

Index

A

- accumulation
 - snow 17, 41, 42, 72, 127, 182, 327
 - snowdrift 28
 - zone 39
- active defense 3
- active temporary avalanche
 - protection 326
- aerial images 354
- aerosol 311
- Alpine living space, shaped by
 - avalanches 2
- Alpine regions 1
- Alpine valleys 1, 18, 20, 47
- Alps 1, 10, 21, 45, 195
 - avalanche disasters in 10
 - demand for technical avalanche
 - protection in 2
 - Japanese 3
 - New Zealand 3
 - safe transit corridors across 1
 - typical avalanche path in alpine
 - valleys 20
- American national standard (ANSI) 177
- anchor grout 146, 150, 151, 204, 205, 206, 207, 232, 268, 270
- angle
 - critical 71
 - deflection 80, 86, 167, 237, 241
 - inclination 252
 - slope 173, 240
- Apennines, mountain range 3
- application
 - avalanche models 64, 65
 - engineering practice 77, 78
- artificial avalanche release 8, 331
 - commonly used methods 329, 330
 - comparison of methods/systems 334, 335
 - by Doppler radar 342
 - effects of 327, 328
 - facilities with system Gazex® 9
 - fundamentals 326, 327
 - Grosstal avalanche 361
 - methods 326
 - safety plan 326
 - use of 325
- artificial release systems
 - construction and operation 336
 - Gazex® system 336–339
 - Wyssen Avalanche Tower
 - LS12-5® 339–342
- assessment
 - condition 281, 286
 - hazard
 - methods 97–99
 - potential 77
 - quantitative risk assessment 37
 - of reliability of measure 288
- Austria
 - annual number of avalanche
 - victims in 11
 - EUROCODE and national
 - standards 177
 - extreme snow height in 180–182
 - historical foundation methods 153, 154
 - standards for construction-technical
 - assessment 178
 - standards for geotechnical proof
 - of safety 220
- Austrian Research Centre for Forests 358
- Austria's Forest Act 39
- automatic weather station 26
- avalanche action on buildings 311–314
- avalanche action on objects 78. *See also*
 - obstacles
- avalanche body 55, 56
- avalanche cycles 12, 16, 18
- avalanche defense
 - design of structures 124–126
 - general planning procedures 121–124
 - goal hierarchy, overview of 114
 - historical development 13–16
 - measures 3
 - classification scheme 5

- protective objectives, principles of 113
- quantitative and risk-based protection goals 115–117
- avalanche dynamics monitoring 355
- flow depth 358
- impact forces with load cells 356–358
- measuring velocity
 - with optical sensors 359
 - with pulsed dual doppler radar 359–361
- systems for monitoring avalanche motion 355, 356
- Avalanche Guard[®] system 343
- avalanche guiding walls 242
- avalanche impact pressure 195
- avalanche monitoring technology 9, 345–347
- automatic weather stations 348
- meteorological monitoring 347–350
- remote sensing technology 354
- snow cover 350–353
- snow forces, measures 354, 355
- snow mechanics 354
- weather radar 348–350
- Avalanche Pipe[®] 344
- Avalanche Pipe Booster 500[®] 344
- avalanche pipe models 346, 347
- Avalanche Pipe Mörser 5400[®] 344
- avalanche pressure instruments 357
- avalanche protection forest 48
- effects of vegetation and forest 48–51
- avalanche protection structures
 - condition levels 288
- avalanche protection system
 - Avalanche Guard[®] 343, 344
 - Avalanche Master[®] 342
 - Avalanche Pipe[®] 344
 - Avalanche Pipe Booster 500[®] 344
 - Innauen-Schätti 342
 - in Mot da Ri sector 344
- avalanche radar device 360
- avalanche retarding dam 7
- avalanche table 17
- avalanche tail 57

B

- Baikal mountains 3
- blasting 328
 - avalanche 331
 - helicopter 330
 - methods 328
 - negative 325
 - positive 328
 - residual risk 333
 - site, topography 327
- bolt connections 205
- bolt grout 207
- Buckingham Π theorem 57
- building materials 204
 - construction steel 204
 - construction wood 204
 - fundamentals of 204
- building protection 311
 - agricultural 314
 - against avalanches, principles 311
 - design and commercial products for protection 318, 319
 - in front of building 319
 - impact walls 321, 322
 - roof terrace 321
 - splitting wedges 319–322
 - primary goal 311
 - protection measures, with temporary effect 317, 318
 - reinforced building components 317
 - structural measures 311, 314
 - constructive measures 314–317
 - shape and orientation 314

