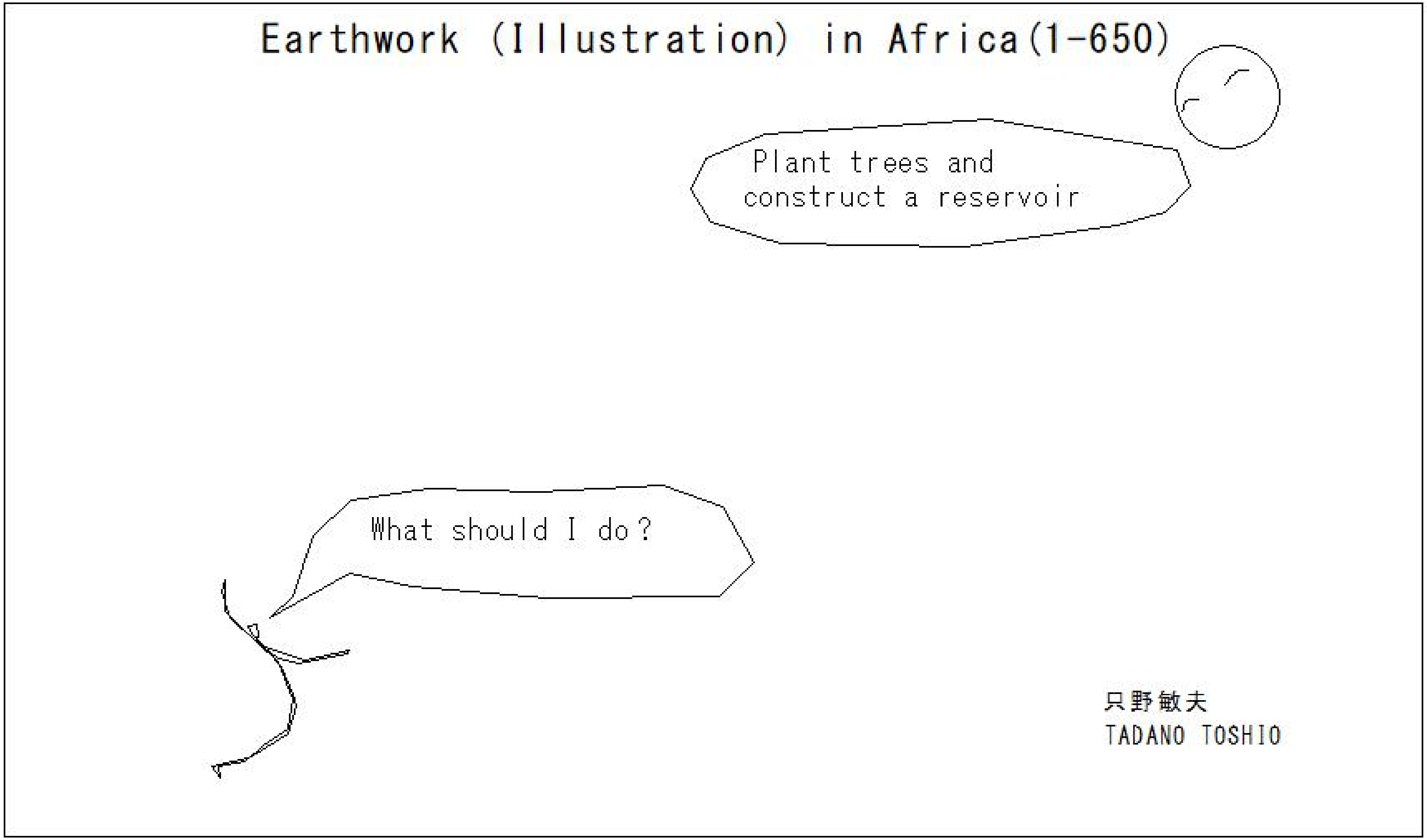
Earthworks(Illustration) in Africa(1-650)



Reference

①土木工学ハンドブック　土木学会編　技報堂
①Civil Engineering Handbook　Japan Society of Civil Engineers　GIHODO SHUPPAN Co., Ltd.

②図解　土質　基礎用語集　東洋書店
②Illustrated soil quality basic glossary　Toyo Shoten Co., Ltd.

③図解テキスト　土木一般　(1-5)　市ケ谷出版社
③Illustrated Text　General civil engineering(1-5)　ICHIGAYA Publishing Co., Ltd

④図解　土質・基礎用語集　東洋書店
④Illustrated Glossary of Soil Characteristics and Basic Terms　Toyo Shoten Co., Ltd.

⑤応用地質用語集　東洋書店
⑤Glossary of applied geological terms　Toyo Shoten Co., Ltd.

⑥実用英和対訳　土木用語辞典　工学出版株式会社
⑥Practical English-Japanese translation Dictionary of civil engineering terms　Engineering Publishing Co., Ltd.

⑦農業土木用語集　東洋書店
⑦Glossary of agricultural civil engineering terms　Toyo Shoten Co., Ltd.

⑧土木施工用語集　東洋書店
⑧Glossary of civil engineering construction terms　Toyo Shoten Co., Ltd.

⑨土木コンクリート用語集　東洋書店
⑨Glossary of civil engineering and concrete terms　Toyo Book Book Store

⑩絵とき　土木施工　オーム社
⑩Illustrated Civil engineering construction　Ohmsha, Ltd

只野敏夫
Tadano Toshio

35 (E35)Soil test-Particle size test	Soil test
36 (E36)Soil test-Consistency test	Soil test
37 (E37)Soil test-Consistency test	Soil test
38 (E38)Testing of soil mechanical properties-Permeability test	Soil test
39 (E39)Field test-Constant level permeability test	Soil test
40 (E40)Field test-Alternating water level permeability test	Soil test
41 (E41)Direct shear test	Soil test
42 (E42)Uniaxial compression test	Soil test
43 (E43)Triaxial compression test	Soil test
44 (E44)Consolidation test	Soil test
45 (E45)Compaction test	Soil test
46 (E46)Zero void curve: ρdsat - compaction curve	Soil test
47 (E47)CBR test On-site CBR	Soil test
48 (E48)CBR test-Design CBR	Soil test
49 (E49)Modified CBR	Soil test
50 (E50)Use of soil survey results-Ripper work	Soil survey
51 (E51)Use of soil survey results-Trafficability of construction machinery	Soil survey
52 (E52)Use of soil survey results-Judgment of supporting ground	Soil survey
53 (E53)Use of soil survey results-Safety factor against sliding failure of embankment	Soil survey
54 (E54)Use of soil survey results-Earth pressure calculation	Soil survey
55 (E55)Use of soil survey results-Calculation of embankment height limit on soft ground	Soil survey
56 (E56)Use of soil survey results-Settlement amount of clay layer	Soil survey
57 (E57)Use of soil survey results-Compaction of embankment	Soil survey
58 (E58)Embankment	Embankment
59 (E59)Embankment material	Embankment
60 (E60)Embankment material	Embankment
61 (E61)Suitability of embankment materials	Embankment
62 (E62)Embankment slope standard-Road embankment	Embankment
63 (E63)Embankment slope standard-Railway embankment	Embankment
64 (E64)Embankment slope standard-River embankment	Embankment
65 (E65)Embankment slope standard-Berm	Embankment
66 (E66)Embankment slope standard-Embankment materials are different	Embankment
67 (E67)Stability study of embankment slope	Embankment
68 (E68)Slope stability calculation	Embankment

69	(E69)Pore water pressure of embankment	Embankment
70	(E70)Embankment compaction criteria	Compaction
71	(E71)Embankment compaction criteria-Standard by compaction machine	Compaction
72	(E72)Embankment compaction criteria-Criteria based on compaction strength	Compaction
73	(E73)Embankment compaction criteria-Criteria by dry density	Compaction
74	(E74)Embankment compaction criteria-Criteria by dry density	Compaction
75	(E75)Embankment compaction criteria-Criteria based on saturation	Compaction
76	(E76)Embankment compaction criteria	Compaction
77	(E77)Embankment construction	Compaction
78	(E78)Embankment construction-Notes on compaction	Compaction
79	(E79)Embankment construction-Notes on compaction	Compaction
80	(E80)Embankment construction-Notes on compaction	Compaction
81	(E81)Embankment construction-Notes on compaction	Compaction
82	(E82)Embankment construction-Notes on compaction	Compaction
83	(E83)Embankment construction-Notes on compaction	Compaction
84	(E84)Embankment construction-Notes on compaction	Compaction
85	(E85)Embankment precautions-Step cutting construction	Compaction
86	(E86)Embankment precautions-Step cutting construction	Compaction
87	(E87)Embankment precautions-Walling embankment	Embankment
88	(E88)Embankment-structures and embankments	Embankment
89	(E89)Embankment -River embankment	Embankment
90	(E90)Embankment foundation ground	Embankment
91	(E91)Embankment foundation ground-Soft ground judgment	Embankment
92	(E92)Embankment foundation ground-Settlement calculation of soft ground	Embankment
93	(E93)Embankment foundation ground-Settlement calculation of soft ground	Embankment
94	(E94)Embankment foundation ground-Settlement time	Embankment
95	(E95)Embankment foundation ground-Soft ground stability calculation	Embankment
96	(E96)Embankment foundation ground-Soft ground treatment	Embankment
97	(E97)Embankment foundation ground-Soft ground treatment	Embankment
98	(E98)Embankment foundation ground- Slow construction method	Embankment
99	(E99)Embankment foundation ground-Sand mat construction method	Embankment
100	(E100)Embankment foundation ground-Loading bank method	Embankment
101	(E101)Embankment foundation ground-Preloading method	Embankment
102	(E102)Embankment foundation ground-Removal and replacement method	Embankment

103 (E103)Embankment foundation ground-Sand drain method	Embankment
104 (E104)Embankment foundation ground-Paper drain method	Embankment
105 (E105)Embankment foundation ground-Sand compaction pile construction method	Embankment
106 (E106)Embankment foundation ground-Vibro flotation method	Embankment
107 (E107)Embankment foundation ground- Quicklime pile construction method	Embankment
108 (E108)Improvement of soft subgrade-Blocking layer	Embankment
109 (E109)Improvement of soft subgrade-Stabilization method-Lime/quicklime	Embankment
110 (E110)Improvement of soft roadbed-Particle size adjustment method	Embankment
111 (E111)Improvement of soft roadbed-Bitumen stabilization method	Embankment
112 (E112)Improvement of soft roadbed-Cement stabilization treatment	Embankment
113 (E113)Improvement of soft roadbed-Lime stabilization work	Embankment
114 (E114)Improvement of soft roadbed-Improvement of loose sandy ground	Embankment
115 (E115)Improvement of poor roadbed-Improvement of cohesive soil	Embankment
116 (E116)Cut soil slope-Determining factor of cut slope slope	Cut soil slope
117 (E117)Cut soil slope-Cut slope standard	Cut soil slope
118 (E118)Cut soil slope- Single slope	Cut soil slope
119 (E119)Cut soil slope- Gradient with change	Cut soil slope
120 (E120)Cut soil slope- Those with berm	Cut soil slope
121 (E121)Cut soil slope- Construction of rock slope	Cut soil slope
122 (E122)Cut soil slope- Construction of soil slope	Cut soil slope
123 (E123)Slope protection work	Slope protection
124 (E124)Slope protection work-Types of vegetation works	Slope protection
125 (E125)Slope protection work-Seed spraying	Slope protection
126 (E126)Slope protection work-Seed spraying	Slope protection
127 (E127)Slope protection work-Seed spraying	Slope protection
128 (E128)Slope protection work-vegetation mat	Slope protection
129 (E129)Slope protection work-Vegetation board work, vegetation bag work	Slope protection
130 (E130)Slope protection work-vegetation seeds	Slope protection
131 (E131)Slope protection work-Points to note regarding vegetation work	Slope protection
132 (E132)Slope protection work-Mortar concrete spraying work	Slope protection
133 (E133)Slope protection work-Stone masonry	Slope protection
134 (E134)Slope protection work-Block pitching	Slope protection
135 (E135)Slope protection work-Concrete lining	Slope protection
136 (E136)Slope protection work-Concrete block slope protection by mold	Slope protection

137 (E137)Slope protection work-On-site construction work	Slope protection
138 (E138)Slope protection work-Masonry work	Slope protection
139 (E139)Slope protection work-Block construction	Slope protection
140 (E140)Slope protection work-Plain concrete retaining retaining wall	Slope protection
141 (E141)Slope protection work-Reinforced concrete retaining wall construction	Slope protection
142 (E142)Slope protection work-Reinforcement earthworks	Slope protection
143 (E143)Slope protection work-retaining wall work	Slope protection
144 (E144)Slope protection work-Editing shelving	Slope protection
145 (E145)Slope protection work-Slope gabion work	Slope protection
146 (E146)Slope protection work-Rockfall prevention mesh/fencing	Slope protection
147 (E147)Slope protection work-Vegetation work・protection of structures	Slope protection
148 (E148)Drainage method- Shallow sump drainage method	Drainage method
149 (E149)Drainage method-Well point construction method	Drainage method
150 (E150)Drainage method-Deep well method	Drainage method
151 (E151)Drainage method-Deep well vacuum construction method	Drainage method
152 (E152)Drainage method-Electropenetration method	Drainage method
153 (E153)Drainage method-Selection of drainage method	Drainage method
154 (E154)Drainage method-Drainage works	Drainage method
155 (E155)Road embankment – compaction around structures	Embankment
156 (E156)Road embankment-Culvert embankment	Embankment
157 (E157)Soil classification-Name of soil particles based on particle size	Soil classification
158 (E158)Soil classification-Particle size test - Particle size accumulation curve	Soil classification
159 (E159)Soil classification- Uniformity coefficient and curvature curve	Soil classification
160 (E160)Soil classification- Particle size accumulation curve	Soil classification
161 (E161)Soil classification- Triangular coordinates	Soil classification
162 (E162)Soil classification- Consistency limit and relationship between water content and volume change	Soil classification
163 (E163)Soil classification- Plasticity index and plasticity diagram (Japan unified soil classification method)	Soil classification
164 (E164)Compaction regulations	Compaction
165 (E165)Compaction regulations-Construction method regulations	Compaction
166 (E166)Compaction regulations-Proof rolling regulations	Compaction
167 (E167)Compaction regulations-Method to specify based on strength (supporting capacity)	Compaction
168 (E168)Compaction regulations-Method defined by saturation degree and air porosity	Compaction
169 (E169)Compaction regulations-Method defined by saturation degree and air porosity	Compaction
170 (E170)Compaction regulations-Maximum dry density and optimum moisture content ratio	Compaction

171 (E171)Compaction regulations	Compaction
172 (E172)Earthworks-Embankment materials	Earthworks
173 (E173)Earthworks-Embankment materials-Soil unsuitable for embankment	Earthworks
174 (E174)Earthworks-Embankment materials-waste soil	Earthworks
175 (E175)Earthworks-Embankment materials-Embankment material by grain size	Earthworks
176 (E176)Earthworks-Trafficability-measures	Earthworks
177 (E177)Earthworks-Embankment construction- Leveling thickness	Earthworks
178 (E178)Earthworks-Embankment construction-Compaction of embankment	Earthworks
179 (E179)Earthworks-Embankment construction-Embankment on sloping ground	Earthworks
180 (E180)Earthworks-Embankment construction-Embankments and structures	Earthworks
181 (E181)Earthworks-Selection of equipment for earthwork	Earthworks
182 (E182)Earthworks-Characteristics of Earthmoving Machinery	Earthworks
183 (E183)Earthworks-Characteristics of Earthmoving Machinery	Earthmoving Machinery
184 (E184)Earthworks-Characteristics of Earthmoving Machinery	Earthmoving Machinery
185 (E185)Earthworks-Characteristics of Earthmoving Machinery	Earthmoving Machinery
186 (E186)Earthworks-Characteristics of Earthmoving Machinery	Earthmoving Machinery
187 (E187)Earthworks-Characteristics of Earthmoving Machinery	Earthmoving Machinery
188 (E188)Earthworks-Characteristics of Earthmoving Machinery	Earthmoving Machinery
189 (E189)Earthworks-Excavation and transportation method	Earthmoving Machinery
190 (E190)Earthworks-Slow construction method	Soft ground
191 (E191)Earthworks-Sand mat method	Soft ground
192 (E192)Earthworks-Pressure embankment method	Soft ground
193 (E193)Earthworks-Preloading method	Soft ground
194 (E194)Earthworks-Removal and replacement method	Soft ground
195 (E195)Earthworks-Sand drain method	Soft ground
196 (E196)Earthworks-Sand compaction pile method (vibrocomposer method)	Soft ground
197 (E197)Earthworks-Vibroflotation method	Soft ground
198 (E198)Earthwork plan	Earthwork plan
199 (E199)Earthwork plan-Value of soil volume conversion factor f	Earthwork plan
200 (E200)Earthwork plan-Construction machinery construction volume	Earthwork plan
201 (E201)Earthwork plan-Land volume curve diagram	Earthwork plan
202 (E202)Earthwork plan-Properties of volume curve	Earthwork plan
203 (E203)Earthwork plan-Use of volume curve	Earthwork plan
204 (E204)Earthwork plan-Use of volume curve	Earthwork plan

205 (E205)Earthwork plan-Improving the efficiency of construction machinery	Earthwork plan
206 (E206)Embankment materials – compaction test	Embankment
207 (E207)Embankment materials – general properties	Embankment
208 (E208)Embankment construction on sloping ground	Embankment
209 (E209)Embankment construction of the connection part with the structure	Embankment
210 (E210)Embankment construction-Compaction machine	Embankment
211 (E211)Embankment construction-Sand mat method	Embankment
212 (E212)Road earthwork-Cracks occur on the upper pavement surface	Earthworks
213 (E213)Earthworks-Countermeasures for soils with insufficient trafficability	Earthworks
214 (E214)Liquid limit and plastic limit	Soil classification
215 (E215)Tire roller/vibration roller	Earthmoving Machinery
216 (E216)Replacement method	Earthworks
217 (E217)Loading bank method	Earthworks
218 (E218)Sand mat method	Earthworks
219 (E219)Sand compaction pile method	Earthworks
220 (E220)Soft ground improvement method-Preloading method	Earthworks
221 (E221)Slope protection work-Vegetation work	Slope protection work
222 (E222)Slope protection work-Vegetation work	Slope protection work
223 (E223)Drainage method	Drainage method
224 (E224)Drainage method-Deep well construction method	Drainage method
225 (E225)Drainage method-Well point construction method	Earthmoving machinery
226 (E226)Construction plan-Earthmoving machinery	Earthmoving machinery
227 (E227)Construction plan-Appropriate machines for each task	Earthmoving machinery
228 (E228)Construction plan-Appropriate machines for each task	Earthmoving machinery
229 (E229)Construction plan-Appropriate machines for each task	Earthmoving machinery
230 (E230)Construction plan-Appropriate machines for each task	Earthmoving machinery
231 (E231)Construction plan-Appropriate machines for each task	Earthmoving machinery
232 (E232)Construction plan-Appropriate machines for each task	Earthmoving machinery
233 (E233)Construction plan-Appropriate machines for each task	Earthmoving machinery
234 (E234)Construction plan-Appropriate machines for each task	Earthmoving machinery
235 (E235)Construction plan-Appropriate machines for each task	Earthmoving machinery
236 (E236)Construction plan-Appropriate machines for each task	Earthmoving machinery
237 (E237)Transport distance and applicable machine type	Earthmoving machinery
238 (E238)Transport distance and applicable machine type	Earthmoving machinery

239 (E239)Transport distance and applicable machine type	Earthmoving machinery
240 (E240)Compaction machinery and soil quality	Earthmoving machinery
241 (E241)Front attachment and aptitude work	Earthmoving machinery
242 (E242)Temporary plan for earthworks	Earthworks
243 (E243)Temporary plan for earthworks-Structure excavation・cutting	Earthworks
244 (E244)Earthworks-Earth retaining wall timbering method	Earthworks
245 (E245)Earthworks-Earth retaining wall timbering method	Earthworks
246 (E246)Earthworks-Earth retaining wall timbering method	Earthworks
247 (E247)Earthworks-Earth retaining wall timbering method	Earthworks
248 (E248)Earthworks-Earth retaining wall timbering method	Earthworks
249 (E249)Earthworks-Earth retaining wall timbering method	Earthworks
250 (E250)Earthworks-Earth retaining wall timbering method	Earthworks
251 (E251)Earthworks-Earth retaining wall timbering method	Earthworks
252 (E252)Earthworks-Earth retaining wall timbering method	Earthworks
253 (E253)Earthworks-Earth anchor method	Earthworks
254 (E254)Earthworks-Island method	Earthworks
255 (E255)Earthworks-Parent pile horizontal sheet pile /Steel sheet pile/Continuous wall	Earthworks
256 (E256)Earthworks- Heaving destruction	Earthworks
257 (E257)Earthworks-Boiling destruction	Earthworks
258 (E258)Earthwork plan-Construction machinery construction volume	Earthwork plan
259 (E259)Earthwork plan-Amount of work done by construction machinery	Earthwork plan
260 (E260)Earthwork plan-Rate of change in soil volume	Earthwork plan
261 (E261)Earthwork plan-Rate of change in soil volume	Earthwork plan
262 (E262)Earthwork plan-Value of soil volume conversion factor (f)	Earthwork plan
263 (E263)Earthwork plan-Transport to embankment point	Earthwork plan
264 (E264)Earthwork plan-Amount of soil to be transported	Earthwork plan
265 (E265)Earthwork plan-Cycle time calculation	Earthmoving machinery
266 (E266)Earthwork plan-Standard construction speed QR	Earthmoving machinery
267 (E267)Earthwork plan-Bulldozer work	Earthmoving machinery
268 (E268)Earthwork plan-Construction speed of compaction machine	Earthmoving machinery
269 (E269)Earthwork plan-Construction speed of compaction machine	Earthmoving machinery
270 (E270)Earthwork plan-Power excavator construction speed	Earthmoving machinery
271 (E271)Earthwork plan-Land volume curve diagram(mass curve)	Earthwork plan
272 (E272)Earthwork plan-Land volume curve diagram(mass curve)	Earthwork plan

273	(E273)Earthwork plan-Land volume curve diagram(mass curve)	Earthwork plan
274	(E274)Earthwork construction plan-Slope of foundation ground to prevent embankment from sliding	soft ground
275	(E275)Earthwork construction plan-How to treat soft ground-Pressure embankment method	soft ground
276	(E276)Earthwork construction plan-How to treat soft ground-Replacement method	soft ground
277	(E277)Earthwork construction plan-How to treat soft ground- Slow construction method	soft ground
278	(E278)Earthwork construction plan-How to treat soft ground- Countermeasures against settlement-Loading method	soft ground
279	(E279)Earthwork construction plan-How to treat soft ground- Countermeasures against settlement-Sand drain method	soft ground
280	(E280)Earthwork construction plan-How to treat soft ground- Slip and subsidence measures-Sand compaction method	soft ground
281	(E281)Earthwork construction plan-How to treat soft ground- Earthquake countermeasures (liquefaction prevention)	soft ground
282	(E282)Earthwork construction plan-gradient	Earthwork construction
283	(E283)Earthwork construction plan-slope gradient	Earthwork construction
284	(E284)Earthwork construction plan-slope gradient	Earthwork construction
285	(E285)Earthwork construction plan-Safety measures for excavation work	Earthwork construction
286	(E286)Earthwork construction plan-Earth retaining work	Earthwork construction
287	(E287)Earthwork construction plan-penetration of sheet piles-heaving	Earthwork construction
288	(E288)Earthwork construction plan-penetration of sheet piles-Boiling	Earthwork construction
289	(E289)Earthmoving machinery-Excavating machine	Excavating machine
290	(E290)Earthmoving machinery-Excavating machine	Excavating machine
291	(E291)Earthmoving machinery-loading machine-Crawler type tractor excavator	Loading machine
292	(E292)Earthmoving machinery-loading machine-Wheeled tractor excavator	Loading machine
293	(E293)Earthmoving machinery-loading machine-Loading method	Loading machine
294	(E294)Earthmoving machinery-loading machine-Loading method	Loading machine
295	(E295)Earthmoving machinery-loading machine-Loading method	Loading machine
296	(E296)Earthmoving machinery-loading machine-Loading method	Loading machine
297	(E297)Earthmoving machinery-transport machinery-Straight dozer	Loading machine
298	(E298)Earthmoving machinery-transport machinery-Angle dozer	Transport machinery
299	(E299)Earthmoving machinery-transport machinery-Tilt dozer	Transport machinery
300	(E300)Earthmoving machinery-transport machinery-U dozer	Transport machinery
301	(E301)Earthmoving machinery-transport machinery-Rake dozer	Transport machinery
302	(E302)Earthmoving machinery-transport machinery-Tridozer	Transport machinery
303	(E303)Earthmoving machinery-transport machinery-Bucket dozer	Transport machinery
304	(E304)Earthmoving machinery-transport machinery-Bucket dozer	Transport machinery
305	(E305)Earthmoving machinery-transport machinery-Installation pressure	Transport machinery
306	(E306)Earthmoving machinery-transport machinery-Scraper	Transport machinery

307 (E307)Earthmoving machinery-transport machinery-Scraper-Work procedure	Transport machinery
308 (E308)Earthmoving machinery-transport machinery-Scraper-Type of scraper	Transport machinery
309 (E309)Earthmoving machinery-transport machinery-Motor grader	Transport machinery
310 (E310)Earthmoving machinery-Compaction machines	Compaction machines
311 (E311)Earthmoving machinery-Compaction machines-Road roller	Compaction machines
312 (E312)Earthmoving machinery-Compaction machines-Tandem roller (two axes and two wheels)	Compaction machines
313 (E313)Earthmoving machinery-Compaction machines-Three-axis tandem roller (three-axis three-wheel)	Compaction machines
314 (E314)Earthmoving machinery-Compaction machines-Tamping roller	Compaction machines
315 (E315)Earthmoving machinery-Compaction machines-Tire roller	Compaction machines
316 (E316)Earthmoving machinery-Compaction machines-Vibration roller	Compaction machines
317 (E317)Earthmoving machinery-Compaction machines-Vibration roller	Compaction machines
318 (E318)Earthmoving machinery-Compaction machines-Vibration compactor	Compaction machines
319 (E319)Earthmoving machinery-Compaction machines-Wetland bulldozer	Compaction machines
320 (E320)Earthmoving machinery-Ground improvement machine-Sand drain method	Ground improvement machine
321 (E321)Earthmoving machinery-Ground improvement machine-Sand compaction method	Ground improvement machine
322 (E322)Earthmoving machinery-Ground improvement machine-Vibroflotation method	Ground improvement machine
323 (E323)Earthmoving machinery-Ground improvement machine-Wellpont construction method	Ground improvement machine
324 (E324)Earthmoving machinery-Transport machinery-Bucket wheel excavator	Ground improvement machine
325 (E325)Earthworks-Types of earthworks	Earthworks
326 (E326)Earthworks-Slope gradient	Earthworks
327 (E327)Earthworks-Slope gradient	Earthworks
328 (E328)Earthworks-Standard slope of embankment	Earthworks
329 (E329)Earthworks-Standard cutting slope	Earthworks
330 (E330)Earthworks-Earthwork ruler	Earthworks
331 (E331)Earthworks-Change in soil volume	Earthworks
332 (E332)Earthworks-Change in soil volume-Calculation of loosened soil volume	Earthworks
333 (E333)Earthworks-Change in soil volume-Calculation of compacted soil volume	Earthworks
334 (E334)Earthworks-Change in soil volume-Soil volume change rate	Earthworks
335 (E335)Earthworks-Change in soil volume-Soil volume conversion factor f	Earthworks
336 (E336)Earthworks-Land volume map (mass curve)-Earthwork planning	Earthworks
337 (E337)Earthworks-Land volume map (mass curve)-Embankment volume map -Cut and earth volume map	Earthworks
338 (E338)Earthworks-Land volume map (mass curve)-Characteristics of land mass map	Earthworks
339 (E339)Earthworks-Land volume map (mass curve)-Selection of earthmoving machinery	Earthworks
340 (E340)Earthworks-Earthmoving machinery-Work type - Appropriate machine	Earthworks

341 (E341)Earthmoving machinery-Combination of earthmoving machines	Earthmoving machinery
342 (E342)Earthmoving machinery-Machine selection based on transportation distance	Earthmoving machinery
343 (E343)Earthmoving machinery-Cone index	Earthmoving machinery
344 (E344)Earthmoving machinery-Types of bulldozers-Straight dozer	Earthmoving machinery
345 (E345)Earthmoving machinery-Types of bulldozers-U dozer	Earthmoving machinery
346 (E346)Earthmoving machinery-Types of bulldozers-Angle dozer	Earthmoving machinery
347 (E347)Earthmoving machinery-Types of bulldozers-Tridozer	Earthmoving machinery
348 (E348)Earthmoving machinery-Types of bulldozers-Tilt dozer	Earthmoving machinery
349 (E349)Earthmoving machinery-Types of bulldozers-Rake dozer	Earthmoving machinery
350 (E350)Earthmoving machinery-Scraper-Self-propelled motor scraper	Earthmoving machinery
351 (E351)Earthmoving machinery-Scraper-Scraper + bulldozer combination	Earthmoving machinery
352 (E352)Earthmoving machinery-Shovel type excavation machinery	Earthmoving machinery
353 (E353)Earthmoving machinery-How to excavate the ground (by machine)- Bench cut method	Earthmoving machinery
354 (E354)Earthmoving machinery-How to excavate the ground (by machine)- Downhill construction method	Earthmoving machinery
355 (E355)Earthmoving machinery-How to excavate the ground (by machine)-Combination method	Earthmoving machinery
356 (E356)Earthmoving machinery-Spreading Leveling/compaction-Motor grader	Earthmoving machinery
357 (E357)Earthmoving machinery-Compaction machine-Static pressure	Earthmoving machinery
358 (E358)Earthmoving machinery-Compaction machine-Vibration	Earthmoving machinery
359 (E359)Earthmoving machinery-Compaction machine-Impact	Earthmoving machinery
360 (E360)Earthmoving machinery-Combination of compaction machine and soil type-Combination of compaction machine and soil type	Earthmoving machinery
361 (E361)Earthmoving machinery-Combination of compaction machine and soil type-Combination of compaction machine and soil type	Earthmoving machinery
362 (E362)Earthmoving machinery-Combination of compaction machine and soil type-Combination of compaction machine and soil type	Earthmoving machinery
363 (E363)Earthmoving machinery-Combination of compaction machine and soil type-Combination of compaction machine and soil type	Earthmoving machinery
364 (E364)Earthmoving machinery-Combination of compaction machine and soil type-Combination of compaction machine and soil type	Earthmoving machinery
365 (E365)Slope protection-Embankment slope	Slope protection
366 (E366)Slope protection-Embankment slope-Vegetation work (embankment)	Slope protection
367 (E367)Slope protection-Embankment slope-Vegetation work (embankment)	Slope protection
368 (E368)Slope protection-Embankment slope-Vegetation work (embankment)	Slope protection
369 (E369)Slope protection-Cut and embankment slope	Slope protection
370 (E370)Slope protection-Concrete block construction	Slope protection
371 (E371)Slope protection-Concrete block masonry	Slope protection
372 (E372)Dredging work-Pump dredger	Dredging work
373 (E373)Dredging work-Grab dredger	Dredging work
374 (E374)Dredging work-Bucket dredger	Dredging work

375 (E375)Dredging work-Dipper dredger	Dredging work
376 (E376)Dredging work-Pump ship・Grab ship・Dipper dredge・Bucket dredger	Dredging work
377 (E377)Earthwork planning/design-Bulldozer working capacity	Earthwork planning/design
378 (E378)Earthwork planning/design-Bulldozer working capacity	Earthwork planning/design
379 (E379)Earthwork planning/design-Bulldozer working capacity	Earthwork planning/design
380 (E380)Earthwork planning/design-Bulldozer working capacity	Earthwork planning/design
381 (E381)Earthwork planning/design-Bulldozer working capacity	Earthwork planning/design
382 (E382)Earthwork planning/design-Working capacity of excavator type excavator	Earthwork planning/design
383 (E383)Earthwork planning/design-Working capacity of excavator type excavator	Earthwork planning/design
384 (E384)Earthwork planning/design-Cycle time Cm of excavator type excavator	Earthwork planning/design
385 (E385)Earthwork planning/design-Features and selection criteria of excavators	Earthwork planning/design
386 (E386)Earthwork planning/design-Working capacity of excavator type excavator-Work load of power shovel	Earthwork planning/design
387 (E387)Earthwork planning/design-Dump truck working capacity	Earthwork planning/design
388 (E388)Earthwork planning/design-Required number of dump trucks	Earthwork planning/design
389 (E389)Earthwork planning/design-Required number of dump trucks	Earthwork planning/design
390 (E390)Structure excavation-Direct foundation-Normal ground	Structure excavation
391 (E391)Structure excavation-Direct foundation-Bedrock	Structure excavation
392 (E392)Structure excavation-Slope open cut	Structure excavation
393 (E393)Structure excavation-Sheet pile + Timbering Slope open cut method	Structure excavation
394 (E394)Structure excavation-Sheet pile + Timbering	Structure excavation
395 (E395)Structure excavation-Sheet pile + Timbering-Slope open cut method	Structure excavation
396 (E396)Structure excavation-Sheet pile + Timbering-open cut method	Structure excavation
397 (E397)Structure excavation-Points to note during planning structural excavation	Structure excavation
398 (E398)Structure excavation-Points to note during planning structural excavation	Structure excavation
399 (E399)Structure excavation-Points to note During construction	Structure excavation
400 (E400)Structure excavation-Structure-Supporting ground	Structure excavation
401 (E401)Structure excavation-Structure - Excavation slope gradient- Soil quality	Structure excavation
402 (E402)Structure excavation-Structure - Excavation slope gradient- Soil quality	Structure excavation
403 (E403)Structure excavation-Structure - Excavation slope gradient- Soil quality	Structure excavation
404 (E404)Structure excavation-Structure - Excavation slope gradient- Soil quality	Structure excavation
405 (E405)Structure excavation-Slope open cut method	Structure excavation
406 (E406)Structure excavation-Structures - Excavation machine selection	Structure excavation
407 (E407)Structure excavation- Slope protection work	Structure excavation
408 (E408)Structure excavation-Structures - Excavation machine selection-Points to note during excavating	Structure excavation

409 (E409)Structure excavation-Structures - Excavation machine selection-Points to note during excavating	Structure excavation
410 (E410)Structure excavation-Structures - Excavation machine selection-Points to note during excavating	Structure excavation
411 (E411)Structure excavation-Boiling	Boiling
412 (E412)Structure excavation- Piping phenomenon	Piping phenomenon
413 (E413)Structure excavation-Earth retaining wall	Earth retaining wall
414 (E414)Structure excavation-Slope protection	Slope protection
415 (E415)Structure excavation-bearing ground	bearing ground
416 (E416)Structure excavation-wastewater treatment	wastewater treatment
417 (E417)Structure excavation-flooring surface	flooring surface
418 (E418)Structure excavation-Protection of flooring surface	Protection of flooring surface
419 (E419)Structure excavation-Protection of flooring surface	Protection of flooring surface
420 (E420)Structure excavation- earth retaining works	earth retaining works
421 (E421)Structure excavation-Permanent slope	Structure excavation
422 (E422)Structure excavation- Groundwater investigation	Structure excavation
423 (E423)Structure excavation- Construction period	Structure excavation
424 (E424)Structure excavation-Groundwater investigation-Drainage method plan	Structure excavation
425 (E425)Structure excavation-Groundwater investigation	Structure excavation
426 (E426)Structure excavation-Groundwater level decline depending on season and time	Structure excavation
427 (E427)Structure excavation-Groundwater recharge source/influence area	Structure excavation
428 (E428)Structure excavation-Calculation of groundwater decline and spring water amount	Structure excavation
429 (E429)Structure excavation- Measure the impact of groundwater decline on the surrounding area	Structure excavation
430 (E430)Structure excavation- Place of installation of drainage equipment Wastewater treatment	Structure excavation
431 (E431)Structure excavation-Drainage method	Structure excavation
432 (E432)Structure excavation-How to check soil bearing capacity	Structure excavation
433 (E433)Structure excavation- Replacement of defective soil	Structure excavation
434 (E434)Structure excavation- Change basic shape of foundation	Structure excavation
435 (E435)Structure excavation- Change to pile foundation	Structure excavation
436 (E436)Structure excavation- cobble stone construction method	Structure excavation
437 (E437)Structure excavation-Leveled concrete (t=100mm)	Structure excavation
438 (E438)Structure excavation-Check points for foundation bottom surface treatment	Structure excavation
439 (E439)Structure excavation-Backfill structure of embankment abutment	Structure excavation
440 (E440)Structure excavation-Backfill structure of cut section abutment	Structure excavation
441 (E441)Structure excavation-Quality of structural backfill materials	backfilling
442 (E442)Structure excavation-Construction of backfilling and backfilling soil	backfilling

443 (E443)Structure excavation-Points to note regarding backfilling and backfilling soil	backfilling
444 (E444)Structure excavation-Points to note regarding backfilling and backfilling soil	backfilling
445 (E445)Structure excavation-Points to note regarding backfilling and backfilling soil	backfilling
446 (E446)Structure excavation-Points to note regarding backfilling and backfilling soil	backfilling
447 (E447)Structure excavation-Points to note regarding backfilling and backfilling soil	backfilling
448 (E448)Structure excavation-Points to note during excavating-compaction appropriate	backfilling
449 (E449)Structure excavation-Structures - Points to note during excavating-Drainage works	Drainage works
450 (E450)Structure excavation-Structures - Points to note during excavating-Drainage works	Drainage works
451 (E451)Structure excavation-Structures -Drainage works	Drainage works
452 (E452)Structure excavation-Structures -Drainage works	Drainage works
453 (E453)Dry Field reclamation	Earthworks
454 (E454)Dry Field reclamation	Earthworks
455 (E455)Liquefaction	Soil
456 (E456)Well point construction method	Drainage
457 (E457)Anchor method	Retaingwall
458 (E458)Consolidation	Soil
459 (E459)Shallow sump drainage	Drainage
460 (E460)cutting	Earthworks
461 (E461)Quicksand phenomenon	Quicksand phenomenon
462 (E462)ridge and ditch	ridge and ditch
463 (E463)Farmland block	Farmland block
464 (E464)berm	berm
465 (E465)(Mixing tillage) Mixed layer cultivation	(Mixing tillage) Mixed layer cultivation
466 (E466)Landslide	Landslide
467 (E467)Slope failure	Slope failure
468 (E468)hydrological cycle	hydrological cycle
469 (E469)bench terraced fields	bench terraced fields
470 (E470)groundwater level	groundwater level
471 (E471)groundwater level	groundwater level
472 (E472)underground dam	underground dam
473 (E473)Replacement method	Replacement method
474 (E474)geological profiile	geological profiile
475 (E475)geological column	geological column
476 (E476)fixed ruler :finishing stake	fixed ruler :finishing stake

477 (E477)earth pressure	earth pressure
478 (E478)Soil stabilization treatment-Runways, roads, etc.-Improvement of roadbed and roadbed	Soil stabilization treatment
479 (E479)Soil stabilization treatment-By on-road mixing method-Simple paving of farm roads, parking lots, etc.	Soil stabilization treatment
480 (E480)Soil stabilization treatment-Temporary road for construction-pavement	Soil stabilization treatment
481 (E481)Soil stabilization treatment-Sliding failure of embankment	Soil stabilization treatment
482 (E482)Soil stabilization treatment-Building foundation ground improvement	Soil stabilization treatment
483 (E483)Soil stabilization treatment-Underground dam wall	Soil stabilization treatment
484 (E484)geotextile-Embankment drainage reinforcement	geotextile
485 (E485)geotextile-Separation of different materials	geotextile
486 (E486)geotextile- Reinforcement of ground, roadbed, etc.	geotextile
487 (E487)geotextile- Preventing suction of earth and sand	geotextile
488 (E488)soil structure	soil structure
489 (E489)soil structure-Bonding of soil particles	soil structure
490 (E490)subsoil improvement	subsoil improvement
491 (E491)Earth retaining work	Earth retaining work
492 (E492)levee widening-Cross-sectional expansion of the existing levee (filling)	levee widening
493 (E493)heaving	heaving
494 (E494)sheet erosion	sheet erosion
495 (E495)shallow well	shallow well
496 (E496)culvert drainage	culvert drainage
497 (E497)pumice stone (floating rock)	pumice stone (floating rock)
498 (E498)fill in (Backfilling)	fill in (Backfilling)
499 (E499)Sensitivity ratio	Sensitivity ratio
500 (E500)liquefaction	liquefaction
501 (E501)counter weight banking:Pressed embankment	counter weight banking
502 (E502)surcharge process:Pressing embankment method	surcharge process
503 (E503)Open cut method	Open cut method
504 (E504)greenhouse gas	greenhouse gas
505 (E505)Open cutting method	Open cutting method
506 (E506)Open channel	Open channel
507 (E507)raising of embankment	raising of embankment
508 (E508)Over-compaction	Over-compaction
509 (E509)River channel	River channel
510 (E510)Cover	Cover

511 (E511)Shallow sump	Shallow sump
512 (E512)gully erosion	gully erosion
513 (E513)Environmental Quality Standards	Environmental Quality Standards
514 (E514)Pipeline	Pipeline
515 (E515)Culvert	Culvert
516 (E516)unscreened gravel	unscreened gravel
517 (E517)strut	strut
518 (E518)walling	walling
519 (E519)angle brace	angle brace
520 (E520)broken stone foundation	broken stone foundation
521 (E521)hydraulic radius	hydraulic radius
522 (E522)non overflow groyne:non-overflow water control	non overflow groyne
523 (E523)Flood Control	Flood Control
524 (E524)border	border
525 (E525)field permeability test	field permeability test
526 (E526)major bed	major bed
527 (E527)rigid pavement	rigid pavement
528 (E528)berm	berm
529 (E529)left bank right bank	left bank right bank
530 (E530)erosion control works	erosion control works
531 (E531)hillside works	hillside works
532 (E532)hillside covering works	hillside covering works
533 (E533)test pit	test pit
534 (E534)land slide	land slide
535 (E535)allowable bearing capacity	allowable bearing capacity
536 (E536)slope distance	slope distance
537 (E537)slope failure	slope failure
538 (E538)Longitudinal slope	Longitudinal slope
539 (E539)Longitudinal alignment	Longitudinal alignment
540 (E540)Gravity water	Gravity water
541 (E541)vadose water:Circulating water	vadose water
542 (E542)dredging	dredging
543 (E543)planted slope protection:Vegetation engineering	planted slope protection
544 (E544)seepage line:Infiltration line	seepage line

545 (E545)cycle of erosion	cycle of erosion
546 (E546)axle of drop hammer	axle of drop hammer
547 (E547)Stage:water gauge	Stage:water gauge
548 (E548)water pollution	water pollution
549 (E549)water erosion control	water erosion control
550 (E550)diverion of water channel	diverion of water channel
551 (E551)aqueduct	aqueduct
552 (E552)undermining	undermining
553 (E553)Scoop	Scoop
554 (E554)leaving concrete	leaving concrete
555 (E555)sliding surface	sliding surface
556 (E556)conformity	conformity
557 (E557)productive green tract of land	productive green tract of land
558 (E558)formation level-railroad track	formation level-railroad track
559 (E559)zero air voids curve	zero air voids curve
560 (E560)fan	fan
561 (E561)undecurrent	undecurrent
562 (E562)agle of repose	agle of repose
563 (E563)rammer	rammer
564 (E564)fault	fault
565 (E565)ground water level	ground water level
566 (E566)erosion control works	erosion control works
567 (E567)geologic survey	geologic survey
568 (E568)Geological map	Geological map
569 (E569)impregnation method	impregnation method
570 (E570)plastic deformation of soil	plastic deformation of soil
571 (E571)shaft sinking	shaft sinking
572 (E572)riverside land-land side	riverside land-land side
573 (E573)low water channel work	low water channel work
574 (E574)section of levee	section of levee
575 (E575)contour line	contour line
576 (E576)reconnaissance	reconnaissance
577 (E577)earthwork	earthwork
578 (E578)roadway diagraph	roadway diagraph

579 (E579)blade bowl	blade bowl
580 (E580)sediment settling	sediment settling
581 (E581)mass curve	mass curve
582 (E582)debris flow	debris flow
583 (E583)soil profile	soil profile
584 (E584)foundation work	foundation work
585 (E585)Trafficability	Trafficability
586 (E586)sheathing work	sheathing work
587 (E587)trench cut method	trench cut method
588 (E588)batter board	batter board
589 (E589)double filtration	double filtration
590 (E590)interflow	interflow
591 (E591)trench excavation	trench excavation
592 (E592)penetration	penetration
593 (E593)negative friction	negative friction
594 (E594)wheel barrow	wheel barrow
595 (E595)wet masonry	wet masonry
596 (E596)spread foundation	spread foundation
597 (E597)slope pile	slope pile
598 (E598)slope protection	slope protection
599 (E599)branch river	branch river
600 (E600)barrier free	barrier free
601 (E601)confined ground water	confined ground water
602 (E602)angle brace	angle brace
603 (E603)secondary levee	secondary levee
604 (E604)sluice	sluice
605 (E605)wind erosion control	wind erosion control
606 (E606)wind erosion farm	wind erosion farm
607 (E607)deep well	deep well
608 (E608)deep well method	deep well method
609 (E609)Impermeable layer	Impermeable layer
610 (E610)Preloading	Preloading
611 (E611)plate bearing test	plate bearing test
612 (E612)card-board wicks method	card-board wicks method

613 (E613)bentonite	bentonite
614 (E614)boiling	boiling
615 (E615)groyne net	groyne net
616 (E616)groyne wood	groyne wood
617 (E617)windbreak	windbreak
618 (E618)paddy field land	paddy field land
619 (E619)artesian well	artesian well
620 (E620)main levee	main levee
621 (E621)macadam	macadam
622 (E622)spreading	spreading
623 (E623)spreading depth	spreading depth
624 (E624)hydraulic filling method	hydraulic filling method
625 (E625)water bound macadam	water bound macadam
626 (E626)leveling	leveling
627 (E627)trench dozing	trench dozing
628 (E628)shoulder sodding	shoulder sodding
629 (E629)filling up	filling up
630 (E630)follower	follower
631 (E631)landslide	landslide
632 (E632)land reclamation in natural slope	land reclamation in natural slope
633 (E633)batter board	batter board
634 (E634)retarding baisn	retarding baisn
635 (E635)landslide restraining works	landslide restraining works
636 (E636)landslide control works	landslide control works
637 (E637)quarter crossing joint	quarter crossing joint
638 (E638)extra banking	extra banking
639 (E639)freeboard	freeboard
640 (E640)turbulent flow	turbulent flow
641 (E641)thalweg	thalweg
642 (E642)flow net	flow net
643 (E643)water course	water course
644 (E644)method of average end areas	method of average end areas
645 (E645)rill erosion	rill erosion
646 (E646)rate of filtration	rate of filtration

647 (E647)filter film	filter film
648 (E648)filter material	filter material
649 (E649)Mass curve	Mass curve
650 (E650)diversion filling	diversion filling

441 (E441)Structure excavation-Quality of structural backfill materials	backfilling
442 (E442)Structure excavation-Construction of backfilling and backfilling soil	backfilling
443 (E443)Structure excavation-Points to note regarding backfilling and backfilling soil	backfilling
444 (E444)Structure excavation-Points to note regarding backfilling and backfilling soil	backfilling
445 (E445)Structure excavation-Points to note regarding backfilling and backfilling soil	backfilling
446 (E446)Structure excavation-Points to note regarding backfilling and backfilling soil	backfilling
447 (E447)Structure excavation-Points to note regarding backfilling and backfilling soil	backfilling
448 (E448)Structure excavation-Points to note during excavating-compaction appropriate	backfilling
465 (E465)(Mixing tillage) Mixed layer cultivation	(Mixing tillage) Mixed layer cultivation
562 (E562)agle of repose	agle of repose
535 (E535)allowable bearing capacity	allowable bearing capacity
602 (E602)angle brace	angle brace
519 (E519)angle brace	angle brace
551 (E551)aqueduct	aqueduct
619 (E619)artesian well	artesian well
546 (E546)axle of drop hammer	axle of drop hammer
600 (E600)barrier free	barrier free
588 (E588)batter board	batter board
633 (E633)batter board	batter board
415 (E415)Structure excavation-bearing ground	bearing ground
469 (E469)bench terraced fields	bench terraced fields
613 (E613)bentonite	bentonite
464 (E464)berm	berm
528 (E528)berm	berm
579 (E579)blade bowl	blade bowl
411 (E411)Structure excavation-Boiling	Boiling
614 (E614)boiling	boiling
524 (E524)border	border
599 (E599)branch river	branch river
520 (E520)broken stone foundation	broken stone foundation
612 (E612)card-board wicks method	card-board wicks method
70 (E70)Embankment compaction criteria	Compaction
71 (E71)Embankment compaction criteria-Standard by compaction machine	Compaction
72 (E72)Embankment compaction criteria-Criteria based on compaction strength	Compaction

73 (E73)Embankment compaction criteria-Criteria by dry density	Compaction
74 (E74)Embankment compaction criteria-Criteria by dry density	Compaction
75 (E75)Embankment compaction criteria-Criteria based on saturation	Compaction
76 (E76)Embankment compaction criteria	Compaction
77 (E77)Embankment construction	Compaction
78 (E78)Embankment construction-Notes on compaction	Compaction
79 (E79)Embankment construction-Notes on compaction	Compaction
80 (E80)Embankment construction-Notes on compaction	Compaction
81 (E81)Embankment construction-Notes on compaction	Compaction
82 (E82)Embankment construction-Notes on compaction	Compaction
83 (E83)Embankment construction-Notes on compaction	Compaction
84 (E84)Embankment construction-Notes on compaction	Compaction
85 (E85)Embankment precautions-Step cutting construction	Compaction
86 (E86)Embankment precautions-Step cutting construction	Compaction
164 (E164)Compaction regulations	Compaction
165 (E165)Compaction regulations-Construction method regulations	Compaction
166 (E166)Compaction regulations-Proof rolling regulations	Compaction
167 (E167)Compaction regulations-Method to specify based on strength (supporting capacity)	Compaction
168 (E168)Compaction regulations-Method defined by saturation degree and air porosity	Compaction
169 (E169)Compaction regulations-Method defined by saturation degree and air porosity	Compaction
170 (E170)Compaction regulations-Maximum dry density and optimum moisture content ratio	Compaction
171 (E171)Compaction regulations	Compaction
310 (E310)Earthmoving machinery-Compaction machines	Compaction machines
311 (E311)Earthmoving machinery-Compaction machines-Road roller	Compaction machines
312 (E312)Earthmoving machinery-Compaction machines-Tandem roller (two axes and two wheels)	Compaction machines
313 (E313)Earthmoving machinery-Compaction machines-Three-axis tandem roller (three-axis three-wheel)	Compaction machines
314 (E314)Earthmoving machinery-Compaction machines-Tamping roller	Compaction machines
315 (E315)Earthmoving machinery-Compaction machines-Tire roller	Compaction machines
316 (E316)Earthmoving machinery-Compaction machines-Vibration roller	Compaction machines
317 (E317)Earthmoving machinery-Compaction machines-Vibration roller	Compaction machines
318 (E318)Earthmoving machinery-Compaction machines-Vibration compactor	Compaction machines
319 (E319)Earthmoving machinery-Compaction machines-Wetland bulldozer	Compaction machines
601 (E601)confined ground water	confined ground water
556 (E556)conformity	conformity

575 (E575)contour line	contour line
501 (E501)counter weight banking:Pressed embankment	counter weight banking
510 (E510)Cover	Cover
515 (E515)Culvert	Culvert
496 (E496)culvert drainage	culvert drainage
116 (E116)Cut soil slope-Determining factor of cut slope slope	Cut soil slope
117 (E117)Cut soil slope-Cut slope standard	Cut soil slope
118 (E118)Cut soil slope- Single slope	Cut soil slope
119 (E119)Cut soil slope- Gradient with change	Cut soil slope
120 (E120)Cut soil slope- Those with berm	Cut soil slope
121 (E121)Cut soil slope- Construction of rock slope	Cut soil slope
122 (E122)Cut soil slope- Construction of soil slope	Cut soil slope
545 (E545)cycle of erosion	cycle of erosion
582 (E582)debris flow	debris flow
607 (E607)deep well	deep well
608 (E608)deep well method	deep well method
550 (E550)diverion of water channel	diverion of water channel
650 (E650)diversion filling	diversion filling
589 (E589)double filtration	double filtration
456 (E456)Well point construction method	Drainage
459 (E459)Shallow sump drainage	Drainage
148 (E148)Drainage method- Shallow sump drainage method	Drainage method
149 (E149)Drainage method-Well point construction method	Drainage method
150 (E150)Drainage method-Deep well method	Drainage method
151 (E151)Drainage method-Deep well vacuum construction method	Drainage method
152 (E152)Drainage method-Electropenetration method	Drainage method
153 (E153)Drainage method-Selection of drainage method	Drainage method
154 (E154)Drainage method-Drainage works	Drainage method
223 (E223)Drainage method	Drainage method
224 (E224)Drainage method-Deep well construction method	Drainage method
449 (E449)Structure excavation-Structures - Points to note during excavating-Drainage works	Drainage works
450 (E450)Structure excavation-Structures - Points to note during excavating-Drainage works	Drainage works
451 (E451)Structure excavation-Structures -Drainage works	Drainage works
452 (E452)Structure excavation-Structures -Drainage works	Drainage works

542 (E542)dredging	dredging
372 (E372)Dredging work-Pump dredger	Dredging work
373 (E373)Dredging work-Grab dredger	Dredging work
374 (E374)Dredging work-Bucket dredger	Dredging work
375 (E375)Dredging work-Dipper dredger	Dredging work
376 (E376)Dredging work-Pump ship・Grab ship・Dipper dredge・Bucket dredger	Dredging work
477 (E477)earth pressure	earth pressure
413 (E413)Structure excavation-Earth retaining wall	Earth retaining wall
491 (E491)Earth retaining work	Earth retaining work
420 (E420)Structure excavation- earth retaining works	earth retaining works
183 (E183)Earthworks-Characteristics of Earthmoving Machinery	Earthmoving Machinery
184 (E184)Earthworks-Characteristics of Earthmoving Machinery	Earthmoving Machinery
185 (E185)Earthworks-Characteristics of Earthmoving Machinery	Earthmoving Machinery
186 (E186)Earthworks-Characteristics of Earthmoving Machinery	Earthmoving Machinery
187 (E187)Earthworks-Characteristics of Earthmoving Machinery	Earthmoving Machinery
188 (E188)Earthworks-Characteristics of Earthmoving Machinery	Earthmoving Machinery
189 (E189)Earthworks-Excavation and transportation method	Earthmoving Machinery
215 (E215)Tire roller/vibration roller	Earthmoving Machinery
225 (E225)Drainage method-Well point construction method	Earthmoving machinery
226 (E226)Construction plan-Earthmoving machinery	Earthmoving machinery
227 (E227)Construction plan-Appropriate machines for each task	Earthmoving machinery
228 (E228)Construction plan-Appropriate machines for each task	Earthmoving machinery
229 (E229)Construction plan-Appropriate machines for each task	Earthmoving machinery
230 (E230)Construction plan-Appropriate machines for each task	Earthmoving machinery
231 (E231)Construction plan-Appropriate machines for each task	Earthmoving machinery
232 (E232)Construction plan-Appropriate machines for each task	Earthmoving machinery
233 (E233)Construction plan-Appropriate machines for each task	Earthmoving machinery
234 (E234)Construction plan-Appropriate machines for each task	Earthmoving machinery
235 (E235)Construction plan-Appropriate machines for each task	Earthmoving machinery
236 (E236)Construction plan-Appropriate machines for each task	Earthmoving machinery
237 (E237)Transport distance and applicable machine type	Earthmoving machinery
238 (E238)Transport distance and applicable machine type	Earthmoving machinery
239 (E239)Transport distance and applicable machine type	Earthmoving machinery
240 (E240)Compaction machinery and soil quality	Earthmoving machinery

241 (E241)Front attachment and aptitude work	Earthmoving machinery
265 (E265)Earthwork plan-Cycle time calculation	Earthmoving machinery
266 (E266)Earthwork plan-Standard construction speed QR	Earthmoving machinery
267 (E267)Earthwork plan-Bulldozer work	Earthmoving machinery
268 (E268)Earthwork plan-Construction speed of compaction machine	Earthmoving machinery
269 (E269)Earthwork plan-Construction speed of compaction machine	Earthmoving machinery
270 (E270)Earthwork plan-Power excavator construction speed	Earthmoving machinery
341 (E341)Earthmoving machinery-Combination of earthmoving machines	Earthmoving machinery
342 (E342)Earthmoving machinery-Machine selection based on transportation distance	Earthmoving machinery
343 (E343)Earthmoving machinery-Cone index	Earthmoving machinery
344 (E344)Earthmoving machinery-Types of bulldozers-Straight dozer	Earthmoving machinery
345 (E345)Earthmoving machinery-Types of bulldozers-U dozer	Earthmoving machinery
346 (E346)Earthmoving machinery-Types of bulldozers-Angle dozer	Earthmoving machinery
347 (E347)Earthmoving machinery-Types of bulldozers-Tridozer	Earthmoving machinery
348 (E348)Earthmoving machinery-Types of bulldozers-Tilt dozer	Earthmoving machinery
349 (E349)Earthmoving machinery-Types of bulldozers-Rake dozer	Earthmoving machinery
350 (E350)Earthmoving machinery-Scraper-Self-propelled motor scraper	Earthmoving machinery
351 (E351)Earthmoving machinery-Scraper-Scraper + bulldozer combination	Earthmoving machinery
352 (E352)Earthmoving machinery-Shovel type excavation machinery	Earthmoving machinery
353 (E353)Earthmoving machinery-How to excavate the ground (by machine)- Bench cut method	Earthmoving machinery
354 (E354)Earthmoving machinery-How to excavate the ground (by machine)- Downhill construction method	Earthmoving machinery
355 (E355)Earthmoving machinery-How to excavate the ground (by machine)-Combination method	Earthmoving machinery
356 (E356)Earthmoving machinery-Spreading Leveling/compaction-Motor grader	Earthmoving machinery
357 (E357)Earthmoving machinery-Compaction machine-Static pressure	Earthmoving machinery
358 (E358)Earthmoving machinery-Compaction machine-Vibration	Earthmoving machinery
359 (E359)Earthmoving machinery-Compaction machine-Impact	Earthmoving machinery
360 (E360)Earthmoving machinery-Combination of compaction machine and soil type-Combination of compaction machine and soil type	Earthmoving machinery
361 (E361)Earthmoving machinery-Combination of compaction machine and soil type-Combination of compaction machine and soil type	Earthmoving machinery
362 (E362)Earthmoving machinery-Combination of compaction machine and soil type-Combination of compaction machine and soil type	Earthmoving machinery
363 (E363)Earthmoving machinery-Combination of compaction machine and soil type-Combination of compaction machine and soil type	Earthmoving machinery
364 (E364)Earthmoving machinery-Combination of compaction machine and soil type-Combination of compaction machine and soil type	Earthmoving machinery
2 (E2)Earthwork-②Protection of embankment slope	Earthwork
3 (E3)Earthwork-③Soft ground	Earthwork
4 (E4)Problems with Earthwork	Earthwork

577 (E577)earthwork	earthwork
282 (E282)Earthwork construction plan-gradient	Earthwork construction
283 (E283)Earthwork construction plan-slope gradient	Earthwork construction
284 (E284)Earthwork construction plan-slope gradient	Earthwork construction
285 (E285)Earthwork construction plan-Safety measures for excavation work	Earthwork construction
286 (E286)Earthwork construction plan-Earth retaining work	Earthwork construction
287 (E287)Earthwork construction plan-penetration of sheet piles-heaving	Earthwork construction
288 (E288)Earthwork construction plan-penetration of sheet piles-Boiling	Earthwork construction
198 (E198)Earthwork plan	Earthwork plan
199 (E199)Earthwork plan-Value of soil volume conversion factor f	Earthwork plan
200 (E200)Earthwork plan-Construction machinery construction volume	Earthwork plan
201 (E201)Earthwork plan-Land volume curve diagram	Earthwork plan
202 (E202)Earthwork plan-Properties of volume curve	Earthwork plan
203 (E203)Earthwork plan-Use of volume curve	Earthwork plan
204 (E204)Earthwork plan-Use of volume curve	Earthwork plan
205 (E205)Earthwork plan-Improving the efficiency of construction machinery	Earthwork plan
258 (E258)Earthwork plan-Construction machinery construction volume	Earthwork plan
259 (E259)Earthwork plan-Amount of work done by construction machinery	Earthwork plan
260 (E260)Earthwork plan-Rate of change in soil volume	Earthwork plan
261 (E261)Earthwork plan-Rate of change in soil volume	Earthwork plan
262 (E262)Earthwork plan-Value of soil volume conversion factor (f)	Earthwork plan
263 (E263)Earthwork plan-Transport to embankment point	Earthwork plan
264 (E264)Earthwork plan-Amount of soil to be transported	Earthwork plan
271 (E271)Earthwork plan-Land volume curve diagram(mass curve)	Earthwork plan
272 (E272)Earthwork plan-Land volume curve diagram(mass curve)	Earthwork plan
273 (E273)Earthwork plan-Land volume curve diagram(mass curve)	Earthwork plan
377 (E377)Earthwork planning/design-Bulldozer working capacity	Earthwork planning/design
378 (E378)Earthwork planning/design-Bulldozer working capacity	Earthwork planning/design
379 (E379)Earthwork planning/design-Bulldozer working capacity	Earthwork planning/design
380 (E380)Earthwork planning/design-Bulldozer working capacity	Earthwork planning/design
381 (E381)Earthwork planning/design-Bulldozer working capacity	Earthwork planning/design
382 (E382)Earthwork planning/design-Working capacity of excavator type excavator	Earthwork planning/design
383 (E383)Earthwork planning/design-Working capacity of excavator type excavator	Earthwork planning/design
384 (E384)Earthwork planning/design-Cycle time Cm of excavator type excavator	Earthwork planning/design

385 (E385)Earthwork planning/design-Features and selection criteria of excavators	Earthwork planning/design
386 (E386)Earthwork planning/design-Working capacity of excavator type excavator-Work load of power shovel	Earthwork planning/design
387 (E387)Earthwork planning/design-Dump truck working capacity	Earthwork planning/design
388 (E388)Earthwork planning/design-Required number of dump trucks	Earthwork planning/design
389 (E389)Earthwork planning/design-Required number of dump trucks	Earthwork planning/design
172 (E172)Earthworks-Embankment materials	Earthworks
173 (E173)Earthworks-Embankment materials-Soil unsuitable for embankment	Earthworks
174 (E174)Earthworks-Embankment materials-waste soil	Earthworks
175 (E175)Earthworks-Embankment materials-Embankment material by grain size	Earthworks
176 (E176)Earthworks-Trafficability-measures	Earthworks
177 (E177)Earthworks-Embankment construction- Leveling thickness	Earthworks
178 (E178)Earthworks-Embankment construction-Compaction of embankment	Earthworks
179 (E179)Earthworks-Embankment construction-Embankment on sloping ground	Earthworks
180 (E180)Earthworks-Embankment construction-Embankments and structures	Earthworks
181 (E181)Earthworks-Selection of equipment for earthwork	Earthworks
182 (E182)Earthworks-Characteristics of Earthmoving Machinery	Earthworks
212 (E212)Road earthwork-Cracks occur on the upper pavement surface	Earthworks
213 (E213)Earthworks-Countermeasures for soils with insufficient trafficability	Earthworks
216 (E216)Replacement method	Earthworks
217 (E217)Loading bank method	Earthworks
218 (E218)Sand mat method	Earthworks
219 (E219)Sand compaction pile method	Earthworks
220 (E220)Soft ground improvement method-Preloading method	Earthworks
242 (E242)Temporary plan for earthworks	Earthworks
243 (E243)Temporary plan for earthworks-Structure excavation・cutting	Earthworks
244 (E244)Earthworks-Earth retaining wall timbering method	Earthworks
245 (E245)Earthworks-Earth retaining wall timbering method	Earthworks
246 (E246)Earthworks-Earth retaining wall timbering method	Earthworks
247 (E247)Earthworks-Earth retaining wall timbering method	Earthworks
248 (E248)Earthworks-Earth retaining wall timbering method	Earthworks
249 (E249)Earthworks-Earth retaining wall timbering method	Earthworks
250 (E250)Earthworks-Earth retaining wall timbering method	Earthworks
251 (E251)Earthworks-Earth retaining wall timbering method	Earthworks
252 (E252)Earthworks-Earth retaining wall timbering method	Earthworks

253 (E253)Earthworks-Earth anchor method	Earthworks
254 (E254)Earthworks-Island method	Earthworks
255 (E255)Earthworks-Parent pile horizontal sheet pile /Steel sheet pile/Continuous wall	Earthworks
256 (E256)Earthworks- Heaving destruction	Earthworks
257 (E257)Earthworks-Boiling destruction	Earthworks
325 (E325)Earthworks-Types of earthworks	Earthworks
326 (E326)Earthworks-Slope gradient	Earthworks
327 (E327)Earthworks-Slope gradient	Earthworks
328 (E328)Earthworks-Standard slope of embankment	Earthworks
329 (E329)Earthworks-Standard cutting slope	Earthworks
330 (E330)Earthworks-Earthwork ruler	Earthworks
331 (E331)Earthworks-Change in soil volume	Earthworks
332 (E332)Earthworks-Change in soil volume-Calculation of loosened soil volume	Earthworks
333 (E333)Earthworks-Change in soil volume-Calculation of compacted soil volume	Earthworks
334 (E334)Earthworks-Change in soil volume-Soil volume change rate	Earthworks
335 (E335)Earthworks-Change in soil volume-Soil volume conversion factor f	Earthworks
336 (E336)Earthworks-Land volume map (mass curve)-Earthwork planning	Earthworks
337 (E337)Earthworks-Land volume map (mass curve)-Embankment volume map -Cut and earth volume map	Earthworks
338 (E338)Earthworks-Land volume map (mass curve)-Characteristics of land mass map	Earthworks
339 (E339)Earthworks-Land volume map (mass curve)-Selection of earthmoving machinery	Earthworks
340 (E340)Earthworks-Earthmoving machinery-Work type - Appropriate machine	Earthworks
453 (E453)Dry Field reclamation	Earthworks
454 (E454)Dry Field reclamation	Earthworks
460 (E460)cutting	Earthworks
58 (E58)Embankment	Embankment
59 (E59)Embankment material	Embankment
60 (E60)Embankment material	Embankment
61 (E61)Suitability of embankment materials	Embankment
62 (E62)Embankment slope standard-Road embankment	Embankment
63 (E63)Embankment slope standard-Railway embankment	Embankment
64 (E64)Embankment slope standard-River embankment	Embankment
65 (E65)Embankment slope standard-Berm	Embankment
66 (E66)Embankment slope standard-Embankment materials are different	Embankment
67 (E67)Stability study of embankment slope	Embankment

68 (E68)Slope stability calculation	Embankment
69 (E69)Pore water pressure of embankment	Embankment
87 (E87)Embankment precautions-Walling embankment	Embankment
88 (E88)Embankment-structures and embankments	Embankment
89 (E89)Embankment -River embankment	Embankment
90 (E90)Embankment foundation ground	Embankment
91 (E91)Embankment foundation ground-Soft ground judgment	Embankment
92 (E92)Embankment foundation ground-Settlement calculation of soft ground	Embankment
93 (E93)Embankment foundation ground-Settlement calculation of soft ground	Embankment
94 (E94)Embankment foundation ground-Settlement time	Embankment
95 (E95)Embankment foundation ground-Soft ground stability calculation	Embankment
96 (E96)Embankment foundation ground-Soft ground treatment	Embankment
97 (E97)Embankment foundation ground-Soft ground treatment	Embankment
98 (E98)Embankment foundation ground- Slow construction method	Embankment
99 (E99)Embankment foundation ground-Sand mat construction method	Embankment
100 (E100)Embankment foundation ground-Loading bank method	Embankment
101 (E101)Embankment foundation ground-Preloading method	Embankment
102 (E102)Embankment foundation ground-Removal and replacement method	Embankment
103 (E103)Embankment foundation ground-Sand drain method	Embankment
104 (E104)Embankment foundation ground-Paper drain method	Embankment
105 (E105)Embankment foundation ground-Sand compaction pile construction method	Embankment
106 (E106)Embankment foundation ground-Vibro flotation method	Embankment
107 (E107)Embankment foundation ground- Quicklime pile construction method	Embankment
108 (E108)Improvement of soft subgrade-Blocking layer	Embankment
109 (E109)Improvement of soft subgrade-Stabilization method-Lime/quicklime	Embankment
110 (E110)Improvement of soft roadbed-Particle size adjustment method	Embankment
111 (E111)Improvement of soft roadbed-Bitumen stabilization method	Embankment
112 (E112)Improvement of soft roadbed-Cement stabilization treatment	Embankment
113 (E113)Improvement of soft roadbed-Lime stabilization work	Embankment
114 (E114)Improvement of soft roadbed-Improvement of loose sandy ground	Embankment
115 (E115)Improvement of poor roadbed-Improvement of cohesive soil	Embankment
155 (E155)Road embankment – compaction around structures	Embankment
156 (E156)Road embankment-Culvert embankment	Embankment
206 (E206)Embankment materials – compaction test	Embankment

207 (E207)Embankment materials – general properties	Embankment
208 (E208)Embankment construction on sloping ground	Embankment
209 (E209)Embankment construction of the connection part with the structure	Embankment
210 (E210)Embankment construction-Compaction machine	Embankment
211 (E211)Embankment construction-Sand mat method	Embankment
513 (E513)Environmental Quality Standards	Environmental Quality Standards
530 (E530)erosion control works	erosion control works
566 (E566)erosion control works	erosion control works
289 (E289)Earthmoving machinery-Excavating machine	Excavating machine
290 (E290)Earthmoving machinery-Excavating machine	Excavating machine
638 (E638)extra banking	extra banking
560 (E560)fan	fan
463 (E463)Farmland block	Farmland block
564 (E564)fault	fault
525 (E525)field permeability test	field permeability test
498 (E498)fill in (Backfilling)	fill in (Backfilling)
629 (E629)filling up	filling up
647 (E647)filter film	filter film
648 (E648)filter material	filter material
476 (E476)fixed ruler :finishing stake	fixed ruler :finishing stake
523 (E523)Flood Control	Flood Control
417 (E417)Structure excavation-flooring surface	flooring surface
642 (E642)flow net	flow net
630 (E630)follower	follower
558 (E558)formation level-railroad track	formation level-railroad track
584 (E584)foundation work	foundation work
639 (E639)freeboard	freeboard
567 (E567)geologic survey	geologic survey
475 (E475)geological column	geological column
568 (E568)Geological map	Geological map
474 (E474)geological profiile	geological profiile
484 (E484)geotextile-Embankment drainage reinforcement	geotextile
485 (E485)geotextile-Separation of different materials	geotextile
486 (E486)geotextile- Reinforcement of ground, roadbed, etc.	geotextile

487 (E487)geotextile- Preventing suction of earth and sand	geotextile
540 (E540)Gravity water	Gravity water
504 (E504)greenhouse gas	greenhouse gas
320 (E320)Earthmoving machinery-Ground improvement machine-Sand drain method	Ground improvement machine
321 (E321)Earthmoving machinery-Ground improvement machine-Sand compaction method	Ground improvement machine
322 (E322)Earthmoving machinery-Ground improvement machine-Vibroflotation method	Ground improvement machine
323 (E323)Earthmoving machinery-Ground improvement machine-Wellpont construction method	Ground improvement machine
324 (E324)Earthmoving machinery-Transport machinery-Bucket wheel excavator	Ground improvement machine
565 (E565)ground water level	ground water level
470 (E470)groundwater level	groundwater level
471 (E471)groundwater level	groundwater level
615 (E615)groyne net	groyne net
616 (E616)groyne wood	groyne wood
512 (E512)gully erosion	gully erosion
493 (E493)heaving	heaving
532 (E532)hillside covering works	hillside covering works
531 (E531)hillside works	hillside works
624 (E624)hydraulic filling method	hydraulic filling method
521 (E521)hydraulic radius	hydraulic radius
468 (E468)hydrological cycle	hydrological cycle
609 (E609)Impermeable layer	Impermeable layer
569 (E569)impregnation method	impregnation method
590 (E590)interflow	interflow
632 (E632)land reclamation in natural slope	land reclamation in natural slope
534 (E534)land slide	land slide
466 (E466)Landslide	Landslide
631 (E631)landslide	landslide
636 (E636)landslide control works	landslide control works
635 (E635)landslide restraining works	landslide restraining works
554 (E554)leaving concrete	leaving concrete
529 (E529)left bank right bank	left bank right bank
492 (E492)levee widening-Cross-sectional expansion of the existing levee (filling)	levee widening
626 (E626)leveling	leveling
500 (E500)liquefaction	liquefaction

291 (E291)Earthmoving machinery-loading machine-Crawler type tractor excavator	Loading machine
292 (E292)Earthmoving machinery-loading machine-Wheeled tractor excavator	Loading machine
293 (E293)Earthmoving machinery-loading machine-Loading method	Loading machine
294 (E294)Earthmoving machinery-loading machine-Loading method	Loading machine
295 (E295)Earthmoving machinery-loading machine-Loading method	Loading machine
296 (E296)Earthmoving machinery-loading machine-Loading method	Loading machine
297 (E297)Earthmoving machinery-transport machinery-Straight dozer	Loading machine
539 (E539)Longitudinal alignment	Longitudinal alignment
538 (E538)Longitudinal slope	Longitudinal slope
573 (E573)low water channel work	low water channel work
621 (E621)macadam	macadam
620 (E620)main levee	main levee
526 (E526)major bed	major bed
581 (E581)mass curve	mass curve
649 (E649)Mass curve	Mass curve
644 (E644)method of average end areas	method of average end areas
593 (E593)negative friction	negative friction
522 (E522)non overflow groyne:non-overflow water control	non overflow groyne
506 (E506)Open channel	Open channel
503 (E503)Open cut method	Open cut method
505 (E505)Open cutting method	Open cutting method
508 (E508)Over-compaction	Over-compaction
618 (E618)paddy field land	paddy field land
592 (E592)penetration	penetration
514 (E514)Pipeline	Pipeline
412 (E412)Structure excavation- Piping phenomenon	Piping phenomenon
543 (E543)planted slope protection:Vegetation engineering	planted slope protection
570 (E570)plastic deformation of soil	plastic deformation of soil
611 (E611)plate bearing test	plate bearing test
610 (E610)Preloading	Preloading
557 (E557)productive green tract of land	productive green tract of land
418 (E418)Structure excavation-Protection of flooring surface	Protection of flooring surface
419 (E419)Structure excavation-Protection of flooring surface	Protection of flooring surface
497 (E497)pumice stone (floating rock)	pumice stone (floating rock)

637 (E637)quarter crossing joint	quarter crossing joint
461 (E461)Quicksand phenomenon	Quicksand phenomenon
507 (E507)raising of embankment	raising of embankment
563 (E563)rammer	rammer
646 (E646)rate of filtration	rate of filtration
576 (E576)reconnaissance	reconnaissance
473 (E473)Replacement method	Replacement method
457 (E457)Anchor method	Retaingwall
634 (E634)retarding baisn	retarding baisn
462 (E462)ridge and ditch	ridge and ditch
527 (E527)rigid pavement	rigid pavement
645 (E645)rill erosion	rill erosion
509 (E509)River channel	River channel
572 (E572)riverside land-land side	riverside land-land side
578 (E578)roadway diagraph	roadway diagraph
553 (E553)Scoop	Scoop
603 (E603)secondary levee	secondary levee
574 (E574)section of levee	section of levee
580 (E580)sediment settling	sediment settling
544 (E544)seepage line:Infiltration line	seepage line
499 (E499)Sensitivity ratio	Sensitivity ratio
571 (E571)shaft sinking	shaft sinking
511 (E511)Shallow sump	Shallow sump
495 (E495)shallow well	shallow well
586 (E586)sheathing work	sheathing work
494 (E494)sheet erosion	sheet erosion
628 (E628)shoulder sodding	shoulder sodding
555 (E555)sliding surface	sliding surface
536 (E536)slope distance	slope distance
467 (E467)Slope failure	Slope failure
537 (E537)slope failure	slope failure
597 (E597)slope pile	slope pile
365 (E365)Slope protection-Embankment slope	Slope protection
366 (E366)Slope protection-Embankment slope-Vegetation work (embankment)	Slope protection

367 (E367)Slope protection-Embankment slope-Vegetation work (embankment)	Slope protection
368 (E368)Slope protection-Embankment slope-Vegetation work (embankment)	Slope protection
369 (E369)Slope protection-Cut and embankment slope	Slope protection
370 (E370)Slope protection-Concrete block construction	Slope protection
371 (E371)Slope protection-Concrete block masonry	Slope protection
414 (E414)Structure excavation-Slope protection	Slope protection
598 (E598)slope protection	slope protection
123 (E123)Slope protection work	Slope protection
124 (E124)Slope protection work-Types of vegetation works	Slope protection
125 (E125)Slope protection work-Seed spraying	Slope protection
126 (E126)Slope protection work-Seed spraying	Slope protection
127 (E127)Slope protection work-Seed spraying	Slope protection
128 (E128)Slope protection work-vegetation mat	Slope protection
129 (E129)Slope protection work-Vegetation board work, vegetation bag work	Slope protection
130 (E130)Slope protection work-vegetation seeds	Slope protection
131 (E131)Slope protection work-Points to note regarding vegetation work	Slope protection
132 (E132)Slope protection work-Mortar concrete spraying work	Slope protection
133 (E133)Slope protection work-Stone masonry	Slope protection
134 (E134)Slope protection work-Block pitching	Slope protection
135 (E135)Slope protection work-Concrete lining	Slope protection
136 (E136)Slope protection work-Concrete block slope protection by mold	Slope protection
137 (E137)Slope protection work-On-site construction work	Slope protection
138 (E138)Slope protection work-Masonry work	Slope protection
139 (E139)Slope protection work-Block construction	Slope protection
140 (E140)Slope protection work-Plain concrete retaining retaining wall	Slope protection
141 (E141)Slope protection work-Reinforced concrete retaining wall construction	Slope protection
142 (E142)Slope protection work-Reinforcement earthworks	Slope protection
143 (E143)Slope protection work-retaining wall work	Slope protection
144 (E144)Slope protection work-Editing shelving	Slope protection
145 (E145)Slope protection work-Slope gabion work	Slope protection
146 (E146)Slope protection work-Rockfall prevention mesh/fencing	Slope protection
147 (E147)Slope protection work-Vegetation work・protection of structures	Slope protection
221 (E221)Slope protection work-Vegetation work	Slope protection work
222 (E222)Slope protection work-Vegetation work	Slope protection work

604 (E604)sluice	sluice
190 (E190)Earthworks-Slow construction method	Soft ground
191 (E191)Earthworks-Sand mat method	Soft ground
192 (E192)Earthworks-Pressure embankment method	Soft ground
193 (E193)Earthworks-Preloading method	Soft ground
194 (E194)Earthworks-Removal and replacement method	Soft ground
195 (E195)Earthworks-Sand drain method	Soft ground
196 (E196)Earthworks-Sand compaction pile method (vibrocomposer method)	Soft ground
197 (E197)Earthworks-Vibroflotation method	Soft ground
274 (E274)Earthwork construction plan-Slope of foundation ground to prevent embankment from sliding	soft ground
275 (E275)Earthwork construction plan-How to treat soft ground-Pressure embankment method	soft ground
276 (E276)Earthwork construction plan-How to treat soft ground-Replacement method	soft ground
277 (E277)Earthwork construction plan-How to treat soft ground- Slow construction method	soft ground
278 (E278)Earthwork construction plan-How to treat soft ground- Countermeasures against settlement-Loading method	soft ground
279 (E279)Earthwork construction plan-How to treat soft ground- Countermeasures against settlement-Sand drain method	soft ground
280 (E280)Earthwork construction plan-How to treat soft ground- Slip and subsidence measures-Sand compaction method	soft ground
281 (E281)Earthwork construction plan-How to treat soft ground- Earthquake countermeasures (liquefaction prevention)	soft ground
455 (E455)Liquefaction	Soil
458 (E458)Consolidation	Soil
10 (E10)Soil classification	Soil classification
11 (E11)Japanese unified classification	Soil classification
12 (E12)Soil classification	Soil classification
13 (E13)Soil classification	Soil classification
157 (E157)Soil classification-Name of soil particles based on particle size	Soil classification
158 (E158)Soil classification-Particle size test - Particle size accumulation curve	Soil classification
159 (E159)Soil classification- Uniformity coefficient and curvature curve	Soil classification
160 (E160)Soil classification- Particle size accumulation curve	Soil classification
161 (E161)Soil classification- Triangular coordinates	Soil classification
162 (E162)Soil classification- Consistency limit and relationship between water content and volume change	Soil classification
163 (E163)Soil classification- Plasticity index and plasticity diagram (Japan unified soil classification method)	Soil classification
214 (E214)Liquid limit and plastic limit	Soil classification
583 (E583)soil profile	soil profile
19 (E19)Soil sampling method-Cutter method	Soil sampling
20 (E20)Soil sampling method-How to take out as a lump of soil	Soil sampling

21 (E21)Sounding-boring survey	Soil sampling
22 (E22)Standard penetration test	Soil sampling
23 (E23)Swedish sounding	Soil sampling
24 (E24)Cone penetration test	Soil sampling
25 (E25)Vane test	Soil sampling
26 (E26)Plate loading test	Soil sampling
27 (E27)Sampling-Bowling	Soil sampling
28 (E28)Sampling-Bowling-hand auger boring	Soil sampling
29 (E29)Sampling-Bowling-Rotary boring	Soil sampling
30 (E30)Sampling-Bowling-Thin wall sampler	Soil sampling
478 (E478)Soil stabilization treatment-Runways, roads, etc.-Improvement of roadbed and roadbed	Soil stabilization treatment
479 (E479)Soil stabilization treatment-By on-road mixing method-Simple paving of farm roads, parking lots, etc.	Soil stabilization treatment
480 (E480)Soil stabilization treatment-Temporary road for construction-pavement	Soil stabilization treatment
481 (E481)Soil stabilization treatment-Sliding failure of embankment	Soil stabilization treatment
482 (E482)Soil stabilization treatment-Building foundation ground improvement	Soil stabilization treatment
483 (E483)Soil stabilization treatment-Underground dam wall	Soil stabilization treatment
488 (E488)soil structure	soil structure
489 (E489)soil structure-Bonding of soil particles	soil structure
1 (E1)Earthwork-①Soil survey	Soil survey
5 (E5)Soil survey points to note	Soil survey
6 (E6)Soil survey procedure-Preliminary survey	Soil survey
7 (E7)Soil survey procedure-Field reconnaissance	Soil survey
8 (E8)Soil survey procedure-Main survey	Soil survey
9 (E9)Soil survey method	Soil survey
50 (E50)Use of soil survey results-Ripper work	Soil survey
51 (E51)Use of soil survey results-Trafficability of construction machinery	Soil survey
52 (E52)Use of soil survey results-Judgment of supporting ground	Soil survey
53 (E53)Use of soil survey results-Safety factor against sliding failure of embankment	Soil survey
54 (E54)Use of soil survey results-Earth pressure calculation	Soil survey
55 (E55)Use of soil survey results-Calculation of embankment height limit on soft ground	Soil survey
56 (E56)Use of soil survey results-Settlement amount of clay layer	Soil survey
57 (E57)Use of soil survey results-Compaction of embankment	Soil survey
14 (E14)In situ test	Soil test
15 (E15)Seismic exploration	Soil test

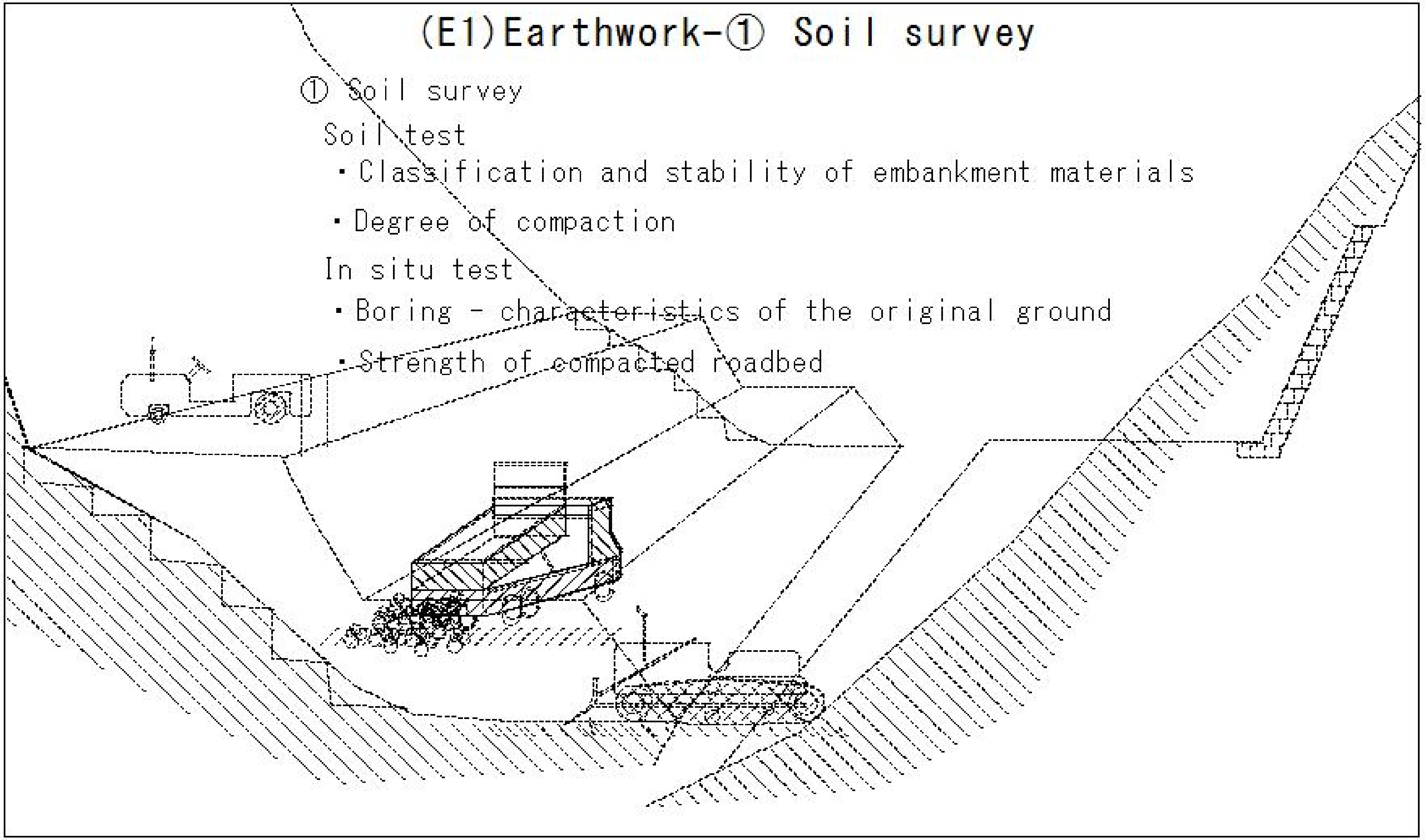
16 (E16)Electric prospecting	Soil test
17 (E17)Unit volume mass test	Soil test
18 (E18)Soil sampling method-Sand replacement method	Soil test
31 (E31)Soil test-Water content test	Soil test
32 (E32)Soil test-Unit volume mass test	Soil test
33 (E33)Soil test-Soil particle density test	Soil test
34 (E34)Soil test-Relative density test	Soil test
35 (E35)Soil test-Particle size test	Soil test
36 (E36)Soil test-Consistency test	Soil test
37 (E37)Soil test-Consistency test	Soil test
38 (E38)Testing of soil mechanical properties-Permeability test	Soil test
39 (E39)Field test-Constant level permeability test	Soil test
40 (E40)Field test-Alternating water level permeability test	Soil test
41 (E41)Direct shear test	Soil test
42 (E42)Uniaxial compression test	Soil test
43 (E43)Triaxial compression test	Soil test
44 (E44)Consolidation test	Soil test
45 (E45)Compaction test	Soil test
46 (E46)Zero void curve: ρdsat - compaction curve	Soil test
47 (E47)CBR test On-site CBR	Soil test
48 (E48)CBR test-Design CBR	Soil test
49 (E49)Modified CBR	Soil test
596 (E596)spread foundation	spread foundation
622 (E622)spreading	spreading
623 (E623)spreading depth	spreading depth
547 (E547)Stage:water gauge	Stage:water gauge
390 (E390)Structure excavation-Direct foundation-Normal ground	Structure excavation
391 (E391)Structure excavation-Direct foundation-Bedrock	Structure excavation
392 (E392)Structure excavation-Slope open cut	Structure excavation
393 (E393)Structure excavation-Sheet pile + Timbering Slope open cut method	Structure excavation
394 (E394)Structure excavation-Sheet pile + Timbering	Structure excavation
395 (E395)Structure excavation-Sheet pile + Timbering-Slope open cut method	Structure excavation
396 (E396)Structure excavation-Sheet pile + Timbering-open cut method	Structure excavation
397 (E397)Structure excavation-Points to note during planning structural excavation	Structure excavation

398 (E398)Structure excavation-Points to note during planning structural excavation	Structure excavation
399 (E399)Structure excavation-Points to note During construction	Structure excavation
400 (E400)Structure excavation-Structure-Supporting ground	Structure excavation
401 (E401)Structure excavation-Structure - Excavation slope gradient- Soil quality	Structure excavation
402 (E402)Structure excavation-Structure - Excavation slope gradient- Soil quality	Structure excavation
403 (E403)Structure excavation-Structure - Excavation slope gradient- Soil quality	Structure excavation
404 (E404)Structure excavation-Structure - Excavation slope gradient- Soil quality	Structure excavation
405 (E405)Structure excavation-Slope open cut method	Structure excavation
406 (E406)Structure excavation-Structures - Excavation machine selection	Structure excavation
407 (E407)Structure excavation- Slope protection work	Structure excavation
408 (E408)Structure excavation-Structures - Excavation machine selection-Points to note during excavating	Structure excavation
409 (E409)Structure excavation-Structures - Excavation machine selection-Points to note during excavating	Structure excavation
410 (E410)Structure excavation-Structures - Excavation machine selection-Points to note during excavating	Structure excavation
421 (E421)Structure excavation-Permanent slope	Structure excavation
422 (E422)Structure excavation- Groundwater investigation	Structure excavation
423 (E423)Structure excavation- Construction period	Structure excavation
424 (E424)Structure excavation-Groundwater investigation-Drainage method plan	Structure excavation
425 (E425)Structure excavation-Groundwater investigation	Structure excavation
426 (E426)Structure excavation-Groundwater level decline depending on season and time	Structure excavation
427 (E427)Structure excavation-Groundwater recharge source/influence area	Structure excavation
428 (E428)Structure excavation-Calculation of groundwater decline and spring water amount	Structure excavation
429 (E429)Structure excavation- Measure the impact of groundwater decline on the surrounding area	Structure excavation
430 (E430)Structure excavation- Place of installation of drainage equipment Wastewater treatment	Structure excavation
431 (E431)Structure excavation-Drainage method	Structure excavation
432 (E432)Structure excavation-How to check soil bearing capacity	Structure excavation
433 (E433)Structure excavation- Replacement of defective soil	Structure excavation
434 (E434)Structure excavation- Change basic shape of foundation	Structure excavation
435 (E435)Structure excavation- Change to pile foundation	Structure excavation
436 (E436)Structure excavation- cobble stone construction method	Structure excavation
437 (E437)Structure excavation-Leveled concrete (t=100mm)	Structure excavation
438 (E438)Structure excavation-Check points for foundation bottom surface treatment	Structure excavation
439 (E439)Structure excavation-Backfill structure of embankment abutment	Structure excavation
440 (E440)Structure excavation-Backfill structure of cut section abutment	Structure excavation
517 (E517)strut	strut

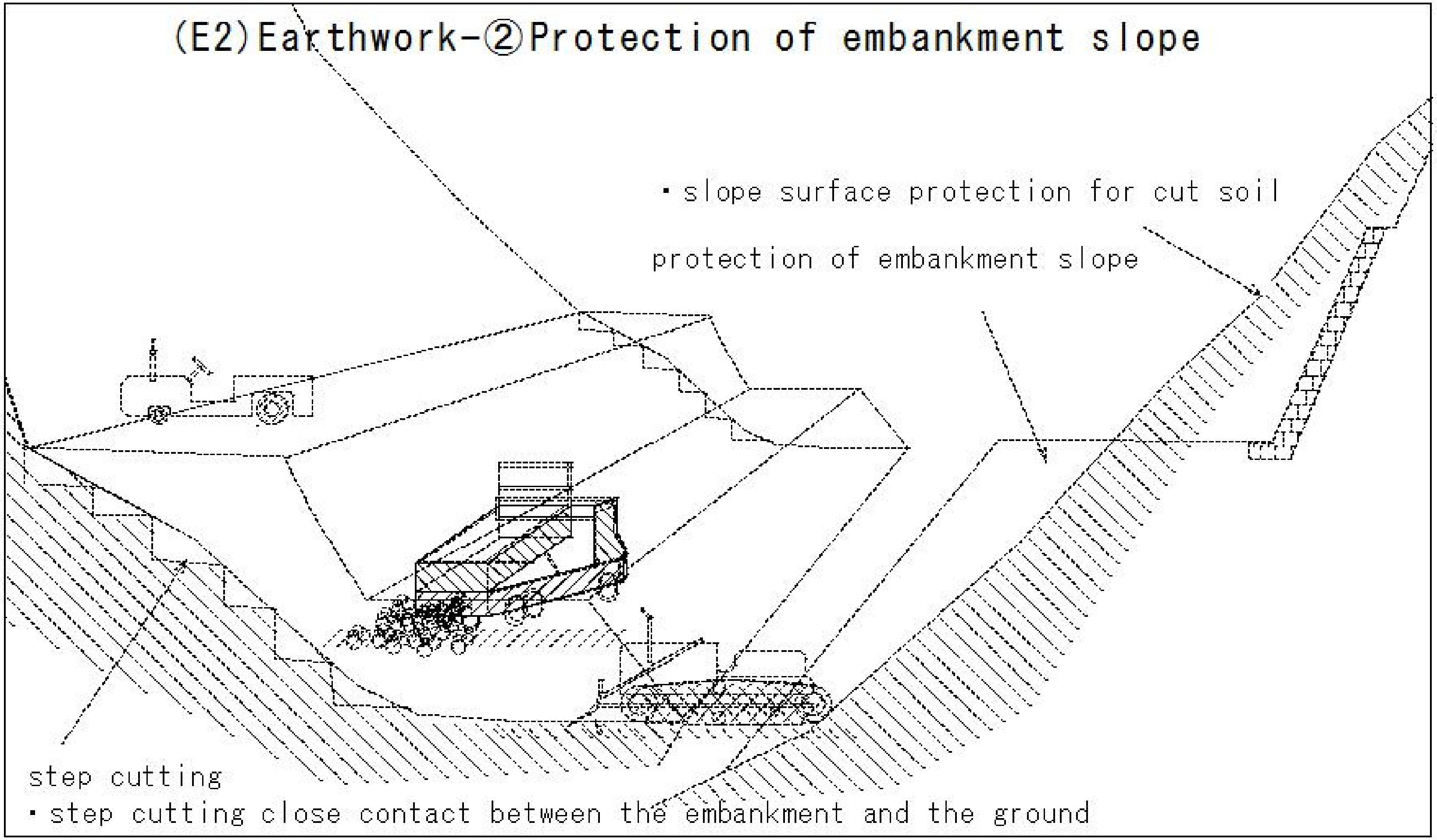
490 (E490)subsoil improvement	subsoil improvement
502 (E502)surcharge process:Pressing embankment method	surcharge process
533 (E533)test pit	test pit
641 (E641)thalweg	thalweg
585 (E585)Trafficability	Trafficability
298 (E298)Earthmoving machinery-transport machinery-Angle dozer	Transport machinery
299 (E299)Earthmoving machinery-transport machinery-Tilt dozer	Transport machinery
300 (E300)Earthmoving machinery-transport machinery-U dozer	Transport machinery
301 (E301)Earthmoving machinery-transport machinery-Rake dozer	Transport machinery
302 (E302)Earthmoving machinery-transport machinery-Tridozer	Transport machinery
303 (E303)Earthmoving machinery-transport machinery-Bucket dozer	Transport machinery
304 (E304)Earthmoving machinery-transport machinery-Bucket dozer	Transport machinery
305 (E305)Earthmoving machinery-transport machinery-Installation pressure	Transport machinery
306 (E306)Earthmoving machinery-transport machinery-Scraper	Transport machinery
307 (E307)Earthmoving machinery-transport machinery-Scraper-Work procedure	Transport machinery
308 (E308)Earthmoving machinery-transport machinery-Scraper-Type of scraper	Transport machinery
309 (E309)Earthmoving machinery-transport machinery-Motor grader	Transport machinery
627 (E627)trench dozing	trench dozing
587 (E587)trench cut method	trench cut method
591 (E591)trench excavation	trench excavation
640 (E640)turbulent flow	turbulent flow
561 (E561)undecurrent	undecurrent
472 (E472)underground dam	underground dam
552 (E552)undermining	undermining
516 (E516)unscreened gravel	unscreened gravel
541 (E541)vadose water:Circulating water	vadose water
518 (E518)walling	walling
416 (E416)Structure excavation-wastewater treatment	wastewater treatment
625 (E625)water bound macadam	water bound macadam
643 (E643)water course	water course
549 (E549)water erosion control	water erosion control
548 (E548)water pollution	water pollution
595 (E595)wet masonry	wet masonry
594 (E594)wheel barrow	wheel barrow

605 (E605)wind erosion control	wind erosion control
606 (E606)wind erosion farm	wind erosion farm
617 (E617)windbreak	windbreak
559 (E559)zero air voids curve	zero air voids curve

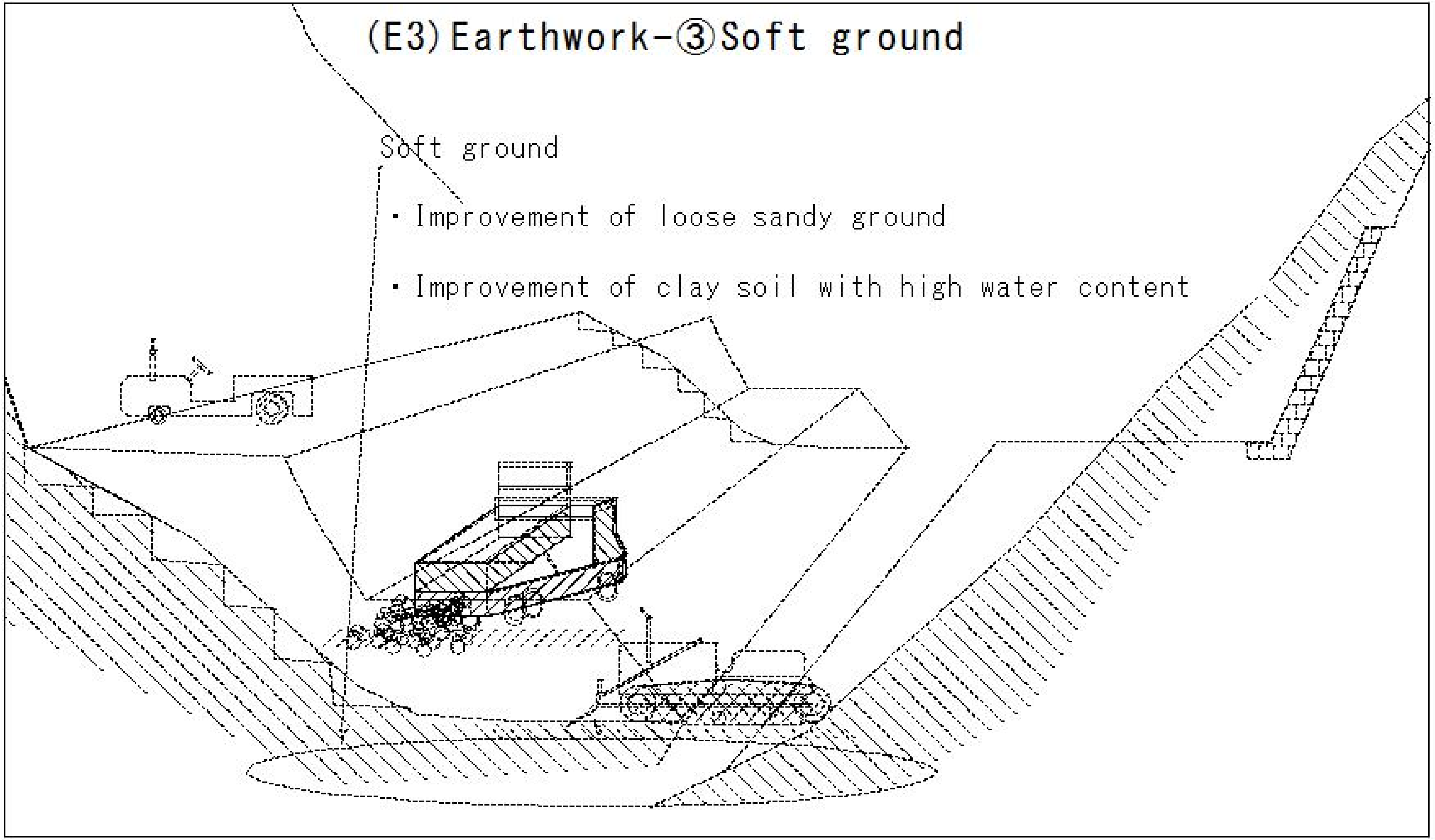
(E1)Earthwork-① Soil survey



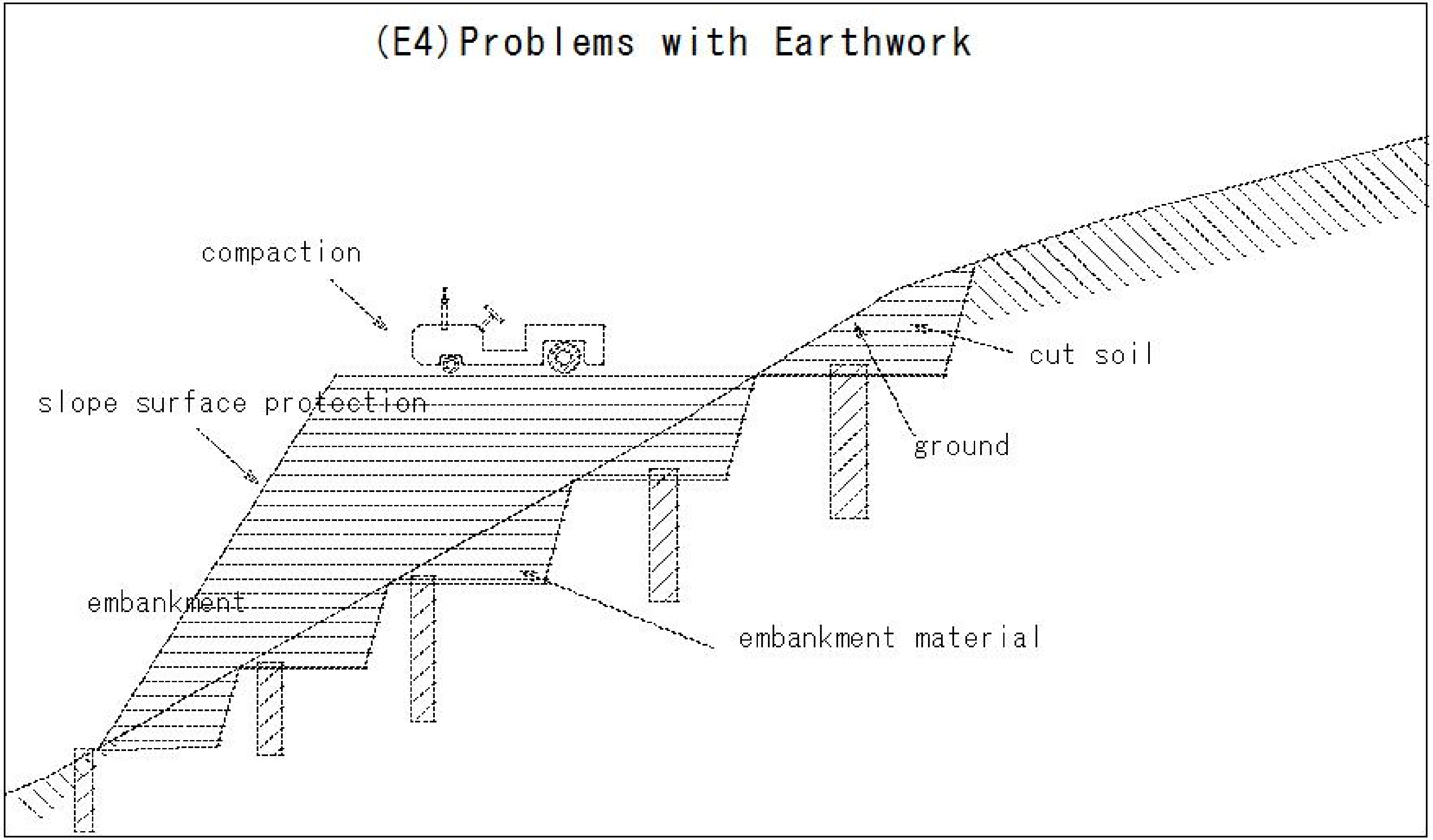
(E2)Earthwork-②Protection of embankment slope



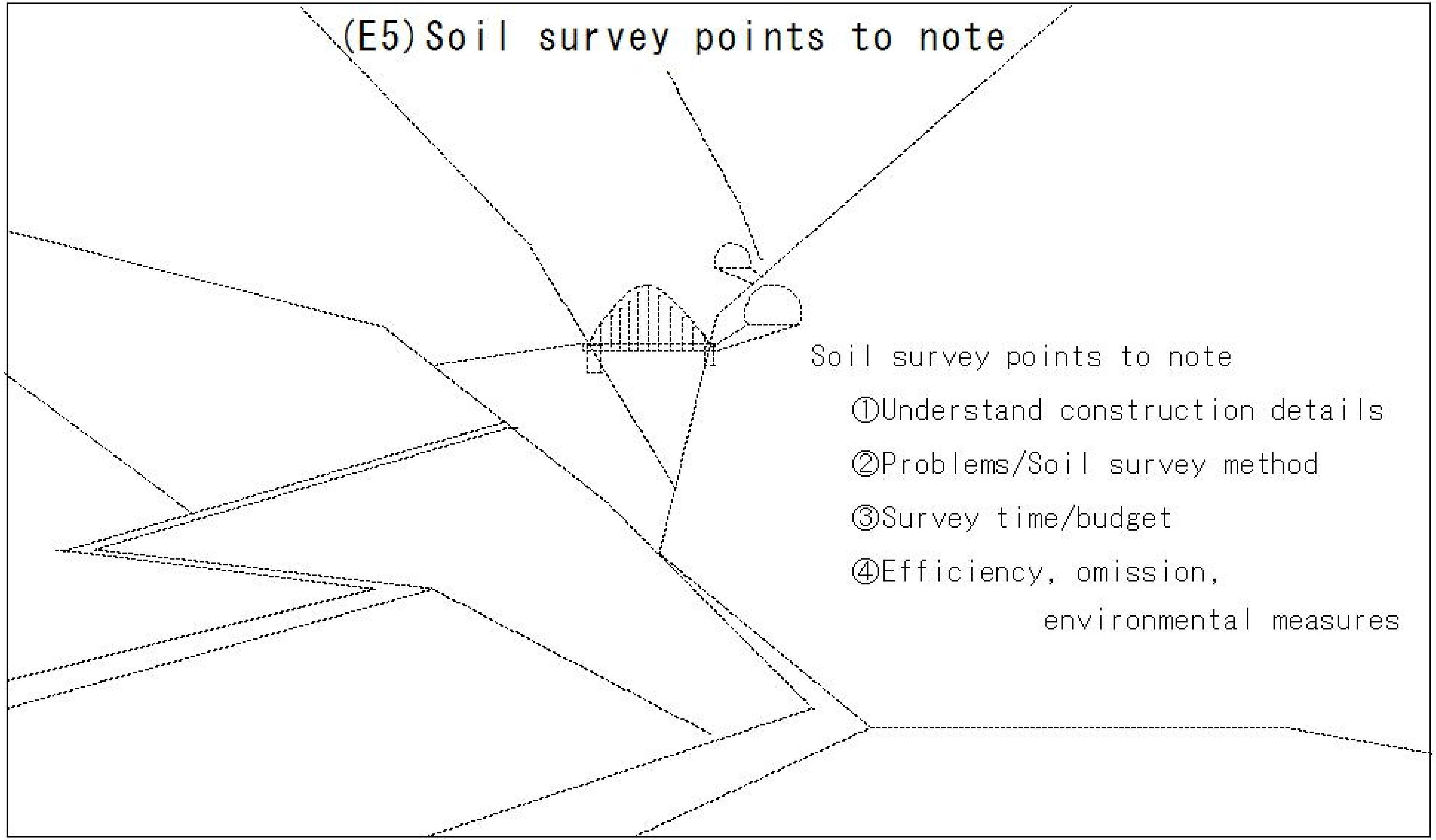
(E3)Earthwork-③Soft ground



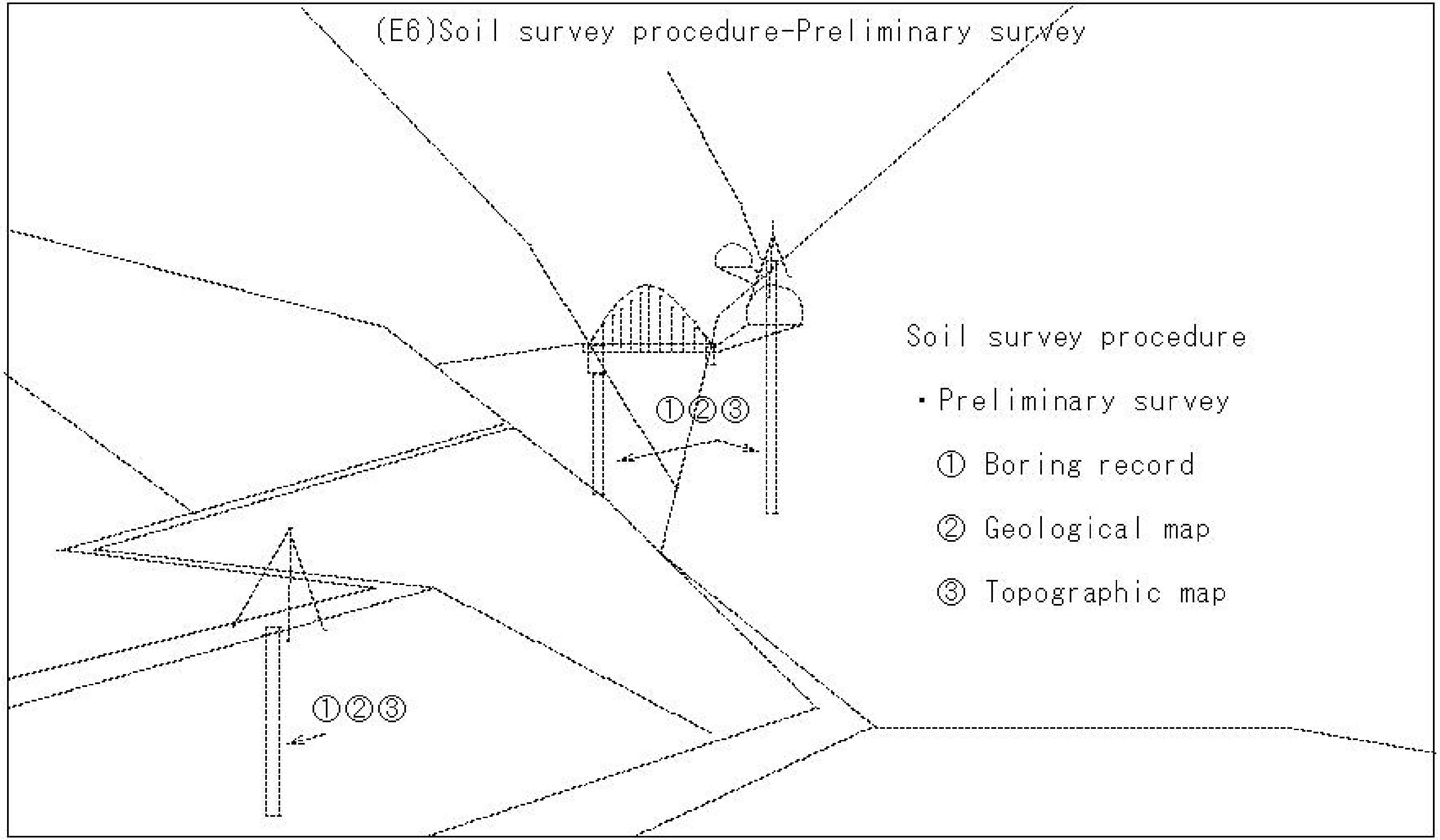
(E4)Problems with Earthwork



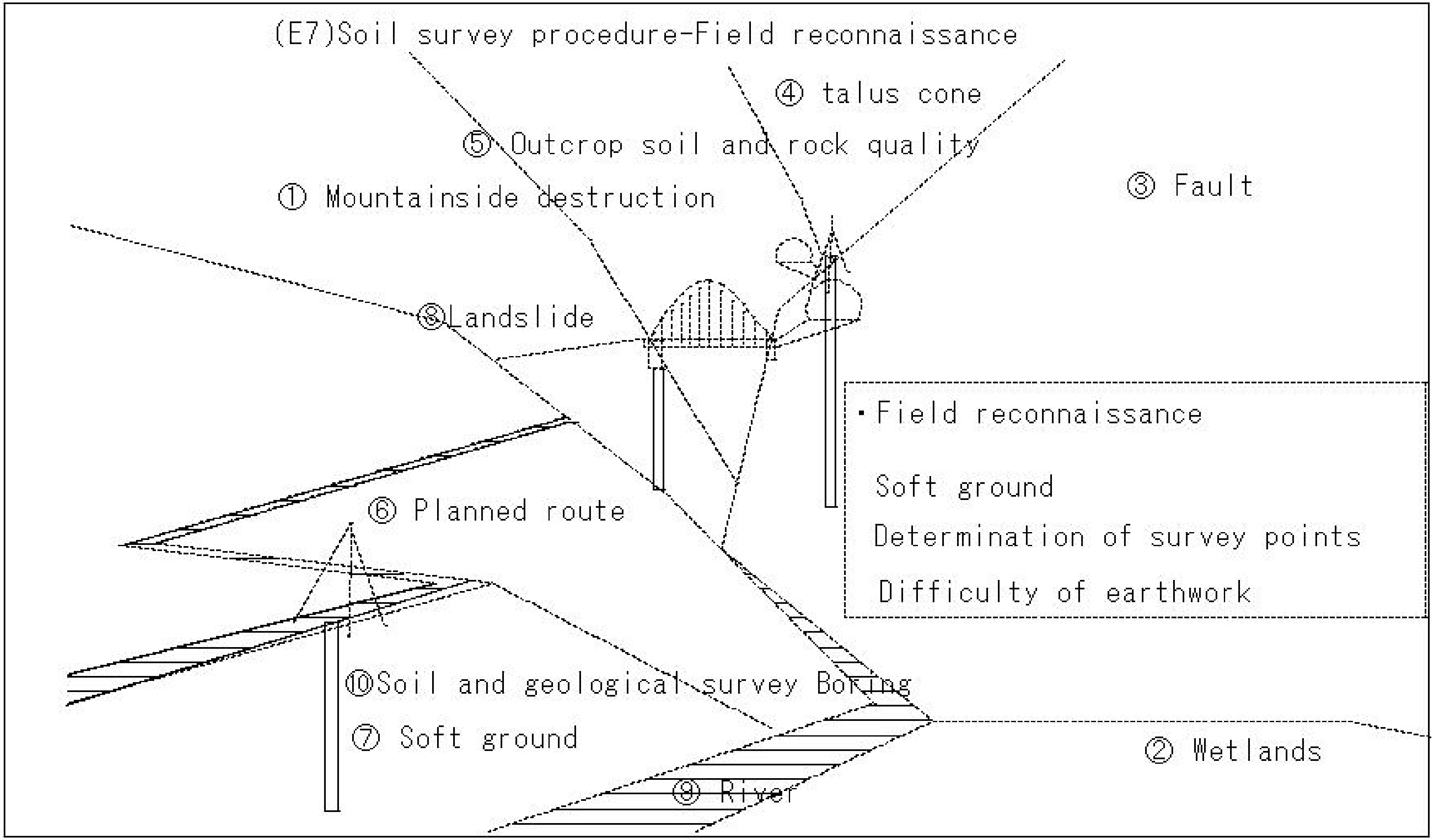
(E5)Soil survey points to note



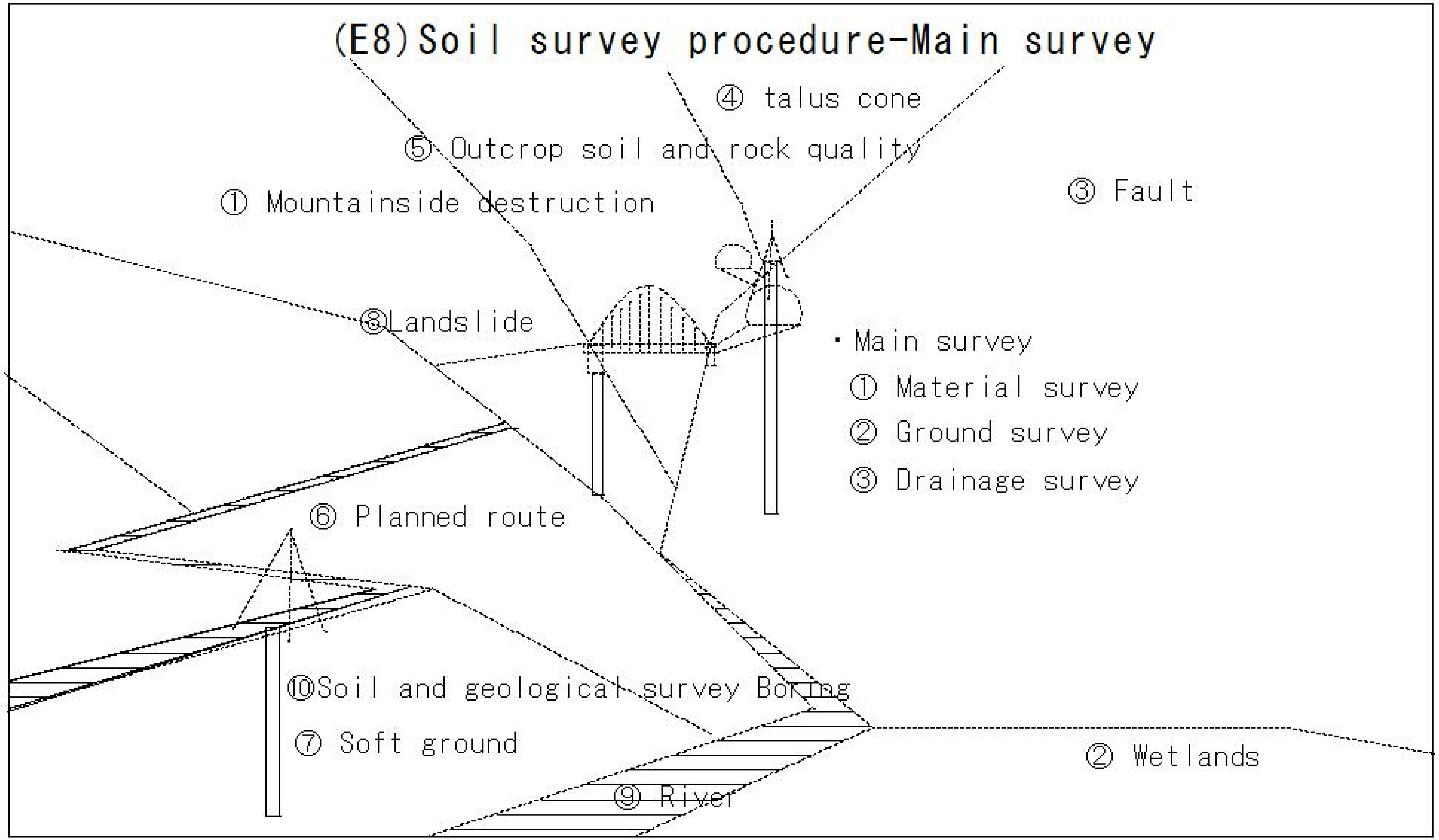
(E6)Soil survey procedure-Preliminary survey



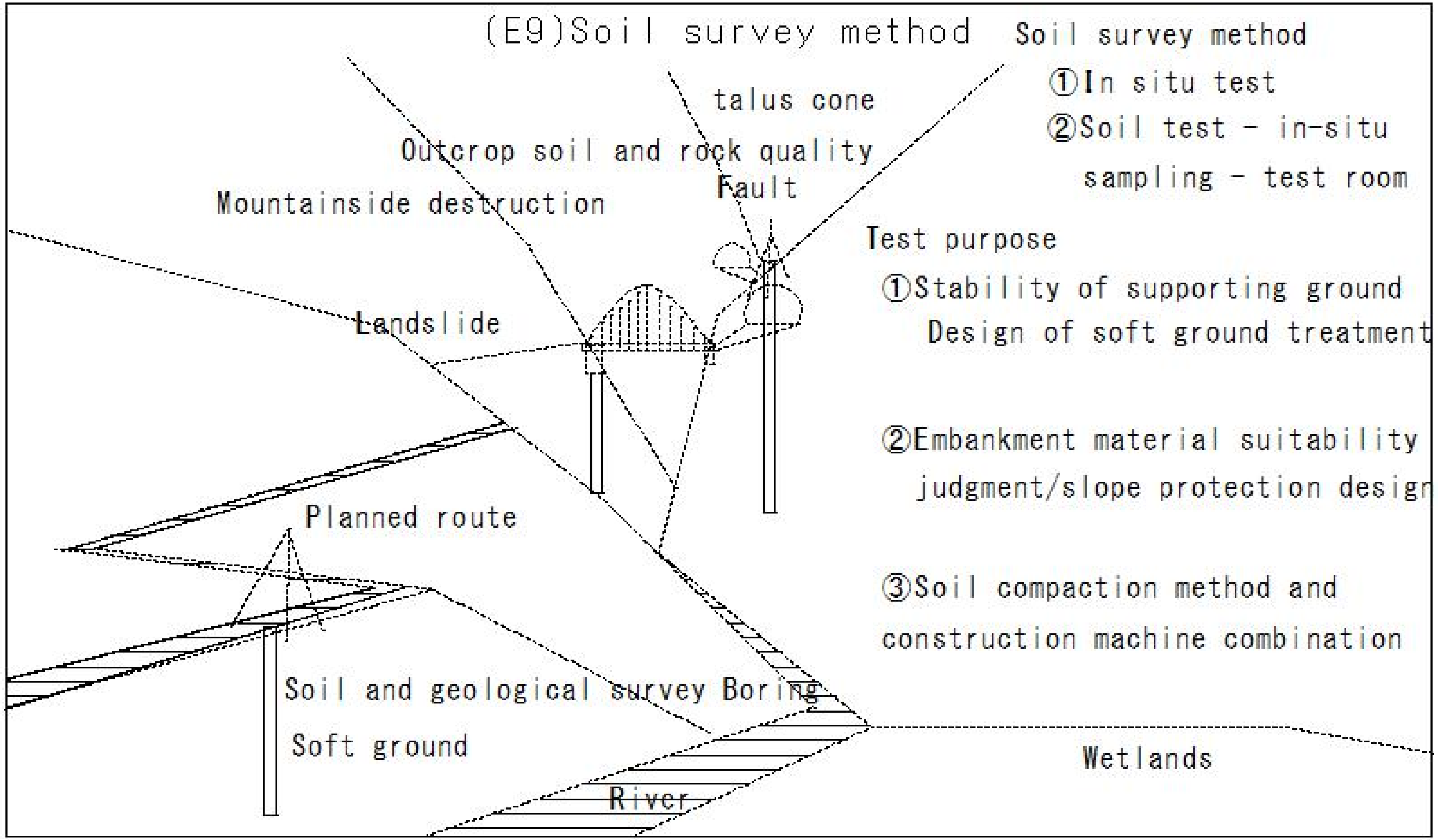
(E7)Soil survey procedure-Field reconnaissance



(E8)Soil survey procedure-Main survey

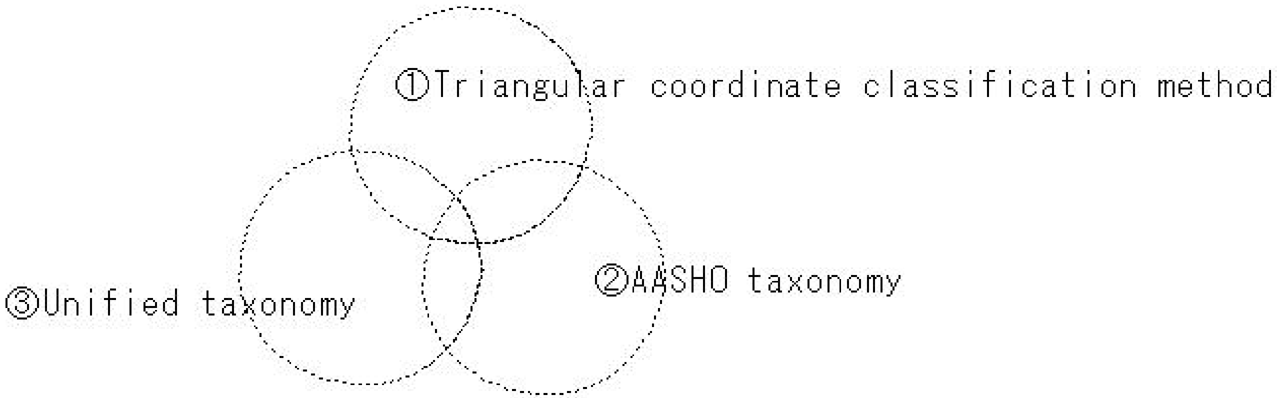


(E9)Soil survey method

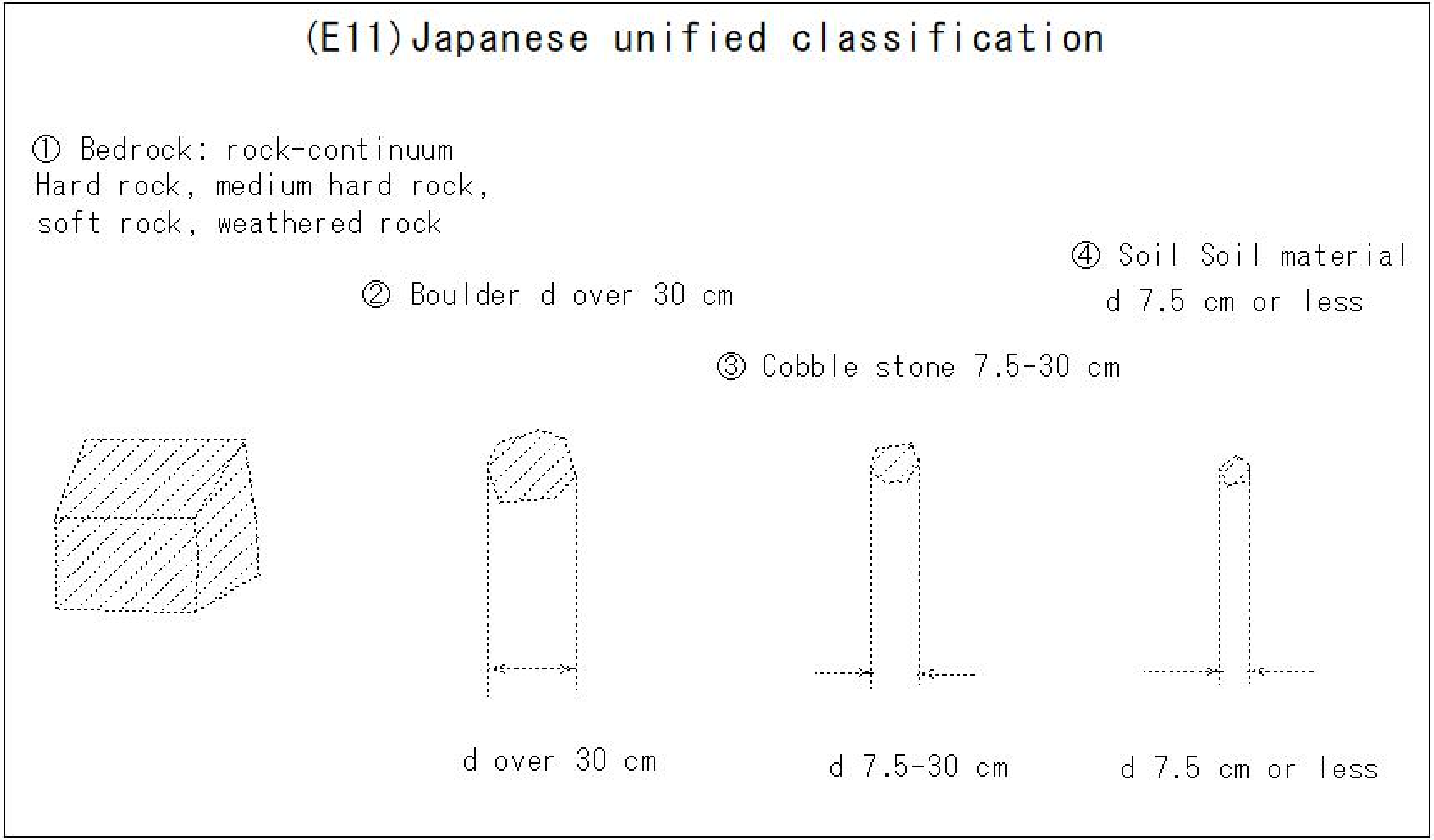


(E10)Soil classification

(E10)Soil classification



(E11)Japanese unified classification



(E12)Soil classification

(E12)Soil classification

		Grained soil (G)	Gravel (G)
	coarse soil		Gravel soil (GF)
		Sand grain soil (S)	Sand (S)
			Sandy soil (SF)
	Fine soil (F)		Silt (M)
soil material			Clay (C)
			Organic soil (O)
			Volcanic cohesive soil(V)
	High organic soil (Pt)		Peat (Pt)
			Black mud (Mk)
			Waste (W)

(E13)Soil classification

(E13)Soil classification

Soil classification

Notation additions

①Granularity - good W example: Sand with good granularity (SW)

②Grain size - bad P example: Sand with bad grain size (SP)

③Mixed gravel Example: Clay mixed with gravel (Cg)

④Soil with a proper name is also included in the classification

crushed stone (G)

Kanto Loam(V)

Sirasu(S)

decomposed granite soil (SF)

(E14)In situ test

(E14)In situ test

In situ test

①Electric prospecting

Knowing the distribution of rocks and soil and formulating excavation plans

②Unit volume mass test

Construction management of compaction

③Standard penetration test

Finding soft ground and finding the bearing capacity of the ground

④Swedish sounding

Soil hardness and degree of compaction

⑤Cone penetration test

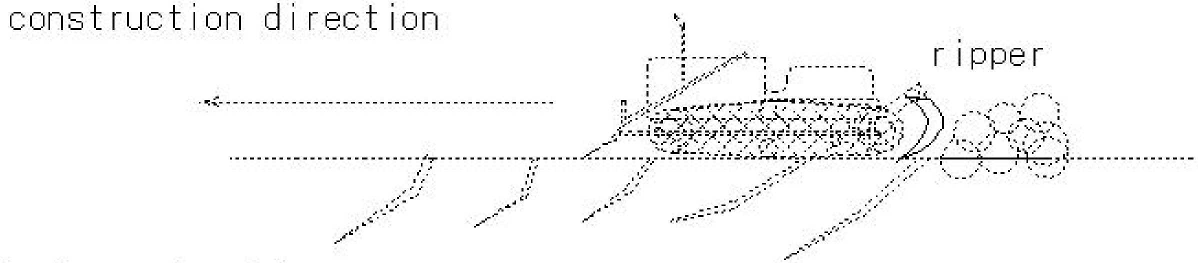
Materials for selecting construction machinery

⑥Plate loading test

Obtain bearing capacity by compacting the embankment

(E15)Seismic exploration

(E15)Seismic exploration



Seismic exploration

① Elastic wave velocity - fast - hard rock

② Elastic wave velocity - slow - soft rock

③ Elastic wave over 2500m/sec

④ Blasting - ripper work

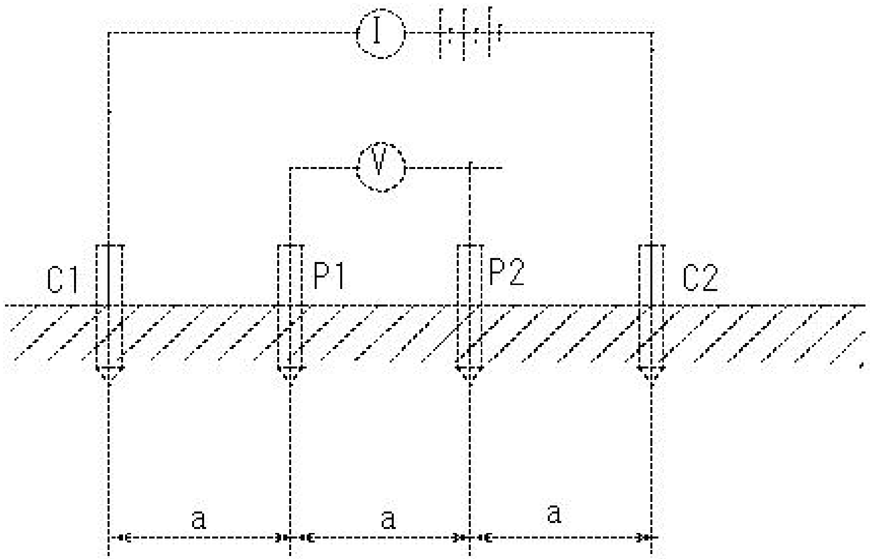
⑤ Digging capacity - rippability (weight of bulldozer), number of claws

⑥ Rock crack - right angle downward slope

(E16)Electric prospecting

(E16)Electric prospecting

Electric prospecting



①Electrical resistance of the ground

water-retentive ground resistance ratio - difference -

Groundwater status confirmation

(E17)Unit volume mass test

(E17)Unit volume mass test

Unit volume mass test

①Base/embankment Determine the mass per unit volume

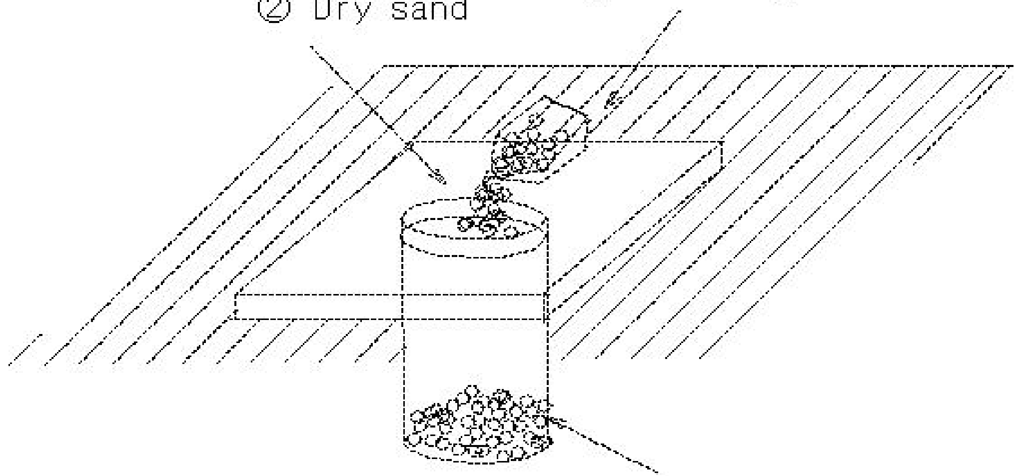
②Optimal water content ratio

③Wet density/dry density

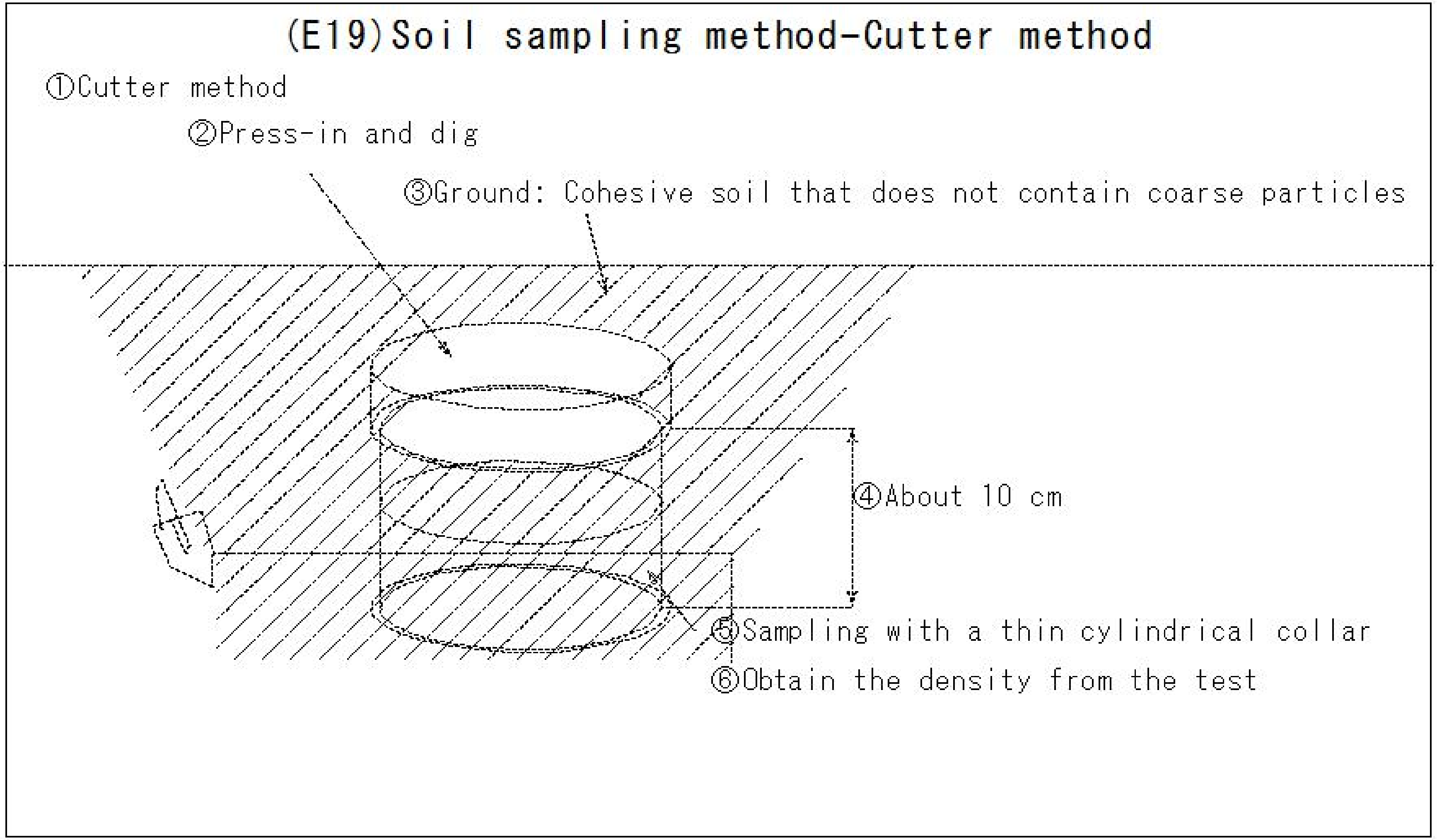
(E18)Soil sampling method-Sand replacement method

(E18)Soil sampling method-Sand replacement method

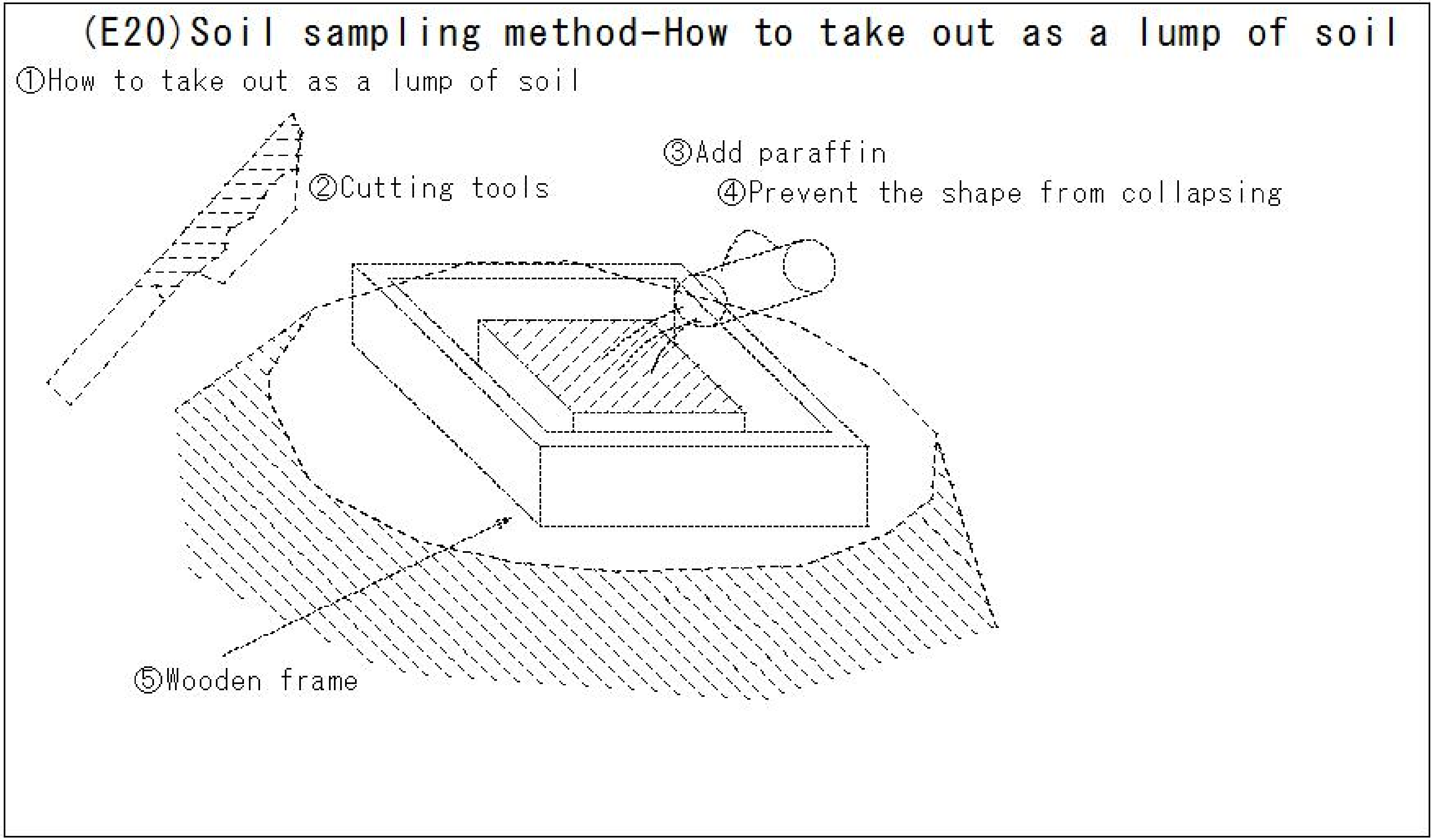
① Sand replacement method



(E19)Soil sampling method-Cutter method



(E20)Soil sampling method-How to take out as a lump of soil



(E21)Sounding-boring survey

(E21)Sounding-boring survey

Sounding

Boring survey

In situ test

①Standard penetration test

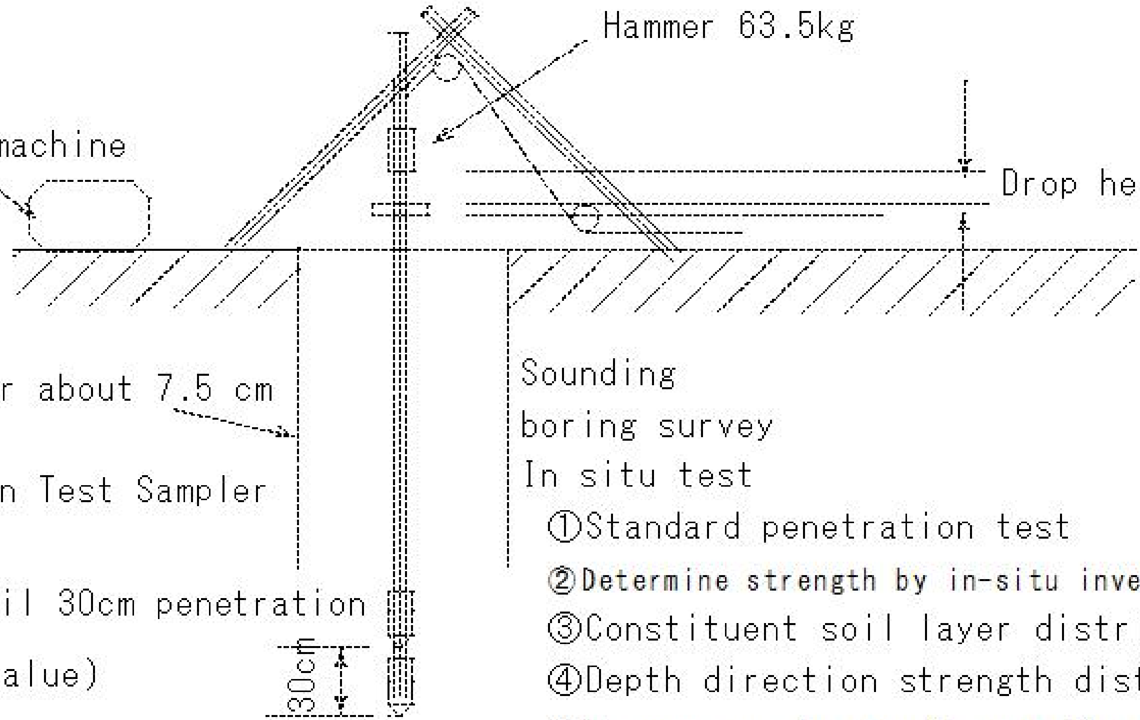
②Swedish sounding

③Cone penetration test

④Vane test

(E22)Standard penetration test

(E22)Standard penetration test

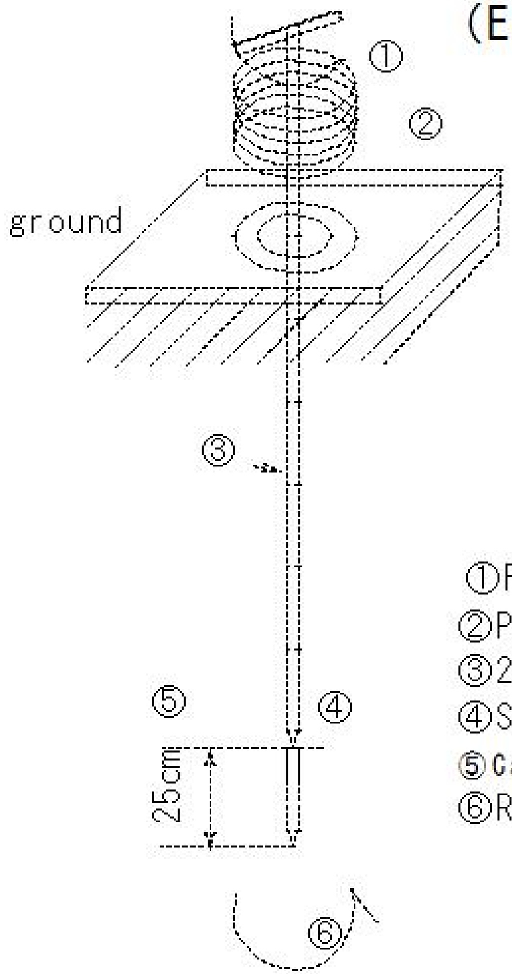


Sounding
boring survey
In situ test

①Standard penetration test
②Determine strength by in-situ investigation
③Constituent soil layer distribution
④Depth direction strength distribution
⑤Presence or absence of supporting ground
⑥Can be used with bowling
⑦N value - Soil consistency (softness) and compressive strength determined

(E23)Swedish sounding

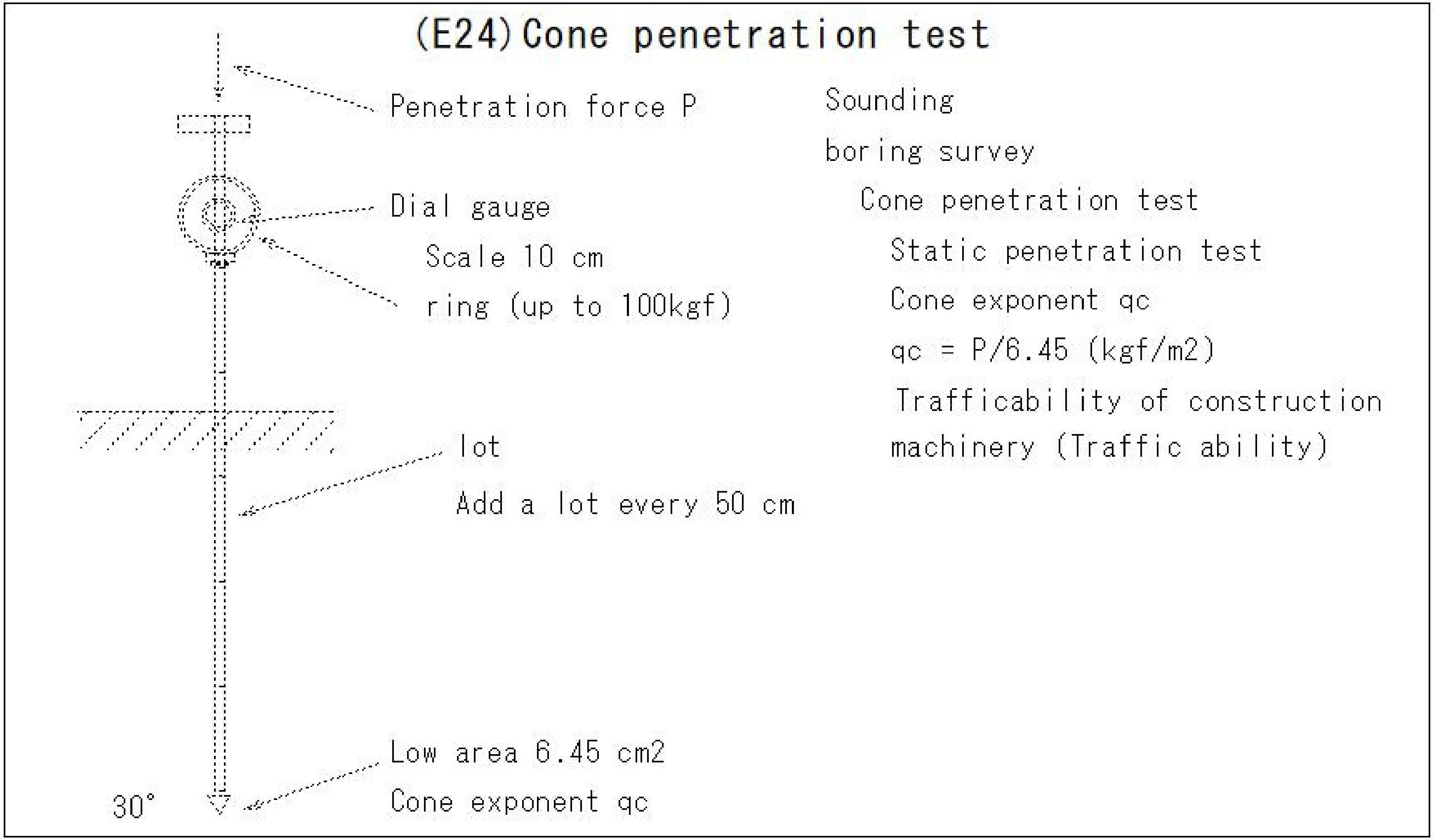
(E23) Swedish sounding



Sounding
boring survey
In situ test
Swedish sounding
- Large area soil survey
- Ns: Determine the bearing capacity of the ground and the degree of compaction of the soil

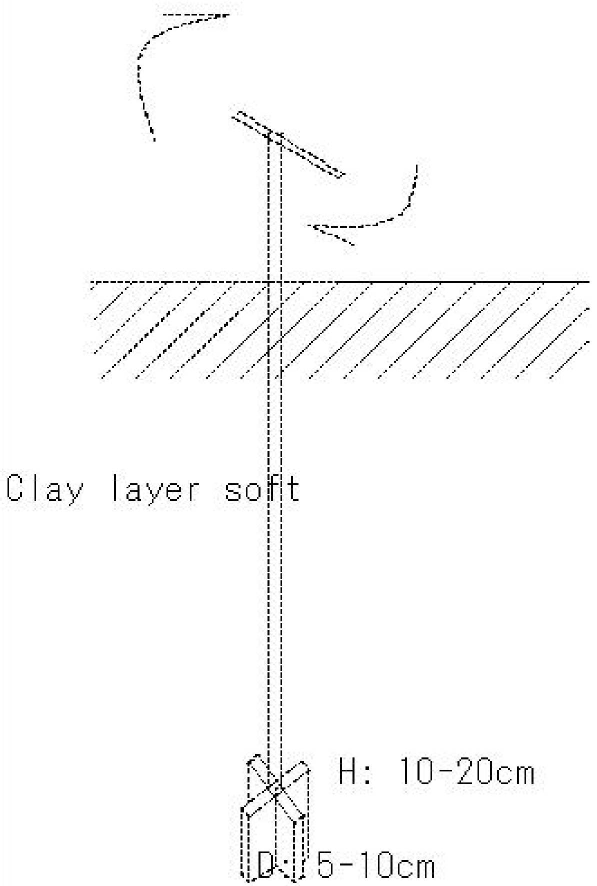
①Free fall with a static load of 100kgf
②Penetration by rotational force after subsidence stops
③25 cm graduated rod
④Screw point
⑤Calculate the half rotation number N required for 25 cm subsidence
⑥Rotate in halves

(E24)Cone penetration test



(E25)Vane test

(E25)Vane test



Vane test

Clay layer soft

Undisturbed sampling

α : Vane-specific constant (458-3665)

M : Rotational force

τ : shear bearing capacity

$\tau = M/\alpha$ (kgf/cm2)

Measure rotational force M

soft clay ground

Cylindrically sheared

(E26)Plate loading test

(E26)Plate loading test

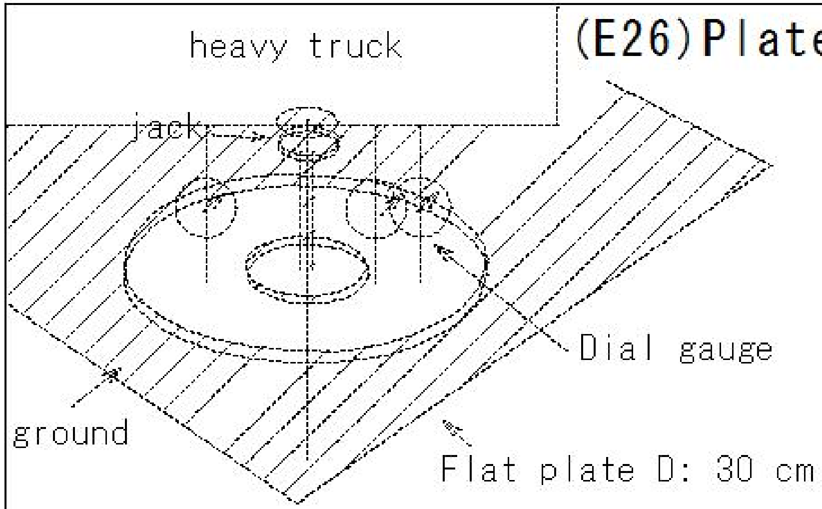


Plate loading test

Bearing capacity measurement of subgrade and roadbed

①Hydraulic jack

②Flat plate subsidence measurement

③Settlement amount: δ

④K: Ground coefficient

$K=P/(A\times \delta)$

(E27)Sampling-Bowling

(E27)Sampling-Bowling

Sampling

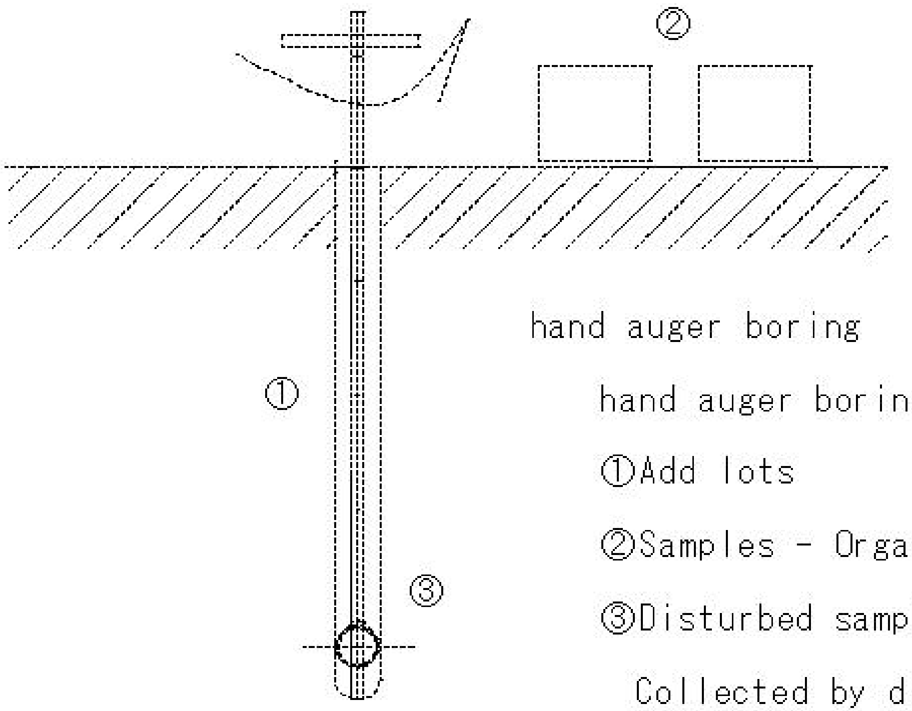
Bowling

①Excavation Sampling Confirmation of stratification

②Soft ground - sample collection Inside the hole - in situ test

(E28)Sampling-Bowling-hand auger boring

(E28)Sampling-Bowling-Auger boring



hand auger boring

hand auger boring

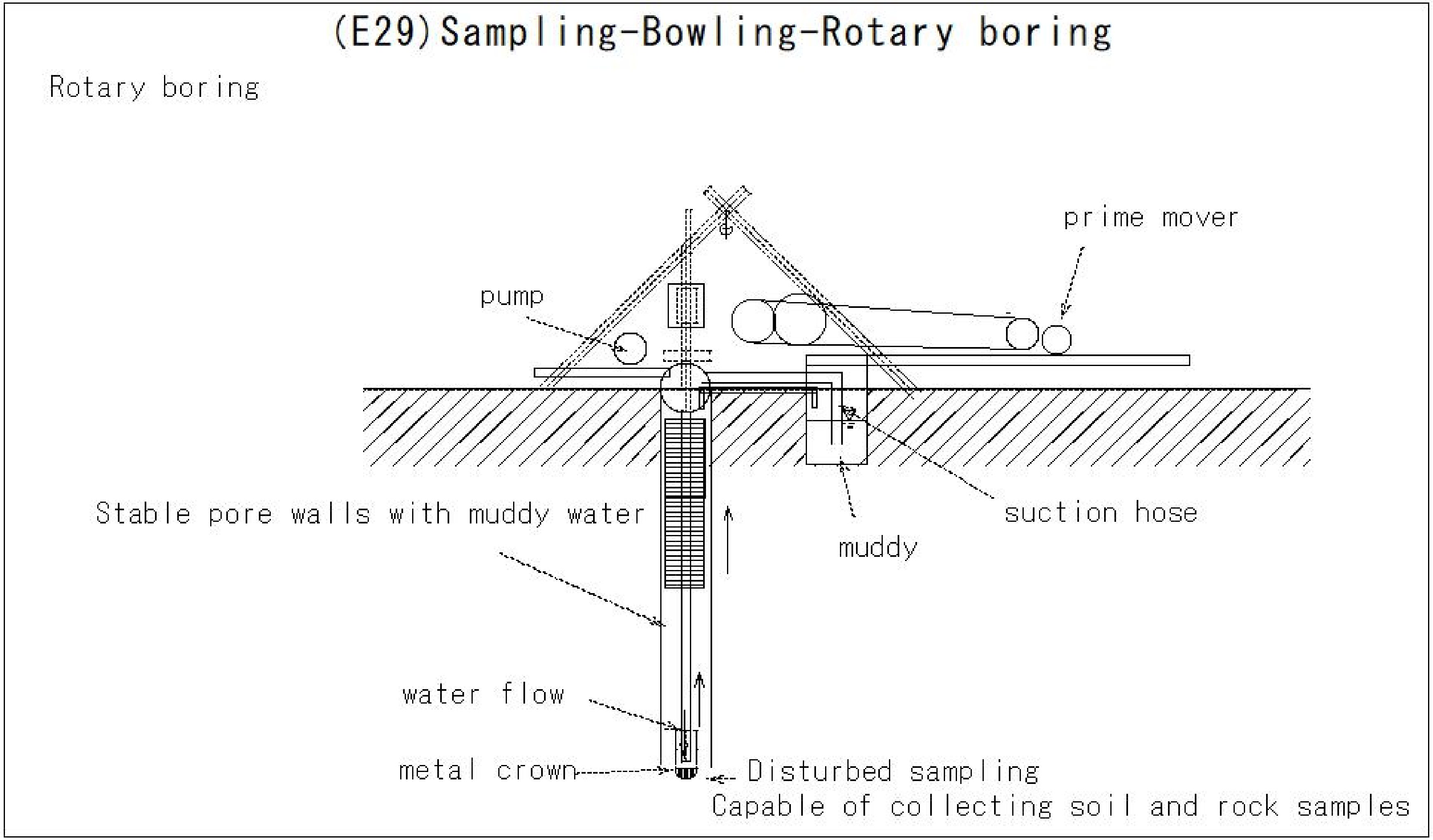
①Add lots

②Samples - Organize samples by depth 1m 2m

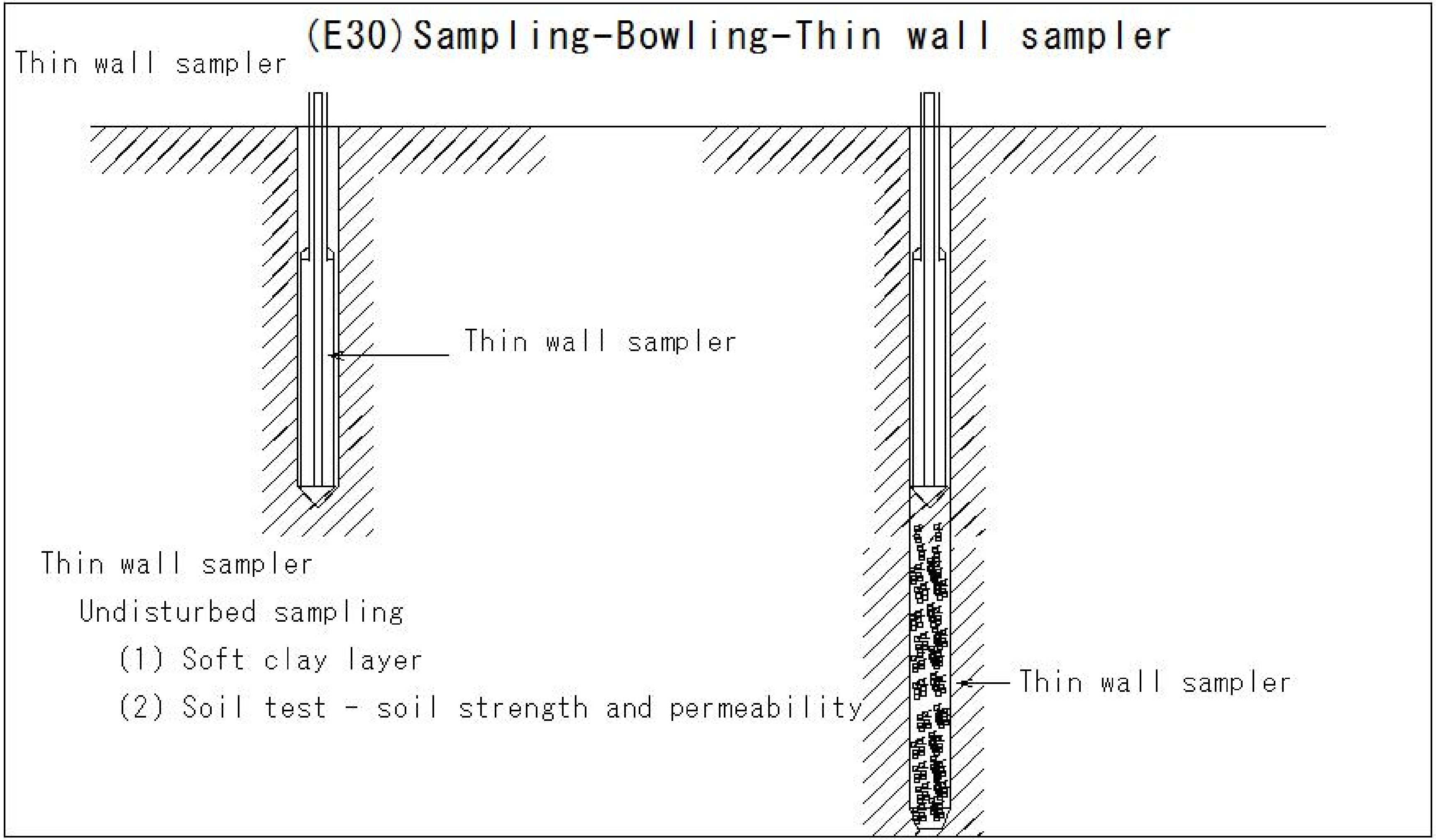
③Disturbed sample

Collected by disturbing the soil in situ

(E29)Sampling-Bowling-Rotary boring



(E30)Sampling-Bowling-Thin wall sampler

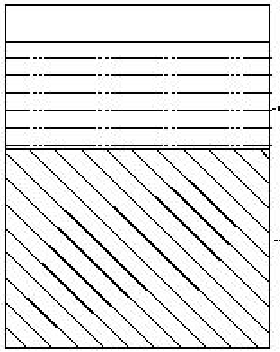


(E31)Soil test-Water content test

Soil test

(E31)Soil test-Water content test

Soil discrimination classification test



soil model

(1) Water content test

(2) Dry the sample and measure the moisture content

(3) Water content ratio w (%) =

mass of soil × 100/mass of soil particles

・How to use the results

・Soil compaction

(E32)Soil test-Unit volume mass test

(E32)Soil test-Unit volume mass test

Unit volume mass test

Wet density: ρt

Dry density: ρd

Wet density: $\rho t = W/V$ (g/cm3)

Dry density: $\rho d = \rho t/(1 + w/100)$ (g/cm3)

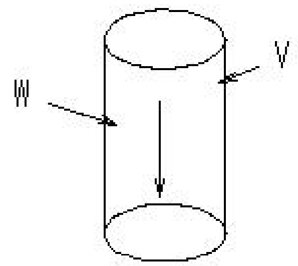
W: Weight of molded specimen (g)

V: Predetermined volume of sample (cm3)

soil compaction

Slope stability design

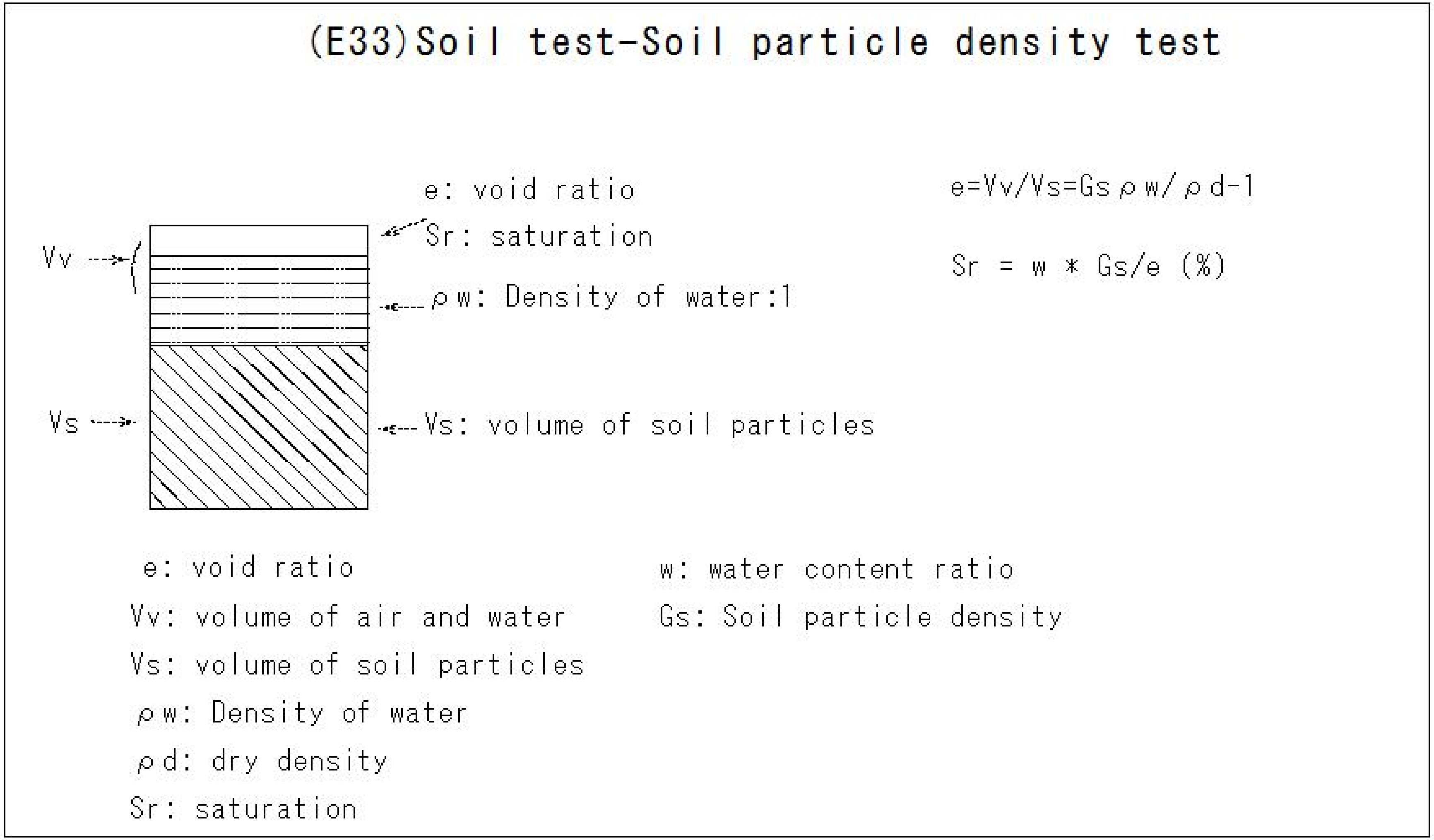
Soil specimen



shaped into a cylinder

w: water content ratio

(E33)Soil test-Soil particle density test



(E34)Soil test-Relative density test

(E34)Soil test-Relative density test

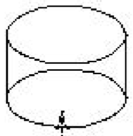
Relative density test

Relative density Dr

Relative density Dr

Dr=((emax-e)/(emax-e))

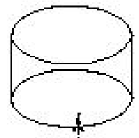
e: In-situ sand void ratio



pack loosely

Void ratio: emax

Collect sand from in situ and pack



pack tightly

Void ratio: emin

Coarse Dr<0.33

Normal 0.33≦ Dr≦0.7

Dense: Dr>0.7

・Judging the degree of compaction of sandy ground

・Judgment of liquefaction of sand layer

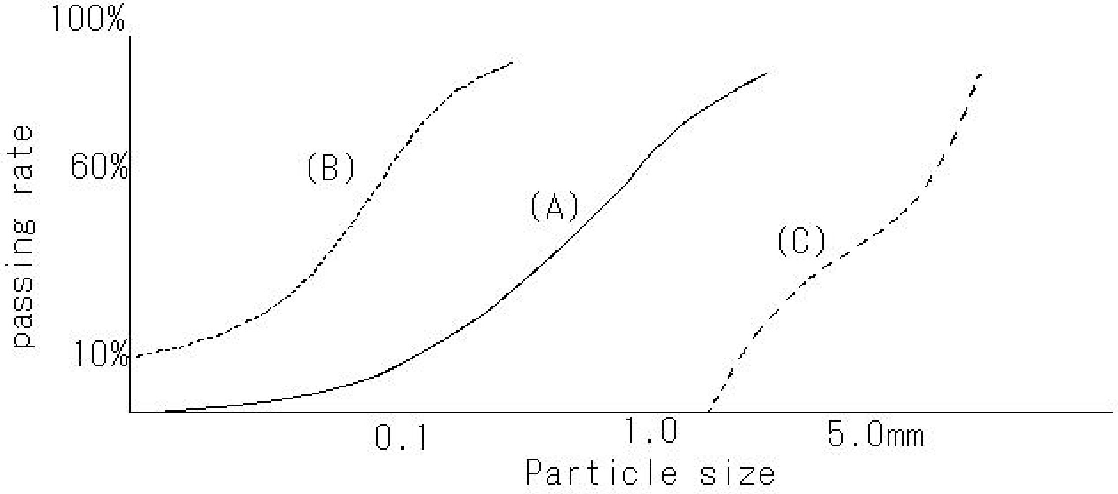
(E35)Soil test-Particle size test

Particle size test

(E35)Soil test-Particle size test

Sieving a soil sample to draw a particle size accumulation curve

Particle size addition curve



Effective Diameter: D10

Uniform coefficient: Uc

Uc≧10 Good particle size distribution

Uc<10 Poor particle size distribution

・Embankment material judgment

・Determination of hydraulic conductivity

・Judgment of liquefaction

(A): Good particle size distribution

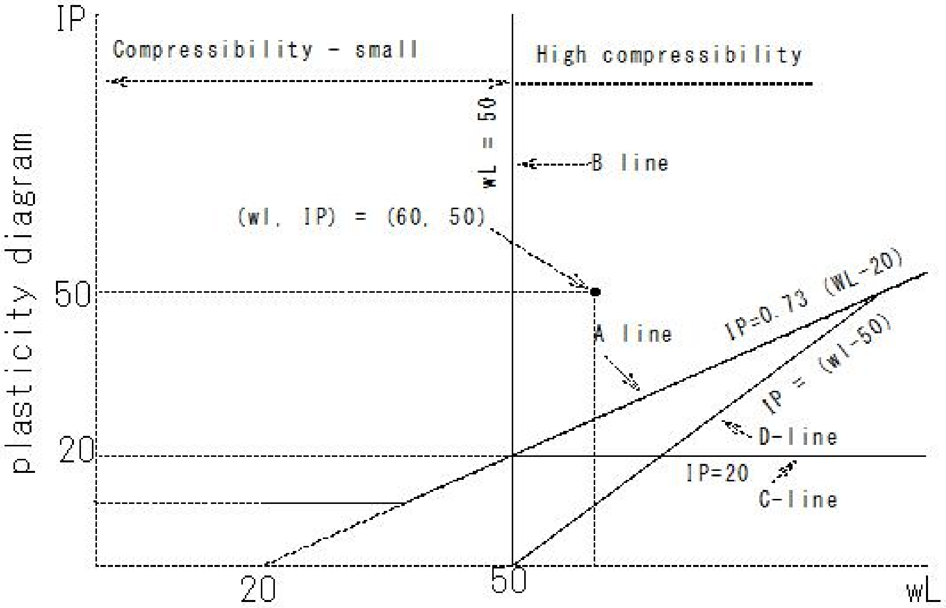
(B): Many fine grains

(C): Many coarse grains

Uniformity factor Uc=D60/D10

(E36)Soil test-Consistency test

(E36)Soil test-Consistency test



Water content of soil in situ: wn

liquid limit: wl

plastic limit: wp

Plasticity index: Ip

Soil classification
plasticity diagram

Consistency index: Ic

wl: liquid limit: minimum water content ratio indicating liquidity

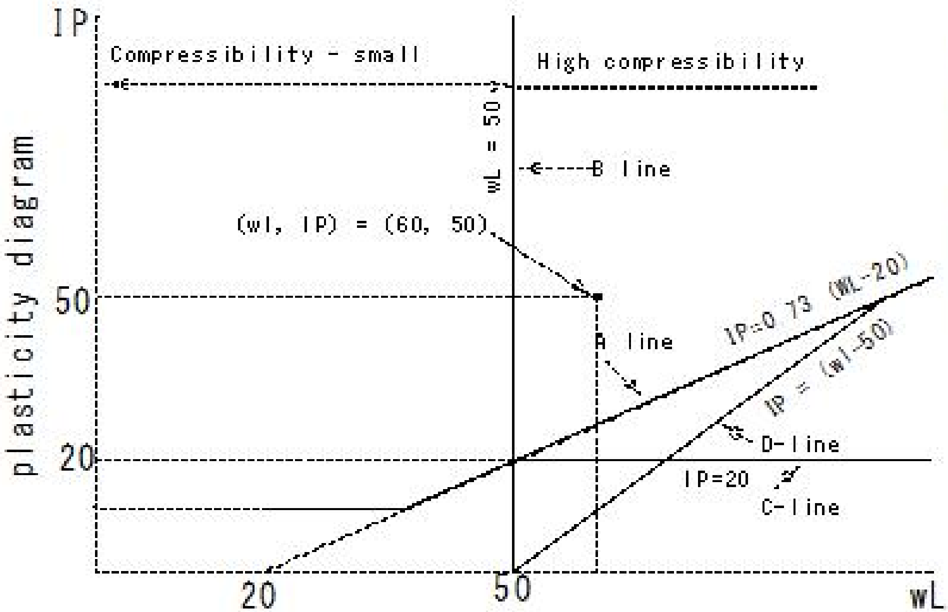
wp: plastic limit: maximum water content in semi-solid state

Plasticity index: Ip = wl - wp

Plasticity diagram: Used to determine soil properties
defined by coordinates (wl, IP)

(E37)Soil test-Consistency test

(E37)Soil test-Consistency test



(wl, IP) = (60, 50)
High compressibility and dry strength
Water permeability - small

Consistency index: Ic = ((wL-wn)/(wL-wp)
Ic ≧ 1: semi-solid
0≧Ic≧1: Plasticity
Ic<0: Liquid

B line: Left side: Compressibility - small
Right side: High compressibility
Line A: Upper side: Volume change rate/dry strength - high, water permeability - low
Lower side: Volume change rate/dry strength - small, water permeability - large

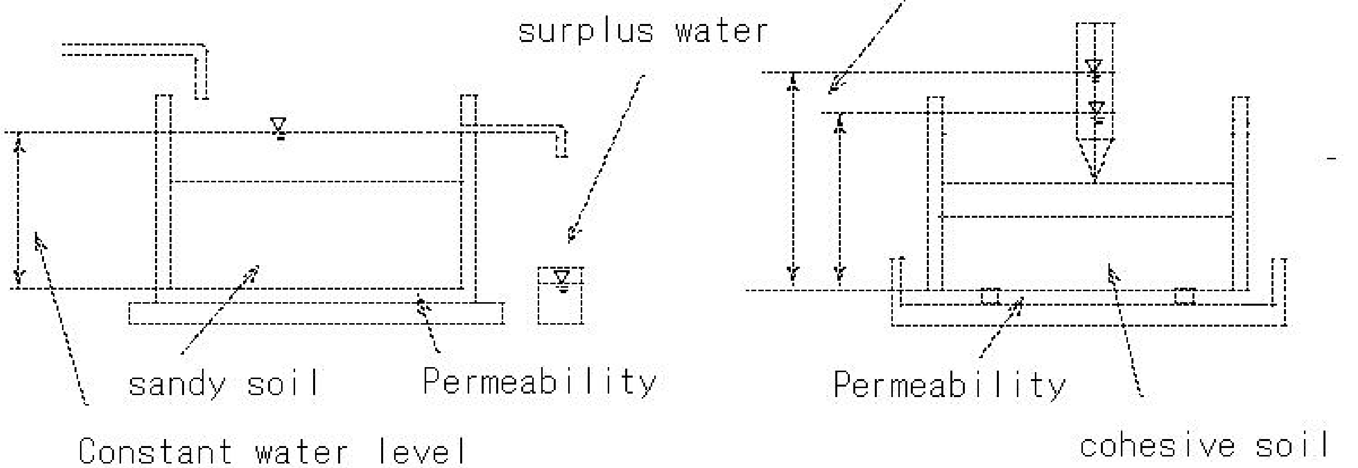
(E38)Testing of soil mechanical properties-Permeability test

(E38)Testing of soil mechanical properties-Permeability test

Permeability test

△: Indoor test

Permeability coefficient: k



How to use the results

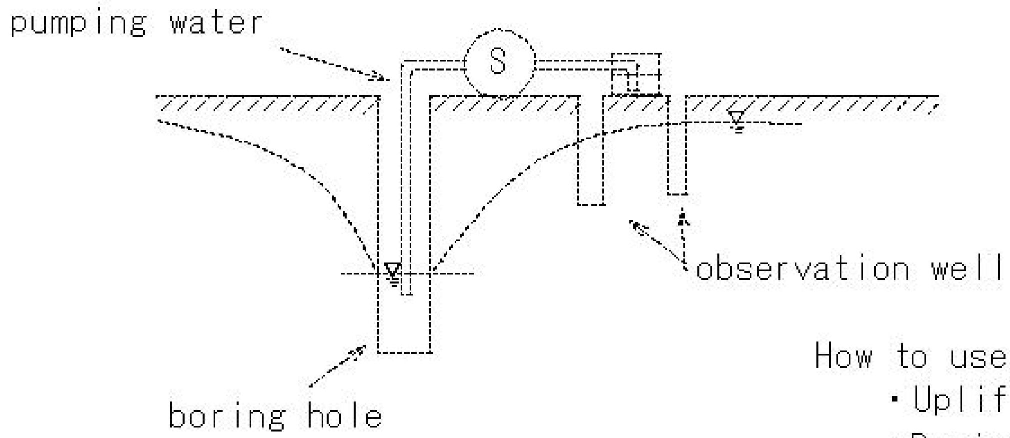
・Uplift calculation

・Design of cut-off wall and drainage

(E39)Field test-Constant level permeability test

(E39)Field test-Constant level permeability test

Constant level permeability test



How to use the results

- Uplift calculation
- Design of cut-off wall and drainage

Calculating hydraulic conductivity
from groundwater gradient

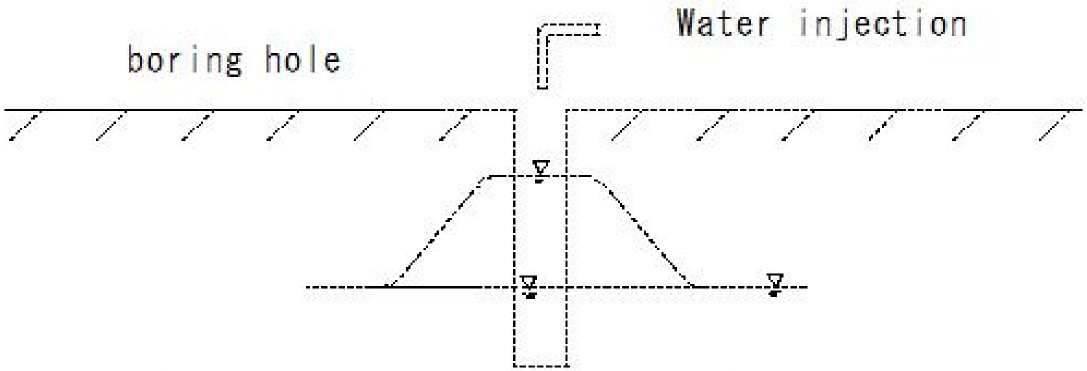
Approximate value of in-situ hydraulic conductivity

Sand:0.0001
Sandy soil:0.00001
Cohesive soil:0.0000001
Clay:0.0000001or more

(E40)Field test-Alternating water level permeability test

(E40)Field test-Alternating water level permeability test

Alternating water level permeability test



・Calculate the coefficient of permeability from the time it takes to return to normal groundwater after injecting water into the well

Approximate value of in-situ hydraulic conductivity

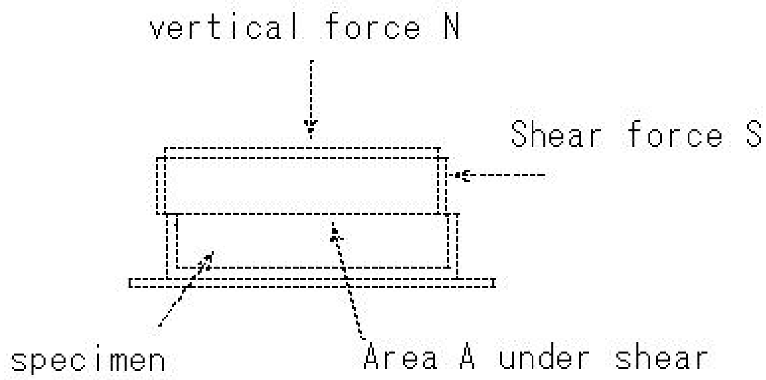
Sand:0.0001
Sandy soil:0.00001
Cohesive soil:0.0000001
Clay:0.0000001or more

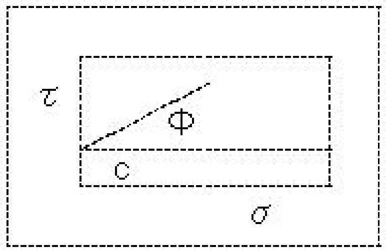
How to use the results

・Uplift calculation
・Design of cut-off wall and drainage

(E41)Direct shear test

(E41)Direct shear test





Shear force: $\tau = S/A$
Normal stress: $\sigma = N/A$

Direct shear test

Internal friction angle: Φ
Adhesion: c
Compressive strength: qu
Sensitivity ratio: St

・Graph τ and σ to find the internal friction angle (shear resistance angle) Φ and adhesion c

How to use the results

・Soil bearing capacity
・Slope stability
・Judgment of fine-grained soil

(E42)Uniaxial compression test

(E42)Uniaxial compression test

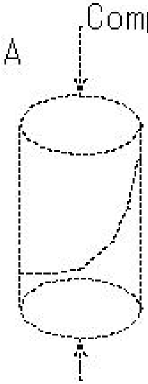
Uniaxial compressive strength: qu

Sensitivity ratio: St

Compressive force P

Area A

specimen

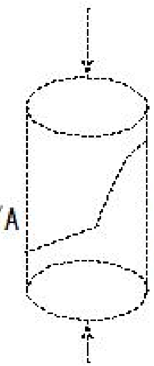


Fracture surface

Axial compressive strength: qu = P/A

Shear strength: τ = qu/2

undisturbed cohesive soil



Uniaxial compressive strength: qur

Sensitivity ratio: St=qu/qur

repeat sample (disturbed)

Sensitivity ratio is used to judge the kneading phenomenon of cohesive soil

Value - large - losing bearing capacity by kneading

suitable for clay soil

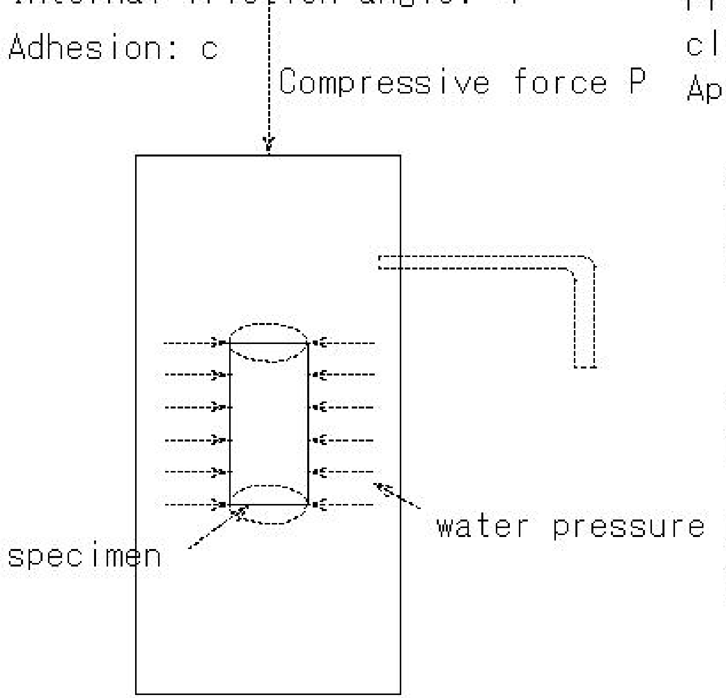
(E43)Triaxial compression test

(E43)Triaxial compression test

triaxial compression test

Internal friction angle: Φ

Adhesion: c



side pressure

Pressure from three axial directions

close to on-site conditions

Applicable to all types of soil

Shear test conditions

UU test: no compression no water absorption

Non-consolidation and non-drainage

CU test: Compression No water supply/drainage

Consolidationundrained

CD test: consolidation water supply and drainage

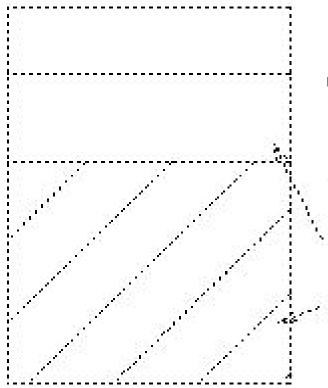
Consolidation drainage

(E44)Consolidation test

(E44)Consolidation test

Consolidation test
Compression index
Compression factor: av
Volume compression factor: mv
Consolidation coefficient: cv
Compression index: Cc
Permeability coefficient: k

H: Consolidation drainage distance
T: time factor
cv: Consolidation coefficient

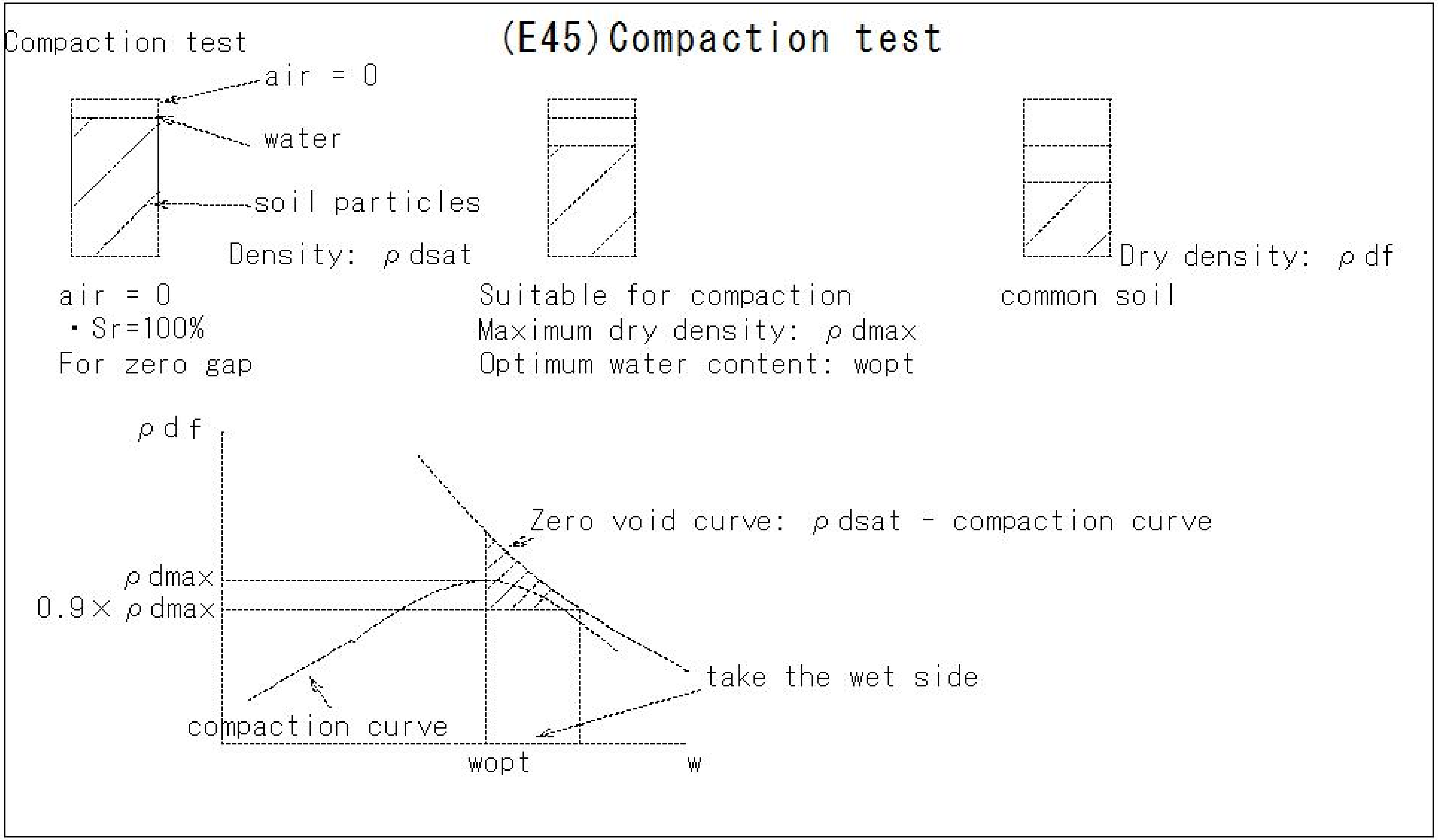


How to use the results
- Calculation of subsidence
- Calculation of Settlement
- Time required for Settlement

- Performed on cohesive soil saturated with water
- Drainage of interstitial water due to sustained consolidation
- Volume - Decrease
- Settlement: S=((eo-e)/(1+eo))*Ho
- Settling time t = TH^2/cv

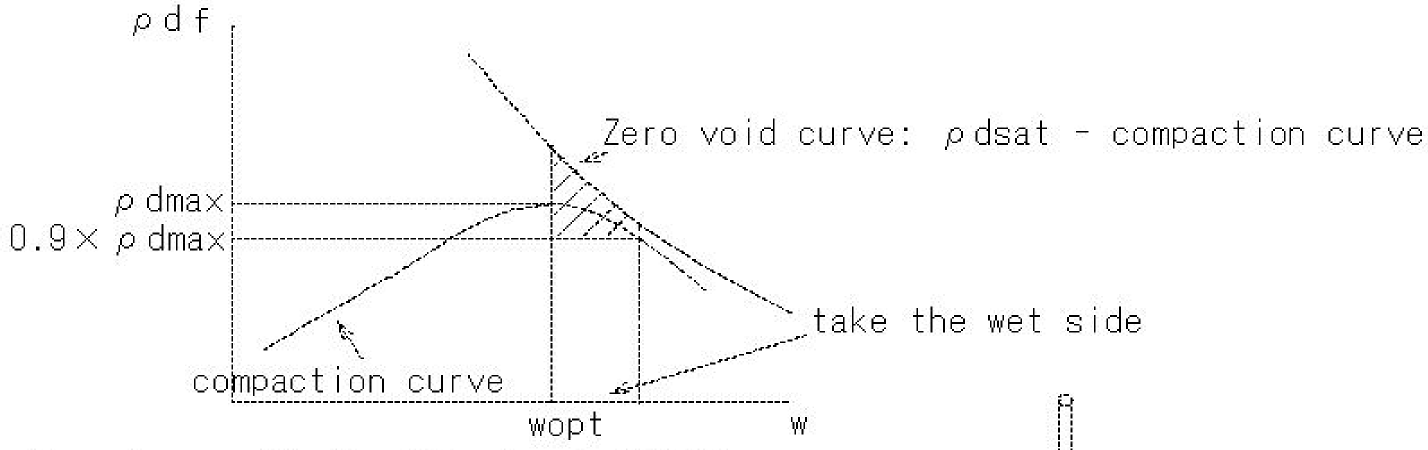
eo: initial void ratio
e: Void ratio after consolidation
Ho: Layer thickness of cohesive soil

(E45)Compaction test



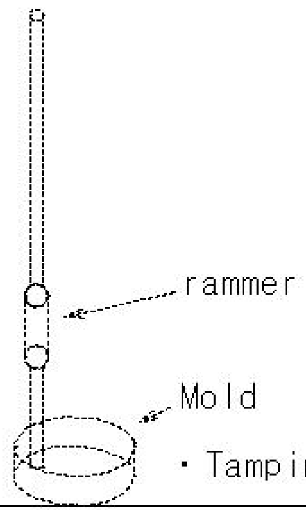
(E46)Zero void curve: ρdsat - compaction curve

(E46)Zero void curve: ρdsat - compaction curve



・Compaction degree Cd=((ρdf/ρdmax)*100(%)
Cd≧90 Embankment roadbed
Cd≧95 Roadbed/Roadbed

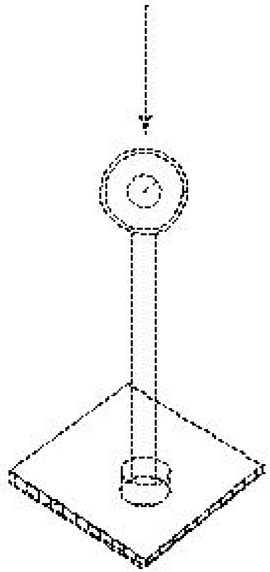
・Tamping method
First class (2.5 kg rammer)
Second class (4.5 kg rammer)
Mold diameter 10 cm
Mold diameter 15 cm



・Tamping method

(E47)CBR test On-site CBR

(E47)CBR test On-site CBR



How to use the results

- Determination of pavement thickness
- Ground bearing capacity
- Determination of traffic-ability

・On-site CBR

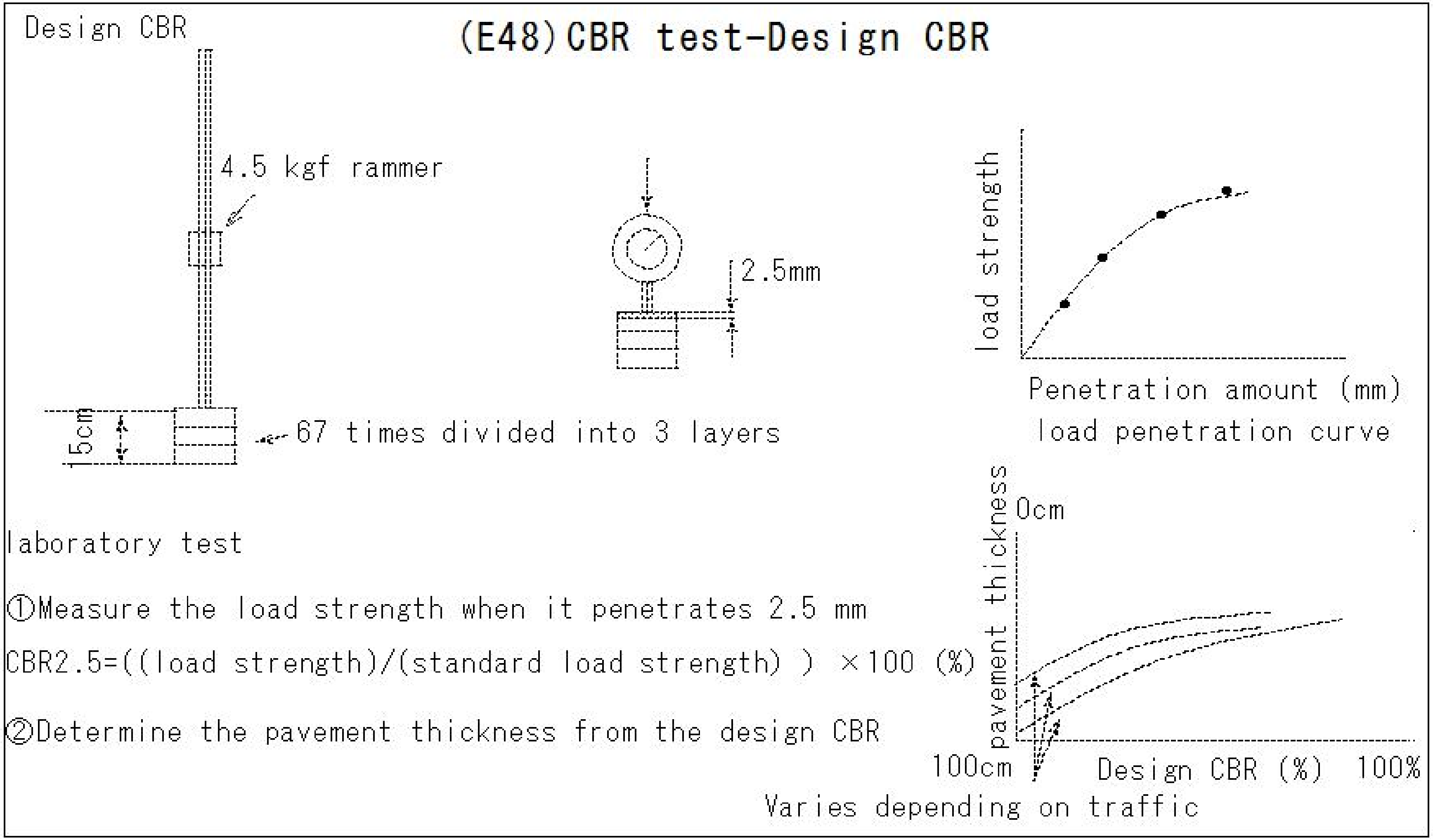
(1) Used to determine the bearing capacity of the roadbed of cut material

(2) Direct measurement of the roadbed bearing capacity of the original ground

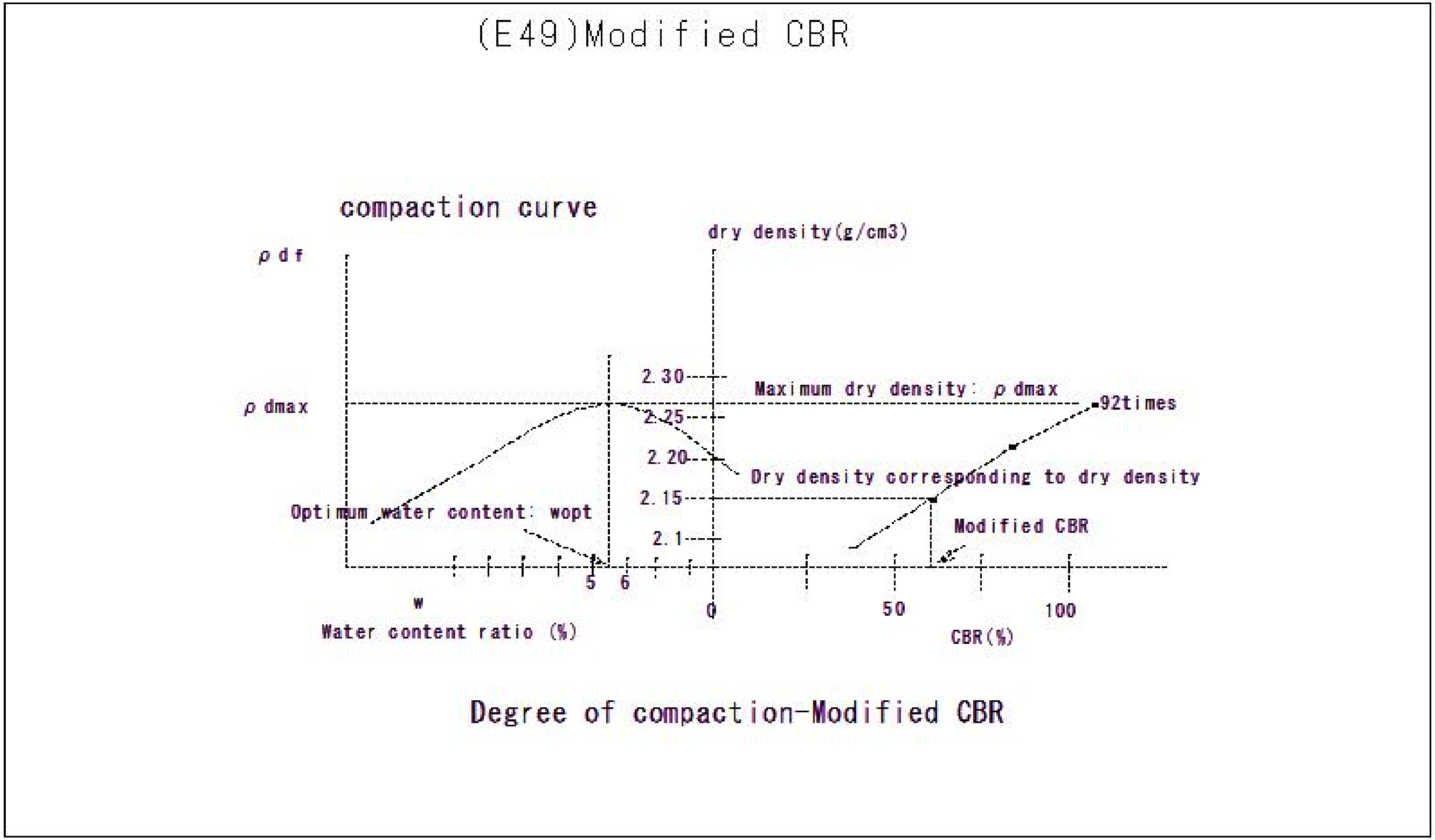
(3) On-site CBR = ((load strength/standard load strength) x 100) (%)

(4) Used for calculation of design CBR

(E48)CBR test-Design CBR



(E49)Modified CBR



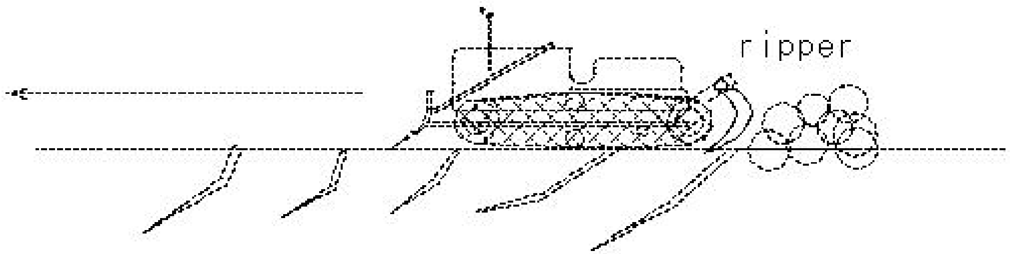
(E50)Use of soil survey results-Ripper work

(E50)Use of soil survey results-Ripper work

Use of soil survey results

(1) Ripper work: Determine elastic wave velocity by elastic wave exploration

Excavation - work method - decision



(E51)Use of soil survey results-Trafficability of construction machinery

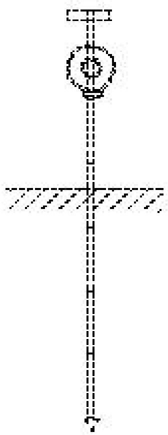
(E51)Use of soil survey results-Trafficability of construction machinery

Trafficability of construction machinery

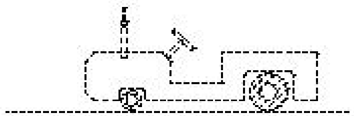
①Obtain cone index qc by cone penetration test

②Crawler type or wheel type depending on qc value

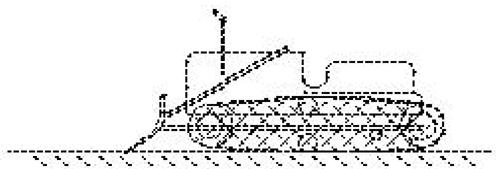
③Undercarriage washing of construction machinery



cone penetration test



Wheel type



Crawler type

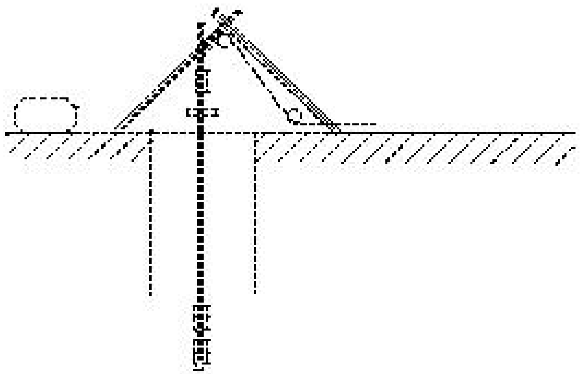
(E52)Use of soil survey results-Judgment of supporting ground

(E52)Use of soil survey results-Judgment of supporting ground

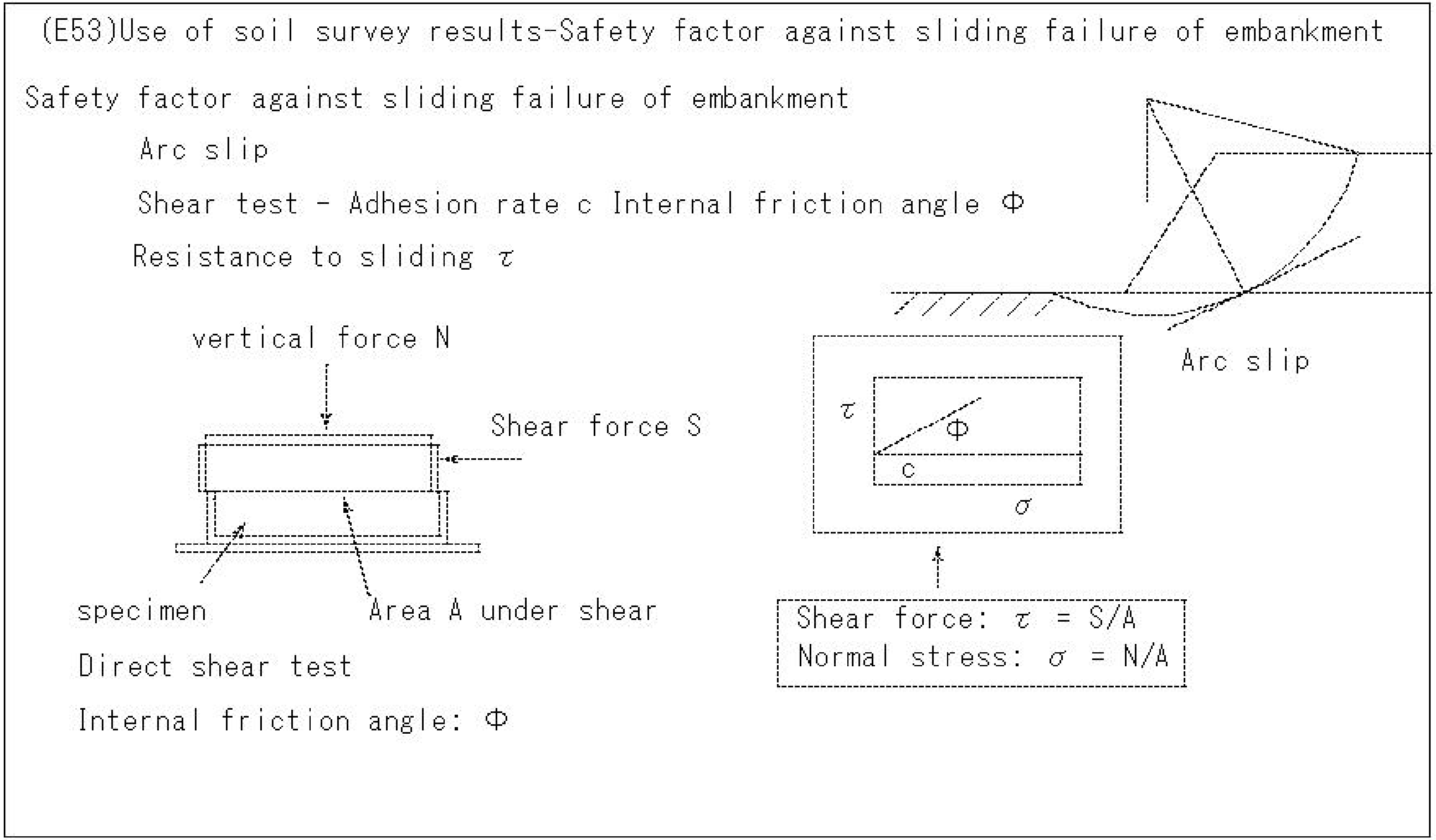
Judgment of supporting ground

Judgment by **N** value obtained by standard penetration test

N ≧50 Good as foundation ground



(E53)Use of soil survey results-Safety factor against sliding failure of embankment

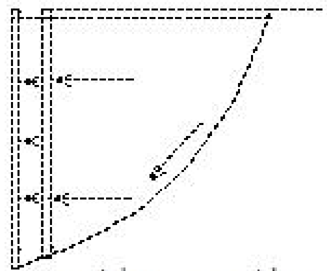


(E54)Use of soil survey results-Earth pressure calculation

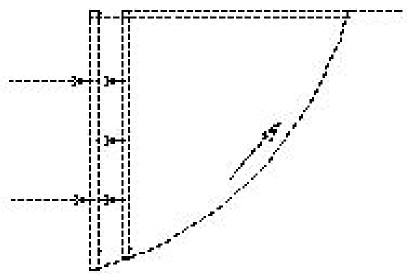
(E54)Use of soil survey results-Earth pressure calculation

Earth pressure calculation

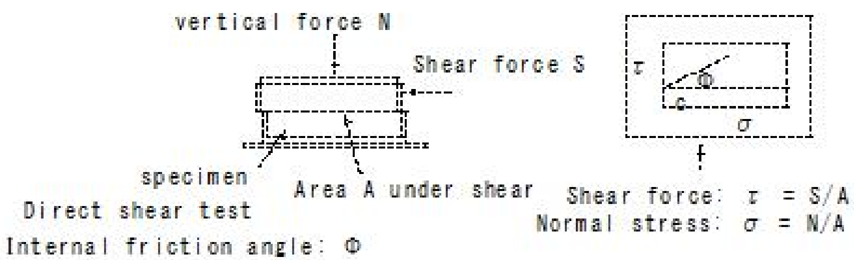
Earth pressure acting on a structure
passive earth pressure
active earth pressure
Earth pressure calculation
c Φ
Earth pressure coefficient: KA
Unit volume weight γt



active earth pressure



passive earth pressure



(E55)Use of soil survey results-Calculation of embankment height limit on soft ground

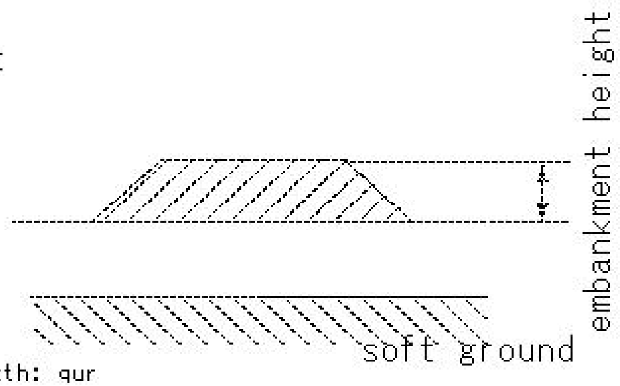
(E55)Use of soil survey results-Calculation of embankment height limit on soft ground

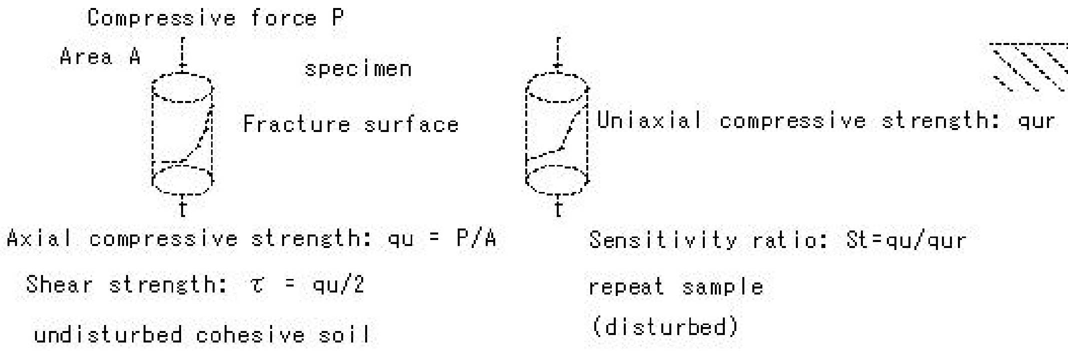
Use of soil survey results

Calculation of embankment height limit on soft ground

Uniaxial compressive strength of soft ground

Calculate τ kgf/cm2 from the unit mass of embankment





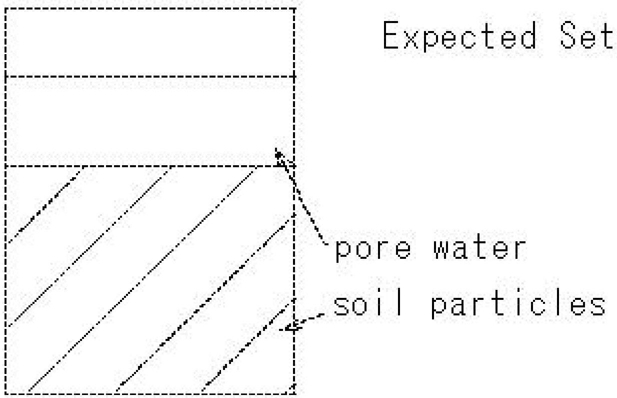
(E56)Use of soil survey results-Settlement amount of clay layer

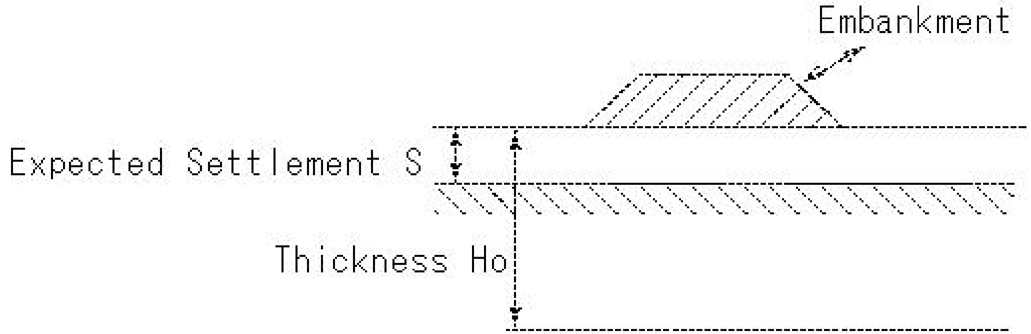
(E56)Use of soil survey results-Settlement amount of clay layer

