

(01) Dam works (Illustration) in Africa(1-328)

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TADANO TOSHIO

## Reference

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36 (D36)Concrete dam construction equipment(grouting)	grouting
37 (D37)River treatment(Temporary drainage tunnel)	cofferdam
38 (D38)River treatment(half river cofferdam)	cofferdam
39 (D39)River treatment(Temporary drainage opening channel)	cofferdam
40 (D40)River treatment(temporary cofferdam)	cofferdam
41 (D41)River treatment(temporary cofferdam)	cofferdam
42 (D42)foundation excavation(topsoil excavation)	foundation excavation
43 (D43)foundation excavation(rough excavation)	foundation excavation
44 (D44)foundation excavation(finishing excavation)	foundation excavation
45 (D45)foundation excavation(excavation surface protection)	foundation excavation
46 (D46)Construction of concrete dam (conventional method)	placing concrete
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48 (D48)Construction of concrete dam (conventional method)	placing concrete
49 (D49)Construction of concrete dam (conventional method)	placing concrete
50 (D50)Construction of concrete dam (conventional method)	placing concrete
51 (D51)Construction of concrete dam (conventional method)	placing concrete
52 (D52)Construction of concrete dam (placing concrete)	placing concrete
53 (D53)Construction of concrete dam (placing concrete)	placing concrete
54 (D54)Construction of concrete dam (placing concrete)	placing concrete
55 (D55)Construction of concrete dam (placing concrete)	placing concrete
56 (D56)Construction of concrete dam (placing concrete)	placing concrete
57 (D57)Construction of concrete dam (placing concrete)	placing concrete
58 (D58)Construction of concrete dam (placing concrete)	placing concrete
59 (D59)Construction of concrete dam (placing concrete)	placing concrete
60 (D60)Construction of concrete dam (placing concrete)	placing concrete
61 (D61)Construction of concrete dam (placing concrete-formwork)	placing concrete-formwork
62 (D62)Construction of concrete dam (placing concrete-formwork)	placing concrete-formwork
63 (D63)Construction of concrete dam (placing concrete-formwork)	placing concrete-formwork
64 (D64)Construction of concrete dam (Concrete temperature regulation)	cooling
65 (D65)Concrete temperature regulation(Pre-cooling)	Pre-cooling
66 (D66)Concrete temperature regulation(Pipe cooling)	Pipe cooling
67 (D67)Concrete temperature regulation(Pipe cooling)	Pipe cooling
68 (D68)Concrete temperature regulation(Pipe cooling)	Pipe cooling



69 (D69)Concrete temperature regulation(Pipe cooling)	Pipe cooling
70 (D70)Concrete temperature regulation(Joint grouting)	grouting
71 (D71)Construction of concrete dam (Corridor)	Corridor
72 (D72)Construction of concrete dam (Foundation drainage hole)	grouting
73 (D73)Construction of concrete dam (Water stop plate and joint drainage hole)	Water stop plate
74 (D74)Construction of concrete dam using RCD method	RCD method
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76 (D76)RCD method	RCD method
77 (D77)RCD method	RCD method
78 (D78)RCD method	RCD method
79 (D79)RCD method	RCD method
80 (D80)RCD method	RCD method
81 (D81)RCD method	RCD method
82 (D82)RCD method	RCD method
83 (D83)RCD method	RCD method
84 (D84)RCD method	RCD method
85 (D85)RCD method	RCD method
86 (D86)RCD method	RCD method
87 (D87)fill dam	fill dam
88 (D88)fill dam	fill dam
89 (D89)fill dam	fill dam
90 (D90)fill dam	fill dam
91 (D91)fill dam	fill dam
92 (D92)fill dam	fill dam
93 (D93)fill dam	fill dam
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96 (D96)fill dam	fill dam
97 (D97)fill dam(test filling)	fill dam
98 (D98)fill dam(test filling)	fill dam
99 (D99)fill dam(test filling)	fill dam
100 (D100)fill dam(test filling)	fill dam
101 (D101)fill dam	fill dam
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121 (D121)fill dam	fill dam
122 (D122)fill dam	fill dam
123 (D123)fill dam	fill dam
124 (D124)foundation treatment(grouting)	grouting
125 (D125)foundation treatment(grouting)	grouting
126 (D126)foundation treatment(grouting)	grouting
127 (D127)foundation treatment(grouting)	grouting
128 (D128)foundation treatment(grouting)	grouting
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147 (D147)foundation treatment(grouting)	grouting
148 (D148)foundation treatment(grouting)	grouting
149 (D149)foundation treatment(grouting)	grouting
150 (D150)dam	dam
151 (D151)dam	dam
152 (D152)dam	dam
153 (D153)dam	dam
154 (D154)dam	dam
155 (D155)dam	dam
156 (D156)dam	dam
157 (D157)dam	dam
158 (D158)dam	dam
159 (D159)dam	dam
160 (D160)dam	dam
161 (D161)dam(Diversion works)	dam(Diversion works)
162 (D162)dam(Diversion works)	dam(Diversion works)
163 (D163)dam(Diversion works)	dam(Diversion works)
164 (D164)dam(construction order)	dam(construction order)
165 (D165)dam(construction order)	dam(construction order)
166 (D166)dam(construction order)	dam(construction order)
167 (D167)dam(construction order)	dam(construction order)
168 (D168)dam(fill dam)	fill dam
169 (D169)dam(rock fill dam)	fill dam
170 (D170)dam(rock fill dam)	fill dam

171 (D171)dam(rock fill dam)	fill dam
172 (D172)dam(earth dam)	earth dam
173 (D173)dam(earth dam)	earth dam
174 (D174)dam(arch dam)	earth dam
175 (D175)dam(RCD method)	RCD method
176 (D176)dam(potential head)	hydraulics
177 (D177)impact crusher	construction machinery
178 (D178)winch	construction machinery
179 (D179)aerial cableway	construction machinery
180 (D180)design flood discharge	hydraulics
181 (D181)cable crane	construction machinery
182 (D182)concrete bucket	construction machinery
183 (D183)conveyor	construction machinery
184 (D184)crusher	construction machinery
185 (D185)surge-tank	hydraulics
186 (D186) differential surge-tank	hydraulics
187 (D187)natural head	hydraulics
188 (D188)control section	hydraulics
189 (D189)jib crane	construction machinery
190 (D190)sheeps-foot roller	construction machinery
191 (D191)cofferdam	cofferdam
192 (D192)cofferdam	cofferdam
193 (D193)cofferdam	cofferdam
194 (D194)cofferdam	cofferdam
195 (D195)closing dyke	cofferdam
196 (D196)supercritical flow(shooting flow /rapid flow)	hydraulics
197 (D197)gravity dam	dam
198 (D198)water-intake	intake
199 (D199)intake	intake
200 (D200)intake dam	intake
201 (D201)intake dam	intake
202 (D202)dredging(Pump dredger)	dredging
203 (D203)dredging(Bucket dredger)	dredging
204 (D204)dredging(Grab dredger)	dredging

205 (D205)dredging(Dipper dredger)  
206 (D206)wetted perimeter  
207 (D207)ordinary flow  
208 (D208)jaw crusher  
209 (D209)penstock root  
210 (D210)stage  
211 (D211)water-level recorder  
212 (D212)water-level recorder  
213 (D213)water hammmmer  
214 (D214)chamber surge tank  
215 (D215)hydraulic turbine  
216 (D216)efficiency of hydraulic turbine  
217 (D217)gate  
218 (D218)best hydraulic cross-section  
219 (D219)Hydraulic water depth  
220 (D220)conduct type water power  
221 (D221)weir  
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223 (D223)hollow gravity dam  
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228 (D228)sediment settling  
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233 (D233)sharp crested weir  
234 (D234)batcher plant  
235 (D235)batcher plant  
236 (D236)auxiliary dam  
237 (D237)unsteady flow  
238 (D238)impermeability layer

dredging  
water-level recorder  
hydraulics  
construction machinery  
hydraulics  
water-level recorder  
water-level recorder  
water-level recorder  
hydraulics  
hydraulics  
hydraulics  
hydraulics  
gate  
hydraulics  
hydraulics  
hydraulics  
weir  
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dam  
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dam  
hydraulics  
fill dam  
fill dam  
hydraulics  
dam  
weir  
batcher plant  
batcher plant  
dam  
hydraulics  
hydraulics

239 (D239)floating dam	dam
240 (D240)watershed	hydraulics
241 (D241)equilibrium slope	hydraulics
242 (D242)parallel drainage	hydraulics
243 (D243)radial drainage	hydraulics
244 (D244)tail-race surge tank	hydraulics
245 (D245)spatter's effect	hydraulics
246 (D246)effective head	hydraulics
247 (D247)pumped storage power	hydraulics
248 (D248)pump-up head	hydraulics
249 (D249)spillway	dam
250 (D250)log-chute	dam
251 (D251)basin coefficient	hydraulics
252 (D252)discharge -duration curve	hydraulics
253 (D253)flow net	hydraulics
254 (D254)velocity of flow	hydraulics
255 (D255)water course	hydraulics
256 (D256)rock fill dam	fill dam
257 (D257)concrete arch dam	arch dam
258 (D258)roller compacted concrete dams(RCD)	RCD
259 (D259)roller compacted concrete dams(RCD)	RCD
260 (D260)roller compacted concrete dams(RCD)	RCD
261 (D261)Movable weir	weir
262 (D262)exterior concrete	dam
263 (D263)cofferdam	cofferdam
264 (D264)cofferdam	cofferdam
265 (D265)dam type power	dam
266 (D266)green cut	dam
267 (D267)clean plant	dam
268 (D268)Slanted seam	dam
269 (D269)cable crane	dam
270 (D270)dam and conduit type power	dam
271 (D271)Quarry	Quarry
272 (D272)spillway	spillway

273 (D273)concrete replacement	concrete replacement
274 (D274)RCD method(concrete vibrating joint cutter)	RCD method
275 (D275)Concrete batching and mixing plant	Concrete batching
276 (D276)Concrete pump	construction machinery
277 (D277)consolidation grouting	grouting
278 (D278)fixed jib crane	construction machinery
279 (D279)Concrete gravity dam	dam
280 (D280)joint grouting lift	grouting
281 (D281)Stage grouting	grouting
282 (D282)slide form	dam
283 (D283)dowelling method	concrete replacement
284 (D284)longitudinal joint	dam
285 (D285)Dam concrete division	dam
286 (D286)dam construction equipments	construction machinery
287 (D287)concrete replacement for faults	concrete replacement
288 (D288)Diversion works-Temporary drainage tunnel	cofferdam
289 (D289)Diversion works-Half cofferdam	cofferdam
290 (D290)Diversion works(Temporary drainage open ditch)	Diversion works
291 (D291)Training wall	dam
292 (D292)pipe cooling	cooling
293 (D293)vibrator	construction machinery
294 (D294)Fillet-gravity dam	dam
295 (D295)rod vibrator	construction machinery
296 (D296)transeverse joint	dam
297 (D297)arch dam	arch dam
298 (D298)temporary cofferdam	cofferdam
299 (D299)grouting	grouting
300 (D300)energy dissipator	dam
301 (D301)core type dam	dam
302 (D302)Concrete mixer	construction machinery
303 (D303)flood sluice of fill dam	flood sluice
304 (D304)flood sluice of fill dam	flood sluice
305 (D305)flood sluice of fill dam	flood sluice
306 (D306)flood sluice of fill dam	flood sluice

307 (D307)flood sluice of fill dam	flood sluice
308 (D308)flood sluice of fill dam	flood sluice
309 (D309)flood sluice of fill dam	flood sluice
310 (D310)flood sluice of fill dam	flood sluice
311 (D311)flood sluice of fill dam	flood sluice
312 (D312)flood control	hydraulics
313 (D313)water level	hydraulics
314 (D314)hydraulic cycle	hydraulics
315 (D315)underground dam	dam
316 (D316)regulating reservoir	dam
317 (D317)fill dam	fill dam
318 (D318)fill dam	fill dam
319 (D319)fill dam	fill dam
320 (D320)fill dam	fill dam
321 (D321)effective storage capacity	hydraulics
322 (D322)spillway	dam
323 (D323)flow net	hydraulics
324 (D324)flow net	hydraulics
325 (D325)fixed wheel gate	gate
326 (D326)Diversion works	Diversion works
327 (D327)earth dam(fill dam)	fill dam
328 (D328)RCD method(Roller Compacted Dam-Concrete)	RCD



257 (D257)concrete arch dam	arch dam
297 (D297)arch dam	arch dam
234 (D234)batcher plant	batcher plant
235 (D235)batcher plant	batcher plant
1 (D1)Classification of dams	Classification of dams
37 (D37)River treatment(Temporary drainage tunnel)	cofferdam
38 (D38)River treatment(half river cofferdam)	cofferdam
39 (D39)River treatment(Temporary drainage opening channel)	cofferdam
40 (D40)River treatment(temporary cofferdam)	cofferdam
41 (D41)River treatment(temporary cofferdam)	cofferdam
191 (D191)cofferdam	cofferdam
192 (D192)cofferdam	cofferdam
193 (D193)cofferdam	cofferdam
194 (D194)cofferdam	cofferdam
195 (D195)closing dyke	cofferdam
263 (D263)cofferdam	cofferdam
264 (D264)cofferdam	cofferdam
288 (D288)Diversion works-Temporary drainage tunnel	cofferdam
289 (D289)Diversion works-Half cofferdam	cofferdam
298 (D298)temporary cofferdam	cofferdam
275 (D275)Concrete batching and mixing plant	Concrete batching
14 (D14)Concrete dam construction equipment	Concrete dam construction equipment
15 (D15)Concrete dam construction equipment	Concrete dam construction equipment
16 (D16)Concrete dam construction equipment	Concrete dam construction equipment
17 (D17)Concrete dam construction equipment	Concrete dam construction equipment
18 (D18)Concrete dam construction equipment	Concrete dam construction equipment
19 (D19)Concrete dam construction equipment	Concrete dam construction equipment
20 (D20)Concrete dam construction equipment	Concrete dam construction equipment
21 (D21)Concrete dam construction equipment	Concrete dam construction equipment
22 (D22)Concrete dam construction equipment	Concrete dam construction equipment
23 (D23)Concrete dam construction equipment	Concrete dam construction equipment
24 (D24)Concrete dam construction equipment	Concrete dam construction equipment
25 (D25)Concrete dam construction equipment	Concrete dam construction equipment
26 (D26)Concrete dam construction equipment	Concrete dam construction equipment

27 (D27)Concrete dam construction equipment	Concrete dam construction equipment
28 (D28)Concrete dam construction equipment	Concrete dam construction equipment
29 (D29)Concrete dam construction equipment	Concrete dam construction equipment
30 (D30)Concrete dam construction equipment	Concrete dam construction equipment
31 (D31)Concrete dam construction equipment	Concrete dam construction equipment
273 (D273)concrete replacement	concrete replacement
283 (D283)dowelling method	concrete replacement
287 (D287)concrete replacement for faults	concrete replacement
177 (D177)impact crusher	construction machinery
178 (D178)winch	construction machinery
179 (D179)aerial cableway	construction machinery
181 (D181)cable crane	construction machinery
182 (D182)concrete bucket	construction machinery
183 (D183)conveyor	construction machinery
184 (D184)crusher	construction machinery
189 (D189)jib crane	construction machinery
190 (D190)sheeps-foot roller	construction machinery
208 (D208)jaw crusher	construction machinery
276 (D276)Concrete pump	construction machinery
278 (D278)fixed jib crane	construction machinery
286 (D286)dam construction equipments	construction machinery
293 (D293)vibrator	construction machinery
295 (D295)rod vibrator	construction machinery
302 (D302)Concrete mixer	construction machinery
64 (D64)Construction of concrete dam (Concrete temperature regulation)	cooling
292 (D292)pipe cooling	cooling
71 (D71)Construction of concrete dam (Corridor)	Corridor
32 (D32)length of crest	dam
150 (D150)dam	dam
151 (D151)dam	dam
152 (D152)dam	dam
153 (D153)dam	dam
154 (D154)dam	dam
155 (D155)dam	dam

156 (D156)dam	dam
157 (D157)dam	dam
158 (D158)dam	dam
159 (D159)dam	dam
160 (D160)dam	dam
197 (D197)gravity dam	dam
223 (D223)hollow gravity dam	dam
227 (D227)penstock (head race)	dam
232 (D232)dentated sill	dam
236 (D236)auxiliary dam	dam
239 (D239)floating dam	dam
249 (D249)spillway	dam
250 (D250)log-chute	dam
262 (D262)exterior concrete	dam
265 (D265)dam type power	dam
266 (D266)green cut	dam
267 (D267)clean plant	dam
268 (D268)Slanted seam	dam
269 (D269)cable crane	dam
270 (D270)dam and conduit type power	dam
279 (D279)Concrete gravity dam	dam
282 (D282)slide form	dam
284 (D284)longitudinal joint	dam
285 (D285)Dam concrete division	dam
291 (D291)Training wall	dam
294 (D294)Fillet-gravity dam	dam
296 (D296)transeverse joint	dam
300 (D300)energy dissipator	dam
301 (D301)core type dam	dam
315 (D315)underground dam	dam
316 (D316)regulating reservoir	dam
322 (D322)spillway	dam
8 (D8)Dam construction plan	Dam construction plan
9 (D9)Dam construction plan	Dam construction plan



95 (D95)fill dam	fill dam
96 (D96)fill dam	fill dam
97 (D97)fill dam(test filling)	fill dam
98 (D98)fill dam(test filling)	fill dam
99 (D99)fill dam(test filling)	fill dam
100 (D100)fill dam(test filling)	fill dam
101 (D101)fill dam	fill dam
102 (D102)fill dam	fill dam
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119 (D119)fill dam	fill dam
120 (D120)fill dam	fill dam
121 (D121)fill dam	fill dam
122 (D122)fill dam	fill dam
123 (D123)fill dam	fill dam
168 (D168)dam(fill dam)	fill dam
169 (D169)dam(rock fill dam)	fill dam
170 (D170)dam(rock fill dam)	fill dam
171 (D171)dam(rock fill dam)	fill dam
229 (D229)internal impervious wall	fill dam

230 (D230)internal impervious wall	fill dam
317 (D317)fill dam	fill dam
318 (D318)fill dam	fill dam
319 (D319)fill dam	fill dam
320 (D320)fill dam	fill dam
327 (D327)earth dam(fill dam)	fill dam
256 (D256)rock fill dam	fill dam
303 (D303)flood sluice of fill dam	flood sluice
304 (D304)flood sluice of fill dam	flood sluice
305 (D305)flood sluice of fill dam	flood sluice
306 (D306)flood sluice of fill dam	flood sluice
307 (D307)flood sluice of fill dam	flood sluice
308 (D308)flood sluice of fill dam	flood sluice
309 (D309)flood sluice of fill dam	flood sluice
310 (D310)flood sluice of fill dam	flood sluice
311 (D311)flood sluice of fill dam	flood sluice
42 (D42)foundation excavation(topsoil excavation)	foundation excavation
43 (D43)foundation excavation(rough excavation)	foundation excavation
44 (D44)foundation excavation(finishing excavation)	foundation excavation
45 (D45)foundation excavation(excavation surface protection)	foundation excavation
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325 (D325)fixed wheel gate	gate
33 (D33)Concrete dam construction equipment(Stage grouting)	grouting
34 (D34)Concrete dam construction equipment(Stage grouting)	grouting
35 (D35)Concrete dam construction equipment(grouting)	grouting
36 (D36)Concrete dam construction equipment(grouting)	grouting
70 (D70)Concrete temperature regulation(Joint grouting)	grouting
72 (D72)Construction of concrete dam (Foundation drainage hole)	grouting
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125 (D125)foundation treatment(grouting)	grouting
126 (D126)foundation treatment(grouting)	grouting
127 (D127)foundation treatment(grouting)	grouting
128 (D128)foundation treatment(grouting)	grouting
129 (D129)foundation treatment(grouting)	grouting

130 (D130)foundation treatment(grouting)	grouting
131 (D131)foundation treatment(grouting)	grouting
132 (D132)foundation treatment(grouting)	grouting
133 (D133)foundation treatment(grouting)	grouting
134 (D134)foundation treatment(grouting)	grouting
135 (D135)foundation treatment(grouting)	grouting
136 (D136)foundation treatment(grouting)	grouting
137 (D137)foundation treatment(grouting)	grouting
138 (D138)foundation treatment(grouting)	grouting
139 (D139)foundation treatment(grouting)	grouting
140 (D140)foundation treatment(grouting)	grouting
141 (D141)foundation treatment(grouting)	grouting
142 (D142)foundation treatment(grouting)	grouting
143 (D143)foundation treatment(grouting)	grouting
144 (D144)foundation treatment(grouting)	grouting
145 (D145)foundation treatment(grouting)	grouting
146 (D146)foundation treatment(grouting)	grouting
147 (D147)foundation treatment(grouting)	grouting
148 (D148)foundation treatment(grouting)	grouting
149 (D149)foundation treatment(grouting)	grouting
277 (D277)consolidation grouting	grouting
280 (D280)joint grouting lift	grouting
281 (D281)Stage grouting	grouting
299 (D299)grouting	grouting
176 (D176)dam(potential head)	hydraulics
180 (D180)design flood discharge	hydraulics
185 (D185)surge-tank	hydraulics
186 (D186) differential surge-tank	hydraulics
187 (D187)natural head	hydraulics
188 (D188)control section	hydraulics
196 (D196)supercritical flow(shooting flow /rapid flow)	hydraulics
207 (D207)ordinary flow	hydraulics
209 (D209)penstock root	hydraulics
213 (D213)water hammer	hydraulics

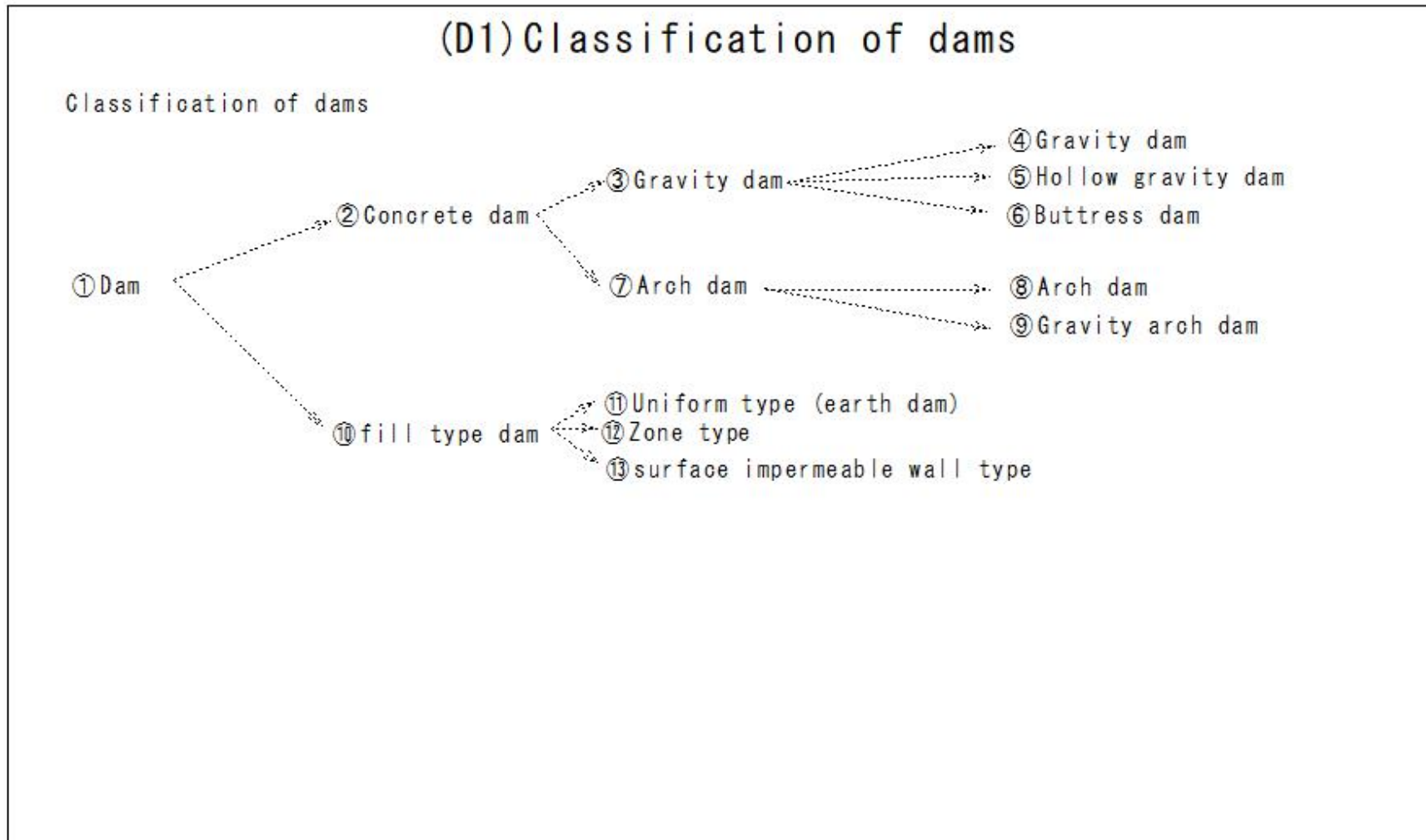
214 (D214)chamber surge tank	hydraulics
215 (D215)hydraulic turbine	hydraulics
216 (D216)efficiency of hydraulic turbine	hydraulics
218 (D218)best hydraulic cross-section	hydraulics
219 (D219)Hydraulic water depth	hydraulics
220 (D220)conduct type water power	hydraulics
222 (D222)backwater curve	hydraulics
224 (D224)hydraulic jump	hydraulics
225 (D225)deflector	hydraulics
226 (D226)head works	hydraulics
228 (D228)sediment settling	hydraulics
231 (D231)interflow	hydraulics
237 (D237)unsteady flow	hydraulics
238 (D238)impermeability layer	hydraulics
240 (D240)watershed	hydraulics
241 (D241)equilibrium slope	hydraulics
242 (D242)parallel drainage	hydraulics
243 (D243)radial drainage	hydraulics
244 (D244)tail-race surge tank	hydraulics
245 (D245)spatter's effect	hydraulics
246 (D246)effective head	hydraulics
247 (D247)pumped storage power	hydraulics
248 (D248)pump-up head	hydraulics
251 (D251)basin coefficient	hydraulics
252 (D252)discharge -duration curve	hydraulics
253 (D253)flow net	hydraulics
254 (D254)velocity of flow	hydraulics
255 (D255)water course	hydraulics
312 (D312)flood control	hydraulics
313 (D313)water level	hydraulics
314 (D314)hydraulic cycle	hydraulics
321 (D321)effective storage capacity	hydraulics
323 (D323)flow net	hydraulics
324 (D324)flow net	hydraulics



198 (D198)water-intake	intake
199 (D199)intake	intake
200 (D200)intake dam	intake
201 (D201)intake dam	intake
66 (D66)Concrete temperature regulation(Pipe cooling)	Pipe cooling
67 (D67)Concrete temperature regulation(Pipe cooling)	Pipe cooling
68 (D68)Concrete temperature regulation(Pipe cooling)	Pipe cooling
69 (D69)Concrete temperature regulation(Pipe cooling)	Pipe cooling
46 (D46)Construction of concrete dam (conventional method)	placing concrete
47 (D47)Construction of concrete dam (conventional method)	placing concrete
48 (D48)Construction of concrete dam (conventional method)	placing concrete
49 (D49)Construction of concrete dam (conventional method)	placing concrete
50 (D50)Construction of concrete dam (conventional method)	placing concrete
51 (D51)Construction of concrete dam (conventional method)	placing concrete
52 (D52)Construction of concrete dam (placing concrete)	placing concrete
53 (D53)Construction of concrete dam (placing concrete)	placing concrete
54 (D54)Construction of concrete dam (placing concrete)	placing concrete
55 (D55)Construction of concrete dam (placing concrete)	placing concrete
56 (D56)Construction of concrete dam (placing concrete)	placing concrete
57 (D57)Construction of concrete dam (placing concrete)	placing concrete
58 (D58)Construction of concrete dam (placing concrete)	placing concrete
59 (D59)Construction of concrete dam (placing concrete)	placing concrete
60 (D60)Construction of concrete dam (placing concrete)	placing concrete
61 (D61)Construction of concrete dam (placing concrete-formwork)	placing concrete-formwork
62 (D62)Construction of concrete dam (placing concrete-formwork)	placing concrete-formwork
63 (D63)Construction of concrete dam (placing concrete-formwork)	placing concrete-formwork
65 (D65)Concrete temperature regulation(Pre-cooling)	Pre-cooling
271 (D271)Quarry	Quarry
258 (D258)roller compacted concrete dams(RCD)	RCD
259 (D259)roller compacted concrete dams(RCD)	RCD
260 (D260)roller compacted concrete dams(RCD)	RCD
328 (D328)RCD method(Roller Compacted Dam-Concrete)	RCD
74 (D74)Construction of concrete dam using RCD method	RCD method
75 (D75)RCD method	RCD method

76 (D76)RCD method	RCD method
77 (D77)RCD method	RCD method
78 (D78)RCD method	RCD method
79 (D79)RCD method	RCD method
80 (D80)RCD method	RCD method
81 (D81)RCD method	RCD method
82 (D82)RCD method	RCD method
83 (D83)RCD method	RCD method
84 (D84)RCD method	RCD method
85 (D85)RCD method	RCD method
86 (D86)RCD method	RCD method
175 (D175)dam(RCD method)	RCD method
274 (D274)RCD method(concrete vibrating joint cutter)	RCD method
272 (D272)spillway	spillway
73 (D73)Construction of concrete dam (Water stop plate and joint drainage hole)	Water stop plate
206 (D206)wetted perimeter	water-level recorder
210 (D210)stage	water-level recorder
211 (D211)water-level recorder	water-level recorder
212 (D212)water-level recorder	water-level recorder
221 (D221)weir	weir
233 (D233)sharp crested weir	weir
261 (D261)Movable weir	weir

## (D1) Classification of dams



## (D2)Dam structure

### Dam structure

#### ①Gravity dam

- Spillway: Possible to install on the downstream side of the embankment body
- Structural stability of gravity dams

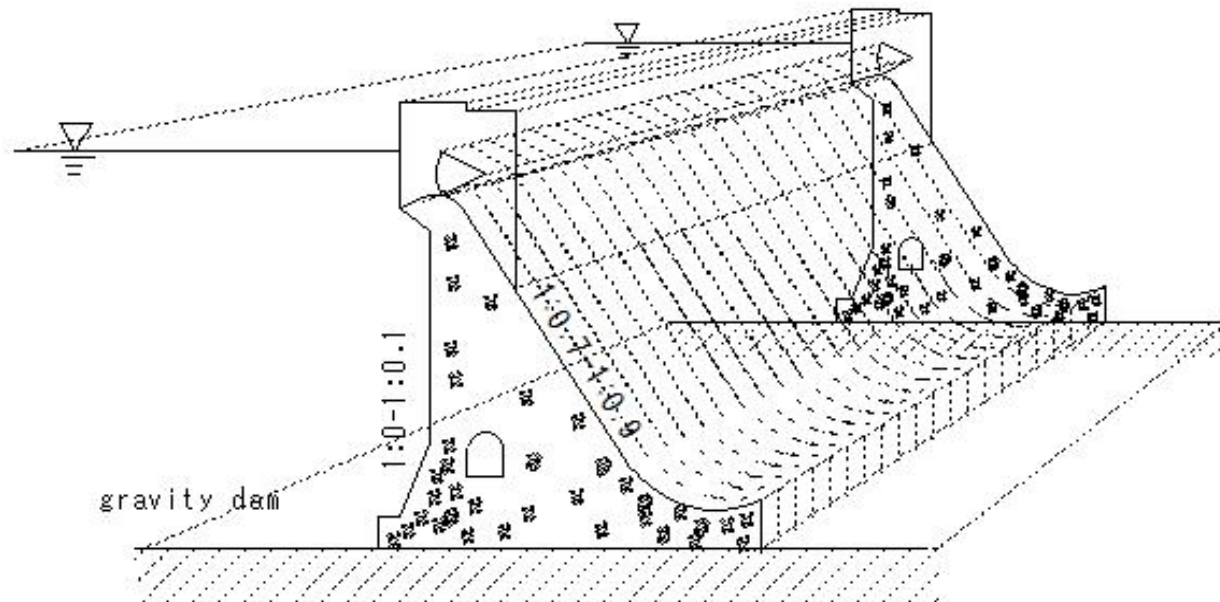
①No vertical tensile stress is generated on the upstream surface of the dam body.

②Contact surface between dam body and foundation rock

Be safe against shear forces

③The stress within the dam body does not exceed the allowable stress of the concrete.

### (D2)Dam structure



## (D3) Dam structure

### (D3) Dam structure

#### Dam structure

##### ② Arch dam

- External forces such as water pressure are transmitted to both banks by the arching action of the embankment body.

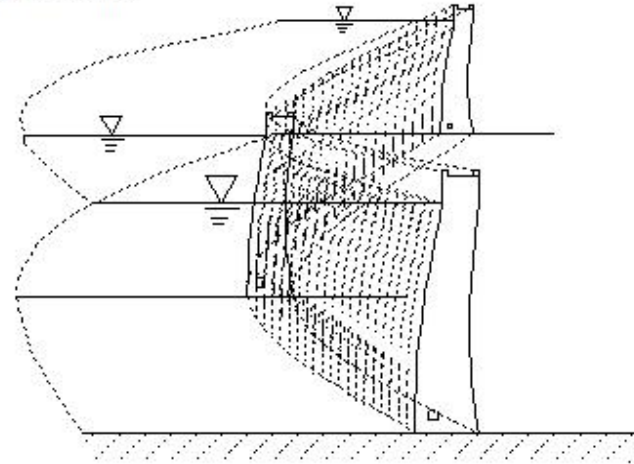
Supported by the shear resistance of the foundation rock

- Both cross section and planar shape have a convex curve upstream.
- Solid rock is required from the riverbed to the high areas on both banks.
- Structural stability of arch dam

① The stress within the dam body does not exceed the allowable stress of the concrete.

② Contact surface between dam body and foundation rock

Be safe against shear forces



## (D4) Dam structure

### (D4) Dam structure

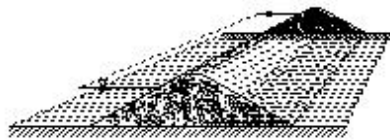
#### Dam structure

##### ② fill type dam

- The stress acting on the foundation ground is small.
- The embankment body adapts to slight deformation of the foundation.
- Can be constructed on all types of ground
- Seepage failure: It is necessary to consider damage to the embankment body due to overflow.
- Do not install a spillway (discharge facility) on the embankment body.

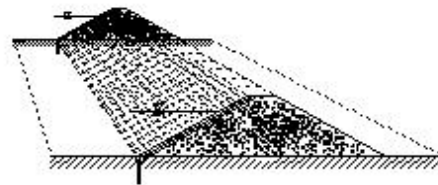
#### fill type dam stability condition

- Safe against infiltration water
- Safe against slipping



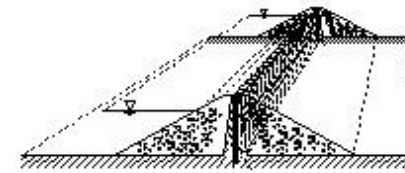
Uniform type

R591



Surface impermeable wall type

R592



artificial material core

R593

## (D5) Dam structure

### (D5) Dam structure

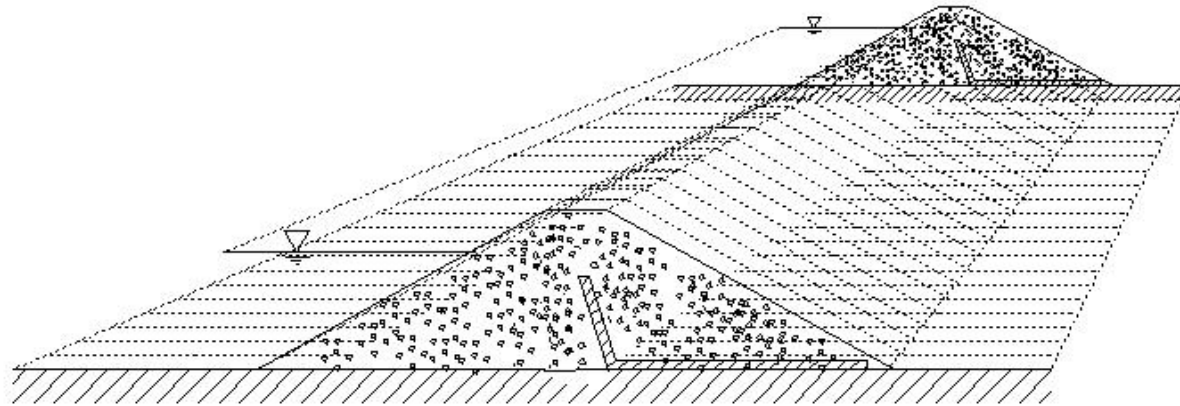
#### Dam structure

② fill type dam

① Uniform type

Drain placed downstream

- Easy to construct
- Pore water pressure is difficult to dissipate during construction
- shear strength of material-low
- Used for dams with low embankments (30 m or less)



Uniform type

spillway installed on the ground



## (D6) Dam structure

### (D6) Dam structure

Dam structure

② fill type dam

② Zone type

composition

- impermeable zone (Waterproof zone)

- Semi-permeable zone

- Permeable zone

- Central core type and inclined core type at the position of the water-blocking zone

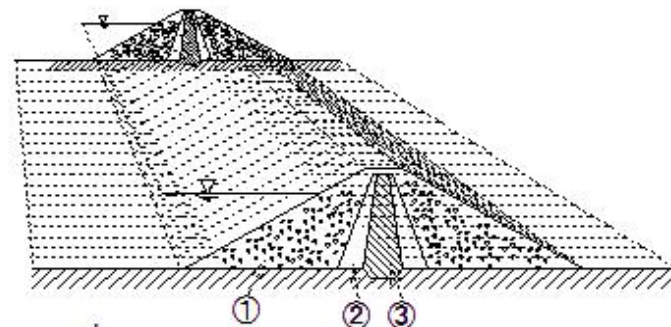
- The most suitable design can be made according to the topography, geology, and materials of the dam.

- It has the widest range of application and is adopted for large-scale field dams.

① permeable material

② Semi-permeable material

③ Waterproof (Impermeable) material



spillway installed on the ground

zone type

R590

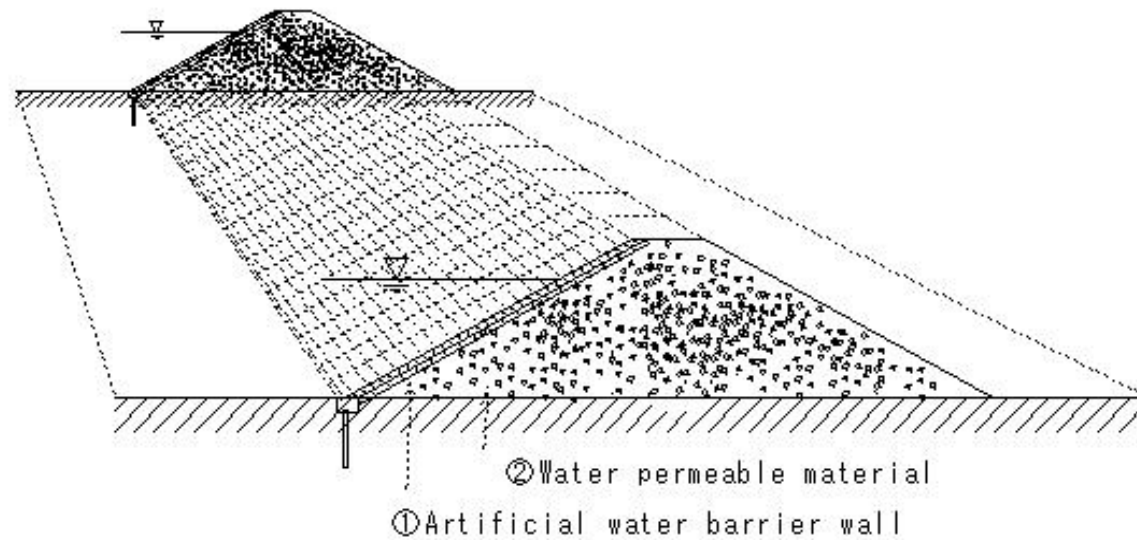


## (D7)Dam structure

### (D7)Dam structure

Dam structure

- ② fill type dam
- ③ Surface impermeable wall type
  - Upstream side of water-blocking zone
  - Asphalt, concrete, reinforced concrete, creating a water-blocking wall
  - Safe against sudden drops in water level



spillway installed on the ground

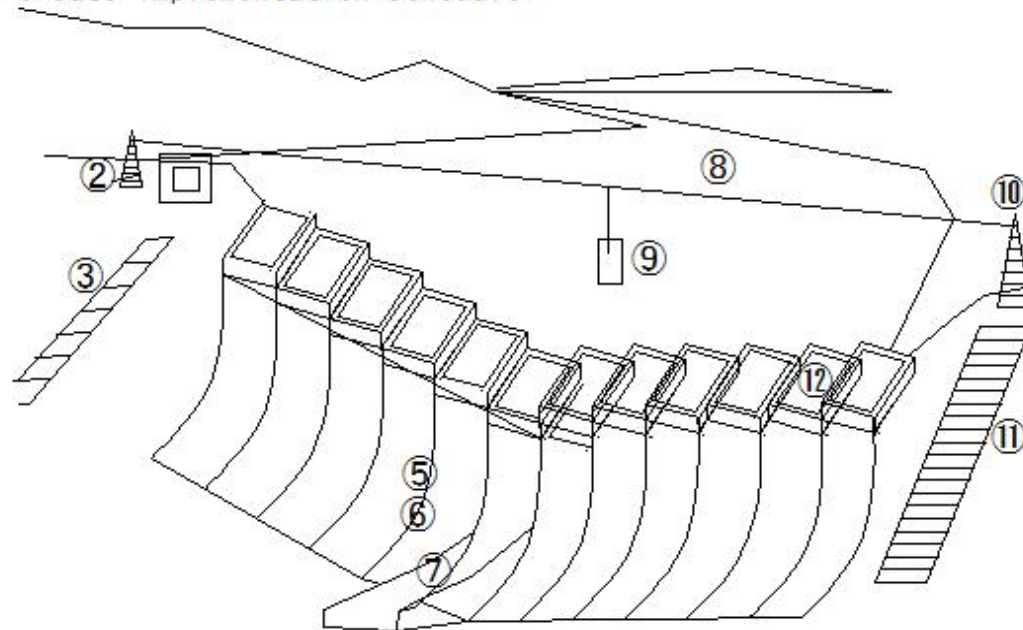
Surface impermeable wall type

R592

## (D8) Dam construction plan

### Dam construction plan

- Process planning
- Dam construction: A collection of various construction works
- Understand critical work types that affect the entire process
- Create implementation schedule



### (D8) Dam construction plan

- ① Layer construction method
- ② crane fixed tower
- ③ transfer car
- ④ Precautions when transporting concrete
- ⑤ transverse seam
- ⑥ insert the water stop plate
- ⑦ drainage channel
- ⑧ cable crane
- ⑨ concrete bucket
- ⑩ crane running tower
- ⑪ Adjust the position according to the placement location
- ⑫ sliding formwork
- ⑬ no vertical seams
- ⑭ Laitance processing
- ⑮ green cut
- ⑯ continuous driving
- ⑰ 1 lift: 1.5m to 2.0m
- ⑱ Construction in 34 layers
- ⑲ hydration heat treatment
- ⑳ Consideration for cold joints

C906

## (D9) Dam construction plan

### (D9) Dam construction plan

#### Dam construction plan

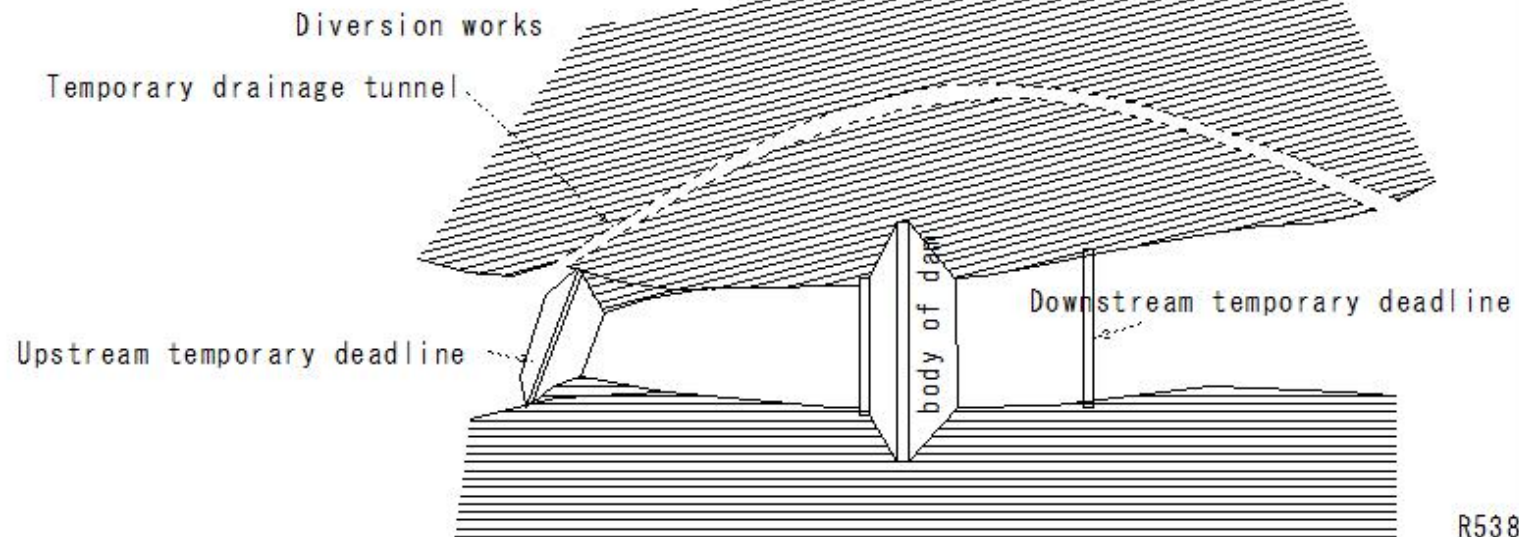
Points to keep in mind when planning the process

#### ① Diversion works

- Excavation of temporary drainage tunnel outside the embankment

Construction by single push from the downstream side

- After completion of off-site temporary drainage channel  
temporary cofferdam work begin-Non-water period  
temporary cofferdam



R538

## (D10) Dam construction plan

### (D10) Dam construction plan

#### Dam construction plan

Points to keep in mind - planning the process

#### ② foundation treatment

- Grouching: Simultaneous construction at the same location as the main construction  
Process adjustment between both parties is required.

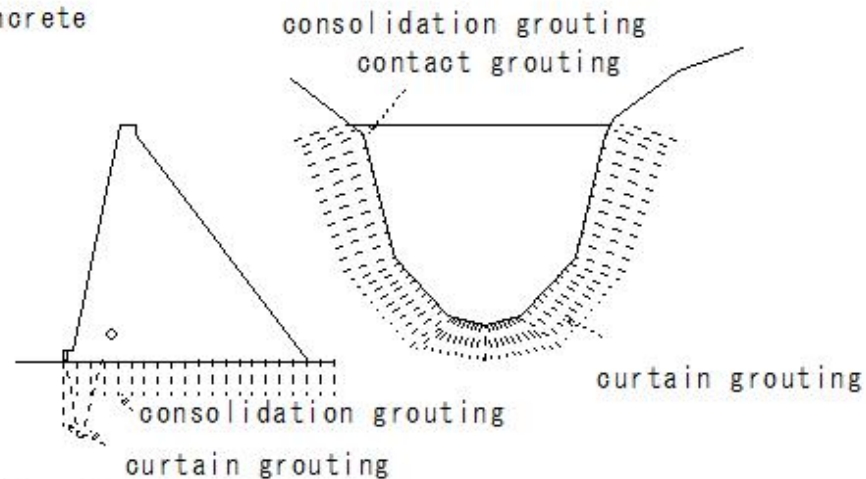
- Concrete dam

#### ① Between consolidation grouting and main concrete

fill dam stability condition

Between blanket grouting and body raising

Process adjustment required



#### Adjustment of basic treatment process

① Increase in the number of machinery and equipment

② Construction during main construction suspension period in winter

③ Speed up with Packachon boring machine



## (D11)Dam construction plan

### (D11)Dam construction plan

#### Dam construction plan

Points to keep in mind- planning the process

#### ③ main body work

##### ① Concrete dam

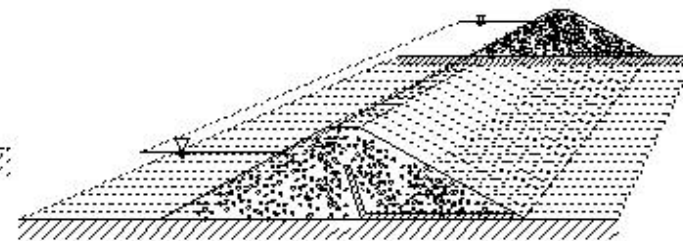
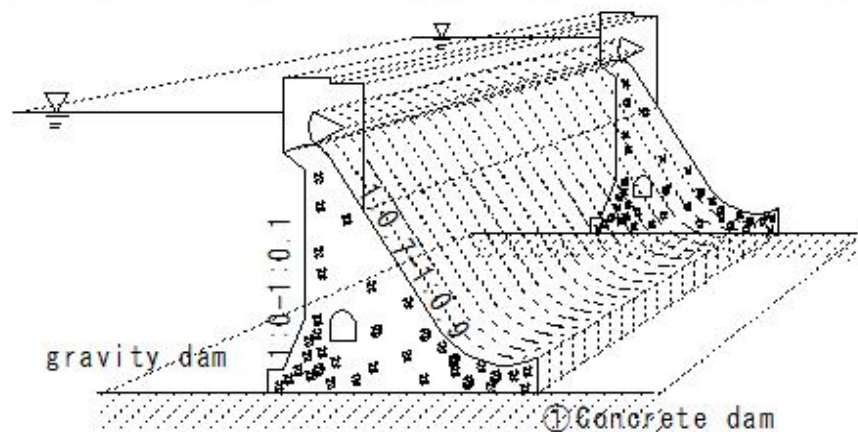
Main body concrete placement process

- Create a lift schedule that takes into consideration construction capacity, pouring intervals, lift differences, etc.
- Highly accurate study

##### ② fill dam

- Determine construction capacity from the rough construction period of heaving

Consider the selection and placement of construction machinery that suits the site conditions



D2 D4

## (D12) Dam construction plan

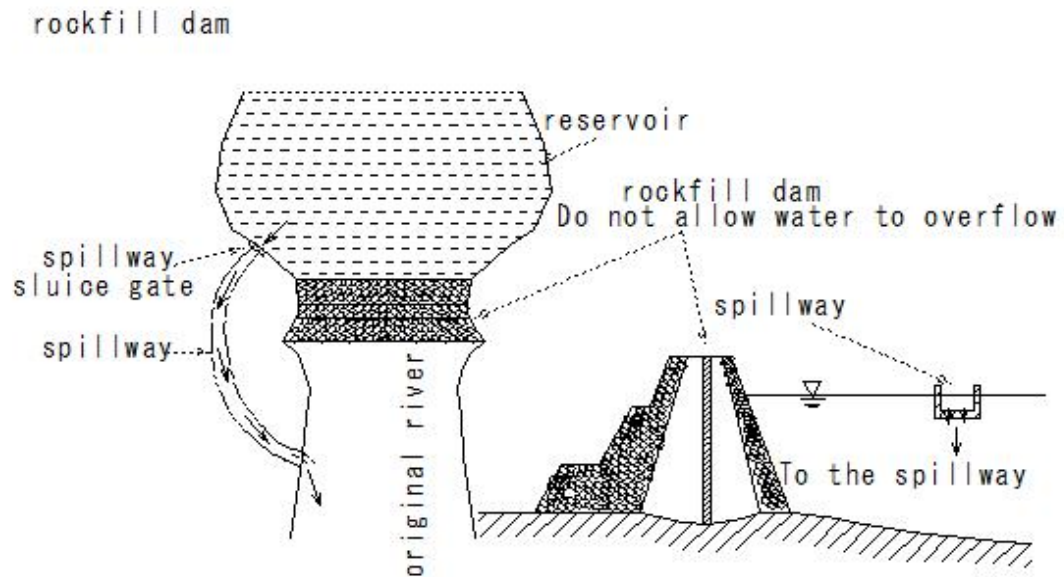
### (D12) Dam construction plan

#### Dam construction plan

Points to keep in mind - planning the process

#### ④ Closure work

- The period of blockage for both the off-site temporary drainage channel and the on-site temporary drainage channel is the non-flow period.



R505

## (D13) Dam construction plan

### (D13) Dam construction plan

#### Dam construction plan

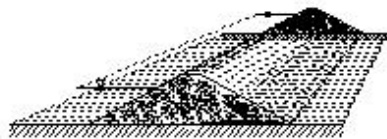
Points to keep in mind -planning the process

#### ⑤ spillway(floodway) of fill type dam

- Floodwaters of field dams must not be built on the embankment body.
- Rocks on the ground
- case of the spillway(floodway) contact with the body

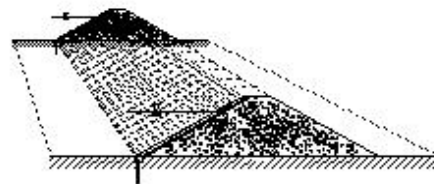
To avoid any hindrance to the embankment filling process

Advance concrete pouring



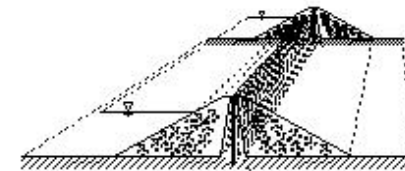
Uniform type

R591



Surface impermeable wall type

R592



artificial material core

R593

(D14)Concrete dam construction equipment

(D14) Concrete dam construction equipment

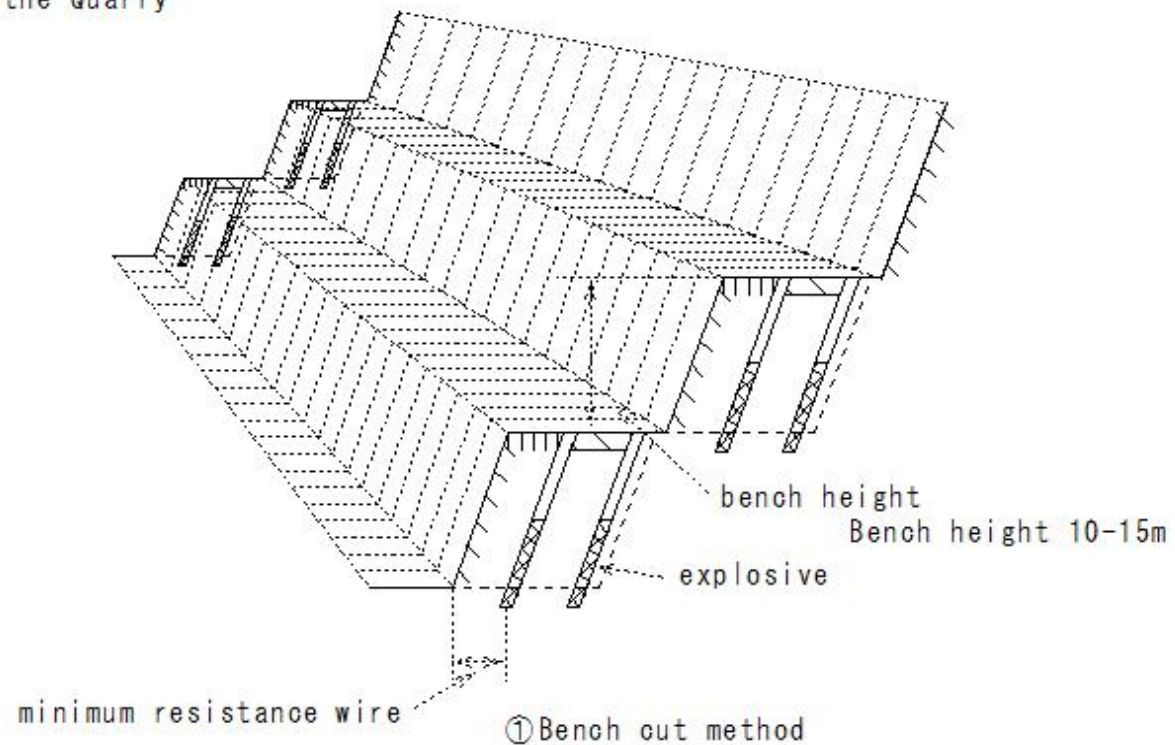
Aggregate manufacturing equipment

①Aggregate collection

• Aggregate: River gravel

Collecting rough stones from the Quarry

Excavation of Quarry





## (D15)Concrete dam construction equipment

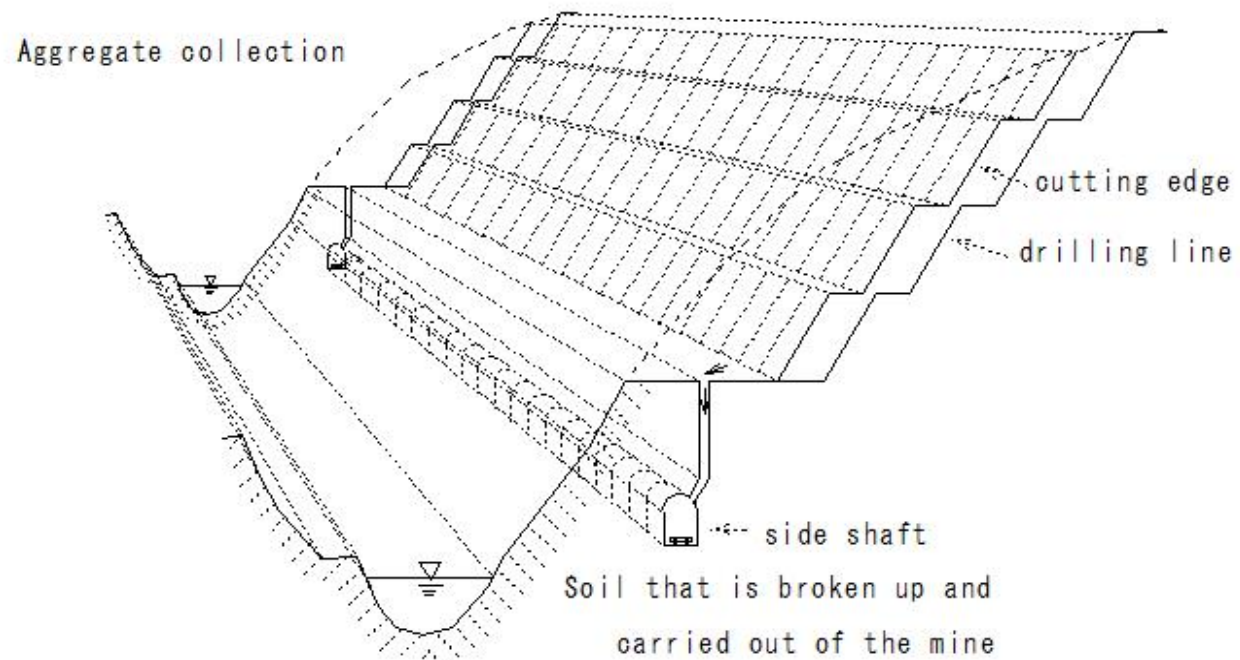
### (D15) Concrete dam construction equipment

Concrete dam construction equipment

Aggregate manufacturing equipment

① Aggregate collection

② side shaft: Soil that is broken up and carried out of the mine



(D16)Concrete dam construction equipment

(D16) Concrete dam construction equipment

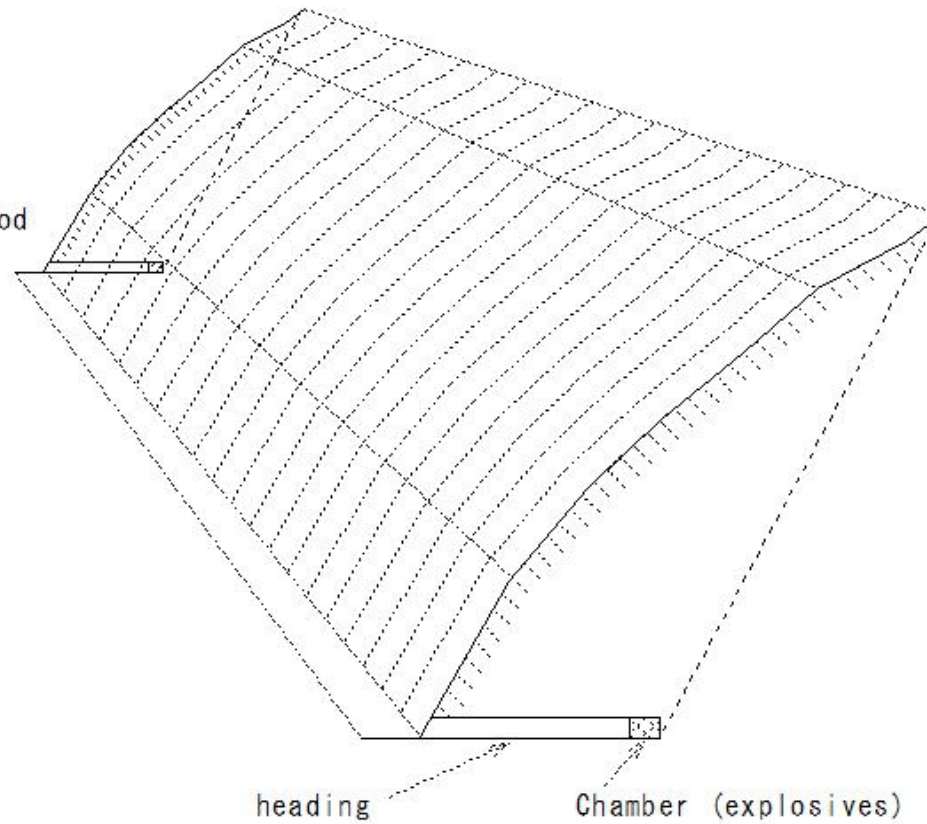
Concrete dam construction equipment

Aggregate manufacturing equipment

①Aggregate collection

③heading blasting method

heading blasting method



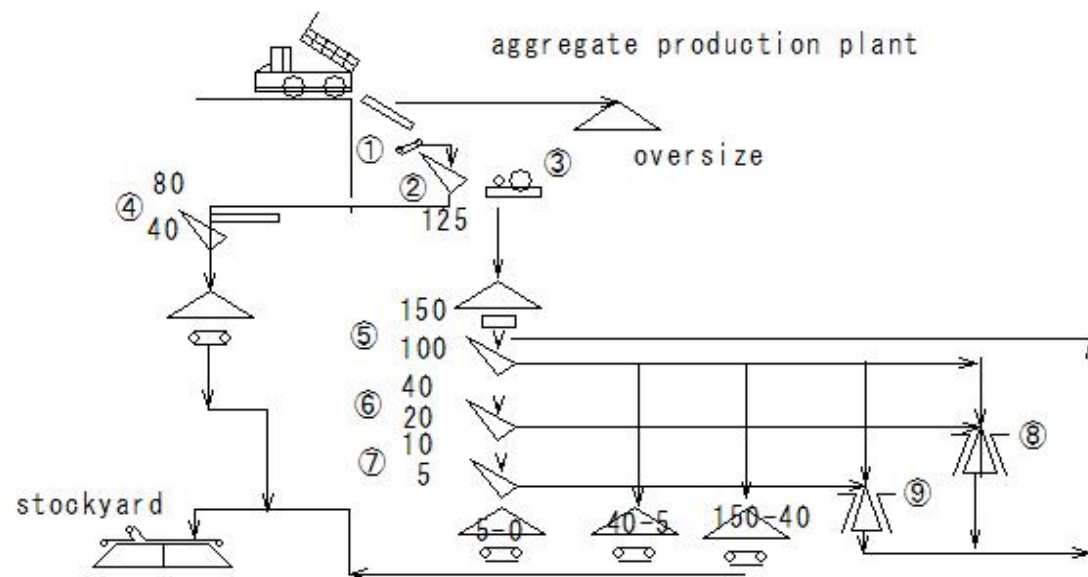
## (D17)Concrete dam construction equipment

### (D17) Concrete dam construction equipment

#### Concrete dam construction equipment

##### Aggregate manufacturing equipment

- Crushing, sorting, and cleaning of rough stone
- Have specified particle size and quality
- Equipment capacity: lift schedule
- Consideration of aggregate production volume that corresponds to the monthly maximum pouring volume



#### aggregate production plant

- ① Apron feeder
- ② Vibrating sieve
- ③ Jaw crusher
- ④ Vibrating sieve
- ⑤ Vibrating sieve
- ⑥ Vibrating sieve
- ⑦ Vibrating sieve
- ⑧ Cone crusher
- ⑨ Super fine crusher

(D18)Concrete dam construction equipment

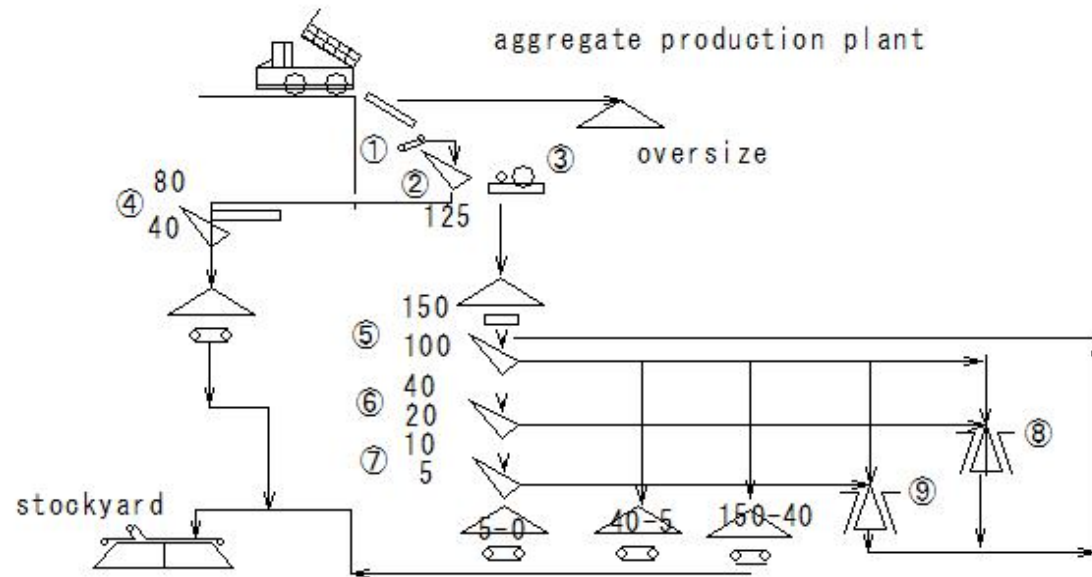
(D18) Concrete dam construction equipment

Concrete dam construction equipment

Aggregate manufacturing equipment

①Crushing equipment

- Primary crushing equipment: jaw crusher
- Second and tertiary crushing equipment: Cone crusher



aggregate production plant

- ①Apron feeder
- ②Vibrating sieve
- ③Jaw crusher
- ④Vibrating sieve
- ⑤Vibrating sieve
- ⑥Vibrating sieve
- ⑦Vibrating sieve
- ⑧Cone crusher
- ⑨Super fine crusher

## (D19)Concrete dam construction equipment

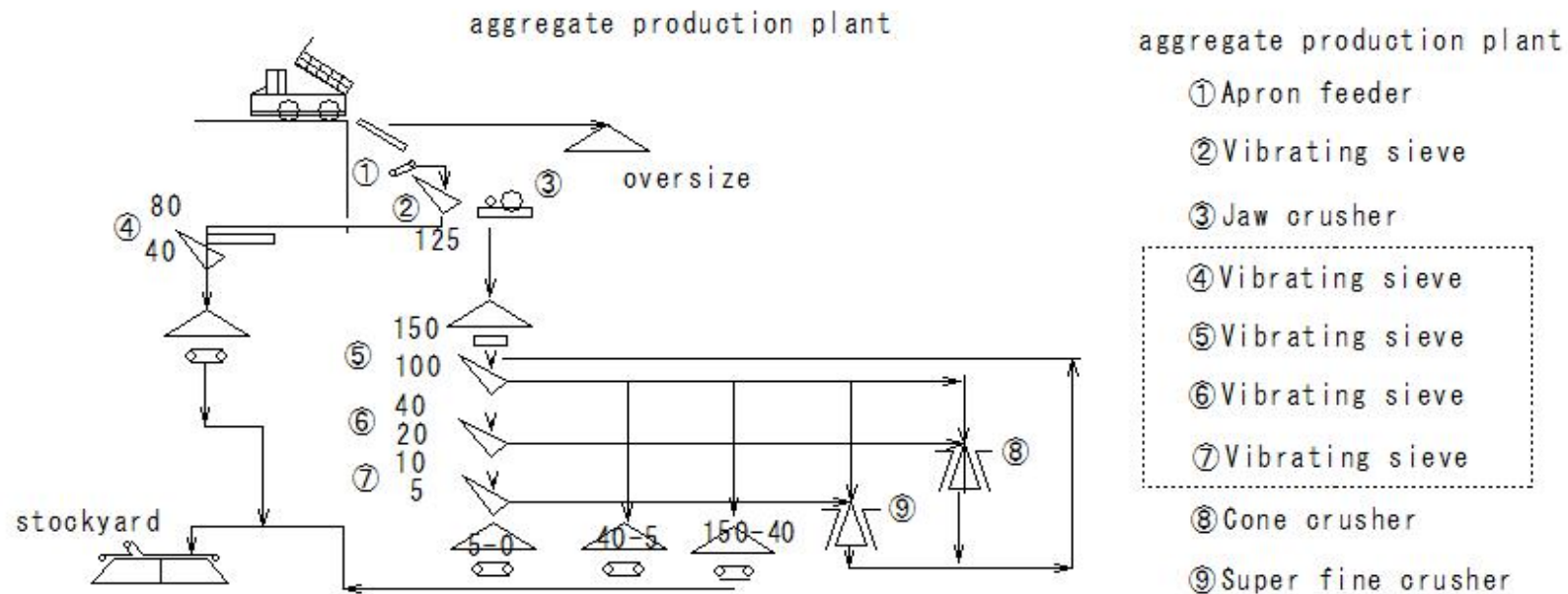
### (D19) Concrete dam construction equipment

Concrete dam construction equipment

Aggregate manufacturing equipment

② Sieving equipment

- Sieving of aggregate: vibrating sieve
- Slanted type (for large particle size)
- Horizontal type (for medium and small particle size)





## (D20)Concrete dam construction equipment

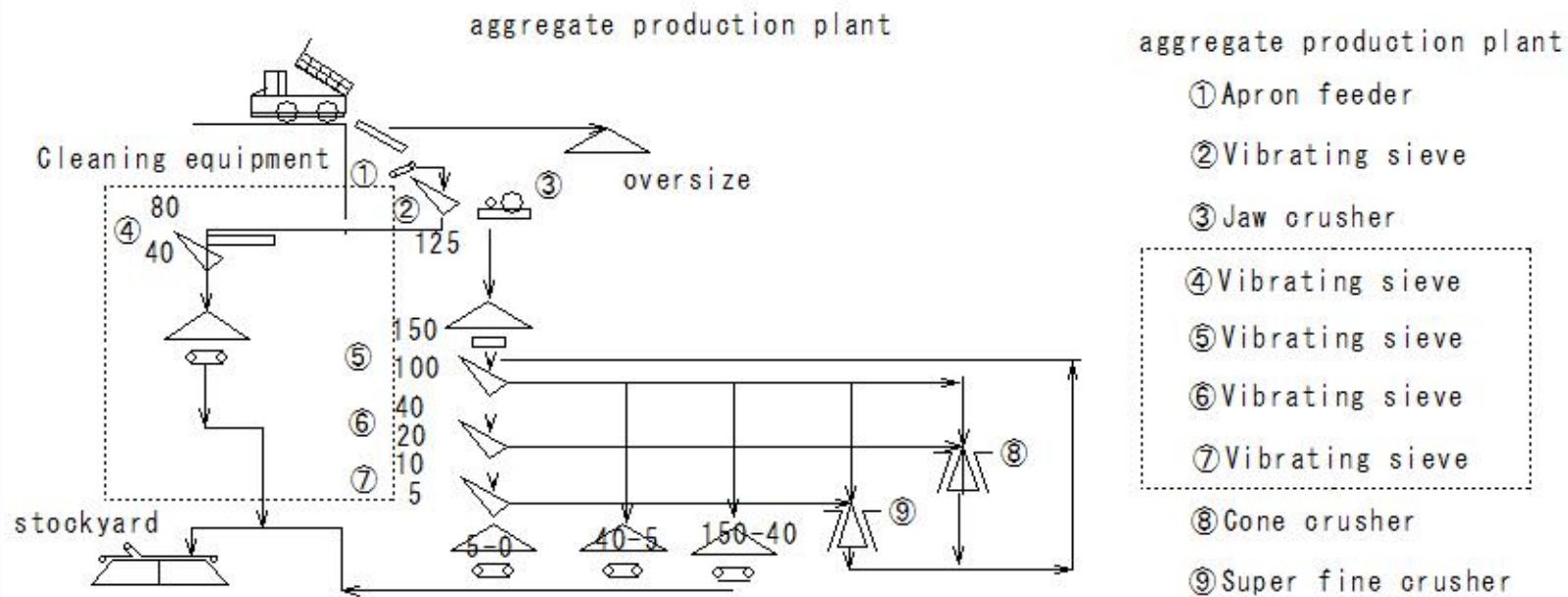
### (D20) Concrete dam construction equipment

Concrete dam construction equipment

Aggregate manufacturing equipment

#### ③ Cleaning equipment

- Cleaning: Removes clay and harmful minerals mixed with aggregate
- Spray pressurized water during sieving



## (D21)Concrete dam construction equipment

### (D21)Concrete dam construction equipment

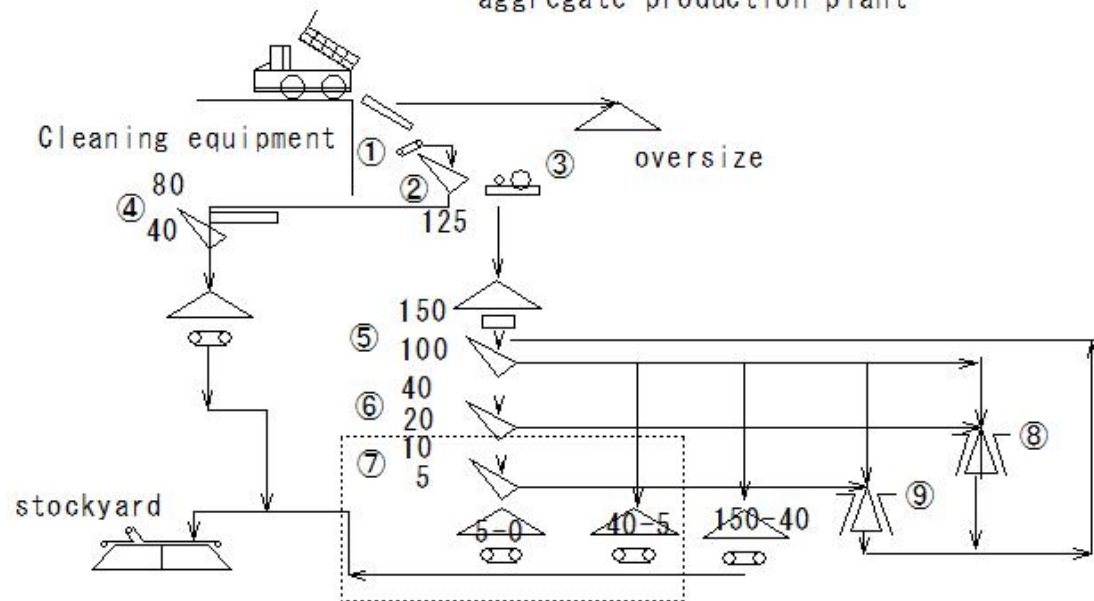
Concrete dam construction equipment

Aggregate manufacturing equipment

#### ④ Sand making equipment

- Aggregates with a diameter of 20 mm or less are used as raw materials.
- Manufactured with a rod mill
- Installing rough stone bins to ensure uniform supply of material

aggregate production plant



aggregate production plant

- ① Apron feeder
- ② Vibrating sieve
- ③ Jaw crusher
- ④ Vibrating sieve
- ⑤ Vibrating sieve
- ⑥ Vibrating sieve
- ⑦ Vibrating sieve
- ⑧ Cone crusher
- ⑨ Super fine crusher

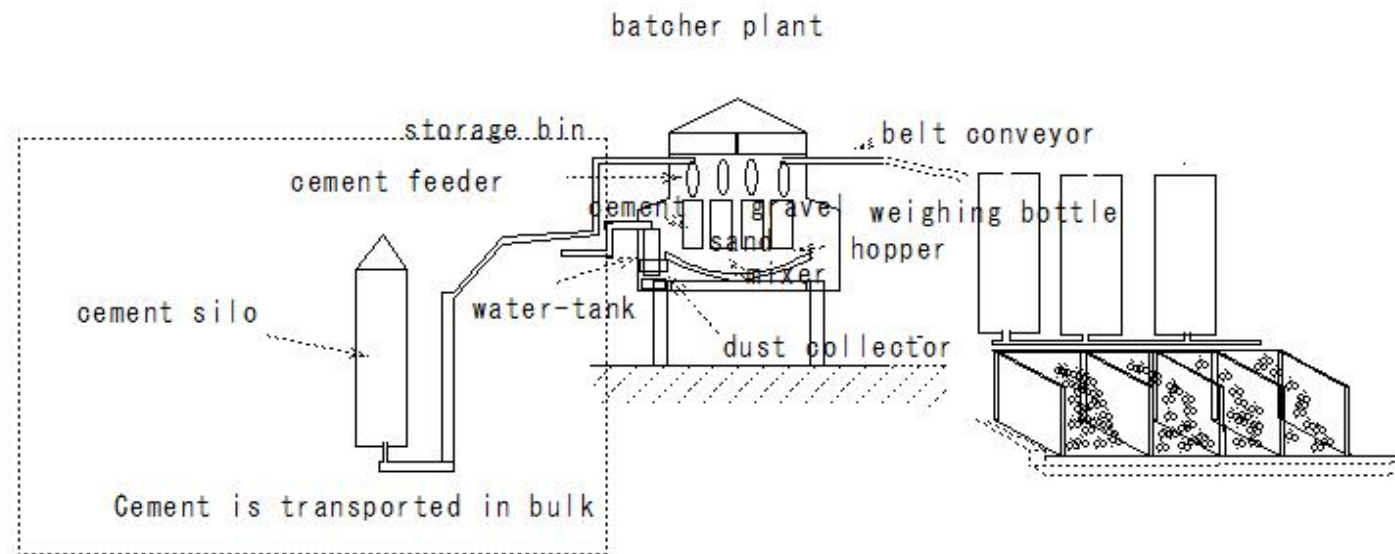
## (D22)Concrete dam construction equipment

### (D22) Concrete dam construction equipment

Concrete dam construction equipment

cement storage equipment

- Cement silo: Steel cylindrical silo
- Capacity: 2-5 days worth of average daily usage fee



C860



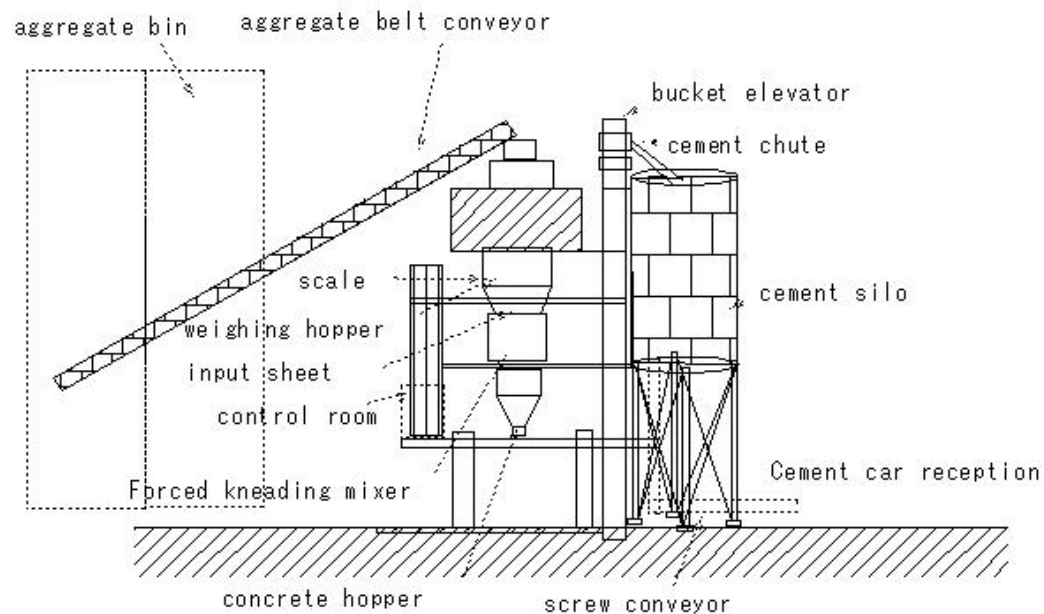
## (D23)Concrete dam construction equipment

### (D23)Concrete dam construction equipment

concrete manufacturing equipment

Batcher plant capacity: Based on monthly maximum pouring volume

- Operating hours per working day
- Considering the maximum pouring capacity of concrete transport equipment
- Represented by mixer capacity
- Mixer: Tilting mixer, 2-shaft forced kneading mixer



C1031

(D24)Concrete dam construction equipment

(D24) Concrete dam construction equipment

Concrete dam construction equipment

Concrete transportation equipment

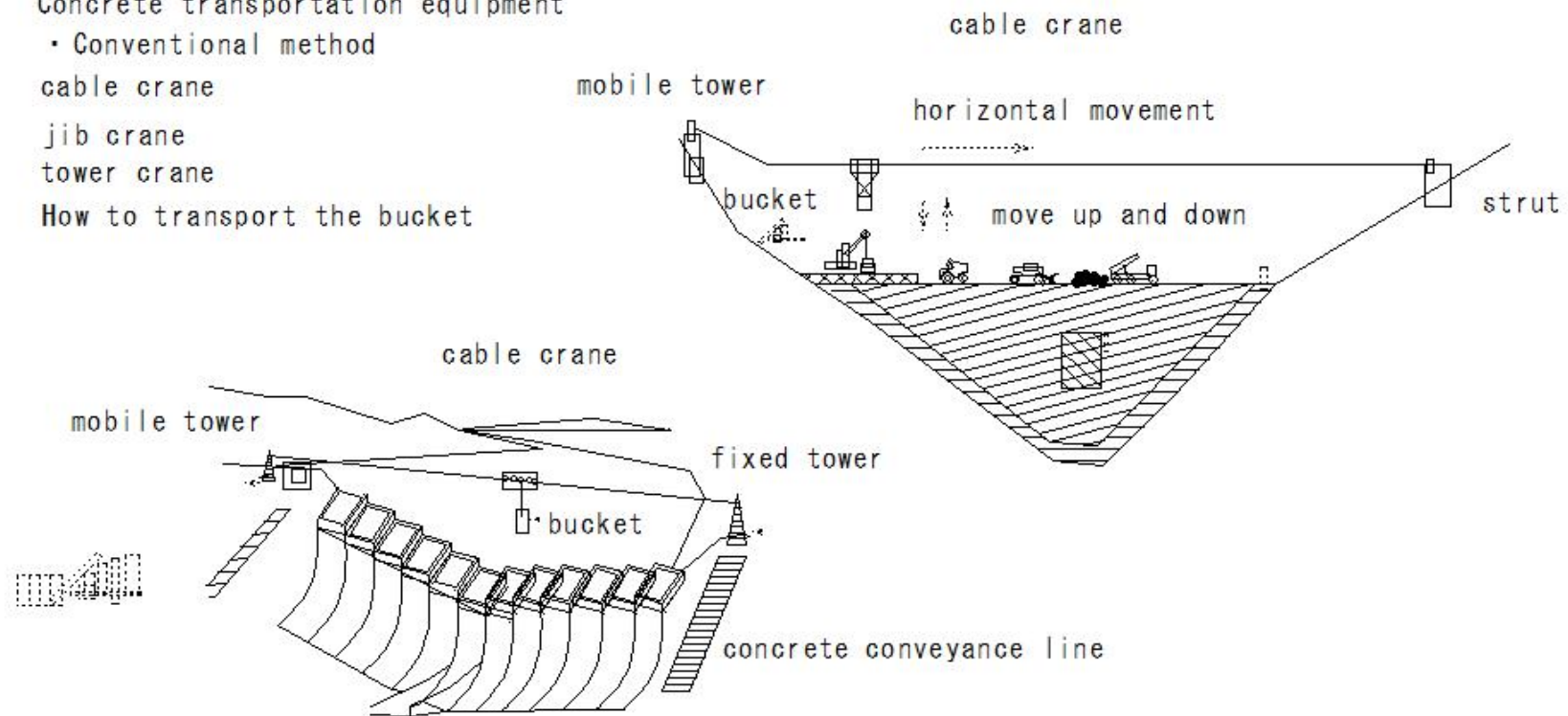
• Conventional method

cable crane

jib crane

tower crane

How to transport the bucket



## (D25)Concrete dam construction equipment

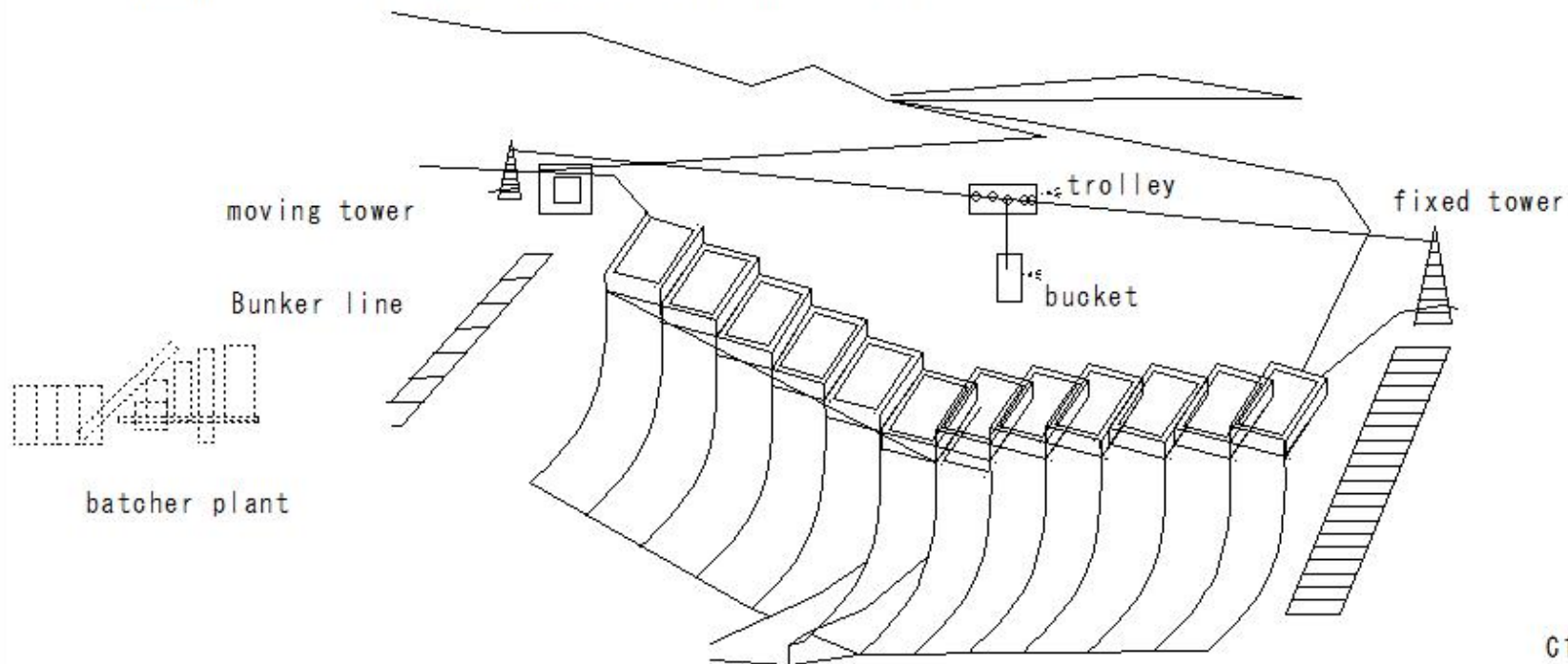
### (D25) Concrete dam construction equipment

Concrete dam construction equipment

Concrete transportation equipment

① Bunker line (concrete transport line)

- Concrete released from batcher plant
- Transported to the crane loading area by bunker line



## (D26)Concrete dam construction equipment

### (D26) Concrete dam construction equipment

Concrete dam construction equipment

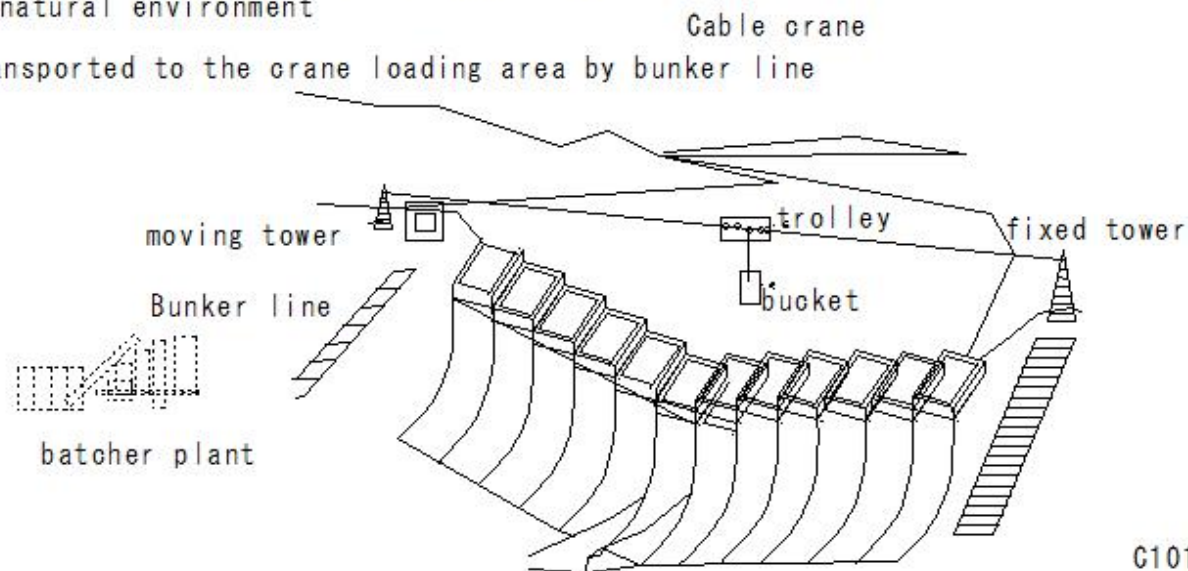
Concrete transportation equipment

② Main concrete transportation equipment

(a) Cable crane

- Used in many dams
- Fixed type, traveling type, track type
- Traveling type: wide coverage area and good workability
- High impact on the natural environment

- Transported to the crane loading area by bunker line



## (D27)Concrete dam construction equipment

### (D27) Concrete dam construction equipment

Concrete dam construction equipment

Concrete transportation equipment

② Main concrete transportation equipment

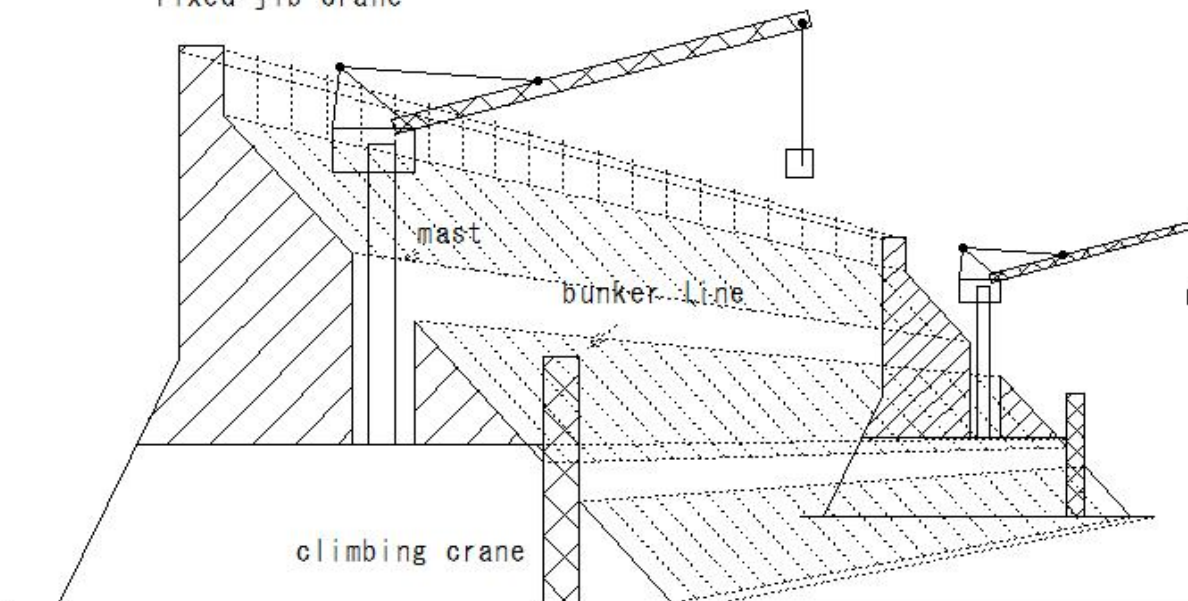
(b) Jib crane

• Installed parallel to the dam axis

• It takes time to install and relocate

Great benefits in terms of environmental conservation

fixed jib crane



C1036



## (D28)Concrete dam construction equipment

### (D28) Concrete dam construction equipment

Concrete dam construction equipment

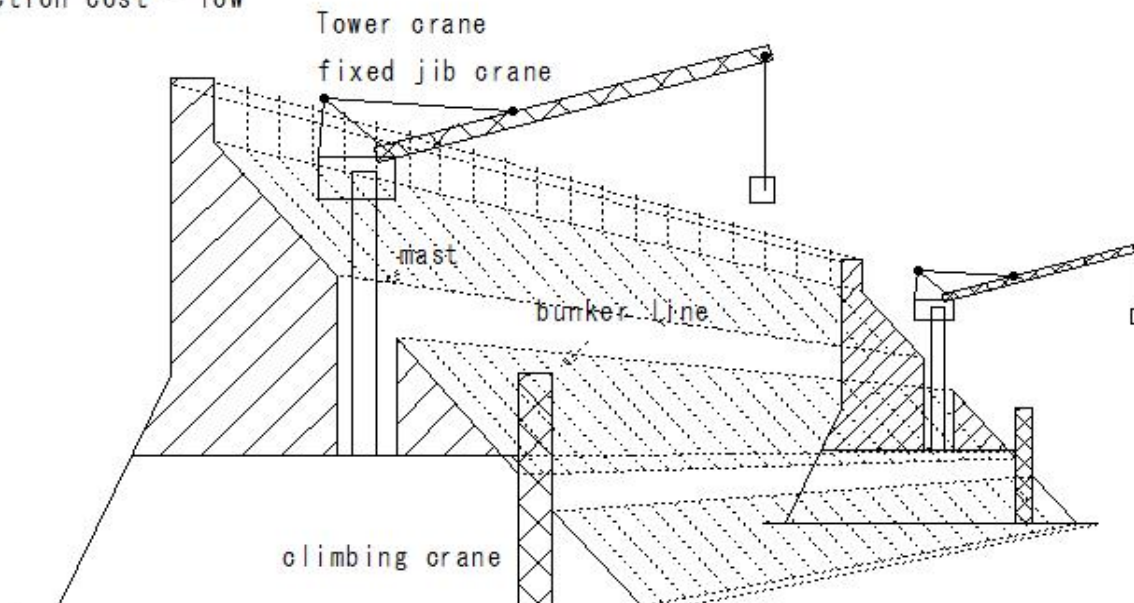
Concrete transportation equipment

#### ③ Tower crane

Fixed jib crane with swivel on top of a high tower

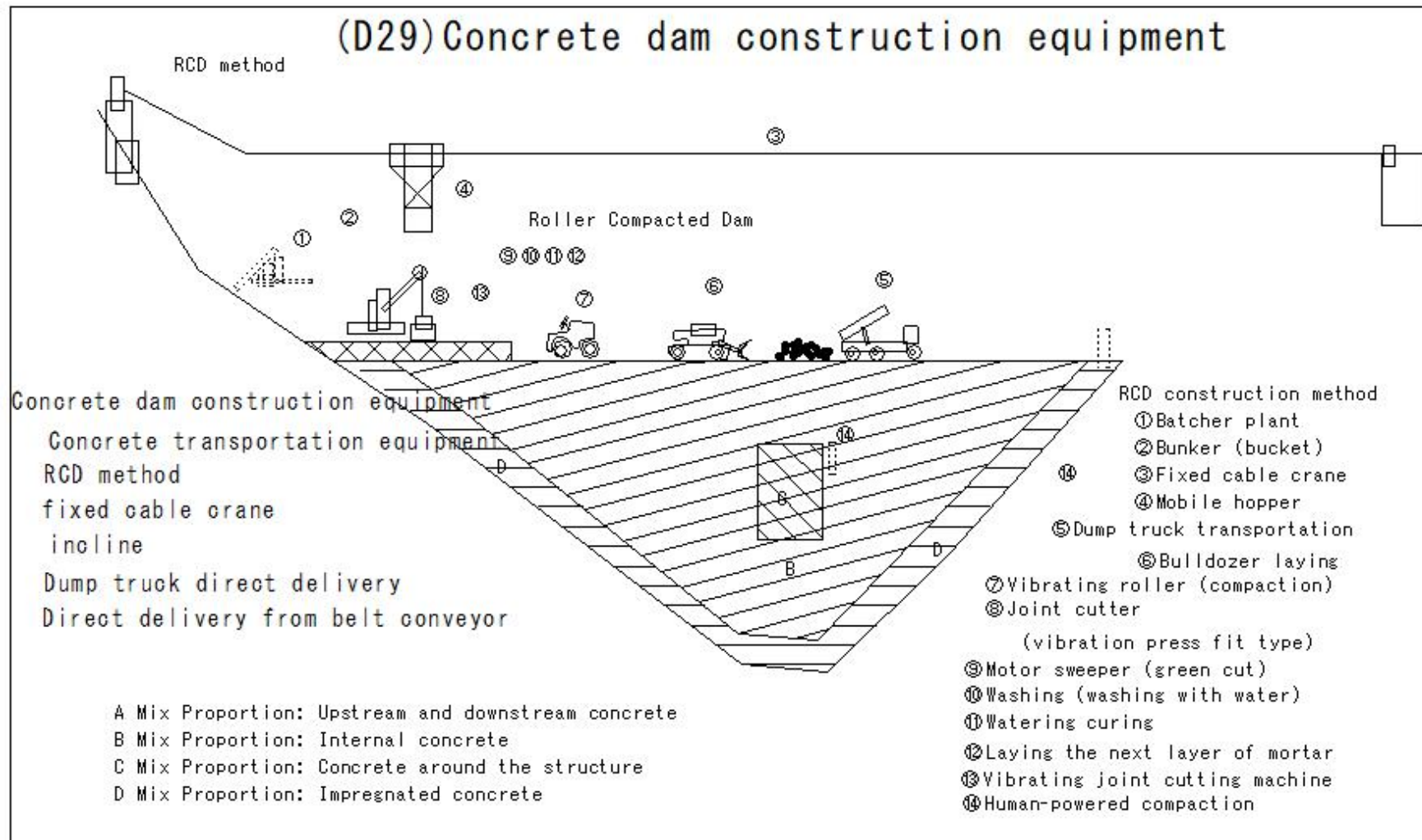
Main transportation equipment for small and medium sized dams

- Bunker lines are easy to place
- Foundation construction cost - low



C1036

(D29)Concrete dam construction equipment



(D30)Concrete dam construction equipment

(D30) Concrete dam construction equipment

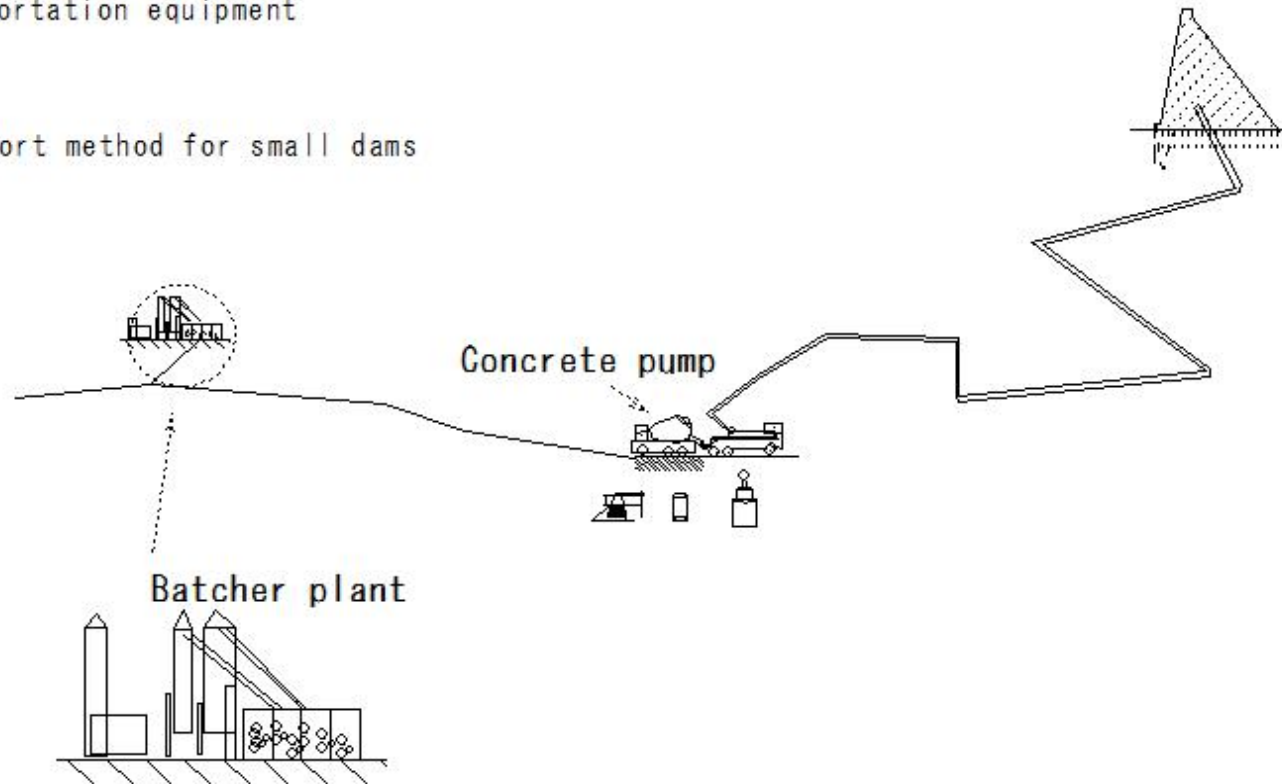
Concrete dam construction equipment

Concrete transportation equipment

PCD method

concrete pump

Concrete transport method for small dams





## (D31)Concrete dam construction equipment

### (D31)Concrete dam construction equipment

Concrete dam construction equipment

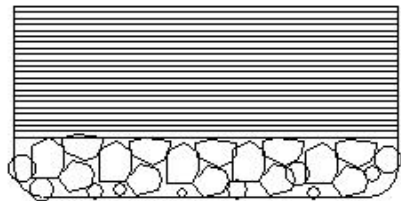
cooling equipment

- Prevention of concrete cracking due to temperature stress

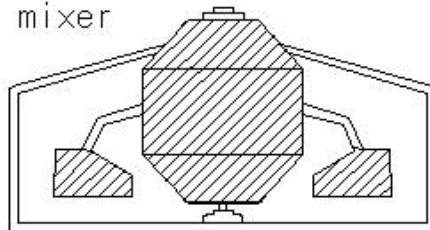
- Pre-cooling

Aggregate cooling

Cooling (air cooling/water cooling)



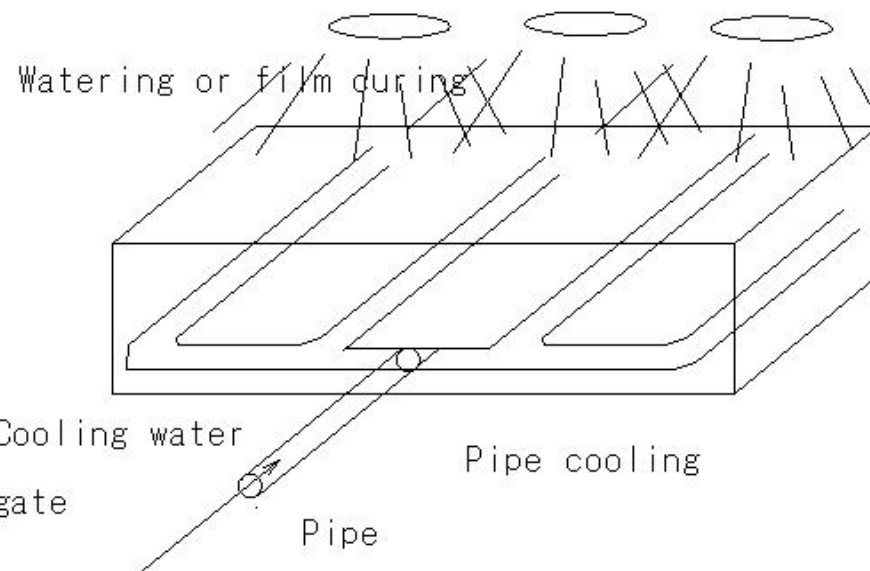
mixer



Cement  
Cooling aggregate  
Cold water  
Ice

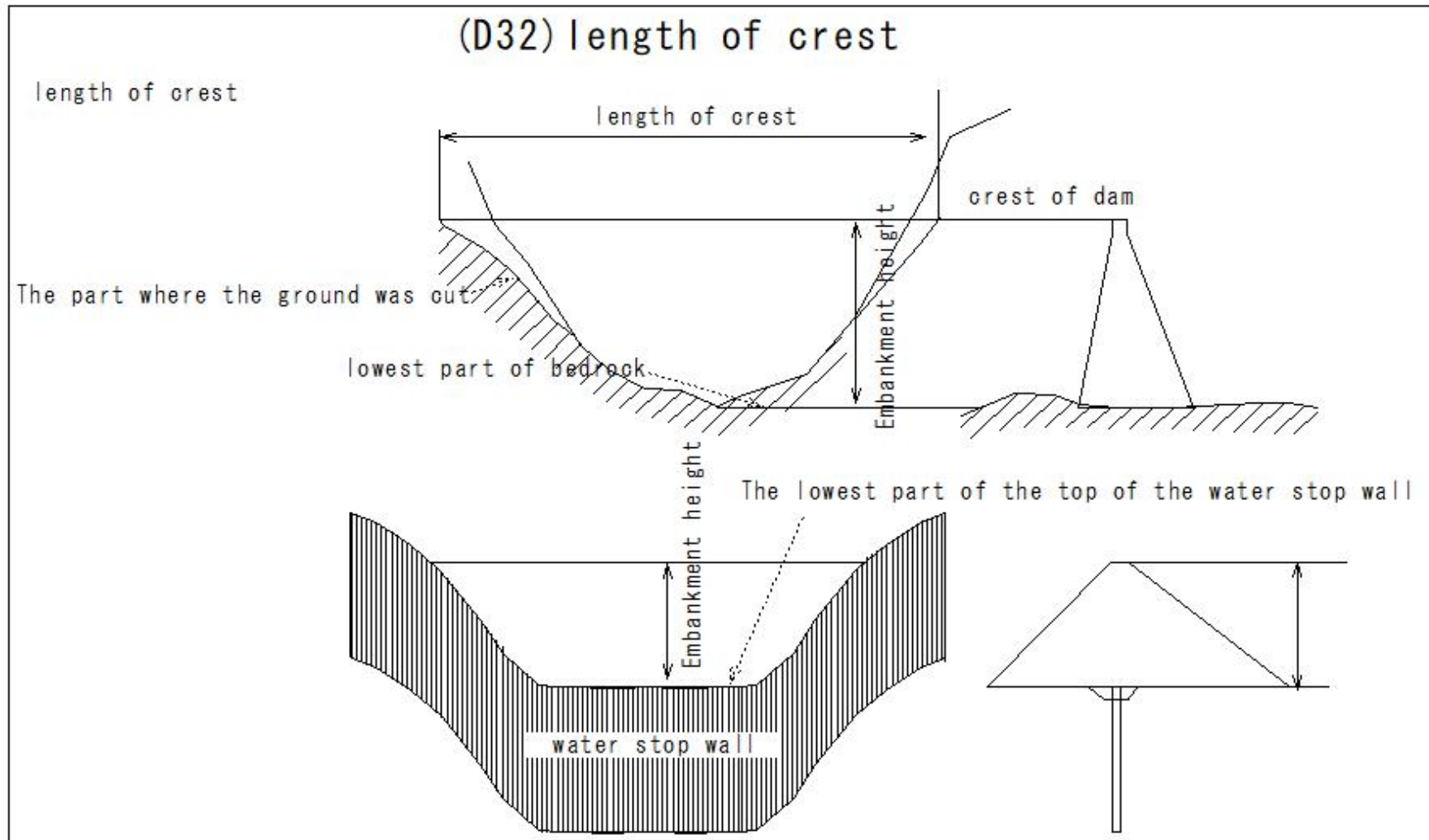
C1388

- Pipe cooling

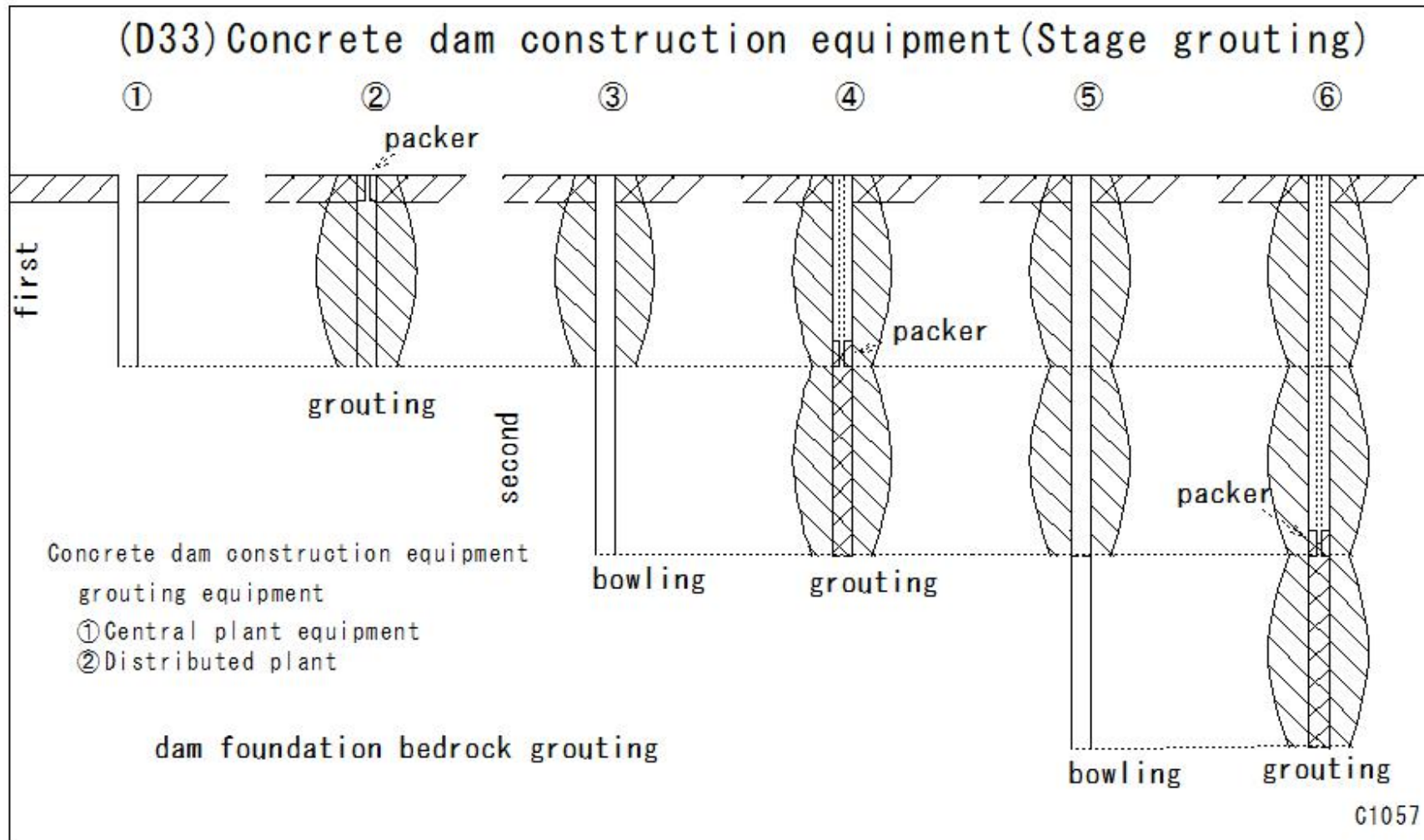


C867

(D32) length of crest



(D33)Concrete dam construction equipment



(D34)Concrete dam construction equipment(grouting)