C

- cables 205
- calibration, of numerical avalanche models 345
- Canadian standard (CSA) 177
- catastrophes
 - chronicle of avalanche 10
 - events 2
 - chronicle of avalanche catastrophes 10–13
 - management 5, 348

- mudflow in Huascarán 12
 - natural 1
 - catching dams 239–241
 - deposition length 242
 - maximum storage capacity 242
 - Caucasus Mountains 3
 - center of mass model 67
 - centric pressure force 212
 - Chezy friction 66
 - Chinese Tianshan 3
 - civil engineering 257
 - clamping rail 206
 - coefficients
 - Euler 212
 - friction 244
 - pressure 236
 - cohesionless 29, 268
 - communication 266
 - facilities 257
 - radio 281
 - compressive stress 31, 130, 185, 253
 - computer-based models 9
 - for prognosis 10
 - concrete foundation 228, 271, 273, 274, 299, 307–308
 - coniferous wood 51, 205
 - connecting means 205
 - conservation
 - equations 59
 - good state of 288, 305
 - measures 282
 - constitutive law 59
 - constraints 245
 - in avalanche path 78
 - economic 325
 - space 255
 - construction
 - framework
 - conditions 256
 - requirements changes 258
 - machines 255
 - material and equipment
 - storage and handling 258–260
 - methods
 - for access roads in the Alpine area 262, 263
 - in avalanche defense in starting zone 267–275
 - for defense systems 198, 199
 - principles, in avalanche control 267, 268
 - recommended distances, for underground lateral drainage 263
 - ropeway systems in starting zone 265
 - sites 255
 - elements of equipment for avalanche site 257
 - facilities 255
 - social and office premises 258
 - supporting structures to secure unstable embankments 264
 - work in Alpine environments 255
 - zones, supply and disposal at 260, 261
 - continuum
 - flowing 59
 - mechanical 59
 - one-dimensional granular 67
 - corrosion 218
 - protection for foundations 227, 228
 - protection for steel structures 218
 - reduction in diameter of steel rods 229
 - creep 185
 - factor 186
 - movements 231, 232
 - pressure 251
 - rates 231, 232
 - crossbeams 205, 212
 - curvature, of dam axis 240
- D**
- Daisybell® system 338, 339
 - damage
 - analysis 284, 285
 - and condition assessment 286–289
 - to anchors and micropiles 297, 298
 - at avalanche dams 290
 - at avalanche galleries and tunnels 290
 - causes
 - for anchorage and micropiles 296
 - on crossbeams for snow supporting structure 290

- on earth dams and deflective walls of steel 300
- on load-bearing constructions for snow supporting structure 292
- consequences 285
- forecast for 286
- mapping condition levels, for structural safety and 287, 288
- to constructions, avalanche pressure and 318
- defined 285
- effects
 - of avalanches 87–89
 - damage potential in relation to pressure 90
 - by flow avalanches 89
 - impact of massive components 85
 - by powder snow avalanches 90
- and functional deficits 284
- causes for 285, 286
- to ground plates and concrete foundations 299
- to load-bearing construction 293, 294
- outline causes, to snow supporting structures 286
- regeneration methods based on causes of 304
- to snowdrift structures 302
- to snow nets 295, 296
- to support grate 291
- vulnerability to 286
- dam construction, rules 245–247
- avalanche catching dams 246
- preparation of dam bed 245
- data
 - for avalanche modelling 65
 - required for performing, hazard analysis 101
- dead weight 195
- deceleration 40, 127, 208
- runout 76
- defense area, vertical extension of 196
- deflection dams 237, 239–241
- deformations 60, 208, 253
- design
 - avalanche breakers 247–249
 - avalanche galleries (tunnels) 248–253
 - foundations of snow supporting structures 219–224
 - geotechnical 219
 - avalanche deflection and retarding dams 244–247
 - principles 219
 - girder foundations 224–227
 - parameters required fulfilling design criteria 238
 - position of protected objects 182, 183
 - rules for avalanche defense structures 179
 - situations 220
 - snowdrift protection structures 233–247
 - snow height 180
 - extreme snow height 179–182
 - methodology 180
 - of snow supporting structures on permafrost sites 230–233
 - static systems 183, 184
 - structural design for buildings 315, 316
 - structure assessment and 208–233
- detonation
 - blasting ropeway and snow cloud 331
 - of explosive charge 327
 - of gas 328
- digital 3D-terrain models (DTM) 65
- digital measuring technology 9
- dimensions 212
 - digital terrain surface 67
 - granular continuum 67
 - grates in steel 213
 - snow glide structures 160
 - snow nets 215–217
 - snow rakes 217, 218
 - structures in wood 213–215
 - supporting constructions in steel 212, 213
- documentation
 - of avalanche events in databases 346
 - condition 284
 - continuous 348
 - of events 100
 - systematic 346
- Doppler radar 355, 361