Settlement amount of clay layer

- Consolidation test - Void ratio
- Clay - thickness

Consolidation test

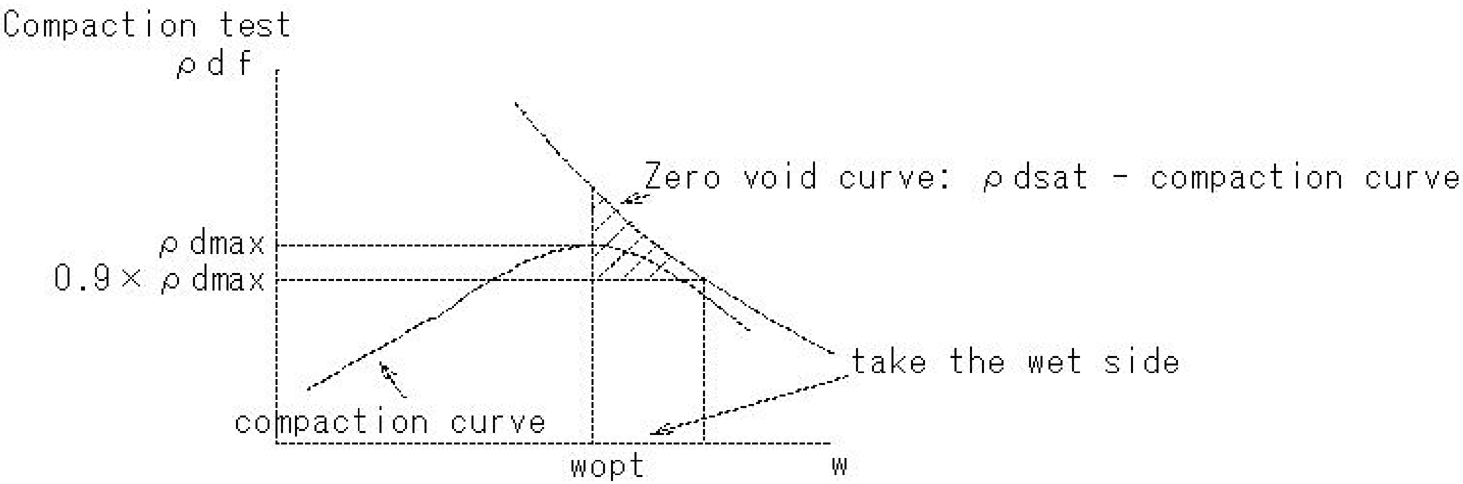




(E57)Use of soil survey results-Compaction of embankment

(E57)Use of soil survey results-Compaction of embankment

Compaction of embankment



(E58)Embankment

(E58)Embankment

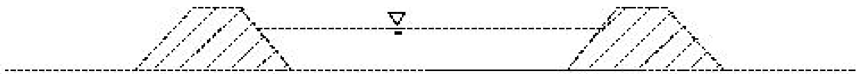
Embankment

embankment material

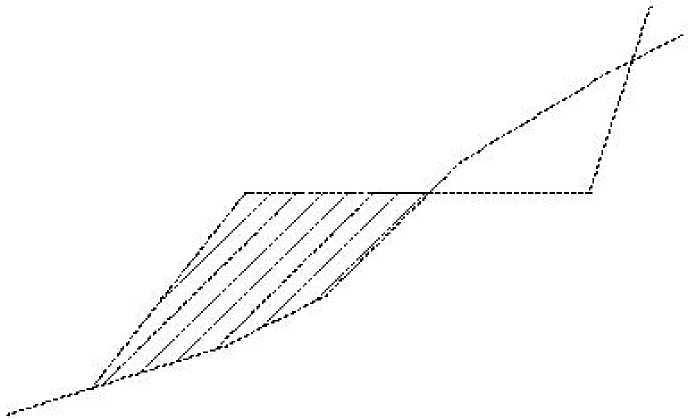
・Quality of embankment materials

(1) Rivers and earth dams: stop water

(2) Roads and railways: load support



Embankment(Rivers)



Embankment(Roads)

(E59)Embankment material

(E59)Embankment material

Embankment material

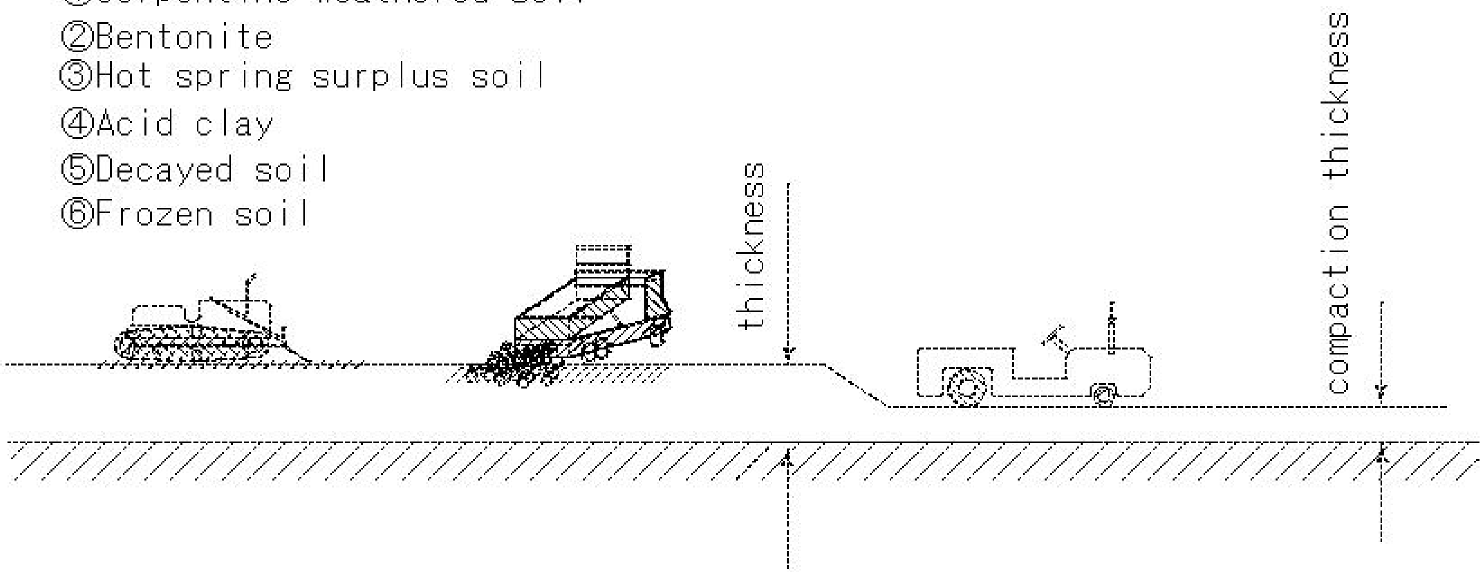
Diameter 30 cm or more

Unrolled Thickness - Uncompactable

Diameter - large - unfavorable

Embankment material - avoid due to soil stability

①Serpentine weathered soil
②Bentonite
③Hot spring surplus soil
④Acid clay
⑤Decayed soil
⑥Frozen soil



(E60)Embankment material

(E60)Embankment material

Embankment material

High water content: clay/cohesive soil - construction machinery - trafficability - bad - countermeasures

①Decrease in moisture content due to drying trafficability - improve

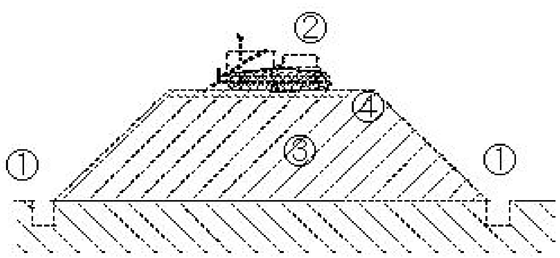
②Wetland bulldozer use

③Lay good quality soil only on the transport route

Conveyance route - soil kneading - decrease in corn index - prevent

④Soil stabilization

(soil + cement / asphalt mixture) - increase bearing capacity



(E61)Suitability of embankment materials

(E61)Suitability of embankment materials

Suitability of embankment materials		
Embankments such as roads*	Soil classification	Embankment embankment
1	Gravel (G)	7
2	Gravel soil (GF)	1
3	Sand (S)	6
4	sandy soil (SF)	2
5	Silt (M)	3
6	Cohesive soil (C)	4
8	Organic soil (O)	8
7	Volcanic ash chamber cohesive soil (V) **	5

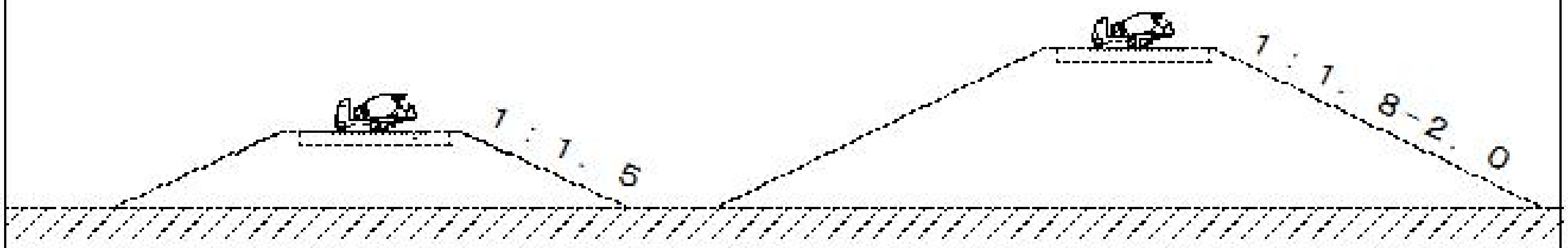
*: Embankment bearing capacity is a major factor　　Proportional in order of particle size

**: (V) is not stable as a slope surface

(E62)Embankment slope standard-Road embankment

(E62)Embankment slope standard-Road embankment

Road embankment



Embankment height - low

embankment material - good

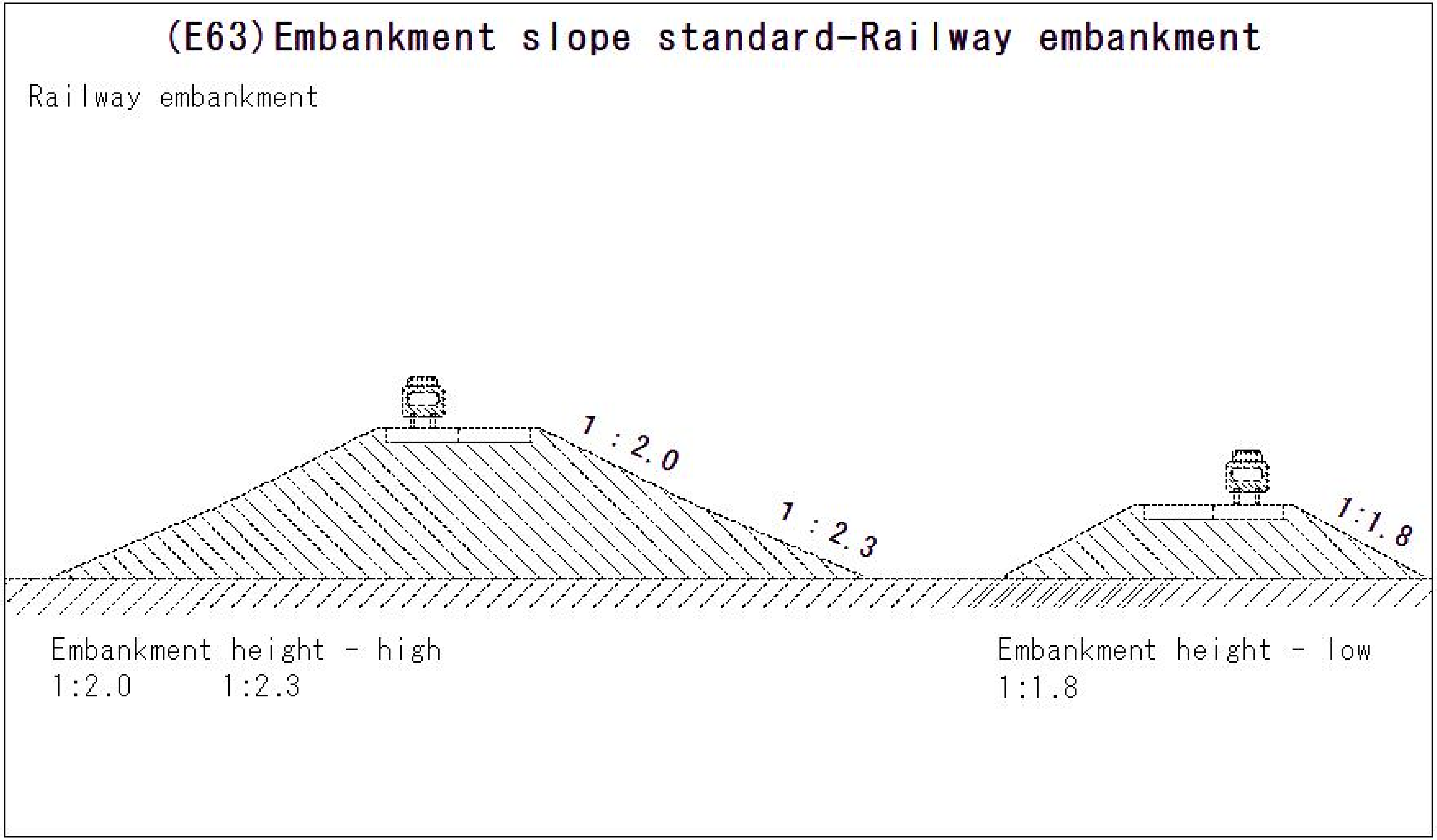
1:1.5

embankment high

Embankment material - bad

1:1.8-2.0

(E63)Embankment slope standard-Railway embankment



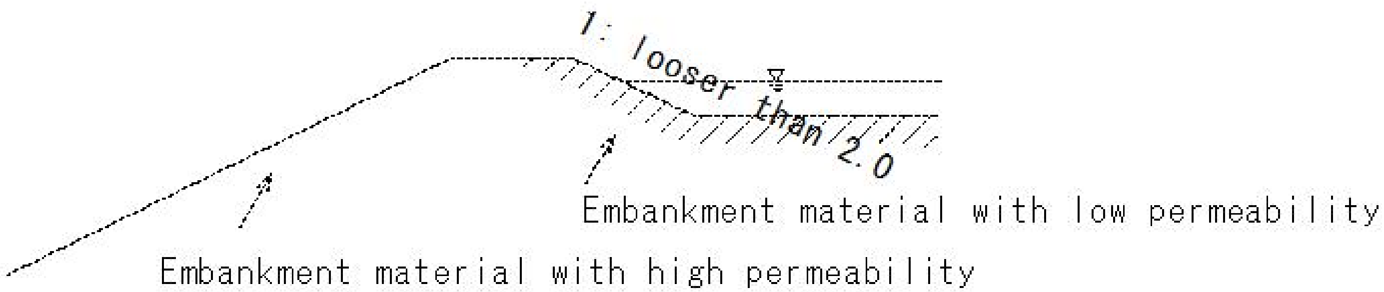
(E64)Embankment slope standard-River embankment

(E64)Embankment slope standard-River embankment

Embankment slope standard

Slope shape

Embankment standard gradient



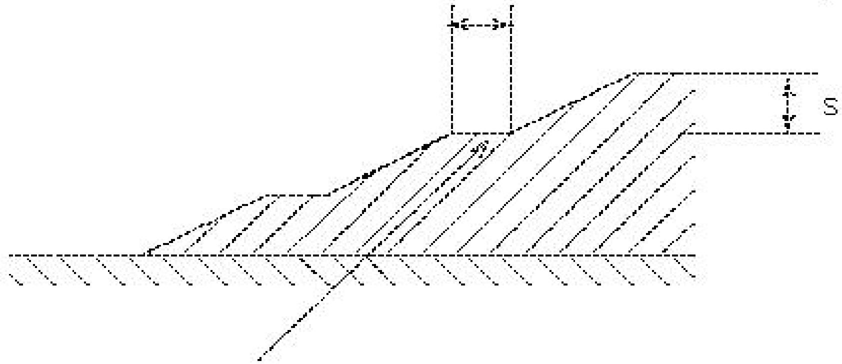
River embankment

(E65)Embankment slope standard-Berm

(E65)Embankment slope standard-Berm

Berm

Berm
1-2m
Embankment stability



slope height
Set every 6m

Erosion prevention
Slope management

3m or more in the case of embankments

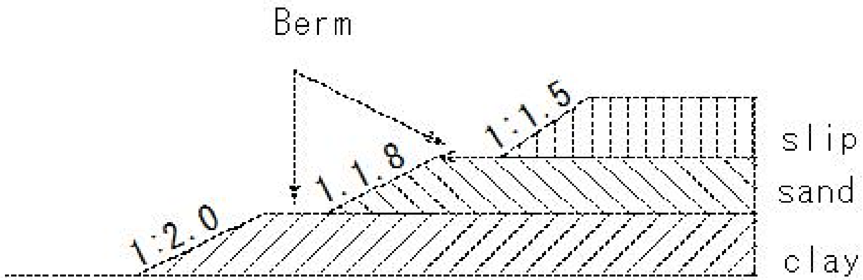
Install a drainage ditch in the small steps

embankment height is large

(E66)Embankment slope standard-Embankment materials are different

(E66)Embankment slope standard-Embankment materials are different

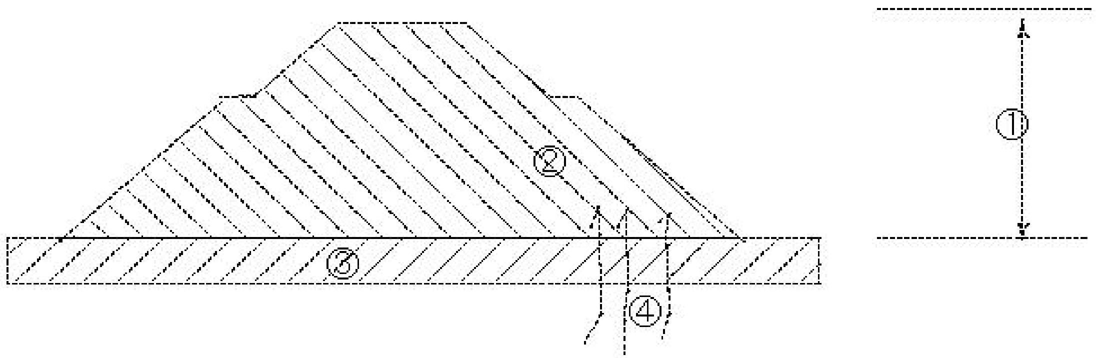
Embankment materials are different



(E67)Stability study of embankment slope

(E67)Stability study of embankment slope

Stability study of embankment slope



Stability study of embankment slope

①Embankment height - large

②High water content ratio Shear strength - small

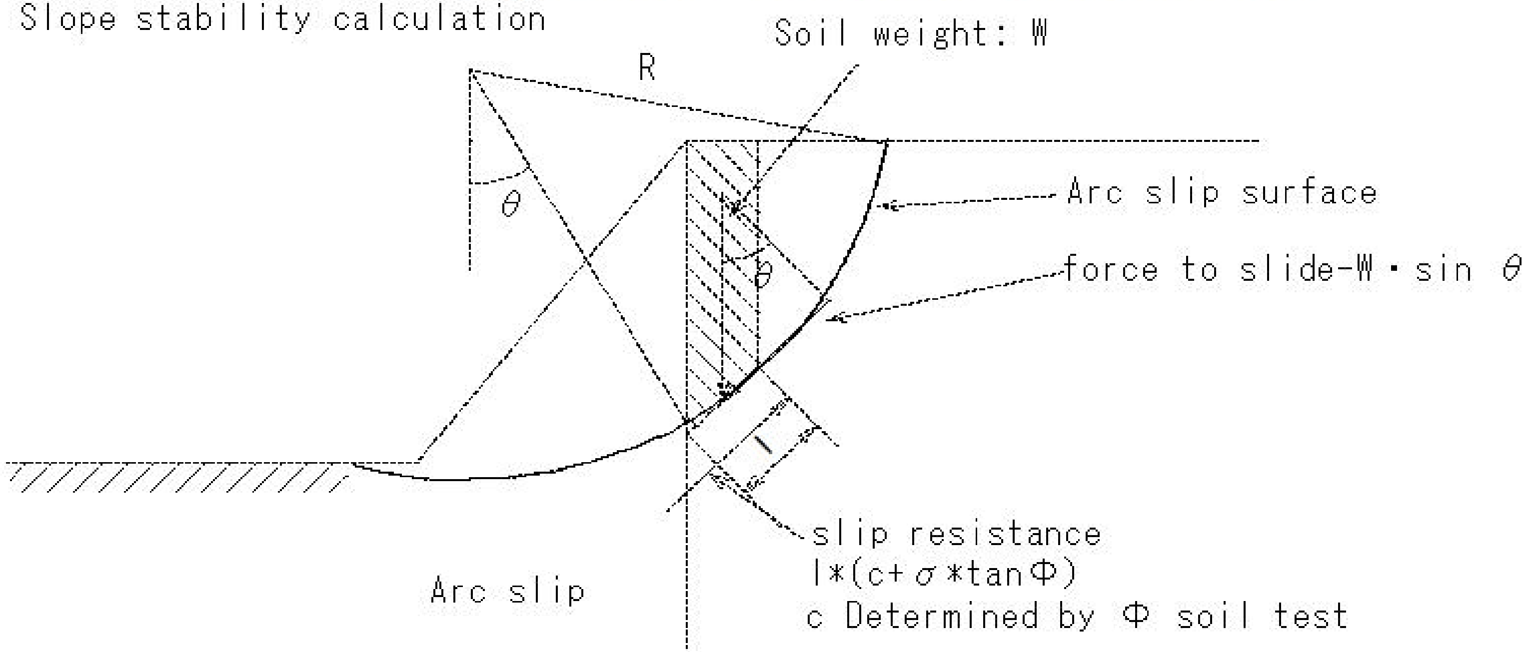
③Soft ground

④Spring water - erosion

(E68)Slope stability calculation

(E68)Slope stability calculation

Slope stability calculation



Safety factor when starting to slide: Fs

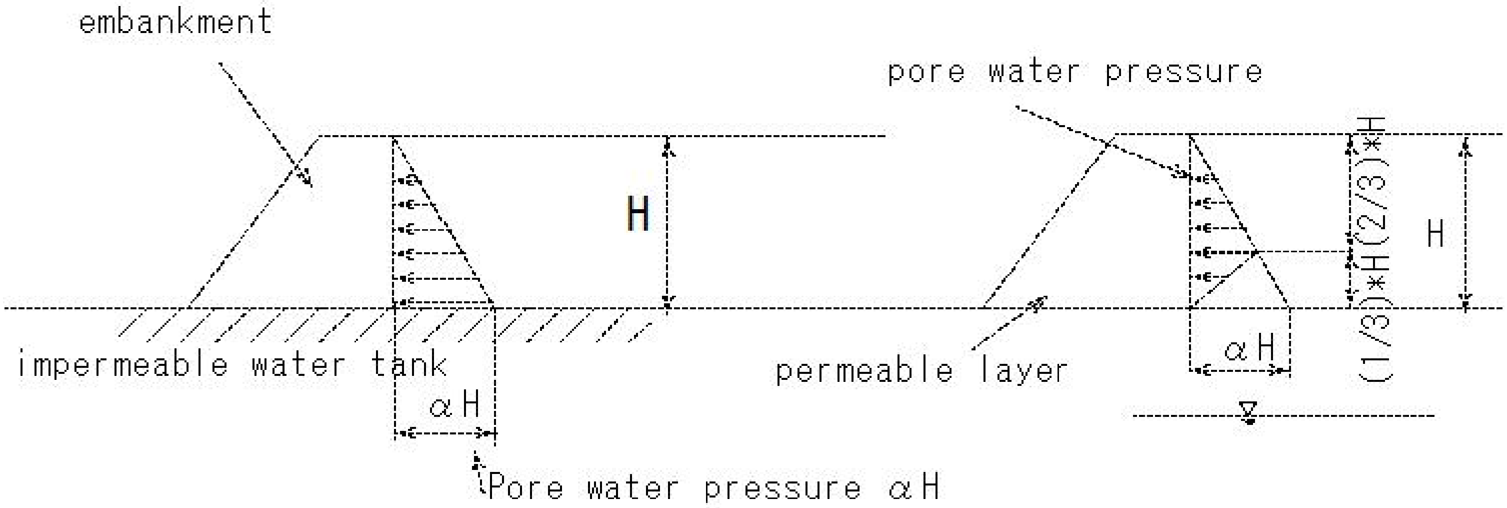
Fs=Σl・((c+σ*tanΦ)/(ΣW・sinθ))

(1.2≦Fs≦1.25)

(E69)Pore water pressure of embankment

(E69)Pore water pressure of embankment

Pore water pressure of embankment



High water content clay α=1

Ordinary soil α=0.5

Uniaxial compression test
triaxial compression test
direct shear test

Adhesion: c Internal friction angle: Φ

(E70)Embankment compaction criteria

(E70)Embankment compaction criteria

Embankment compaction criteria

Density increase of embankment uniformity

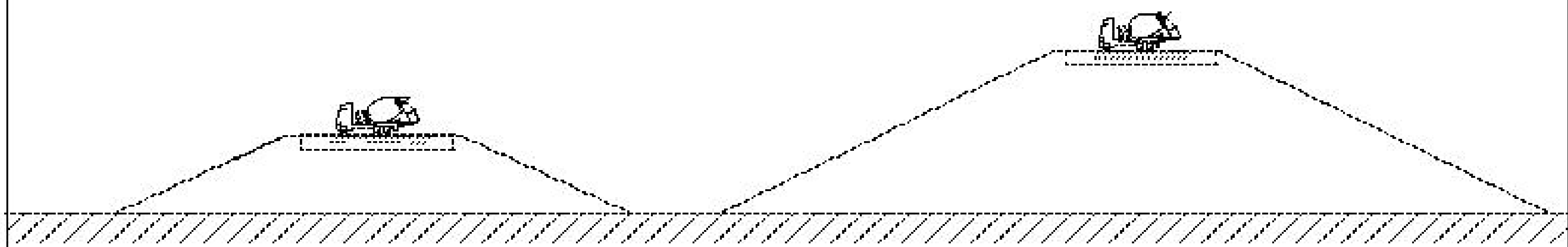
Permeability drop Improving embankment stability

Compaction - purpose

(1) Increased bearing capacity

(2) Decrease in consolidation settlement

(3) Prevention of softening due to water immersion



Embankment height - low

embankment high

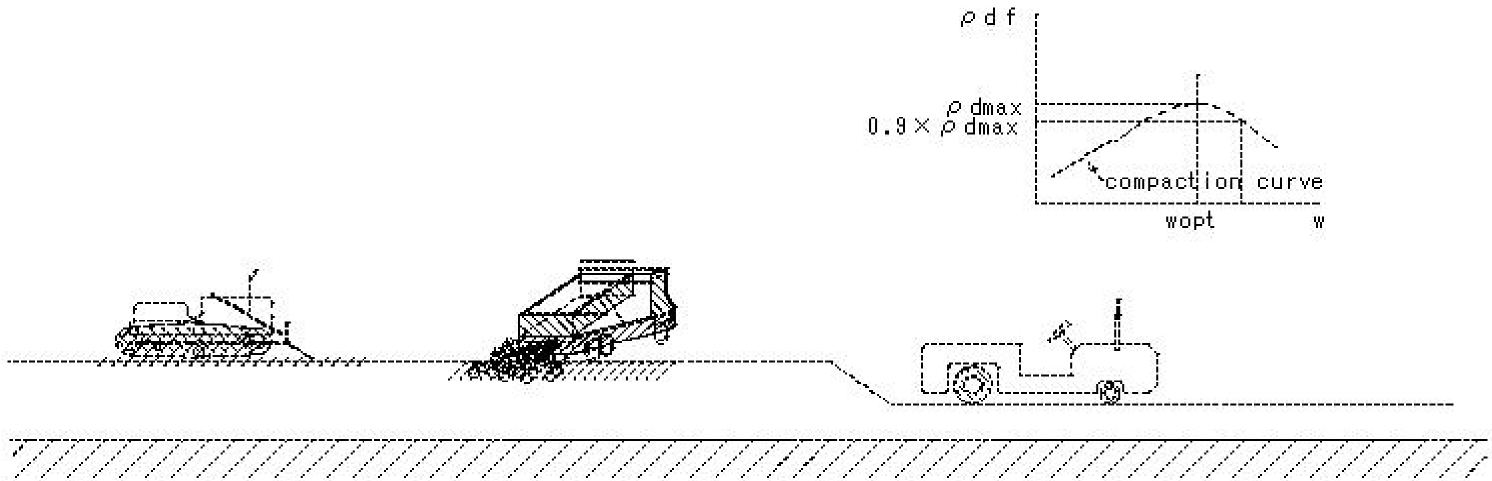
(E71)Embankment compaction criteria-Standard by compaction machine

(E71)Embankment compaction criteria-Standard by compaction machine

Embankment compaction criteria

Standard by compaction machine

- Construction method standards
- Boulders and cobblestones embankment materials
  that are not affected by the water content ratio
- On-site compaction test - construction method regulations



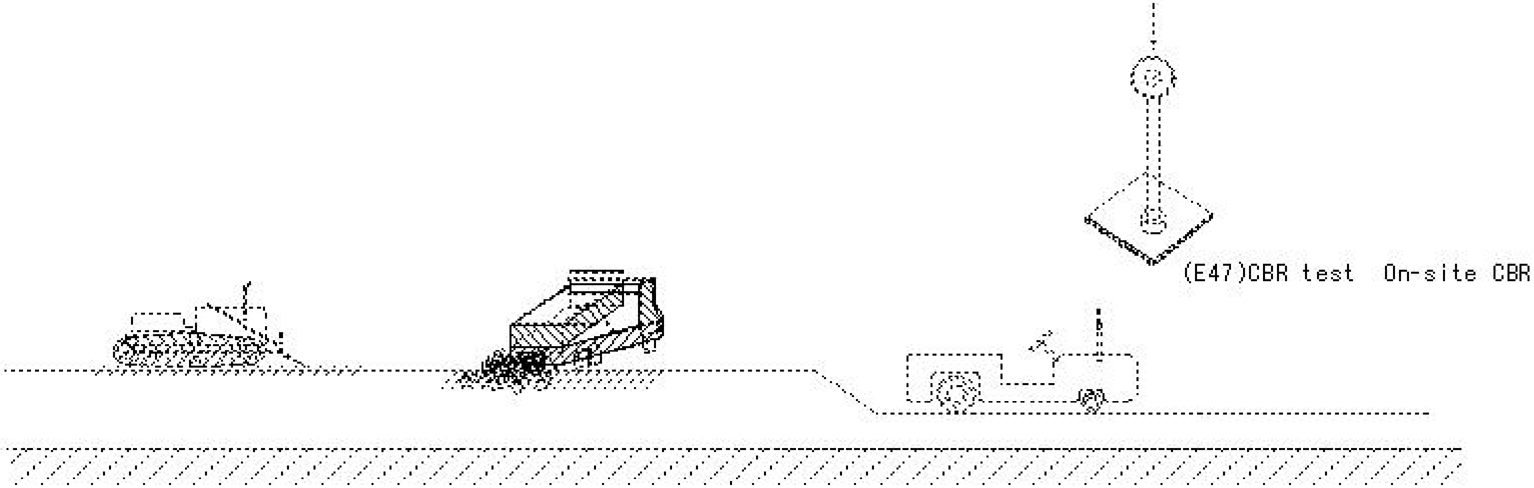
(E72)Embankment compaction criteria-Criteria based on compaction strength

(E72)Embankment compaction criteria-Criteria based on compaction strength

Embankment compaction criteria

Criteria based on compaction strength

- Strength of compacted embankment ground
- On-site CBR Ground coefficient Measured by penetration test
- Convenient if the strength does not change depending on the water content
- Suitable for boulders, cobbles, sand and sandy soil
- Clay/cohesive soil - strength changes depending on water content - unsuitable



(E73)Embankment compaction criteria-Criteria by dry density

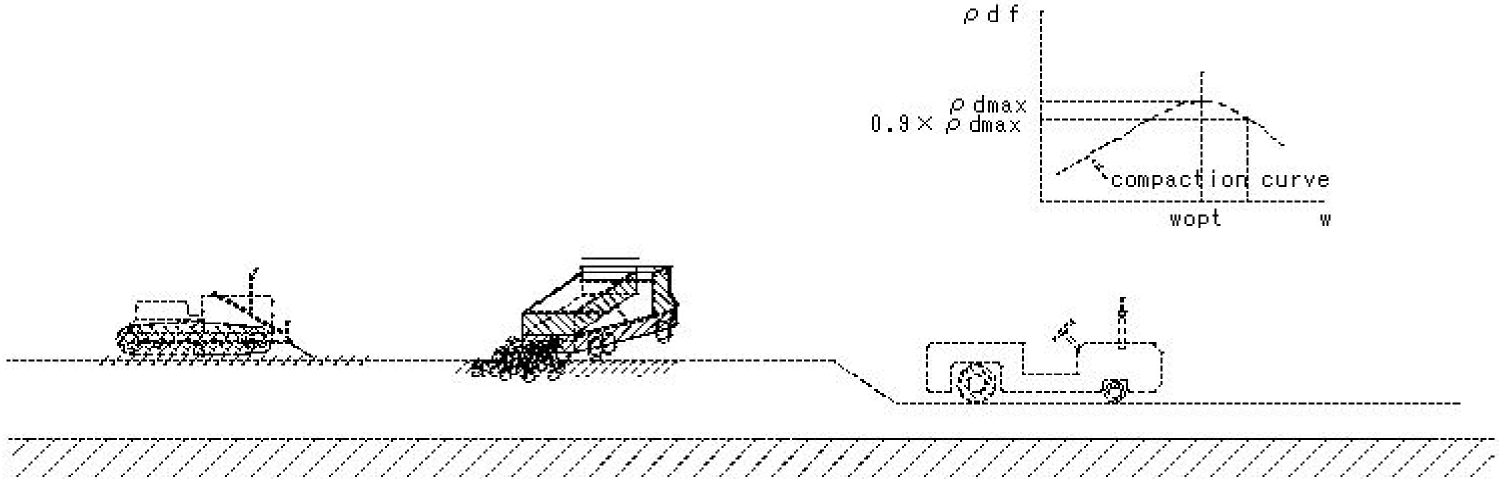
(E73)Embankment compaction criteria-Criteria by dry density

Embankment compaction criteria

Criteria by dry density

- Embankment material - Indoor tamping test
- Maximum dry density $\rho dmax$
- Density when compacted on site: ρd

Compaction degree: $Cd=((\rho d)/(\rho dmax))*100\%$



(E74)Embankment compaction criteria-Criteria by dry density

(E74)Embankment compaction criteria-Criteria by dry density

Embankment compaction criteria

Criteria by dry density

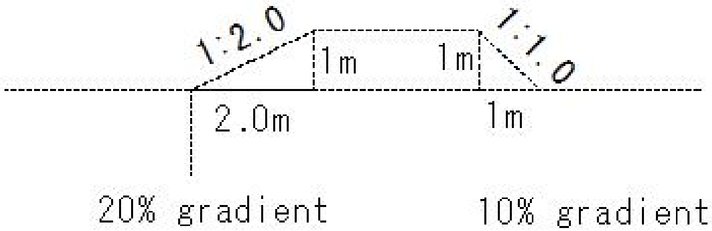
・Road embankment

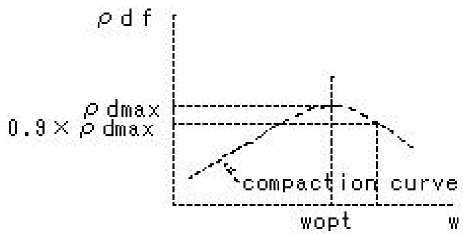
Cd≧90%　　Cd≧85%

・River embankment

Cd≧85%

Slope of slope　1 height　lateral length　1:2.0





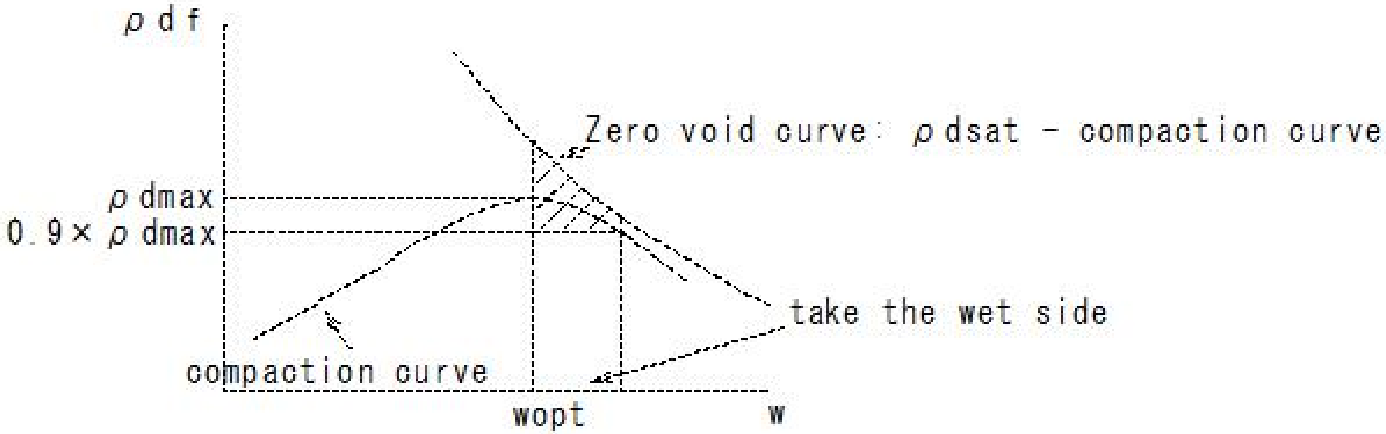
(E75)Embankment compaction criteria-Criteria based on saturation

(E75)Embankment compaction criteria-Criteria based on saturation

Embankment compaction criteria

- Criteria based on saturation
- Embankment material for cohesive soil with high water content
- Pay attention to the water content of cohesive soil
- For roads

  Saturation 85%<Sr<95%



- Compaction degree $Cd=((\rho df/\rho dmax)*100(\%)$

(E76)Embankment compaction criteria

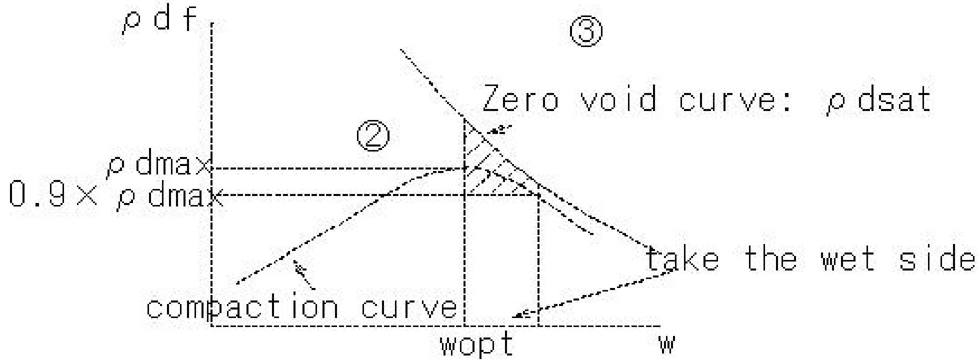
(E76)Embankment compaction criteria

Embankment compaction criteria

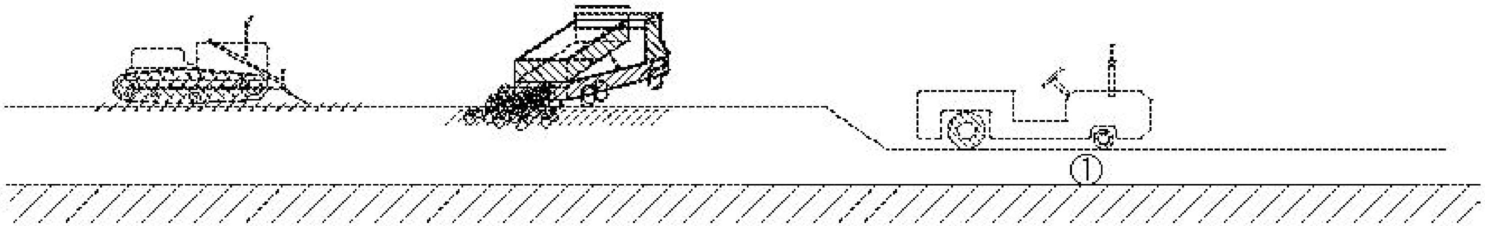
①Rock masses and cobblestones: Standards for compaction strength
Standards for construction methods

②Criteria for dry density

③Criteria for saturation



・Compaction degree Cd=((ρdf/ρdmax)*100(%)

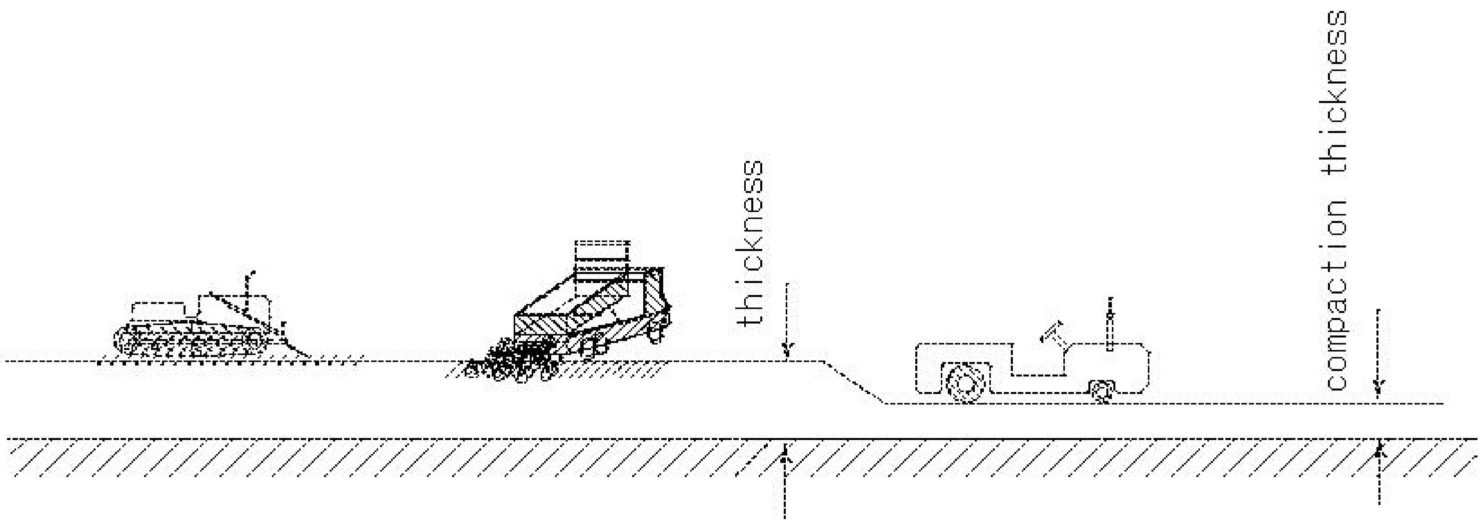


(E77)Embankment construction

(E77)Embankment construction

Embankment construction

- leveling and compaction
- leveling thickness (unrolled thickness) 20-50 cm
- Compaction thickness after compaction 20-30 cm

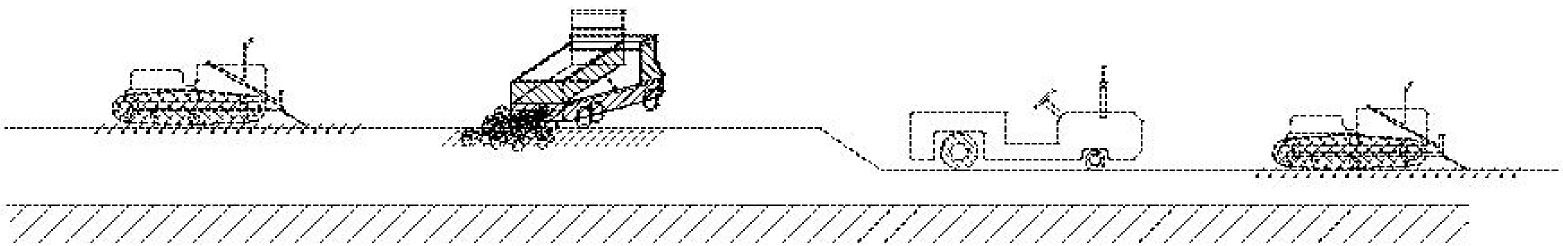


(E78)Embankment construction-Notes on compaction

(E78)Embankment construction-Notes on compaction

Notes on compaction

①Compaction machine depending on embankment material: tire roller, bulldozer



(E79)Embankment construction-Notes on compaction

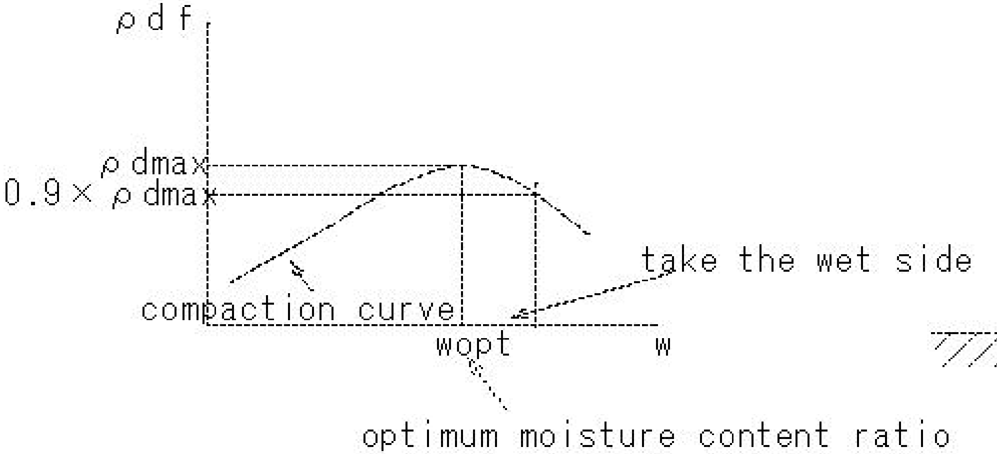
(E79)Embankment construction-Notes on compaction

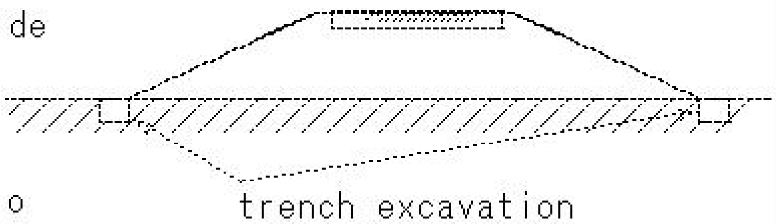
Notes on compaction

②Moisture content ratio of embankment material:

Around the optimum moisture content ratio

Wet side - trench excavation - lowering of water content - compaction





・Compaction degree Cd=((ρdf/ρdmax)*100(%)

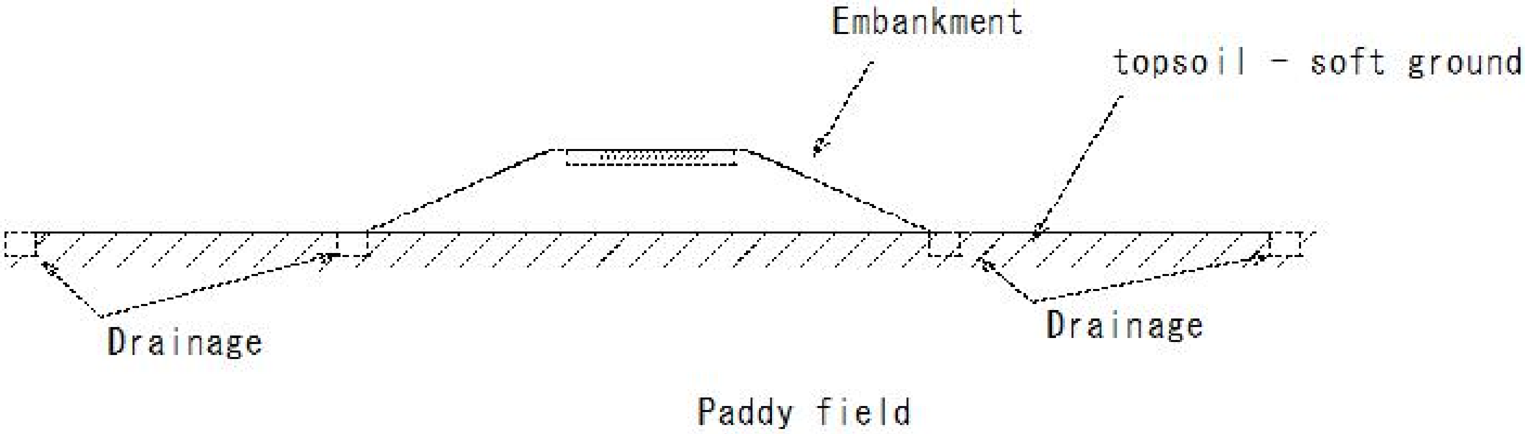
(E80)Embankment construction-Notes on compaction

(E80)Embankment construction-Notes on compaction

Notes on compaction

③Paddy field - foundation ground - topsoil - soft ground

Embankment outside - Drainage



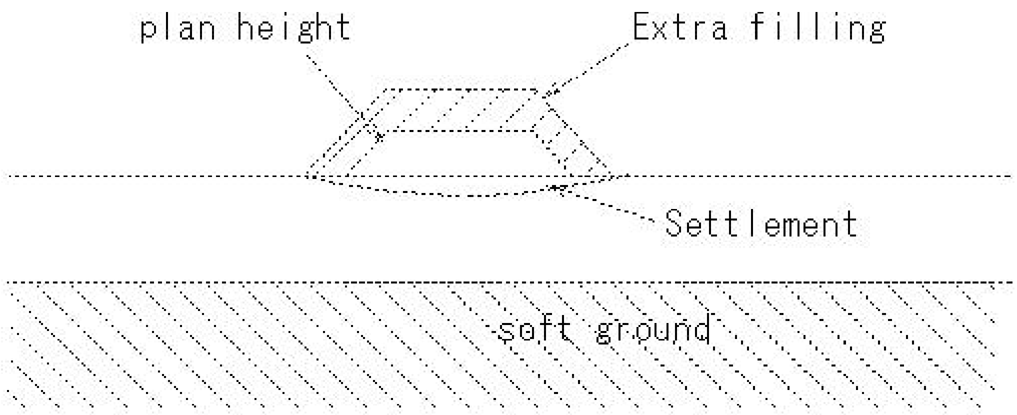
(E81)Embankment construction-Notes on compaction

(E81)Embankment construction-Notes on compaction

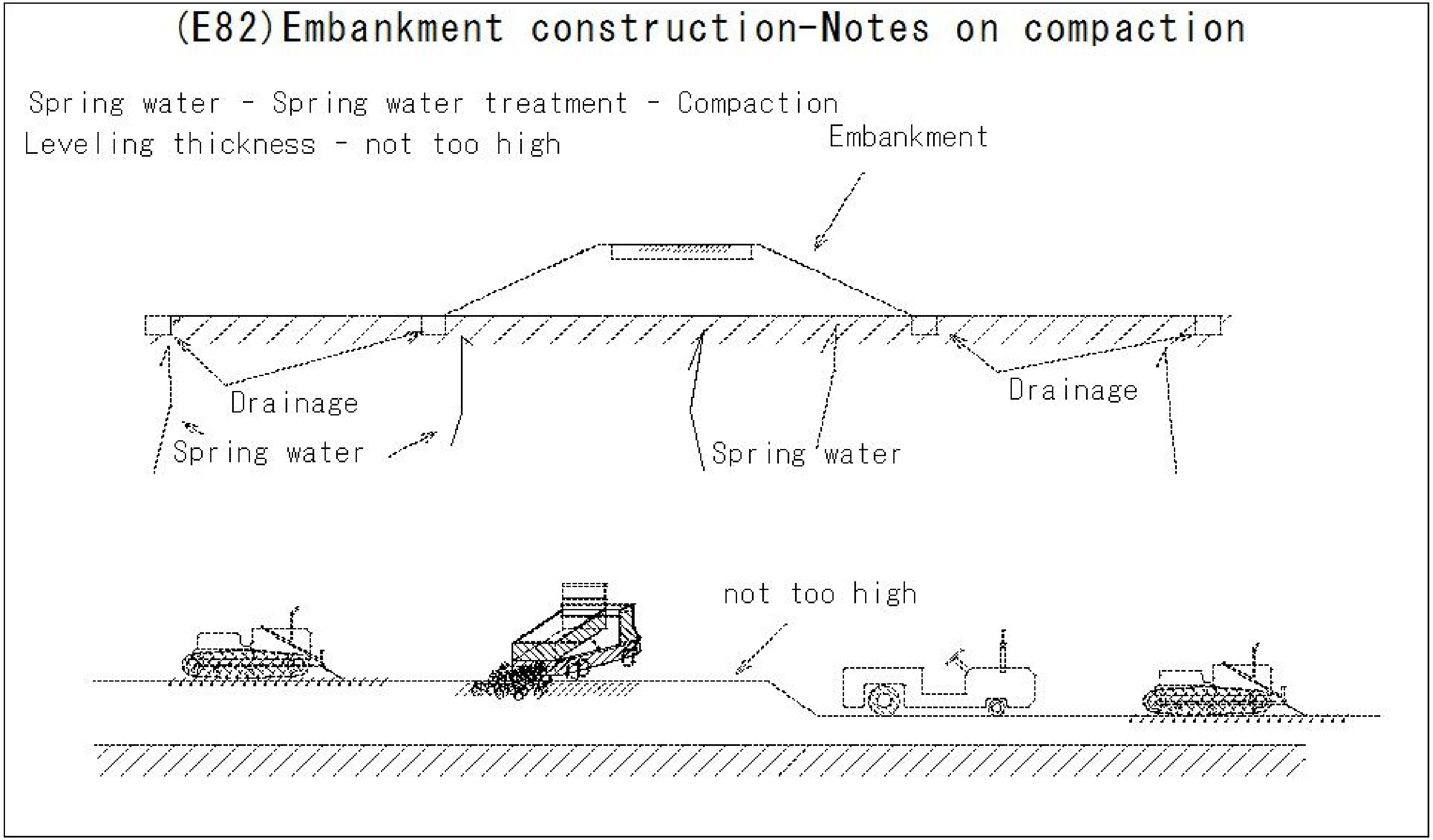
Embankment -Settlement

Top, Slope surface, Small steps-Extra filling

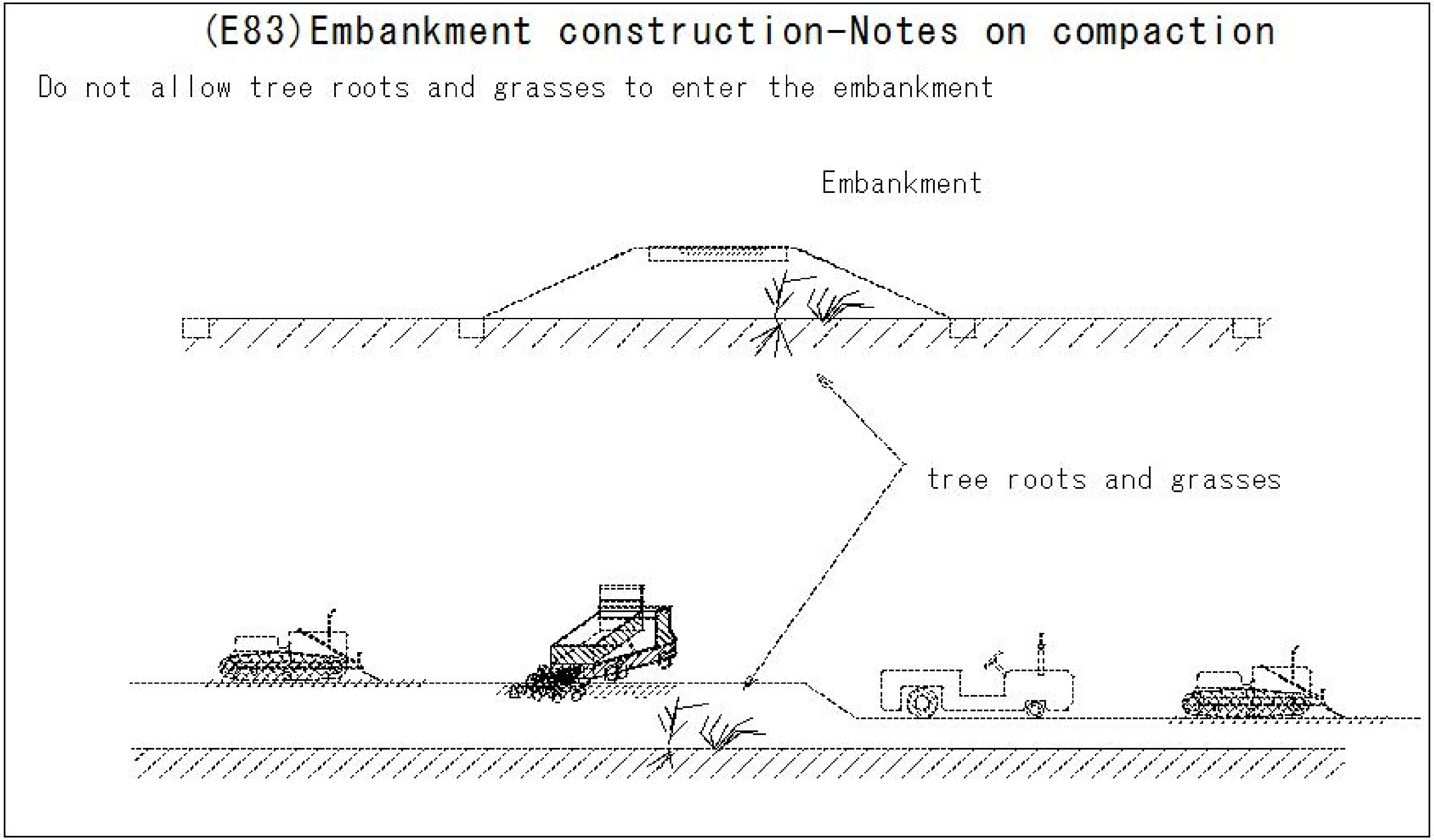
Top, slope surface, Small steps-Extra filling



(E82)Embankment construction-Notes on compaction



(E83)Embankment construction-Notes on compaction



(E84)Embankment construction-Notes on compaction

(E84)Embankment construction-Notes on compaction

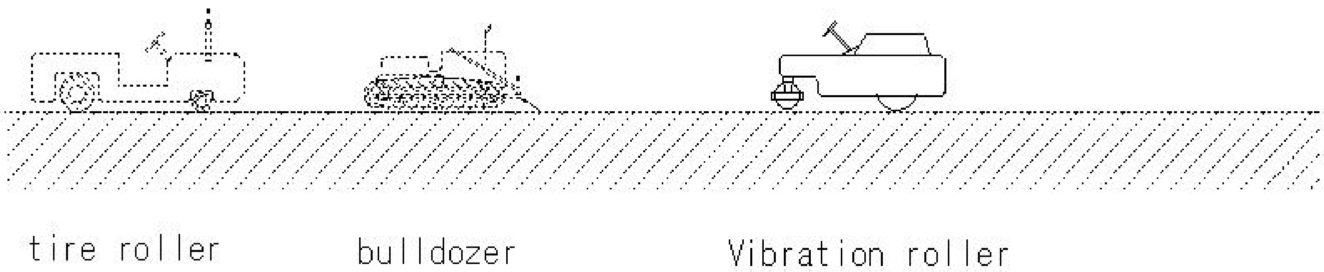
Selection of construction machinery according to soil quality

①High water content silt, clay, etc. - Less kneading - Wetland bulldozer

②Decomposed granite soil containing fine particles ・Mountain gravel - tire roller

③Sandy soil/Fine-grained rock - Vibration roller

④Compaction of hard clay - tamping roller

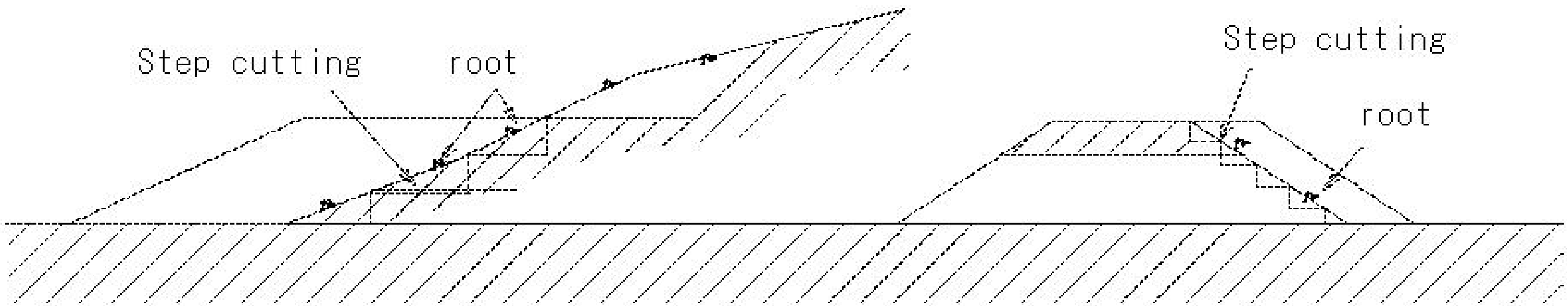


(E85)Embankment precautions-Step cutting construction

(E85)Embankment precautions-Step cutting construction

Step cutting construction

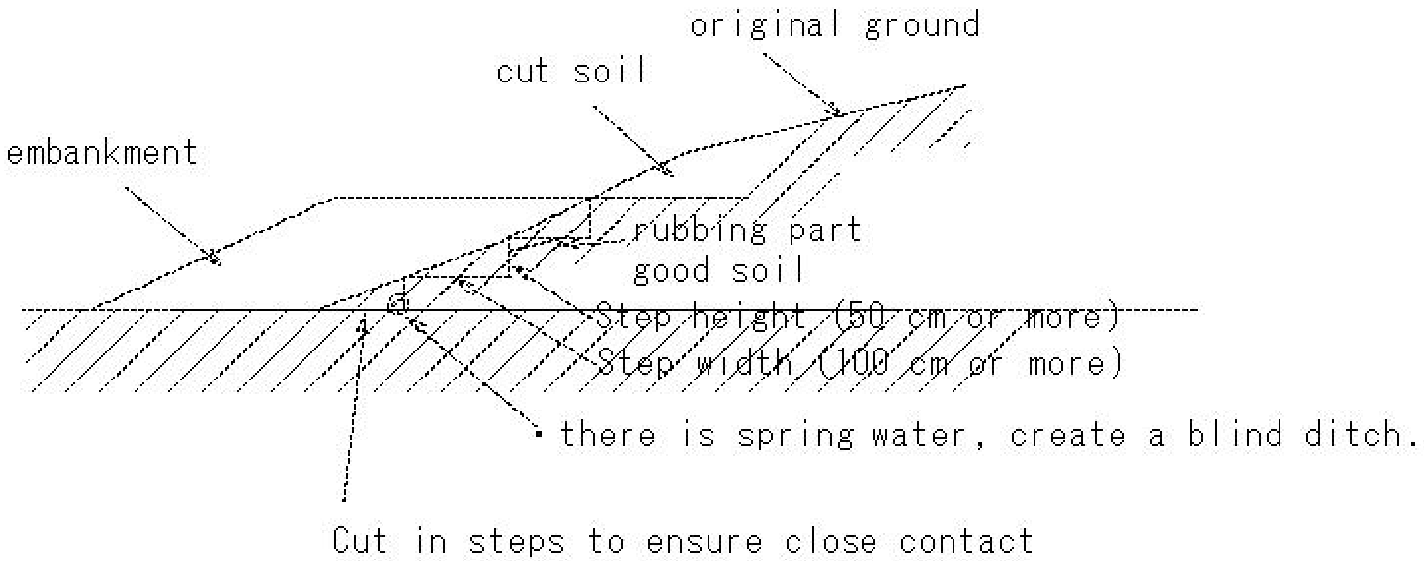
- Step cutting/clearing root - from the necessary part
- Leave for a long time - no good



(E86)Embankment precautions-Step cutting construction

(E86)Embankment precautions-Step cutting construction

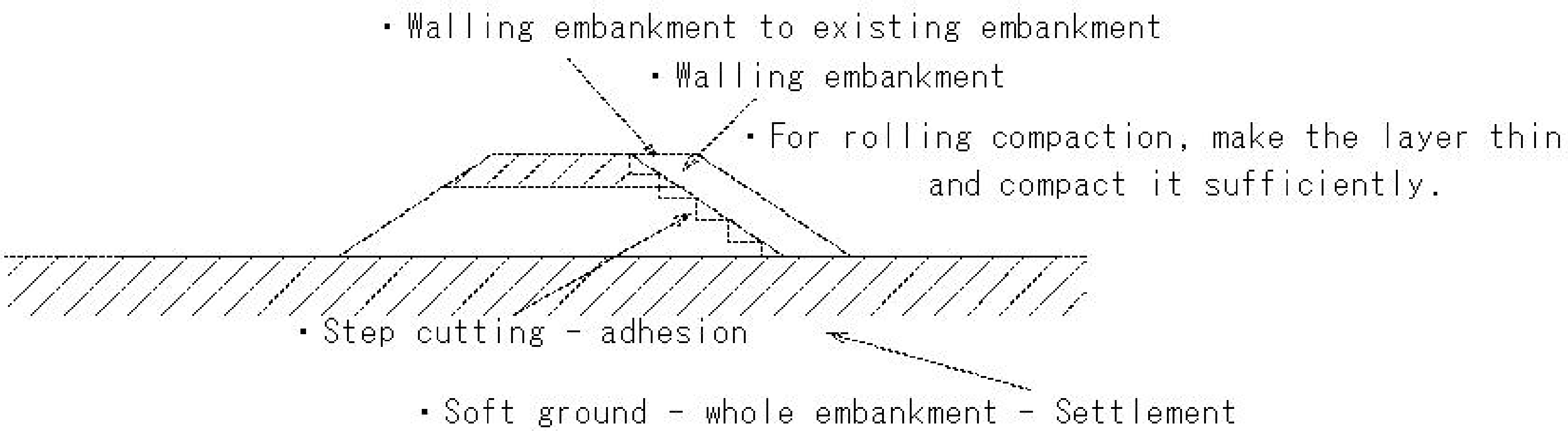
・Embankment and cut soil are sloped with the same cross-section



(E87)Embankment precautions-Walling embankment

(E87)Embankment precautions-Walling embankment

Embankment precautions-Walling embankment

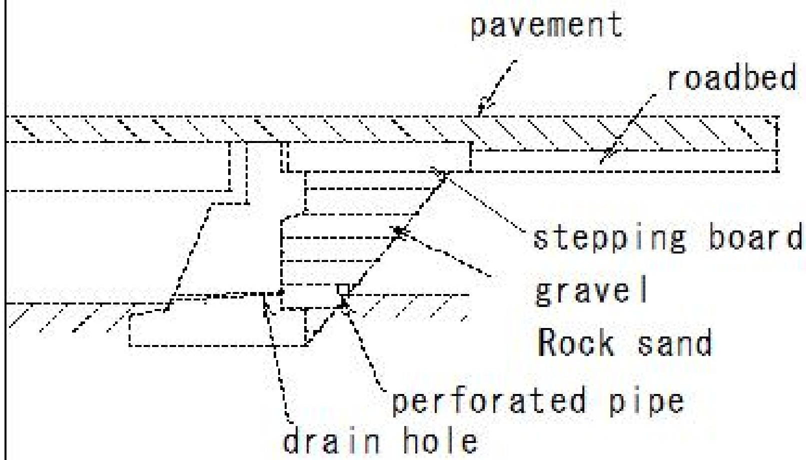


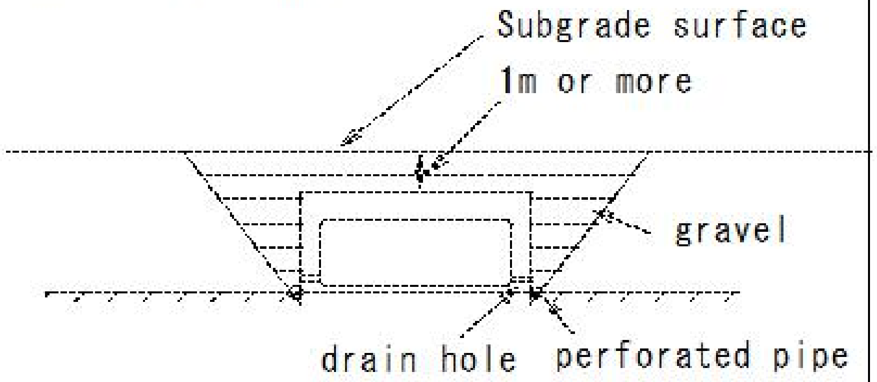
(E88)Embankment-structures and embankments

(E88)Embankment-structures and embankments

structures and embankments

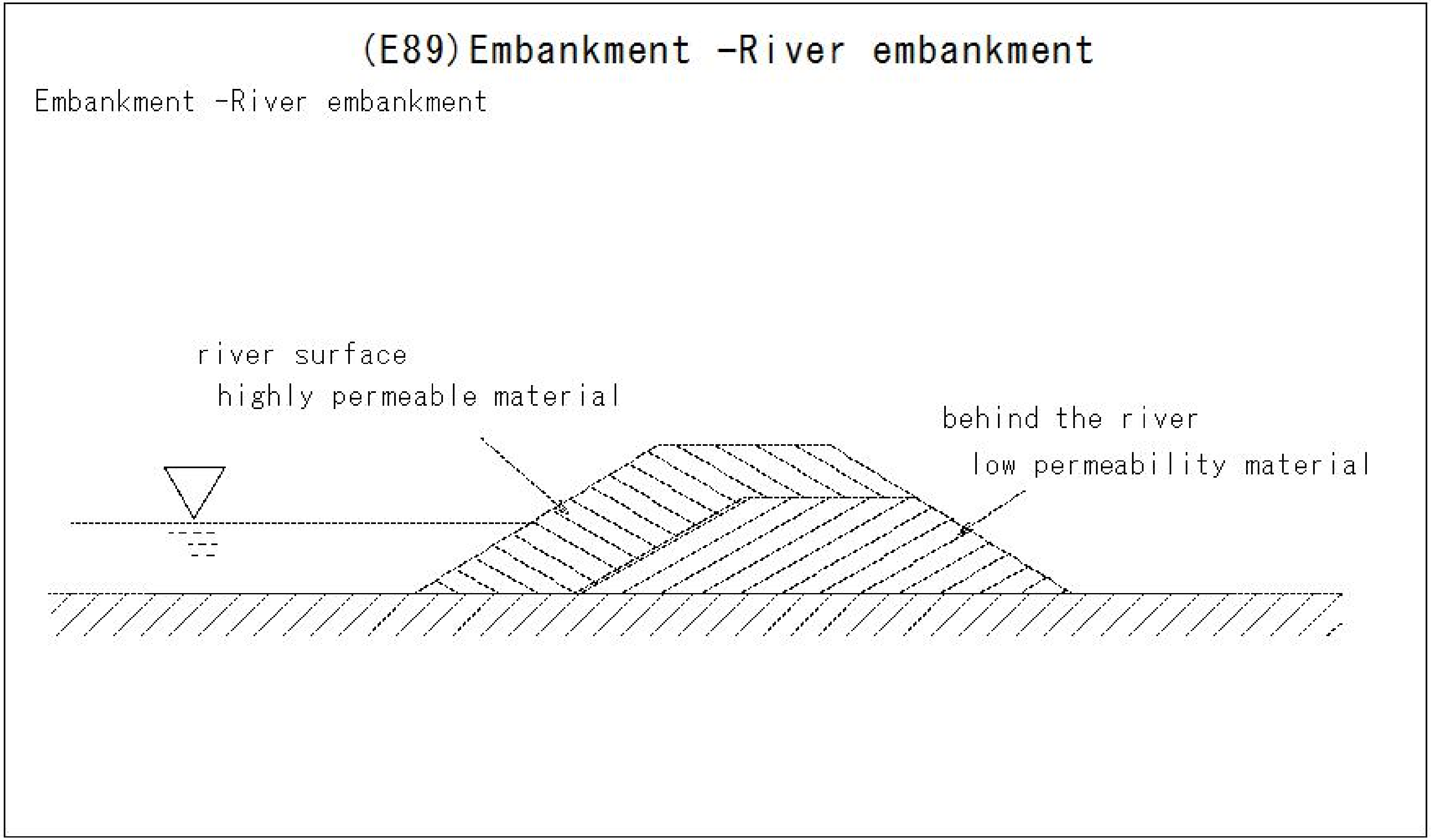
①Connecting point of embankment and structure
②Embankment -Settlement
③Joint part - good soil
④Structures - Avoid knitting pressure
⑤Thin layer - symmetrical - compaction
⑥Connection part - stepping plate - installation
⑦Compacting machine - vibration compactor, rammer, tamper





Culvertoe embankment

(E89)Embankment -River embankment



(E90)Embankment foundation ground

(E90)Embankment foundation ground

Embankment foundation ground

Foundation Ground Problems

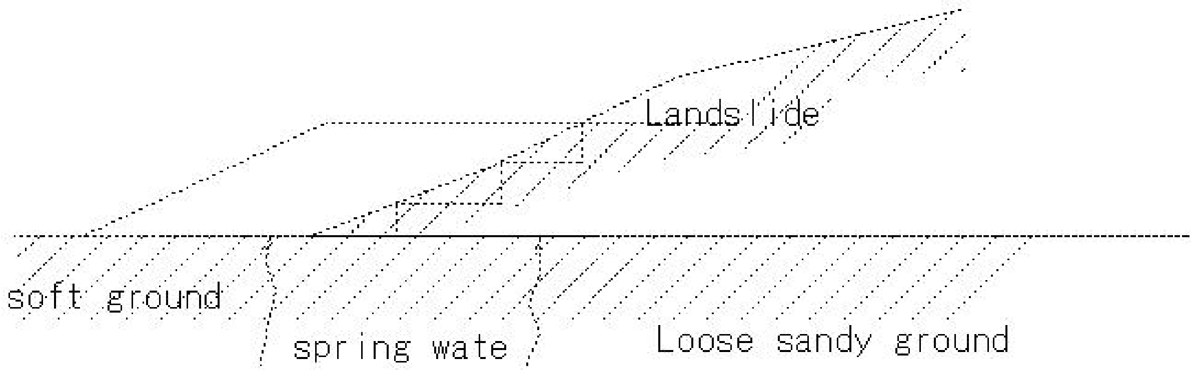
(1) Clay/silt/Peat saturated soft ground

(2) Loose sandy ground Ground that is prone to fluidization due to earthquakes...

Sand pile driving (Standard Penetration Test N<10)

(3) Landslide-prone ground: Countermeasures against landslides

(4) Steeply sloped ground with spring water: wastewater treatment



(E91)Embankment foundation ground-Soft ground judgment

(E91)Embankment foundation ground-Soft ground judgment

Soft ground judgment

Standard penetration test	cone penetration test	Measures for foundation ground
N value (times)	qc (kgf/cm2)	
N≧4	qc≧4	No countermeasure required
2≦N<4	2≦qc<4	Consider settlement
N<2	qc<2	Measures for stability and settlement

Cone index qc < 4 Soft ground

Soft ground judgment

Type of soil	Water content test	Uniaxial compression test	Consideration and countermeasures for
	(%)	(kgf/cm2)	stability and subsidence
nothing special	40 or less	0.6 or more	no problem
clay	40-70	0.4-0.6	Consideration of settlement
clay	70-100	0.4 or less	Consideration of settlement
organic clay	100-300	0.4 or less	Settlement and safety study
organic soil	300 or more	0.4 or less	Settlement and safety study

Cone index qc < 4 Soft ground

(E92)Embankment foundation ground-Settlement calculation of soft ground

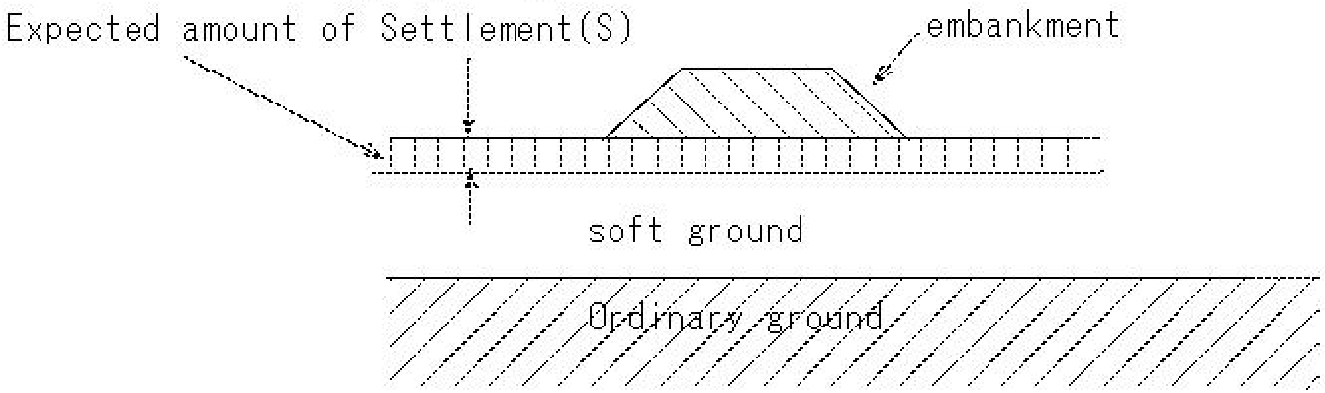
(E92) Embankment foundation ground-Settlement calculation of soft ground

Settlement calculation of soft ground

①Calculation of consolidation settlement amount S

②Calculation of consolidation settlement time t

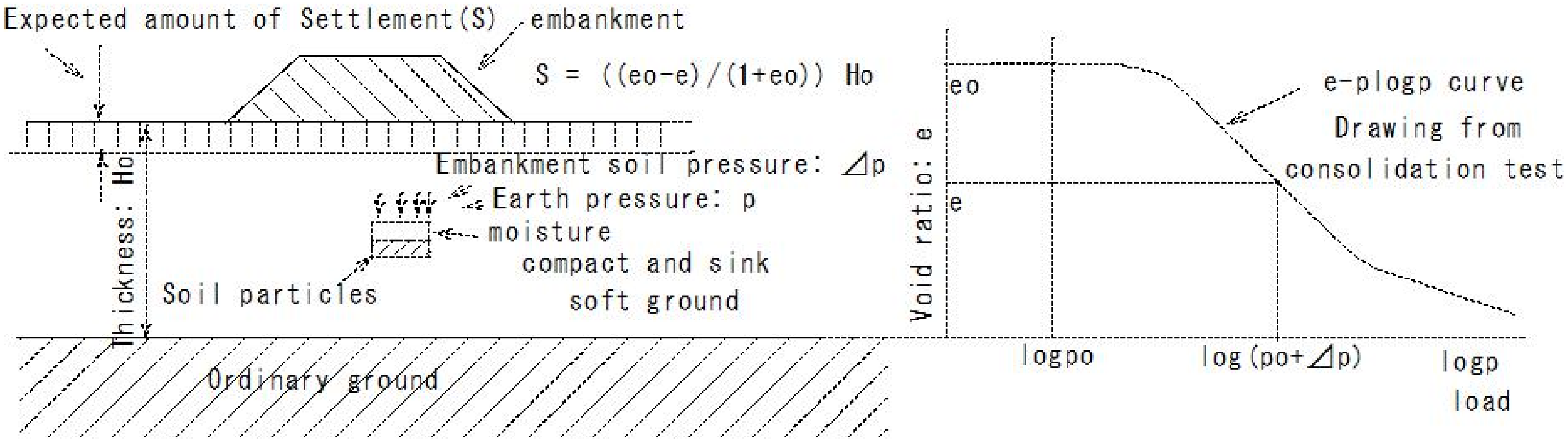
- Embankment - long-term pressure Soft ground
- A large amount of water - pressure - water is squeezed out
- Exhausted water - Cavity
- Cavity - Embankment - Settlement
- Soft ground - consolidation settlement
- A large amount of water is discharged
- Soil-bearing capacity



(E93)Embankment foundation ground-Settlement calculation of soft ground

(E93)Embankment foundation ground-Settlement calculation of soft ground

Settlement calculation of soft ground



Settlement calculation of soft ground

- Consolidation settlement S
  - Consolidation test
  - Load po
  - Void ratio eo
  - Pressure increase due to embankment ⊿p
  - Soft layer thickness Ho
  - Time required for consolidation settlement t

Settlement amount

Expected amount of subsidence

(E94)Embankment foundation ground-Settlement time

(E94)Embankment foundation ground-Settlement time

Settlement time

$t = ((TH^2)/(cv))$

H: Drainage distance

Consolidation coefficient: cv

Obtained from consolidation test

time factor: t

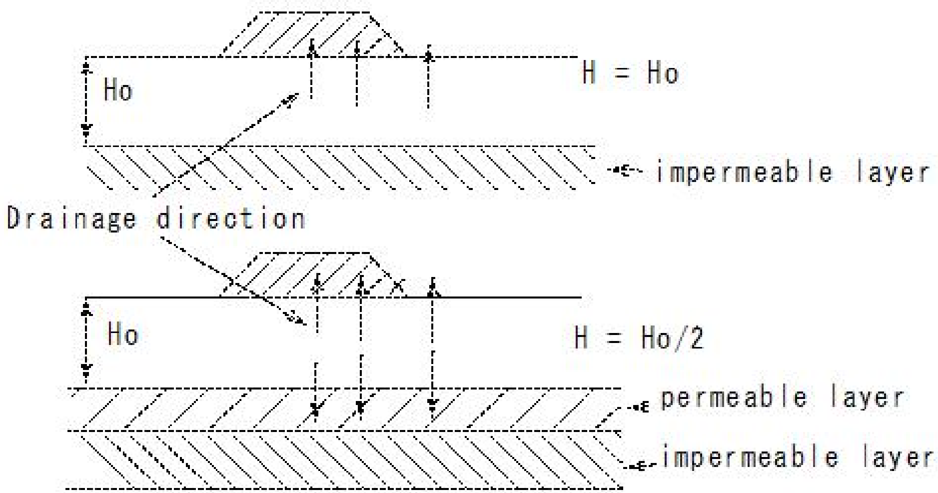
Coefficient of degree of consolidation progress

50%→T≒0.2

70%→T≒0.4

90%→T≒0.8

100%→T≒1.0



basic concept of

soft ground treatment measures

To complete consolidation early

Reduced drainage distance H

(t is shortened in proportion

to the square of H)

(E95)Embankment foundation ground-Soft ground stability calculation

(E95)Embankment foundation ground-Soft ground stability calculation

Soft ground stability calculation

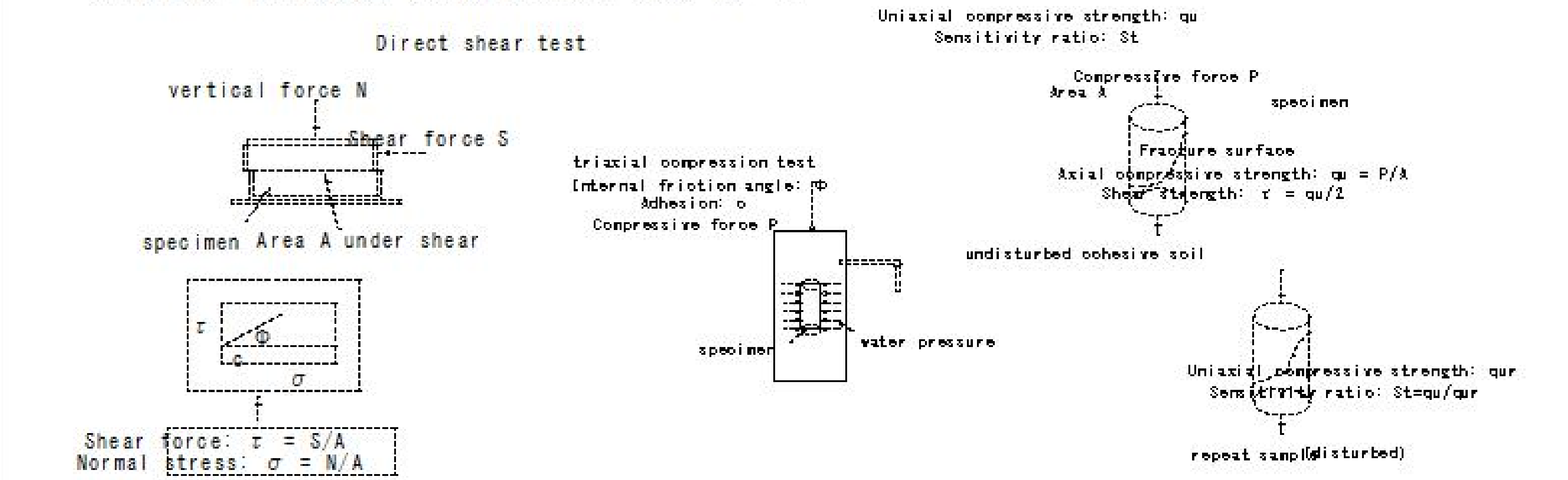
・Arc slip c, Φ

Applied to general soil without considering consolidation phenomenon: total stress method

Direct shear test c and Φ

Applied to soft soil considering consolidation phenomenon: effective stress method

Triaxial Uniaxial compression test c, Φ



(E96)Embankment foundation ground-Soft ground treatment

(E96)Embankment foundation ground-Soft ground treatment

Soft ground treatment

① Concept of soft layer (standard penetration test N value 10 or less)

loose sand layer

- Loose sand layer containing water

Fluidization - bearing capacity - declining due to earthquake

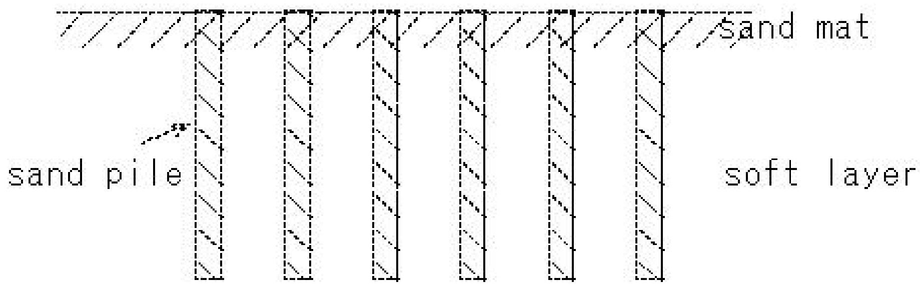
- Prevention measures

sand piling - driving

Sand soil compaction

Fluidization - Prevention

Sand drain method



(E97)Embankment foundation ground-Soft ground treatment

(E97)Embankment foundation ground-Soft ground treatment

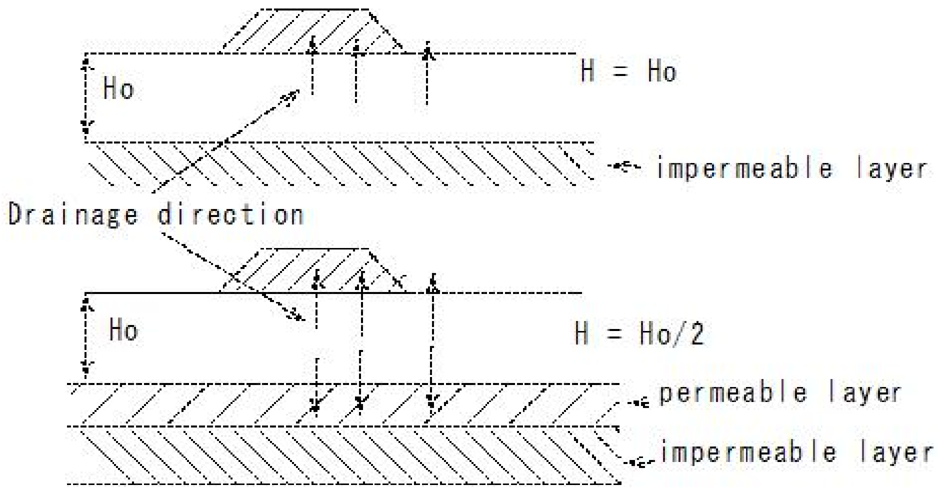
②Concept of soft layer (standard penetration test N value 4 or less)

- Soft layer - consolidation settlement - early
- Consolidation settlement rate $t = TH^2/cv$

Consolidated water drainage distance proportional to the square of H

Shortening H is effective

Consolidation drainage distance: Shorten H



basic concept of
soft ground treatment measures

To complete consolidation early
Reduced drainage distance H
(t is shortened in proportion
to the square of H)

(E98)Embankment foundation ground- Slow construction method

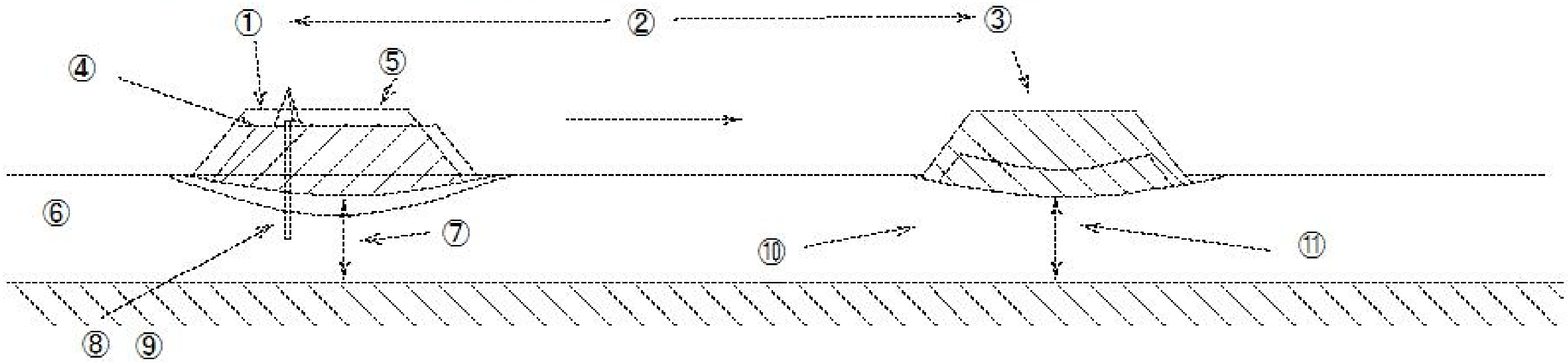
(E98)Embankment foundation ground- Slow construction method

Soft ground countermeasure construction method

- Compact the ground
- Drainage distance - shortened

1 Slow construction method

①Within the bearing capacity of soft ground
②Wait for the bearing capacity of the soft ground to increase so that the arc slip does not occur.
③Embankment against ground bearing capacity after consolidation
④Embankment after consolidation settlement
⑤Embankment before deformation
⑥Soft ground
⑦Soil after consolidation
⑧Soil survey
⑨Find the bearing capacity of the soil against the ground after consolidation
⑩Calculate the ground bearing capacity after consolidation
⑪Continue until the bearing capacity for the specified embankment is reached



(E99)Embankment foundation ground-Sand mat construction method

(E99)Embankment foundation ground-Sand mat construction method

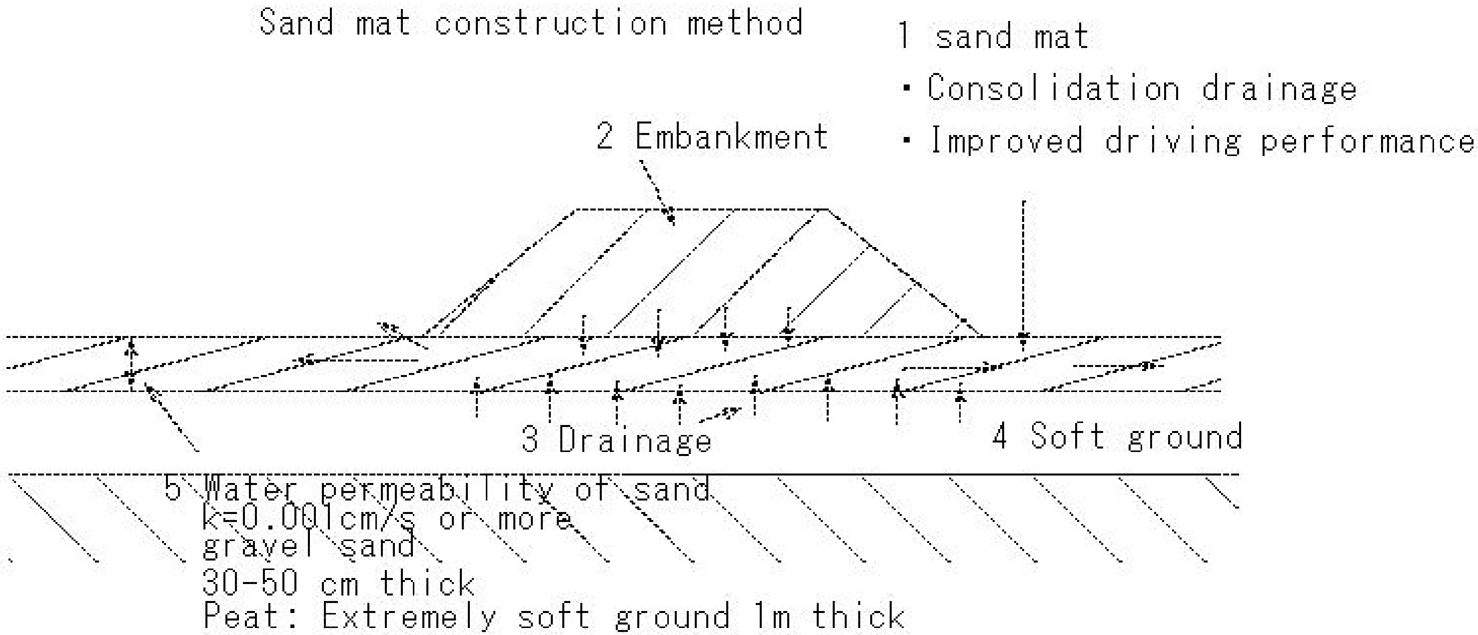
2 Sand mat construction method

①Spread sand with good permeability on the soft ground

②Improved trafficability of construction machinery

③Drainage route from soft ground

④Combined with other construction methods

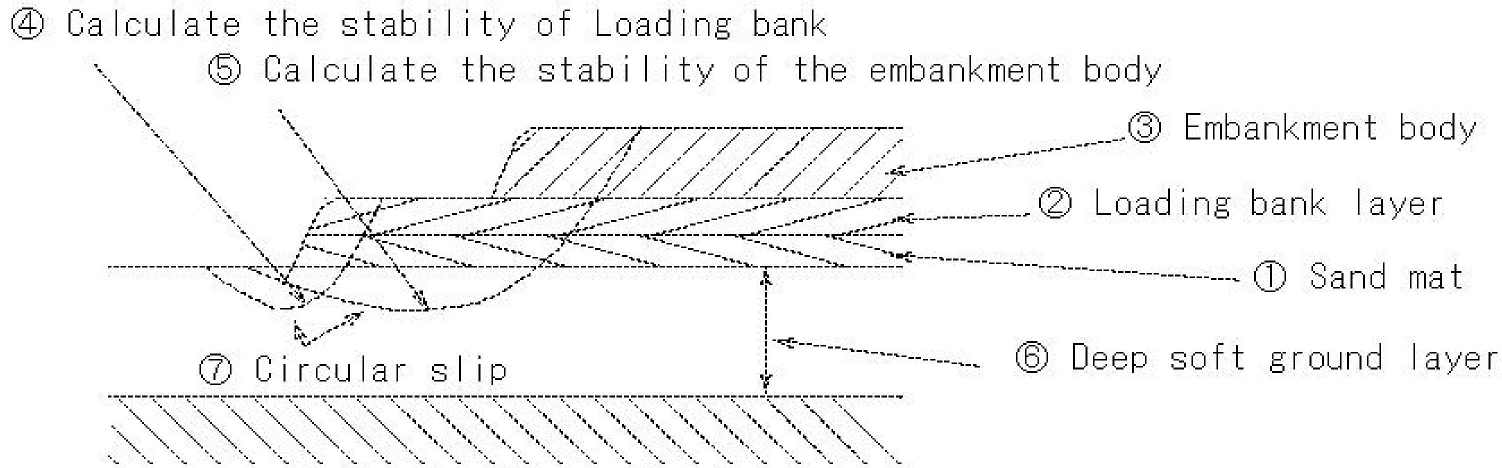


(E100)Embankment foundation ground-Loading bank method

(E100)Embankment foundation ground-Loading bank method

3 Loading bank method

① Prevention of embankment slippage failure
② Increase slip resistance
③ Soft layer - thick
④ Combined with sand drain construction method



3 Loading bank method

(E101)Embankment foundation ground-Preloading method

(E101)Embankment foundation ground-Preloading method

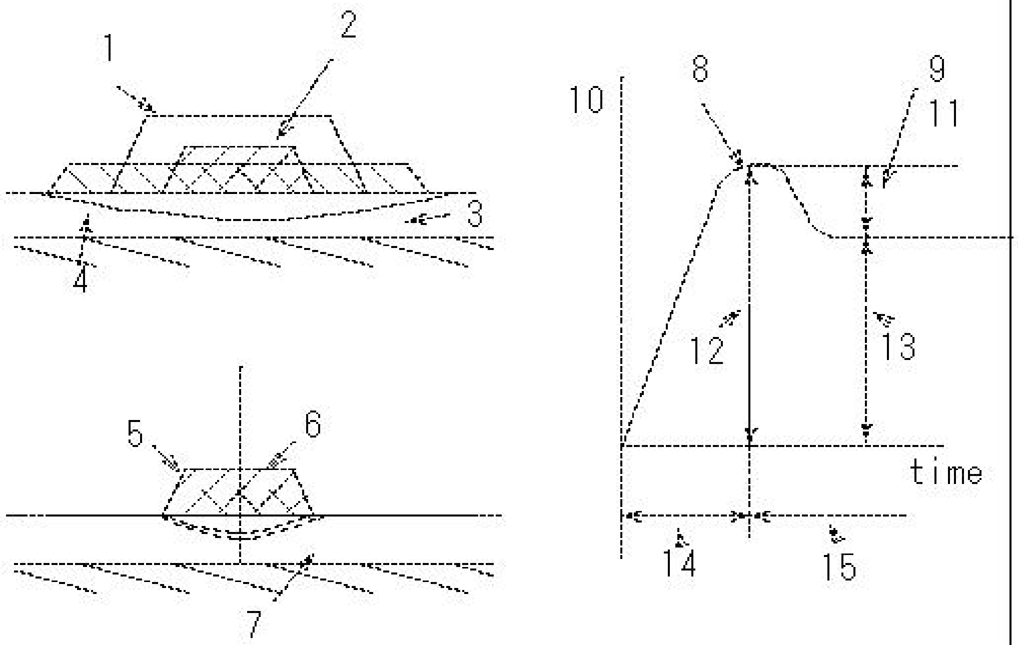
Preloading method

①Load the weight to be embanked

②Settlement

③Extra weight (preload): surcharge method

1 Preload height
2 Planned amount
3 Poor ground
4 Using a construction method to lower the groundwater level
5 Planned amount
6 Preload removal
7 Consolidation completed ground
8 Preload consolidation completion point
9 Residual settlement amount SR
10 Settlement amount
11 Organic soil is large
12 Total settlement amount
13 Planned settlement amount
14 preload height
15 Planned amount



(E102)Embankment foundation ground-Removal and replacement method

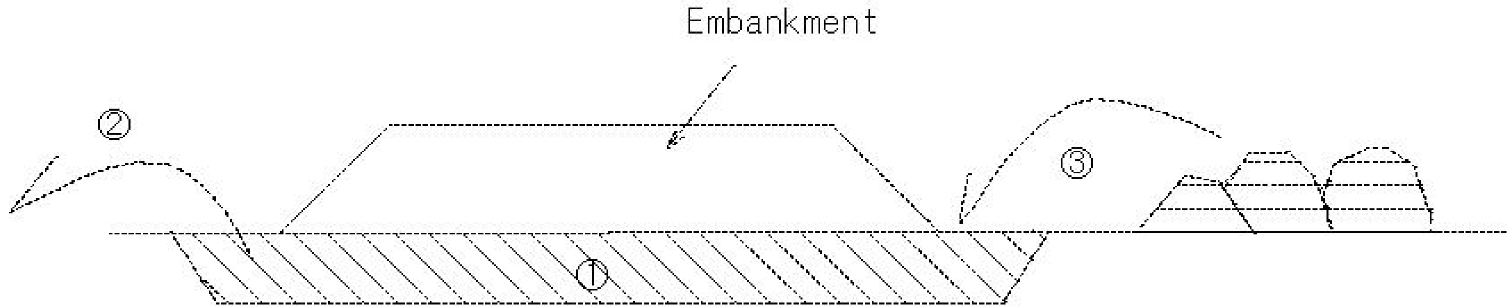
(E102)Embankment foundation ground-Removal and replacement method

Removal and replacement method

① Poor layer - shallow

② Poor ground -excavation and removal

③ Good soil - replacement



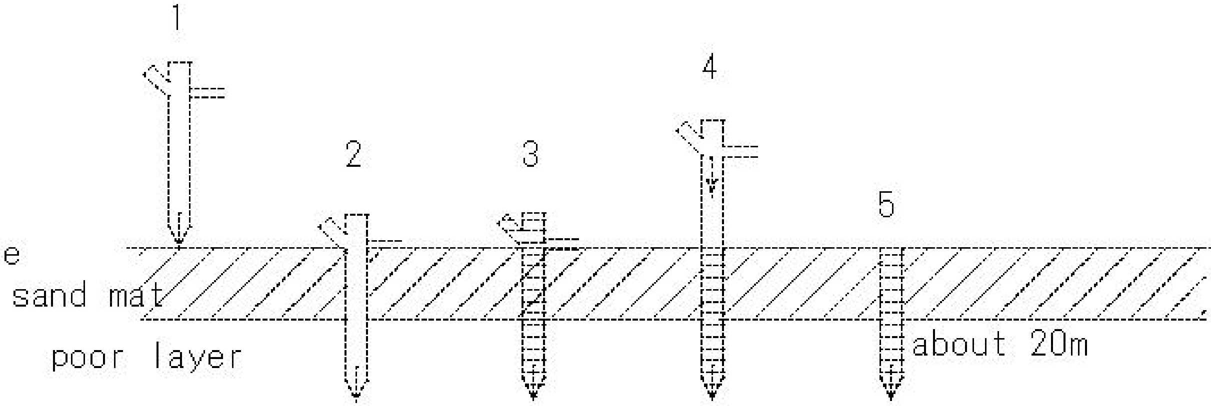
(E103)Embankment foundation ground-Sand drain method

(E103)Embankment foundation ground-Sand drain method

Drain method

1 Cohesive soil poor ground
2 Artificial drainage channel (drain)
3 Drainage distance - short
4 Sand pile (bearing capacity - no)

1 Mandrel
poor layer
Compressed air
2 Driving
3 Add sand
4 Compressed air
5 Pull out the sand pile
about 20m



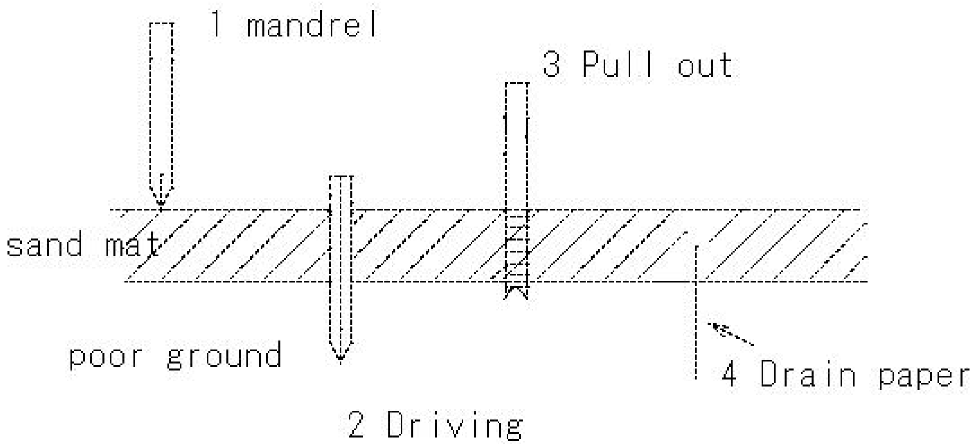
Sand drain method

(E104)Embankment foundation ground-Paper drain method

(E104)Embankment foundation ground-Paper drain method

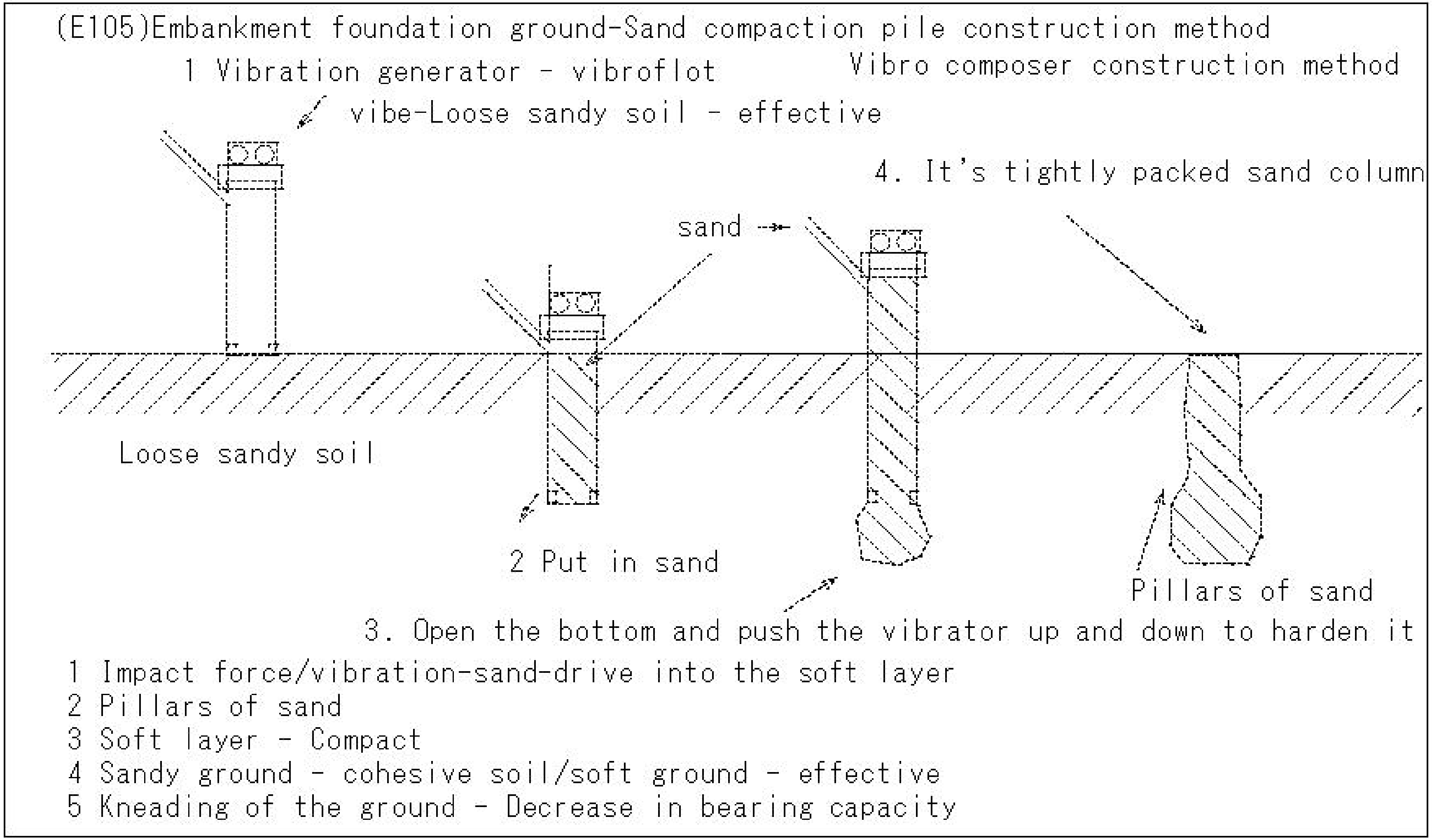
Paper drain method

- Cardboard/perforated cardboard fiber
- Drain construction method - acceleration of consolidation settlement
- Shear strength - increased

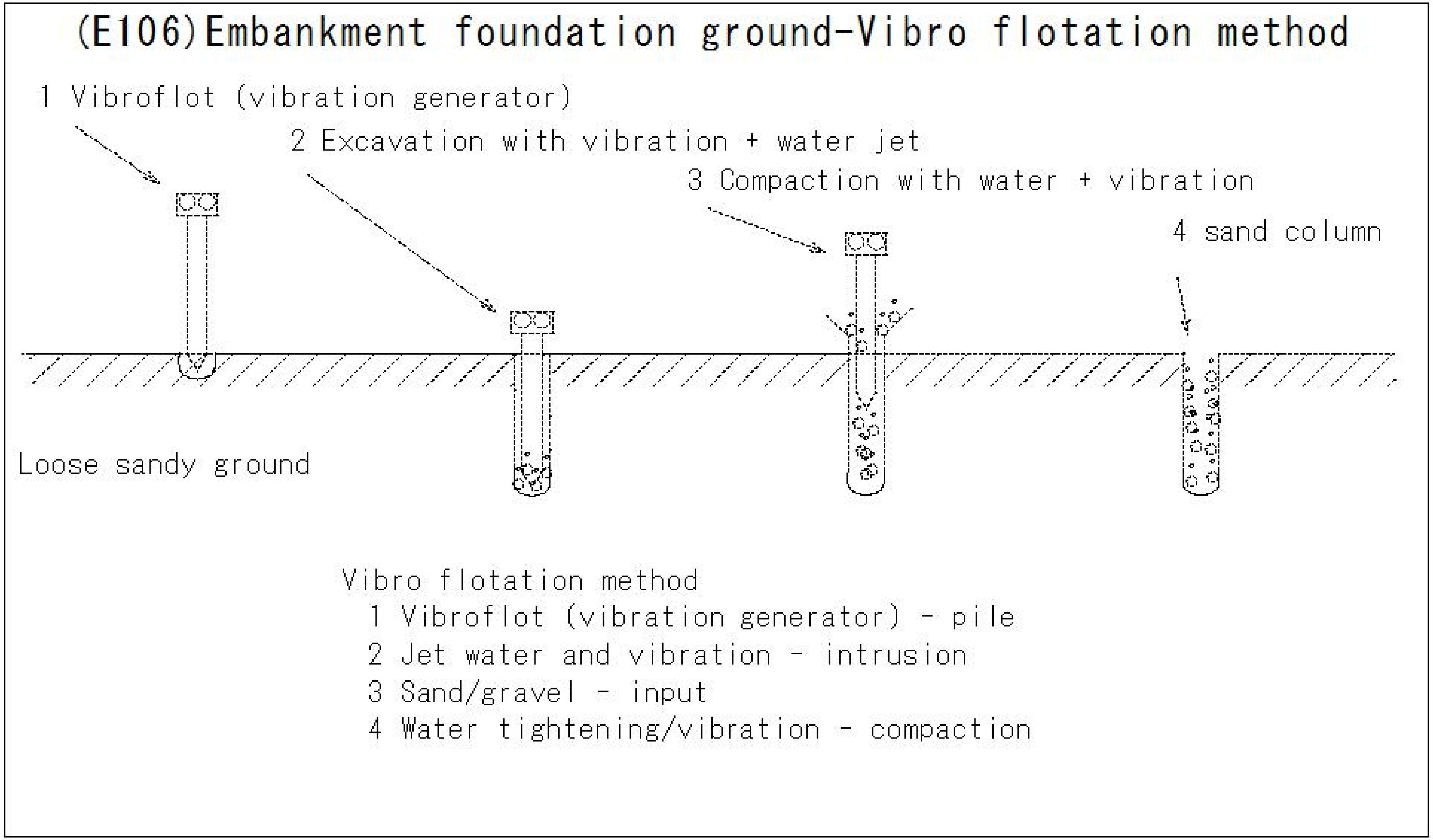


Paper drain method

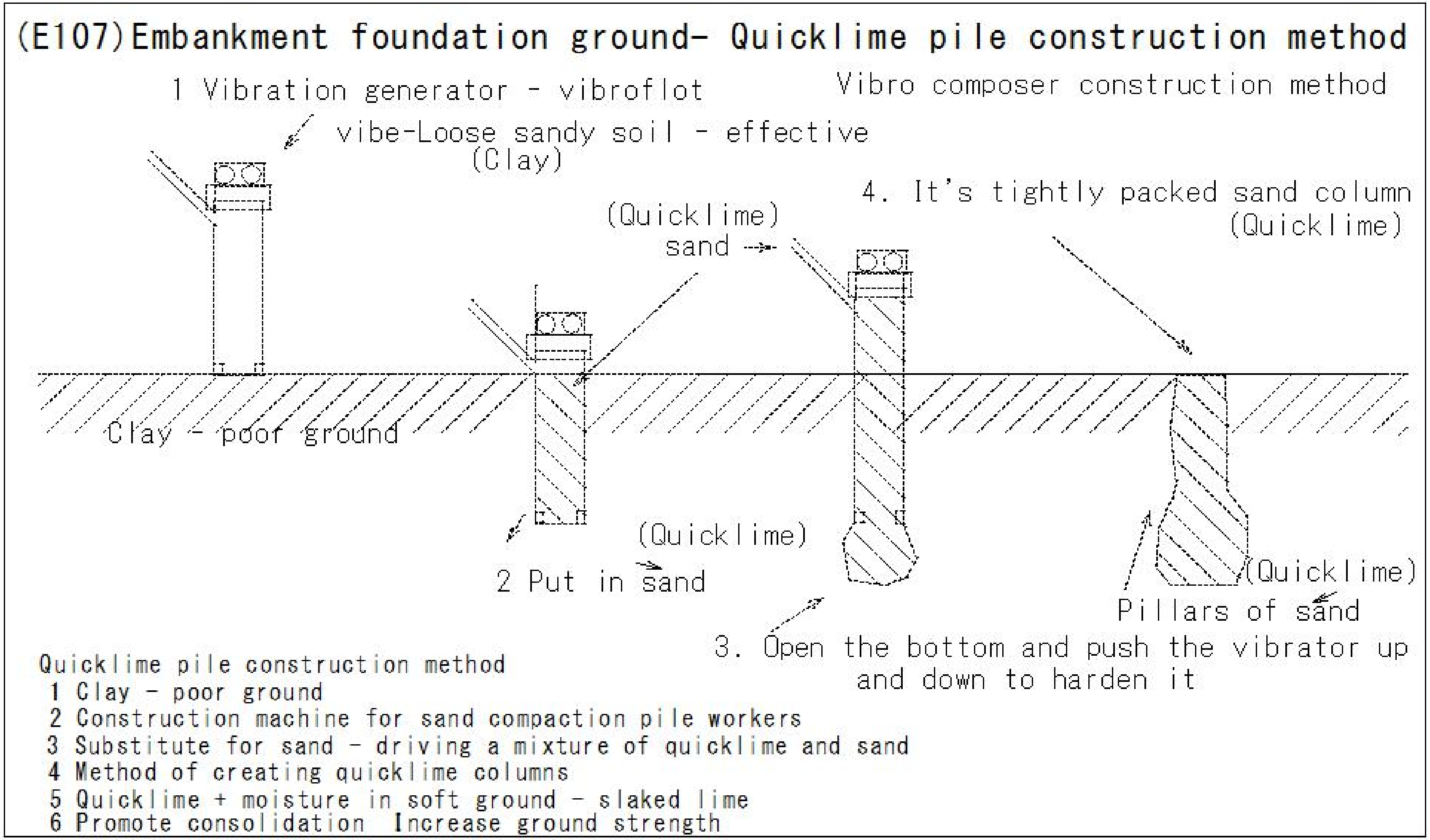
(E105)Embankment foundation ground-Sand compaction pile construction method



(E106)Embankment foundation ground-Vibro flotation method



(E107)Embankment foundation ground- Quicklime pile construction method



(E108)Improvement of soft subgrade-Blocking layer

(E108)Improvement of soft subgrade-Blocking layer

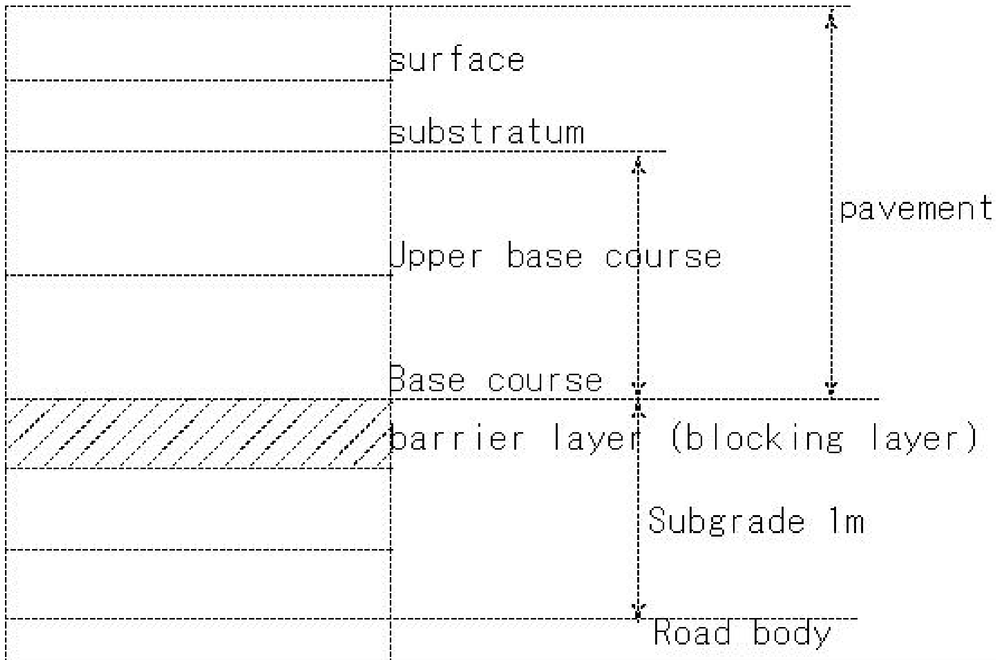
Improvement of soft subgrade

1 Blocking layer

1 Subgrade bearing capacity less than CBR Value 3

2 Blocking layer: river sand/cut gravel

3 Roll compaction with a small soil compactor, a light roller, and a bulldozer

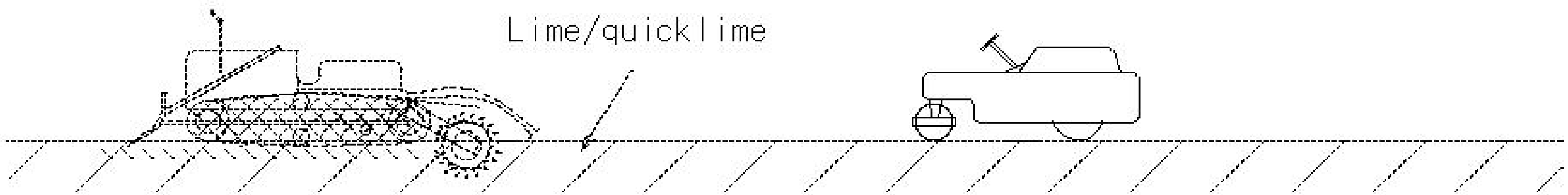


(E109)Improvement of soft subgrade-Stabilization method-Lime/quicklime

(E109)Improvement of soft subgrade-Stabilization method-Lime/quicklime

Stabilization method

1 Lime/quicklime
2 Quicklime for high water content clay - effective
3 Drain during construction
4 Distribute the additive evenly
5.Mix to a predetermined depth
6 Level the surface with a bulldozer
7 Compaction with tire rollers and vibrating rollers
8 Quicklime - Beware of heat generation



(E110)Improvement of soft roadbed-Particle size adjustment method

(E110) Improvement of soft roadbed-Particle size adjustment method

Improvement of soft roadbed

1 Particle size adjustment method

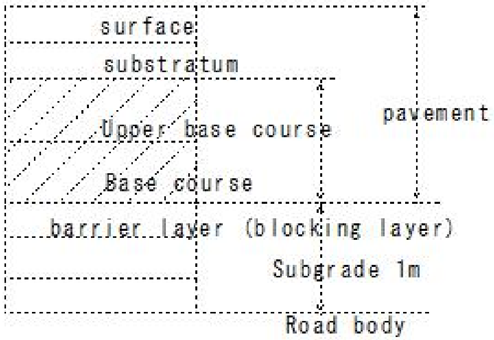
1 Grain size adjustment crushed stone, cut crushed stone, slag, mountain sand mixture

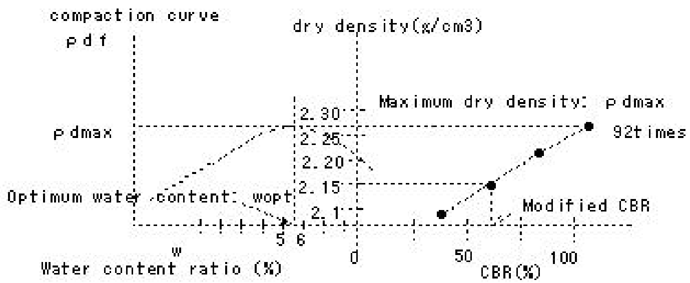
2 Modified CBR 80 or more - mixed at the plant

3 Transportation to the site by dump truck

4 Spread evenly with an aggregate spreader/motor grader

5 Finished thickness of one layer 15 cm or less





Degree of compaction-Modified CBR

(E111)Improvement of soft roadbed-Bitumen stabilization method

(E111) Improvement of soft roadbed-Bitumen stabilization method

Bitumen stabilization method

1 Bitumen material: straight asphalt 4-6%

2 Supplementary material: Add crushed stone and sand and mix at the plant

3 Asphalt shear

4 Compaction with tire rollers and vibrating rollers

(E112)Improvement of soft roadbed-Cement stabilization treatment

(E112) Improvement of soft roadbed-Cement stabilization treatment

Cement stabilization treatment

1 Supplementary materials for local materials
2 Portland cement, blast furnace cement, silica cement, etc. Mixed at the plant
3 After compaction, compact the layer 10-20 cm with a Macadam roller
4 After finishing, spray 0.5-1l/m3 of asphalt emulsion, etc. on the surface

(E113)Improvement of soft roadbed-Lime stabilization work

(E113)Improvement of soft roadbed-Lime stabilization work

Lime stabilization work

1 Mixing local materials with aggregate, fly ash, etc. for grain size adjustment

2 Add lime amount equivalent to unconfined compression strength of 10 kgf/cm2 and mix at the plant

3 Spread evenly with an aggregate spreader/motor grader

4 Finished thickness of one layer 10-20 cm

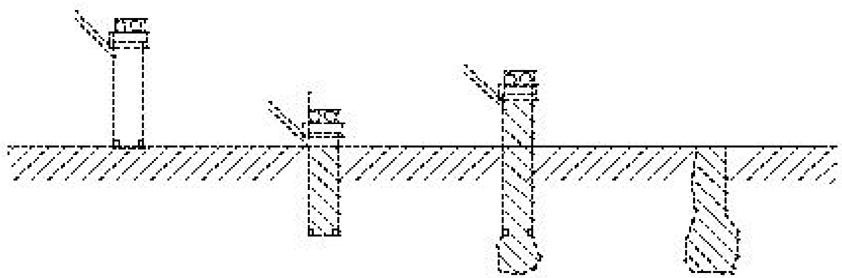
5 Moisture content: Wet side from the optimum moisture content ratio

(E114)Improvement of soft roadbed-Improvement of loose sandy ground

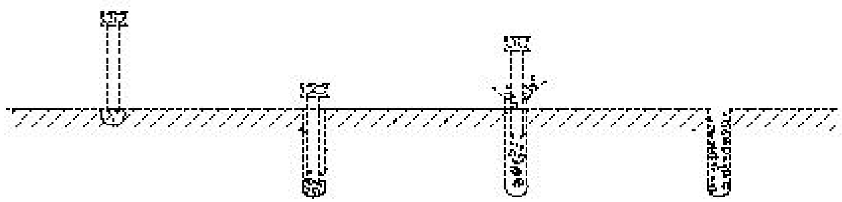
(E114) Improvement of soft roadbed-Improvement of loose sandy ground

Improvement of loose sandy ground

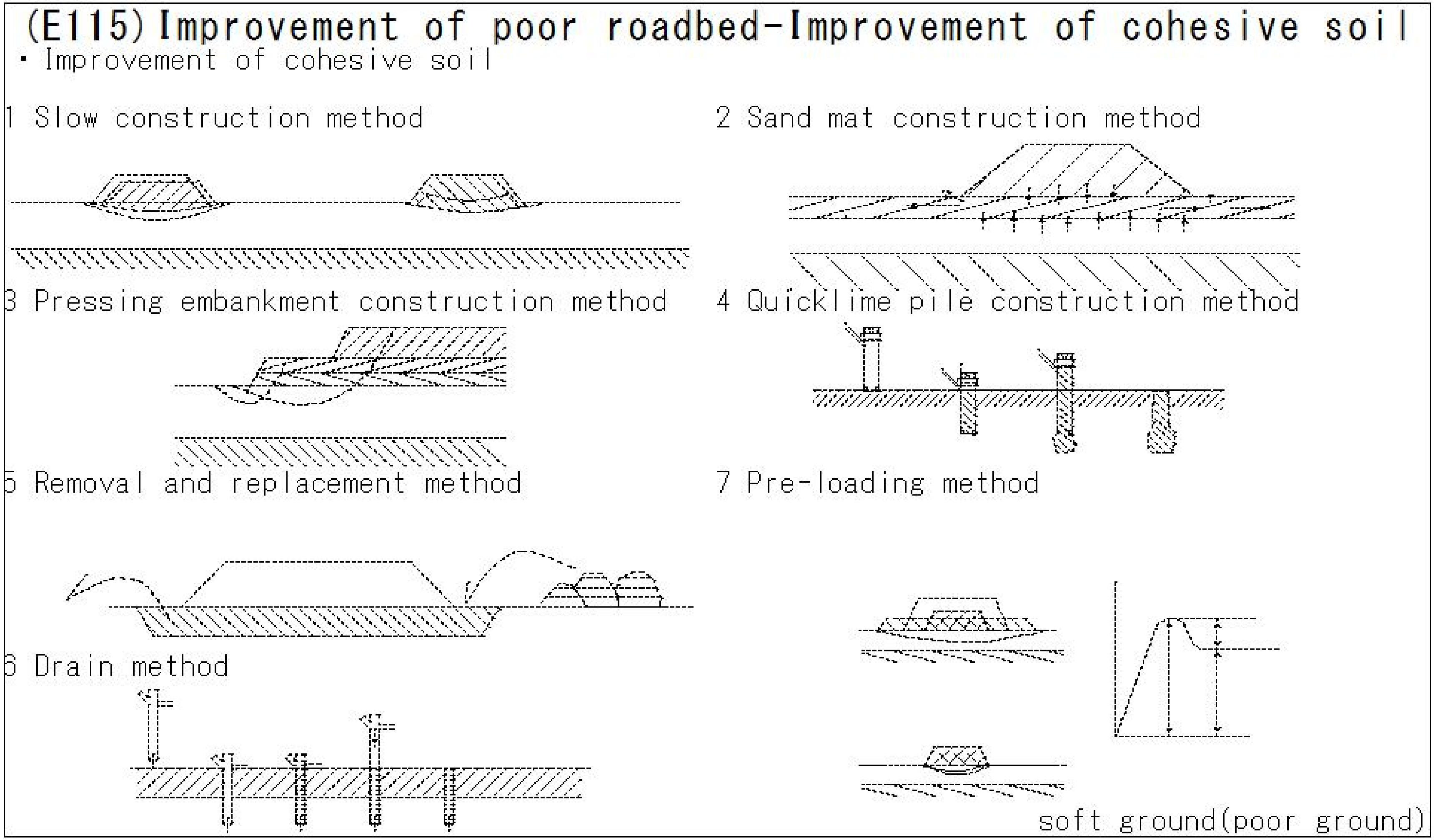
・Sand compaction pile construction method



・Vibro flotation method



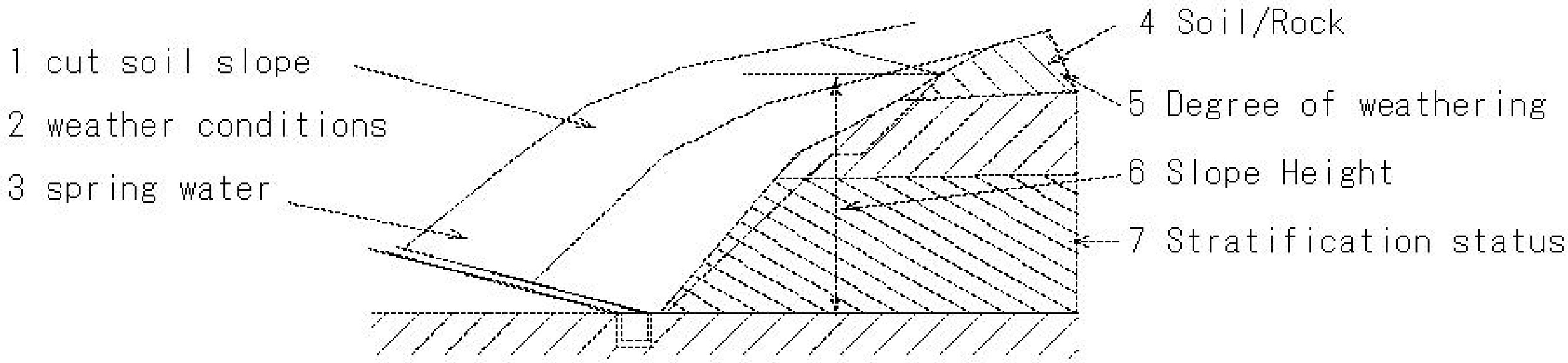
(E115)Improvement of poor roadbed-Improvement of cohesive soil



(E116)Cut soil slope-Determining factor of cut slope slope

(E116)Cut soil slope-Determining factor of cut slope slope

Determining factor of cut slope slope



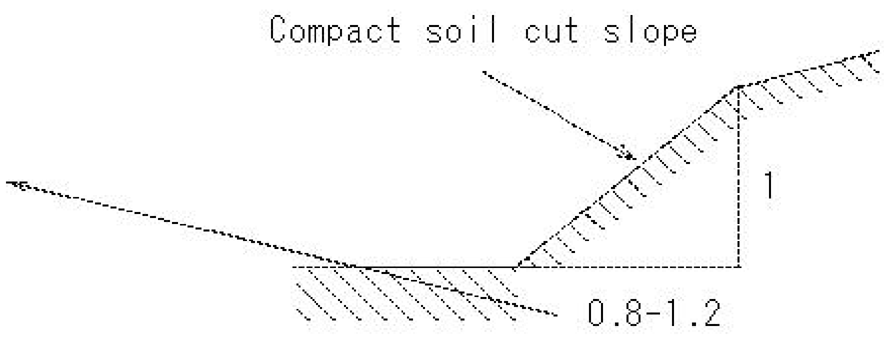
(E117)Cut soil slope-Cut slope standard

(E117)Cut soil slope-Cut slope standard

Cut slope standard

Cut slope standard

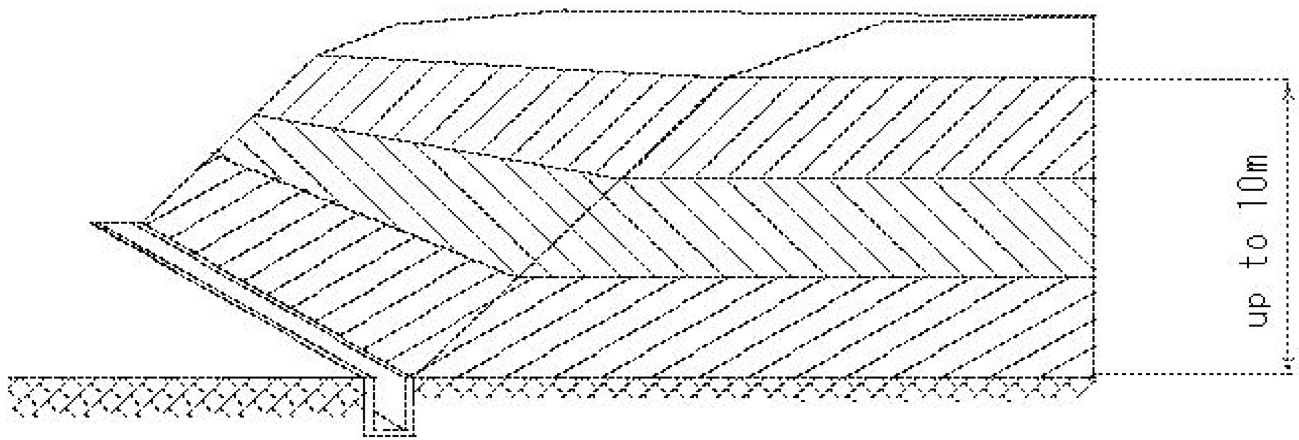
soil/geology	slope gradient
hard rock	1:0.3-1:0.8
soft rock	1:0.5-1:1.2
sand	1:1.5-
firm soil	1:0.8-1:1.2
loose soil	1:1.2-1:1.5



(E118)Cut soil slope- Single slope

(E118)Cut soil slope- Single slope

Cut soil slope- Single slope



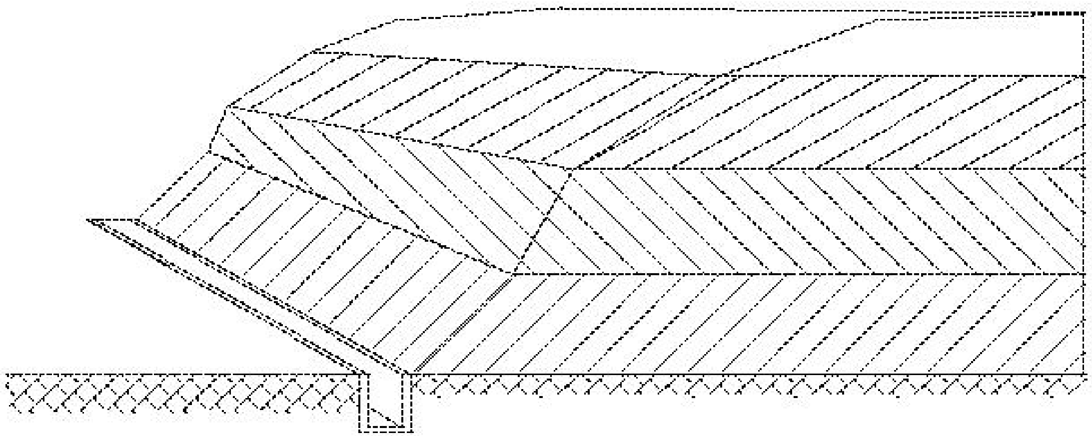
1 Single slope Suitable for homogeneous hard rock with a cutting height of 7-10m

(E119)Cut soil slope- Gradient with change

(E119)Cut soil slope- Gradient with change

Cut soil slope shape

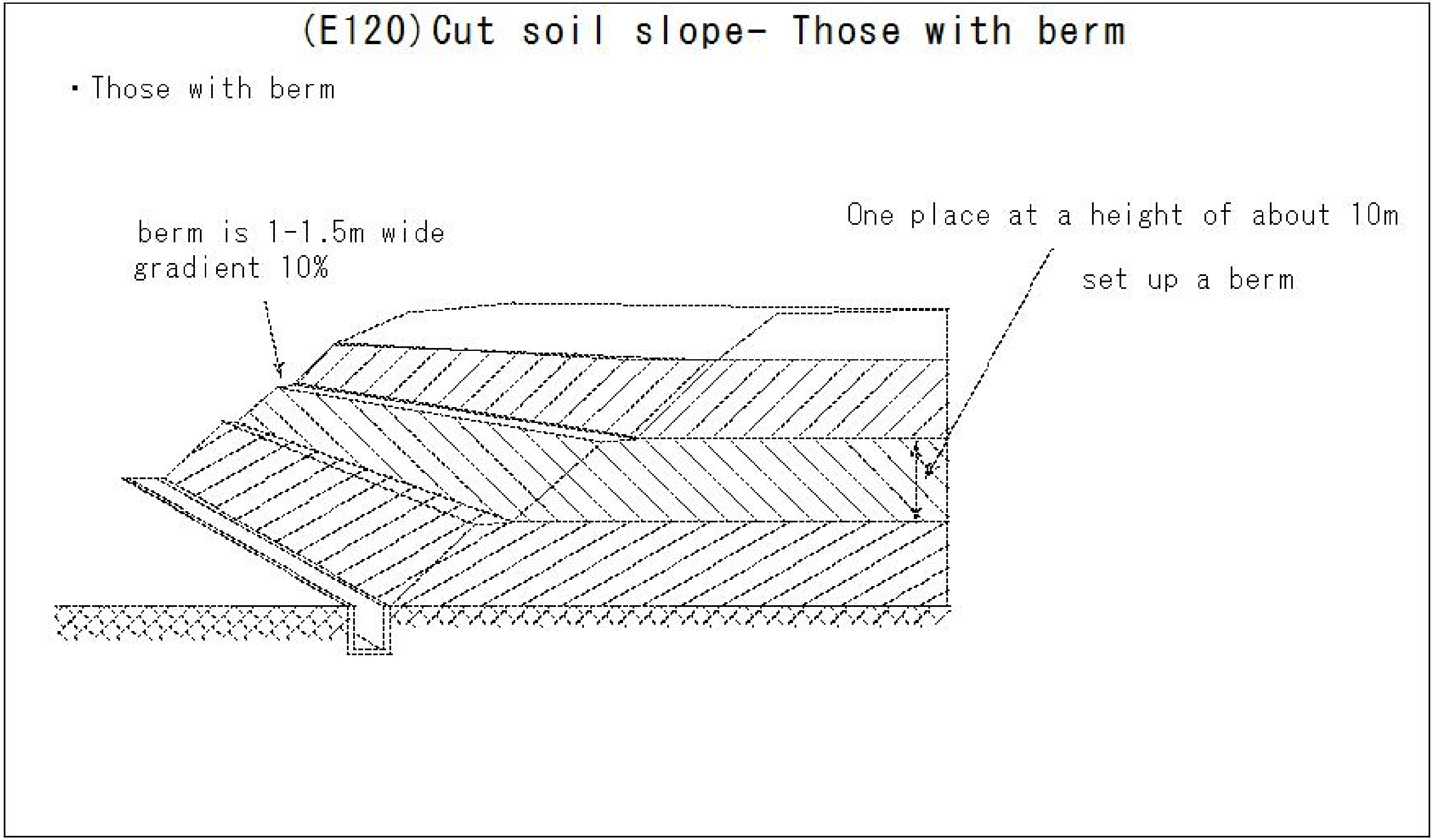
Gradient with change



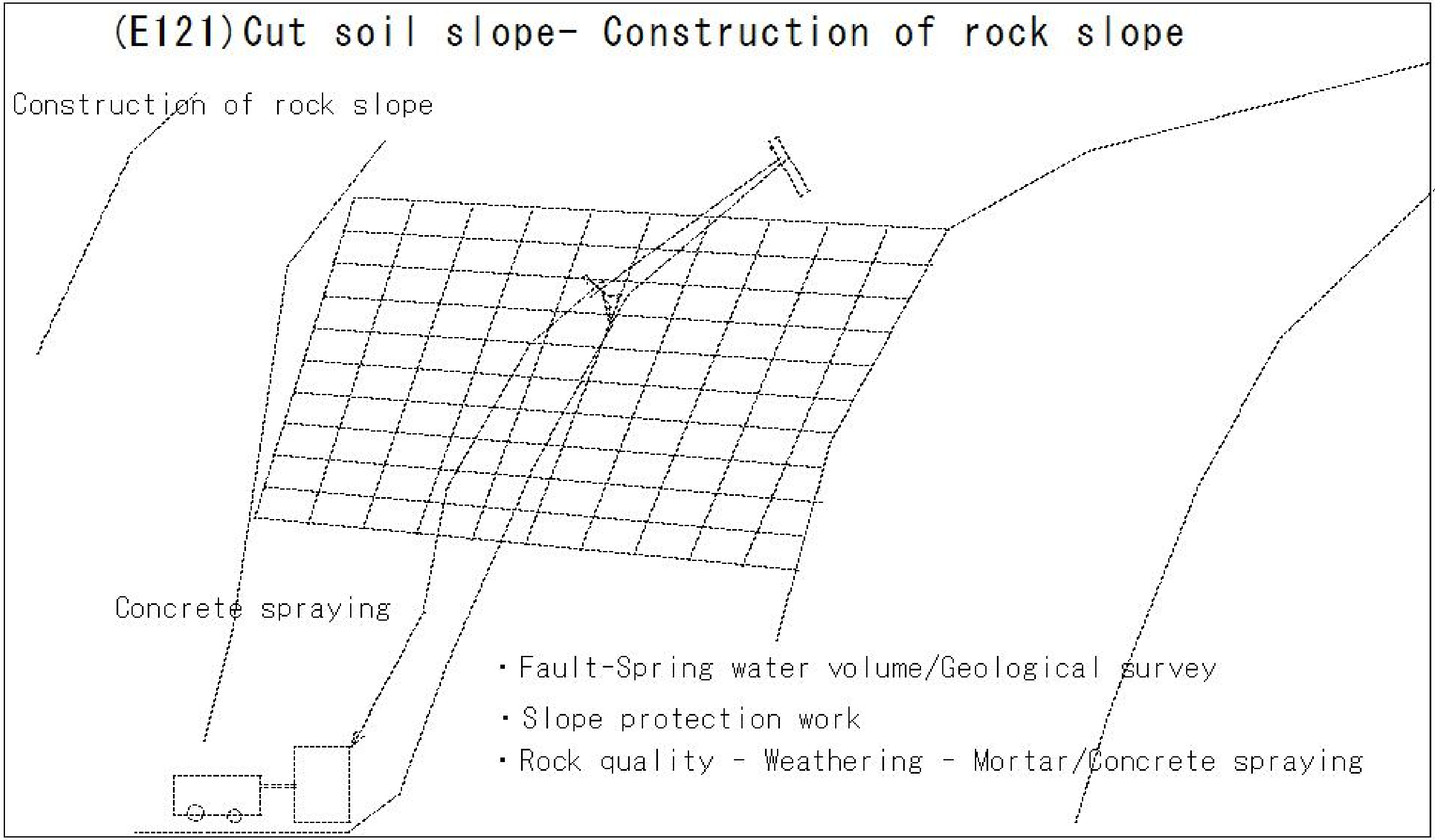
Make changes according to the condition of the soil layer

Gradient by strata

(E120)Cut soil slope- Those with berm



(E121)Cut soil slope- Construction of rock slope



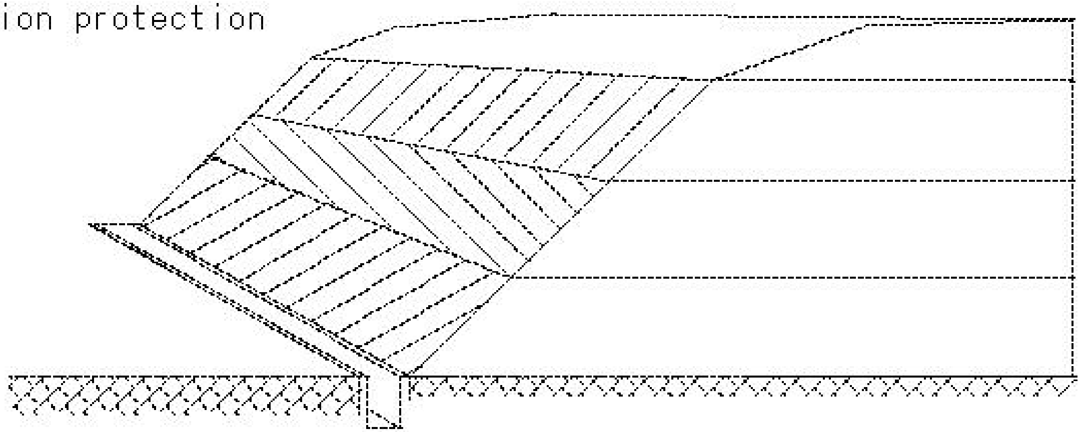
(E122)Cut soil slope- Construction of soil slope

(E122)Cut soil slope- Construction of soil slope

Construction of soil slope

- Earth slope
- Vegetation protection
- Rainwater treatment, spring water treatment - measures during construction
- Cracks/frozen soil - slope protection work

・Vegetation protection



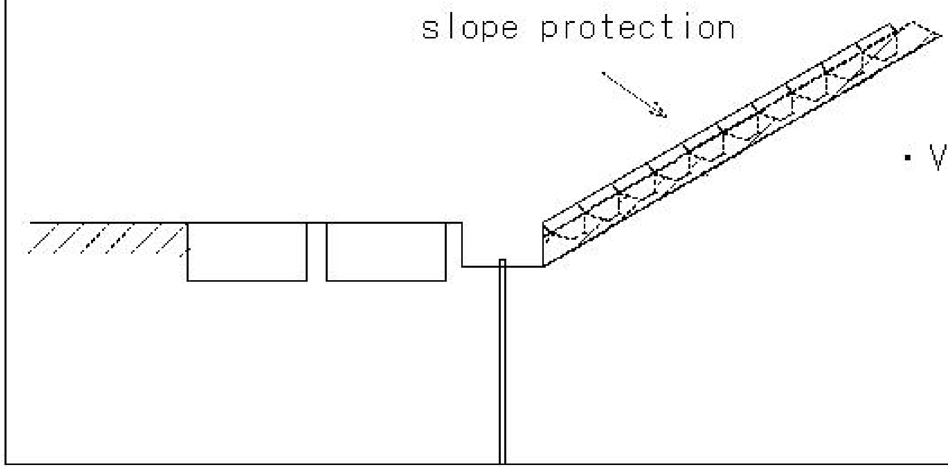
(E123)Slope protection work

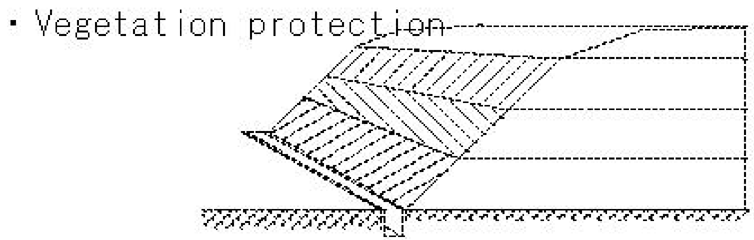
(E123)Slope protection work

Slope protection work

- Embankment/cut earth – slope protection work
  - stability
  - Environmental conservation/Ensuring aesthetics

- Slope protection -planting plants on the slope
  - Vegetation – Embankment slope
  - Cut soil, rock quality, shaded areas under bridges – vegetation work – inappropriate





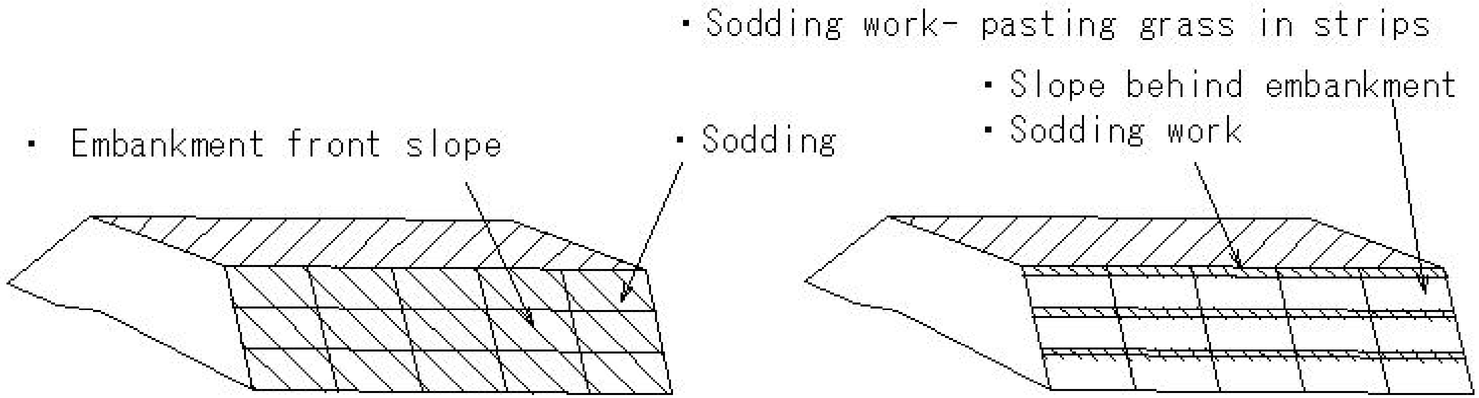
(E124)Slope protection work-Types of vegetation works

(E124)Slope protection work-Types of vegetation works

Types of vegetation works

(1) Sodding lawn applying to the slope

- Vegetation season - avoid winter and summer



The entire area will be covered in 2-3 years

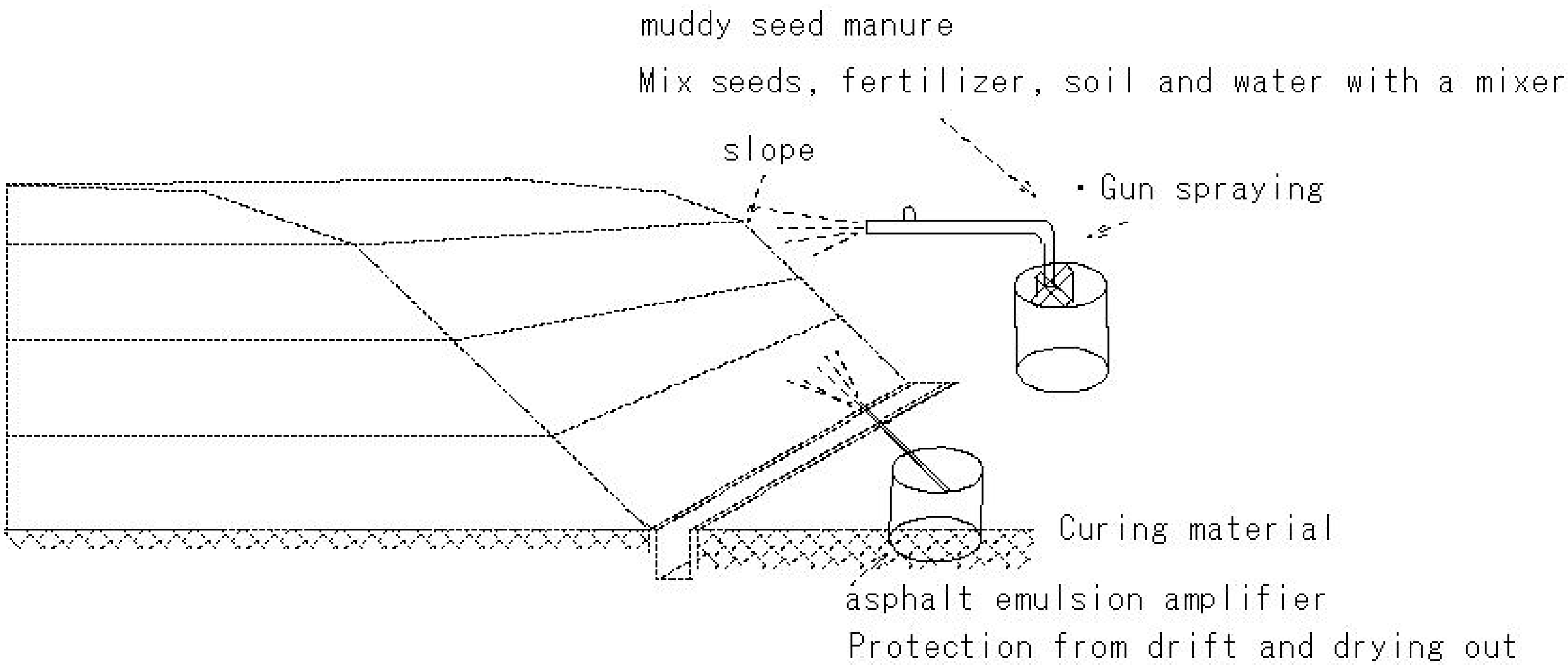
(E125)Slope protection work-Seed spraying

(E125)Slope protection work-Seed spraying

Types of vegetation works

Seed spraying

- Use of gun
  - Gun spraying

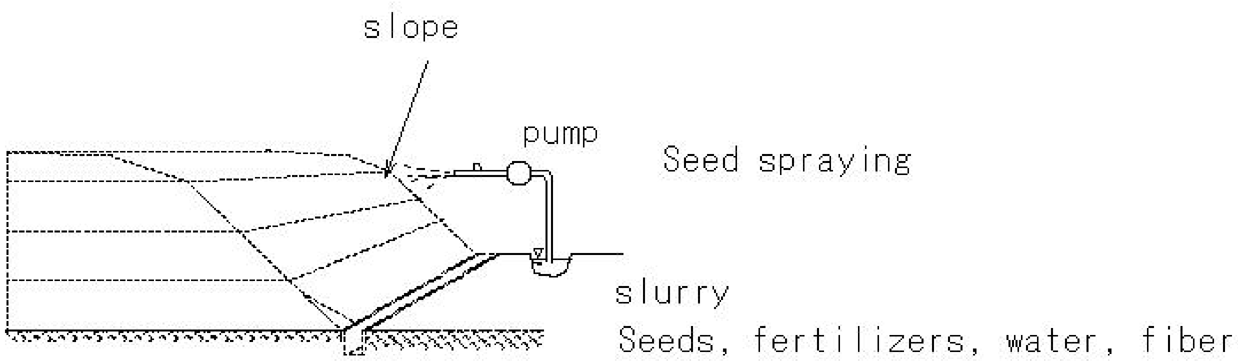


(E126)Slope protection work-Seed spraying

(E126)Slope protection work-Seed spraying

Seed spraying

Use of pumps - seed, fertilizer, water, fiber

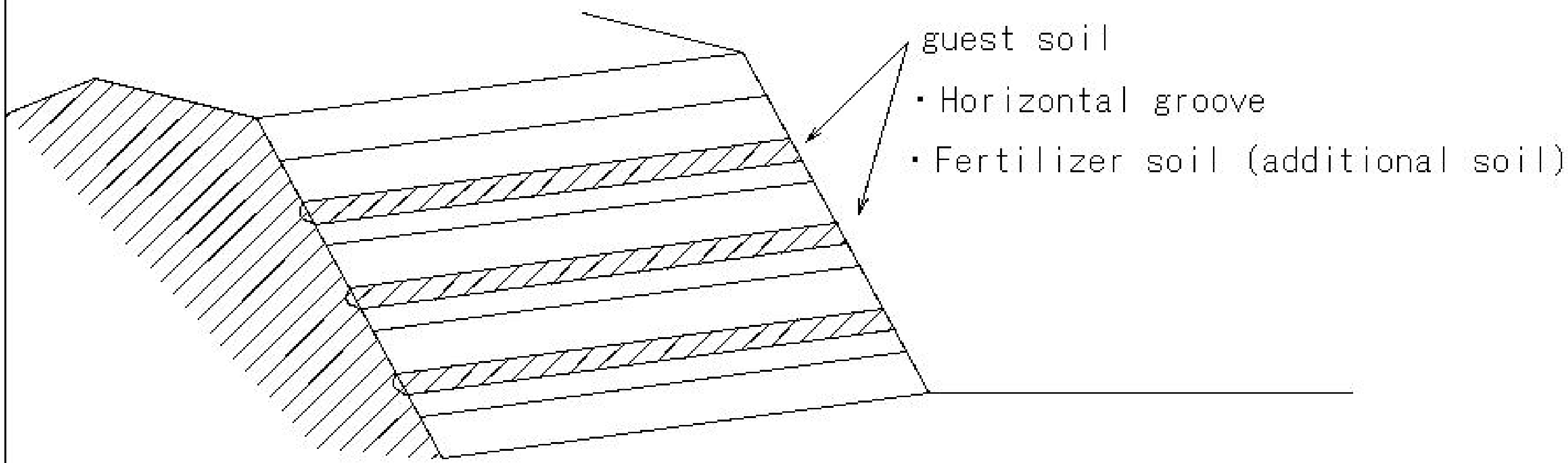


(E127)Slope protection work-Seed spraying

(E127)Slope protection work-Seed spraying

Types of vegetation works

Seed spraying



・Soil on the slope: unsuitable for growing plants

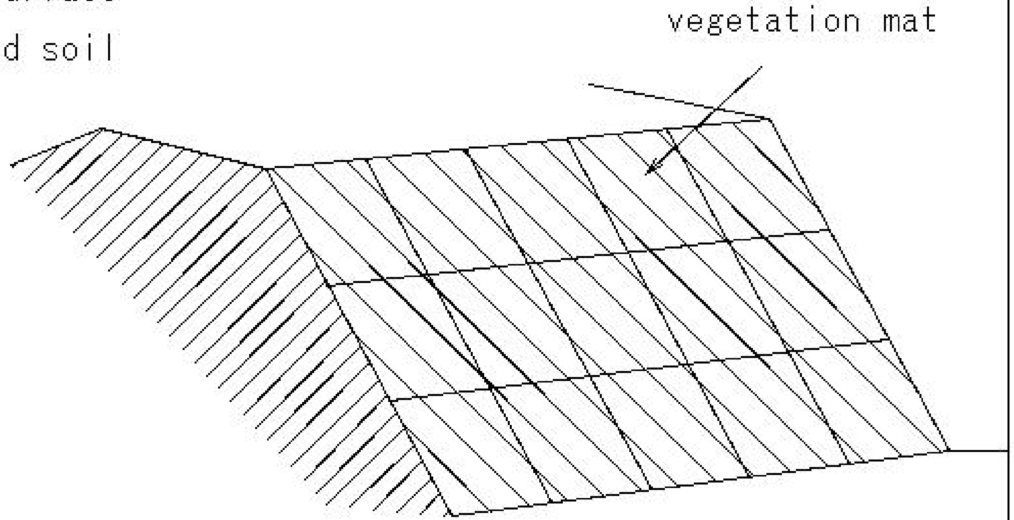
(E128)Slope protection work-vegetation mat

(E128)Slope protection work-vegetation mat

Types of vegetation works

vegetation mat

- Straw blind ・Coarse cloth ・Felt
- Adhesion of seeds and fertilizers
- Plant cultivation
- Affixed to the embankment surface
- Unsuitable for soft rock and soil
- No vegetation season



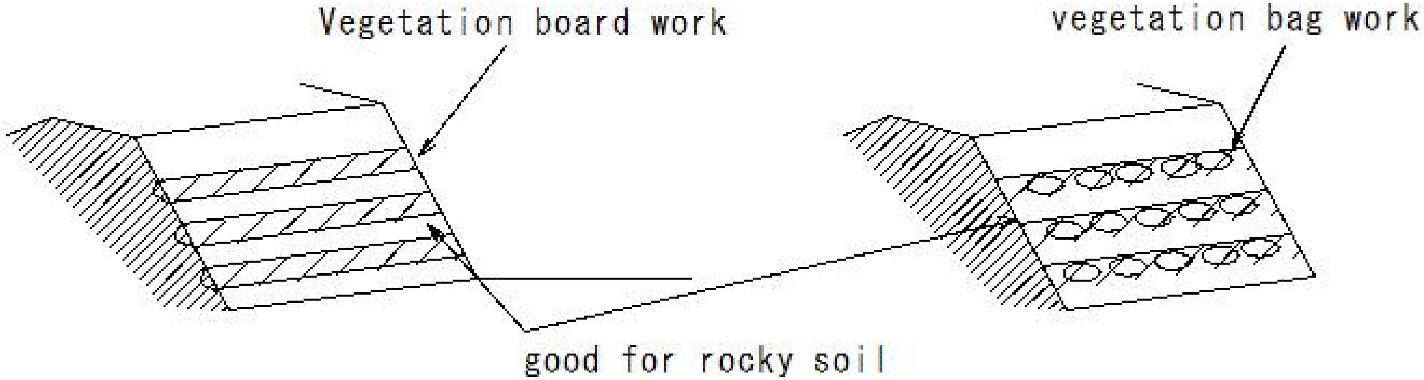
(E129)Slope protection work-Vegetation board work, vegetation bag work

(E129) Slope protection work-Vegetation board work, vegetation bag work

Types of vegetation works

Vegetation board work, vegetation bag work

- Factory production
- Chemical fertilizer + seed - vegetation disc
- Embed in the slope surface
- Additional soil effect



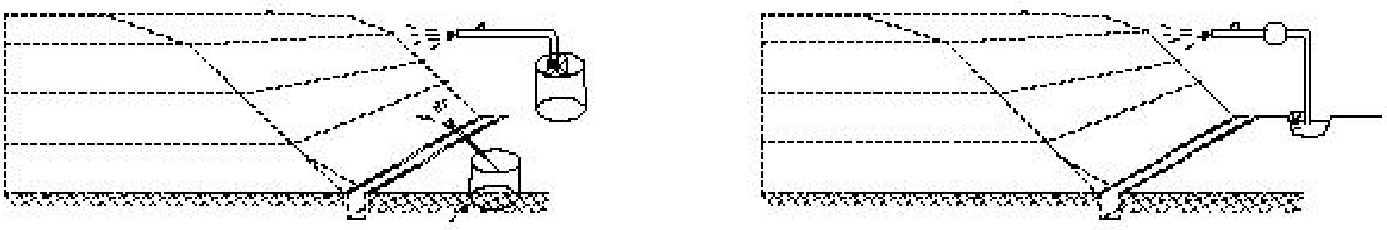
(E130)Slope protection work-vegetation seeds

(E130)Slope protection work-vegetation seeds

vegetation seeds

①Weeping love glass
②Kentucky 31 fescue
③Italian ryegrass
④White clover
⑤Creeping Red Fescue

Seed spraying



(E131)Slope protection work-Points to note regarding vegetation work

(E131)Slope protection work-Points to note regarding vegetation work

Points to note regarding vegetation work

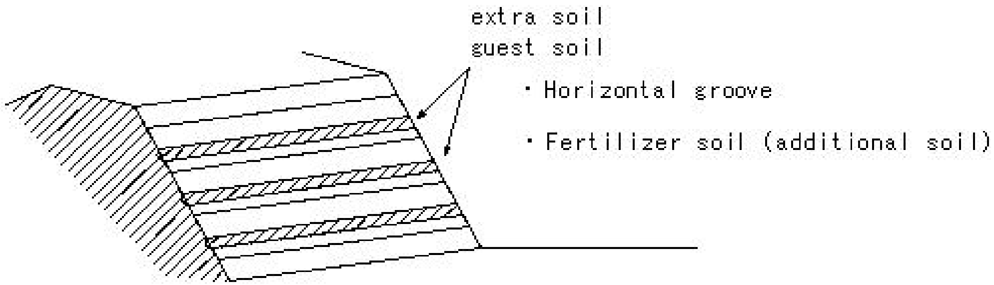
①Rocky soil: sand, gravel, rock mass - extra soil

②Unfavorable conditions - breeding - seed selection

Consideration of vegetation season

③Cut soil slope surface thin slope surface - fertilize once a year

④Cold regions: Prevention of frozen soil collapse on the slope surface Gradient of 1:1.5 or more



(E132)Slope protection work-Mortar concrete spraying work

(E132)Slope protection work-Mortar concrete spraying work

Structural slope protection work

- Vegetation work is difficult

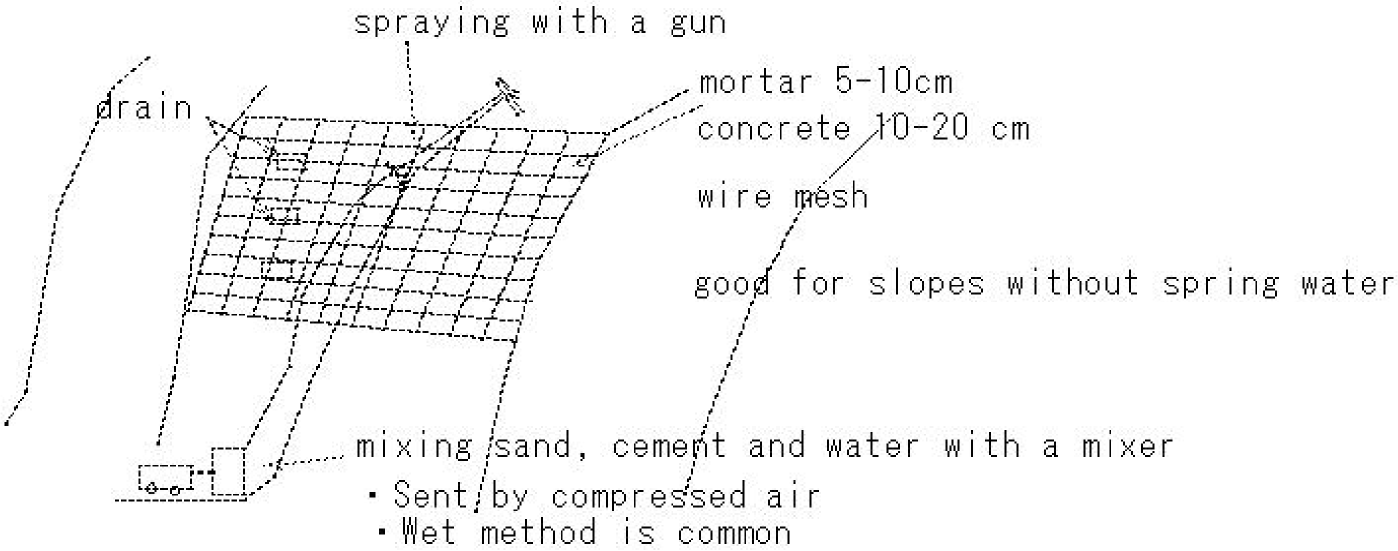
  can't do vegetation work

Mortar concrete spraying work

- Prevents weathering, peeling, and collapse of the slope of the cut soil

  \- Problems with spring water, frozen soil, durability

  a problem with aesthetics



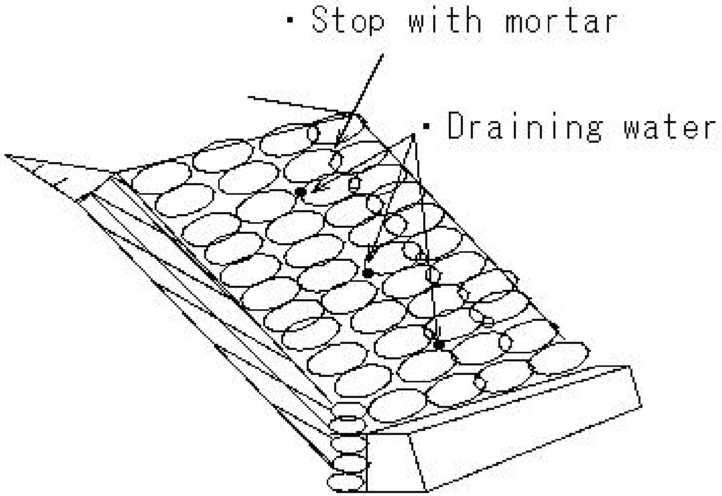
(E133)Slope protection work-Stone masonry

(E133)Slope protection work-Stone masonry

Structural slope protection work

stone masonry

- Constructed on a surface with a slope gradient of 1:1 or less
- Erosion prevention, weathering prevention, collapse prevention
- Establish a joint of 10-20m

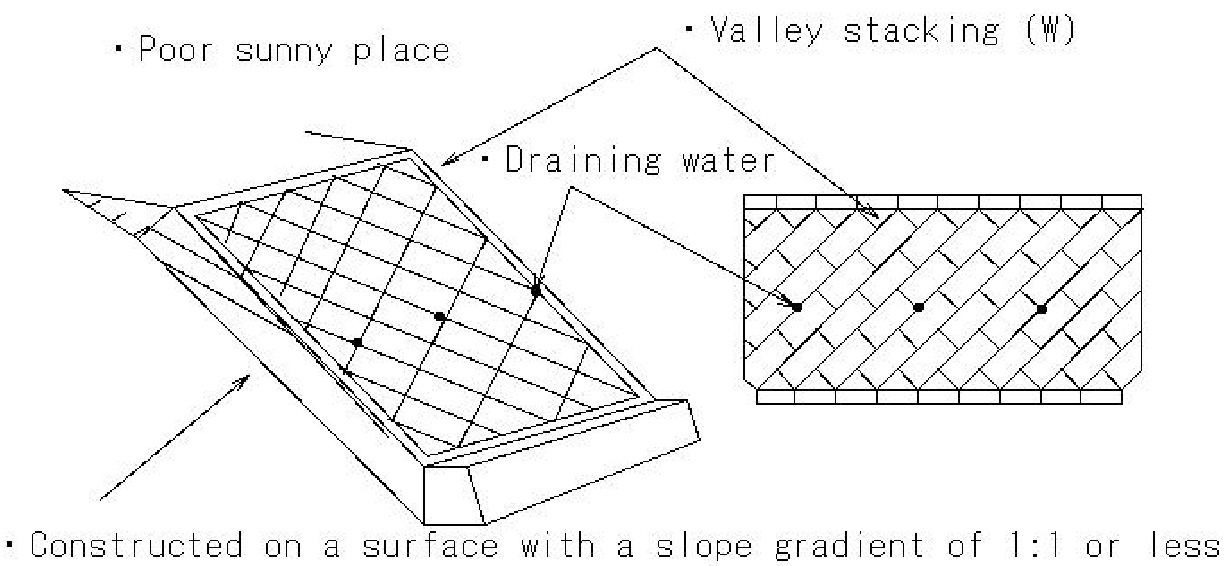


(E134)Slope protection work-Block pitching

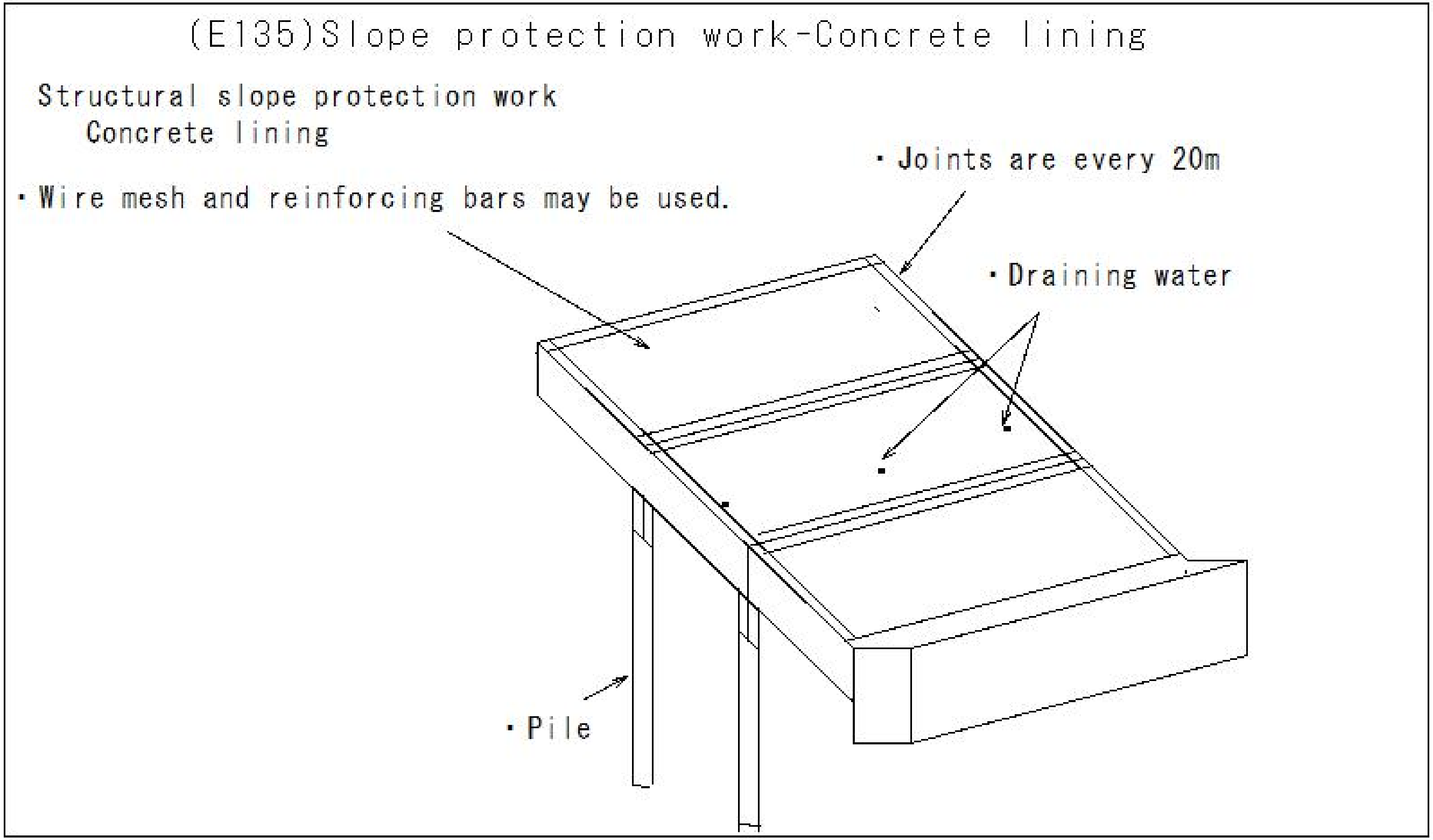
(E134)Slope protection work-Block pitching

Structural slope protection work

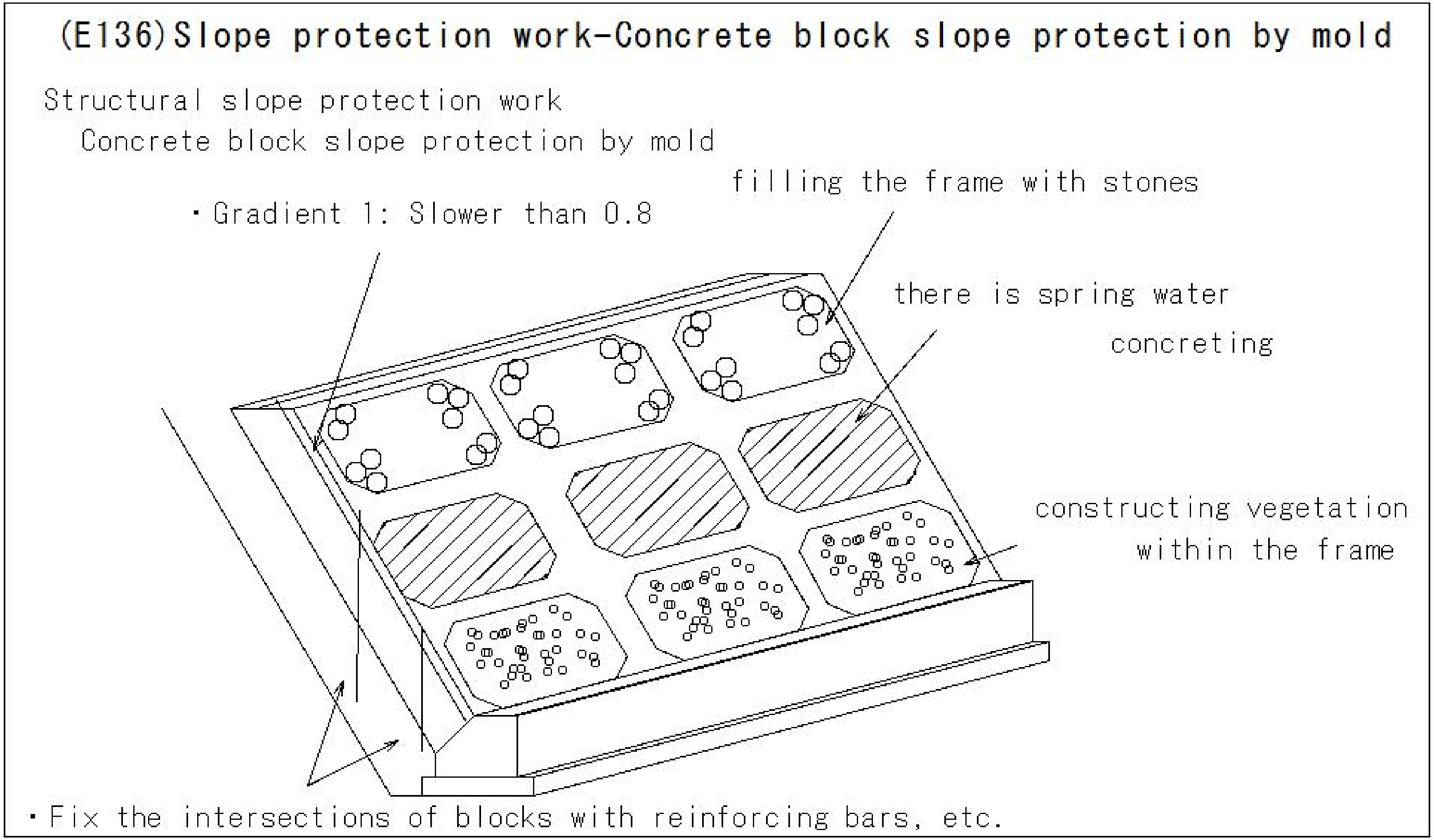
Block pitching



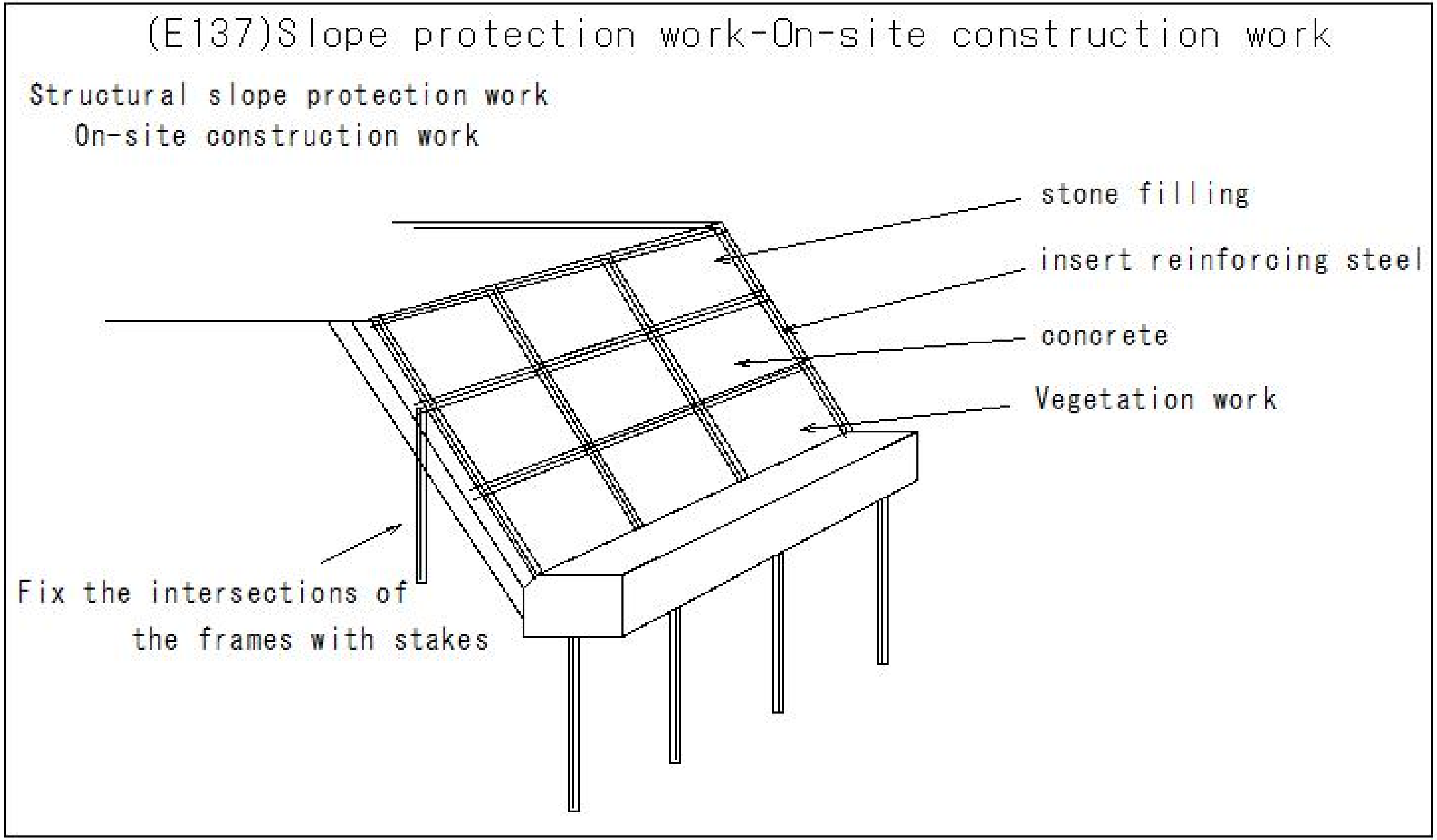
(E135)Slope protection work-Concrete lining



(E136)Slope protection work-Concrete block slope protection by mold



(E137)Slope protection work-On-site construction work

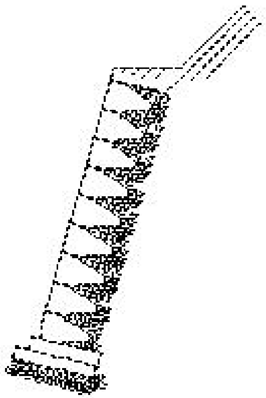


(E138)Slope protection work-Masonry work

(E138)Slope protection work-Masonry work

Retaining wall

Masonry work

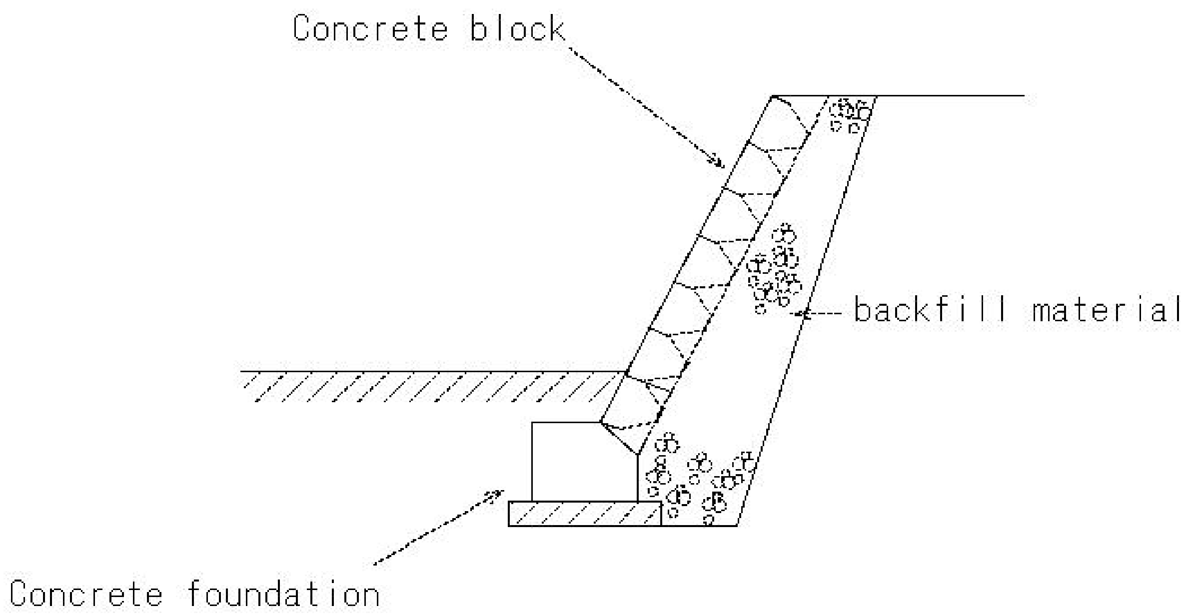


(E139)Slope protection work-Block construction

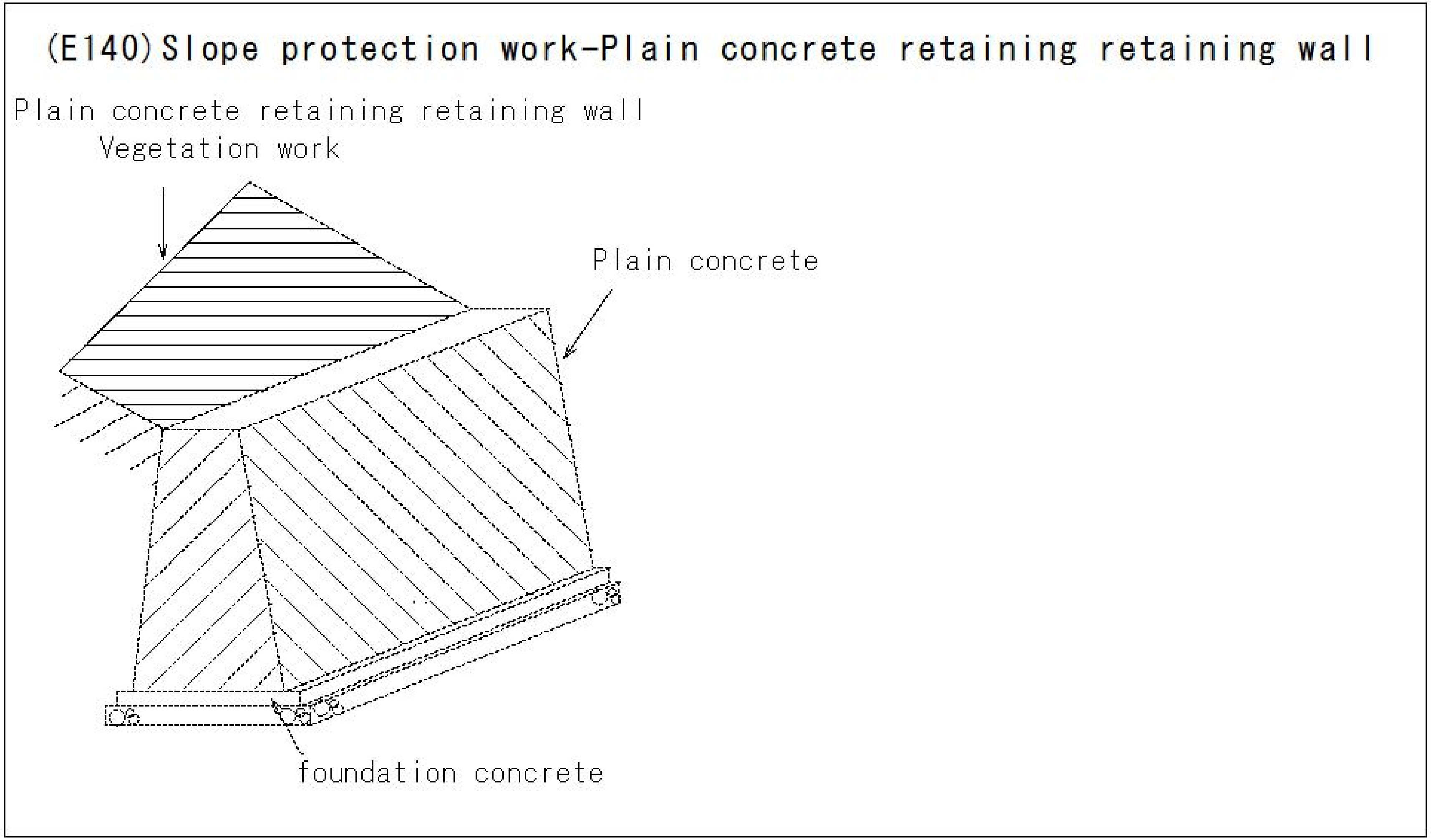
(E139)Slope protection work-Block construction

Retaining wall

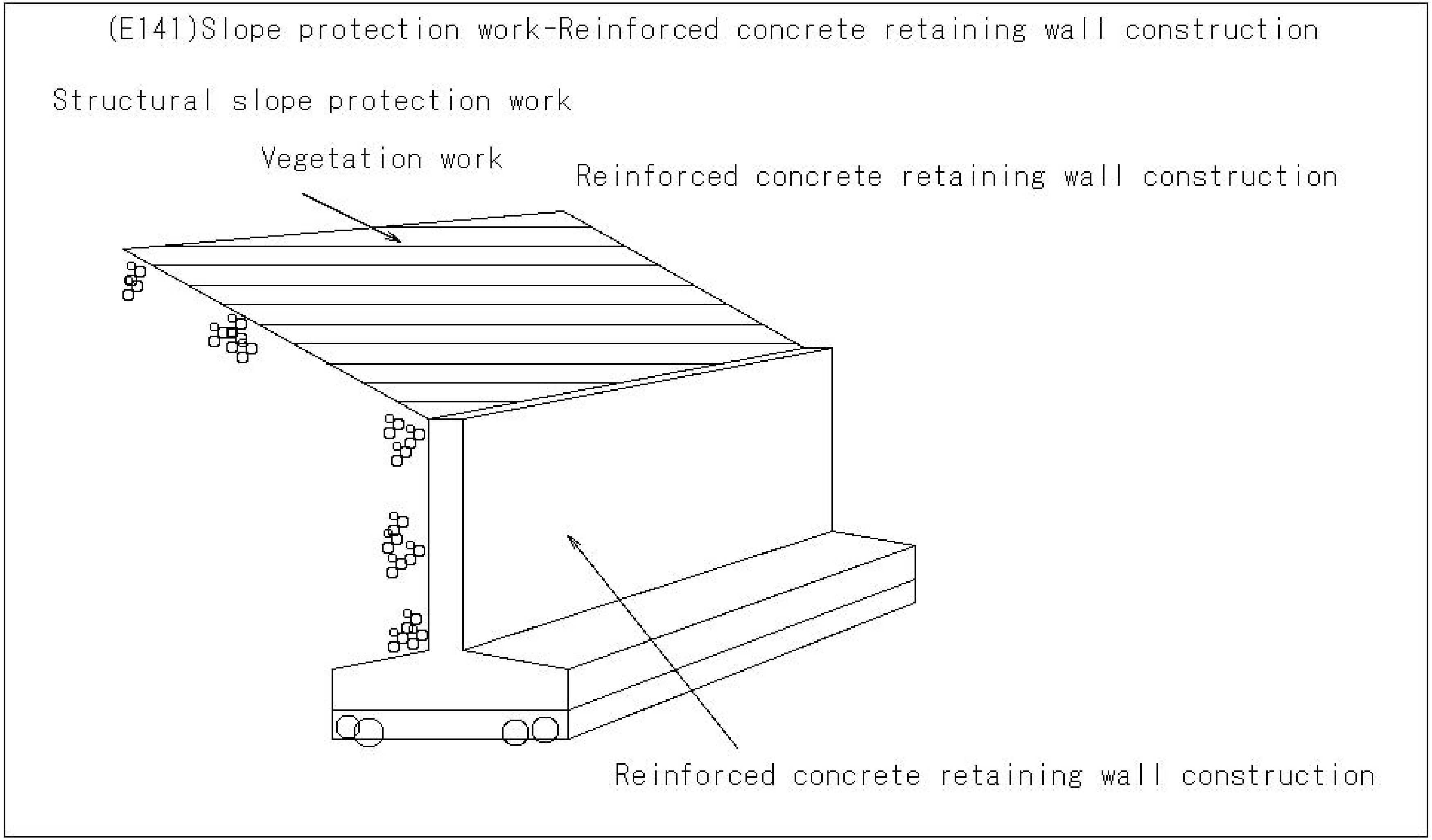
Block construction



(E140)Slope protection work-Plain concrete retaining retaining wall



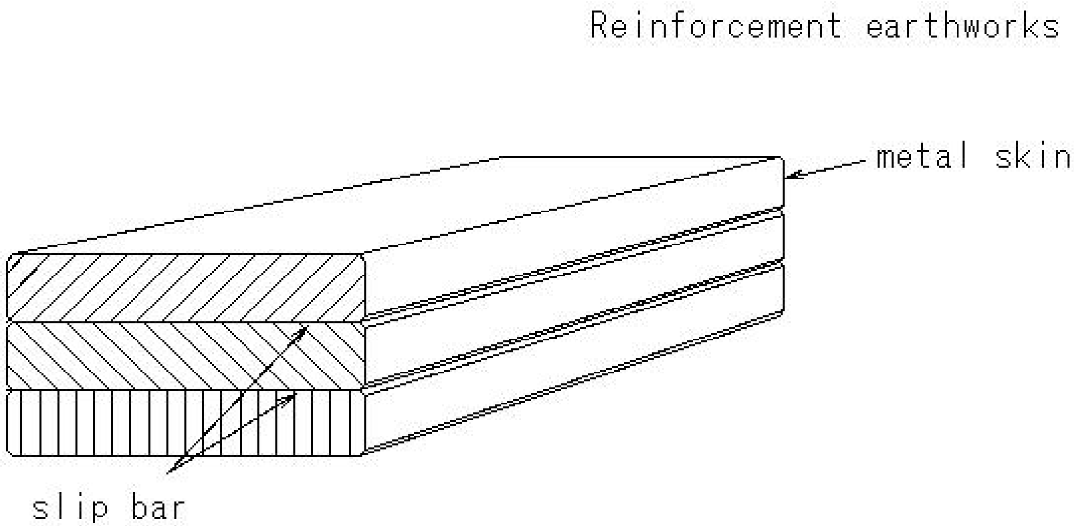
(E141)Slope protection work-Reinforced concrete retaining wall construction



(E142)Slope protection work-Reinforcement earthworks

(E142)Slope protection work-Reinforcement earthworks

Structural slope protection work

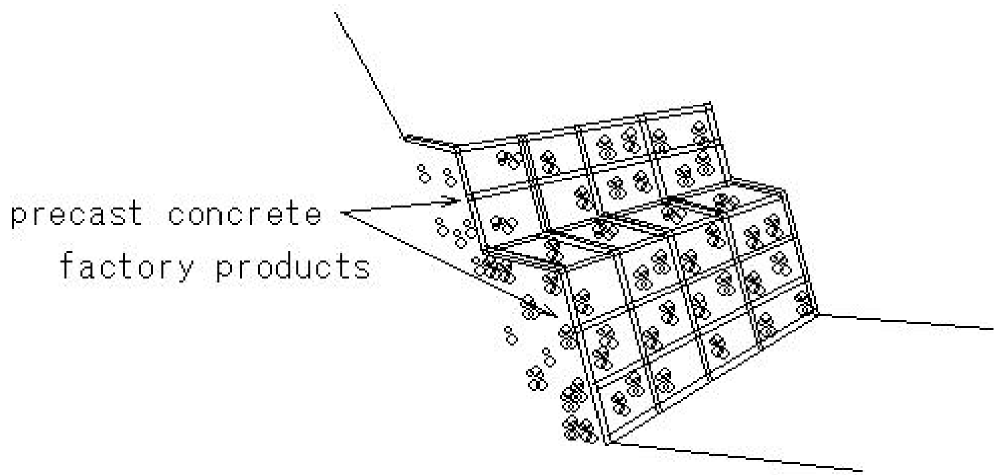


(E143)Slope protection work-retaining wall work

(E143)Slope protection work-retaining wall work

Structural slope protection work

retaining wall

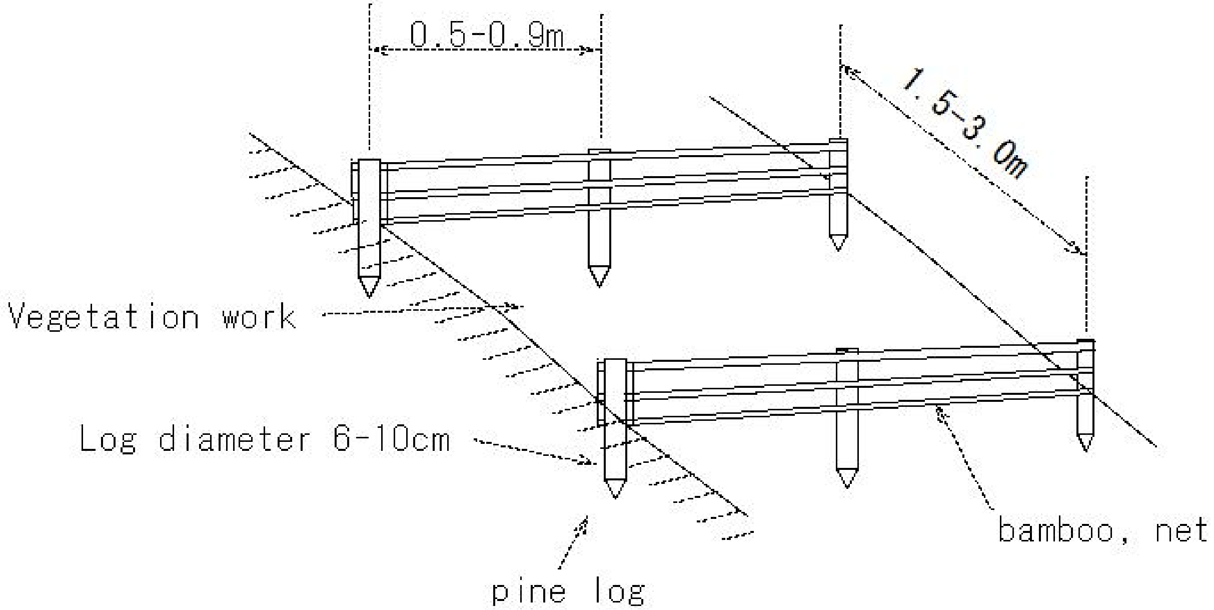


(E144)Slope protection work-Editing shelving

(E144)Slope protection work-woven fence work

Structural slope protection work

woven fence work

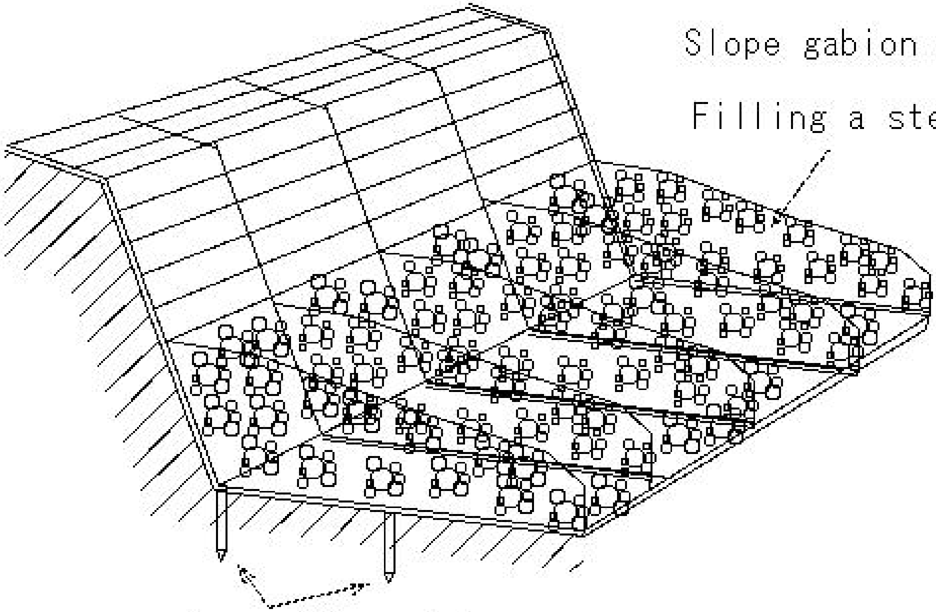


(E145)Slope protection work-Slope gabion work

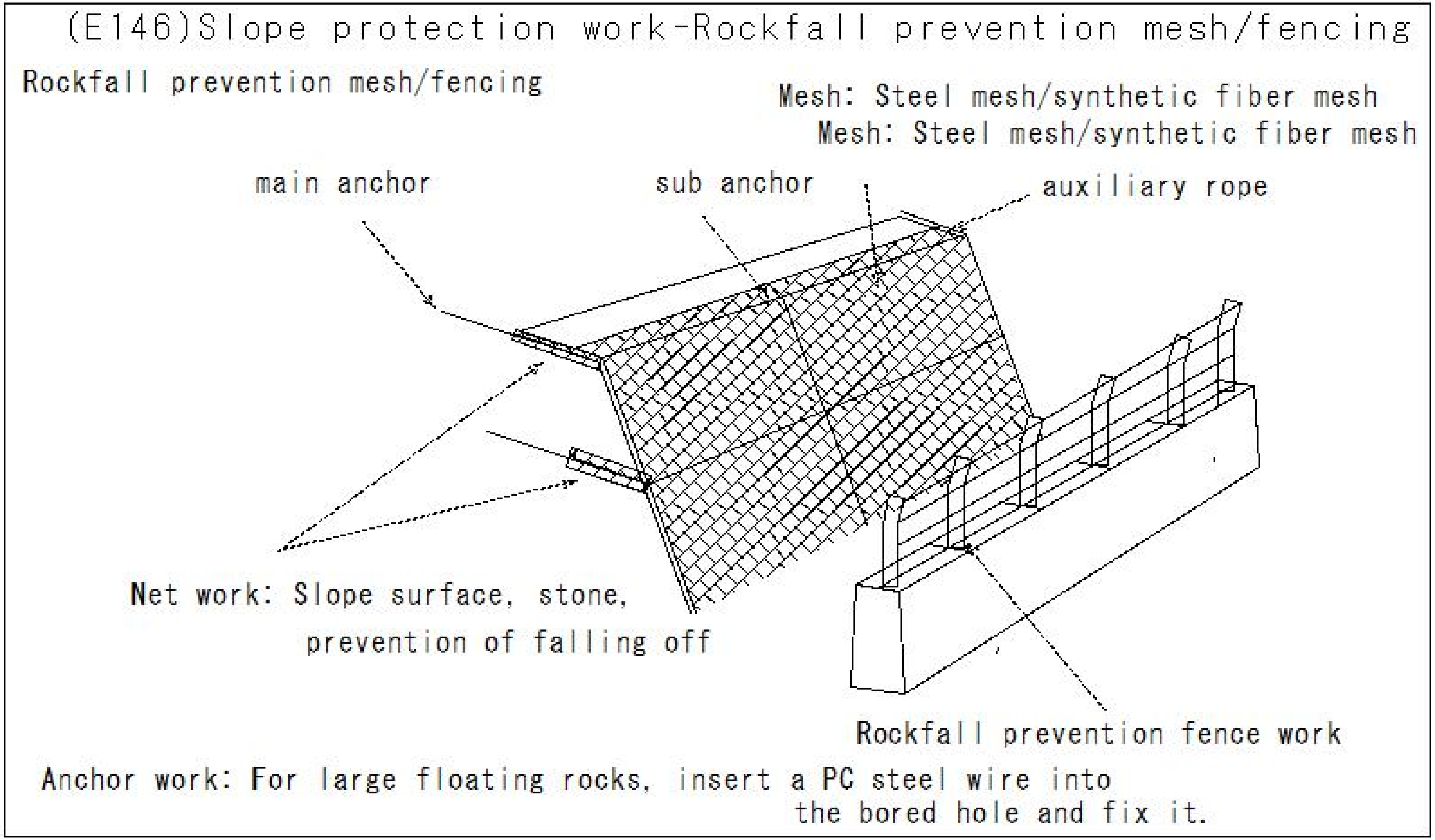
(E145)Slope protection work-Slope gabion work

Structural slope protection work

Slope gabion work



(E146)Slope protection work-Rockfall prevention mesh/fencing



(E147)Slope protection work-Vegetation work・protection of structures

(E147)Slope protection work-Vegetation work・protection of structures

Slope protection work

Vegetation work

①Turf: Overall protection required for 2-3 years

②Seed spraying: Wet type is better Gun spraying Pump spraying

③Vegetation mat work: Regardless of the vegetation season, soft rock and soil cannot be constructed

④Vegetation board/bag work: suitable for sandy soil that cannot retain nutrients

Protection of structures

①Mortar/concrete spraying work

②pitching masonry:Stone pitching, block pitching, concrete pitching

③Slope protection by mold On-site construction work: A long slope with a steep slope

④Retaining wall work: masonry, block pitching, reinforcement earthwork, well girder retaining wall

⑤Other protection work:fence work slope gabion work rockfall prevention mesh/fencing

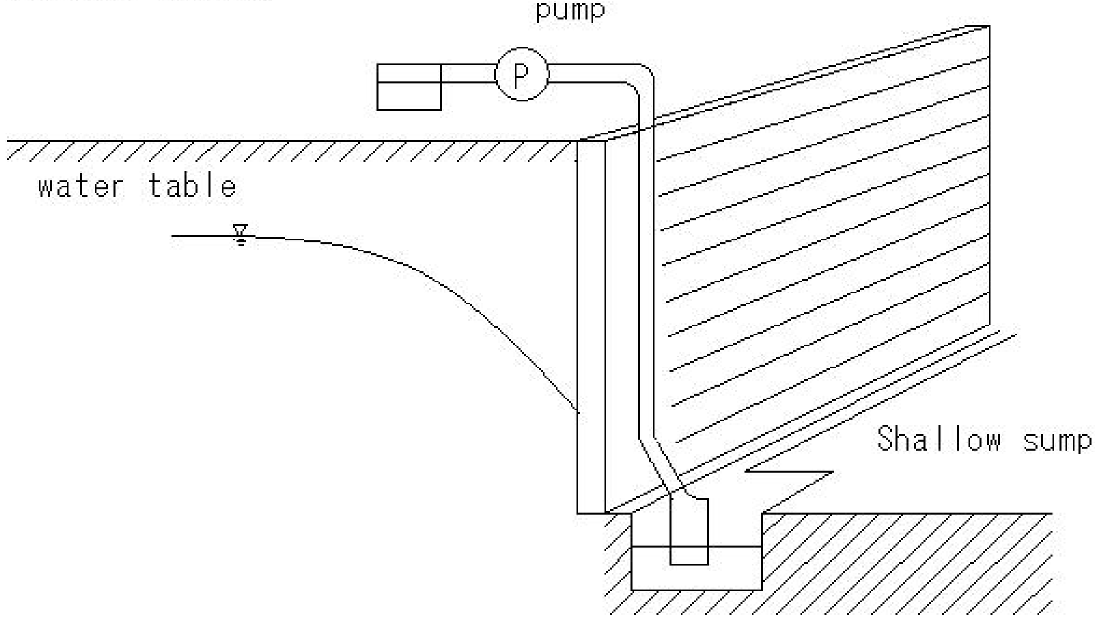
(E148)Drainage method- Shallow sump drainage method

(E148)Drainage method- Shallow sump drainage method

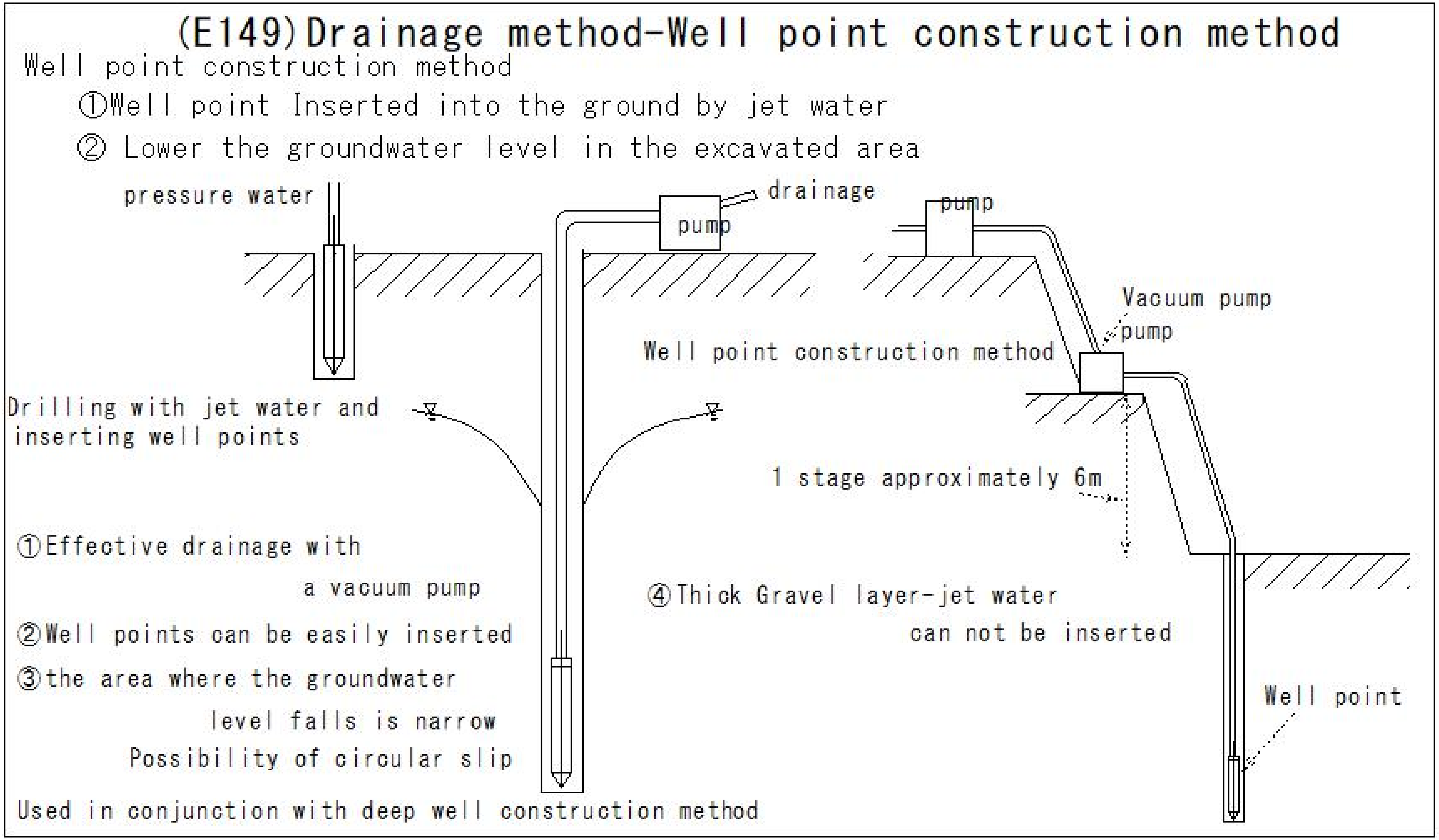
Shallow sump drainage

①Less amount of groundwater flowing out

②Excavation of shallow ground



(E149)Drainage method-Well point construction method



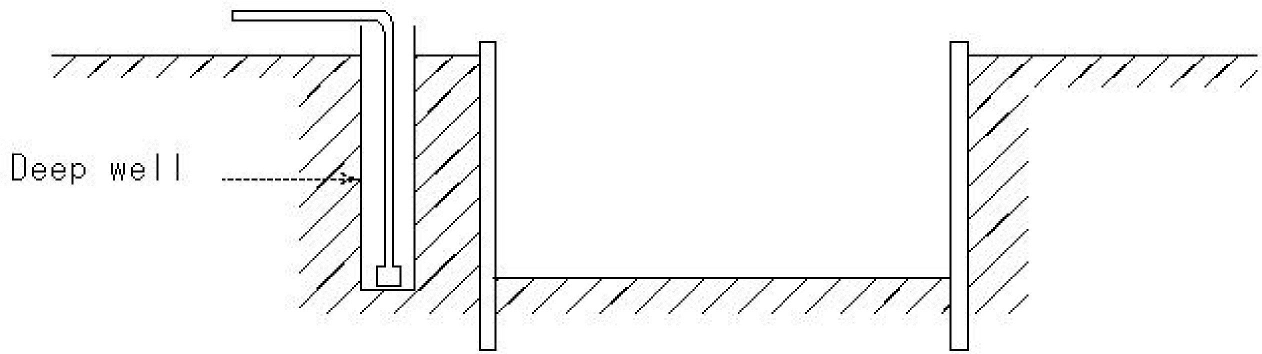
(E150)Drainage method-Deep well method

(E150)Drainage method- Deep well construction method

Used in conjunction with deep well construction method

①Dig a deep well around the excavation part
②Pumping up water from a well and draining it
③Groundwater level lowering method

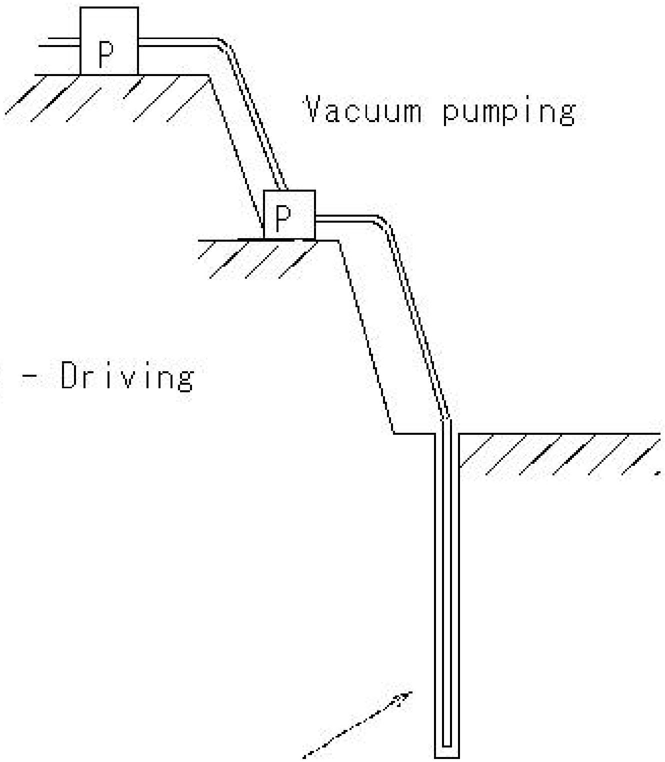
location
④Groundwater drop over a wide area
⑤there is a possibility of heaving on the bottom of the excavation
⑥the water permeability is large and the amount of drainage is large



(E151)Drainage method-Deep well vacuum construction method

(E151)Drainage method-Deep well vacuum construction method

Deep well vacuum construction method



Deep well vacuum construction method

①Strainer (filtering wire mesh) (steel pipe) - Driving
②Several stages of pump installation
③Vacuum pumping
④the amount of water discharged is large

(E152)Drainage method-Electropenetration method

(E152)Drainage method-Electropenetration method

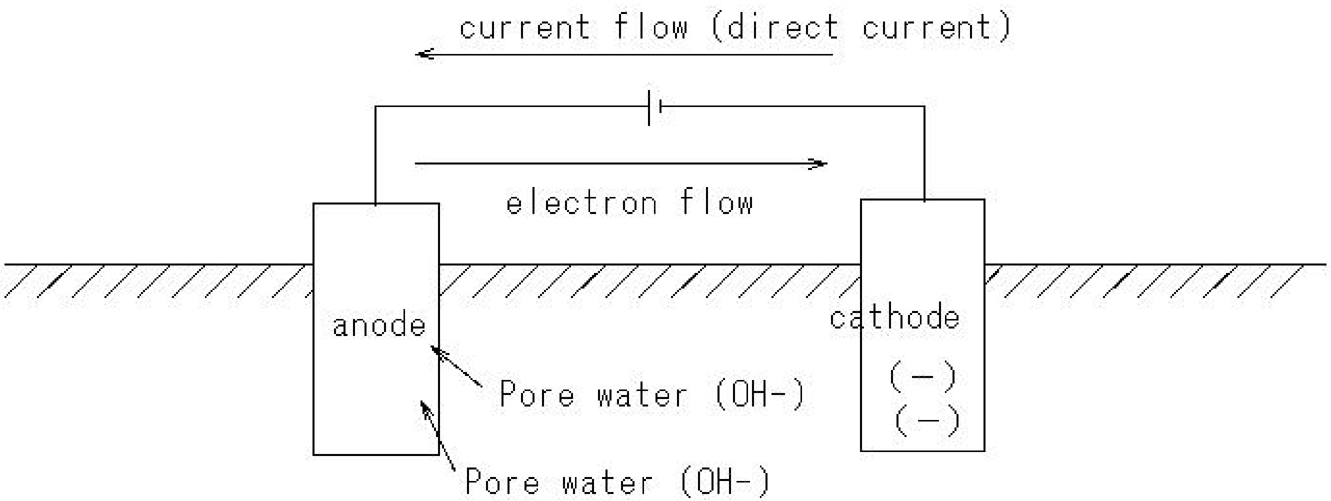
Electropenetration method

①Direct current underground

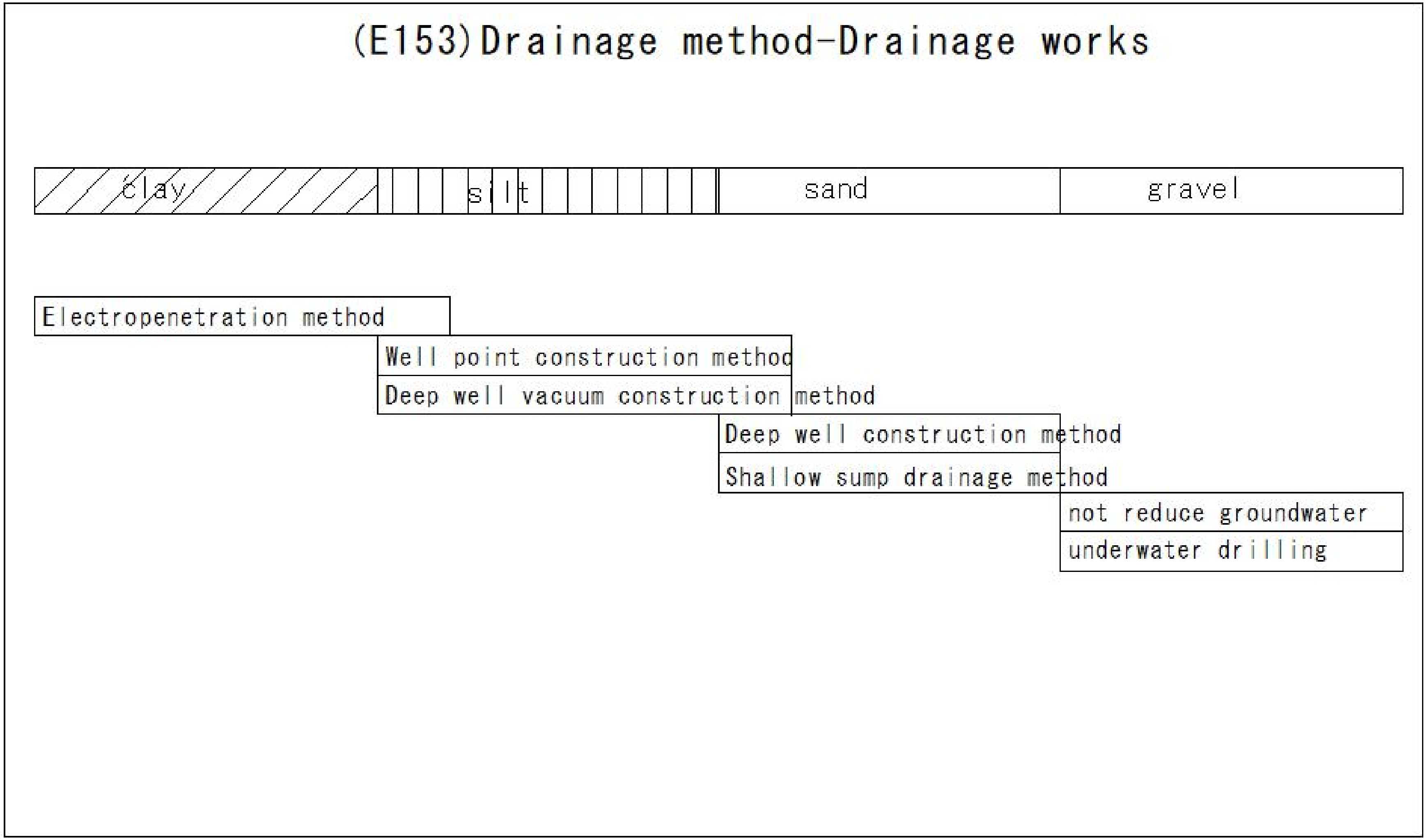
②Interstitial water -using movement toward the cathode

