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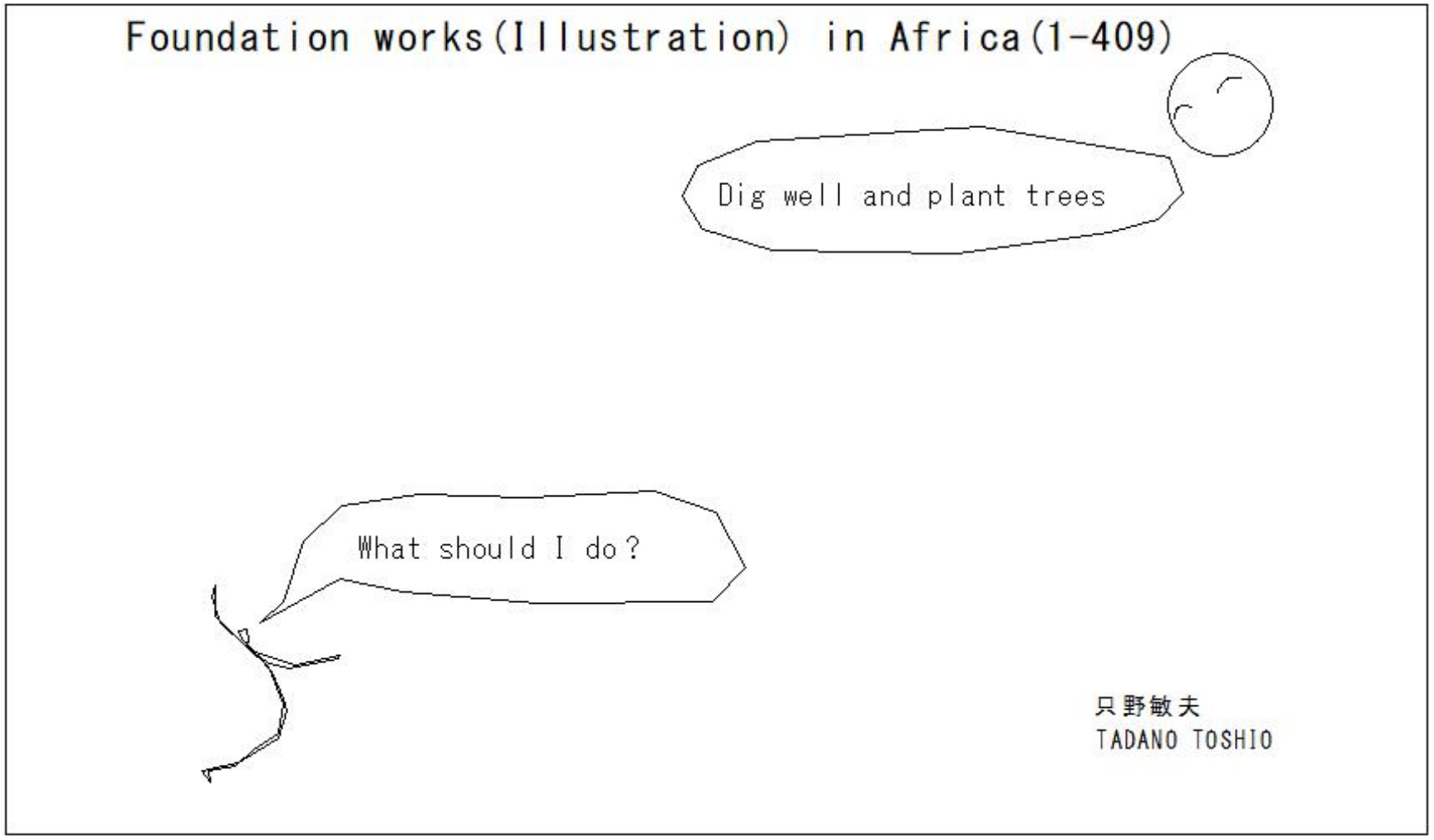

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388 (F388)Foundation work-pile foundation-caisson foundation	caisson foundation
389 (F389)Earth retaining wall	Earth retaining wall
390 (F390)Earth retaining work-Steel sheet pile work	Earth retaining work-Steel sheet pile work
391 (F391)Earth retaining work-Earth anchor method	Earth anchor method
392 (F392)heaving	heaving
393 (F393)Boiling	Boiling
394 (F394)Ground improvement work	Ground improvement work
395 (F395)Ground improvement work-Vibroflotation method	Vibroflotation method
396 (F396)Ground improvement work-Vibro Composer method	Vibro Composer method
397 (F397)Ground improvement work-Sand compaction method	Sand compaction method
398 (F398)Ground improvement work-Preloading method	Preloading method
399 (F399)Ground improvement work-Sand drain method	Sand drain method
400 (F400)Ground improvement work-Paper drain method	Paper drain method
401 (F401)spread foundation：direct foundation	spread foundation：direct foundation
402 (F402)spread foundation-direct foundation	spread foundation-direct foundation
403 (F403)classification of pile foundation work	pile foundation work
404 (F404)cast-in-place pile Benoto method	Benoto method
405 (F405)cast-in-place pile Earth drill method	Earth drill method
406 (F406)cast-in-place pile Reverse construction method	Reverse construction method
407 (F407)cast-in-place pile Open caisson construction method	Open caisson construction method
408 (F408)cast-in-place pile pneumatic caisson	pneumatic caisson

409 (F409)Foundation construction machinery(Pedestal method)

Pedestal method

218 (F218)air lock	air lock
345 (F345)all casing excavator	all casing excavator
222 (F222)all casing method	all casing method
237 (F237)allowable bearing capacity	allowable bearing capacity
213 (F213)anchor bolt	anchor bolt
320 (F320)anchor method	anchor method
137 (F137)Underground structure(Anchor type of earth retaining works)	Anchor type of earth retaining works
269 (F269)anchor wall / anchor rod	anchor wall / anchor rod
270 (F270)backfill	backfill
250 (F250)base drawing	base drawing
257 (F257)base stone	base stone
292 (F292)battered pile	battered pile
289 (F289)bearing layer	bearing layer
235 (F235)bearing pile	bearing pile
288 (F288)bearing pile	bearing pile
48 (F48)pile foundation-(Construction management of Benoto Earth Drill Reverse Method)	Benoto Earth Drill Reverse Method
44 (F44)pile foundation-(Benoto method)	Benoto method
105 (F105)cast-in-place pile(Benoto method)	Benoto method
114 (F114)Foundation construction machinery(Benoto method)	Benoto method
193 (F193)cast-in-place pile(Benoto method)	Benoto method
404 (F404)cast-in-place pile Benoto method	Benoto method
189 (F189)cast-in-place pile(Benoto method: All casing method)	Benoto method: All casing method
378 (F378)Benoto method:All casing construction method	Benoto method:All casing construction method
316 (F316)benoto method:open:all casing method	benoto method:open:all casing method
349 (F349)cast in place concrete-Benoto pile	Benoto pile
49 (F49)pile foundation-(Construction management of Benoto piles)	Benoto piles
50 (F50)pile foundation-(Benoto piles Slime processing)	Benoto piles
373 (F373)cast-in-place concrete- bentonite solution	bentonite solution
265 (F265)bituminous membrane water proofing	bituminous membrane water proofing
366 (F366)block masonry-hard vinyl chloride pipe	block masonry-hard vinyl chloride pipe
78 (F78)foundation-Temporary closing(Boiling)	Boiling
165 (F165)Earth retaining work(boiling)	boiling
393 (F393)Boiling	Boiling
245 (F245)boulders stratum	boulders stratum

226 (F226)broken stone	broken stone
227 (F227)broken stone foundation	broken stone foundation
279 (F279)Bulb pile Pedestal pile	Bulb pile Pedestal pile
285 (F285)caisson	caisson
231 (F231)Caisson foundation	Caisson foundation
3 (F3)Foundation work-Caisson foundation	Caisson foundation
53 (F53)pile foundation-(caisson foundation)	caisson foundation
54 (F54)pile foundation-(caisson foundation)	caisson foundation
55 (F55)pile foundation-(caisson foundation)	caisson foundation
56 (F56)pile foundation-(caisson foundation)	caisson foundation
57 (F57)pile foundation-(caisson foundation)	caisson foundation
58 (F58)pile foundation-(pneumatic caisson)	caisson foundation
59 (F59)pile foundation-(pneumatic caisson)	caisson foundation
60 (F60)pile foundation-(pneumatic caisson)	caisson foundation
61 (F61)pile foundation-(pneumatic caisson)	caisson foundation
62 (F62)pile foundation-(Comparison of open caisson and pneumatic caisson)	caisson foundation
153 (F153)Types of foundation work(caisson foundation)	caisson foundation
388 (F388)Foundation work-pile foundation-caisson foundation	caisson foundation
217 (F217)caisson foundation	caisson foundation
204 (F204)Caisson foundation with legs	Caisson foundation with legs
230 (F230)Caisson Fundation	Caisson Fundation
293 (F293)cantilever sheet pile	cantilever sheet pile
277 (F277)card-board-drain method	card-board-drain method
229 (F229)casing	casing
365 (F365)casing tube	casing tube
309 (F309)cast in place concrete	cast in place concrete
348 (F348)cast in place concrete	cast in place concrete
387 (F387)Foundation work-pile foundation-cast in place pile	cast in place pile
42 (F42)pile foundation-(cast-in-place pile)	cast-in-place pile
197 (F197)cast-in-place pile	cast-in-place pile
200 (F200)cast-in-place pile	cast-in-place pile
152 (F152)Types of foundation work(cast-in-place pile foundation)	cast-in-place pile foundation
381 (F381)Foundation work-(Ready-made pile foundation)-Cast-in-place pile foundation	Cast-in-place pile foundation
21 (F21)Foundation work-Cast-in-place pile method	Cast-in-place pile method

111 (F111)Foundation construction machinery(Cast-in-place piles)	Cast-in-place piles
219 (F219)circle of influence	circle of influence
16 (F16)Foundation work-Classification of piles	Classification of piles
202 (F202)Sheet pile type foundation work(closing steel sheet pile method)	closing steel sheet pile method
291 (F291)compaction pile	compaction pile
262 (F262)comparative base line	comparative base line
19 (F19)Foundation work-composite pile	composite pile
286 (F286)composite pile	composite pile
234 (F234)composer method	compozer method
91 (F91)Foundation work-(concrete continuous underground wall)	concrete continuous underground wall
142 (F142)Open cut method(concrete continuous underground wall)	concrete continuous underground wall
113 (F113)Foundation construction machinery(concrete piles)	concrete piles
274 (F274)cone penetration test	cone penetration test
47 (F47)pile foundation-(Construction management of cast-in-place piles)	Construction management
65 (F65)pile foundation-(continuous underground wall)	continuous underground wall
73 (F73)foundation-Temporary closing - gravity type(Corrugated cell)	Corrugated cell
364 (F364)crawler crane	crawler crane
360 (F360)curtain grout	curtain grout
43 (F43)pile foundation-(Deep foundation)	Deep foundation
384 (F384)Foundation work-Deep foundation	Deep foundation
104 (F104)Construction plan for piles and caissons-cast-in-place pile(Deep foundation method)	Deep foundation method
192 (F192)cast-in-place pile(Deep foundation method)	Deep foundation method
196 (F196)cast-in-place pile(Deep foundation method)	Deep foundation method
370 (F370)deep foundation method	deep foundation method
95 (F95)Foundation work-Drainage method(Deep well method)	Deep well method
96 (F96)Foundation work-Drainage method(Deep well vacuum construction method)	Deep well vacuum construction method
145 (F145)Open cut method(Deep well: sandy soil)	Deep well: sandy soil
306 (F306)depth of footing	depth of footing
278 (F278)depth of foundation	depth of foundation
247 (F247)diaphragm wall	diaphragm wall
30 (F30)pile foundation-Driving ready-made piles-Diesel hammer	Diesel hammer
100 (F100)Construction plan for piles and caissons(Diesel hammer)	Diesel hammer
180 (F180)foundation work(diesel hammer)	diesel hammer
150 (F150)Types of foundation work(direct foundation)	direct foundation

166 (F166)foundation work(direct foundation)	direct foundation
167 (F167)foundation work(direct foundation)	direct foundation
168 (F168)foundation work(direct foundation)	direct foundation
169 (F169)foundation work(direct foundation)	direct foundation
170 (F170)foundation work(direct foundation)	direct foundation
171 (F171)foundation work(direct foundation)	direct foundation
385 (F385)Foundation work-direct foundation	direct foundation
8 (F8)Foundation work-Direct foundation (spread foundation)stabilization	Direct foundation (spread foundation)
9 (F9)Foundation work-Stability to supporting ground Direct foundation (spread foundation)stabilization	Direct foundation (spread foundation)
10 (F10)Foundation work-Stability to supporting ground Direct foundation (spread foundation)stabilization	Direct foundation (spread foundation)
11 (F11)Foundation work-Stability to supporting ground Direct foundation (spread foundation)stabilization	Direct foundation (spread foundation)
12 (F12)Foundation work-Stability to supporting ground Direct foundation (spread foundation)stabilization	Direct foundation (spread foundation)
240 (F240)dowel works:Deep foundation method	dowel works:Deep foundation method
307 (F307)drain	drain
304 (F304)drain paper	drain paper
98 (F98)Foundation work-(Drainage method)	Drainage method
260 (F260)drainage method	drainage method
308 (F308)drainage path	drainage path
29 (F29)pile foundation-Driving ready-made piles-Drop hammer	Drop hammer
99 (F99)Construction plan for piles and caissons(Drop hammer)	Drop hammer
182 (F182)foundation work(drop hammer)	drop hammer
254 (F254)drop hammer	drop hammer
299 (F299)dutch cone	dutch cone
351 (F351)earth anchor	earth anchor
391 (F391)Earth retaining work-Earth anchor method	Earth anchor method
117 (F117)Foundation construction machinery(Earth auger method)	Earth auger method
347 (F347)earth drill	earth drill
51 (F51)pile foundation-(Earth drill method Treatment of hole walls)	Earth drill
45 (F45)pile foundation-(Earth drill method)	Earth drill method
106 (F106)cast-in-place pile(Earth drill method)	Earth drill method
115 (F115)Foundation construction machinery(Earth drill method)	Earth drill method
190 (F190)cast-in-place pile(Earth drill method)	Earth drill method
194 (F194)cast-in-place pile(Earth drill method)	Earth drill method
212 (F212)earth drill method	earth drill method

267 (F267)earth drill method	earth drill method
352 (F352)Earth drill method	Earth drill method
405 (F405)cast-in-place pile Earth drill method	Earth drill method
303 (F303)earth retaining wall	earth retaining wall
389 (F389)Earth retaining wall	Earth retaining wall
159 (F159)Earth retaining work	Earth retaining work
342 (F342)Earth retaining work	Earth retaining work
367 (F367)Earth retaining work-Active earth pressure-passive earth pressure	Earth retaining work
163 (F163)Earth retaining work(earth anchor)	Earth retaining work(earth anchor)
162 (F162)Earth retaining work(tie rods)	Earth retaining work(tie rods)
390 (F390)Earth retaining work-Steel sheet pile work	Earth retaining work-Steel sheet pile work
301 (F301)electric resistivity survey	electric resistivity survey
97 (F97)Foundation work-Drainage method(Electropenetration method)	Electropenetration method
302 (F302)equipotential line	equipotential line
319 (F319)extra banking	extra banking
112 (F112)Foundation construction machinery(Features of steel piles)	Features of steel piles
264 (F264)footing	footing
350 (F350)footing foundation	footing foundation
311 (F311)footing foundation Independent footing foundation	footing foundation
312 (F312)footing foundation Composite footing foundation	footing foundation
313 (F313)footing foundation Continuous footing foundation	footing foundation
314 (F314)footing foundation mat foundation	footing foundation
261 (F261)foundation	foundation
147 (F147)Types of foundation work	foundation work
148 (F148)Types of foundation work	foundation work
149 (F149)Types of foundation work	foundation work
224 (F224)Foundation work	Foundation work
251 (F251)foundation work	foundation work
4 (F4)Foundation work plan	Foundation work
5 (F5)Foundation work-Survey for foundation work plan	Foundation work plan
6 (F6)Foundation work-Considerations during designing foundations	Foundation work plan
7 (F7)Foundation work-Types of foundation work	Foundation work plan
266 (F266)friction pile	friction pile
22 (F22)Foundation work-Classification by support method(friction pile Bearing pile)	friction pile Bearing pile

338 (F338)geotextile-Embankment drainage reinforcement	geotextile
339 (F339)geotextile-Separation of different materials	geotextile
340 (F340)geotextile- Reinforcement of ground, roadbed, etc.	geotextile
341 (F341)geotextile- Preventing suction of earth and sand	geotextile
394 (F394)Ground improvement work	Ground improvement work
228 (F228)group of piles	group of piles
284 (F284)group of piles	group of piles
327 (F327)grouting	grouting
79 (F79)foundation-Temporary closing(Heaving)	Heaving
164 (F164)Earth retaining work(heaving)	heaving
310 (F310)heaving	heaving
392 (F392)heaving	heaving
34 (F34)pile foundation-(Hollow excavation pile method/Prefabricated pile)	Hollow excavation pile method
255 (F255)Hollow excavation pile method	Hollow excavation pile method
220 (F220)H-section steel pile	H-section steel pile
36 (F36)pile foundation-(Hydraulic hammer press-in method)	Hydraulic hammer press-in method
216 (F216)ICOS method	ICOS method
125 (F125)Underground structure(Immersed tunnel method)	Immersed tunnel method
238 (F238)impregnation method of ground	impregnation method of ground
273 (F273)influence circle R	influence circle R
155 (F155)Types of foundation work(investigation)	investigation
87 (F87)Foundation work-(Island construction method)	Island construction method
138 (F138)Underground structure(Island construction method of earth retaining works)	Island construction method
211 (F211)island cut method	island cut method
35 (F35)pile foundation-(Jet method)	Jet method
185 (F185)foundation work(Jet method: injection)	Jet method: injection
241 (F241)leaving concrete	leaving concrete
243 (F243)lime pile	lime pile
102 (F102)Construction plan for piles and caissons(Long pre-fabricated piles)	Long pre-fabricated piles
161 (F161)Earth retaining work(Main piles horizontal sheet pile timbering)	Main piles horizontal sheet pile timbering
221 (F221)main rope	main rope
358 (F358)masonry	masonry
363 (F363)masonry	masonry
215 (F215)mat foundation	mat foundation

380 (F380)Foundation work-mat foundation-Spread foundation	mat foundation-Spread foundation
383 (F383)Foundation work-Shallow foundation-mat foundation-Spread foundation	mat foundation-Spread foundation
37 (F37)pile foundation-(Milk injection method)	Milk injection method
126 (F126)Underground structure(Mountain tunnel construction method)	Mountain tunnel construction method
205 (F205)multi-column foundation	multi-column foundation
259 (F259)negative friction	negative friction
276 (F276)observation well	observation well
330 (F330)open caisson	open caisson
355 (F355)caisson excavation workng foundation-open caisson	open caisson
407 (F407)cast-in-place pile Open caisson construction method	Open caisson construction method
108 (F108)cast-in-place pile(Open caisson foundation)	Open caisson foundation
198 (F198)cast-in-place pile(open caisson foundation)	open caisson foundation
275 (F275)open -caisson method	open -caisson method
382 (F382)Foundation work-open caisson-pneumatic caisson	open caisson-pneumatic caisson
131 (F131)Underground structure(Open cut method)	Open cut method
132 (F132)Underground structure(Open cut method)	Open cut method
133 (F133)Underground structure(Open cut method)	Open cut method
134 (F134)Underground structure(Open cut method)	Open cut method
239 (F239)open cut method	open cut method
361 (F361) open cut method	open cut method
400 (F400)Ground improvement work-Paper drain method	Paper drain method
27 (F27)pile foundation-treatment of pile head-PC pile	PC pile
409 (F409)Foundation construction machinery(Pedestal method)	Pedestal method
377 (F377)pedestal pile	pedestal pile
258 (F258)penetration	penetration
283 (F283)pile driving frame	pile driving frame
282 (F282)pile driving resistance	pile driving resistance
186 (F186)foundation work(On-site jointing of ready-made piles - Pile cap treatment)	Pile cap treatment
376 (F376)pile driver	pile driver
379 (F379)pile driving	pile driving
23 (F23)pile foundation-Comparison of construction depth	pile foundatio
24 (F24)pile foundation-Standard application of piles	pile foundatio
25 (F25)pile foundation-Standard application of piles	pile foundatio
2 (F2)Foundation work-Pile foundation	Pile foundation

172 (F172)foundation work(pile foundation)	pile foundation
173 (F173)foundation work(pile foundation)	pile foundation
174 (F174)foundation work(pile foundation)	pile foundation
175 (F175)foundation work(pile foundation)	pile foundation
321 (F321)pile foundation	pile foundation
322 (F322)pile foundation	pile foundation
323 (F323)pile foundation	pile foundation
324 (F324)Classification of piles	pile foundation
325 (F325)Functional classification of pile foundations	pile foundation
326 (F326)Geological strata conditions and applicable range of various piles	pile foundation
403 (F403)classification of pile foundation work	pile foundation work
386 (F386)Foundation work-pile foundation-ready made piles	pile foundation-ready made piles
225 (F225)pile-driver	pile-driver
329 (F329)piles group	piles group
40 (F40)pile foundation-(piling)	piling
359 (F359)Piling	Piling
369 (F369)piling	piling
371 (F371)piling	piling
80 (F80)foundation-Temporary closing(Piping)	Piping
244 (F244)plasticity	plasticity
199 (F199)cast-in-place pile(Pneumatic caisson)	Pneumatic caisson
408 (F408)cast-in-place pile pneumatic caisson	pneumatic caisson
109 (F109)cast-in-place pile(Pneumatic caisson construction method)	Pneumatic caisson construction method
357 (F357)pneumatic caisson-air lock	pneumatic caisson-air lock
296 (F296)point bearing pile	point bearing pile
154 (F154)Types of foundation work(points of planning)	points of planning
33 (F33)pile foundation-Driving ready-made piles-(Pre-boring method)	Pre-boring method
64 (F64)pile foundation-(precast well)	precast well
398 (F398)Ground improvement work-Preloading method	Preloading method
184 (F184)foundation work(Press-in method)	Press-in method
52 (F52)pile foundation-(cast-in-place piles Prevention of construction pollution)	Prevention of construction pollution
328 (F328)quicksand	quicksand
81 (F81)foundation-Temporary closing(Quicksand phenomenon)	Quicksand phenomenon
372 (F372)rammer	rammer

26 (F26)pile foundation-treatment of pile head-RC pile	RC pile
188 (F188)On-site joints for ready-made piles(RC pile) - Pile joints	RC pile - Pile joints
18 (F18)Foundation work-RC pile (concrete pile) PC pile	RC pile (concrete pile) PC pile
20 (F20)Foundation work-Ready-made pile construction method	Ready-made pile construction method
151 (F151)Types of foundation work(Ready-made pile foundation)	Ready-made pile foundation
110 (F110)Foundation construction machinery(Ready-made piles)	Ready-made piles
176 (F176)foundation work(ready-made piles)	ready-made piles
177 (F177)foundation work(ready-made piles)	ready-made piles
178 (F178)foundation work(built-in construction method)	ready-made piles
179 (F179)foundation work(Impact construction method for ready-made piles)	ready-made piles
84 (F84)Foundation work-(retaining wall)	retaining wall
85 (F85)Foundation work-(retaining wall)	retaining wall
86 (F86)Foundation work-(retaining wall)	retaining wall
46 (F46)pile foundation-(Reverse circulation method)	Reverse circulation method
116 (F116)Foundation construction machinery(Reverse circulation method)	Reverse circulation method
346 (F346)Reverse circulation method	Reverse circulation method
353 (F353)Reverse circulation methodd	Reverse circulation methodd
82 (F82)Foundation work-cast-in-place pile(Reverse construction method)	Reverse construction method
191 (F191)cast-in-place pile(Reverse construction method)	Reverse construction method
195 (F195)cast-in-place pile(Reverse construction method)	Reverse construction method
406 (F406)cast-in-place pile Reverse construction method	Reverse construction method
107 (F107)cast-in-place pile(Reverse method)	Reverse method
143 (F143)Open cut method(Road lining and excavation)	Road lining
119 (F119)Soil improvement(Sand compaction method/Vibro Composer method)	Sand compaction method
397 (F397)Ground improvement work-Sand compaction method	Sand compaction method
118 (F118)Soil improvement(Sand drain method)	Sand drain method
158 (F158)Soft ground improvement method(Sand drain method)	Sand drain method
232 (F232)sand drain method	sand drain method
331 (F331)sand drain method	sand drain method
399 (F399)Ground improvement work-Sand drain method	Sand drain method
233 (F233)sand pile	sand pile
287 (F287)Sandpile, Sand Drain, Sand Mat	Sandpile, Sand Drain, Sand Mat
290 (F290)settlement of ground	settlement of ground
268 (F268)shallow foundation	shallow foundation

92	(F92)Foundation work-(Drainage method-Shallow sump)	Shallow sump
93	(F93)Foundation work-(Drainage method-Shallow sump)	Shallow sump
297	(F297)shear failure	shear failure
295	(F295)shear stress	shear stress
252	(F252)sheathing work	sheathing work
88	(F88)Foundation work-(Earth retaining work-Sheet pile (wood) earth retaining)	Sheet pile (wood) earth retaining
139	(F139)Underground structure(Open cut method-Sheet pile (wood) earth retaining)	Sheet pile (wood) earth retaining
63	(F63)pile foundation-(sheet pile foundation)	sheet pile foundation
74	(F74)foundation-Temporary closing-sheet pile type(Free-standing type - single sheet pile)	sheet pile type
75	(F75)foundation-Temporary closing-sheet pile type(strut beam type - single/double sheet pile)	sheet pile type
76	(F76)foundation-Temporary closing-sheet pile type(Cell type)	sheet pile type
77	(F77)foundation-Temporary closing	sheet pile type
201	(F201)Sheet pile type foundation work	Sheet pile type foundation work
127	(F127)Underground structure(Shield method)	Shield method
246	(F246)single pile	single pile
294	(F294)sliding surface	sliding surface
156	(F156)Soft ground improvement method	Soft ground improvement method
249	(F249)soil covering	soil covering
332	(F332) Soil stabilization treatment-Runways, roads, etc.-Improvement of roadbed and roadbed	Soil stabilization treatment
333	(F333)Soil stabilization treatment-Soil stabilization treatment-By on-road mixing method-Simple paving of farm roads, parking lots, etc.	Soil stabilization treatment
334	(F334)Soil stabilization treatment-Temporary road for construction-pavement	Soil stabilization treatment
335	(F335)Soil stabilization treatment-Sliding failure of embankment	Soil stabilization treatment
336	(F336)Soil stabilization treatment-Building foundation ground improvement	Soil stabilization treatment
337	(F337)Soil stabilization treatment-Underground dam wall	Soil stabilization treatment
38	(F38)pile foundation-(Soundproof cover)	Soundproof cover
248	(F248)spread foundation	spread foundation
1	(F1)Foundation work-spread foundation Direct basis	spread foundation Direct basis
401	(F401)spread foundation：direct foundation	spread foundation：direct foundation
402	(F402)spread foundation-direct foundation	spread foundation-direct foundation
15	(F15)Foundation work-Stability against falls	Stability against falls
14	(F14)Foundation work-Stability against sliding	Stability against sliding
13	(F13)Foundation work-Stability to supporting ground	Stability to supporting ground
362	(F362)stand	stand
263	(F263)standard penetration test	standard penetration test

181 (F181)foundation work(steam hammer)	steam hammer
31 (F31)pile foundation-Driving ready-made piles-Steam hammer/air hammer	Steam hammer/air hammer
17 (F17)Foundation work-Steel pile	Steel pile
89 (F89)Foundation work-(Steel pile (main pile) horizontal sheet pile earth retaining)	Steel pile (main pile)
140 (F140)Open cut method(Steel pile (main pile) horizontal sheet pile earth retaining)	Steel pile (main pile)
28 (F28)pile foundation-treatment of pile head-steel pipe	steel pipe
187 (F187)foundation work(Steel pipe pile-cap treatment)	Steel pipe pile-cap treatment
90 (F90)Foundation work-(Steel sheet pile earth retaining work)	Steel sheet pile
160 (F160)Earth retaining work(steel sheet pile)	steel sheet pile
141 (F141)Open cut method(Steel sheet pile earth retaining work)	Steel sheet pile earth retaining work
318 (F318)stone field drain	stone field drain
242 (F242)stone levee	stone levee
41 (F41)pile foundation-(Stop piling)	Stop piling
256 (F256)strip footing	strip footing
280 (F280)strut	strut
136 (F136)Underground structure(strut type of earth retaining works)	strut type of earth retaining works
83 (F83)Foundation work-(strut type temporary closing work)	strut type temporary closing work
300 (F300)subsurface dam	subsurface dam
70 (F70)foundation-Temporary closing - gravity type(levee method)	Temporary closing
71 (F71)foundation-Temporary closing - gravity type(Caisson method)	Temporary closing
72 (F72)foundation-Temporary closing - gravity type(Cellular block method)	Temporary closing
203 (F203)Sheet pile type foundation work(Temporary closing steel sheet pile method)	Temporary closing steel sheet pile method
103 (F103)Construction plan for piles and caissons(Test piles)	Test piles
236 (F236)test pit	test pit
298 (F298)tie rod	tie rod
281 (F281)tip of pile	tip of pile
343 (F343)tremie	tremie
374 (F374)cast-in-place concrete- tremie pipe	tremie pipe
305 (F305)trench	trench
253 (F253)trench cut method	trench cut method
344 (F344)trench excavation	trench excavation
135 (F135)Underground structure(Types of earth retaining works)	Types of earth retaining works
315 (F315)under flow water	under flow water
214 (F214)under pinning method	under pinning method

206 (F206)Underground continuous wall foundation	Underground continuous wall foundation
207 (F207)Underground continuous wall foundation	Underground continuous wall foundation
122 (F122)Underground structure	Underground structure
123 (F123)Underground structure	Underground structure
124 (F124)Underground structure	Underground structure
128 (F128)Underground structure	Underground structure
129 (F129)Underground structure	Underground structure
130 (F130)Underground structure	Underground structure
354 (F354)Underpeening method - supporting foundation	Underpeening method
66 (F66)pile foundation-(Underpinning)	Underpinning
67 (F67)pile foundation-(Underpinning)	Underpinning
68 (F68)pile foundation-(Underpinning)	Underpinning
69 (F69)pile foundation-(Underpinning)	Underpinning
208 (F208)Underpinning method	Underpinning method
209 (F209)Underpinning method	Underpinning method
210 (F210)Underpinning method	Underpinning method
183 (F183)foundation work(vibration method)	vibration method
396 (F396)Ground improvement work-Vibro Composer method	Vibro Composer method
32 (F32)pile foundation-Driving ready-made piles-Vibro hammer	Vibro hammer
120 (F120)Soil improvement(vibroflotation method)	vibroflotation method
395 (F395)Ground improvement work-Vibroflotation method	Vibroflotation method
157 (F157)Soft ground improvement method(Vibroflow tension method)	Vibroflow tension method
101 (F101)Construction plan for piles and caissons(Vibrohammer)	Vibrohammer
375 (F375)Vibrohammer method	Vibrohammer method
146 (F146)underground structure(waterproof)	waterproof
368 (F368)wave dissipation block	wave dissipation block
317 (F317)weep drain	weep drain
39 (F39)pile foundation-(Welding)	Welding
356 (F356)well point	well point
144 (F144)Open cut method(Well point construction method)	Well point
94 (F94)Foundation work-Drainage method(Well point construction method)	Well point construction method
121 (F121)Soil improvement(Well point method)	Well point method
271 (F271)wellpoint method	wellpoint method
272 (F272)wellpoint method	wellpoint method

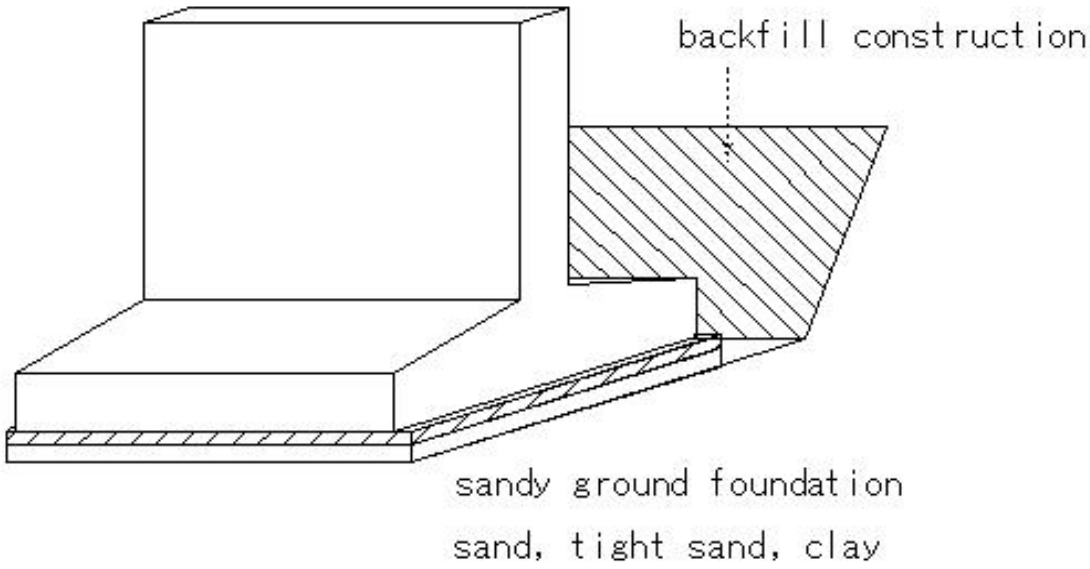
223 (F223)wooden maul

wooden maul

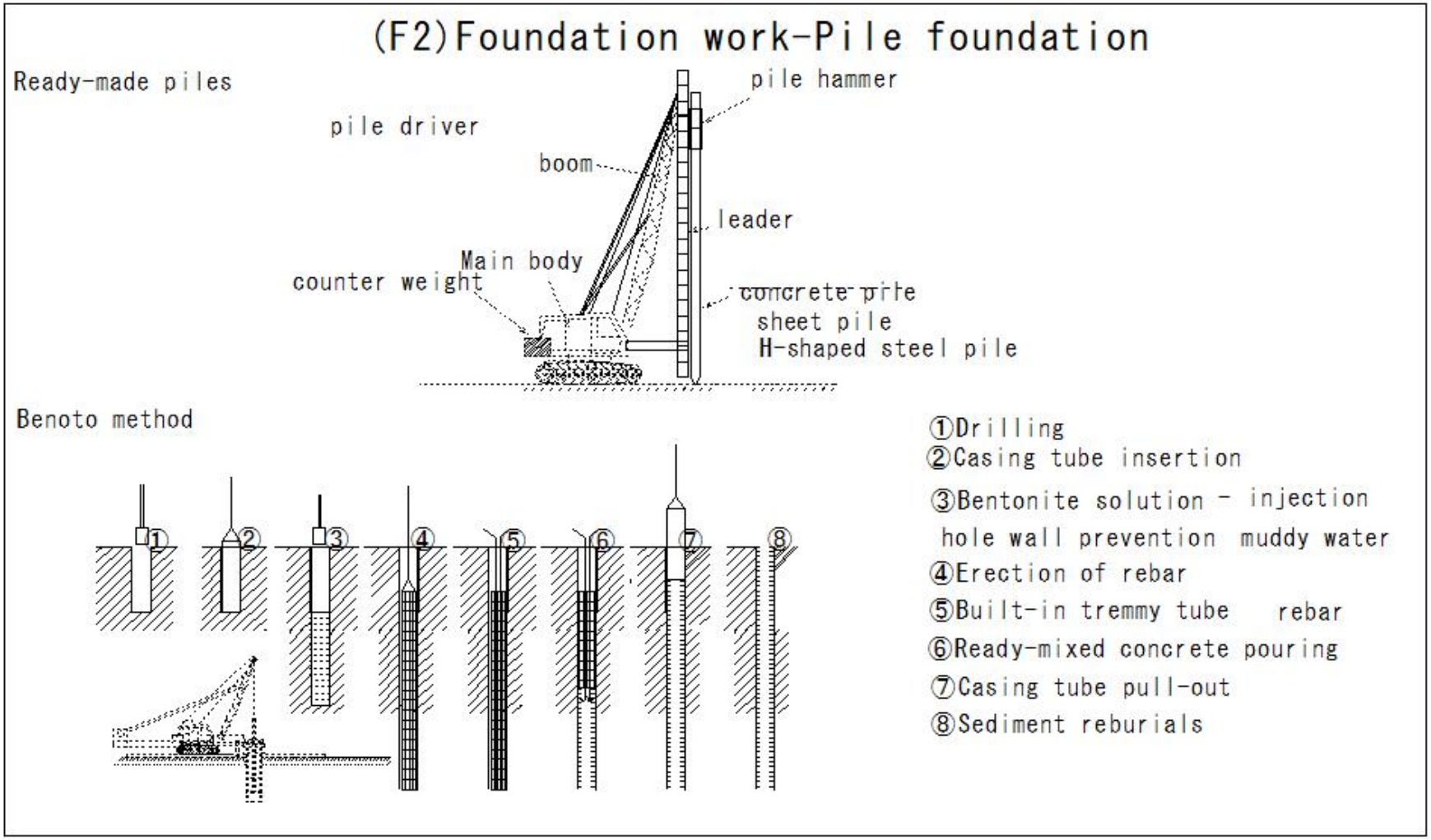
(F1)Foundation work-spread foundation Direct basis

(F1)Foundation work-spread foundation Direct basis

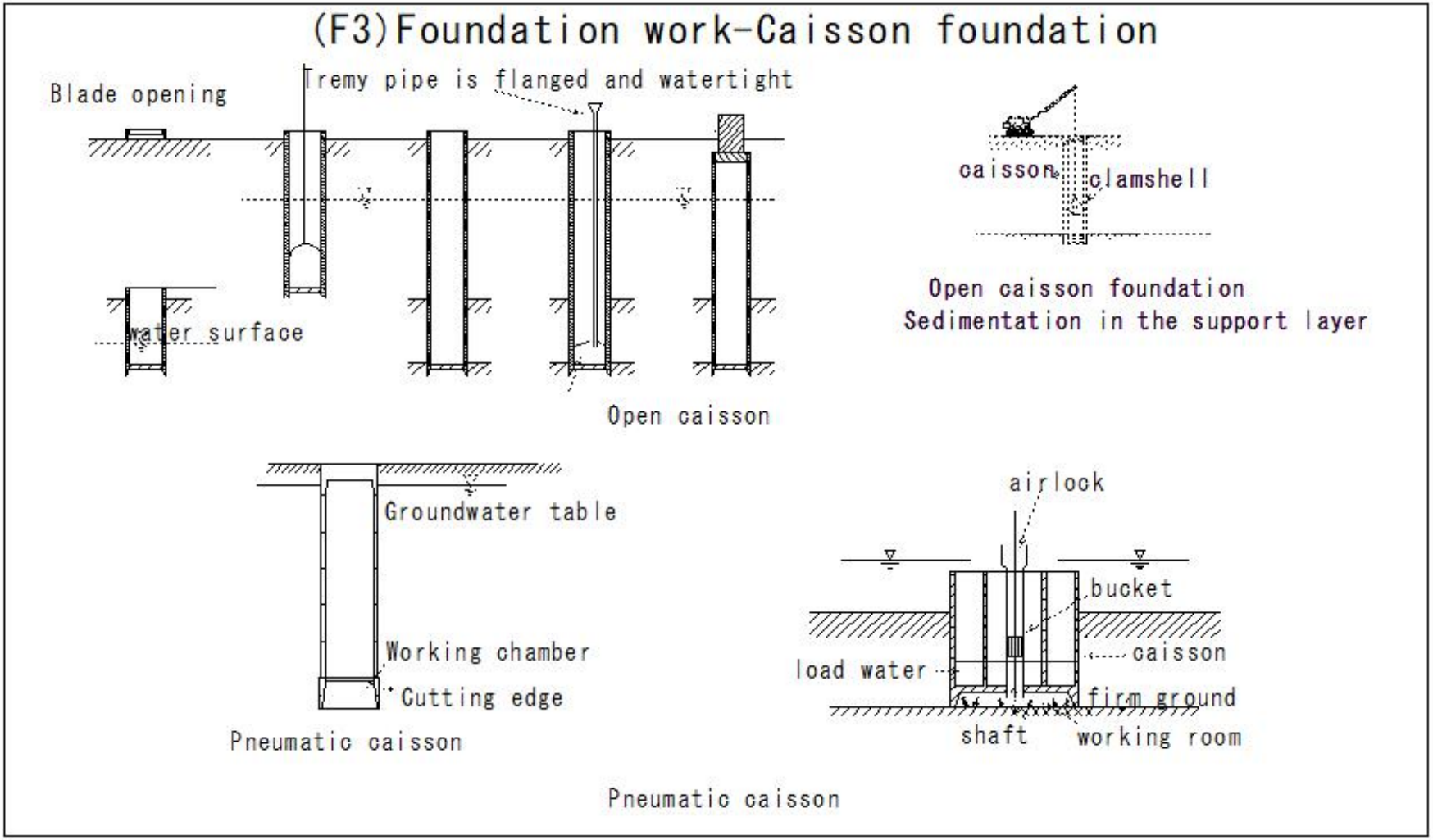
spread foundation:Direct basis



(F2)Foundation work-Pile foundation



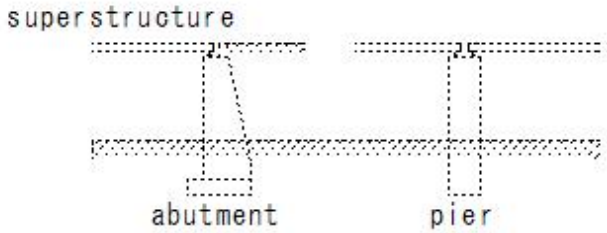
(F3)Foundation work-Caisson foundation

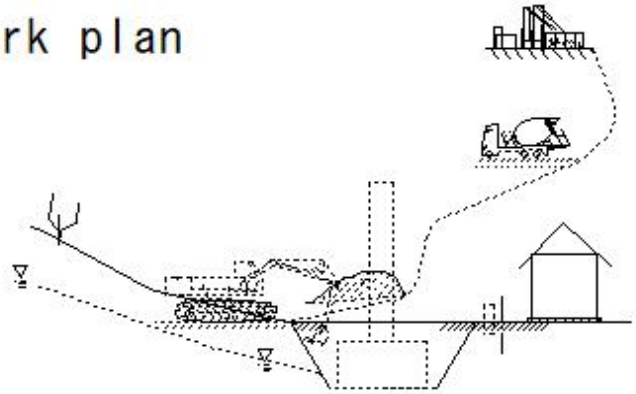


(F4)Foundation work plan

(F4)Foundation work plan

Foundation work plan

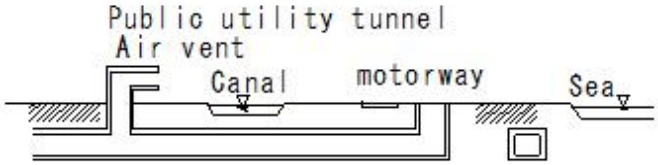


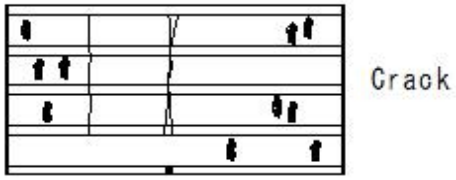


(2) Safe -reliable construction -economic

(4) Environmental harmony

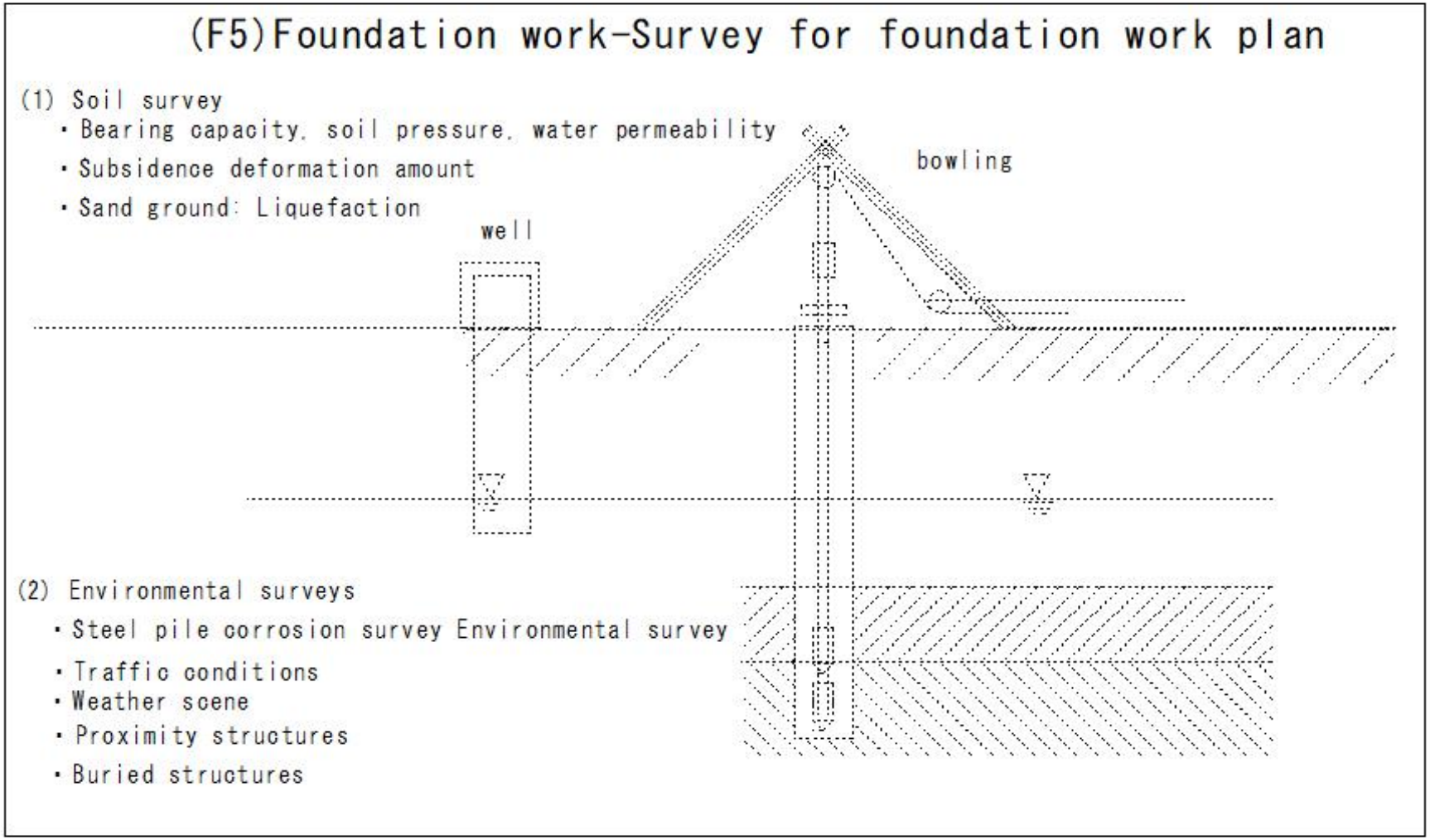
(1) Integrated with the superstructure





(3) Durability, maintenance and repair

(F5)Foundation work-Survey for foundation work plan

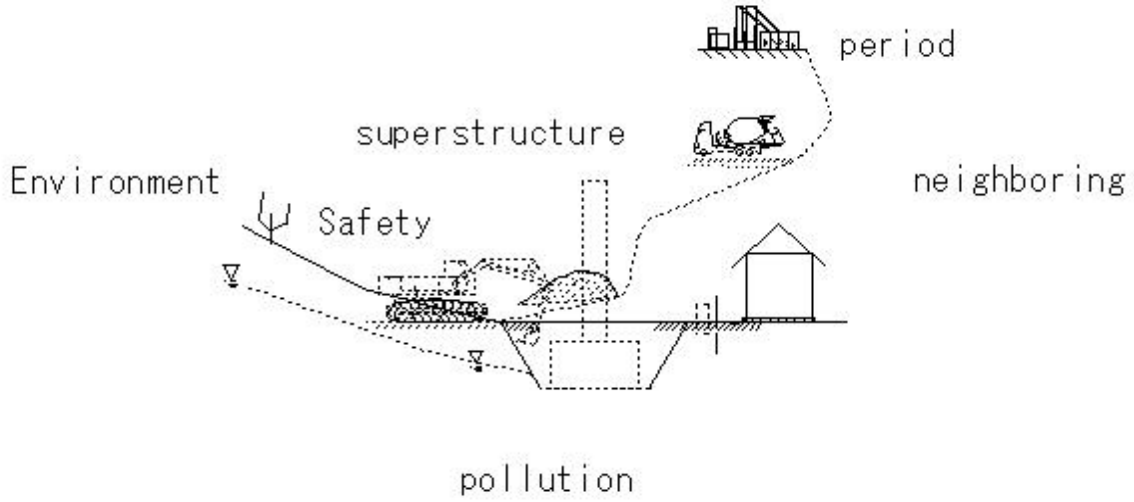


(F6)Foundation work-Considerations during designing foundations

(F6)Foundation work-Considerations during designing foundations

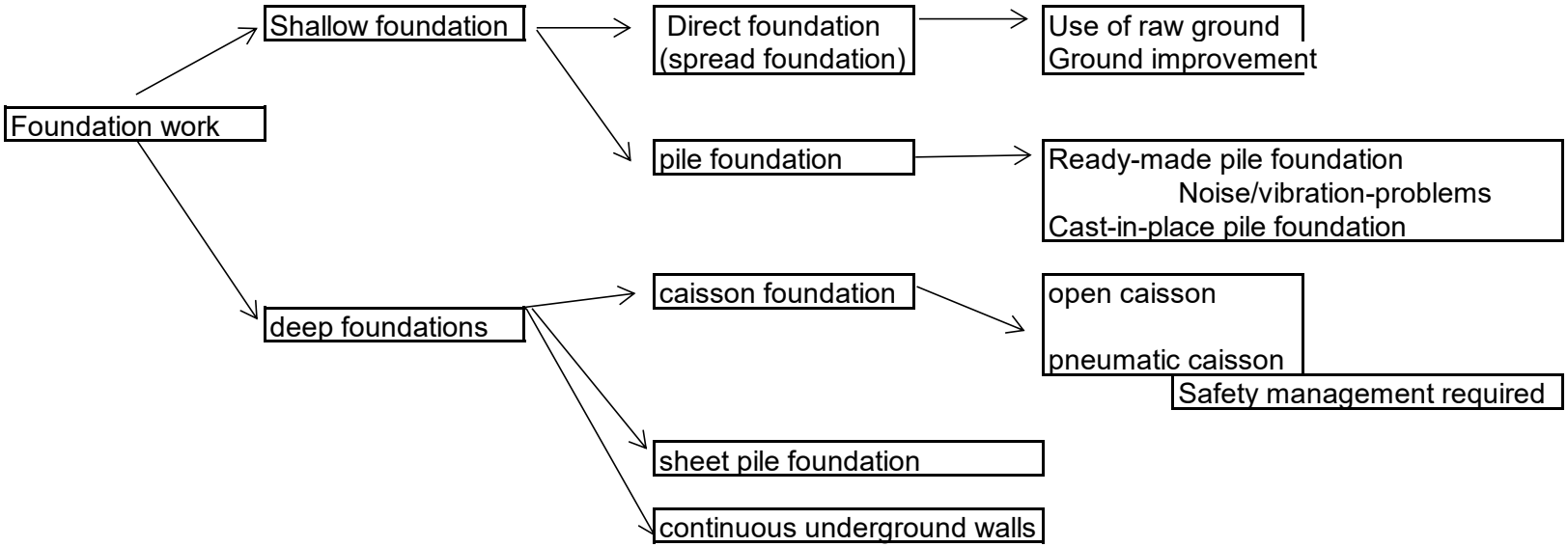
Considerations during designing foundations

(1) Impact on neighboring structures
(2) Prevention of pollution
(3) Construction period
(4) Balance with superstructure
(5) Safety and reliability of construction
(6) Environment



(F7)Foundation work-Types of foundation work

Foundation work-Considerations during designing foundations
Basic construction classification
Types of foundation work

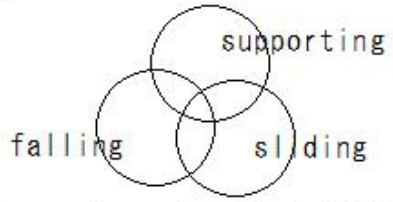


(F8)Foundation work-Direct foundation (spread foundation)stabilization

(F8)Foundation work-Direct foundation (spread foundation)stabilization

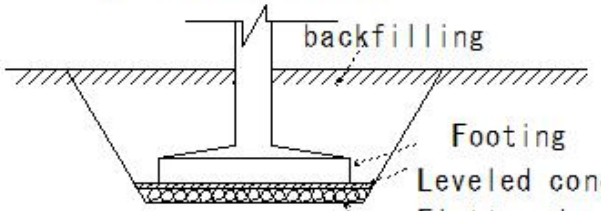
Direct foundation (spread foundation)stabilization

① Stability of supporting ground
② Stability against sliding (sliding)
③ Stability against falling

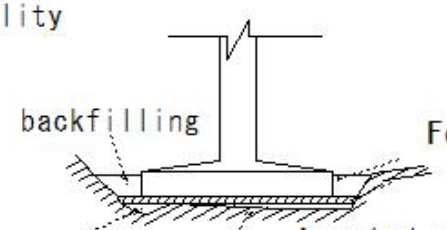


Three elements of stability

Structure excavation
・Normal ground
・Direct foundation



Foundation material (cobble stone/gravel t=200mm)



Replacement concrete
Bedrock surface cleaning

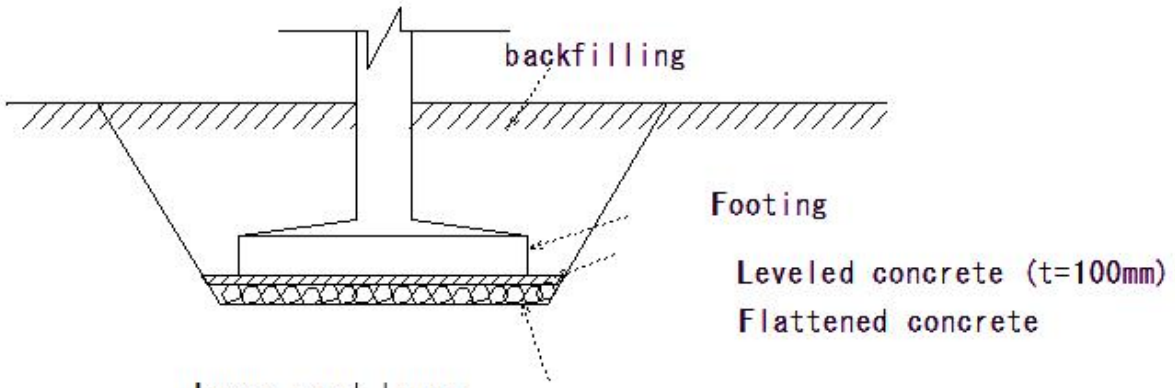
(F9)Foundation work-Stability to supporting ground Direct foundation (spread foundation)stabilization

(F9)Foundation work-Stability to supporting ground Direct foundation (spread foundation)stabilization

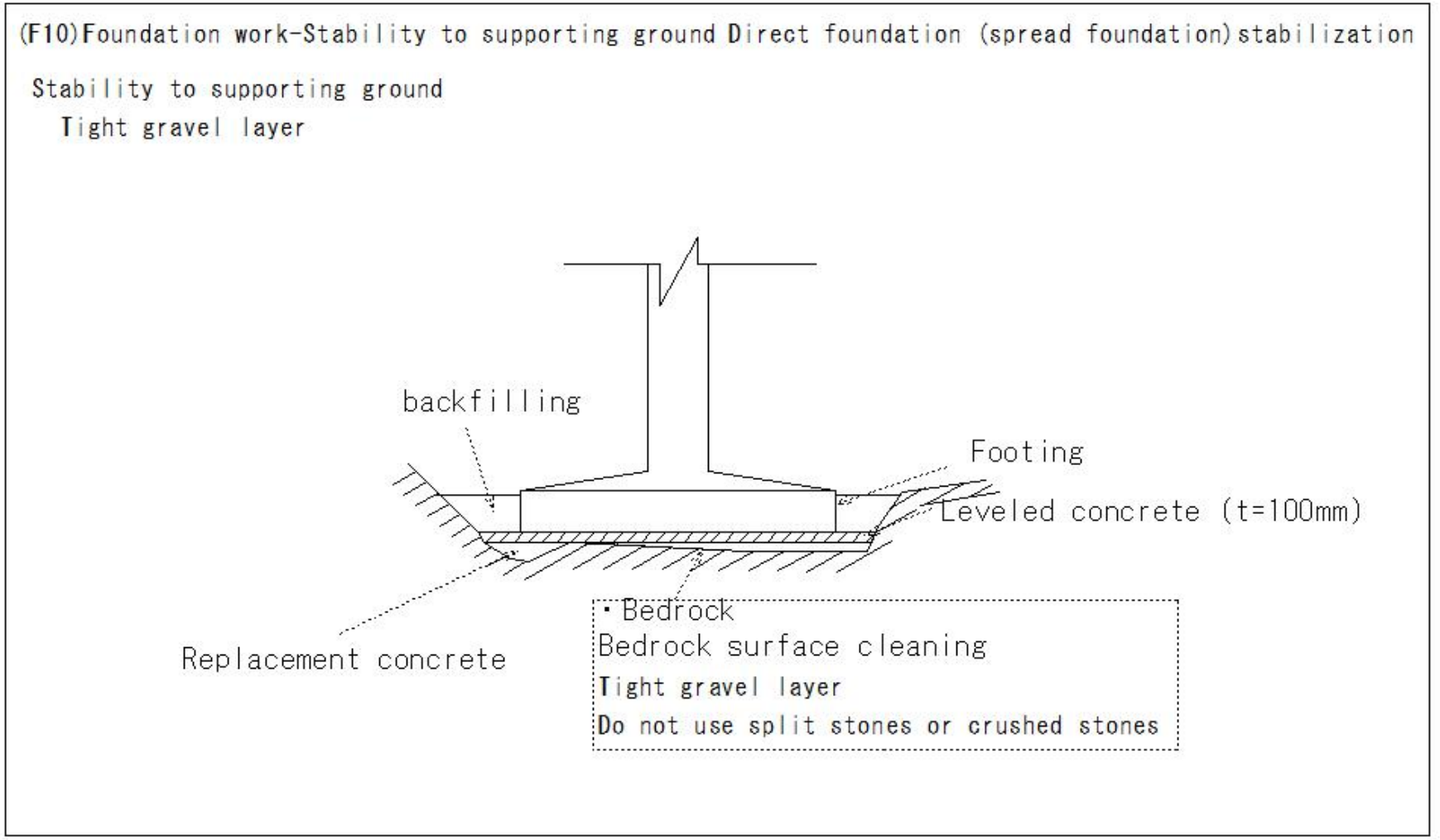
Stability to supporting ground

(spread foundation)

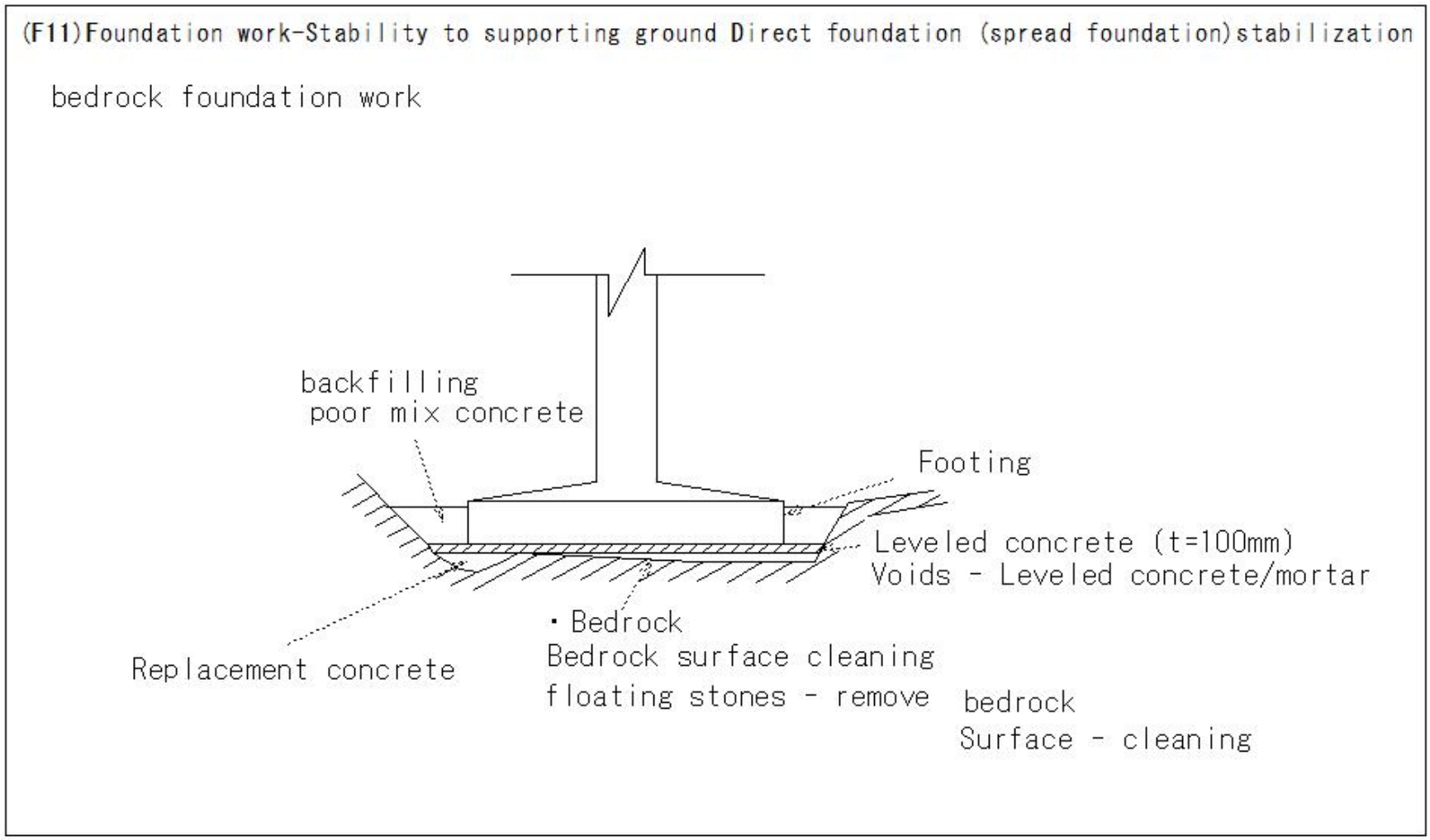
Direct foundation



(F10)Foundation work-Stability to supporting ground Direct foundation (spread foundation)stabilization



(F11)Foundation work-Stability to supporting ground Direct foundation (spread foundation)stabilization



(F12)Foundation work-Stability to supporting ground Direct foundation (spread foundation)stabilization

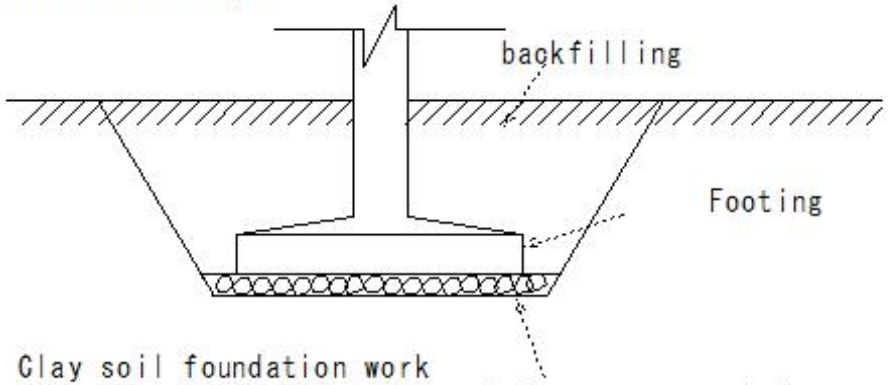
(F12)Foundation work-Stability to supporting ground Direct foundation (spread foundation)stabilization

Stability to supporting ground

Clay soil foundation work
Ground improvement
Deeply penetration

Clay soil foundation work

Clay soil - spreading the low plate has no effect
①Build the foundation after consolidation drainage
②Increase the penetration depth



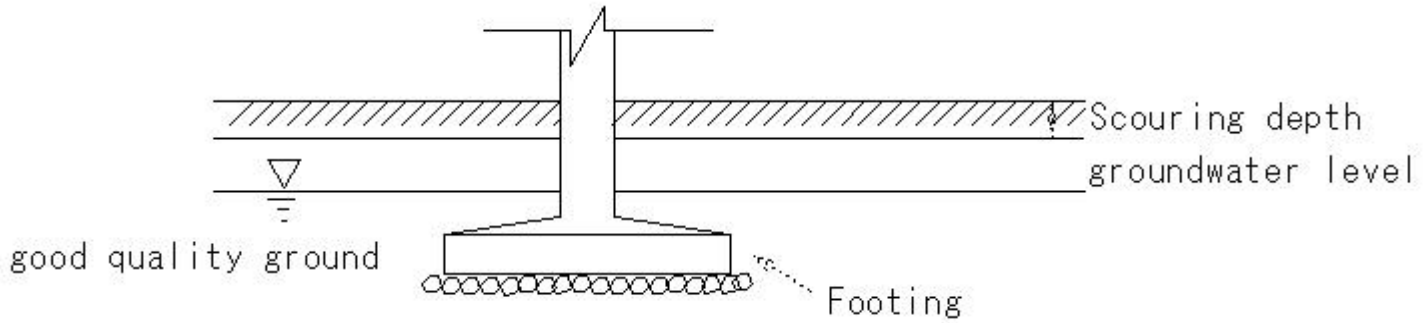
(F13)Foundation work-Stability to supporting ground

(F13)Foundation work-Stability to supporting ground

Stability to supporting ground

In the case of a foundation built directly on a river

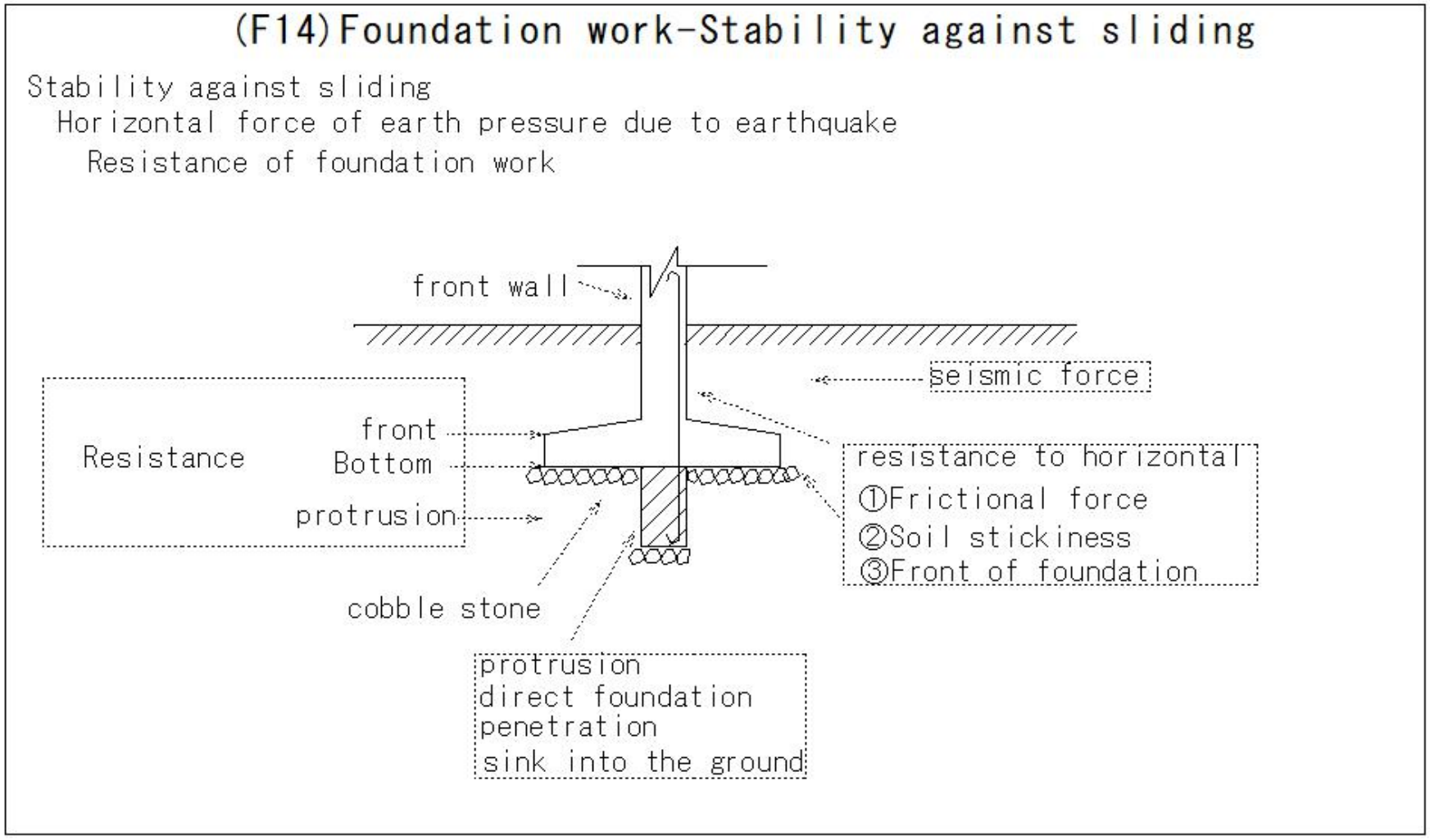
- Washing consideration
- Below the groundwater level
- Following freeze-thaw effects



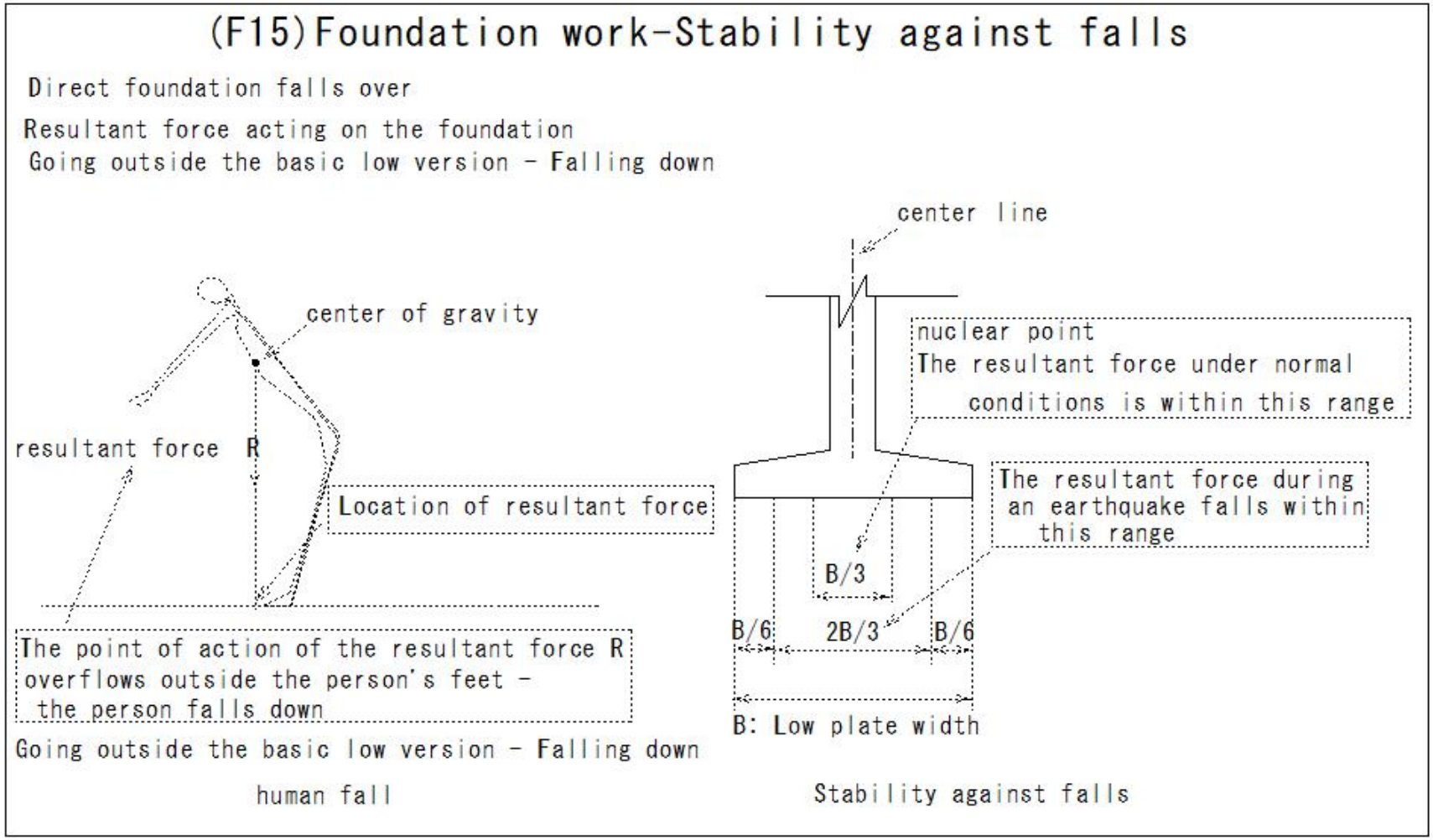
①Below the groundwater level

②penetration below freezing depth

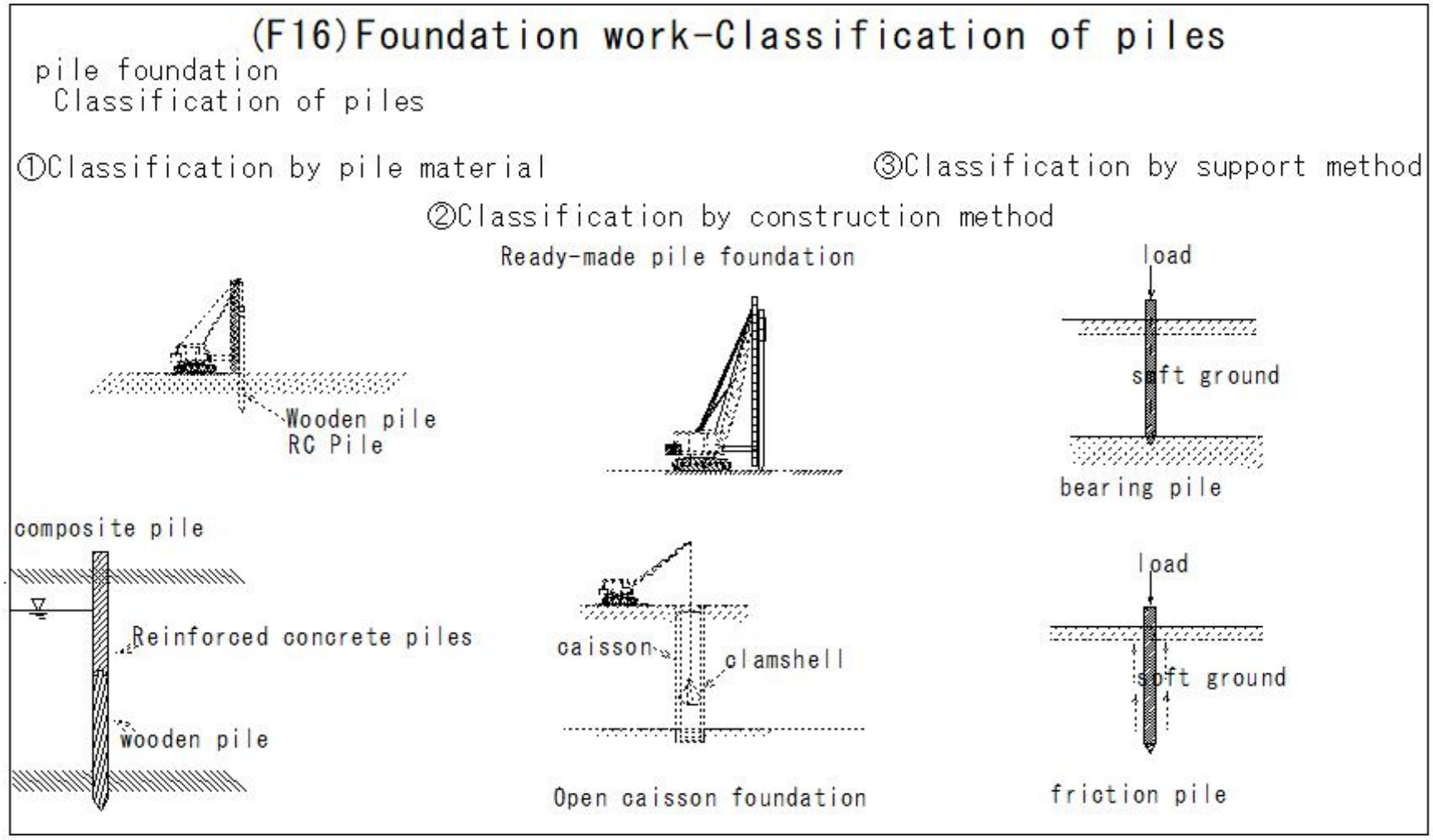
(F14)Foundation work-Stability against sliding



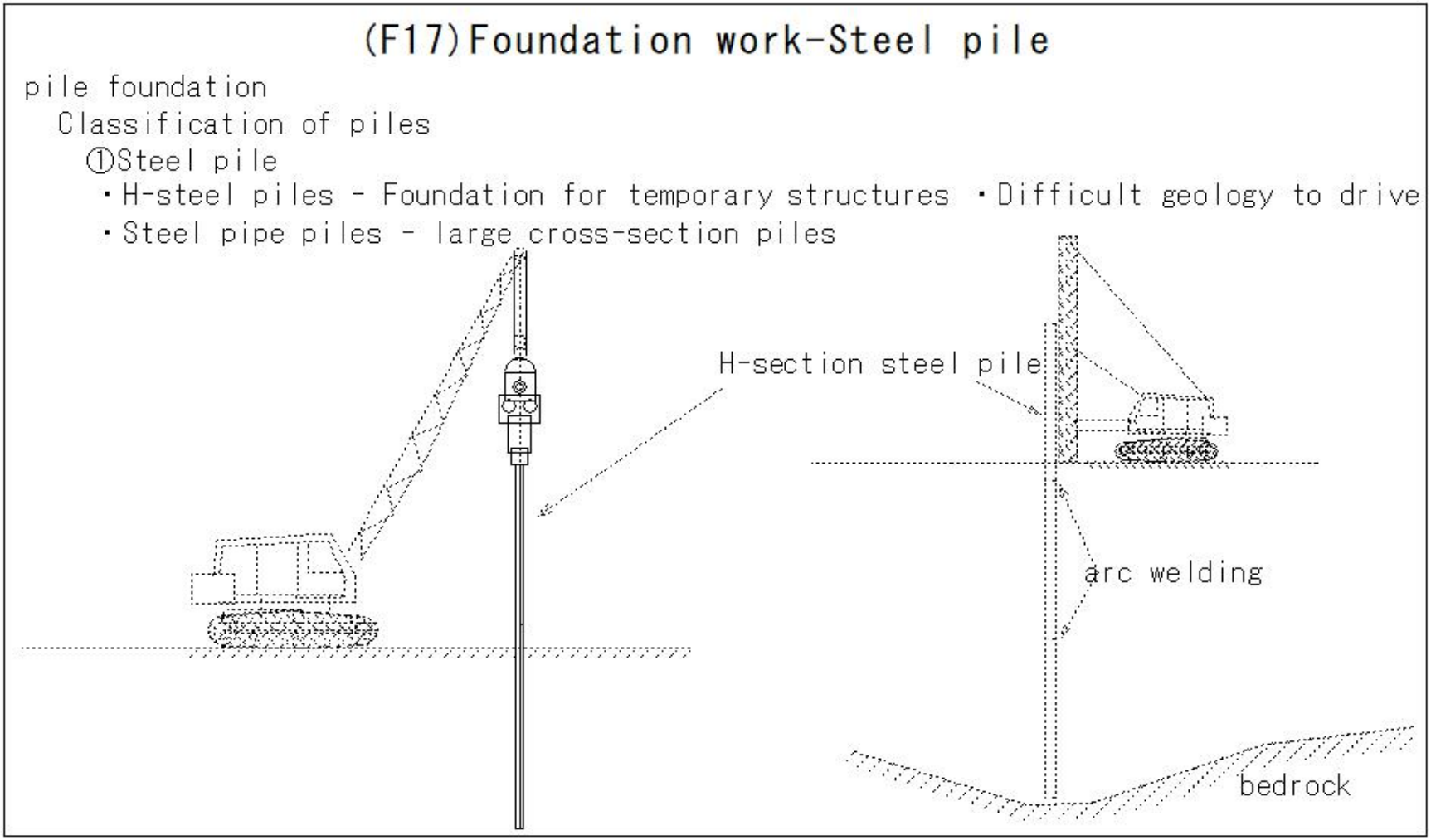
(F15)Foundation work-Stability against falls



(F16)Foundation work-Classification of piles



(F17)Foundation work-Steel pile



(F18)Foundation work-RC pile (concrete pile) PC pile

(F18)Foundation work-RC pile (concrete pile) PC pile

pile foundation

Classification of piles

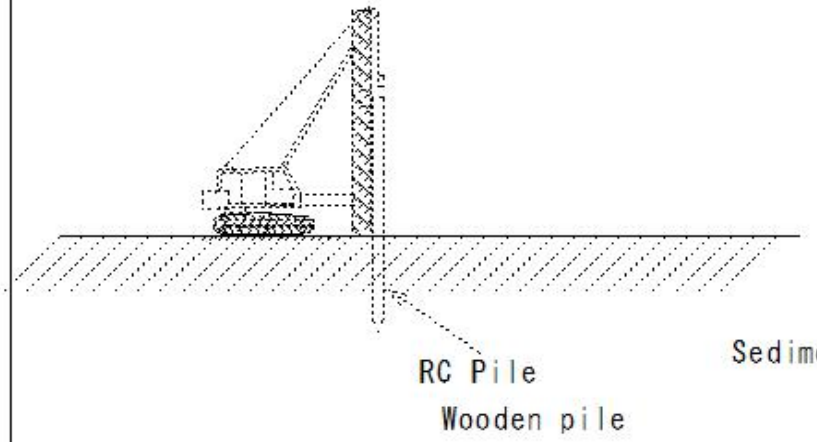
②RC pile (concrete pile)

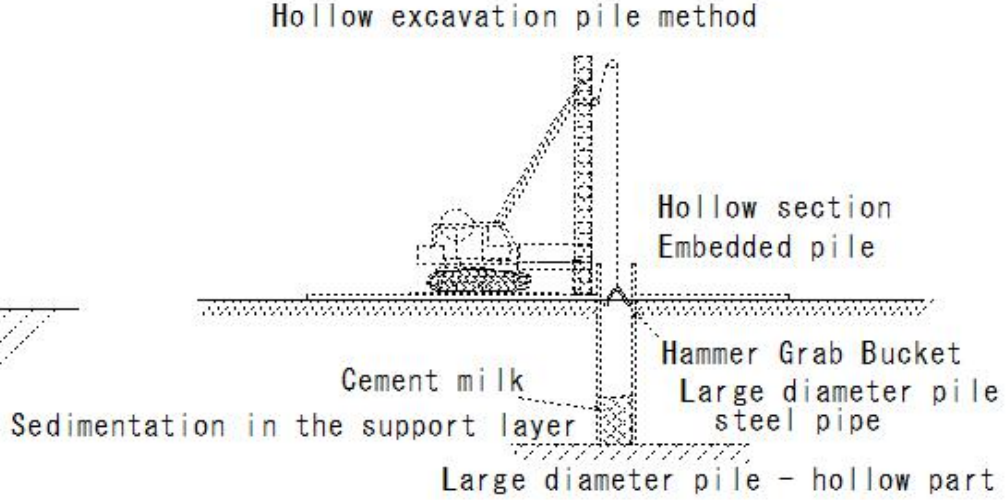
・Precast pile: Factory production
Basics of small structures

・Cast-in-place piles
Pour concrete into a hole dug in the field

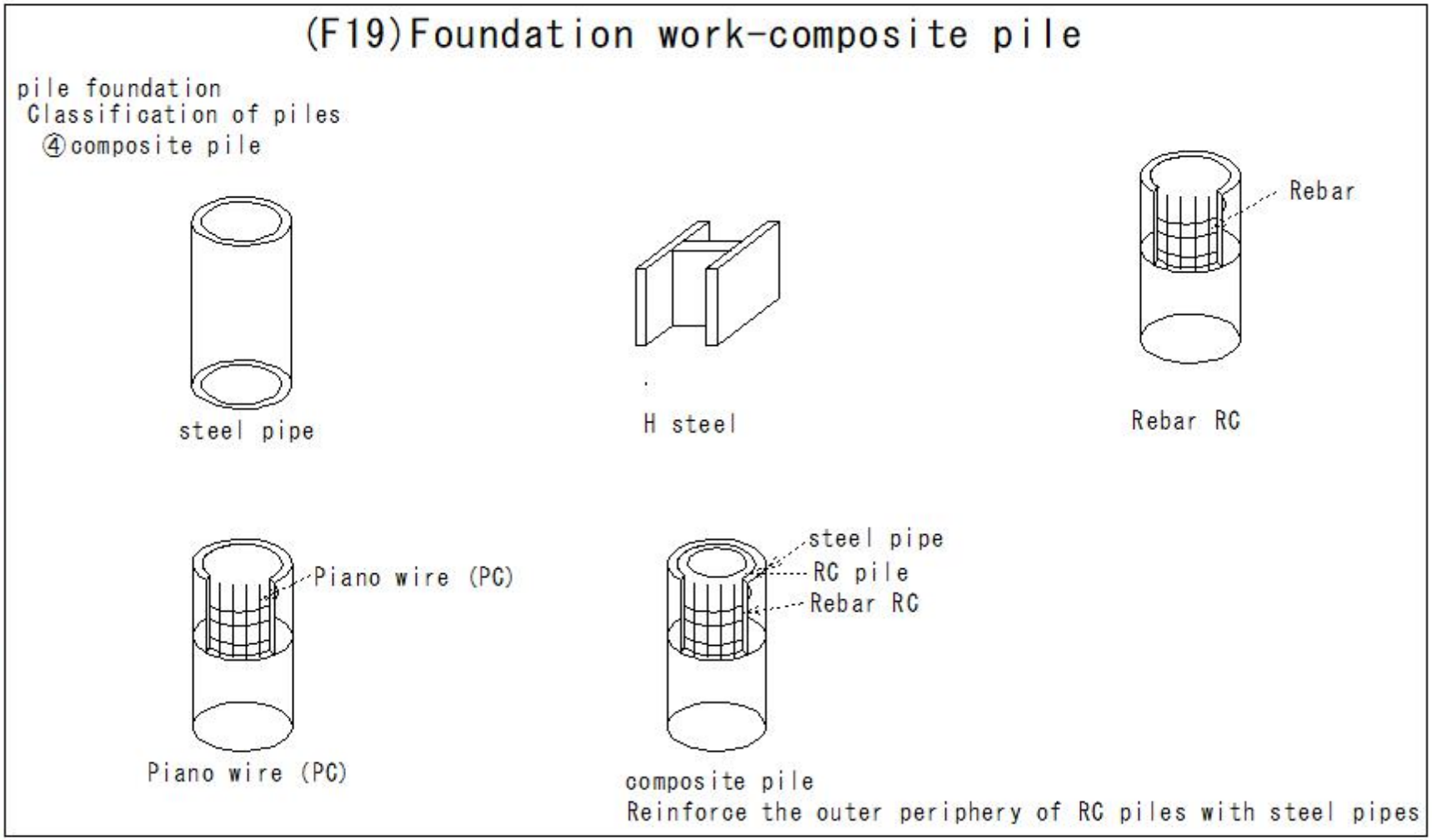
③PC pile

・prestressed piles

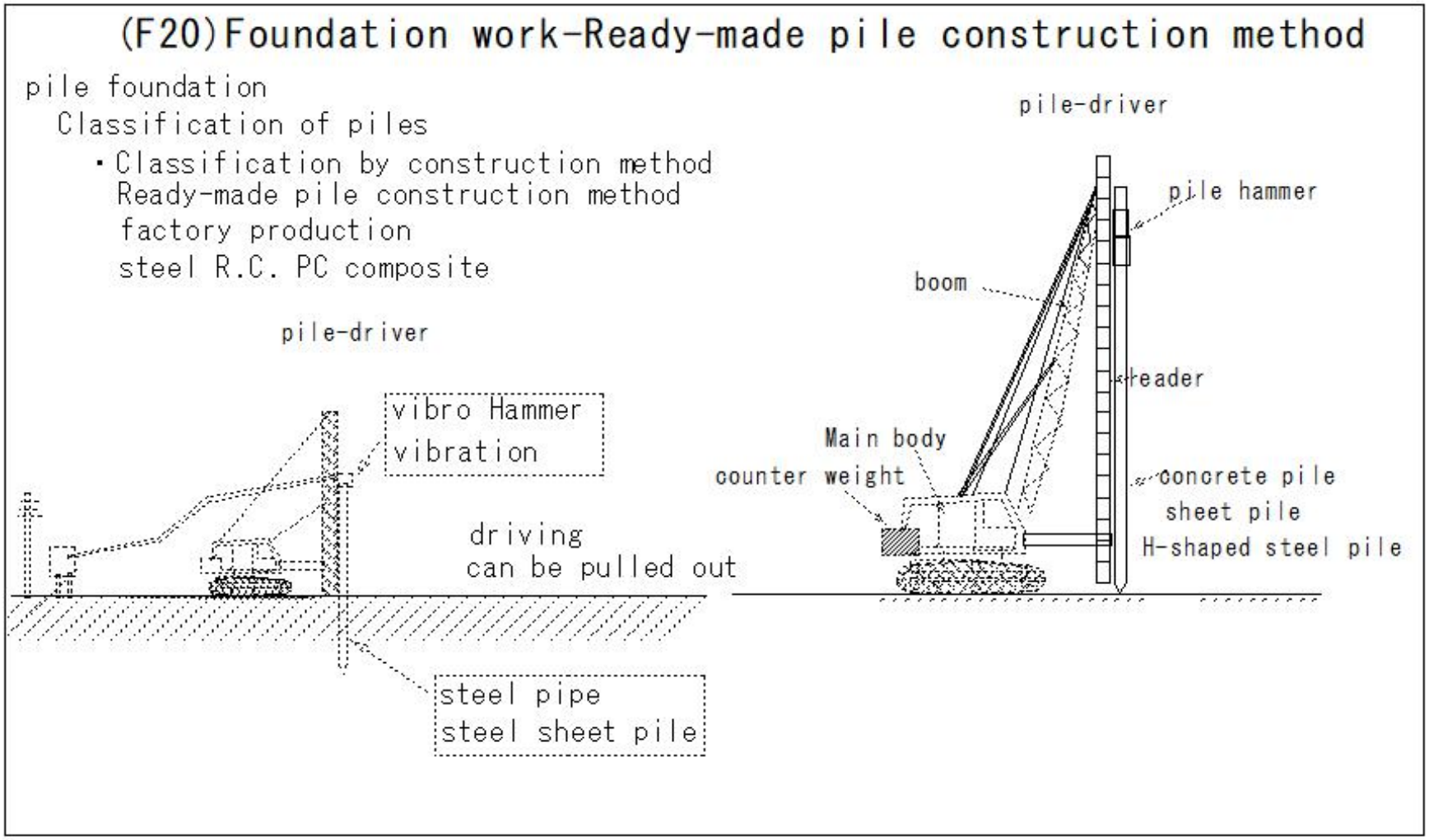




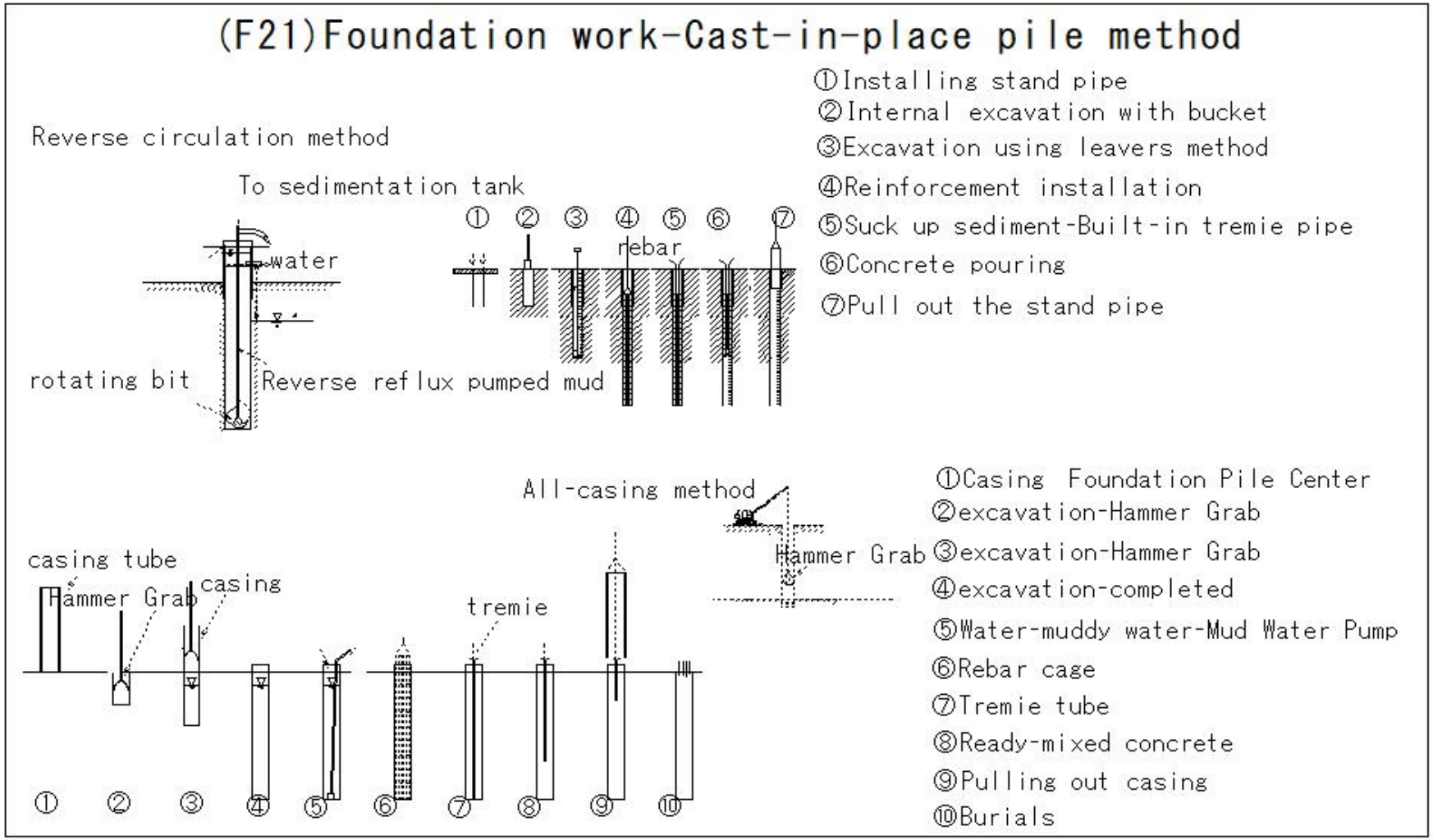
(F19)Foundation work-composite pile



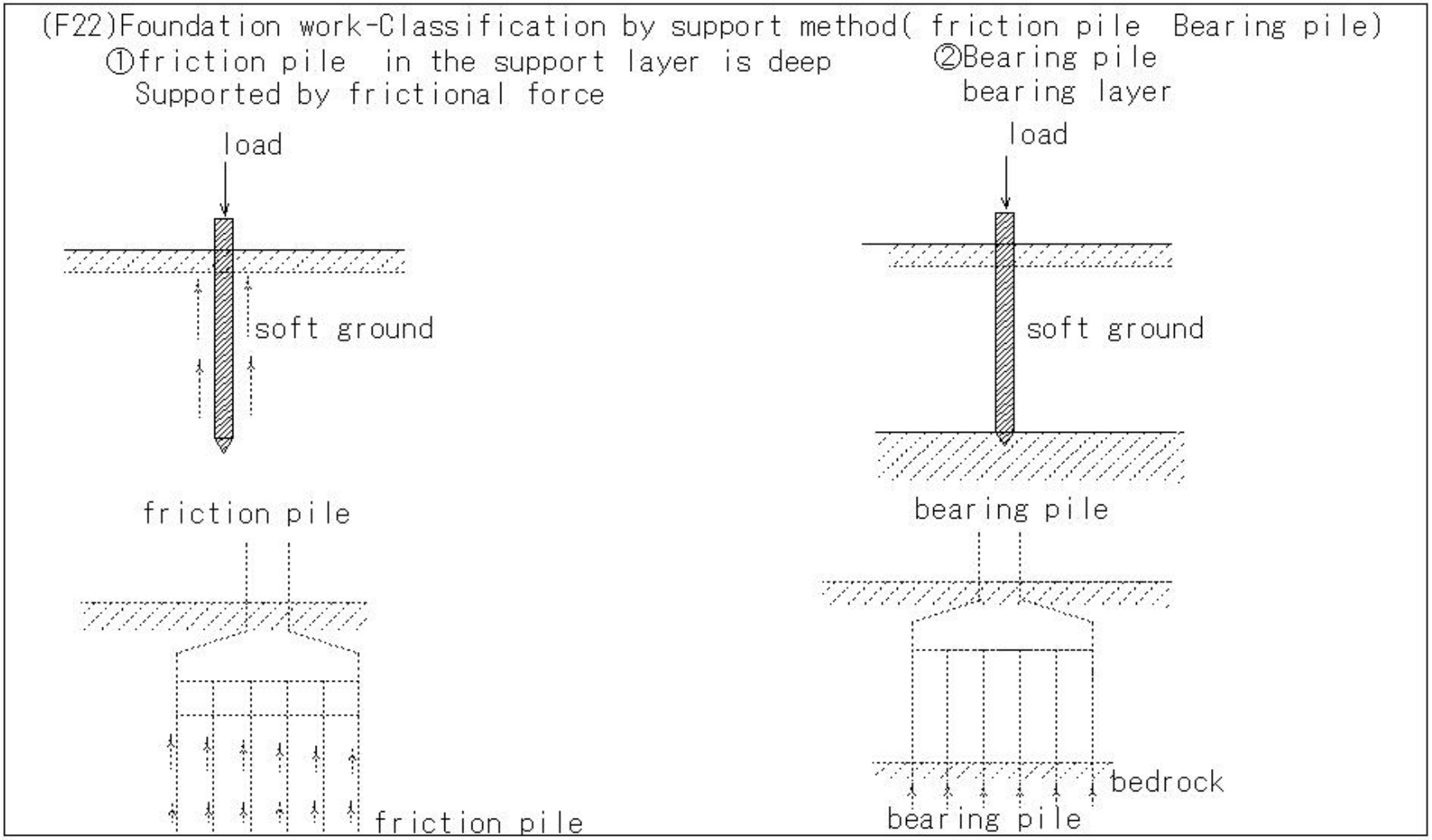
(F20)Foundation work-Ready-made pile construction method



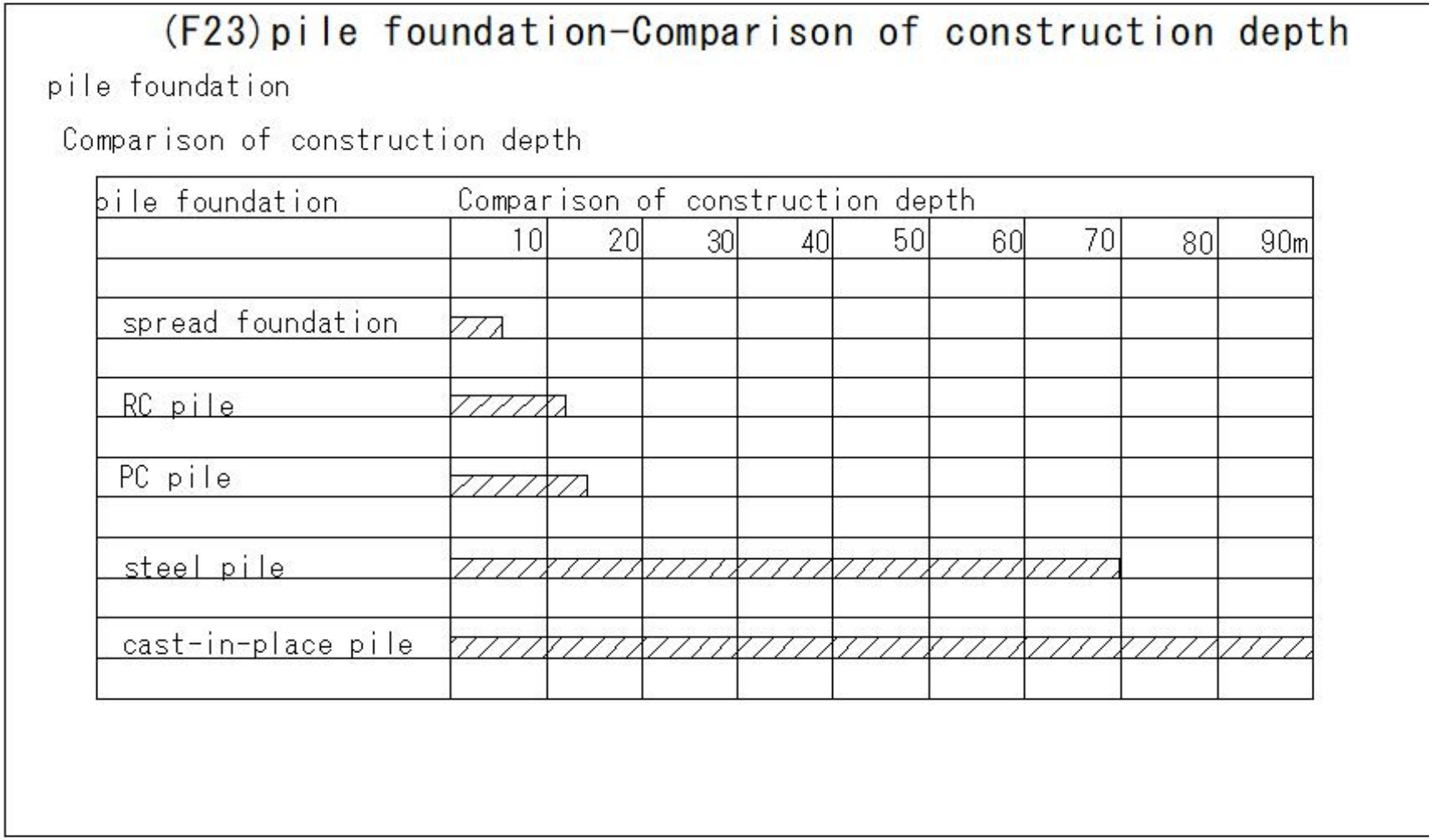
(F21)Foundation work-Cast-in-place pile method



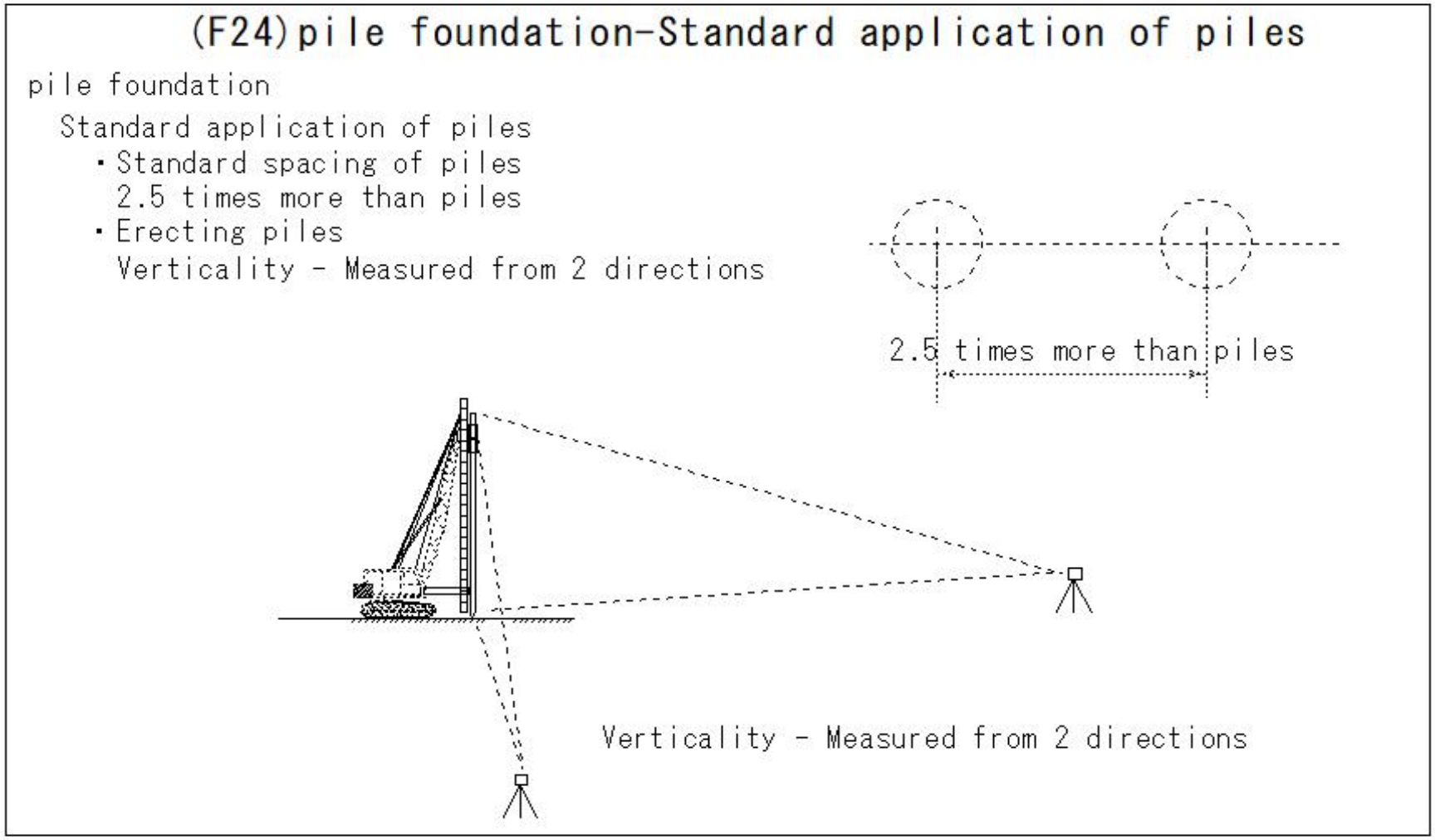
(F22)Foundation work-Classification by support method(friction pile Bearing pile)