- downslope
 - cladding 174
 - creep 230
 - edge of the ground plate 151
 - foundations 135, 154
 - guywire 217
 - stress 33
 - supports 212, 213
- dry snow
 - avalanches 17, 38, 237, 243, 244
 - cover 353
- dynamics 60
 - action by flow avalanche on obstacles (*See flow avalanche*)
 - avalanche action, principles 78
 - avalanche impact forces with load cells 356–358
 - flow and powder snow avalanches 60–62
 - flow depth measurement 358–359
 - impact forces with load cells 356–358
 - mathematical models 58, 59
 - motion, systems for monitoring 355–357
 - pressure 314
 - principles 55
 - velocity measurement
 - with optical sensors 359
 - with pulsed dual doppler radar 359–361

E

- earth pressure 178, 250, 251, 252, 305
 - active 251
 - approach 252
 - distribution, recommended 251
 - horizontal 251
- earthquake forces 195
- Elbrus mountains 3
- electro-mechanical thrust 354
- end-effect loads 189
 - end structures destroyed by 190
- energy 28, 71, 165, 237, 258
 - consumption 270
 - dissipation rate 57, 62

- electrical 261
- impact 267
- supply through solar cells 340
- erosion 163, 263, 286, 287, 290, 296, 297, 301, 307, 308
 - snow 356
- Eurocode-compatible combination coefficients 250
- Eurocode (EC) standard system 177
- Europe
 - avalanche models 67
 - historical development 13
- European Alps
 - human impact noticeable in 2
- European Avalanche Hazard Scale 2, 93, 94
- evaluation 17, 48, 54
 - avalanche hazards 99
 - economic 123
 - monetary units 97
 - object of scenario training during hazard zoning 48
 - of past avalanche events 98
- explosion(s). *See also various avalanche release systems*
 - areas of impact 328
 - damage 87
 - exploder pipe 337
 - heat 328
 - phases 337
 - using an oxygen-propane mixture 336
- extreme snow height 179, 180
 - area average of Hext 181
 - Austria 180–182
 - Canada 182
 - Switzerland 180–182
 - USA 182

F

- fasteners 205
- flow avalanche
 - action on narrow obstacles 81, 82
 - action on obstacles obstructing flow 79–81
 - action on protective gallery 252

- formulas for load ratios on substratum caused by 253
 - pressure on
 - deflecting obstacle 80
 - obstacle surrounded 79, 81
 - resistance coefficient 82
 - flow depth, measurement 358
 - flow height 55, 57, 65, 70, 71, 78, 239, 242, 322, 358
 - fluidized transition layer 62
 - FMCW (frequency-modulated continuous-wave) radars 356
 - forest
 - avalanche protection 48
 - in avalanche starting zone 50
 - brake effect 51
 - coniferous 51
 - density 47
 - destruction 53
 - effects on
 - avalanches on trees and 52
 - formation and movement of avalanches 52
 - ground vegetation in 49
 - natural vegetation 53
 - paths, characterized by tree-free zones 47
 - preventing slab formation 50
 - reserve 51, 52
 - retention of snow 50
 - fracture 60
 - mechanism simulation 31
 - potential height 65
 - primary/secondary 60
 - of a slab avalanche 19
 - zone of a slab avalanche 34
 - frequency
 - of avalanche events 34, 37
 - hazardous avalanches 4
 - of inspection and condition monitoring 282
 - recurrence 37
 - friction 57, 321
 - force 314
 - internal 60
 - reduced 313
 - frost resistance 207
 - Froude number 57, 58, 237, 238, 242
 - frozen soil 230
- G**
- gas-dynamic theories 87
 - Gazex[®] system 336
 - advantages 338
 - artificial release 336–339
 - exploder pipe 337
 - genetic avalanche classification 33, 35, 36
 - geophones 10
 - geophysical processes 34
 - geotechnical proofs (GEO limiting states) 252
 - Germany
 - avalanche protection objectives 115
 - EUROCODE and national standards 177
 - hazard information maps 102
 - standards for construction-technical assessment 178
 - girders 212, 213
 - glide factors 185, 187, 188
 - Grosstal avalanche 342
 - ground based interferometric synthetic aperture radar (GB-SAR signal) 353
 - ground plate foundation 272, 273
 - GSM transceiver 341
 - guiding walls 242
- H**
- hazards 2, 36, 91
 - analysis 91
 - data required in practice/information on 101
 - model 92
 - assessment 77, 91
 - avalanche flow over building 313
 - defined 34, 36
 - low/big 29, 30
 - management 346
 - maps 34, 91, 100, 102–104
 - methods, assessment 97–99
 - scenarios 91
 - zone mapping 77

