy, 77
inspectability, 78
installation standards, 88
joint design, 51
kerfed liner block, 100-101
materials of construction, 88-89
movement accommodation, precast-supported stone, 54
performance factors, 57
resistance, 73
sealed chamber testing, 75
shank-with-disc slot, 100-101
subframes, 87-88
tests, 69-73
vulnerability to material strength inconsistencies, 66
see also Kerf
Anchor capacity and effective engagement length test, 125
data collection requirements, 128
data evaluation, 128-129
interpretations and conclusions, 129
preparations, setup, and execution, 125-129, 125-128
report example, 126-129
ANSI A58.1, 34
Architecture
aesthetic intent, 44
future, modern stone cladding and, 5
integrity, 3
medieval, 9
potential future, 20-21
rejection of traditional styles, 15-16
style and technology changes, 7-8
Assembly, capacity tests, 73-76
ASTM C 97, 30-31, 34, 38, 61, 65, 112
ASTM C 99, 35, 38, 66-69, 112-116, 119-121
ASTM C 119, 58
ASTM C 170, 35, 58, 66, 112
ASTM C 295, 58
ASTM C 331, 58
ASTM C 615, 58
ASTM C 616, 58
ASTM C 629, 58
ASTM C 880, 35, 37, 58, 62, 64, 66-69,
76, 112-113, 114-116, 119-121, 124
ASTM C 1201, 58, 130, 132
ASTM C 1242, 58
AT&T Chicago, 43, 85
Backup, relative stiffness, 88
Bearing wall, evolution, 8-9
Biblioteque Ste-Genevieve, 9-10
Boundary conditions, 1, 3, 40
correctable, 45
Brittle stone, 61
Buffington, Leroy, 12-13
Building codes, 30
Buildings
composite metal-and-masonry construction, 9
cyclical dynamics, 56
evolutional dynamics, 56-57
iron skeleton, 9
Calcite, mineral composition, 60
Cavity
comparmentalization, 56
ventilation, 56
Climate factors, 37
Climatic performance criteria, standards for, contract documents, 42
Cloudscraper, 12-13
Complete assembly full-panel chamber test, 76, 129-133
data collection requirements, 132
data evaluation, 132
interpretations and conclusions, 133
objective and purpose, 131
preparations, setup, and execution, 131
report example, 130, 132
Consistency, 35
anchor design, 77
evaluation, 44
Consolidated uncertainties, 31
Coping bracket, 80
Corrosion, 56
Cubic shapes, 19-20
Curtainwall
early development, 13-14
masonry, 13
metal, adapting stone to, 18
transfer of facade weights to skeleton, 15
Density, 61
Design
existing practices, 41
principal goal, 40
responsibilities, professionals, 1-2
Design loads, 30-31
Diamonds, synthetic industrial, 20
Diamond wire saws, 17
Dimension stone, 7, 18-20
Diorites, 59
Dolomites, 59, 61
Dowel pin anchor, 104-105
inclined, 105-106
Dowels, 90-93
application and optimization, 102-112
conceptual analysis, 107
diameter, 110
hole depth, 110-111
hole diameter, 107
location within panel, 112
shape maintenance under load, 111-112
stress on stone, 107
structural capacity, 102, 104
support mechanisms, 106
Drawings
shop, 45
standards for, contract documents, 42
Dynamic movement criteria, standards, contract documents, 42
Eisenshank, 92
Empirical safety factor approach, 27
Engineering
analysis, evolution, 17-18
process, structure, 40
responsible, 24
sequence, 40-41
Environmental problems, early thin walls, 16
Evaluation
consistency, 44
initial, 43-44
significance of, 4
Exemplars, significance, 57
Fabrication
allowable, contract specification, 44
dimensional tolerances, 53