(F23)pile foundation-Comparison of construction depth



(F24)pile foundation-Standard application of piles



(F25)pile foundation-Standard application of piles

(F25)pile foundation-Standard application of piles

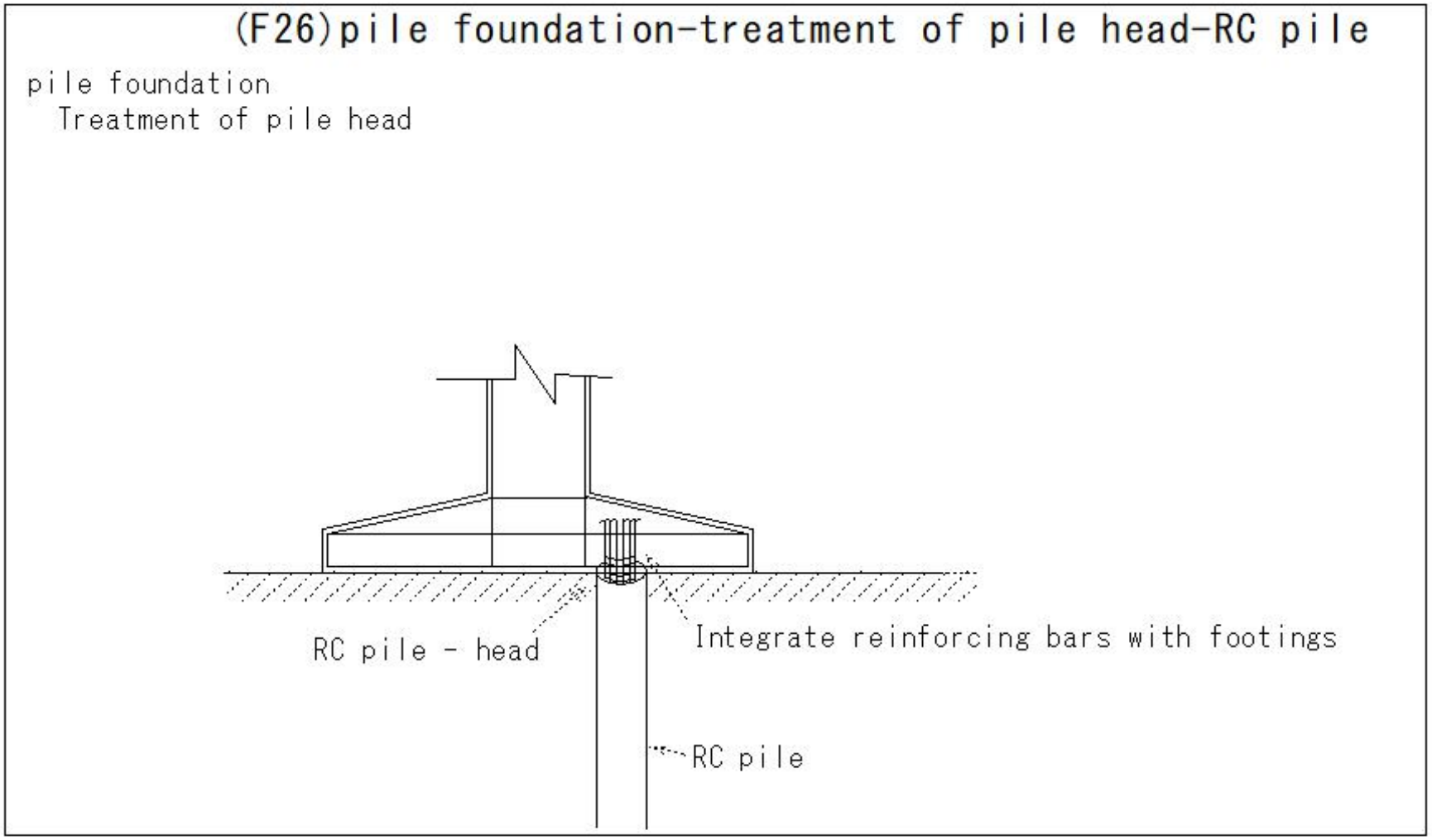
Standard application of piles

Pile type (diameter cm)	Vertical permissible supporting force (tf)	Standard length (m)
RC pile(30)	20-30	6-7
PC pile(40)	40-60	7-8
steel pile(50)	100-120	20-30
H steel pile(30)	30	15-25
cast-in-place pile(100)	200-250	20-30

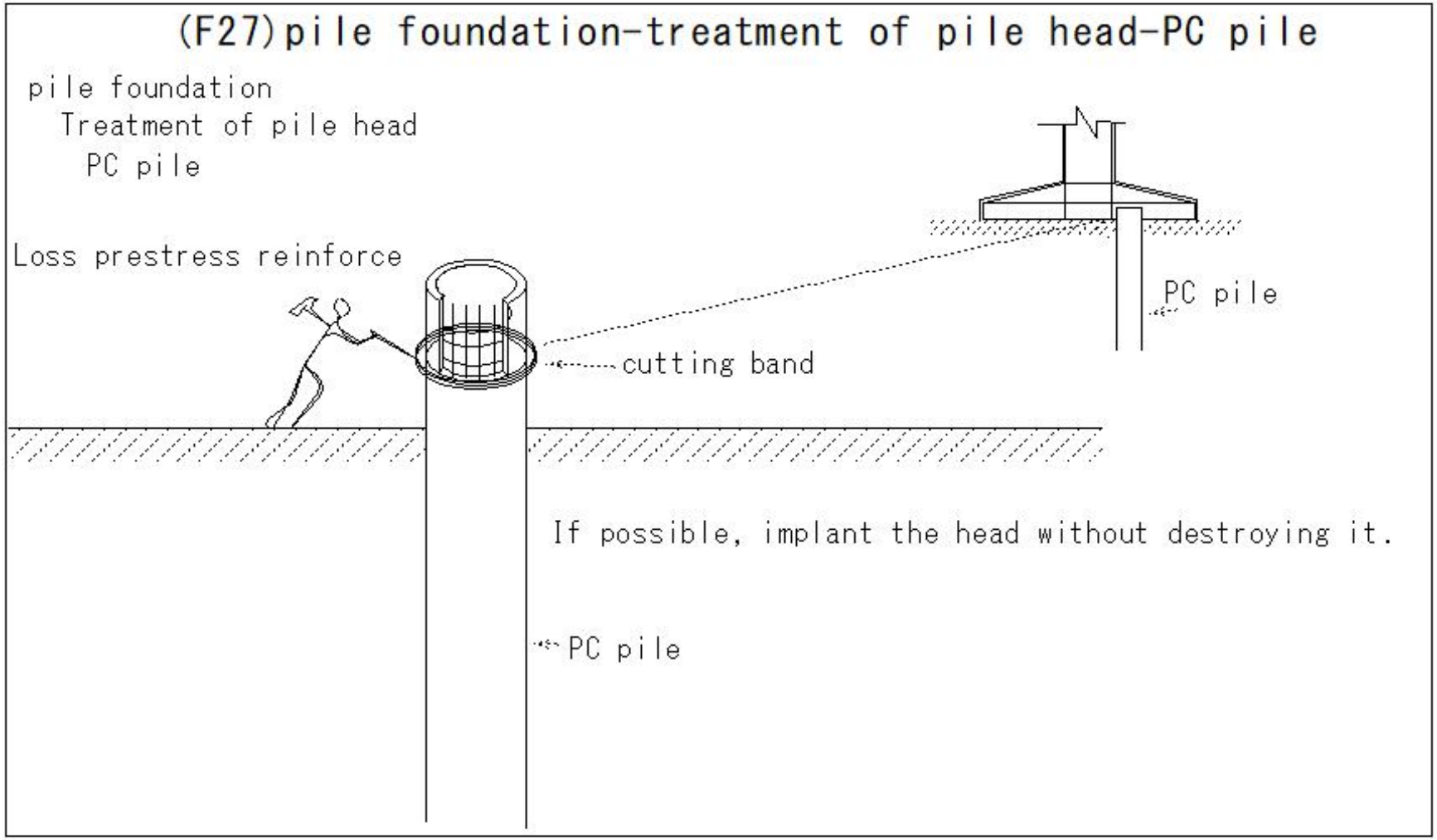
Safety factor for vertical loads

	friction pile	bearing pile
normal times	3	4
earthquake times	2	3

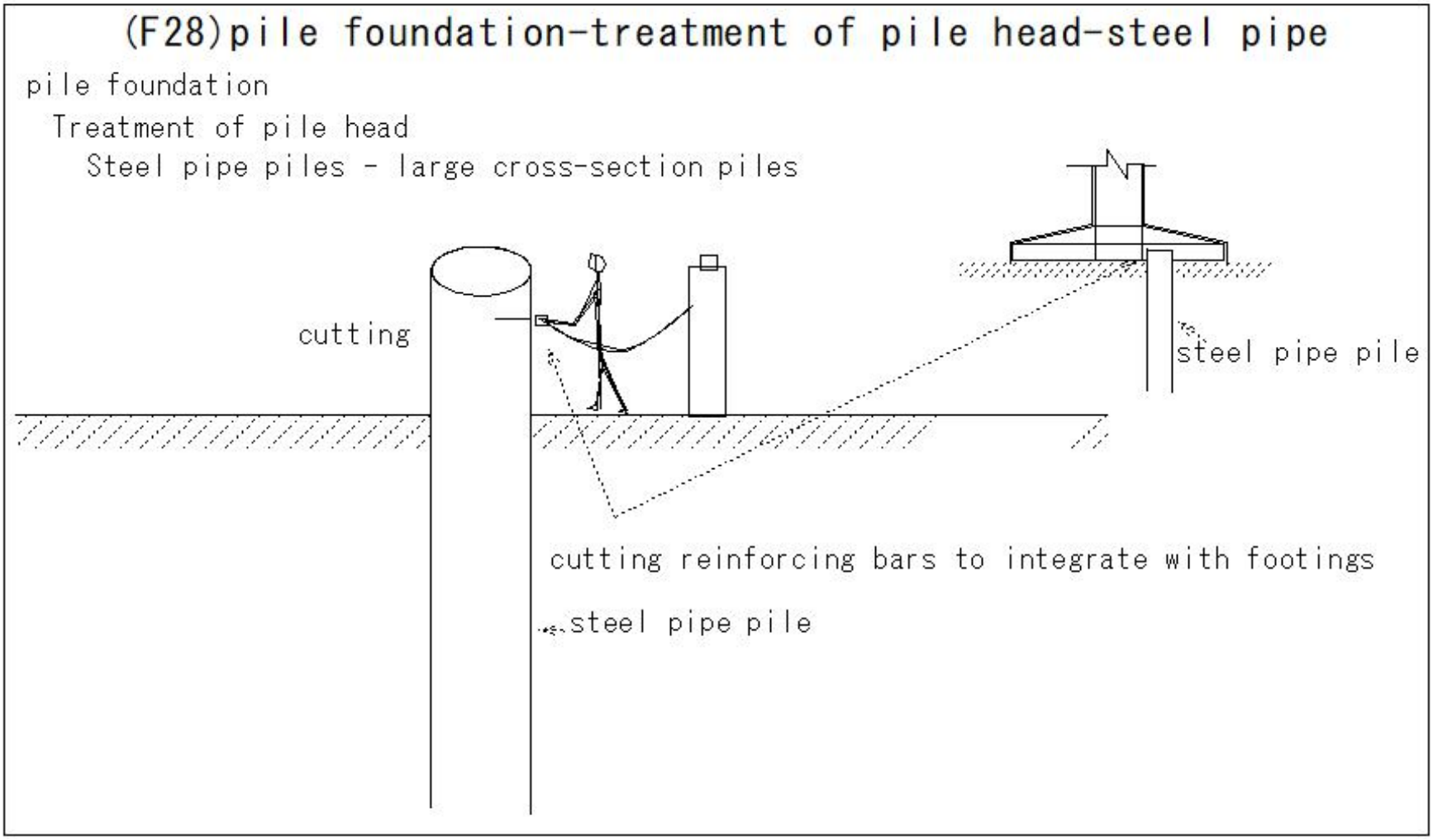
(F26)pile foundation-treatment of pile head-RC pile



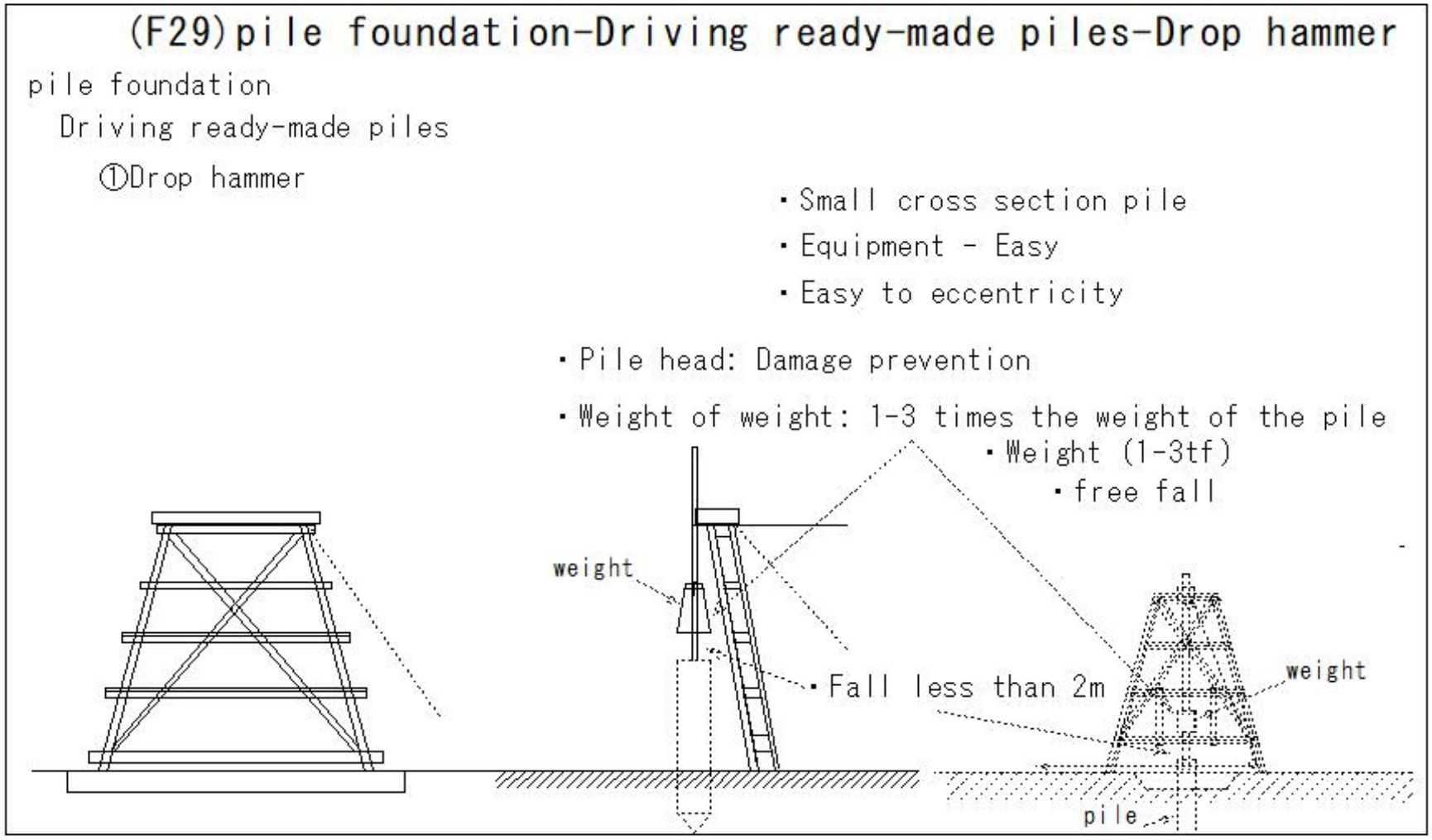
(F27)pile foundation-treatment of pile head-PC pile



(F28)pile foundation-treatment of pile head-steel pipe



(F29)pile foundation-Driving ready-made piles-Drop hammer



(F30)pile foundation-Driving ready-made piles-Diesel hammer

(F30)pile foundation-Driving ready-made piles-Diesel hammer

pile foundation

Driving ready-made piles

② Diesel hammer

・Hard ground Suitable for normal ground

・Number of blows

Steel pile: 3000 times or less

PC pile: 2000 times or less

RC pile: 1000 times or less

1 axis permissible inclination 1/100

2. Allowable deviation of driving position D/4 (10cm) or less

Do not set the piles at a settlement of less than 2 mm

Subsidence amount of 1mm or less at one time

・Diesel damage

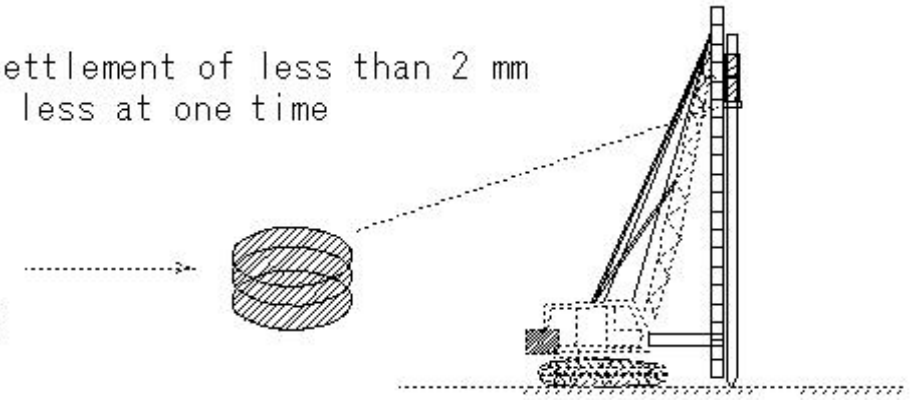
・Damage of piles

hammer cushion

Replace when it gets hard

cardboard paper

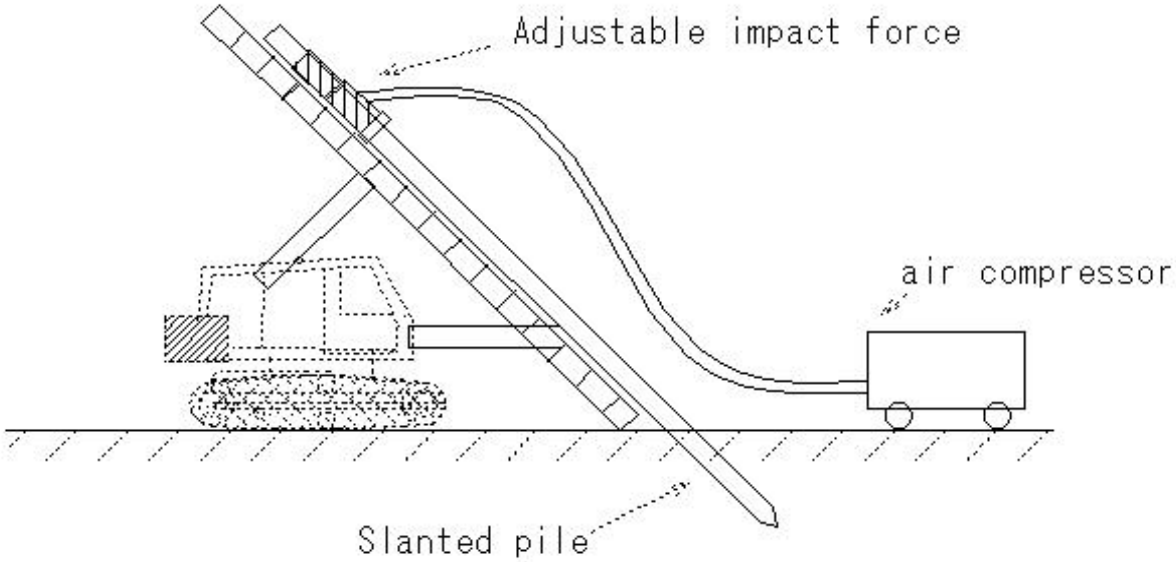
Pile diameter D



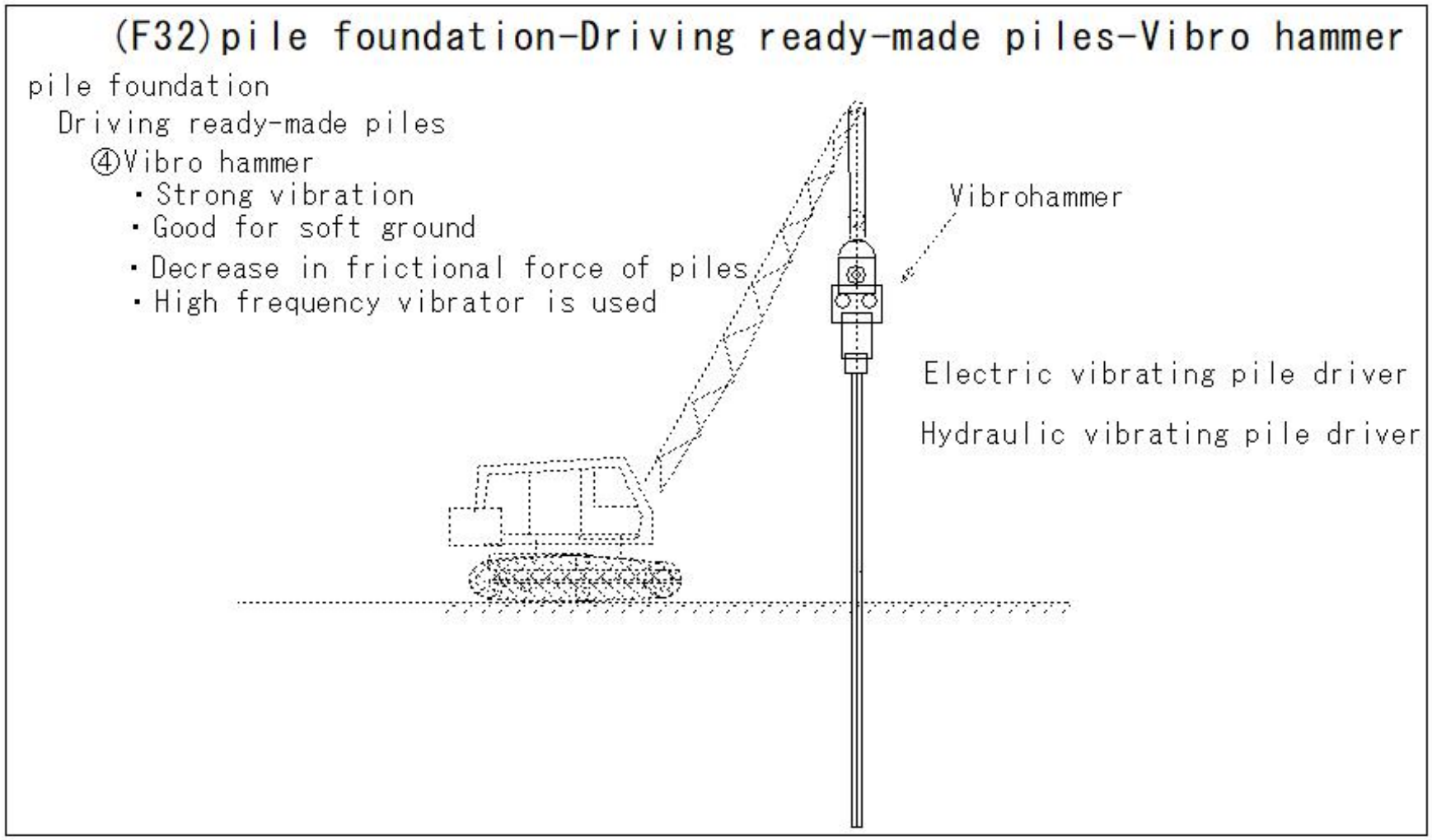
(F31)pile foundation-Driving ready-made piles-Steam hammer/air hammer

(F31)pile foundation-Driving ready-made piles-Steam hammer/air hammer

pile foundation
Driving ready-made piles
③Steam hammer/air hammer
・Equipment - large scale
・Many piles
・Slanted piles can be driven underwater



(F32)pile foundation-Driving ready-made piles-Vibro hammer



(F33)pile foundation-Driving ready-made piles-(Pre-boring method)

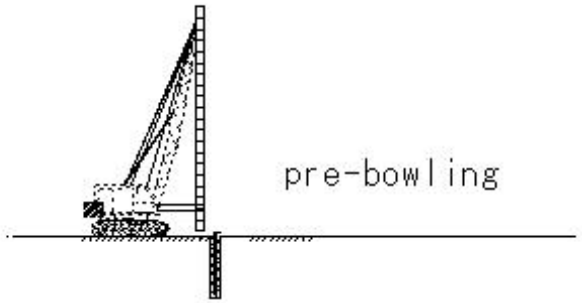
(F33)pile foundation-Driving ready-made piles-(Pre-boring method)

pile foundation
Pollution measures for ready-made piles

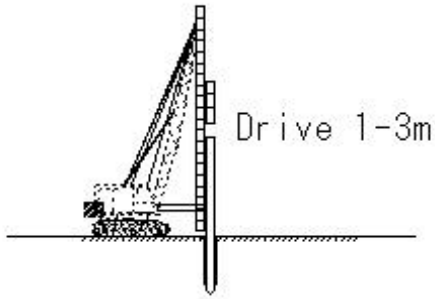
- diesel hammer
- Vibro hammer

Driving ready-made piles - noise and vibration
Low-pollution ready-made pile driving method

①Pre-boring method



Dig the hole for the ready-made pile with an earth auger etc.



Place concrete in case not pouring

(F34)pile foundation-(Hollow excavation pile method/Prefabricated pile)

(F34)pile foundation-(Hollow excavation pile method/Prefabricated pile)

pile foundation

Pollution measures for ready-made piles

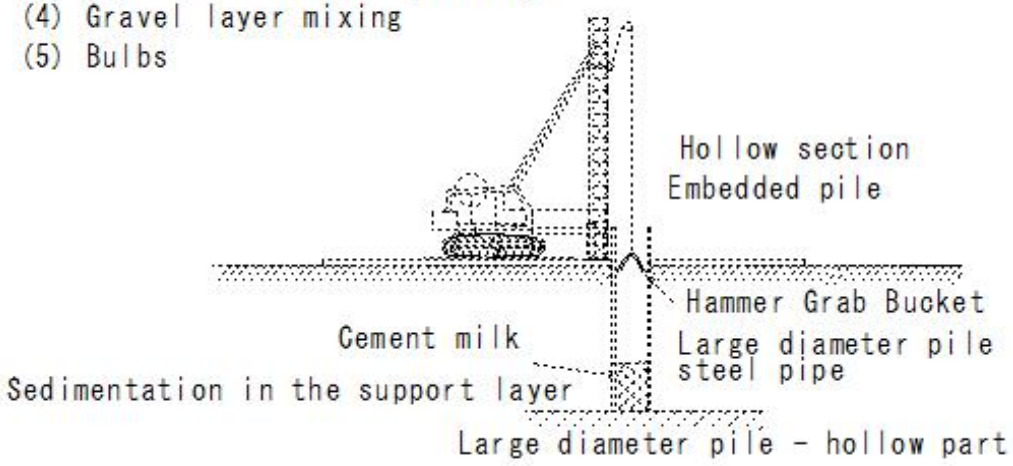
②Hollow excavation pile method/Prefabricated pile

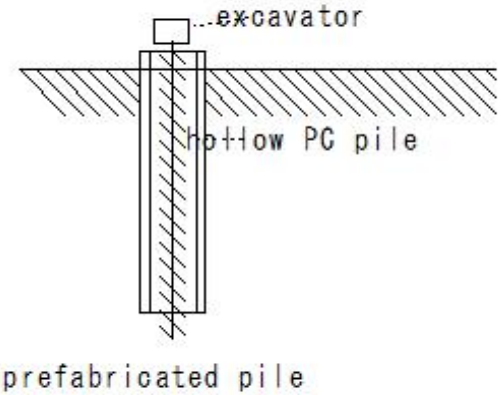
Utilizing hollow parts of piles

Dig the hole for the ready-made pile with an earth auger etc.

Drilling and press-fitting with a bucket

(1) Hammer Grab Bucket-drilling
(2) Rotary press fitting
(3) Tip - Cement milk squirting
(4) Gravel layer mixing
(5) Bulbs

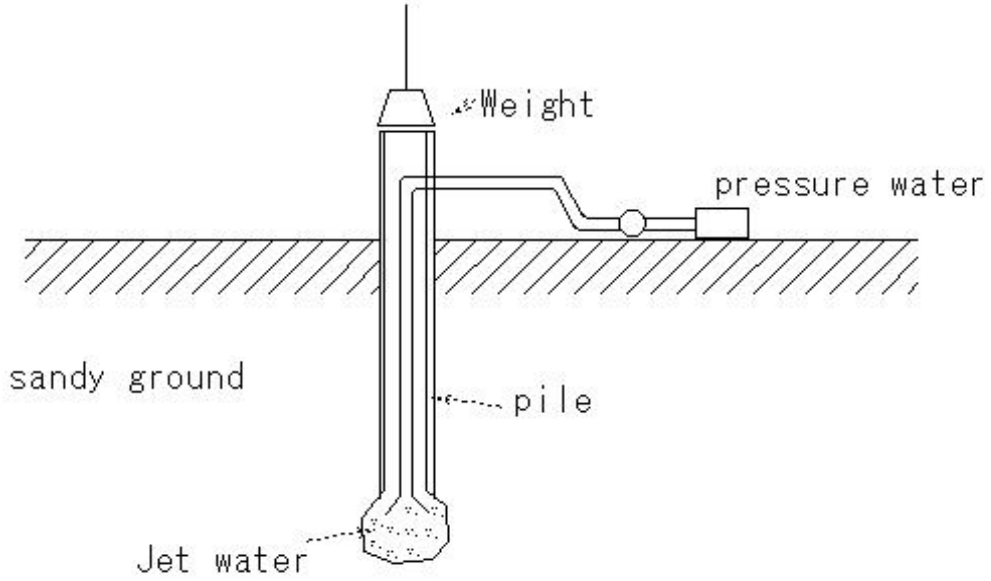




(F35)pile foundation-(Jet method)

(F35)pile foundation-(Jet method)

pile foundation
  Pollution measures for ready-made piles
    ③Jet method
      Sand ground - High pressure water - Injection - Excavation
      Eliminate friction between piles and the ground
      Pile-press fit



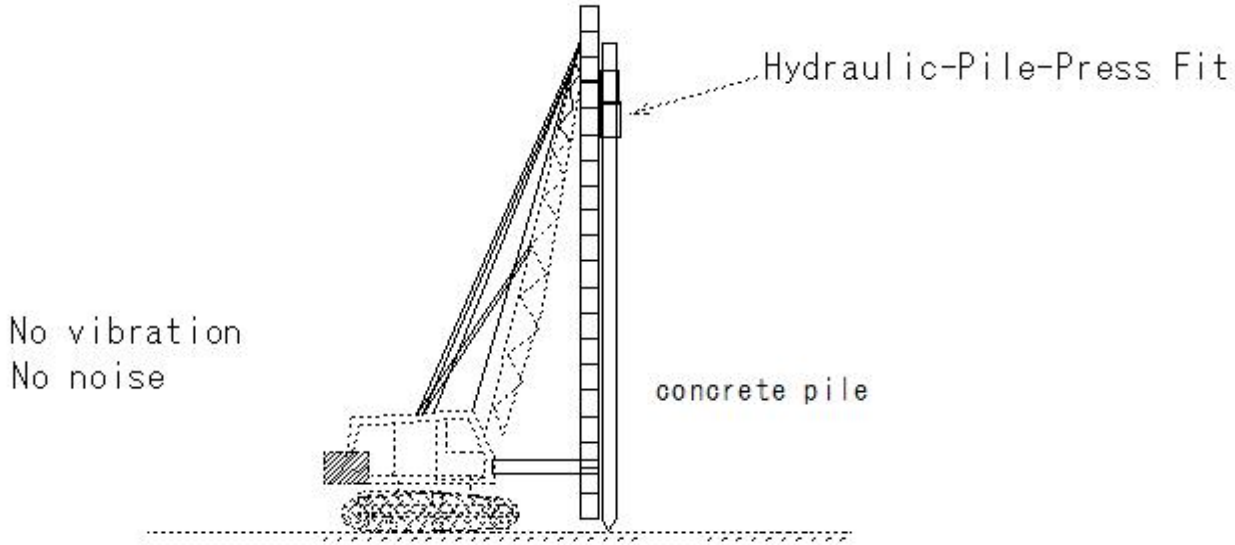
(F36)pile foundation-(Hydraulic hammer press-in method)

(F36)pile foundation-(Hydraulic hammer press-in method)

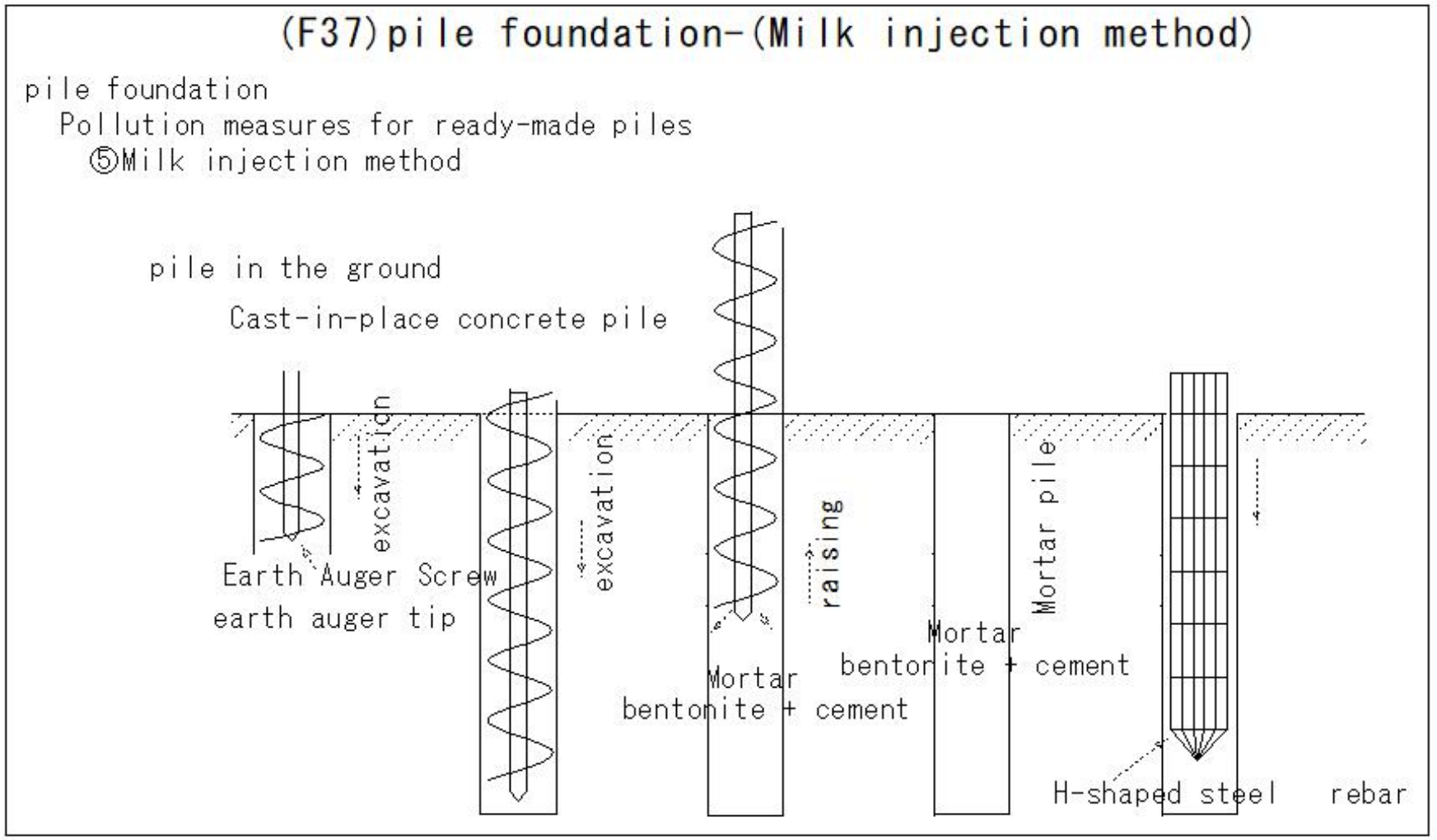
pile foundation

Pollution measures for ready-made piles

④Hydraulic hammer press-in method



(F37)pile foundation-(Milk injection method)



(F38)pile foundation-(Soundproof cover)

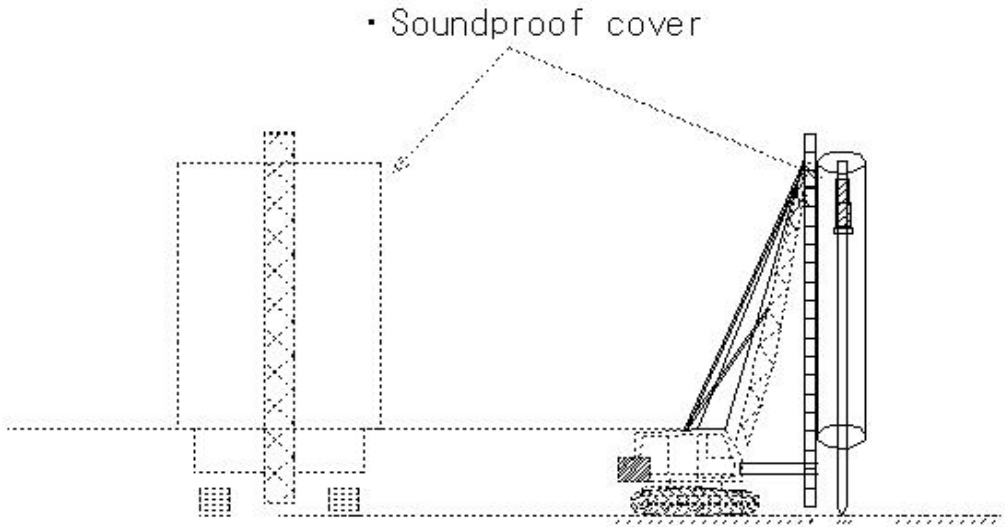
(F38)pile foundation-(Soundproof cover)

pile foundation

Pollution measures for ready-made piles

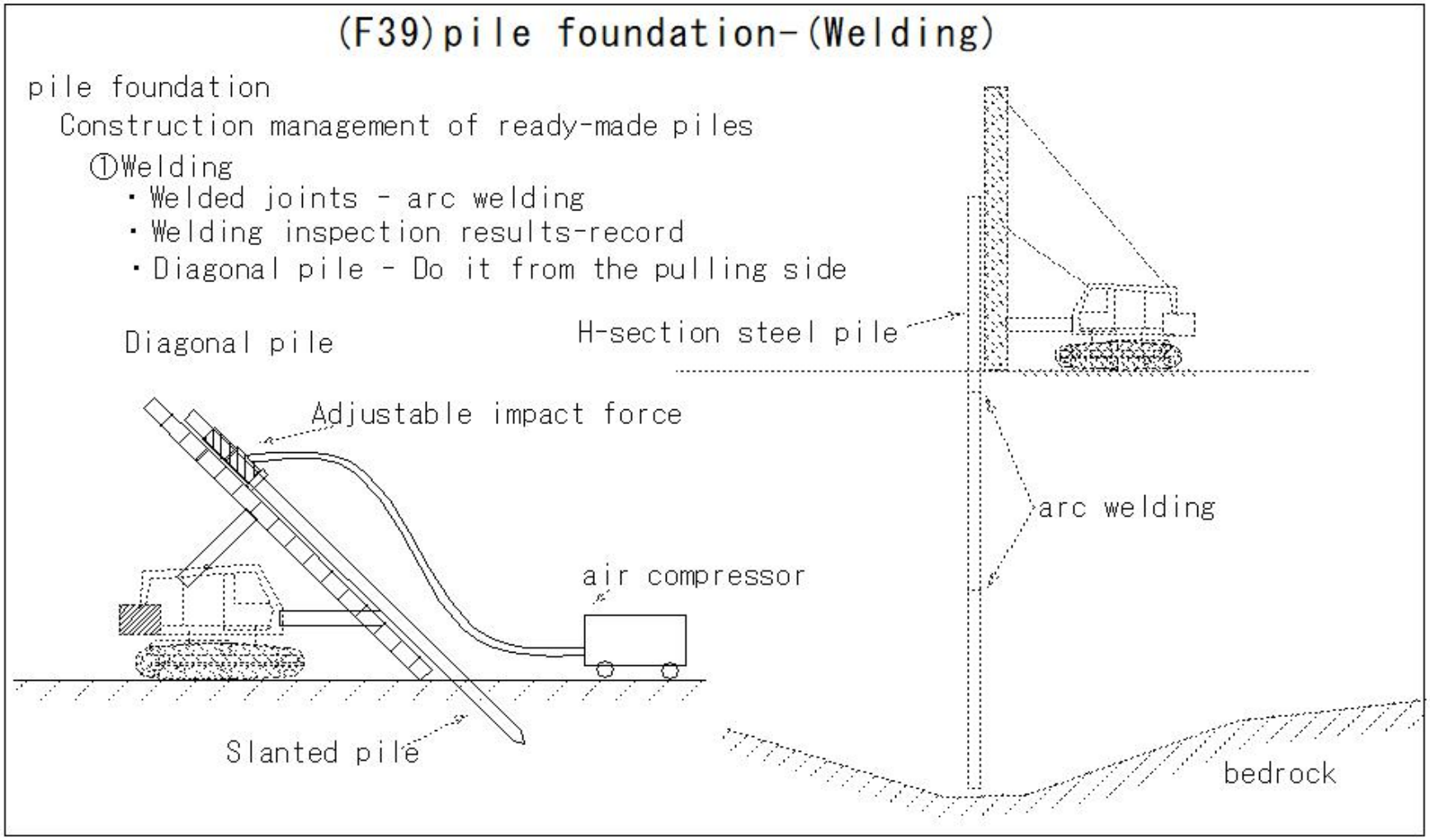
⑥Soundproof cover

diesel hammer



⑥Soundproof cover

(F39)pile foundation-(Welding)



(F40)pile foundation-(piling)

(F40)pile foundation-(piling)

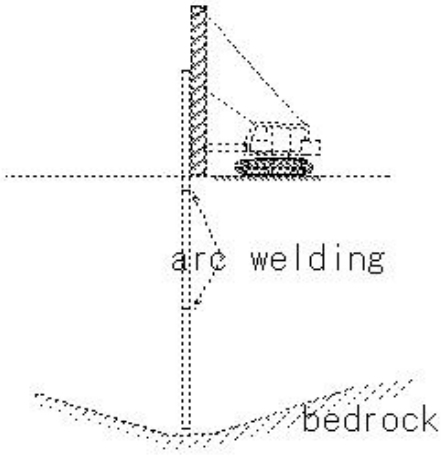
pile foundation

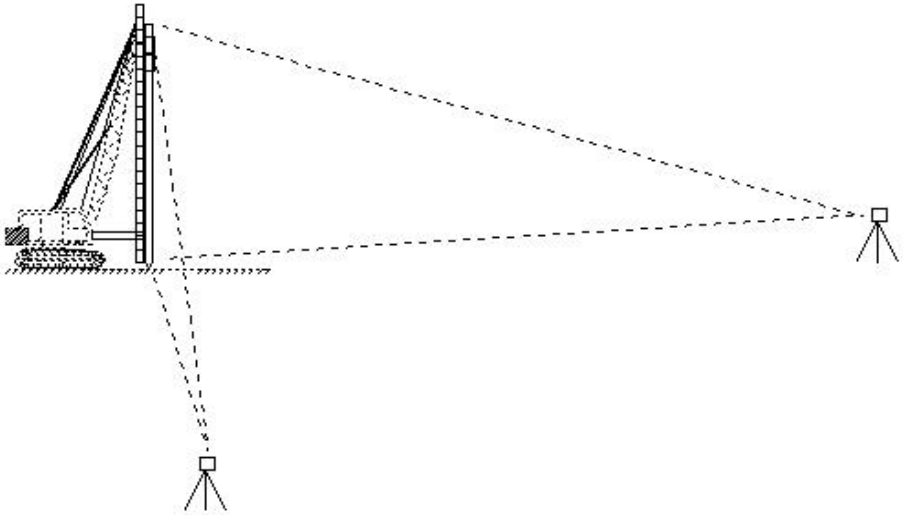
Construction management of ready-made piles

②piling

・Erection of ready-made piles -
inspection from two directions

・Welding inspection results-record





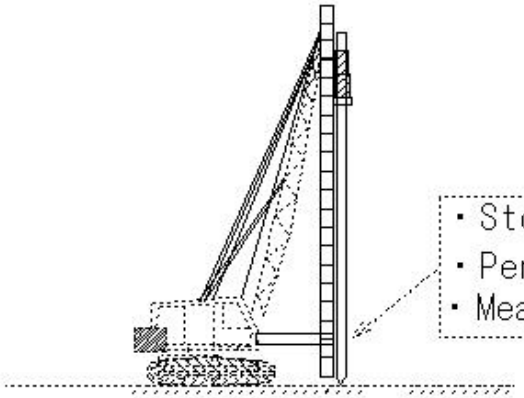
(F41)pile foundation-(Stop piling)

(F41)pile foundation-(Stop piling)

pile foundation

Construction management of ready-made piles

③Stop piling



・Stop management method
・Penetration amount
・Measure the amount of rebound

(F42)pile foundation-(cast-in-place pile)

(F42)pile foundation-(cast-in-place pile)

pile foundation

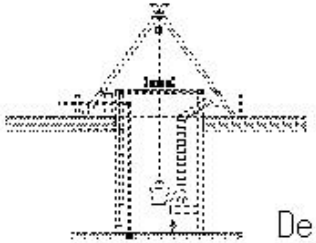
cast-in-place pile

Noise/vibration pollution prevention

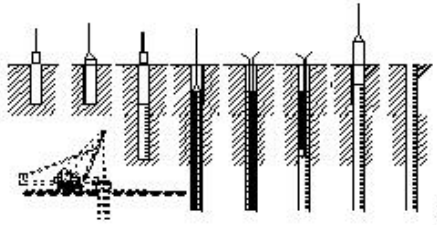
- Equipment - large
- Construction speed - slow
- Construction management-problems

① Deep foundation construction method -manual excavation

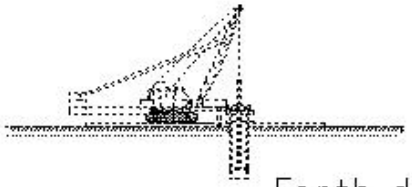
② Benoto method / Earth drill method / Reverse method - Mechanical excavation



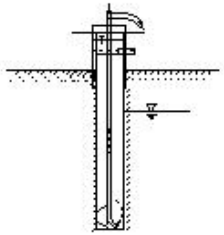
Deep foundation



Benoto method



Earth drill method



Reverse method

(F43)pile foundation-(Deep foundation)

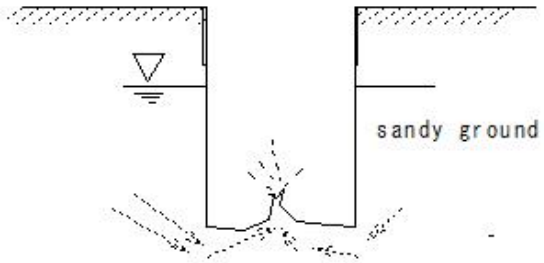
(F43)pile foundation-(Deep foundation)

pile foundation

cast-in-place pile

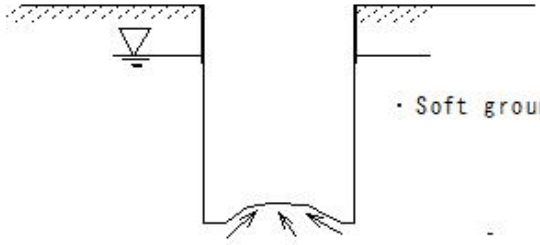
① Deep foundation construction method

- Manual excavation
- Groundwater exclusion
- Possible to blast leaves of rolling stones
- Drainage construction - boiling and heaving
- Confirmation of soil bearing capacity - easy



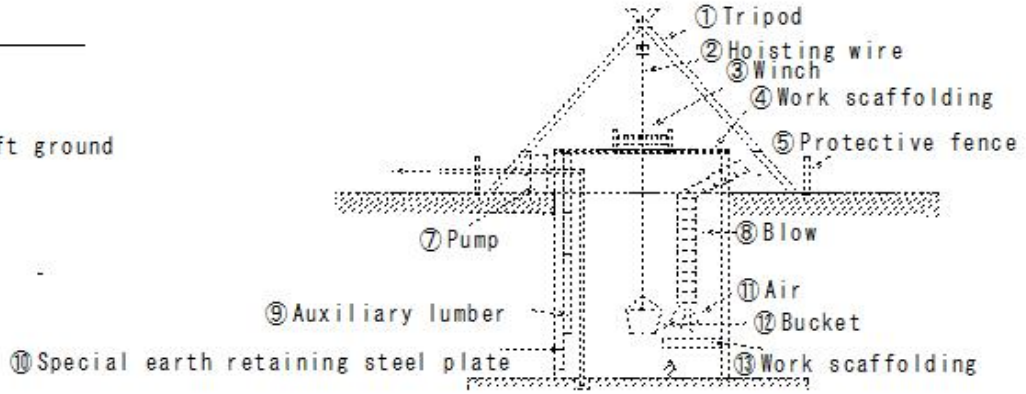
underground water route

Boiling

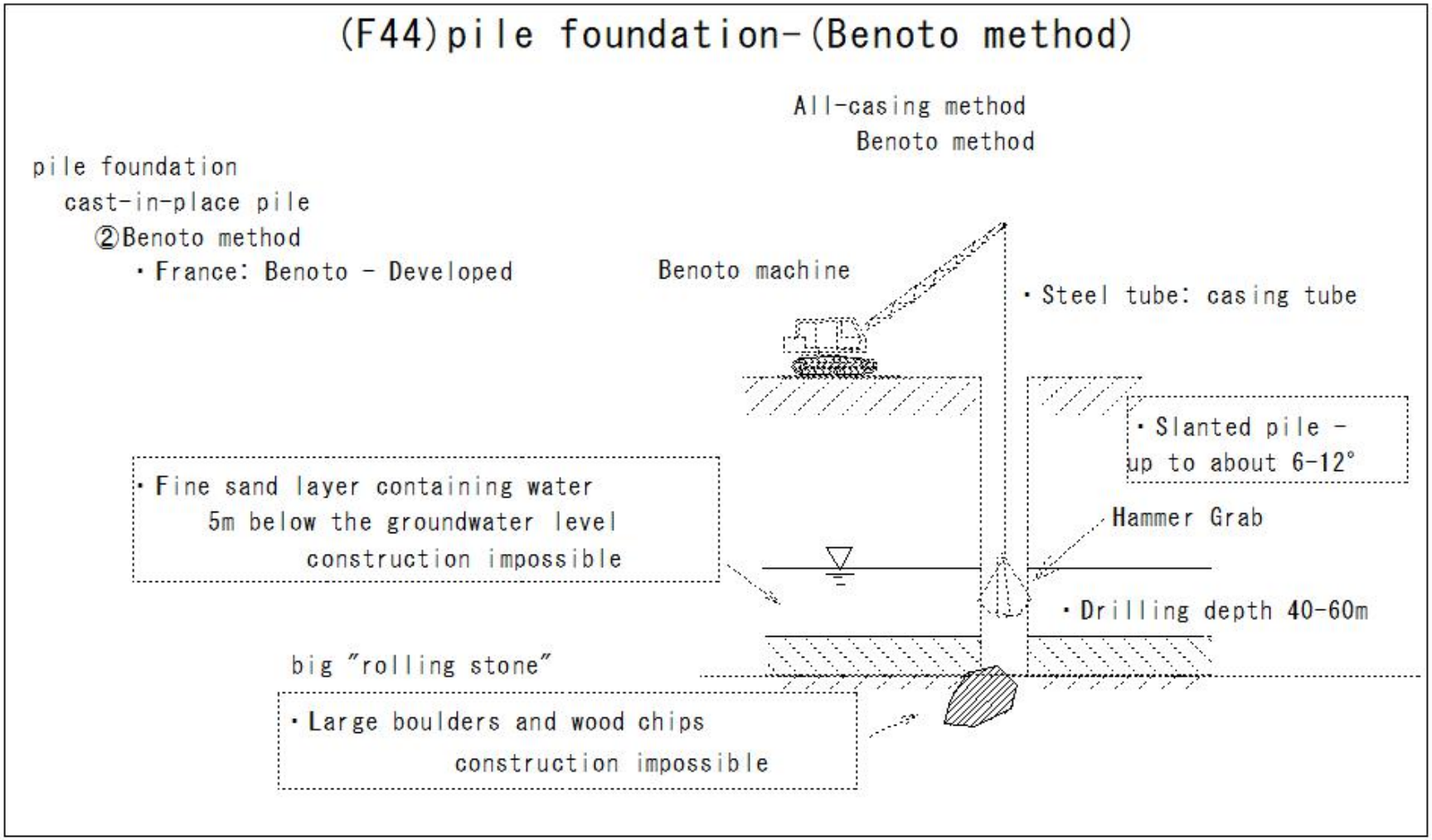


・Water pressure - ground - push up

・Heaving



(F44)pile foundation-(Benoto method)



(F45)pile foundation-(Earth drill method)

(F45)pile foundation-(Earth drill method)

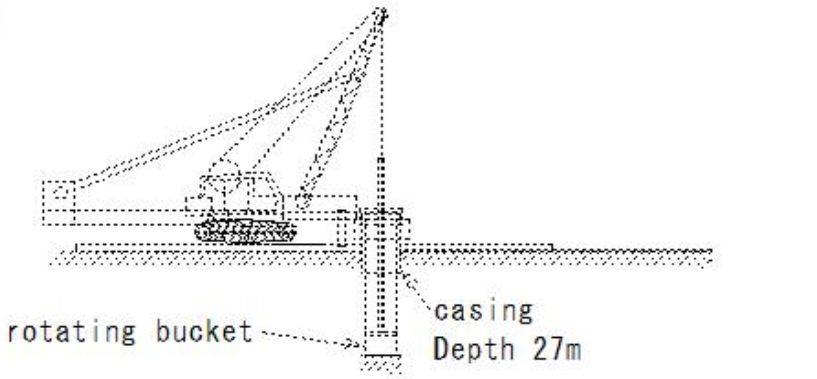
pile foundation

cast-in-place pile

③Earth drill method

- Rotating bucket - excavation
- Construction speed - fast
- Low cost
- Drilling depth - 27m
- Suitable for clay layer
- Weak sandy ground - bentonite solution (stabilizing liquid)

Earth drill method



(F46)pile foundation-(Reverse circulation method)

(F46)pile foundation-(Reverse circulation method)

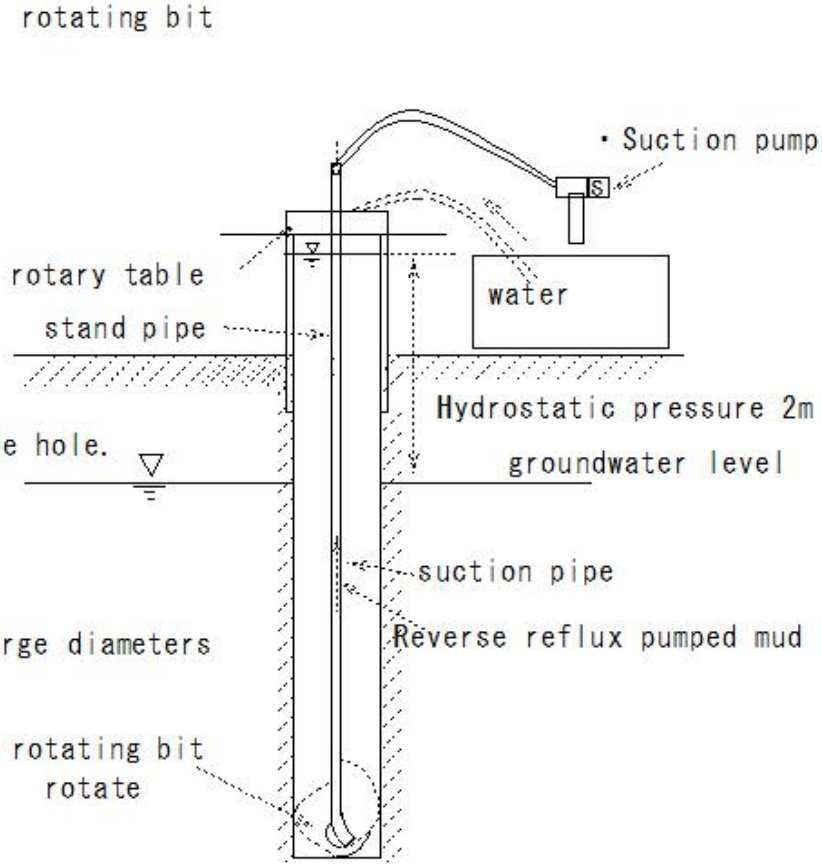
pile foundation

cast-in-place pile

④Reverse method

Reverse circulation method

- Big pile driving
- Continuous drilling
- Large boulders, pressurized water, underground water - construction difficult
- Water construction possible
- The water level inside the hole is 2m higher than the water level outside the hole.
- Good for long and large diameters



(F47)pile foundation-(Construction management of cast-in-place piles)

(F47)pile foundation-(Construction management of cast-in-place piles)

pile foundation

Construction management of cast-in-place piles

①Concrete management

② Slime processing

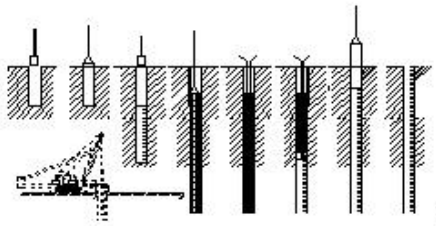
③ Treatment of hole walls

④Pollution prevention management

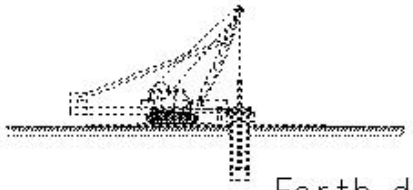
⑤Records of excavation, reinforcing cage installation, and concrete placement

Cast-in-place piles: Low noise and vibration

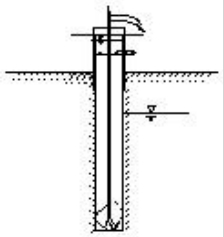
・Muddy water treatment-problems



Benoto method



Earth drill method



Reverse method

(F48)pile foundation-(Construction management of Benoto Earth Drill Reverse Method)

(F48)pile foundation-(Construction management of Benoto Earth Drill Reverse Method)

Construction management of cast-in-place piles

①Concrete management

Benoto Earth Drill Reverse Method

① Drilling

② Reinforcement cage insertion

③ Tremie tube arrangement

④ Drain the water in the tremie tube

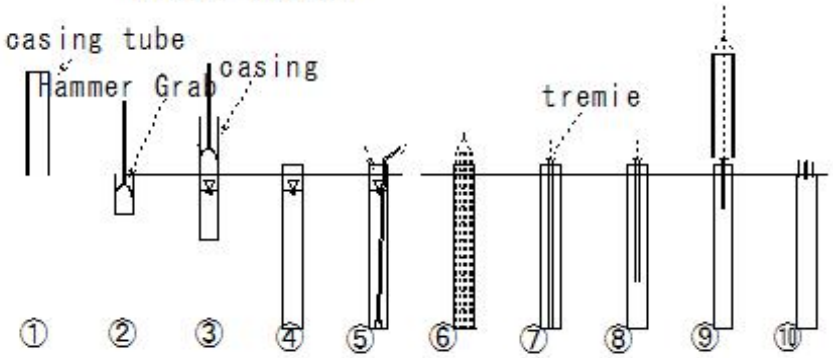
⑤ Underwater concrete placement (slump 17cm, cement amount 370kgf/m3 or more)

⑥ Pulling out the casing - Preventing reinforcing bars from rising together

⑦ Separator depth direction 3-5m interval

⑧ Hole wall protection Concrete top surface Casing tube approximately 2m inserted

Benoto Method



①Casing Foundation Pile Center
②excavation-Hammer Grab
③excavation-Hammer Grab
④excavation-completed
⑤Water-muddy water-Mud Water Pump
⑥Rebar cage
⑦Tremie tube
⑧Ready-mixed concrete
⑨Pulling out casing
⑩Burials

(F49)pile foundation-(Construction management of Benoto piles)

(F49)pile foundation-(Construction management of Benoto piles)

pile foundation

Construction management of cast-in-place piles

① Construction of Benoto piles

① Insert reinforcing bar cage

Groundwater

casing

② Underwater concrete placement (slump 17cm,

cement amount 370kgf/m3 or more)

tremie tube is flanged and watertight.

Raise the casing approximately 2m

to protect the hole wall

Insert about 2 m on top of concrete

③ Slime (cutting residue) Mixed with muddy water

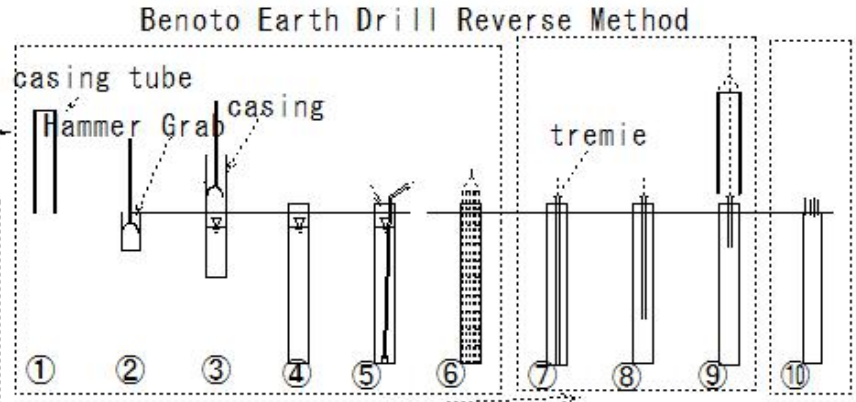
concrete curing

Must not be harmful due to temperature, load, shock, etc.

・Pile head

Add about 0.5m extra

there is muddy water, it is about 1m



(F50)pile foundation-(Benoto piles Slime processing)

(F50)pile foundation-(Benoto piles Slime processing)

pile foundation

Construction management of cast-in-place piles

Benoto Method

② Slime processing

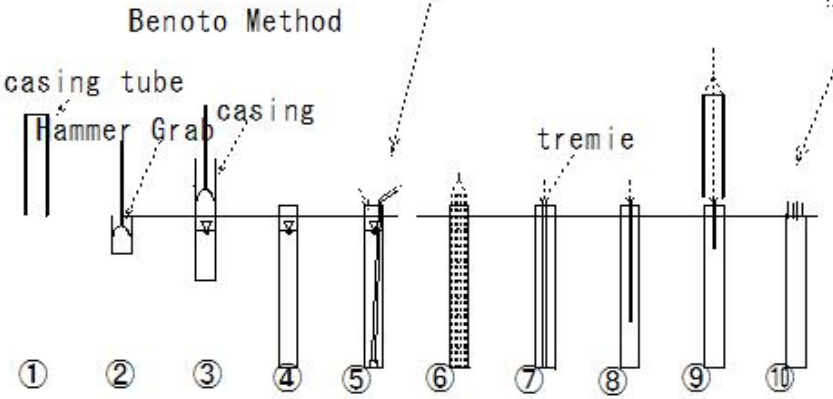
・Pile tip - Excavation residual soil, slime - Strength decrease and uneven settlement

・Slime processing

air lift pump

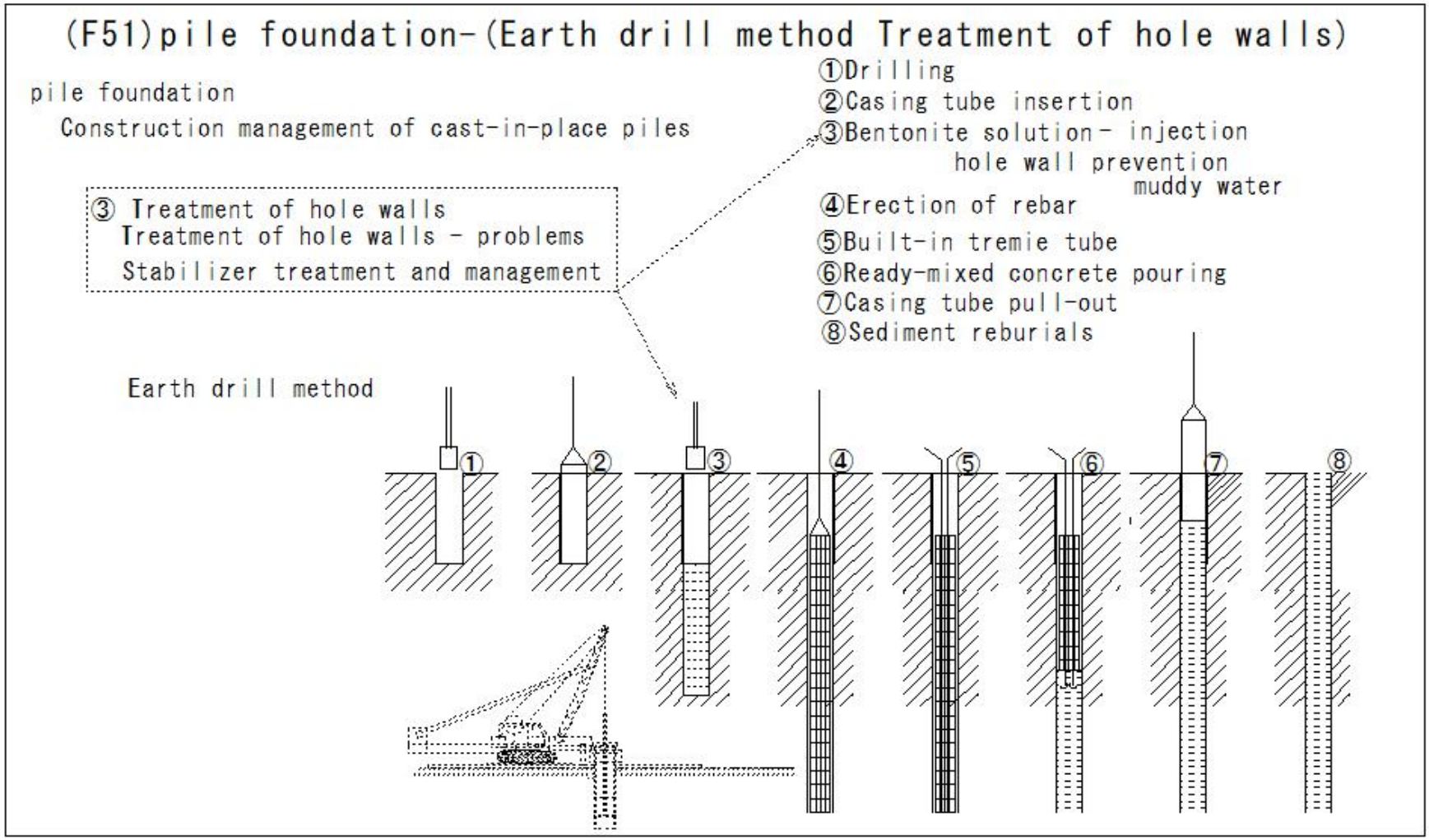
after pouring

slime mixed pile head 0.5-1.0m removed



①Casing Foundation Pile Center
②excavation-Hammer Grab
③excavation-Hammer Grab
④excavation-completed
⑤Water-muddy water-Mud Water Pump
⑥Rebar cage
⑦Tremie tube
⑧Ready-mixed concrete
⑨Pulling out casing
⑩Burials

(F51)pile foundation-(Earth drill method Treatment of hole walls)



(F52)pile foundation-(cast-in-place piles Prevention of construction pollution)

(F52)pile foundation-(cast-in-place piles Prevention of construction pollution)

pile foundation

Construction management of cast-in-place piles

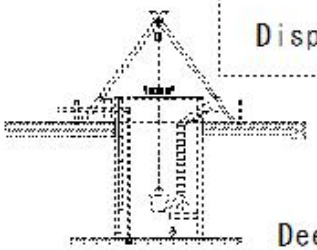
④Prevention of construction pollution

・Water pollution

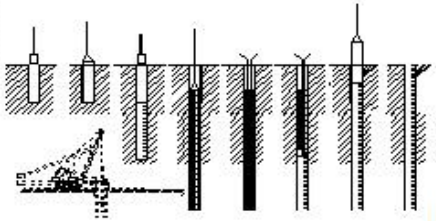
・Disposed of as sludge and sand - industrial waste - as a landfill

Emission standards

Water pollution
Disposed of as sludge and sand

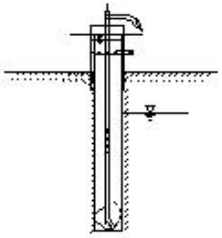


Deep foundation



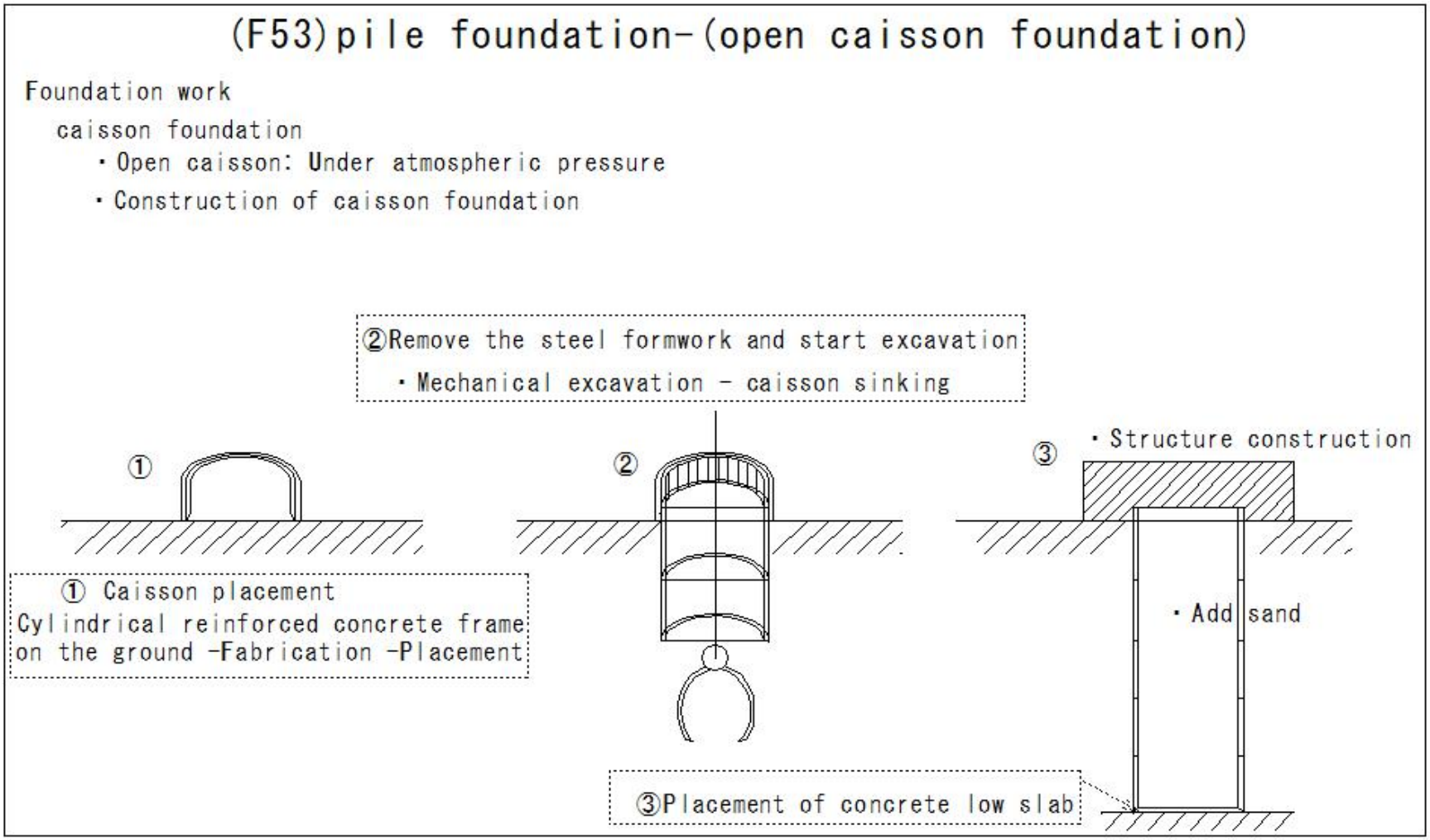
Benoto method

Earth drill method



Reverse method

(F53)pile foundation-(open caisson foundation)



(F54)pile foundation-(open caisson foundation)

(F54)pile foundation-(open caisson foundation)

Foundation work

caisson foundation

・Open caisson construction order

①Steel formwork erected above the cutting edge

②Concrete placement

③Caisson completed

④Ground excavation

⑤Caisson sinking

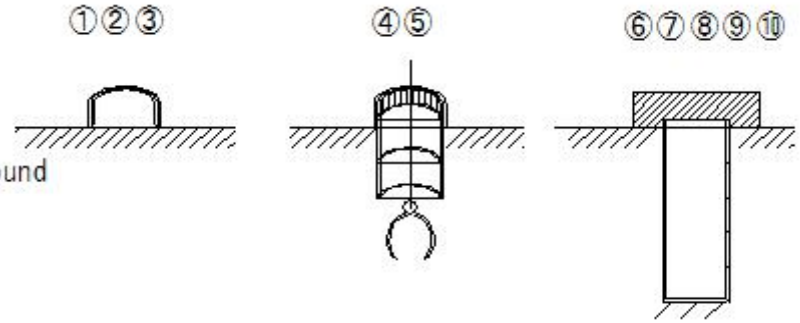
⑥Joining the cutting edge and supporting ground

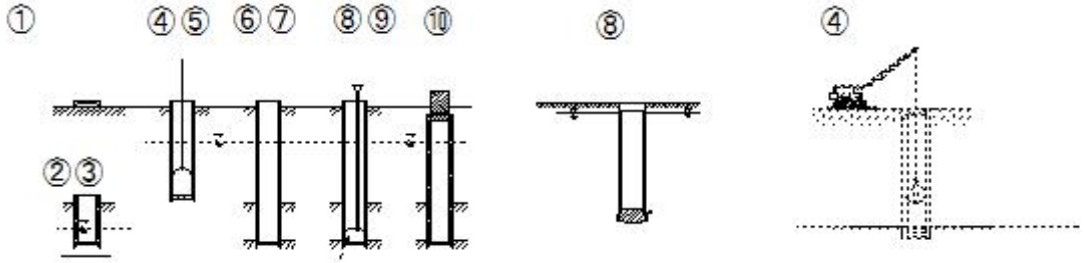
⑦Bottom cleaning

⑧Underwater concrete placement at the bottom

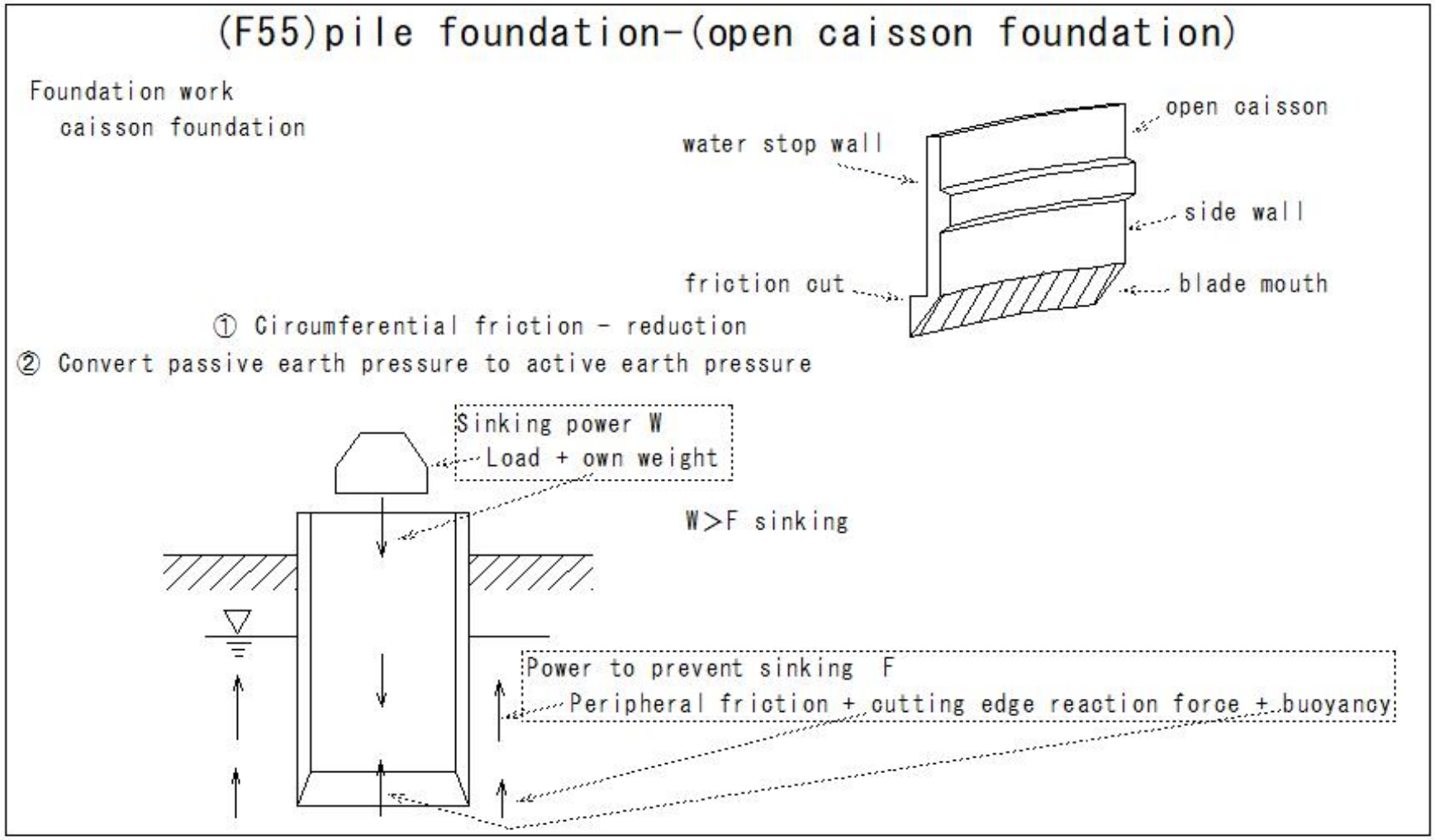
⑨Caisson filling

⑩Structure construction

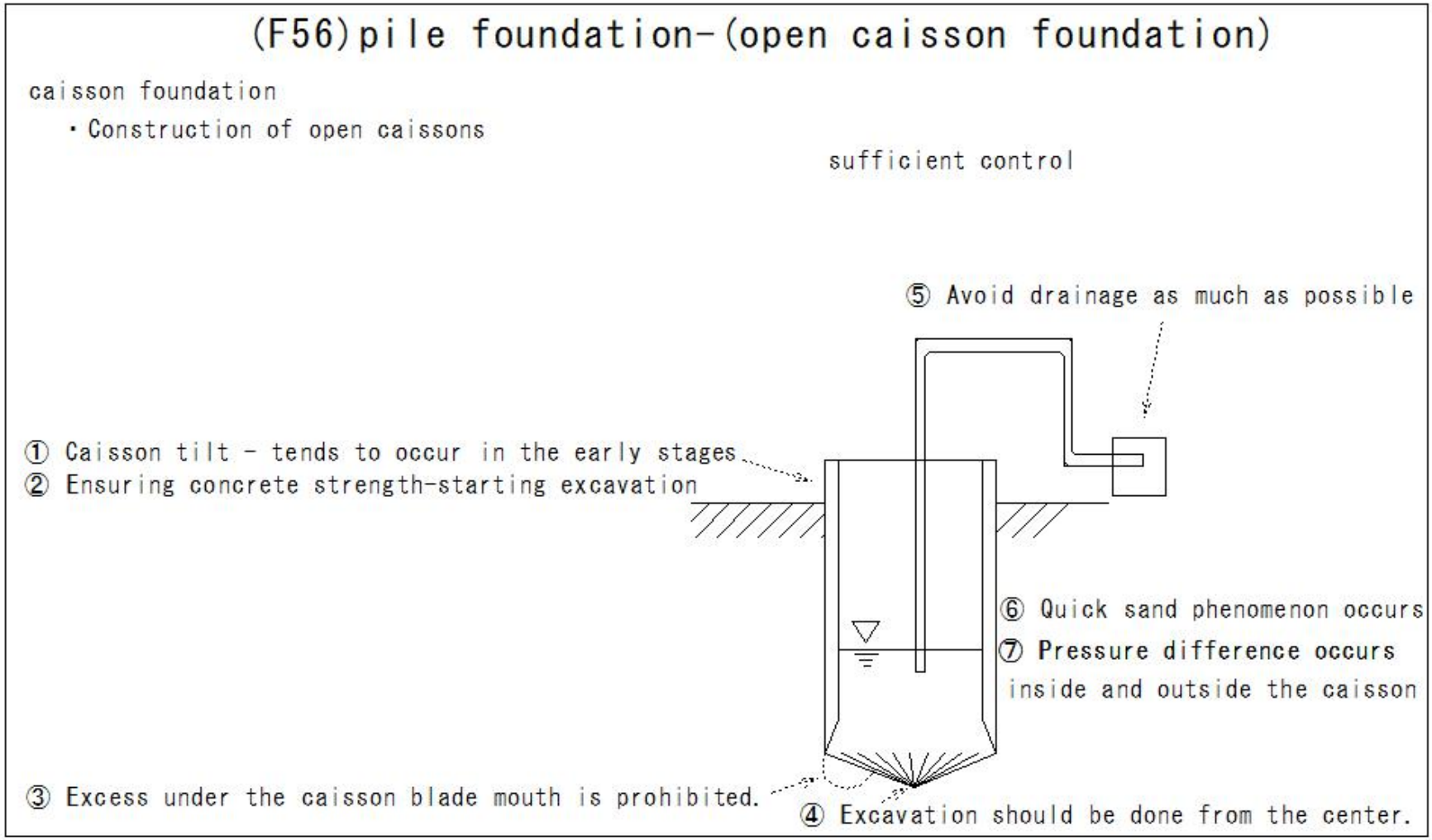




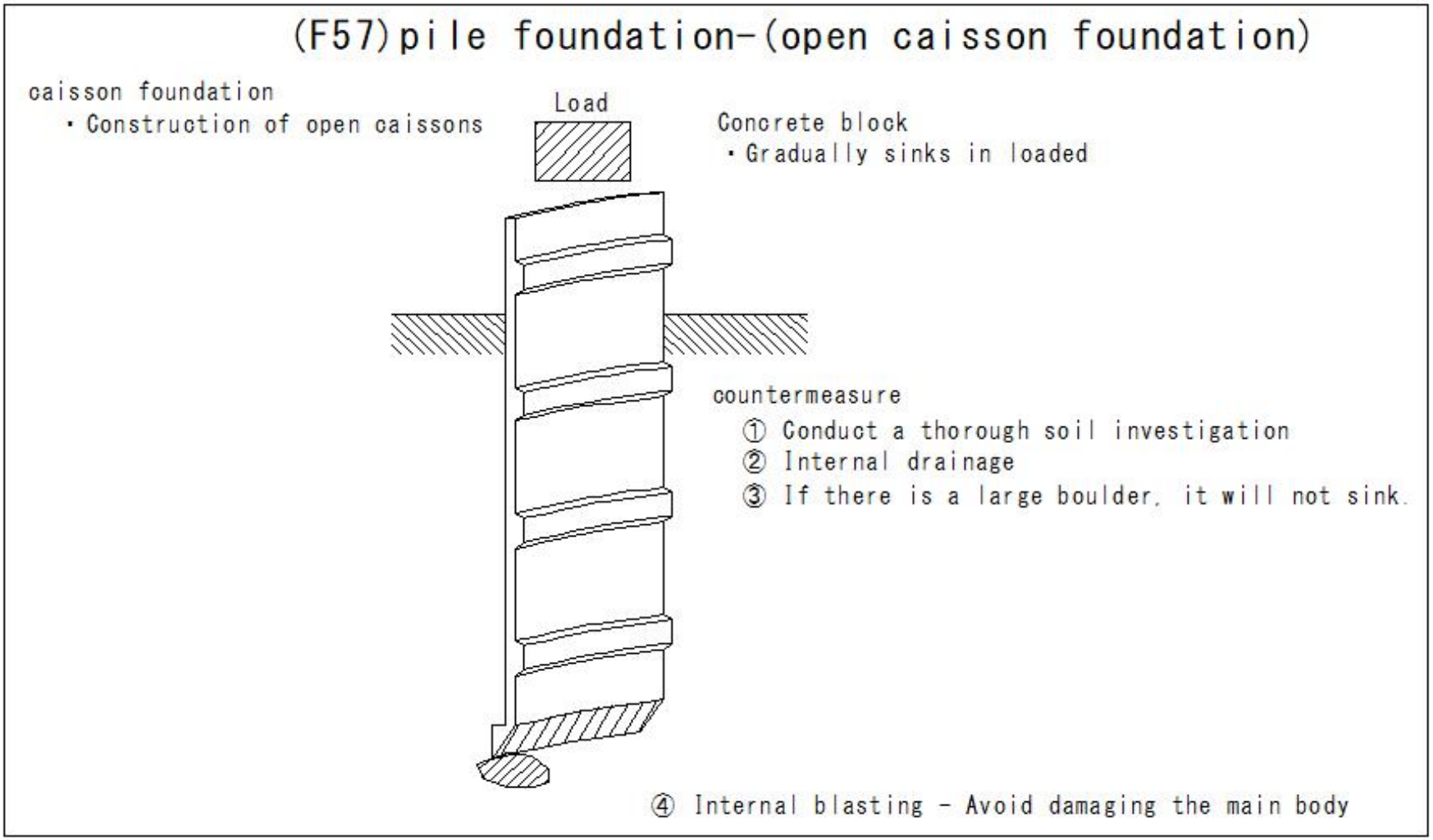
(F55)pile foundation-(open caisson foundation)



(F56)pile foundation-(open caisson foundation)



(F57)pile foundation-(open caisson foundation)



(F58)pile foundation-(pneumatic caisson)

(F58)pile foundation-(pneumatic caisson)

Foundation work

caisson foundation

pneumatic caisson

・Establish a work area at the bottom of the open caisson

・Manual excavation - Settling

Construction order

① Installation of the blade mouth

② Construction of workshop

③ Open excavation construction of second rod

④ Installing the airlock and shaft

⑤ Drilling

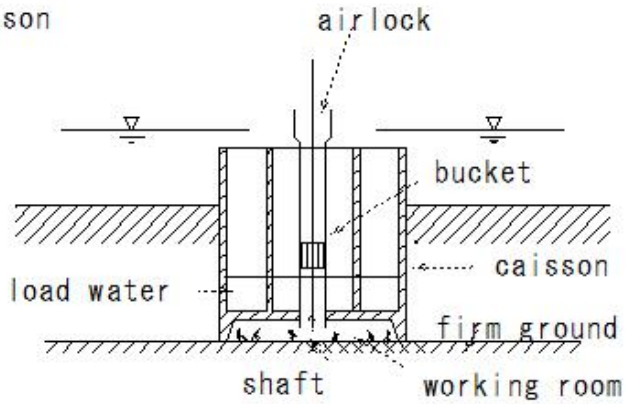
⑥ settlement

⑦ Loading test

⑧ Placement of bottom filling concrete in the works area

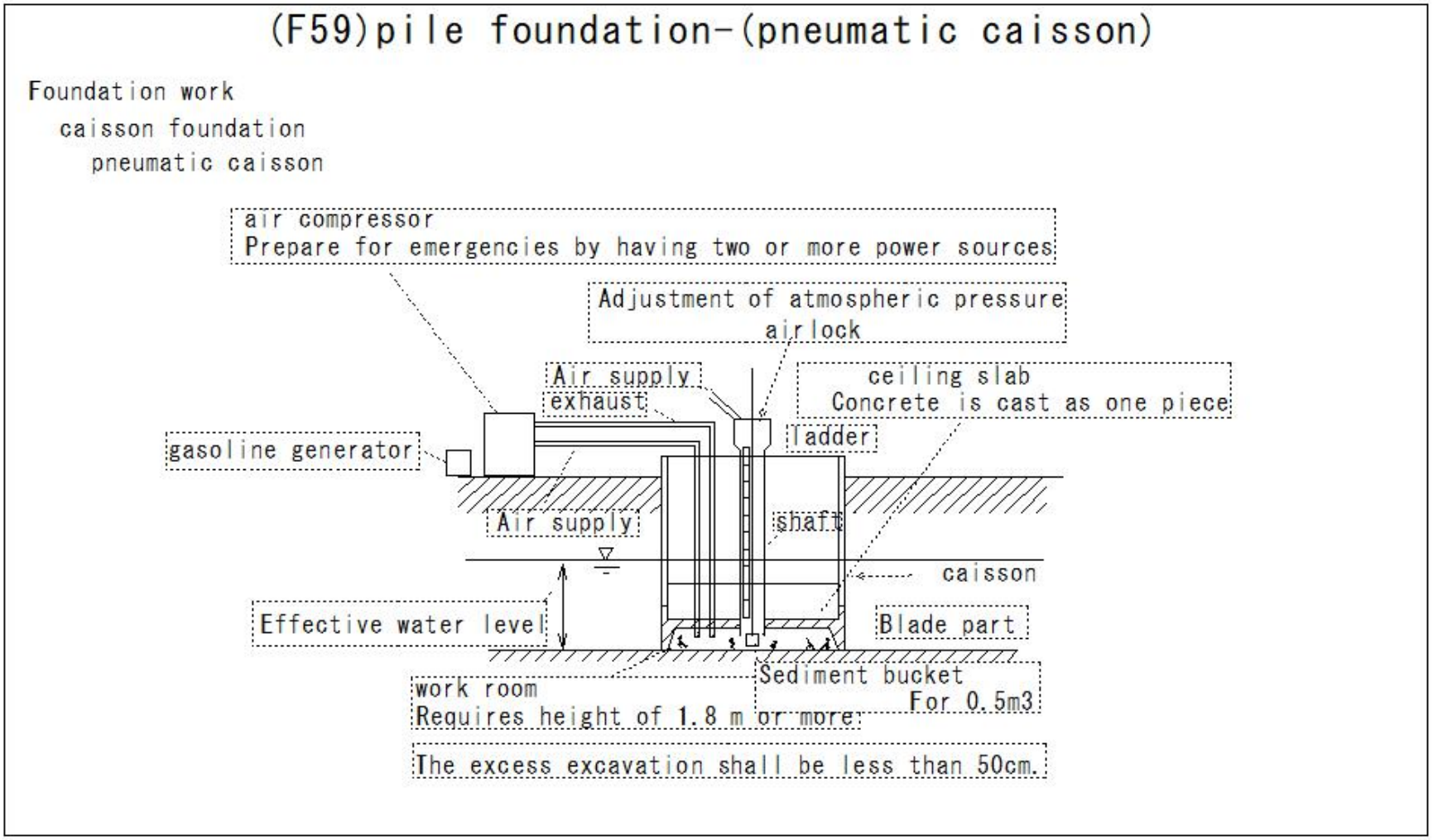
・Working under high pressure (3.5 kgf/cm2)

・Foundation of long bridge, foundation of important structure



Pneumatic caisson

(F59)pile foundation-(pneumatic caisson)

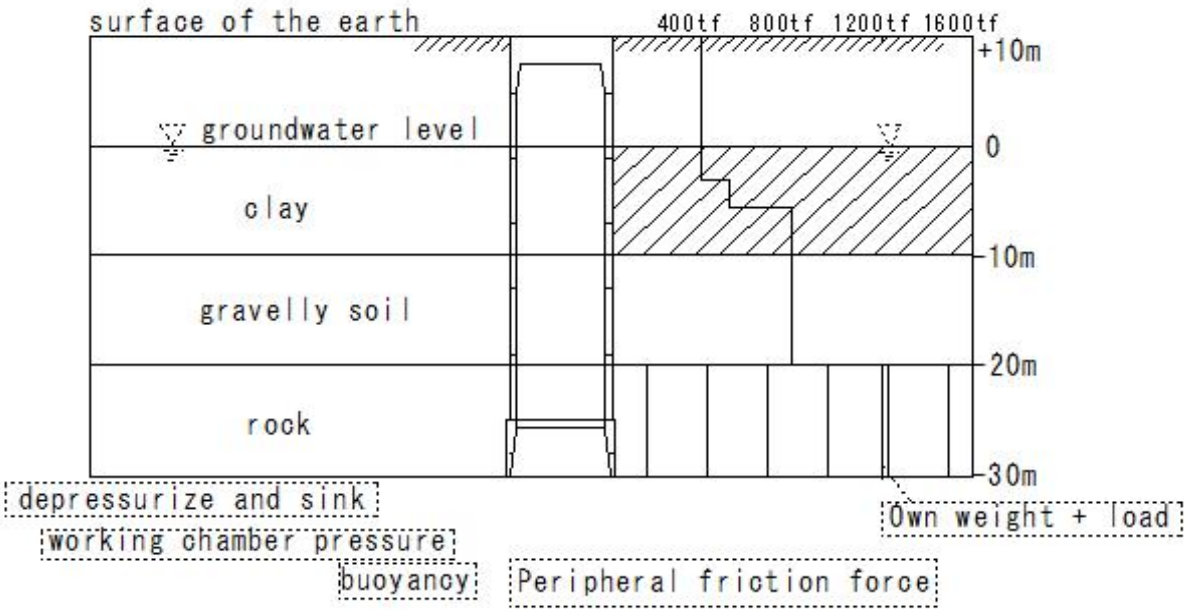


(F60)pile foundation-(pneumatic caisson)

(F60)pile foundation-(pneumatic caisson)

Foundation work
caisson foundation
pneumatic caisson

Pneumatic caisson
Settling map



(F61)pile foundation-(pneumatic caisson)

(F61)pile foundation-(pneumatic caisson)

Foundation work

caisson foundation

pneumatic caisson

・Construction points

① Excavation from the center to the periphery

② Excess moat is less than 50cm

Prohibition of use of internal combustion engines

③ Decompression

Evacuation of workers - confirmation

④ Filling concrete in the caisson

Adjusted by atmospheric pressure - rise - exhaust

⑤ Pressure of 1 atmosphere or more (1kgf/cm2) or more

Hospital lock installation

⑥Shaft human lock

Materials, soil, etc. - Material lock

⑦Pressure - until the end of excavation

Work interruption - pressurized air - required

⑧Caisson work room: Slab and cutting edge are driven at the same time

seamless

⑨ Power supply - 2 or more systems

⑩ Height of work room - 1.8 m or more

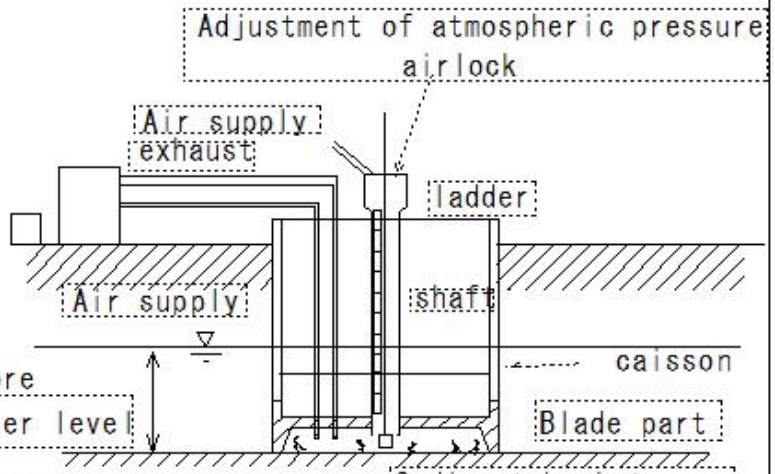
⑪Caisson tilt: Early stage of excavation, tends to occur up to about 10m

③ Decompression

air compressor

Prepare for emergencies by having two or more power sources

gasoline generator



The excess moat shall be less than 50cm.