- zone plans 91, 101, 105
- zoning in countries strongly affected by 106, 107
- height
 - calculation 180
 - catching and deflection dams 237
 - dam 169, 239, 240
 - extreme snow heights 180–182
 - marked profiles 354
 - run-off 311
 - snow supporting structures 199, 200
 - structures distances, according to 200
- helicopter
 - installation of the snow bridge by 275
 - safety regulation for transportation 281
 - for transporting heavy loads 267
 - use in avalanche defense construction works 267
- high-speed cameras 10
- high-tech systems 2
- Himalaya 3, 24
- Hindu Kusch 3
- historical avalanche defense structures 13
- holistic systems, for avalanche defense 4
- horizontal
 - cable systems 279
 - earth pressure 251
 - extension of defense area 197
 - force 87
 - loads 251
 - pressure 250
- housing for workers 257
- human activity
 - in higher elevation areas 1
 - outdoor leisure activities 1
- humid flowing avalanches 48
- hundred-year avalanche 2
- hydraulic
 - drive 270, 272
 - excavators 262
 - jump 238, 239, 241
 - motor 269

I

Iceland 3
impact 34, 37

- intensity of avalanche 38
- measuring impact forces, with load cells 356–358
- Inauen-Schätti AG 342
- industry 1, 101, 111
 - construction, occupational safety 275
- infrastructure-poor mountain regions 1
- initial
 - fracture 60
 - metamorphism 27, 28
- inspection 281, 282
- intensity
 - of avalanche impact 38, 39
 - classification, according to 95
 - precipitation 348
 - probability-intensity diagram 117
 - snowfall 35

J

jet roof 8, 235
joint bolt connections 205, 206
jump height 240, 241

L

Lähn 1
Lahngrube 13
Lahnkeller 13
land use planning 1, 5, 38
landslides 196, 290
lateral

- distance between structures 201
- loads 195
- spread 316
- structures intermediate distances 203
- torsional buckling 212

Lavin 1
Lawinengruften 13
layout 196

- general rules 196

light

- construction type 140
- doors 87
- loads 267
- precipitation 348
- work and MOT approved 280