③Ground reinforcement

Electropenetration method



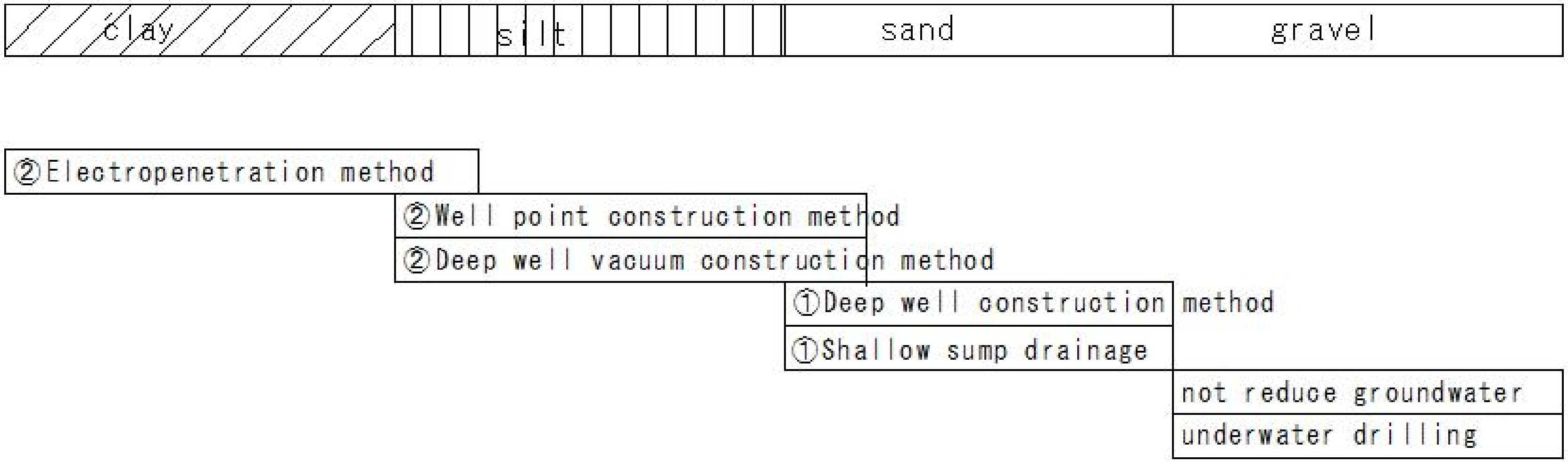
(E153)Drainage method-Selection of drainage method



(E154)Drainage method-Drainage works

(E154)Drainage method-Drainage works

Drainage works



①Gravity drainage system method -Shallow sump drainage・ Deep well method

②Forced drainage system methods - Well point method・Deep well vacuum method
Electropenetration method

(E155)Road embankment compaction around structures

(E155)Road embankment-compaction around structures

compaction around structures

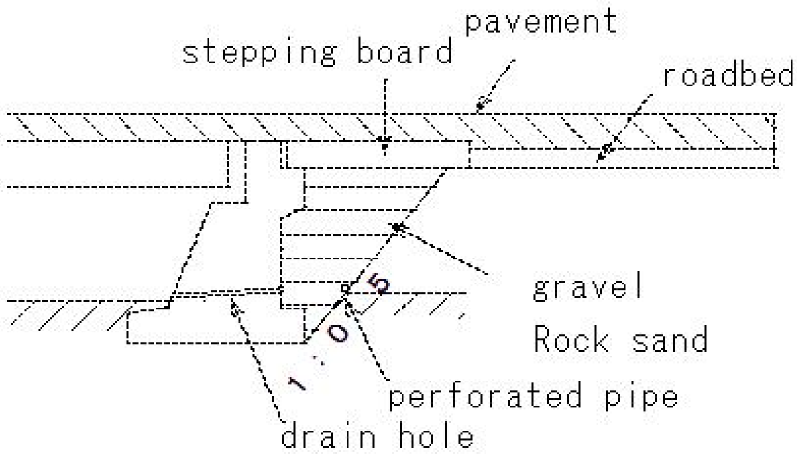
①large machine - unusable

②insufficient compaction

③easy to settlement

④good permeability and compaction

⑤compressibility - small



(E156)Road embankment-Culvert embankment

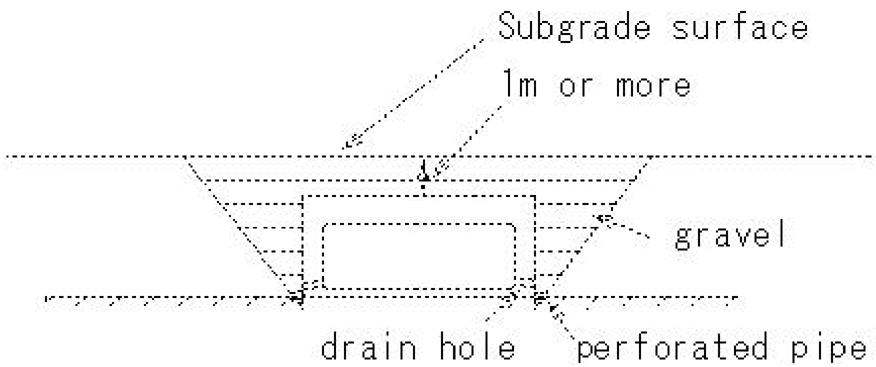
(E156)Road embankment-Culvert embankment

Culvert embankment

①Embankment around structures receiving earth pressure from both sides

②Spread thinly and symmetrically

③Vibration compactor, rammer, tamper, etc.: compaction with small construction machines



Culvert embankment

(E157)Soil classification-Name of soil particles based on particle size

(E157)Soil classification-Name of soil particles based on particle size

Name of soil particles based on particle size

0	0.001	0.005	0.074	2.0 Particle size(mm)
colloid	clay	silt	fine sand sand coarse sand	gravel
small ←		Water permeability	→	large

①Small soil particles

- Water permeability - poor
- High water content - soft clay - difficult to drain
- Drain construction method - improvement

②Soil containing a lot of silt

- Water permeability - large
- Compaction - Loose ground - Containing water - Vibration - Liquefaction
- Supporting capacity - eliminated
- Drainage - Well point construction method

(E158)Soil classification-Particle size test - Particle size accumulation curve

(E158)Soil classification-Particle size test - Particle size accumulation curve

Particle size test - Particle size accumulation curve

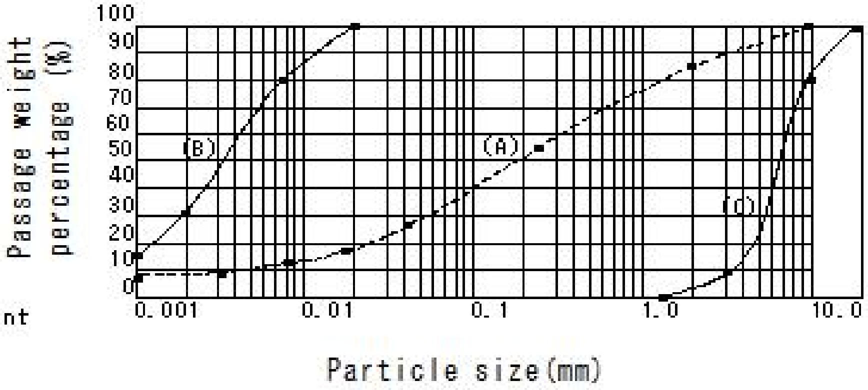
soil with a mass of 80g is sieved

Particle size (mm)	Retained mass (g)	Retained cumulative		passing percentage
		Mass	Percentage (%)	
9.52	0	0	0	100
0.84	36	36	45	55
0.074	24	60	75	25
0.001	15	75	94	6

(A): Good particle size distribution
Easy to compact
Particle size distribution - good

(B): much fine grains
Compaction with water ? difficult
mixing phenomenon
Particle size distribution - bad

(C): Coarse grains are common, compaction is not sufficient
Water permeability - large
Particle size distribution - bad



(E159)Soil classification- Uniformity coefficient and curvature curve

(E159)Soil classification- Uniformity coefficient and curvature curve

Soil classification

Uniformity coefficient and curvature curve

・particle size accumulation curve

D10: Particle size (mm) at 10% of the particle size accumulation curve

D30: Particle size (mm) at 30% of the particle size accumulation curve

D60: Particle size (mm) at 60% of the particle size accumulation curve

Equalization coefficient Uc=D60/D10

judgement

UC>10 Good particle size

UC<4 Poor particle size

Curvature coefficient Uc'=((D30)^2)/(D60×D10))

Uc'=1-3 Good granularity

fine-grained soil

Uc>10

Uc'=1-3

Particle size accumulation curve (A)

D10=0.0045mm

D30=0.067mm

D60=0.50mm

Uc=D60/D10=0.5/0.0045=111 Uc>10

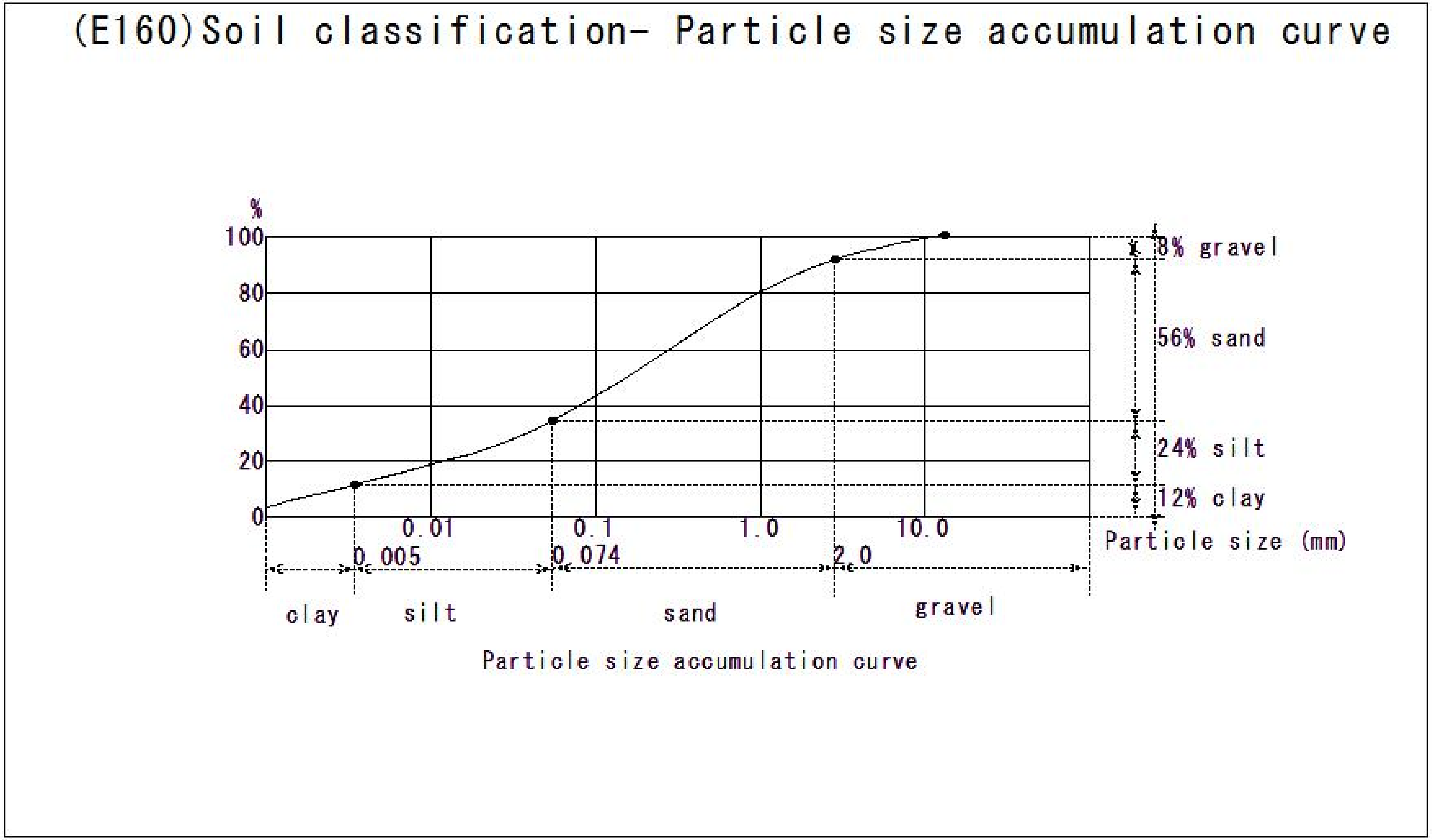
Curvature coefficient Uc'=((D30)^2)/(D60×D10))

0.5/(0.0045*0.5)=2.0

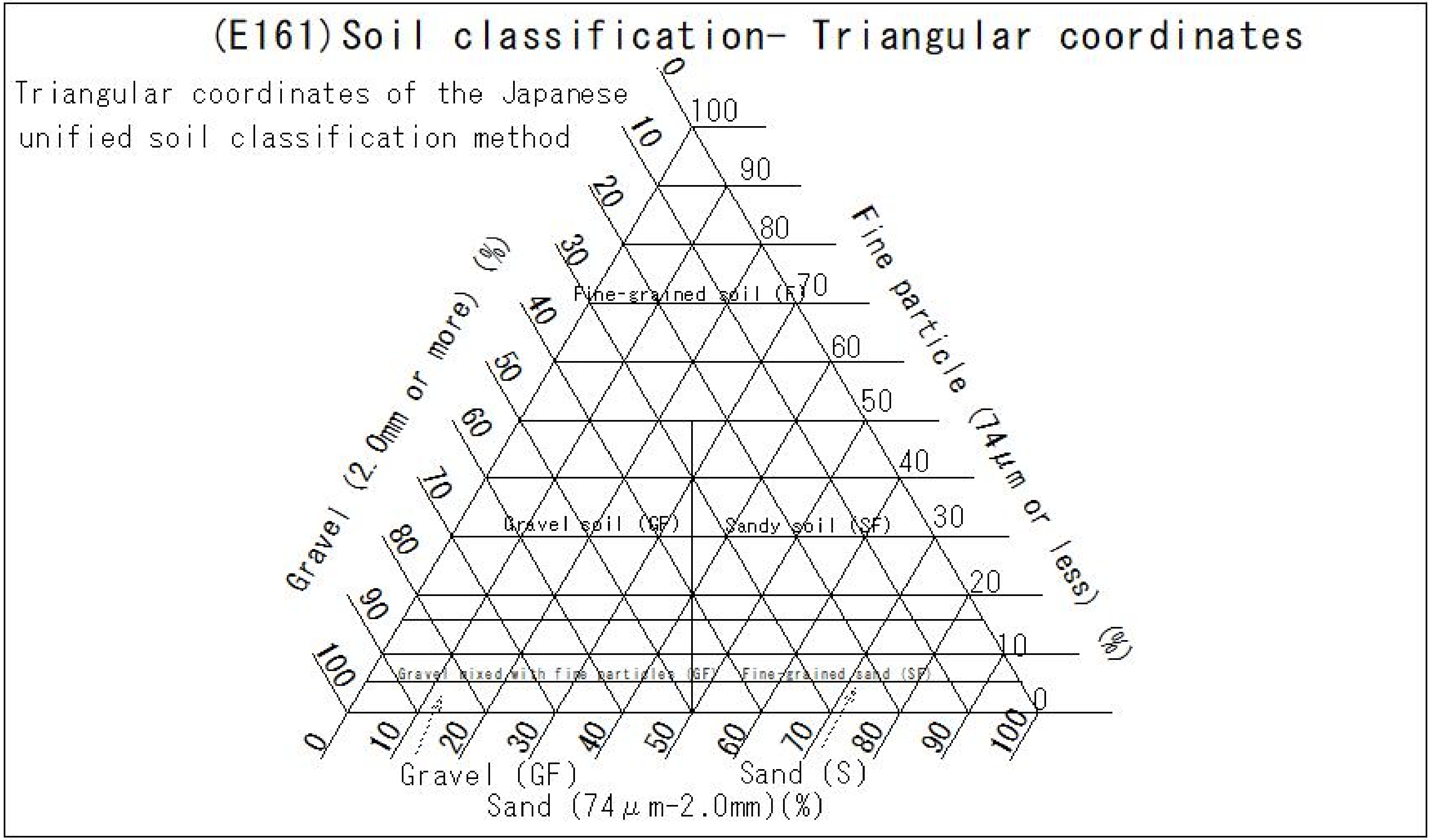
Uc'=1-3

Good particle size

(E160)Soil classification- Particle size accumulation curve



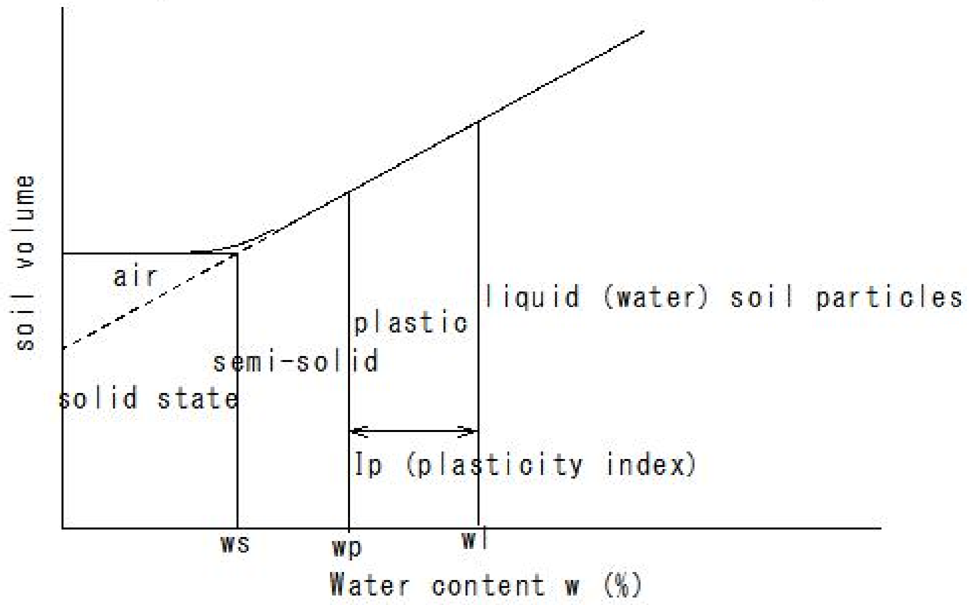
(E161)Soil classification- Triangular coordinates



(E162)Soil classification- Consistency limit and relationship between water content and volume change

(E162)Soil classification- Consistency limit and relationship between water content and volume change

Consistency limit and relationship between water content and volume change



①Soil - water content ratio - large - liquid

②Soil - water content ratio - small - solid

wL: liquid limit

wp: plastic limit

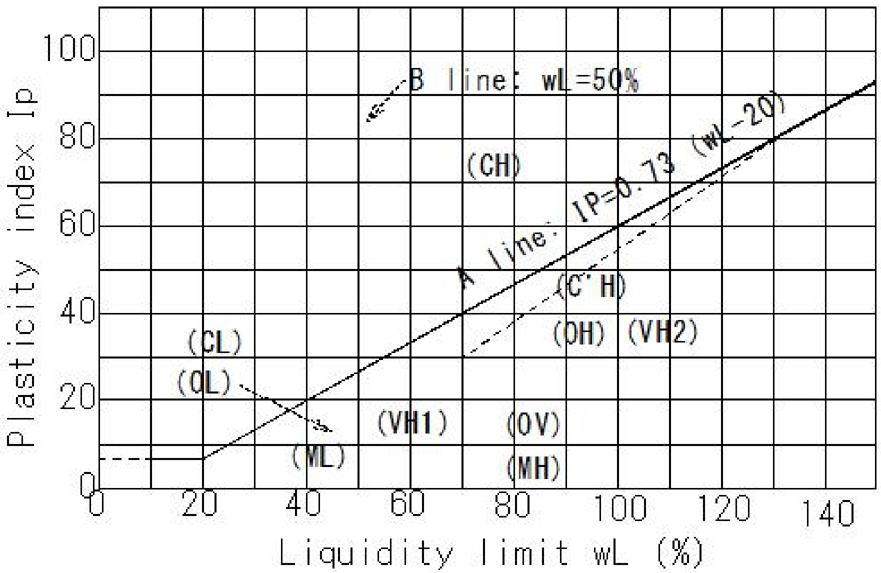
ws: shrinkage limit

Consistency limits for each limit

(E163)Soil classification- Plasticity index and plasticity diagram

(E163)Soil classification- Plasticity index and plasticity diagram

Plasticity index and plasticity diagram (Japan unified soil classification method)



plasticity diagram

OL: organic clay soil
CL: clay soil
ML: Silt (low liquid limit)
CH: Clay
OH: organic clay
VH2: Volcanic ash clay (type II)
OV: organic volcanic ash
VH1: Volcanic ash clay soil (type I)
MH: Silt (high liquid limit)

Plasticity index (IP) = wL - wp

IP: Large -easy compaction

example
WL=95%
wp = 15%
Plasticity index Ip=wL-wp=95-15=70%
Point (wL, Ip) = (95, 70)
clay

(E164)Compaction regulations

(E164)Compaction regulations

Compaction regulations

Compaction: compacting the embankment

increase density homogeneity

Water permeability - decrease

Improving embankment stability

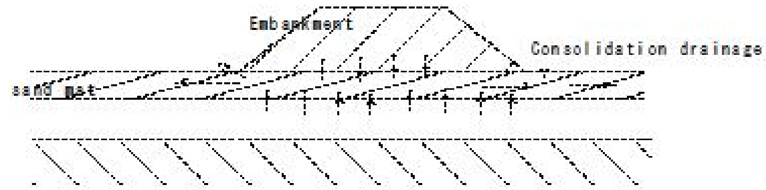
① Supporting capacity - increase

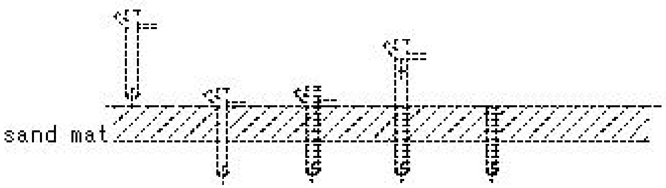
- Compression settlement - reduction
- Prevention of softening due to water intrusion

②Specified by construction method

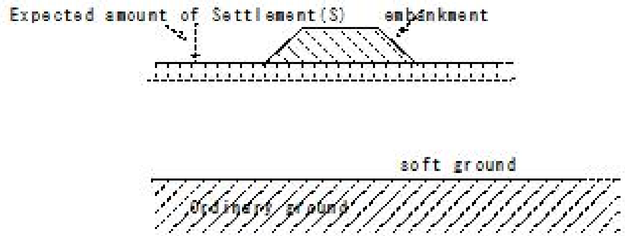
③Quality regulations for embankment compaction

Sand mat construction method





Sand drain method



(E165)Compaction regulations-Construction method regulations

(E165)Compaction regulations-Construction method regulations

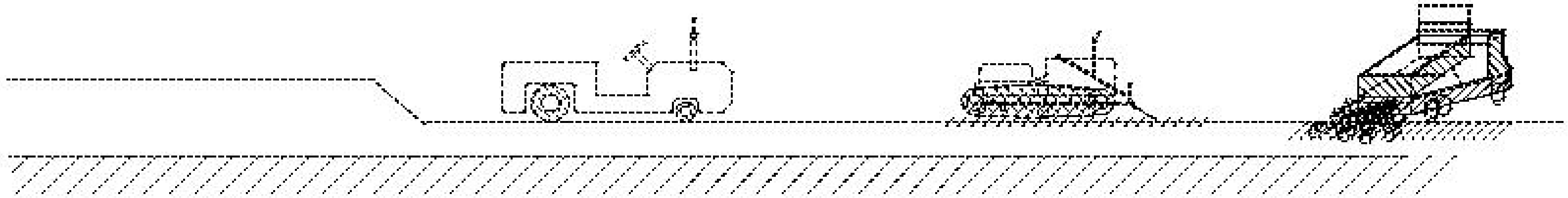
compaction regulations

Construction method regulations

・Method of specifying the number of times the rolling compaction machine runs

①Compaction test on site

②Bulldozer Compaction regulations based on the number of roller runs



(E166)Compaction regulations-Proof rolling regulations

(E166)Compaction regulations-Proof rolling regulations

Compaction regulations

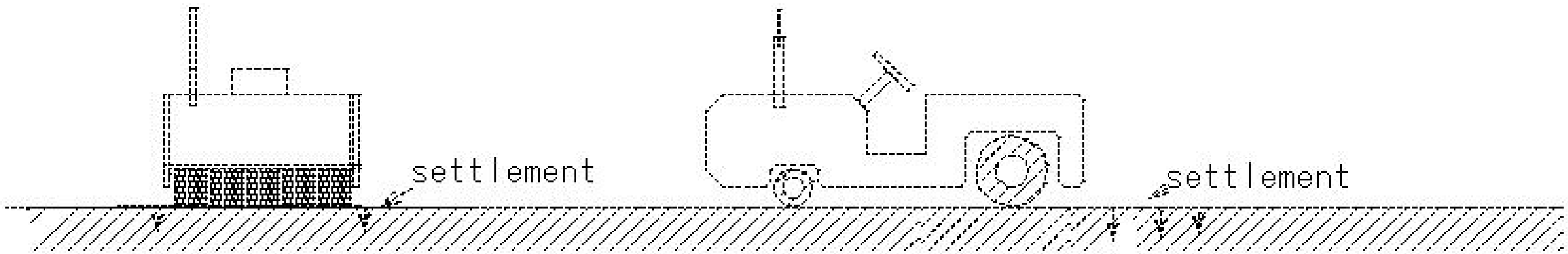
Construction method regulations

・Proof rolling regulations

①Compacted embankment

②Supporting capacity -determined by the amount of settlement of Proof rolling

Tyre roller



(E167)Compaction regulations-Method to specify based on strength (supporting capacity)

(E167)Compaction regulations-Method to specify based on strength (supporting capacity)

Compaction regulations

Quality regulation method

- the specified penetration resistance
- density
- degree of saturation a predetermined value

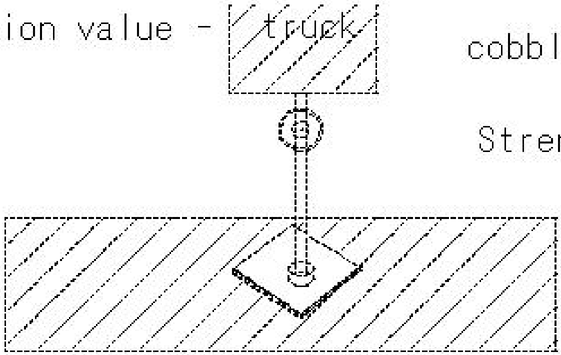
Method to specify based on strength (supporting capacity)

- Embankment material: cobblestone, gravel, sandy soil
- Not affected by water content
- K value CBR value Penetration value - Quality regulations
- Compaction appropriate Strength regulations

・K value CBR value Penetration value -

Quality regulations

CBR test On-site CBR



cobblestone, gravel, sandy soil

↓

Strength regulations

(E168)Compaction regulations-Method defined by saturation degree and air porosity

(E168)Compaction regulations-Method defined by saturation degree and air porosity

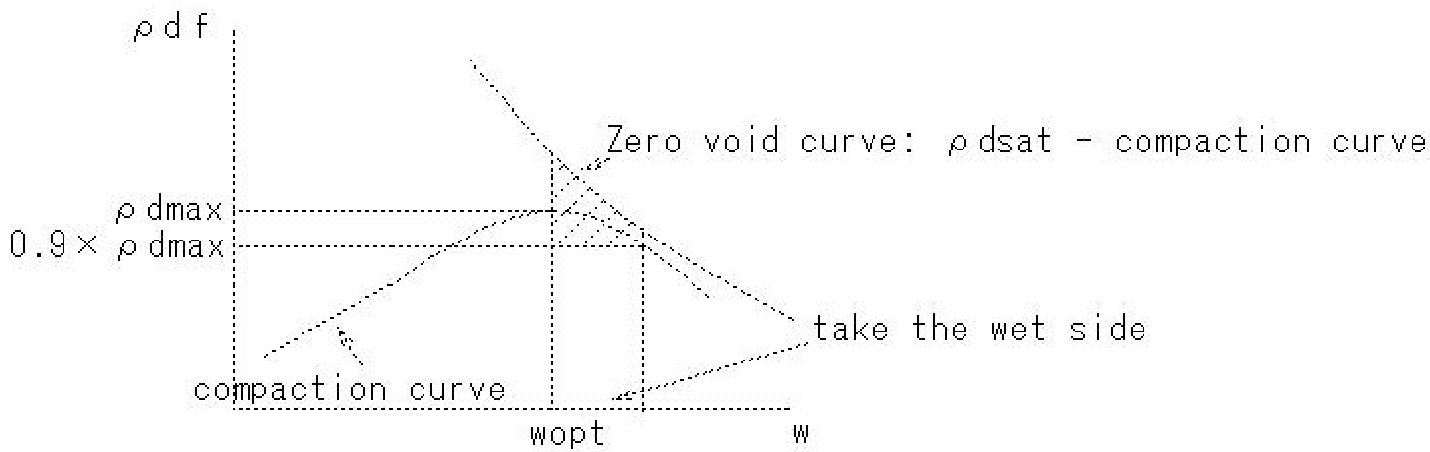
Compaction regulations

Quality regulation method

Method defined by saturation degree and air porosity

- High water content ratio - soft cohesive soil - applicable
- Soil particle density test - saturation Sr
- Air porosity νa - Specify compaction status

Zero void curve: $\rho dsat$ - compaction curve



(E169)Compaction regulations-Method defined by saturation degree and air porosity

(E169)Compaction regulations-Method defined by saturation degree and air porosity

Compaction regulations

Quality regulation method

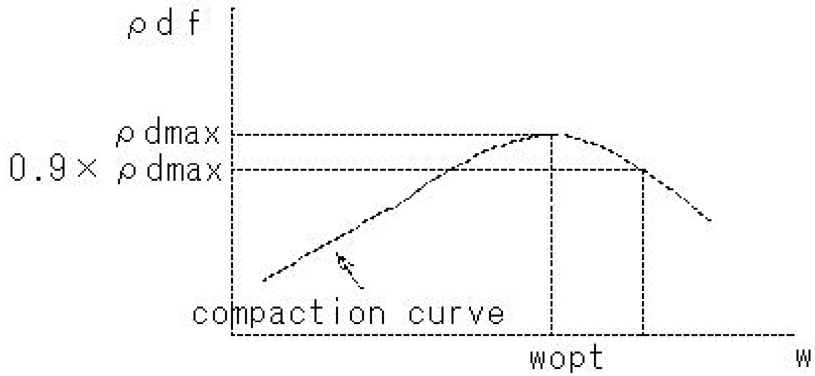
Method specified by dry density

・General soil

・Based on maximum dry density ρdmax - tamping test

・Site dry density ρd

Compaction degree: Cd=((ρd)/(ρdmax))*100%



・Compaction degree Cd=((ρdf/ρdmax)*100(%)

Cd≧90　Embankment roadbed

Cd≧95 Roadbed/Roadbed

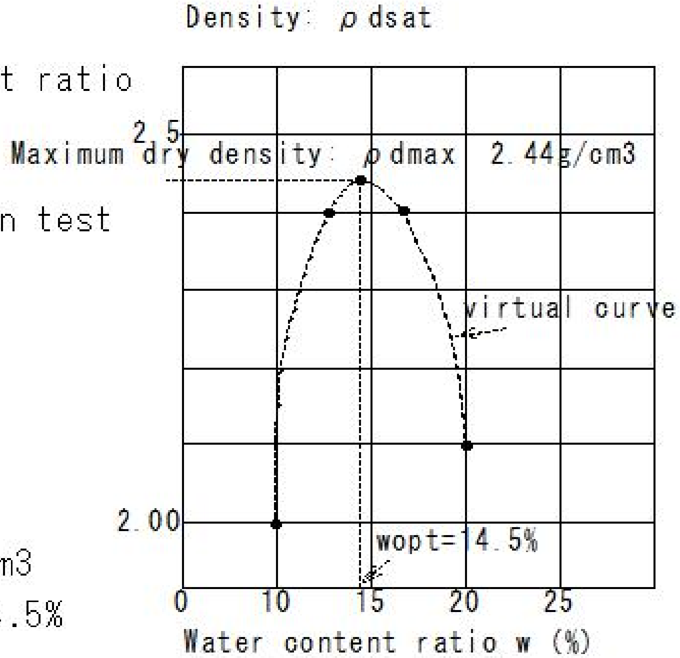
(E170)Compaction regulations-Maximum dry density and optimum moisture content ratio

(E170)Compaction regulations-Maximum dry density and optimum moisture content ratio

Compaction regulations

Quality regulation method

- Maximum dry density and optimum moisture content ratio
- Compaction degree Cd=((ρdf/ρdmax)*100(%)
- compaction test
- Based on maximum dry density ρdmax - compaction test
- Optimal water content ratio wopt
  - compaction test
  - Water content ratio
  - Wet density



Maximum dry density: ρdmax 2.44g/cm3

Optimal water content ratio: wopt=14.5%

example

number	1	2	3	4
Water content ratio w (%)	10	13	17	20
Wet density: ρt=W/V(g/cm3)	2.2	2.71	2.81	2.52
Dry density: ρd=ρt/(1+w/100)(g/cm3)	2.00	2.40	2.40	2.10

(E171)Compaction regulations

(E171)Compaction regulations

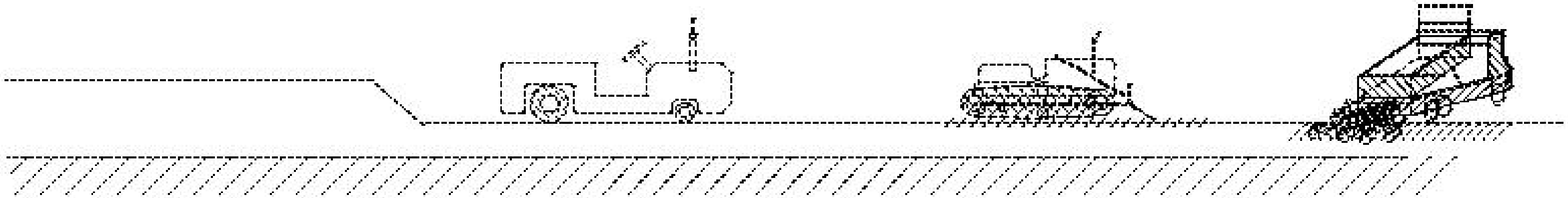
Compaction regulations

Regulation of degree of compaction	Suitable material	regulations
Construction method regulations	rock mass/boulder	Rolling compaction times/ sinking amount
Regulation of strength characteristics	Cobblestone, gravel, sand, sandy soil	CBR value, K value, penetration amount
Dry density regulation	clay/silt	Compaction degree Cd
Saturation regulation	High water content material	Saturation degree Sr Air porosity νa

(E172)Earthworks-Embankment materials

(E172)Earthworks-Embankment materials

- Embankment materials
  ①Basic properties of embankment materials
  ②Soil dressing on land - uneconomical
  ③Cut-embankment-diversion
  ④ Bad materials - how to use them
  - Basic properties of embankment materials
  ⑤Ensure trafficability of construction machinery
  ⑥Embankment slope Stable Possible Shear strength Compressibility - small
  ⑦Consolidation settlement of embankment -no negative impact on road surface



(E173)Earthworks-Embankment materials-Soil unsuitable for embankment

(E173)Earthworks-Embankment materials-Soil unsuitable for embankment

Soil unsuitable for use as embankment material

・Soil unsuitable for embankment

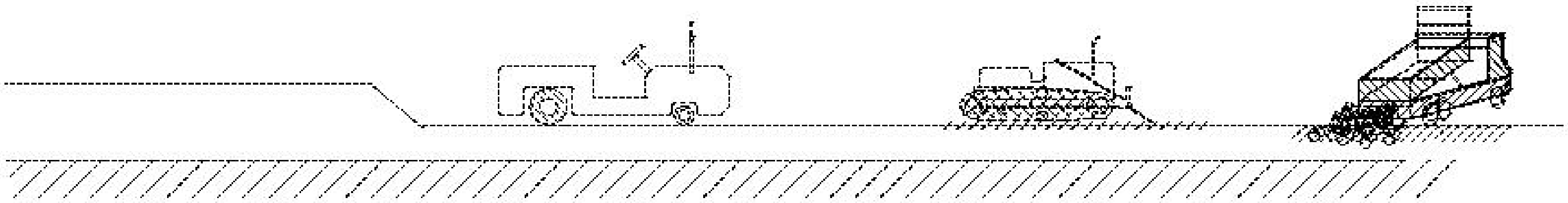
・Absorbs water and expands abnormally

①Bentonite

②Hot spring soil

③Acidic clay

④Organic soil



(E174)Earthworks-Embankment materials-waste soil

(E174)Earthworks-Embankment materials-waste soil

Embankment materials-waste soil

①Enough shear strength to accommodate the embankment height and shape of the embankment

②Balance of cutting and filling volume When cutting volume is large

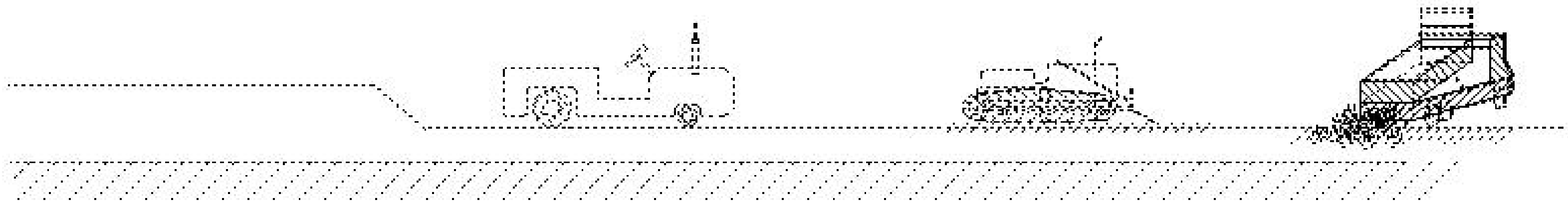
Distribution plan for disposing of bad soil

③Unsuitable for use due to construction method

Wetland bulldozer study cone index

$5 \leqq qc \leqq 10$ Construction after drying

$qc < 5$ Waste soil



(E175)Earthworks-Embankment materials-Embankment material by grain size

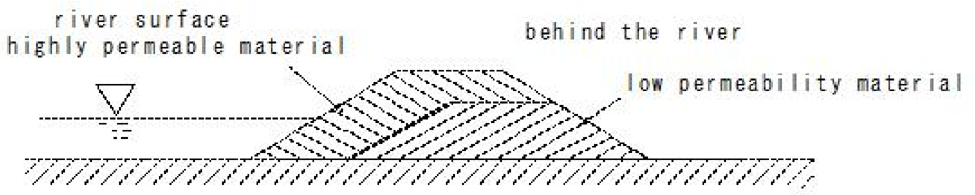
(E175)Earthworks-Embankment materials-Embankment material by grain size

Embankment material by grain size

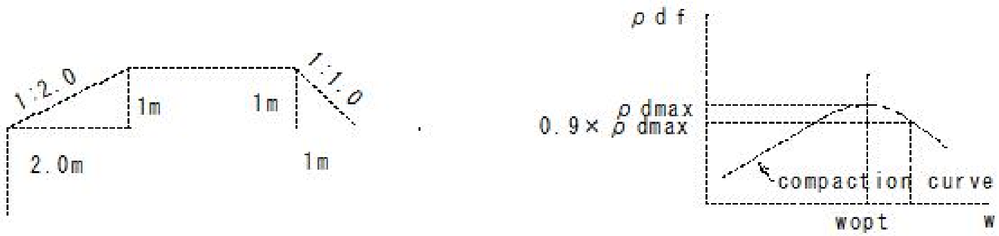
①River embankment embankment - water cut-off

②Road embankment - bearing capacity

③Normal materials under 30 cm



River embankment embankment



Road embankment

(E176)Earthworks-Trafficability-measures

(E176)Earthworks-Trafficability-measures

Trafficability-measures

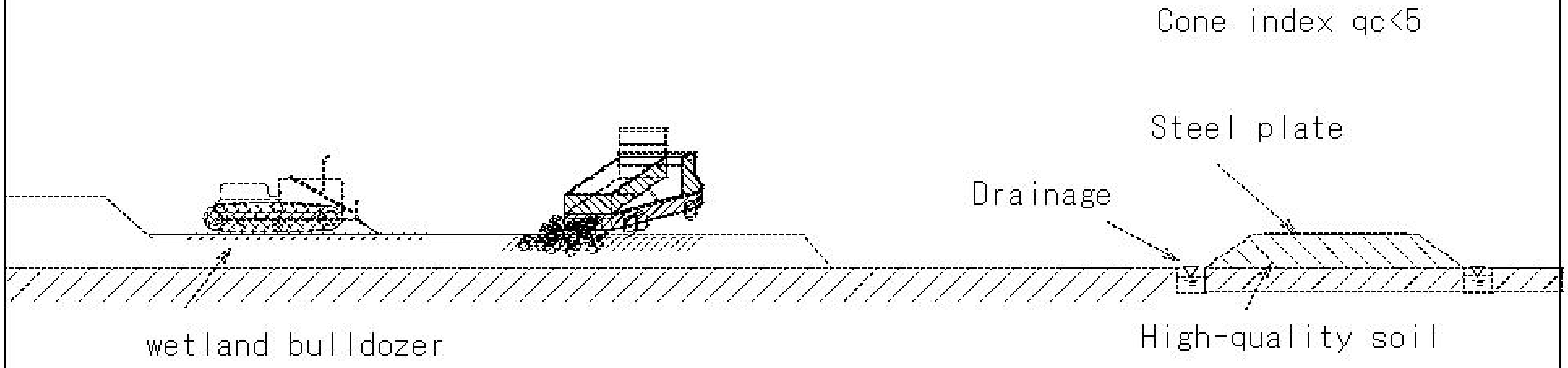
Cone index qc<5

countermeasure

① Compaction by wetland bulldozer

② Drainage work - Drain water - Surface drainage method

③ High-quality soil Steel plate laying Kneading-avoid laying construction method



(E177)Earthworks-Embankment construction- Leveling thickness

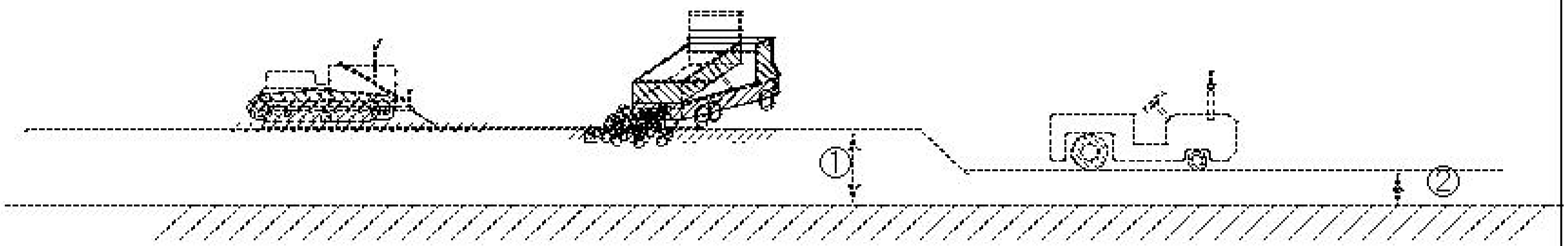
(E177)Earthworks-Embankment construction- Leveling thickness

Embankment construction- Leveling thickness

①Spreading thickness (unrolled thickness) 20-50 cm

②Thickness after compaction: 20-30cm

suitable construction equipment

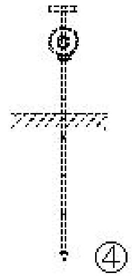


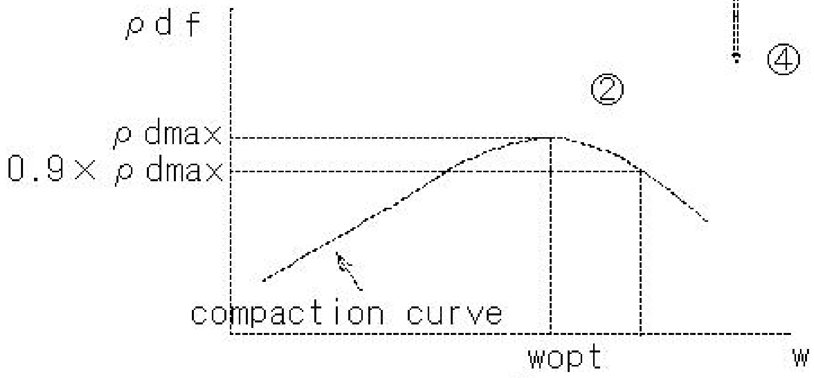
(E178)Earthworks-Embankment construction-Compaction of embankment

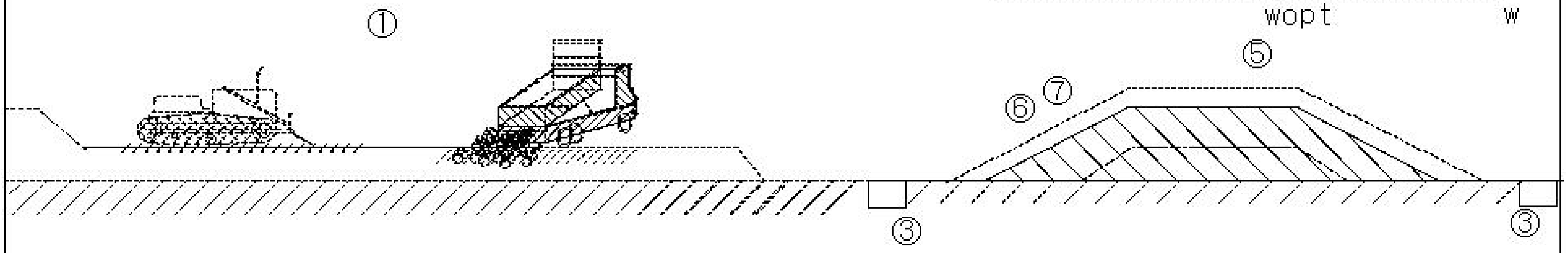
(E178)Earthworks-Embankment construction-Compaction of embankment

Embankment construction-Compaction of embankment

①Roadway for transportation vehicles: Evenly compacted, not in one place
②Embankment material - condition close to optimal moisture content
③During construction, drain water
④Compact with construction machinery according to the cone index
⑤Embankment -settlement - Overfill
⑥Gradient of slope 1: looser than 1.8
⑦1:2 or less Rolling with a bulldozer







(E179)Earthworks-Embankment construction-Embankment on sloping ground

(E179)Earthworks-Embankment construction-Embankment on sloping ground

Embankment construction-Embankment on sloping ground

・Discontinuous cracks between embankment and cut earth

① Water retarding treatment: Underdrain installed at the intersection of cut and embankment

②Cut and embankment 4% slope slope section

③Embankment and original ground step cutting

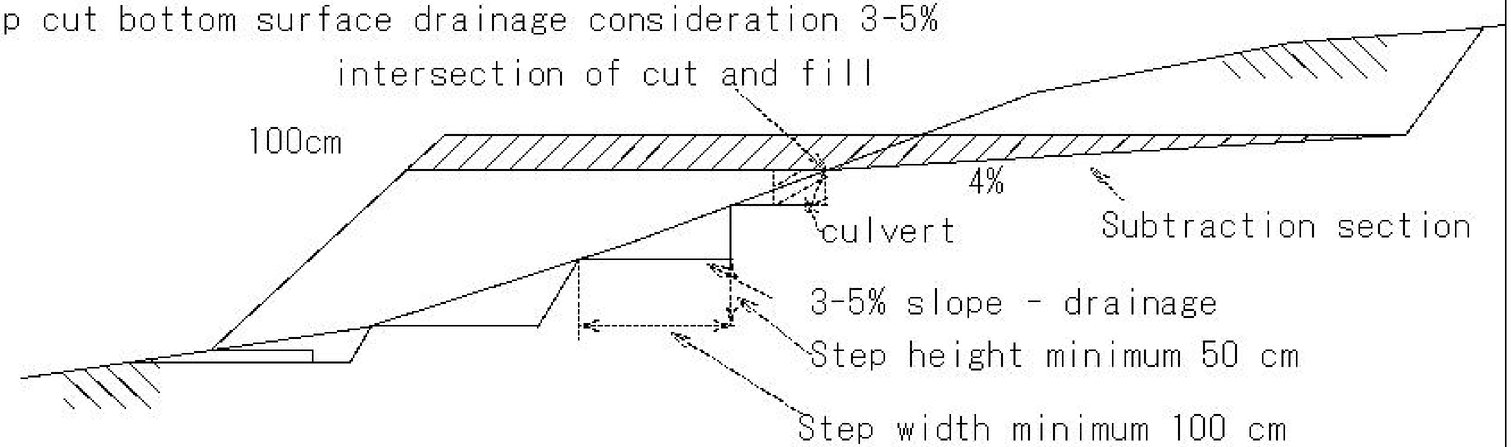
Minimum step cutting width 1m Bulldozer construction approximately 3m

Step height: 50cm or more

④In the case of bedrock, if there are many rubbing sections - uneconomical

Gradient 1: 5th or higher

⑤Step cut bottom surface drainage consideration 3-5%



(E180)Earthworks-Embankment construction-Embankments and structures

(E180)Earthworks-Embankment construction-Embankments and structures

Embankments and structures

- Joint point between structure and embankment
- Large construction machinery - cannot be used
- Easy to settle unevenly

Points

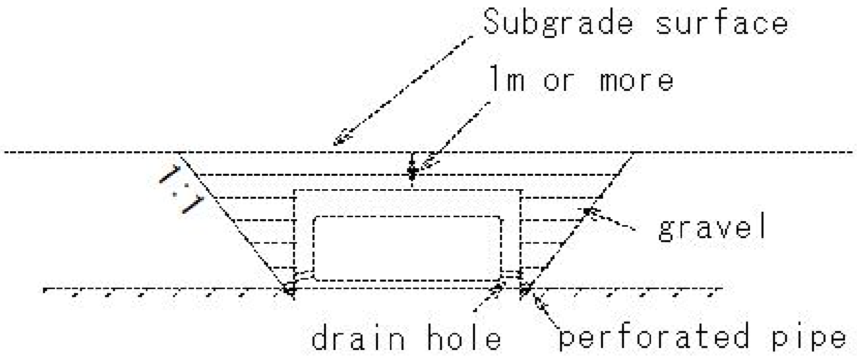
①Backfilling material -good water permeability easy to compact
Less loss of supporting capacity due to water Compressibility - small

②Small construction machinery so as not to put too much pressure on the structure

③Unrolling thickness - thinner Compact the target to avoid knitting pressure

④Drainage measures during rainfall

⑤Compaction standards - General section - Strict



(E181)Earthworks-Embankment construction-Selection of equipment for earthwork

(E181)Earthworks-Selection of equipment for earthwork

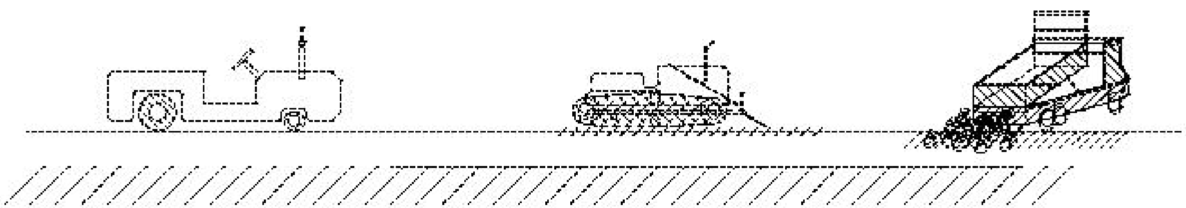
Selection of equipment for earthwork

1 Compatibility of construction conditions and model/capacity
2 Economical selection of machines
3 Combination of machines

example

- Drilling depth
- Shoulder gradient
- Construction road conditions
- Conditions of soil disposal site
- Traffic conditions
- Material weight
- Construction volume and required construction speed

- Survey and examine machine suitability
- Selection of suitable model
- Balance of combination machine



(E182)Earthworks-Characteristics of Earthmoving Machinery

(E182)Earthworks-Characteristics of Earthmoving Machinery

Characteristics of Earthmoving Machinery

1 Work 2 model 3 Transportation 4 Soil quality 5 Work conditions

1-1 Loading and transportation

2-1 Motor scraper

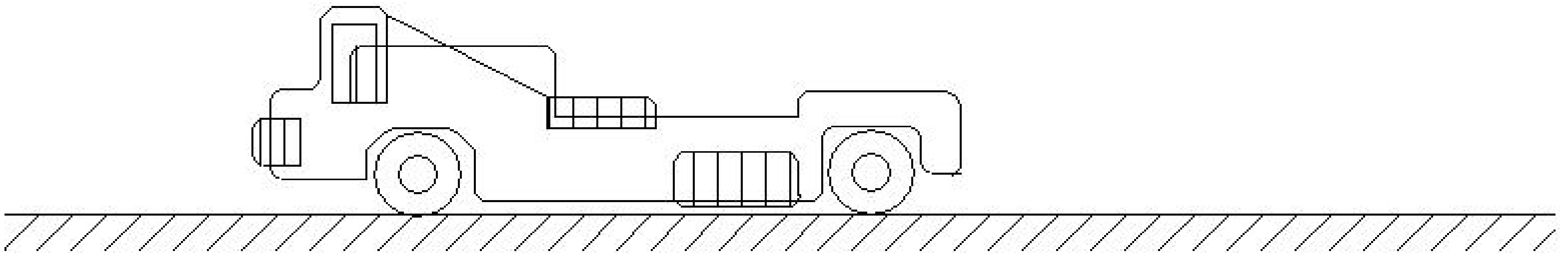
3-1 200-1200m medium distance

4-1 Cobble stones - few Cone index qc = 10 or more Cone index qc = 10 or more

Suitable for sandy soil and gravel soil

5-1 Ensuring traffic availability on transportation routes

Securing a workspace for changing direction, etc.

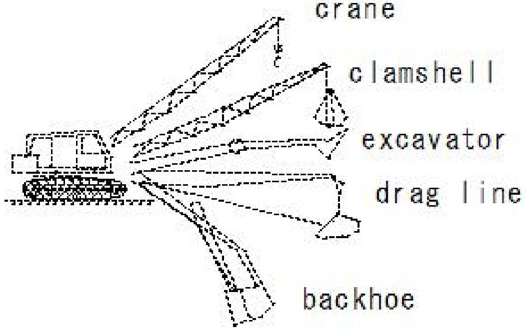


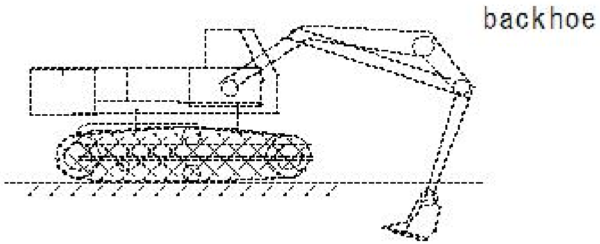
Motor scraper

(E183)Earthworks-Characteristics of Earthmoving Machinery

(E183)Earthworks-Characteristics of Earthmoving Machinery

Characteristics of Earthmoving Machinery				
①Work	②model	③Transportation	④Soil quality	⑤Work conditions
①-2 Excavation/loading				
		③-2 Combination with dump truck		
		③-2 Transportation distance 70m or more		
			④-2 Cone index qc = 12 or more	
		④-2 The excavated soil can be either hard or soft.		
	②-2 Backhoe	⑤-2 Excavation location - lower than the ground		
	②-2 Clamshell	⑤-2 Underwater drilling -drilling at great depths		
	②-2 drag line		⑤-2 Wide areas such as rivers	
	②-2 Excavator	⑤-2 Where the excavation point is higher than the ground		

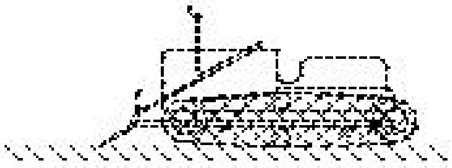




(E184)Earthworks-Characteristics of Earthmoving Machinery

(E184)Earthworks-Characteristics of Earthmoving Machinery

Characteristics of Earthmoving Machinery				
①Work	②model	③Transportation	④Soil quality	⑤Work conditions
①-3 Excavation/Dossing				
	②-3 Bulldozer			
		③-3 Short-distance excavation transportation		
			④-3 Cone index	
			Ordinary bulldozer qc = 5-7 or more	
		③-3 Transportation distance of 70m or less		
			④-3Wetland bull qc = 3 or more	
			Super wetlands qc = 2 or more	
			⑤-3 qc = 3 (2) or less Unable to drive	

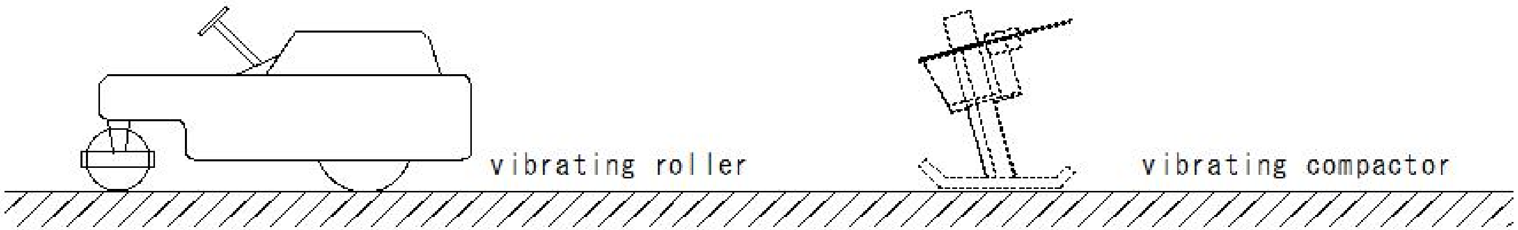


Bulldozer

(E185)Earthworks-Characteristics of Earthmoving Machinery

(E185)Earthworks-Characteristics of Earthmoving Machinery

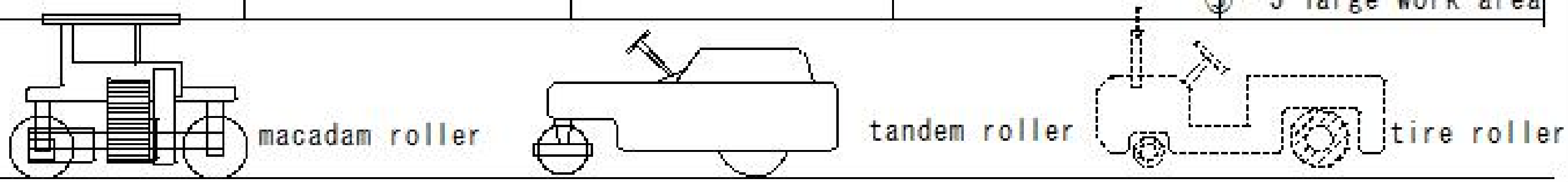
Characteristics of Earthmoving Machinery				
①Work	②model	③Transportation	④Soil quality	⑤Work conditions
①-4 Compaction (centrifugal force)				
	②-4 vibrating roller			
		③-4 Working speed 0.9km/h		
			④-4 Gravel soil/sandy soil	
				⑤-4 large work area
①-4 Compaction (centrifugal force)				
	②-4 vibrating compactor			
		③-4 Working speed 0.6-0.8km/h		
			④-4 Gravel soil/sandy soil	
				⑤-4 narrow workplace space



(E186)Earthworks-Characteristics of Earthmoving Machinery

(E186)Earthworks-Characteristics of Earthmoving Machinery

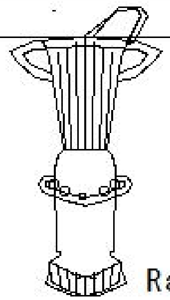
Characteristics of Earthmoving Machinery				
①Work	②model	③Transportation	④Soil quality	⑤Work conditions
①－5 static pressure				
	②－5 macadam roller			
		③－5 Working speed 2km/h		
			④－5 Rock mass, gravel, sand, sandy soil	
				⑤－5 large work area
①－5 static pressure				
	②－5 tandem roller			
		③－5 Working speed 2.5km/h		
			④－5 Rock mass, gravel, sand, sandy soil	
			⑤－5 narrow workplace space	
①－5 static pressure				
	②－5 tire roller			
		③－5 Working speed 3km/h		
			④－5 sandy soil clayey soil	
				⑤－5 large work area



(E187)Earthworks-Characteristics of Earthmoving Machinery

(E187)Earthworks-Characteristics of Earthmoving Machinery

Characteristics of Earthmoving Machinery				
①Work	②model	③Transportation	④Soil quality	⑤Work conditions
①－6 impact				
	②－6 Ranma			
			④－6 Grassy soil, sand, sandy soil	
				⑤－6 narrow workplace space
①－6 impact				
	②－6 tampa			
			④－6 Grassy soil, sand, sandy soil	
				⑤－6 narrow workplace space
①－6 impact				
	②－6 tamping road			
			④－6 hard clay clay soil	
				⑤－6 narrow workplace space

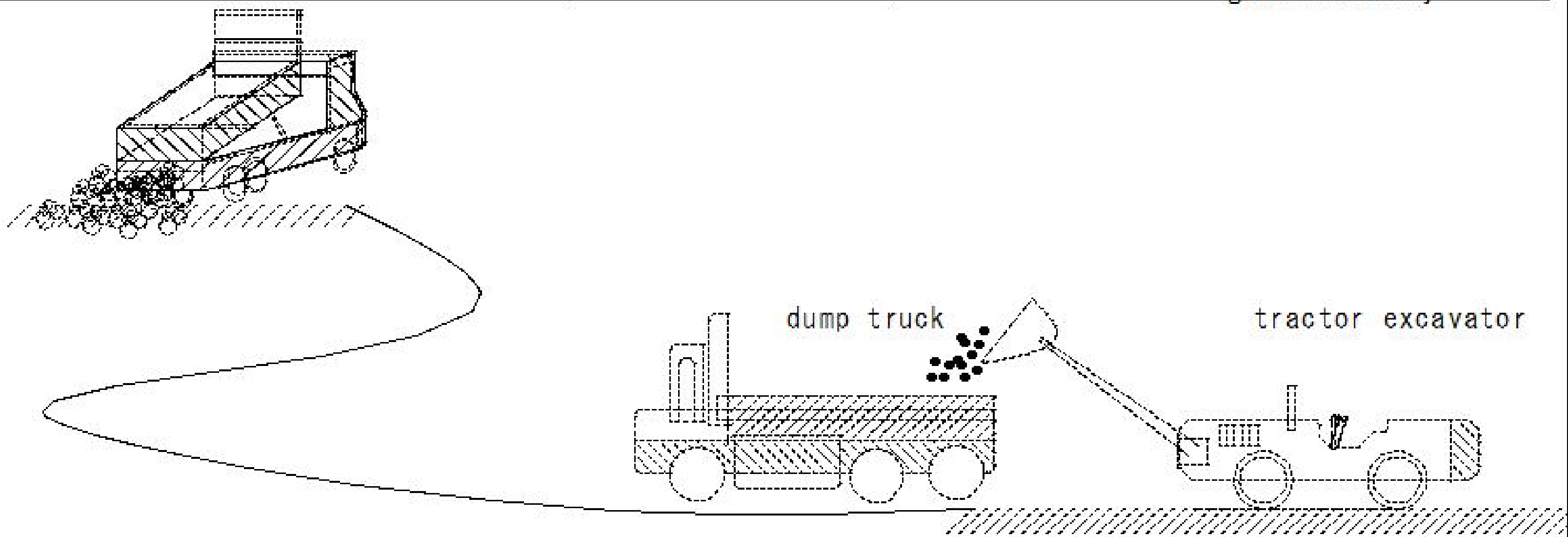


Ranma

(E188)Earthworks-Characteristics of Earthmoving Machinery

(E188)Earthworks-Characteristics of Earthmoving Machinery

Characteristics of Earthmoving Machinery				
①Work	②model	③Transportation	④Soil quality	⑤Work conditions
①-7 Excavation/loading				
	②-7 tractor excavator			
		③-7 combination with dump truck		
			④-7 Suitable for excavation and loading of soft soil	
				⑤-7 Suitable for excavating in low places
				good mobility

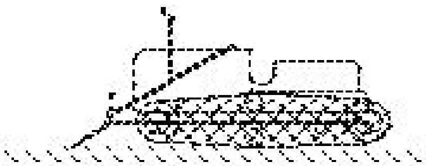


(E189)Earthworks-Excavation and transportation method

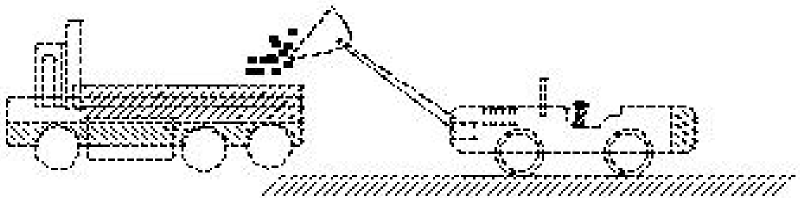
(E189)Earthworks-Excavation and transportation method

Excavation and transportation method

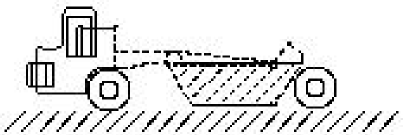
① Bulldozer method (70m or less)
② Excavator and dump truck (70m or more)
③ Towed scraper (about 500m)
④ Scrape dozer method (Suitable for cohesive soil (70 m or more)
⑤ Water content adjustment: Plow, desk harrow, motor grader, sprinkler truck



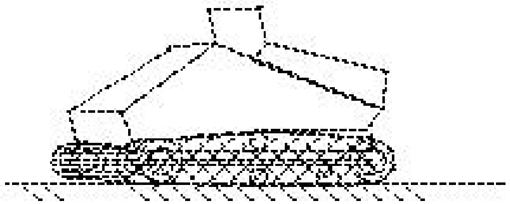
Bulldozer



Excavator and dump truck



Motor Scraper



Scrape dozer

(E190)Earthworks-Slow construction method

(E190)Earthworks-Slow construction method

Cohesive soil soft ground improvement method

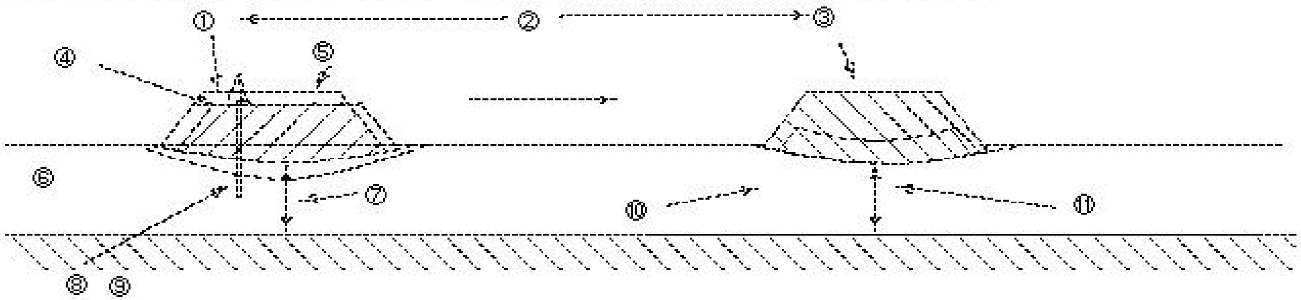
Slow construction method

①Purpose Consolidation by draining interstitial water in soft cohesive soil
Increases shear strength

②Method Embankment on soft ground to promote drainage and consolidation

③Characteristic: Slow consolidation drainage speed

①Within the bearing capacity of soft ground
②Wait for the bearing capacity of the soft ground to increase so that the arc slip does not occur.
③Embankment against ground bearing capacity after consolidation
④Embankment after consolidation settlement
⑤Embankment before deformation
⑥Soft ground
⑦Soil after consolidation
⑧Soil survey
⑨Find the bearing capacity of the soil against the ground after consolidation
⑩Calculate the ground bearing capacity after consolidation
⑪Continue until the bearing capacity for the specified embankment is reached



(E191)Earthworks-Sand mat method

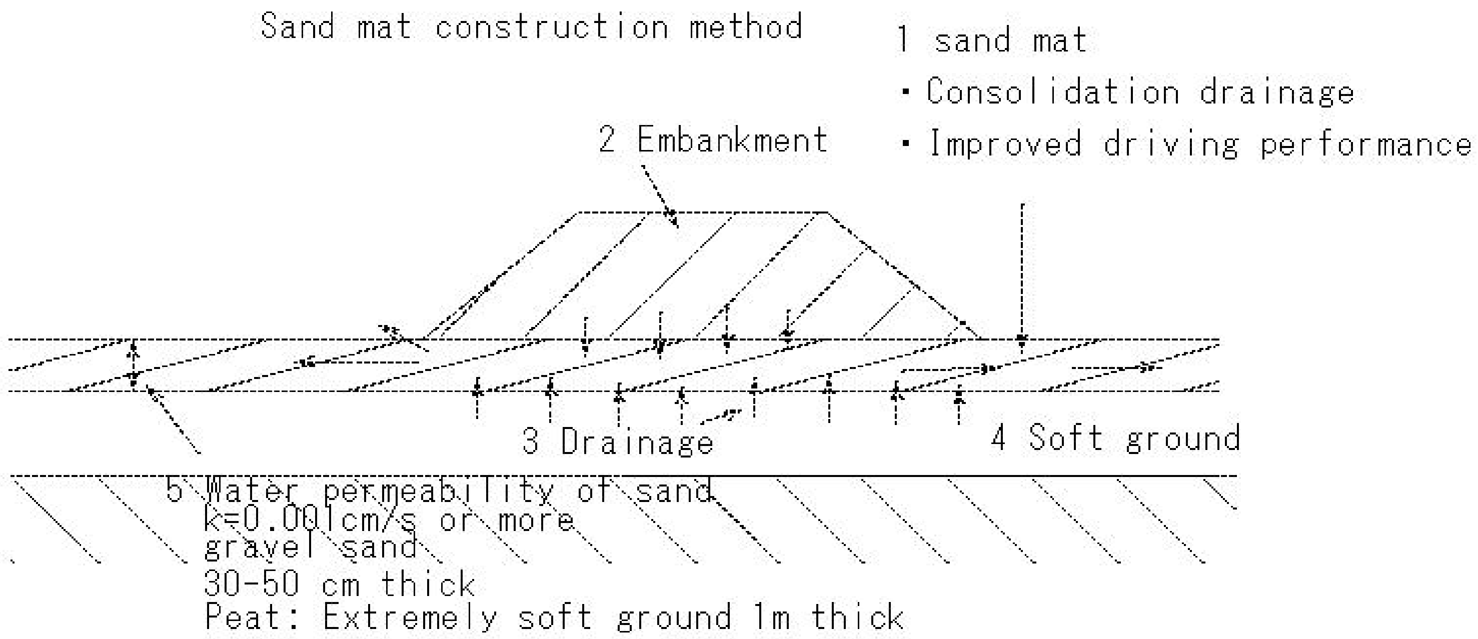
(E191)Earthworks-Sand mat method

Cohesive soil soft ground improvement method

①Purpose Improvement of traffic ability Creation of a consolidation drainage channel

②Method Spread 50-120cm sand with good water permeability

③Features Sand drain construction method Preparatory work for the holding embankment construction method



(E192)Earthworks-Pressure embankment method

(E192)Earthworks-Pressure embankment method

Cohesive soil soft ground improvement method

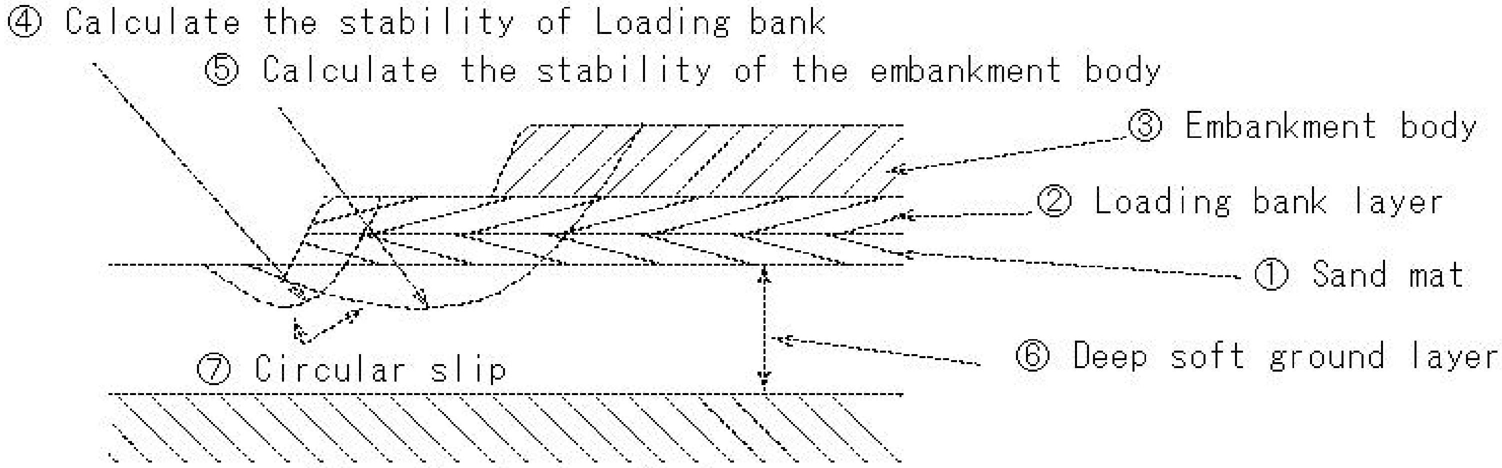
Pressure embankment method

① Purpose: Prevention of embankment sliding failure

② Method: Embank on the left and right of the embankment section

③ Characteristics:Large land required

the soft cohesive soil layer is thick



3 Loading bank method

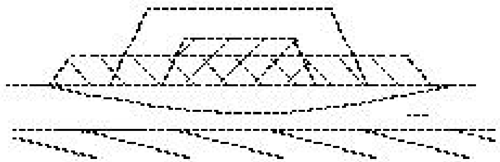
(E193)Earthworks-Preloading method

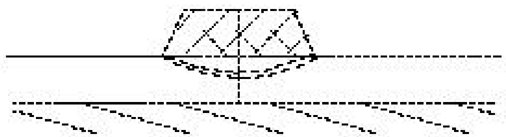
(E193)Earthworks-Preloading method

Cohesive soil soft ground improvement method

Preloading method

①Purpose: Embankment higher than the design cross section to promote consolidation
②Method: High embankment within the land area
③Features: Securing a disposal site after consolidation is completed





(E194)Earthworks-Removal and replacement method

(E194)Earthworks-Removal and replacement method

Cohesive soil soft ground improvement method

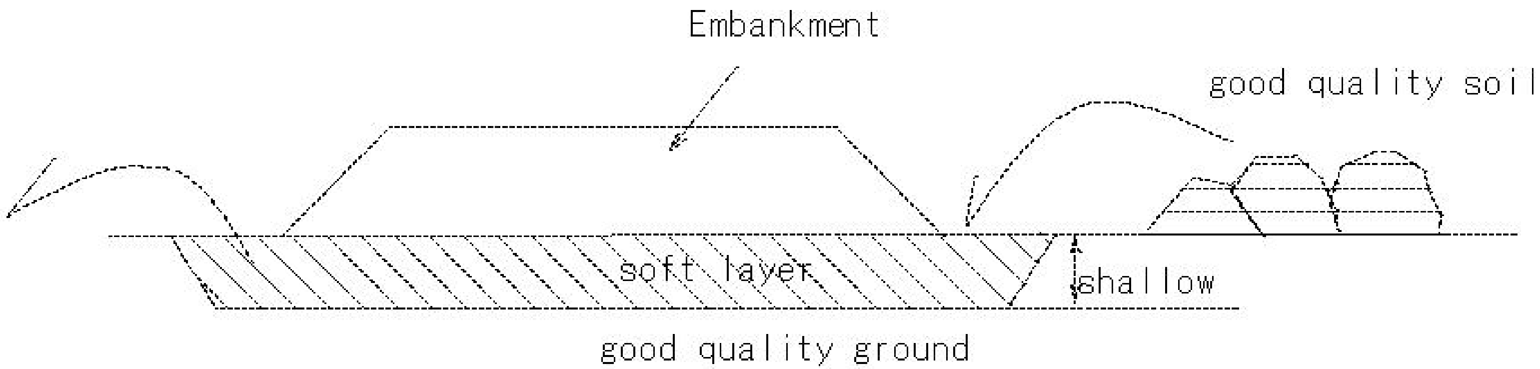
Removal and replacement method

① Purpose: Increase support capacity in a short period of time

② Method: Remove soil from soft ground and replace with good quality soil

③ Characteristics Soft ground layer - shallow case

Soil dump site: Securing good quality soil - easy



(E195)Earthworks-Sand drain method

(E195)Earthworks-Sand drain method

Cohesive soil soft ground improvement method

Drain method

Sand drain method
Paper drain method

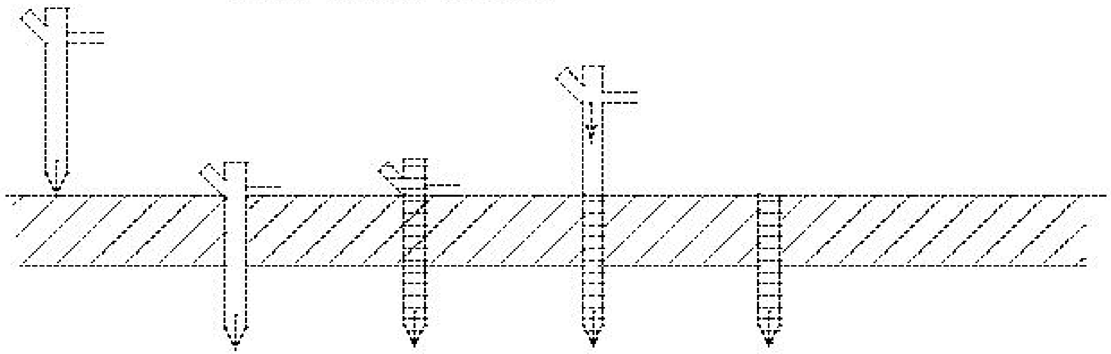
① Purpose: Create a consolidation drainage channel and shorten consolidation drainage time

② Method: Sand pillars: Drive paper and boards into the soft ground to create drainage channels.

③ Characteristics Pre-loading method combined with slow speed method

End consolidation early
Sand drain effective for consolidation of deep soft clay layers of 15m or more

Sand drain method



(E196)Earthworks-Sand compaction pile method (vibrocomposer method)

(E196)Earthworks-Sand compaction pile method (vibrocomposer method)

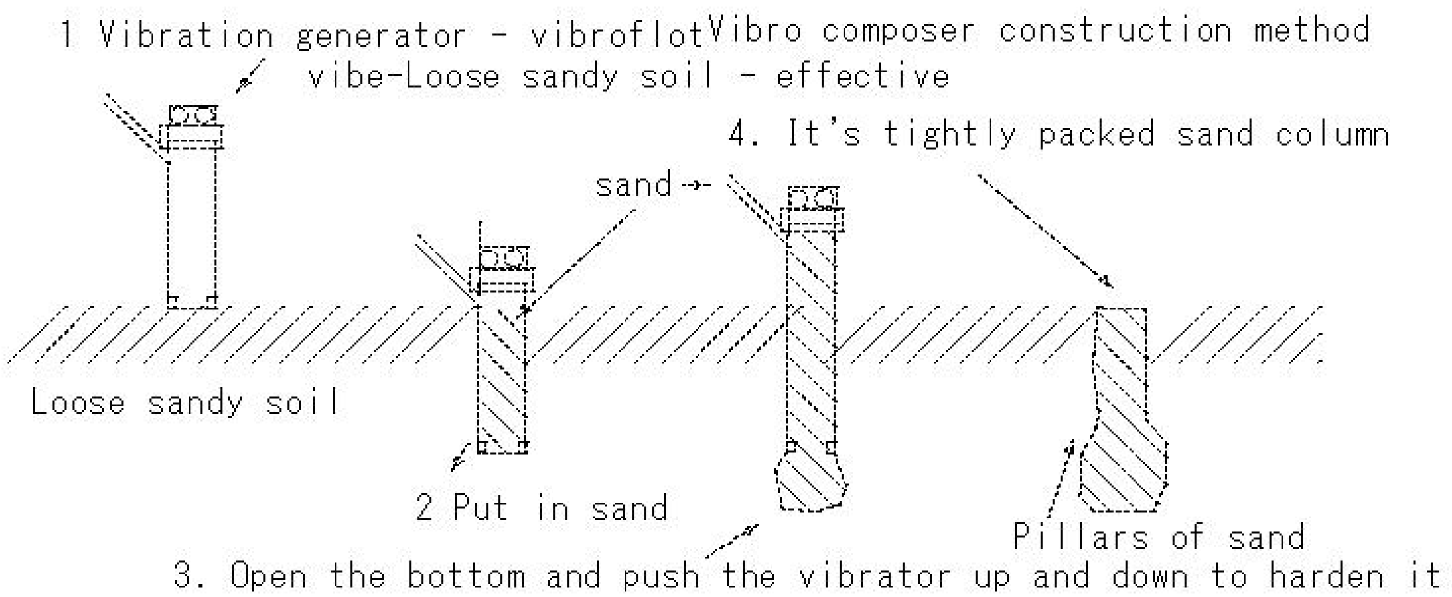
Improvement of soft sand ground

Sand compaction pile method (vibrocomposer method)

① Purpose Loose sandy ground, soft viscous ground, hard sand column, ground compaction, increased bearing capacity

② Method: Vibropipe - hard sand pillar underground

③Characteristics: Both loose sandy ground and soft viscous ground can be improved.



(E197)Earthworks-Vibroflotation method

(E197)Earthworks-Vibroflotation method

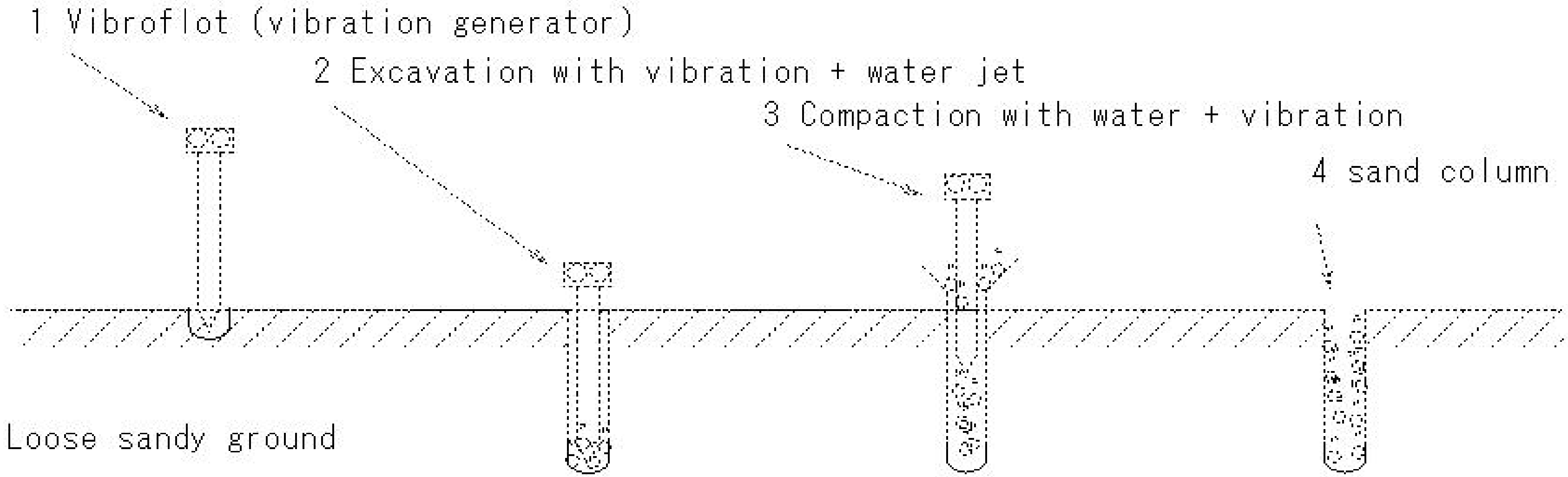
Improvement of soft sand ground

Vibroflotation method

① Purpose: Loose sand ground, hard sand pillars, ground compaction, and the sand pillars themselves have supporting capacity.

② Method: Create a sand column by tightening water with a vibroflot

③ Features: Prevention of sand fluidization



Vibroflotation method

(E198)Earthwork plan

(E198)Earthwork plan

Earthwork plan

Amount of work done by construction machinery

Earthwork: Repetitive work

Cm (min): Cycle time for one cycle of repetitive work

q(m3): Construction volume per cycle

Q: Construction volume per hour

$Q=60\times q/Cm$ ・・・(1・1)

Processing times per hour: Completely impossible

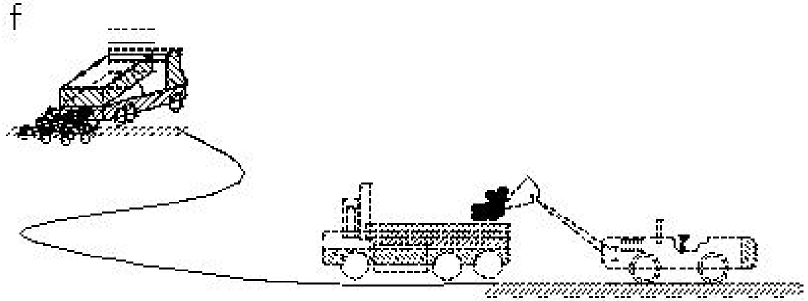
E: work efficiency

$Q=60\times q\times E/Cm$ ・・・(1・2)

Conversion factor for soil mass volume f(=1/L)

Amount of work per cycle time q’ = q x f

$Q=60\times q\times f\times E/Cm$ ・・・(1・3)



(E199)Earthwork plan-Value of soil volume conversion factor f

(E199)Earthwork plan-Value of soil volume conversion factor f

Earthwork plan

Construction machinery construction volume

Value of soil volume conversion factor f

	Volume of ground soil	Volume of loosened soil	Volume of loosened soil
Land volume Amount of soil to be excavated	1	L	C
Loosen soil volume Amount of soil to be transported	1/L	1	C/L
Compacted soil volume Completed embankment amount	1/C	L/C	1

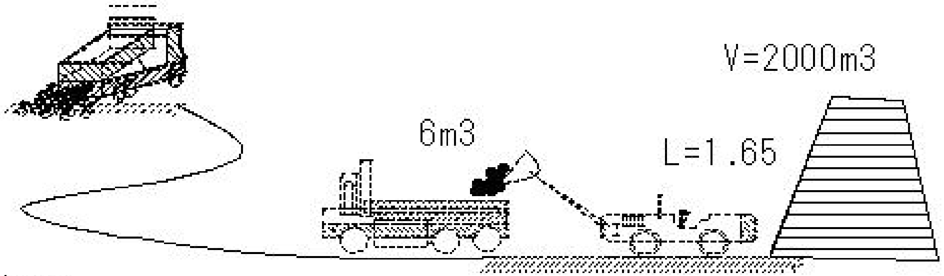
(E200)Earthwork plan-Construction machinery construction volume

(E200)Earthwork plan-Construction machinery construction volume

Earthwork planning

Construction machinery construction volume

Earthly rock V=2000m3
Dump truck 6m3
Rock loosening rate L=1.65
Number of round trips ?



Dump truck 6m3 = loosened soil volume
Volume of ground soil volume

①Natural ground V = 2000m3 → Amount of loosened soil V = 2000 x 1.65 = 3300m3
Dump truck V=6m3
Number of round trips = 3300/6 = 550 times

②Dump truck V = 6m3 (amount loosened) → soil volume V = 6/1.65 = 3.636m3
Number of round trips = 2000/3.636=550 times

(E201)Earthwork plan-Land volume curve diagram

(E201)Earthwork plan-Land volume curve diagram

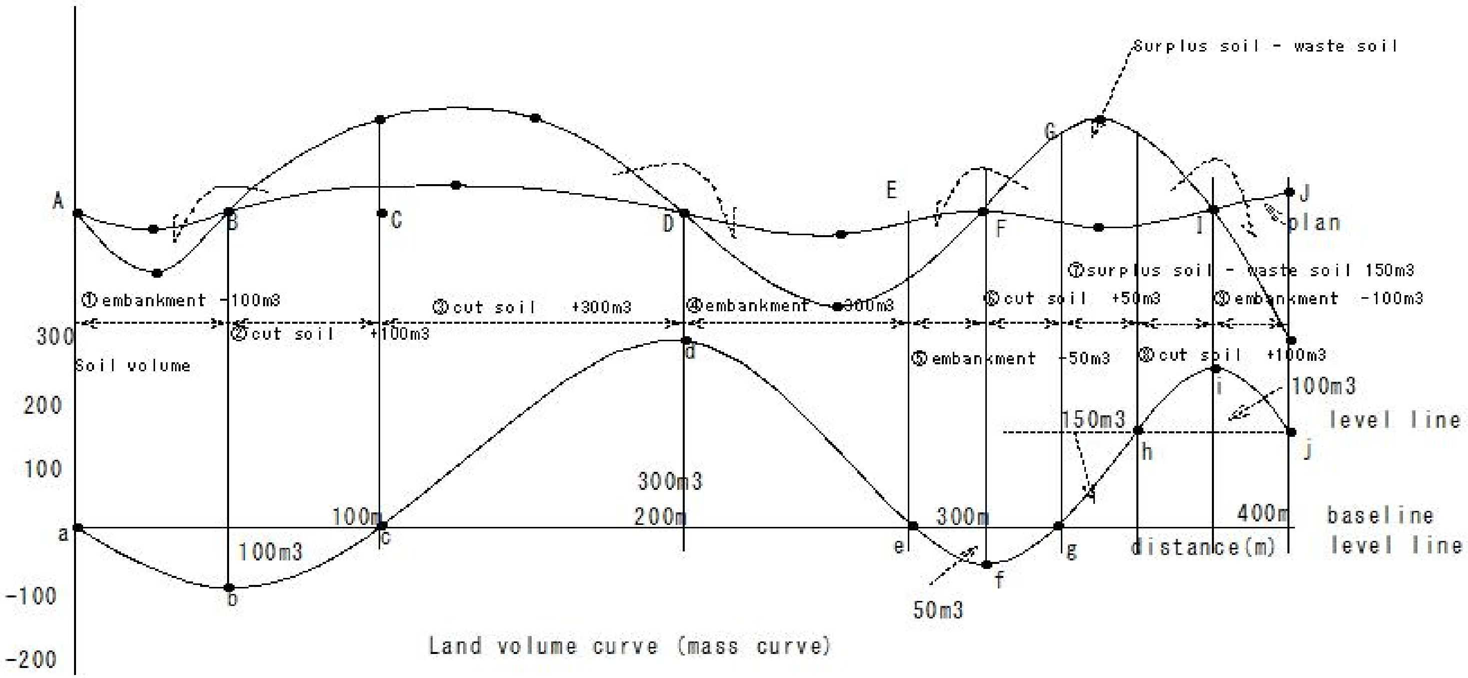
Land volume curve diagram mass curve

①Amount of soil to be moved – minimum

②Improved economic efficiency and workability

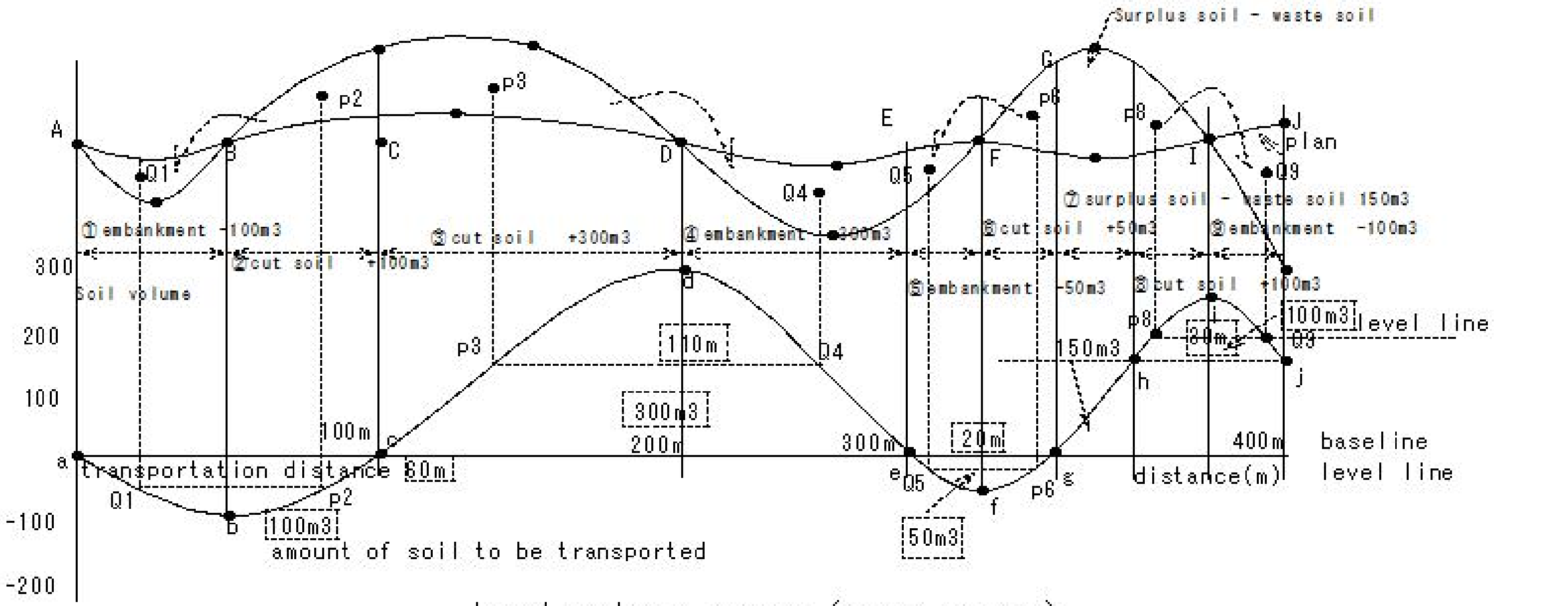
③Soil volume distribution

④Land volume curve (mass curve)



(E202)Earthwork plan-Properties of volume curve

(E202)Earthwork plan-Properties of volume curve



Land volume curve (mass curve)

Earthwork plan

Properties of volume curve

1 Point b Point f Displacement point from the embankment section to the cutting section

2 Point d Point i Displacement point from cut section to fill section

3 The volume of soil is flat in the section surrounded by the earth volume curve and flat line / baseline

4 points a c e g b i j are flat points

5 bb'=100m3 dd'=300m3 ff'=50m3 ii'=100m3 Volume of soil to be treated in each section

6 Distance from baseline to flat line hh'=i''I'=jj'=150m3

Above the baseline - surplus soil

Soil disposal plan

the level line is on the lower side - replenishment soil volume is required

PQ: Transportation distance

P, Q points Center of gravity of each section

(E203)Earthwork plan-Use of volume curve

(E203)Earthwork plan-Use of volume curve

Use of volume curve

1 Calculate the amount of soil transported and the transport distance

2 Selection of appropriate earthmoving machinery

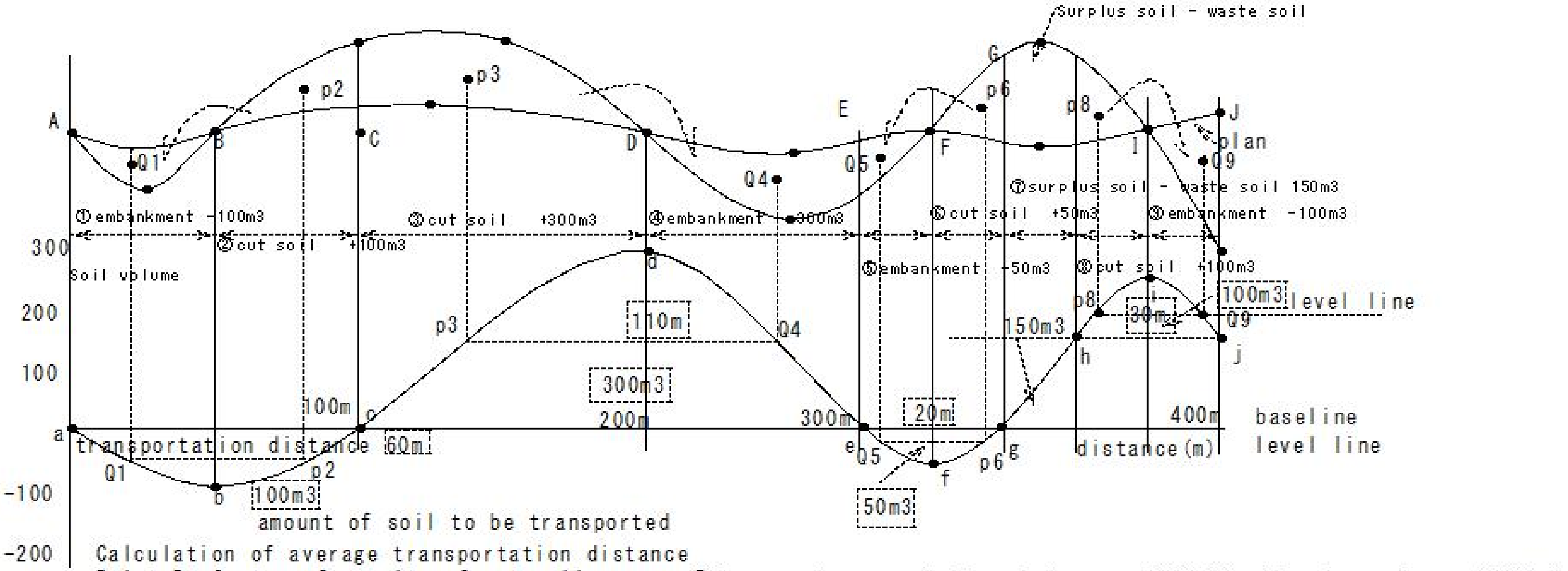
3 Improvement of work efficiency of construction machinery

4 Distribution of soil volume in the construction plan

Land volume curve (mass curve)

PQ: Transportation distance

P, Q points Center of gravity of each section



Calculation of average transportation distance

Point P: Center of gravity of cut soil

Point Q: Center of gravity of embankment

Average transportation distance

① Average transportation distance P1Q1=60m Moved a volume of 100m3

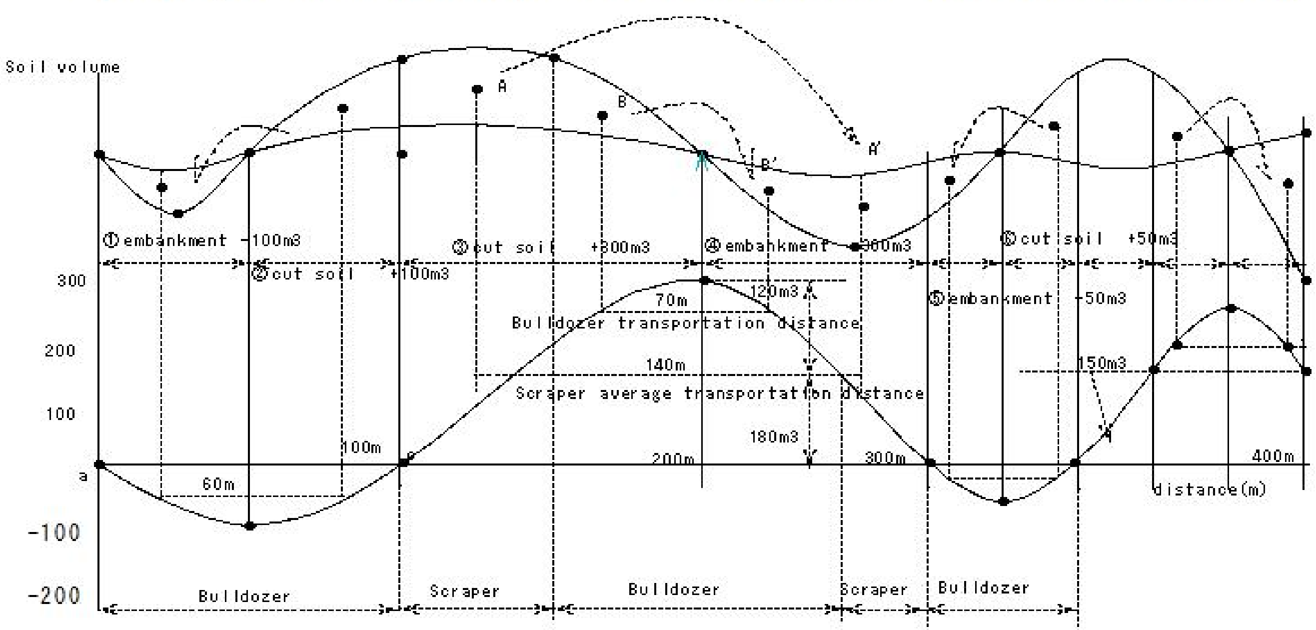
② Average transportation distance P3Q4 = 110m Moved 300m3 of soil

③ Average transportation distance P6Q5=20m Moved 50m3 of soil

④ Average transportation distance P8Q9=30m Moved 100m3 of soil

(E204)Earthwork plan-Selection of earthmoving machinery

(E204)Earthwork plan-Selection of earthmoving machinery



Earthwork plan

Use of volume curve

Selection of earthmoving machinery

- Bulldozers are used for short-distance excavation and transportation.
- Scraper is medium range

a Section ①② Average transportation distance of 70m or less - Bulldozer

b Section ③④ Average transportation distance 110m

- Calculate from the volume curve so that the average transportation distance is 70m
- Use a scraper excavator and a dump truck for transportation distances of 70 m or more
- A-A' scraper ・Scraper Transport volume: 180m3

c ⑤ ⑥ section is 20m average transported soil volume - using a bulldozer

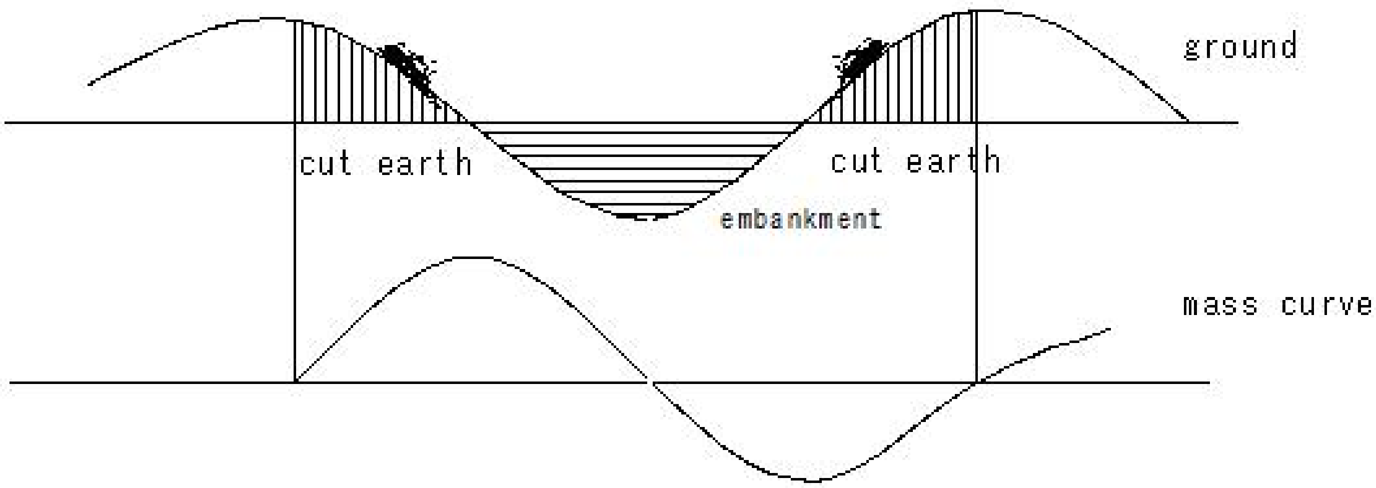
- B-B' bulldozer ・Amount of earth transported by bulldozer: 120m3

(E205)Earthwork plan-Improving the efficiency of construction machinery

(E205)Earthwork plan-Improving the efficiency of construction machinery

Improving the efficiency of construction machinery

・Improve work efficiency
・Work on a downhill slope



Curve with good work efficiency

(E206)Embankment materials – compaction test

(E206)Embankment materials - compaction test

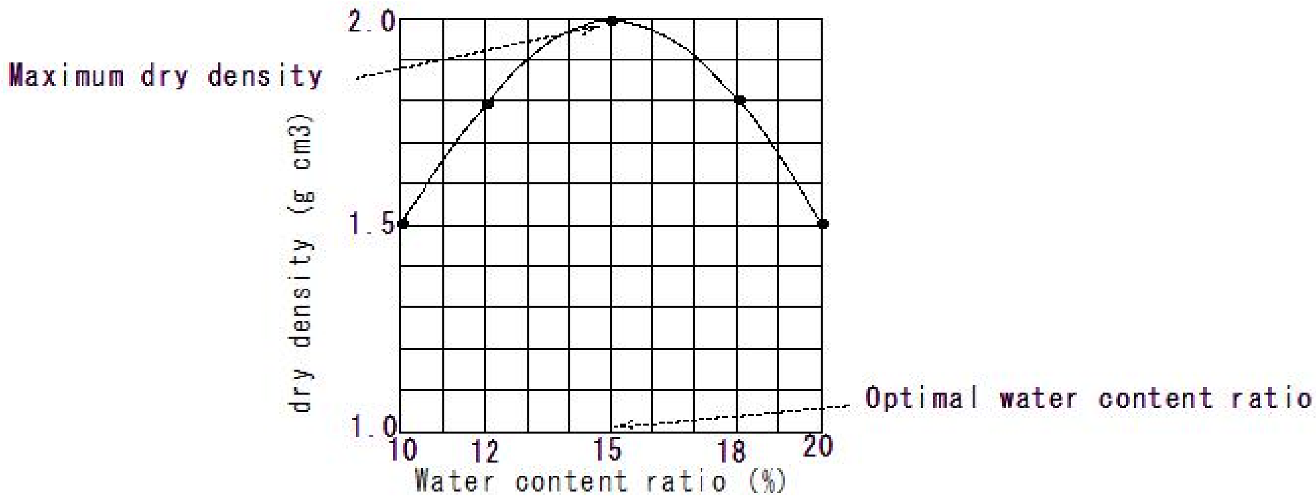
Embankment materials -compaction test

①Compaction curve

②Optimal water content ratio Maximum dry density

③Compaction degree 90% - construction moisture content range

number	1	2	3	4	5
Water content ratio (%)	10.0	18.0	15.0	12.0	20.0
Wet density ρt (g cm3)	1.650	2.124	2.300	2.016	1.800
dry density ρd=ρt/(1+w/100)	1.5	1.8	2.0	1.8	1.5



(E207)Embankment materials – general properties

(E207)Embankment materials -general properties

Embankment materials -general properties

①Plasticity index - large

Soil with good workability

②Little settlement and deformation; strong against rain erosion

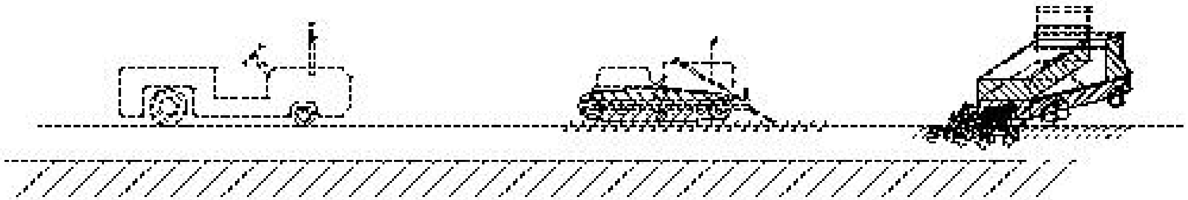
③Strong soil

Embankment stability

①Confirm each characteristic of embankment material by test kneading

②Selection of appropriate compaction machine

Adequate compaction



(E208)Embankment construction on sloping ground

(E208)Embankment construction on sloping ground

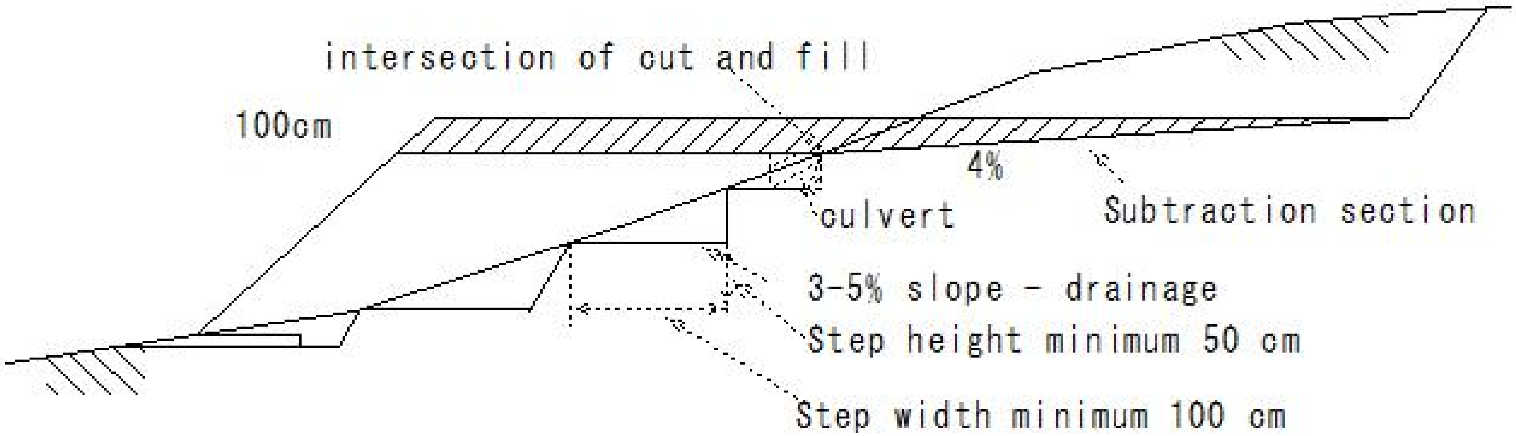
Embankment construction

・Embankment construction on sloping ground

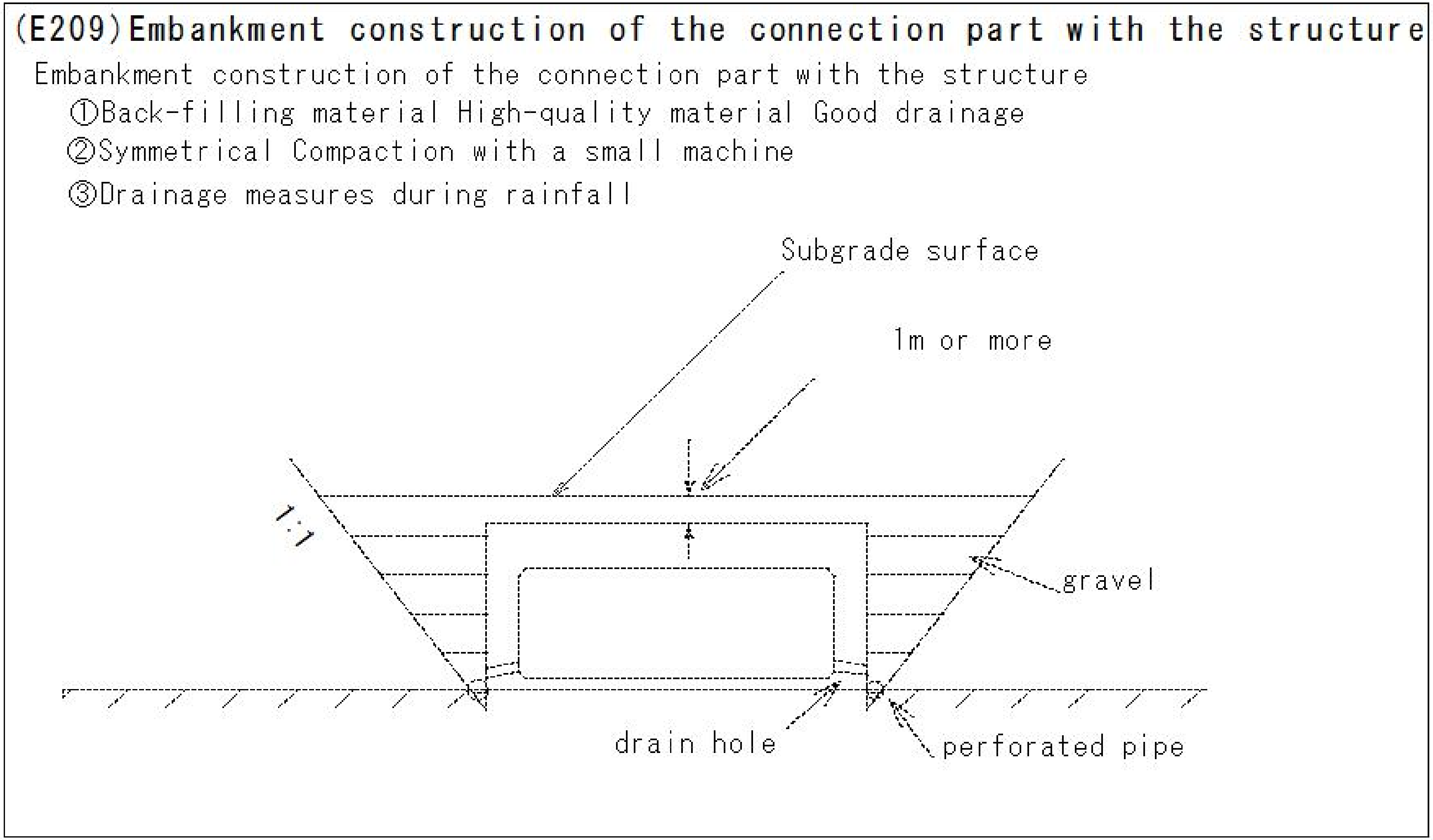
①Original ground Height 50 cm Width 100 cm Stepped
Embankment adhesion

②Spring water inside the embankment Blind ditch Prevent softening of the embankment

③Stepped surface, drainage consideration, 3-5% slope
Spreading thickness - small



(E209)Embankment construction of the connection part with the structure



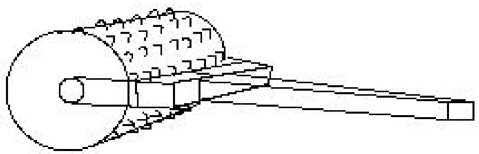
(E210)Embankment construction-Compaction machine

(E210)Embankment construction-Compaction machine

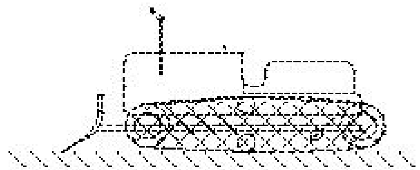
Embankment construction
compaction machine

①Tamping roller
Compaction of hard clay/clay soil

②Wetland bulldozer
Compaction of very soft clay/cohesive soil



Tamping roller



Wetland bulldozer

(E211)Embankment construction-Improved trafficability

(E211)Embankment construction-Improved trafficability

Improved trafficability

①Sand mat method

Place about 50-120cm of sand on top of the soft layer.

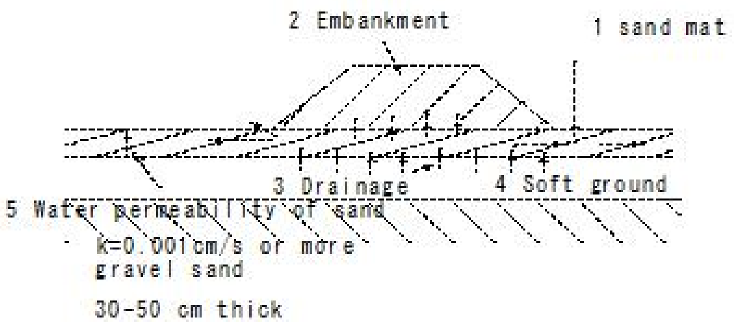
②Surface drainage method

Drainage ditch

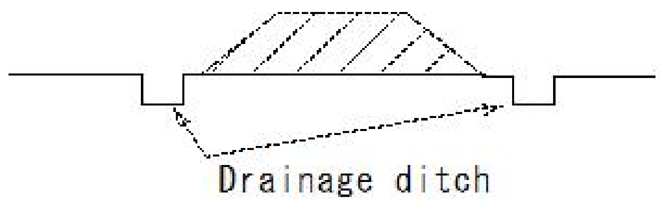
Water content ratio - decrease

Topsoil - drying

①Sand mat method



②Surface drainage method



Improved trafficability

(E212)Road earthwork-Cracks occur on the upper pavement surface

(E212)Road earthwork-Cracks occur on the upper pavement surface

Road earthwork-Cracks occur on the upper pavement surface

Cracks occur on the upper pavement surface at the connection between cutting and embankment.

①Cause of cracks

Bearing capacity of subgrade -discontinuity

①Measures against cracks

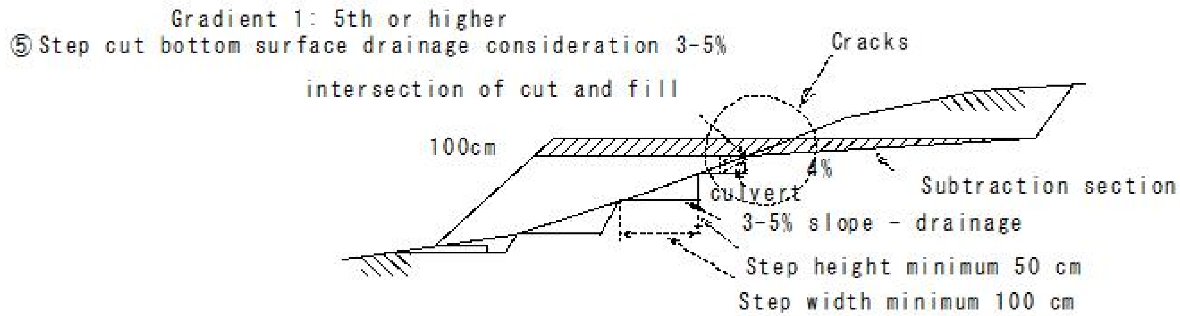
Set up a section with a 4% slope and thoroughly compact it.

②Cause of cracks

Spring water softens the embankment at the connection.

②Measures against cracks

Cut into stages and create a culvert to collect water and drain water.



(E213)Earthworks-Countermeasures for soils with insufficient trafficability

(E213)Earthworks-Countermeasures for soils with insufficient trafficability

Countermeasures for soils with insufficient trafficability

①Sand mat method

Soft surface layer, 50-120 cm of sand

Ensuring the running performance of construction machinery

groundwater exclusion

②Surface drainage method

Decrease in water content ratio

Shear bearing capacity - increase

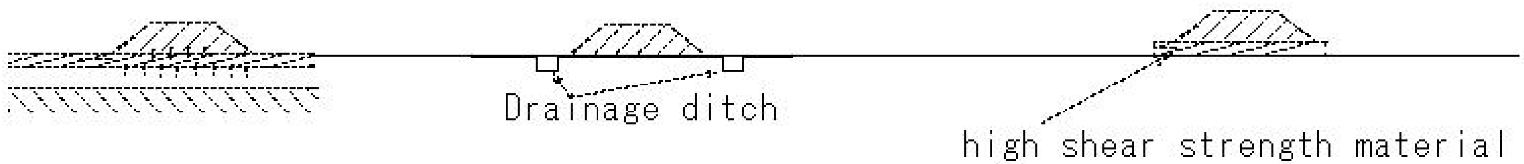
Drainage method installing a blind ditch

③Laying material method

Prevention of shear failure in soft ground

Laying material with high shear strength on soft ground - distributing the load

①Sand mat method ②Surface drainage method ③Laying material method



Improved trafficability

(E214)Liquid limit and plastic limit

(E214)Liquid limit and plastic limit

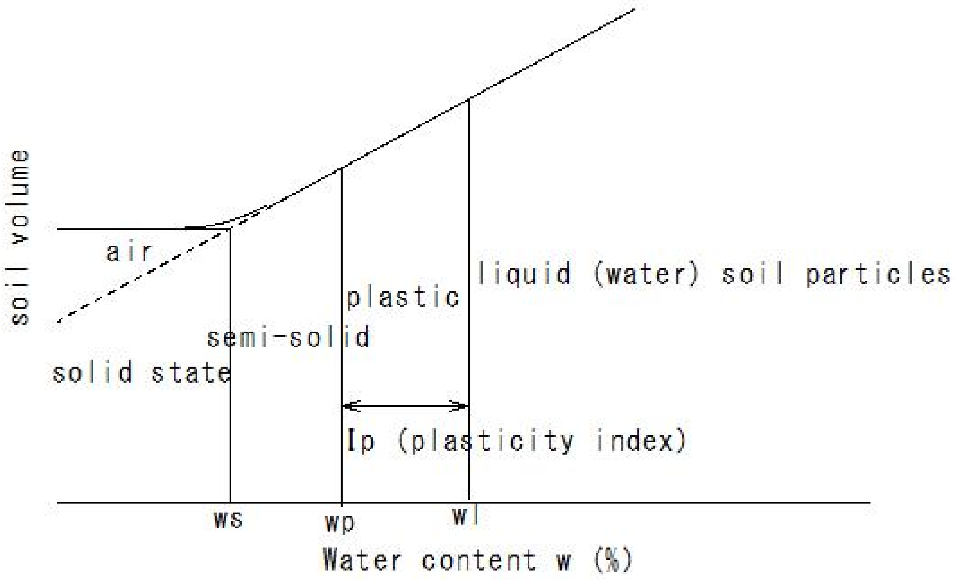
Liquid limit and plastic limit

①Mix a large amount of water with the soil - liquid

②Water content - sequential evaporation - plasticity - semi-solid - solid

③Water content ratio when changing from liquid to plasticity - liquidity limit

④Plastic state-Change to semi-solid state-Plastic limit



wL: liquid limit

wp: plastic limit

ws: shrinkage limit

Consistency limits for each limit

(E215)Tire roller/vibration roller

(E215) Tire roller・vibration roller

Tire roller/vibration roller

① Tire roller

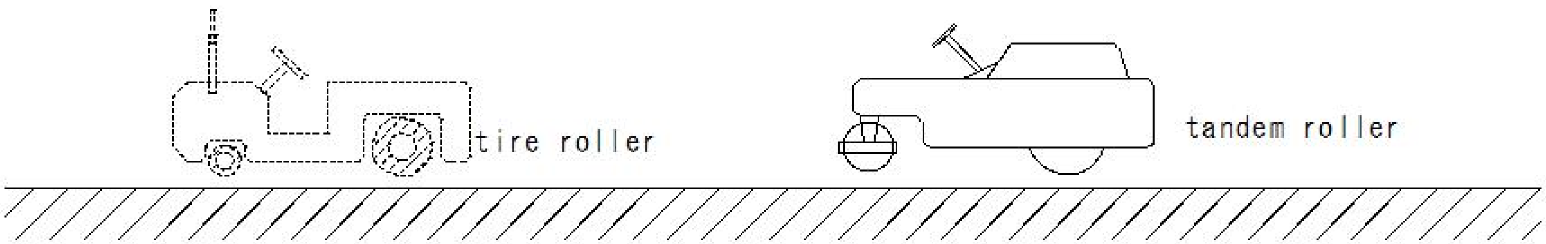
rubber tire roller

gravity of rollers etc.

compaction

②Vibrating roller

Iron wheel roller vertical vibration compaction sandy soil compaction



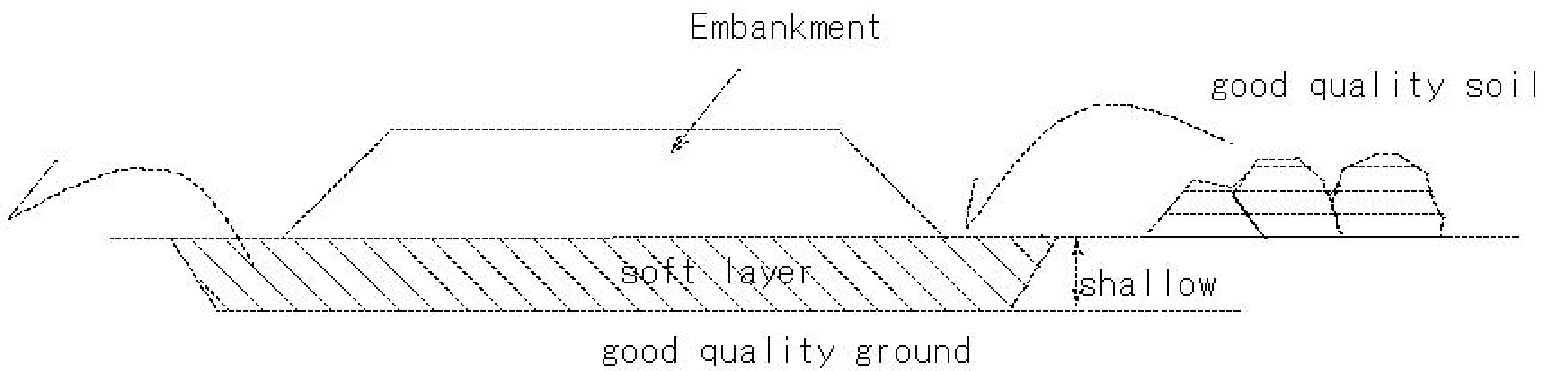
(E216)Replacement method

(E216)Replacement method

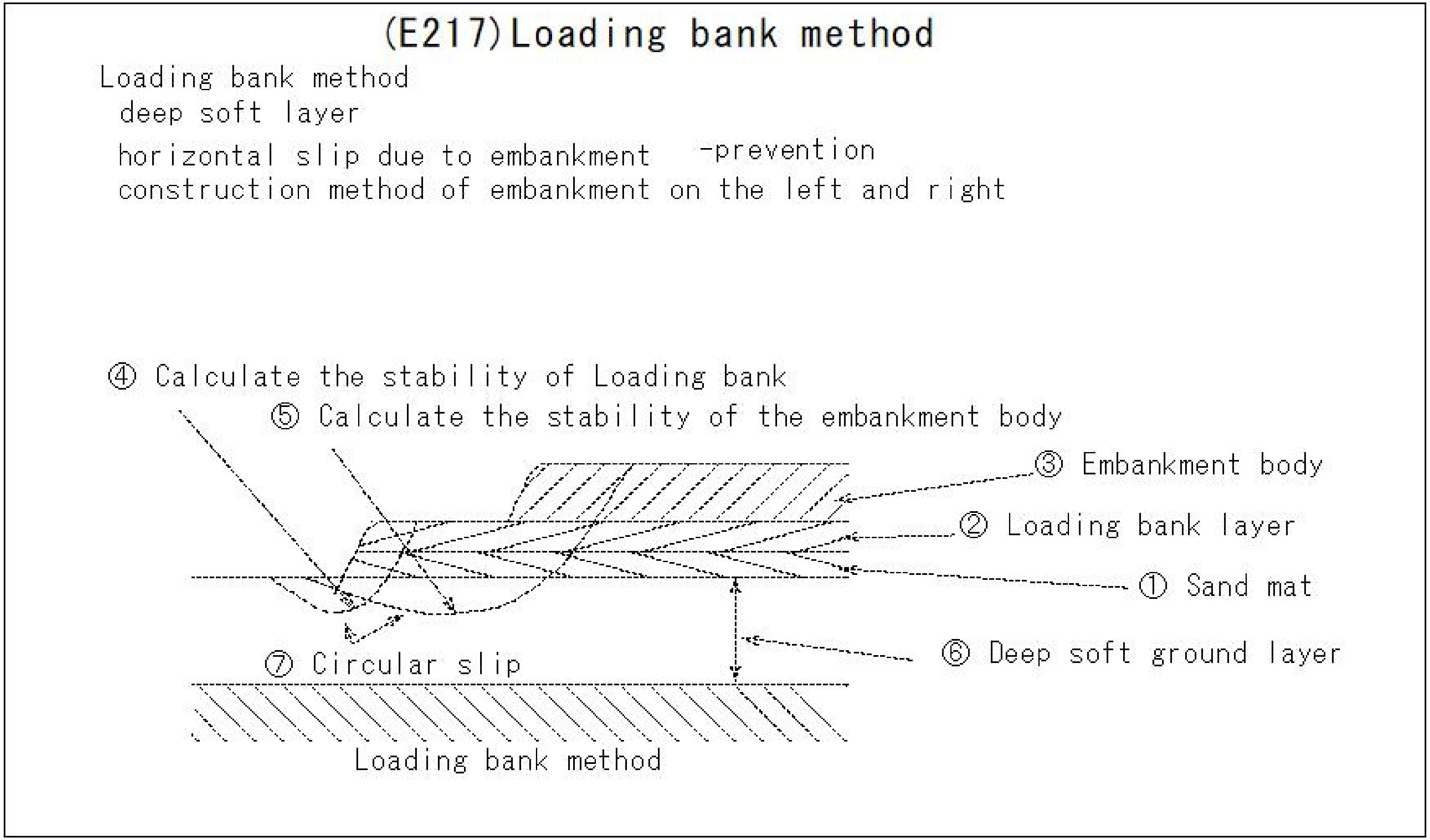
Replacement method

the soft foundation ground is thin

Replace soft soil with good soil



(E217)Loading bank method



(E218)Sand mat method

(E218)Sand mat method

Sand mat method

①Purpose

- Improvement of running performance of construction machinery
- Drainage channel using drain method

②Method

- Construction of 50-120 cm of sand on soft ground

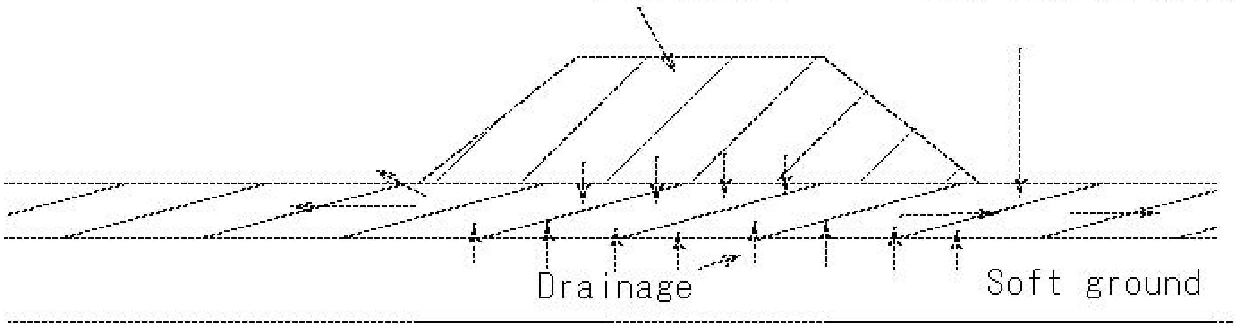
③Points to note during construction

- Sand material: Good water permeability
- Materials with poor water permeability: Create a blind groove for drainage

Sand mat construction method

sand mat

- Consolidation drainage
- Improved driving performance



(E219)Sand compaction pile method

(E219)Sand compaction pile method

Sand compaction pile method

①Purpose

Driving sand pillars into loose sandy ground

- Compact sandy ground to prevent liquefaction
- Shear strength-increase

②Method

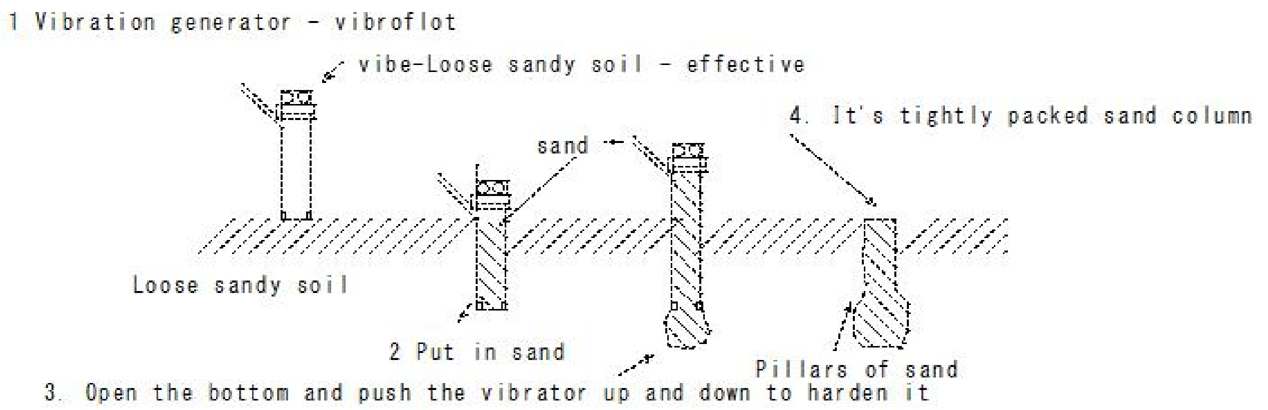
Drive the pipe by vibration or impact

- Pour sand into the pipe
- Remove the pipe while compacting the sand

③Precautions for construction

- In case of sticky soil, drive sand pillars
- Supporting capacity may decrease
- Confirm the effect and carry out embankment

Sand compaction pile method



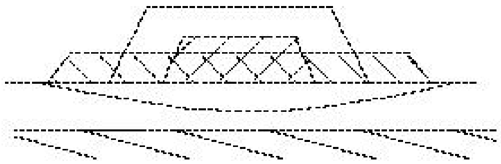
(E220)Soft ground improvement method-Preloading method

(E220)Soft ground improvement method-Preloading method

Soft ground improvement method

Preloading method

①Purpose



- Embankment larger than the designed cross section
- Load the embankment
- Drains pore water in soft ground and increases shear strength

②Method

- Increase the height of the embankment to the extent that the soft ground does not start to slide.
- Promote consolidation
- After consolidation is completed, the embankment height is corrected to the design cross section.

③Precautions for construction

- Since the preloading method requires a long consolidation time, consider whether the construction period is sufficient.
- Think about disposal of remaining soil after consolidation is completed at the planning stage
- Embanking, monitor soft ground for slippage.

(E221)Slope protection work-Vegetation work

(E221)Slope protection work-Vegetation work

Slope protection work

Vegetation work

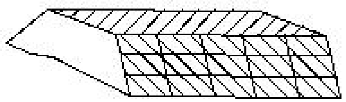
①Purpose

- Plants on the slope, covering the soil on the slope with roots
- Prevention of rainwater erosion and frozen soil
- Preserve the environment by integrating with structures through greening

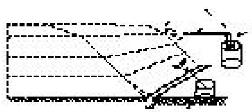
② Points to note during construction

- Construction season varies depending on the type of plant.
- Supplementary measures such as soil are required for poor slopes.

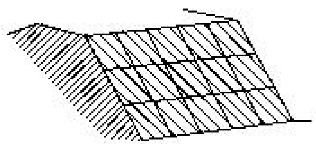
turf



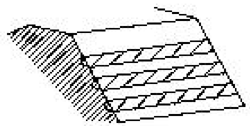
Seed spraying



vegetation mat



Vegetation board work



(E222)Slope protection work-Vegetation work

(E222)Slope protection work-Vegetation work

Slope protection work

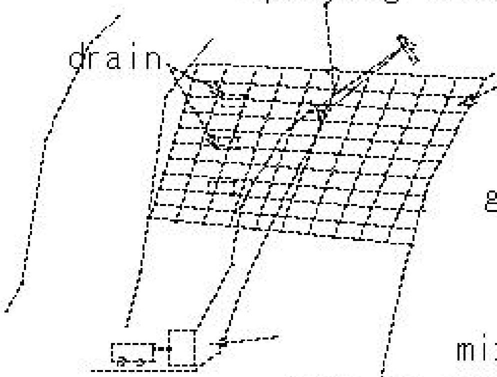
mortar sprayer

①Purpose

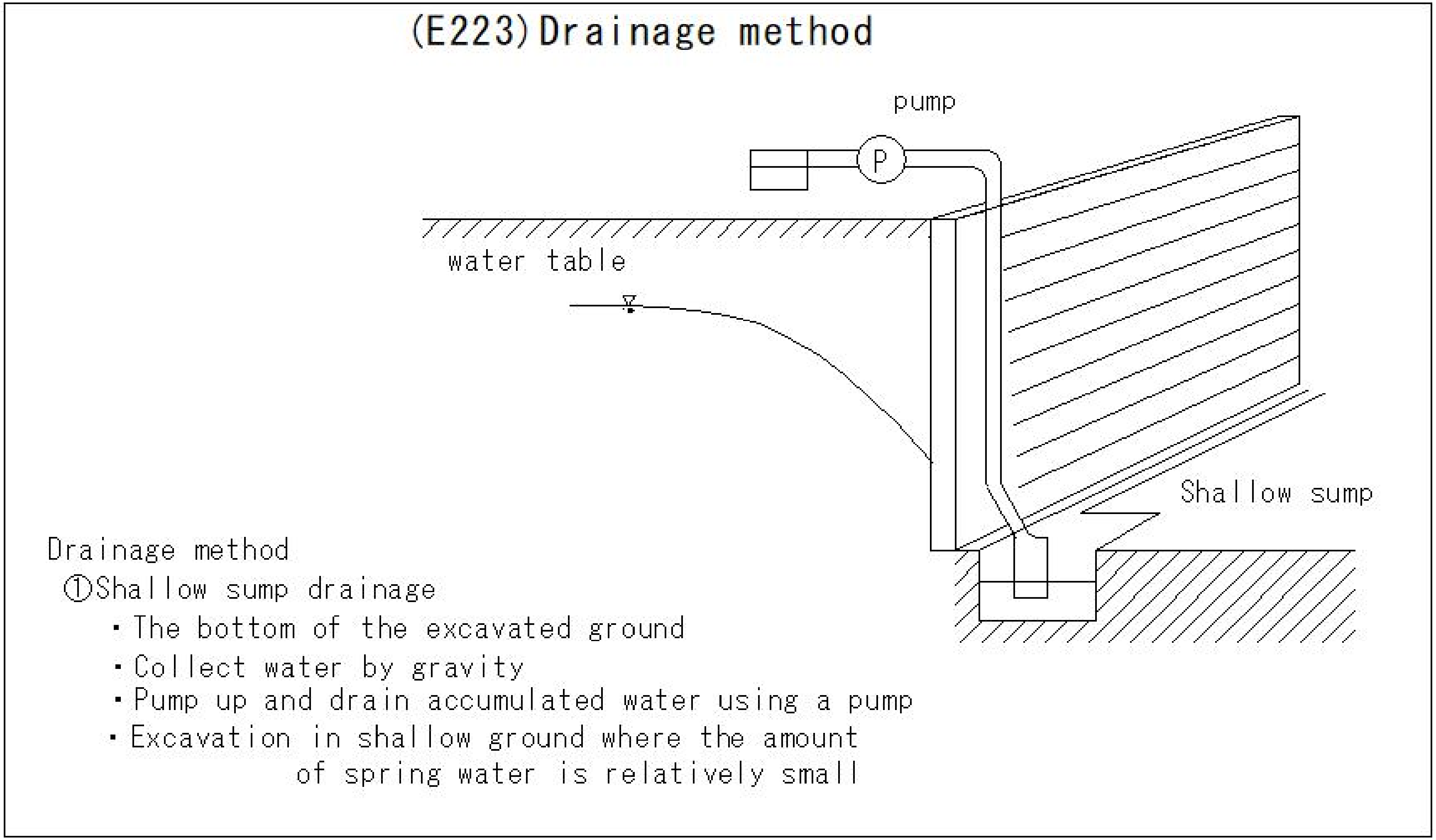
- Used for cutting slopes: Rocks that easily weather, protection of slopes that tend to flake off
- Places that are not suitable for shade or earthen vegetation
- Slope protection

② Points to note during construction

- Remove floating stones and dirt
- Prepare the base so that the mortar will adhere well.
- there is spring water, provide a drainage hole.
- Reinforced with wire mesh



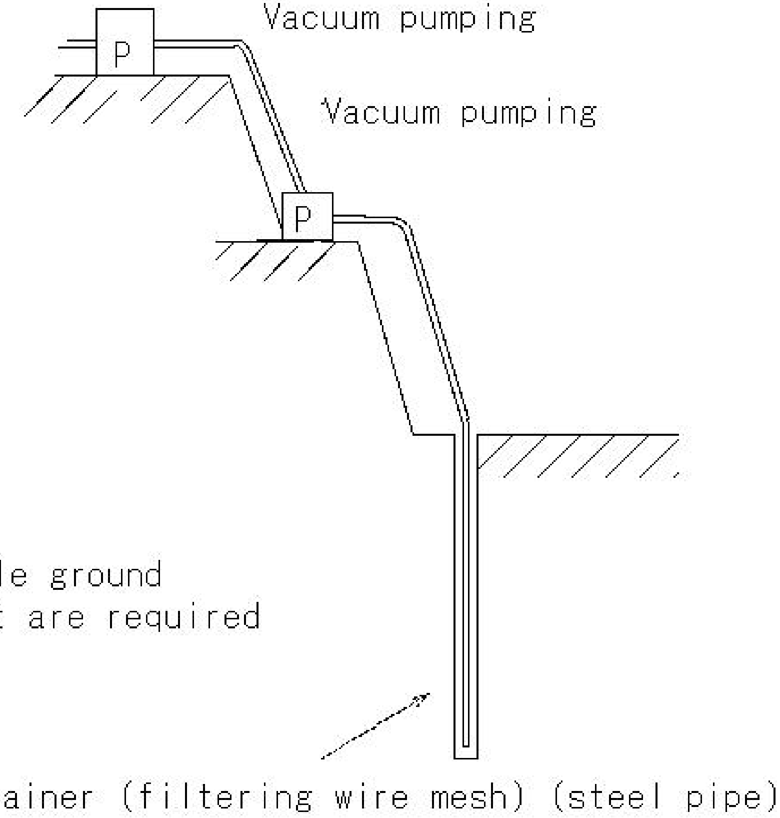
(E223)Drainage method



(E224)Drainage method-Deep well construction method

(E224)Drainage method-Deep well construction method

Deep well construction method



Drainage method

Deep well construction method

- Dig a well around the excavated ground
- Collect groundwater using gravity
- Drainage pumped up with a pump
- Lowering groundwater
- Wide groundwater decline
- Drainage volume increases due to permeable ground
- Environmental measures such as settlement are required

(E225)Drainage method-Well point construction method

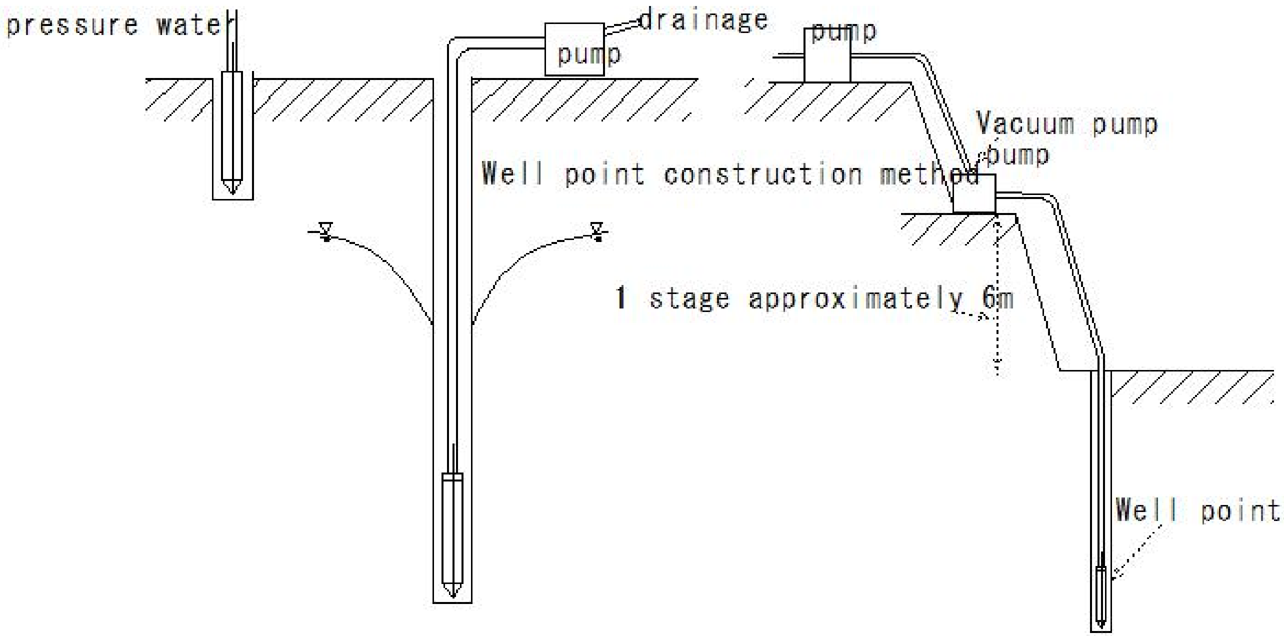
(E225)Drainage method-Well point construction method

Drainage method

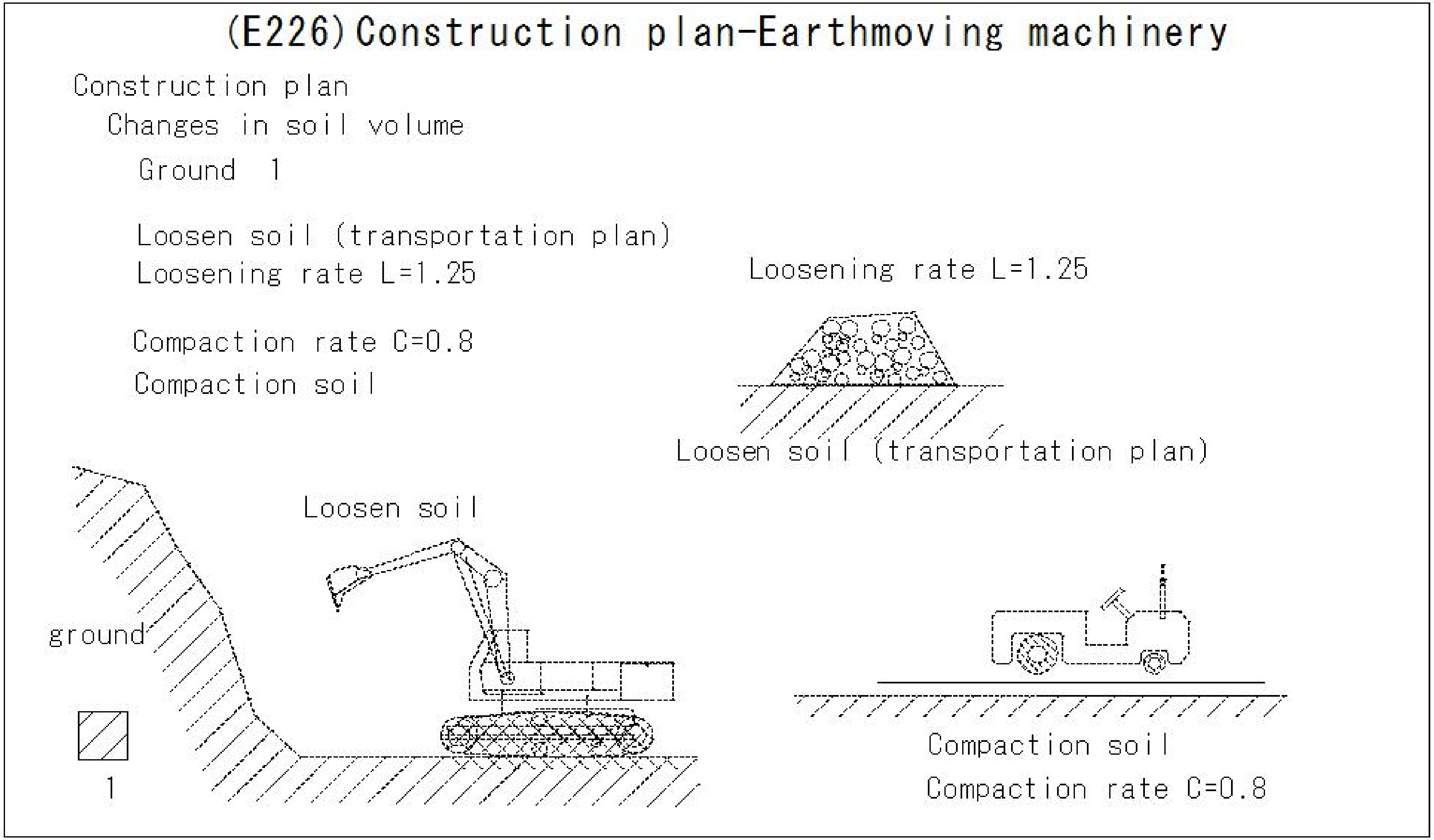
Well point construction method

- Insert well point with jet water
- Forcibly absorb and drain water
- Circular slip may occur

Well point construction method



(E226)Construction plan-Earthmoving machinery



(E227)Construction plan-Appropriate machines for each task

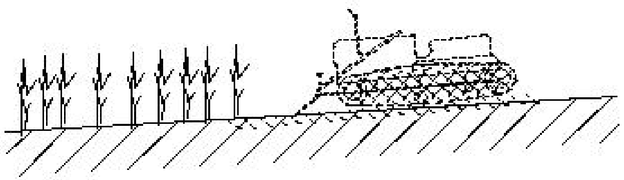
(E227)Construction plan-Appropriate machines for each task

Appropriate machines for each task

Type of work

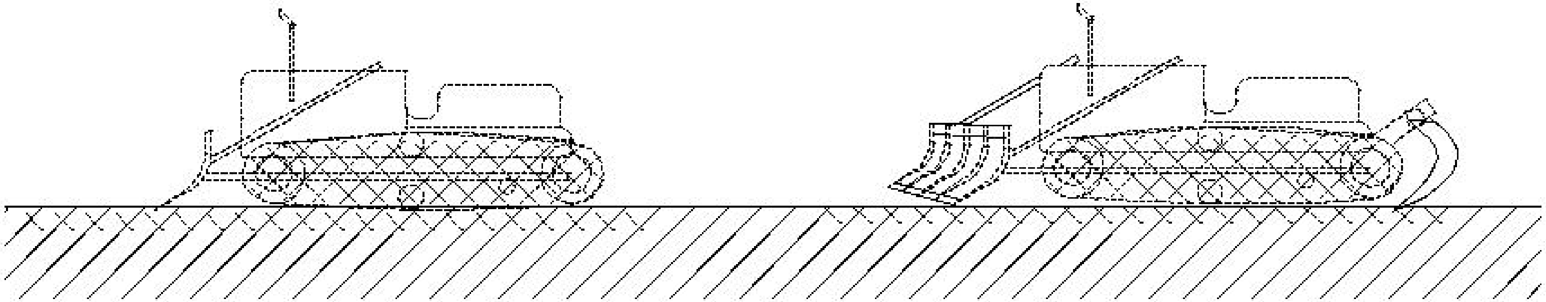
Types of construction machinery

clearing



bulldozer

rake dozer

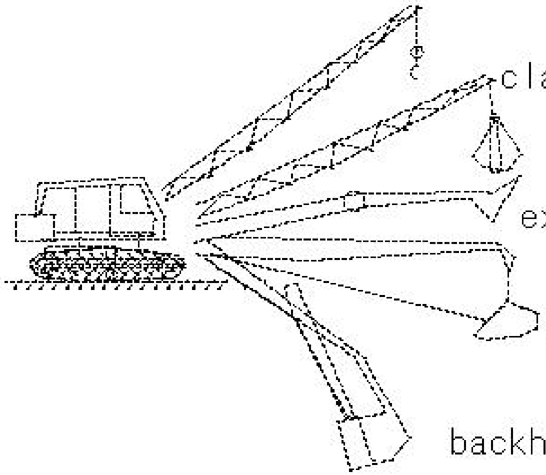


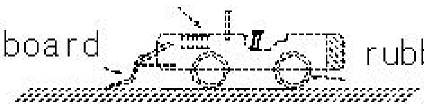
(E228)Construction plan-Appropriate machines for each task

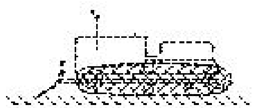
(E228)Construction plan-Appropriate machines for each task

Appropriate machines for each task

- Excavation
  - excavator
  - backhoe
  - drag-in
  - clamshell
  - tractor excavator
  - bulldozer





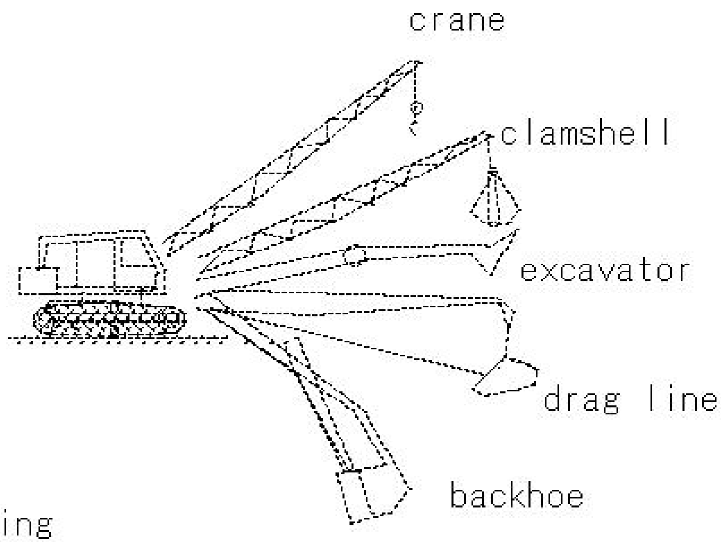


(E229)Construction plan-Appropriate machines for each task

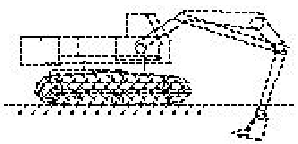
(E229)Construction plan-Appropriate machines for each task

Appropriate machines for each task

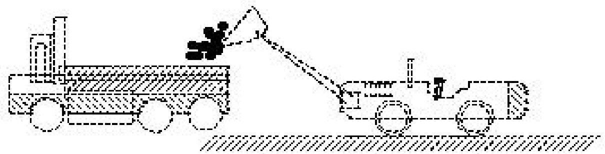
- Loading
  - Excavator
  - backhoe
  - drag line
  - clamshell



Loading

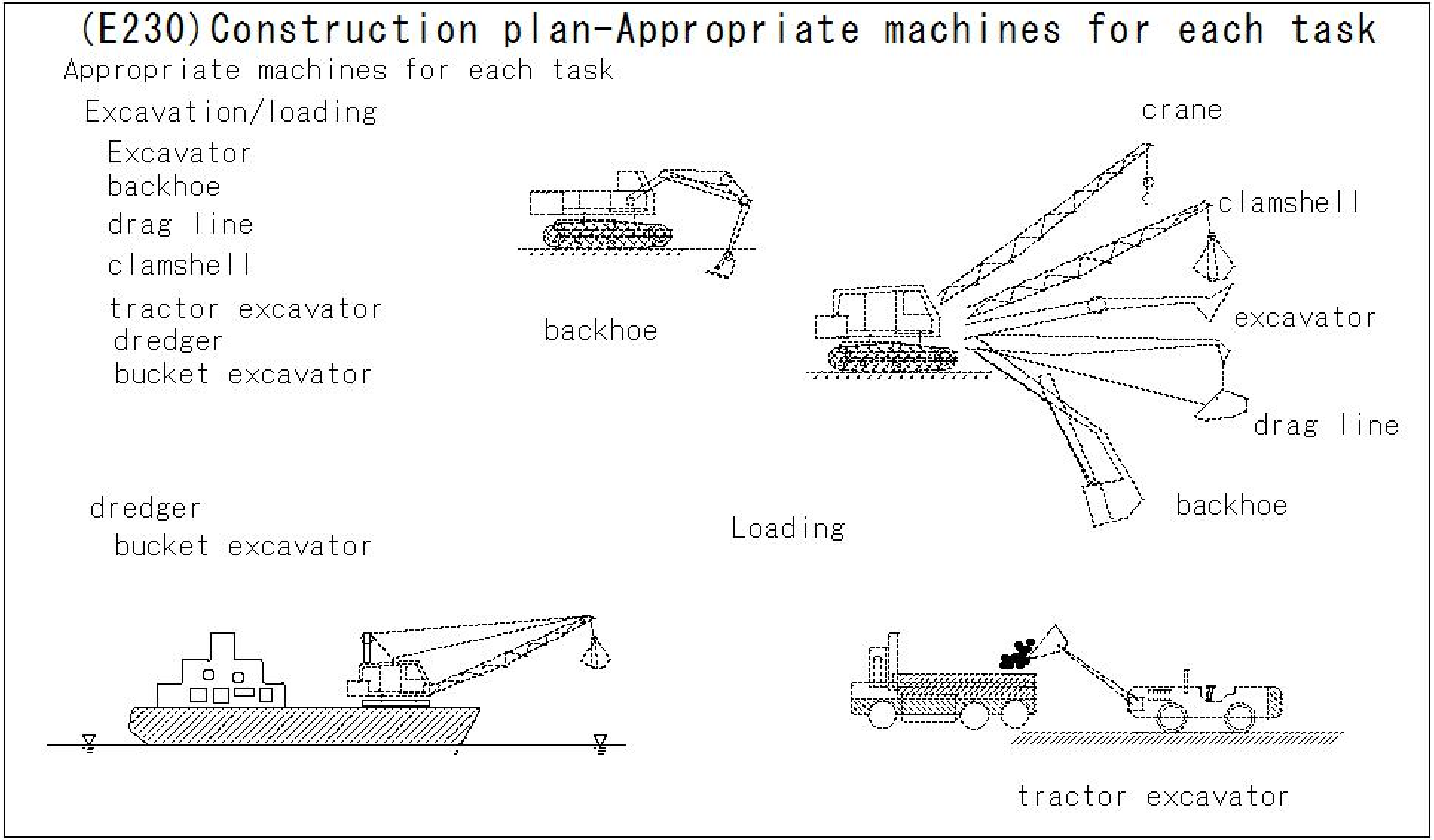


backhoe



tractor excavator

(E230)Construction plan-Appropriate machines for each task



(E231)Construction plan-Appropriate machines for each task

(E231)Construction plan-Appropriate machines for each task

Appropriate machines for each task

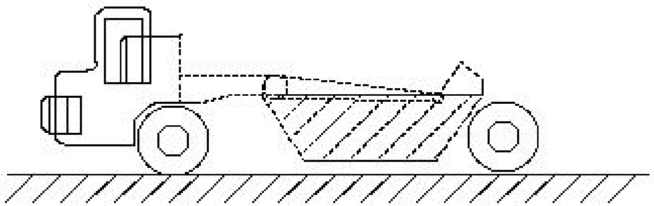
Excavation/Transportation

bulldozer

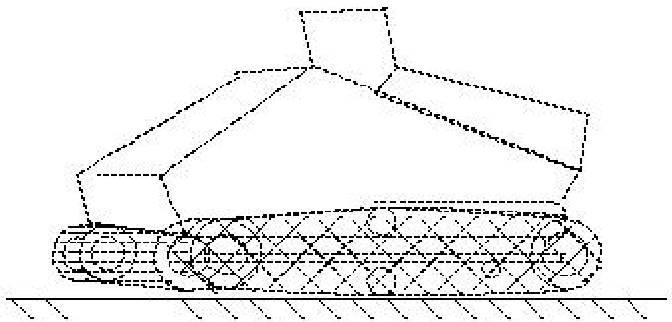
scrape dozer

scraper

tractor excavator



Motor Scraper



Scrape dozer

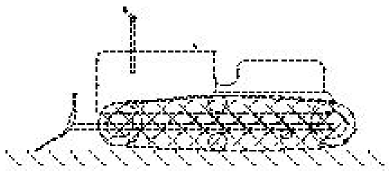
(E232)Construction plan-Appropriate machines for each task

(E232)Construction plan-Appropriate machines for each task

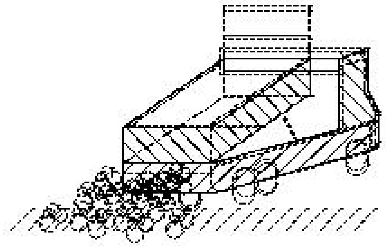
Appropriate machines for each task

transportation

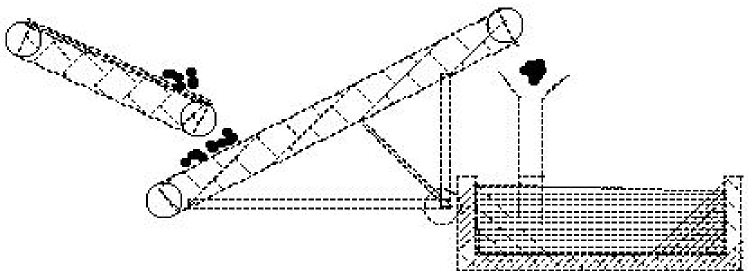
- bulldozer
- dump truck
- belt conveyor
- aerial cableway



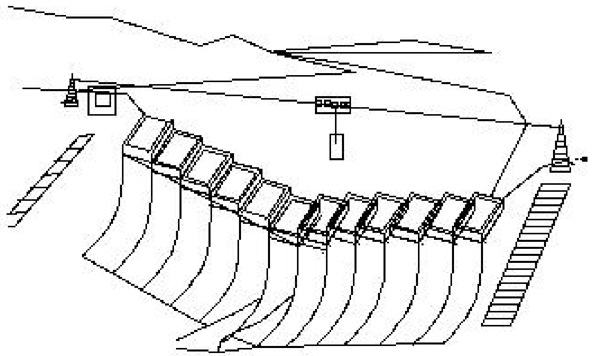
bulldozer



dump truck



belt conveyor



aerial cableway

(E233)Construction plan-Appropriate machines for each task

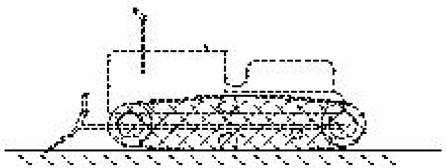
(E233)Construction plan-Appropriate machines for each task

Appropriate machines for each task

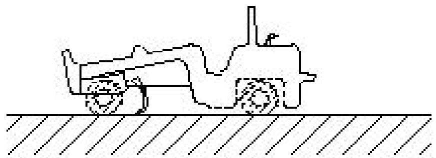
leveling(spreading)

bulldozer

motor grader



bulldozer



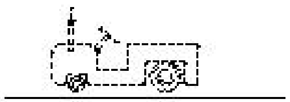
motor grader

(E234)Construction plan-Appropriate machines for each task

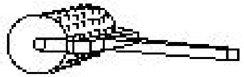
(E234)Construction plan-Appropriate machines for each task

Appropriate machines for each task

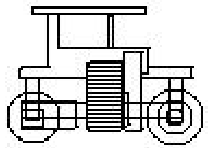
- compaction
  - tire roller
  - tamping roller
  - vibrating roller
  - vibrating compactor
  - rammer
  - bulldozer



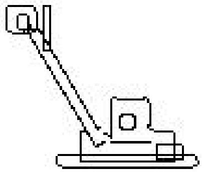
tire roller



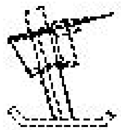
tamping roller



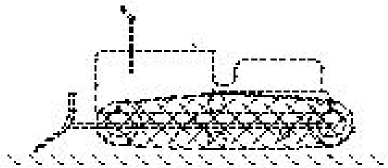
vibrating roller



vibrating compactor



rammer



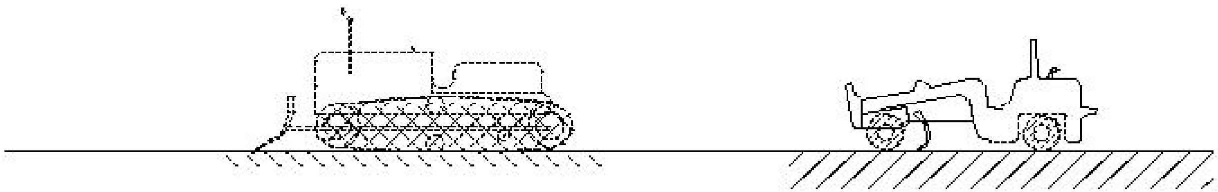
bulldozer

(E235)Construction plan-Appropriate machines for each task

(E235)Construction plan-Appropriate machines for each task

Appropriate machines for each task

- Leveling the ground
  - bulldozer
  - motor grader



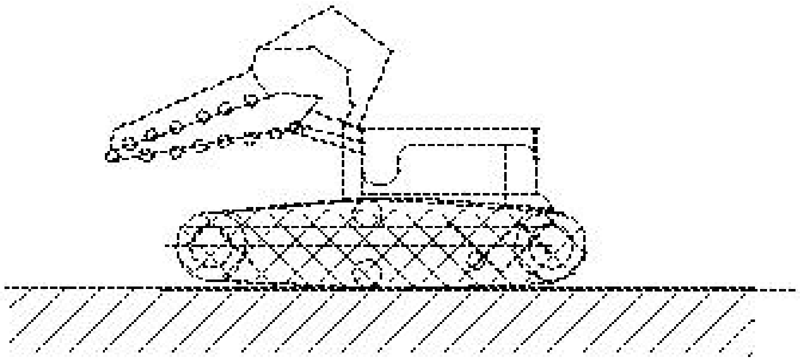
bulldozer   motor grader

(E236)Construction plan-Appropriate machines for each task

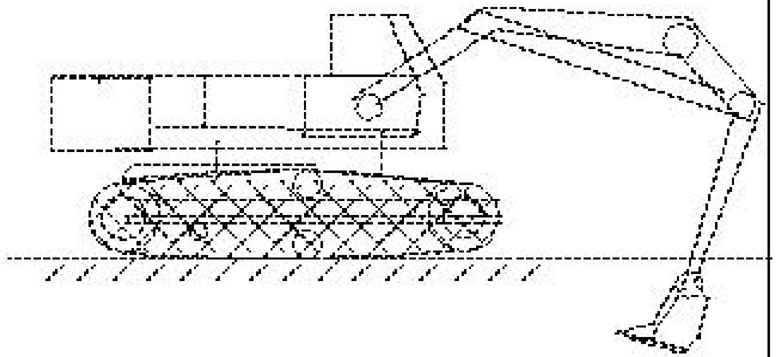
(E236)Construction plan-Appropriate machines for each task

Appropriate machines for each task

- trench
  - trencher
  - backhoe



trencher



backhoe

(E237)Transport distance and applicable machine type

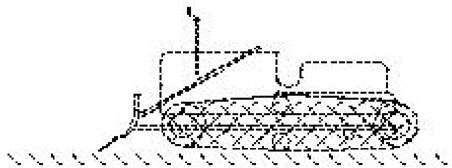
(E237)Transport distance and applicable machine type

Transport distance and applicable machine type

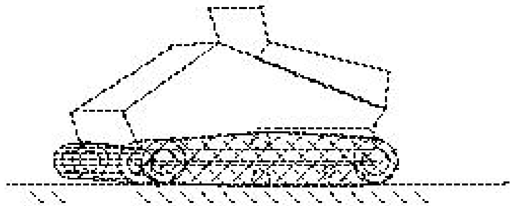
short distance

70m or less

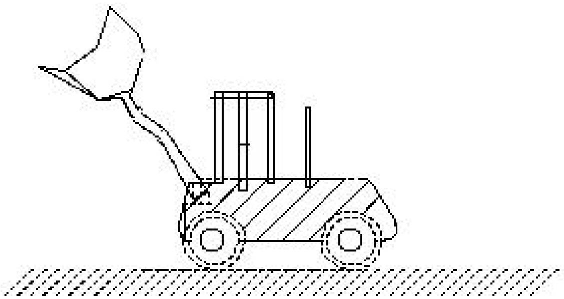
- bulldozer
- scrape dozer
- tractor excavator
- bucket dozer



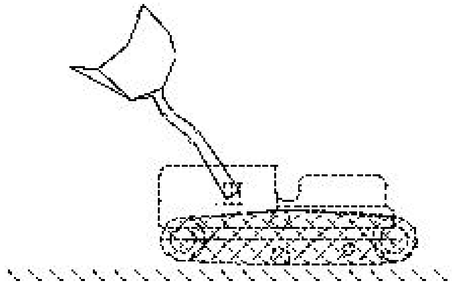
bulldozer



scrape dozer

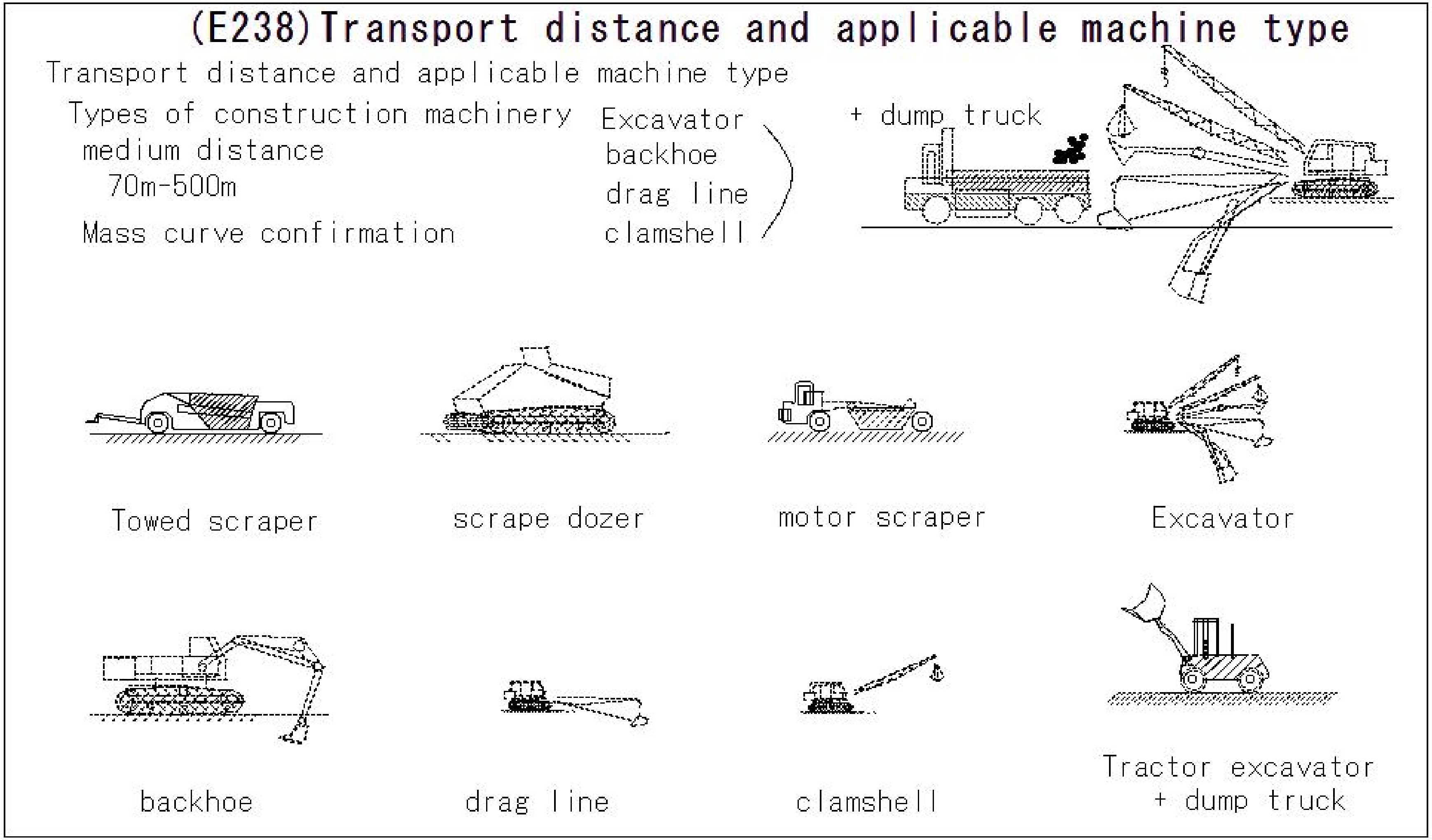


tractor excavator



bucket dozer

(E238)Transport distance and applicable machine type

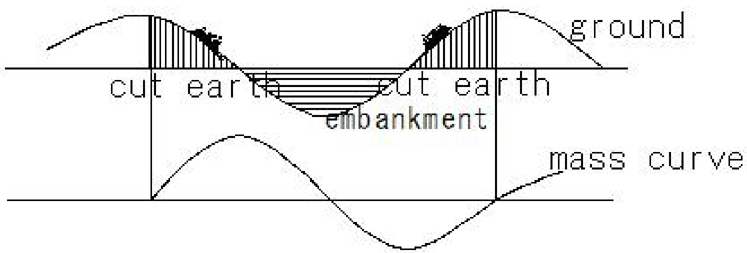


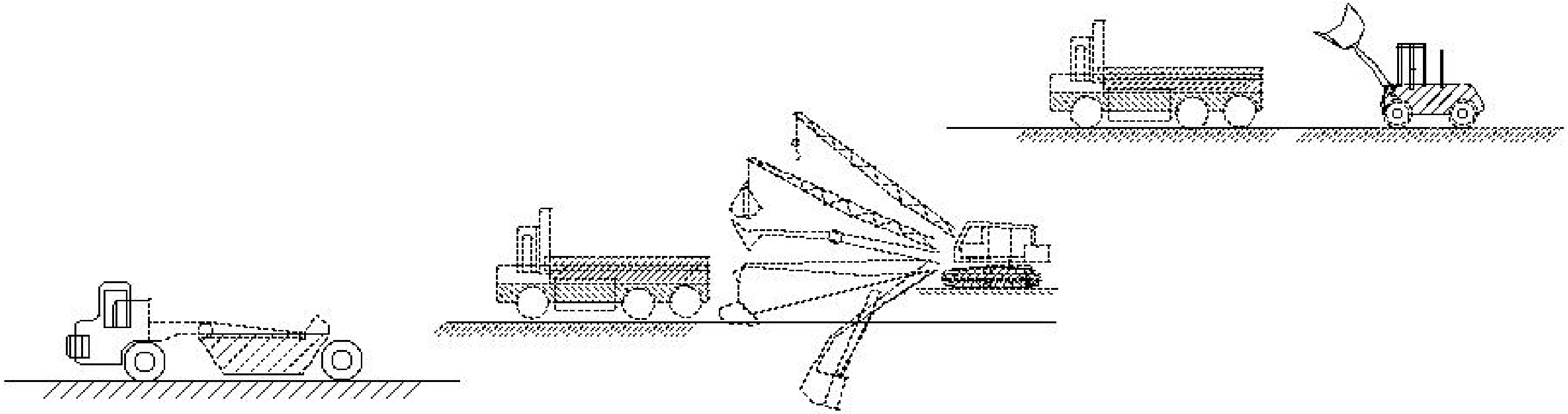
(E239)Transport distance and applicable machine type

(E239)Transport distance and applicable machine type

Transport distance and applicable machine type

- Types of construction machinery
  - long distance
  - 500m or more
  - motor scraper
    - shovel type excavator + dump truck
    - tractor excavator + dump truck
  - Mass curve confirmation





motor scraper

shovel type excavator
+ dump truck

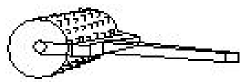
tractor excavator
+ dump truck

(E240)Compaction machinery and soil quality

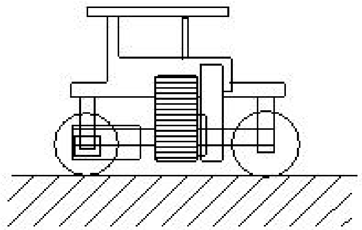
(E240)Compaction machinery and soil quality

Compaction machinery and soil quality

machine	Soil quality
tamping roller	hard clay
road roller	cobblestone-sandy soil
tire roller	gravel soil-clay soil
vibrating roller	cobblestone-sandy soil
vibrating compactor	gravel soil - sandy soil
rammer	gravel soil - sandy soil
bulldozer	cobblestone-sandy soil
Wetland bulldozer	soft clay

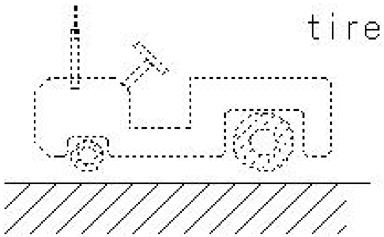


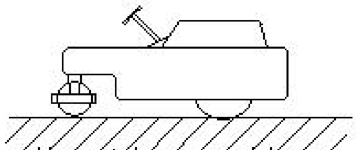
tamping roller



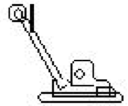
road roller

tire roller

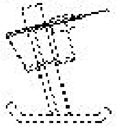




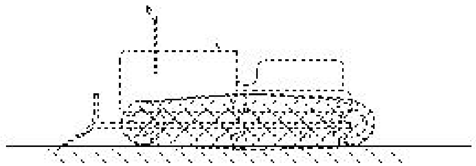
vibrating roller



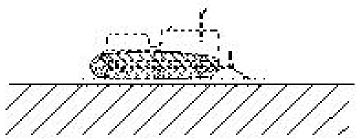
vibrating compactor



rammer

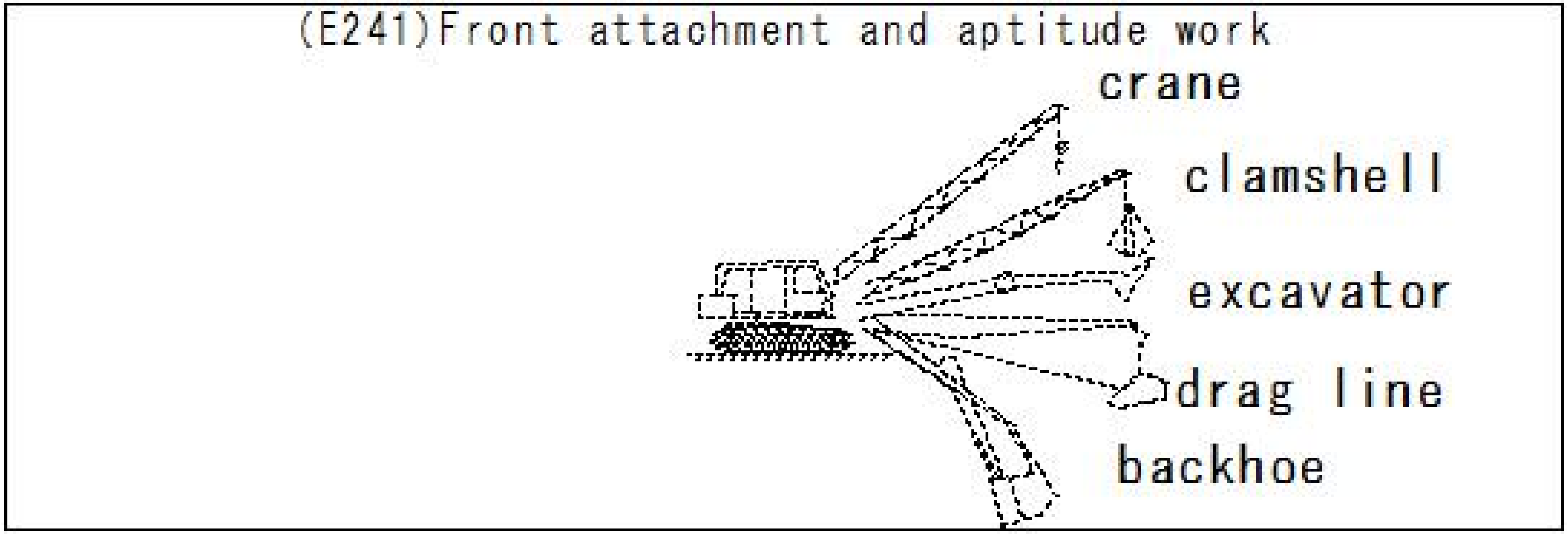


bulldozer



Wetland bulldozer

(E241)Front attachment and aptitude work



Front attachment and aptitude work

		excavator	backhoe	drag line	clamshell
digging power		big	big	small	small
・drilling material	hard soil/rock	◎	◎	×	×
	underwater drilling	×	○	◎	◎
・drilling position	higher than the ground	◎	×	×	○
	lower than the ground	×	◎	◎	○
	precise drilling	◎	◎	×	○
	wide area	×	×	◎	◎
・adaptation work	cutting at high places	◎	×	×	×
	Narrow V-shaped ditch	×	◎	×	○
	Topsoil removal and leveling	○	×	◎	×
	Lifting winch work	×	×	○	◎

◎: Extremely suitable
○: Aptitude
×: Inappropriate

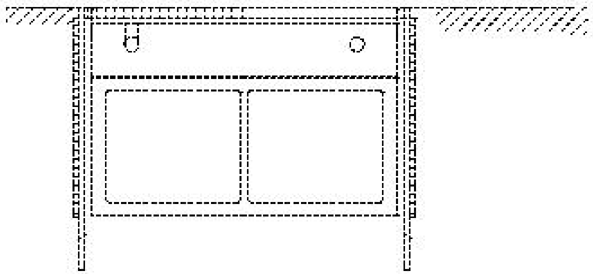
(E242)Temporary plan for earthworks

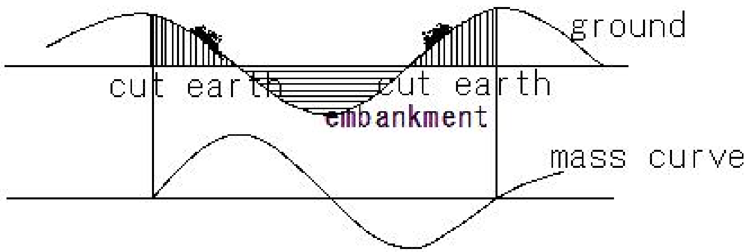
(E242)Temporary plan for earthworks

Temporary plan for earthworks

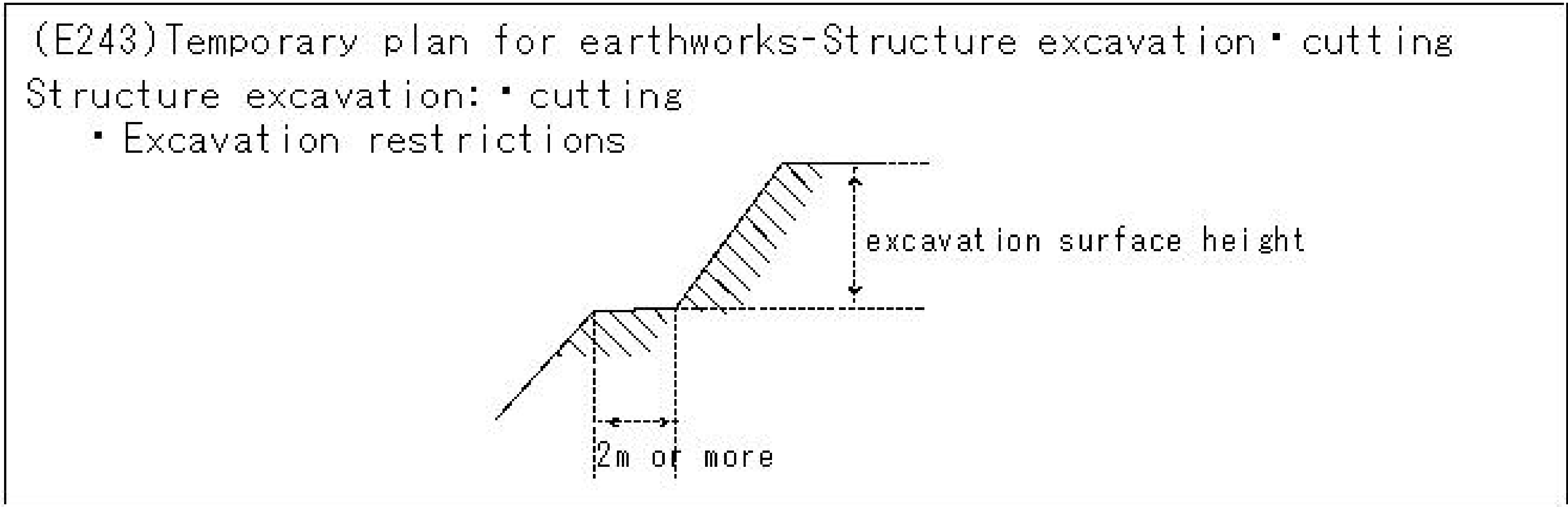
- Structure excavation: root cutting
- Excavation with a depth of 1.5 m or more - earth retaining work
  - Structure excavation:cutting
  - preliminary survey

①Underground buried objects relocation/curing
②Impact investigation on nearby structures Safety confirmation
③Amount and treatment of groundwater
④Confirmation of safety and economic efficiency of mountain retaining method
⑤Examination of safety management of excavated soil removal and transportation methods





(E243)Temporary plan for earthworks-Structure excavation・cutting



・Excavation restrictions

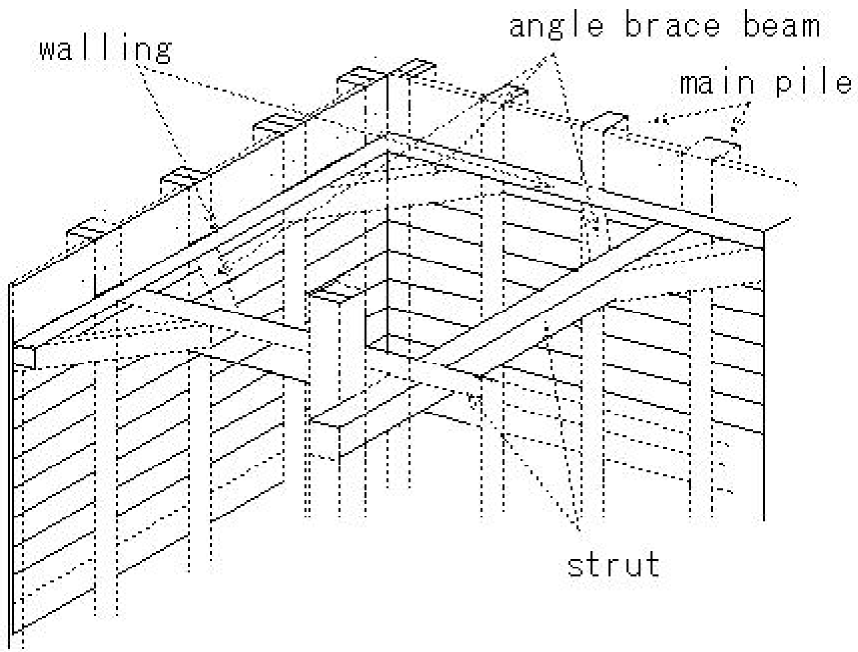
ground	excavation surface height	Slope
A ground consisting of bedrock or hard clay	Less than 5m 5m or more	90° or less 75° or less
Other rocks	Less than 2m Less than 2-5m 5m or more	90° or less 75° or less 60° or less
ground made of sand	Less than 5m	35° or less
Conglomerate susceptible to collapse due to blasting, etc.	Less than 2m	45° or less

(E244)Earthworks-Earth retaining wall timbering method

(E244)Earthworks-Earth retaining wall timbering method

Earth retaining wall timbering method

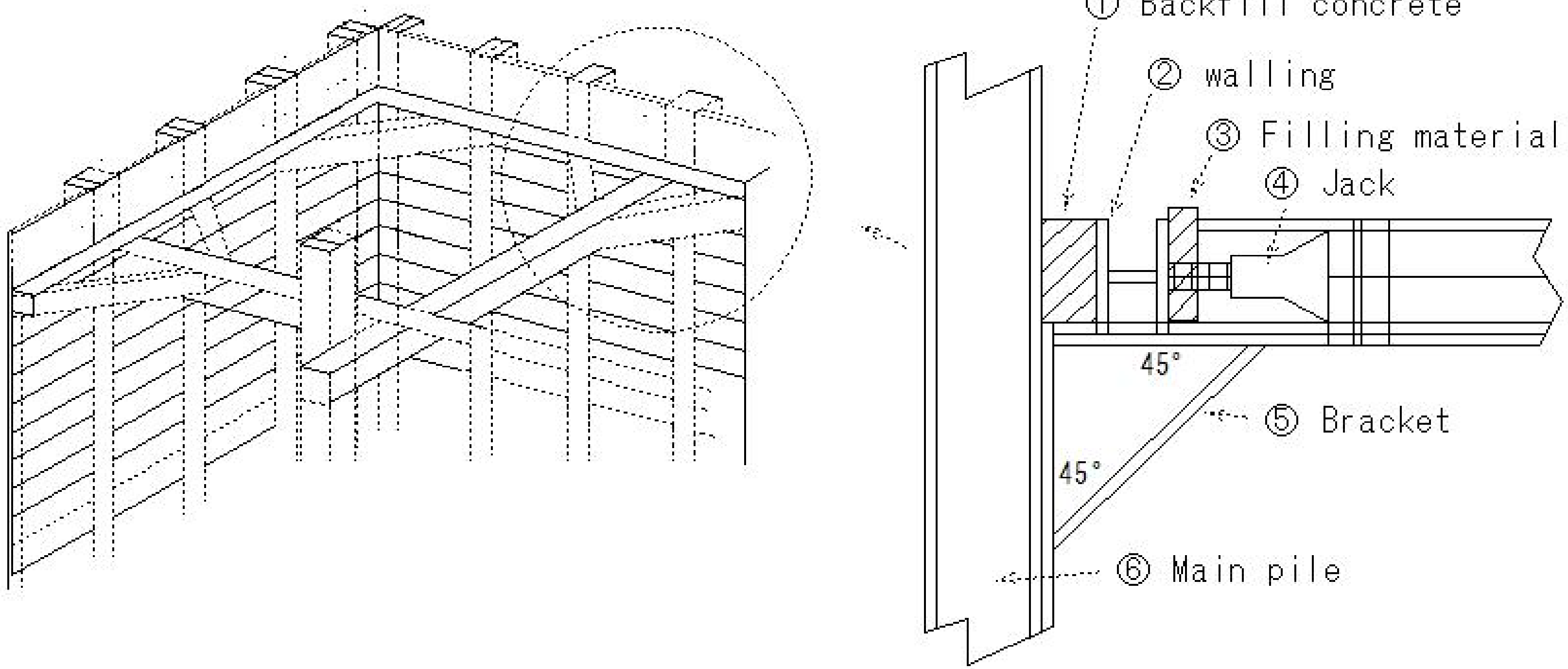
- Earth retaining wall timbering



(E245)Earthworks-Earth retaining wall timbering method

(E245)Earthworks-Earth retaining wall timbering method

- Main pile horizontal sheet pile strut construction method
- Installing struts

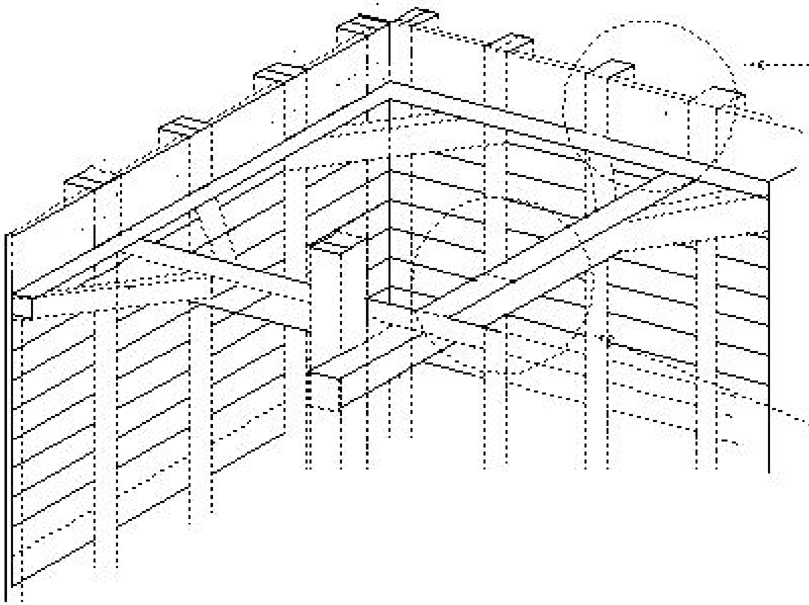


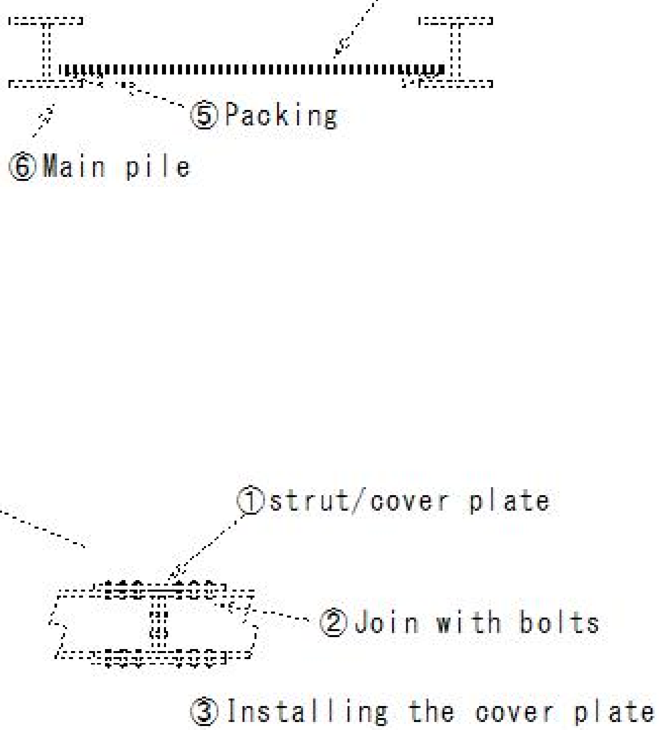
(E246)Earthworks-Earth retaining wall timbering method

(E246)Earthworks-Earth retaining wall timbering method

Earth retaining wall timbering method

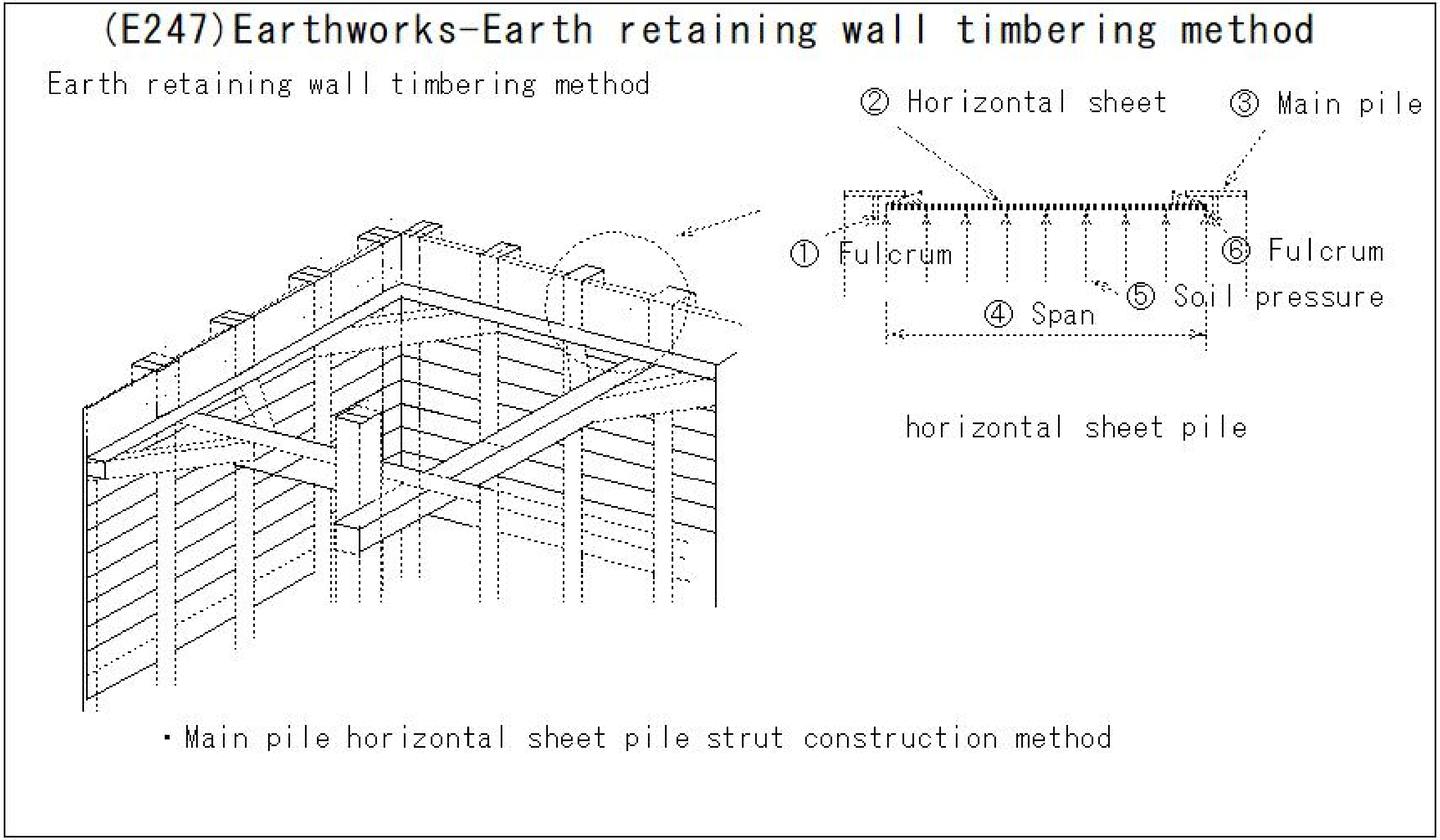
・Main pile horizontal sheet pile strut construction method



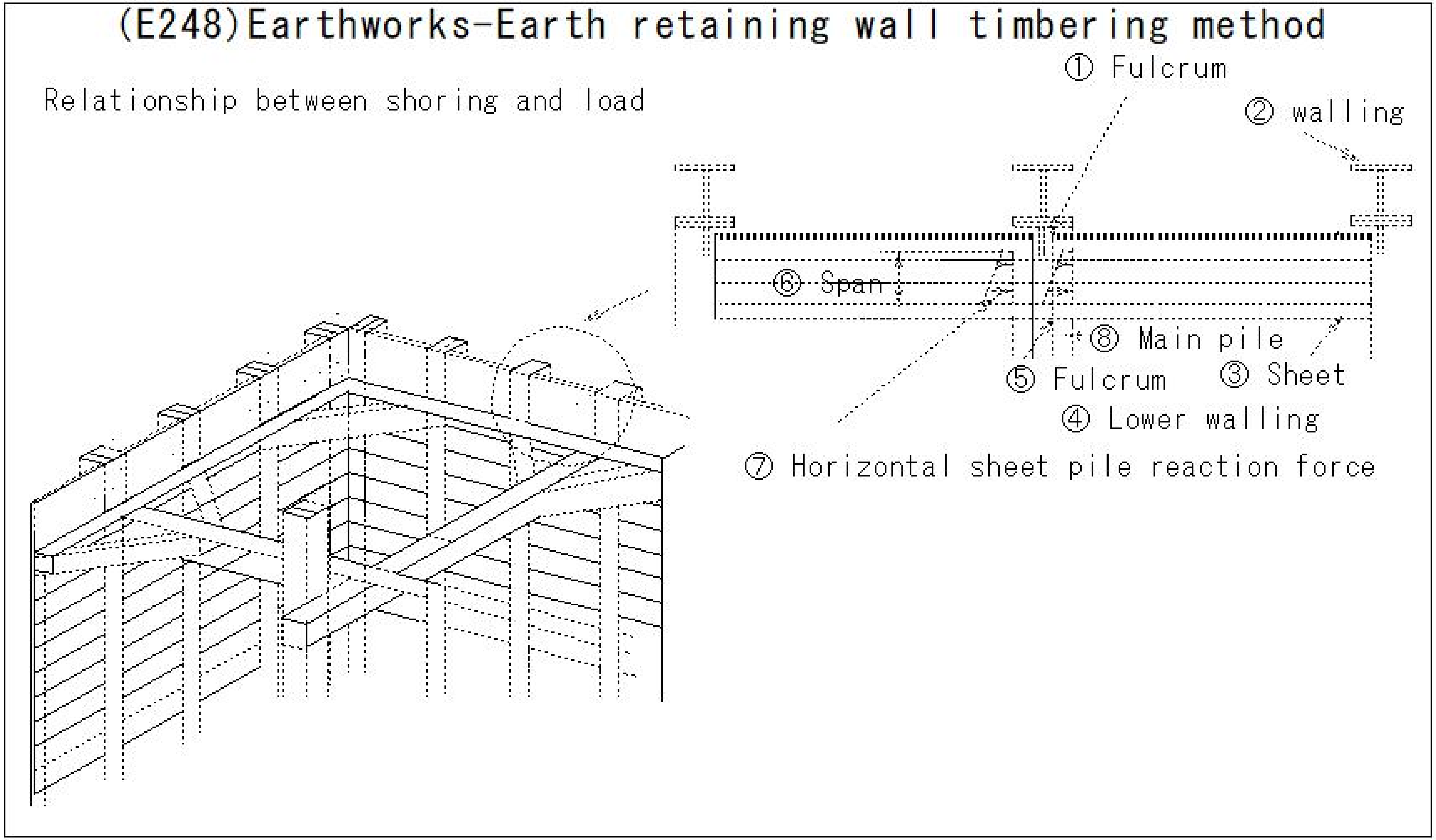


・Horizontal sheet pile installation

(E247)Earthworks-Earth retaining wall timbering method



(E248)Earthworks-Earth retaining wall timbering method

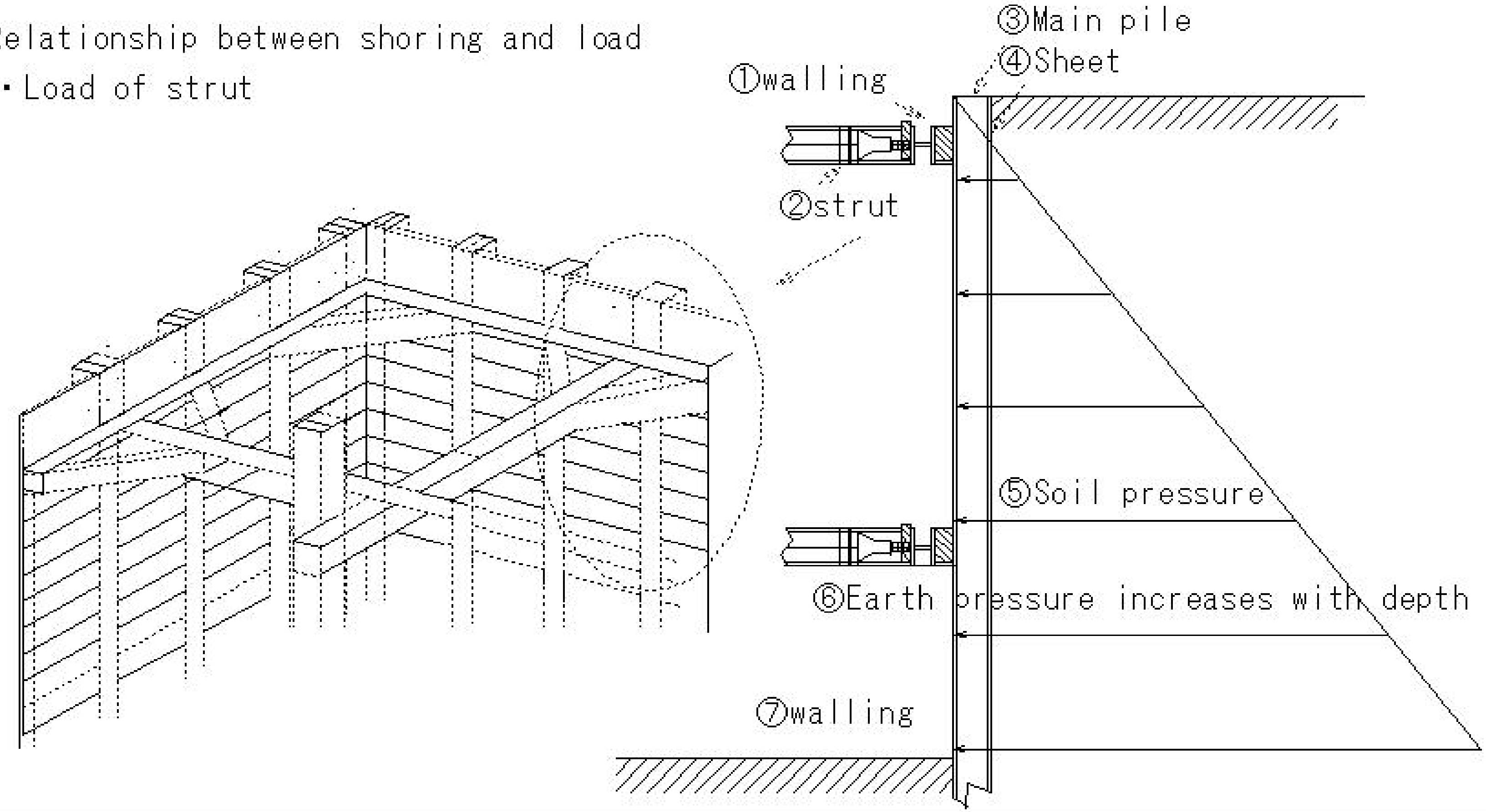


(E249)Earthworks-Earth retaining wall timbering method

(E249)Earthworks-Earth retaining wall timbering method

・Relationship between shoring and load

・Load of strut

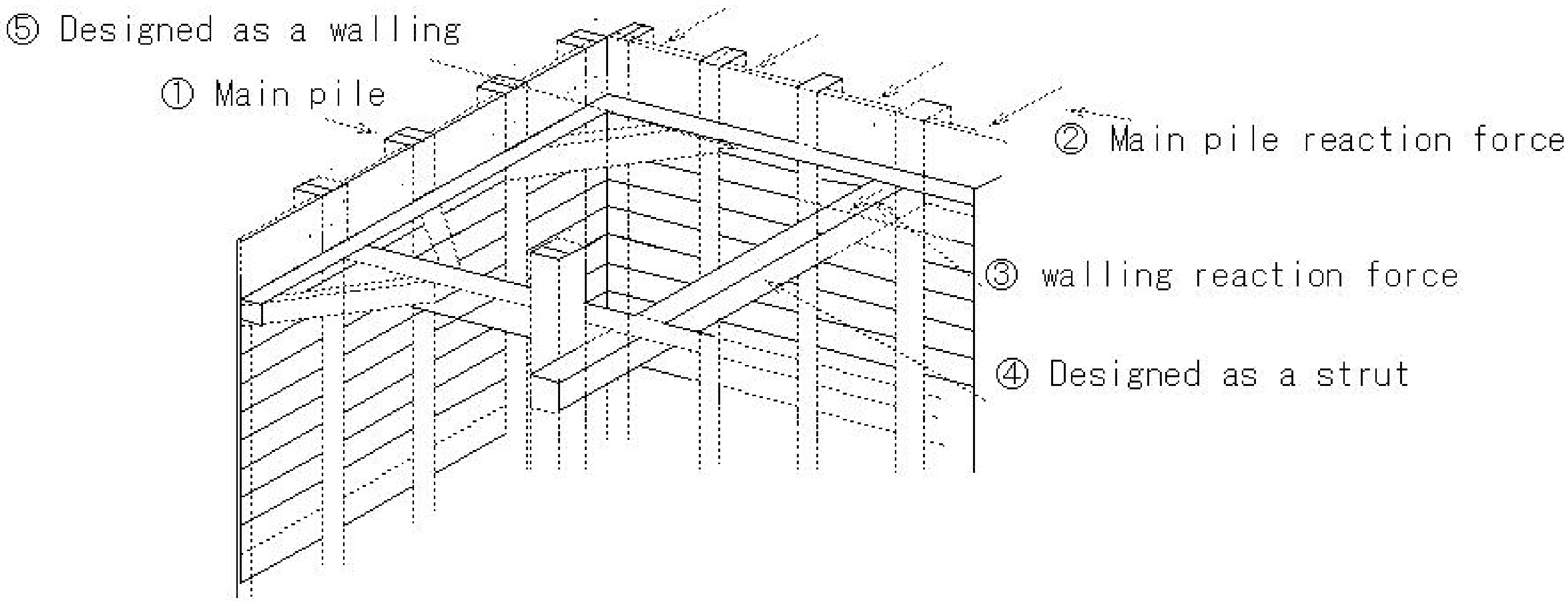


(E250)Earthworks-Earth retaining wall timbering method

(E250)Earthworks-Earth retaining wall timbering method

・Relationship between timbering and load

・Load of strut

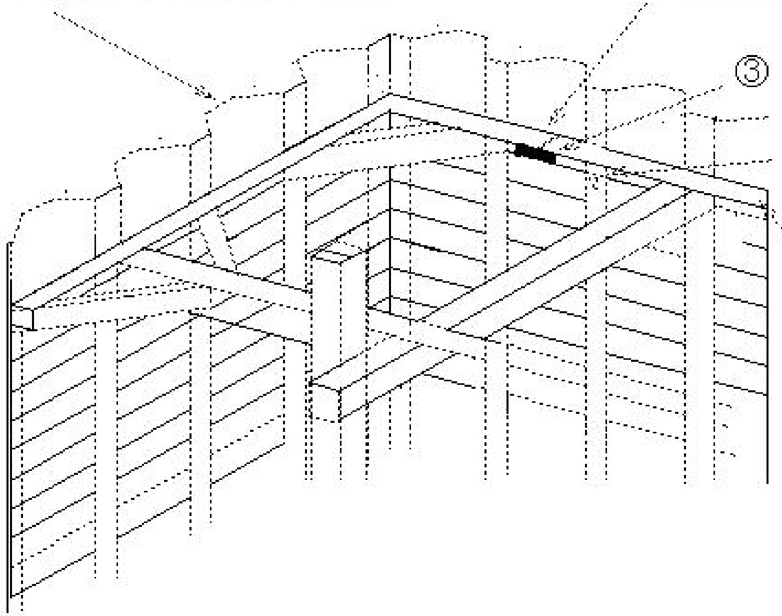


(E251)Earthworks-Earth retaining wall timbering method

(E251)Earthworks-Earth retaining wall timbering method

Earth retaining wall timbering method

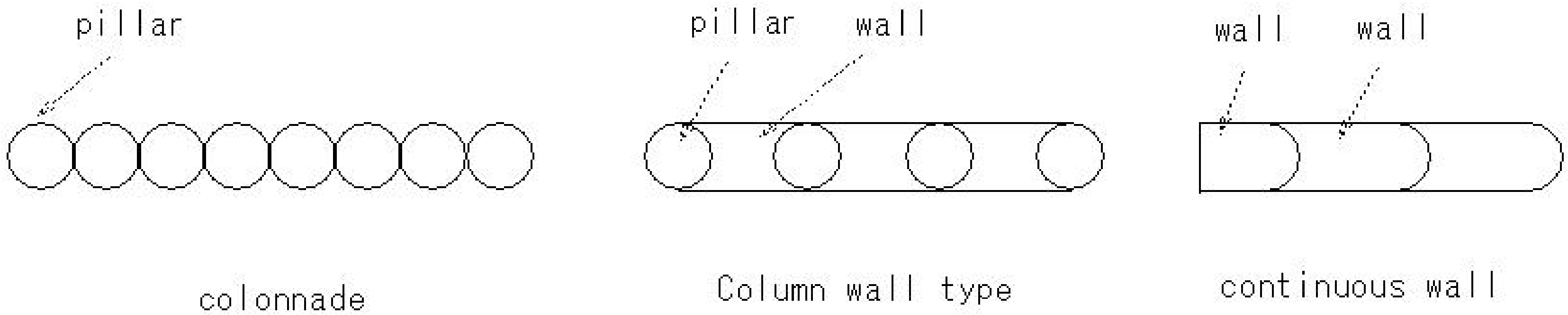
- Relationship between steel sheet pile and walling
- Sheet pile (steel sheet pile) strut construction method



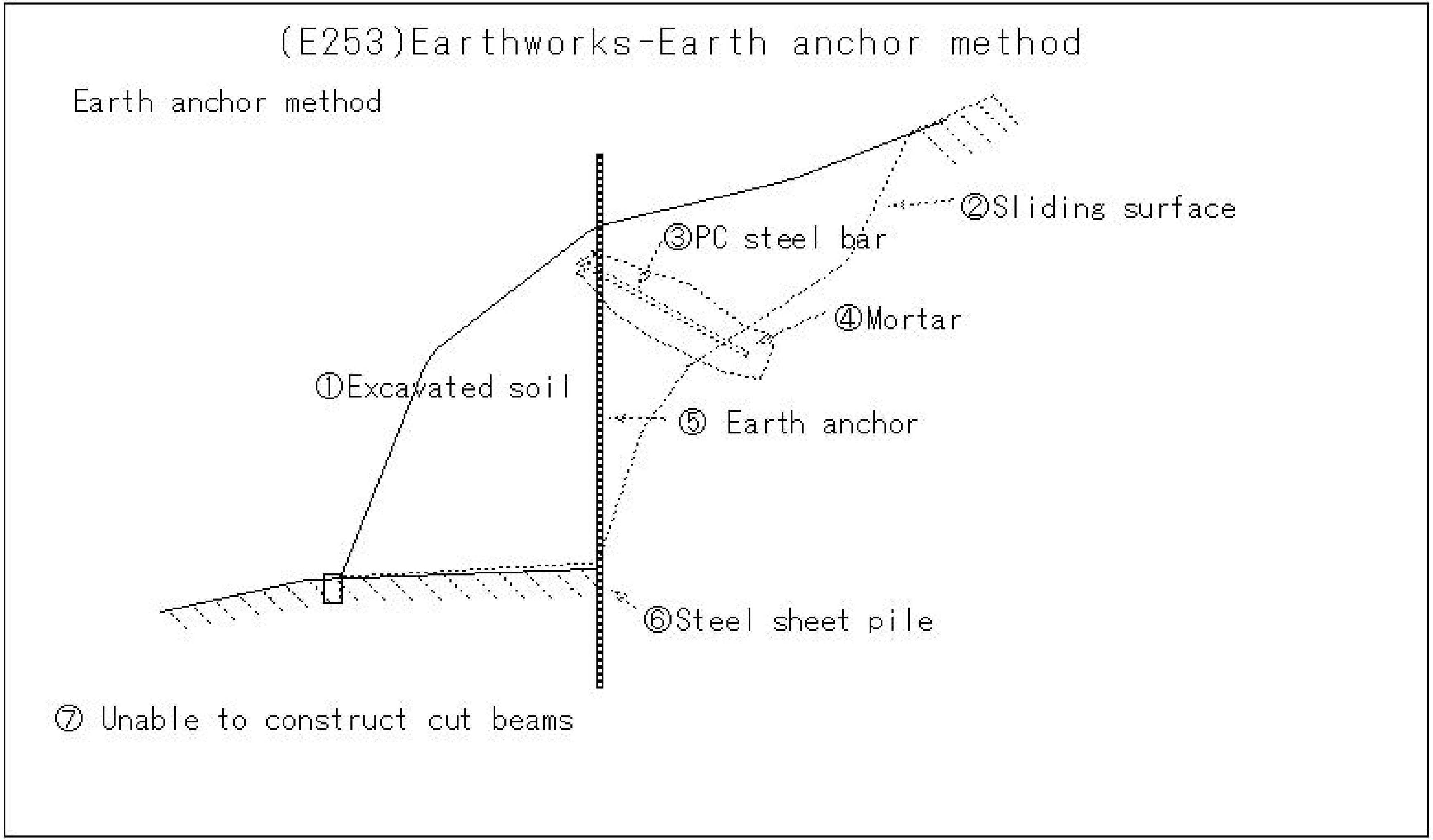
(E252)Earthworks-Earth retaining wall timbering method

(E252)Earthworks-Earth retaining wall timbering method

・Continuous wall construction method



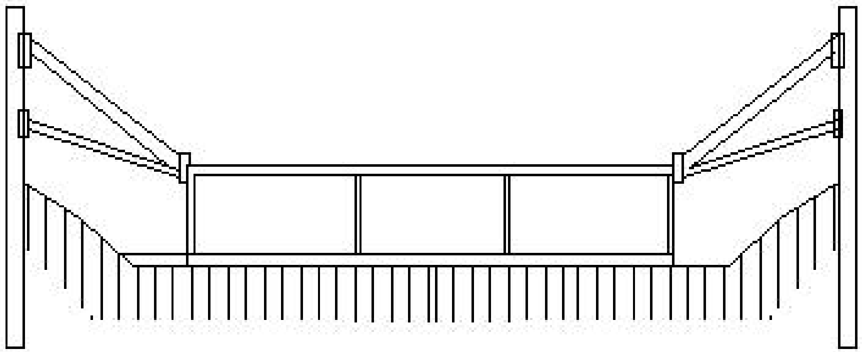
(E253)Earthworks-Earth anchor method



(E254)Earthworks-Island method

(E254)Earthworks-Island method

Island method

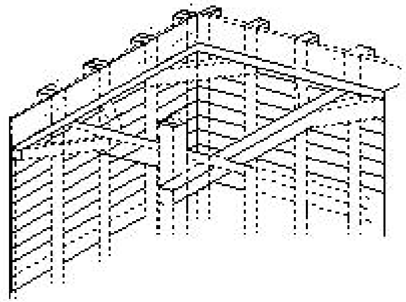


① Wide excavation width - wide

(E255)Earthworks-Parent pile horizontal sheet pile /Steel sheet pile/Continuous wall

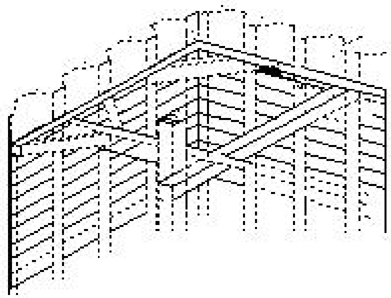
(E255)Earthworks-Parent pile horizontal sheet pile /Steel sheet pile/Continuous wall

①Parent pile horizontal sheet pile construction method



- Groundwater: None
- Shallow and wide gravel layer

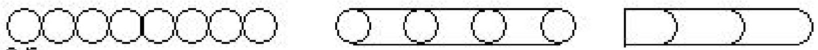
②Steel sheet pile construction method



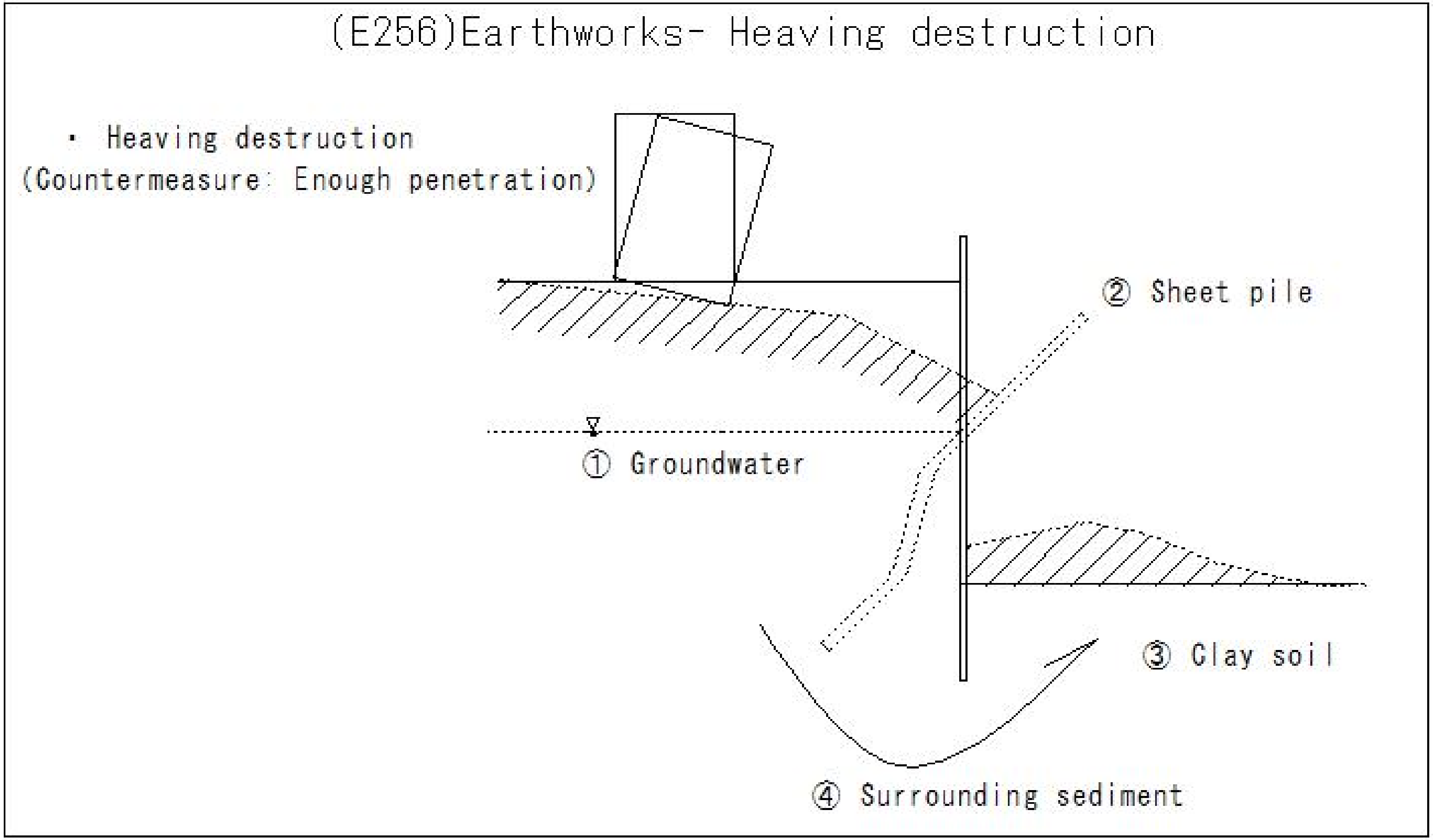
- With groundwater
- Deep and wide soft layer

③Continuous wall construction method

- Walls are rigid
- Suitable for soft layers with groundwater
- Earth retaining work in urban areas



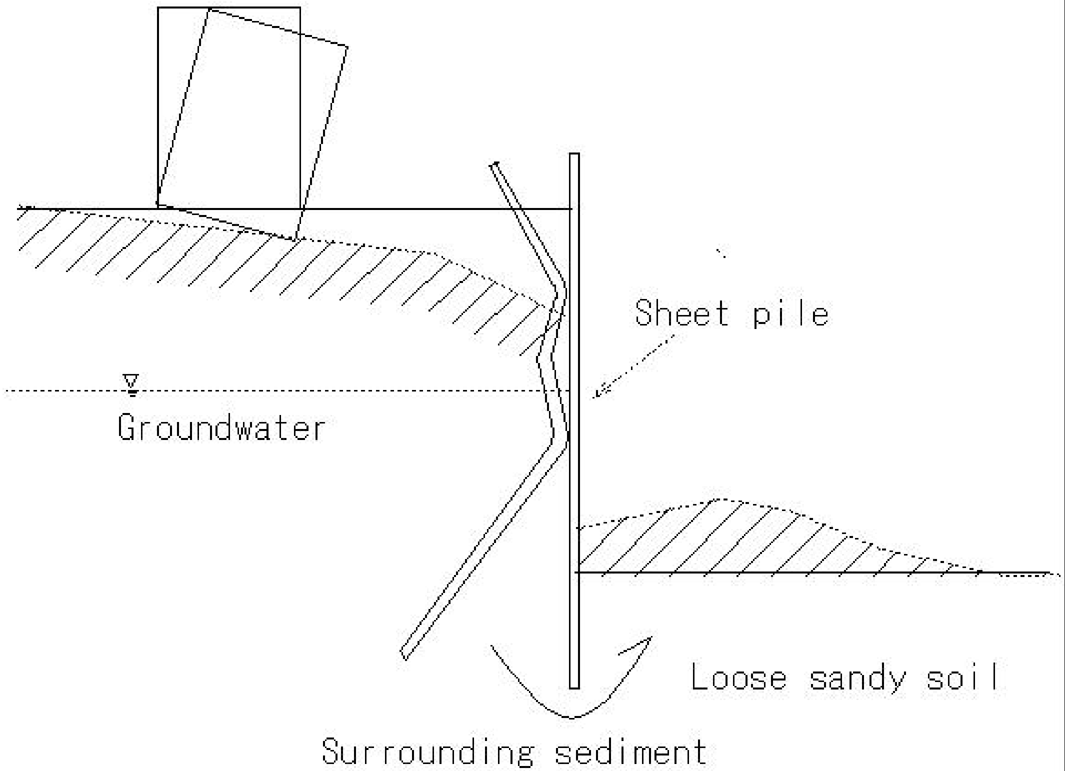
(E256)Earthworks- Heaving destruction



(E257)Earthworks-Boiling destruction

(E257)Earthworks-Boiling destruction

・Boiling destruction
(Countermeasure: Enough penetration)



(E258)Earthwork plan-Construction machinery construction volume

(E258)Earthwork plan-Construction machinery construction volume

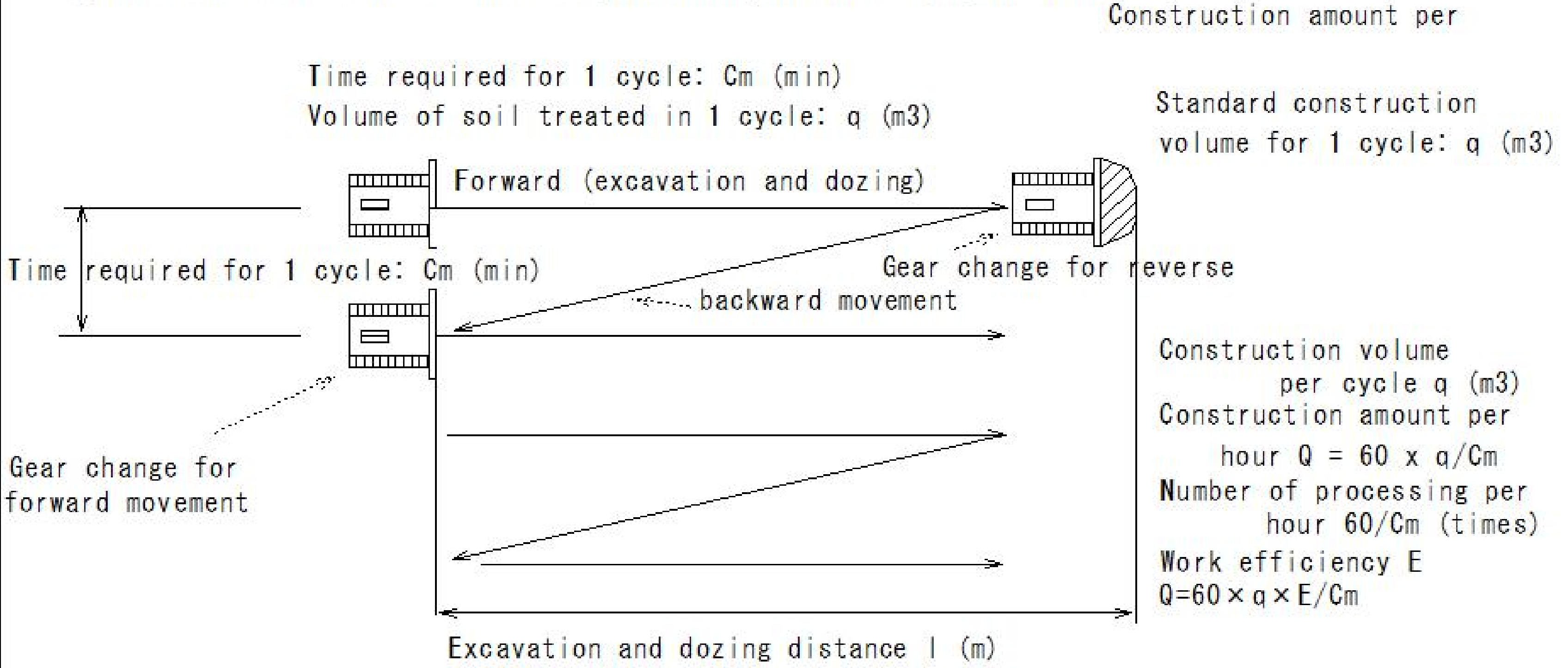
Construction machinery construction volume

①Cycle time (min): 1 cycle of repetitive work

②Bulldozer dozing - return to original position

③Dump truck: Loading - transportation - dumping soil 1 cycle

④The number of times that can be processed per hour = (60/Cm) times



(E259)Earthwork plan-Amount of work done by construction machinery

(E259)Earthwork plan-Amount of work done by construction machinery

Earthwork plan

Amount of work done by construction machinery

Gravel V=1000m3

Dump truck 1 cycle processing volume q = 6m3

L=18.0km Aggregate storage area

Dump truck 1 cycle time Cm=30min

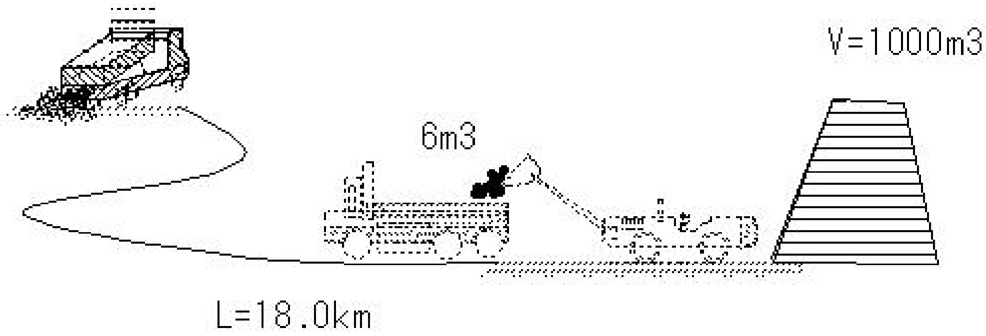
Work efficiency E=0.8

Construction amount per hour Q=60×q×E/Cm

=60*6*0.8/30 9.6m3/h

Time required to process 1000m3

=1000/9.6 104.2h 105 hours rounded up



(E260)Earthwork plan-Rate of change in soil volume

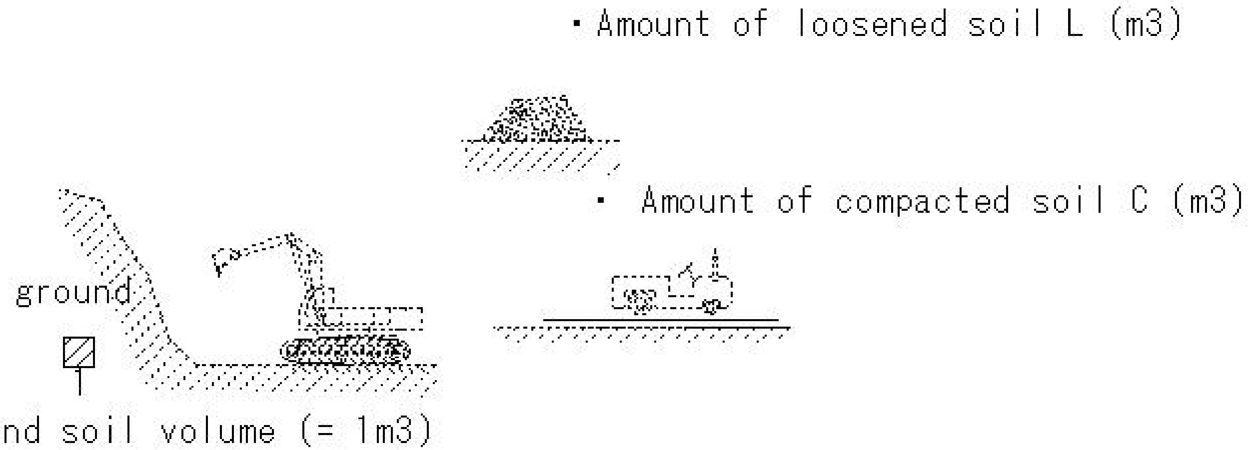
(E260)Earthwork plan-Rate of change in soil volume

Rate of change in soil volume

- Ground soil volume (= 1m3)
- Amount of loosened soil L (m3)
- Amount of compacted soil C (m3)
- L C earth volume change rate

L = Loosen soil volume (m3) /Amount of ground soil (m3)

C = Amount of compacted soil (m3) / Amount of ground soil (m3)



(E261)Earthwork plan-Rate of change in soil volume

(E261)Earthwork plan-Rate of change in soil volume

	Rate of change in soil volume	
name	L	C
①Conglomerate	1.30-2.00	1.00-1.50
②Conglomerate/Boulders	1.10-1.15	0.95-1.05
③Gravel/gravel soil	1.10-1.45	1.00-1.30
④Sand	1.10-1.20	0.85-1.00
⑤Sandy soil	1.20-1.45	0.85-0.95
⑥Clay soil	1.25-1.45	0.85-0.95
⑦Clay	1.20-1.45	0.85-0.95

(E262)Earthwork plan-Value of soil volume conversion factor (f)

(E262)Earthwork plan-Value of soil volume conversion factor (f)

Value of soil volume conversion factor (f)

① Based on the amount of loosened soil
②Based on the amount of compacted soil
Land volume 1
Loosen soil volume L
Compacted soil volume C
Soil conversion factor f
The amount of work per cycle time is q
q'=q・f・E
Q=60×q×f×E/Cm

Q to seek Basic q	Volume of ground soil	Volume of loosened soil	Volume of compacted soil
Land volume (excavated soil volume)	1	L	C
Amount of soil loosened (Amount of soil to be transported)	1/L	1	C/L
Amount of soil compacted (Completed amount of embankment)	1/C	L/C	1

(E263)Earthwork plan-Transport to embankment point

(E263)Earthwork plan-Transport to embankment point

Transport to embankment point

How many round trips?