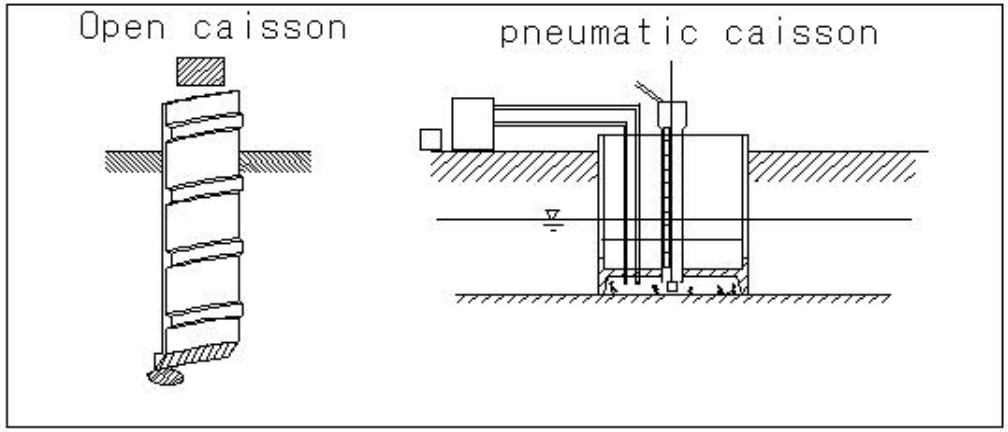
(F62)pile foundation-(Comparison of open caisson and pneumatic caisson)

(F62)pile foundation-(Comparison of open caisson and pneumatic caisson)

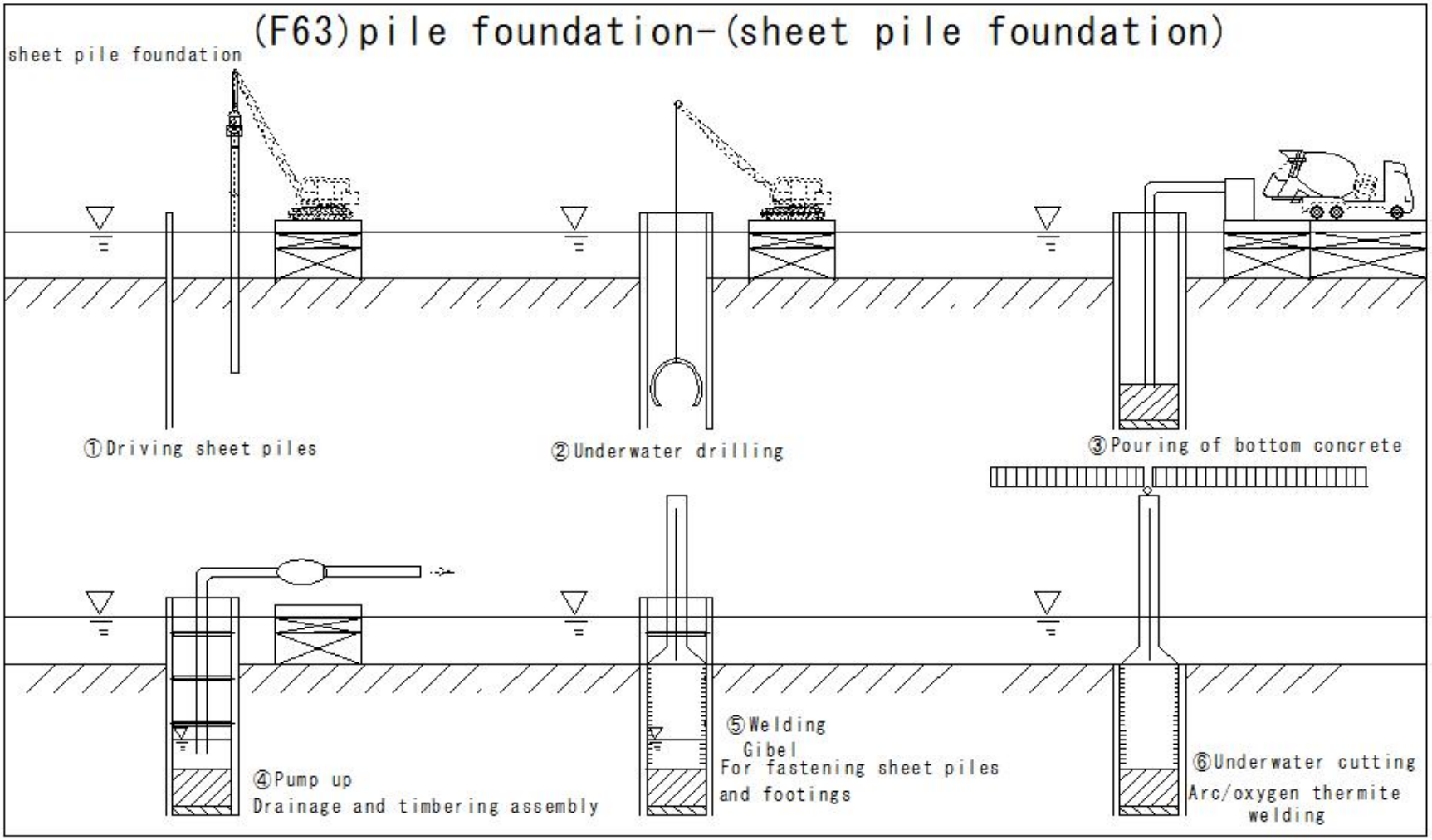
Foundation work
caisson foundation

Comparison of open caisson and pneumatic caisson

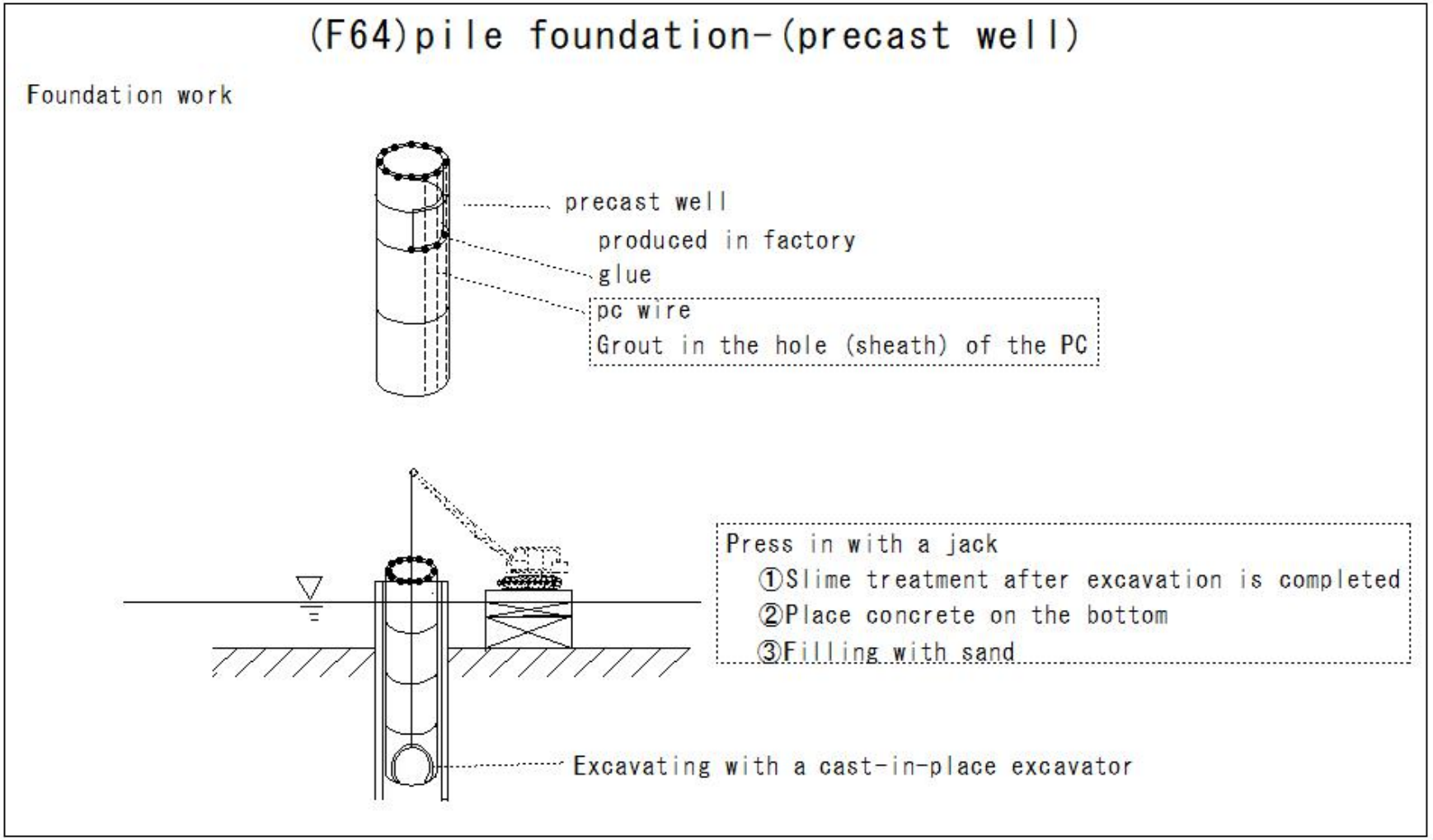
① Comparison target	Open caisson	pneumatic caisson
②Temporary equipment	Cheap	Expensive
③Pollution	Suitable for urban areas	Air compressor/exhaust noise - loud
④Surrounding ground	Groundwater decline/ground loosening	no effect
⑤Construction depth	Up to about 60m	Up to 30 m (up to pressure that humans can withsta
⑥ Construction period	undecided	determined
⑦Transfer processing	difficulty	easy
⑧Safety management	no problem	high pressure work
⑨Supporting capacity confirmation	difficulty	easy



(F63)pile foundation-(sheet pile foundation)



(F64)pile foundation-(precast well)



(F65)pile foundation-(continuous underground wall)

(F65)pile foundation-(continuous underground wall)

Foundation work

continuous underground wall

・Continuously driving bridge piles

Continuous underground wall construction

①Construction with low vibration and low noise

②Can be constructed from soft ground to bedrock

③Possible to perform construction in close proximity, minimal impact on surrounding areas

④High adhesion to the ground and large bearing capacity

⑤Foundation construction of any shape possible

⑥Closing cross section - rigidity - high

⑦Can be constructed up to a depth of 150m

⑧High safety due to construction from the ground

・Continuous underground wall construction method

(1) Pillars and pillars

(2) Pillars and walls

(3) Walls and walls

(F66)pile foundation-(Underpinning)

(F66)pile foundation-(Underpinning)

Foundation work

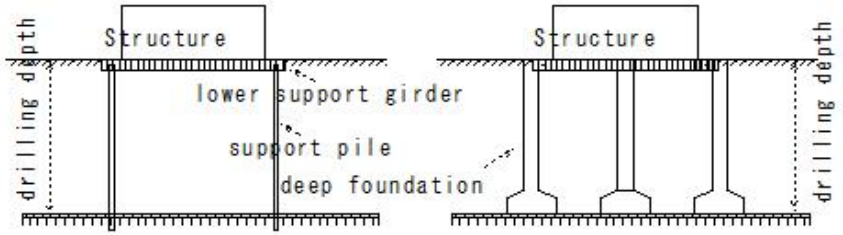
Underpinning

・Reinforcement and expansion of foundations of existing structures

① Existing foundation - Insufficient bearing capacity
(Water level falls, consolidation progresses)

②Existing foundation - protection
Excavation work next door

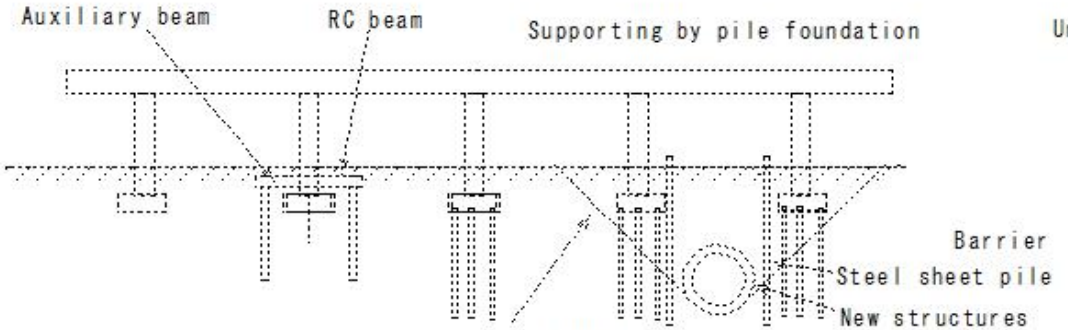
③Existing foundation - transformation
ground settlement



Supporting by pile foundation

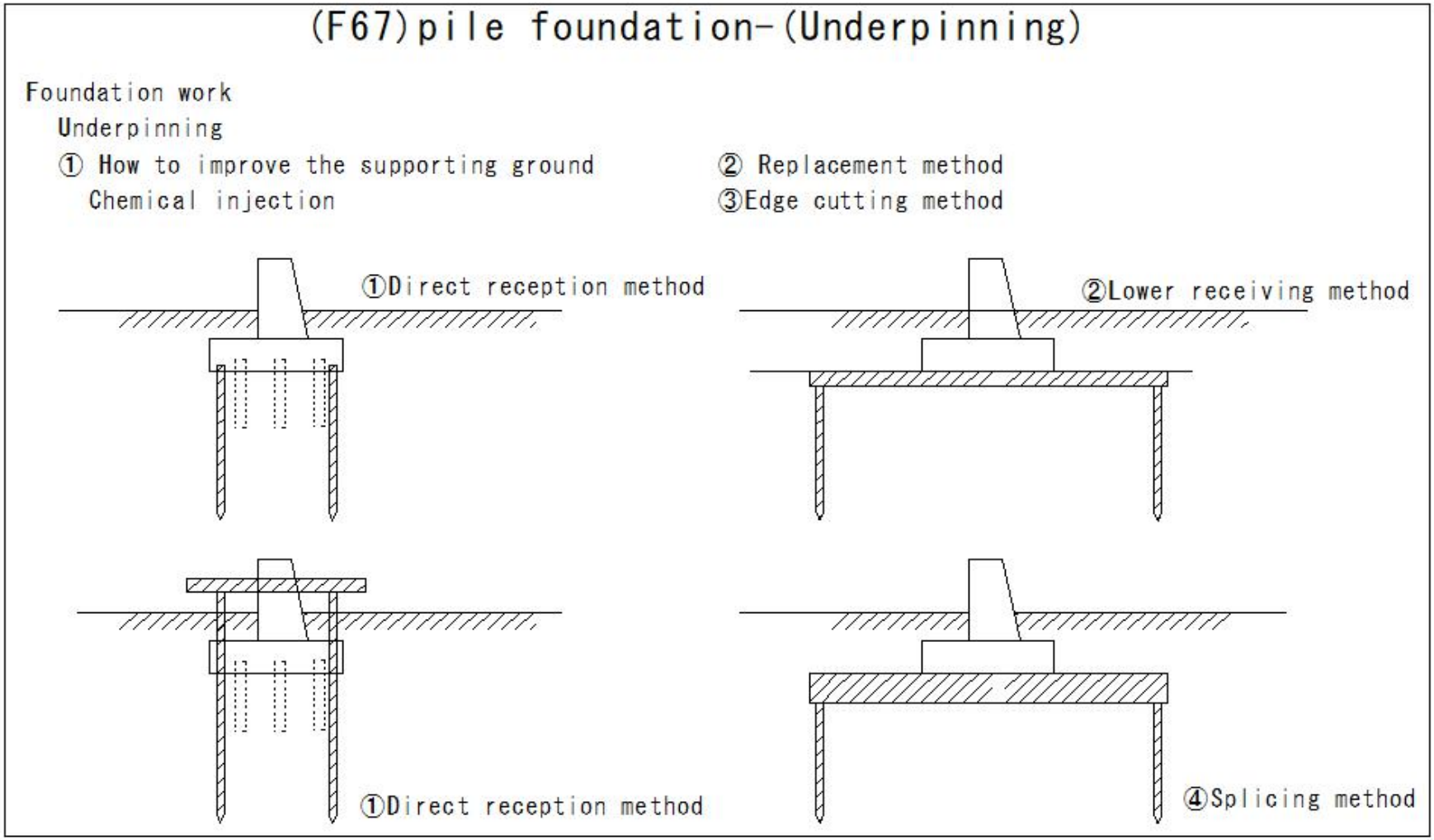
Underpinning by deep foundation

・Auxiliary beam method

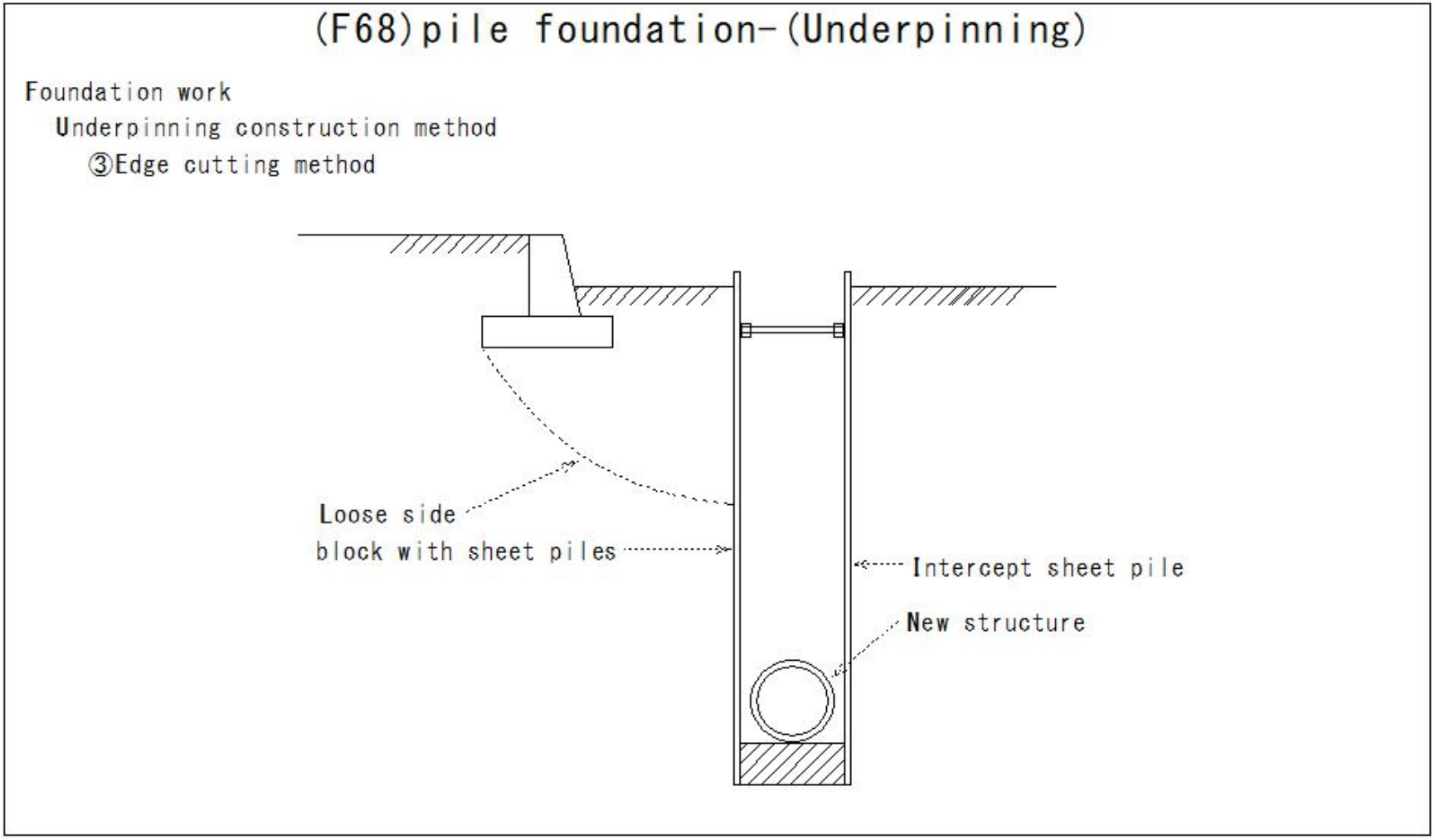


・Edge cutting method

(F67)pile foundation-(Underpinning)



(F68)pile foundation-(Underpinning)



(F69)pile foundation-(Underpinning)

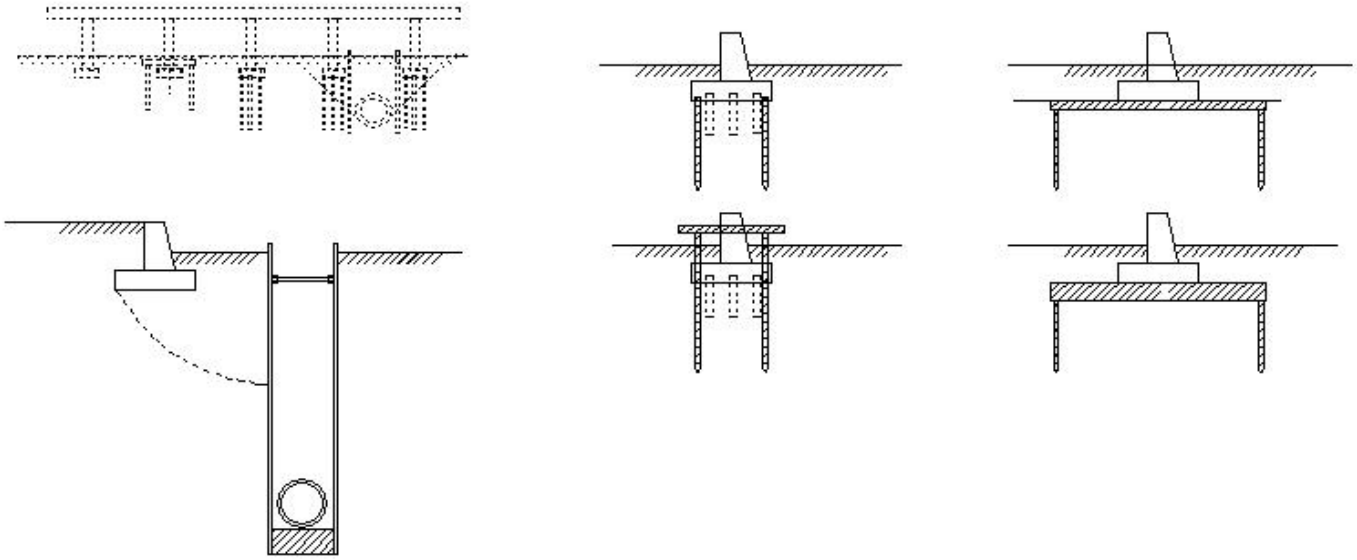
(F69)pile foundation-(Underpinning)

Foundation work

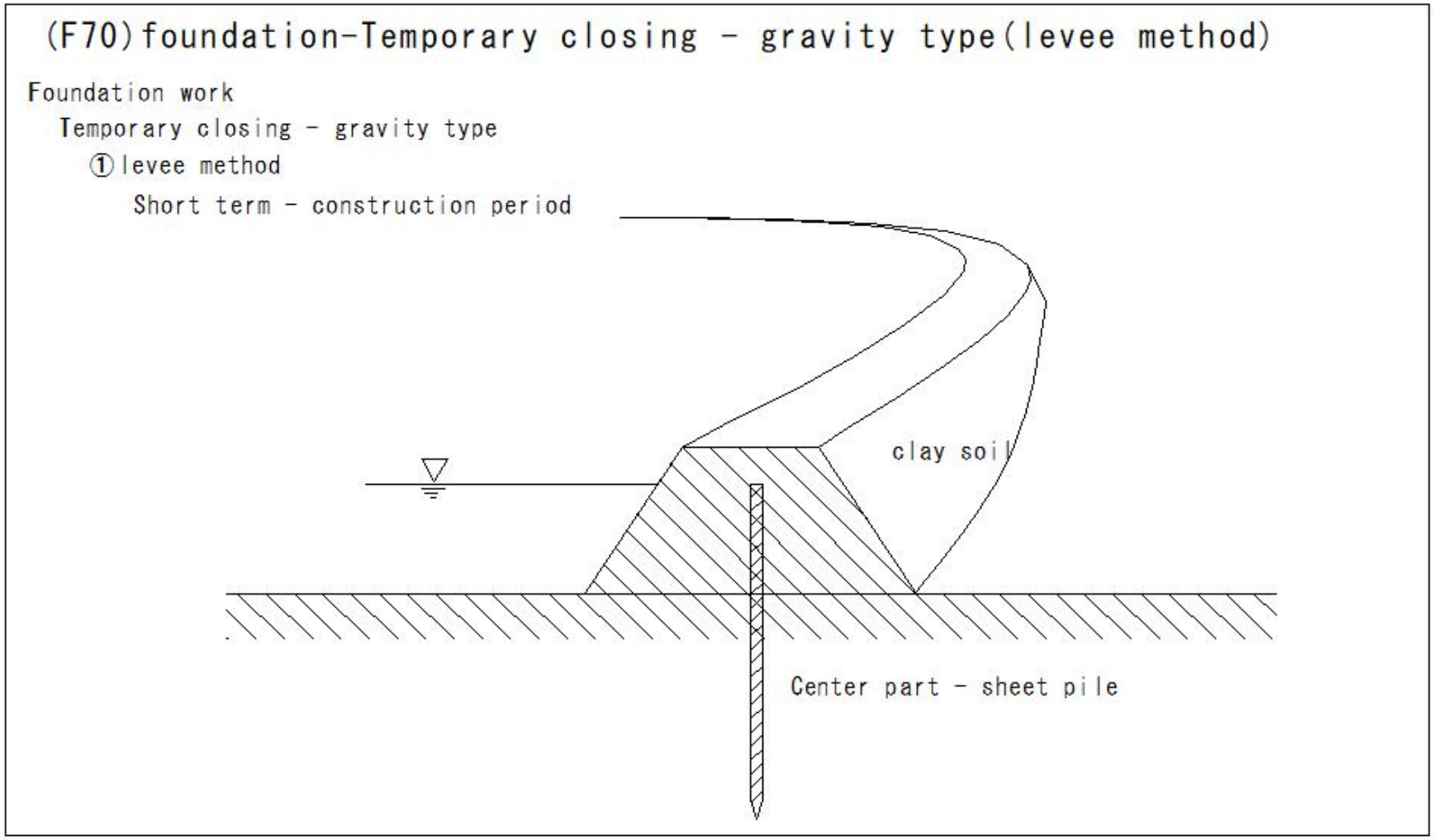
Underpinning construction method

Points to note during construction

①Settlement ②Slope ③Stress ④Deformation



(F70)foundation-Temporary closing - gravity type(levee method)



(F71)foundation-Temporary closing - gravity type(Caisson method)

(F71)foundation-Temporary closing - gravity type(Caisson method)

Foundation work

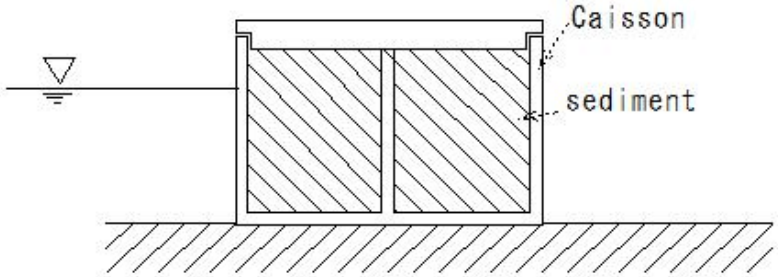
Temporary closing - gravity type

②Caisson method

large equipment

Construction conditions - poor - construction possible

Part of main body construction



Caisson method

(F72)foundation-Temporary closing - gravity type(Cellular block method)

(F72)foundation-Temporary closing - gravity type(Cellular block method)

Foundation work

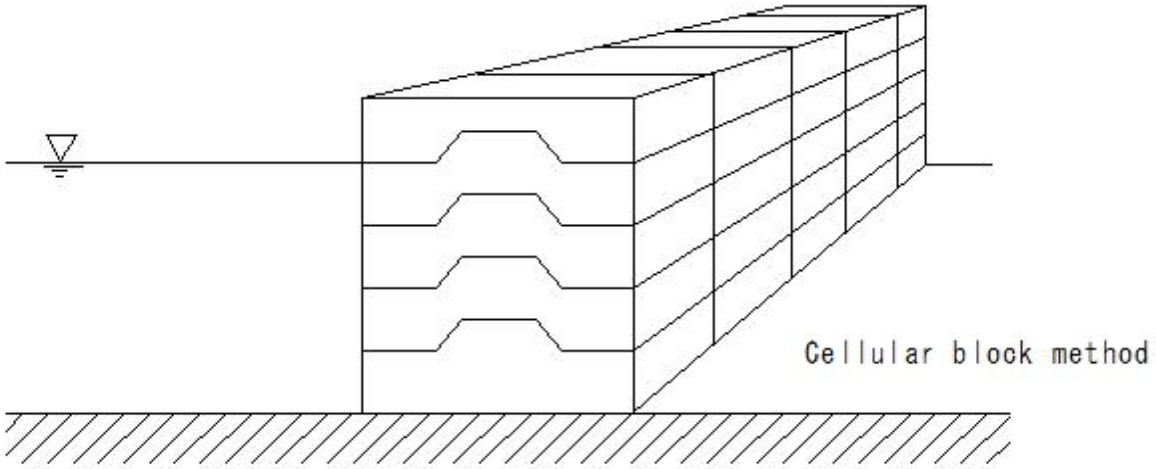
Temporary closing - gravity type

③Cellular block method

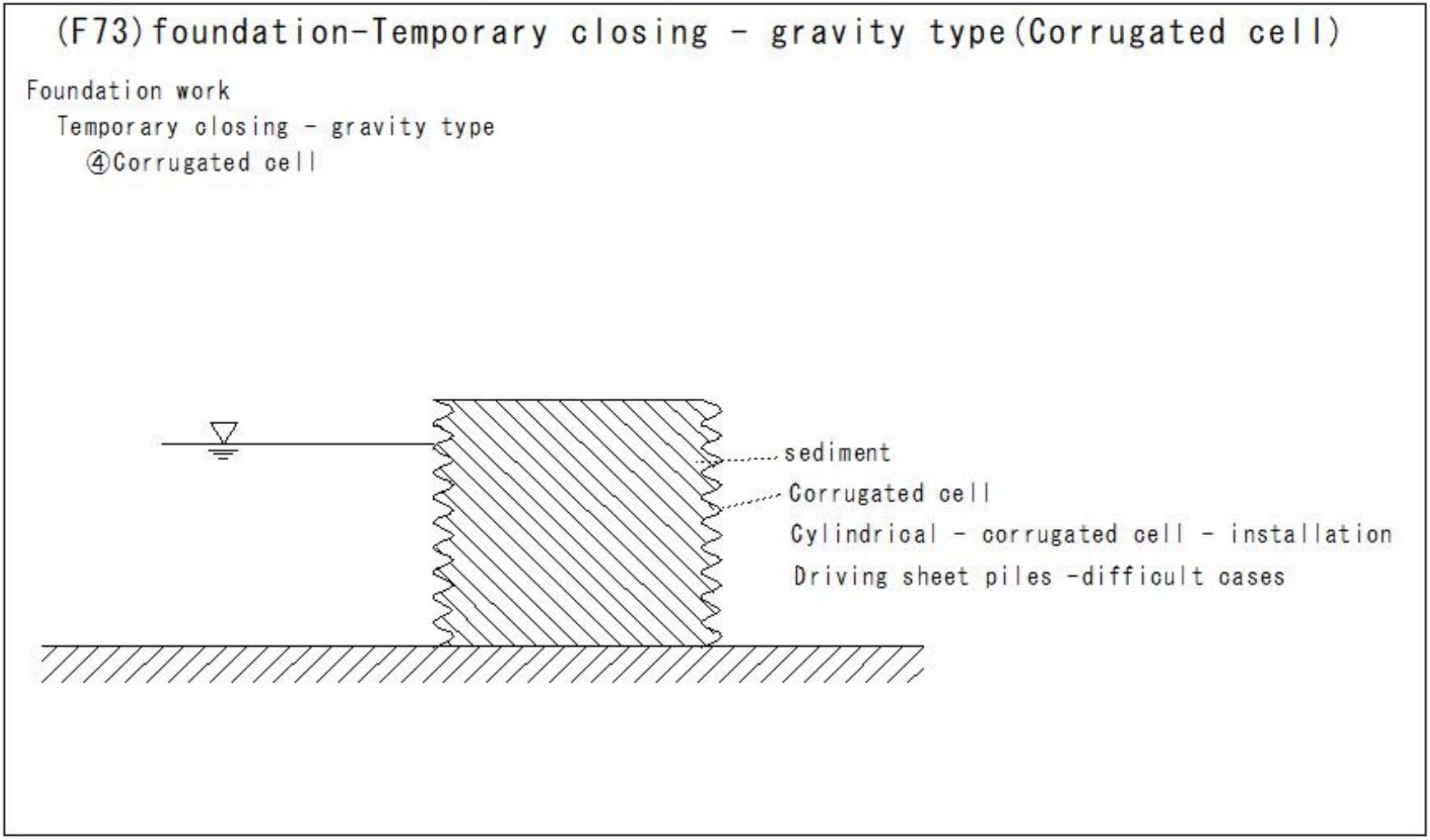
Construction conditions - poor - construction possible problem

Waterproofing of joint part

Water-tightness at the joint between the ground and the block



(F73)foundation-Temporary closing - gravity type(Corrugated cell)



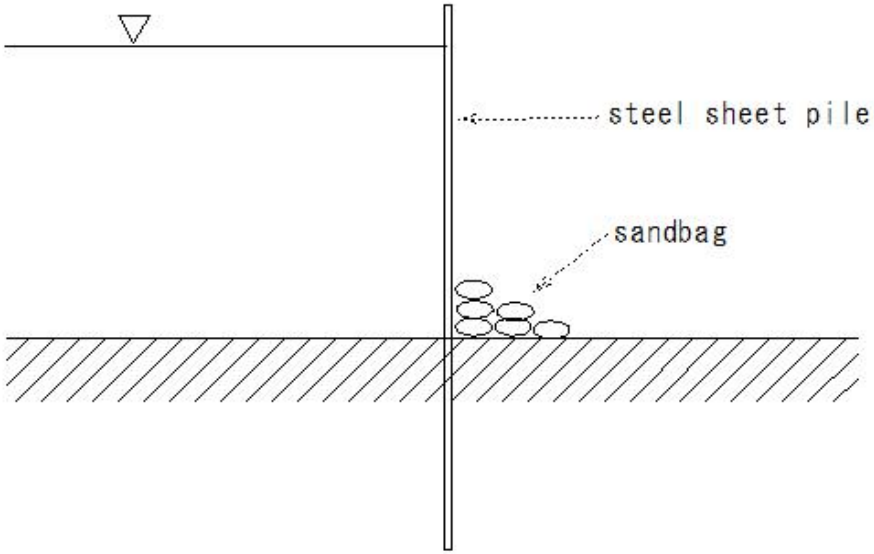
(F74)foundation-Temporary closing-sheet pile type(Free-standing type - single sheet pile)

(F74)foundation-Temporary closing-sheet pile type(Free-standing type-single sheet pile)

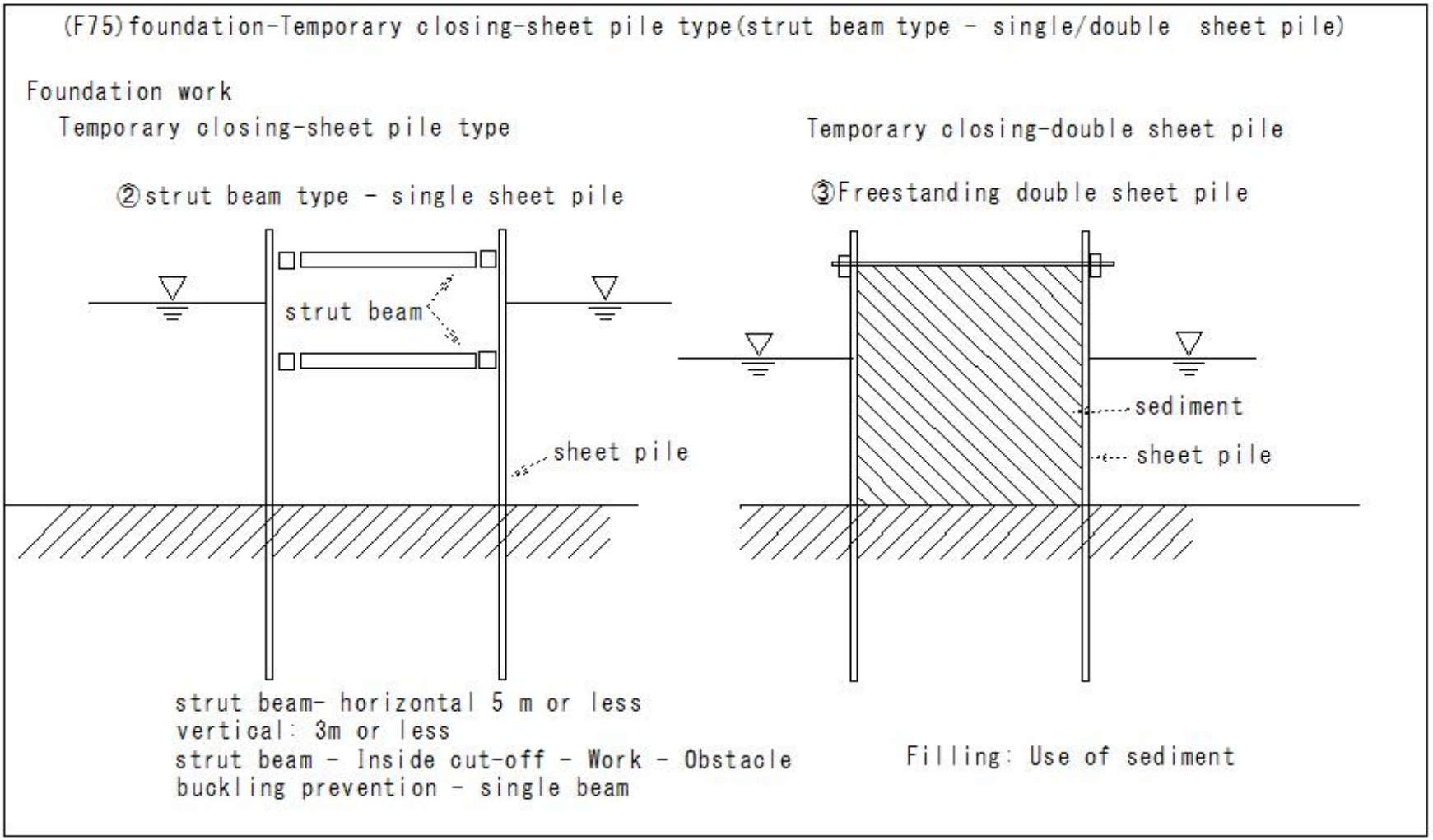
Foundation work

Temporary closing-sheet pile type

①Free-standing type - single sheet pile



(F75)foundation-Temporary closing-sheet pile type(strut beam type - single/double sheet pile)



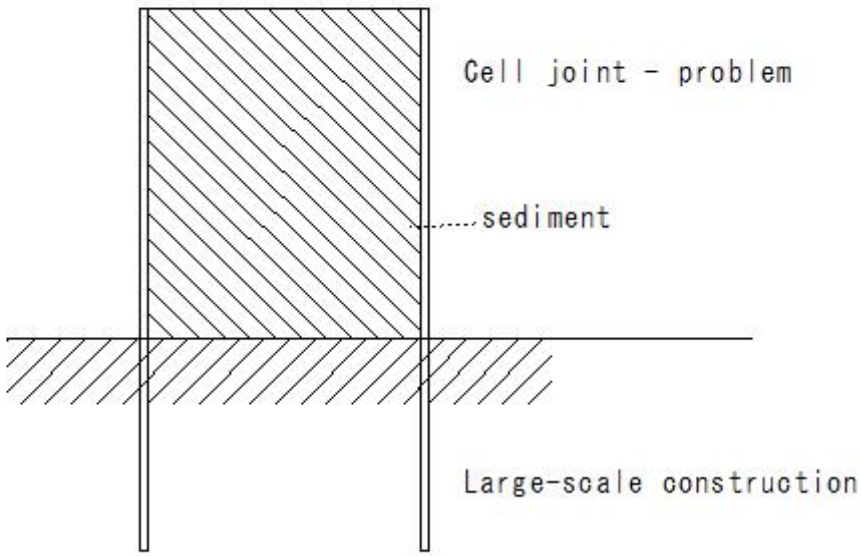
(F76)foundation-Temporary closing-sheet pile type(Cell type)

(F76)foundation-Temporary closing-sheet pile type(Cell type)

Foundation work

Temporary closing-sheet pile type

④Cell type



Filling: Use of sediment

(F77)foundation-Temporary closing

(F77)foundation-Temporary closing

Foundation work

Temporary closing - safety

① Penetration depth

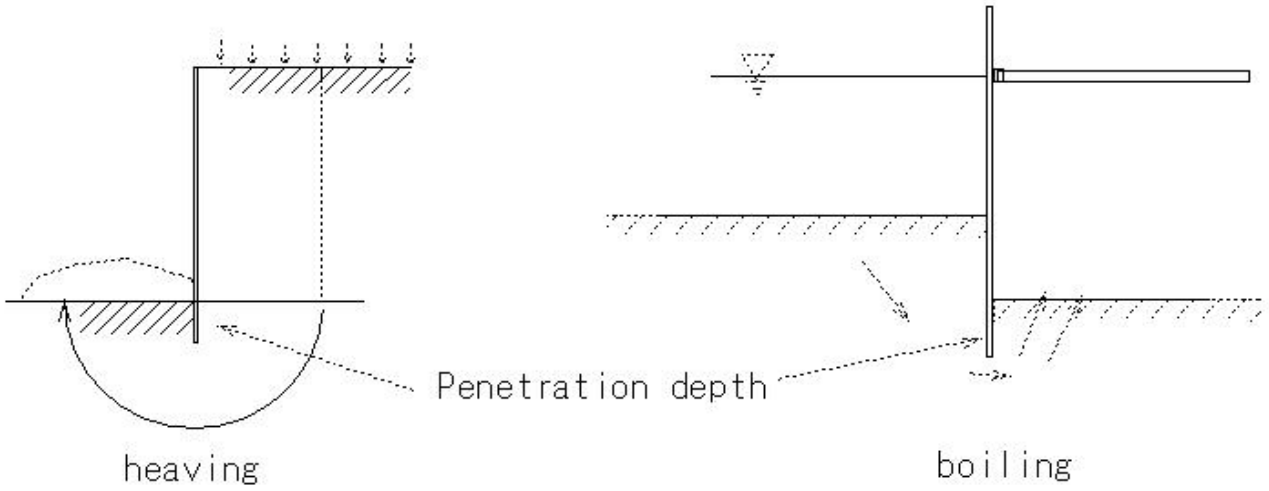
Temporary closure - Acting load - Water pressure/Earth pressure

Steel sheet pile: Penetration

① 1.2 times more Penetration

② Consideration of heaving and boiling

③ H pile: Minimum penetration 1.5m or more



(F78)foundation-Temporary closing(Boiling)

(F78)foundation-Temporary closing(Boiling)

Foundation work

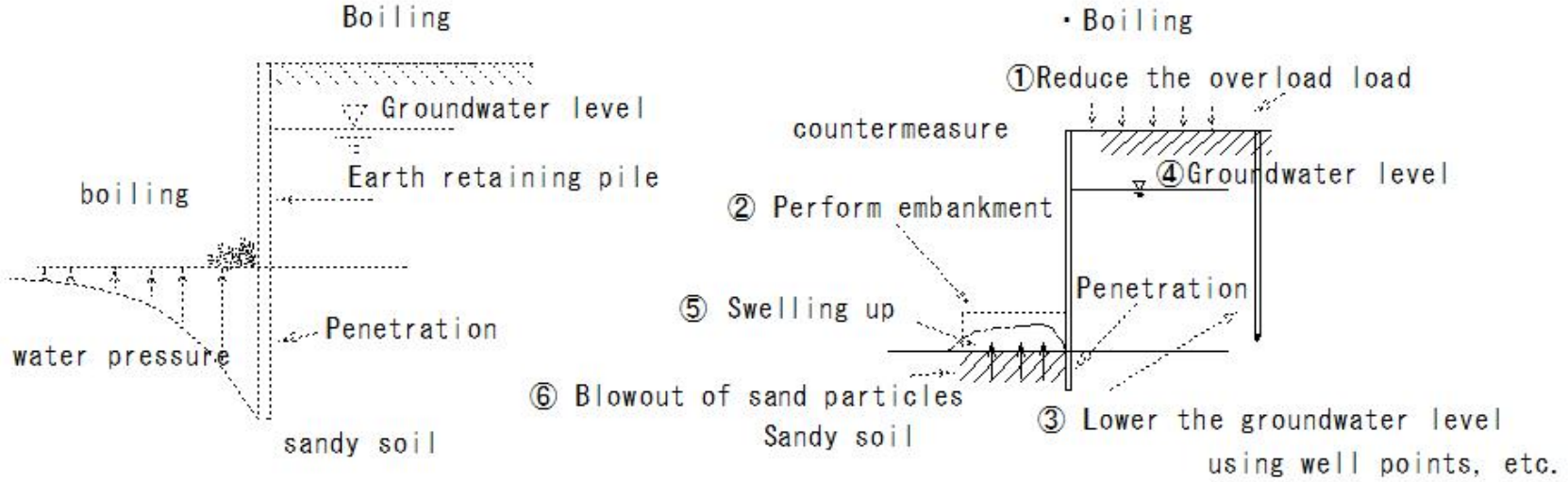
Temporary closing - safety

①Boiling

- Loose sandy ground
- Groundwater level difference-high
- Ground: Sand

countermeasure

- Safe Penetration



(F79)foundation-Temporary closing(Heaving)

(F79)foundation-Temporary closing(Heaving)

Foundation work

Temporary closing- safety

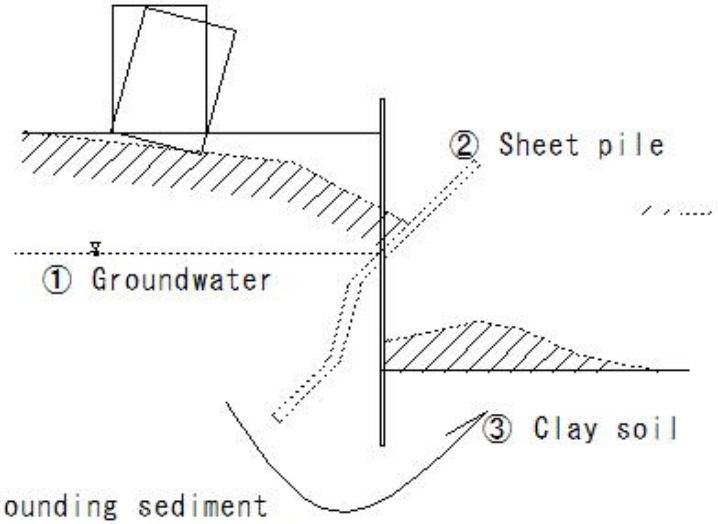
②Heaving

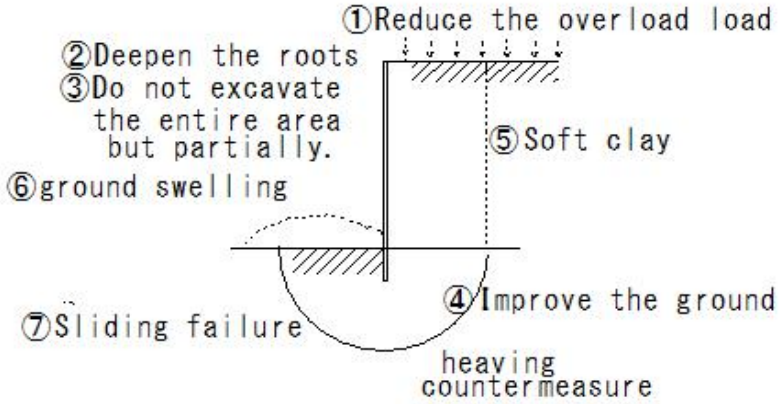
soft clay layer

・Groundwater level difference - high

・Drilling low version -lifting countermeasure

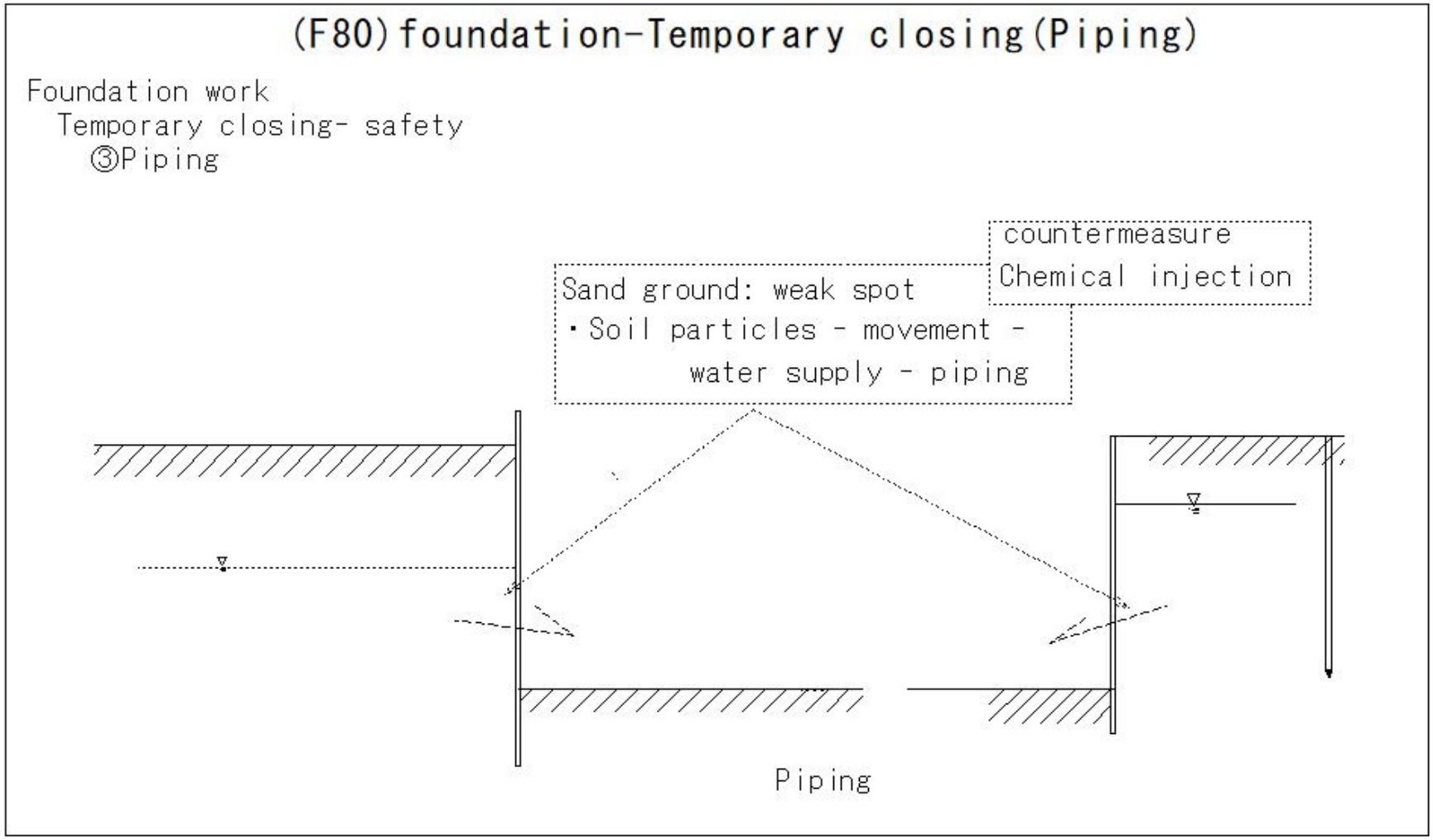
・Safe Penetration





heaving

(F80)foundation-Temporary closing(Piping)



(F81)foundation-Temporary closing(Quicksand phenomenon)

(F81)foundation-Temporary closing(Quicksand phenomenon)

Foundation work

Temporary closing- safety

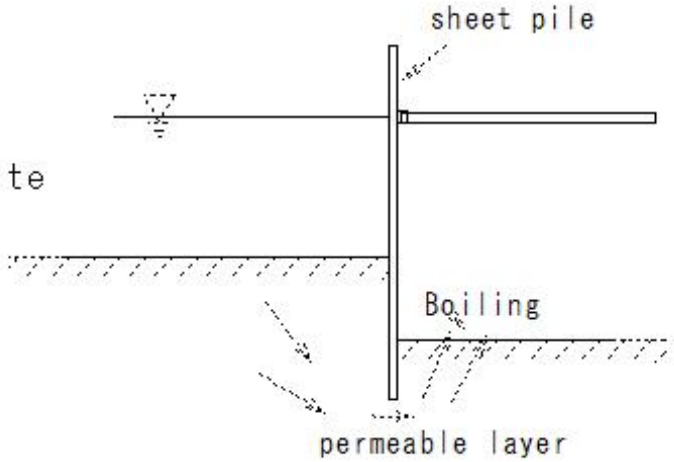
④Quicksand phenomenon

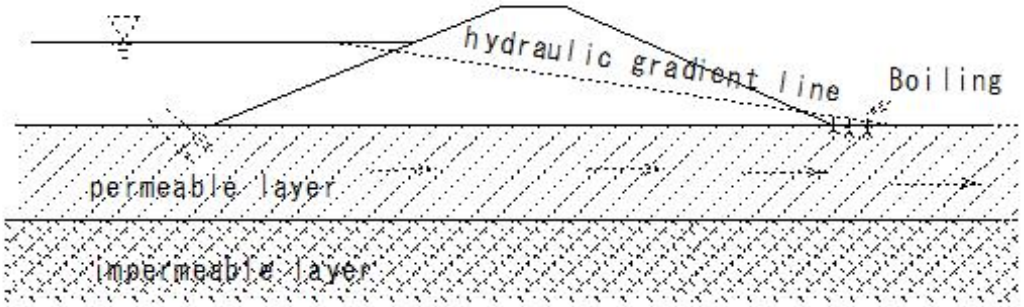
- Piping in sandy ground
- Sandy liquid
- A large amount of sand movement
- Ground settlement around the construction site

countermeasure

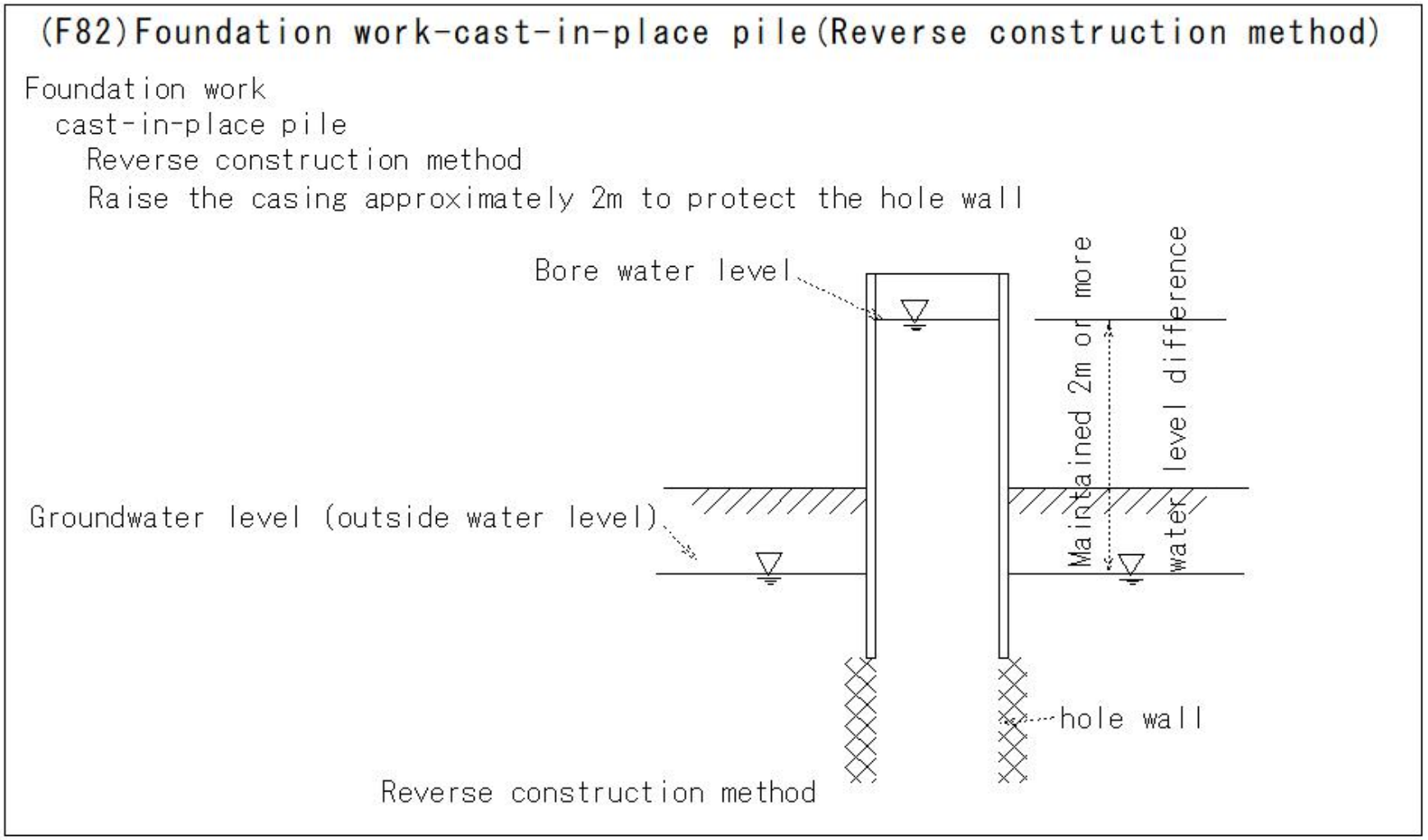
sand particle size

N value - consideration





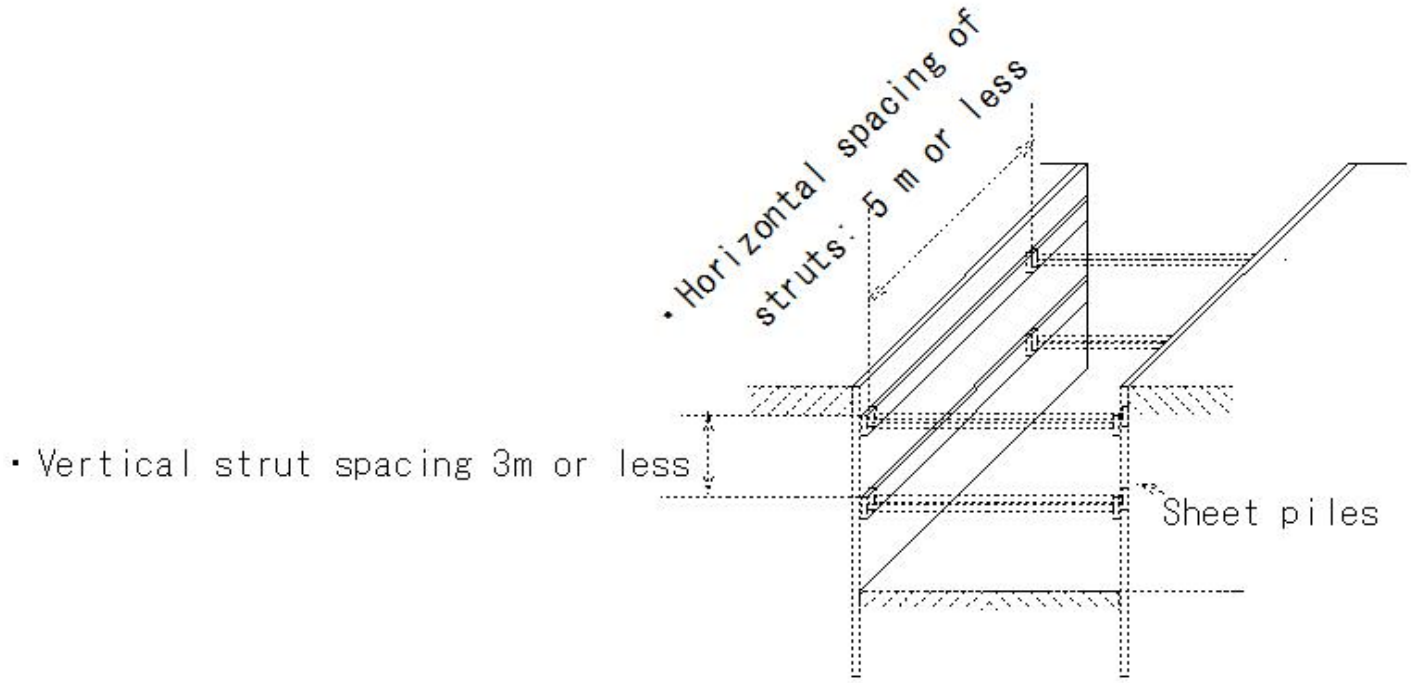
(F82)Foundation work-cast-in-place pile(Reverse construction method)



(F83)Foundation work-(strut type temporary closing work)

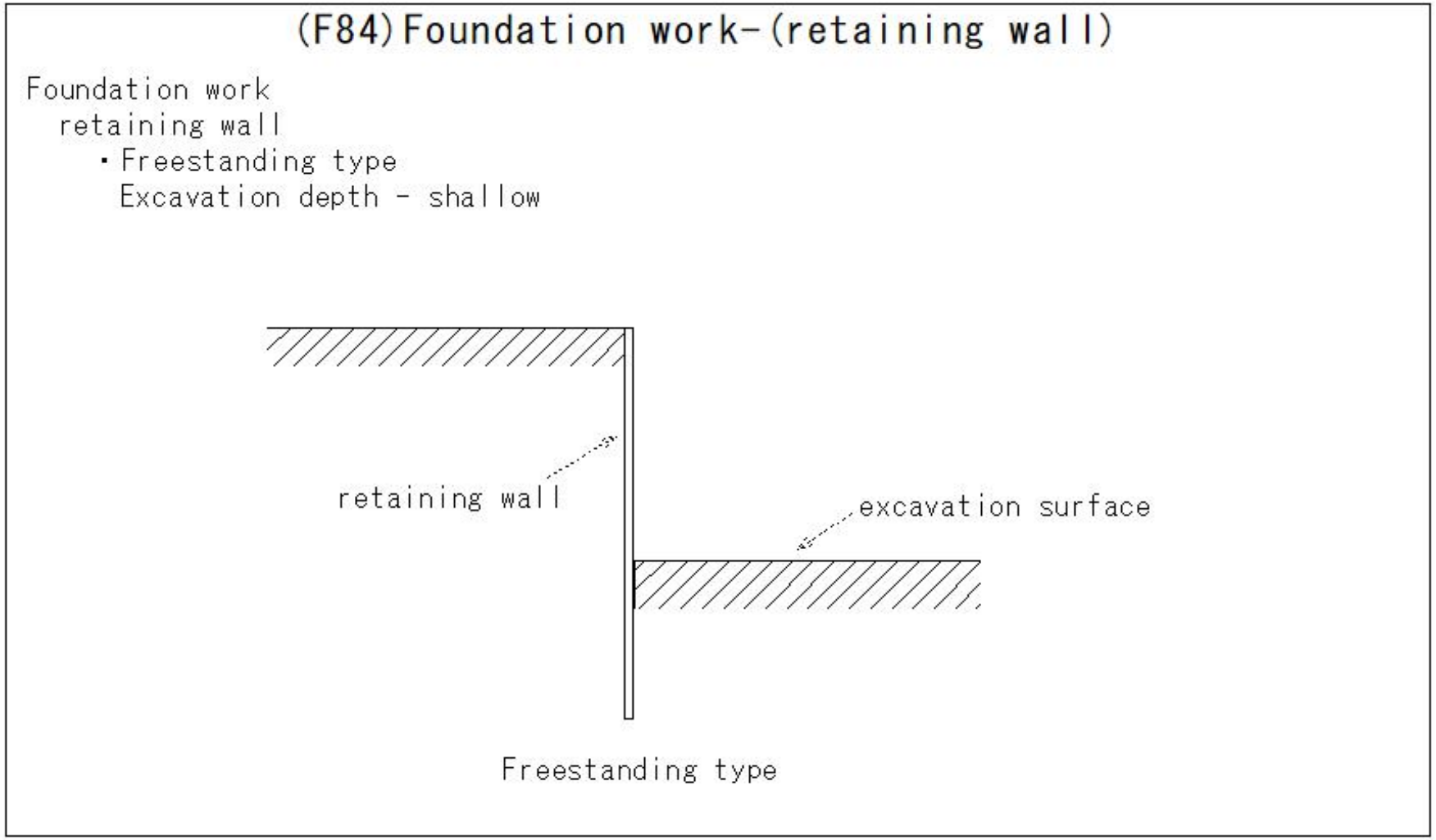
(F83)Foundation work-(strut type temporary closing work)

Foundation work
strut type temporary closing work



Stray beam type temporary cofferdam

(F84)Foundation work-(retaining wall)



(F85)Foundation work-(retaining wall)

(F85)Foundation work-(retaining wall)

Foundation work

retaining wall

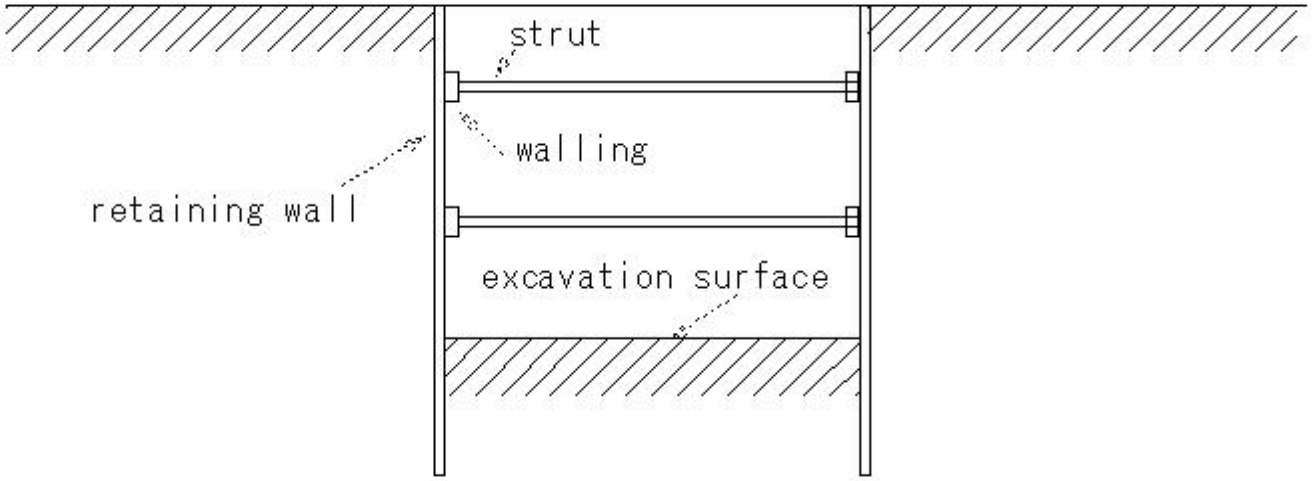
strut type

・Features: Application

drilling -deep

Site - narrow

Excavation amount - want to reduce



strut type

(F86)Foundation work-(retaining work)

(F86)Foundation work-(retaining wall)

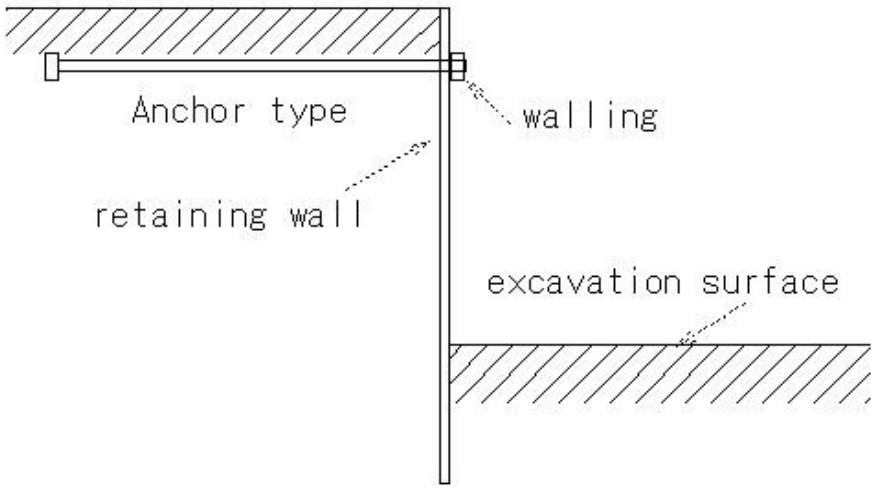
Foundation work

Earth retaining work

- Anchor type
- Features: Application

Inside the excavation - large space

- Anchor driving possible



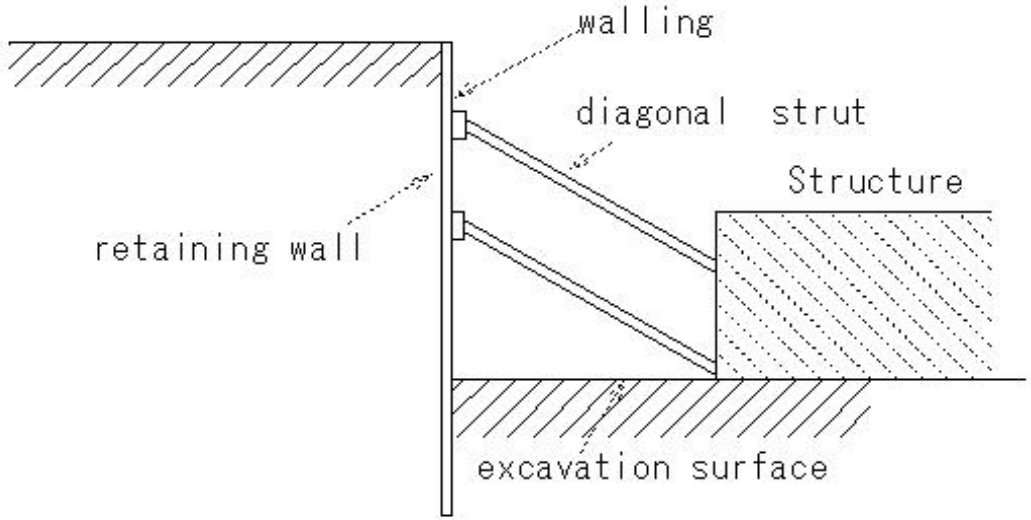
Anchor type

(F87)Foundation work-(Island construction method)

(F87)Foundation work-(Island construction method)

Earth retaining work

- Island construction method
  - Features: Application
    Excavation area - large
    strut・timbering-disadvantageous
    soft ground
    Heaving prevention



(F88)Foundation work-(Earth retaining work-Sheet pile (wood) earth retaining)

(F88)Foundation work-(Earth retaining work-Sheet pile (wood) earth retaining)

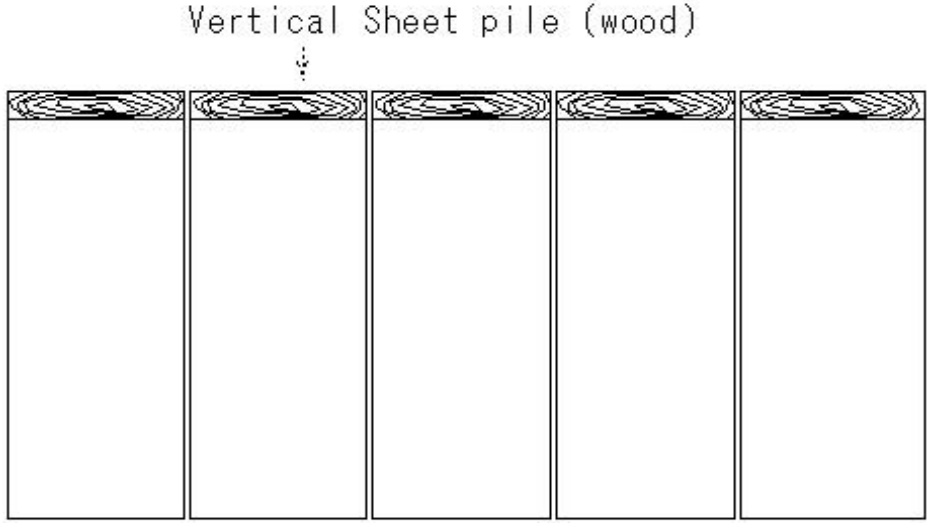
Earth retaining work

Sheet pile (wood) earth retaining

- shape-Vertical sheet pile
- Applicable condition
  - simple earthwork
  - trench method
- Features

  Construction costs -low

  weak strength



Sheet pile (wood) earth retaining

(F89)Foundation work-(Steel pile (main pile) horizontal sheet pile earth retaining)

(F89)Foundation work-(Steel pile (main pile) horizontal sheet pile earth retaining)

Earth retaining work

Steel pile (main pile) horizontal sheet pile earth retaining

- Applicable condition

  Groundwater - low

  No spring water

  Normal ground: Boiling, no heaving

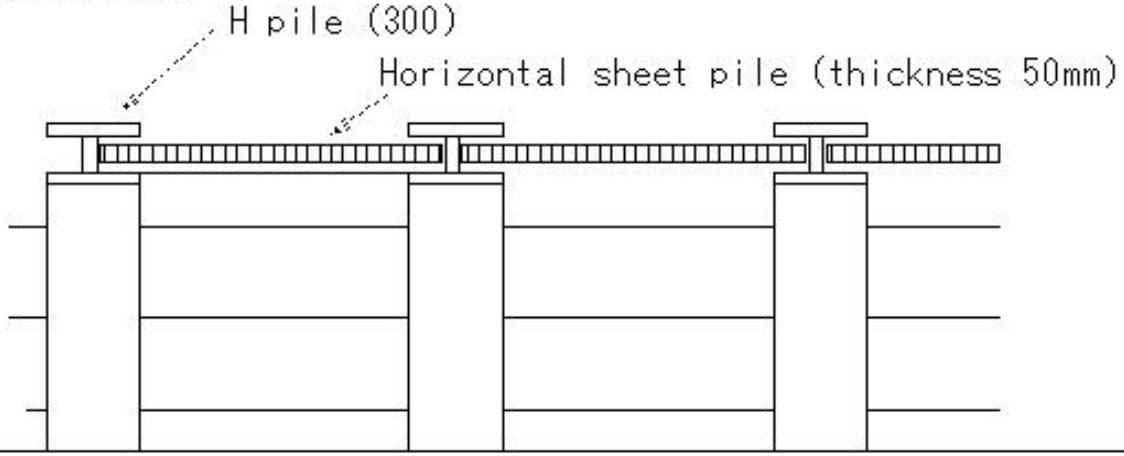
  Road support possible

- Features

  Construction cost - cheap

  Obstacles - construction possible

  Earth retaining - close contact



(F90)Foundation work-(Steel sheet pile earth retaining work)

(F90)Foundation work-(Steel sheet pile earth retaining work)

Earth retaining work

Steel sheet pile earth retaining work

- Applicable condition

  Groundwater - high - sandy ground

  Role of earth retaining and water stopping

  Heaving/boiling - suitable for soft ground

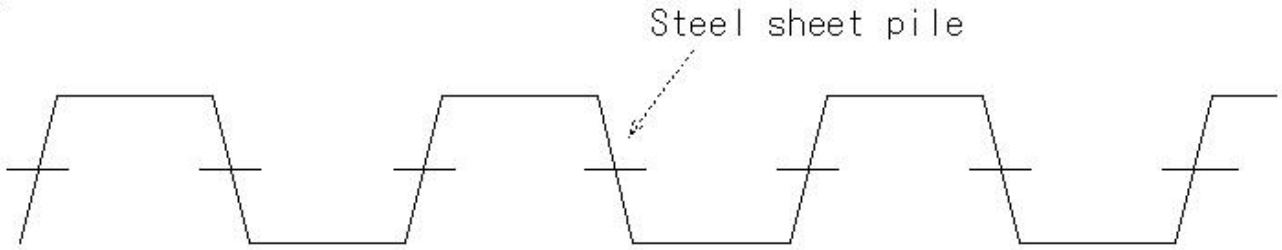
- Features

  Material can be used repeatedly

  Buried objects - cannot be constructed continuously

  Cobblestones/hard ground - unsuitable

  noise



(F91)Foundation work-(concrete continuous underground wall)

(F91)Foundation work-(concrete continuous underground wall)

Earth retaining work

concrete continuous underground wall

- Applicable condition

  Road load support

  Role of earth retaining and water stopping

  No-noise, no-vibration - construction

  Prevention of surrounding ground settlement

  Excavation depth - deep

- Features

  Main structure - use

  Length/Thickness - Free

  Temporary fixing - expensive work

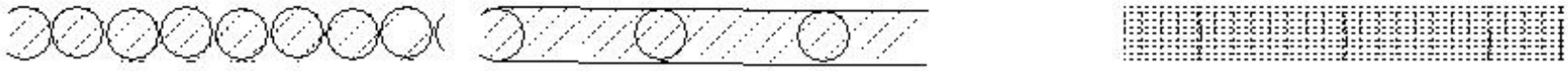
  Column style - close contact

- Continuous underground wall construction method

(1) Pillars and pillars

(2) Pillars and walls

(3) Walls and walls

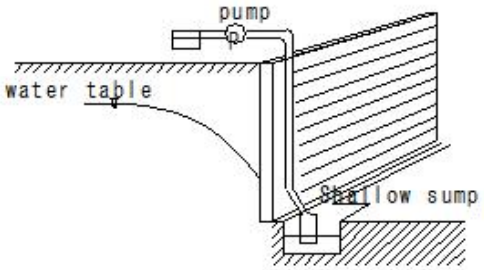


(F92)Foundation work-(Drainage method)

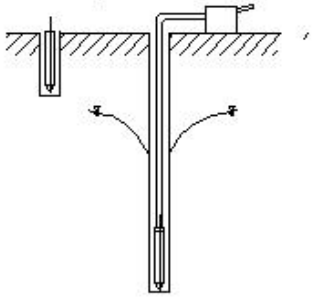
(F92)Foundation work-(Drainage method)

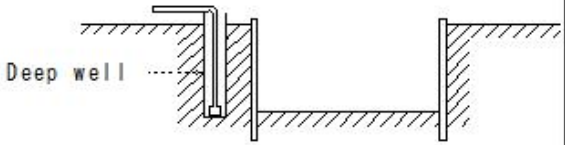
Drainage method

- Excavation - below groundwater level
- Pumping up groundwater - drying up of well water
- Decline in surrounding groundwater
- Surrounding area survey

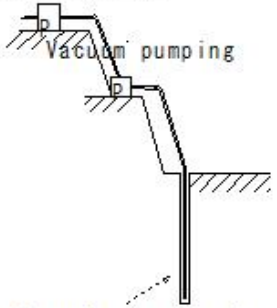


Well point construction method

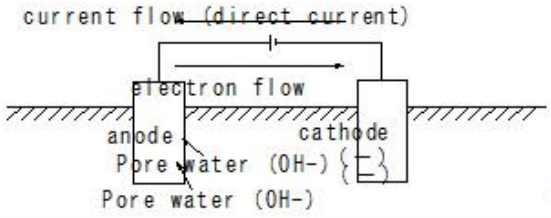




Vacuum pumping



Electropenetration method



Strainer (filtering wire mesh) (steel pipe)

(F93)Foundation work-(Drainage method-Shallow sump)

(F93)Foundation work-(Drainage method-Shallow sump)

Drainage method

Shallow sump drainage method

Shallow sump

rainwater

pump up

water

sheet pile

spring water

drain

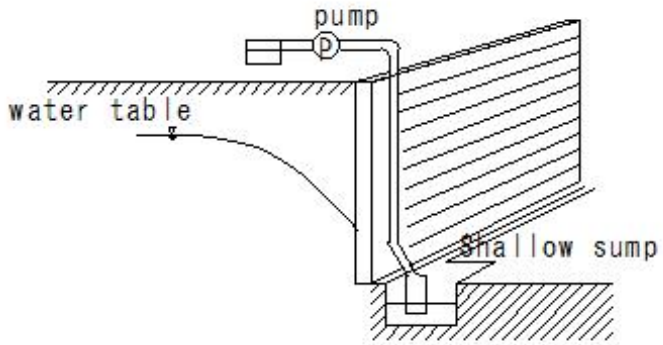
shallow sump

collect in one place

Shallow sump

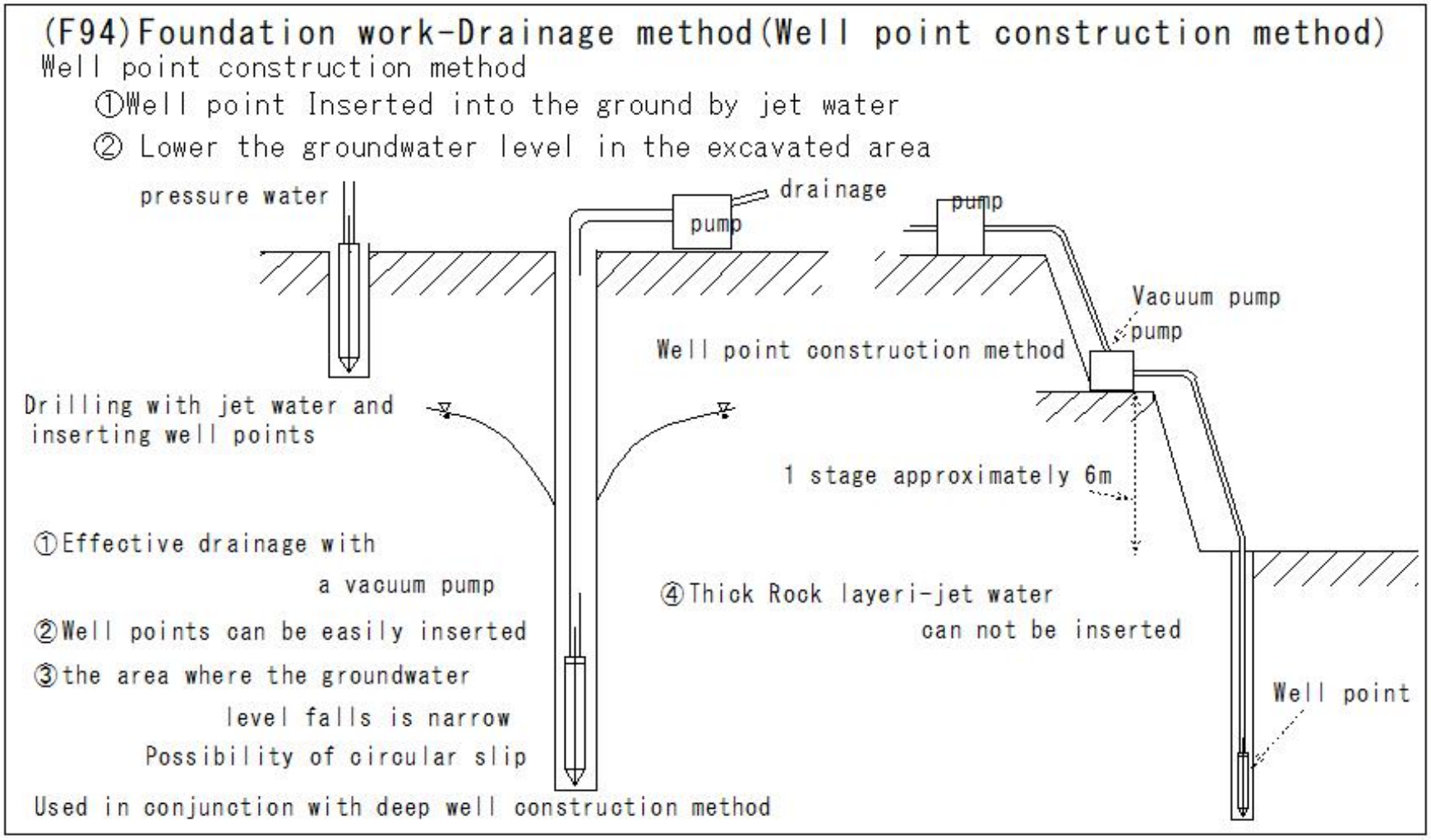
① Less amount of groundwater flowing out

②Excavation of shallow ground



Construction method suitable for gravel layer

(F94)Foundation work-Drainage method(Well point construction method)



(F95)Foundation work-Drainage method(Deep well method)

(F95)Foundation work-Drainage method(Deep well 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

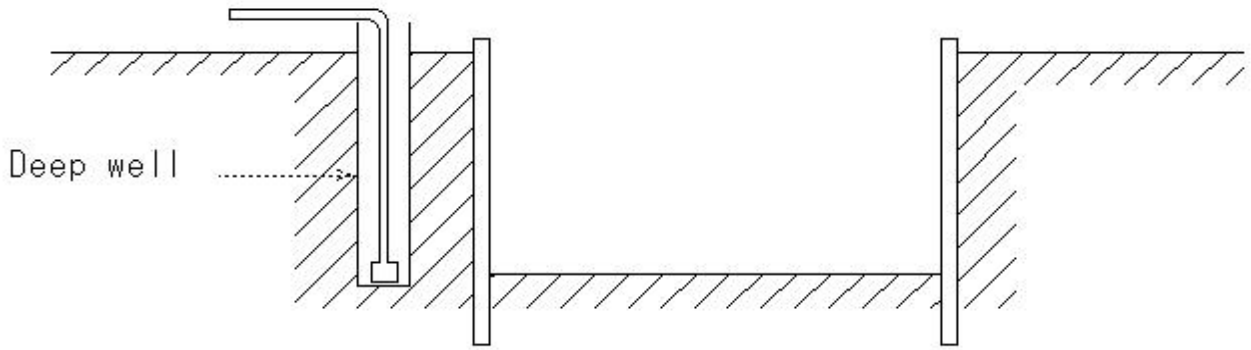
③Groundwater level lowering method

location

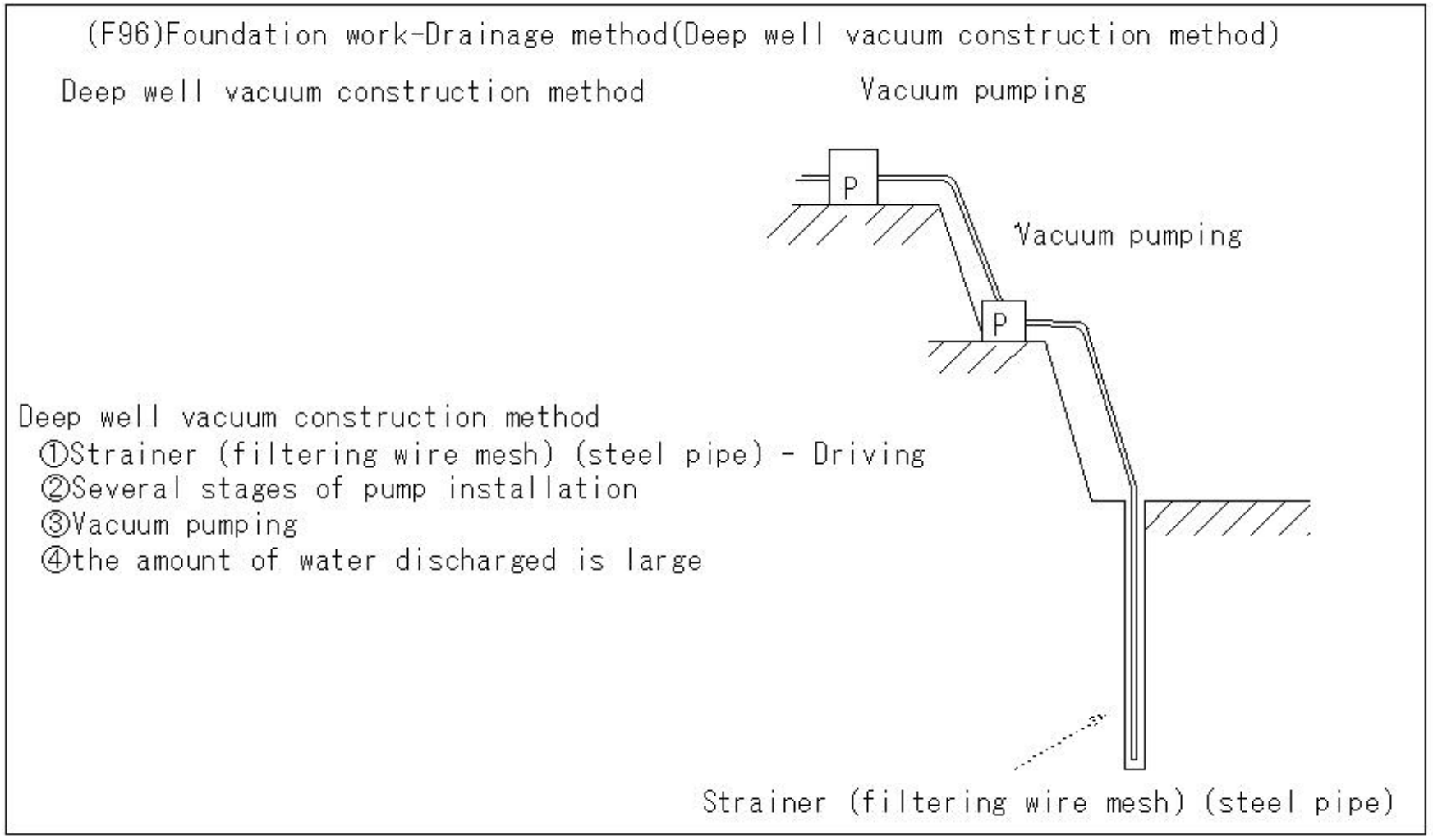
④Groundwater drop over a wide area

⑤there is a possibility of heaving on the bottom of the excavation

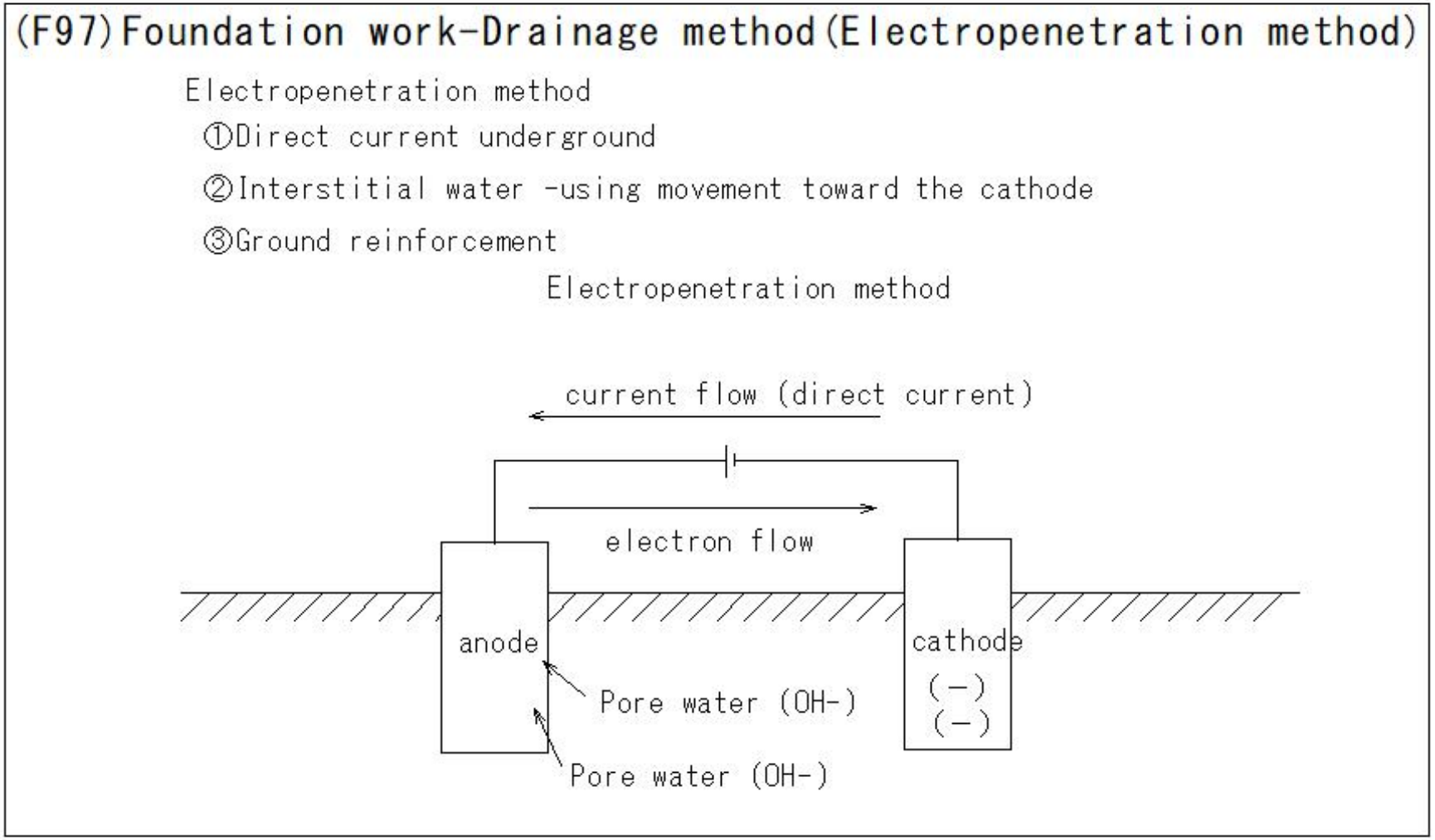
⑥the water permeability is large and the amount of drainage is large



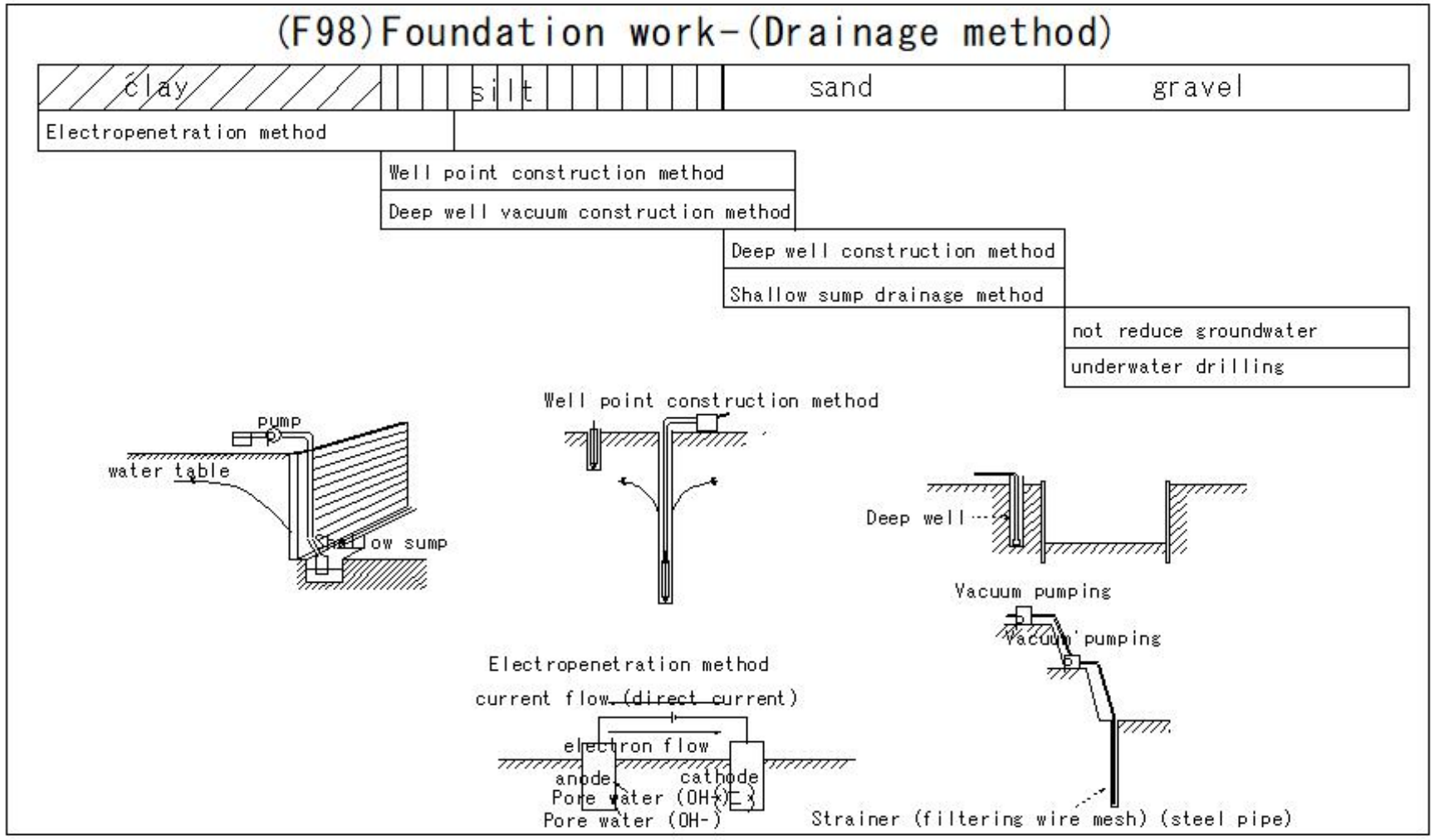
(F96)Foundation work-Drainage method(Deep well vacuum construction method)



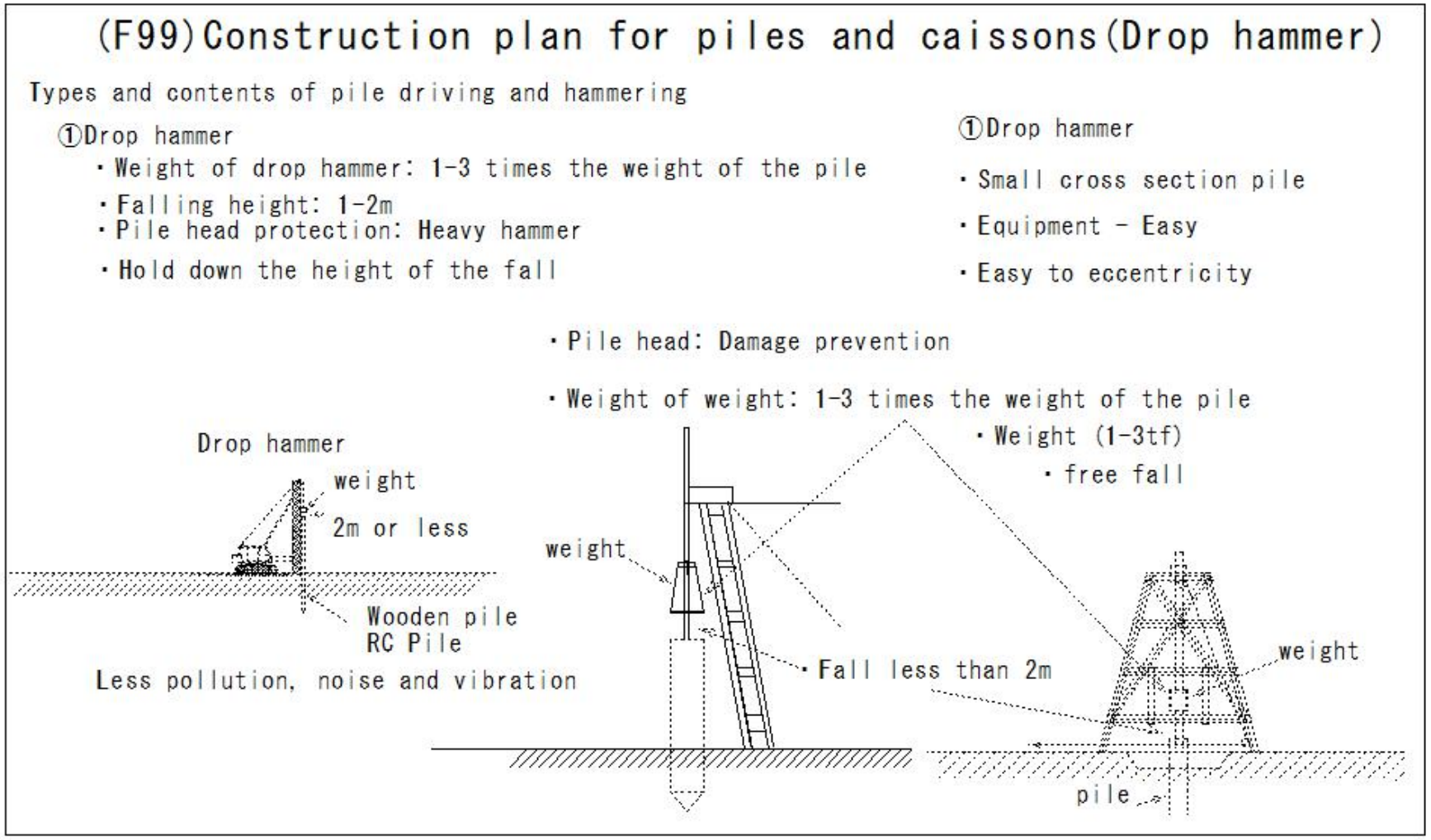
(F97)Foundation work-Drainage method(Electropenetration method)



(F98)Foundation work-(Drainage method)



(F99)Construction plan for piles and caissons(Drop hammer)



(F100)Construction plan for piles and caissons(Diesel hammer)

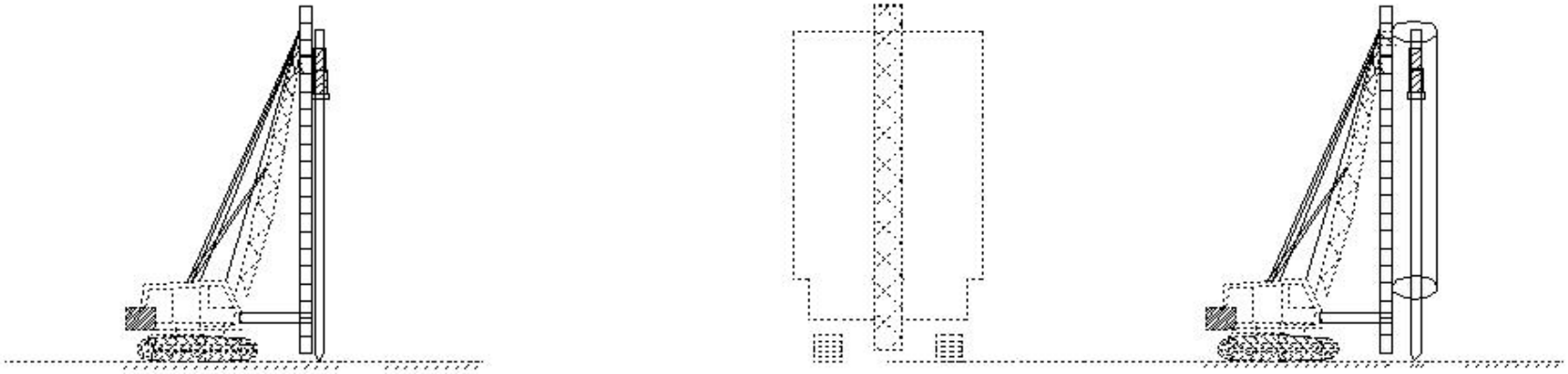
(F100)Construction plan for piles and caissons(Diesel hammer)

Types and contents of pile driving and hammering

②Diesel hammer

- Falling ram
- Inside cylinder gas explosion
- Big impact energy
- Ram size 1.26-6.0t

Diesel hammer



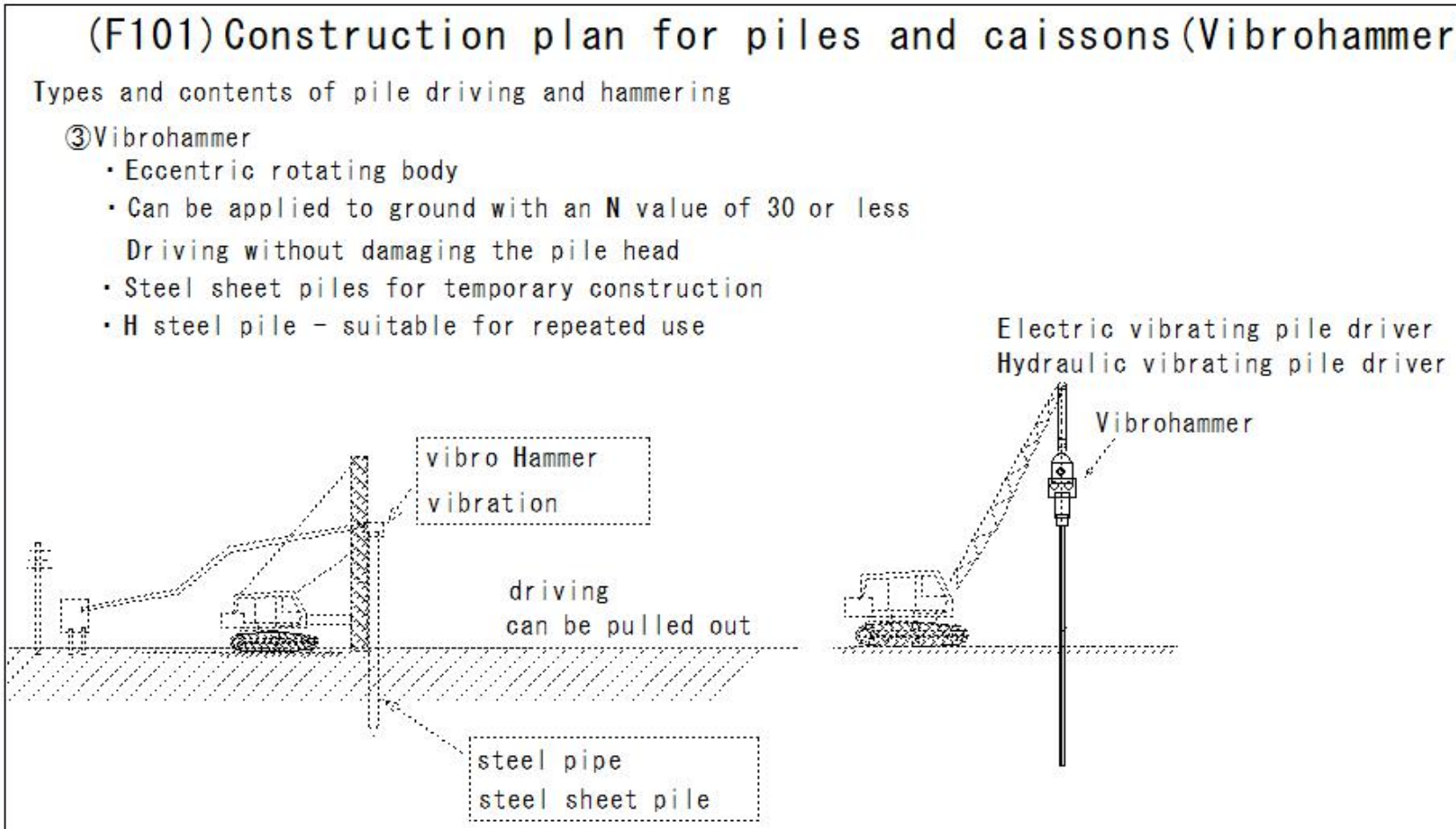
(F101)Construction plan for piles and caissons(Vibrohammer)

(F101)Construction plan for piles and caissons(Vibrohammer)

Types and contents of pile driving and hammering

③Vibrohammer

- Eccentric rotating body
- Can be applied to ground with an N value of 30 or less
  Driving without damaging the pile head
- Steel sheet piles for temporary construction
- H steel pile - suitable for repeated use



(F102)Construction plan for piles and caissons(Long pre-fabricated piles)

(F102)Construction plan for piles and caissons(Long pre-fabricated piles)

Types and contents of pile driving and hammering

- Long pre-fabricated piles preferably no on-site joints
  transportable length 10-15m

pile foundation

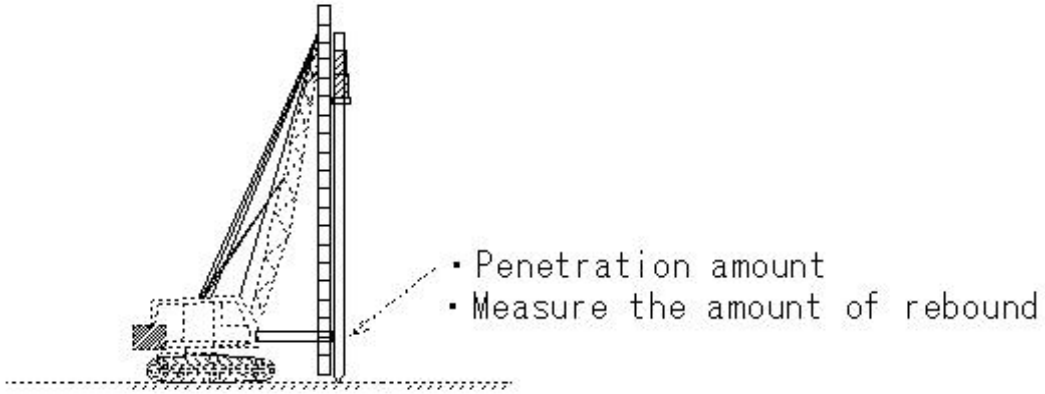
Comparison of construction depth

pile foundation	Comparison of construction depth								
	10	20	30	40	50	60	70	80	90m
spread foundation	▨								
RC pile	▨	▨							
PC pile	▨	▨							
steel pile	▨	▨	▨	▨	▨	▨	▨		
cast-in-place pile	▨	▨	▨	▨	▨	▨	▨	▨	▨

(F103)Construction plan for piles and caissons(Test piles)

(F103)Construction plan for piles and caissons(Test piles)

Geological survey by boring
Bearing capacity calculation
Determine the length of the pile
Soil conditions - Calculated bearing capacity - Actual bearing capacity - Difference
Construction: Stalled situation - Confirmation of supporting capacity through loading test



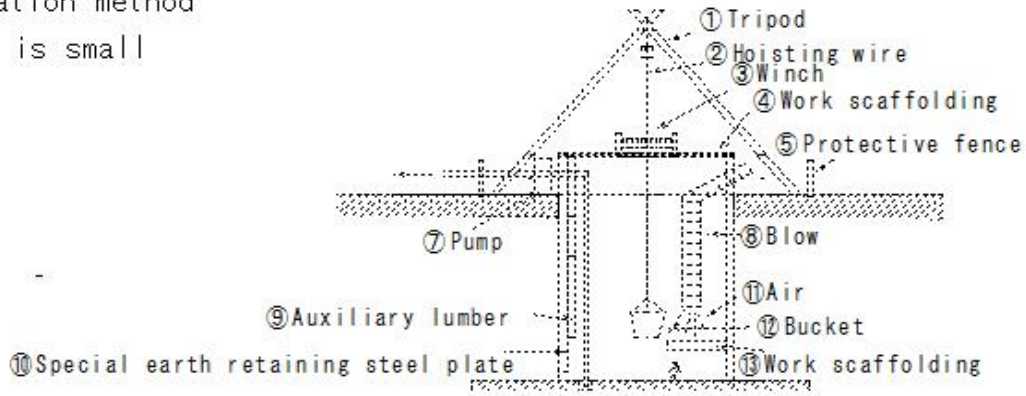
(F104)Construction plan for piles and caissons-cast-in-place pile(Deep foundation method)

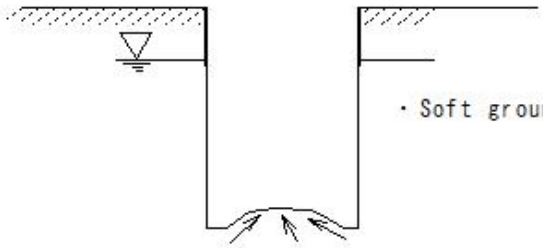
(F104)Construction plan for piles and caissons-cast-in-place pile(Deep foundation method)

cast-in-place pile

Deep foundation method

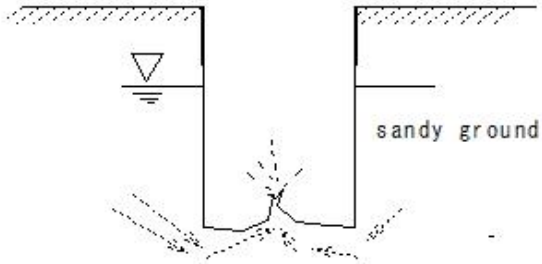
Work space is small





・Water pressure - ground - push up

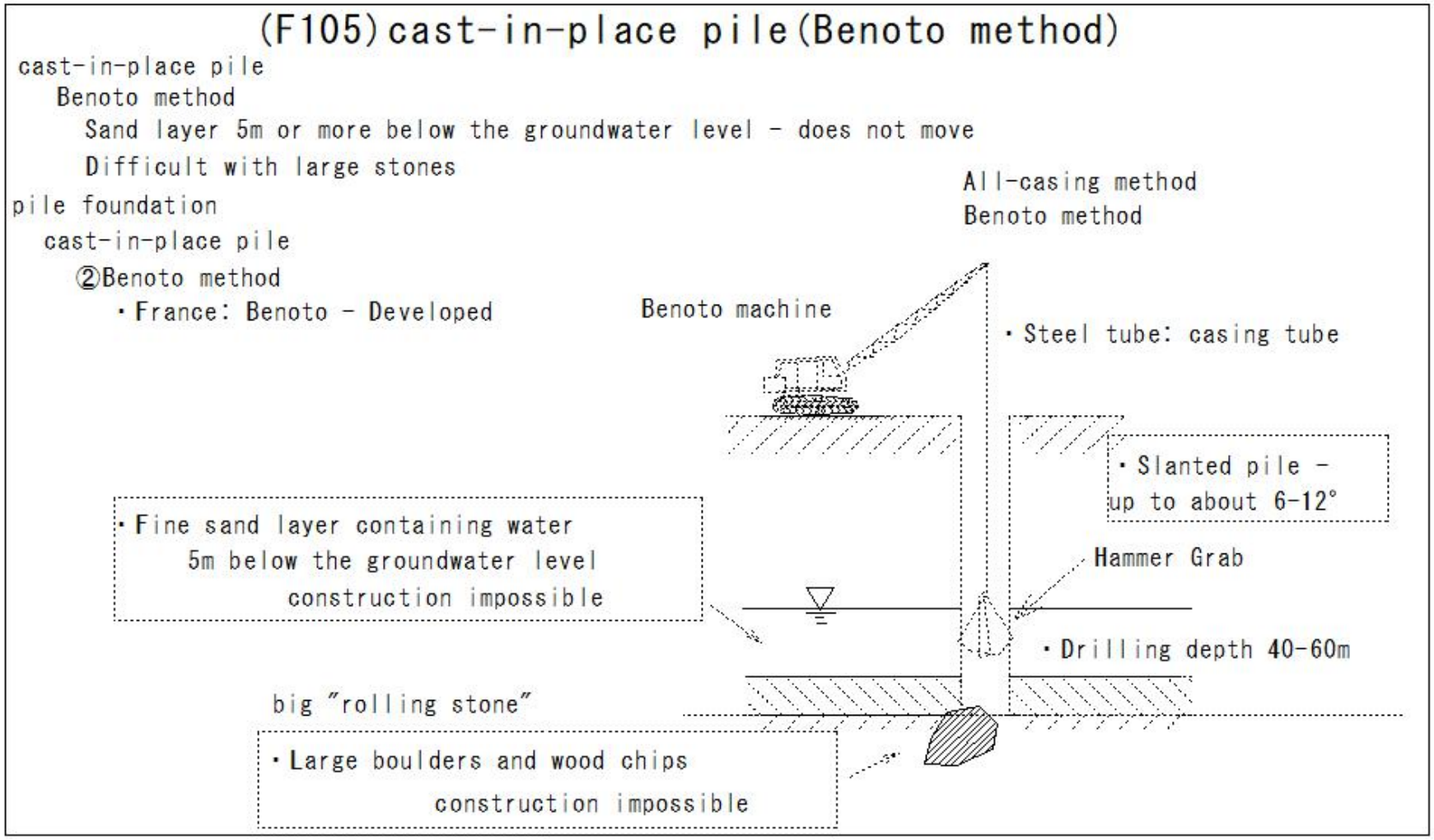
・Heaving



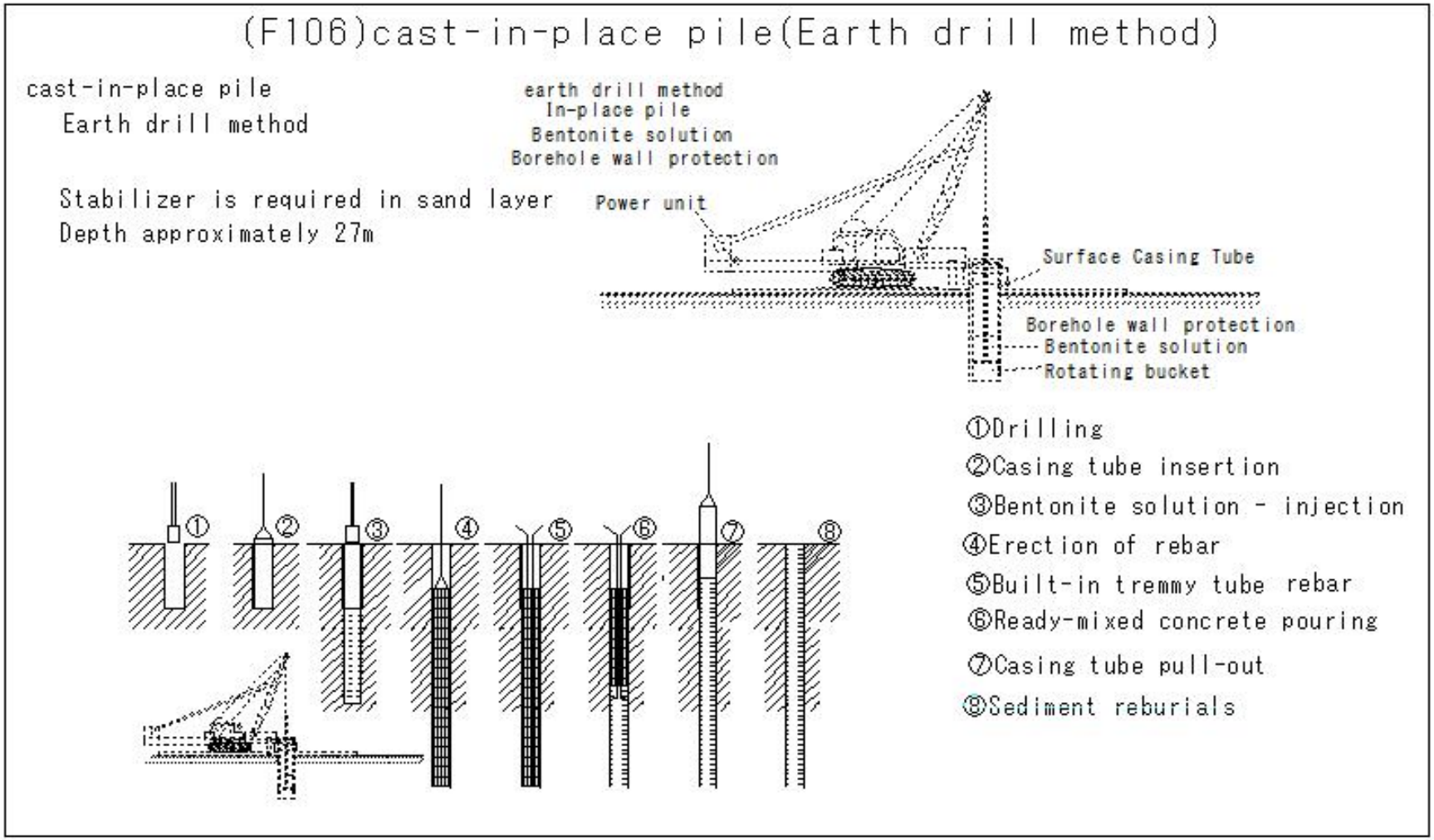
underground water route

Boiling

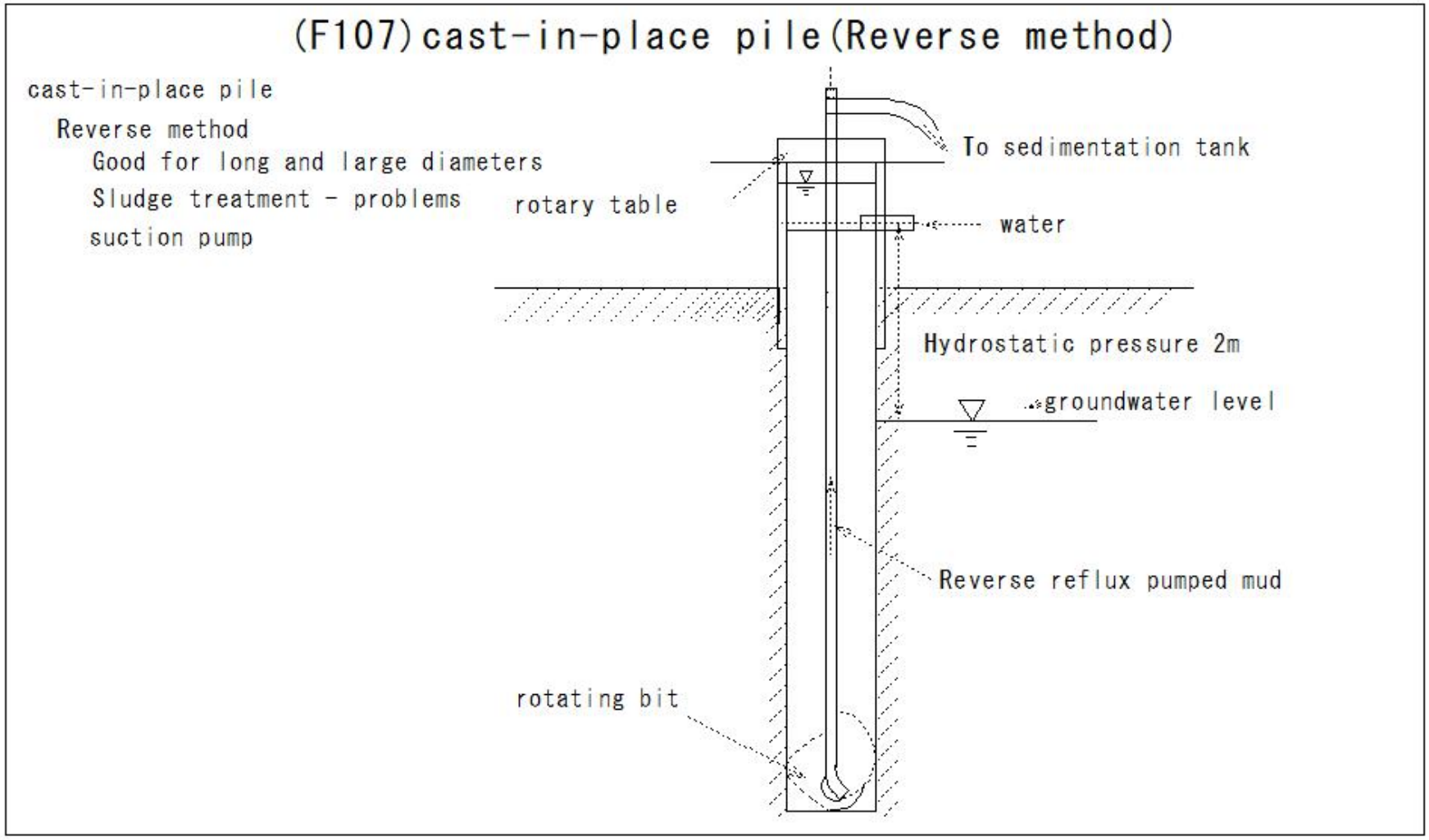
(F105)cast-in-place pile(Benoto method)