individual stone tolerances, 46
Facade
freeing from frame, 15
other elements, 55
Face plane, variation from, 46
Failure, 36
anchor design, 77
engineering definition, 28
limiting risk, 29
risk of, 28
Feldspar, mineral composition, 60
Finish
effects on structural performance, 62
factors, 37
Finite-element structural analysis, 117-123
comparison to initial standard strength
method tests, 121
comparison to preliminary panel test, 124-125
data collection requirements, 119
data evaluation, 120-121
interpretations and conclusions, 121
objective and purpose, 117-118
panel analysis model, 117-118
preliminary panel test, 121-123
preparations, setup, and execution, 118-119
Fireproofing, 10-13
Flexural strength, tests, 67, 114
Flexural stress distribution, 36
Fracture, 28
Freedom-of-movement, 51
Freeze-thaw cycling, 37
Full curtainwall mock-up dynamic
water test, 74
Full panel chamber test, 74
Gang saw, 19
Garnet, 61
Gasket durometer, 52
Gasket materials, 30
Geological formation, 58-61
Granites, 35, 58-59
Gravity loads, 34
Grout, non-shrink, 50
Hardness, 61
Heterogeneous stone, 61
Holes, depth, 110-111
Home Insurance Building, 11, 13
Horneblende, 60
Hot spots, 30
Igneous stones, 58-59
Inspectability, anchorage, 78
Installation
handling and placing stone onto
anchorages, 86-89
standards, 88
tolerances, 44, 53
Interfacing work, 45
limits and dependencies, 45
International Style, 7, 13-16
Iron framing
encasement for fire protection, 9-10
multistory, 9-10, 12-13
Iron skeleton, buildings, 9
Jenney, William LeBaron, 11, 13
Joint filler, functions and capability, 48-50
Jointing, automated, 20
Joints
design at anchors, 51
horizontal widths, factors, 56-57
in-plane shear, 55
isolating components occupying, 51-52
proper design widths, 52
sealant backup, 51-52
shear, 55
sizing
anchorage movement, precast-supported stone, 54
cavity compartmentalization, 56
cavity ventilation, 56
corrosion, 56
cumulative movement affects, 54-55
dynamic effects, 53-56
internal moisture collection, 56
moisture control, 56
moving joint alignment, 55
other facade elements, 55
static effects, 53
structural isolation, 55
soft, 51
vertical widths, factors, 57
Kerf
capacity, 72
effective length of engagement, 72
engaging leg thickness, 103
lateral and vertical reaction points of
contact, 82
proper application and optimization, 97-103
capacity, 99
depth of contact, 99
leg contact, 99
maximum width of slot, 97
minimum stone material strength, 99
minimum thickness of fin, 98
parameters affecting capacity, 97-99
slot depth, 103
slot length, 103
slot widths, 103
Kerf anchor, 90
breakout test, 70
capacity test results, 127
conceptual analysis, 101
independent pin test, 71
independent test, 70, 127
location within panel, 103
shape maintenance under load, 103
support mechanisms, 101
types, 89
Kerf bar, 36
Level, variation from, 46
Limestones, 35, 59
Limit-state approach, 23-25, 58
Limit-state function, 29
Linear building lines, variation from, 46
Liner blocks
kerf, anchor, 100-101
lateral and vertical reaction points of
contact, 82
Load-and-resistance factor design, 23-25
full, research necessary for
development, 58
Load derivation, 30-31
Load factors, 34
Local codes, standards for, contract documents, 42