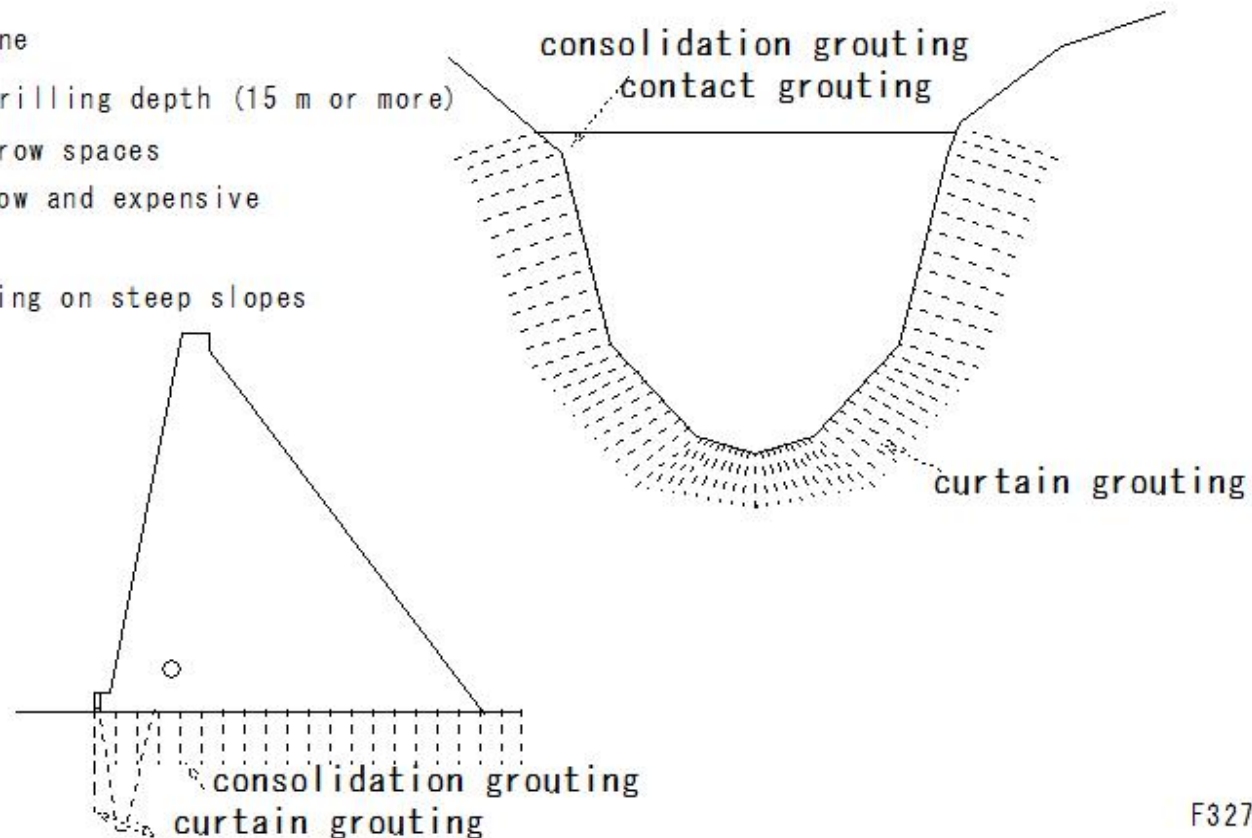
(D34) Concrete dam construction equipment(grouting)

Concrete dam construction equipment

bowling machine

① Rotary boring machine

- Suitable for deep drilling depth (15 m or more)
- Able to work in narrow spaces
- Drilling speed - slow and expensive
- Curtain grout
- Consolidation grouting on steep slopes



## (D35)Concrete dam construction equipment(grouting)

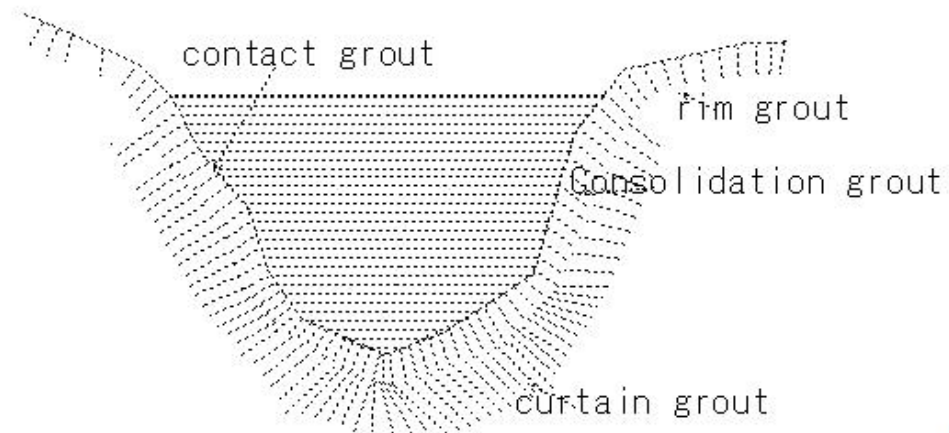
### (D35) Concrete dam construction equipment(grouting)

#### Concrete dam construction equipment

bowling machine

②percussion boring machine

- Drilling speed - fast
  - Economic
  - Generation of rock powder - large
  - Drilling depth limit: approximately 15m
  - Consolidation grouting for dams based on hard rock
- Used for blanket grouting
- Drilling hole diameter 65mm



F360

(D36)Concrete dam construction equipment(grouting)

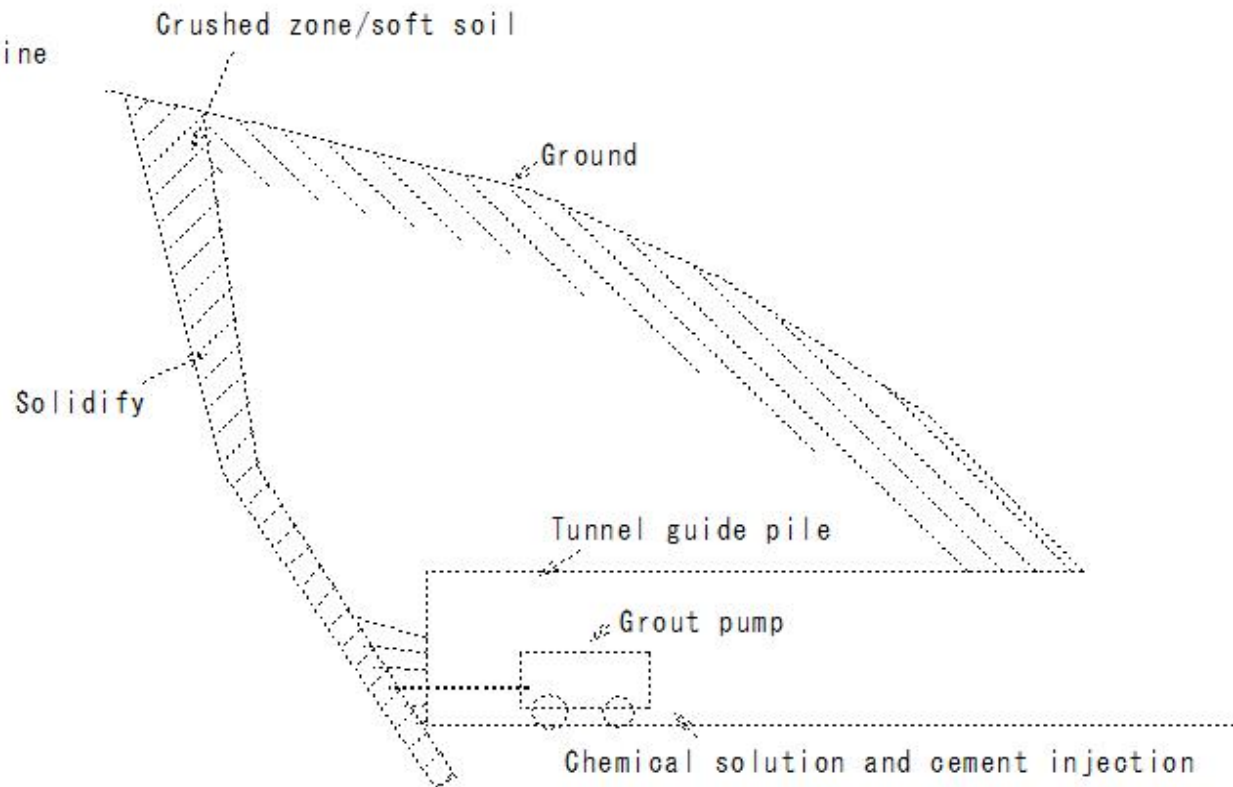
(D36) Concrete dam construction equipment(grouting)

Concrete dam construction equipment

bowling machine

③ Injection machine

- Grout mixer
- agitator
- Gout pump





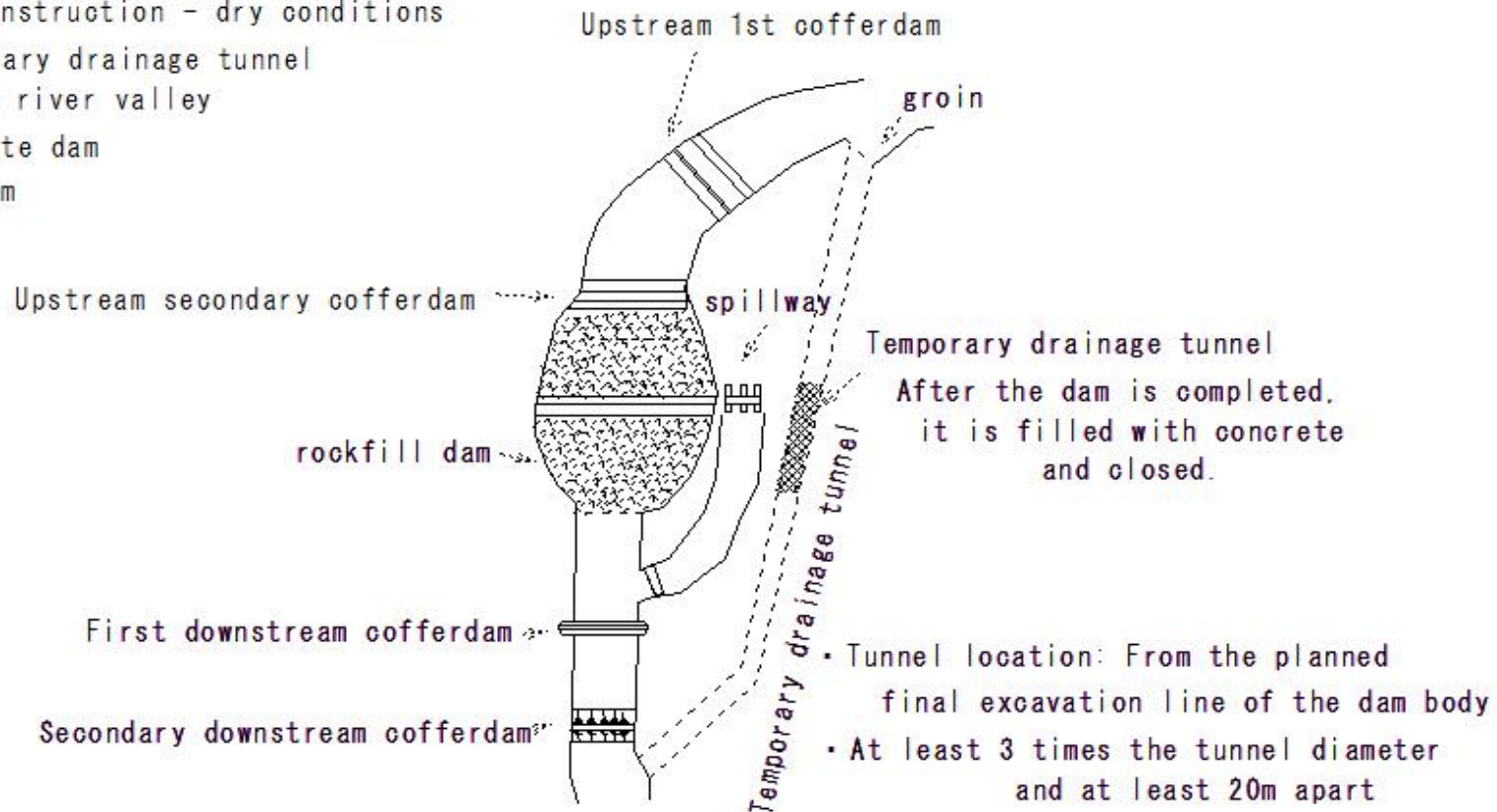
(D37)River treatment(Temporary drainage tunnel)

(D37)River treatment(Temporary drainage tunnel)

River treatment

River treatment method

- Dam construction - dry conditions
- ① Temporary drainage tunnel
- Narrow river valley
- Concrete dam
- Filldam



(D38)River treatment(half river cofferdam)

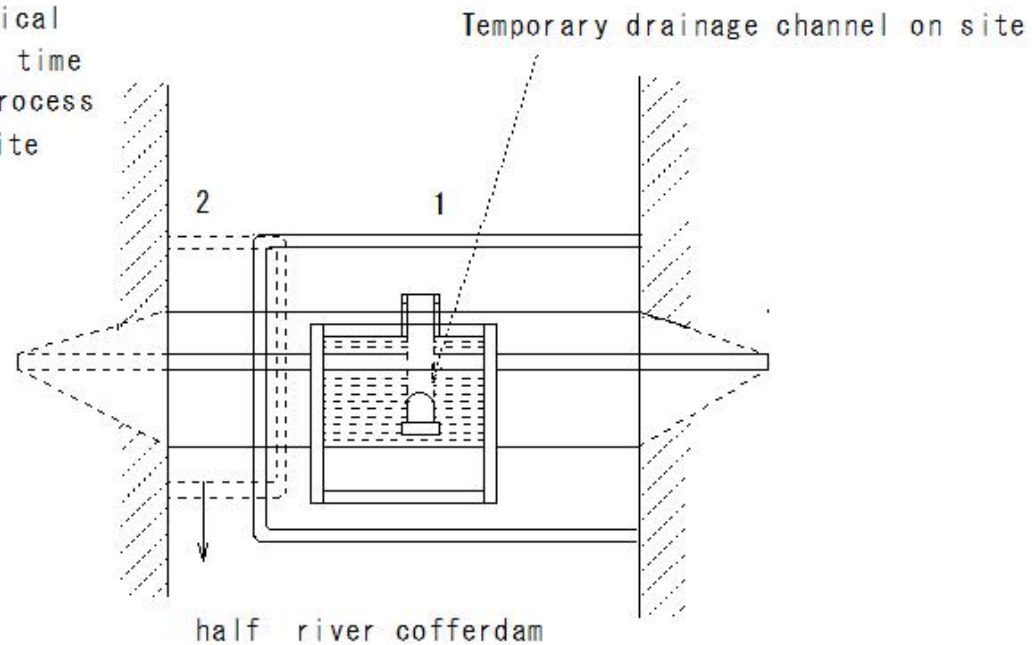
(D38)River treatment(half river cofferdam)

River treatment

② half river cofferdam

- River width - wide river
- Flow rate - large
- Temporary drainage tunnel-  
temporary drainage opening channel  
Difficult to adopt - Uneconomical
- Construction on one side at a time
- case of no problem with the process

Temporary drainage channel on site





(D39)River treatment(Temporary drainage opening channel)

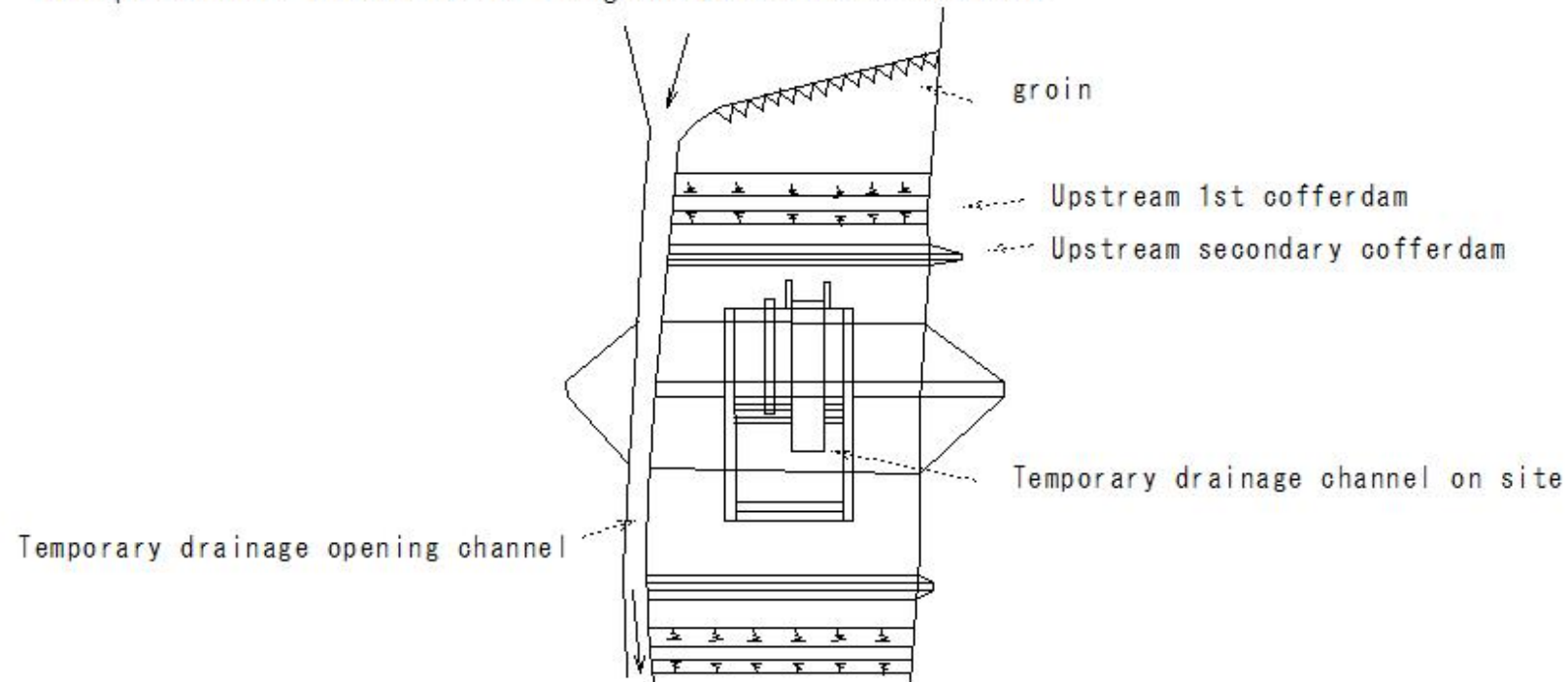
(D39)River treatment(Temporary drainage opening channel)

River treatment

③ Temporary drainage opening channel

- discharge - not large
- River width - wide

An open channel was installed along the riverbank on one side.



(D40)River treatment(temporary cofferdam)

(D40)River treatment(temporary cofferdam)

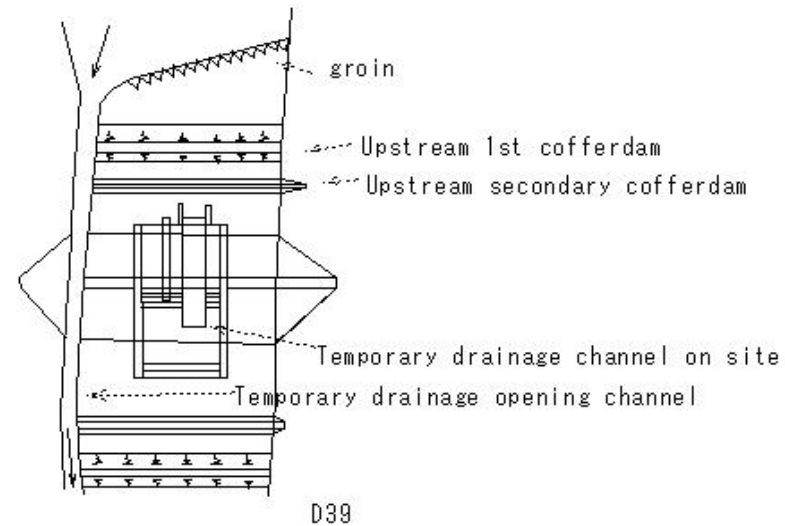
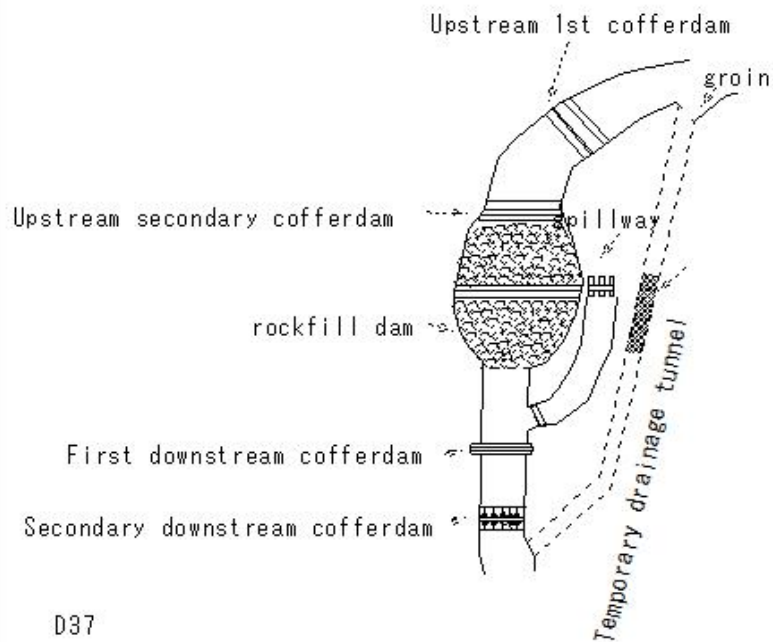
River treatment

temporary cofferdam

Upstream/downstream cofferdam

Secondary cofferdam - case of riverbed sediment is shallow- Concrete type

Secondary cofferdam - case of river bed sediment is thick - fill type



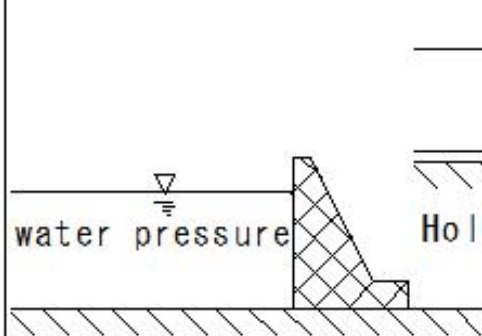
(D41)River treatment(temporary cofferdam)

(D41)River treatment(temporary cofferdam)

River treatment

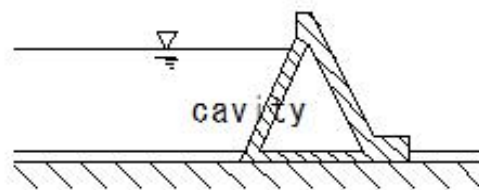
discharge for river flow treatment

format	discharge for river flow treatment
gravity dam	Probable flood volume once or twice a year
hollow gravity dam	2-1.5 year probability flood volume
arch dam	2-1.5 year probability flood volume
fill dam	15-20 year probability flood volume



Gravity dam

C904



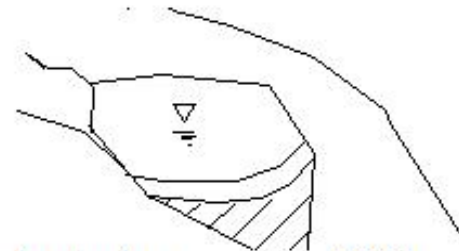
Hollow gravity dam

C904



fill dam

R590



Arch dam

C904

(D42) foundation excavation(topsoil excavation)

(D42) foundation excavation(topsoil excavation)

foundation excavation

topsoil excavation

Before excavation

- Cutting down plants
- Root cutting
- Humus
- Rolling stones

process

God Bless You

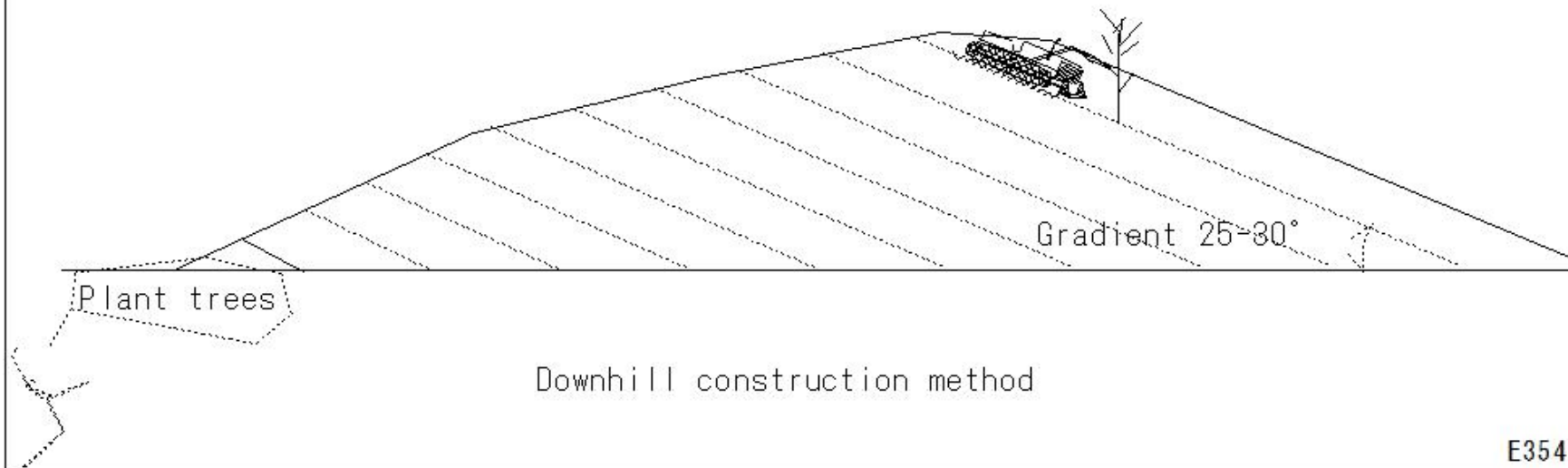


Gradient 25-30°

Plant trees

Downhill construction method

E354



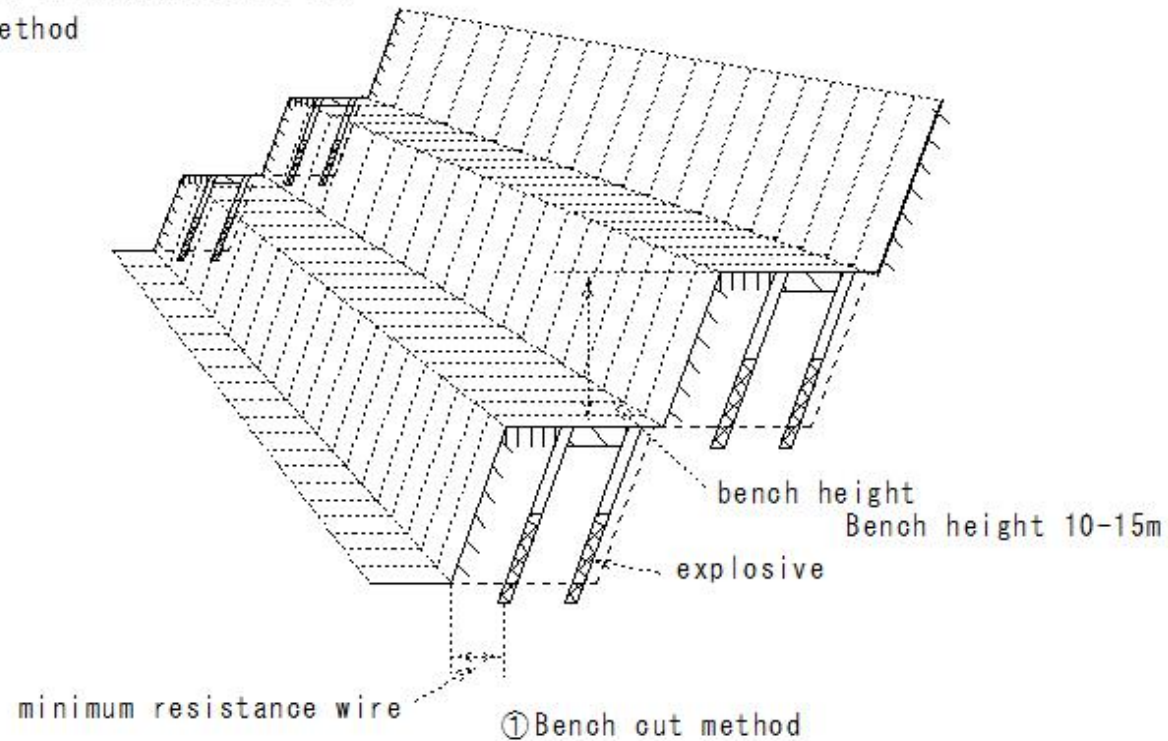
(D43) foundation excavation(rough excavation)

(D43) foundation excavation(rough excavation)

foundation excavation

rough excavation

- Mechanical excavation of weathered rock
- Gunpowder drilling of medium hard rock
- Blast-bench cut method



## (D44) foundation excavation(finishing excavation)

### (D44) foundation excavation(finishing excavation)

foundation excavation

finishing excavation

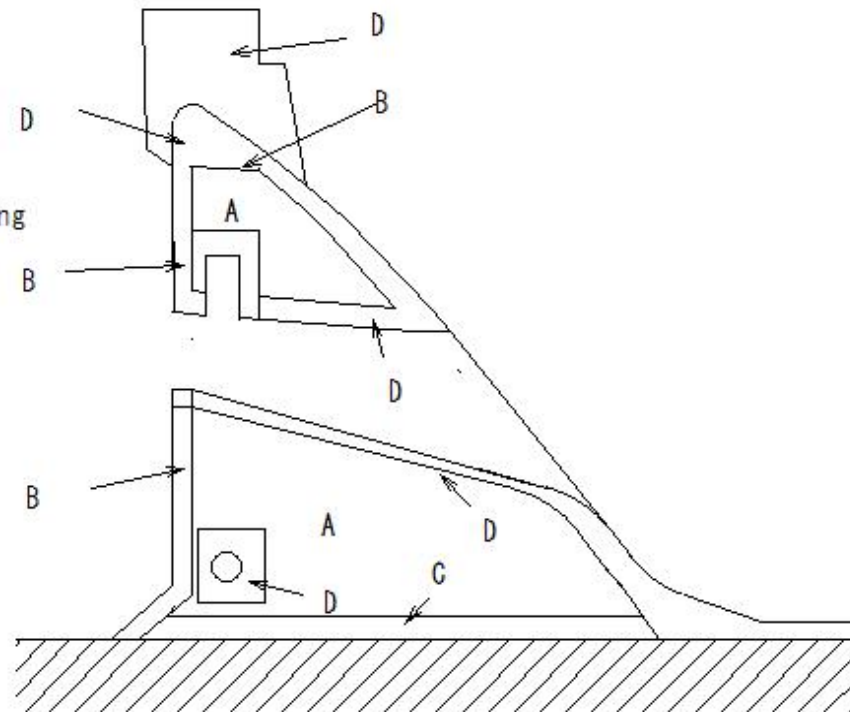
- Near the planned excavation surface
- Reduces the impact on the foundation rock
- Prevention of loosening
- Pick hammer, crowbar
- Final excavation by hand
- Final excavation is done before concrete pouring
- Just before preparing the core
- Thickness about 50cm

A: Internal concrete: Poor mix

B: External concrete

C: Rock-clad concrete:  
watertightness and durability

D: Structural concrete: Rich  
mix concrete: Maximum particle  
size small



C1064



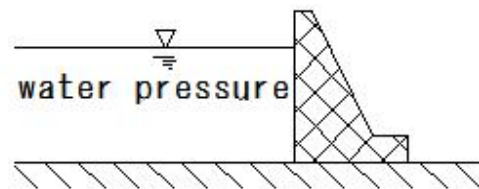
(D45) foundation excavation(excavation surface protection)

(D45) foundation excavation(excavation surface protection)

foundation excavation

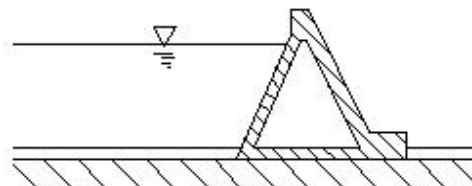
excavation surface protection

- After rough excavation
- Until main body construction
- Prevents weathering and loosening
- cover
- Mortar spraying
- Concrete spraying



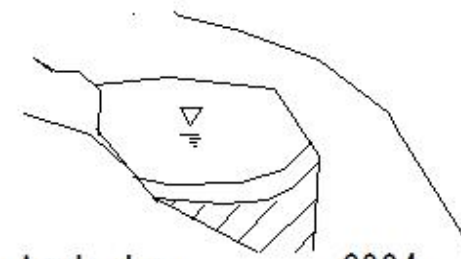
Gravity dam

C904



Hollow gravity dam

C904



Arch dam

C904

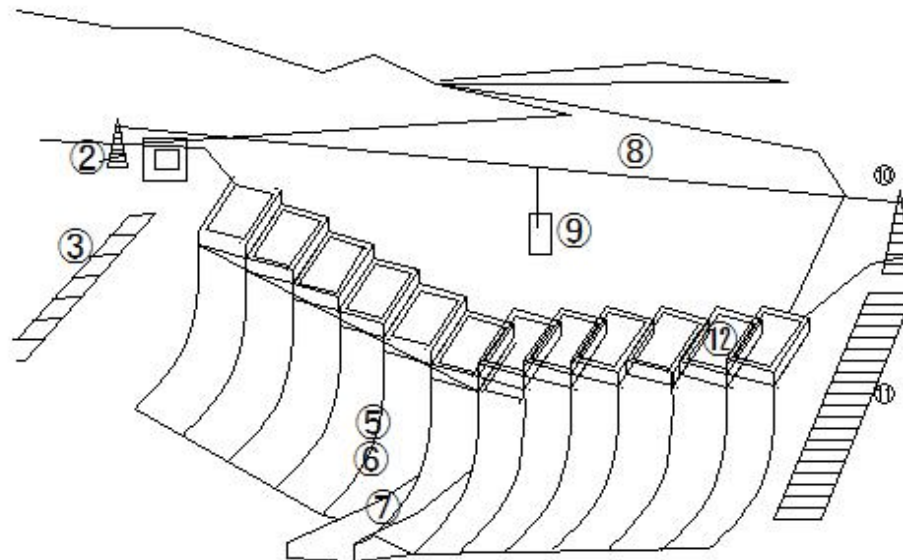
## (D46)Construction of concrete dam (conventional method)

### (D46) Construction of concrete dam (conventional method)

Construction of concrete dam (conventional method)

shrink seam

- Temperature cracking: due to concrete hydration heat
- Establish contraction joints
- Horizontal joints: Perpendicular to the dam axis - spacing of 15 m or less
- Vertical joints: Parallel to the dam axis - spacing of 40 m or less



Place concrete block by block

C965



(D47)Construction of concrete dam (conventional method)

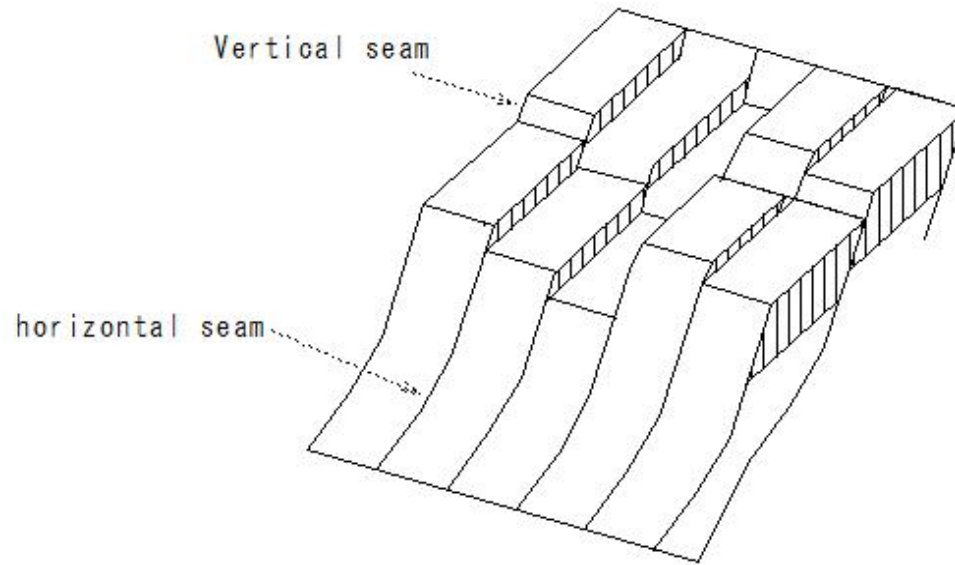
(D47) Construction of concrete dam (conventional method)

Construction of concrete dam (conventional method)

• place method

① Block method (column construction method)

placing method divided by vertical and horizontal seams



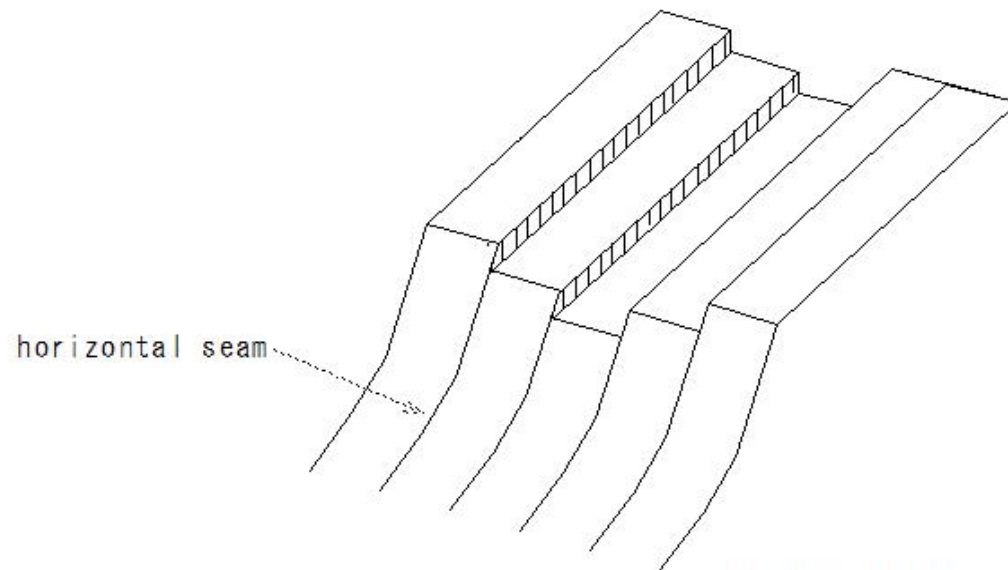
block method

(D48)Construction of concrete dam (conventional method)

(D48)Construction of concrete dam (conventional method)

Construction of concrete dam (conventional method)

- placing method
- ② Layer method
- Horizontal seams only
- No vertical seams



Layer method

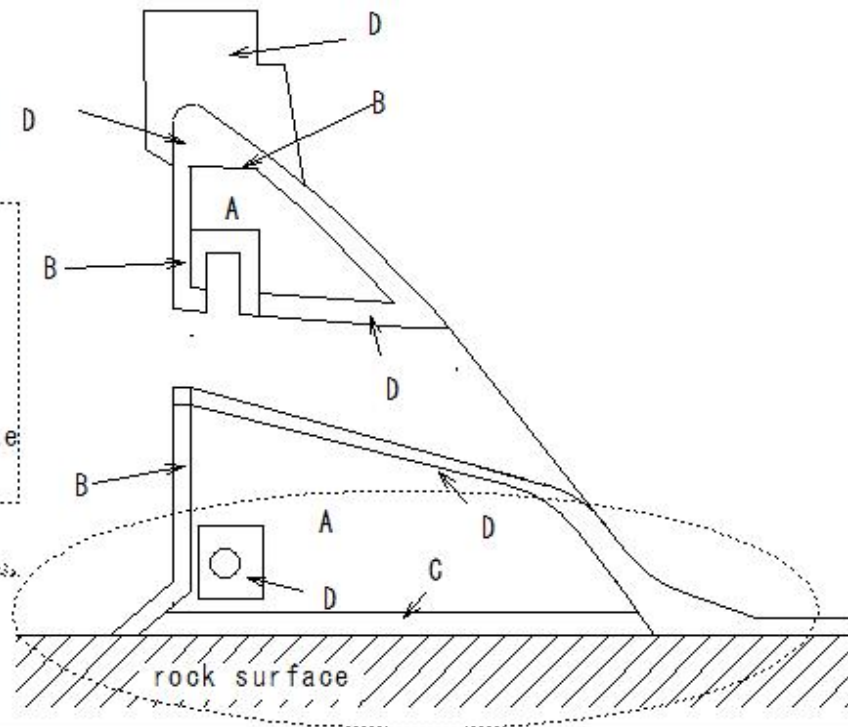
## (D49)Construction of concrete dam (conventional method)

### (D49) Construction of concrete dam (conventional method)

Construction of concrete dam (conventional method)

- Processing before placing
- ① Treatment of rock surface
  - Improve the adhesion between the foundation rock and embankment concrete

- Removal of sprayed mortar
- Excavation of weathered rock
- Removal of floating rocks
- Filling of open cracks
- Replacement of faults etc. with concrete
- Laying mortar on the bedrock when pouring concrete  
mortar thickness 2cm



(D50)Construction of concrete dam (conventional method)

(D50)Construction of concrete dam (conventional method)

Construction of concrete dam (conventional method)

- Processing before placing
- ②Horizontal seam processing
  - Concrete lift surface
  - laitance concentration by bleeding
  - Water jet (high pressure water) - perform green cutting
  - Green cutting period

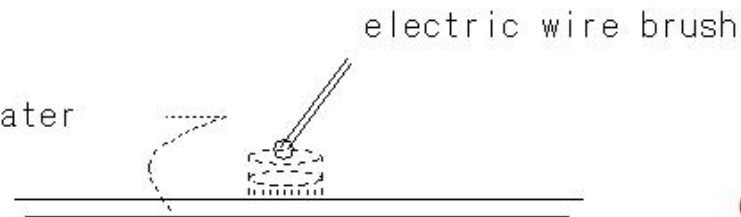
Summer - 6-12 hours after pouring concrete

Winter - 12-24 hours after concrete pouring

- Remove artifacts and dirt attached to the concrete surface and apply mortar
- Mortar thickness 1.5cm
- Rainfall during concrete pouring (approx. 4mm/h) - Canceled
- Cold joint part: Perform treatment similar to horizontal pouring joint.



C880



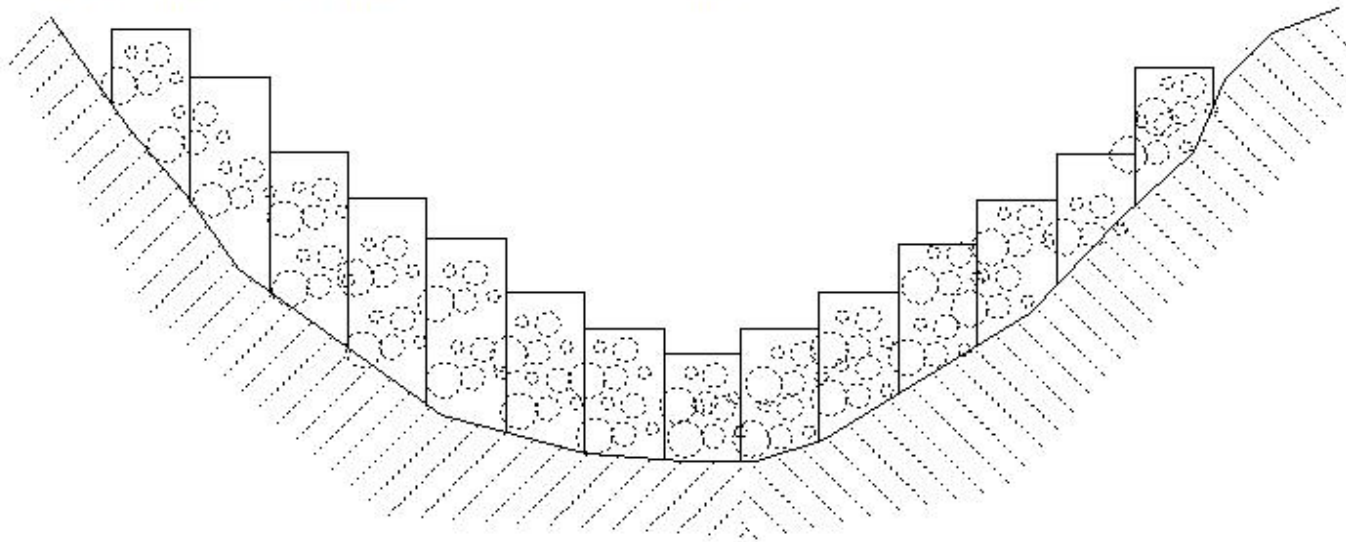
C1016

## (D51)Construction of concrete dam (conventional method)

### (D51)Construction of concrete dam (conventional method)

#### Construction of concrete dam (conventional method)

- Pour concrete
- ① Lift thickness
  - 1.5–2.0m
- Rock landing area: pouring concrete onto concrete that has been suspended for a long time
- Prevention of temperature cracks
  - 0.75-1.0m lift (half lift) - several lifts





(D52)Construction of concrete dam (placing concrete)

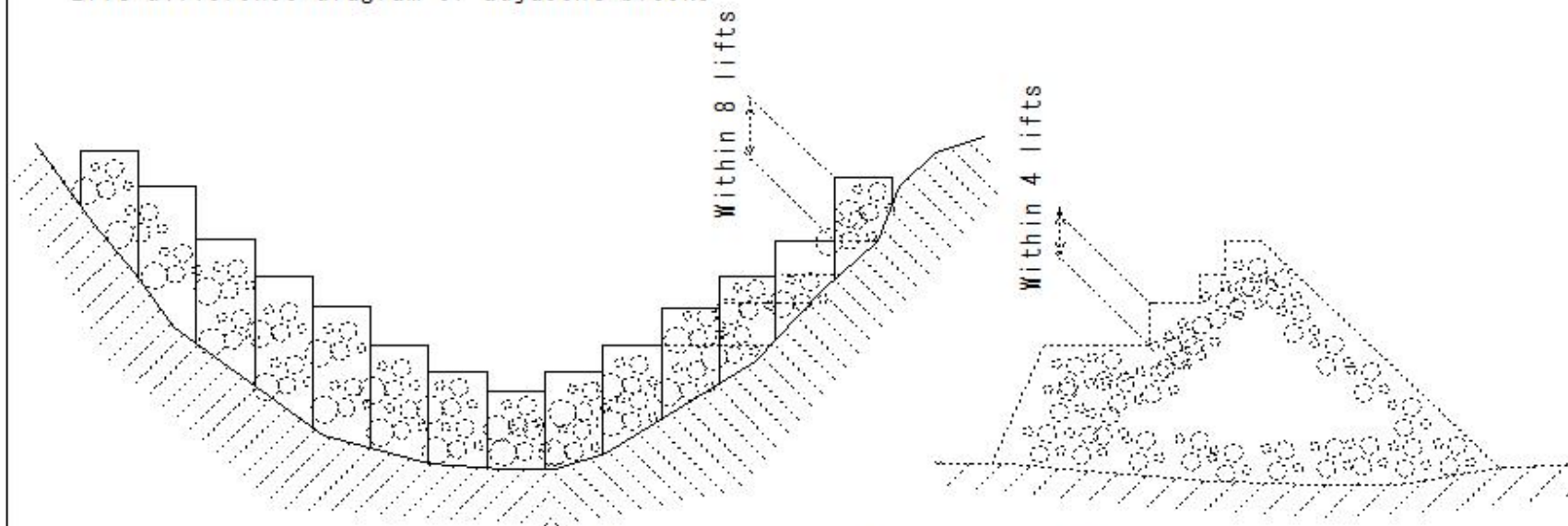
(D52) Construction of concrete dam (placing concrete)

Construction of concrete dam (conventional method)

- placing concrete
- ② Lift difference between adjacent blocks
  - Within 4 lifts in upstream and downstream direction
  - Within 8 lifts in the dam axis direction

Center

Lift difference diagram of adjacent blocks



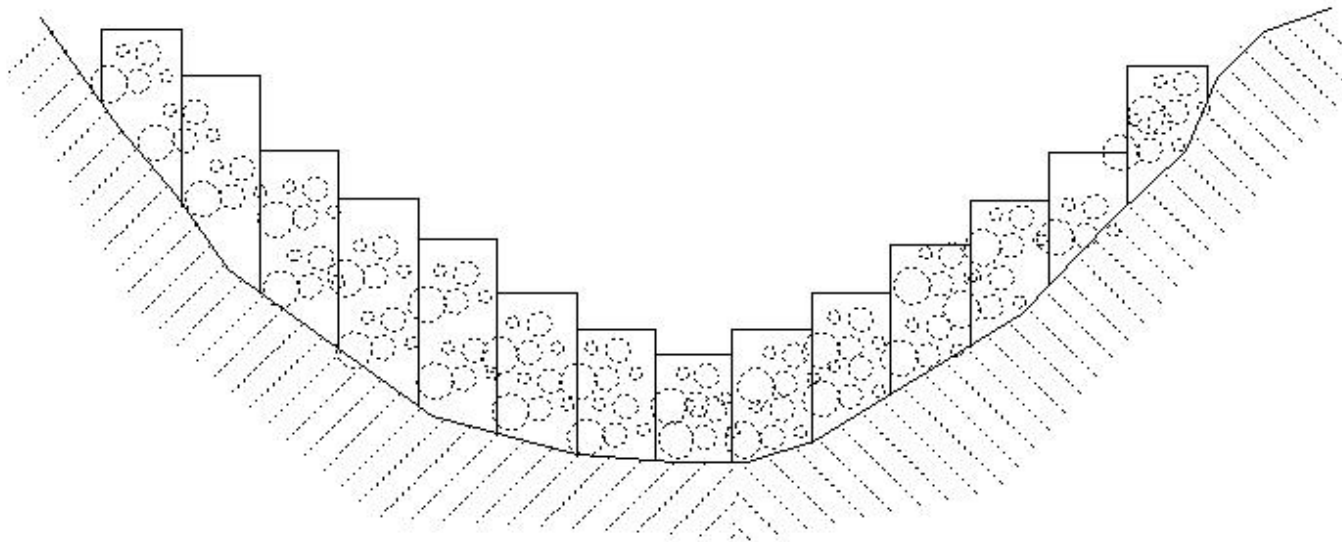
Lift difference diagram of adjacent blocks

## (D53) Construction of concrete dam (placing concrete)

### (D53) Construction of concrete dam (placing concrete)

Construction of concrete dam (conventional method)

- placing concrete
- ③ Block construction order
  - To increase construction efficiency by increasing the number of placing blocks
  - Alternately create unevenness and launch evenly
  - Prevent flood water from flowing down on the foundation rock during floods
  - Slightly lower the river bed
  - Concreting on slopes - advance



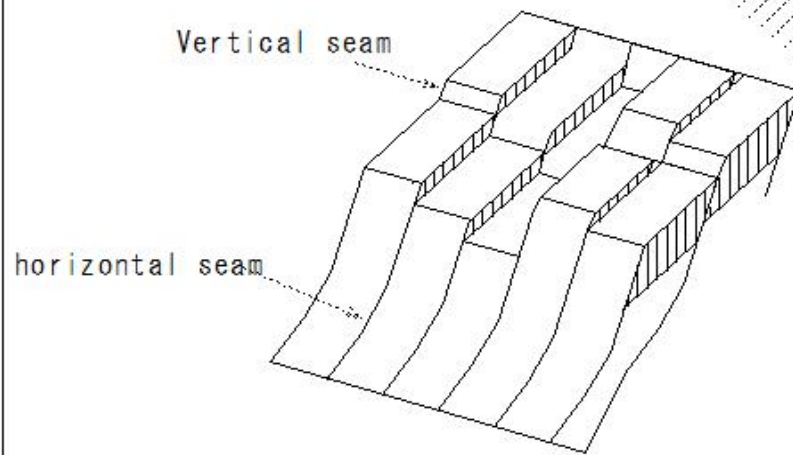


(D54) Construction of concrete dam (placing concrete)

(D54) Construction of concrete dam (placing concrete)

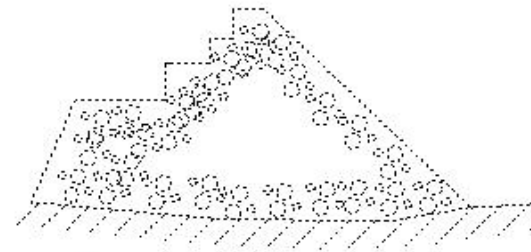
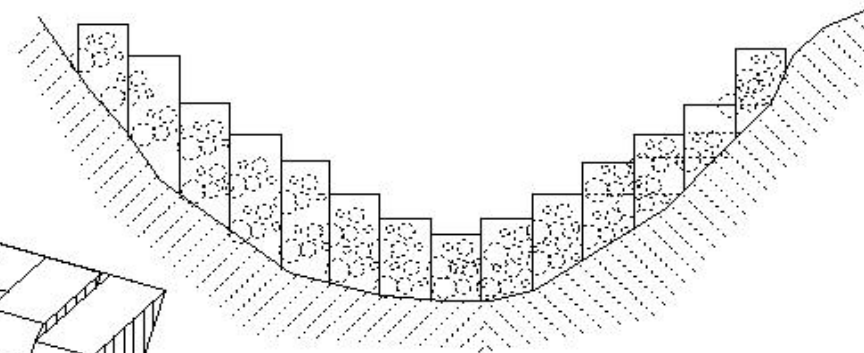
Construction of concrete dam (conventional method)

- placing concrete
- ④ Standard pouring interval
- For standard lift - 5 days
- 3 days for half lift



block method

D47



Lift difference diagram of adjacent blocks

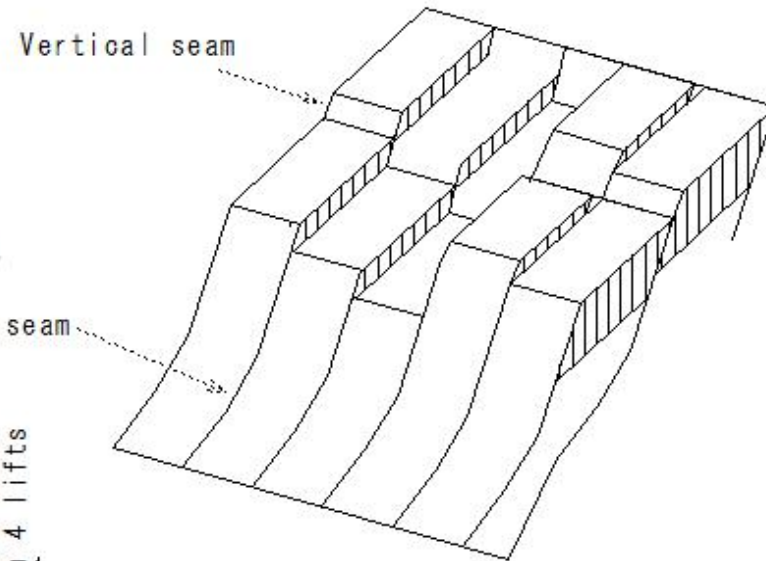
D52

(D55) Construction of concrete dam (placing concrete)

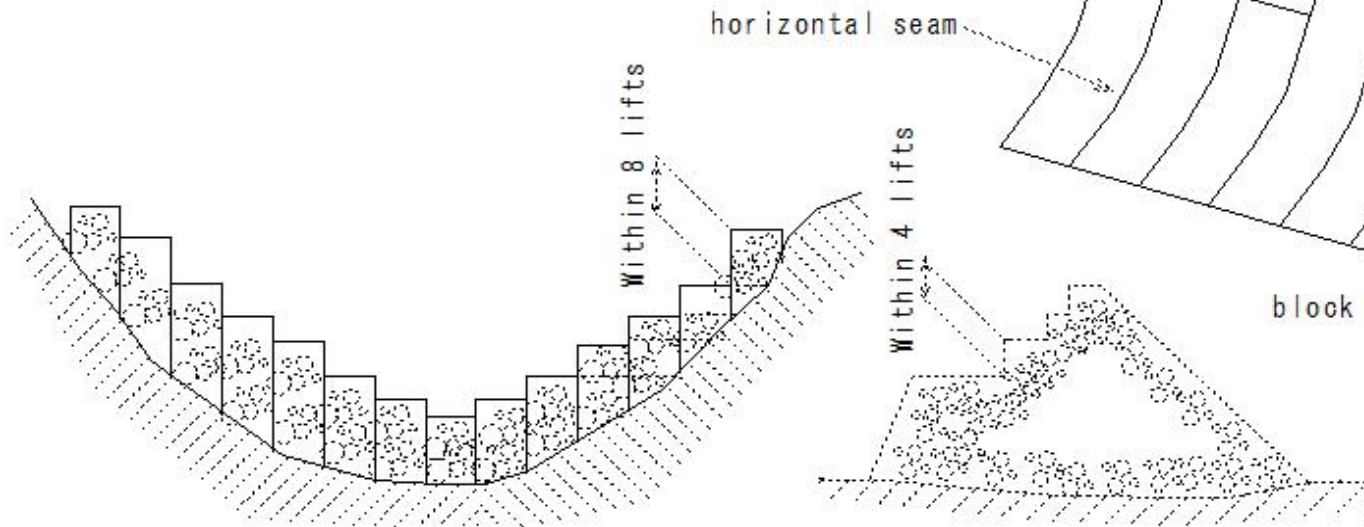
(D55) Construction of concrete dam (placing concrete)

Construction of concrete dam (conventional method)

- placing concrete
- ⑤ Concrete placing
  - Concrete 1 lift thickness 1.5-2.0m
  - Concrete unrolling thickness 50cm thickness after compaction
  - Unrolling 3-4 layers and compacting to form 1 lift



block method D47



Lift difference diagram of adjacent blocks

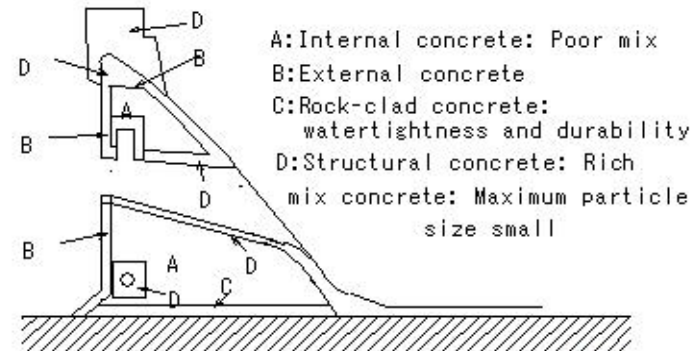
D52

(D56)Construction of concrete dam (placing concrete)

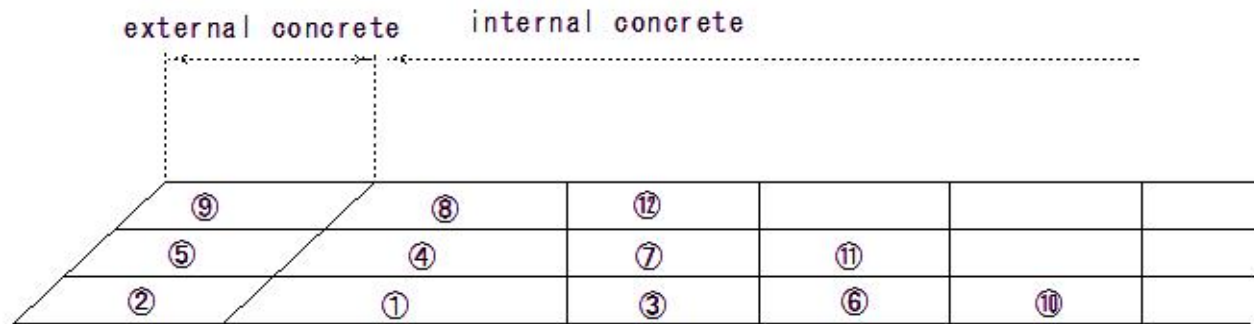
(D56) Construction of concrete dam (placing concrete)

Construction of concrete dam (conventional method)

- placing concrete
  - ⑤ Concrete placing
  - Concrete placing order
  - case of unloading concrete from the bucket
- Unloading height: within 1m



G1064



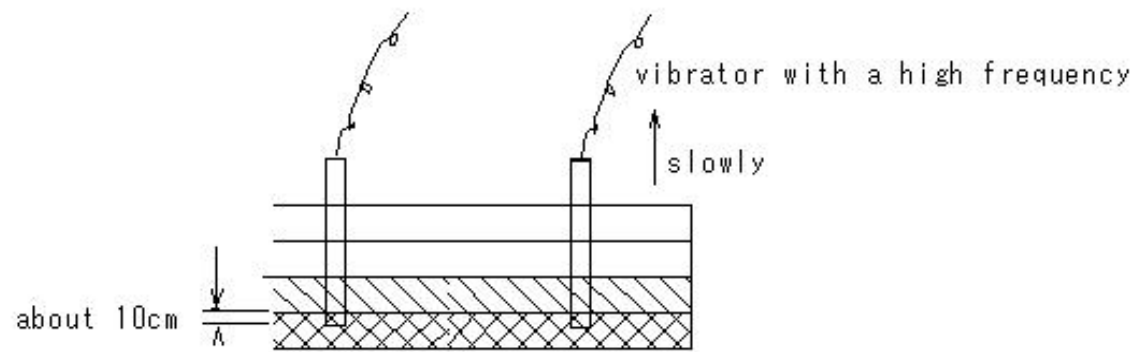
Concrete unrolling order

## (D57)Construction of concrete dam (placing concrete)

### (D57)Construction of concrete dam (placing concrete)

#### Construction of concrete dam (placing concrete)

- placing concrete
- ⊕ Compaction
  - Dam concrete internal vibrator
  - Put the tip into the concrete below for about 10cm.  
Pull out the vibrator slowly
  - Do not leave any holes
  - Concrete mixing (slump is small) - use a vibrator with a high frequency



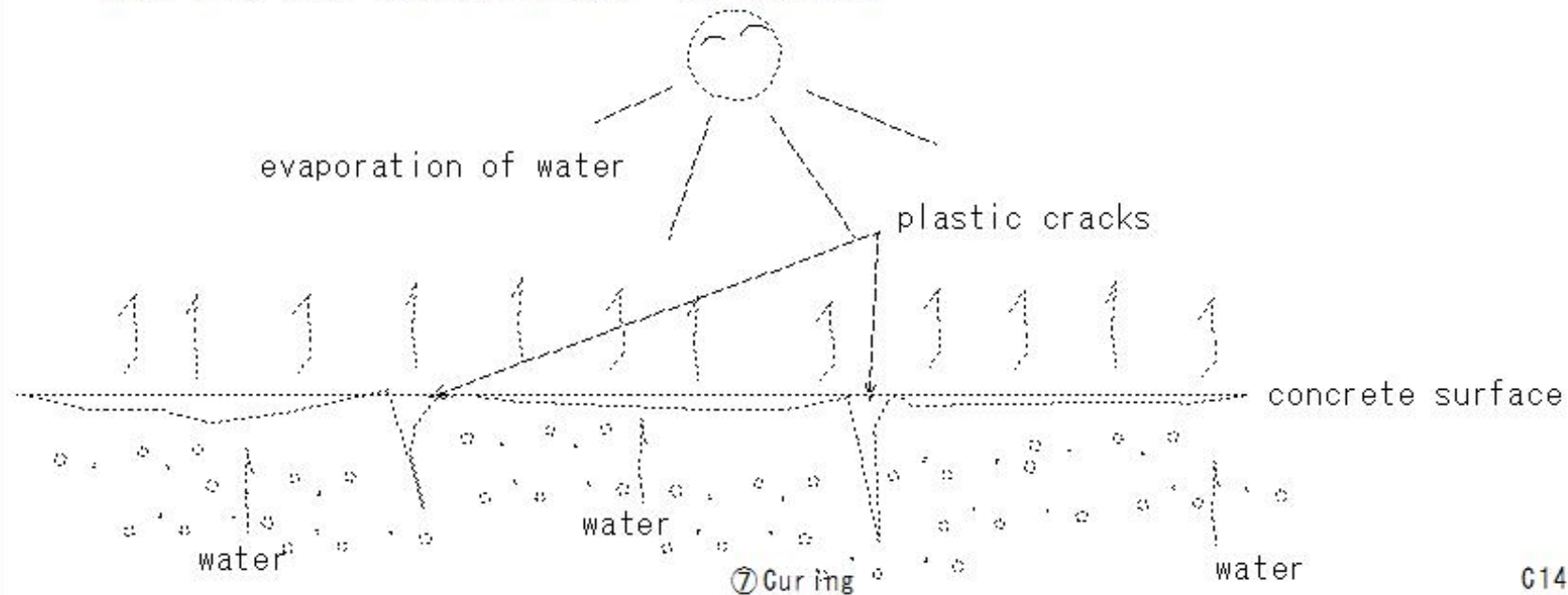
⊕ Compaction

(D58)Construction of concrete dam (placing concrete)

(D58) Construction of concrete dam (placing concrete)

Construction of concrete dam (placing concrete-curing)

- placing concrete
- ⑦ Curing
  - Concrete surface
  - Sheet curing after concrete placing
  - Watering - Preventing dryness
  - Water spray after concrete hardens - wet condition



C1430



(D59)Construction of concrete dam (placing concrete)

(D59) Construction of concrete dam (placing concrete)

Construction of concrete dam (placing concrete)

- placing concrete

⑦ Curing

In the case of hot weather concrete

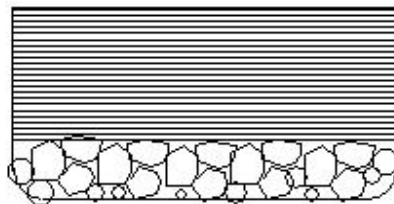
- Evaporation of water from the surface
- Plastic cracks due to drying
- Measures to prevent the surface from drying out immediately after pouring
- case of concrete temperature exceeds 25 degrees
- Temperature cracks - concrete materials - pre-cooling
- Concrete placing - night
- Concrete temperature drop

Cooling during kneading

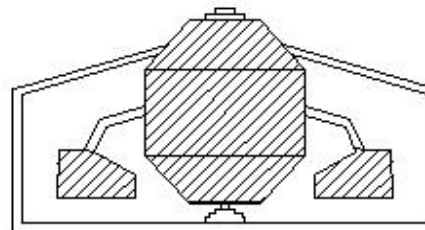
Aggregate cooling

Cooling (air cooling/water cooling)

Cement  
Cooling aggregate  
Cold water  
Ice



Pre-cooling



mixer

G1388

## Construction of concrete dam (placing concrete)

### (D60) Construction of concrete dam (placing concrete)

Construction of concrete dam (placing concrete)

- placing concrete

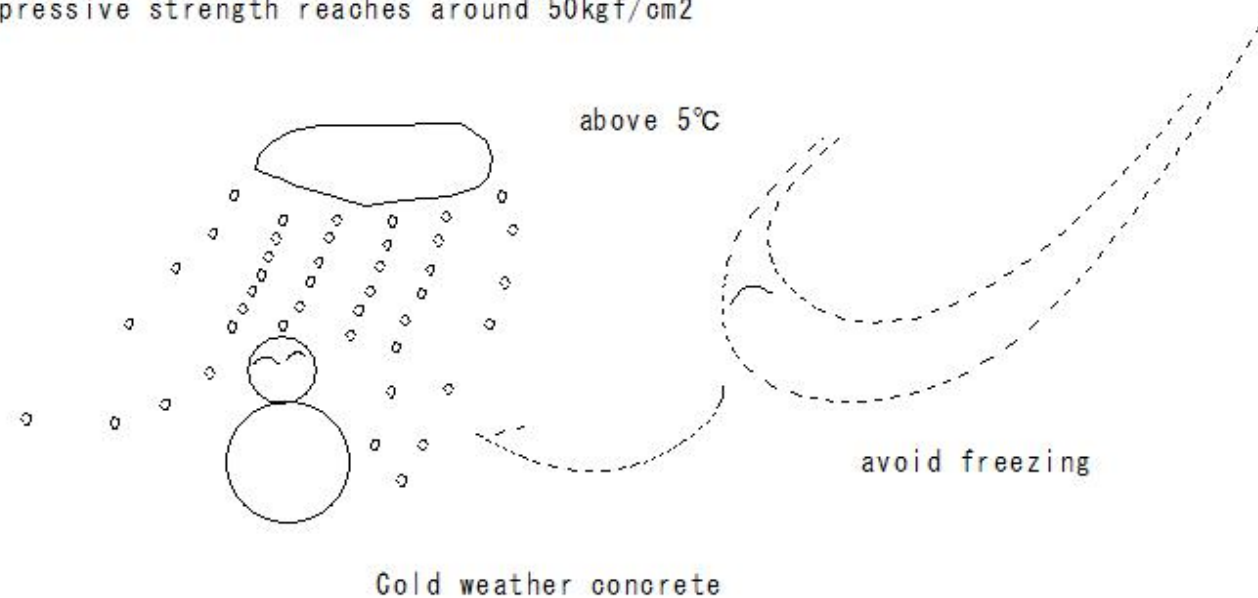
⑦ Curing

Cold weather concrete

- Concrete surface - avoid freezing

- to keep above 5°C

- until concrete compressive strength reaches around 50kgf/cm<sup>2</sup>





## (D61)Construction of concrete dam (placing concrete-formwork)

### (D61)Construction of concrete dam (placing concrete-formwork)

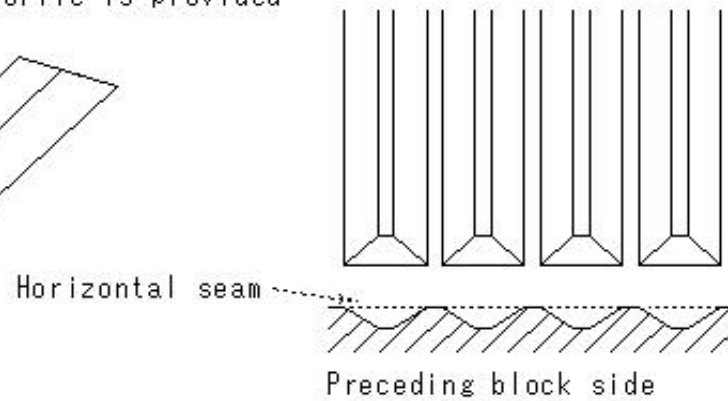
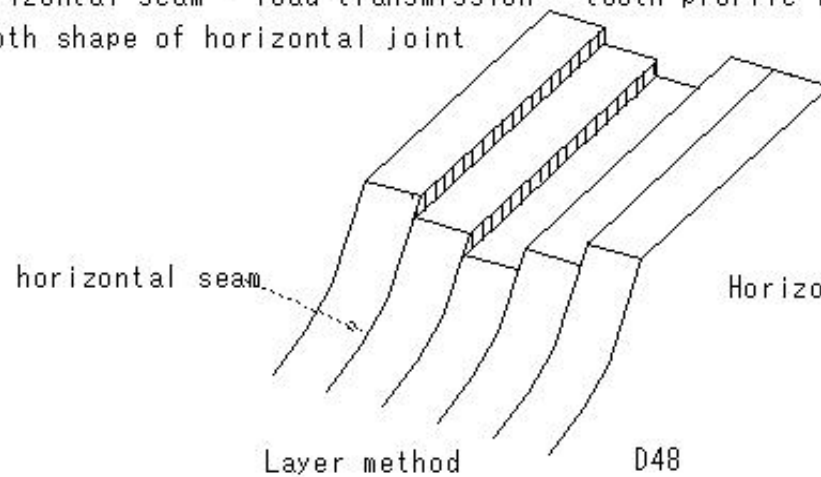
Construction of concrete dam (placing concrete-formwork)

• placing concrete

- ⑥ Formwork
- ① Formwork for upstream and downstream surfaces
- ② Horizontal joint Vertical joint formwork
- ③ Corridor formwork
- ④ Formwork for overflow surface
- ⑤ Formwork for the pier
- ⑥ Other formwork

Horizontal seam - load transmission - tooth profile is provided

Tooth shape of horizontal joint



Tooth shape of horizontal joint

## (D62)Construction of concrete dam (placing concrete-formwork)

### (D62)Construction of concrete dam (placing concrete-formwork)

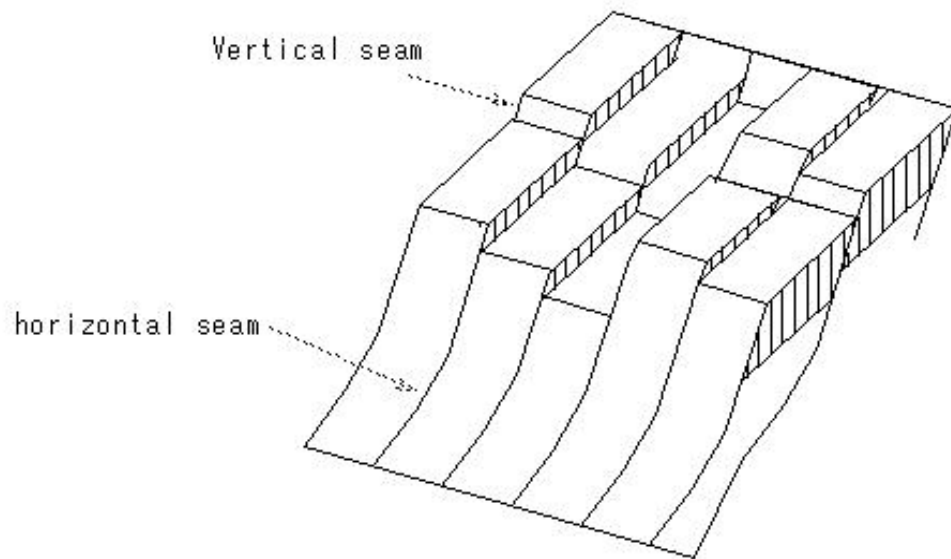
Construction of concrete dam (placing concrete-formwork)

- placing concrete

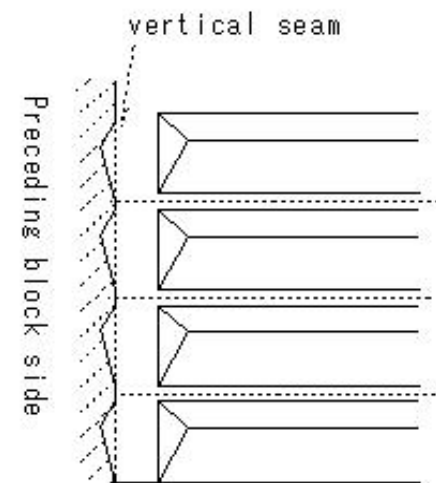
ⓄFormwork

Horizontal seam - load transmission - tooth profile is provided

Tooth shape of vertical seam



block method



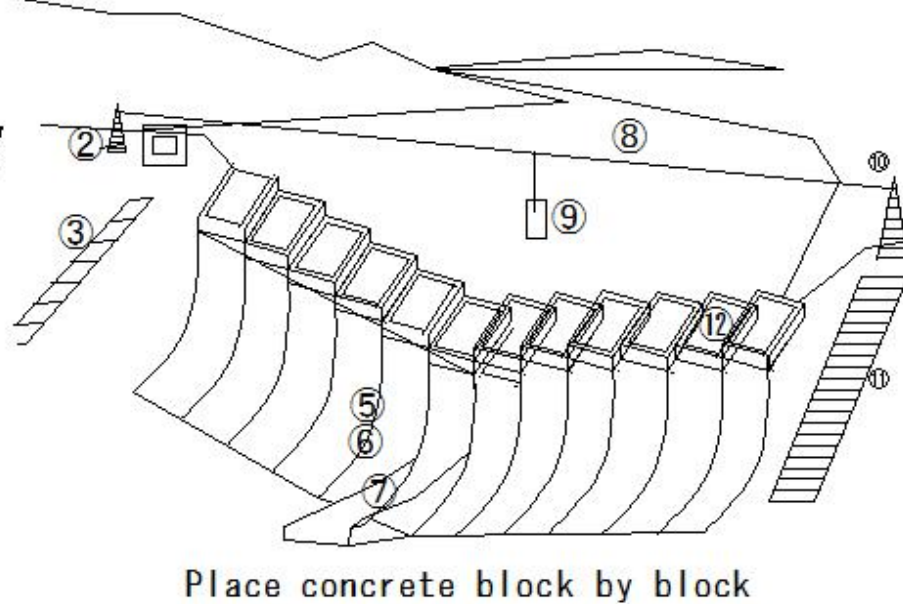
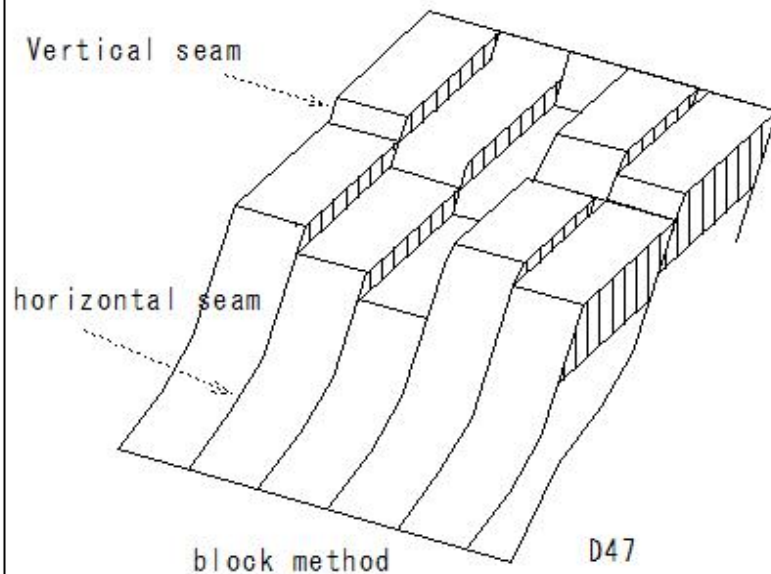
Tooth shape of vertical seam

(D63)Construction of concrete dam (placing concrete-formwork)

(D63) Construction of concrete dam (placing concrete-formwork)

Construction of concrete dam (placing concrete-formwork)

- placing concrete
  - ⑧ Formwork
    - Formwork removal time
    - Vertical surface - Concrete compressive strength 35kgf/cm<sup>2</sup>
    - Arch opening inside the corridor/dam body
- Concrete compressive strength 100kgf/cm<sup>2</sup>



## (D64)Construction of concrete dam (Concrete temperature regulation)

### (D64)Construction of concrete dam (Concrete temperature regulation)

#### Construction of concrete dam (Concrete temperature regulation)

- Concrete temperature regulation

##### ① Purpose

- concrete hardens

#### Temperature rise due to heat of hydration of cement

- Mass concrete construction
- control of concrete temperature rise
- Prevention of temperature cracks
- Countermeasures (temperature regulation)

Clean plant

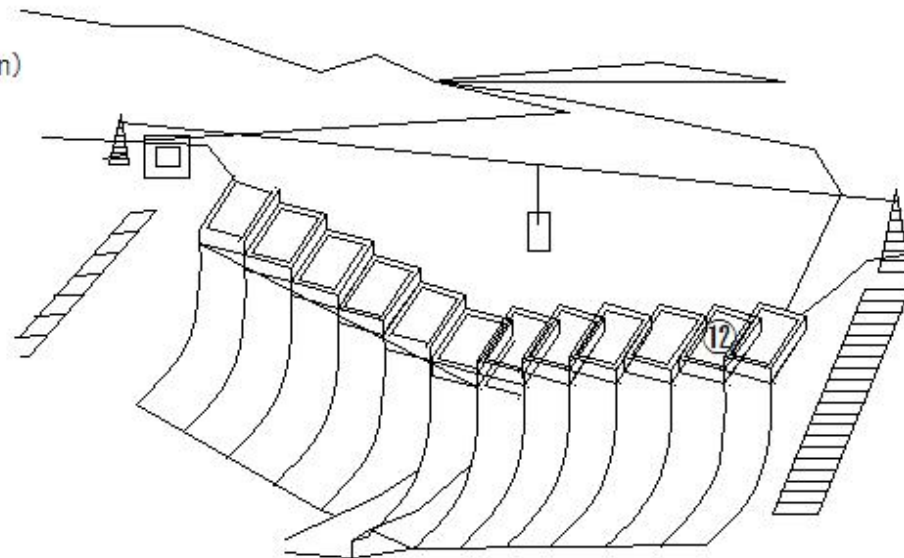
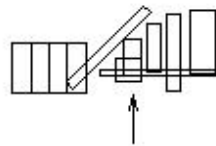
mass concrete

Suppression of temperature rise

① Aggregate cooling

② Mixing water cooling: Pre-cooling

③ Pipe cooling



G1017

## (D65)Concrete temperature regulation(Pre-cooling)

### (D65) Concrete temperature regulation(Pre-cooling)

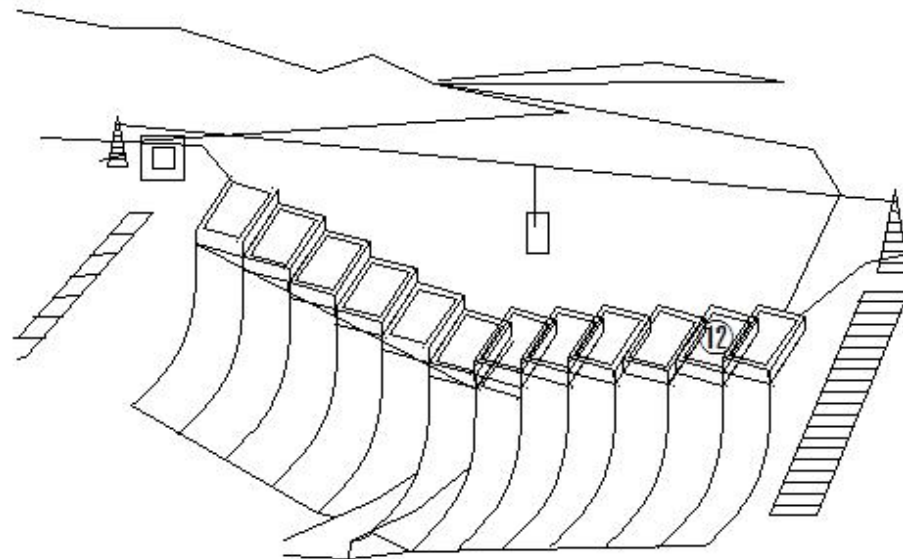
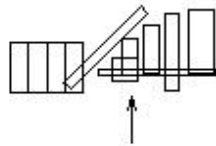
Construction of concrete dam (Concrete temperature regulation)

- Concrete temperature regulation
  - ② Pre-cooling
    - Cooling concrete materials before mixing
- lower concrete temperature
- Method: Cooling of mixing water
  - Cooling of mixing water, replace with ice
  - Cooling of coarse aggregate
  - No cooling of cemen, fine aggregate:

Clean plant  
mass concrete

Suppression of temperature rise

- ① Aggregate cooling
- ② Mixing water cooling: Pre-cooling
- ③ Pipe cooling



C1017

## (D66)Concrete temperature regulation(Pipe cooling)

### (D66)Concrete temperature regulation(Pipe cooling)

Construction of concrete dam (Concrete temperature regulation)

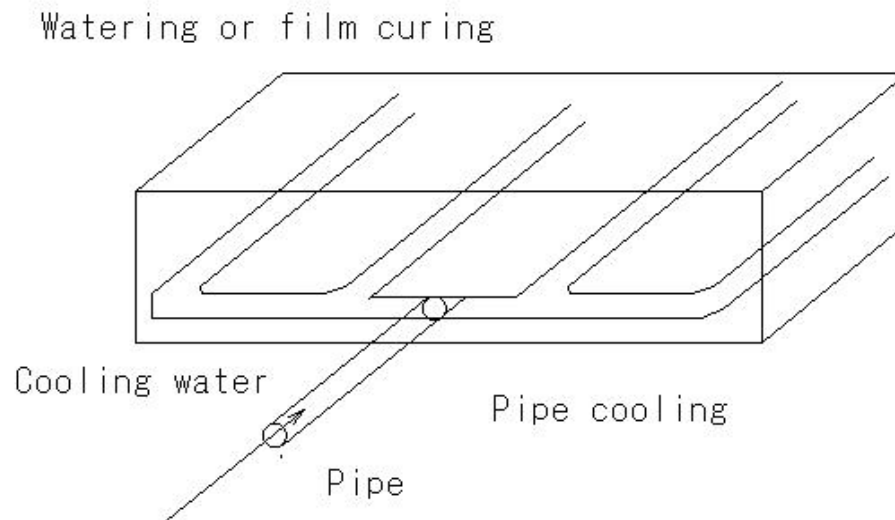
- Concrete temperature regulation

#### ③Pipe cooling

- Concrete cooling
- Block construction method (column construction method)
- Used with joint grouting

1st cooling

Secondary cooling



C867



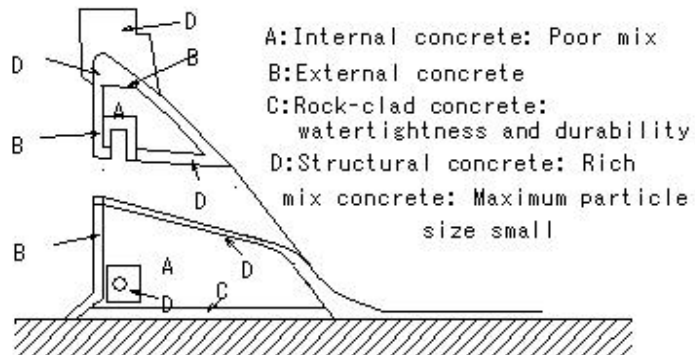
## (D67)Concrete temperature regulation(Pipe cooling)

### (D67)Concrete temperature regulation(Pipe cooling)

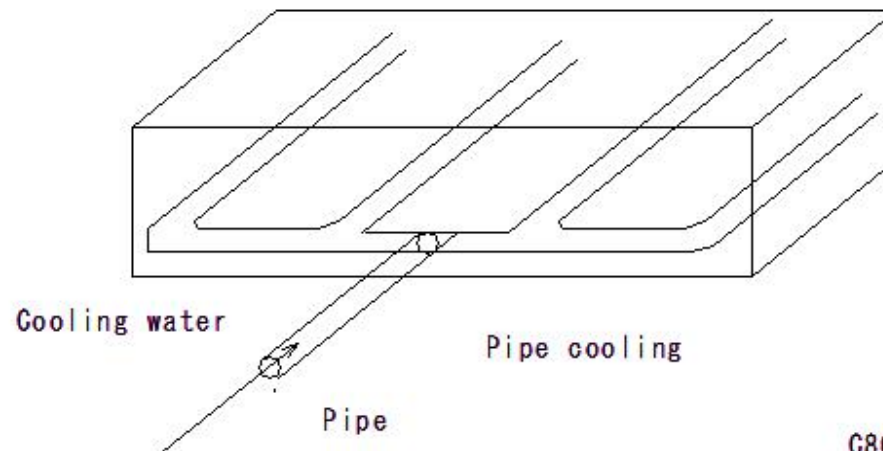
Construction of concrete dam (Concrete temperature regulation)

#### ③ Pipe cooling

- Diameter 1 inch 25.4mm
- Cooling pipe
- Piping in the dam axis direction (left and right bank direction)
- Prevent water paths



Watering or film curing



C1064

C867



## (D68)Concrete temperature regulation(Pipe cooling)

### (D68)Concrete temperature regulation(Pipe cooling)

Concrete temperature regulation(Pipe cooling)

#### ③Pipe cooling

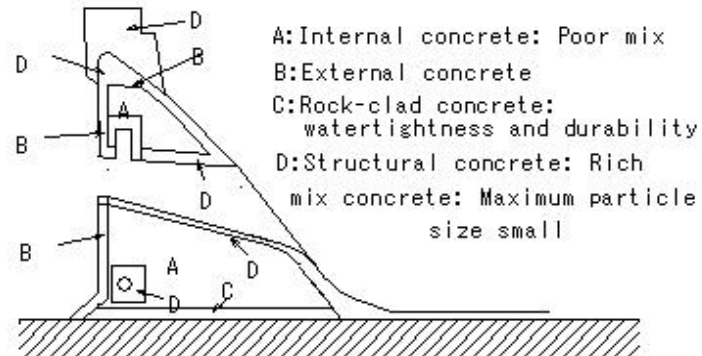
Pipe cooling period

- First cooling period

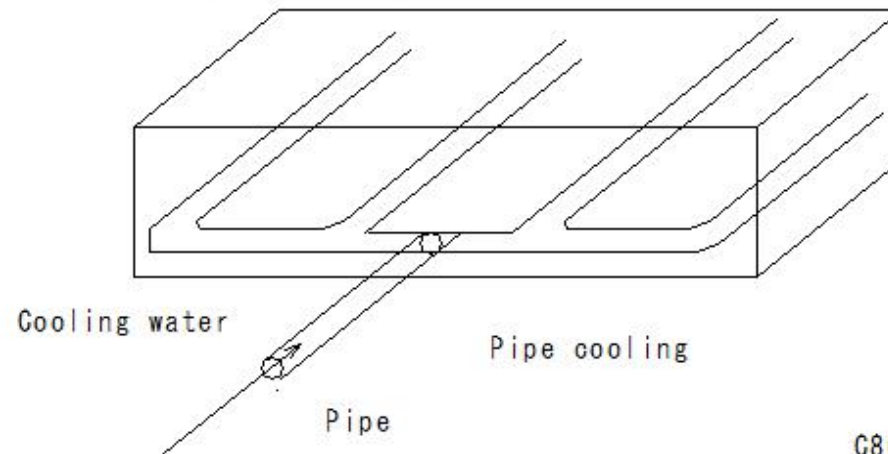
Immediately after placing, approximately 2 weeks to 1 month

- Second cooling period

for about 40-60 days



Watering or film curing



C1064

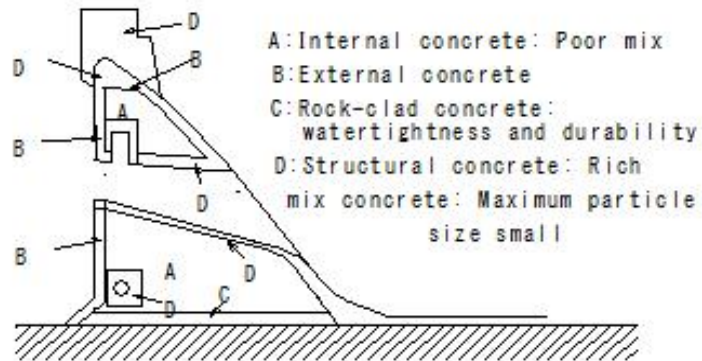
C867

## (D69)Concrete temperature regulation(Pipe cooling)

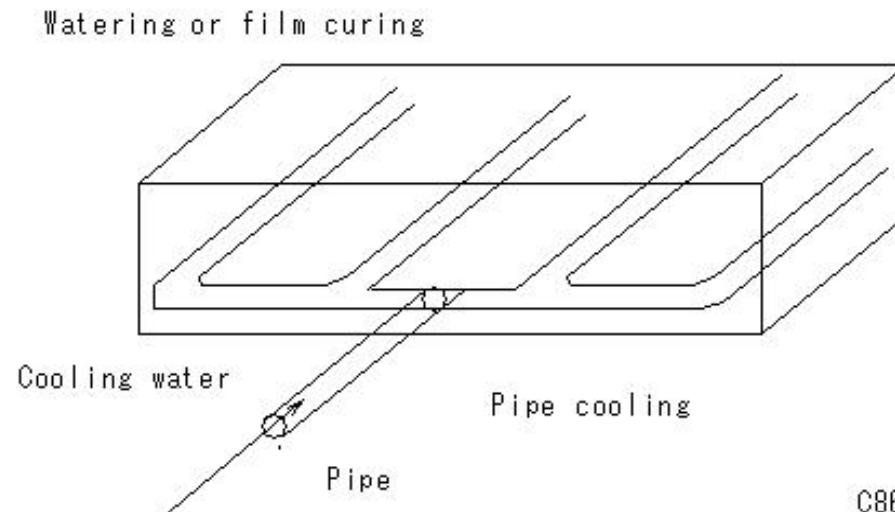
### (D69)Concrete temperature regulation(Pipe cooling)

#### Concrete temperature regulation(Pipe cooling)

- Concrete temperature regulation
- ③Pipe cooling
- ④Cooling management
- Cold water flow direction in the cooling pipe
- Reverse cold water flow direction every other day (every 24 hours)  
cools uniformly



C1064



C867

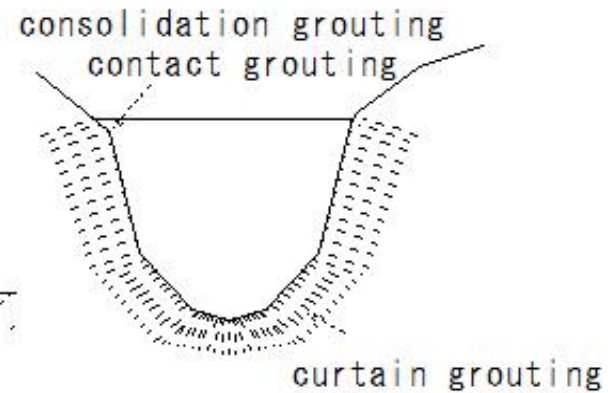
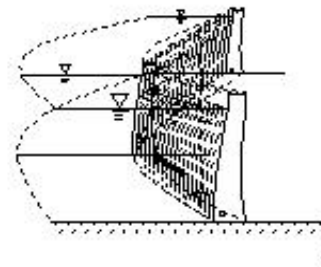
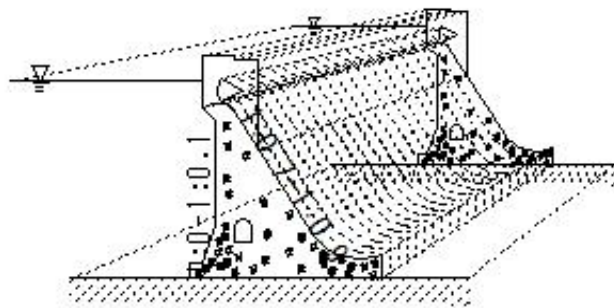
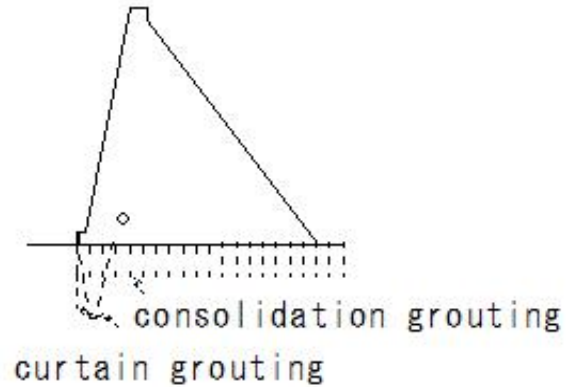
(D70)Concrete temperature regulation(Joint grouting)

(D70)Concrete temperature regulation(Joint grouting)

Concrete temperature regulation(Joint grouting)

④Joint grouting

- Unify structures that are divided into blocks
- Vertical joint of gravity dam
- Horizontal joint of arch dam
- Detracts from integration
- Perform joint grouting on the seams
- The standard lift height for joint grouting is 15-16 m.