(F106)cast-in-place pile(Earth drill method)



(F107)cast-in-place pile(Reverse method)



(F108)cast-in-place pile(Open caisson foundation)

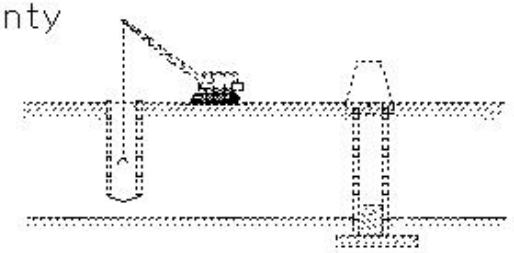
(F108)cast-in-place pile(Open caisson foundation)

cast-in-place pile

caisson foundation

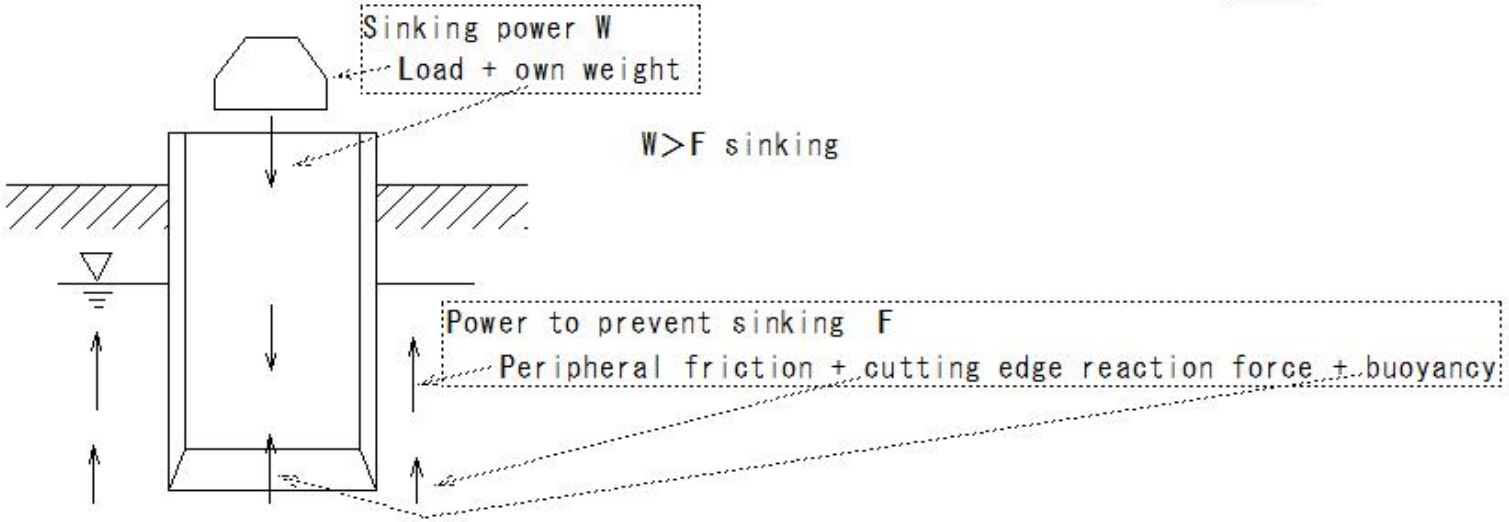
① Open caisson foundation

Open caisson: Underwater excavation - poor certainty
relatively easy
Construction cost - cheap

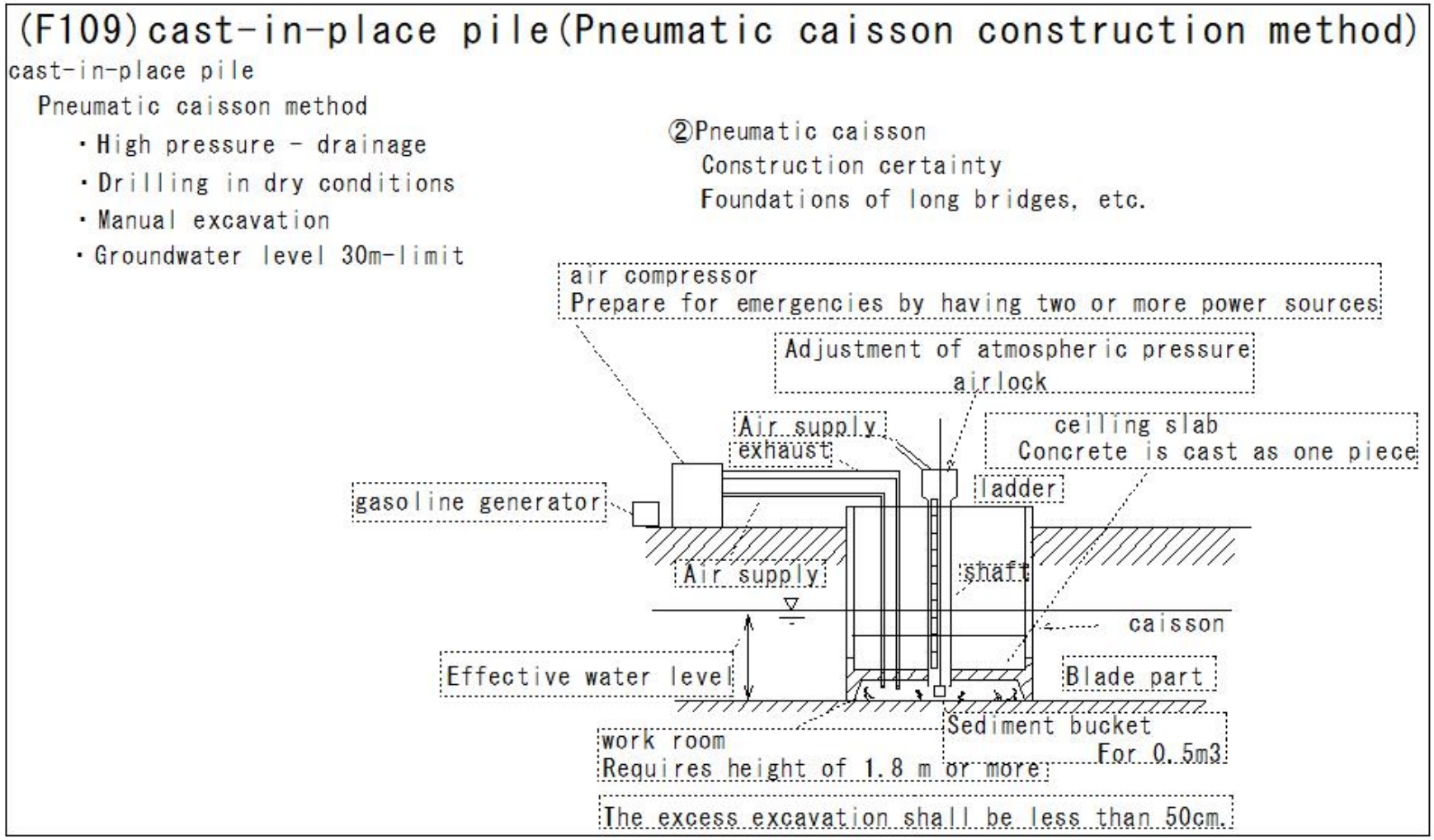


① Circumferential friction - reduction

② Convert passive earth pressure to active earth pressure



(F109)cast-in-place pile(Pneumatic caisson construction method)



(F110)Foundation construction machinery(Ready-made piles)

(F110)Foundation construction machinery(Ready-made piles)

Construction plan for piles and caissons

Foundation construction machinery

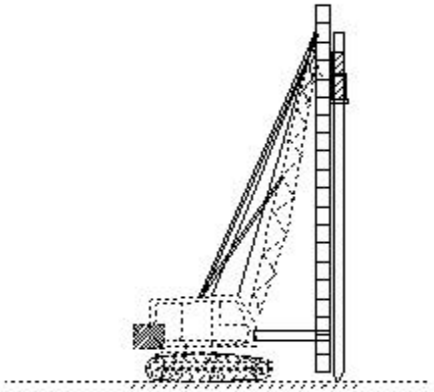
①Ready-made piles

Impact construction method

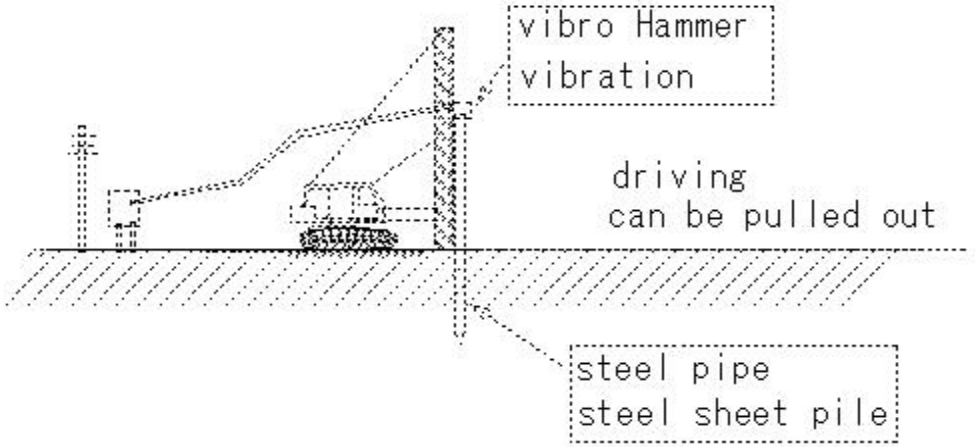
Vibration method

Press-in method

Combined construction method



Diesel hammer



(F111)Foundation construction machinery(Cast-in-place piles)

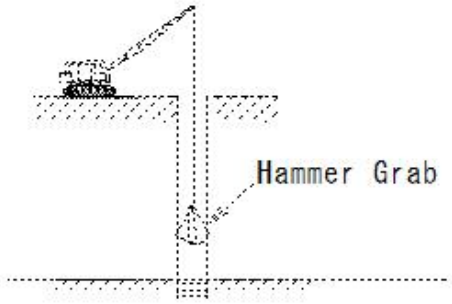
(F111)Foundation construction machinery(Cast-in-place piles)

Construction plan for piles and caissons

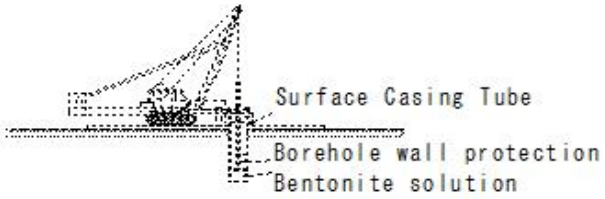
Foundation construction machinery

② Cast-in-place piles

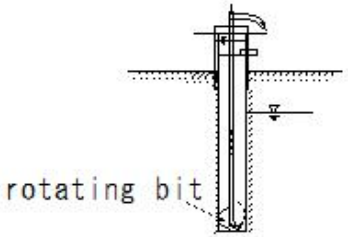
All-casing method(Benoto method)



earth drill method



Reverse circulation method



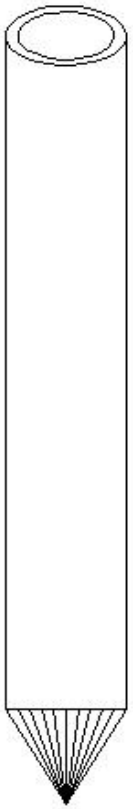
(F112)Foundation construction machinery(Features of steel piles)

(F112)Foundation construction machinery(Features of ready-made piles)

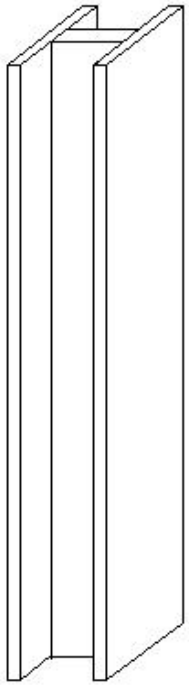
Features of ready-made piles

- Characteristics of steel piles
  - Withstands large impact forces
  - Supporting capacity - large
  - High bending strength

steel pipe



H steel



(F113)Foundation construction machinery(concrete piles)

(F113)Foundation construction machinery(concrete piles)

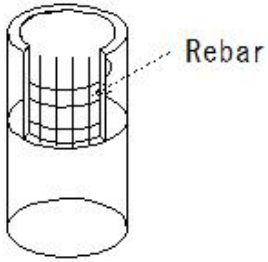
Construction plan for piles and caissons

Foundation construction machinery

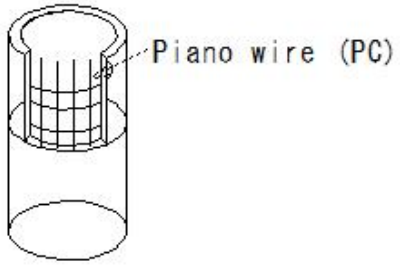
Characteristics of concrete piles

- Does not corrode
- High strength
- Easy to work

Rebar RC

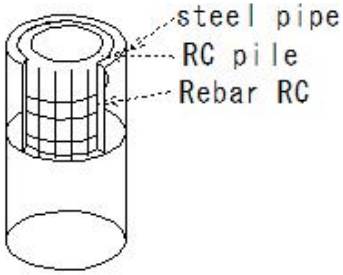


Piano wire (PC)



composite pile

Reinforce the outer periphery of RC piles with steel pipes



(F114)Foundation construction machinery(Benoto method)

(F114)Foundation construction machinery(Benoto method)

Construction plan for piles and caissons

Foundation construction machinery

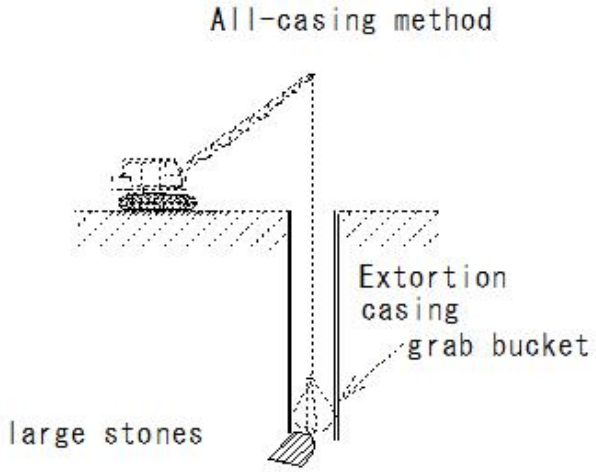
- Benoto method
- Large diameter pile
- 6 degree and 12 degree diagonal piles - possible

Strong Points

- Hard ground can be excavated
  Soft ground, no landslides
- Completed pile -no cracks

weak point

- Large machine required
- Casing tube - difficult to pull out
- Difficult to excavate with large stones



(F115)Foundation construction machinery(Earth drill method)

(F115)Foundation construction machinery(Earth drill method)

Construction plan for piles and caissons

Foundation construction machinery

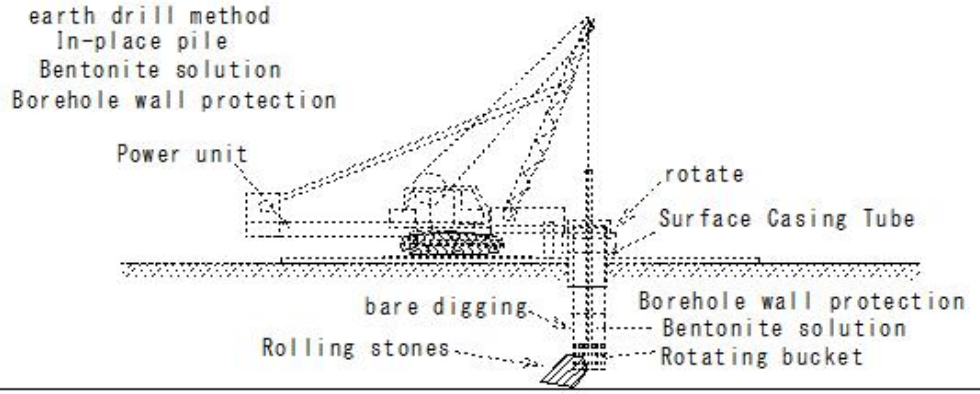
Earth drill method

Strong Points

- The price of piles is low
- Mobility available
- Supporting layer - excavated sand - can be confirmed

weak points

- Large machine required
- Rolling stones - excavation - difficult
- Concrete loss - large amount
- Difficult excavated soil treatment



(F116)Foundation construction machinery(Reverse circulation method)

(F116)Foundation construction machinery(Reverse circulation method)

Construction plan for piles and caissons

Foundation construction machinery

・Reverse circulation method

Strong Points

①Preventing hole wall collapse due to muddy water

No casing required

②Excavation depth-large

③Pore size -freely selectable

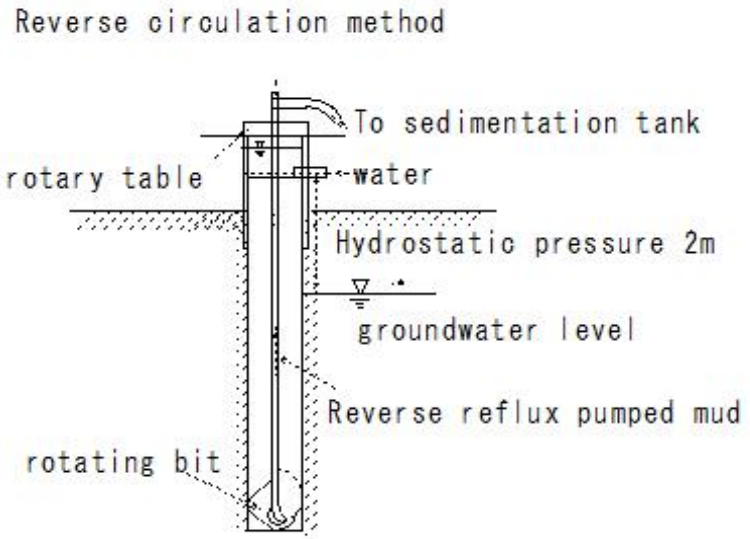
weak points

①Water Sedimentation tank - required

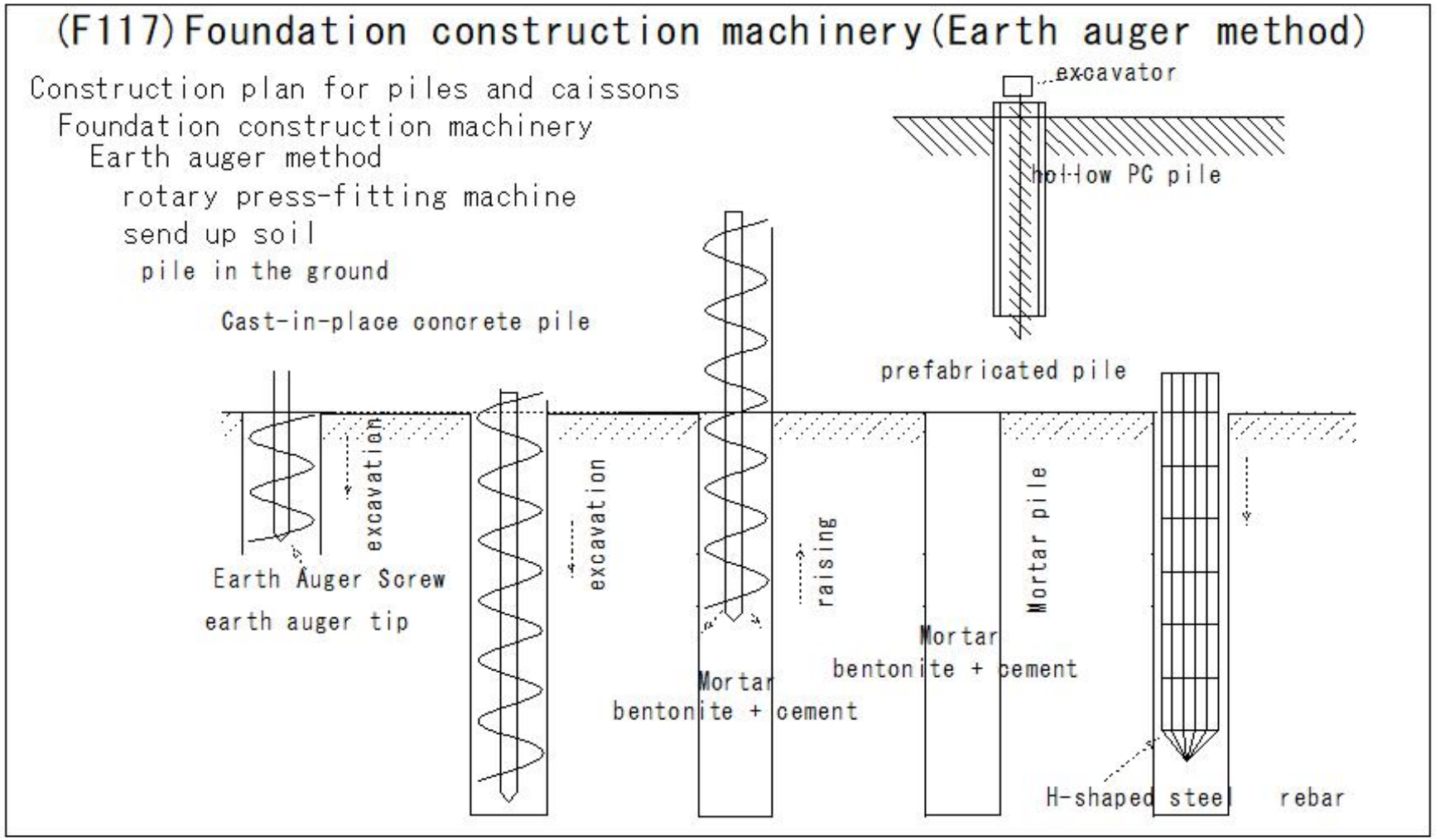
Narrow space - disadvantage

②Obstacles - Difficult to excavate

③Permeable layer - water level drop - hole wall - collapse



(F117)Foundation construction machinery(Earth auger method)



(F118)Soil improvement(Sand drain method)

(F118)Soil improvement(Sand drain method)

Soil improvement

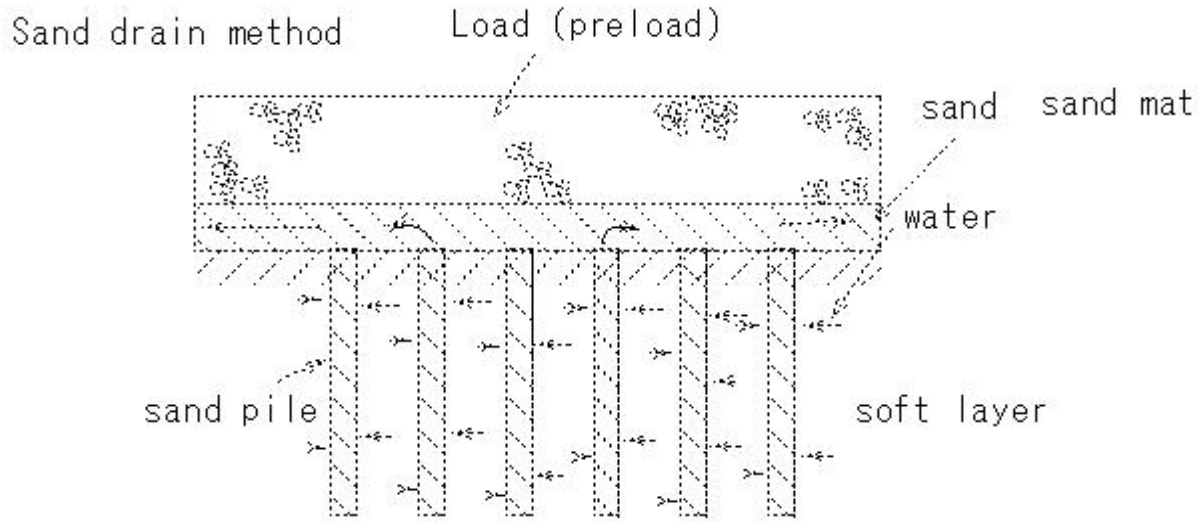
①Sand drain method

Supporting capacity - increase

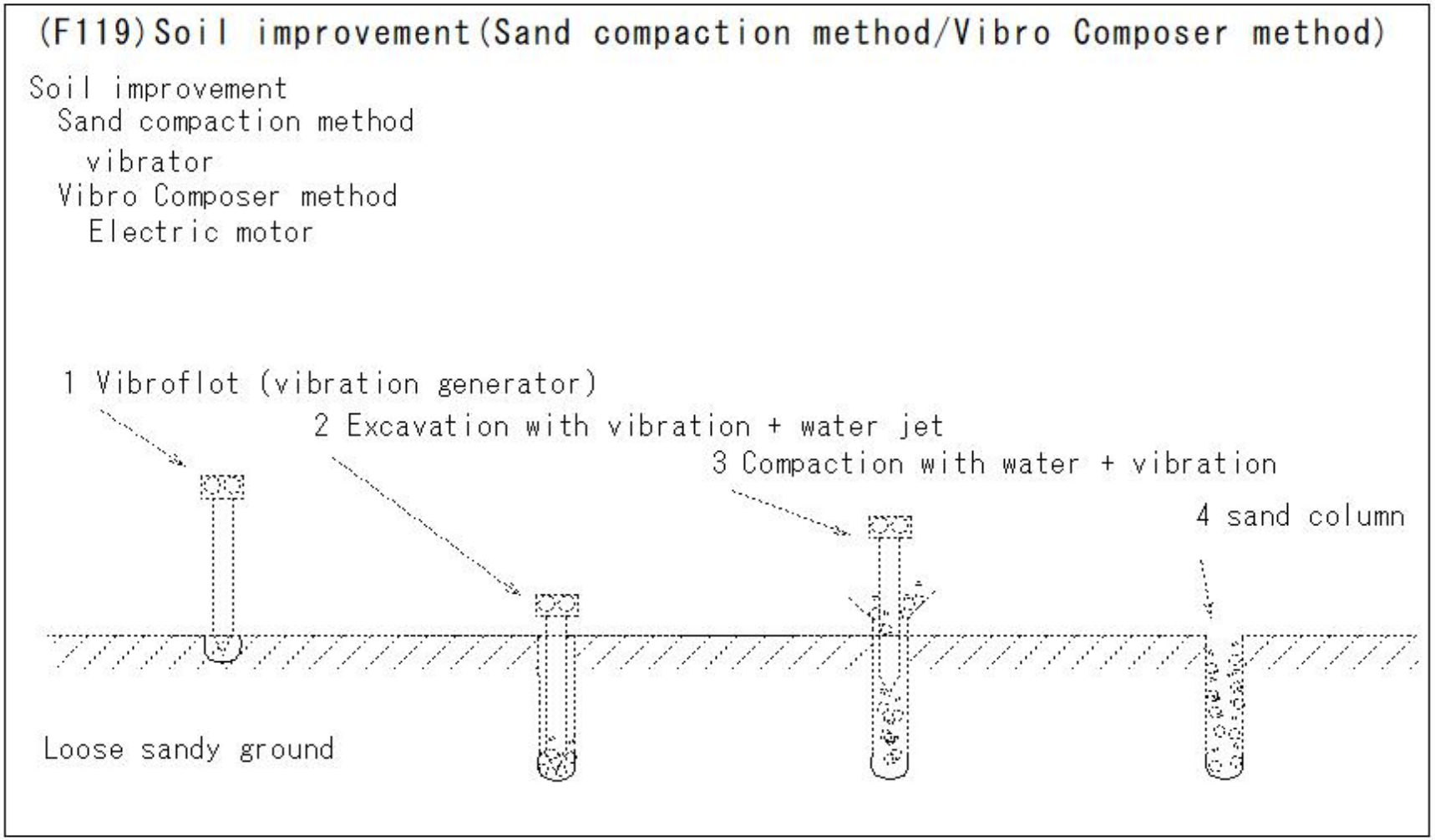
Settling- prevention

Ground improvement

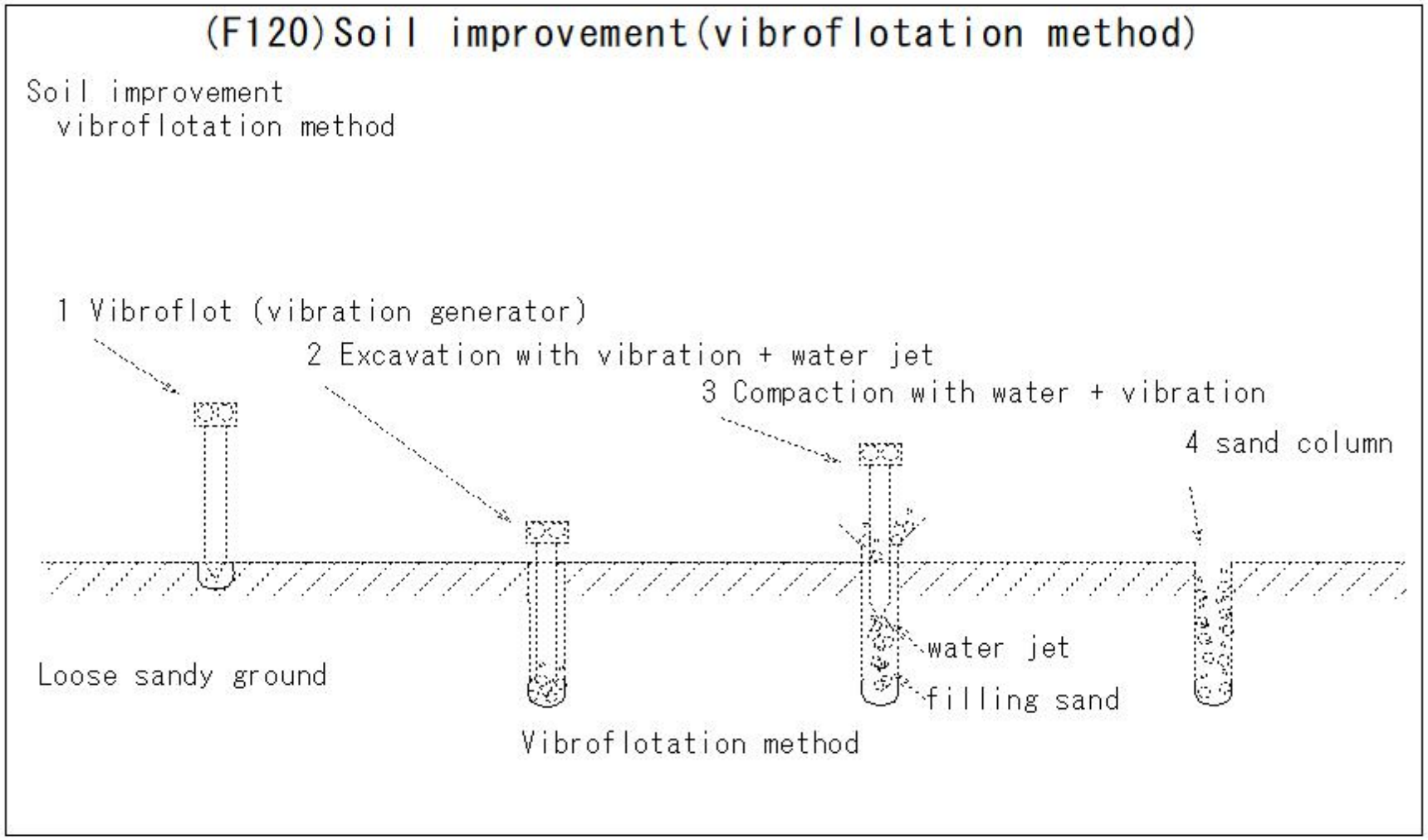
Load/preload



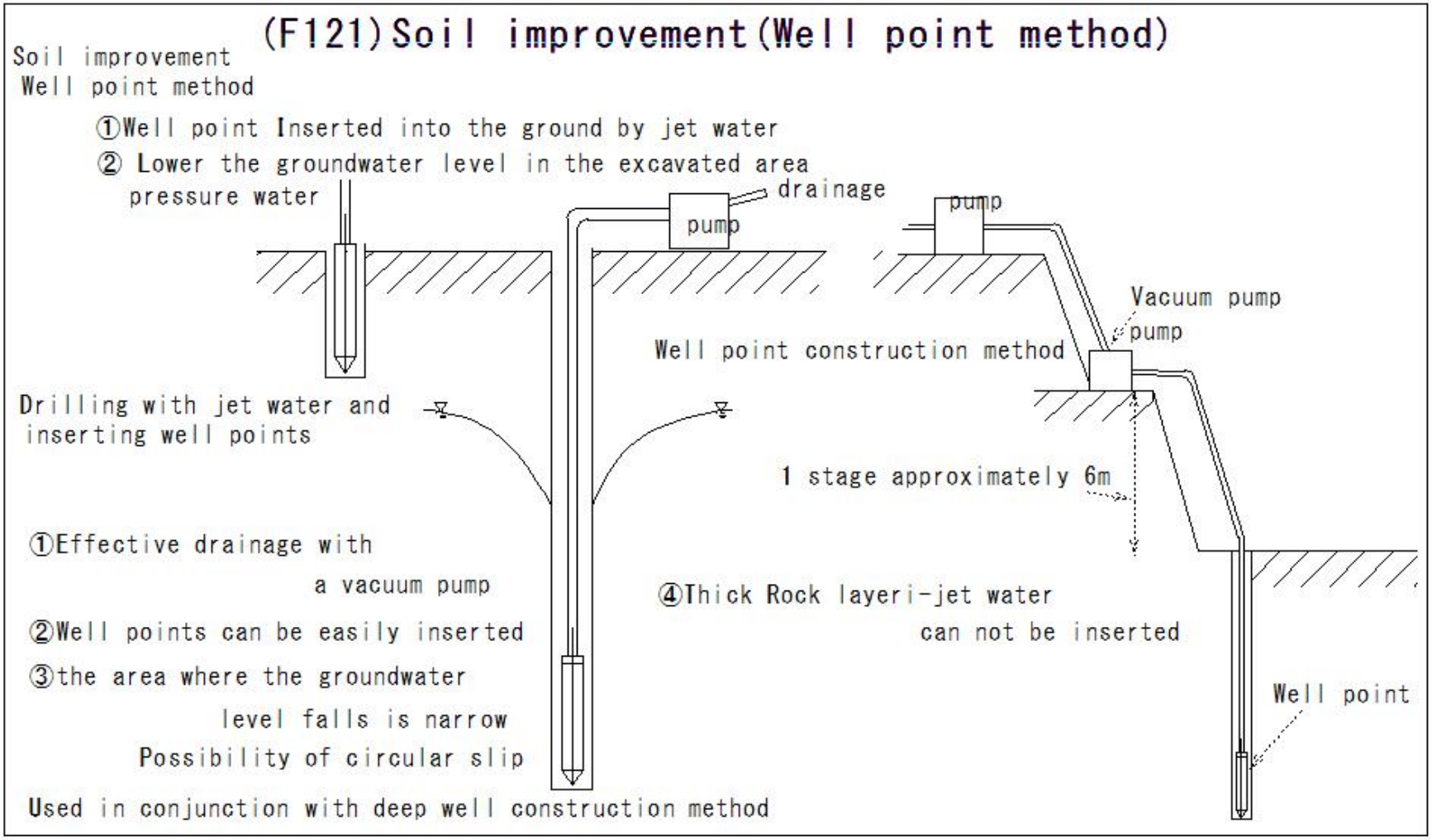
(F119)Soil improvement(Sand compaction method/Vibro Composer method)



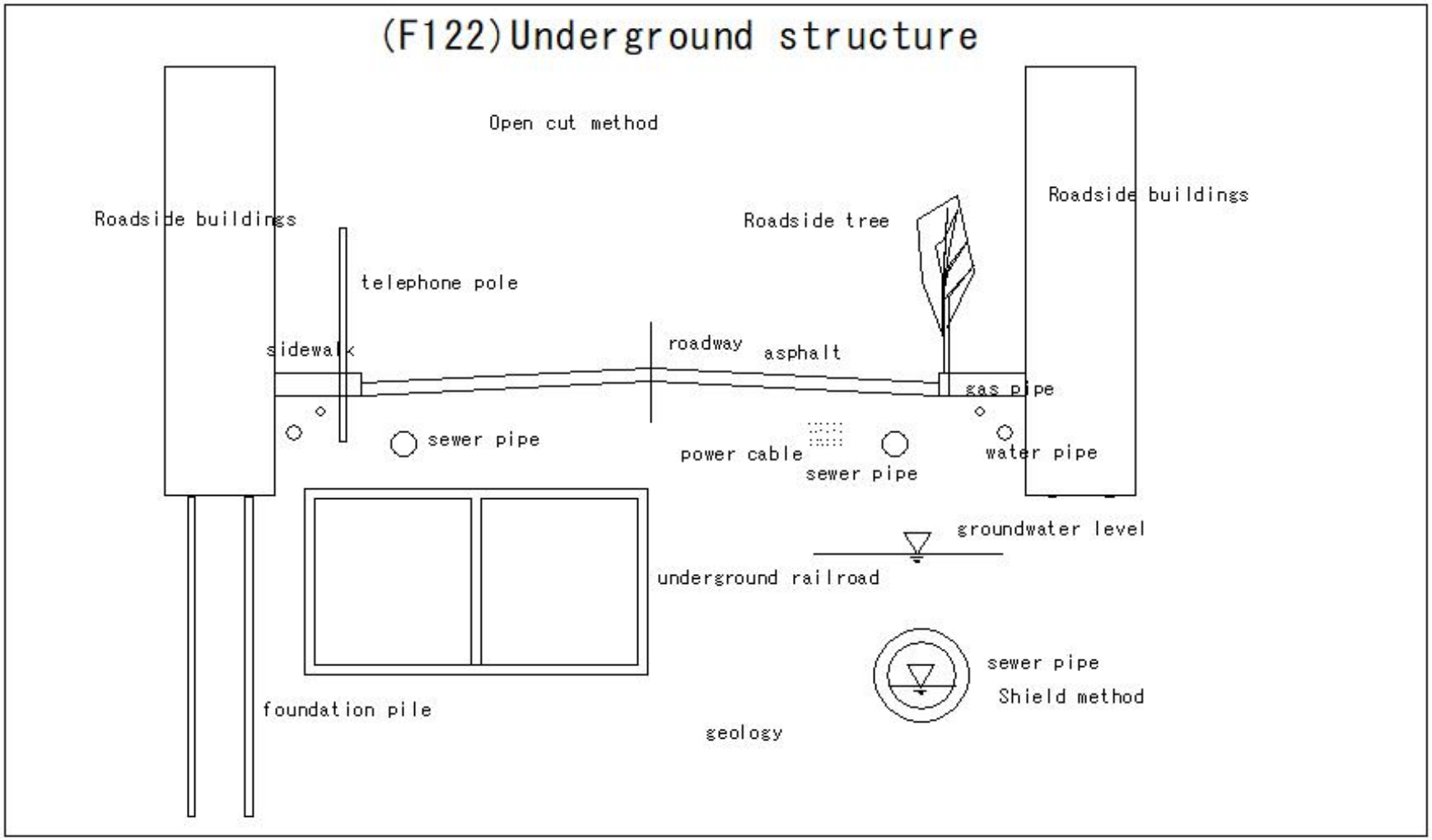
(F120)Soil improvement(vibroflotation method)



(F121)Soil improvement(Well point method)



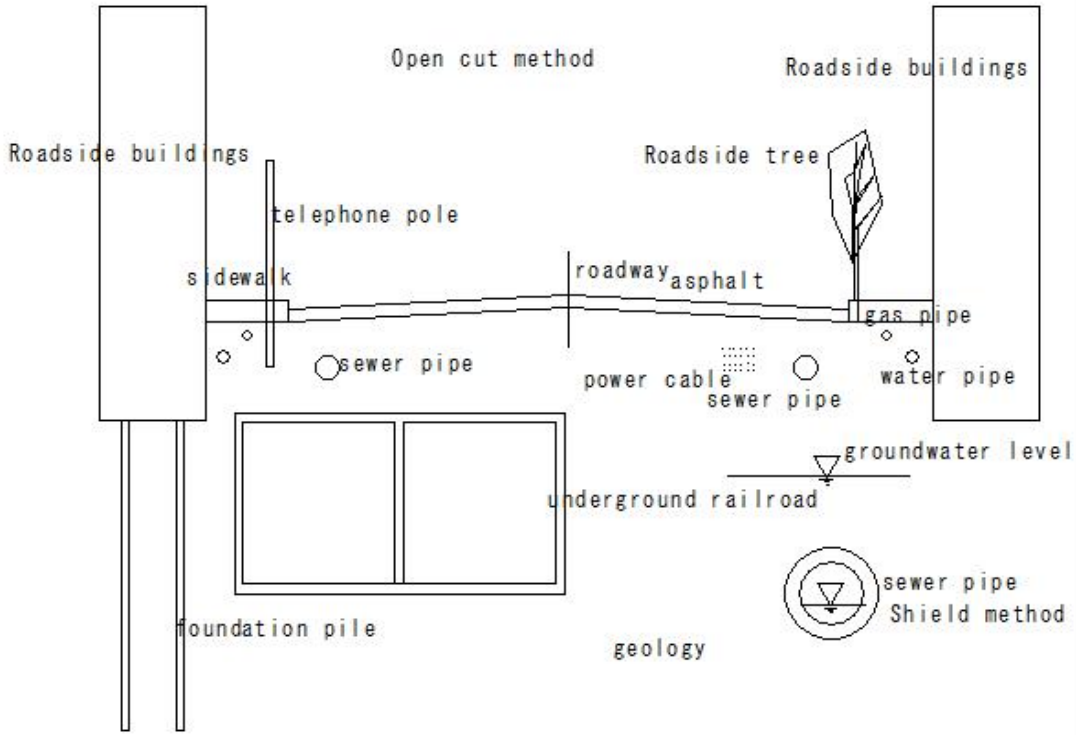
(F122)Underground structure



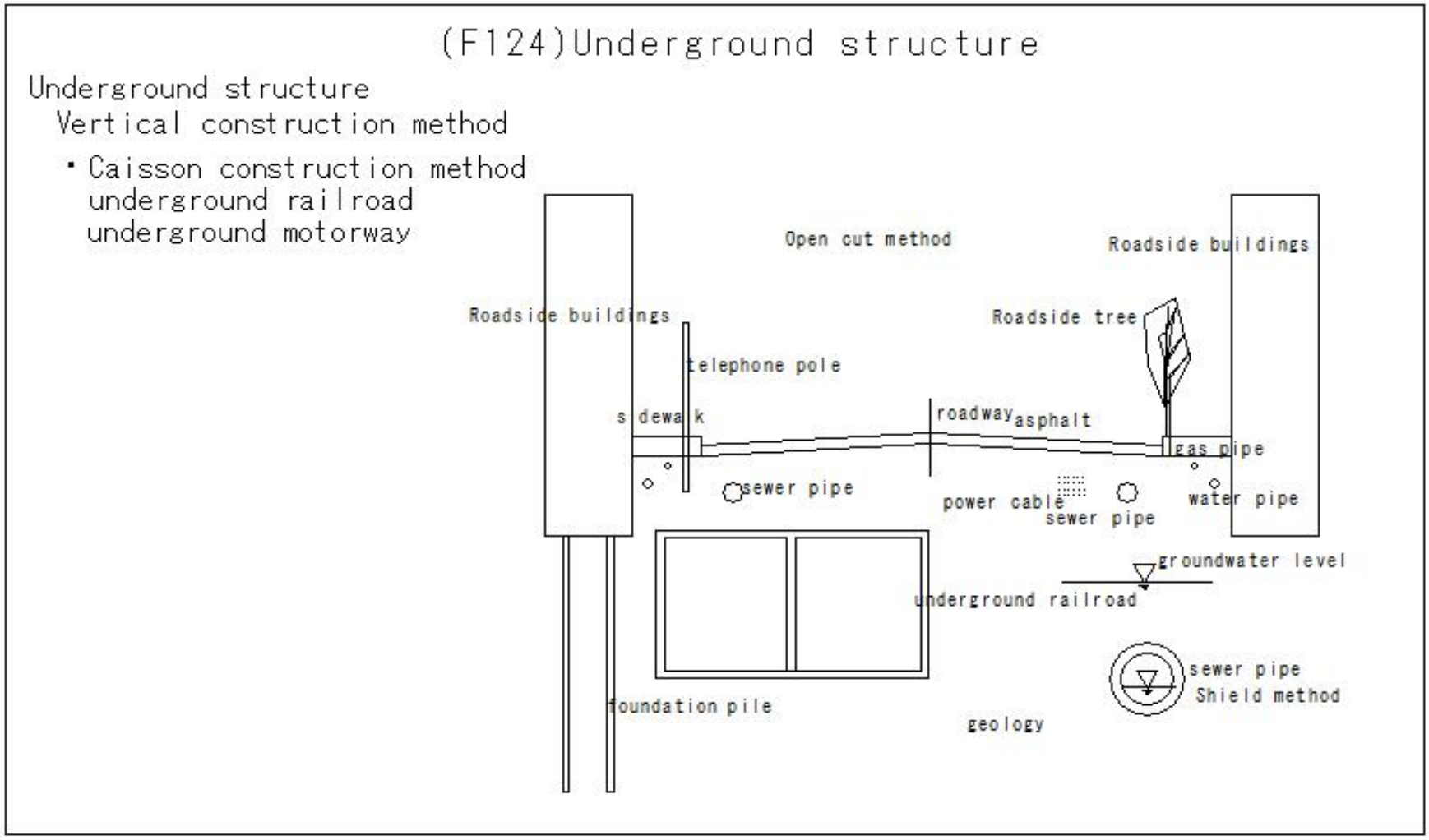
(F123)Underground structure

(F123)Underground structure

Underground structure
  Vertical construction method
    ・Open-cut method
      underground railroad
      underground motorway
      Underground carpark
      underground shopping mall
      water pipe
      sewer pipe
      pipeline
      power line
      common ditch



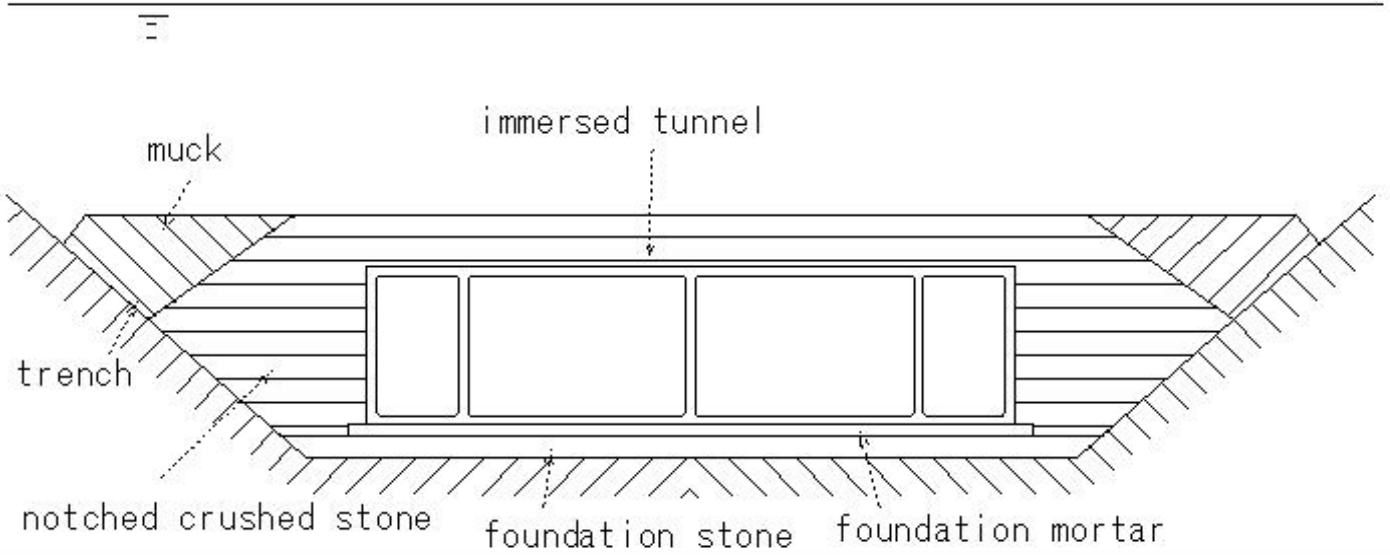
(F124)Underground structure



(F125)Underground structure(Immersed tunnel method)

(F125)Underground structure(Immersed tunnel method)

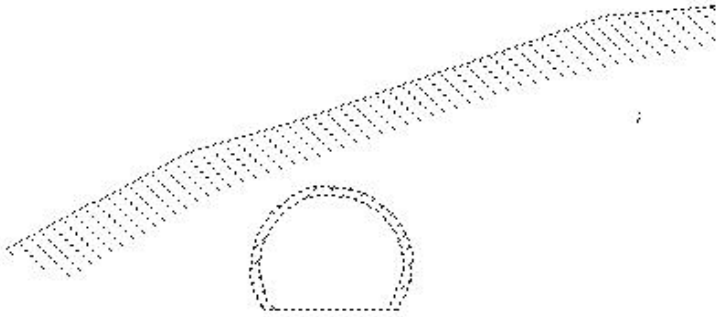
Underground structure
- Vertical construction method
  - Trench method
  - Immersed tunnel method
  - underground railroad
  - underground motorway



(F126)Underground structure(Mountain tunnel construction method)

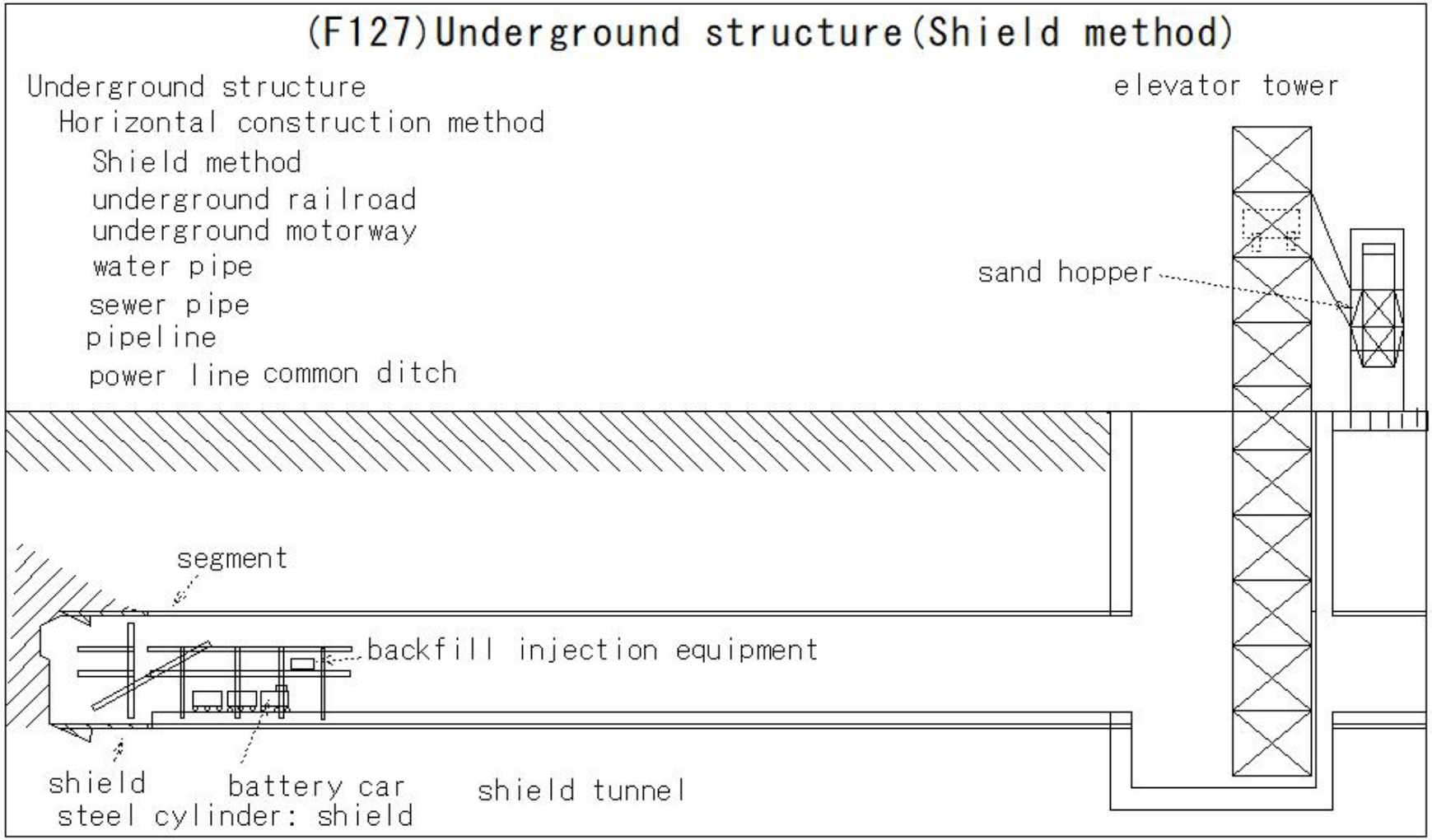
(F126)Underground structure(Mountain tunnel construction method)

Underground structure
- Horizontal construction method
  - Mountain tunnel construction method
  - underground railroad
  - underground motorway
  - underground power plant
  - underground substation
  - underground tank



Mountain tunnel

(F127)Underground structure(Shield method)



(F128)Underground structure

(F128) Underground structure

Underground structure

Features of underground construction

①Load

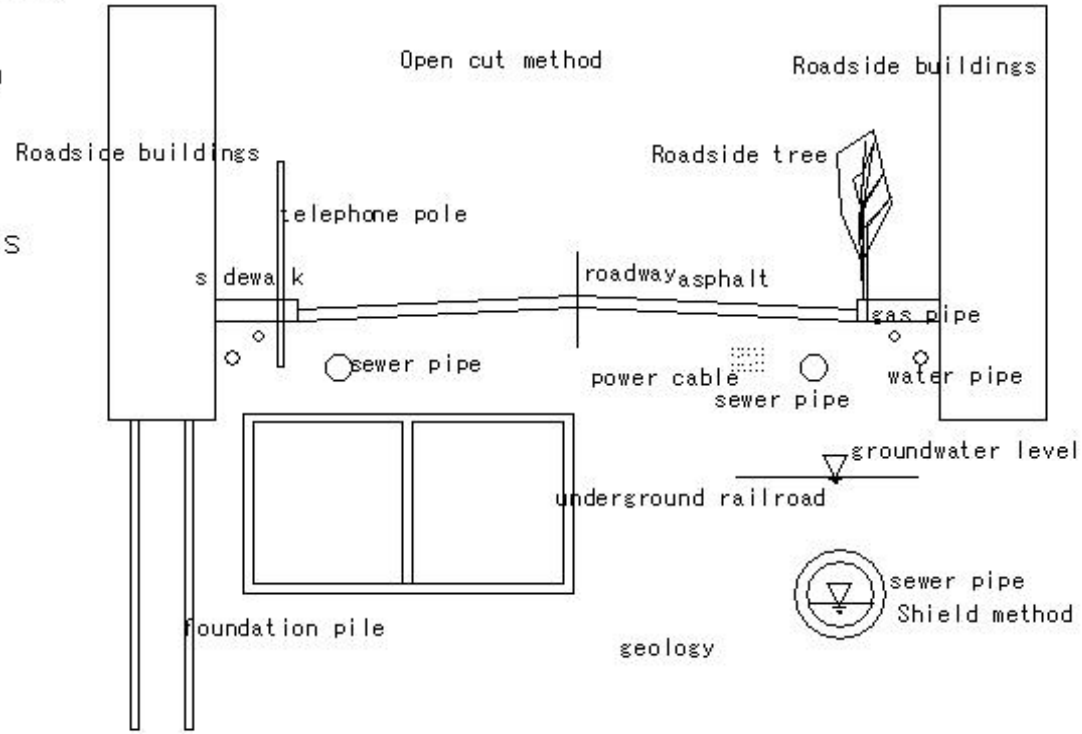
②Watertightness: Waterproofing

③Under construction

After completion

social regulation

settlement, groundwater level decline, buried objects



(F129)Underground structure

(F129)Underground structure

Underground structure

Points to note - designing and constructing underground structures

・investigation

①Land use status

②Road conditions and traffic volume

③Roadside buildings

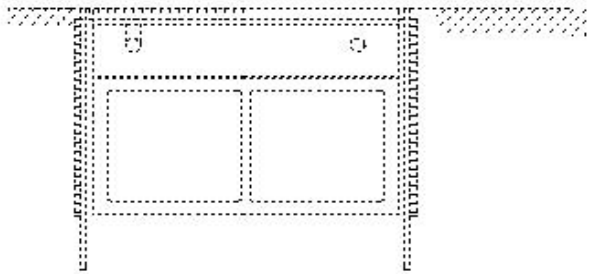
④Buried objects

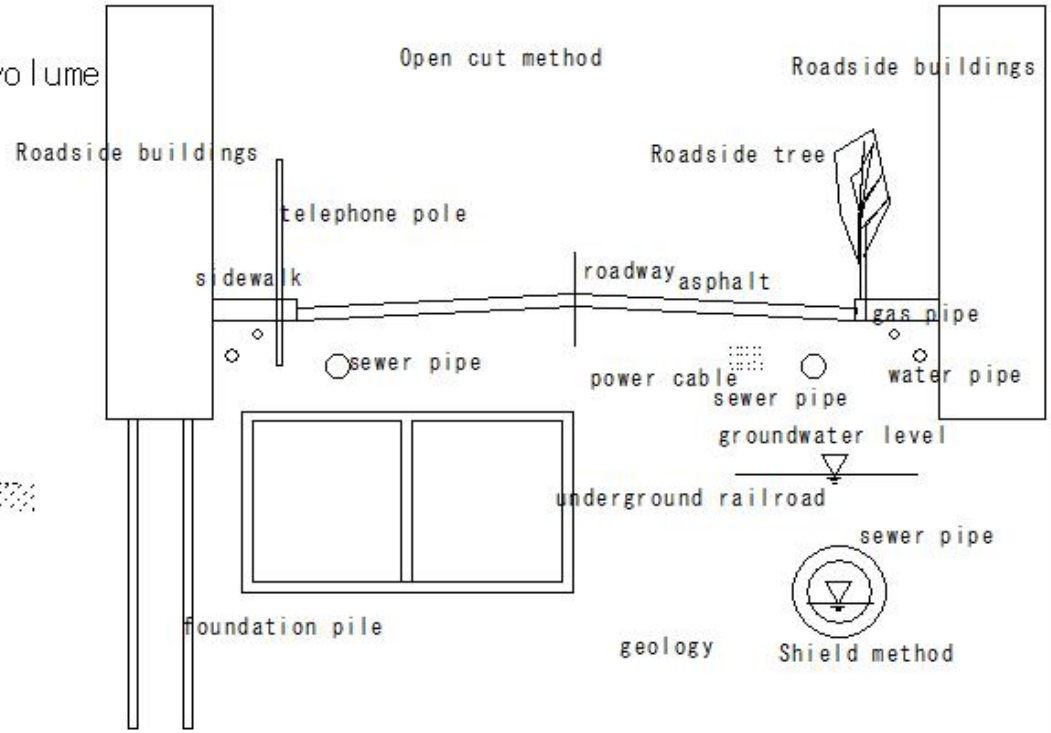
⑤Old well

⑥Geology

⑦Groundwater

⑧Oxygen deficiency/toxic gas





(F130)Underground structure

(F130) Underground structure

Underground structure

Points to note when designing and constructing underground structures

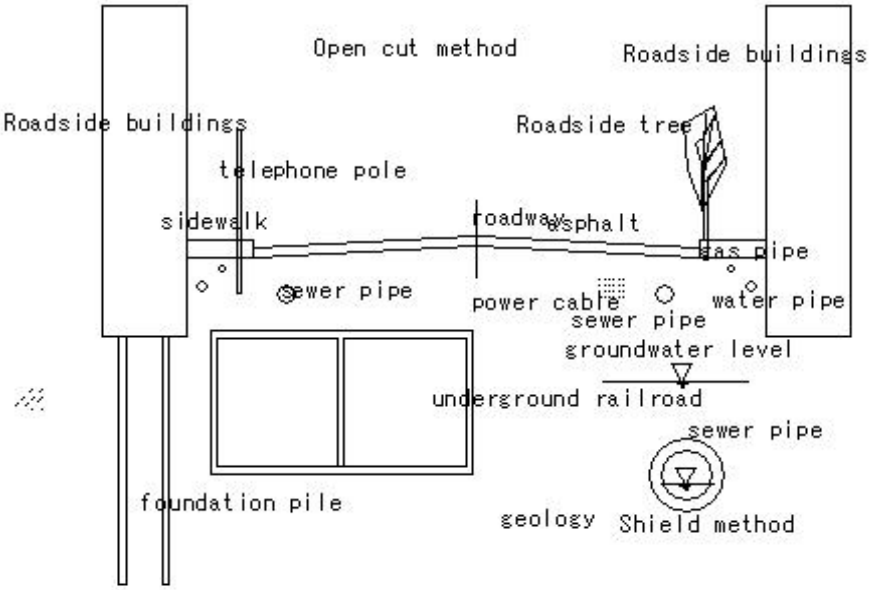
・Construction plan

Underground structure, depth, construction environment ,construction method

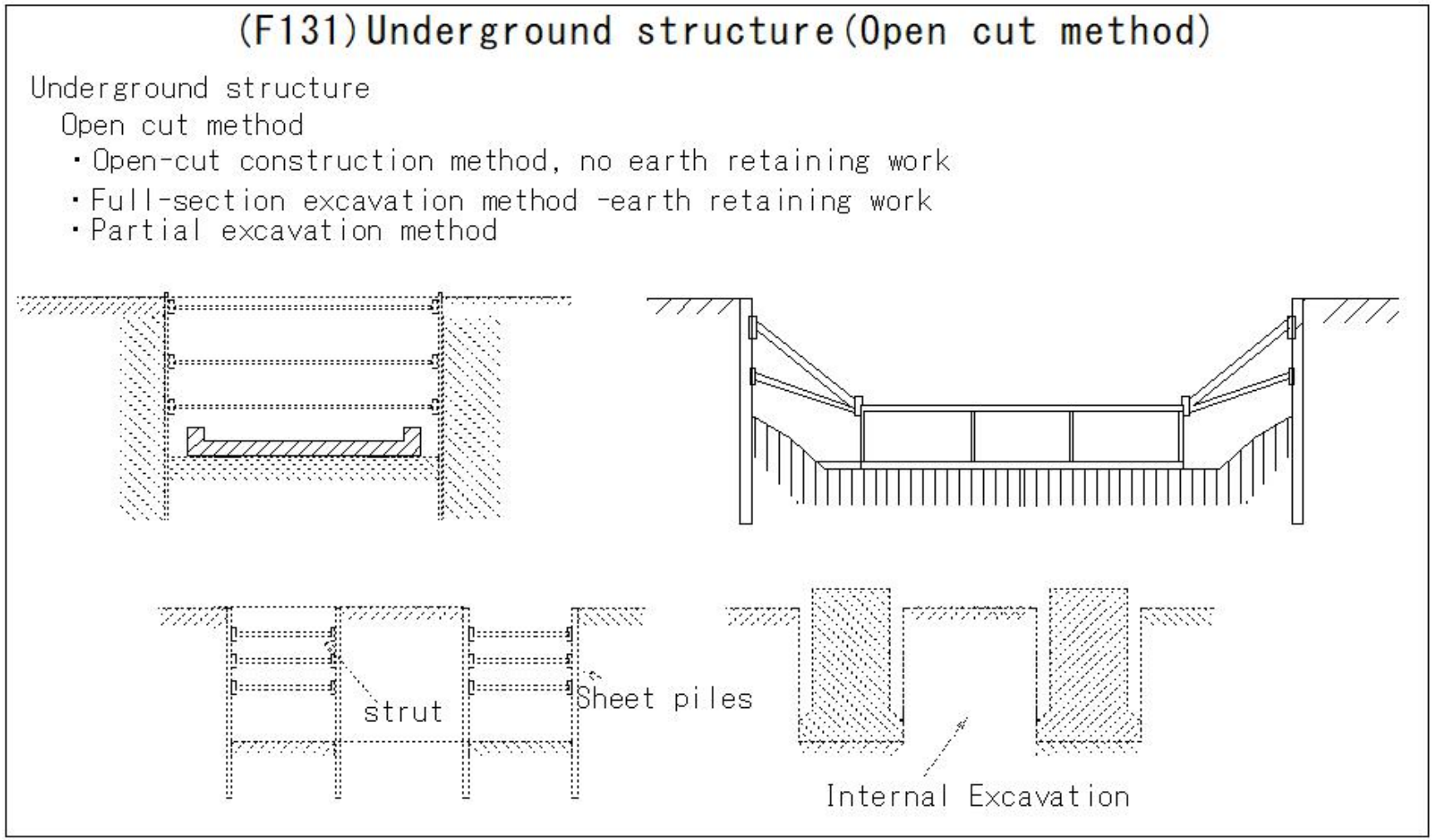
Environmental conservation measures

Noise/vibration, pollution prevention, ground subsidence,
well depletion, oxygen deficiency

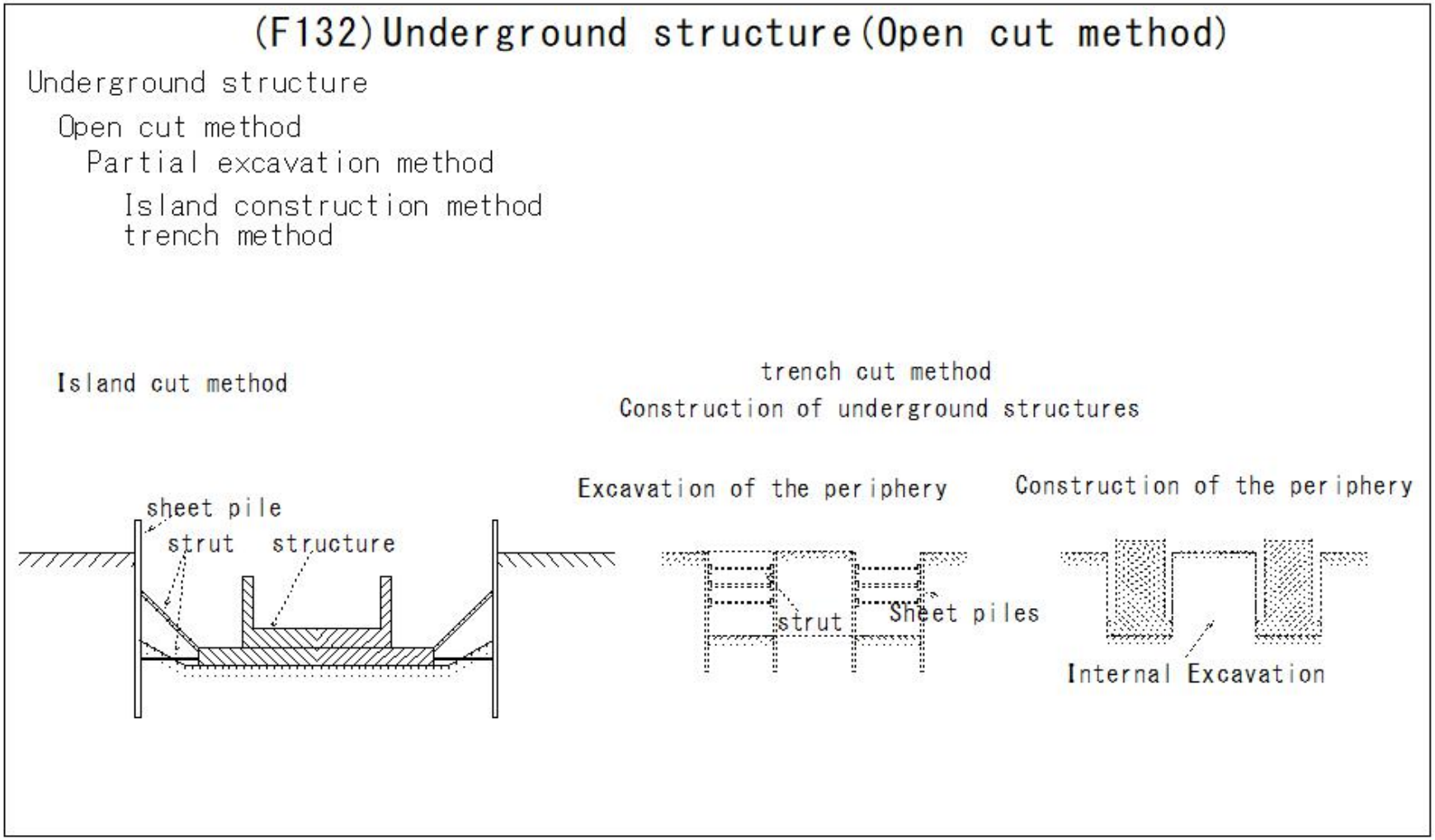
Ground stabilization method



(F131)Underground structure(Open cut method)



(F132)Underground structure(Open cut method)



(F133)Underground structure(Open cut method)

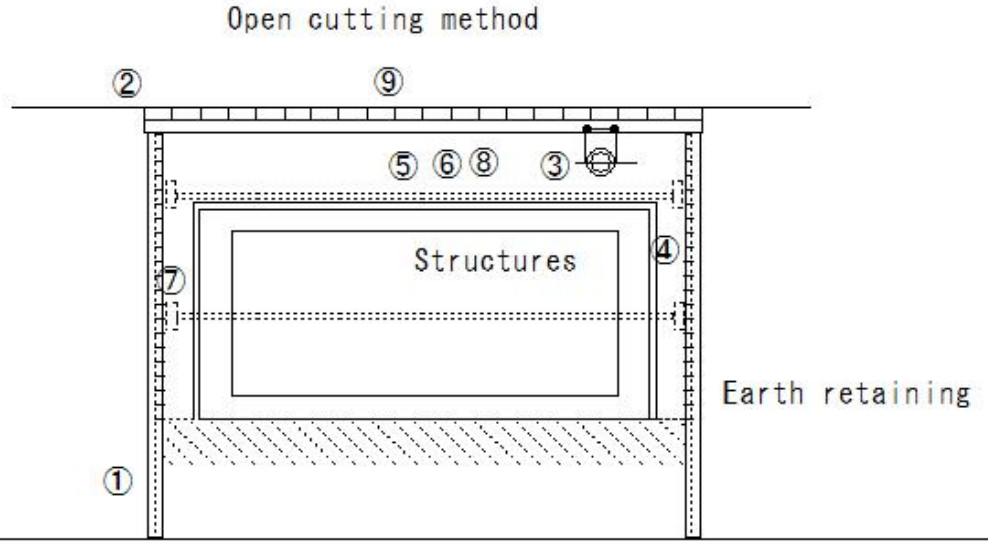
(F133)Underground structure(Open cut method)

Underground structure

Open cut method

・Construction sequence of full-section excavation method

①Pile driving
②Road surface lining
③Protection of buried objects
④Earth retaining shoring
⑤Records of excavation, reinforcing cage installation, and concrete placement
⑥Construction
⑦Waterproof
⑧Backfilling
⑨Road lining removal



(F134)Underground structure(Open cut method)

(F134)Underground structure(Open cut method)

Underground structure

Advantages and disadvantages of open cut method

①Advantages

shallow

Construction equipment and construction methods -easy and economical

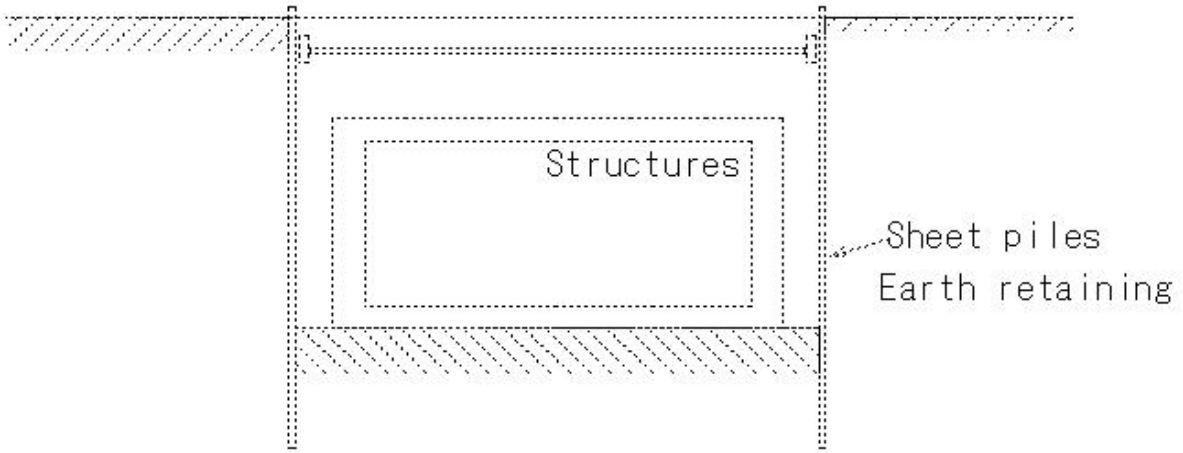
②Disadvantages

Deep below the surface

Excavation work Earth retaining work - getting bigger

long period

uneconomical

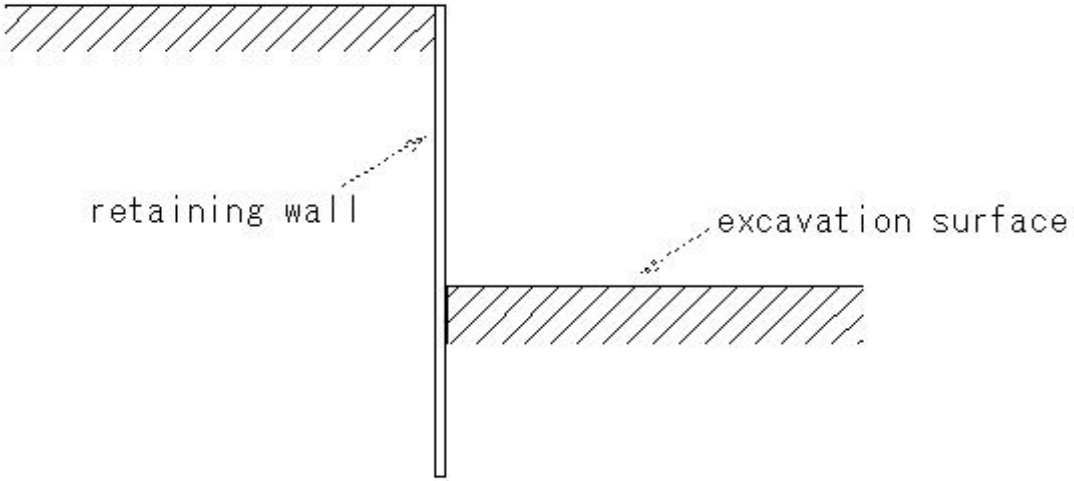


(F135)Underground structure(Types of earth retaining works)

(F135)Underground structure(Types of earth retaining works)

Types of earth retaining works

・Freestanding type
retaining wall
excavation surface
・Features: Application
Excavation depth - shallow



Freestanding type

(F136)Underground structure(strut type of earth retaining works)

(F136)Underground structure(strut type of earth retaining works)

Types of earth retaining works

Earth retaining work

・strut type

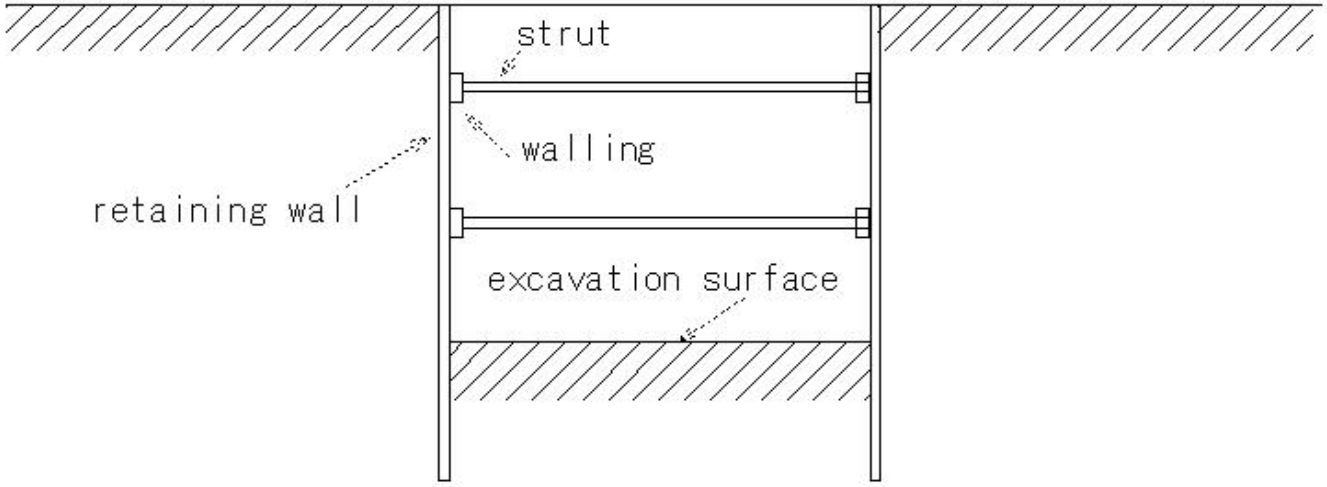
retaining wall

・Features: Application

drilling deep

Site - narrow

Excavation amount - want to reduce



strut type

(F137)Underground structure(Anchor type of earth retaining works)

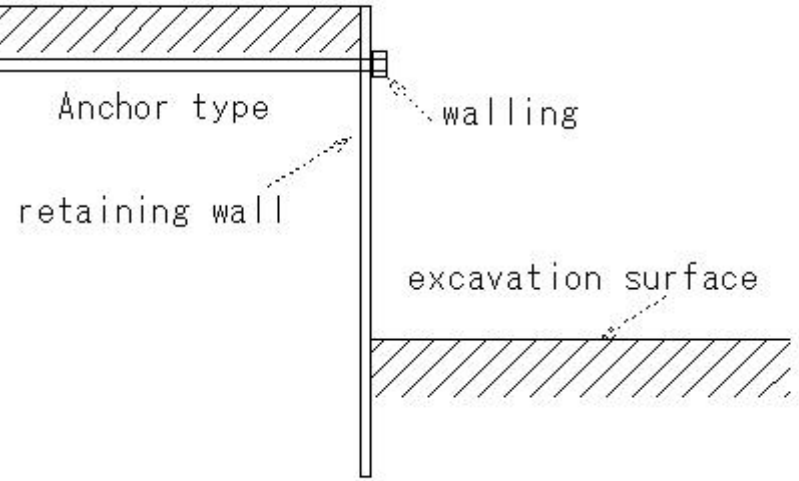
(F137)Underground structure(Anchor type of earth retaining works)

Types of earth retaining works

Earth retaining work

- Anchor type
- Features: Application

  Anchor driving possible



Anchor type

(F138)Underground structure(Island construction method of earth retaining works)

(F138)Underground structure(Island construction method of earth retaining works)

Types of earth retaining works

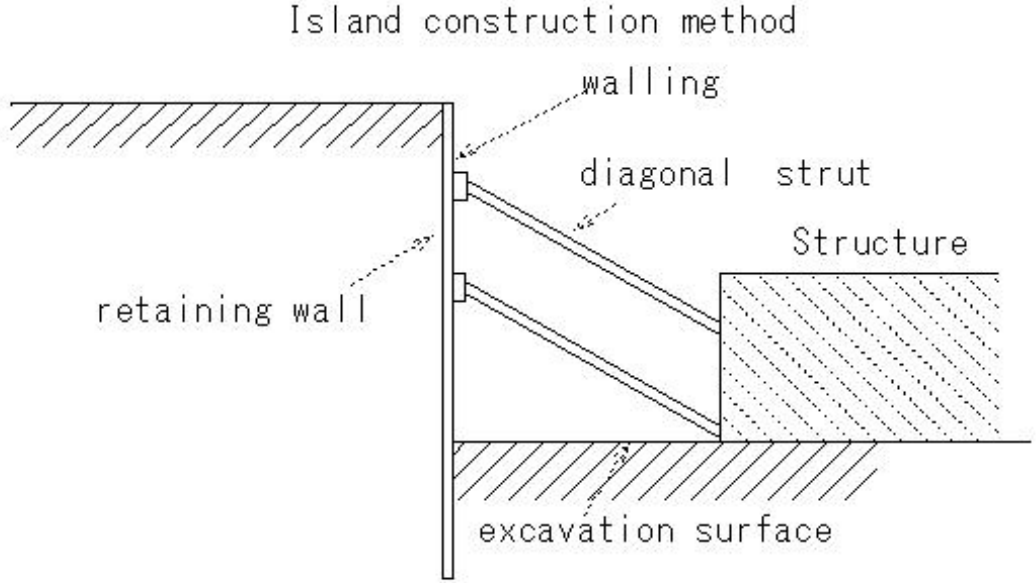
Earth retaining work

- Island construction method
- Features: Application

Excavation area - large

Strut and timbering -disadvantageous soft ground

Heaving prevention



(F139)Underground structure(Open cut method-Sheet pile (wood) earth retaining)

(F139)Underground structure(Open cut method-Sheet pile (wood) earth retaining)

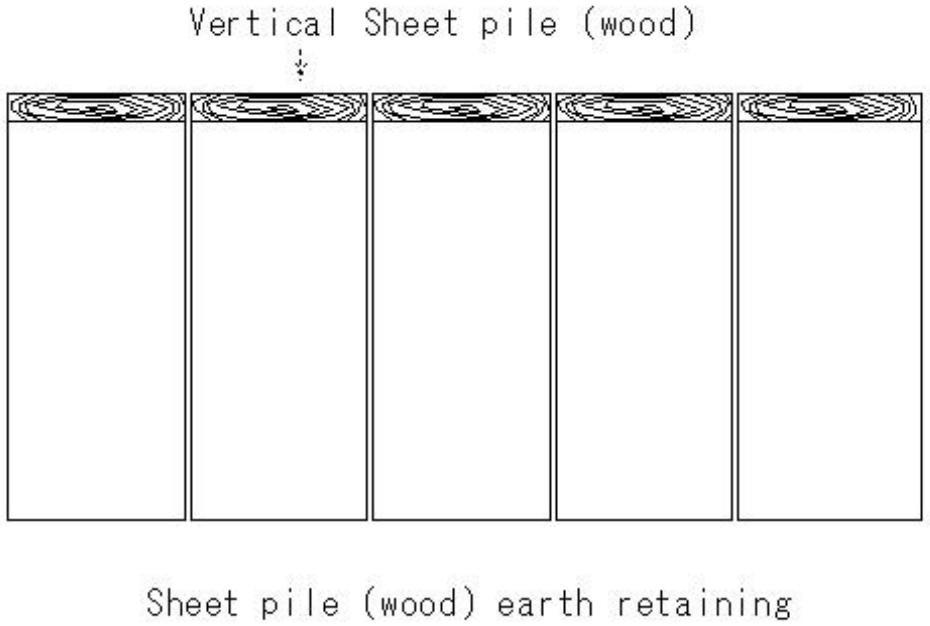
Earth retaining work

Sheet pile (wood) earth retaining

- shape-Vertical sheet pile
- Applicable condition
  - simple earthwork
  - trench method
- Features

  Construction costs -low

  weak strength



Sheet pile (wood) earth retaining

(F140)Open cut method(Steel pile (main pile) horizontal sheet pile earth retaining)

(F140)Open cut method(Steel pile (main pile) horizontal sheet pile earth retaining)

Earth retaining work

Steel pile (main pile) horizontal sheet pile earth retaining

・Applicable condition

Groundwater - low

No spring water

Normal ground: Boiling, no heaving

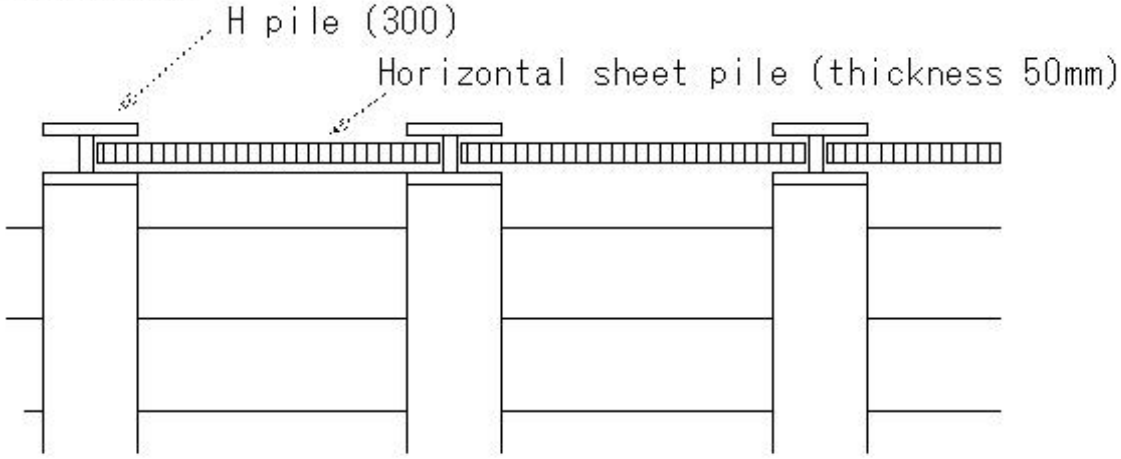
Road support possible

・Features

Construction cost - cheap

Obstacles - construction possible

Earth retaining - close contact



(F141)Open cut method(Steel sheet pile earth retaining work)

(F141)Open cut method(Steel sheet pile earth retaining work)

Earth retaining work

Steel sheet pile earth retaining work

- Applicable condition

  Groundwater - high - sandy ground

  Role of earth retaining and water stopping

  Heaving/boiling - suitable for soft ground

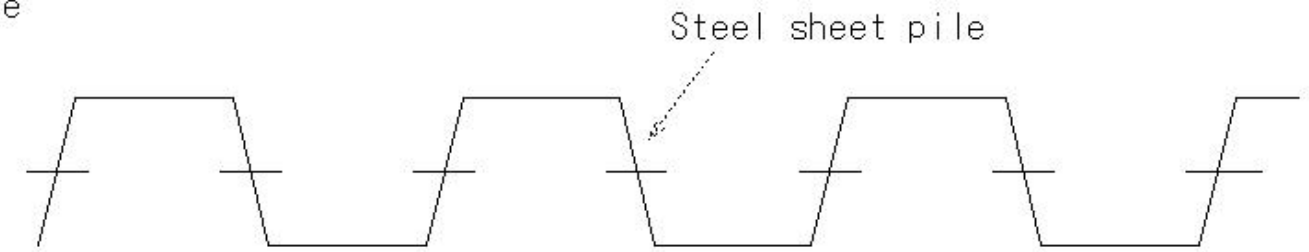
- Features

  Material can be used repeatedly

  Buried objects - cannot be constructed continuously

  Cobblestones/hard ground - unsuitable

  noise



(F142)Open cut method(concrete continuous underground wall)

(F142)Open cut method(concrete continuous underground wall)

Earth retaining work

concrete continuous underground wall

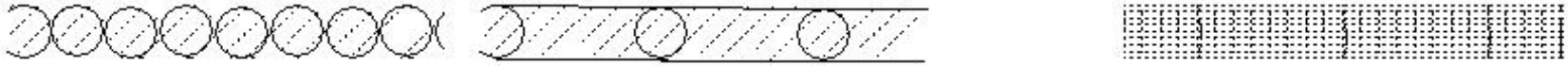
- Applicable condition
  - Road load support
  - Role of earth retaining and water stopping
  - No-noise, no-vibration - construction
  - Prevention of surrounding ground settlement
  - Excavation depth - deep
- Features
  - Main structure - use
  - Length/Thickness - Free
  - Temporary fixing - expensive work
  - Column style - close contact

・Continuous underground wall construction method

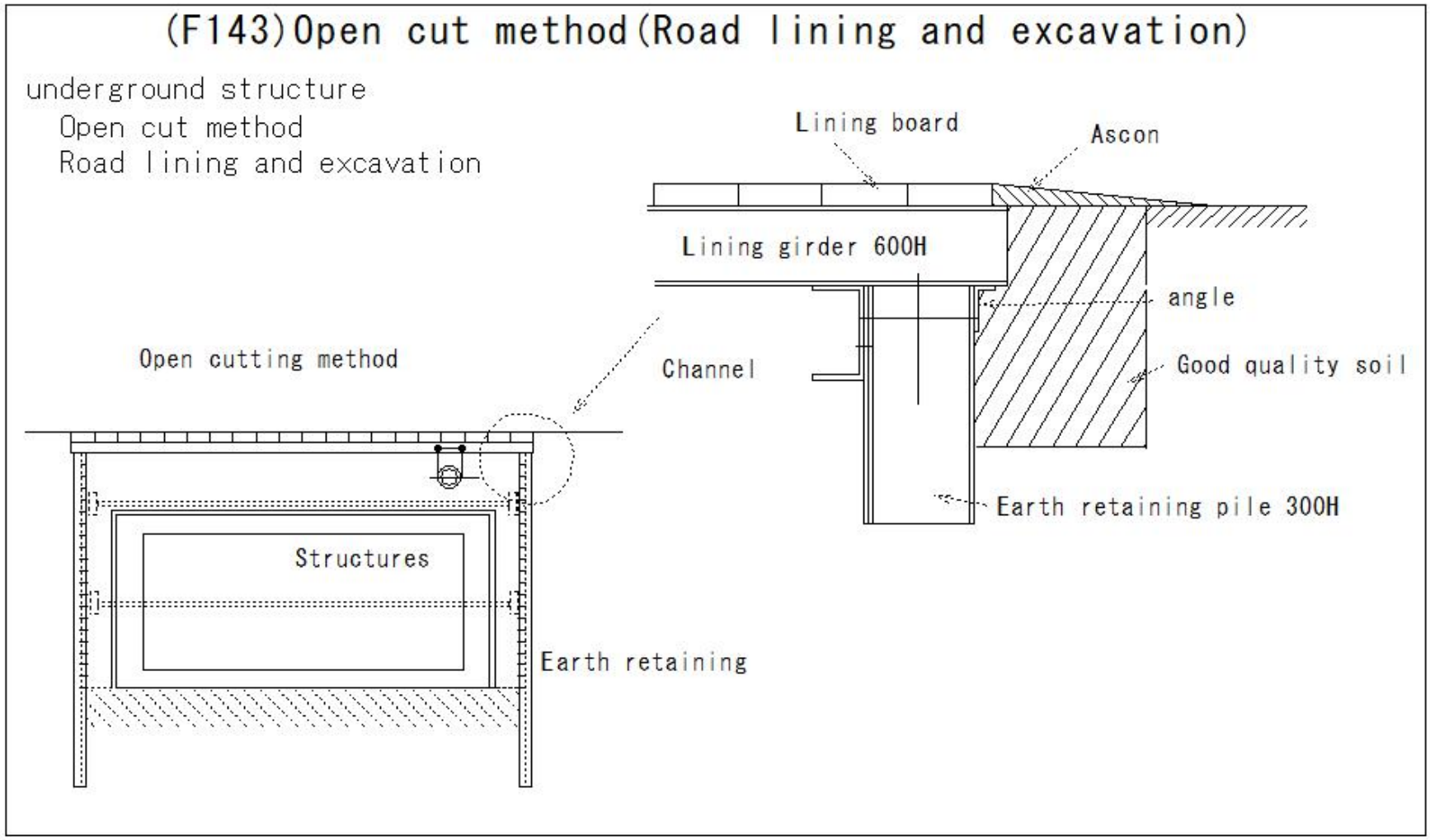
(1) Pillars and pillars

(2) Pillars and walls

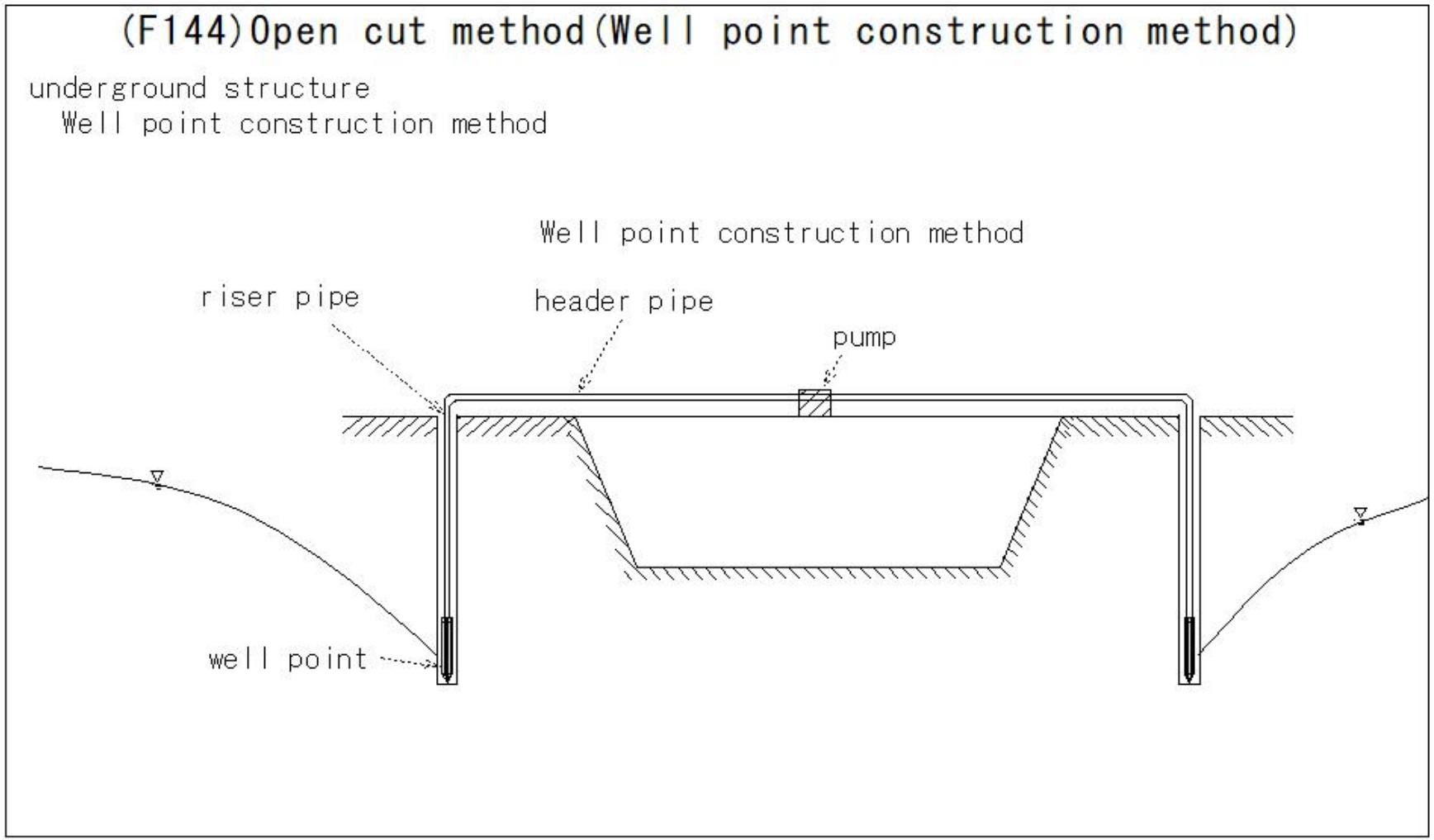
(3) Walls and walls



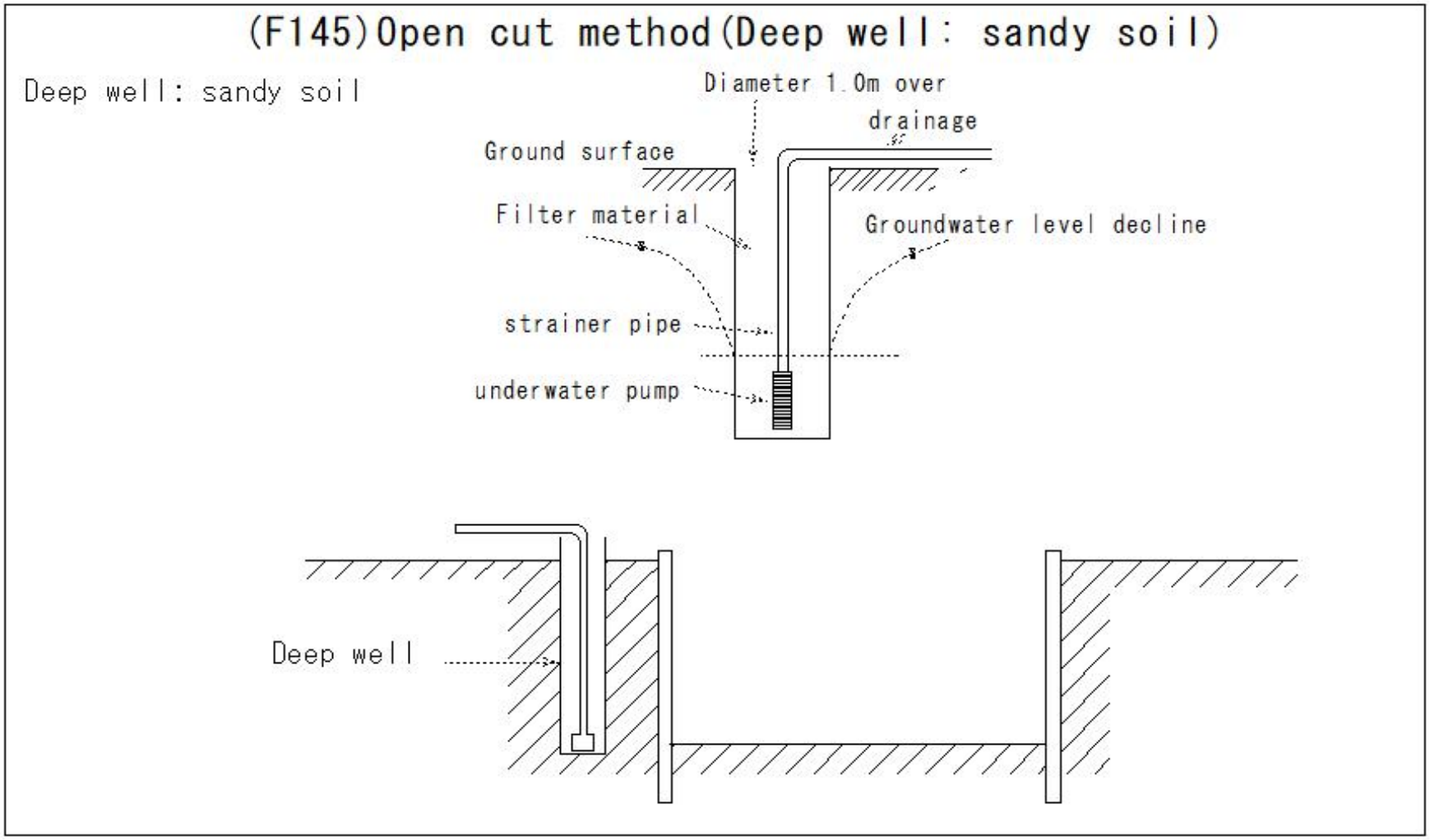
(F143)Open cut method(Road lining and excavation)



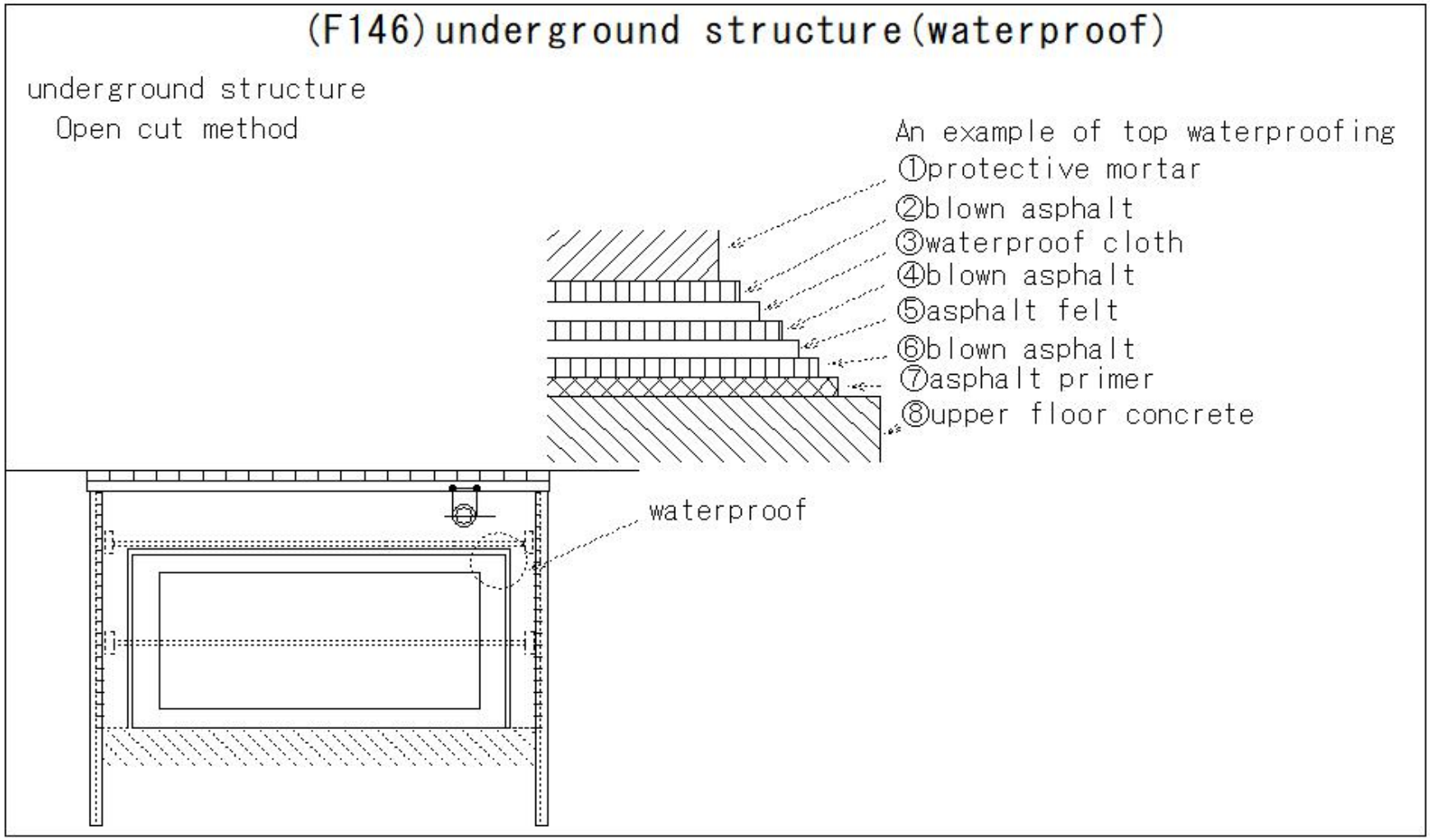
(F144)Open cut method(Well point construction method)



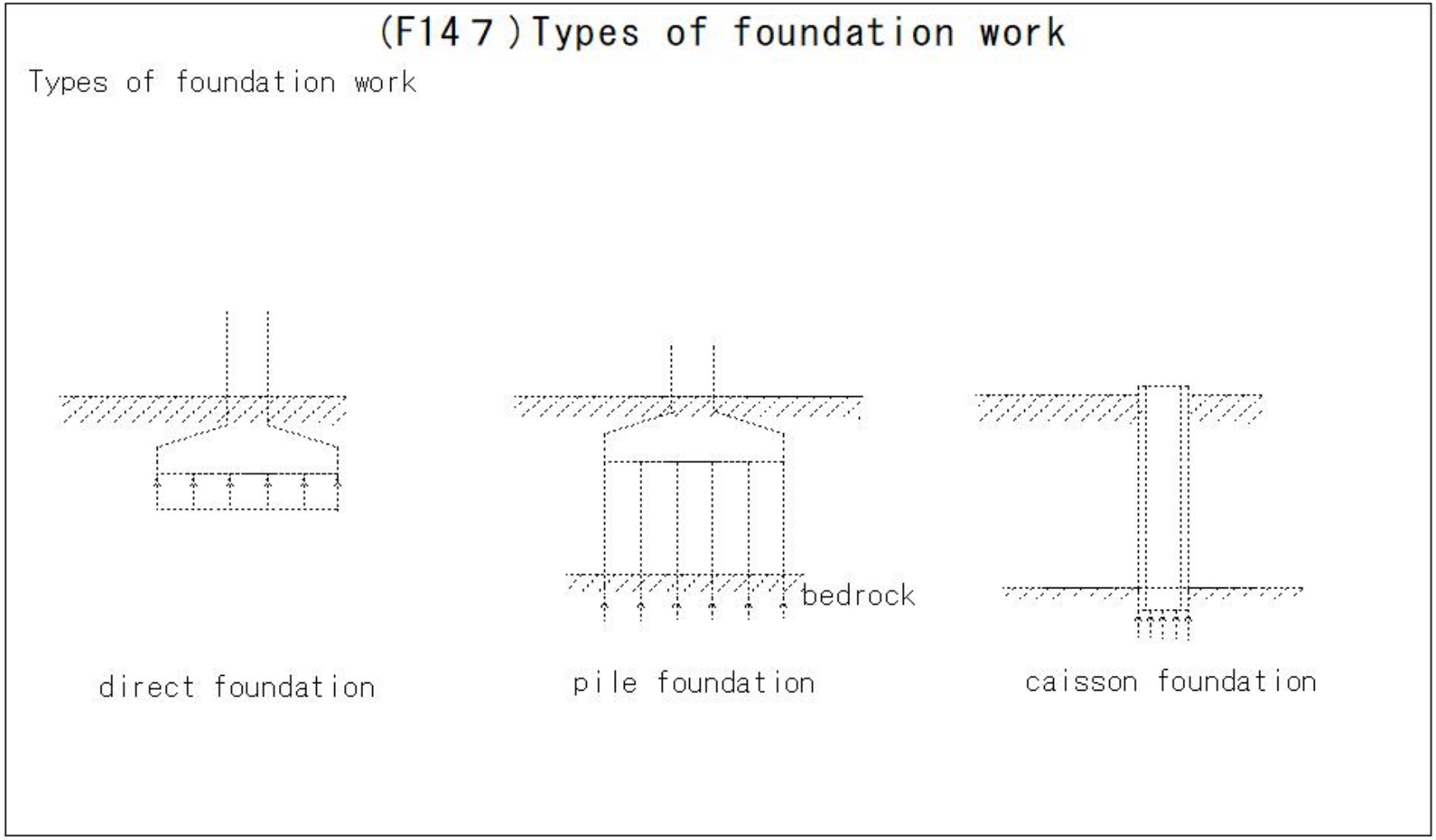
(F145)Open cut method(Deep well: sandy soil)



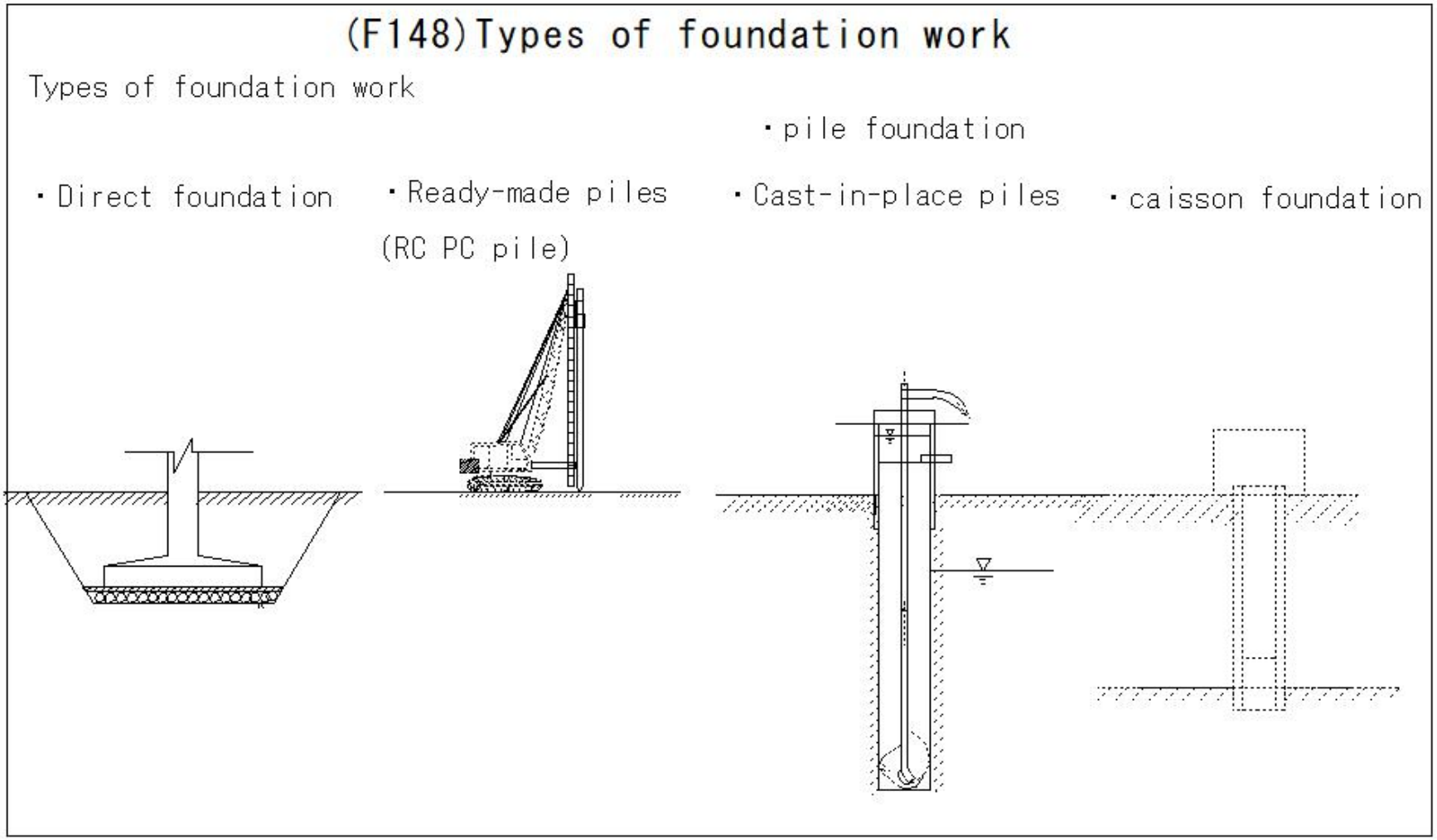
(F146)underground structure(waterproof)



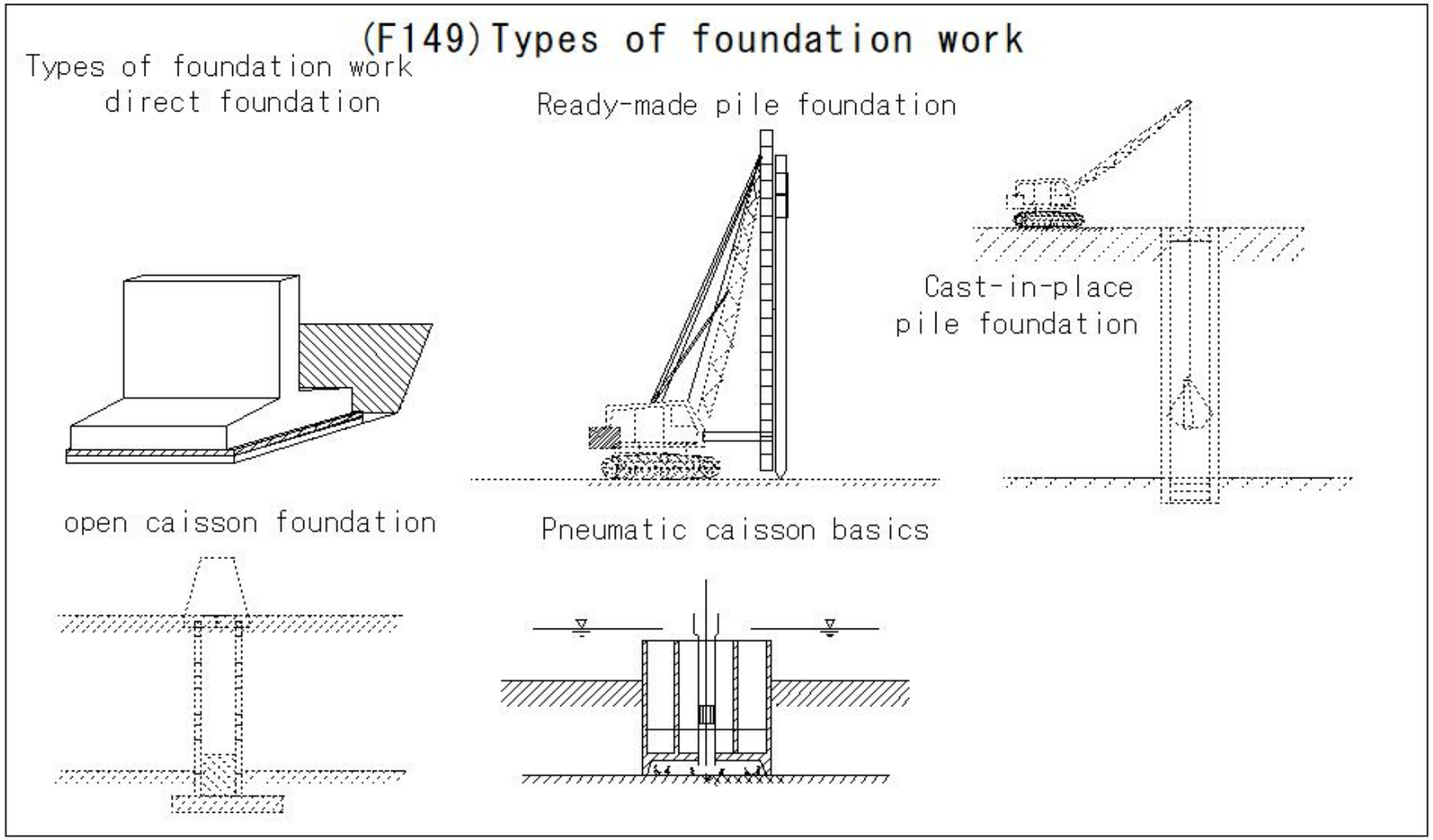
(F147)Types of foundation work



(F148)Types of foundation work



(F149)Types of foundation work



(F150)Types of foundation work(direct foundation)

(F150)Types of foundation work(direct foundation)

Types of foundation work

direct foundation

- advantages

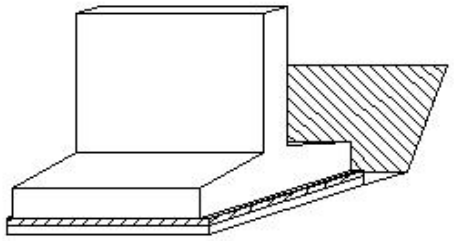
  Cost - minimum

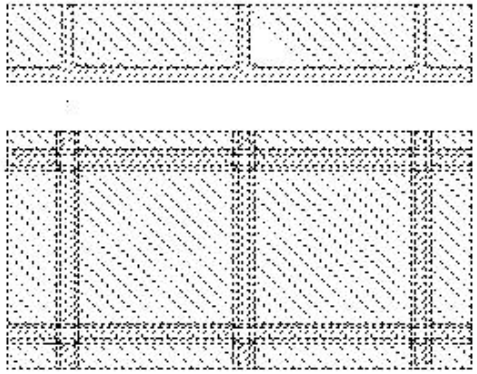
- disadvantages

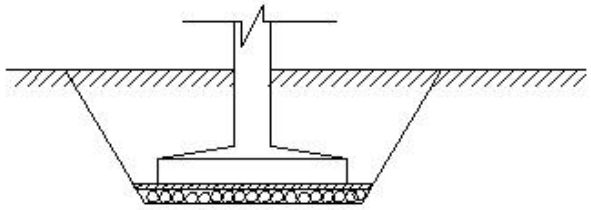
  Scope of application - limited

  direct foundation

  footing foundation





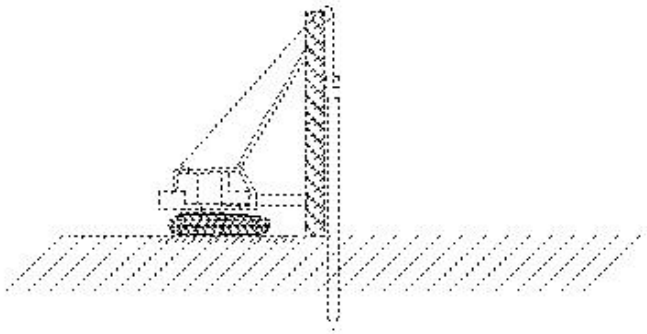


(F151)Types of foundation work(Ready-made pile foundation)

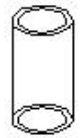
(F151)Types of foundation work(Ready-made pile foundation)

Types of foundation work
Ready-made pile foundation

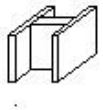
- advantages
  Steps: Less work Cost: cheap
  Construction period: short
- Disadvantages
  Geological confirmation: impossible
  Noise/vibration: large
  Cobblestone: Difficult to construct
- Classification by construction method
  Wooden pile, RC pile, PC pile, steel pile



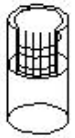
RC pile



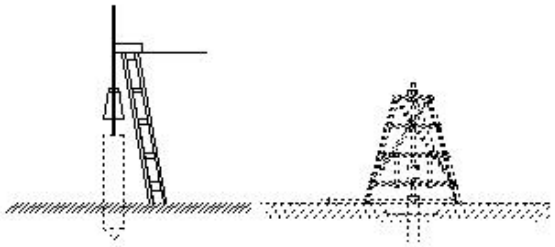
RC pile



H steel pile



steel pile



Wooden pile

(F152)Types of foundation work(cast-in-place pile foundation)

(F152)Types of foundation work(cast-in-place pile foundation)

Types of foundation work

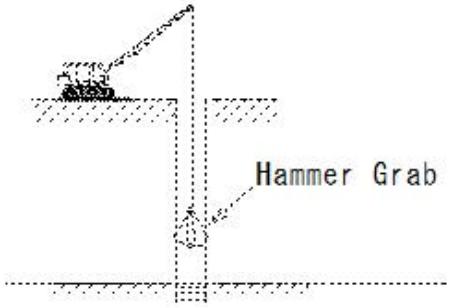
cast-in-place pile

・advantages
Noise/vibration: low
Supporting capacity: sure

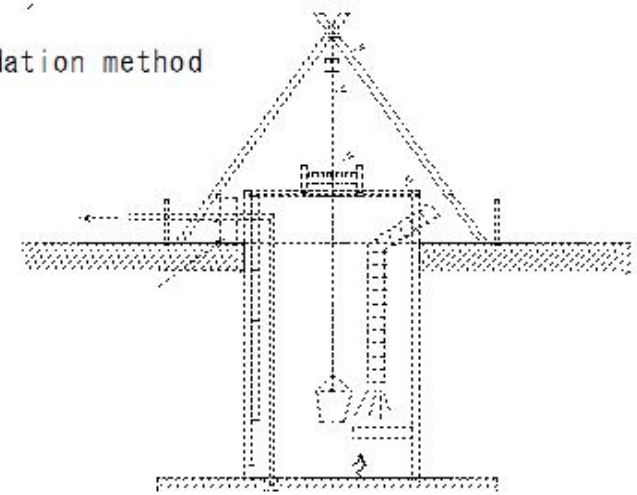
・Disadvantages
Step: A lot of work
Cost: high

・Classification by construction method

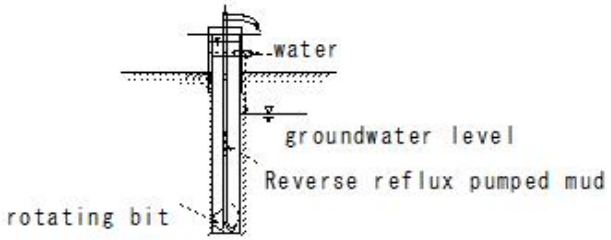
All-casing method
Benoto pile



Deep foundation method



Reverse circulation method



(F153)Types of foundation work(caisson foundation)

(F153)Types of foundation work(caisson foundation)

Types of foundation work

caisson foundation

open caisson foundation

Pneumatic caisson basics

・advantages

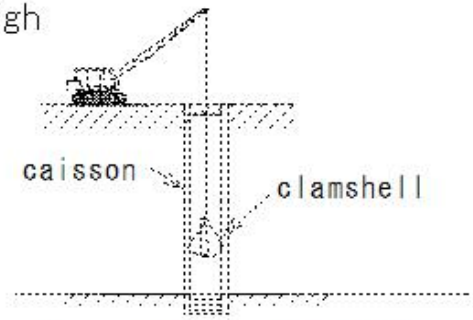
Large supporting force and horizontal resistance force can be obtained.

