## Subject Index

### A

<table>
<thead>
<tr>
<th>AASHTO. American Association of State Highway and Transportation Officials</th>
</tr>
</thead>
<tbody>
<tr>
<td>AASHTO Materials Reference Laboratory, 30</td>
</tr>
<tr>
<td>Acceptable limits of variability (see Illinois, India, Saudi Arabia)</td>
</tr>
<tr>
<td>ACI (see American Concrete Institute)</td>
</tr>
<tr>
<td>Alkali content</td>
</tr>
<tr>
<td>cement samples, India, 73, 77</td>
</tr>
<tr>
<td>Alkali reactive aggregates</td>
</tr>
<tr>
<td>reaction to high alkali cements in concrete, 40</td>
</tr>
<tr>
<td>Alkali-silica reactions, India</td>
</tr>
<tr>
<td>as cause of stress to dams, 77</td>
</tr>
<tr>
<td>American Concrete Institute (ACI)</td>
</tr>
<tr>
<td>318 building code, 27</td>
</tr>
<tr>
<td>AMRL (see AASHTO Materials Reference Laboratory)</td>
</tr>
<tr>
<td>ANOVA. Analysis of variation, 15</td>
</tr>
<tr>
<td>ASTM Standards</td>
</tr>
<tr>
<td>C 109: 15</td>
</tr>
<tr>
<td>C 109-80: 81</td>
</tr>
<tr>
<td>C 109-86: 15, 37-38, 43</td>
</tr>
<tr>
<td>C 114-85: 82-87</td>
</tr>
<tr>
<td>C 127-84: 29</td>
</tr>
<tr>
<td>C 131-81: 29</td>
</tr>
<tr>
<td>C 150-85a: 3-4, 15</td>
</tr>
<tr>
<td>C 204-84: 87</td>
</tr>
<tr>
<td>C 430-83: 38</td>
</tr>
<tr>
<td>C 670-84: 37</td>
</tr>
<tr>
<td>C 778-80a: 82, 83</td>
</tr>
<tr>
<td>C 917-82: 1-5, 14-15, 22-29</td>
</tr>
<tr>
<td>ASTM strength requirements, 5</td>
</tr>
</tbody>
</table>

### C

<table>
<thead>
<tr>
<th>CCRL (see Cement and Concrete Reference Laboratory)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
</tr>
<tr>
<td>strength evaluation, 22, 23-24 (table)</td>
</tr>
<tr>
<td>statistical analysis, 42-43</td>
</tr>
<tr>
<td>Cement and Concrete Reference Laboratory (CCRL)</td>
</tr>
<tr>
<td>cooperative studies with NBS units, 40</td>
</tr>
<tr>
<td>data application, 37-42</td>
</tr>
<tr>
<td>laboratory inspection program</td>
</tr>
<tr>
<td>conformance of test equipment, 30-35</td>
</tr>
<tr>
<td>conformance analysis, 34 (table)</td>
</tr>
<tr>
<td>overview, 31</td>
</tr>
<tr>
<td>participation summary, 32 (table)</td>
</tr>
<tr>
<td>sample programs, 34-36, 73</td>
</tr>
<tr>
<td>standards development, 30-31, 37, 41</td>
</tr>
<tr>
<td>technical studies, 37</td>
</tr>
<tr>
<td>Cement and Pozzolan Unit, Waterways Experiment station (WES), 14</td>
</tr>
<tr>
<td>Cement mixes</td>
</tr>
<tr>
<td>compressive strength variability effects, Saudi Arabia</td>
</tr>
<tr>
<td>due to mix proportions of mortars, 82</td>
</tr>
<tr>
<td>due to sand grading, 82-84</td>
</tr>
<tr>
<td>due to water/cement ratio, 82</td>
</tr>
<tr>
<td>Cement mixing methods, Saudi Arabia (see also Concrete mix design, Mixing methods)</td>
</tr>
<tr>
<td>effect of different mixing methods, Saudi Arabia, 85-86, 92</td>
</tr>
<tr>
<td>Cement mortar</td>
</tr>
<tr>
<td>compressive strength, Saudi Arabia 23-24 (table), 25-26 (figs), 27-29, 89</td>
</tr>
<tr>
<td>Cement plants</td>
</tr>
<tr>
<td>plant technology</td>
</tr>
<tr>
<td>India, 66</td>
</tr>
<tr>
<td>Saudi Arabia, 80</td>
</tr>
<tr>
<td>Cement product (concrete)</td>
</tr>
<tr>
<td>Saudi Arabia, 22-29</td>
</tr>
<tr>
<td>Cement production</td>
</tr>
<tr>
<td>India, 66-67</td>
</tr>
<tr>
<td>Saudi Arabia, 80</td>
</tr>
<tr>
<td>Cement Quality Management System (CQMS)</td>
</tr>
<tr>
<td>data analysis procedure, 14-16</td>
</tr>
<tr>
<td>manufacturers' data, 75 sources of portland cement, 14-15</td>
</tr>
</tbody>
</table>