Mountain volume 2000m3

Dump truck 6m3

rock

Loosening rate L = 1.65

Dump truck: loosened soil volume 6m3

Ground soil volume (   ) m3

Coefficient f for conversion to soil mass

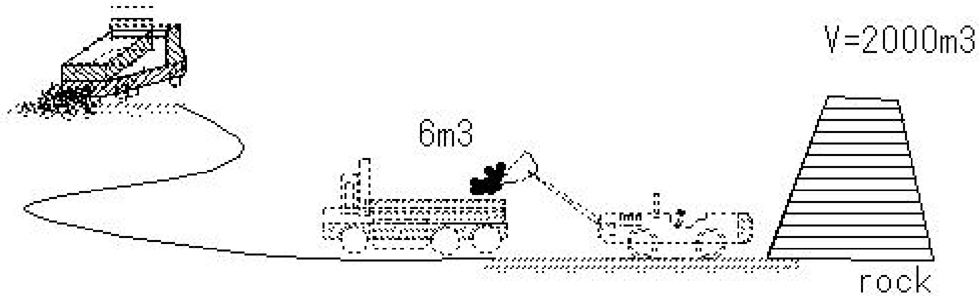
$f=1/L=1/1.65 \fallingdotseq 0.606$

Volume of earth soil q' loaded into one dump truck

$q'=f \cdot q=0.606 \times 6=3.636$m3

Number of transports required

$n=2000/3.636=550$ times



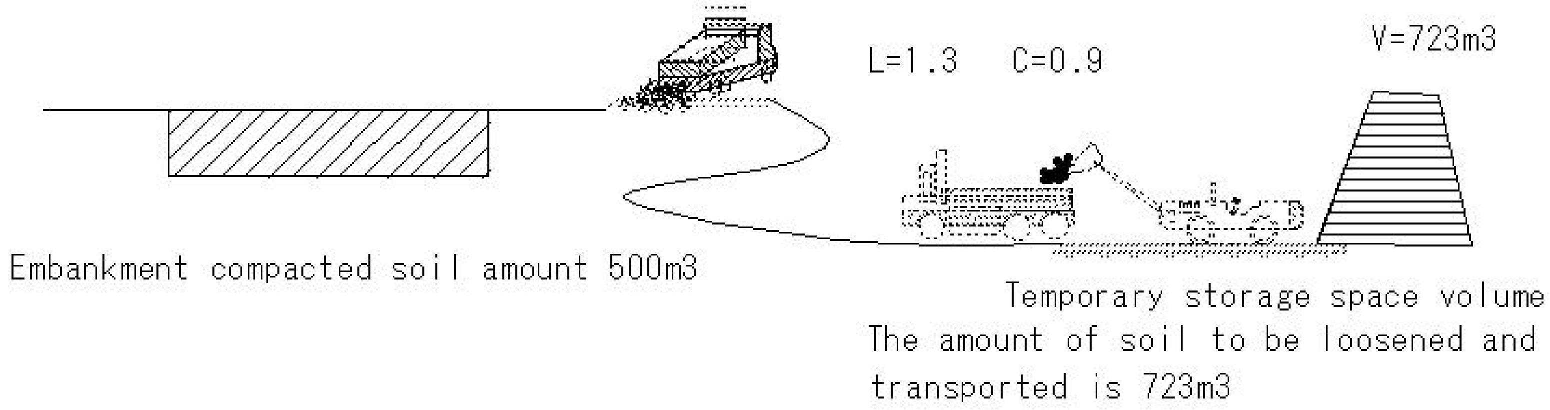
(E264)Earthwork plan-Amount of soil to be transported

(E264)Earthwork plan-Amount of soil to be transported

temporary storage
sandy soil
Embankment compacted soil amount 500m3
Soil in the temporary storage area: loosened soil volume
Based on the ground
L=1.3
C=0.9

Amount of soil required to create a 500m3 embankment
500/C=500/0.9=555.5=≒556m3
Transport and store in a temporary storage area
Temporary storage space volume
556×L=556×1.3＝722.8m3≒723m3
It takes 556m3 of ground soil to create a 500m3 embankment.
The amount of soil to be loosened and transported is 723m3

Amount of soil to be transported
Conversion factor f=L/C
500×f=500×1.3/0.9＝722.2≒723m3



(E265)Earthwork plan-Cycle time calculation

(E265)Earthwork plan-Cycle time calculation

Cycle time calculation

1 cycle time Cm(min)

bulldozer

Excavation and dozing distance (average) l (m)

Forward speed V1 (m/min)

Reverse speed V2 (m/min)

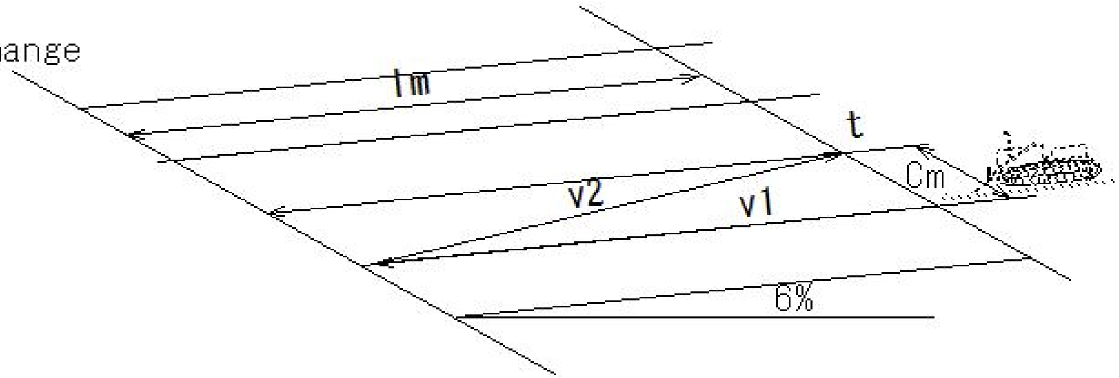
Gear change (2 times) t

Cycle time Cm(min)=l/v1+l/v2+t

Time required to move forward

Time required to reverse

Time required for gear change



(E266)Earthwork plan-Standard construction speed QR

(E266)Earthwork plan-Standard construction speed QR
Downhill slope 6%
Average excavation and transportation distance l = 20m Cutting 2.5m3 treatment
Processing capacity increased by 1.12 times due to Downward slope
Standard construction speed of bulldozer QR?
Rate of change in soil volume L=1.25
Forward speed V1=40m/min
Reverse speed V2=100m/min
Gear change t=0.5min

Cycle time Cm(min)=l/v1+l/v2+t

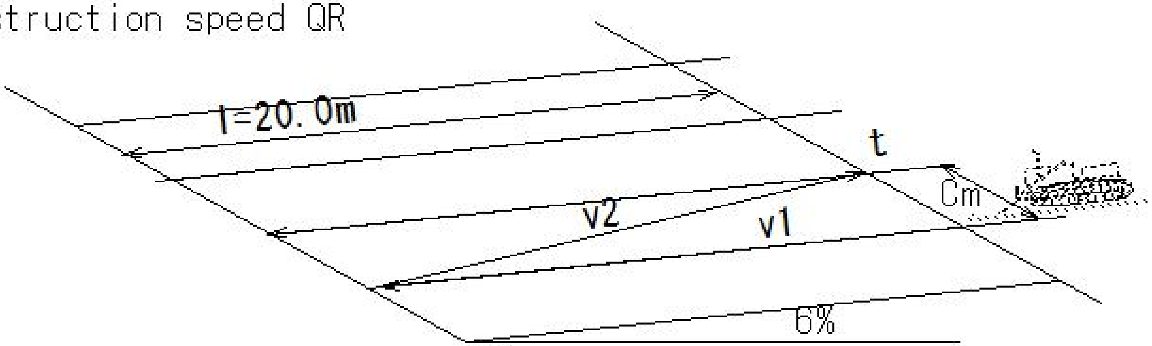
=20/40+20/100+0.5=1.2min

1 cycle time: Excavation/dosing volume q’
q’=q・f・E
=2.5×1/L×1.12=2.5×1・1.25×1.12=2.24m3

Standard construction speed QR

QR=60×q'/Cm=60×2.24/1.2=112m3/h

Standard construction speed QR



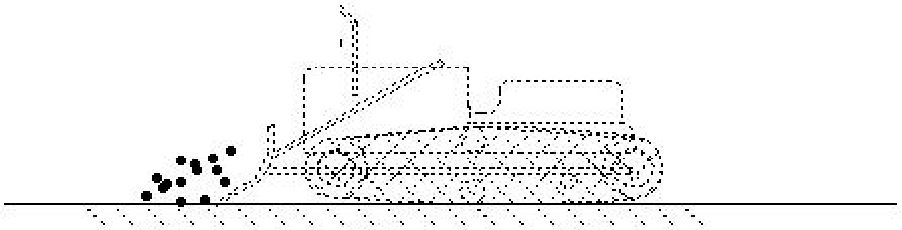
Processing capacity increased by 1.12 times due to Downward slope

(E267)Earthwork plan-Bulldozer work

(E267)Earthwork plan-Bulldozer work

Volume of soil processed in 1 cycle		
	Unit: qm3	
11t bulldozer	19t bulldozer	27t bulldozer
1.35	2.3	3.8

Work efficiency E		
sand	clay	crushed rock
0.7	0.5	0.3



Rate of change in soil volume		
Land volume:1m3	Loosen soil volume L	Compacted soil volume C
sand	1.15	0.9
clay	1.35	0.9

(E268)Earthwork plan-Construction speed of compaction machine

(E268)Earthwork plan-Construction speed of compaction machine
Construction speed of compaction machi (E268)Earthwork plan-Construction speed of compaction machine
Construction speed: Q (m3/h)

Compaction construction speed Q (m3/h)

Q=V・W・D・f・E/N(m3/h)

①Standard compaction speed: V (m/h)

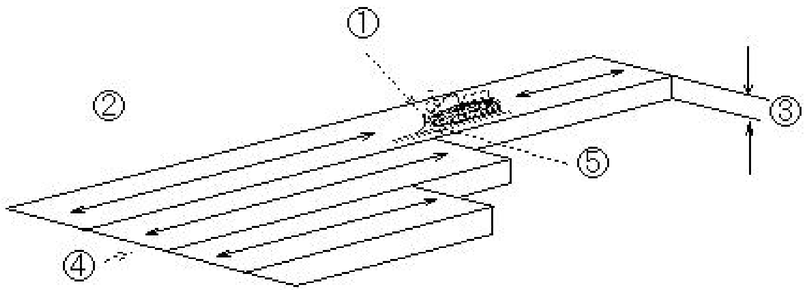
②bulldozer・tyre roller

③Finished thickness after compaction: D (m)
Finished thickness after compaction Dm
Roadbed/embankment 0.3m or less
Roadbed 0.2m or less

Leveling thickness (unrolling thickness)
Roadbed/embankment 0.35-0.45m or less
Roadbed 0.25-0.35m or less

④Number of compactions: N
Road body/embankment 5 times
Roadbed 7 times

⑤Machine width: W (m)
11t class bull 0.7m
19t Bull 0.8m



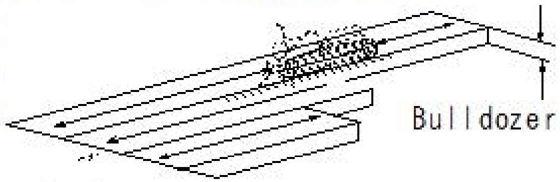
(E269)Earthwork plan-Construction speed of compaction machine

(E269)Earthwork plan-Construction speed of compaction machine

Standard compaction speed: V (m/h) 4000m/h

11t bulldozer

200m3 Compact



Finished thickness after compaction D=0.2m

how many hours ?

Bulldozer width W=0.7m

Compaction number: 7 times

Work efficiency E=0.8

Rate of change in soil volume of sandy soil f=1.15

bulldozer compaction speed

$Q=V\cdot W\cdot D\cdot f\cdot E/N\,(m^3/h)$

$=4000\times 0.7\times 0.2\times 1.15\times 0.8/7=73.6\fallingdotseq 74$

Required time t

$t=200/Q=200/74=2.7\fallingdotseq 3$ hours

(E270)Earthwork plan-Power excavator construction speed

(E270)Earthwork plan-Power excavator construction speed

Power excavator construction speed

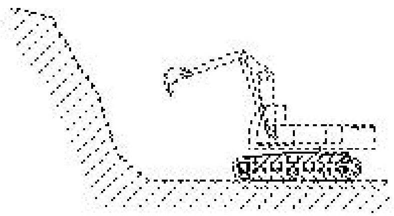
Power shovel reference materials

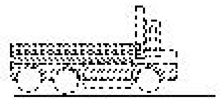
Excavation loading amount per cycle qm3	
Bucket for 0.3m3	0.26m3
Bucket for 0.6m3	0.53m3
Bucket for 1.2m3	1.06m3

Cycle time by rotation angle Cm(min)

45°	90°	135°	180°
0.23	0.30	0.33	0.40

bucket





Work efficiency E

Varies depending on site conditions and soil quality of the ground

$0.2 < E < 0.9$

Earth: 200m3

Power shovel (bucket for 0.6m3)

One loading amount q=0.53m3

Average 135° turn

Cycle time Cm=0.33min

Efficiency E=0.33

Power shovel construction speed Qm3/h

How many hours does it take to process?

Rate of change in soil volume L=1.25

Loading amount for 1 cycle q'

$q' = q \cdot f = 0.53 \times 1/1.25 = 0.424m3$

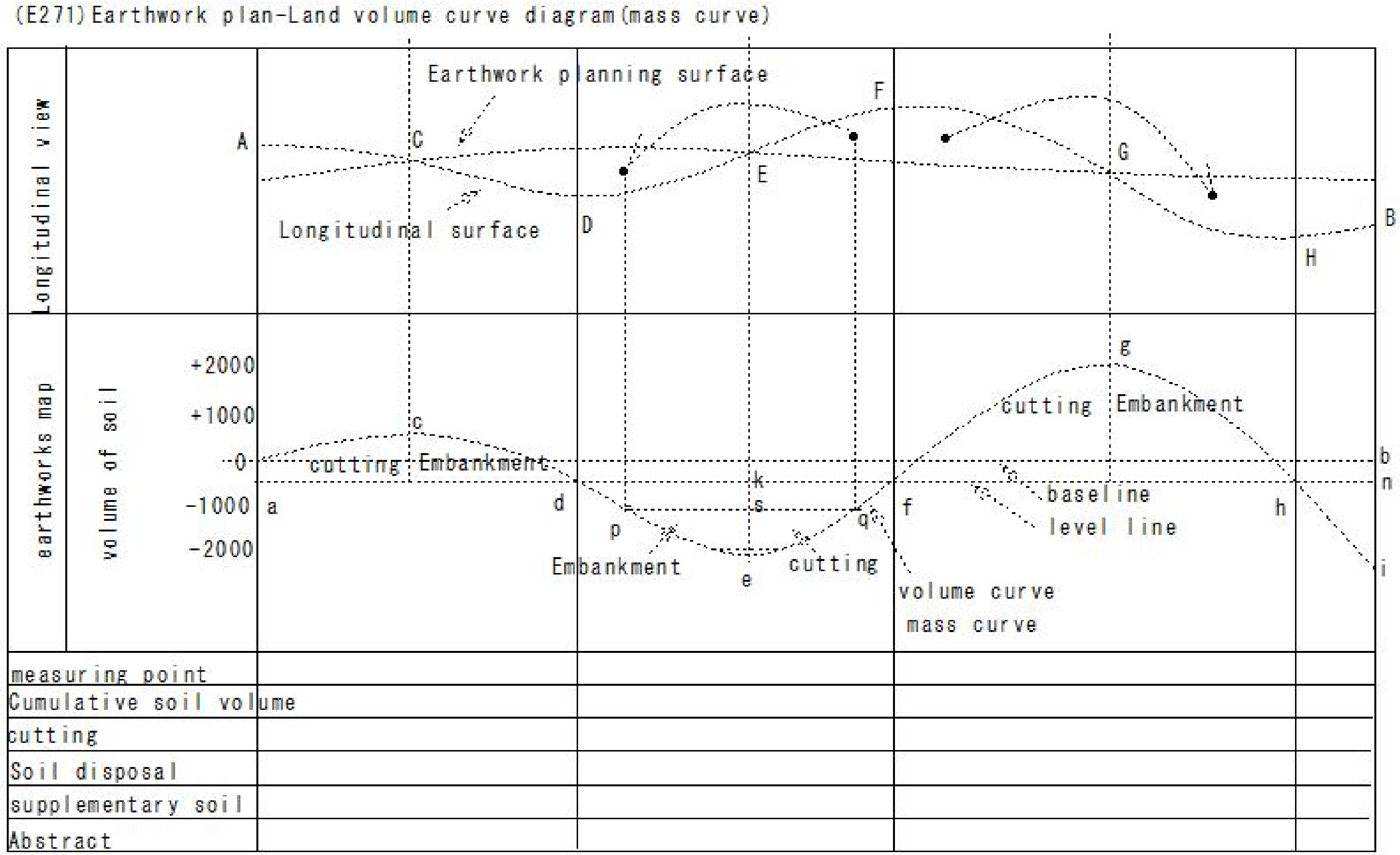
Work volume per hour (construction speed) Q (m3/h)

$Q = 60 \times q' \times E/Cm = 60 \times 0.424 \times 0.33/0.33 = 25.44m3/h$

Working time t

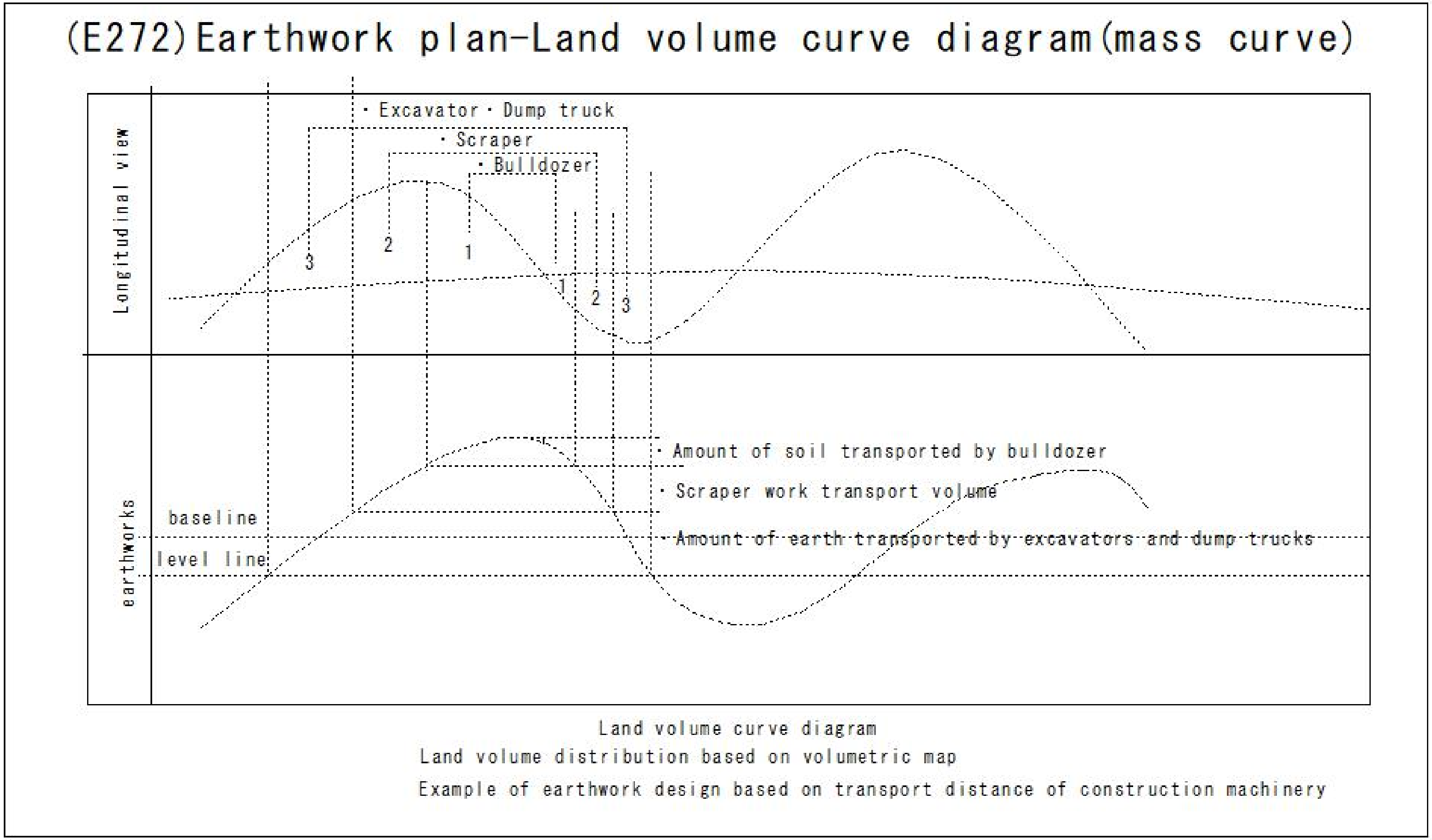
$t = 200/Q = 200/25.44 = 7.8h \fallingdotseq 8h$

(E271)Earthwork plan-Land volume curve diagram(mass curve)



Land volume curve diagram(mass curve)

(E272)Earthwork plan-Land volume curve diagram(mass curve)

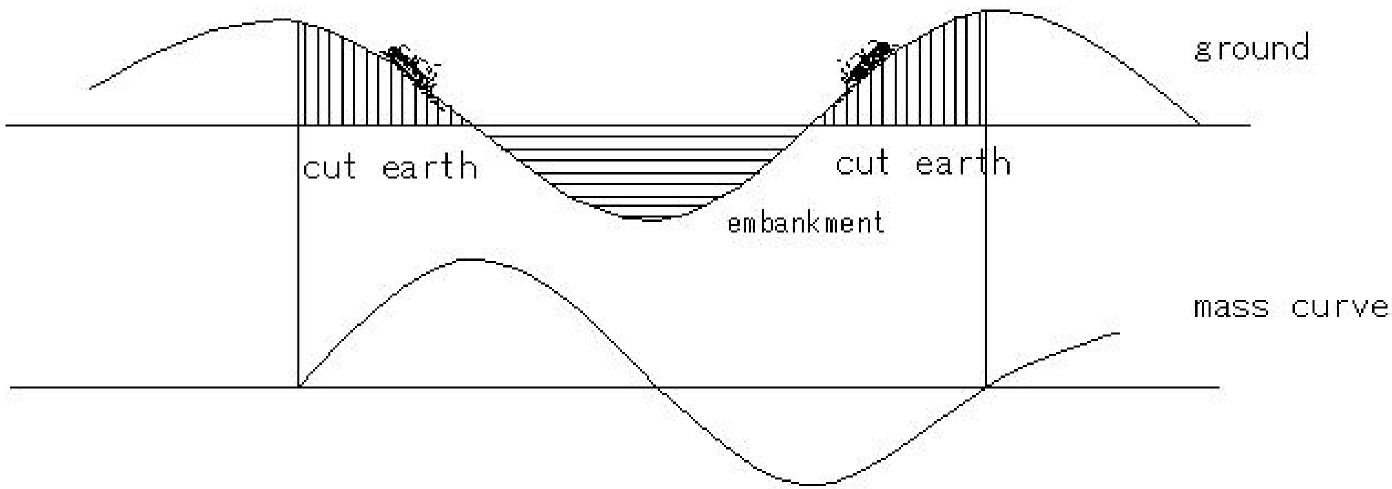


(E273)Earthwork plan-Land volume curve diagram(mass curve)

(E273)Earthwork plan-Land volume curve diagram(mass curve)

Improving the efficiency of construction machinery

Mass curve with good work efficiency

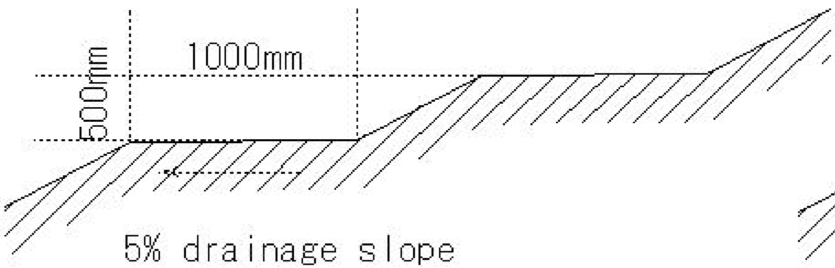


Curve with good work efficiency

(E274)Earthwork construction plan-Slope of foundation ground to prevent embankment from sliding

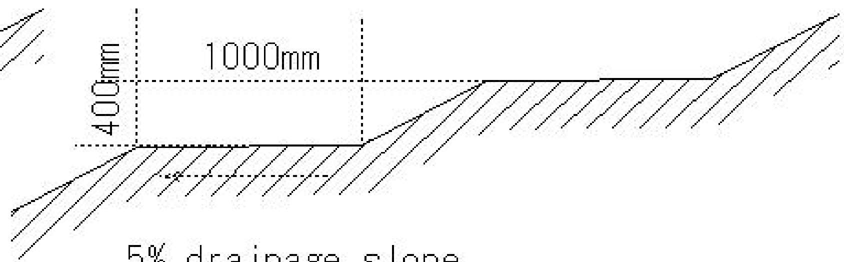
(E274)Earthwork construction plan-Slope of foundation ground to prevent embankment from sliding

Slope of foundation ground to prevent embankment from sliding



5% drainage slope

・Step cutting for soil



5% drainage slope

・Step cutting for rocks

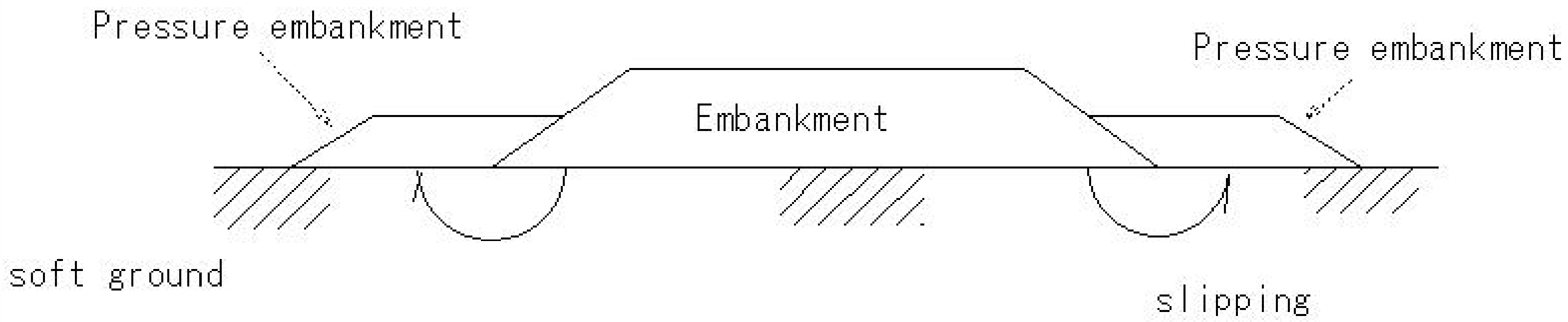
(E275)Earthwork construction plan-How to treat soft ground-Pressure embankment method

(E275)Earthwork construction plan-How to treat soft ground-Pressure embankment method

How to treat soft ground

Slip prevention

Pressure embankment method



(E276)Earthwork construction plan-How to treat soft ground-Replacement method

(E276)Earthwork construction plan-How to treat soft ground-Replacement method

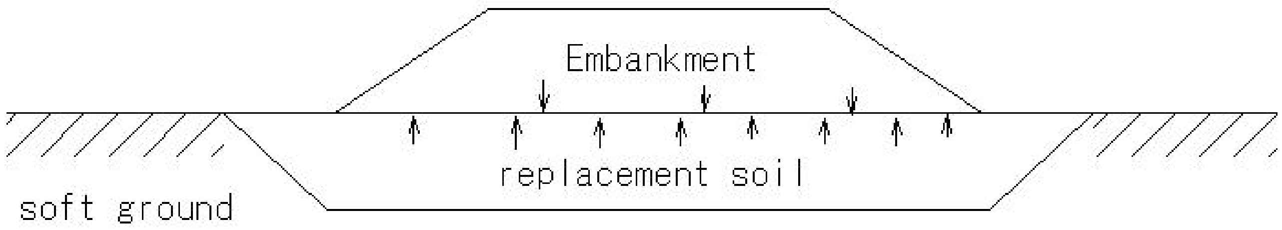
Earthwork construction plan

How to treat soft ground

Slip prevention

Soft ground - good quality material (sand) - replacement

Limited construction range/thickness



Replacement method

(E277)Earthwork construction plan-How to treat soft ground- Slow construction method

(E277)Earthwork construction plan-How to treat soft ground- Slow construction method

Earthwork construction plan

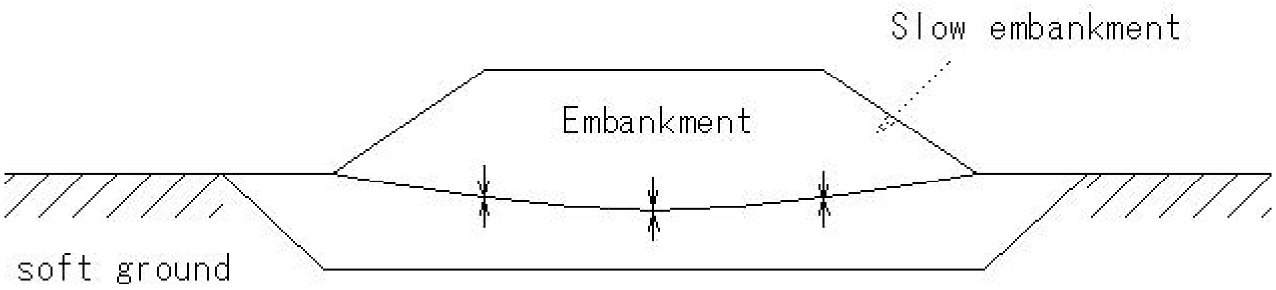
How to treat soft ground

Slip prevention

Slow construction method

Rapid construction - ground/balance - collapse

Construction slowly over time



Adapts to the ground (suppresses strength decline)

See details

Slow construction method

(E278)Earthwork construction plan-How to treat soft ground- Countermeasures against settlement

(E278)Earthwork construction plan-How to treat soft ground- Countermeasures against settlement-Loading method

Earthwork construction plan

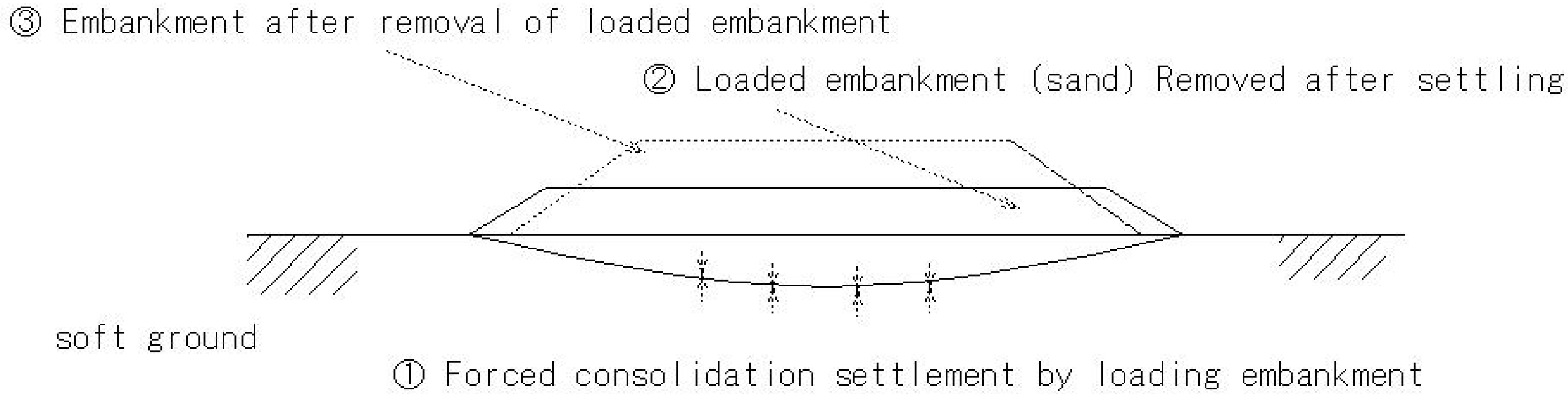
How to treat soft ground

Countermeasures against settlement

Loading method

Sand/earth – loading onto soft ground

Forced consolidation settlement



Loading method

(E279)Earthwork construction plan-How to treat soft ground- Countermeasures against settlement-Sand drain method

(E279)Earthwork construction plan-How to treat soft ground- Countermeasures against settlement-Sand drain method

Earthwork construction plan

How to treat soft ground

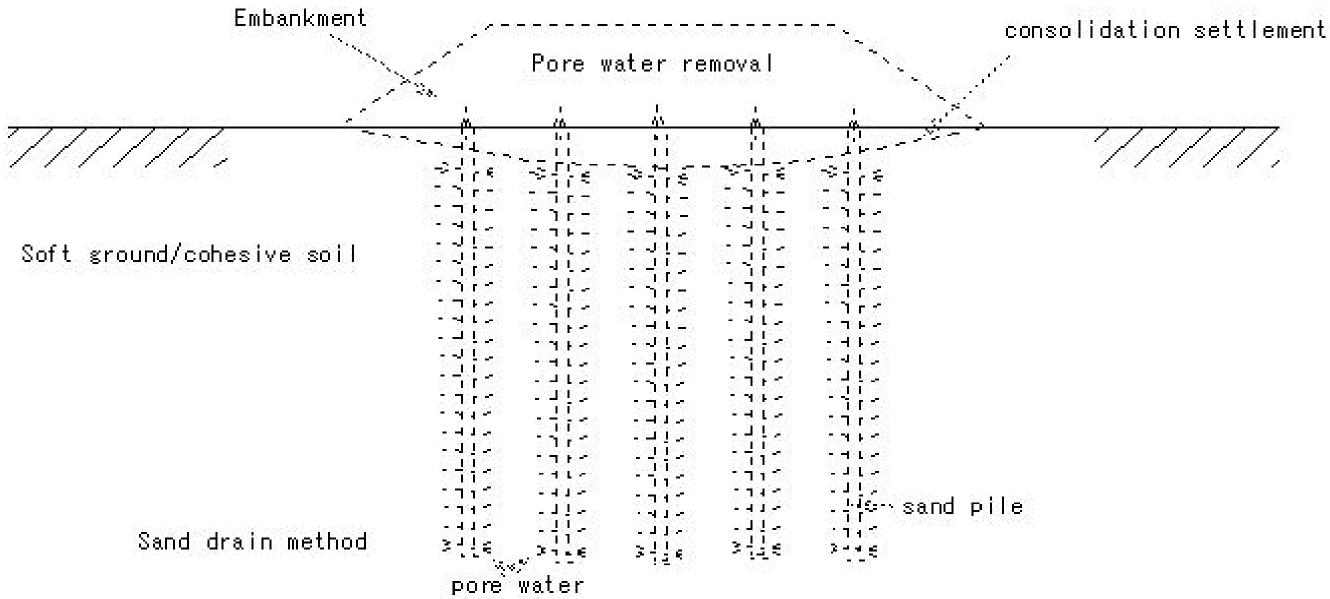
Countermeasures against settlement

Sand drain method

Driving sand piles into sticky soil

Eliminates pore water in cohesive soil

・Consolidation settlement in a short time



(E280)Earthwork construction plan-How to treat soft ground- Slip and subsidence measures-Sand compaction method

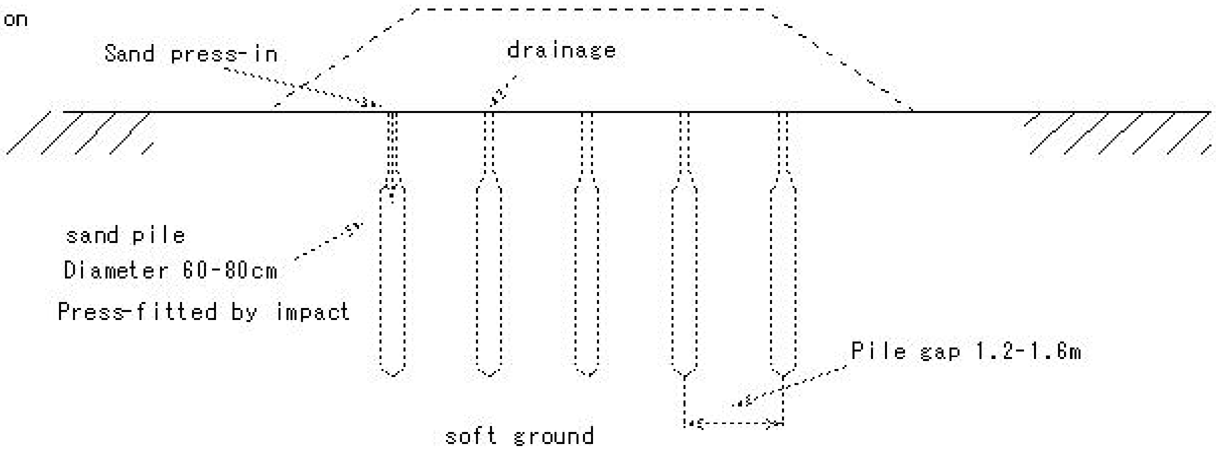
(E280)Earthwork construction plan-How to treat soft ground- Slip and subsidence measures-Sand compaction method

Earthwork construction plan

How to treat soft ground

Slip and subsidence measures

- Sand compaction method
- Shock/vibration load
- Press in sand
- Hardened sand pile
- Sand pile bearing capacity - stability
- Total subsidence amount - decrease
- Increased sliding resistance
- Liquefaction prevention



(E281)Earthwork construction plan-How to treat soft ground- Earthquake countermeasures (liquefaction prevention)

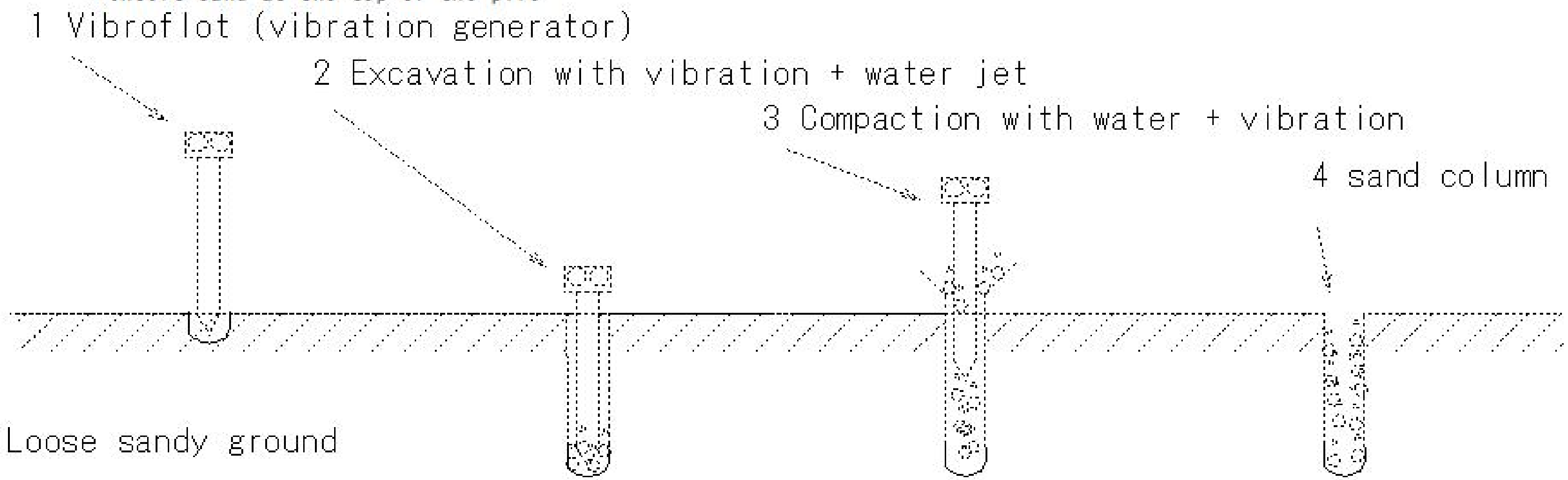
(E281)Earthwork construction plan-How to treat soft ground- Earthquake countermeasures (liquefaction prevention)

Earthwork construction plan

How to treat soft ground

Slip and subsidence measures

- Earthquake countermeasures (liquefaction prevention)
- Vibroflotation method
- Loose sandy ground
- Rod-shaped vibrator
- Effect of vibration water injection
- Soil compaction
- Insert sand at the top of the pile



(E282)Earthwork construction plan-gradient

(E282)Earthwork construction plan-gradient
Earthwork construction plan
Slope gradient
Standard slope for cutting

soil quality of the ground		cutting high	Slope gradient
hard rock			1：0.3-1：0.8
soft rock			1：0.5-1：1.2
sand	(Not dense and with poor particle size distribution		1：1.5－
sandy soil	dense	5m or less 5-10m	1：0.8-1：1.0 1：1.0-1：1.2
	not dense	5m or less 5-10m	1：1.0-1：1.2 1：1.2-1：1.5
Sandy soil mixed with with gravel and rock lumps	dense and good particle size distribution	10m or less 10-15m	1：0.8-1：1.0 1：1.0-1：1.2
	Not dense/poor particle size distribution	10m or less 10-15m	1：1.0-1：1.2 1：1.2-1：1.5
clay soil		10m or less	1：0.8-1：1.2
Cohesive soil mixed with rock masses and cobbles		5m or less 5-10m	1：1.0-1：1.2 1：1.2-1：1.5

(E283)Earthwork construction plan-slope gradient

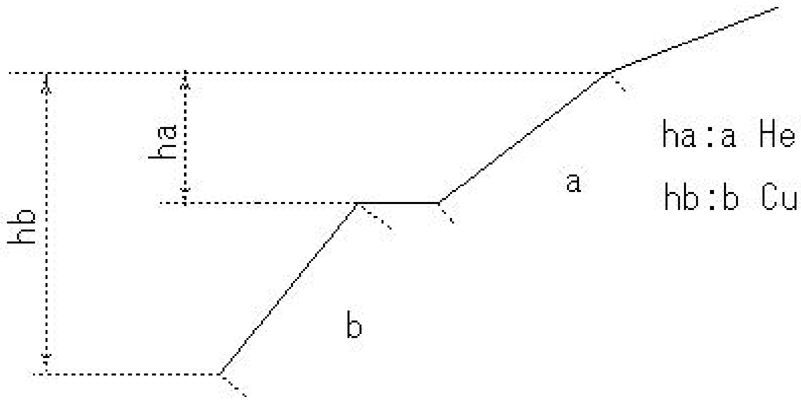
(E283)Earthwork construction plan-slope gradient

Earthwork construction plan

Slope gradient

Single slope is not possible due to soil composition, etc.

Concept of cutting height and slope



ha:a Height of cut relative to slope surface

hb:b Cut height relative to slope surface

(E284)Earthwork construction plan-slope gradient

(E284)Earthwork construction plan-slope gradient
Earthwork construction plan
Slope slope
Standard slope for embankment material and embankment height

Embankment material	Embankment height (m)	slope gradient
Sand with good grain size (SW) Gravel mixed with debris and fine particles (GM) (GC) (GW) (GP)	5m below	1:1.5−1:1.8
	5−15m	1:1.8−1:2.0
Sand with poor grain size (SP)	10m below	1:1.8−1:2.0
Gravel mass (including shear)	10m below 10−20m	1:1.5−1:1.8 1:1.8−1:2.0
Sandy soil (SM) (SC) hard clay soil, hard clay	5m below 5−10m	1:1.5−1:1.8 1:1.8−1:2.0
Volcanic ash clay soil (VH2)	5m below	1:1.8−1:2.0

(E285)Earthwork construction plan-Safety measures for excavation work

(E285)Earthwork construction plan-Safety measures for excavation work

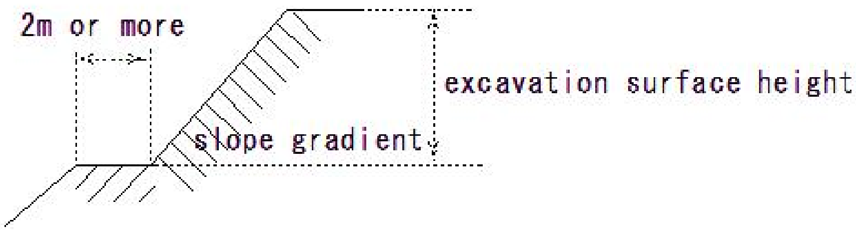
Safety measures for excavation work

open excavation

slope of excavation surface

excavation limits

ground	excavation surface height	slope gradient
A ground consisting of bedrock or hard clay	5m below	90° or less
	5m over	75° or less
Other geological formations	2m below	90° or less
	2-5m	75° or less
	5m over	60° or less
ground made of sand	5m below	35° or less
Rocks that are susceptible to collapse due to blasting, etc.	2m below	45° or less



The excavation surface is separated into horizontal stages of 2 m or more.

(E286)Earthwork construction plan-Earth retaining work

(E286)Earthwork construction plan-Earth retaining work

Safety measures for excavation work

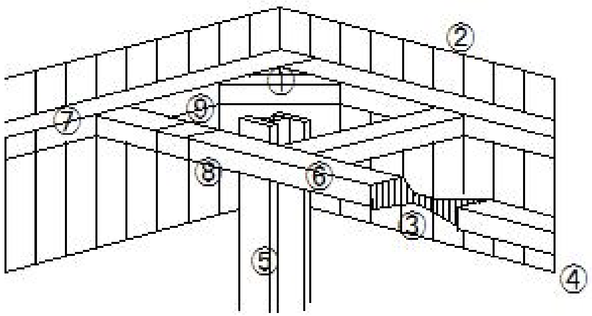
Earth retaining work

①angle brace

②Sheet piles

③Compressed materials: angle brace The joint is a butt joint

④the strut is supported by a structure, it must be able to withstand the load.



⑤Intermediate support column

⑥beam

⑦walling

⑧Securely attach to sheet piles, piles, and intermediate support columns

⑨Connection of strut and angle brace

The intersection between the struts is tightened with plate bolts.

Make it solid by welding, etc.

⑩Inspection

⑩Inspection

・Period not exceeding 7 days

・In the case of an earthquake of medium or higher magnitude

・case of there is a risk of weakening of the ground due to heavy rain

(E287)Earthwork construction plan-penetration of sheet piles-heaving

(E287)Earthwork construction plan-penetration of sheet piles-heaving

Safety measures for excavation work

Earth retaining work

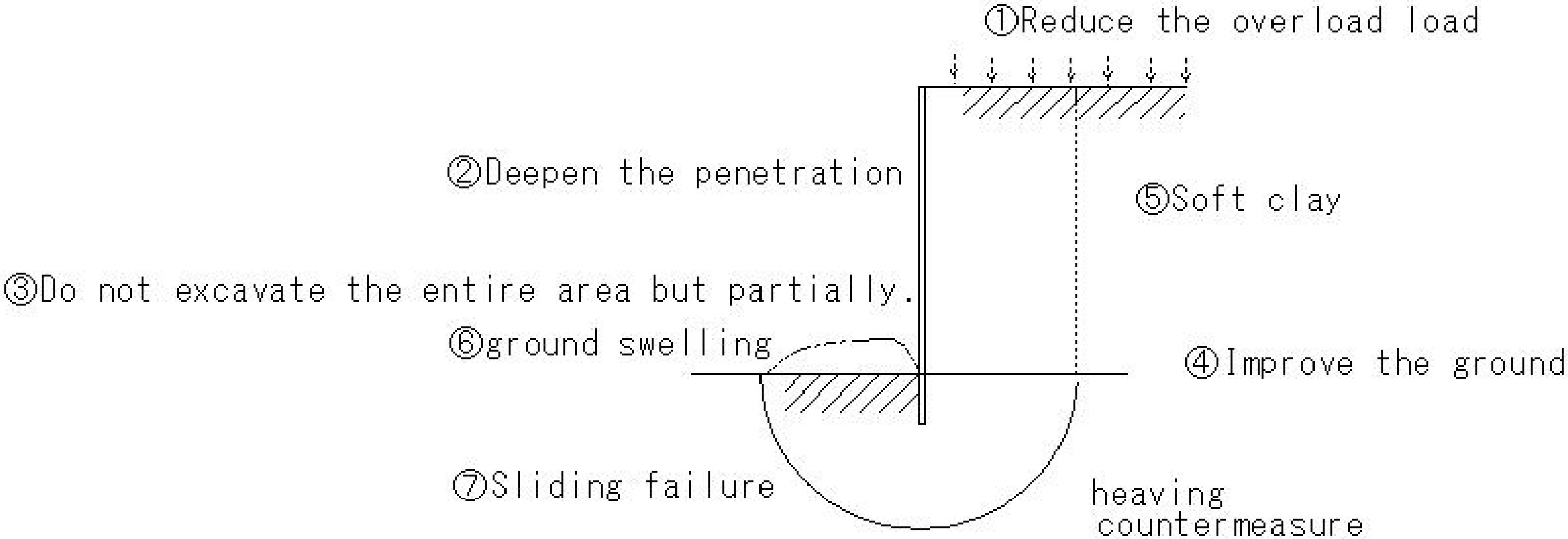
penetration of sheet piles

・Active earth pressure behind earth retaining

Examining the safety level against passive earth pressure at the front

heaving

the base of the excavation to swell:heaving causes



(E288)Earthwork construction plan-penetration of sheet piles-Boiling

(E288)Earthwork construction plan-penetration of sheet piles-Boiling

Safety measures for excavation work

Earth retaining work

penetration of sheet piles

・Active earth pressure behind earth retaining

Examining the safety level against passive earth pressure at the front

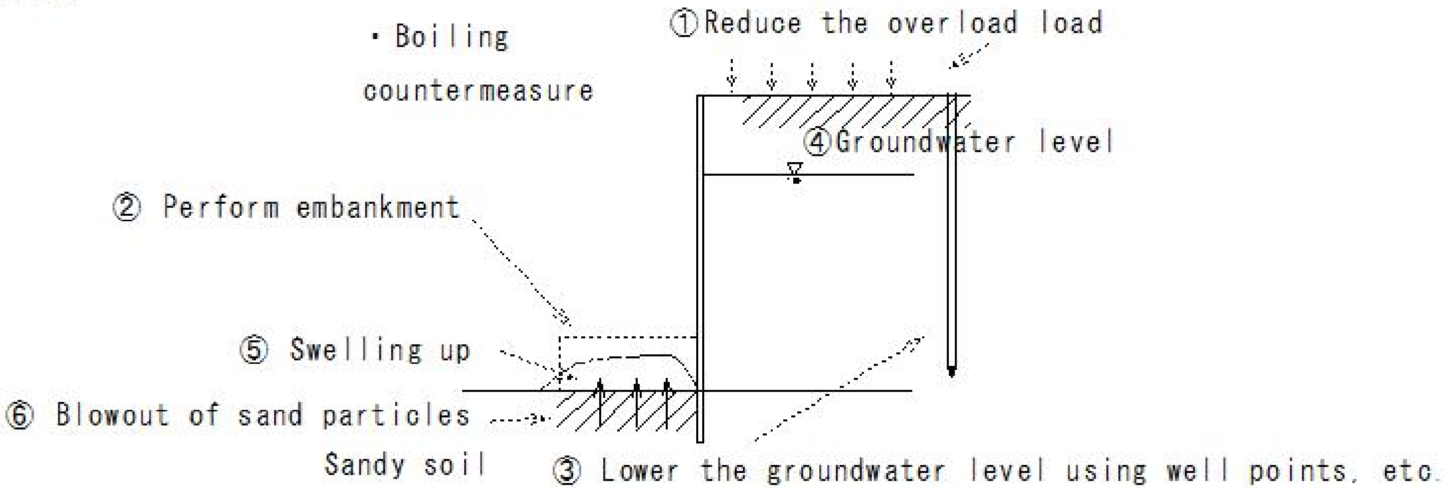
loose sandy ground

This is caused by the difference in water level between the back and front of the sheet pile.

piping boiling

・Boiling

countermeasure



(E289)Earthmoving machinery-Excavating machine

(E289)Earthmoving machinery-Excavating machine

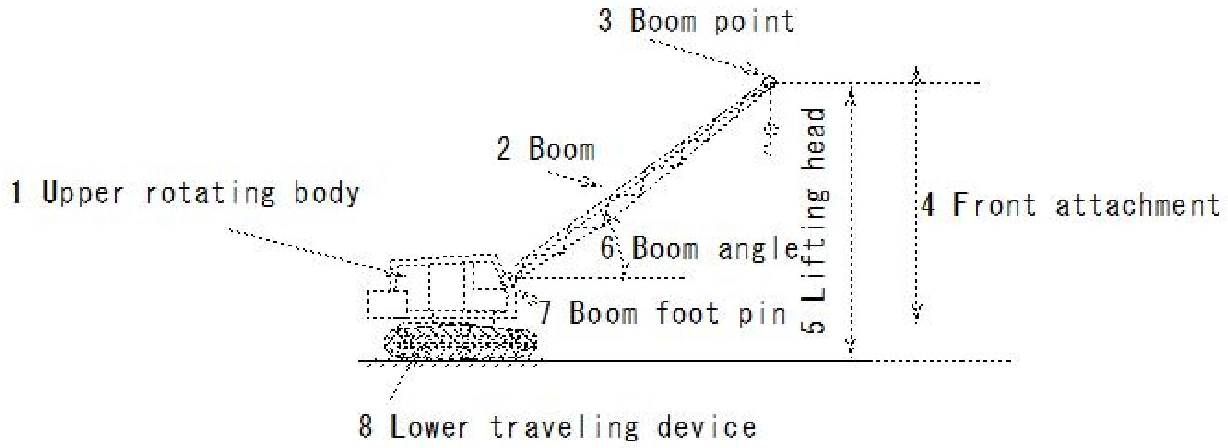
Earthmoving machinery

Excavating machine

①Shovel type excavator

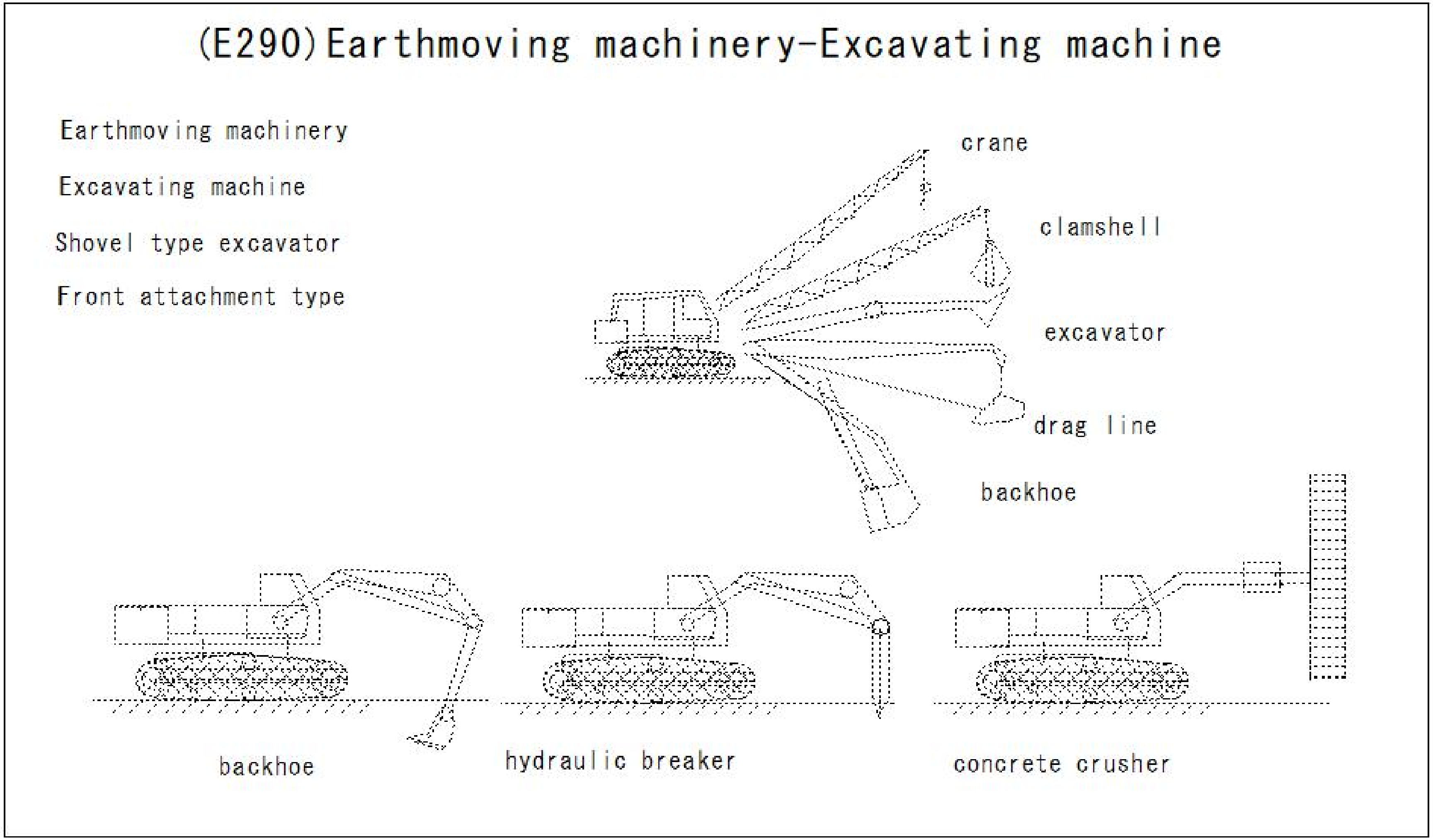
②Bulldozer type excavator Excavation + transportation work

③Continuous bucket excavator



Shovel type excavator

(E290)Earthmoving machinery-Excavating machine



(E291)Earthmoving machinery-loading machine-Crawler type tractor excavator

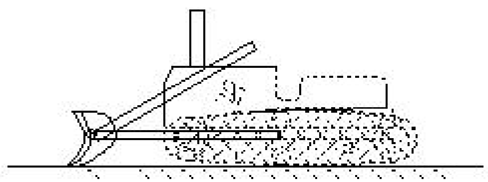
(E291)Earthmoving machinery-loading machine-Crawler type tractor excavator

Earthmoving machinery

loading machine

Crawler type tractor excavator

- Based on bulldozer
- Installing a bucket instead of a blade
- Excavating power - inferior
- Ground pressure - low
- Good running performance on soft ground and uneven ground



Crawler type tractor excavator

(E292)Earthmoving machinery-loading machine-Wheeled tractor excavator

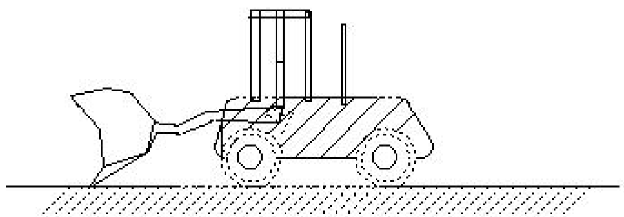
(E292)Earthmoving machinery-loading machine-Wheeled tractor excavator

Earthmoving machinery

Loading machine

Wheeled tractor excavator

- Running speed - fast
- High mobility
- Paved roads - do not damage the road surface
- work freely

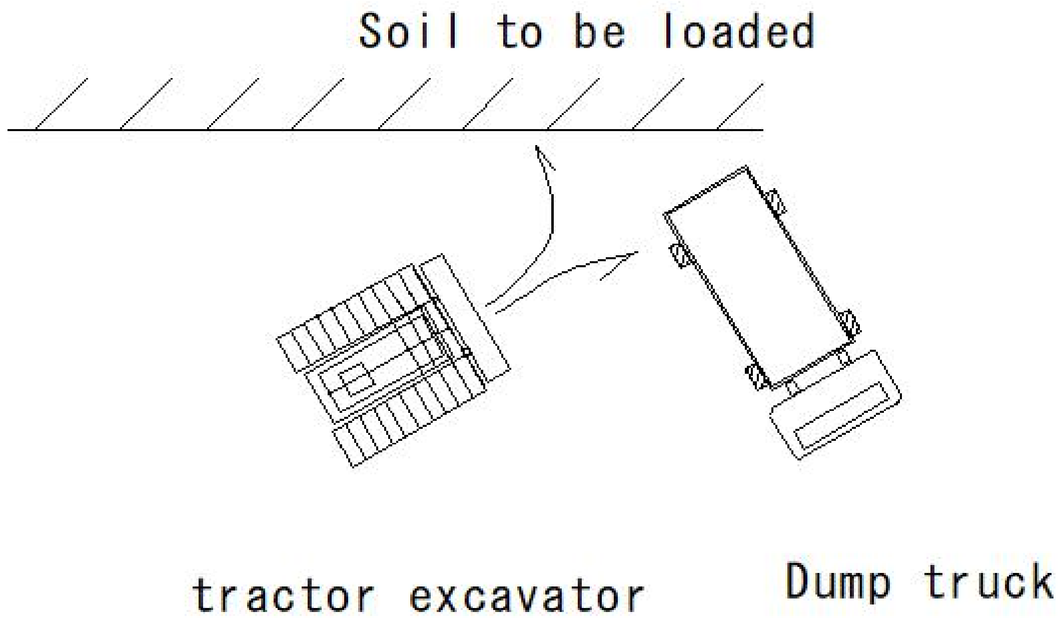


tractor excavator

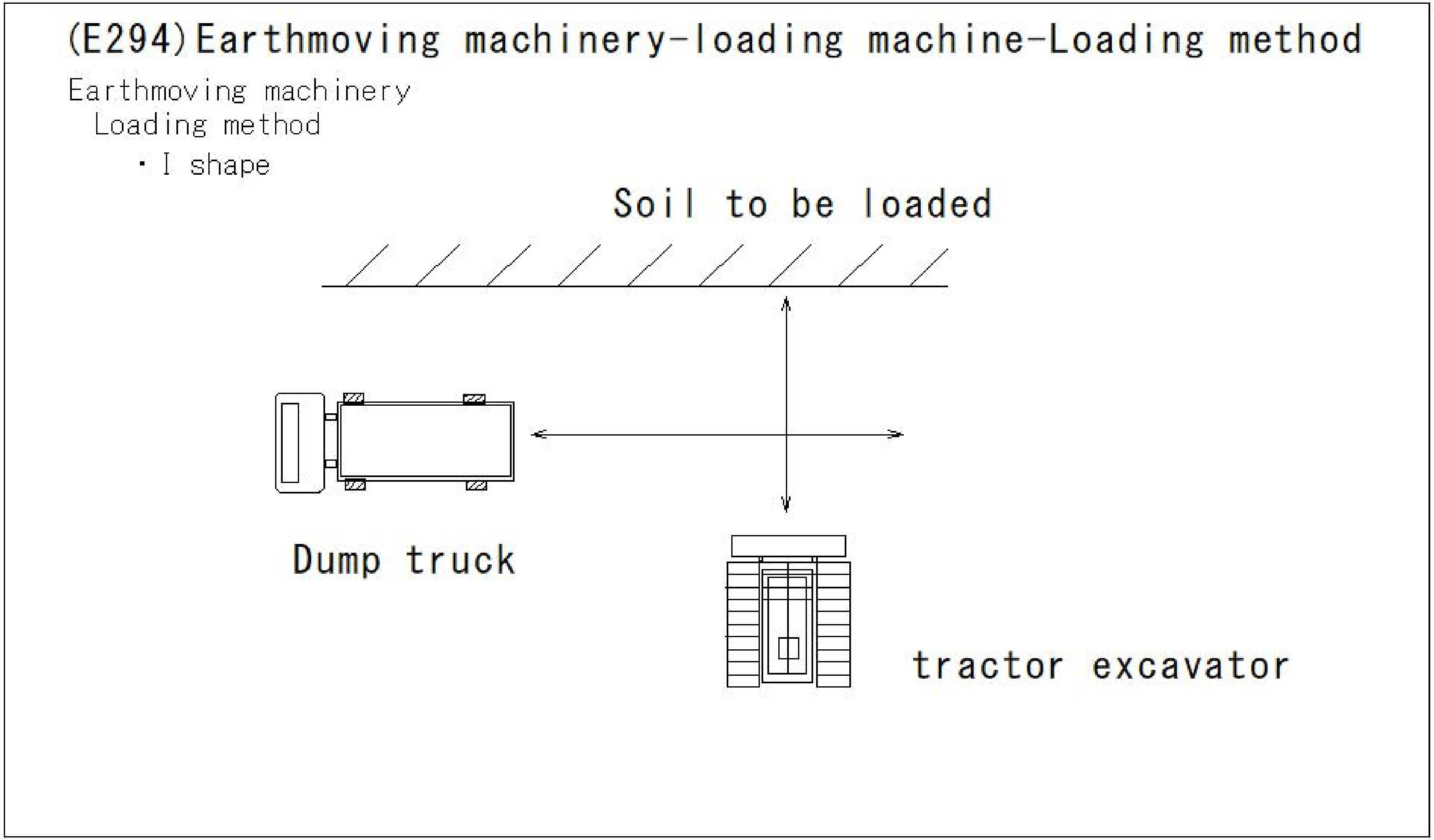
(E293)Earthmoving machinery-loading machine-Loading method

(E293)Earthmoving machinery-loading machine-Loading method

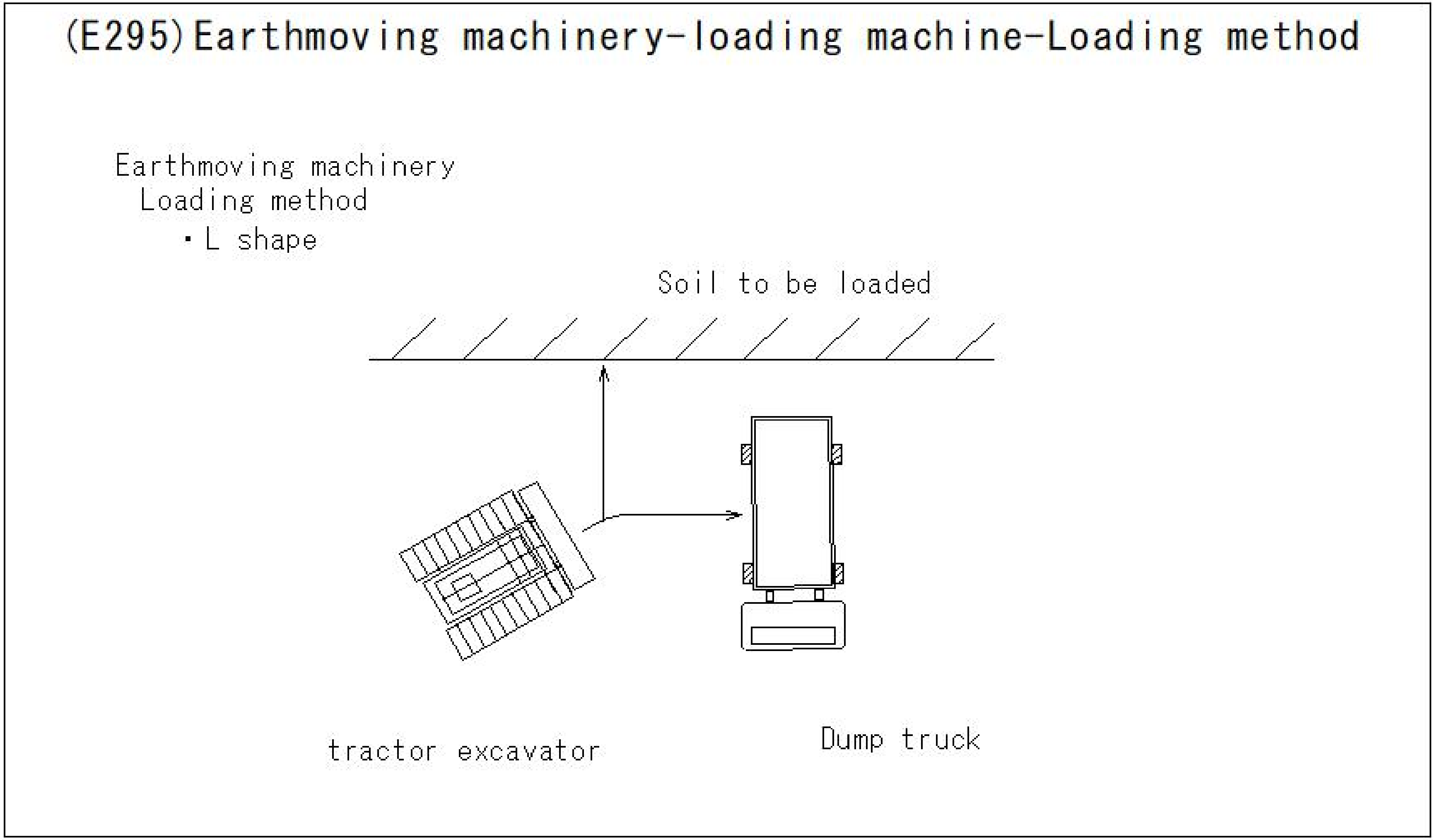
Earthmoving machinery
Loading method
・V shape



(E294)Earthmoving machinery-loading machine-Loading method



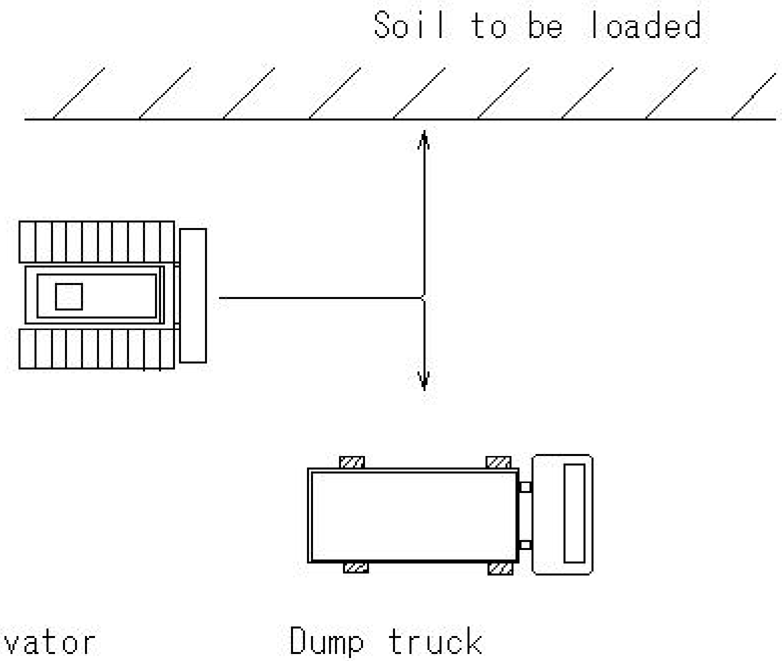
(E295)Earthmoving machinery-loading machine-Loading method



(E296)Earthmoving machinery-loading machine-Loading method

(E296)Earthmoving machinery-loading machine-Loading method

Earthmoving machinery
Loading method
・T shape



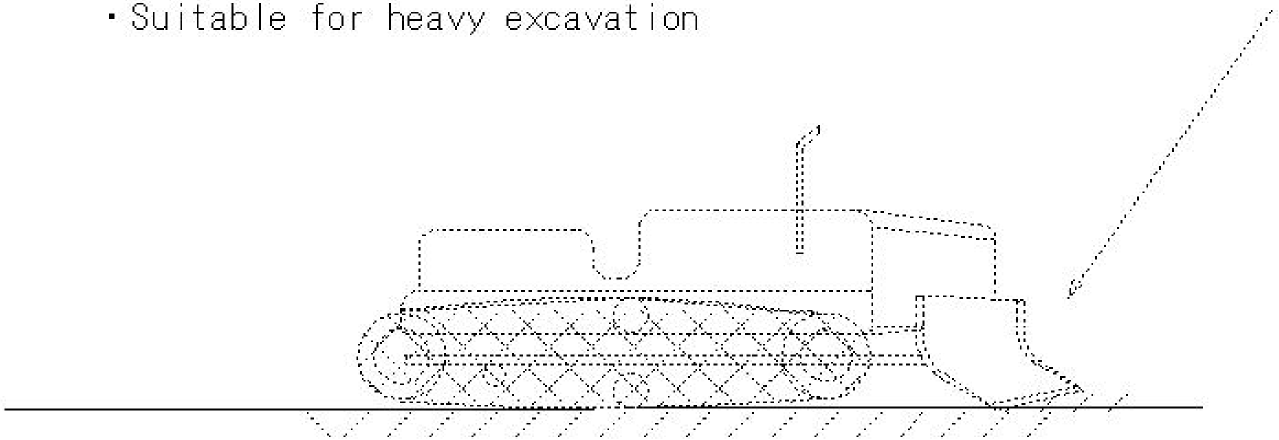
(E297)Earthmoving machinery-transport machinery-Straight dozer

(E297)Earthmoving machinery-transport machinery-Straight dozer

Earthmoving machinery

Transport machinery

- Straight dozer
- Angle is fixed
- Attach the soil removal plate (blade) at right angles to the direction of travel.
- Suitable for heavy excavation



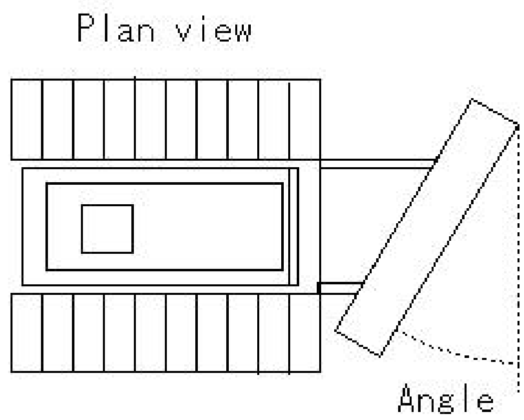
(E298)Earthmoving machinery-transport machinery-Angle dozer

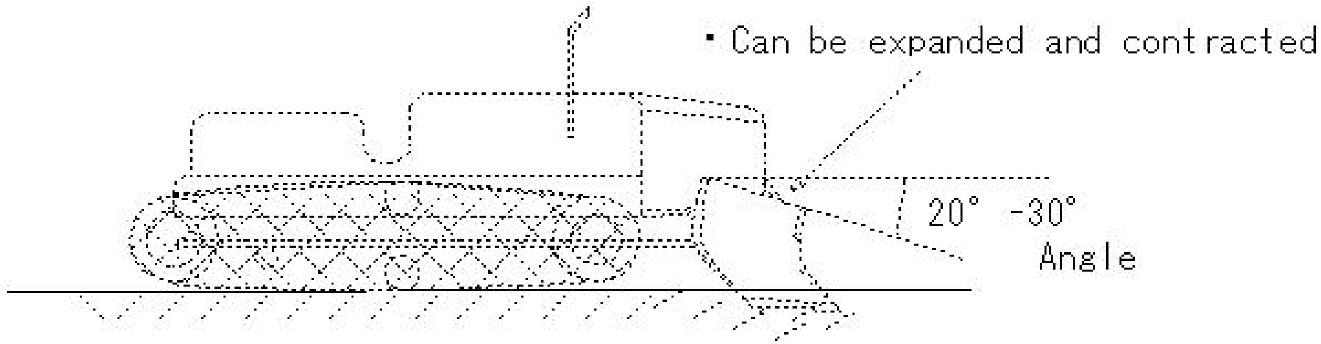
(E298)Earthmoving machinery-transport machinery-Angle dozer

Earthmoving machinery

Transport machinery

- Angle dozer
- Slope excavation/ground leveling
- Not suitable for heavy excavation





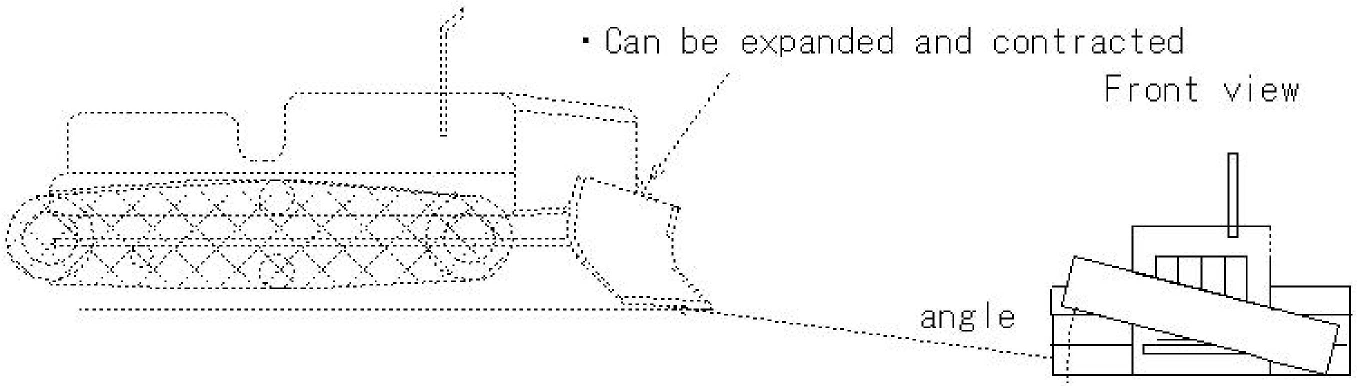
(E299)Earthmoving machinery-transport machinery-Tilt dozer

(E299)Earthmoving machinery-transport machinery-Tilt dozer

Earthmoving machinery

Transport machinery

- Tilt dozer
- Can be expanded and contracted
- Change the height of the left and right blades
- Ditching, cutting, hard soil excavation

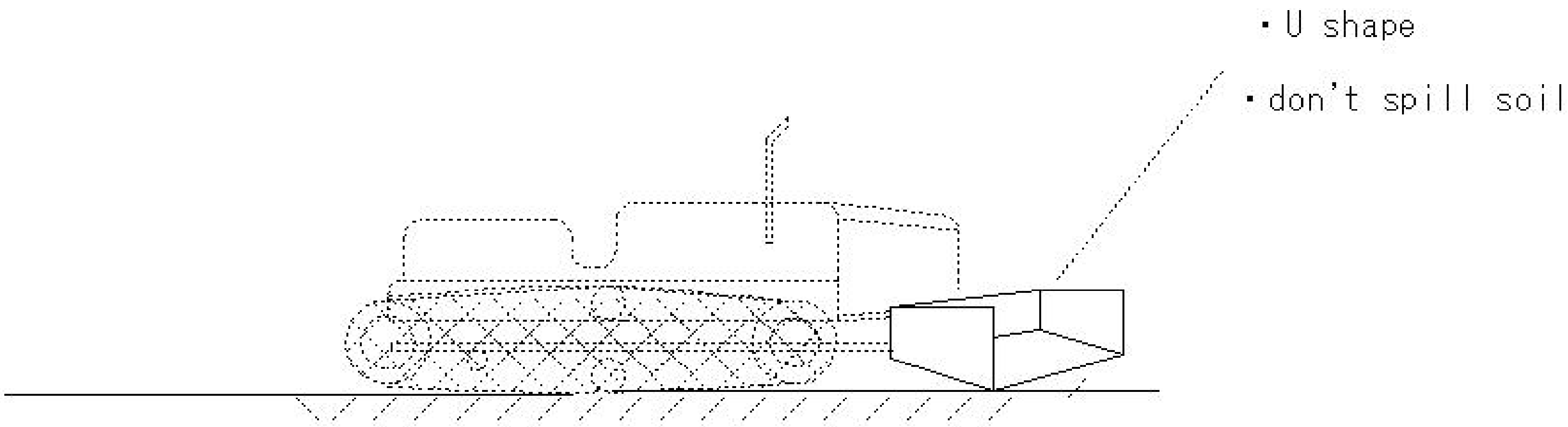


(E300)Earthmoving machinery-transport machinery-U dozer

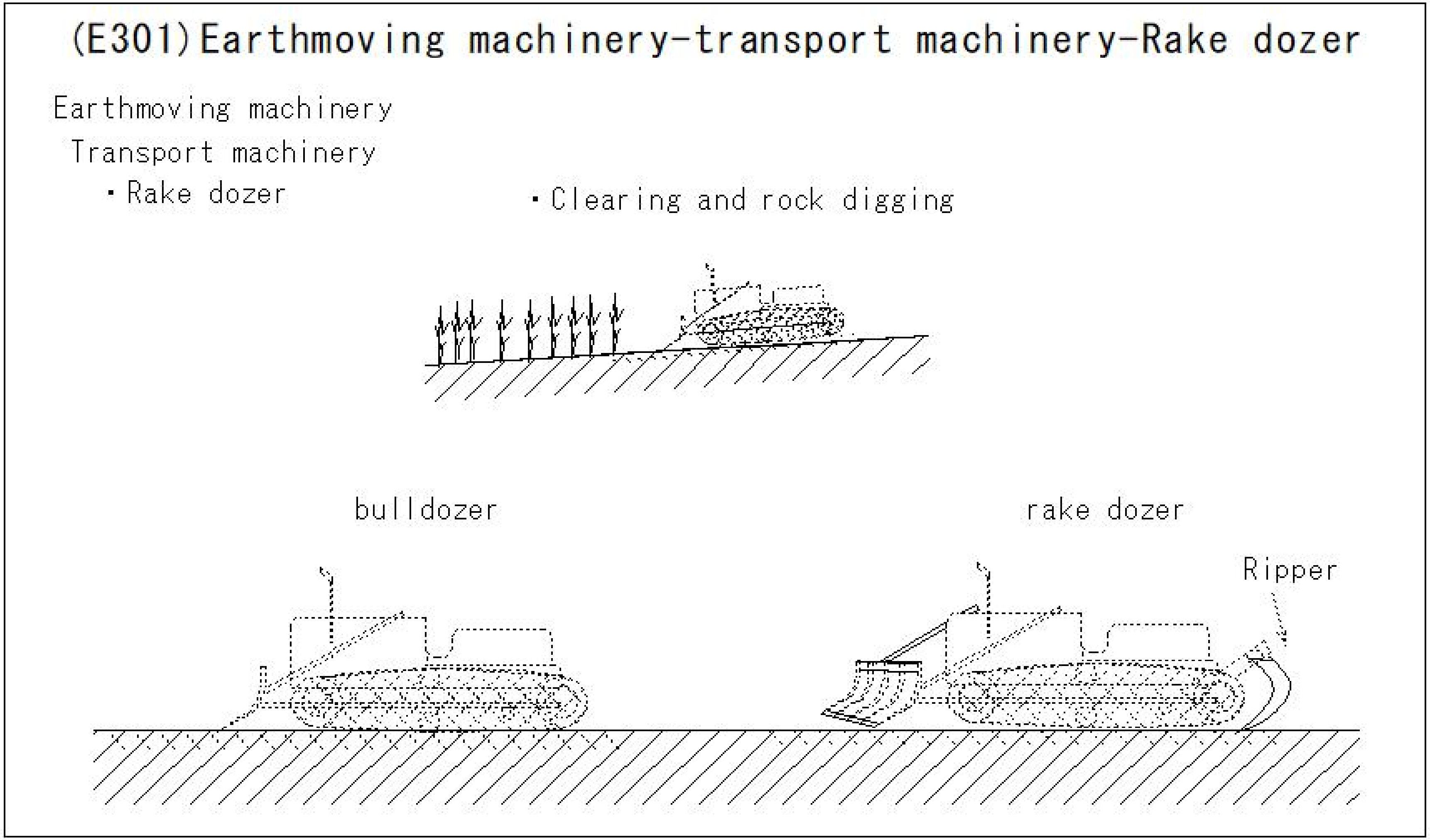
(E300)Earthmoving machinery-transport machinery-U dozer

Earthmoving machinery
  Transport machinery

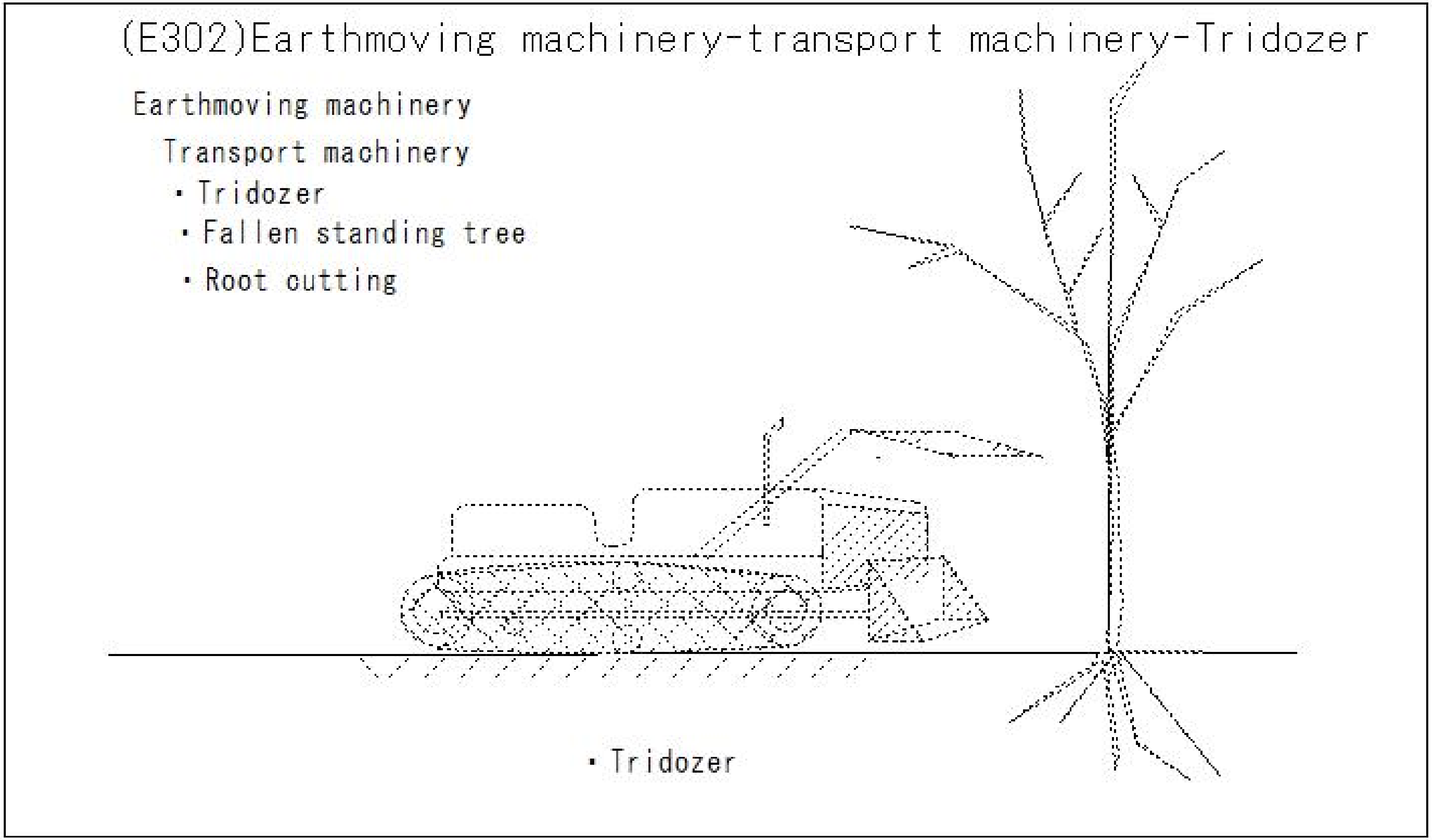
- ・U dozer
- ・Improved soil transportation efficiency



(E301)Earthmoving machinery-transport machinery-Rake dozer



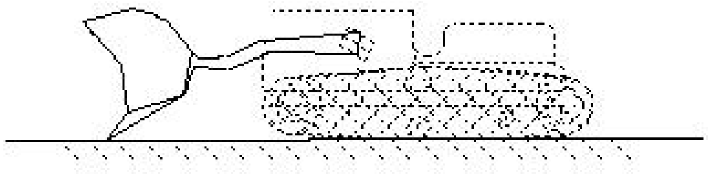
(E302)Earthmoving machinery-transport machinery-Tridozer



(E303)Earthmoving machinery-transport machinery-Bucket dozer

(E303)Earthmoving machinery-transport machinery-Bucket dozer

Earthmoving machinery
Transport machinery
- Bucket dozer
- Loading of earth and sand
- Transportation



bucket dozer

(E304)Earthmoving machinery-transport machinery-Ripper

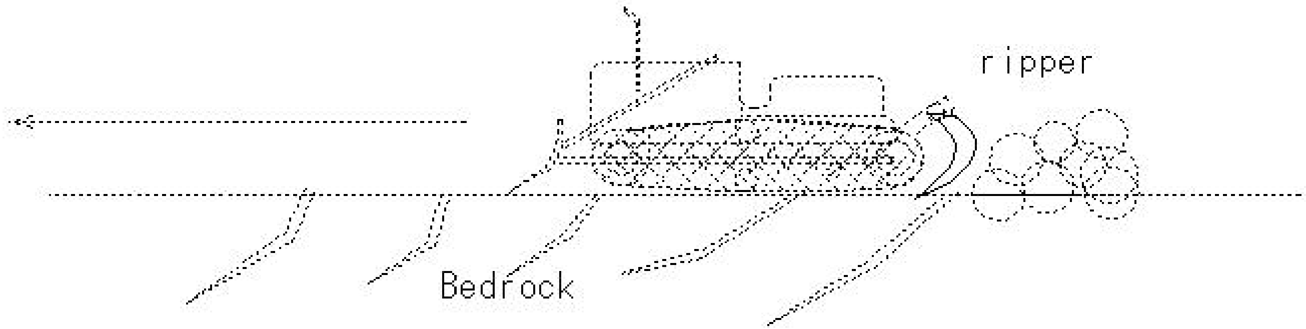
(E304)Earthmoving machinery-transport machinery-Ripper

Earthmoving machinery

Transport machinery

・Ripper

・Bedrock excavation



(E305)Earthmoving machinery-transport machinery-Installation pressure

(E305)Earthmoving machinery-transport machinery-Installation pressure

Earthmoving machinery

Transport machinery

・Installation pressure

・Average installation pressure (kgf/cm2)

・Operating and maintenance weight/total installation area

= Total weight (kgf/cm2) / 2 x crawler width x ground contact length (cm)

example

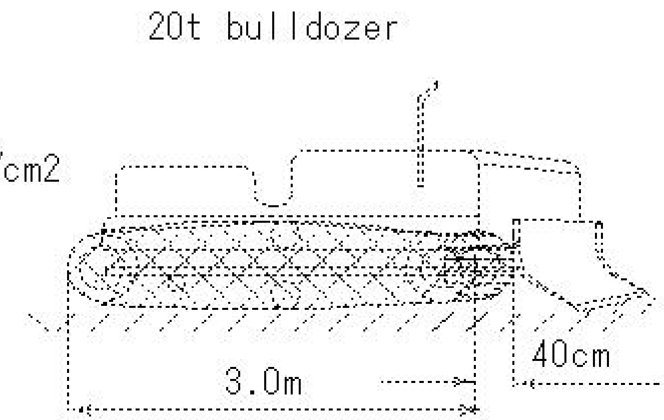
・20t bulldozer

・Width 40cm

・Length 3.0m

・Installation pressure

＝20000kgf/ (2×40cm×300cm) =0.83kagf/cm2

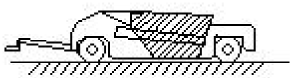


(E306)Earthmoving machinery-transport machinery-Scraper

(E306)Earthmoving machinery-transport machinery-Scraper

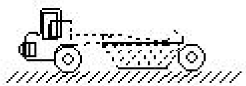
Earthmoving machinery
 Transport machinery
- Scraper
- 1 cycle: excavation, loading, transportation, unrolling, leveling
- Transportation at high speed and in large quantities

①Towed scraper
②Self-propelled scraper (motor scraper)
③Scraper dozer: bulldozer + scraper



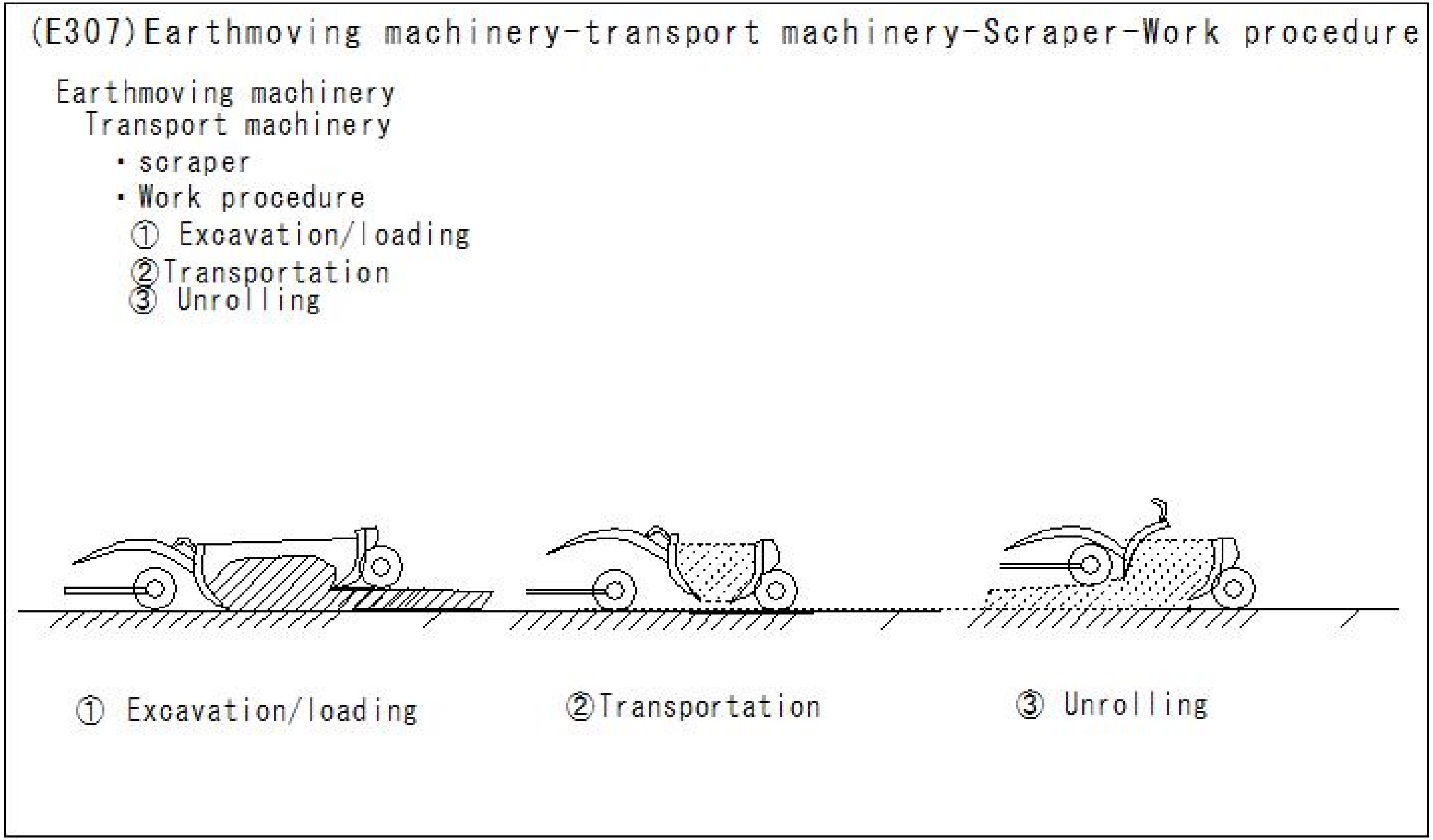
Towed scraper

scrape dozer



motor scraper

(E307)Earthmoving machinery-transport machinery-Scraper-Work procedure

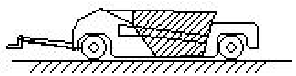


(E308)Earthmoving machinery-transport machinery-Scraper-Type of scraper

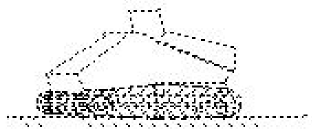
(E308)Earthmoving machinery-transport machinery-Scraper-Type of scraper

Earthmoving machinery
Transport machinery
- scraper
- Type of scraper

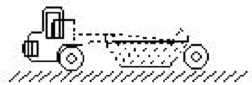
①Towed scraper
②Self-propelled scraper (motor scraper)
③Scraper dozer: bulldozer + scraper



Towed scraper



scrape dozer



motor scraper

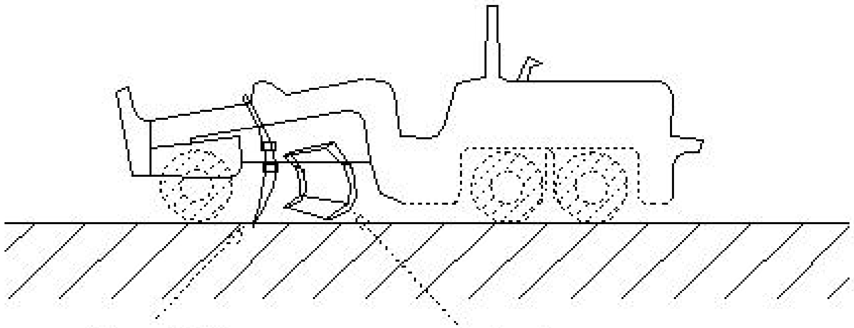
(E309)Earthmoving machinery-transport machinery-Motor grader

(E309)Earthmoving machinery-transport machinery-Motor grader

Earthmoving machinery

Transport machinery

- Spreading
- Motor grader



motor grader

(E310)Earthmoving machinery-Compaction machines

(E310)Earthmoving machinery-Compaction machines

Earthmoving machinery

Compaction machines

・Types of compaction machines

①Compaction machine

- ②Static
  - ⑤Iron wheel (road roller)
    - ⑫Self-propelled
      - 21Macadam roller
      - 22Tandem roller
      - 23 3-axis tandem roller
    - ⑬Towed style
  - ⑥Tire (tire roller)
    - ⑭Self-propelled
    - ⑮Towed style
  - ⑦Iron wheel + tire (combined roller)
- ③Dynamic
  - ⑧Iron ring (vibration roller)
    - ⑯Self-propelled
    - ⑰Towed style
    - ⑱Band guide type
  - ⑨Tire (vibrating roller)
    - ⑲Self-propelled
    - ⑳Towed style
  - ⑩Flat plate (vibrating compactor)
- ④Shocking
  - ⑪Flat plate (tamper, rammer)

(E311)Earthmoving machinery-Compaction machines-Road roller

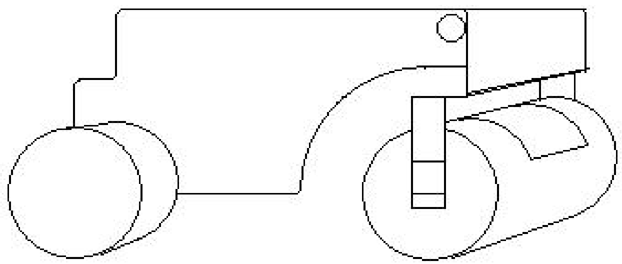
(E311)Earthmoving machinery-Compaction machines-Road roller

Earthmoving machinery

Compaction machines

Road roller

- Macadam roller (two-axle three-wheeled)
- Weight can be adjusted
- Guide wheel (1 wheel side) Linear pressure is low
- Initial compaction Initial compaction with drive wheels



macadam roller

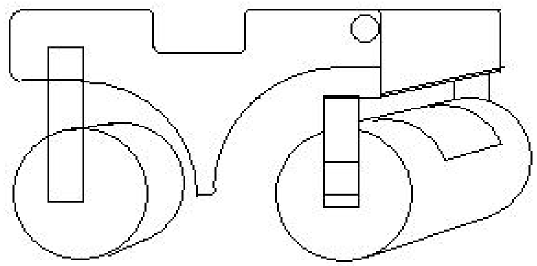
(E312)Earthmoving machinery-Compaction machines-Tandem roller (two axes and two wheels)

(E312)Earthmoving machinery-Compaction machines-Tandem roller (two axes and two wheels)

Earthmoving machinery

Compaction machines

- Tandem roller (two axes and two wheels)
- Anteroposterior axis - independent
- Asphalt pavement finish



・Tandem roller (two axes and two wheels)

(E313)Earthmoving machinery-Compaction machines-Three-axis tandem roller (three-axis three-wheel)

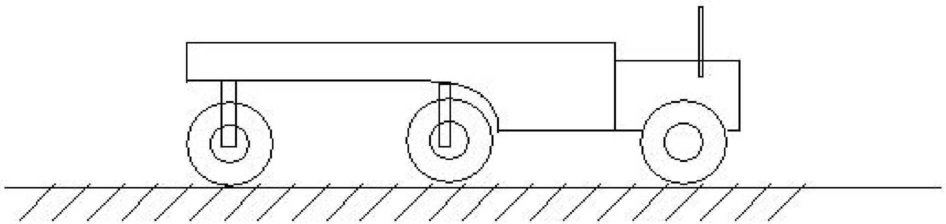
(E313)Earthmoving machinery-Compaction machines-Three-axis tandem roller (three-axis three-wheel)

Earthmoving machinery

Compaction machines

・Three-axis tandem roller (three-axis three-wheel)

・Flatness - improved compaction



Three-axis tandem roller (three-axis three-wheel)

(E314)Earthmoving machinery-Compaction machines-Tamping roller

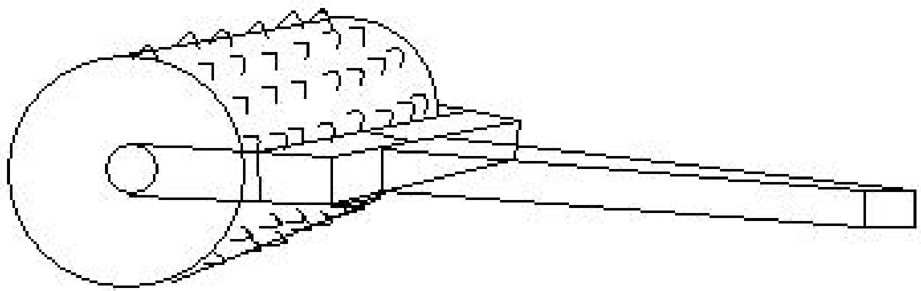
(E314)Earthmoving machinery-Compaction machines-Tamping roller

Earthmoving machinery

Compaction machines

・Tamping roller

・Compaction of hard clay



Tamping roller

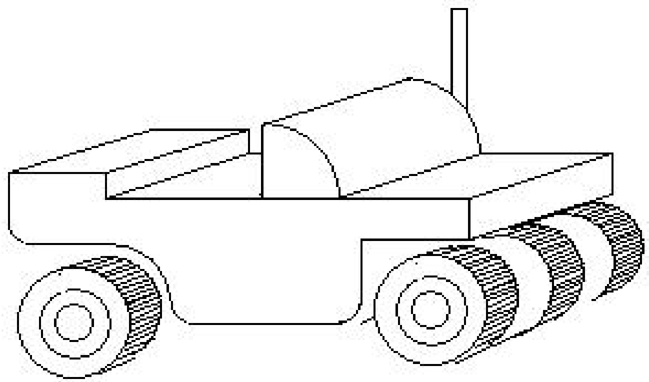
(E315)Earthmoving machinery-Compaction machines-Tire roller

(E315)Earthmoving machinery-Compaction machines-Tire roller

Earthmoving machinery

Compaction machines

- Tire roller
- Air pressure adjustment Linear pressure adjustment
- Raise ballast (weight) - line pressure -
- Rolling from relatively soft ground to hard ground
- Not suitable for compacting soft soil



Tire roller

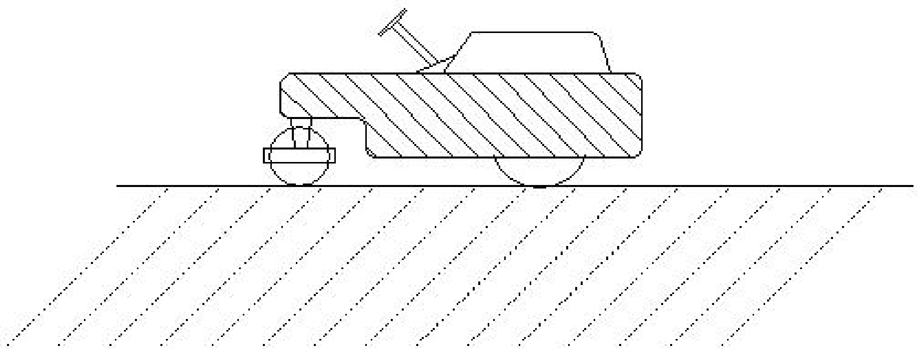
(E316)Earthmoving machinery-Compaction machines-Vibration roller

(E316)Earthmoving machinery-Compaction machines-Vibration roller

Earthmoving machinery

Compaction machines

- Vibration roller
- Lack of own weight
- Supplement with Vibration
- Small machines
- Compaction of gravel and sandy soil



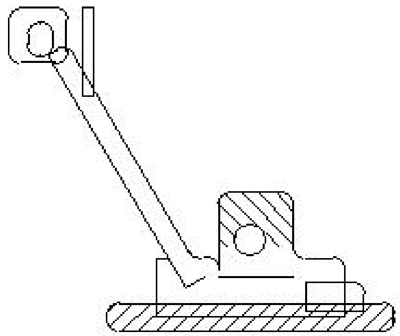
Vibration roller

(E317)Earthmoving machinery-Compaction machines-Vibration compactor

(E317)Earthmoving machinery-Compaction machines-Vibration compactor

Earthmoving machinery
Compaction machines

- Vibration compactor
- Work place - narrow space



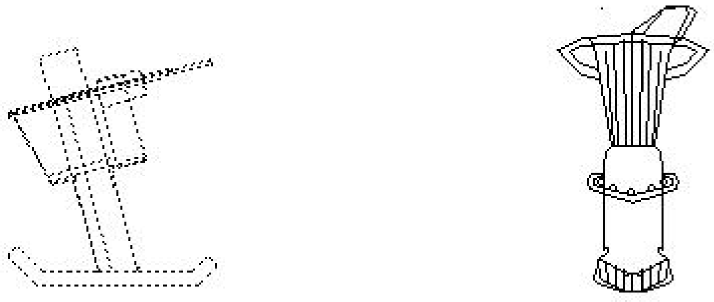
vibrating compactor

(E318)Earthmoving machinery-Compaction machines-Vibration compactor

(E318)Earthmoving machinery-Compaction machines-Vibration compactor

Earthmoving machinery
Compaction machines

- Tampa Ranma
- Increased impact load - compaction
- Soft soil - unsuitable

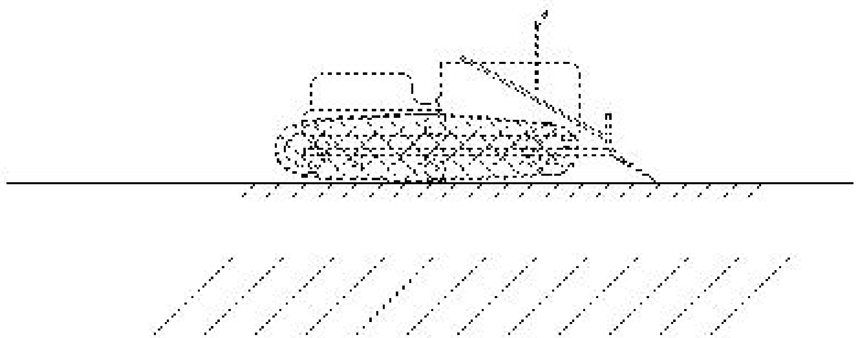


Tampa Ranma

(E319)Earthmoving machinery-Compaction machines-Wetland bulldozer

(E319)Earthmoving machinery-Compaction machines-Wetland bulldozer

Earthmoving machinery
Compaction machines
・Compaction of soft ground
・Wetland bulldozer

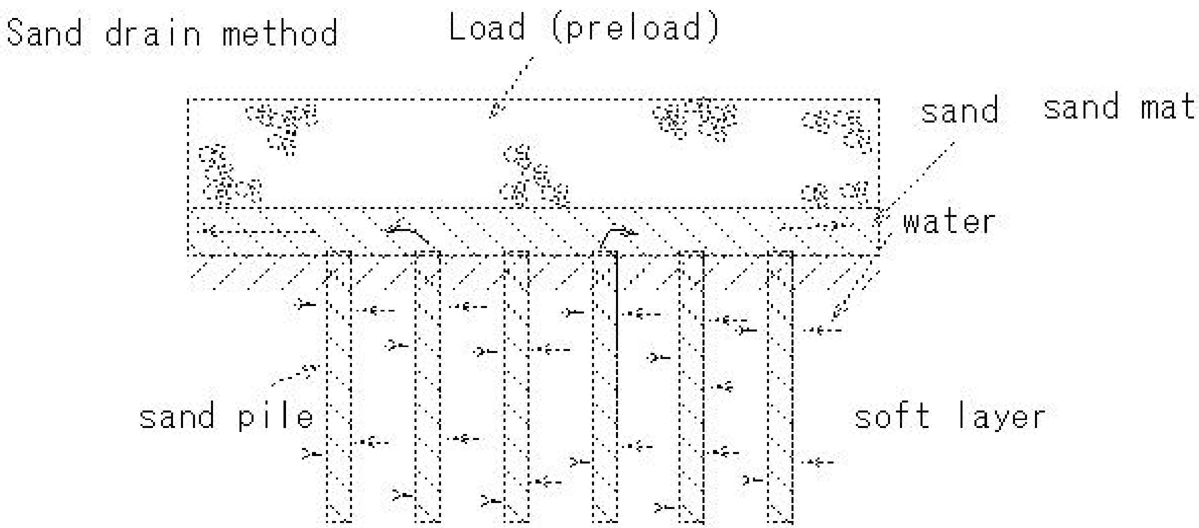


wetland bulldozer

(E320)Earthmoving machinery-Ground improvement machine-Sand drain method

(E320)Earthmoving machinery-Ground improvement machine-Sand drain method

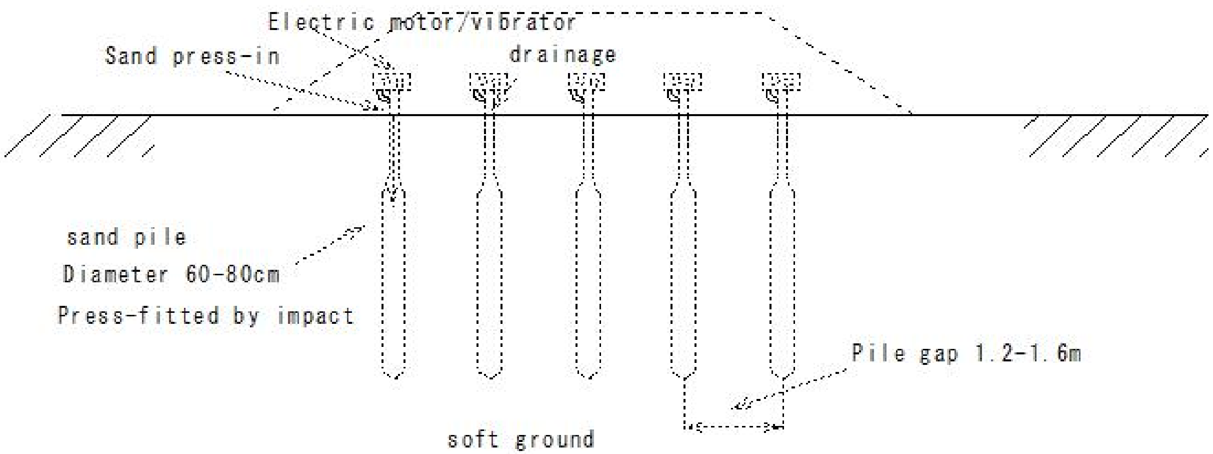
Earthmoving machinery
  Ground improvement machine
    ・Sand drain method
      ・Steel pipe - driven into the ground
      ・Add sand
      ・Steel pipe - drawing
      ・Sand pile construction



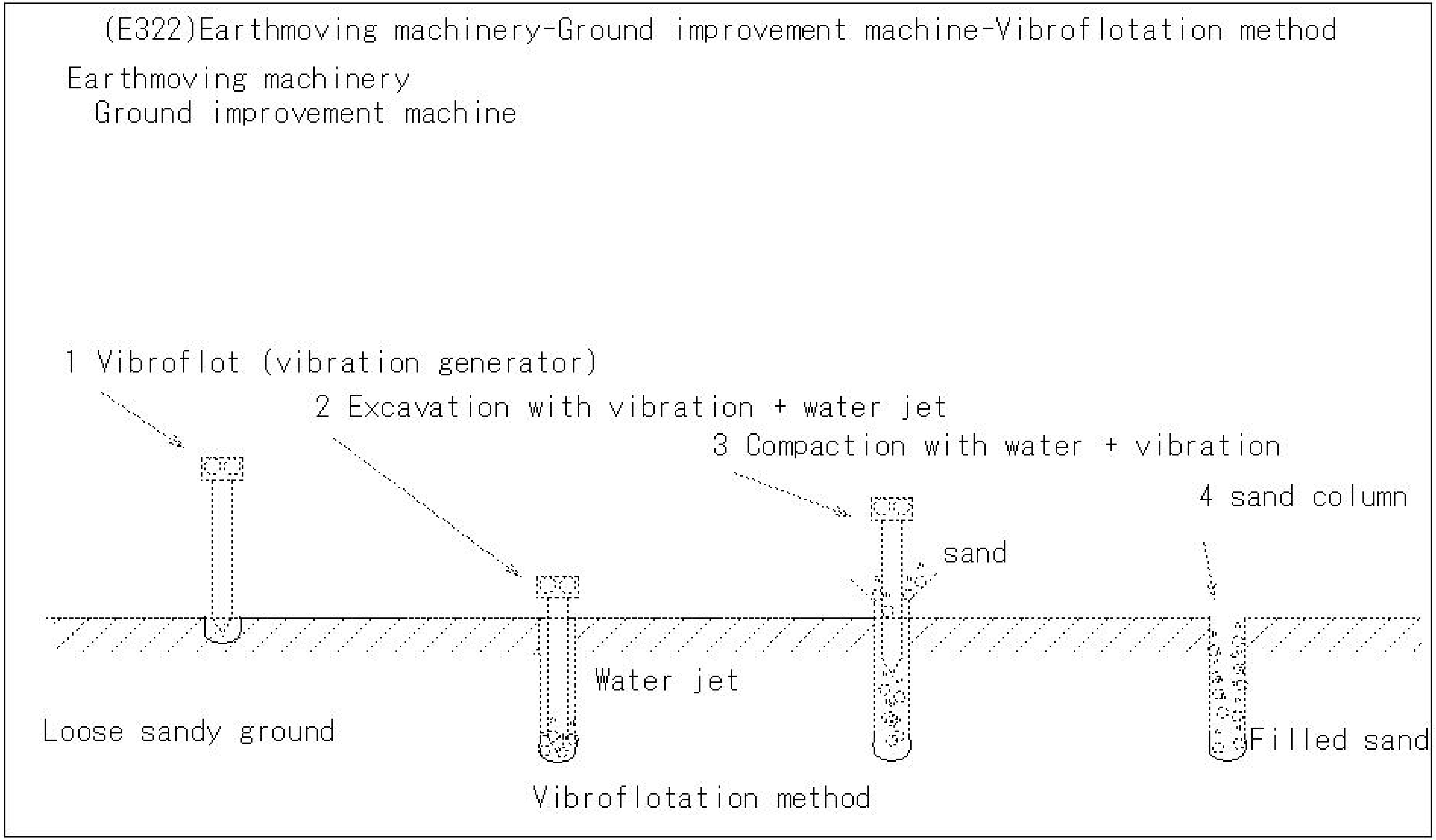
(E321)Earthmoving machinery-Ground improvement machine-Sand compaction method

(E321)Earthmoving machinery-Ground improvement machine-Sand compaction method

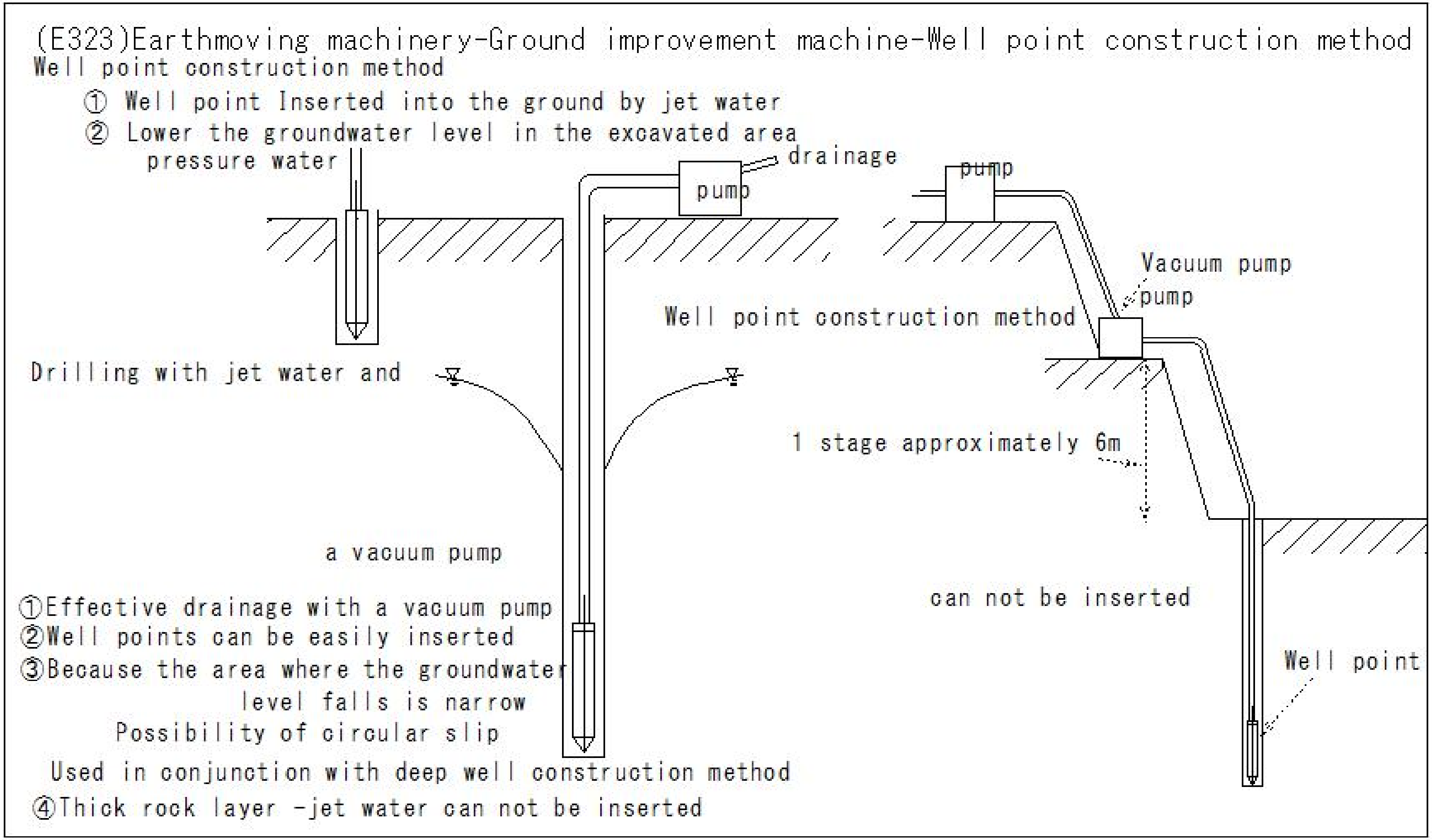
Earthmoving machinery
Ground improvement machine
- Sand compaction method
- (Vibro Composer method)
- Electric motor/vibrator
- Tamp the ground
- Much sand pile construction
- Increased ground strength
- Settlement reduction



(E322)Earthmoving machinery-Ground improvement machine-Vibroflotation method



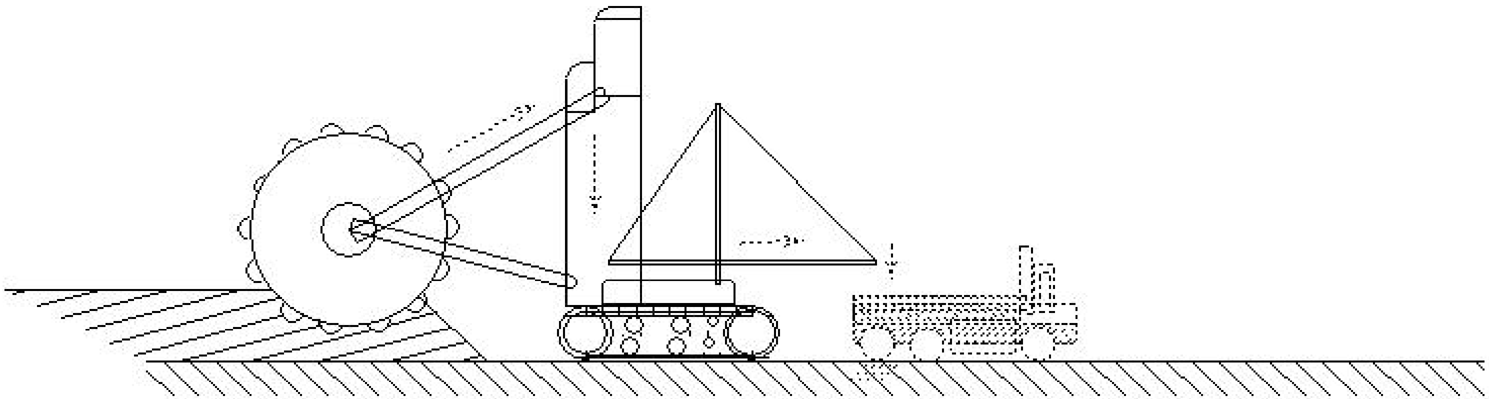
(E323)Earthmoving machinery-Ground improvement machine-Well point construction method



(E324)Earthmoving machinery-Transport machinery-Bucket wheel excavator

(E324)Earthmoving machinery-Transport machinery-Bucket wheel excavator

Earthmoving machinery
  Transport machinery
- Bucket wheel excavator
- Bucket wheel
- Large-scale civil engineering work
- Use of large residential land development



Bucket wheel excavator

(E325)Earthworks-Types of earthworks

(E325)Earthworks-Types of earthworks

Earthworks

Types of earthworks

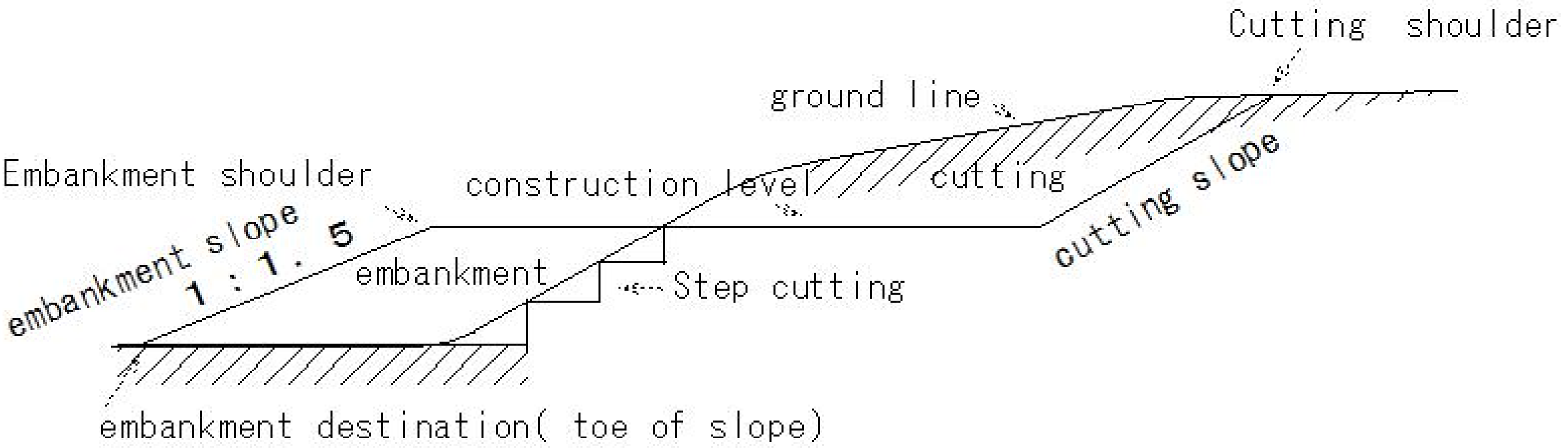
① Excavation, transportation, embankment, land leveling

② Cutting/excavation

Embankment/embankment

③ Underwater work: Cutting and dredging

Embankment - Reclamation

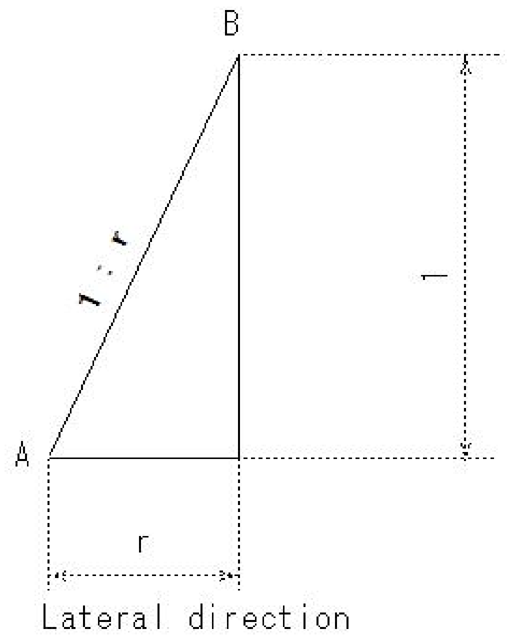


Embankment step cutting: Preventing landslides

(E326)Earthworks-Slope gradient

(E326)Earthworks-Slope gradient

Earthworks-Slope gradient
Horizontal ratio to height 1

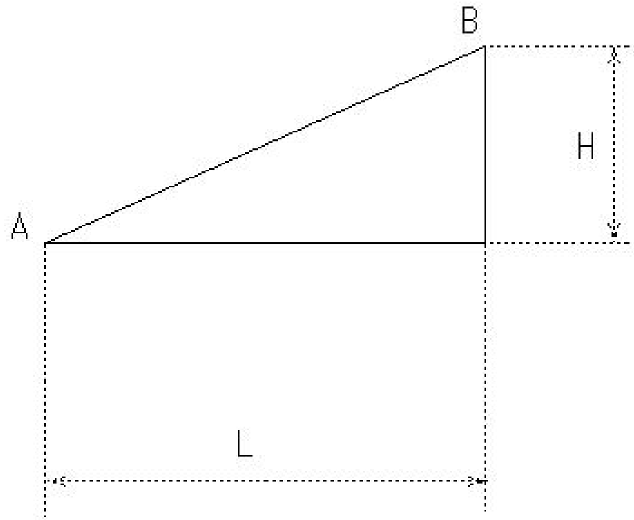


(E327)Earthworks-Slope gradient

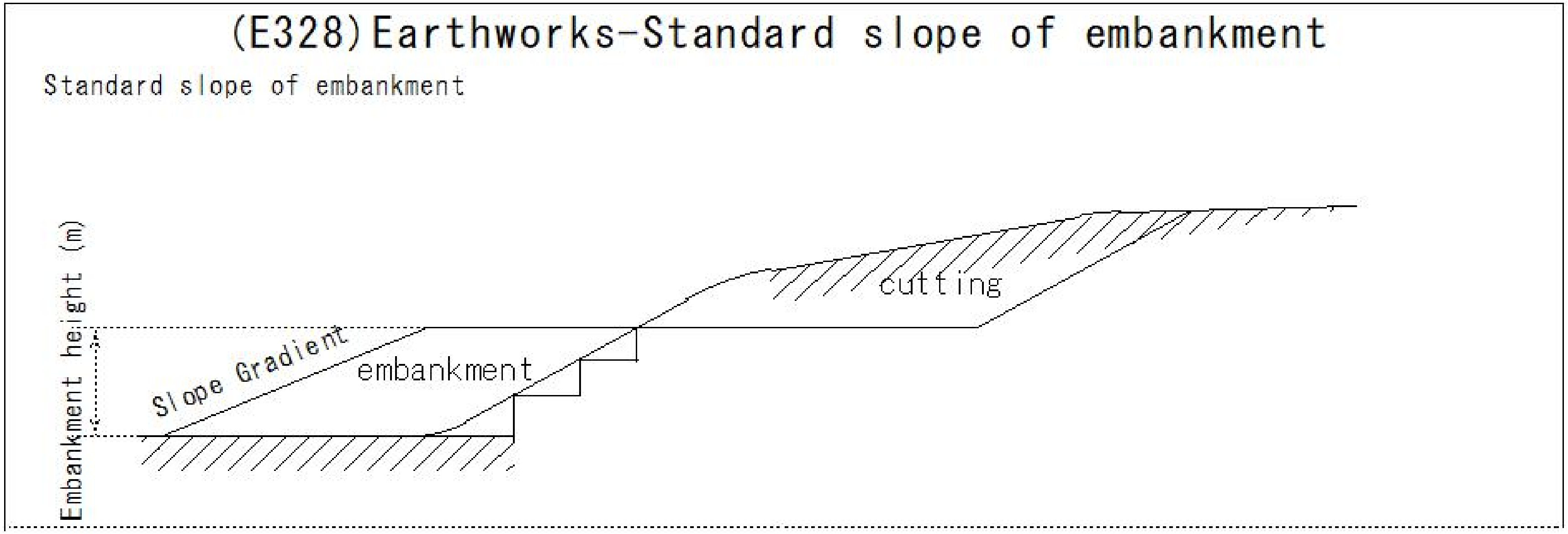
(E327)Earthworks-Slope gradient

Earthworks-Slope gradient

	Ratio of height to horizontal distance
road	H/L=1/100 1 percent
railway	H/L=1/1000 1 per mil



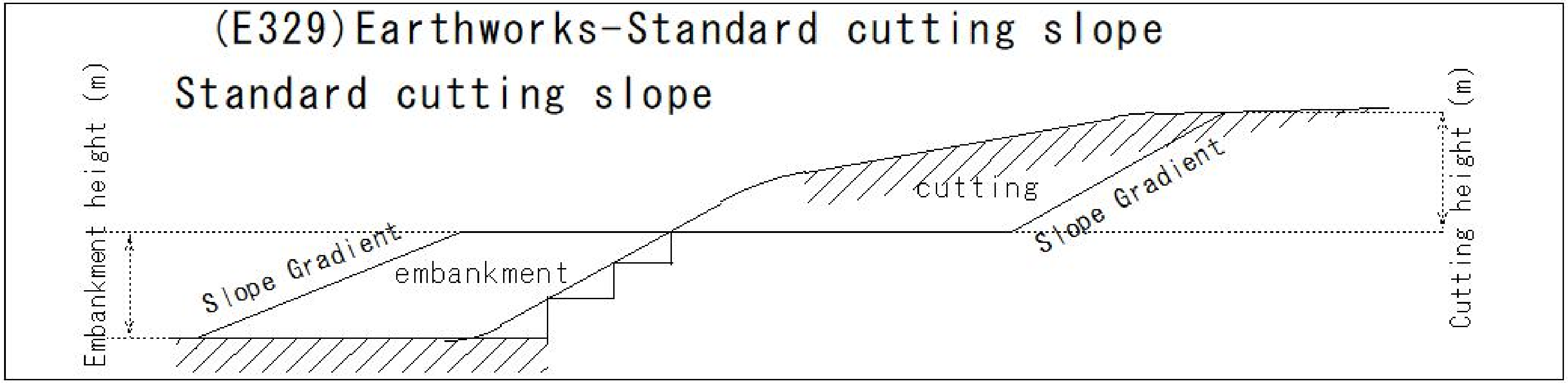
(E328)Earthworks-Standard slope of embankment



(E328)Earthworks-Standard slope of embankment
Standard slope of embankment

	Embankment height (r	Slope Gradient
①Sand with good particle size distribution Gravel soil with good particle size distribution	0-5 5−15	1.5-1.8 1．8−2.0
②Sand with poor particle size distribution	0−10	1．8−2.0
③Gravel mass, boulder	0−10 10−20	1.5-1.8 1．8−2.0
④Sandy soil, hard clay soil, hard clay	0-5 5−10	1.5-1.8 1．8−2.0
⑤Soft clay soil　soft clay	0-5	1．8−2.0

(E329)Earthworks-Standard cutting slope



(E329)Earthworks-Standard cutting slope

Soil quality of the ground, geology		cut height	Gradient
①Conglomerate rock			0.3-0.8
②Conglomerate rock			0.5−1.2
③Sand			1.5−
④Sandy soil	⑧Tight	5m or less 5-10m	0.8−1.0 1.0−1.2
	⑨Loose	5m or less 5-10m	1.0−1.2 1.2−1.5
⑤Gravel soil Gravel mass, sandy soil mixed with cobbles	⑩Tight, good particle size distribution	10m or less 10-15m	0.8-1.0 1.0-1.2
	⑪Not compact particle size distribution - bad	10m or less 10-15m	1.0-1.2 1.2−1.5
⑥Clay/clay soil		10m or less	0.8-1.2
⑦Gravel mass, clay mixed with cobbles, clay		5m or less 5-10m	1.0-1.2 1.2−1.5

(E330)Earthworks-Earthwork ruler

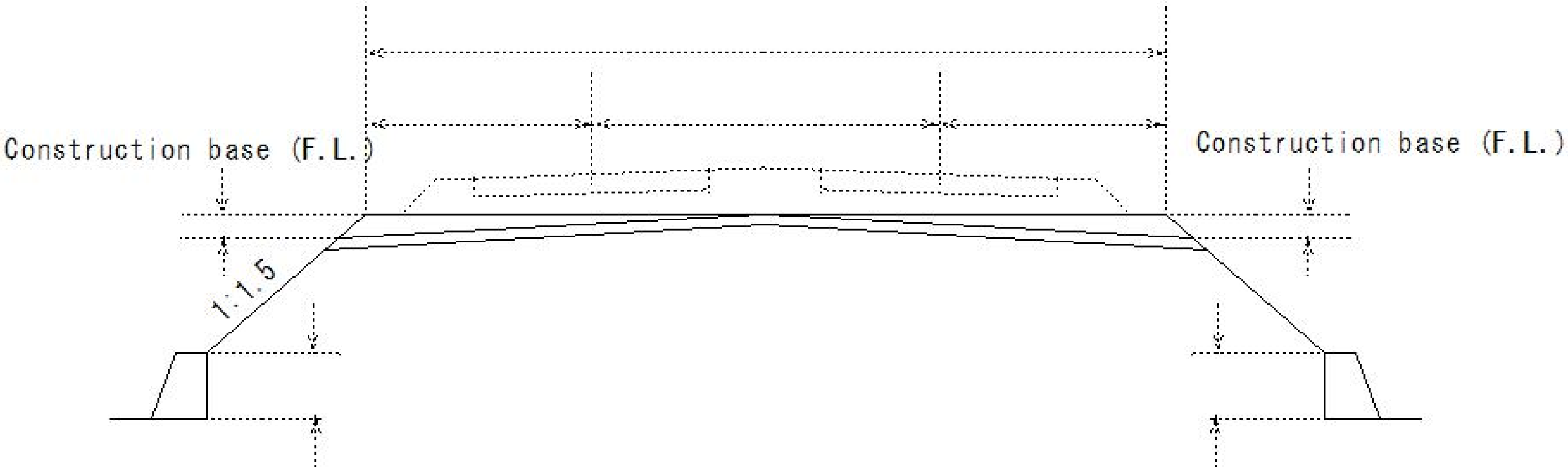
(E330)Earthworks-Earthwork ruler

Earthwork ruler

Cutting/filling standard cross-sectional shape

Finished surface: construction base surface

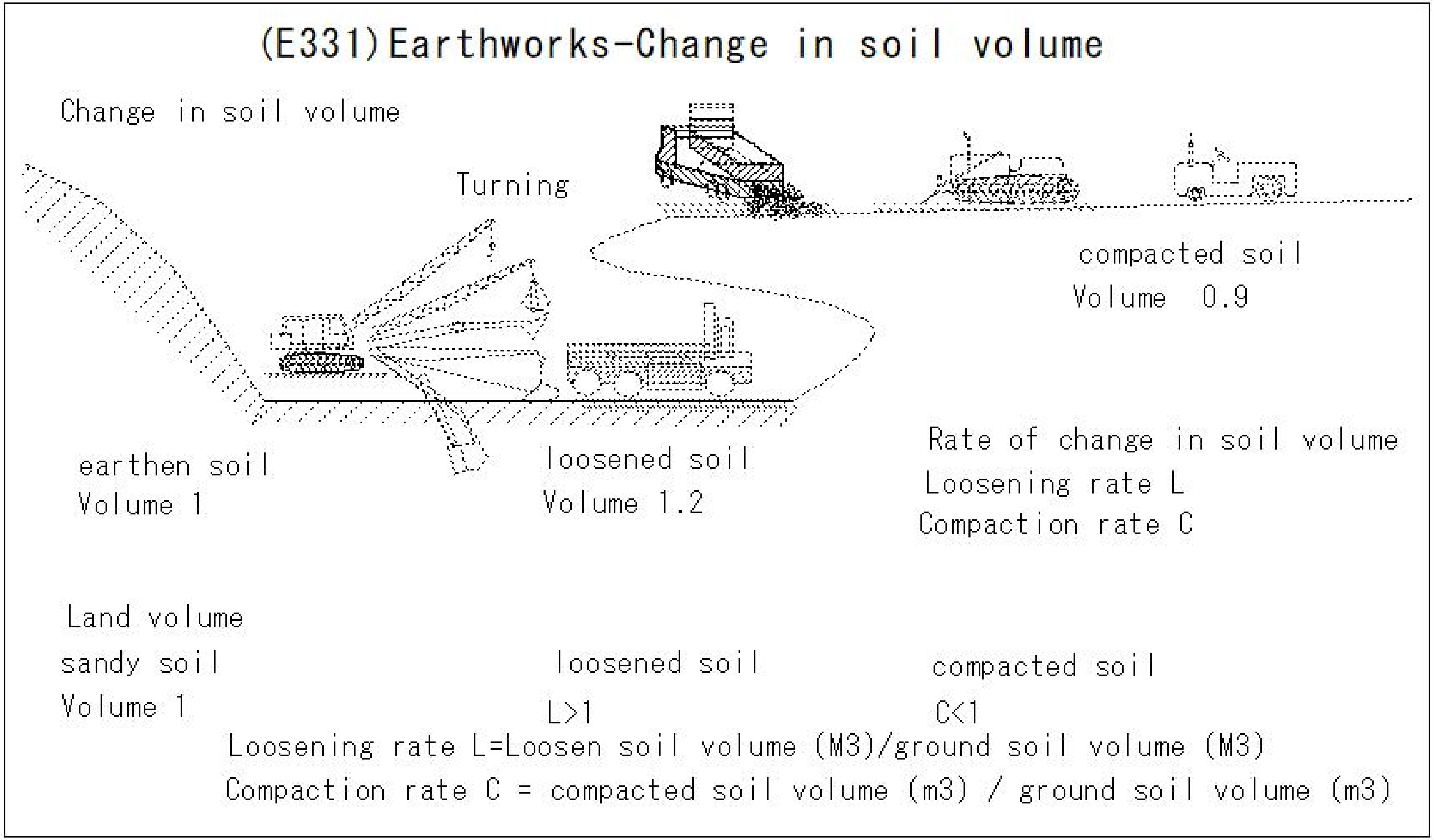
Example of earthwork ruler



Earthwork ruler

Cutting/filling standard cross-sectional shape

(E331)Earthworks-Change in soil volume



(E332)Earthworks-Change in soil volume-Calculation of loosened soil volume

(E332)Earthworks-Change in soil volume-Calculation of loosened soil volume

Change in soil volume

Calculation of loosened soil volume

Earth: 1000m3

Dump truck: 6m3　How many ?

Loosening rate L=1.2

①Amount of soil loosened - standard

$1000 \times 1.2 = 1200m3$

Required number

N=1200/6=200 times

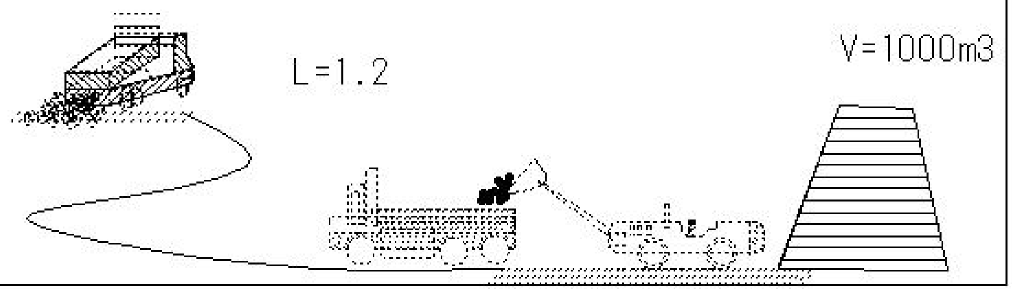
② Land volume - standard

Volume of soil transported per dump truck Q

$Q = 6 \times 1/L = 6 \times 1/1.2 = 5m3$

Required number of units N=1000/5=200 units

1/L = soil volume conversion factor f



(E333)Earthworks-Change in soil volume-Calculation of compacted soil volume

(E333)Earthworks-Change in soil volume-Calculation of compacted soil volume

Change in soil volume

Calculation of compacted soil volume

Earth volume - excavation: 200m3

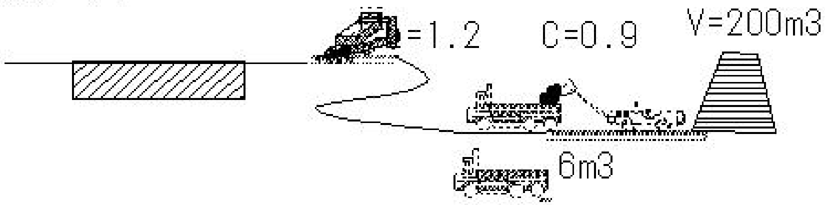
embankment

Transport of 2 dump trucks 6m3

Required number n ?

Volume of soil after compaction V ?

L=1.2 C=0.9



・Amount of ground that can be transported with one dump truck Q1

・Q1=f×6=1/1.2×6=5m3

・Dump trucks 2 units ? Transport volume Q

・Q=2×Q1=2×5=10m3

・Number of dump trucks transported n

・n=200/Q=200/10=20 units

Embankment - volume of soil after compaction V

V＝C×200＝0.9×200=180m3

(E334)Earthworks-Change in soil volume-Soil volume change rate

(E334)Earthworks-Change in soil volume-Soil volume change rate

Soil volume change rate

Volume ratio to ground mass

name		Rate of change in loosened soil volume L	Rate of change in volume of compacted soil C
Gravel or stone	Hard conglomerate	1.65-2.00	1.30-1.50
	Medium hard conglomerate	1.50-1.70	1.20-1.40
	Soft conglomerate	1.30-1.70	1.00-1.30
	conglomerate mass/boulder	1.10-1.20	0.95-1.05
Gravel mixed soil	Gravel	1.10-1.20	0.85-1.05
	Gravel soil	1.10-1.30	0.85-1.00
	Consolidated gravel soil	1.25-1.45	1.10-1.30
Sand	Sand	1.10-1.20	0.85-0.95
	Sand mixed with gravel masses and cobbles	1.15-1.20	0.90-1.00
Ordinary soil	Sandy soil	1.20-1.30	0.85-0.95
	Sandy soil mixed with gravel masses and cobbles	1.40-1.45	0.90-1.00
Cohesive soil	Clay soil	1.20-1.45	0.85-0.95
	Clayey soil mixed with gravel	1.30-1.40	0.90-1.00
	Cohesive soil mixed with gravel masses and cobbles	1.40-1.45	0.90-1.00

・L = Loosen soil volume / Earth soil volume > 1

・C=Amount of soil after compaction/ground mass <1

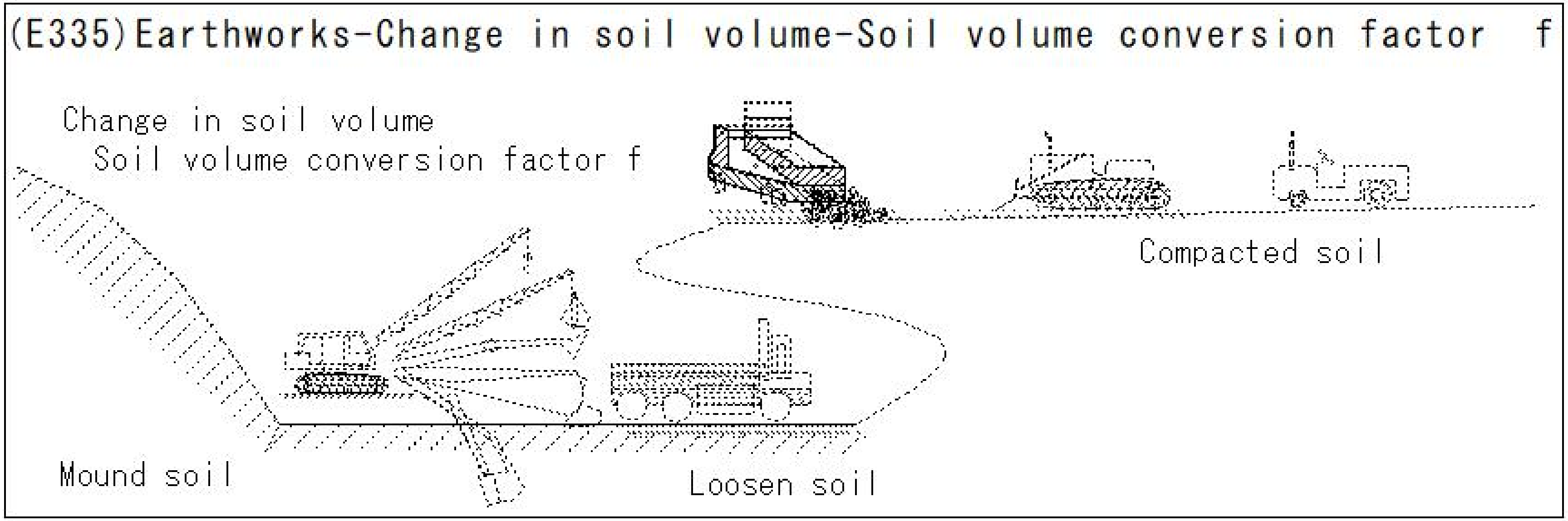
・This does not apply case of gravel are included.

・Volume of earth: volume of soil to be excavated

・Amount of soil loosened: Amount of soil to be transported

・Volume of soil after compaction: Volume of completed embankment

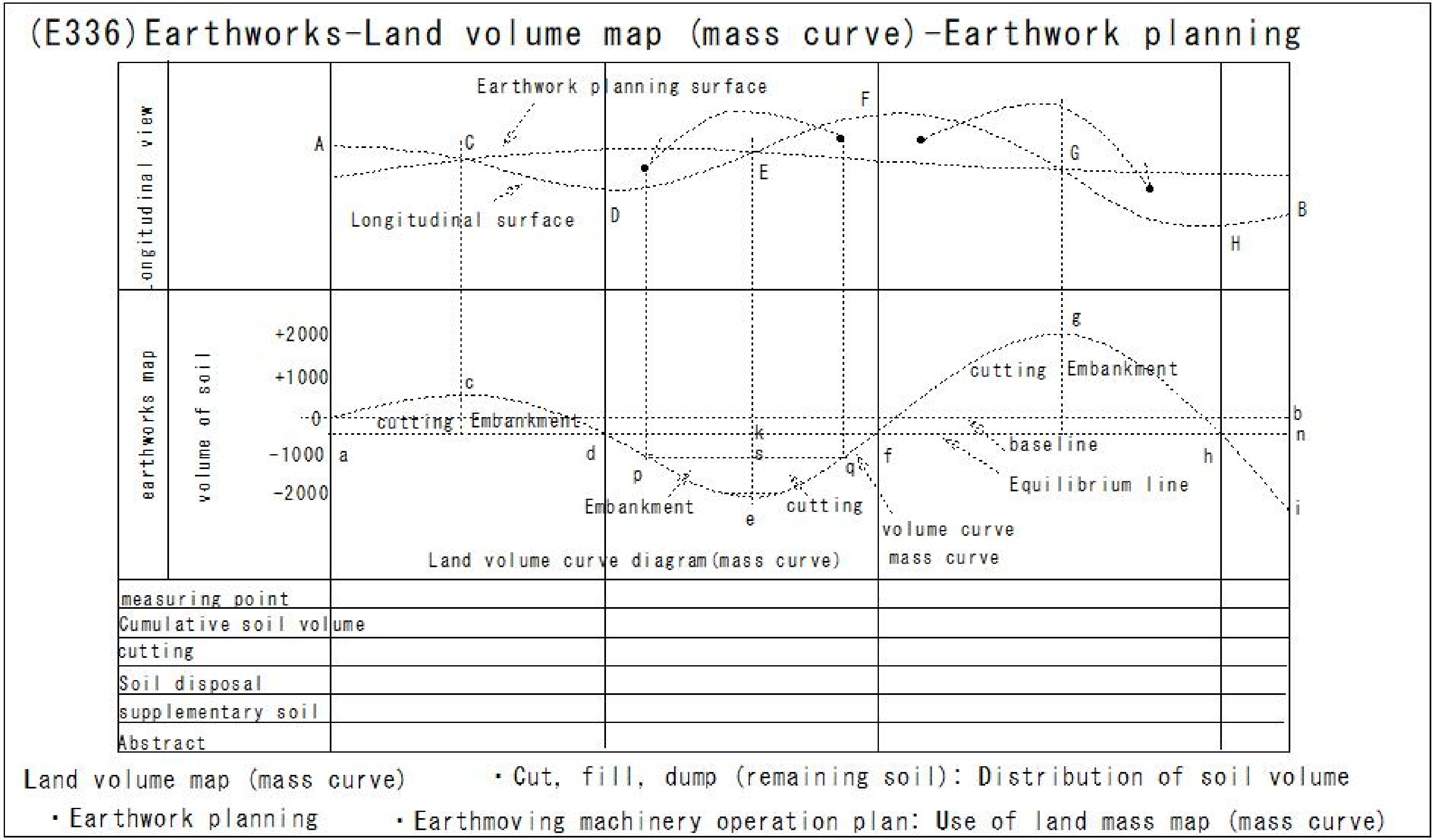
(E335)Earthworks-Change in soil volume-Soil volume conversion factor f



(E335)Earthworks-Change in soil volume-Soil volume conversion factor f
Change in soil volume
Soil volume conversion factor f

Soil condition when finding Q Reference soil condition of q	Mound soil	Loosen soil	Compacted soil
Mound soil	1	L	C
Loosen soil	1/L	1	C/L
Compacted soil	1/C	L/C	1

(E336)Earthworks-Land volume map (mass curve)-Earthwork planning



(E337)Earthworks-Land volume map (mass curve)-Embankment volume map -Cut and earth volume map

(E337)Earthworks-Land volume map (mass curve)-Embankment volume map -Cut and earth volume map

Land volume map (mass curve)

1 Embankment volume map (correction of cutting volume to embankment volume)

- Corrected earth volume = (cutting volume) x C
- C: Compaction rate
- Two or more types of cutting soil

2 Cut and earth volume map (Correct the amount of embankment to the amount of cut)

- Corrected earth volume = (embankment volume) x 1/C
- Cut one type of soil type

(E338)Earthworks-Land volume map (mass curve)-Characteristics of land mass map

(E338)Earthworks-Land volume map (mass curve)-Characteristics of land mass map

Land volume map (mass curve)

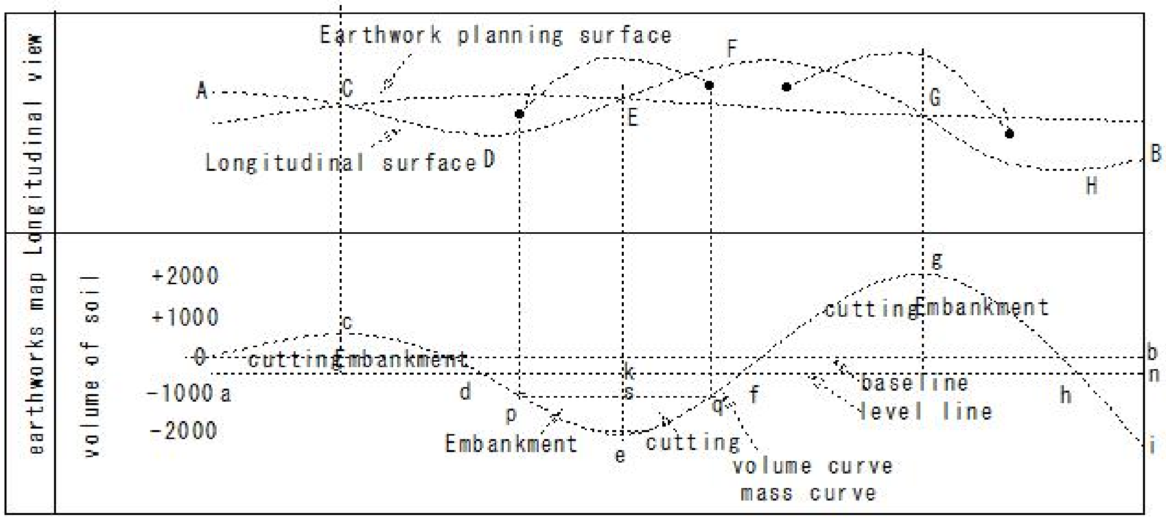
・Characteristics of land mass map

1 ・Mass curve

- ・Curve rise-cutting
- ・Descent of curve - Embankment

2 Equilibrium line (any line parallel to the base line)

- ・Amount of cut and fill between df - Equal
- ・The distance between df is the transportation distance of cutting and embankment.



(E339)Earthworks-Land volume map (mass curve)-Selection of earthmoving machinery

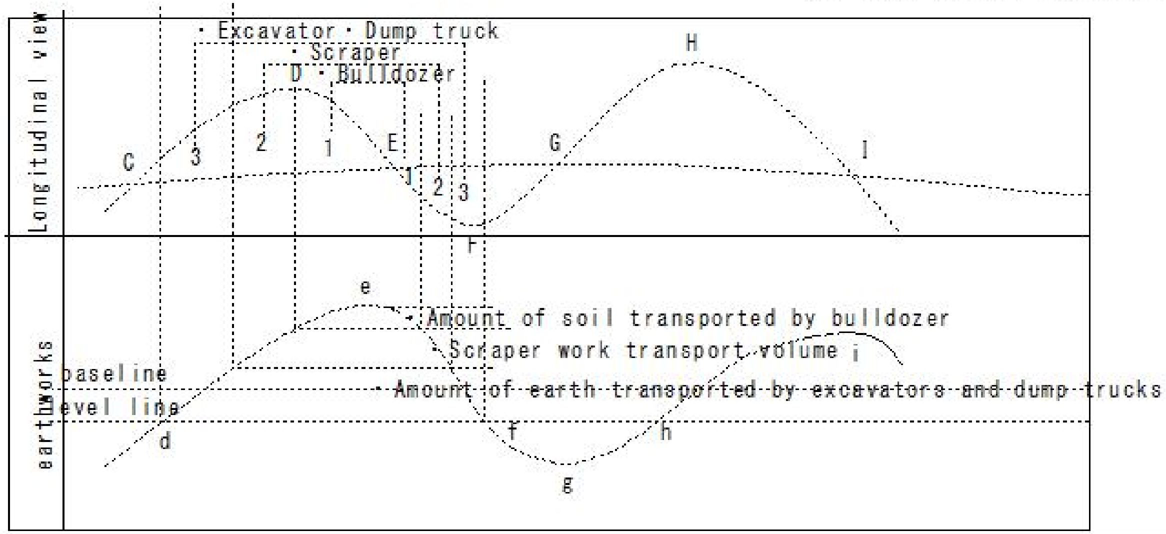
(E339)Earthworks-Land volume map (mass curve)-Selection of earthmoving machinery

Land volume map (mass curve)

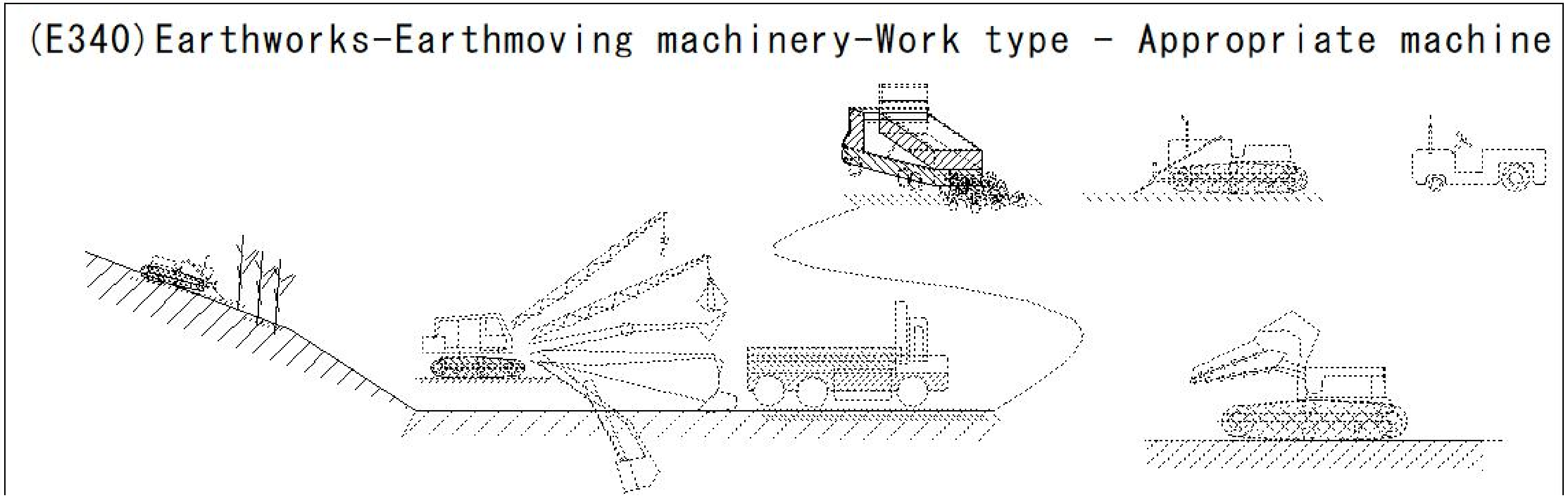
- Selection of earthmoving machinery
  - Earth volume distribution
    - Use a land mass map

Considering transportation distance, amount of soil transported, soil conditions, topography, etc.

- Selection of economical earthmoving machinery
- Soil map: Calculate the volume and distance of soil transported by earthmoving machines



(E340)Earthworks-Earthmoving machinery-Work type - Appropriate machine



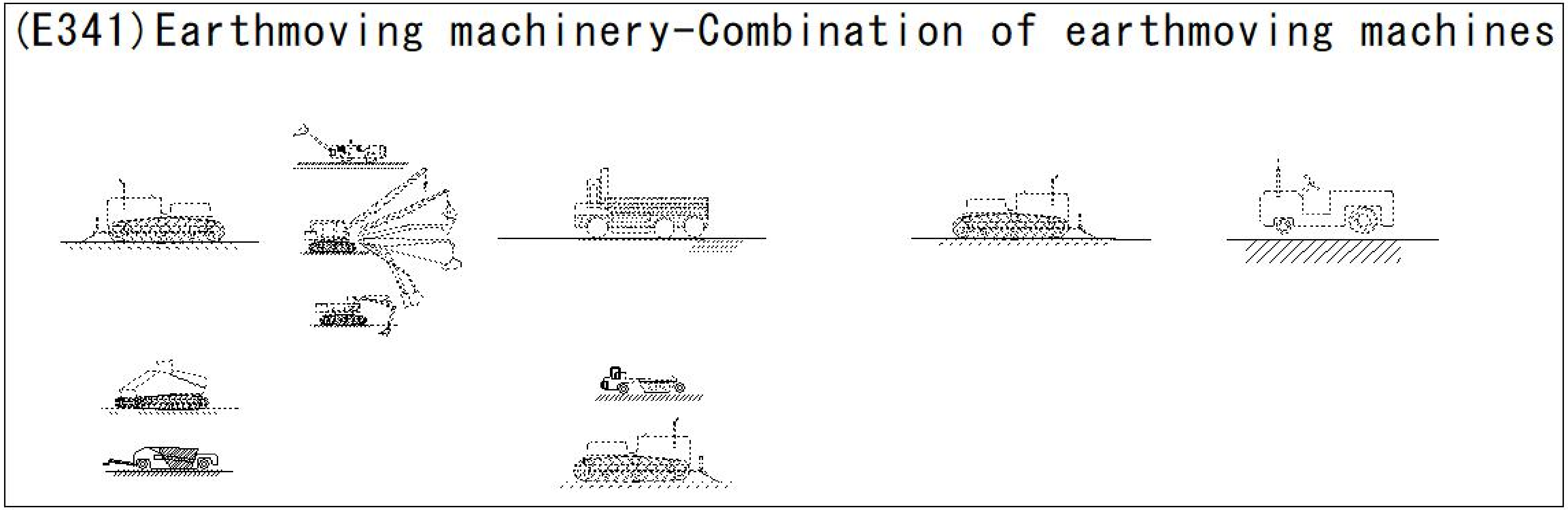
Earthmoving machinery
・Work type - Appropriate machine

1 Clearance	12 Bulldozer/Rakedozer
2. Excavation	13 Excavator type excavator (power shovel, backhoe, dragline, clamshell) Tractor excavator bulldozer ripper
3 Loading	14 Excavator type excavator Tractor excavator
4 Excavation/loading	15 Excavator type excavator Tractor excavator
5 Excavation/Transportation	16 Bulldozer, scrape dozer, scraper, tractor excavator
6 Transportation	17 Bulldozer, dump truck, belt conveyor, aerial cableway
7 Leveling the floor	18 Bulldozer, motor grader, spreader
8 Water content ratio adjustme	19 Stabilizer/Motor grader/Water truck
9 Compaction	20 Road roller, tire roller, tamping roller, vibrating roller, vibrating compactor, rammer, tamper, bulldozer
10 Land leveling	21 Bulldozer/motor grader
11 Trench	22 Trencher backhoe

(E341)Earthmoving machinery-Combination of earthmoving machines

(E341)Earthmoving machinery-Combination of earthmoving machines
Earthmoving machinery
・Combination of earthmoving machines
・Working Capacity/Combination Machine: Minimum Working Capacity - Determination
・Machine selection based on transport equipment

1 Excavation soil collection	2 Loading	3 Transport waste soil	4. Leveling the floor	5 Compaction
1-1 Bulldozer	2-1 Tractor shovel/power shovel	3-1 Dump truck	4-1 Bulldozer	5-1 Tire rollers and others
	2-2 Tractor shovel/power shovel		4-2 Bulldozer	
	2-3 Scraper/motor scraper	3-2 Scoop dozer/bulldozer		5-2 Tire rollers and others

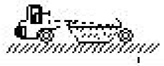
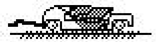
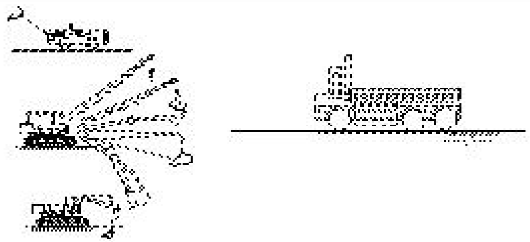


(E342)Earthmoving machinery-Machine selection based on transportation distance

(E342)Earthmoving machinery-Machine selection based on transportation distance

Earthmoving machinery

・Machine selection based on transportation distance

	Distance (m)	Types of construction machinery	
Short distance	100m or less	Bulldozer	
Middle distance	50-500m	Scrape dozer	
	70-500m	Towed scraper	
Long distance	200-2000m	Motor scraper	
	70m or more	Excavator type excavator tractor excavator +dump truck	

(E343)Earthmoving machinery-Cone index

(E343)Earthmoving machinery-Cone index

Earthmoving machinery
・Cone index
・required for earthmoving machinery
1. Quality of running on soft soil
Trafficabiliy is represented by the Cone Index
2 Construction machinery Required cone index
Wetland bulldozer 3 or more
Dump truck 12 or more

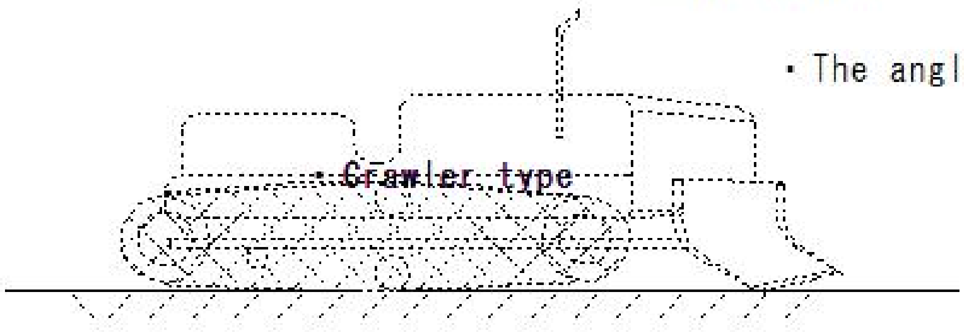
Required for earthmoving machinery

Construction machinery	Cone index (kgf/cm2)	(N/cm2)
Wetland bulldozer	3 over	0.29 over
Bulldozer (medium size)	5 over	0.49 over
Scrape dozer	6 over	0.59 over
Covered scraper	7 over	0.69 over
Motor scraper	10 over	0.98 over
Dump truck	12 over	1.18 over

(E344)Earthmoving machinery-Types of bulldozers-Straight dozer

(E344)Earthmoving machinery-Types of bulldozers-Straight dozer

Earthmoving machinery
- ・Types of bulldozers
  - 1 Bulldozer: Excavation, dozing and transportation of soil
  - 2 Suspension: crawler type/wheel type
  - 3. Format of earthwork board
- ・Straight dozer
  - ・Heavy excavation

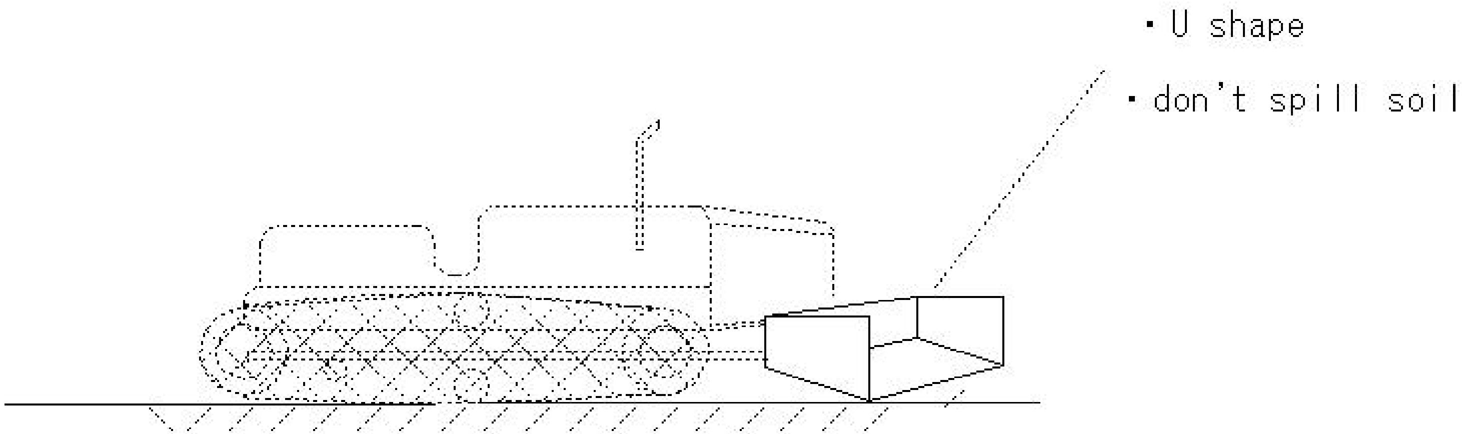


(E345)Earthmoving machinery-Types of bulldozers-U dozer

(E345)Earthmoving machinery-Types of bulldozers-U dozer

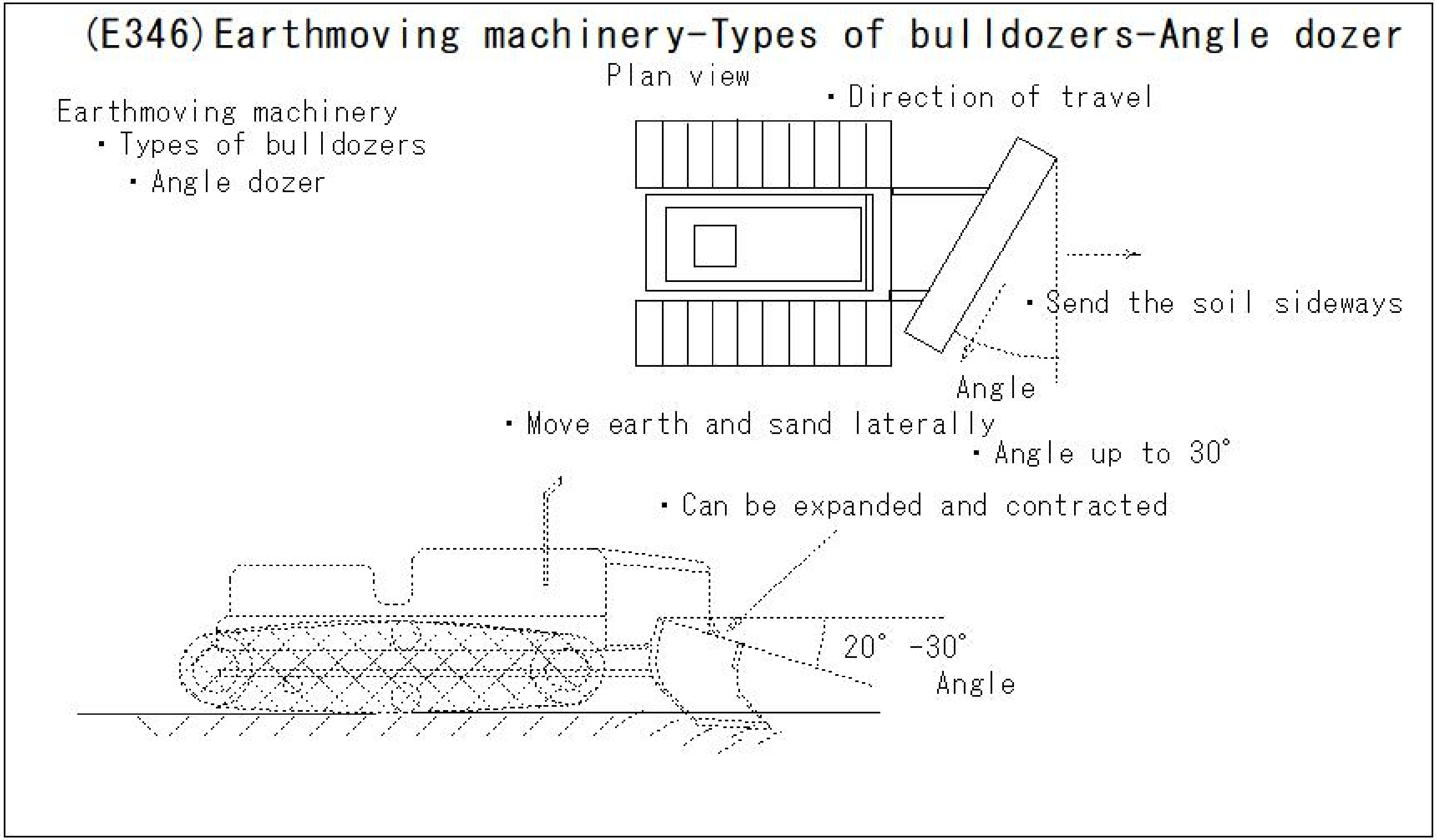
Earthmoving machinery

- Types of bulldozers
  - U dozer



・Improve soil transport efficiency without spilling soil

(E346)Earthmoving machinery-Types of bulldozers-Angle dozer

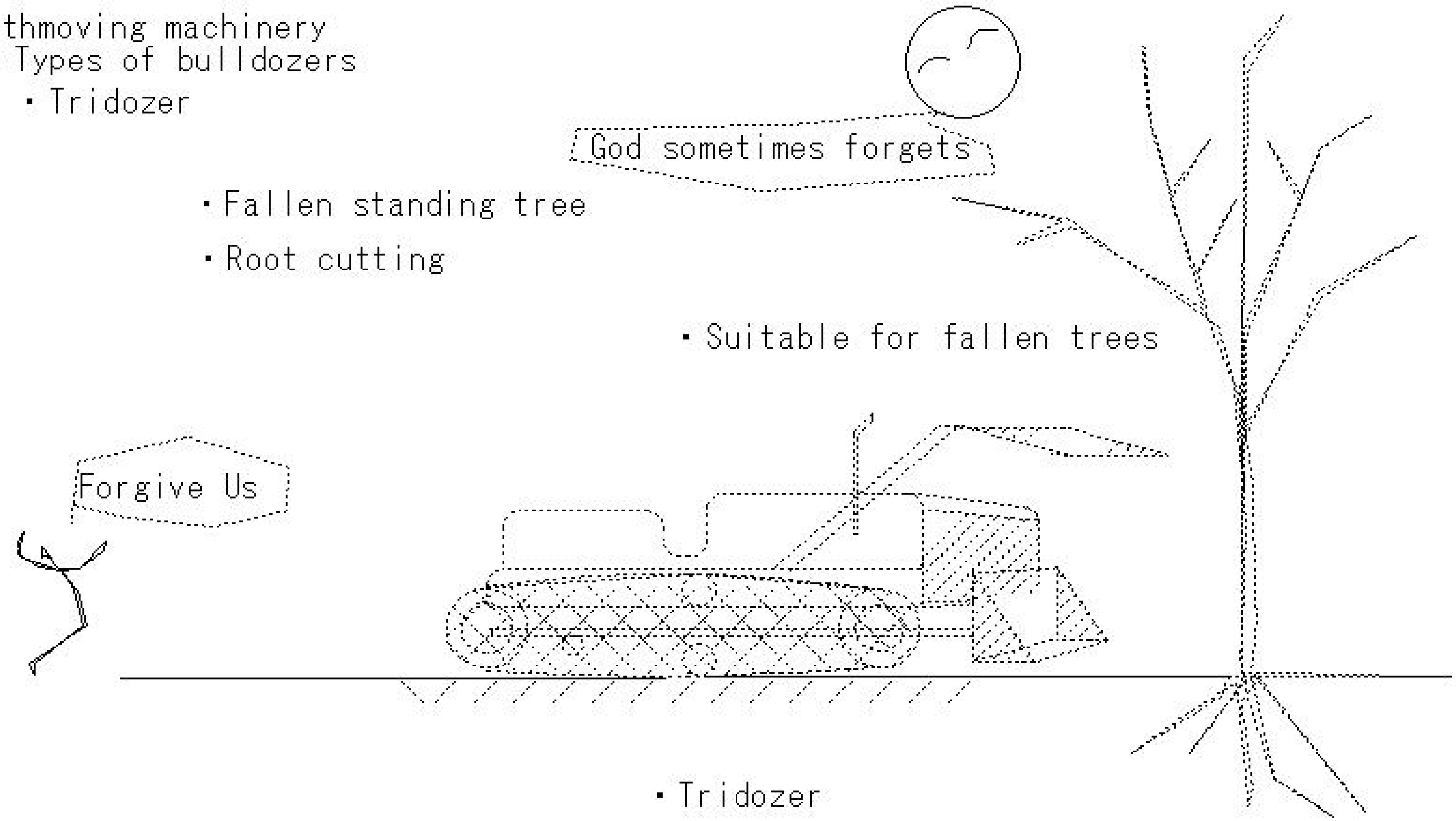


(E347)Earthmoving machinery-Types of bulldozers-Tridozer

Earthmoving machinery
- Types of bulldozers
  - Tridozer

- Fallen standing tree
- Root cutting

- Suitable for fallen trees

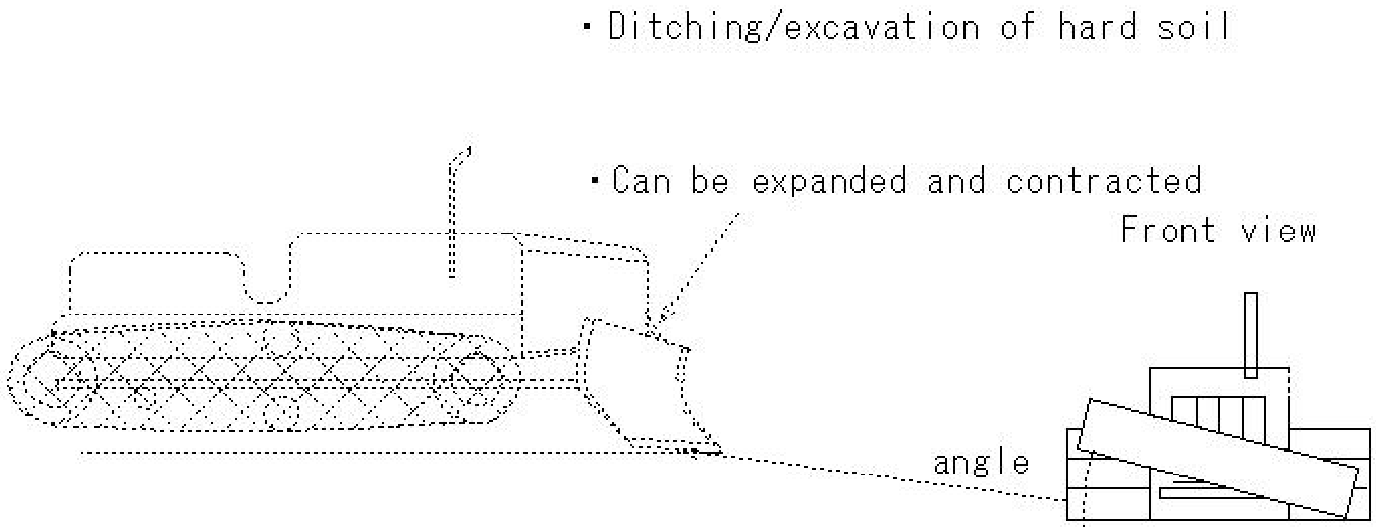


- Tridozer

(E348)Earthmoving machinery-Types of bulldozers-Tilt dozer

(E348)Earthmoving machinery-Types of bulldozers-Tilt dozer

Earthmoving machinery
- Types of bulldozers
  - Tilt dozer

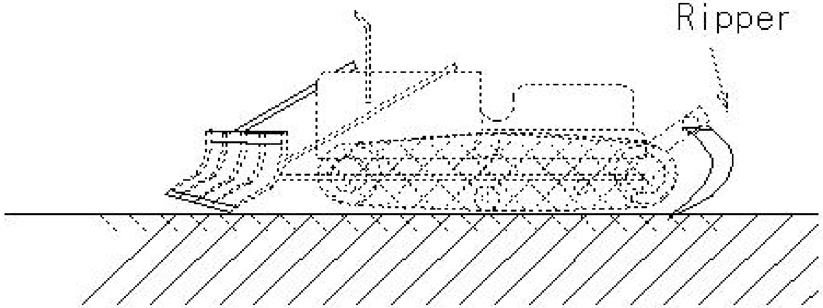


(E349)Earthmoving machinery-Types of bulldozers-Rake dozer

(E349)Earthmoving machinery-Types of bulldozers-Rake dozer

Earthmoving machinery
- Transport machinery
  - ・Rake dozer
    - ・Suitable for clearing land and creating rock trenches
    - ・Ripper Rake

Rake dozer



(E350)Earthmoving machinery-Scraper-Self-propelled motor scraper

(E350)Earthmoving machinery-Scraper-Self-propelled motor scraper

Earthmoving machinery

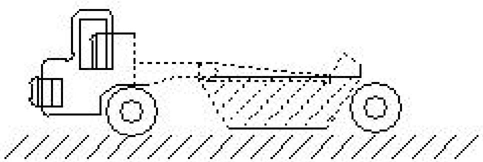
Transport machinery

・Excavation, loading, medium-distance transportation, leveling

・Self-propelled motor scraper

・Tractor-friendly: Covered scraper

・Transportation distance: 200-2000m, large amount of earth and sand, high-speed transportation



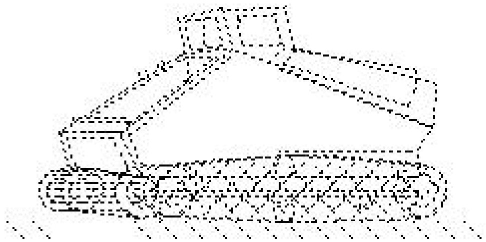
motor scraper

(E351)Earthmoving machinery-Scraper-Scraper + bulldozer combination

(E351)Earthmoving machinery-Scraper-Scraper + bulldozer combination

Earthmoving machinery

- Scrap dozer
- Scraper + bulldozer combination
- Can move forward/backward
- Earthwork work on soft ground
- Transportation distance: 500m or less



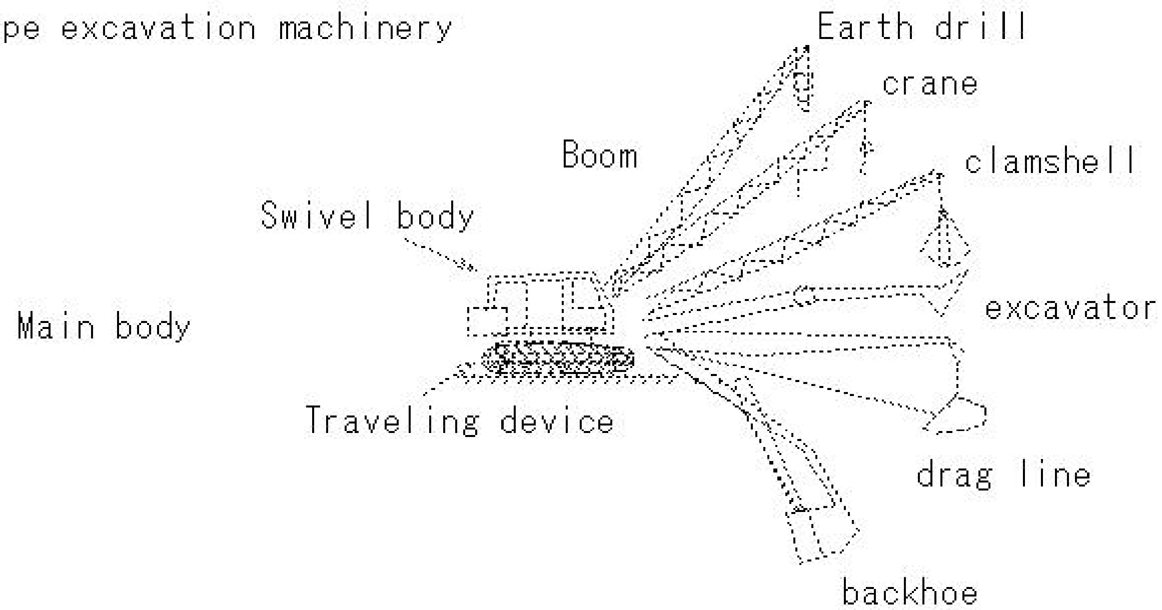
scrape dozer

(E352)Earthmoving machinery-Shovel type excavation machinery

(E352)Earthmoving machinery-Shovel type excavation machinery

Earthmoving machinery

Shovel type excavation machinery



①Attachment installation

②Excavation location - Machine position - High - Power shovel

③Low place drag excavator (backhoe)

④Underwater drilling dragline clamshell

⑤Earth drill: Drilling holes for cast-in-place piles

(E353)Earthmoving machinery-How to excavate the ground (by machine)- Bench cut method

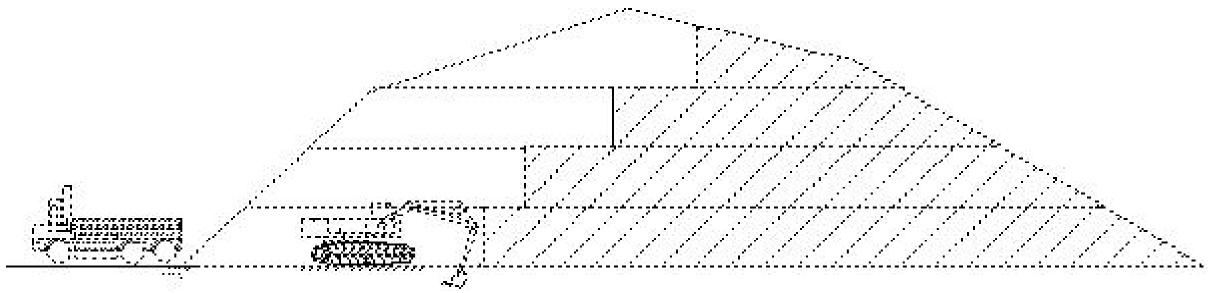
(E353)Earthmoving machinery-How to excavate the ground (by machine)- Bench cut method

Earthmoving machinery

- How to excavate the ground (by machine)

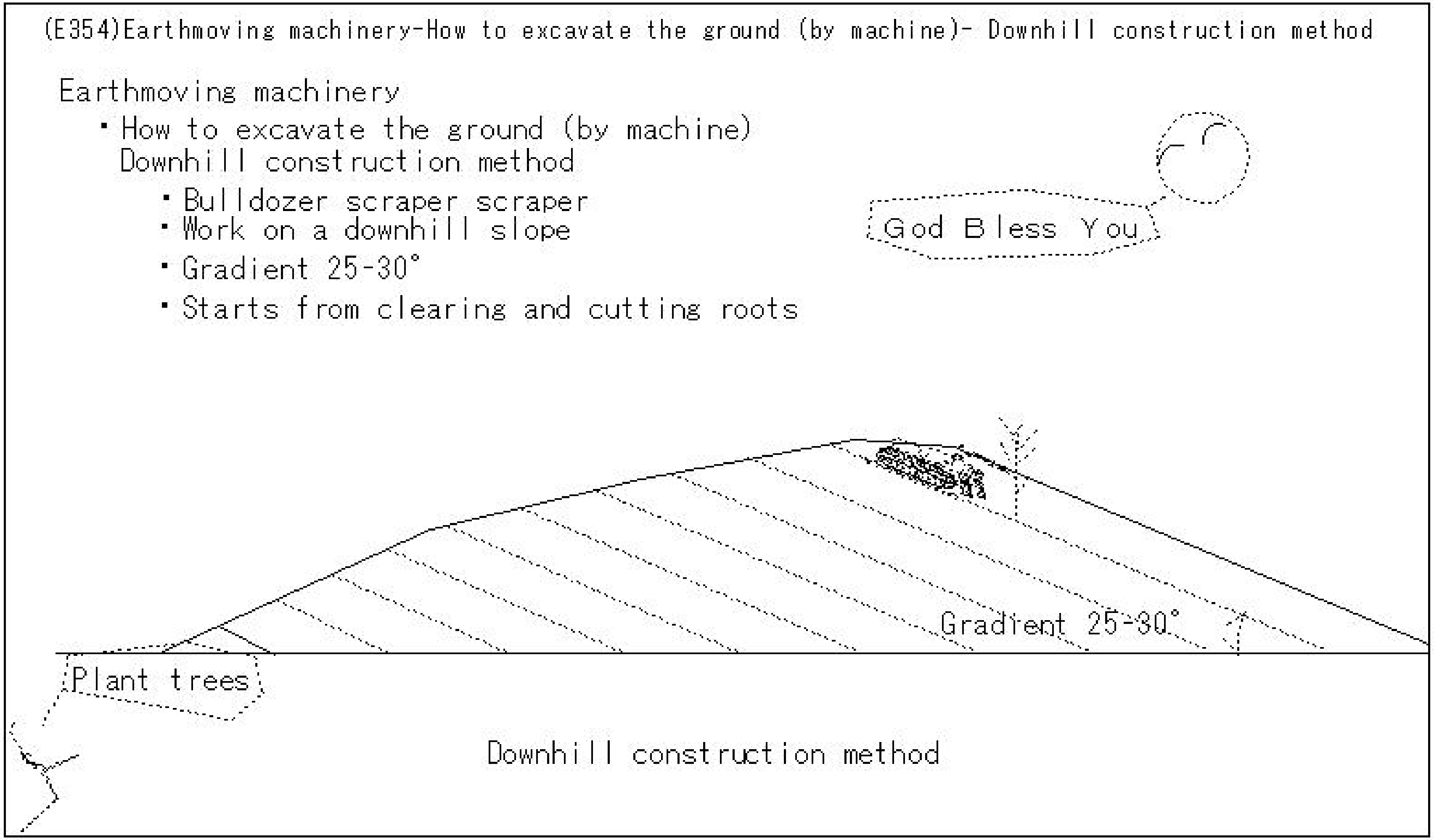
  Bench cut method

  - Step-type power shovel backhoe excavation
  - Dump truck transportation
  - Large-scale earthworks



Bench cut method

(E354)Earthmoving machinery-How to excavate the ground (by machine)- Downhill construction method



(E355)Earthmoving machinery-How to excavate the ground (by machine)-Combination method

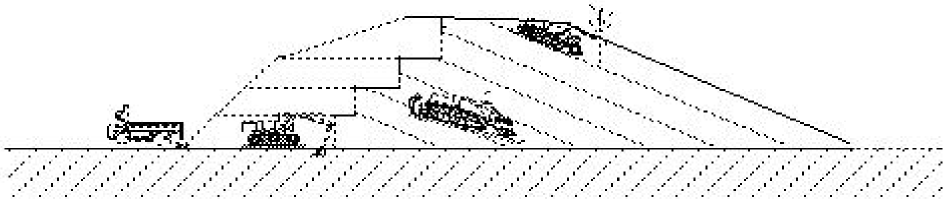
(E355)Earthmoving machinery-How to excavate the ground (by machine)-Combination method

Earthmoving machinery

- How to excavate the ground (by machine)

  Combination method

  - Bench cut method + downhill method
  - Rock excavation: blasting method, ripper method

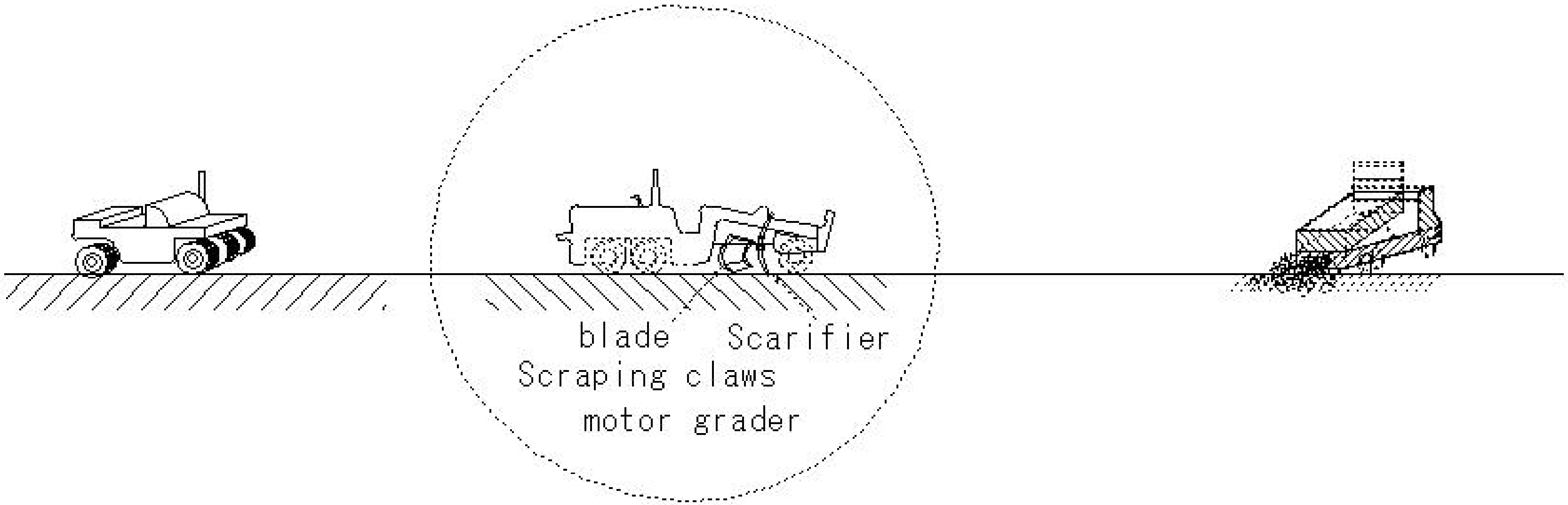


(E356)Earthmoving machinery-Spreading Leveling/compaction-Motor grader

(E356)Earthmoving machinery-Spreading Leveling/compaction-Motor grader

Earthmoving machinery

- Spreading Leveling/compaction
- Motor grader
- Smoothing out uneven road surfaces
- Spreading Leveling of the roadbed
- Earthwork board: Up/down/left/right rotation
- Excavation to create a hard soil moat: Scarifier



(E357)Earthmoving machinery-Compaction machine-Static pressure

(E357)Earthmoving machinery-Compaction machine-Static pressure

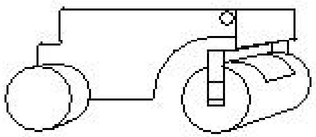
Earthmoving machinery

- Compaction machine
  - Static pressure

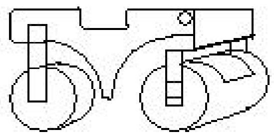
①Road roller macadam roller tandem roller

②Tire roller

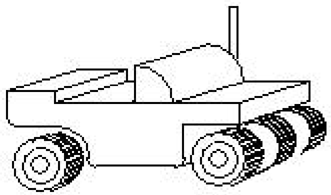
③Tandem roller



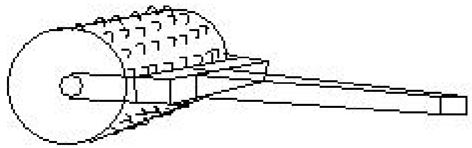
macadam roller



・Tandem roller (two axes and two wheels)



Tire roller



Tamping roller

(E358)Earthmoving machinery-Compaction machine-Vibration

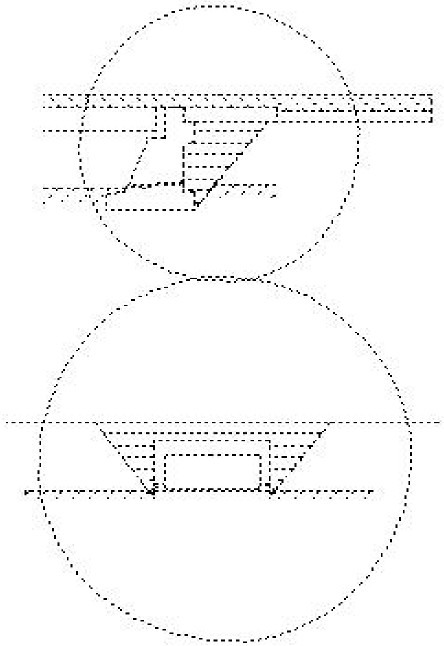
(E358)Earthmoving machinery-Compaction machine-Vibration

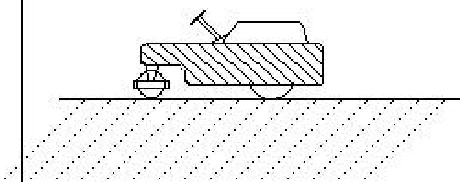
Earthmoving machinery

- Compaction machine
  - Vibration

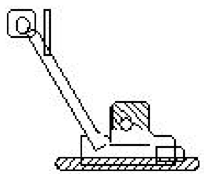
    ①Vibration roller

    ②Vibration compactor





Vibration roller



vibrating compactor

(E359)Earthmoving machinery-Compaction machine-Impact

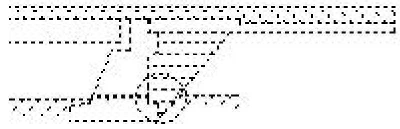
(E359)Earthmoving machinery-Compaction machine-Impact

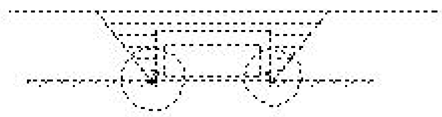
Earthmoving machinery

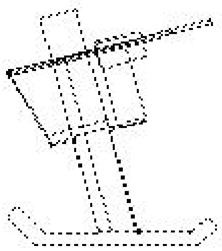
・Compaction machine

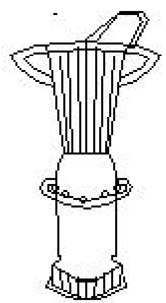
Impact

Rammer　Soil compactor









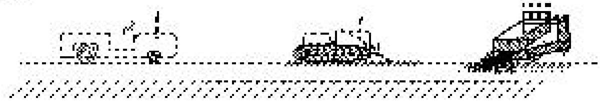
Tampa Rammer

(E360)Earthmoving machinery-Combination of compaction machine and soil type-Combination of compaction machine and soil type

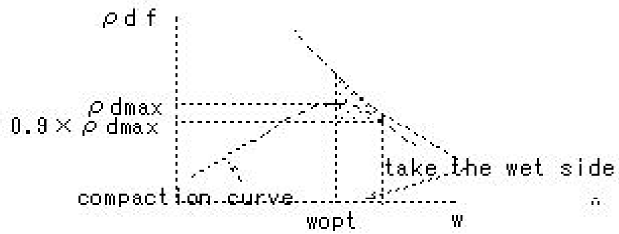
(E360)Earthmoving machinery-Combination of compaction machine and soil type-Combination of compaction machine and soil type

Earthmoving machinery

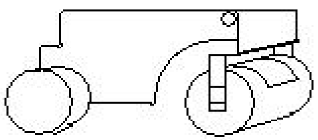
- Combination of compaction machine and soil type
- Compaction of embankment construction
- Adjust water content ratio
- Compaction machine selection
- Determine the rolling number and unrolling thickness



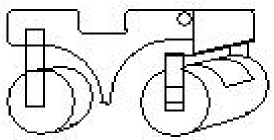
- Compaction machine
- Relationship with soil quality



- Road roller
  - Compaction of roadbed/roadbed
  - Finishing of embankment
  - Suitable for granular materials, cut gravel, and mixed sand



macadam roller



- Tandem roller (two axes and two wheels)

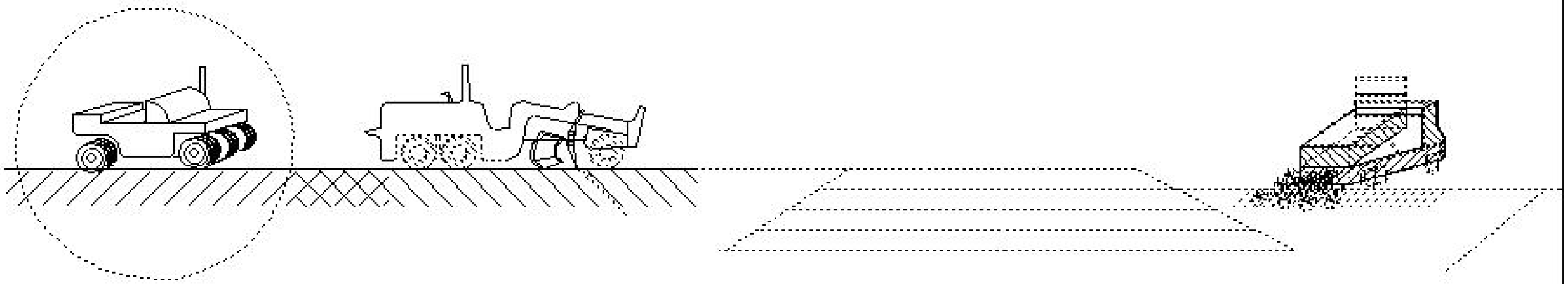
(E361)Earthmoving machinery-Combination of compaction machine and soil type-Combination of compaction machine and soil type

(E361)Earthmoving machinery-Combination of compaction machine and soil type-Combination of compaction machine and soil type

Earthmoving machinery

- Combination of compaction machine and soil type
  - Compaction machine
    - Relationship with soil quality

    - Tire roller
    - Sandy soil, gravel sand, mountain gravel, soil containing a moderate amount of fine particles
    - Ordinary soil



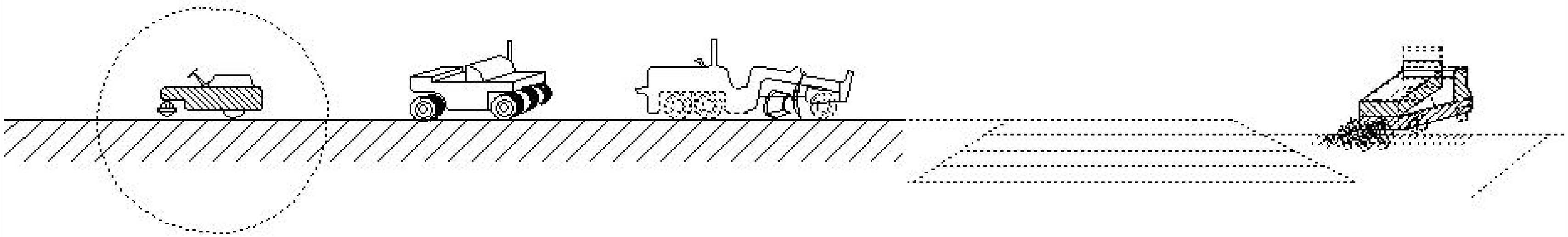
Tire roller

(E362)Earthmoving machinery-Combination of compaction machine and soil type-Combination of compaction machine and soil type

(E362)Earthmoving machinery-Combination of compaction machine and soil type-Combination of compaction machine and soil type

Earthmoving machinery

- Combination of compaction machine and soil type
  - Compaction machine
  - Relationship with soil quality
    - Vibration roller
    - Crused gravel, sandy soil
    - Compaction of slope surface



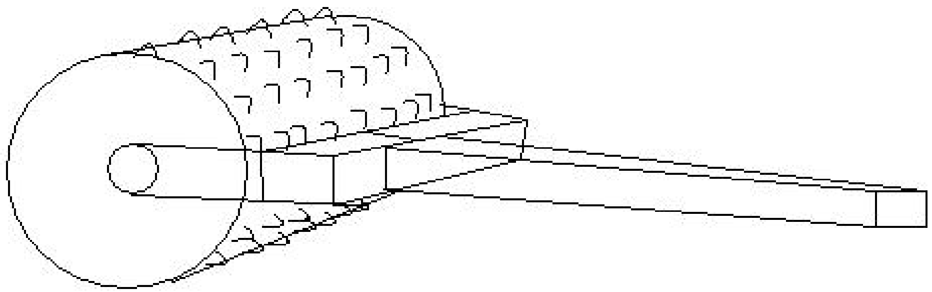
Vibration roller

(E363)Earthmoving machinery-Combination of compaction machine and soil type-Combination of compaction machine and soil type

(E363)Earthmoving machinery-Combination of compaction machine and soil type-Combination of compaction machine and soil type

Earthmoving machinery

- Combination of compaction machine and soil type
  - Compaction machine
  - Relationship with soil quality
    - Tamping roller
    - Weathered rock,Rock- clay soil, low sensitivity soil



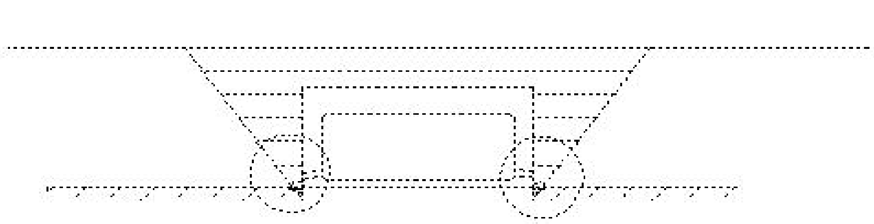
Tamping roller

(E364)Earthmoving machinery-Combination of compaction machine and soil type-Combination of compaction machine and soil type

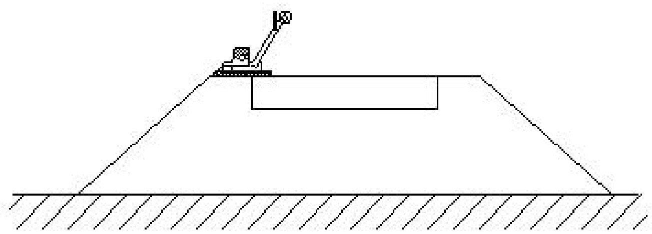
(E364)Earthmoving machinery-Combination of compaction machine and soil type-Combination of compaction machine and soil type

Earthmoving machinery

- Combination of compaction machine and soil type
  - Compaction machine
  - Relationship with soil quality
  - Vibration compactor Tamper ・Tampa
  - Applicable to almost all soils
  - Narrow space
  - Apply shoulders on slope



vibrating compactor



(E365)Slope protection-Embankment slope

(E365)Slope protection-Embankment slope

Slope protection

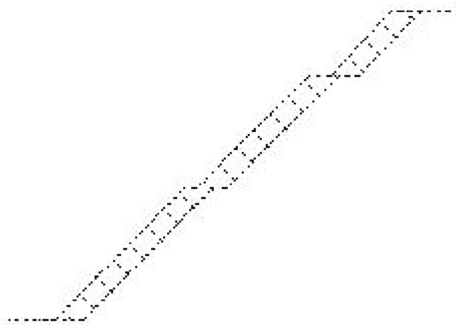
Embankment slope

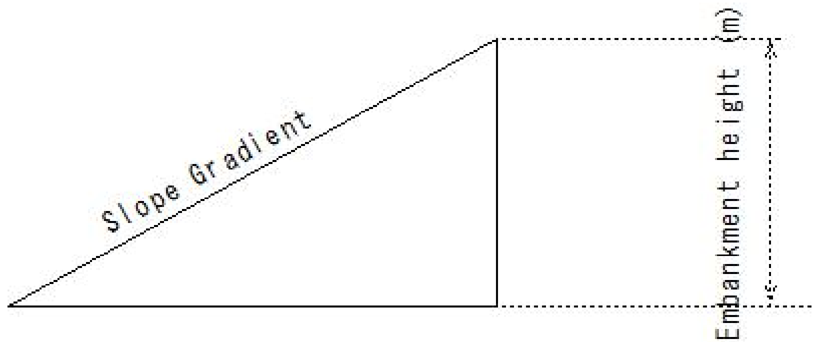
- Embankment height and slope

Embankment height (m)	Gradient	Embankment materials
0-5	1.5-1.8	Sandy soil/sand with good particle
		size distribution
5-15	1.8-2.0	3-2 Hard clay soil/gray soil
10-20	1.8-2.0	3-3 Gravel mass, boulder

If the foundation ground is soft, reduce the slope

Install small steps on high embankments



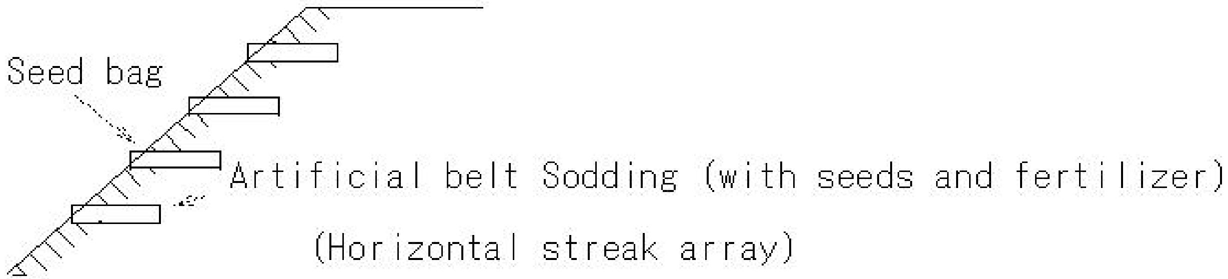


(E366)Slope protection-Embankment slope-Vegetation work (embankment)

(E366)Slope protection-Embankment slope-Vegetation work (embankment)

Slope protection

・Vegetation work (embankment)

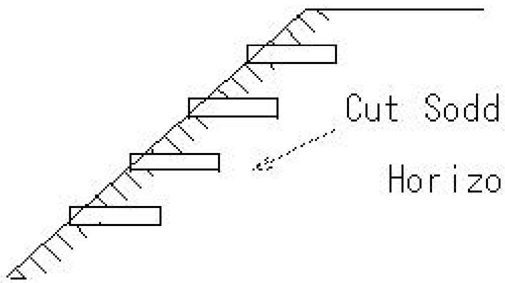


(E367)Slope protection-Embankment slope-Vegetation work (embankment)

(E367)Slope protection-Embankment slope-Vegetation work (embankment)

Slope protection

・Vegetation work (embankment)

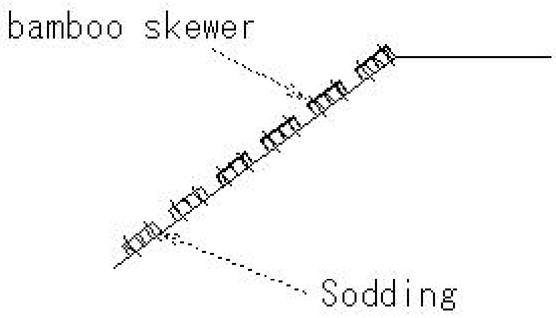


(E368)Slope protection-Embankment slope-Vegetation work (embankment)

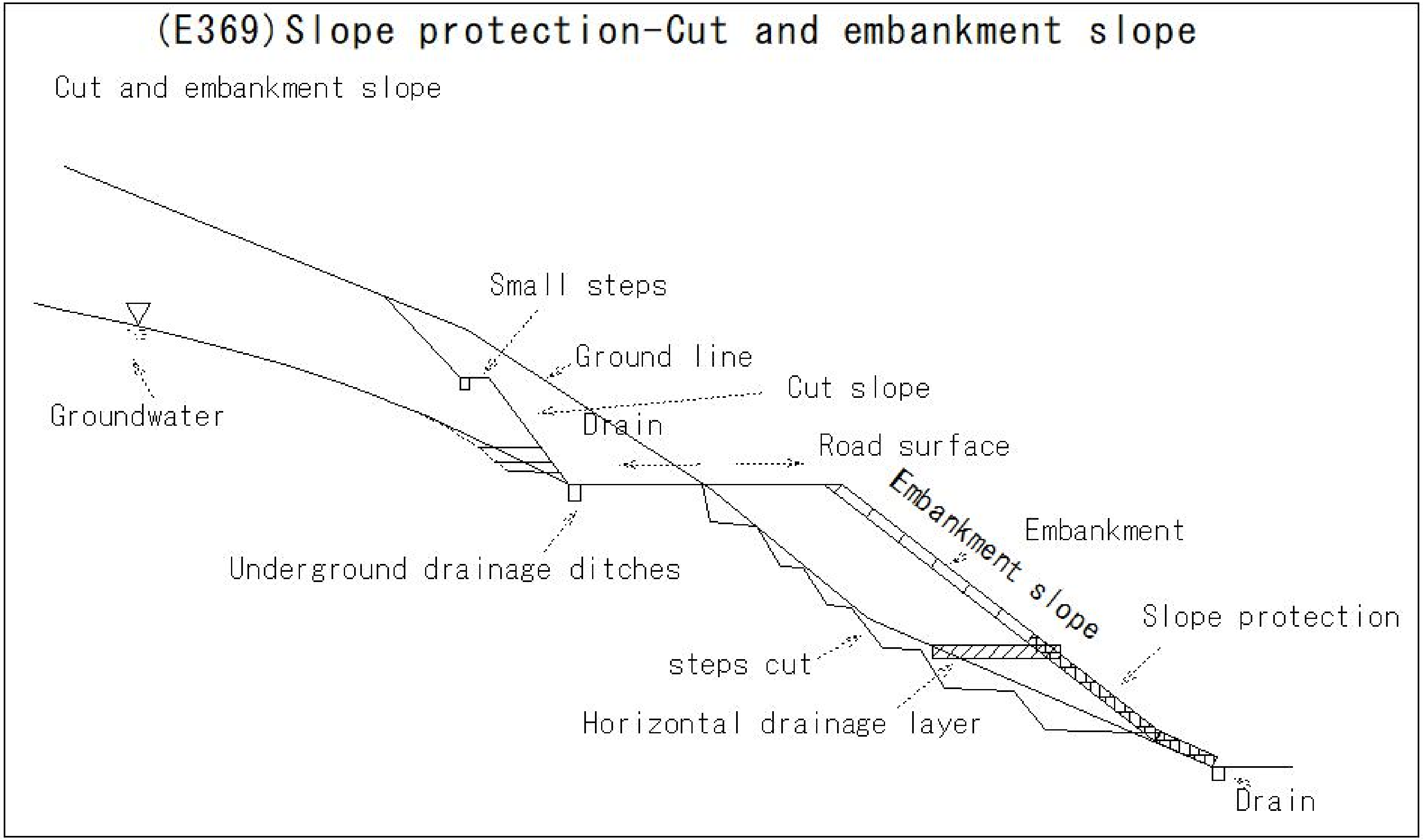
(E368)Slope protection-Embankment slope-Vegetation work (embankment)

Slope protection

・Vegetation work (embankment)



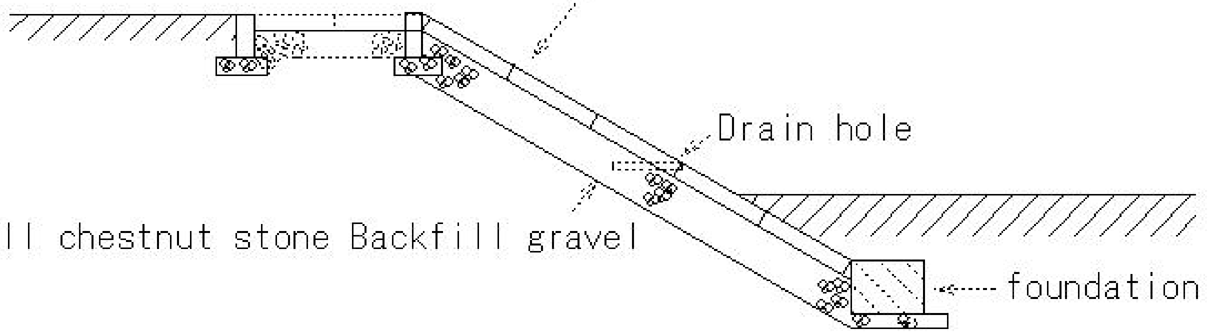
(E369)Slope protection-Cut and embankment slope



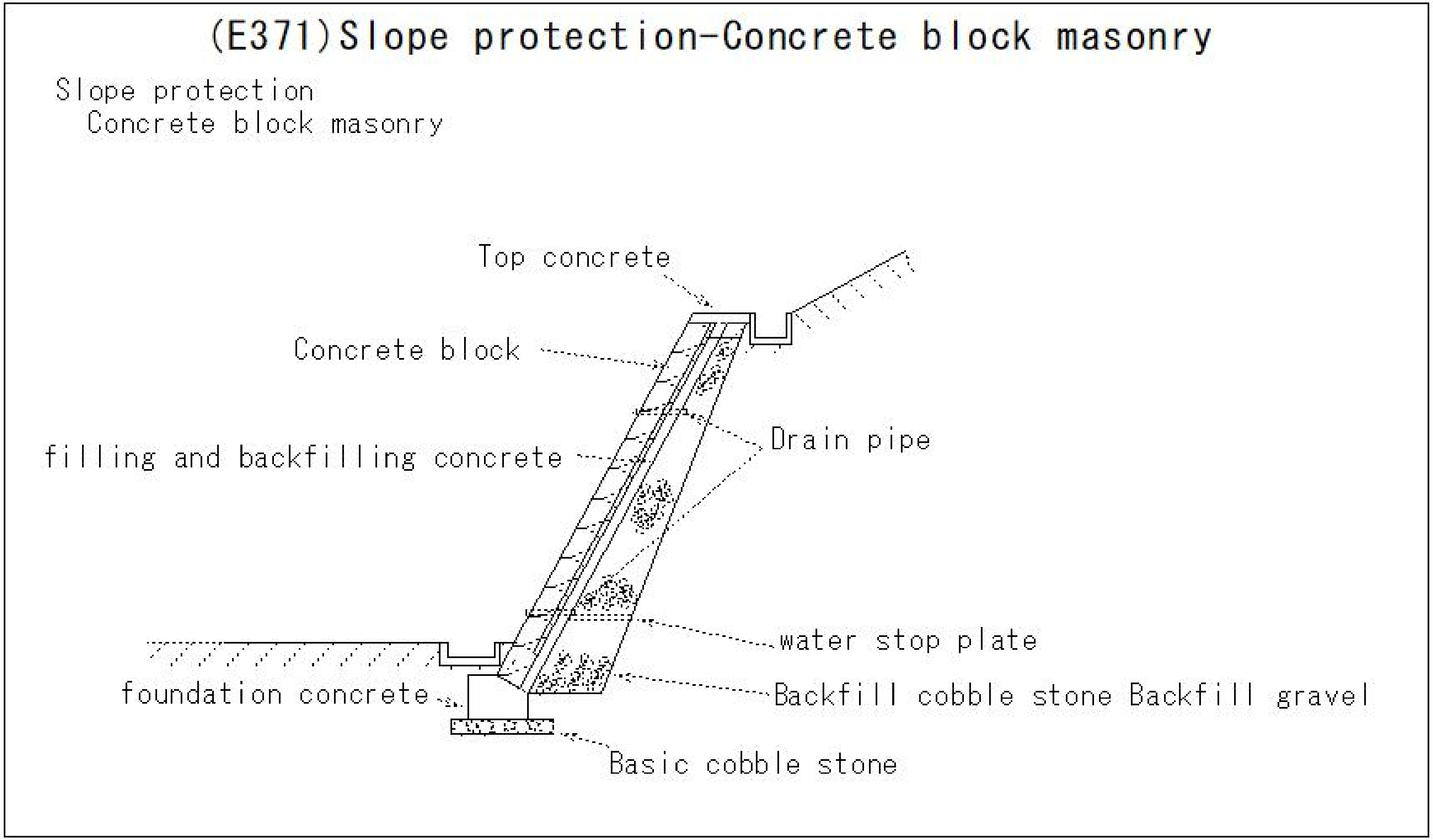
(E370)Slope protection-concrete block construction

(E370)Slope protection-concrete block construction

Slope protection
Concrete block construction



(E371)Slope protection-Concrete block masonry

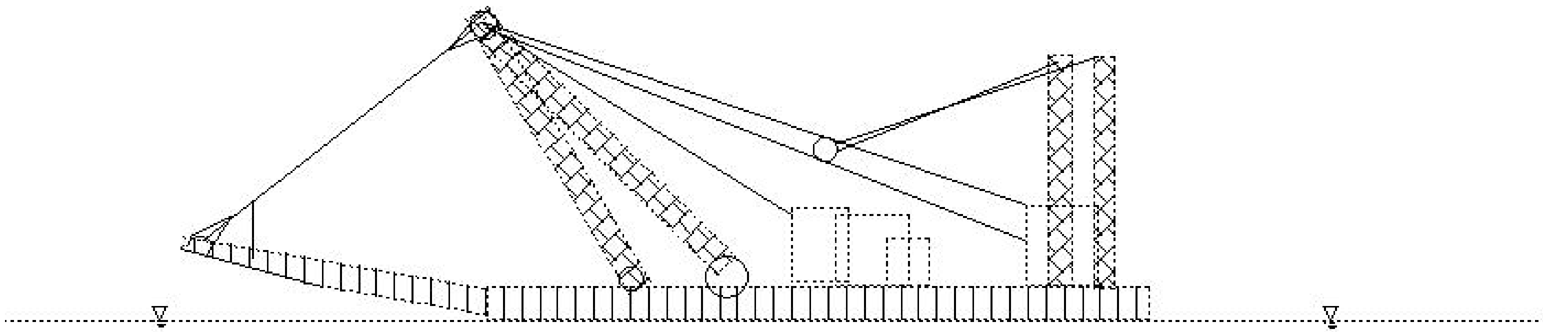


(E372)Dredging work-Pump dredger

(E372)Dredging work-Pump dredger

Dredging work

- Constant water depth in the channel within the port
- Sediment excavation on the seabed
  - Pump dredger
  - Large-scale dredging work



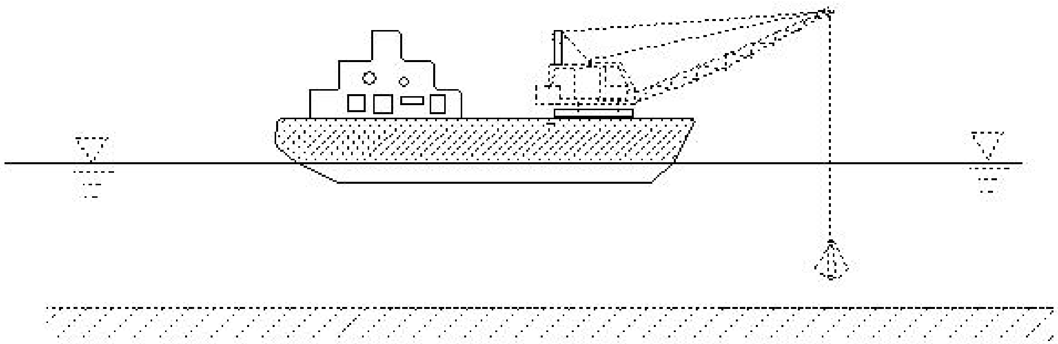
・Pump dredger

(E373)Dredging work-Grab dredger

(E373)Dredging work-Grab dredger

Dredging work

- Constant water depth in the channel within the port
- Sediment excavation on the seabed
  - Grab dredger
  - Small-scale dredging of narrow areas
  - Excavation of soft soil



Grab dredger

(E374)Dredging work-Bucket dredger

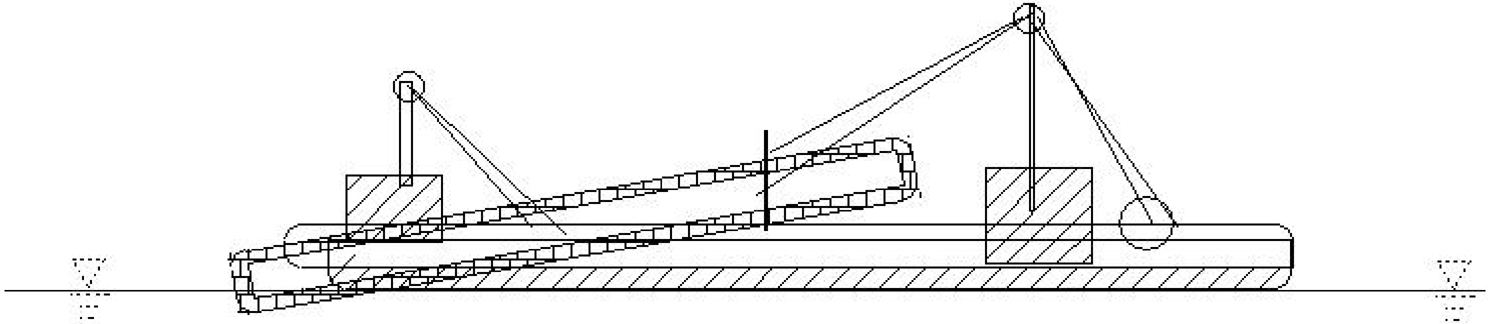
(E374)Dredging work-Bucket dredger

Dredging work

- Constant water depth in the channel within the port
- Sediment excavation on the seabed

Bucket dredger

stair bucket



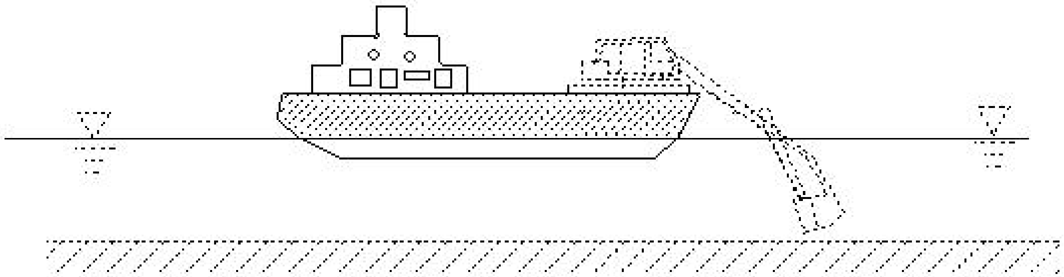
Bucket dredger

(E375)Dredging work-Dipper dredger

(E375)Dredging work-Dipper dredger

Dredging work

- Constant water depth in the channel within the port
- Sediment excavation on the seabed
  - Dipper dredger
  - Strong digging power
  - Solid ground

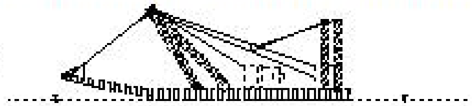


Dipper dredger

(E376)Dredging work-Pump ship・Grab ship・Dipper dredge・Bucket dredger

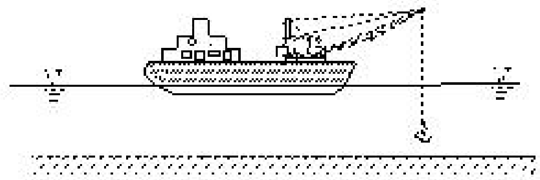
(E376)Dredging work-Pump ship・Grab ship・Dipper dredge・Bucket dredger

Dredging work
- Constant water depth in the channel within the port
  - Sediment excavation on the seabed



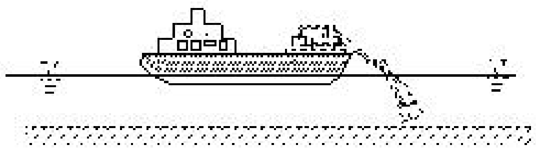
Pump dredger

Dredger
- Pump Dredger
  Drag suction (self-propelled)
  Pump dredger (non-propelled)
  Pump sucks up sediment from the bottom of the water along with water
- Grab dredger
  Non-self-propelled type
  Attach the grab bucket to the tip of the jib
  Dredging work using grab bucket

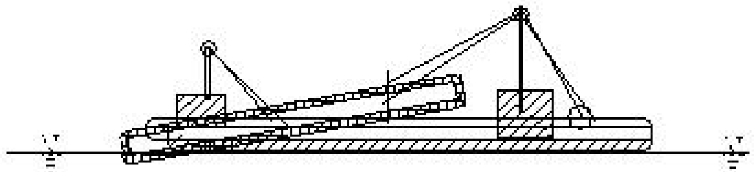


Grab dredger

- Dipper dredger non-self-propelled type
  Attach the power shovel to the hull
- Bucket dredger non-self-propelled type
  Continuously rotating multiple buckets to scoop up sediment from the bottom of the water

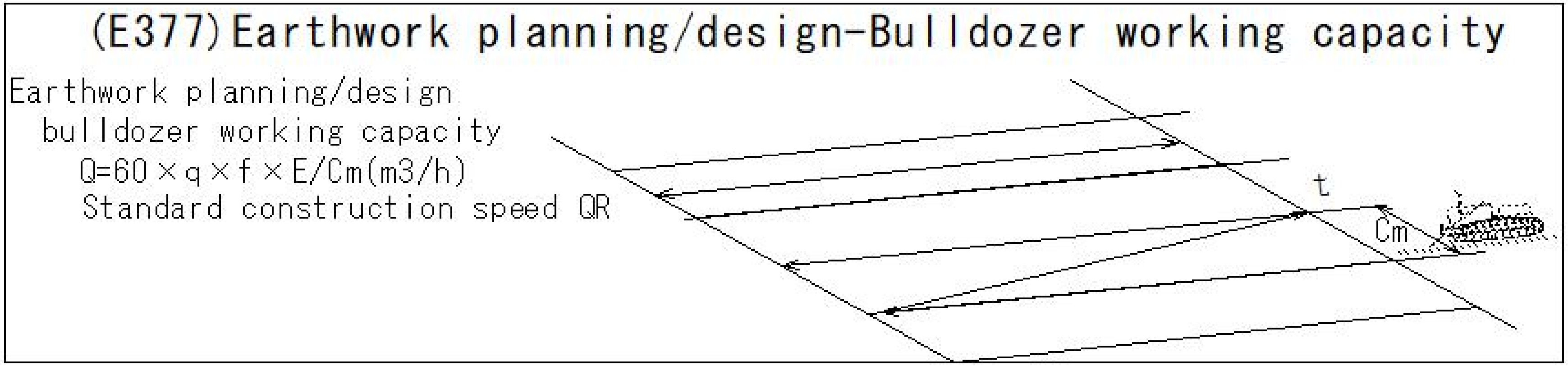


Dipper dredger



Bucket dredger

(E377)Earthwork planning/design-Bulldozer working capacity



(E377)Earthwork planning/design-Bulldozer working capacity
Earthwork planning/design
bulldozer working capacity
$Q=60\times q\times f\times E/Cm(m3/h)$
$q=qo\times\rho$
qo: Bulldozer earthwork board capacity (m3)
ρ: Coefficient depending on dosing distance and slope
f: Convert to volume of earth (f=1/L)
Cm: Cycle time
E: Work efficiency
Bulldozer standards and workload

1 Format	2 Standards	3 Output (PS)	4 Mass (t)	5 Earthwork board dimensions (m) L x H	6 Earthwork board capacity qo (m3)	7 Installation pressure (kgf/cm2)	8 Earthwork board format
9 Normal type	11t	116	12.2	3.71×0.87	1.95	0.59	11 angle
	15t	151	15	3.92×1.00	2.72	0.62	11 angle
	21t	212	22.2	3.70×1.30	4.33	0.73	12 Straight
	32t	313	38.6	4.13×1.59	7.23	1.03	12 Straight

(E378)Earthwork planning/design-Bulldozer working capacity

(E378)Earthwork planning/design-Bulldozer working capacity

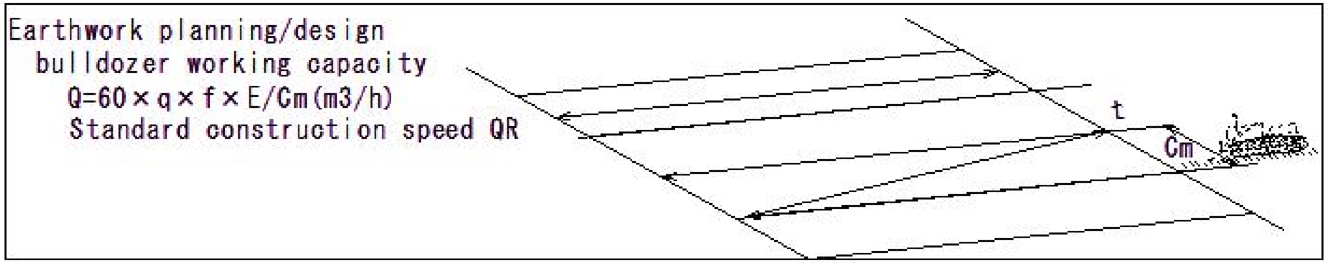
Earthwork planning/design

bulldozer working capacity

Q=60×q×f×E/Cm(m3/h)

Coefficient ρ related to dosing distance and slope of transport road

1 Transport distance (m)		20	30	40	50	60	70	80
	2 Gradient (%)							
3. Flat	0	0.96	0.92	0.88	0.84	0.8	0.76	0.72
4 Downhil	5	1.08	1.03	0.99	0.94	0.9	0.85	0.81
	10	1.23	1.18	1.13	1.08	1.02	0.97	0.92
	15	1.41	1.35	1.29	1.23	1.18	1.12	1.06
5 Upward	5	0.85	0.82	0.78	0.75	0.71	0.68	0.64
	10	0.77	0.74	0.7	0.67	0.64	0.61	0.58
	15	0.7	0.67	0.64	0.61	0.58	0.56	0.53



(E379)Earthwork planning/design-Bulldozer working capacity

(E379)Earthwork planning/design-Bulldozer working capacity

Earthwork planning/design

Bulldozer working capacity

$Q=60\times q\times f\times E/Cm(m3/h)$

・Bulldozer work efficiency E (reference value)

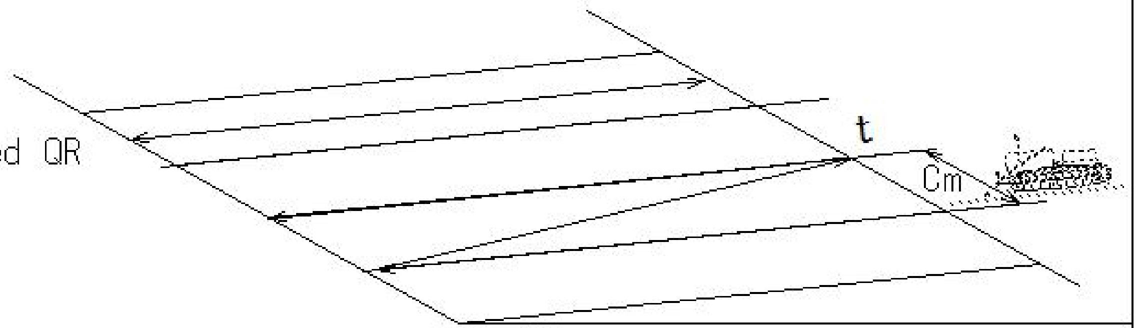
1	Type of soil	2 Work efficiency	3 Remarks
1	Rock mass/boulder	0.20-0.35	
2	Rock mixed soil	0.30-0.55	Those that are solidified - lower limit value
3	Sand	0.40-0.70	
4	Ordinary soil	0.35-0.60	
5	Clay soil	0.30-0.60	It is greatly influenced by the quality of traffic cavities.