Marble, 35, 59
Margin-of-safety, material strength variability and, 63
Masonry, curtainwall, 13
Material, quality, 88-89
Material strengths, 35-36
anchor design, 77
ASTM standard tests, 112-113
data evaluation standard tests, 115, 117
minimum, kerf, 99
standard tests
comparison to finite-element analysis, 121
data collection requirements, 114
data evaluation for historical tests, 114
historical tests, interpretations and conclusions, 114-115
interpretations and conclusions, 115-117
objective and purpose, 112-113
preparations, setup and execution, 113
report, 115
variability, 63

Metals
in contact with stone, 47
curtainwall, adapting stone to, 18
integrity and compatibility, 47-48
noble, 48
not in contact with stone, 48
separations, 48

Metamorphic stones, 59-60
Mica, 60
Microcracking, from process finishes, 37

Minerals
accessory, 60
compositions, 60
esential, 60
geological compositions, 58
original, 60
secondary, 60
structure, 60

Modulus of rupture, 66, 114

Moisture
collection or retention, anchorage, 84
control, 56
internal, collection, 56
in stone, 62

Mortar
staining from, 50
weatherproofing joints, 50

Movement, accommodation between floors, 81
Nonisotropic stone, 61
Nonlinearly elastic stone, 62

Olivine, 61
190 South LaSalle Street, 105-109

Originality factors, 37
Overloads, 33
Panel corners, concentrated movement, 55
Panel supports, nonplanar displaced arrangement, 73
Performance factors affecting, 3
proofs, 43
Pin anchorage
    lateral and vertical reaction points of contact, 83
test, 71
Plumb, variation from, 46
Pneumatic diamond drilling, 16
Points of contact, anchorage, 82-83
Polishing line, 18-19
Preliminary panel test, 121-123
    comparison to finite-element analysis, 124-125
data collection, 123
data evaluation, 124
example report, 122-123
interpretations and conclusions, 124-125
objective and purpose, 121-122
preparations, setup, and execution, 122-123
Probabilistic evaluation, 33
Probability of failure, 29-30
Pyrite, 61

Quality assurance tests, 64
Quartz, 60
Quartzite, 60

Radial diamond saw, 20
Reliability, 29-30
Reliability indexes, 30
Resistance factors, 35
Responsibilities, 4-5
Restraining stone panel, avoiding movement, 50-51
Retention system, performance record, 46-47
Risk compared with consequences, 28-29
degree of, 29
Rod anchor, see Dowels
Rod-and-plug anchor, 92-94
Rupture, 36
    modulus, 114
    modulus of, 66
Safety factors, 4, 27, 31-32
allowable-stress design, 117
assigning, 35
Sample size, effects on structural performance, 62
Sandstone, 59
Schist, 60

Sealants
    backup in joints, 51-52
    matching modulus to project, 52
    maximum material capabilities, 52
    movement range, 52
    weatherproofing joints, 49

Segregated uncertainties, 31-32
Service load, factored, 32
77 West Wacker, 110-111
Shanks, headed, lateral and vertical reaction points of contact, 83
Shear, joint, 55
Skin, separate from skeleton, 15
Skyscrapers, 14, 24
Slate, 59-60
Slippage, anchorage design, 84-86
Specifications, standards for, contract documents, 42
Specific gravity, bulk, tests, 65
Staining, from gasket materials, 50

Standards
    ASTM, material strength tests, 112-113
    installation, 88

Stone
    characteristics, 2
    consistencies, 35
dimensional changes, 56
    nonlinear elasticity, anchor design, 77
    performance factors, 57
    physical properties, anchor design, 77
    predicting stress, dowel anchor, 107
    properties, 40
    structural role, 1
    tradition as shelter, 8

Stone cladding
    fundamentals, development, 2-5
    structural functions, 2
    system originality, 37

Stone designer
    expertise, 46-47
    retention system performance record, 46-47
    specialist qualifications, 46

Stone fabrication, 19
Stone material limit state, standards, contract documents, 42-43

Stonework
    preceding work, conformance, 45-46
    standards for depicting and specifying, 41-47
    allowable stone fabrication and installation tolerances, 44
    anchorage device limit state, 43
    architectural aesthetic intent, 44
    climatic performance criteria, 42
    consistency evaluation, 44
    in contract documents, 42-45
drawings, 42
dynamic movement criteria, 42
initial evaluation, 43-44
interfacing work, 45
local codes, 42
performance proofs, 43
shop drawings, 45
specifications, 42
stone material limit state, 42-43
thermal resistance and performance
criteria, 42
wind load resistance and
performance criteria, 42
tolerances for finished exterior, 45-46
Stress
criteria for, 4
predicting on stone, 103
Stress-state comparisons, 67-68
Stress-strain behaviors, 62
Strongback, 79-80
Structural isolation, 35
Structural materials, comparative
reliabilities and failure probabilities, 30
Structural permanence, 3
Structural reliability, cost, 30
Structure, of stone, 61
Subframes, 87-88
Support framing, 36
Swingstage, 86
Terracotta, 7
Tests, 3-4
anchorage evaluation, 69-73
evaluation process, 64
historical, 64, 111, 113
material strength, 114-115
initial, 64
interpretation, 3-4
interpretation of values, 65
modifications to standardized, 68
non-standard unit-evaluation, 69
project-representative material, 64
quality assurance, 64
sequence, 57
Thermal resistance and performance
criteria, standards, contract documents, 42
Tooled-rod anchor, 94-96
Travertines, 59
255 Fifth Street, 109-110
Uncertainties
analysis of individual, 57-58
consolidated, 31
overloads, 33
segregated, 31-32
understrength, 33
Union Central Life Building, 13
Variability, in natural stone, 63
Wall system, attachment, 79
Weathering tests, accelerated, 4
Weight support, anchorage, 81-82
Wind loads
lateral, 34-35
resistance and performance criteria,
standards, contract documents, 42
Wire tie anchor, 95-96
Workmanship, consistent, weatherproofing
joints, 51
Yield, 28