### B

<table>
<thead>
<tr>
<th>Belgian Research Institute of the Cement Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>heterogeneities—statistical analysis by segmentation, appendix tables, 55-64</td>
</tr>
<tr>
<td>laboratories testing of standard deviations, 43</td>
</tr>
<tr>
<td>Buildings</td>
</tr>
<tr>
<td>CCRL standards, 34, 37</td>
</tr>
</tbody>
</table>
UNIFORMITY OF CEMENT STRENGTH

standard deviations, 21 (tables)
variations among sources, 16-17
Cement sampling and testing, 15, 73
Cement strength
effect of mold release agents on, 38
validity of records, 49-53
variability
analysis of, 48
effecting concrete performance, 4
methods for measuring differences
mean square, 44-45
stochastic model, 45-46
statistical analysis, 42-43
test procedures, Saudi Arabia, 80-81
Cement testing, 22-23
strength results of samples, 23-24 (table)
Cement uniformity (see also Illinois Department of Transportation, India, Saudia Arabia)
in concrete mix design
Illinois Dept. of Transportation, 4 (C 917 reports), 6-11 (tables)
Saudi Arabia, 22, 23-24 (table), 29
Cements, India, 66-79
Chromatography, ion, 40
Coal used in cement production, India, 70
CMRL (see Construction Materials Reference Laboratories)
COMS (see Cement Quality Management System)
Compaction method of cement mixing. Saudi Arabia
value of compressive strength, studies, 86, 92
Composite sample cements
standard deviation compared to grab-sampled cements, 21 (table)
Compressive strength
effect of water/cement ratio
India, 76-77
Saudi Arabia, 25-27, 80-83
Illinois Dept. of Transportation, 4-11
C 109 data, from CQMS records, 16, 17 (table)
variability effect, Saudi Arabia, 80-83
within-plant data, C 109 summary WES, CQMS records, 17 (table)
Compressive strength testing
cement and concrete
Illinois, 3-11
India, 67-68 (table)
histograms of compressive strength, 74-76
Saudi Arabia, 22, 23-24 (table), 27-28, 80-92
sample uniformity, 27 (table)

strength data
C 109 mortar cube strengths, 13
C 917 reports, 7-12 (tables)
within-plant variation, 18
Compressive strength uniformity (see also Concrete mix design)
Illinois Dept. of Transportation, 4-11
India, 67-68
Saudi Arabia
evaluation, 22, 29
standard deviation, 91
variability, 80-97 (tables)
Concrete mix design
cement strength variability
Illinois, 4-5, 8-13
India, 67-68 (table)
Saudi Arabia, 82-86 (figs, tables)
Concrete performance
factors affecting, 4
Concrete testing
Belgium, 42-54
appendix tables, 55-64
Illinois, 3-13
India, 66-79
Saudi Arabia, 22-29, 80-92
Construction materials
standards development for cement and concrete, 30-34
Construction Materials Reference Laboratories (CMRL), NBS
cement and concrete testing—laboratory inspections and evaluation, 30-34 (tables)
Corps of Engineers (see Cement Quality Management System)
CQMS (see Cement Quality Management System, Corps of Engineers)