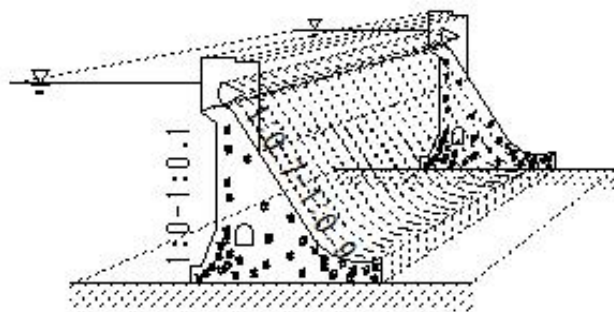
F327

## (D71)Construction of concrete dam (Corridor)

### (D71)Construction of concrete dam (Corridor)

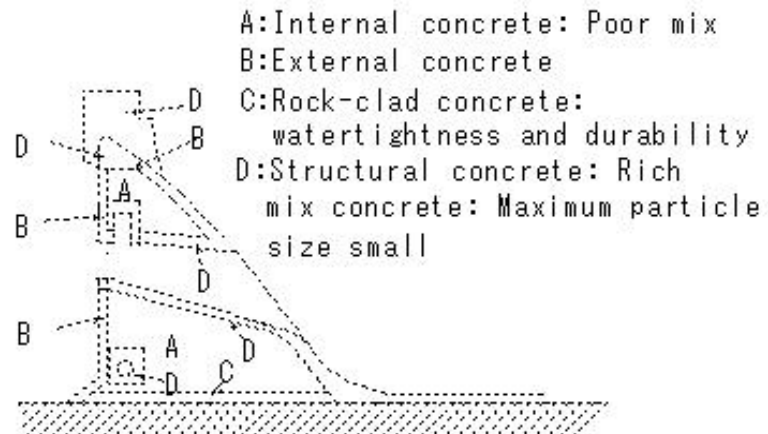
#### Construction of concrete dam (Corridor)

- Corridor
- Safety management of embankment body
- Construction of curtain grouting
- Installation of drainage holes
- Connection route to discharge equipment
- Minimum distance between corridor and upstream surface: 3m
- Minimum distance between corridor and foundation rock: around 2m



gravity dam

D2



gravity dam

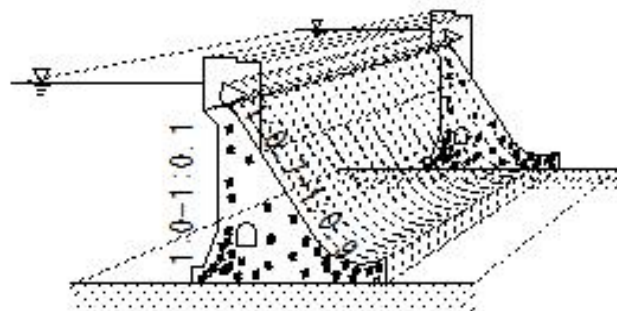
C1064

(D72)Construction of concrete dam (Foundation drainage hole)

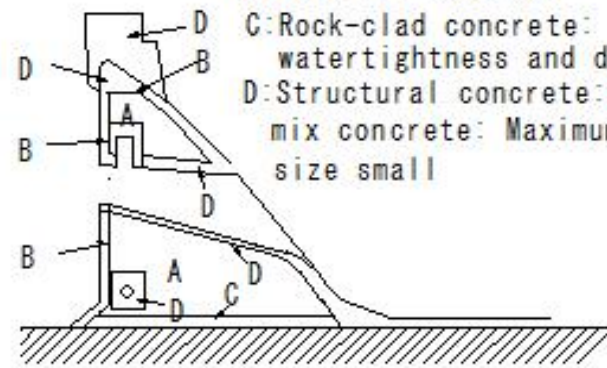
(D72)Construction of concrete dam (Foundation drainage hole)

Construction of concrete dam (Foundation drainage hole)

- Foundation drainage hole
- Concrete dam  
Install foundation drainage holes to reduce uplift pressure acting on the dam body.
- Foundation drainage holes are drilled from the safety corridor provided parallel to the dam axis.
- Drainage hole depth: about 3-5m



gravity dam  
D2



A: Internal concrete: Poor mix  
B: External concrete  
C: Rock-clad concrete:  
watertightness and durability  
D: Structural concrete: Rich  
mix concrete: Maximum particle  
size small

gravity dam  
C1064

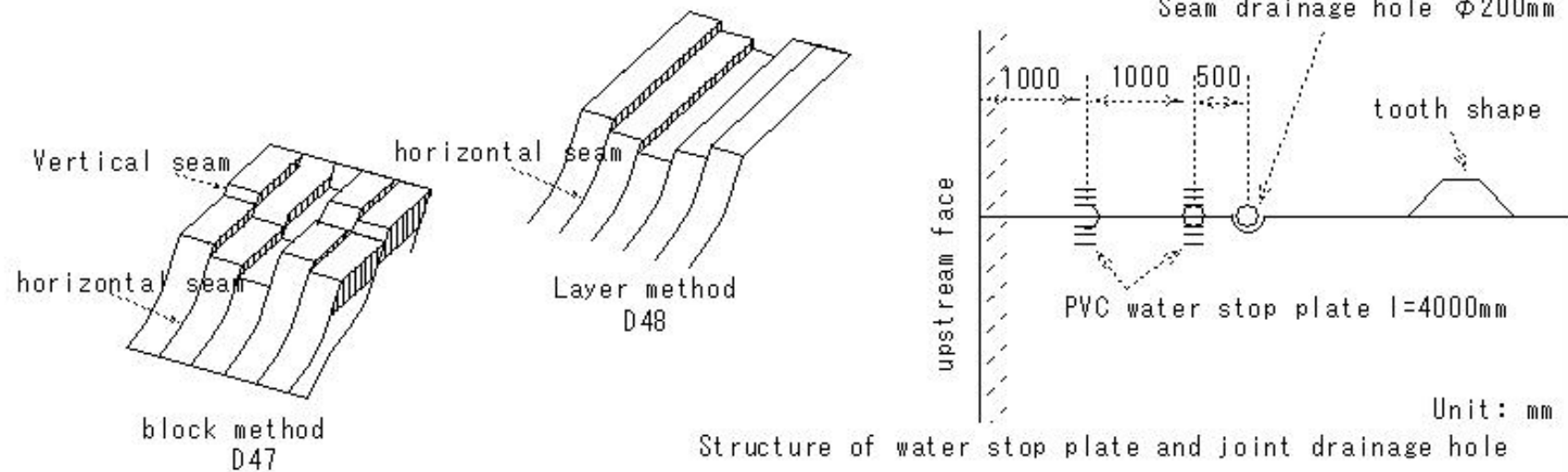


## (D73) Construction of concrete dam (Water stop plate and joint drainage hole)

### (D73) Construction of concrete dam (Water stop plate and joint drainage hole)

#### Construction of concrete dam

- Water stop plate and joint drainage hole
- Horizontal joint of concrete dam
- Reservoir water leakage route
- Install a water stop plate near the upstream end of the horizontal joint
- Seam drainage holes are provided after the water stop plate.
- Collect and drain water leakage that occurs when the water stop plate is incomplete
- Water stop plate: Placed only on the upstream side of the non-overflow area
- Water stop plate: Placed on both sides of overflow section - upstream and downstream sides



(D74)Construction of concrete dam using RCD method

(D74)Construction of concrete dam using RCD method

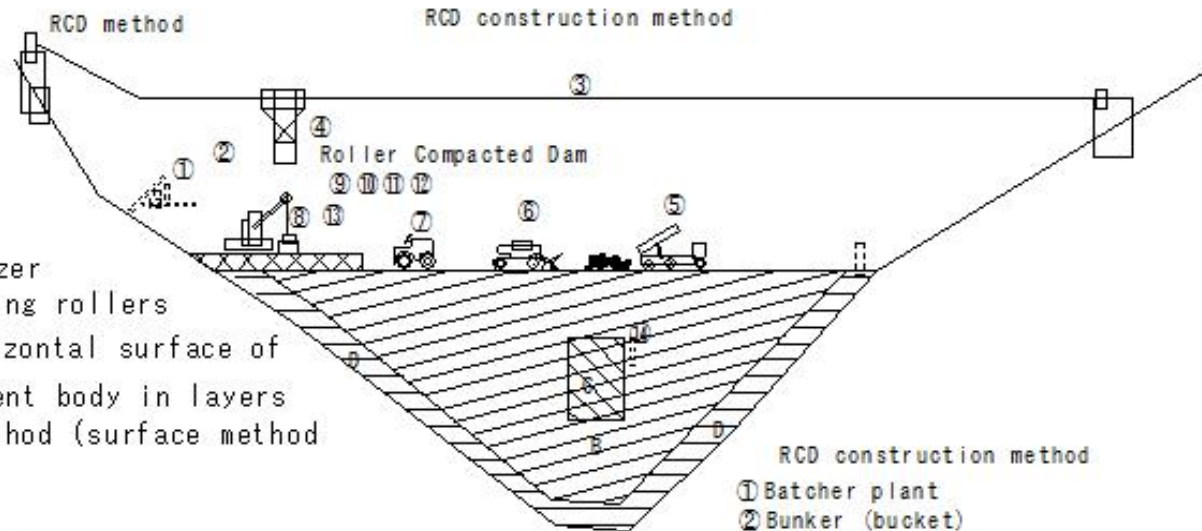
Construction of concrete dam using RCD method

RCD method

- Streamlining dam construction
- Poor mix ultra-hard concrete
- Concrete for RCD
- Dump truck
- Fixed cable crane
- Incline
- belt conveyor

transportation

- spreading with a bulldozer
- Compaction using vibrating rollers
- Concrete the entire horizontal surface of the embankment body in layers
- Full surface layer method (surface method)



- A Mix Proportion: Upstream and downstream concrete
- B Mix Proportion: Internal concrete
- C Mix Proportion: Concrete around the structure
- D Mix Proportion: Impregnated concrete

- ⑨ Motor sweeper (green cut)
- ⑩ Washing (washing with water)
- ⑪ Watering curing
- ⑫ Laying the next layer of mortar
- ⑬ Vibrating joint cutting machine
- ⑭ Human-powered compaction

RCD construction method

- ① Batcher plant
- ② Bunker (bucket)
- ③ Fixed cable crane
- ④ Mobile hopper
- ⑤ Dump truck transportation
- ⑥ Bulldozer laying
- ⑦ Vibrating roller (compaction)
- ⑧ Joint cutter
- (vibration press fit type)

C981



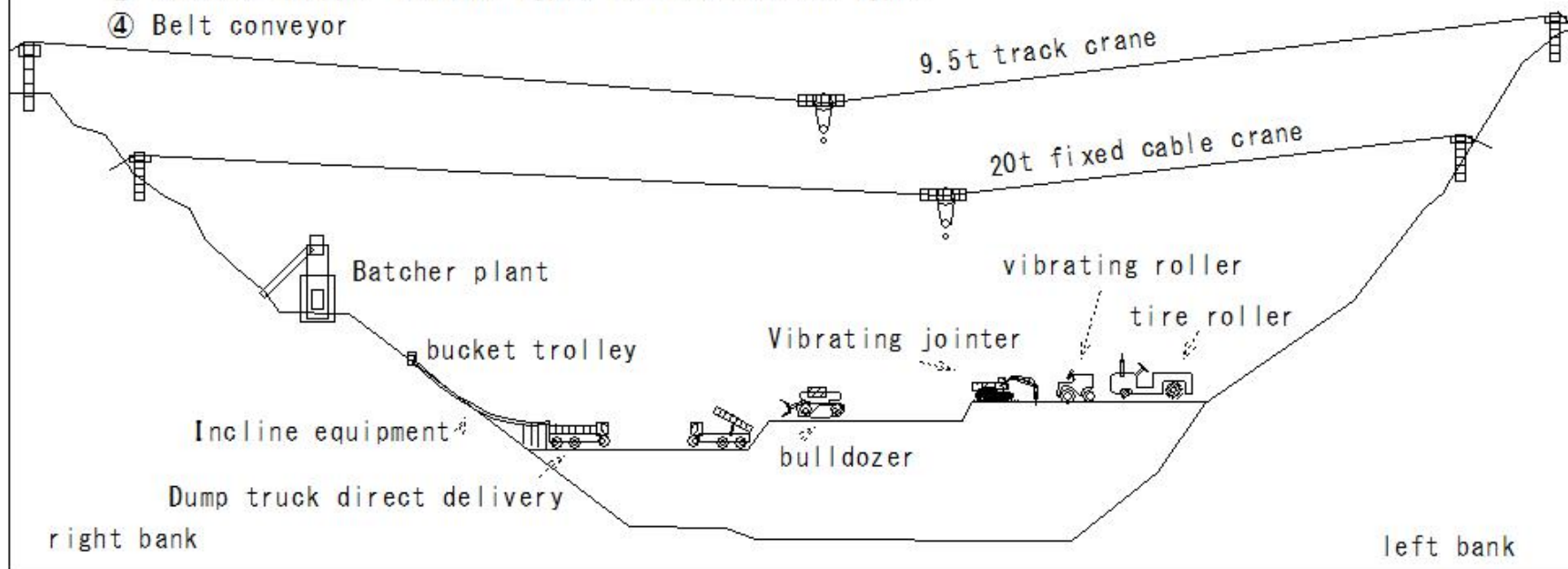
## (D75)RCD method

### (D75)RCD method

#### RCD method

##### Characteristics of RCD method

- ① Poor mix of concrete: ultra-hard concrete
- ② Method of transporting concrete from the batcher plant to the embankment casting surface
  - ① Direct delivery from dump truck
  - ② Fixed type (track type) cable crane
  - ③ Incline (hopper station type, vehicle-mounted type)
  - ④ Belt conveyor



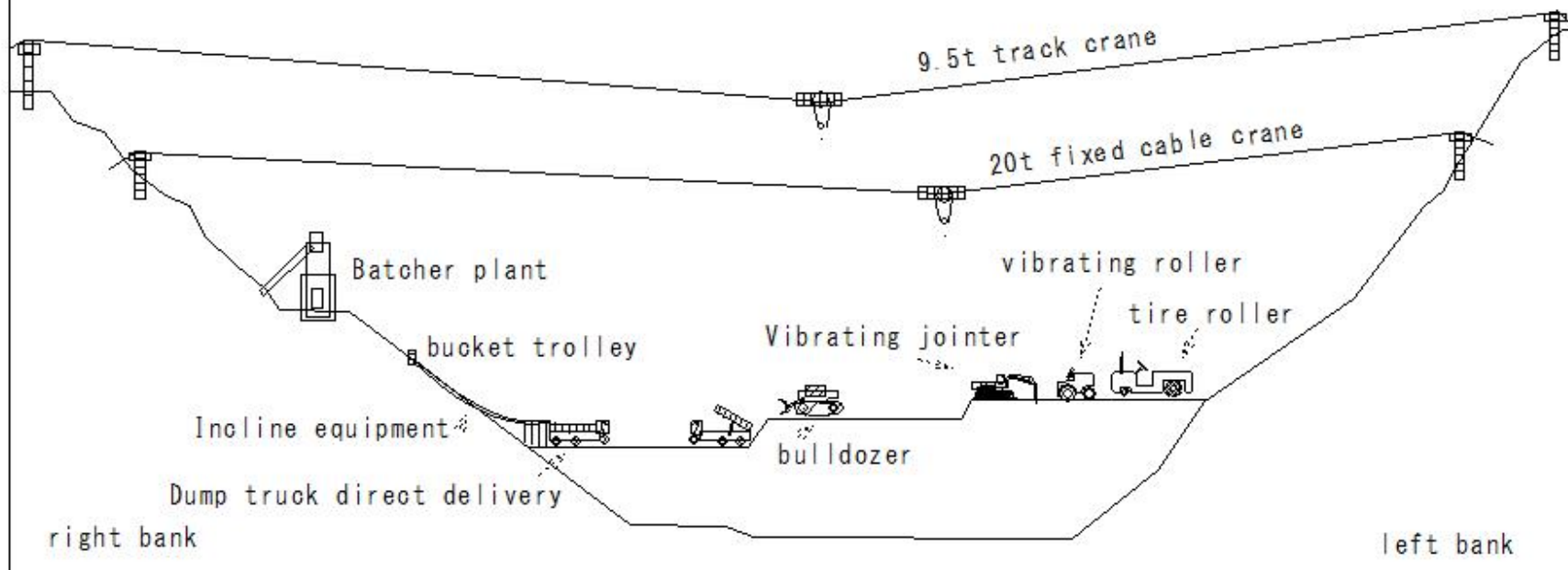
## (D76)RCD method

### (D76)RCD method

Construction of concrete dam using RCD method

Characteristics of RCD method

- ③ Transportation of concrete in the horizontal direction to the placing location on the embankment body



## (D77)RCD method

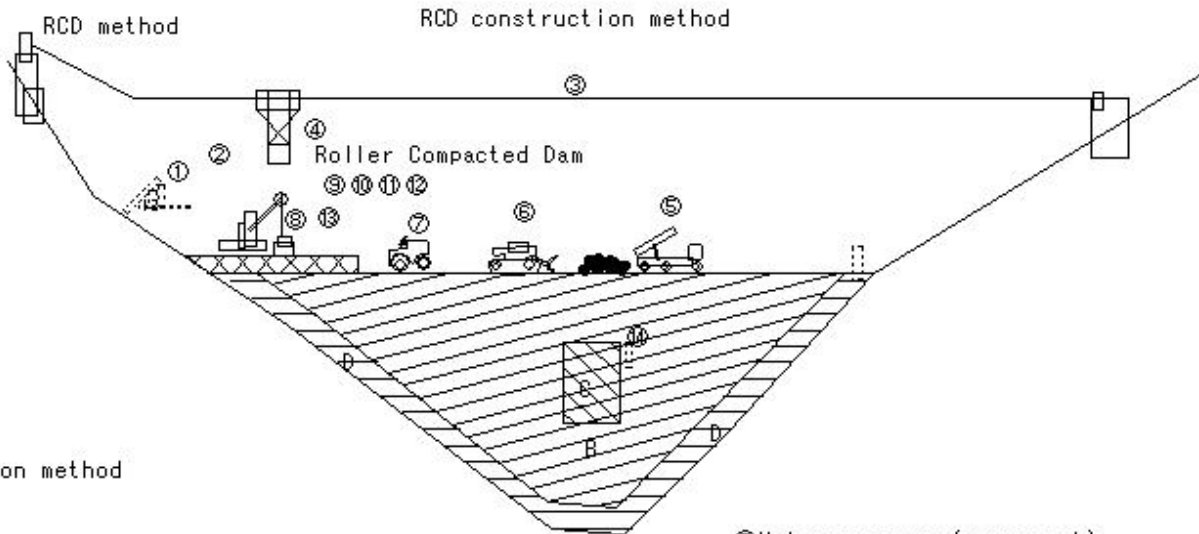
### (D77) RCD method

Construction of concrete dam using RCD method

Characteristics of RCD method

④ Placing method

Full layer method



RCD construction method

- ① Batcher plant
- ② Bunker (bucket)
- ③ Fixed cable crane
- ④ Mobile hopper
- ⑤ Dump truck transportation
- ⑥ Bulldozer laying
- ⑦ Vibrating roller (compaction)
- ⑧ Joint cutter  
(vibration press fit type)

- ⑨ Motor sweeper (green cut)
- ⑩ Washing (washing with water)
- ⑪ Watering curing
- ⑫ Laying the next layer of mortar
- ⑬ Vibrating joint cutting machine
- ⑭ Human-powered compaction

## (D78)RCD method

### (D78) RCD method

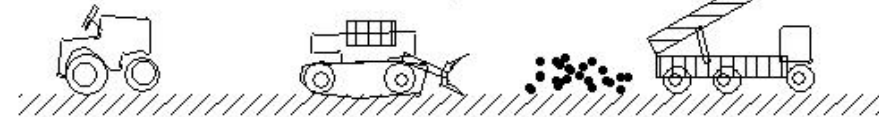
Construction of concrete dam using RCD method

Characteristics of RCD method

⑤spreading

- Prevention of aggregate segregation
- Increased bulk compaction effect
- How to spread a thin layer several times

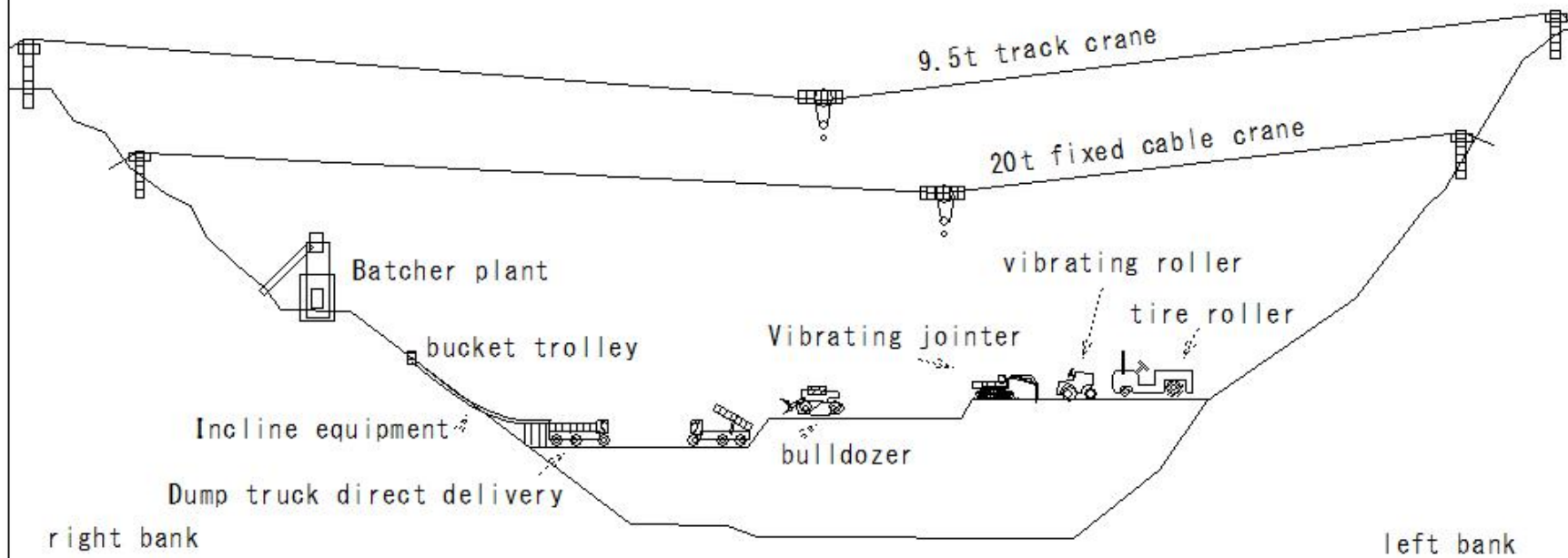
Roller Compacted Dam



compaction  
roller

leveling  
bulldozer

C907



(D79)RCD method

(D79)RCD method

Construction of concrete dam using RCD method

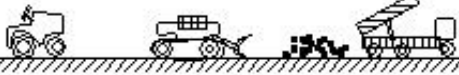
Characteristics of RCD method

⊗ Contraction joints in the levee body -do not create vertical joints

RCD method

Roller Compacted Dam

50-100cm



Incline

compaction  
roller

1 lift: 1.5m to 2.0m  
spread in 3-4 layers

leveling  
bulldozer

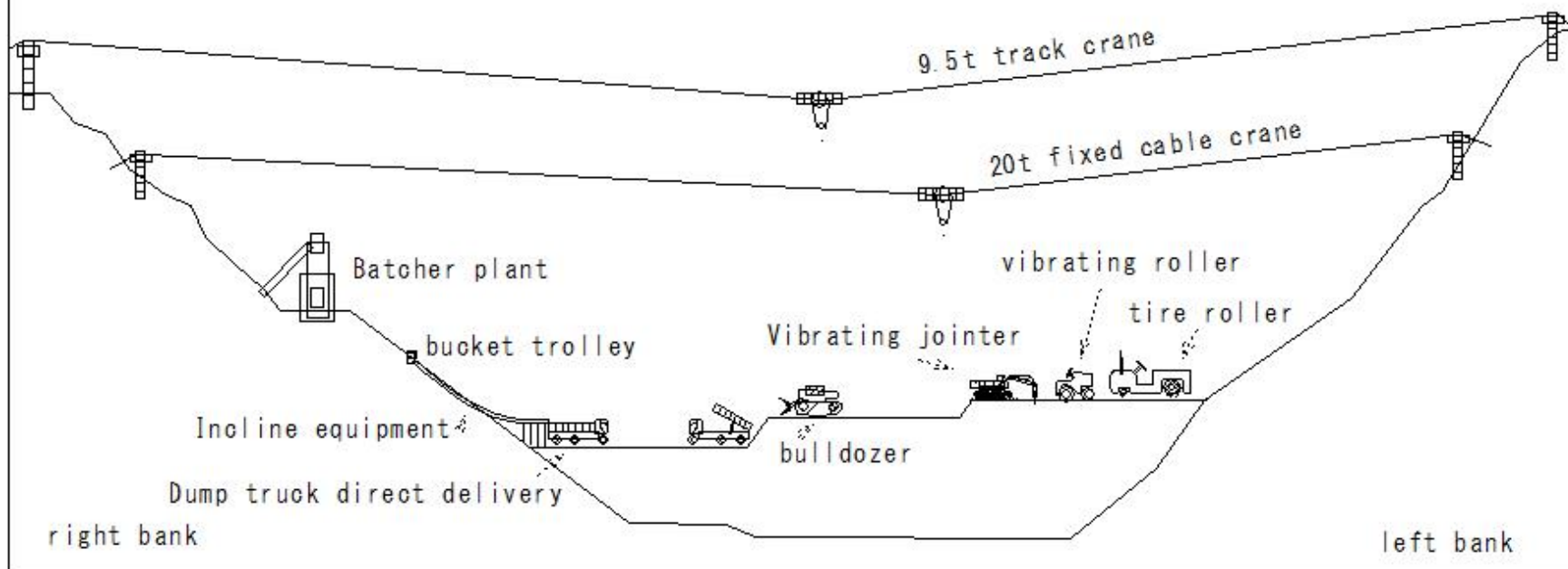
## (D80)RCD method

### (D80) RCD method

Construction of concrete dam using RCD method

Characteristics of RCD method

- ⑦ After shrinkage joints of the embankment body - horizontal joints - spreading of concrete manufactured using a vibrating jointer





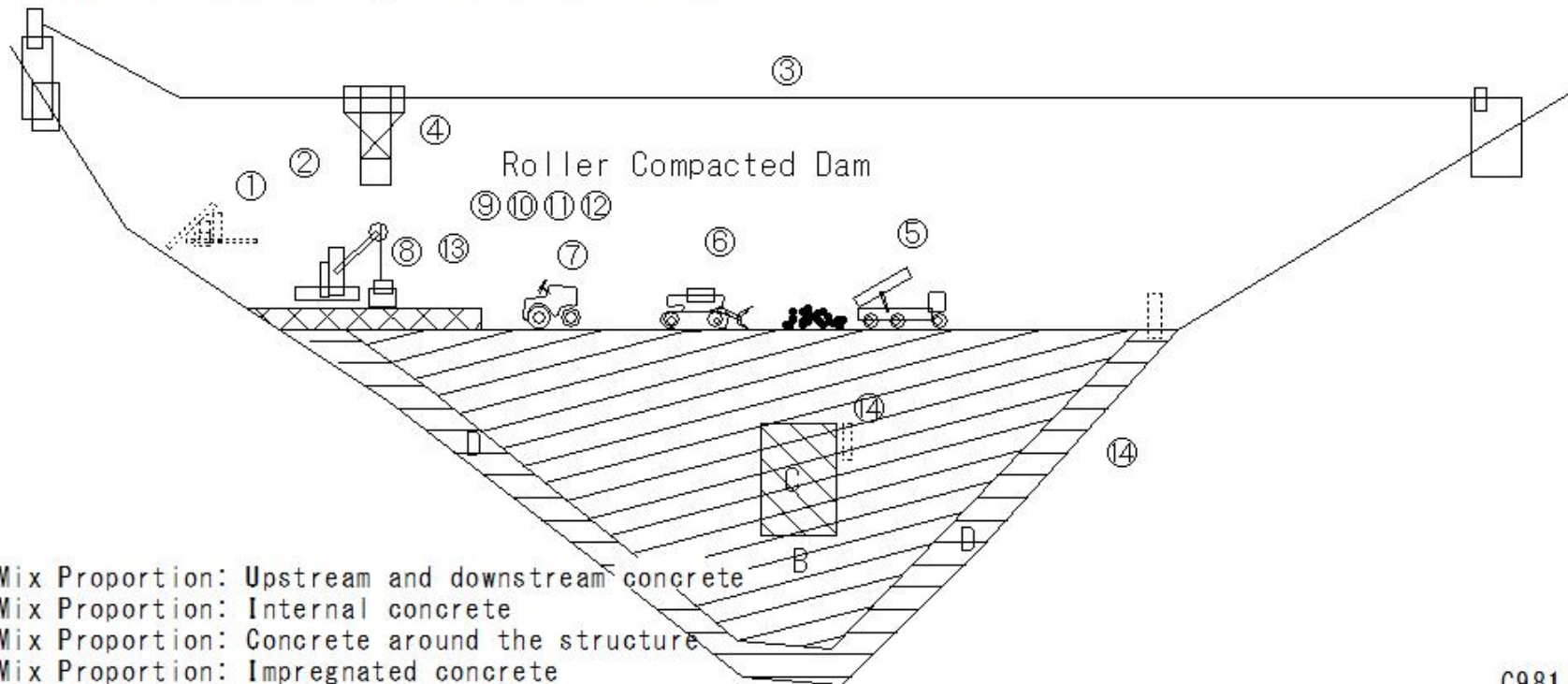
## (D81)RCD method

### (D81) RCD method

Construction of concrete dam using RCD method

Characteristics of RCD method

- ⑧ Compaction of RCD concrete - self-propelled vibrating roller
- External concrete - by conventional method



C981

(D82)RCD method

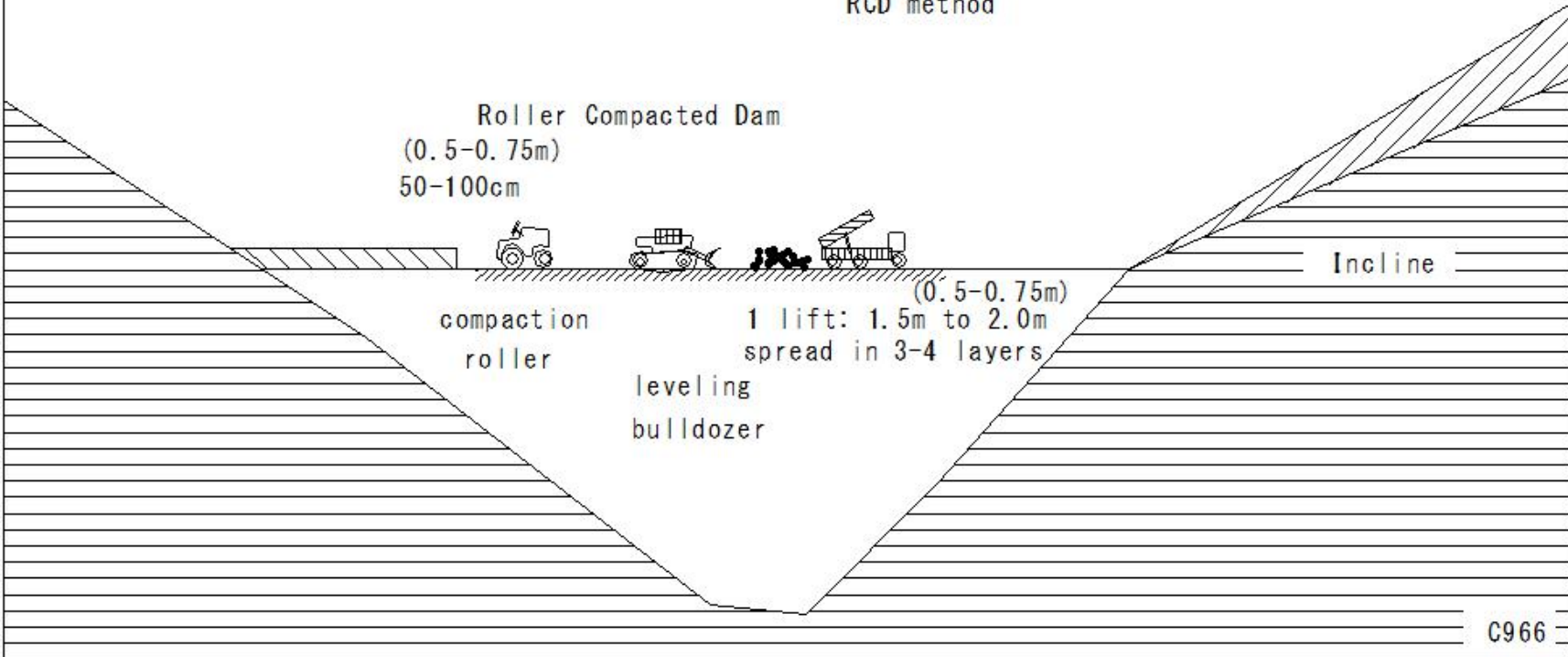
(D82) RCD method

Construction of concrete dam using RCD method

Characteristics of RCD method

⑨ RCD concrete lift thickness: 0.5-0.75m

RCD method



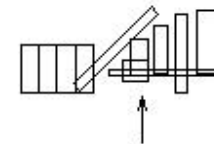
(D83)RCD method

(D83) RCD method

Construction of concrete dam using RCD method

Characteristics of RCD method

- ⑩ Temperature regulation pre-cooling
- Do not perform pipe cooling



plant

mass concrete

Suppression of temperature rise

- ① Aggregate cooling
- ② Mixing water cooling: Pre-cooling
- ③ Pipe cooling

D65

Cooling during kneading

Cement

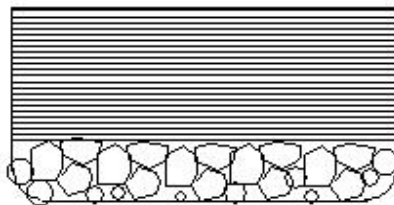
Cooling aggregate

Cold water

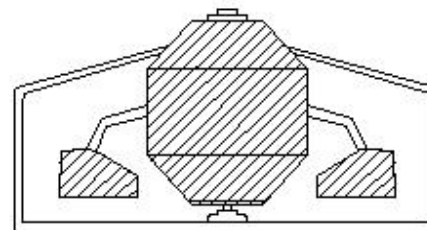
Ice

Aggregate cooling

Cooling (air cooling/water cooling)



Pre-cooling



mixer

D59

G1388

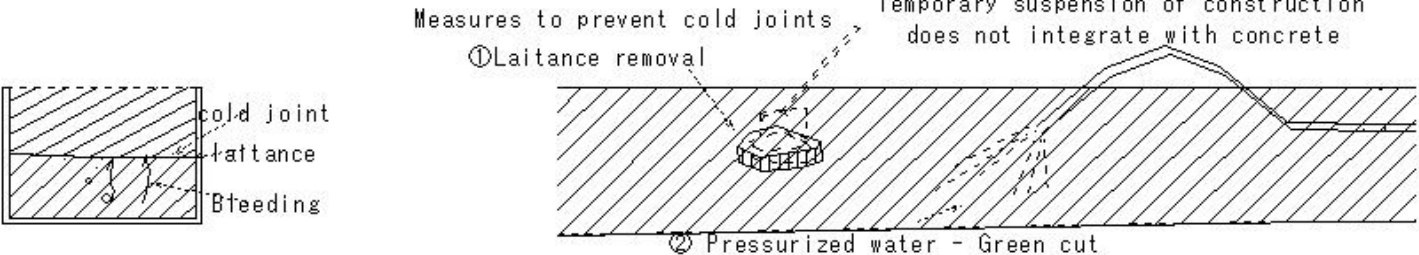
(D84)RCD method

(D84)RCD method

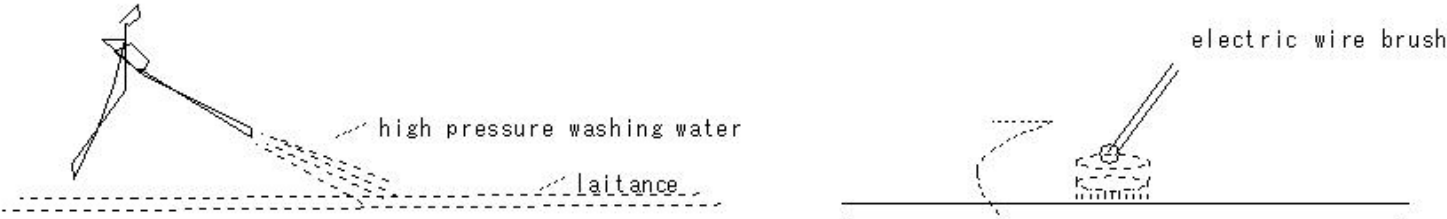
Construction of concrete dam using RCD method

Characteristics of RCD method

- ① Green cut at horizontal placing seam
- Self-propelled type such as motor sweeper



C880



C1016

(D85)RCD method

(D85) RCD method

Construction of concrete dam using RCD method RCD method

Characteristics of RCD method

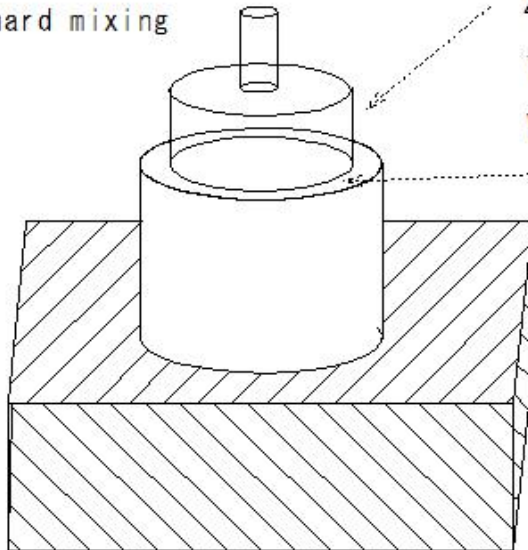
⑫ Consistency management of RCD concrete

VC exam-value



VC test

Super hard mixing



20kg weight

vibrating compaction value

VC value

time required for mortar bleeding on surface

RCD concrete

vibration

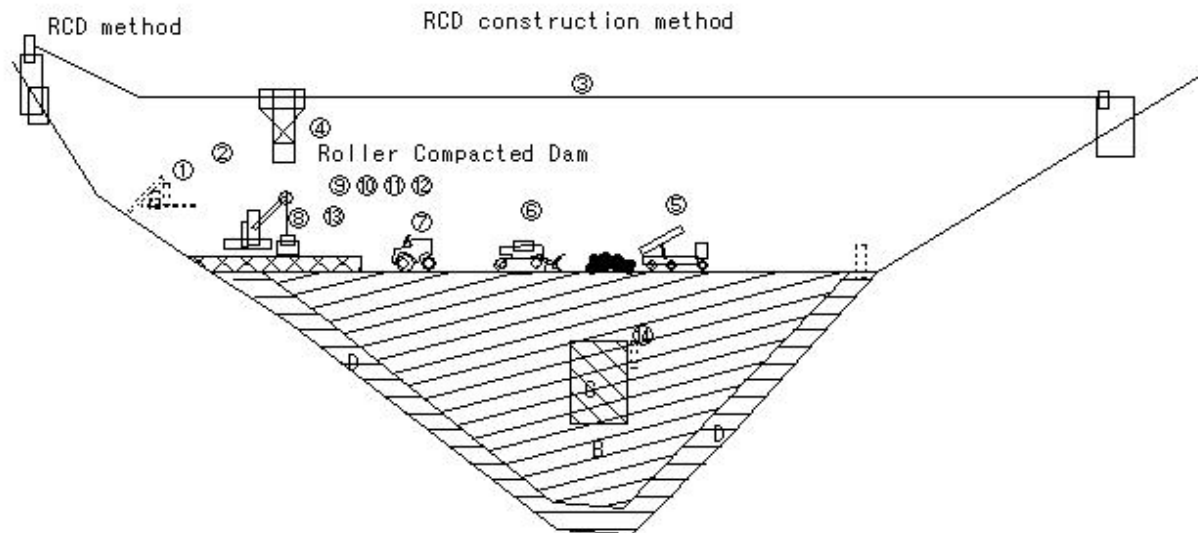
## (D86)RCD method

### (D86) RCD method

Construction of concrete dam using RCD method

Characteristics of RCD method

- Economic
  - Shorten construction period - Possible
- ① Valley shape of the dam site: V-shaped steep topography
  - ② case of discharge equipment many buried objects such as corridors
  - ③ Dam-small scale
  - ④ Rainfall: Rainfall of 2mm or more per hour -placing is prohibited





## (D87)fill dam

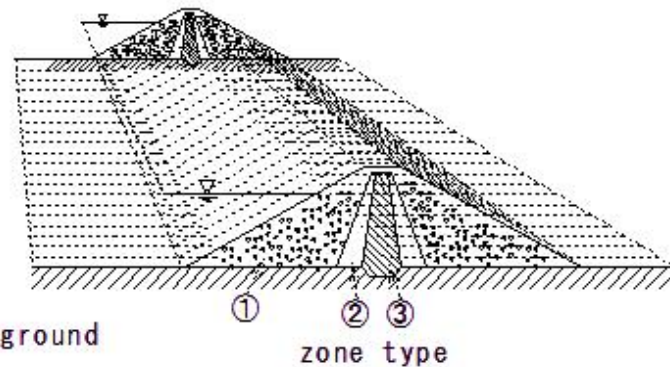
### (D87)fill dam

#### fill dam

##### Characteristics of field material

- Coarse grain material - Water permeable material, semi-water permeable material
- Impermeable materials - soil materials, artificial Impermeable materials
- permeable material-shear strength
- Compaction construction - easy
- Consolidation settlement after compaction - small
- not contain harmful amounts of organic matter
- Contains about 10-20% of clay + silt fine particles (0.074 mm or less)
- Material with high plasticity index containing about 50% gravel

- ① permeable material
- ② Semi-permeable material
- ③ Waterproof material



spillway installed on the ground

zone type

D6  
R590

## (D88)fill dam

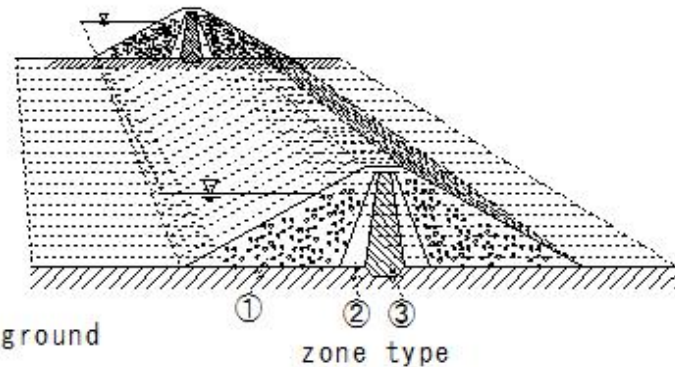
fill dam

### (D88)fill dam

Characteristics of field material

- Coarse grain material - Water permeable material, semi-water permeable material
- Water-shielding materials - soil materials, artificial water-shielding materials
- ② Semi-permeable material
  - particle size - appropriate
  - Has the required shear strength and water permeability
- ① Filter material
  - Only water is discharged for seepage water from the water-blocking zone
  - Prevents fine particles from flowing out in water-blocking materials
- ② Transition material
  - Between the impermeable zone and the permeable zone
  - Reducing sudden changes in rigidity and water permeability

- ① permeable material
- ② Semi-permeable material
- ③ Waterproof material



spillway installed on the ground

zone type

D6  
R590

## (D89)fill dam

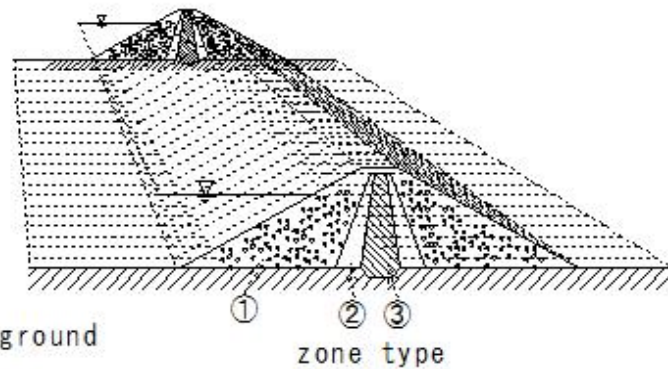
fill dam

## (D89) fill dam

Characteristics of field material

- Coarse grain material - Water permeable material, semi-water permeable material
- Impermeable materials - soil materials, artificial Impermeable materials
- ③ permeable material
  - Hardness and durability
  - Shear strength-improves drainage
  - Rock - hard
  - appropriately large and small particle shapes - mixed
- Density - large

- ① permeable material
- ② Semi-permeable material
- ③ Waterproof material



spillway installed on the ground

zone type

D6  
R590

## (D90)fill dam

### (D90) fill dam

fill dam

material collection

① Collection and adjustment of water-Impermeable materials

Uniform particle size and water content ratio

- case of appropriate materials cannot be obtained

Stockpile creation

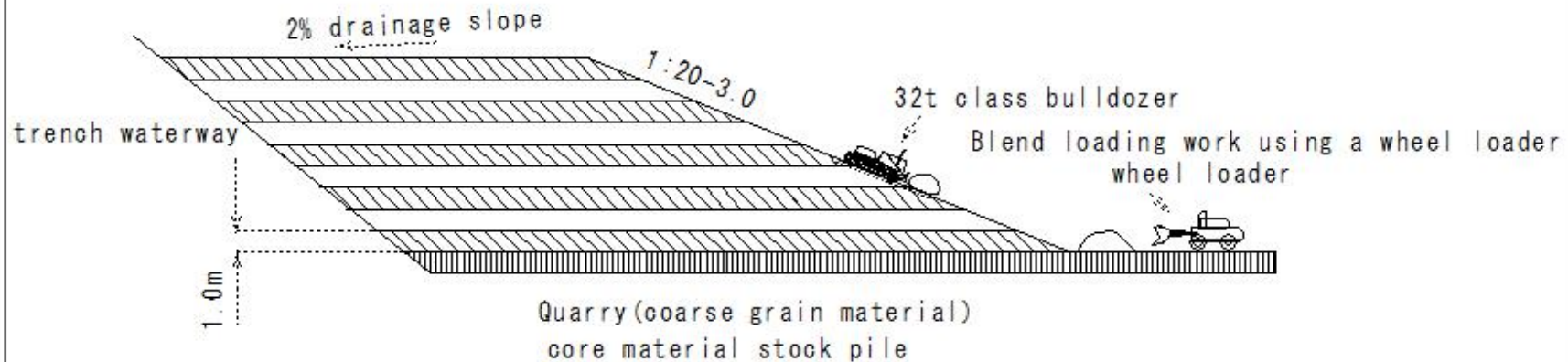
Moisture content ratio/particle size adjustment

- Adjustment of water content ratio

Aeration Water sprinkling

- Particle size adjustment uniformity

Temporarily mix 2-3 types of materials in layers





## (D91)fill dam

### (D91)fill dam

fill dam

material collection

② Collection and preparation of semi-permeable materials

- Used as filter material for embankment body

filter law criteria

- Materials with specified particle size range
- Materials used: riverbed gravel, quarry: semi-weathered rock
- Adjustment of filter material - particle size adjustment

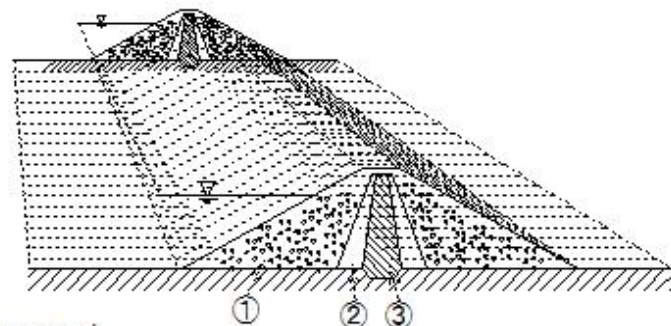
oversize removal

Washing with water

Coarse grain material - blend - fine grain

Crushing plant - overall particle size control - combination

- ① permeable material
- ② Semi-permeable material
- ③ Waterproof material



spillway installed on the ground

zone type

D89

D6

R590

# (D92)fill dam

## (D92)fill dam

fill dam

material collection

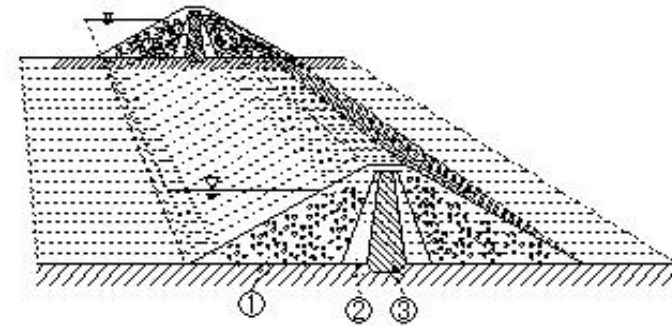
③Collection of permeable materials

• Collecting rock material - Collecting from quarry

• Collection method - Bench cut method

Blasting - Rock - Large lump - Riprap material

- Temporary storage



zone type

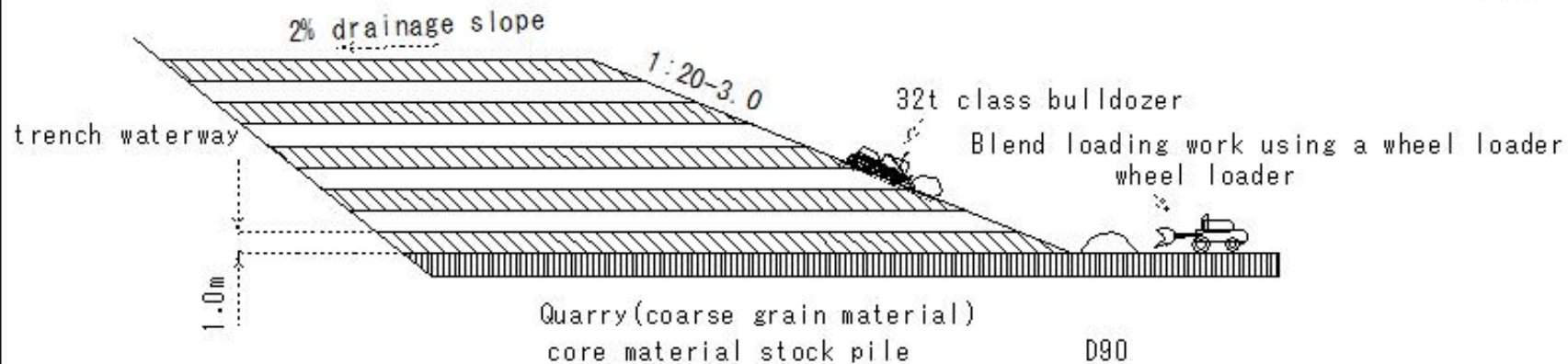
①permeable material

②Semi-permeable material

③Waterproof material

spillway installed on the ground D6

R590





## (D93)fill dam

### (D93) fill dam

fill dam

foundation of fill dam

① foundation of the water-Impermeable zone

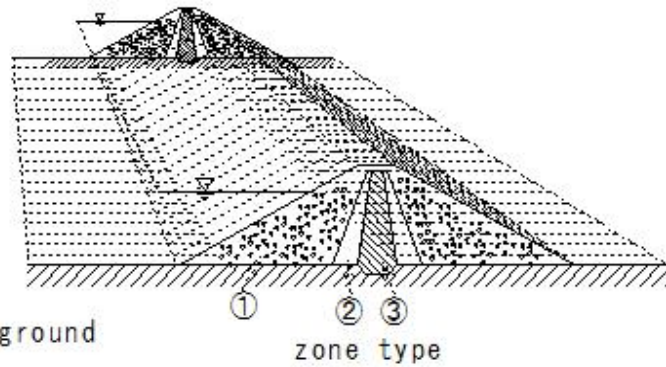
- Supporting capacity and permeability
- Excavation to bedrock
- Smooth finish

① permeable material

② Semi-permeable material

③ Impermeable zone

spillway installed on the ground



zone type

D6  
R590

(D94)fill dam

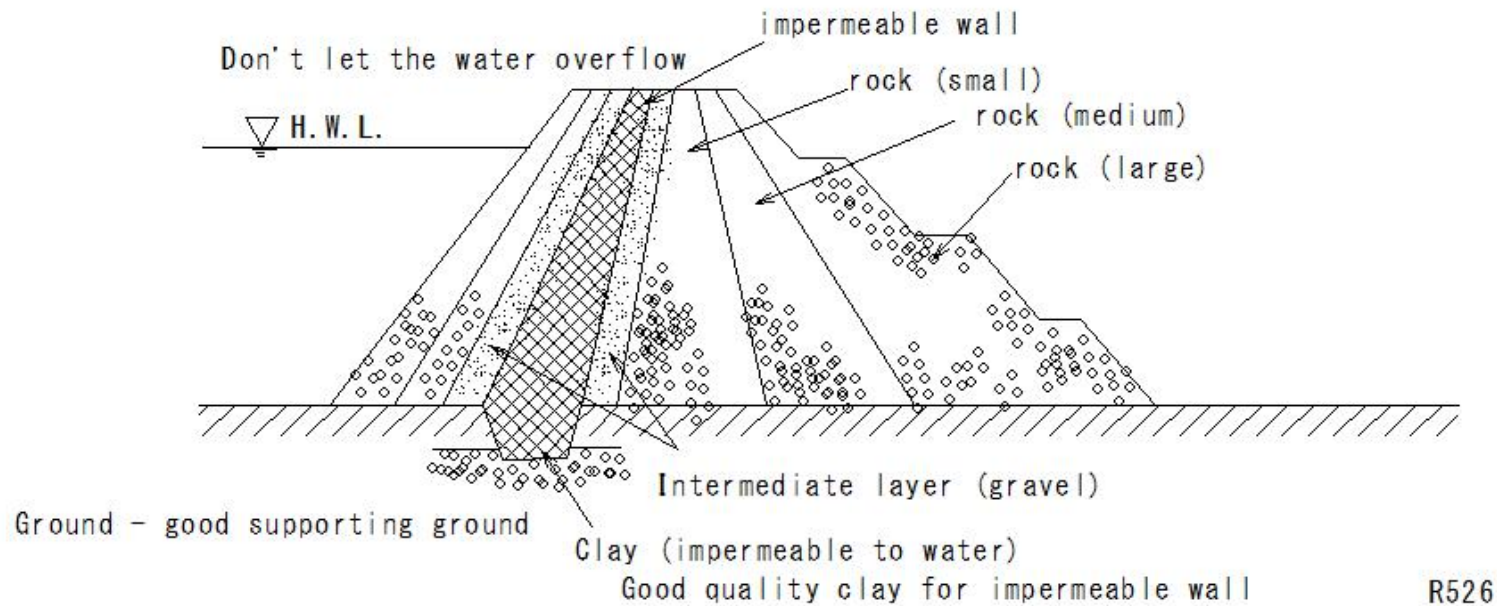
(D94) fill dam

fill dam

foundation of fill dam

② Foundation of semi-permeable zone

- Variable section between impermeable zone and permeable zone



## (D95)fill dam

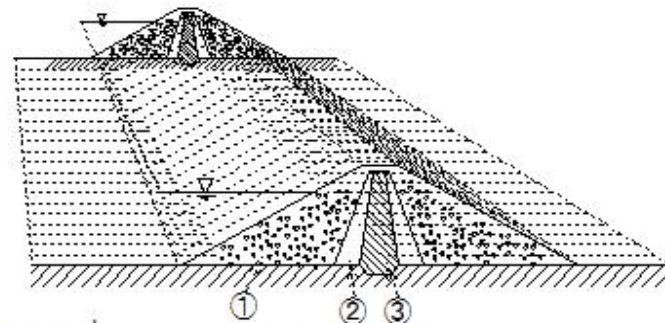
### (D95) fill dam

fill dam

foundation of fill dam

- ③ Foundation of permeable zone
  - same shear strength as rock material
  - Safe against piping caused by seepage flow
  - no deformation of the embankment body.
  - Remove loose parts of the ground
  - Use riverbed gravel

- ① permeable material (zone)
- ② Semi-permeable material
- ③ Waterproof (Impermeable) material



spillway installed on the ground

zone type

## (D96)fill dam

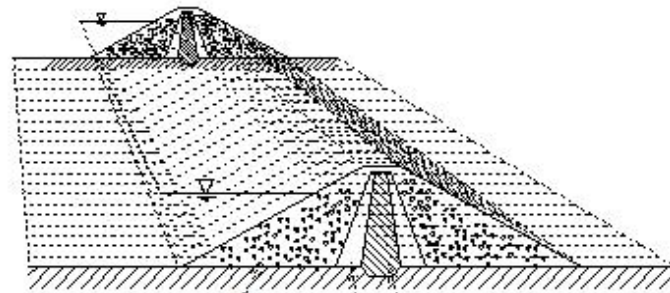
### (D96)fill dam

fill dam

Weather conditions and filling

- Construction of core zone
- Easy to be affected by weather conditions

- ① permeable material (zone)
- ② Semi-permeable material
- ③ Waterproof (Impermeable) material



spillway installed on the ground

zone type

## (D97)fill dam(test filling)

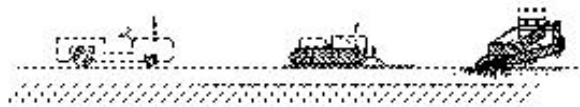
### (D97)fill dam(test filling)

fill dam

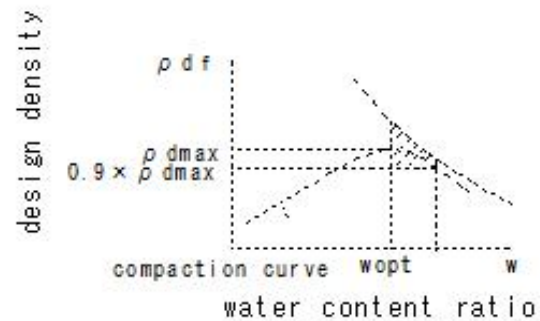
test filling

① On-site build-up test

- Design value of embankment material
- Determination of construction moisture content
- design density
- Determine rational construction methods and construction management standards



- Determine the rolling number and unrolling thickness



(D98)fill dam(test filling)

(D98)fill dam(test filling)

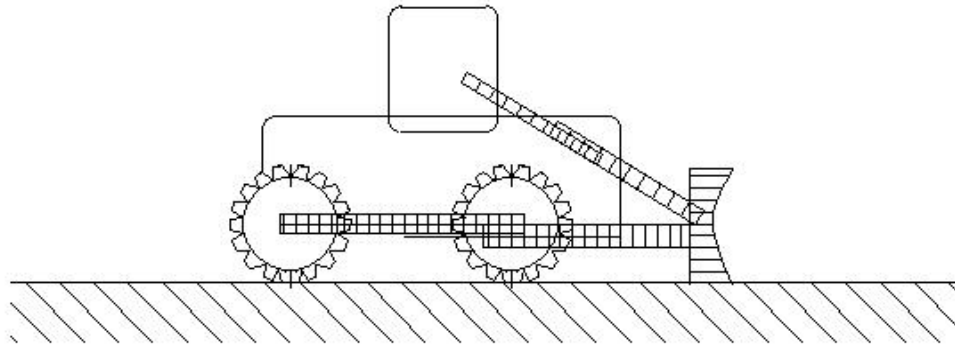
fill dam

test filling

② Compaction model

① Self-propelled tamping roller

- Crushing effect of rock fragments
- Mixing effect of materials
- Good familiarity with the next layer
- Used for viscous materials



① Self-propelled tamping roller



(D99)fill dam(test filling)

(D99)fill dam(test filling)

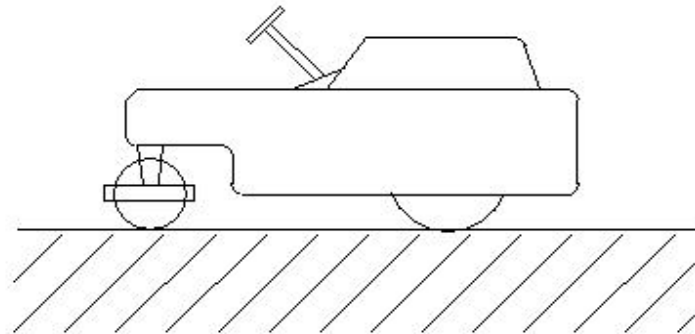
fill dam

test filling

② Compaction model

② Vibration roller

• Compaction of non-cohesive soil



vibrating roller

(D100)fill dam(test filling)

(D100)fill dam(test filling)

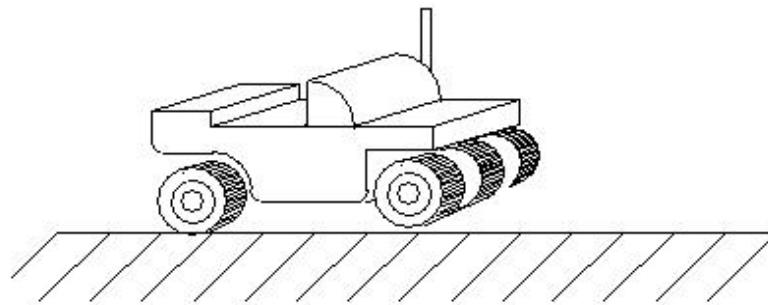
fill dam

test filling

② Compaction model

③ Tire roller

- Suitable for fine-grained materials
- Low compaction effect to deep parts
- Can also handle slightly high water content ratios



③ Tire roller

### (D101)fill dam

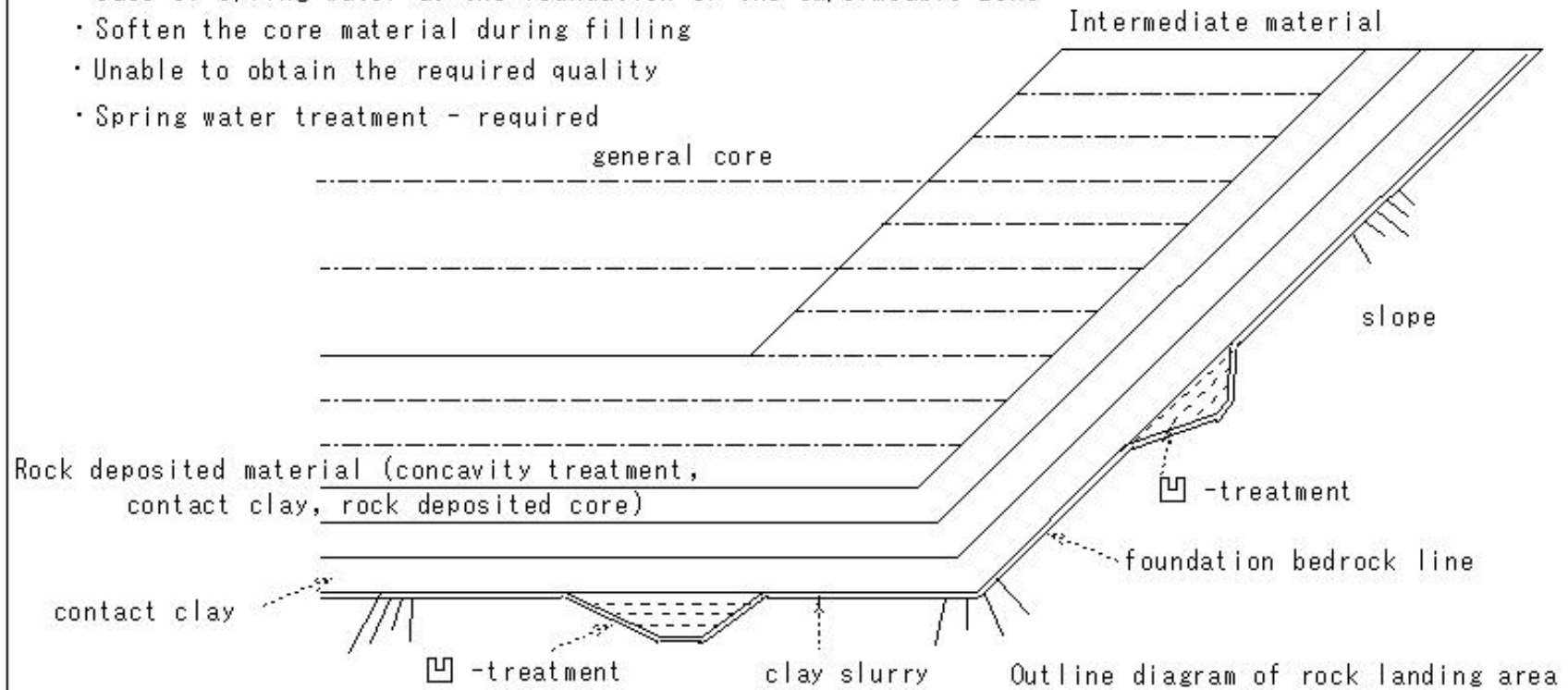
#### (D101)fill dam

fill dam

Construction of rock landing area

①Spring water treatment

- case of spring water at the foundation of the Impermeable zone
- Soften the core material during filling
- Unable to obtain the required quality
- Spring water treatment - required



## (D102)fill dam

### (D102)fill dam

fill dam

Construction of rock landing area

② Treatment of rock surface

• For the rock landing surface in the water-blocking zone

① Bedrock cleaning

② Open joint crack treatment

③ Chipping of concrete surfaces such as corridors

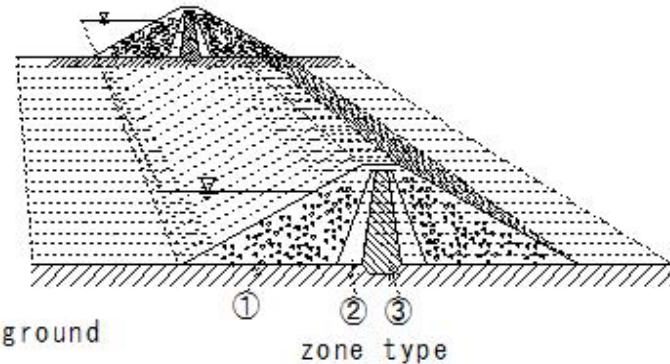
④ Water treatment on bedrock and concrete surfaces

① permeable material

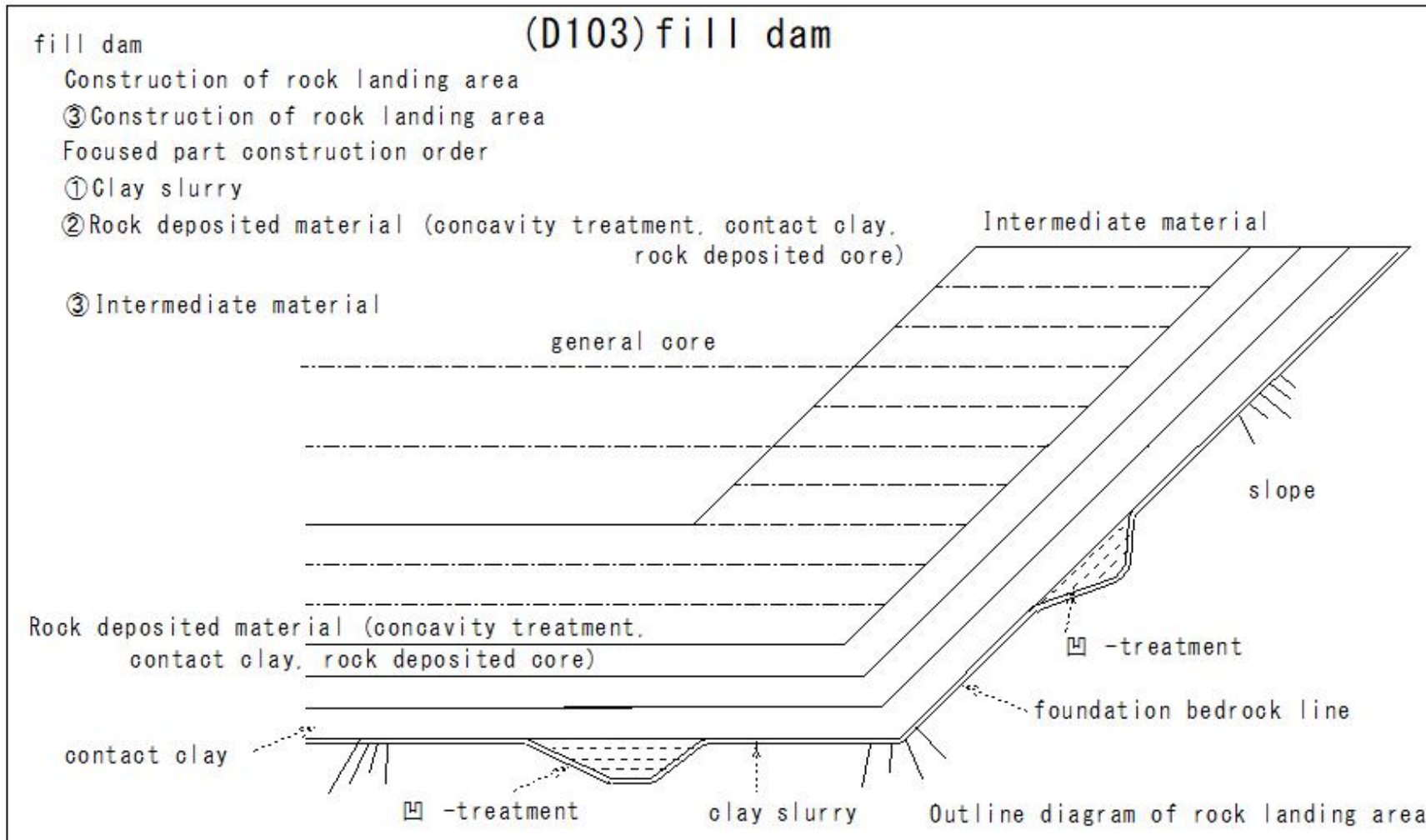
② Semi-permeable material

③ Waterproof (Impermeable) material

③ Impermeable material



(D103)fill dam



## (D104)fill dam

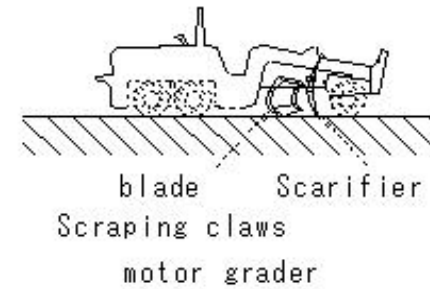
### (D104)fill dam

#### fill dam

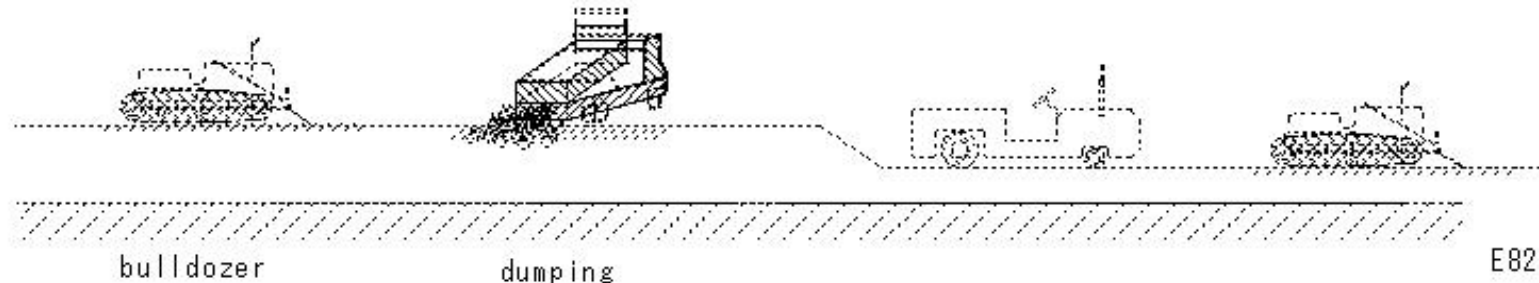
Build-up of Impermeable zone

##### ①Unrolling

- Continuous dumping at appropriate intervals
- thickness (20-30cm) using a bulldozer
- Evenly in the dam axis direction
- Spread horizontally
- Unwinding
- Rake the surface layer of the compacted layer
- Stir it up with a scarifier, etc., and spread out the next one.
- case of the surface of the compaction layer is excessively dry or wet
- Remove this part
- Alternatively, stir it up, water it, aerate it, sprinkle the next layer.



E356



E82



## (D105)fill dam

### (D105) fill dam

#### fill dam

Build-up of Impermeable zone

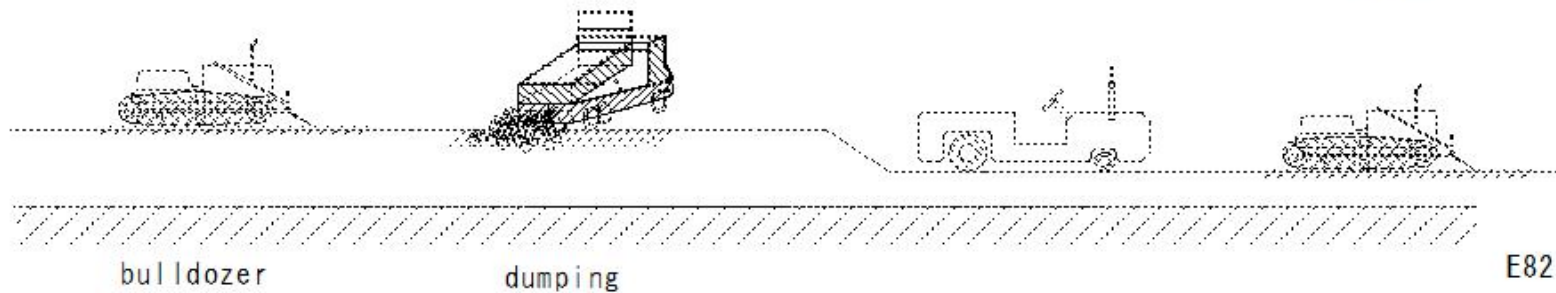
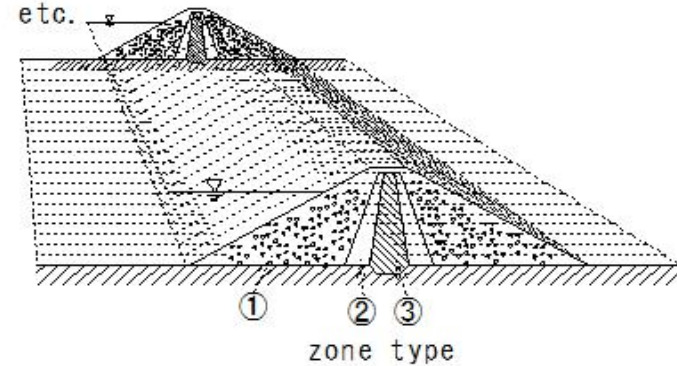
#### ② Compaction

- According to the construction method (material type, number of compactions, speed) determined by test pile-up, etc.
- Rolling is performed in the direction of the dam axis.
- Compaction of the same lift
- Overlap by about 20-30cm

① permeable material

② Semi-permeable material

③ Waterproof (Impermeable) material



E82

## (D106)fill dam

### (D106)fill dam

fill dam

Build-up of Impermeable zone

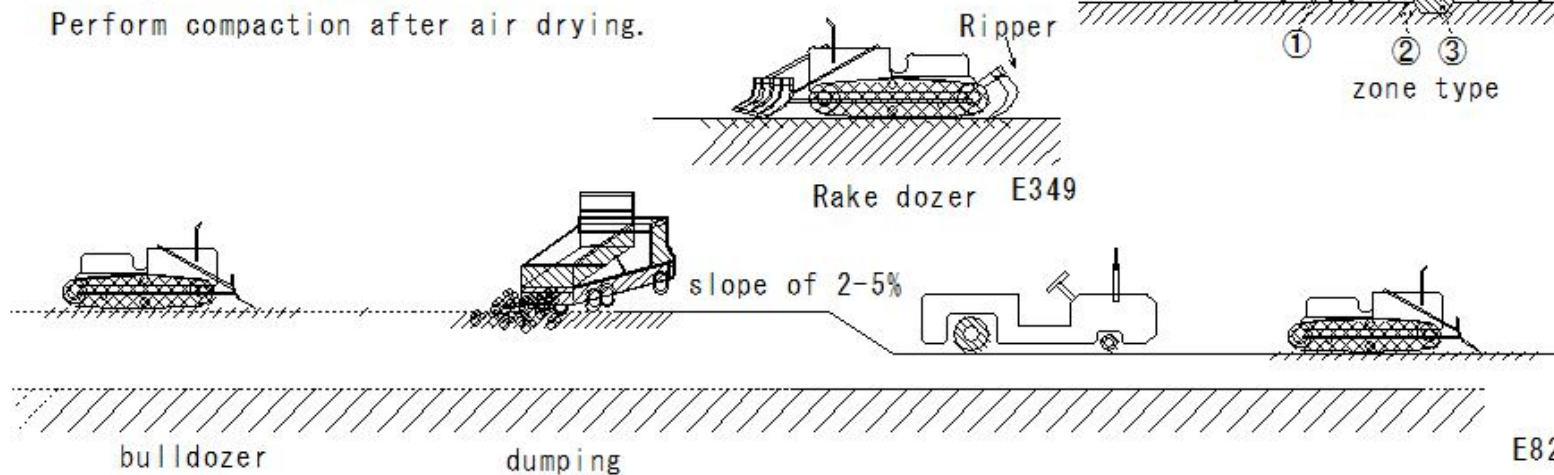
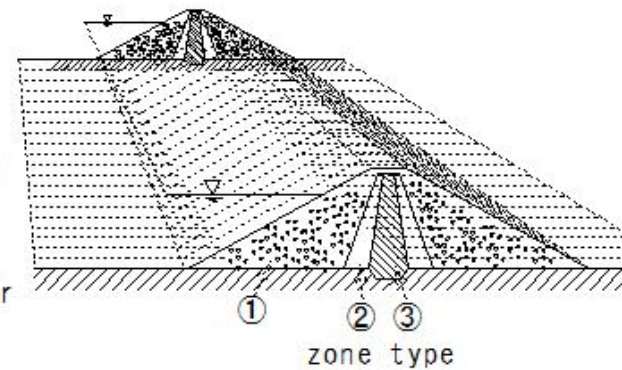
③ Processing during rainfall

- case of rain is expected
- Temporarily rolling with a smooth roller.
- Cover with a sheet to prevent rainwater from penetrating
- Add a slope of 2-5% in the upstream and downstream direction
- Promptly and carefully treat wastewater after rainfall.

Stir up with a rake dozer etc.

Perform compaction after air drying.

- ① permeable material
- ② Semi-permeable material
- ③ Waterproof (Impermeable) material



## (D107)fill dam

### (D107) fill dam

#### fill dam

Build-up of Impermeable zone

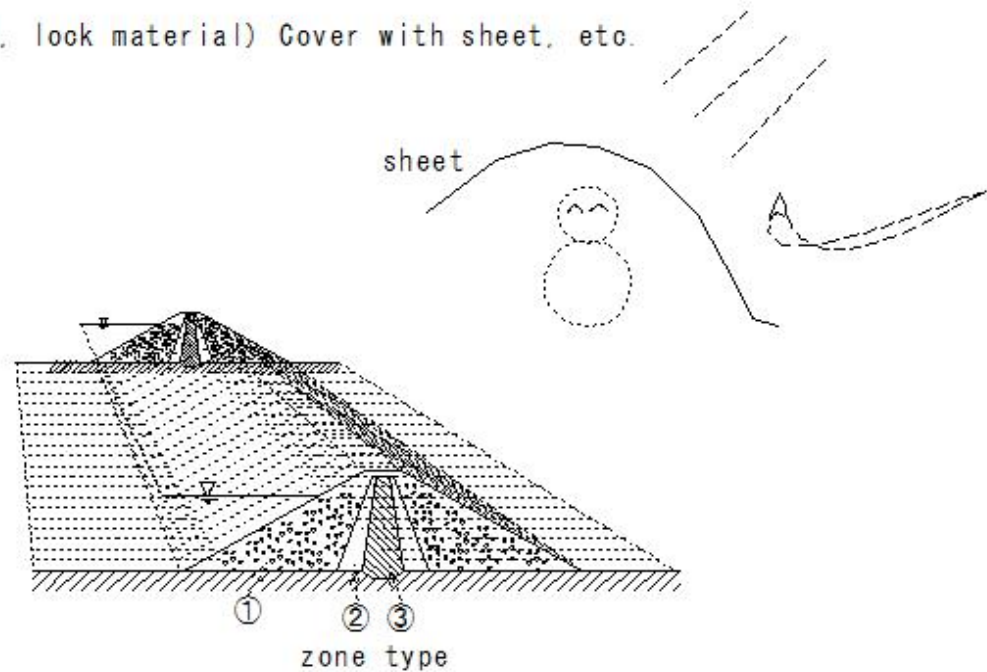
#### ④Overwintering treatment

- Cold region: Suspension of filling for a long period of time during winter
- Prevents core from freezing, prevents water from entering during snow melting
- Protect the core
- Protective material (core material, lock material) Cover with sheet, etc.

① permeable material

② Semi-permeable material

③ Waterproof (Impermeable) material



## (D108)fill dam

### (D108) fill dam

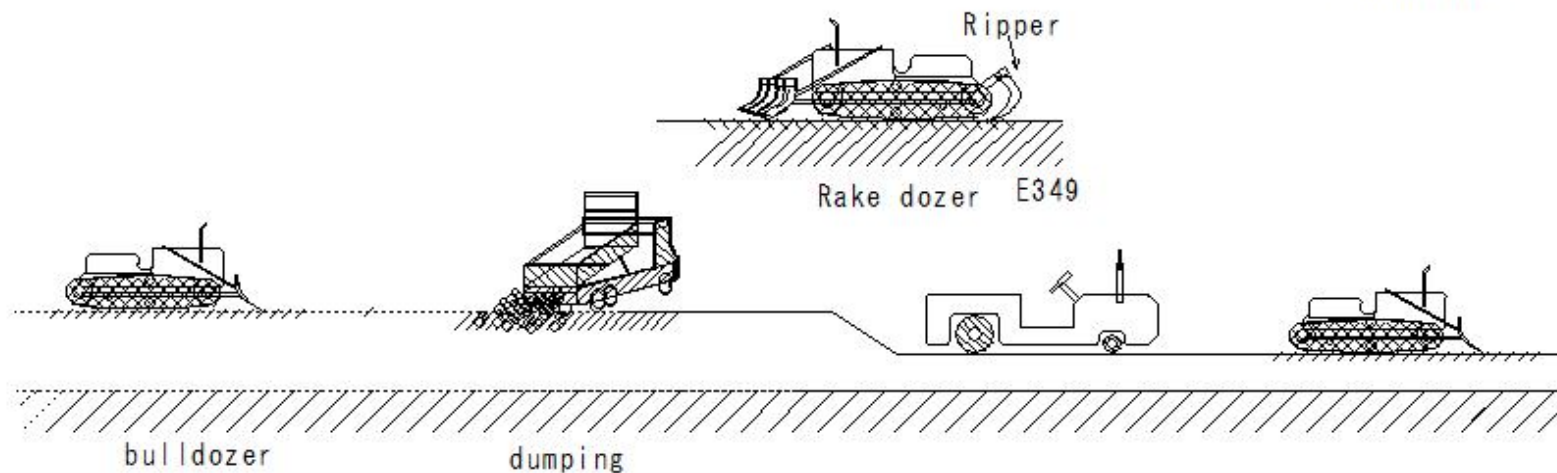
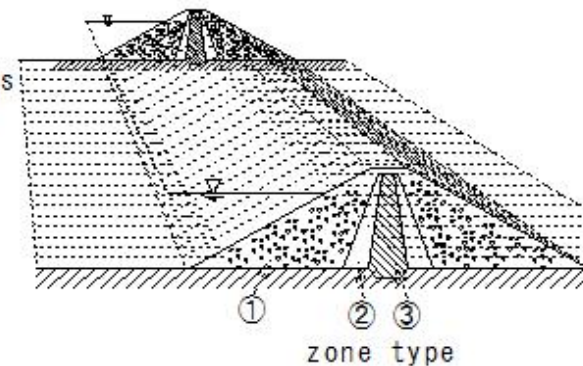
fill dam

Build-up of semi-permeable zone

#### ① Unrolling

- Use a bulldozer etc. to dump materials at appropriate intervals
- Ensure the specified thickness (30-40cm) and spread it evenly.
- Unwinding: To improve engagement with the lower layer
- Use a rake dozer etc. to scrape up the surface and build up the next layer.

- ① permeable material
- ② Semi-permeable material
- ③ Waterproof (Impermeable) material





## (D109)fill dam

### (D109) fill dam

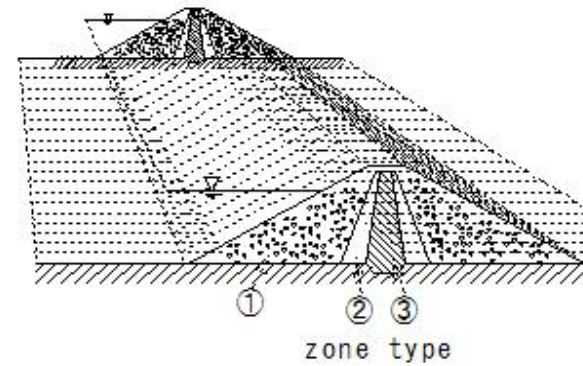
fill dam

Build-up of semi-permeable zone

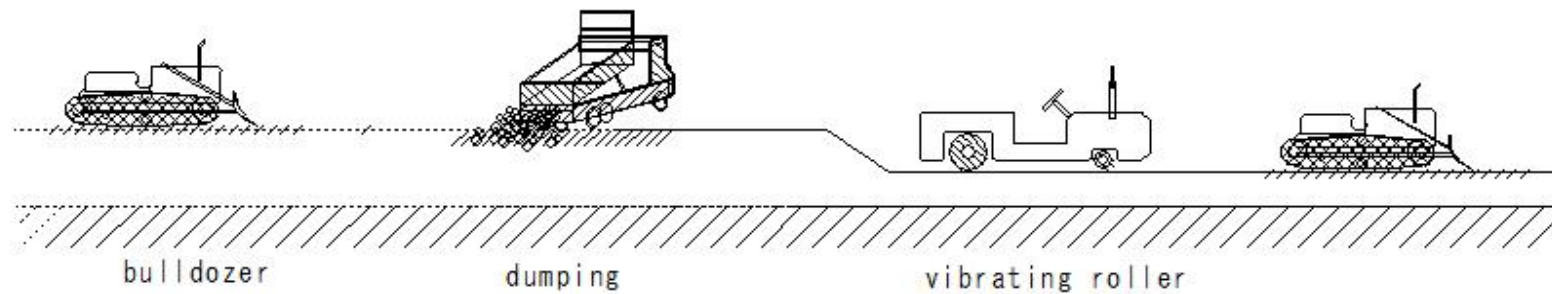
② Compaction model

- Using a vibrating roller, double rolling pressure is applied parallel to the dam axis.

- ① permeable material
- ② Semi-permeable material
- ③ Waterproof (Impermeable) material



zone type



E82

## (D110)fill dam

### (D110) fill dam

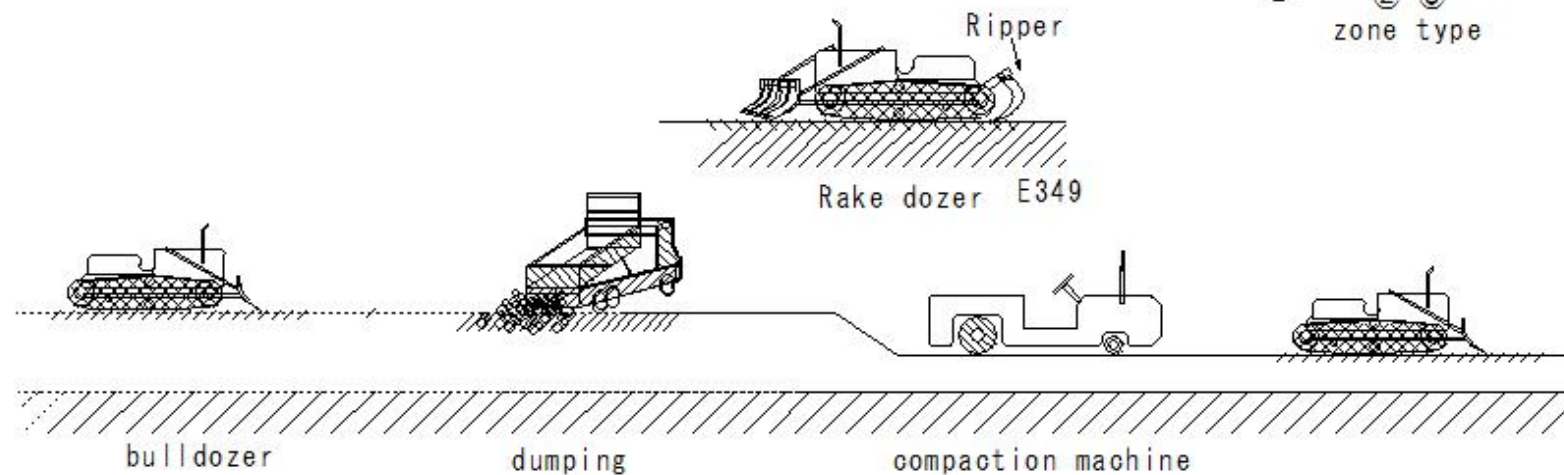
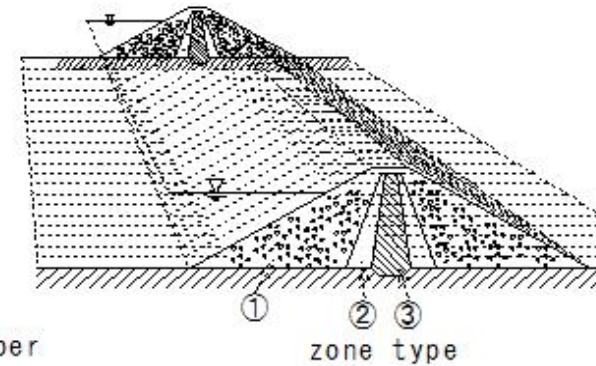
#### fill dam

##### Build-up of permeable zone

##### ① Unrolling

- Unwind the material in a layer of 0.5-2.0m
- Compacted with compaction machine
- Thin layer rolling method
- To ensure good interlocking with the next layer, stir with a ripper etc.
- case of separating materials during dumping, be careful

- ① permeable material
- ② Semi-permeable material
- ③ Waterproof (Impermeable) material





## (D111)fill dam

### (D111)fill dam

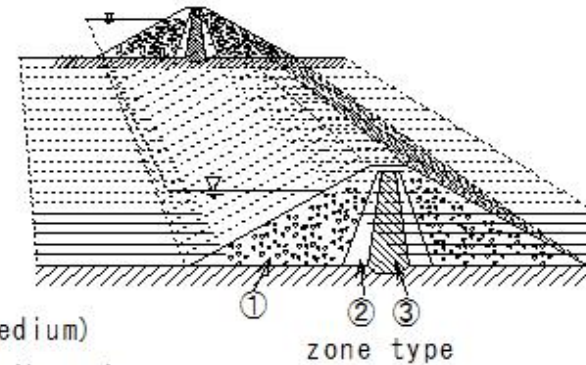
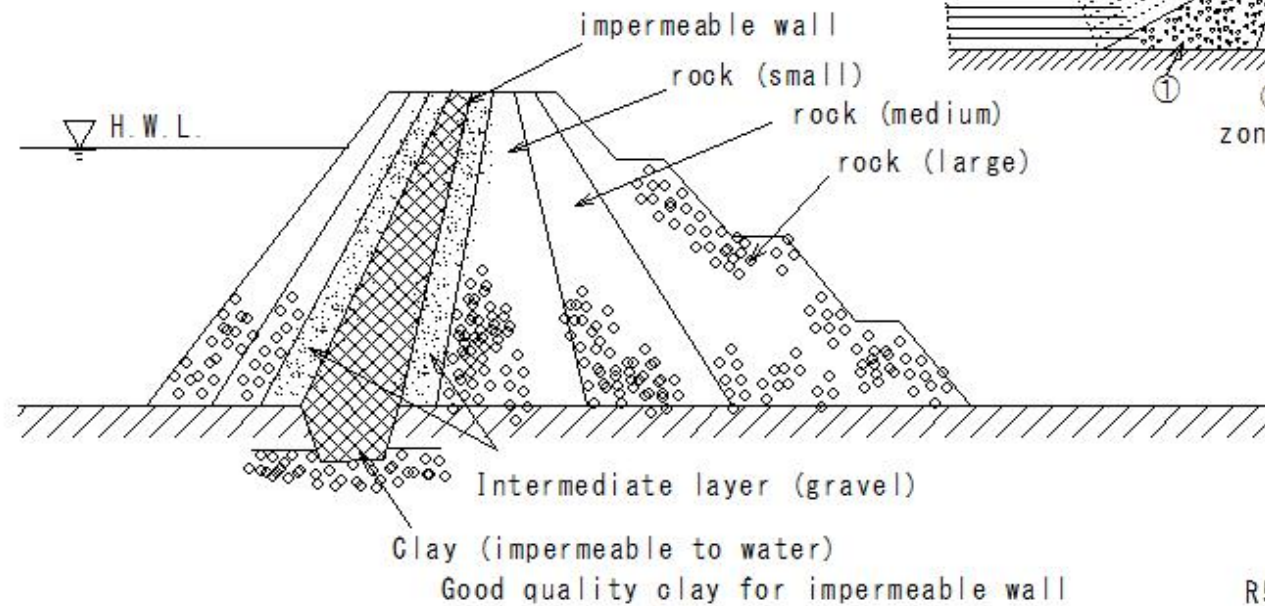
fill dam

Build-up of permeable zone

② Compaction model

- Rolling with large vibrating rollers
- Do not leave unrolled parts
- Double compaction - principle

- ① permeable material
- ② Semi-permeable material
- ③ Waterproof (Impermeable) material



R526

(D112)fill dam

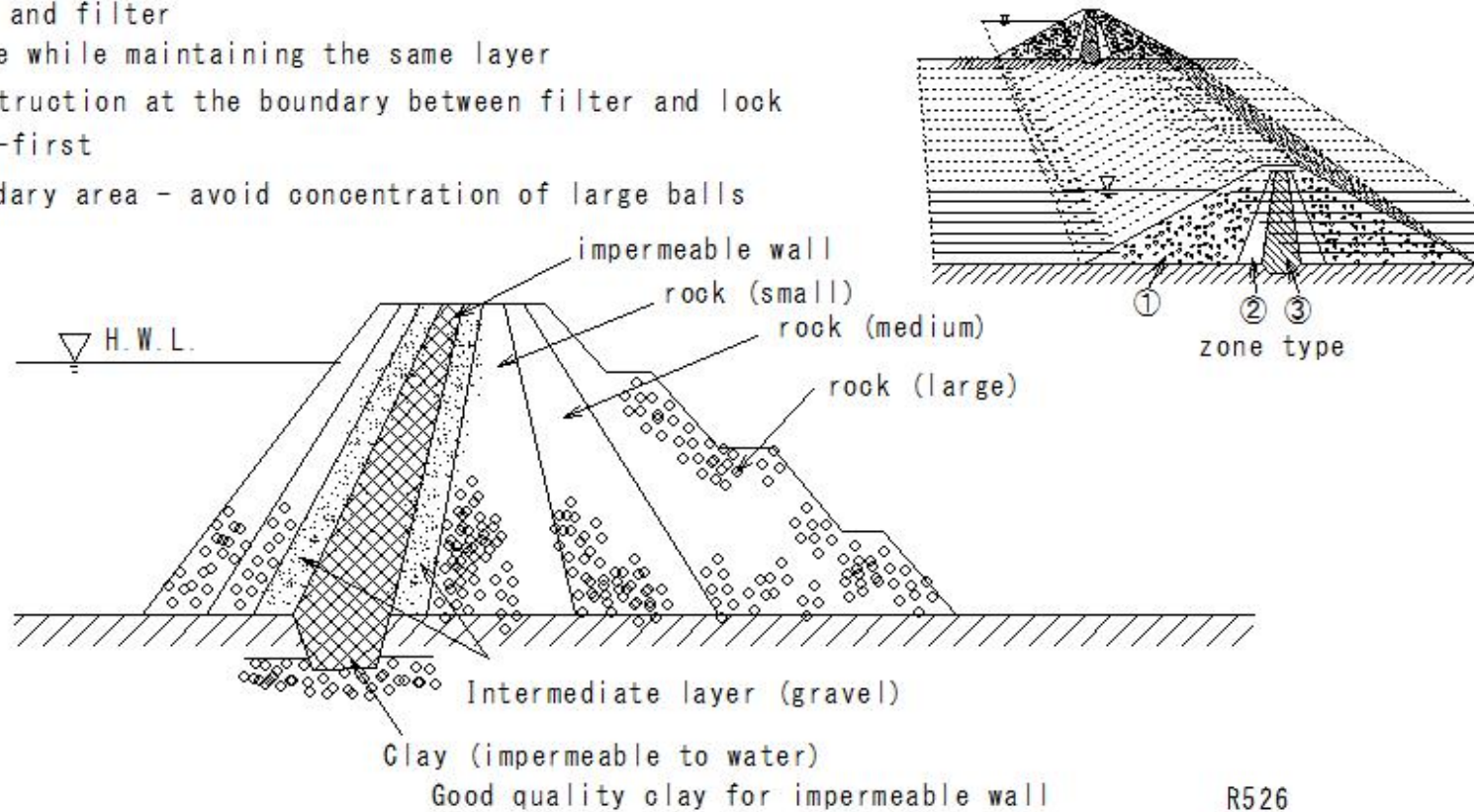
(D112)fill dam

fill dam

filling of zone boundaries

- Core and filter
- Place while maintaining the same layer
- Construction at the boundary between filter and lock
- Rock-first
- Boundary area - avoid concentration of large balls

- ① permeable material
- ② Semi-permeable material
- ③ Waterproof (Impermeable) material



## (D113)fill dam

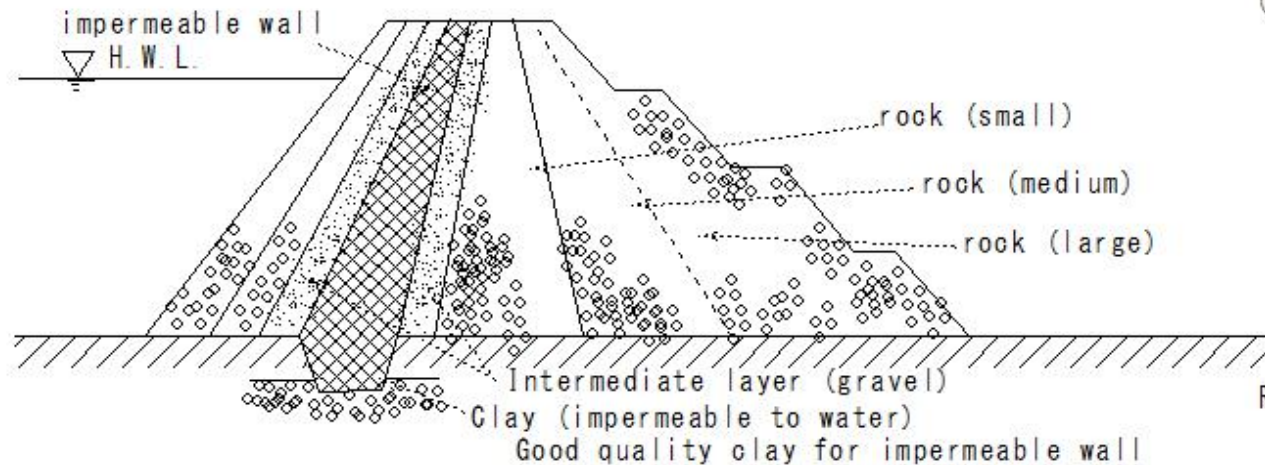
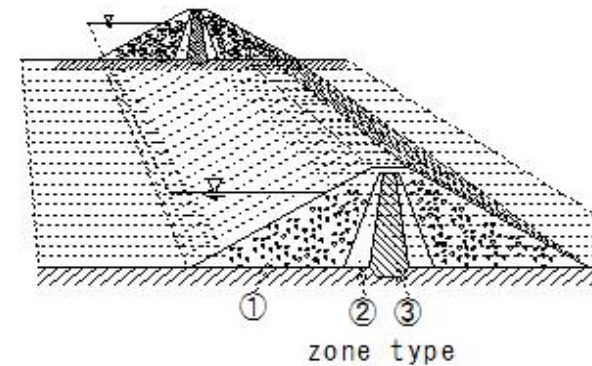
fill dam

## (D113)fill dam

Slope protection work

- Upstream side of the dam
- Wave erosion prevention
- Prevention of washing out
- Preventing weathering of the dam surface layer
- Prevention of fine graining
- Upstream and downstream surfaces: Slope protection work, riprap, and vegetation construction.
- Riprap material: Sufficient particle size, weight, and durability

- ① permeable material
- ② Semi-permeable material
- ③ Waterproof (Impermeable) material





## (D114)fill dam

### (D114) fill dam

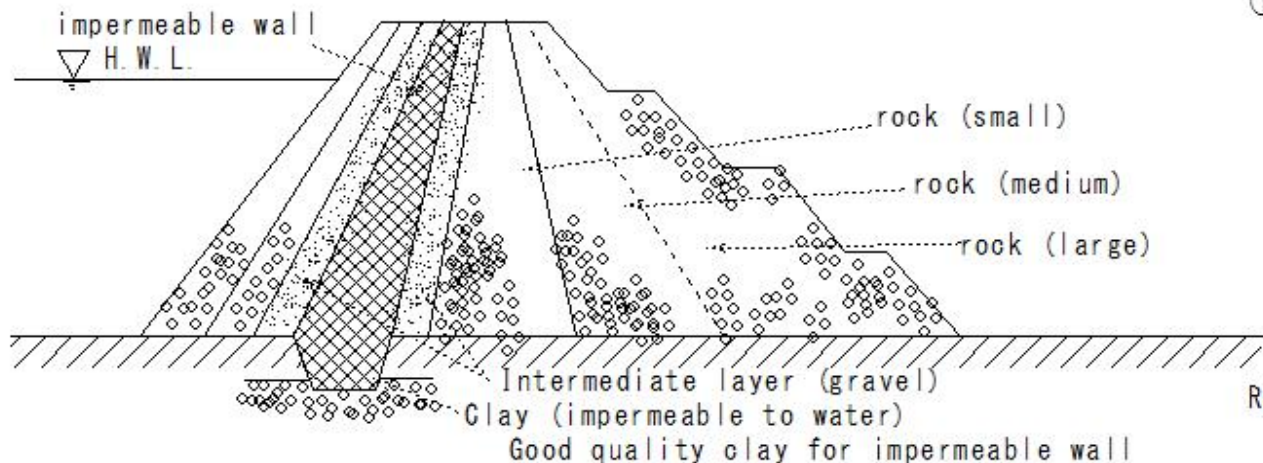
fill dam

Extra filling

- After dam completion
- Foundation ground settlement
- Required shape impermeable zone top height
- extra filling portion
- Design extra filling
- Construction surplus
- extra filling that takes into account the amount of settlement
- About 1-2% of the embankment height

impermeable wall

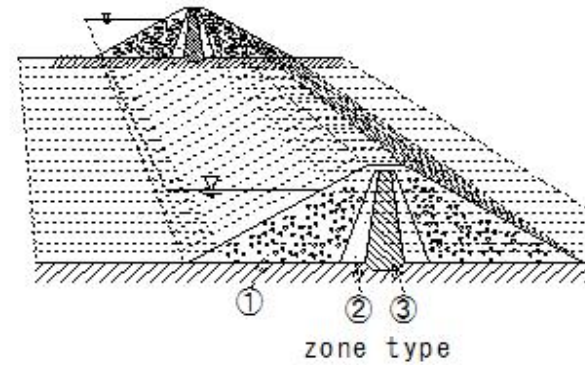
H. W. L.



① permeable material

② Semi-permeable material

③ Waterproof (Impermeable) material



R526

## (D115)fill dam

### (D115)fill dam

fill dam

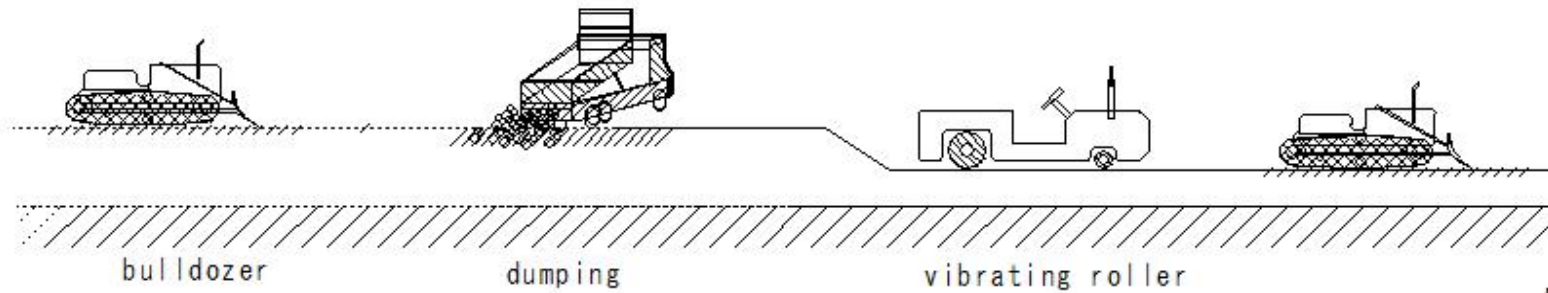
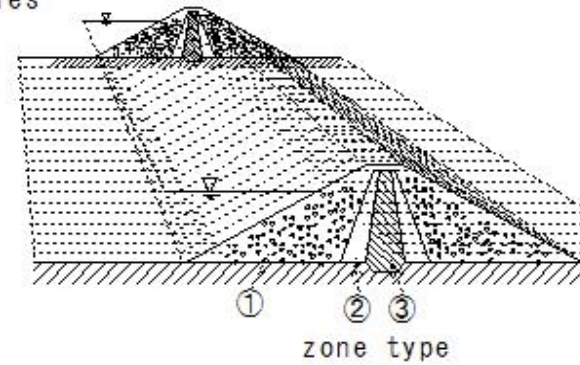
quality management

- Quality control of filling materials
- Testing prior to filling - Collection site stockpile samples

Collection site Stockpile samples

- Check the design value is satisfied after filling
- Conducted using sample after filling

- ① permeable material
- ② Semi-permeable material
- ③ Waterproof (Impermeable) material



D109

(D116)fill dam

(D116) fill dam

fill dam

quality management

Control items for each material

① Management items

core material

Moisture content ratio

particle size adjustment

particle size

tamping

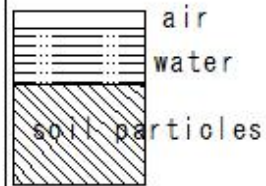
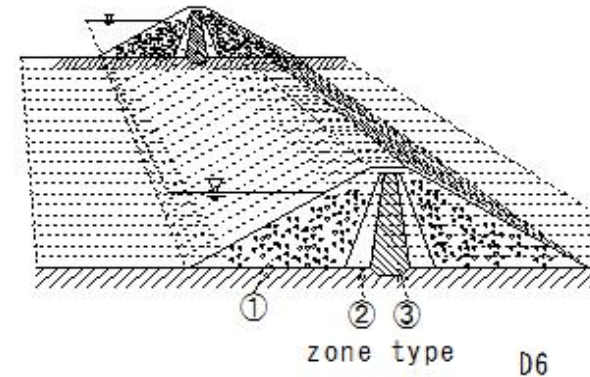
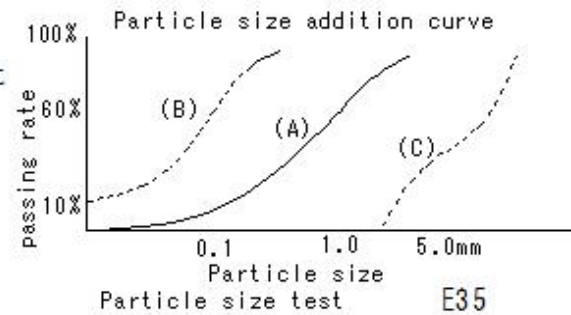
field density test

field permeability test

① permeable material

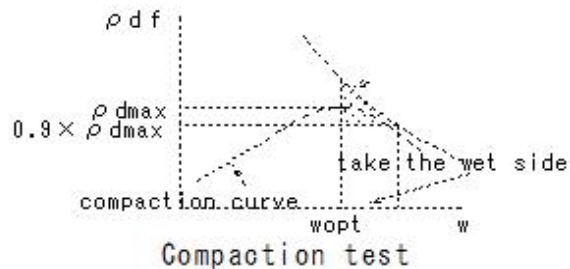
② Semi-permeable material

③ Waterproof (Impermeable) material



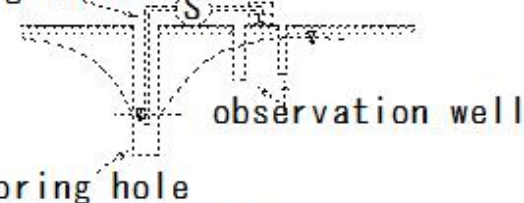
Water content test

E31



E45

pumping water



field permeability test

E39



(D117)fill dam

(D117)fill dam

- ① permeable material
- ② Semi-permeable material
- ③ Waterproof (Impermeable) material

fill dam

quality management

Control items for each material

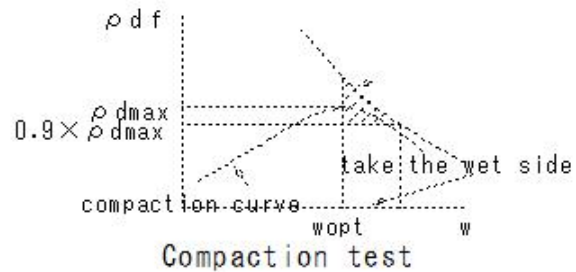
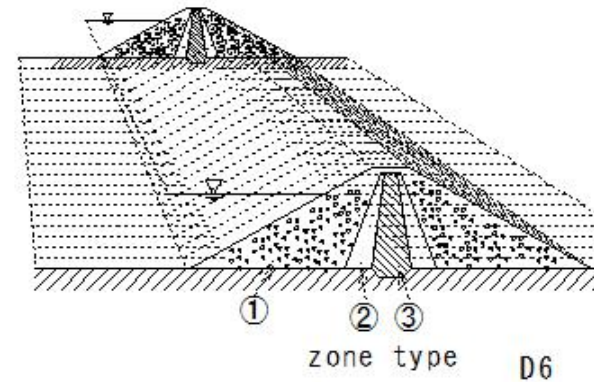
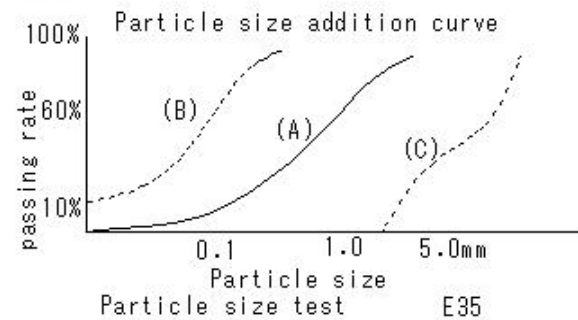
① Management items

Filter material

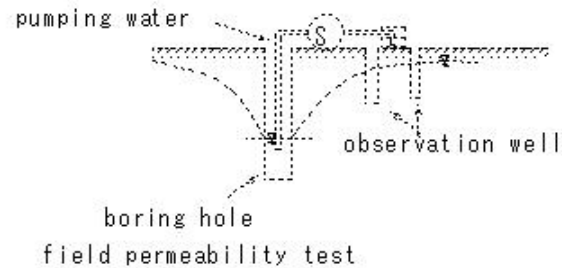
particle size test

field density test

field permeability test



E45



E39

(D118)fill dam

(D118) fill dam

fill dam

quality management

Control items for each material

① Management items

rock material

Specific gravity/water absorption

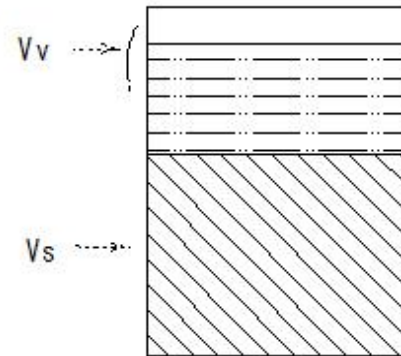
particle size

$e$ : void ratio

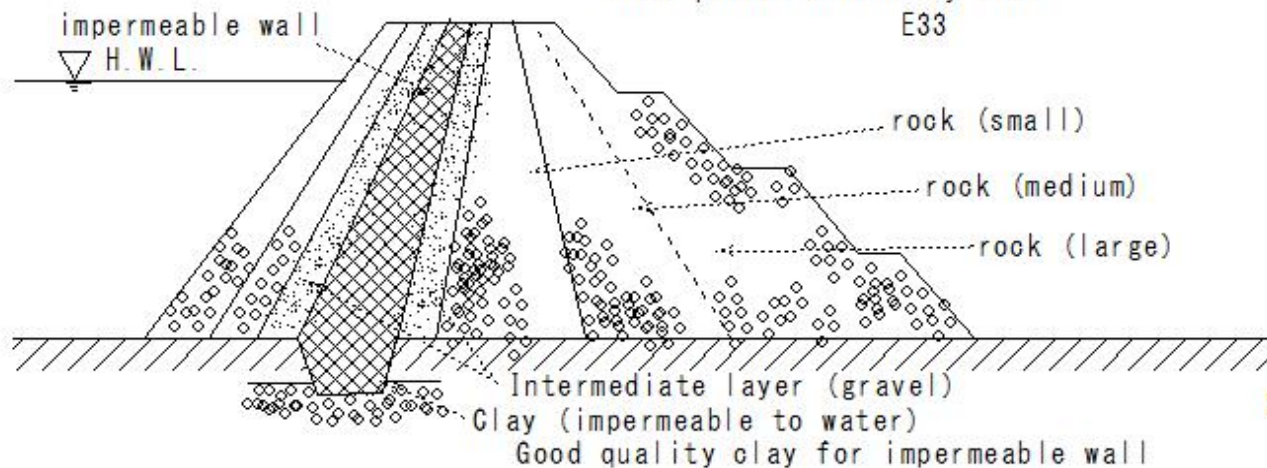
$S_r$ : saturation

$\rho_w$ : Density of water:1

$V_s$ : volume of soil particles



Soil particle density test  
E33



R526

(D119)fill dam

(D119) fill dam

fill dam

quality management

Control items for each material

① Management items

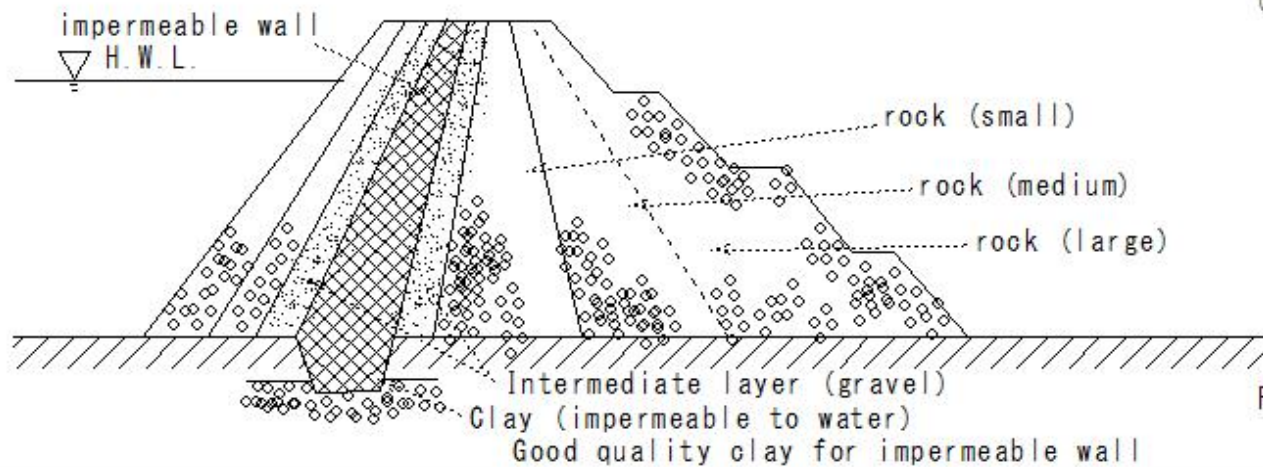
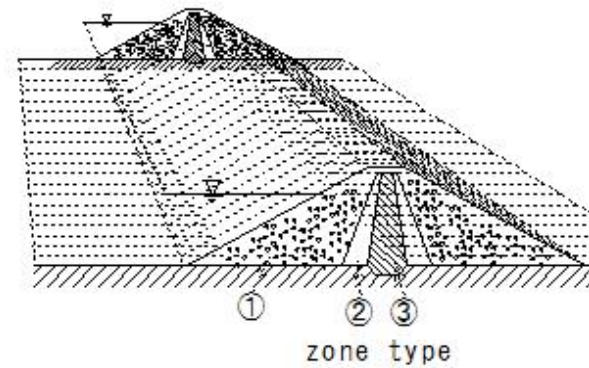
Riprap

Specific gravity/water absorption

① permeable material

② Semi-permeable material

③ Waterproof (Impermeable) material



R526

(D120)fill dam

(D120)fill dam

fill dam

quality management

② Management standards

① Water content ratio

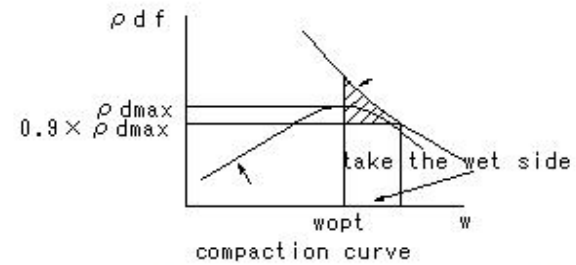
Optimal water content ratio (Wopt) 1-2% Minimum

Minimum Permeability coefficient on wet side

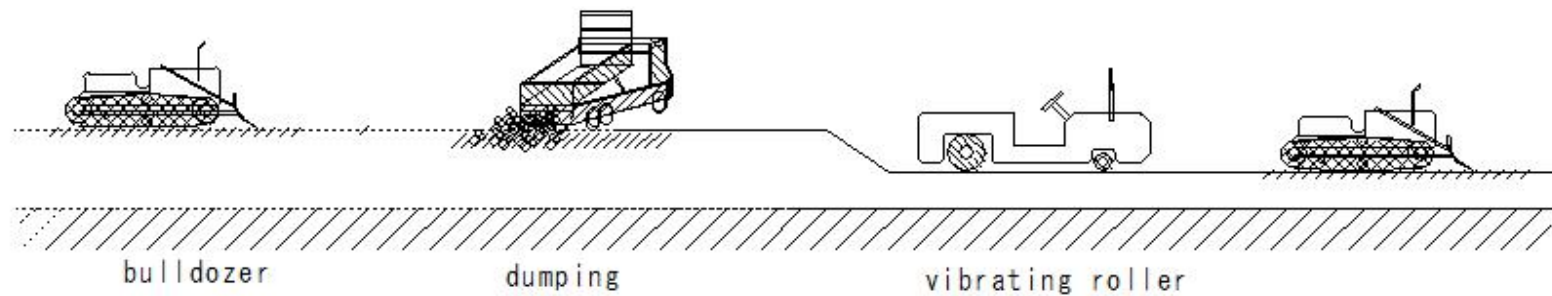
Material filled up on the wet side -

less prone to cracking

• Standard value  $W_{opt} \pm 0 - +3\%$



Compaction test E45





(D121)fill dam

(D121)fill dam

- ① permeable material
  - ② Semi-permeable material
  - ③ Waterproof (Impermeable) material
- Core material

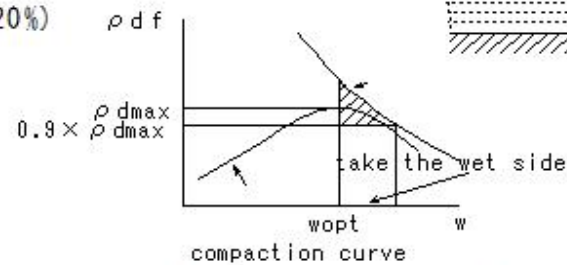
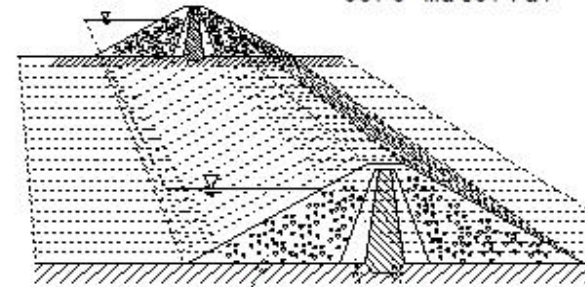
fill dam

quality management

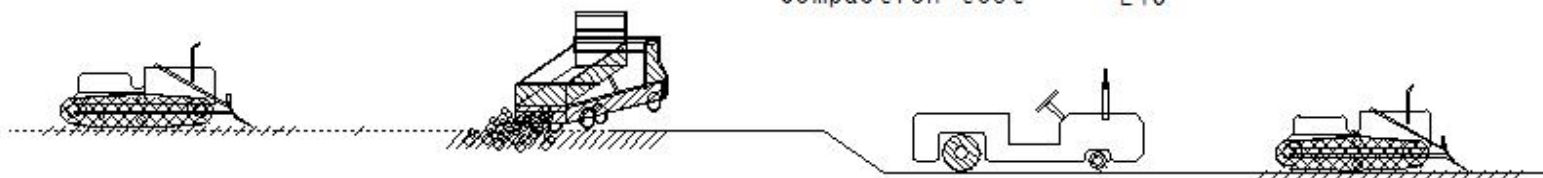
② Particle size

- Past cases
- Range defined on particle size curve
- Core material:

Content rate of 0.074 mm  
or less (approximately 10%-20%)



Compaction test E45



bulldozer

dumping

vibrating roller

E82

(D122)fill dam

(D122)fill dam

fill dam

quality management

③Hydraulic conductivity coefficient

core material stock pile

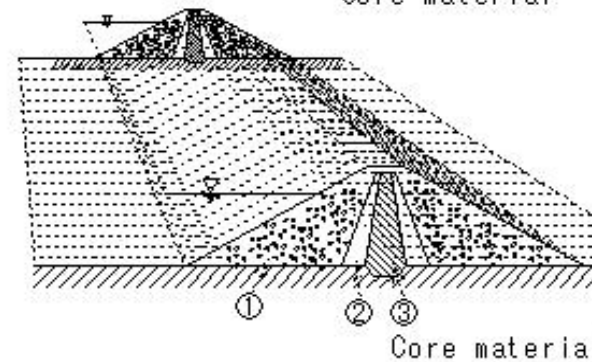
On-site Permeability coefficient:  $1 \times 10^{-5}$  cm/s or less

