

Subject Index

A

2DHAV, 97, 177–178
 Absolute humidity, 2
 Advanced numerical models,
 hygrothermal research, 90–105
 background, 91–94
 benefits, 91
 building envelope system and sub-
 system effects, 100, 102
 convection modeling, 154–155
 deterministic and stochastic approach,
 97–98
 directional properties, 100
 dissemination and standardization,
 155
 engineering model features, 97–98
 holistic hygrothermal analysis, 103–
 104
 integration of models, 155
 interior and exterior environmental
 conditions, 98–99
 liquid transport properties, 100
 list of models, 101
 local thermodynamic equilibrium, 94
 material properties, 99–102
 multidimensional models for heat and
 moisture transfer, 154
 outputs from models, 104
 sorption isotherms, 99–100
 theoretical background, 93–94
 transport mechanisms, 94–97
 validation and benchmark testing, 155
 vapor permeability, 100
 whole building modeling, 155–156
 Air
 equation of state, 2DHAV, 177
 properties, 2–6
 Airflow, MOISTURE-EXPERT, 165
 Air flux, 29
 Air leakage sites, 12
 Air mass balance, DIM3.1, 175–176
 Air permeability, 32, 34
 Air permance, 34
 Air retarders, 10
 Air spaces, modeling in MOIST, 123
 Air transport, modeling, 96
 ASHRAE SPC 160P, 16, 102–103, 142
 ASTM C 177, 33
 ASTM C 518, 33
 ASTM C 522, 34
 ASTM C 755, 10
 ASTM D 1413-99, 67
 ASTM D 1758-96, 67
 ASTM D 2830-96, 67
 ASTM E 96, 9, 33, 95
 ASTM E 283, 10
 ASTM E 1677, 10

B

Bacteria, biodeterioration and, 70–71
 Basements, flooded and damp, 9
 Biodeterioration, 70–75
 bacteria, 70–71
 critical conditions
 mold, 73–74
 rot decay, 73–75
 effects of materials on development of
 mold and decay, 74–75
 environmental factors, 70–71
 fungi, 71–72
 insects, 72–73
 Brick
 clay, hygrothermal properties, 41
 red, hygrothermal properties, 38
 reheated red, hygrothermal properties,
 39
 white, hygrothermal properties, 40
 BS 7543-1992, 67
 Building contents, acceptable moisture
 levels, 11
 Building envelope system and sub-
 system effects, 100, 102
 moisture storage, 136–137
 Building materials
 air retarders, 10
 dimensional changes in wood, 10
 moisture absorption, 10
 moisture content, 30–31
 properties, 9
 standards and requirements for
 service life, 66–67
 vapor retarders, 10
 water vapor transmission, 9–10
 see also Hygrothermal properties
 Building structure, acceptable moisture
 levels, 11–12

C

Calcium silicate board, hygrothermal
 properties, 63
 Canadian Weather Energy and
 Engineering Data Sets, 16
 Capacitive property, 29
 Capillarity, 14
 Cellulose, 69
 Cellulose insulation, hygrothermal
 properties, 54
 Cement board sheathing, hygrothermal
 properties, 48
 CEN Standard 89 N 336 E, 33
 CEN Standard 89 N 337 E, 33
 CEN Standard 89 N 370 E, 34
 Climate, definitions for moisture control,
 16, 20
 Concrete
 aerated, hygrothermal properties, 37

 hygrothermal properties, 36
 Conservation equations, 29
 Continuity of mass, SIMPLE-FULUV,
 167
 Convection modeling, 154–155
 Convective vapor transport, 85
 Corrosion, 75–76
 Crawl spaces, flooded and damp, 9
 CSA S478-1995, 67
 CWEEDS, 16

D

Darcy flow equation, TCCC2D, 171
 Decay fungi
 biodeterioration and, 72
 effects of materials on development,
 74–75
 Degree of saturation, 30
 Density, 29–30
 Density of airflow rate, 29
 Density of heat flow rate, 29
 Density of moisture flow rate, 29
 Density of vapor flow rate, 29
 Desorption isotherm, 33
 Dew point, 1
 Dew point method, 107–108
 Diffusion, moisture, 13–14
 DIM3.1, 175–176
 Directional properties, 100
 Dry air mass balance, HMTRA, 173
 Dry-bulb temperature, 3