Geological confirmation: impossible

・Disadvantages

Step: a lot of work

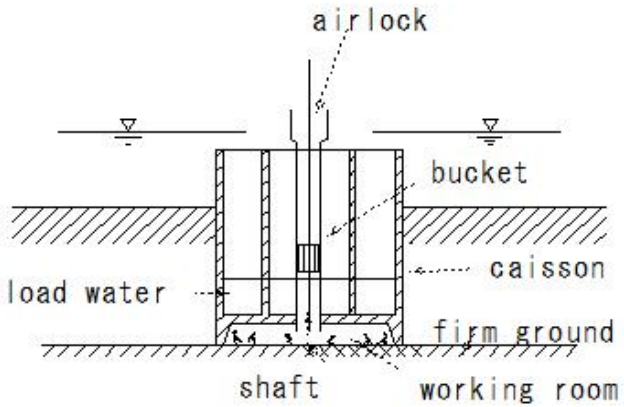
Cost: high



Open caisson foundation

Sedimentation in the support layer

Open caisson



Pneumatic caisson

(F154)Types of foundation work(points of planning)

(F154)Types of foundation work(points of planning)

Types of foundation work

Foundation work
points of planning

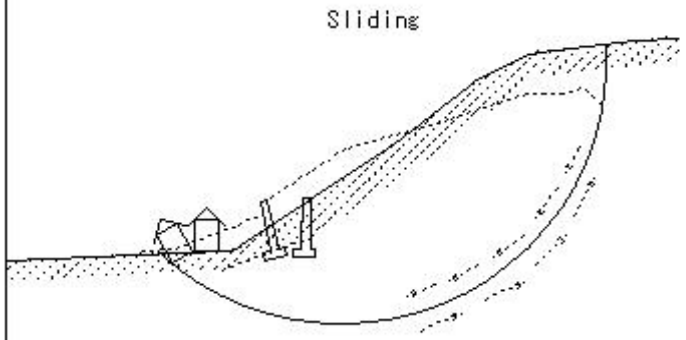
①Superstructure - Integration

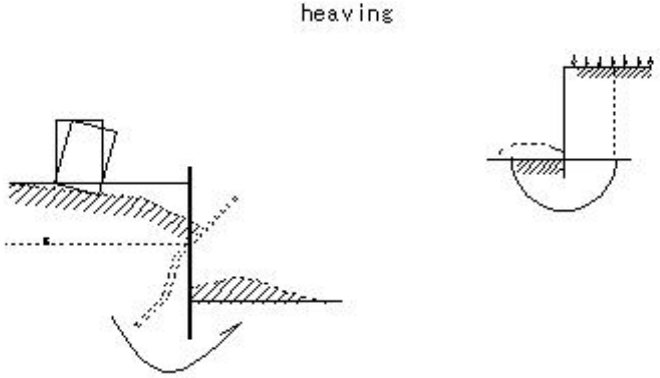
②Safe and reliable construction

No uneven settlement

③Durability/maintenance-easy

④ During construction, environmentally friendly and economical



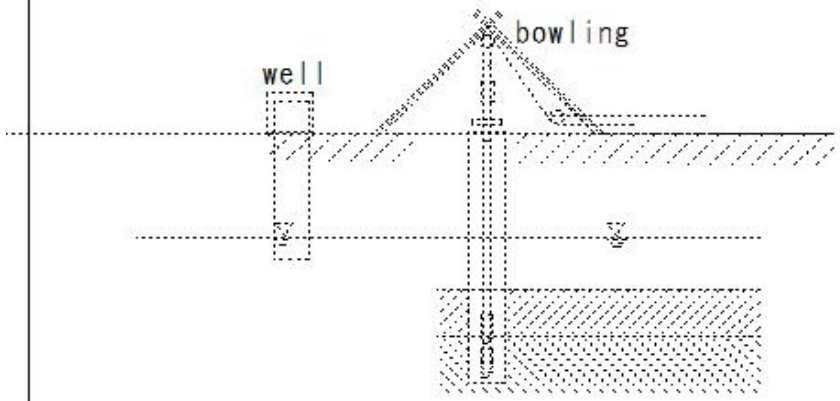


(F155)Types of foundation work(investigation)

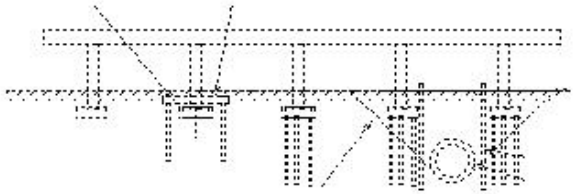
(F155)Types of foundation work(investigation)

Types of foundation work

Foundation work
investigation
①Soil investigation
②Environmental survey
③Investigation of construction conditions
and environmental conditions



under pinning method



(F156)Soft ground improvement method

(F156)Soft ground improvement method

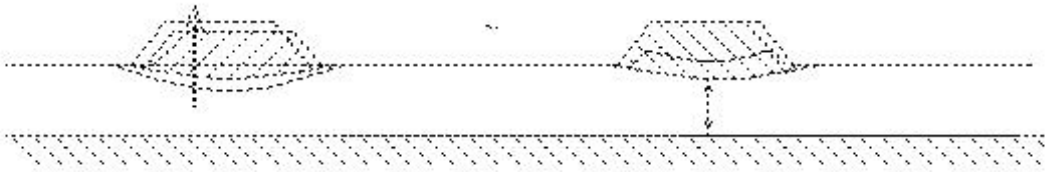
Soft ground improvement method

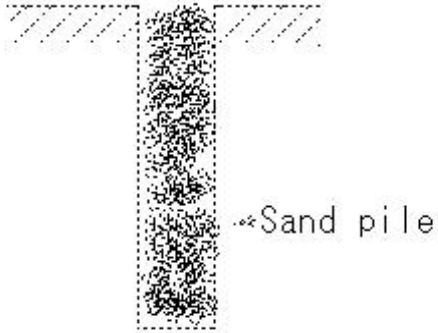
① Soil - compaction

② Drainage - ground bearing capacity - increase

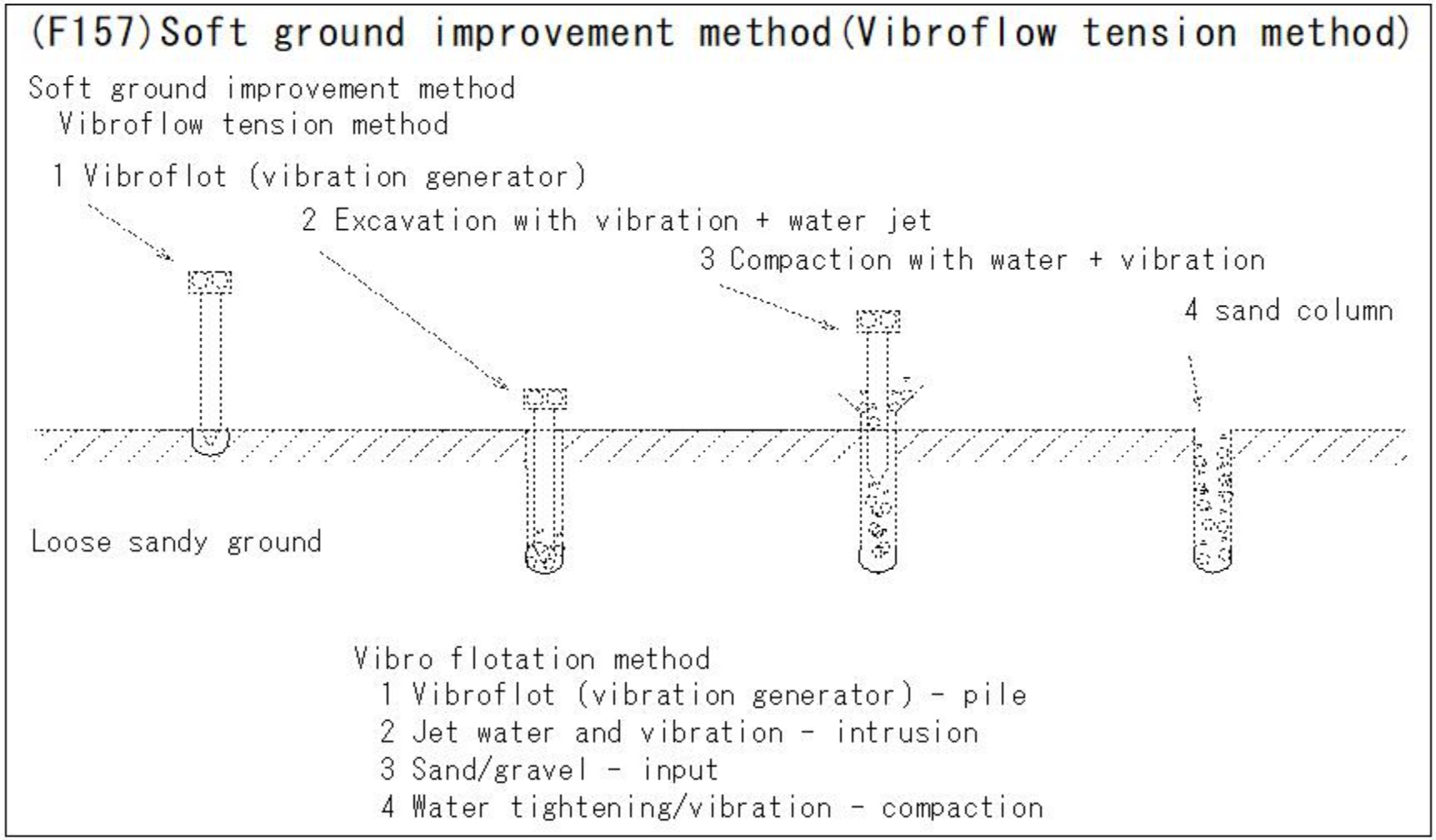
Soft ground - standard penetration test - N value <5

Slow consolidation drainage speed





(F157)Soft ground improvement method(Vibroflow tension method)



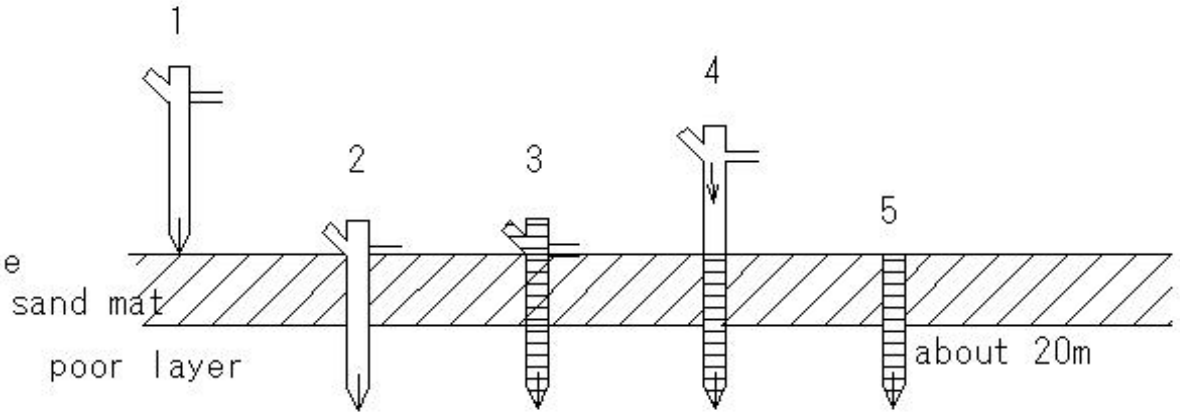
(F158)Soft ground improvement method(Sand drain method)

(F158)Soft ground improvement method(Sand drain method)

Soft ground improvement method
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



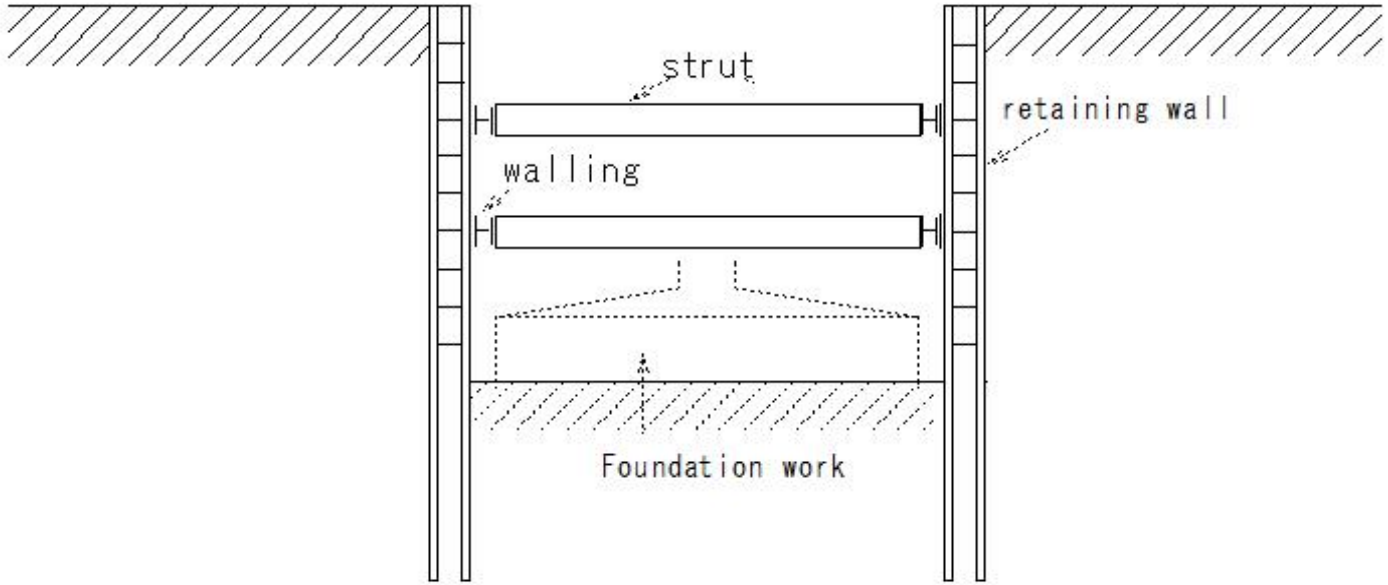
Sand drain method

(F159)Earth retaining work

(F159)Earth retaining work

Earth retaining work

Earth retaining work: temporary construction - during foundation excavation - prevention of landslides

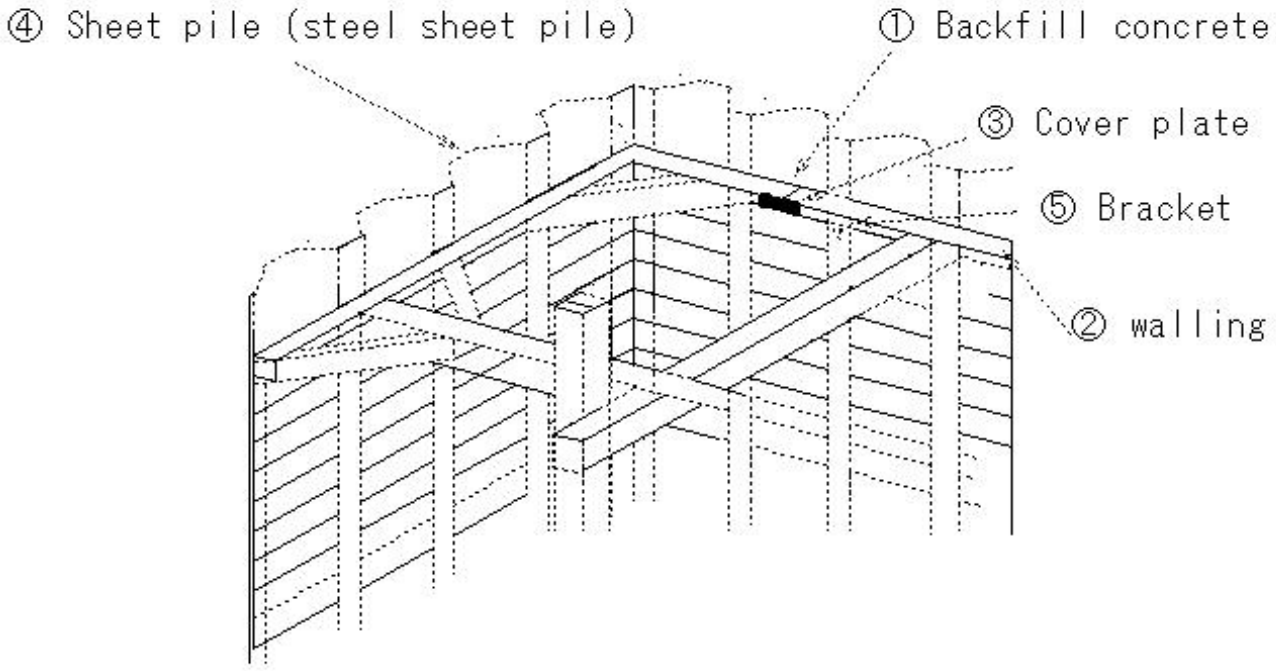


(F160)Earth retaining work(steel sheet pile)

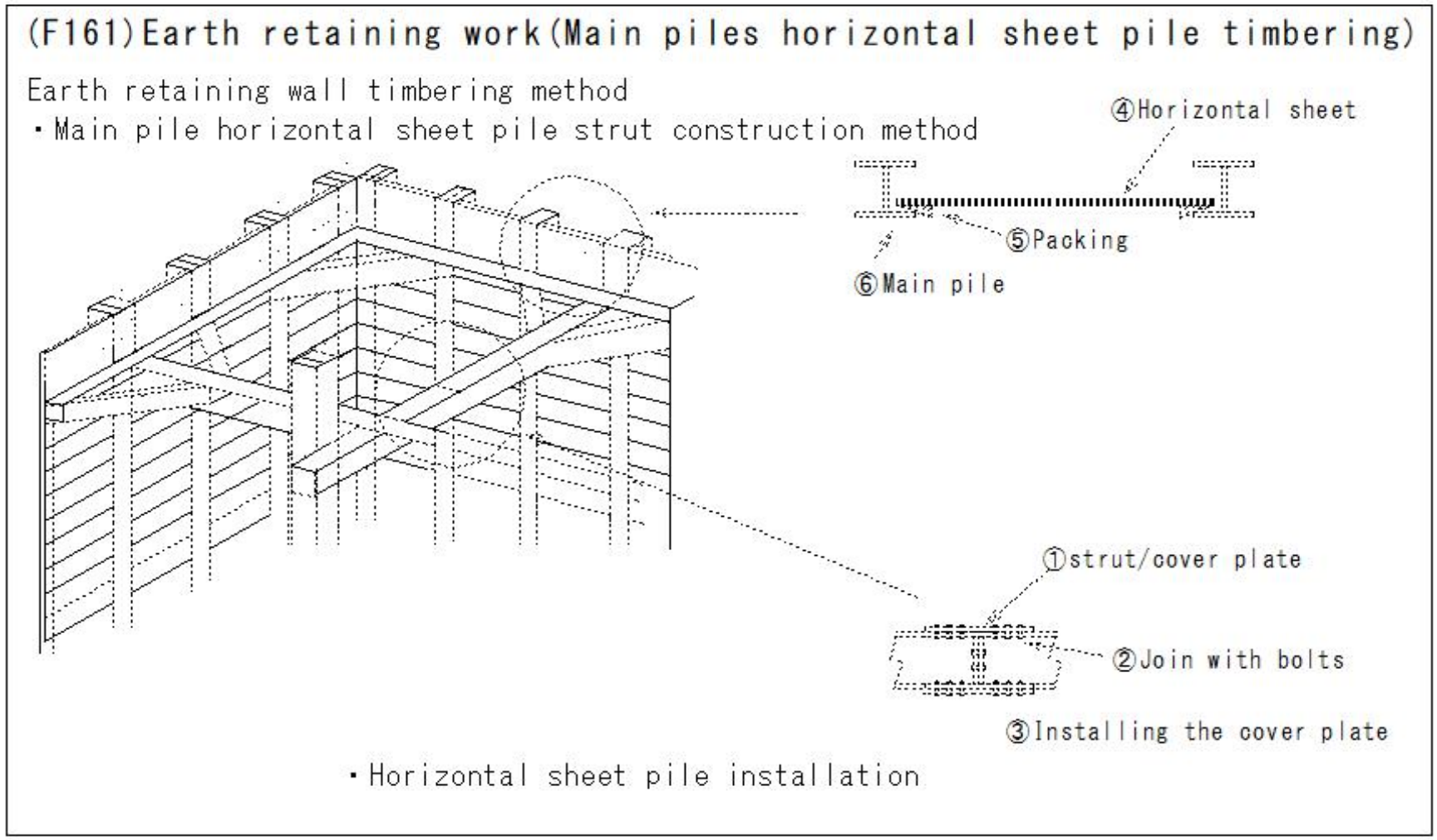
(F160)Earth retaining work(steel sheet pile)

Earth retaining wall timbering method

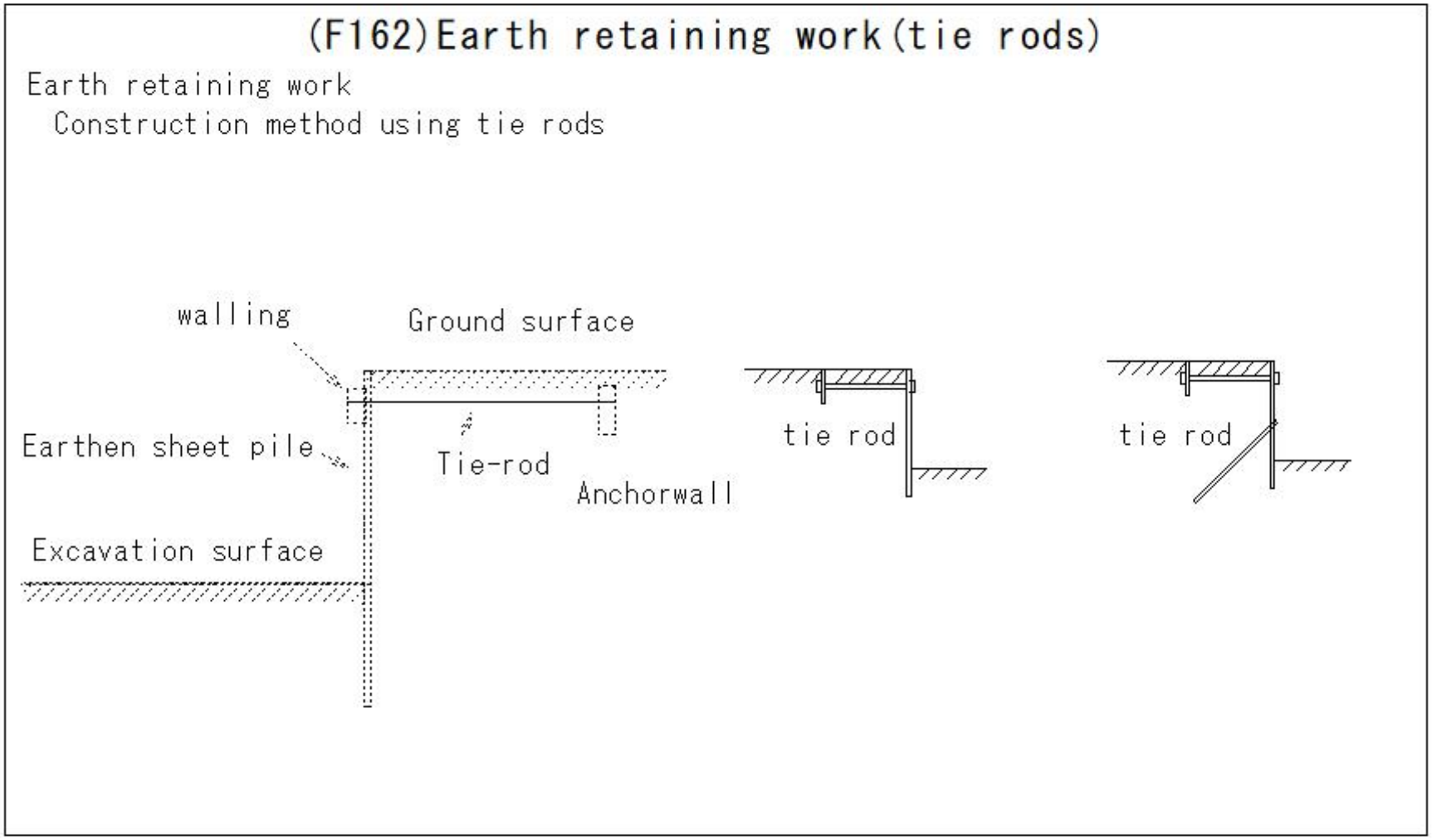
- Relationship between steel sheet pile and walling
- Sheet pile (steel sheet pile) strut construction method



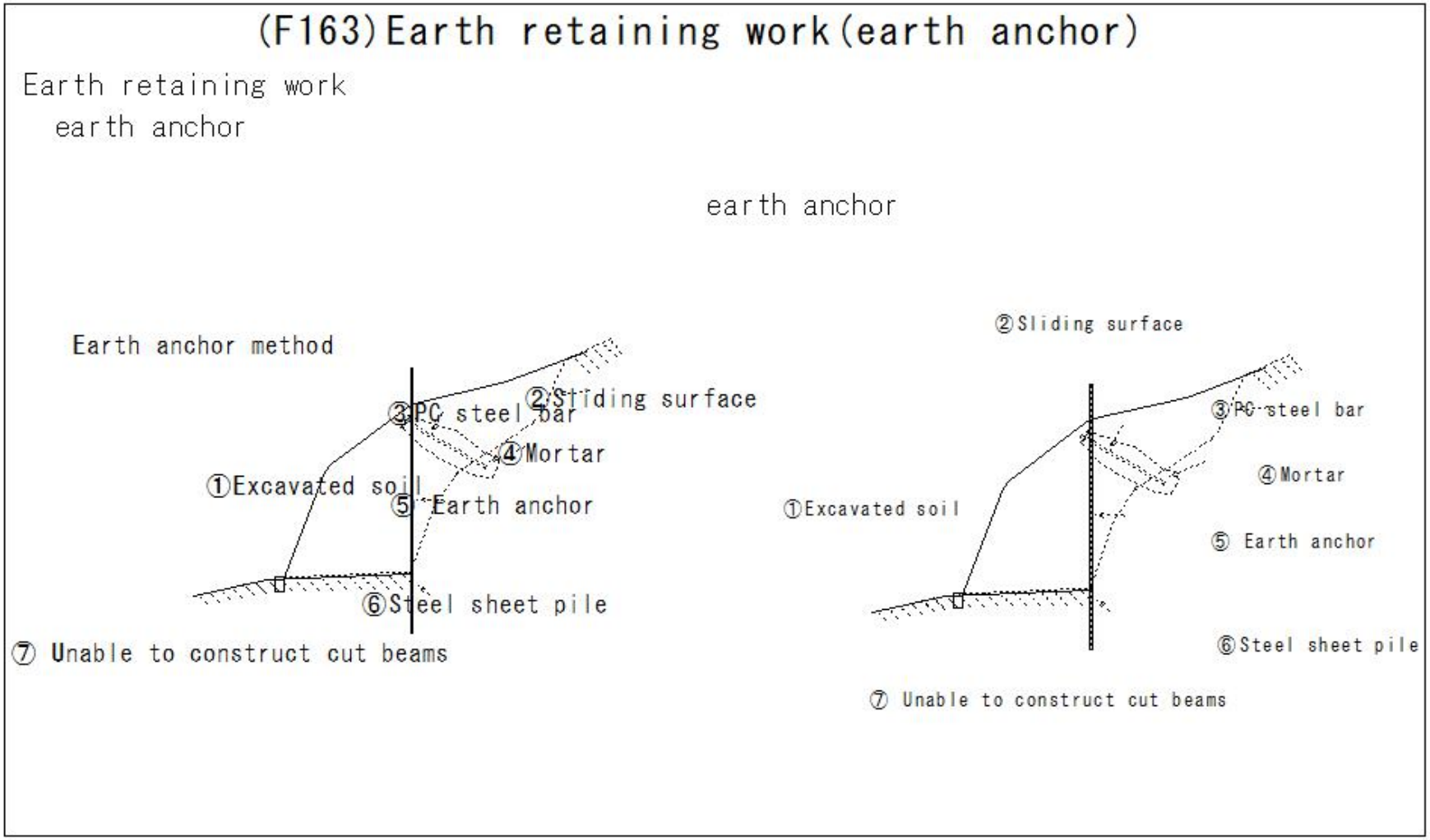
(F161)Earth retaining work(Main piles horizontal sheet pile timbering)



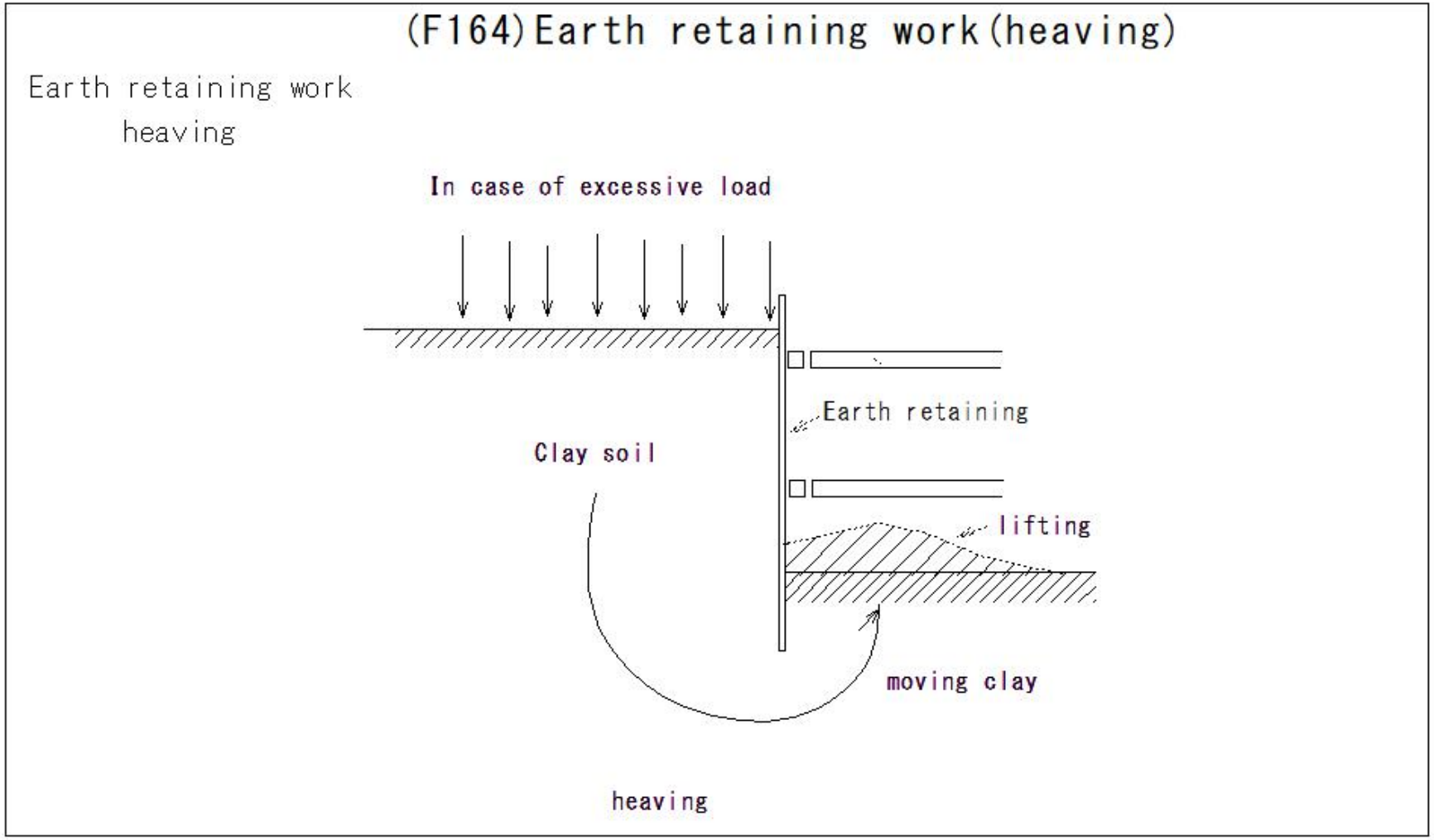
(F162)Earth retaining work(tie rods)



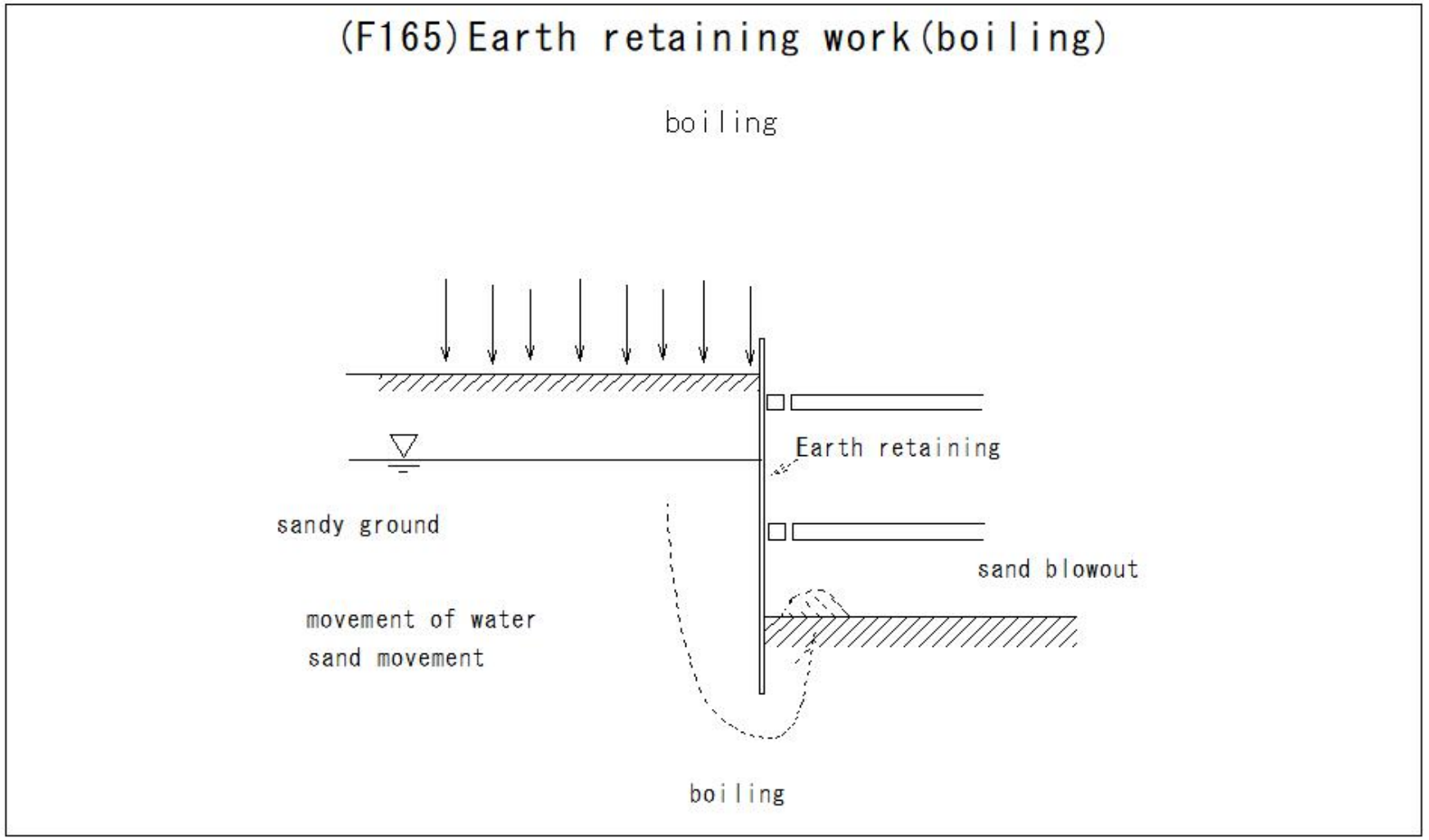
(F163)Earth retaining work(earth anchor)



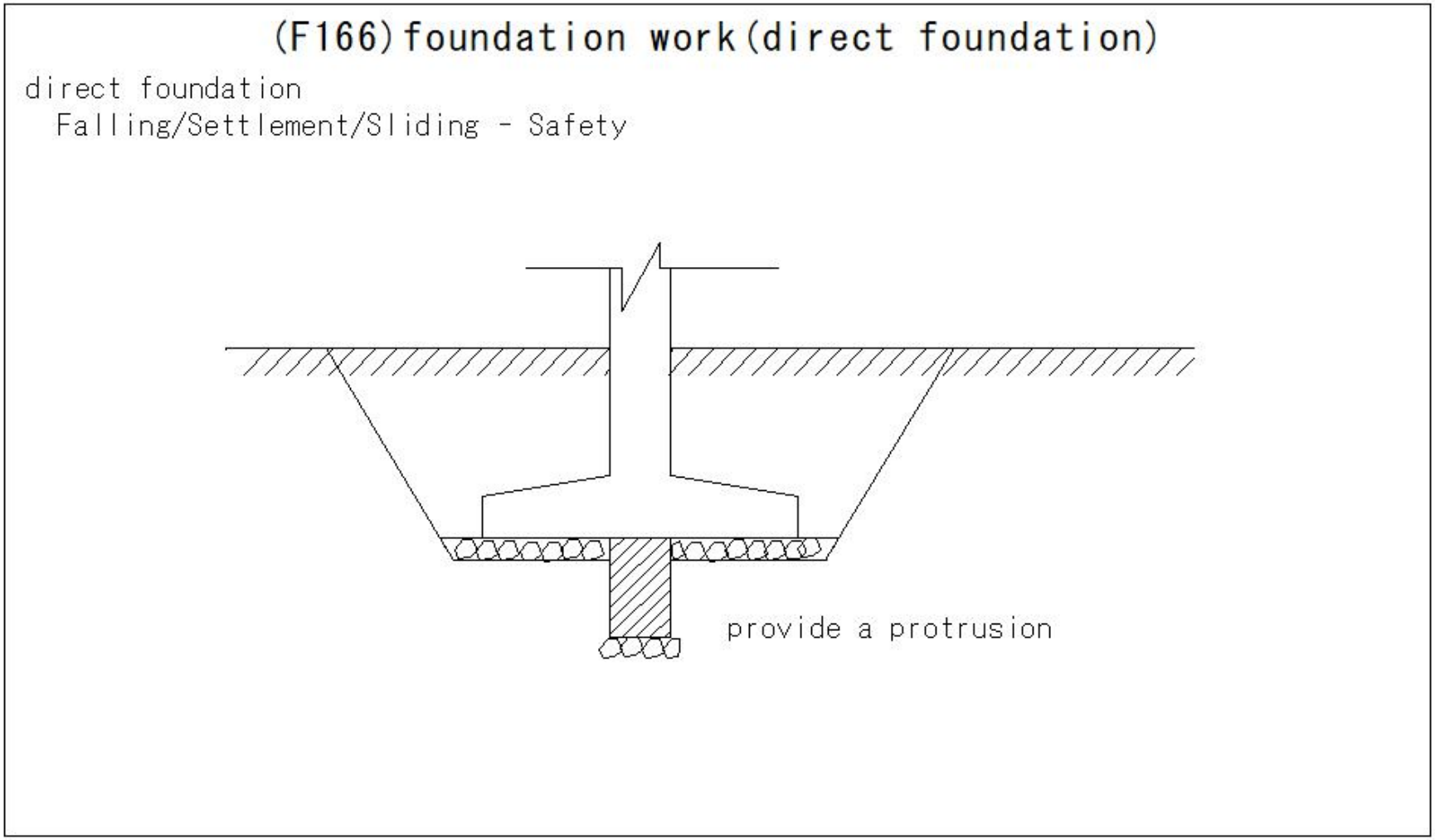
(F164)Earth retaining work(heaving)



(F165)Earth retaining work(boiling)



(F166)foundation work(direct foundation)

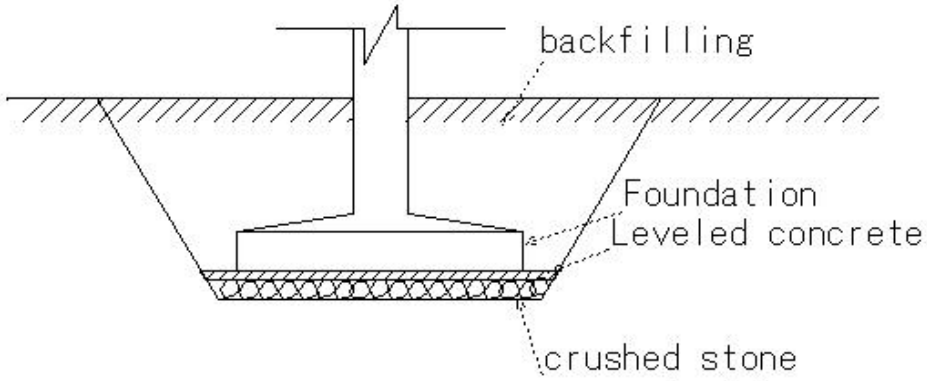


(F167)foundation work(direct foundation)

(F167)foundation work(direct foundation)

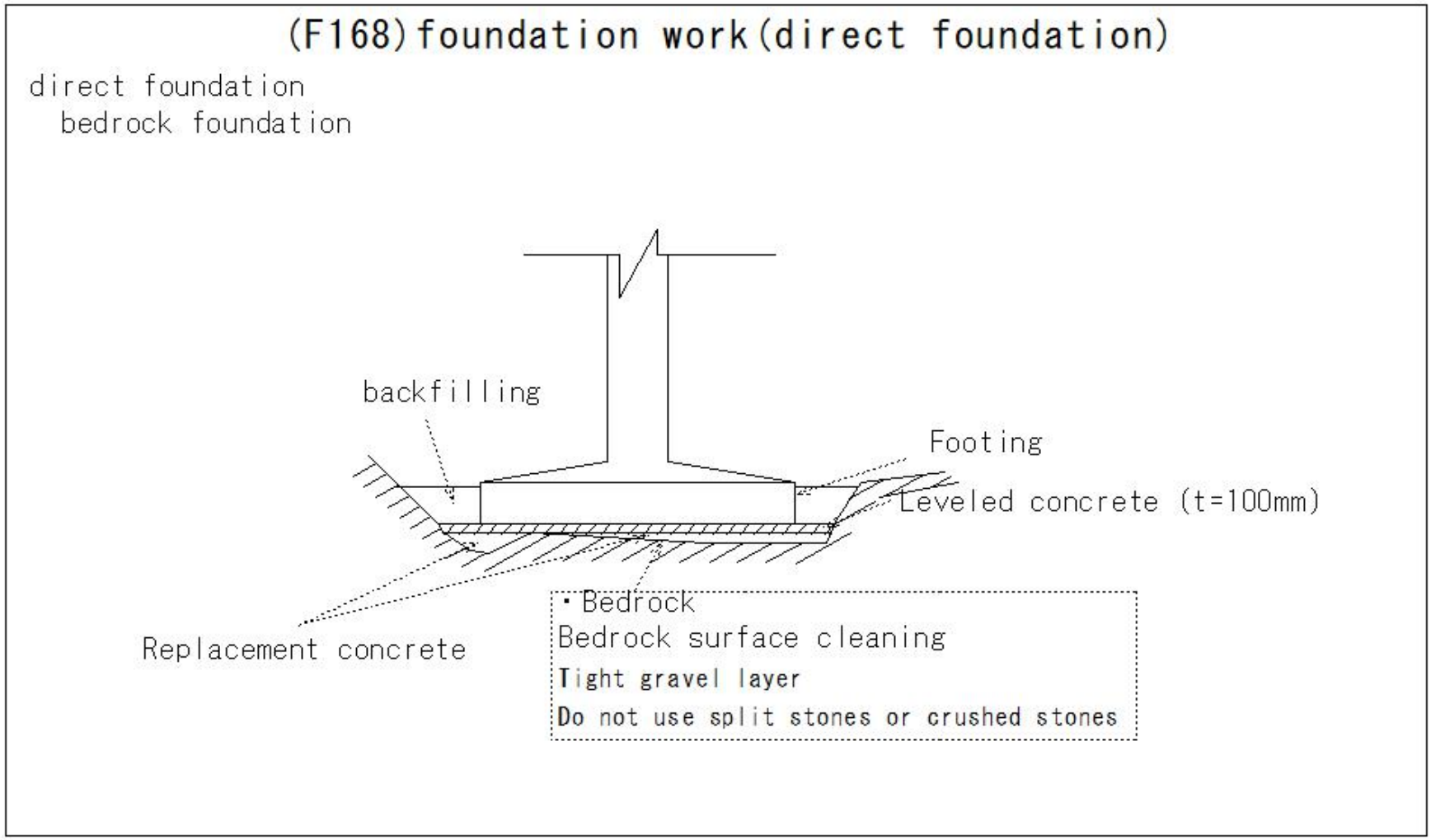
direct foundation

Foundation of sandy soil



Foundation of sandy soil

(F168)foundation work(direct foundation)



(F169)foundation work(direct foundation)

(F169)foundation work(direct foundation)

direct foundation

Features of direct foundation work

①Depth to supporting ground -5m

Groundwater treatment - easy

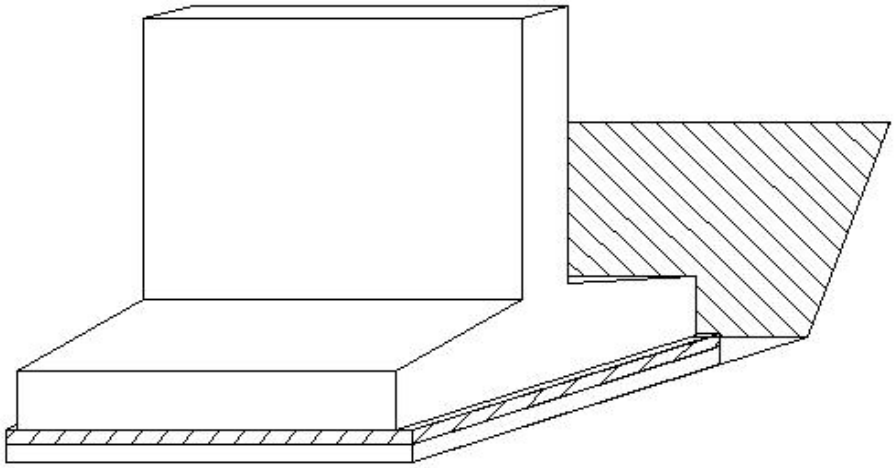
Supporting ground - shallow

②Supporting capacity judgment - easy

③Noise and vibration during construction - little

Adjacent structures - Minor impact

④Work space during construction - small



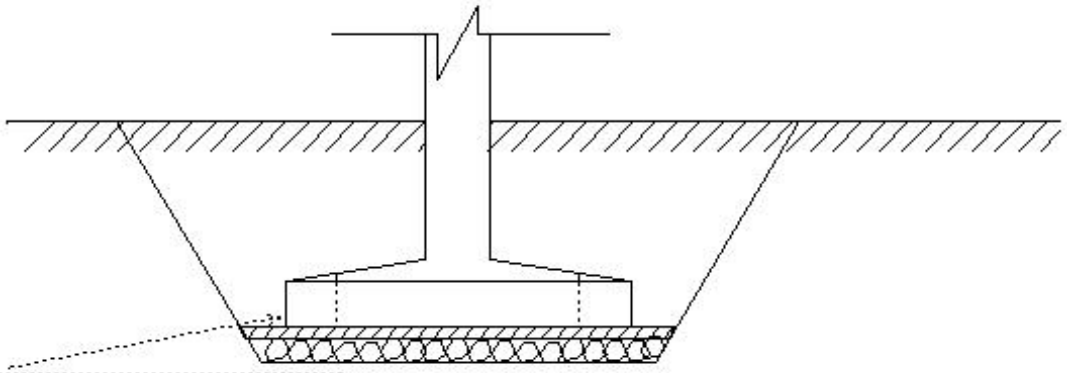
(F170)foundation work(direct foundation)

(F170) foundation work(direct foundation)

direct foundation

Changing the size and depth of the direct foundation

Foundation of sandy soil

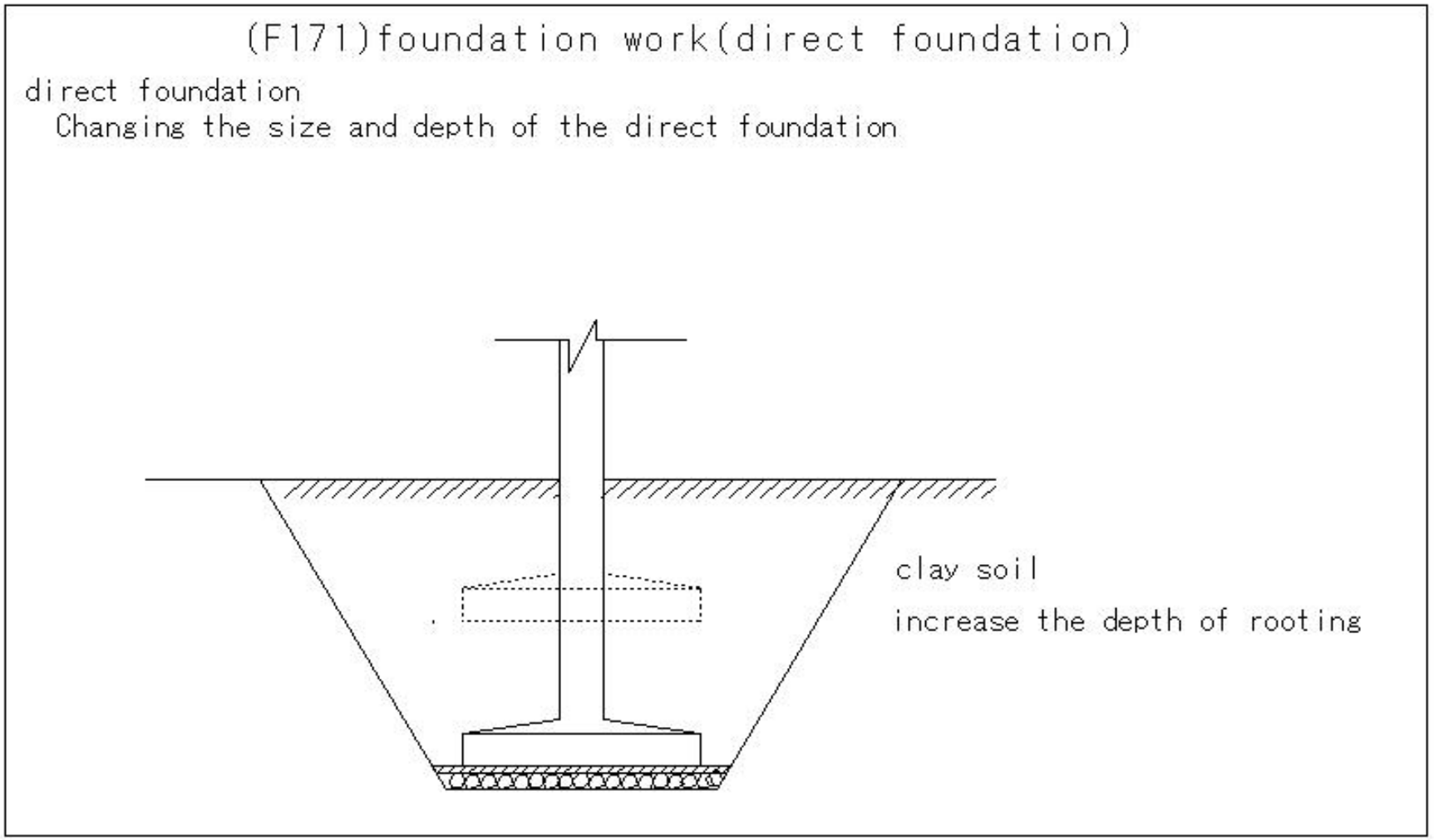


Insufficient support capacity

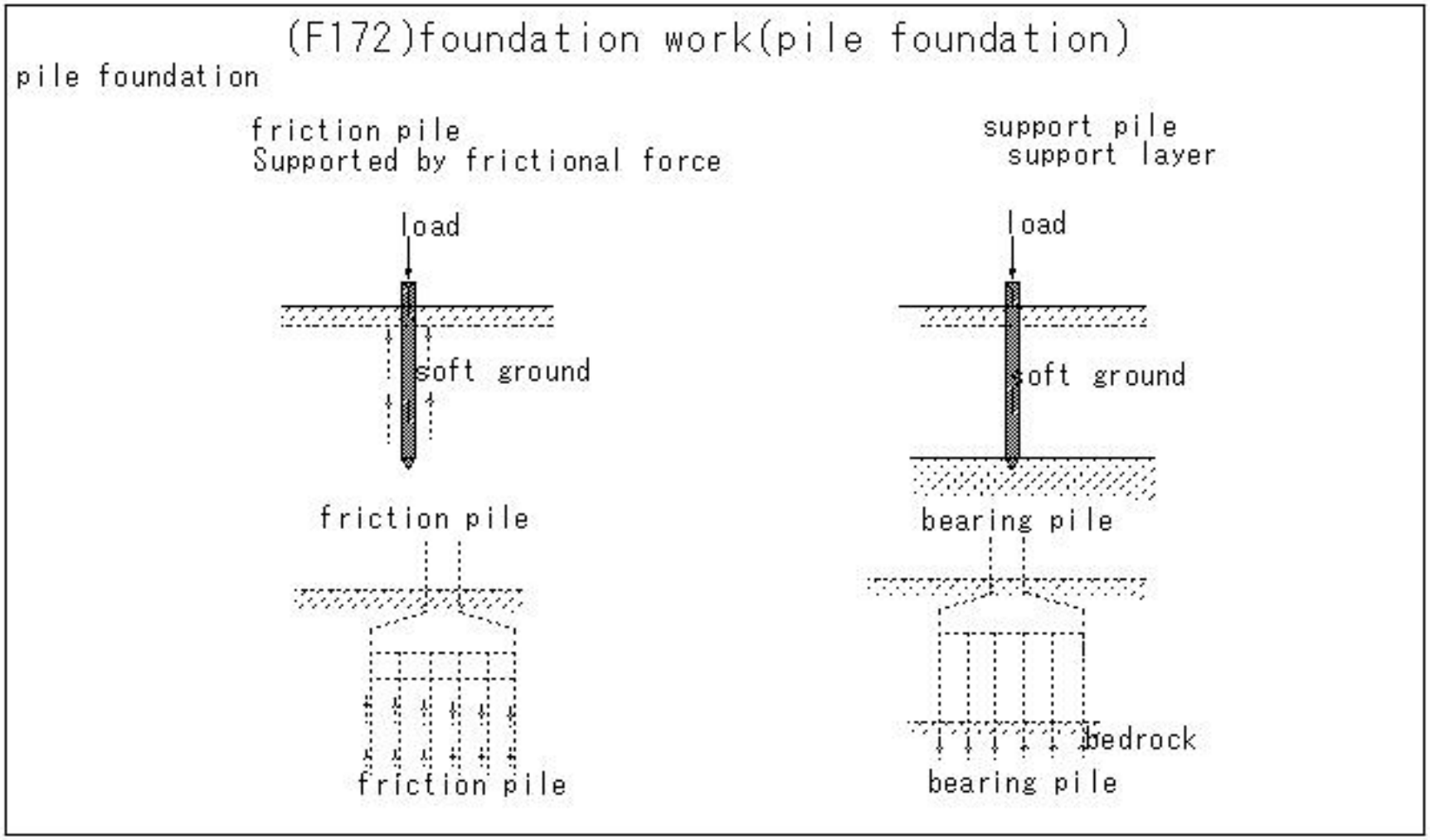
Bottom area - Increase

Foundation of sandy soil

(F171)foundation work(direct foundation)



(F172)foundation work(pile foundation)



(F173)foundation work(pile foundation)

foundation work(pile foundation)

pile foundation

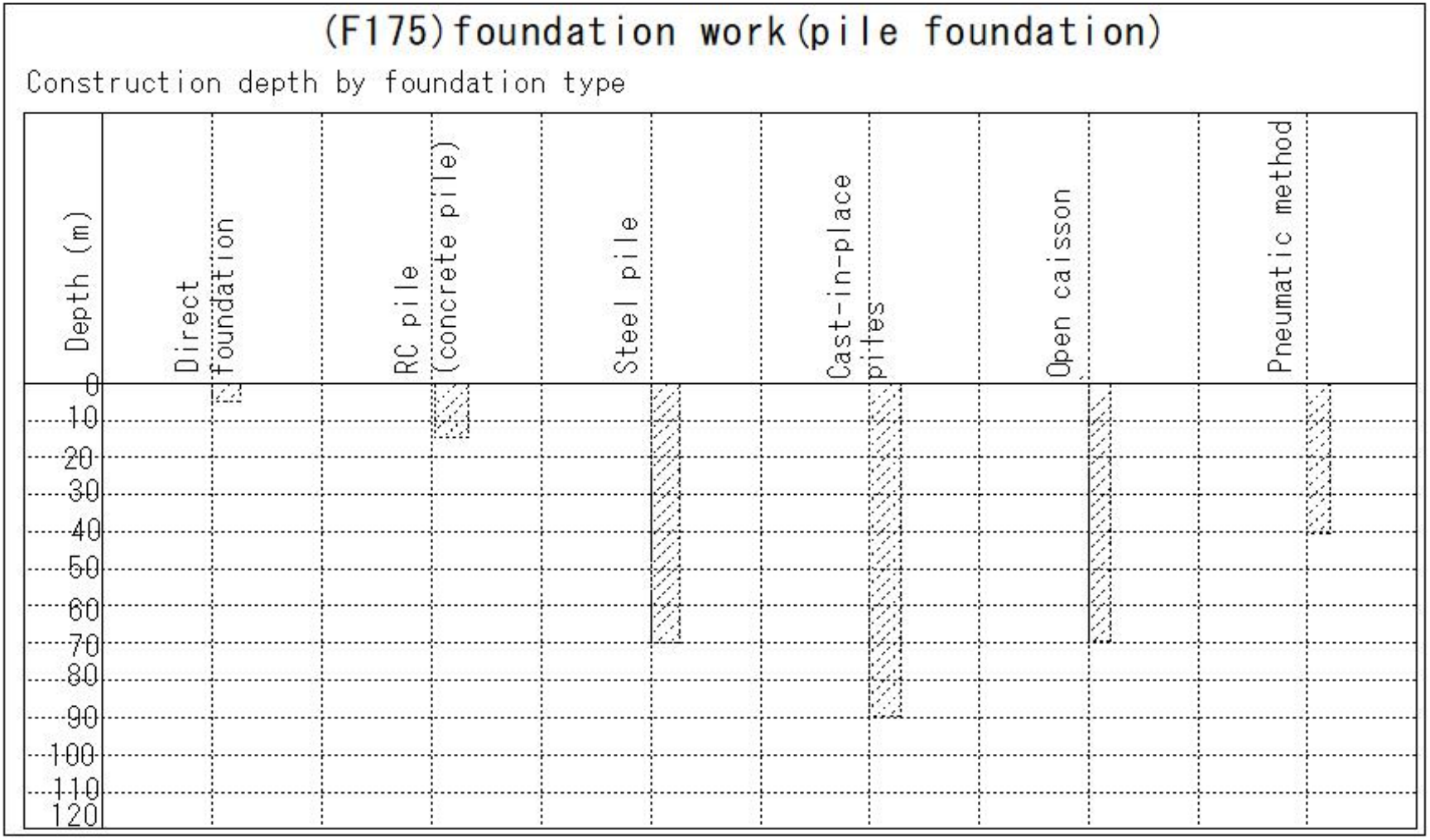
- Pile foundation
  - Percussion method
  - Vibration method
  - Press-in method
  - Jet method
  - Pre-boring method
  - Prefabricated pile method
    - Wooden stake
    - RC pile (reinforced concrete pile)
    - PC pile (prestressed concrete pile)
    - Steel pile (H steel pile, steel pipe pile)
- Cast-in-place piles
  - Drilling method
    - Mechanical excavation
      - Benoto pile
      - Reverse construction method
      - Earth drill method
    - Manual excavation-deep foundation method
  - Penetration method
    - Pedestal pile
    - Franky pile

(F174)foundation work(pile foundation)

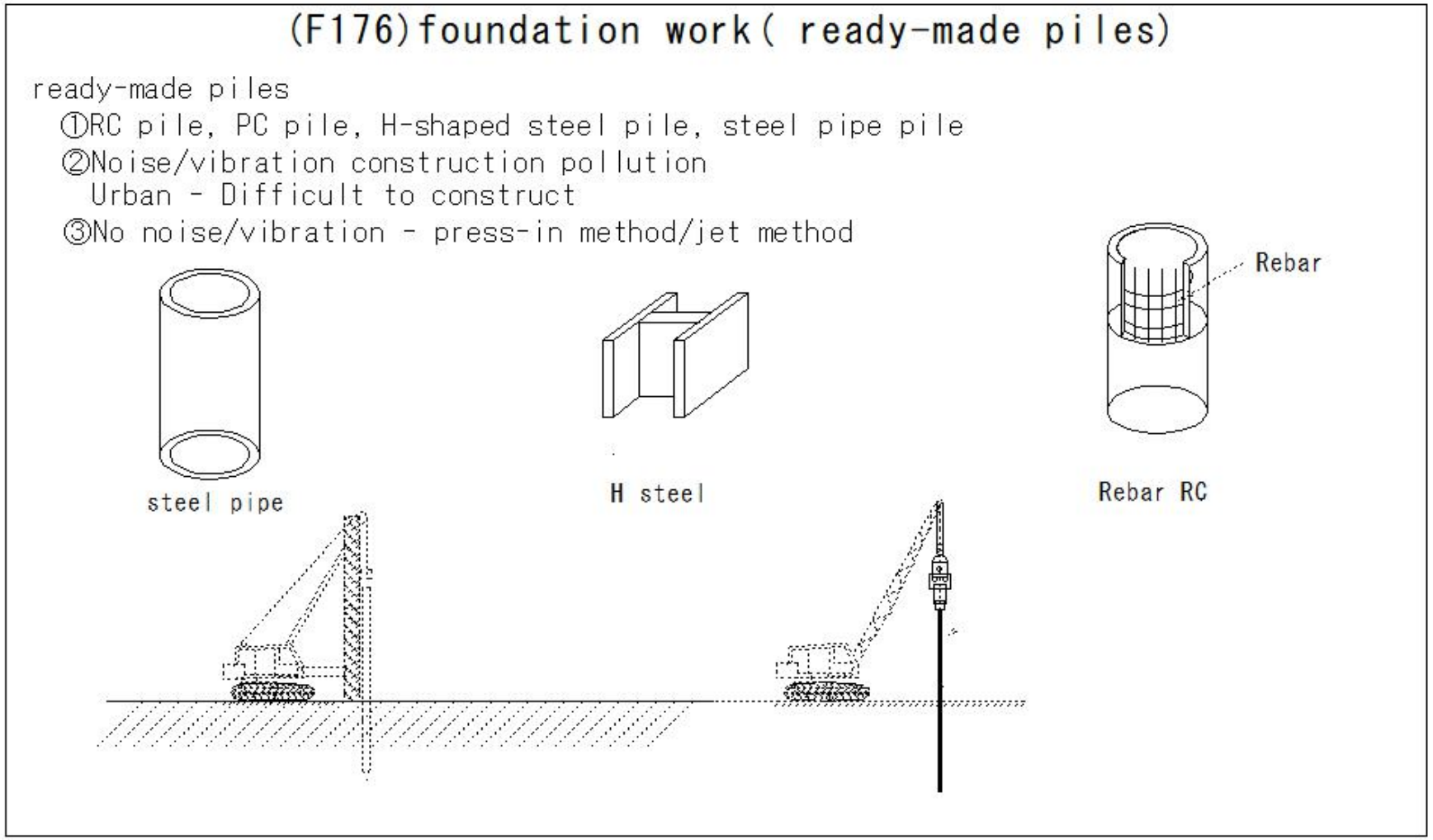
(F174)foundation work(pile foundation)

Pile and apply Type of pile (diameter cm)	Vertical allowable supporting force (kN/m2)	Standard length (m)	Application
RC pile (30)	196-294	6-7	Solid/hollow section
PC pile(40)	392-588	7-8	hollow section
H-shaped steel pile (width 30)	294	15-25	Both welded and rolled products
Steel pipe pile (50)	980-1176	20-30	Both welded and rolled products
Cast-in-place piles (100)	1960-2450	20-30	Use of various excavators

(F175)foundation work(pile foundation)



(F176)foundation work(ready-made piles)

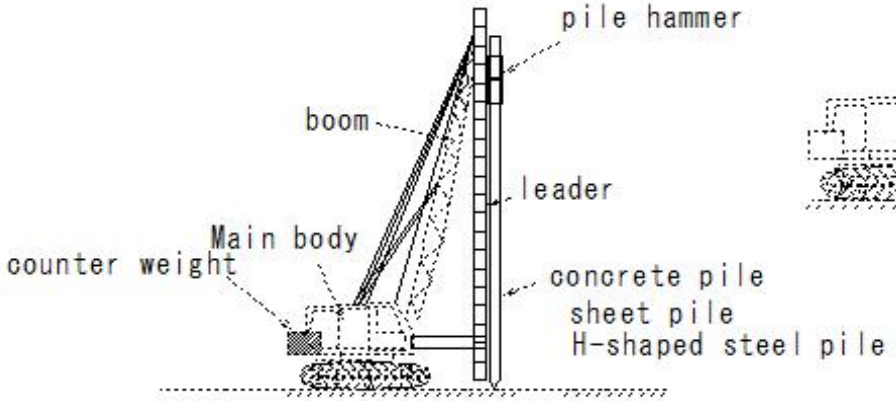


(F177)foundation work(ready-made piles)

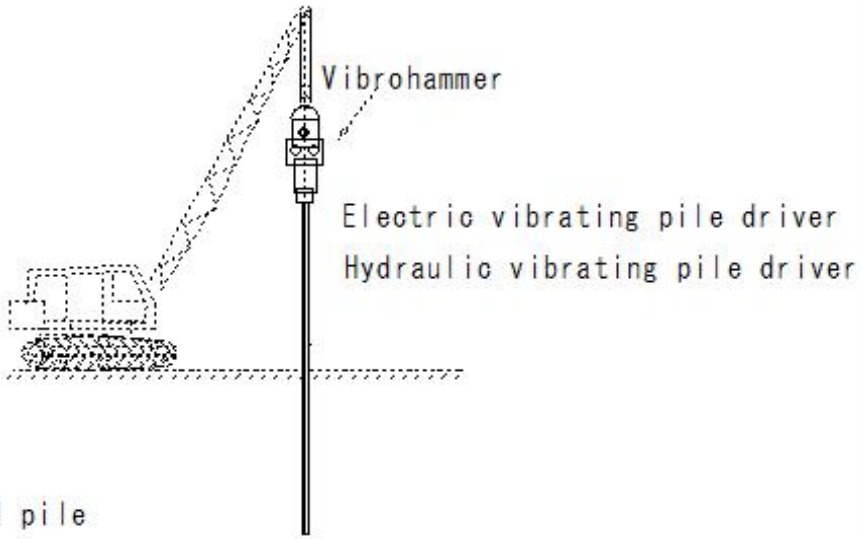
(F177)foundation work(ready-made piles)

Features of ready-made piles

①Factory production, high quality
②Construction - Easy Construction speed - Fast
③Construction management - Easy Construction cost - Cheap
④Noise Control Act Pile driving work 85 dB or less
⑤Safety measures



pile driver

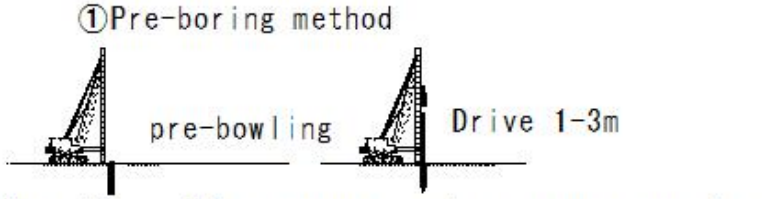


Vibrohammer

(F178)foundation work(built-in construction method)

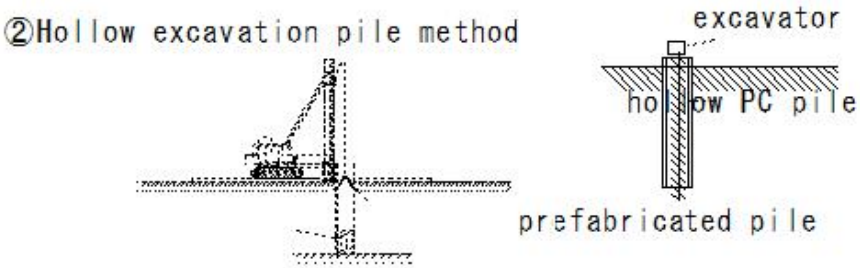
(F178)foundation work(built-in construction method)

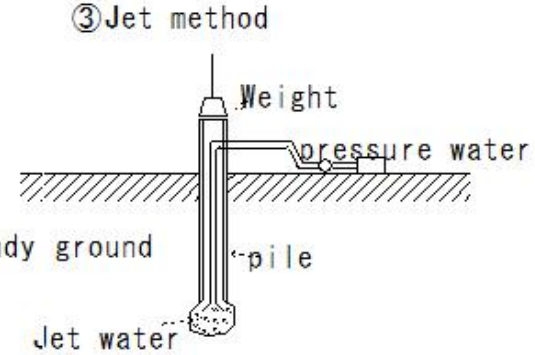
Construction method of ready-made piles
built-in construction method
Noise and vibration prevention
①Pre-boring method
②Hollow excavation pile method
③Jet method



Dig the hole for the ready-made pile with an earth auger etc.

Place concrete in case not pouring





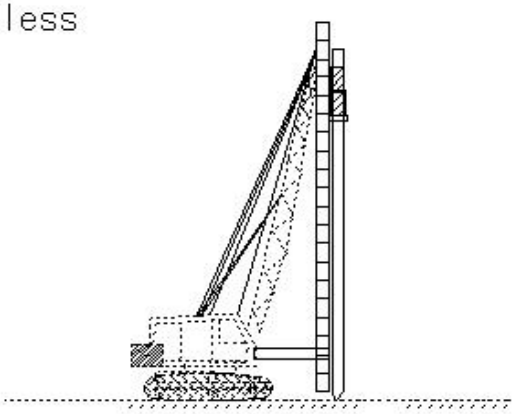
(F179)foundation work(Impact construction method for ready-made piles)

(F179)foundation work(Impact construction method for ready-made piles)

Impact construction method for ready-made piles

①Pile weight 1-3 times
②Fall height 2? or less
③Pile driving from the center to the outside
④Number of blows Steel pile 3000 times or less
PC pile 2000 times or less
RC pile or less 1000 times or less
⑤Pile driving prevention
Penetration amount per blow - 2mm or less

Diesel hammer



Driving ready-made piles

(F180)foundation work(diesel hammer)

(F180)foundation work(diesel hammer)

Impact construction method for ready-made piles

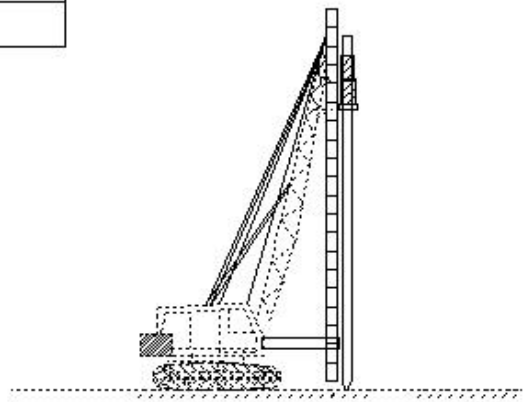
Driving method for ready-made piles

Impact construction method

・diesel hammer

・Construction method	Diesel engine - piston driving
・noise	big
・vibration	big
・Construction speed	fast
・advantages points	Low-fuel consumption
	Easy to operate
	Good mobility
・Disadvantages	Weak layer - does not start

Diesel hammer



(F181)foundation work(steam hammer)

steam hammer

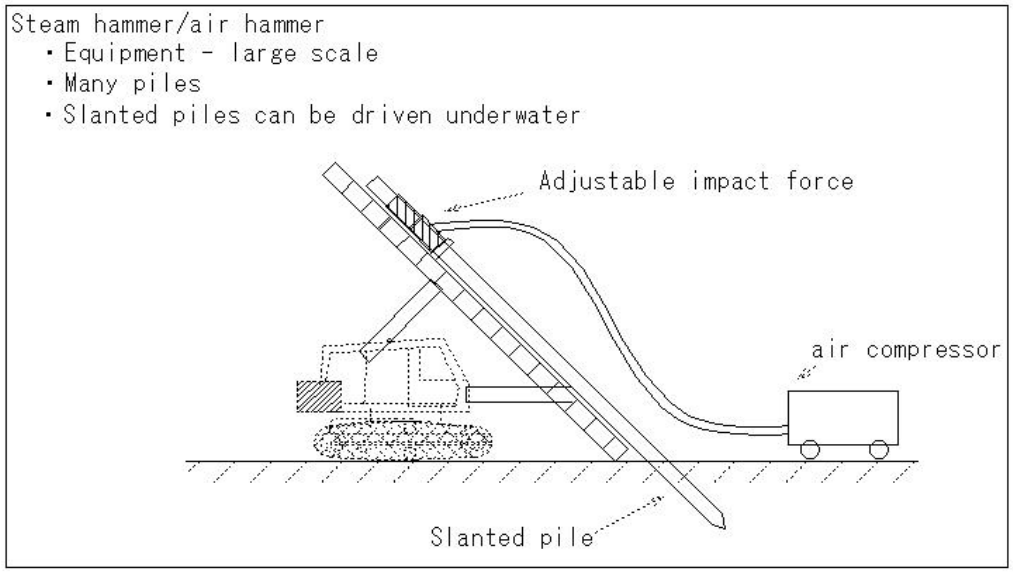
Impact construction method for ready-made piles

Driving method for ready-made piles

Impact construction method

steam hammer

・Construction method	Steam pressure - piston - driving
·noise	big
·vibration	big
・Construction speed	fast
・Strong Points	Impact force - adjustable
・Disadvantages	Fire/soot



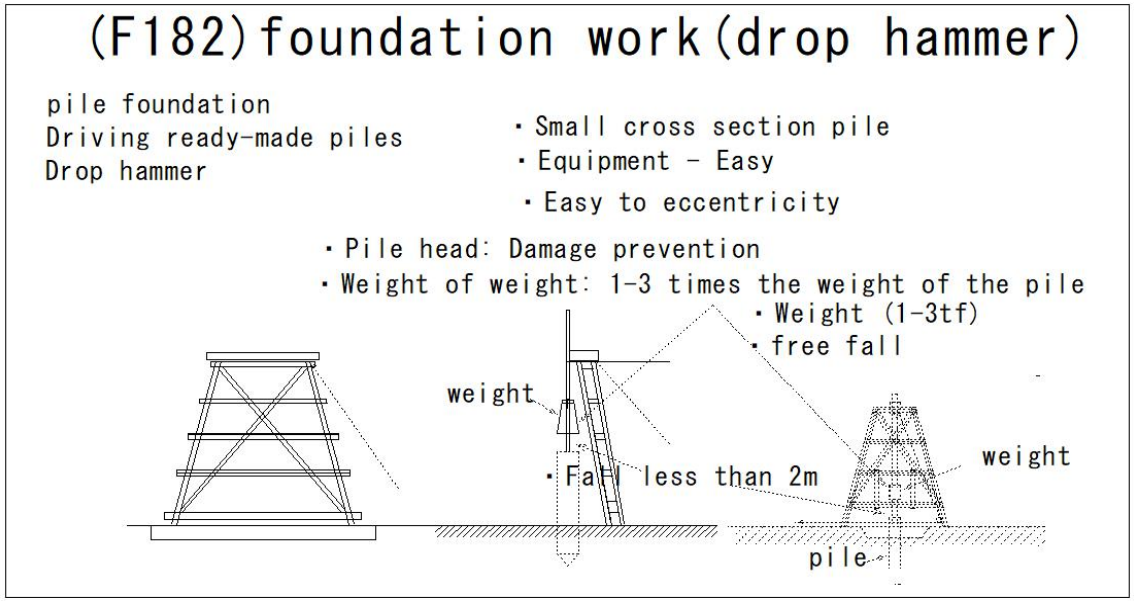
(F182)foundation work(drop hammer)

foundation work(drop hammer)
impact construction method for ready-made piles
Driving method for ready-made piles

Impact construction method

drop hammer

・Construction method	Hammer Gravity Fall - Driving
·noise	big
·vibration	few
・Construction speed	slow
・Strong Points	Fewer breakdowns
・Disadvantages	prone to eccentricity



(F183)foundation work(vibration method)

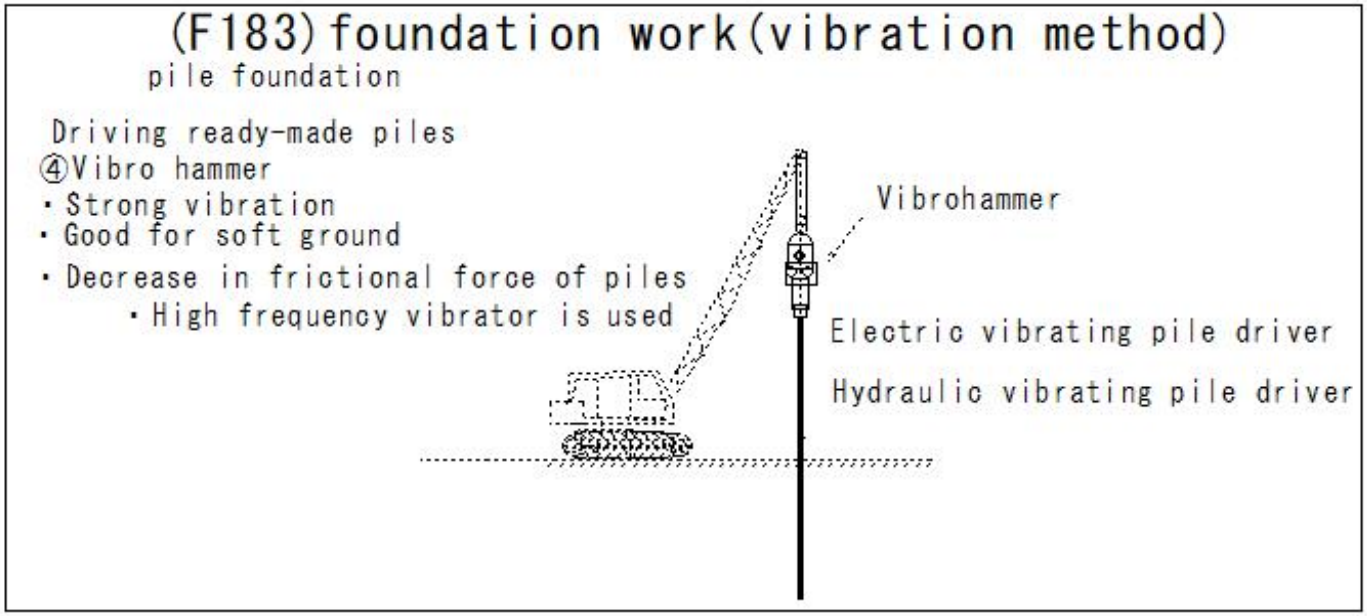
foundation work(vibration method)

Impact construction method for ready-made piles

Driving method for ready-made piles

vibration method

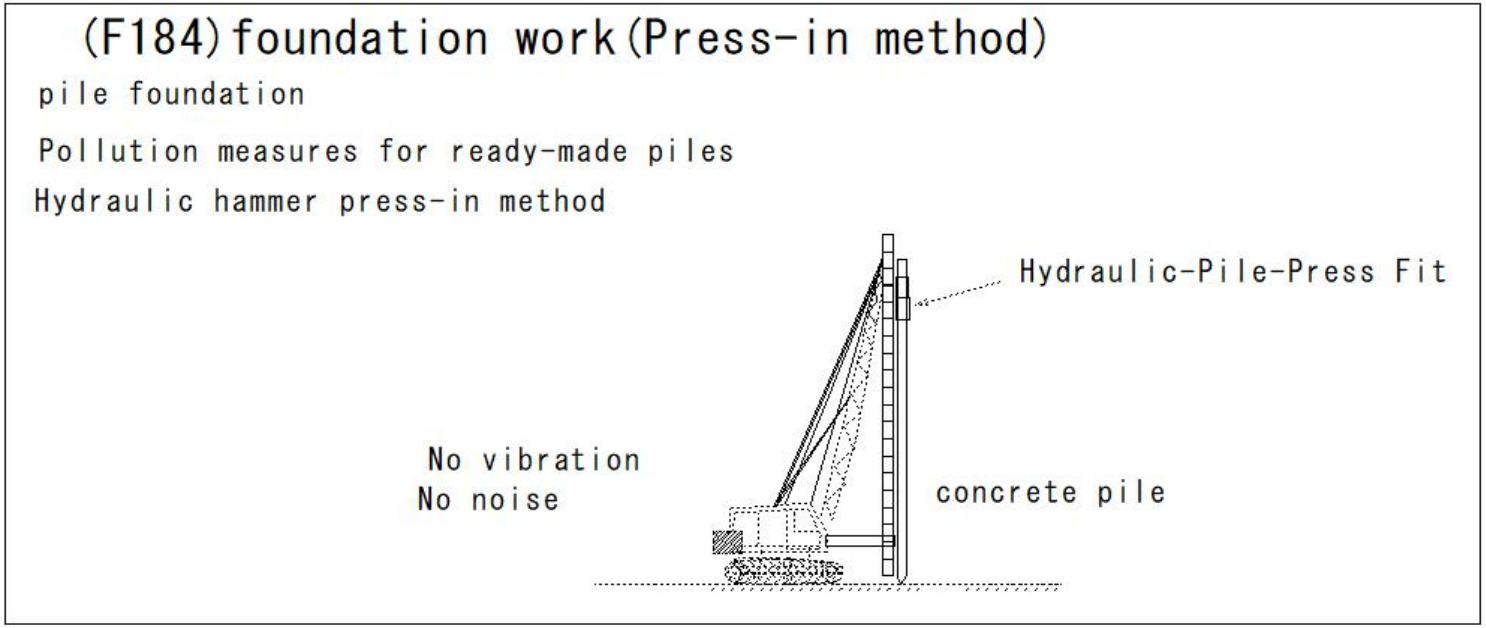
・Construction method	vibro hammer
·noise	small
·vibration	bag
・Construction speed	usually
·Strong Points	Suitable for soft ground
・Disadvantages	Electrical equipment – required



(F184)foundation work(Press-in method)

(F184)foundation work(Press-in method)
Impact construction method for ready-made piles
Driving method for ready-made piles
Press-in method

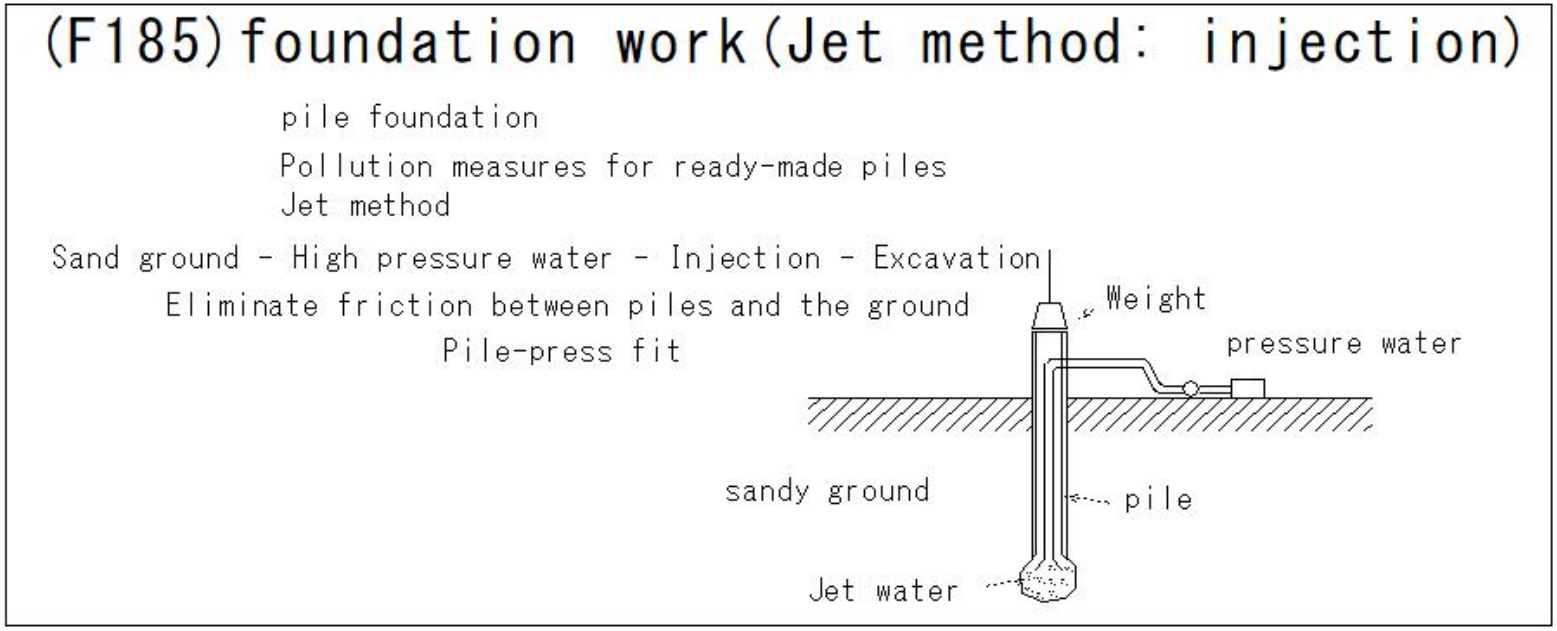
・Construction method	hydraulic jack
·noise	none
·vibration	none
・Construction speed	usually
·Strong Points	For both driving and pulling
・Disadvantages	Use only straight sections



(F185)foundation work(Jet method: injection)

foundation work(Jet method: injection)
Impact construction method for ready-made piles
Driving method for ready-made piles
Jet method: injection

・Construction method	Excavation by jet stream
·noise	none
·vibration	none
・Construction speed	usually
·Strong Points	For both driving and pulling
・Disadvantages	Water equipment - required



(F186)foundation work(On-site jointing of ready-made piles - Pile cap treatment)

(F186)foundation work(On-site jointing of ready-made piles - Pile cap treatment)

On-site jointing of ready-made piles - Pile cap treatment

①RC pile-head-destruction

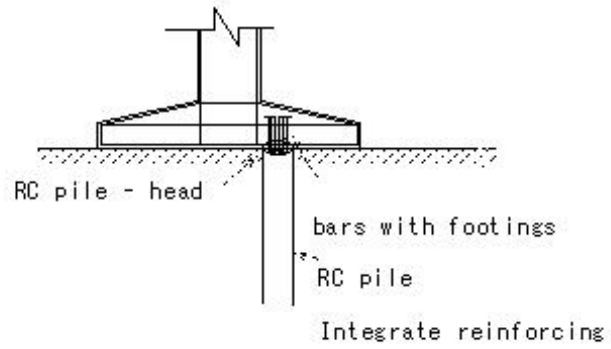
Integration of footing reinforcing bars

Rebar and welding integrated with footing

②PC pile - reinforcement

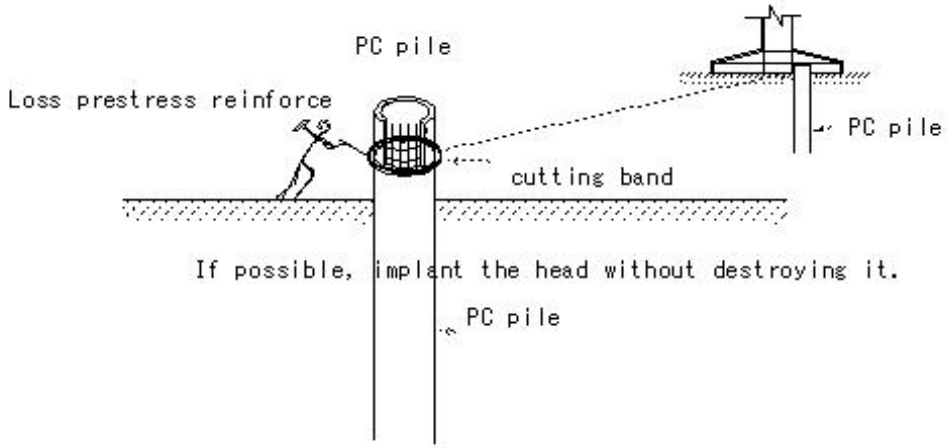
pile foundation

Treatment of pile head

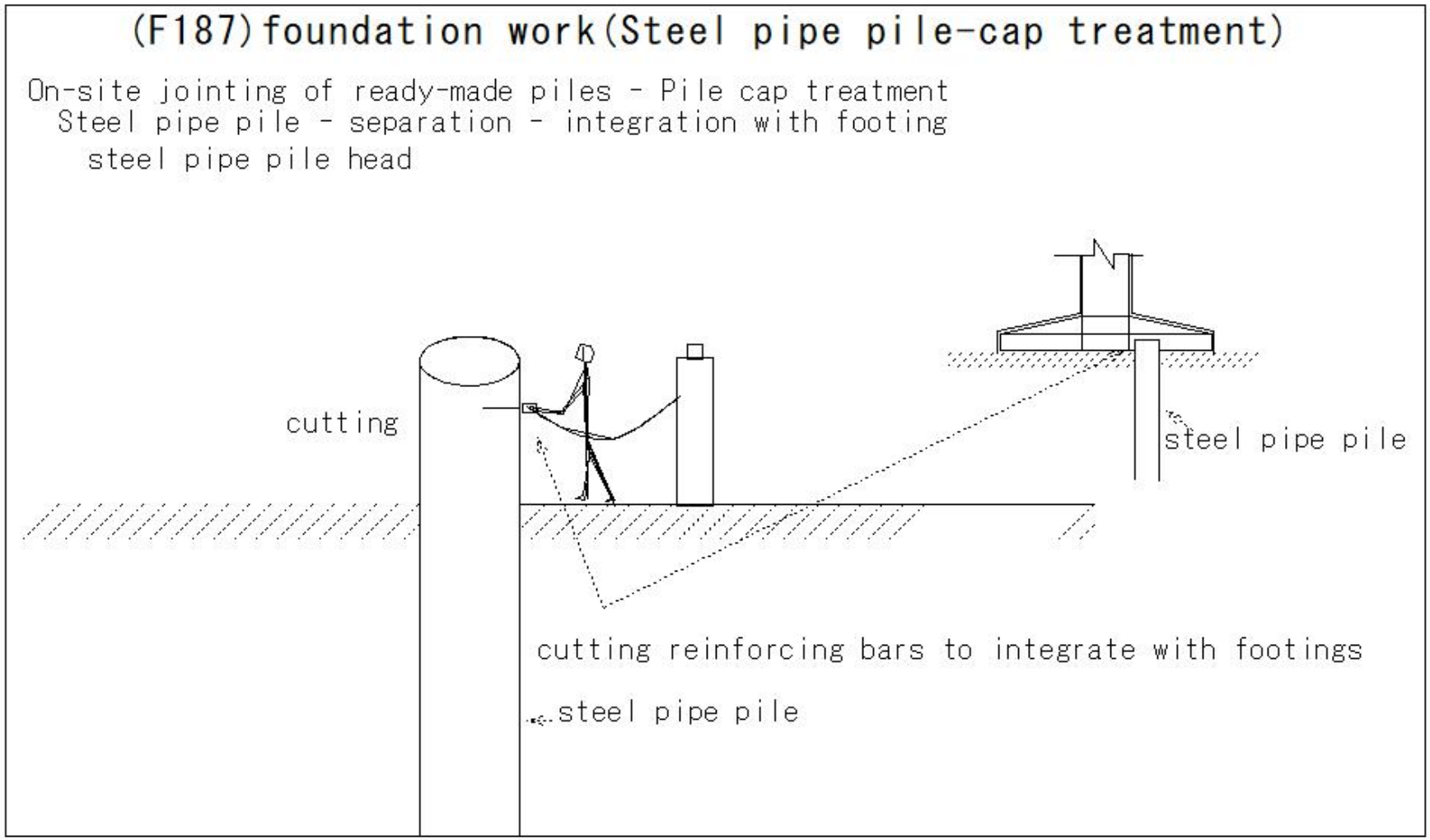


pile foundation

Treatment of pile head



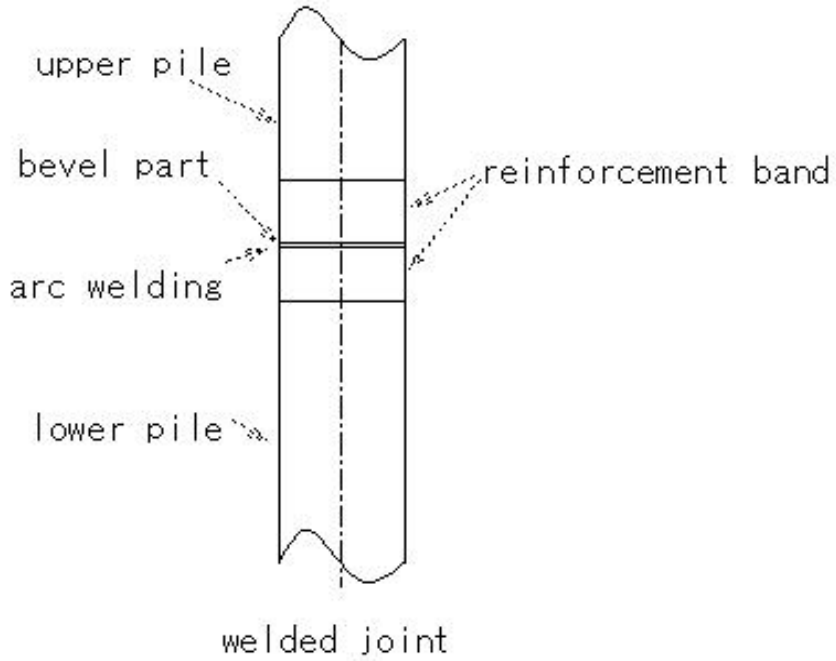
(F187)foundation work(Steel pipe pile-cap treatment)



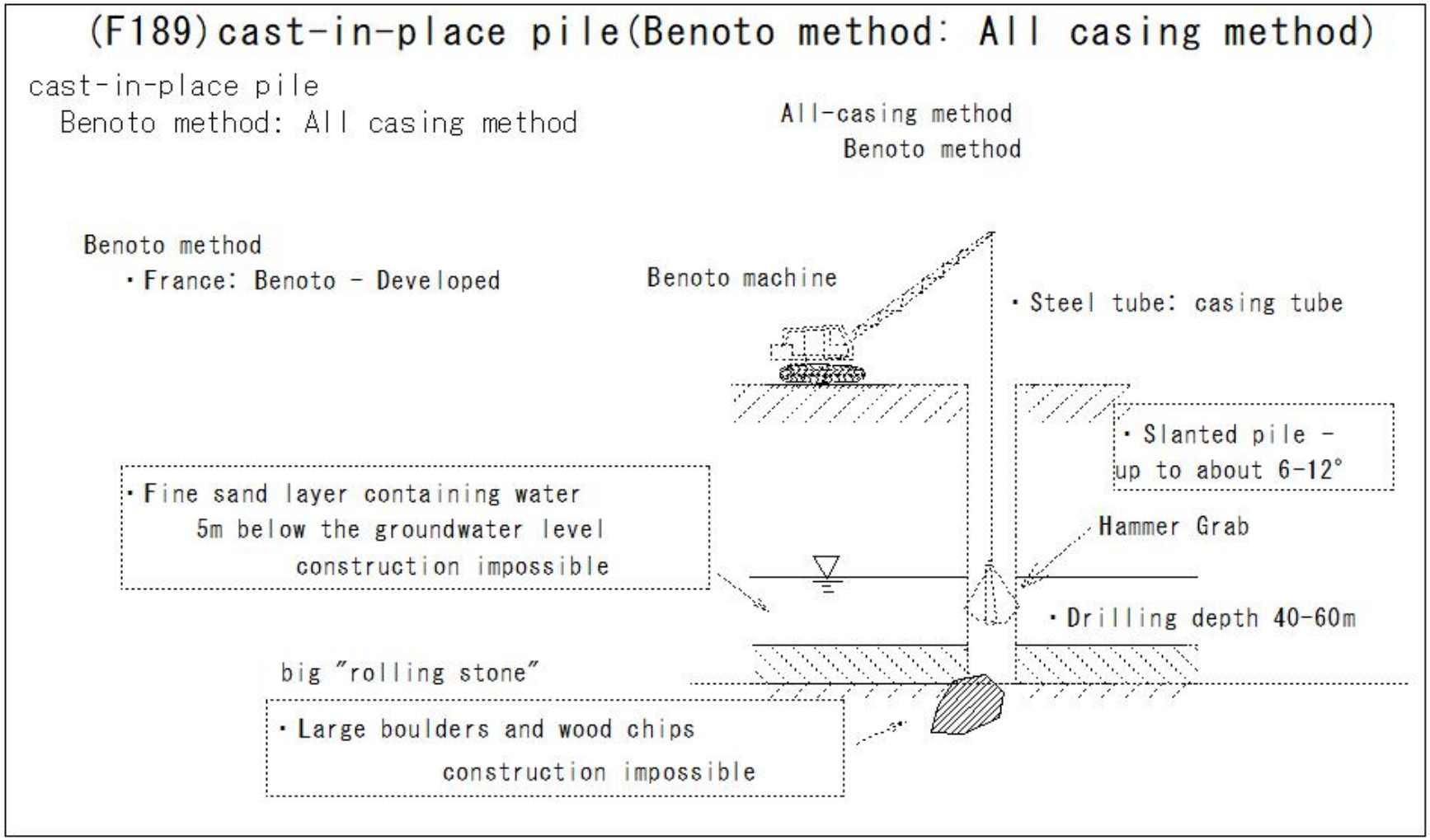
(F188)On-site joints for ready-made piles(RC pile) - Pile joints

(F188)On-site joints for ready-made piles(RC pile) - Pile joints

On-site joints for ready-made piles(RC pile) - Pile joints



(F189)cast-in-place pile(Benoto method: All casing method)



(F190)cast-in-place pile(Earth drill method)

(F190)cast-in-place pile(Earth drill method)

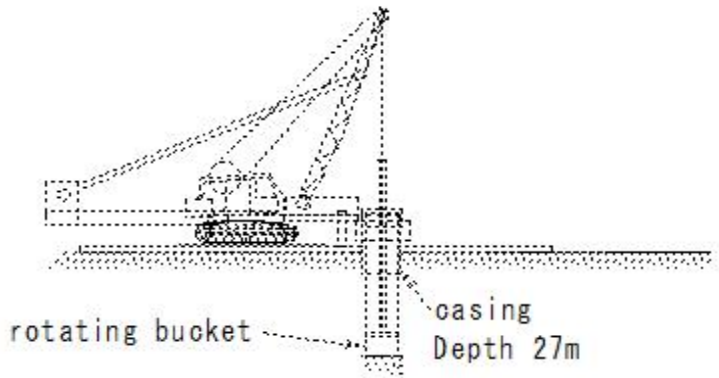
cast-in-place pile

Earth drill method

Earth drill method

- Rotating bucket - excavation
- Construction speed - fast
- Low cost
- Drilling depth - 27m
- Suitable for clay layer
- Weak sandy ground - bentonite solution (stabilizing liquid)

Earth drill method



(F191)cast-in-place pile(Reverse construction method)

(F191)cast-in-place pile(Reverse construction method)

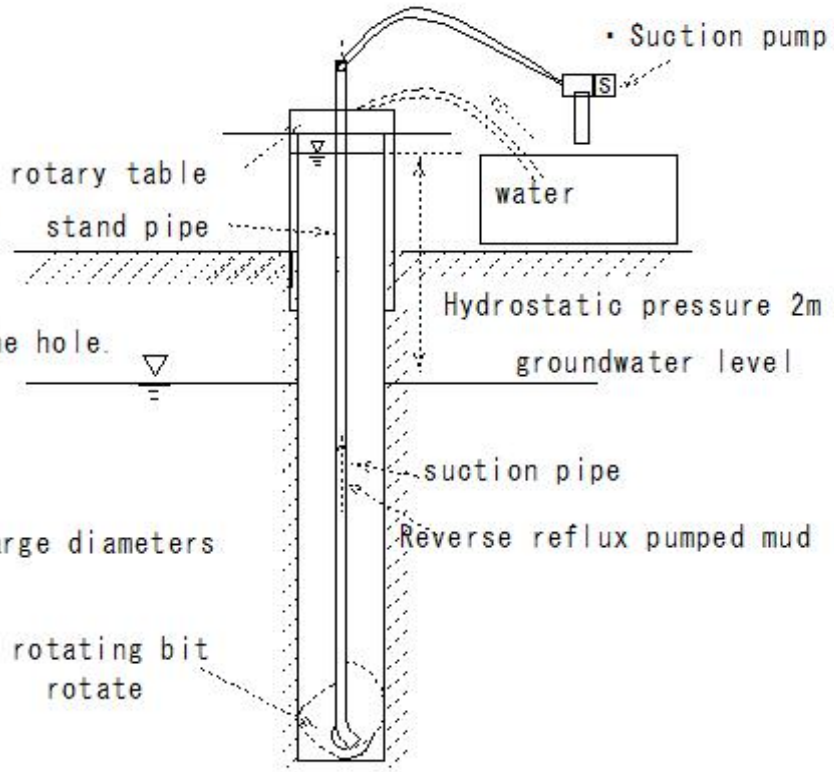
cast-in-place pile

Reverse method

Reverse circulation method

- Big pile driving
- Continuous drilling
- Large boulders, pressurized water, underground water - construction difficult
- Water construction possible
- The water level inside the hole is 2m higher than the water level outside the hole.