D

Data analysis
cement strength records, 42-43
Data analysis procedure
mortar cube test, 15-16
Duncan’s New Multiple Range Test
statistical analysis, 15

E

European standards
EN-196, 43
Evaluation
compressive strength uniformity, 22, 29
CCRL laboratory evaluation
conformance analysis, 32-36
test equipment and procedures, 32-34
(sample programs, 34, 35-36)

F
Fineness control
cement samples, 87-89 (tables)

G
Grab sampled cements
compressive strength variability, 15
standard deviations from composite sampled cements, 21 (table)
data analysis procedure, 15-16

H
Heterogeneities (see also Cement strength, Variability)
analysis of variance, 48
cement strength records validity, 49
methods for measuring
mean square, 44-45
stochastic model, 45-46
Histograms, compressive strength
India, 74-76

I
IDOT (see Illinois Department of Transportation)
Illinois Department of Transportation cement uniformity
acceptance testing, 4-5
control limits, 3-13
requirements, C 197 reports, 6-11 (tables)
variability, 4-5
India. National Council of Cement and Building Materials (NBS), 67
Indian Standards Institution (ISI) cement production methods and specifications
ordinary portland cement (OPC), 66-67
portland pozzolana cement (PPC), 66-67
portland slag cement (PSC), 66-67
certification mark scheme, 72
production methods, 66
statistical analysis of compressive strengths and physical characteristics of cements, 68
ion chromatography (see Chromatography)

L
Laboratory evaluation
CCRL inspection program, 31-36 (tables, figs)
Light spectrophotometry (see Spectrophotometry)

M
Mean (see Standard deviation, Statistical methods, variability)
Mean square successive difference method for measuring heterogeneities, 44-45
Mix proportions
compressive strength
effect on variability, 82
effect of mixing methods on, 85, 92
Mixing methods
according to different standards, 85 (table), 92
Mold release agents
effects on cement strengths, 38
Mortar cube tests, CQMS-WES
ASTM C 109 compressive strength data and analysis, 15-17
Mortar prisms
standard deviation test results, 92

N
National Council of Cement and Building Materials (NCB), India
quality control of cement production, 67
National Sand and Gravel Assoc., 40
NCB [see National Council of Cement and Building Materials (NCB), India]
NSGA (see National Sand and Gravel Assoc.)

O
Ordinary portland cement (OPC)
India, 66, 70, 73

P
Physical characteristics of cement
India
statistical analysis, 73
water-cement ratio, 67, 77-78
Portland cement testing
Illinois, for strength uniformity standards, 6-12 (tables)
India, 66-73
standards development for, 30-32
UNIFORMITY OF CEMENT STRENGTH

Portland pozzolana cement (PPC)
India, 66–73
Portland slag cement (PSC)
India, 66–73
Pozzolan (see Waterways Experiment Station (WES), Cement and Pozzolan unit)
Prism specimens, 89

Q
Quality control (see also Cement and Concrete Reference Laboratory, Evaluation, Laboratory evaluation, Standards)
cement production
India, 79
Saudi Arabia, 22, 29, 80, 92
fineness of cement, 87
variability of strength, 87