E

Exterior insulation finish systems,
 hygrothermal properties, 47
 EN 113, 1991, 67
 EN 12086:1997, 95
 Energy balance
 DIM3.1, 175–176
 FRET, 182
 HMTRA, 173
 LATENITE, 88
 MOISTURE-EXPERT, 165
 SIMPLE-FULUV, 167
 TCCC2D, 171
 TRATMO2, 97
 WUFI, 163
 Energy conservation, equations, 96–97
 Exponential weighing factors, 134
 External environment
 conditions, 98–99
 other than outdoor air, 152

F

Failure, 66–79
 advanced numerical tools, 77–78
 corrosion, 75–76

Failure—*continued*
 criteria, 77–78
 future, 153–154
 definitions, 66
 direct and indirect moisture problems, 67–68
 future prospects, 79
 life cycle perspective, 154
 mold growth estimation, 78
 prediction
 calculation, 76–79
 uncertainty and errors, 78–79
 risk analysis, 153–154
 stochastic modeling, 153
 Fick's first law, 95
 Finishing materials, hygrothermal properties, 65
 Freezing point depression and equilibrium liquid moisture content, FRET, 182
 FRET, 182
 FSEC 3.0, 183–184
 Fungi, 66
 biodegradation and, 71–72

G

Glaser diagram, 111
 Glaser's method, 86
 Glass fibre insulation, hygrothermal properties, 55–57
 Glossary, xx–xxiv
 Governing transport equation, WUFI ORNL/IBP, 139–140
 Gravity-driven liquid flow, 85
 Gypsum boards
 composition, 69
 hygrothermal properties, 43

H

Heartwood, decay resistance, 69
 Heat equation of state, 2DHAV, 177
 Heat flow models, 86
 Heat flux, 29
 Heat Mass Transient Analysis, 173–174
 Heat transfer
 modeling, 96
 multidimensional models, 154
 HMTRA, 173–174
 Holistic hygrothermal analysis, 103–104
 Human health and comfort, acceptable moisture levels, 10–12
 Humidity ratio, 2
 Hygroscopic memory, 134
 Hygroscopic range, 30
 Hygrothermal analysis methods, 81–88
 2DHAV, 97, 177–178
 boundary conditions, 84
 DIM3.1, 175–176
 enclosure geometry, 84
 FRET, 182
 FSEC 3.0, 183–184
 heat flow models, 86
 HMTRA, 173–174
 holistic method, 103–104
 LATENITE, 88, 97, 179–181
 material properties, 84
 modeling, 83–84
 physics, 84–85
 MOISTURE-EXPERT, 165–166
 need for, 81–83
 performance thresholds, 85
 required information, 84–85
 review of computer models, 86–88
 SIMPLE-FULUV, 97, 167–168

simplified models, 86
 TCCC2D, 97, 171–172
 tools, 85–88
 TRATMO2, 97, 169–170
 WUFI ORNL/IBP, *see* WUFI ORNL/IBP
 Hygrothermal properties, 29–65
 aerated concrete, 37
 calcium silicate board, 63
 cellulose insulation, 54
 cement board sheathing, 48
 clay brick, 41
 concrete, 36
 conservation equations, 29
 EIFS, 47
 expanded polystyrene insulation, 58–59
 extruded polystyrene insulation, 60–61
 finishing materials, 65
 glass fibre insulation, 55–57
 gypsum board, 43
 moisture diffusivity, 34
 mortar, 42
 OSB, 51
 perlite board, 63
 pine, 50
 plaster, 44
 plywood, 52
 polyurethane foam insulation, 62
 red brick, 38
 reheated red brick, 39
 sand limestone, 45
 sheathing membranes, 64
 spruce, 49
 stucco, 46
 suction isotherm, 33–34
 thermal conductivity, 33
 transport equations, 29
 water vapor, *see* Water vapor
 white brick, 40
 wood fibreboard, 53
 Hygrothermal research, *see* Advanced numerical models, hygrothermal research

I

IEA Annex 14, 35, 126, 152
 IEA Annex 24, 35, 91–92, 132, 152
 Indoor climate, 156
 quality assurance, 154
 WUFI ORNL/IBP, 142
 Indoor environment, boundary conditions, 140–142
 Insects, biodegradation and, 72–73
 In-situ measurements, equipment, 156
 Interior environmental conditions, 98–99
 ISO 6707-1 1989, 66
 ISO 9223, 76
 ISO 9699-1994, 66–67