- Good for long and large diameters



(F192)cast-in-place pile(Deep foundation method)

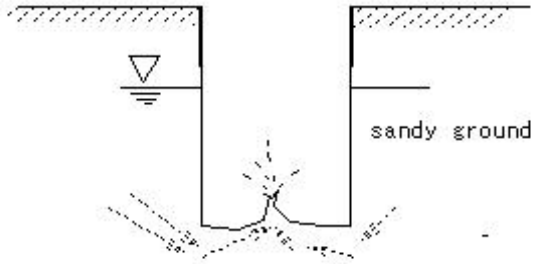
(F192)cast-in-place pile(Deep foundation method)

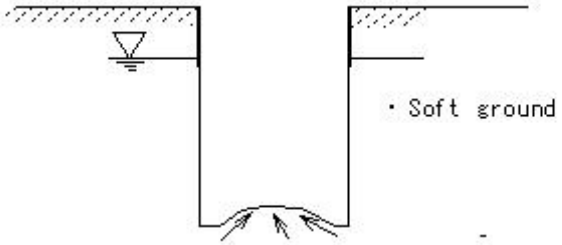
cast-in-place pile

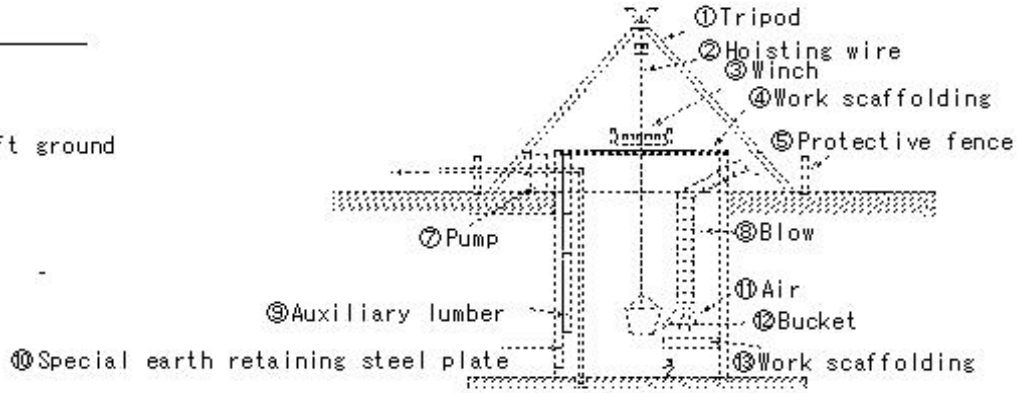
Deep foundation method

Deep foundation construction method

- Manual excavation
- Groundwater exclusion
- Possible to blast leaves of rolling stones
- Drainage construction - boiling and heaving
- Confirmation of soil bearing capacity - easy



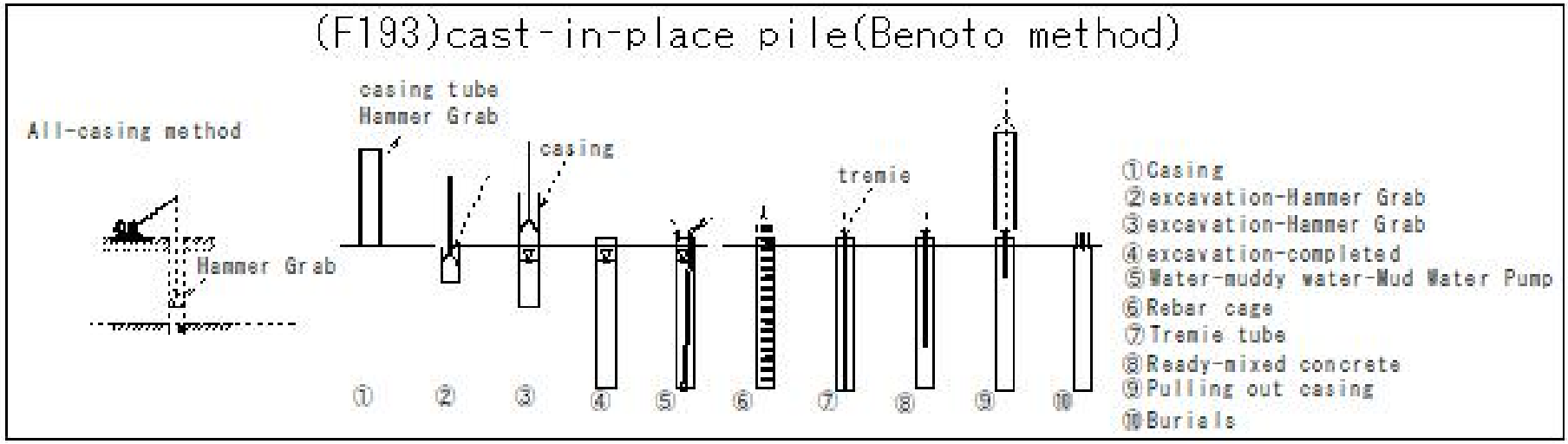




(F193)cast-in-place pile(Benoto method)

cast-in-place pile(Benoto method)

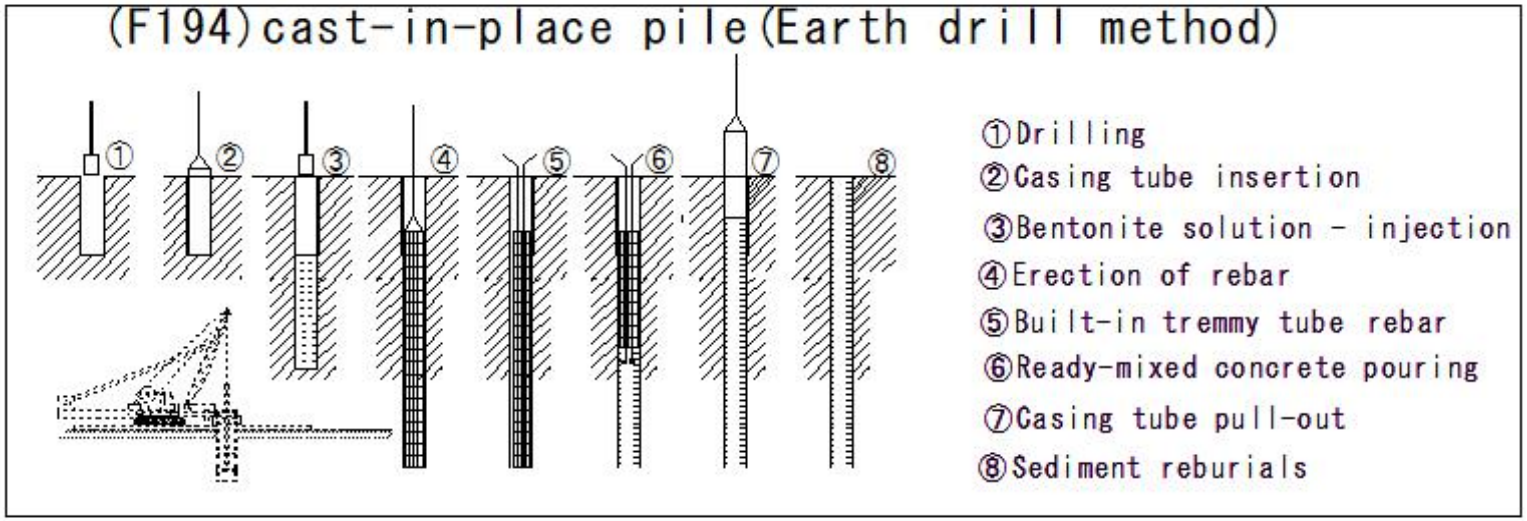
cast-in-place pile	cast-in-place pile			
construction method	construction method		mechanical drilling	Benoto method
Excavation method	hammer grab	bucket		
hole wall retention	casing tube			
Pile diameter	80-200cm			
Depth: limit	About 40m			
Soil conditions				
Clay/silt layer	○			
sand layer	△			
Gravel/rock layer	△			
cobblestone layer	△			
soft rock	×			



(F194)cast-in-place pile(Earth drill method)

cast-in-place pile(Earth drill method)

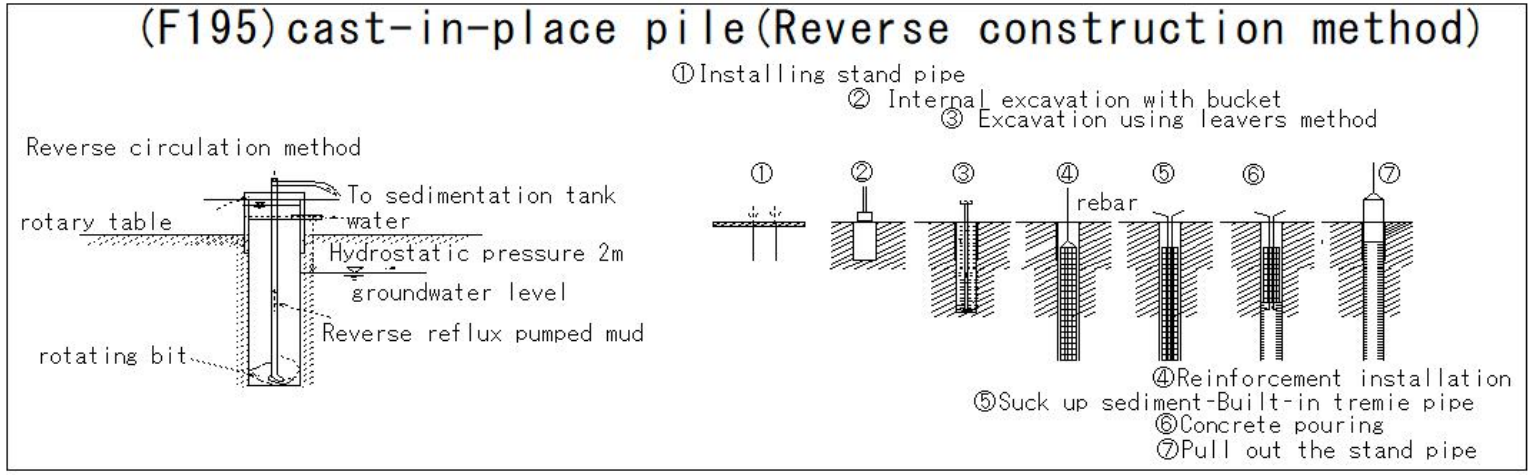
cast-in-place pile	cast-in-place pile
construction method	construction method mechanical drilling　Earth drill method
Excavation method	rotating bucket
hole wall retention	Bare digging/mud water pressure
Pile diameter	80-120cm
Depth: limit	About 60m
Soil conditions	
Clay/silt layer	○
sand layer	△
Gravel/rock layer	△
cobblestone layer	×
soft rock	×



(F195)cast-in-place pile(Reverse construction method)

(F195)cast-in-place pile(Reverse construction method)

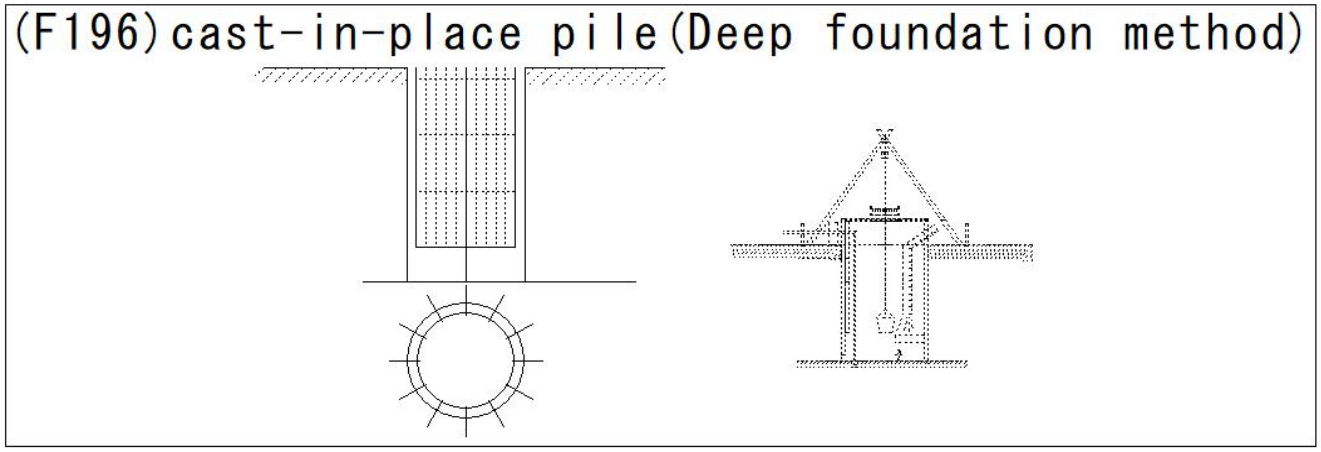
cast-in-place pile	cast-in-place pile
construction method	construction method
	mechanical drilling
	Reverse construction method
Excavation method	rotating bit
hole wall retention	hydrostatic pressure
Pile diameter	80-200cm
Depth: limit	Approximately 27m, no slam
Soil conditions	
Clay/silt layer	○
sand layer	○
Gravel/rock layer	△
cobblestone layer	△
soft rock	×



(F196)cast-in-place pile(Deep foundation method)

(F196)cast-in-place pile(Deep foundation method)

cast-in-place pile	cast-in-place pile
construction method	construction method
	manual excavation
	Deep foundation method
Excavation method	manual excavation
hole wall retention	Special mountain retaining steel plate
Pile diameter	140-300cm
Depth: limit	About 30m
Soil conditions	
Clay/silt layer	○
sand layer	○
Gravel/rock layer	○
cobblestone layer	○
soft rock	×



(F197)cast-in-place pile

(F197)cast-in-place pile

pile foundation

Construction management of cast-in-place piles

① Construction of Benoto piles

① Insert reinforcing bar cage

Groundwater

casing

② Underwater concrete placement (slump 17cm,

cement amount 370kgf/m3 or more)

tremie tube is flanged and watertight.

Raise the casing approximately 2m

to protect the hole wall

Insert about 2 m on top of concrete

③ Slime (cutting residue) Mixed with muddy water

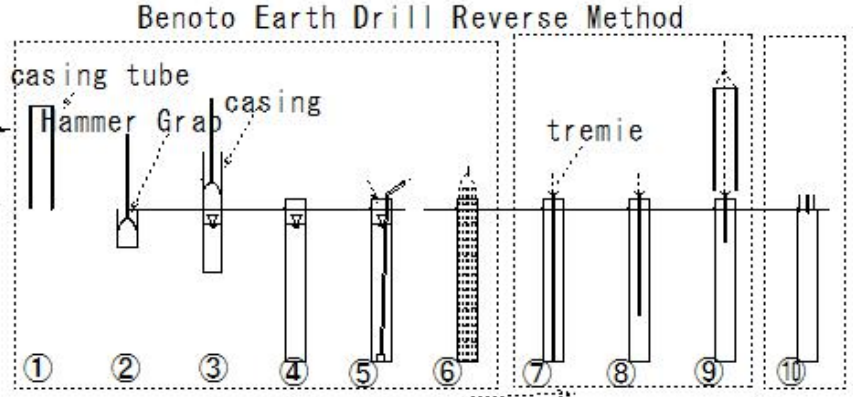
concrete curing

Must not be harmful due to temperature, load, shock, etc.

・Pile head

Add about 0.5m extra

there is muddy water, it is about 1m



(F198)cast-in-place pile(open caisson foundation)

(F198)cast-in-place pile(open caisson foundation)

Cast-in-place piles - construction

open caisson foundation

① Lower end of the caisson: Installation of the cutting edge hardware

Rebar formwork

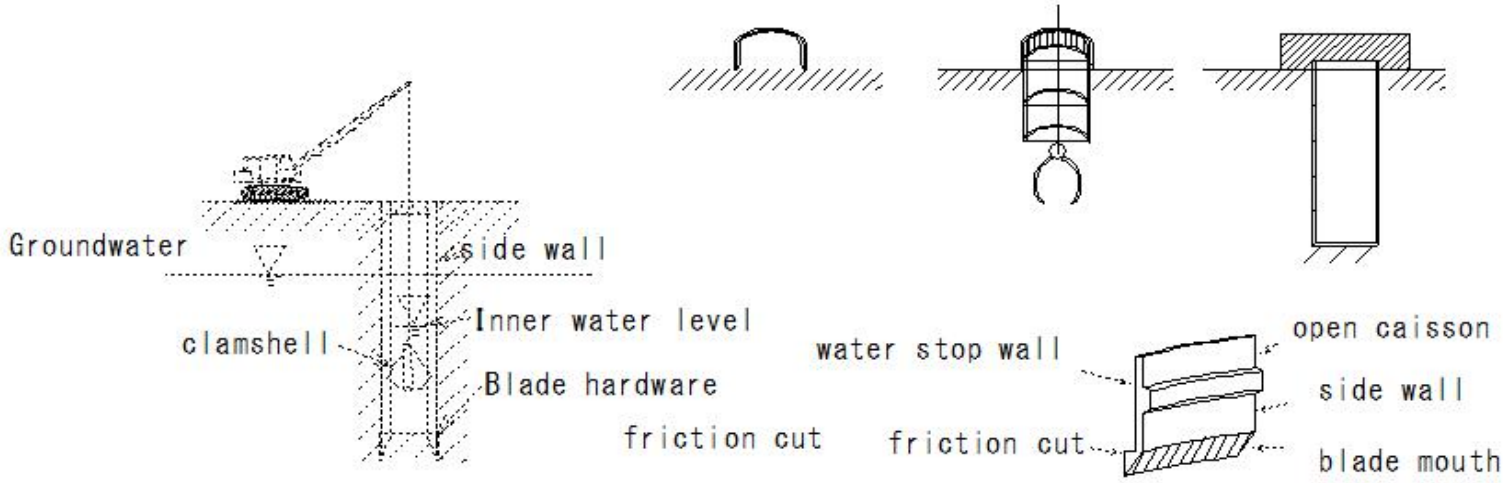
②Concrete placement

After curing - formwork - removal

③Ground excavation - caisson sinking

④Low concrete pouring

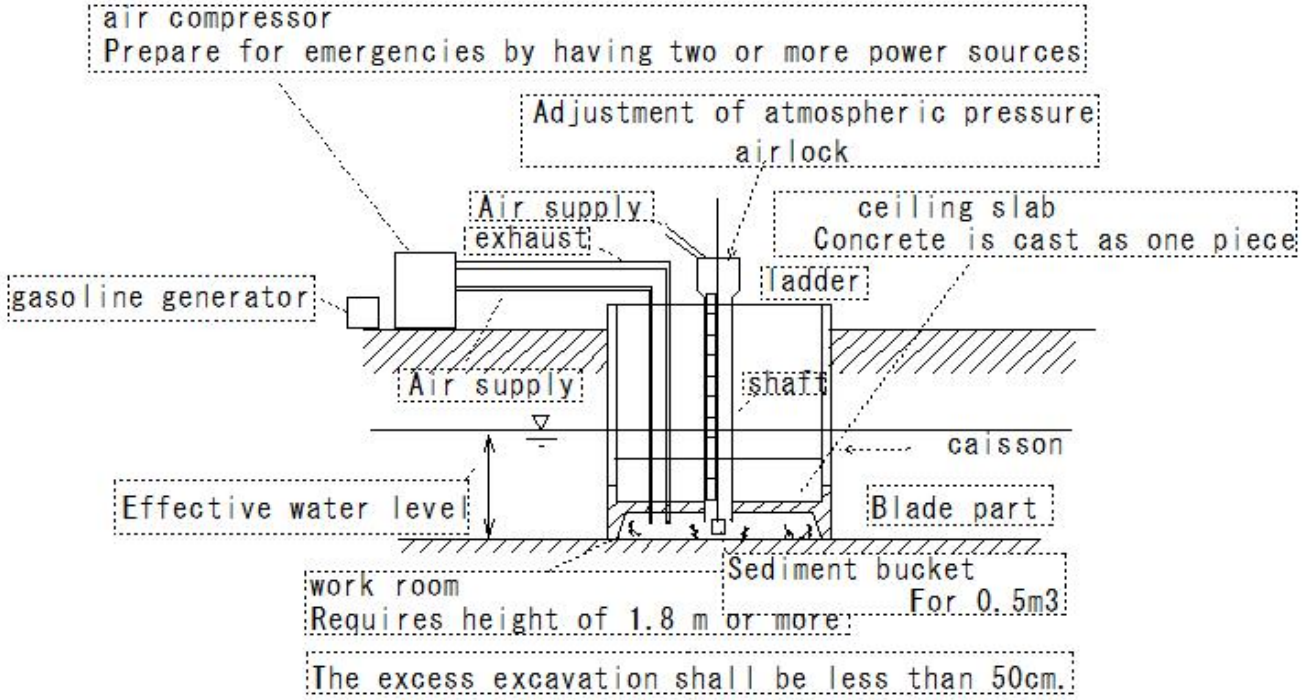
⑤Caisson - Filling - Lid concrete: Superstructure construction



(F199)cast-in-place pile(Pneumatic caisson)

(F199)cast-in-place pile(Pneumatic caisson)

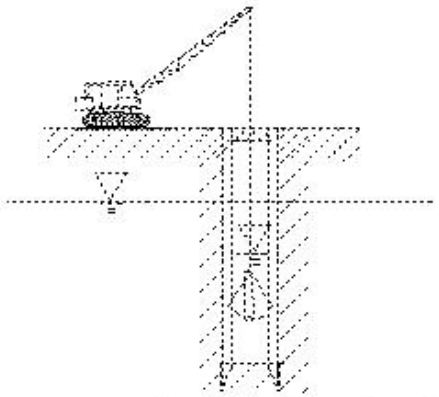
Cast-in-place piles - construction
Pneumatic caisson



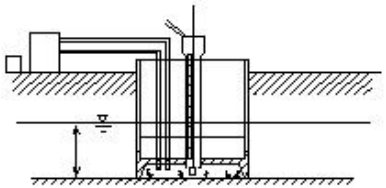
(F200)cast-in-place pile

(F200)cast-in-place pile

Cast-in-place piles - construction		
	open caisson foundation	pneumatic caisson
temporary equipment	easy	Complex: Expensive
Pollution	no problem	noise
Surrounding ground	Groundwater - decline	Surrounding ground - no impact
	Loosen the surrounding ground	
Construction	Depth - 60m	Depth -40m

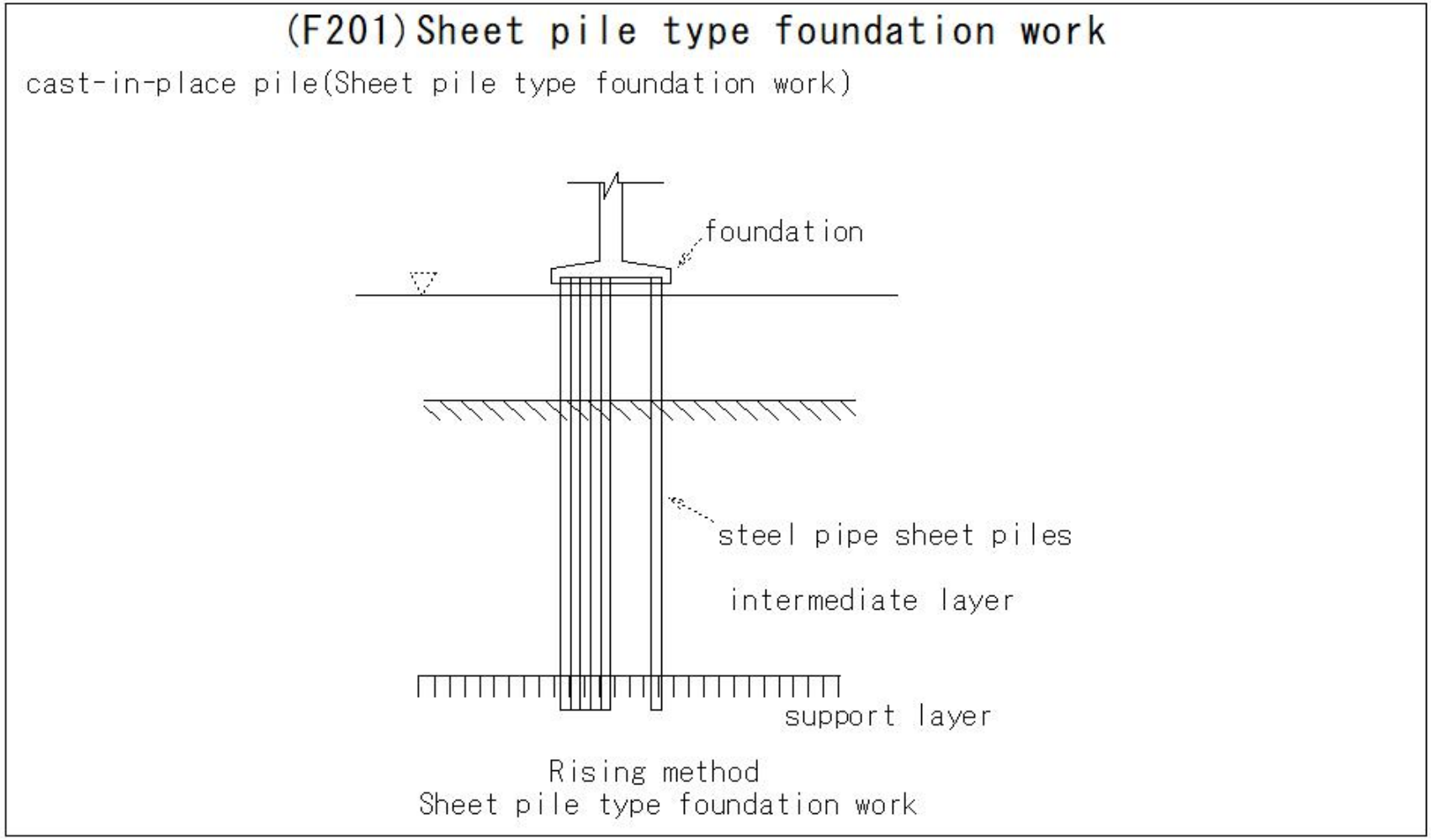


open caisson foundation



pneumatic caisson

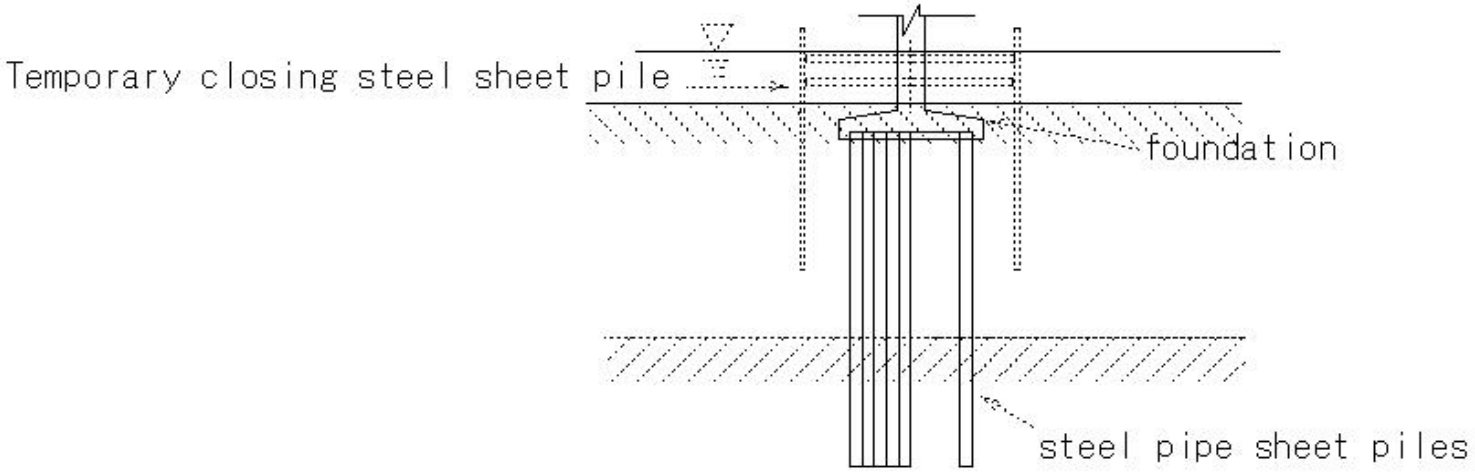
(F201)Sheet pile type foundation work



(F202)Sheet pile type foundation work(closing steel sheet pile method)

(F202)Sheet pile type foundation work(closing steel sheet pile method)

Sheet pile type foundation work
closing steel sheet pile method



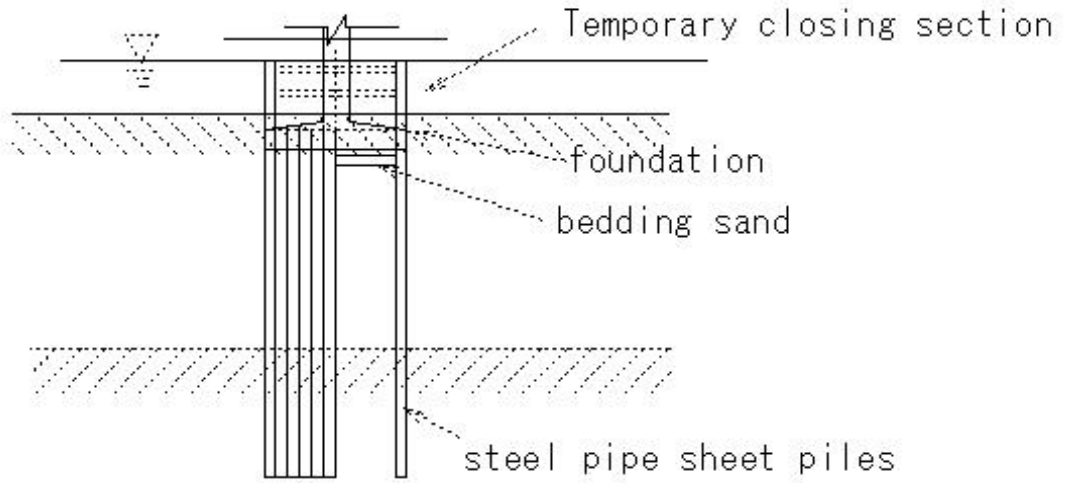
closing steel sheet pile method

Sheet pile type foundation work

(F203)Sheet pile type foundation work(Temporary closing steel sheet pile method)

(F203)Sheet pile type foundation work(Temporary closing steel sheet pile method)

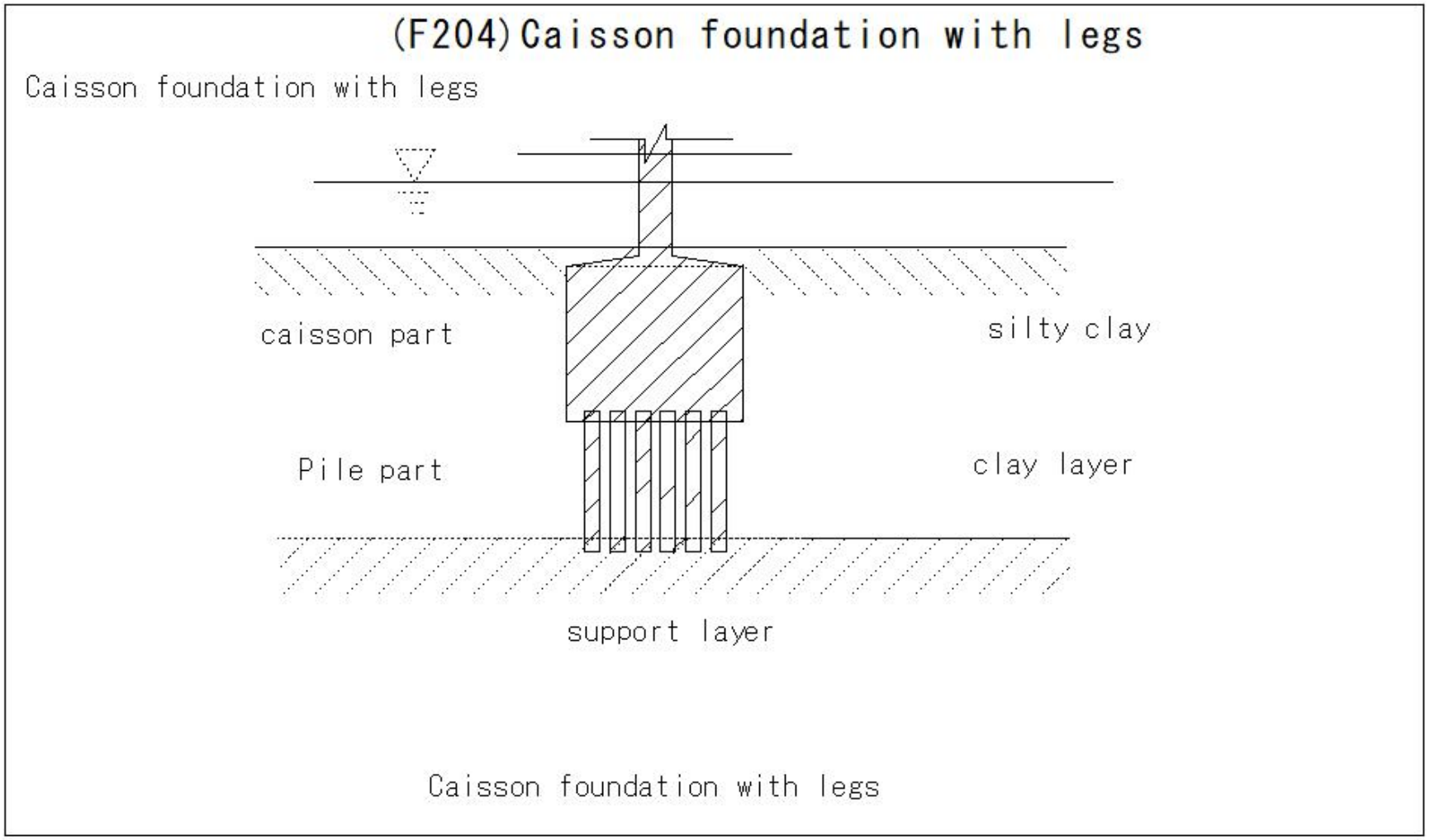
Sheet pile type foundation work
Temporary closing method



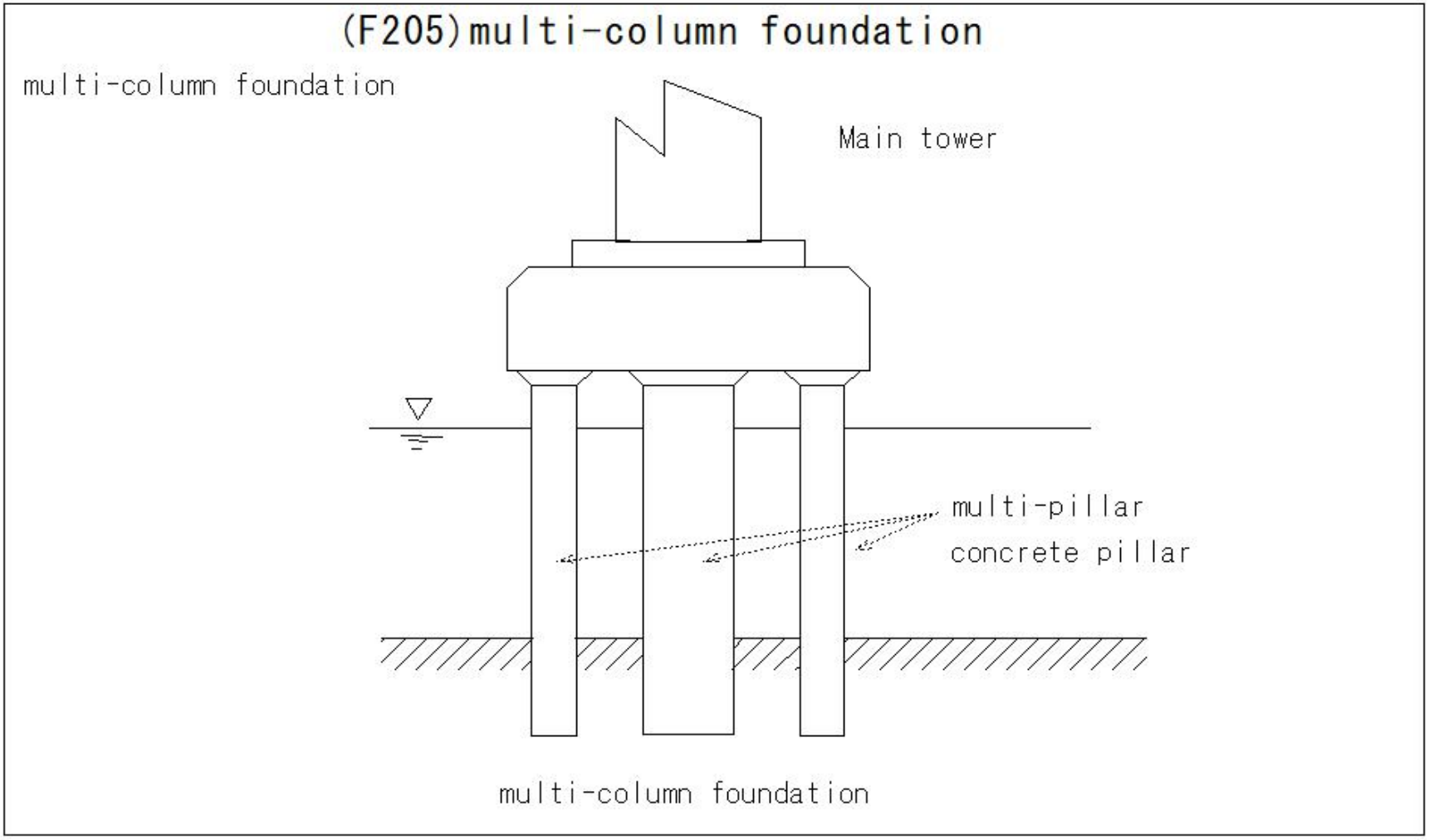
Temporary closing method

Sheet pile type foundation work

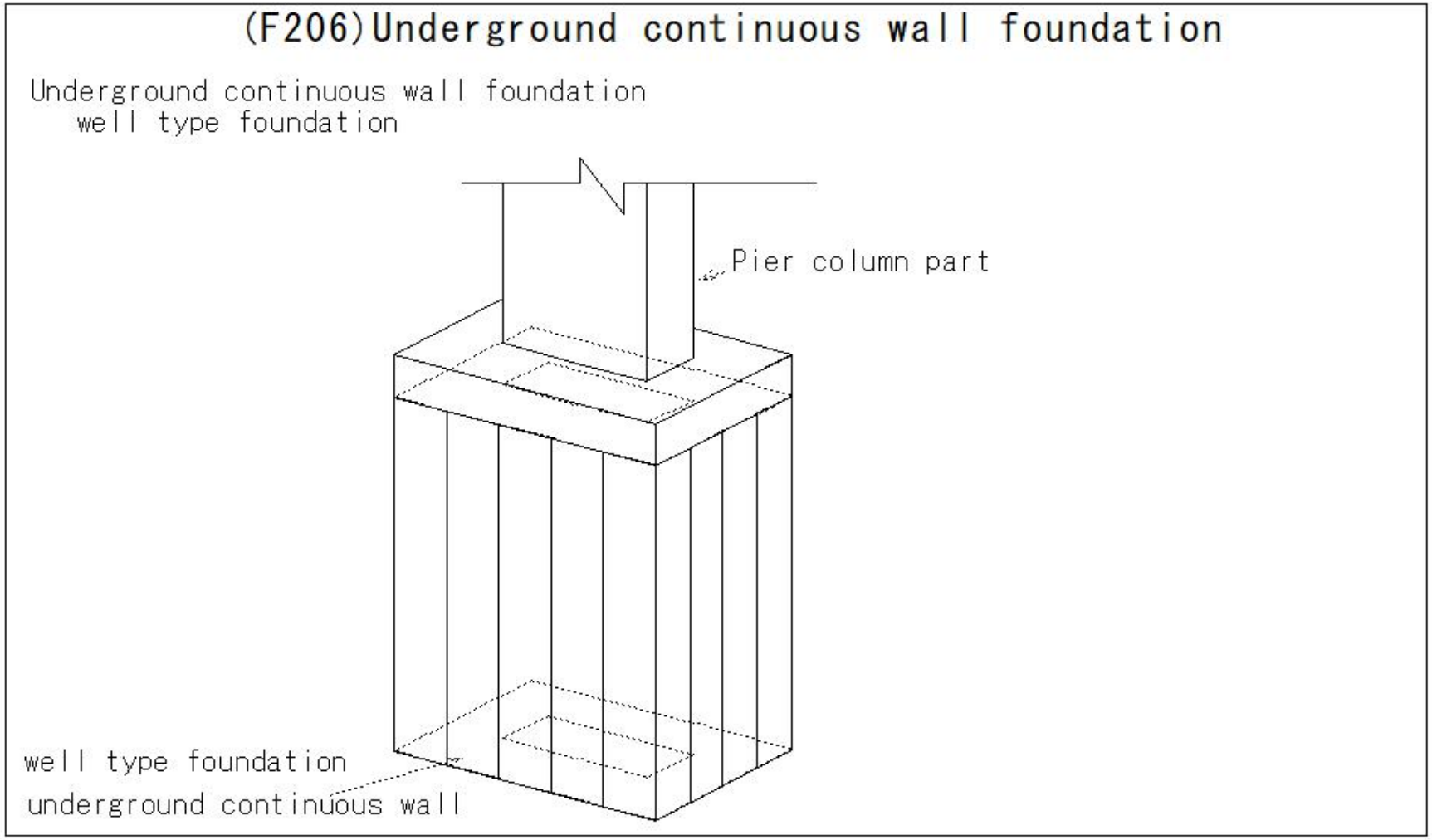
(F204)Caisson foundation with legs



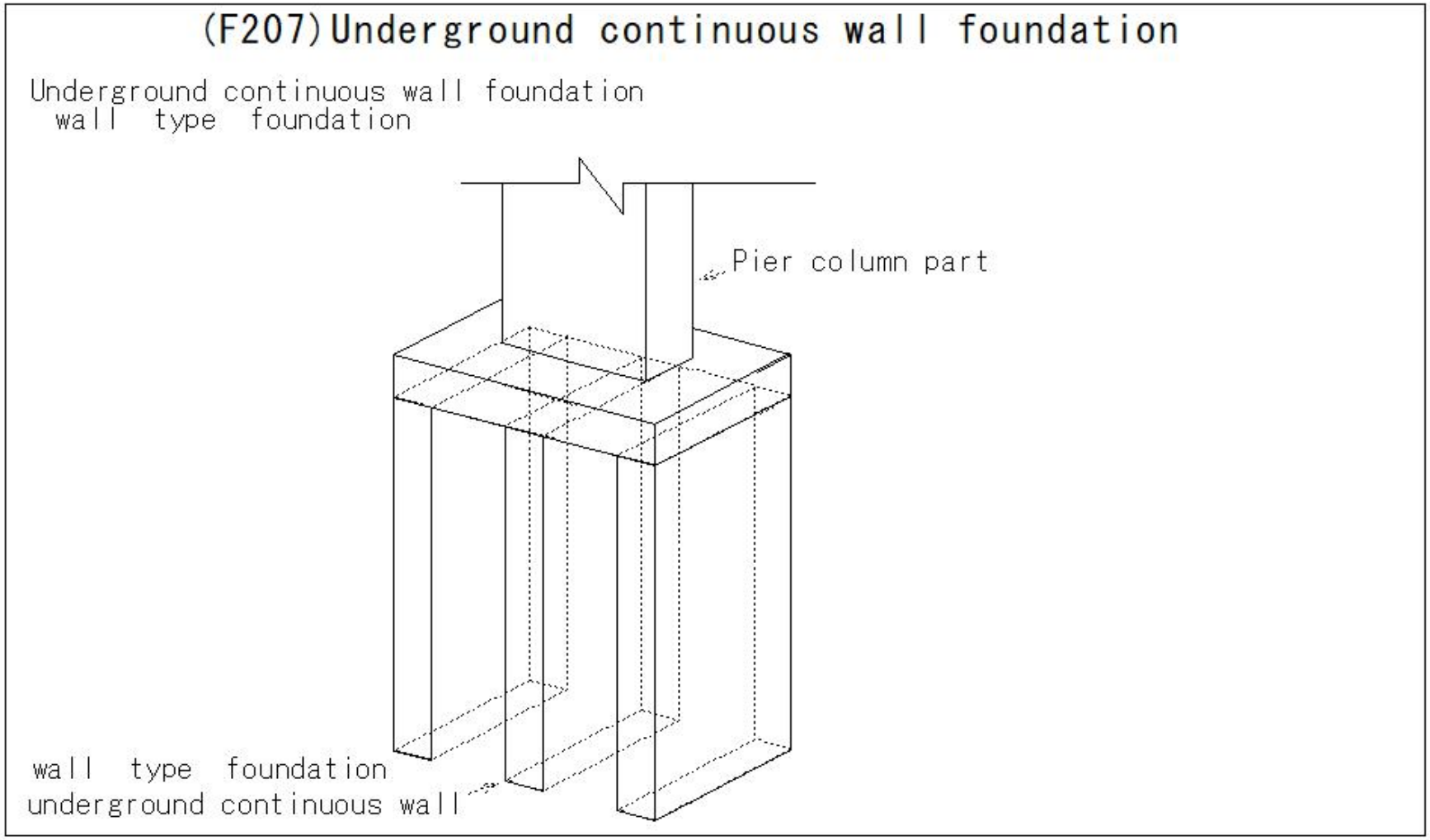
(F205)multi-column foundation



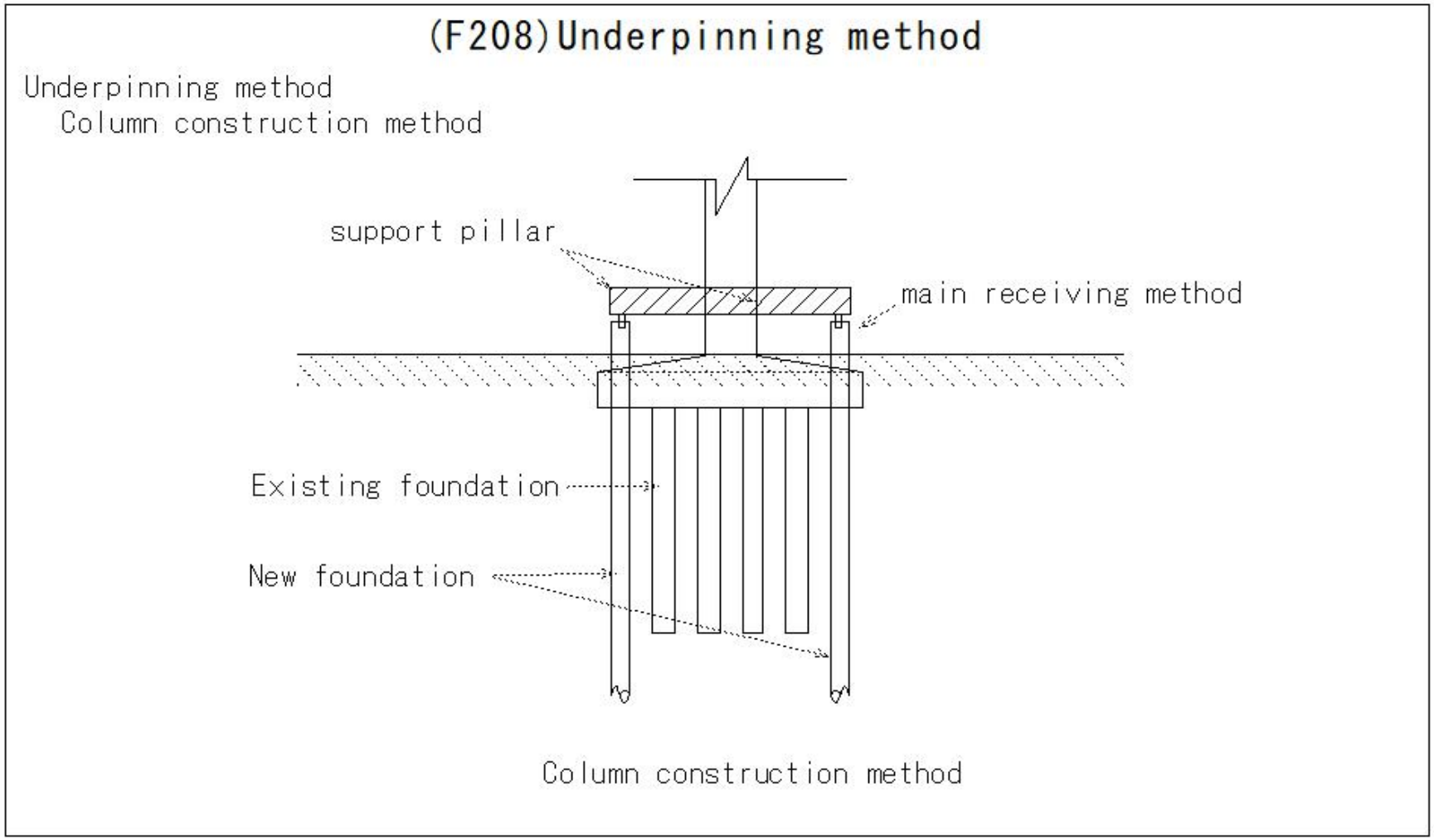
(F206)Underground continuous wall foundation



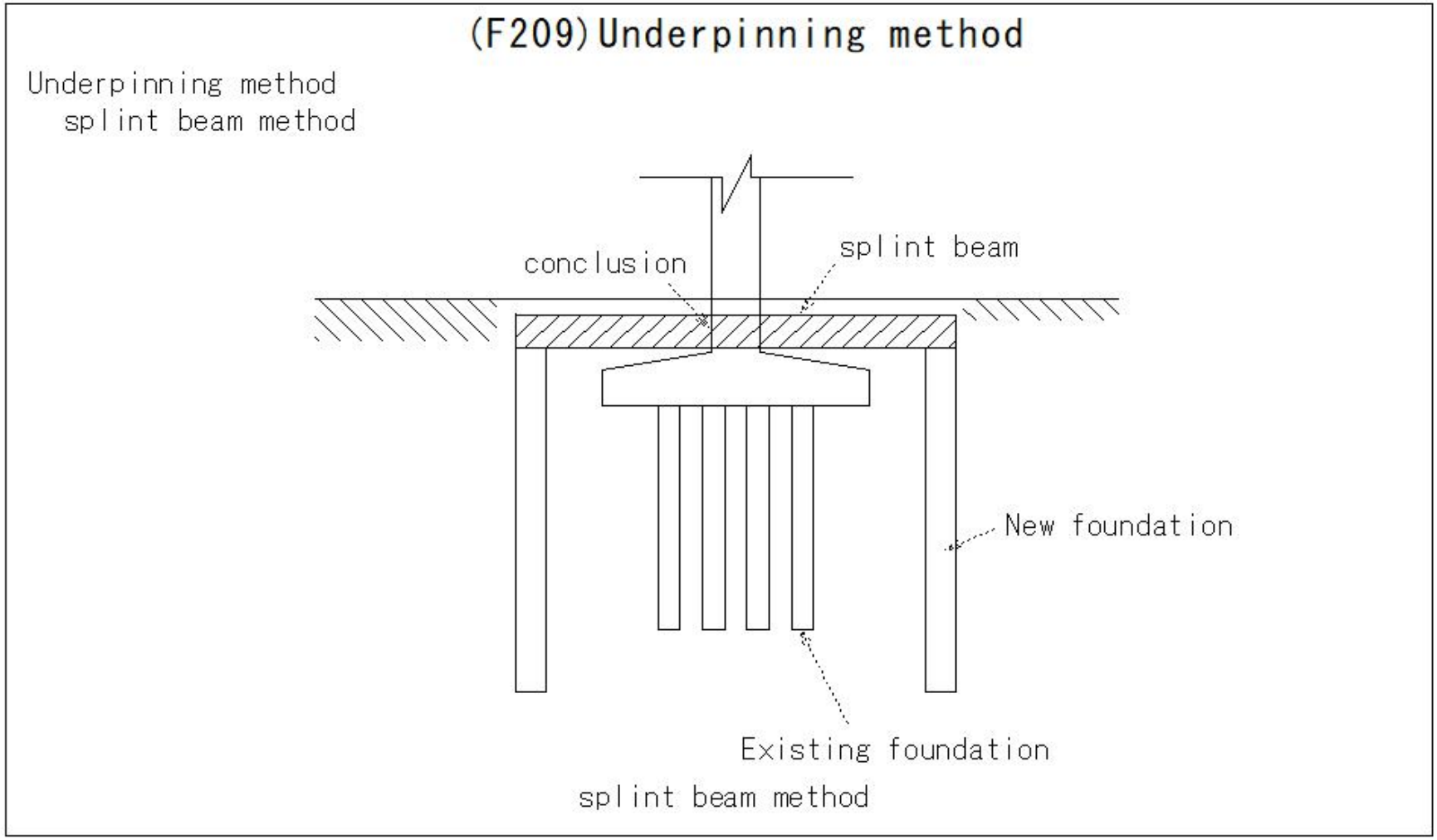
(F207)Underground continuous wall foundation