load cells 356

load measurement 356

M

magnitudes 56

– of avalanche events 34, 37, 38

maintenance

– avalanche defense structures 281

– lifecycle of 281, 282

– measures for 302–305

– costs of 308, 309

– functions and strategies of 282–284

– inspection and condition
assessment 284

– management

– in avalanche defense structures 283

– and condition assessment 281

– principles of maintenance 281

– strategies for avalanche protection
structures 283

– urgency 302–305

mass balance equation 58, 59

mass density 55

material snow, properties 24, 25

mathematical models 58, 62

meteorological monitoring 347

– automatic weather (snow) station 349

– automatic weather stations 348

– fundamentals 347, 348

– weather radar 348, 350

– station on the Valluga 350

micropiles 232

– foundations

– and drill technology 268–270

– in solid rock (rock anchor) 274

– tests 228

mixed-motion avalanches 62

mobile diesel generators 261

models

– alpha-beta model 67

– applications 64, 65

– digital 3D-terrain models (DTM) 65

– ELBA+-model 67

– MSU-dense 67

– numerical avalanche models 64

– overview and classification 66

– PCM 67

– physical-dynamic 66, 69

– AVAL-ID 71–73

– RAMMS 74, 75

– SamosAT 67, 74, 76, 77

– Voellmy-Salm model 69–71

– friction parameters 69

– principles and data for 65

– slide model for mass movements 68

– statistical-topographic 67–69

– two-dimensional simulation 67

momentum

– balance 58

– equations 58, 59

– conservation 71

– density 58

– loss 80, 239

monitoring technology 345

– automatic weather stations 348

– meteorological monitoring 347–350

– principles of 345–347

– remote sensing technology 354

– snow cover 350–353

– snow forces, measures 354, 355

– snow mechanics 354

– weather radar 348–350

morphological avalanche classification 18

morphological principles 39

– avalanche catchment area 39

– avalanche path 45, 47

– location-specific framework
conditions 40, 41

– potential runoff zone/deposition
zones 47–49

– starting zone 41–45

mountains

– Baikal 3

– Caucasus 3, 24

– Chinese Tianshan 3

– dwarf 53

– Elbrus 3

– Himalayas 3, 24

– Hindu Kusch 3

– Pamir 3, 24

– Rocky 3, 23

– Russian Altai 3

- movement
 - characteristic criteria 55
 - flow avalanches 60
 - model laws 57
 - slush flows 63
 - wet snow avalanches 63
- mud flows 1
- mudslides 53
- N**
- national application document (NAD) 177
- natural hazard management
 - risk cycle 4, 6
- natural resources 1
- Newtonian fluid 59
- non-normal support surfaces 187
- North East – north-east location 23
- northwestern (precipitation build up) area 20, 21
- Norwegian avalanche test 358
- Norwegian Fjordland 3
- numerical calculation program RAMMS 67
- numerical modelling, for planning defense structures 78
- O**
- O'Bellx[®] system 338
- obstacles 55, 63, 78–83, 99, 155, 173, 198, 233, 268
 - action by flow avalanche on 79–83
 - in avalanche path 55
 - climbing height 81
 - narrow 81
- optical sensors 359
- P**
- Pamir mountain range 3
- parameters
 - from alpha-beta model 68
 - characteristic 65
 - empirical 80, 241
 - erosion 72
 - friction 69, 74
 - simulation 65
 - tensorial 59
 - turbulence 359, 360
- partially secured terrain unit 197
- passive defense 3
- passive temporary avalanche protection 326
- peak pressure 79
- permafrost 230
- personal protective equipment (PPE) 276
- phases
 - design 354
 - preliminary planning 122
 - transitional 57
 - two-phase flows 62
- photo- or videogrammetry, measuring snow/avalanche volume 356
- photovoltaic (solar power) systems 261
- physical-dynamic avalanche models 69
- physical model laws 57
- planning 109
 - avalanche defense structures 109
 - principles 109, 111–113
- plough berms 165
- polystyrene 57
- pore space 207
- powder snow avalanche
 - action by 83–85
 - damage to properties caused by 90
 - layer structure 76
 - in motion 19
 - resistance coefficients 84
- powder snow cloud 60
- precipitation 17, 18, 20, 21, 23, 42, 260, 348
 - frost and solid 25
 - quantitative data 350
- prefabricated snow bridges 16
- pressure 55
 - mounds 165
 - sensors 359
- principles
 - avalanche action on objects 78
 - for avalanche modelling 65
 - avalanche monitoring technology 345
 - building protection against avalanches 311

- construction work in avalanche control 267
- employee protection at construction zones 275
- maintenance of avalanche defense structures 281
- morphological, of avalanche evolution 39–48
- planning of avalanche defense structures 109
- protective objectives 113
- sectorial protection concepts 117
- of snow metamorphosis 27
- structural avalanche defense 127
- transportation systems 261
- protection
 - concepts
 - for settlement areas 118
 - for ski areas 121
 - for traffic routes and supply lines 119–121
 - effect 6
 - integral/comprehensive protection concepts 118
 - sectorial protection concepts 117
 - variant 118
- pull-out devices
 - for testing micropiles 230
- pulsed Doppler radar 359
- Pyrenees 3