K

Kelvin's equation, 95
 Kieper diagram, 111–112

L

LATENITE, 88, 97, 179–181
 Linear momentum balance, HMTRA, 173
 Liquid conductivity, 85
 Liquid transport, 137–139
 modeling, 95–96
 properties, 100

M

Manual analysis tools, 107–115
 dew point method, 107–108
 limitations, 112–113
 numerical tools, 113–115
 recommendations for use, 113
 wall without vapor retarder example, 109–113
 wall with vapor retarder example, 108–109
 Masonry, drying, 144–145
 Mass balance, LATENITE, 88
 Mass balance for air, TRATMO2, 97
 Mass conservation, equations, 96
 Mass transfer, modeling, 95
 Mass transport, 12–14
 Material properties database, 152–153
 formats and conversion of properties, 153
 new measurement techniques, 153
 Mildew, 66
 MOIST, 116–134
 adding new materials to database, 130–132
 adjacent layer boundary conditions, 133
 analysis intervals and indoor parameters, 121–122
 applications, 125–130
 assumptions, 132
 basic transport equations, 132–133
 building construction, 117–118, 120
 building paper permeance, 128–130
 comparing performance of sheathing materials, 129, 131
 construction material drying rates, 126–127
 description, 117–125
 determining need for vapor retarder, 126–127
 editing material database, 118, 120
 house tightness effect on wall moisture, 126–129
 inclusion of paints and wallpapers, 123
 indoor boundary conditions, 133
 indoor climate options, 123
 indoor moisture generation rate effect, 128–129
 input parameters, 118–119, 121
 input processor, 117–122
 limitations, 117
 mathematical description, 131–132
 modeling
 air spaces, 123
 thermal insulation, 123–124
 model theory, 116–117
 ordering program, 131
 outdoor boundary conditions, 133
 output and analysis options, 121–122
 plotting result graphs, 122, 125
 potential for mold and mildew growth in walls, 126, 128
 running an analysis, 122, 124
 selecting units, 117
 simulations using non-WYEC weather data, 130
 space cooling cooperation, 134
 space heating operation, 133–134
 studies verifying, 117
 variable indoor humidity model, 133–134
 window opened operation, 134
 worst case parametric analysis, 125