① permeable material

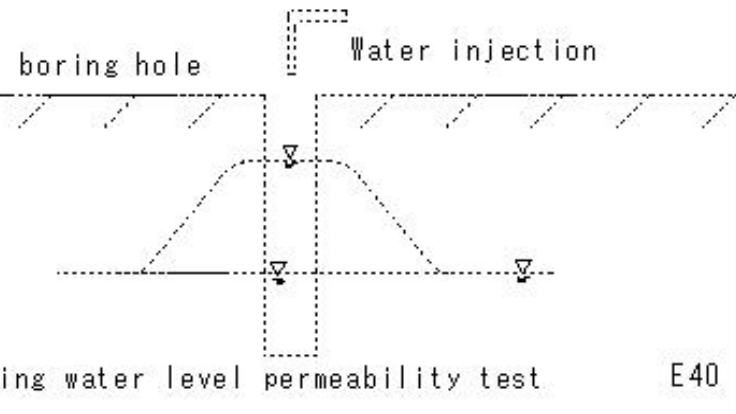
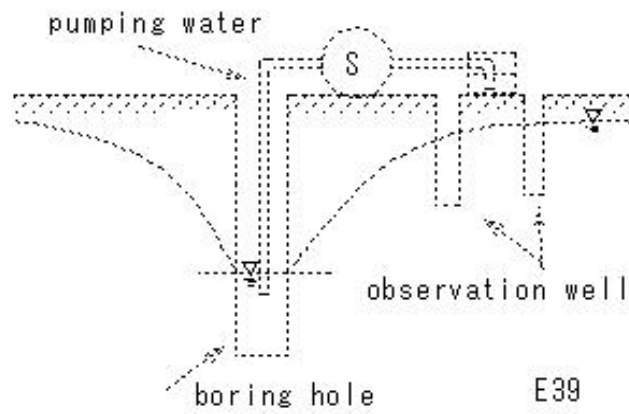
② Semi-permeable material

③ Waterproof (Impermeable) material

Core material



Field test-Constant level permeability test





(D123)fill dam

(D123)fill dam

fill dam

quality management

④Density

Compaction density of core material

D value (on-site dry density/  
indoor tamped maximum dry density x 100%)

D value: 95% or more

Filter material

rock material

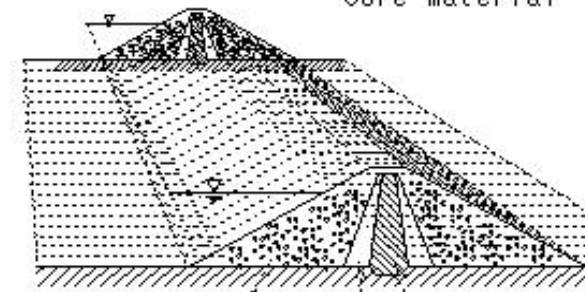
Dry density used for design value

①permeable material (rock material)

②Semi-permeable material

③Waterproof (Impermeable) material

Core material

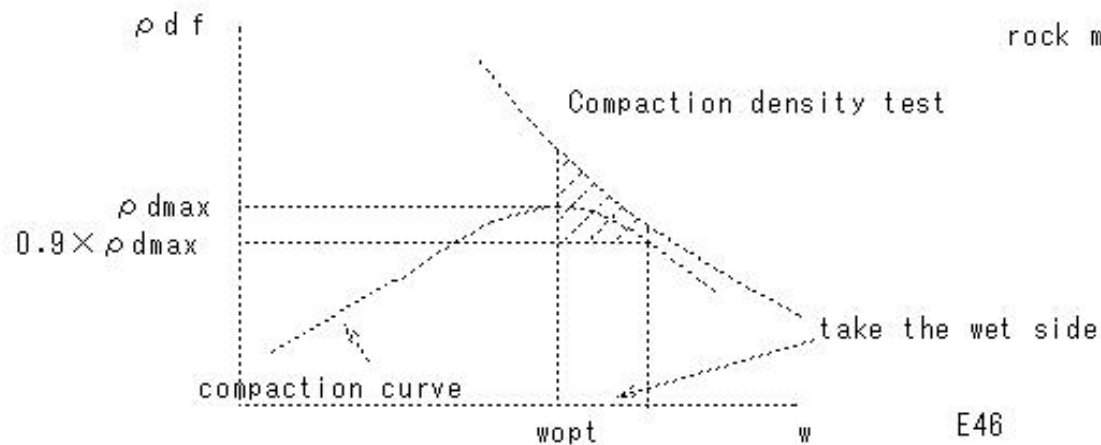


rock material

Core material

Filter material

D6



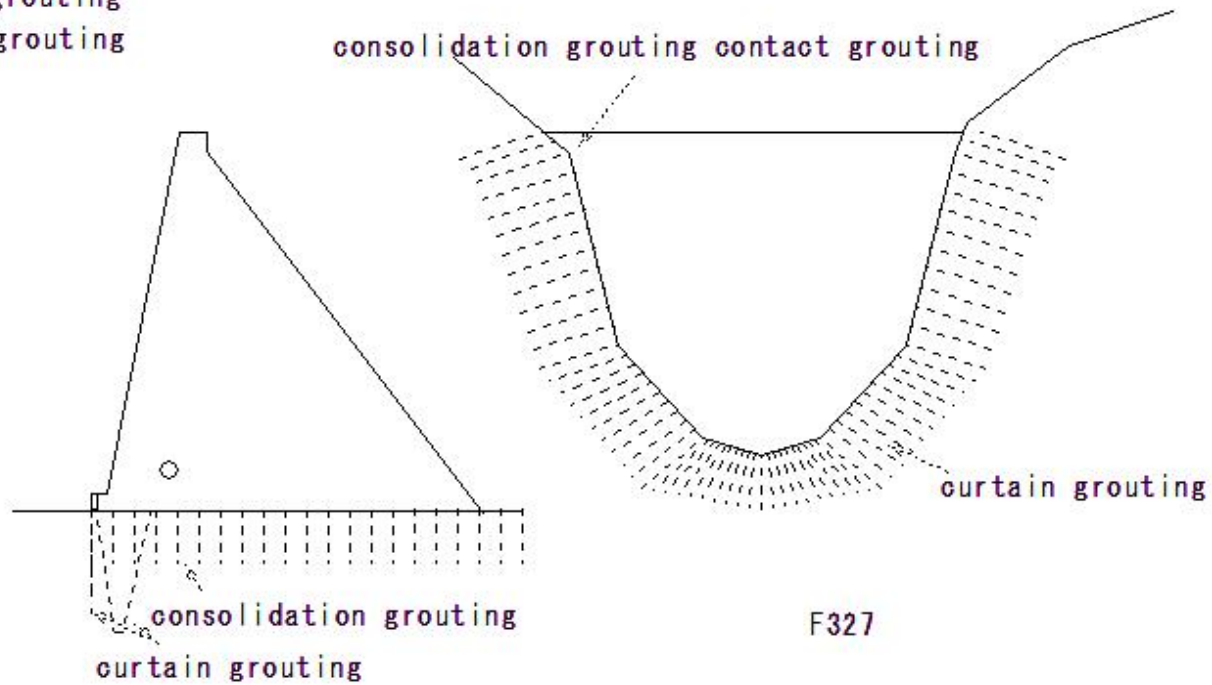
(D124) foundation treatment (grouting)

(D124) foundation treatment (grouting)

foundation treatment

Types of grouting

- ① Consolidation grouting
- ② Blanket grouting
- ③ Curtain grouting
- ④ Contact grouting



(D125)foundation treatment(grouting)

(D125) foundation treatment (grouting)

foundation treatment

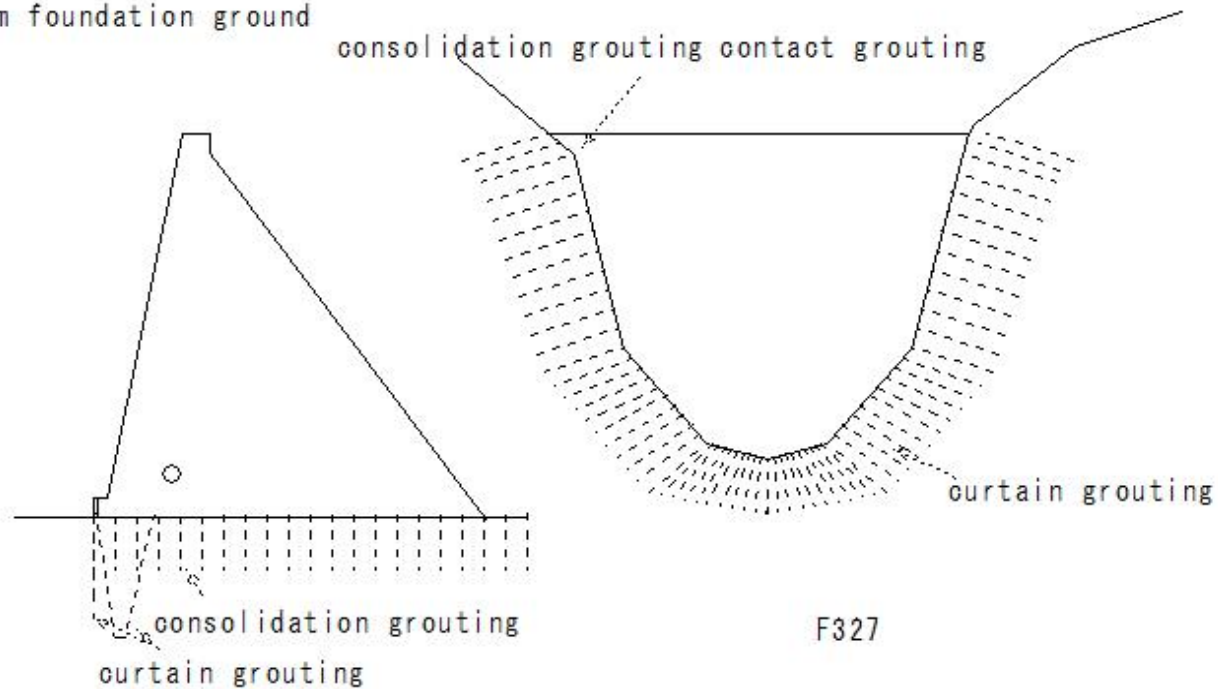
① Consolidation grouting

① Purpose

- Concrete dam embankment Fill dam spillway

Suppresses seepage flow near the contact area with the foundation ground

Uniform foundation ground



F327

(D126) foundation treatment (grouting)

(D126) foundation treatment (grouting)

foundation treatment

① Consolidation grouting

② Improvement target value

Gravity concrete dam approximately 5-10Lu

Arch type concrete dam approximately 2-5Lu

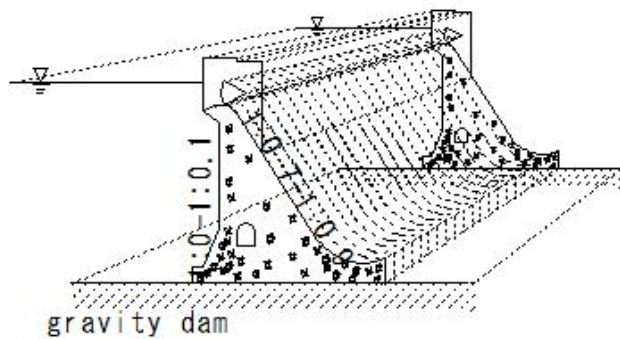
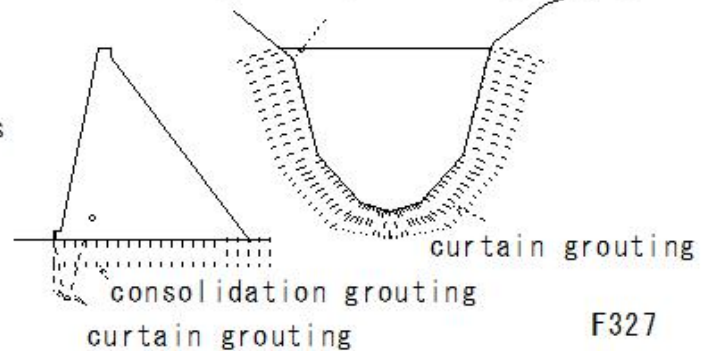
Lu: Lugeon value: evaluates the permeability of rock mass

Under injection pressure of 10kgf/cm<sup>2</sup>

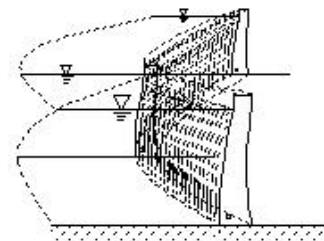
Defined as the number of liters of water

injected per minute per meter of hole length

consolidation grouting contact grouting



D3



D4

(D127)Basic treatment(grouting)

(D127) foundation treatment (grouting)

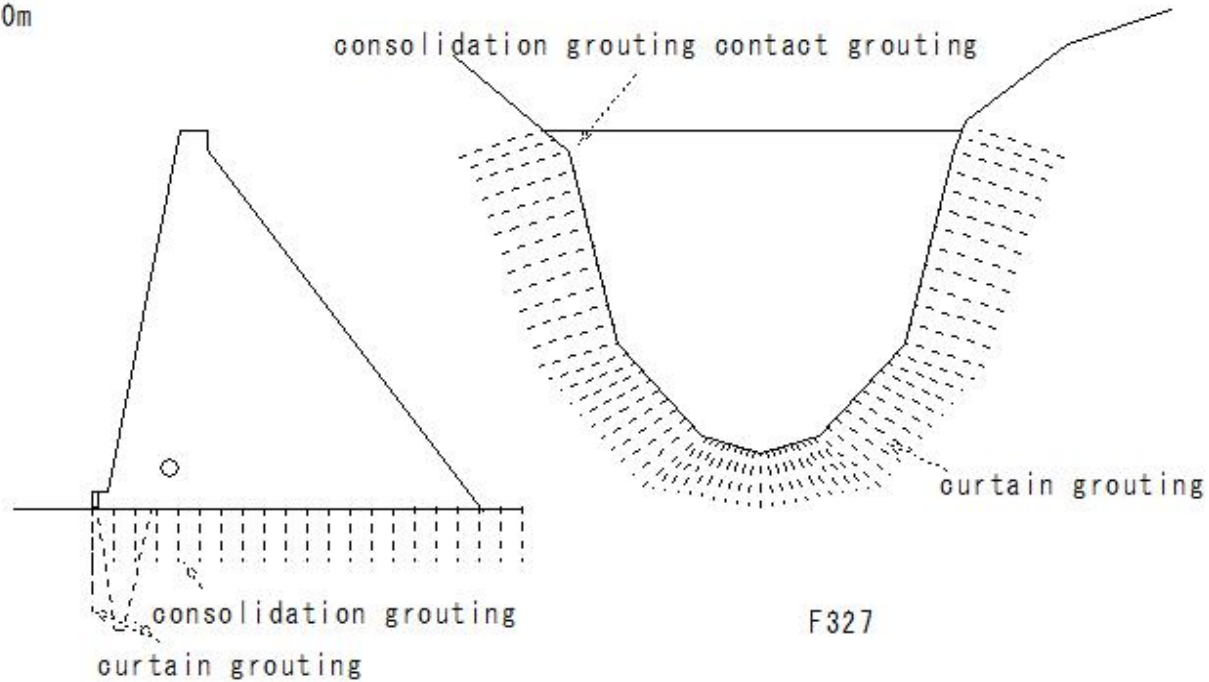
foundation treatment

① Consolidation grouting

③ Construction area

Entire area of concrete dam site

Depth 5-10m



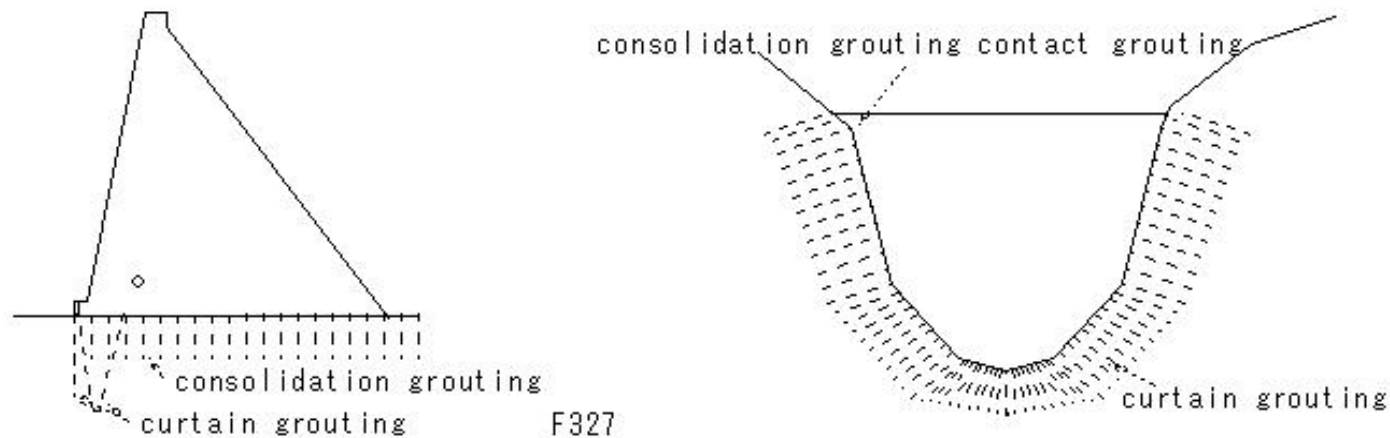
F327

## (D128) foundation treatment (grouting)

### (D128) foundation treatment (grouting)

foundation treatment

- ① Consolidation grouting
- ④ Construction period
  - Bedrock - good, no leaks etc.
  - Final excavation (about 50cm) left
  - Construction directly from the rock surface
  - case of a leak occurs
  - case of displacement occurs in the bedrock
  - Constructed after pouring several lifts of concrete for the main body



F327



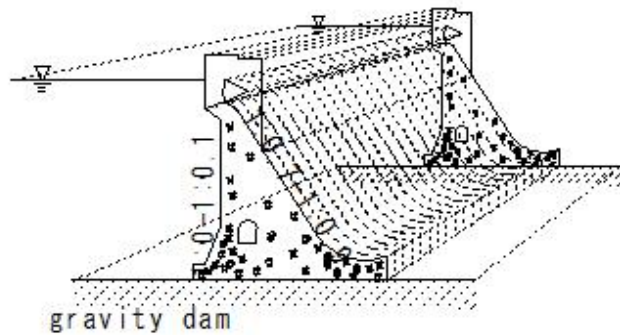
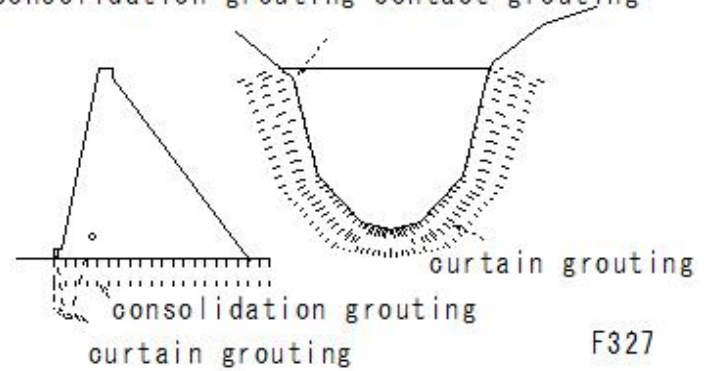
(D129) foundation treatment (grouting)

(D129) foundation treatment (grouting)

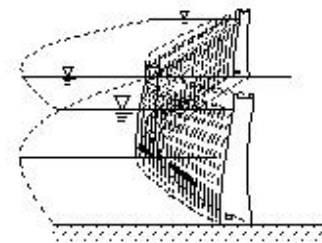
foundation treatment

- ① Consolidation grouting
  - ⑤ Injection pressure
    - 3-5kgf/cm<sup>2</sup>
    - Arch type concrete dam
- Secondary consolidation grouting 5-10kgf/m<sup>2</sup>

consolidation grouting contact grouting



D3



Arch dam

D4

(D130)foundation treatment(grouting)

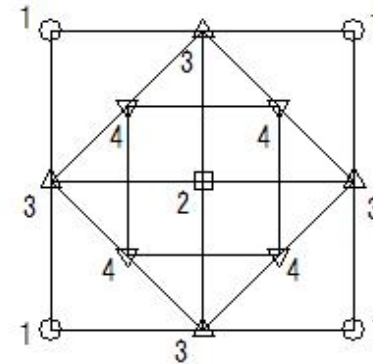
(D130) foundation treatment (grouting)

foundation treatment

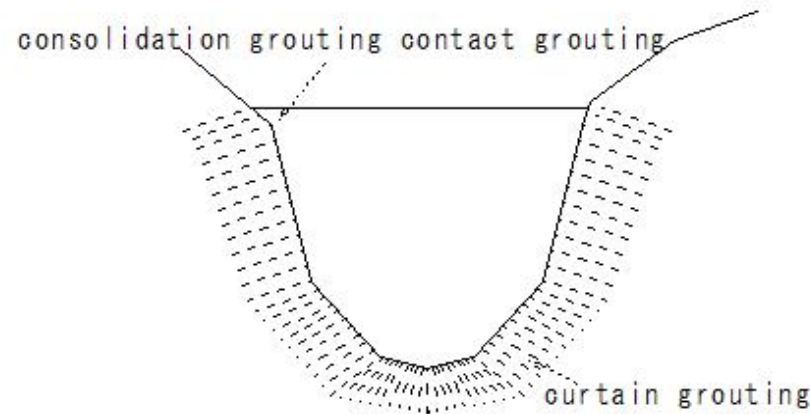
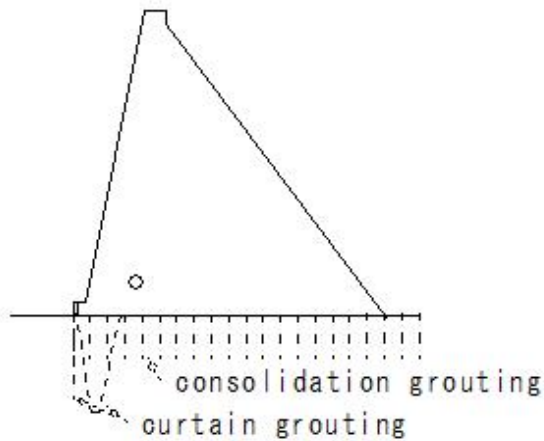
① Consolidation grouting

⑥ Hole arrangement

- Lattice shape
- drilling hole spacing 5m



Drilling layout diagram



## (D131) foundation treatment (grouting)

### (D131) foundation treatment (grouting)

foundation treatment

② Blanket grouting

① Purpose

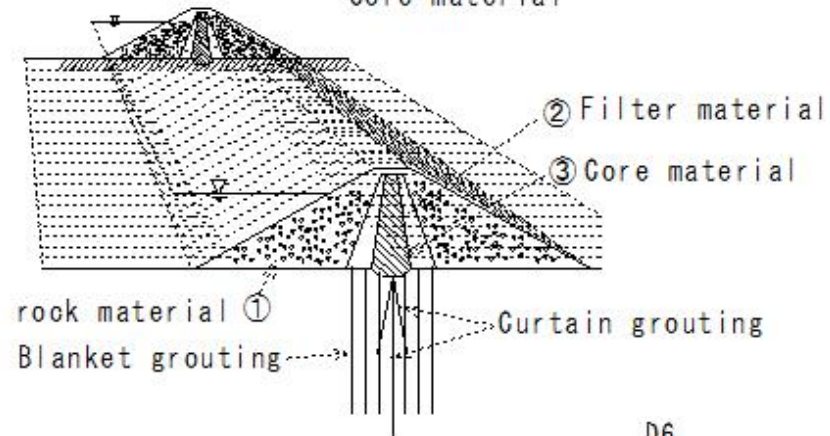
fill dam

- By suppressing seepage flow near the contact area between the core rock landing area of the fill dam and the foundation ground.
- Suppression of leakage of impermeable material of embankment body and piping of foundation ground

① permeable material (rock material)

② Semi-permeable material

③ Waterproof (Impermeable) material  
Core material



D6

(D132) foundation treatment (grouting)

foundation treatment (D132) foundation treatment (grouting)

fill dam

② Blanket grouting

② Improvement target value

Approximately 5-10Lu

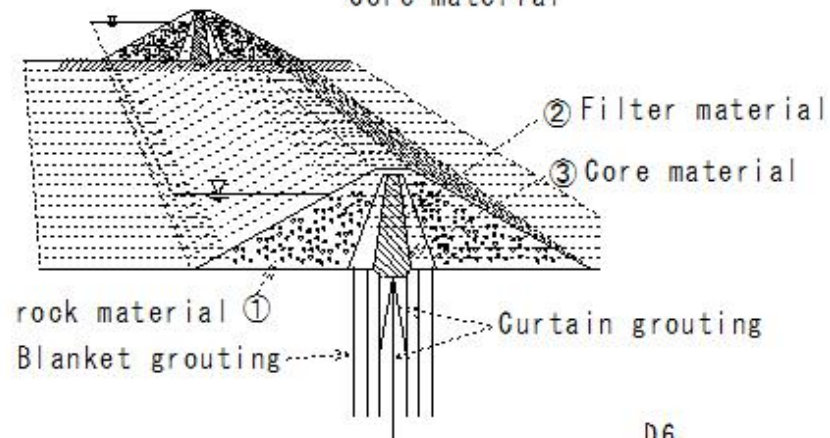
- By suppressing seepage flow near the contact area between the core rock landing area of the fill dam and the foundation ground.
- Suppression of leakage of impermeable material of embankment body and piping of foundation ground

① permeable material (rock material)

② Semi-permeable material

③ Waterproof (Impermeable) material

Core material



(D133) foundation treatment (grouting)

(D133) foundation treatment (grouting)

foundation treatment

fill dam

② Blanket grouting

③ Construction scope

• Entire core area • Depth 5-10m

• By suppressing seepage flow near the contact area between the core rock landing area of the fill dam and the foundation ground.

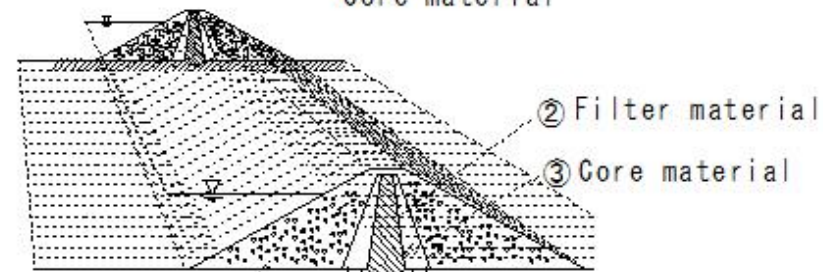
• Suppression of leakage of impermeable material of embankment body and piping of foundation ground

① permeable material (rock material)

② Semi-permeable material

③ Waterproof (Impermeable) material

Core material



rock material ①

Blanket grouting

• Entire core area • Depth 5-10m

Curtain grouting



(D134) foundation treatment (grouting)

(D134) foundation treatment (grouting)

foundation treatment

fill dam

② Blanket grouting

④ Construction period

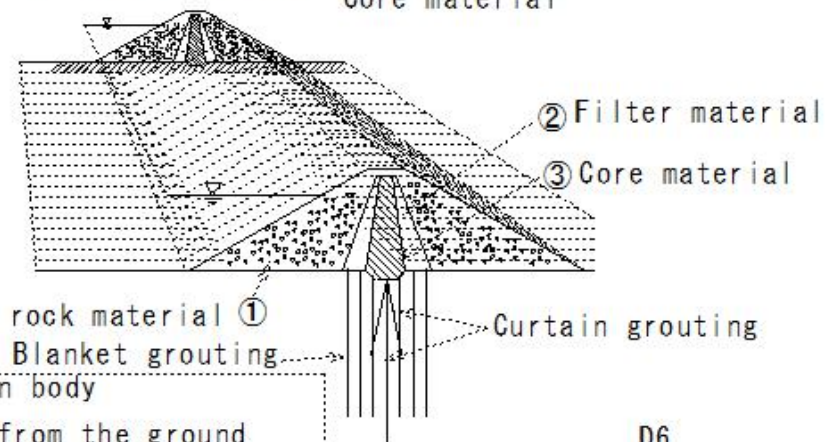
- Before filling the main body
- Construction directly from the ground
- Cover lock • Cover concrete • Mortar spraying • Slash grout

① permeable material (rock material)

② Semi-permeable material

③ Waterproof (Impermeable) material

Core material



- Before filling the main body
- Construction directly from the ground

D6



(D135) foundation treatment (grouting)

(D135) foundation treatment (grouting)

foundation treatment

fill dam

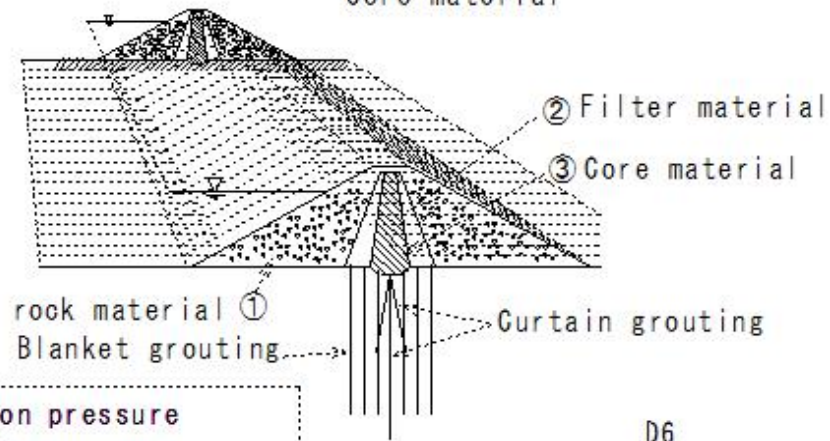
② Blanket grouting

⑤ Injection pressure

• 3kgf/cm<sup>2</sup>

• For soft rock 1-2kgf/cm<sup>2</sup>

- ① permeable material (rock material)
  - ② Semi-permeable material
  - ③ Waterproof (Impermeable) material
- Core material



⑤ Injection pressure

• 3kgf/cm<sup>2</sup>

• For soft rock 1-2kgf/cm<sup>2</sup>

D6

(D136) foundation treatment (grouting)

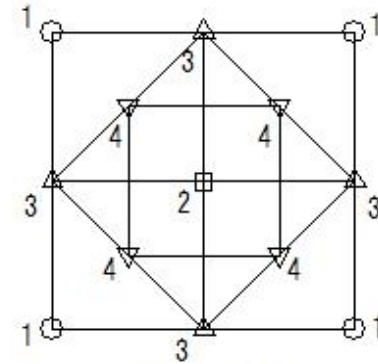
(D136) foundation treatment (grouting)

foundation treatment

fill dam

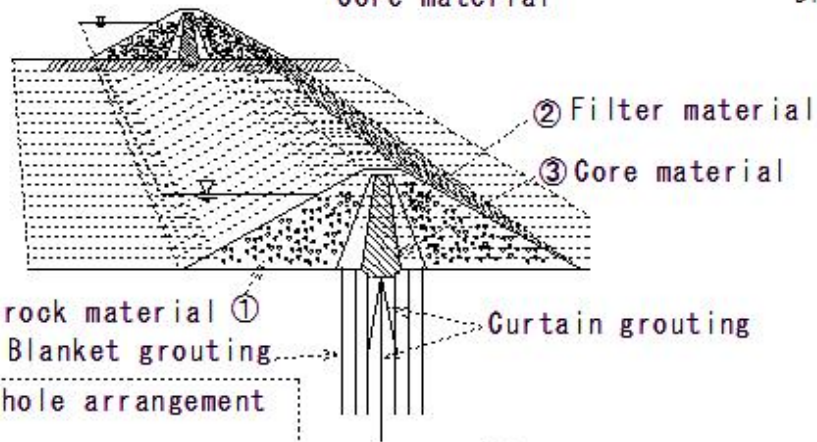
② Blanket grouting

- ① permeable material (rock material)
- ② Semi-permeable material
- ③ Waterproof (Impermeable) material
- Core material



Drilling layout diagram

D129



⑥ drilling hole arrangement  
• 2.5-3m

D6

## (D137) foundation treatment (grouting)

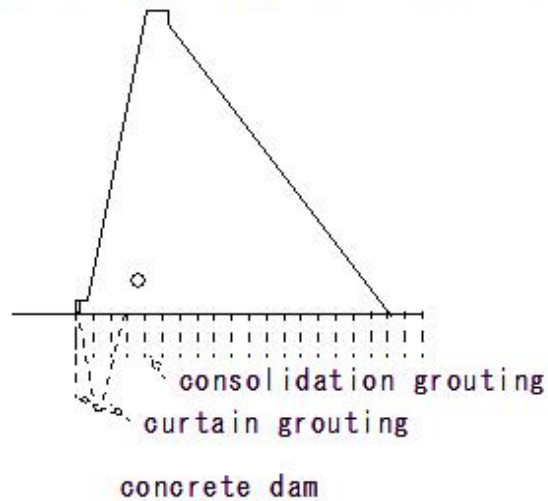
### (D137) foundation treatment (grouting)

foundation treatment

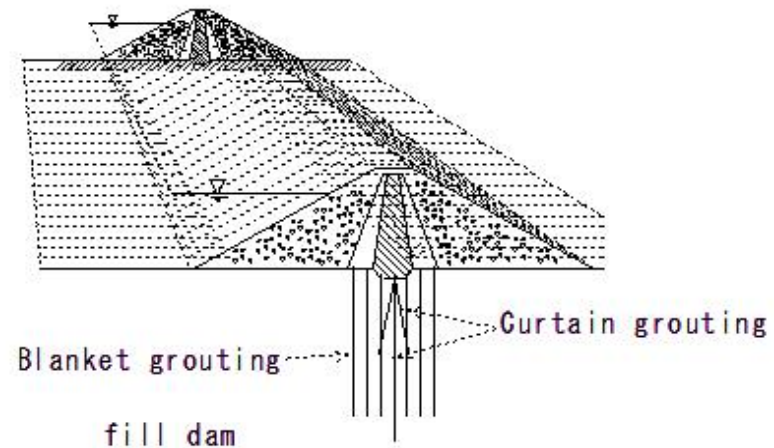
#### ③ Curtain grouting

##### ① Purpose

- Prevents infiltration and outflow of stored water
- Prevent piping in the foundation ground
- Contact surface between concrete dam body and foundation ground
- Reduce uplift force
- Outside of embankment type - rim grouting



D130



D131

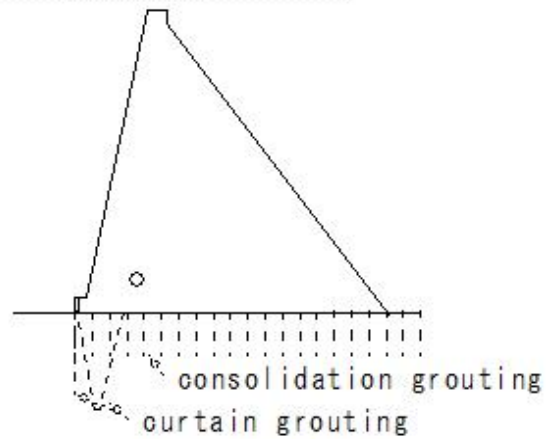
(D138) foundation treatment (grouting)

(D138) foundation treatment (grouting)

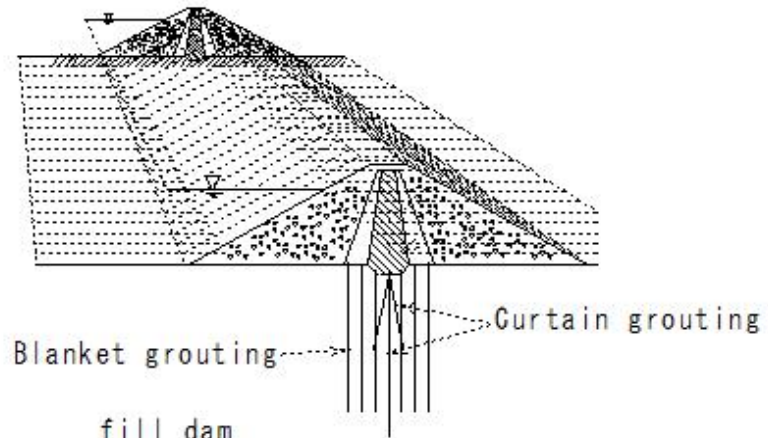
foundation treatment

- ③ Curtain grouting
- ② Improvement target value

- Concrete dam  
Approximately 1-2 Lu
- fill dam  
Approximately 2-5Lu



concrete dam  
Approximately 1-2 Lu



fill dam  
Approximately 2-5Lu

(D139) foundation treatment (grouting)

(D139) foundation treatment (grouting)

foundation treatment

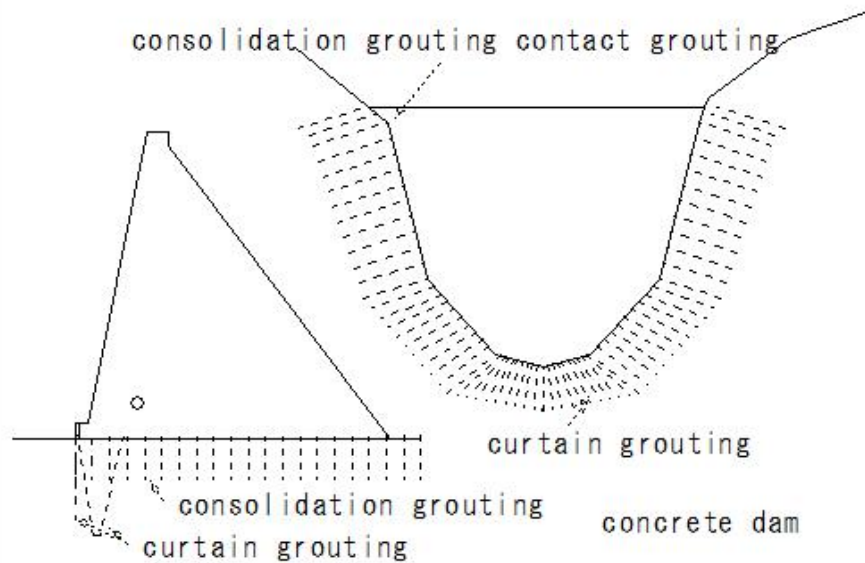
③ Curtain grouting

③ Construction scope

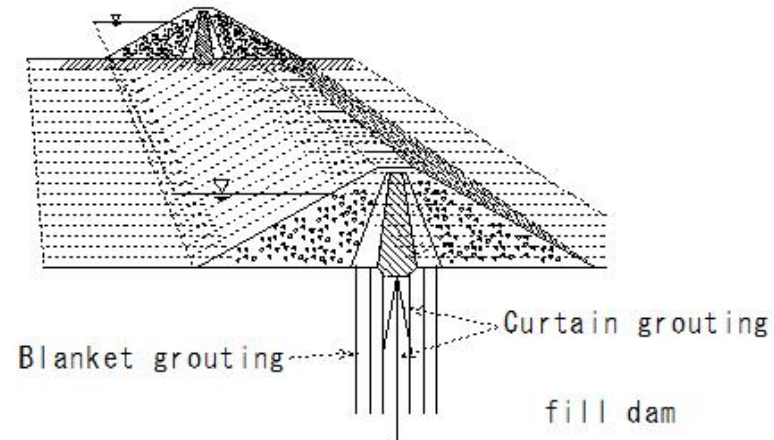
① The depth at which the Lugeon value of the foundation ground reaches the improvement target value

② Range where the underground water level of the ground intersects with the surcharge water level

③ Dam height



D130



D138



## (D140) foundation treatment (grouting)

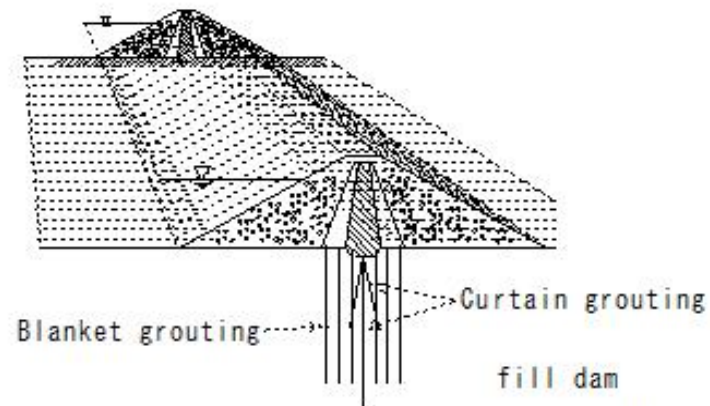
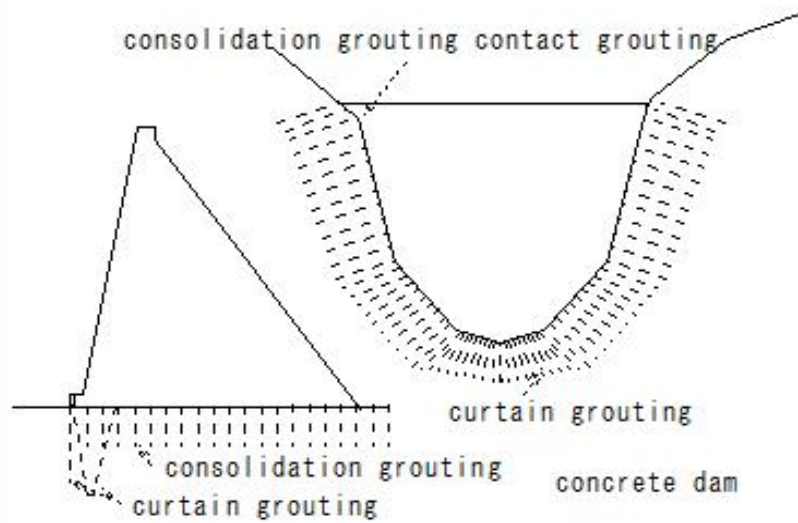
### (D140) foundation treatment (grouting)

foundation treatment

③ Curtain grouting

④ Construction period

- The levee body has risen to some extent.
- It can be effective as an overload load.
- case of the injection pressure can be increased



D139



(D141) foundation treatment (grouting)

(D141) foundation treatment (grouting)

foundation treatment

③ Curtain grouting

⑤ Construction location

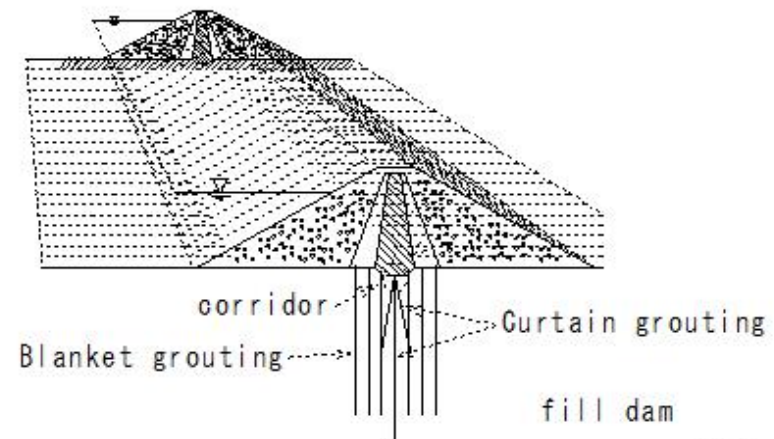
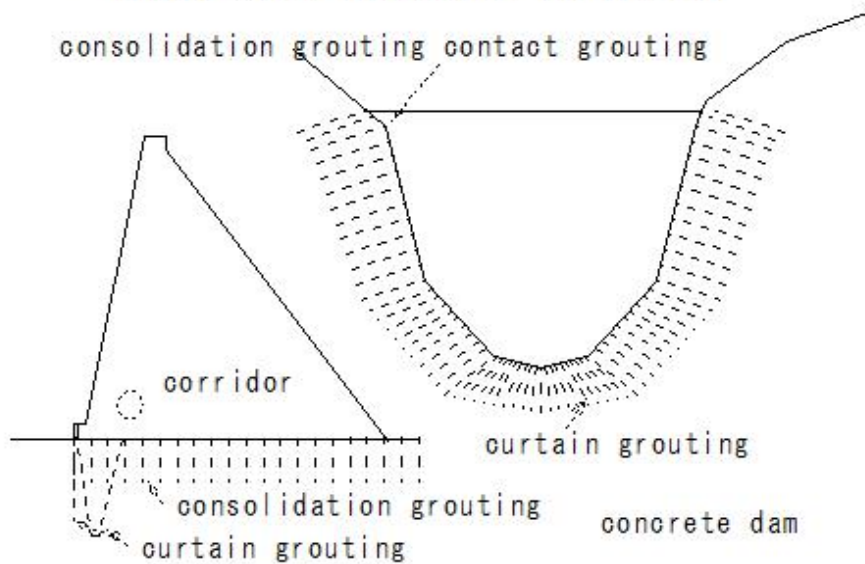
① Concrete dam

- Footing on the upstream side of the embankment body
- Construction from inside the corridor

② fill dam

- Construction from inside the corridor

consolidation grouting contact grouting



(D142) foundation treatment (grouting)

(D142) foundation treatment (grouting)

foundation treatment

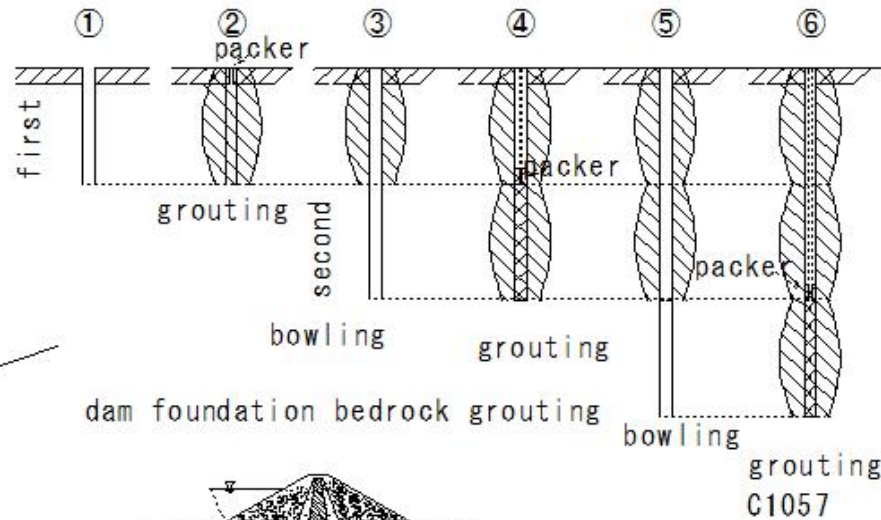
③ Curtain grouting

⑥ Injection pressure

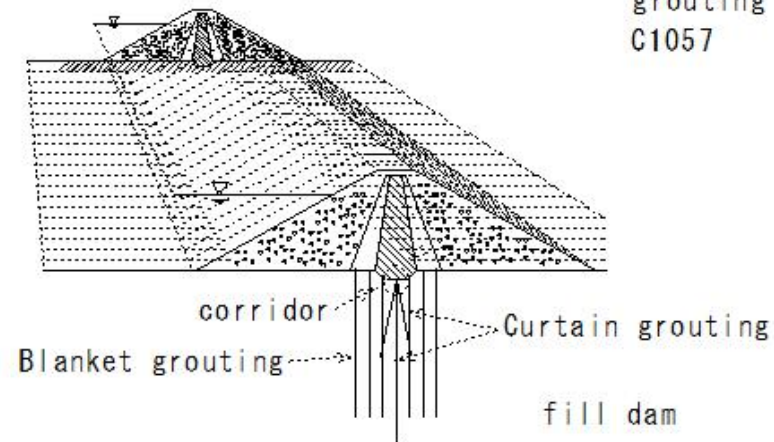
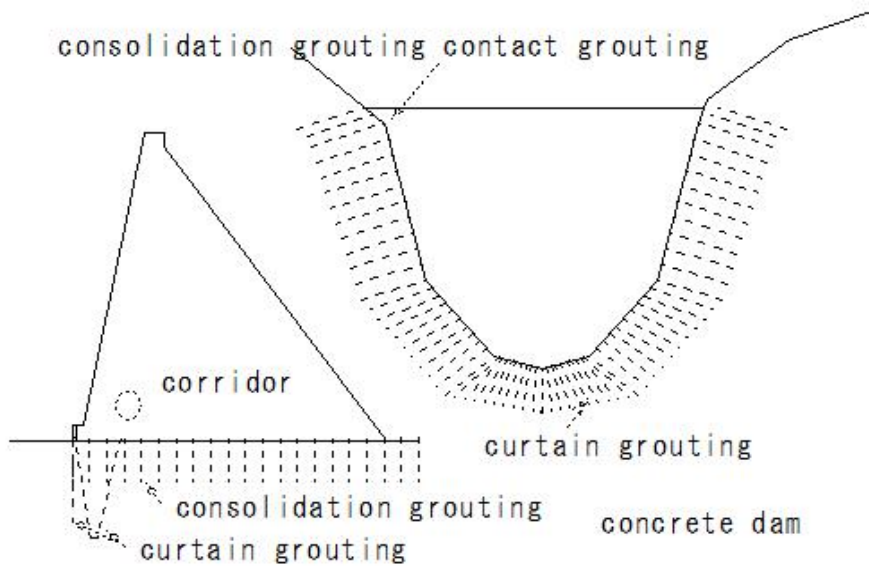
1st stage (stage length: usually 5m)

3-5kgf/cm<sup>2</sup>

- Increase pressure as the stage gets deeper
- Maximum around 20kgf/cm<sup>2</sup>



consolidation grouting contact grouting



(D143) foundation treatment (grouting)

(D143) foundation treatment (grouting)

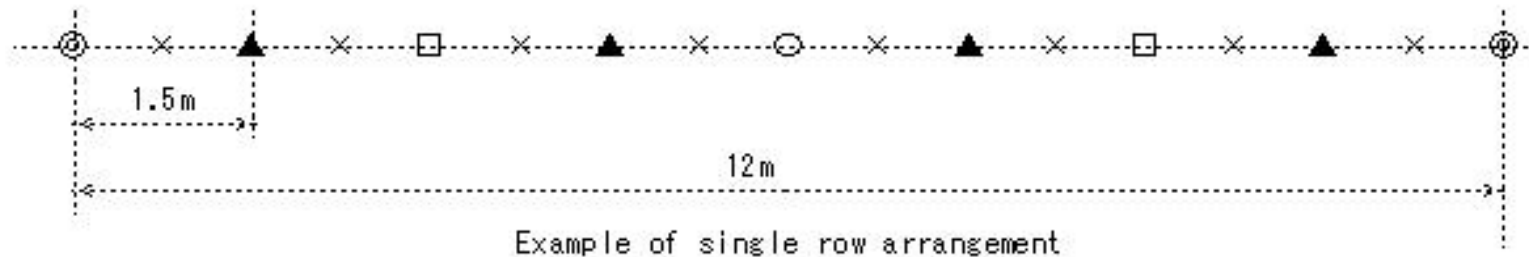
foundation treatment

③ Curtain grouting

⑦ Hole arrangement and depth

① Number of construction rows

- Single row arrangement, multiple row arrangement
- Single row arrangement



Example of single row arrangement

- ⊙ : Pilot hole
- : Primary hole
- : Secondary hole
- ▲ : Tertiary hole
- × : Additional hole

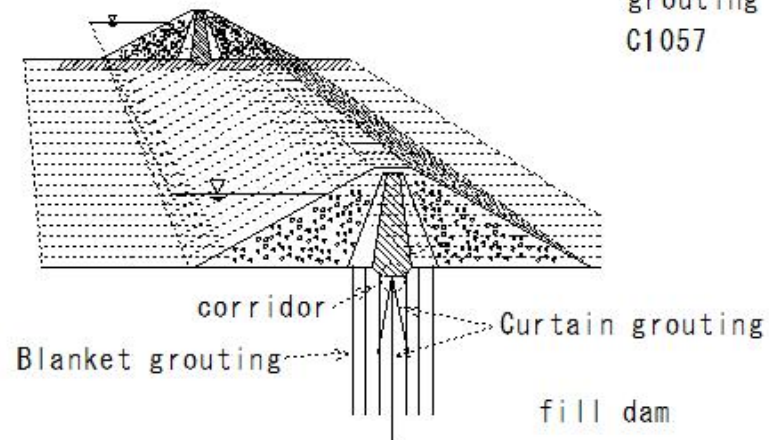
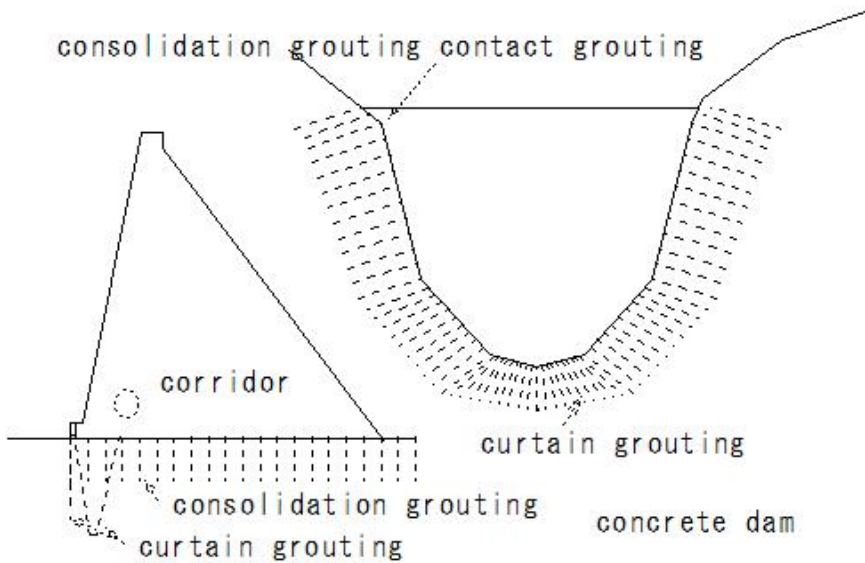
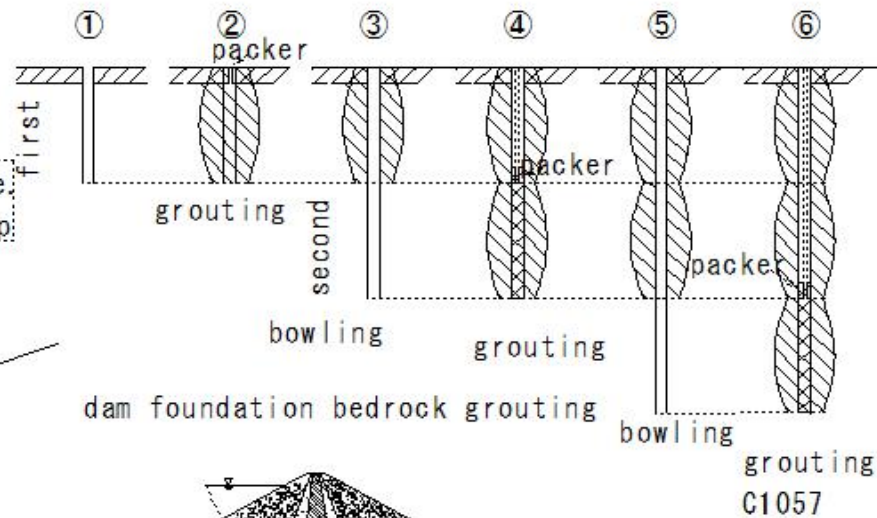
(D144) foundation treatment (grouting)

(D144) foundation treatment (grouting)

foundation treatment

- ③ Curtain grouting
- ⑦ Hole arrangement and depth
- ② Construction depth

The pilot hole is larger than the general hole.  
Construction approximately 2 stages (10m) deep.



(D145) foundation treatment (grouting)

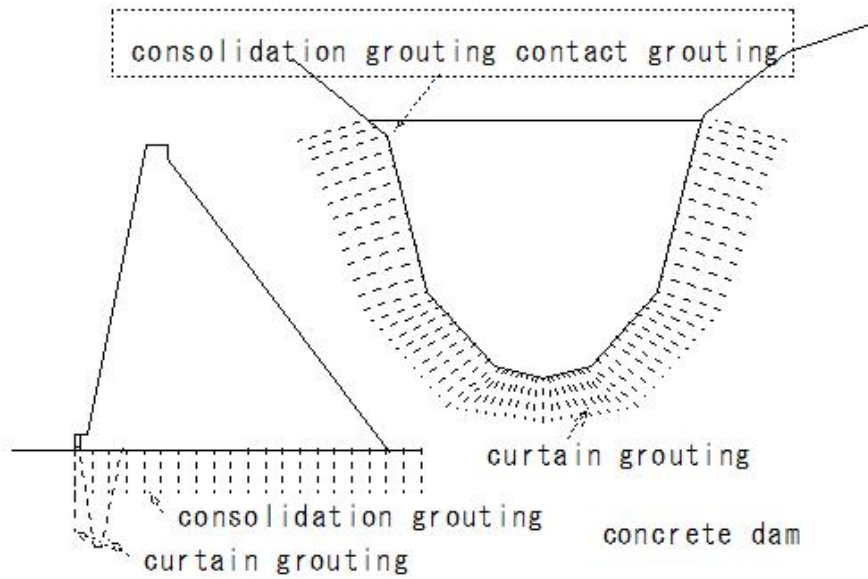
(D145) foundation treatment (grouting)

foundation treatment

④ Contact grouting

① Concrete dam

contact grouting=consolidation grout





## (D146) foundation treatment (grouting)

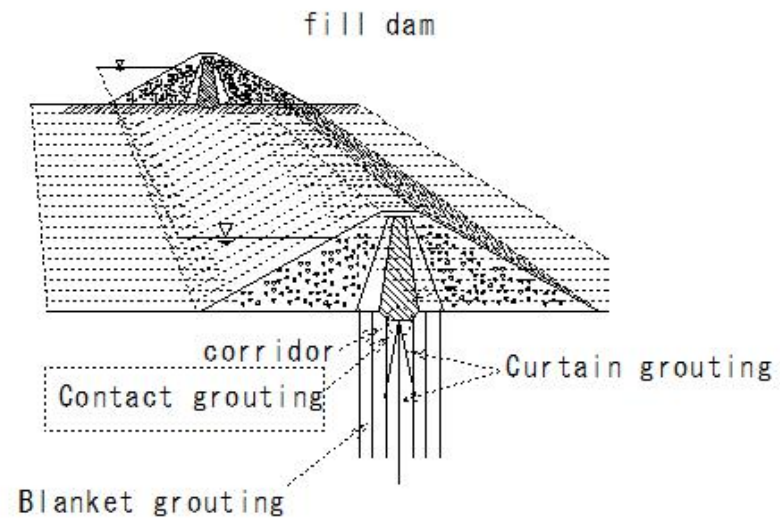
### (D146) foundation treatment (grouting)

foundation treatment

② fill dam

④ Contact grouting

- Reinforcement of looseness around the corridor
- Fill the gap between the corridor and the rock landing area





(D147) foundation treatment (grouting)

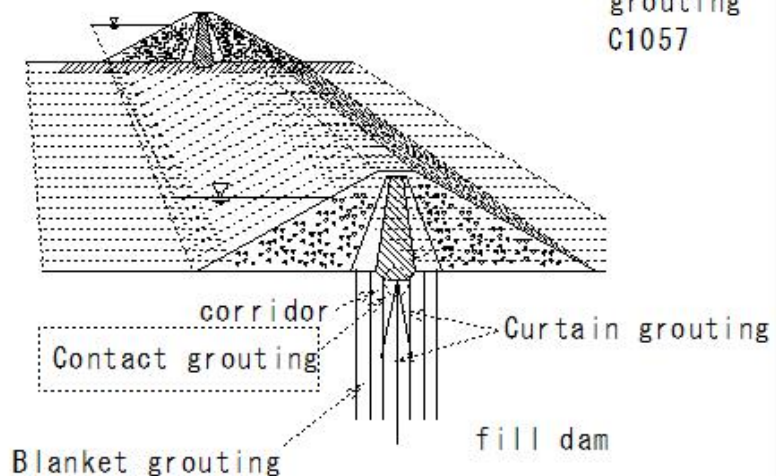
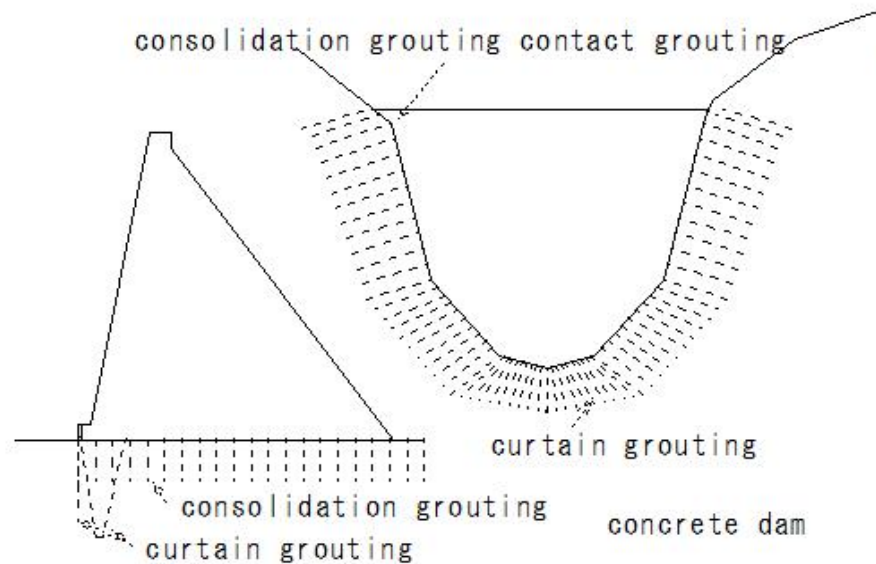
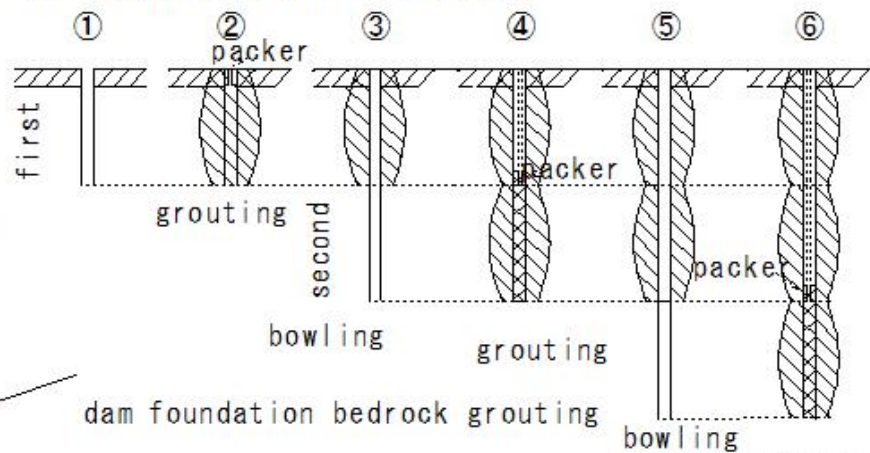
(D147) foundation treatment (grouting)

foundation treatment

Grouting construction

① Grouting plan

- Simultaneous Grouting at the same location as the main construction
- Process adjustment required



grouting C1057

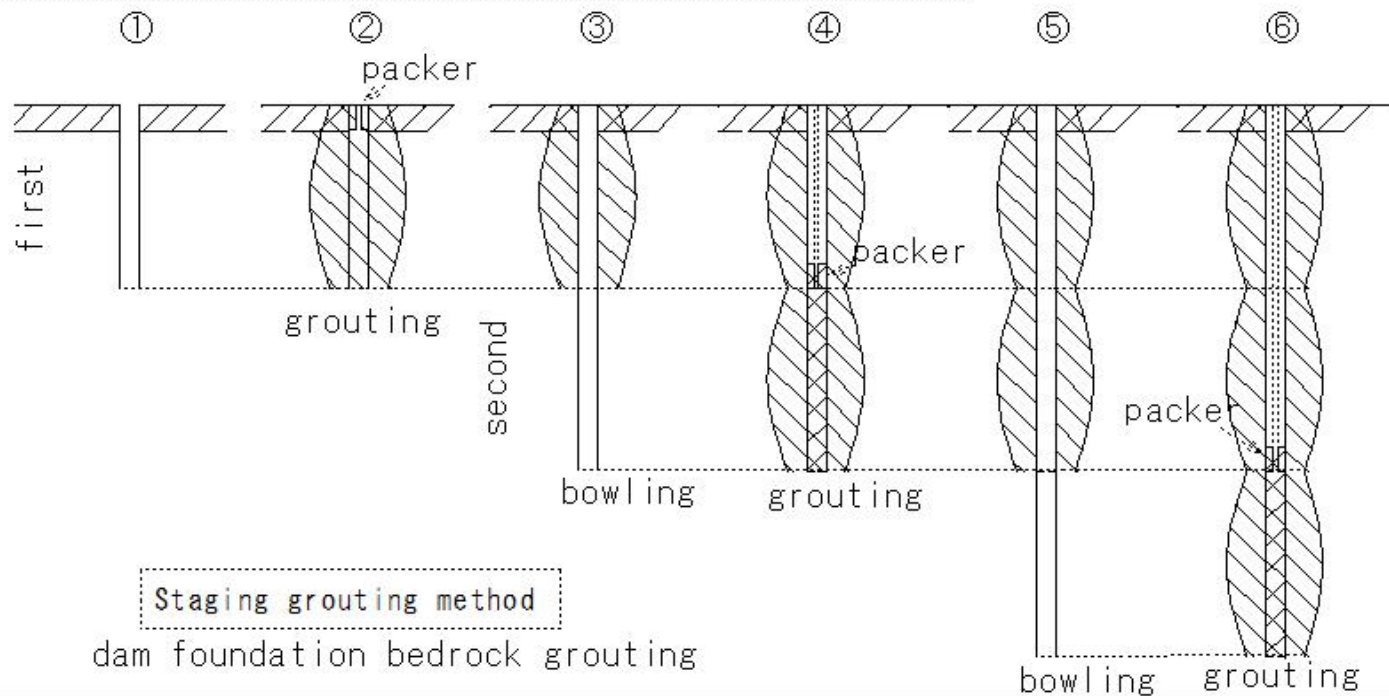
(D148) foundation treatment (grouting)

(D148) foundation treatment (grouting)

foundation treatment

② Construction of grouting

- Staging grouting method
- Stage the entire length of the injection hole (every 5 m)
- Construction of boring and grouting alternately

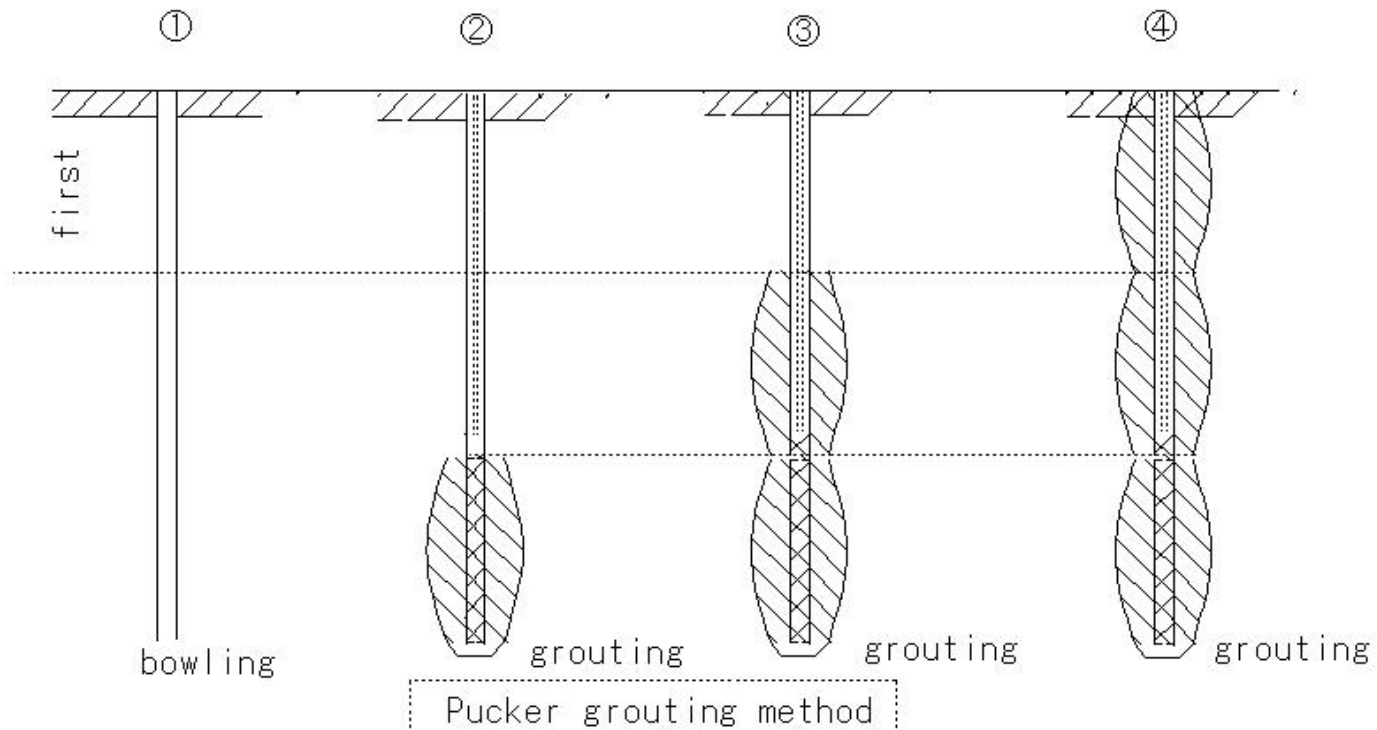


## (D149) foundation treatment (grouting)

foundation treatment (D149) foundation treatment (grouting)

### ② Construction of grouting

- Pucker grouting method
- Drill the entire length of the injection hole at once
- Perform grouting for each stage sequentially starting from the lower stage.



(D150)dam

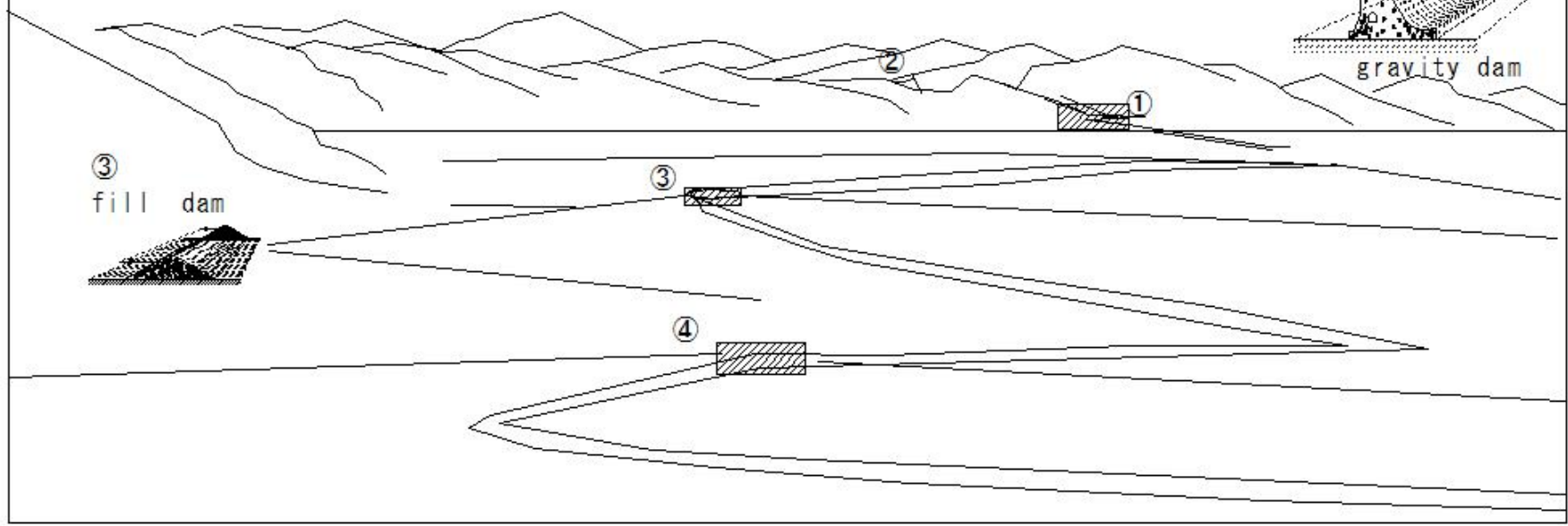
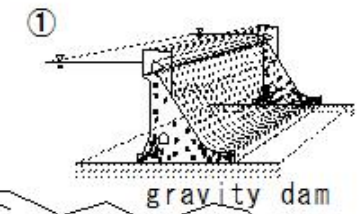
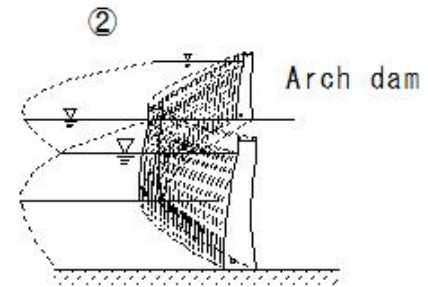
(D150) dam

dam

Types of dams

Classification by purpose

- ① Flood control dam: River flow regulation, flood protection
- ② power generation dam: Securing the amount of water storage necessary for hydroelectric power generation
- ③ Irrigation water dam: Use of agricultural water and water supply
- ④ Multi-purpose dam: 2 or more purposes



③  
fill dam



(D151)dam

(D151) dam

dam

Types of dams

Materials used

concrete dam

rockfill dam

earth dam

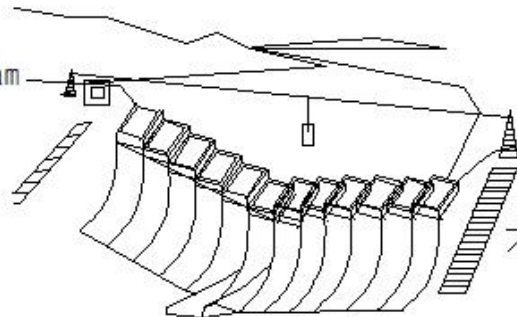
Structural form

gravity dam

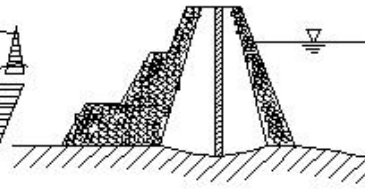
hollow gravity dam

buttress dam

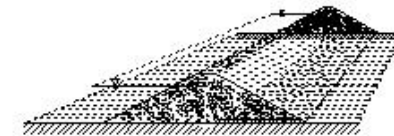
arch dam



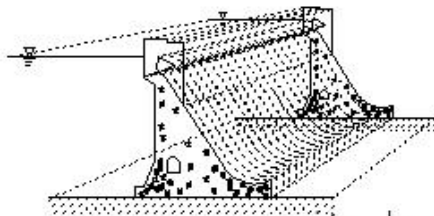
concrete dam



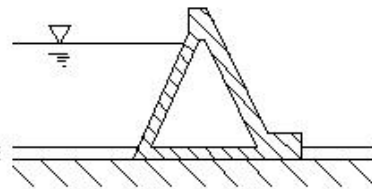
rockfill dam



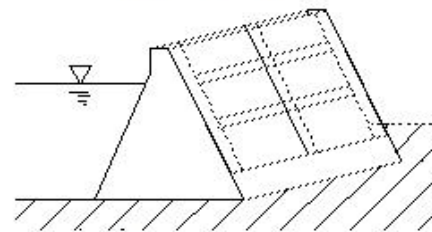
earth dam



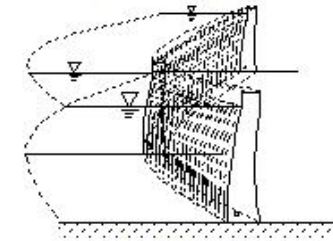
gravity dam



Hollow gravity dam



Buttress dam



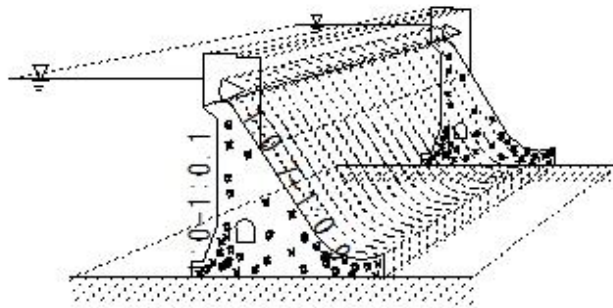
Arch dam

(D152)dam

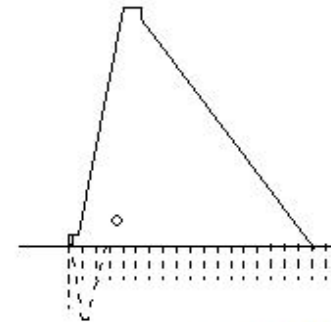
(D152) dam

dam

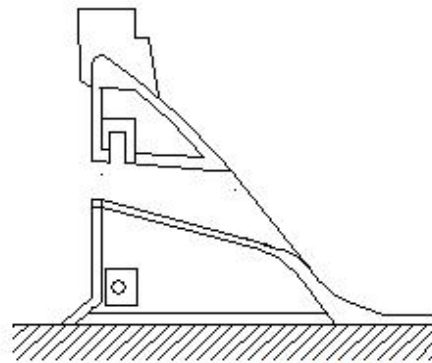
Types of dams  
gravity dam



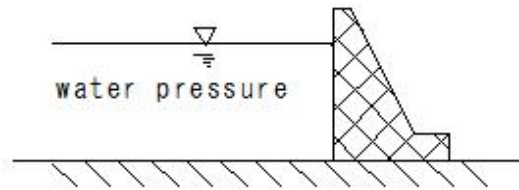
gravity dam D2



gravity dam D10



gravity dam D44



gravity dam C904

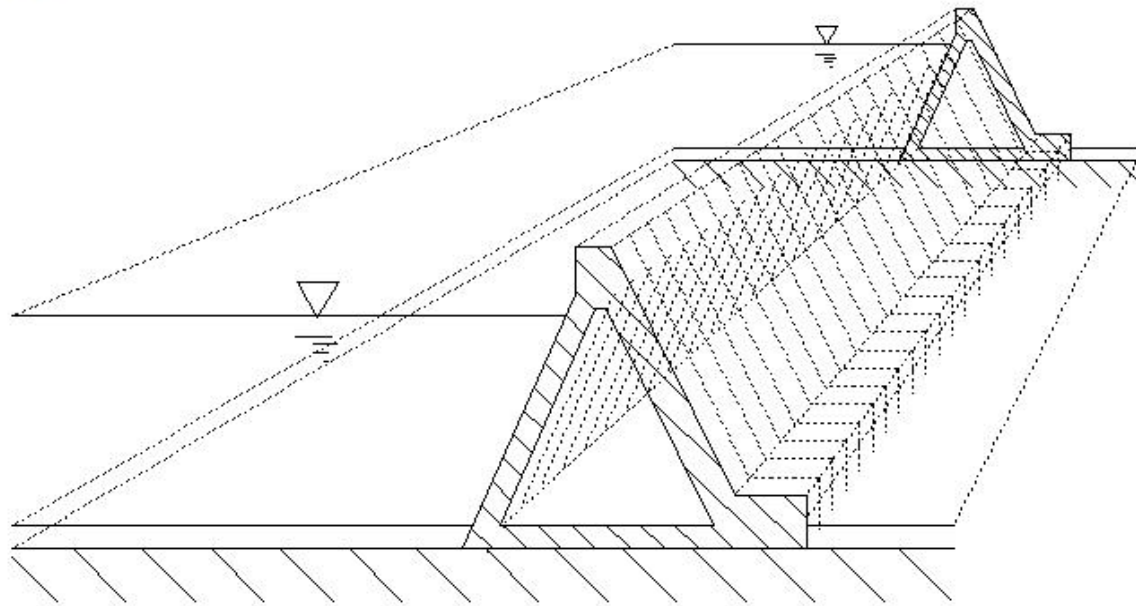


(D153)dam

(D153) dam

dam

Types of dams  
hollow gravity dam



Hollow gravity dam

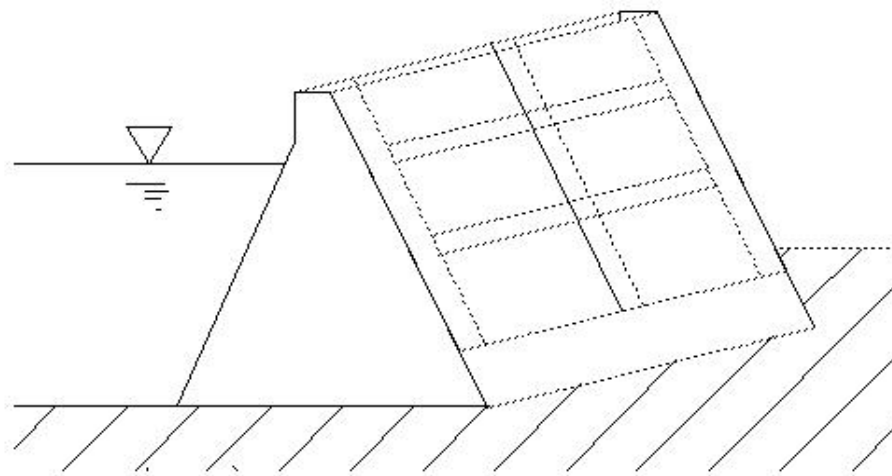
(D154)dam

(D154) dam

dam

Types of dams

buttress dam



Buttress dam

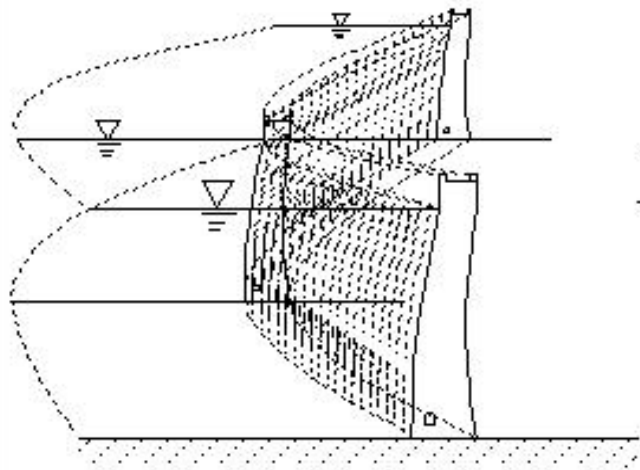
(D155)dam

(D155) dam

dam

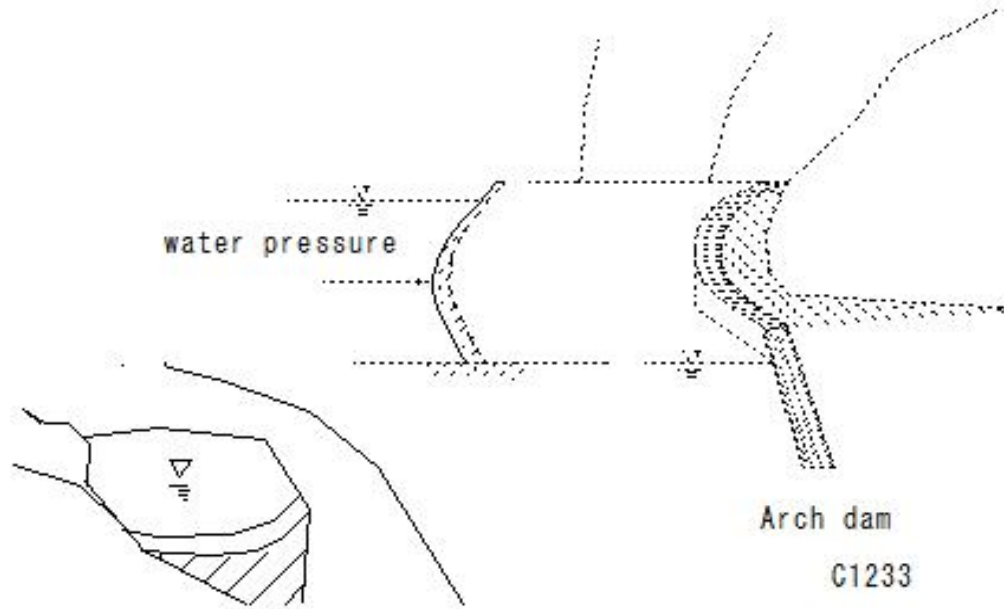
Types of dams

arch dam



D3

water pressure



Arch dam

C1233

Arch dam

C904

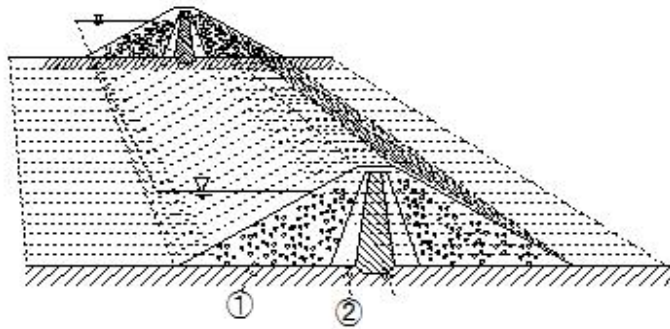
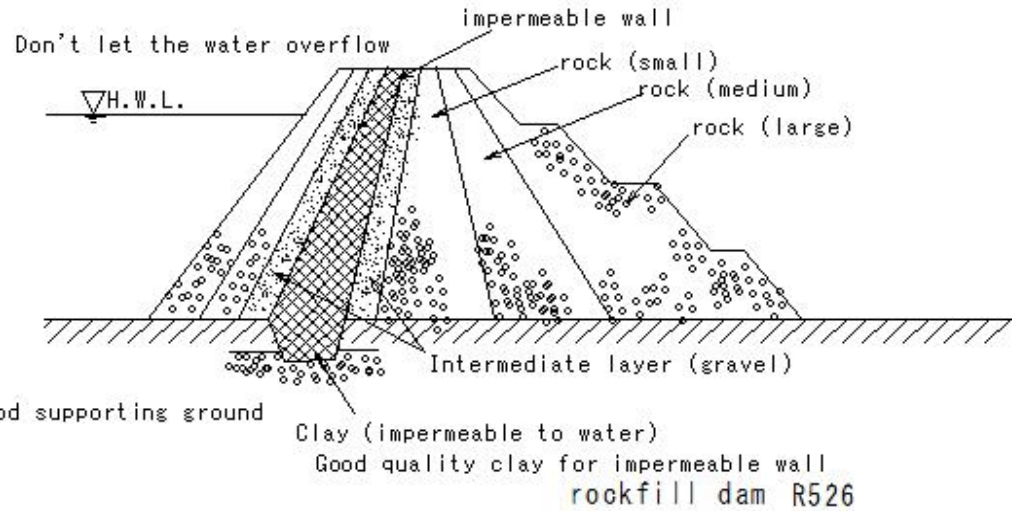
(D156)dam

(D156) dam

dam

Types of dams  
rock fill dam

- ① permeable material
- ② Semi-permeable material
- ③ Impermeable zone



D93

(D157)dam

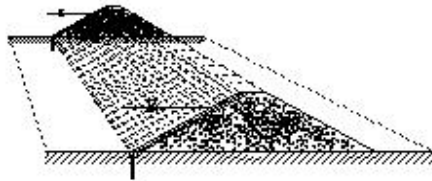
(D157) dam

dam

Types of dams

rock fill dam

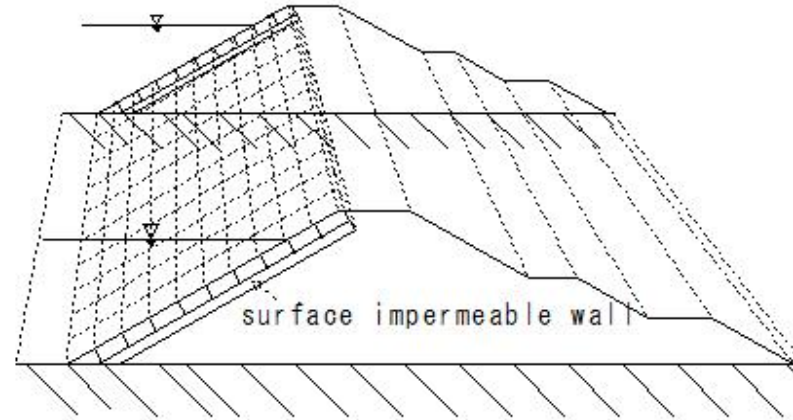
Facing type dam (Surface impermeable)



Surface impermeable wall type

R592  
D4

rock fill dam



R474

## (D158)dam

### (D158) dam

dam

hydroelectric power

- Energy in water
- Continuously drops water from high places
- Convert into velocity and pressure energy
- How to generate electricity with a water turbine generator

① Clean natural environmental energy using the power of nature

② Equipment costs are high

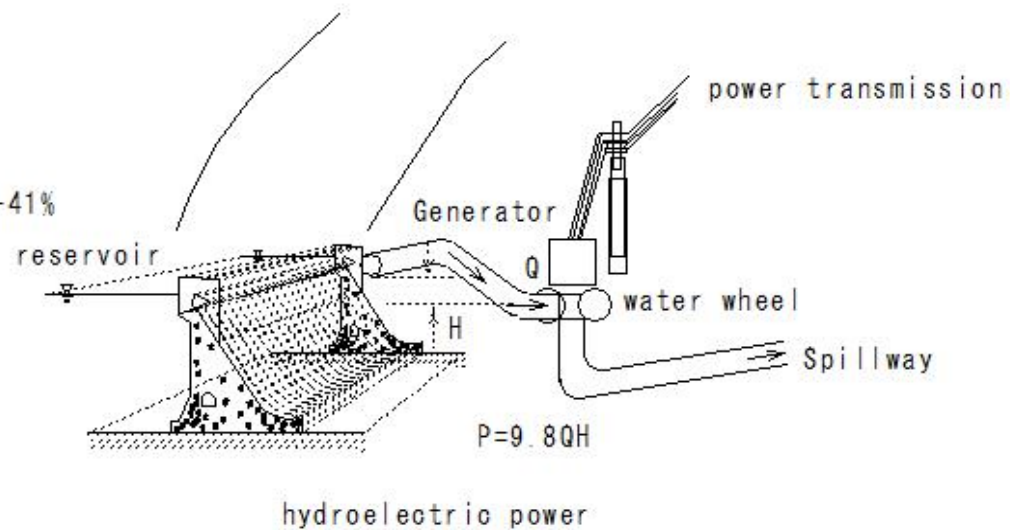
long service life

Operating costs are low

③ Highly reliable technology

④ High efficiency of 85-90%

Thermal power generation is 35-41%





(D159)dam

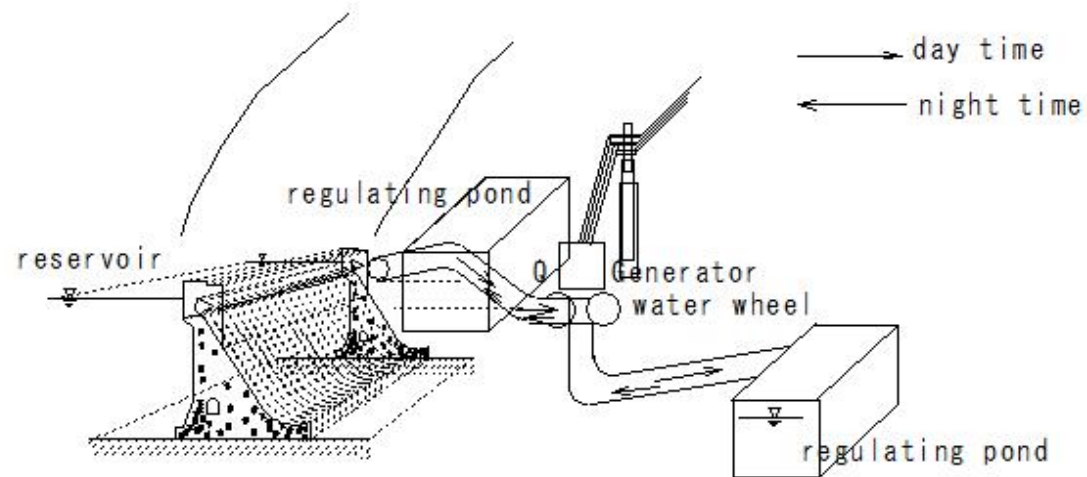
## (D159) dam

dam

hydroelectric power

pumped storage power generation

- Nighttime during electricity demand is low
- Use surplus electricity to operate the pump
- Pump up and store water in a reservoir
- Generate electricity by discharging electricity during daytime peak hours



pumped storage power generation

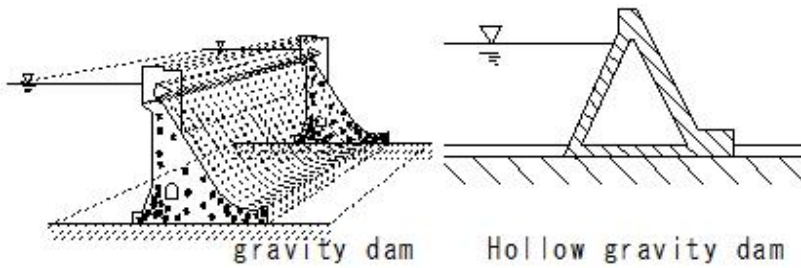
(D160)dam

(D160) dam

dam

concrete dam

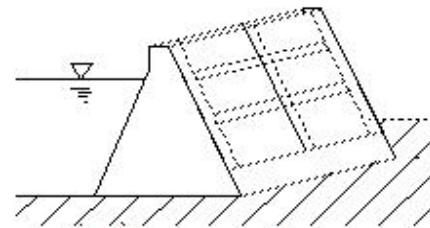
- Requires good bedrock



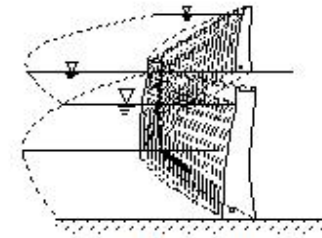
gravity dam

Hollow gravity dam

good bedrock



Buttress dam



Arch dam

D151

(D161)dam(Diversion works)

(D161) dam(Diversion works)

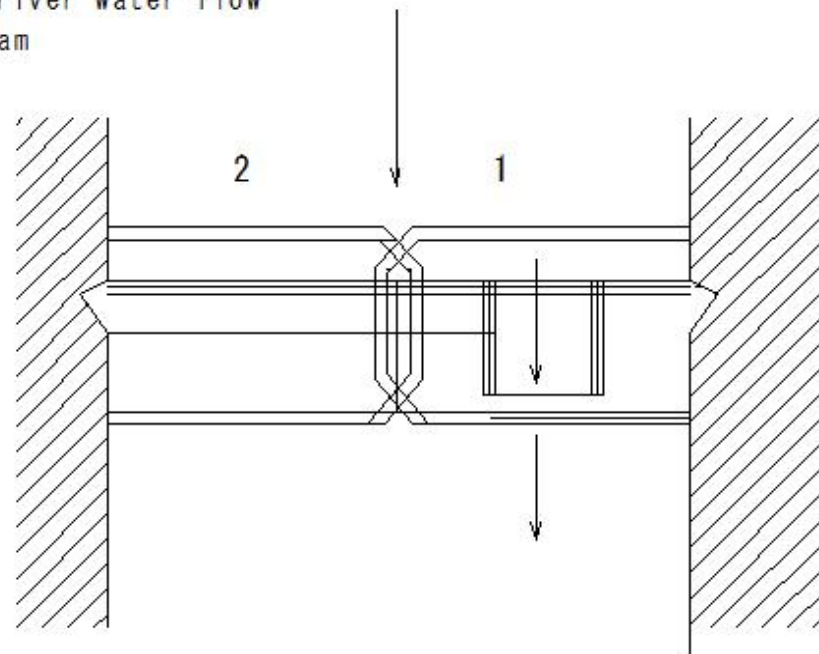
dam

- Diversion work

dam construction

- Temporarily close the river water flow

- ① half temporary cofferdam



Diversion works-Half cofferdam

G1074

(D162)dam(Diversion works)

(D162) dam(Diversion works)

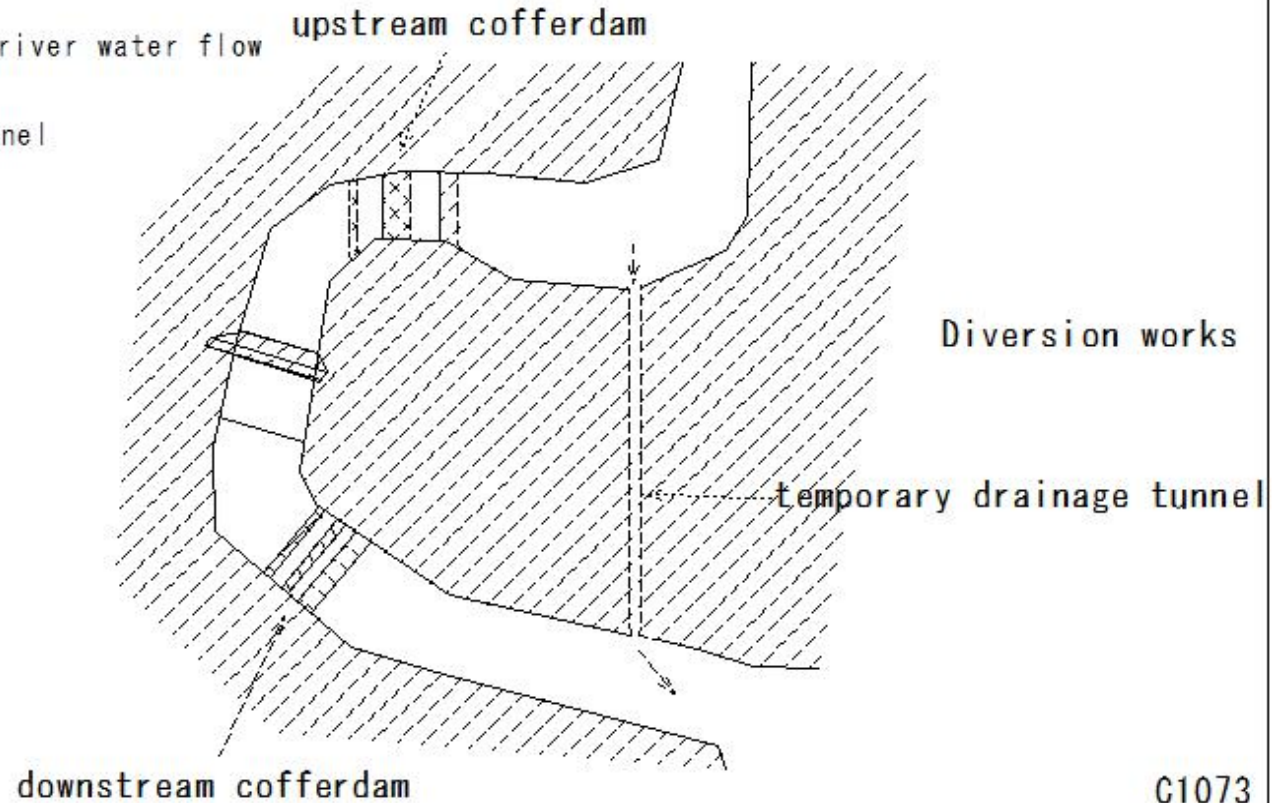
dam

- Diversion work

dam construction

- Temporarily close the river water flow
- Switch and commutation

② Temporary drainage tunnel



C1073

(D163)dam(Diversion works)

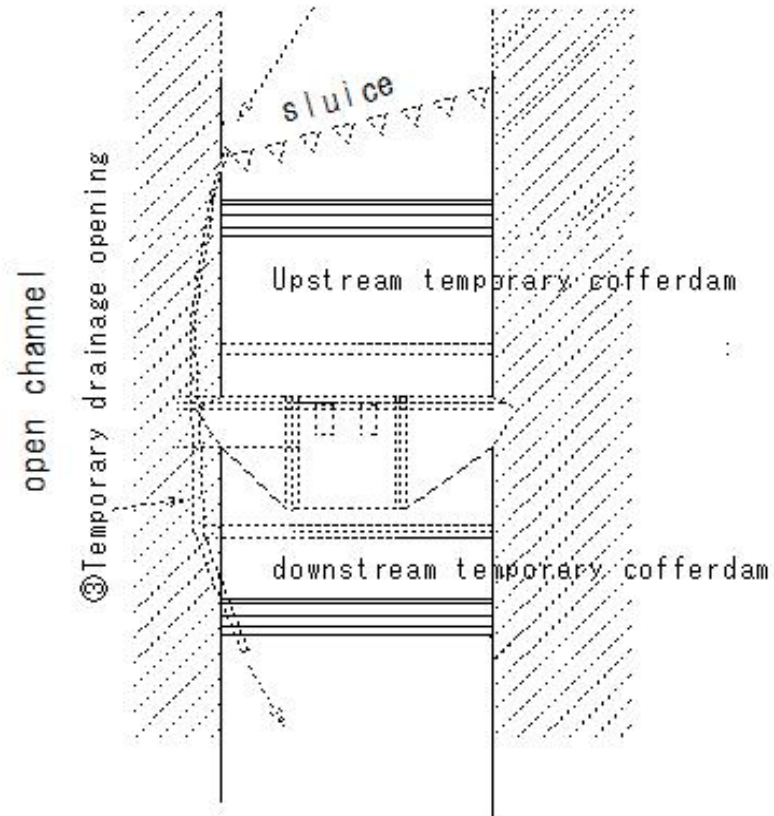
(D163)dam(Diversion works)

dam

- Diversion work

dam construction

- Temporarily close the river water flow
- Switch and commutation
- ③ Temporary drainage opening



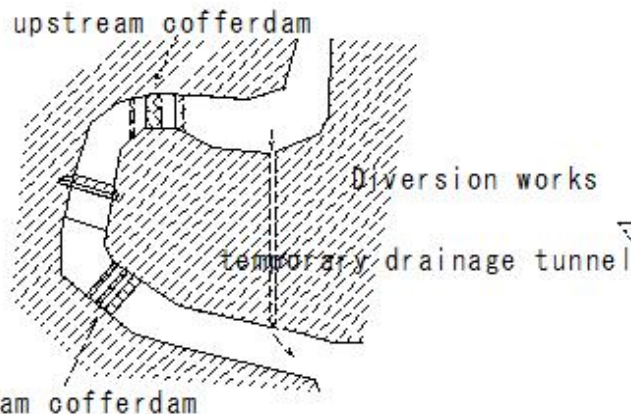
C1075

(D164)dam(construction order)

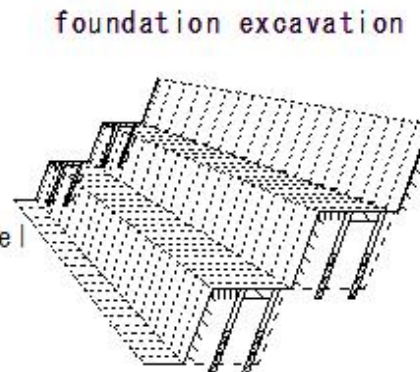
(D164) dam (construction order)

dam

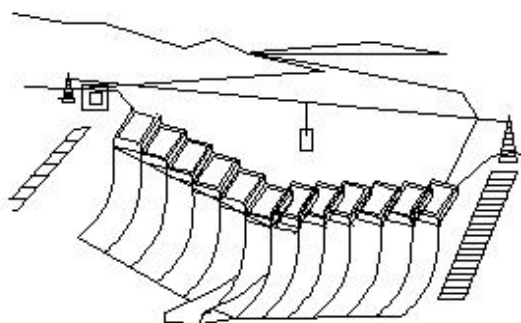
- Dam construction order
- ① Diversion works
  - ② Foundation excavation
  - ③ Concrete placement
  - ④ Grouting



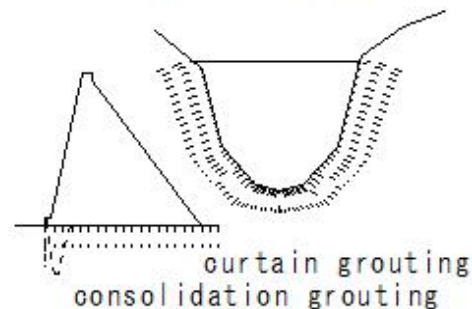
① Diversion works C1073



① Bench cut method  
② Foundation excavation D14  
Blasting method



③ Concrete placement D8



④ Grouting

D145

Dam construction order



(D165)dam(construction order)

(D165)dam(construction order)

dam

Dam construction order

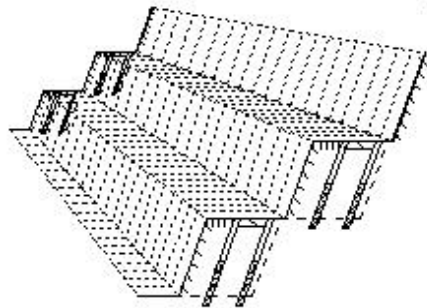
② foundation excavation

bulldozer

Shovel type excavator

Blasting method

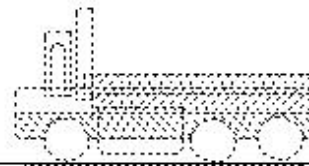
foundation excavation



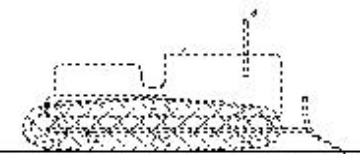
① Bench cut method

② Foundation excavation D14

Blasting method

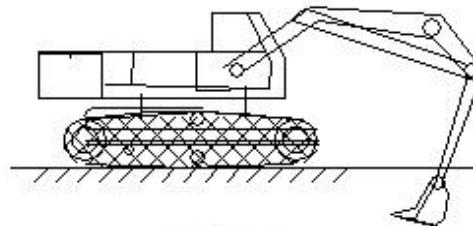


dump truck

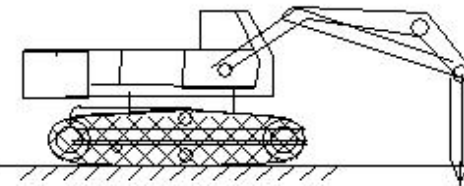


bulldozer

E341



backhoe



hydraulic breaker

E290

(D166)dam(construction order)

(D166) dam (construction order)

dam

Dam construction order

③ Concrete placement

Perform pipe cooling to reduce the heat of hydration

Watering or film curing



Cooling water Pipe cooling Pipe

C867

Clean plant

mass concrete

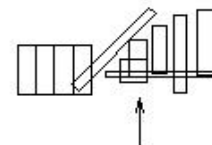
Suppression of temperature rise

① Aggregate cooling

② Mixing water cooling: Pre-cooling

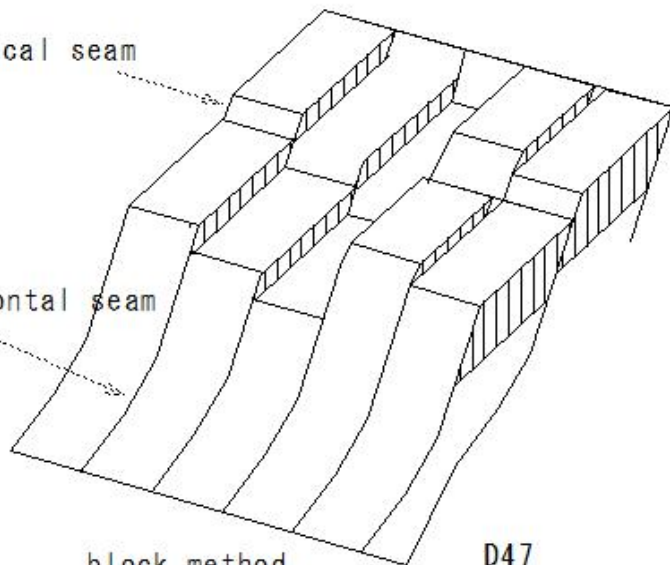
③ Pipe cooling

C1017



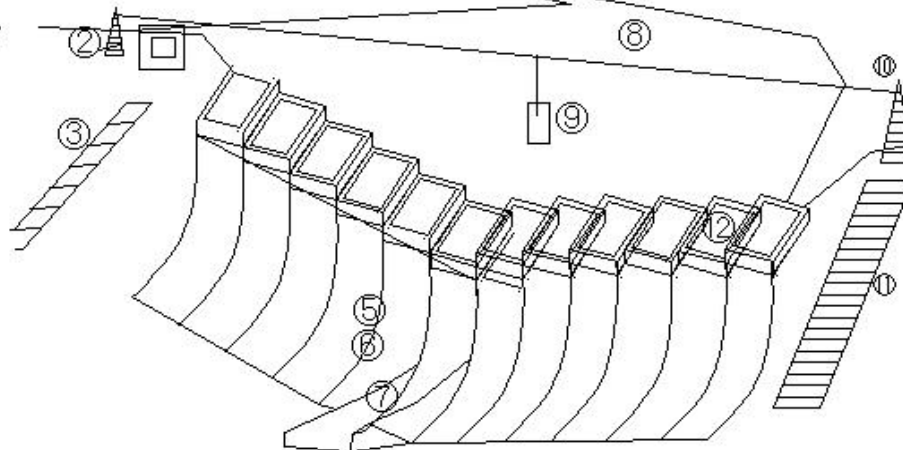
Vertical seam

horizontal seam



block method

D47



Place concrete block by block

(D167)dam(construction order)

### (D167) dam(construction order)

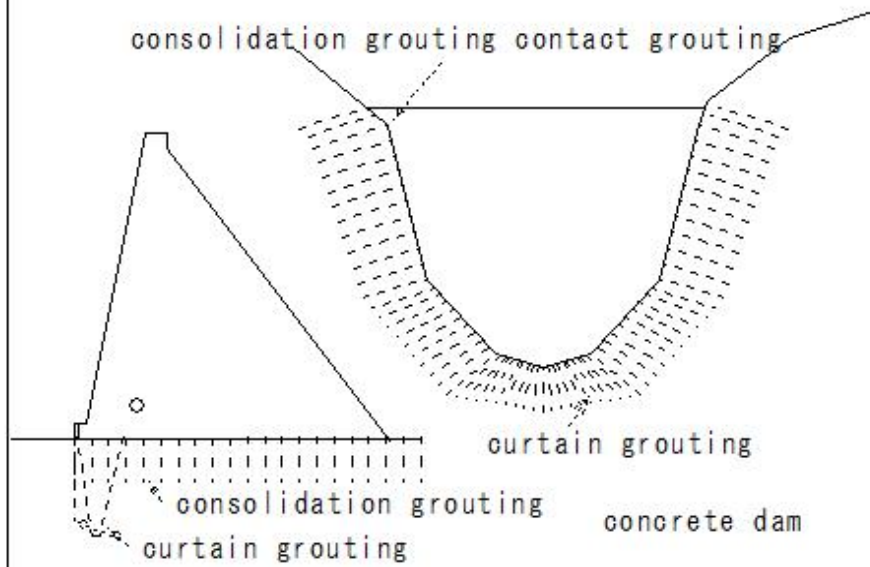
dam

Dam construction order

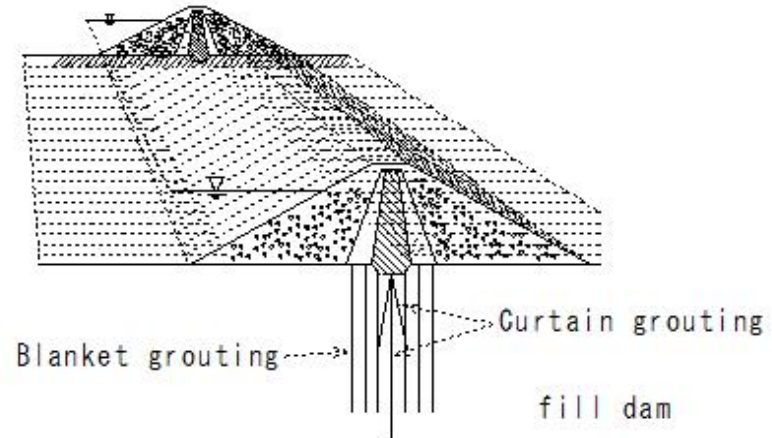
④ Grouting

curtain grout

consolidation grout



D130



D138

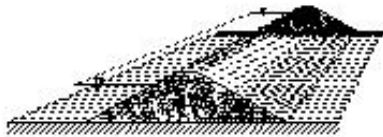
(D168)dam(fill dam)

(D168)dam(fill dam)

fill dam

fill dam

①Earth dam that evenly fills impermeable earth and sand



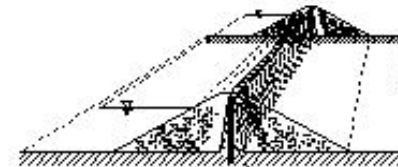
Uniform type

R591



Surface impermeable wall type

R592



artificial material core

R593

D4

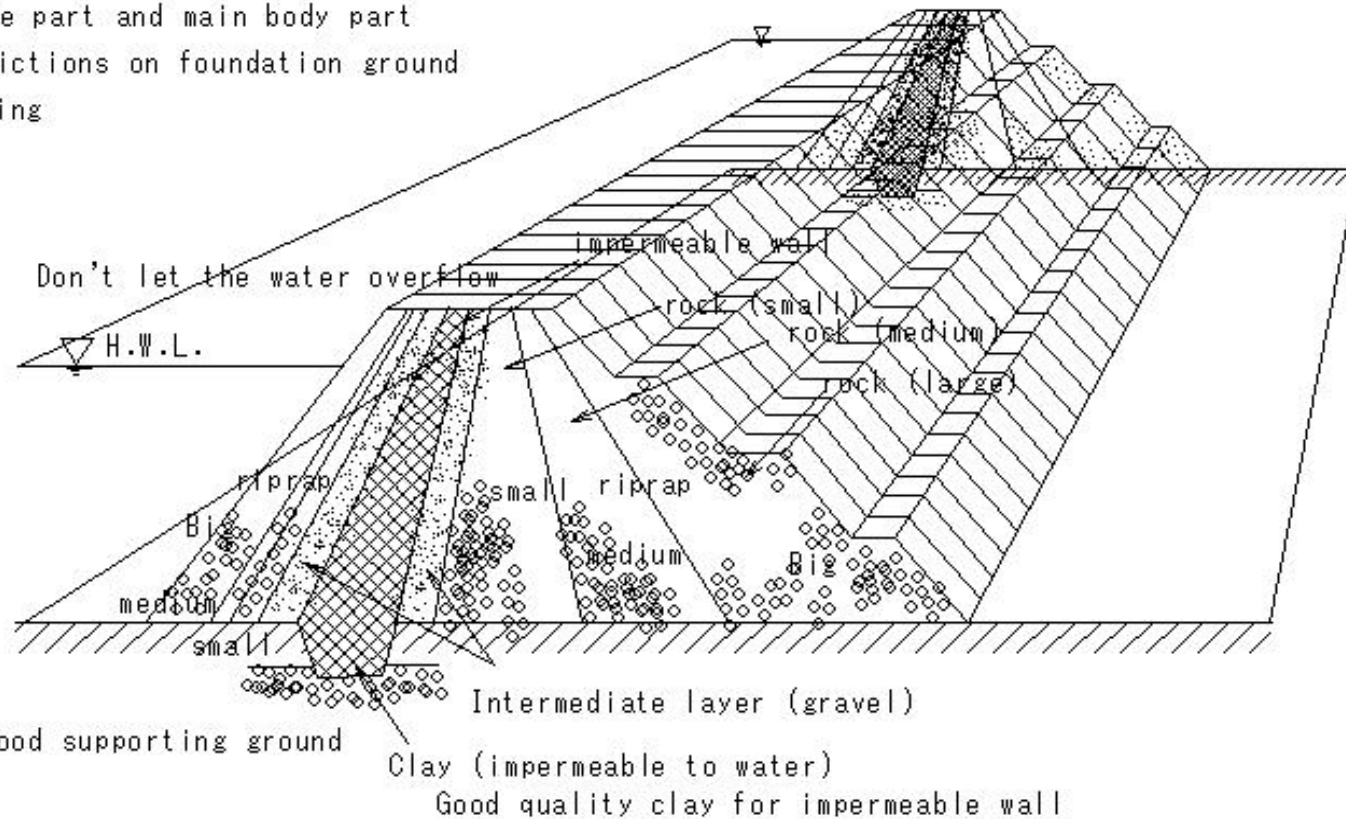
(D169)dam(rock fill dam)

(D169)dam(rock fill dam)

dam

rock fill dam

- Impermeable part and main body part
- Less restrictions on foundation ground
- Rock stacking





(D170)dam(rock fill dam)

(D170) dam (rock fill dam)

dam

rock fill dam

Impermeable (core) zone

① High quality clay with high Impermeable

Compaction can be done easily

relatively dry material

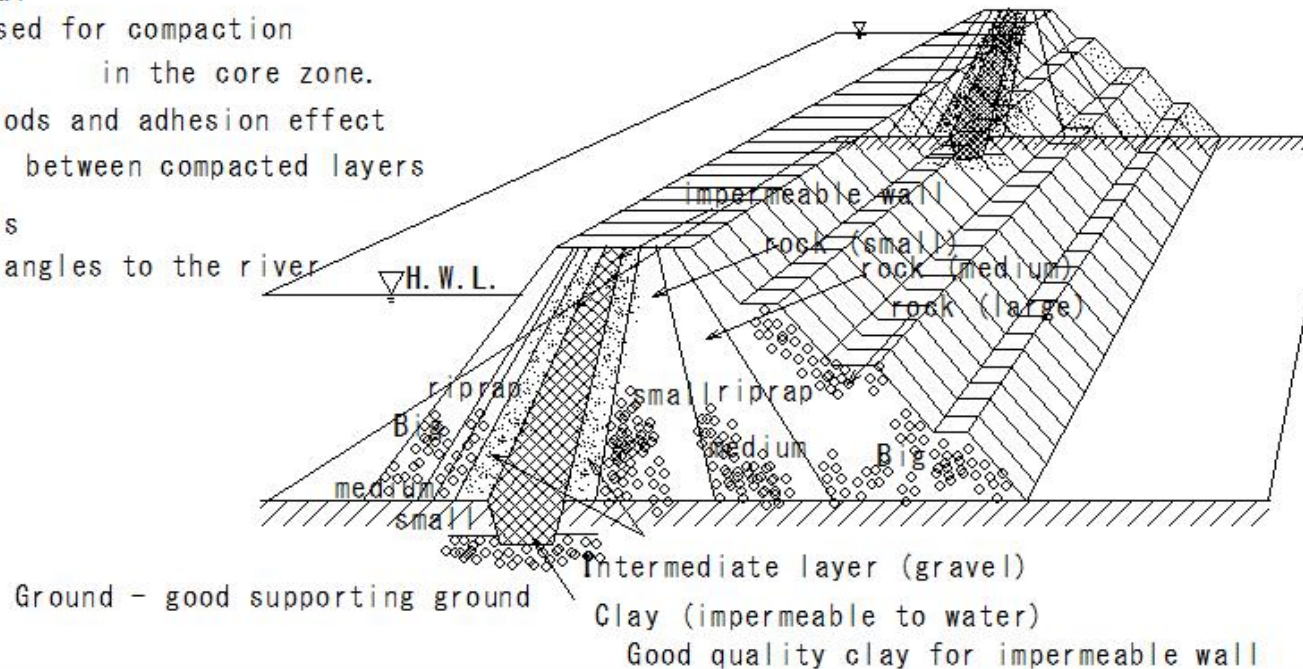
② tamping roller is used for compaction  
in the core zone.