R
Raw materials for cement production, India, 66–70

S
Sampling and testing
cement and concrete data bases, 37
effect of mortar cube type on standard deviation, 16–21
India, 67–73
Saudi Arabia cements
prism specimens, 89
quality control, 87
sample uniformity, 27, 90
statistical analysis of compressive strength, 68
statistical analysis of physical characteristics, 68
Sand grading
variability effect on compressive strength, 82–84
Saudi Arabia (see also Compressive strength testing)
cement mix variability, 82
cement production capacity, 80
cement strength, 80–87, 92
variations due to test procedures, 81–85
Saudi Arabian Standards Organization (SASO)
SSA 142/1979, 81, 87
Saudi Kuwaiti Cement Manufacturing Co. (SKC)
compressive strength tests, ASTM C 917-82
cement mortar, 23–24 (table), 29
concrete, 27
cement cylinders, 28
variability, 27
Segmentation technique
applications, 45
cement strength heterogeneities, 47
stochastic model, 45–46
statistical analysis, appendix tables, 54–64
Sieve correction factor, 38
residues, 39 (figs)
SKC (see Saudi Kuwaiti Cement Manufacturing Co.)
Spectrophotometry, visible light, 40
Standard deviation, 83–84
Illinois
analysis of variance (ANOVA), 15
in compressive strength, 16–21 (tables, figs)
India, 66–79
Saudi Arabia
compressive strength due to sand grading, 85
due to mixing methods by different standards, 85 (table)
due to water-cement ratio, 83
test results, 91 (table), 92
variability, 81–82
segmentation technique for measuring heterogeneities, 47, 55–64 (tables)
Standards, ASTM (see also ASTM standards)
CCRL evaluation of laboratory conformance 32–34
sample programs, 34–36
Standards, compressive strength testing
ASTM C 109-80, 81, 82 (table)
C 204-84, 87
C 778-802
British, BS 12/1978, 82
ACI, 318 Building code, 27
Europe, EN-196, 43
Germany, DIN 1164, 82, 83
India
ISO-REILEM TEST R-679, 82, 82
ISO-R-680, 87
ISO-REILEM-CEMBUREAU method, 83
Saudi Arabia
SSA 142/1979, 81, 83, 87
SSA 143/1979, 80, 82, 87
Switzerland, SIA 115, 82
Statistical methods
analysis of cement strength records
Belgium, 42–43, segmentation
appendix tables, 54–64
India, 68 (table)
ISI Certification Mark Scheme, 73
mean square successive difference, 44-45
segmentation technique, 47-48
appendix tables, 54-64
stochastic model, 45-46 (fig)
validity
Belgium, 49, 50-54, 55-64 (tables)
India, 66-79
Statistical procedure, CCRL, 37
Stochastic model
cement strength heterogeneities, 45, 46 (fig)
Strength data (see also Cement strength, Variability testing)
India
alkali aggregate reactions, 77-78
cement plants, production, 67
concrete mix proportions, 75-76
histograms of compressive strength samples, 74-77
ISI Certification Mark Scheme, 73
quality monitoring by NCB, 67
statistical analysis of physical characteristics of cement, 68 (table)
test method, 76-77
water-cement ratio in mortar mixes, 67-68, 77-78 (figs)
reported to IDOT
C 917 reports, 6-11 (tables)
test verification, 8-11
statistical analysis of records, 42-43, 43 (table)
validity of records, 49, 50-54
Structures
CCRL standards development, 30-41

T
Test procedures (see Compressive strength testing, Illinois, India, Saudi Arabia, Variability testing)
Testing (see also Illinois, India, Saudi Arabia)
cement and concrete data bases, 37

cement uniformity
IDOT, 4-5
India, 66-68, 75-76
compressive strength Saudi Arabia, 80
due to compaction method, 86-87
due to mix proportions, 82
due to quality control, 87
due to sand grading, 82-84
due to specimen shape and size, 86
due to water/cement ratio, 82
Variability testing (see also Compressive strength testing)
Belgium
mean square method, 44-45
segmentation, appendix tables, 55-64
stochastic model, 45-46
validity of strength test records, 49, 50-53 (figs)
grab-sample analysis, 16
Illinois, 3-13
India, 66-67
histograms of cement samples, 69-70
sample from different plants, 71
within-plant variation, 68, 72
Saudi Arabia, variability due to test procedures
compaction method, 86
mix proportions and w/c ratio, 82
mixing by different standards, 85 (table)
mixing method, 84-85
quality control, 87
sand grading, 82-83
source variations, 16
within-plant deviation
data analysis procedure, 15-16
India, 67, 72
Variance, analysis of (ANOVA), 15
Verification of strength data tests
IDOT, 8, 9, 11-13
Visible light spectrophotometry (see Spectrophotometry)

W
Water-cement ratio
effect on compressive strength
India, 76-77 (figs.)
Saudi Arabia, 82, 83 (fig)
Waterways Experiment Station (WES), Cement and Pozzolan Unit, 14, 17 (table)
data analysis procedure, 15-16
Within-plant variability
India, 66
standard deviation, 18-20 (figs)