- Moisture, 1–14
 acceptable levels, 10–12
 capillarity, 14
 diffusion, 13–14
 mass transport, 12–14
 movement, 13–14
- Moisture absorption
 building materials, 10
- Moisture alert systems, 156
- Moisture balance
 FRET, 182
 LATENITE, 88
 MOISTURE-EXPERT, 165
 SIMPLE-FULUV, 167
 TCCC2D, 171
 TRATMO2, 97
 WUFI, 163
- Moisture content
 appropriate, in building spaces, 3
 building materials, 30–31
 capillary saturation, 30
 critical, 30
 maximum, 30
 wood, 70
- Moisture control, manual analysis tools,
 107–115
- Moisture design reference years, 152
- Moisture diffusivity, 32, 34
- Moisture engineering, 90–91
 holistic, 91
- MOISTURE-EXPERT, 97, 99–100, 165–
 166
- Moisture flux, 29
- Moisture mass balance
 DIM3.1, 175–176
 HMTRA, 173
- Moisture models, 13
- Moisture performance criteria database,
 153
- Moisture permeability, 32
- Moisture sources
 construction moisture, 8
 flooded and damp basements and
 crawl spaces, 9
 indoor, 6–8
 outdoor, 8–9
 people as, 6–7
 warm, humid outside air, 9
- Moisture transfer, multidimensional
 models, 154
- Moisture transport, 137–138
- MOISTWALL, 113
- MOISTWALL-2, 114
- Mold, 66
- Mold fungi
 biodeterioration and, 71–72
 critical conditions for development,
 73–74
 effects of materials on development,
 74–75
 growth estimation, 78
- Mold index values, 78
- Momentum, SIMPLE-FULUV, 167
- Momentum conservation, 97
- Mortar, hygrothermal properties, 42
- N**
- Navier-Stokes, TRATMO2, 97
- O**
- OSB, hygrothermal properties, 51
- Outdoor climate, WUFI ORNL/IBP,
 141–142
- Outdoor environment, boundary
 conditions, 140–142
- P**
- Paints, composition, 69–70
- People, as moisture sources, 6–7
- Perlite board, hygrothermal properties,
 63
- Permeance coefficient, 2
- Phase change, modeling, 96
- Pine
 composition, 68
 hygrothermal properties, 50
- Plants, as moisture sources, 8
- Plaster, hygrothermal properties, 44
- Plywood, hygrothermal properties, 52
- Polystyrene insulation
 expanded, hygrothermal properties,
 58–59
 extruded, hygrothermal properties,
 60–61
- Polyurethane foam insulation,
 hygrothermal properties, 62
- Porous medium, advanced numerical
 models, hygrothermal research,
 93–94
- Psychrometric charts, 3–5
- R**
- Rain, wind-driven, 152
- Rainwater
 leaks, 13
 as moisture source, 8–9
- Relative humidity, 1–2
- Renovation, 156–157
- Retrofit, 156–157
- Rising damp, 14
- Roof, flat, seasonal moisture migration,
 144–146
- S**
- SAMSON, 16
- Sand limestone, hygrothermal
 properties, 45
- Saturation point, 1
- Saturation water vapor pressures, 113–
 114
- Self-drying concepts, 157
- Sheathing membranes, hygrothermal
 properties, 64
- SIMPLE-FULUV, 97, 167–168
- Sling psychrometers, 3
- Sorption coefficients, 130–132
- Sorption curve, 30
- Sorption isotherms, 33, 99–100
- Specific heat capacity, 30
- Specific humidity, 2
- Specific moisture capacity, 32
- Spruce, hygrothermal properties, 49
- Stack effect, 12
- Stone facade, exposed, moisture
 behavior, 143, 145
- Stucco, hygrothermal properties, 46
- Suction isotherm, 33–34
- Surface Airways Meteorological and
 Solar Observing Network, 16
- Surface diffusion, 85
- T**
- TCCC2D, 78, 97, 171–172
- Temperature, moisture content in air
 and, 1
- Thermal conductivity, 30
 dry materials, 33
- Thermal diffusivity, 30
- Thermal moisture diffusion coefficient,
 32
- Thermal moisture permeability, 32
- Thermal resistance, 30
- Thermodynamic equilibrium, local, 94
- Time of wetness, 76
- Transport equations, 29
 in MOIST, 132–133
- Transport mechanisms, 94–97
- TRATMO2, 97, 169–170
- Typical Meteorological Year, 16
- V**
- Vapor concentration, 30
- Vapor diffusion, 85
- Vapor diffusion thickness, 32
- Vapor equation of state, 2DHAV, 177
- Vapor flux, 29
- Vapor permeability, 30–31, 100
- Vapor permeance, 31
- Vapor resistance, 31
- Vapor resistance factor, 31–32
- Vapor retarders, 10
- Vapor transport, 137
 modeling, 95
- Variable indoor humidity model, 133–
 134
- Ventilation
 mechanical, 12
 strategy, 156
- Ventilation rate, 134
- Volumetric heat capacity, 30
- Volumetric moisture capacity, 32
- W**
- Wallpapers, composition, 69
- Water absorption coefficient, 32, 34
- Water activity, 70
- Water vapor
 condensation, 1
 diffusion, 13
 flow, 12
- Water vapor permeability, 2, 33
- Water vapor permeance, 2, 33
- Water vapor pressure, 2
- Water vapor resistance and resistivity, 2
- Water vapor transmission, building
 materials, 9–10
- Weather data, 16–27
 future, 152
 moisture analysis, 17–27
 sources, 16
- Weather Year for Energy Calculations,
 16
- Wet-bulb temperature, 3
- Wind pressure, 12
- Wood
 composition, 68–69
 dimensional changes, 10
 equilibrium moisture content, 70
 moisture content, 70
- Wood fibreboard, hygrothermal
 properties, 53
- WUFI ORNL/IBP, 87–88, 100, 136–150,
 163–164
 boundary conditions for indoor and
 outdoor, 140–142
 experimental validation, 145–146
 features, 146–147, 150

WUFI ORNL/IBP—*continued*

- governing transport equation, 139–140
- indoor climate, 142
- input errors, 142
- insufficient knowledge of required data, 143–144
- interface, 147–150
- limitations, 142
- liquid transport, 137–139
- material properties, 140–141
- mathematical model limitations, 144–145
- moisture storage, 136–137
- moisture transport, 137–138
- numerical problems, 145
- outdoor climate, 141–142
- physical background, 136–137
- programming errors, 142