• Fracture of soil clods and adhesion effect  
between compacted layers

• Parallel to dam axis

Constructed at right angles to the river

Don't let the water overflow





(D171)dam(rock fill dam)

(D171)dam(rock fill dam)

dam

rock fill dam

rock zone

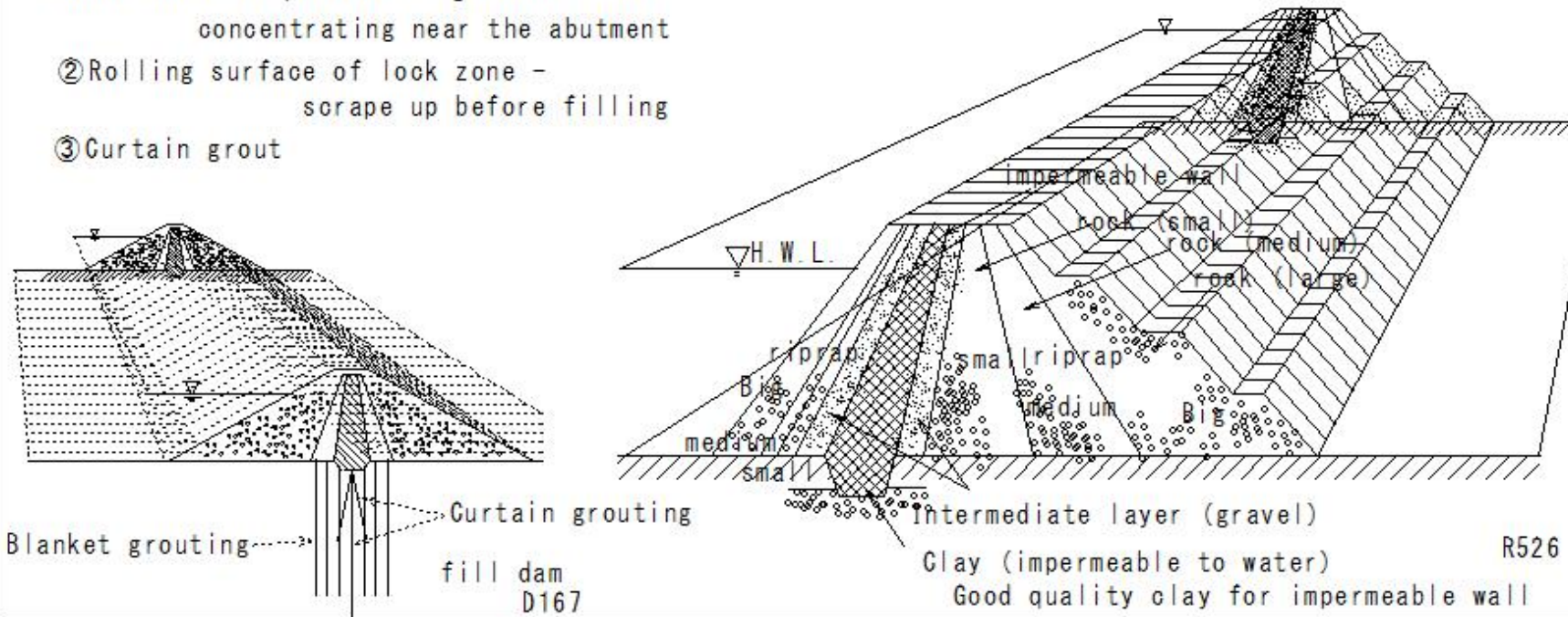
① Rock zone excitement

Boundary area with filter

Constructed to prevent large rocks from  
concentrating near the abutment

② Rolling surface of lock zone -  
scrape up before filling

③ Curtain grout



Blanket grouting

Curtain grouting

fill dam  
D167

Clay (impermeable to water)  
Good quality clay for impermeable wall

R526

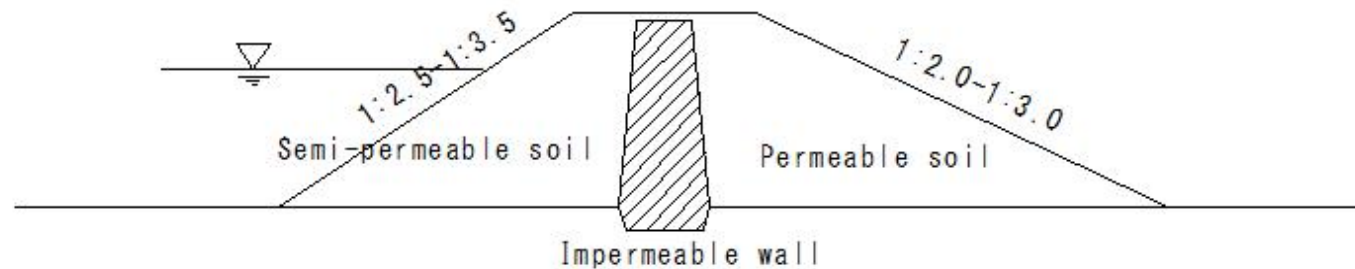
(D172)dam(earth dam)

## (D172) dam (earth dam)

earth dam

Embankment body is soil

- Can be constructed even in places where the foundation ground (bearing capacity) is small



- Central impermeable wall type
- For imperviousness, carefully compact the sticky soil.
- Reinforced concrete using steel plates, etc.

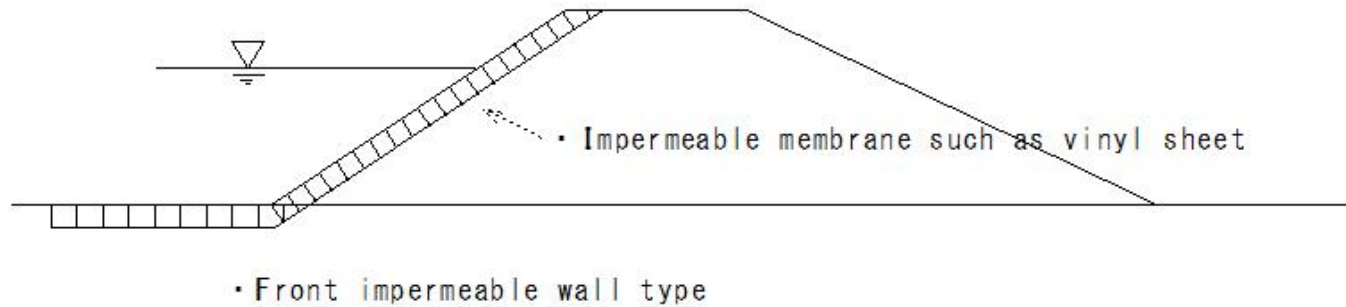
(D173)dam(earth dam)

(D173) dam (earth dam)

earth dam

Embankment body is soil

- Can be constructed even in places where the foundation ground (bearing capacity) is small

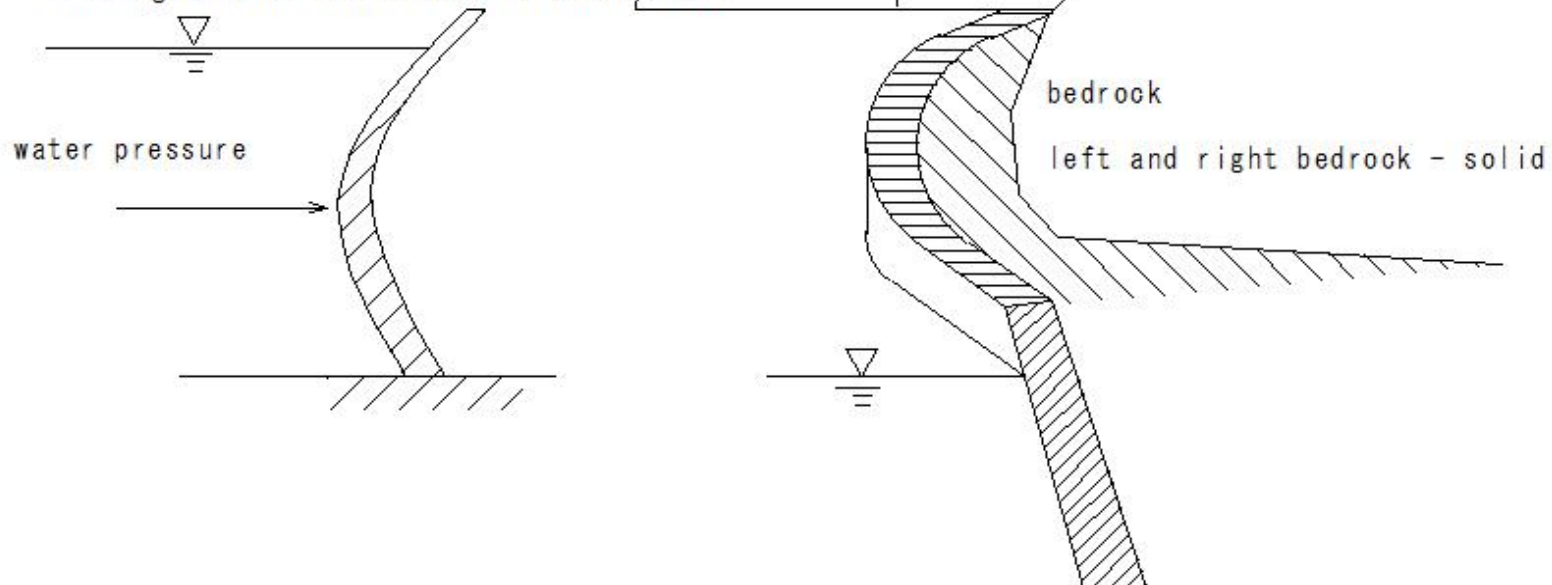


(D174)dam(arch dam)

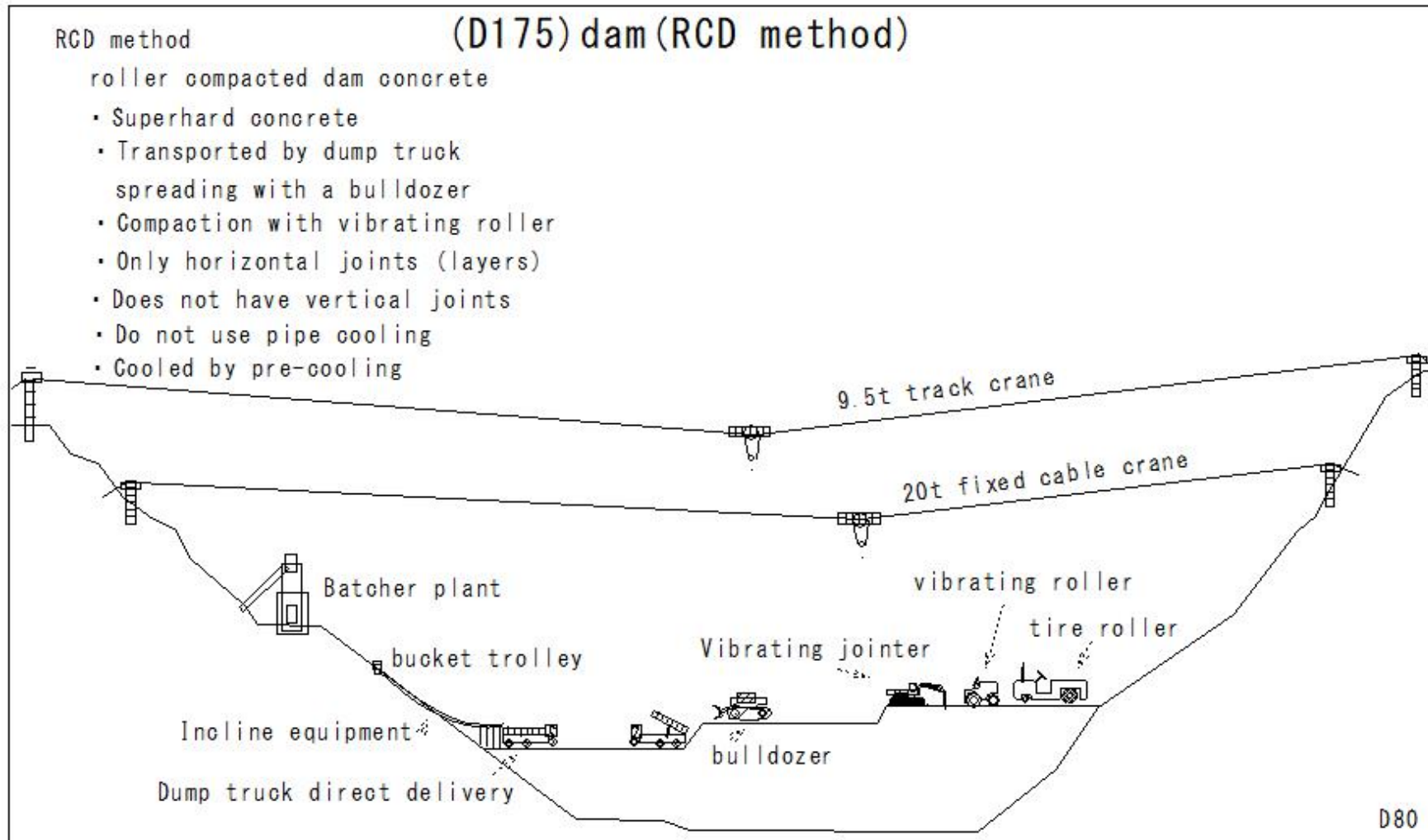
(D174) dam (arch dam)

arch dam

- Horizontal cross section is arch-shaped
- Vertical section is cantilevered
- Concrete dam
- The dam body is arch-shaped
- Only compressive force acts
- Amount of concrete - small
- The ground on both sides is solid rock.



(D175)dam(RCD method)



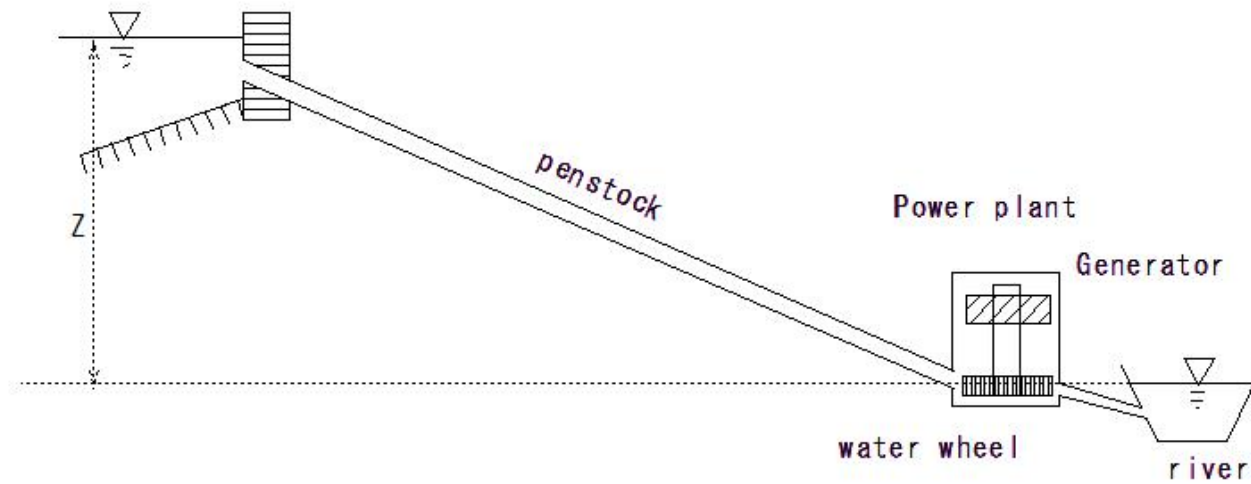
(D176)dam(potential head)

## (D176) dam(potential head)

potential head

- Bernoulli's theorem
- Express the energy at the position where water is placed in the unit of height (m)
- Convert positional water head into electrical energy

Z (position head) (m) Total head in hydropower generation



Z: (potential head) (m) Total head in hydropower generation

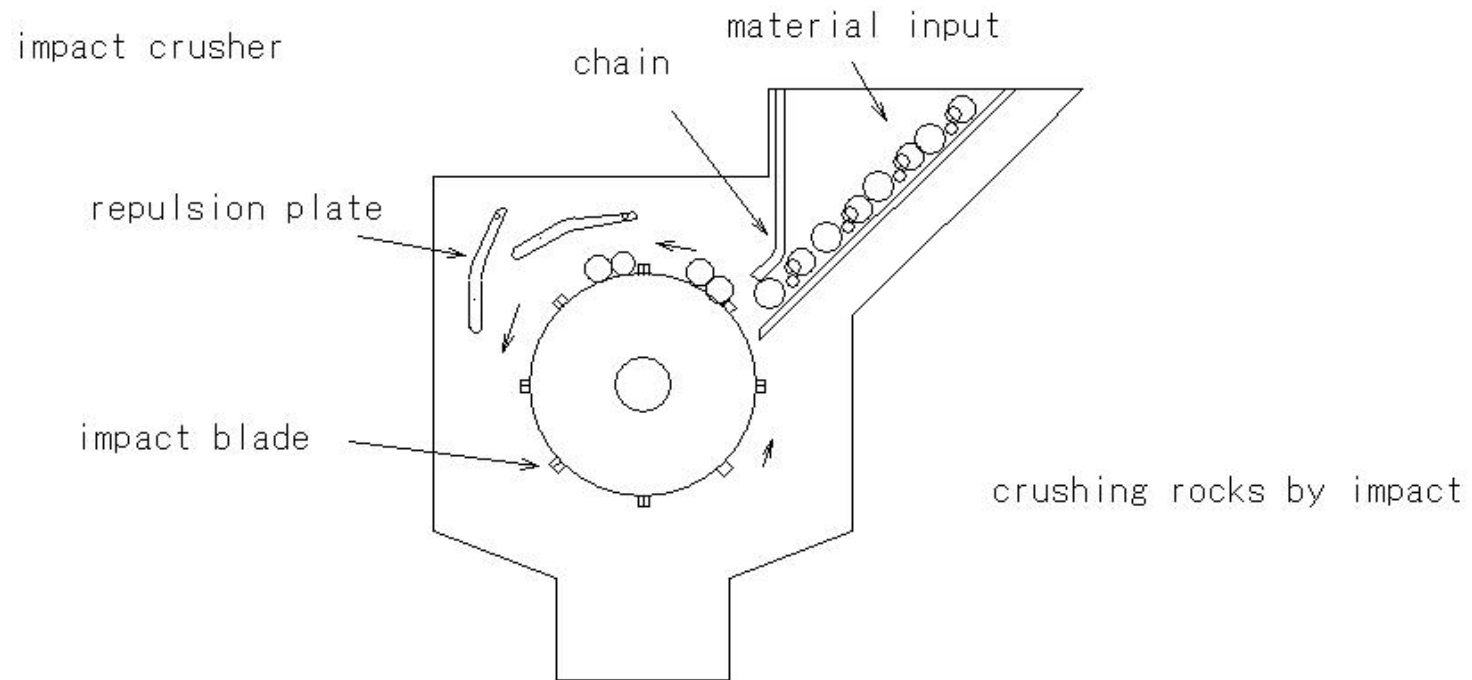


(D177) impact crusher

(D177) impact crusher

impact crusher

- Crush rocks at high speed by impact

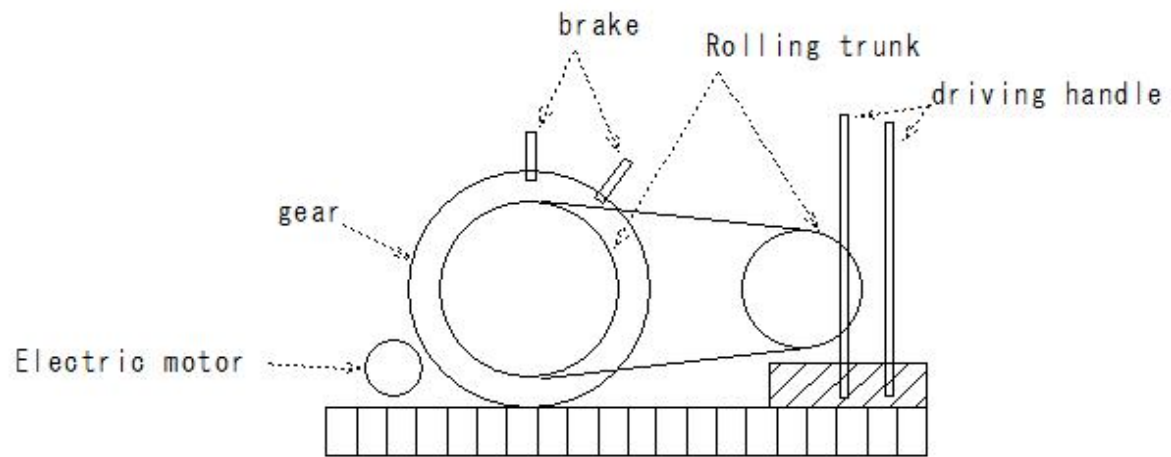


(D178)winch

## (D178) winch

winch

- Wire rope
- Lift up the load
- Pulling

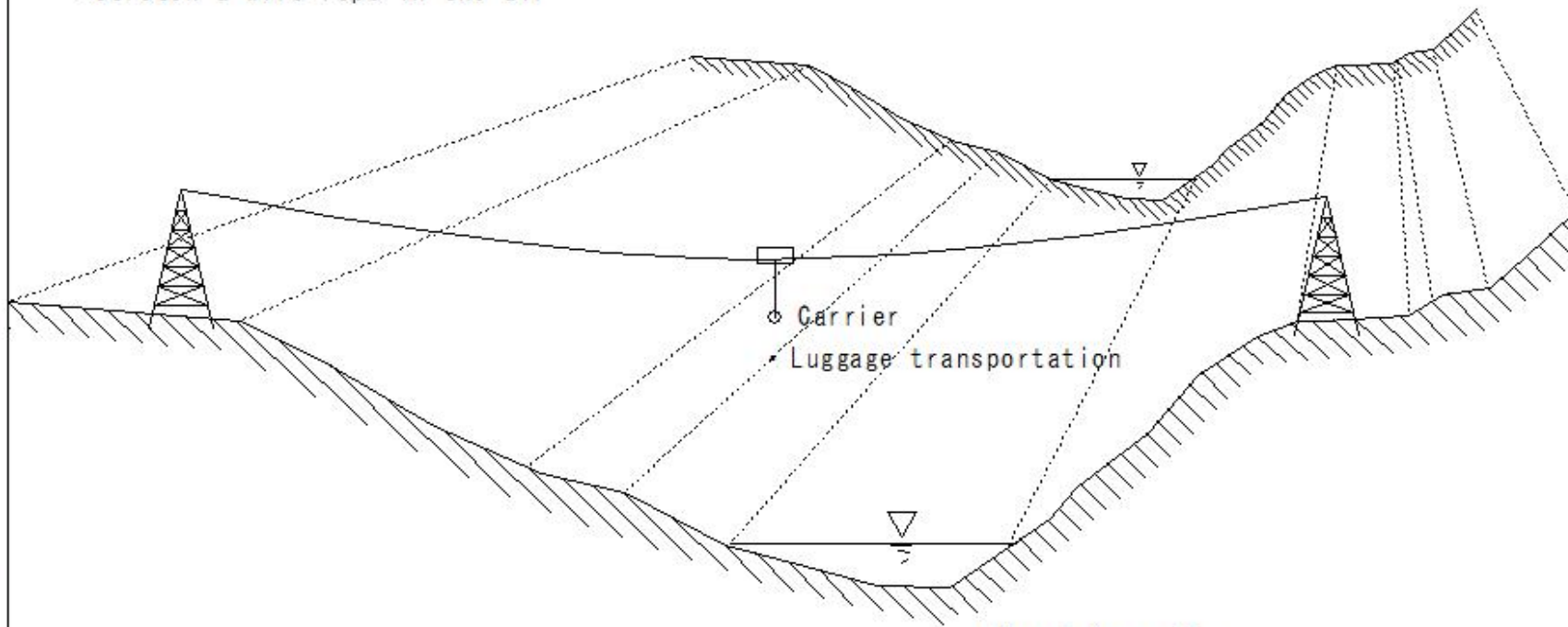


(D179) aerial cableway

(D179) aerial cableway

aerial cableway

- Stretch a wire rope in the air



Carrier  
• Luggage transportation

- Mountain valley
- Places with large unevenness
- Road, railway, river crossing

(D180)design flood discharge

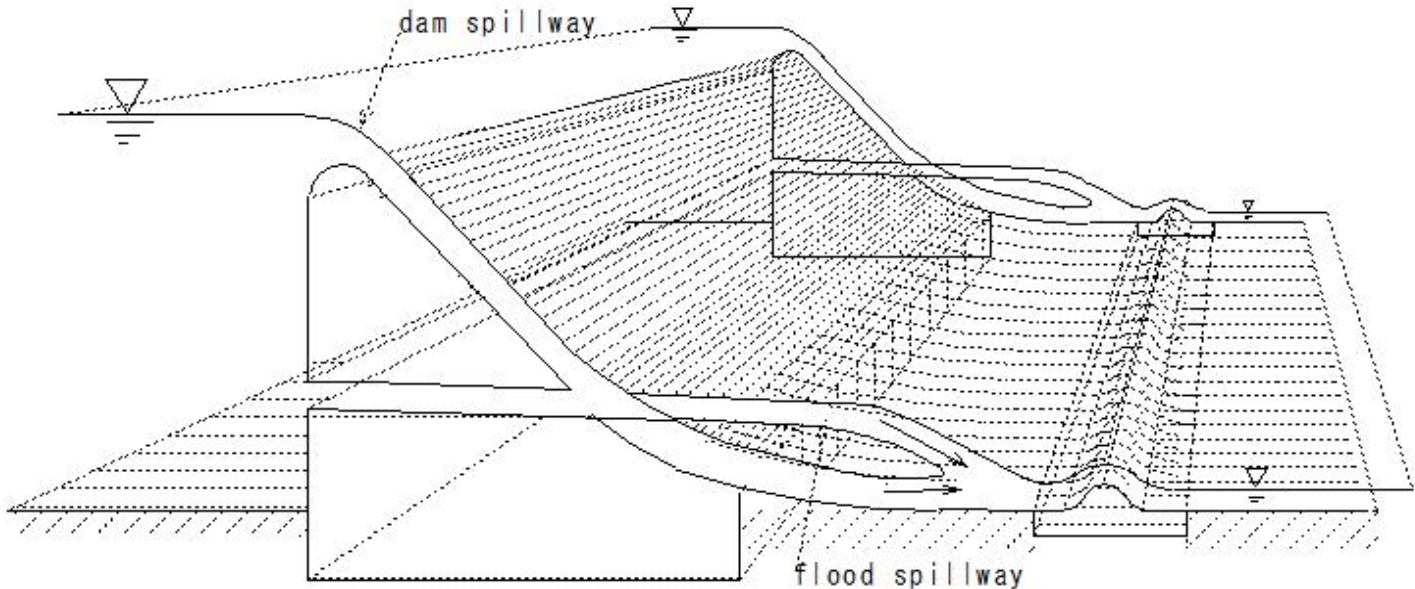
### (D180)design flood discharge

design flood discharge

used in dam design

- Concrete dam probability: flood volume that occurs once in 100 years
- Flood dam probability: flood volume that occurs once every 200 years
- Dam spillway

Designed for safe flow swept away by a spillway



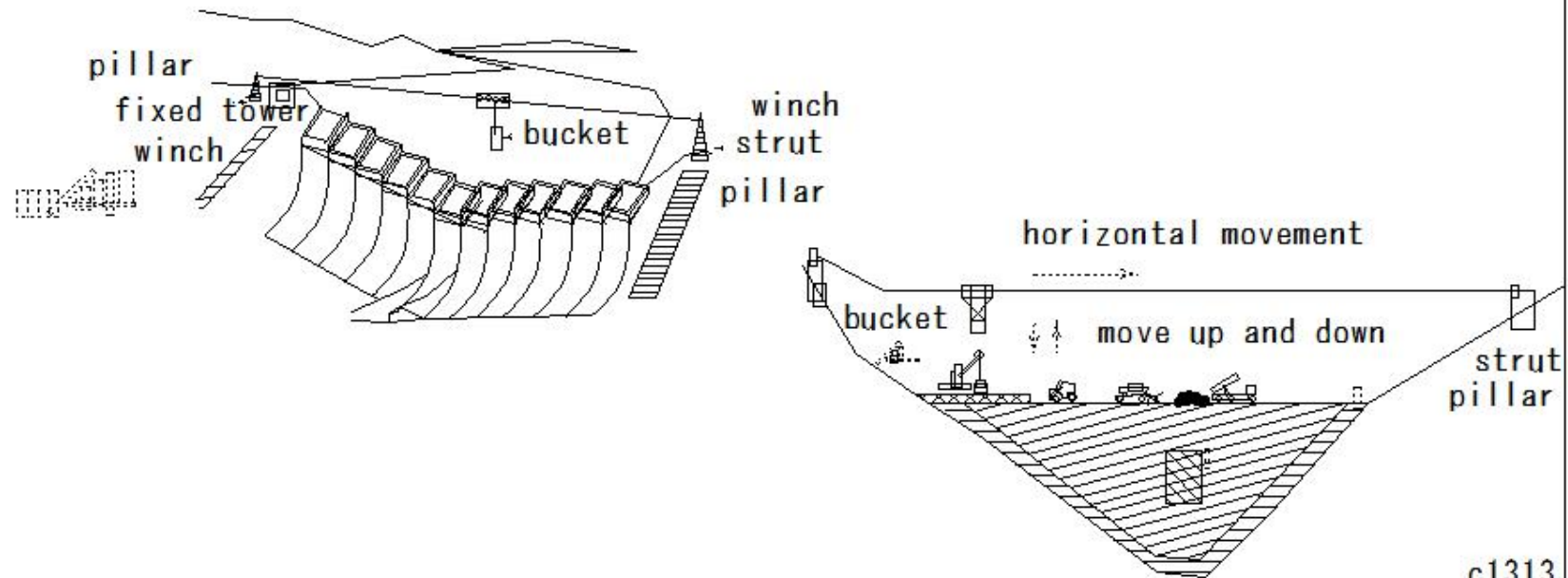
## (D181)cable crane

### (D181) cable crane

cable crane

Supports on both sides

- Wire rope for guidance
- Hoisting rope: move vertically and horizontally
- **Dam construction/river construction**

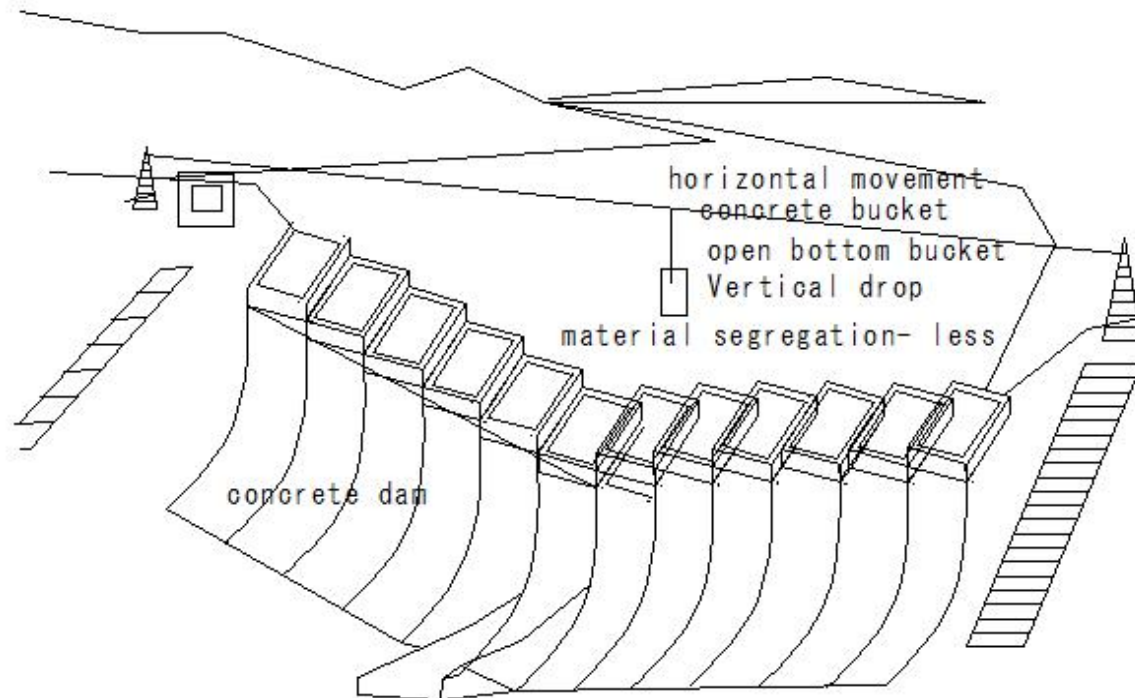


## (D182)concrete bucket

### (D182) concrete bucket

#### concrete bucket

- Transport the concrete to the pouring position while lifting it with a crane
- Dam construction: placing using a crane



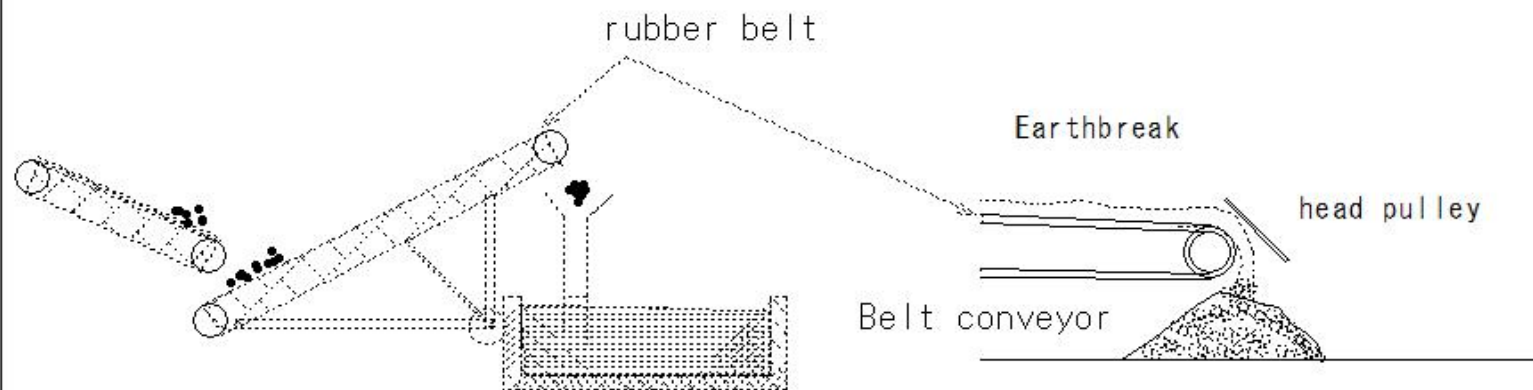


## (D183)conveyor

### (D183) conveyor

#### Conveyor

- From low to high places
- From high places to low places
- Materials Earth and sand, concrete, aggregate - Continuously transported belt conveyor



Continuous transport equipment

(D184)crusher

## (D184) crusher

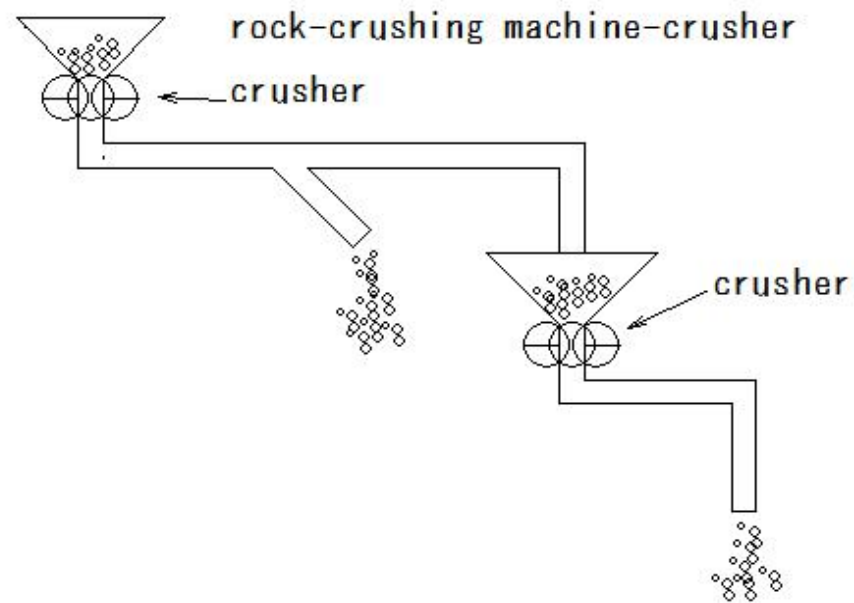
crusher

- A machine that crushes rocks into the required size: Crusher
- Large rough stone - coarse crusher - medium crusher - crusher

Crusher: Jaw crusher, gyratory crusher

Intermediate crusher: Cone crusher, impact crusher, hammer crusher, hydro cone crusher

Grinding machine: rod mill



c1330

## (D185)surge-tank

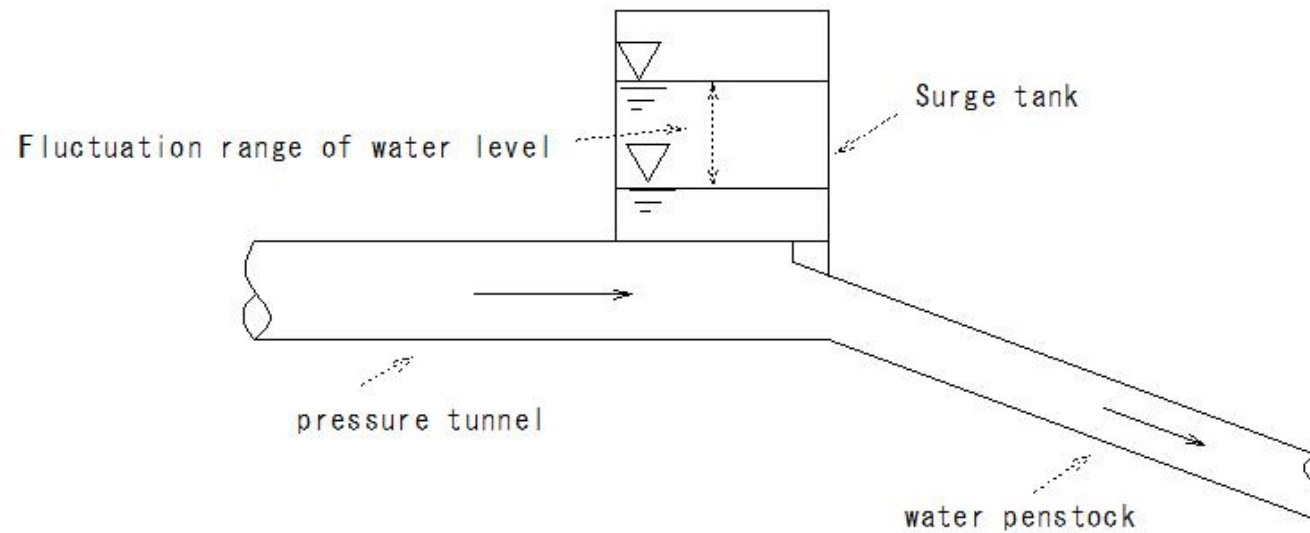
### (D185) surge-tank

surge-tank

Dam waterway power plant

- Reducing water hammer pressure in penstocks
- Absorbs fluctuations in water pressure

Fluctuation range of water level

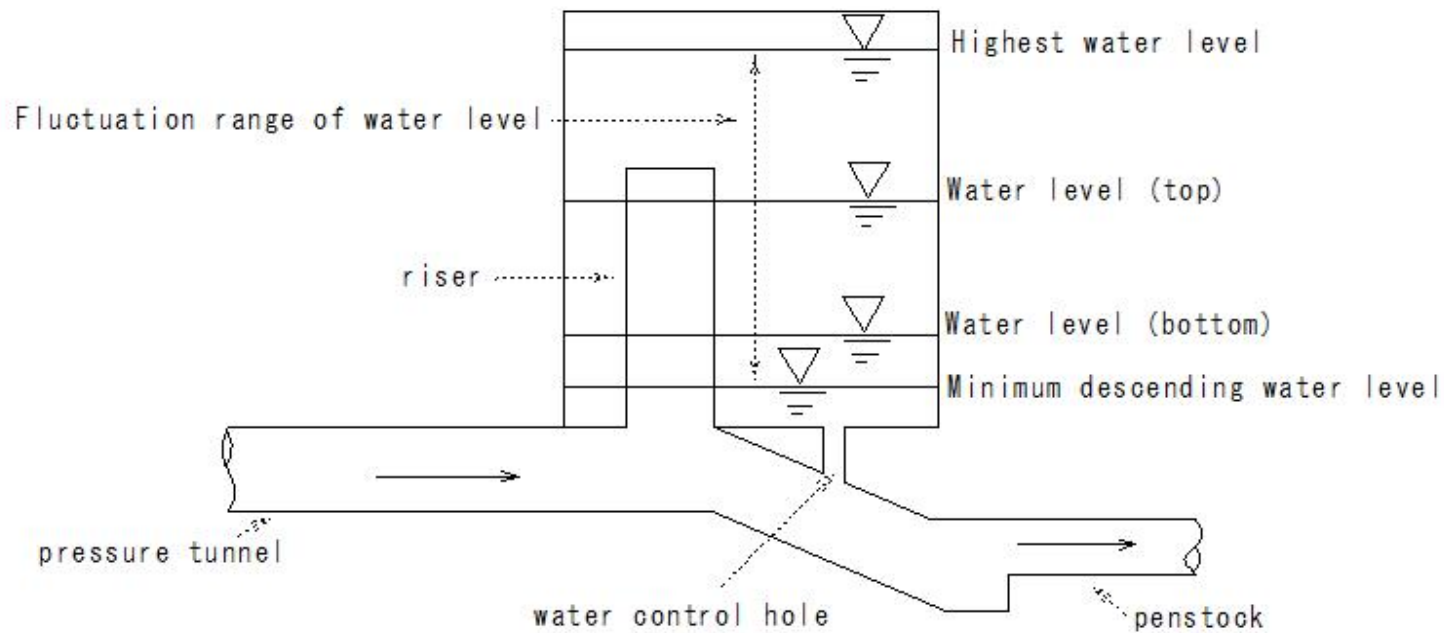


(D186) differential surge-tank

(D186) differential surge-tank

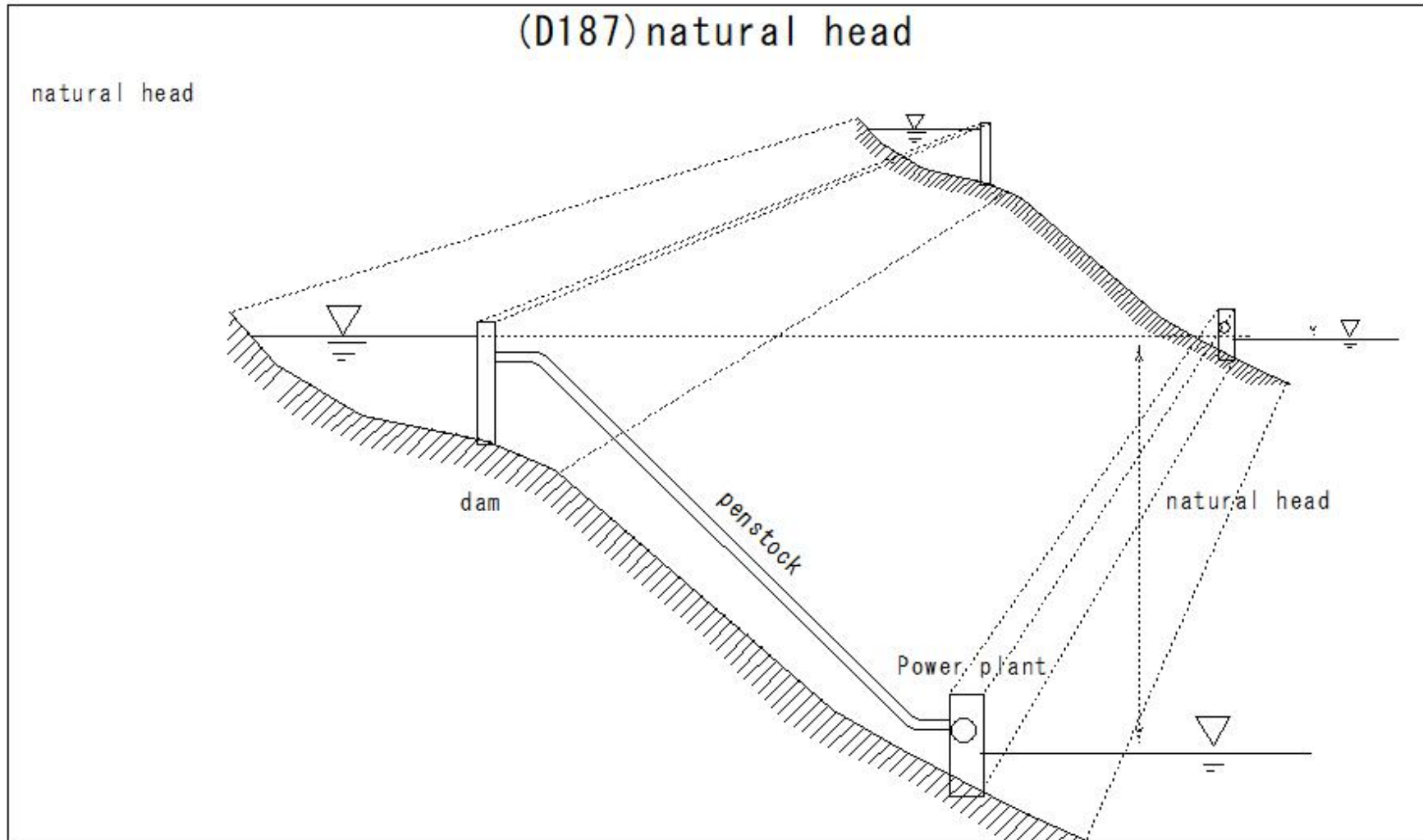
differential surge tank

- the load suddenly changes, the water level inside the riser changes suddenly. equilibrium within a short time



(D187) natural head

(D187) natural head

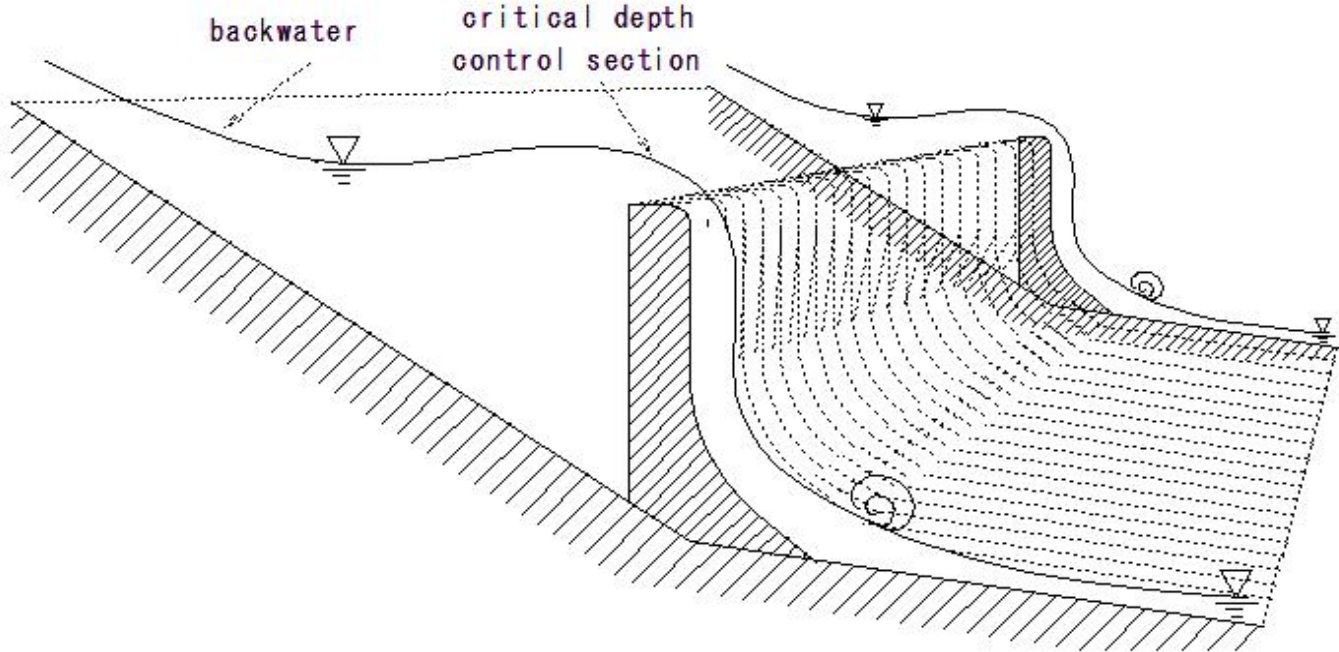


(D188)control section

(D188)control section

control section : The dominant cross section appears at the top of the weir.

Governing the flow conditions in an open channel  
Serves as the starting point for calculating drainage curves.



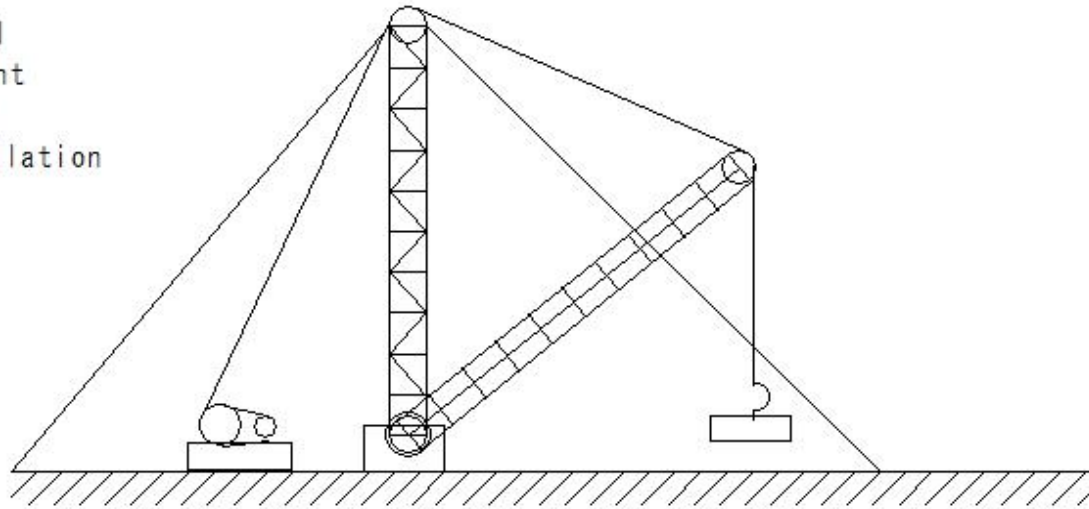


## (D189)jib crane

### (D189) jib crane

jib crane

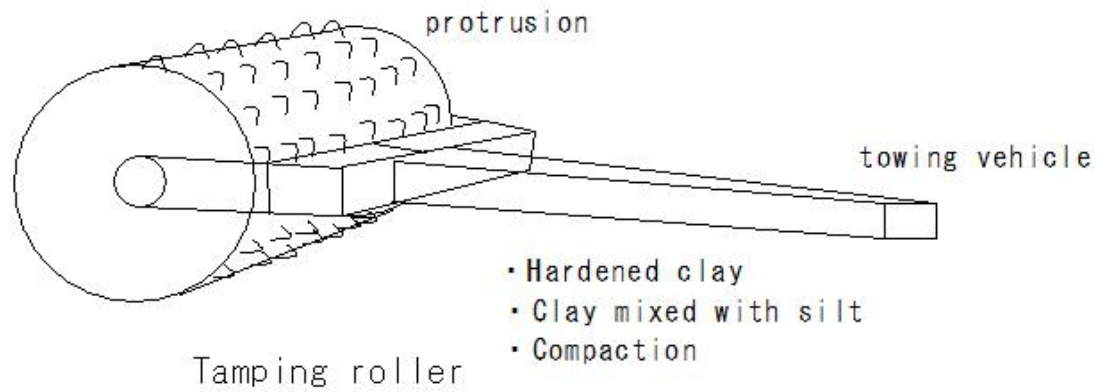
- Erection machinery
- Disassembly/assembly - Easy
- Handling - Easy
- Inexpensive
- Occupied area - small
- Dam concrete placement
- Bank protection work
- Concrete block installation



(D190) sheeps-foot roller

(D190) sheeps-foot roller

- sheeps-foot roller
- tamping roller
- Steel drum



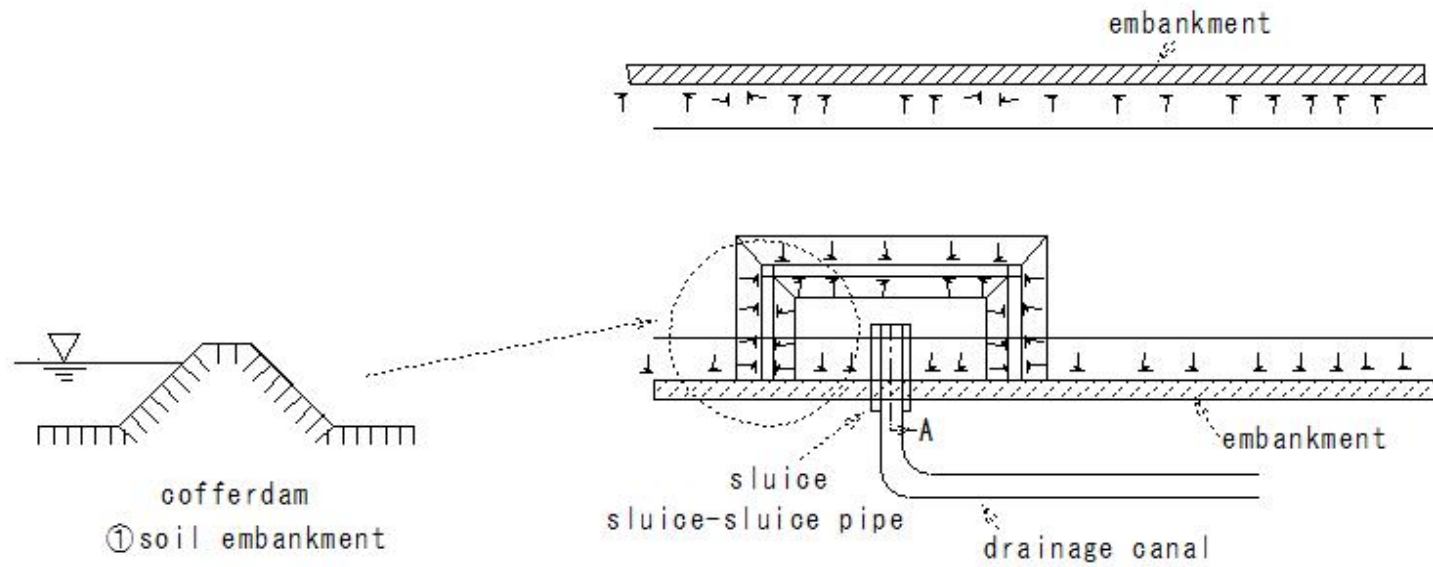
(D191)cofferdam

(D191) cofferdam

cofferdam

river construction

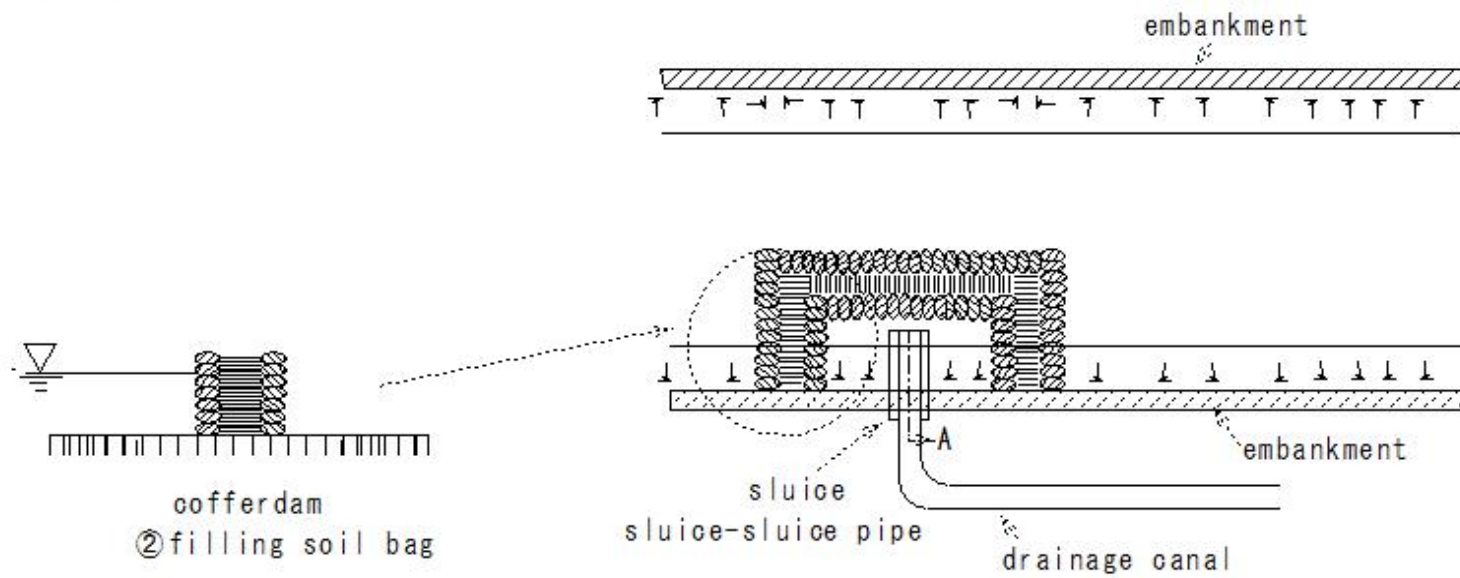
① soil embankment



(D192)cofferdam

### (D192) coffer dam

cofferdam  
river construction  
②filling soil bag



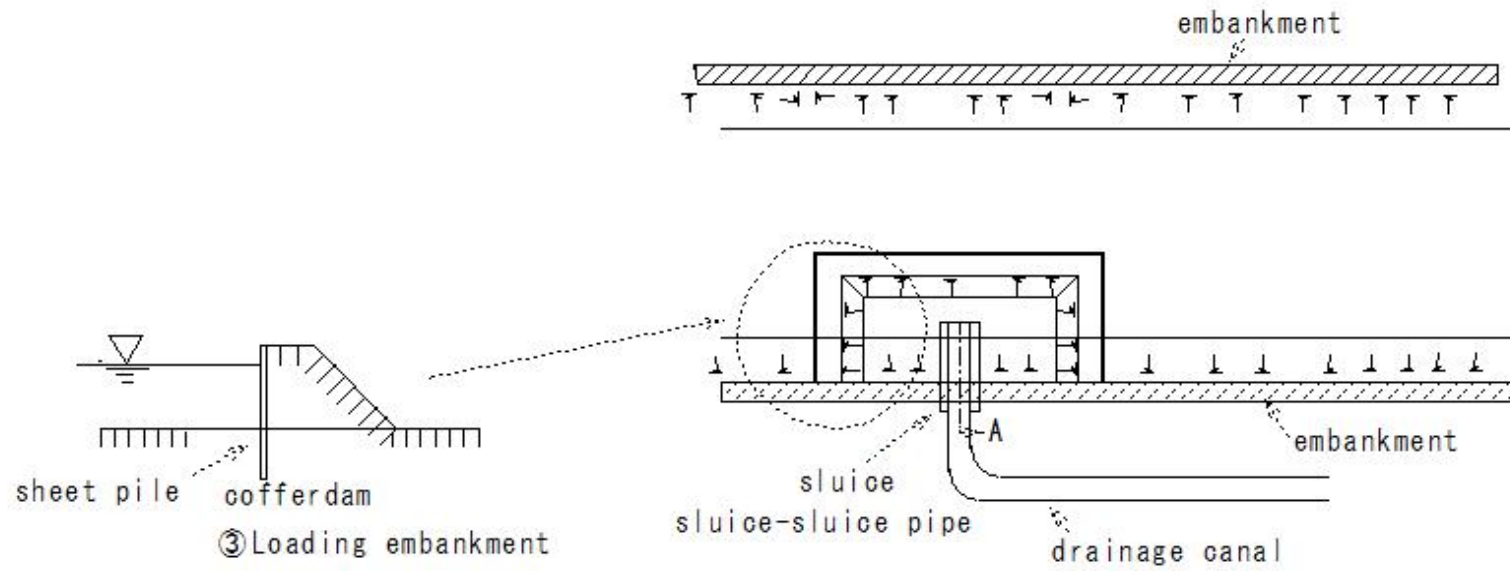
(D193)cofferdam

(D193) coffer dam

cofferdam

river construction

③ Loading embankment



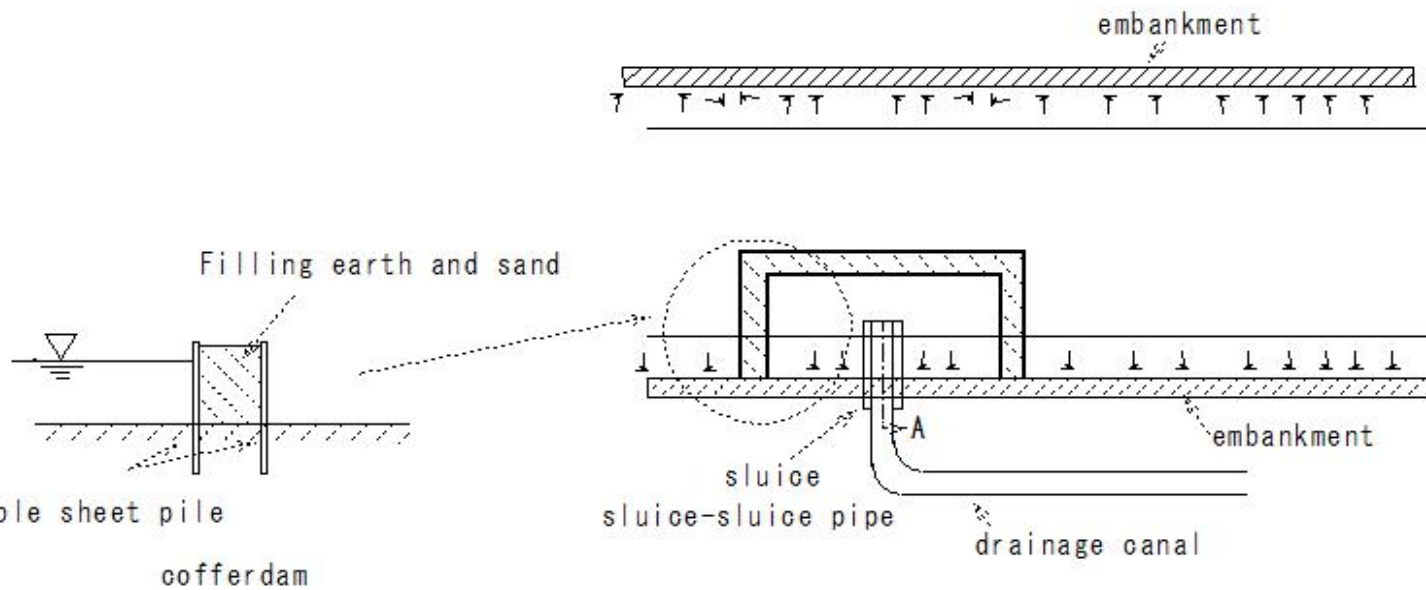
(D194)cofferdam

(D194) cofferdam

cofferdam

river construction

④ double sheet pile





(D195)closing dyke

## (D195)closing dyke

closing dyke

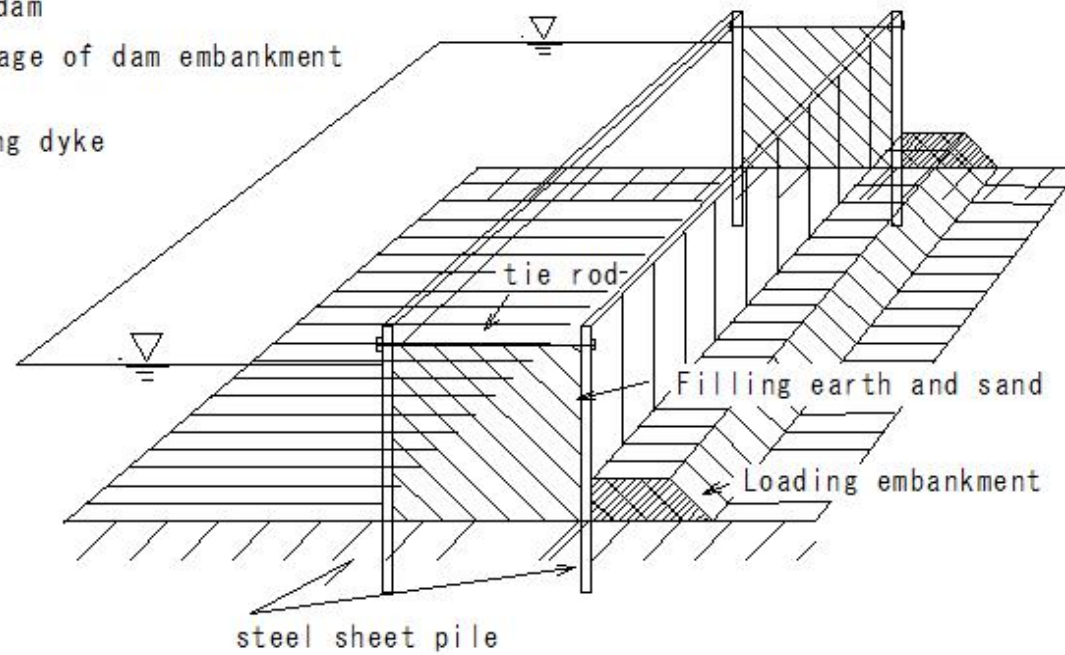
Changing the waterway

Tributary river cofferdam

Purpose of water stoppage of dam embankment

river cross section

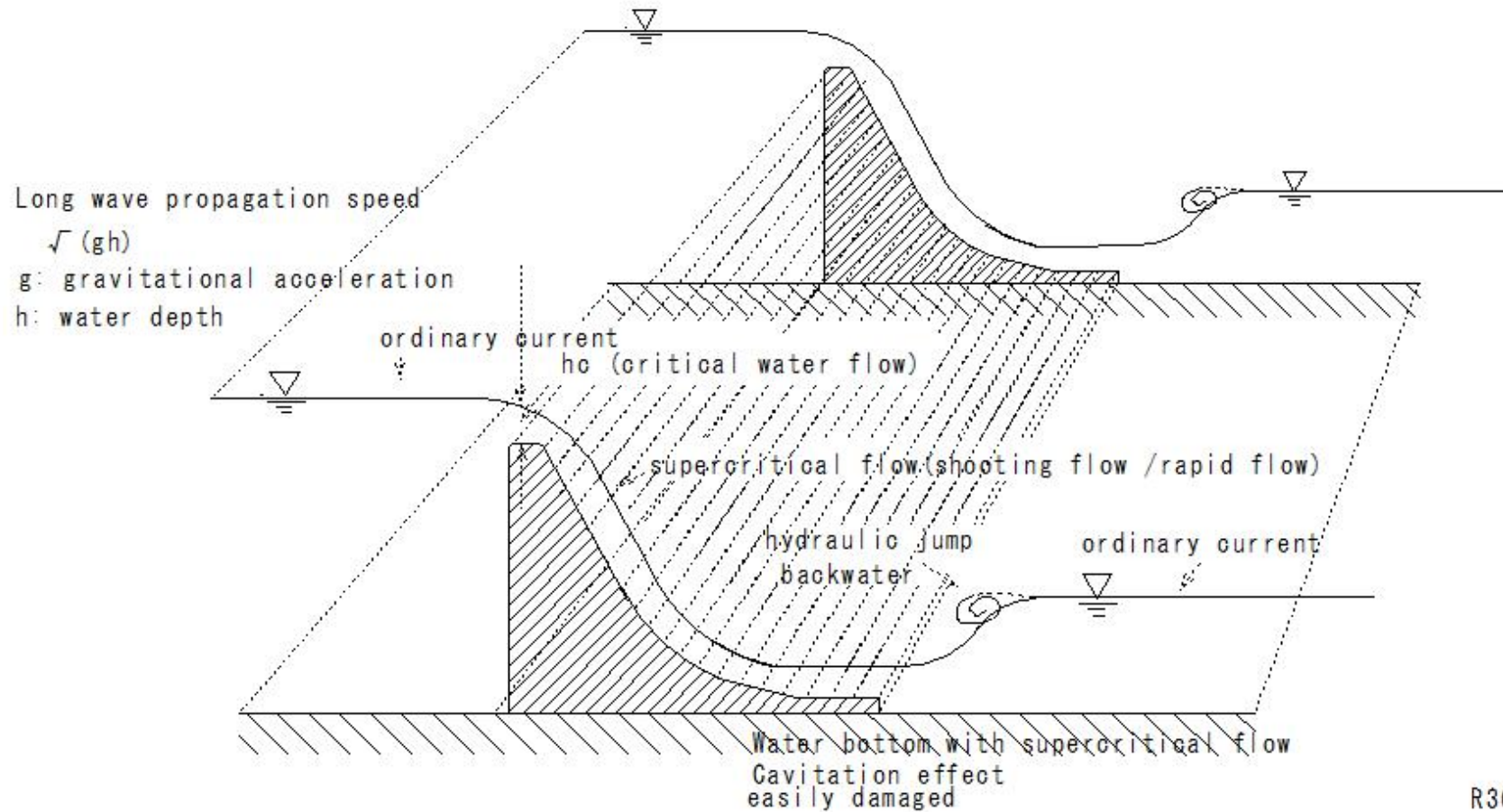
Steel sheet pile closing dyke



R365

(D196)supercritical flow(shooting flow /rapid flow)

(D196)supercritical flow(shooting flow /rapid flow)

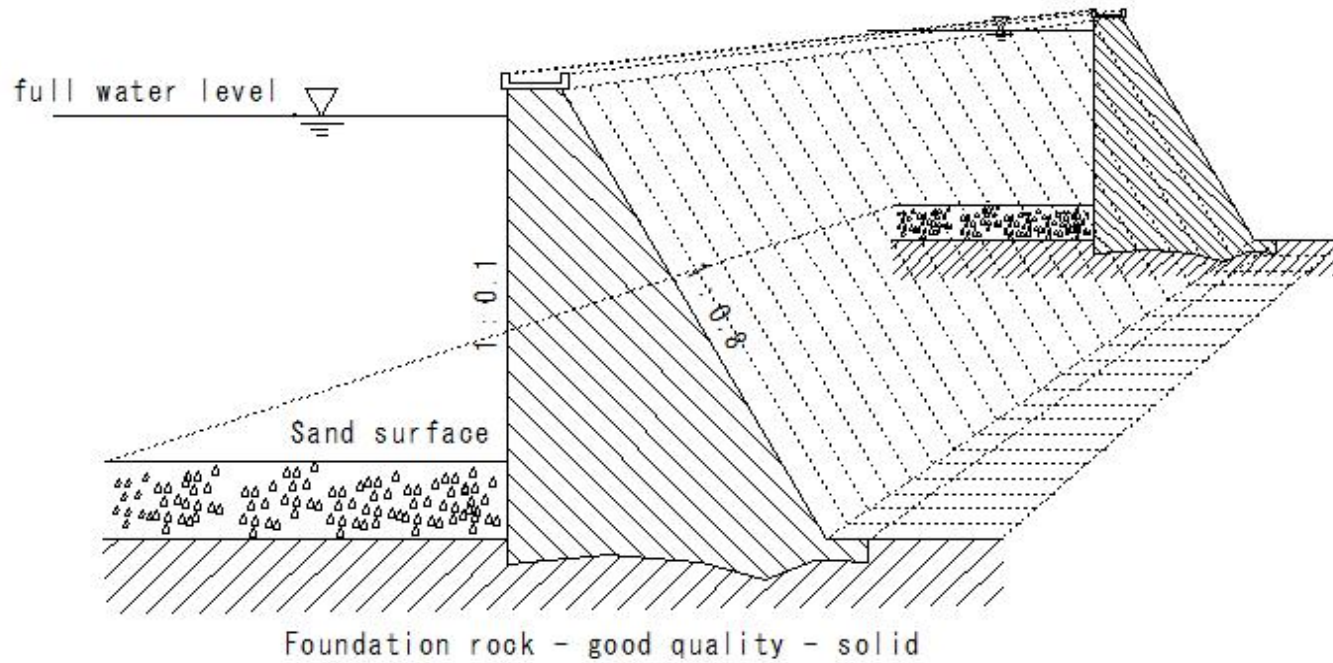


(D197)gravity dam

(D197)gravity dam

gravity dam

- Concrete weight of the dam body
- Water pressure: Withstands external forces
- Foundation rock - good quality - solid



(D198)water-intake

(D198) water-intake

water intake

Taking water for a purpose from a source

source

river  
lake  
reservoir

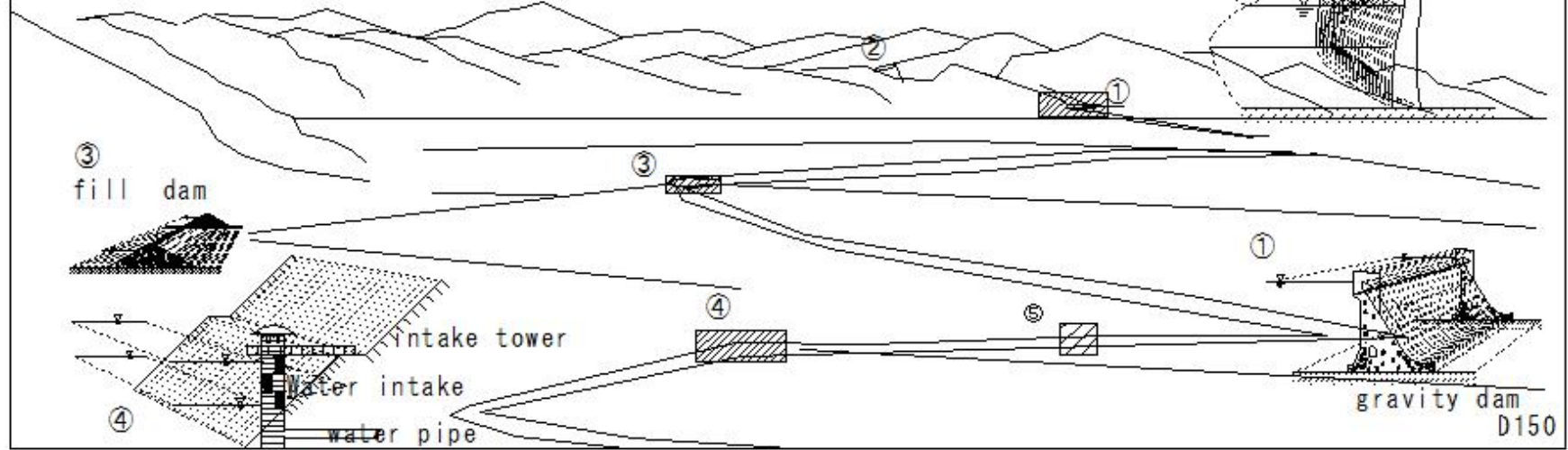
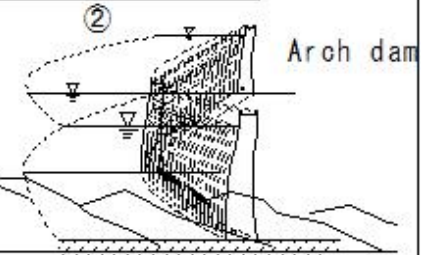
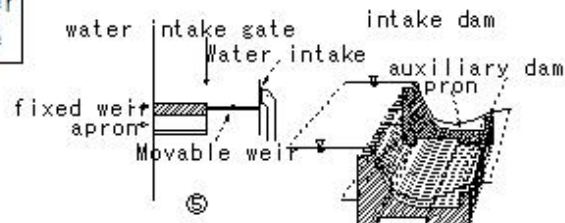
water intake dam  
water intake tower  
water intake gate

Water intake

waterway

purpose use

Power plant  
water supply  
industrial water  
irrigation water



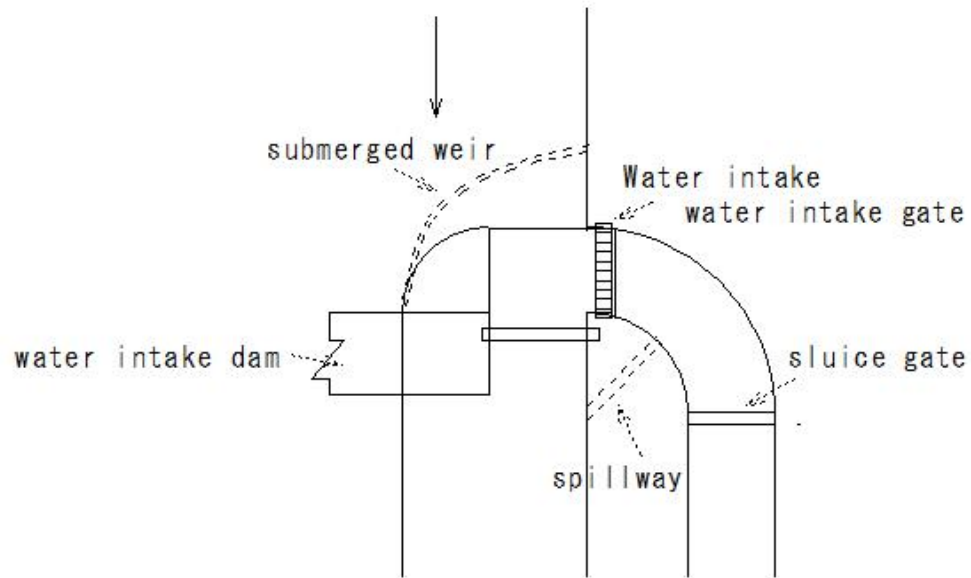
D150

(D199)intake

### (D199) intake

intake

An inlet that introduces water from a river, lake, or reservoir into a waterway





(D200) intake dam

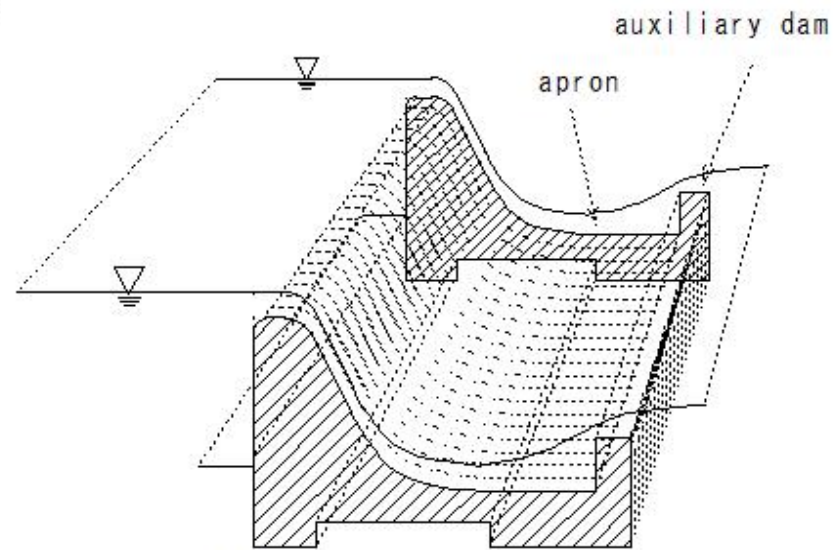
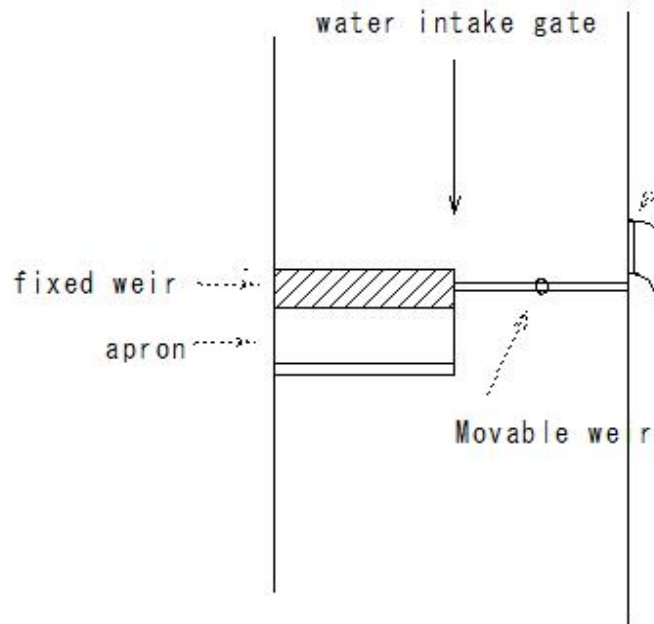
### (D200) intake dam

intake dam

Dams to make it easier to introduce river water into waterways

A dam is an overflow-shaped weir.

Combined with mobile weir



Fixed weir cross section



(D201) intake dam

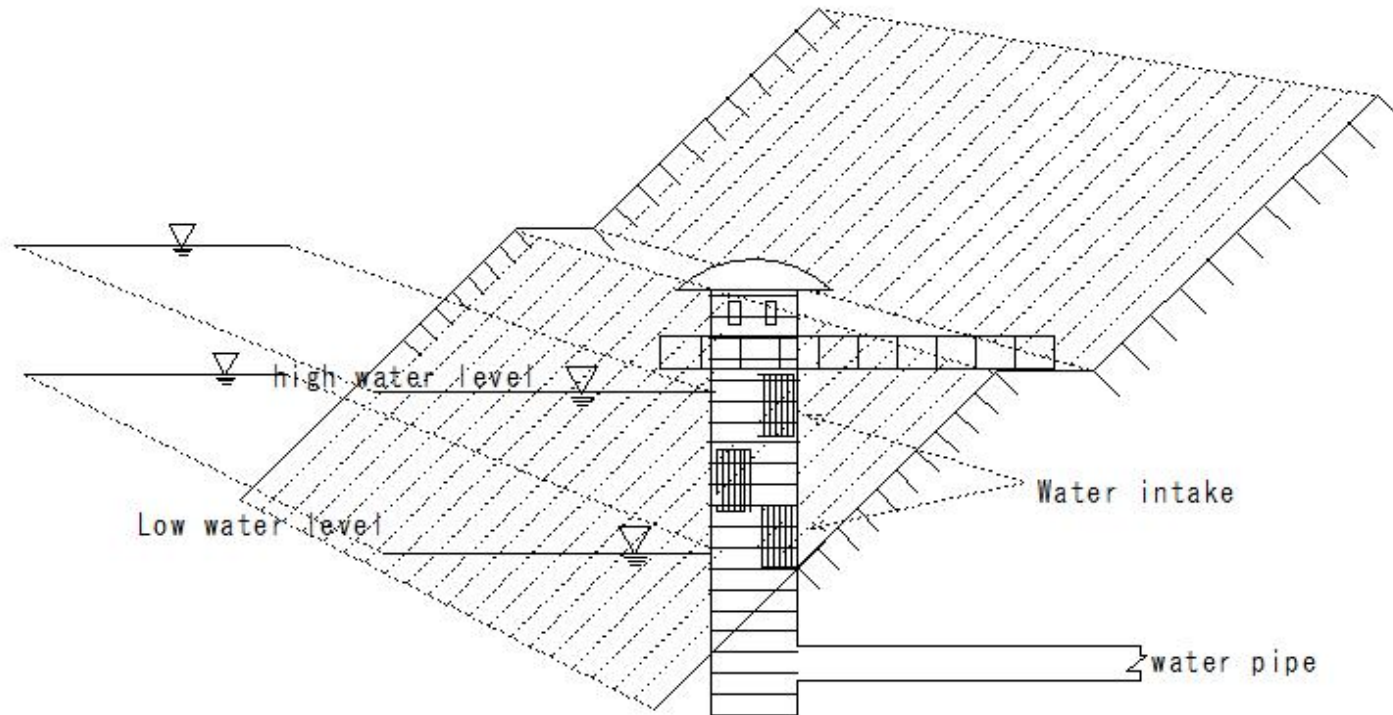
(D201) intake dam

intake tower

Tower for taking water at any depth from rivers, lakes, and reservoirs

A tower built underwater

Various water intakes are provided to accommodate changes in water level.



(D202)dredging(Pump dredger)

(D202) dredging (Pump dredger)

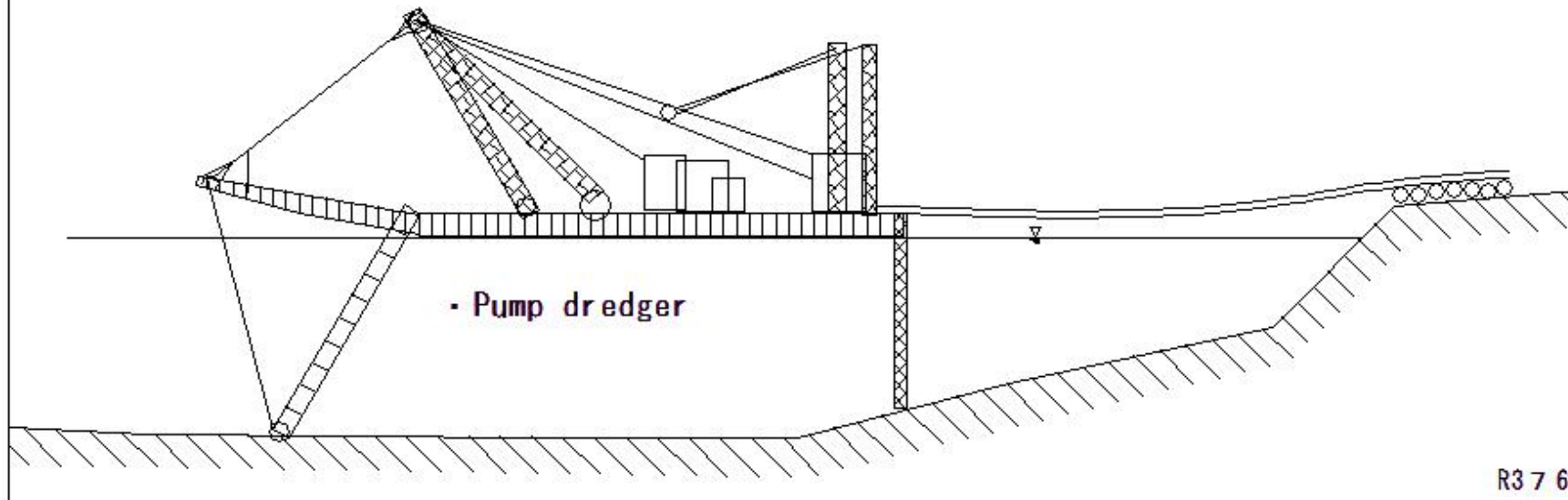
dredging

① Pump dredger

Suction up dirt etc. with a pump

Digging soil involves transportation and disposal work

working dredger



(D203)dredging(Bucket dredger)

(D203) dredging (Bucket dredger)

dredging

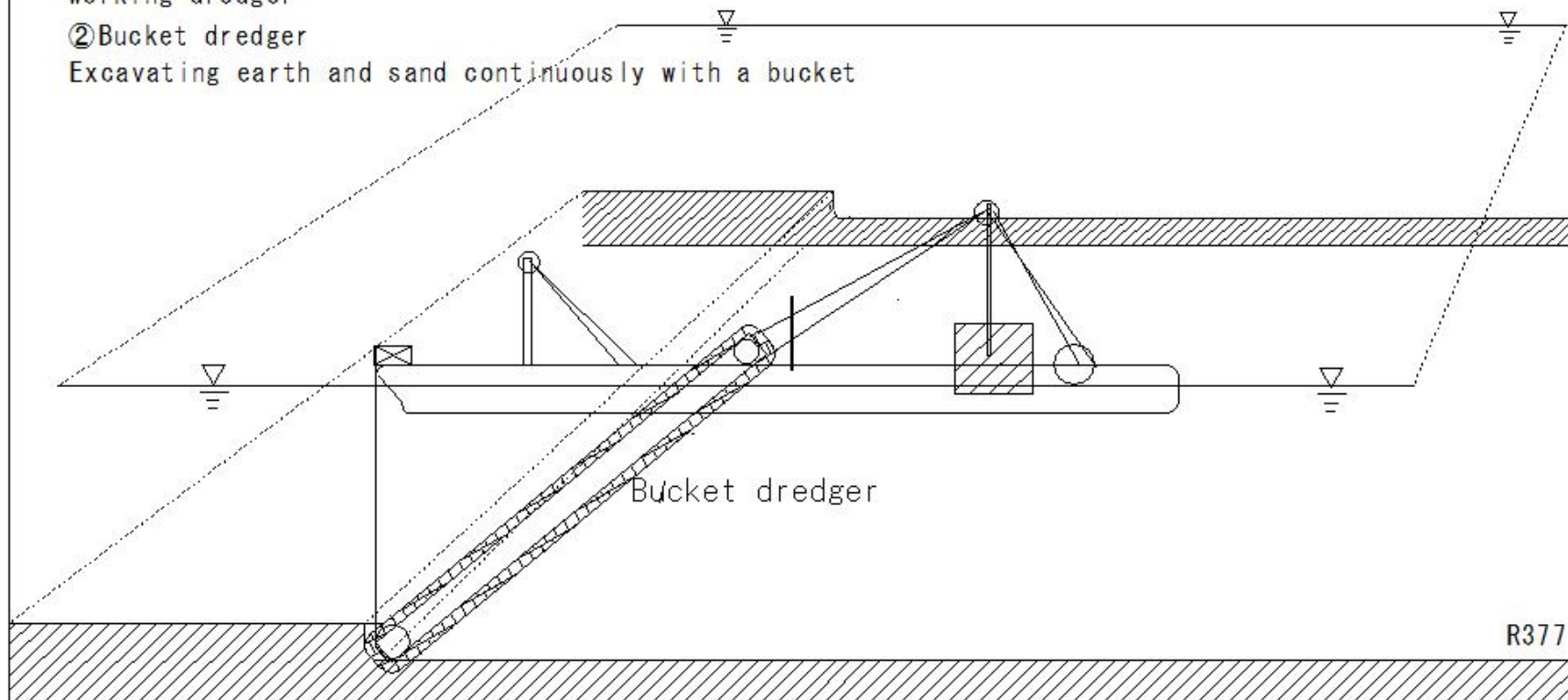
Digging soil involves transportation and disposal work

- Involves transportation and disposal work

working dredger

② Bucket dredger

Excavating earth and sand continuously with a bucket



(D204)dredging(Grab dredger)

(D204) dredging (Grab dredger)

grab dredger

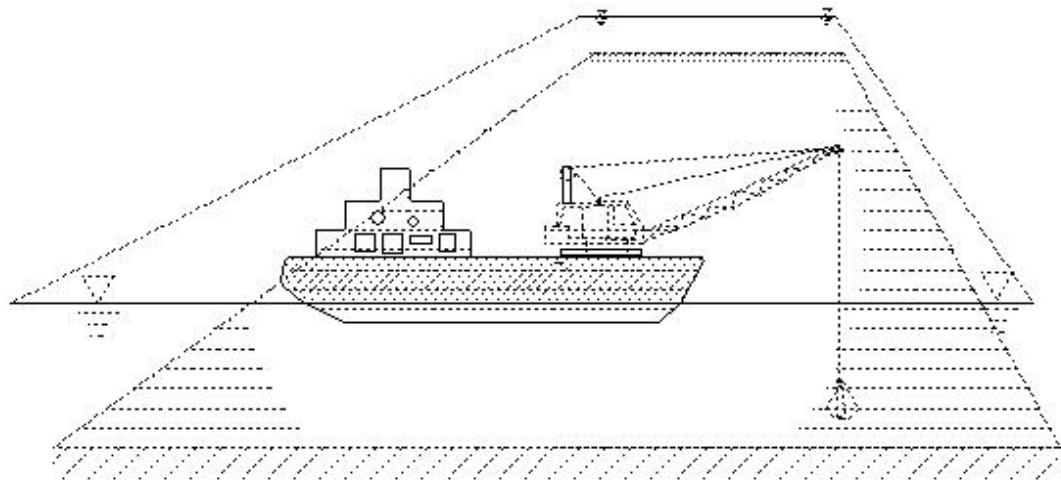
Digging soil involves transportation and disposal work

- Involves transportation and disposal work

working dredger

③ Grab dredger

excavating with a grab bucket



Grab dredger

(D205)dredging(Dipper dredger)

(D205) dredging (Dipper dredger)

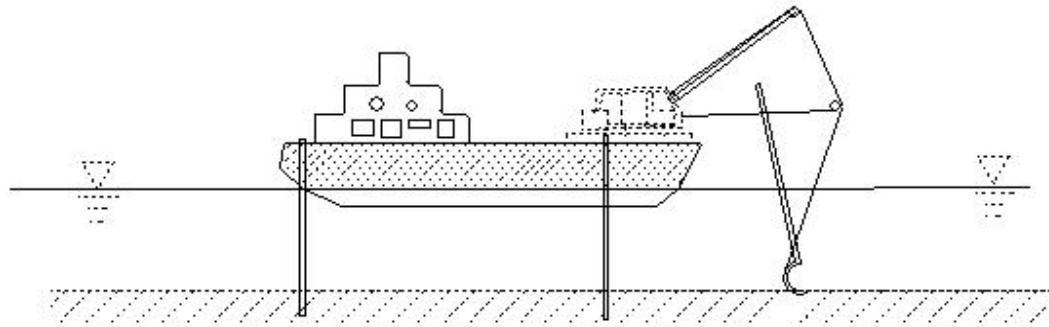
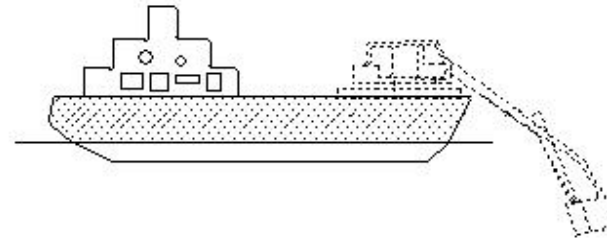
dredging

Digging soil involves transportation and disposal work

- Involves transportation and disposal work
- working dredger

④ Dipper dredger

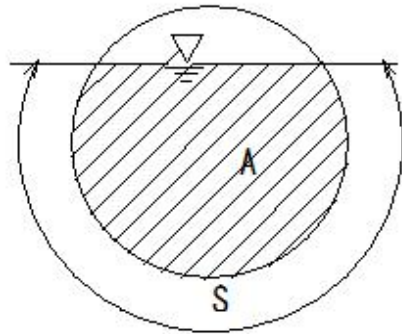
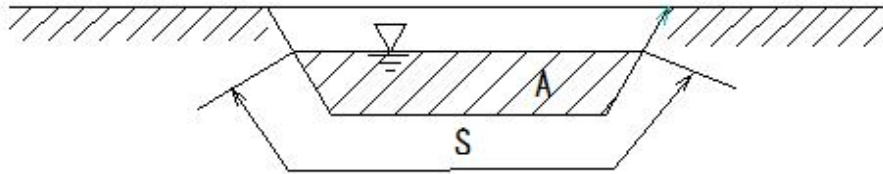
Excavating hard soil with a dipper