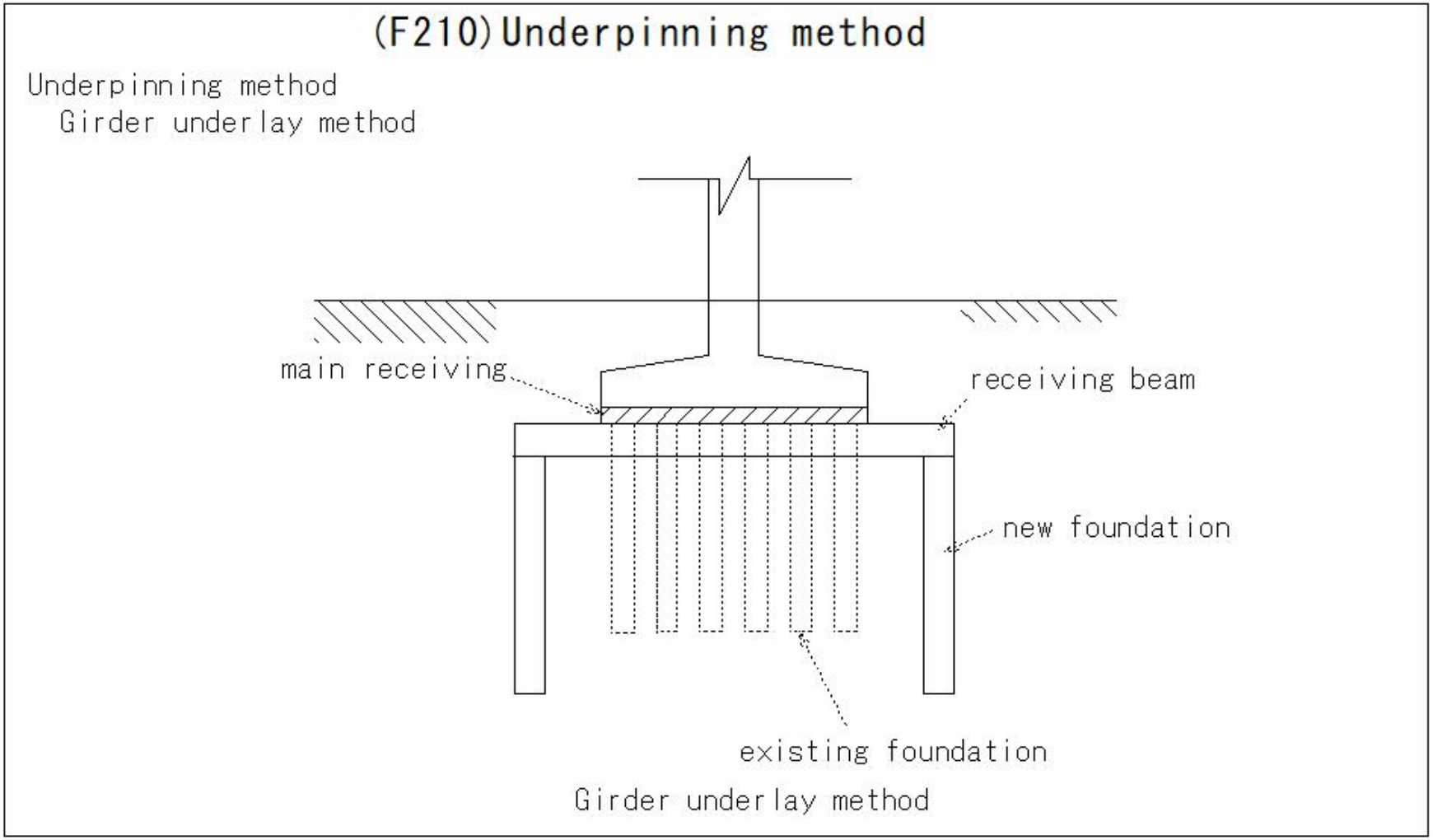
(F208)Underpinning method



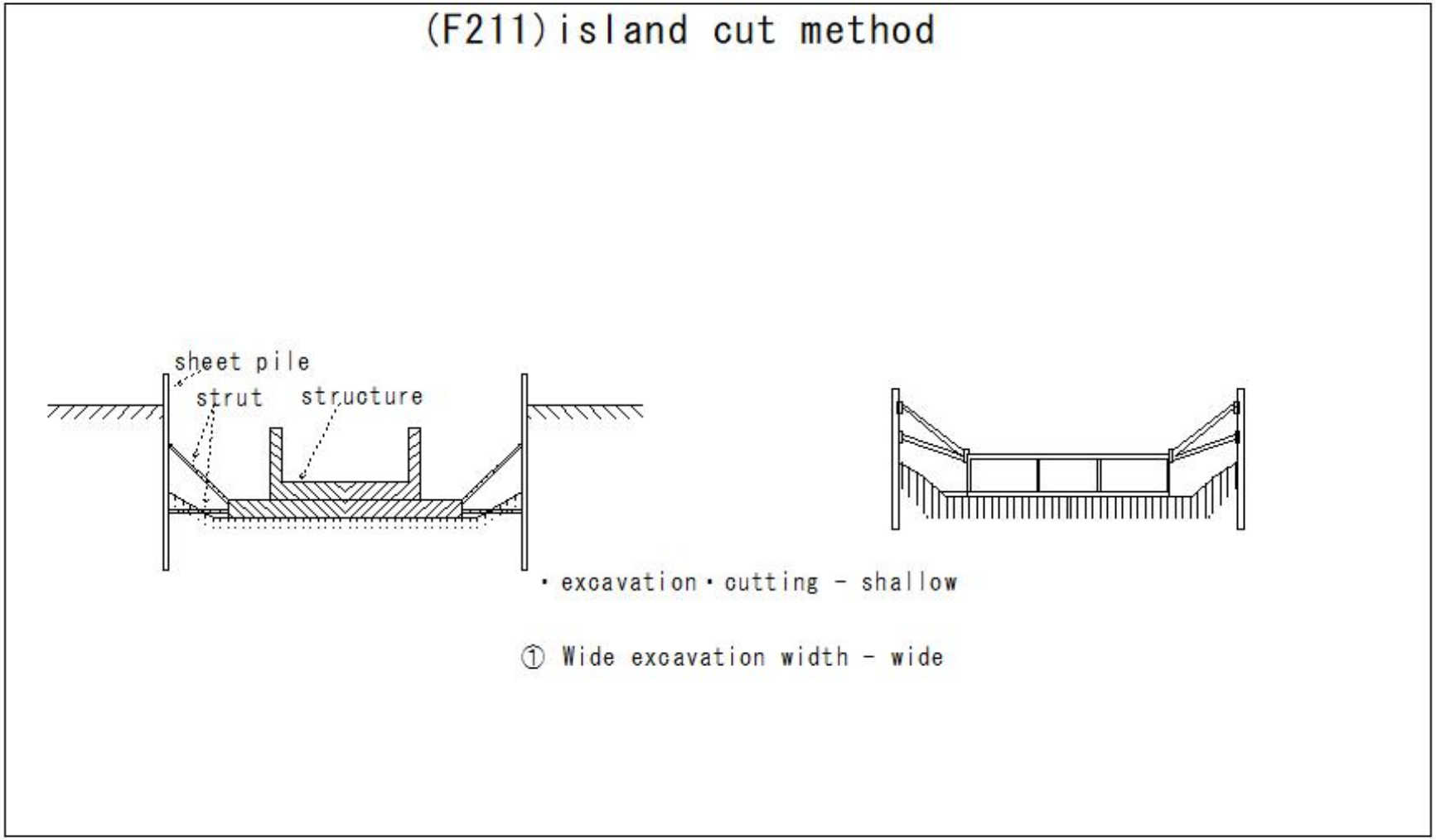
(F209)Underpinning method



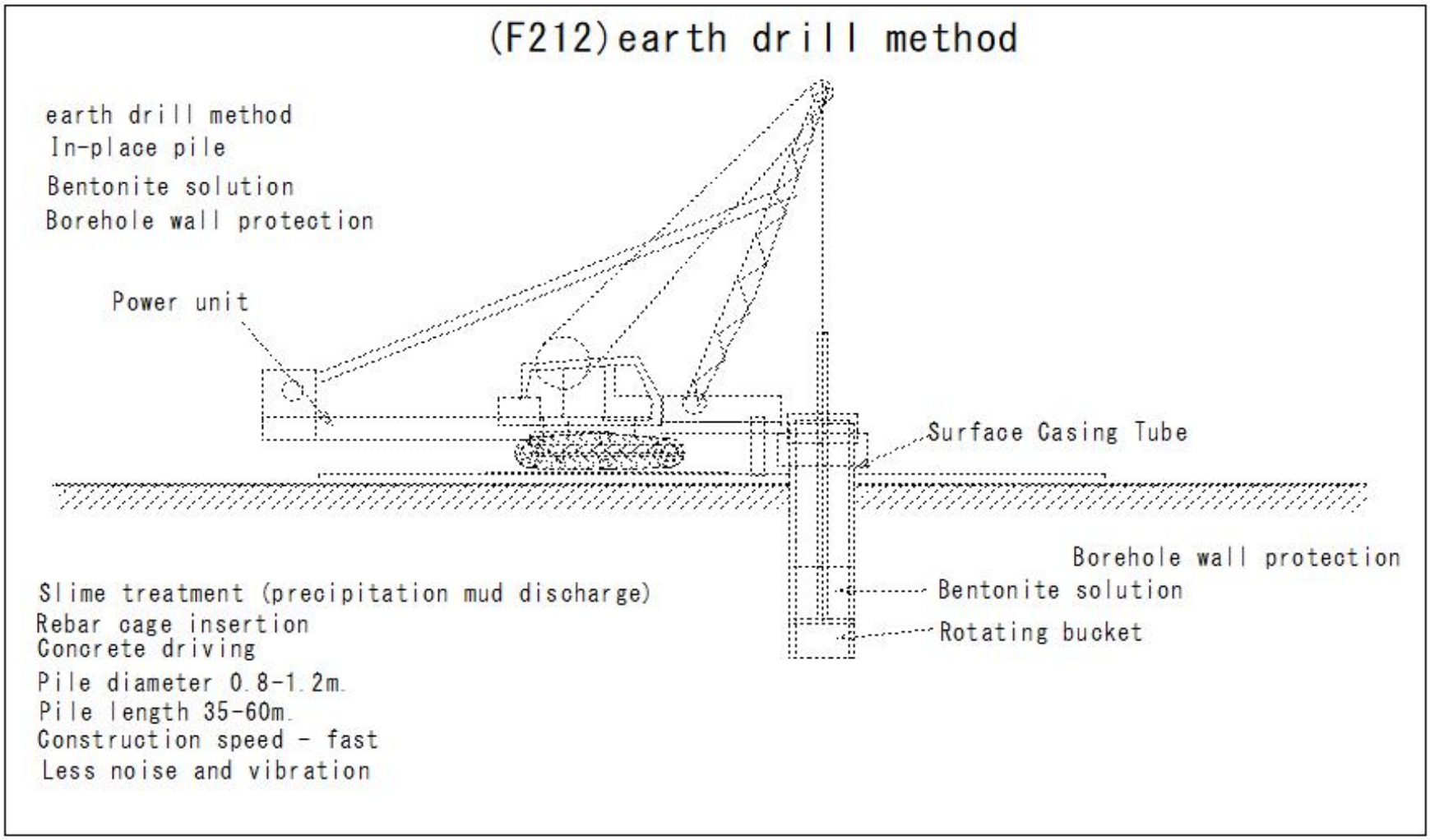
(F210)Underpinning method



(F211)island cut method



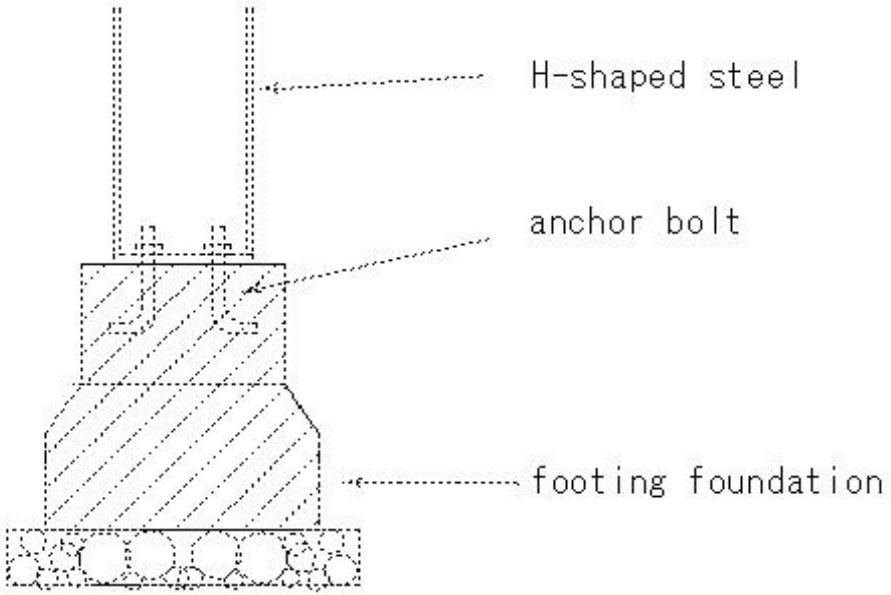
(F212)earth drill method



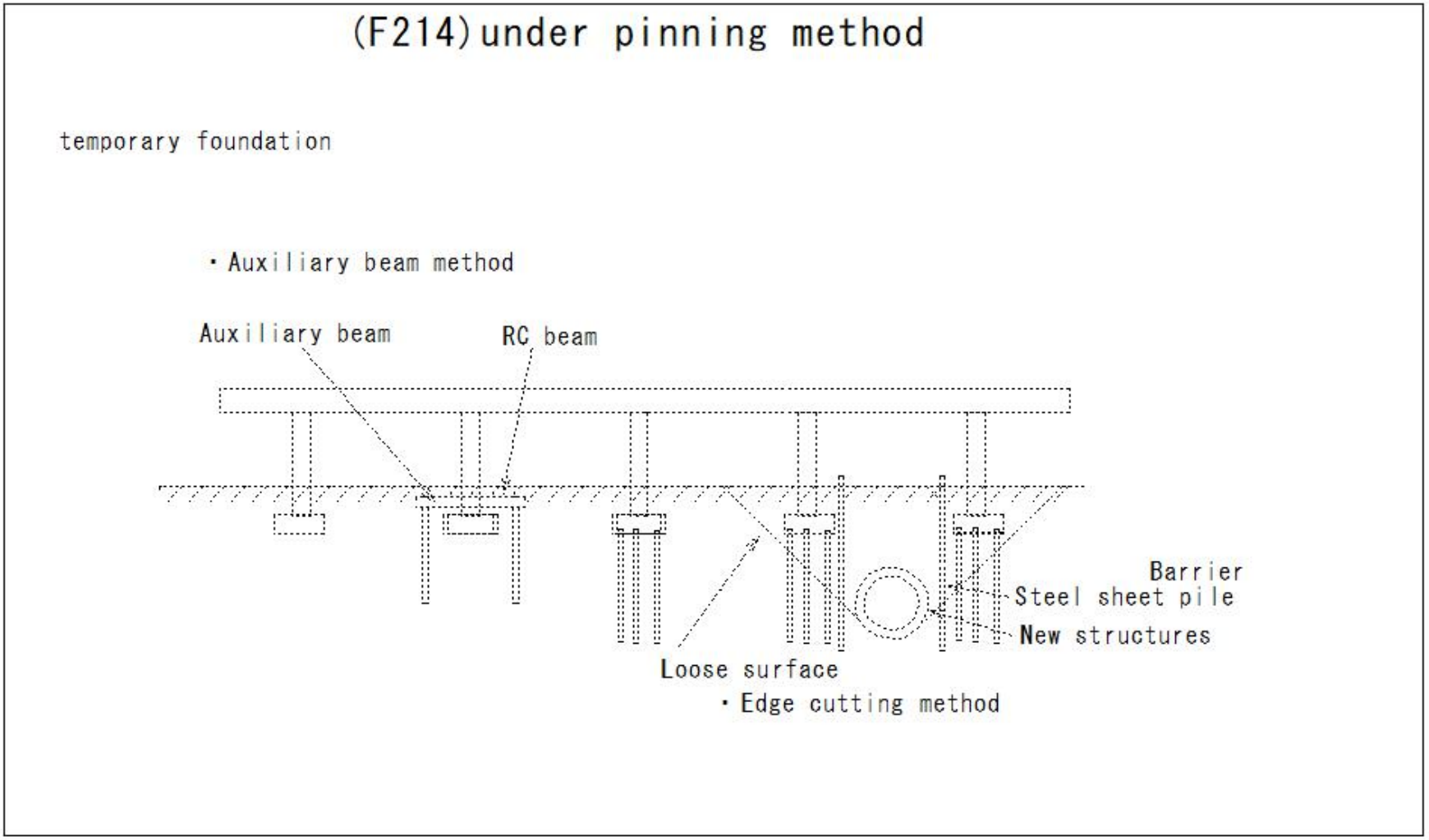
(F213)anchor bolt

(F213) anchor bolt

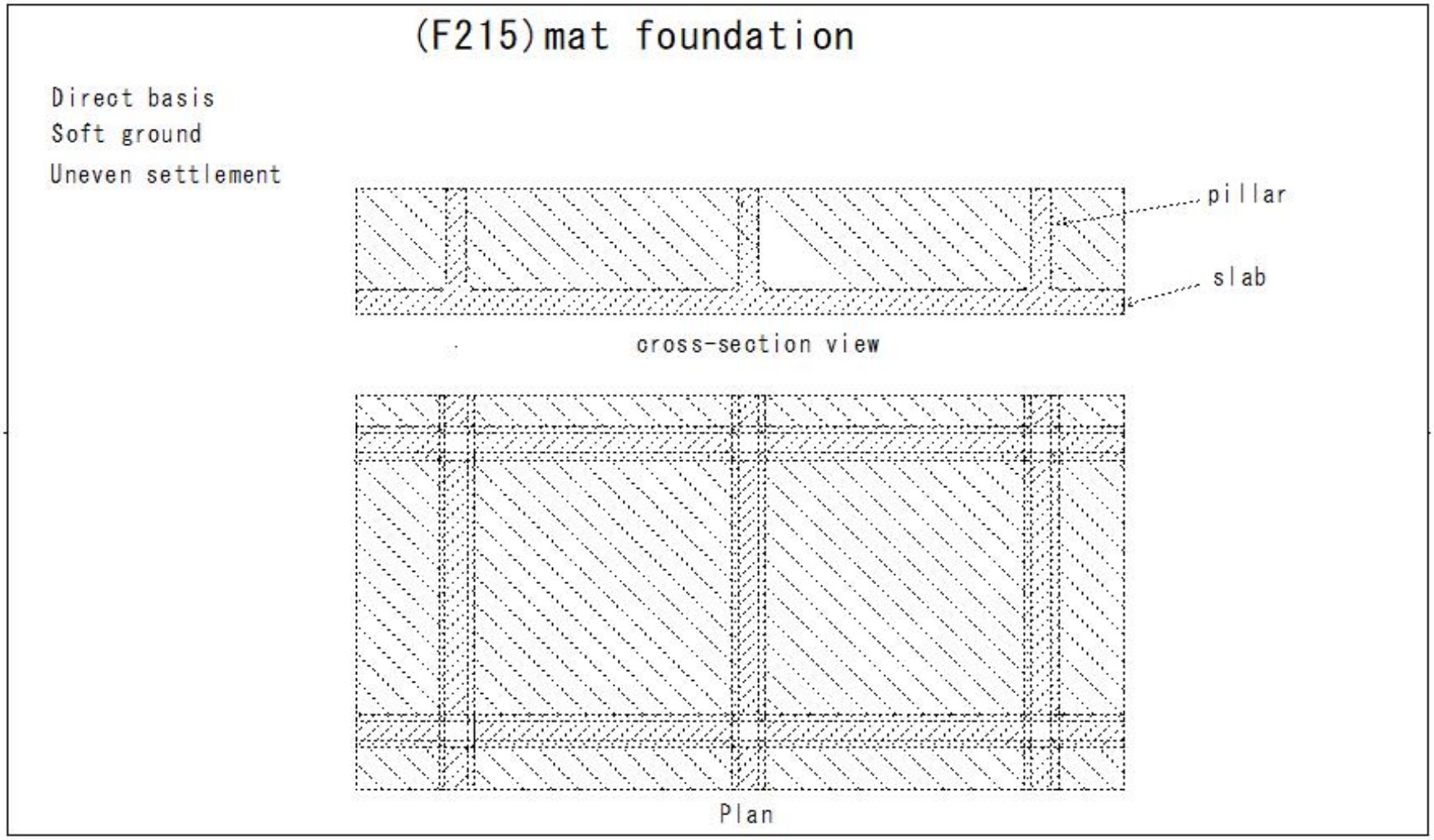
structures and foundations



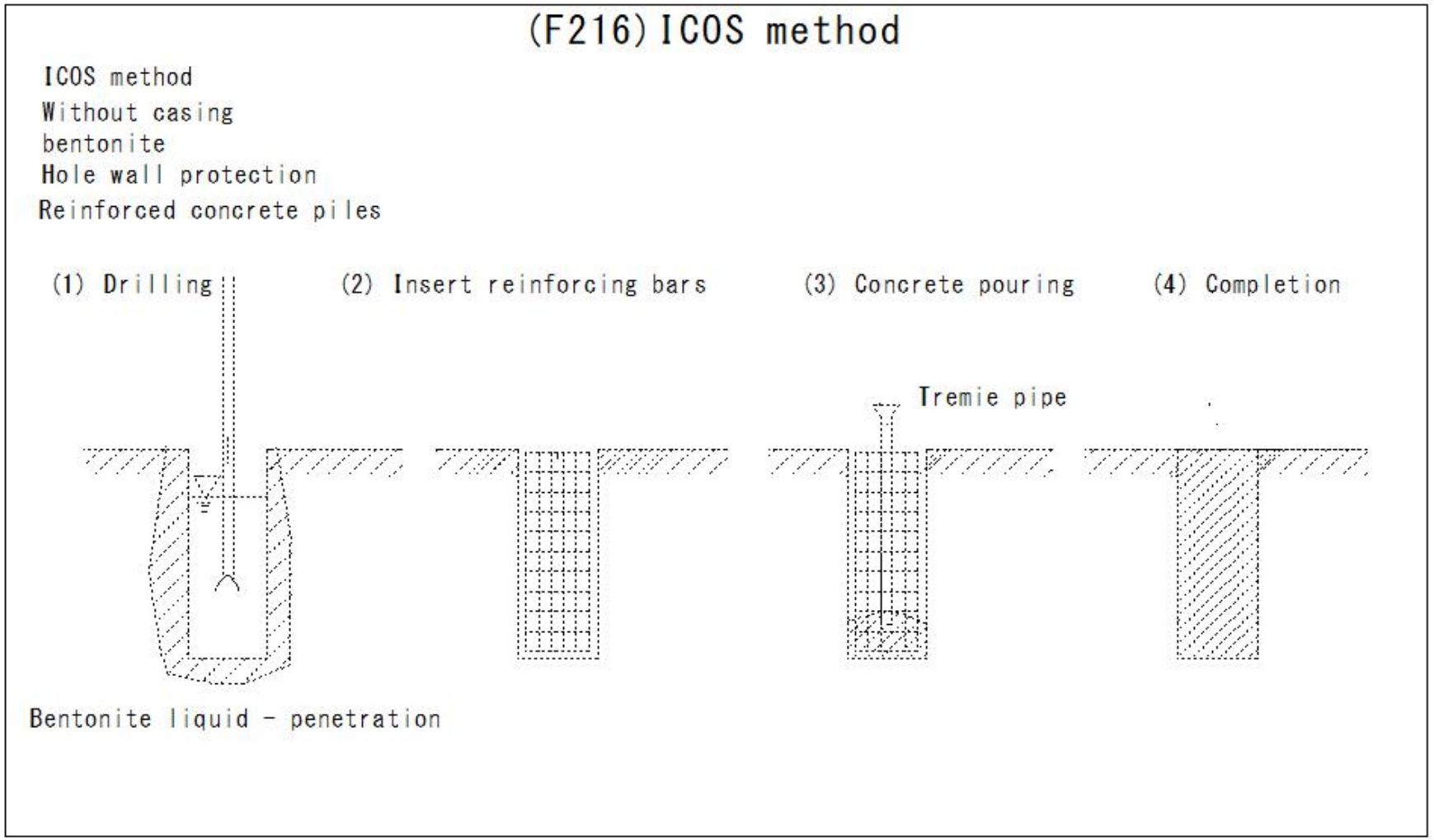
(F214)under pinning method



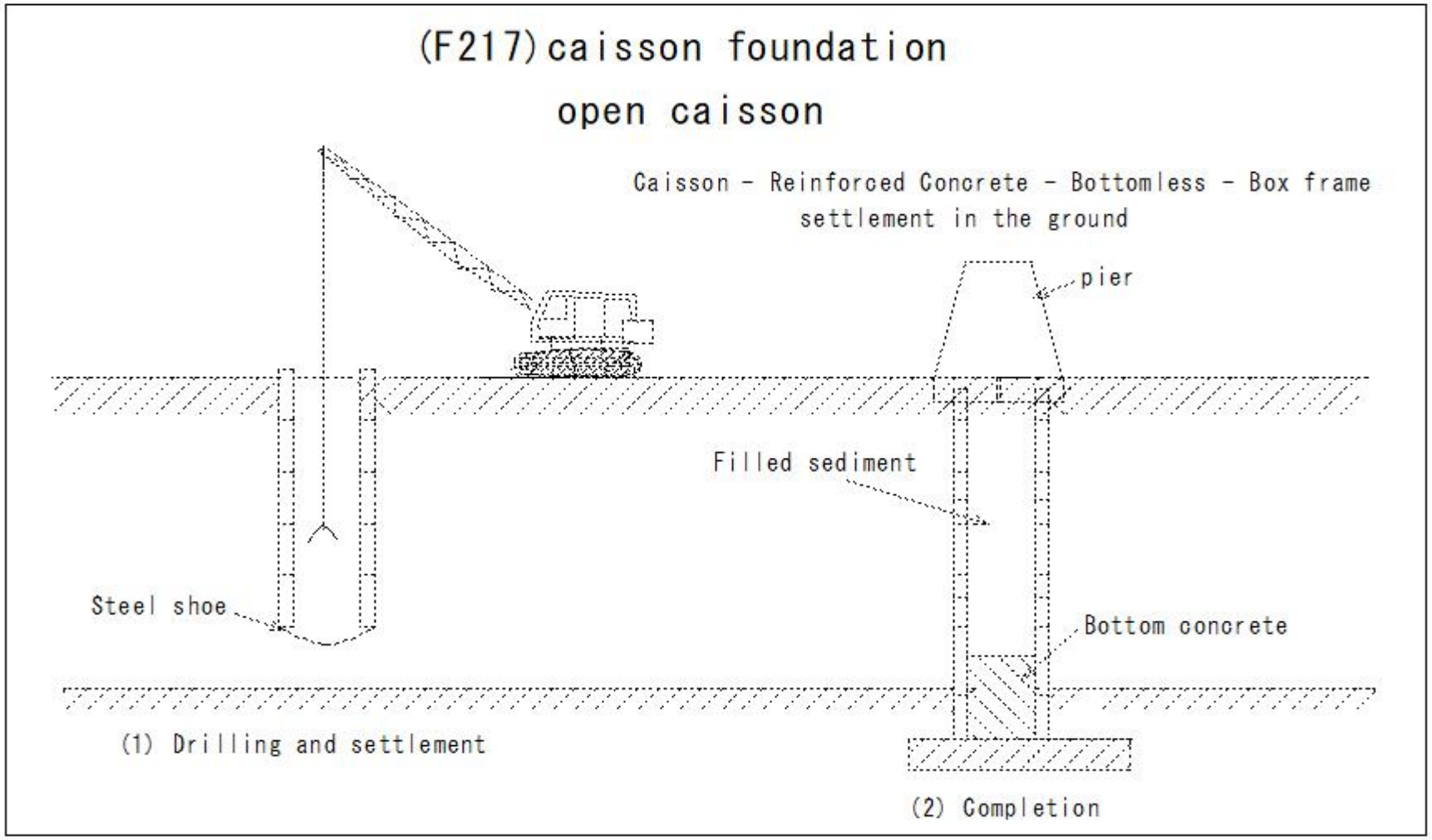
(F215)mat foundation



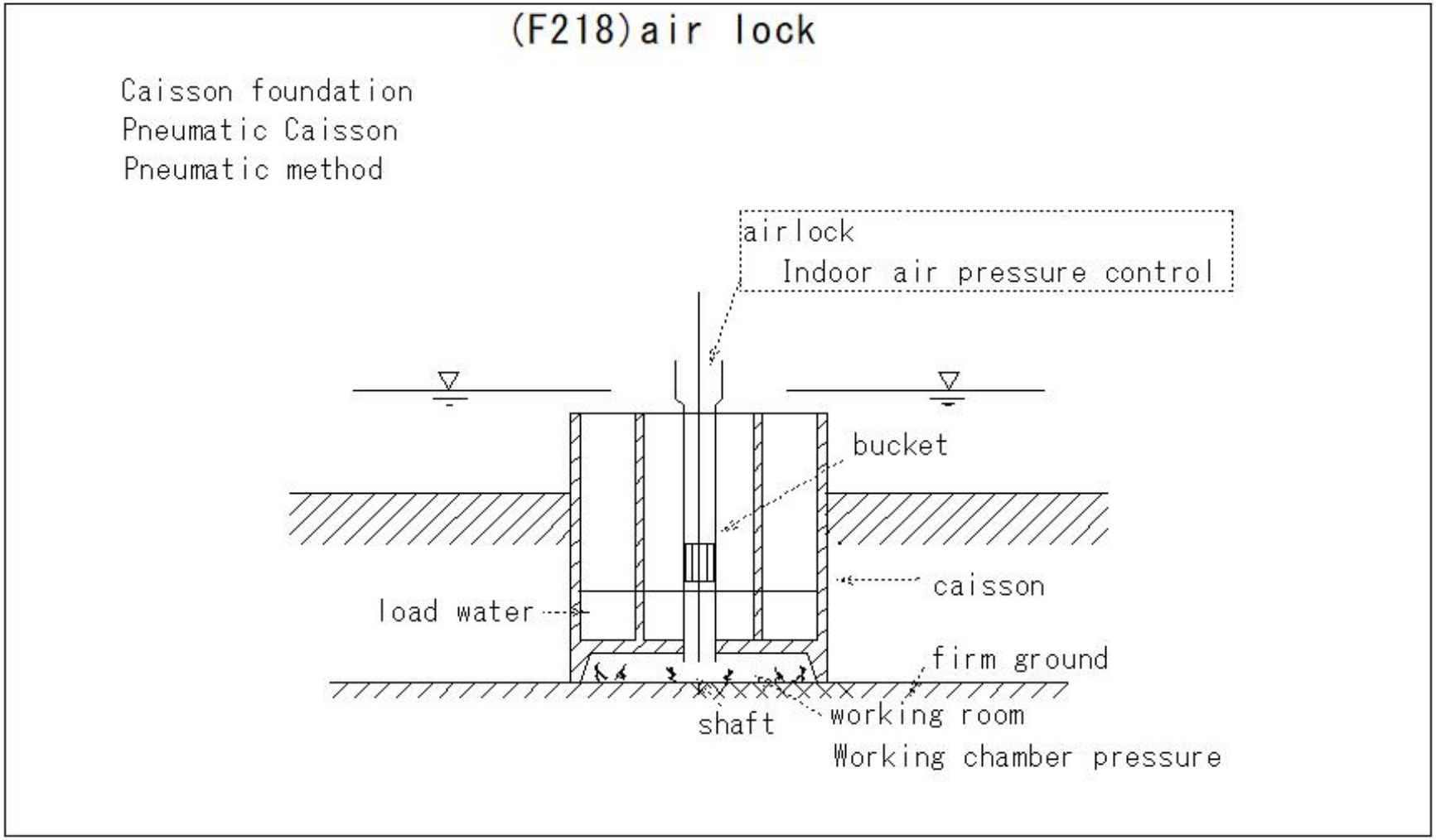
(F216)ICOS method



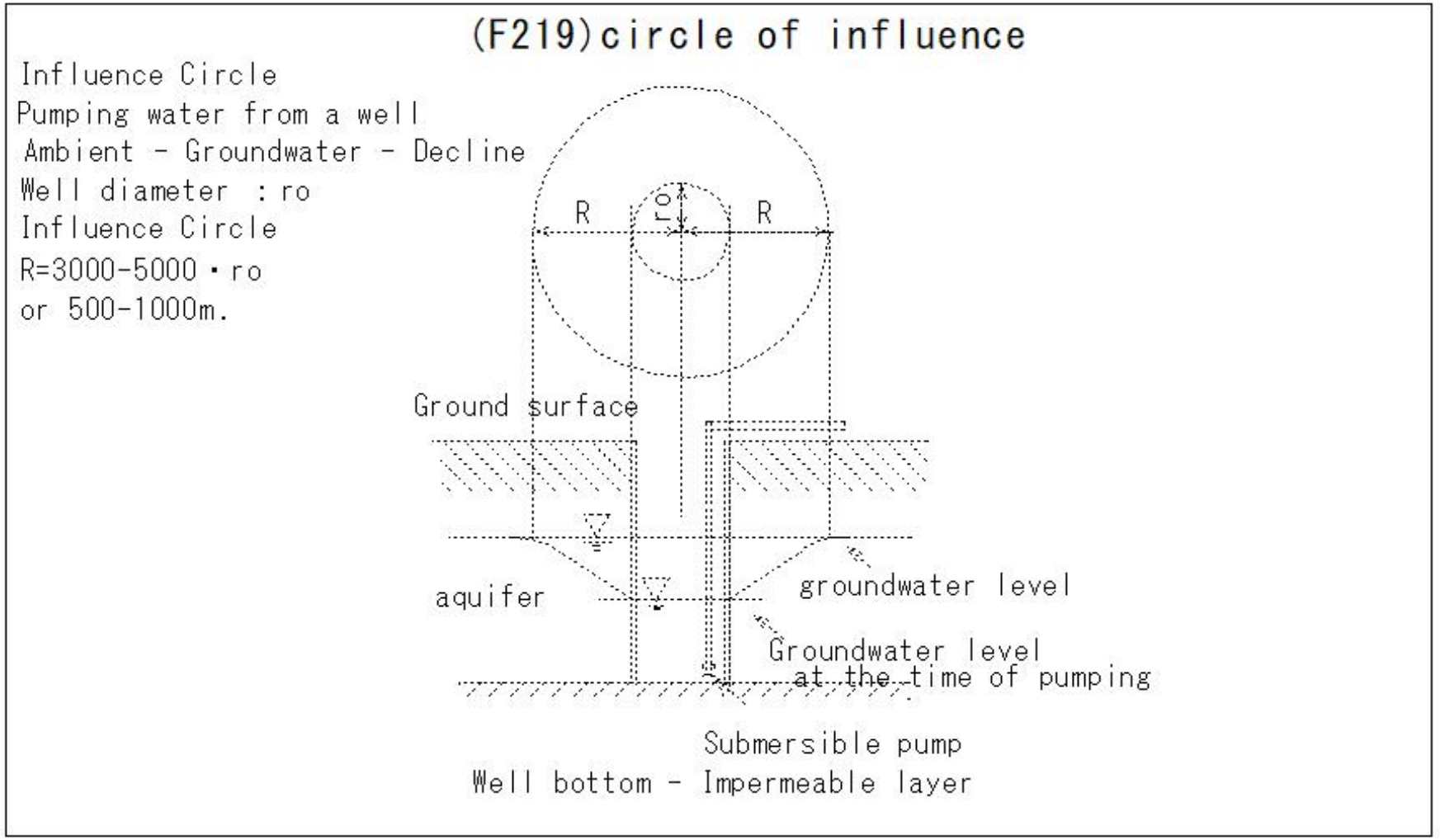
(F217)caisson foundation



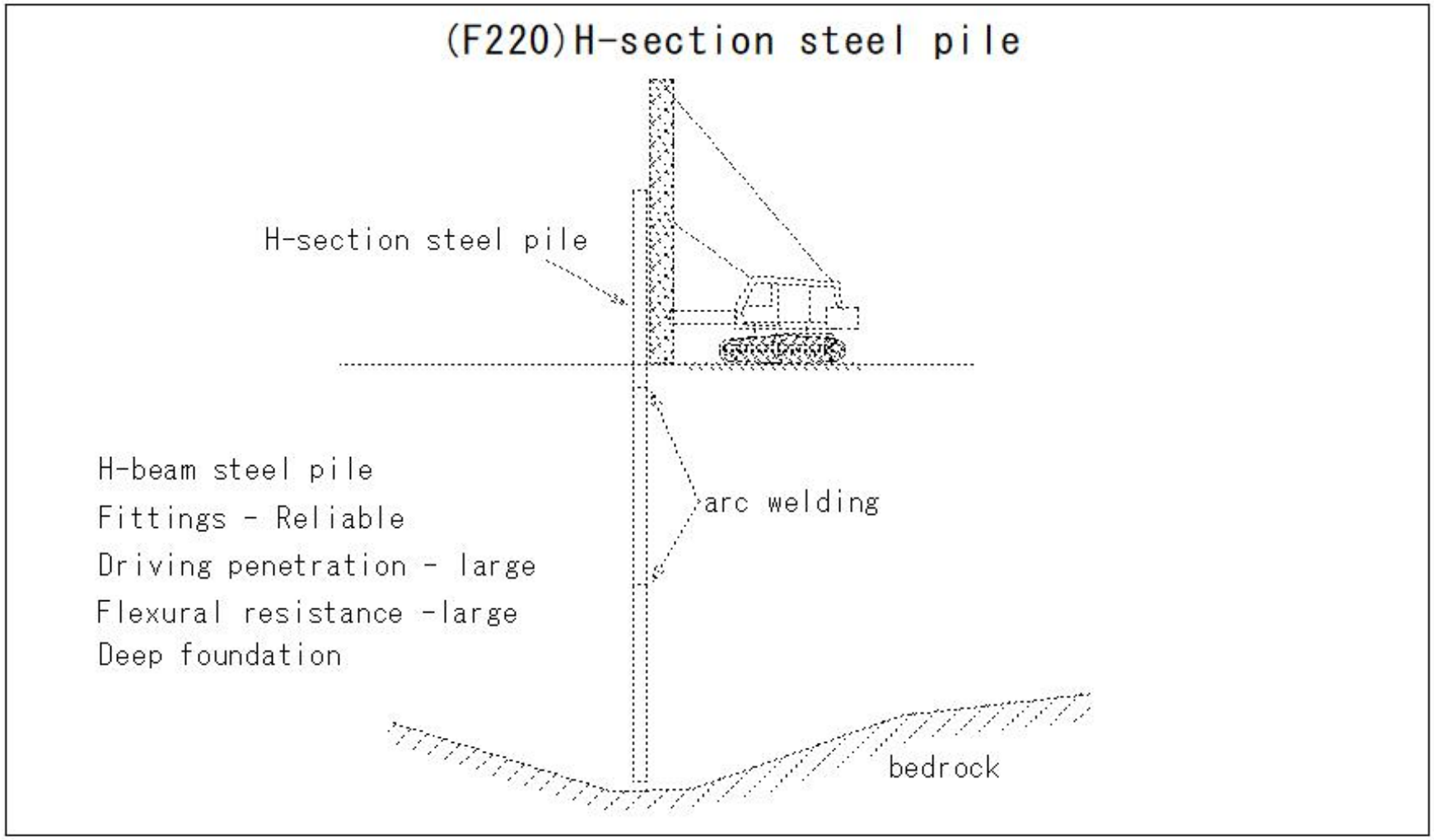
(F218)air lock



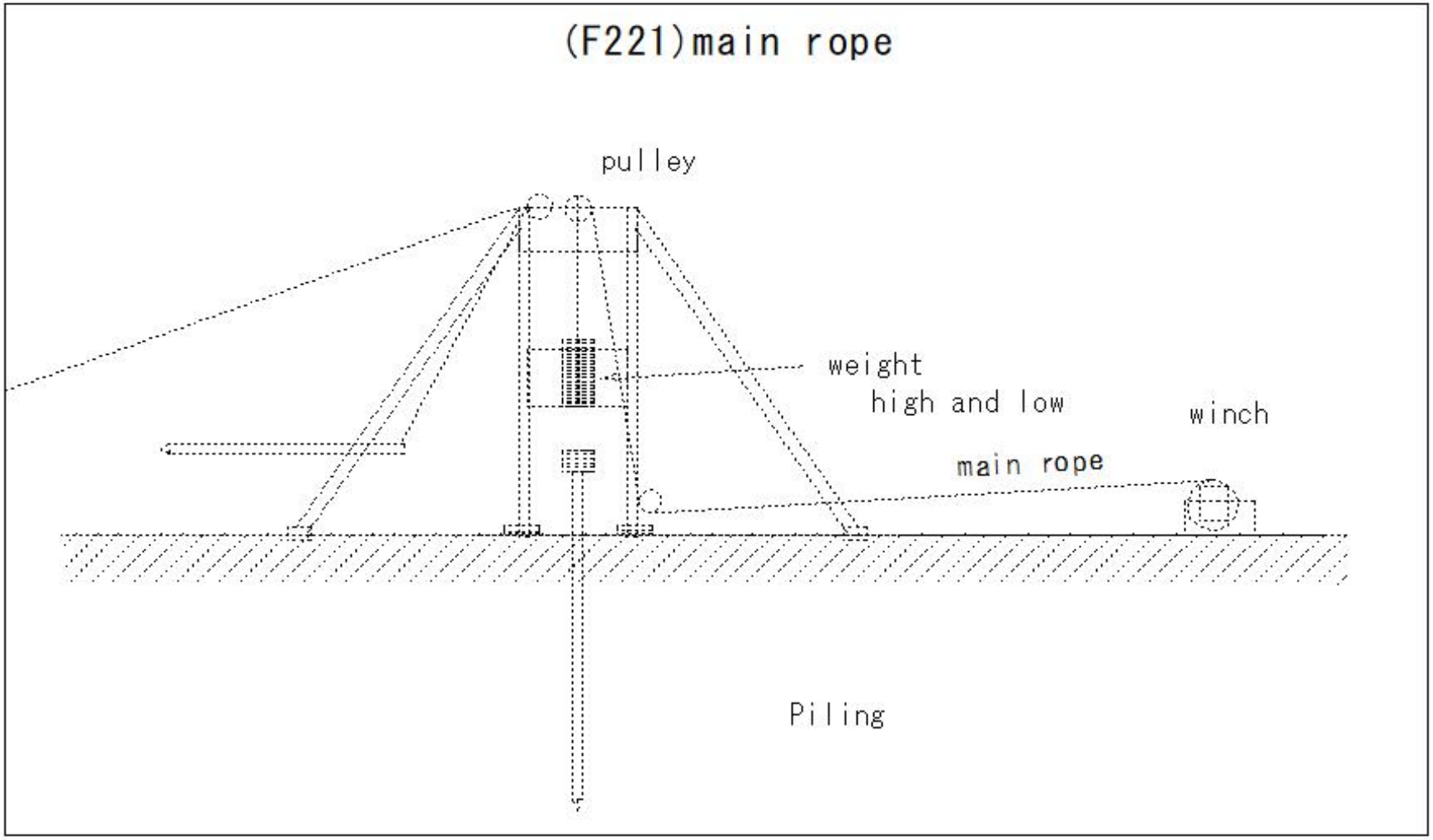
(F219)circle of influence



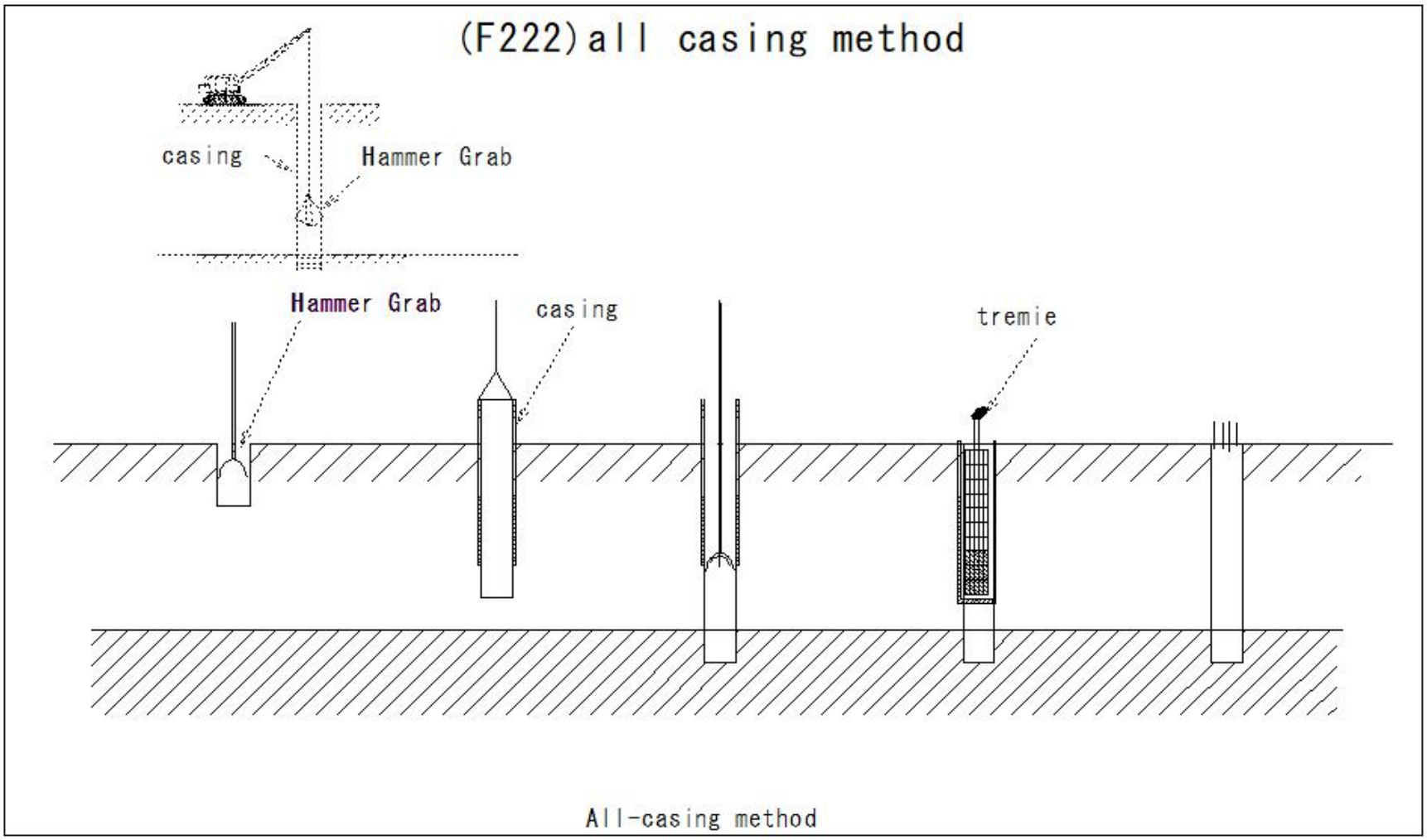
(F220)H-section steel pile



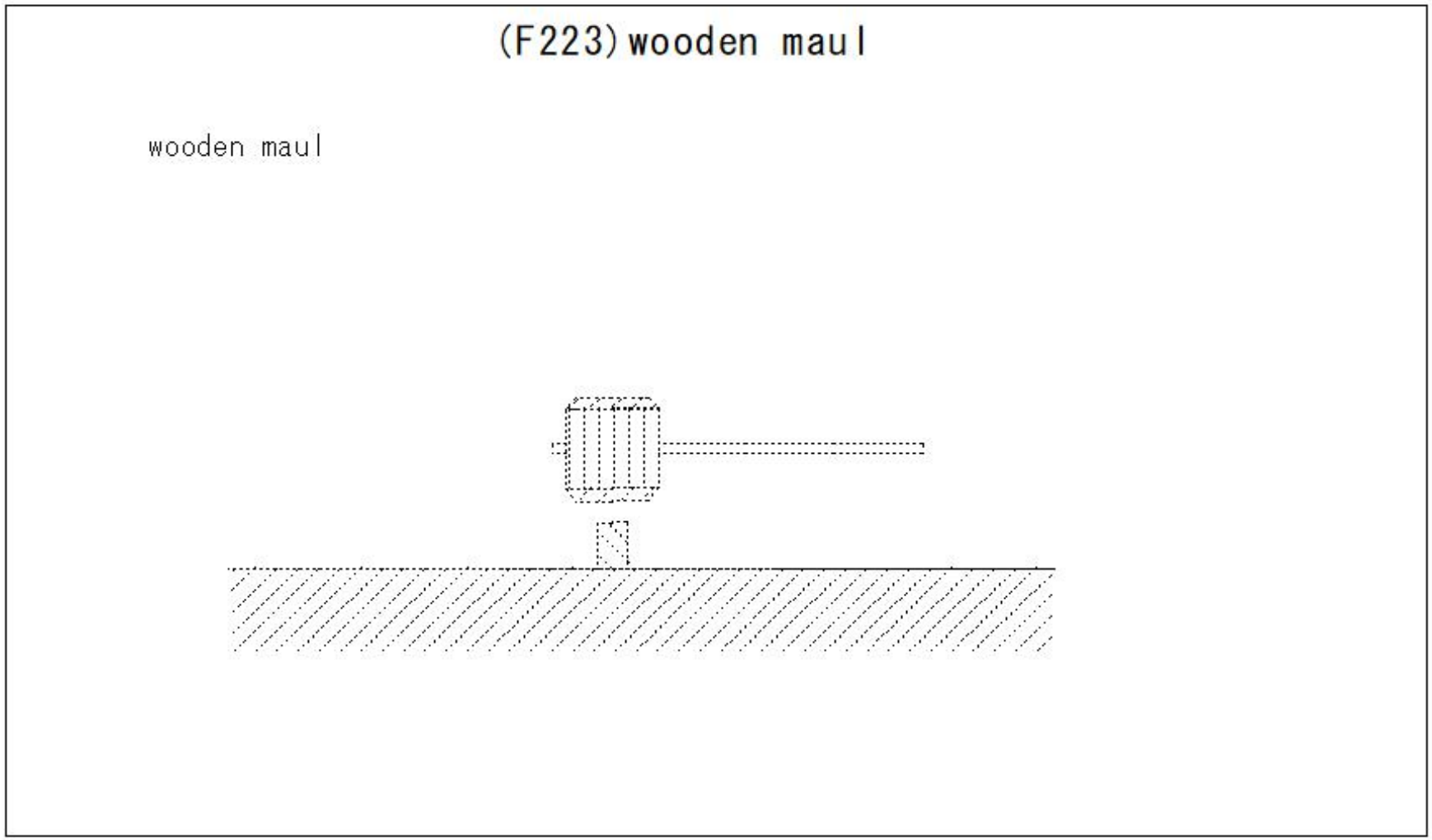
(F221)main rope



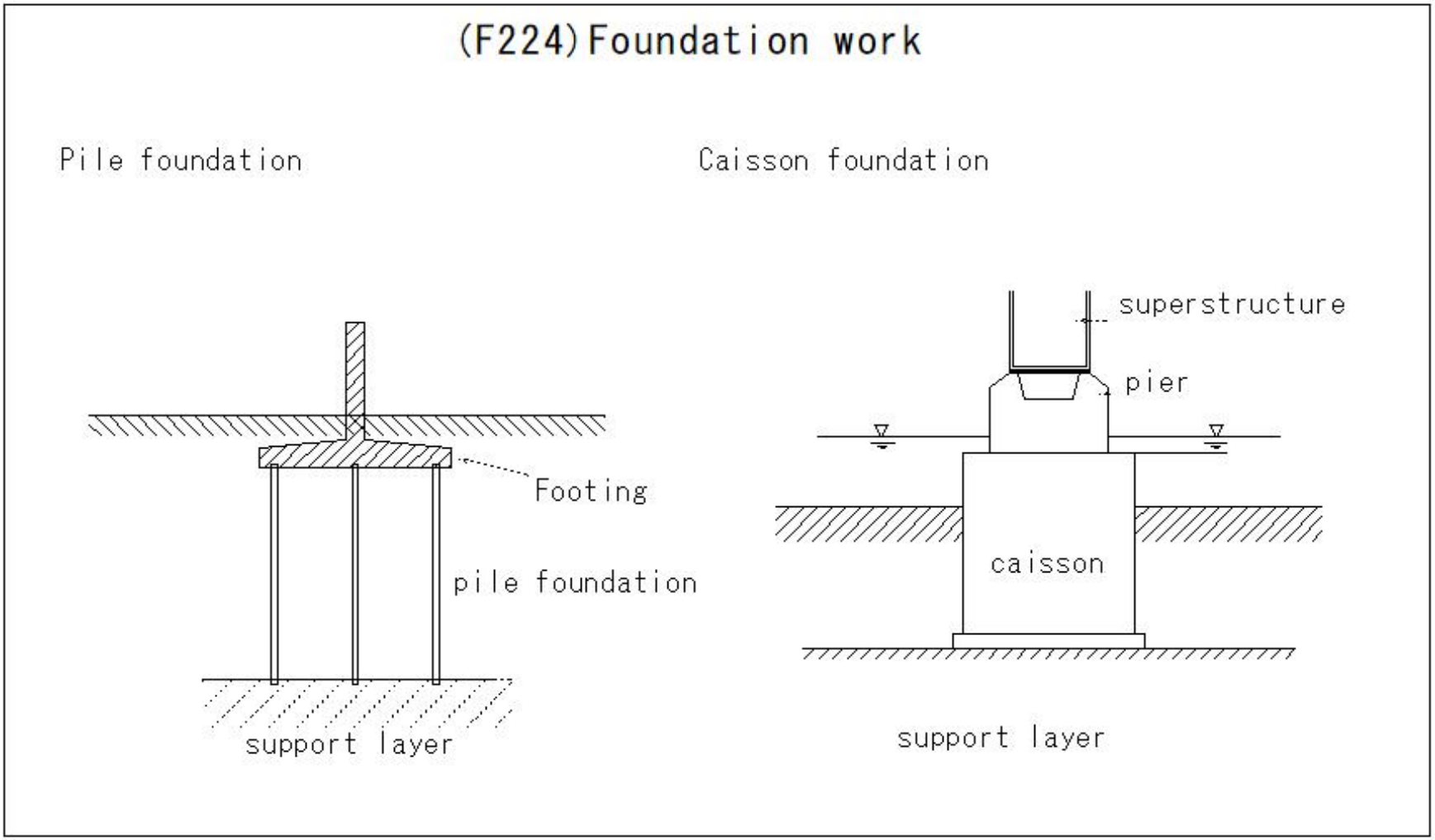
(F222)all casing method



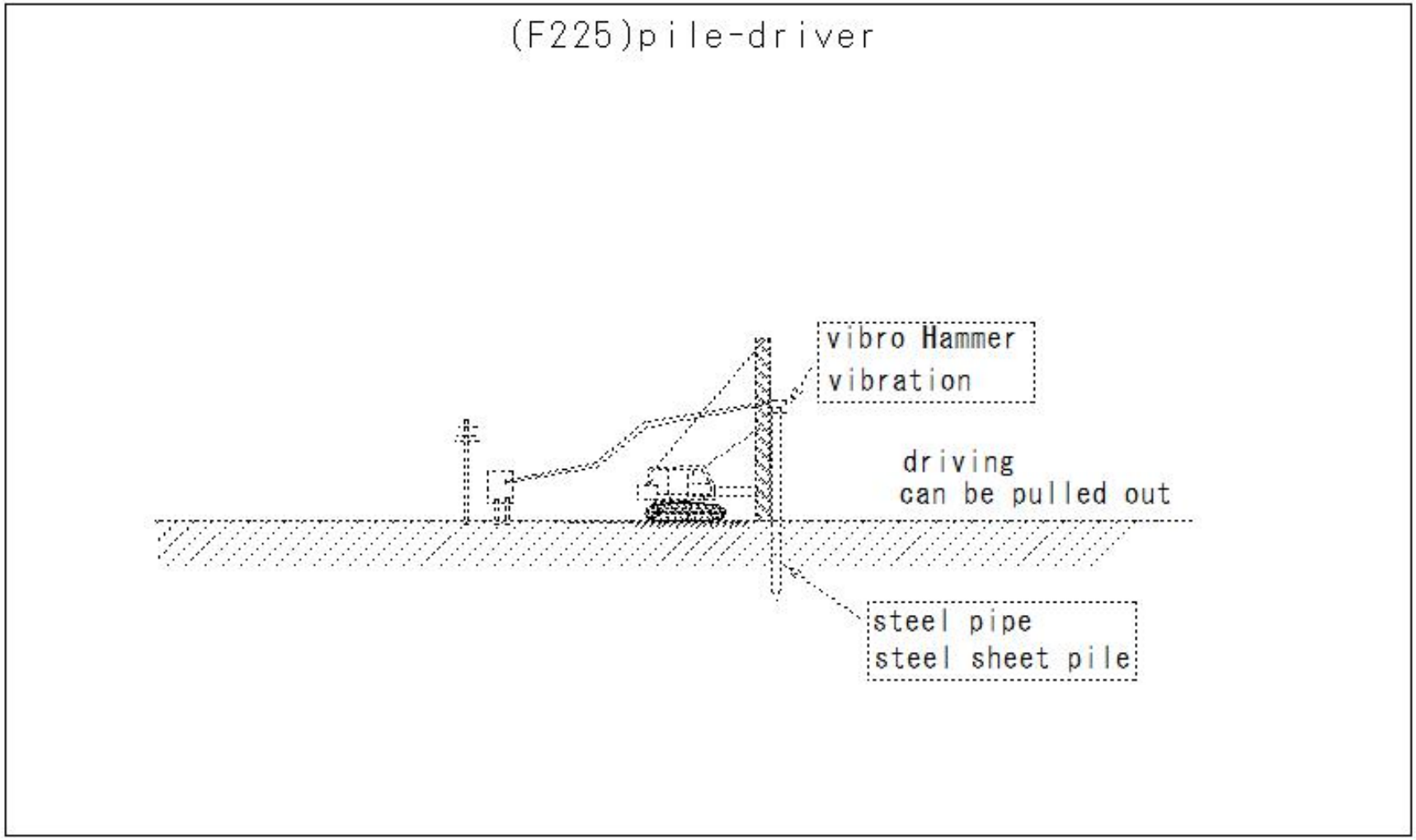
(F223)wooden maul



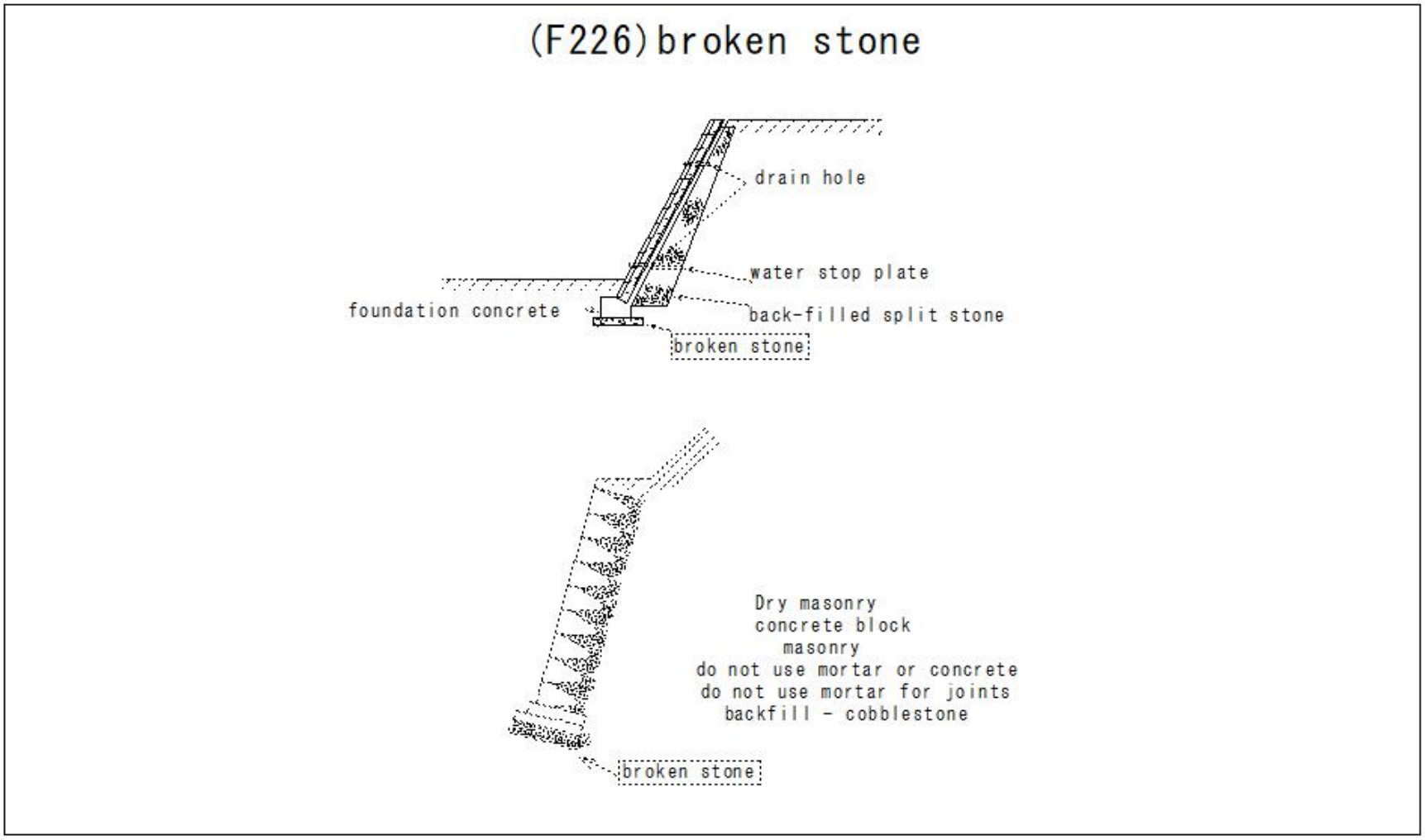
(F224)Foundation work



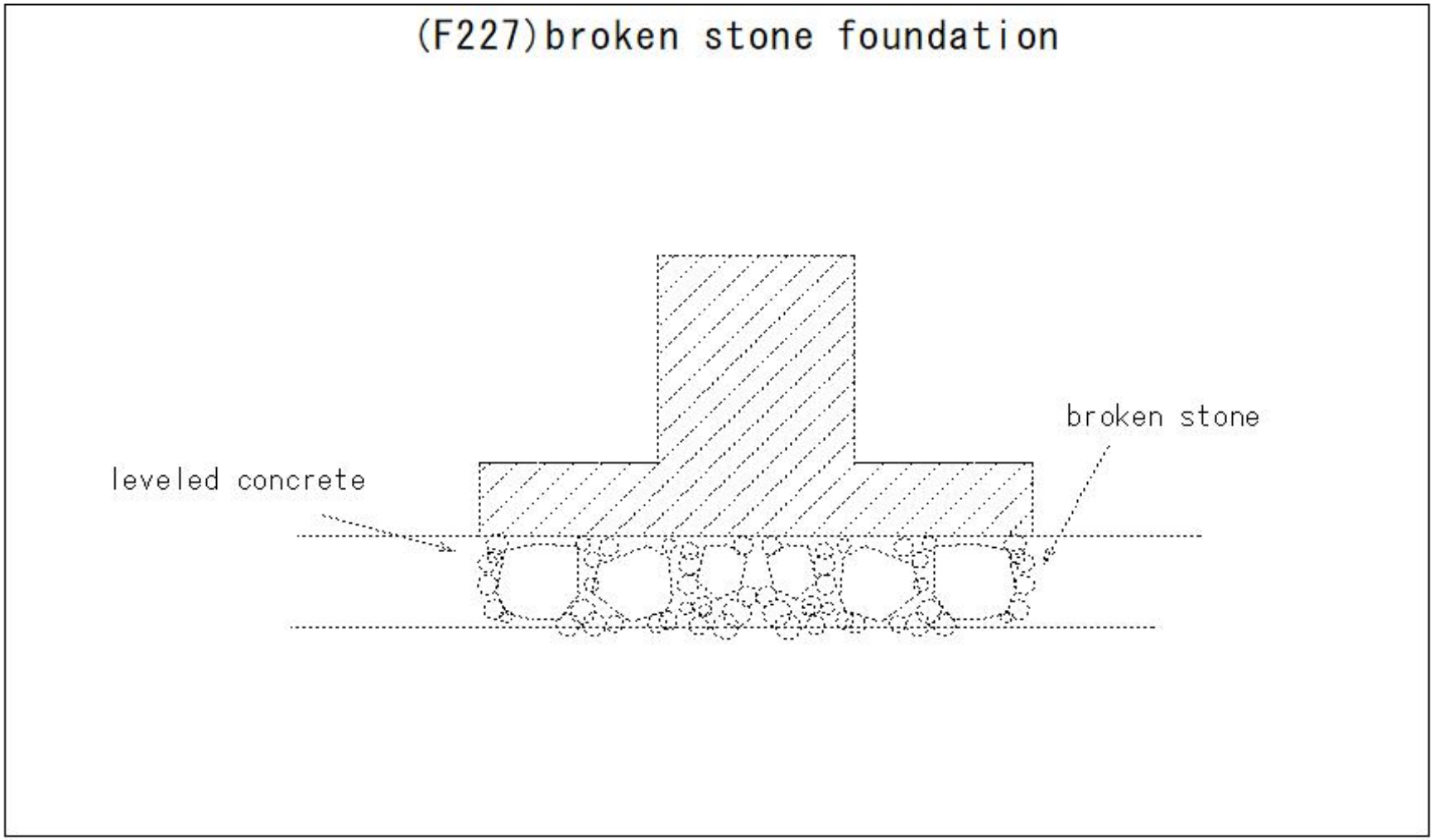
(F225)pile-driver



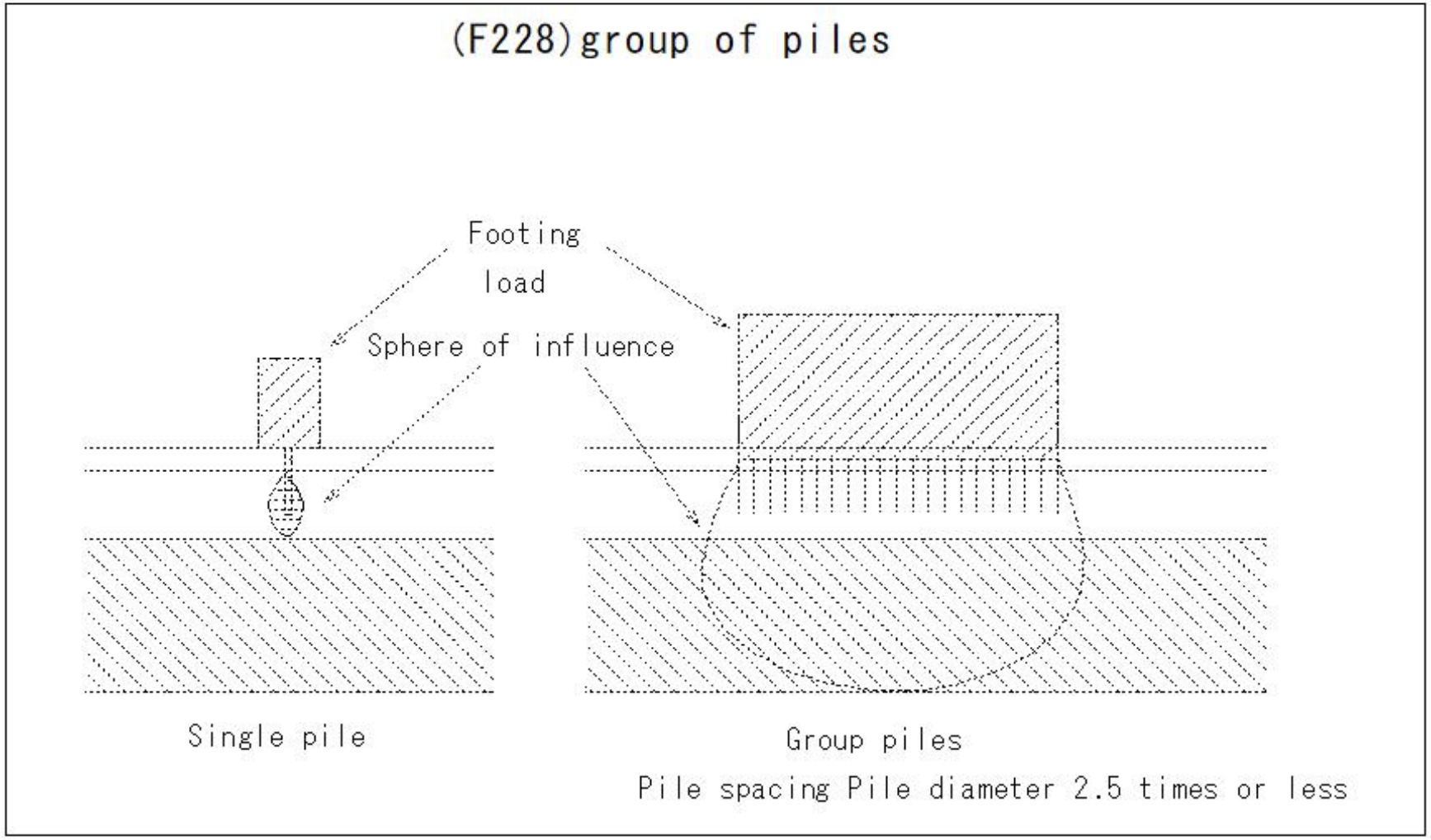
(F226)broken stone



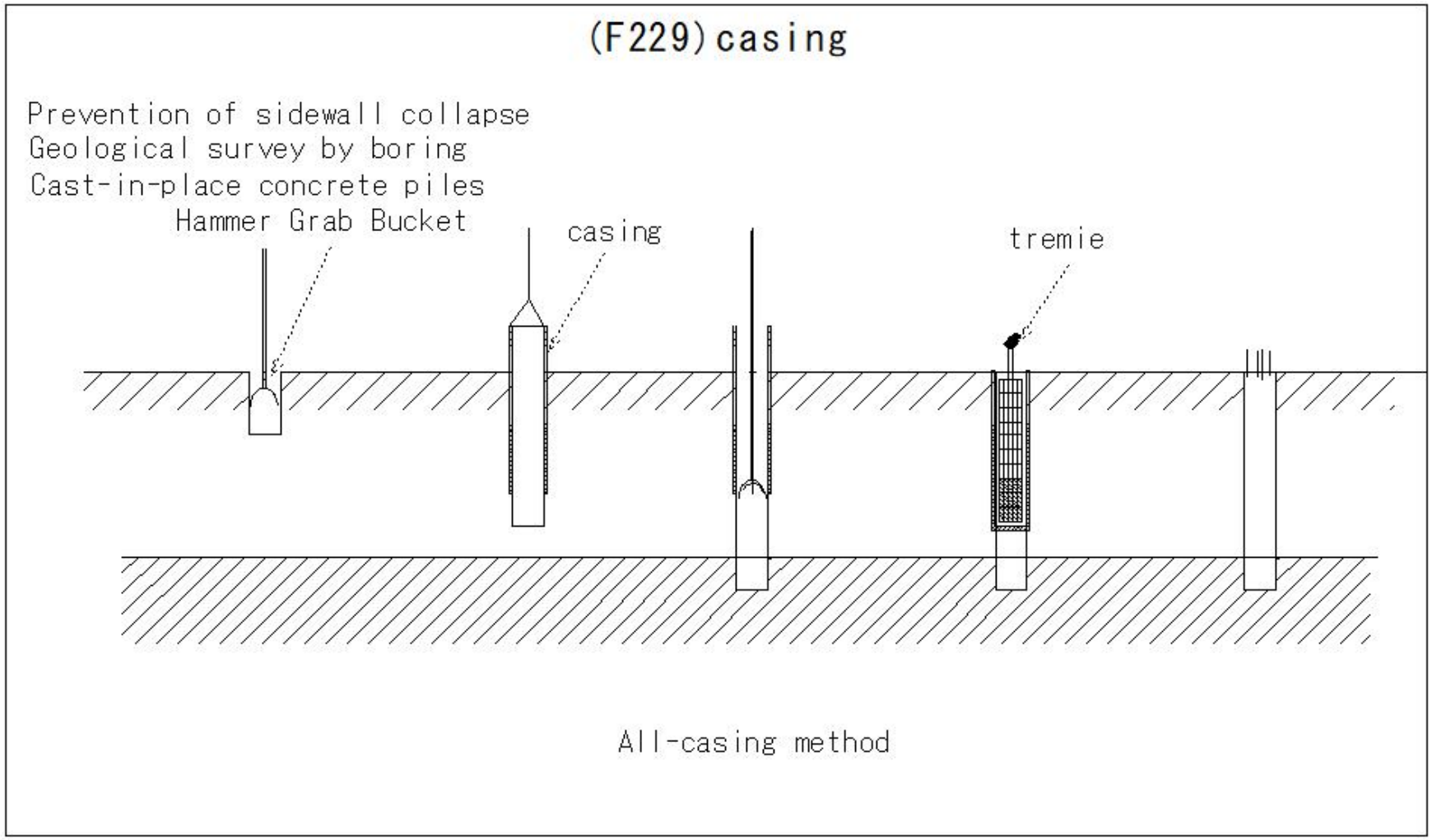
(F227)broken stone foundation



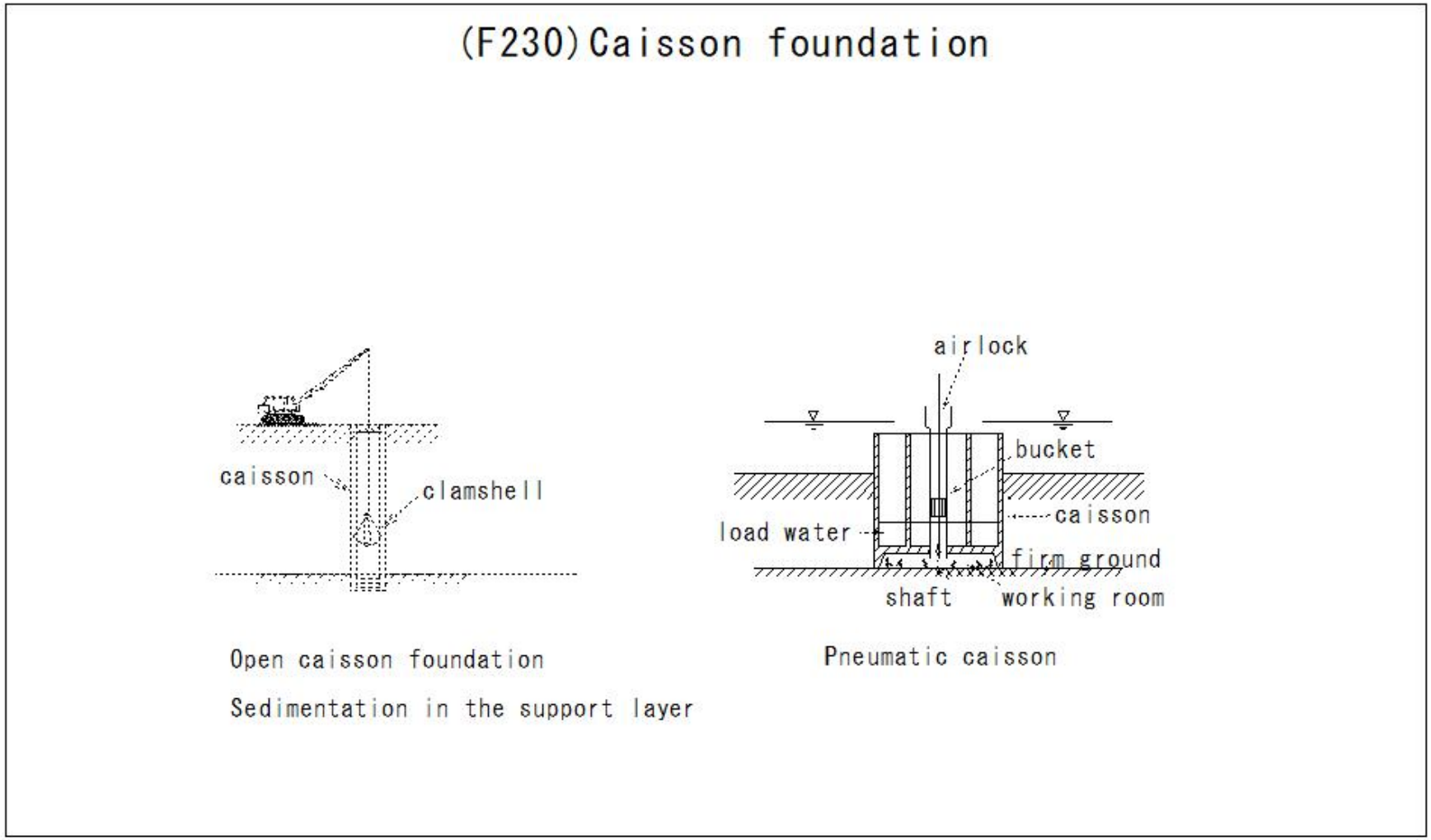
(F228)group of piles



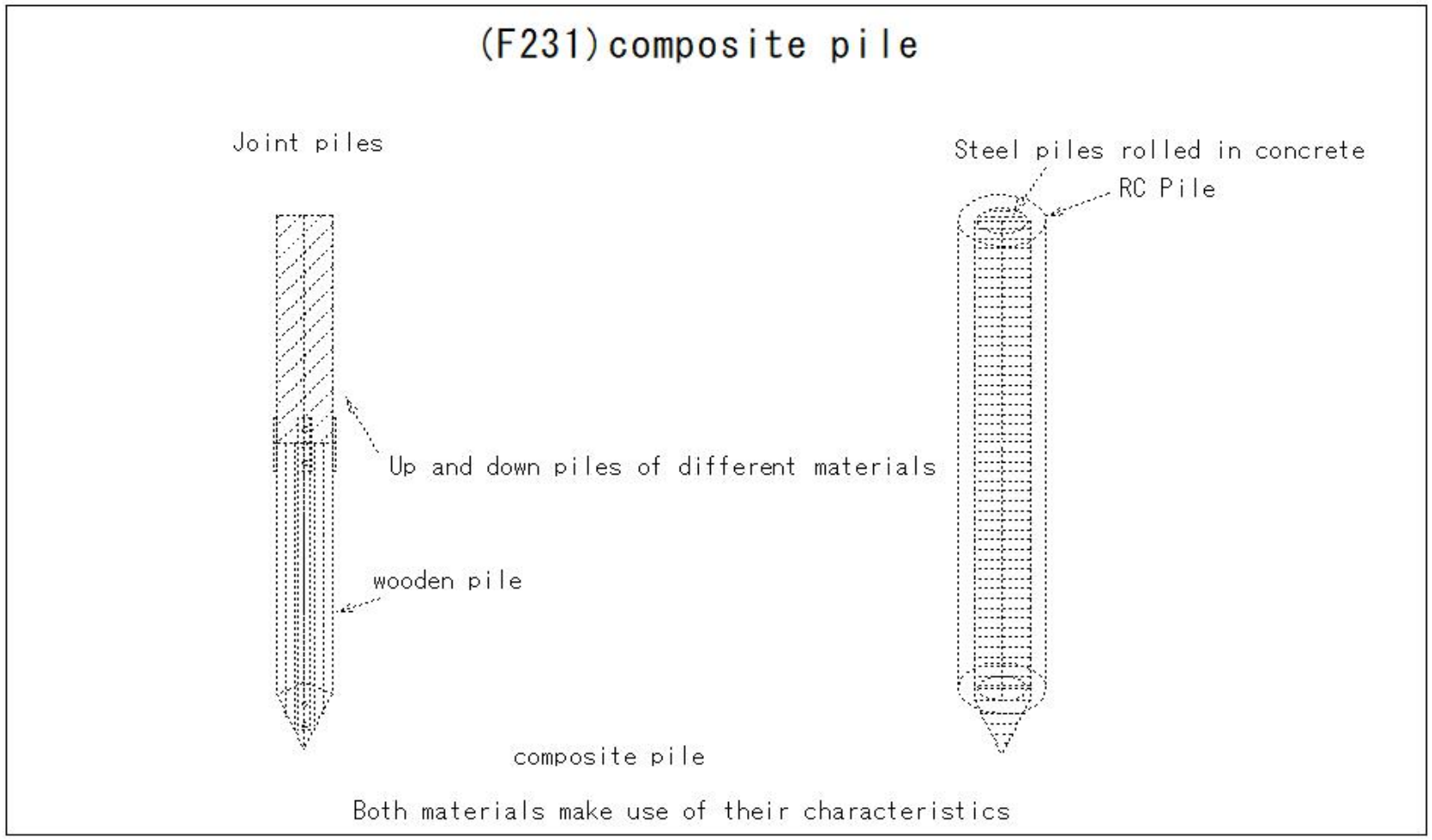
(F229)casing


(F229)casing
Prevention of sidewall collapse
Geological survey by boring
Cast-in-place concrete piles
Hammer Grab Bucket
casing
tremie
All-casing method

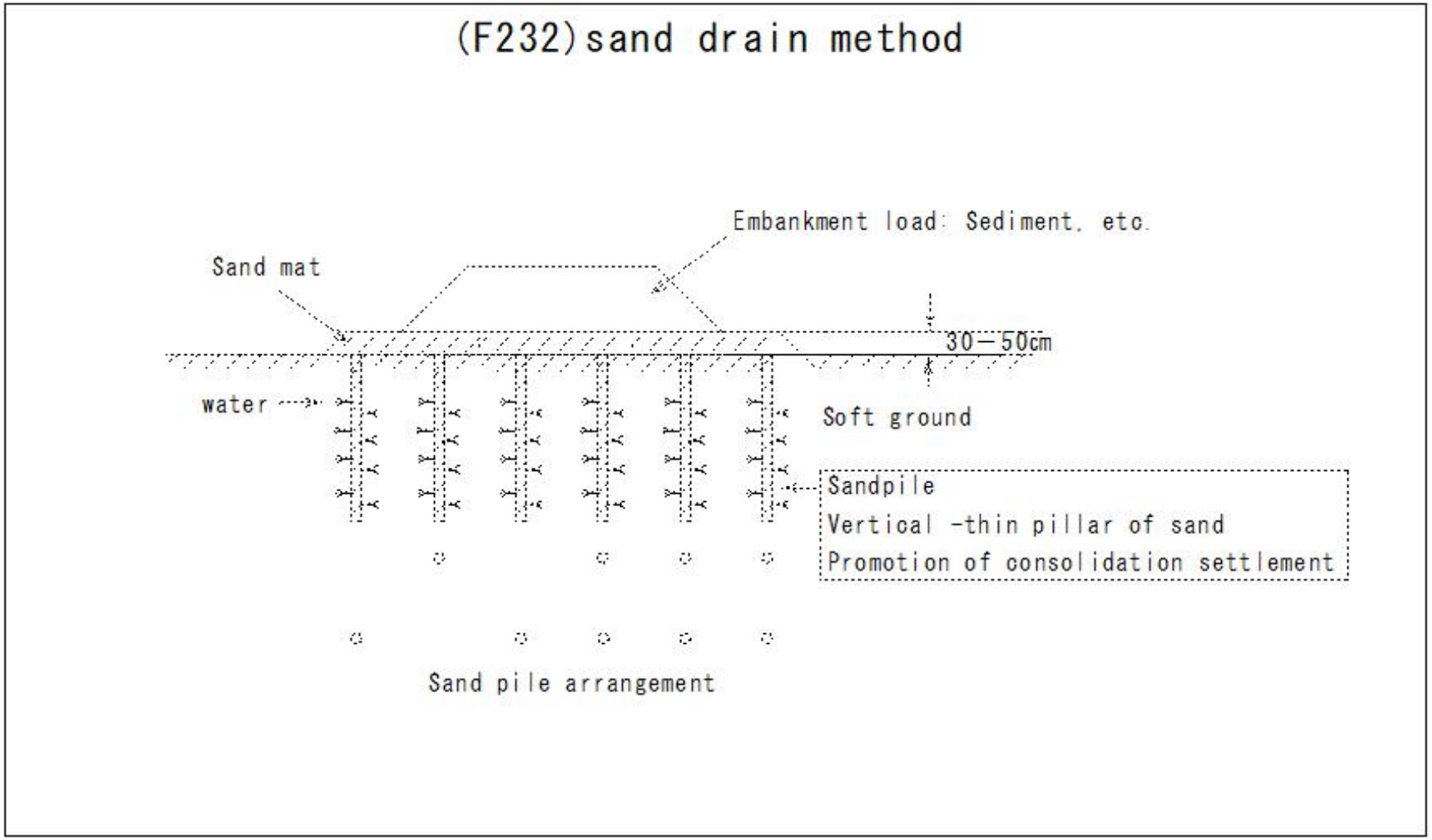
(F230)Caisson foundation



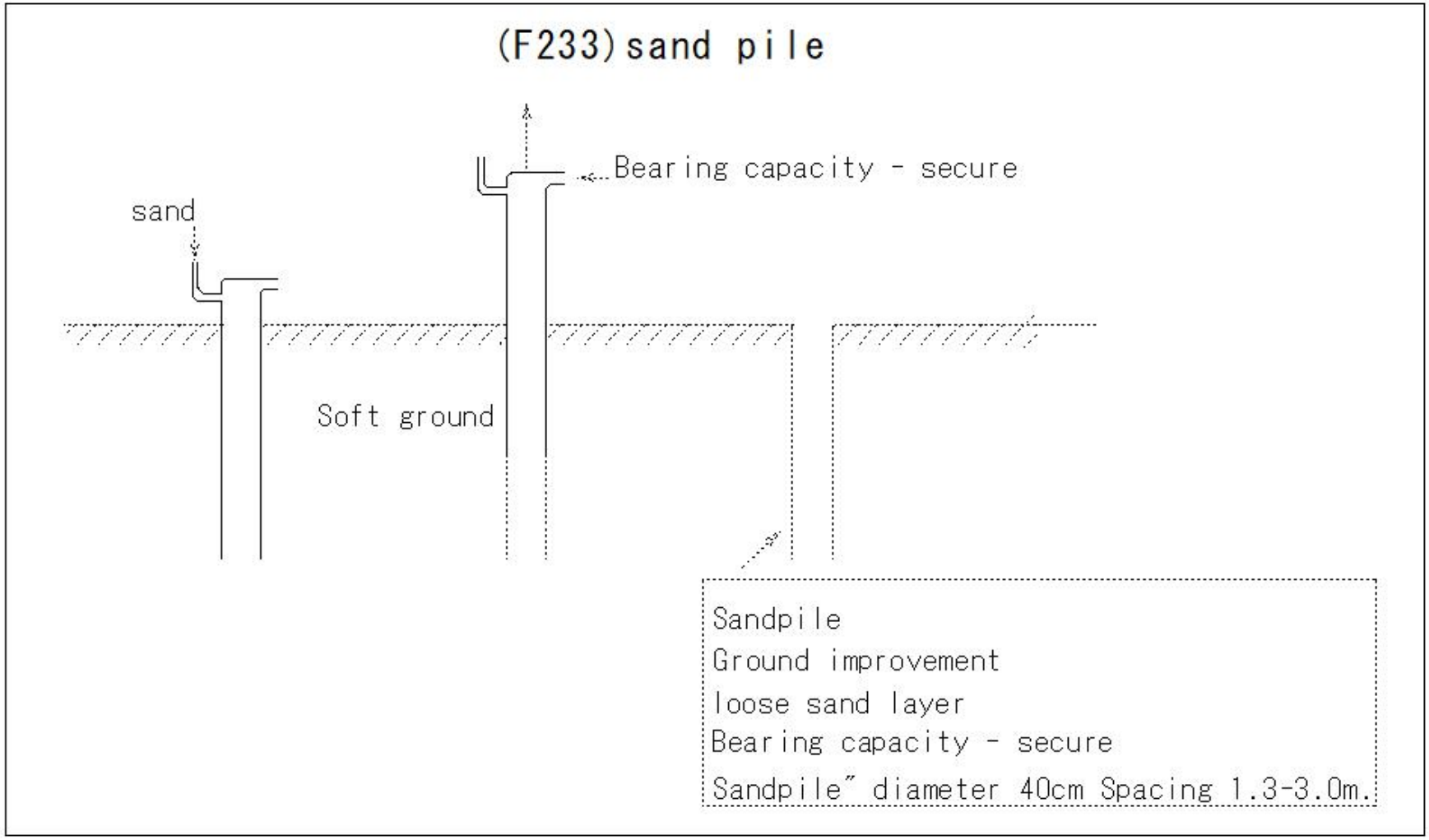
(F231)Caisson foundation



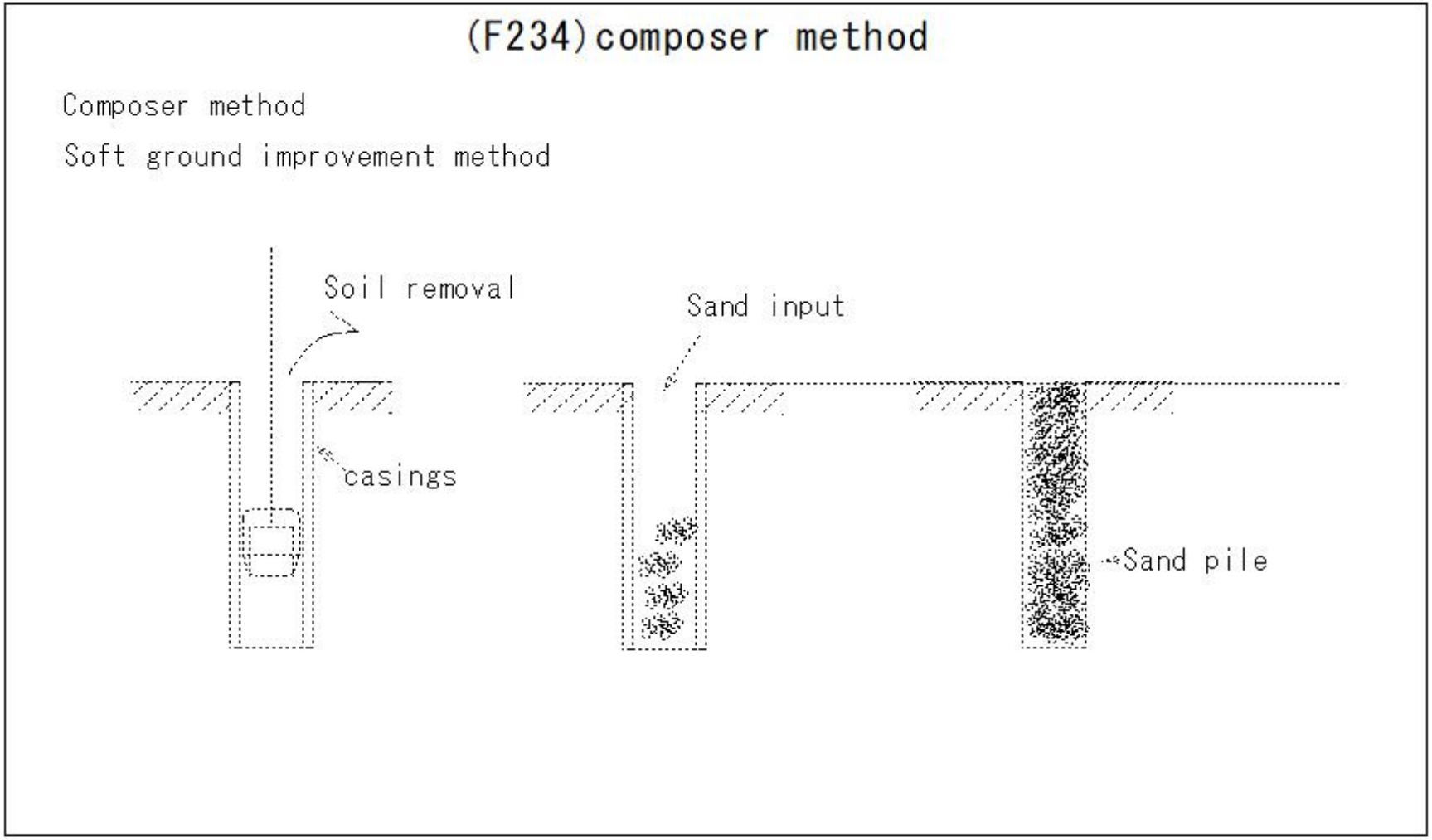
(F232)sand drain method



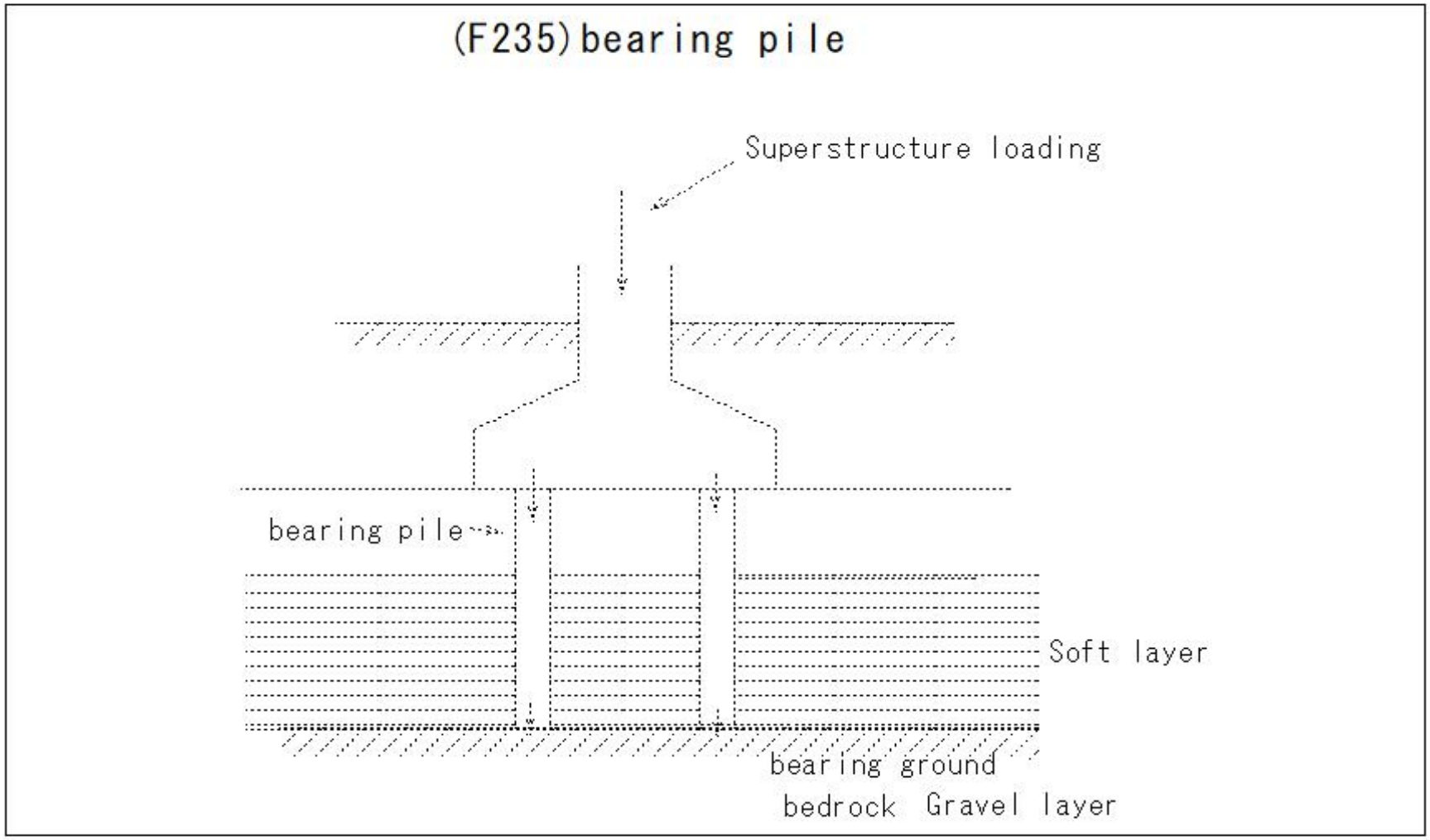
(F233)sand pile



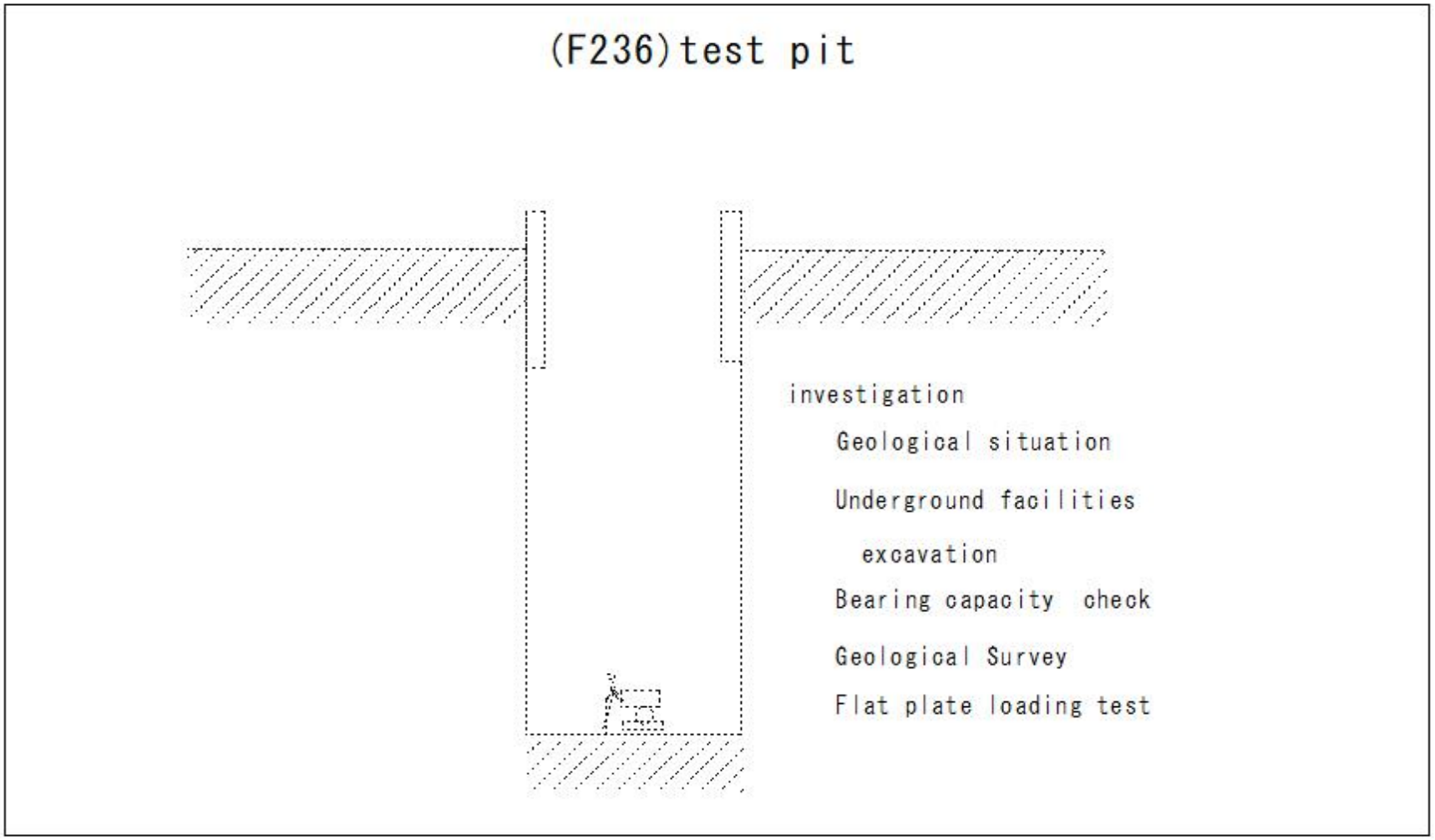
(F234)composer method



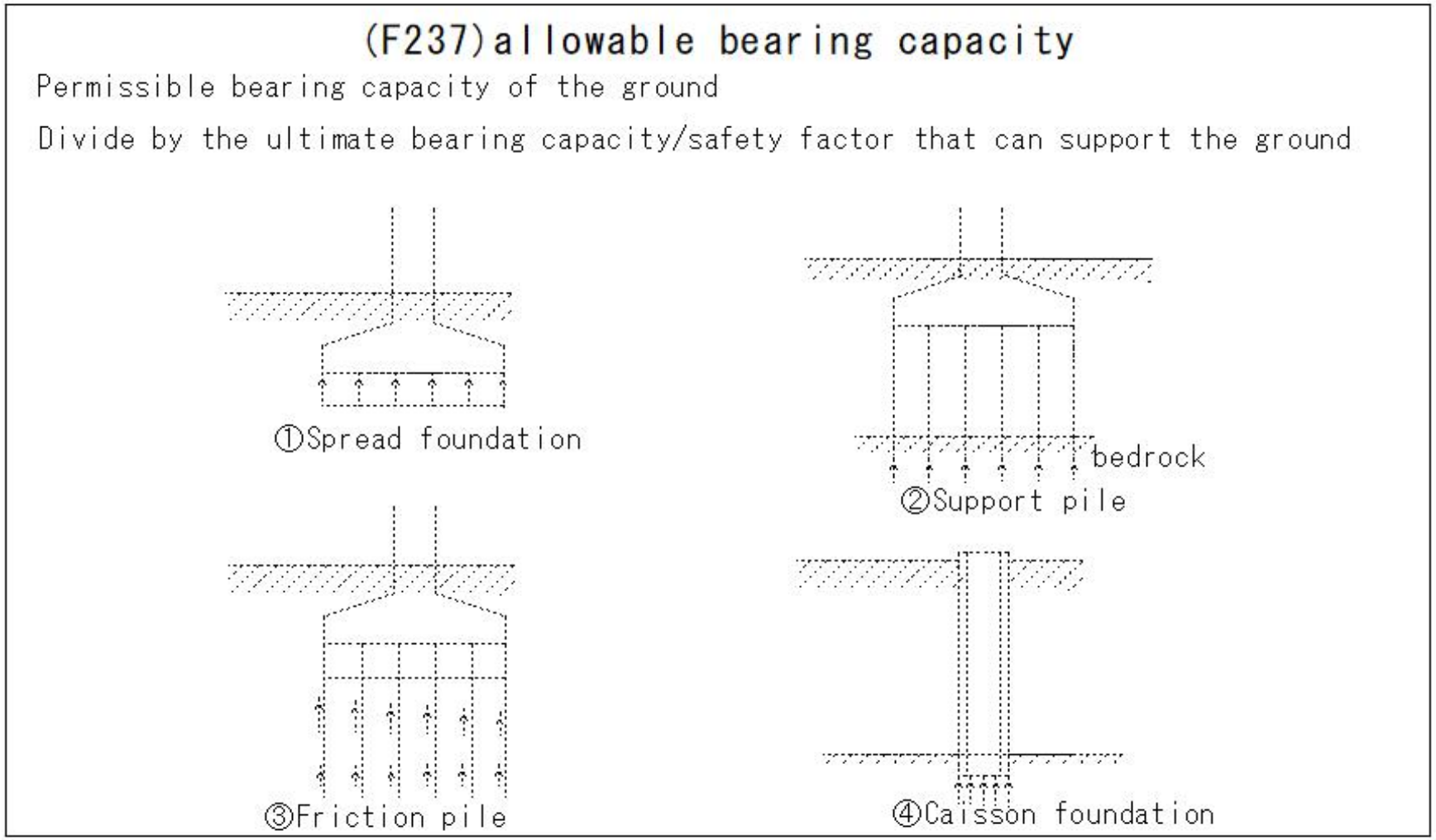
(F235)bearing pile



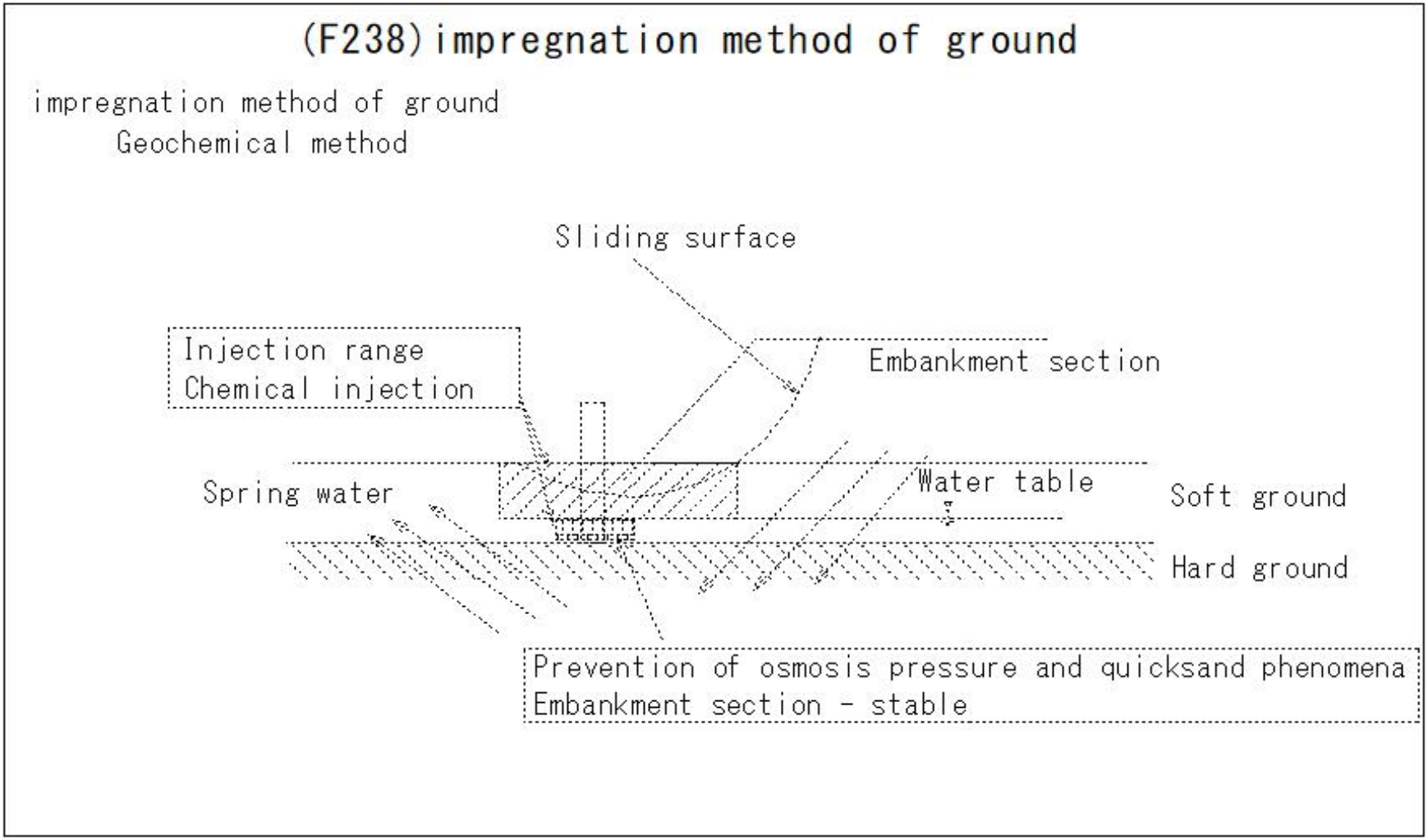
(F236)bearing pile



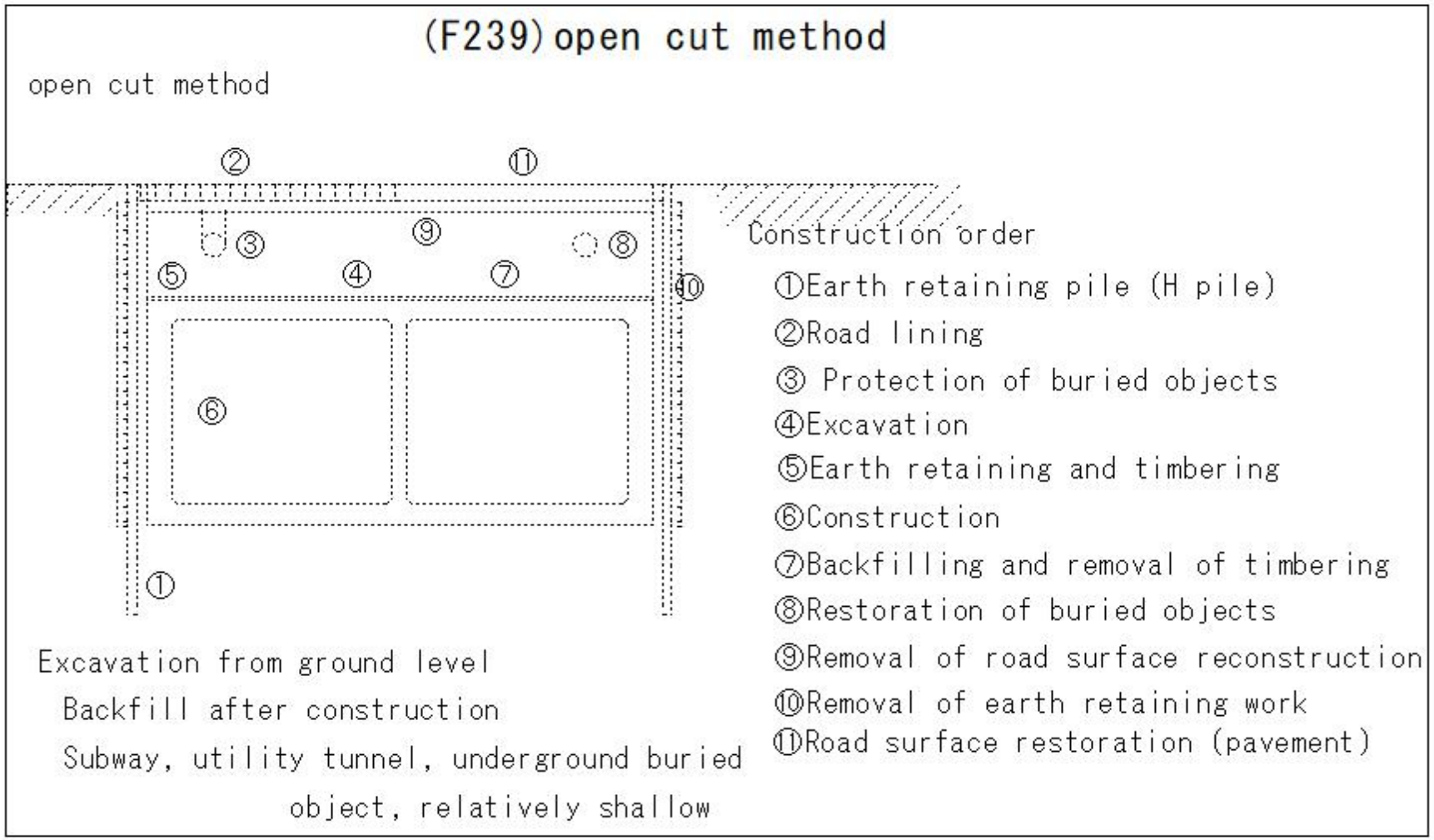
(F237)allowable bearing capacity



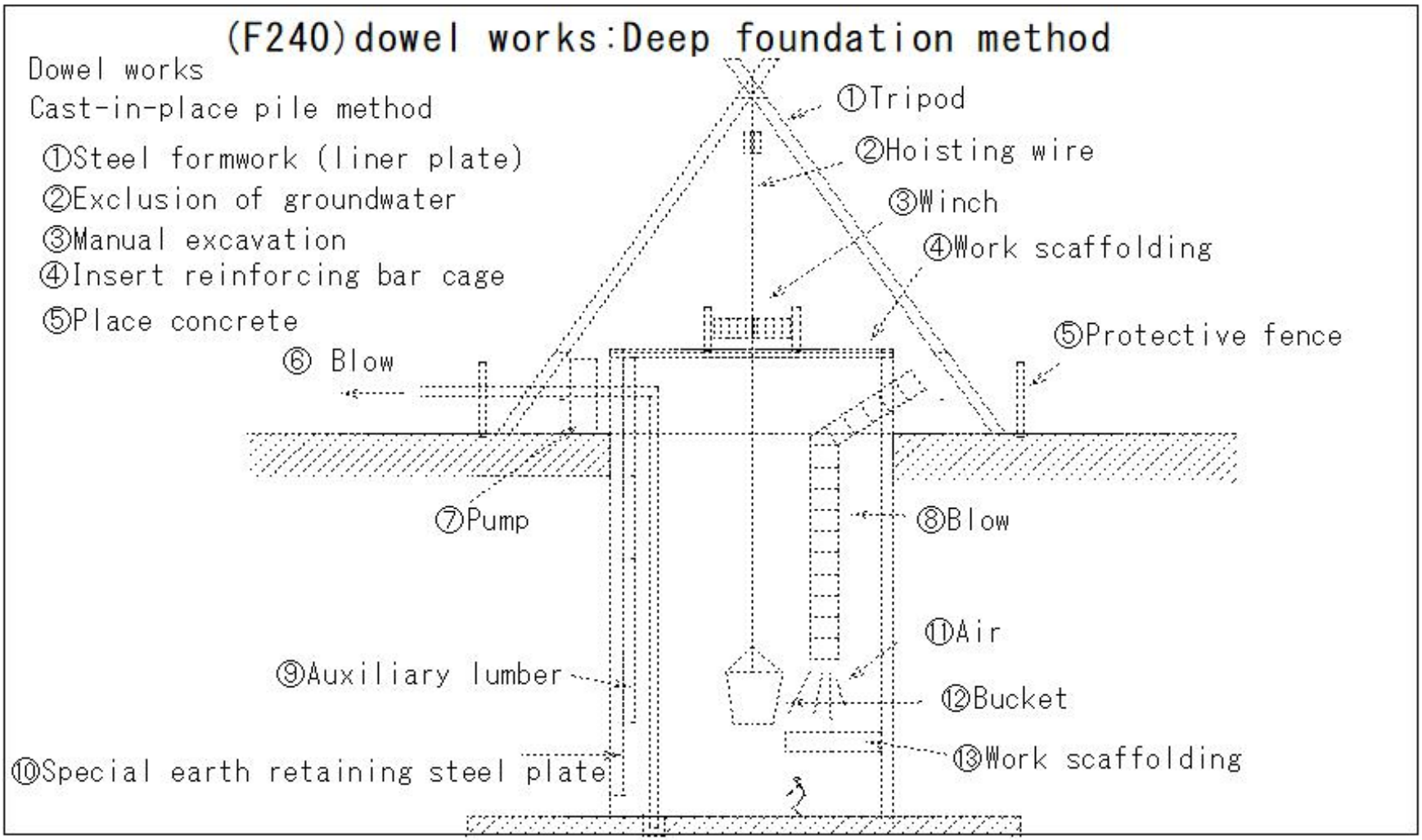
(F238)impregnation method of ground



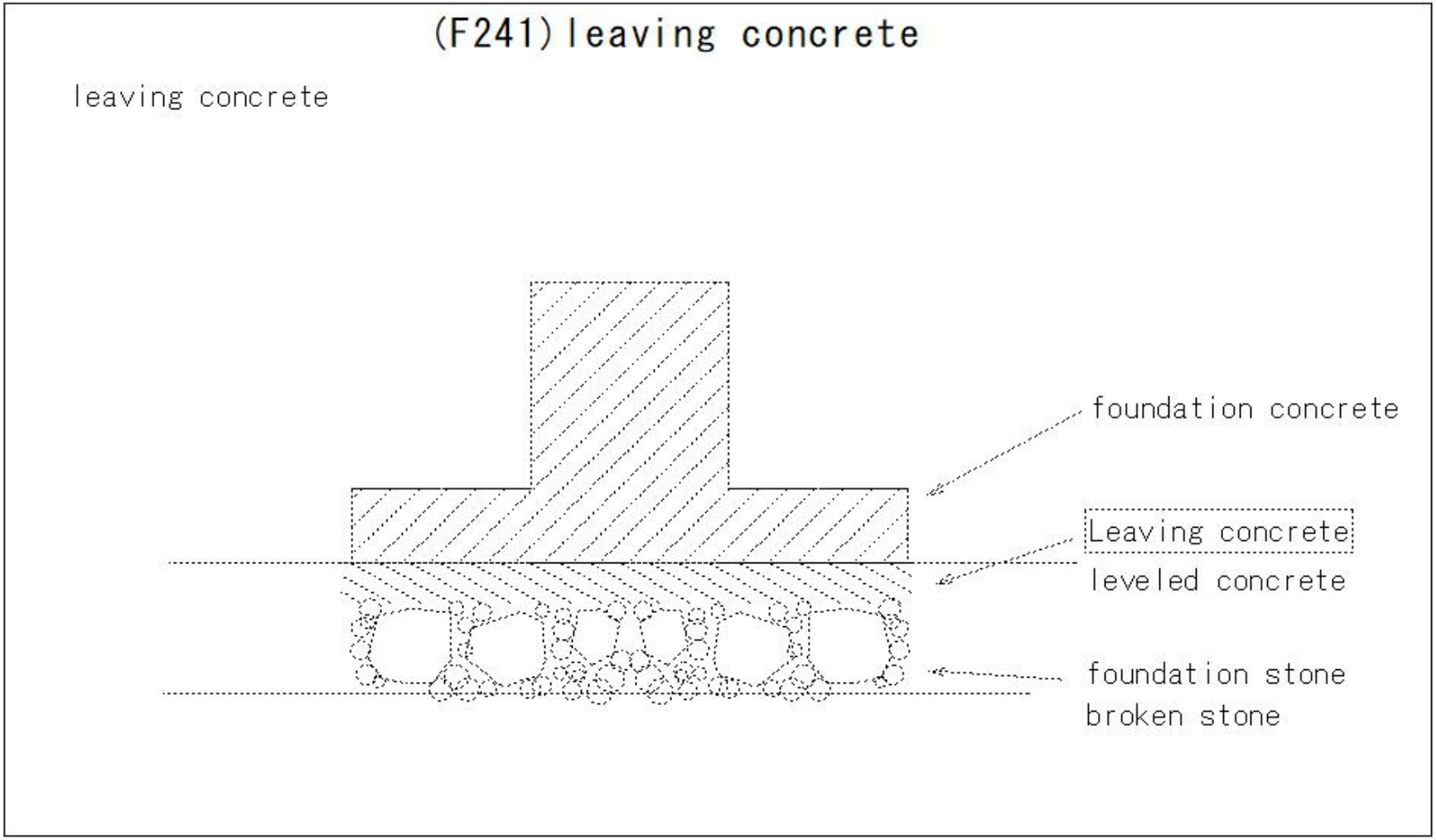
(F239)open cut method



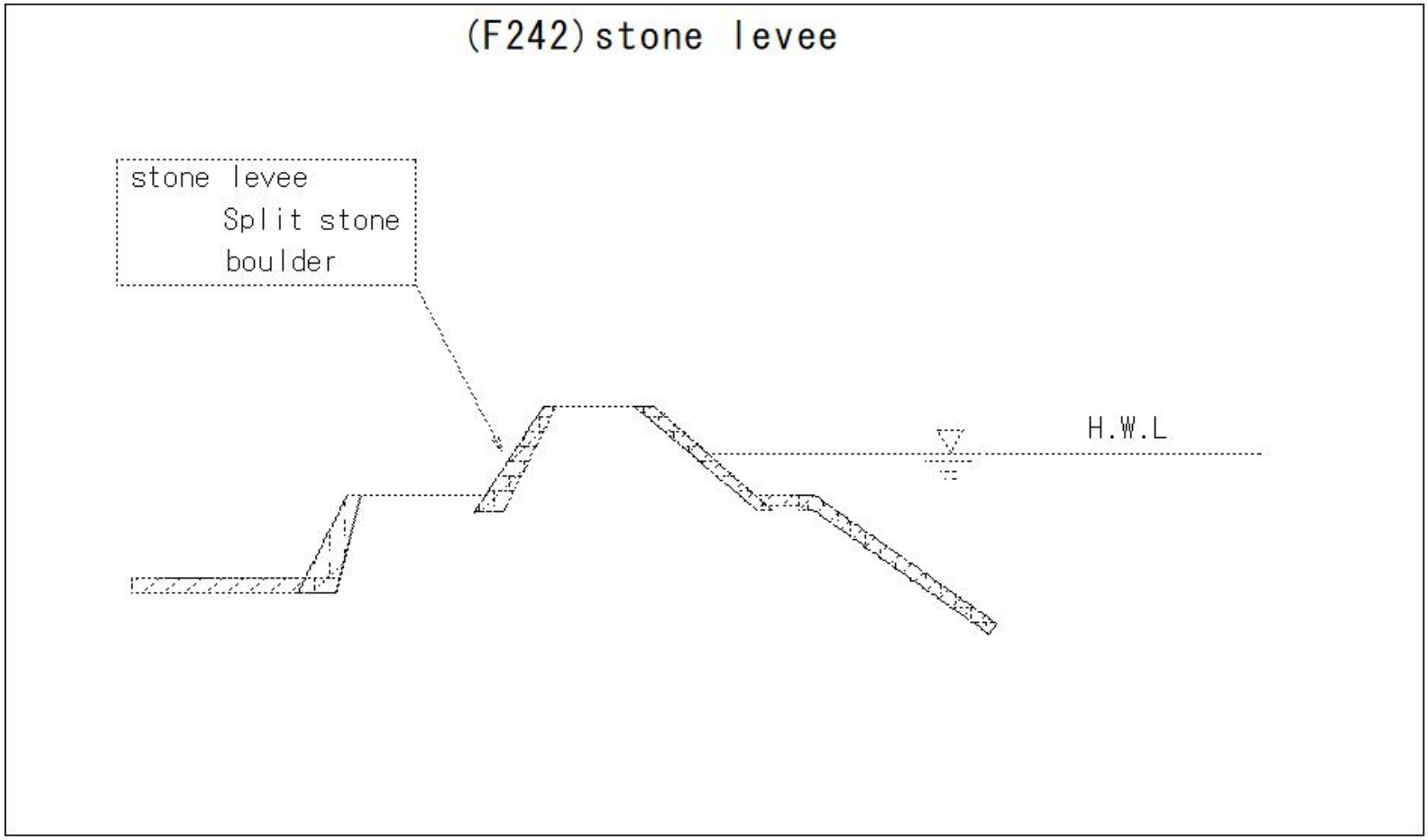
(F240)dowel works:Deep foundation method