Earthwork planning/design

bulldozer working capacity

$Q=60\times q\times f\times E/Cm(m3/h)$

Standard construction speed QR



(E380)Earthwork planning/design-Bulldozer working capacity

(E380)Earthwork planning/design-Bulldozer working capacity

Earthwork planning/design

Bulldozer working capacity

$Q=60\times q\times f\times E/Cm(m3/h)$

・How to find bulldozer cycle time

$t1=l/v1$

$t2=l/v2$

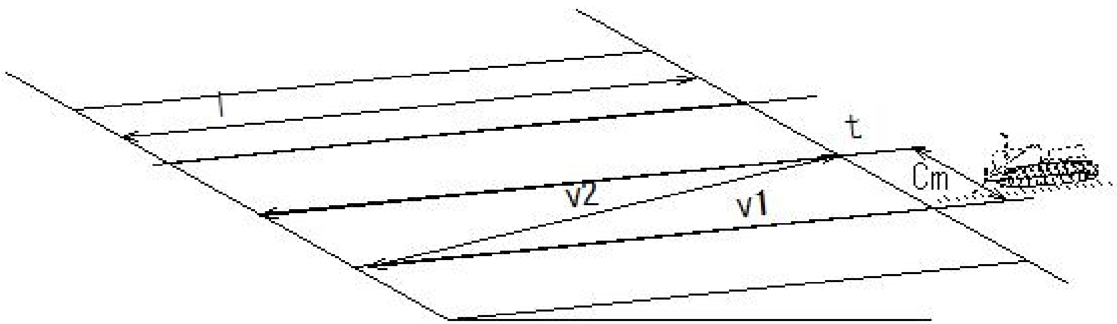
Forward speed: v1 (min)

Reverse speed: v2 (min)

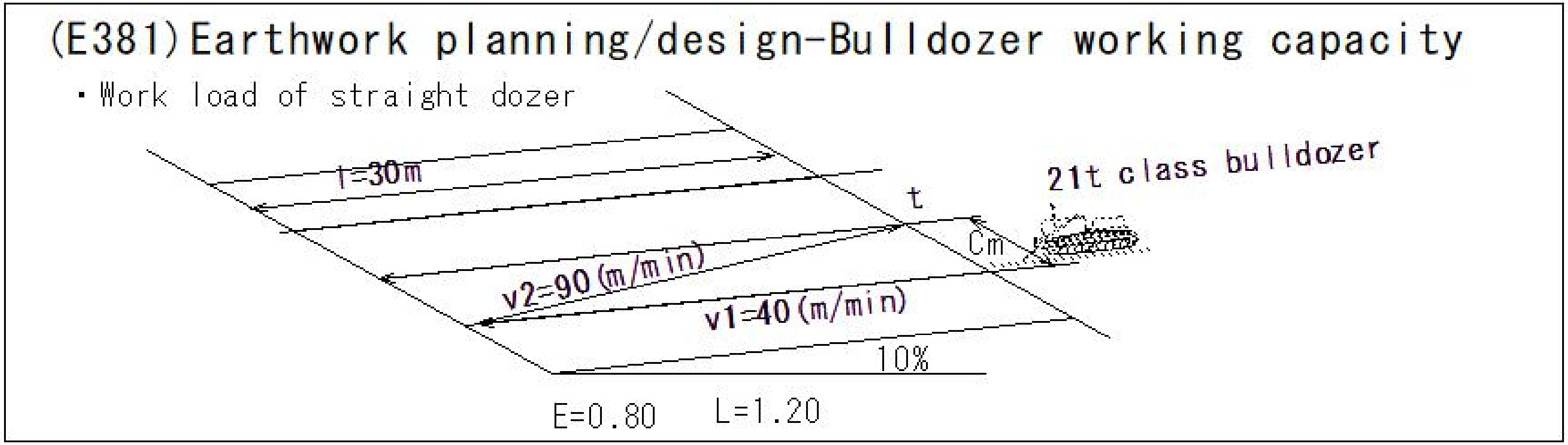
l: distance (m)

Gear change time tg=0.25(min)

Downhill slope has high efficiency ρ



(E381)Earthwork planning/design-Bulldozer working capacity



(E381)Earthwork planning/design-Bulldozer working capacity
Earthwork planning/design

- Work load of straight dozer
- Sandy soil
- Excavating with a 21t class bulldozer
- Downhill slope 10%
- 30m transportation
- Amount of work Amount of ground soil?
- Dozer forward speed v1=40(m/min)
- Reverse speed v2=90(m/min)
- Work efficiency E=0.80
- Rate of change in soil volume L=1.20

①Table: Capacity of earthwork board q0=4.33m3
②Dosing distance and slope coefficient ρ=1.18
③Standard amount of work per time q=4.33×1.18=5.11m3
④ Rate of change in soil volume f=1/L=1/1.20=0.83
⑤Gear change time tg=0.25min
⑥Cycle time Cm=30/40+30/90+0.25=1.33min
⑦ Land volume Q=60×q×f×E/Cm(m3/h)
Q=5.11×(60/1.33)×0.83×0.80=153m3/h

(E382)Earthwork planning/design-Working capacity of excavator type excavator

(E382)Earthwork planning/design-Working capacity of excavator type excavator

Earthwork planning/design

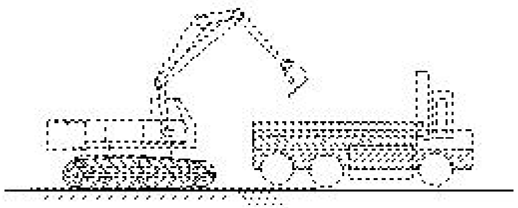
- Working capacity of excavator type excavator
  - $Q=60\times q\times f\times E/Cm(m3/h)$
  - $q=qoK$

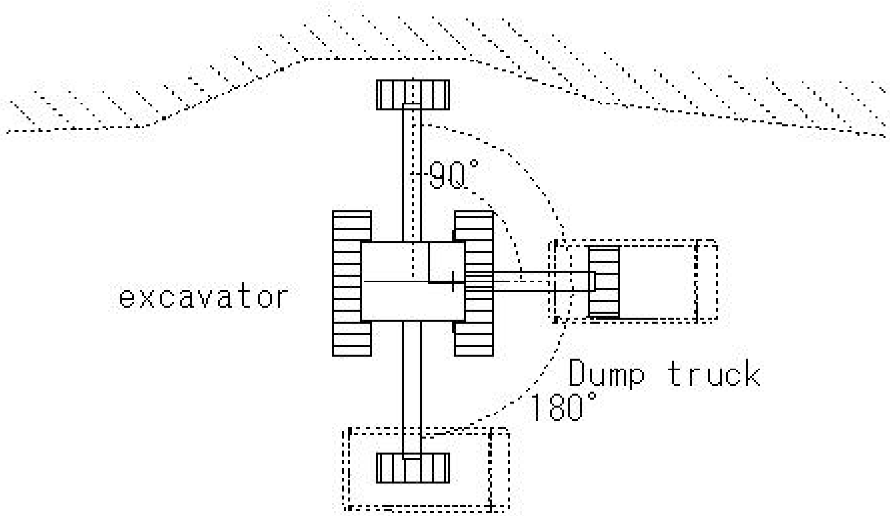
    qo: Bucket standard capacity m3

    K: Bucket coefficient (varies depending on machine type and soil type)
    f: Convert the loosened soil volume to the soil volume of the ground

    E: Work efficiency (0.5-0.8)

    Cm:(sec)





Cm varies depending on where the dump truck is stopped.

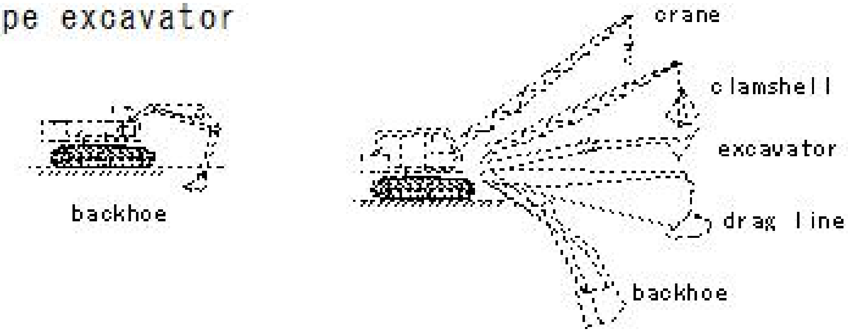
(E383)Earthwork planning/design-Working capacity of excavator type excavator

(E383)Earthwork planning/design-Working capacity of excavator type excavator

Earthwork planning/design

・Working capacity of excavator type excavator

Bucket coefficient K



Working capacity of excavator type excavator

1 Type of soil	2 Backhoe	3 Clamshell	4 Power shovel
①Rocks/Boulders	0.45-0.75	0.40-0.70	0.50-0.80
②Soil mixed with gravel	0.50-0.90	0.45-0.85	0.60-1.00
③Sand	0.80-1.20	0.75-1.10	0.90-1.30
④ Ordinary soil	0.60-1.0	0.55-0.95	0.70-1.10
⑤ Clay soil	0.45-0.75	0.40-0.70	0.50-0.80

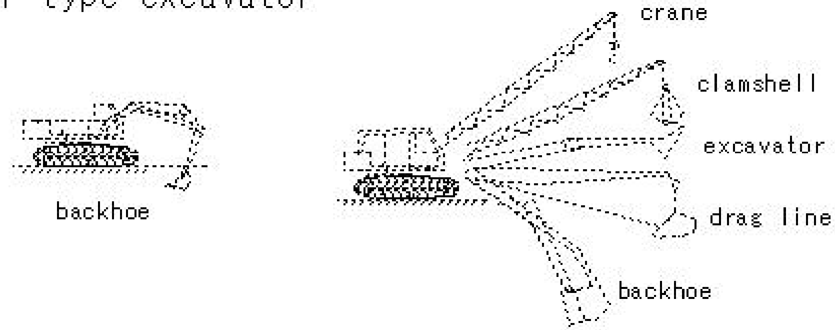
・Heaped voids - few excavation - easy: large coefficient

(E384)Earthwork planning/design-Cycle time Cm of excavator type excavator

(E384)Earthwork planning/design-Cycle time Cm of excavator type excavator

Earthwork planning/design

Cycle time Cm of excavator type excavator



(E384)Earthwork planning/design-Cycle time Cm of excavator type excavator

Cycle time Cm of excavator type excavator

1 model	2 Backhoe	3 Clamshell	4 Power shovel
10 Excavation level (soil type) 6 Standards	7 Hydraulic crawler 0.3-0.7m3 class	8 Mechanical crawler 0.8m3 class	9 Mechanical crawler 0.6m3 class
11 Easy excavation (sand)	20-29(s)	30-37(s)	14-23(s)
12 Medium excavation (normal soil)	23-32	33-42	16-27
13 Somewhat difficult excavation (clay soil, gravel soil)	27-36	37-46	19-32
14 Difficult excavation (rock mass/boulder)	31-41	42-48	21-35

5 Remarks

Large turning angle and excavation depth - Upper limit value

(E385)Earthwork planning/design-Features and selection criteria of excavators

(E385)Earthwork planning/design-Features and selection criteria of excavators
Earthwork planning/design
Features and selection criteria of excavators

	1 Shovel	2 Backhoe	3 Dragline	4 Clamshell
1. Excavation power	A	A	B	C
2. Excavation material				
2-1 Hard rocks and soil	A	A	D	D
2-2 Medium hard soil	A	A	B	B
2-3 Soft soil	A	A	B	B
2-4 Underwater drilling	C	B	A	A
3 Excavation position				
3-1 Places higher than the ground	A	C	C	B
3-2 Above ground	B	B	B	B
3-3 Places lower than the ground	C	A	A	B
3-4 Wide range	C	C	A	B
3-5 Accurate excavation	A	A	C	A
4 Adaptation work				
4-1 Cutting out a high mountain	A	D	D	D
4-2 Basic cutting	C	A	A	B
4-3 Excavation of wide V-shaped trench	B	A	A	C
4-4 Excavation of narrow V-shaped trench	C	A	C	B
4-5 Topsoil stripping and leveling	B	C	A	D
4-6 Molding finish of slope surface	C	B	C	C
4-7 Backfilling work	C	C	B	B
4-8 Loading of crushed pavement	D	B	D	B
4-9 Lifting winch work	C	C	B	A

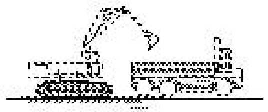
A: Optimal B: Normal C: Inefficient D: Inappropriate

(E386)Earthwork planning/design-Working capacity of excavator type excavator-Work load of power shovel

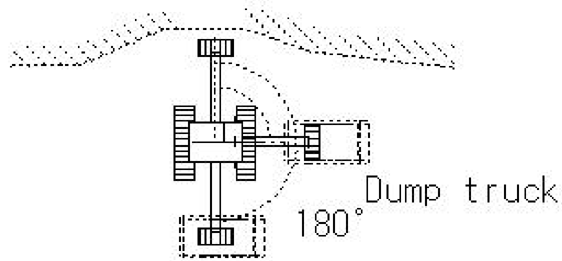
(E386)Earthwork planning/design-Working capacity of excavator type excavator-Work load of power shovel

Earthwork planning/design

- Working capacity of excavator type excavator
- Work load of power shovel
  - Ordinary soil
  - 0.6m3 class power shovel
  - Calculated using ground volume
  - Turning angle 180 degrees
  - Work efficiency E=0.7
  - Rate of change in soil volume L=1.30



0.6m3 class power shovel



Solution

① Bucket capacity qo=0.6m3

② Bucket coefficient K=1.10

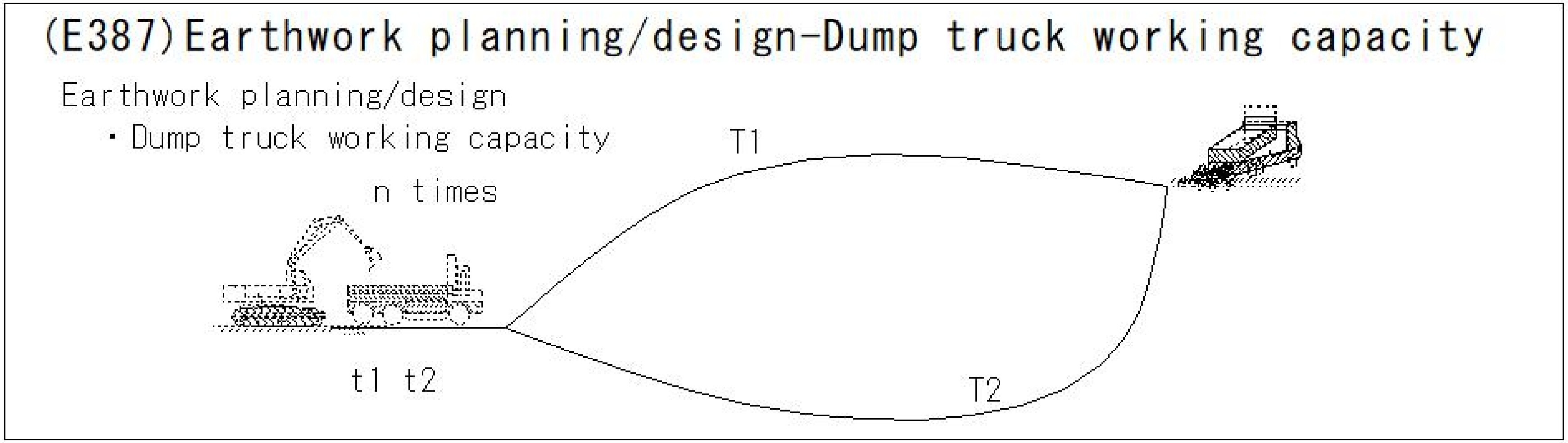
③ Rate of change in soil volume f=1/1.3=0.77

④ Work efficiency E=0.70

⑤ Cycle time Cm=23sec

⑥ Volume of soil $Q=3600\times0.60\times1.10\times0.77\times0.7/23=55.7$ m3/h

(E387)Earthwork planning/design-Dump truck working capacity



(E387)Earthwork planning/design-Dump truck working capacity
Earthwork planning/design
・Dump truck working capacity
1 Medium-distance/long-distance transportation
2 Public roads/construction sites: Vehicles/driving conditions vary
3 Compliance with traffic laws
4 Work amount Q=60×

Cm＝Cmsn/(60Es)+(T1+T2+t1+t2+t3)(min)
Cms: Loading machine cycle time (sec)
n: Number of times loaded onto one dump truck
n=qo/(qsK)
qo: Loading volume of dump truck (m3) (flat loading)
qs: Loading machine bucket capacity (m3)
K: bucket coefficient
Es: Loading machine work efficiency
T1, T2: Dump truck travel time for outbound and return trips
Ti=(D/Vi)60 (i=1 or 2)
D: Travel distance for outbound and return trips (km)
Vi: Outbound trip, return trip, travel speed (km/h)
t1 t2: Unloading/loading waiting time (min)
ts: Sheet removal time (min)
E: Work efficiency depending on road conditions (roadside environment, road surface condition, day and night), etc. (generally 0.9)

(E388)Earthwork planning/design-Required number of dump trucks

(E388)Earthwork planning/design-Required number of dump trucks

Earthwork planning/design

- Required number of dump trucks
- Required number of combined dump trucks M

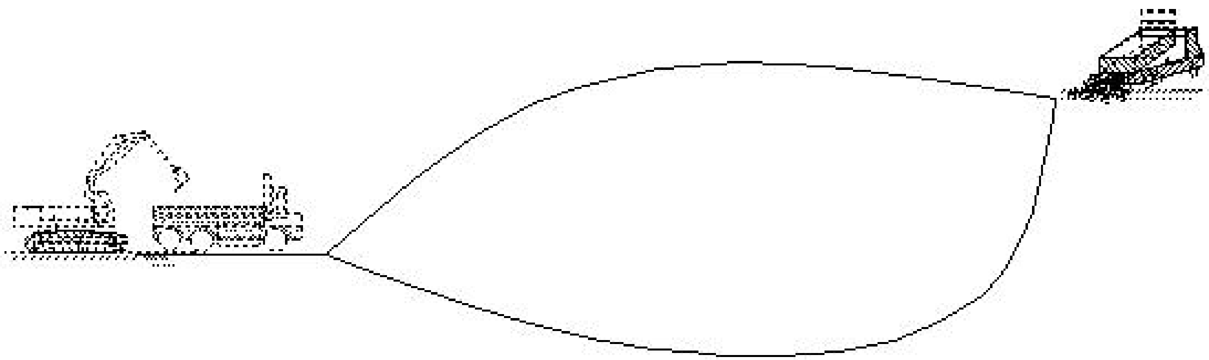
M=Qs/QD

Qs: Bucket capacity of loading machine (m3)

QD: Dump truck work volume (m3/h)

Dump truck standards

standard	Output (PS)	Maximum loading mass (t)	Flat stacking capacity (m3)
2t class	98	2.0	1.54
4t class	170	4.0	2.66
8t class	222	8.0	5.26
11t class	315	11.0	7.27



(E389)Earthwork planning/design-Required number of dump trucks

(E389)Earthwork planning/design-Required number of dump trucks

Earthwork planning/design

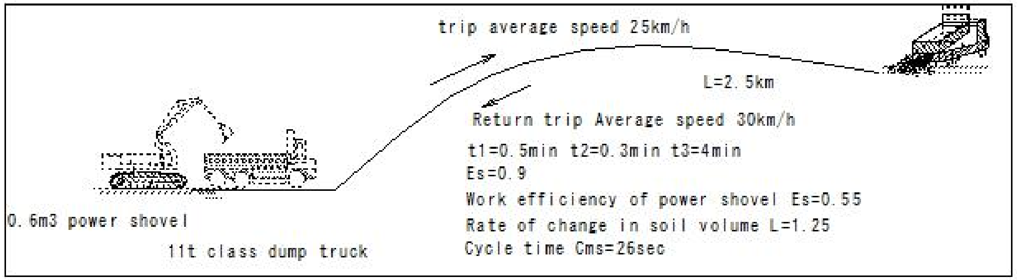
- Required number of dump trucks
- Flat loading 0.6m3 power shovel
- 11t class dump truck
- Combination earthwork
- Gravel mixed soil
- Medium level of excavation
- Transportation road 2 lanes in good condition
- 2.5km embankment area
- Dump truck outward trip average speed 25km/h

Return trip Average speed 30km/h

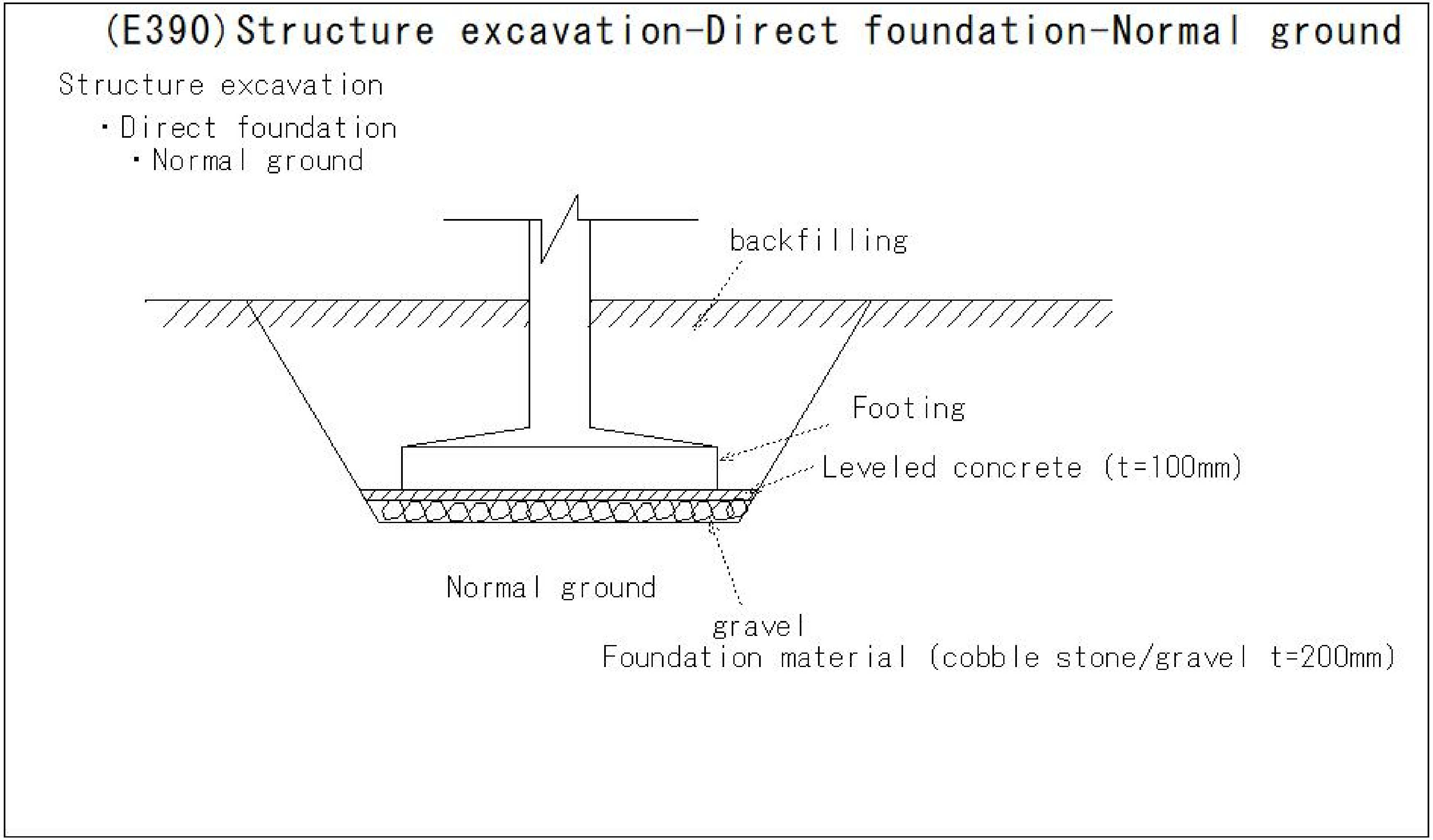
- $t_1=0.5$min $t_2=0.3$min $t_3=4$min
- Work efficiency $Es=0.9$
- Required number of dump trucks
- Work efficiency of power shovel $Es=0.55$
- Rate of change in soil volume $L=1.25$
- Cycle time $Cms=26$sec

1 Dump truck loading capacity qo:7.27m3
Power shovel bucket coefficient $K=0.80$
2 Number of times the power shovel is loaded
$N=7.27/(0.6\times0.80)=16$ times
3 Dump truck cycle time
Outbound average speed $T_1=(2.5/25)\times60=6.0$min
Return trip Average speed $T_2=(2.5/30)\times60=5.0$min
$Cm=26\times16/(60\times0.55)+6.0+5.0+0.5+0.3+4.0=28.4$(min)
Rate of change in soil volume $f=1/1.25=0.80$
4 Work amount per hour of dump truck
$QD=7.27\times(60/28.4)\times0.8\times0.9=11.1$m3/h

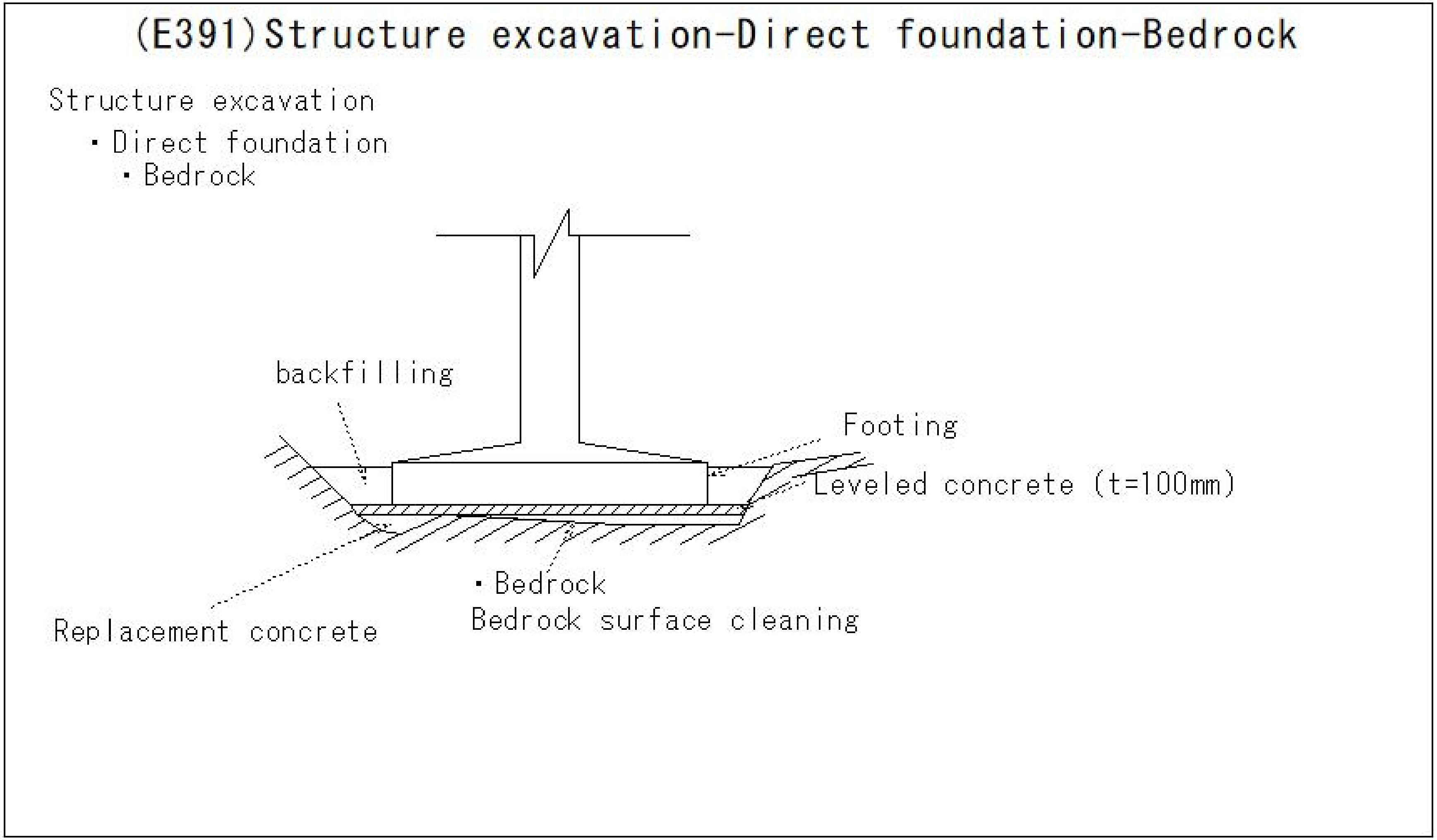
5 Work amount per hour of power shovel
Bucket capacity $qo=0.6$m3
K: Bucket coefficient $K=0.80$
Rate of change in soil volume $f=1/1.25=0.80$
Work efficiency $E=0.55$
6 Cycle time $Cm=26$sec
7 $Q=0.6\times0.8\times3600\times0.80\times0.55/26=29.3$m3/h
8 Required number of dump trucks
$M=29.2/11.1=2.6$ 3 including spares



(E390)Structure excavation-Direct foundation-Normal ground



(E391)Structure excavation-Direct foundation-Bedrock



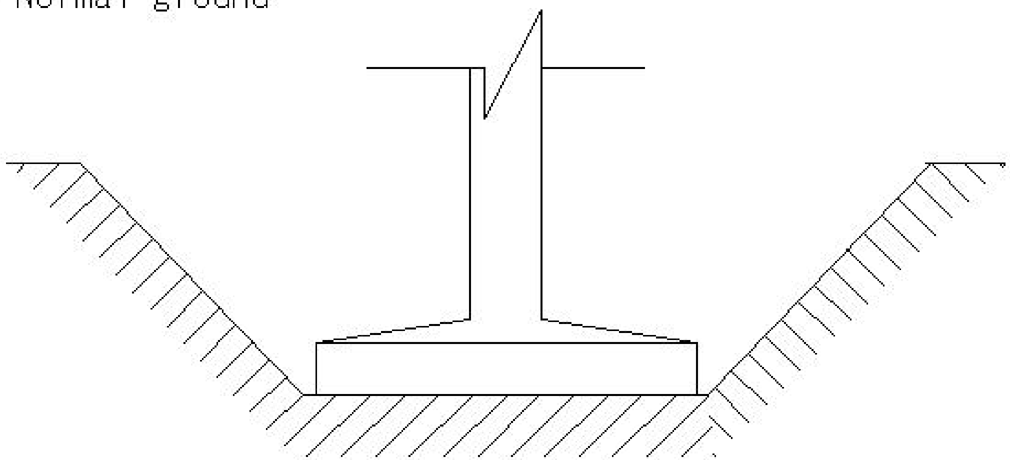
(E392)Structure excavation-Slope open cut

(E392)Structure excavation-Slope open cut

Slope open cut

- Shallow excavation
- Bedrock section excavation
- Low groundwater
- Land - wide

・Normal ground



Slope open cut

(E393)Structure excavation-Sheet pile + Timbering Slope open cut method

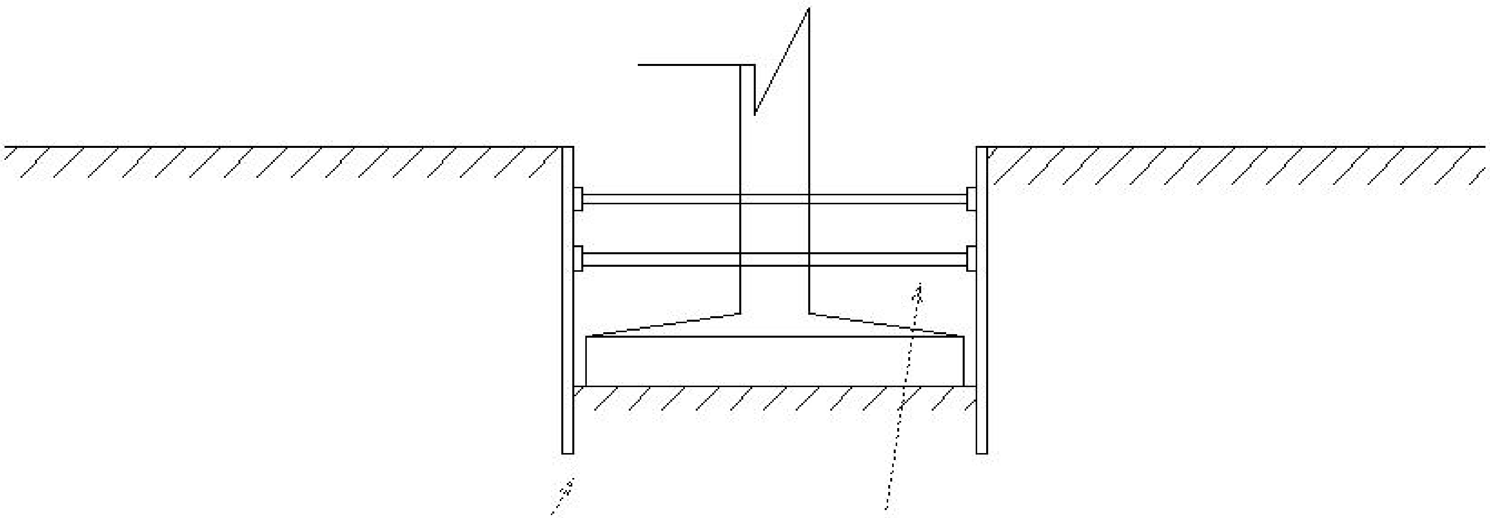
(E393)Structure excavation-Sheet pile + Timbering Slope open cut method

Structure excavation

Sheet pile + Timbering

・Preventing ground collapse

・Sheet pile + Timbering Slope open cut method

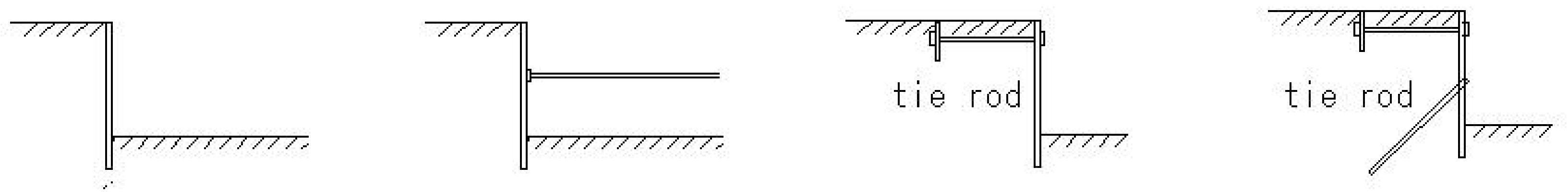


(E394)Structure excavation-Sheet pile + Timbering

(E394)Structure excavation-Sheet pile + Timbering

Structure excavation

・Sheet pile + Timbering method



1 Self-supporting sheet piles　2 Compression Timbering　3 Tension Timbering　4 Tension Timbering

(E395)Structure excavation-Sheet pile + Timbering-Slope open cut method

(E395)Structure excavation-Sheet pile + Timbering-Slope open cut method

Structure excavation

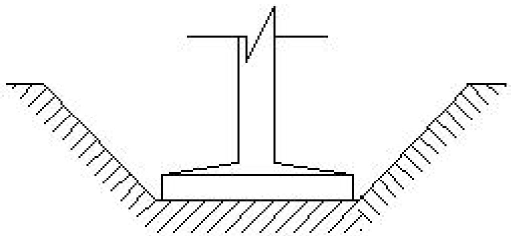
・Slope open cut method

Strong Points

1 Sheet pile + Timbering support area - not required
2 Economical
3 Erection time savings
4 Mechanized construction possible
5 Shortened construction period

Poor Points

1. Requires large site
2. Soft ground -deep excavation is not possible
3. Volume of backfilling soil -increases



Slope open cut

(E396)Structure excavation-Sheet pile + Timbering-open cut method

(E396)Structure excavation-Sheet pile + Timbering-open cut method

Structure excavation

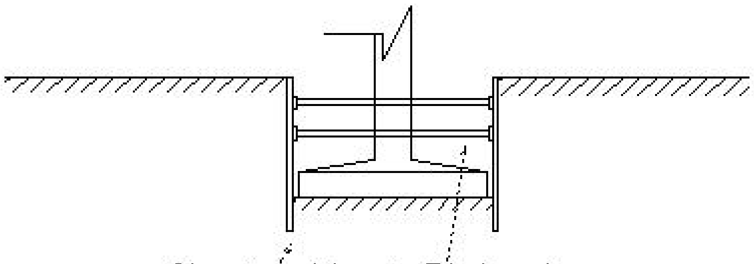
- Sheet pile + Timbering
- Sheet pile + Timbering open cut

Strong Points

1 Excavation area: soil volume - small
2 Soft ground - construction possible

Poor Points

1 Construction cost - high Construction period - long
2 Use of machinery during excavation - restrictions apply
3 Excavation surface - wide, loose parts



Sheet pile + Timbering

- Sheet pile + Timbering open cut

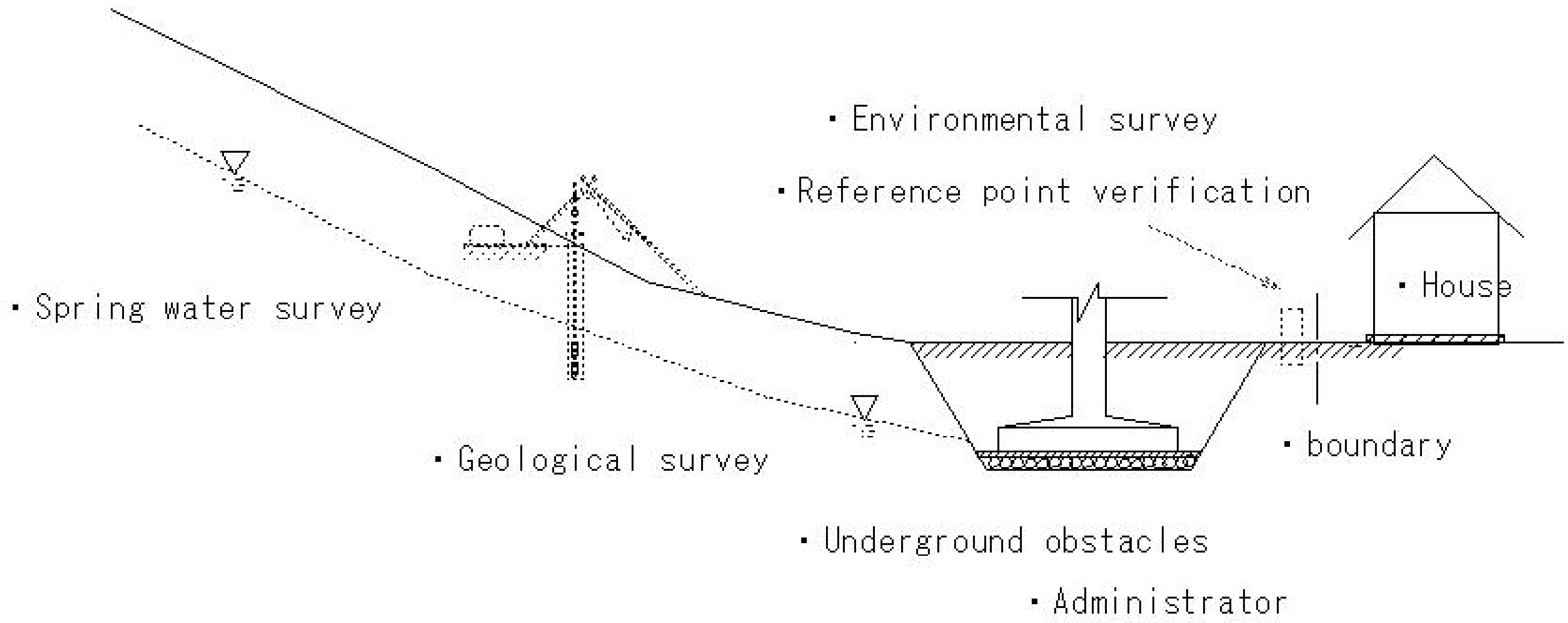
(E397)Structure excavation-Points to note during planning structural excavation

(E397)Structure excavation-Points to note during planning structural excavation

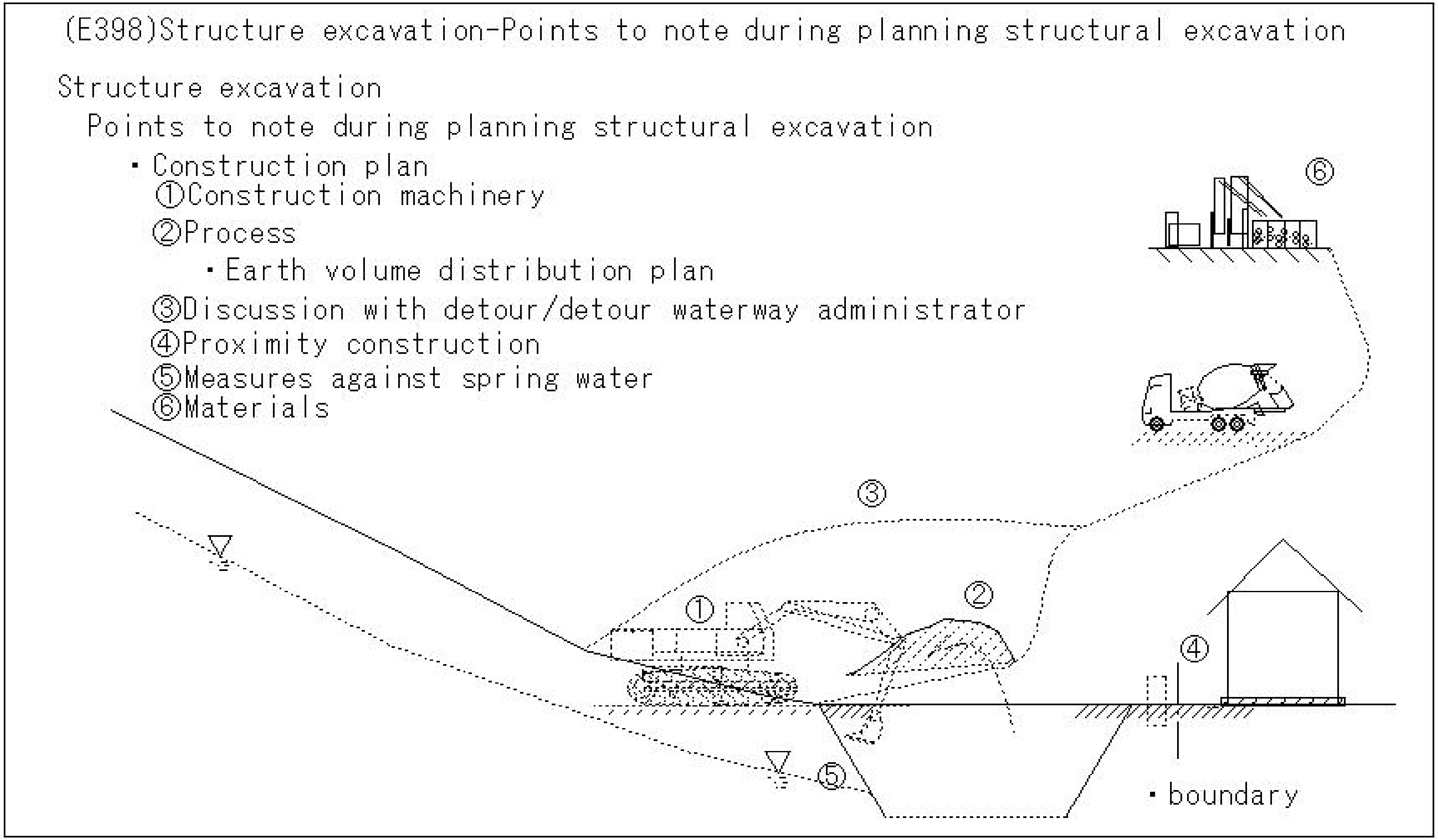
Structure excavation

Points to note during planning structural excavation

・preliminary survey



(E398)Structure excavation-Points to note during planning structural excavation



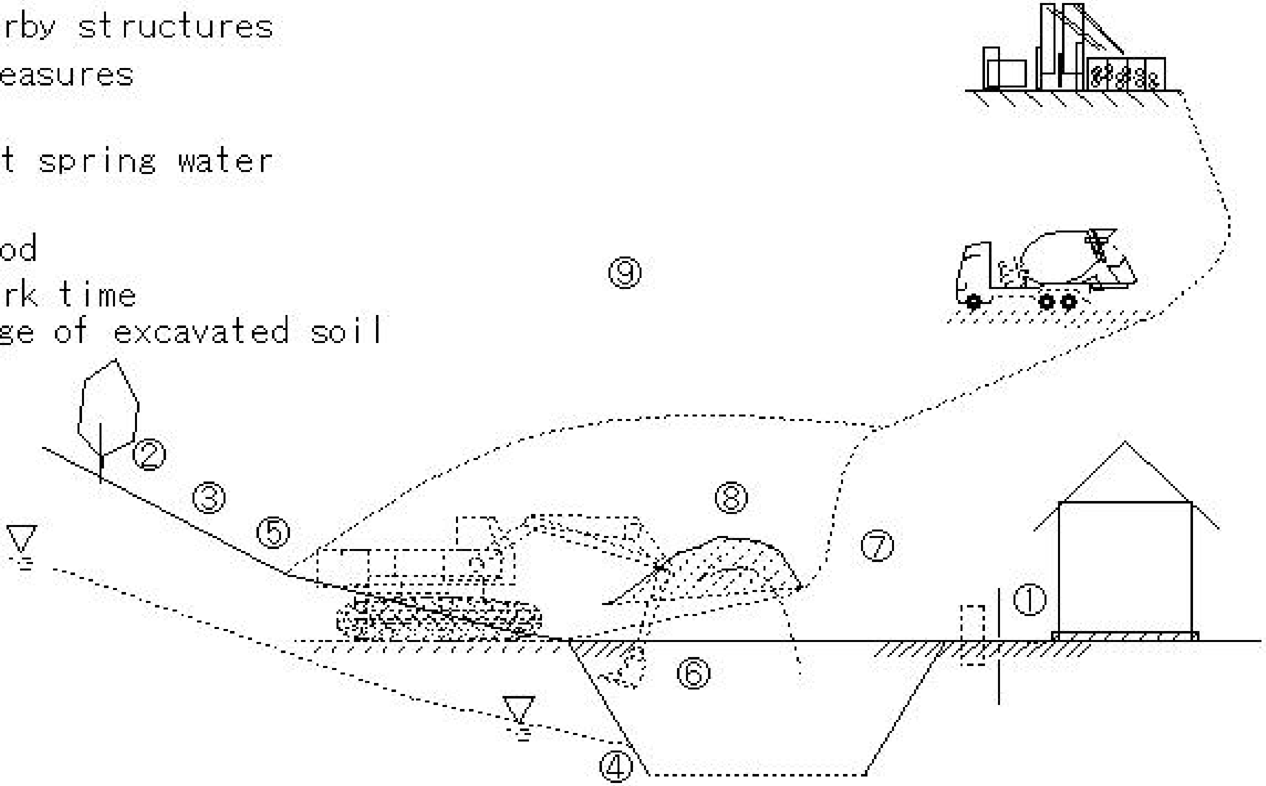
(E399)Structure excavation-Points to note During construction

(E399)Structure excavation-Points to note During construction

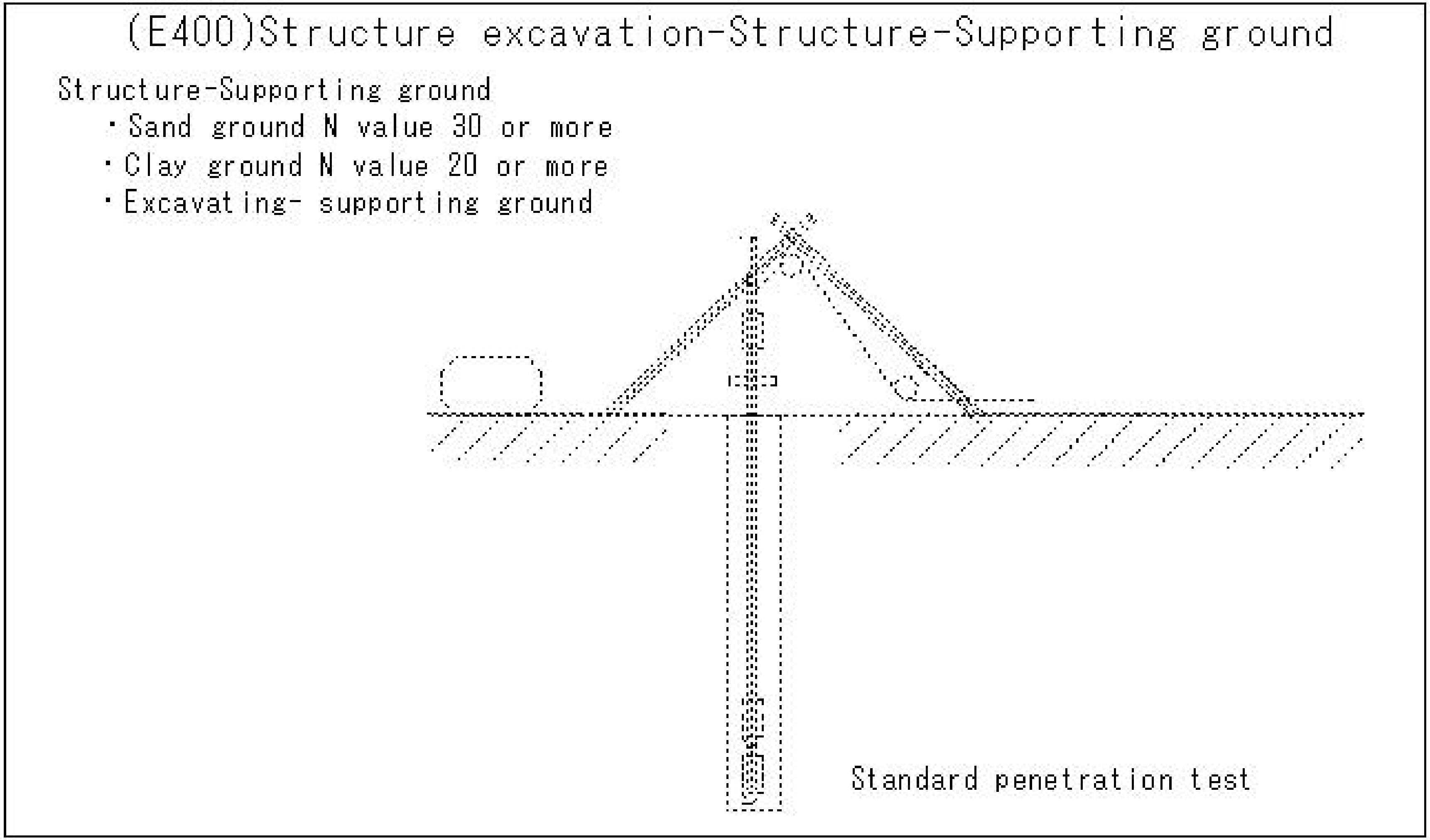
Structure excavation

Points to note During construction

①Mutation of nearby structures
②Environmental measures
③Slope stability
④Measures against spring water
⑤Rainwater flow
⑥Excavating method
⑦Construction work time
⑧Temporary storage of excavated soil
⑨Safety measure



(E400)Structure excavation-Structure-Supporting ground



(E401)Structure excavation-Structure - Excavation slope gradient- Soil quality

(E401)Structure excavation-Structure - Excavation slope gradient- Soil quality

Structure - Excavation slope - Soil quality

- Slope open cut method
- Excavation slope gradient
- Soil quality, excavation height, slope gradient

1 Types of geological formations

1-1 Bedrock Hard clay

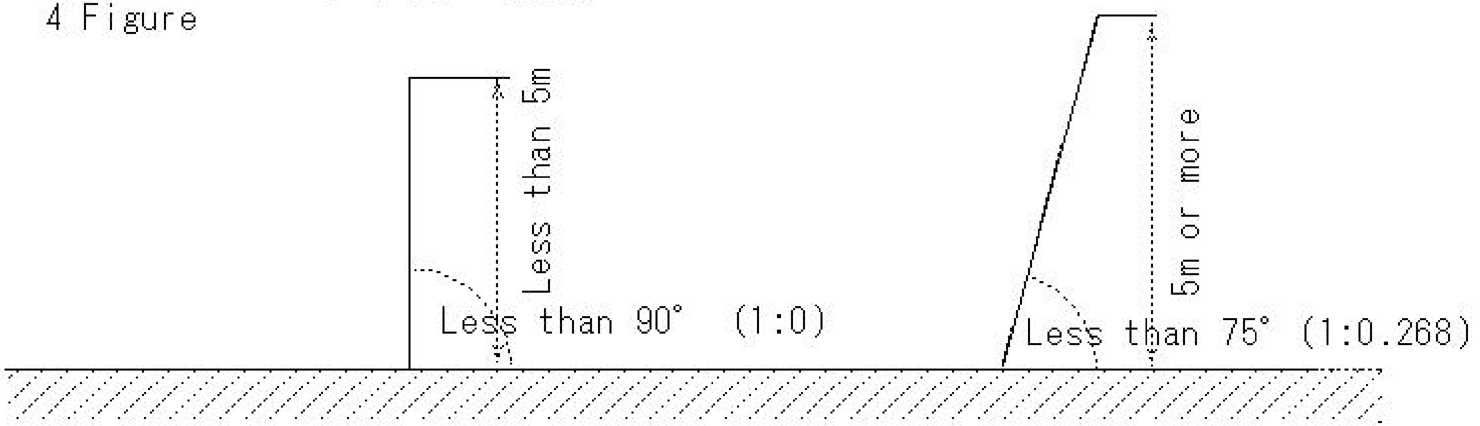
2 Height of excavation surface

2-1 Less than 5m　　5m or more

3 Slope gradient of excavation surface

3-1 90° (1:0)

4 Figure



(E402)Structure excavation-Structure - Excavation slope gradient- Soil quality

(E402)Structure excavation-Structure - Excavation slope gradient- Soil quality

Structure - Excavation slope - Soil quality

- Slope open cut method
- Excavation slope gradient
- Soil quality, excavation height, slope gradient

1 Types of geological formations

1-2 Others

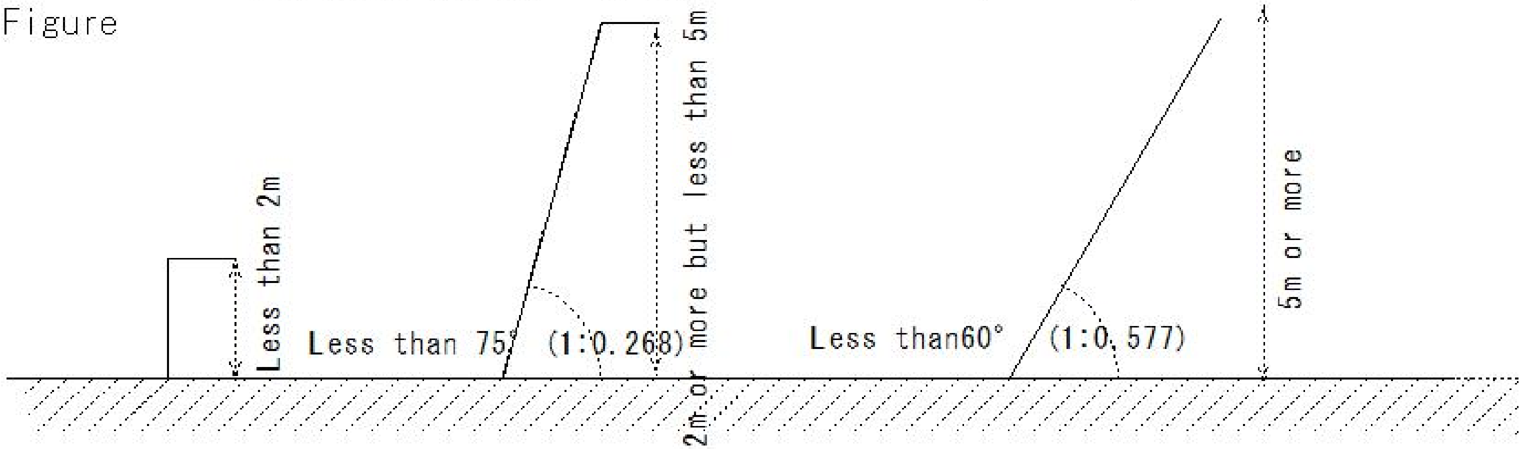
2 Height of excavation surface

2-2 ・ Less than 2m ・2m or more but less than 5m ・5m or more

3 Slope gradient of excavation surface

3-2 Less than90° (1:0) Less than75° (1:0.268) Less than60° (1:0.577)

4 Figure



(E403)Structure excavation-Structure - Excavation slope gradient- Soil quality

(E403)Structure excavation-Structure - Excavation slope gradient- Soil quality

Structure - Excavation slope - Soil quality

- Slope open cut method
- Excavation slope gradient
- Soil quality, excavation height, slope gradient

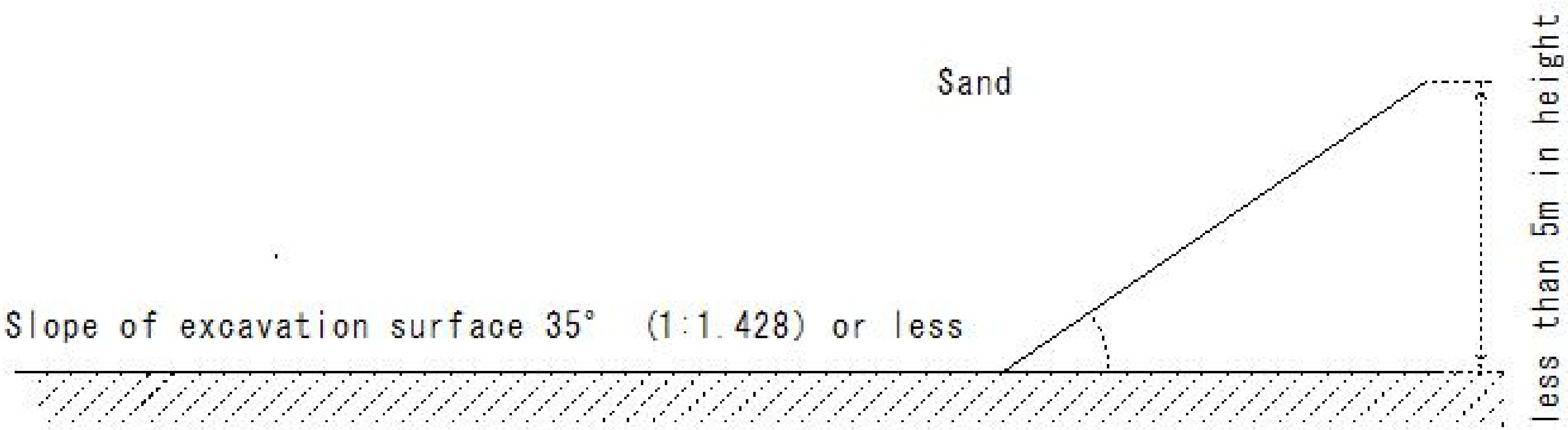
1 Types of geological formations

1-3 Sand

2 Height of excavation surface　　3 Slope gradient of excavation surface

2-3 Slope of excavation surface 35° (1:1.428) or less　　or less than 5m in height

4 Figure



(E404)Structure excavation-Structure - Excavation slope gradient- Soil quality

(E404)Structure excavation-Structure - Excavation slope gradient- Soil quality

Structure - Excavation slope - Soil quality

- Slope open cut method
- Excavation slope gradient
- Soil quality, excavation height, slope gradient

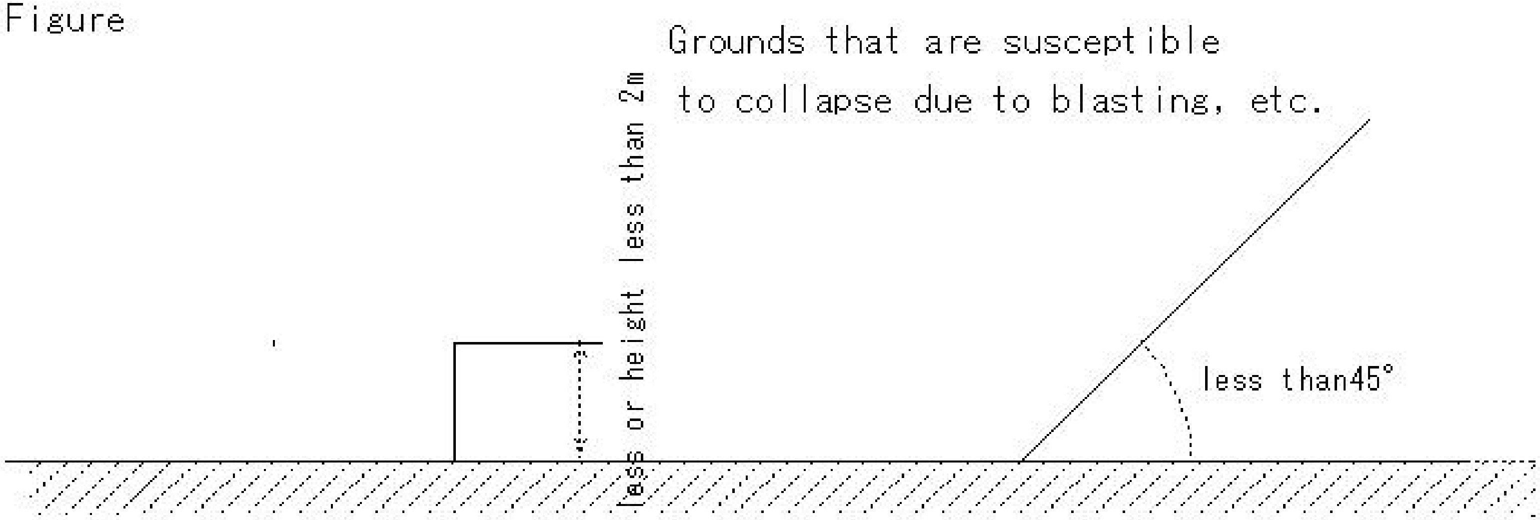
1 Types of geological formations

1-4 Grounds that are susceptible to collapse due to blasting, etc.

2 Height of excavation surface   3 Slope gradient of excavation surface

2-4 Excavation surface slope 45° (1:1) or less or height less than 2m

4 Figure



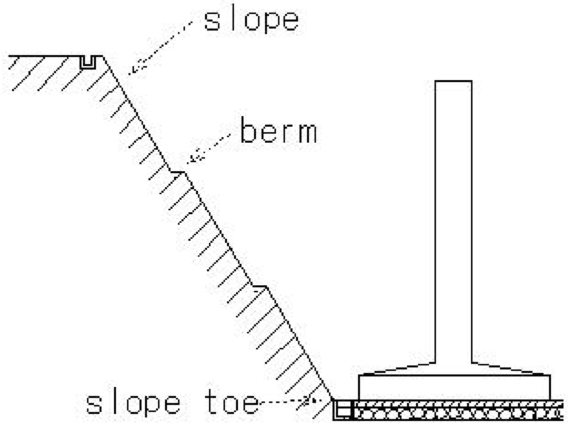
(E405)Structure excavation-Slope open cut method

(E405)Structure excavation-Slope open cut method

Structure - Excavation slope - Soil quality

- Slope open cut method
- Excavation slope gradient
- Soil quality, excavation height, slope gradient

- Deep excavation
- Establish a berm
- Provide berms every 5-10m in height



(E406)Structure excavation-Structures - Excavation machine selection

(E406)Structure excavation-Structures - Excavation machine selection

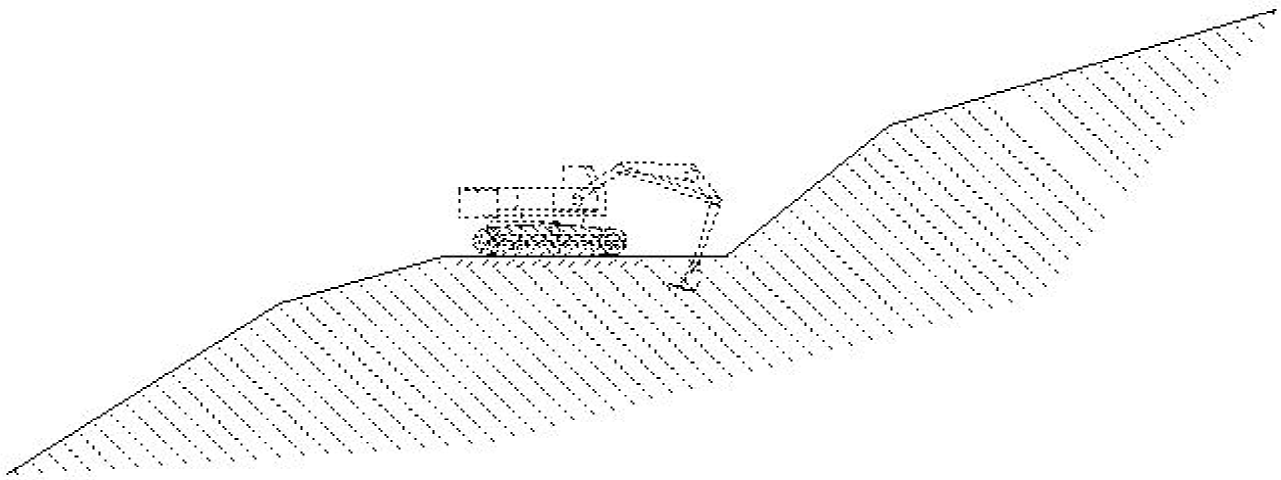
Structures - Excavation machine selection

・Mechanical excavation - points to consider

1 Width (yards)

2 Height: Can the machine rise?

3 Amount (excavated soil amount length)

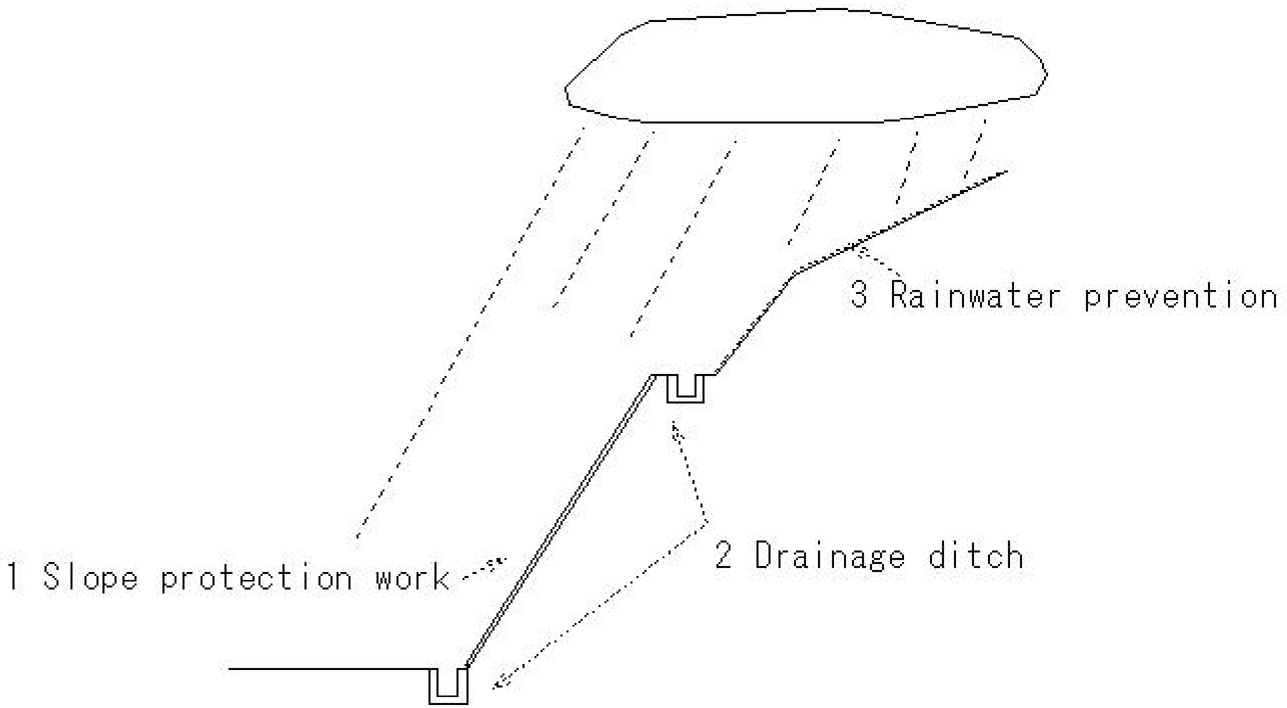


(E407)Structure excavation- Slope protection work

(E407)Structure excavation- Slope protection work

Structures - Points to note during excavating

・Considerations regarding slope



(E408)Structure excavation-Structures - Excavation machine selection-Points to note during excavating

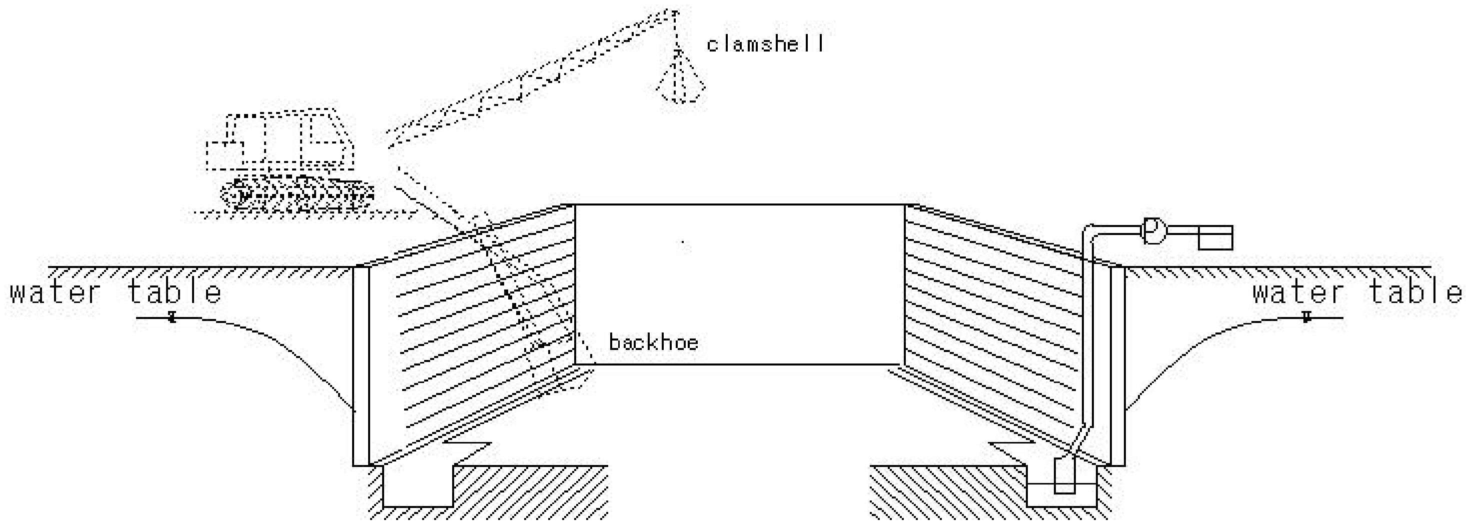
(E408)Structure excavation-Structures - Excavation machine selection-Points to note during excavating

Structures - Points to note during excavating

· The excavation method appropriate

1. Lowering the groundwater level below the excavation level

Avoid excavating in muddy water

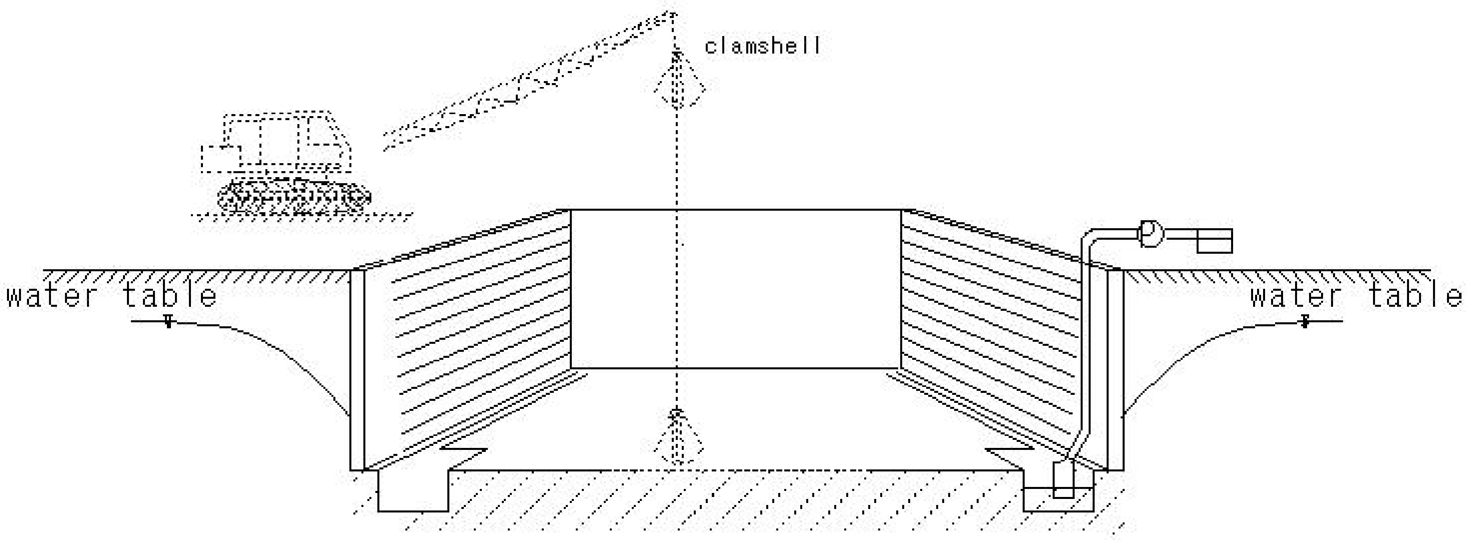


(E409)Structure excavation-Structures - Excavation machine selection-Points to note during excavating

(E409)Structure excavation-Structures - Excavation machine selection-Points to note during excavating

Structures - Points to note during excavating

- Is the excavation method appropriate?
- During excavating mechanically, do not drop the clamshell and stir the foundation ground.

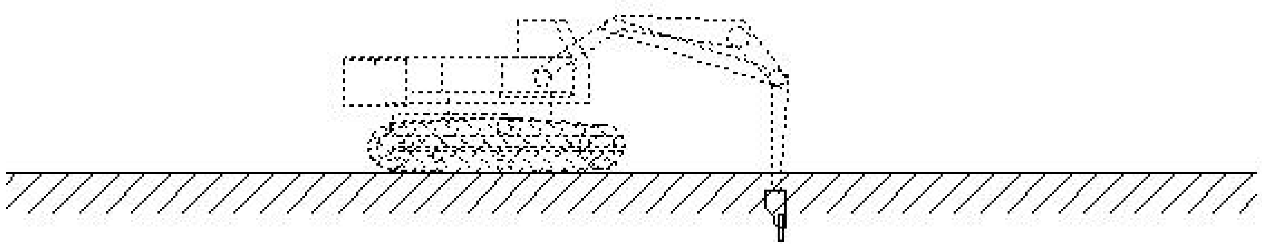


(E410)Structure excavation-Structures - Excavation machine selection-Points to note during excavating

(E410)Structure excavation-Structures - Excavation machine selection-Points to note during excavating

Structures - Points to note during excavating

- Is the excavation method appropriate?
- Consider large breakers for rock excavation



(E411)Structure excavation-Boiling

(E411)Structure excavation-Boiling

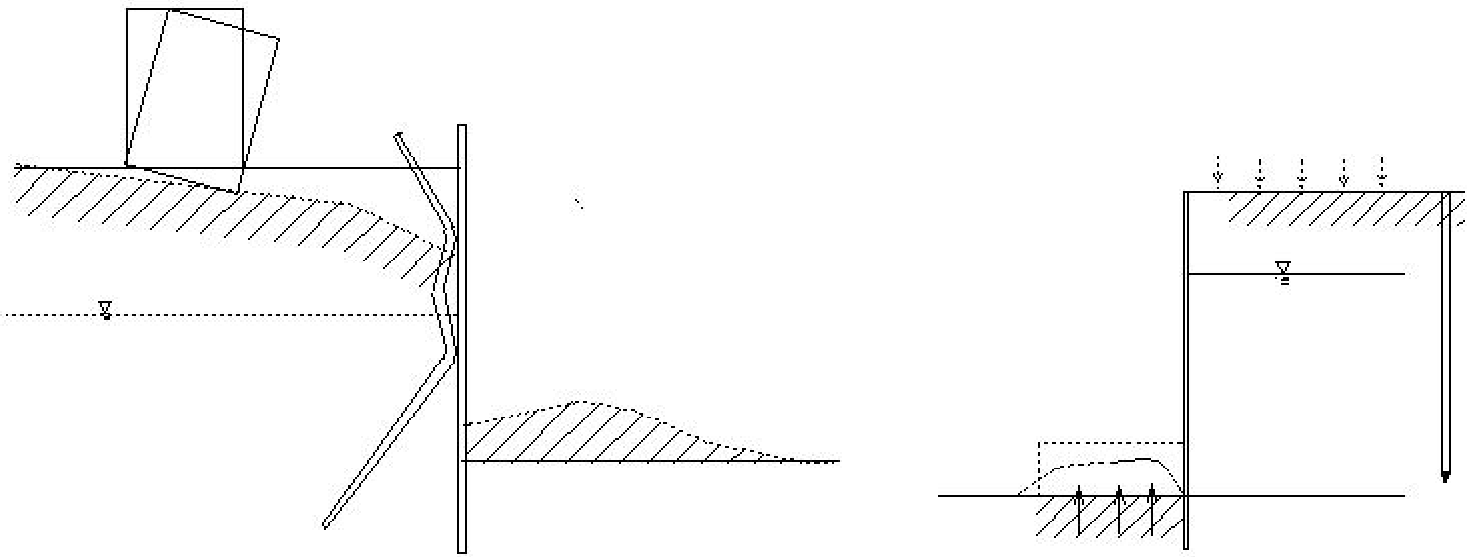
Structures - Points to note during excavating

Is the excavation method appropriate?

- Boiling-like running water at the bottom of the slope

  Sandy ground

- Stabilization measures: Prevent the groundwater level from rising above the bottom of the excavation



Boiling

(E412)Structure excavation- Piping phenomenon

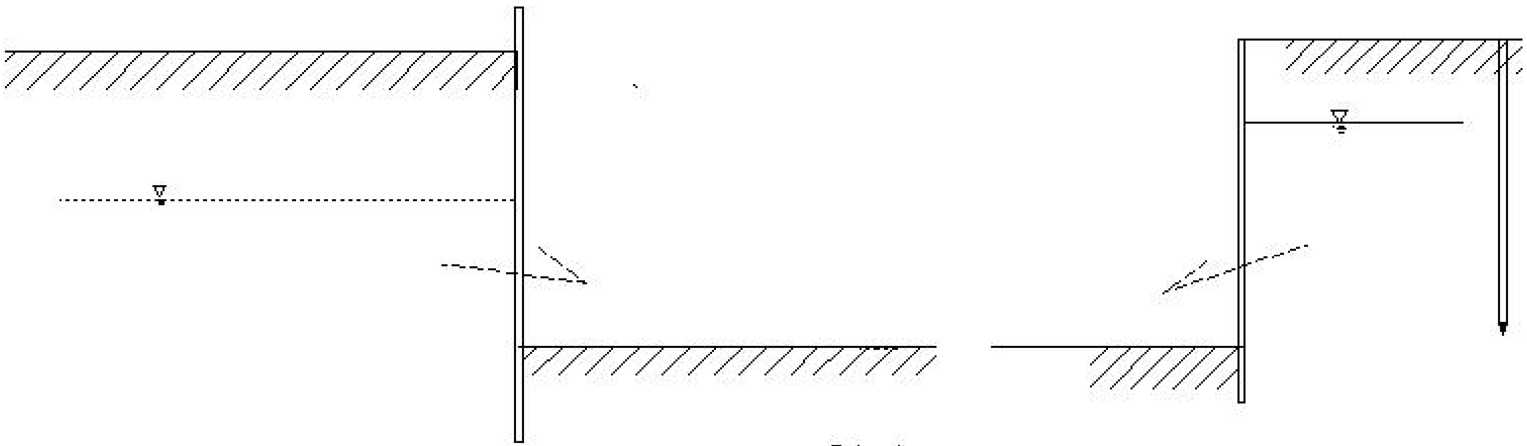
(E412)Structure excavation- Piping phenomenon

Structures - Points to note during excavating

- Is the excavation method appropriate?

Piping phenomenon

- Stabilization measures: Prevent the groundwater level from rising above the bottom of the excavation



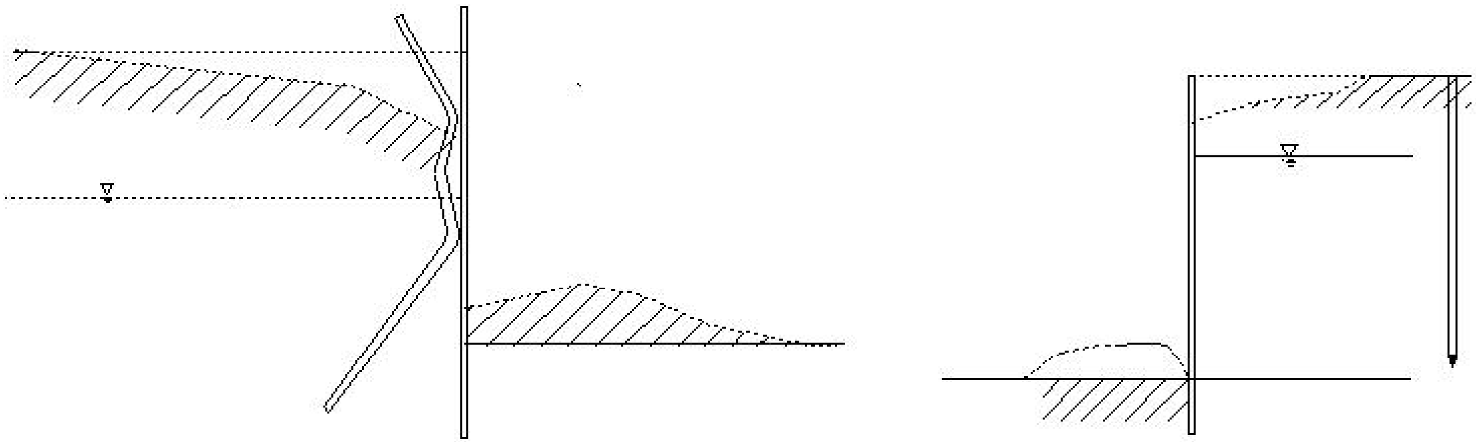
Piping

(E413)Structure excavation-Earth retaining wall

(E413)Structure excavation-Earth retaining wall

Structures - Points to note during excavating

- Is the excavation method appropriate?



- Monitoring of deformation of earth retaining walls

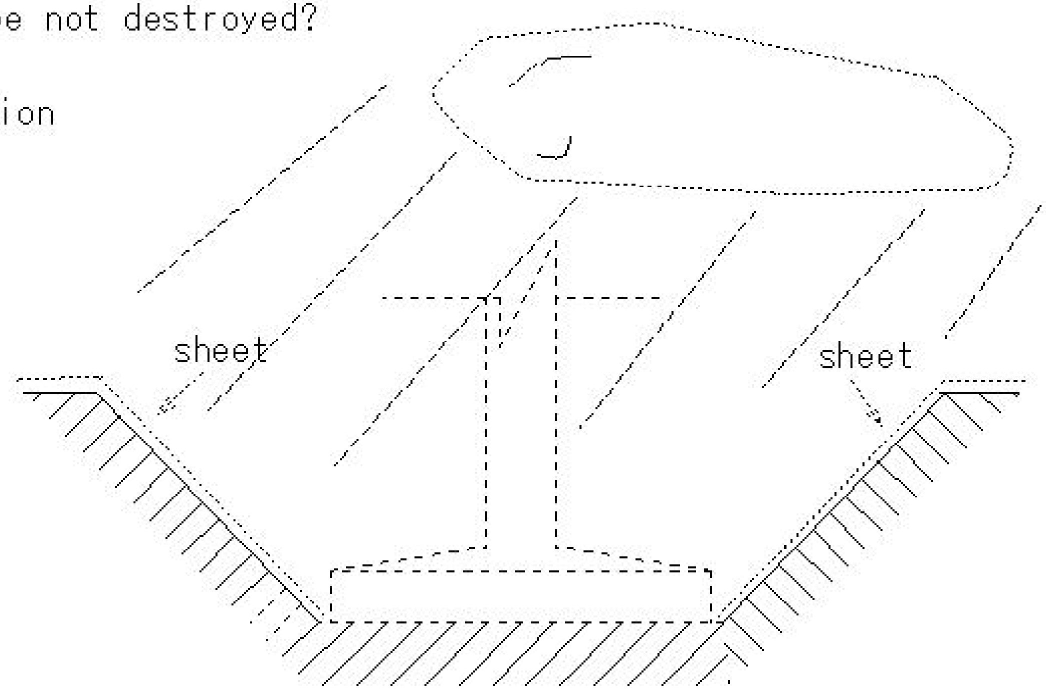
(E414)Structure excavation-Slope protection

(E414)Structure excavation-Slope protection

Structures - Points to note during excavating

- Is the excavation method appropriate?
- Is the slope not destroyed?

Slope protection



Slope open cut

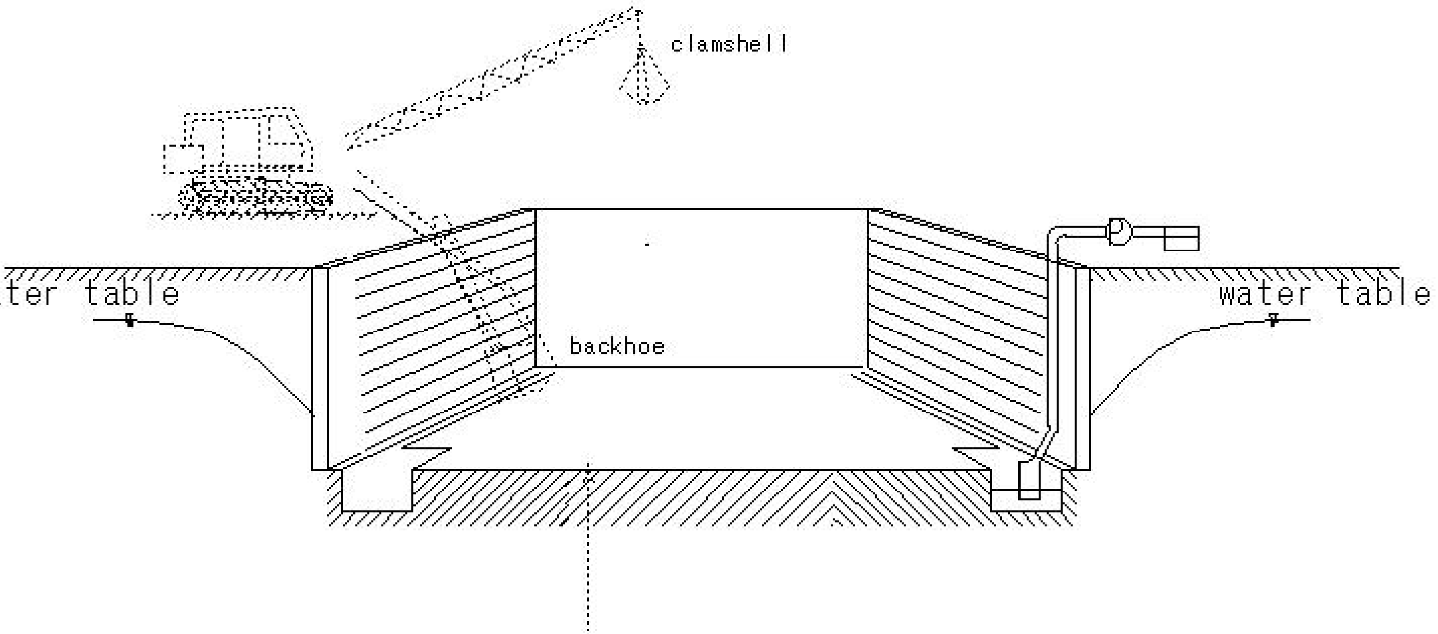
- In case of rain, is the slope covered with a sheet?

(E415)Structure excavation-bearing ground

(E415)Structure excavation-bearing ground

Structures - Points to note during excavating

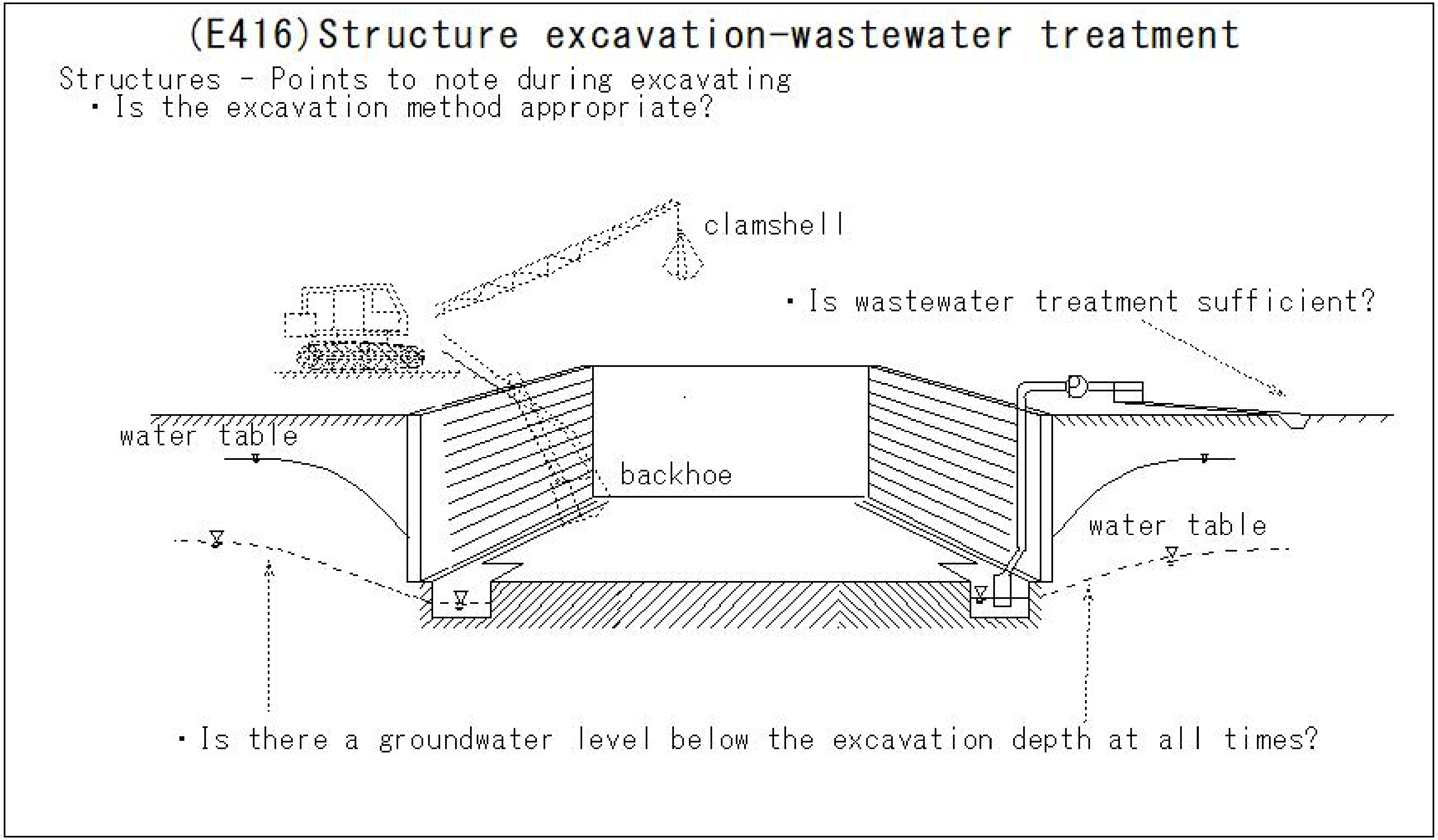
・Is the excavation method appropriate?



・Is the bearing ground not disturbed?

・Excavating too much?

(E416)Structure excavation-wastewater treatment



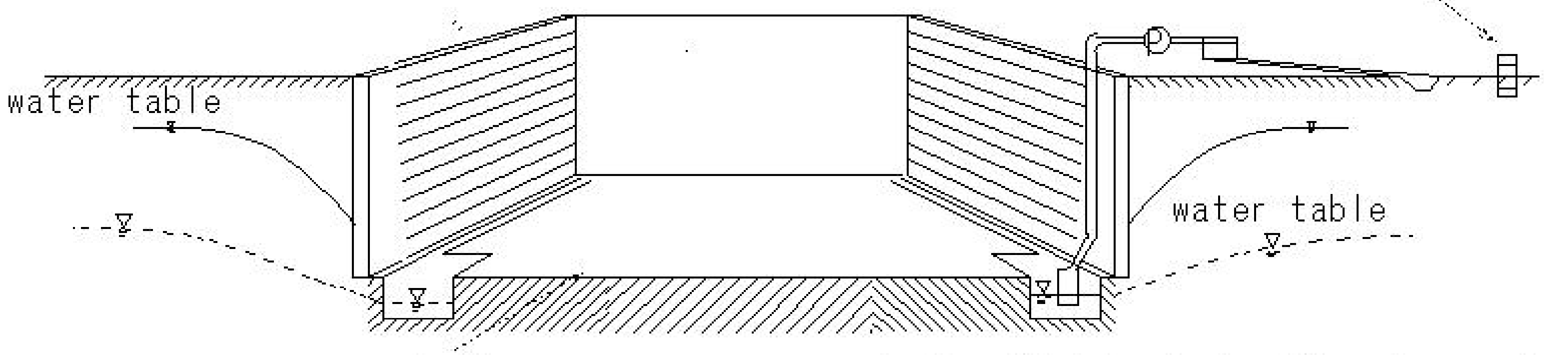
(E417)Structure excavation-flooring surface

(E417)Structure excavation-flooring surface

Structures - Points to note during excavating

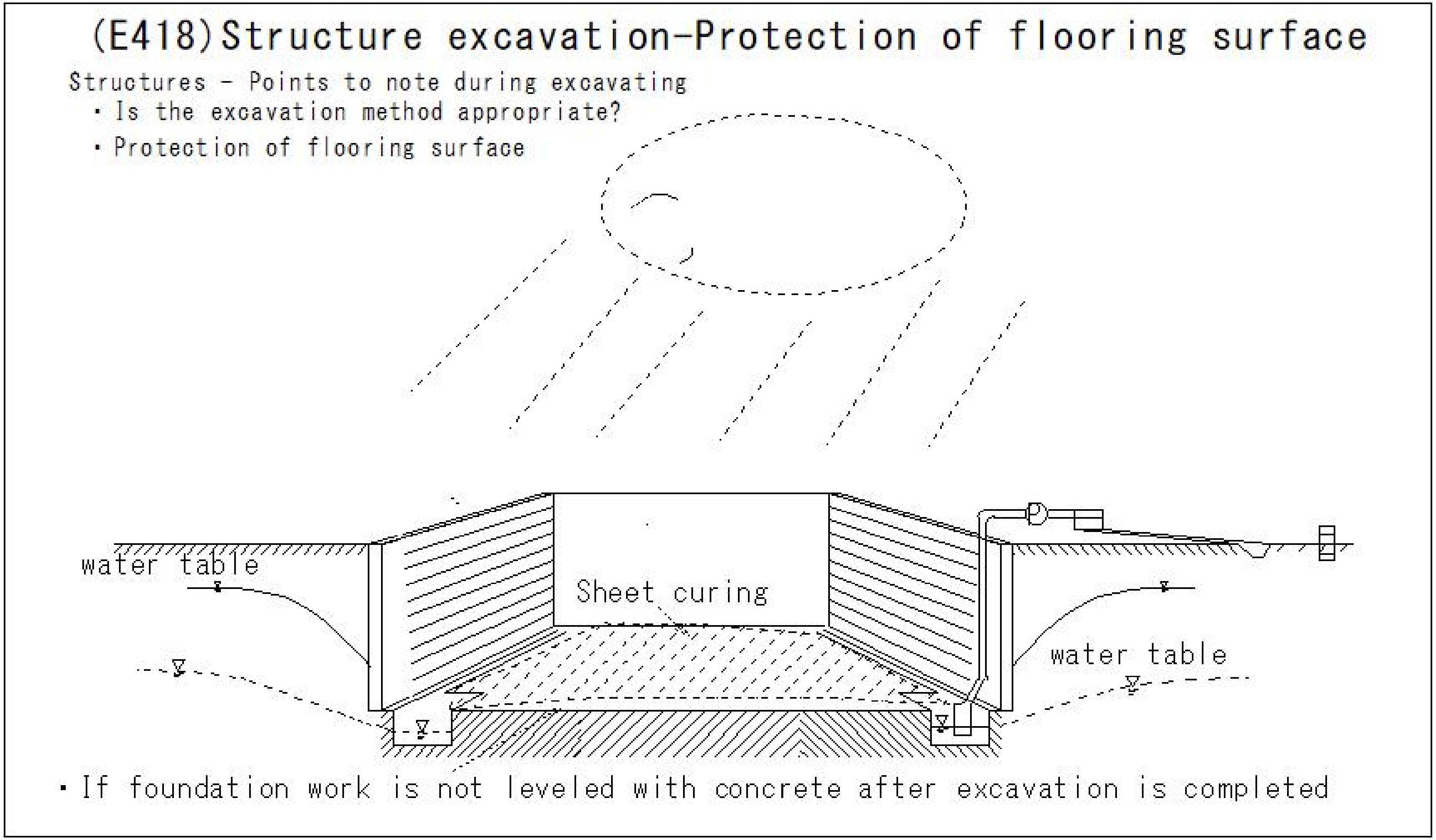
- Is the excavation method appropriate?

- Do you have a temporary B.M.



- Is there any unevenness in the finish of the flooring surface?

(E418)Structure excavation-Protection of flooring surface

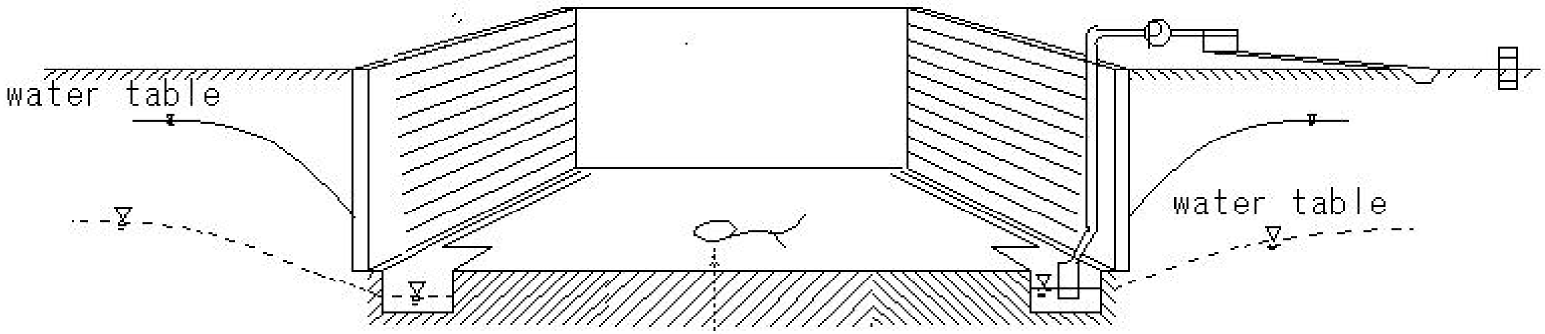


(E419)Structure excavation-Construction of flooring surface

(E419)Structure excavation-Construction of flooring surface

Structures - Points to note during excavating

- Is the excavation method appropriate?
- Floating stones - remove cracked parts



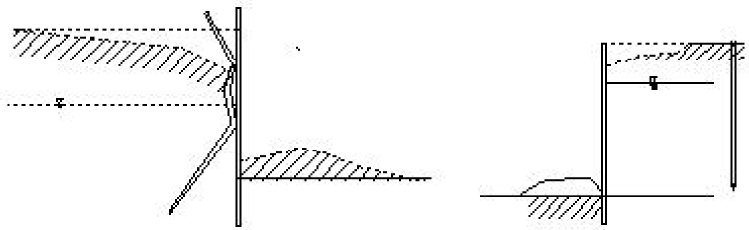
- Pumice-stones - remove cracked parts
- Backfill with concrete
  - Construction of flooring surface

(E420)Structure excavation- earth retaining works

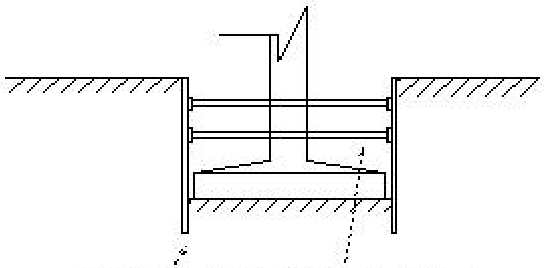
(E420)Structure excavation- earth retaining works

Structures - Points to note during excavating

- Is the excavation method appropriate?
  - Heaving Boiling
  - Earth pressure change on the back of the sheet pile
  - Measure deformation of earth retaining works
  - Bottom surface of excavation - Heaving Boiling
- Soft clay layer
  - Backward sediment flow ・Surrounding situation
  - Soil quality, groundwater, ground, is there any swell?
  - Earth retaining piles,beams strut, outdated ?



Heaving Boiling



Earth retaining wall
(Sheet pile + Timbering)

(E421)Structure excavation-Permanent slope

(E421)Structure excavation-Permanent slope

Structures - Points to note during excavating

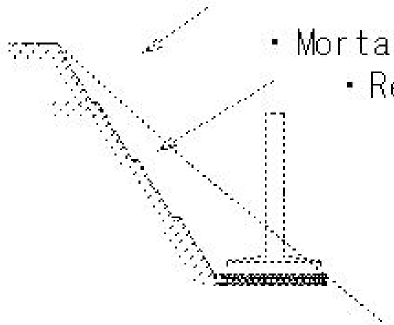
・Permanent slope

・Excavation of structures in mountainous areas

・Permanent slope - consideration of appropriate construction methods

・Mortar spraying

・Reinforced earthwork method



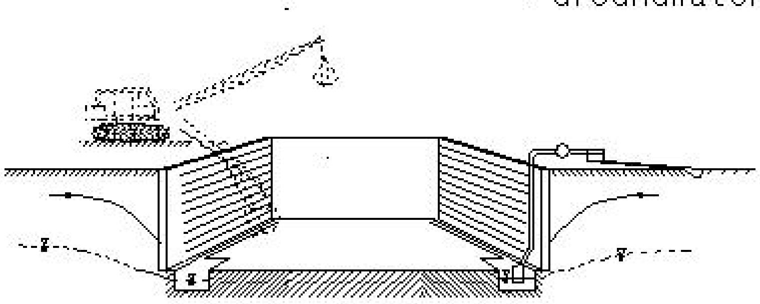
・Structure excavation slope

(E422)Structure excavation- Groundwater investigation

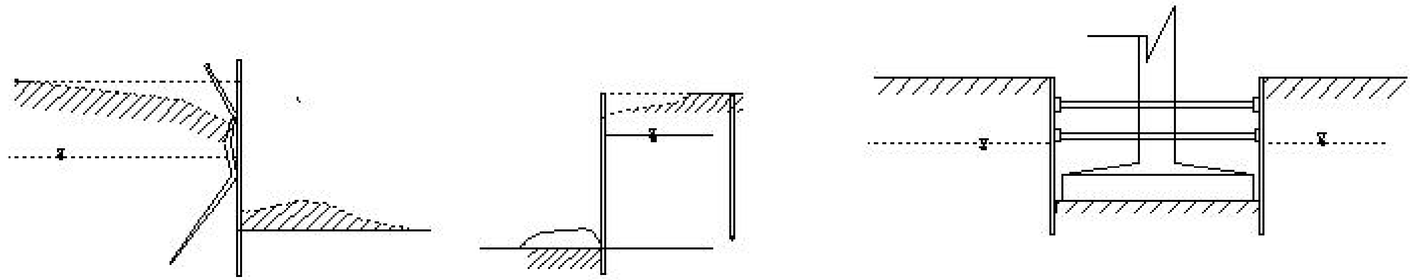
(E422)Structure excavation- Groundwater investigation

・Structures - Points to note during excavating

・Groundwater investigation



・Understanding the groundwater situation



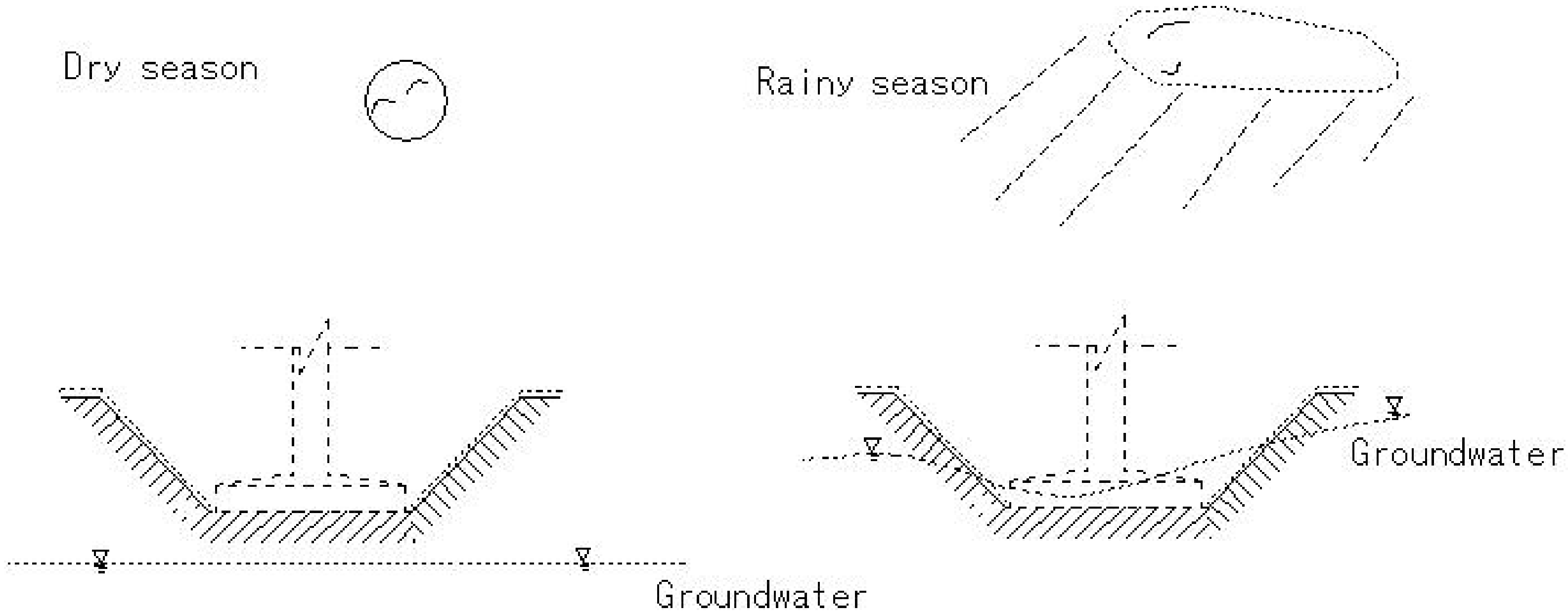
・Heaving destruction

・Quicksand phenomenon

(E423)Structure excavation- Construction period

(E423)Structure excavation- Construction period

- Points to note during excavating-Groundwater investigation
  - Structures - Points to note during excavating
    - Groundwater investigation
    - Construction period - consideration
      - Dry season - groundwater level - low
      - Rainy season - groundwater - high



(E424)Structure excavation-Groundwater investigation-Drainage method plan

(E424)Structure excavation-Groundwater investigation-Drainage method plan

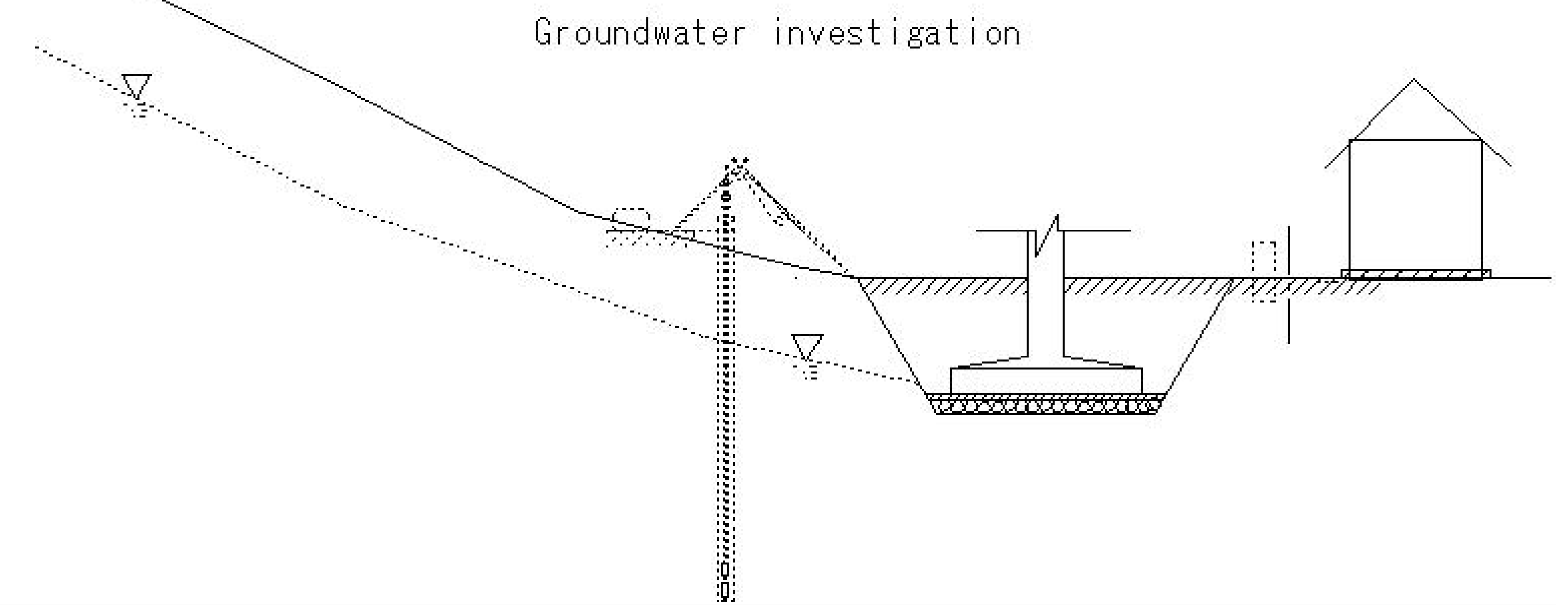
Structures - Points to note during excavating

・Is the excavation method appropriate?

・Groundwater investigation

・Drainage method plan

1.Site/surroundings: soil quality, permeability, stratification status



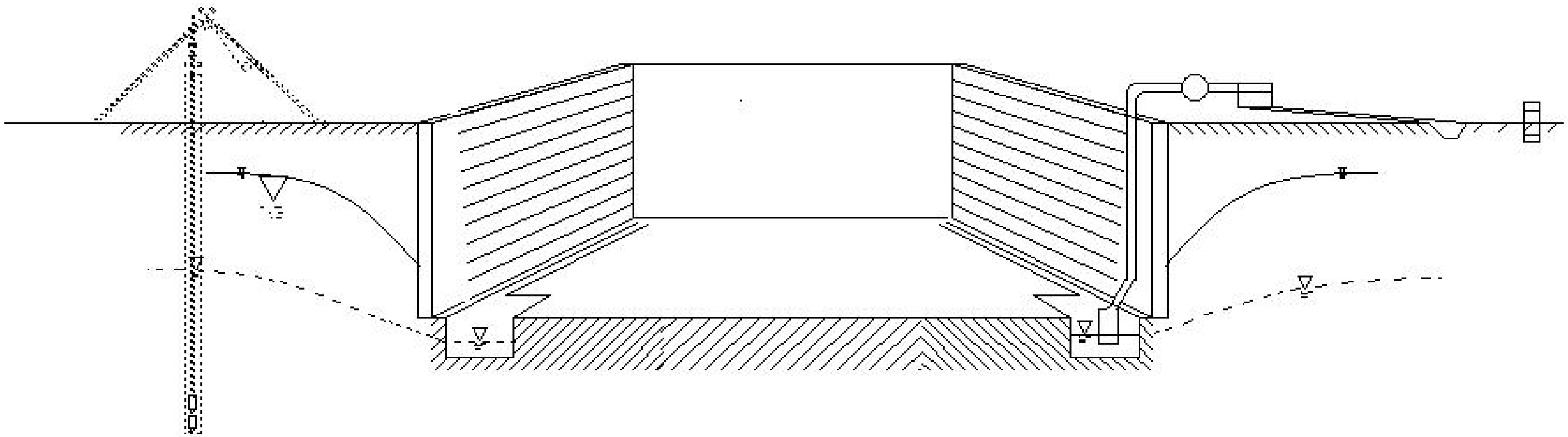
(E425)Structure excavation-Groundwater investigation

(E425)Structure excavation-Groundwater investigation

Structures - Points to note during excavating

- Is the excavation method appropriate?
- Groundwater investigation
- Drainage method plan

  Groundwater level Amount of groundwater level decline



- Groundwater investigation

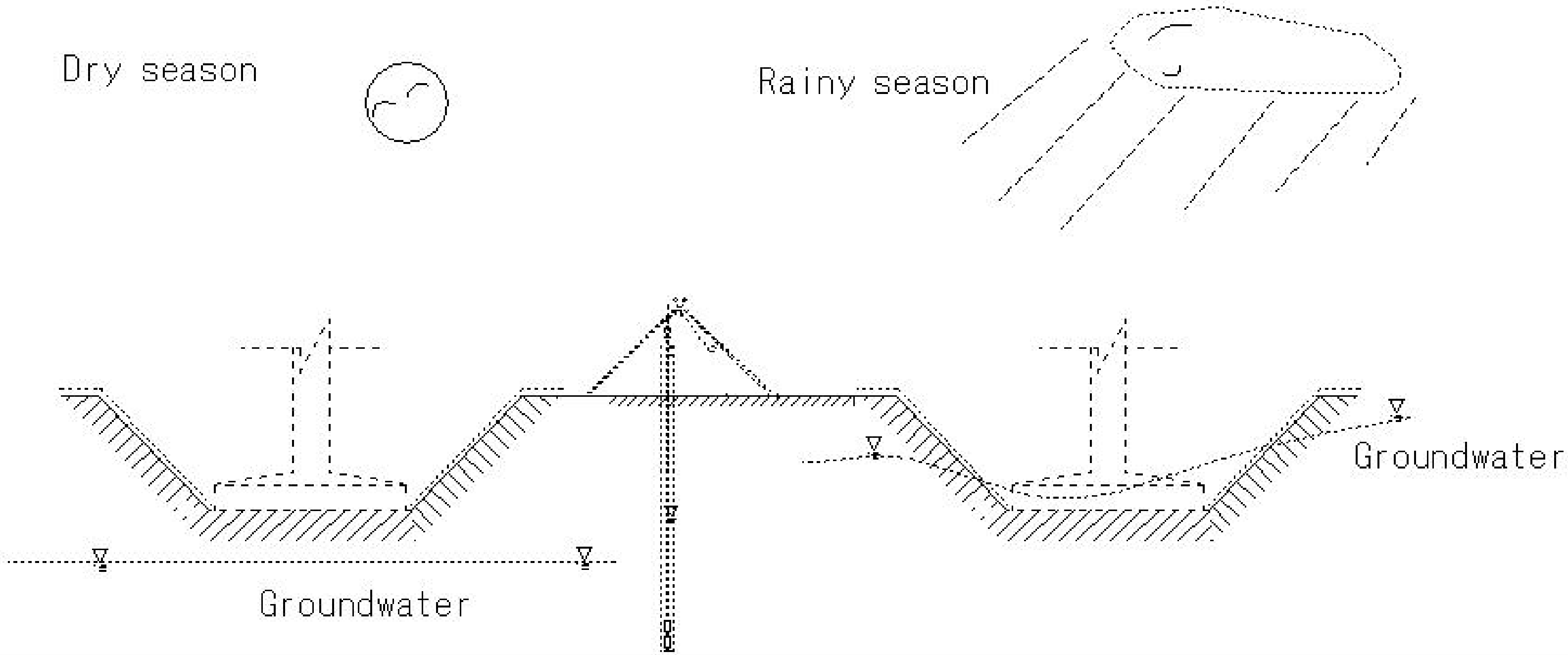
(E426)Structure excavation-Groundwater level decline depending on season and time

(E426)Structure excavation-Groundwater level decline depending on season and time

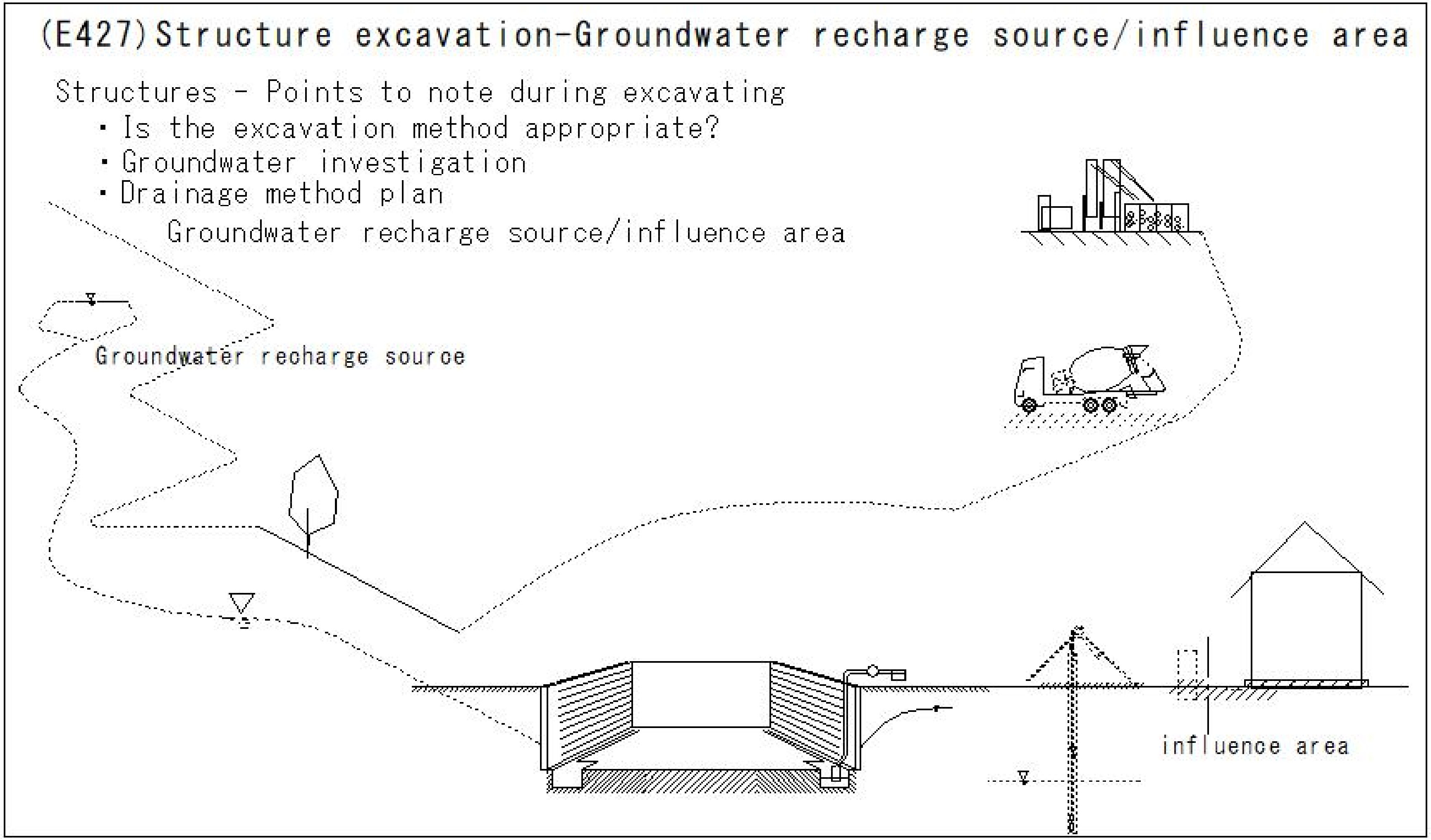
Structures – Points to note during excavating

- Is the excavation method appropriate?
  - Groundwater investigation
  - Drainage method plan

Groundwater level decline depending on season and time



(E427)Structure excavation-Groundwater recharge source/influence area

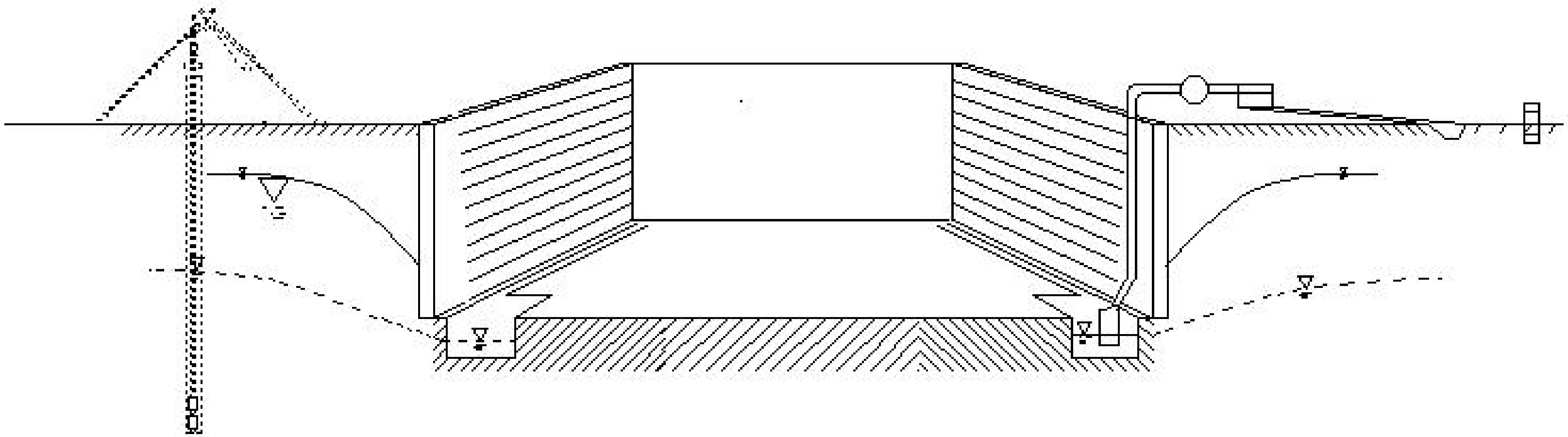


(E428)Structure excavation-Calculation of groundwater decline and spring water amount

(E428)Structure excavation-Calculation of groundwater decline and spring water amount

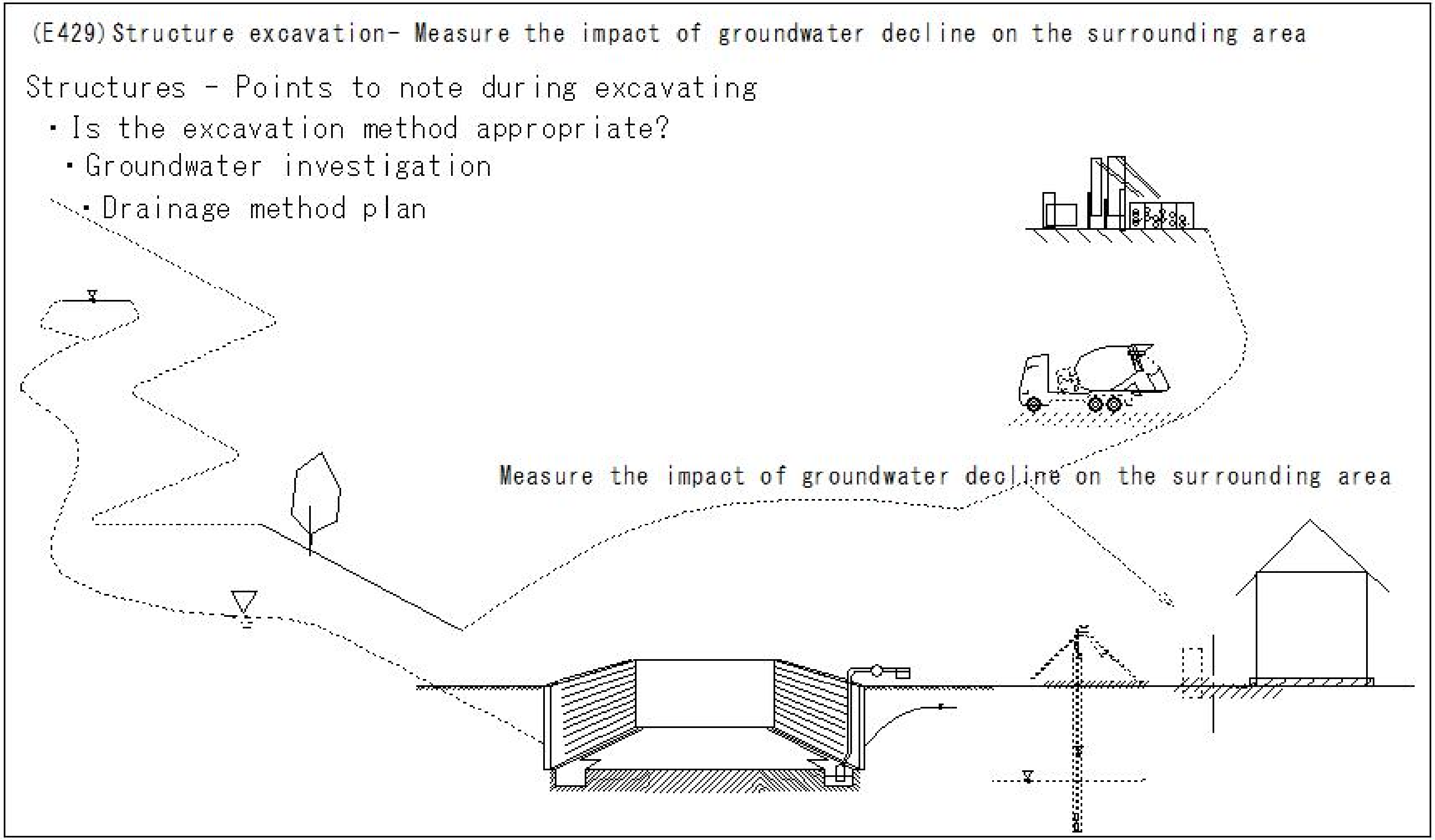
Structures - Points to note during excavating

- Is the excavation method appropriate?
- Groundwater investigation
- Drainage method plan



Calculation of groundwater decline and spring water amount

(E429)Structure excavation- Measure the impact of groundwater decline on the surrounding area

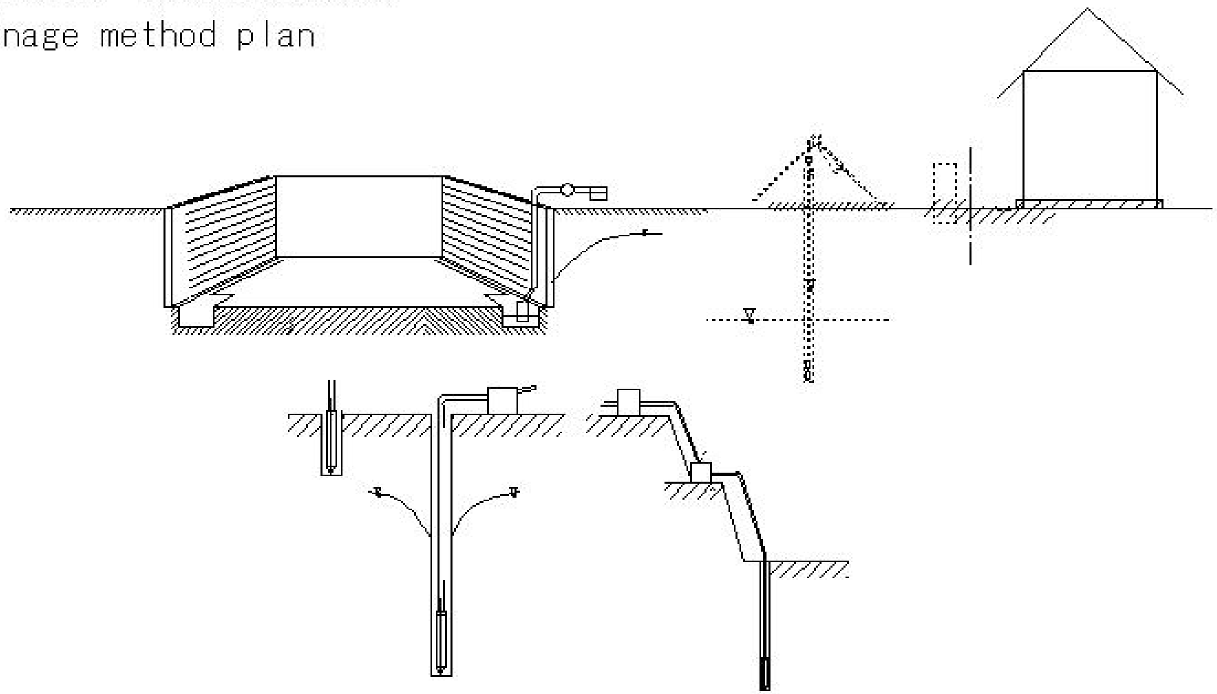


(E430)Structure excavation- Place of installation of drainage equipment Wastewater treatment

(E430)Structure excavation- Place of installation of drainage equipment Wastewater treatment

Structures - Points to note during excavating

- Is the excavation method appropriate?
  - Groundwater investigation
    - Drainage method plan



Place of installation of drainage equipment Wastewater treatment

(E431)Structure excavation-Drainage method

(E431)Structure excavation-Drainage method

Structures - Points to note when excavating

- Is the excavation method appropriate?
  - Drainage method

1 Drainage method

2 Gravity drainage method

4 Shallow sump drainage method

5 Deep well construction method

6. Open・underdrain construction method

3 Forced drainage method

7 Well point construction method

8 Vacuum deep well construction method

9 Electro-percolation method

(E432)Structure excavation-How to check soil bearing capacity

(E432)Structure excavation-How to check soil bearing capacity

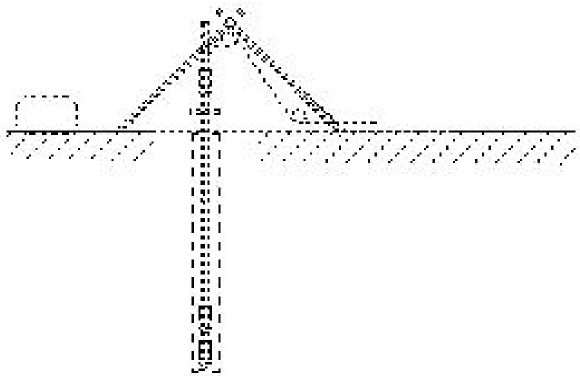
Structures - Points to note during excavating

- Is the excavation during appropriate?
  - How to check soil bearing capacity
    - Confirmation method

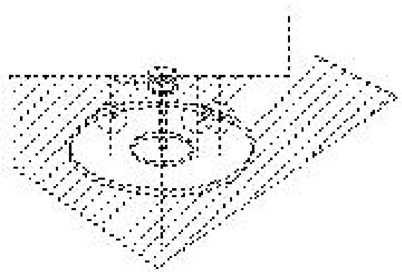
1 Visual confirmation of the geology of the drilling core and the excavated ground

2 Simple N value measurement method

3 Flat plate loading test



N value



Flat plate loading test

(E433)Structure excavation- Replacement of defective soil

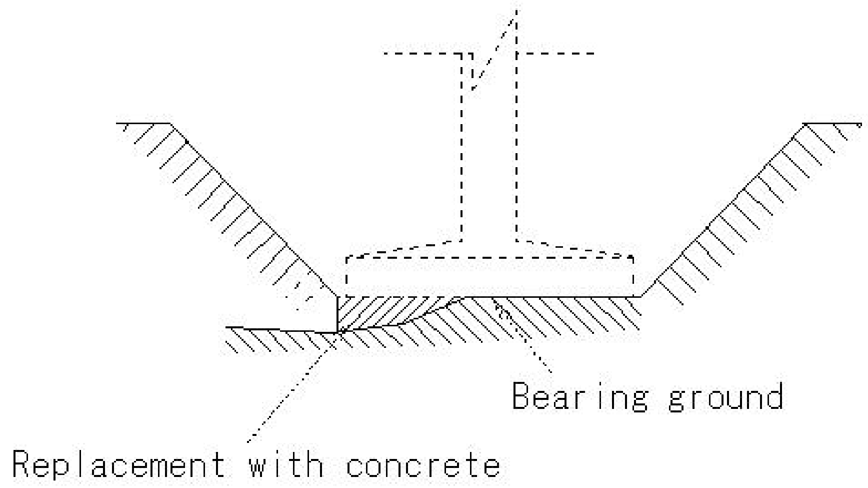
(E433)Structure excavation- Replacement of defective soil

Structures - Points to note during excavating

- Is the excavation during appropriate?
  - Soil bearing capacity - anxiety

    Replacement of defective soil

    Excavate to a good quality support layer

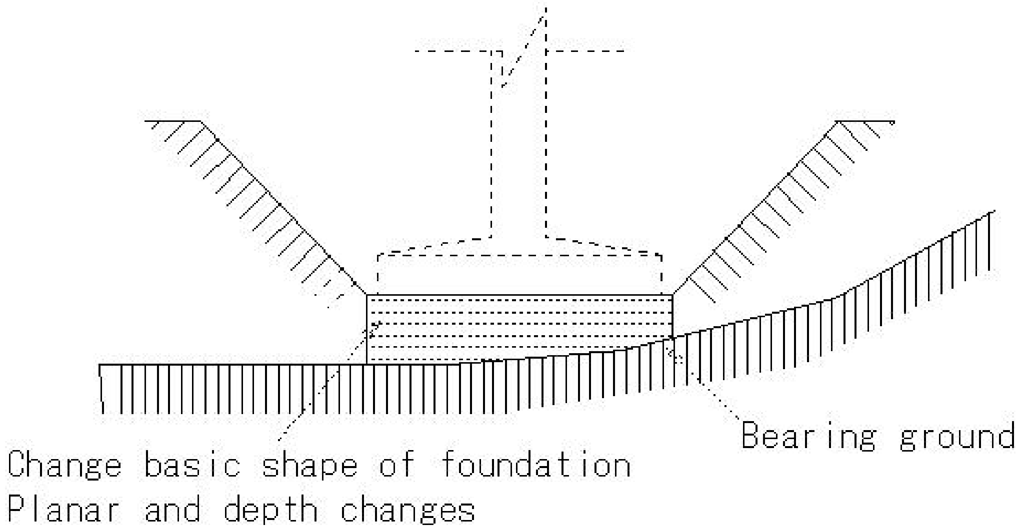


(E434)Structure excavation- Change basic shape of foundation

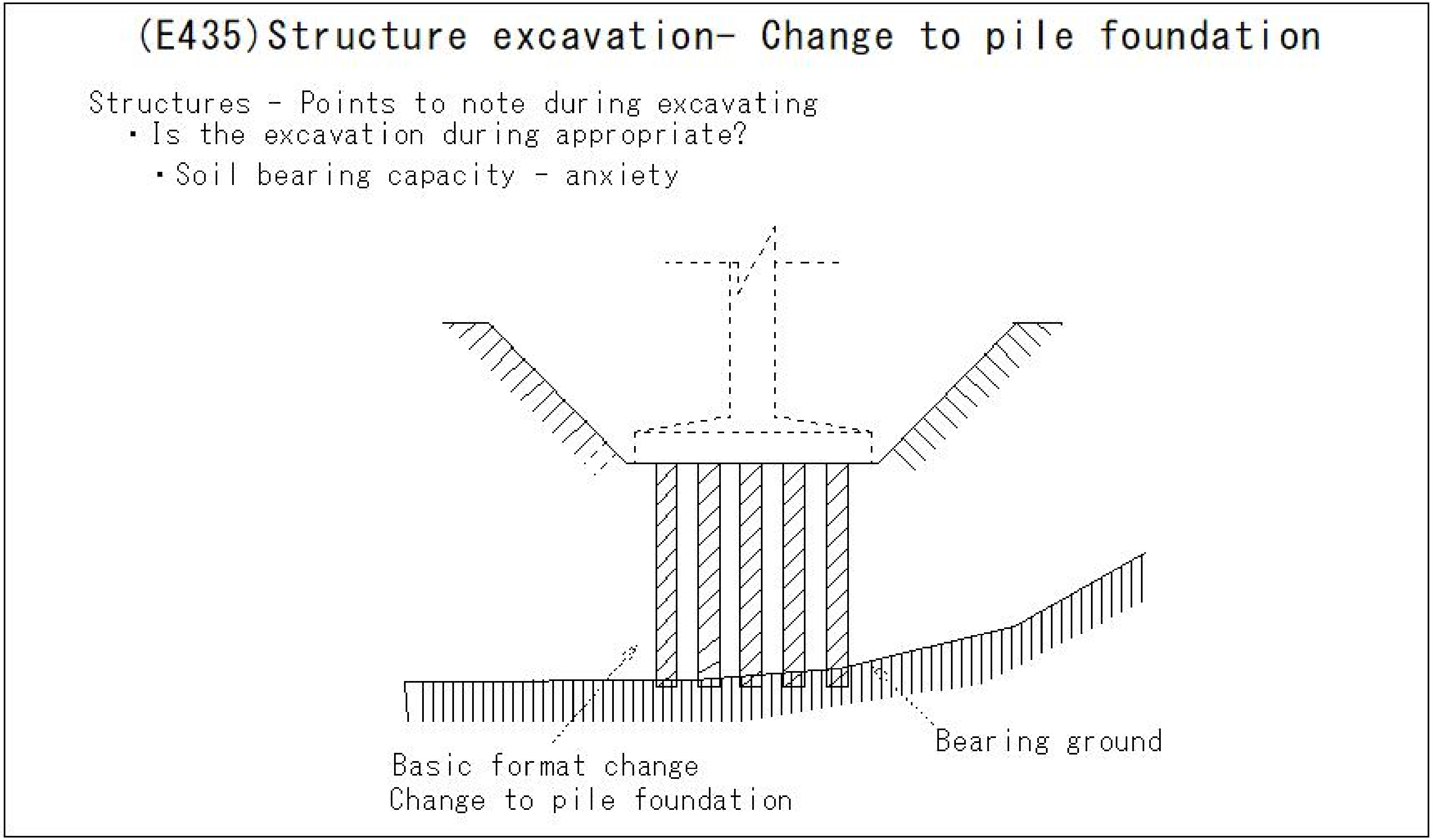
(E434)Structure excavation- Change basic shape of foundation

Structures - Points to note during excavating

- Is the excavation during appropriate?
  - Soil bearing capacity - anxiety



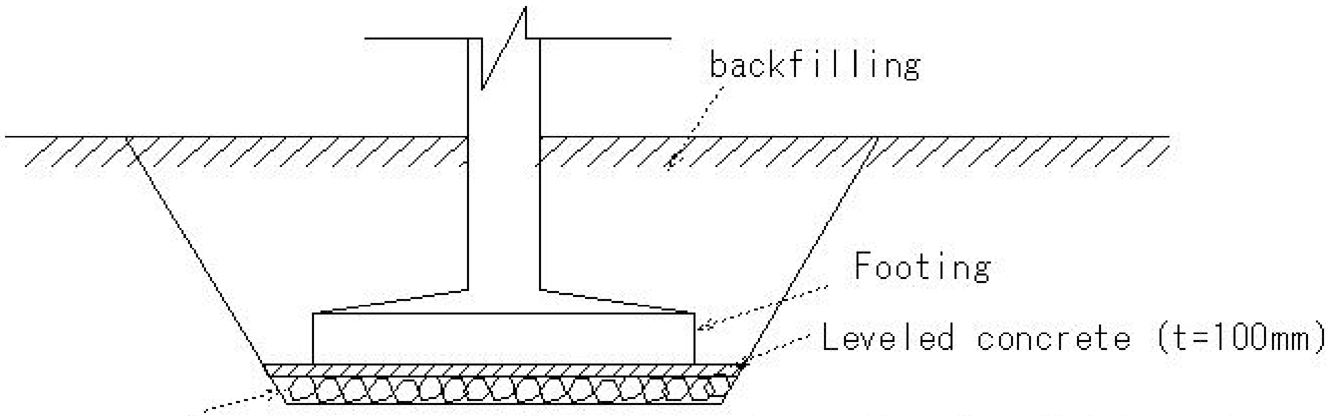
(E435)Structure excavation- Change to pile foundation



(E436)Structure excavation- cobble stone construction method

(E436)Structure excavation- cobble stone construction method

Structures - Points to note during excavating
- Is the excavation during appropriate?
  - Soil bearing capacity - anxiety



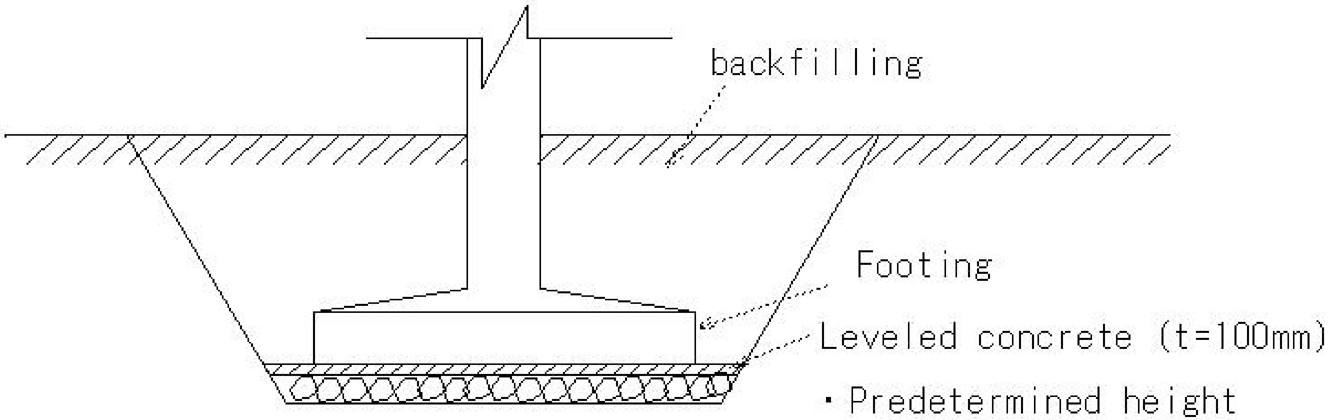
- Foundation material: cobble stone, diameter 10-15cm
- Unscreened gravel
- cobble stone construction method

1 filling stone
2 Crushed stone/gravel/Unscreened gravel
3 Small rammer - tamping

(E437)Structure excavation-Leveled concrete (t=100mm)

(E437)Structure excavation-Leveled concrete (t=100mm)

Structures - Points to note during excavating
- Is the excavation during appropriate?
  - Soil bearing capacity - anxiety



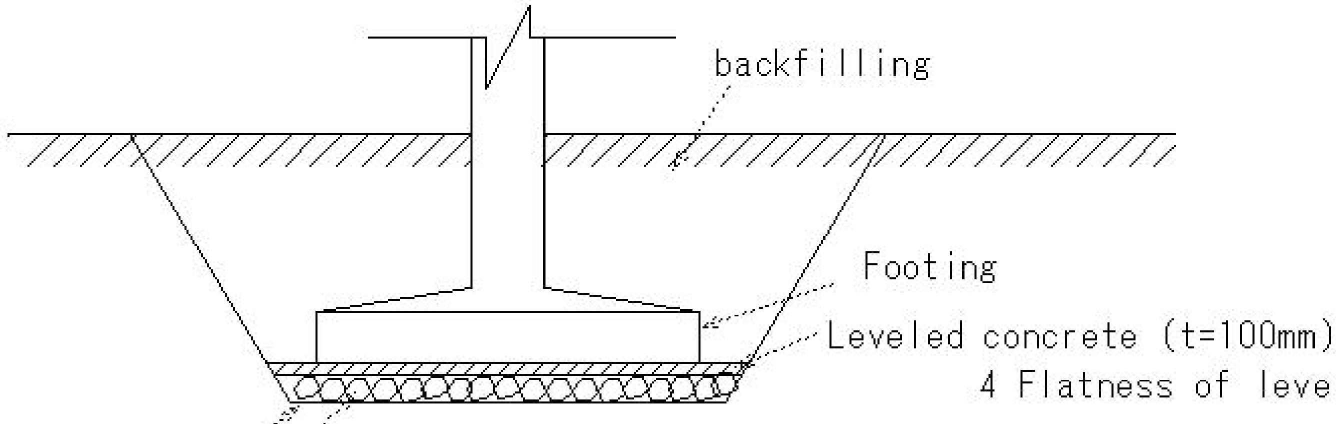
- Predetermined height
- Horizontal finish
- Careful pouring

(E438)Structure excavation-Check points for foundation bottom surface treatment

(E438)Structure excavation-Check points for foundation bottom surface treatment

Structures - Points to note during excavating

- Is the excavation during appropriate?
- Check points for foundation bottom surface treatment



4 Flatness of leveled concrete

2 Checking the plane dimensions and thickness of the cobble stone

3 Is the grain size and compaction of the cobble stone sufficient?

1 Is the foundation ground shaping appropriate?

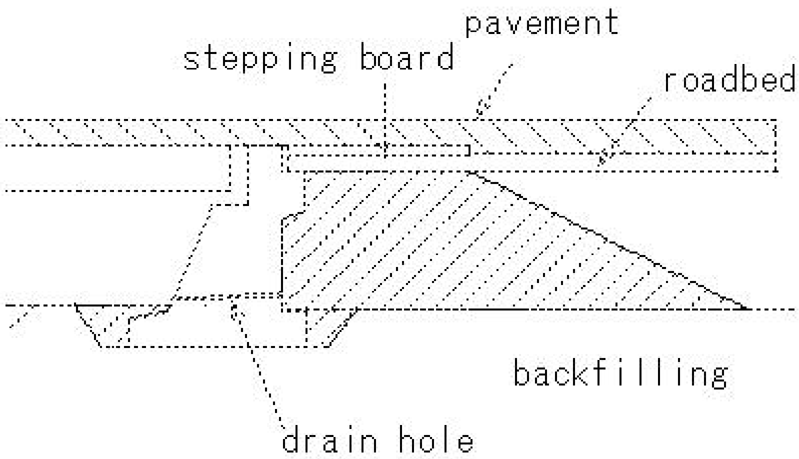
- Height confirmation
- Disturbed ground - removal
- Finished with specified materials

(E439)Structure excavation-Backfill structure of embankment abutment

(E439)Structure excavation-Backfill structure of embankment abutment

Structures - Points to note during excavating

・Is the excavation during appropriate?



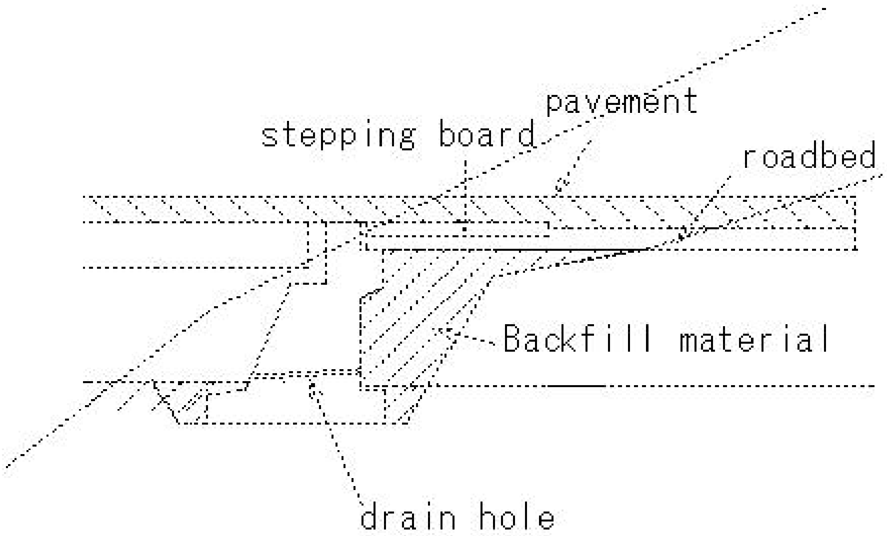
・Backfill structure of embankment abutment

(E440)Structure excavation-Backfill structure of cut section abutment

(E440)Structure excavation-Backfill structure of cut section abutment

Structures - Points to note during excavating

・Is the excavation during appropriate?



・Backfill structure of cut section abutment

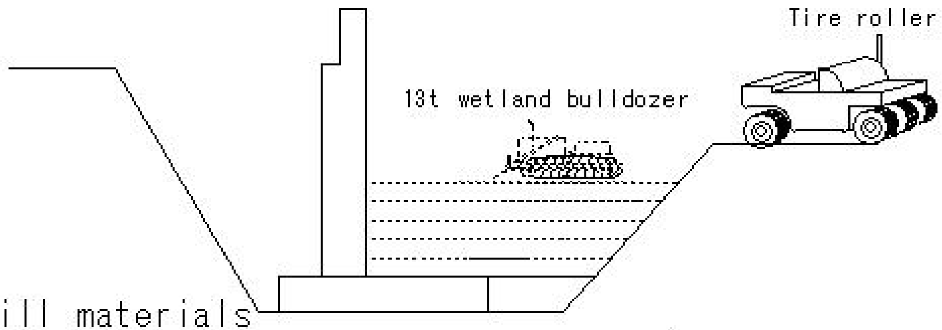
(E441)Structure excavation-Quality of structural backfill materials

(E441)Structure excavation-Quality of structural backfill materials

Structures - Points to note during excavating

- Is the excavation method appropriate?
  - Backfill material
  - Reuse of backfill soil
  - Backfill material A B

- Narrow yard
- Insufficient compaction



Quality of structural backfill materials

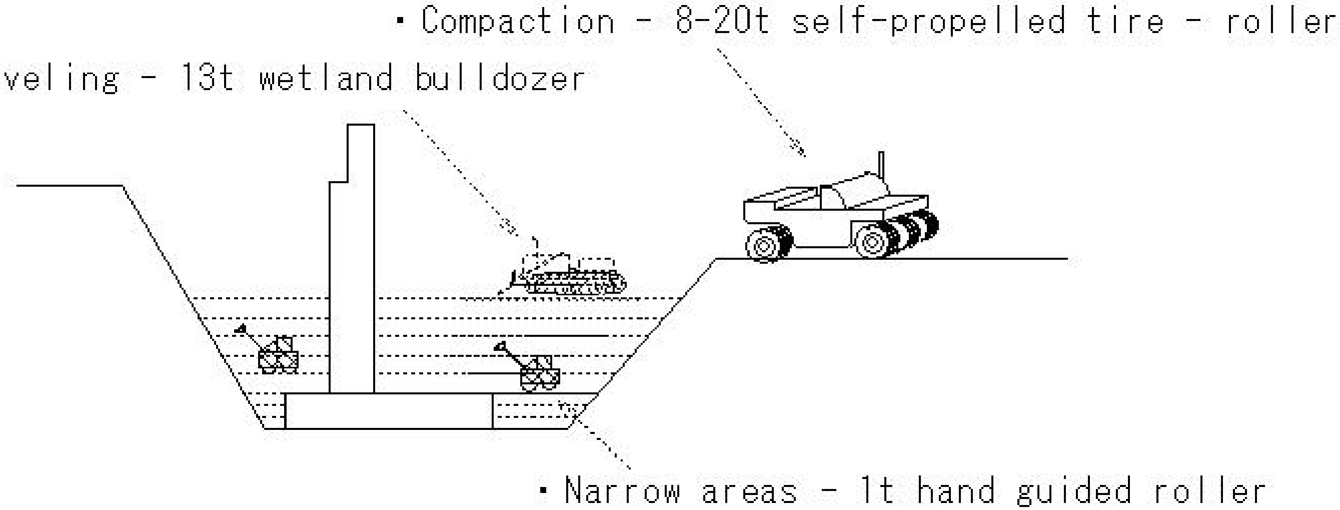
item Type of work	Backfill material A	Backfill material B
Maximum dimensions	150m	300mm
CBR	over10	over5

Backfilling material B - It is preferable to use on-site generated material.

(E442)Structure excavation-Construction of backfilling and backfilling soil

(E442)Structure excavation-Construction of backfilling and backfilling soil

Structures - Points to note during excavating
- Construction of backfilling and backfilling soil



(E443)Structure excavation-Points to note regarding backfilling and backfilling soil

(E443)Structure excavation-Points to note regarding backfilling and backfilling soil

Structures - Points to note during excavating

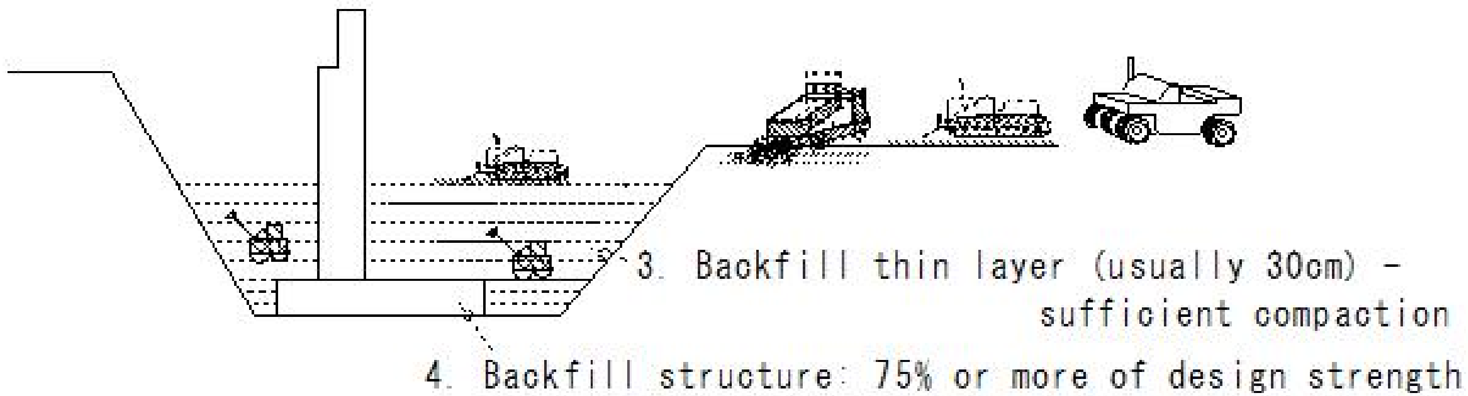
・Points to note regarding backfilling and backfilling soil

(E444)Structure excavation-Points to note regarding backfilling and backfilling soil

(E444)Structure excavation-Points to note regarding backfilling and backfilling soil

Structures - Points to note during excavating

- Points to note regarding backfilling and backfilling soil



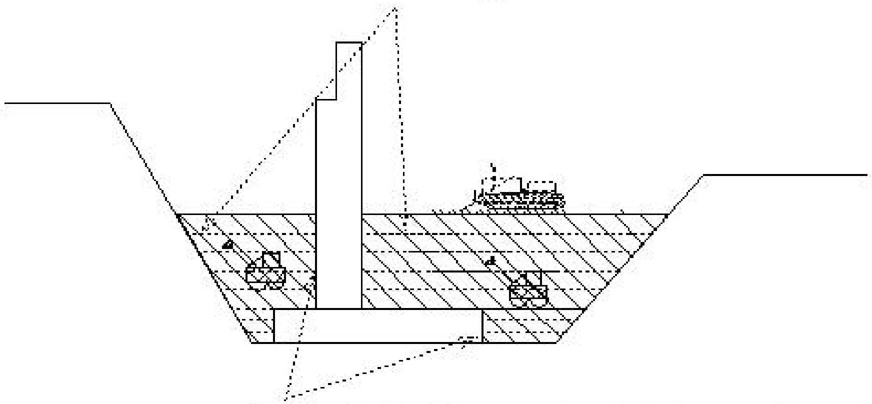
(E445)Structure excavation-Points to note regarding backfilling and backfilling soil

(E445)Structure excavation-Points to note regarding backfilling and backfilling soil

Structures - Points to note during excavating

・Points to note regarding backfilling and backfilling soil

6 Structure backfilling -Perform from both sides at the same time



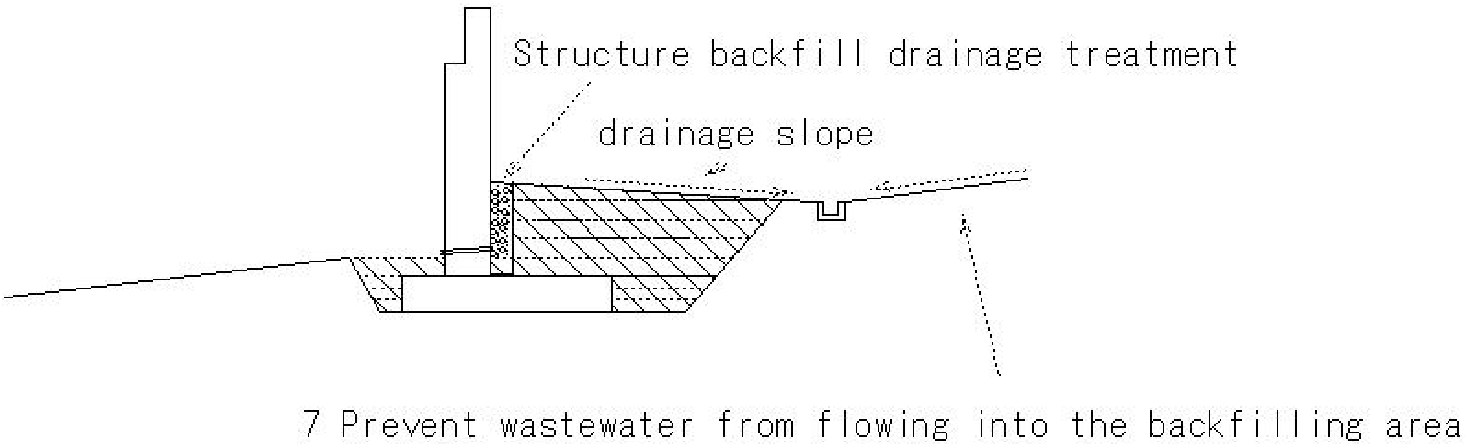
5 Backfilling: Avoid impacting the structure

(E446)Structure excavation-Points to note regarding backfilling and backfilling soil

(E446)Structure excavation-Points to note regarding backfilling and backfilling soil

Structures - Points to note during excavating

・Points to note regarding backfilling and backfilling soil



(E447)Structure excavation-Points to note regarding backfilling and backfilling soil

(E447)Structure excavation-Points to note regarding backfilling and backfilling soil

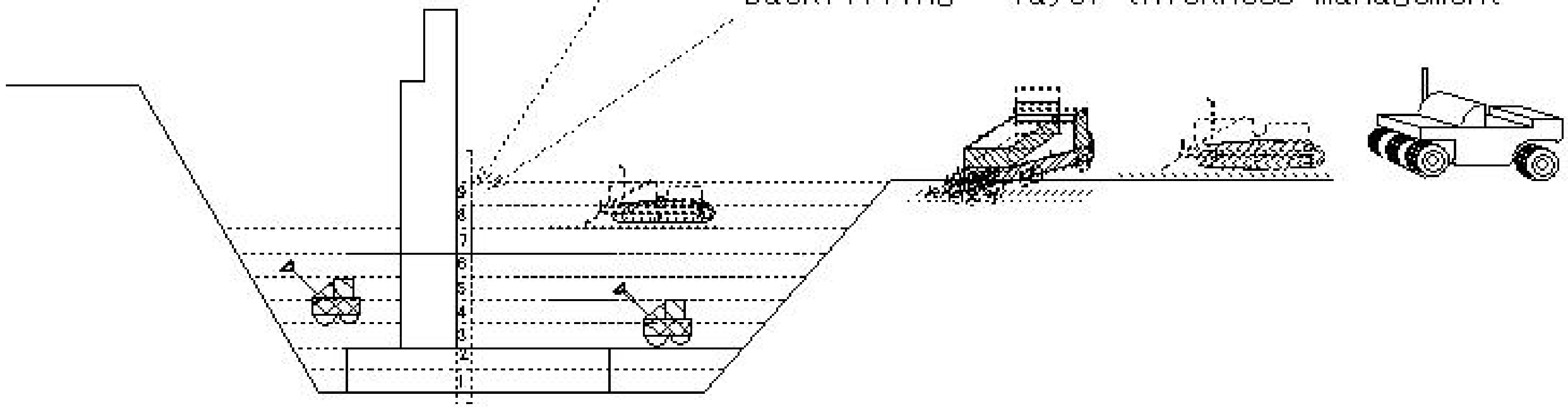
Structures - Points to note during excavating

・Points to note regarding backfilling and backfilling soil

・Layer thickness management

・So that you can understand the finished thickness (layer thickness)

・Backfilling - layer thickness management

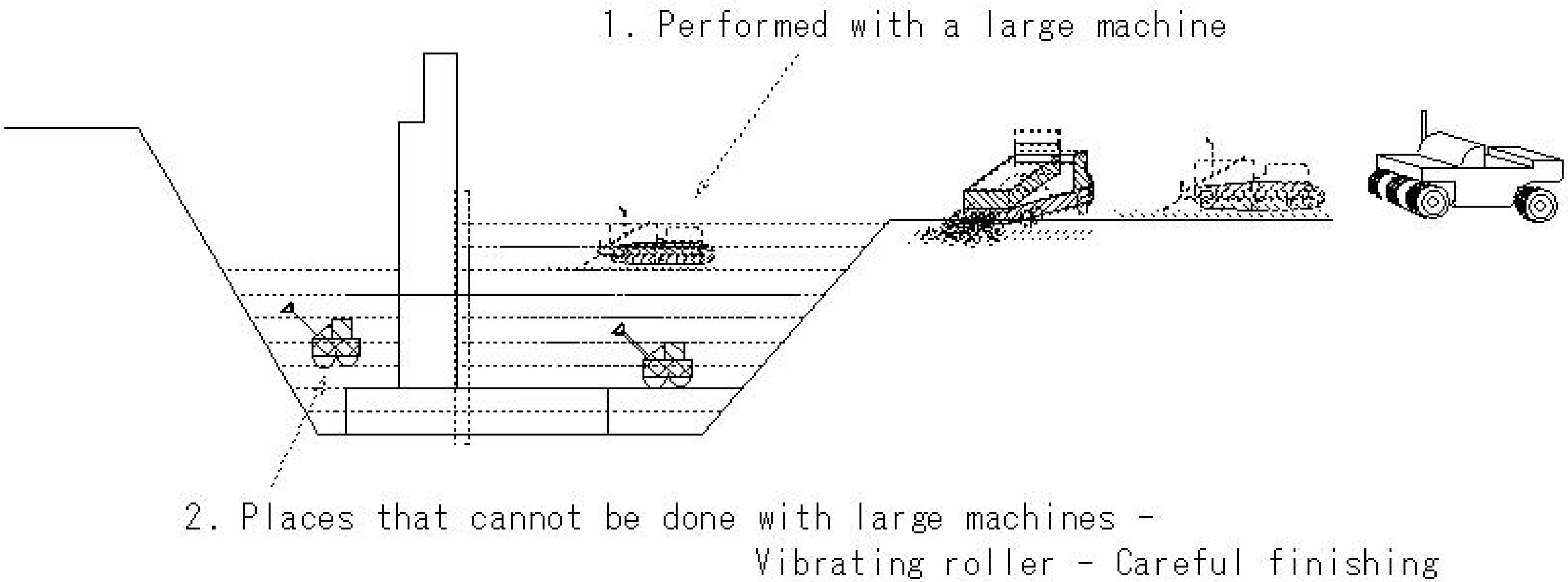


(E448)Structure excavation-Points to note during excavating-compaction appropriate

(E448)Structure excavation-Points to note during excavating-compaction appropriate

Structures - Points to note during excavating

- Is compaction appropriate?