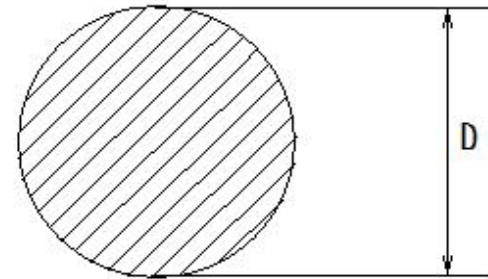
Dipper dredger

(D206)wettered perimeter

(D206)wettered perimeter



open channel



$$R = A/S = (\pi D^2/4) / (\pi D) = D/4$$

pipeline

Cross-sectional area of flow: A

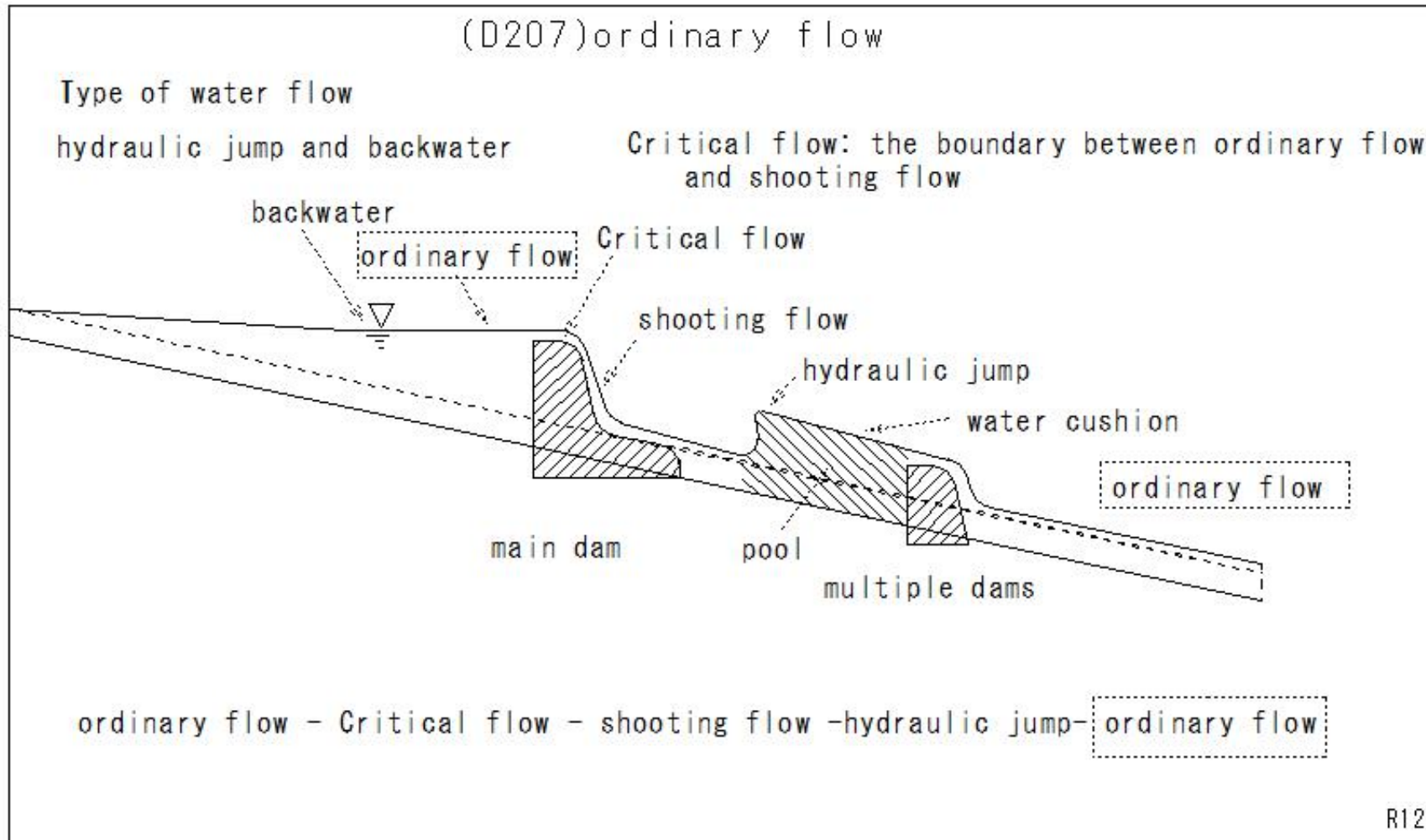
Hydraulic radius: R

$$R = A/S$$

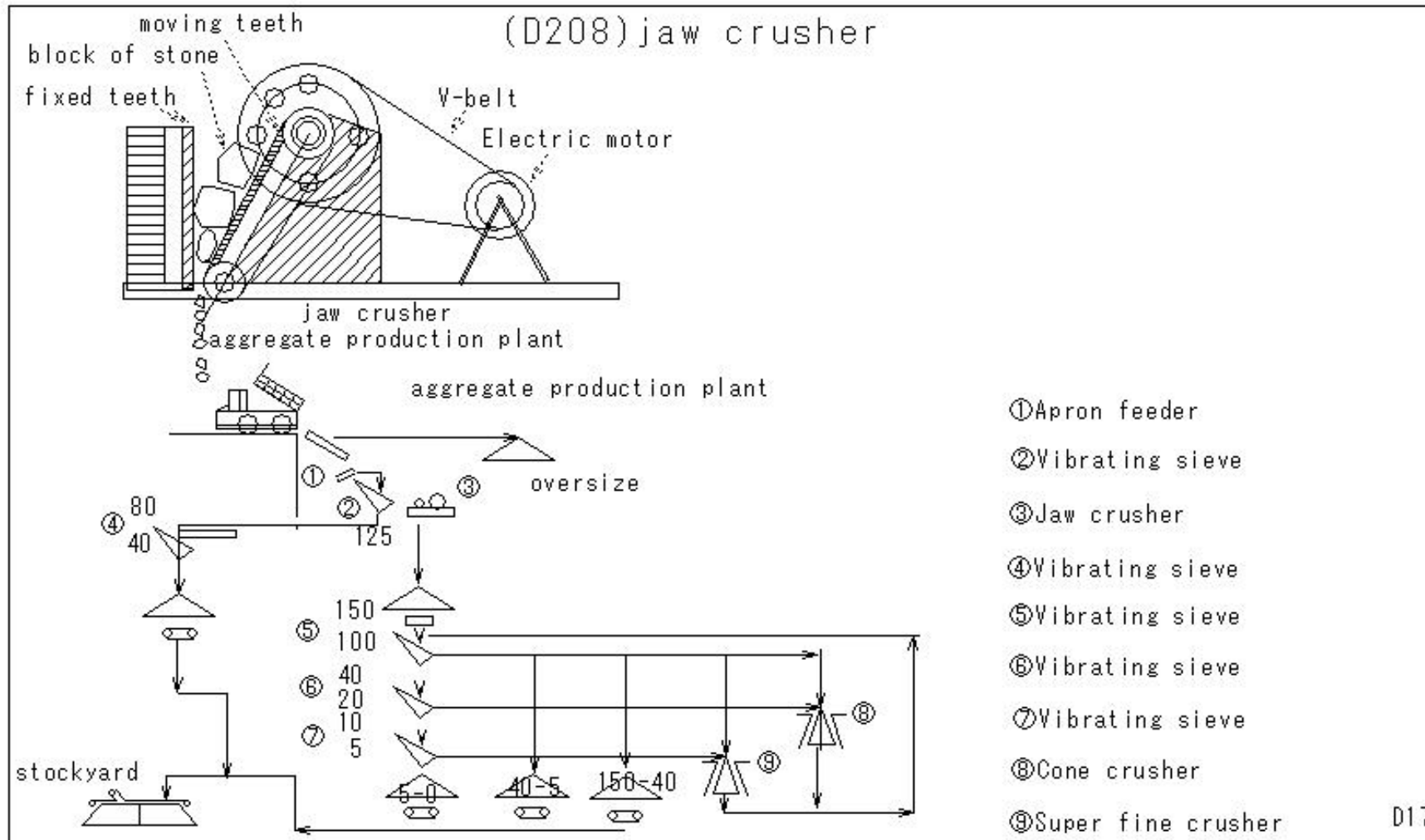
Wettered perimeter: S



(D207)ordinary flow

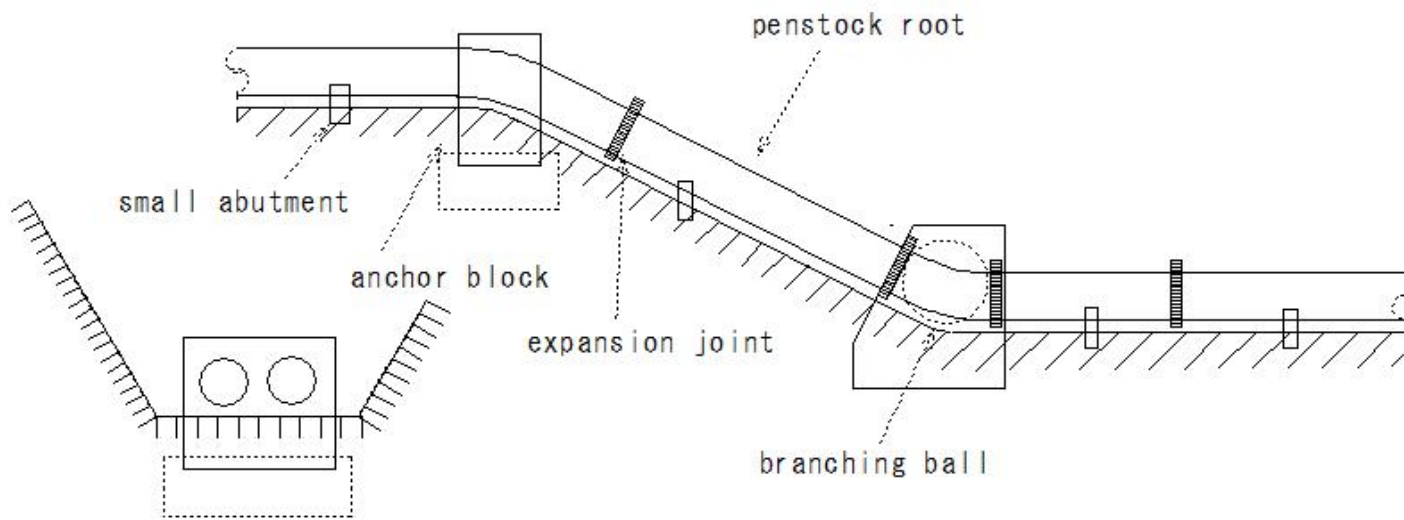


(D208)jaw crusher



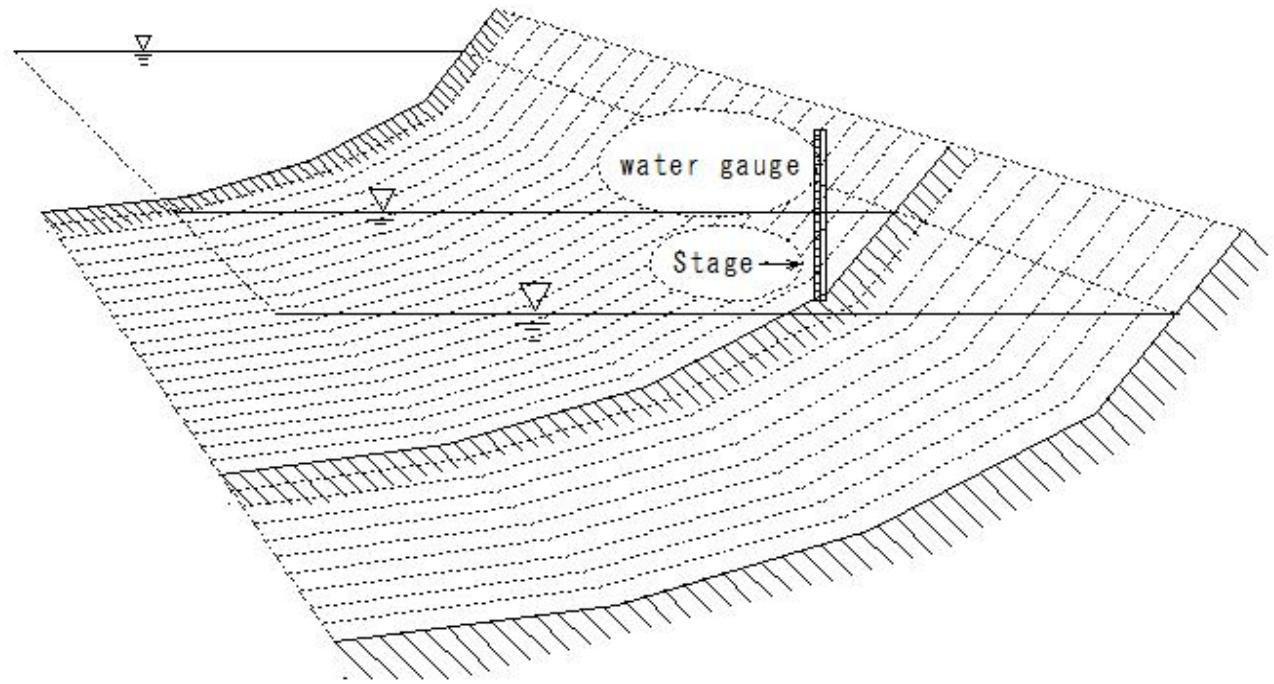
(D209)penstock root

(D209) penstock root



(D210)stage

(D210) stage



r385

(D211)water-level recorder

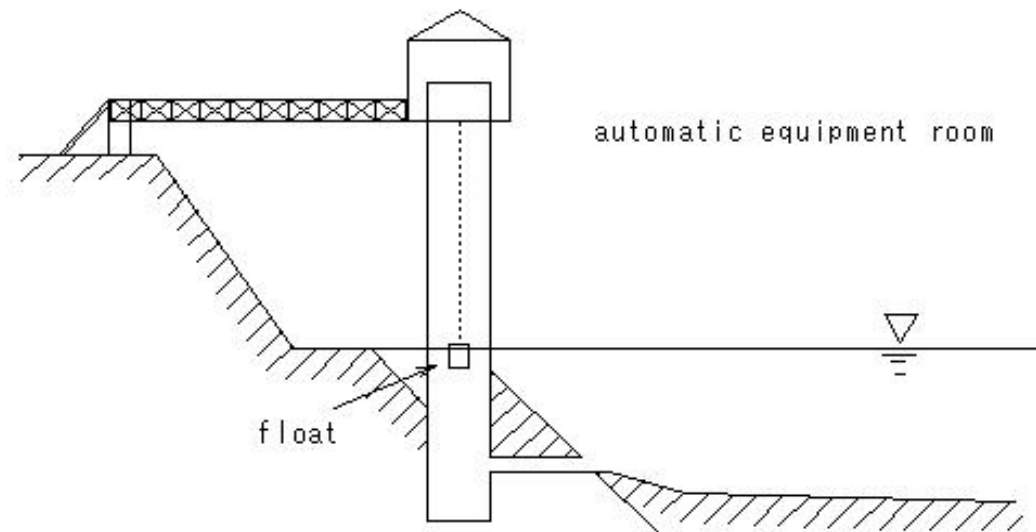
(D211)water-level recorder

water-level recorder

water level gauge

instrument for measuring water level

Self-recording water level gauge



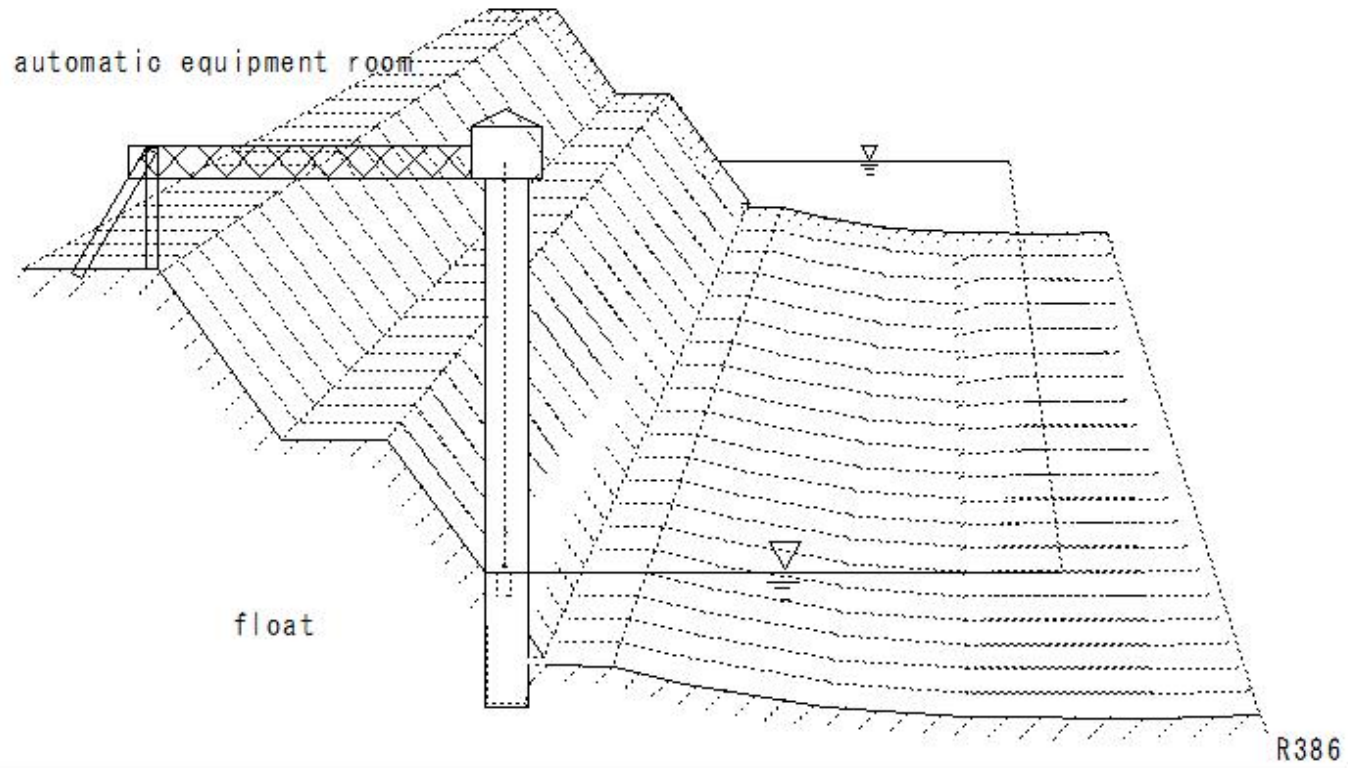
(D212)water-level recorder

(D212)water-level recorder

water-level recorder

instrument for measuring water level

Self-recording water level gauge





(D213)water hammmmer

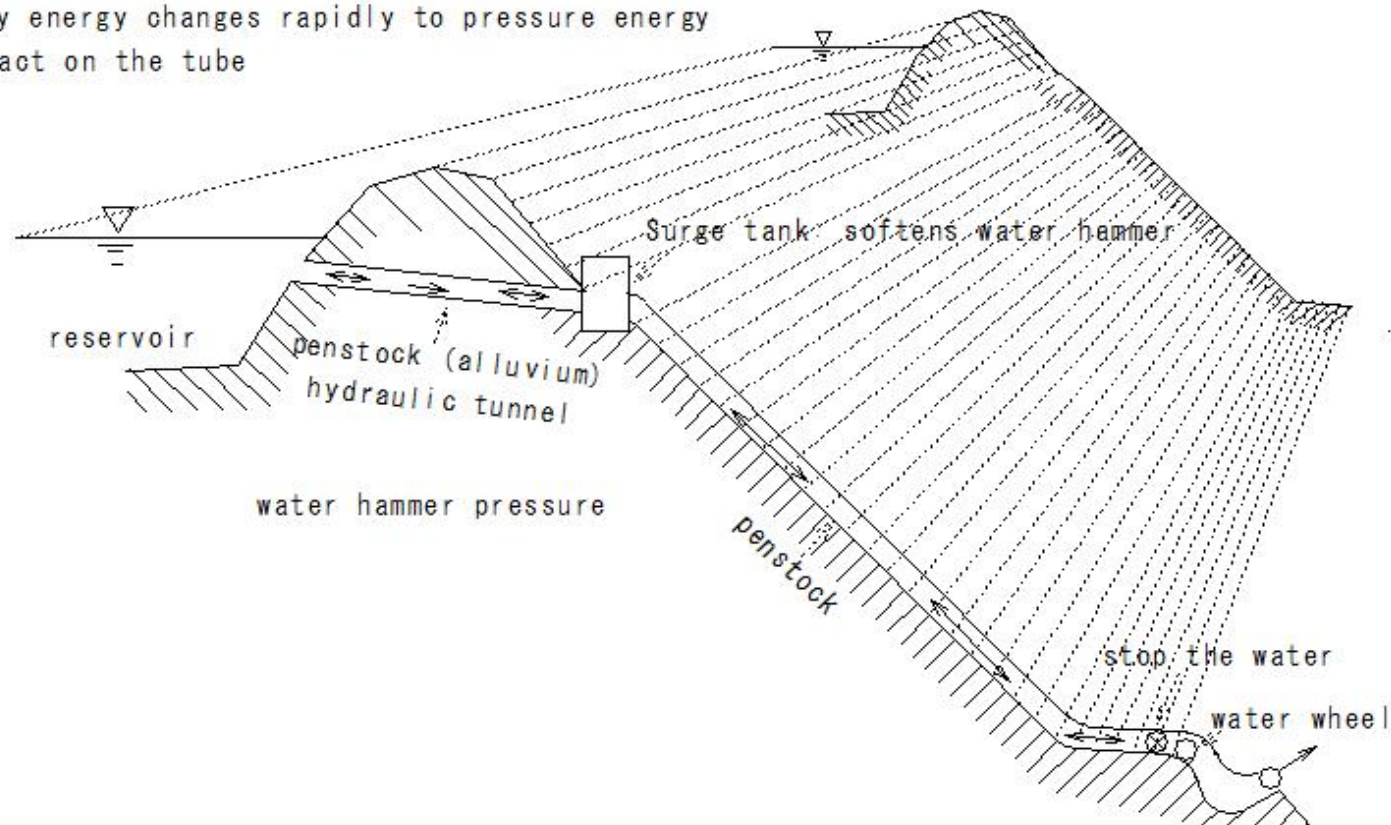
(D213)water hammmmer

water hammer

stop the water suddenly

Velocity energy changes rapidly to pressure energy

big impact on the tube

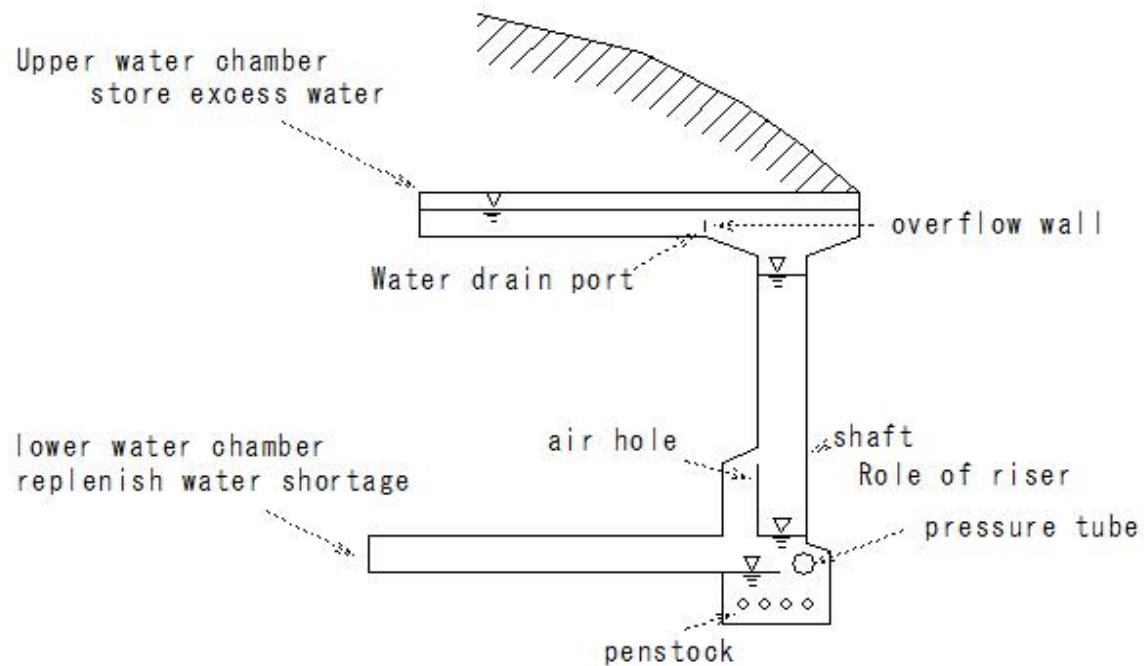


## (D214)chamber surge tank

### (D214)chamber surge tank

chamber surge tank

- Water hammer pressure gives a large impact to the pressure channel
- Upper and lower water chambers: Absorbs water hammer pressure

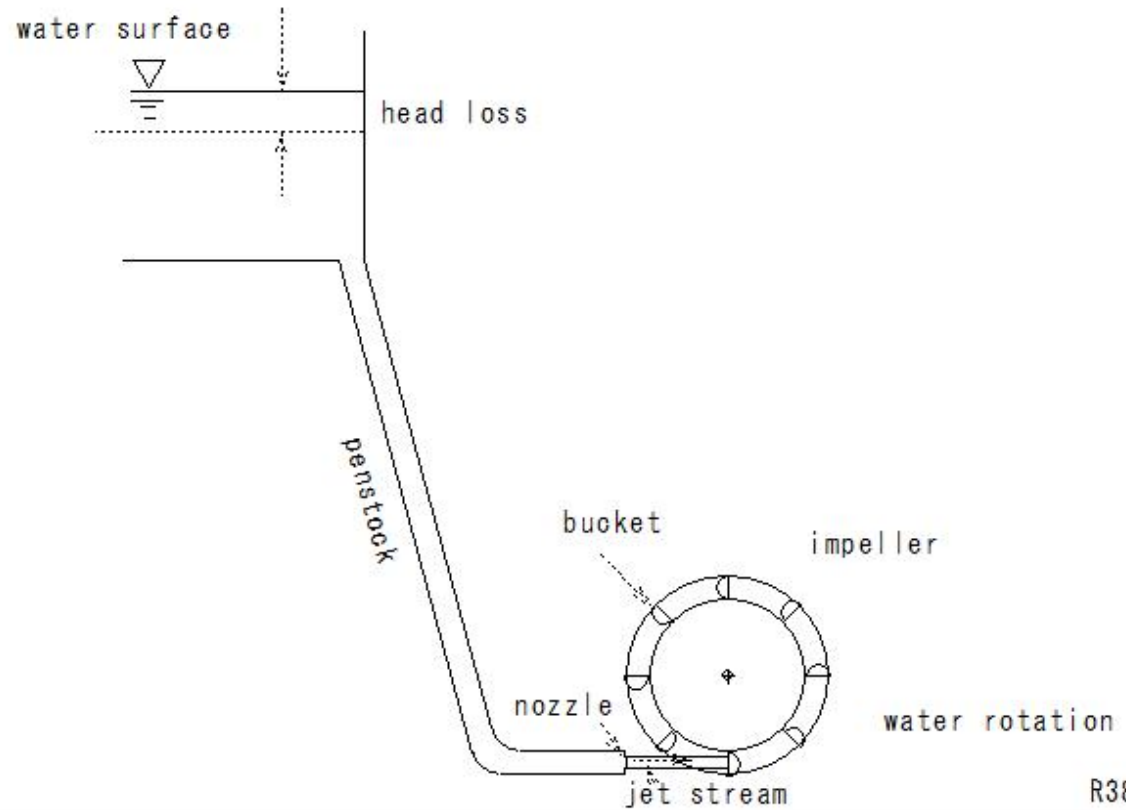


(D215)hydraulic turbine

(D215)hydraulic turbine

hydraulic turbine

Generate electricity by operating a directly connected generator



R389

(D216)efficiency of hydraulic turbine

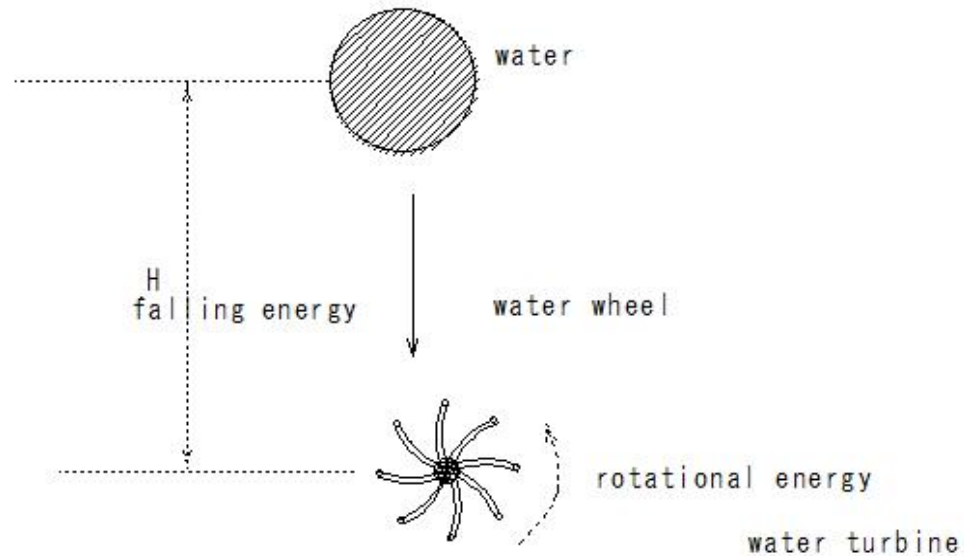
(D216)efficiency of hydraulic turbine

efficiency of hydraulic turbine

• Water from penstock - water wheel runner - high speed rotation - power generation

water energy rotational energy

Degree - Efficiency of a water wheel



(D217)gate

(D217) gate

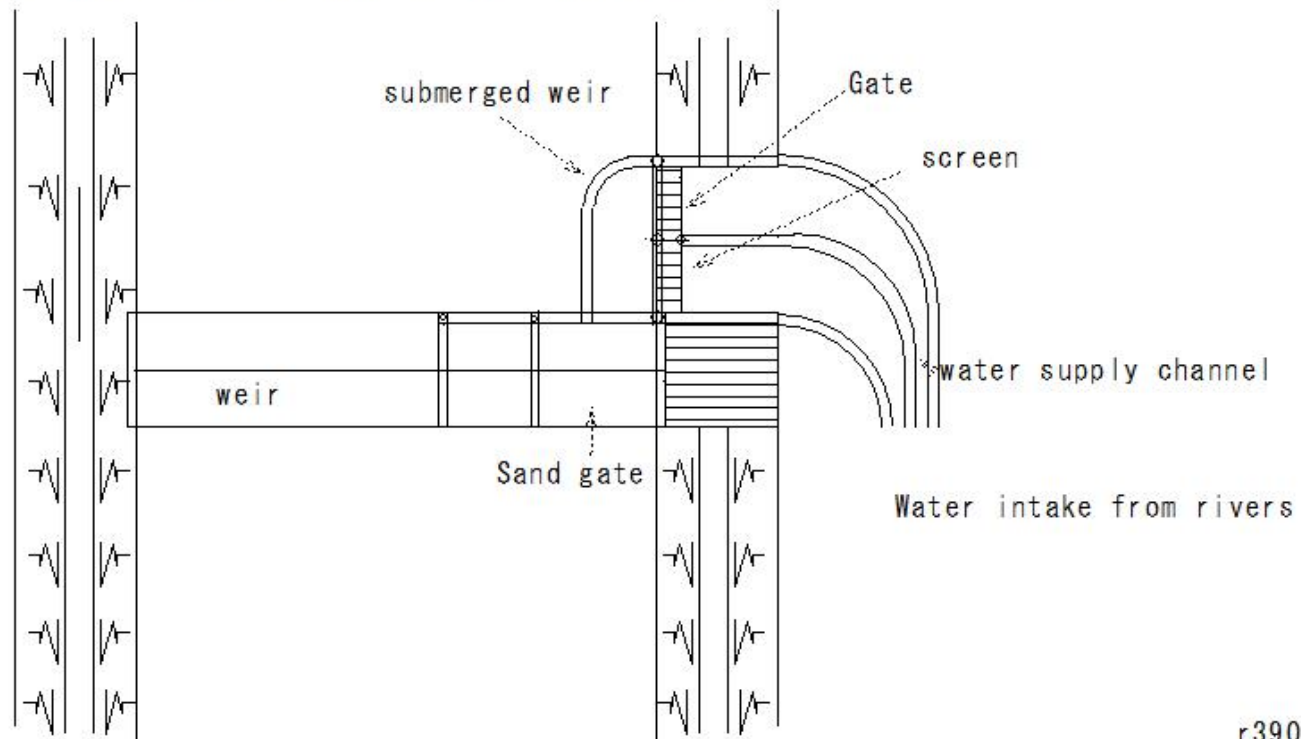
gate

discharge adjustment

water intake

for ship navigation

Movable doors installed across rivers, canals, and embankments

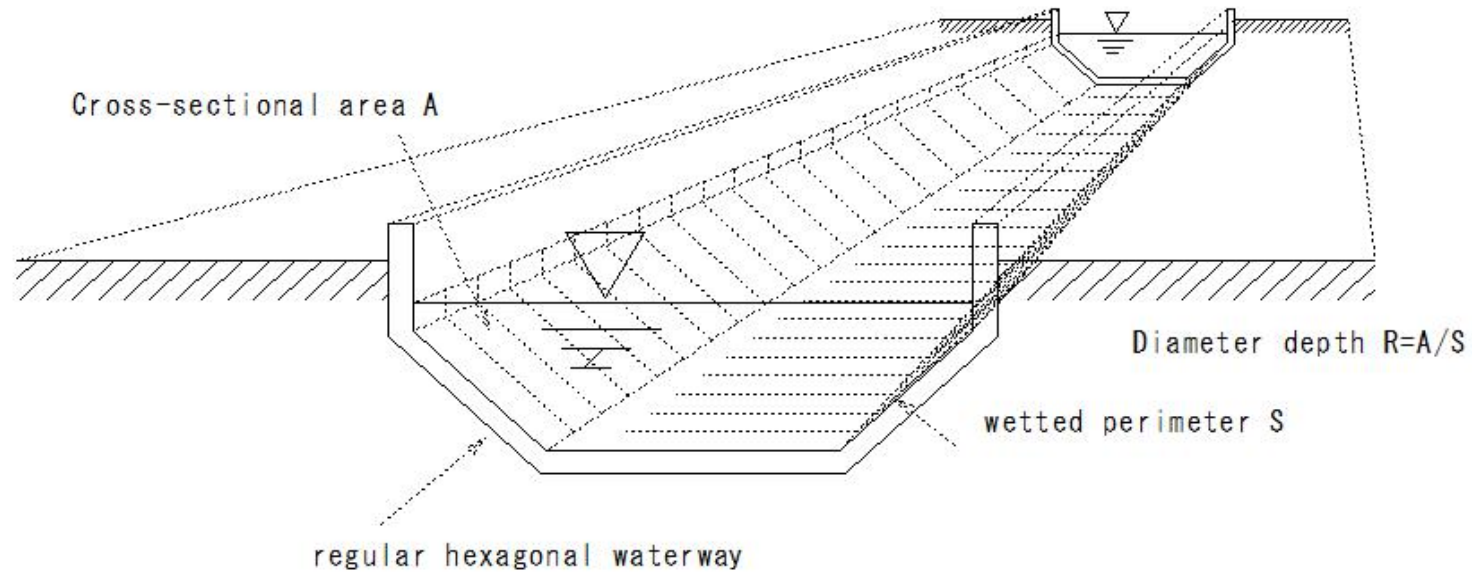


(D218)best hydraulic cross-section

(D218)best hydraulic cross-section

best hydraulic cross-section

Channel cross section that allows the largest discharge to flow with a certain flow area

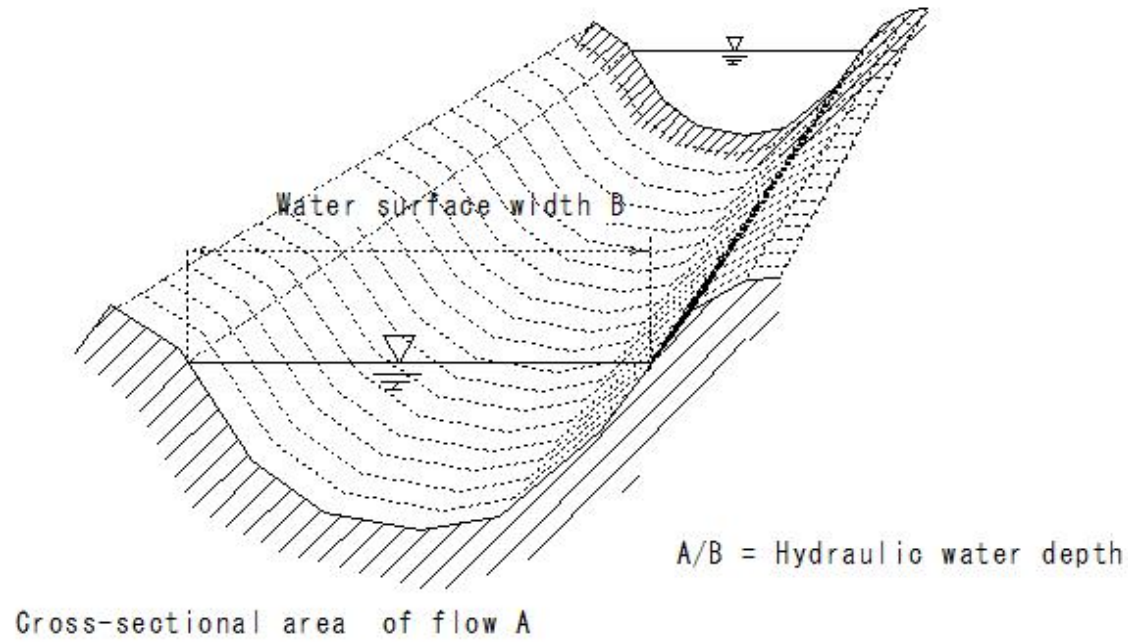




(D219)Hydraulic water depth

(D219)Hydraulic water depth

Hydraulic water depth

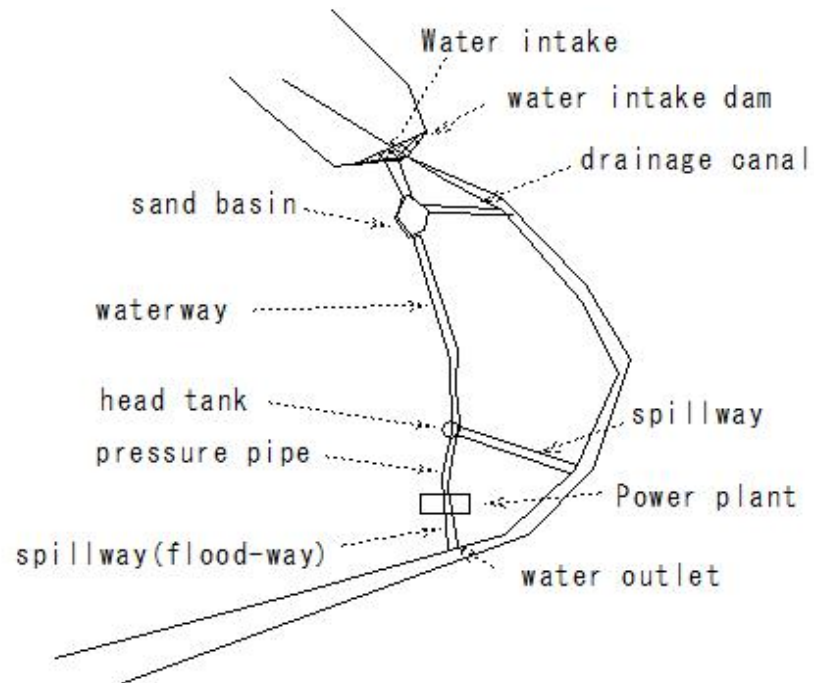


(D220)conduct type water power

(D220)conduct type water power

conduct type water power

Guide river water through a channel to a point where a large head can be obtained.  
Generate electricity by dropping it down with a pressure tube

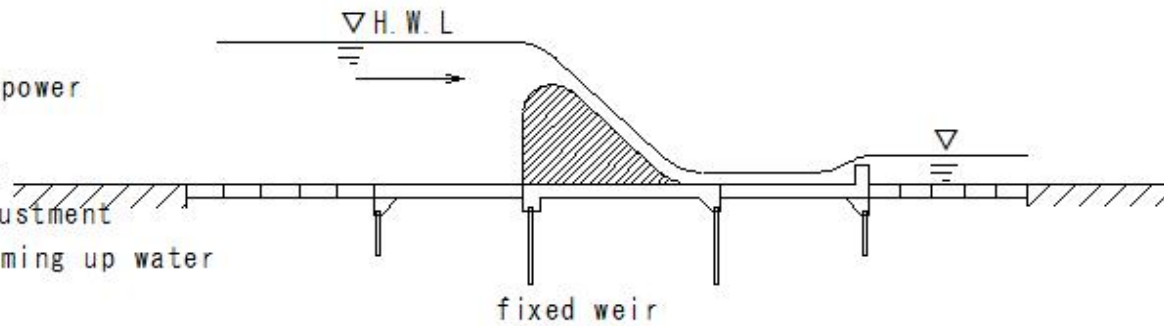


(D221)weir

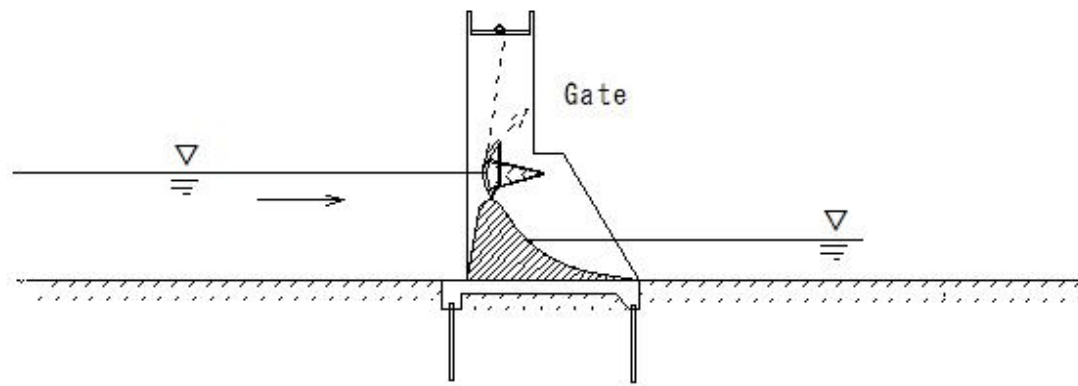
(D221) weir

weir

- irrigation
- water supply
- hydroelectric power
- Water intake
- boat transport
- high water adjustment
- Waterway - damming up water



fixed weir

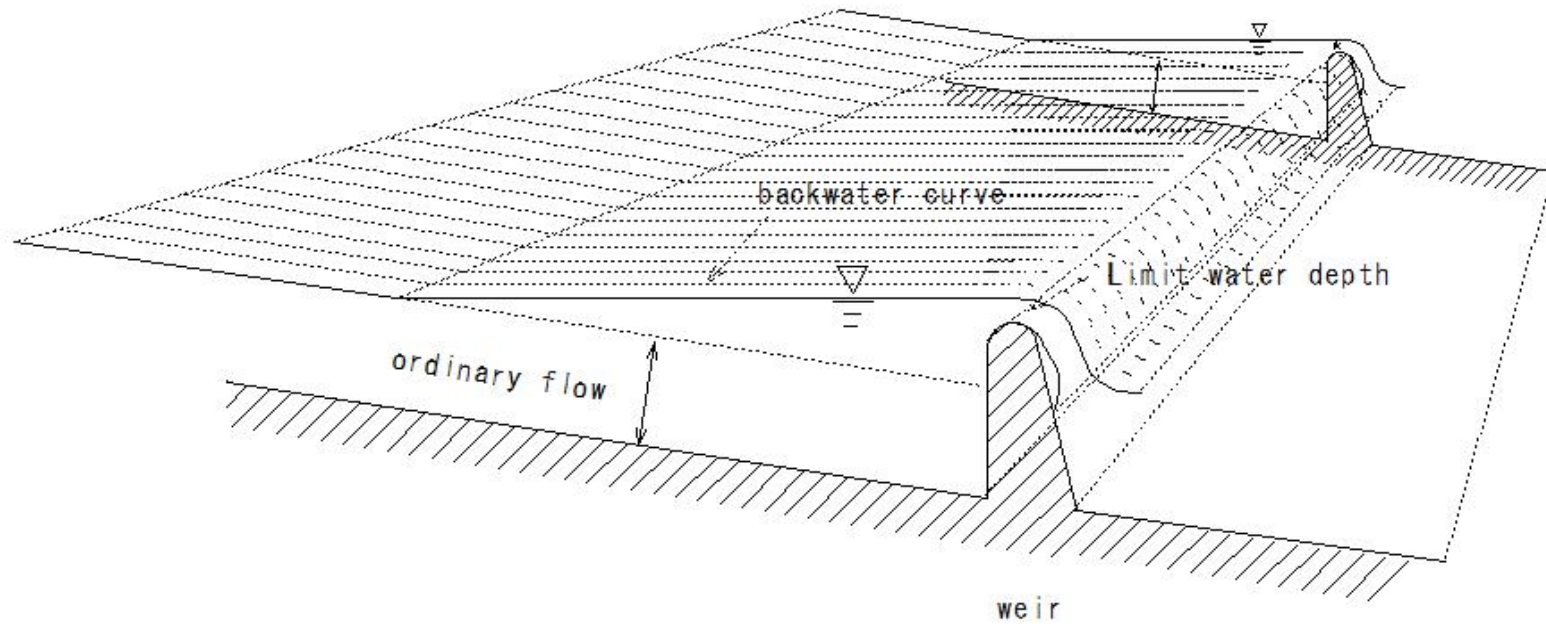


Movable weir

R302

(D222)backwater curve

(D222) backwater curve



R418

## (D223)hollow gravity dam

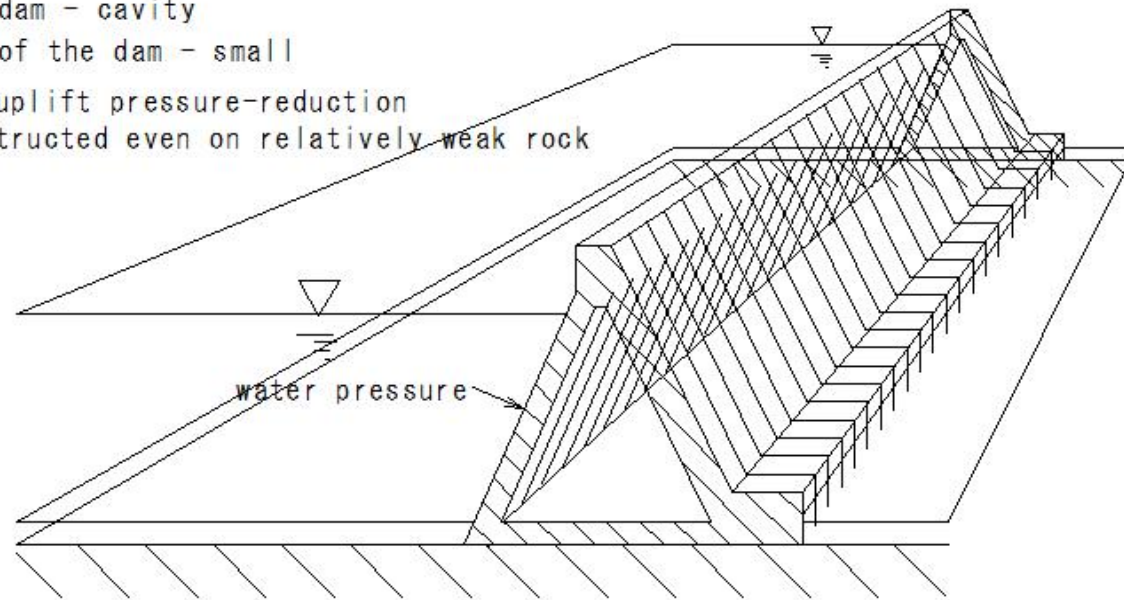
### (D223)hollow gravity dam

dam

Types of dams

hollow gravity dam

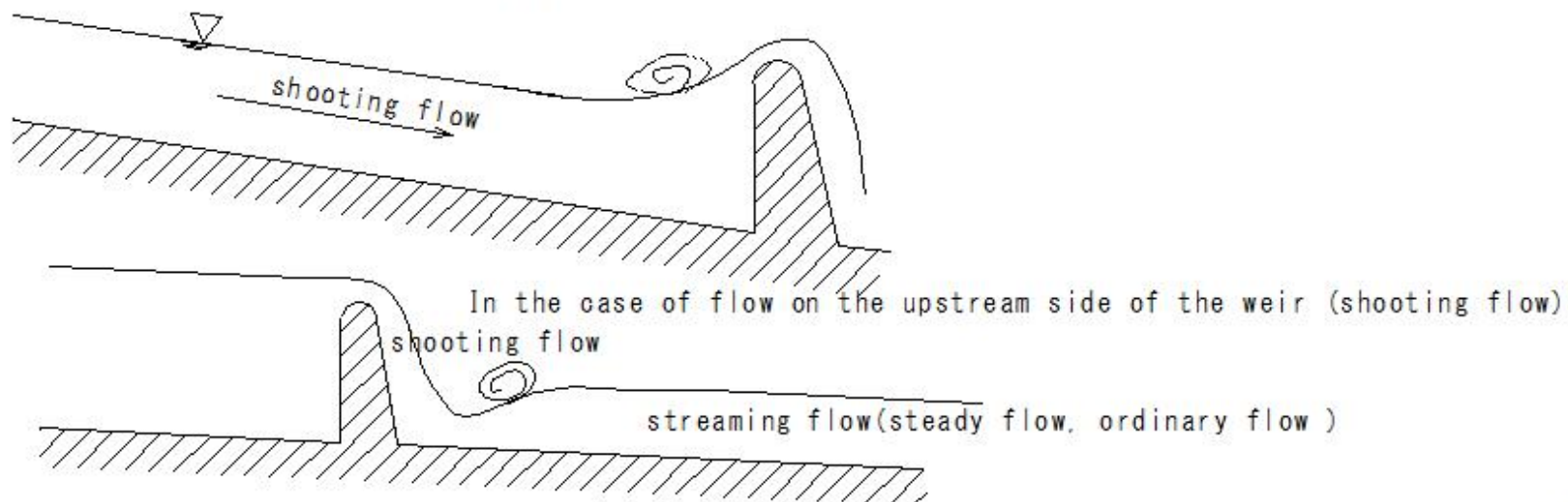
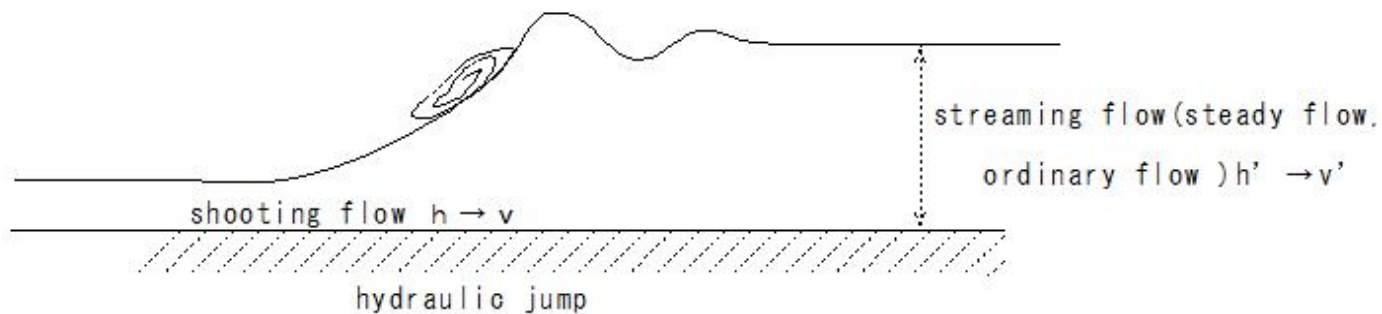
- Inside the dam - cavity
- The weight of the dam - small
- Structural-uplift pressure-reduction
- Can be constructed even on relatively weak rock



Hollow gravity dam

(D224)hydraulic jump

### (D224)hydraulic jump



In case of flow after overflowing a weir

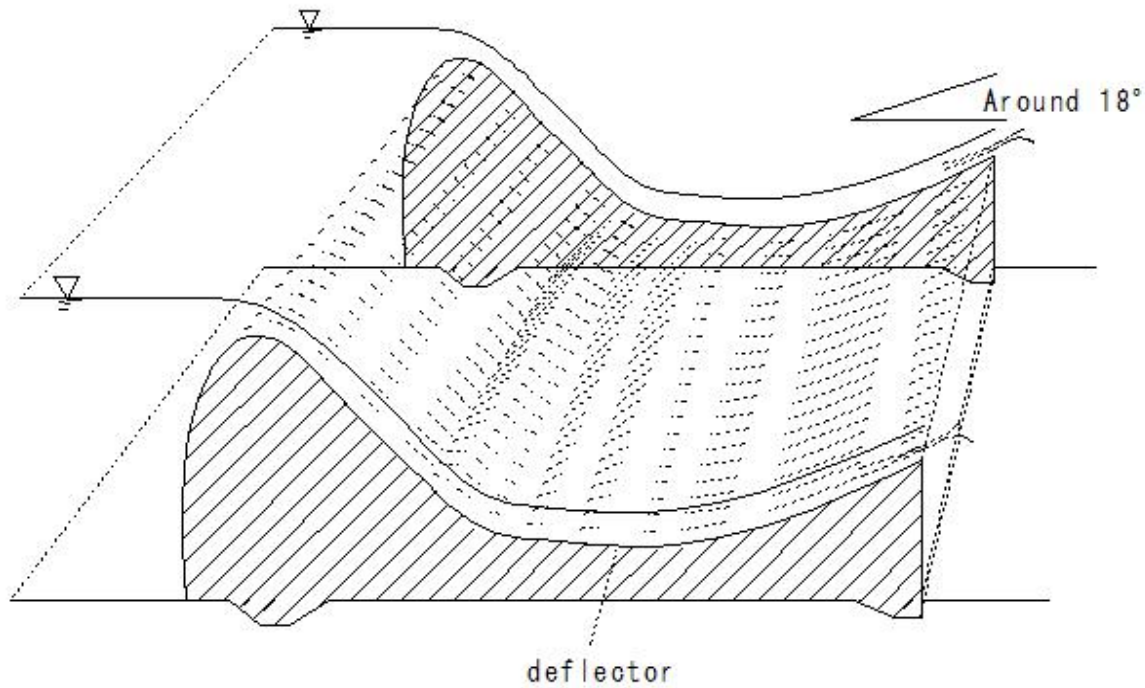


(D225)deflector

### (D225) deflector

deflector

A structure that consumes the energy of water that overflows a dam.



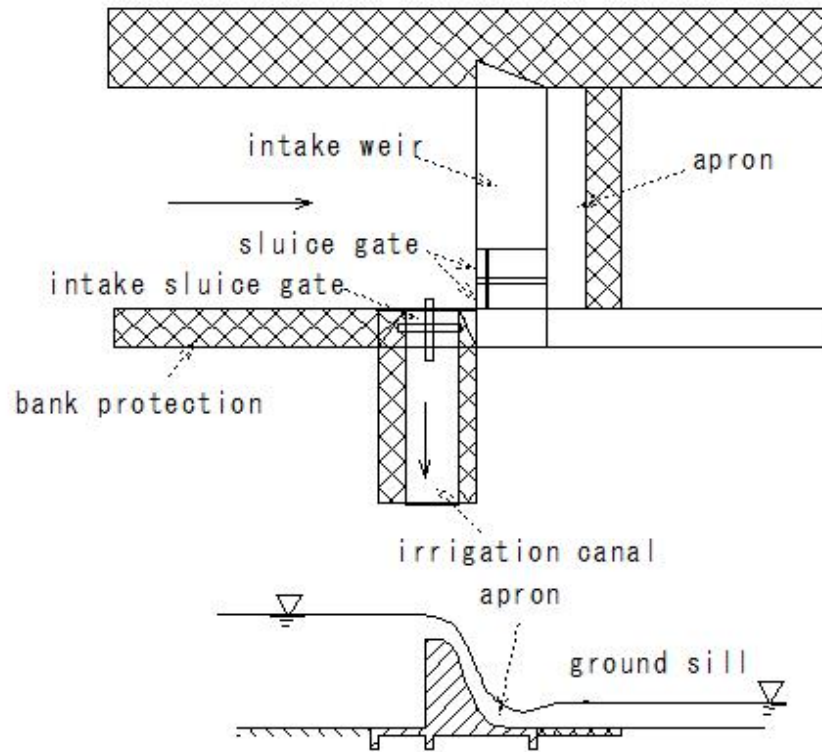
R435

(D226)head works

(D226) head works

weir(head works)

Facilities that draw water from lakes, rivers, etc. to irrigation canals



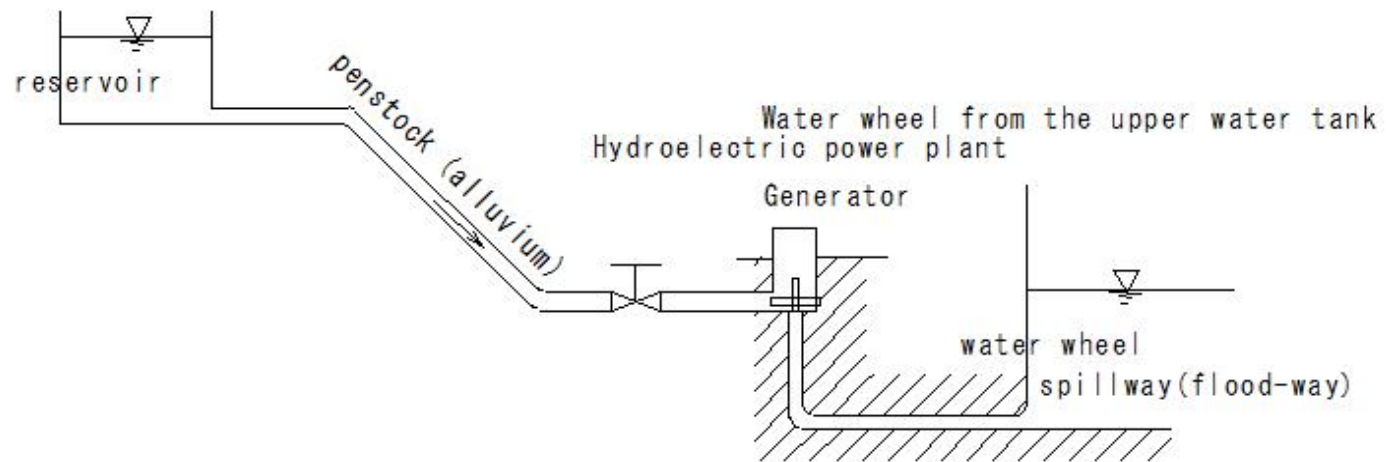
Weir cross section

(D227)penstock (head race)

### (D227)penstock (head race)

penstock (alluvium)

High pressure water pipe that leads water



(D228)sediment settling

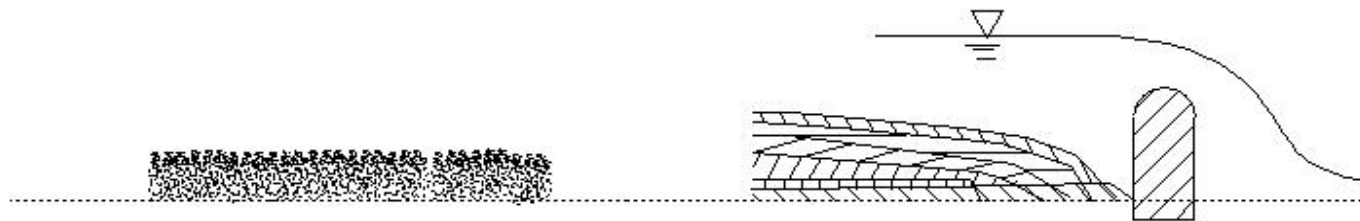
### (D228) sediment settling

sediment settling

Water flow

Stationary soil pressure

Sediment in water - precipitation



Precipitation in still water  
The lower layer has a larger particle size

The tip is attached to the dam  
Deposition

(D229)internal impervious wall

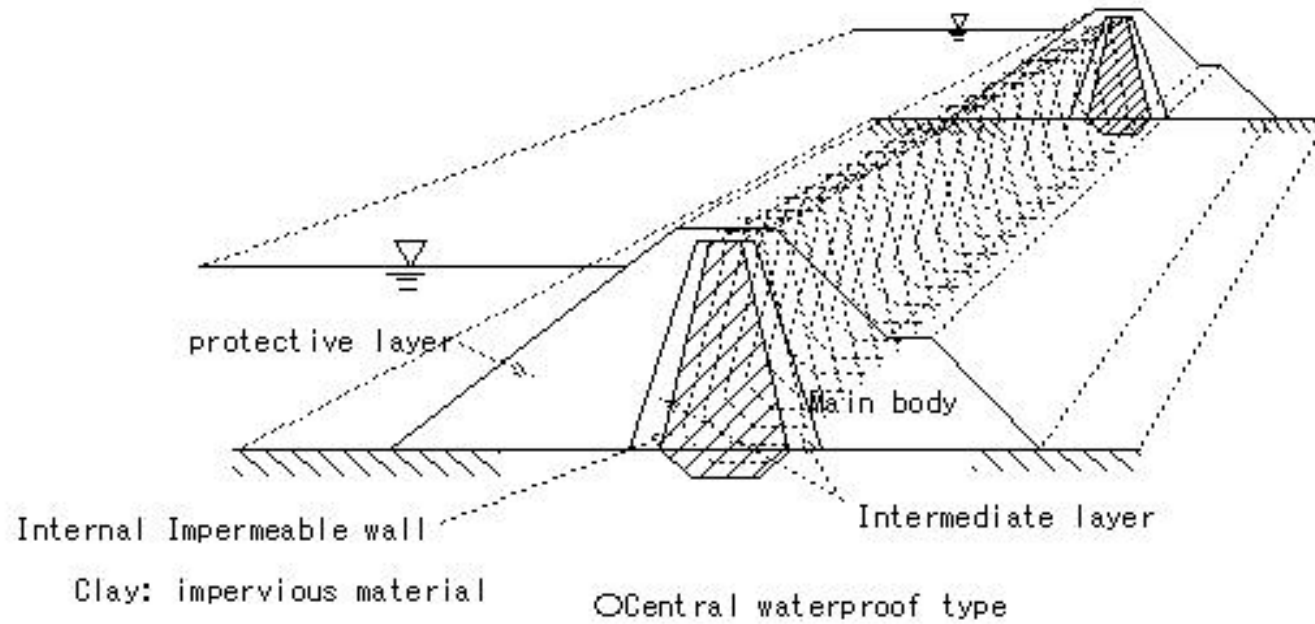
(D229) Impermeable wall

internal impervious wall

earth dam

rock fill dam

- Impermeable wall installed inside the embankment body



## (D230)internal impervious wall

### (D230)internal impervious wall

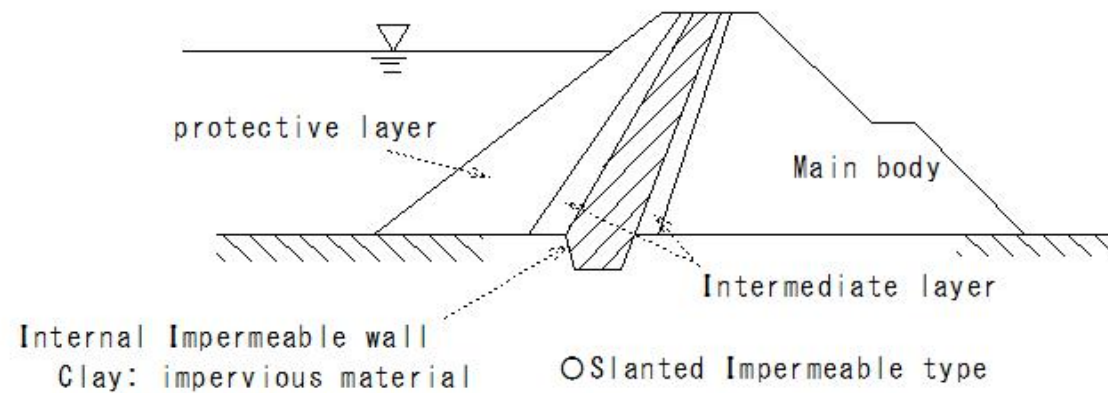
internal impervious wall

earth dam

rock fill dam

- Impermeable wall installed inside the embankment body

○ Slanted Impermeable type





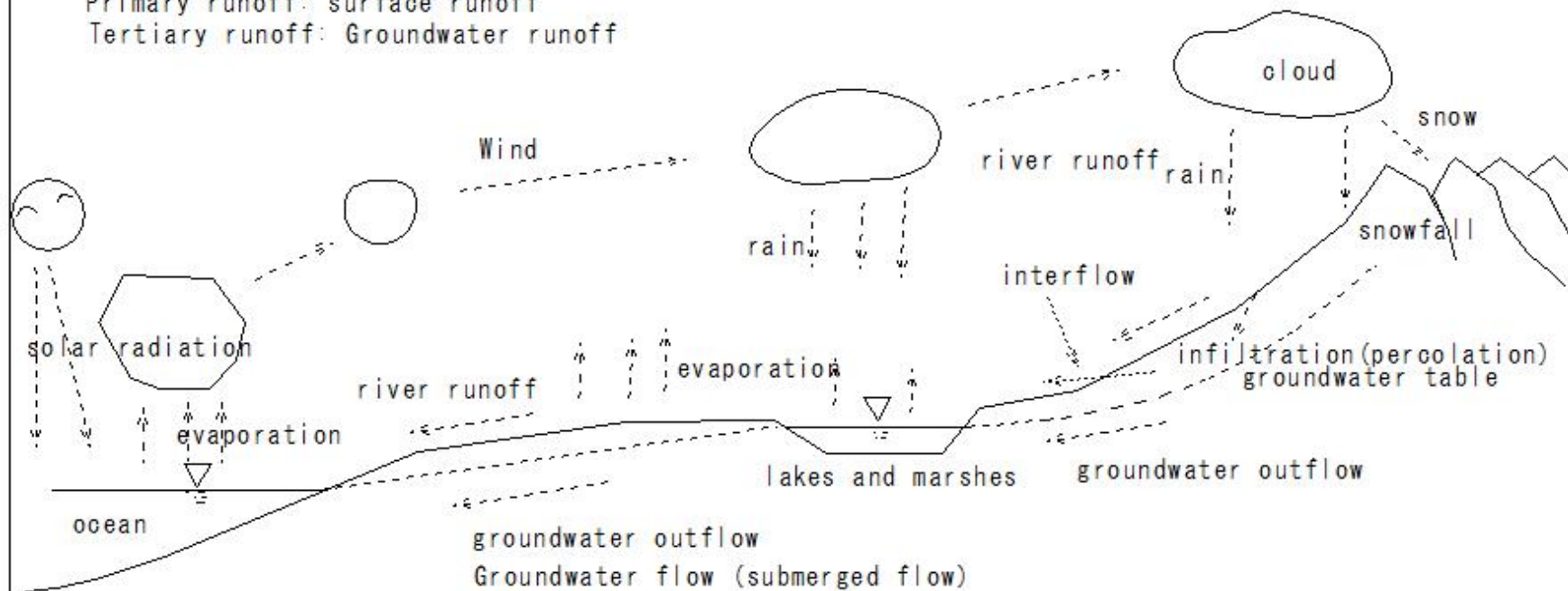
(D231)interflow

(D231) interflow

interflow

Precipitation infiltration(percolation) underground  
Coming to the surface again  
Phenomenon flowing into rivers

Primary runoff: surface runoff  
Tertiary runoff: Groundwater runoff



(D232)dentated sill

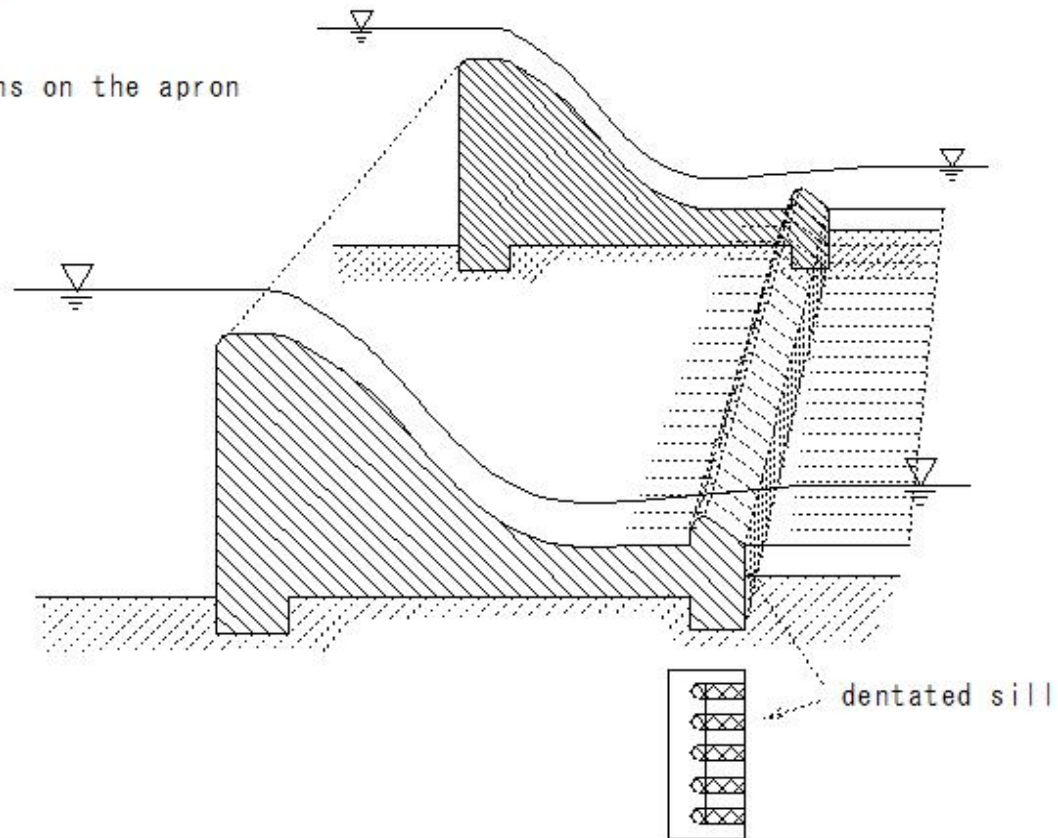
(D232) dentated sill

dentated sill

Overflowing a weir/dam

reduce water energy

Tooth-shaped protrusions on the apron



(D233)sharp crested weir

(D233) sharp crested weir

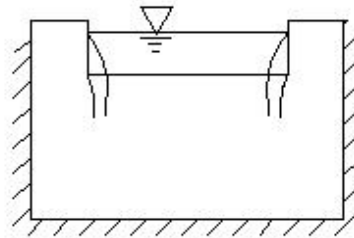
sharp crested weir

The overflow part is sharp.

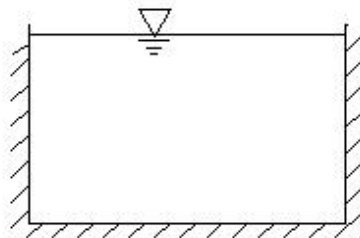
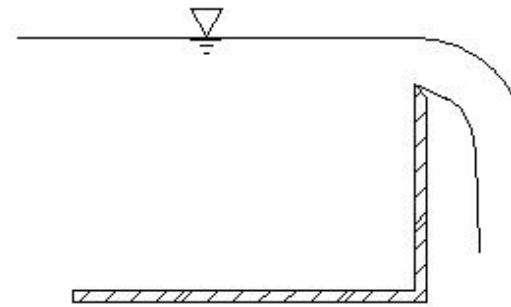
blade shaped weir: Stable nap

Easily measure overflow depth

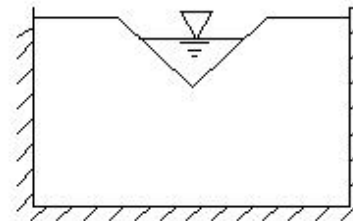
Open channel flow measurement



square notch



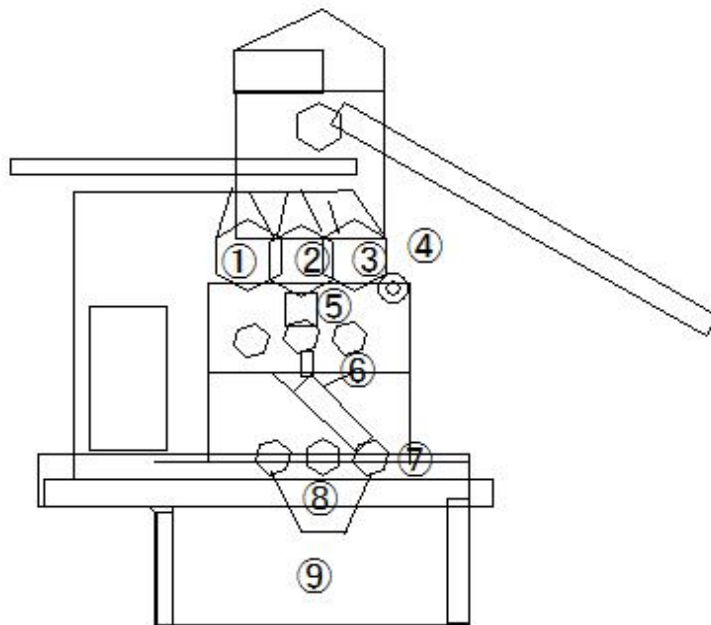
full width weir



triangular weir

(D234)batcher plant

(D234)batcher plant



Batcher plant

Weigh automatically

Mixing

Fresh concrete

①Gravel

②Cement

③Sand

④Storage bin

⑤Weighing device

⑥Collecting hopper

⑦Mixer

⑧Concrete hopper

⑨Bucket agitator

C1378

(D235)batcher plant

(D235)batcher plant

baffle pier

Stabilizes the hydraulic jump(overflows the dam)

reduce energy

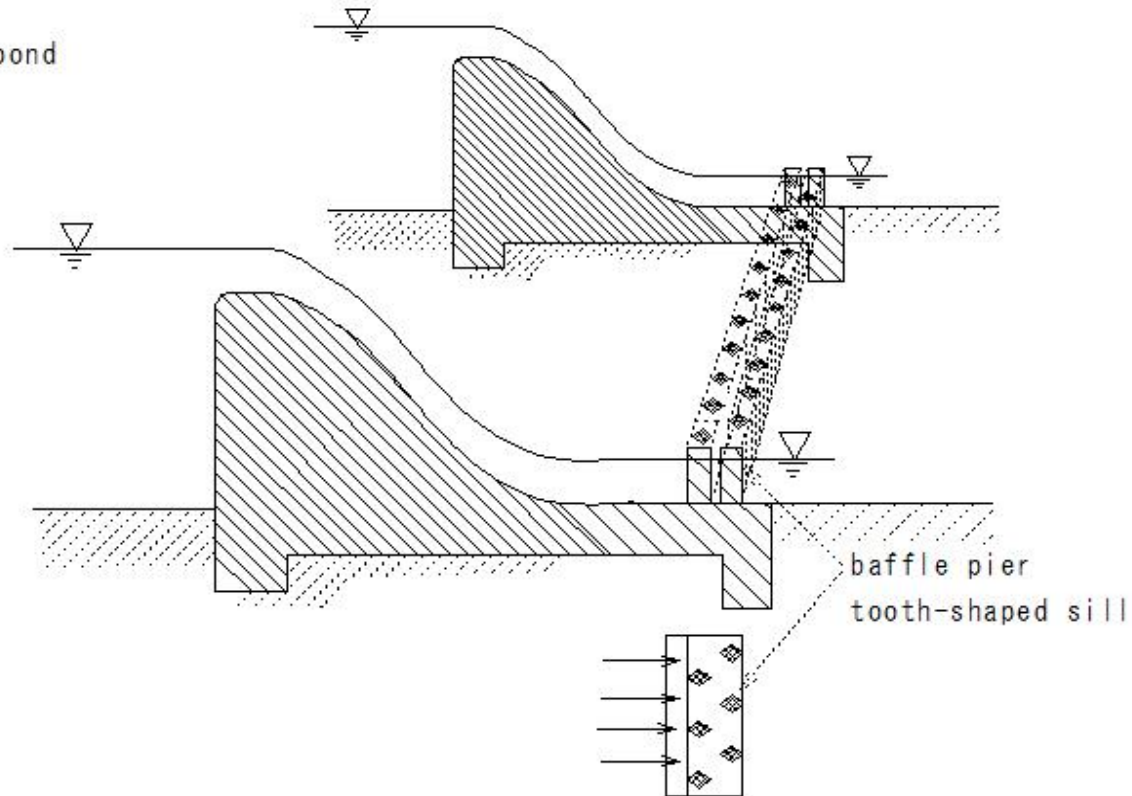
Arranged in front of the pond

protruding obstacles

Energy reduction method

deflector

auxiliary dam



(D236)auxiliary dam

### (D236) auxiliary dam

auxiliary dam

Preventing scouring downstream of overflow dams

Installed at the apron of this dam

small overflow dam

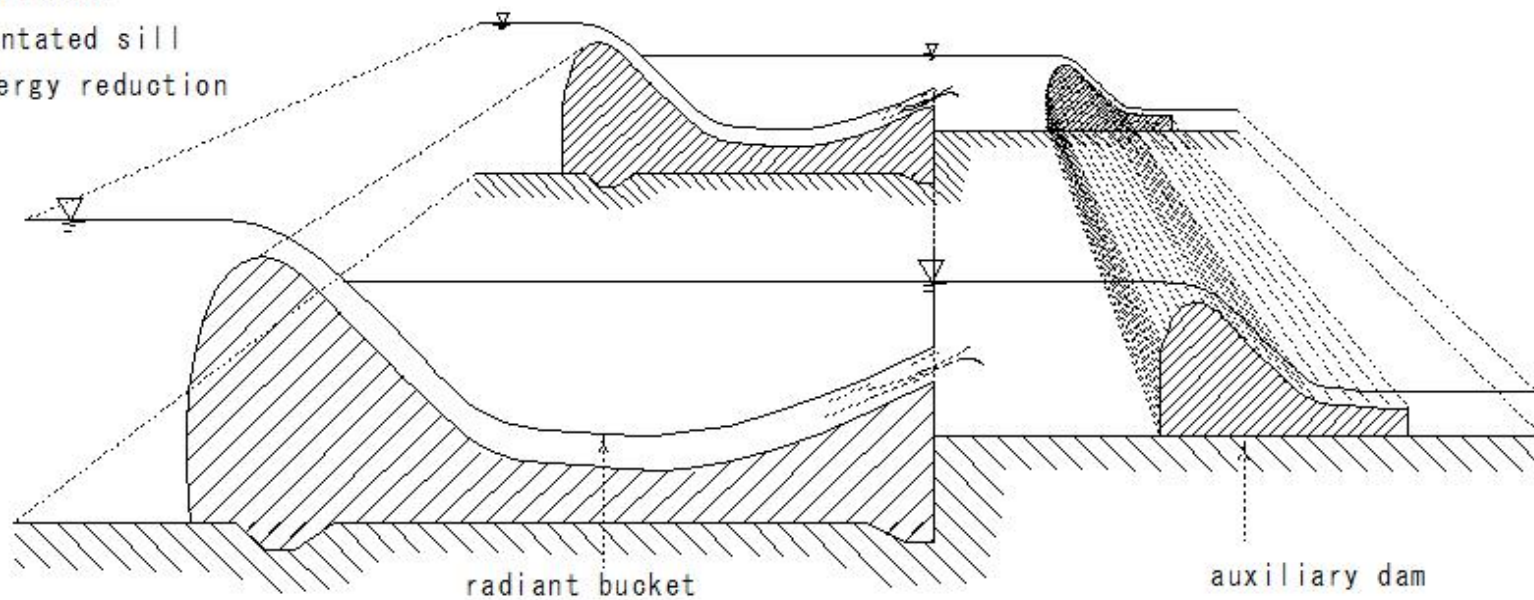
Rear end of apron

baffle pier

deflector

dentated sill

energy reduction



R476



(D237)unsteady flow

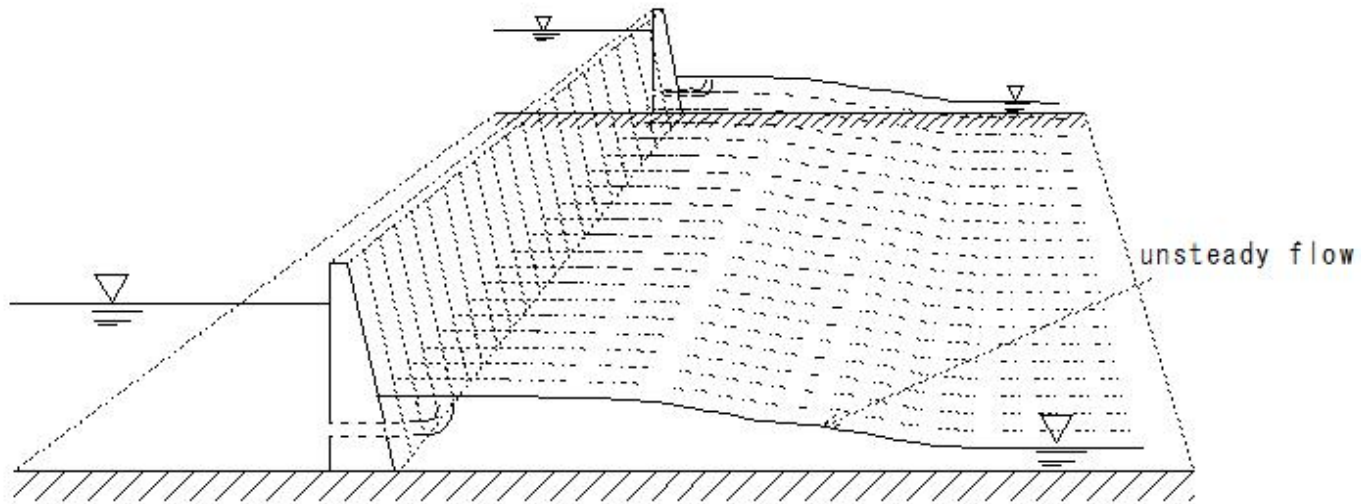
### (D237)unsteady flow

unsteady flow

waterway

flow: volume and velocity change over time

dam discharge

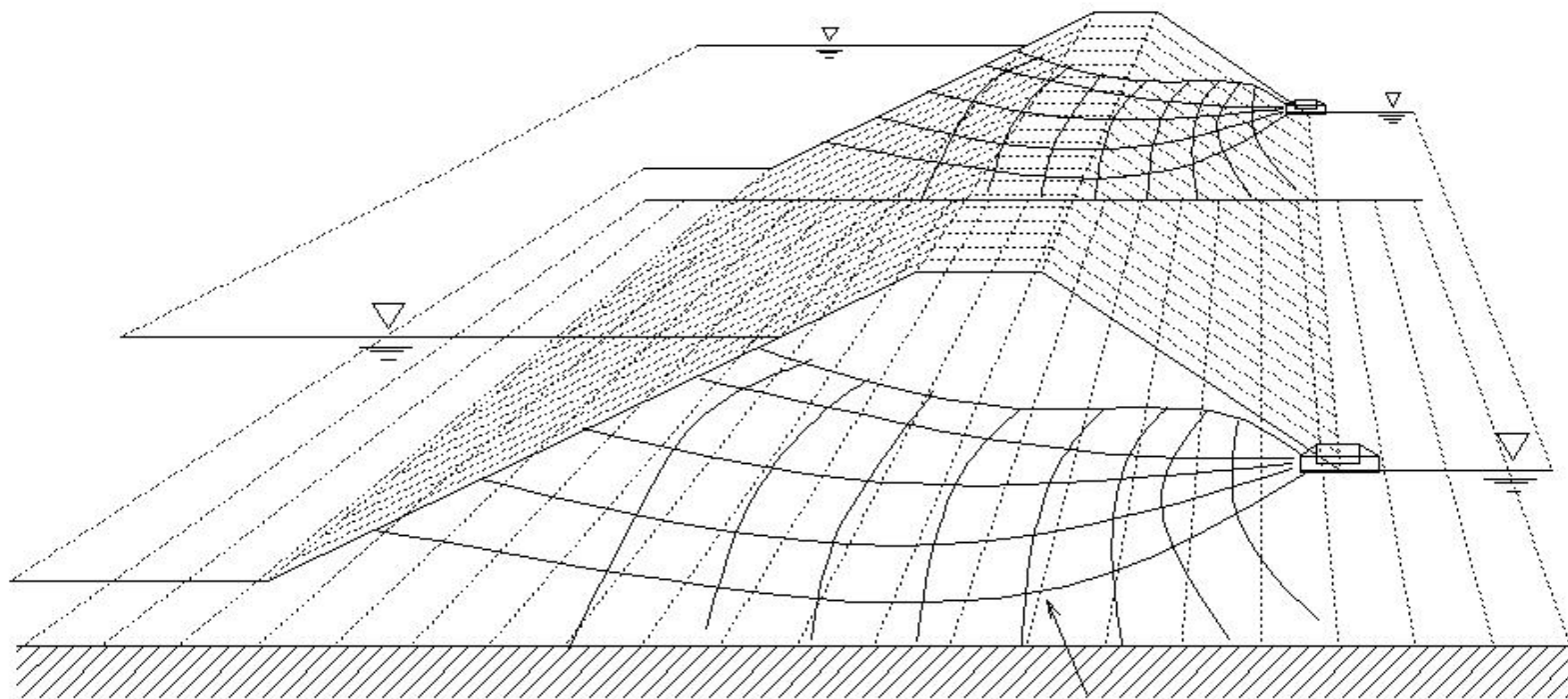


R481

(D238)impermeability layer

(D238) impermeability layer

impermeable layer



Impermeable layer  
infiltration (percolation)  
clay layer  
bedrock

Water permeation  
Streamlined

R482

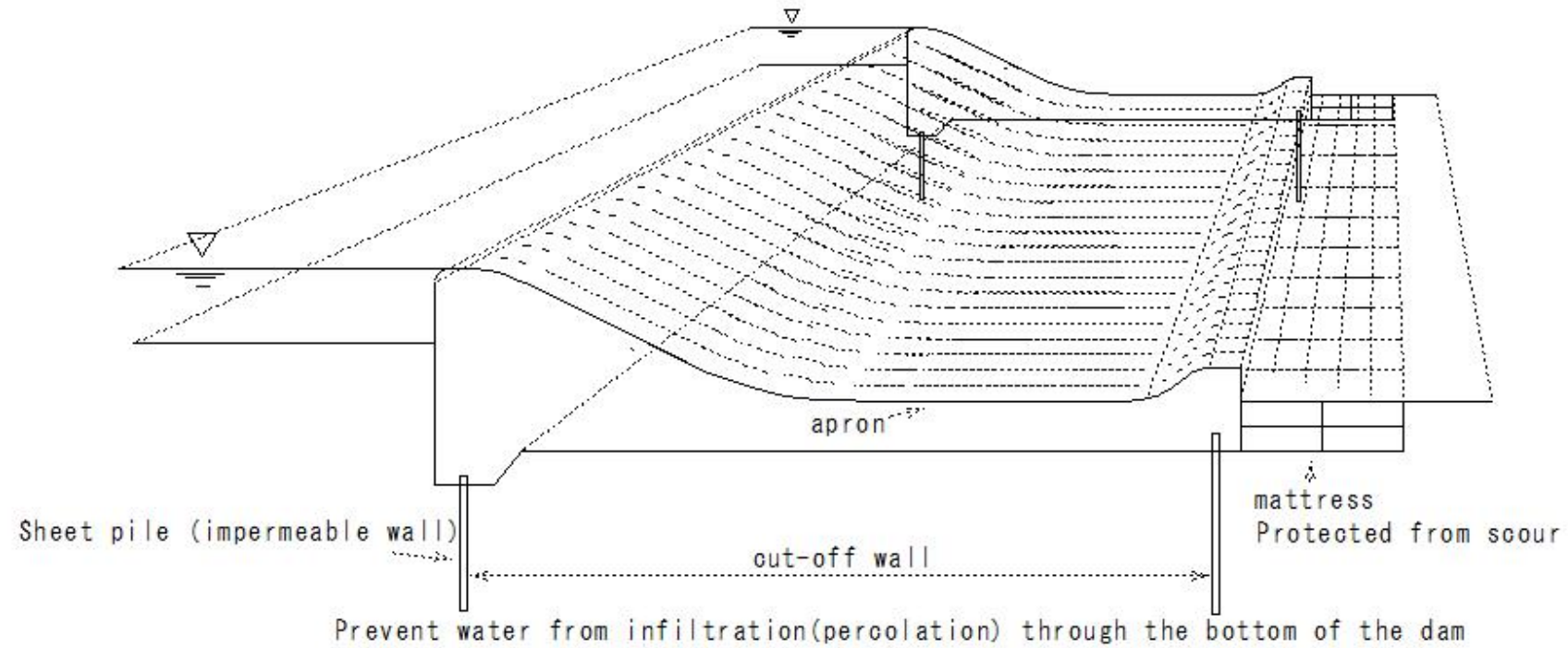
(D239)floating dam

### (D239)floating dam

floating dam

A type of intake dam

Dams built on permeable foundations such as gravel layers



R488

(D240)watershed

(D240) watershed

watershed

Boundary where the basins of each river meet

Upper river area, mountainous area, watershed - clear

The flatland part of the downstream part is not clear

River A basin

River B basin

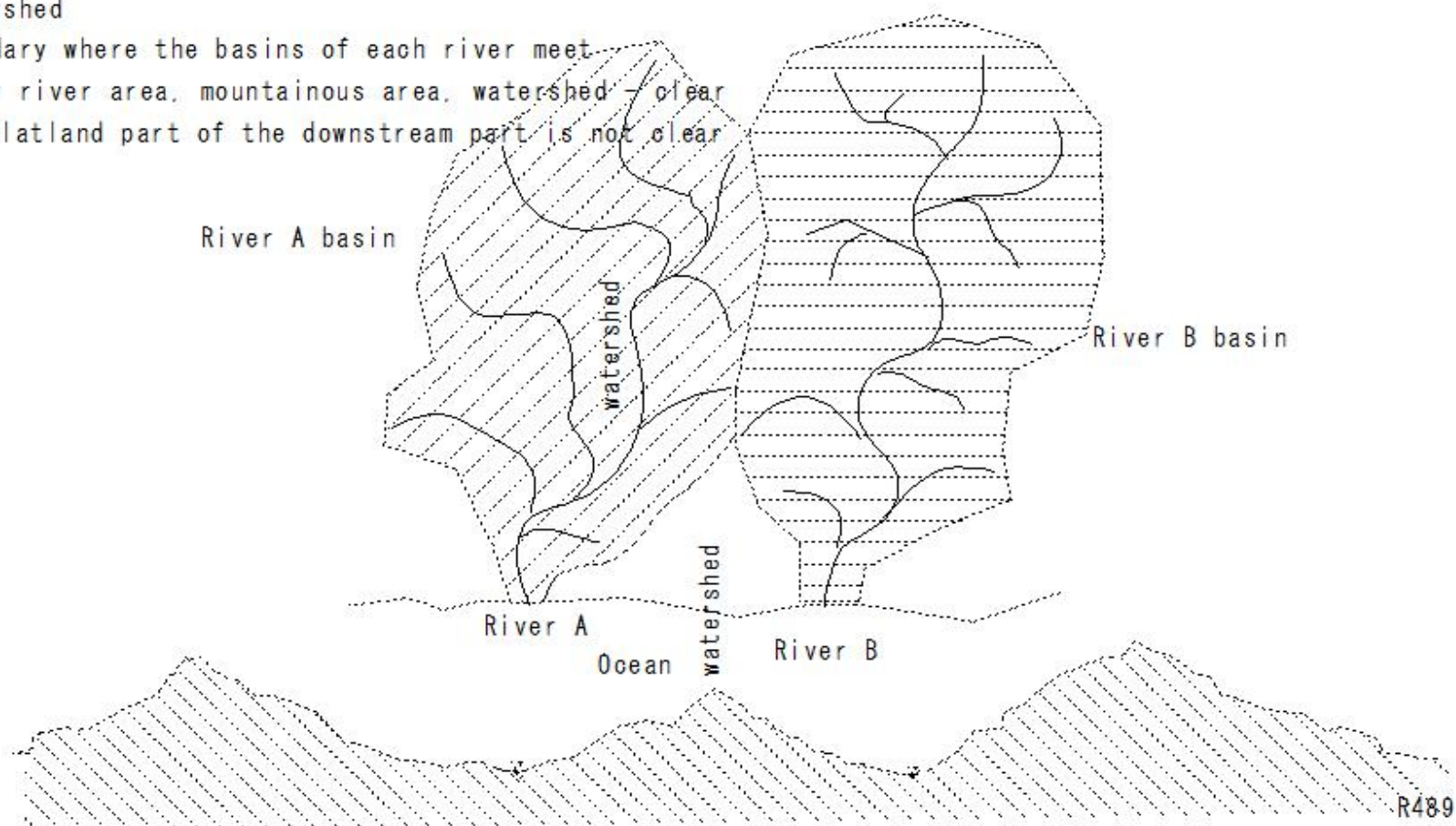
River A

Ocean

watershed

River B

R489

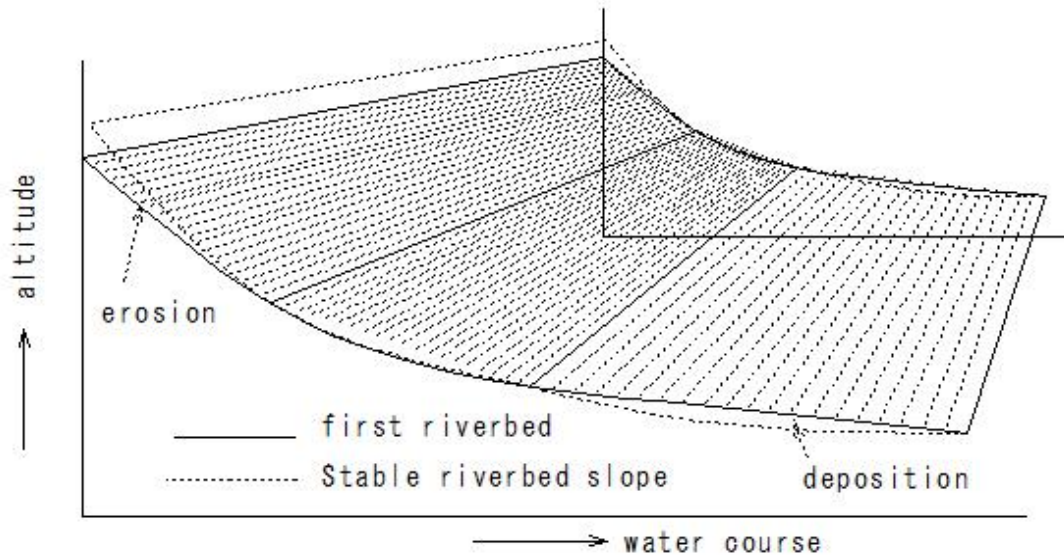


(D241)equilibrium slope

(D241)equilibrium slope

equilibrium slope

In a river with an equilibrium gradient, neither sedimentation nor scouring occurs.  
River water flow, erosion, transportation, deposition

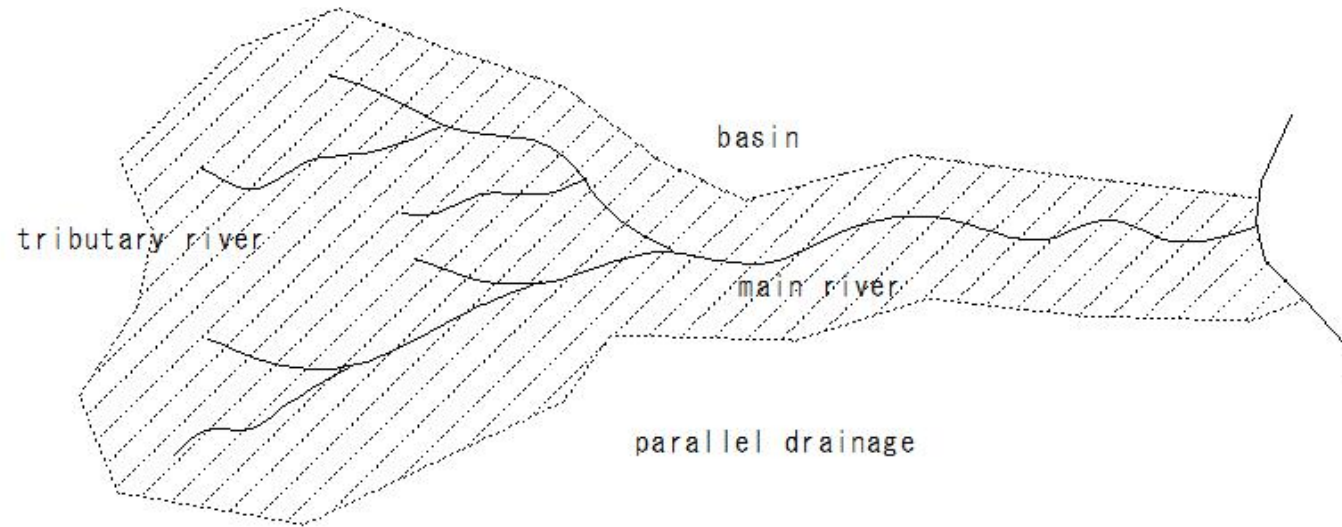




(D242)parallel drainage

(D242)parallel drainage

parallel drainage



R494

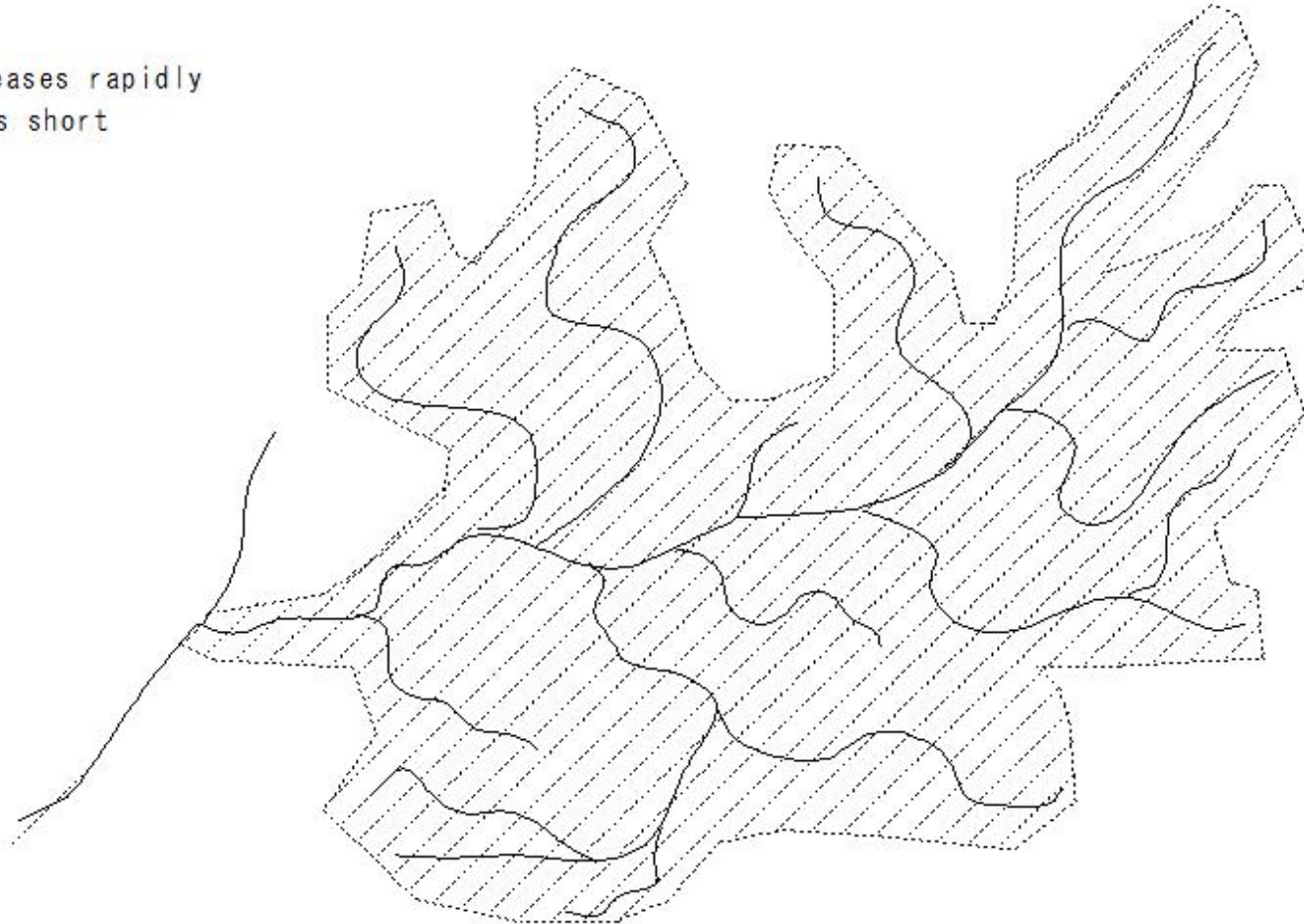


(D243)radial drainage

(D243)radial drainage

radial drainage

discharge increases rapidly  
water season is short



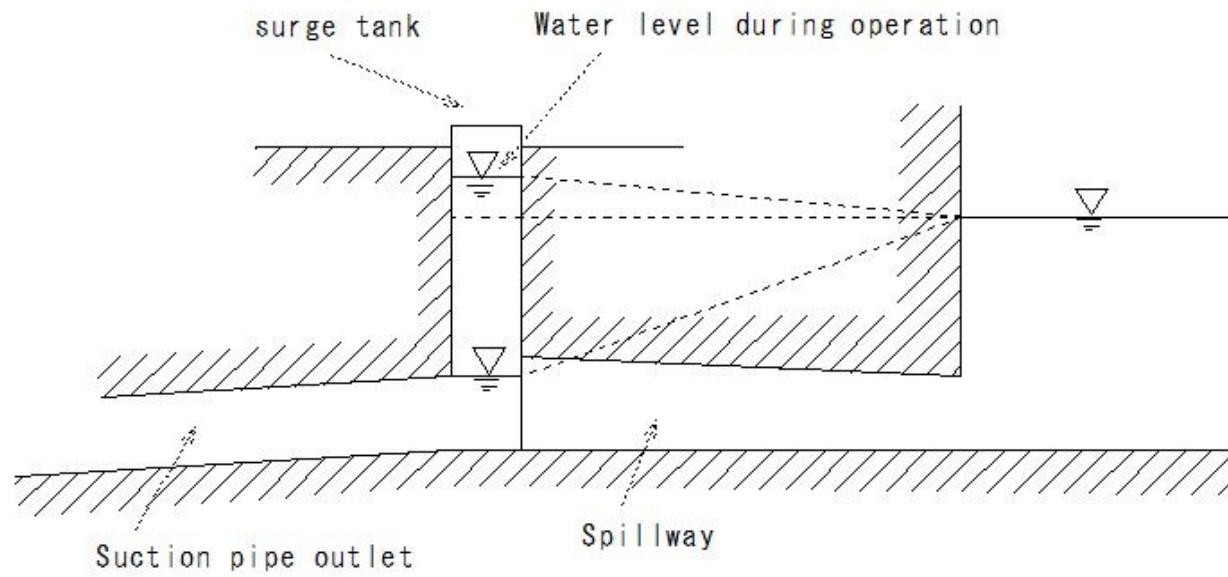
R495

(D244)radial drainage

### (D244)tail-race surge tank

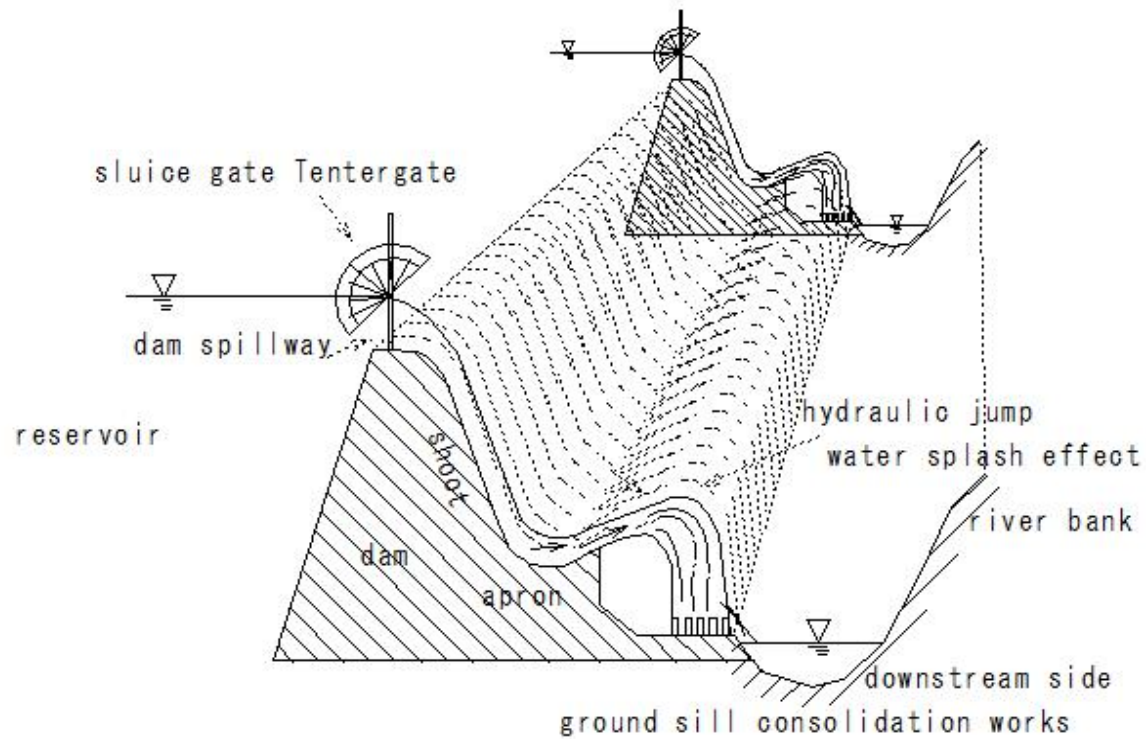
tail-race surge tank

Surge tank: softens water hammer



## (D245) spatter's effect

spatter's effect (water splash effect)  
Diminishing effect

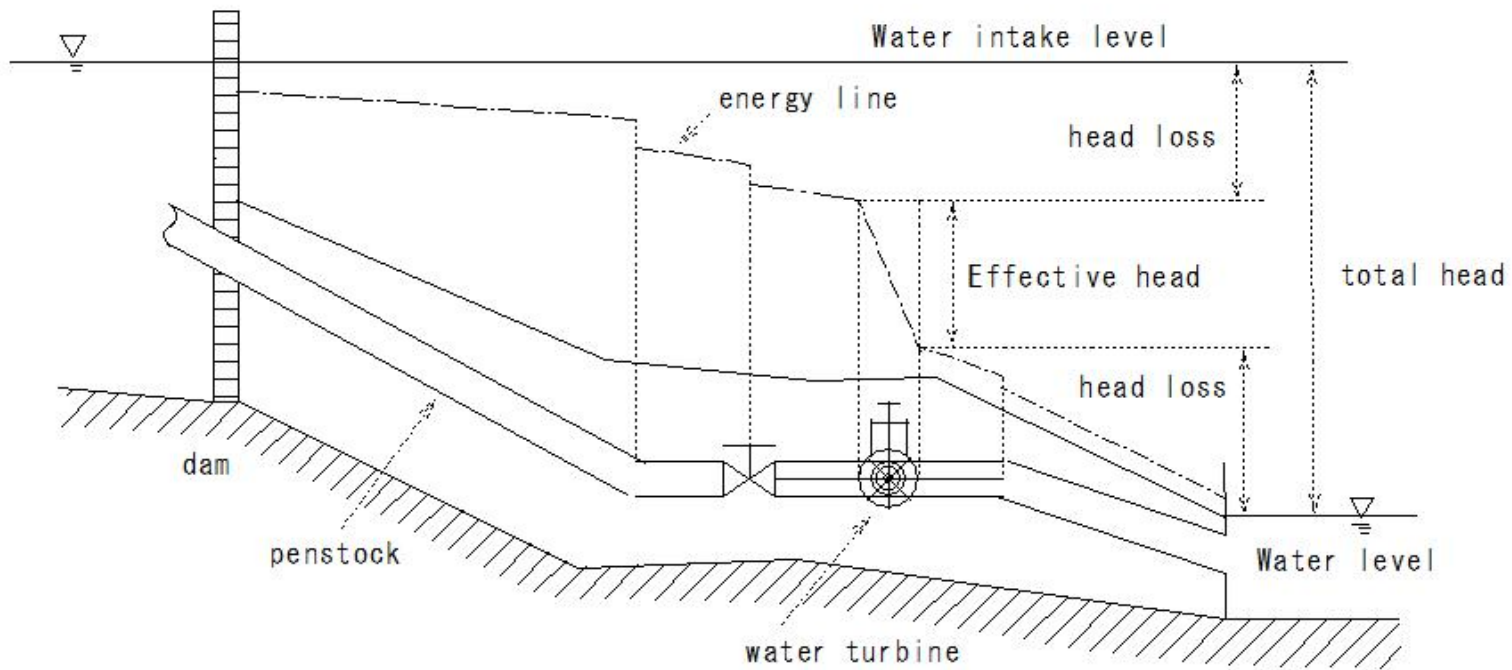


(D246)effective head

### (D246) effective head

effective head

- Can be used for power generation



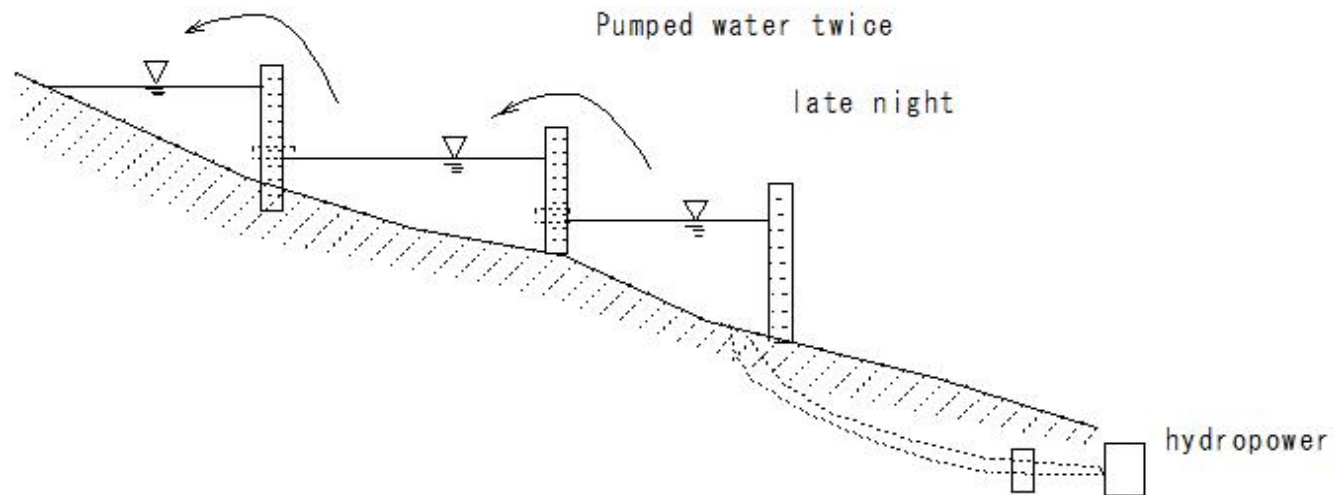
(D247)pumped storage power

(D247) pumped storage power

pumped storage power

- Water storage downstream of the dam
- electricity is available
- Uses electricity and pumps water