Q

quantitative risk assessment (QRA) 37

R

- radar 10, 347, 348, 359
 - coupled systems 359, 361
 - Doppler 342, 355, 359
 - pulsed dual 359
 - weather 348, 350
- radio communication 281, 341, 348
- reinforcing steel 205
- remote sensing technology 9, 354
 - active 354
 - passive 354
 - systems 354
- renovation 302
 - costs of 308, 309
 - methods 302
 - for avalanche walls 305–306
 - for snow nets 308
 - for snow supporting structures 306–308
- resistance
 - air 53
 - coefficient 82, 84
 - design value 220
 - frost 207
 - ground 223, 224
 - of individual building parts 311
 - pull-out 227, 228
 - soil 221
 - tensile 226, 229
- re-suspension layer 62
- Reynolds number 62
- rheology 59
- rigid steel wires 205
- risk
 - assessment 99, 100
 - concept 91
 - defined 36
 - high-risk area 3
 - maps 109
 - residual 333
- rock avalanches 1
- rock fall 196
- rock fill terraces 14, 15
- Rocky Mountains 3, 23
- ropes 205
- rules/standards
 - DIN 4014 178
 - DIN 4017 178
 - DIN 4020 179
 - DIN 4084 178
 - DIN 4085 178
 - DIN EN 1992-1-2/NA 178
 - DIN EN 1993-1-1/NA 178
 - DIN EN 1993-1-8/NA 178
 - DIN EN 1993-1-11/NA 178
 - DIN EN 1995-1-1/NA 178
 - DIN EN 1997-1/NA 178
 - EN 1991-1-3 236

- EN 1991-1-4 195, 235, 236
- EN 1991-2 251
- EN 1992-1-1 178, 253
- EN 1992-3 178
- EN 1993-1-1 178
- EN 1993-1-8 178
- EN 1993-1-11 178
- EN 1997-2 179
- ÖNORM B 1992-1-1 177, 178
- ÖNORM B 1992-3 178
- ÖNORM B 1993-1-1 178
- ÖNORM B 1993-1-8 178
- ÖNORM B 1997-1-1 178, 252
- ÖNORM B 1997-1-2 178
- ÖNORM B 1997-1-3 178
- ÖNORM B 1997-1-4 178, 252
- ÖNORM B 1997-1-5 178
- ÖNORM B 1997-1-6 178
- ÖNORM B 1997-2 179
- ÖNORM B 4007 280
- ÖNORM B 5301 319
- ÖNORM B 5302 319
- ONR 24807 284, 285, 305
- SA EN 1992-1-1 178
- SA EN 1992-3 178
- SA EN 1993-1-1 178
- SA EN 1993-1-8 178
- SA EN 1997-2 179
- SIA 262.001 178
- SIA 262.004 178
- SIA 263.001 178
- SIA 263.008 178
- SIA 267 002 179
- SIA 269 285
- runout ratio 68
- runout zone 17
- Russian Altai 3

S

- safety 2
 - artificial avalanche release, requirements and 330–336
 - concepts for buildings endangered by avalanches 323
 - partial factors for pile foundations 221
 - plan 326
- safety engineering
 - in avalanche control 275
 - employee protection
 - general principles of 275
 - prior start of construction 276
 - fall protection systems 279, 280
 - personal protective equipment (PPE) 276–279
 - safety regulation for helicopter transportation 281
 - suspension scaffolds 279, 280
- SATSIE projects 238
- Savage-Hutter equations 57
- scattering factor 228
- Schneearchen 13
- screws 205
 - connection 206, 296
- seismic sensor 344
- shallow ground 307
- shallow water approach 74
- shear
 - forces 60, 206
 - fractures 130
 - strength 60, 354
 - stresses 31, 84, 153, 199, 356
 - velocity profile 56
- shock theory 238
- shockwave 314
- SIA structural standards 177
- simulations 64–66, 77
 - in complex terrain 78
 - deliver data on velocities and flow heights 78
 - of reference avalanches 78
- single-field beam 212
- single-part supports 212
- ski tourers 1
- slope
 - distance between (rows of) structures 200
 - gradient 41
 - gradients 202
 - inclination 18, 41, 44, 47, 51
 - height development depend on 85
 - suitable for snow supporting structures 196