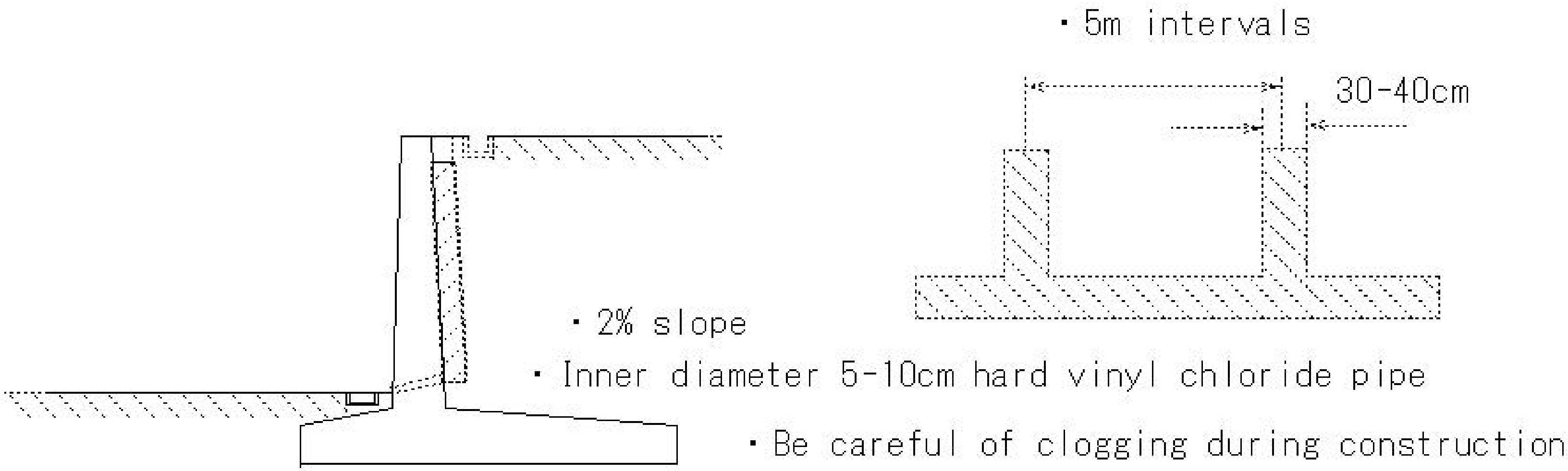


(E449)Structure excavation-Structures - Points to note during excavating-Drainage works

(E449)Structure excavation-Structures - Points to note during excavating-Drainage works

Structures - Points to note during excavating

- Drainage works
  - Water seeping into the back of bridge abutments, retaining walls, etc.
    eliminate water
    Reduction of earth pressure and water pressure



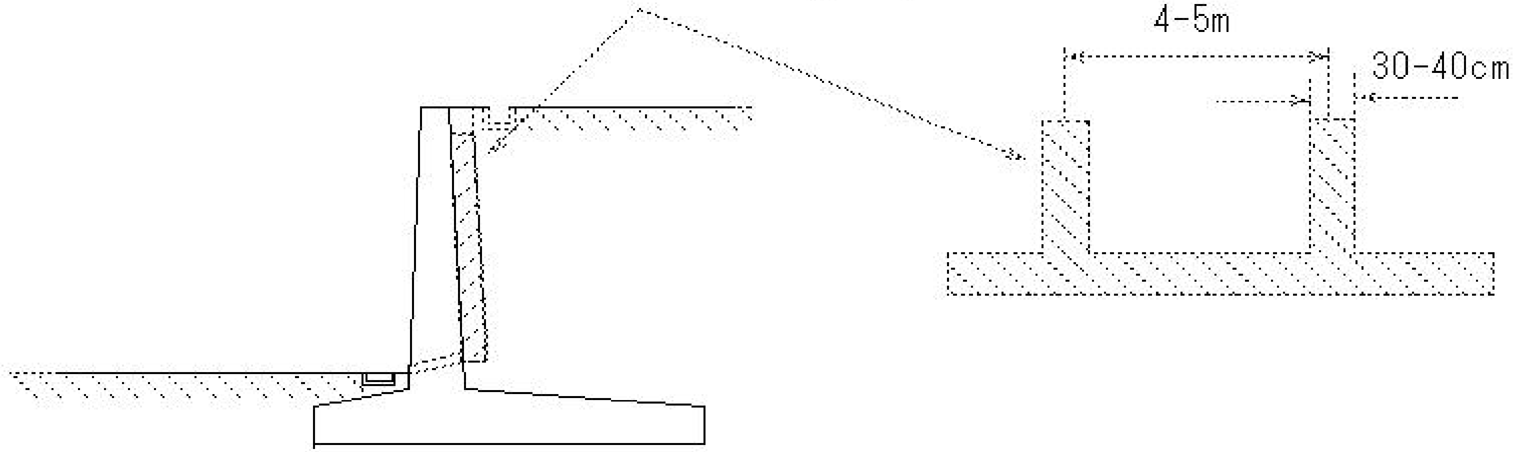
(E450)Structure excavation-Structures - Points to note during excavating-Drainage works

(E450)Structure excavation-Structures - Points to note during excavating-Drainage works

Structures - Points to note during excavating

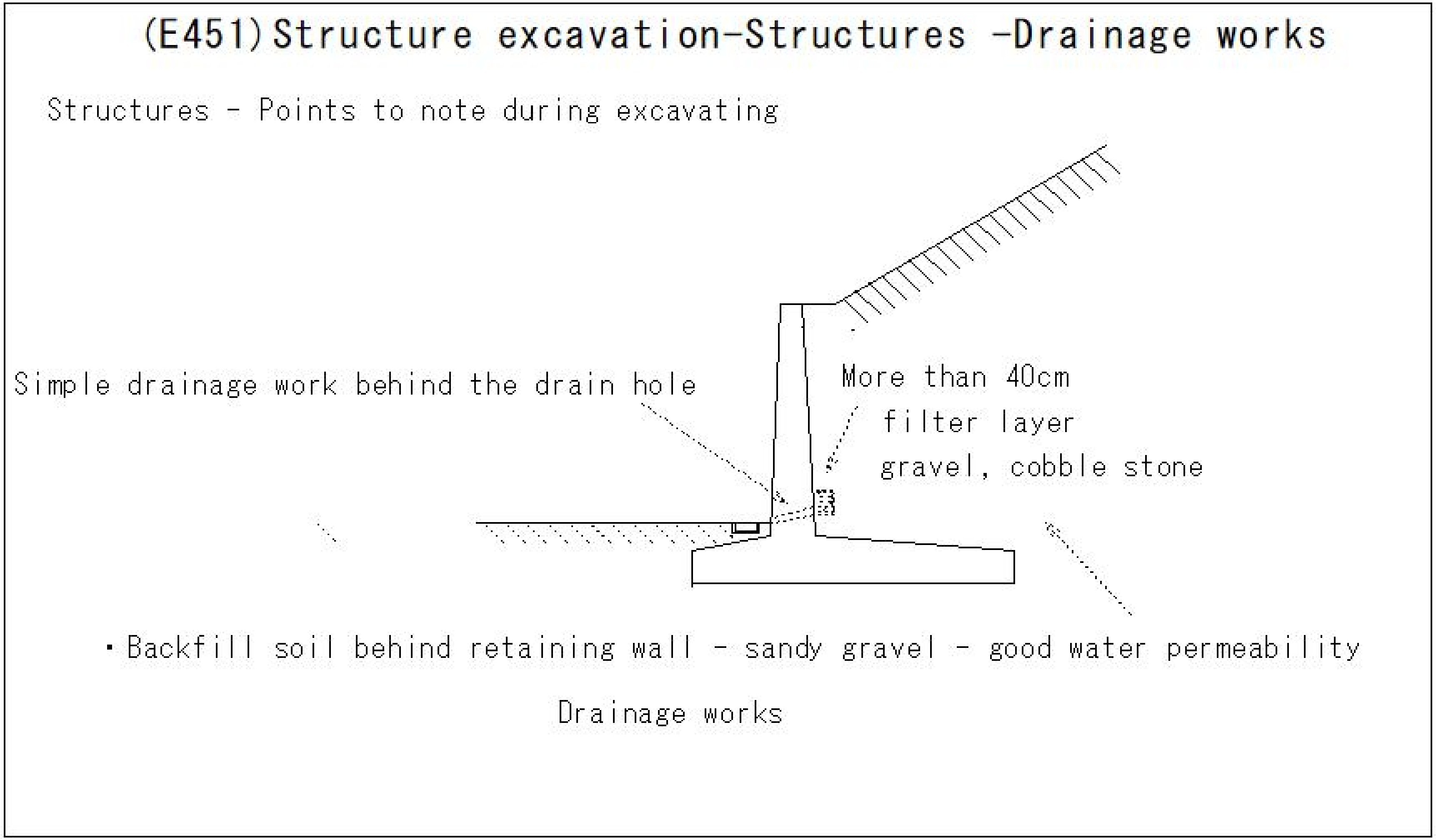
・Drainage works

・Cobble stone drainage layer 30-40cm



・Simple drainage work behind the drain hole

(E451)Structure excavation-Structures -Drainage works

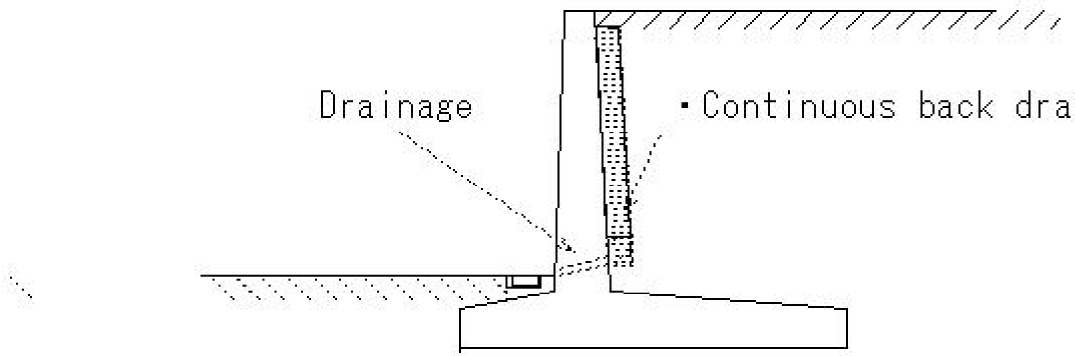


(E452)Structure excavation-Structures -Drainage works

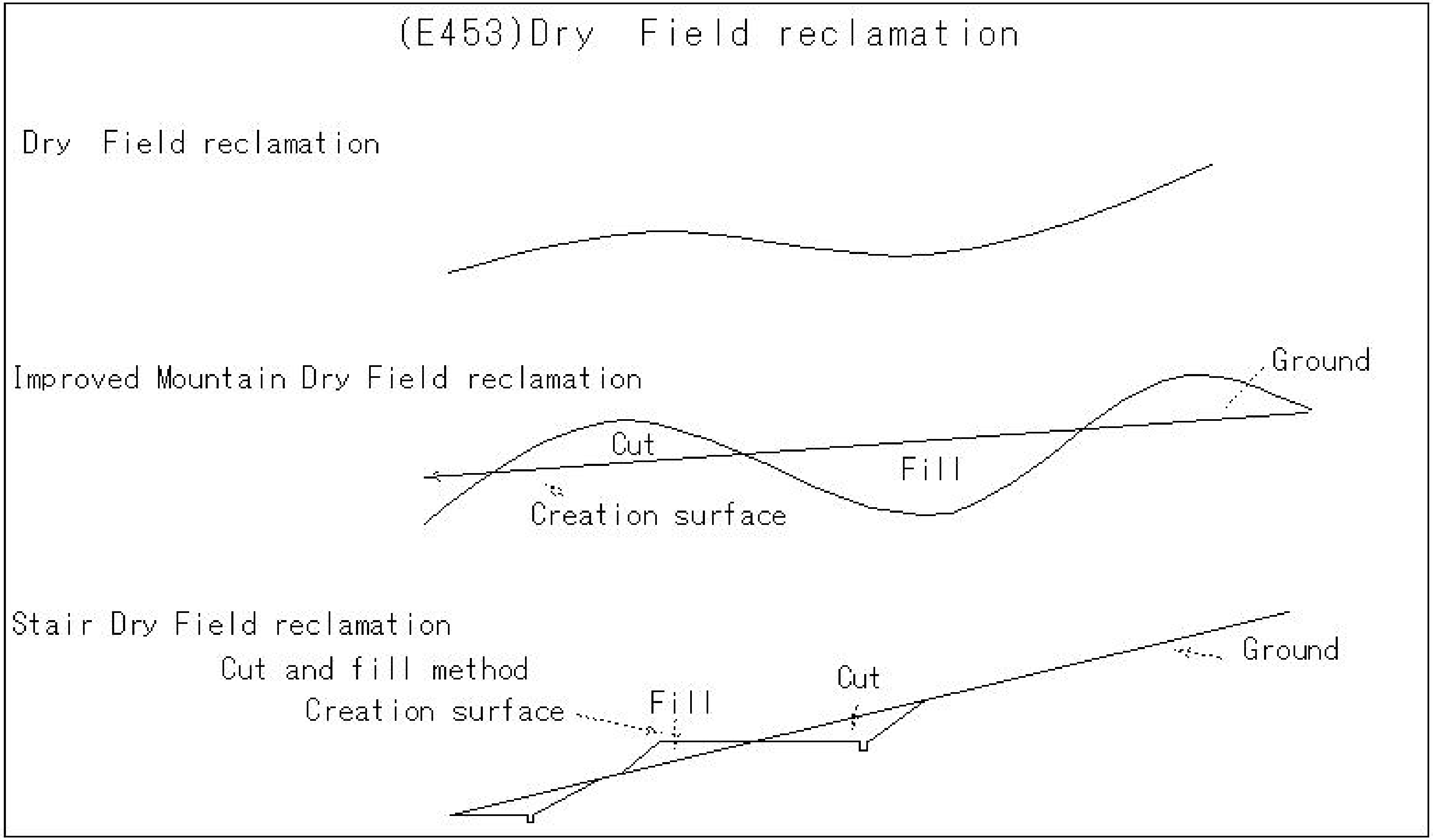
(E452)Structure excavation-Structures -Drainage works

Structures - Points to note during excavating

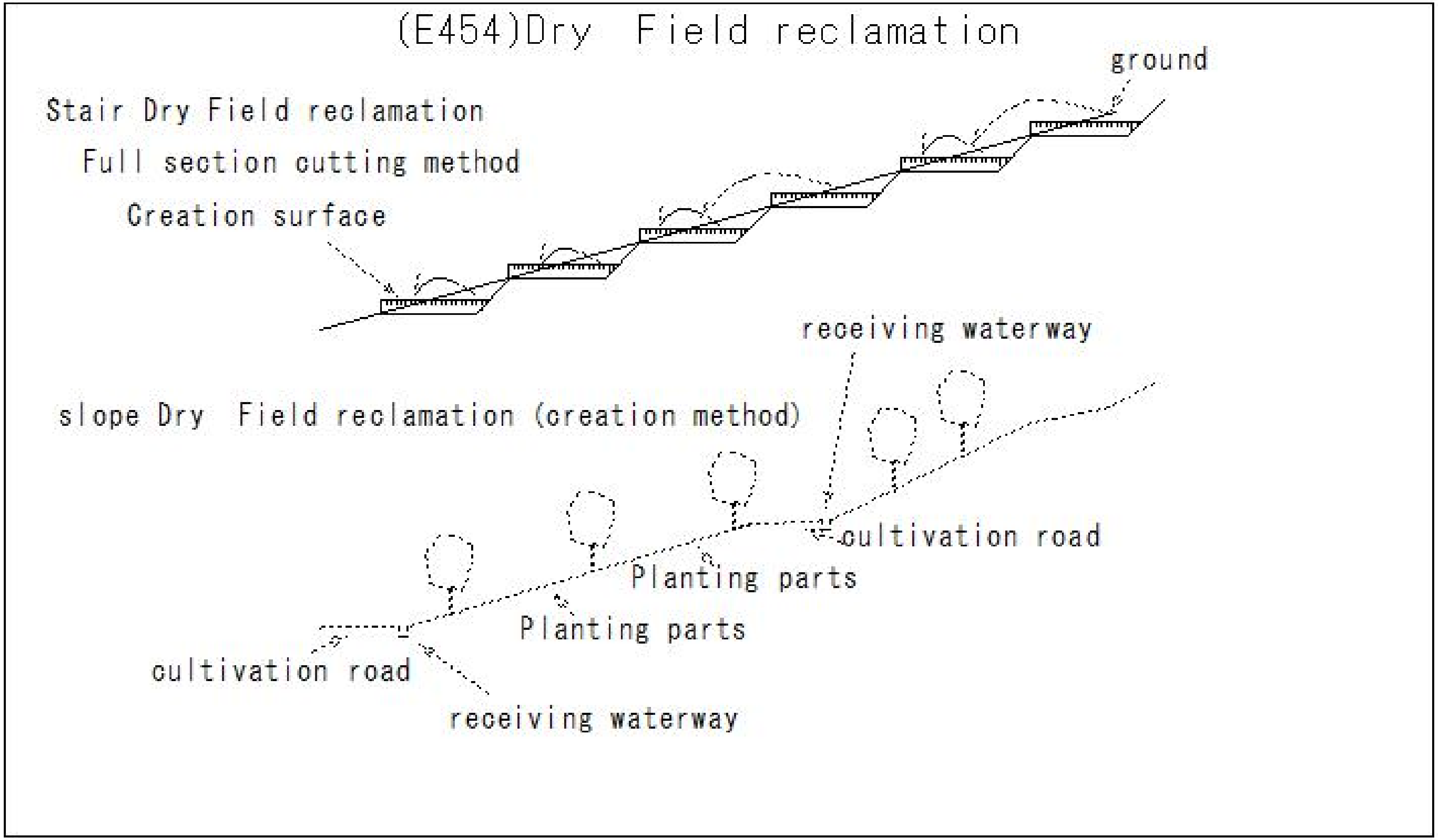
- Continuous back drainage
  - Back of standing wall - entire surface - 30-40cm cobble stone layer



(E453)Dry Field reclamation



(E454)Dry Field reclamation

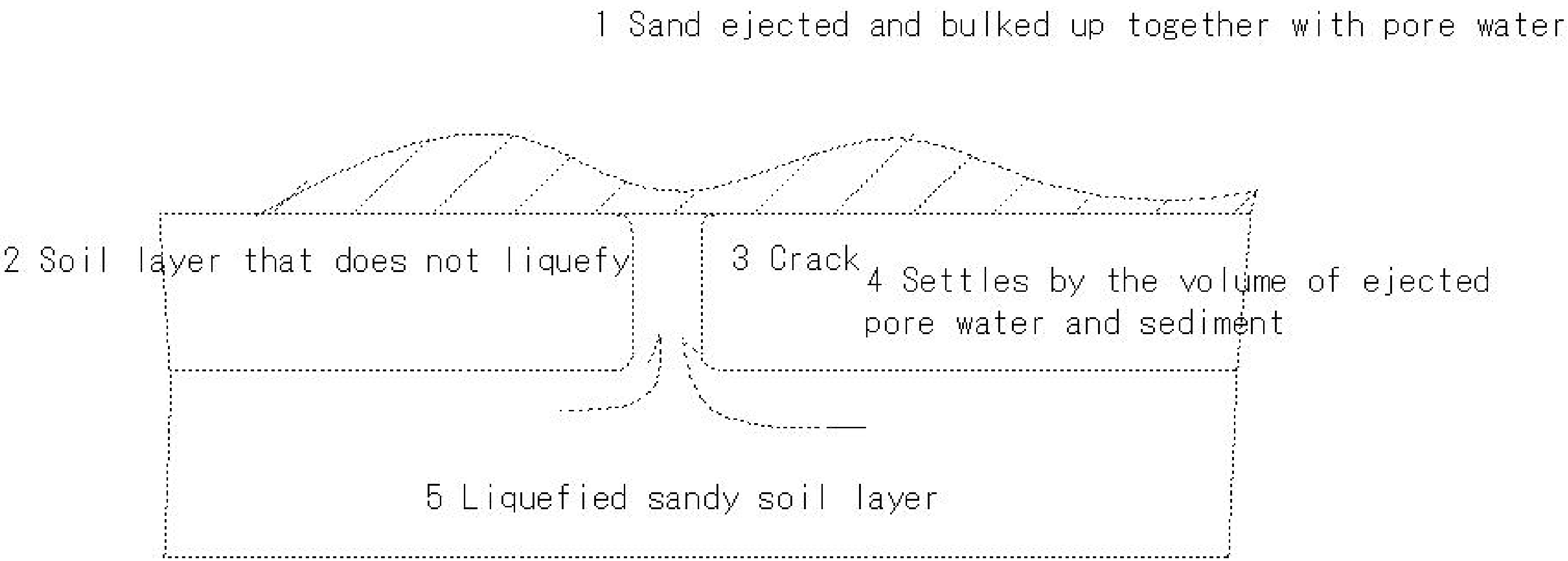


(E455)Liquefaction

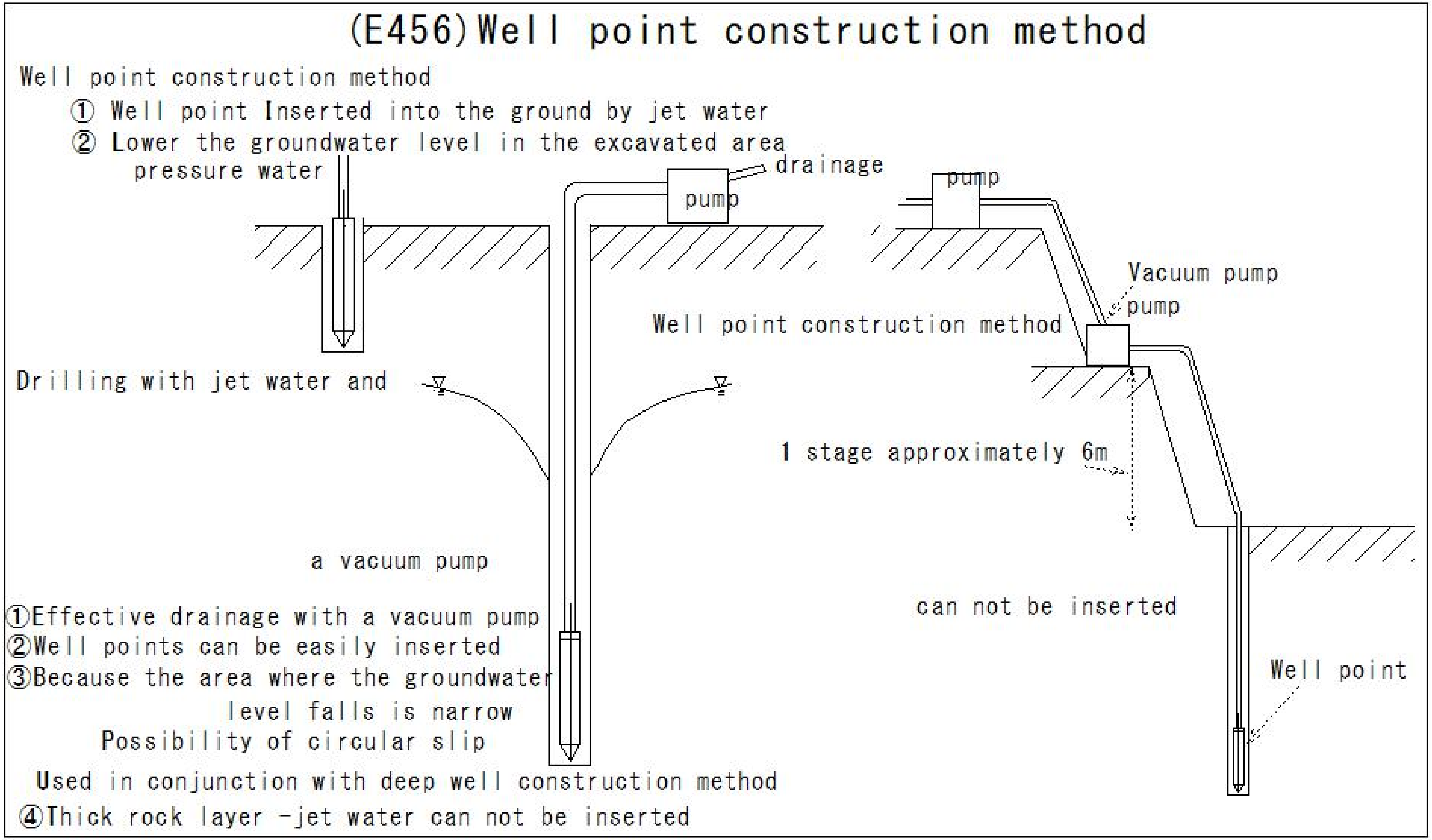
(E455)Liquefaction

Liquefaction

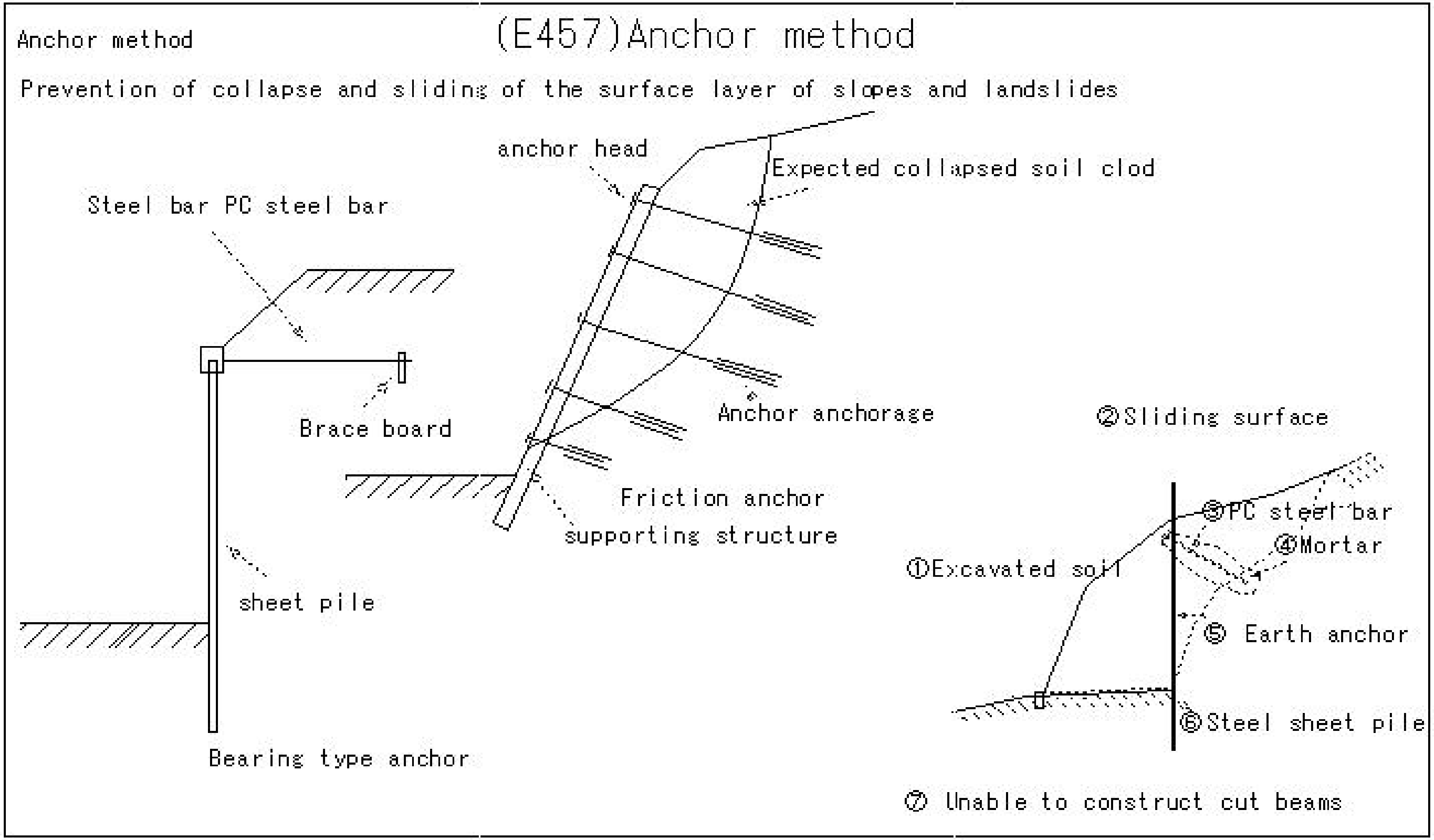
Current status of sand blowing due to liquefaction



(E456)Well point construction method

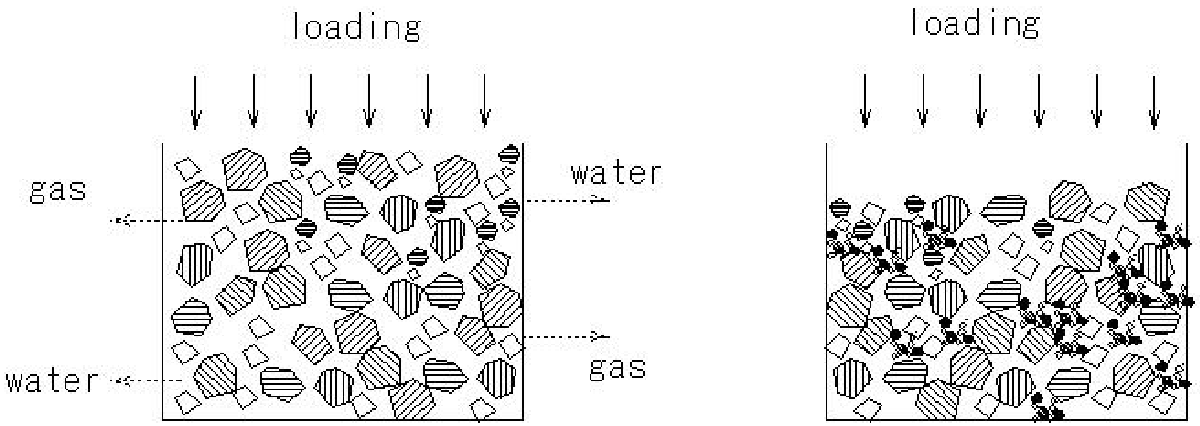


(E457)Anchor method



(E458)Consolidation

(E458)Consolidation



Water and gas release due to loading

Deformation and volumetric contraction of soil particle structure

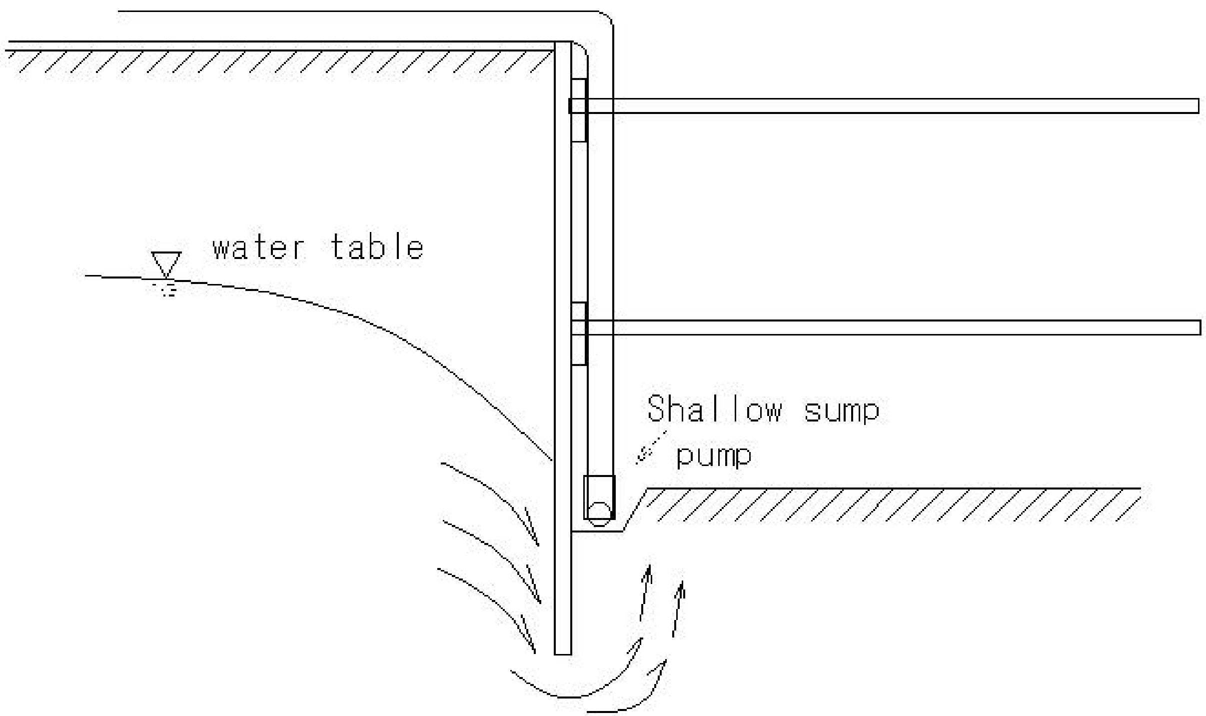
(E459)Shallow sump drainage

(E459)Shallow sump drainage

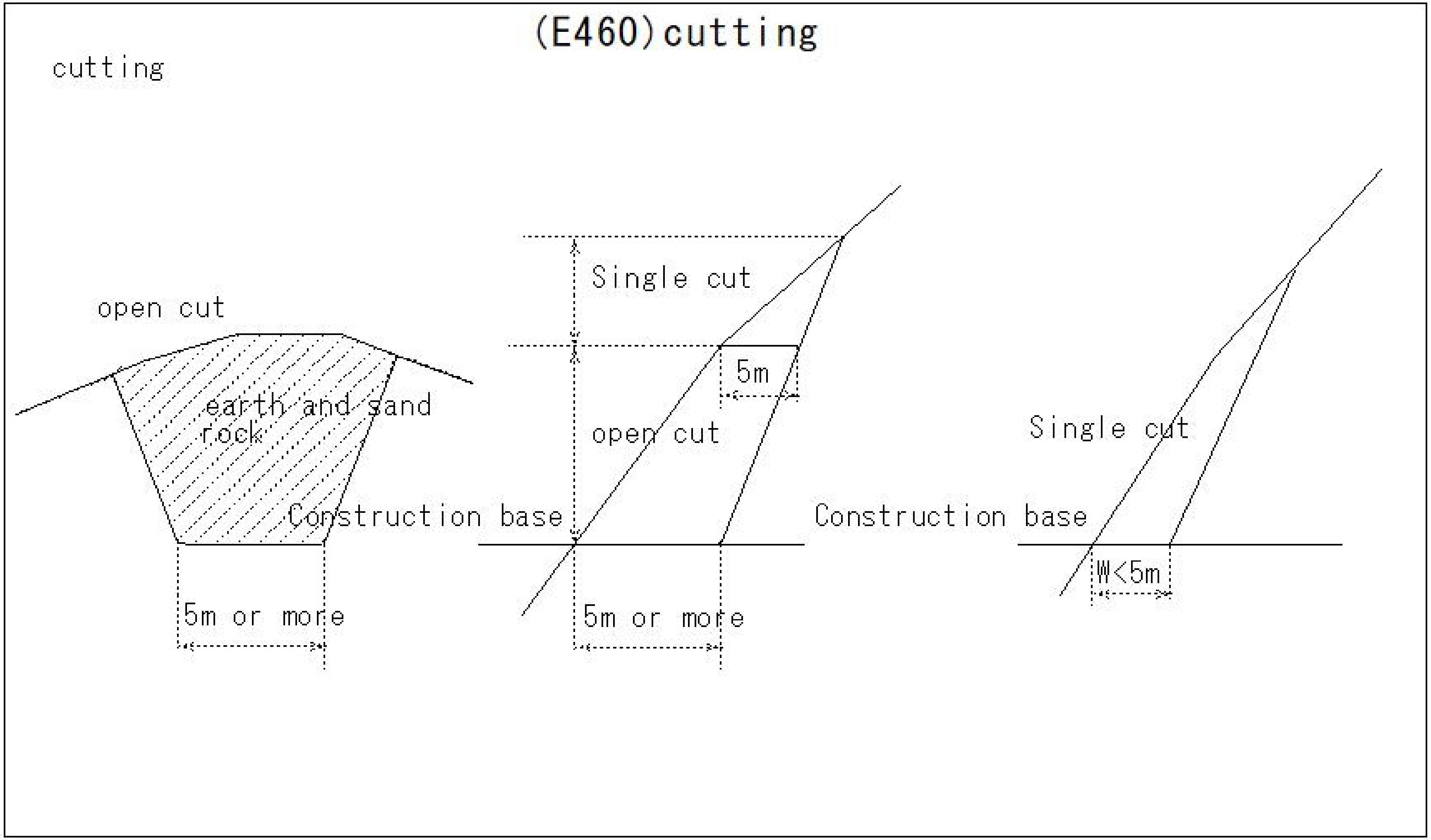
Shallow sump(Shallow ground)drainage method

①Less amount of groundwater flowing out

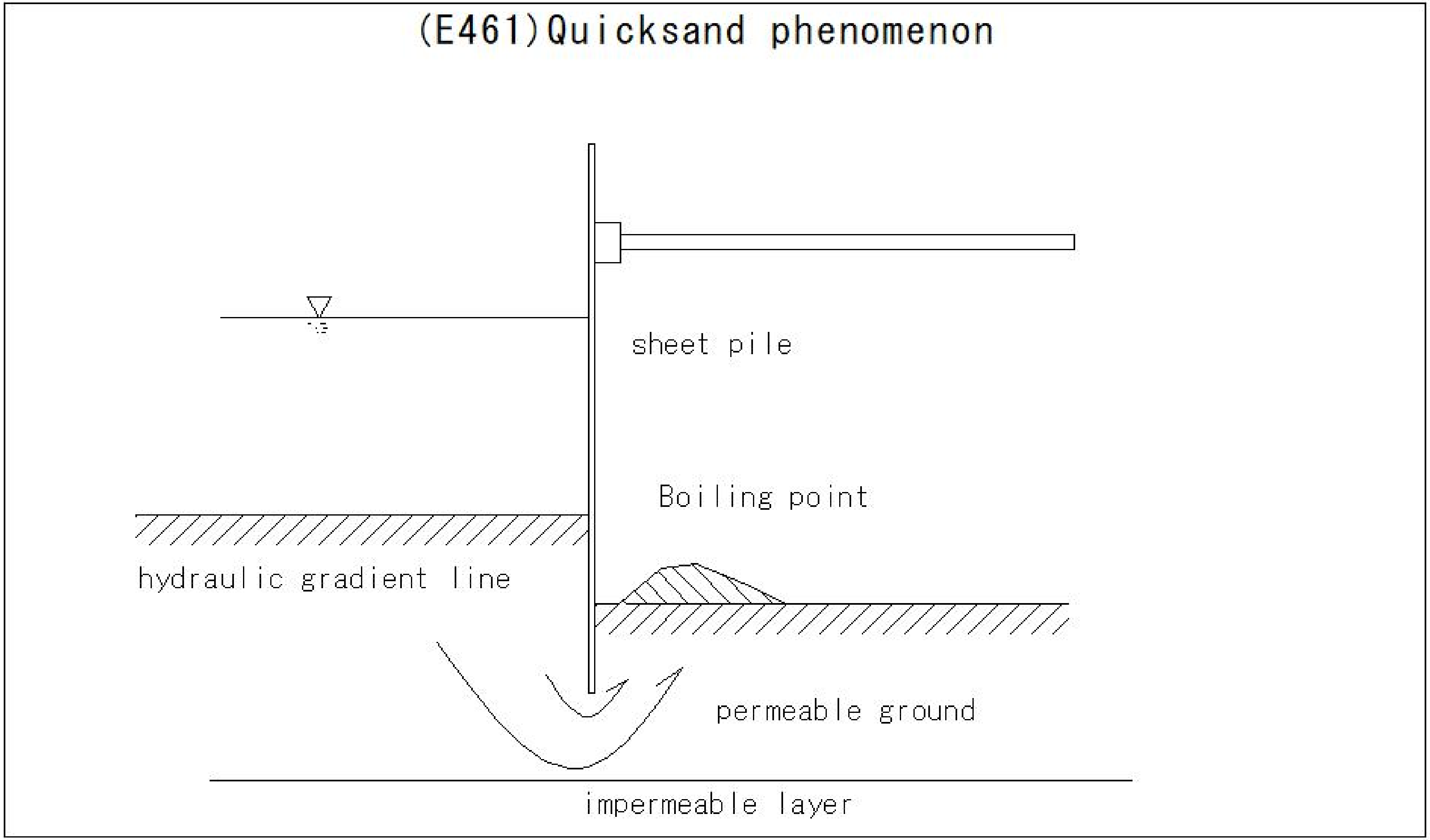
②Excavation of shallow ground



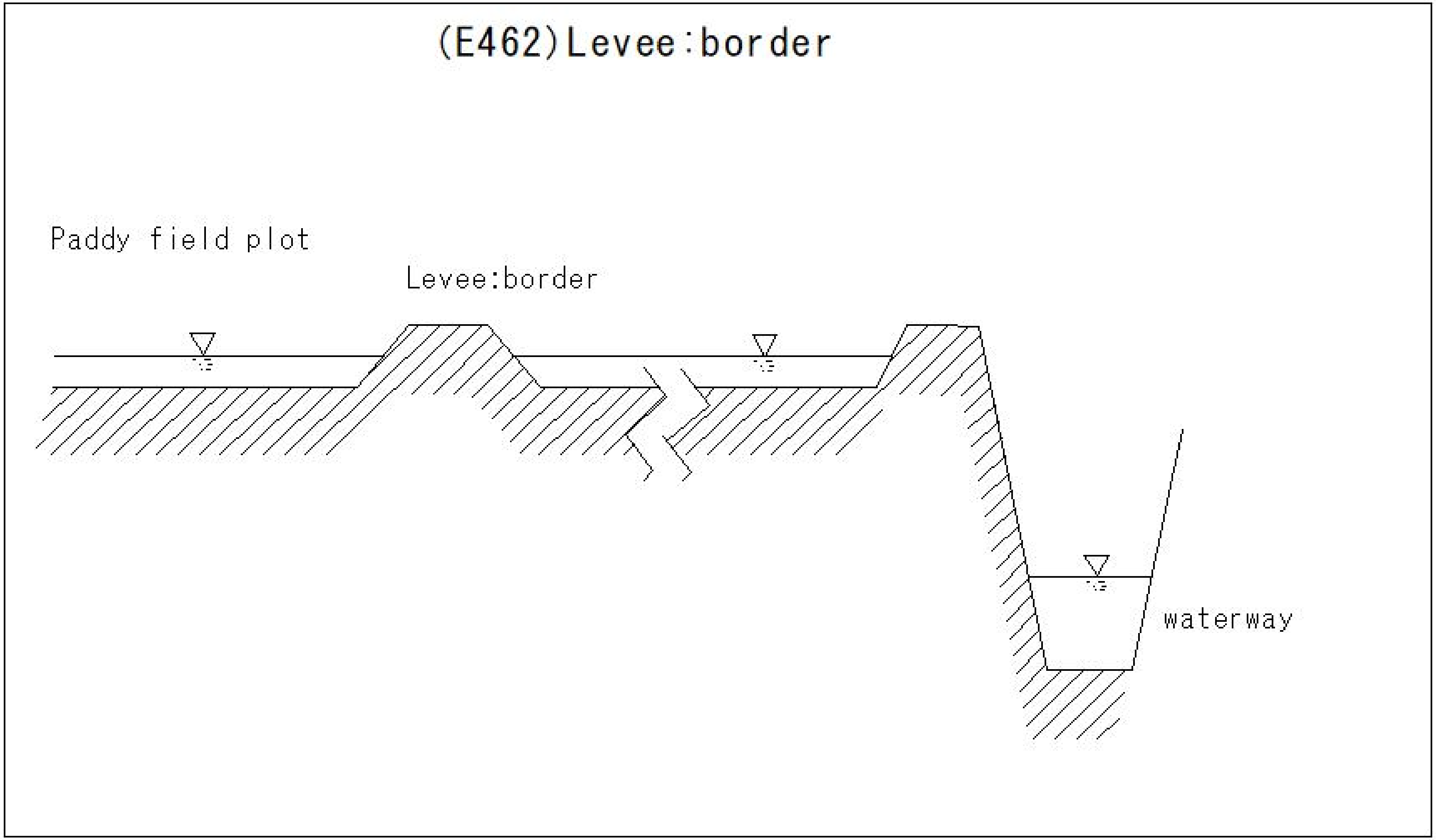
(E460)cutting



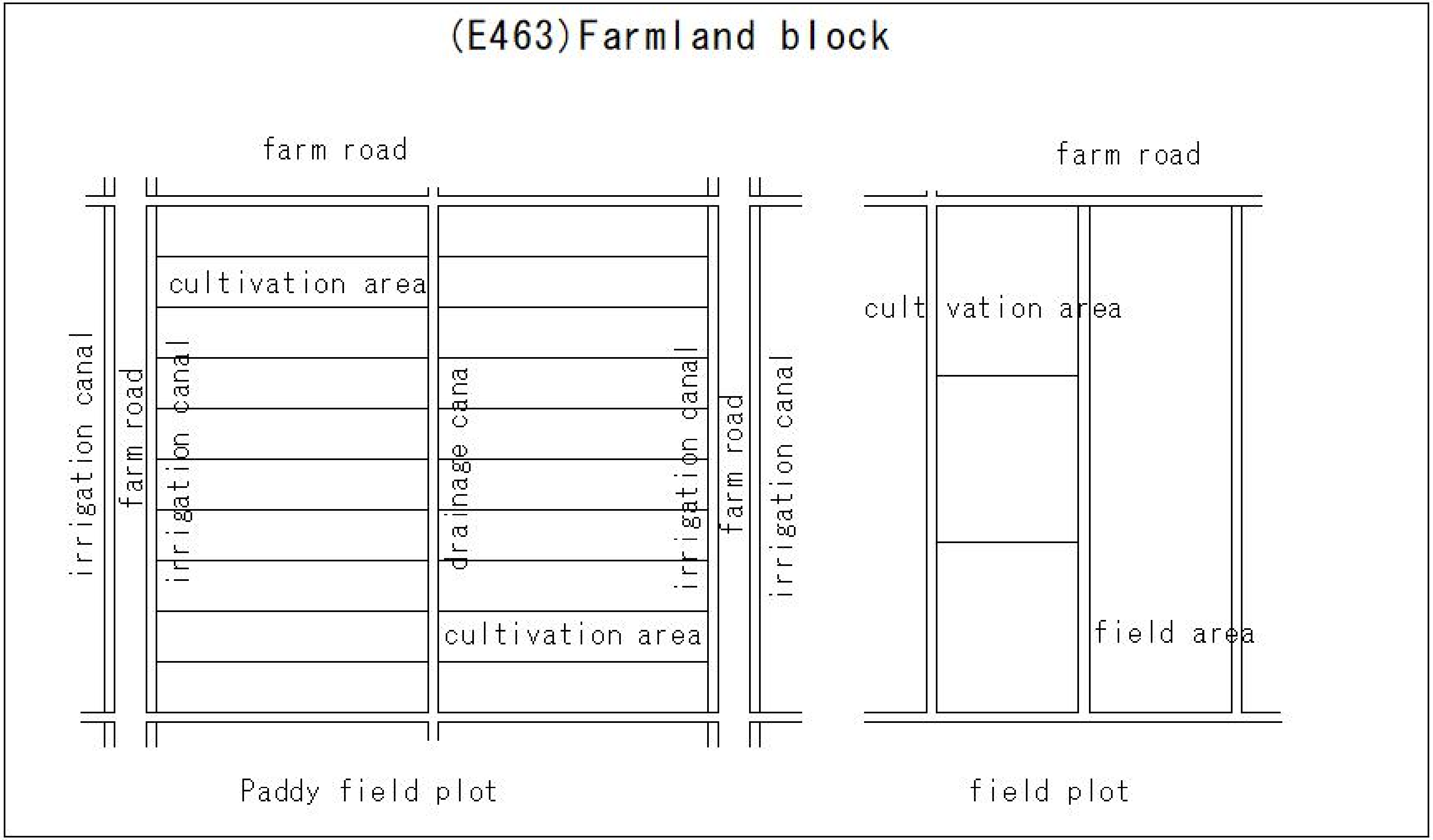
(E461)Quicksand phenomenon



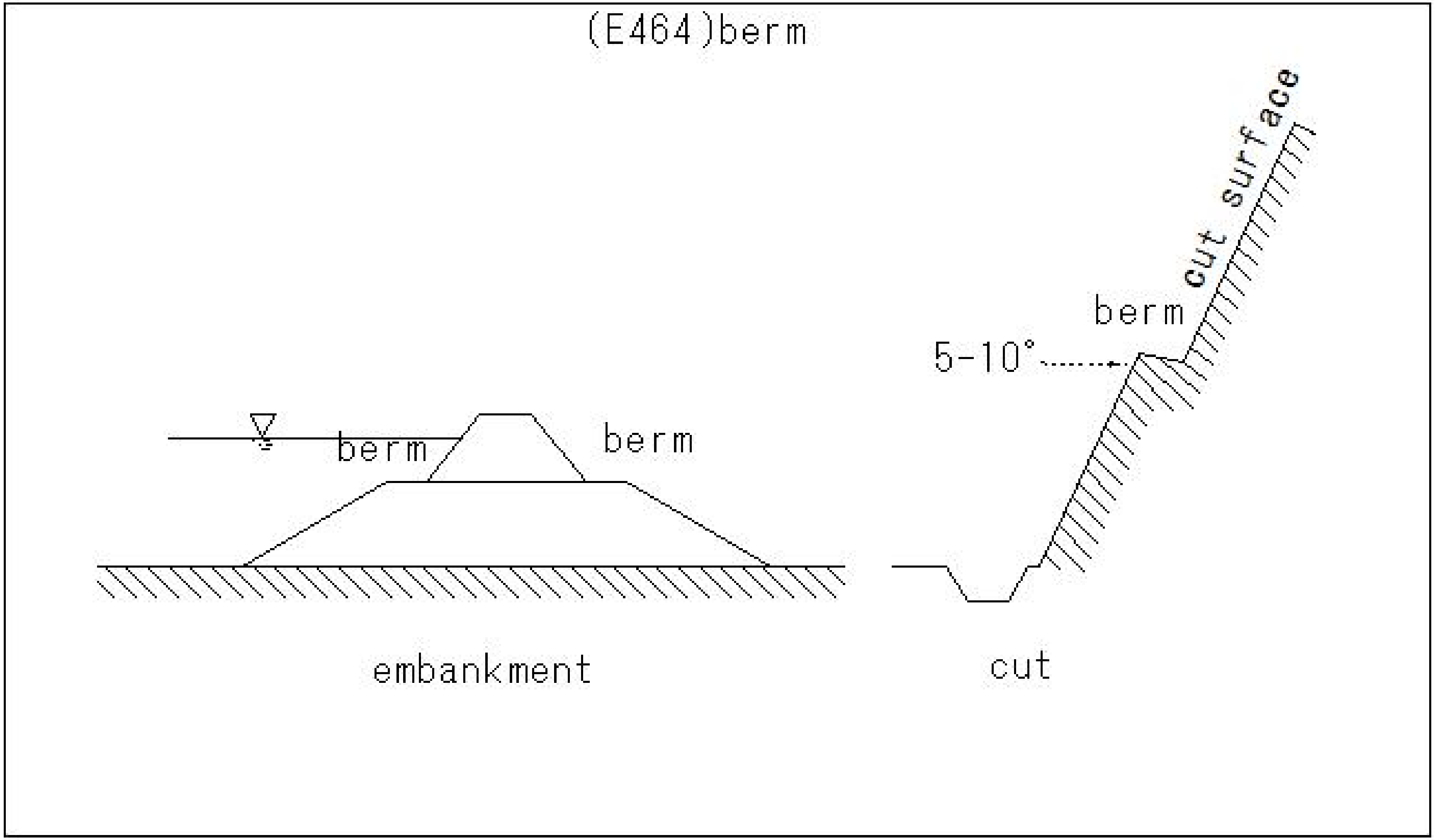
(E462)Levee:border



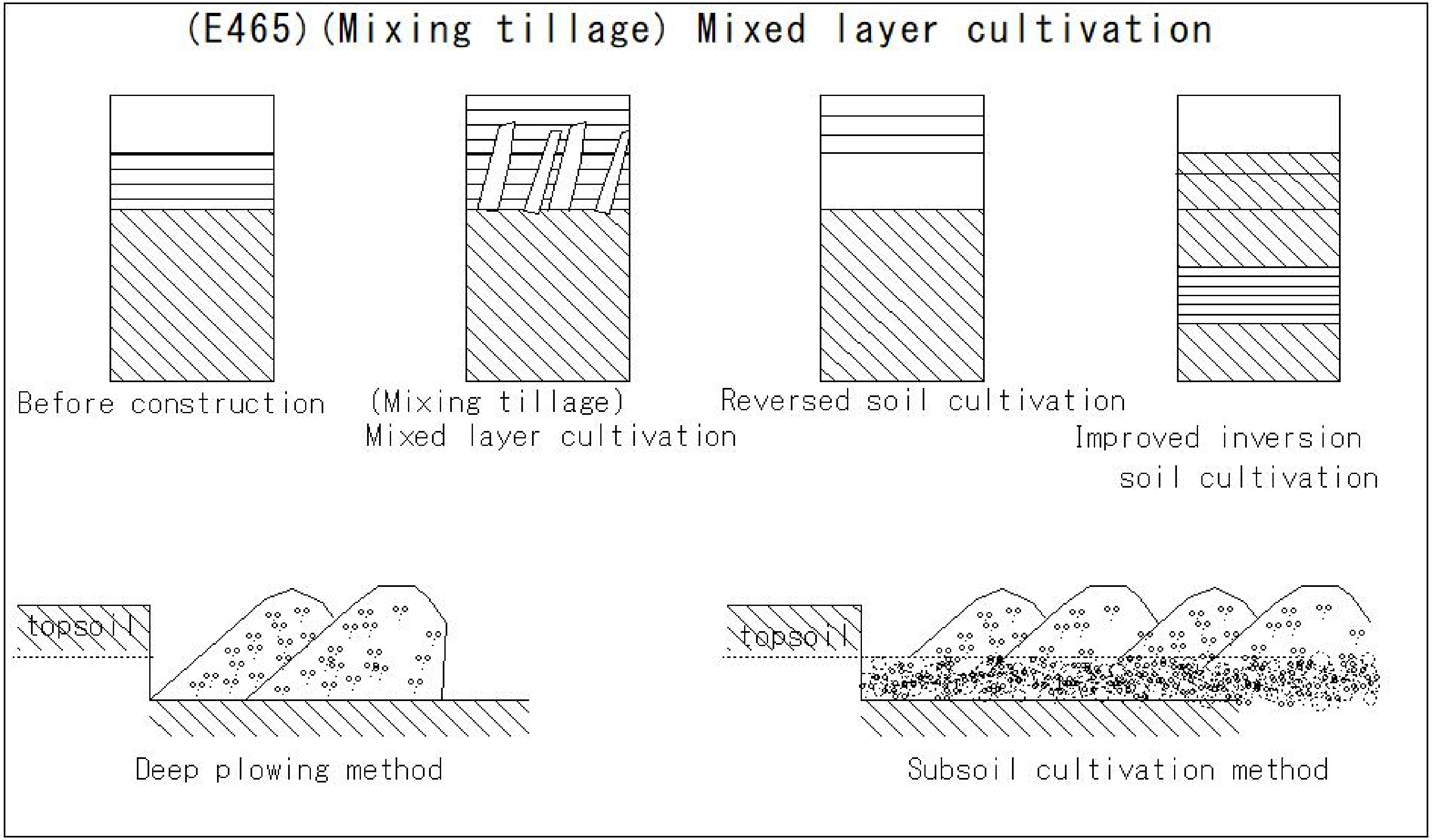
(E463)Farmland block



(E464)berm

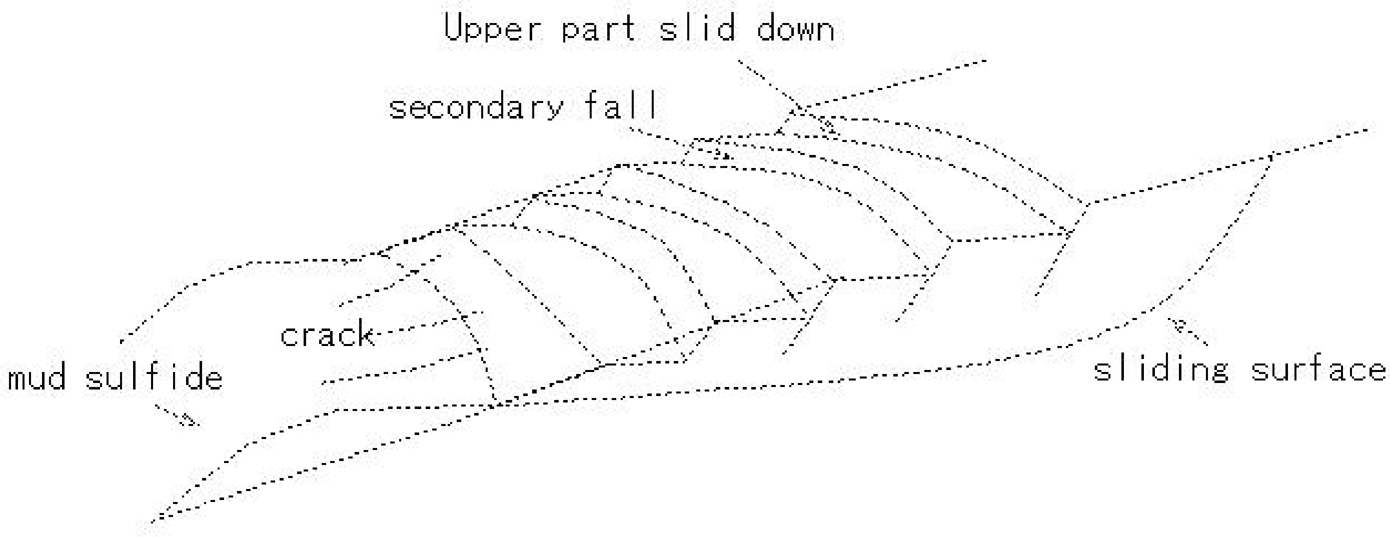


(E465)(Mixing tillage) Mixed layer cultivation

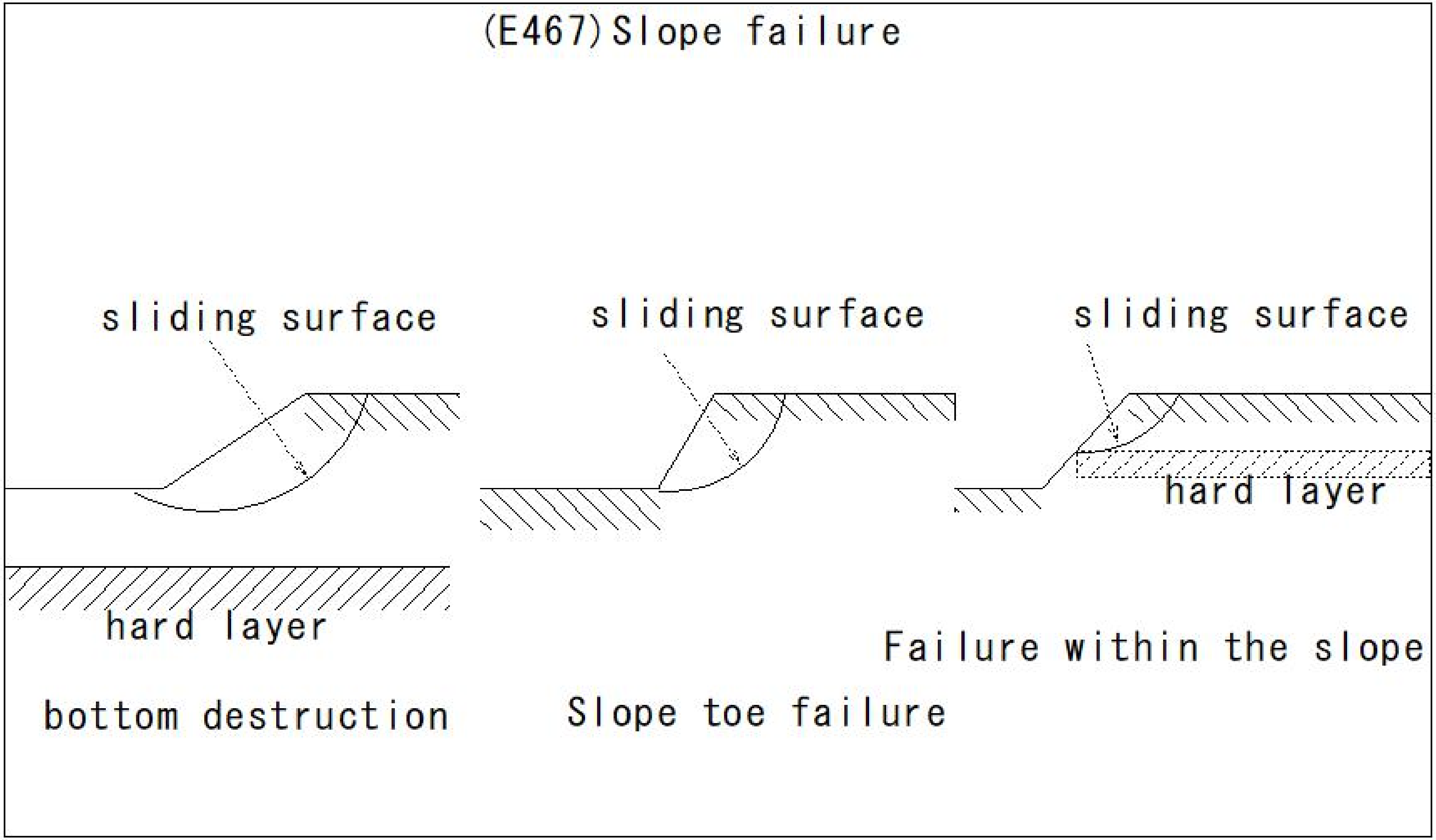


(E466)Landslide

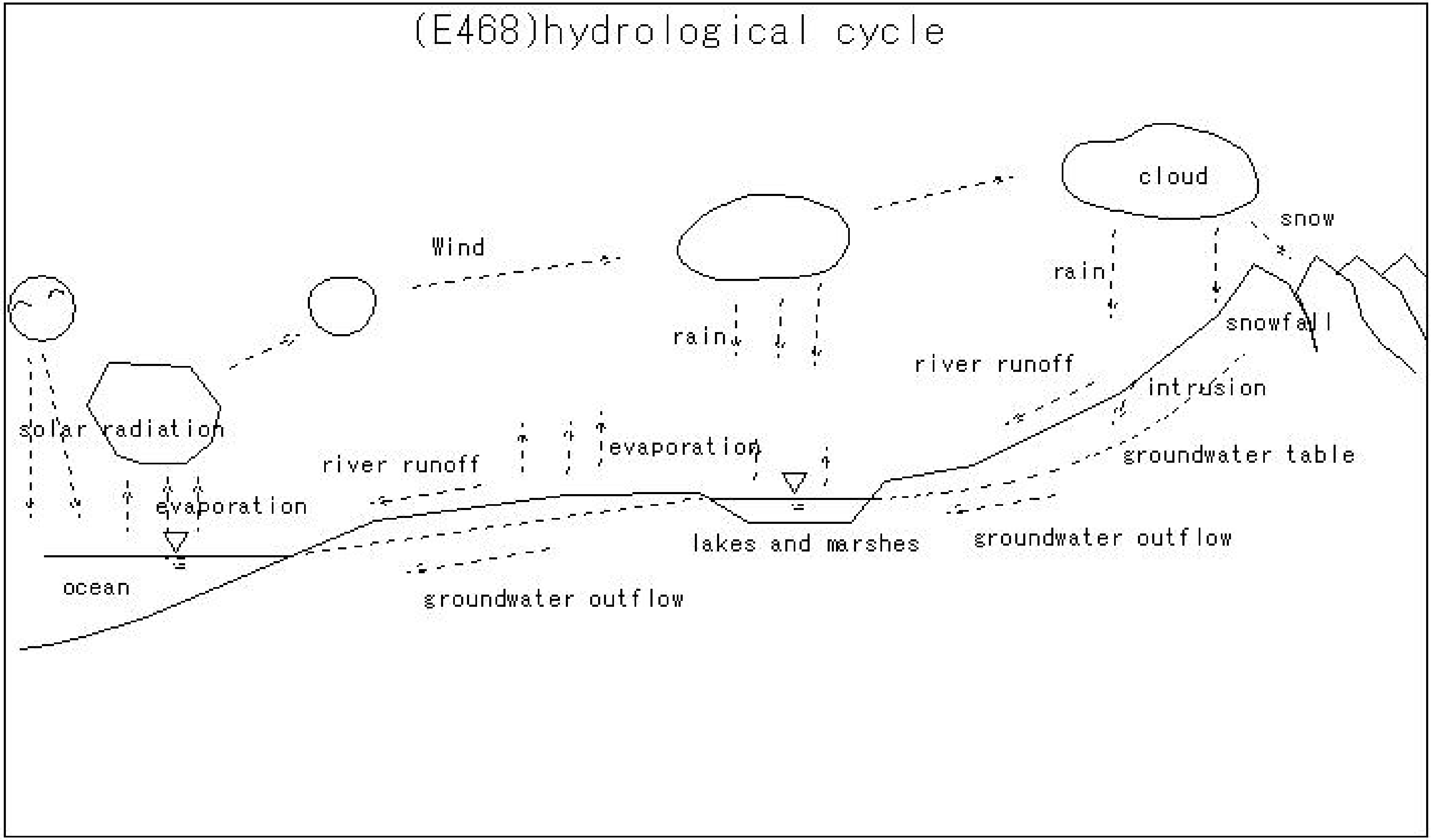
(E466)Landslide



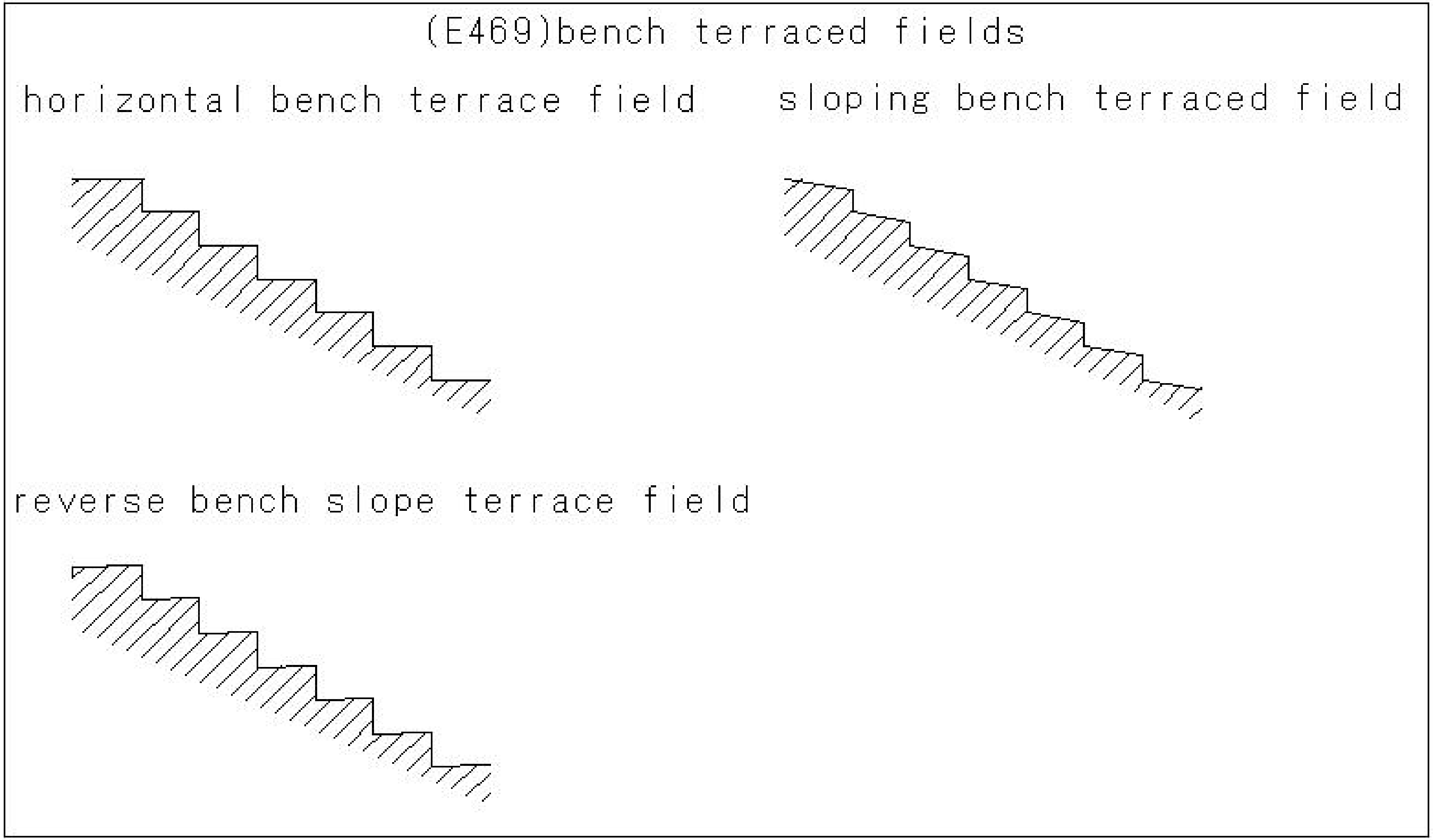
(E467)Slope failure



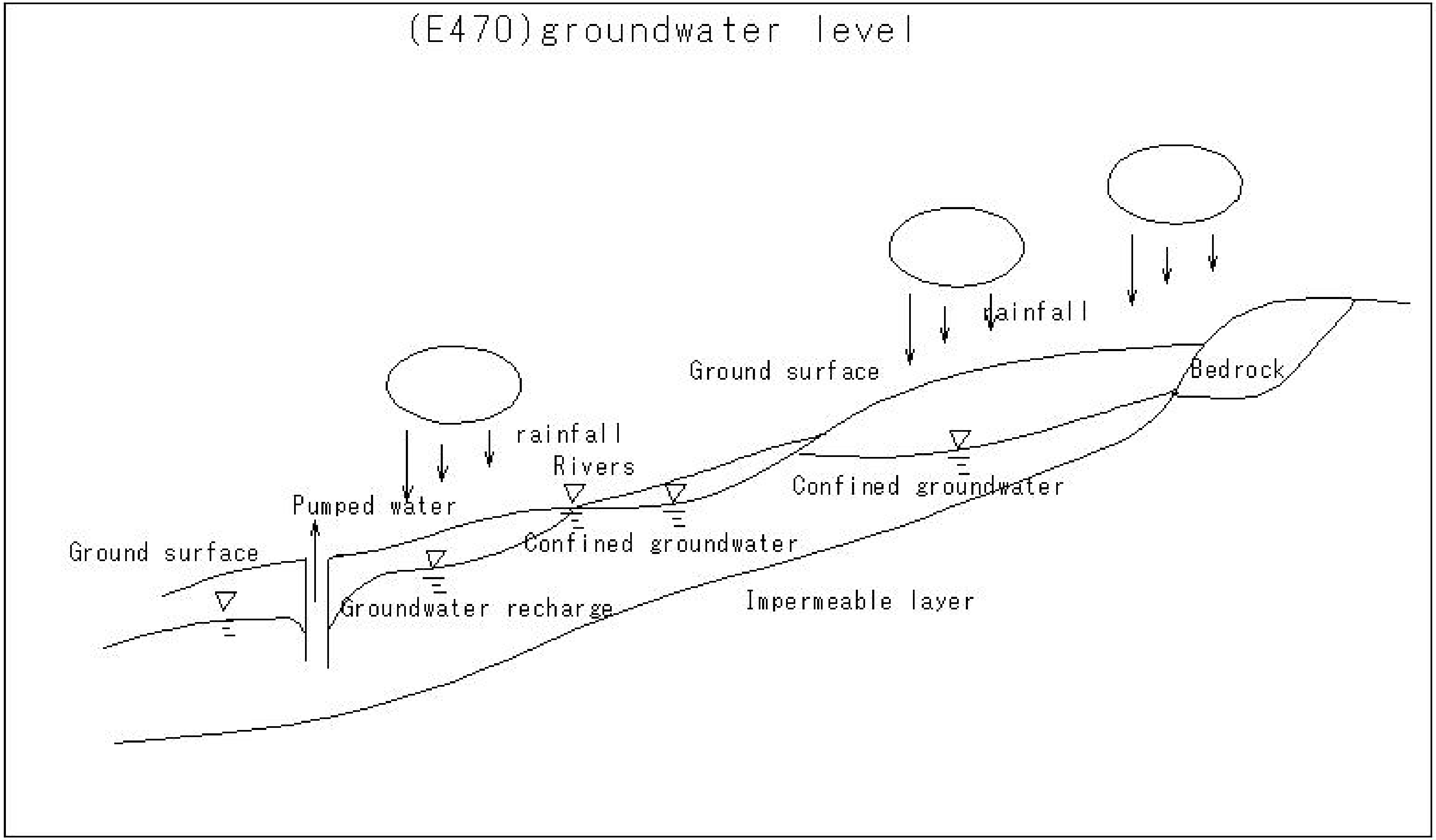
(E468)hydrological cycle



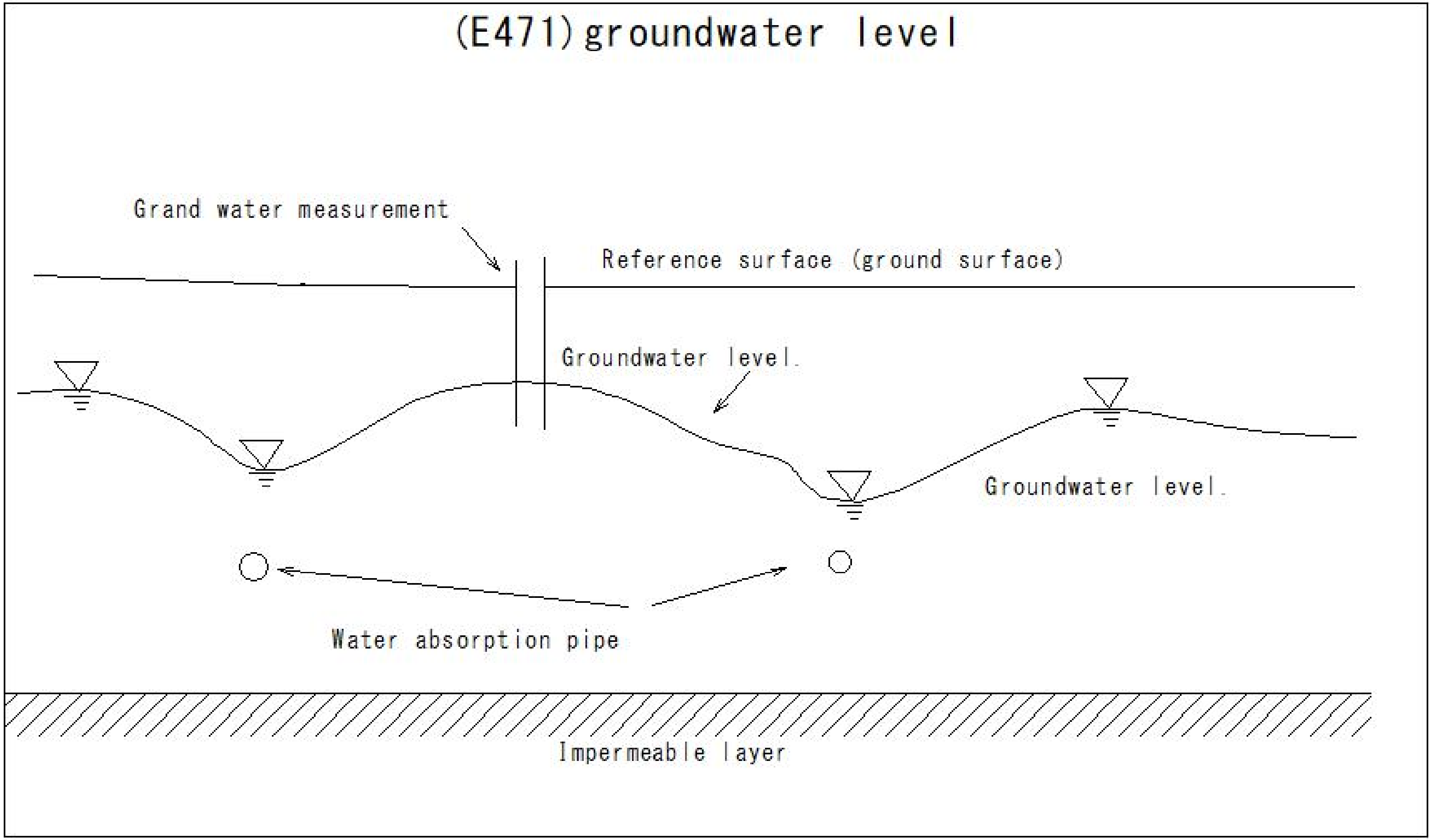
(E469)bench terraced fields



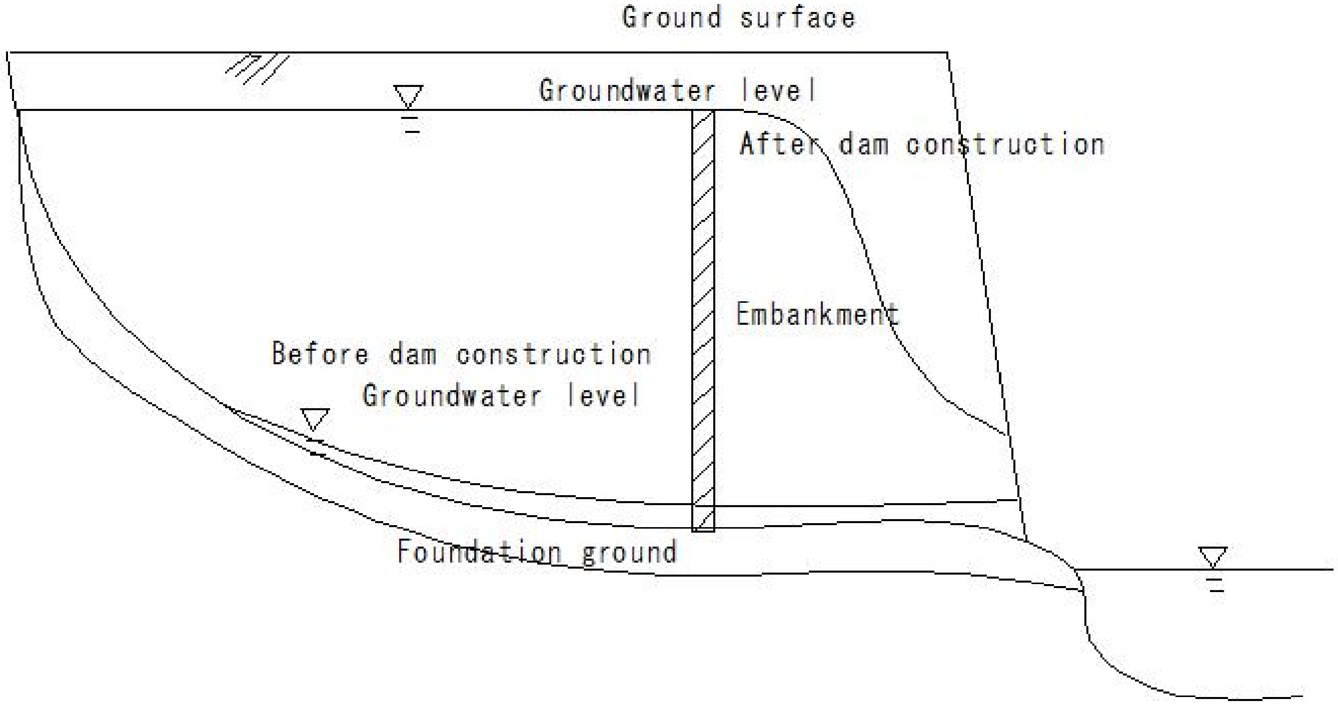
(E470)groundwater level



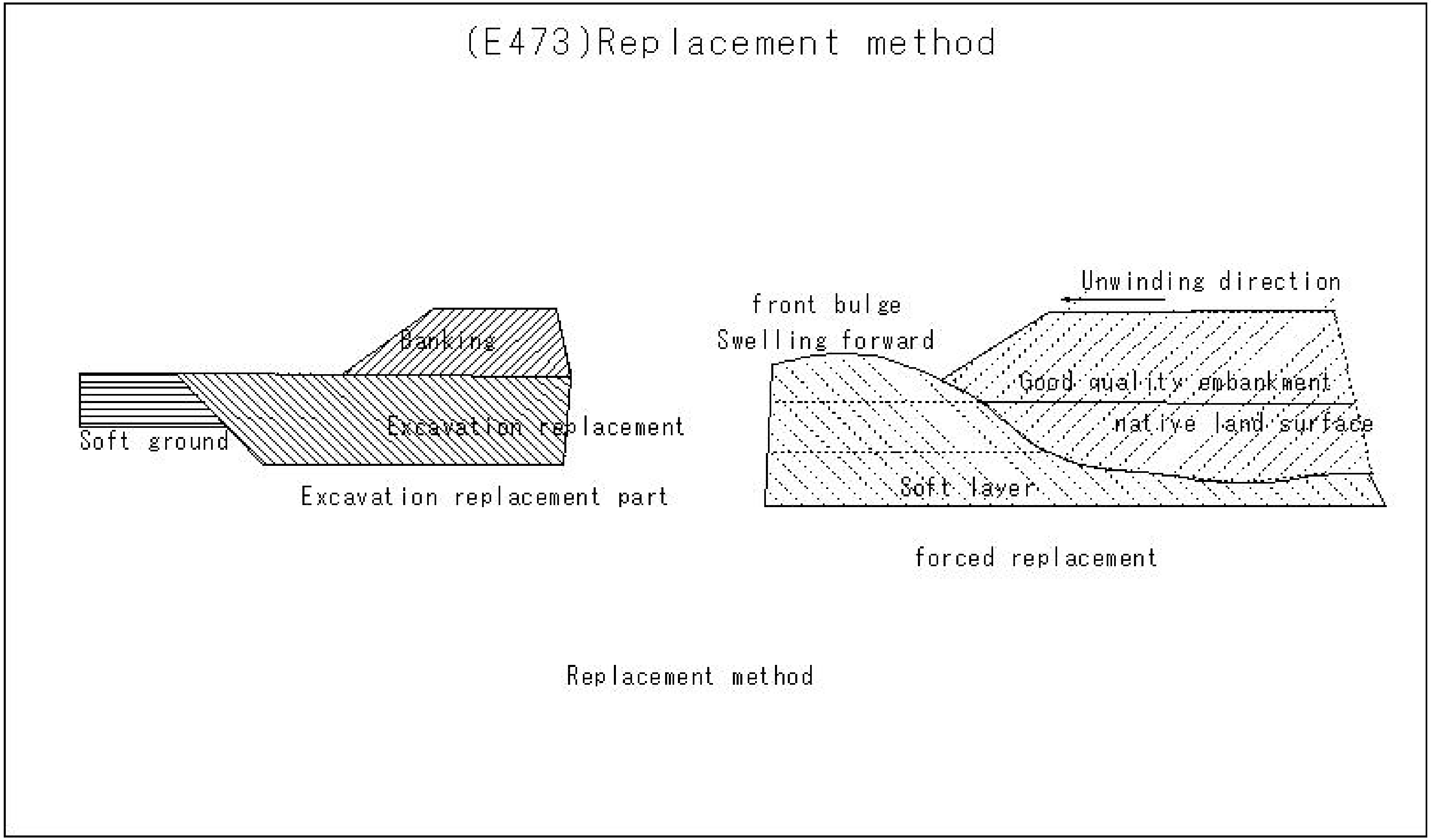
(E471)groundwater level



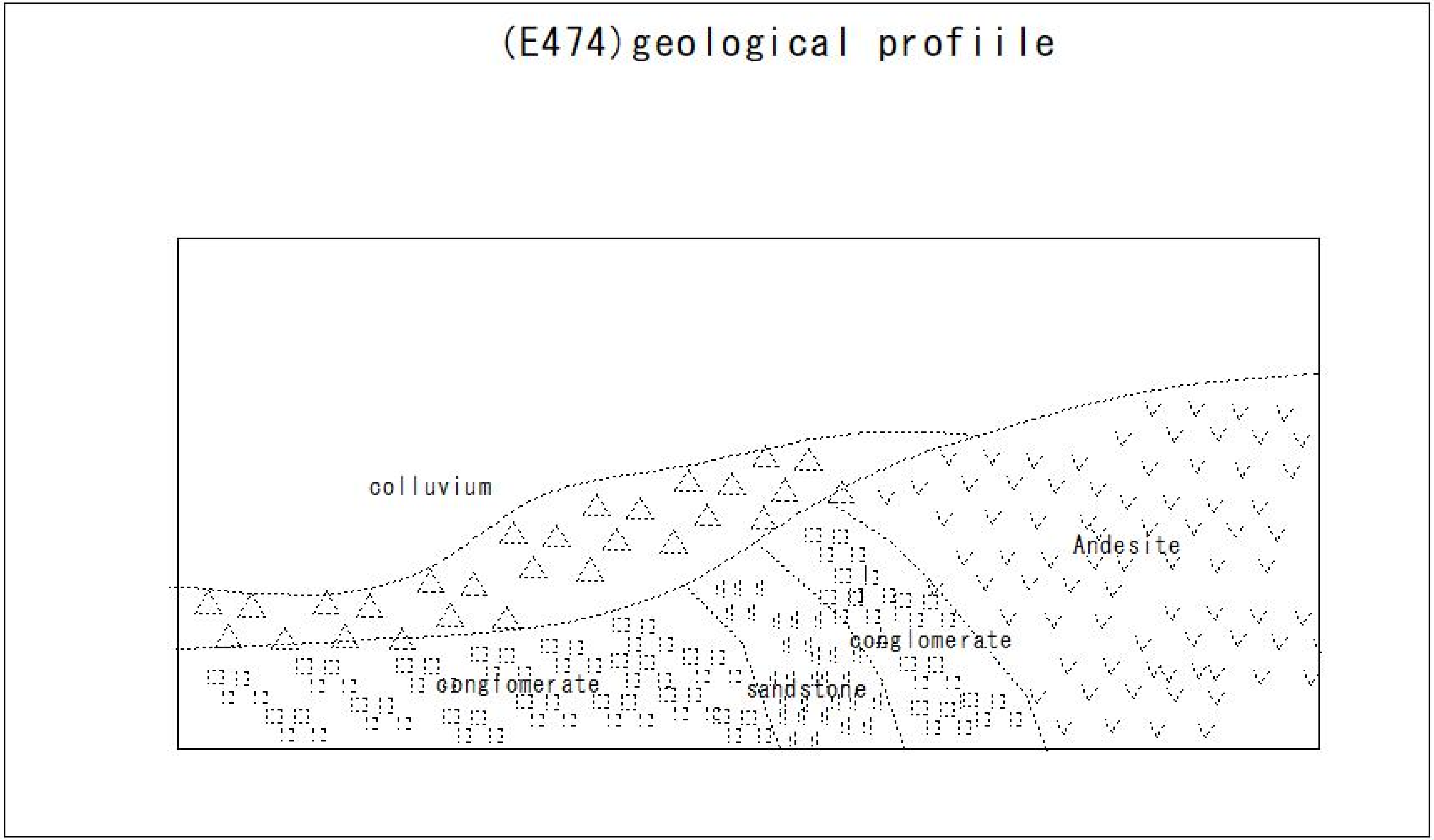
(E472)underground dam



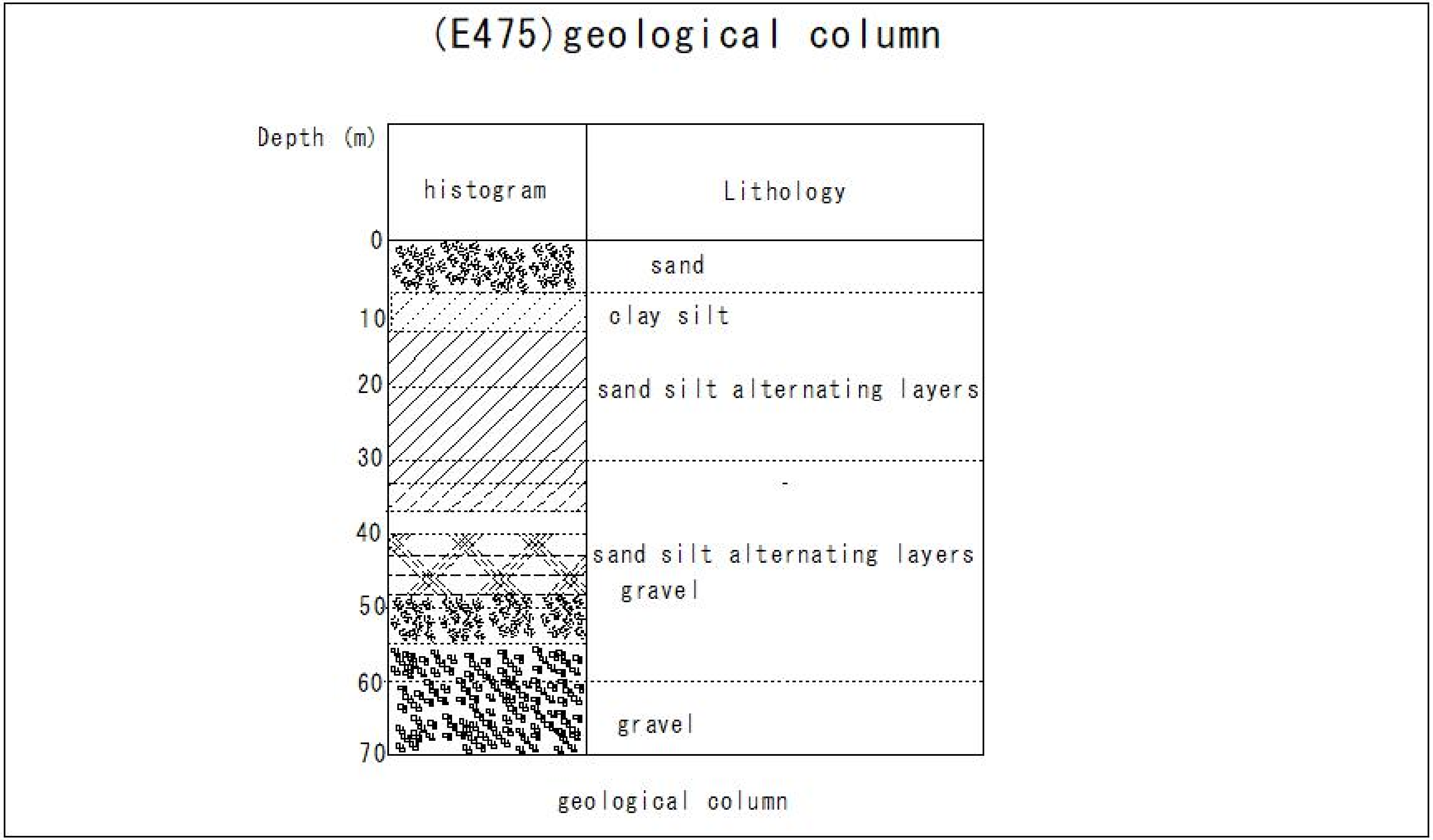
(E473)Replacement method



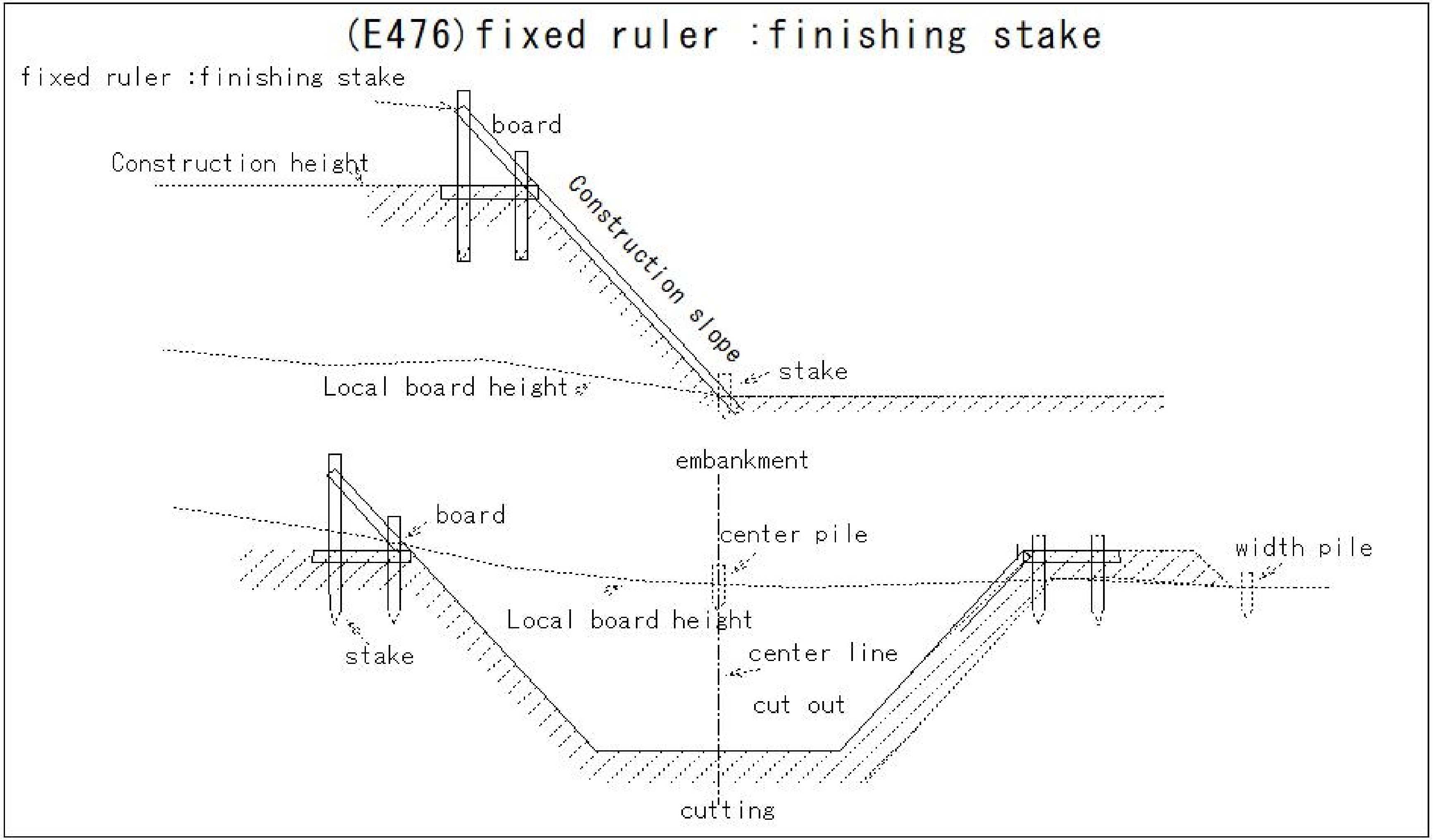
(E474)geological profiile



(E475)geological column

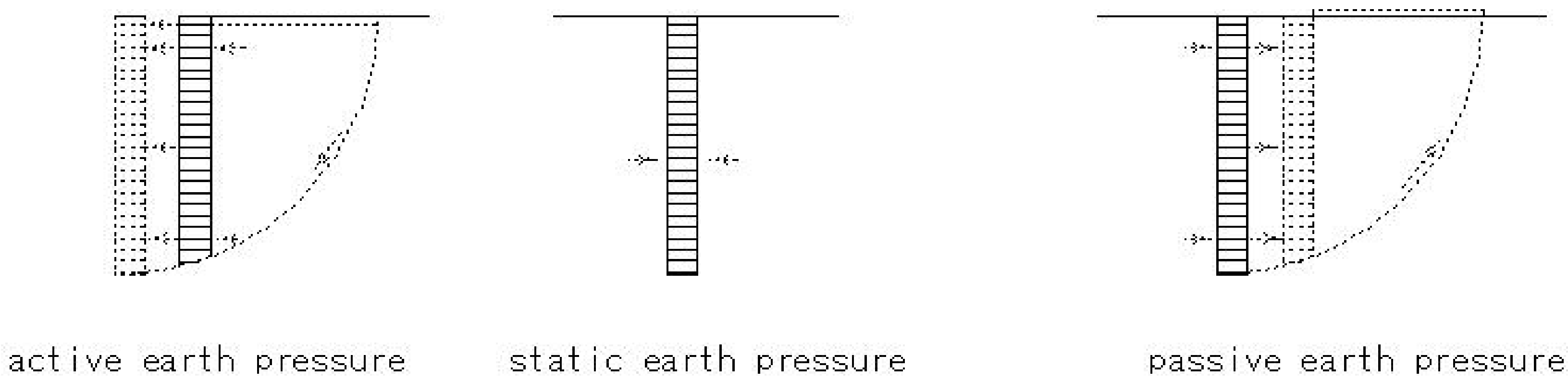


(E476)fixed ruler :finishing stake

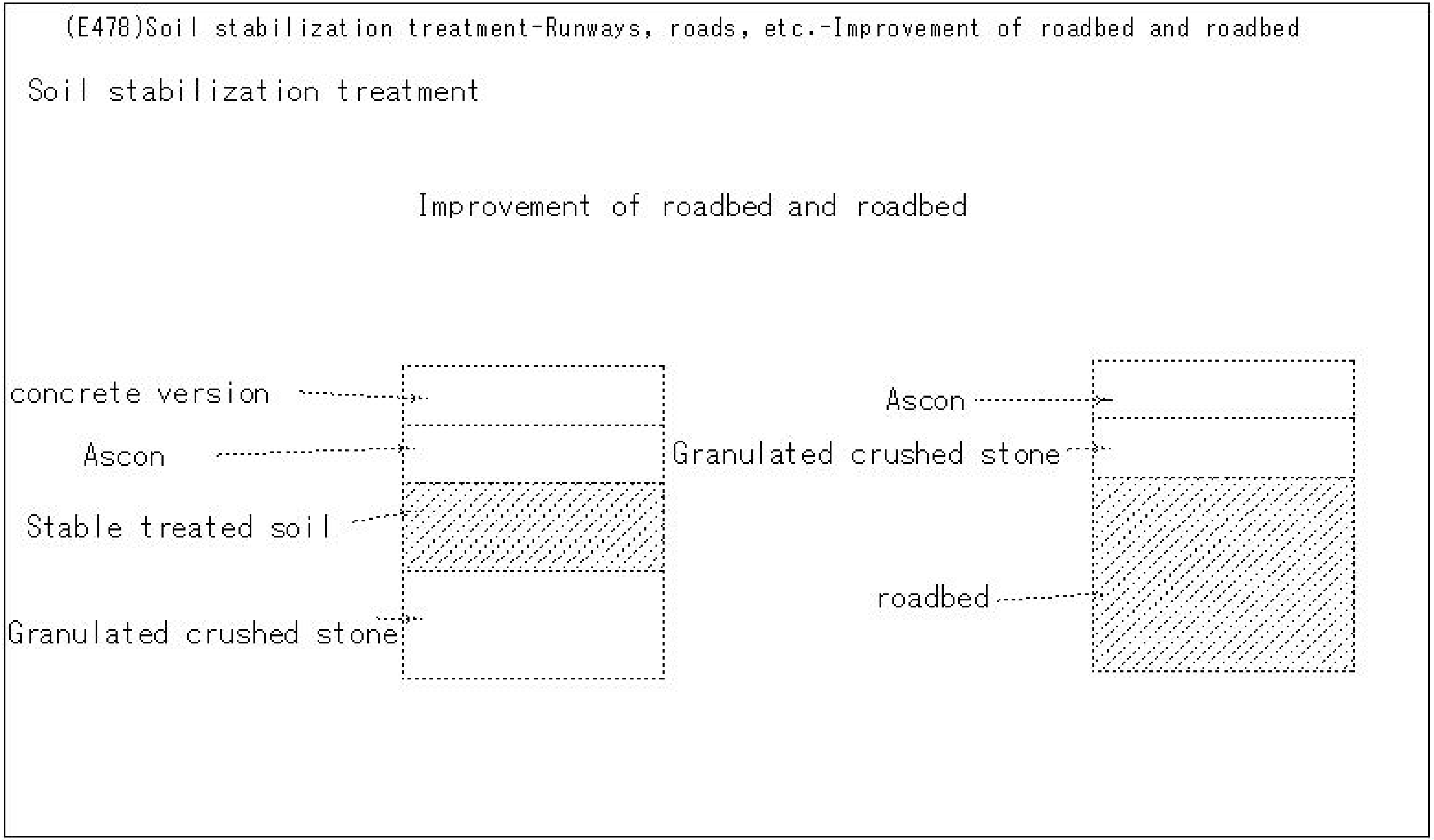


(E477)earth pressure

(E477)earth pressure



(E478)Soil stabilization treatment-Runways, roads, etc.-Improvement of roadbed and roadbed

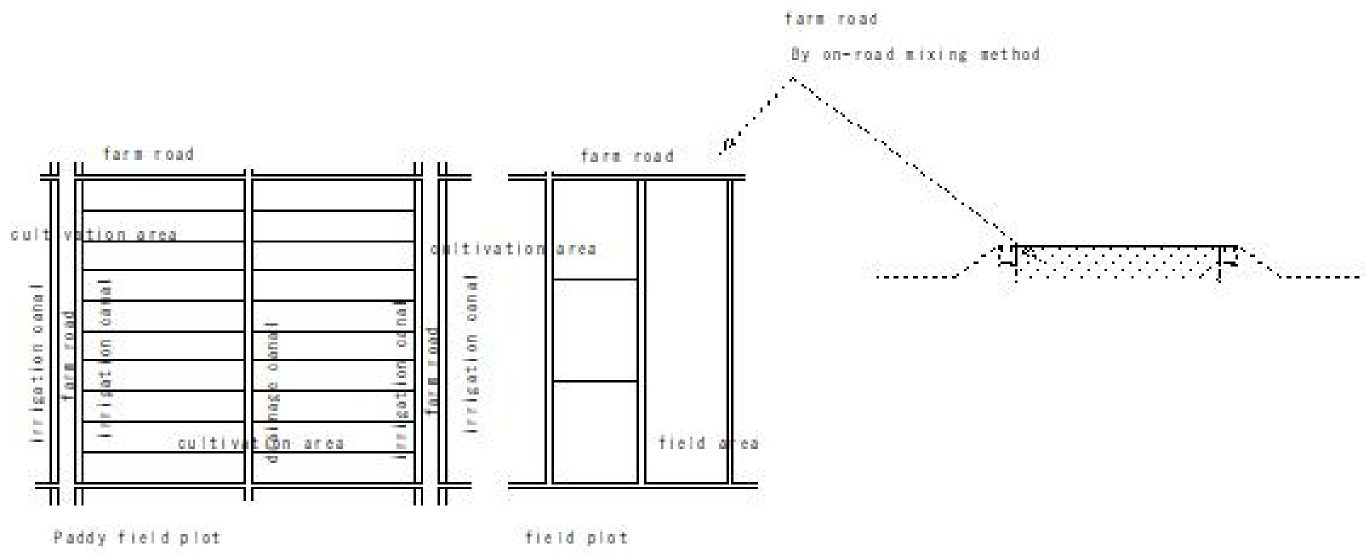


(E479)Soil stabilization treatment-By on-road mixing method-Simple paving of farm roads, parking lots, etc.

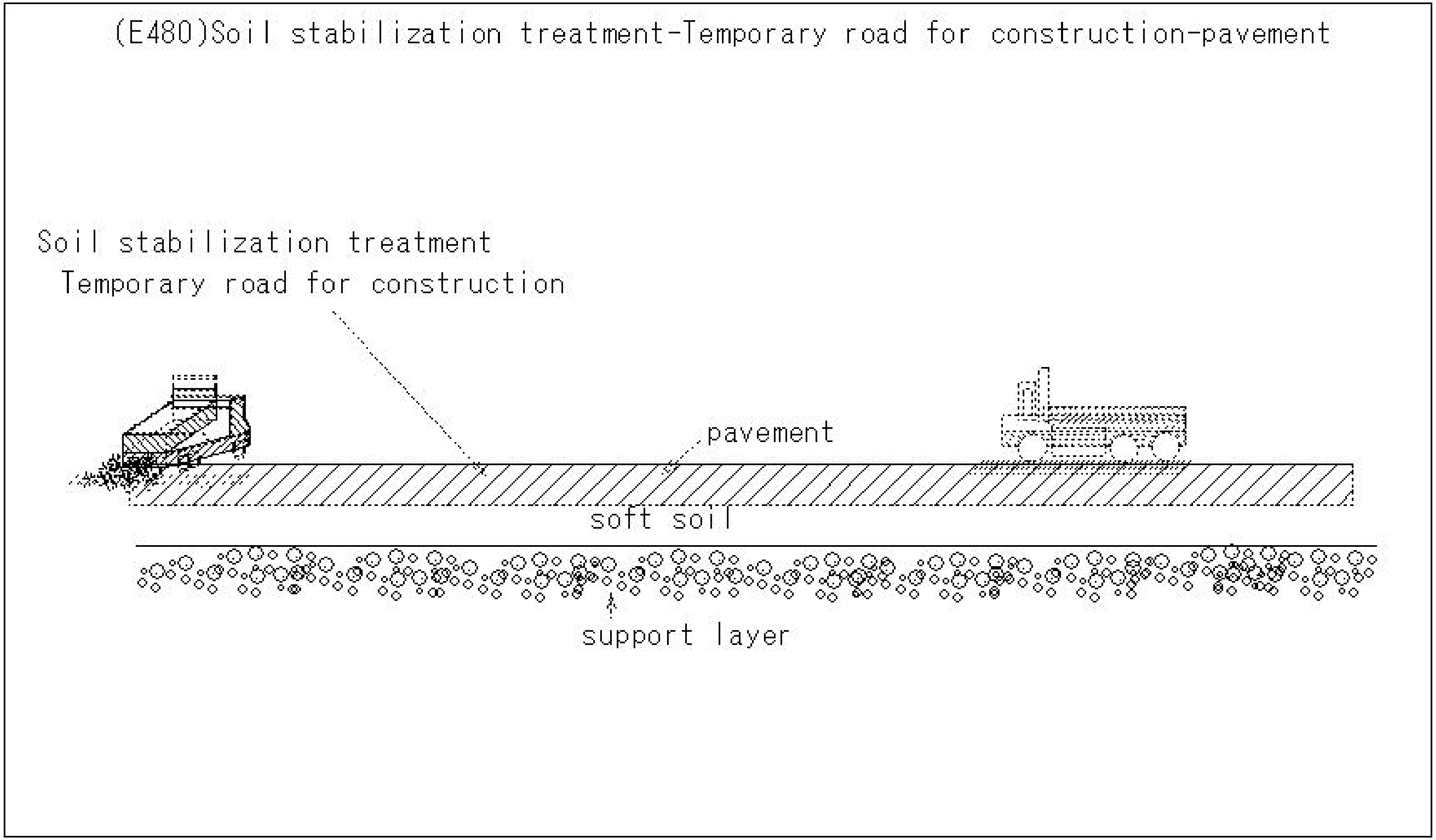
(E479)Soil stabilization treatment-By on-road mixing method-Simple paving of farm roads, parking lots, etc.

Soil stabilization treatment

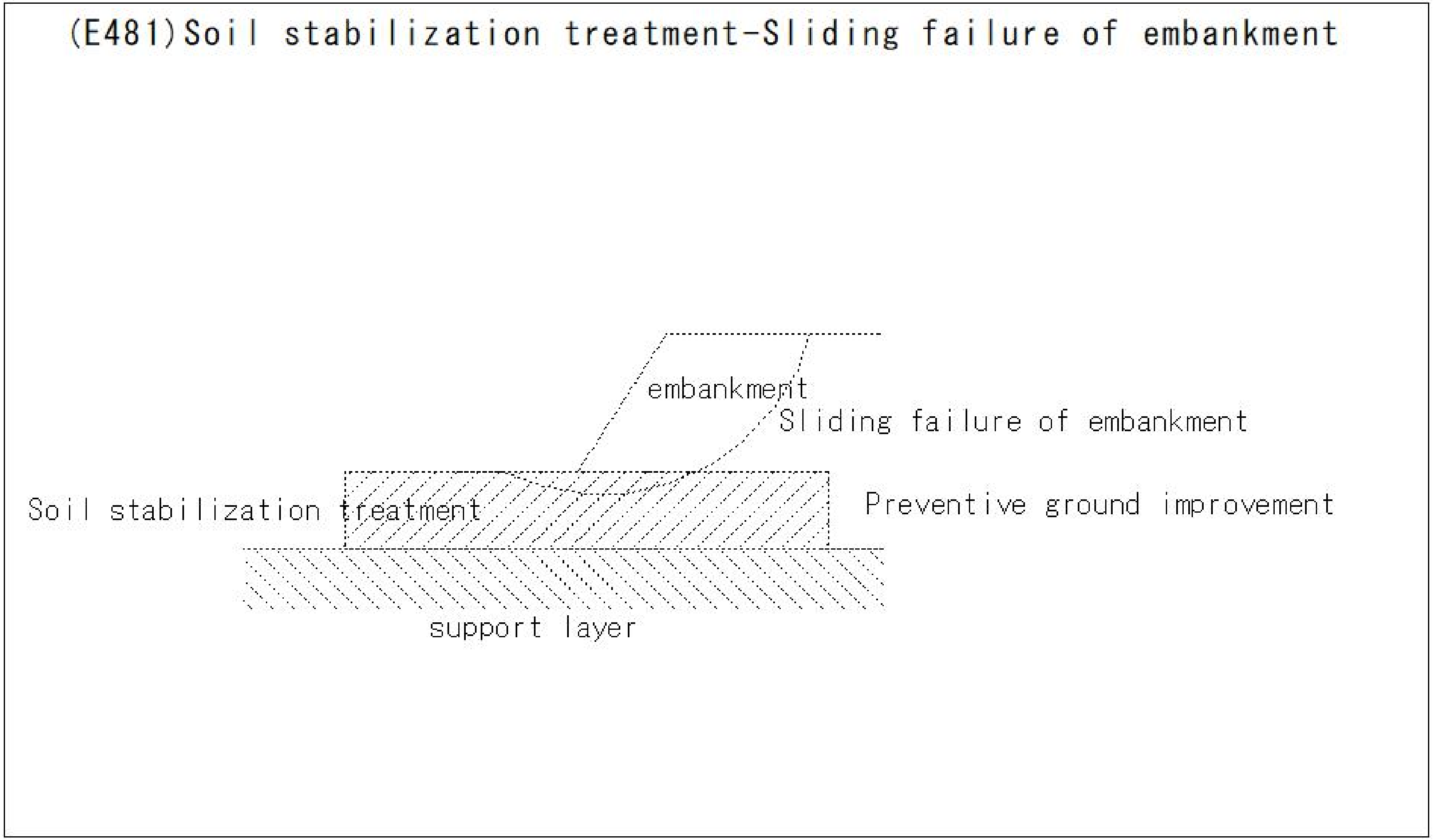
By on-road mixing method



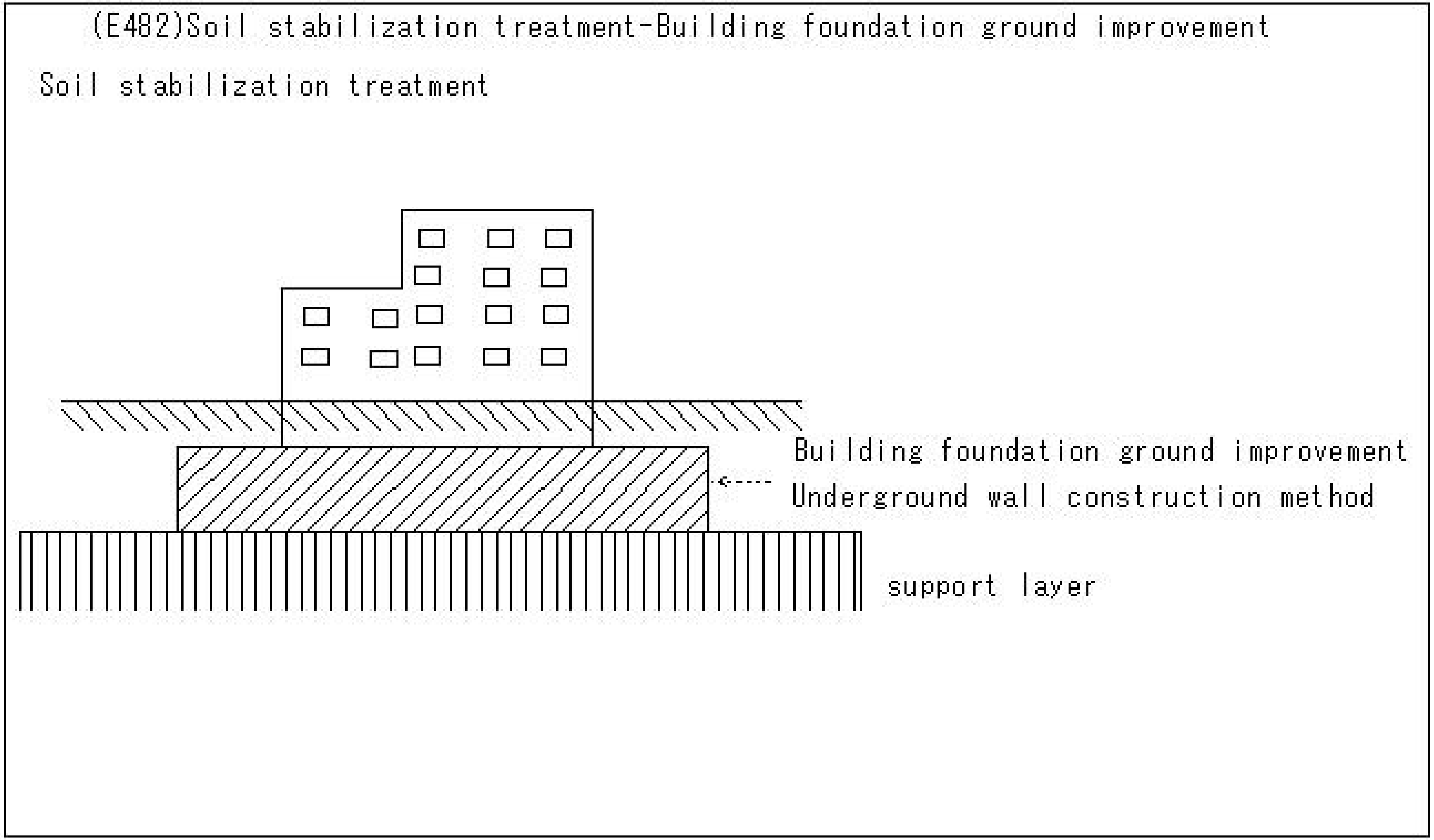
(E480)Soil stabilization treatment-Temporary road for construction-pavement



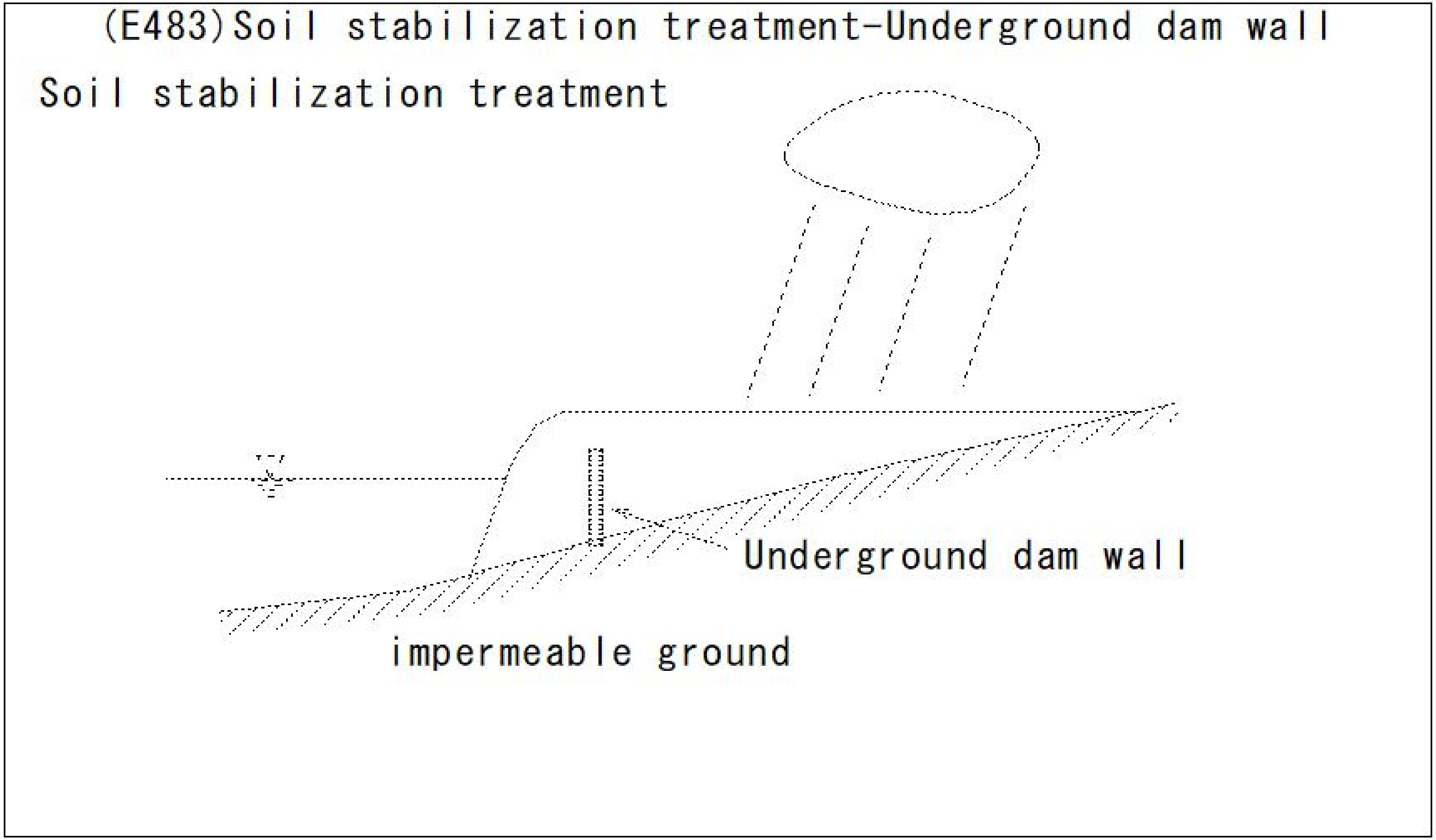
(E481)Soil stabilization treatment-Sliding failure of embankment



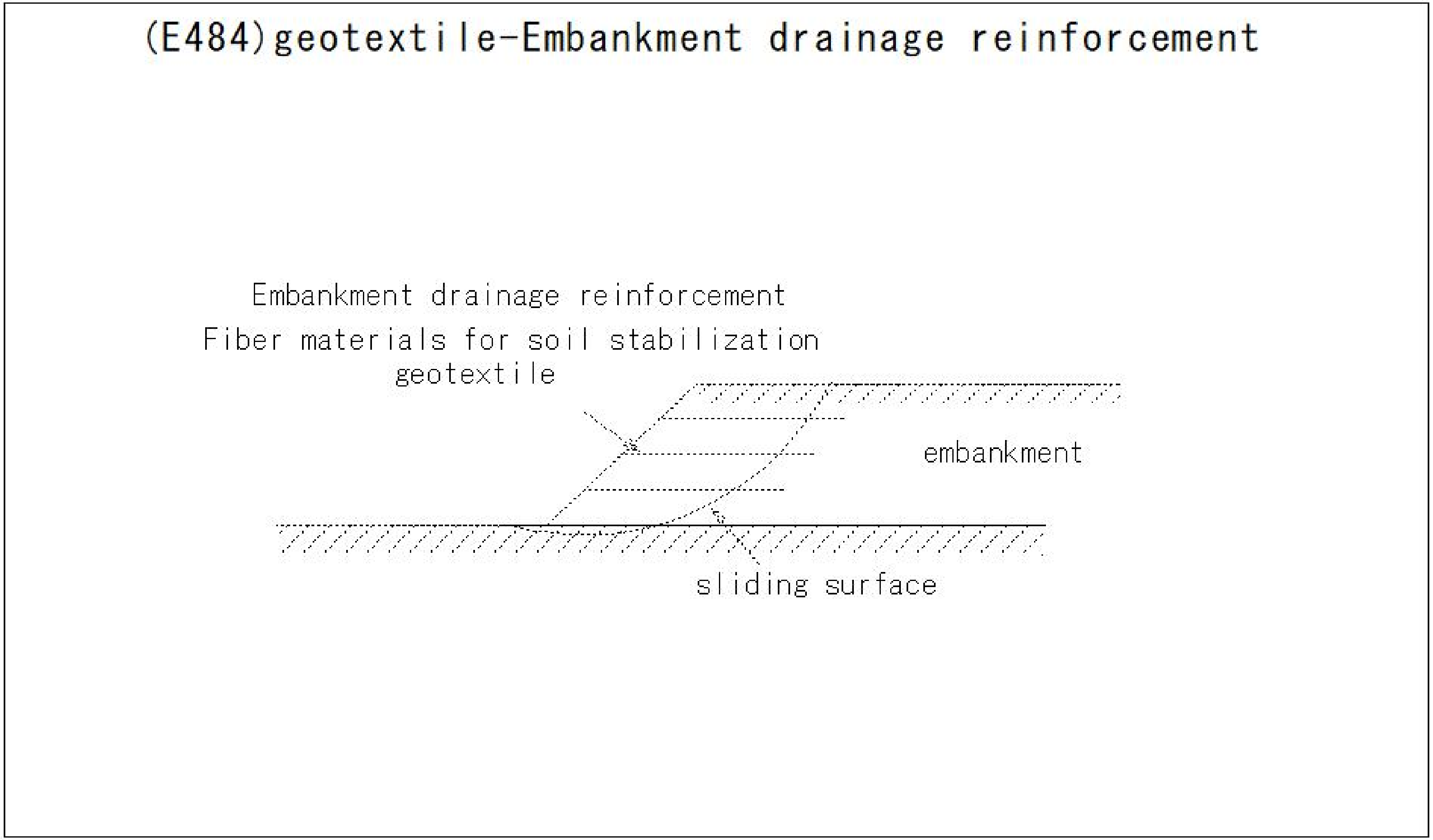
(E482)Soil stabilization treatment-Building foundation ground improvement



(E483)Soil stabilization treatment-Underground dam wall

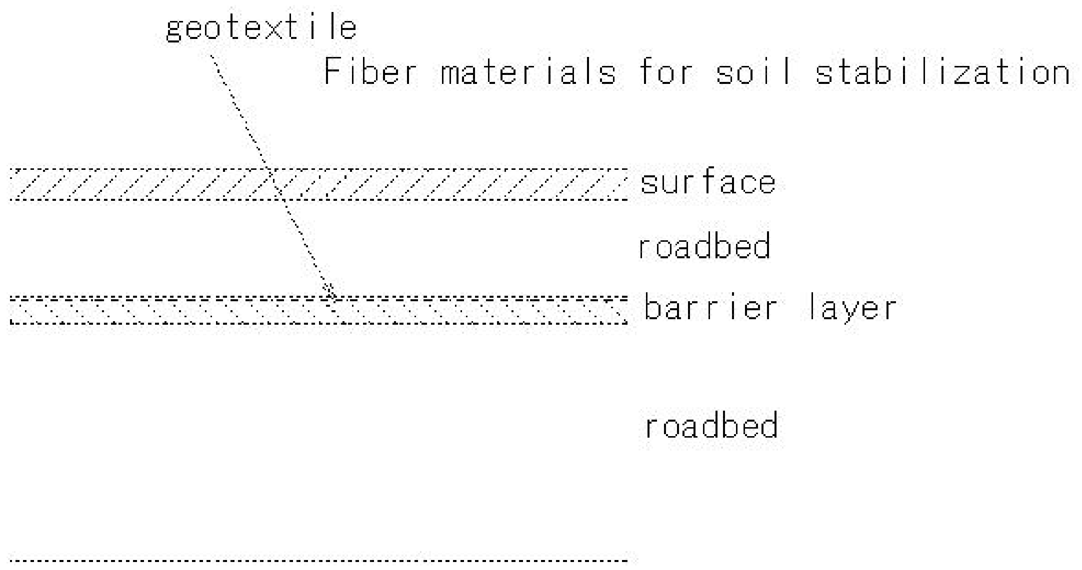


(E484)geotextile-Embankment drainage reinforcement

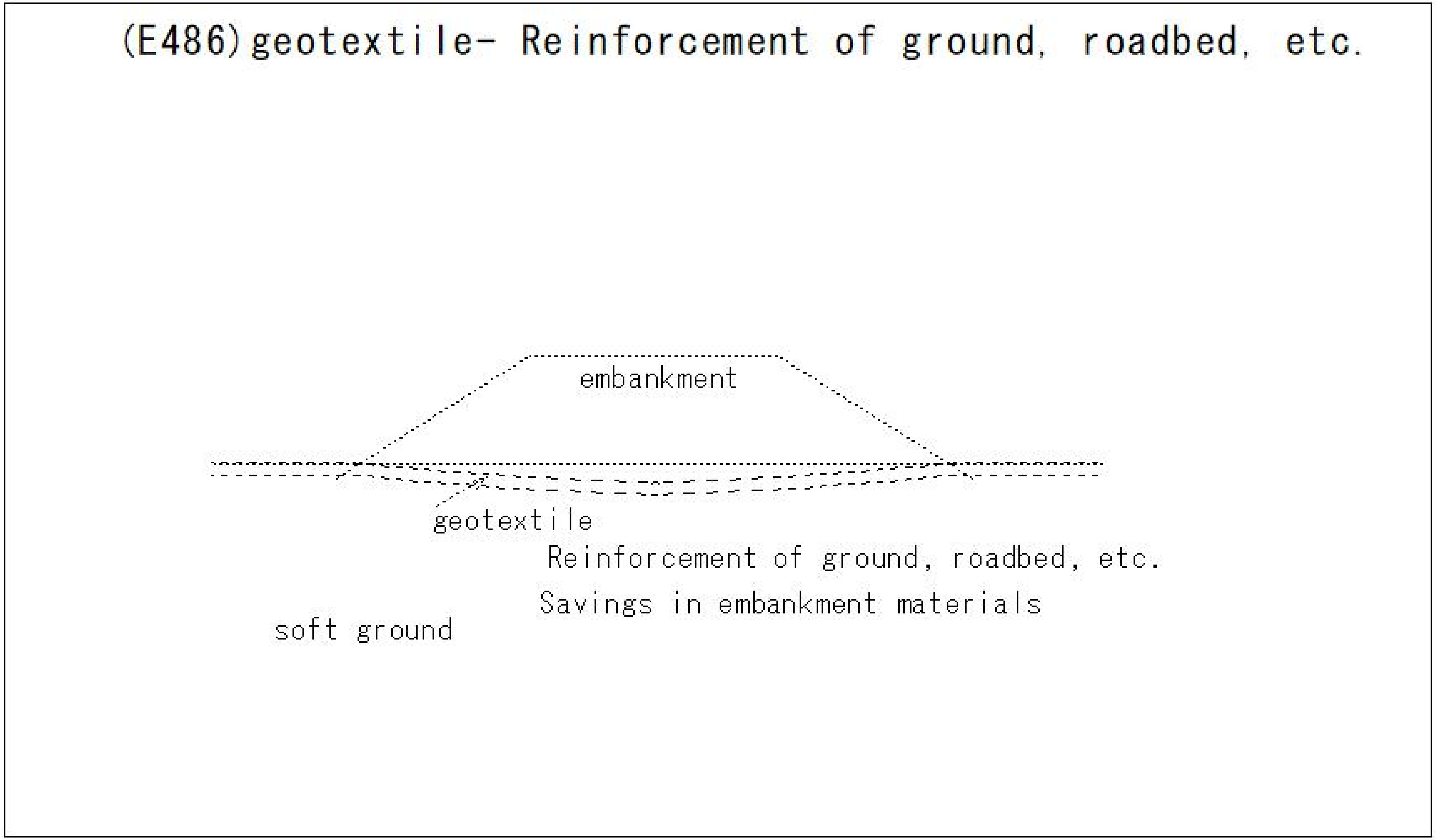


(E485)geotextile-Separation of different materials

(E485)geotextile-Separation of different materials

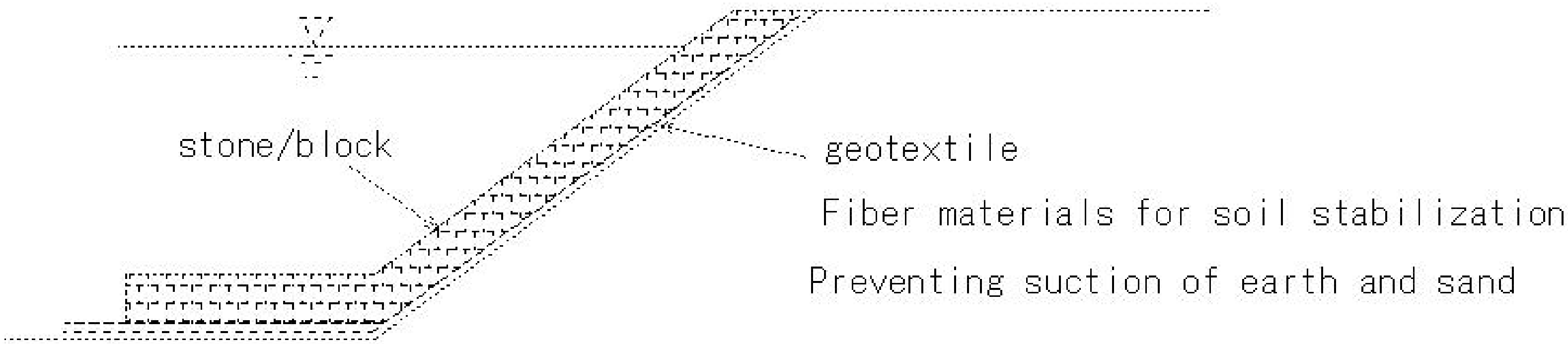


(E486)geotextile- Reinforcement of ground, roadbed, etc.



(E487)geotextile- Preventing suction of earth and sand

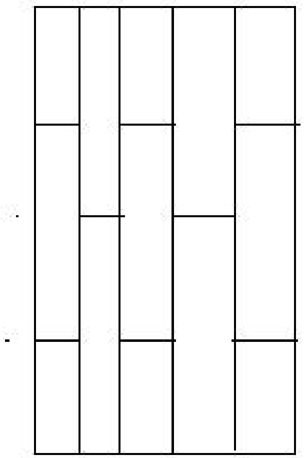
(E487)geotextile- Preventing suction of earth and sand



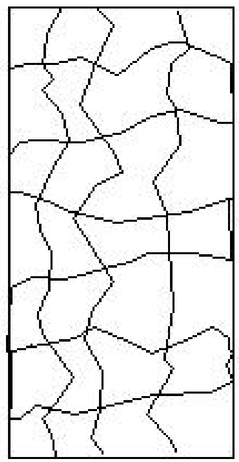
(E488)soil structure

(E488)soil structure

How to enter the earth fissure



Soil column structure



Clumpy structure

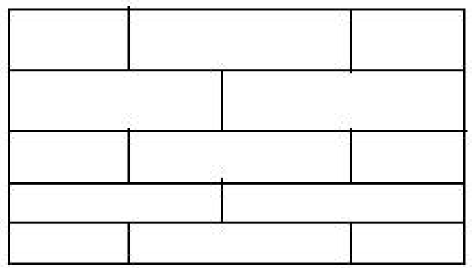
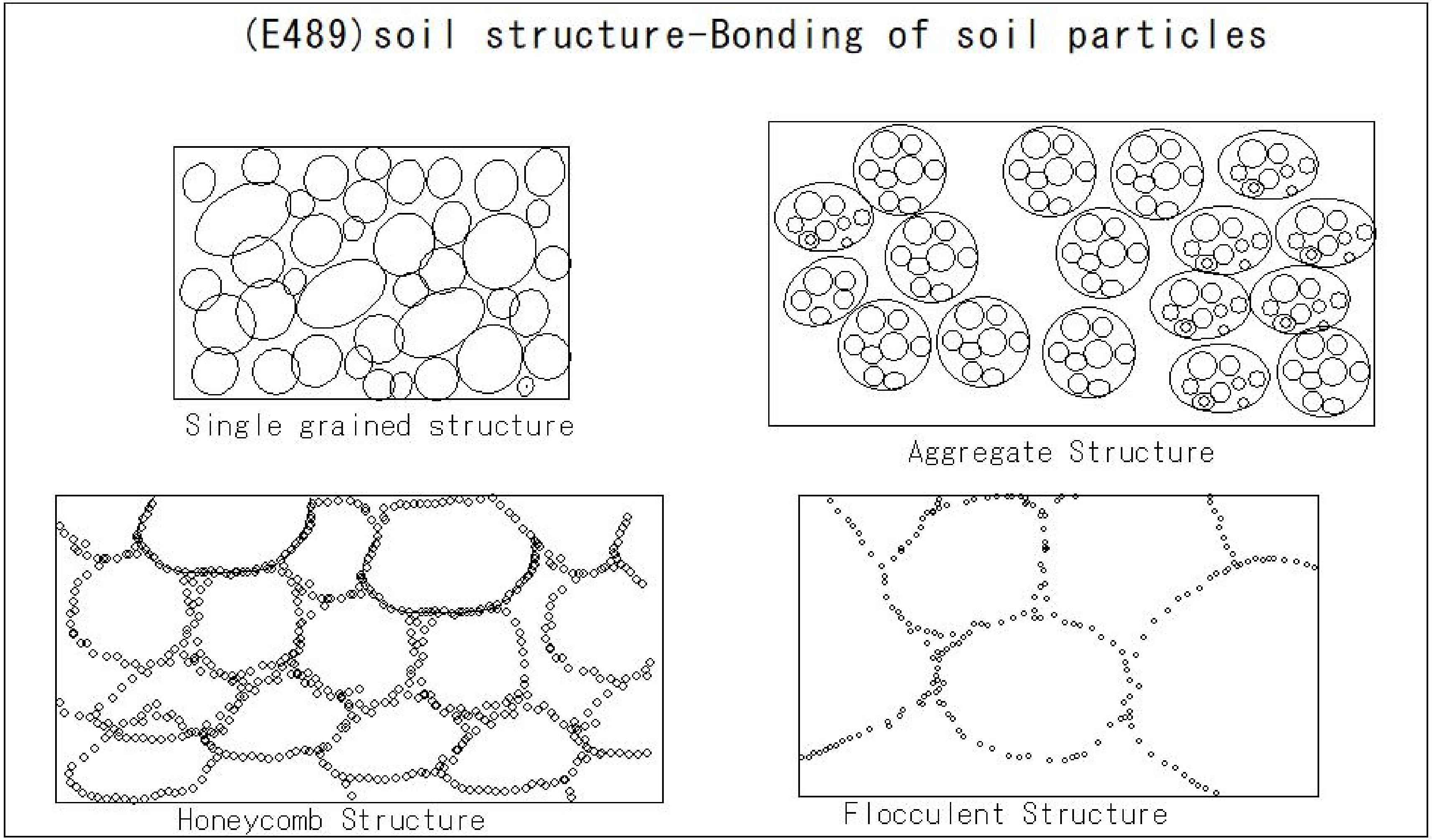
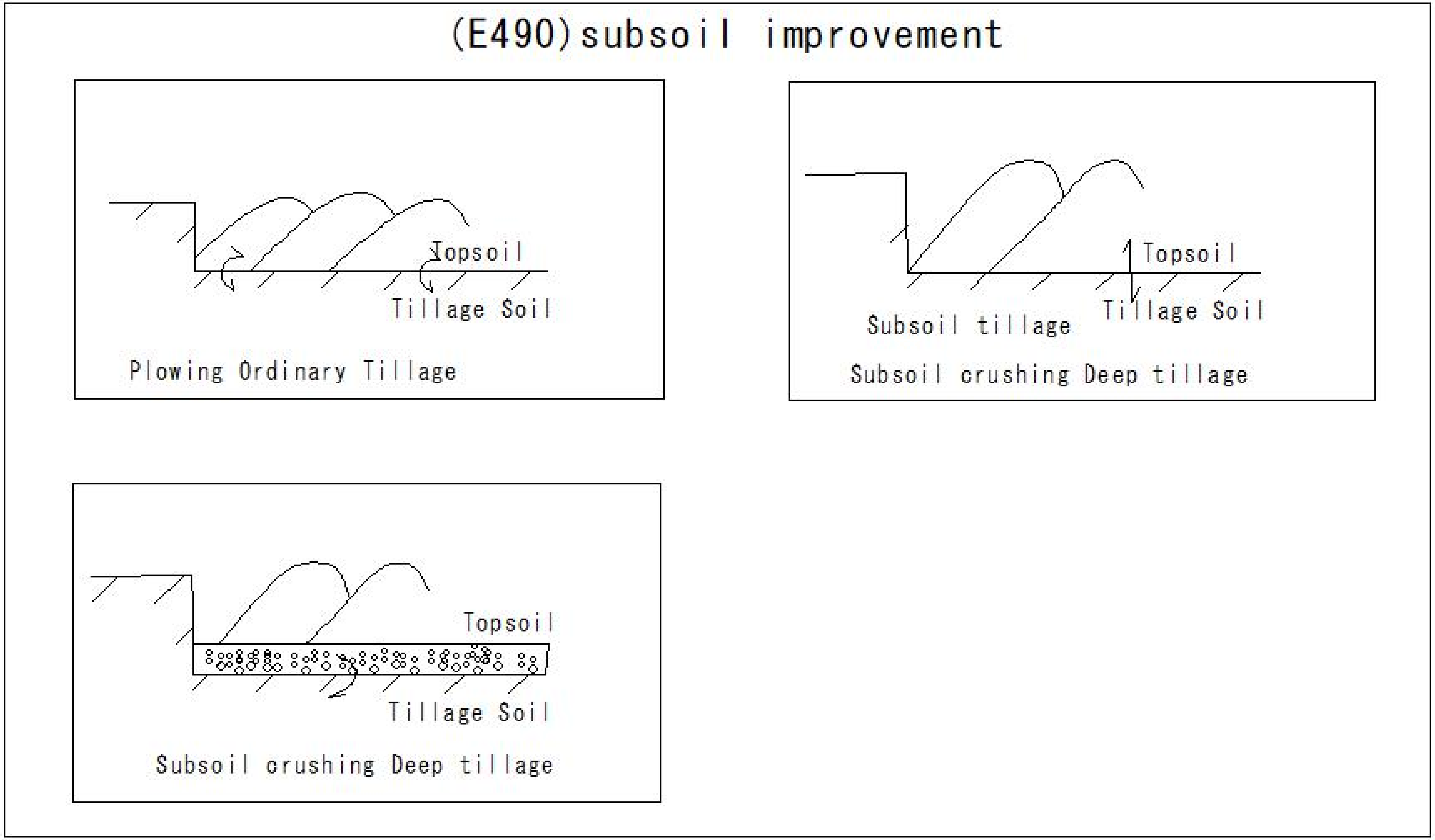


Plate structure

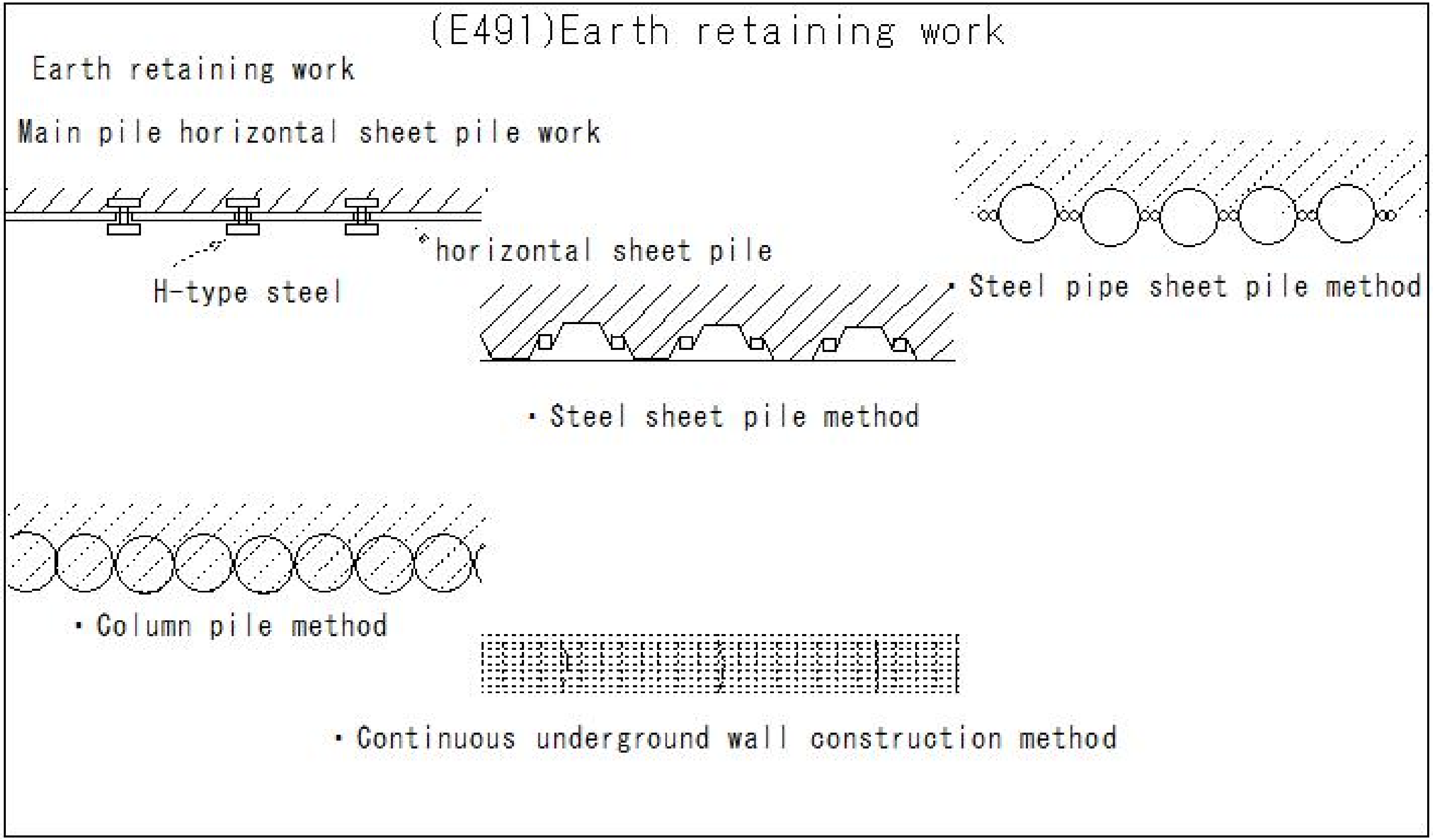
(E489)soil structure-Bonding of soil particles



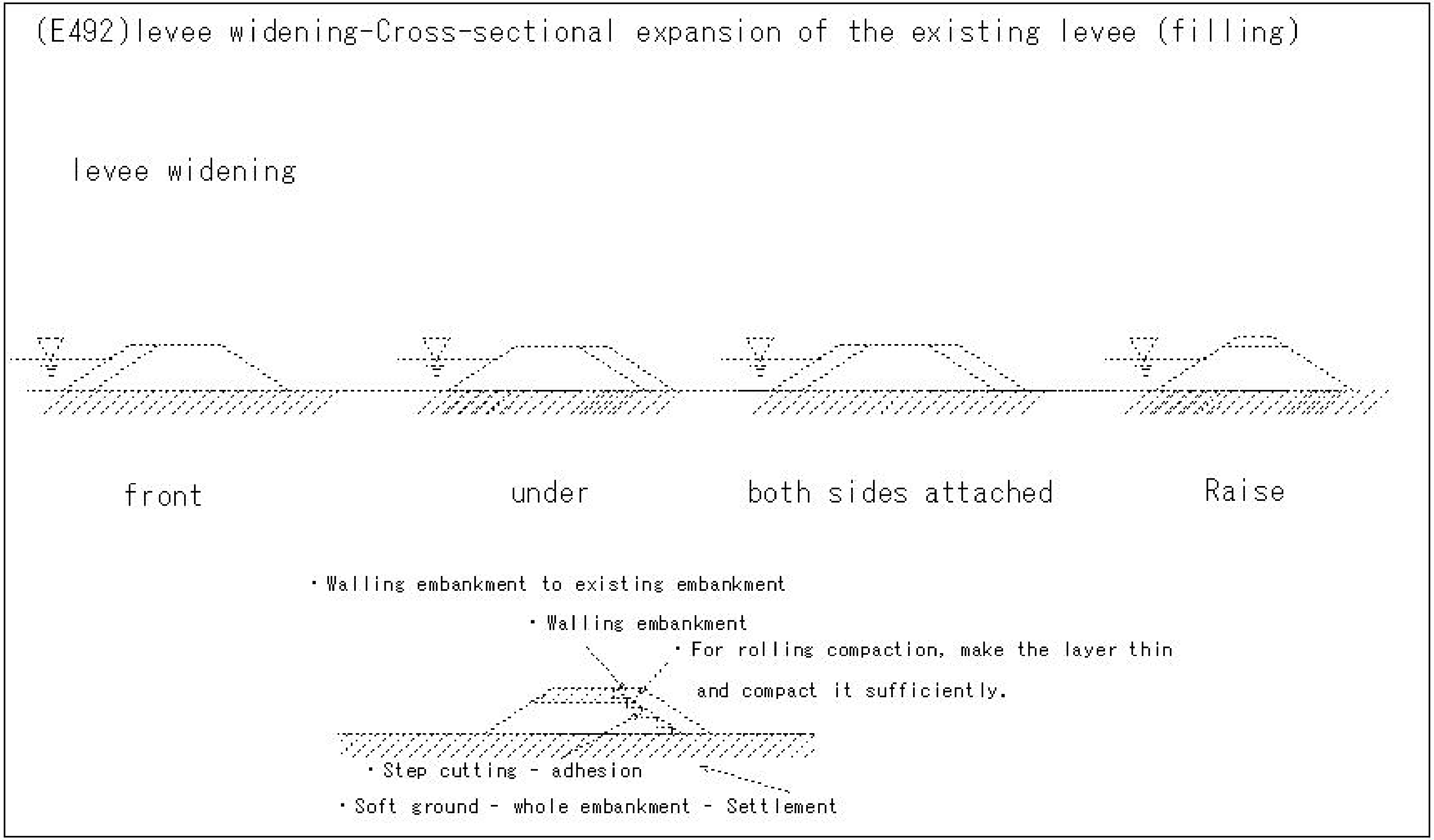
(E490)subsoil improvement



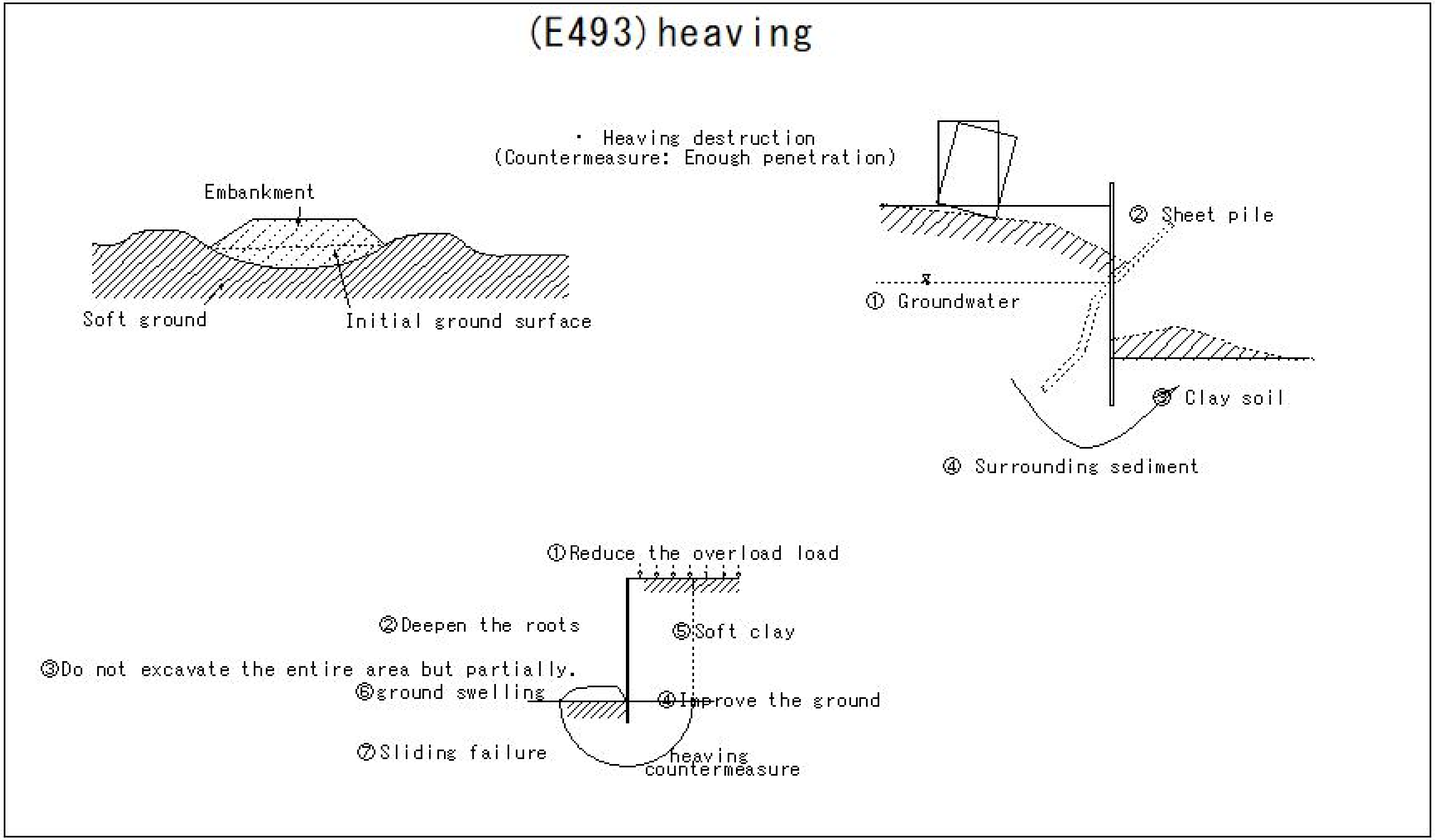
(E491)Earth retaining work



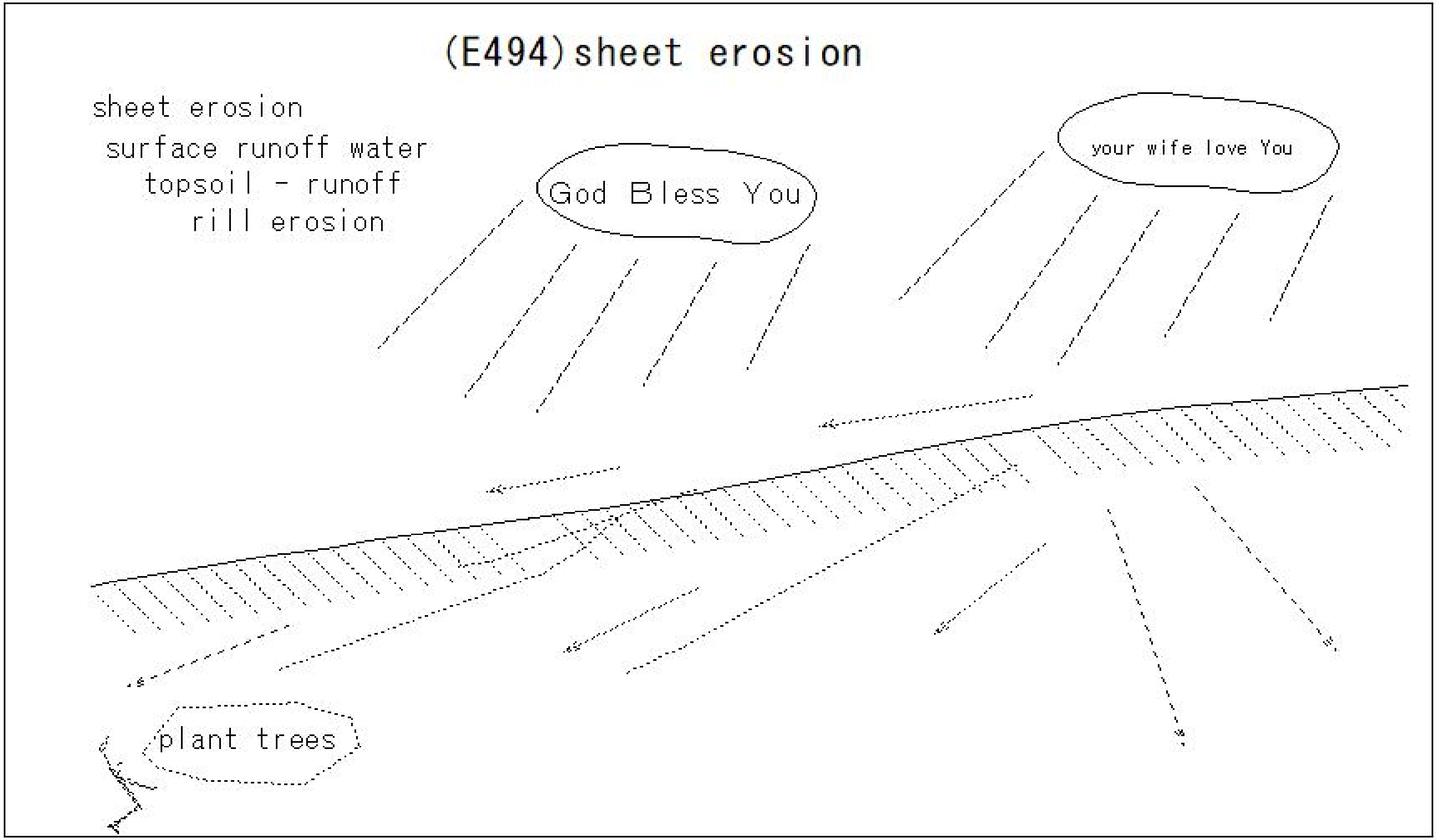
(E492)levee widening-Cross-sectional expansion of the existing levee (filling)



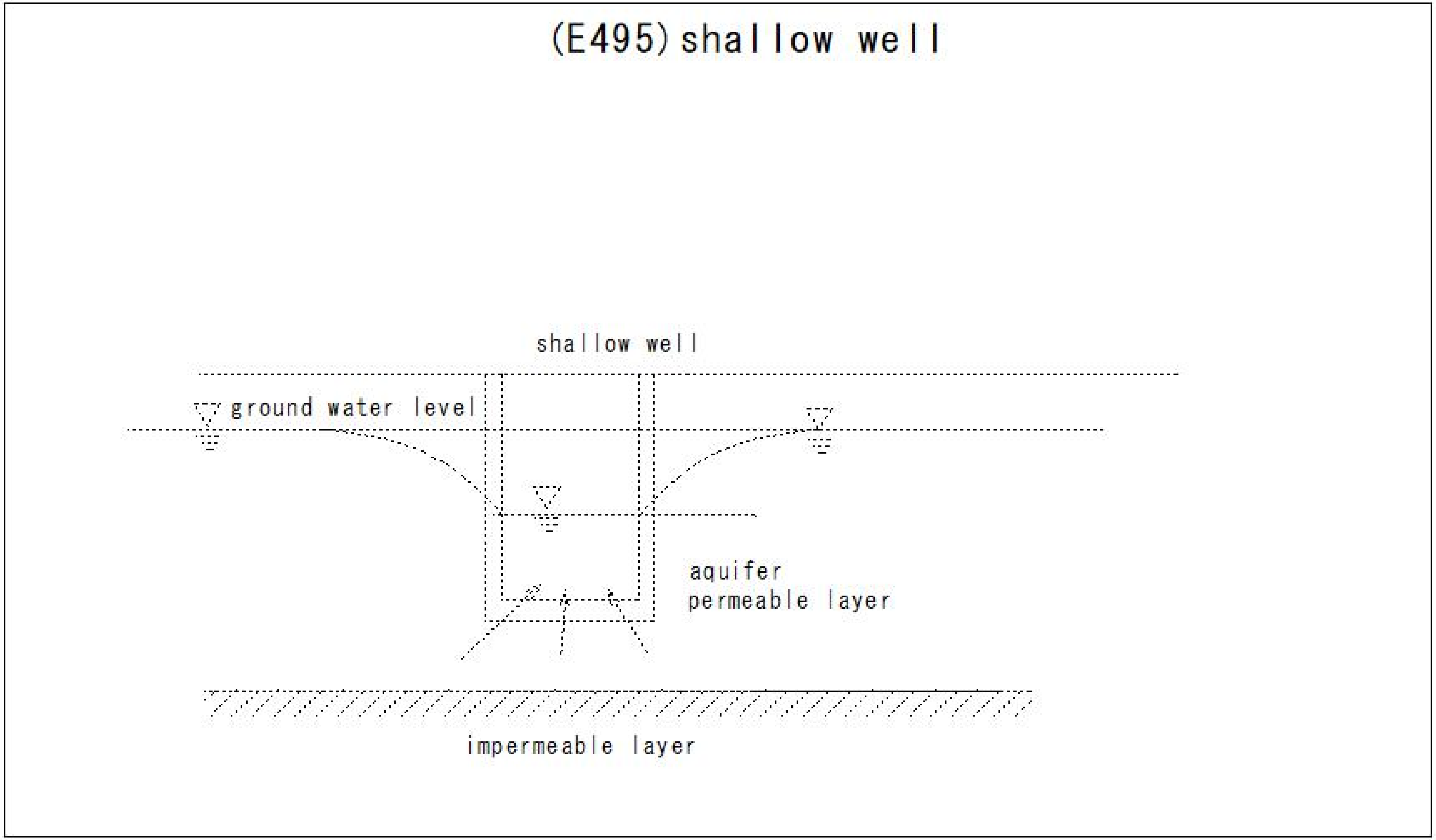
(E493)heaving



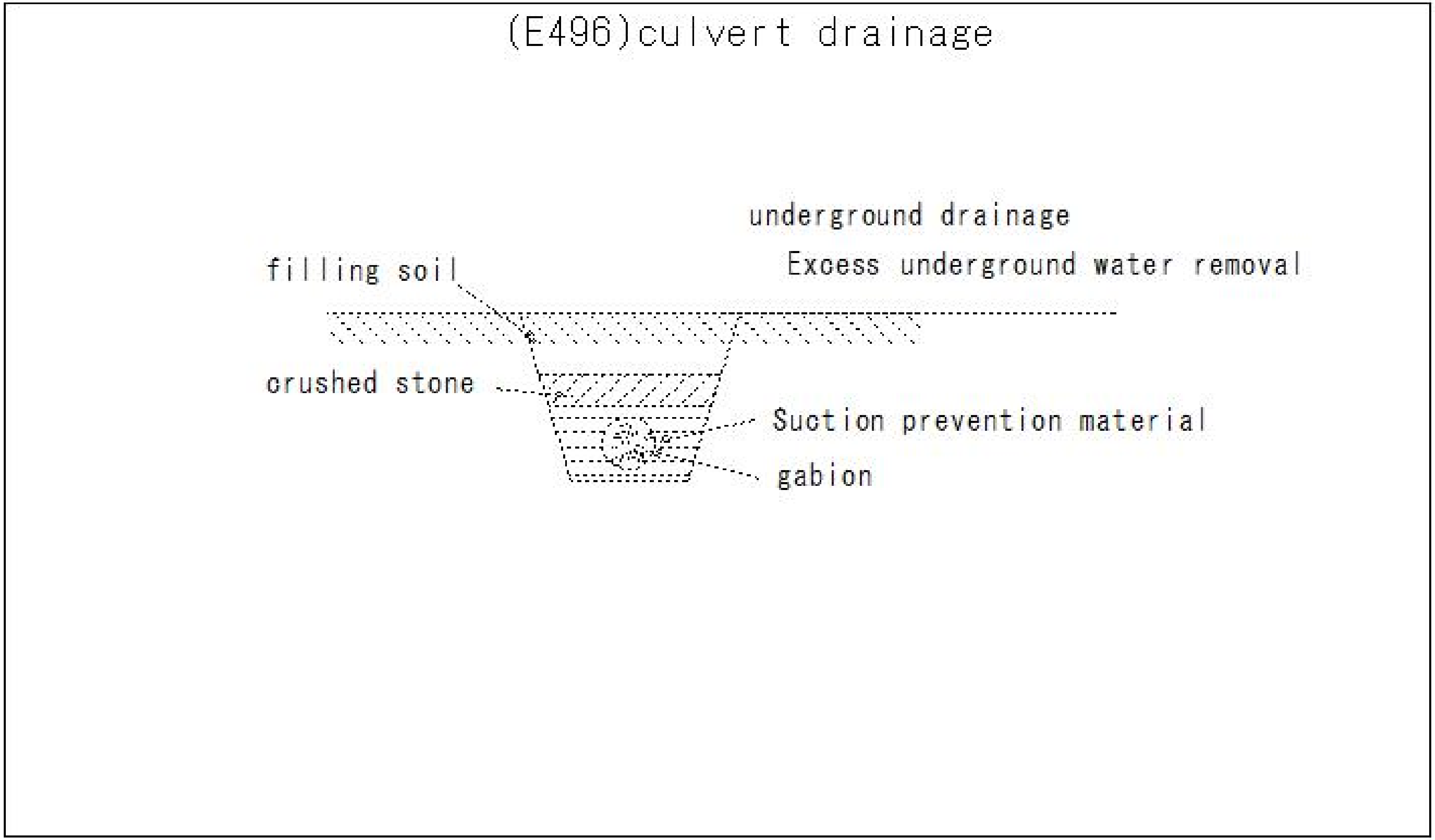
(E494)sheet erosion



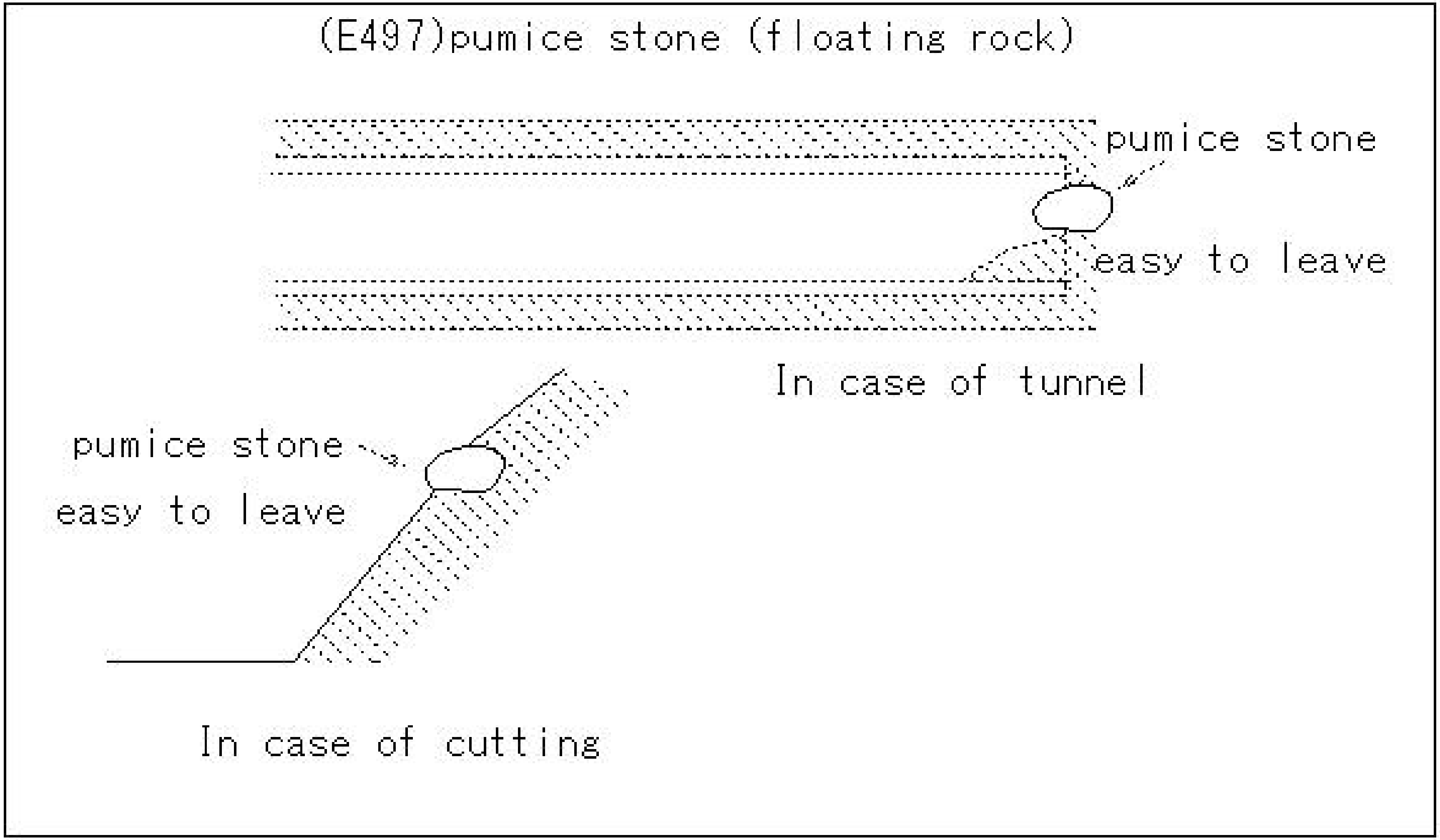
(E495)shallow well



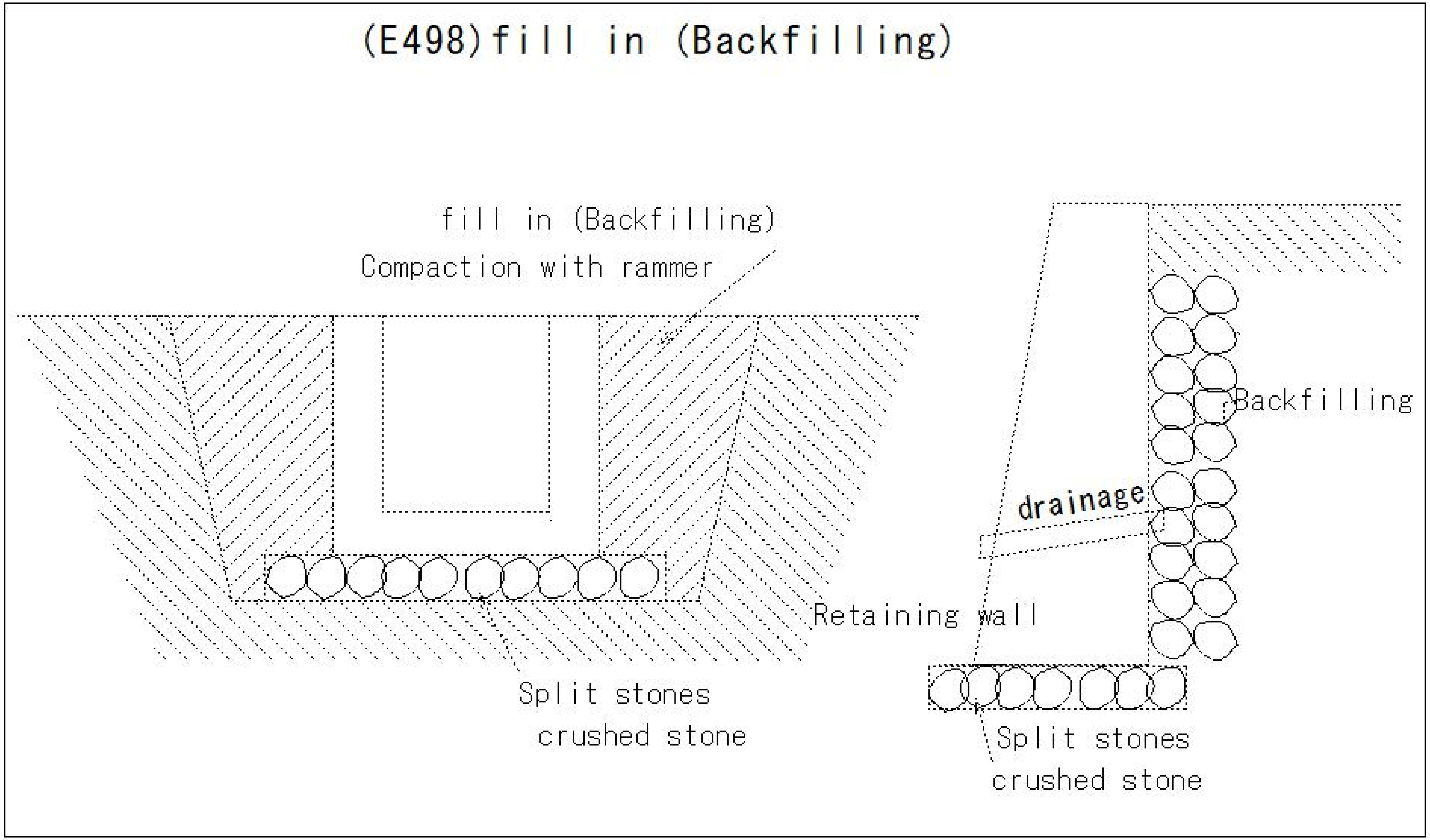
(E496)culvert drainage



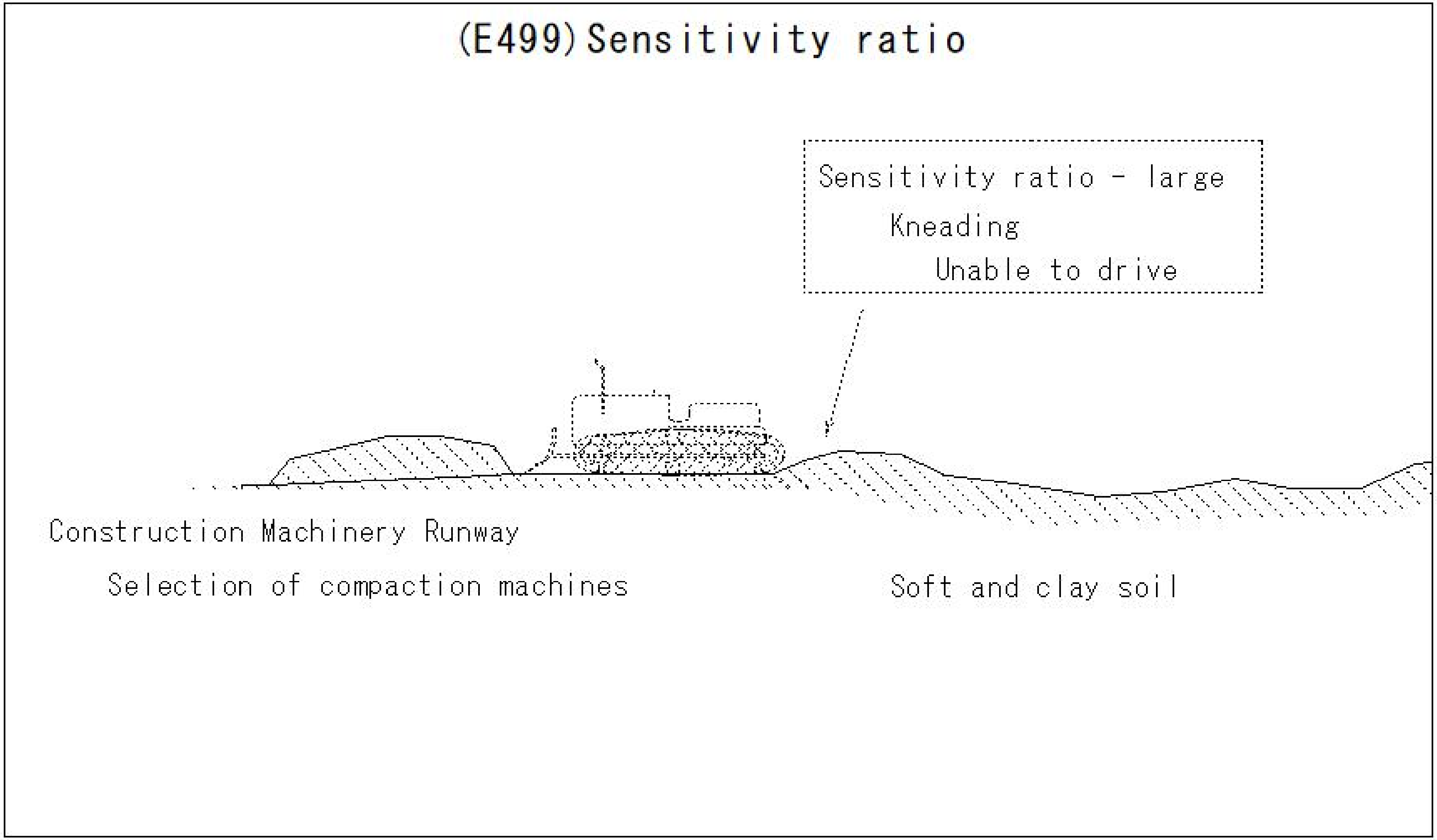
(E497)pumice stone (floating rock)



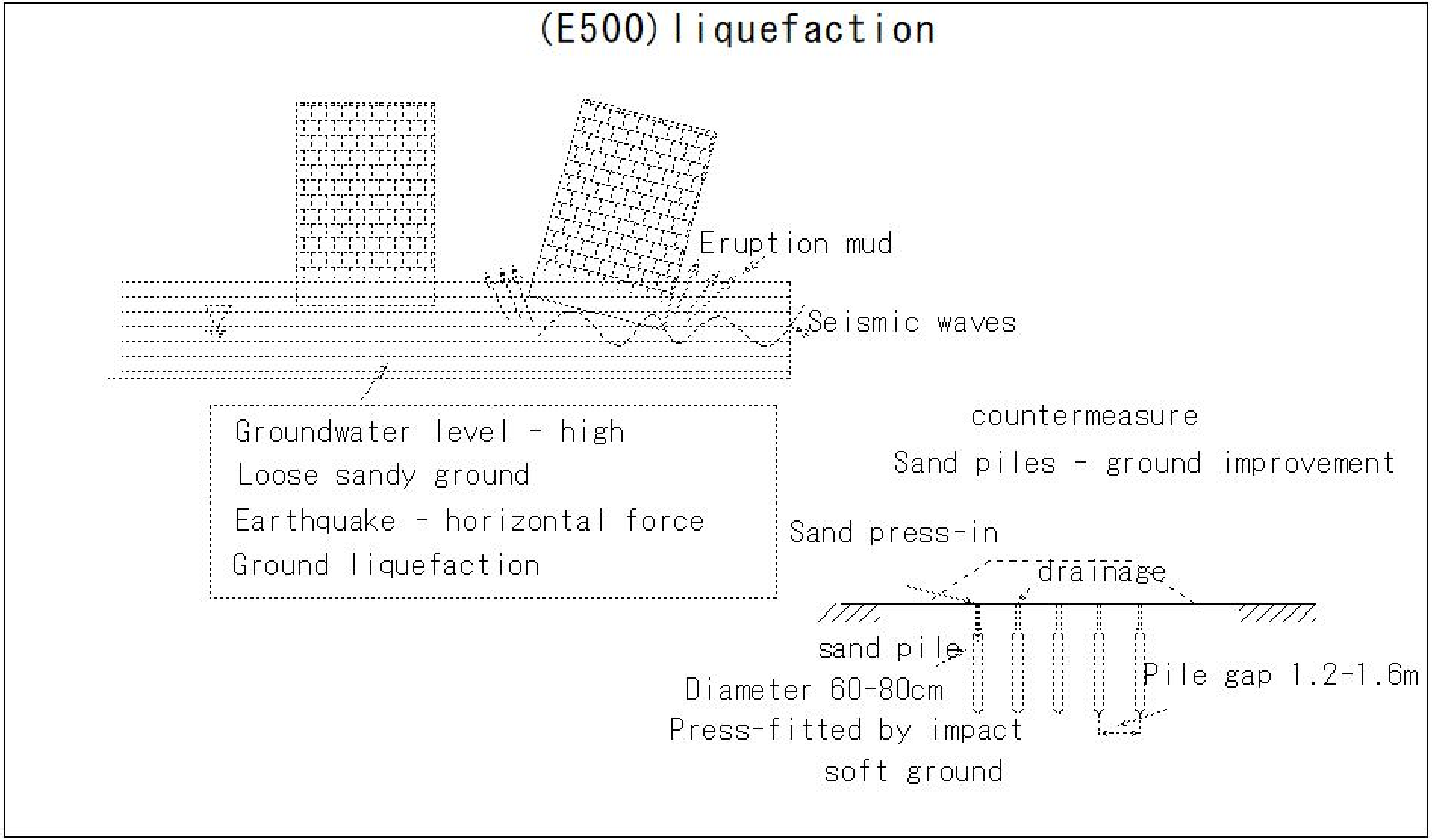
(E498)fill in (Backfilling)



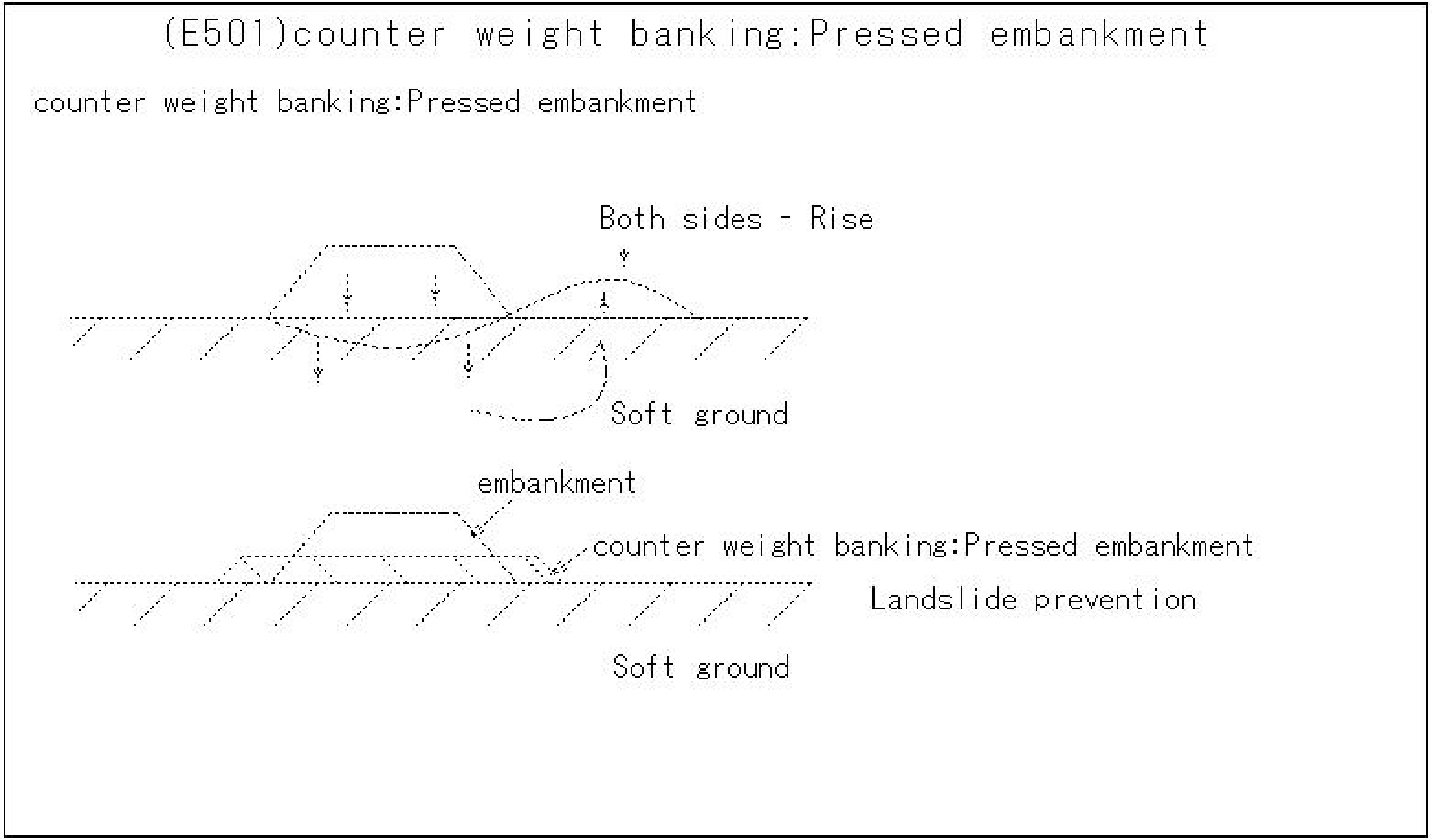
(E499)Sensitivity ratio



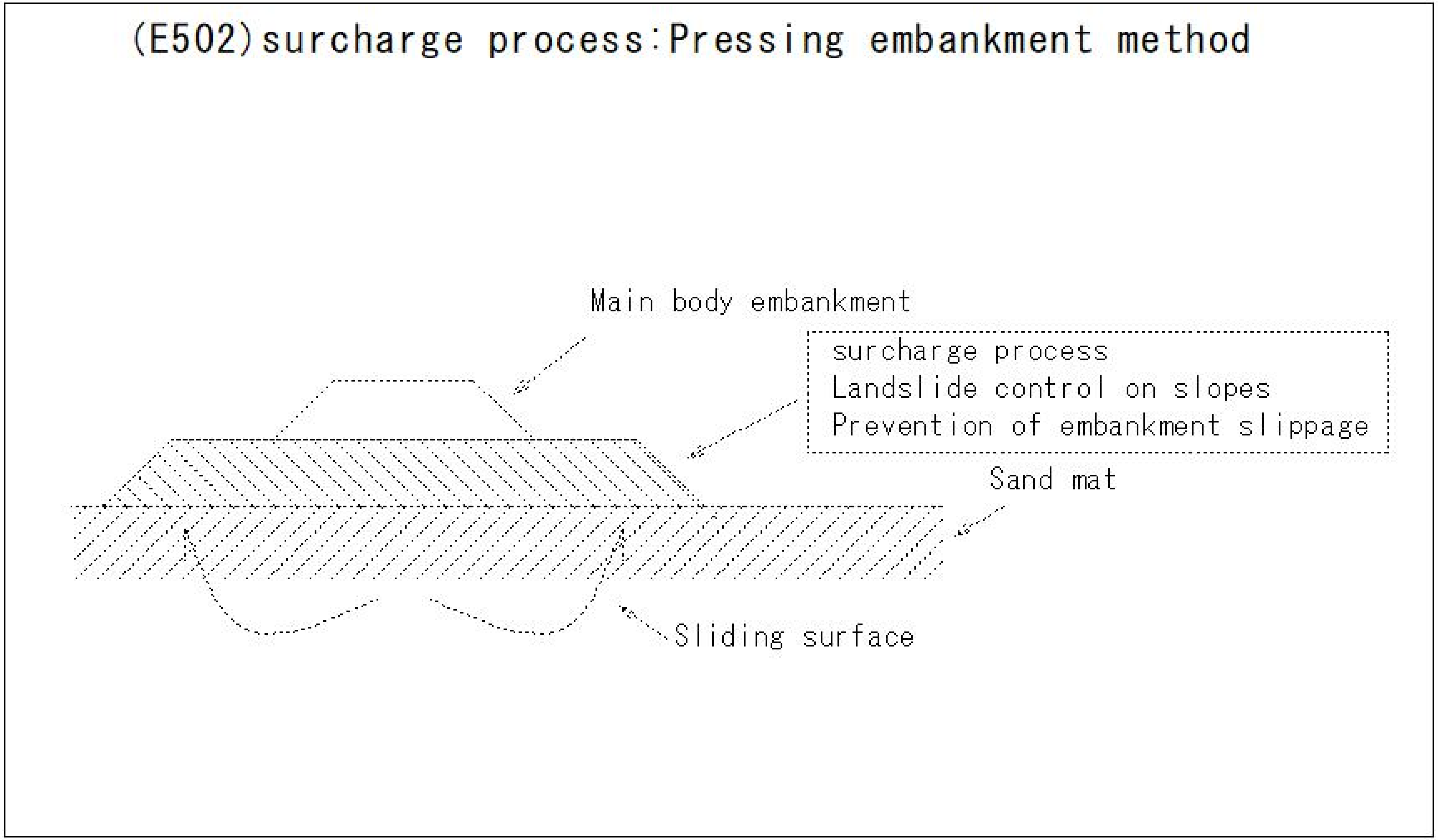
(E500)liquefaction



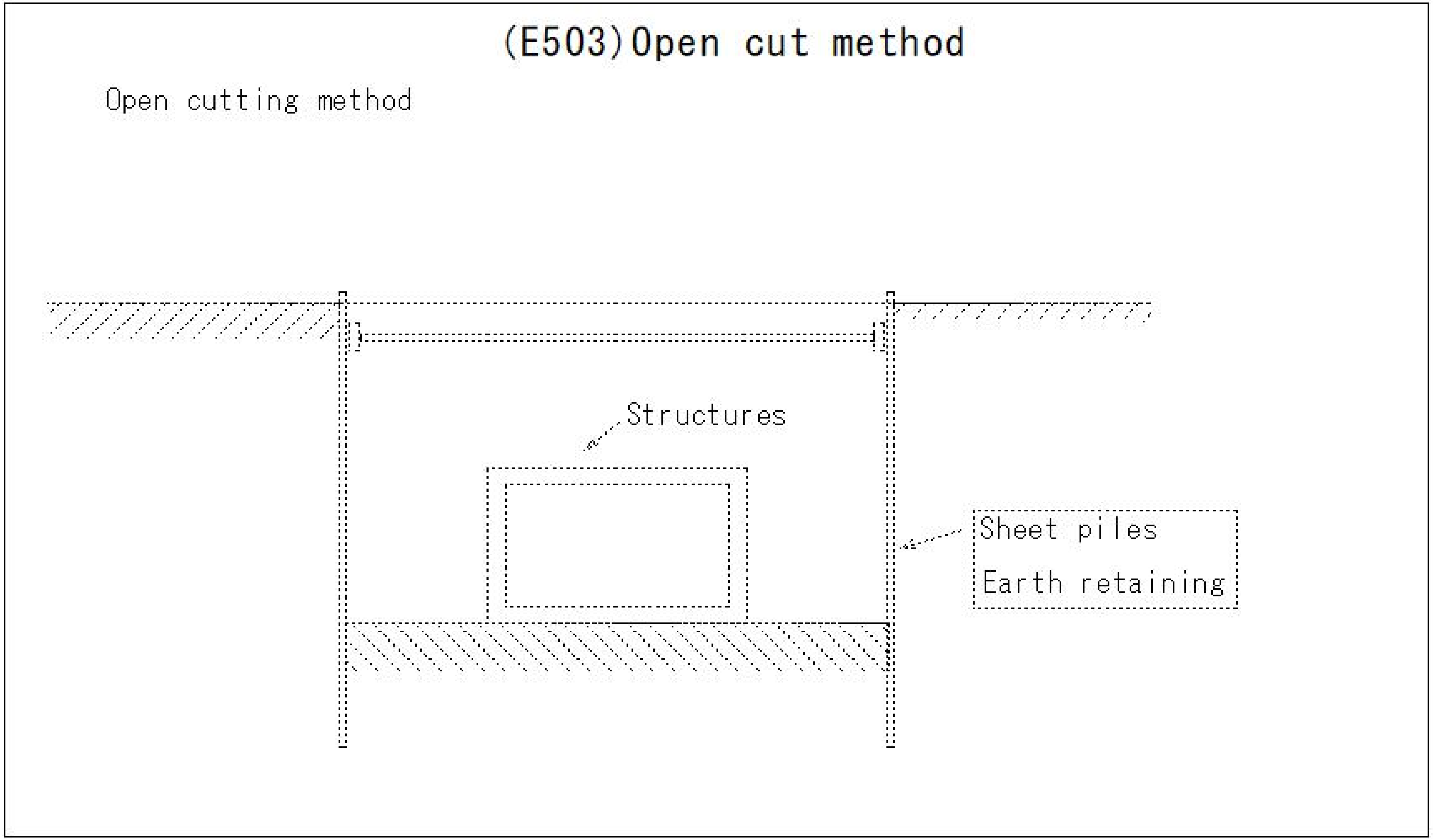
(E501)counter weight banking:Pressed embankment



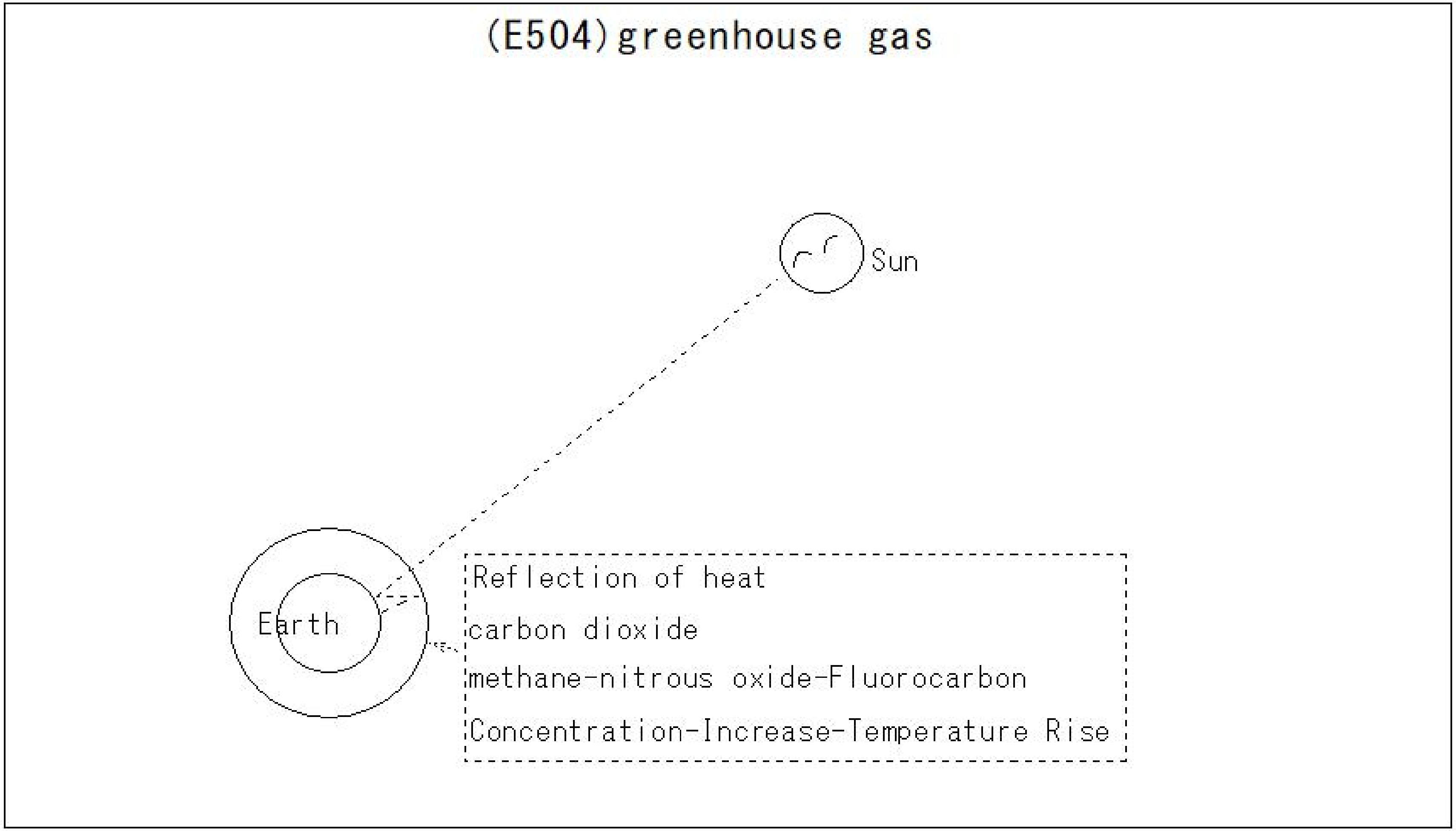
(E502)surcharge process:Pressing embankment method



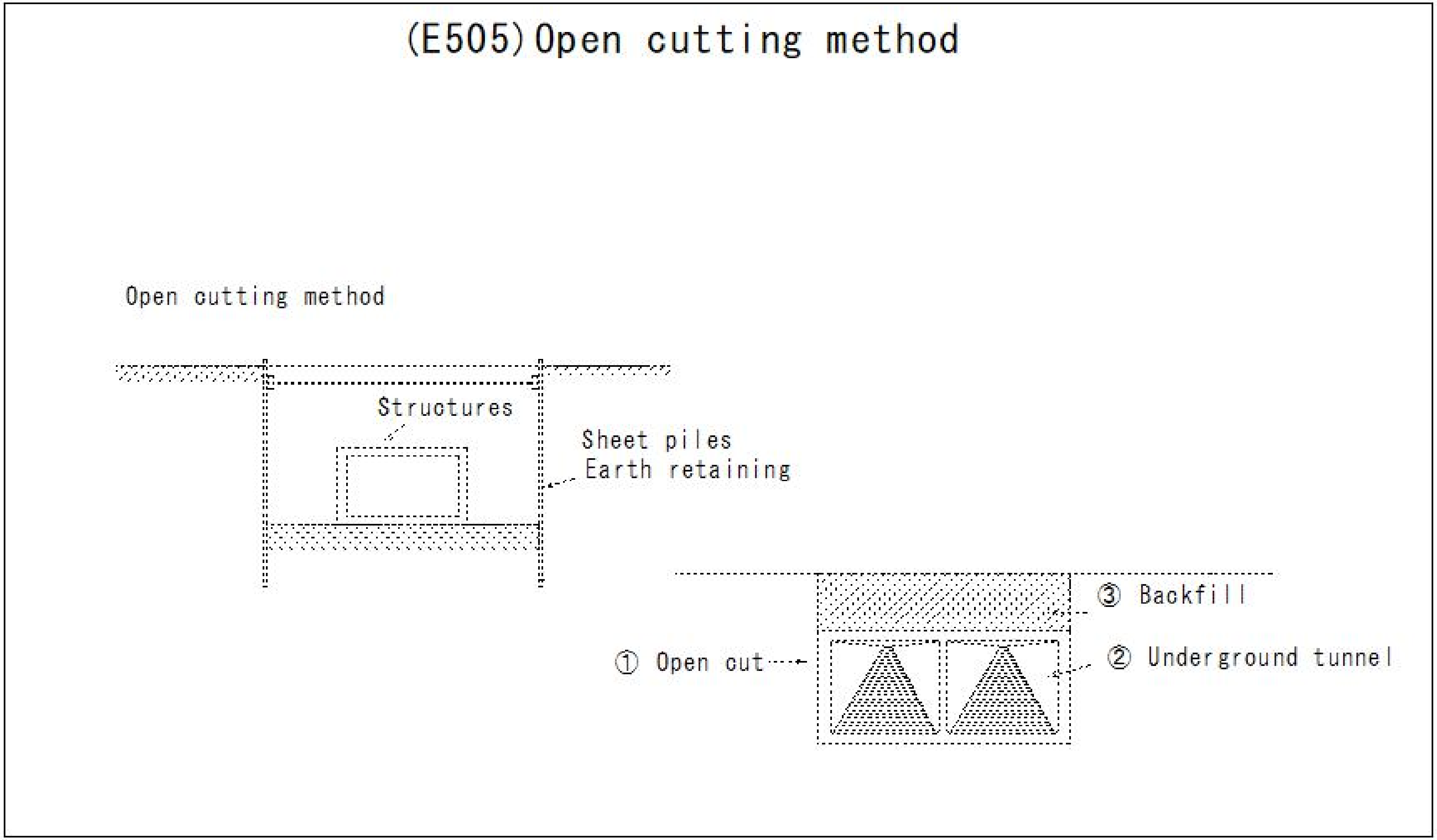
(E503)Open cut method



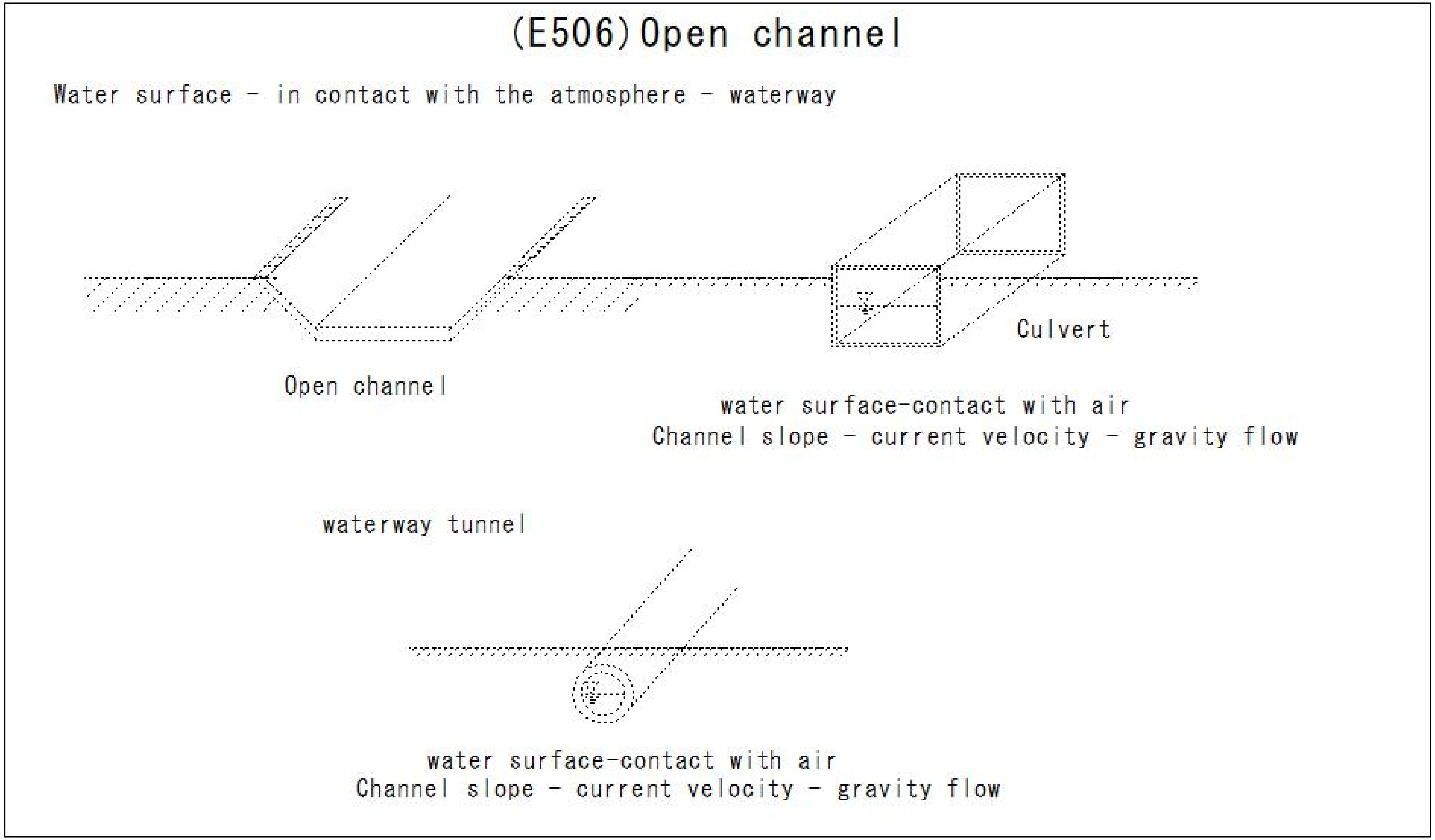
(E504)greenhouse gas



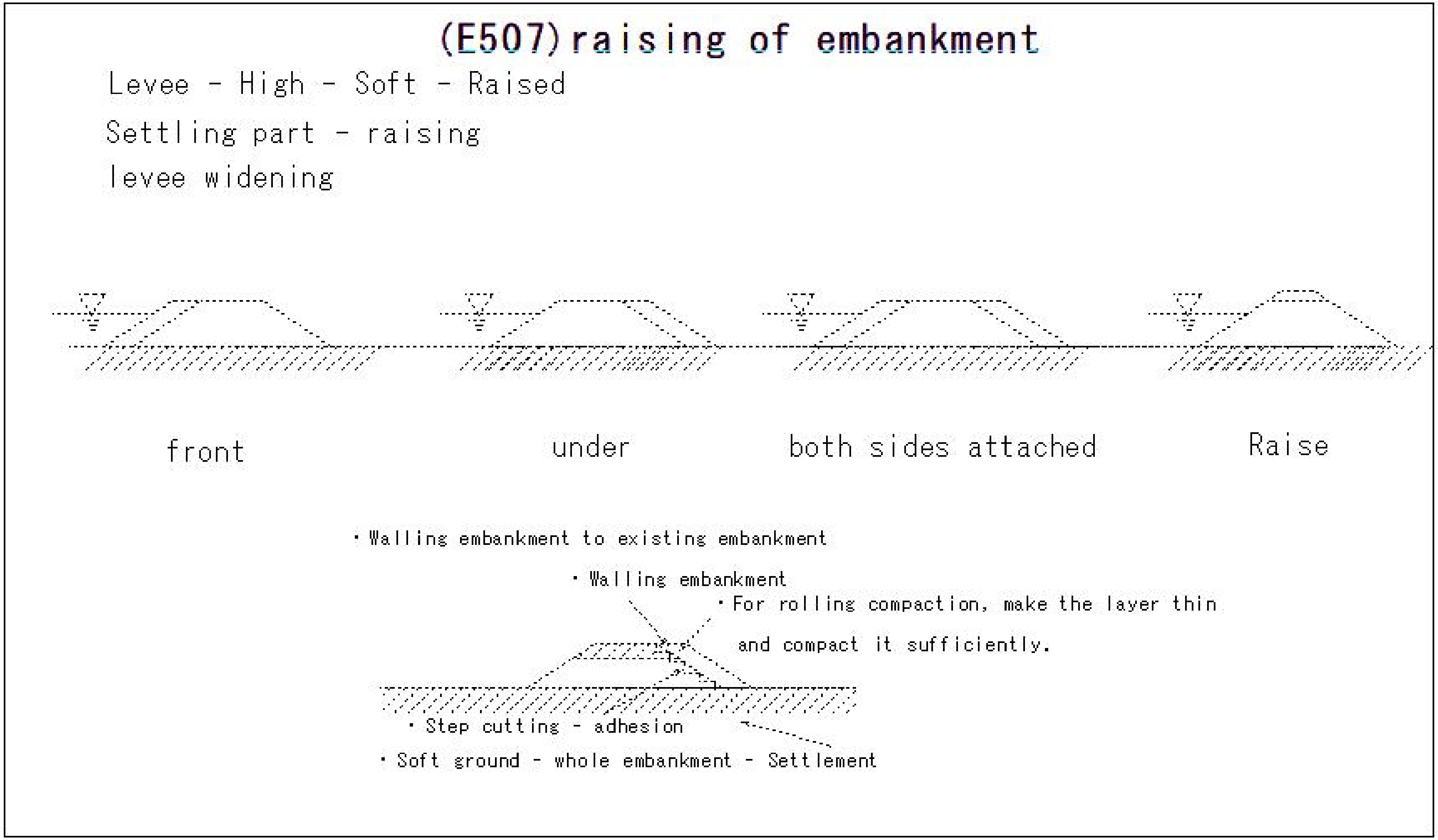
(E505)Open cutting method



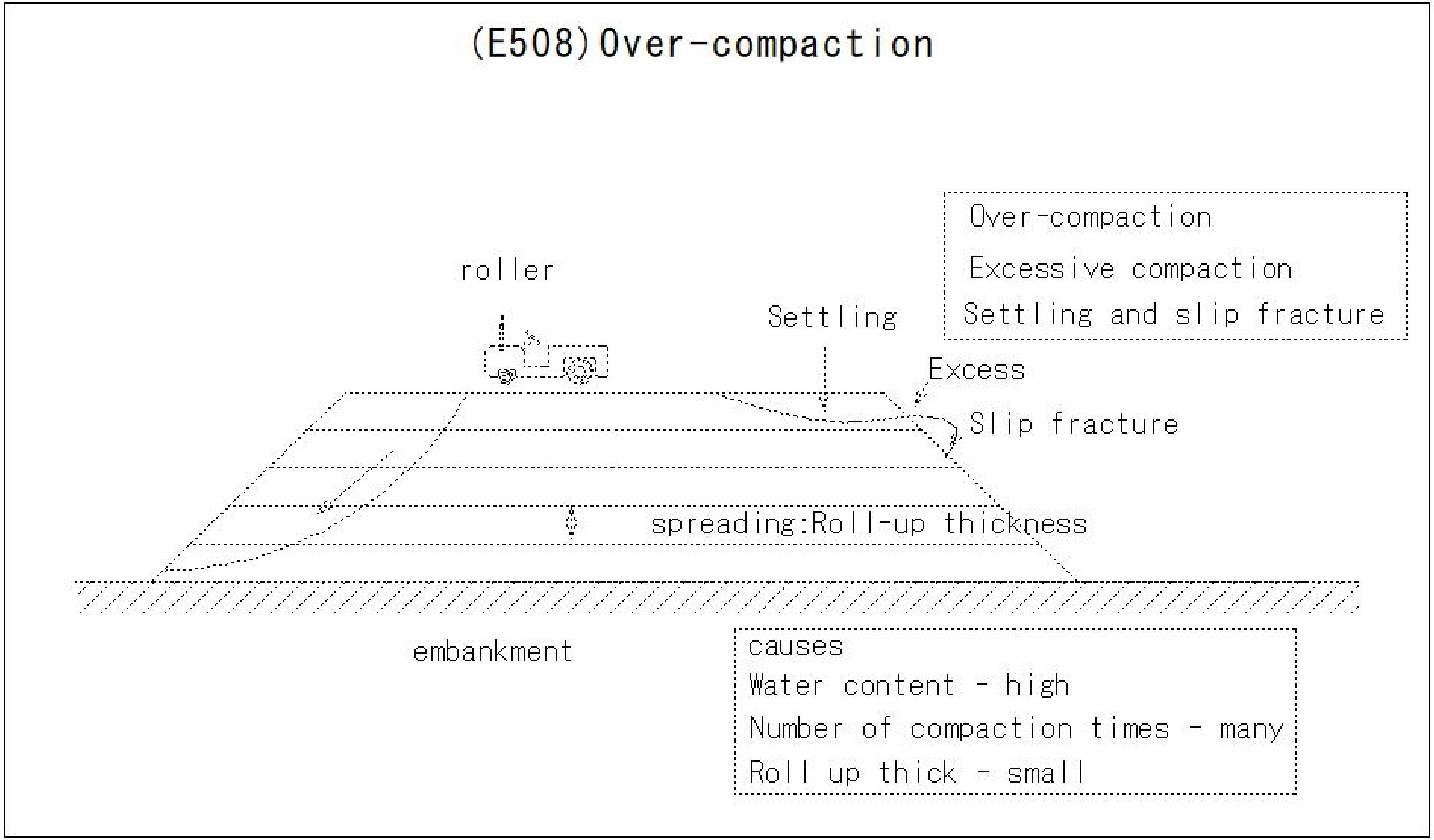
(E506)Open channel



(E507)raising of embankment



(E508)Over-compaction

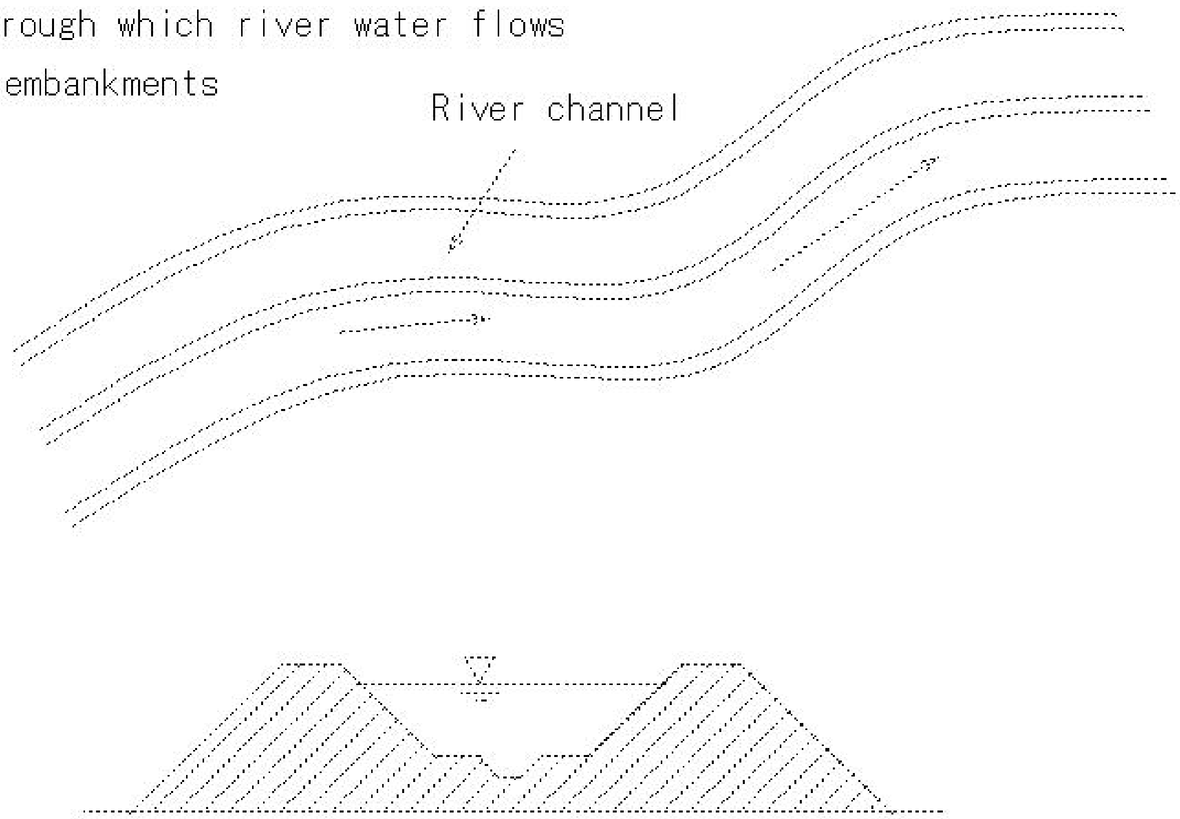


(E509)River channel

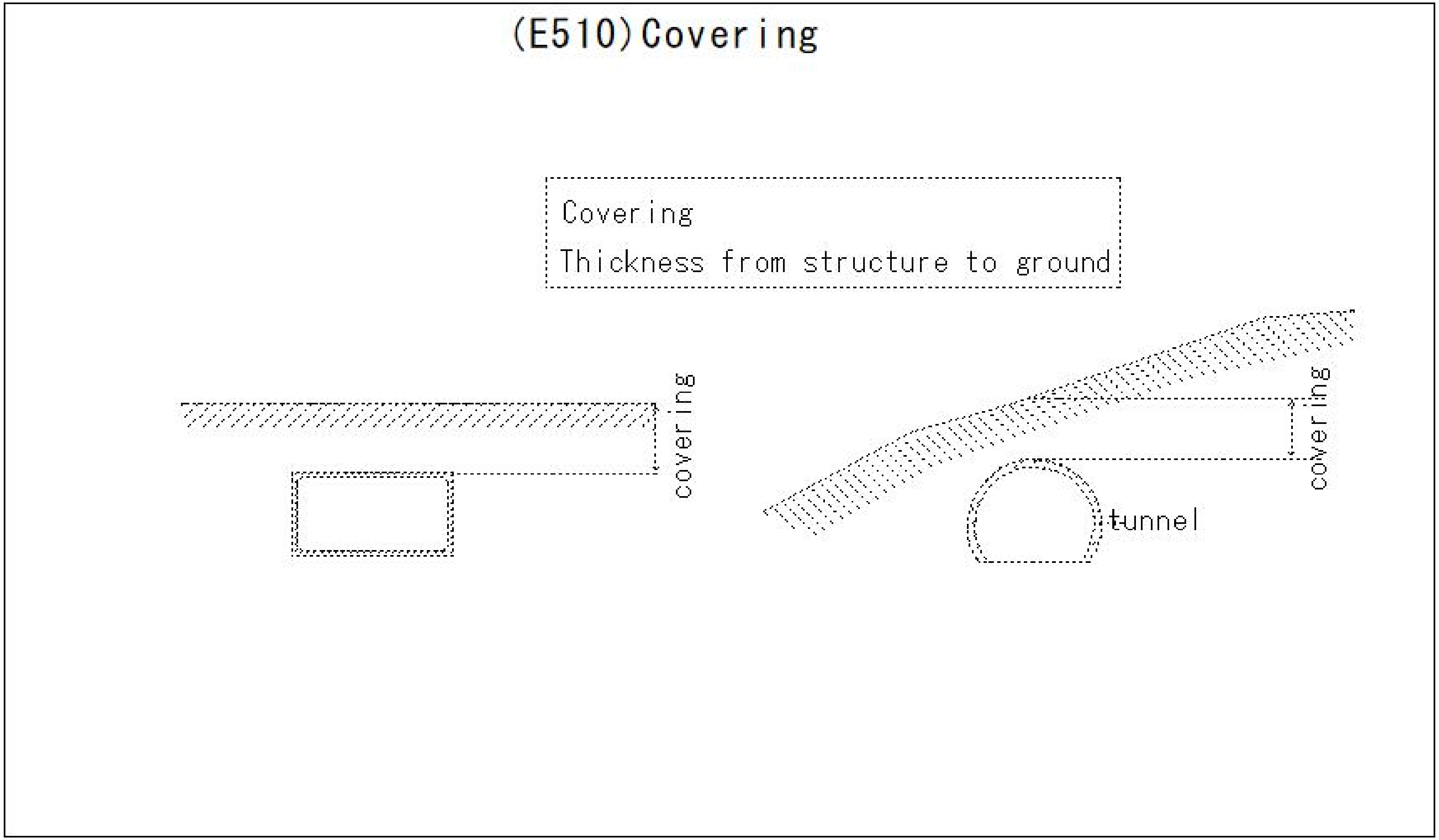
(E509)River channel

The channel through which river water flows

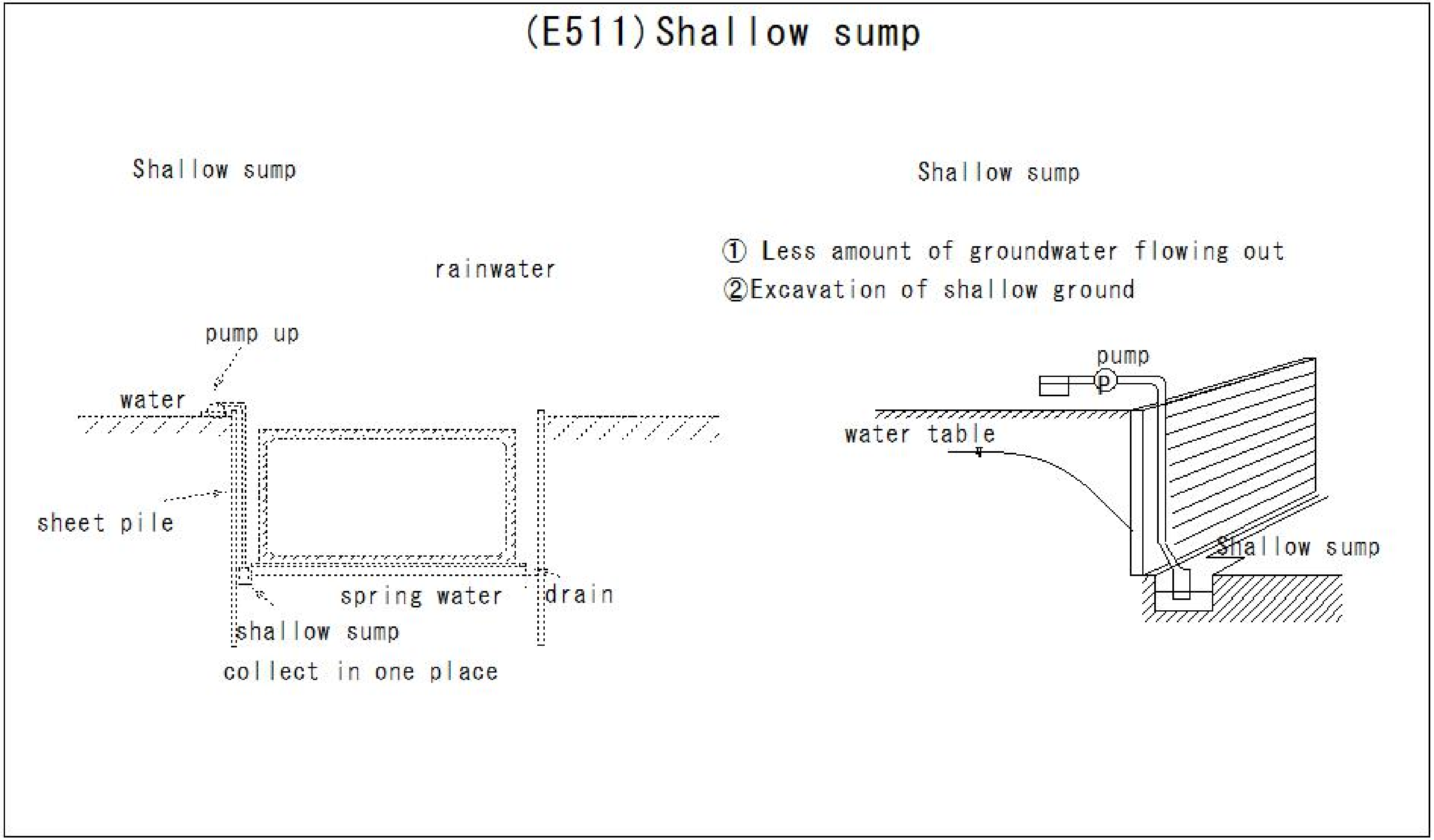
Surrounded by embankments



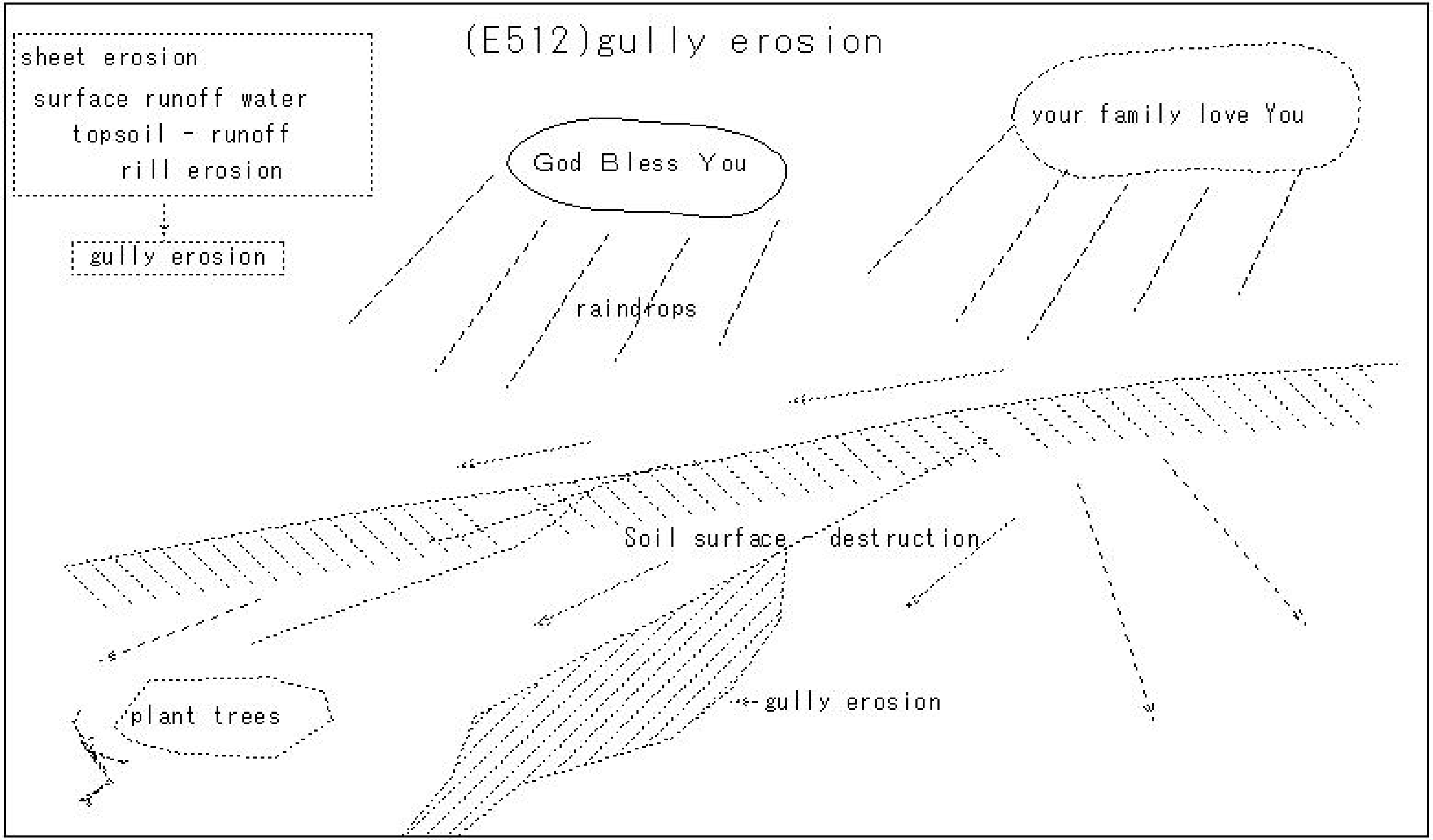
(E510)Cover


(E510)Covering
Covering
Thickness from structure to ground
covering
covering
tunnel

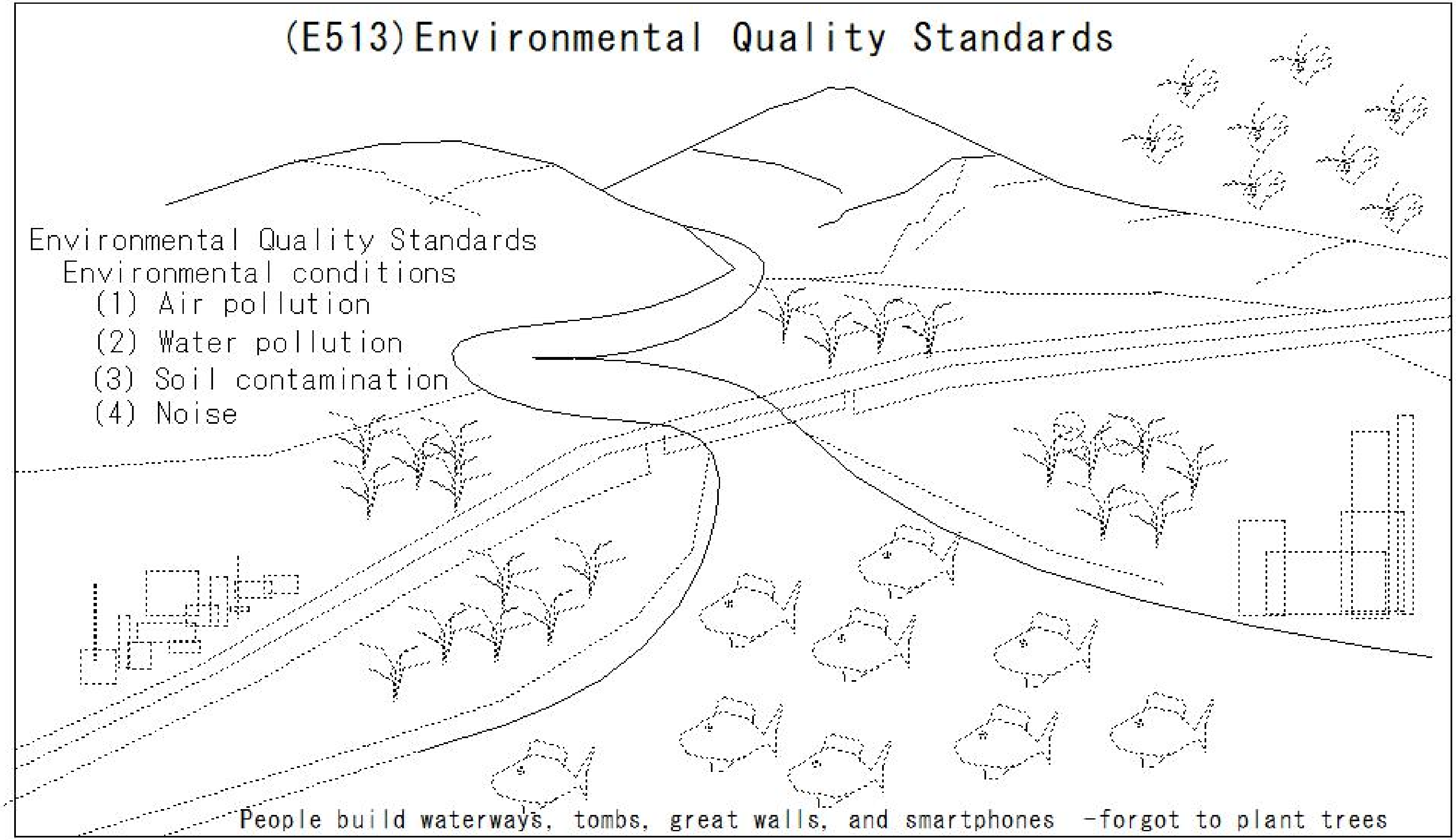
(E511)Shallow sump



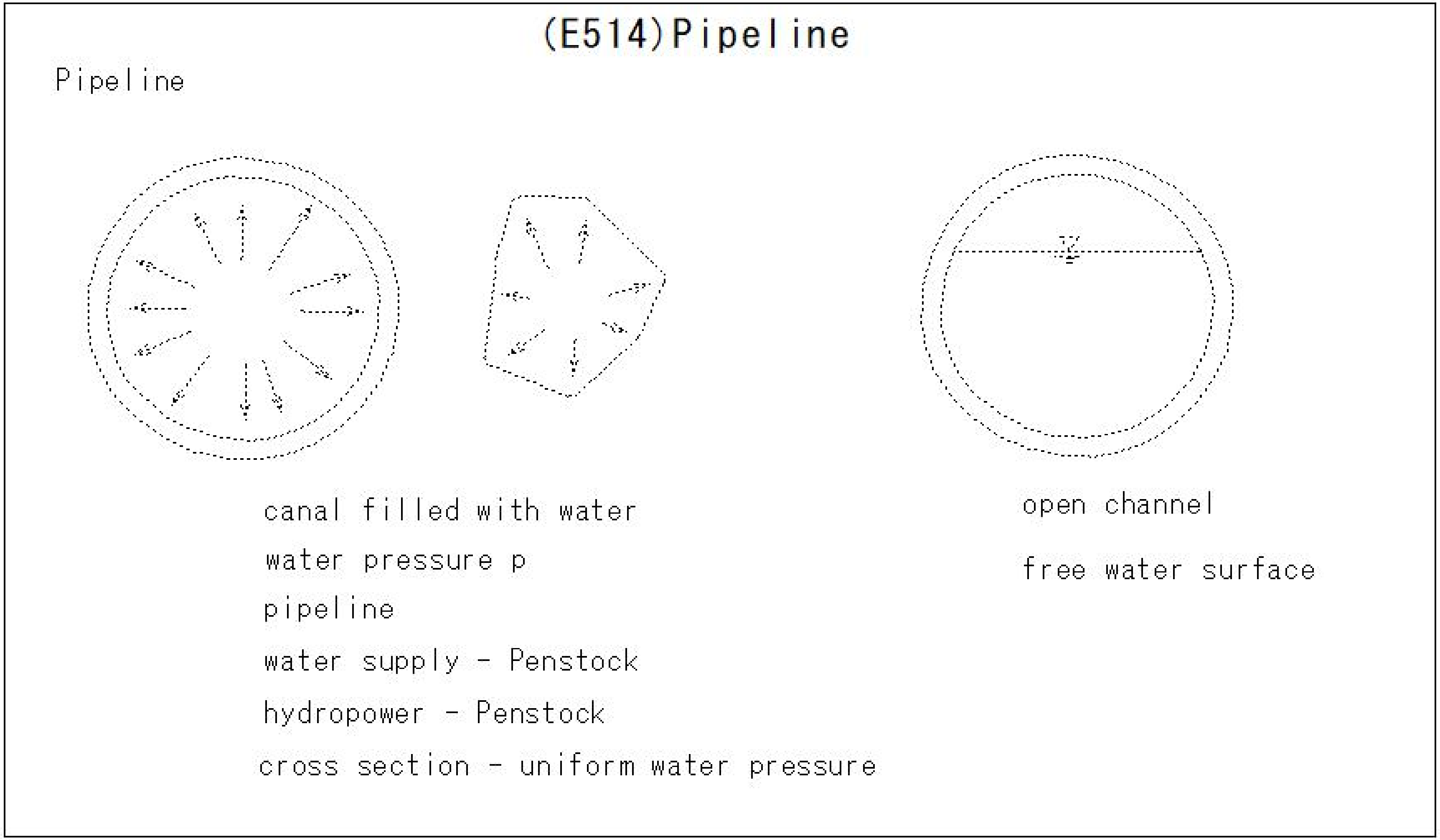
(E512)gully erosion



(E513)Environmental Quality Standards

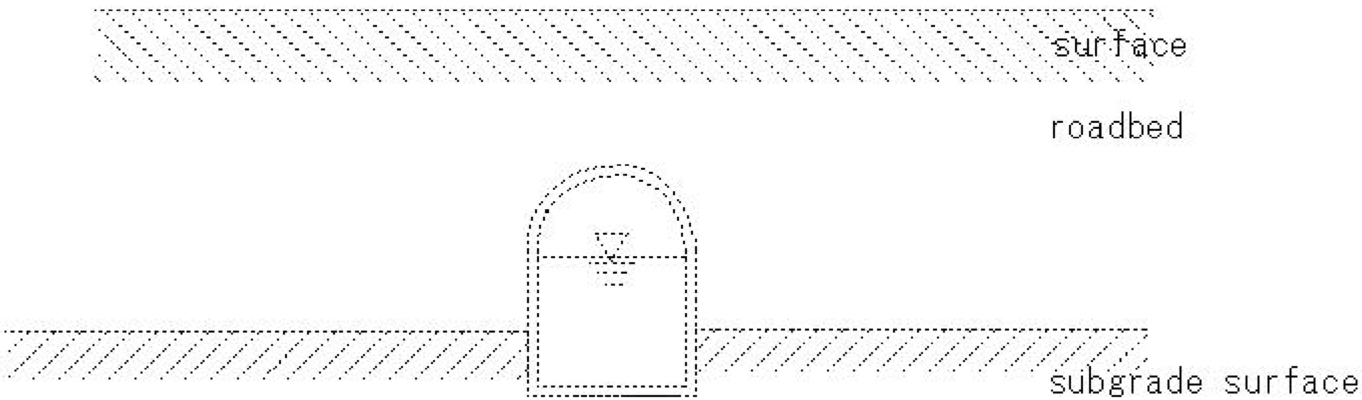


(E514)Pipeline



(E515)Culvert

Culvert

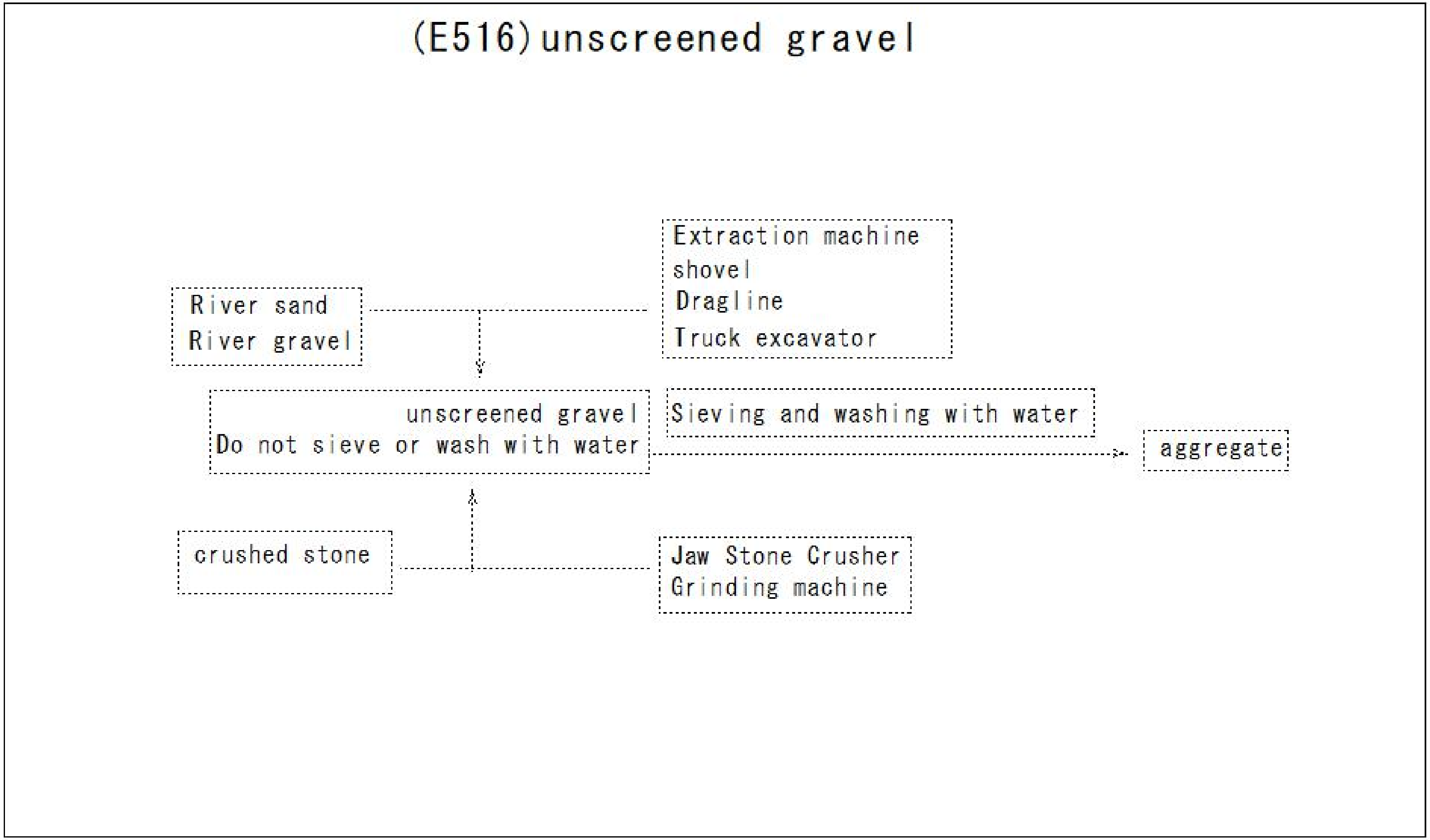


a kind of open channel

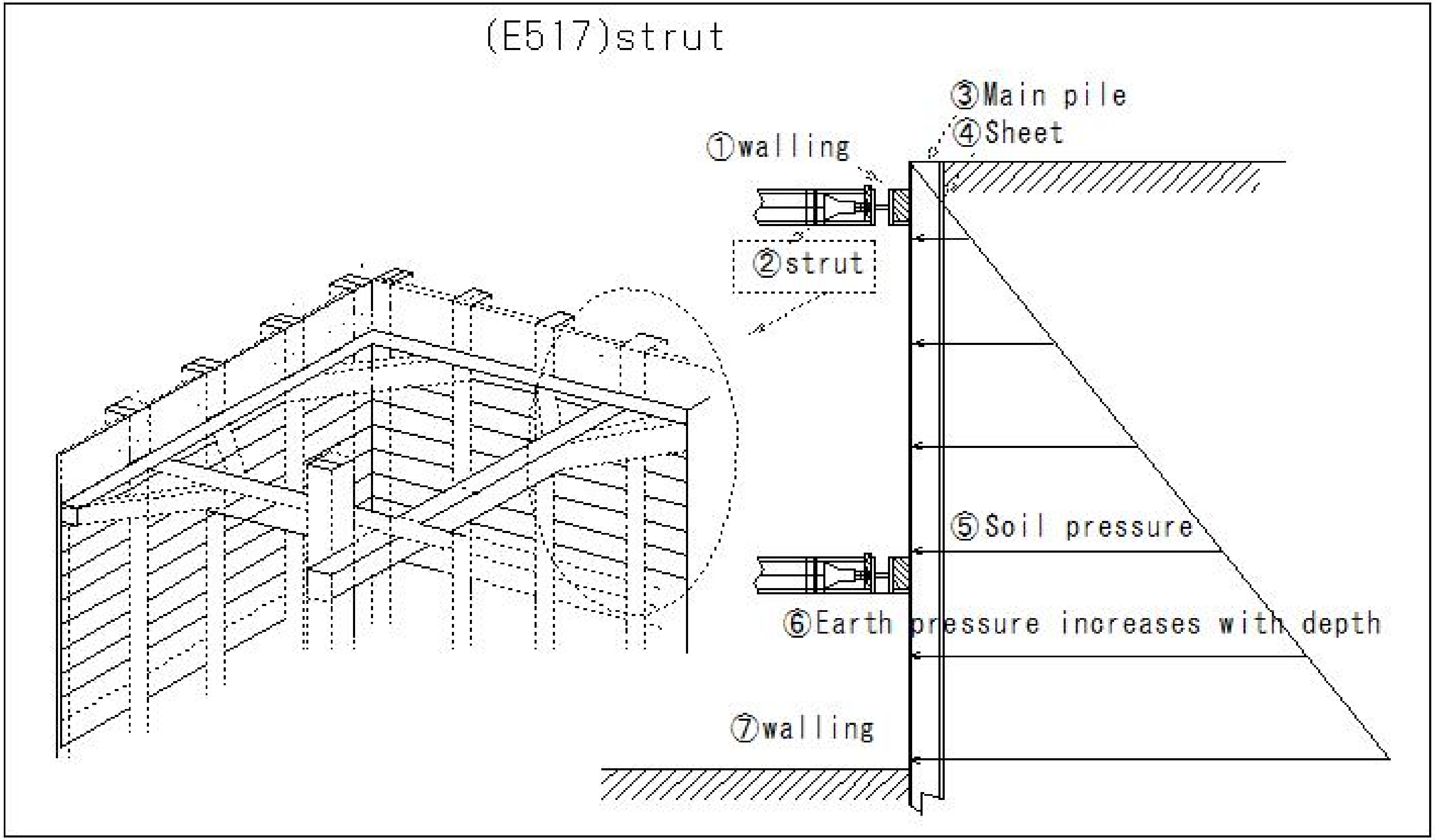
pipe

box culvert

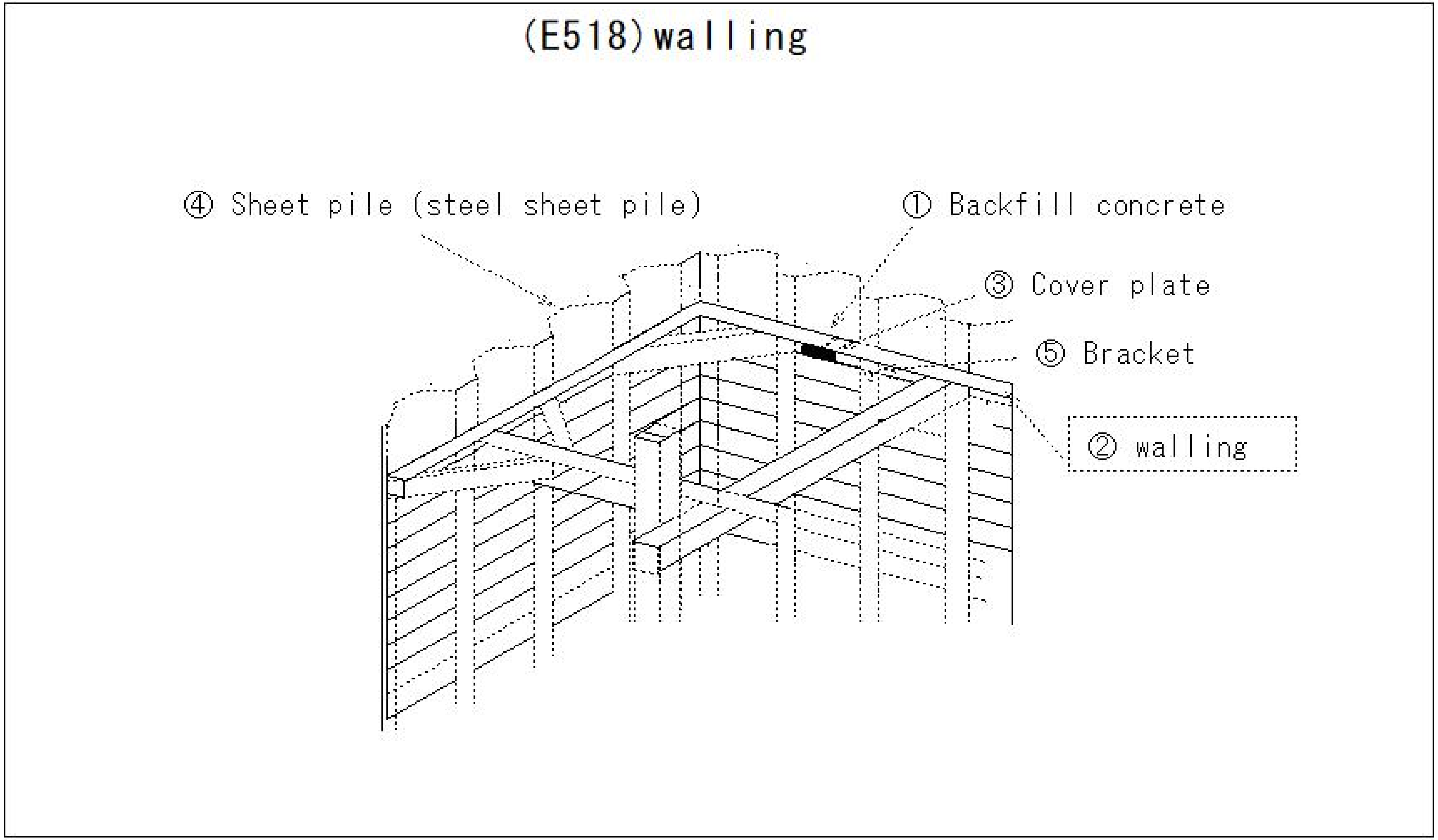
(E516)unscreened gravel



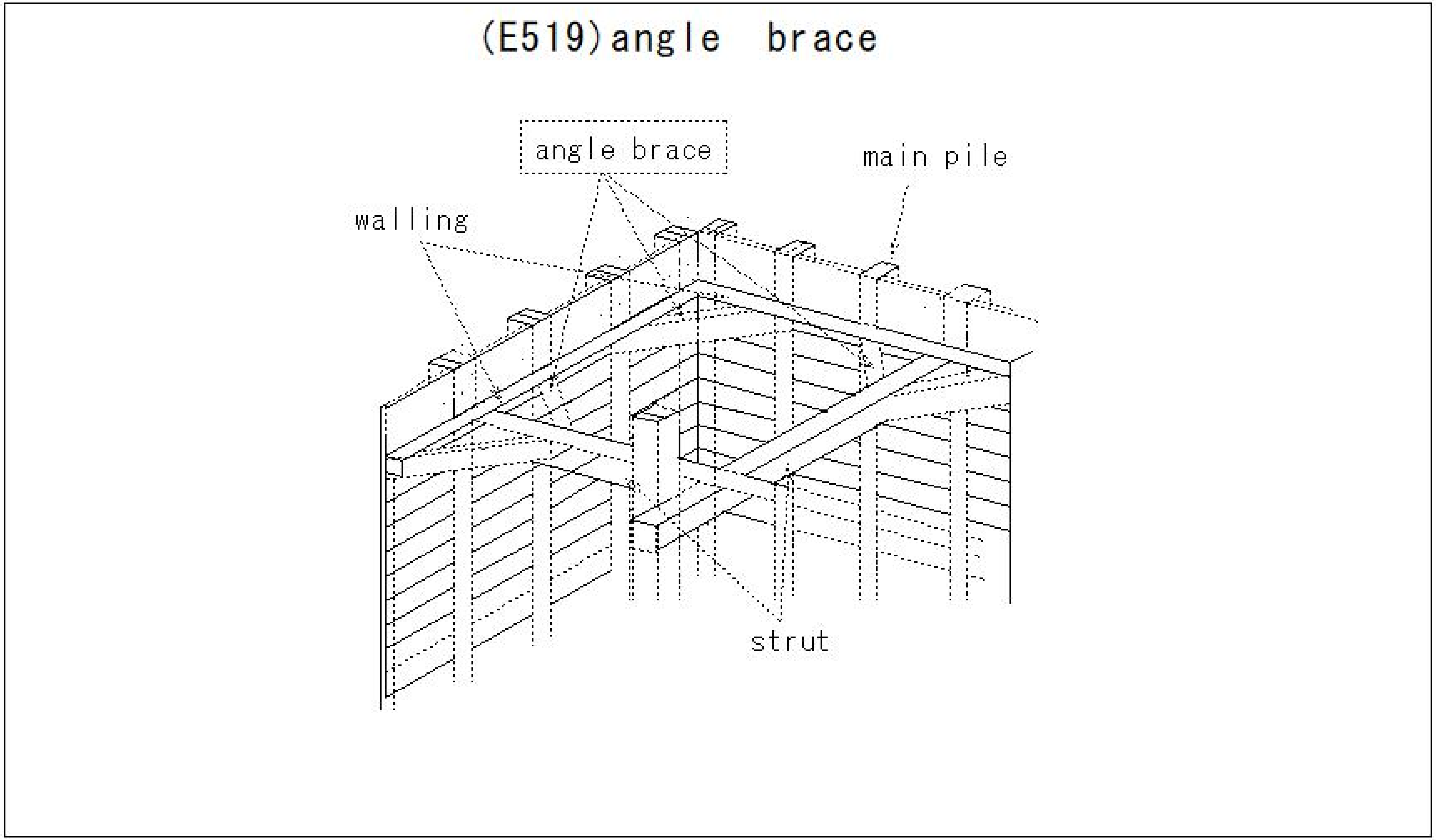
(E517)strut


(E517)strut
①walling
②strut
③Main pile
④Sheet
⑤Soil pressure
⑥Earth pressure inoreases with depth
⑦walling