Generate electricity by letting water flow when there is a power shortage

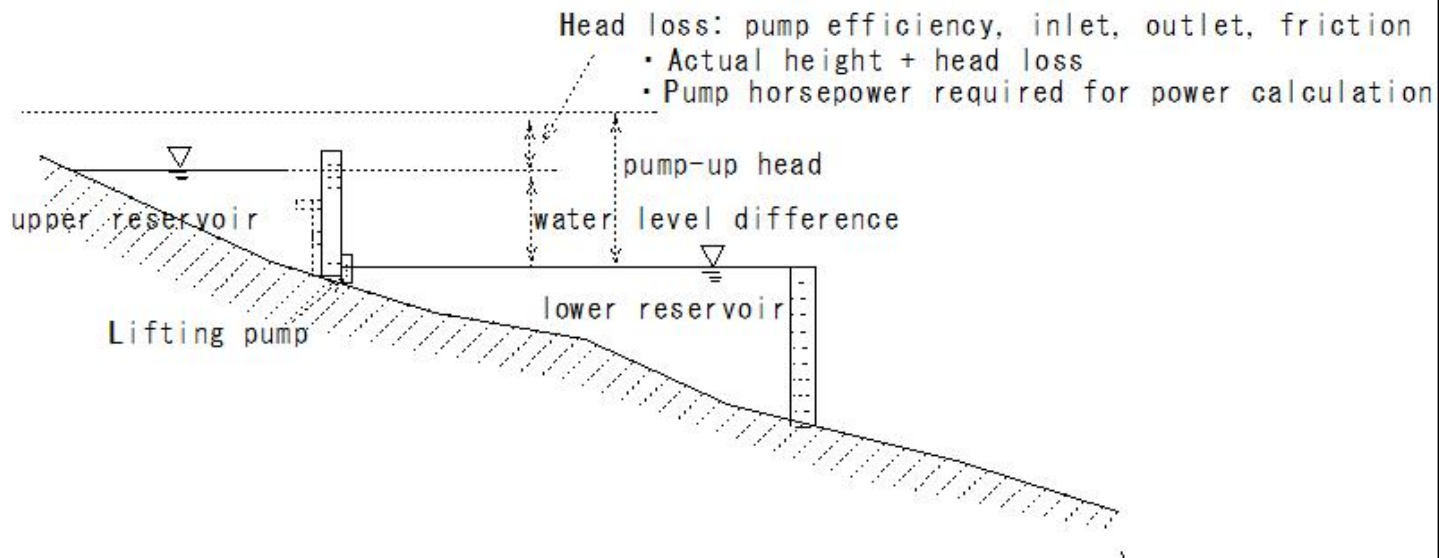


(D248)pump-up head

(D248) pump-up head

pump-up head

- Pump water
- height considering loss





(D249)spillway

### (D249) spillway

spillway

dam

Power plant rockfill dam

A waterway that drains water is not needed for power generation

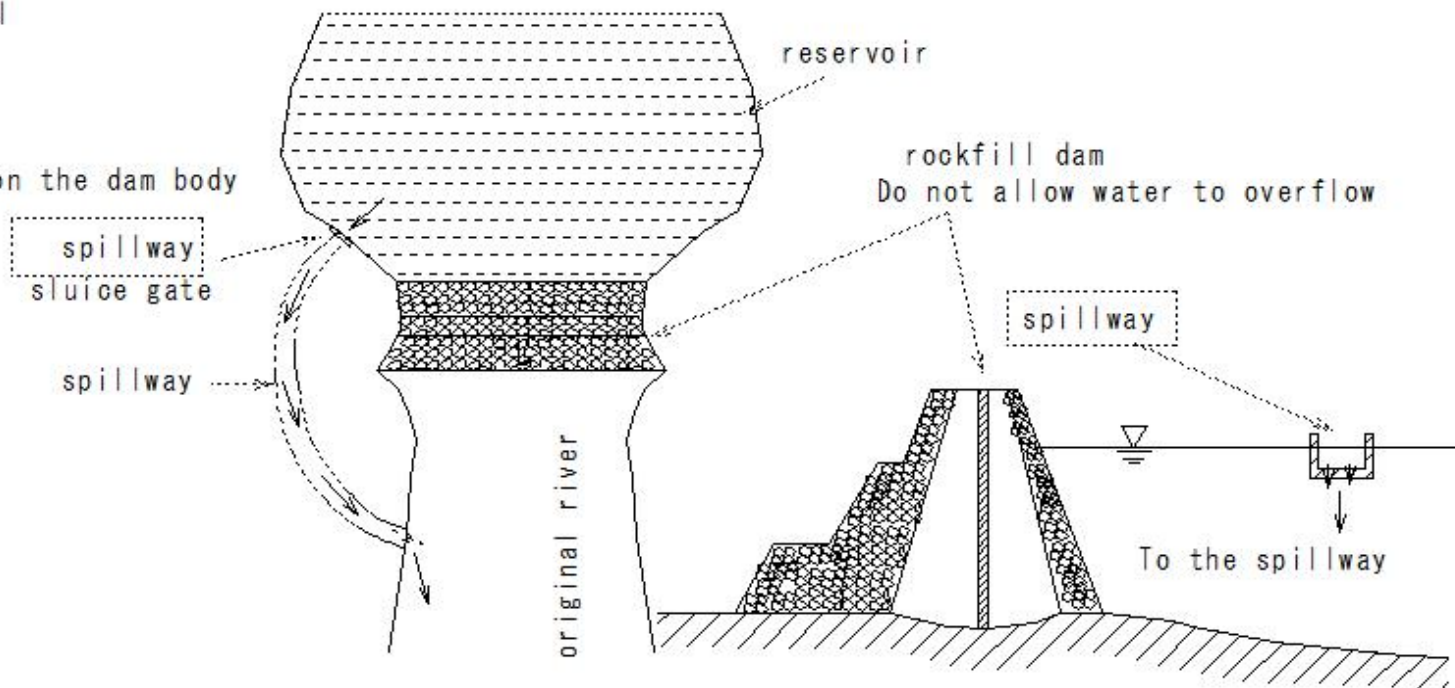
open channel

culvert

tunnel

steel pipe

installed on the dam body



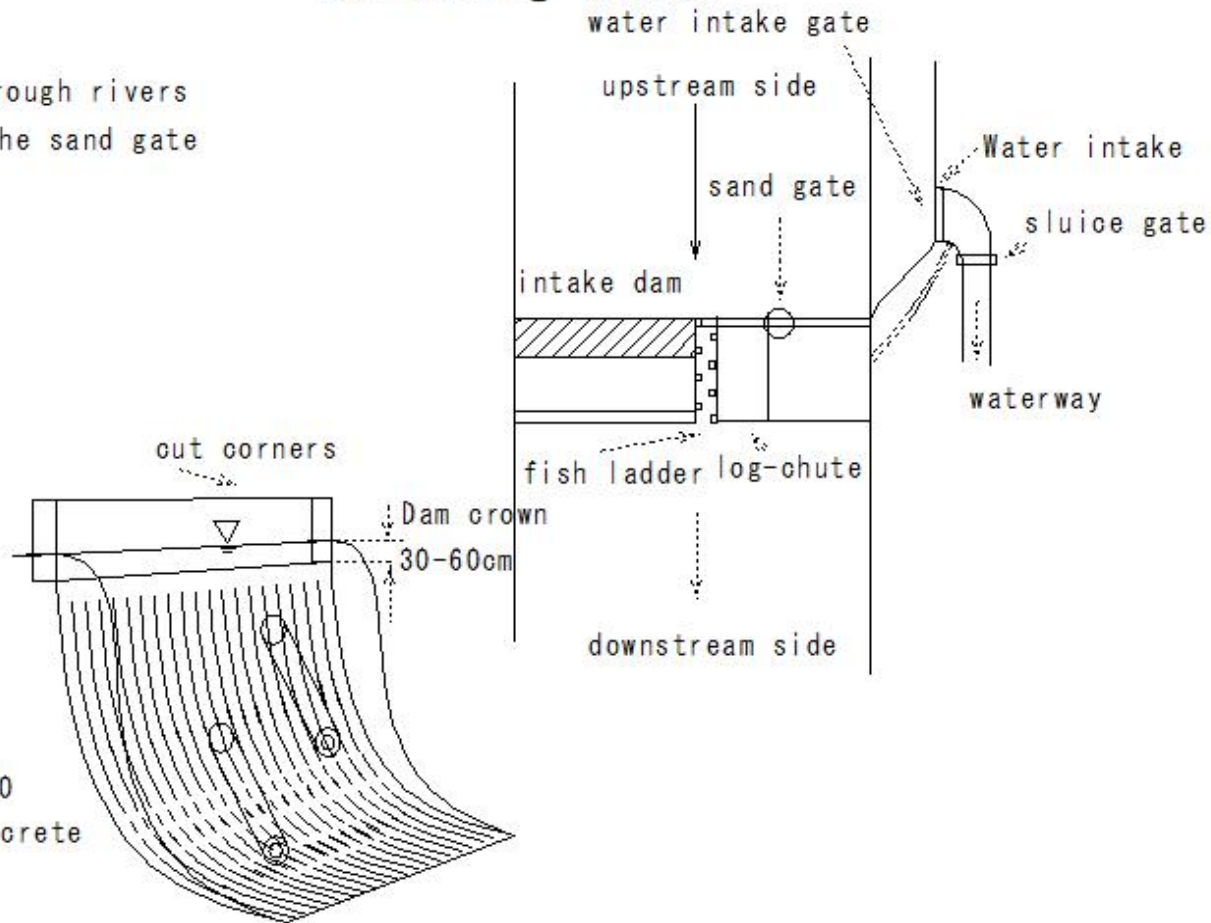
R505

(D250)log-chute

(D250) log-chute

log-chute

flowing wood through rivers  
Parallel with the sand gate



(D251)basin coefficient

(D251)basin coefficient

basin coefficient

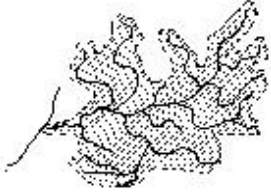

Used to understand the shape and properties of rivers

$$F = A/L^2$$

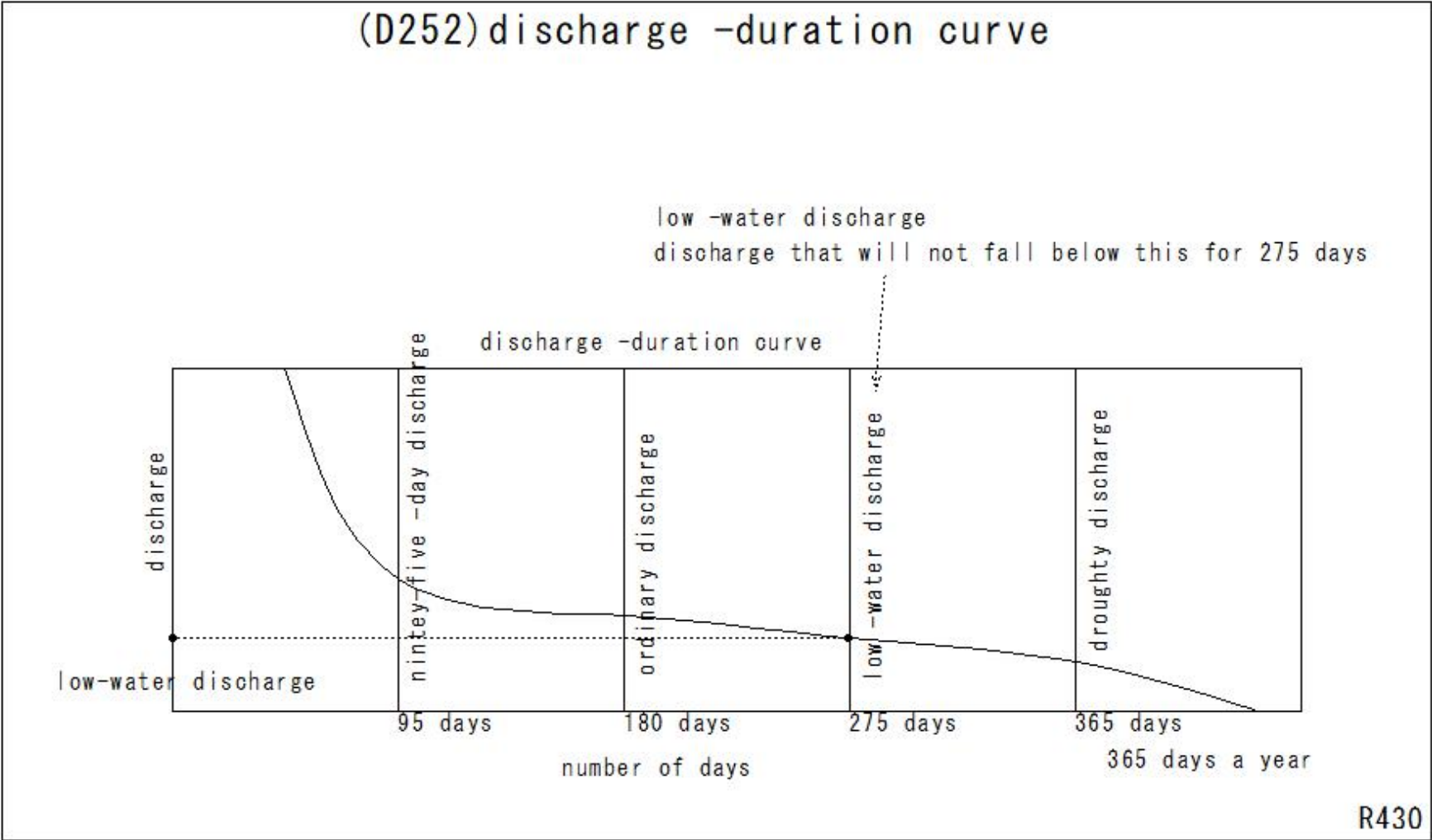
F: basin coefficient

A: Basin area

L: Extension of main water course

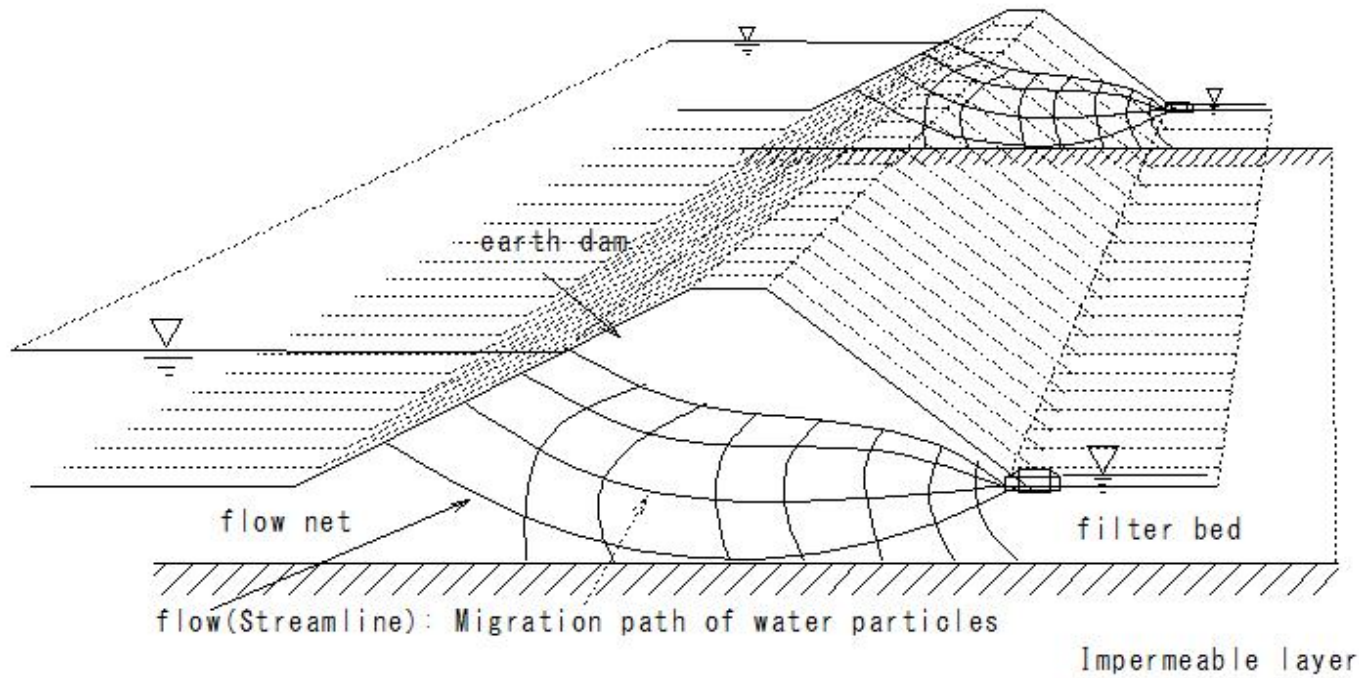
value of (F)	basin	Water flow time	Maximum discharge	Shape example
Big	wide range	short	Big	
small	long	long	small	

(D252)discharge -duration curve



(D253)flow net

(D253) flow net



flow(Streamline): Migration path of water particles

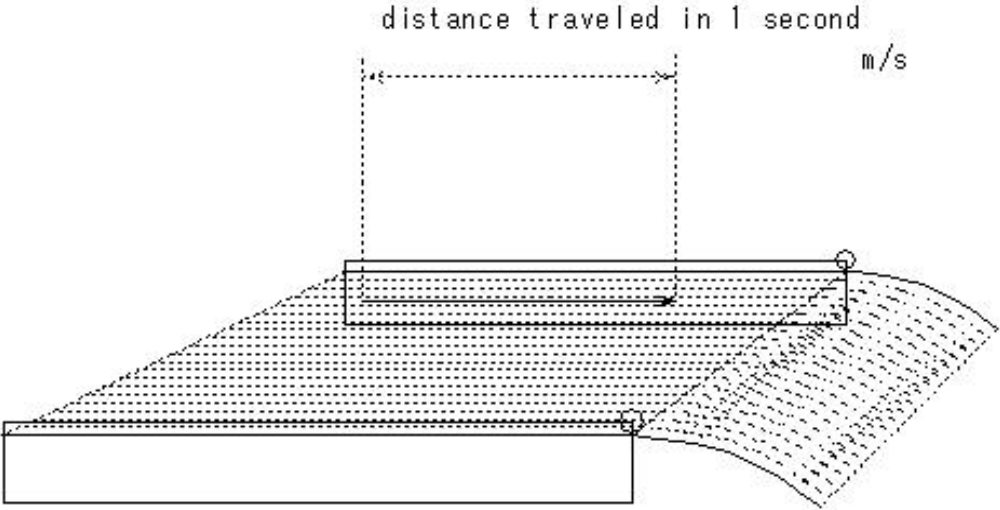
Impermeable layer

Equipotential: equal points in the head of the water

(D254)velocity of flow

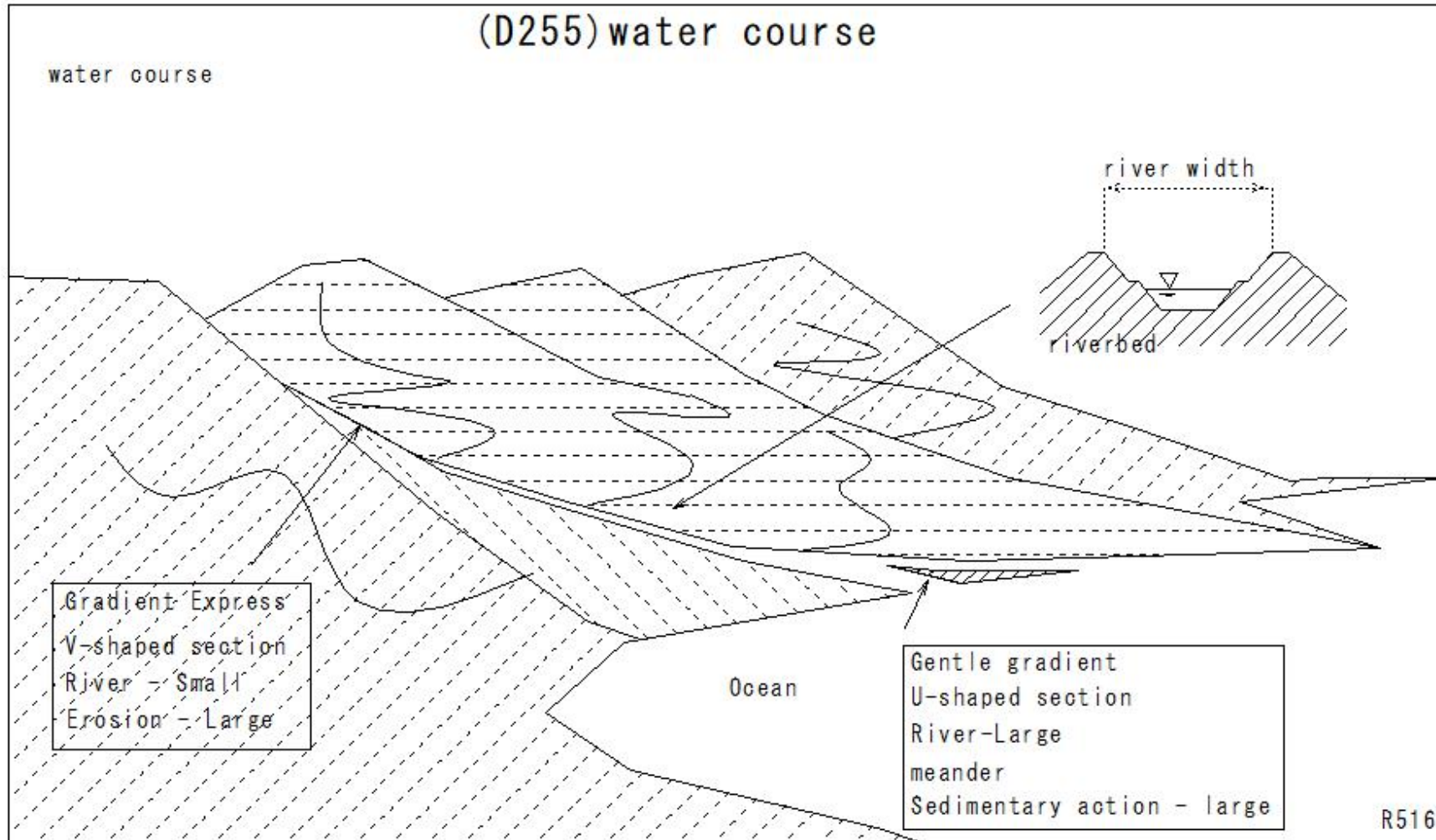
(D254)velocity of flow

velocity of flow





(D255)water course

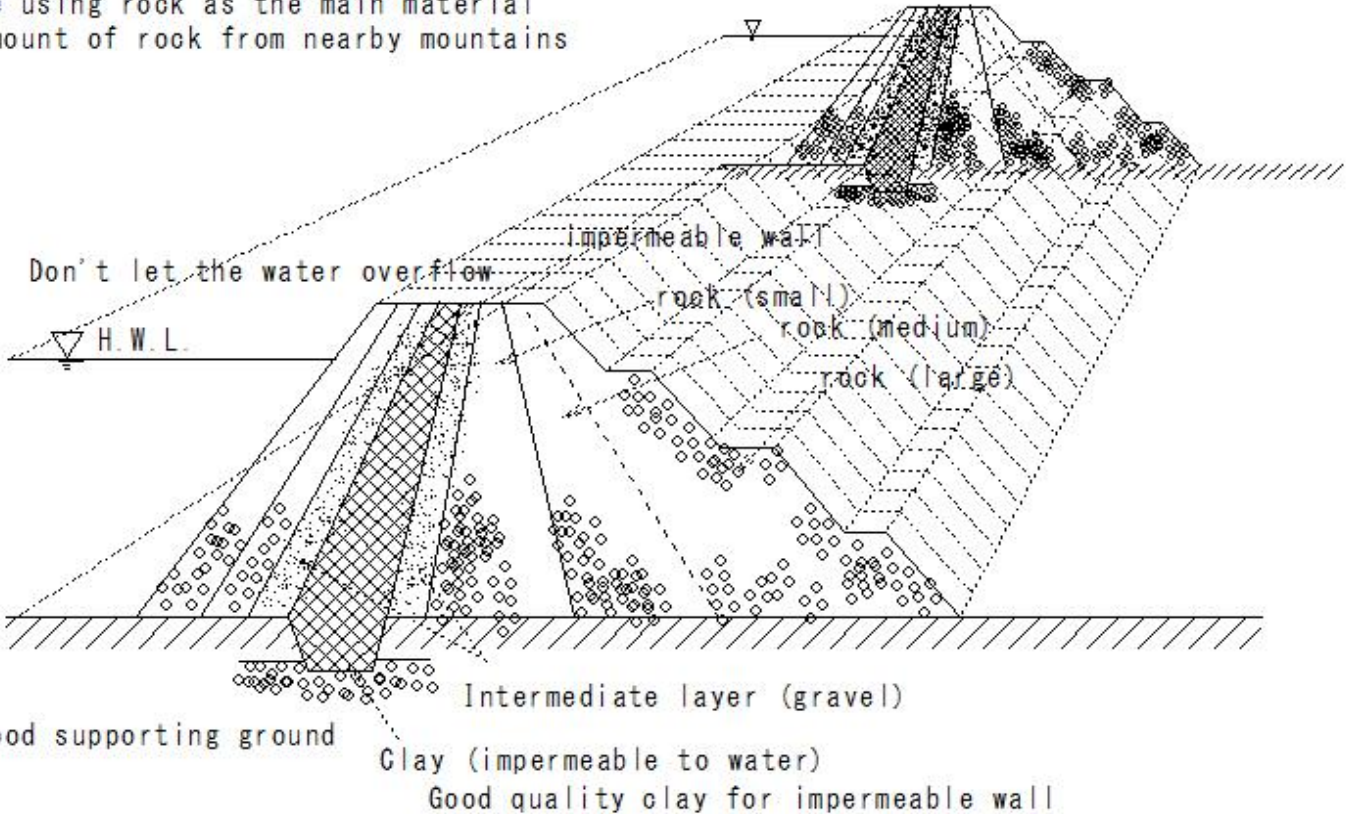


(D256)rock fill dam

(D256)rock fill dam

rock fill dam

A dam made using rock as the main material  
A large amount of rock from nearby mountains

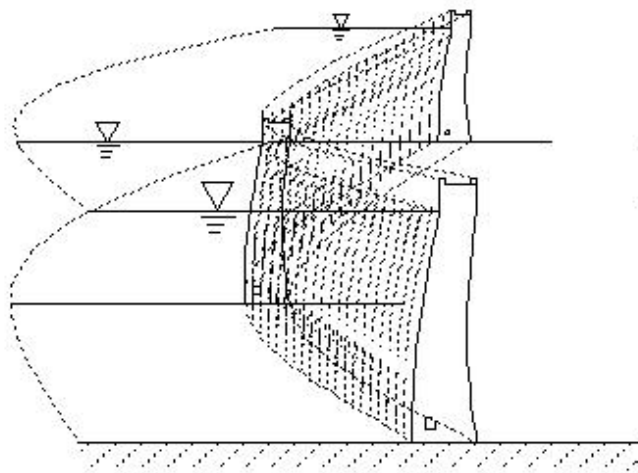


(D257)concrete arch dam

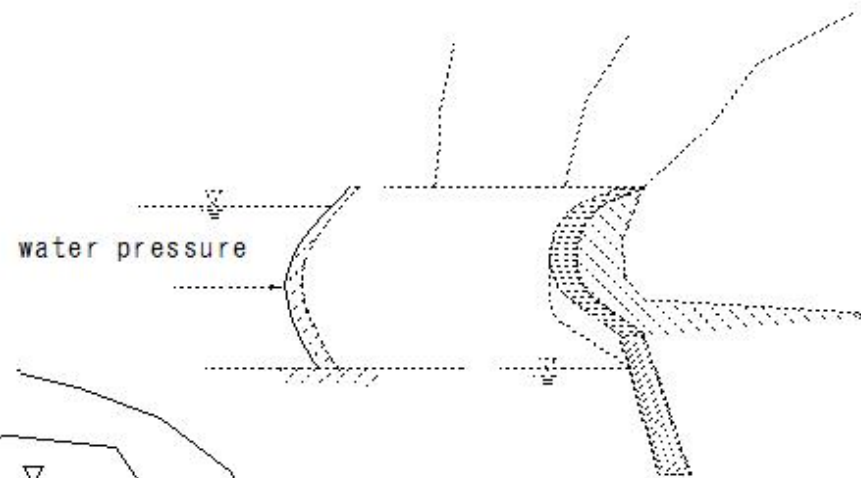
(D257)concrete arch dam

concrete arch dam

- Arch action
- Hydraulic load of reservoir
- Supported by foundation rock on both banks
- Hard foundation rock
- Narrow valley width



D3



Arch dam

C904

Arch dam

C1233

D155

## (D258)roller compacted concrete dams(RCD)

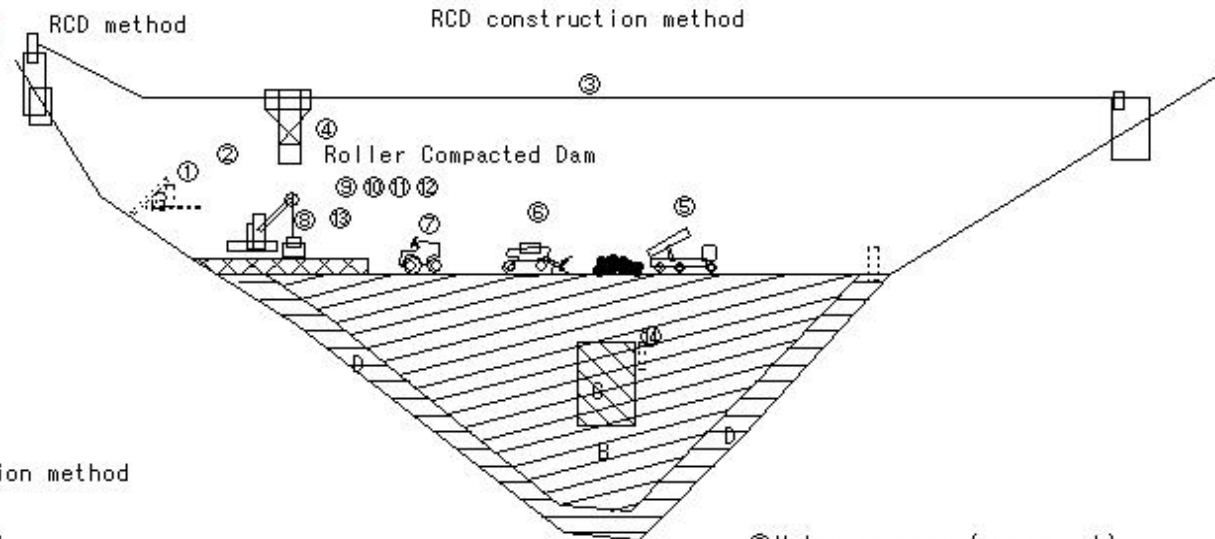
### (D258) roller compacted concrete dams (RCD)

Construction of concrete dam using RCD method

Characteristics of RCD method

④ Placing method

Full layer method



RCD construction method

- ① Batcher plant
- ② Bunker (bucket)
- ③ Fixed cable crane
- ④ Mobile hopper
- ⑤ Dump truck transportation
- ⑥ Bulldozer laying
- ⑦ Vibrating roller (compaction)
- ⑧ Joint cutter  
(vibration press fit type)

- ⑨ Motor sweeper (green cut)
- ⑩ Washing (washing with water)
- ⑪ Watering curing
- ⑫ Laying the next layer of mortar
- ⑬ Vibrating joint cutting machine
- ⑭ Human-powered compaction



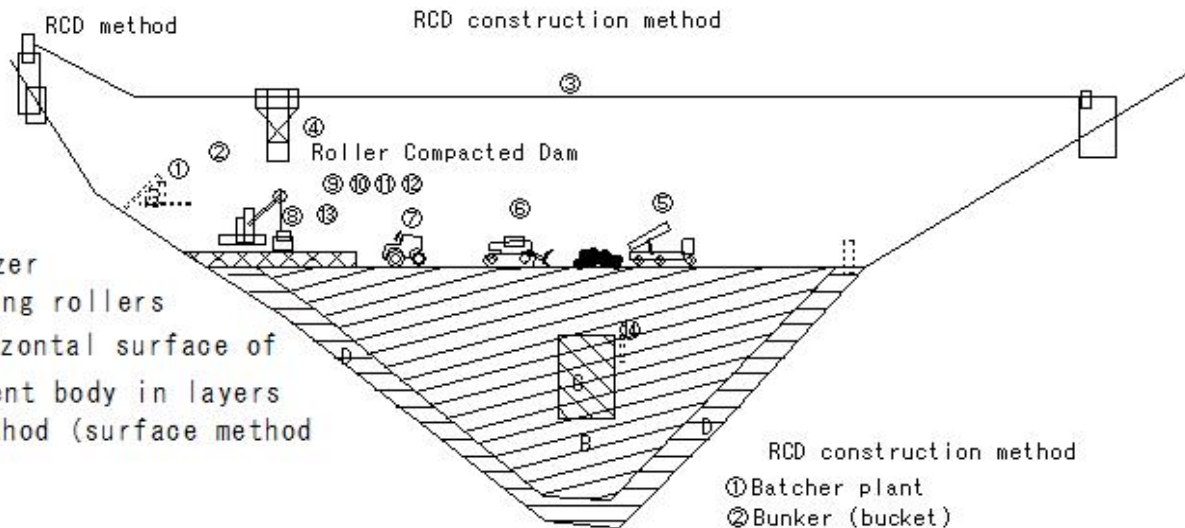
(D259) compacted concrete dams(RCD)

(D259) roller compacted concrete dams (RCD)

Construction of concrete dam using RCD method

RCD method

- Streamlining dam construction
- Poor mix ultra-hard concrete
- Concrete for RCD
- Dump truck
- Fixed cable crane
- Incline
- belt conveyor transportation
- spreading with a bulldozer
- Compaction using vibrating rollers
- Concrete the entire horizontal surface of the embankment body in layers
- Full surface layer method (surface method)



- A Mix Proportion: Upstream and downstream concrete
- B Mix Proportion: Internal concrete
- C Mix Proportion: Concrete around the structure
- D Mix Proportion: Impregnated concrete

- RCD construction method
- ① Batcher plant
  - ② Bunker (bucket)
  - ③ Fixed cable crane
  - ④ Mobile hopper
  - ⑤ Dump truck transportation
  - ⑥ Bulldozer laying
  - ⑦ Vibrating roller (compaction) D74
  - ⑧ Joint cutter C981
  - ⑨ Motor sweeper (green cut)
  - ⑩ Washing (washing with water)
  - ⑪ Watering curing
  - ⑫ Laying the next layer of mortar
  - ⑬ Vibrating joint cutting machine
  - ⑭ Human-powered compaction (vibration press fit type)

(D260)roller compacted concrete dams(RCD)

(D260)roller compacted concrete dams(RCD)

RCD method

fixed cable crane/bucket concrete/Dump truck

Cutting work with a bulldozer/vibrating roller

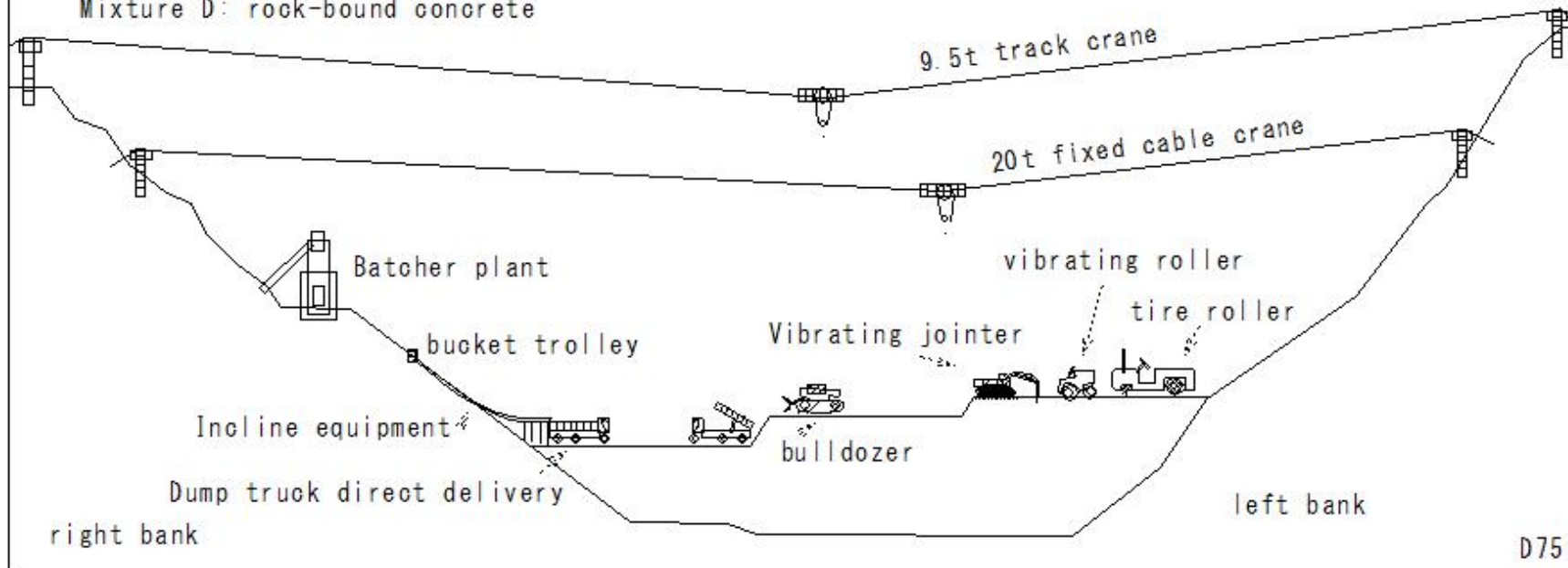
Manufactured using a vibrating jointer/Vibrator - manual compaction

Mixture A: Upstream and downstream concrete

Mixture B: internal concrete

Mixture C: Concrete around the structure

Mixture D: rock-bound concrete

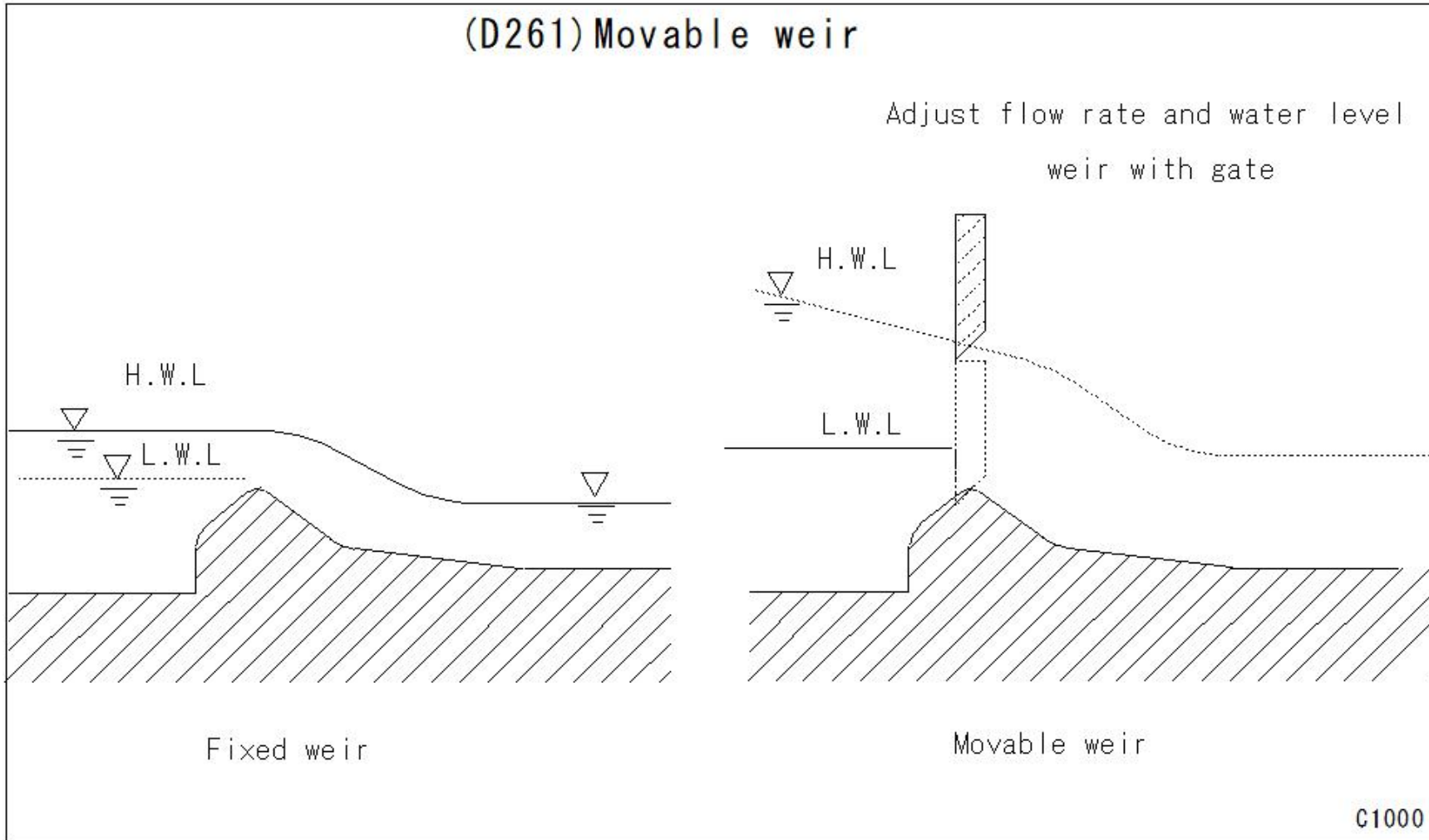




(D261) Movable weir

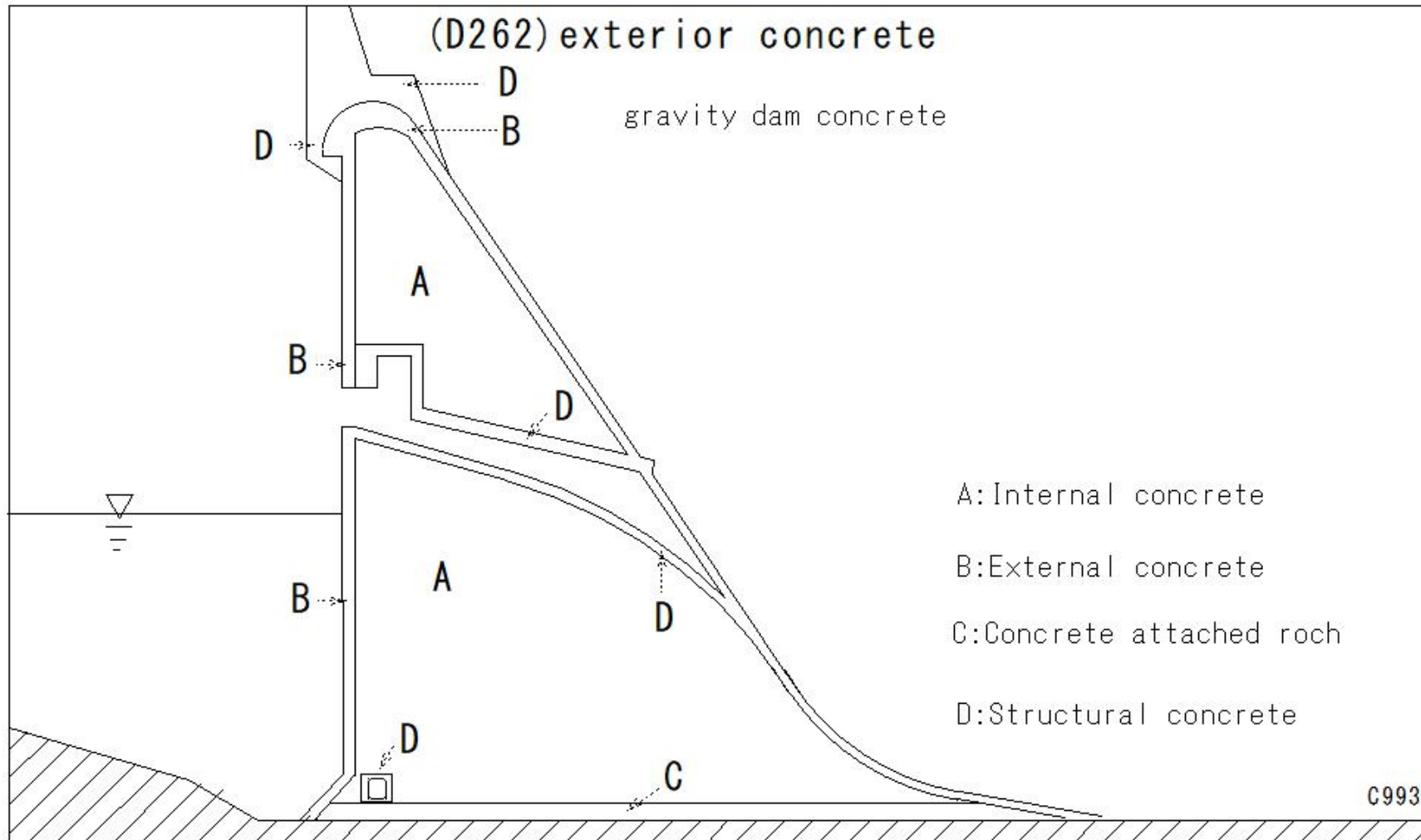
(D261) Movable weir

Adjust flow rate and water level  
weir with gate



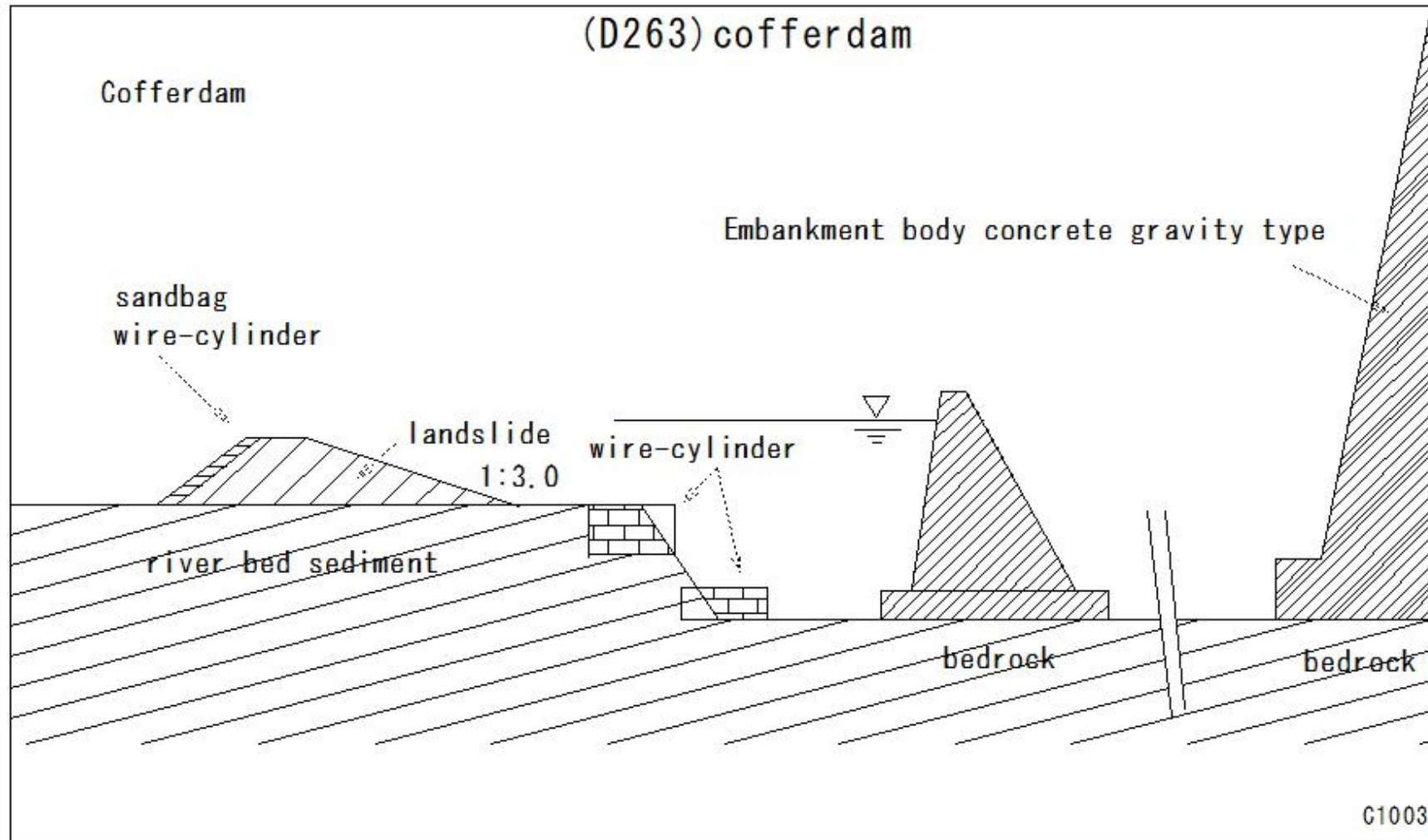
C1000

(D262) exterior concrete



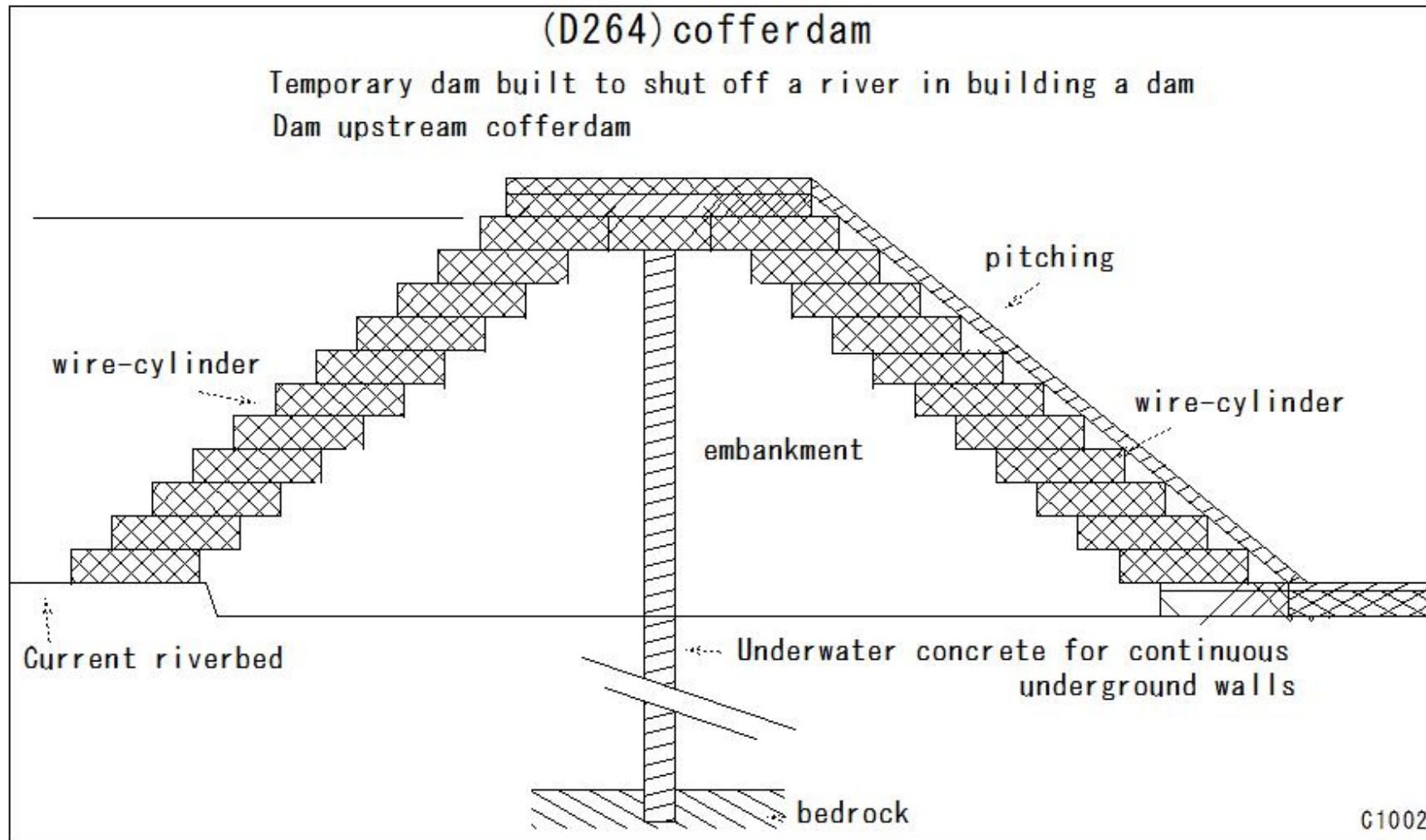
(D263)cofferdam

(D263) cofferdam



G1003

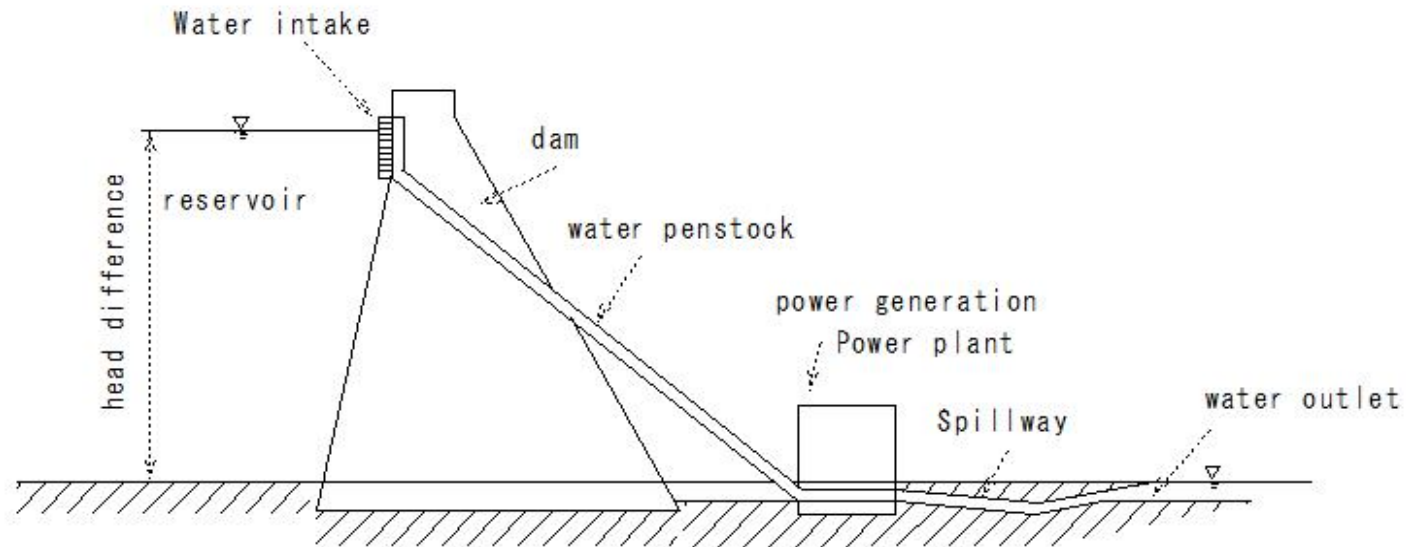
(D264)cofferdam



(D265)dam type power

(D265) dam type power

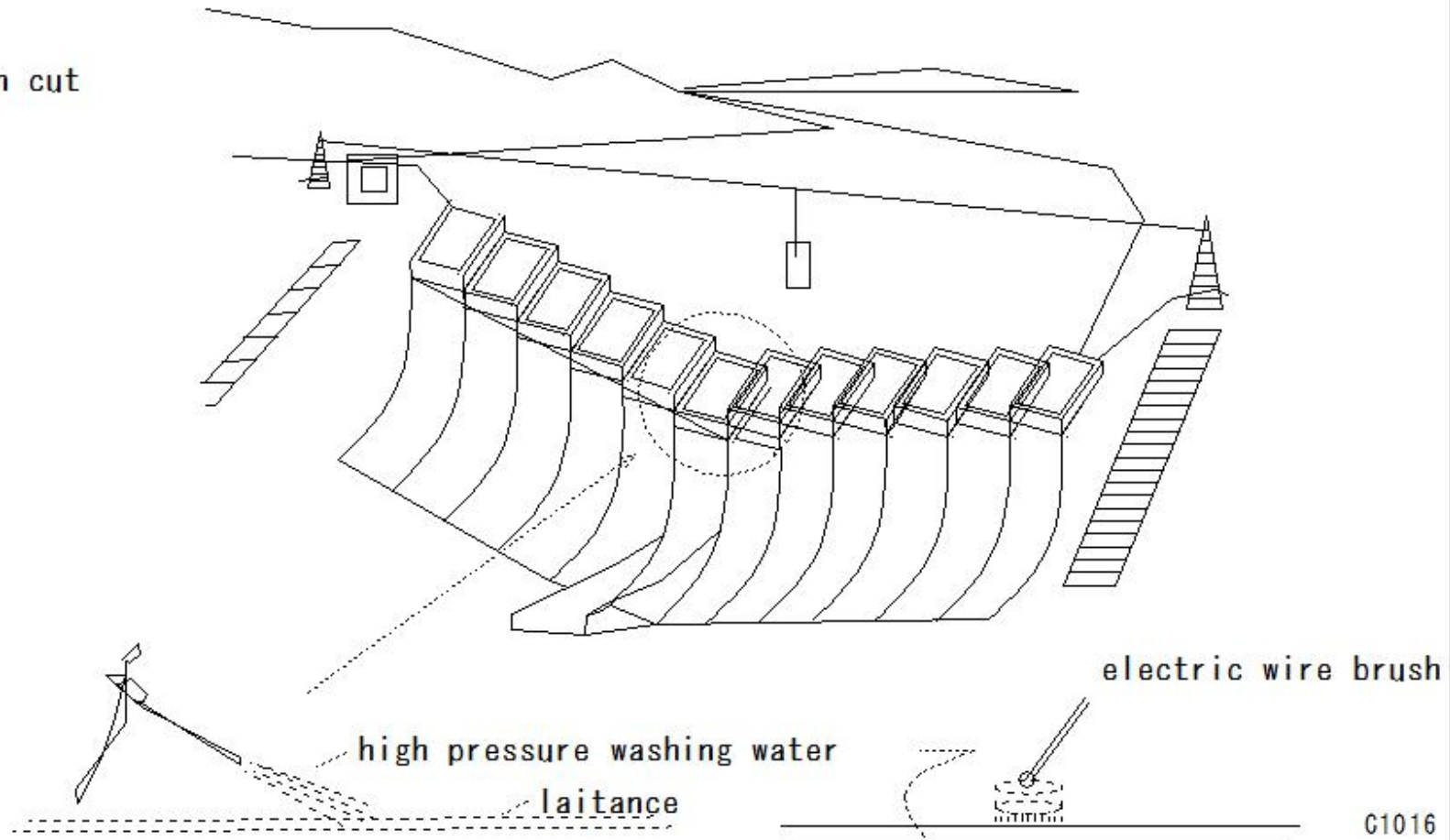
dam type power



(D266)green cut

(D266) green cut

Green cut

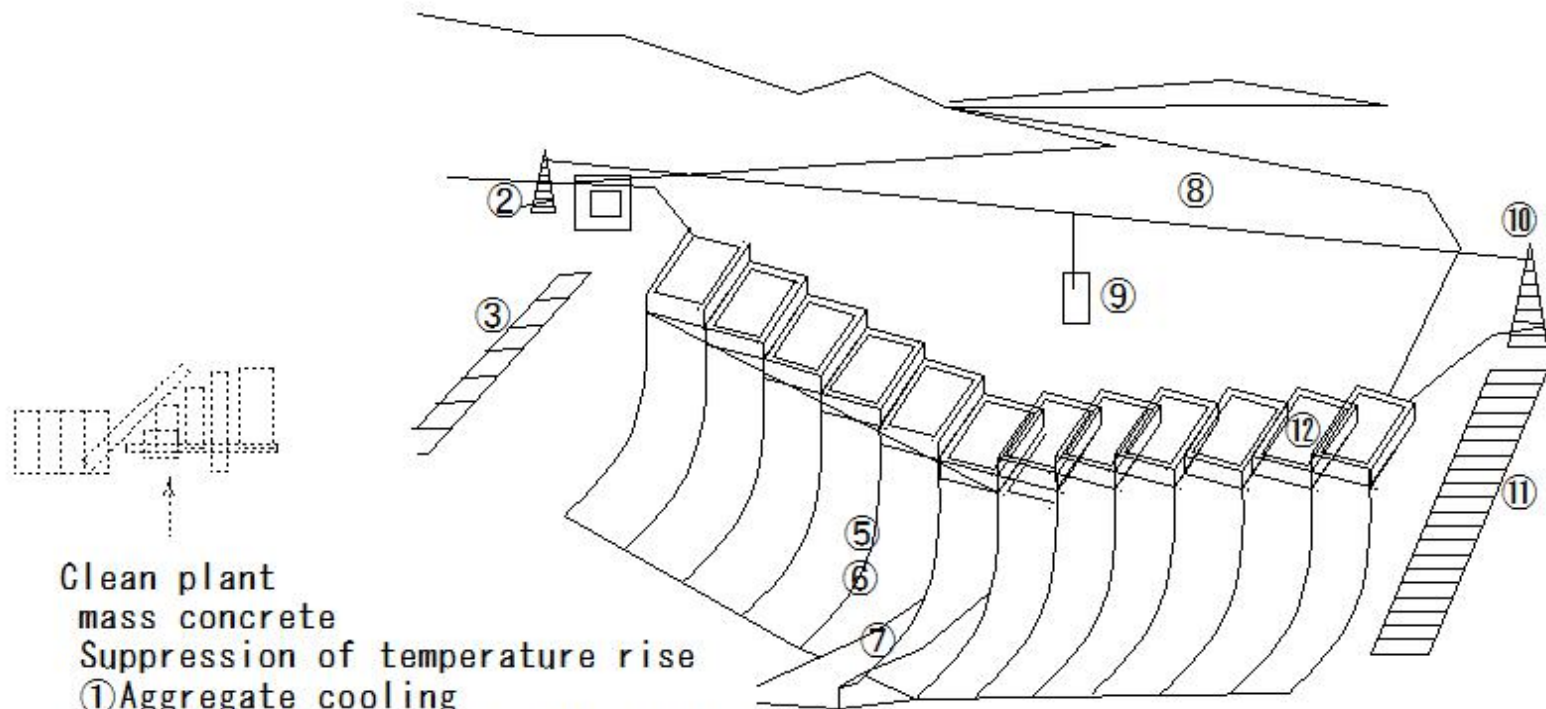


C1016



(D267)clean plant

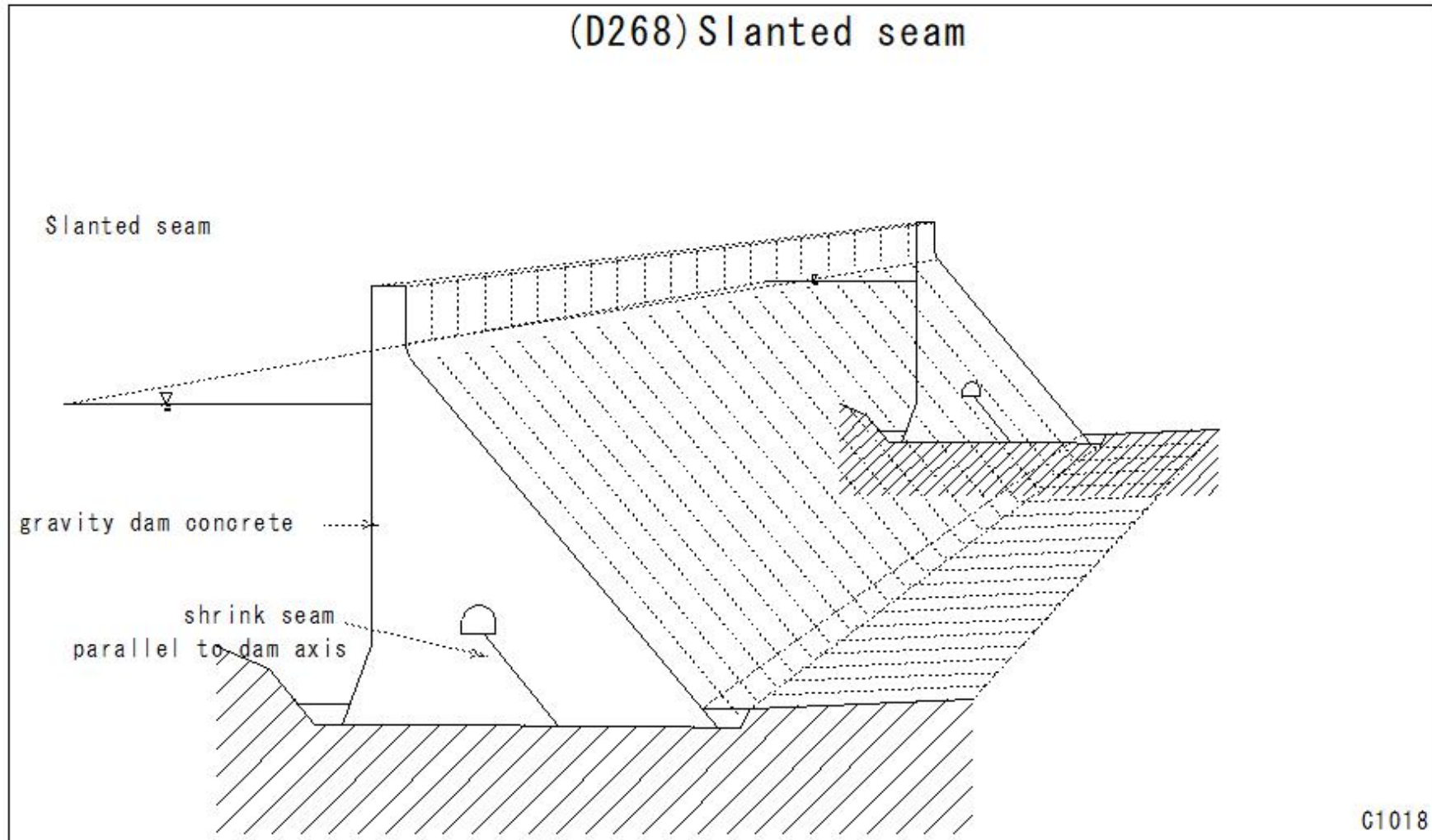
(D267)clean plant



C1017

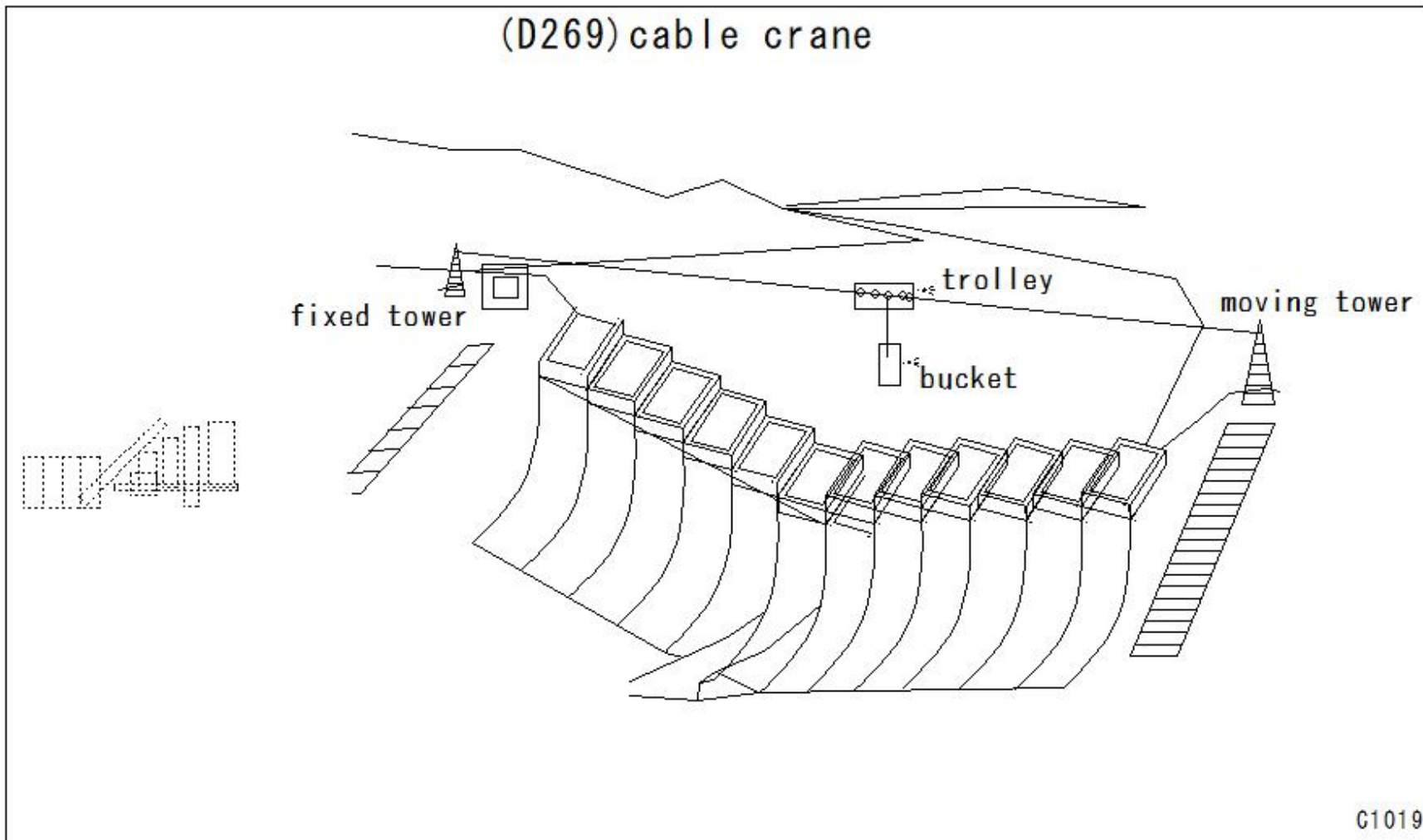
(D268)Slanted seam

(D268) Slanted seam



(D269)cable crane

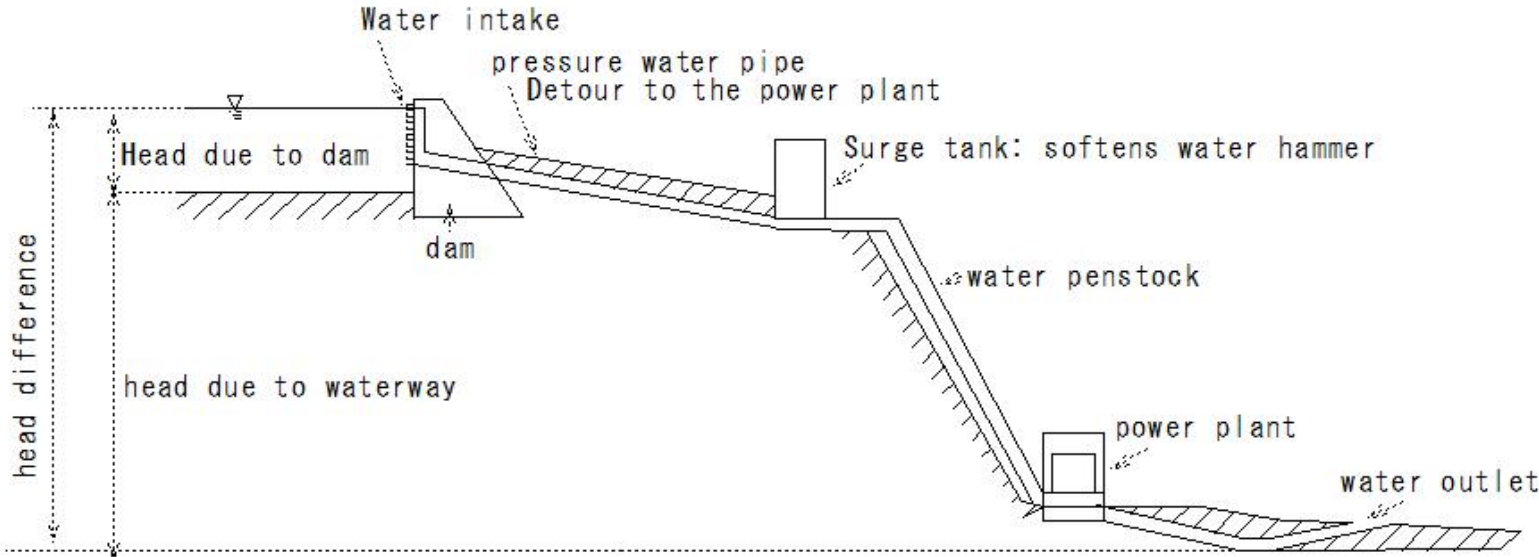
(D269) cable crane



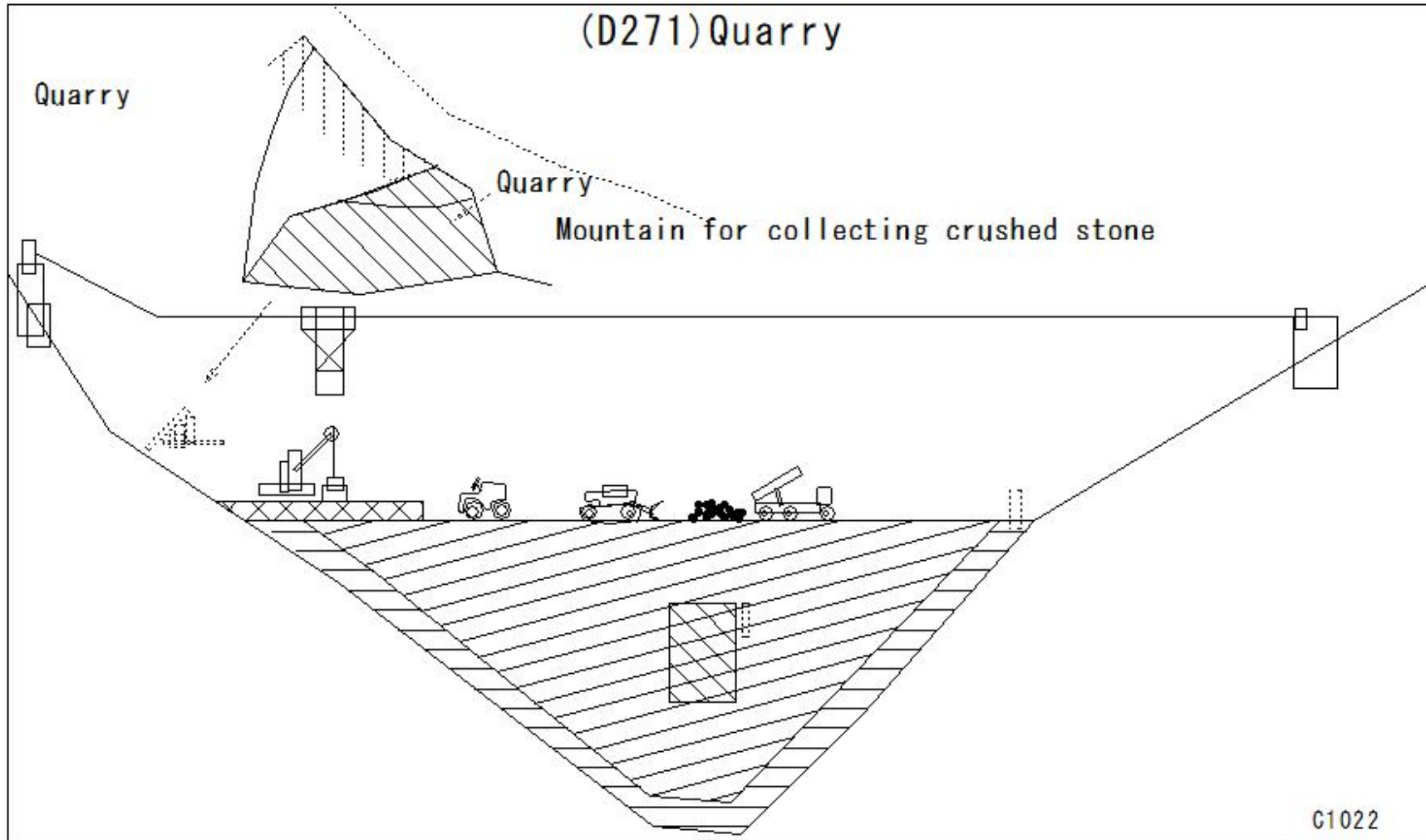
(D270)Energy dissipater

(D270)dam and conduit type power

dam and conduit type power



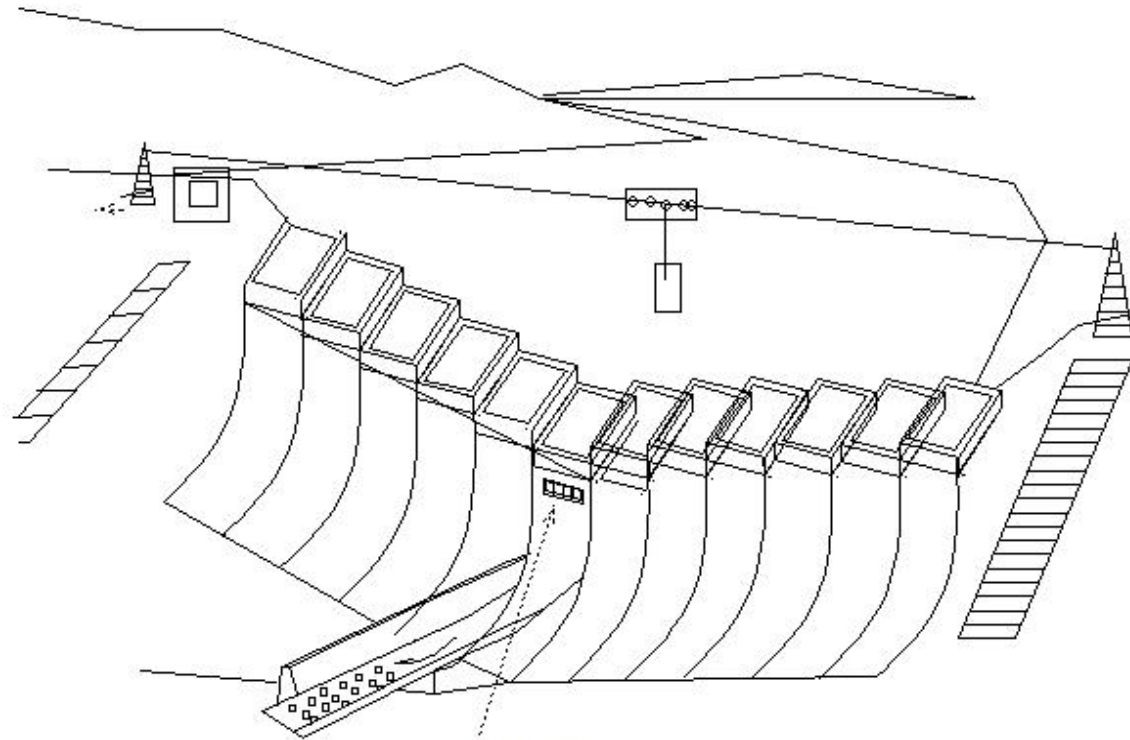
(D271)Quarry



(D272)spillway

(D272) spillway

Spillway



Reservoir water discharge facility

Spillway  
flood control

C1024

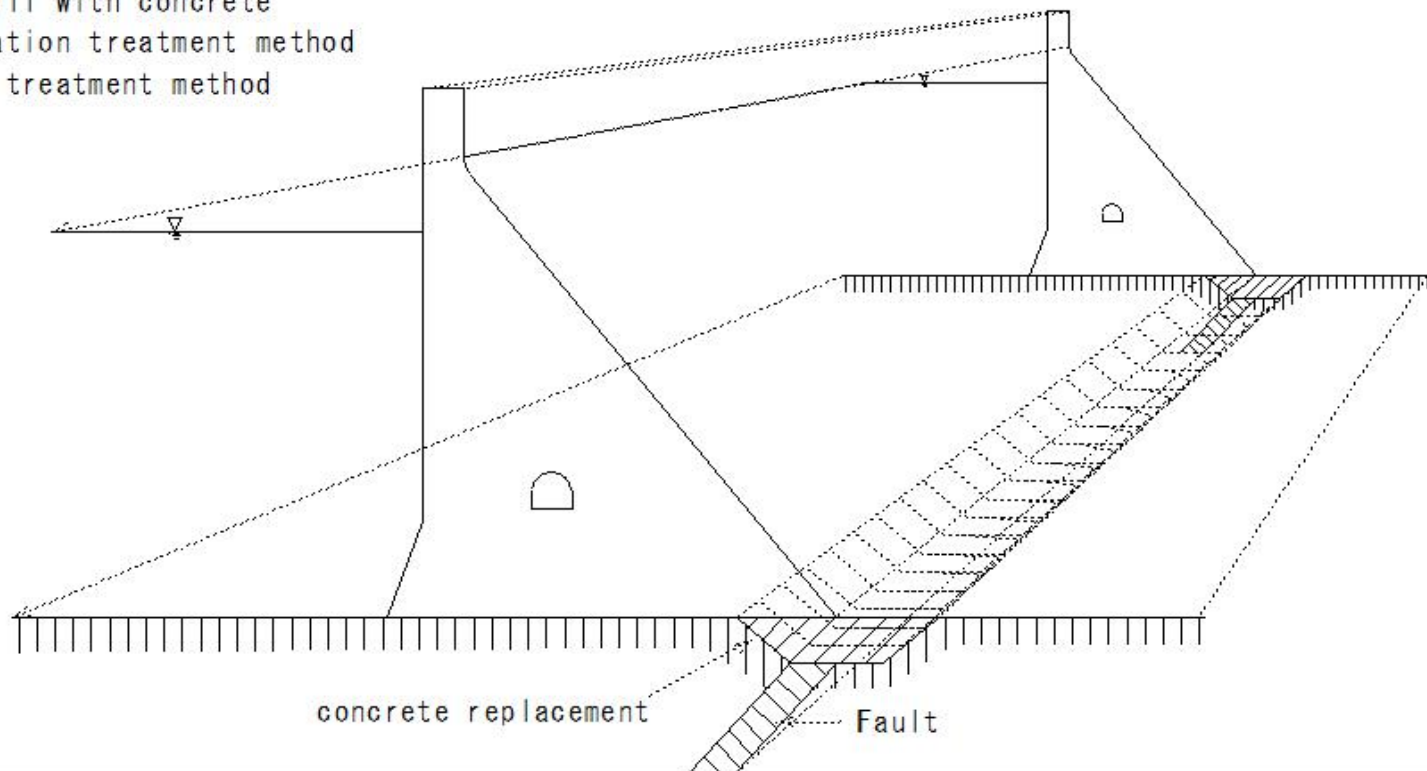


(D273)concrete replacement

(D273)concrete replacement

concrete replacement

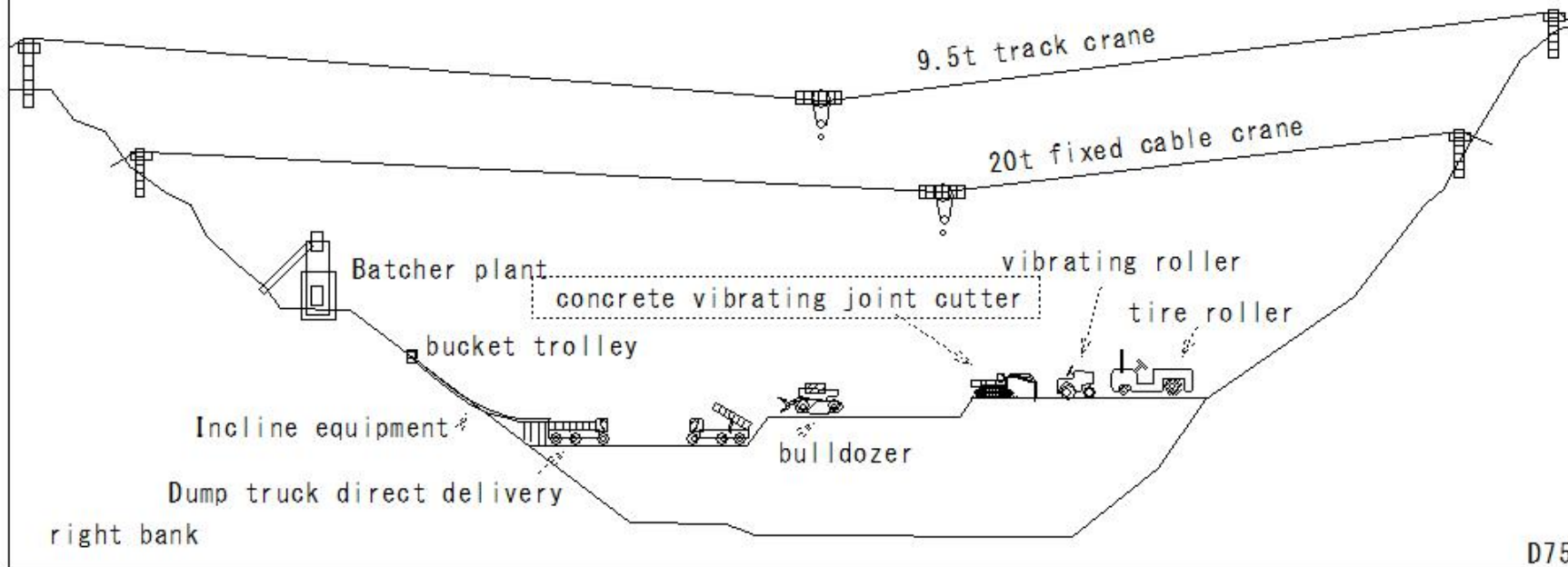
- Weak areas such as large faults in the bedrock
- Weak part: Excavation and removal
- Backfill with concrete
- Foundation treatment method
- Fault treatment method



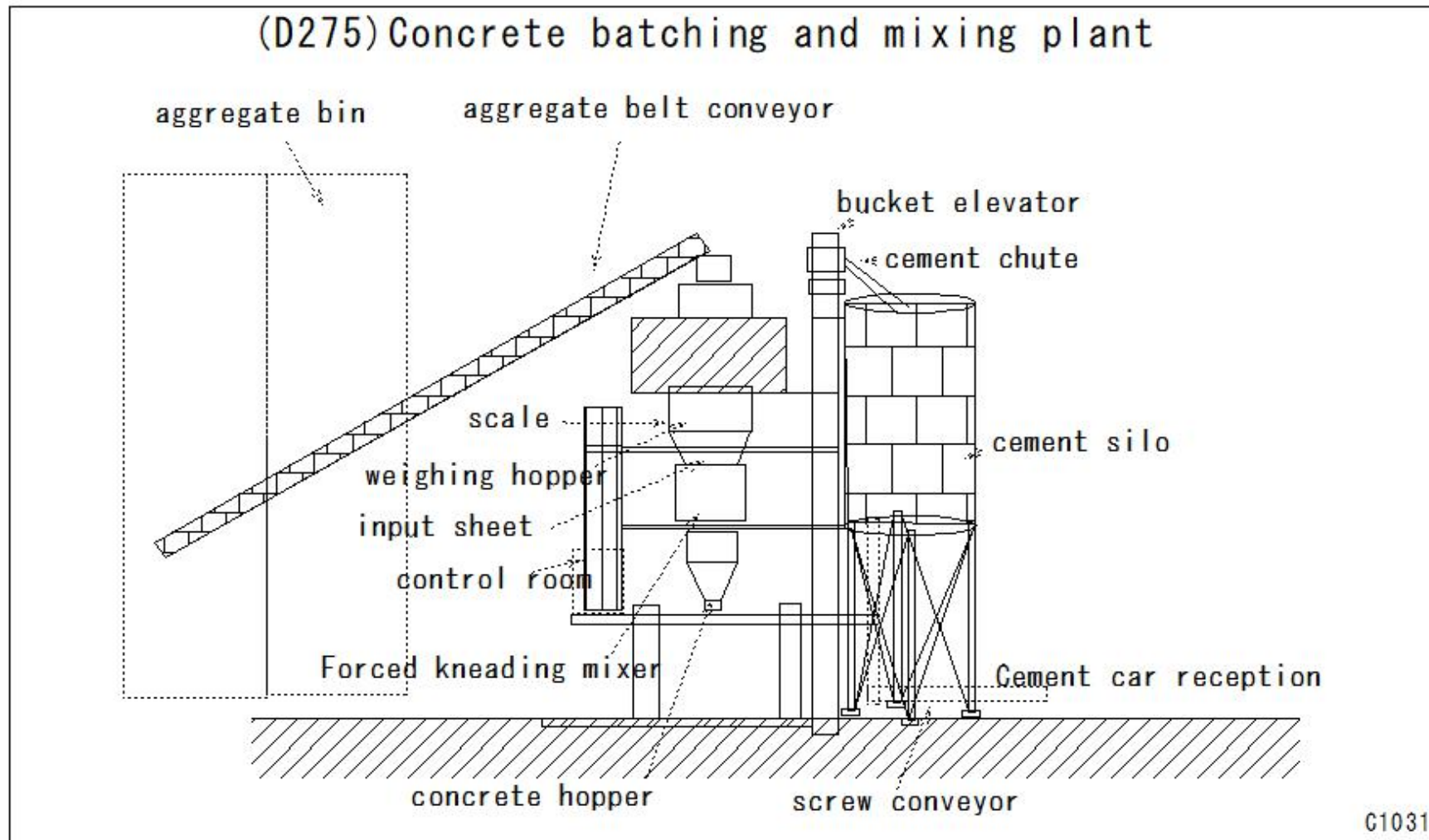
(D274)RCD method(concrete vibrating joint cutter)

(D274) RCD method (concrete vibrating joint cutter)

concrete vibrating joint cutter  
RCD method  
Creating joints in uncured concrete



(D275)Concrete batching and mixing plant

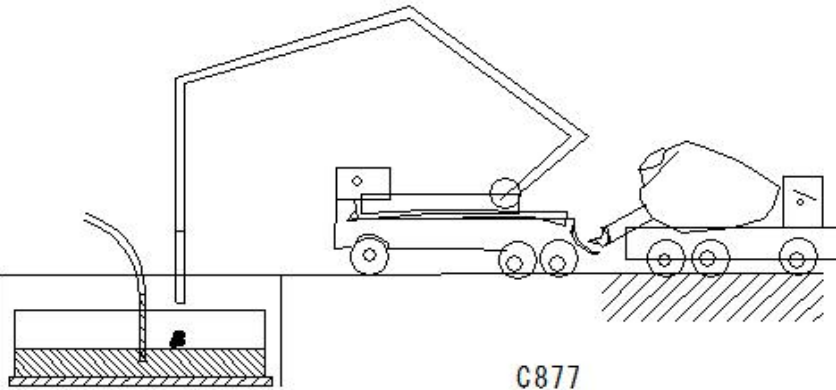


(D276)Concrete pump

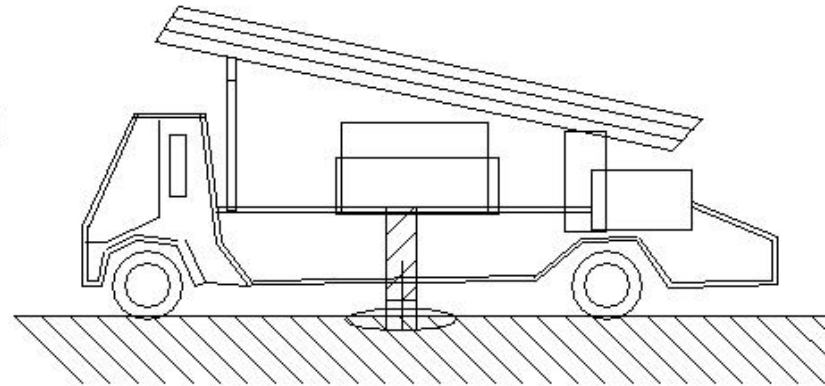
(D276) Concrete pump

Concrete pump

Pressure-fed to the casting site by a pipe  
squeeze type/piston type



C877



Pressure-fed to the casting site by a pipe  
squeeze type  
piston type

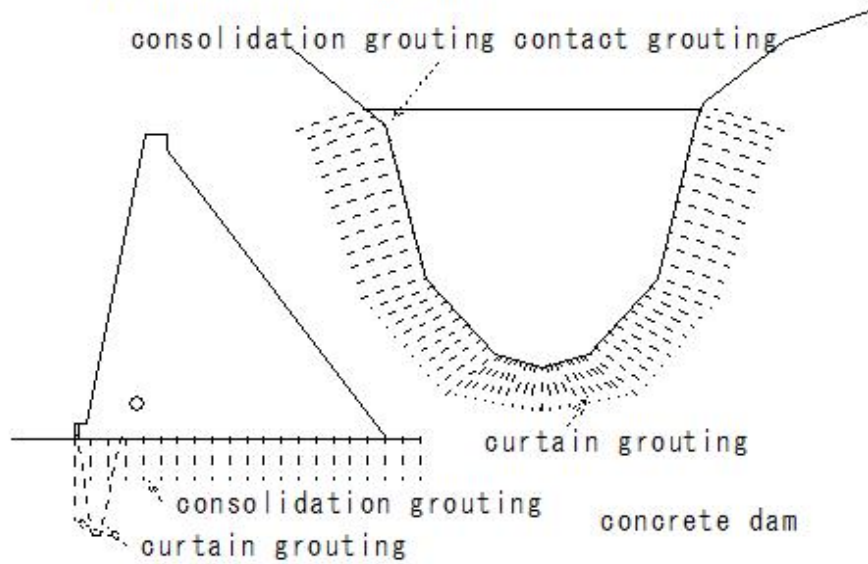
C1032

(D277)consolidation grouting

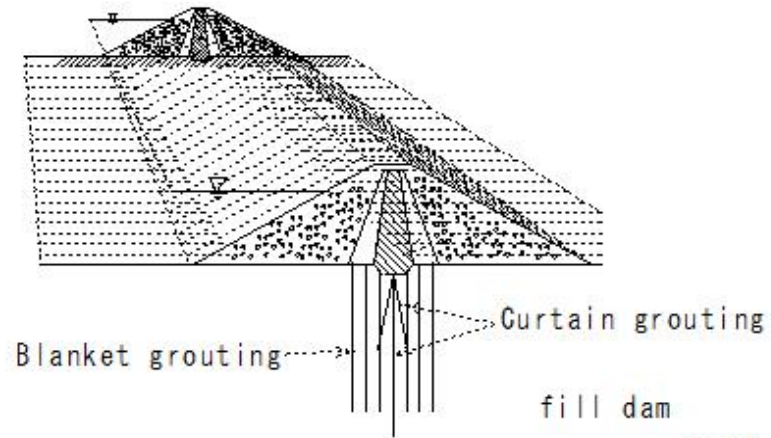
(D277) consolidation grouting

consolidation grouting

- Injection of cement milk into cracks in the foundation rock
- Improvement of rock properties
- Bedrock deformation - Improvement
- Improved water impermeability
- Improvement of loose rock



D130



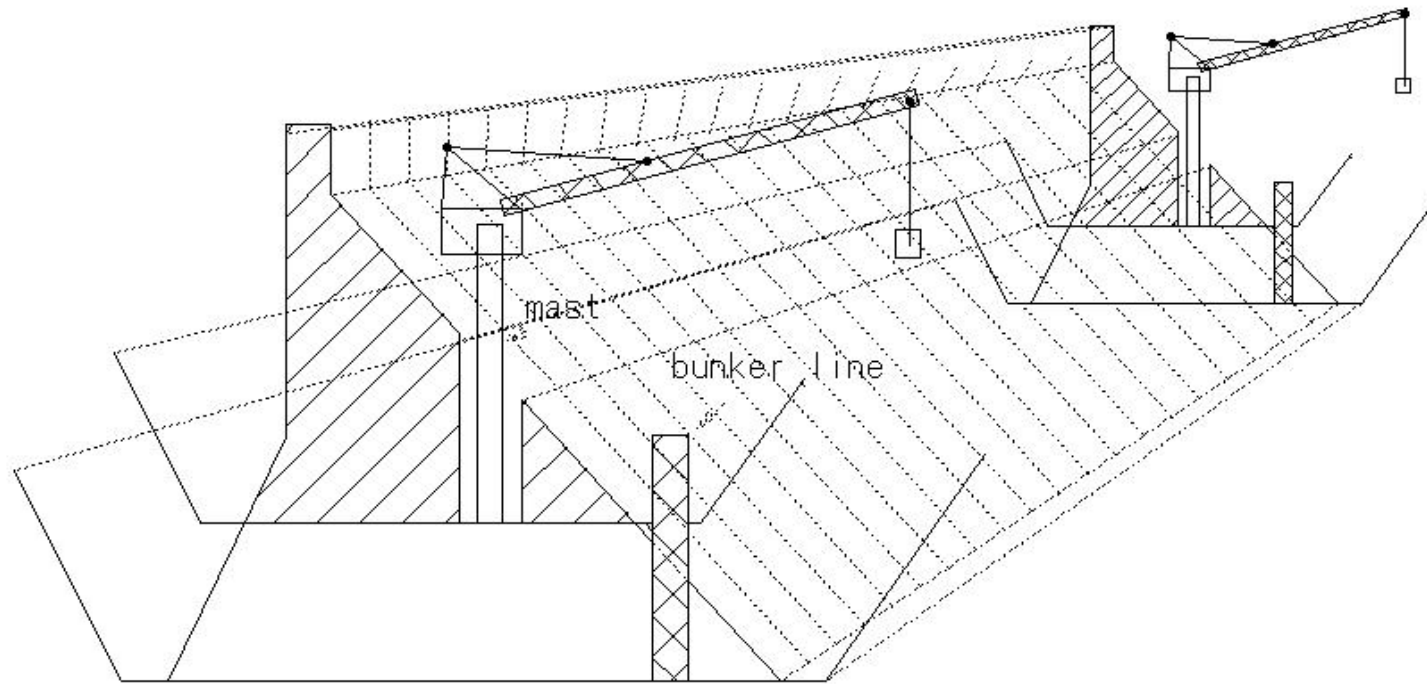
D138

D167

(D278)fixed jib crane

(D278)fixed jib crane

fixed jib crane



climbing crane

C1036



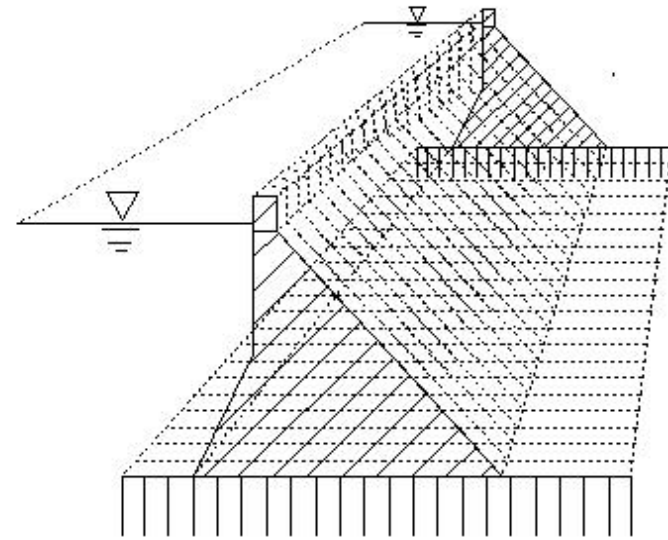
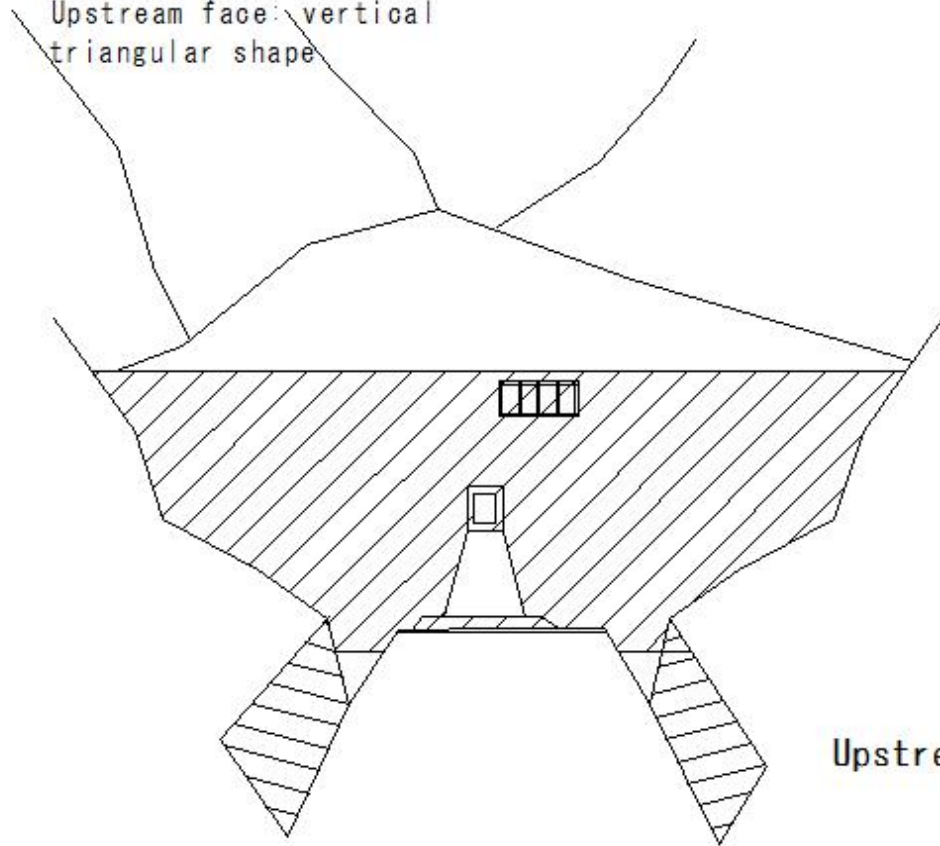
(D279)Concrete gravity dam

(D279)Concrete gravity dam

gravity concrete dam

Use weight

Upstream face: vertical  
triangular shape



Upstream face: vertical  
triangular

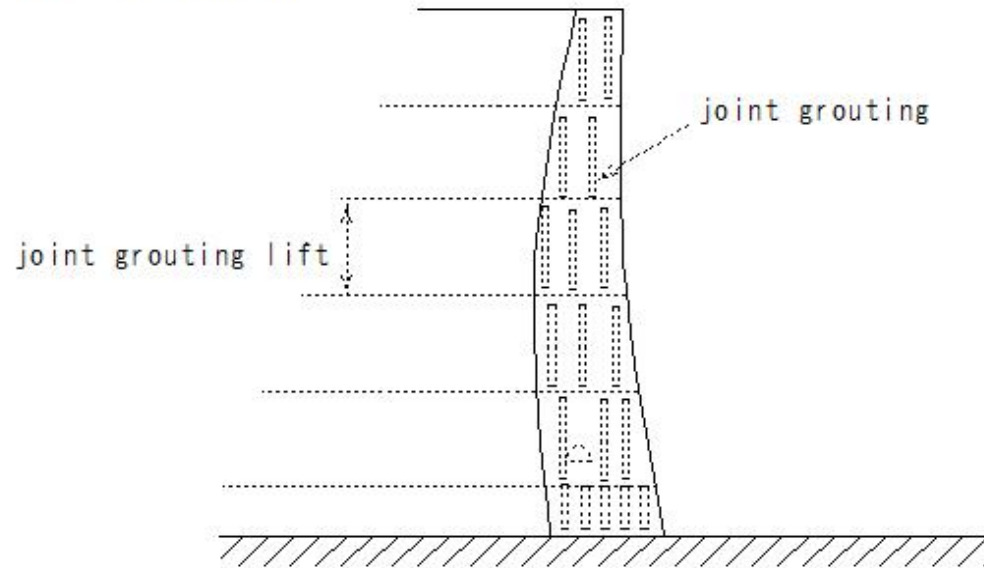
C1041

## (D280) joint grouting lift

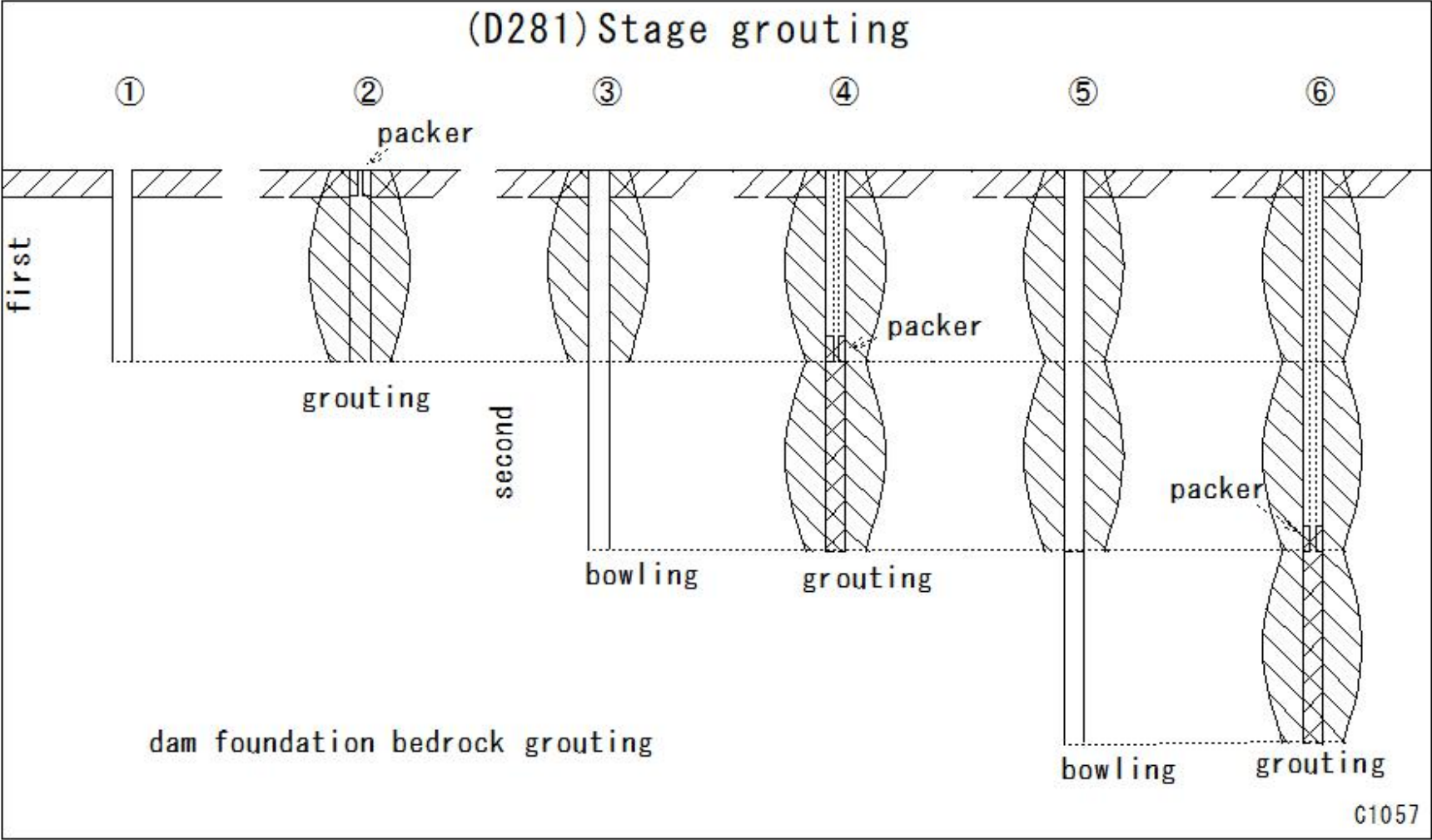
### (D280) joint grouting lift

joint grouting lift

- Concrete shrinkage joints
- Pressure injection of cement milk
- Integration of concrete as a structure
- supply tube
- Usually 12-15m standard



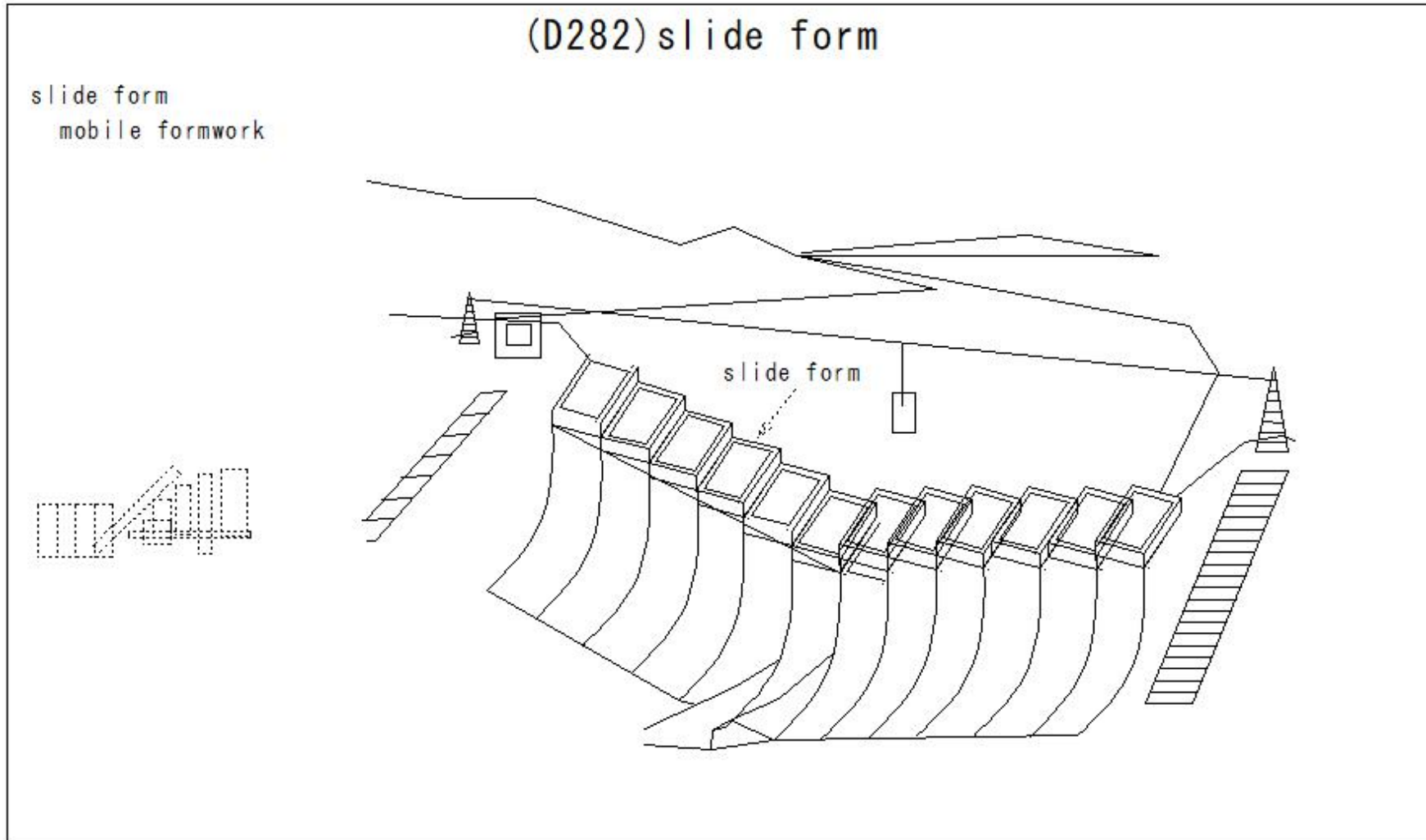
(D281)Stage grouting



(D282)slide form

(D282)slide form

slide form  
mobile formwork

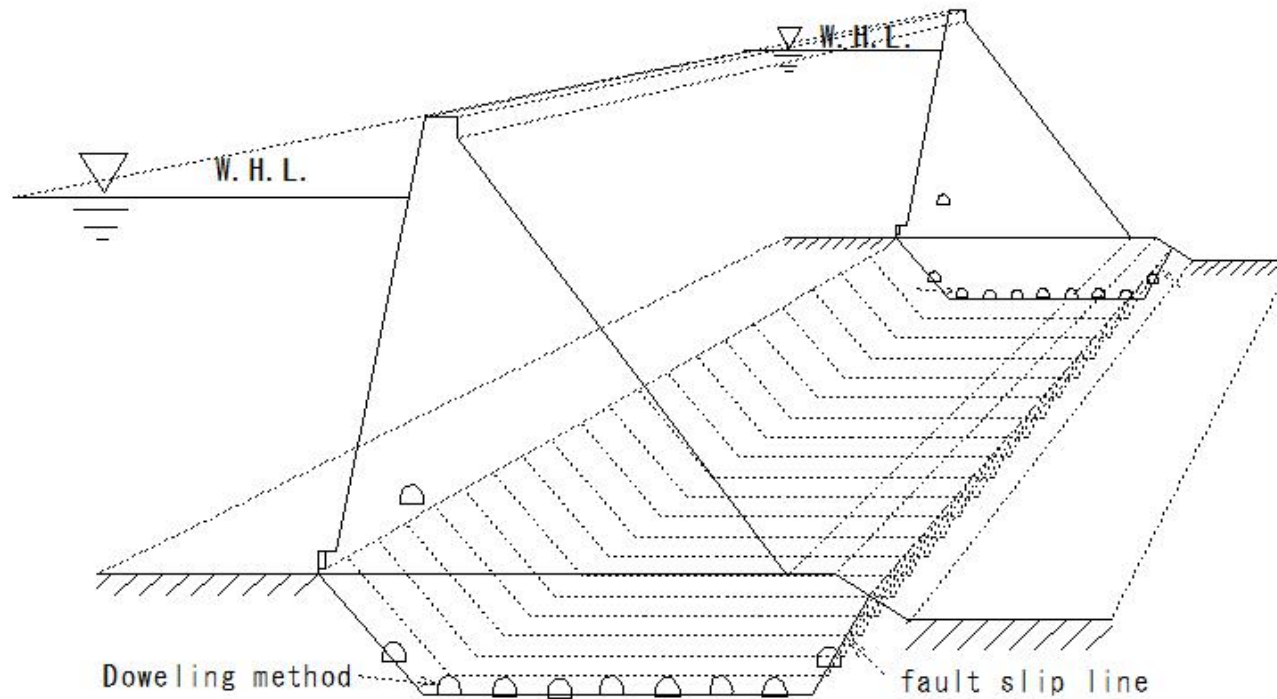


## (D283)dowelling method

### (D283) dowelling method

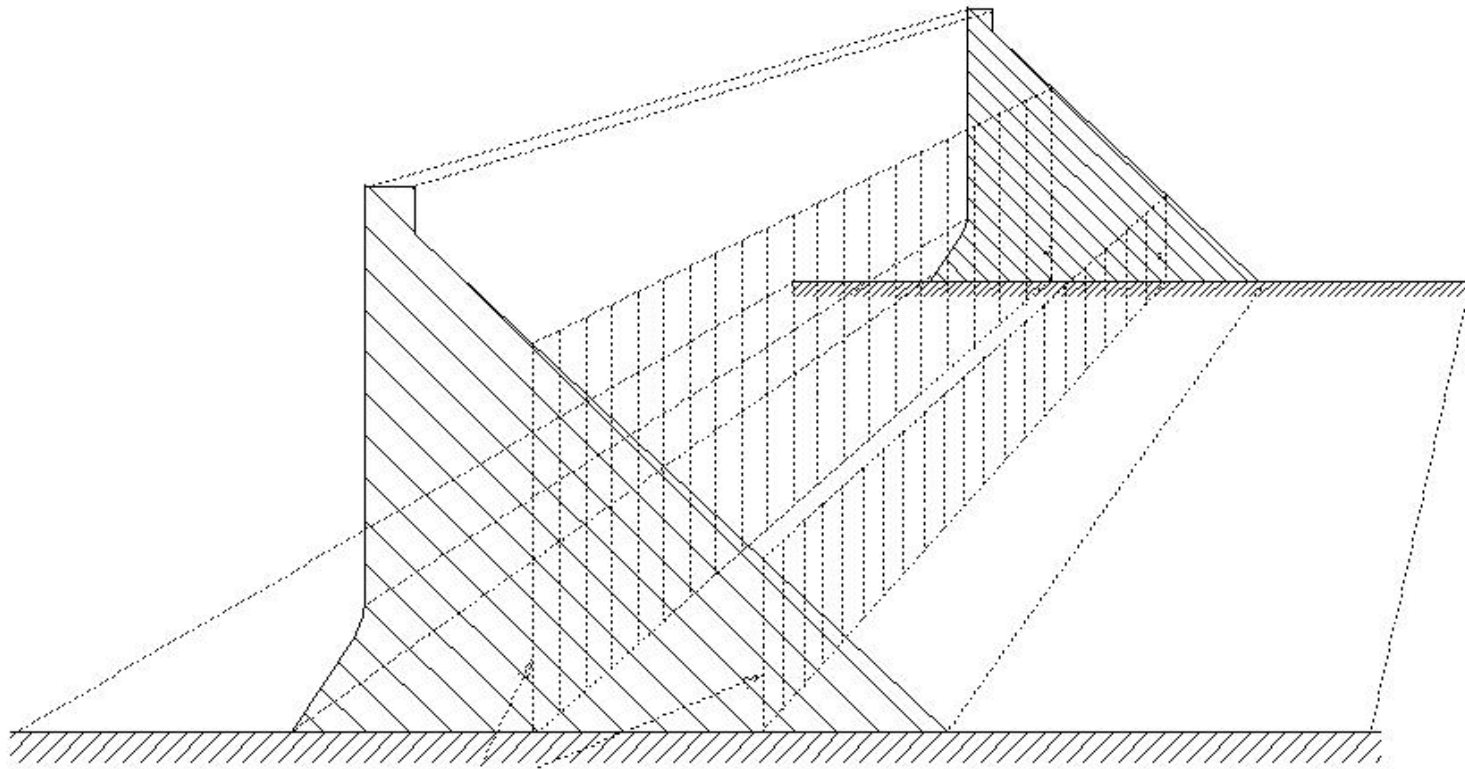
#### Dowelling method

- Foundation rock: slippery faults, etc.
- Replaced with concrete
- Increased safety against sliding