- northern 23
- slope-parallel distance 200
- for different structure heights 200
- between rows of structures 201
 - according to fixed height differences 202
- slush flows 63
- snow
 - avalanche 1
 - cover monitoring 350–353
 - GB SAR 353
 - instruments 352, 353
 - LIDAR 350, 353
 - weather radar data 351
 - creeping 17, 185
 - crystals 26
 - forces monitoring 354
 - snow net monitoring site 355
 - genesis 25
 - glide 17
 - path 57
 - tripod 163, 164
 - load 194
 - on slim components 194, 195
 - mechanics monitoring 354
 - parameters 354
 - rakes 15
 - redistribution, by wind 28
 - slab breakage 63
 - supporting structures, mounting methods for 274, 275
- snowdrift control structures 155
 - construction type 157
 - snowdrift fence 157
 - wind baffle 157–159
 - wind roof (jet roof) 159
 - effects and classification 155
 - snowdrift fences 157
- snowdrift fences 233, 234, 304
 - construction principles 235
 - structural systems on 234
- snowdrift measures 15
- snow glide protection structures 159, 164
 - construction type 162
 - array of posts 162, 163
 - berms 163, 165
 - guideline values for the post spacing 162
 - snow glide tripod 163, 164
 - methods 159–162
 - overview 161
 - protection effects 159
- snow metamorphosis 27
 - equilibrium growth metamorphism 28, 29
 - faceting 29, 30
 - initial metamorphosis 28
 - melt-freeze metamorphism 30
 - principles 27
- snow nets 7, 132, 133, 136–140, 149, 183, 184, 189, 194, 215–217, 270, 272–274, 294, 295, 298, 306, 308, 309, 354, 355
 - monitoring site 355
 - with swivel supports 231, 233
- snowpack 31
 - formation and layering 31, 32
 - movements 31
 - creeping 31
 - glide 31
 - tensions in snow cover 31, 33
- snow pressure 185, 190, 209, 212
 - arrangement of structures with 211
 - component 187
 - on grate 192–194
 - load 186
 - and load arrangement 190–192
 - measurements 185
 - slope-parallel components 186
 - static 184
- snow supporting structures 130, 196
 - assembly of 275
 - classification 130–133
 - concepts for arrangement 197
 - construction types 130
 - combined snow bridge 140–142
 - historical supporting structures 144–146
 - snow bridge and snow rakes of wood 142–144
 - snow bridge of steel 133–136
 - snow net 136–140
 - foundation and anchoring 149

- foundation of avalanche nets 152
- historical foundation methods 151, 153, 154
- methods of foundation (anchorage) 149–151
- frequently used steel profiles on 204
- height of 199, 200
- protection effect 130
- recommended action combinations for 208, 209
- with snow glide defense structures, combination of 203
- type approval test 146, 149
- types used 212
- snow-water equivalent (SWE) 24, 348
- social and office rooms 257
- power supply to 261
- soil classes 188
- soil temperature 232
- solar panels 341
- for power supply 348
- solid precipitation 26
- solifluction 196
- south foehn situation 22, 23
- ground weather map 22
- Spaltecken 13
- spatial/temporal, occurrence of avalanches 17, 18
- spiral wire 205
- splitting wedges 319–322
- stability
- improved 305
- snow pack 30, 51, 93
- static
- reinforcement 316
- snow pressure 184, 314
- system 212
- wind roof systems 235, 236
- stationary pressure 79
- steel strength 205
- steel wire rope anchors 227
- steep
- avalanche paths 45
- ridges 43
- and rocky 279, 343
- shadowy areas 31
- slopes 87, 94, 95, 184
- terrain 63, 94, 257, 268
- storage capacity 242
- upstream of a catching dam 243
- strain
- maximum 194
- mechanical 53
- physical 265
- pressure 213
- wind 236
- stress 8, 24
- adhesive 206
- anchor 354
- bending 212, 308
- compressive 31, 206
- shear 31, 76, 84
- tensile 130, 153, 198
- structural avalanche defense 6
- avalanche galleries and tunnels 172
- avalanche-secure pipe bridge 173–175
- bridging structures 173
- construction type 172
- variations of downslope cladding of openings in galleries 174
- avalanche path and deposition zone 165
- classification 165
- overview 166
- classified by function and location in catchment area 8
- longitudinal defense structures 165
- construction type 165
- deflecting dam (wall) 166–168
- guiding wall 165–167
- protection effects of 165
- in starting zone 127, 128
- snowdrift control structures 128
- snow glide protection structures 129
- snowpack-stabilizing structures 129
- strategies 6
- structures 7
- with temporary effects 7
- transverse defense structures 167
- avalanche breaker 171, 172
- avalanche-retarding cone 169–171
- catching dam (wall) 169, 170
- construction type 169