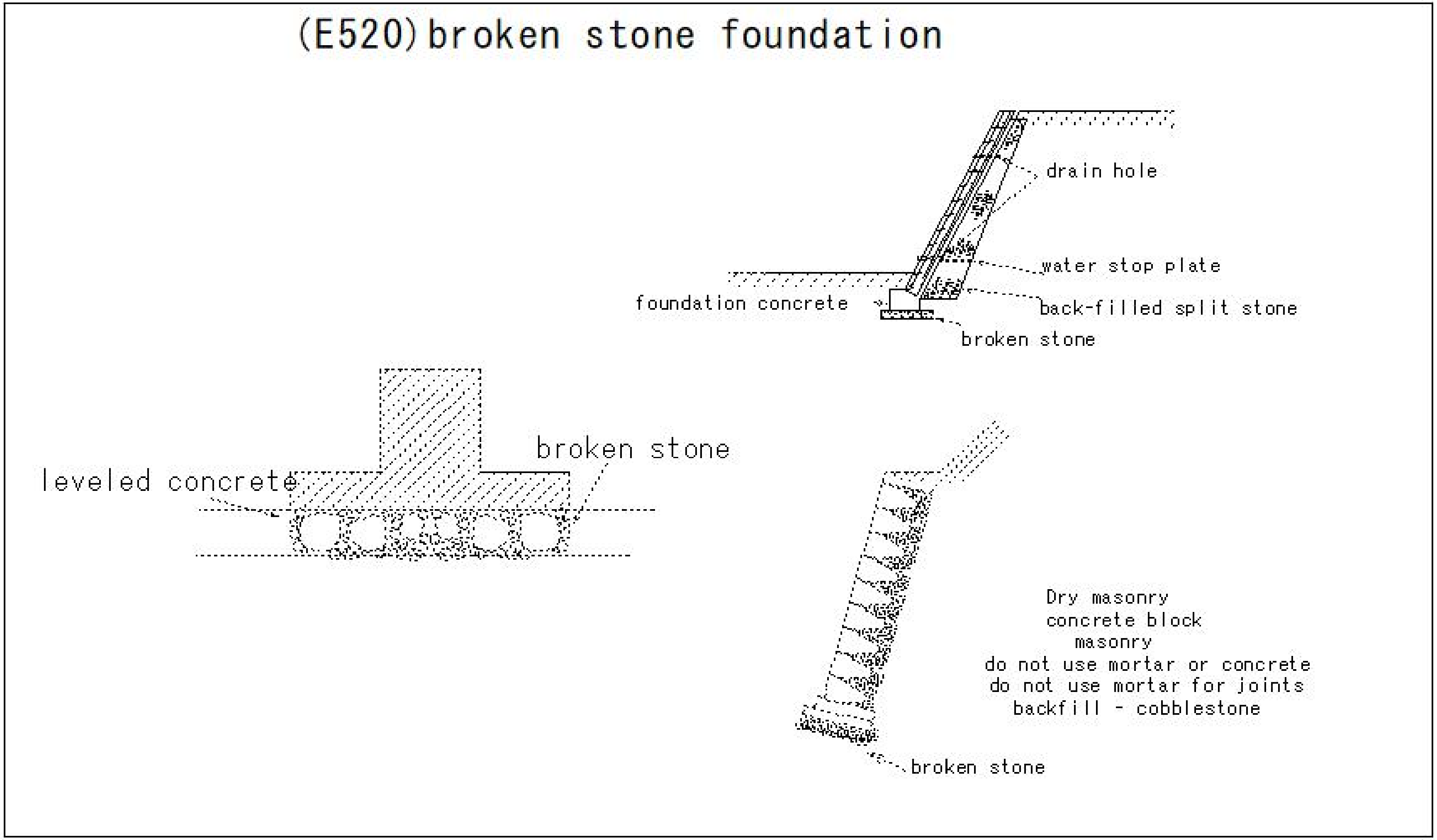
(E518)walling



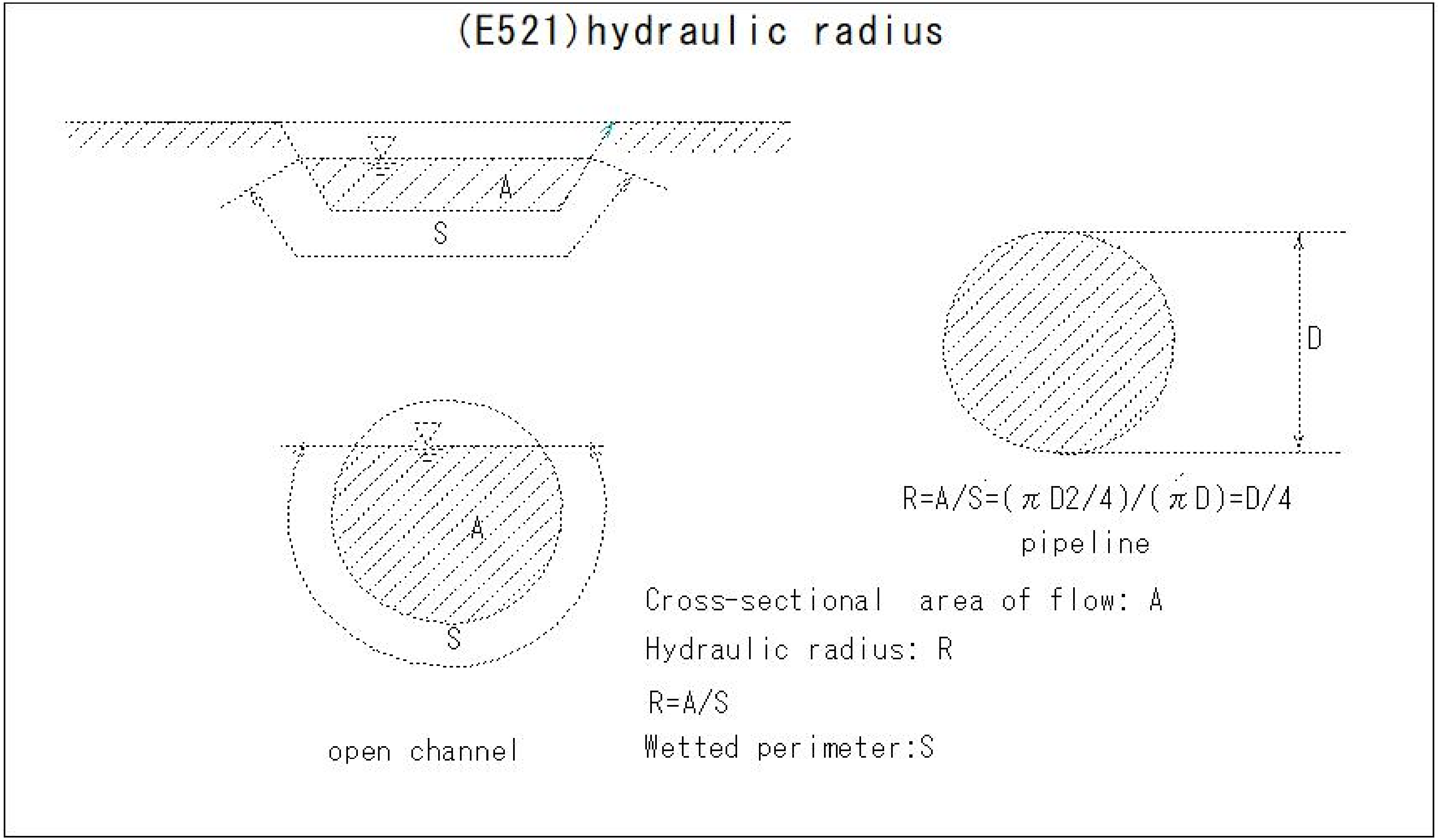
(E519)angle brace



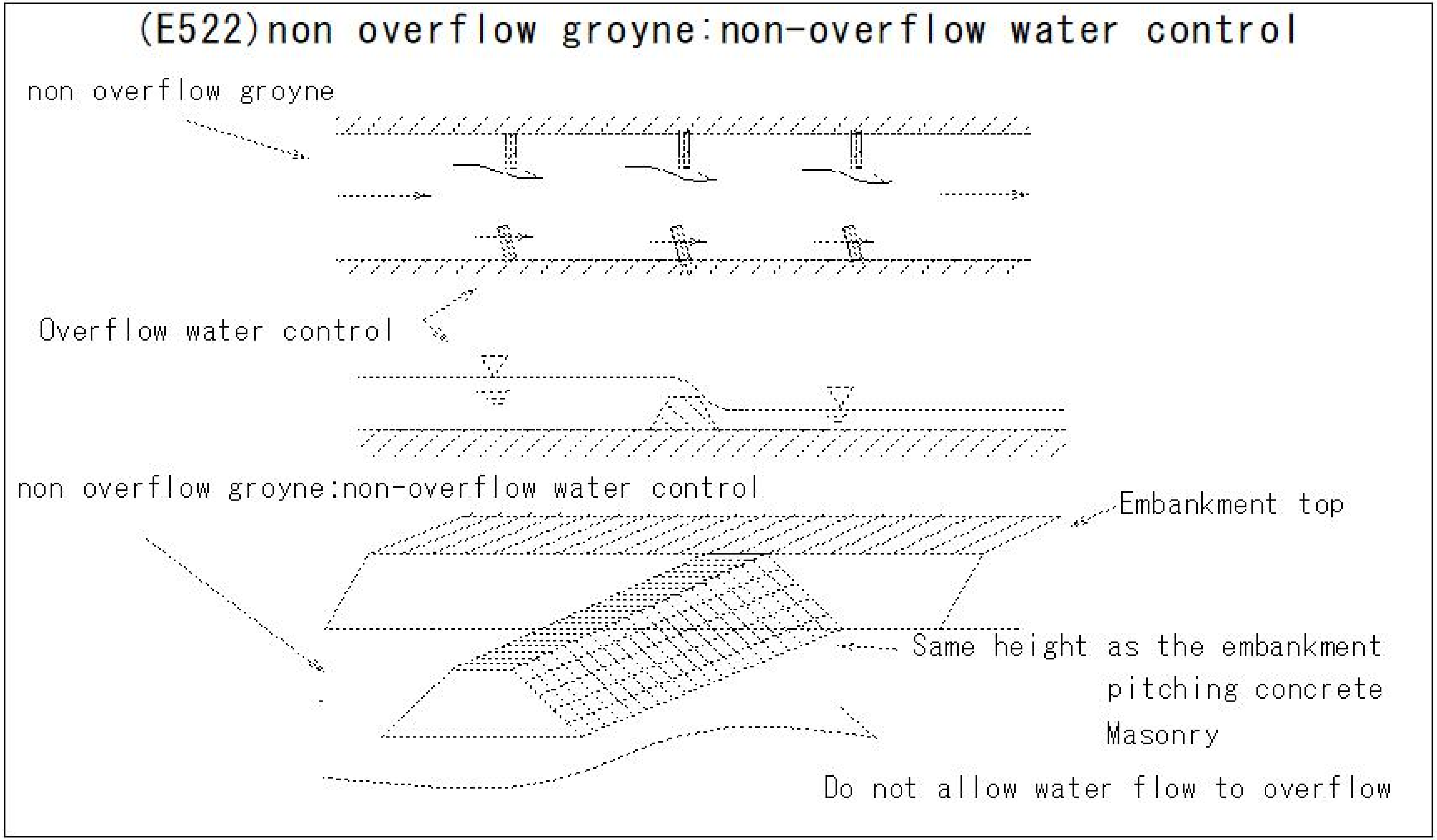
(E520)broken stone foundation



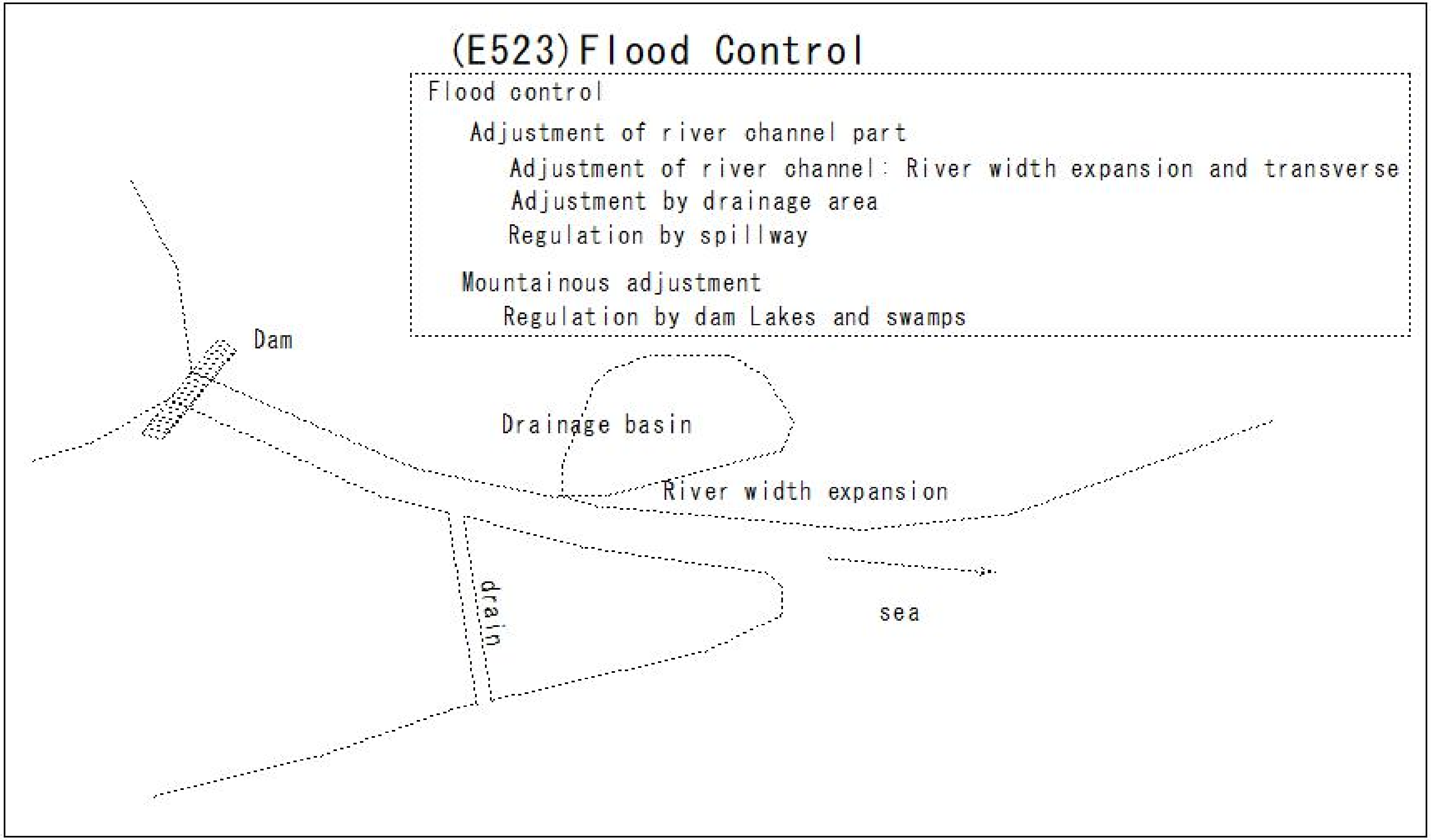
(E521)hydraulic radius



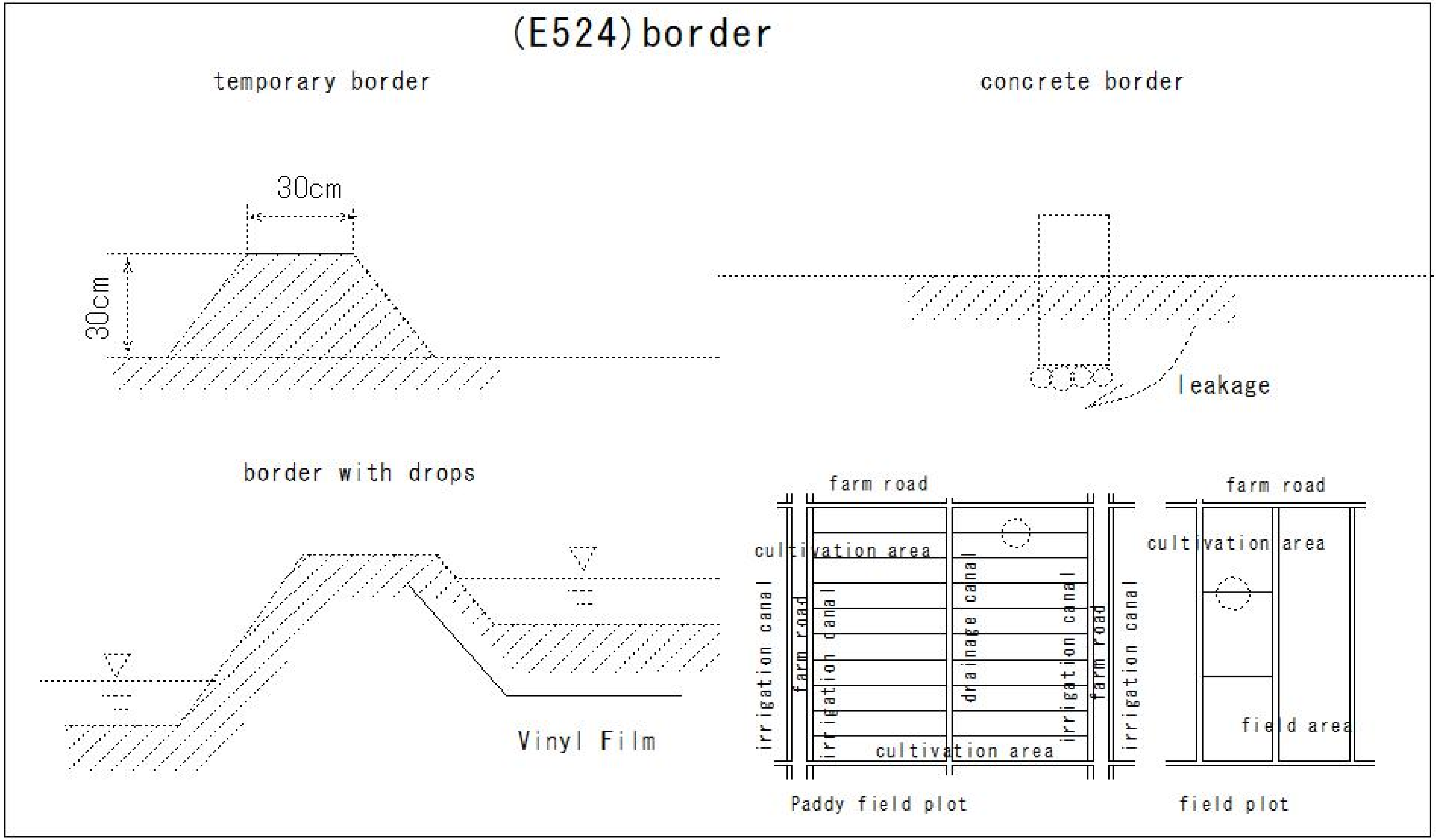
(E522)non overflow groyne:non-overflow water control



(E523)Flood Control



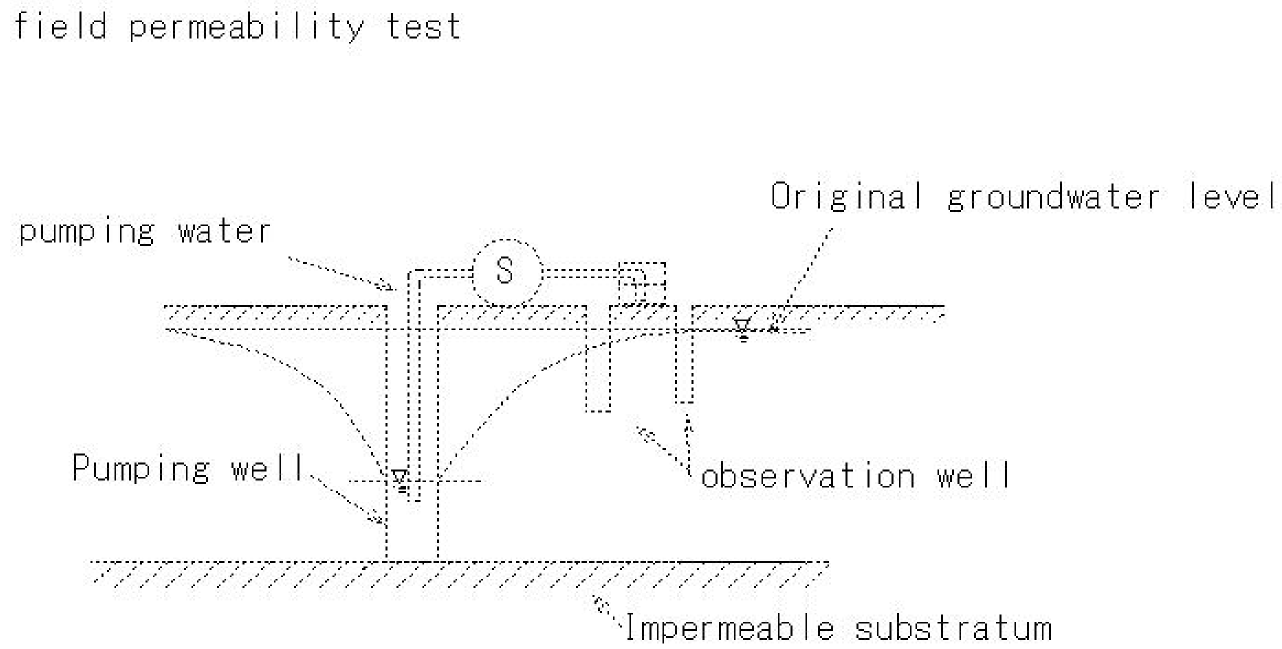
(E524)border



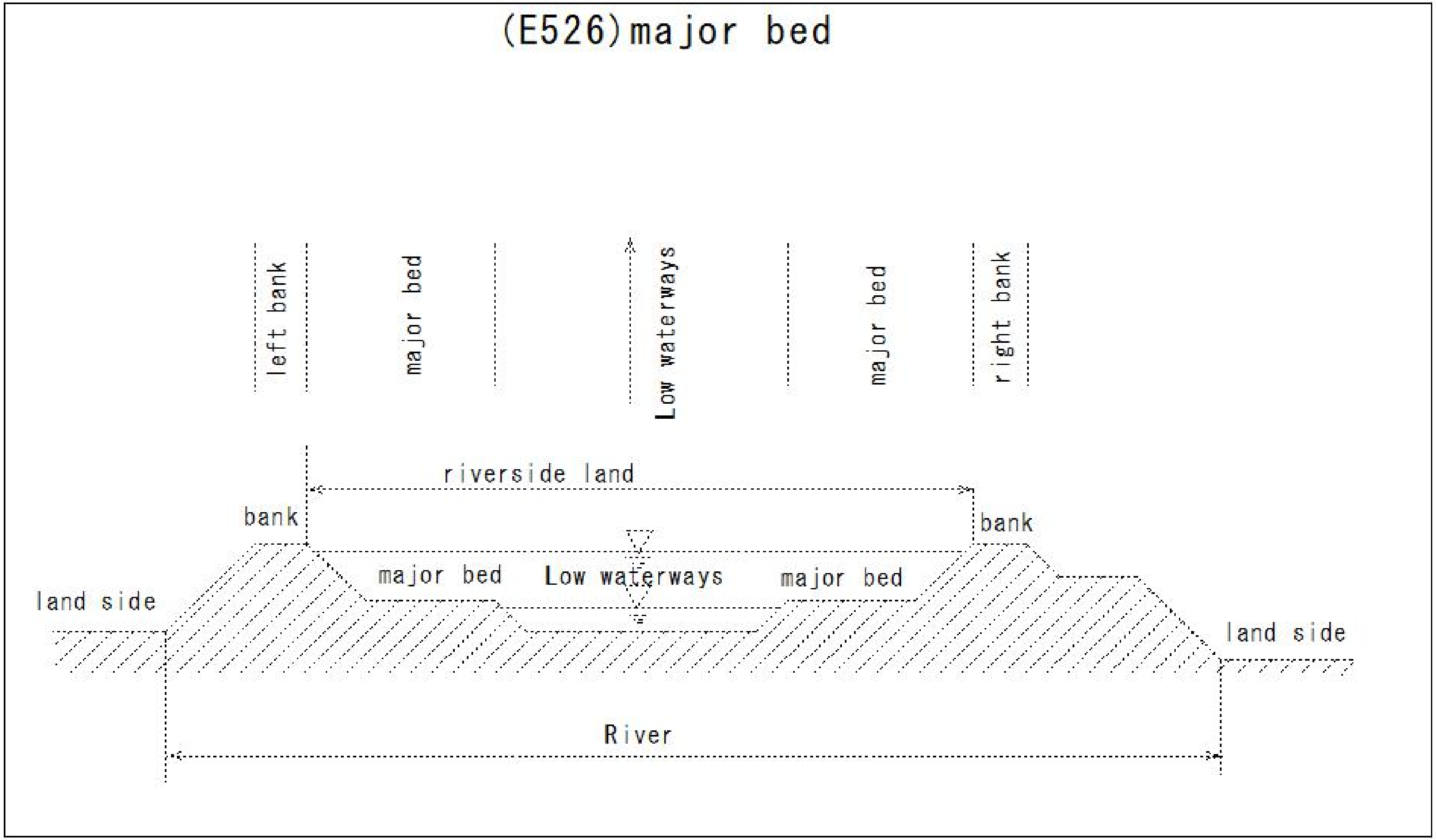
(E524)border
temporary border
30cm
30cm
concrete border
leakage
border with drops
Vinyl Film
farm road
cultivation area
irrigation canal
farm road
irrigation canal
drainage canal
irrigation canal
farm road
irrigation canal
cultivation area
Paddy field plot
farm road
cultivation area
field area
field plot

(E525)field permeability test

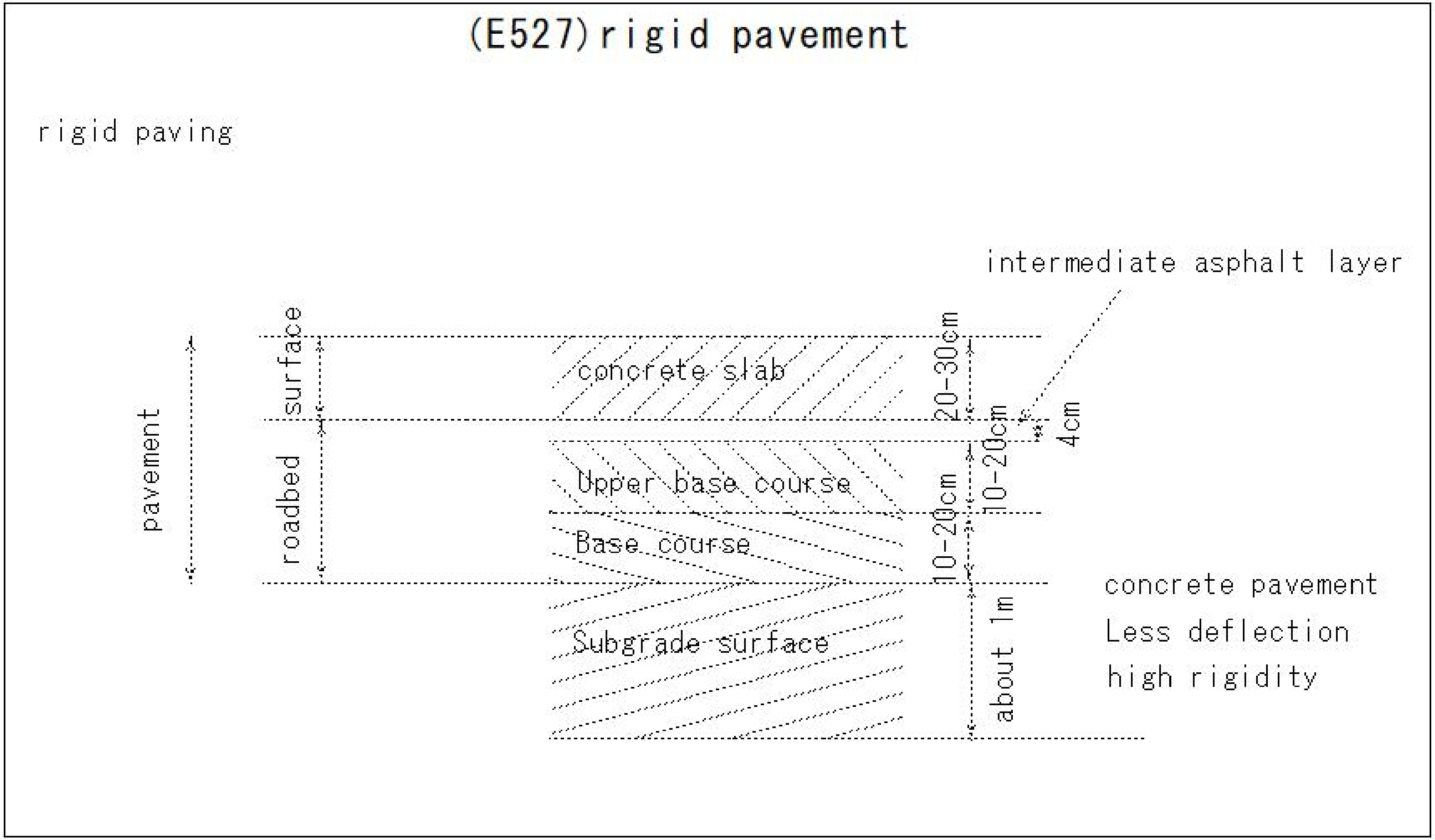
(E525)field permeability test



(E526)major bed

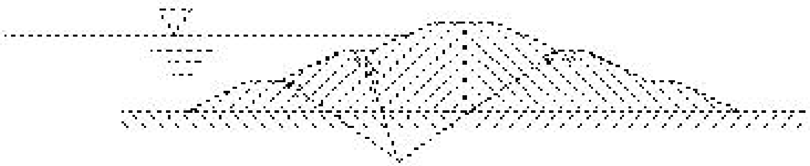


(E527)rigid pavement



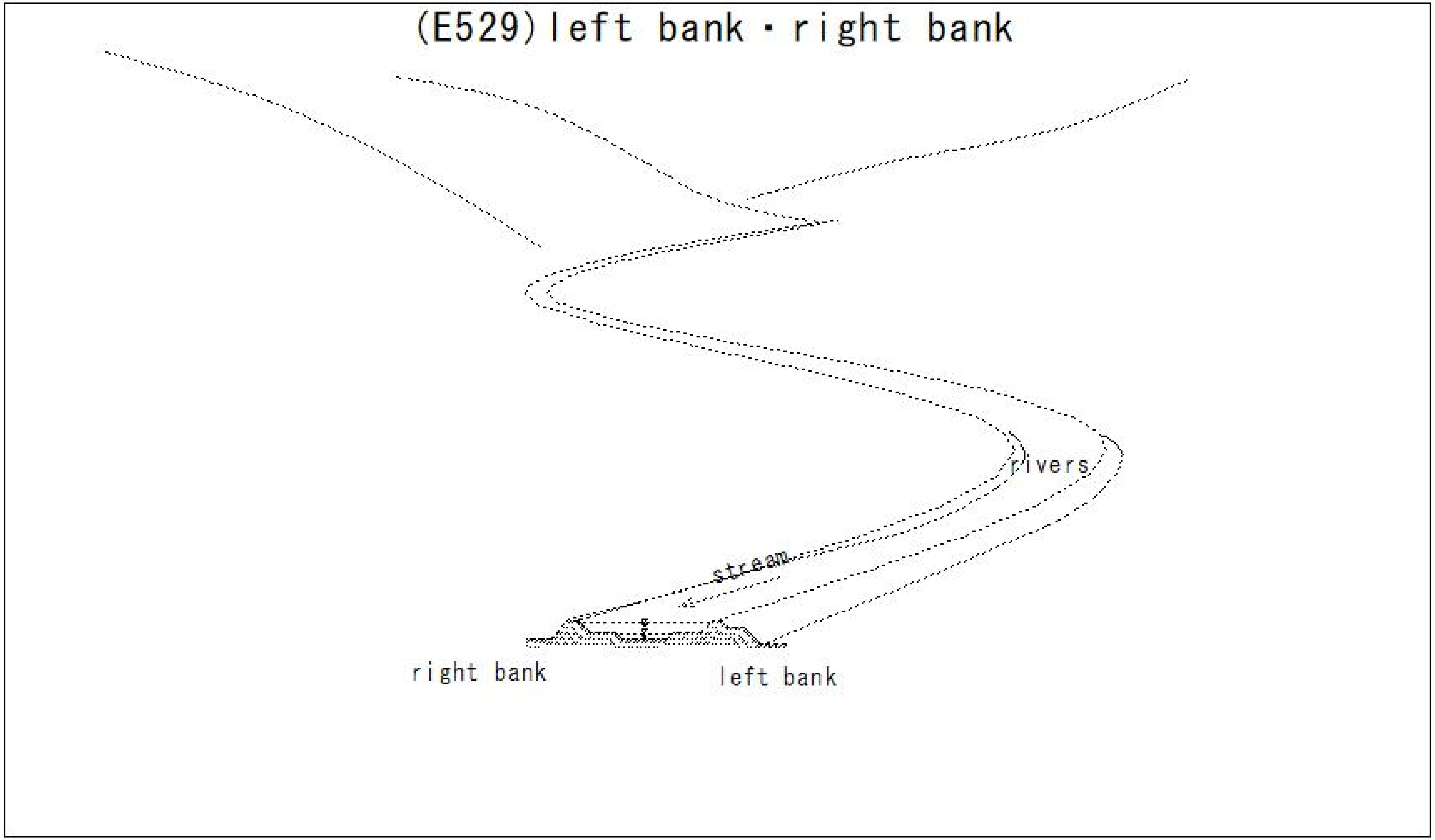
(E528)berm

(E528)berm

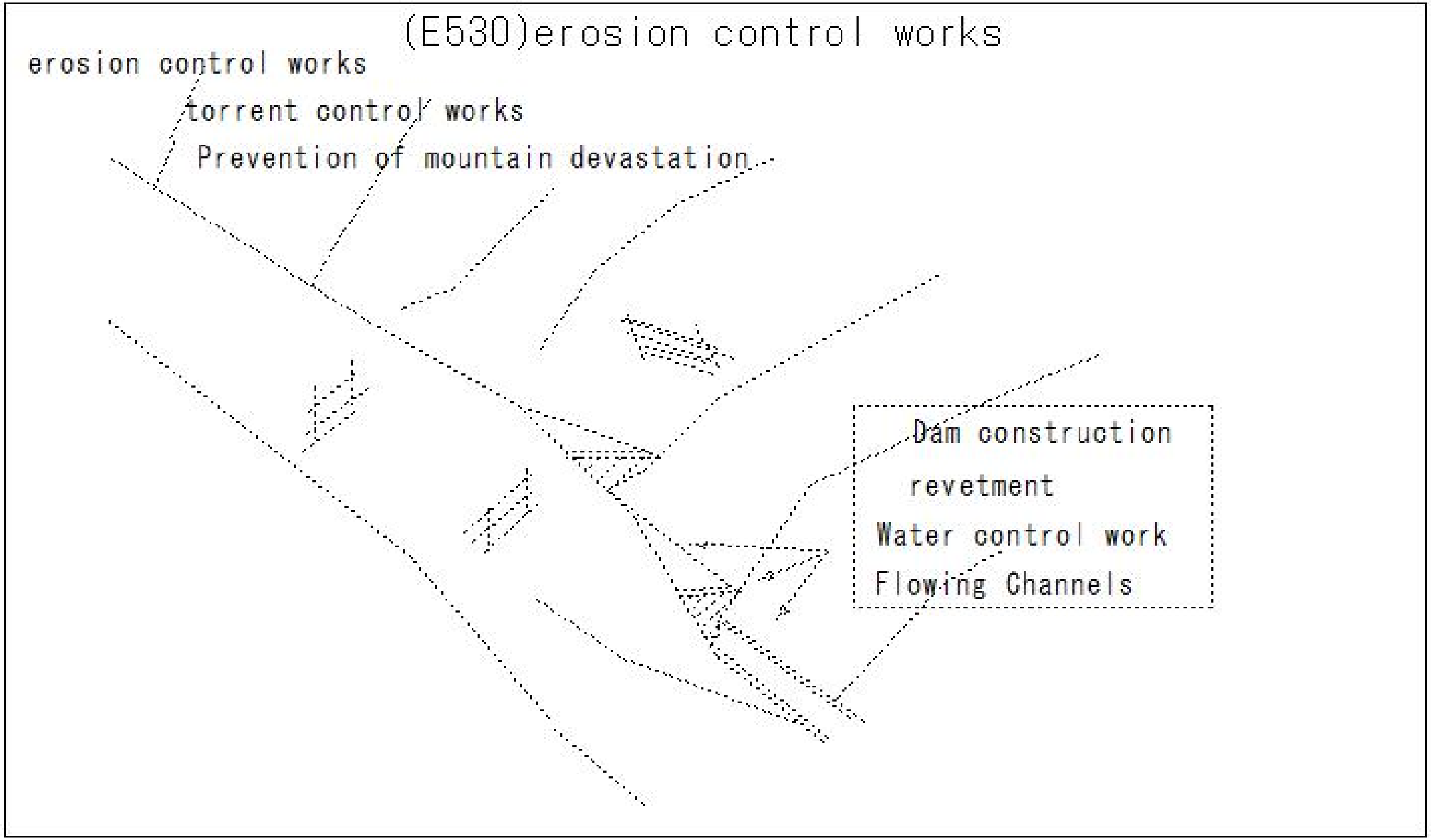


berm
Prevention of collapse
for maintenance

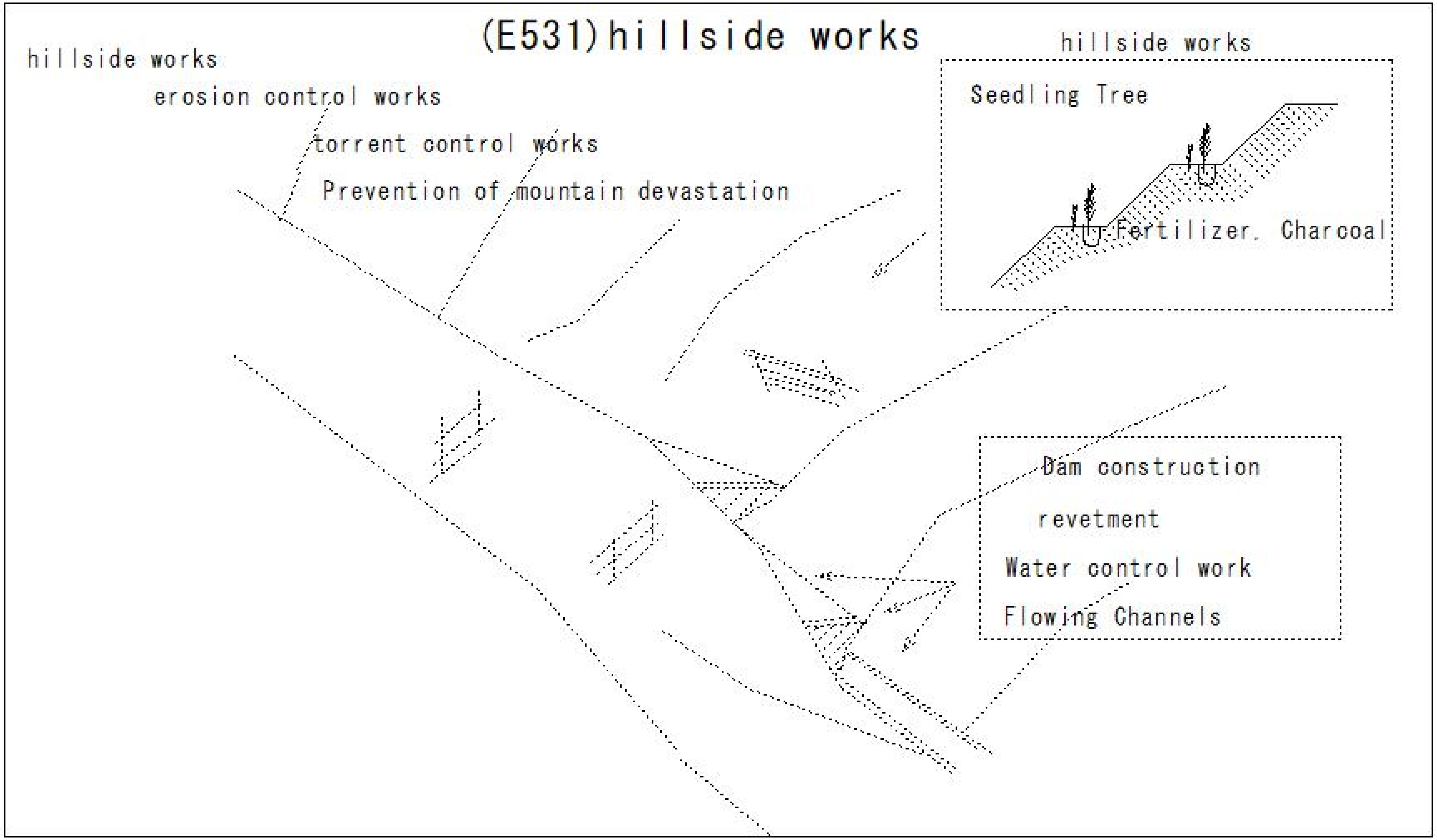
(E529)left bank・right bank



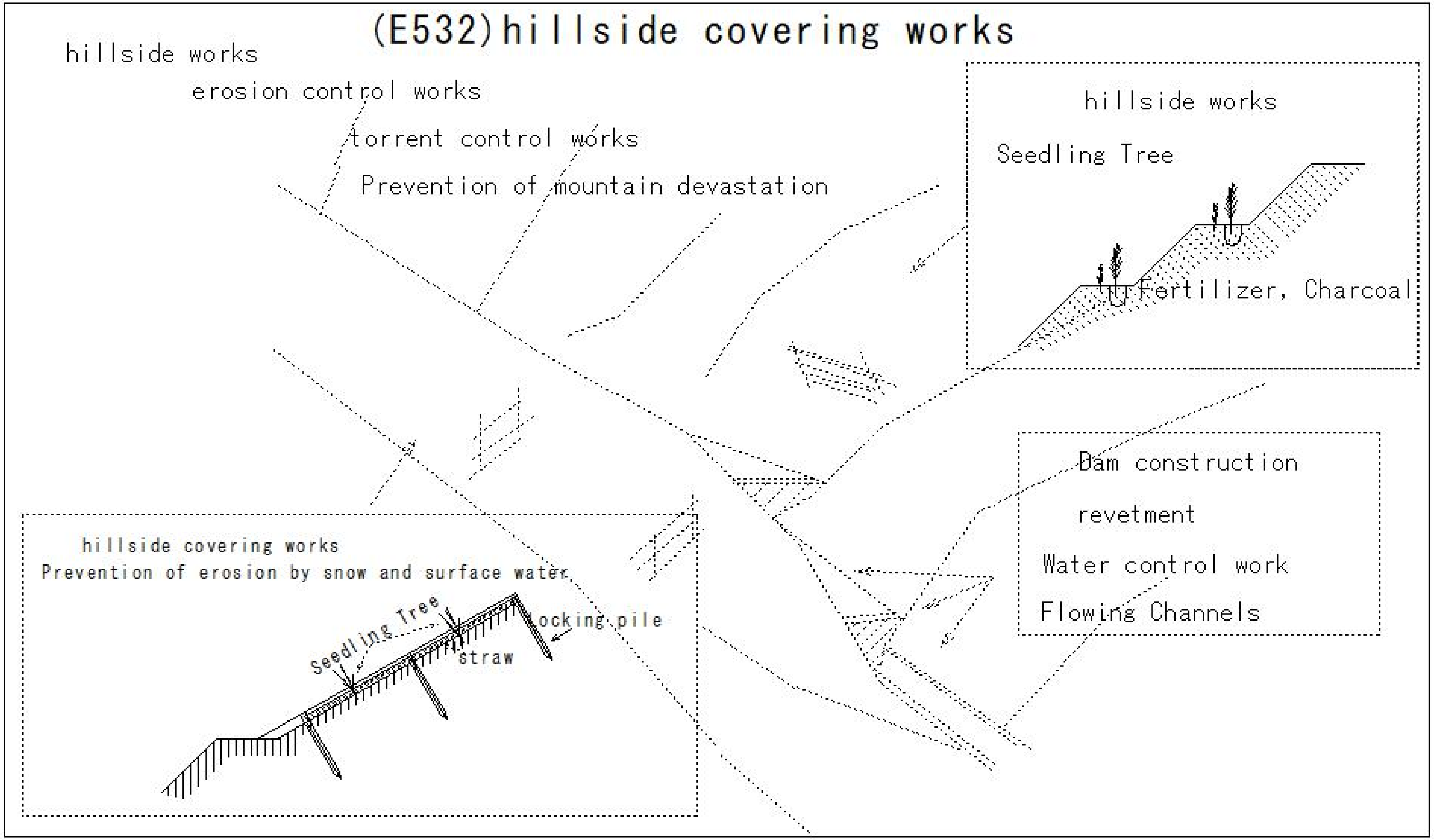
(E530)erosion control works



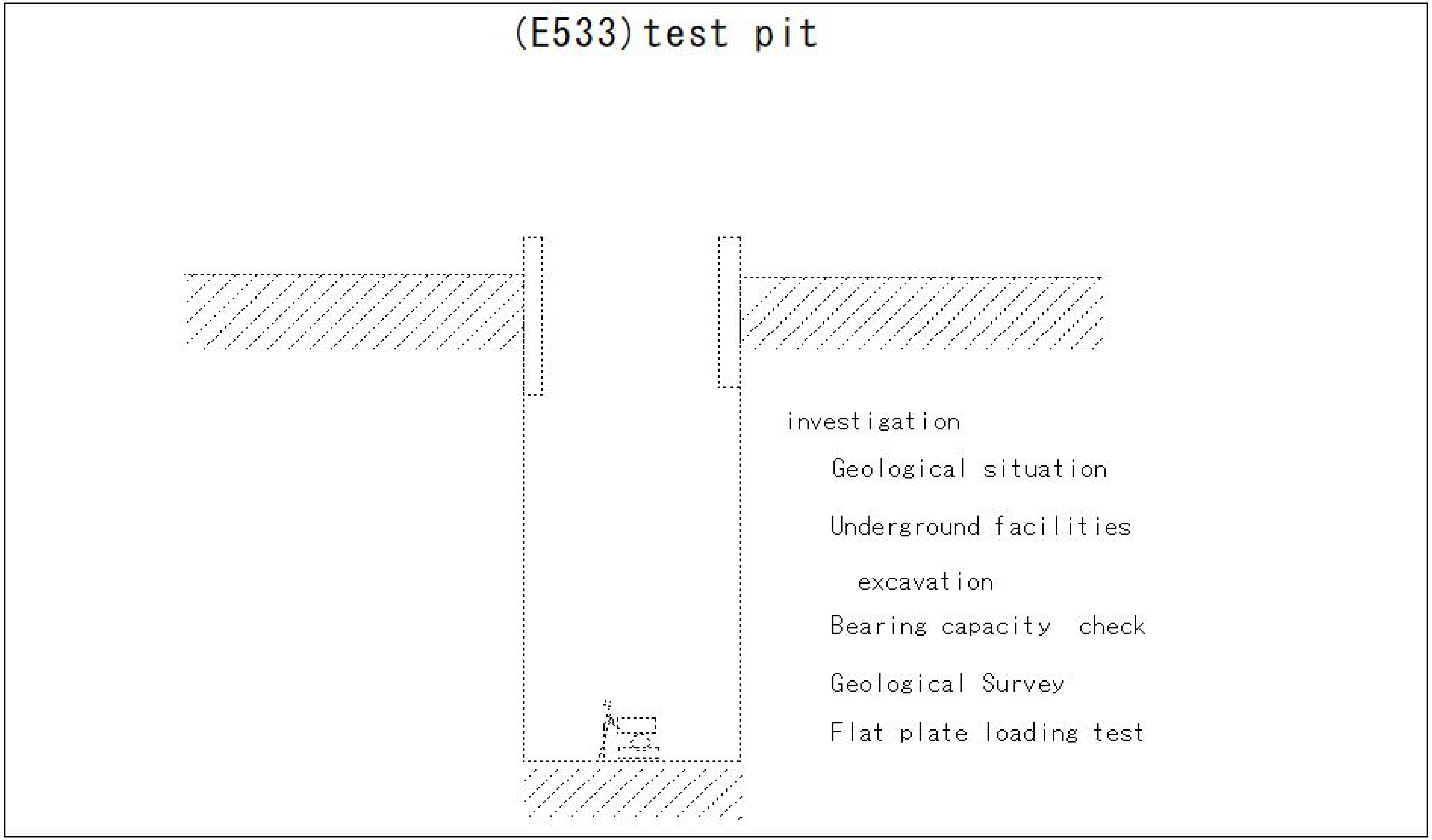
(E531)hillside works



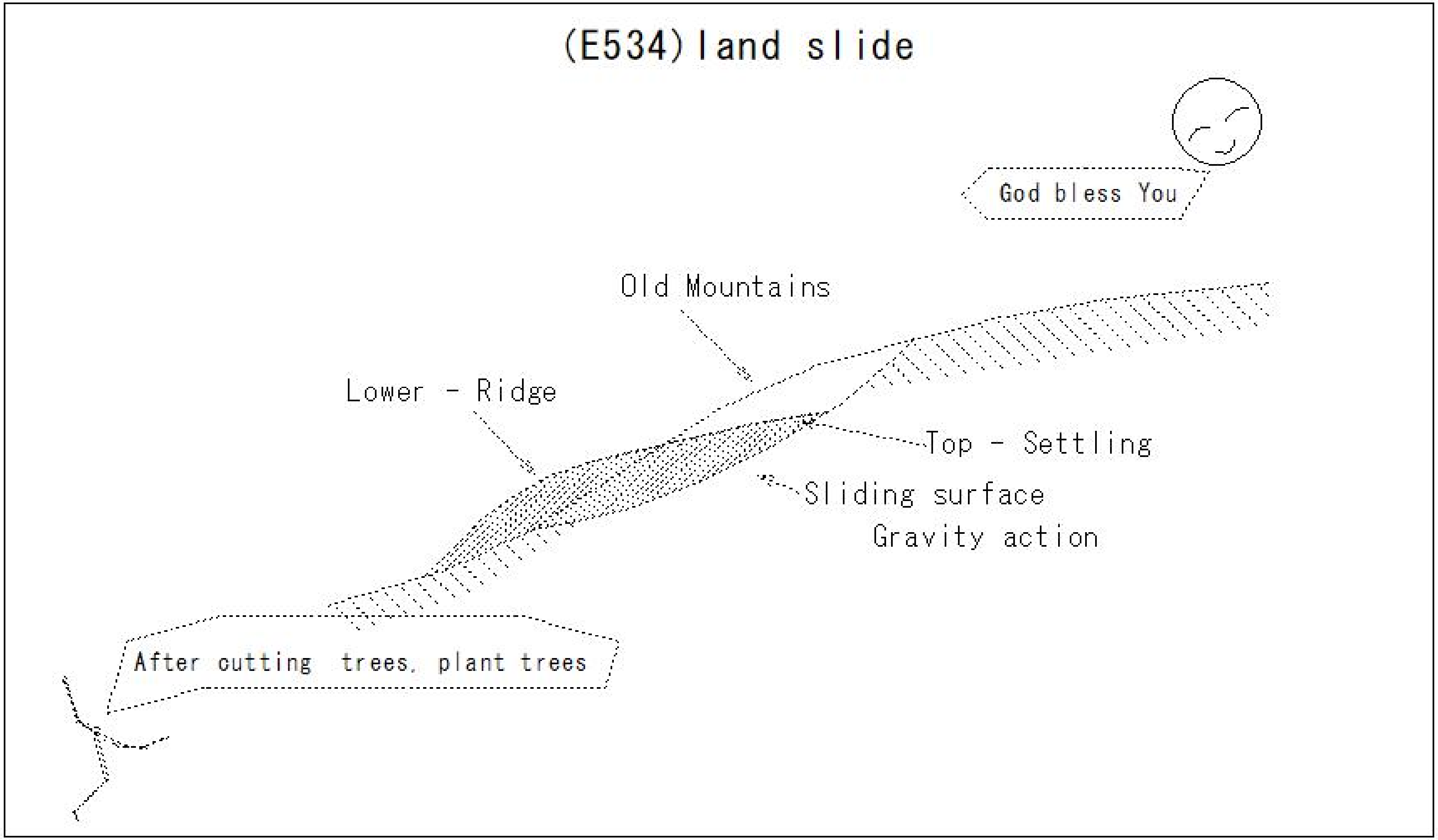
(E532)hillside covering works



(E533)test pit



(E534)land slide

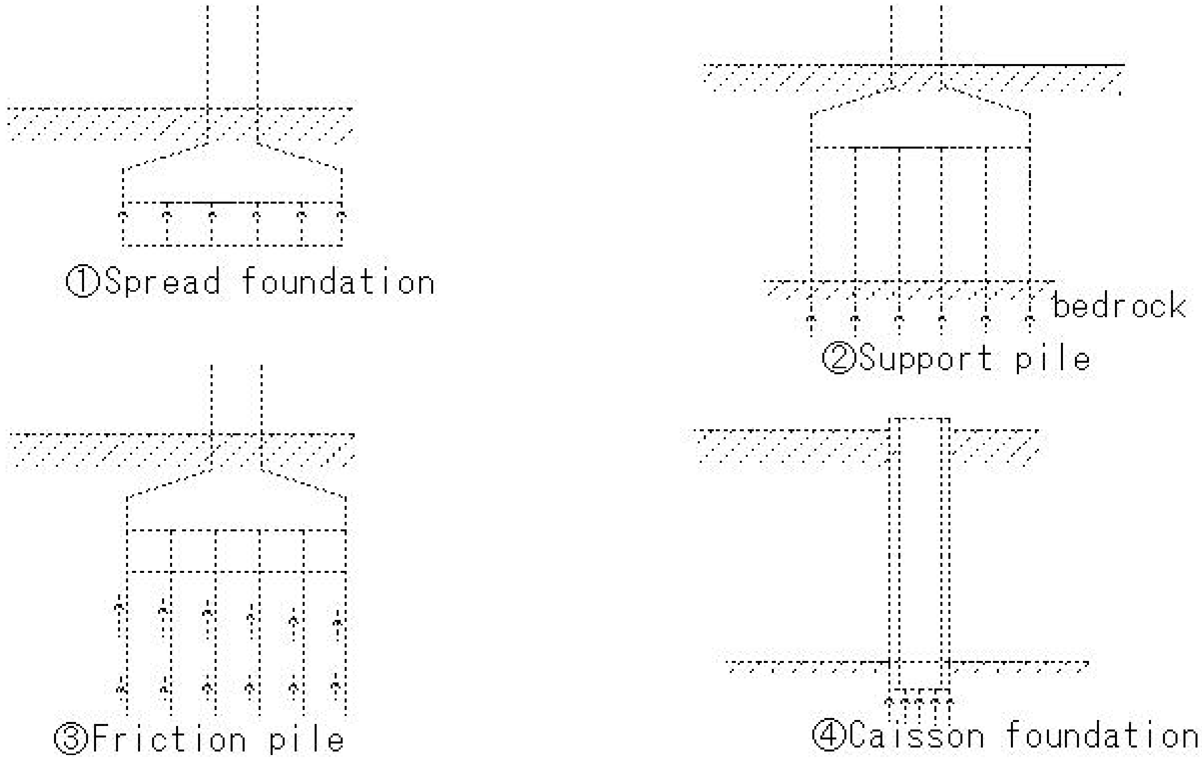


(E535)allowable bearing capacity

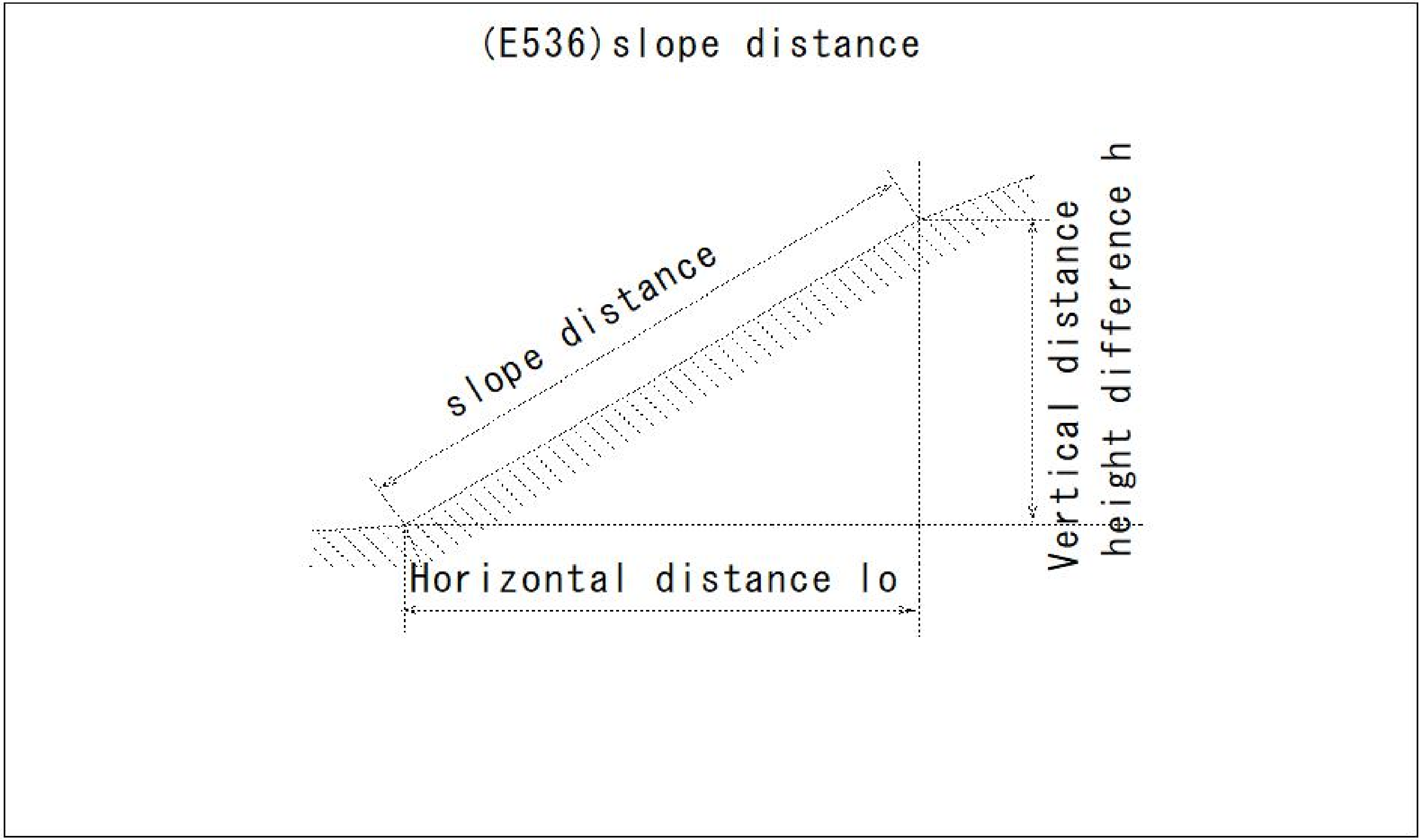
(E535)allowable bearing capacity

Permissible bearing capacity of the ground

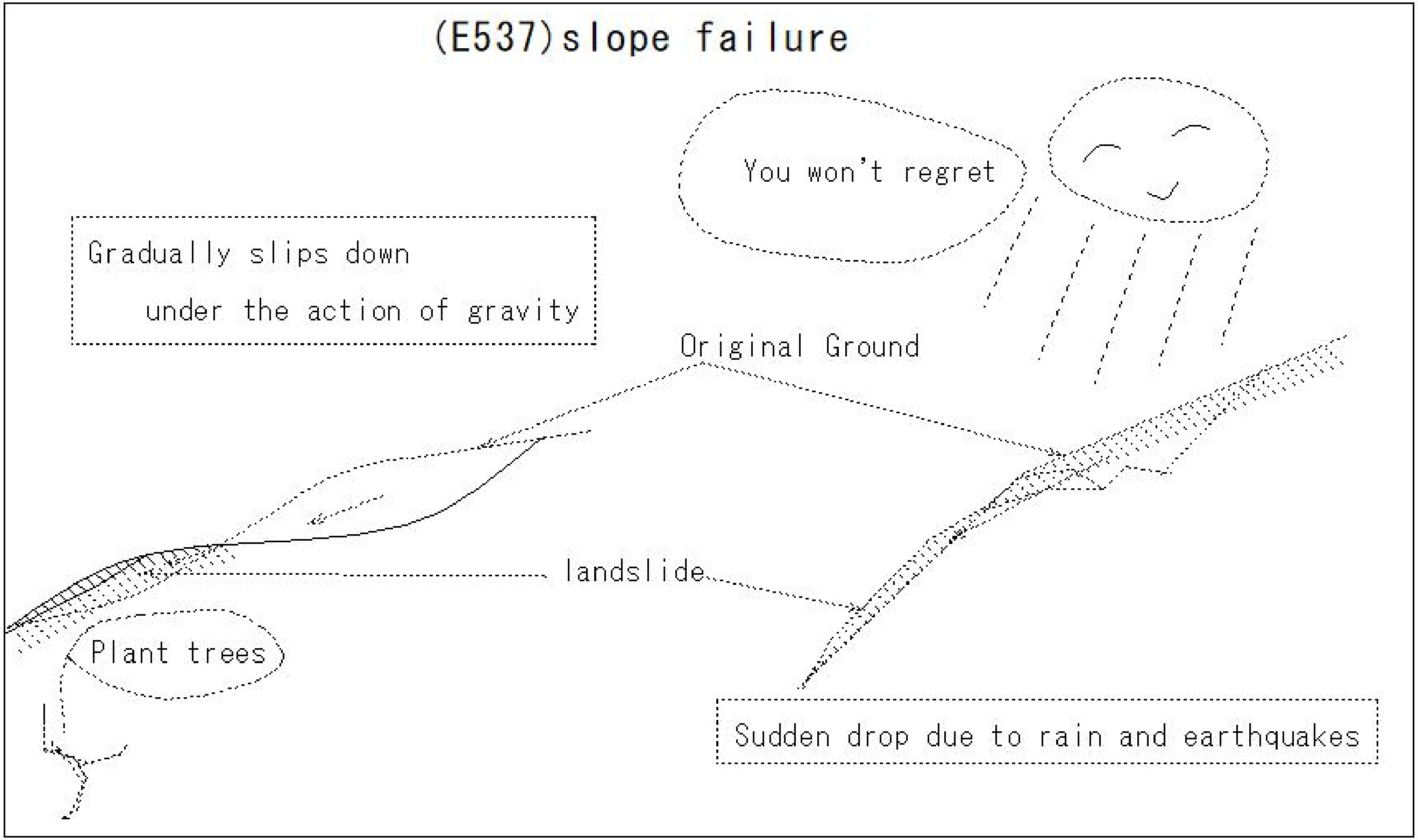
Divide by the ultimate bearing capacity/safety factor that can support the ground



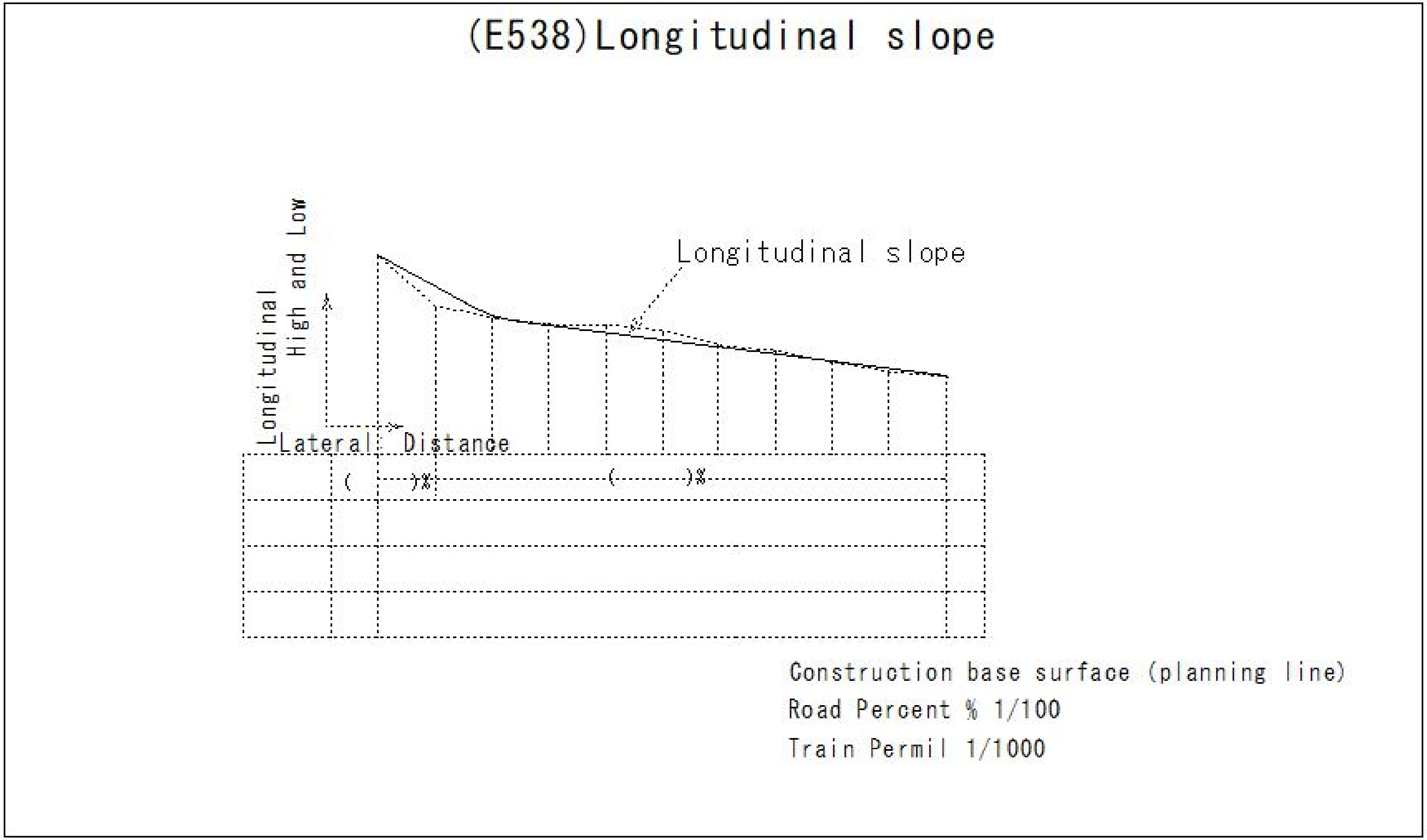
(E536)slope distance



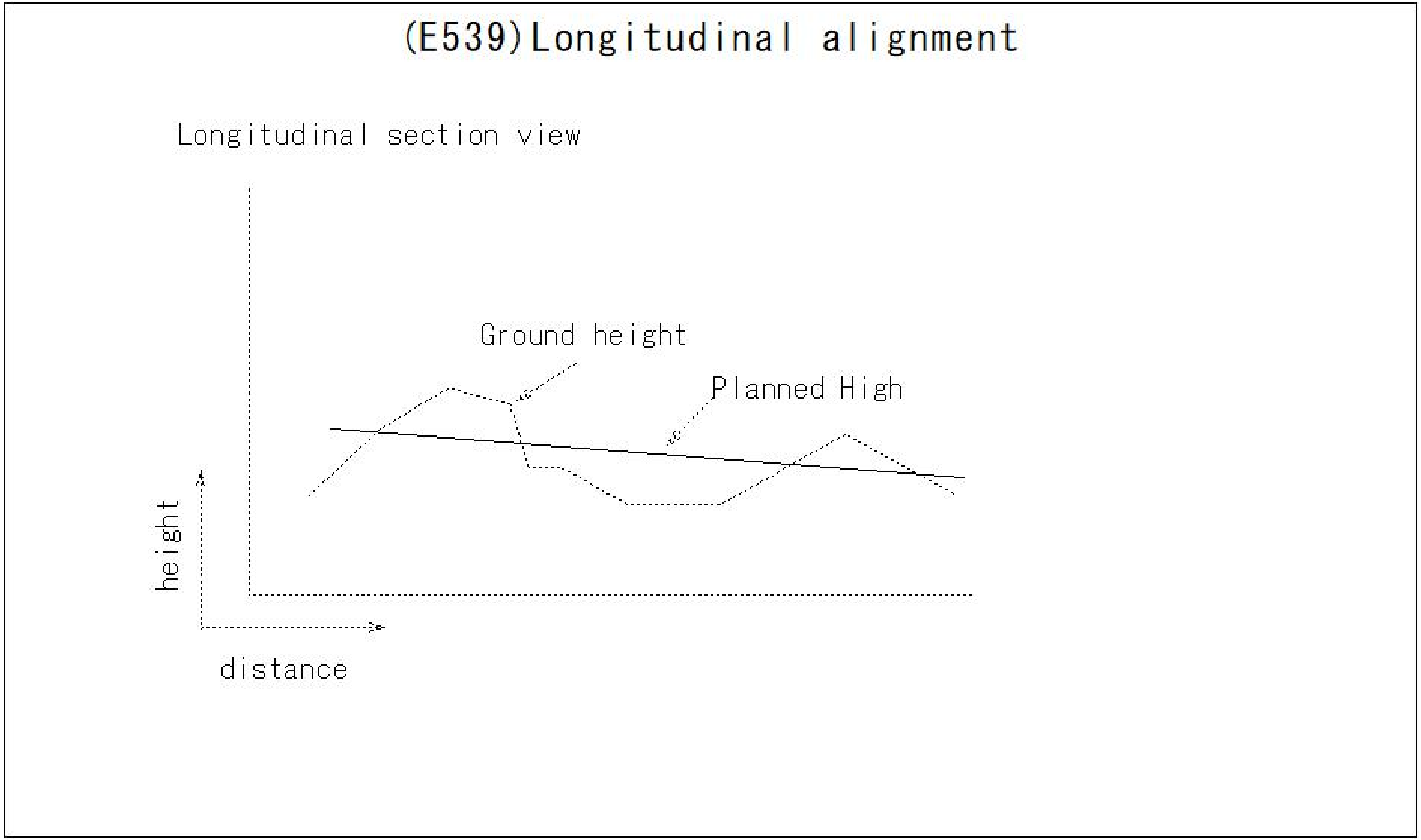
(E537)slope failure



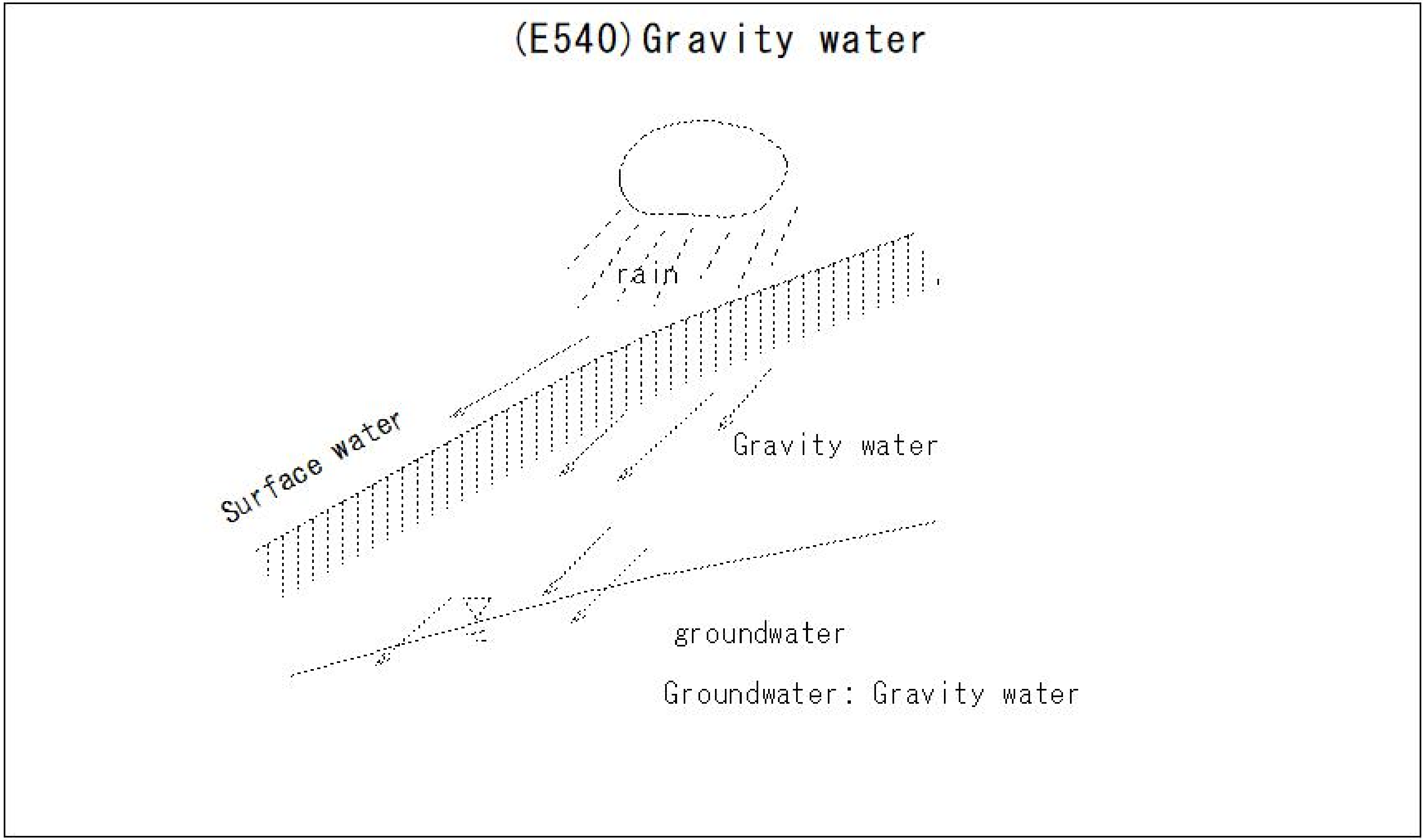
(E538)Longitudinal slope



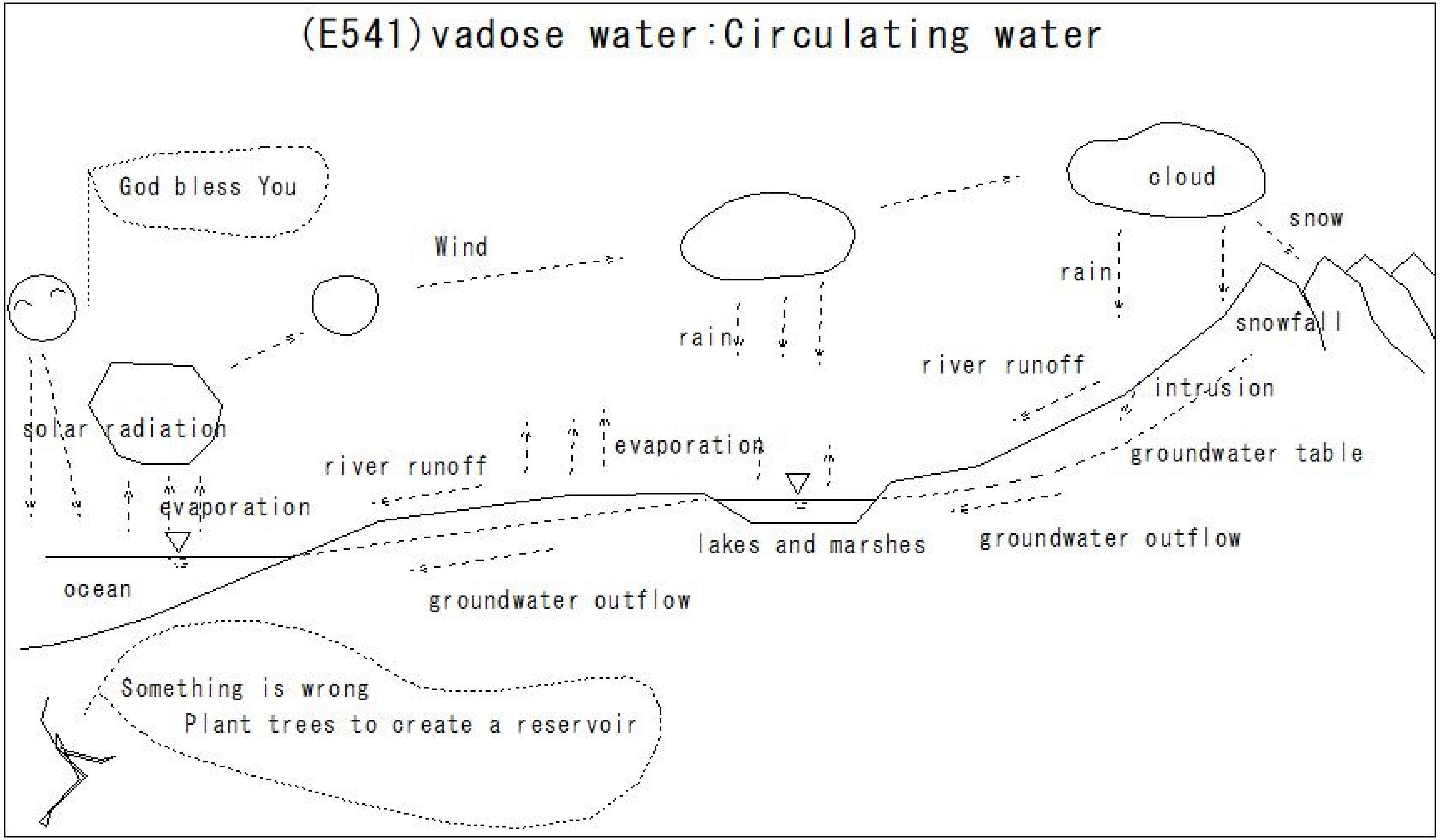
(E539)Longitudinal alignment



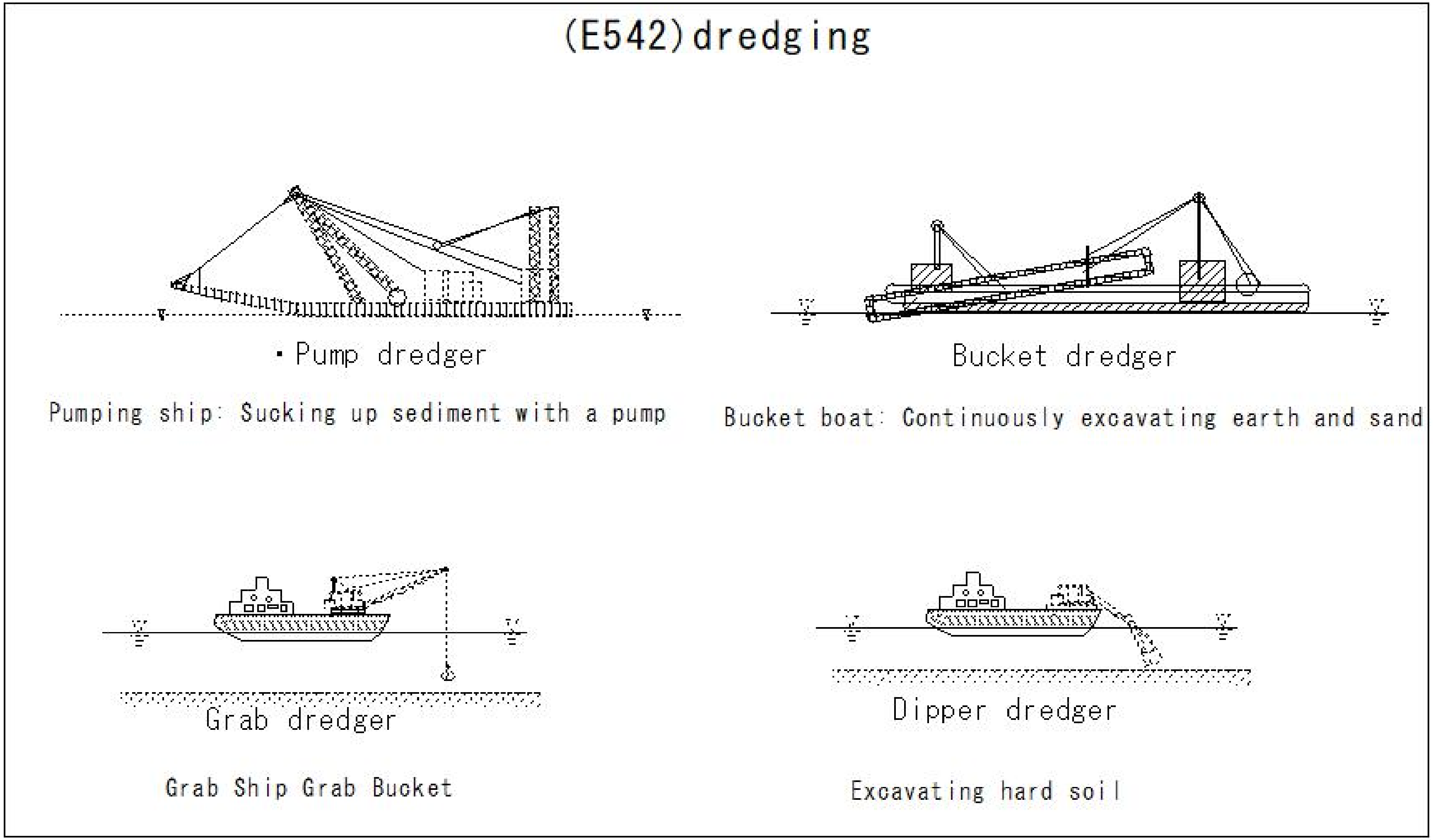
(E540)Gravity water



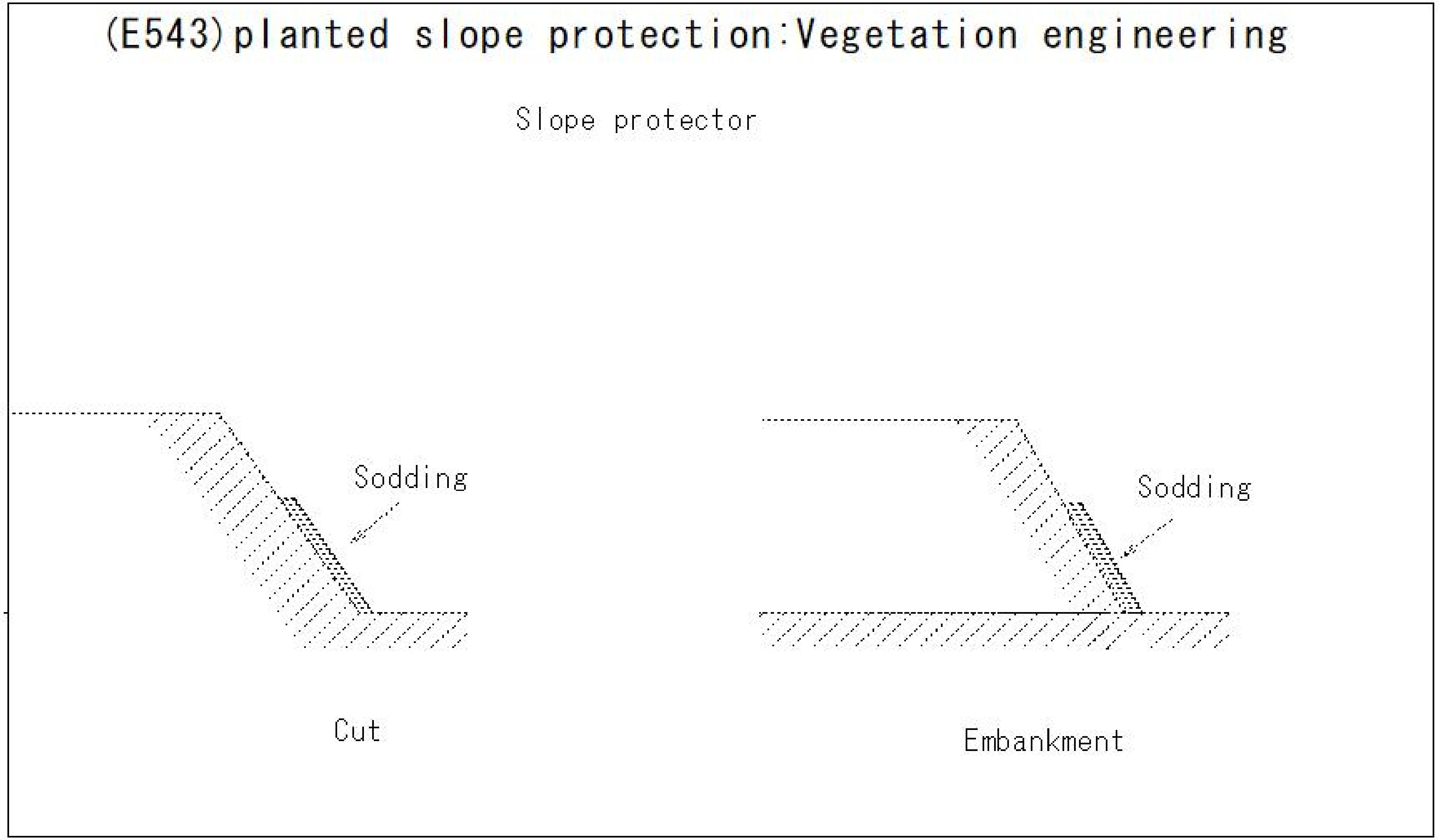
(E541)vadose water:Circulating water



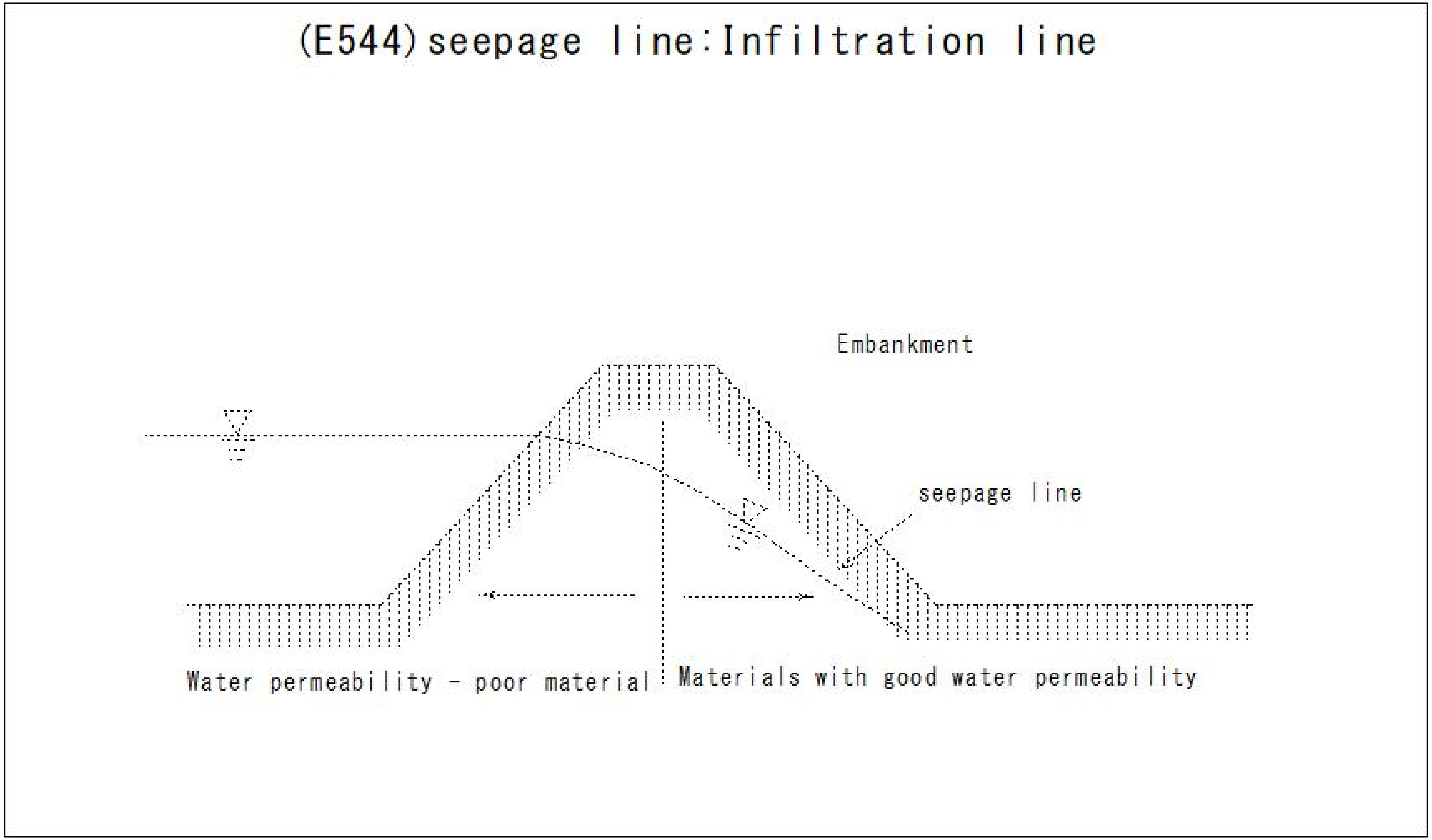
(E542)dredging



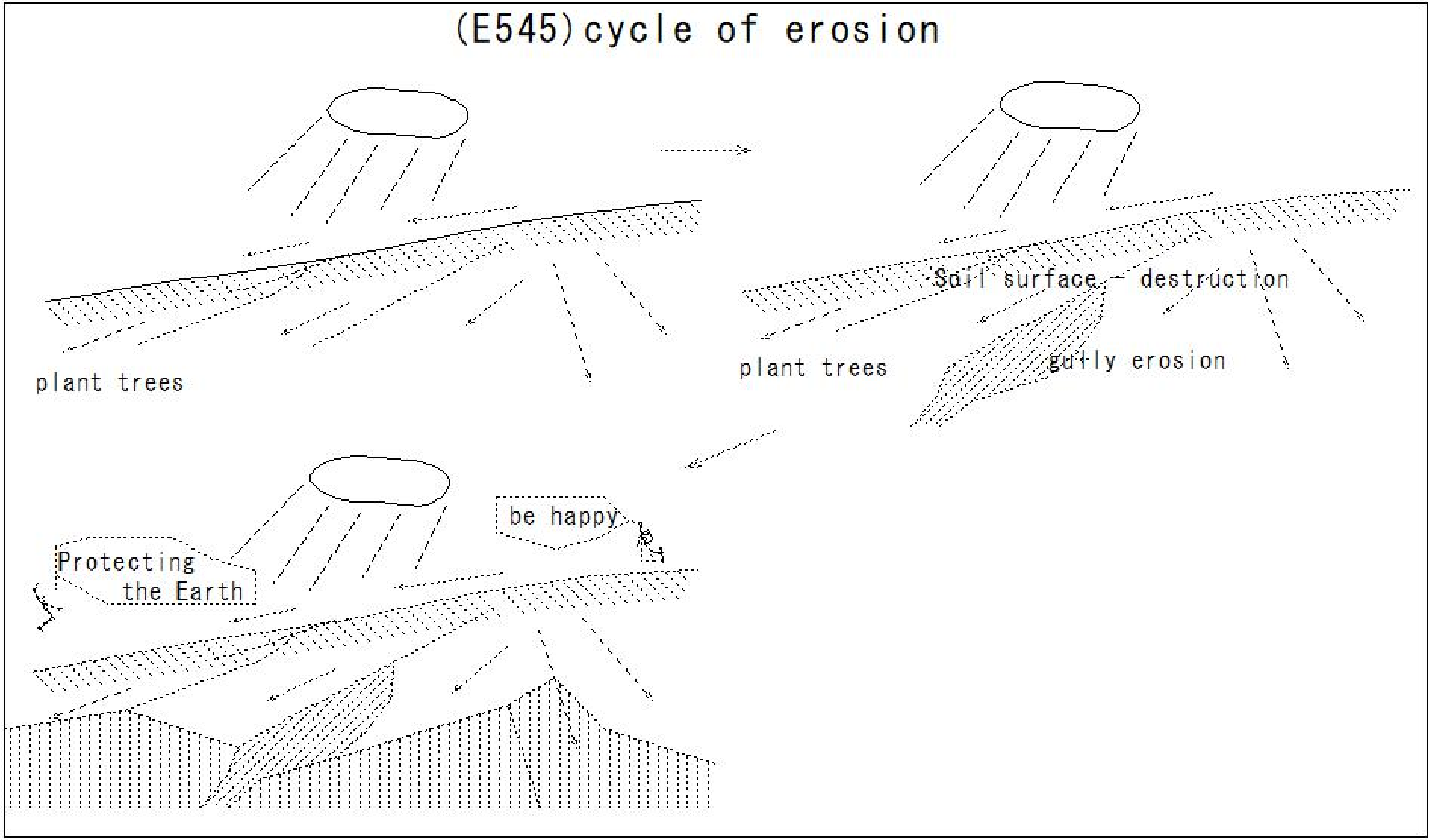
(E543)planted slope protection:Vegetation engineering



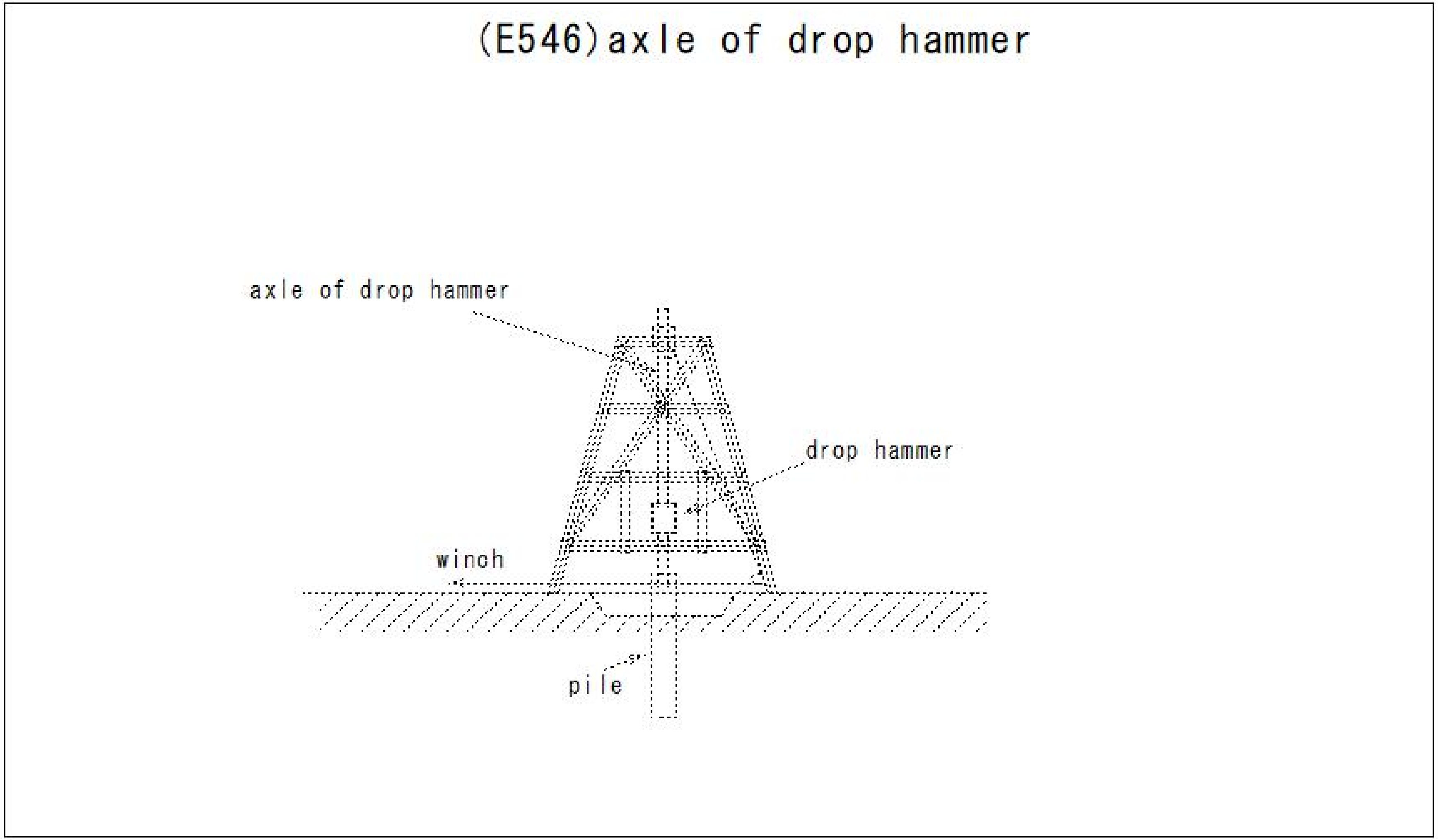
(E544)seepage line:Infiltration line



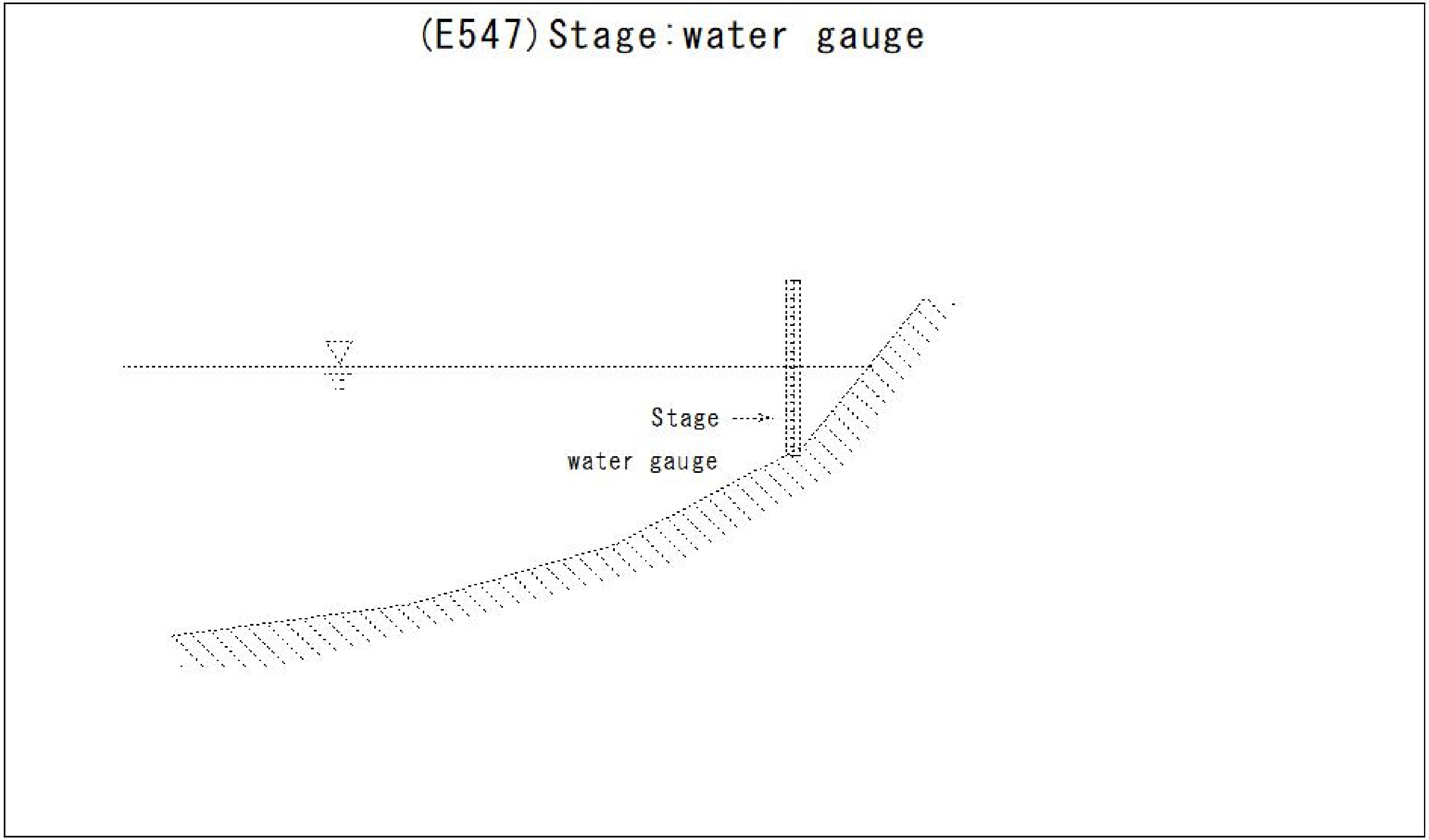
(E545)cycle of erosion



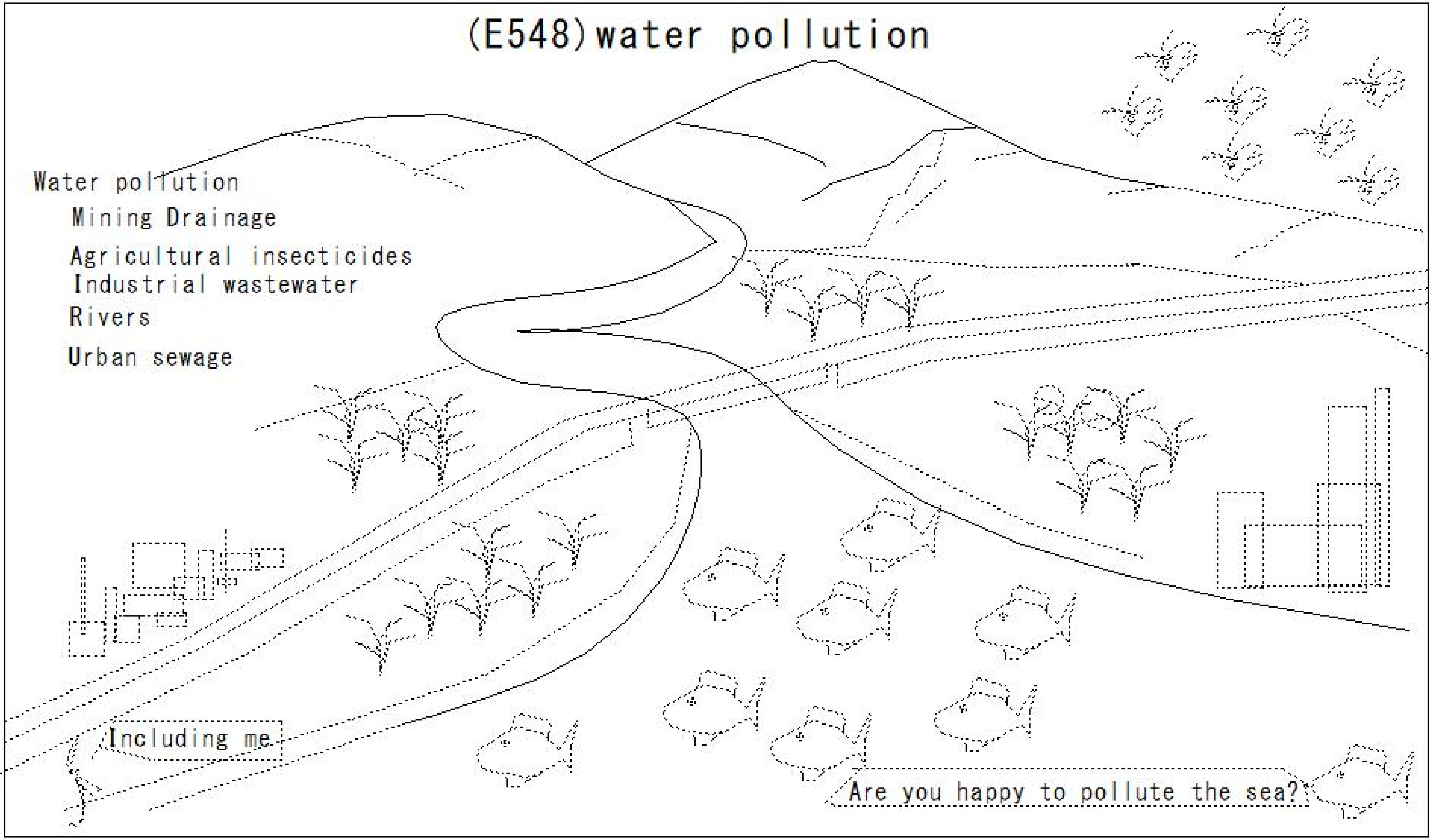
(E546)axle of drop hammer



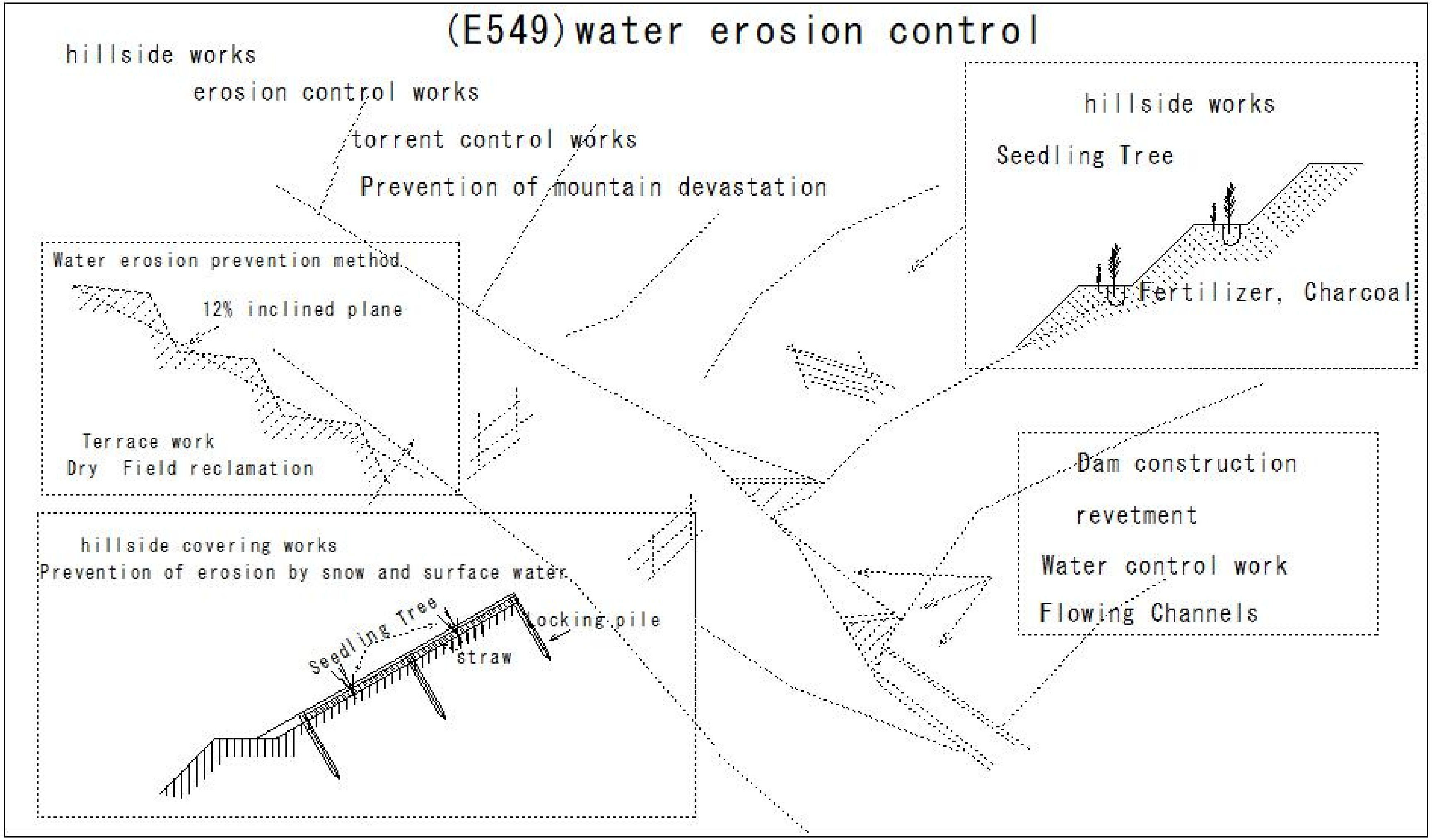
(E547)Stage:water gauge



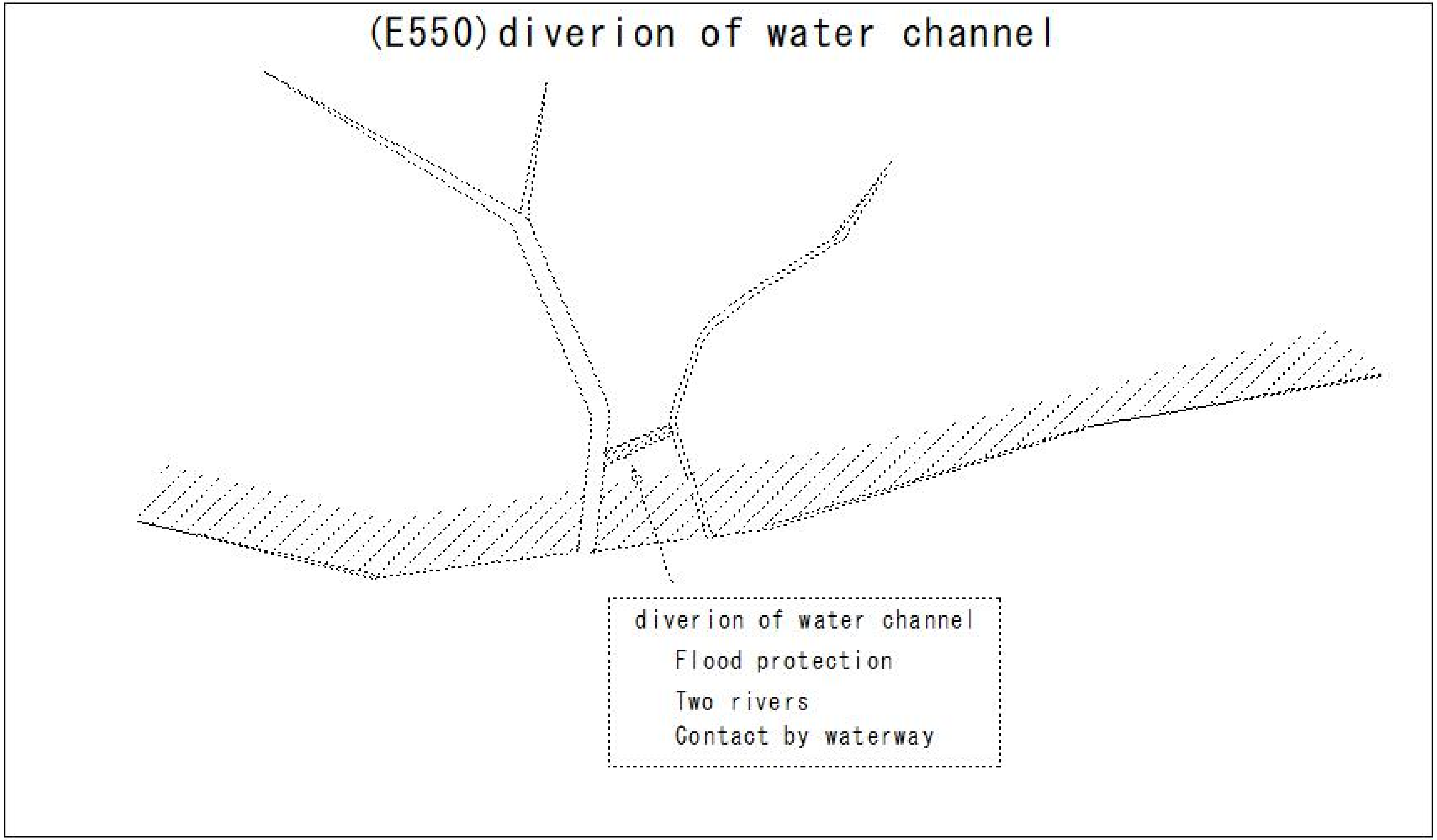
(E548)water pollution



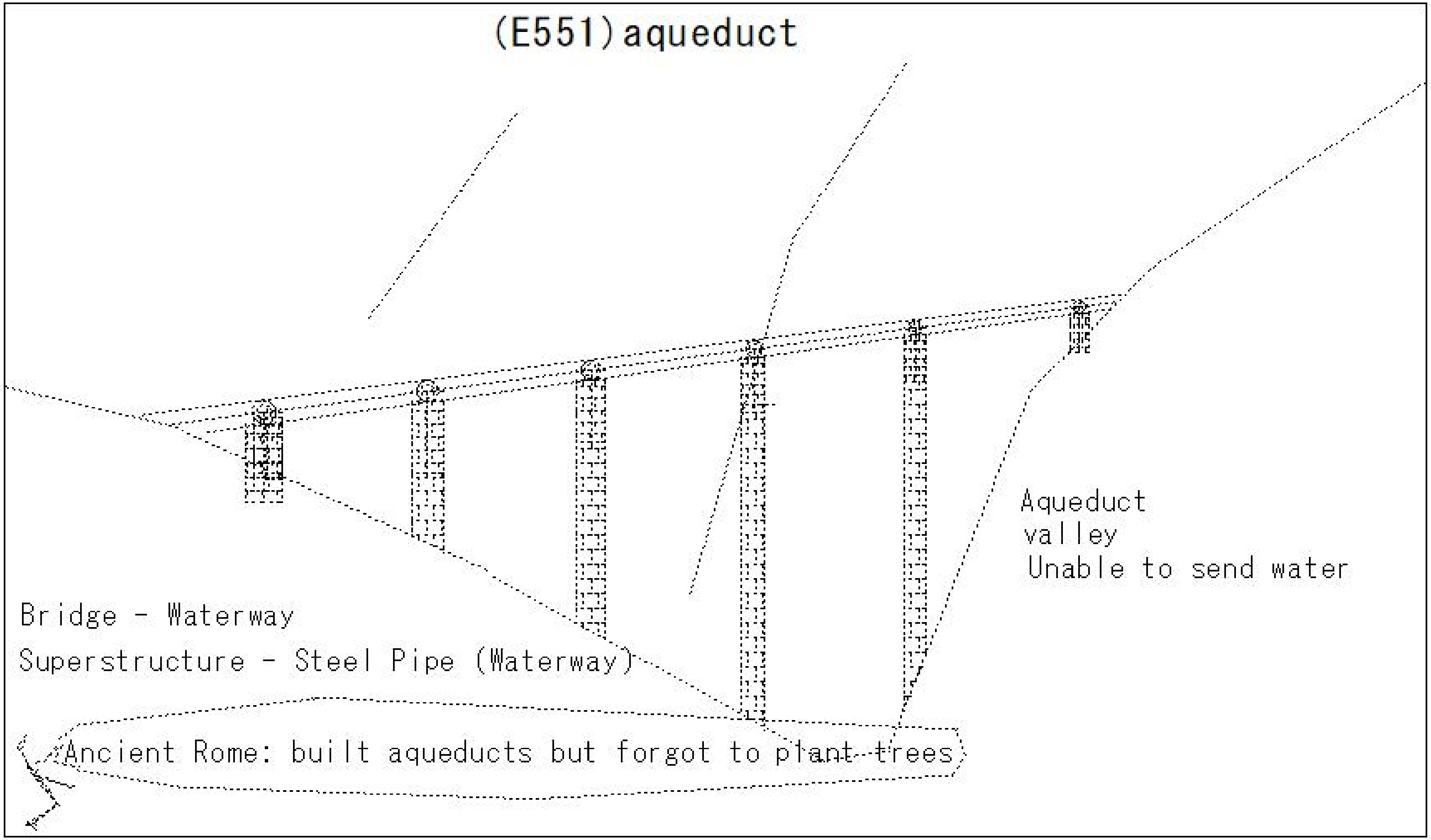
(E549)water erosion control



(E550)diverion of water channel

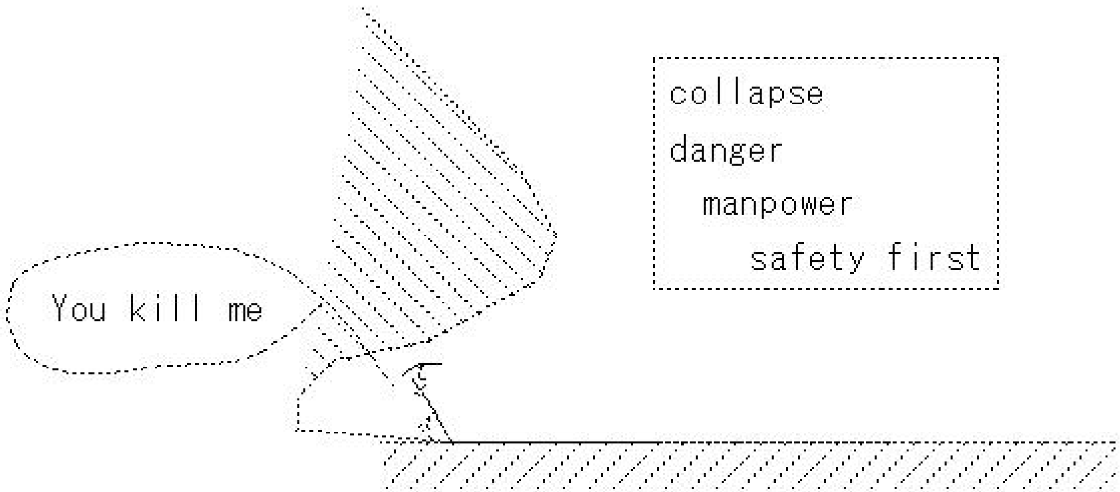


(E551)aqueduct



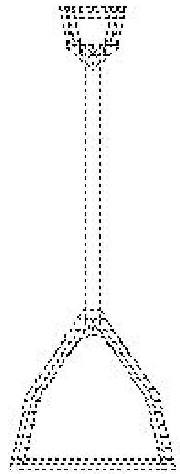
(E552)undermining

(E552)undermining



(E553)Scoop

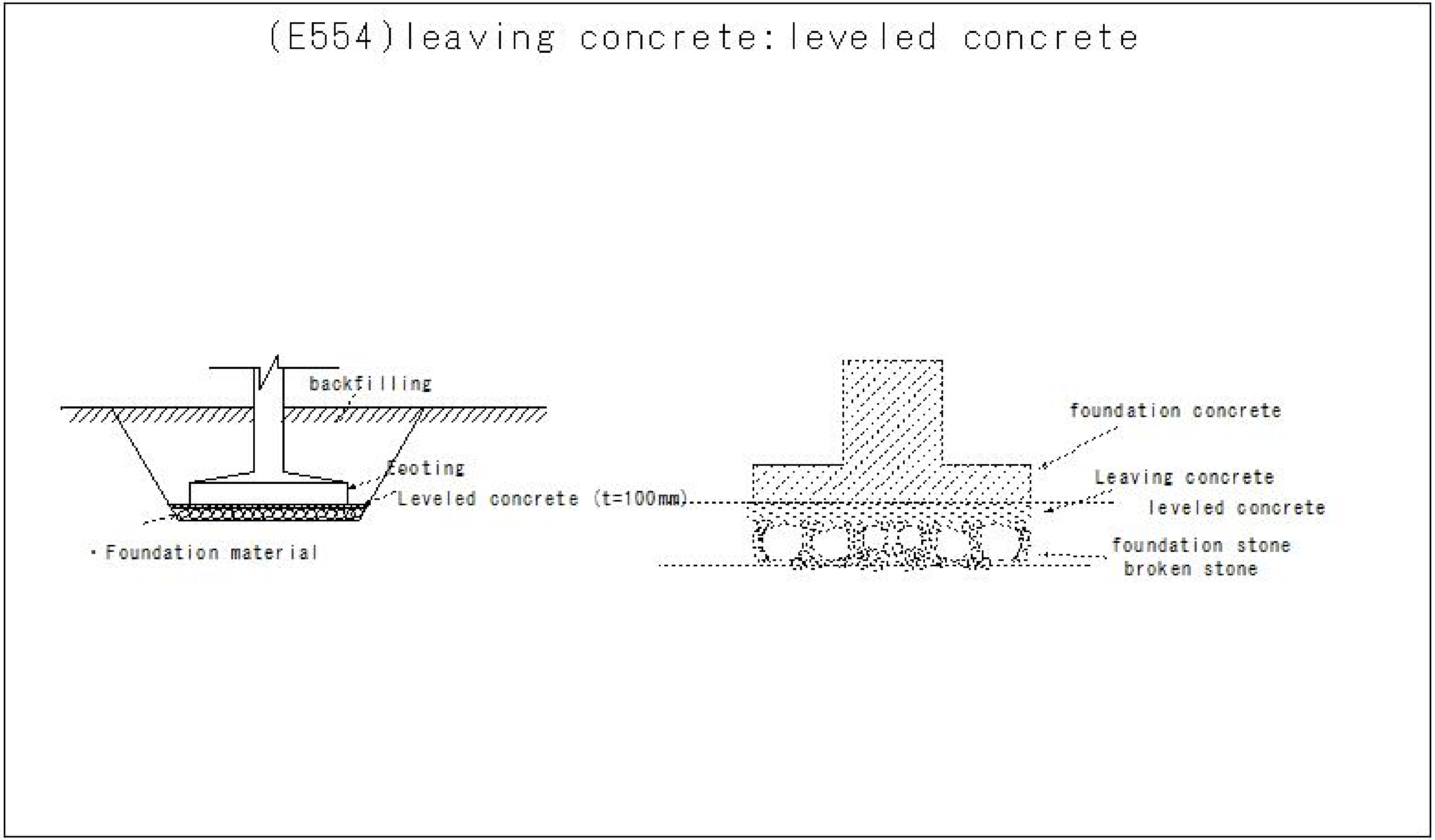
(E553) Scoop



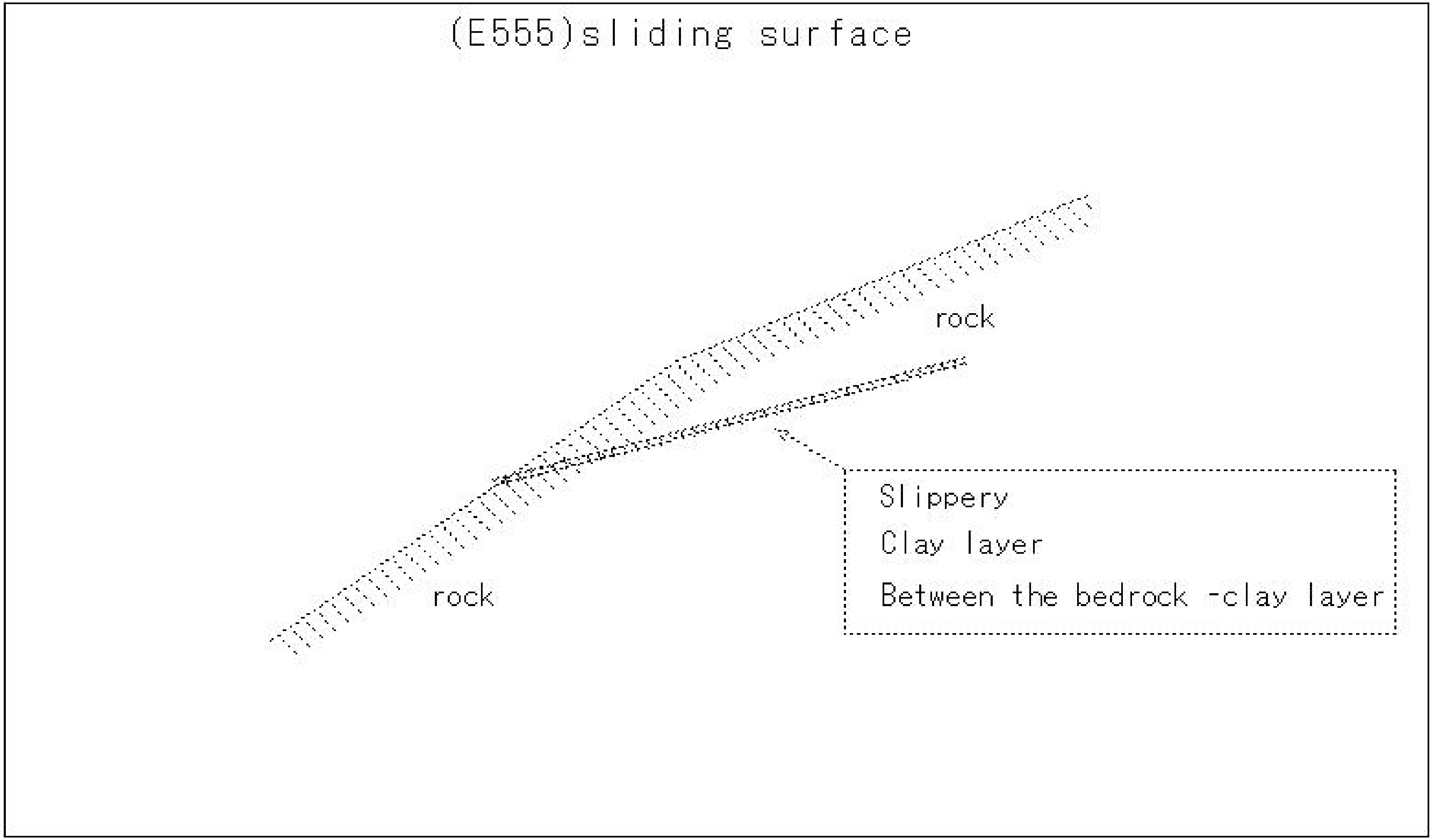
Earthmoving tools

Scooping up sediment

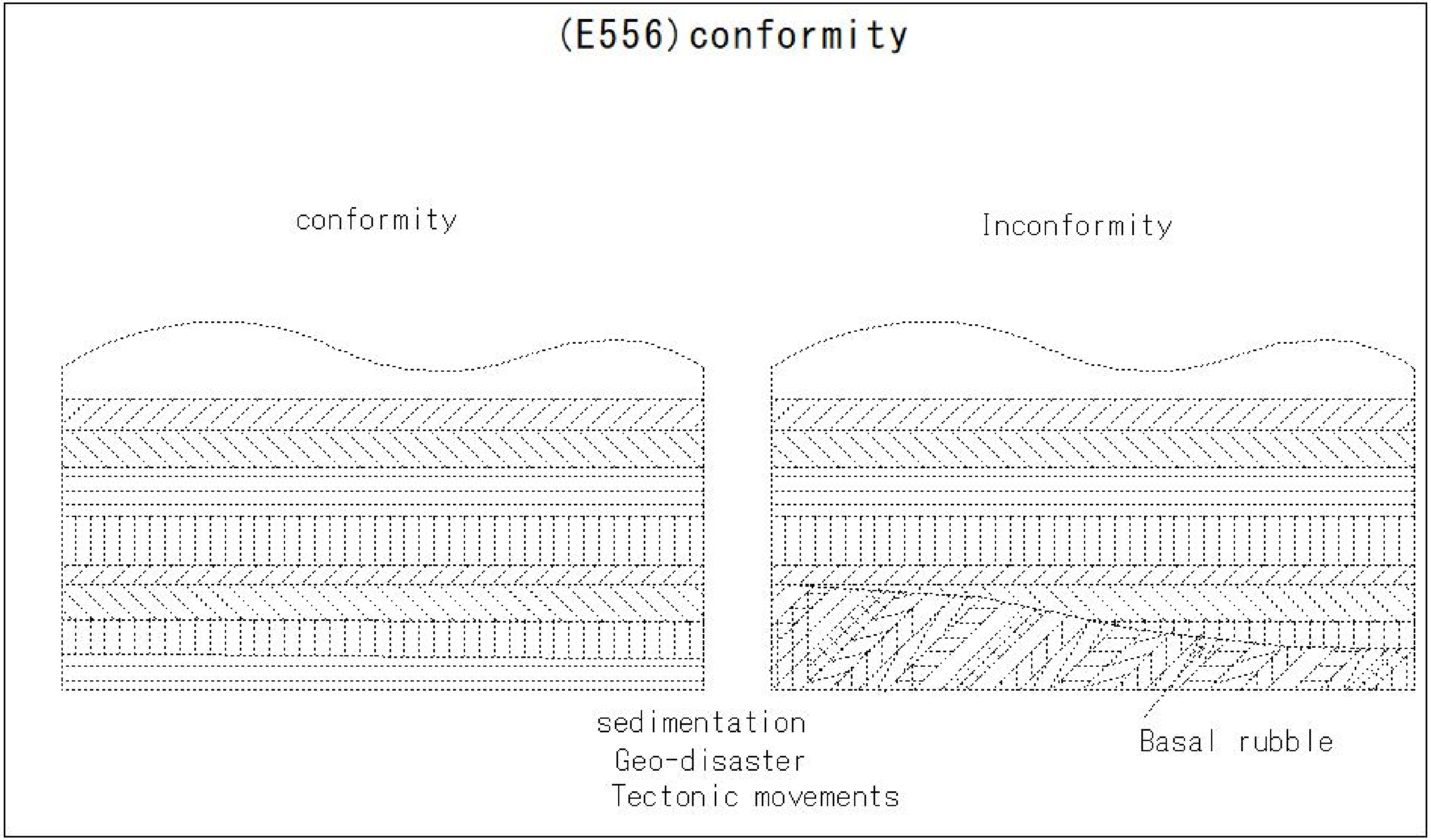
(E554)leaving concrete:leveled concrete



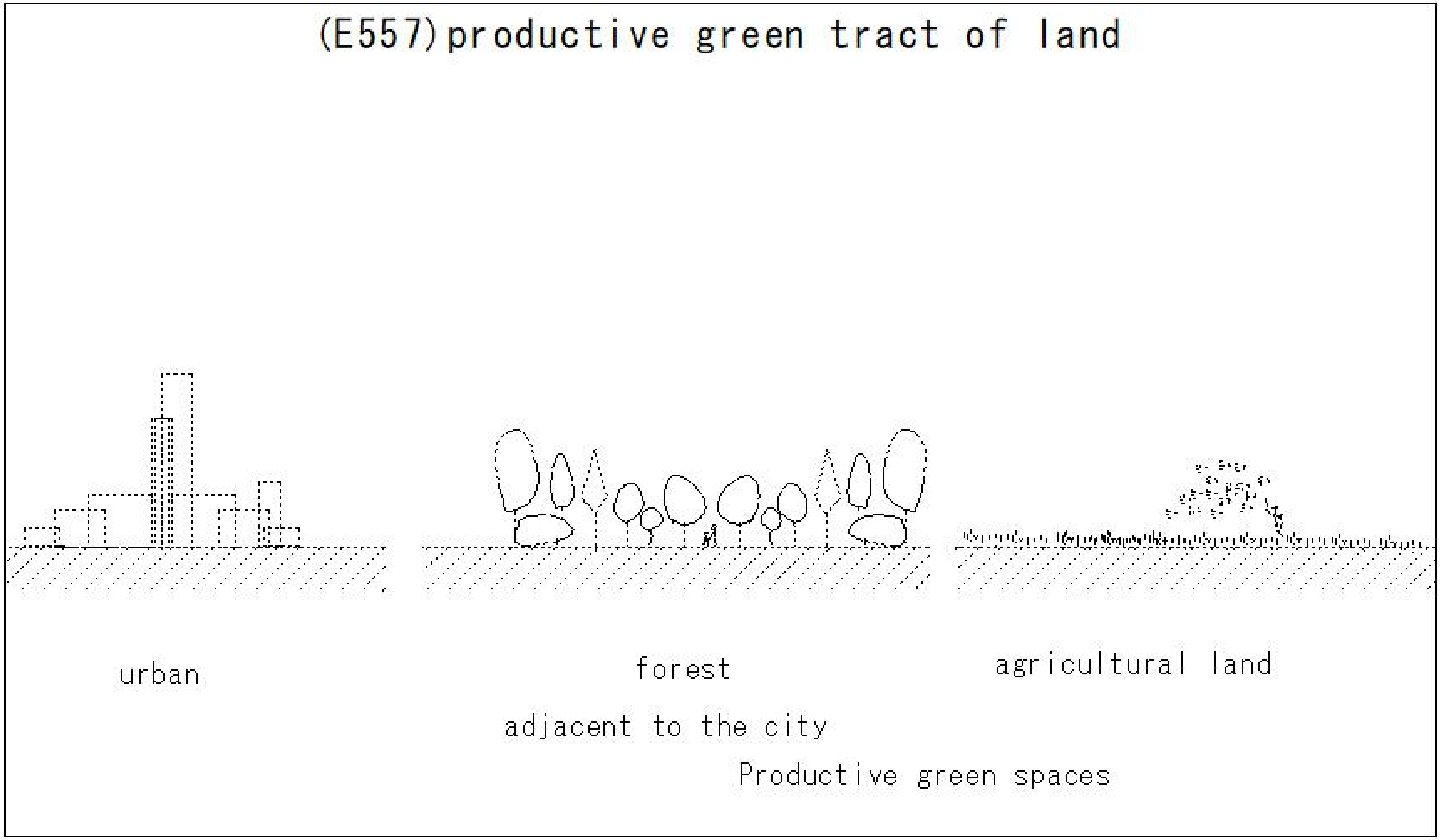
(E555)sliding surface



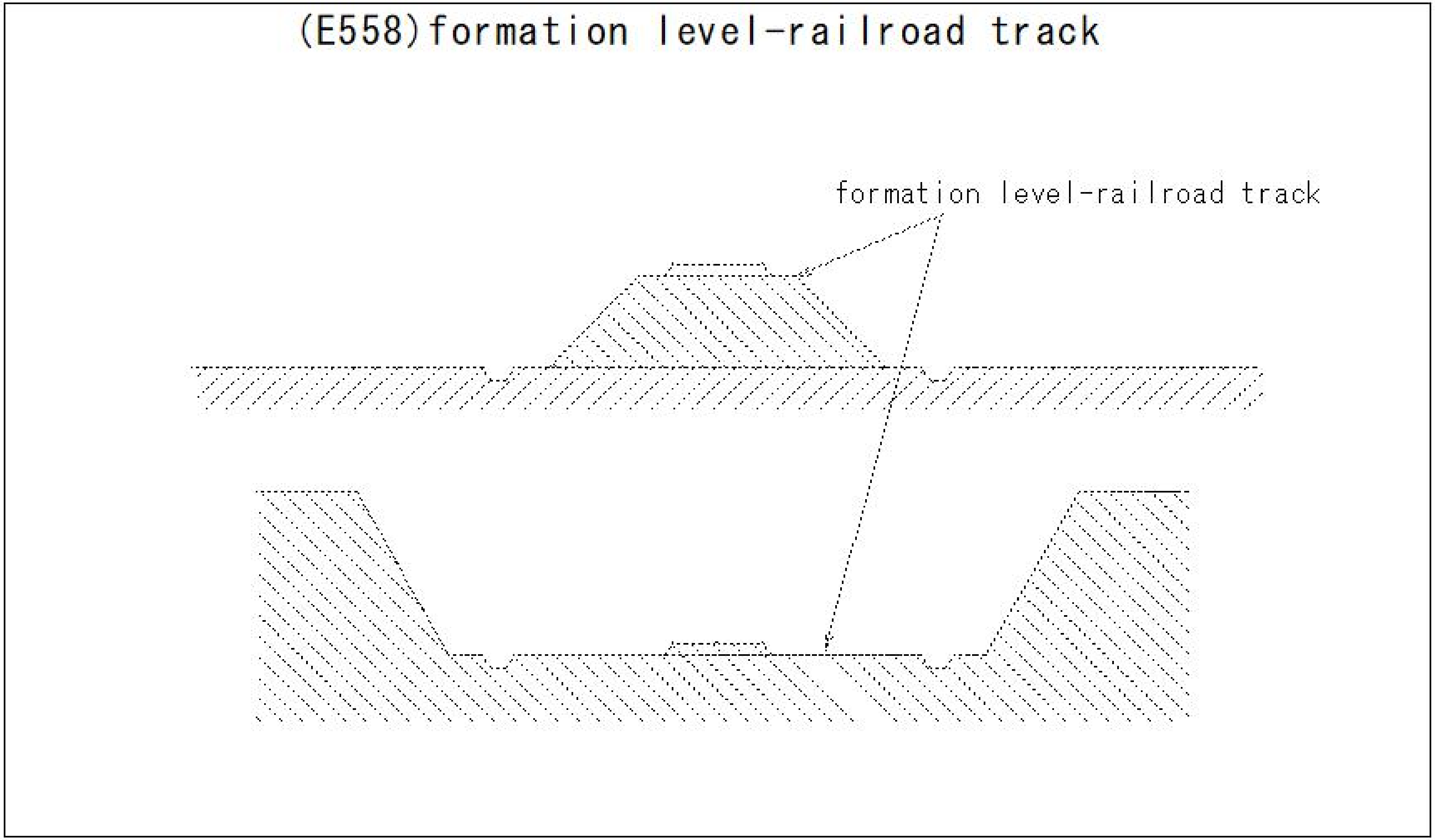
(E556)conformitye556



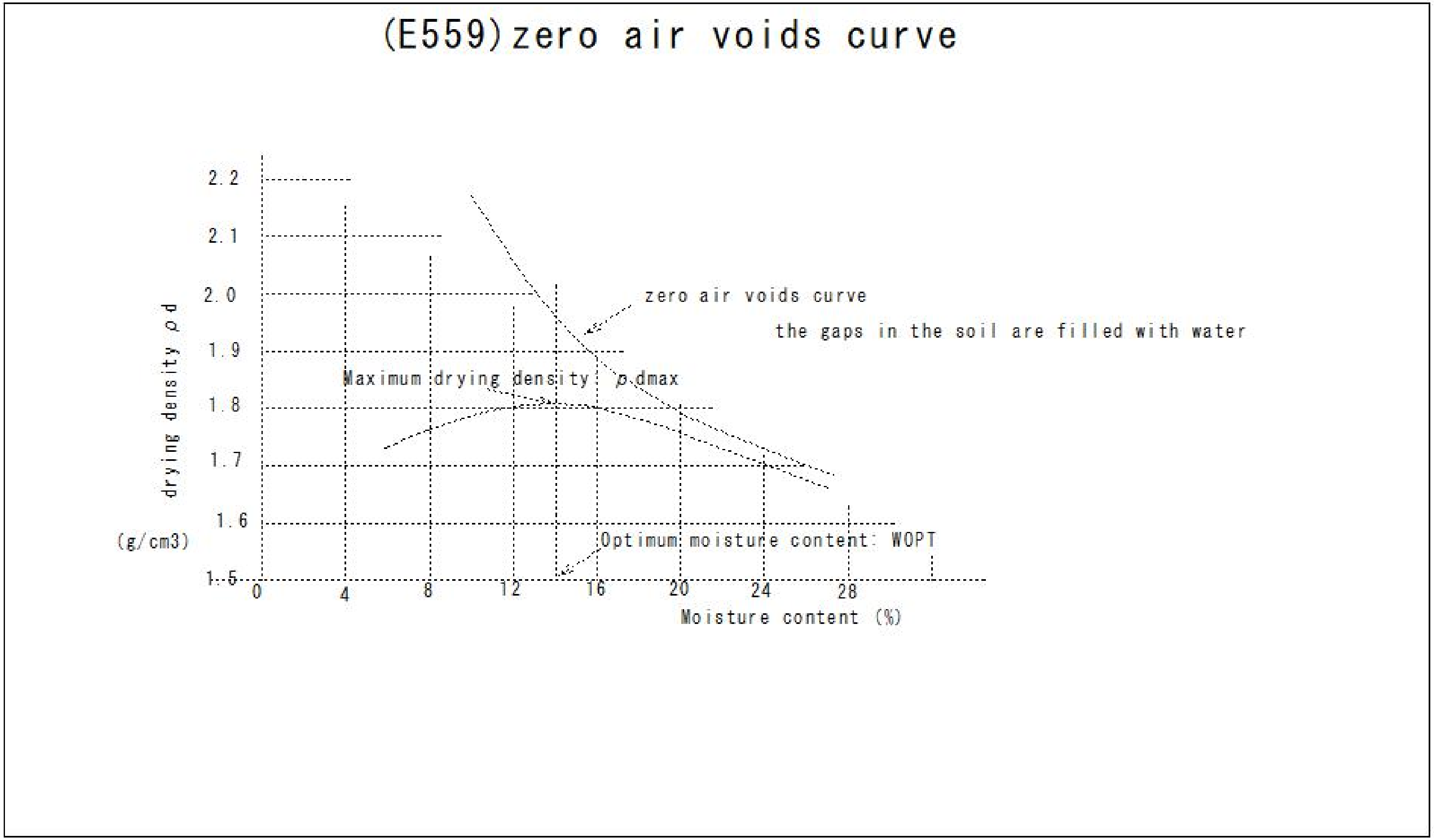
(E557)productive green tract of land



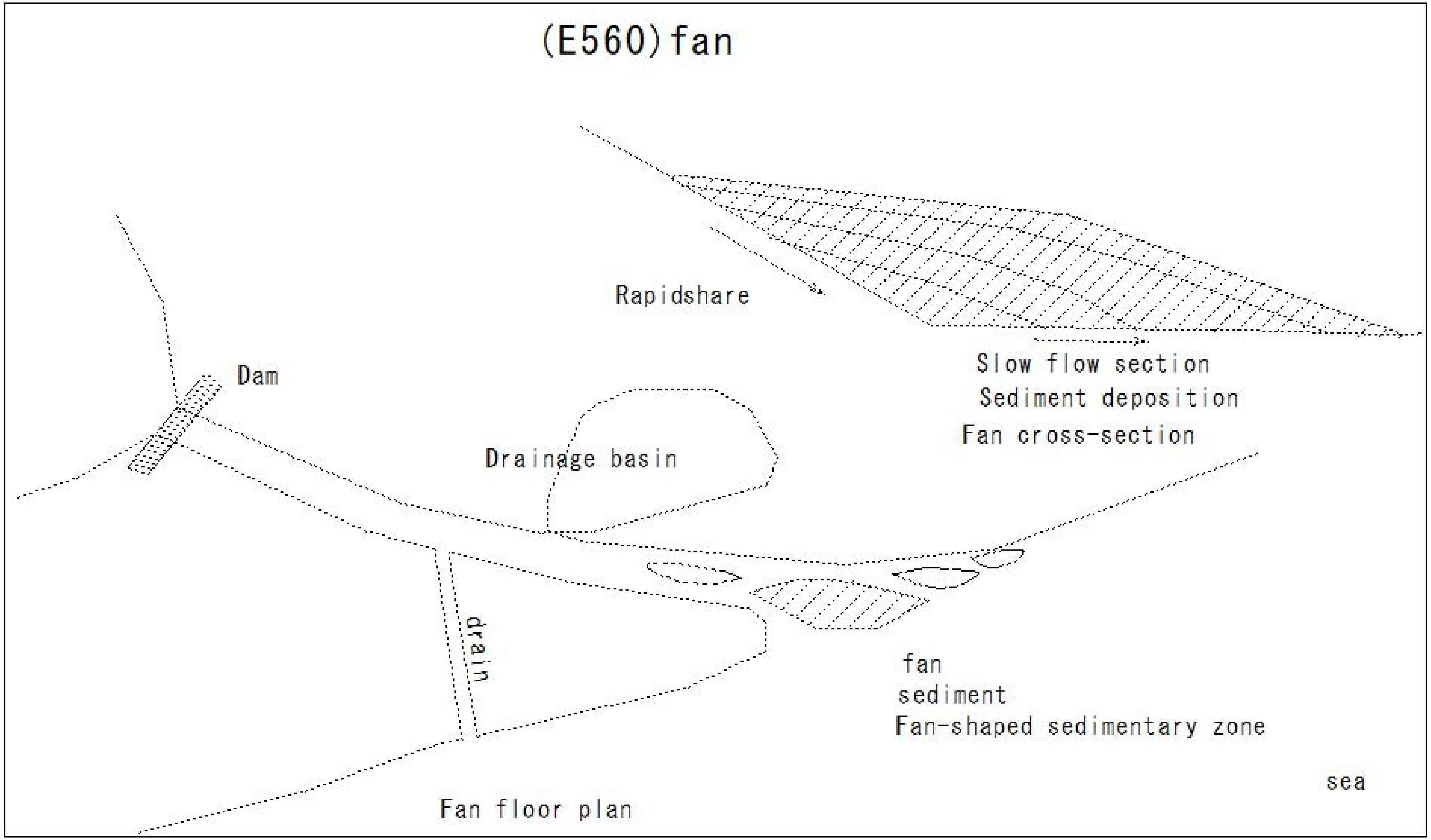
(E558)formation level-railroad track



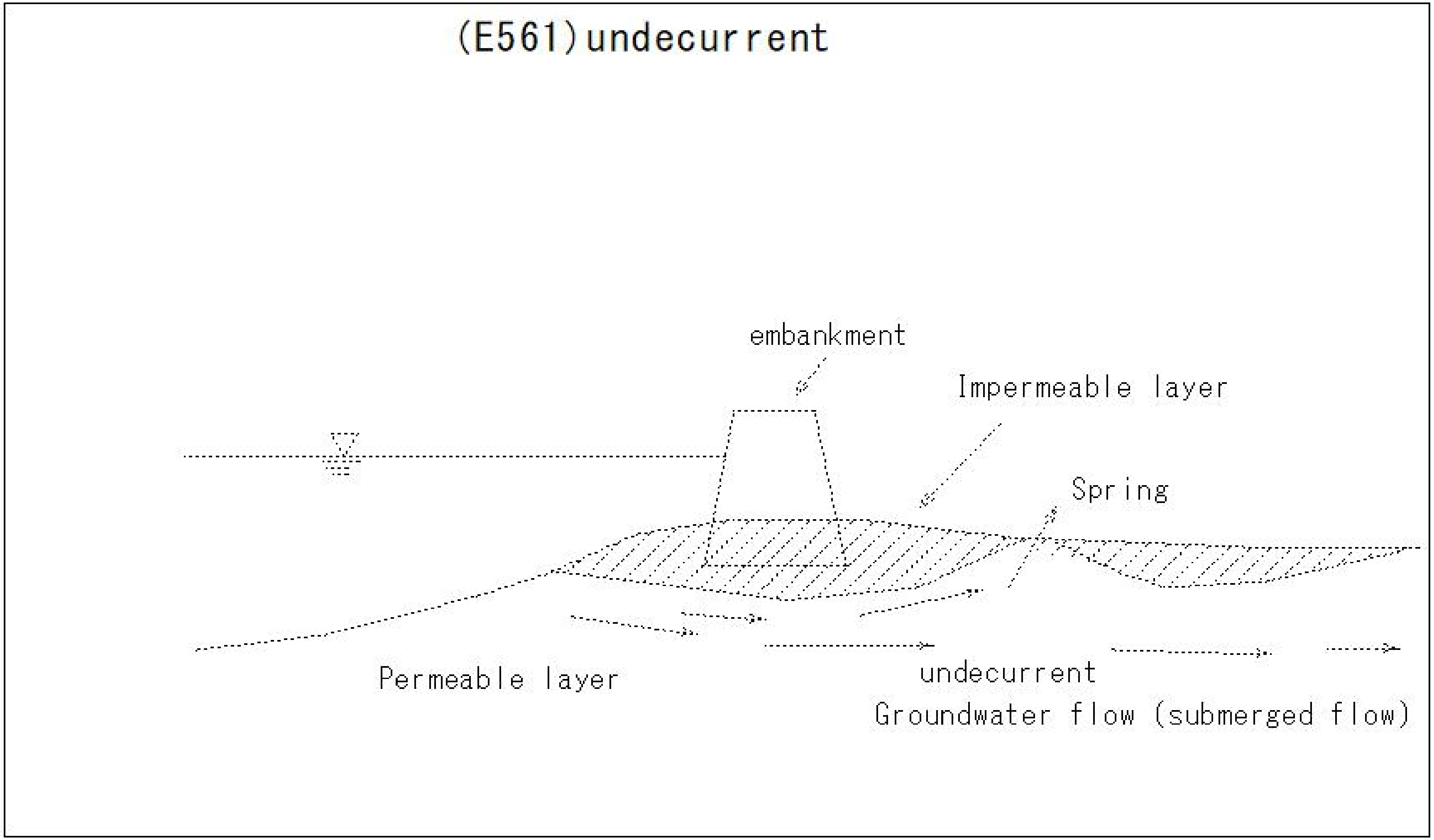
(E559)zero air voids curve



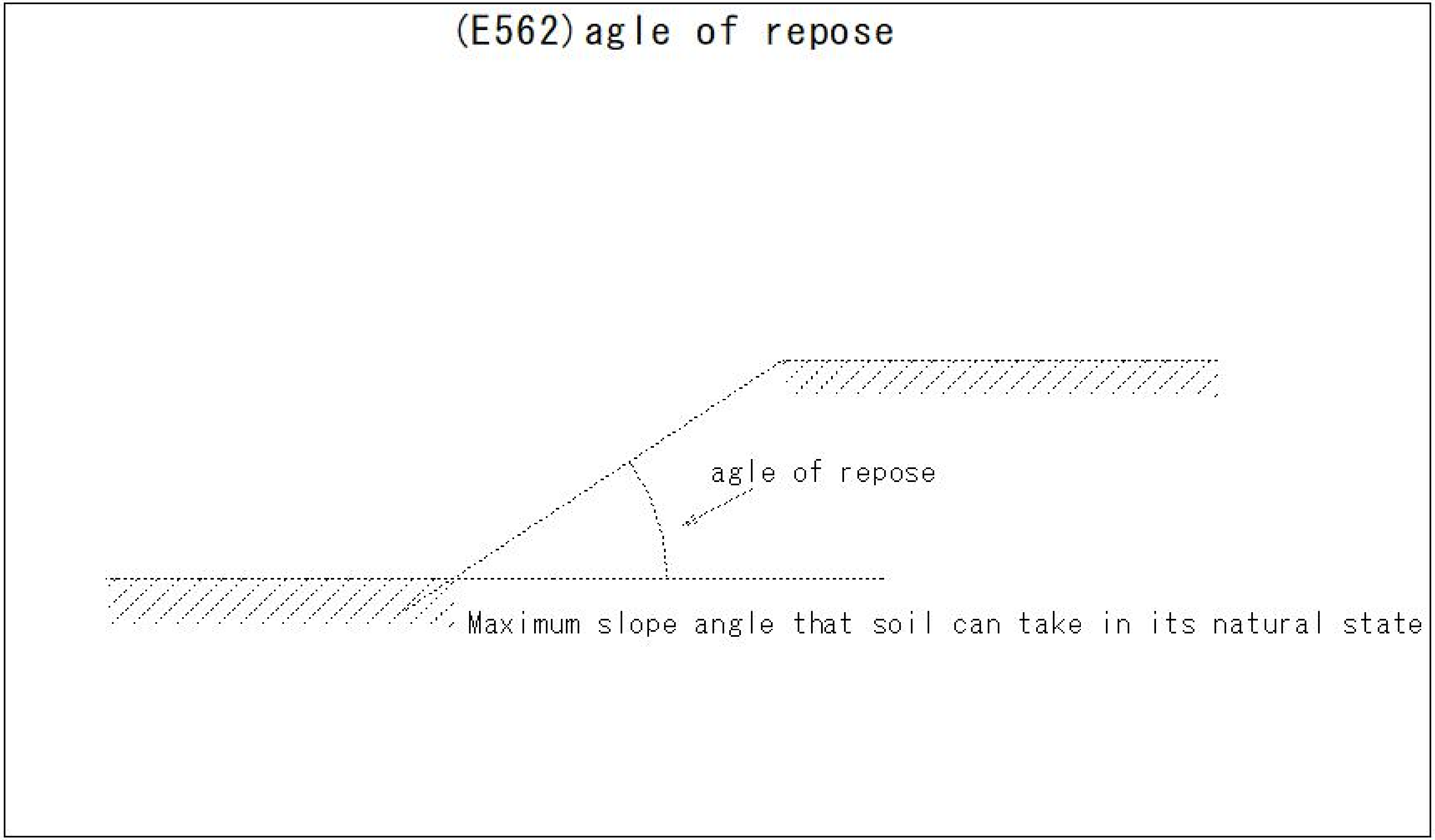
(E560)fan


(E560)fan
Rapidshare
Slow flow section
Sediment deposition
Fan cross-section
Dam
Drainage basin
drain
fan
sediment
Fan-shaped sedimentary zone
sea
Fan floor plan

(E561)undecurrent

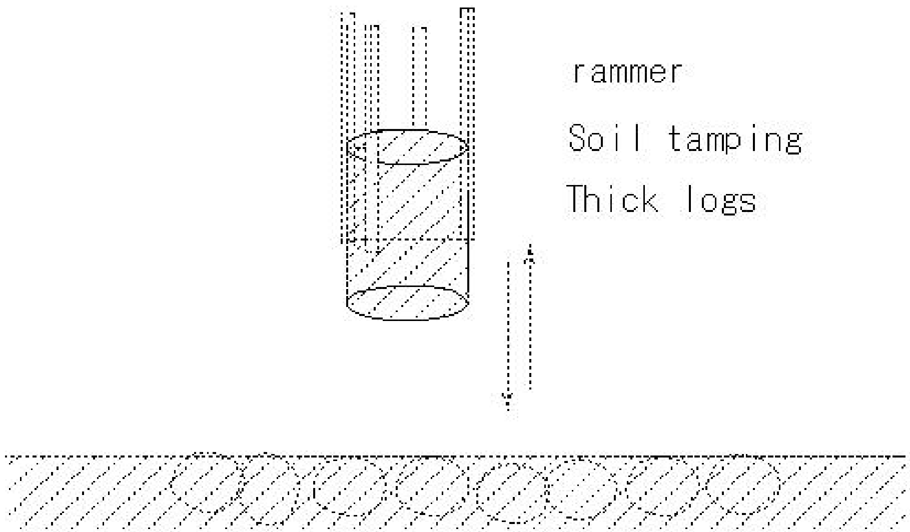


(E562)agle of repose

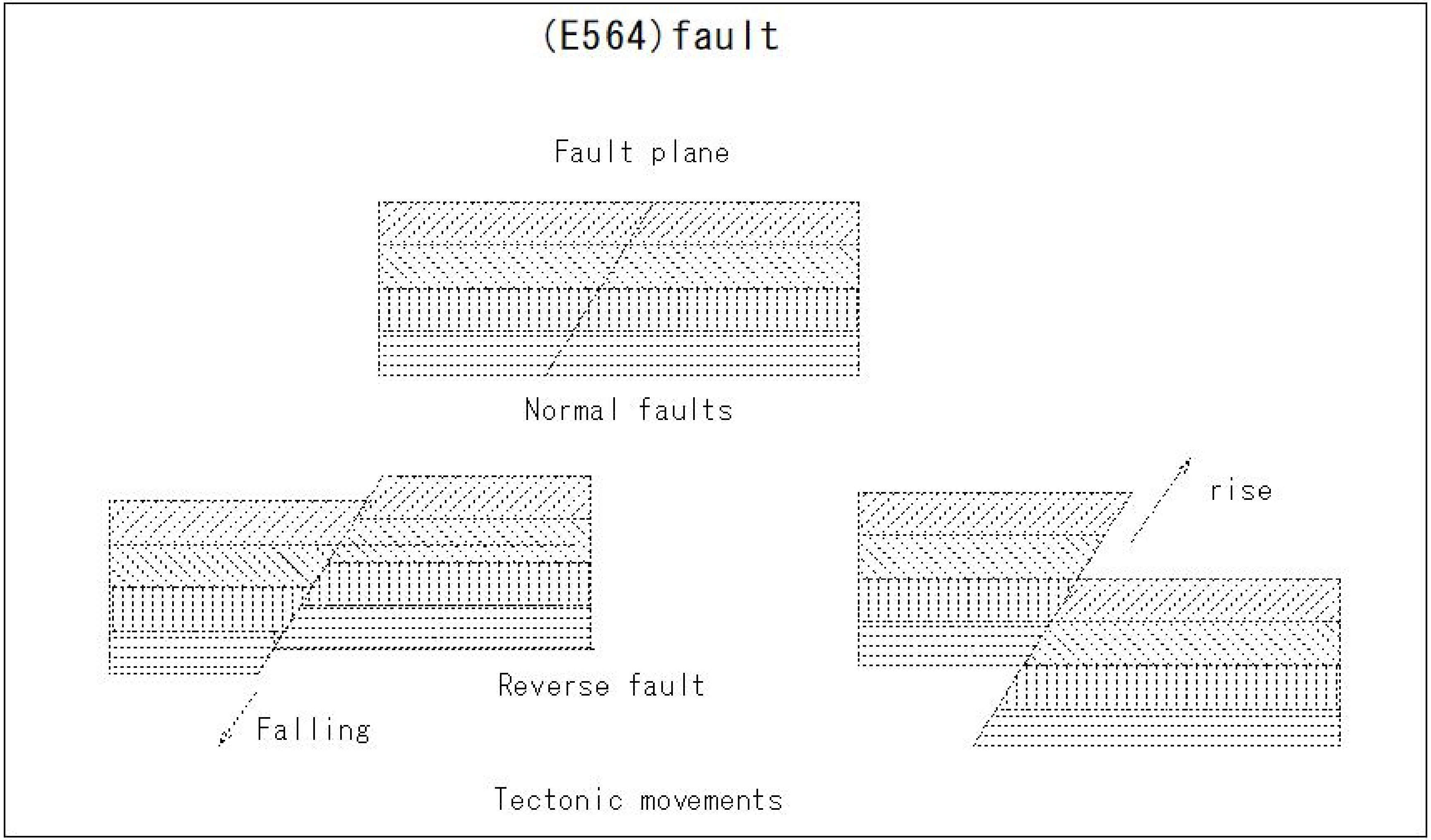


(E563)rammer

(E563)rammer

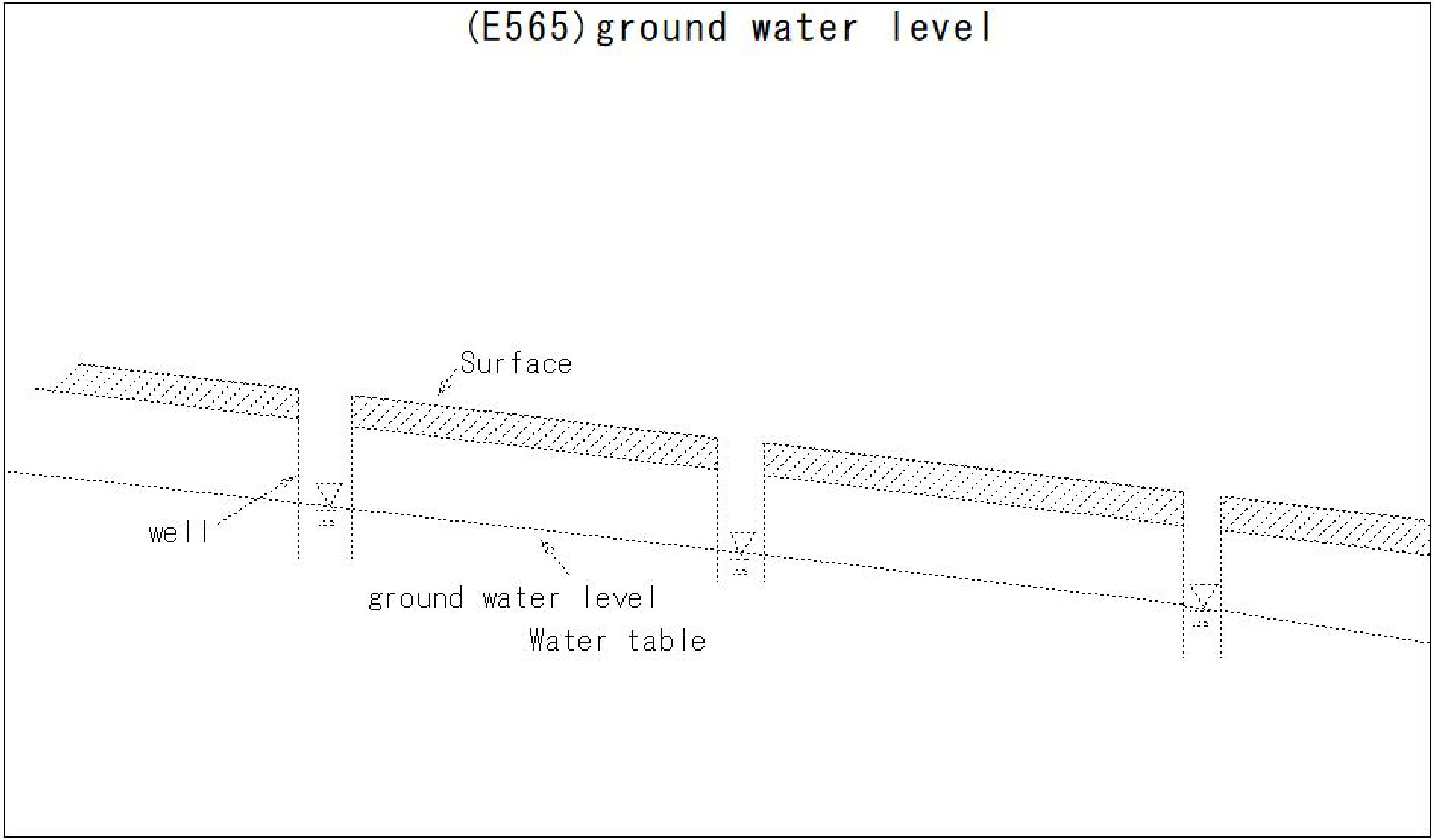


(E564)fault

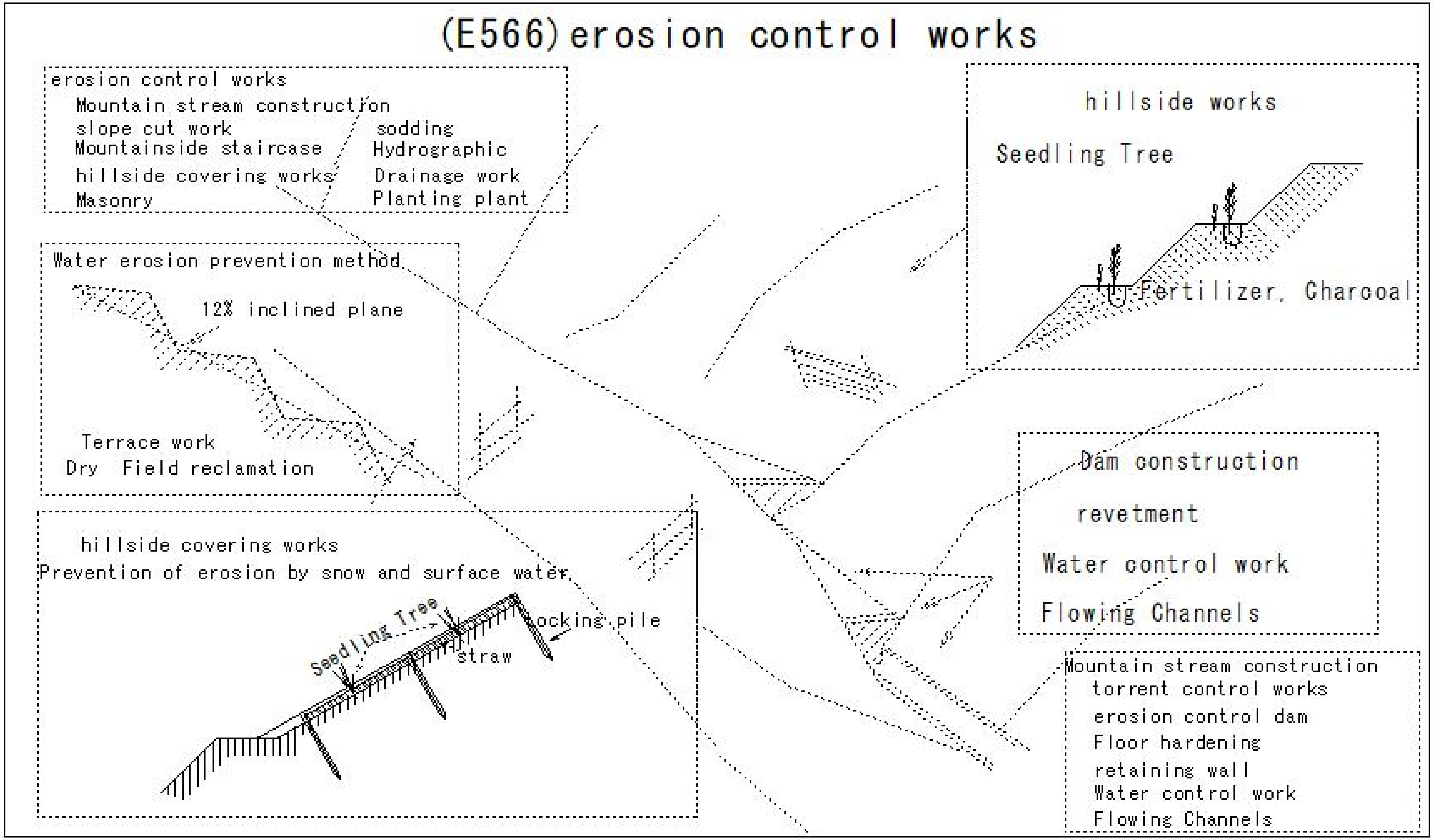


(E564)fault
Fault plane
Normal faults
rise
Reverse fault
Falling
Tectonic movements

(E565)ground water level



(E566)erosion control works

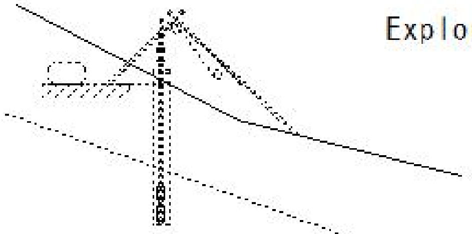


(E567)geologic survey

(E567)geologic survey

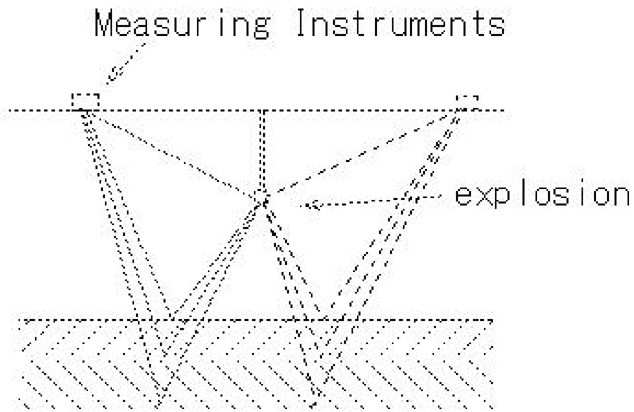
・Geological survey

Types of rocks
Distribution state
Geological structure



Boring

Exploration of the earth's surface



Geophysical Exploration Method

(E568)Geological map

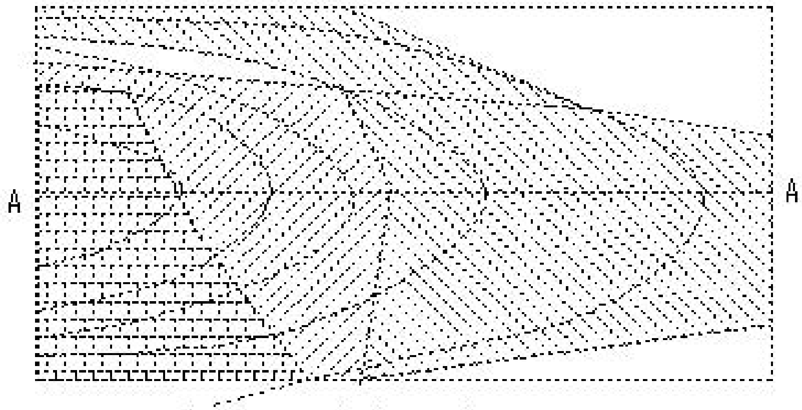
(E568)Geological map

Geological map

Defined symbols

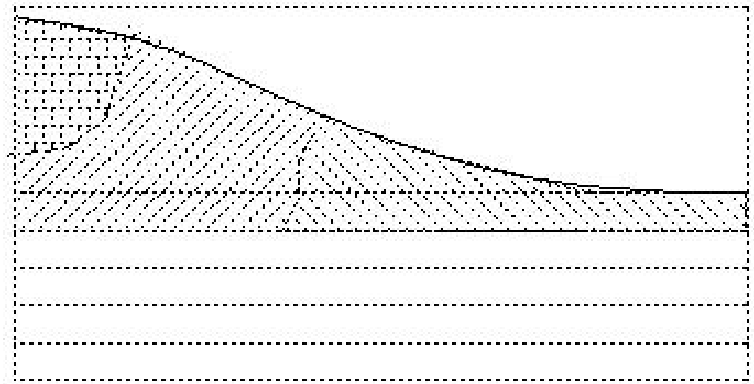
Geological distribution

Formation: Inclined Fault



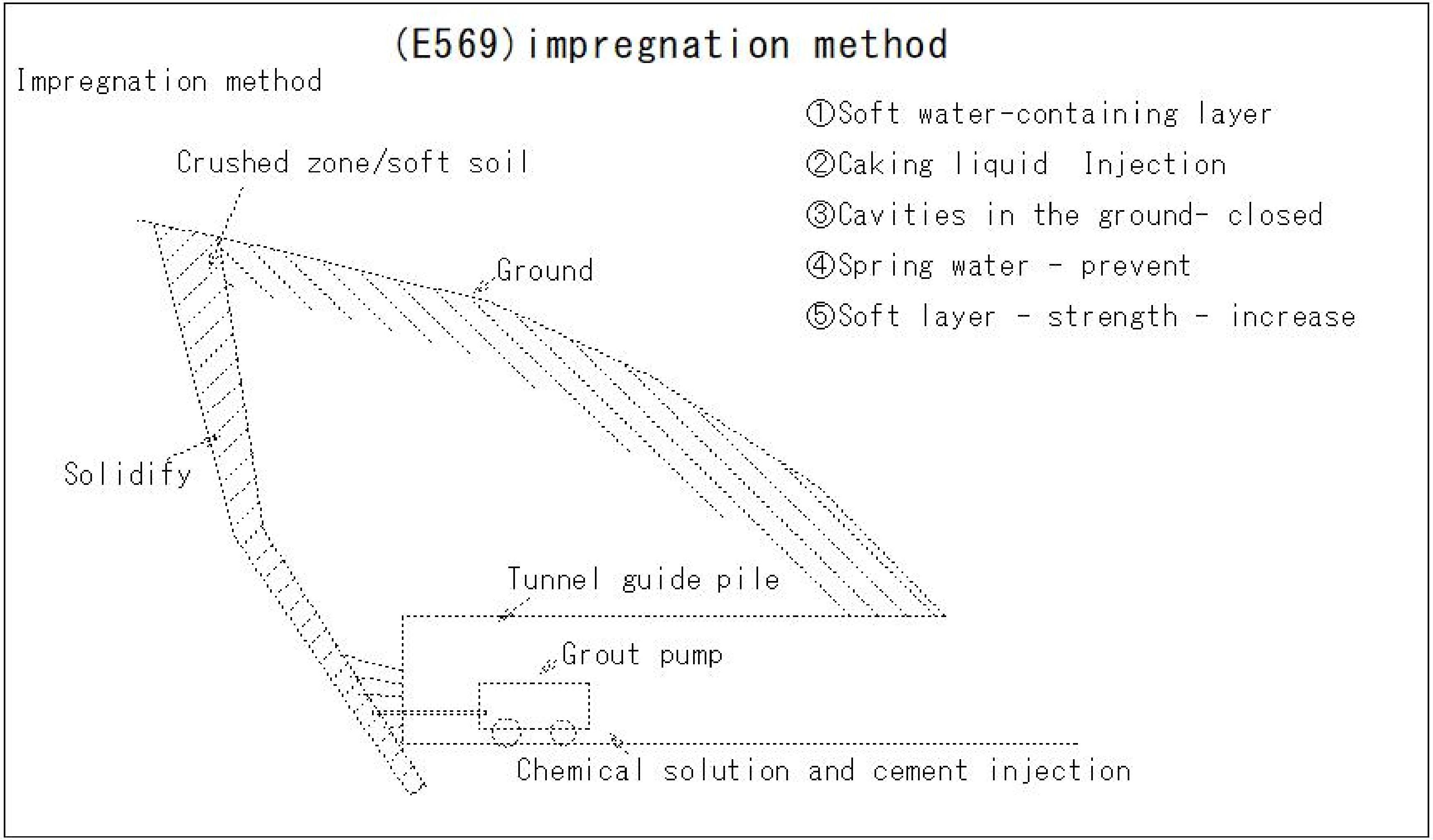
Geological distribution map

A-A section

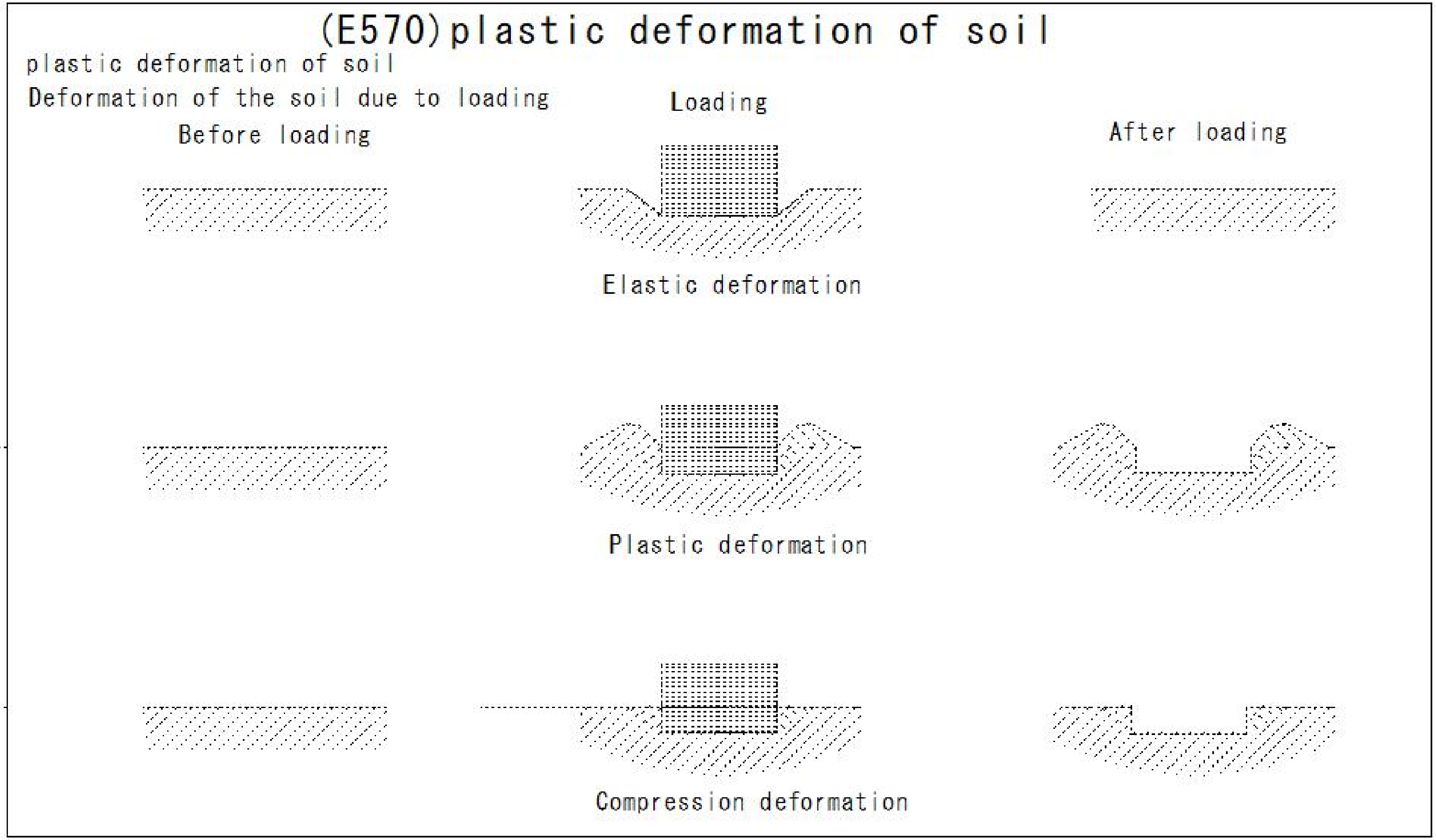


Geological cross-sectional view

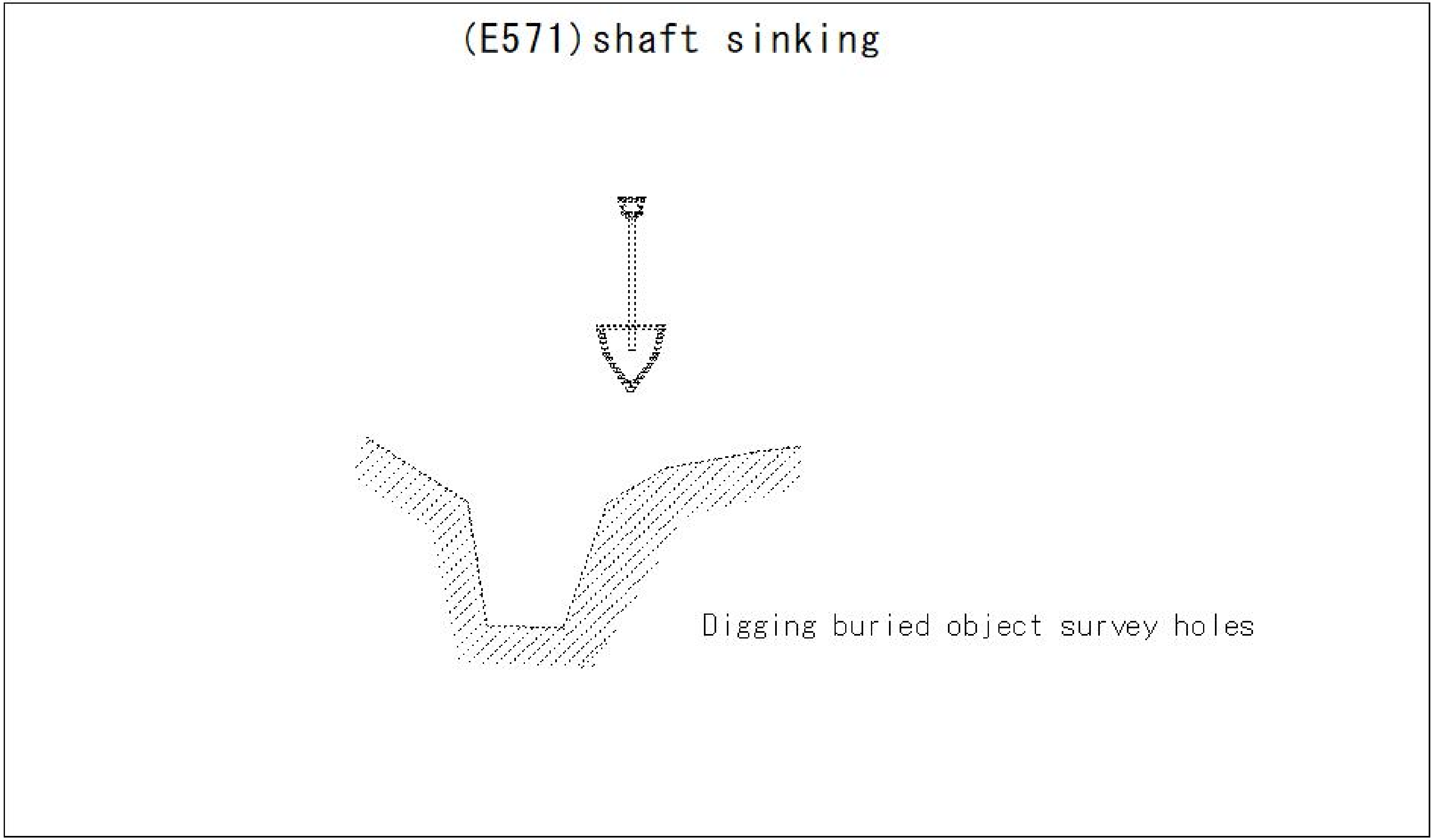
(E569)impregnation method



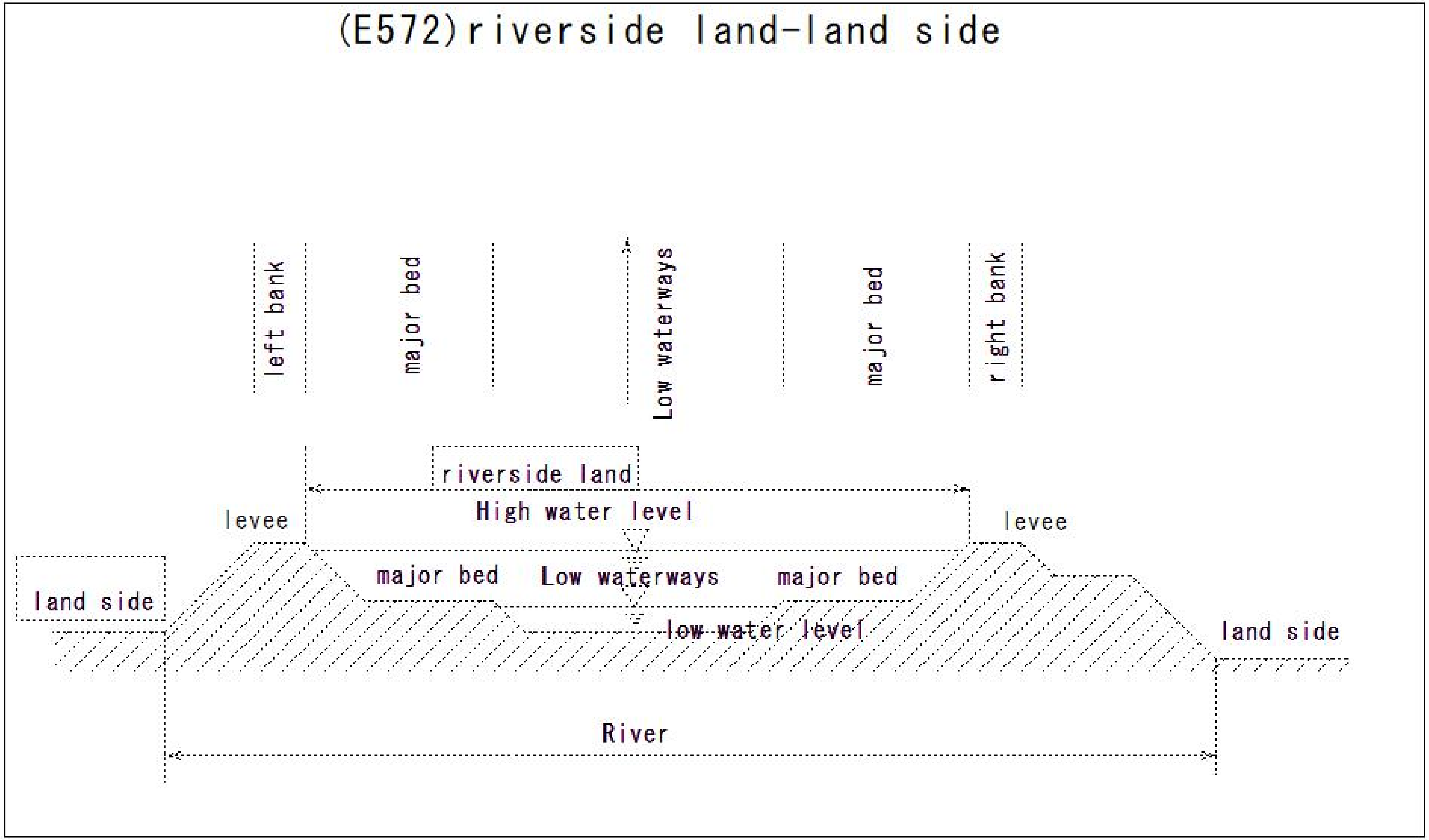
(E570)plastic deformation of soil



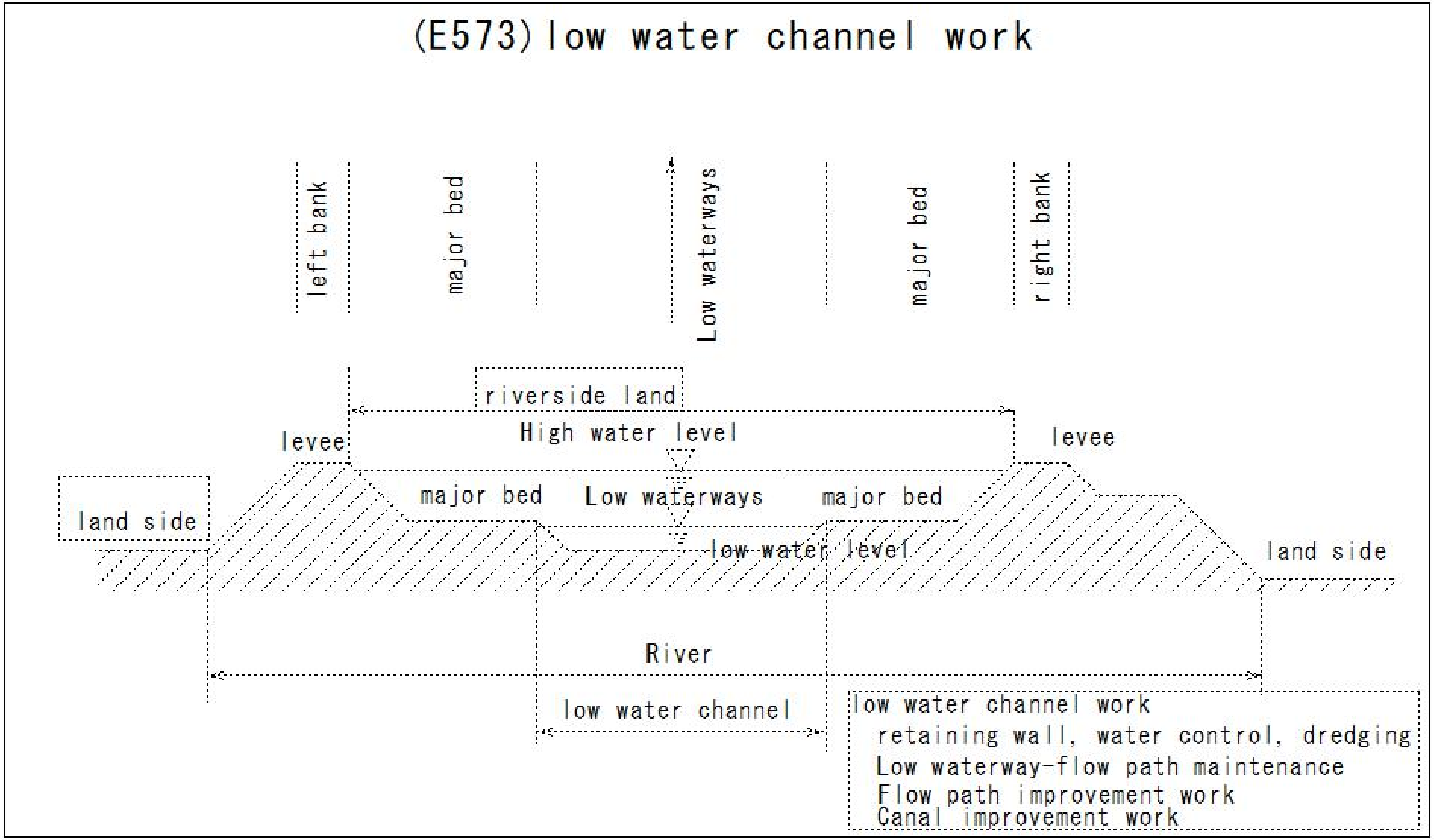
(E571)shaft sinking



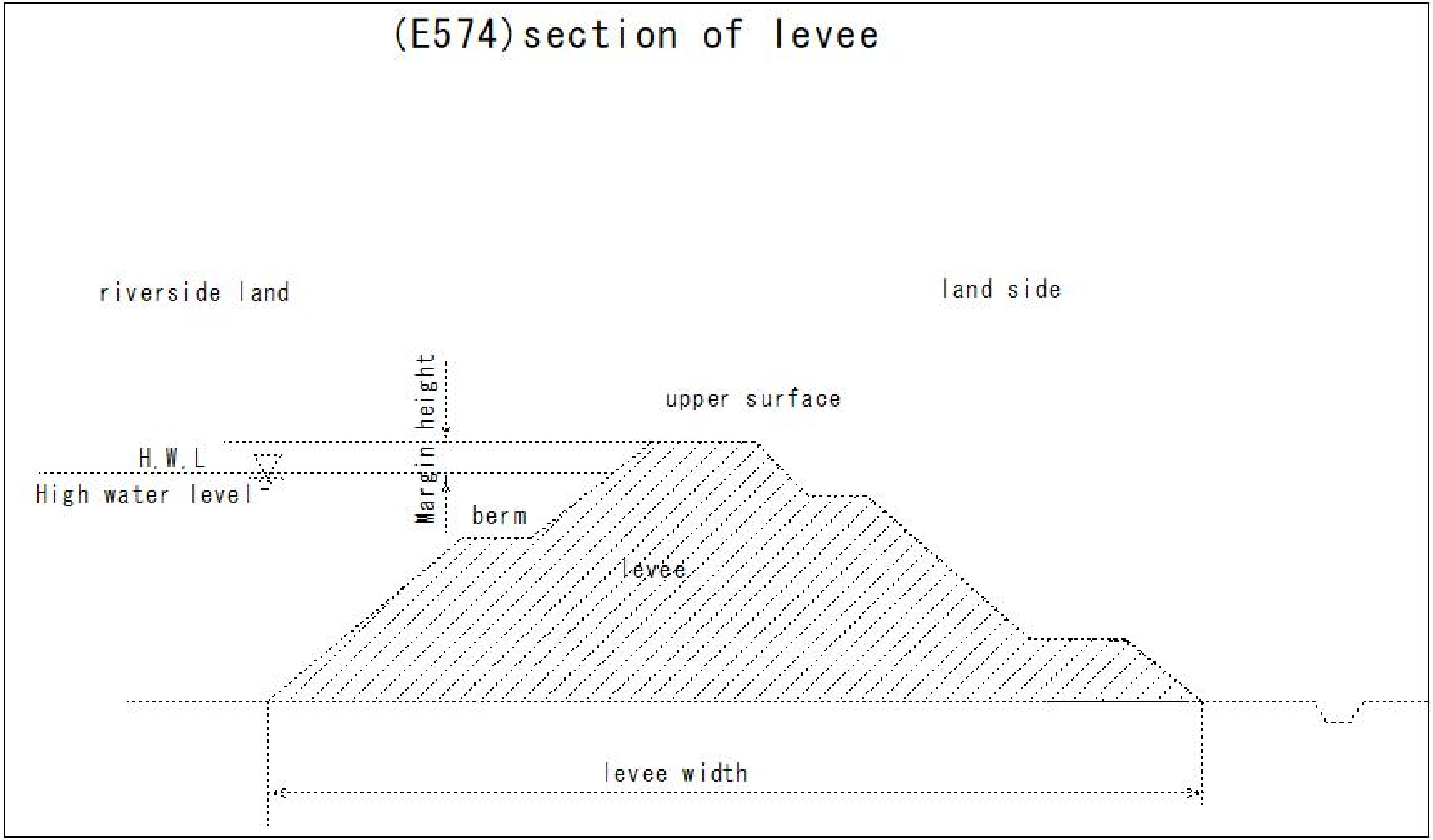
(E572)riverside land-land side



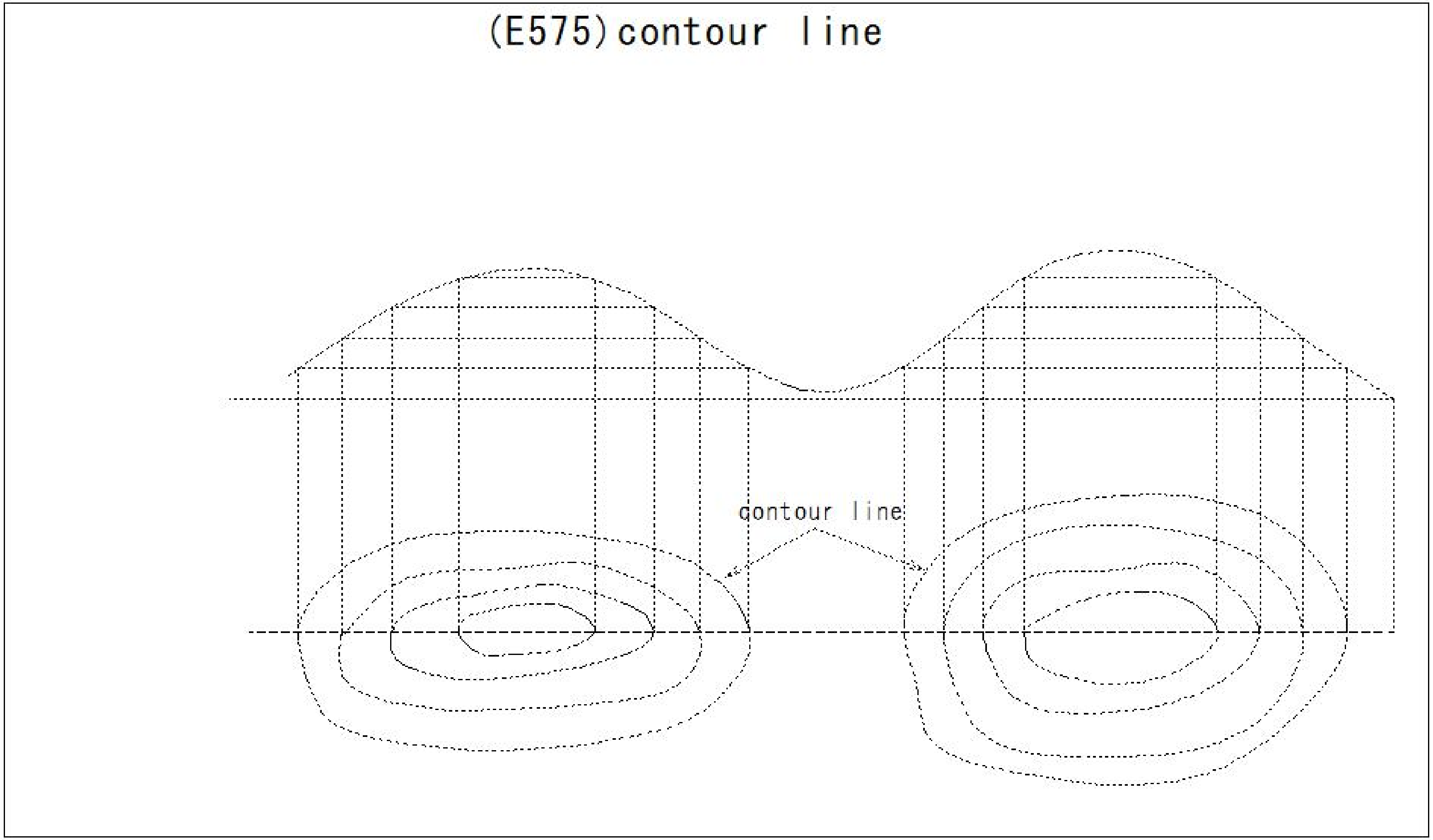
(E573)low water channel work



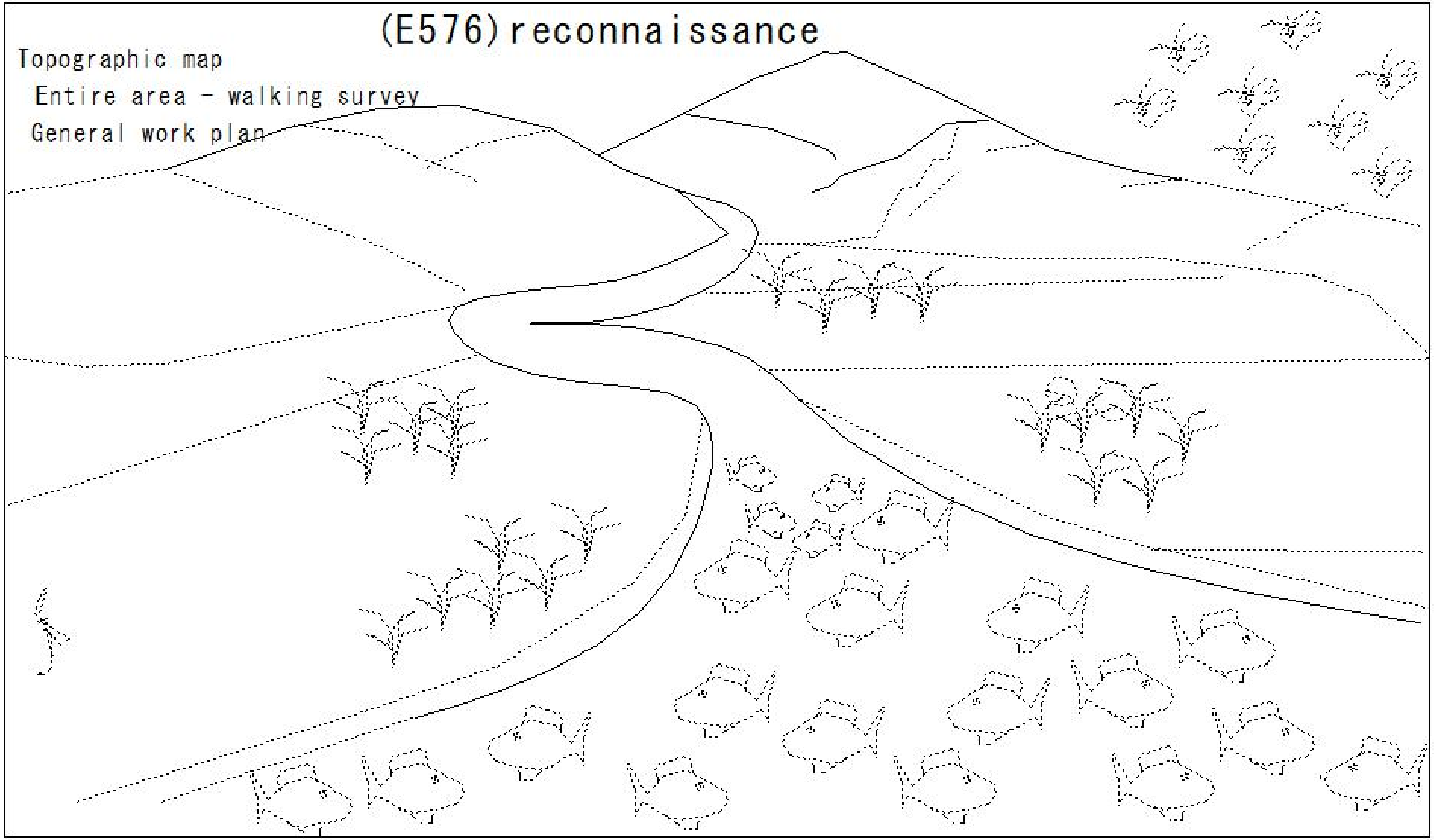
(E574)section of levee



(E575)contour line



(E576)reconnaissance

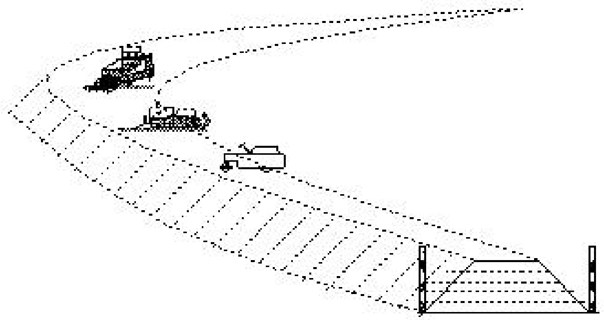


(E577)earthwork

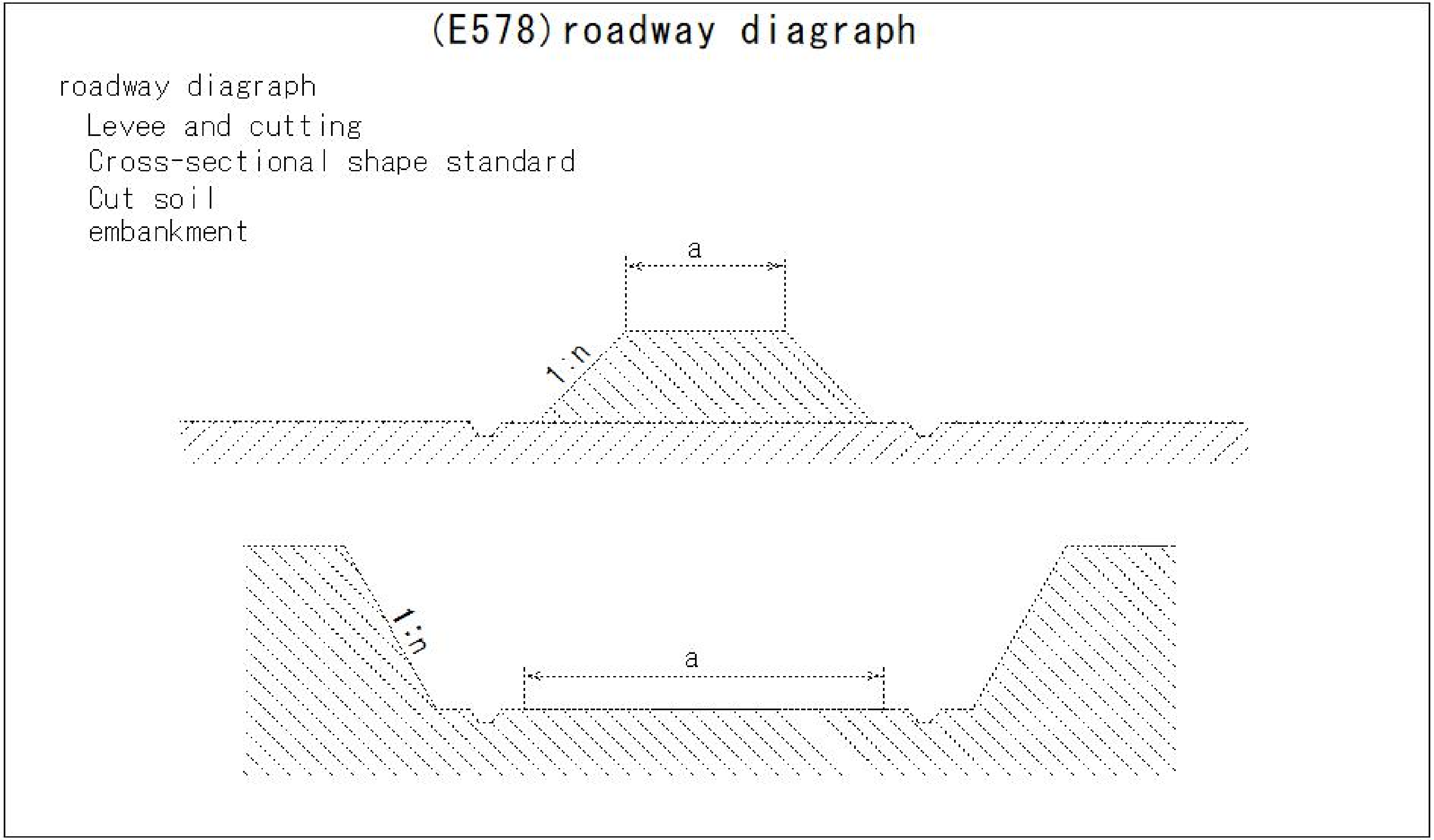
(E577)earthwork

Cutting and embankment of soil

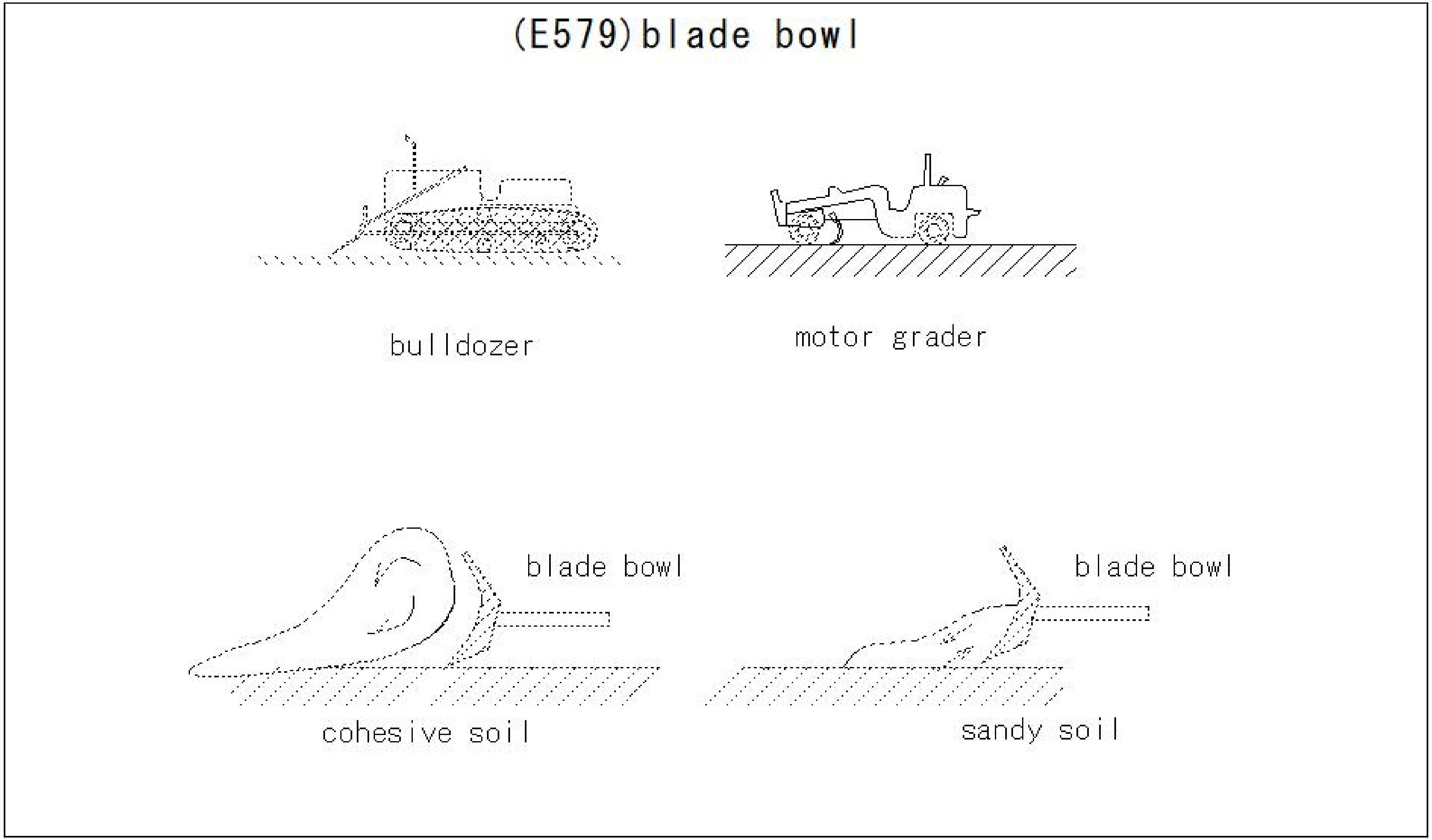
- Cut soil
- transport
- embankment
- Compaction
- Finish
- Mechanical earthwork



(E578)roadway diagraph



(E579)blade bowl



(E580)sediment settling

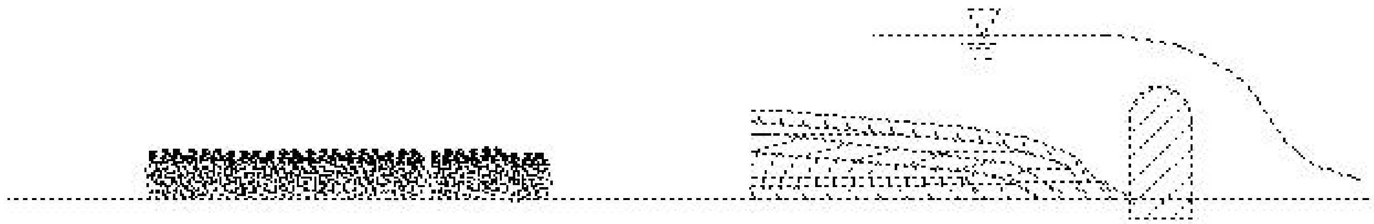
(E580)sediment settling

sediment settling

Water flow

Stationary soil pressure

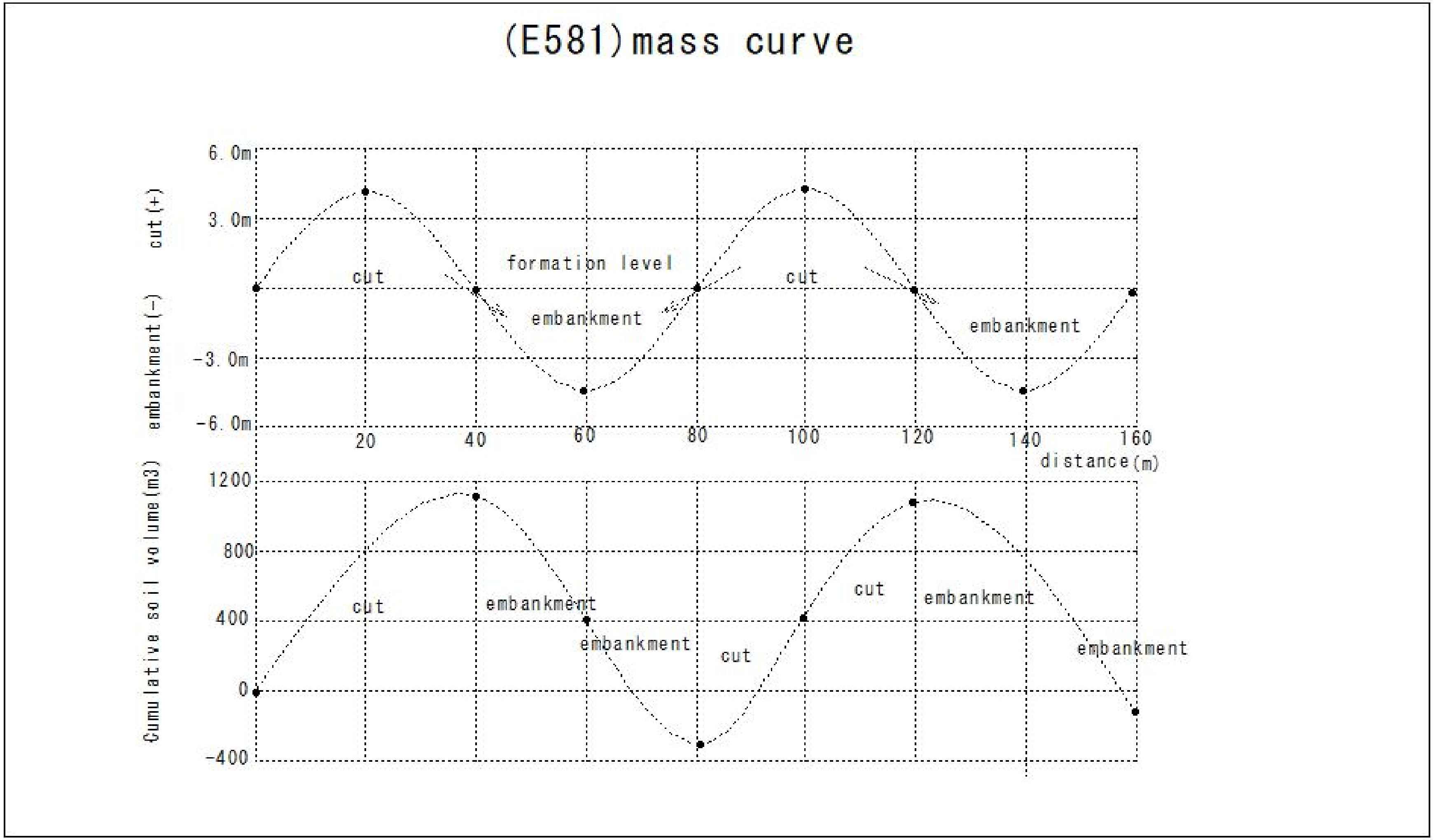
Sediment in water - precipitation



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

The tip is attached to the dam
Deposition

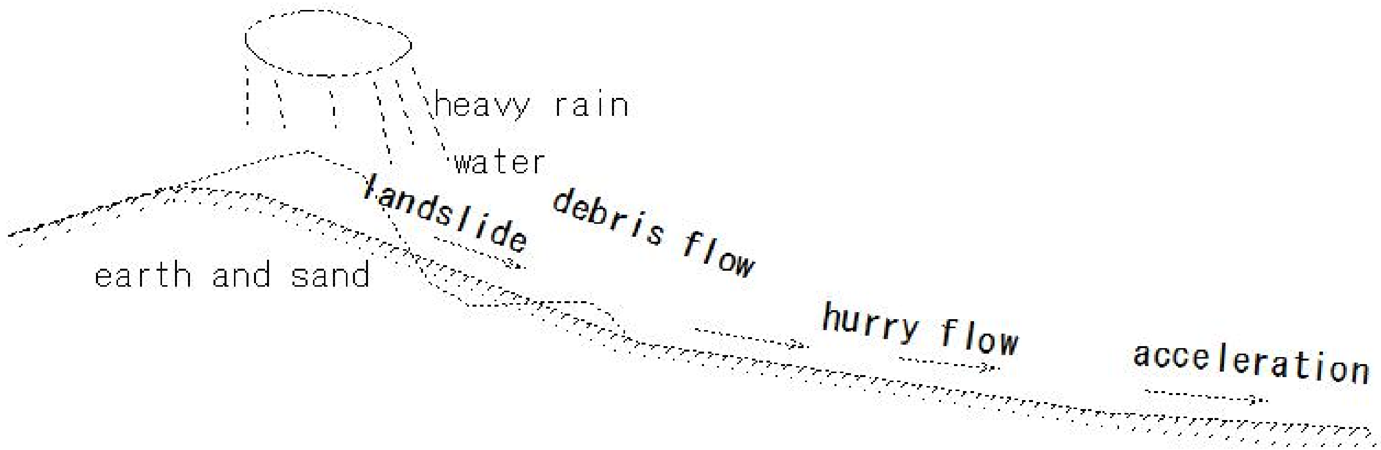
(E581)mass curve



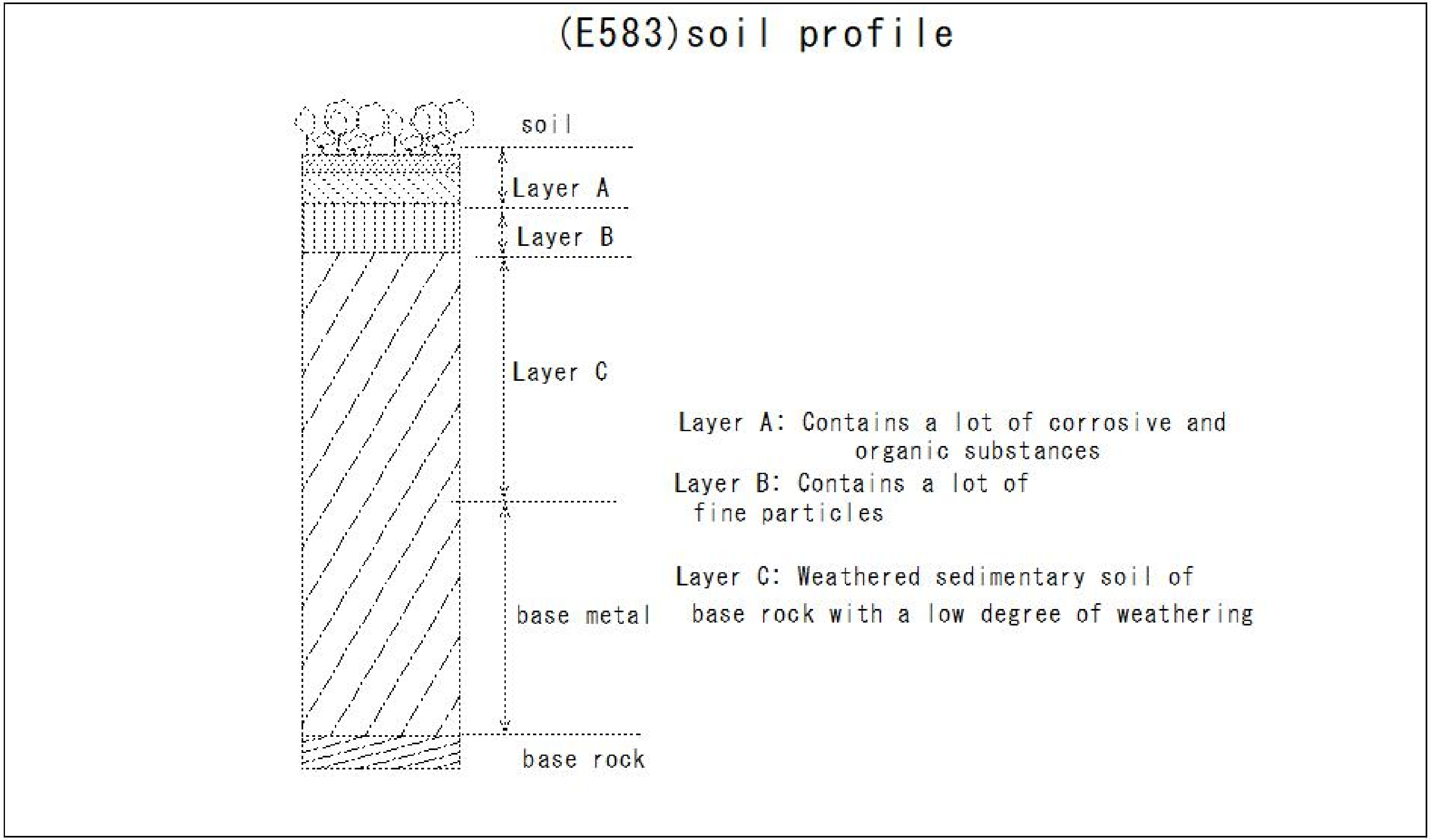
(E582)debris flow

(E582)debris flow

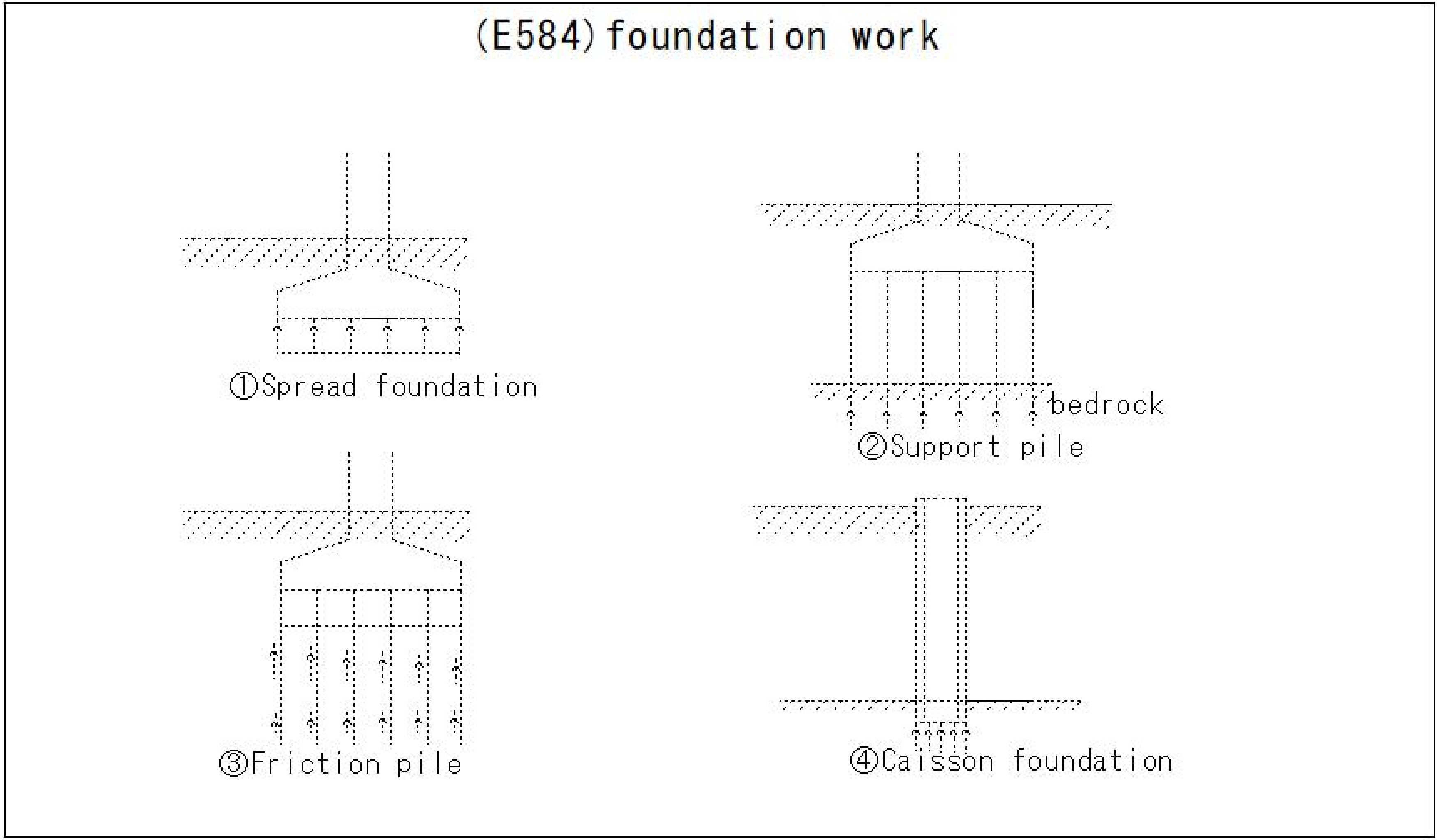
debris flow



(E583)soil profile



(E584)foundation work



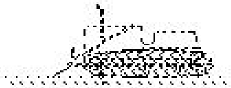
(E585)Trafficability

(E585)Trafficability

Trafficability

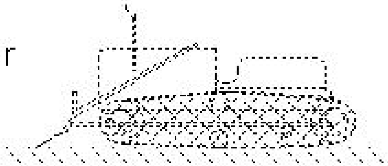
Degree of runnability of the machine	Cone Index (kN/m2)
1 Wetland bulldozer	over 300
2 Scrape Dozer	600 or more
3 Bulldozer	500-700 or more
4 towed scraper	700-1000 or more
5 Motor Scraper	1000-1300 or more
6 Dump Truck	1200-1500 or more