(D284)longitudinal joint

(D284) longitudinal joint



longitudinal joint

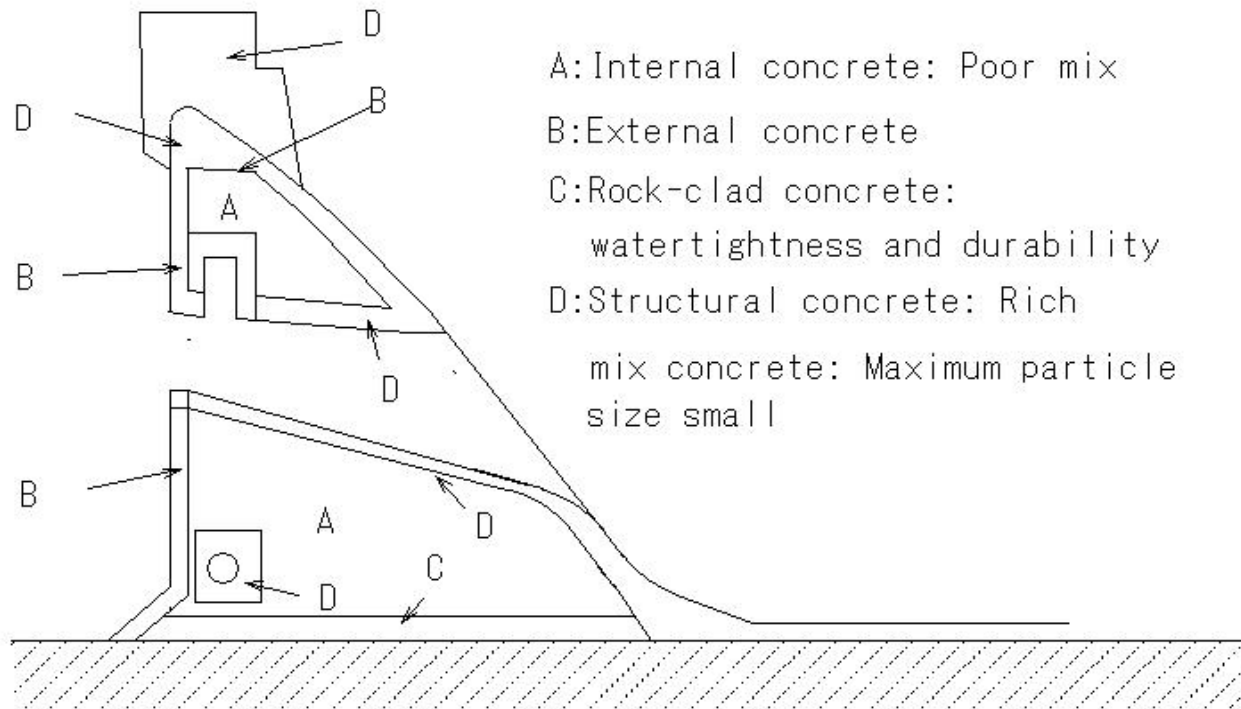
gravity dam

C1063

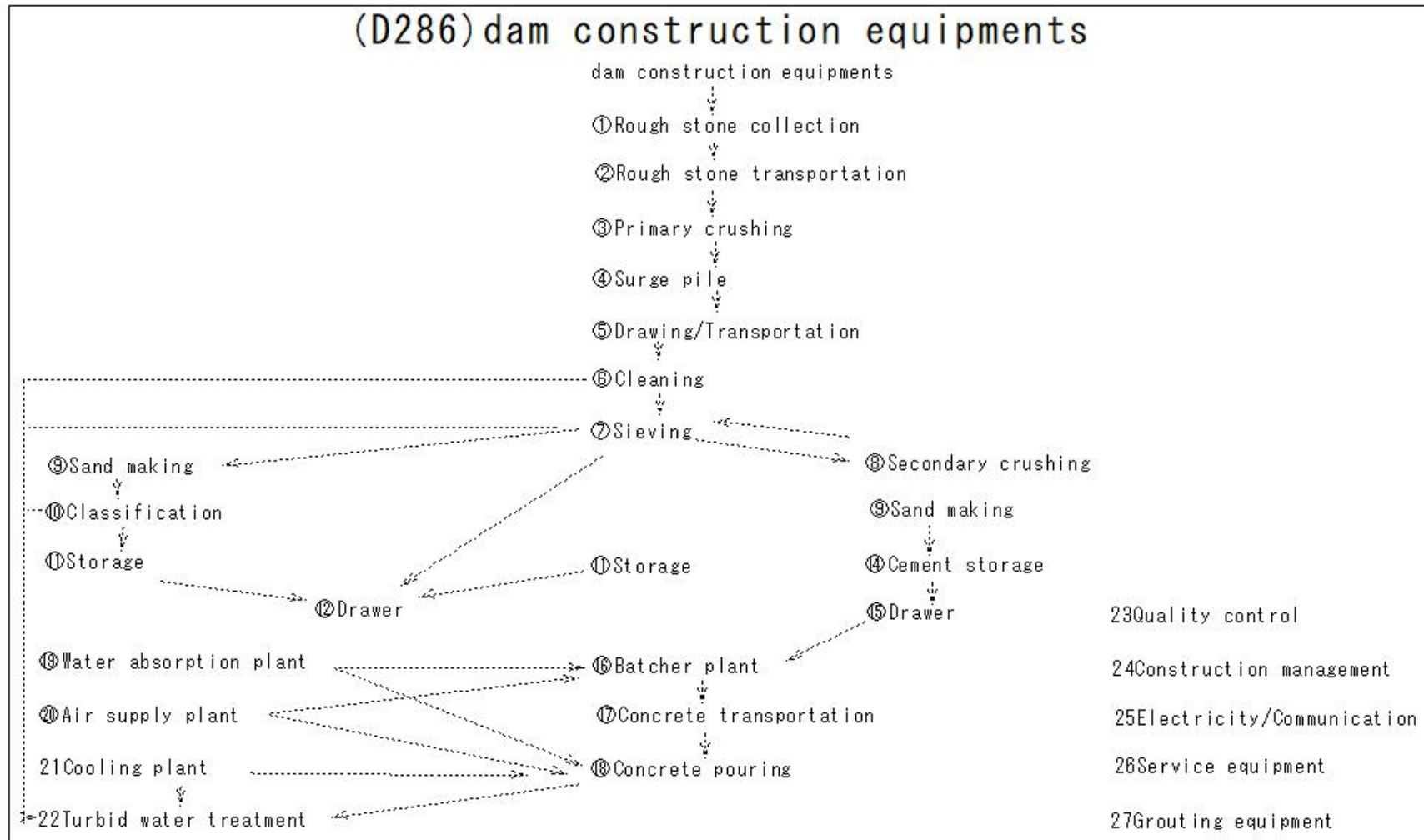


(D285)Dam concrete division

(D285) Dam concrete division



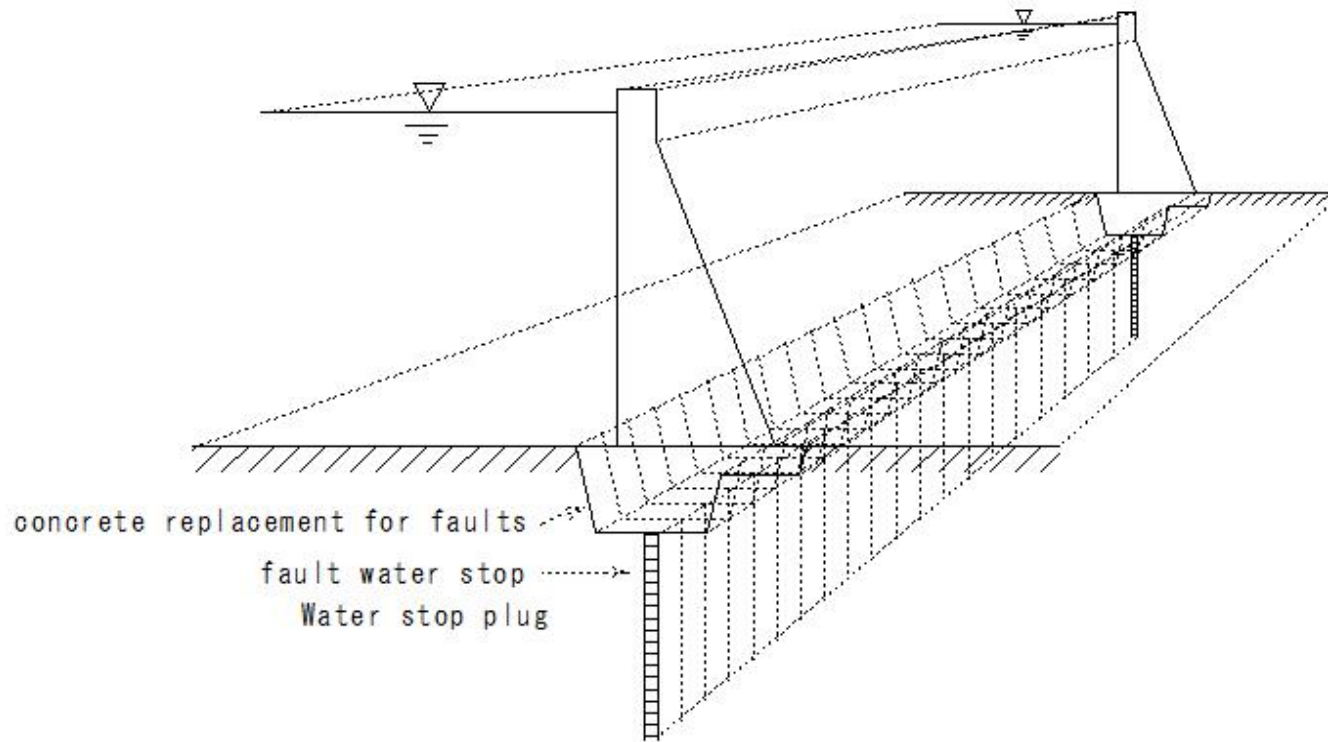
(D286)dam construction equipments



(D287)concrete replacement for faults

### (D287) concrete replacement for faults

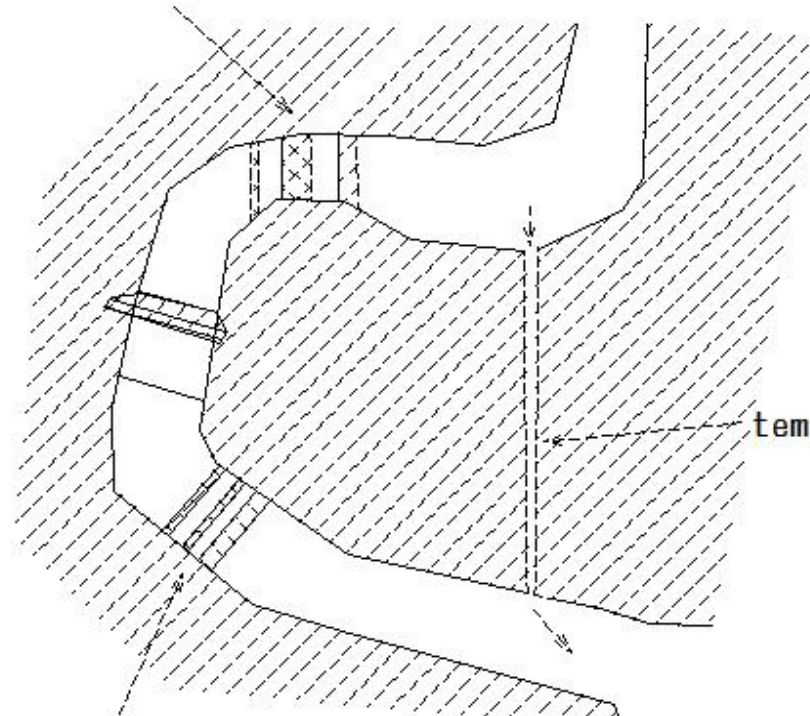
concrete replacement for faults



(D288) Diversion works-Temporary drainage tunnel

(D288) Diversion works-Temporary drainage tunnel

upstream cofferdam



Diversion works

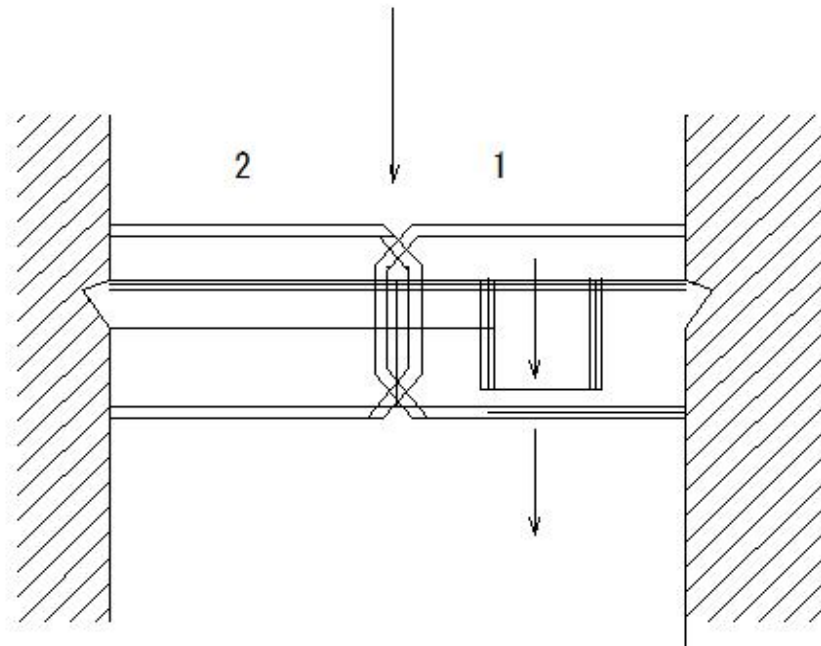
temporary drainage tunnel

downstream cofferdam

C1073

(D289) Diversion works-Half cofferdam

(D289) Diversion works-Half cofferdam



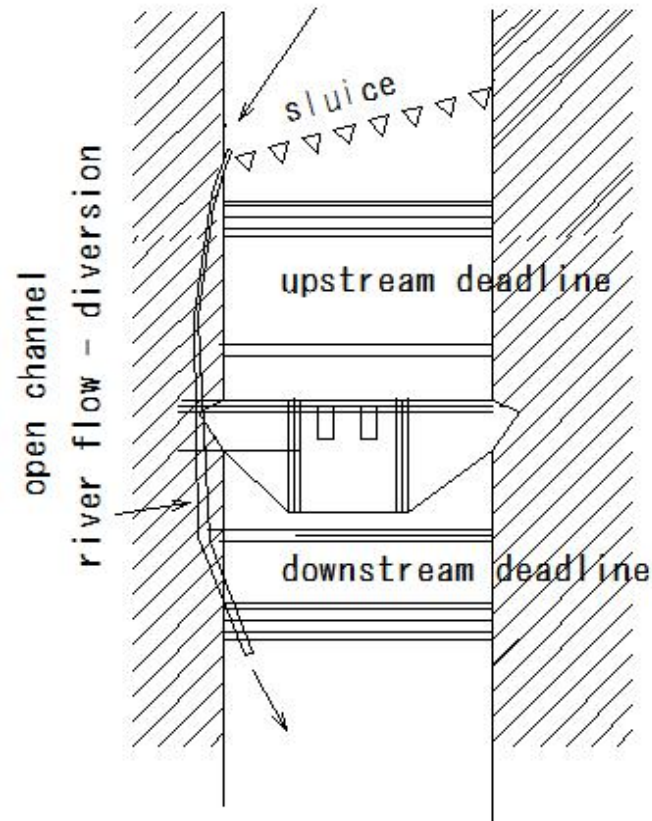
Diversion works-Half cofferdam

C1074

(D290) Diversion works (Temporary drainage open ditch)

(D290) Diversion works (Temporary drainage open ditch)

Temporary drainage open ditch

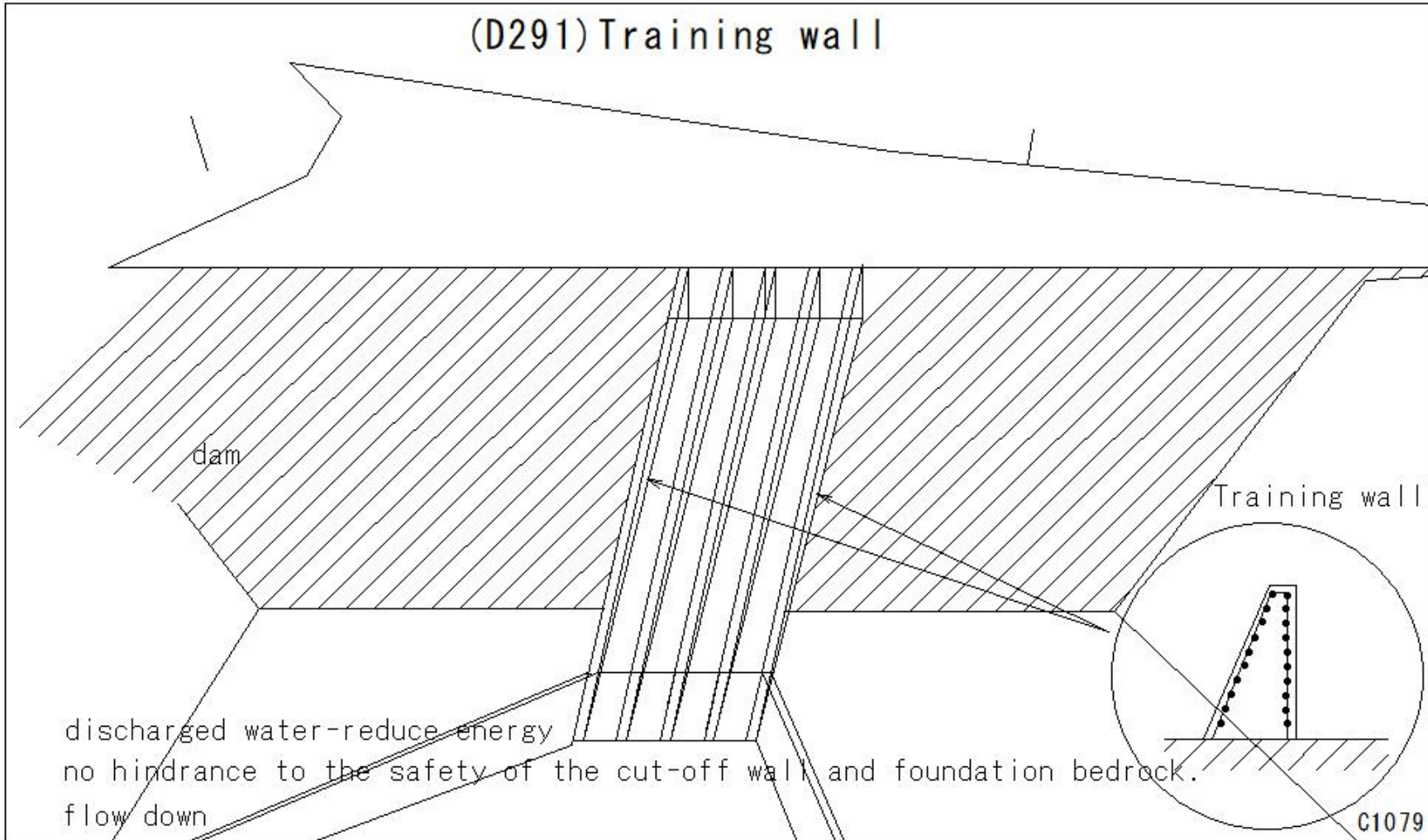


G1075



(D291) Training wall

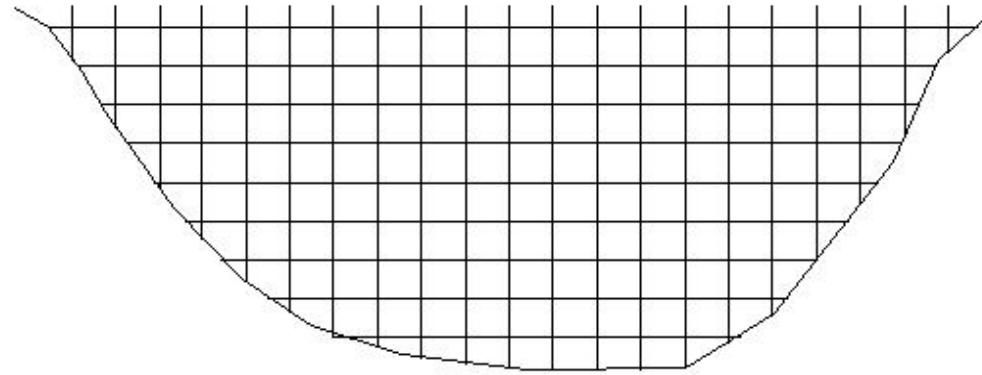
(D291) Training wall



(D292)pipe cooling

(D292)pipe cooling

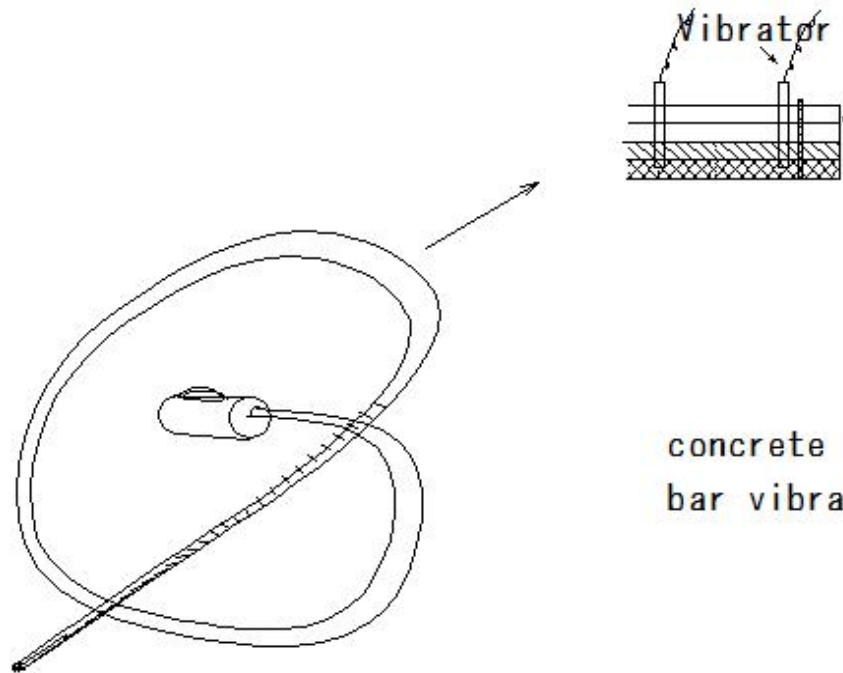
pipe cooling  
concrete dam  
artificial cooling  
Concrete pouring surface  
Diameter 3cm  
thin wall steel pipe  
Cooling water - water flow  
lower concrete temperature



pipe cooling arrangement

(D293)vibrator

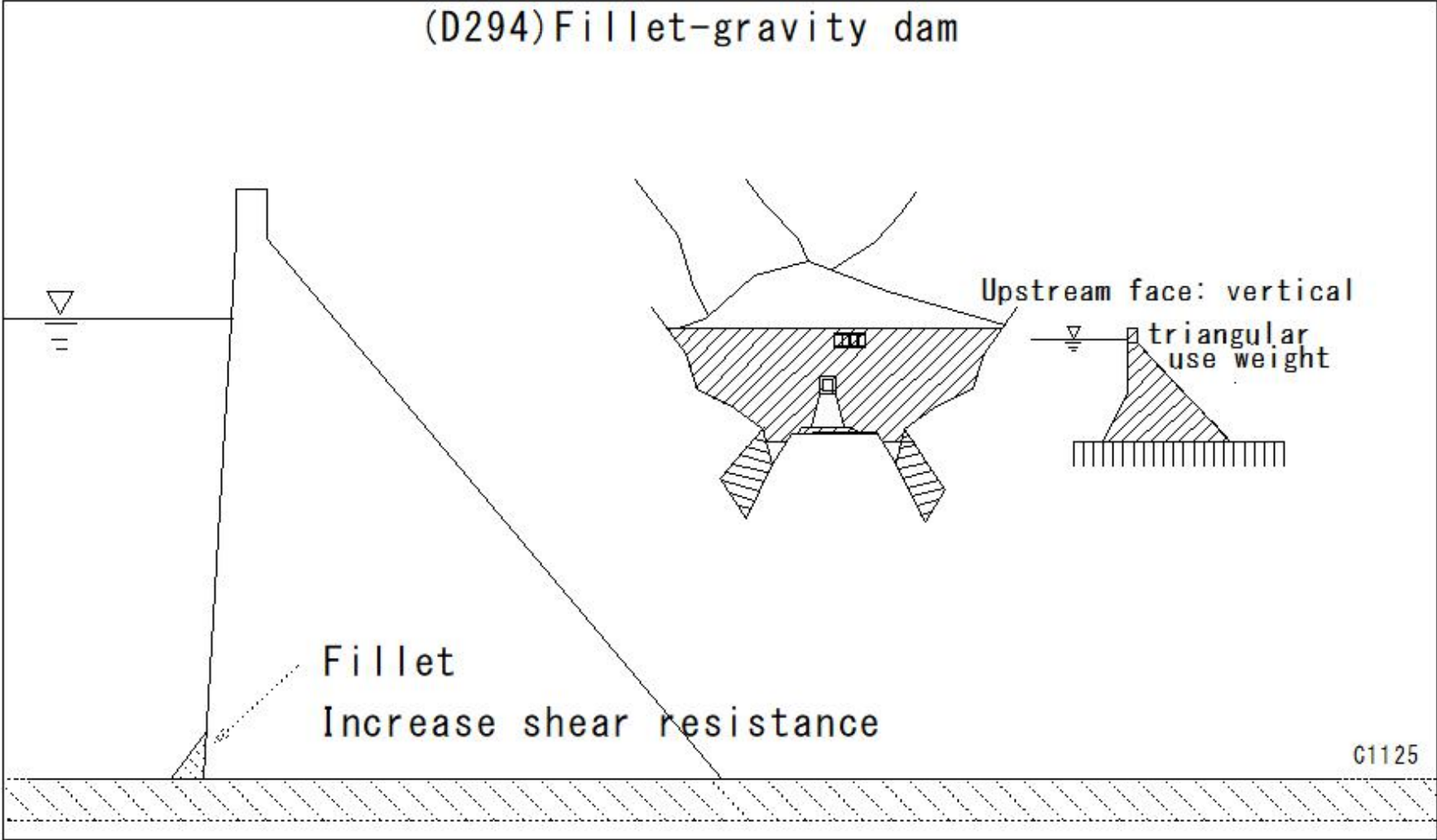
(D293) vibrator



concrete compaction  
bar vibrator

C1102

(D294) Fillet-gravity dam



(D295)rod vibrator

(D295)rod vibrator

rod vibrator

Applying vibration directly to concrete

Rod-shaped vibrator

①Vibration tube

②Switch case

③Buffer rubber

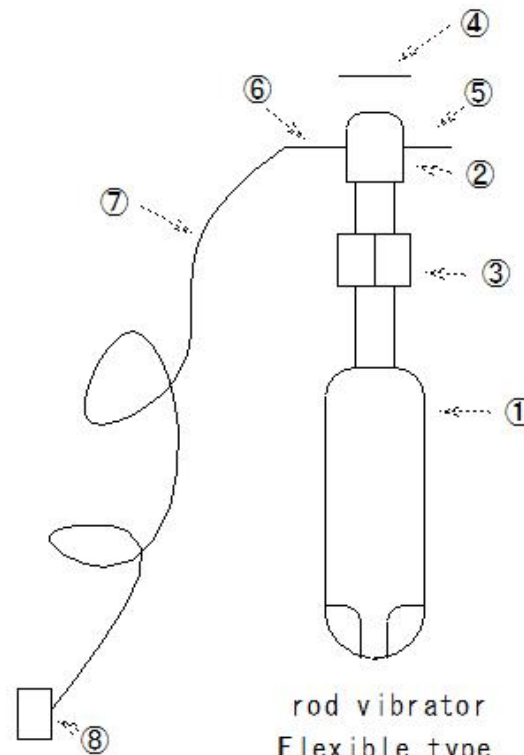
④Switch

⑤Handle

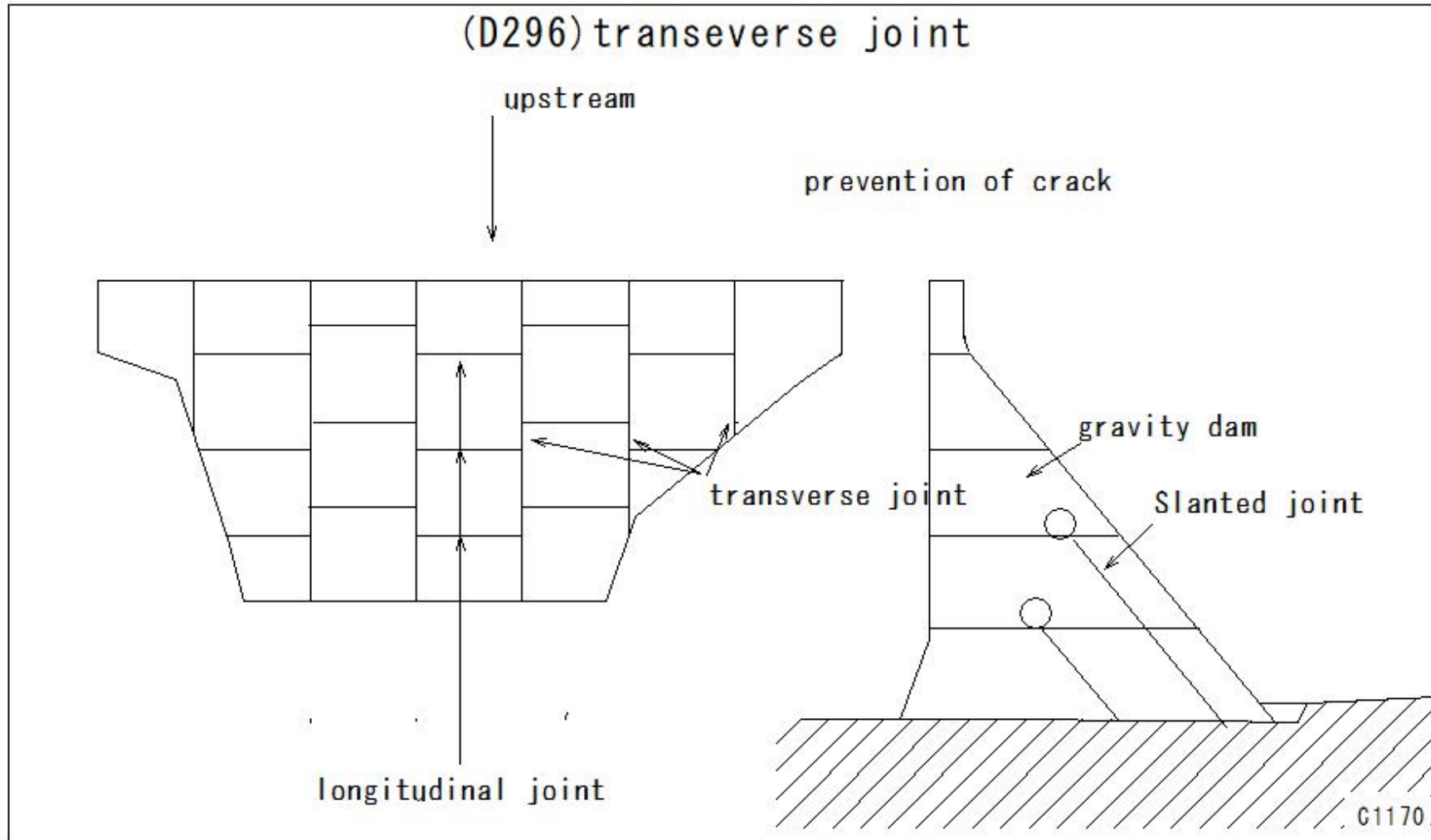
⑥Handle

⑦Cable

⑧Connector



(D296)transeverse joint





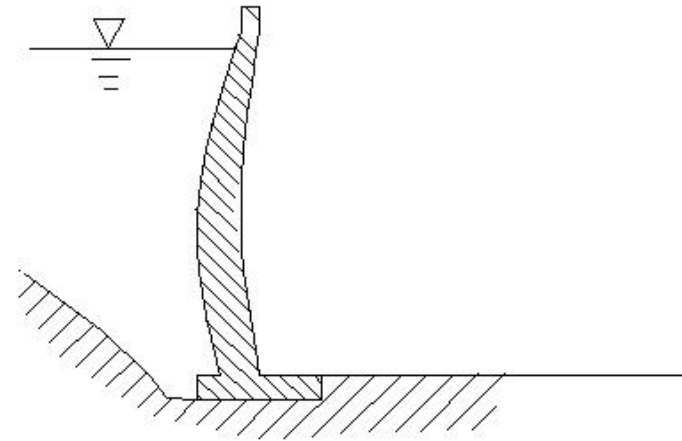
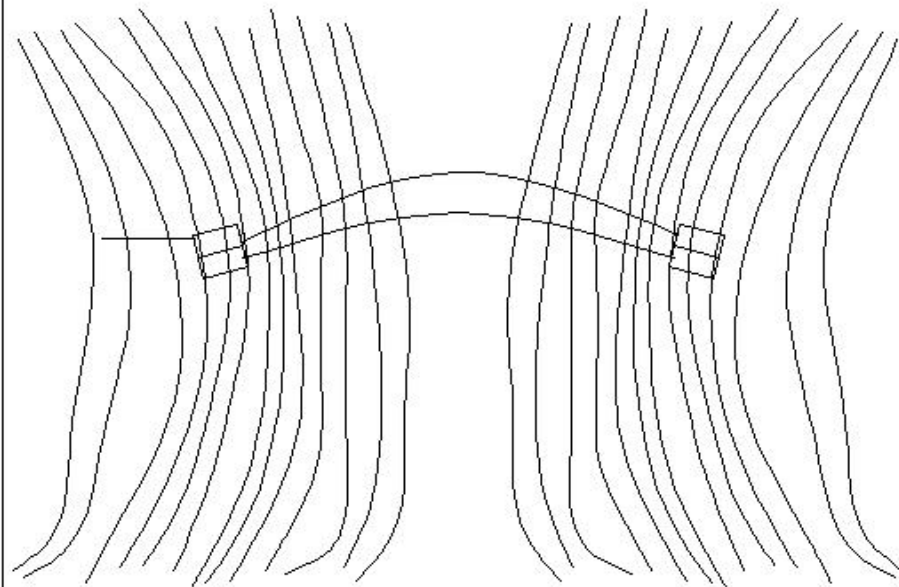
(D297)arch dam

(D297) arch dam

arch dam

Loads such as water pressure  
transmitted to both coasts

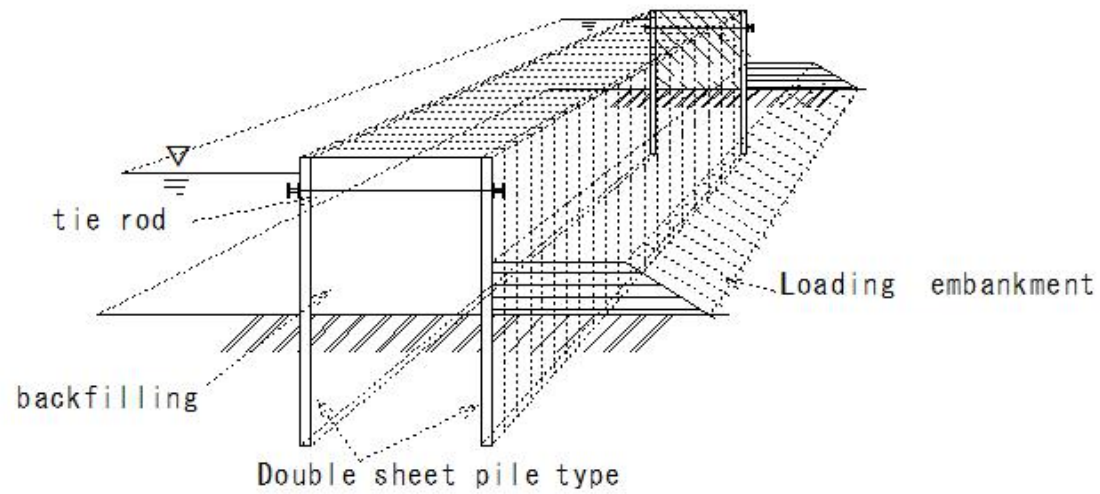
- Dam site bedrock bearing capacity - large
- Valley width - narrow
- Both banks - steep slopes
- V-shaped valley



(D298)temporary cofferdam

### (D298) temporary cofferdam

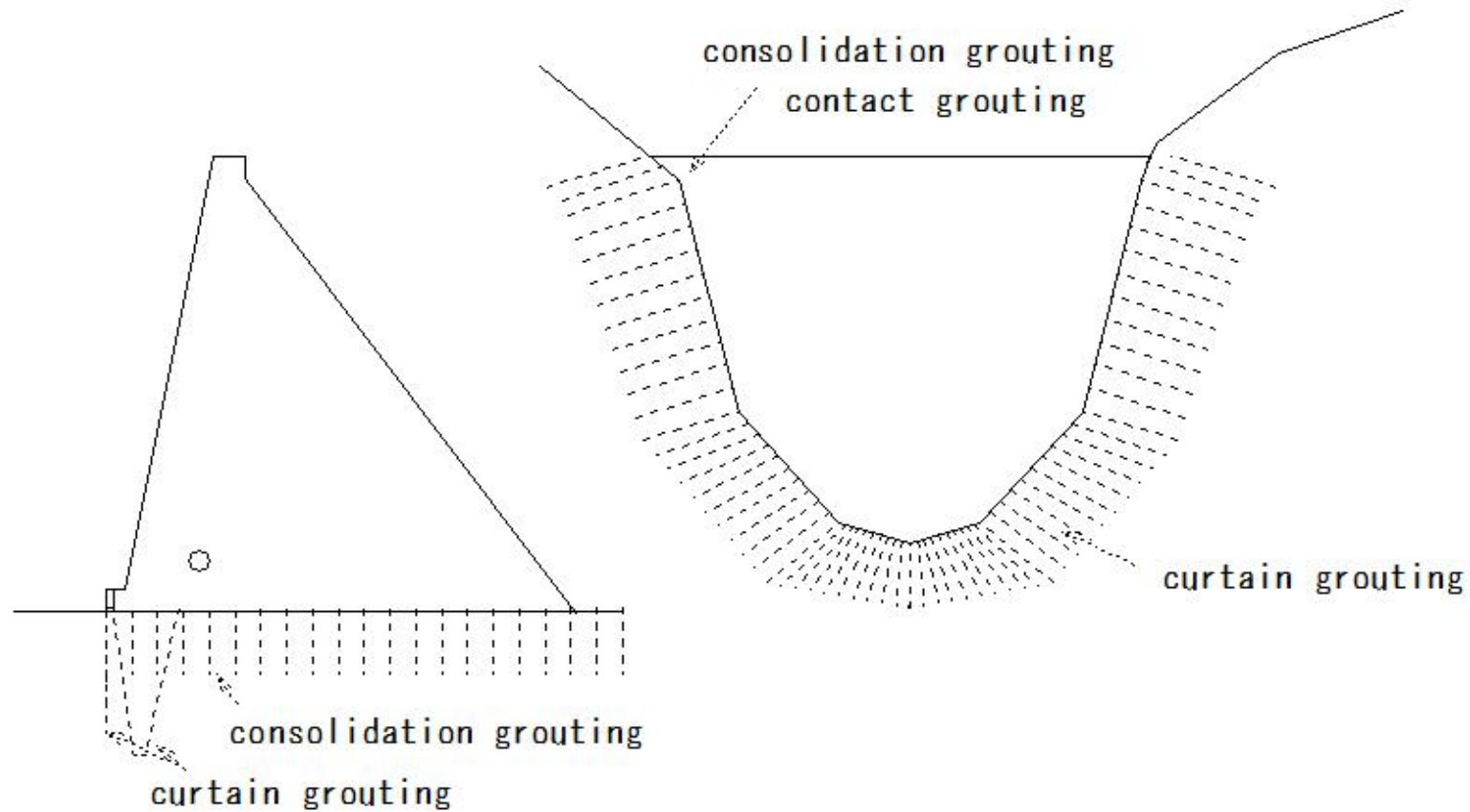
temporary cofferdam  
steel sheet pile



R537

(D299)grouting

(D299) grouting



(D300)energy dissipator

(D300)energy dissipator

energy dissipator

- Discharge channel

Spillway structure

jumping water

shoot block

Energy dissipator

flow guide wall

rocky ground

Overflow embankment top

Downstream surface

of embankment body

stairwork

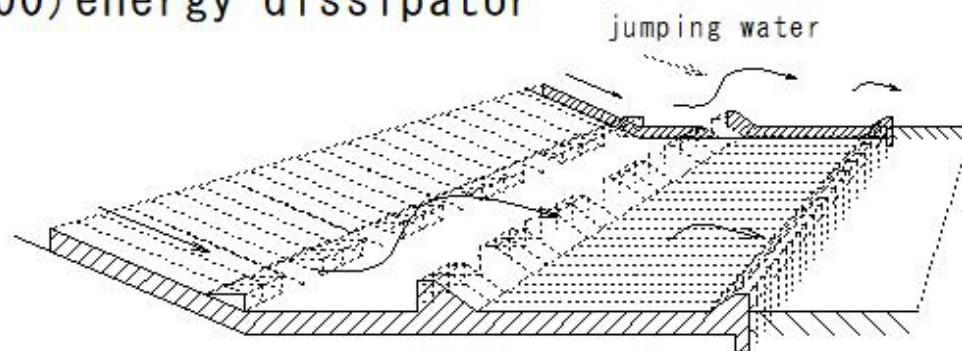
downstream river

Energy dissipator

Overflow embankment top

Overflow

- Discharge channel



Energy dissipator

flow guide wall

rocky ground

downstream river

Downstream surface of embankment body

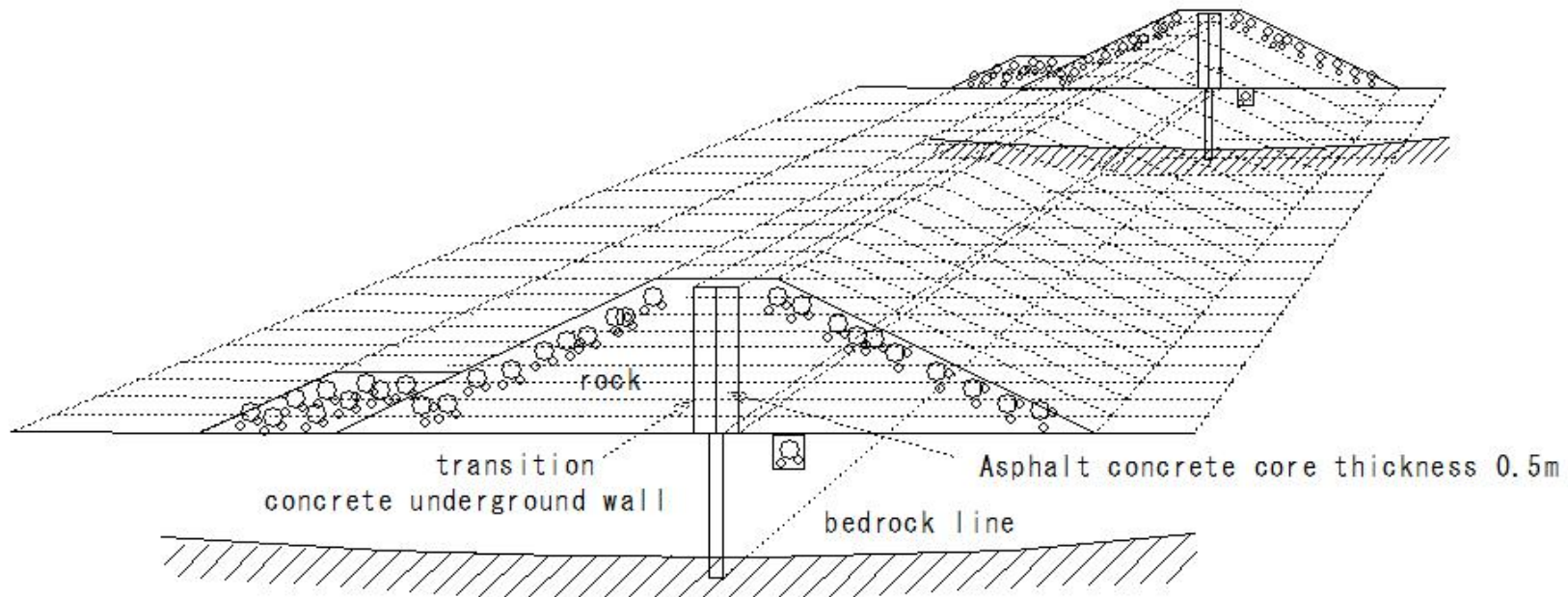
stairwork

Direction type energy reducer

(D301)core type dam

(D301)core type dam

core type dam

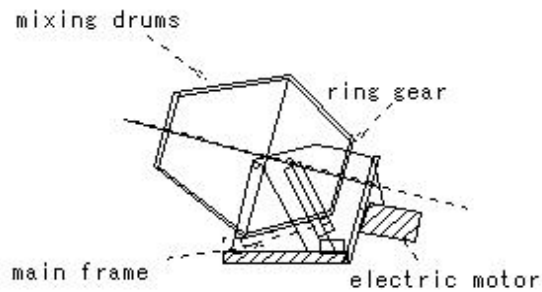
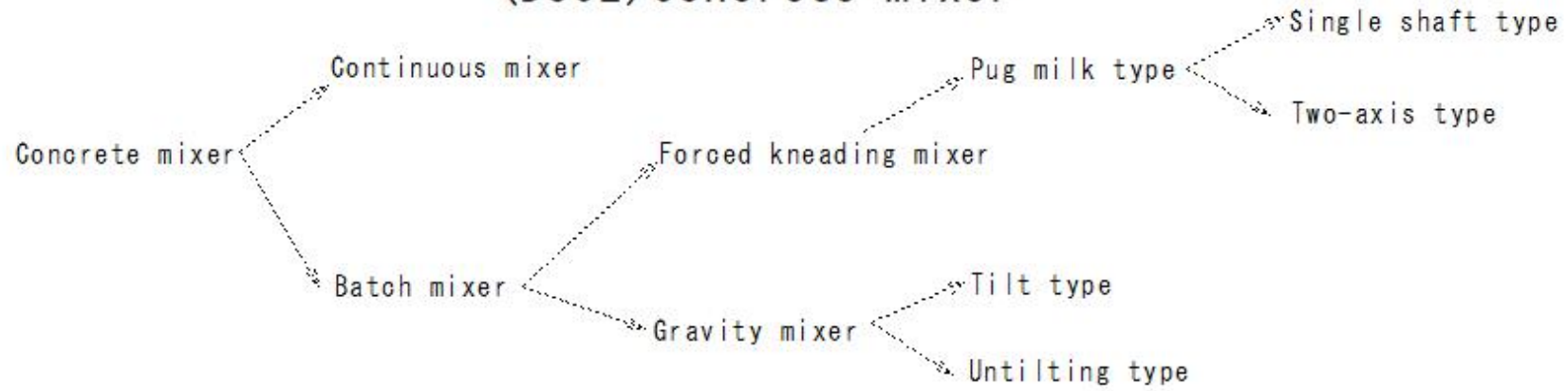


core field dam

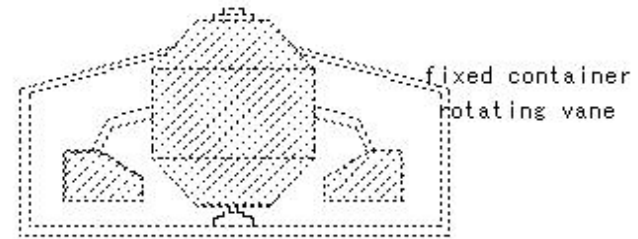
core type dam

(D302)Concrete mixer

(D302) Concrete mixer



C994



forced mixer  
C1300



(D303)flood sluice of fill dam

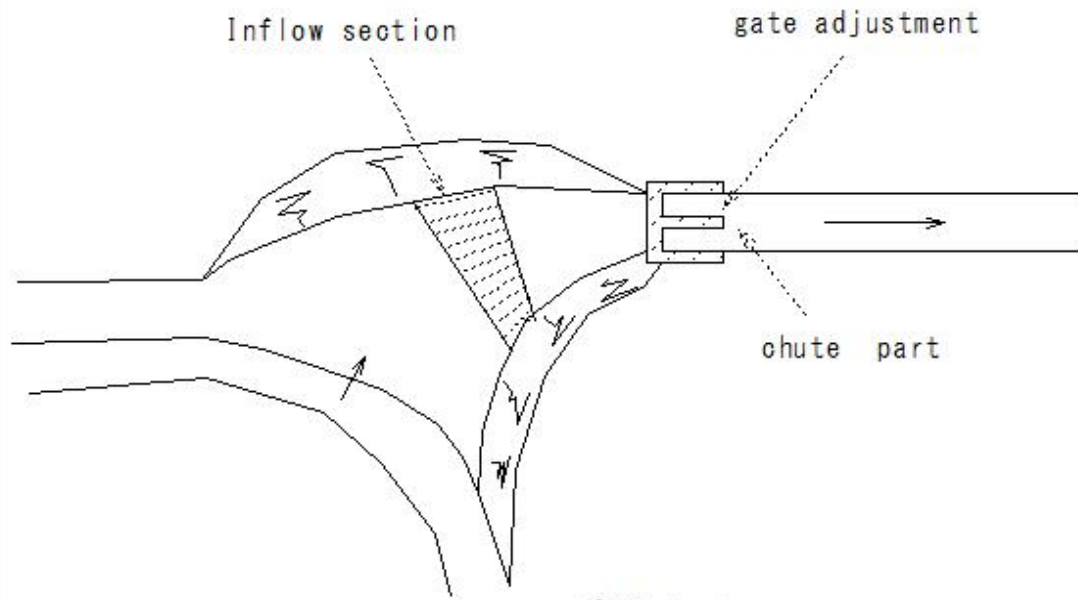
(D303) flood sluice of fill dam

flood sluice

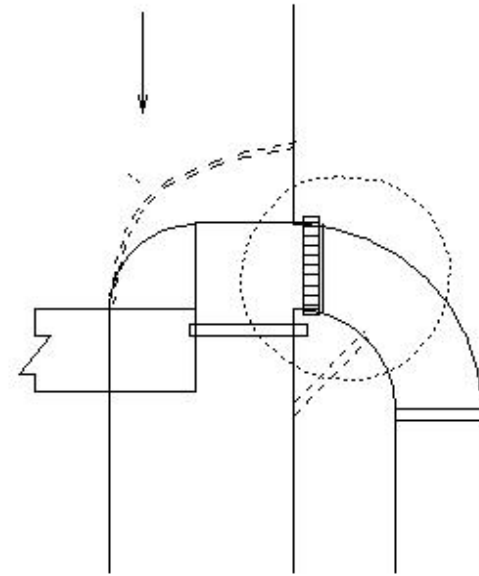
Attached to water intake facility

Easy flow of flood water

① Chute type



① Chute type



D199

(D304)flood sluice of fill dam

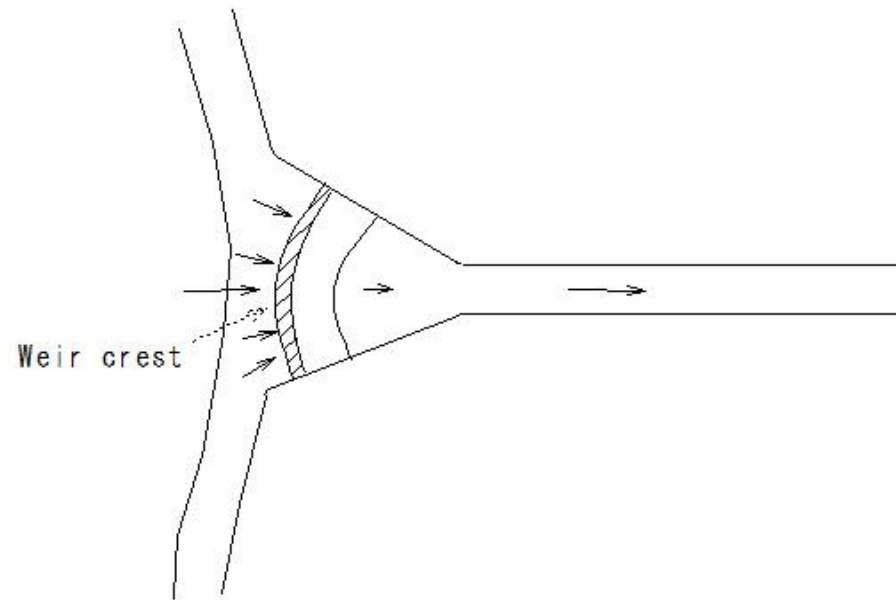
(D304)flood sluice of fill dam

flood sluice of fill dam

Attached to water intake facility

②Standard curve type

Easy flow of flood water



②Standard curve type

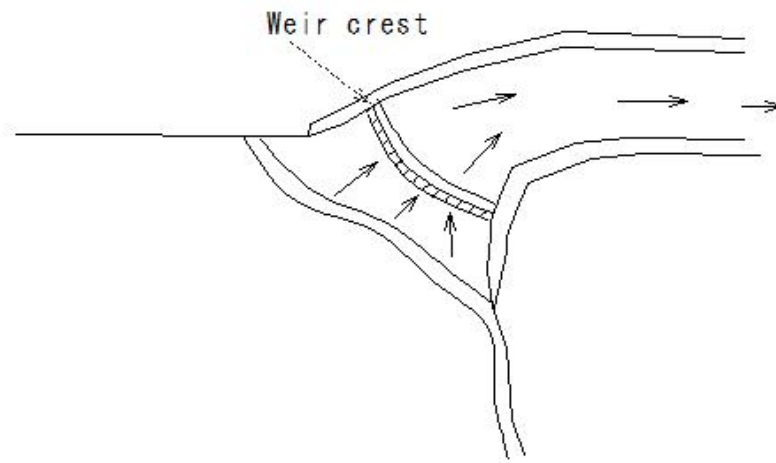
(D305)flood sluice of fill dam

## (D305) flood sluice of fill dam

flood sluice of fill dam

Attached to water intake facility

③Curve type



③Curve type

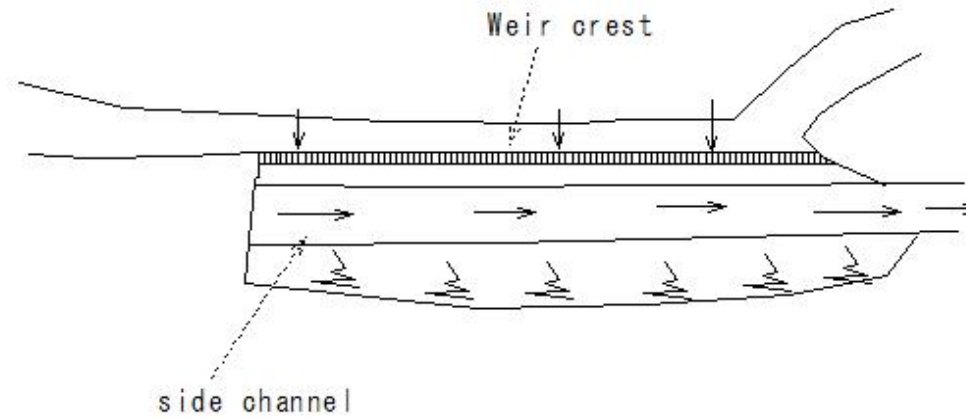
(D306)flood sluice of fill dam

### (D306) flood sluice of fill dam

flood sluice of fill dam

Attached to water intake facility

④ Standard type side waterway



④ Standard type side waterway

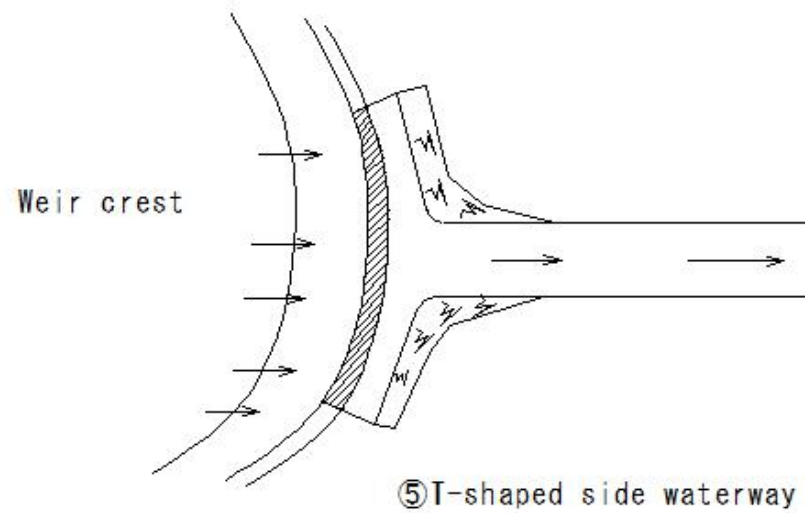
(D307)flood sluice of fill dam

### (D307) flood sluice of fill dam

flood sluice of fill dam

Attached to water intake facility

⑤T-shaped side waterway



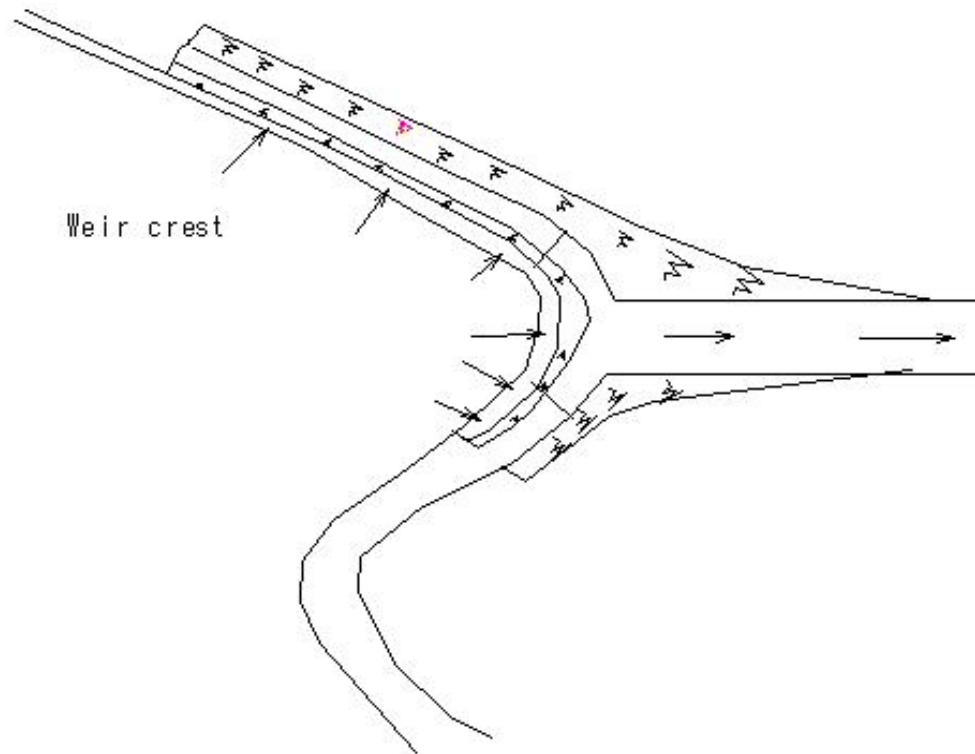
(D308)flood sluice of fill dam

(D308)flood sluice of fill dam

flood sluice of fill dam

Attached to water intake facility

Ⓢ Y-shaped side waterway





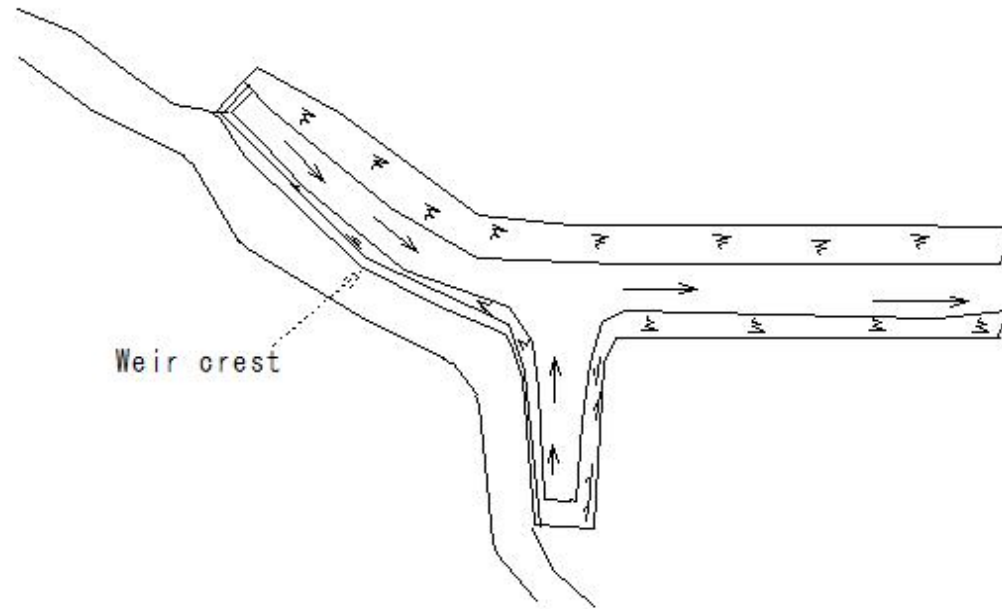
(D309)flood sluice of fill dam

### (D309) flood sluice of fill dam

flood sluice of fill dam

Attached to water intake facility

⑦ Contour type side channel



⑦ Contour type side channel

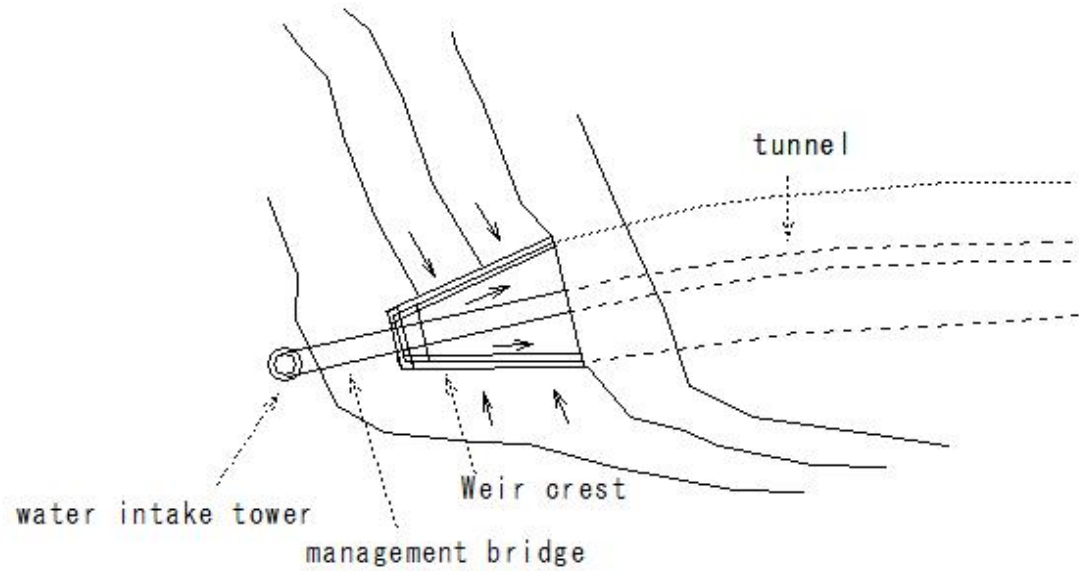
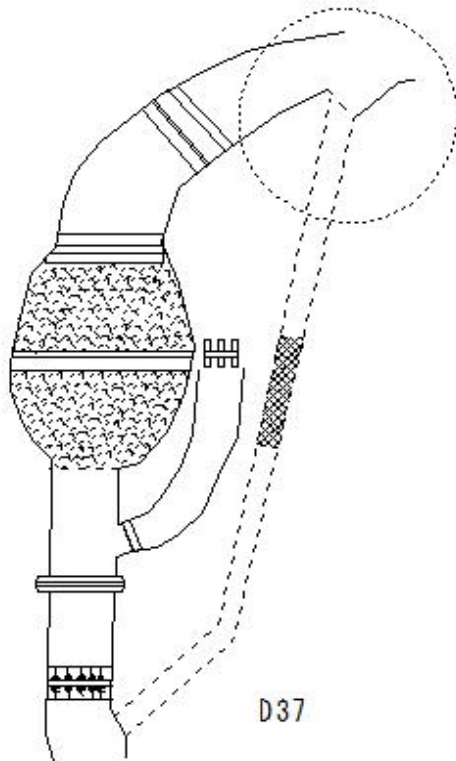
(D310)flood sluice of fill dam

(D310)flood sluice of fill dam

flood sluice of fill dam

Attached to water intake facility

⑧ Double type side waterway



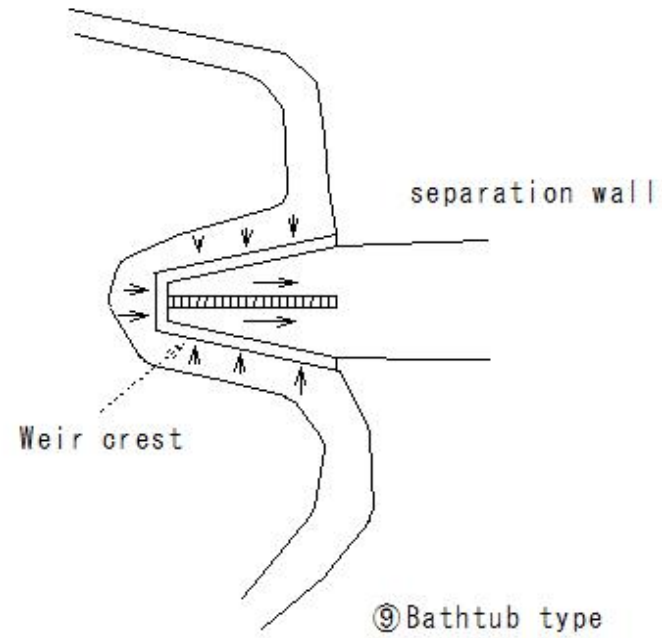
(D311)flood sluice of fill dam

## (D311)flood sluice of fill dam

flood sluice of fill dam

Attached to water intake facility

⑨ Bathtub type



(D312)flood control

(D312) flood control

flood control

discharge

discharge changes over time

A portion of flood runoff is stored in reservoirs, etc. for flood control

and disaster prevention purposes.

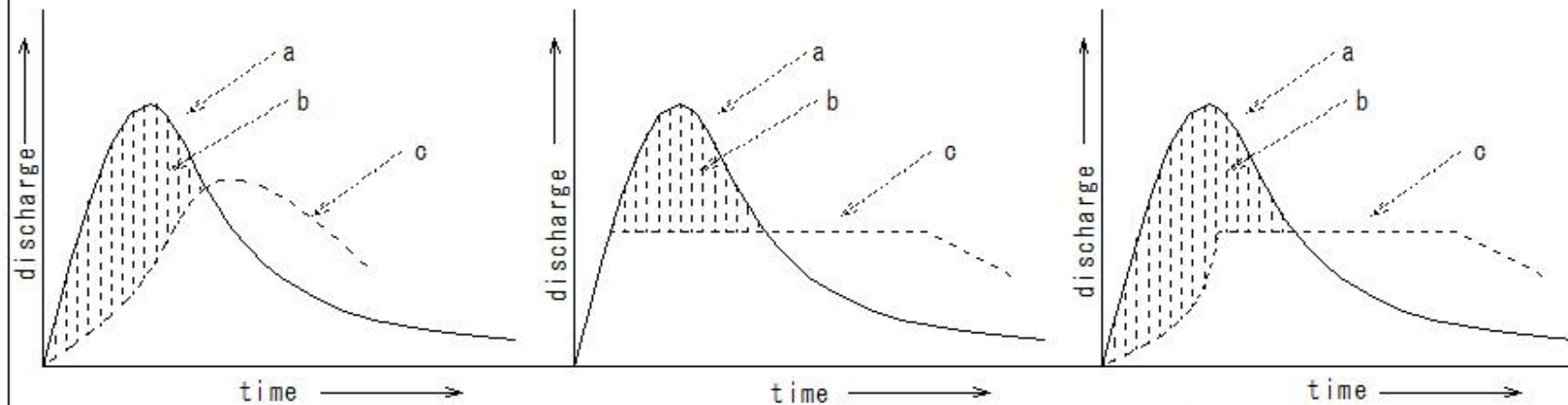
change flow time

Reduce downstream flood peak flows

a: flood discharge

b: discharge after flood control

c: flood control amount



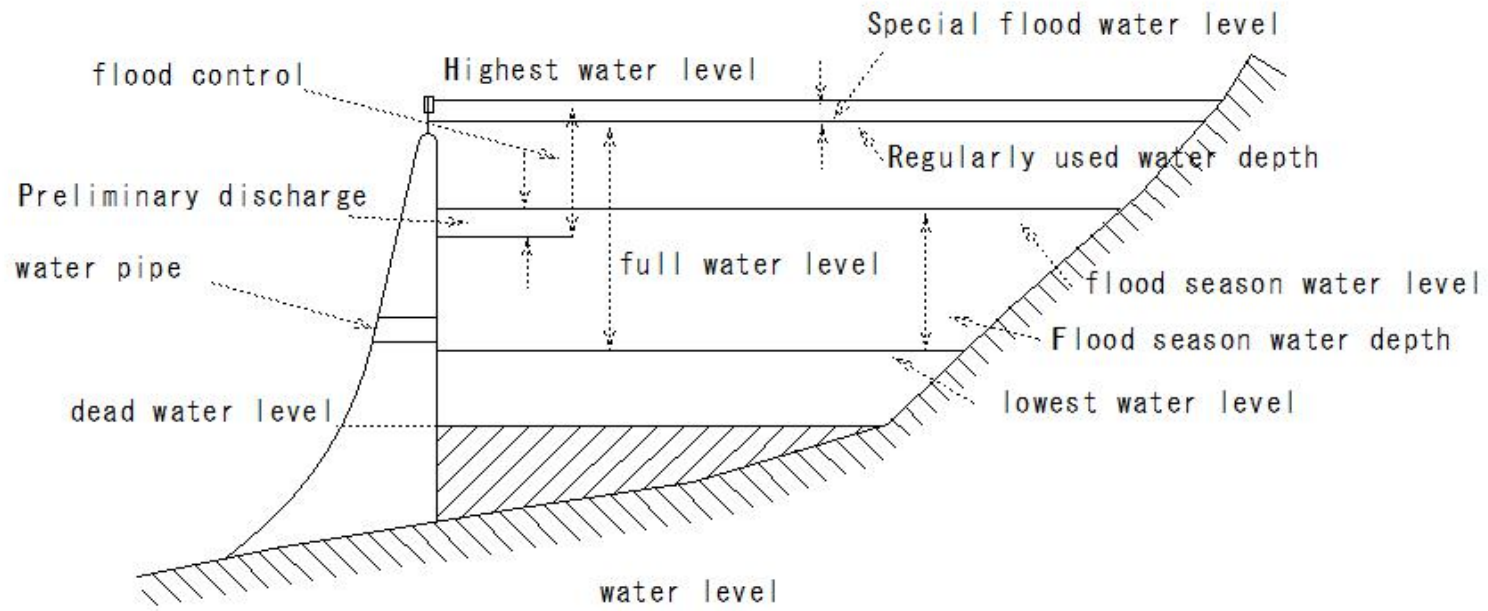
① Natural adjustment method

② Peak cut method

③ Fixed rate fixed amount method

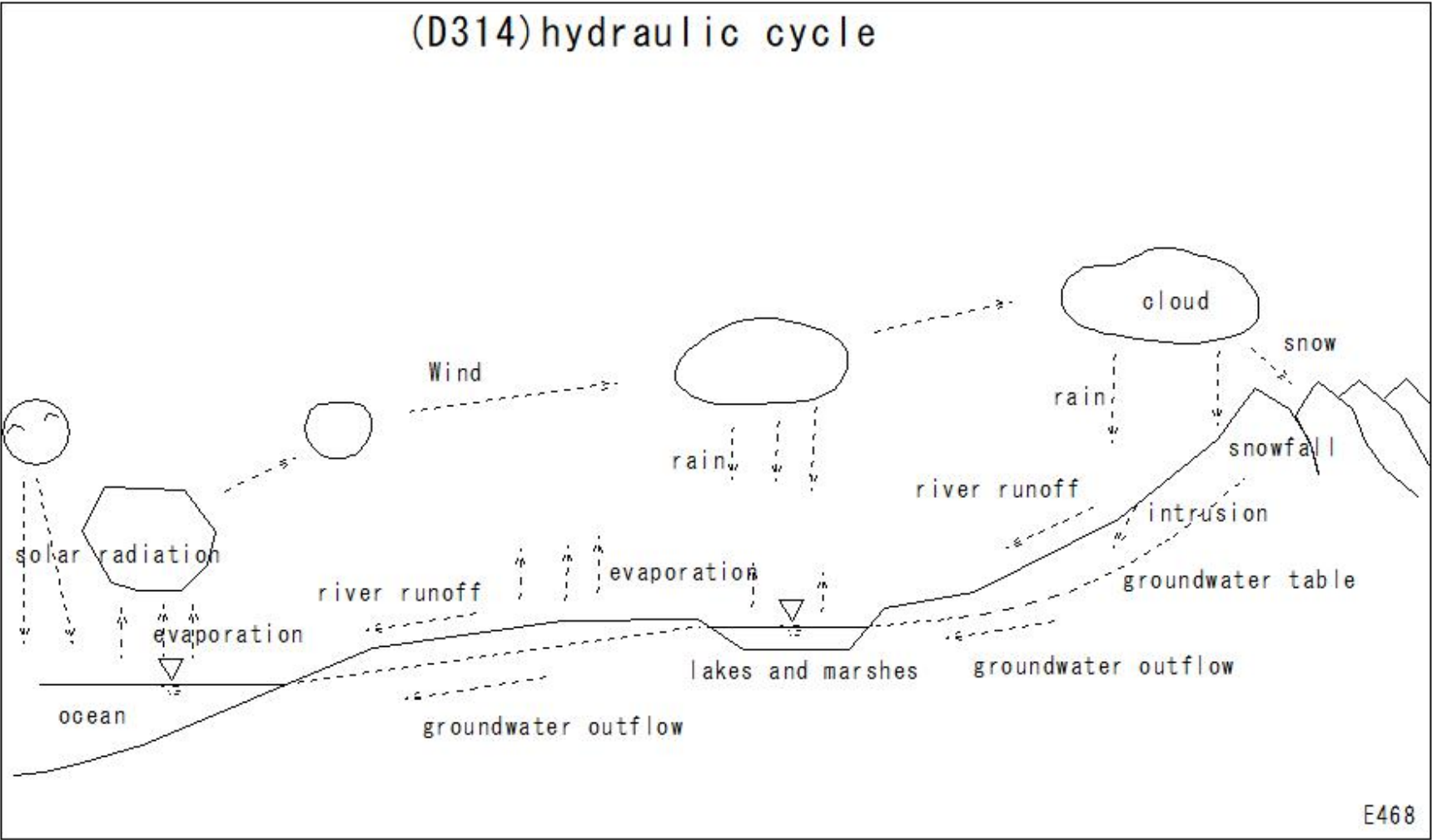
(D313)water level

(D313)water level



(D314)hydraulic cycle

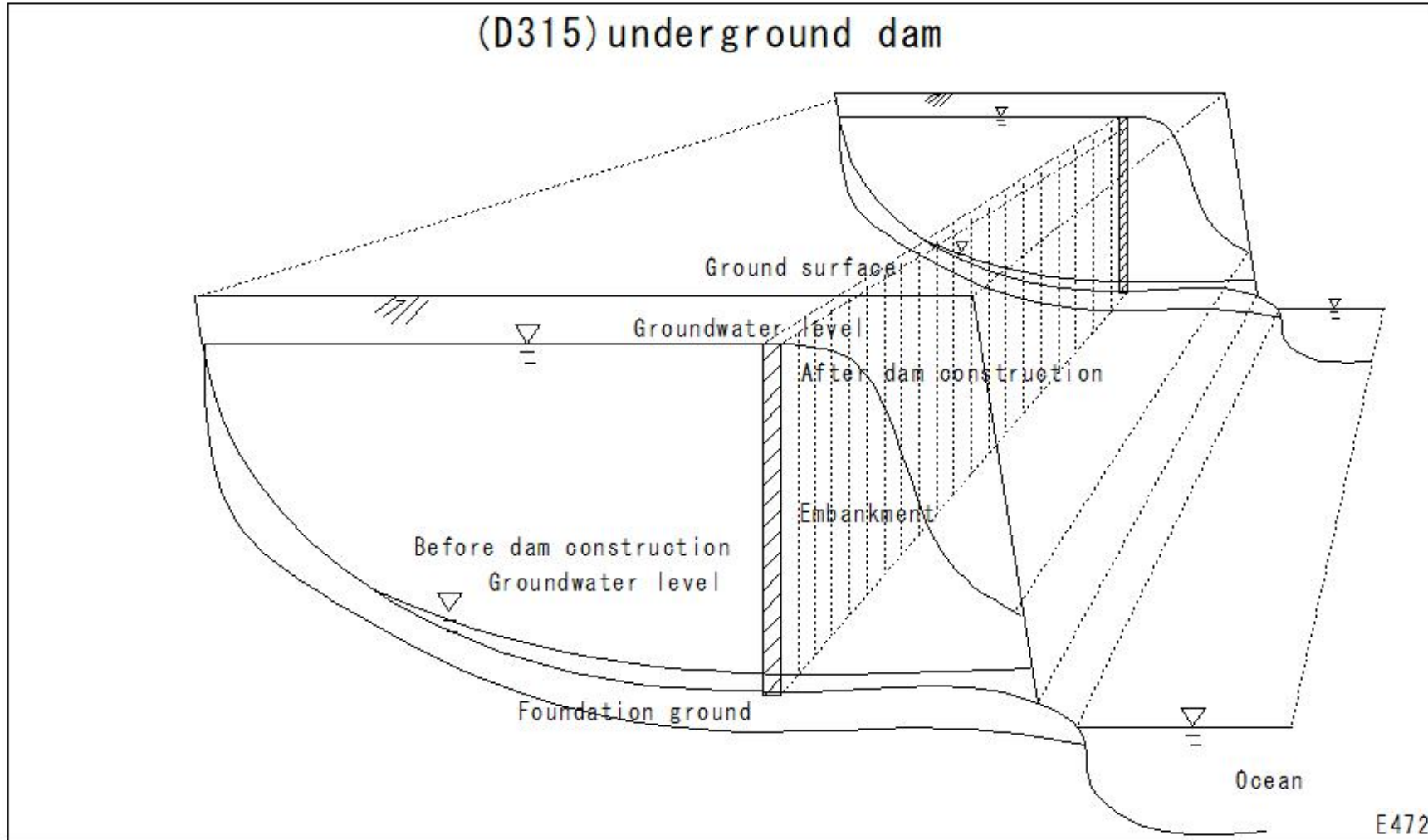
(D314)hydraulic cycle



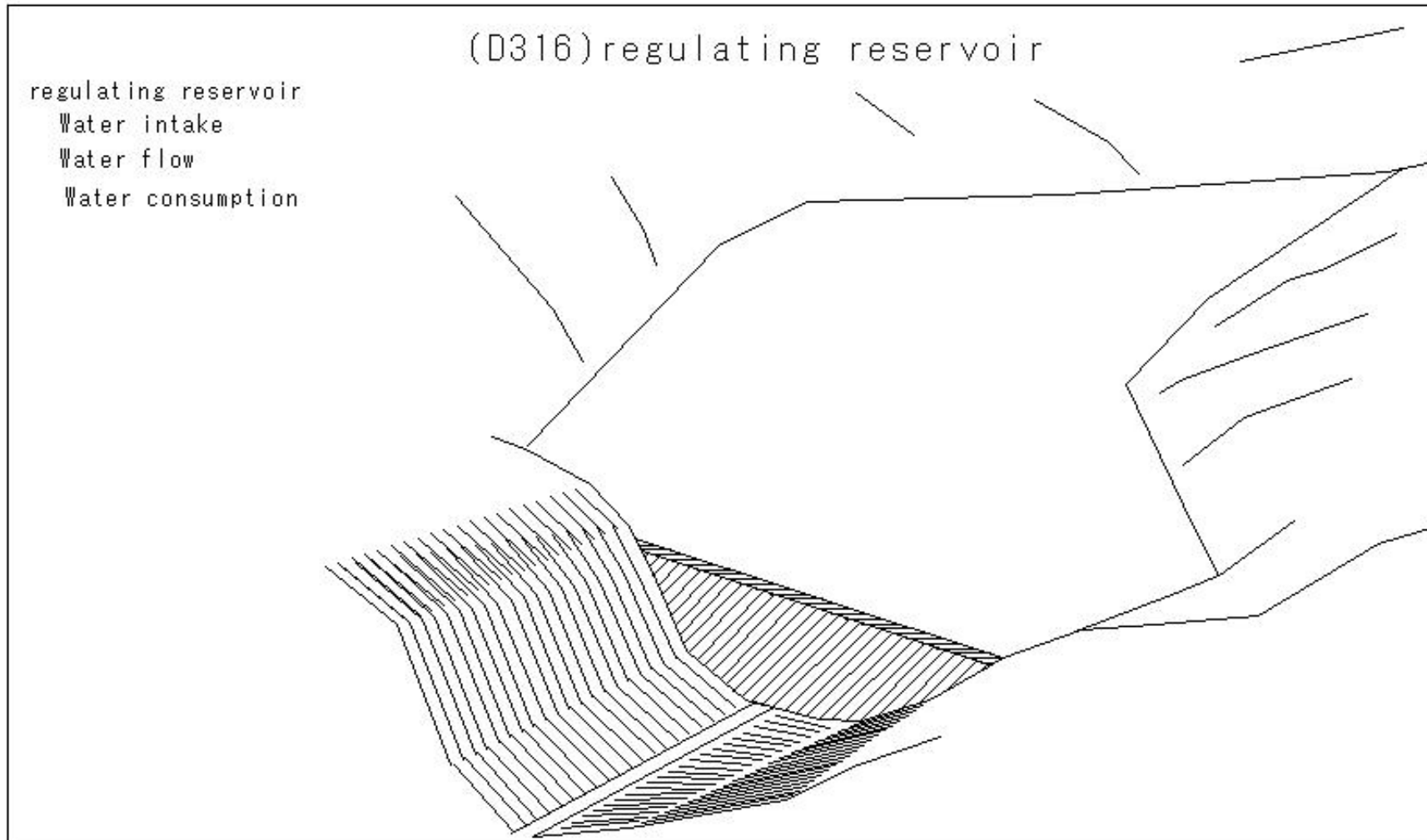


(D315)underground dam

(D315) underground dam



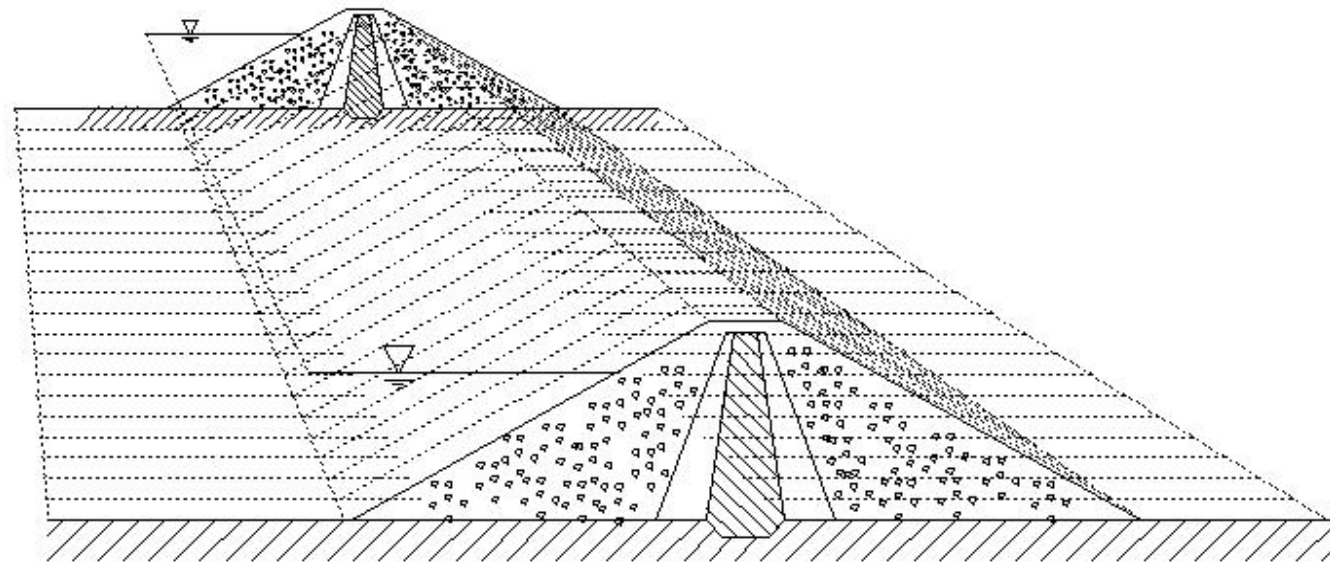
(D316)regulating reservoir



(D317)fill dam

(D317) fill dam

fill-type dam  
soil, gravel, rock  
Embankment materials  
earth dam  
rockfill dam



zone type

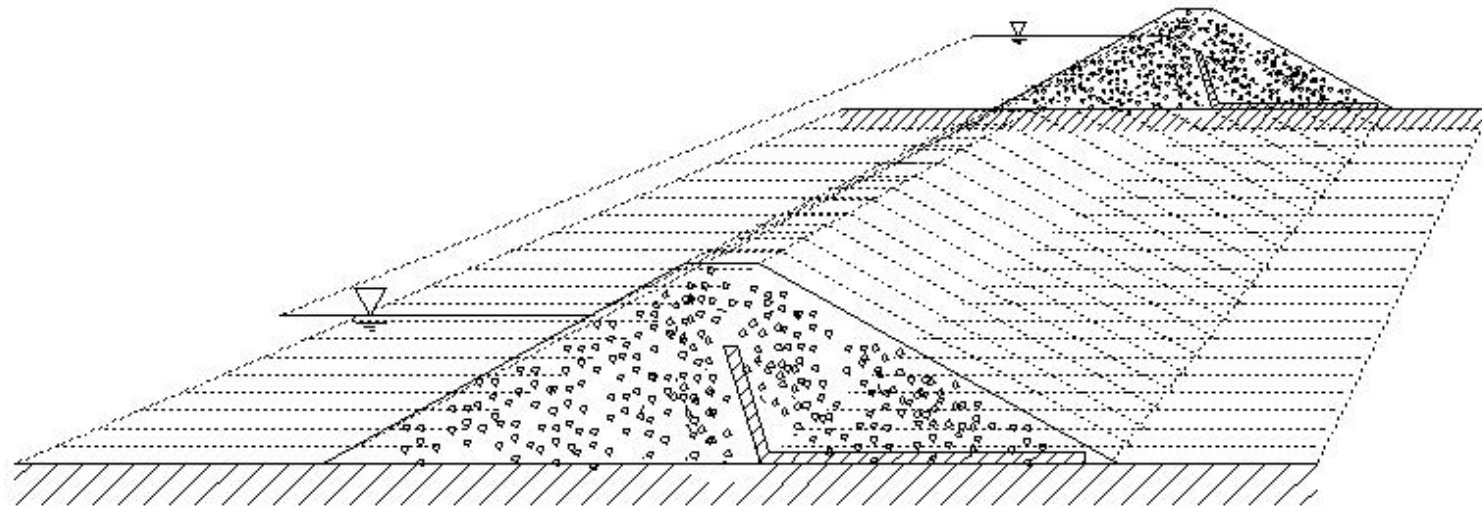
spillway installed on the ground

R590

(D318)fill dam

### (D318) fill dam

fill-type dam  
soil, gravel, rock  
Embankment materials  
earth dam  
rockfill dam



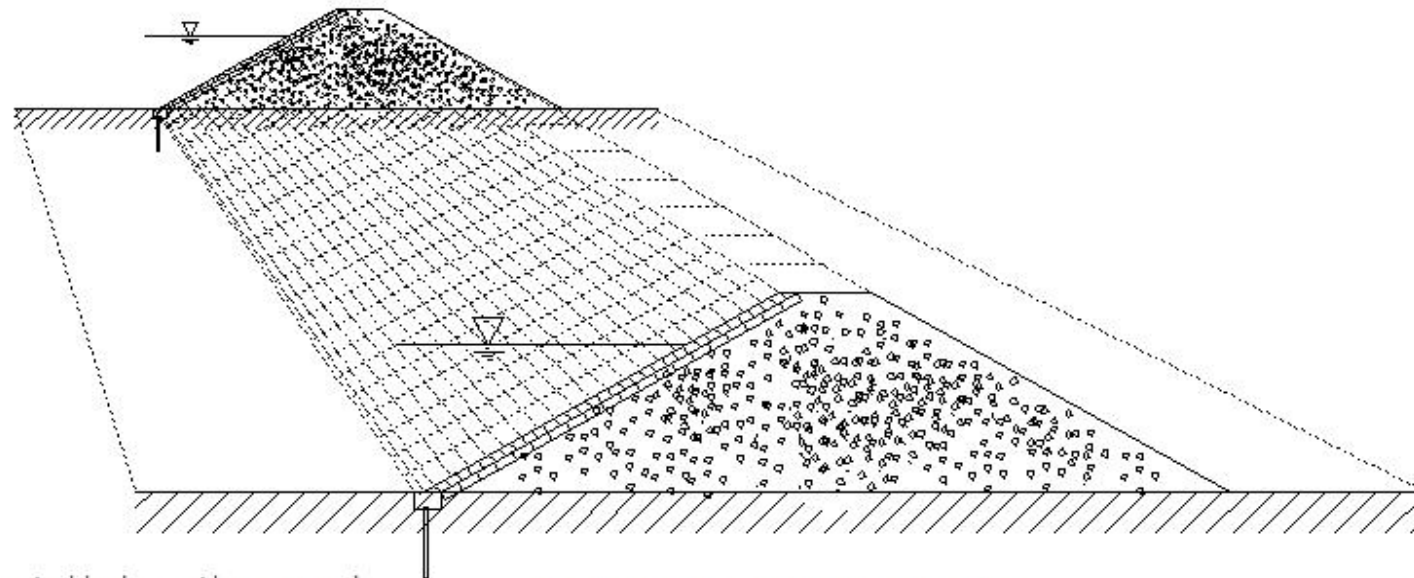
Uniform type

spillway installed on the ground

(D319) fill dam

(D319) fill dam

fill-type dam  
soil, gravel, rock  
Embankment materials  
earth dam  
rockfill dam



spillway installed on the ground

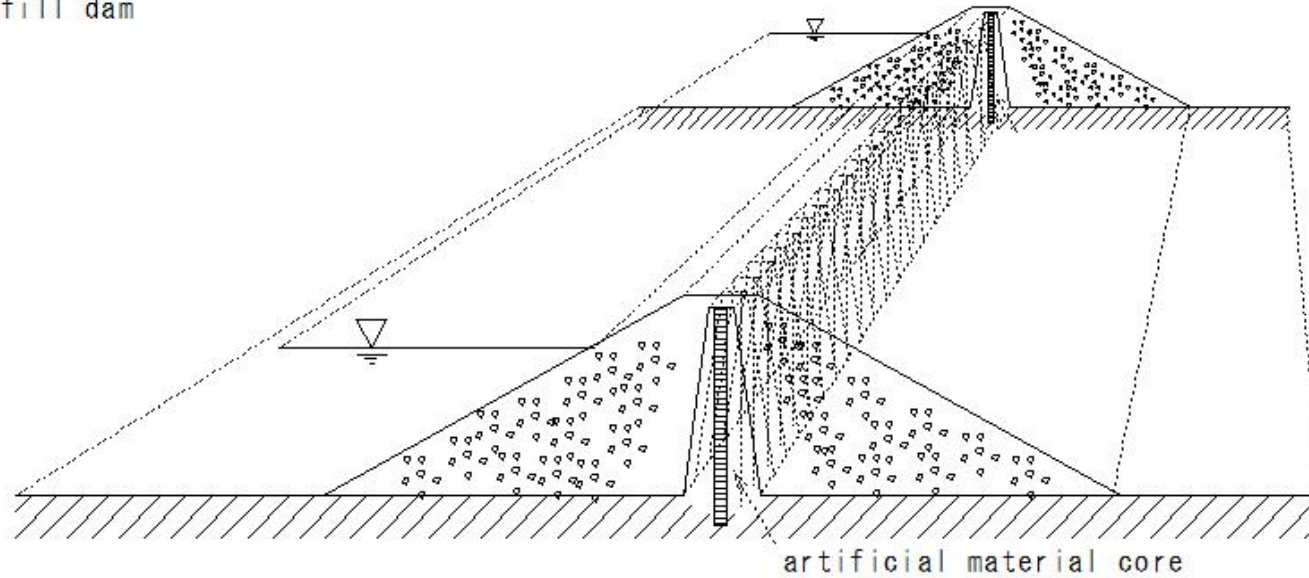
Surface impermeable wall type

R592

(D320)fill dam

### (D320) fill dam

fill-type dam  
soil, gravel, rock  
Embankment materials  
earth dam  
rockfill dam



spillway installed on the ground

Core type

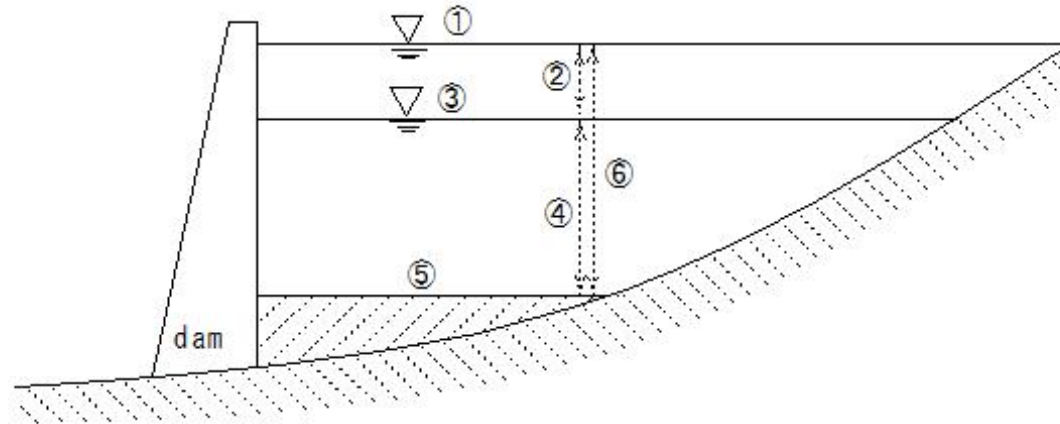


(D321)effective storage capacity

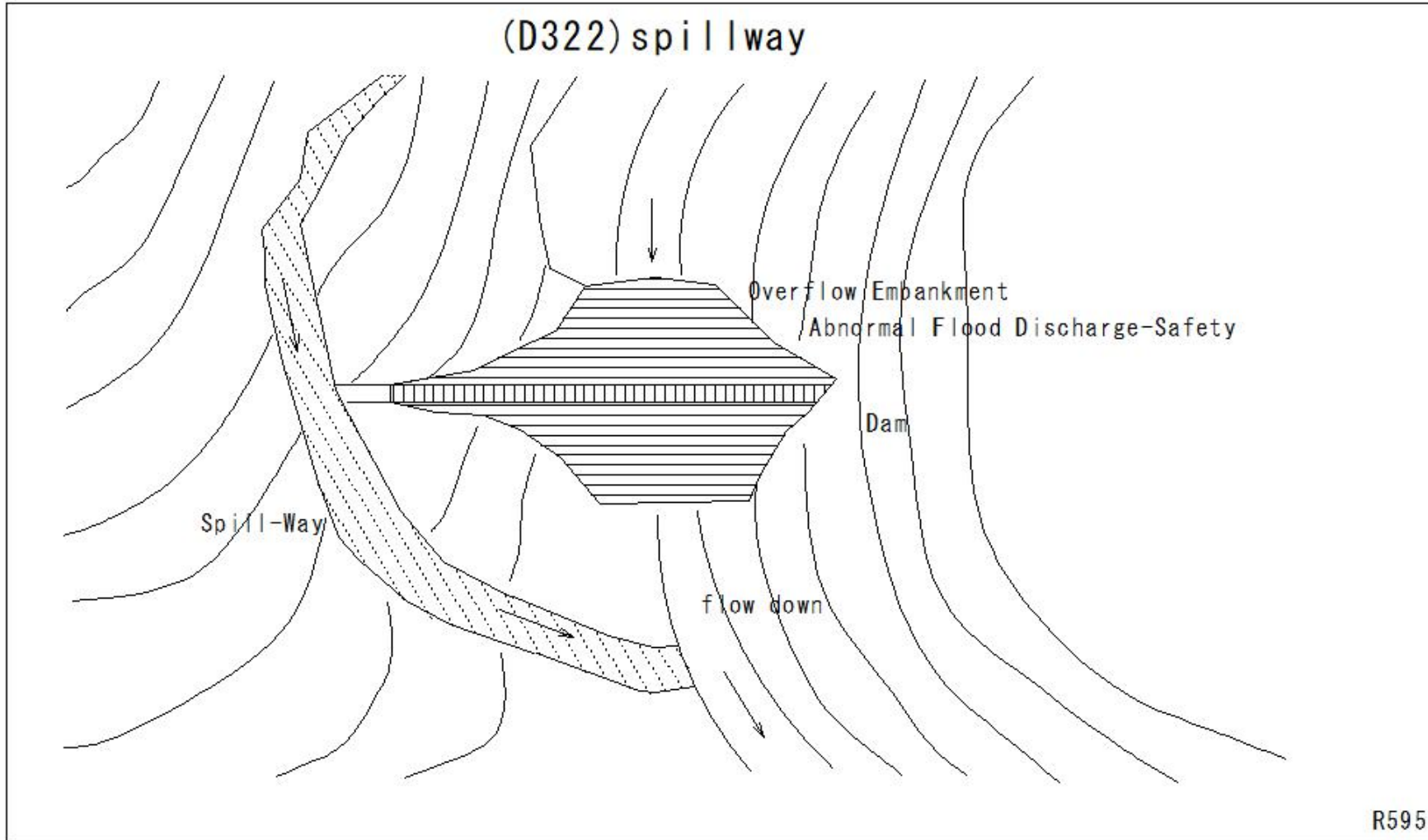
(D321)effective storage capacity

Effective water storage amount

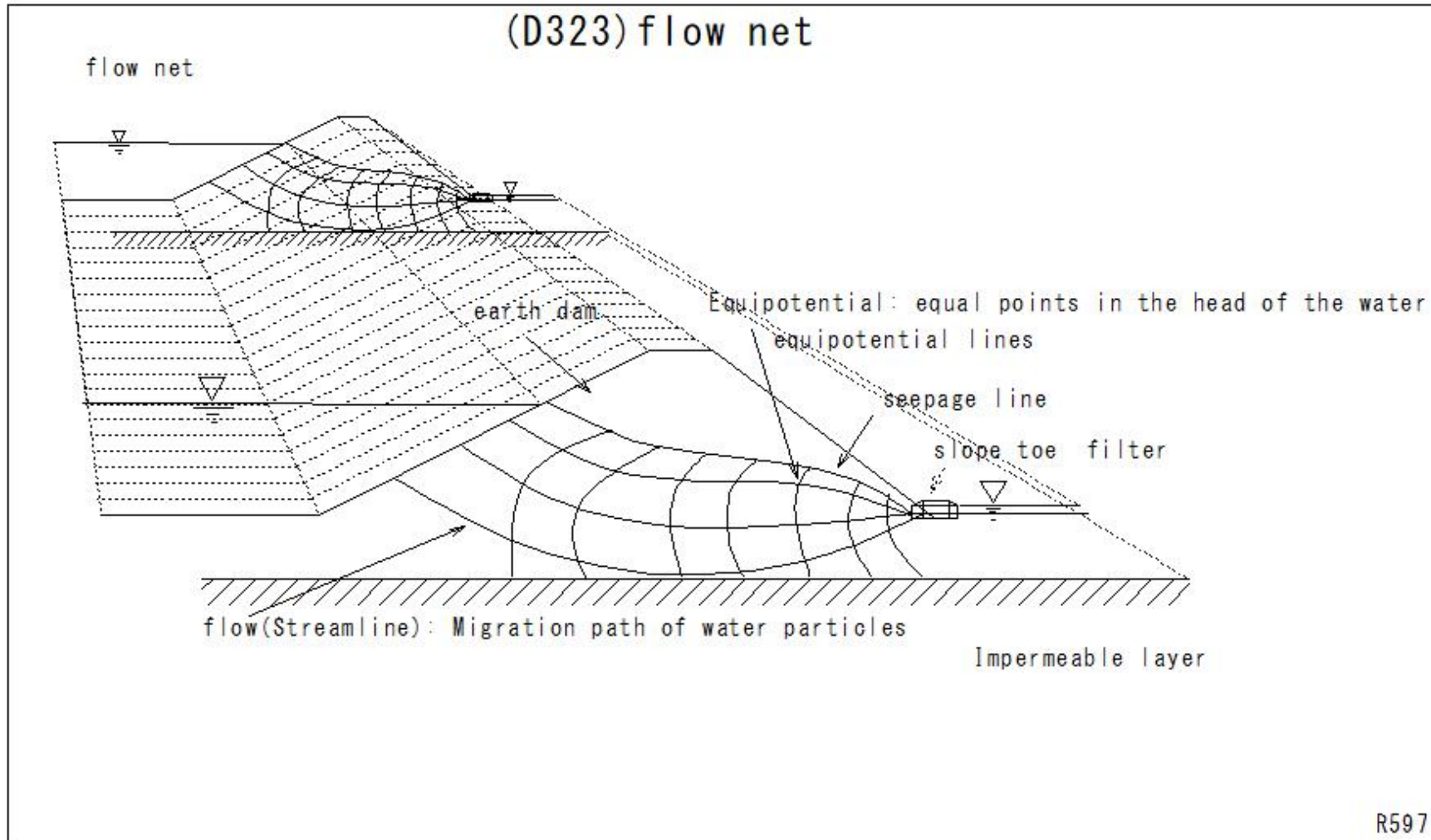
- ① full water level
- ② Flood control capacity (B)
- ③ Flood season limit water level
- ④ Flood season water usage capacity (A)
- ⑤ sand surface
- ⑥ Water usage capacity during non-flood season



(D322)spillway



(D323)flow net

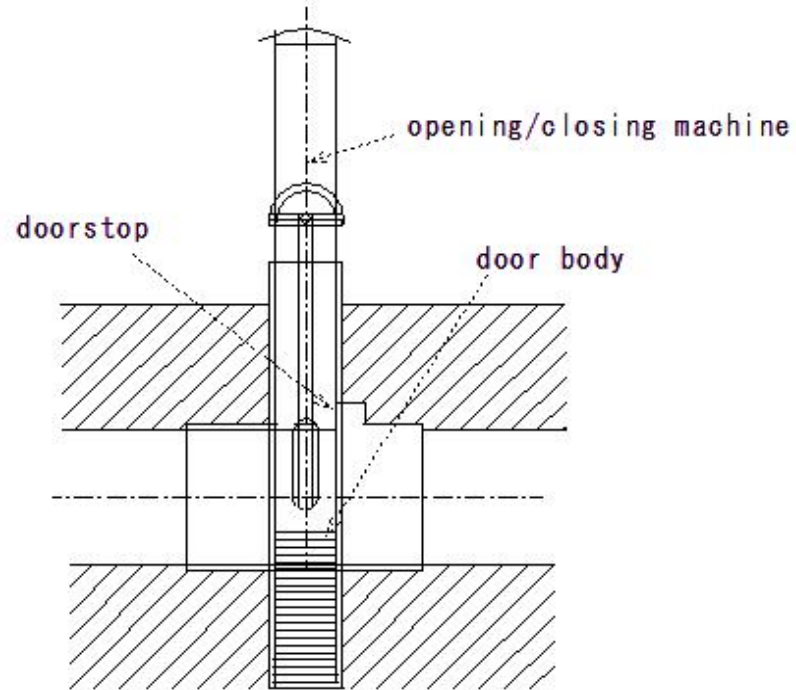




(D325)fixed wheel gate

(D325)fixed wheel gate

fixed wheel gate(roller gate)



ring seal gate(roller gate)

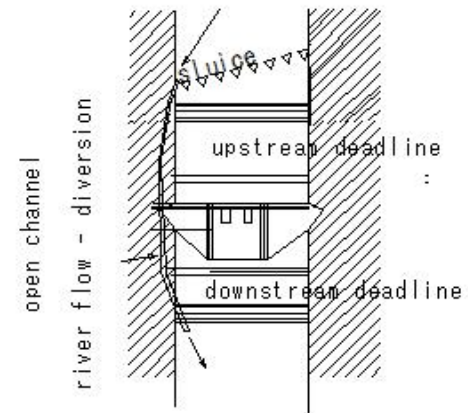
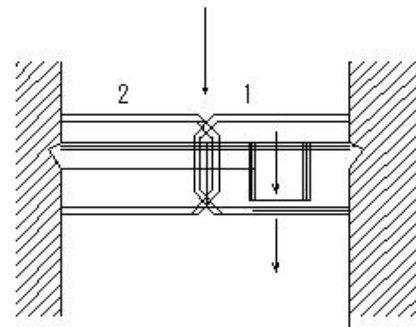
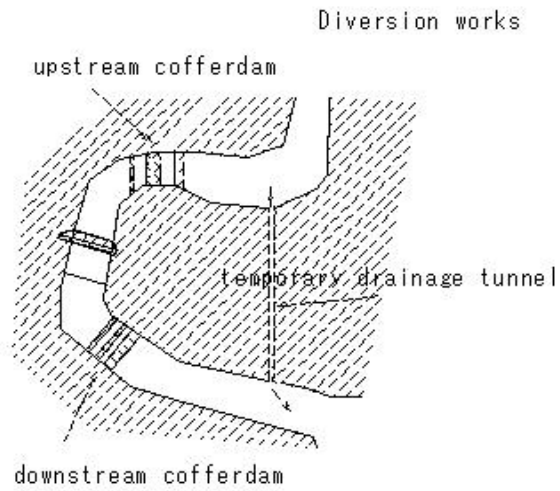
(D326) Diversion works

(D326) Diversion works

temporary drainage tunnel

Half cofferdam

Temporary drainage open ditch



D288

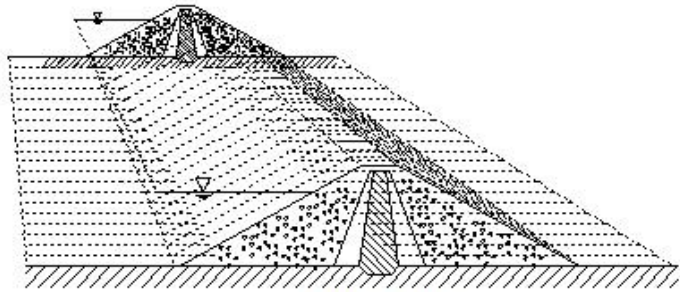
D289

D290



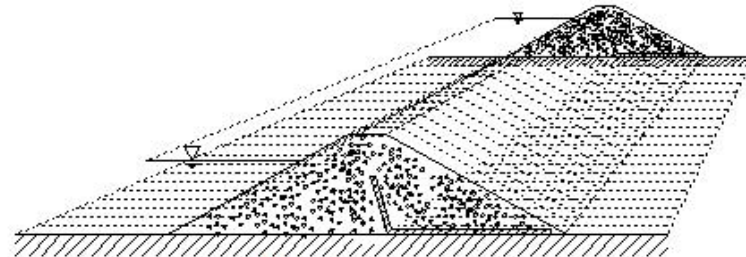
(D327) earth dam(fill dam)

(D327) earth dam(fill dam)



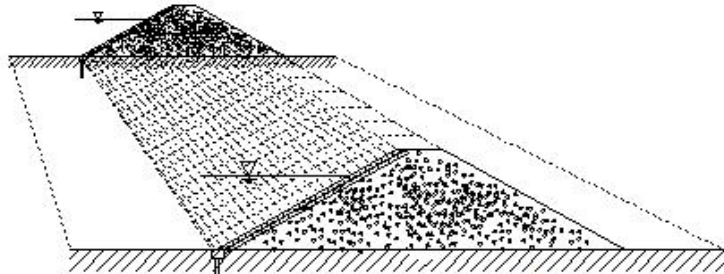
zone type

D317



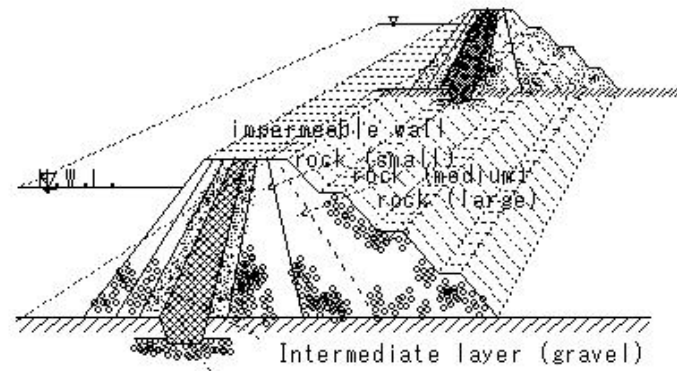
Uniform type

D318



Surface impermeable wall type

D319



Clay (impermeable to water)  
Good quality clay for impermeable wall

D256

(D328)RCD method(Roller Compacted Dam-Concrete)

(D328) RCD method(Roller Compacted Dam-Concrete)