- protection effects 167–169
- structures distances
 - according to fixed height differences
- Swiss Federal Police 341
- Swiss Guideline ‘Defense structures’ 177
- Swiss guidelines* 15, 146, 201, 221, 225, 227, 229
- Swiss Guide PROTECT 288
- Switzerland
 - avalanche 3
 - EUROCODE and national standards 177
 - extreme snow height in 180–182
 - frost resistance index 207
 - hazard zoning 108, 109
 - historical foundation methods 153, 154
 - investment in structural avalanche protection 285
 - protection goal matrix
 - as a benchmark for public investment 116, 117
 - protection target matrix 116
 - standards for construction-technical assessment 178
 - technical defense structures 13
- T**
- tangent
 - bed friction angle 76
 - force 223
 - parallel load 252
 - pressures 80
- technical avalanche defense 6
 - pioneer structures 15
- technical protection 363–371
 - institutions and experts to survey 363
 - international overview 364–371
- technologies
 - for artificial release of avalanches 9
 - avalanche monitoring 345
 - developments 328
 - instruments 352
 - monitoring with remote sensing 354
 - scraping 262
- temperature 10, 19, 25, 29, 35, 36, 50, 51
 - fluctuations 21
 - inversion 20
- temporary defense measures 8, 118, 120
 - avalanche 120, 127, 325
- tensile stress 253
- terrain 232
 - displacement 208
- terrestrial laser scanners (LIDAR) 350
- thermal insulation 257
- thickness
 - flow avalanche 85, 86
 - snow 133, 136, 140, 142, 143, 158, 162, 195, 196, 202
- thin
 - shear layer 57
 - snowpack 23
 - walled profiles 145
- threshold
 - angle 33
 - cirque 44
 - value 325
- topography 256, 261, 341, 352
 - irregular 184
 - realistic 71
 - and shape of the building 311
- torrential processes 247
- torsion 235
 - bars with a high elastic limit 337
 - design 235
 - flexural buckling 213
 - lateral 212
- tourist avalanches 2
- traction 153, 154, 183
 - forces 210
 - strips 235
 - transferred via 142
- transition 47, 62, 238, 242
 - avalanche path to runoff zone 47
 - distance 70, 78, 88
 - fluidized transition layer 62
- transportation systems 1, 258, 261
 - cable crane 267
 - heavy transport helicopters 265–267
 - principles of transportation 261
 - safety regulation for helicopter transportation 281

- transportation road 261–263
- transverse load 212
- turbulent
 - movement 55
 - parameters 359
 - peak pressures 314

U

- ultimate limit state (ULS) 220
- unconfined avalanches 18, 40, 78, 247, 249
- uprooted and broken larches 52
- upslope measurement 319
- upwind side 311

V

- valley avalanches 326
- vegetation
 - in avalanche path 53
 - effects on avalanche formation 48
 - natural 53
 - in starting zones 49
- velocity 51, 55, 59, 70, 74, 80, 85, 171, 241, 244, 356, 359, 360
 - of aerosol 311
 - front 62
 - gradient 60
 - magnitudes of 56
 - measurement methods 57
 - profiles 55
 - propagation 60
- ventilation 257
- vertical
 - deflection 85
 - of flow avalanches 85, 86
 - deviation force 252
 - loads 251
 - movement 21
 - pressure 315
 - upward forces 90
- video cameras 355
- video signal processing 359
- Voellmy-fluid constitutive law 66
- Voellmy-like 2-parameterized friction laws 59
- Voellmy-Salm model 67, 69–72, 74

vulnerability

- to avalanche hazard 2
- of avalanche protection structures 285
- to damage 286
- objects at risk 4

W

- walls
 - design 316
 - impact 319, 321, 322
 - side wing 316
- water 1
 - saturation limit 207
- wave air pressure 318
- weather conditions 257
 - conducive for avalanche formation 18
 - forming avalanches
 - in the European Alps 19, 20
 - in North America 23, 24
 - in other mountain regions 24
- weather radar station 350
- weather stations, fully automatic 348, 349
- western weather conditions 21, 22
- wet-snow avalanches 17, 48, 64
 - action by 87
- Wiestal Avalanche 11
- wind 209
 - baffles 8, 16, 234
 - construction principles 235
 - braces 235
 - conditions 50
 - dynamic pressure 290, 291
 - load 195
 - redistribution of snow by 28
 - roofs 8, 16, 160, 235
 - speed 35, 99, 156, 159, 348
- wire rope anchors 270, 271
- Wyssen Avalanche Tower LS12-5® 339–342
 - components 341
 - features 340

Z

- zinc coating 227