1 Wetland bulldozer

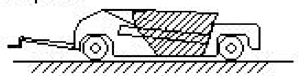


2 Scrape Dozer

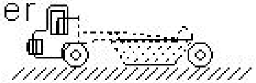
3 Bulldozer



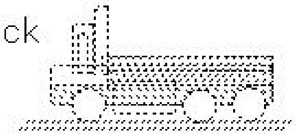
4 towed scraper



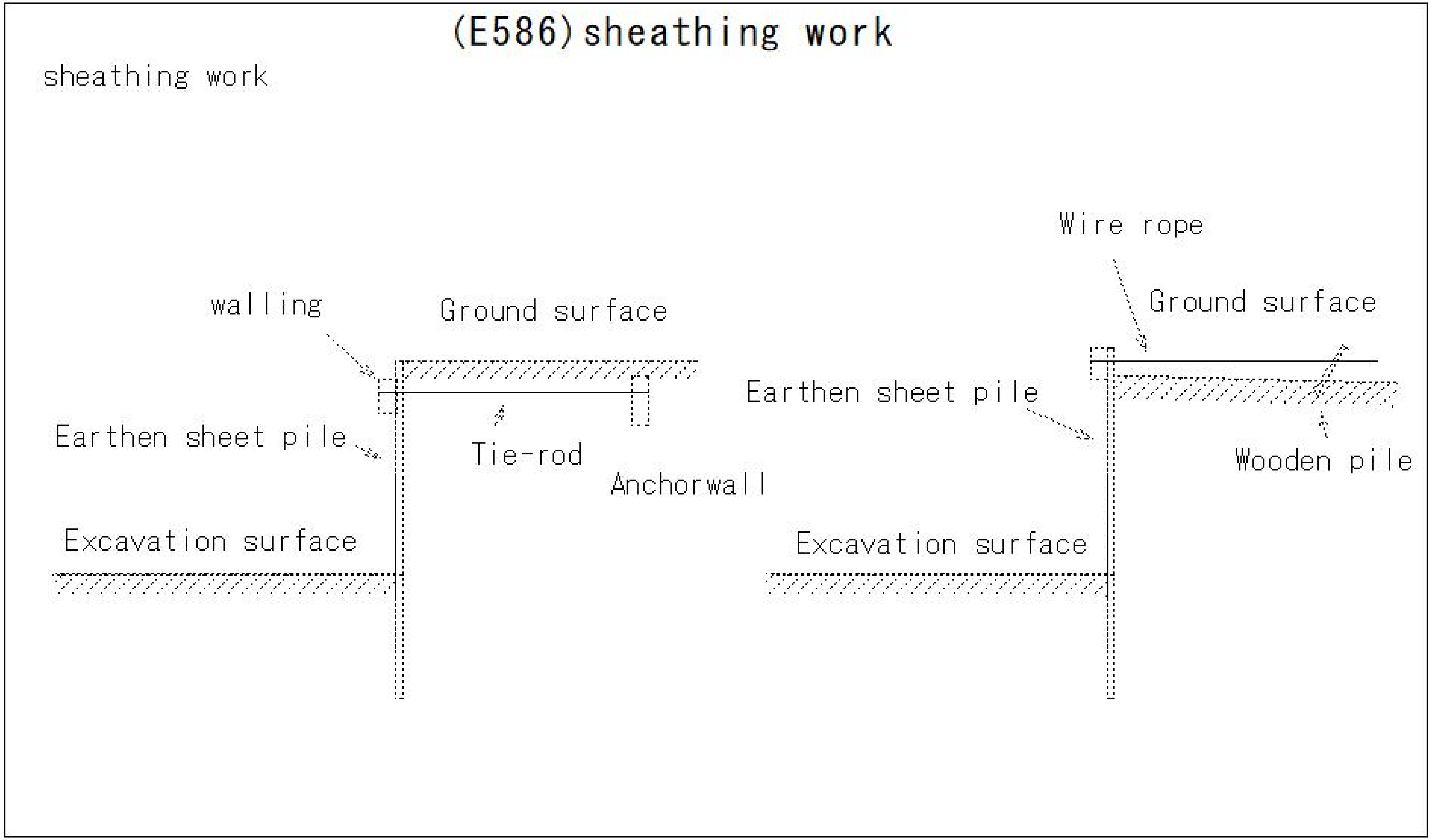
5 Motor Scraper



6 Dump Truck



(E586)sheathing work



(E587)trench cut method

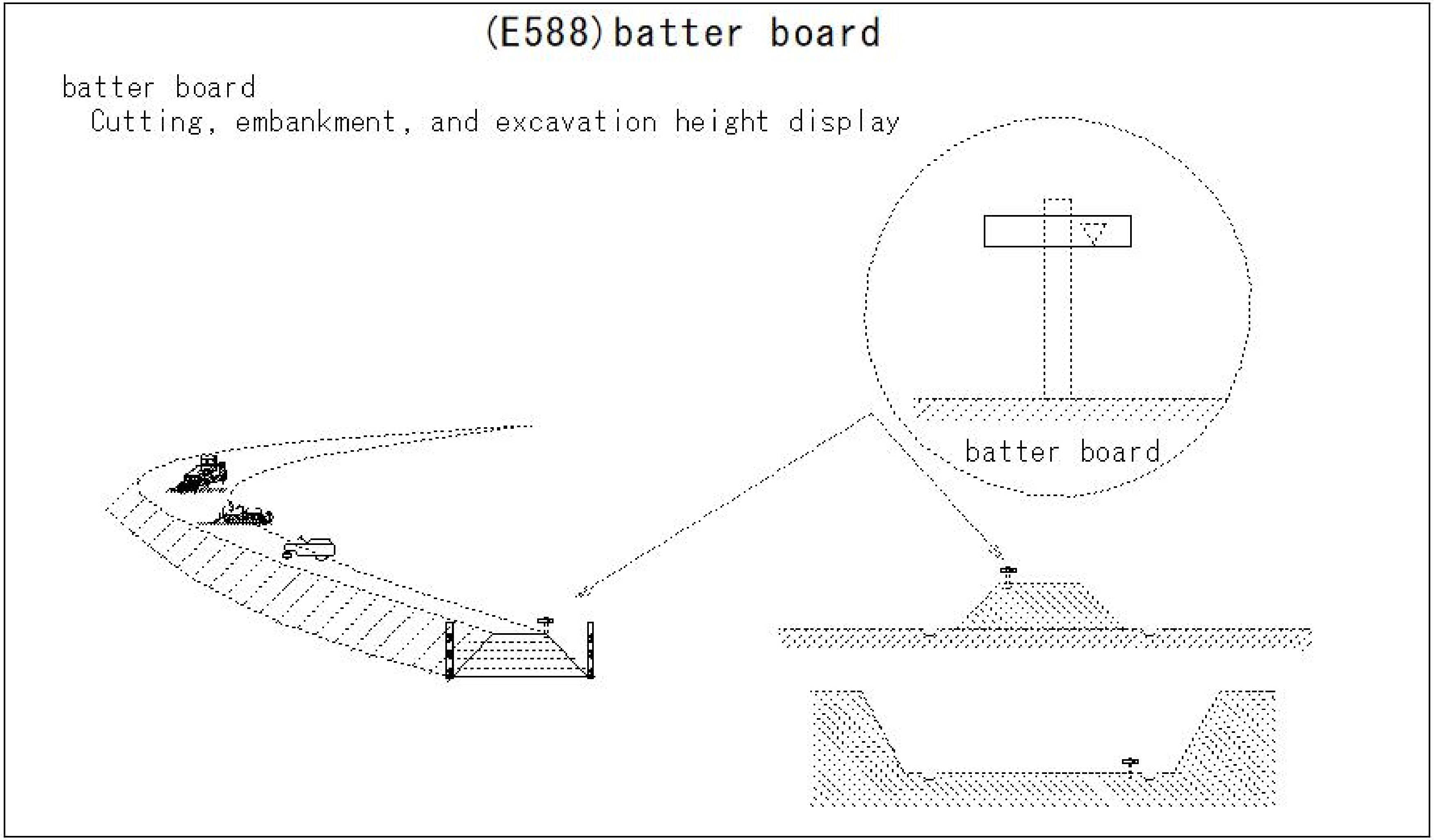
(E587)trench cut method

trench cut method
Construction of underground structures

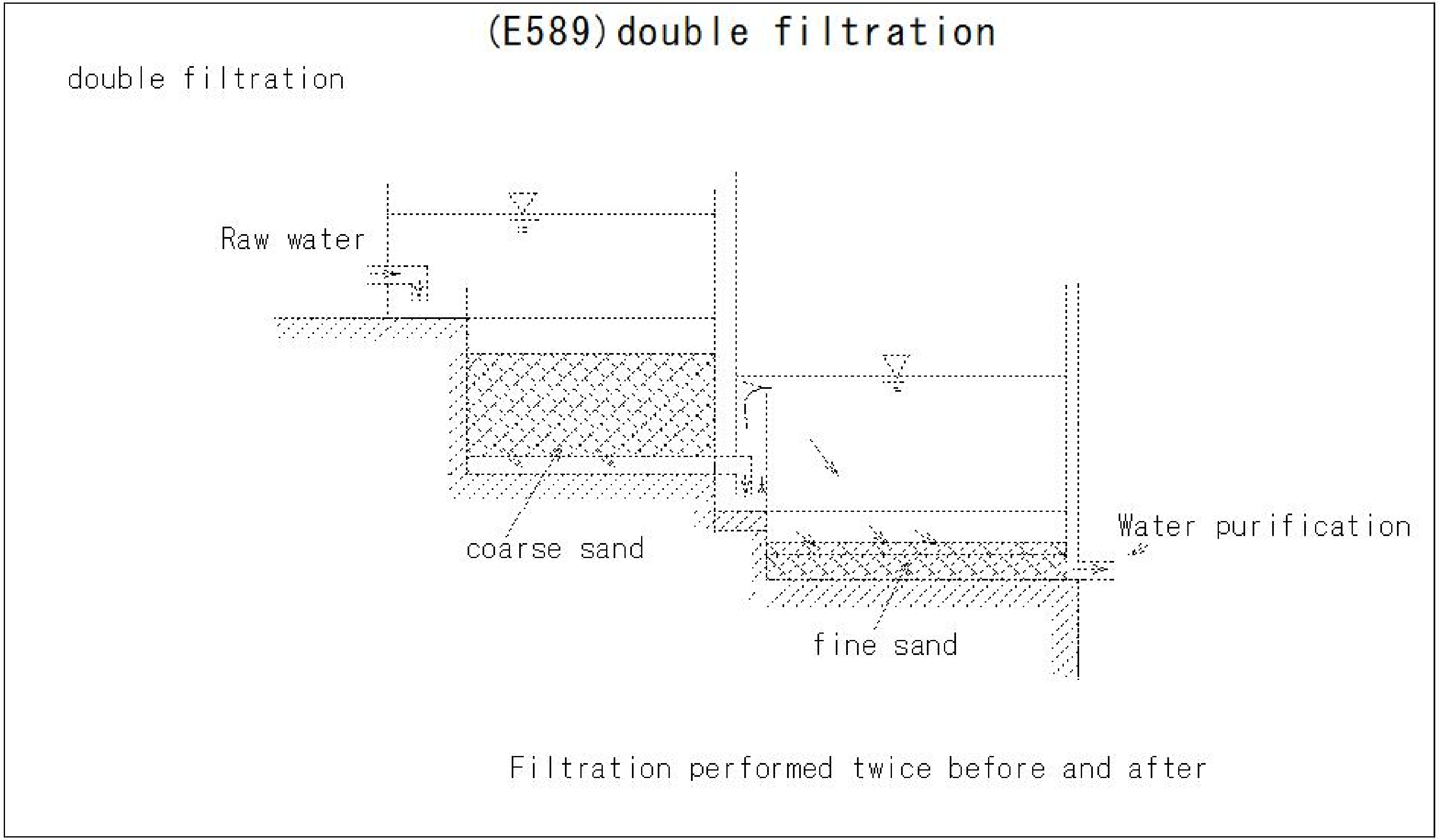
Excavation of the periphery

Construction of the periphery

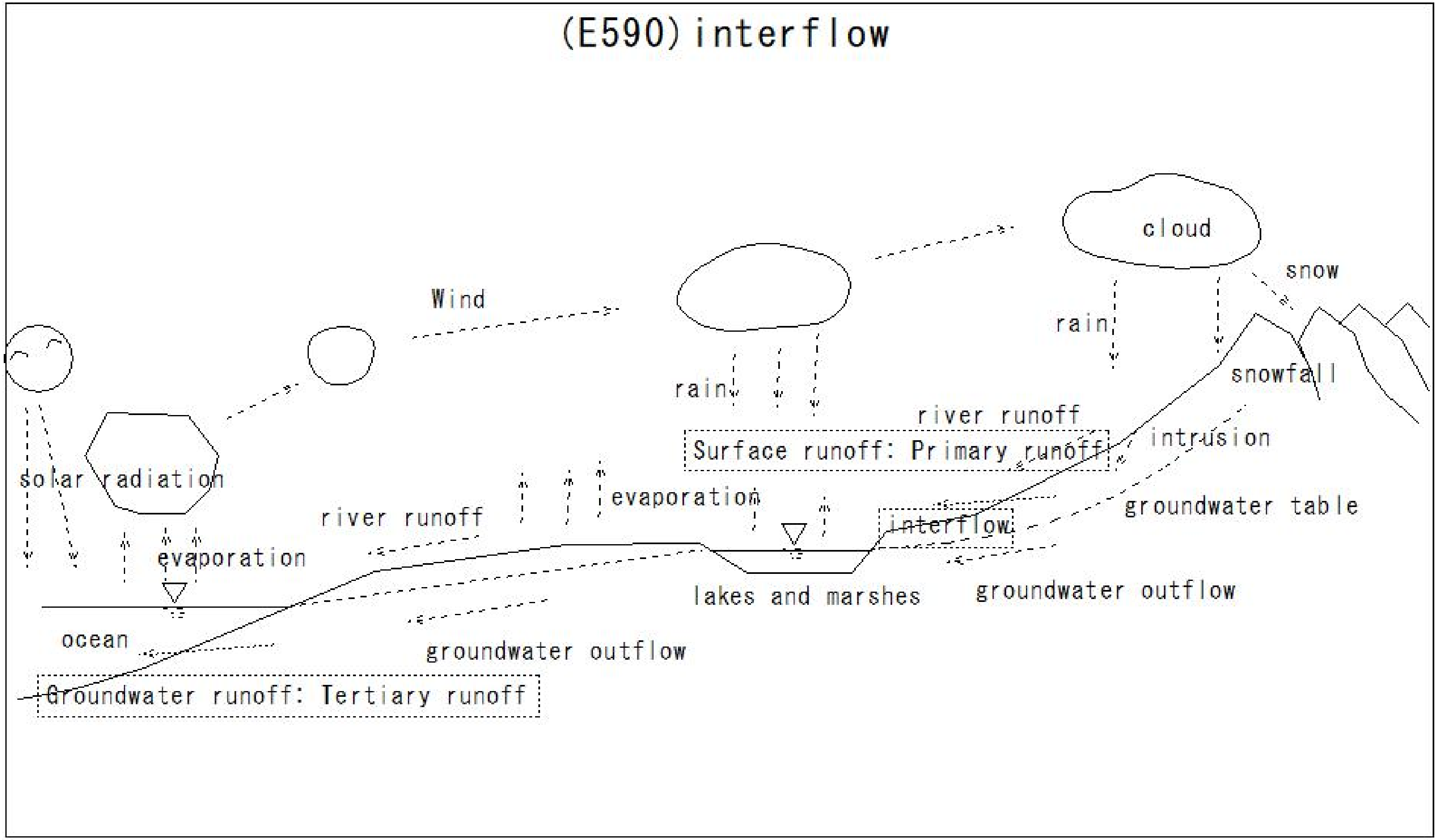
(E588)batter board



(E589)double filtration



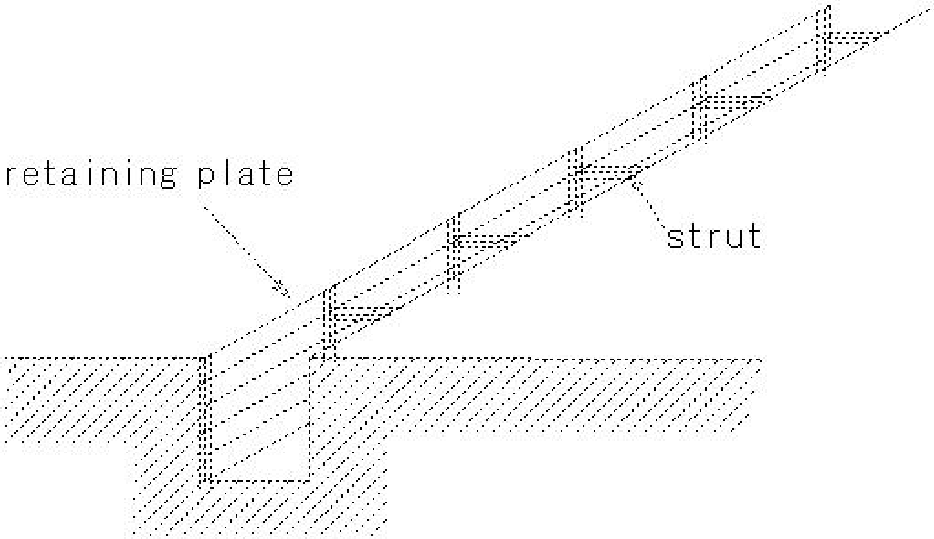
(E590)interflow



(E591)trench excavation

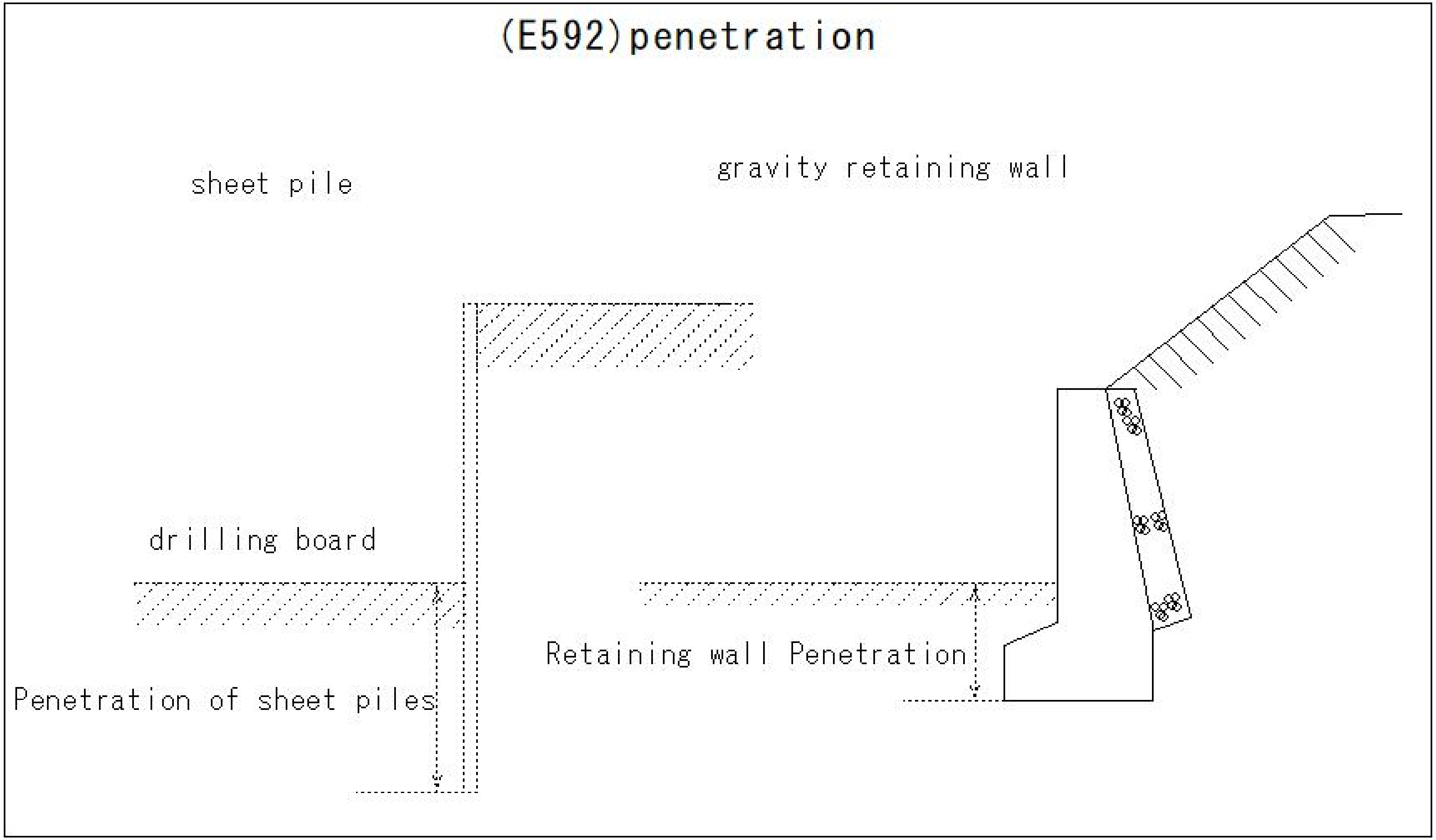
(E591)trench excavation

trench excavation

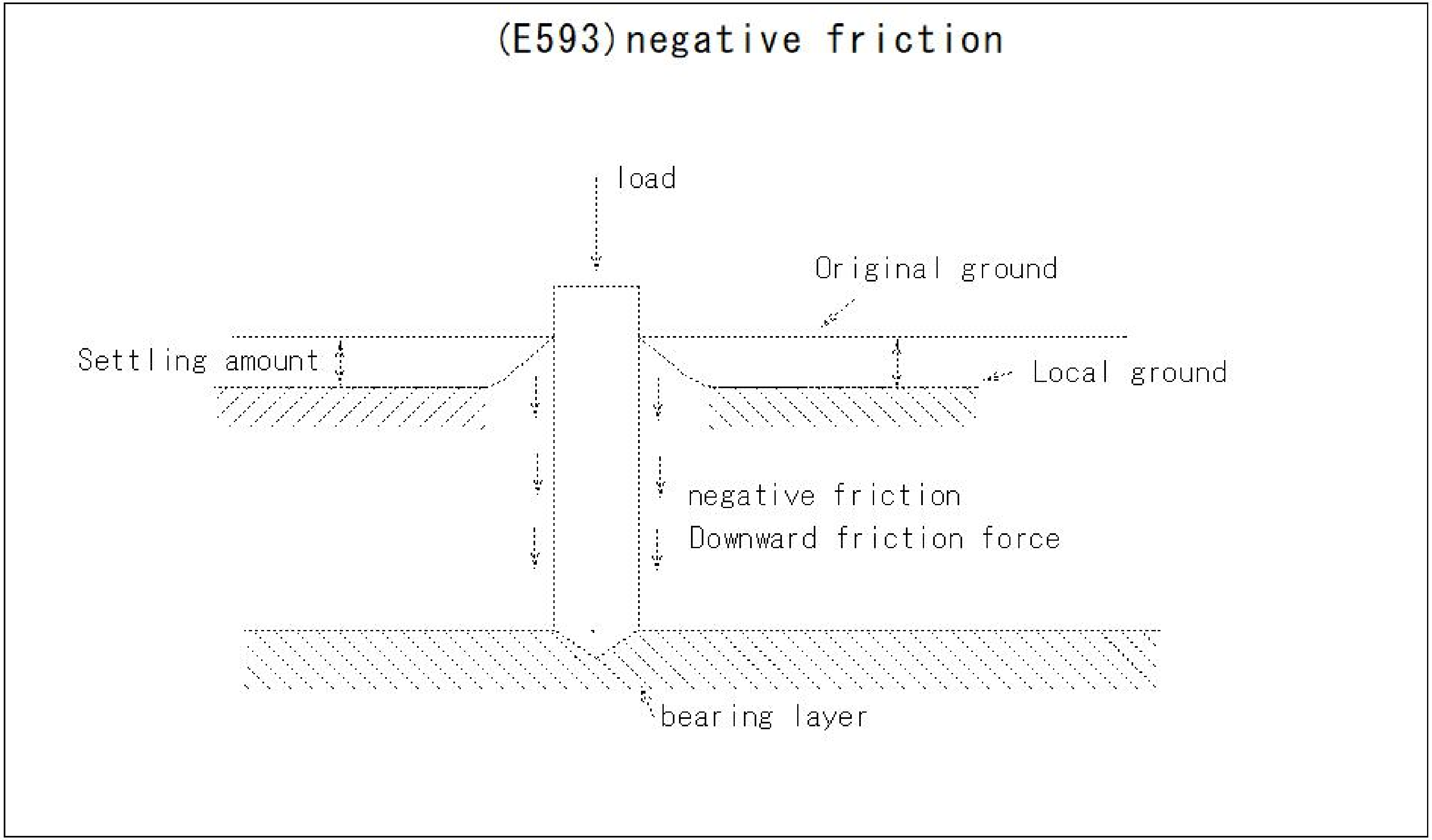


Excavation in the shape of an elongated groove

(E592)penetration

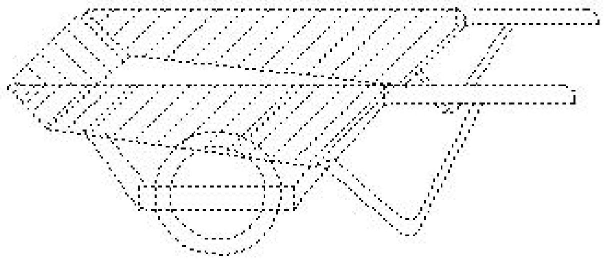


(E593)negative friction

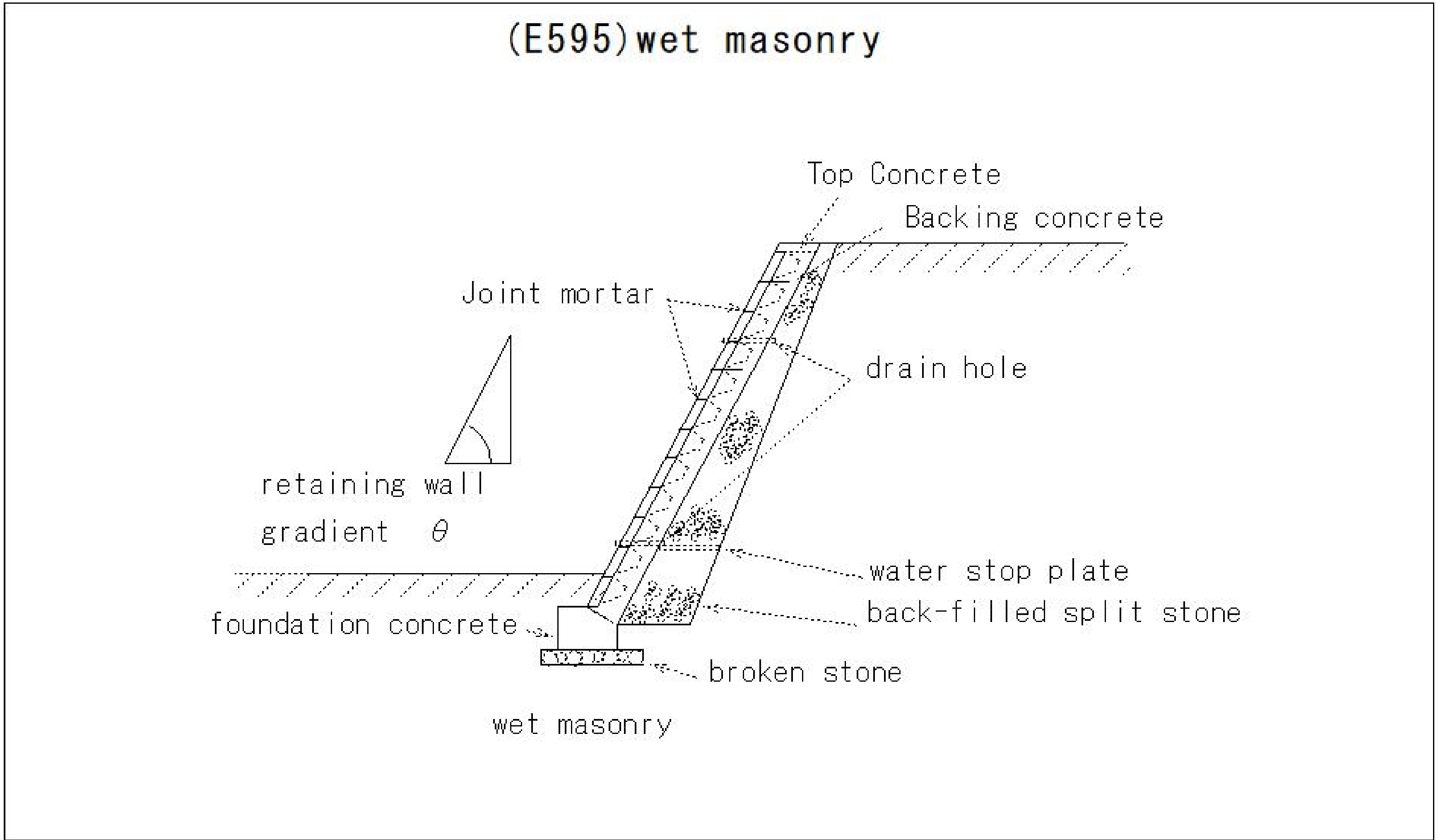


(E594)wheel barrow

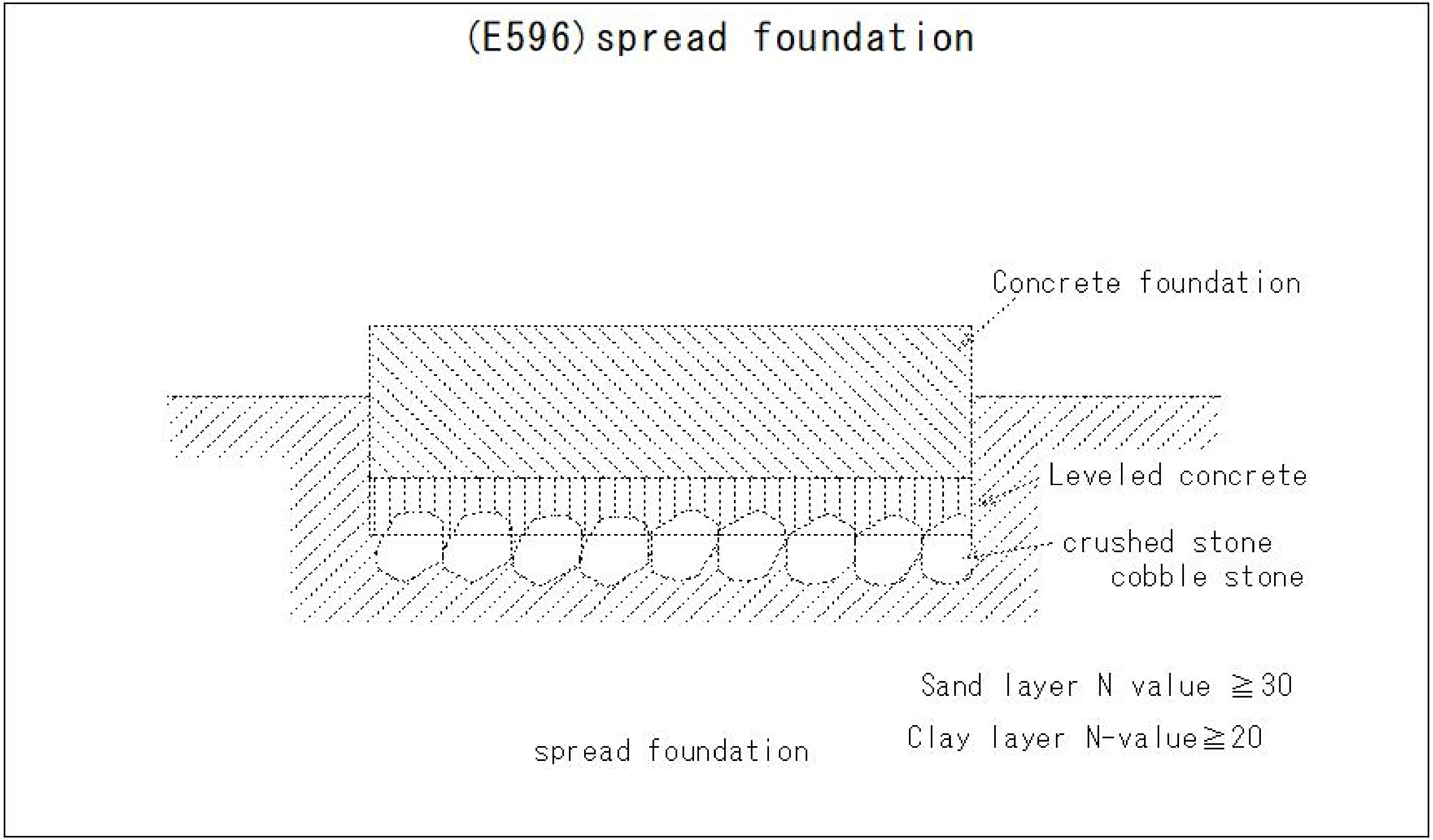
(E594)wheel barrow



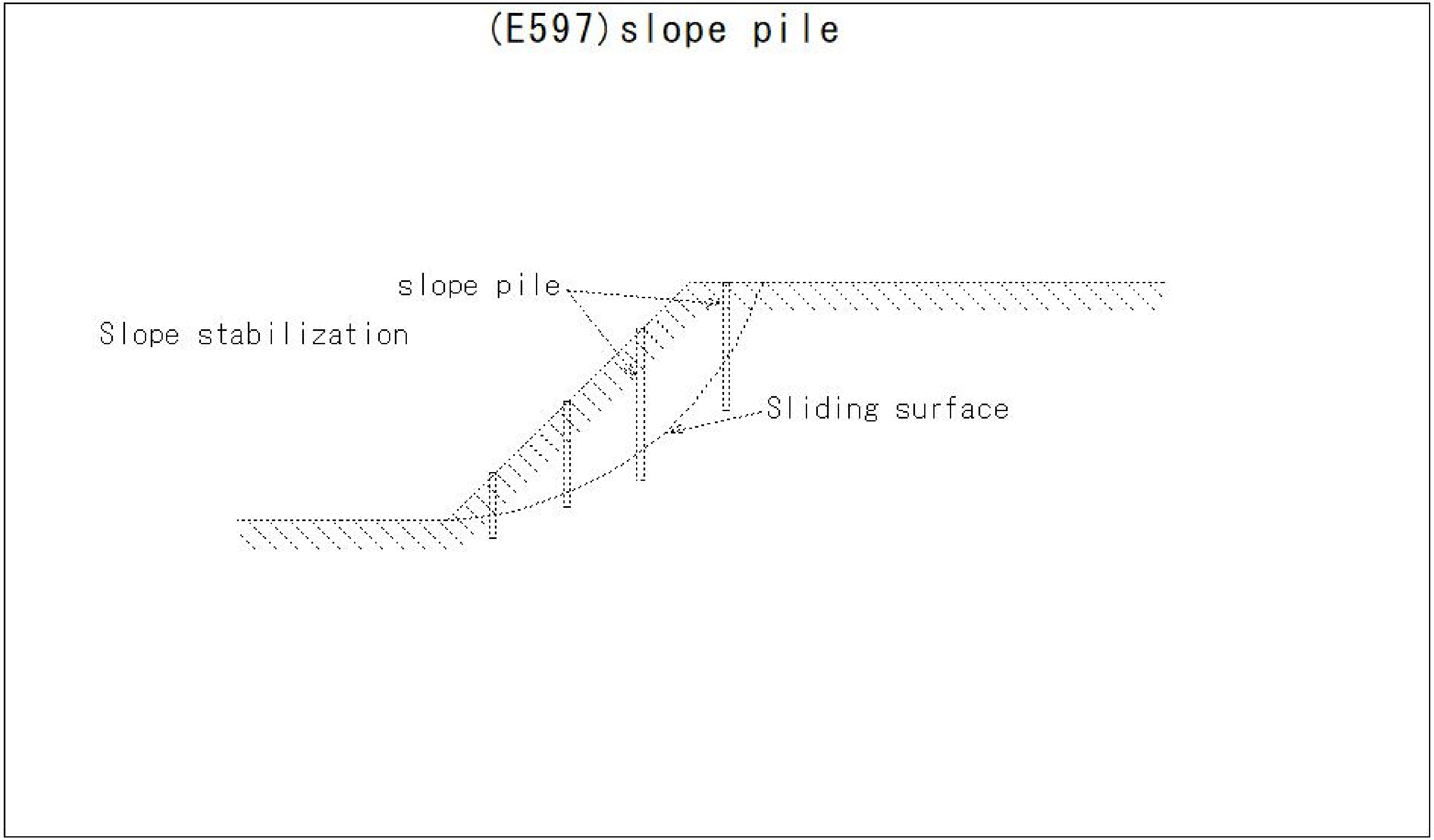
(E595)wet masonry



(E596)spread foundation



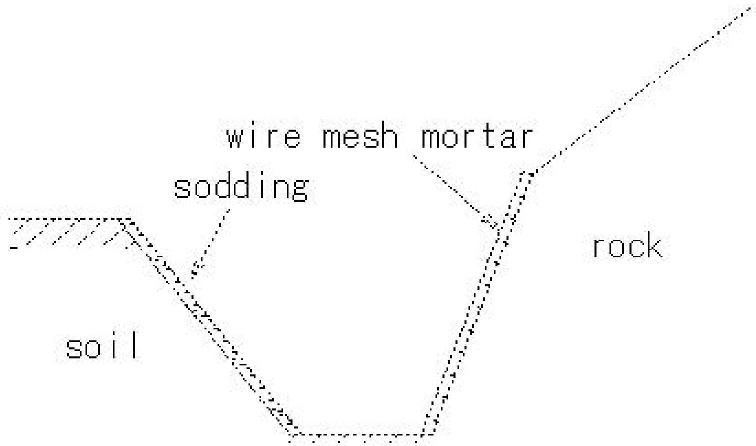
(E597)slope pile



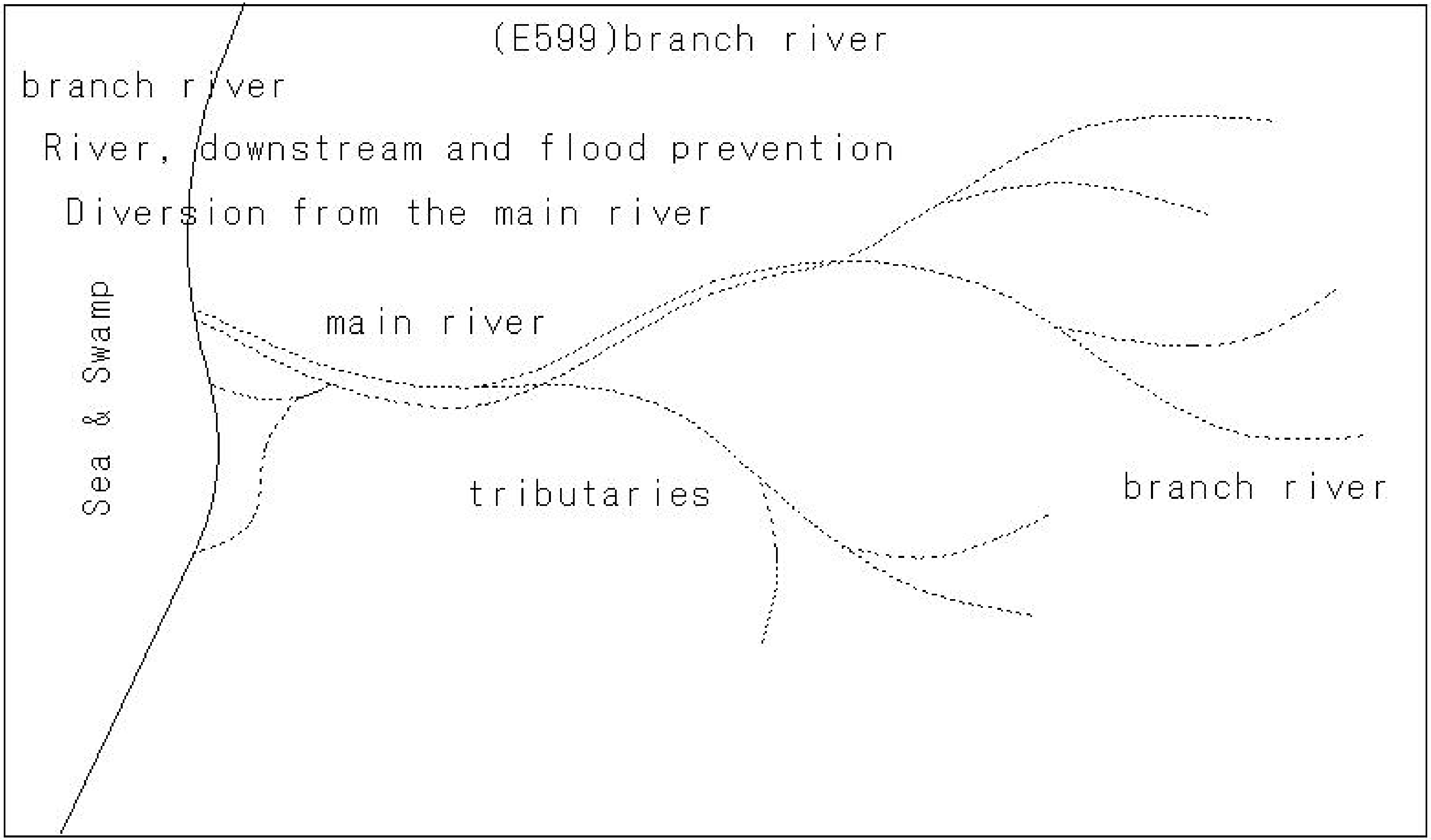
(E598)slope protection

(E598)slope protection

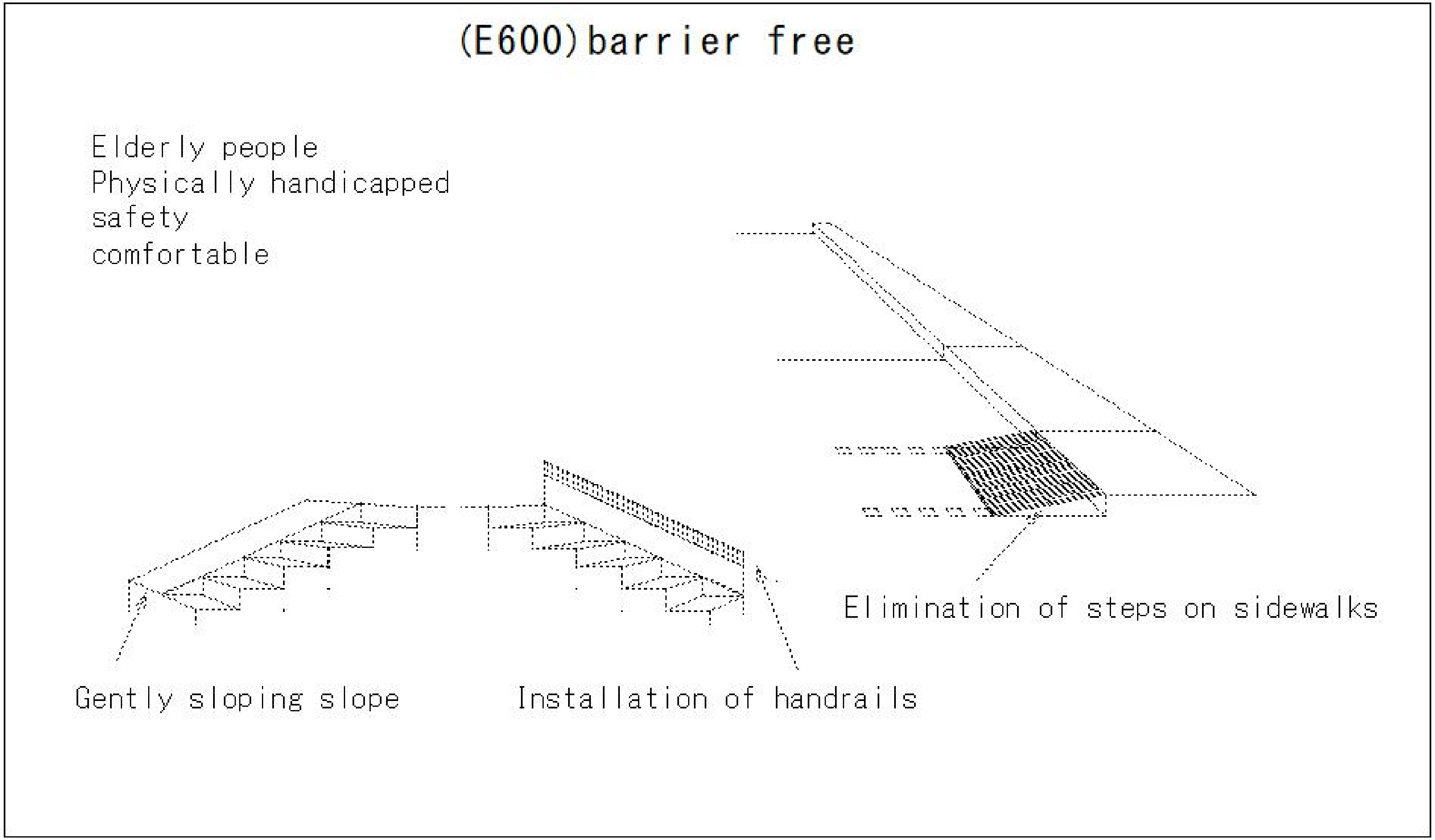
slope protection



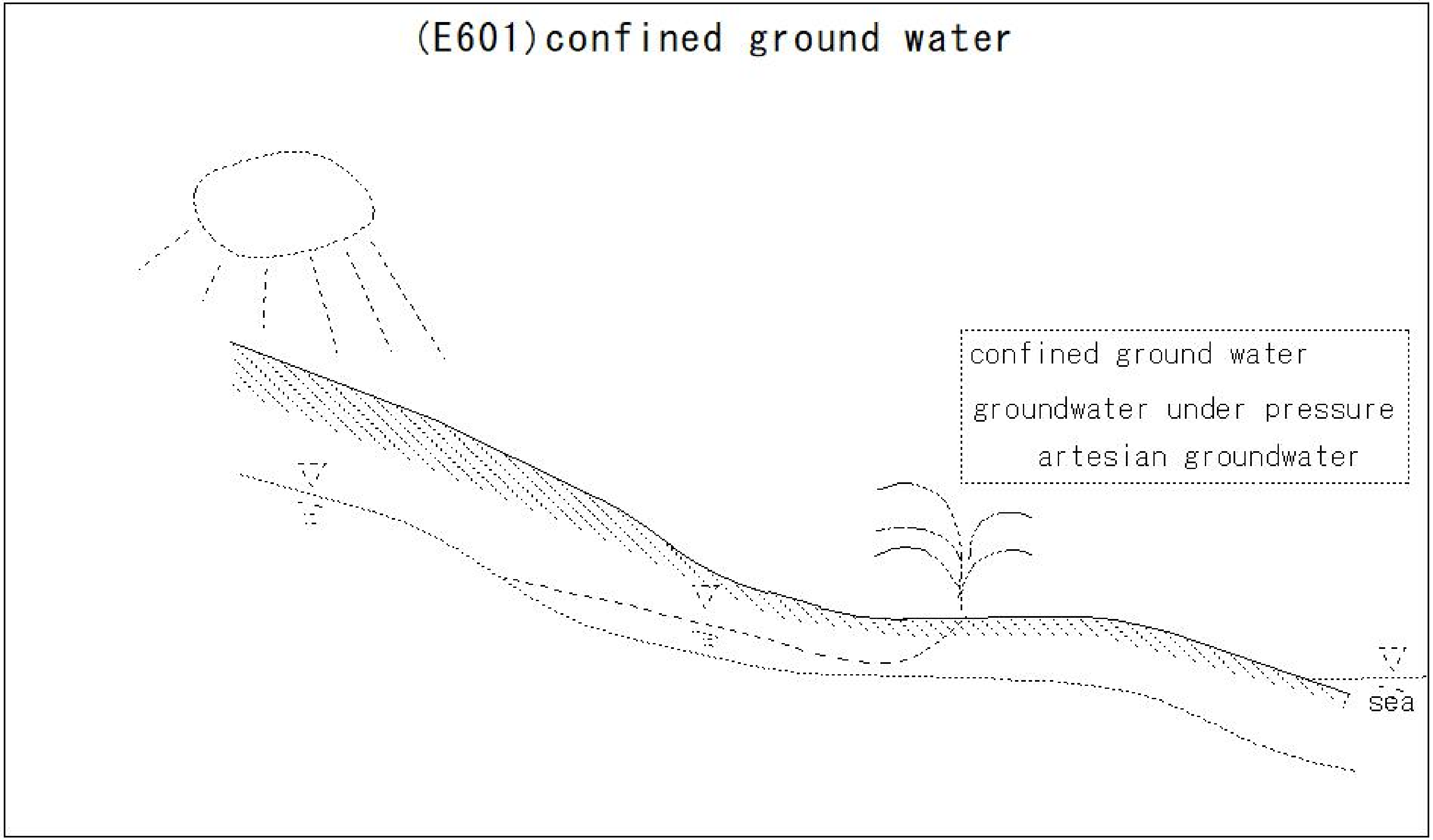
(E599)branch river



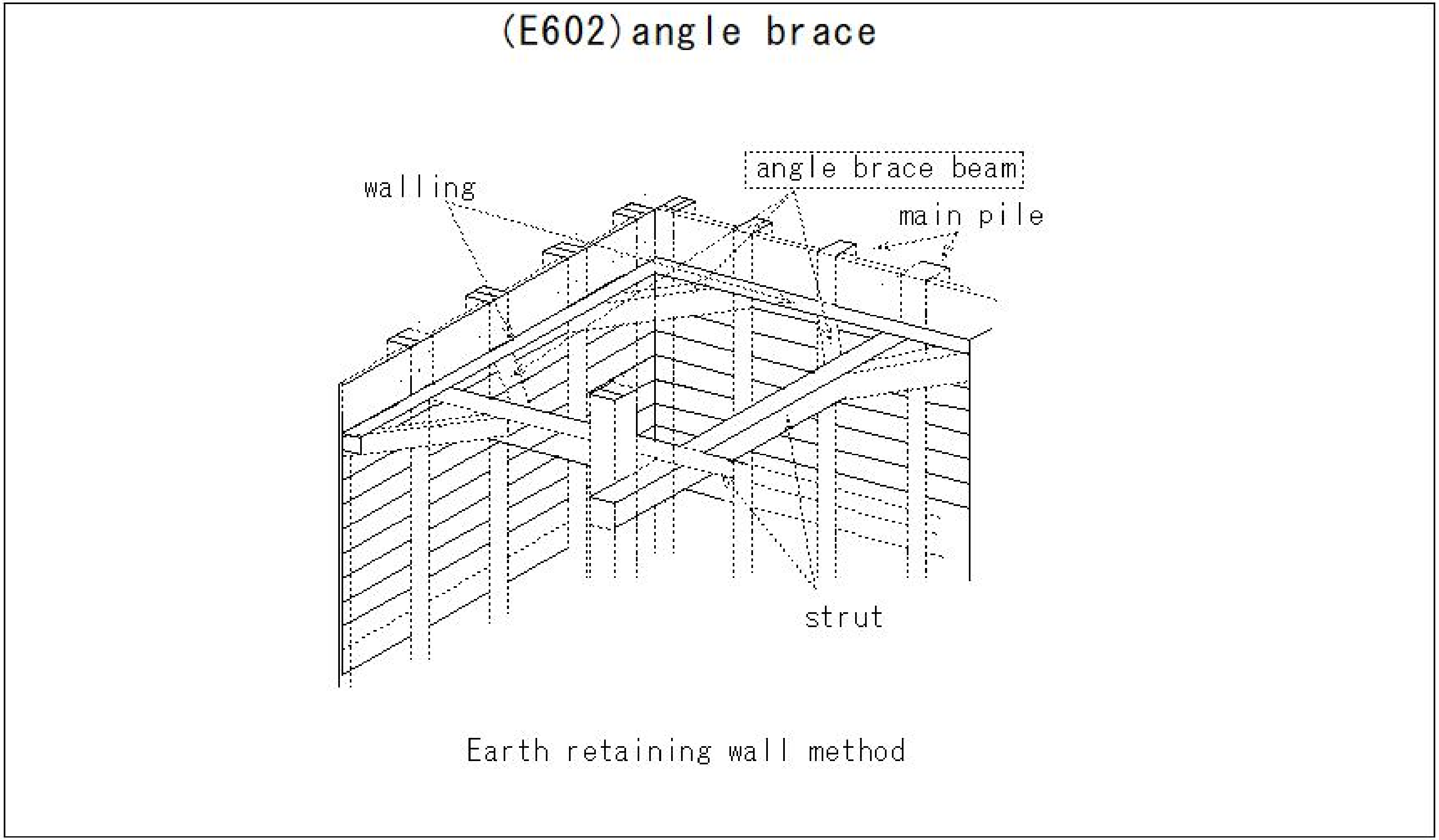
(E600)barrier free



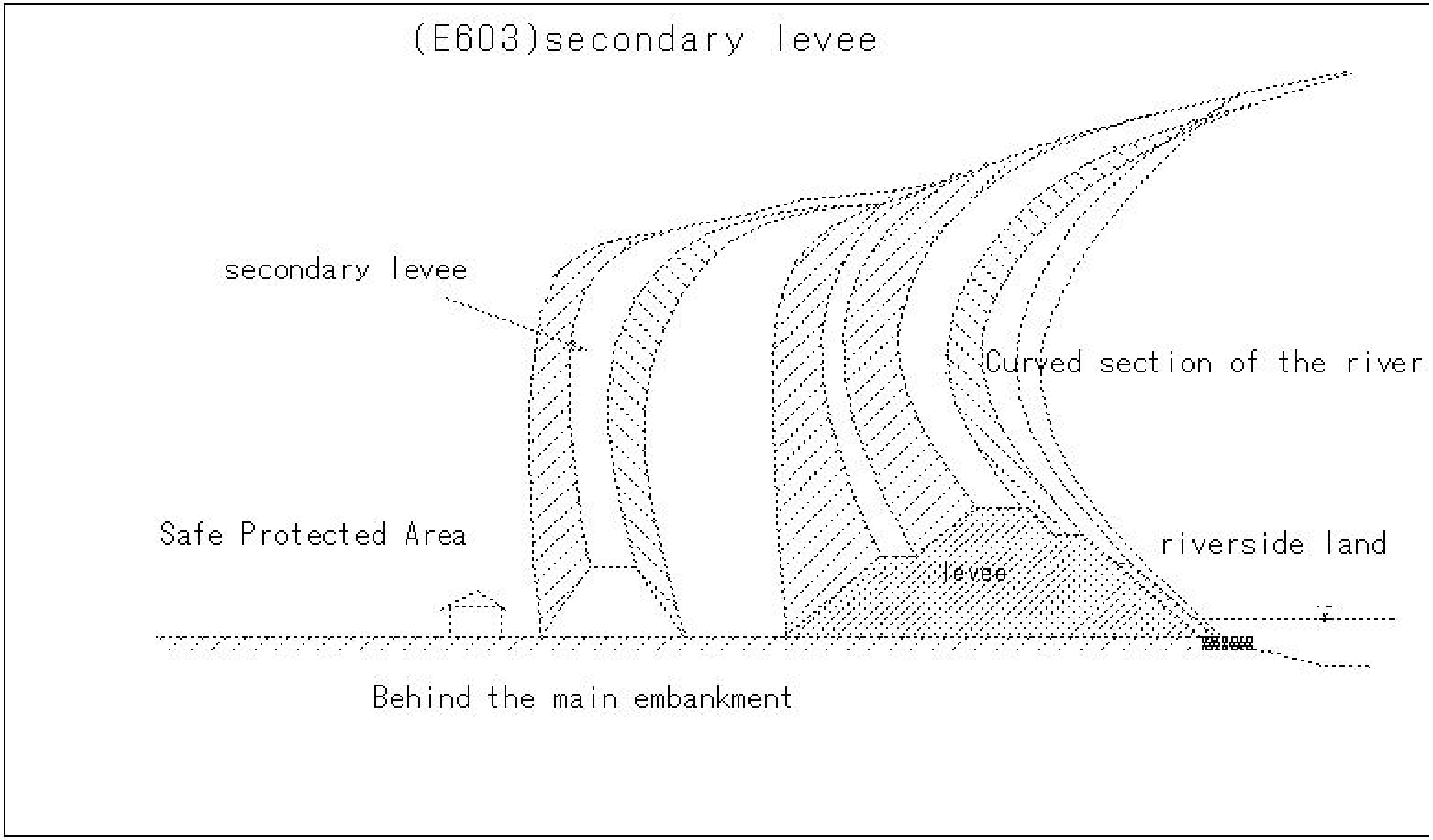
(E601)confined ground water



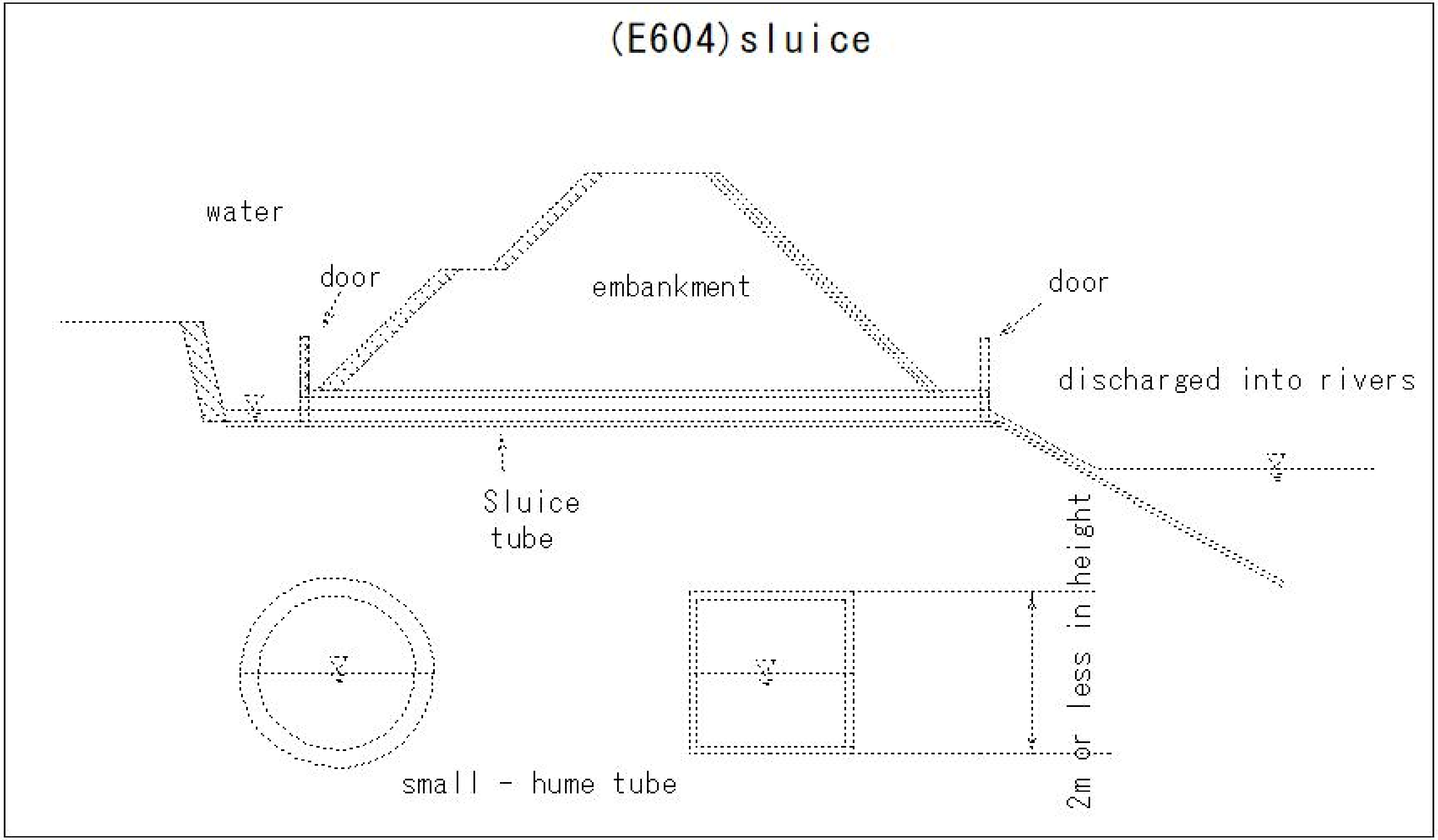
(E602)angle brace



(E603)secondary levee

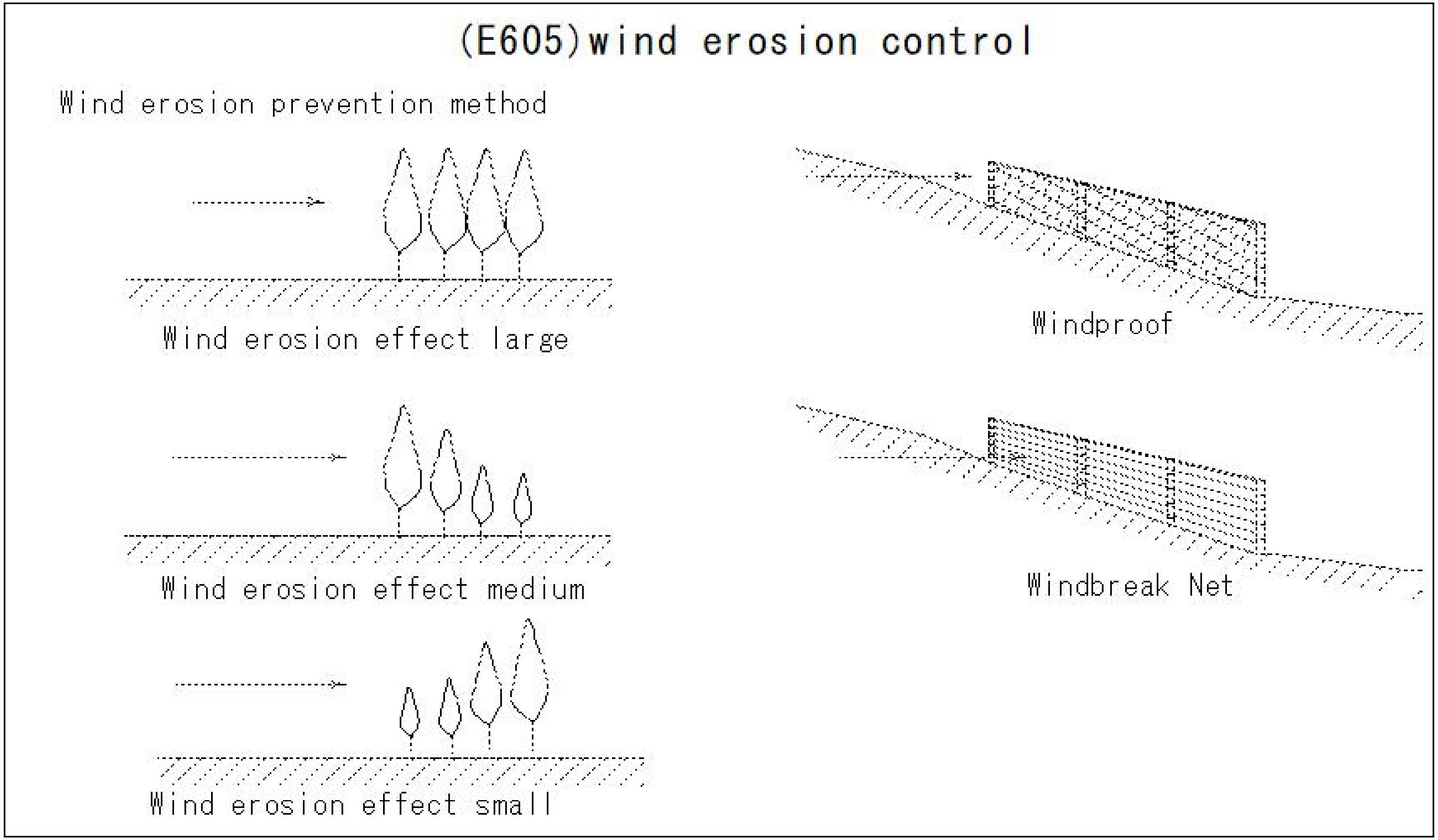


(E604)sluice

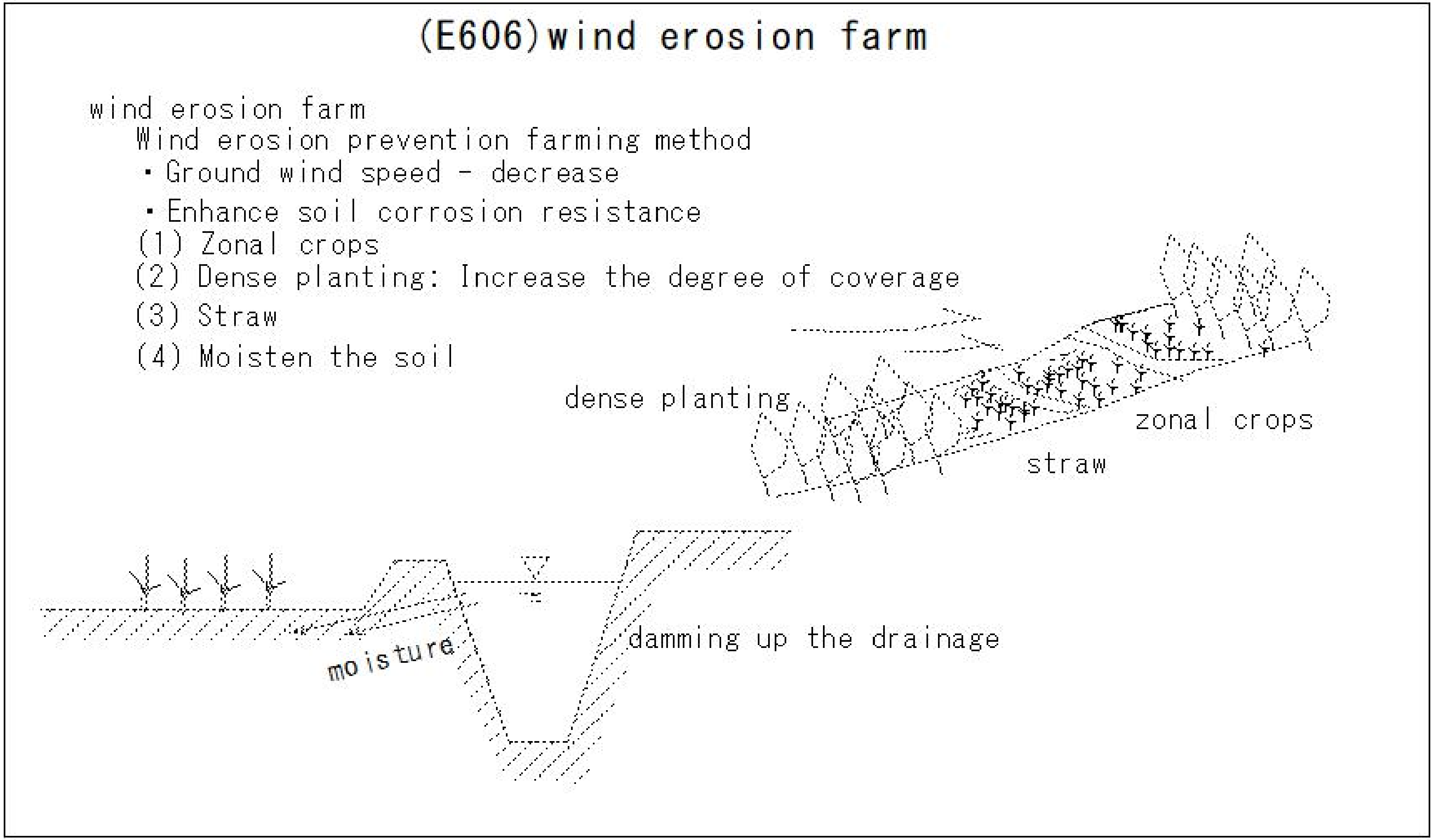


(E604)sluice
water
door
embankment
door
discharged into rivers
Sluice
tube
small - hume tube
2m or less in height

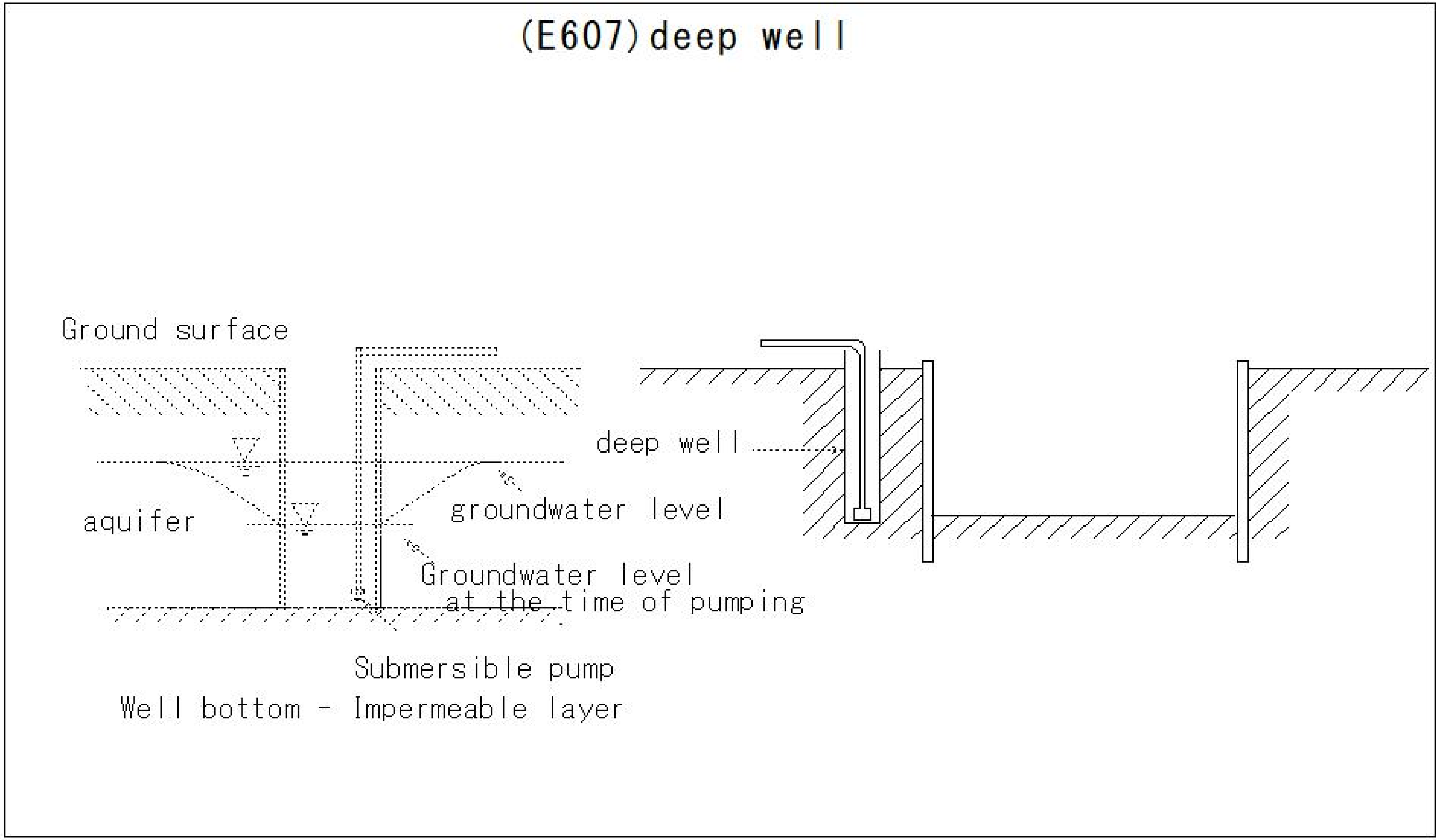
(E605)wind erosion control



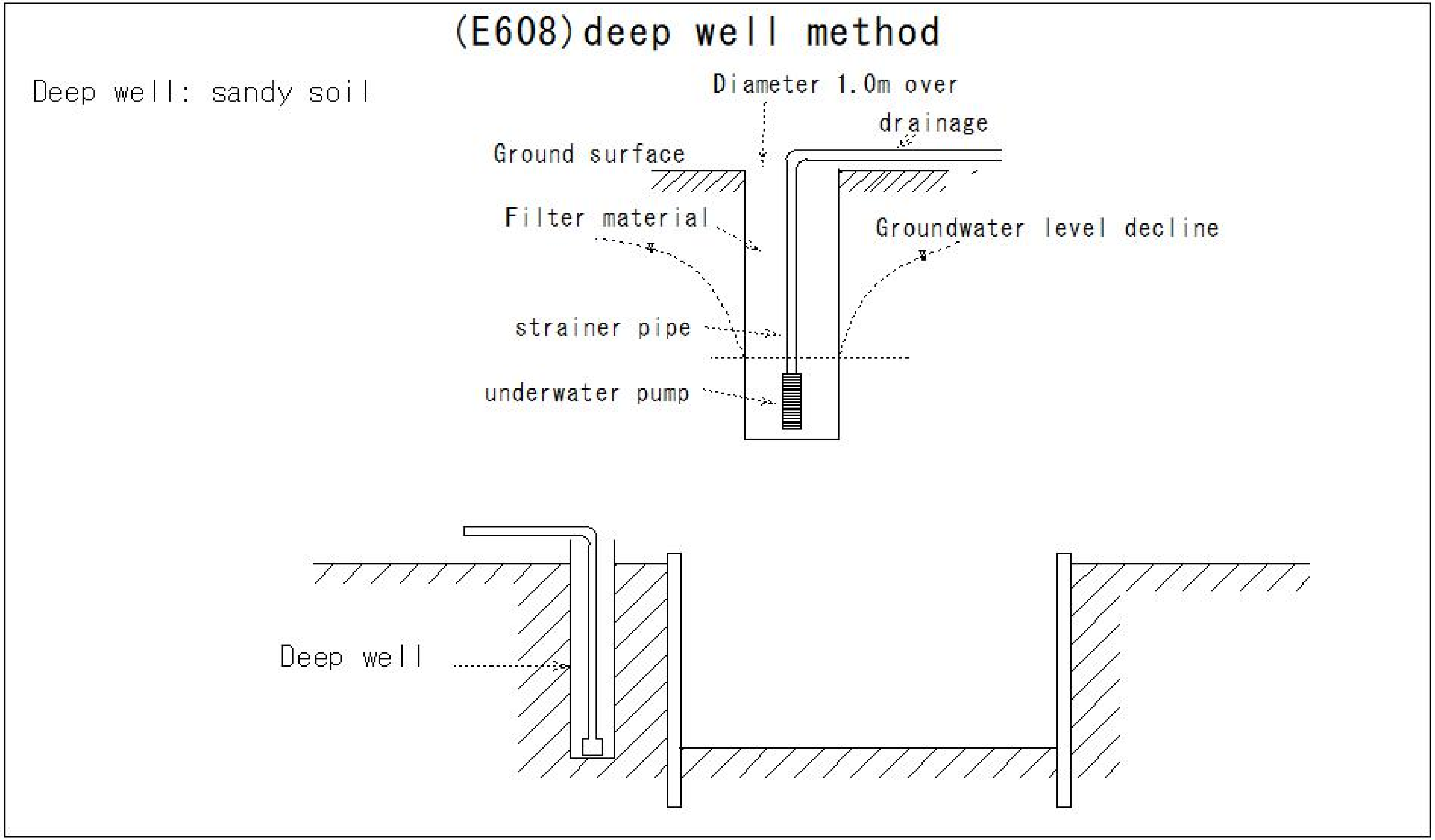
(E606)wind erosion farm



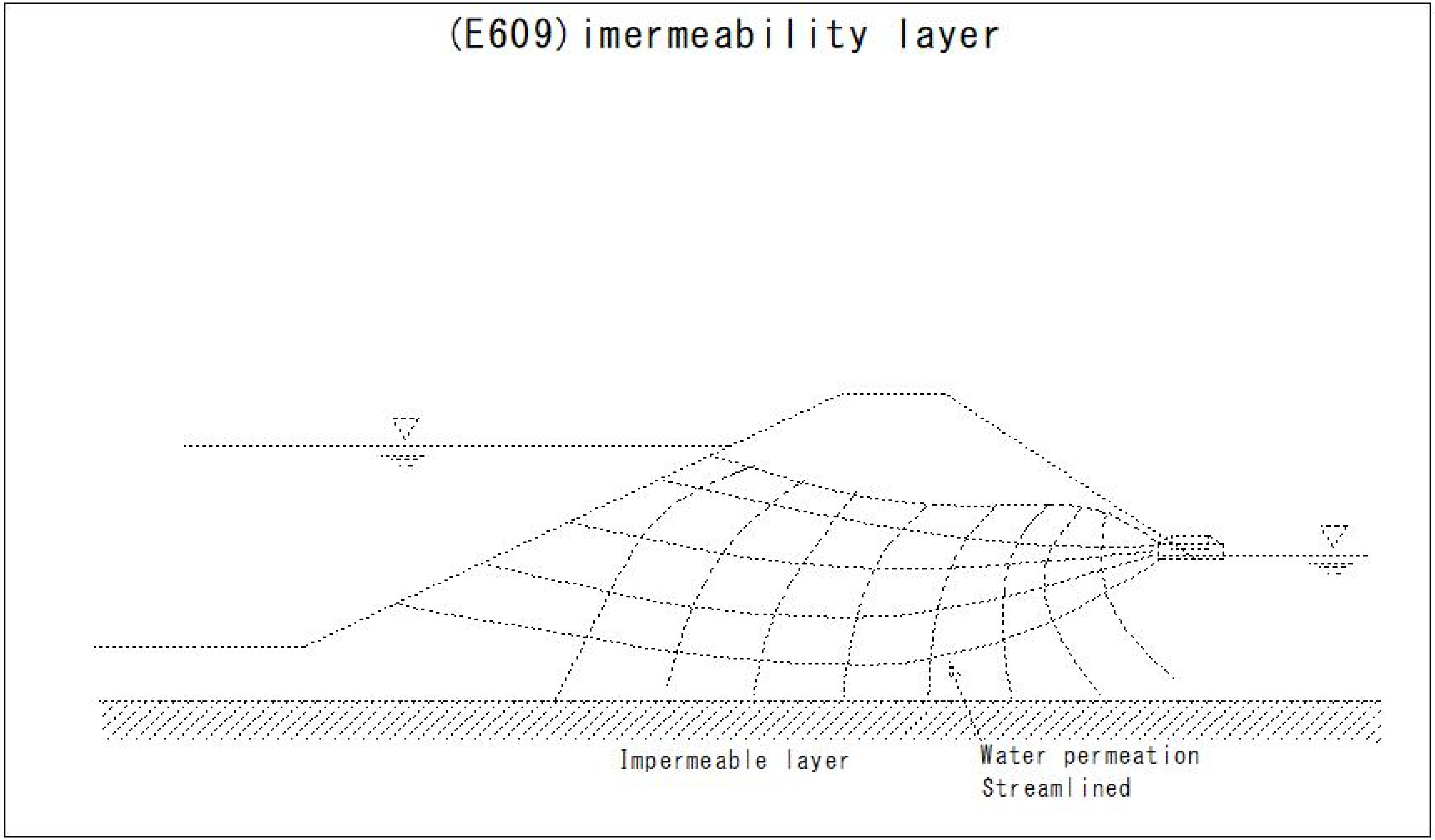
(E607)deep well



(E608)deep well method



(E609)Impermeable layer

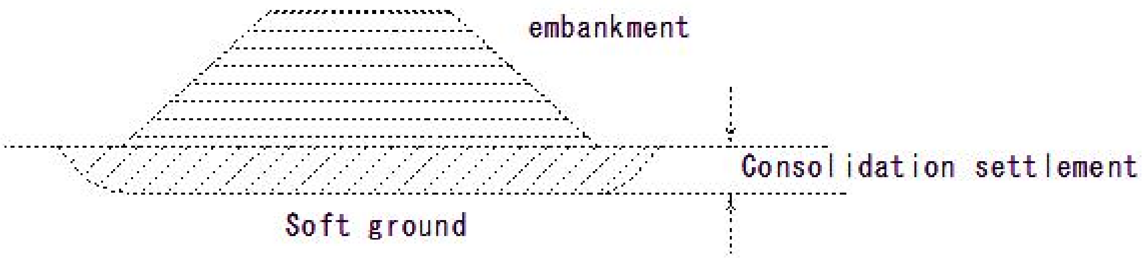


(E610)Preloading

(E610)Preloading

Preloading

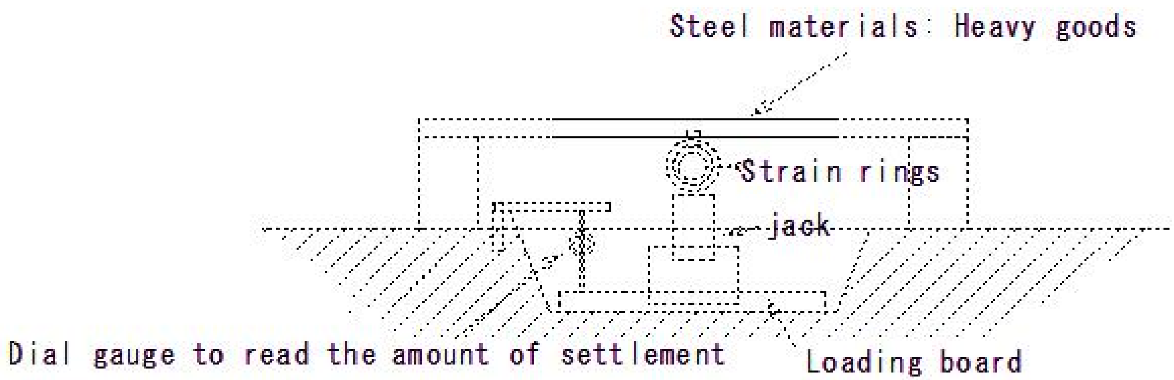
Promotion of consolidation settlement



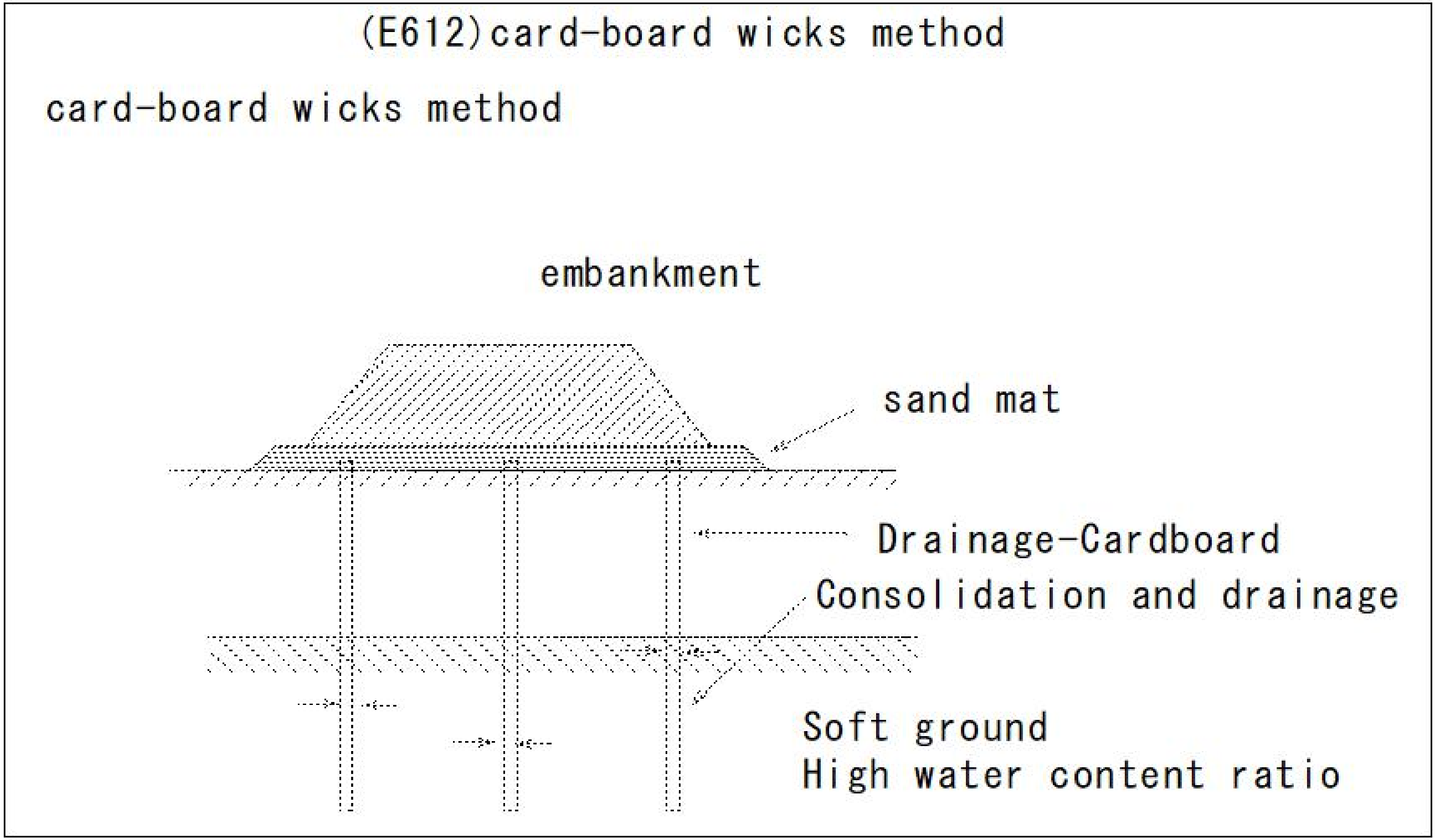
(E611)plate bearing test

(E611)plate bearing test

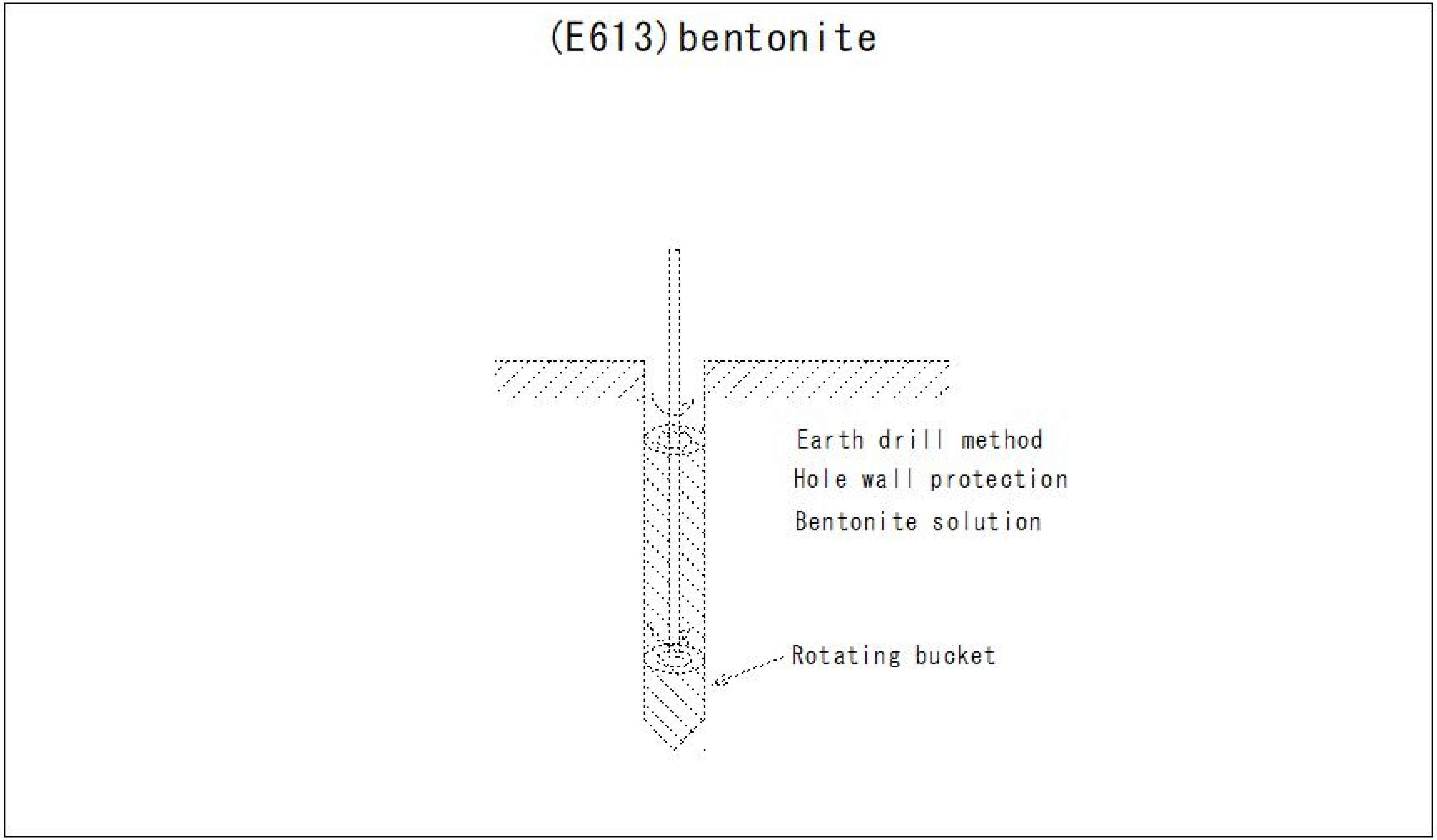
- Loading board:Iron diameter 30cm
- Reaction force device Heavy-duty trucks and steel materials
- Loading equipmentHydraulic jack
- settling quantity measuring device settling meter



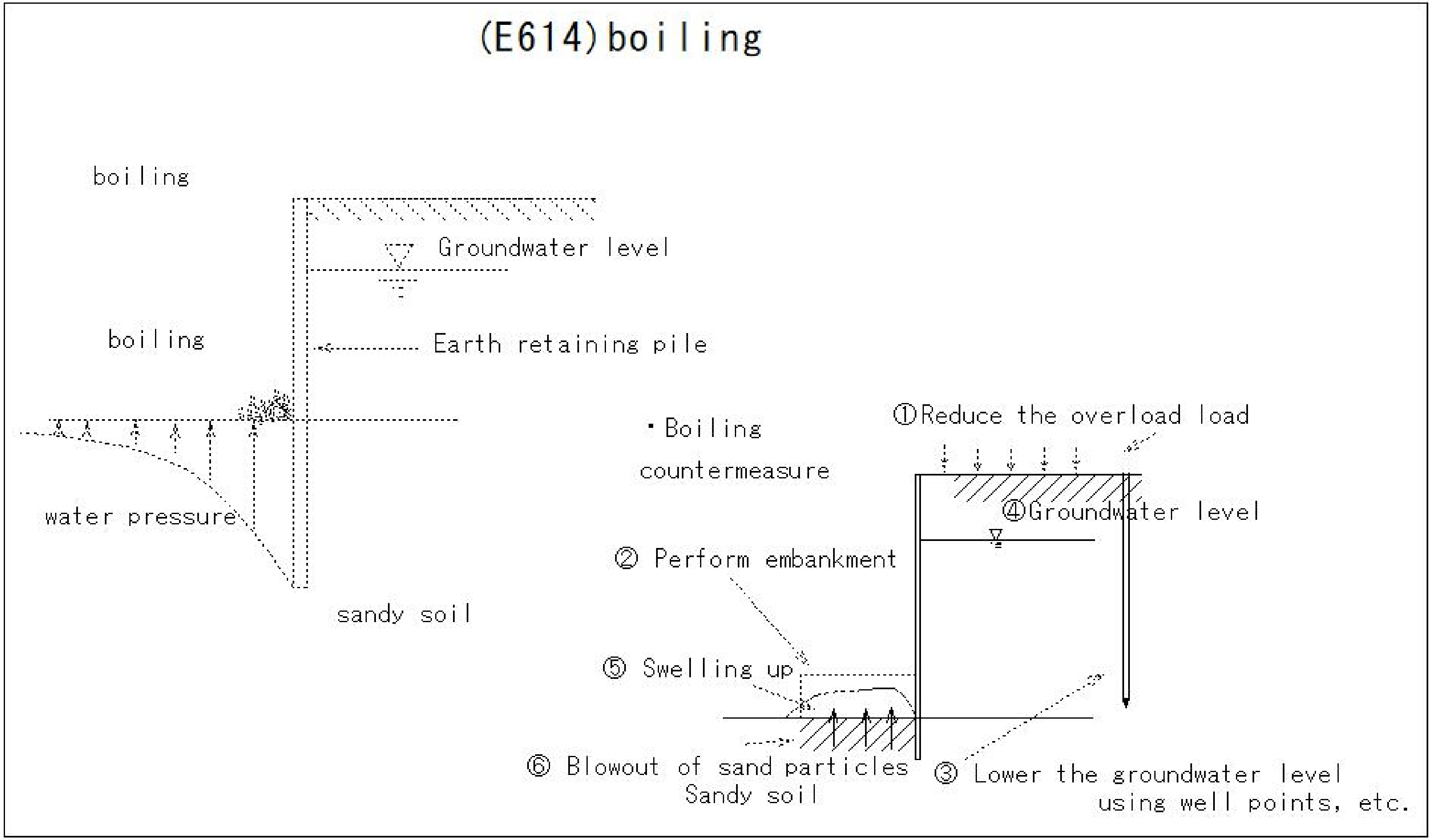
(E612)card-board wicks method



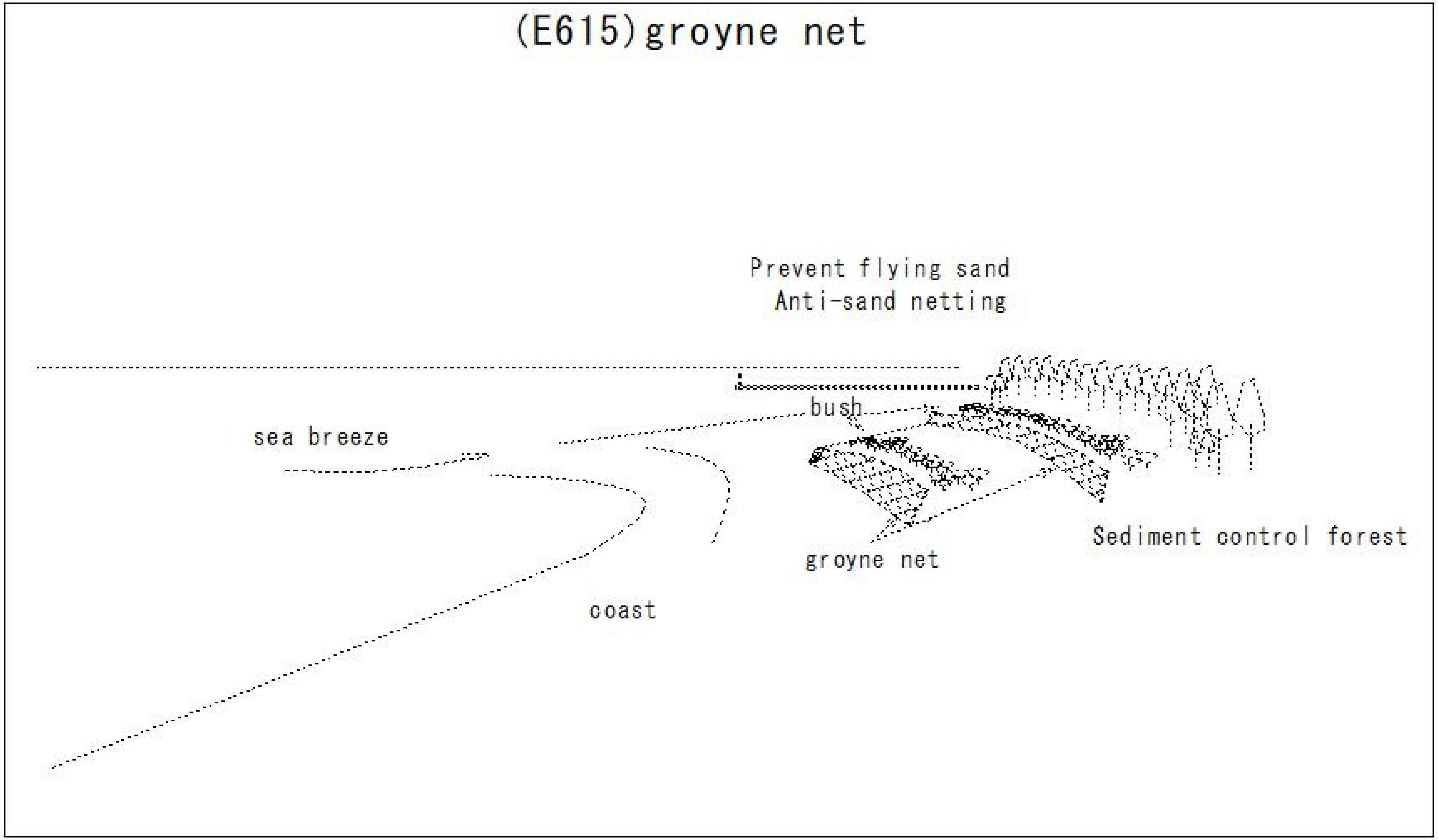
(E613)bentonite



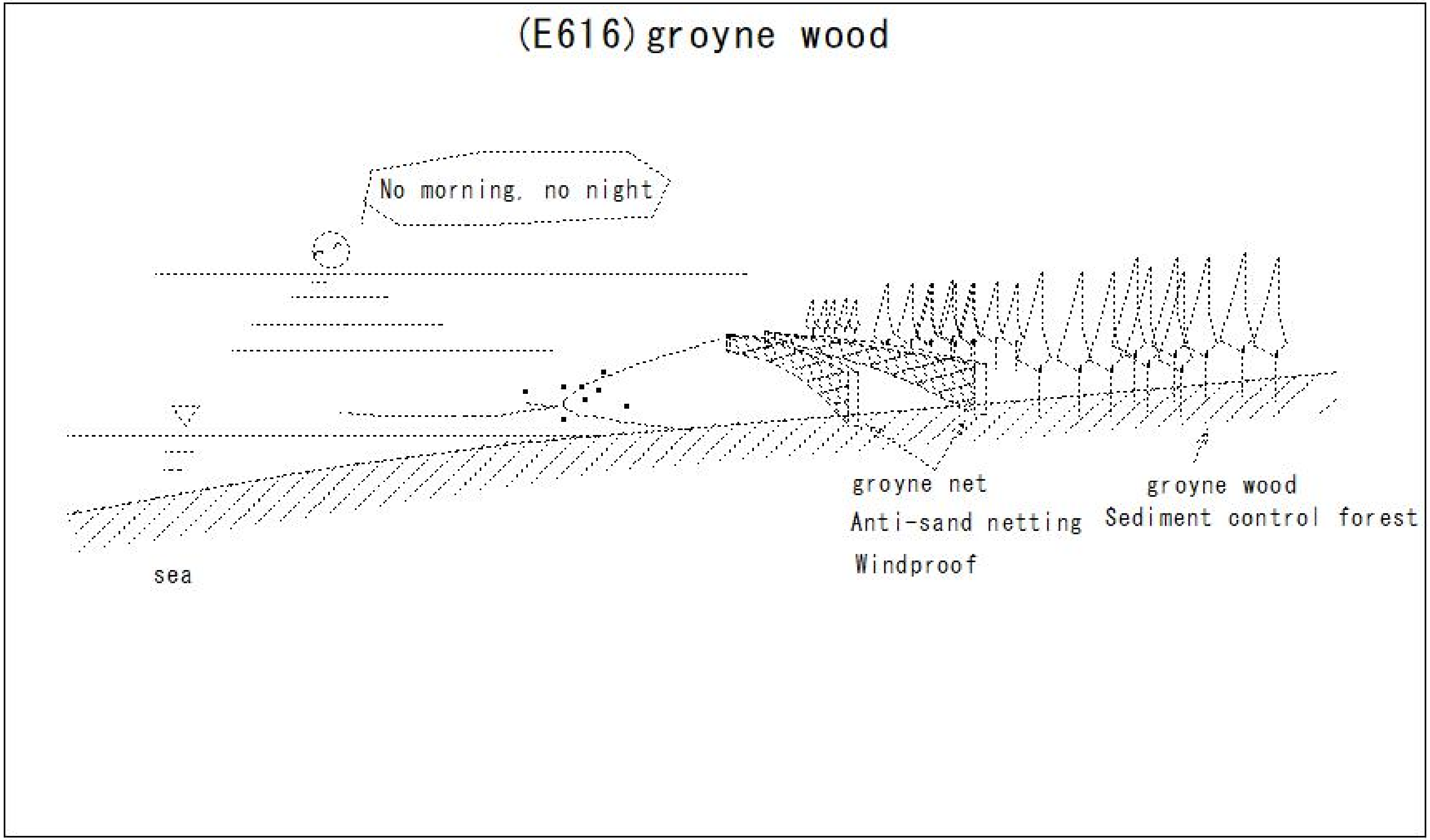
(E614)boiling



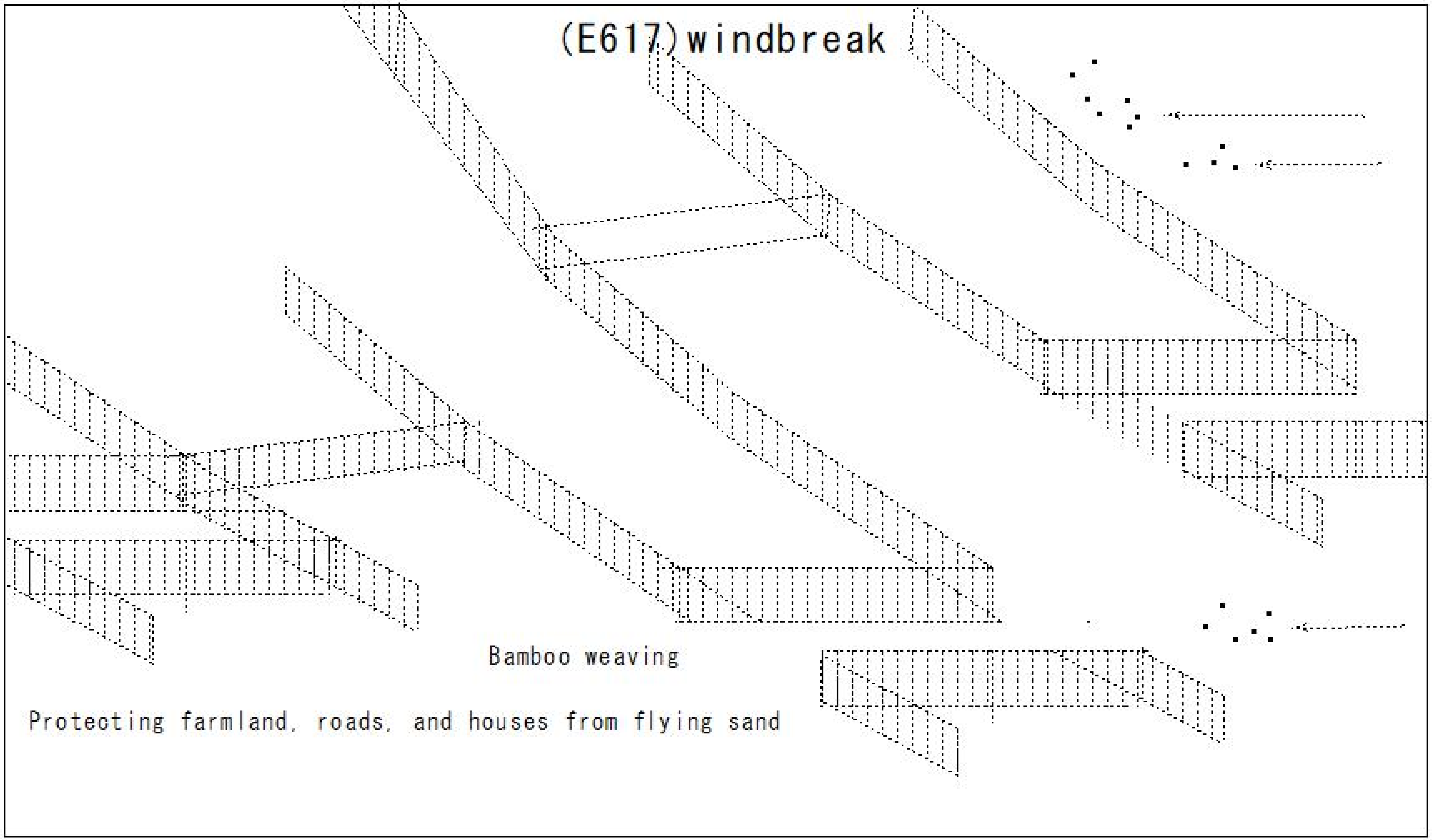
(E615)groyne net



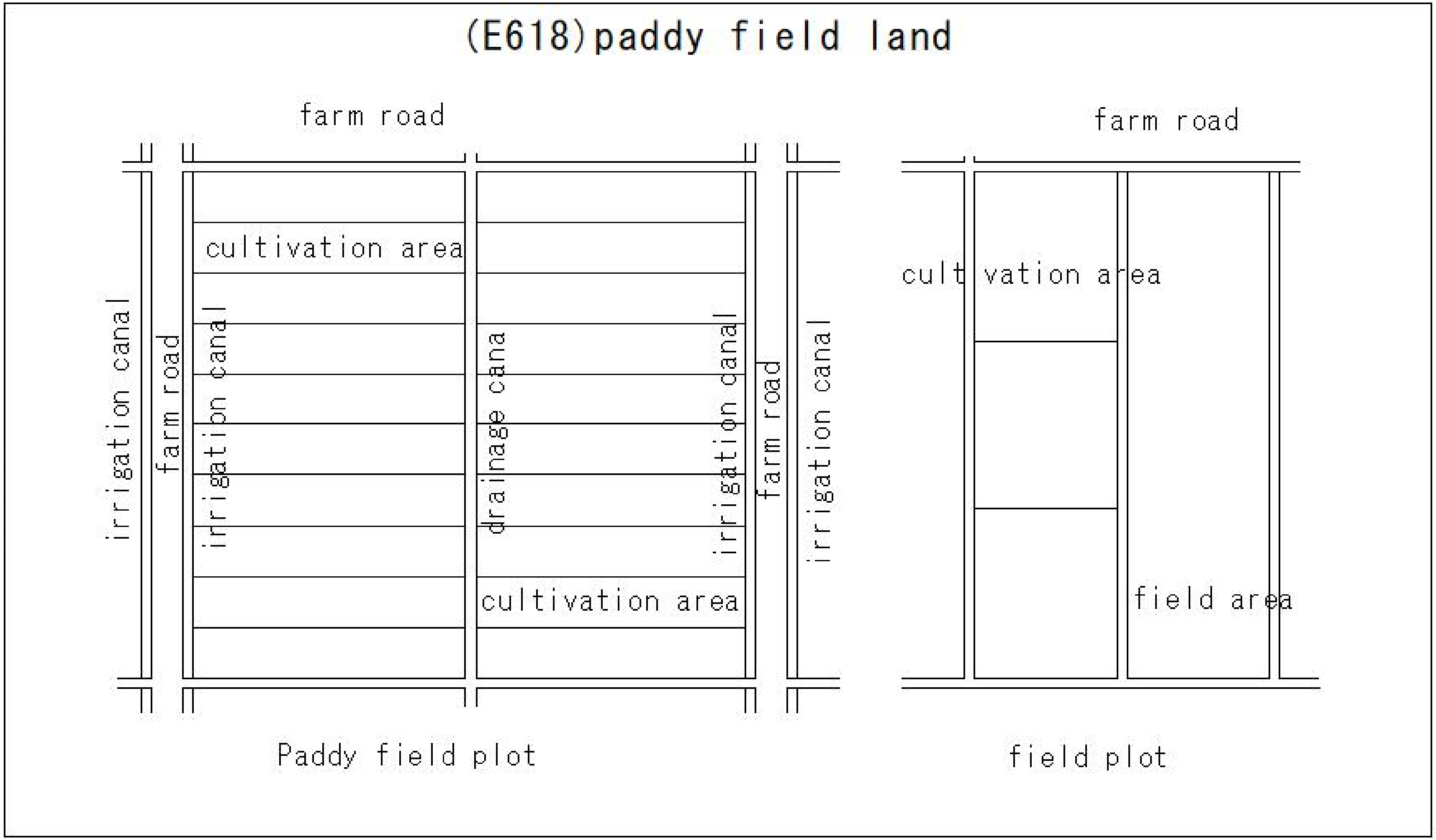
(E616)groyne wood



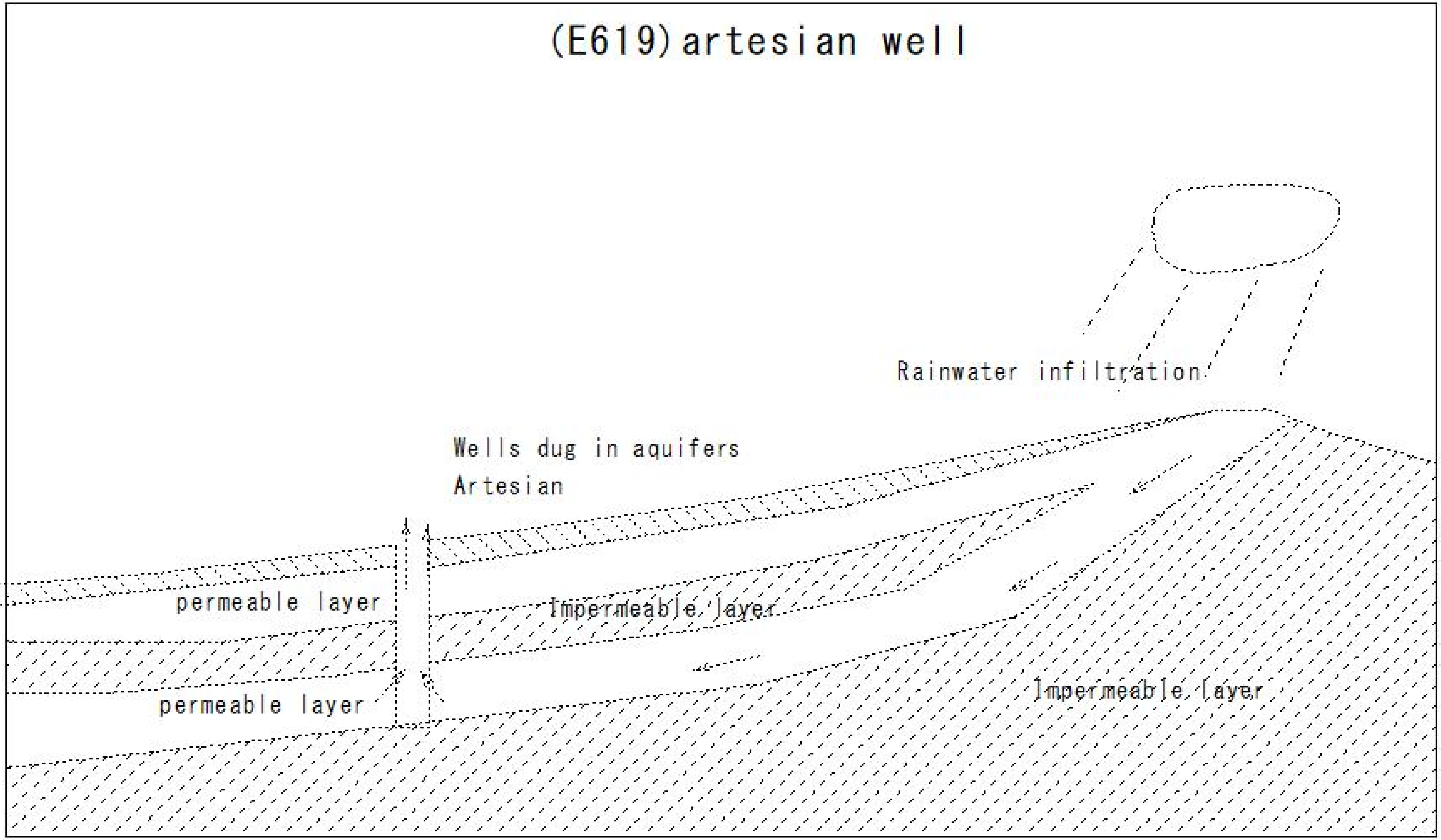
(E617)windbreak



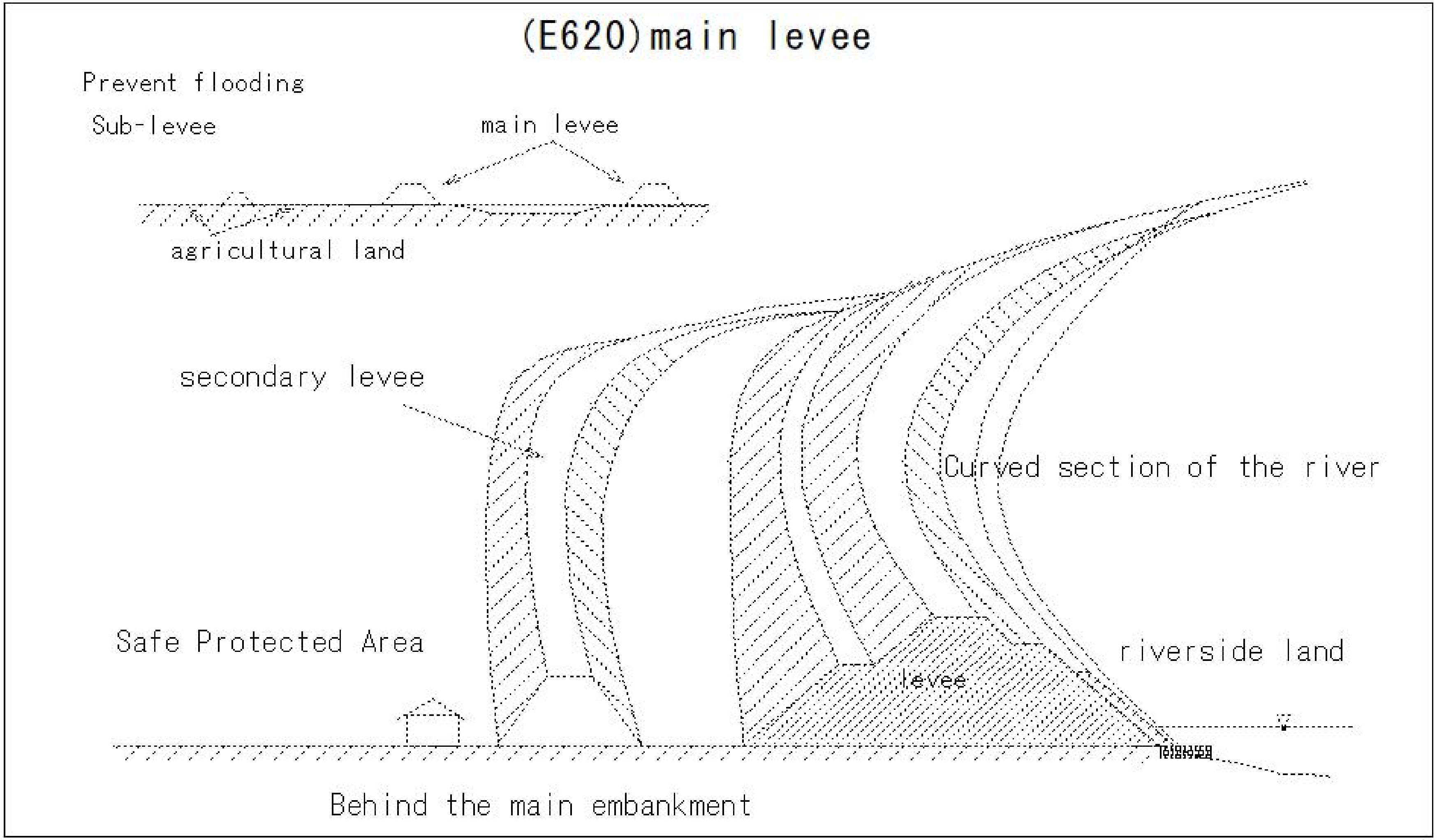
(E618)paddy field land



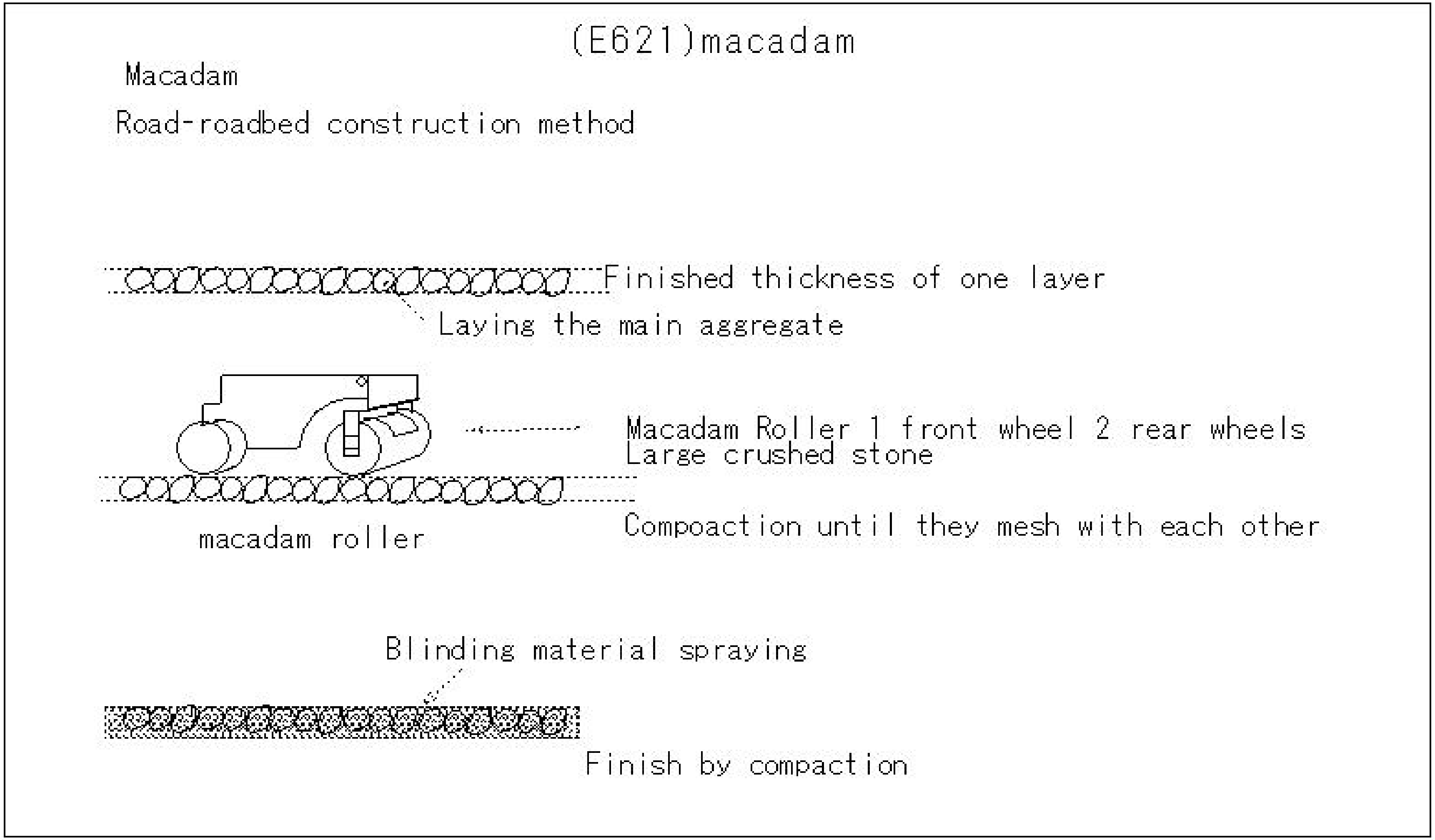
(E619)artesian well



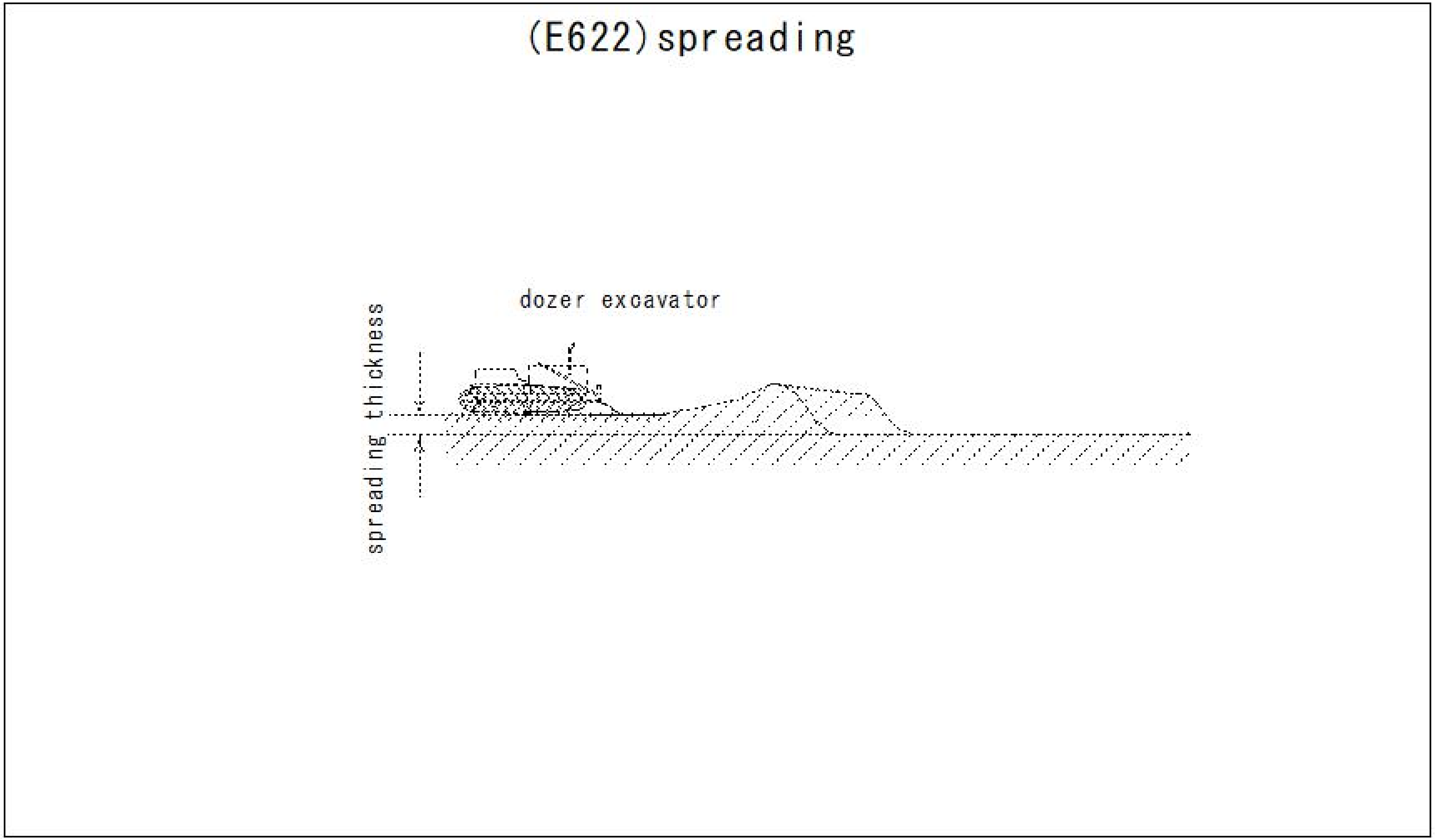
(E620)main levee



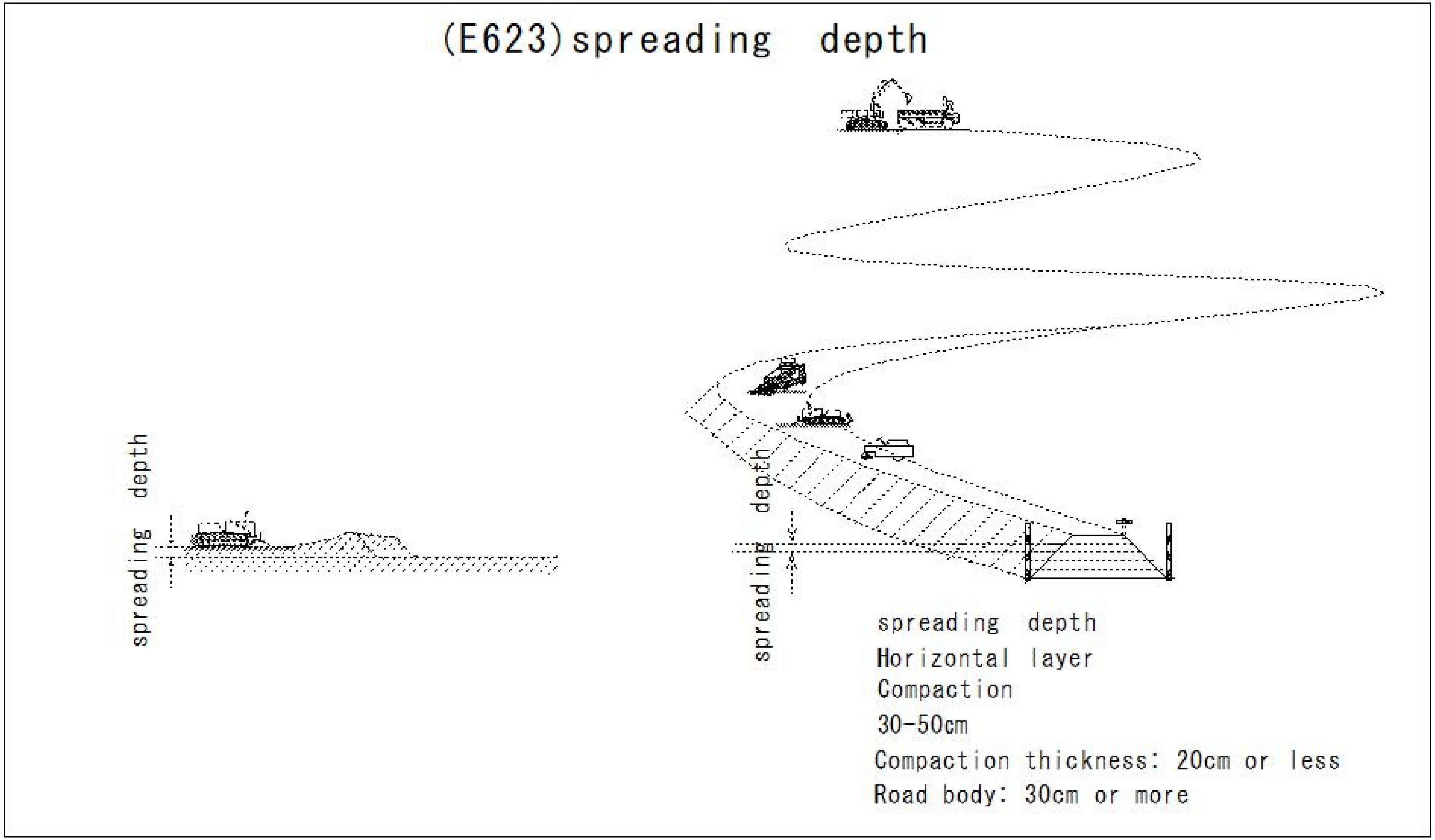
(E621)macadam



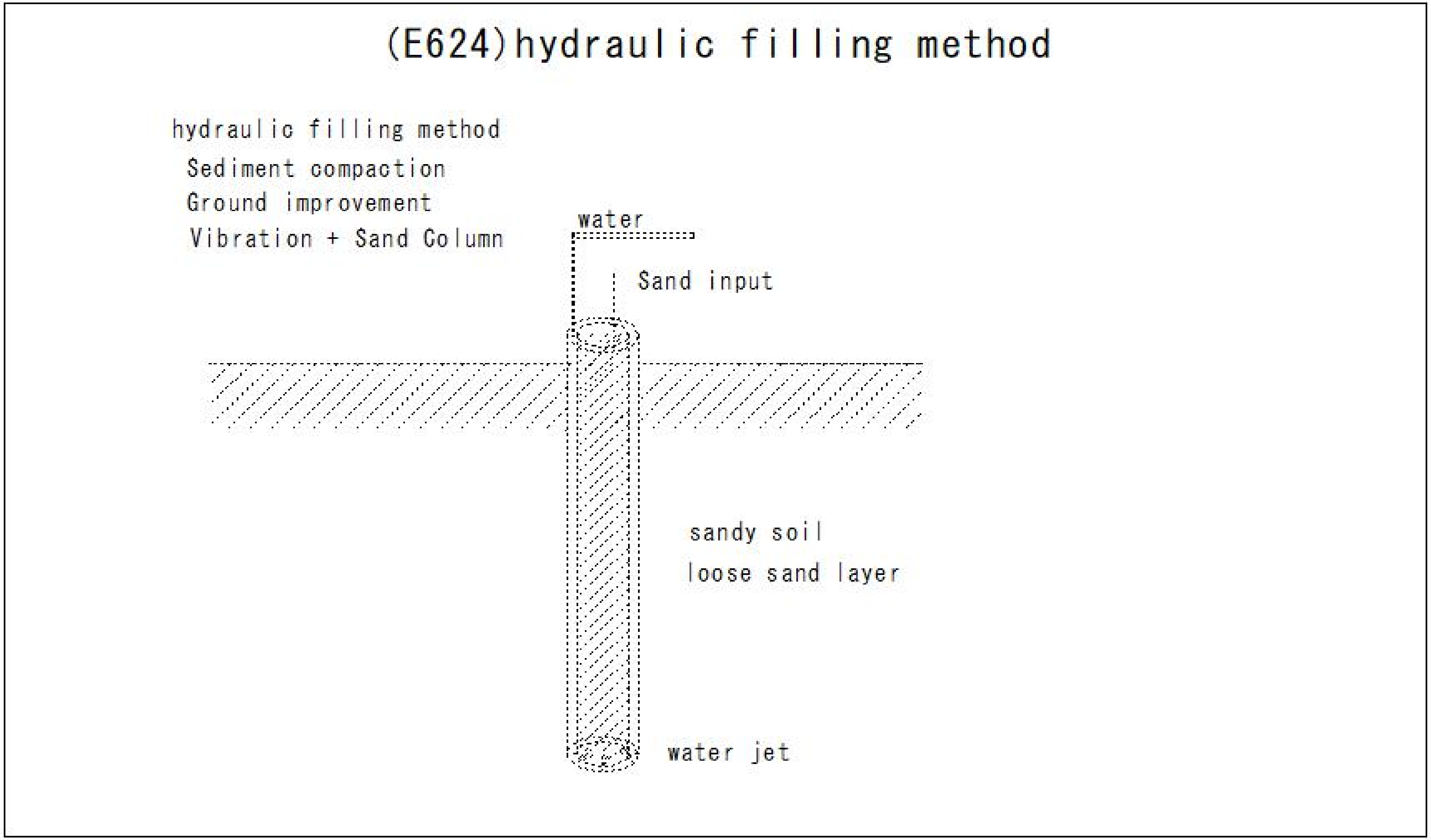
(E622)spreading



(E623)spreading depth



(E624)hydraulic filling method



(E625)hydraulic filling method

(E625)water bound macadam

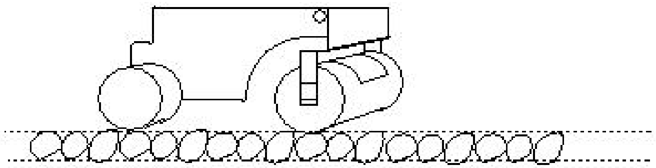
water bound macadam

Macadam method

Water + crushed stone mixture - spraying

Laying the main aggregate

Crushed stone (diameter 20 mm or less)



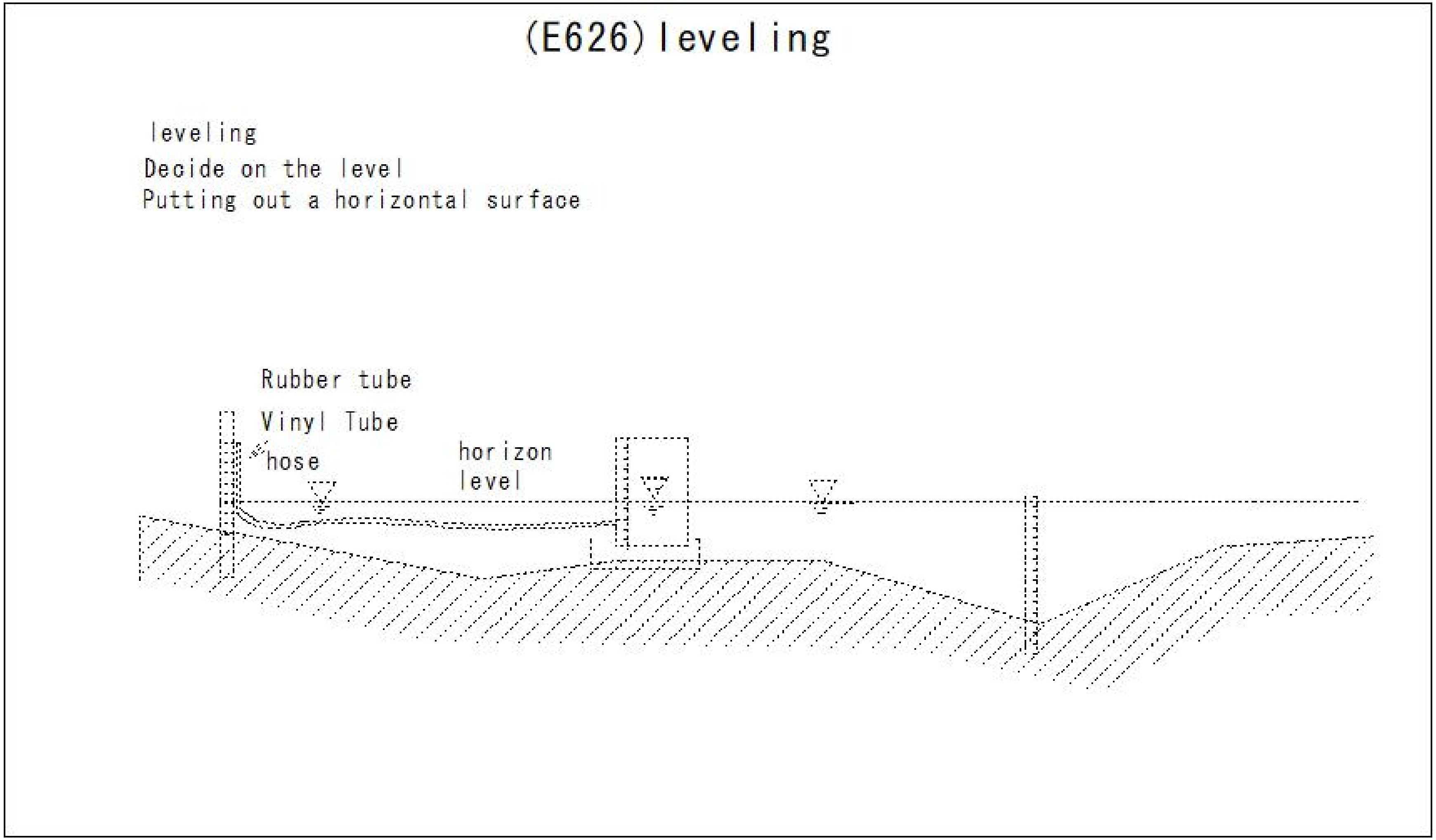
macadam roller

Compaction poured with water

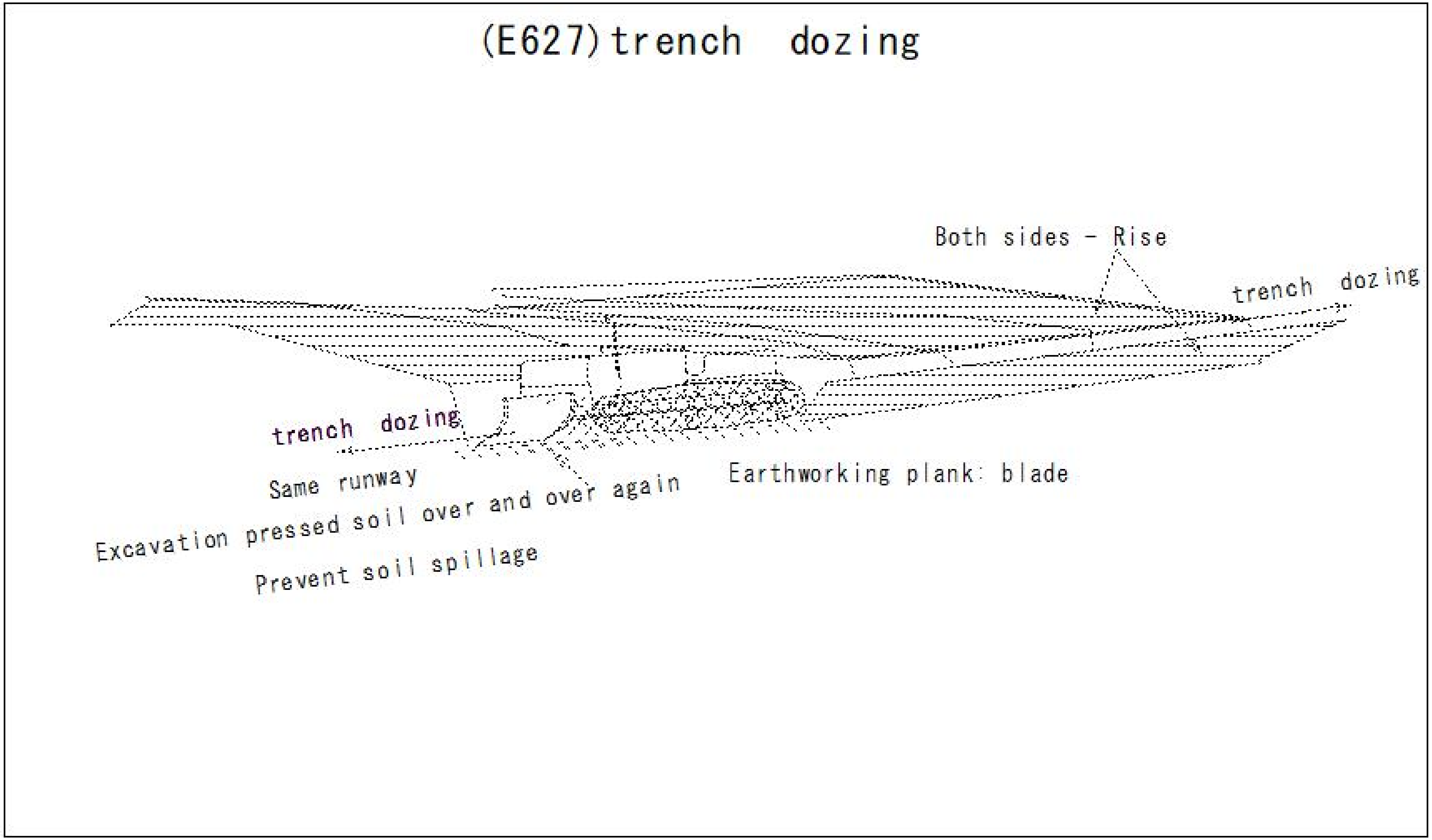
Last-5-13mm crushed stone spraying finish

Compaction with macadam rollers

(E626)leveling

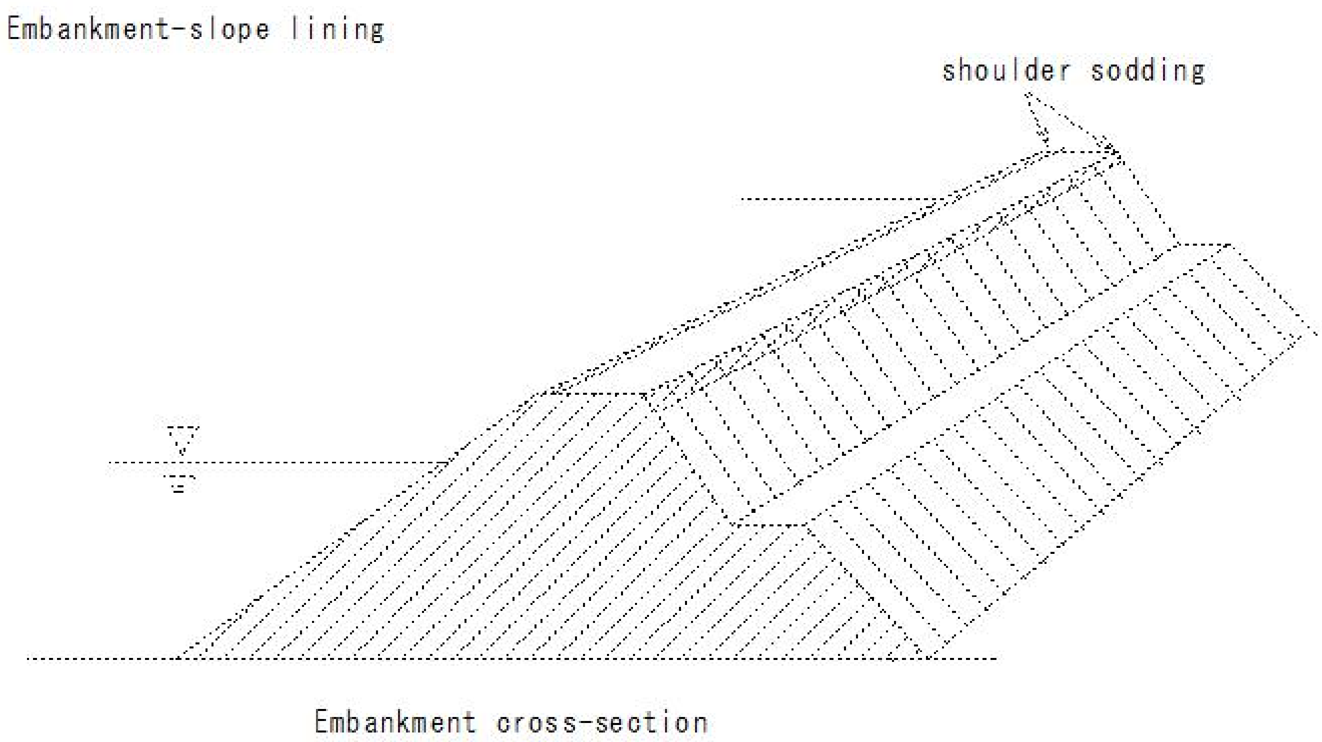


(E627)trench dozing

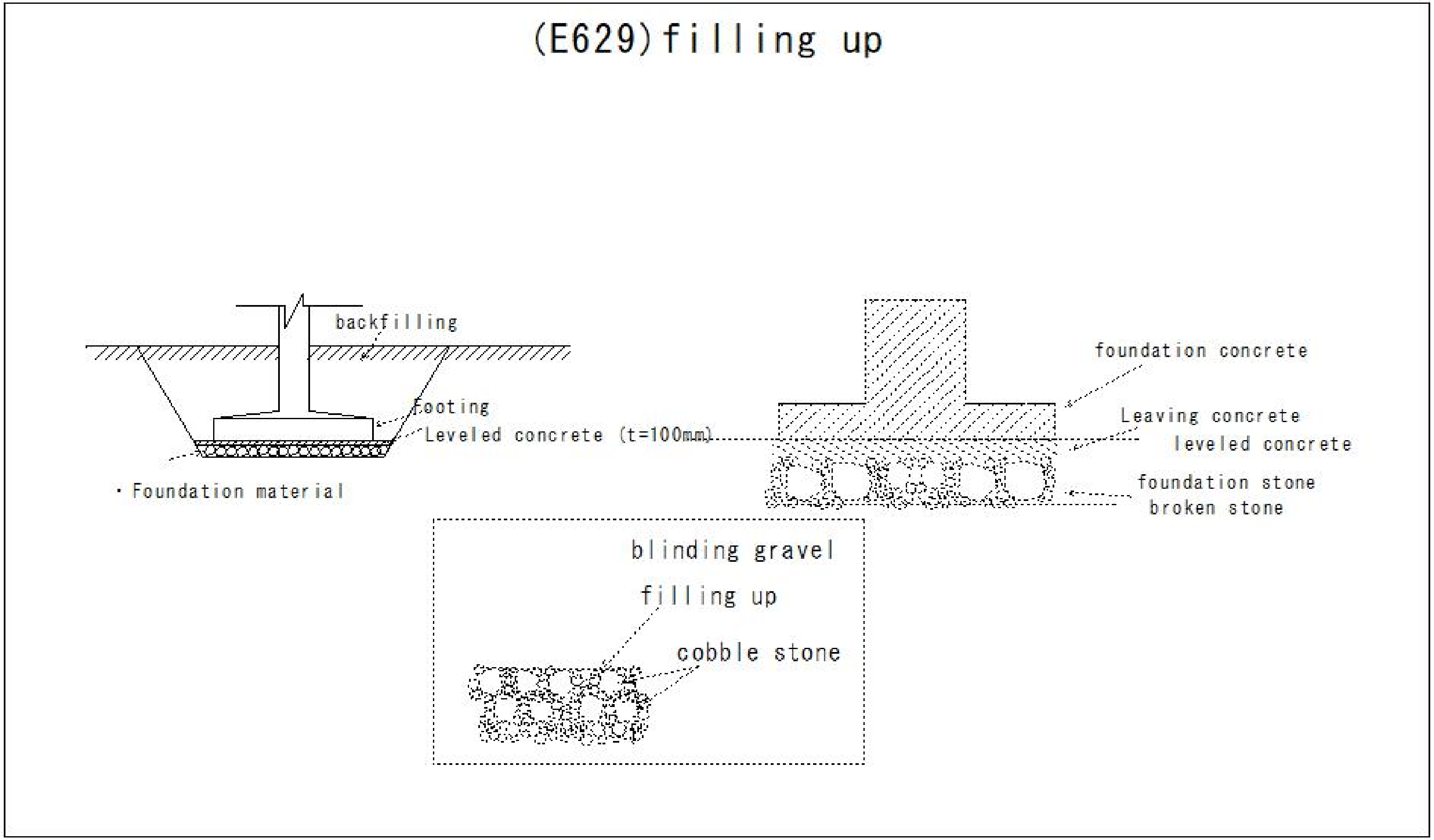


(E628)shoulder sodding

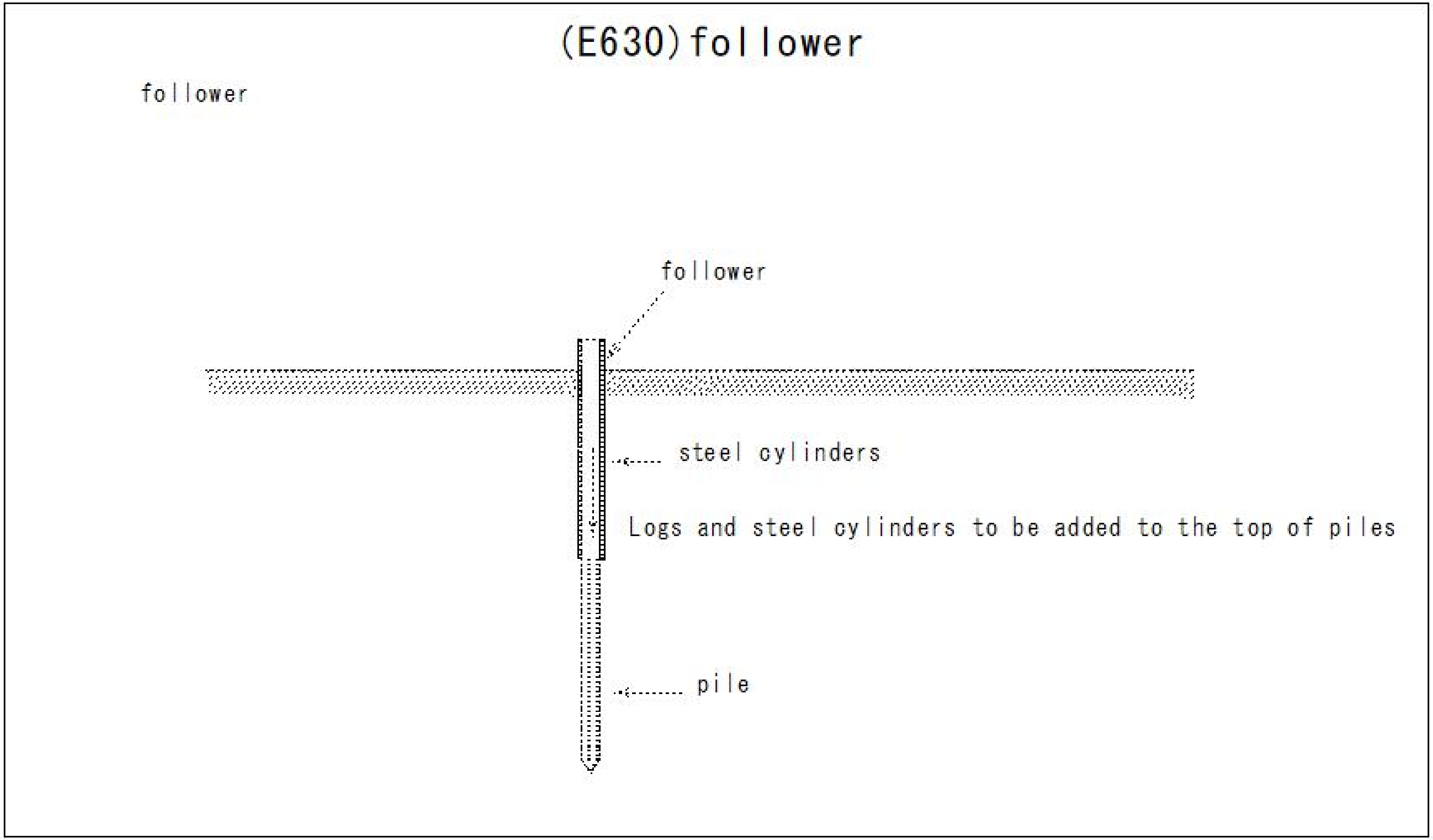
(E628)shoulder sodding



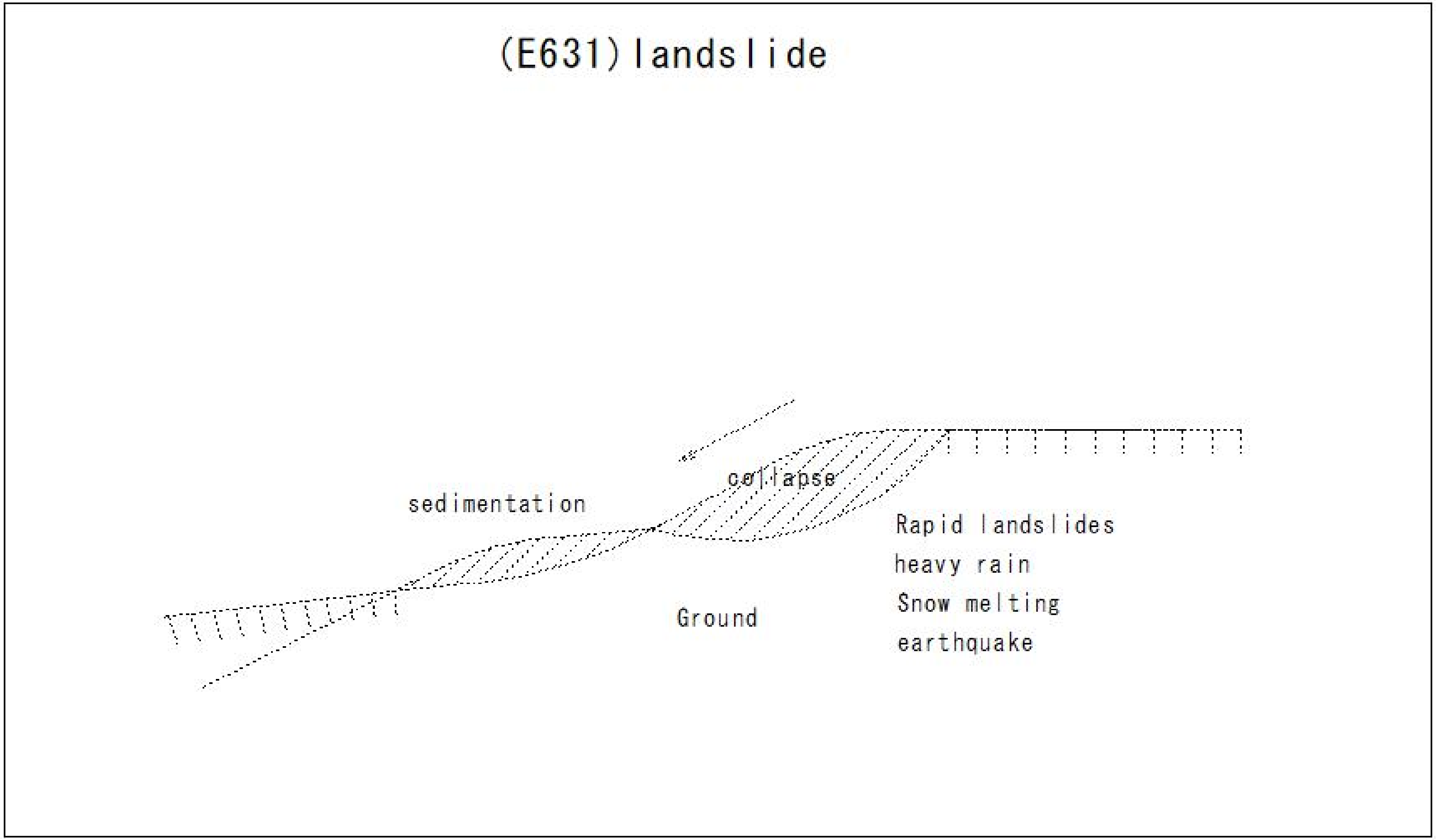
(E629)filling up



(E630)follower

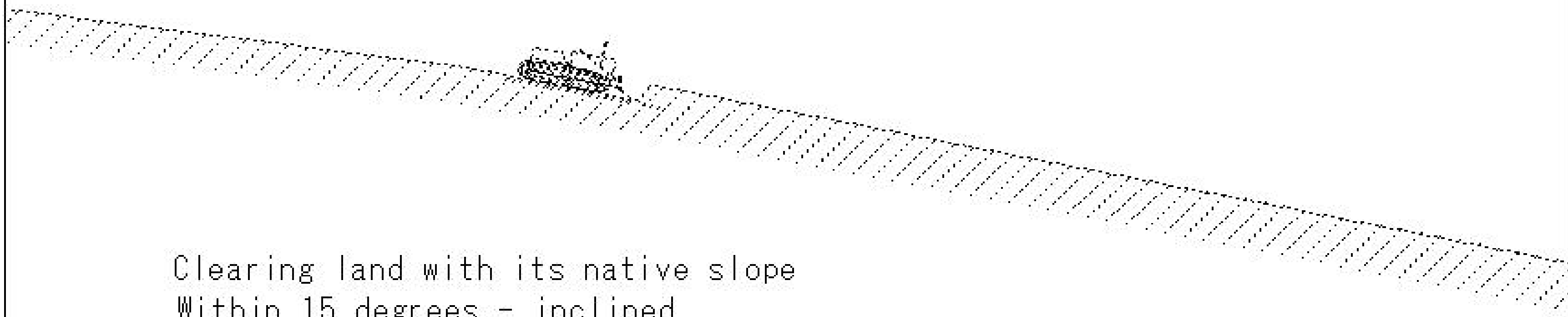


(E631)landslide



(E632)land reclamation in natural slope

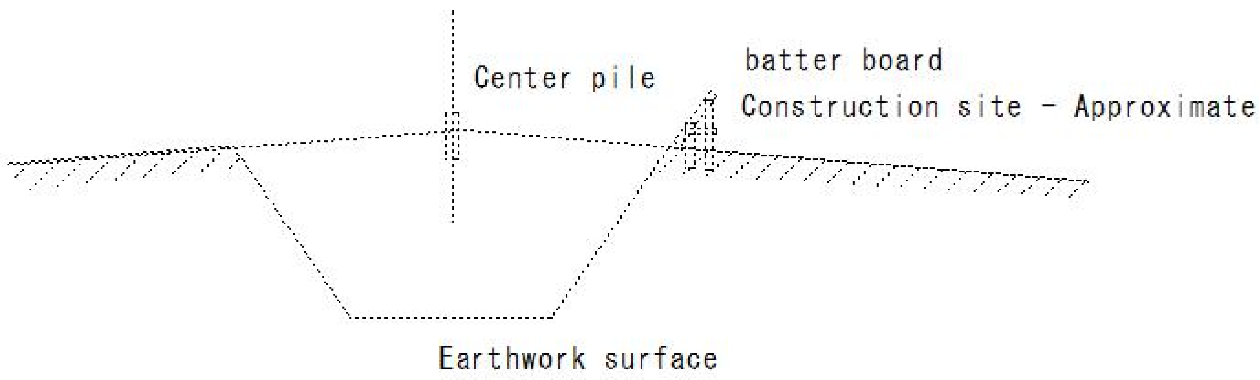
(E632)land reclamation in natural slope



Clearing land with its native slope
Within 15 degrees - inclined
Logging, cutting, burning, rooting, weed tree removal
Loosening the ground

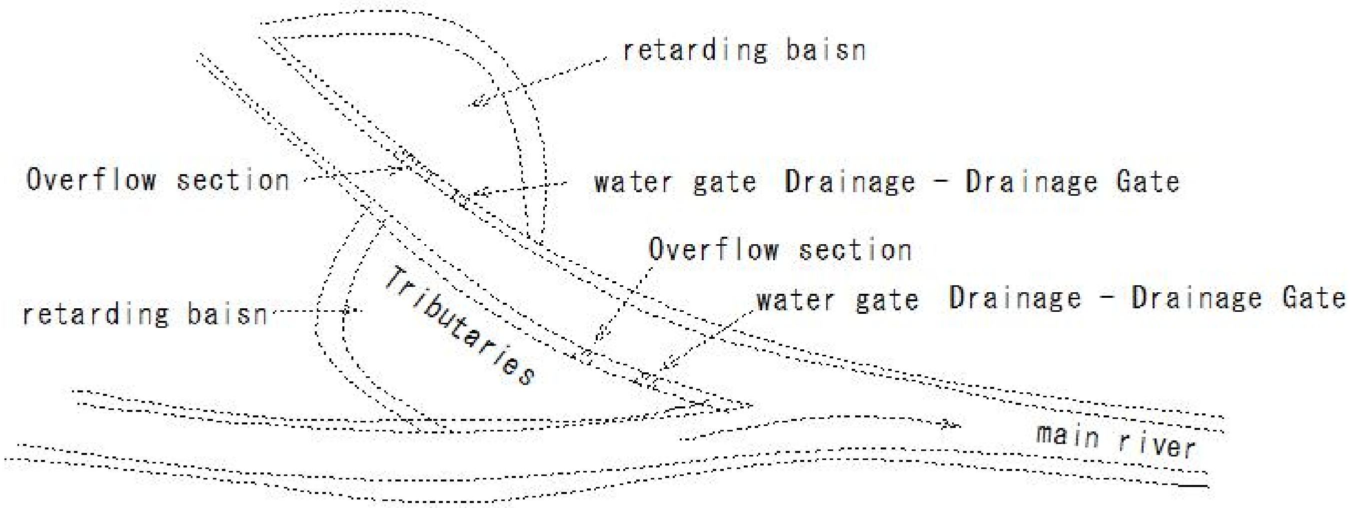
(E633)batter board

(E633)batter board

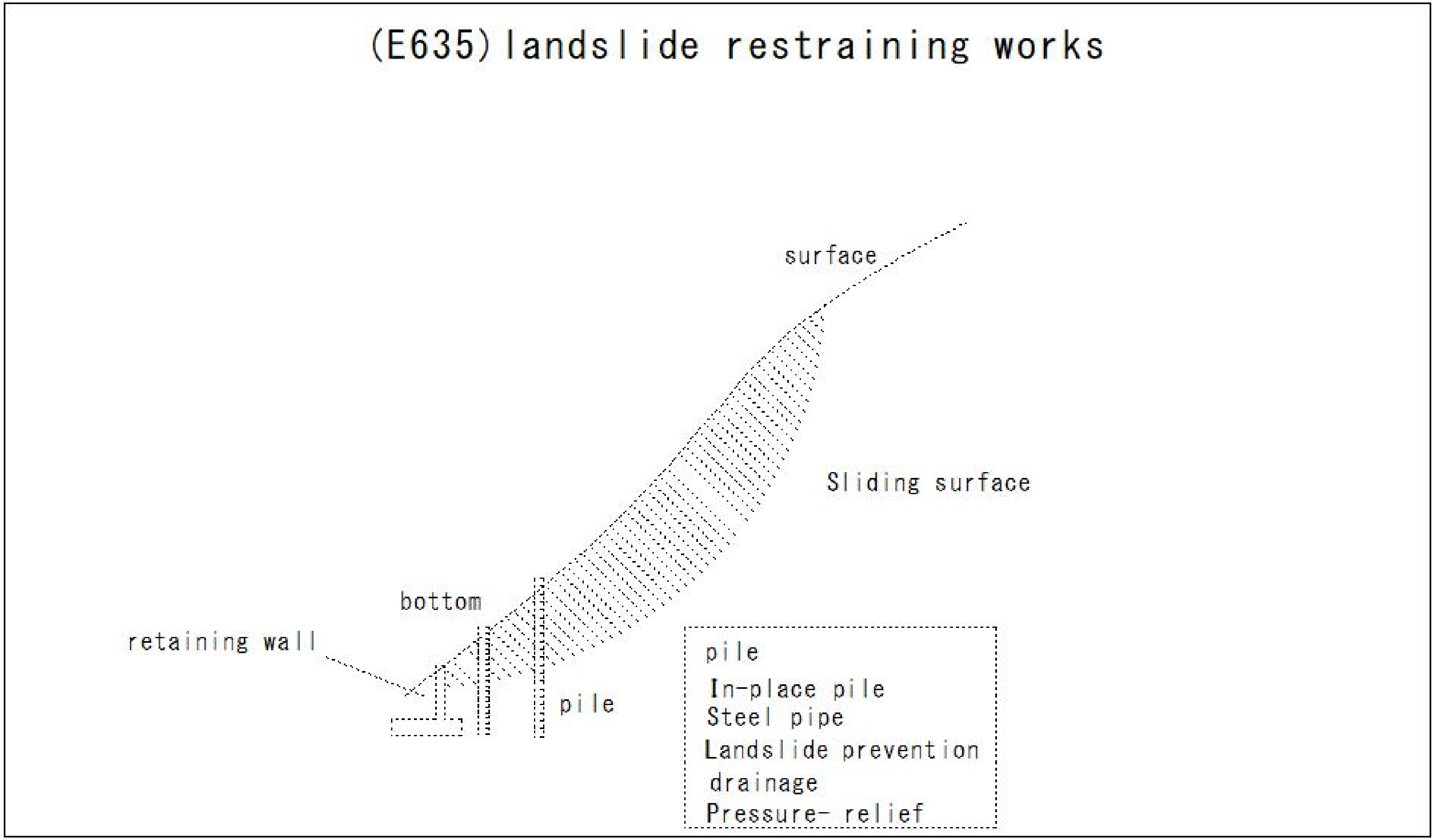


(E634)retarding baisn

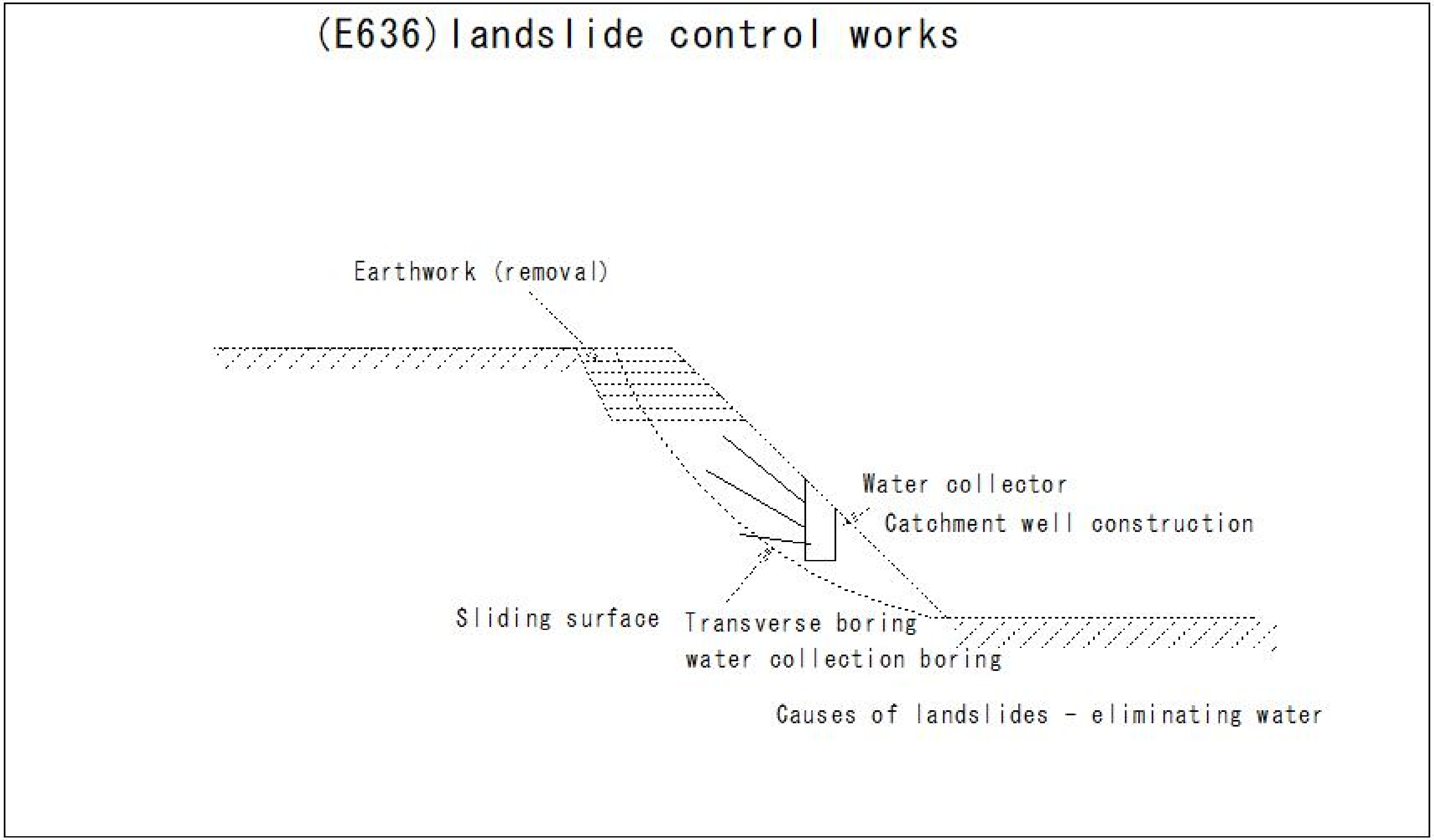
(E634)retarding baisn



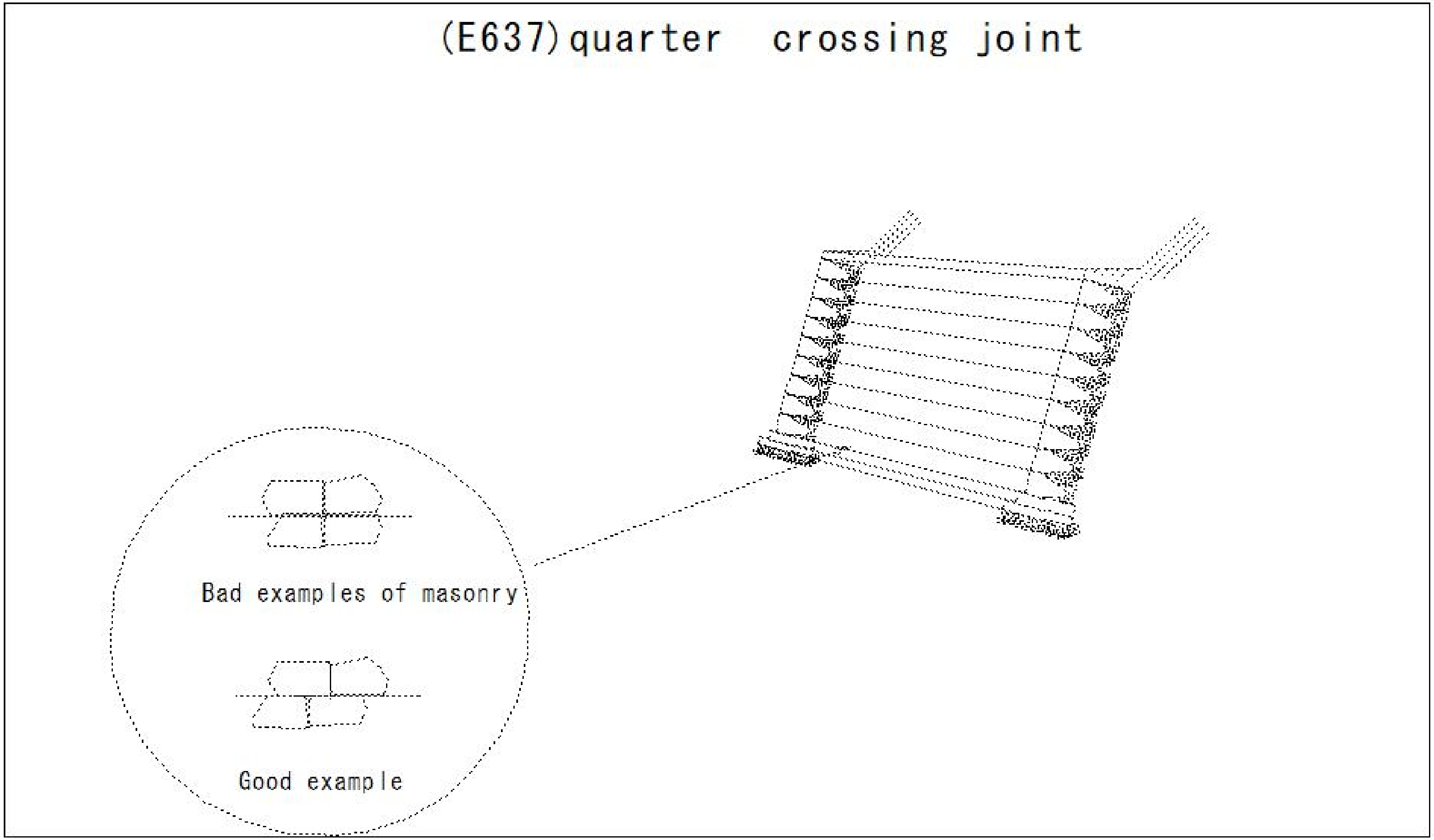
(E635)landslide restraining works



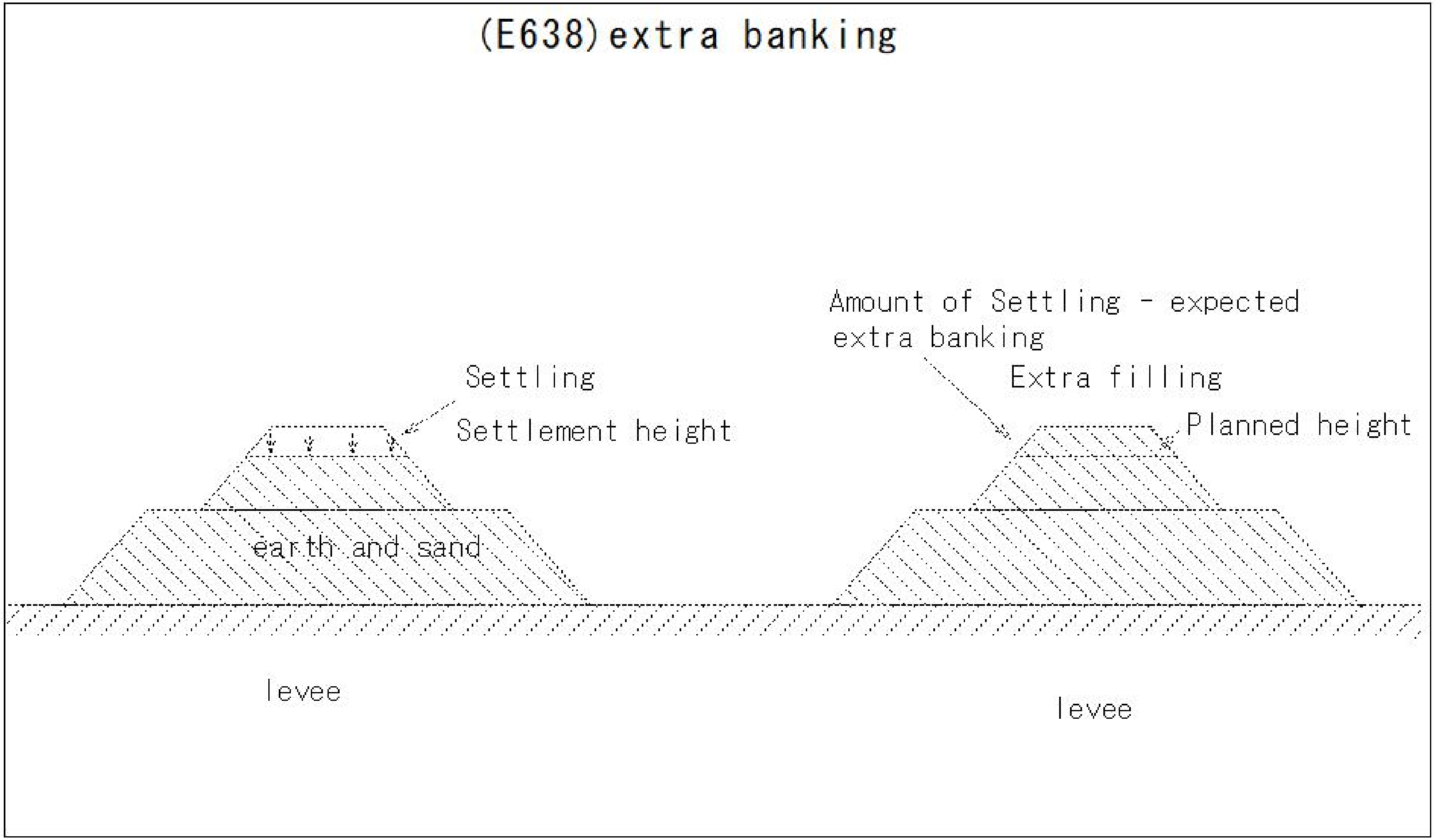
(E636)landslide control works



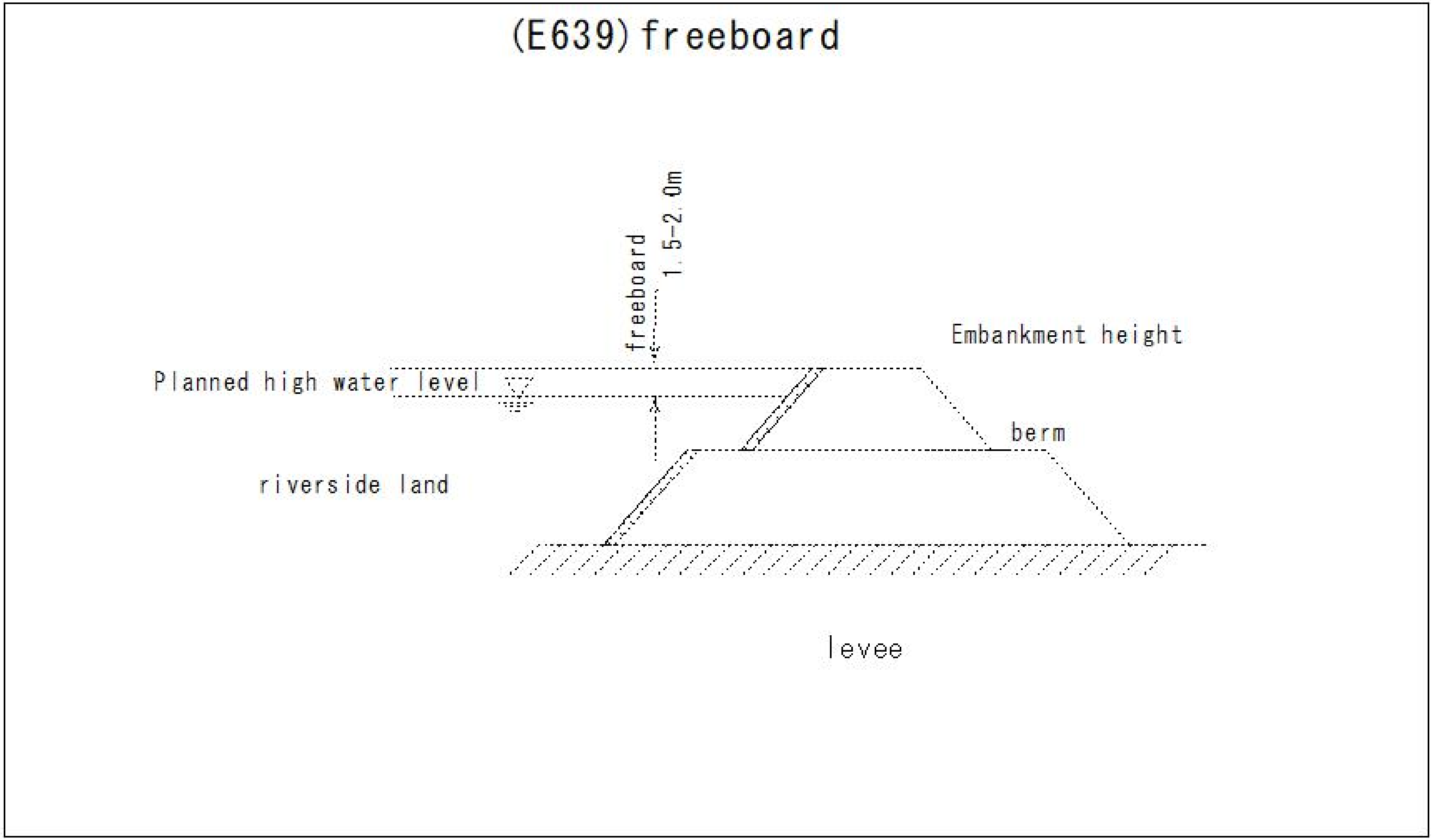
(E637)quarter crossing joint



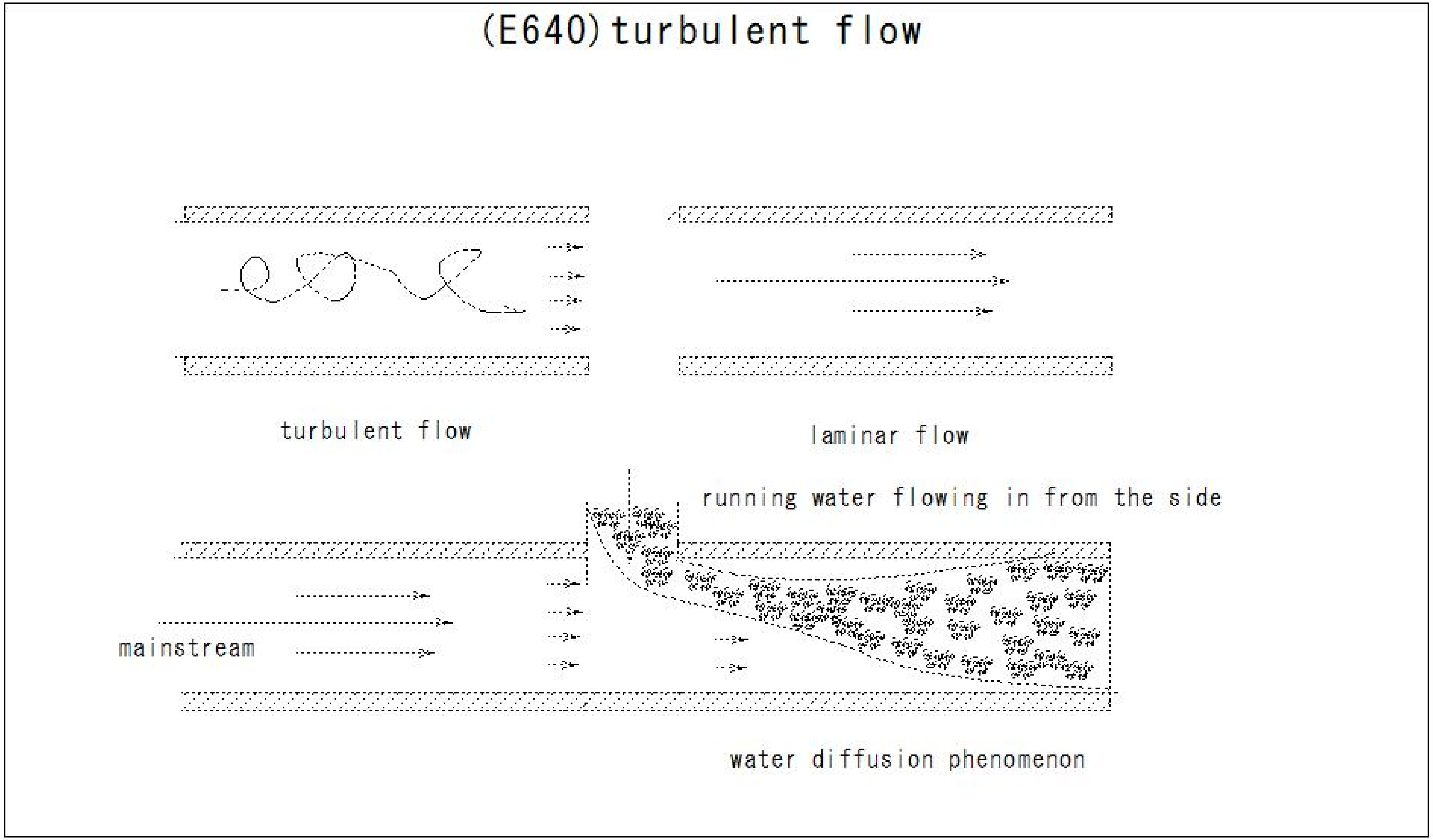
(E638)extra banking



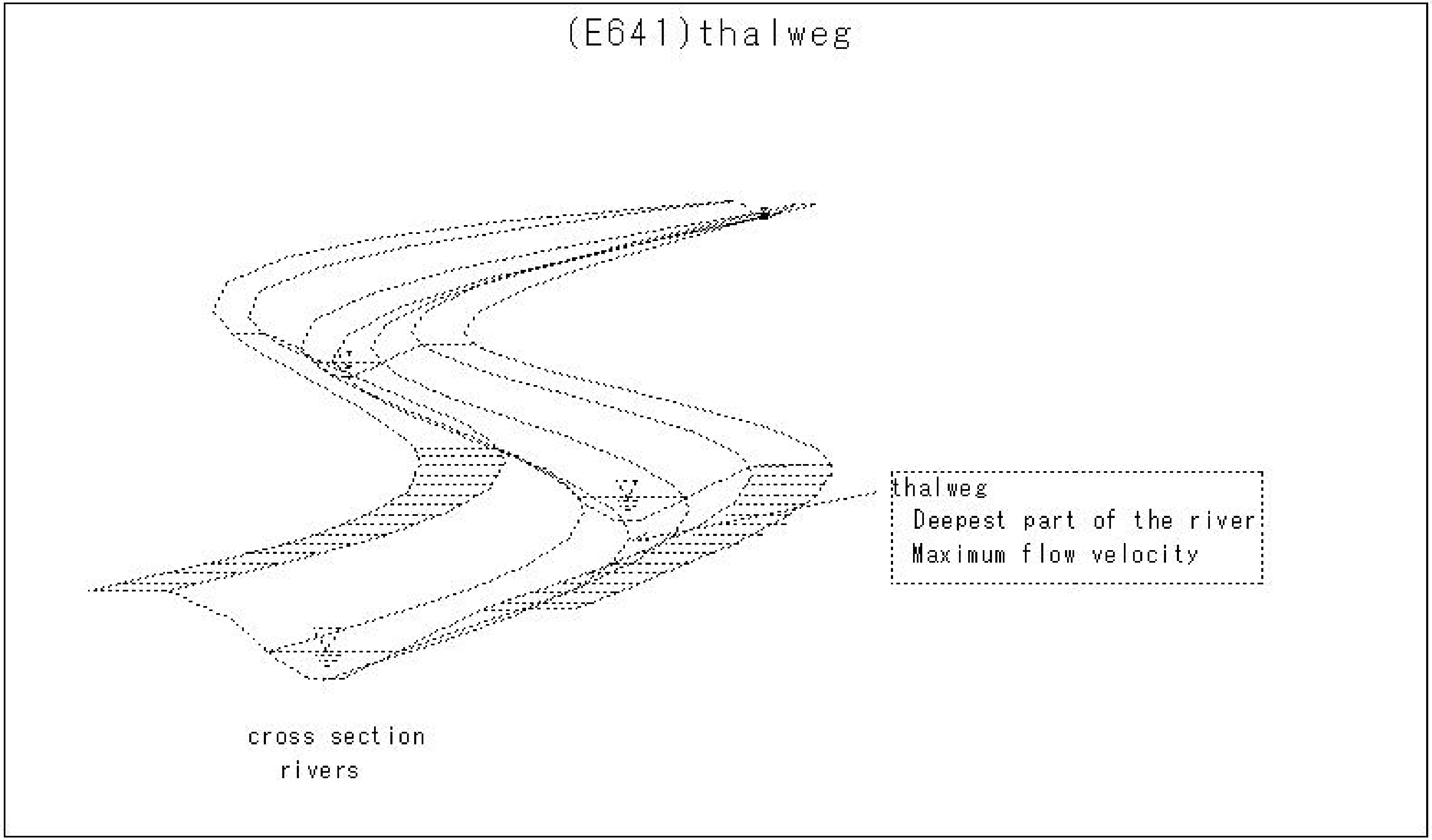
(E639)freeboard



(E640)turbulent flow



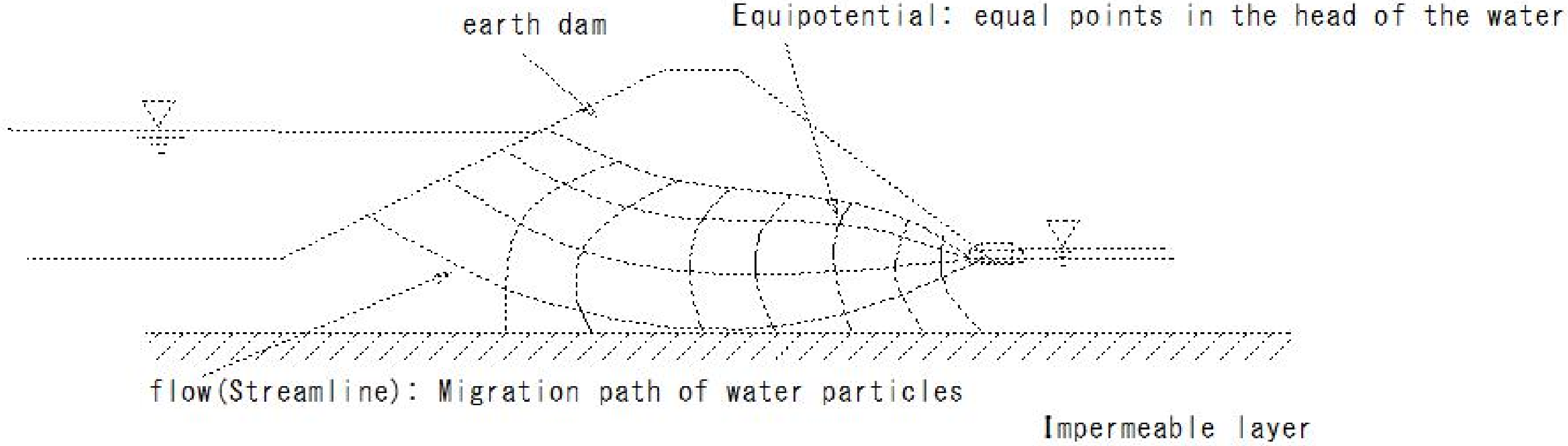
(E641)thalweg



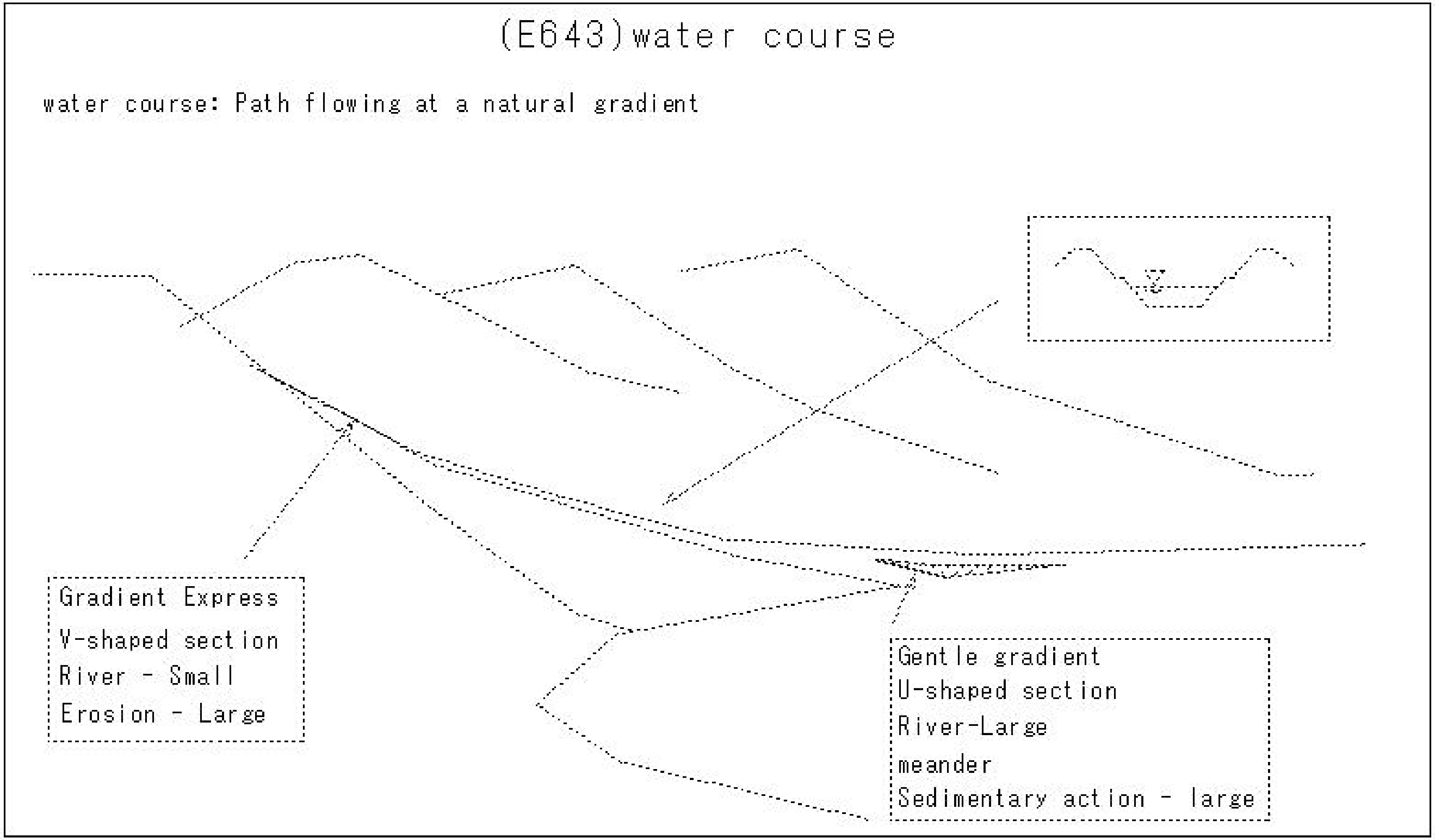
(E642)flow net

(E642)flow net

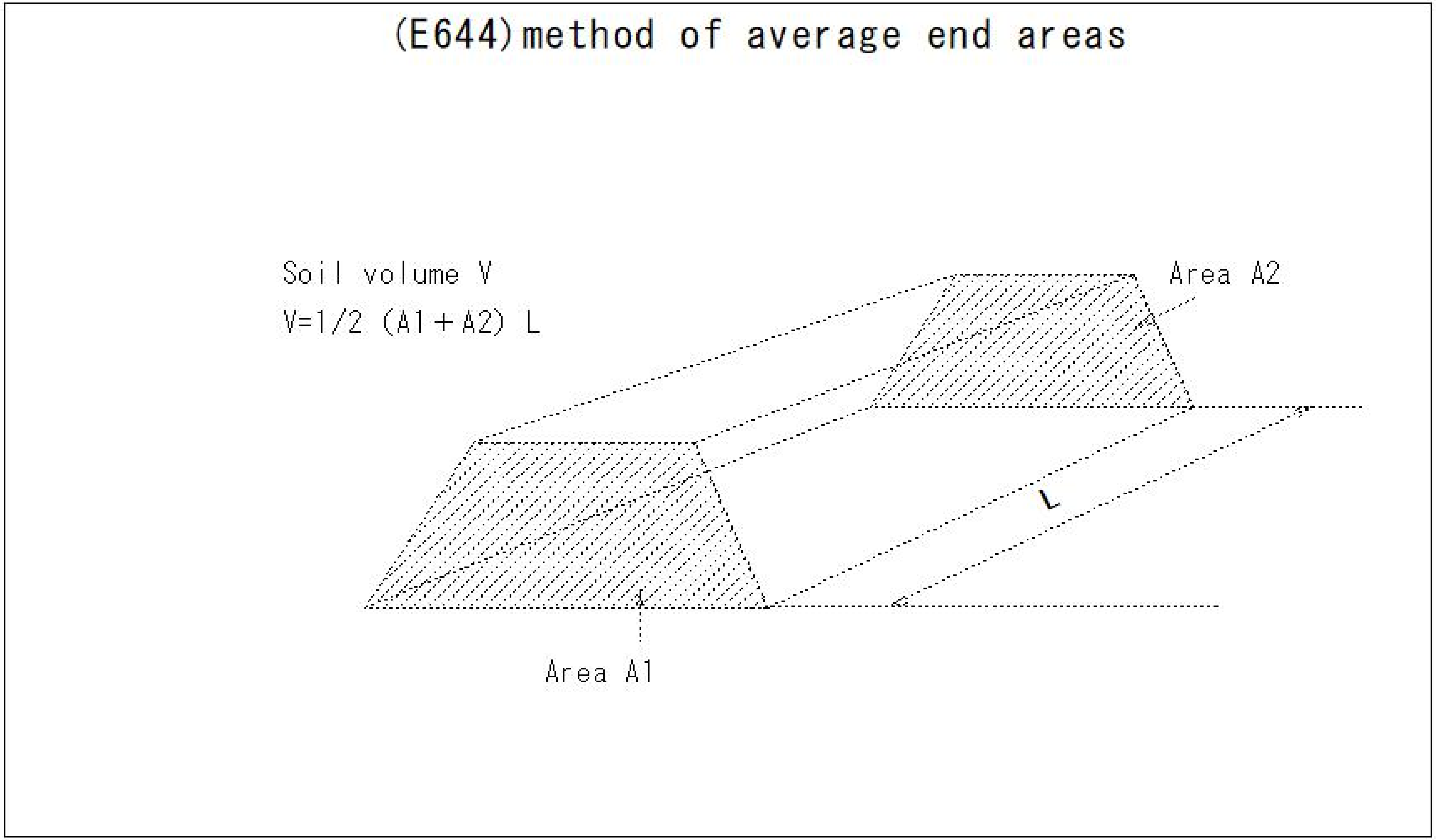
flow net



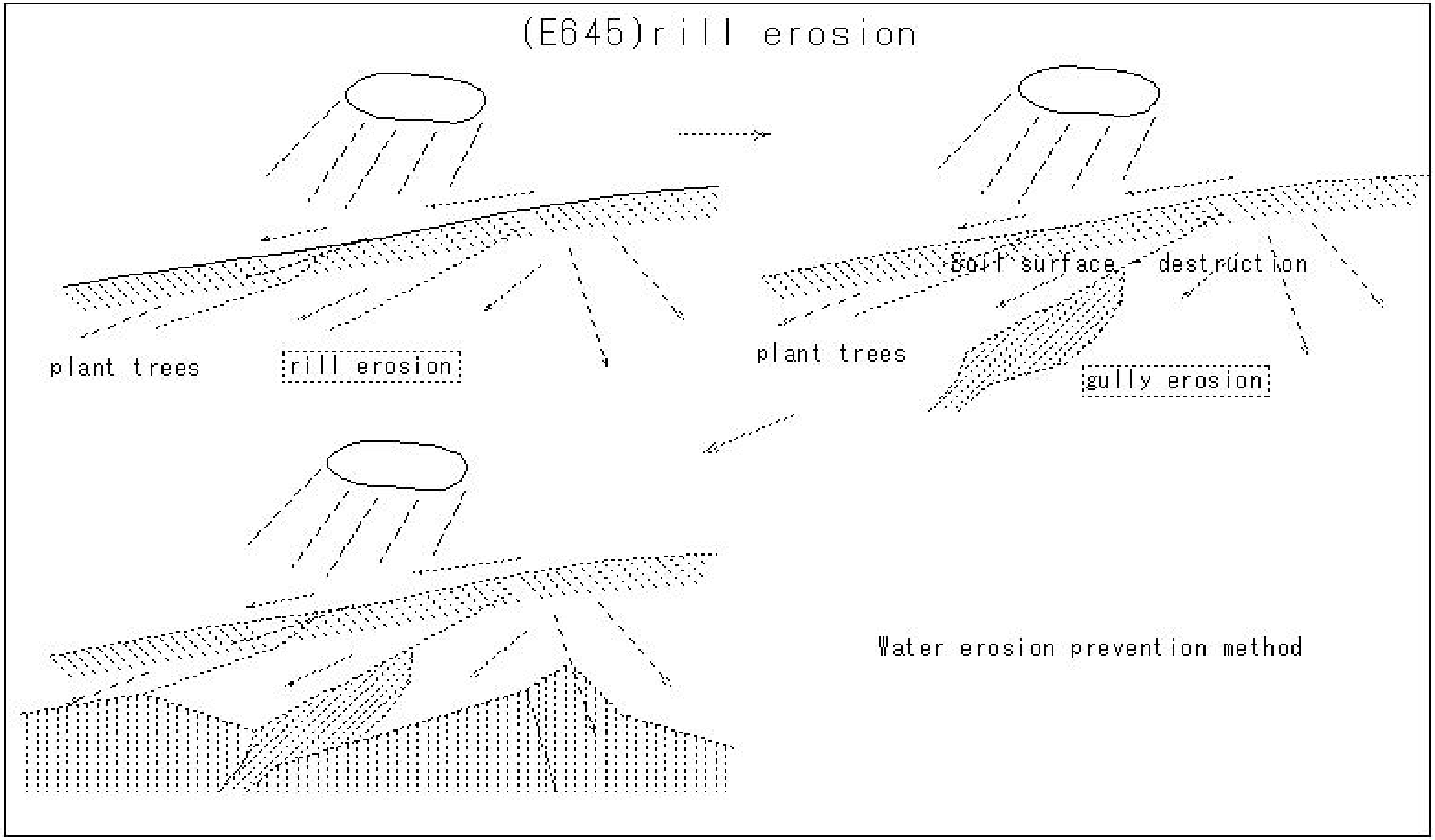
(E643)water course



(E644)method of average end areas

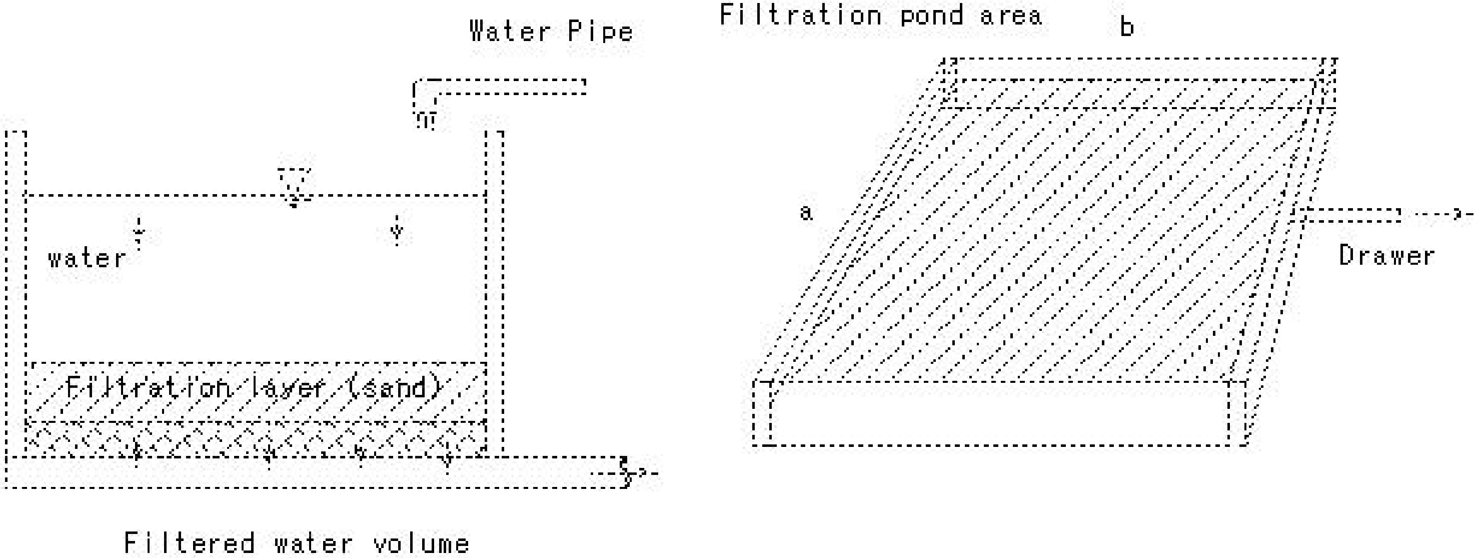


(E645)rill erosion



(E646)rate of filtration

(E646)rate of filtration



rate of filtration

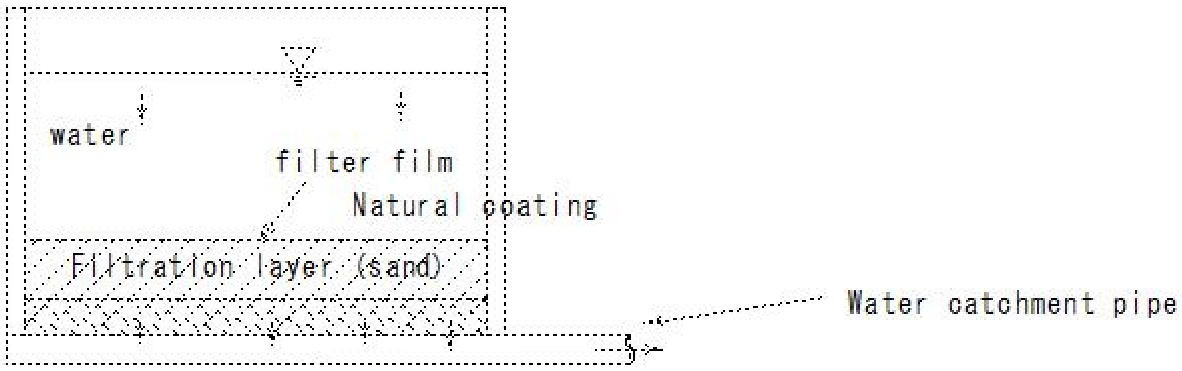
Unit: m3/day

rate of filtration=Daily filtration rate／Filtration pond area=Q/ab(m3/day)

(E647)filter film

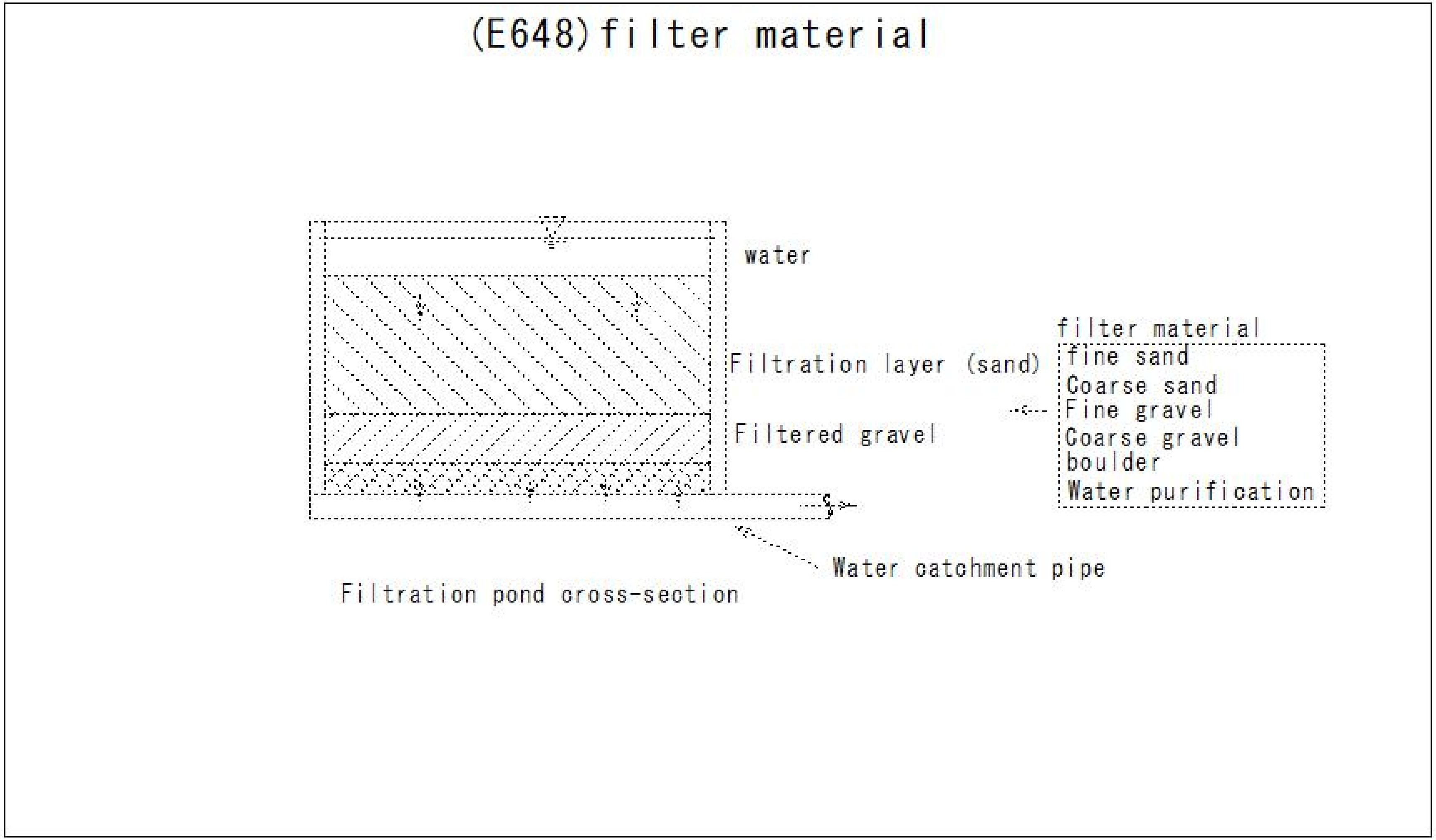
(E647)filter film

filter film

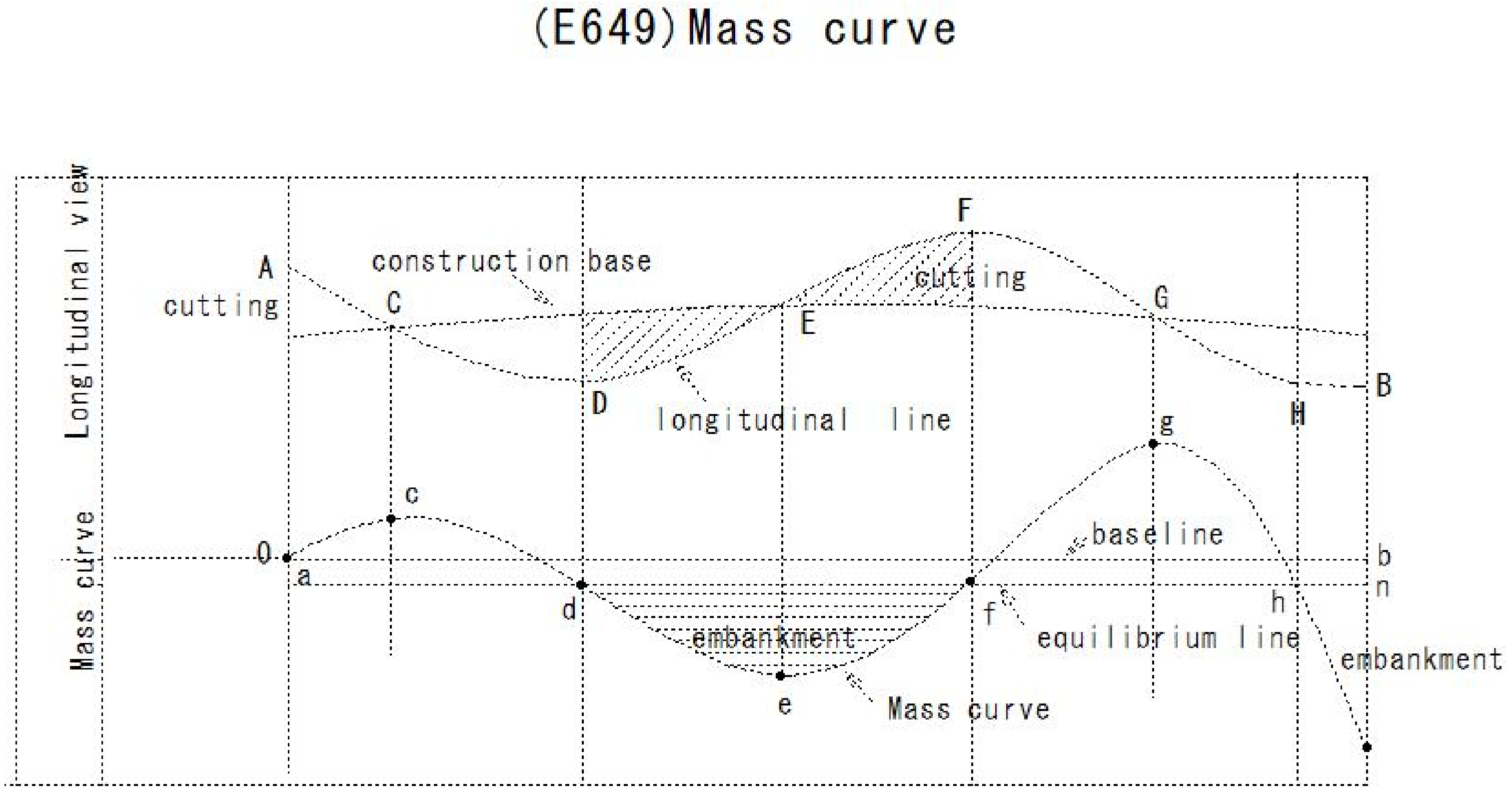


Filtration pond cross-section

(E648)filter material



(E649)Mass curve



Volume distribution for cutting and embankment
soil volume equilibrium
Consider transportation distance

(E650)diversion filling