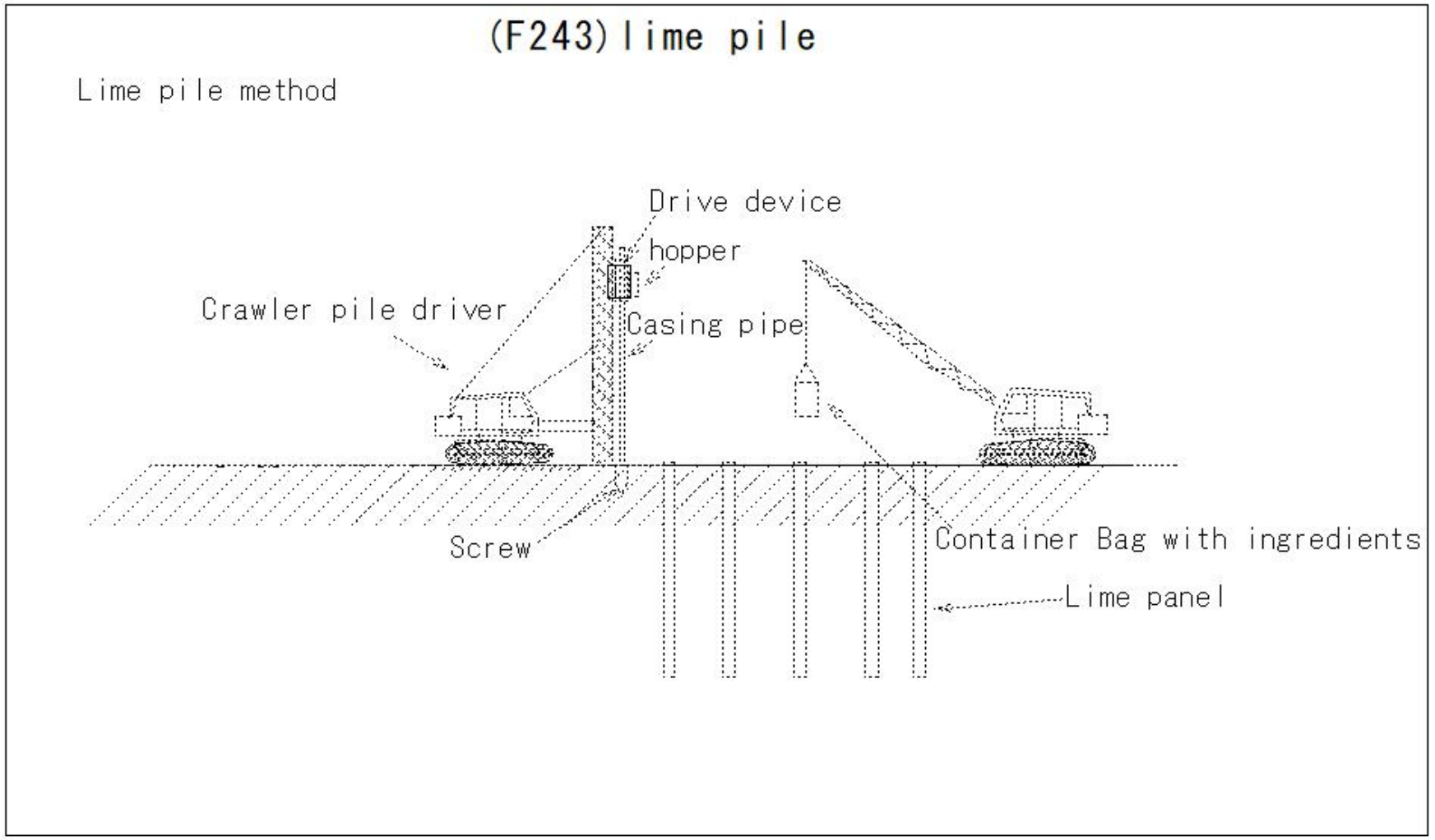
(F241)leaving concrete



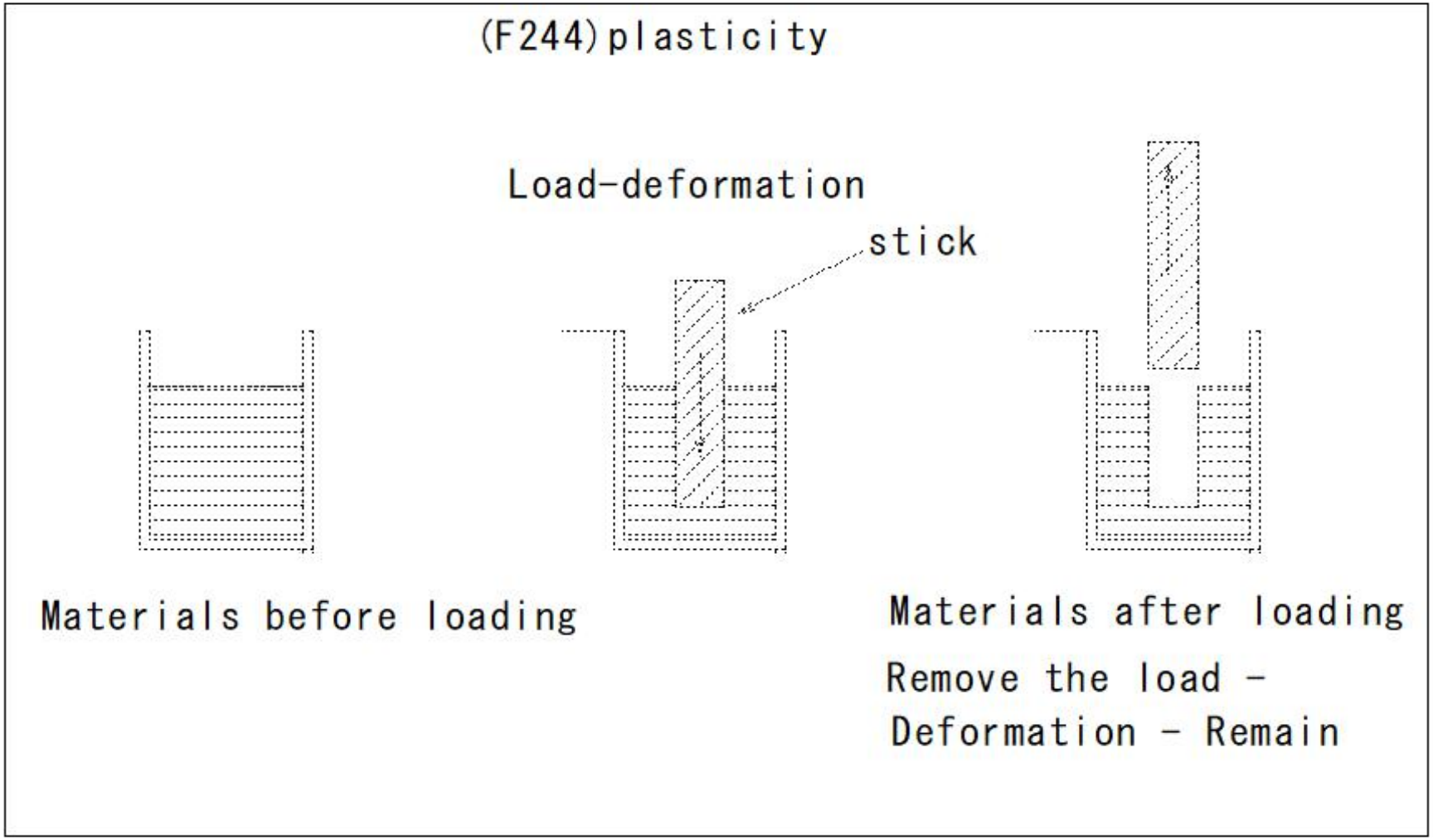
(F242)stone levee



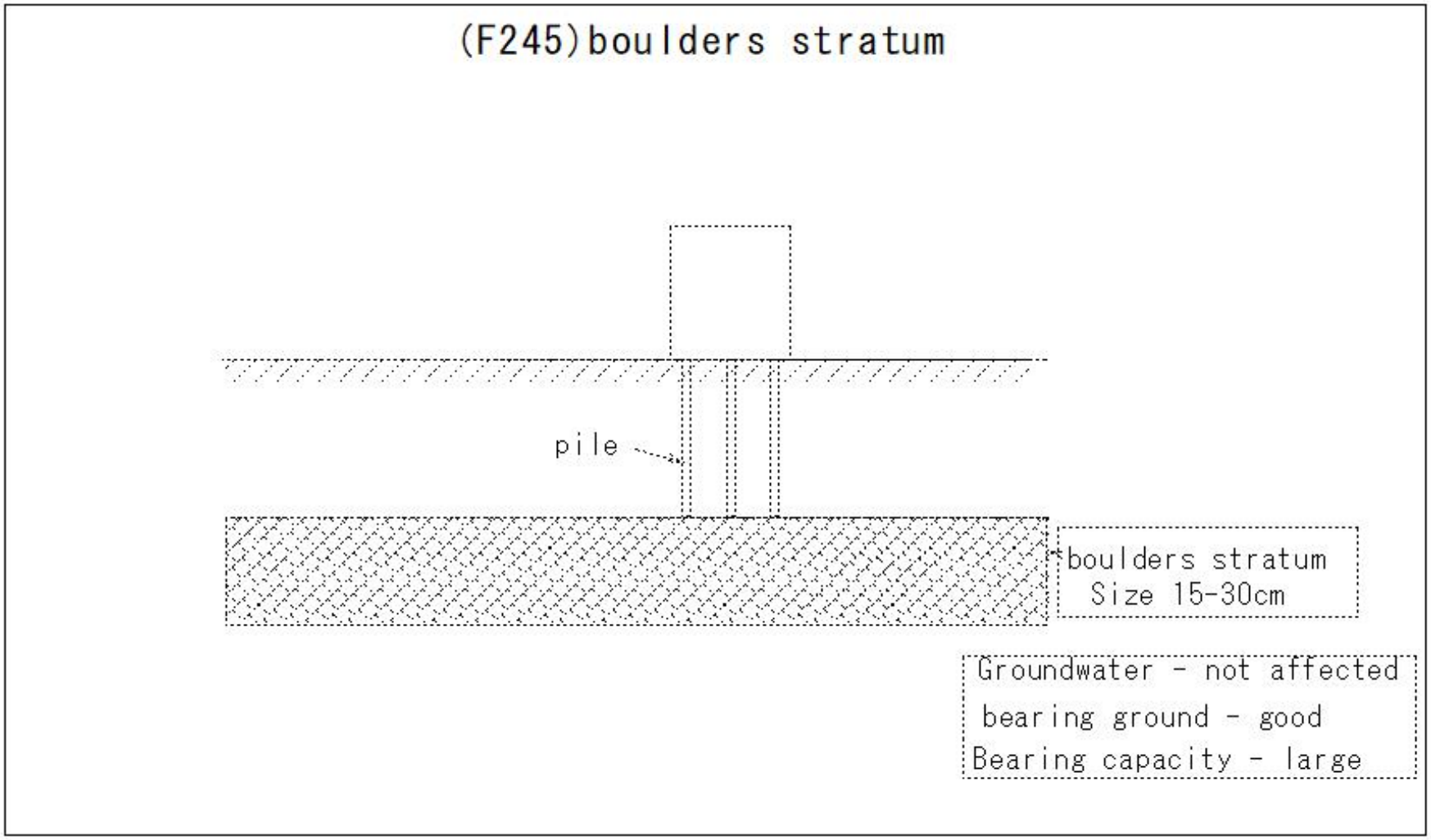
(F243)lime pile



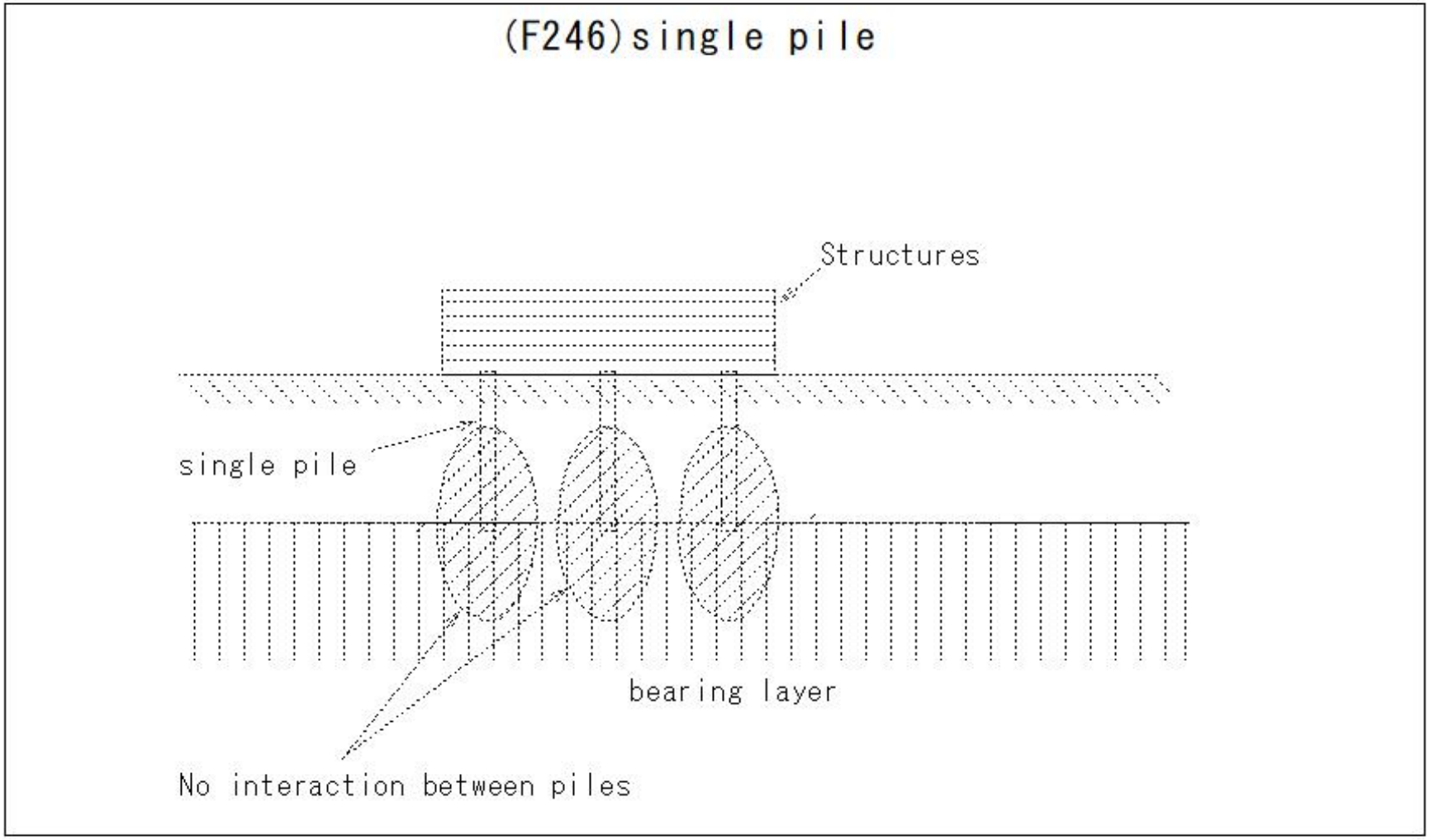
(F244)plasticity



(F245)boulders stratum



(F246)single pile

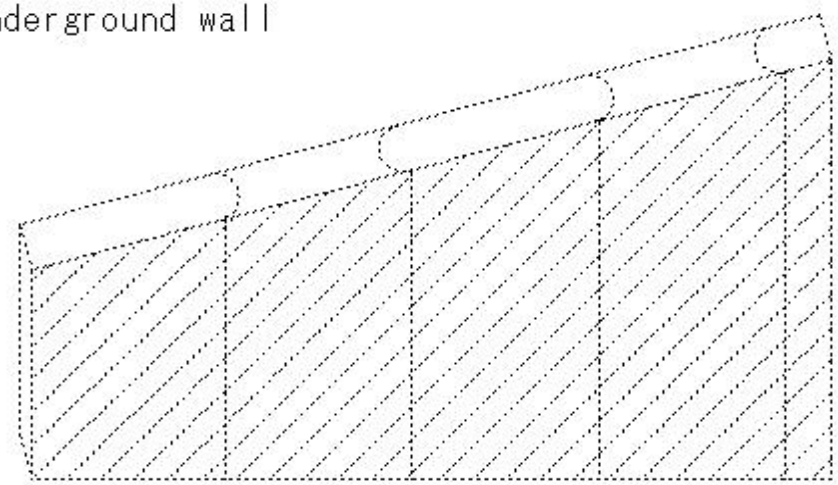


(F247)diaphragm wall

(F247)diaphragm wall

diaphragm wall

Continuous underground wall



Cast-in-place reinforced concrete wall

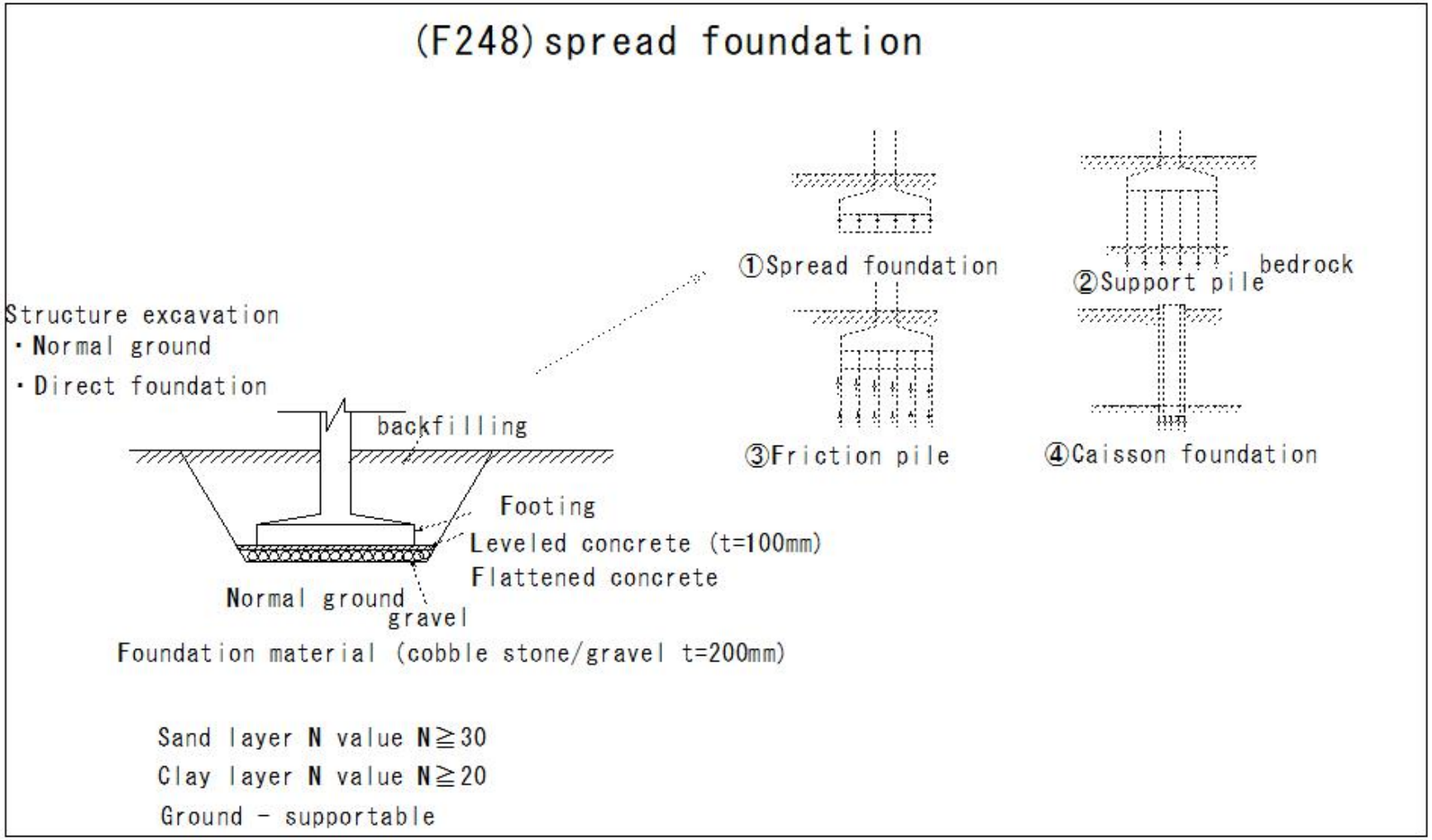
Diaphragm wall

Retaining wall

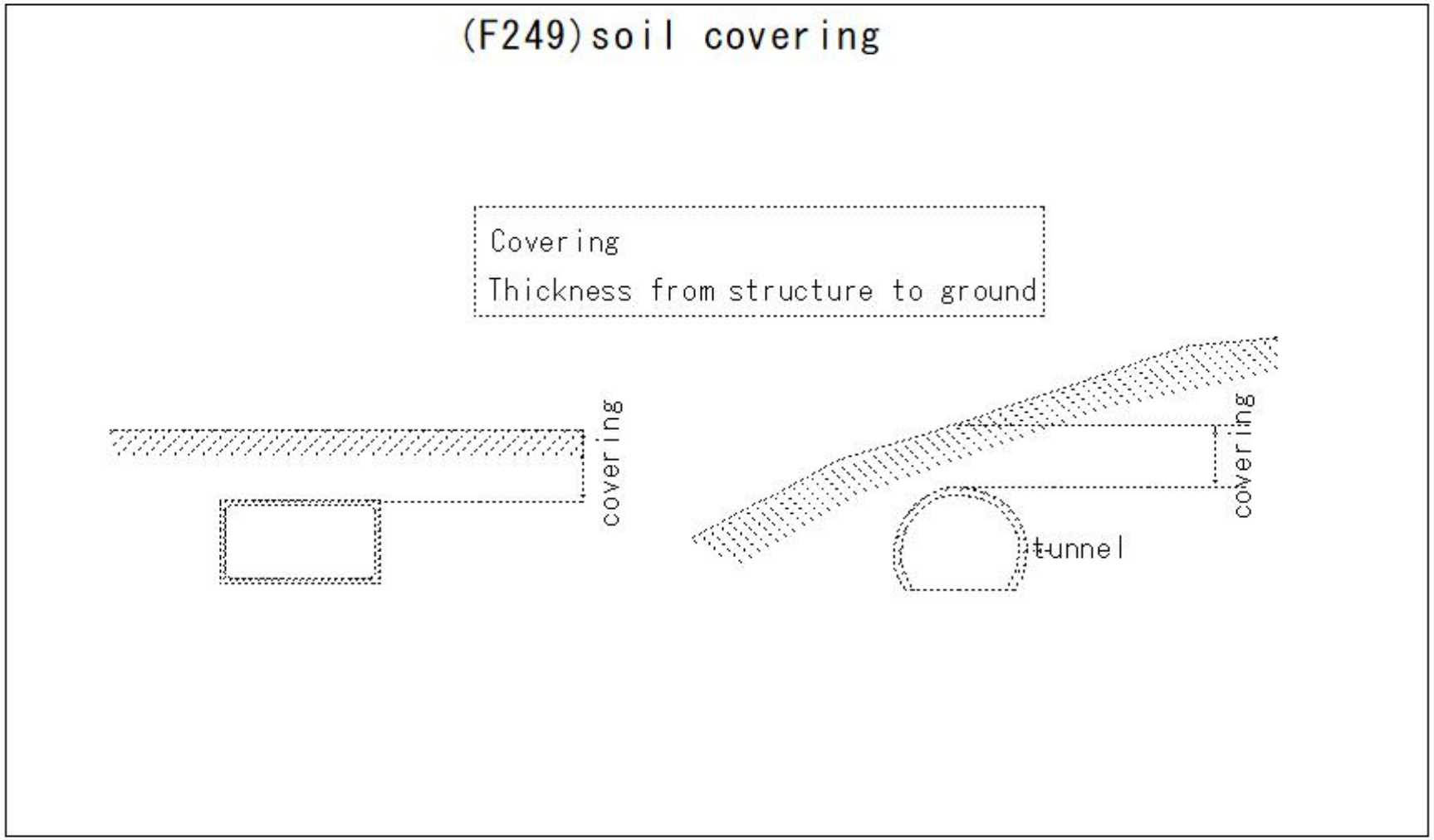
①Rigidity - High

②Soft ground - prevention of heaving and boiling

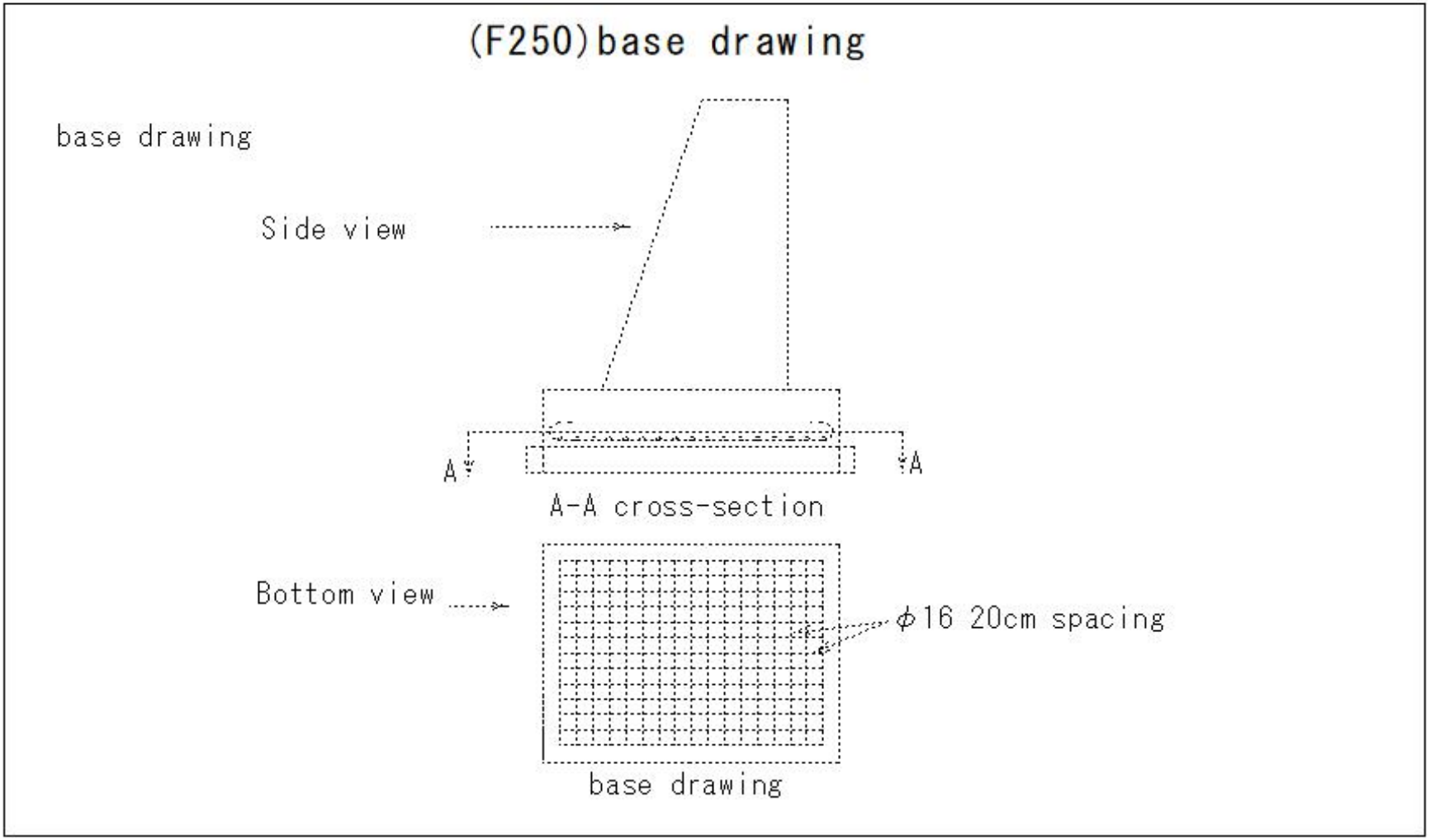
(F248)spread foundation



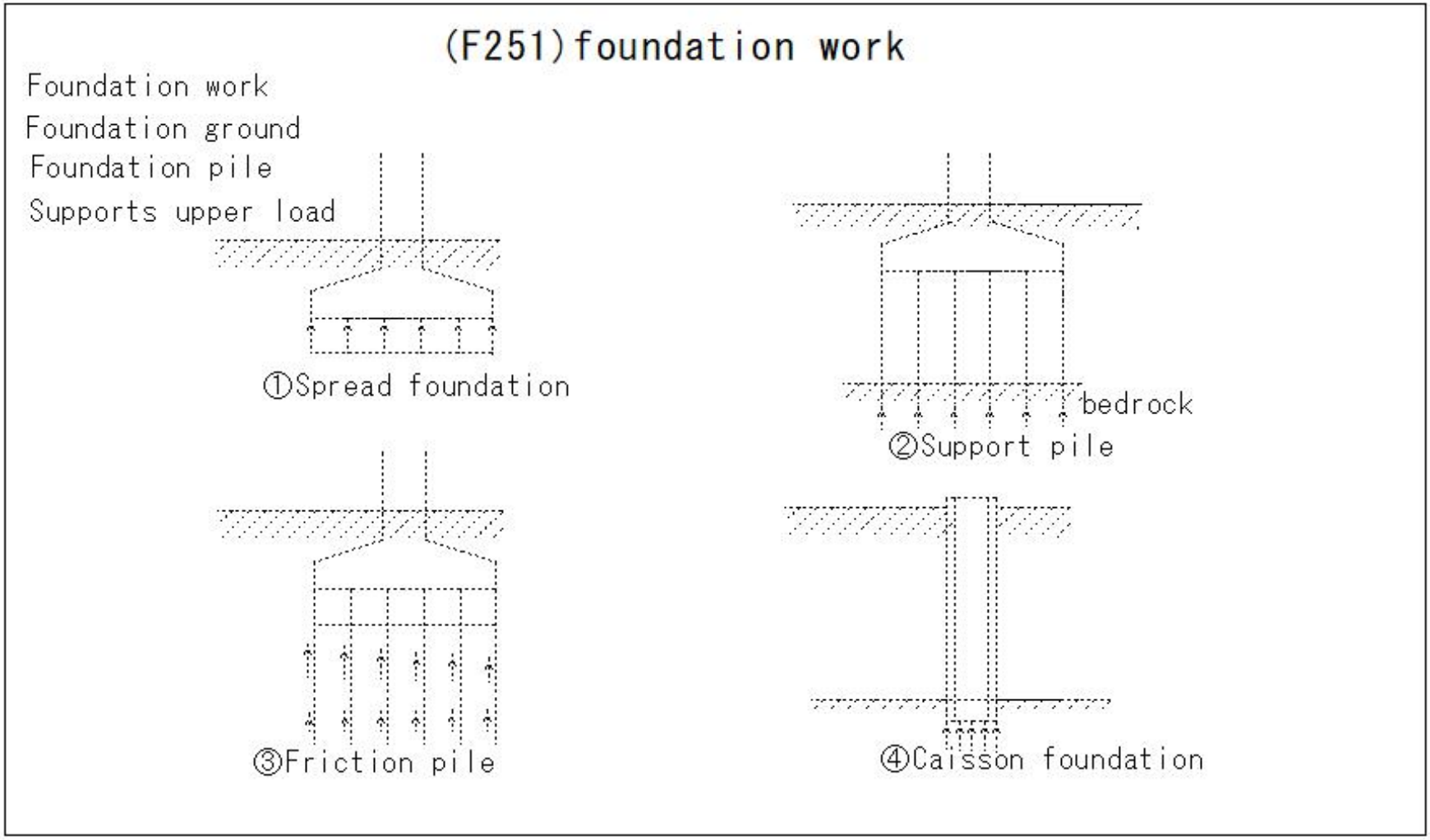
(F249)soil covering



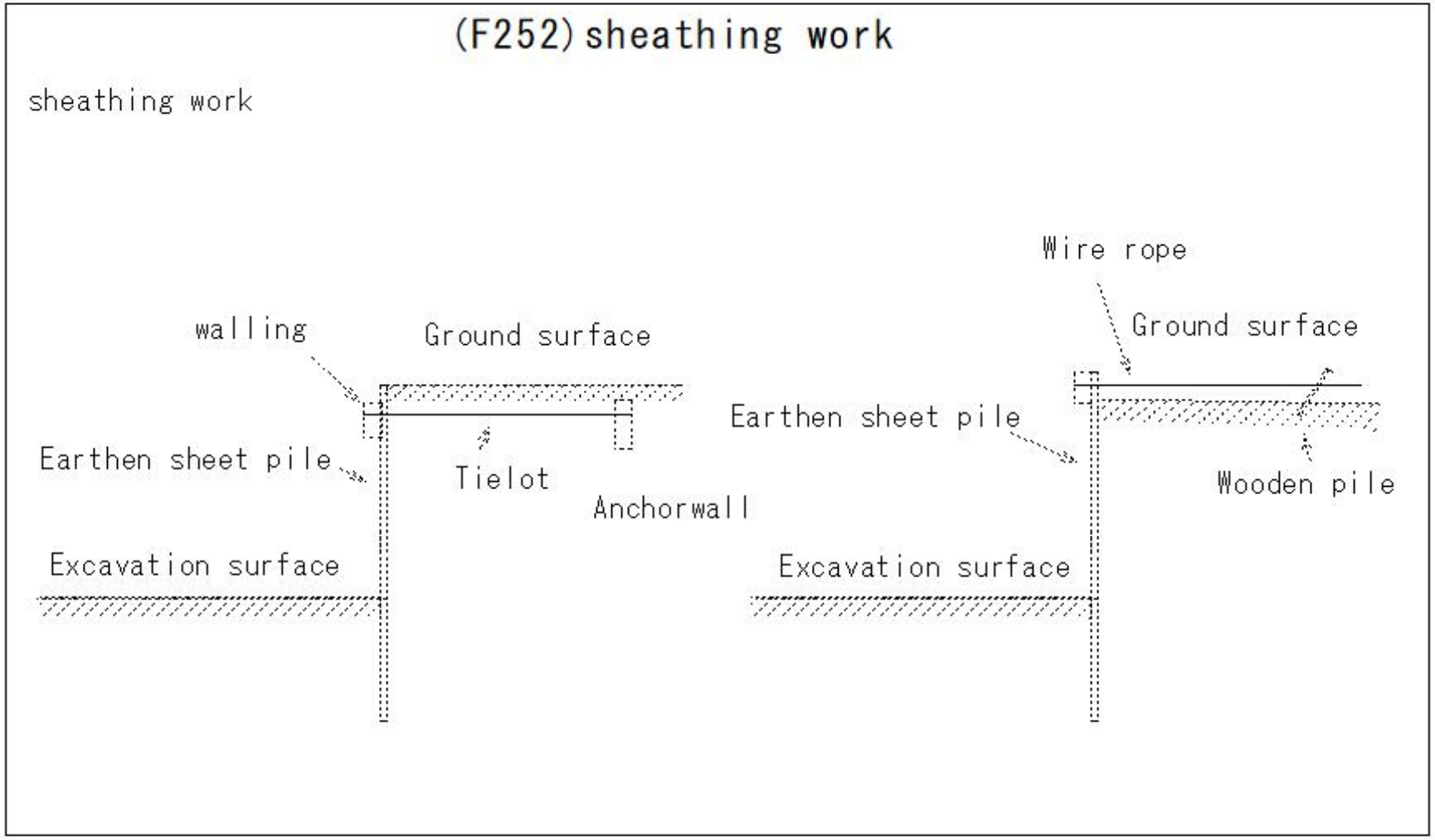
(F250)base drawing



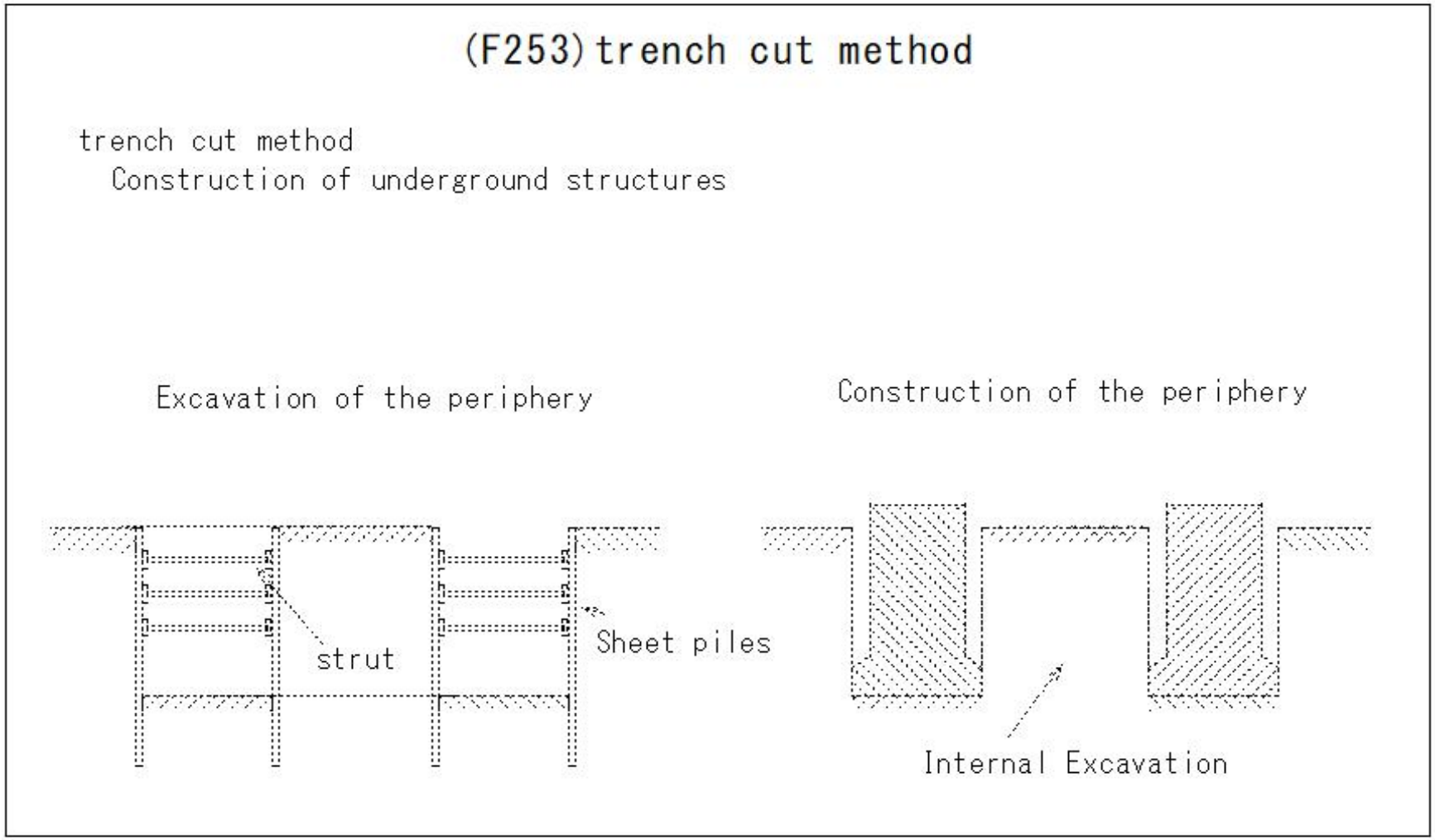
(F251)foundation work



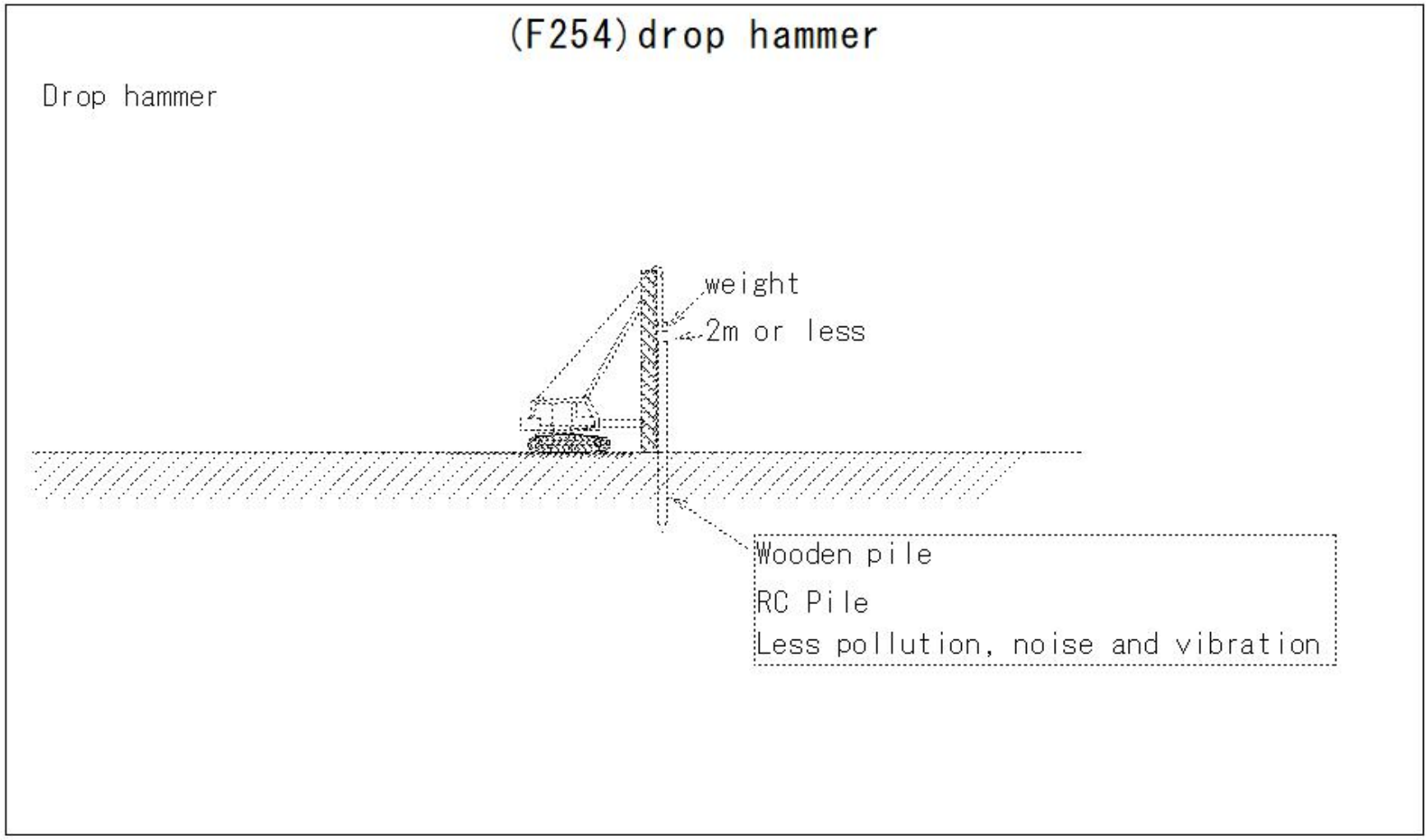
(F252)sheathing work



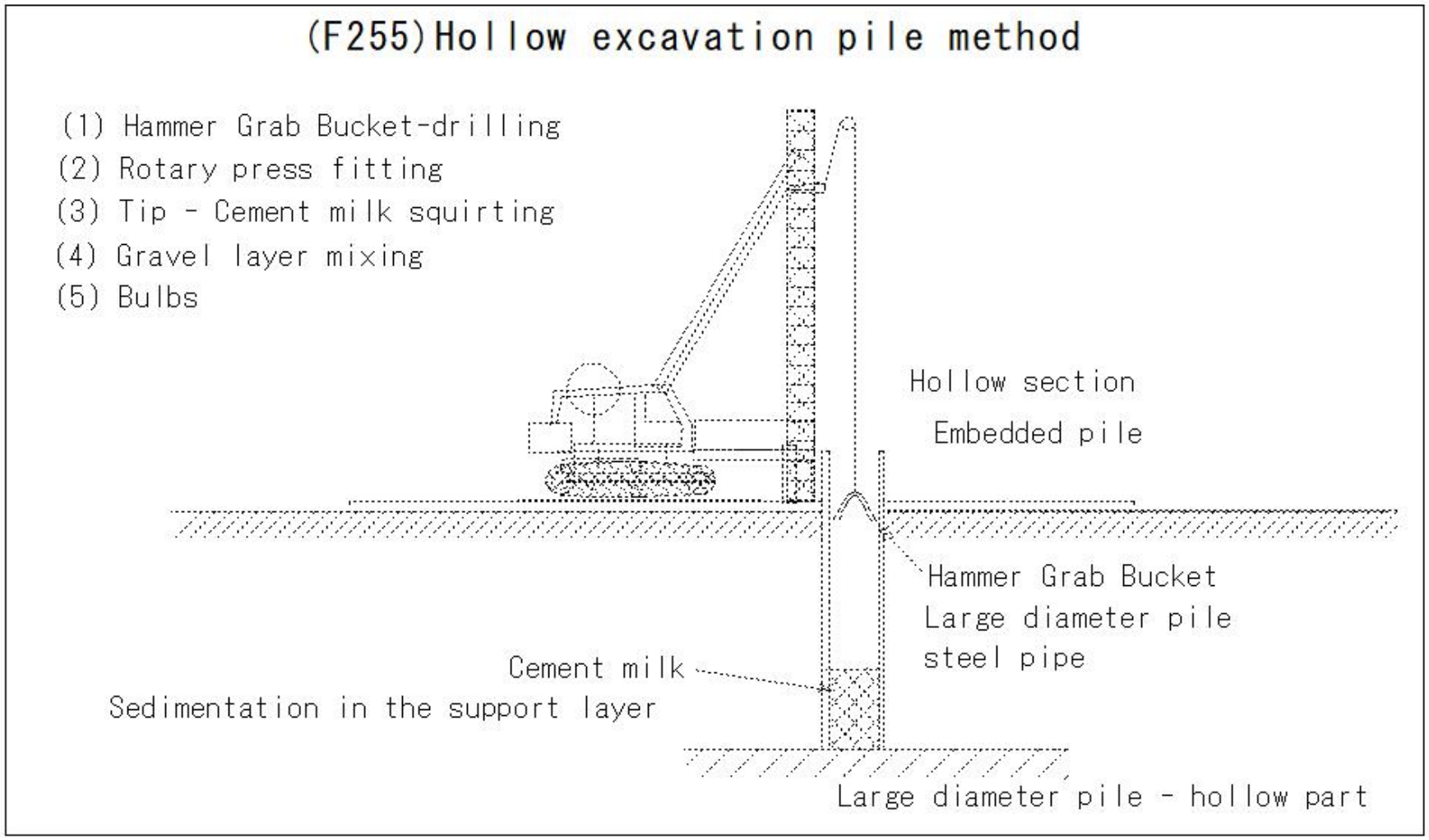
(F253)trench cut method



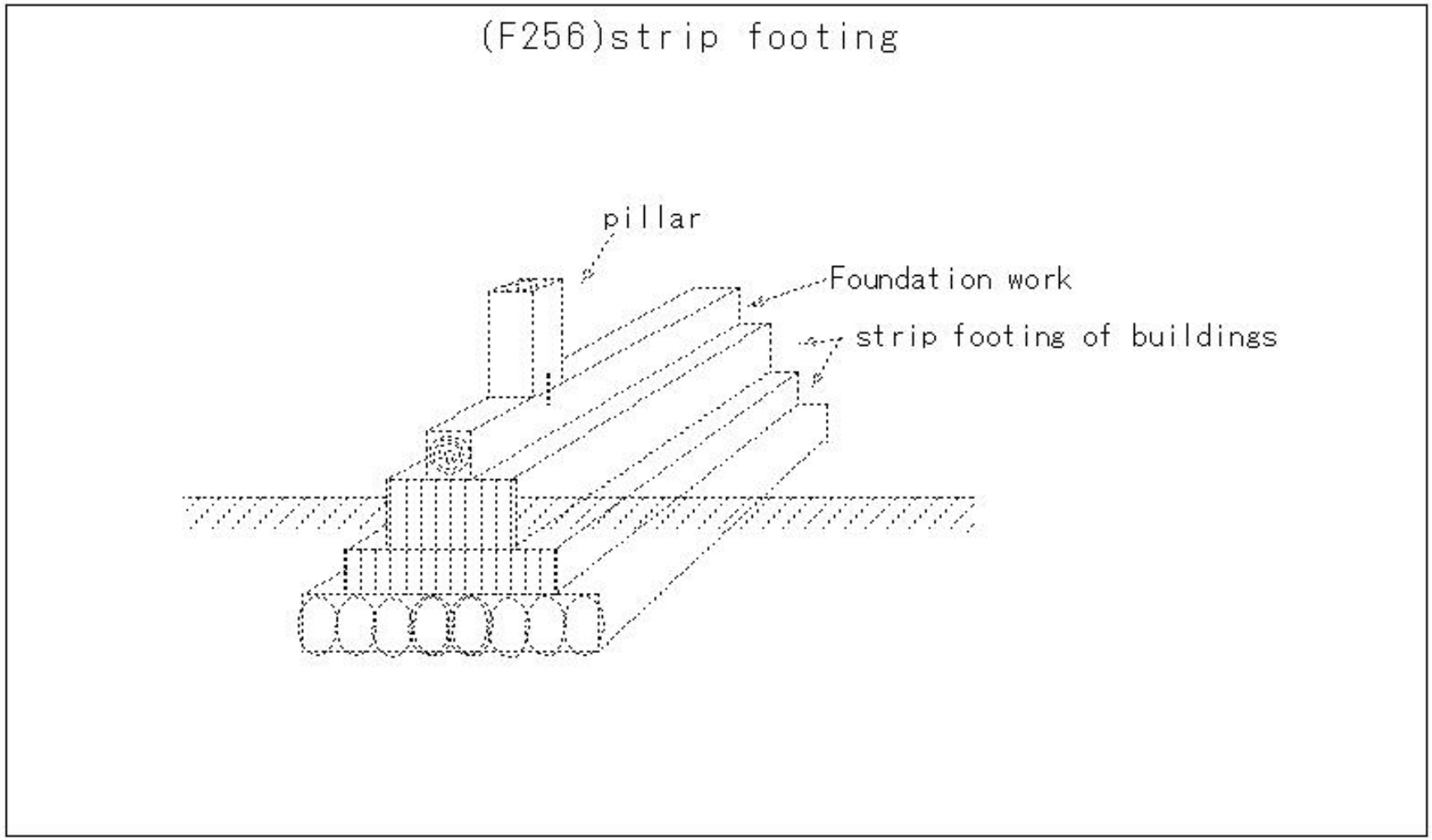
(F254)drop hammer



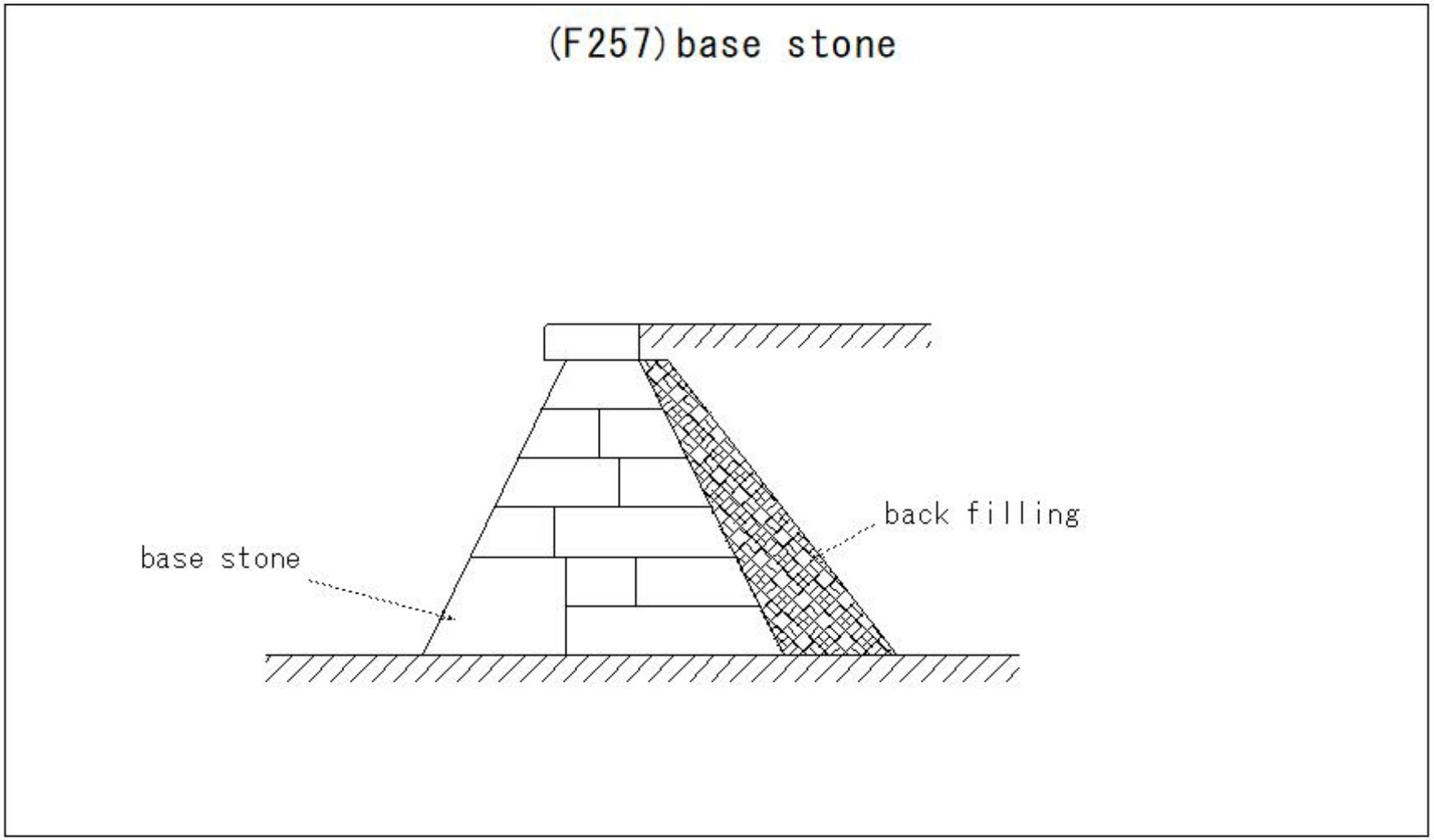
(F255)Hollow excavation pile method



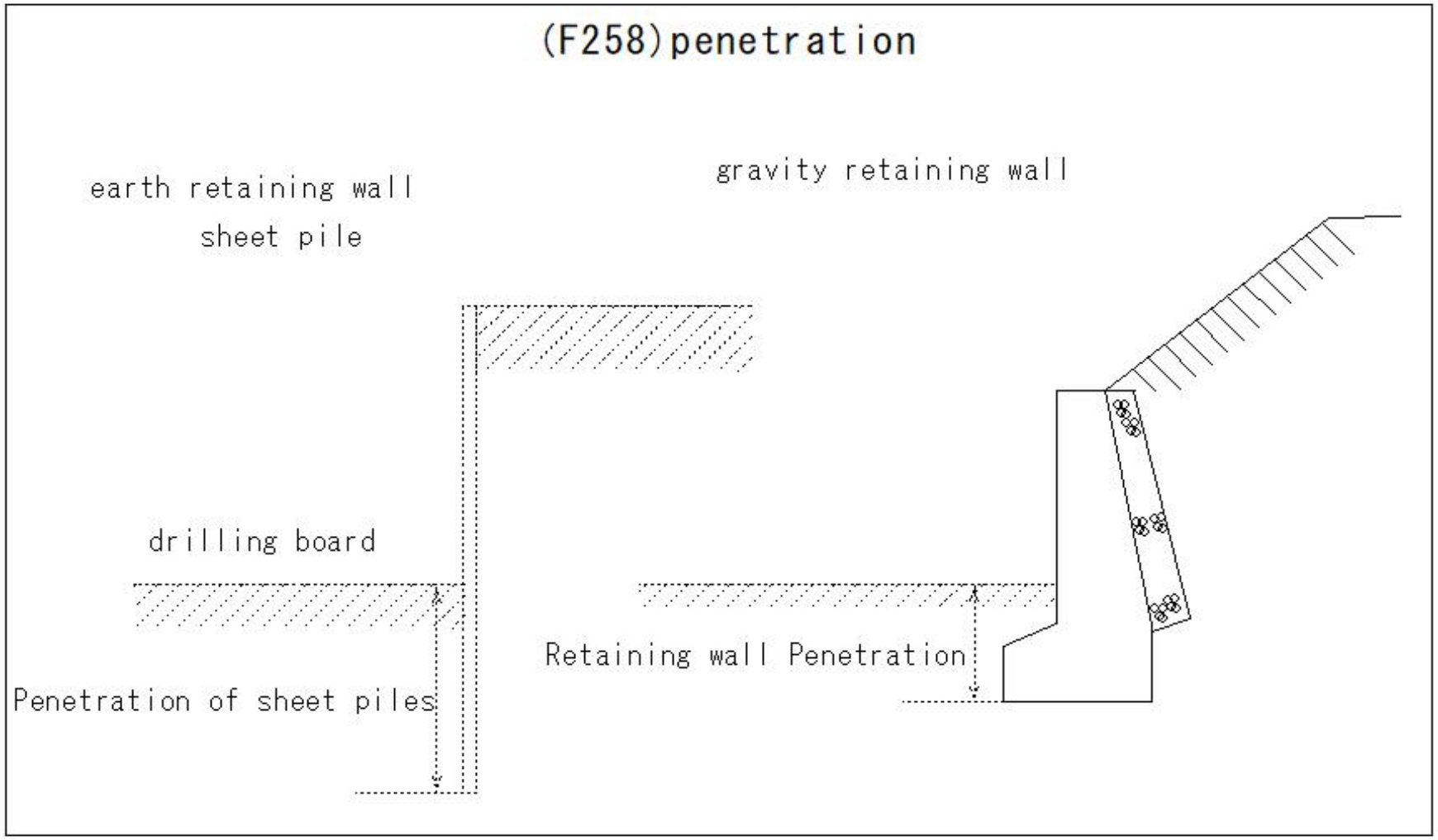
(F256)strip footing



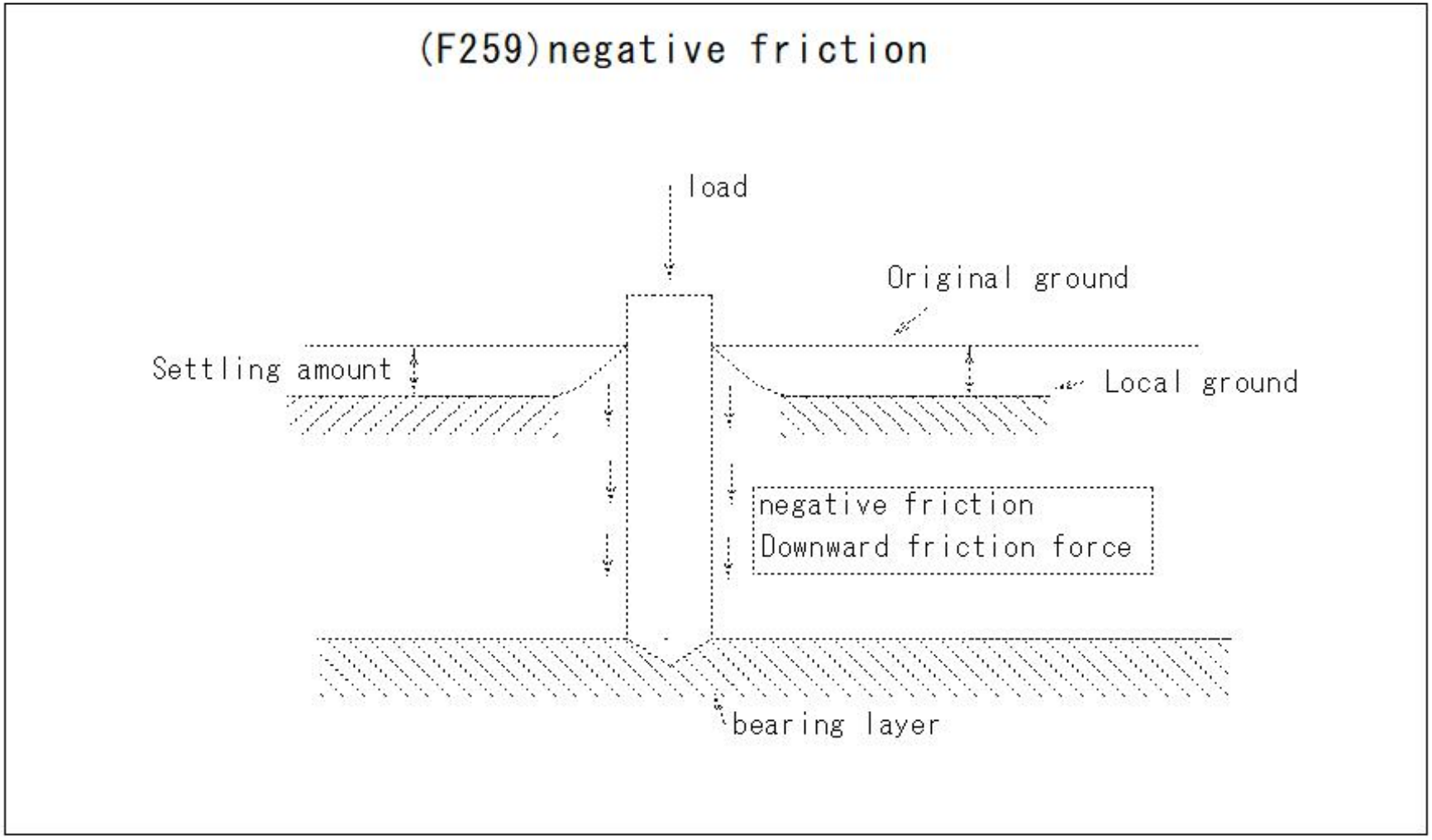
(F257)base stone



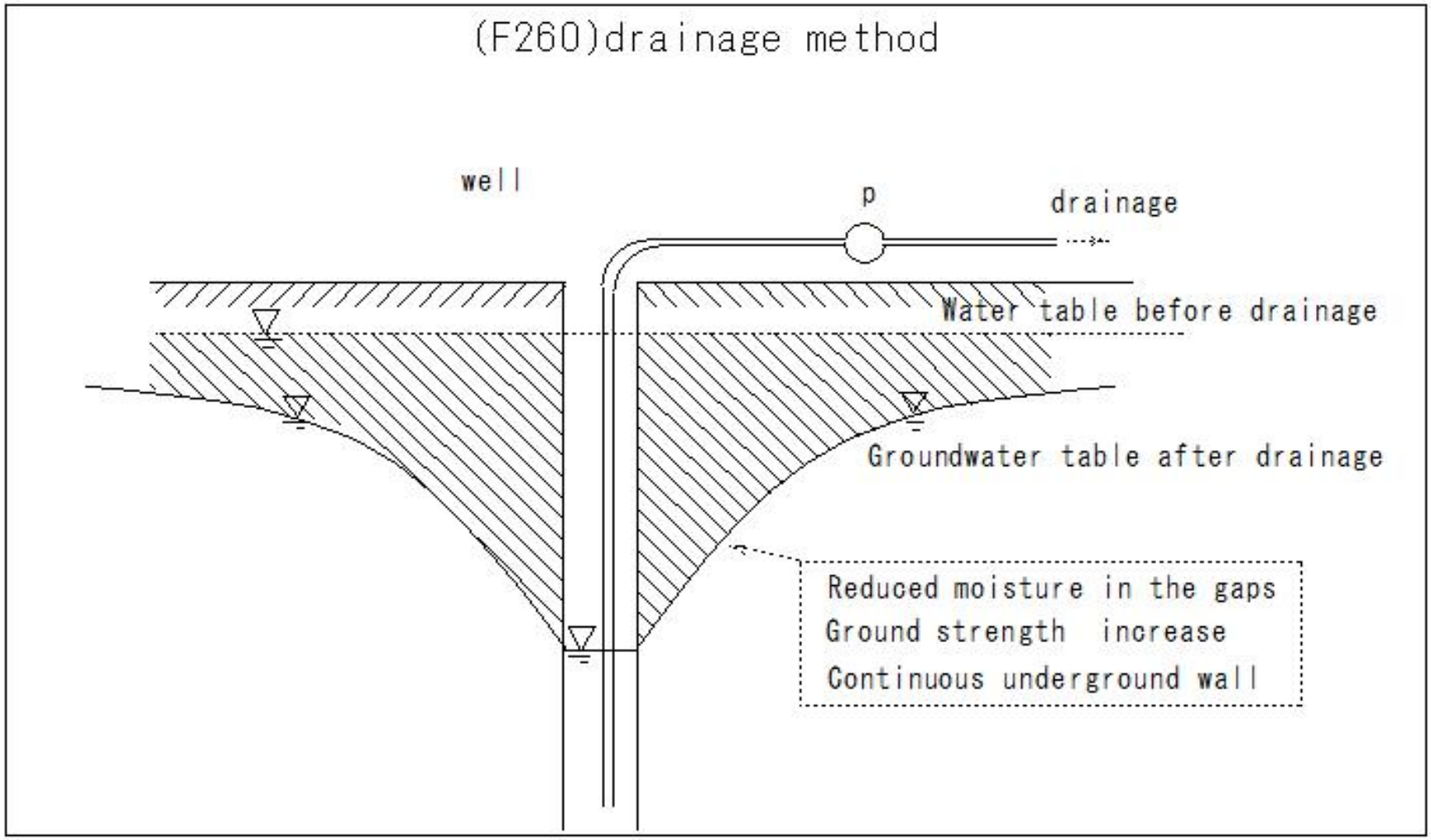
(F258)penetration



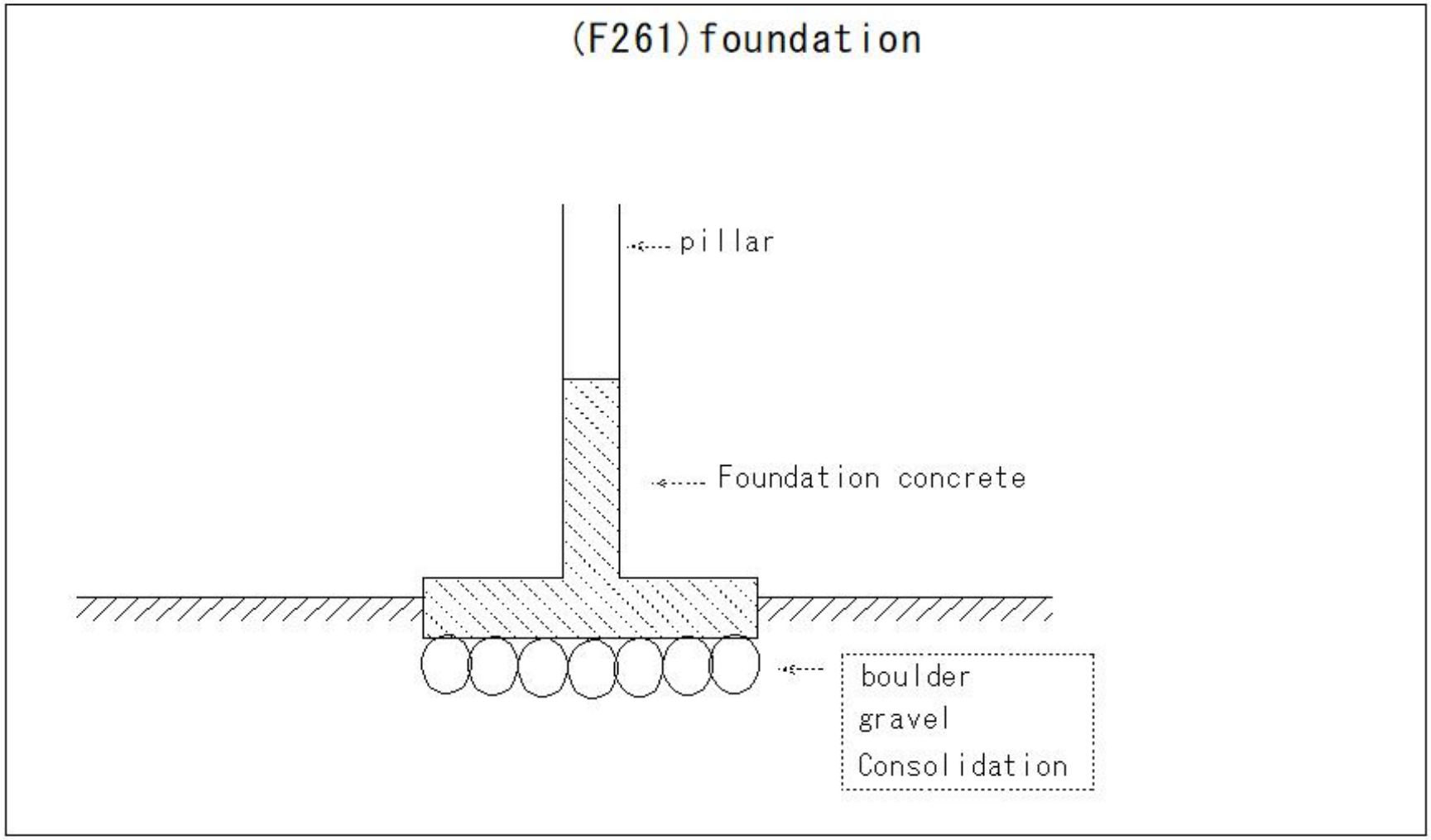
(F259)negative friction



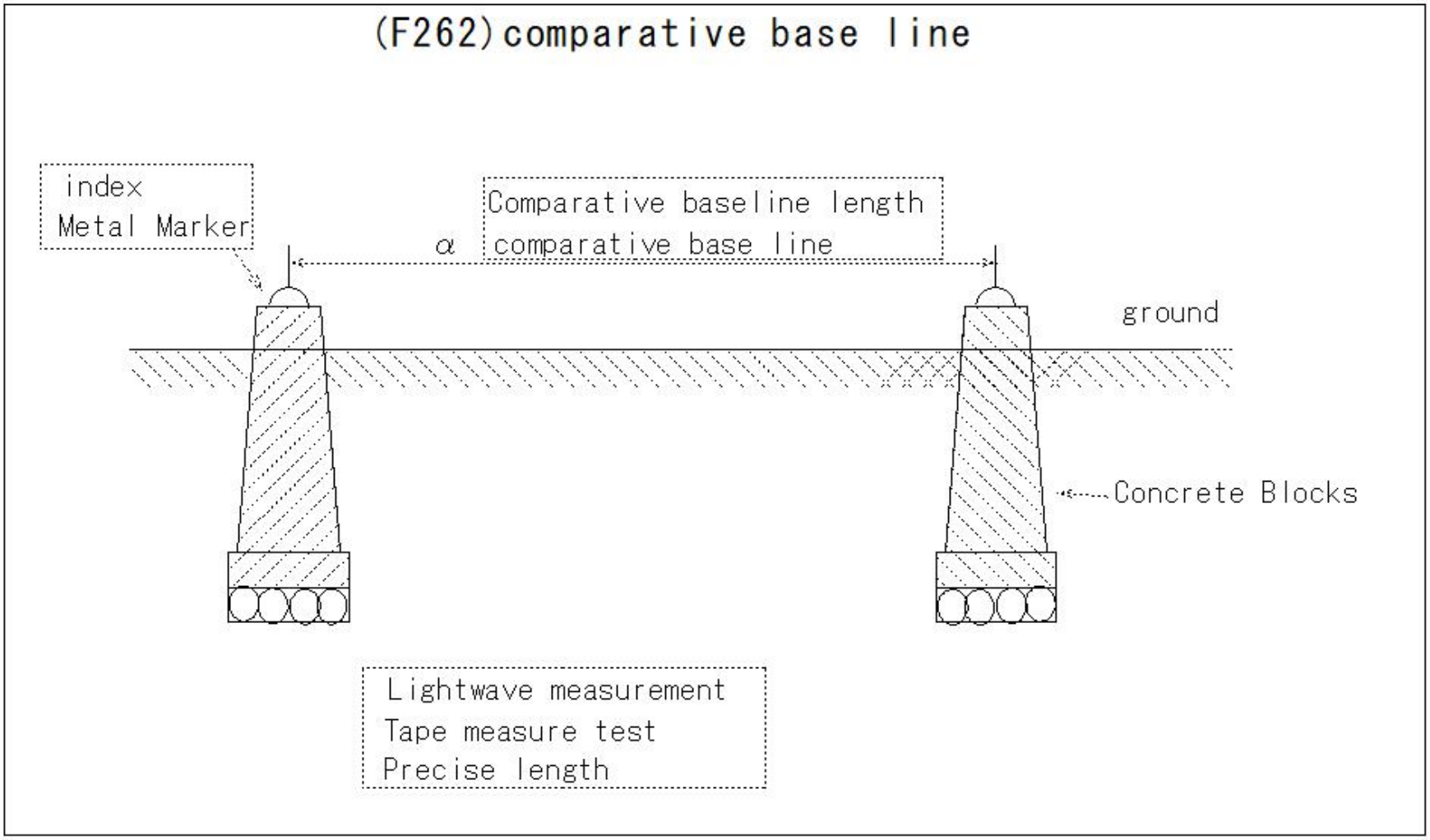
(F260)drainage method



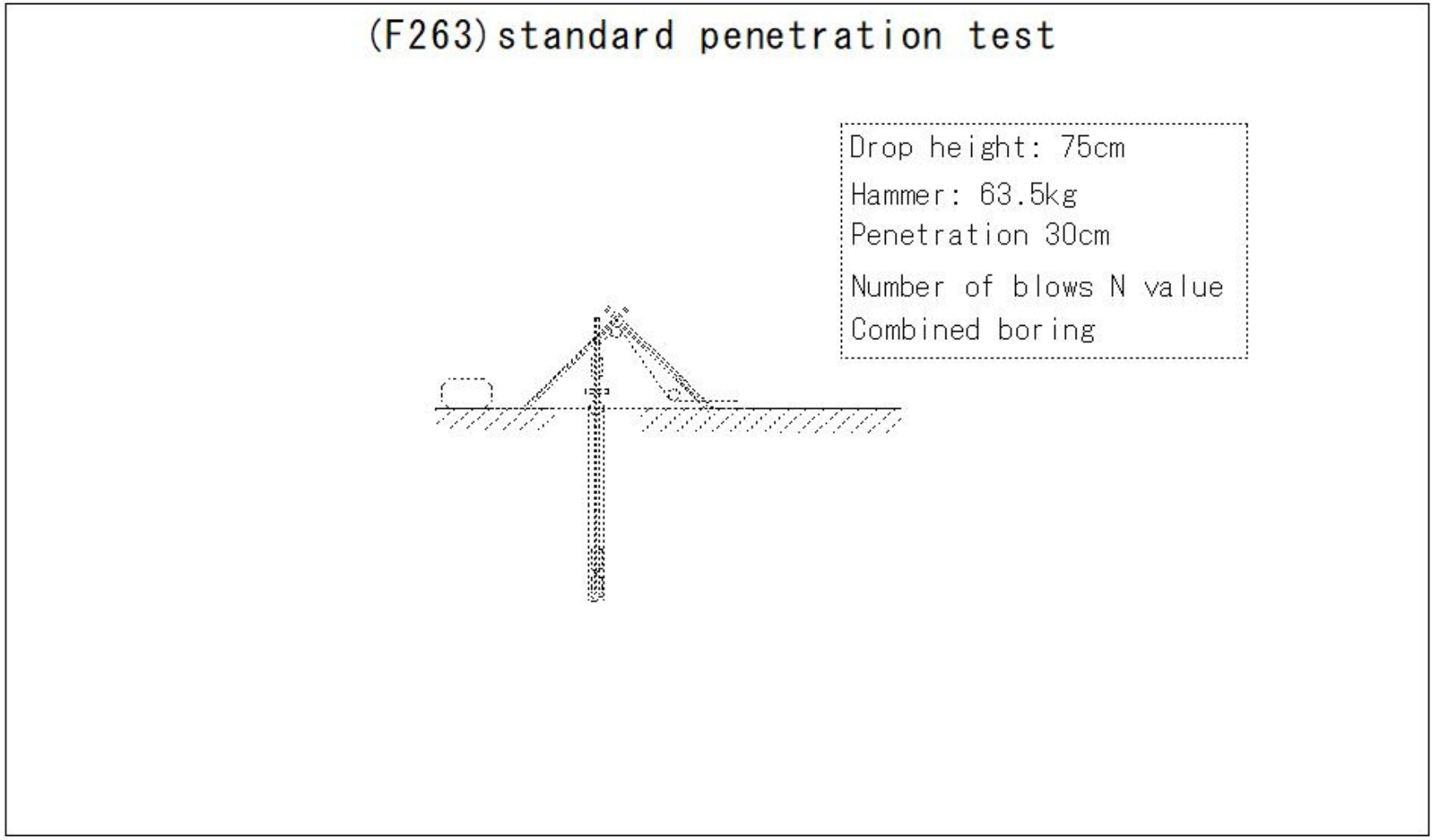
(F261)foundation



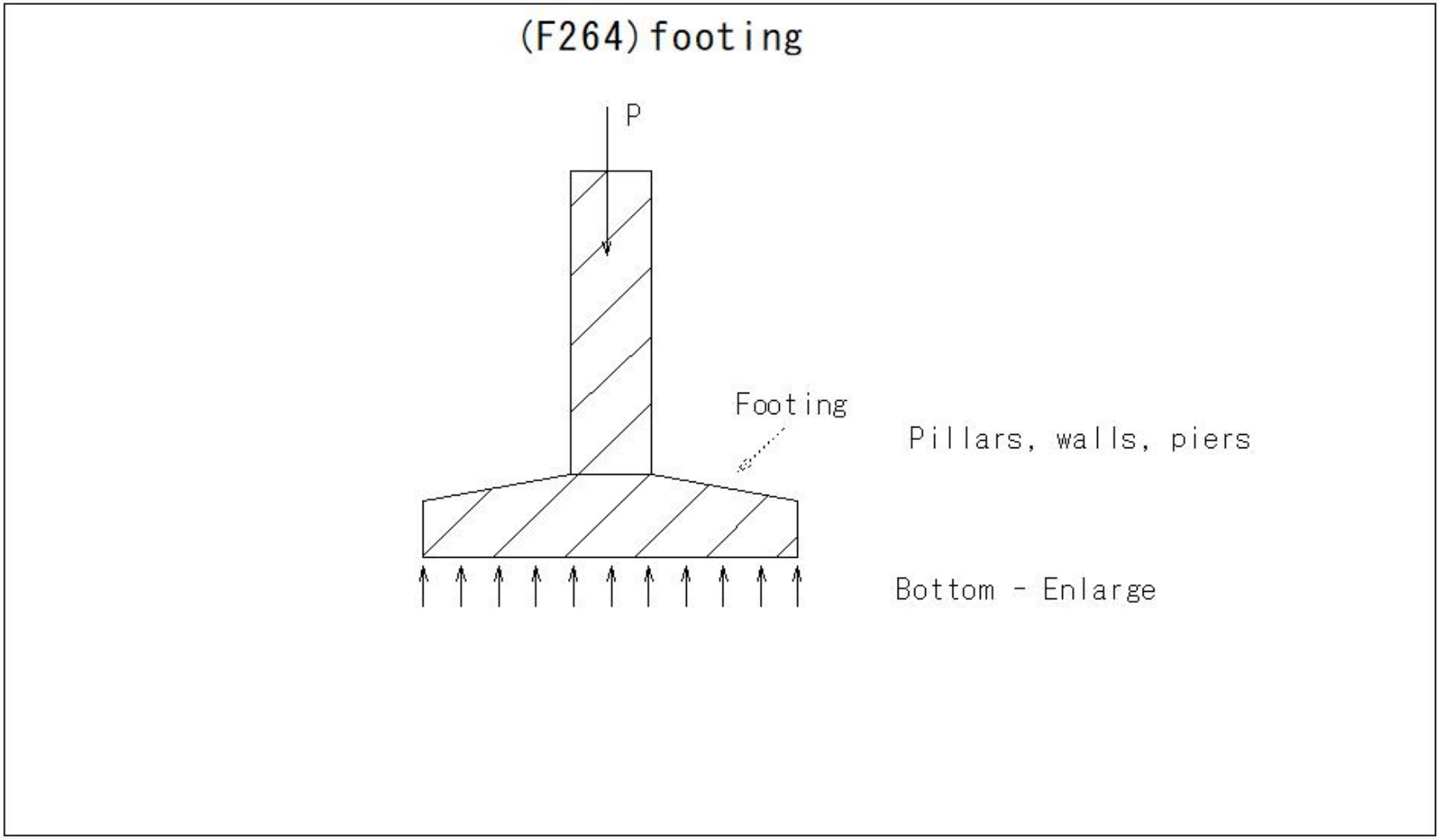
(F262)comparative base line



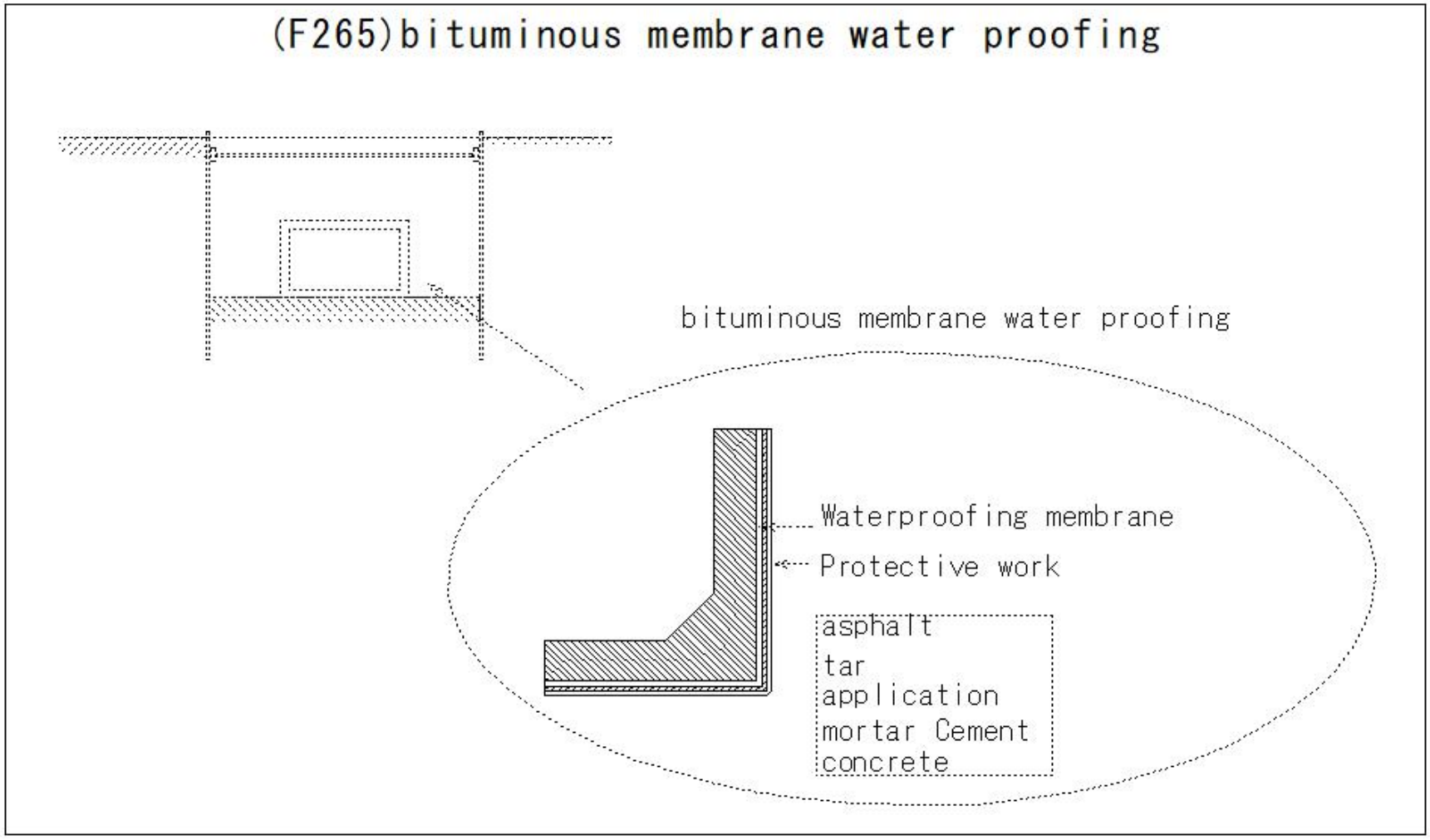
(F263)standard penetration test



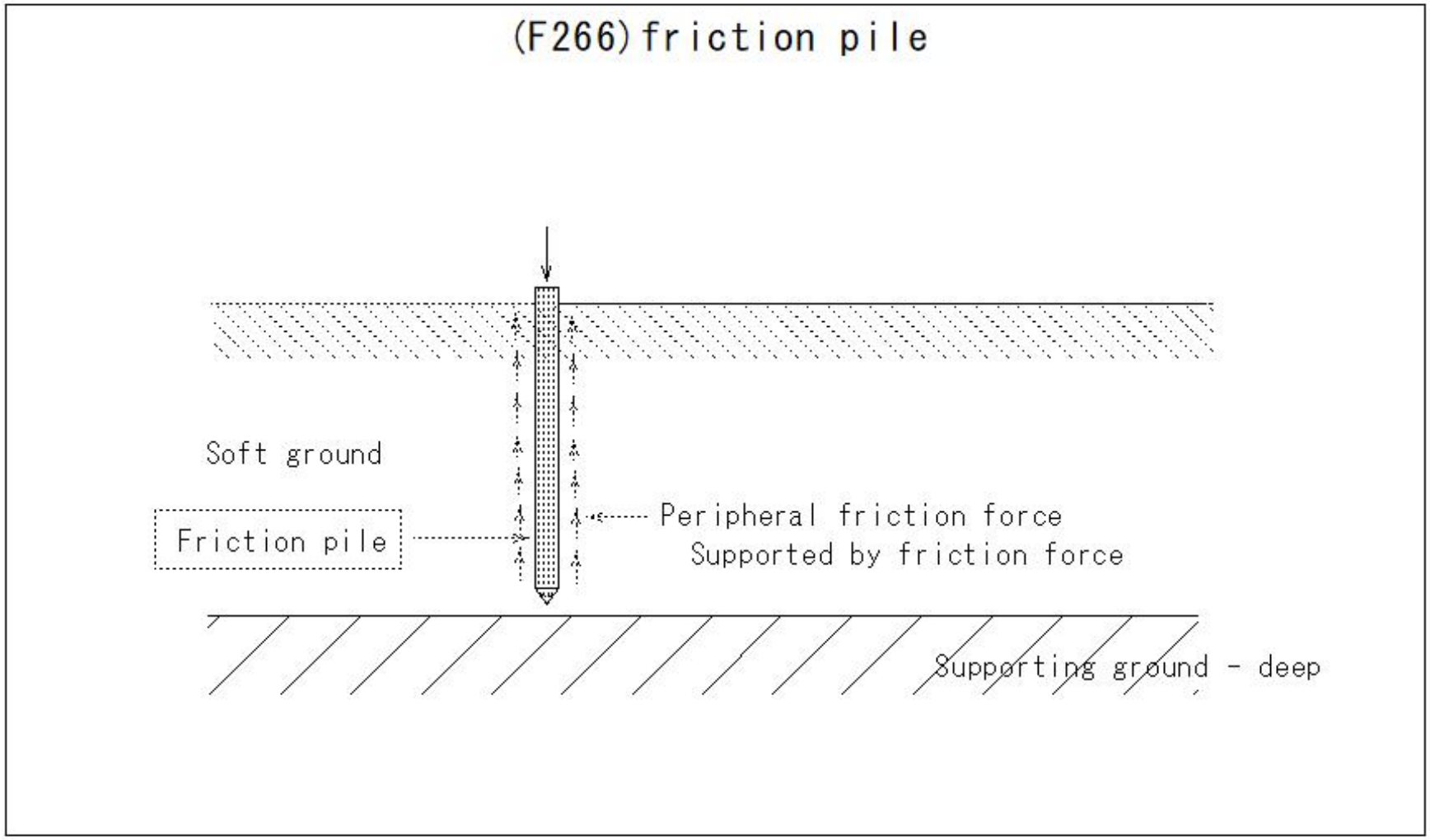
(F264)footing



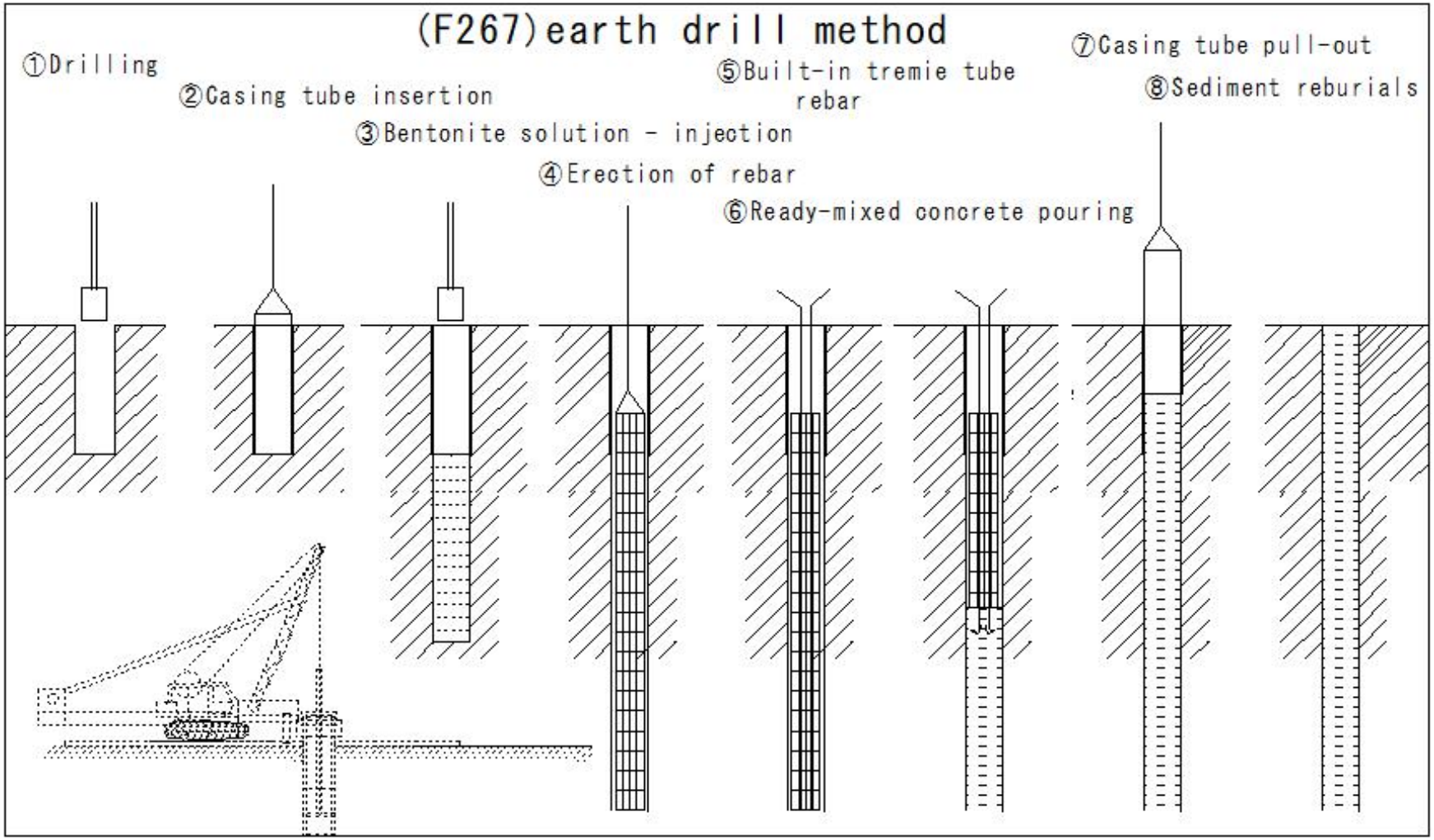
(F265)bituminous membrane water proofing



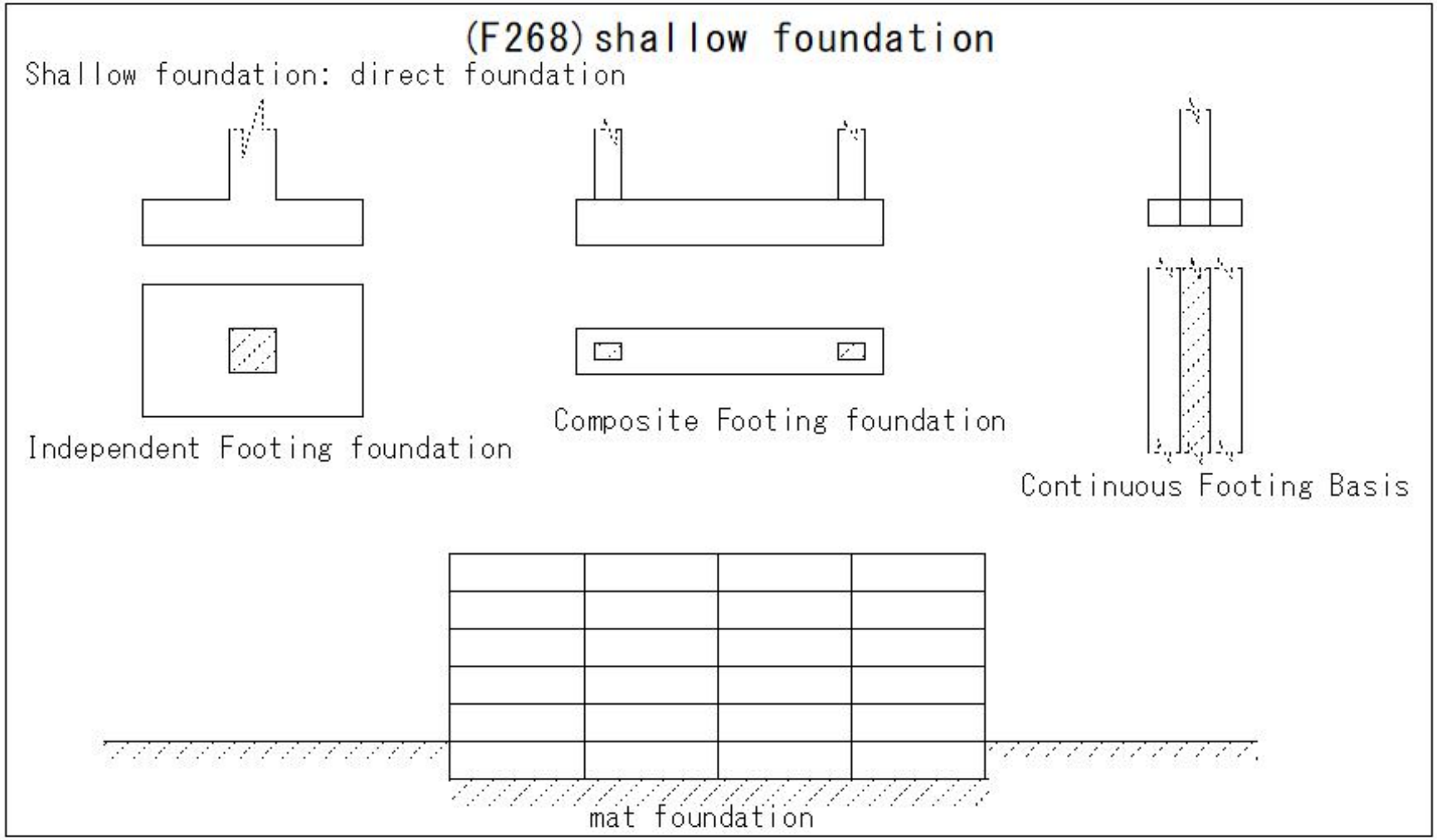
(F266)friction pile



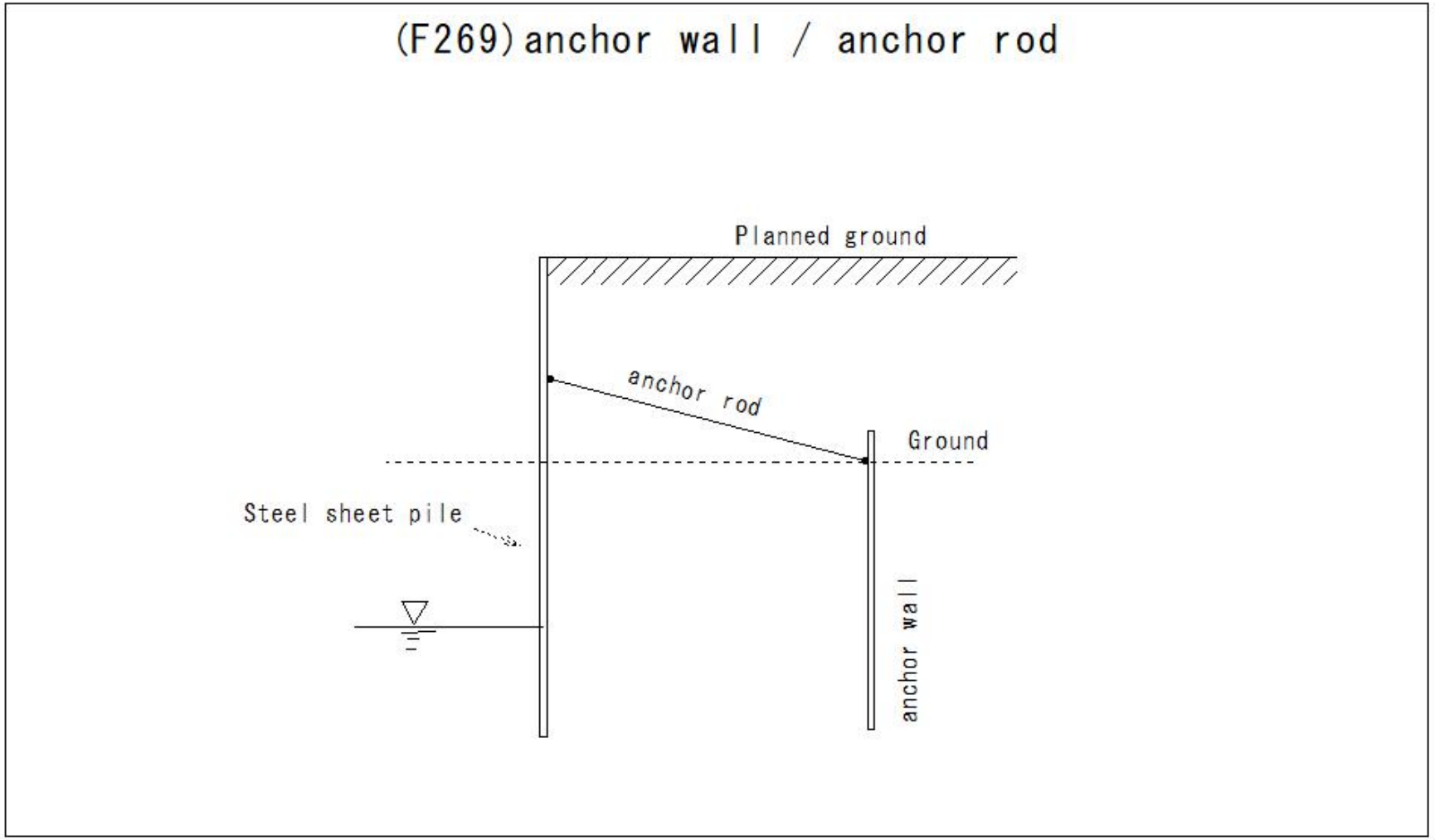
(F267)earth drill method



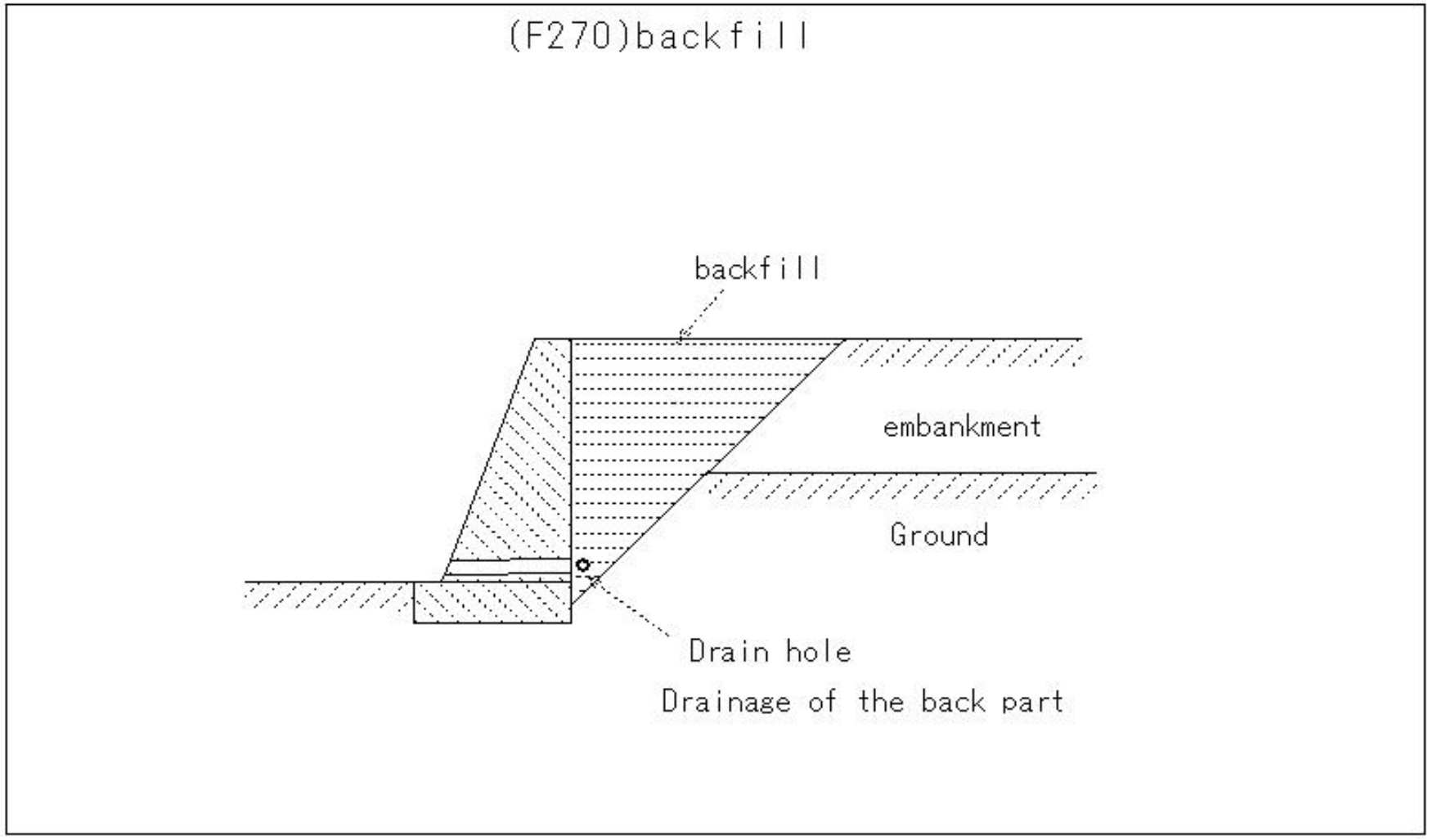
(F268)shallow foundation



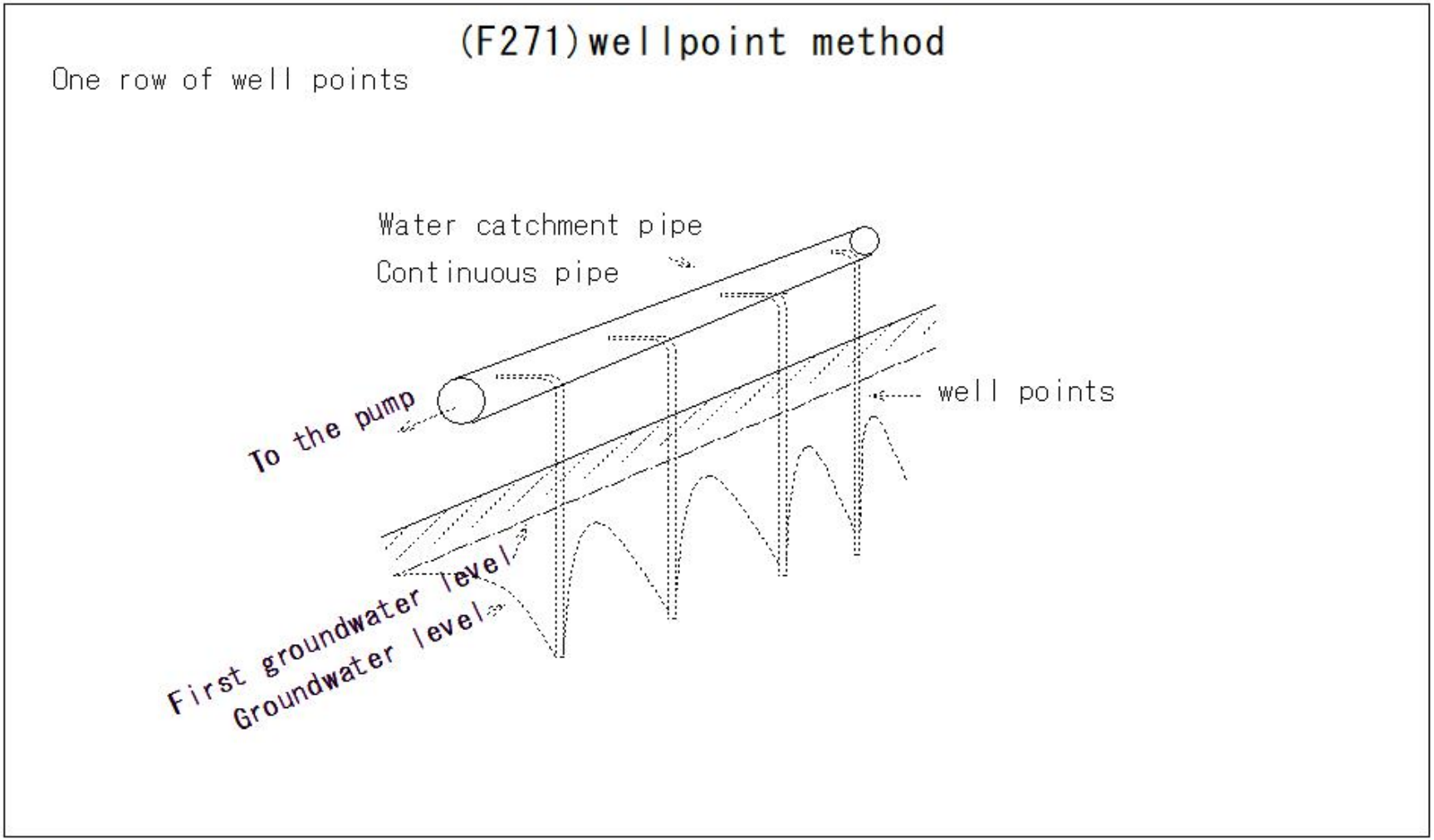
(F269)anchor wall / anchor rod



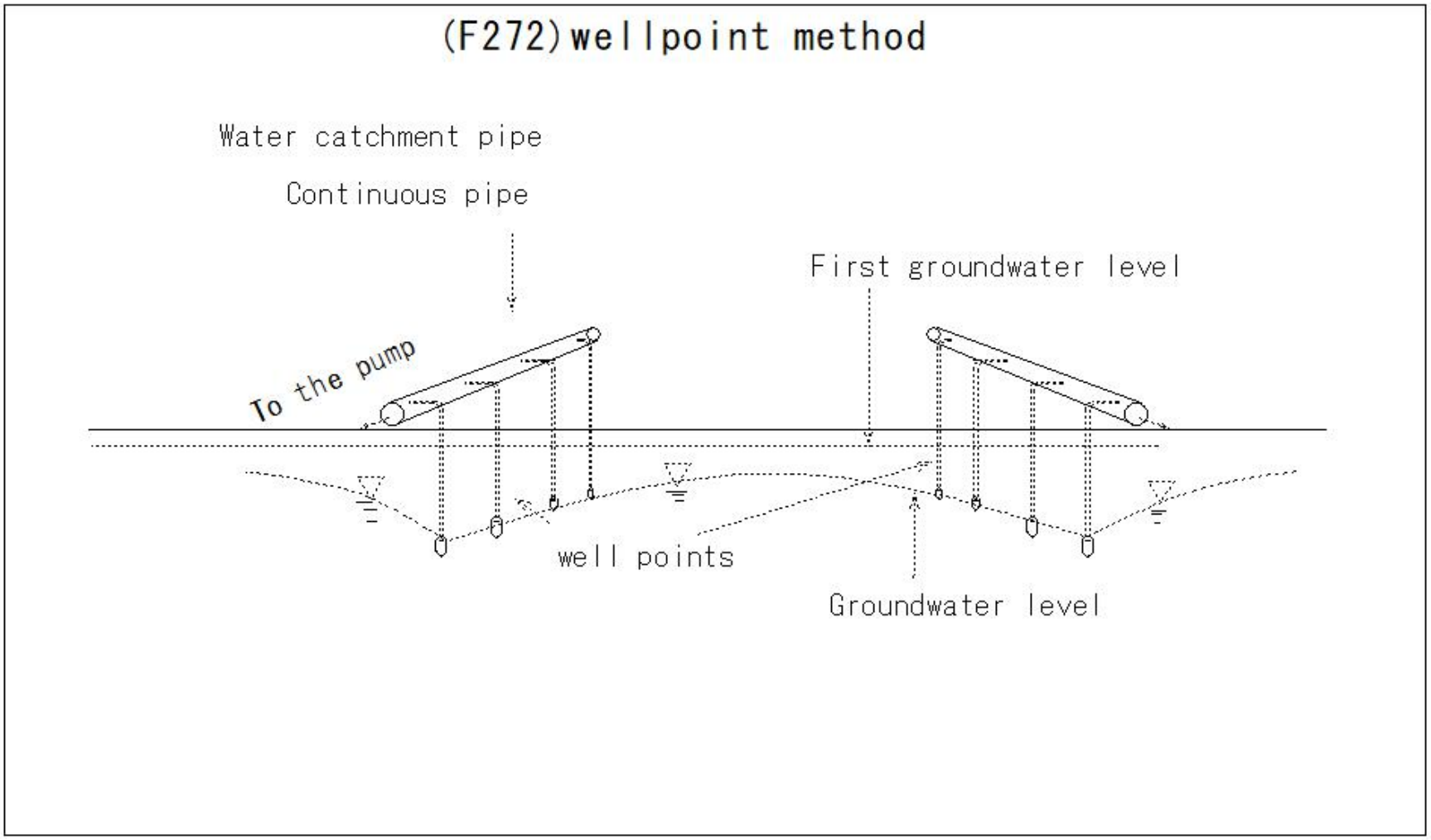
(F270)backfill



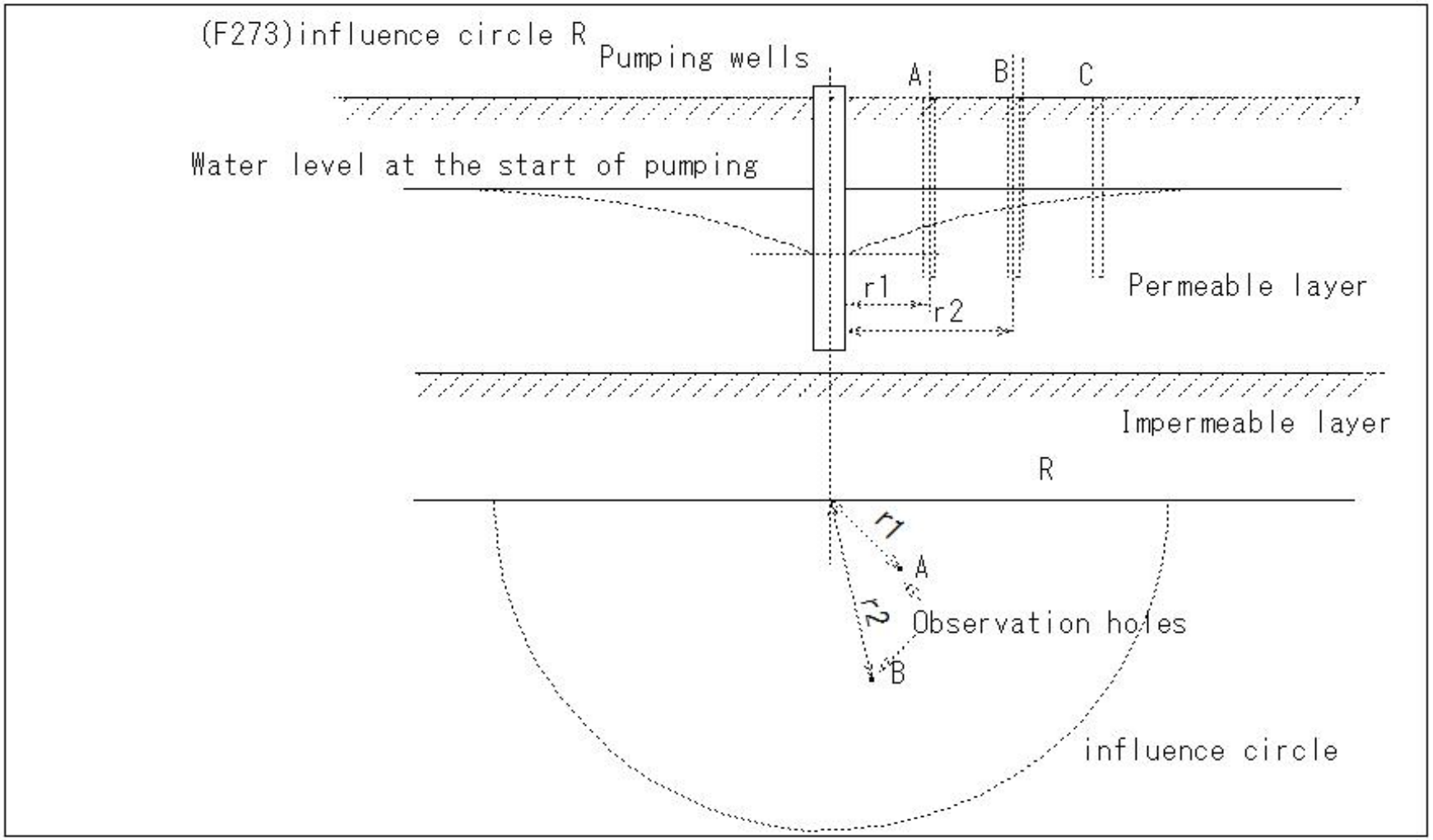
(F271)wellpoint method



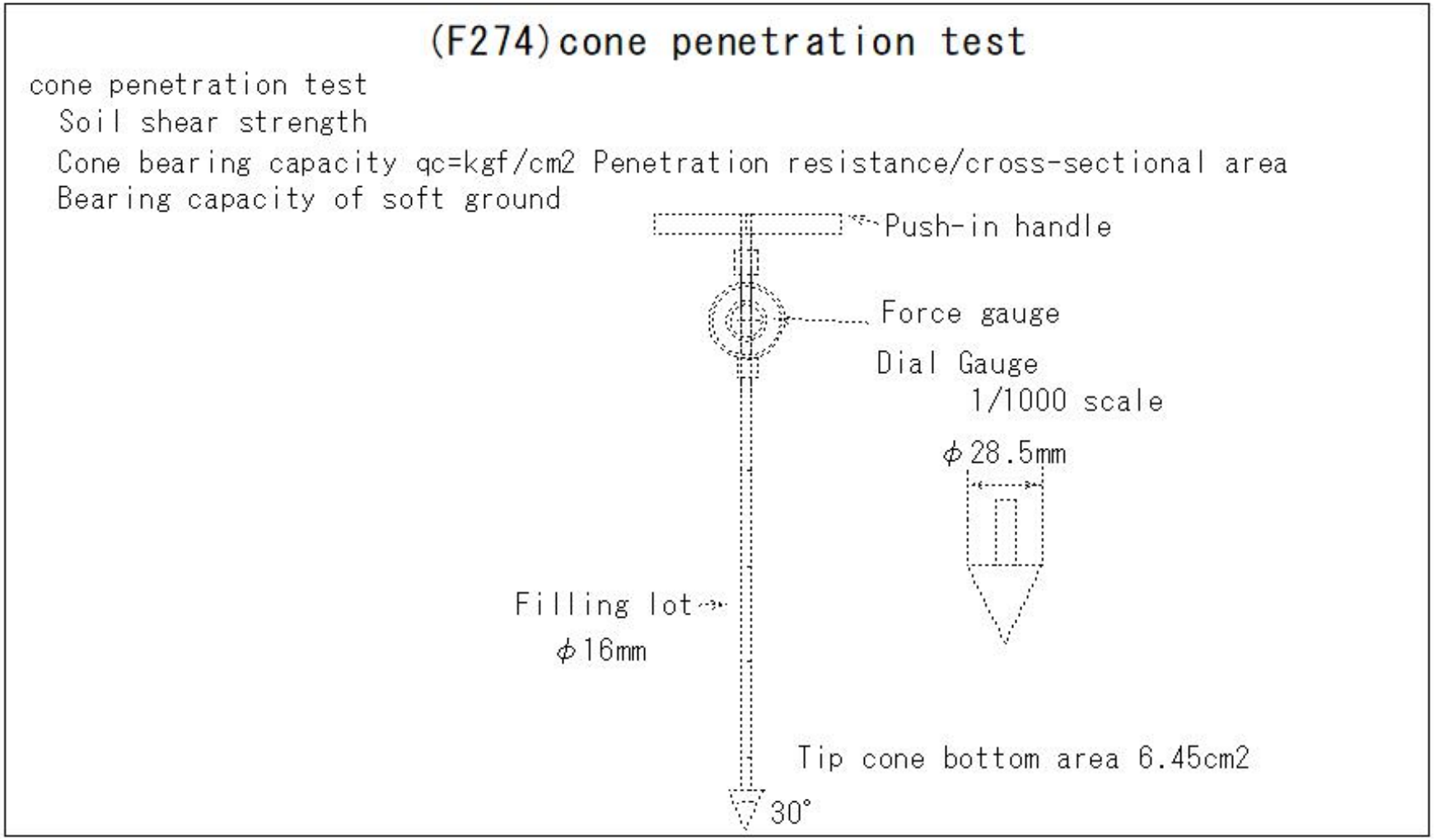
(F272)wellpoint method



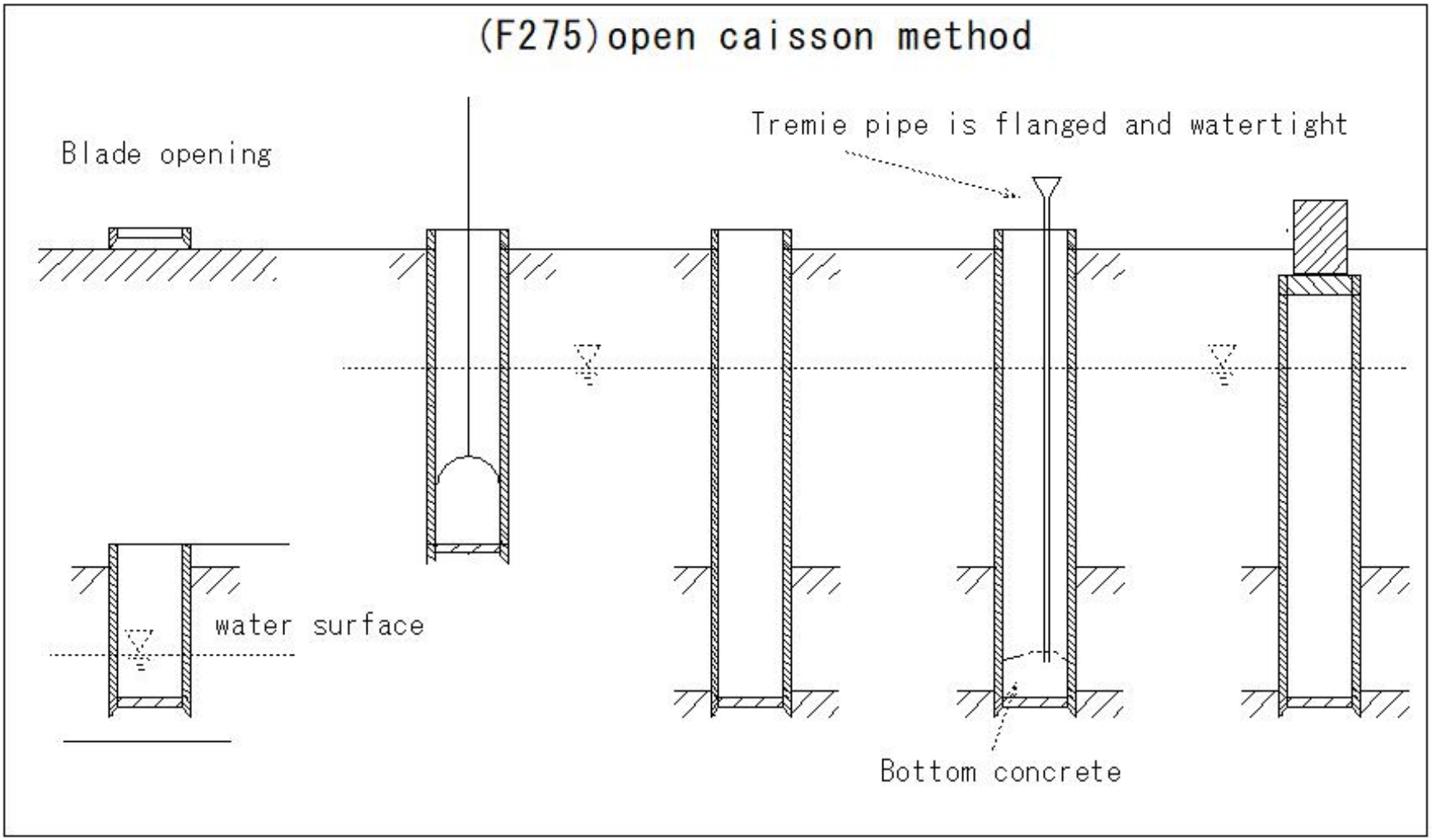
(F273)influence circle R



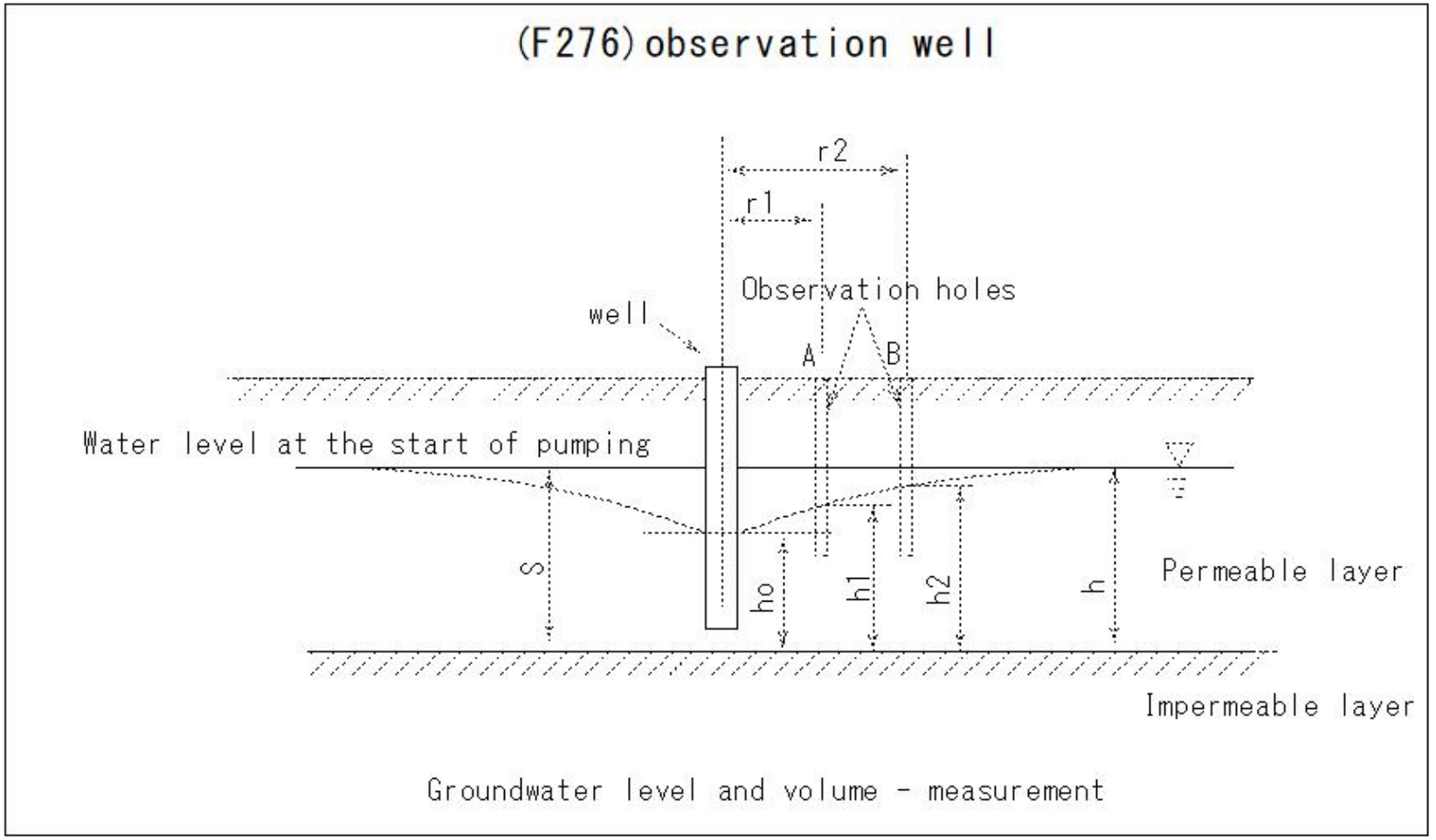
(F274)cone penetration test



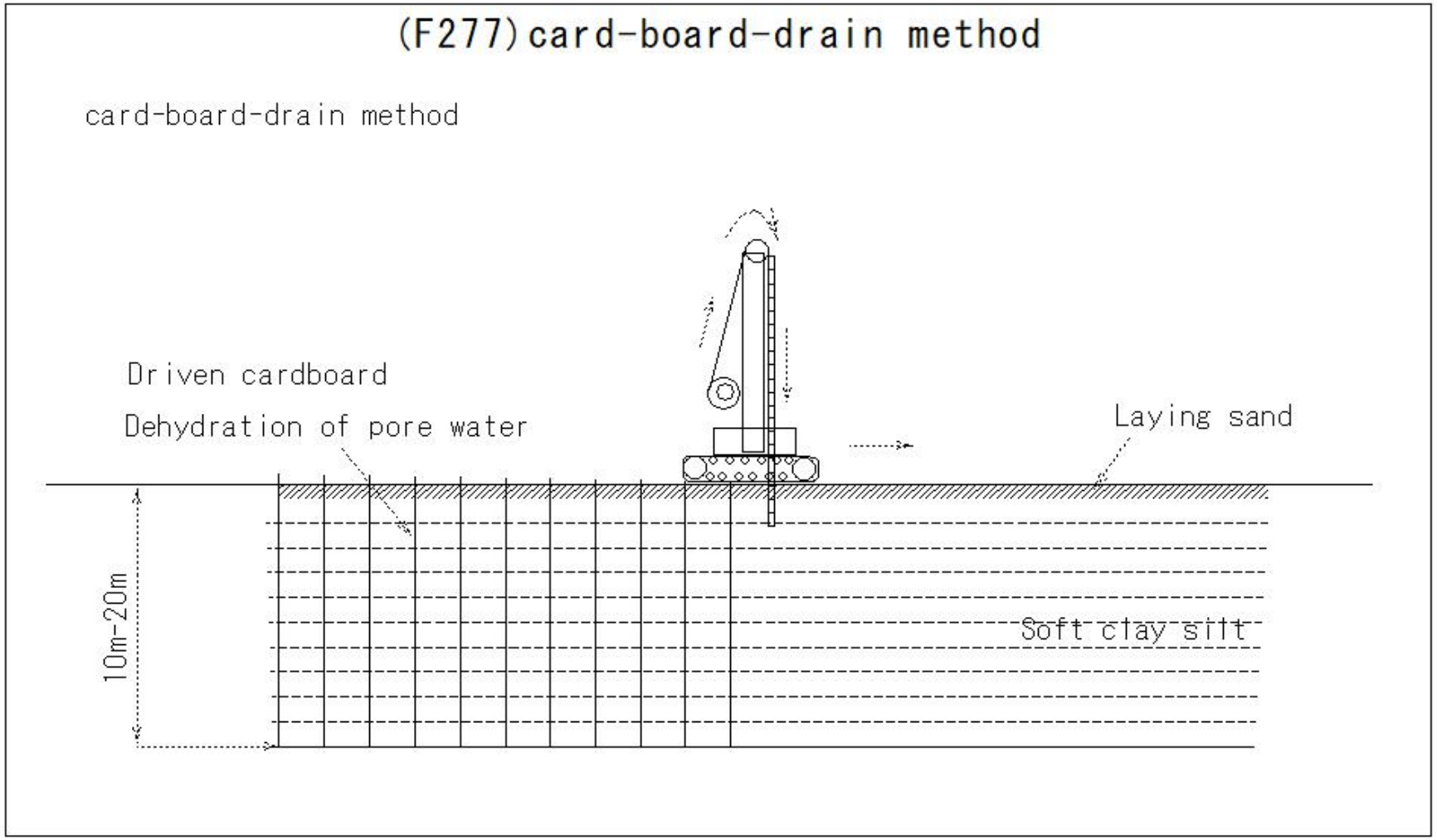
(F275)open caisson method



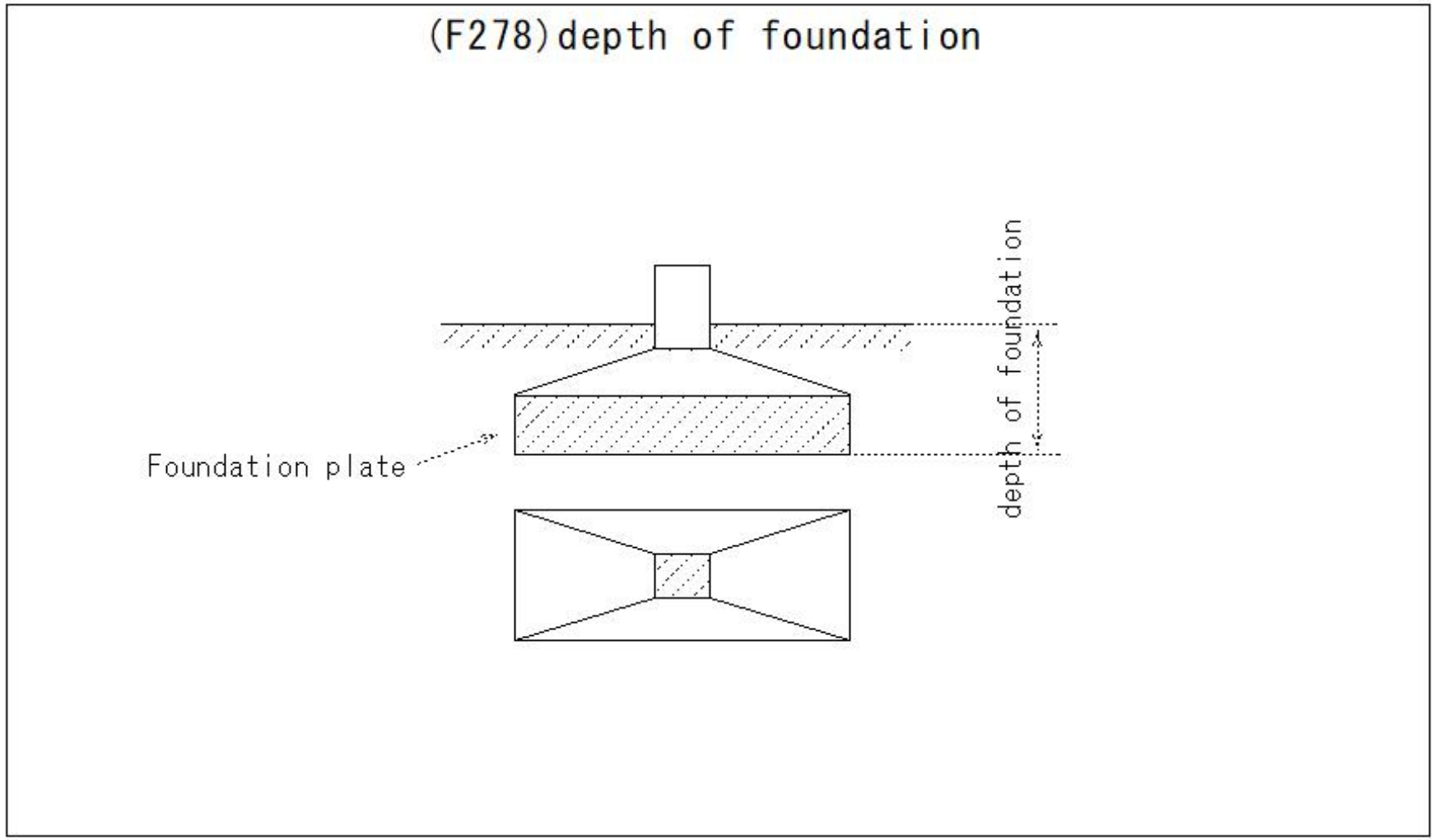
(F276)observation well



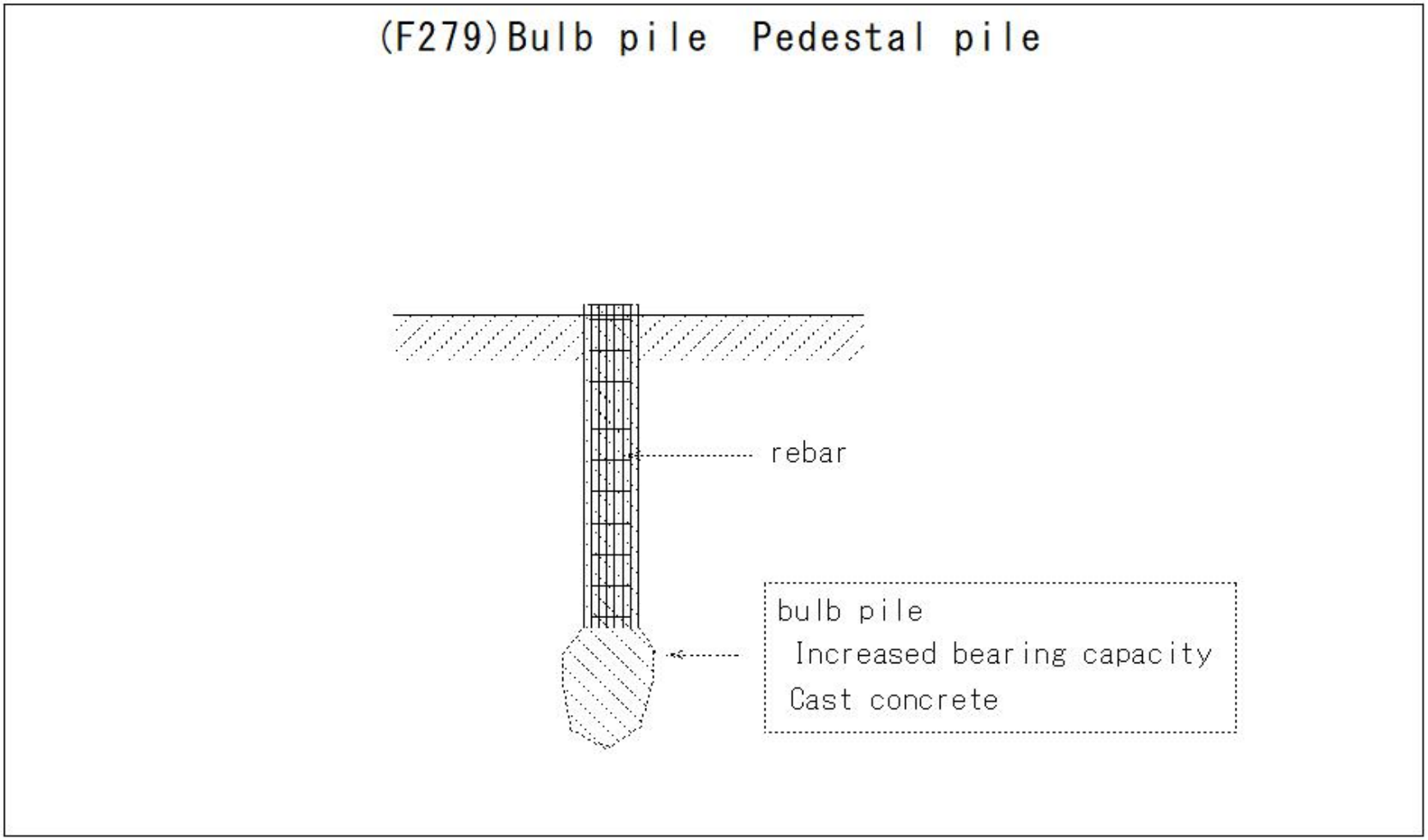
(F277)card-board-drain method



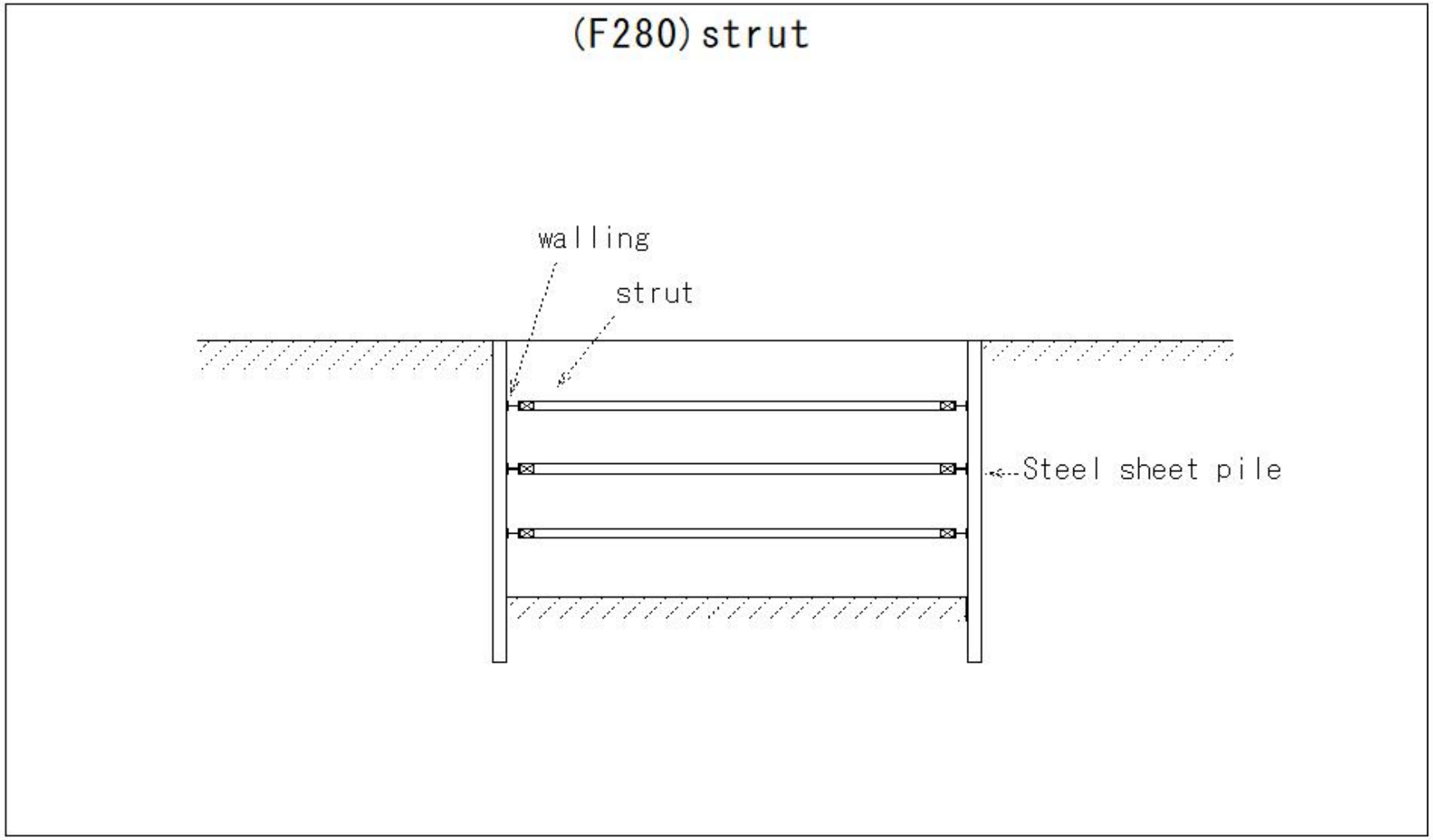
(F278)depth of foundation



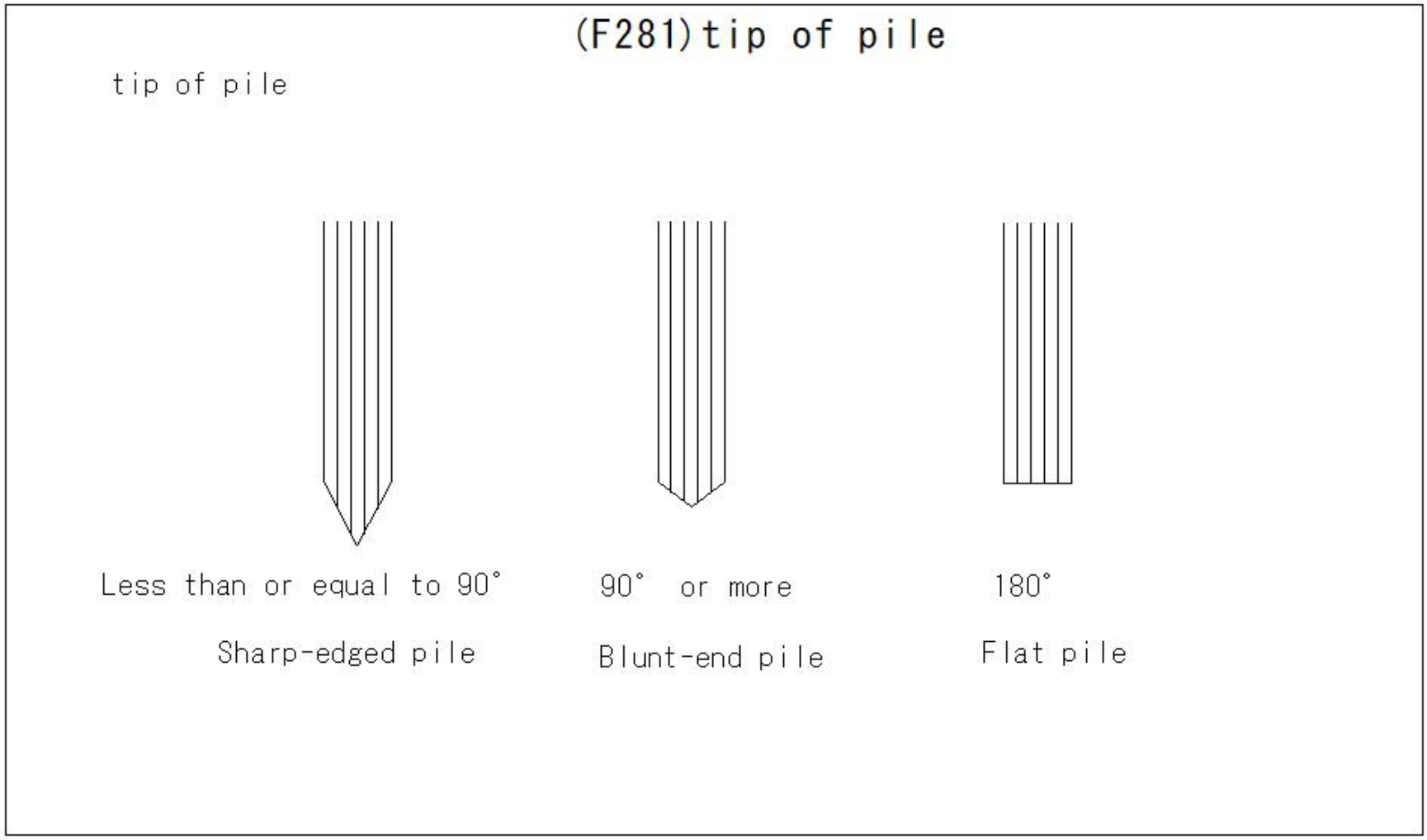
(F279)Bulb pile Pedestal pile



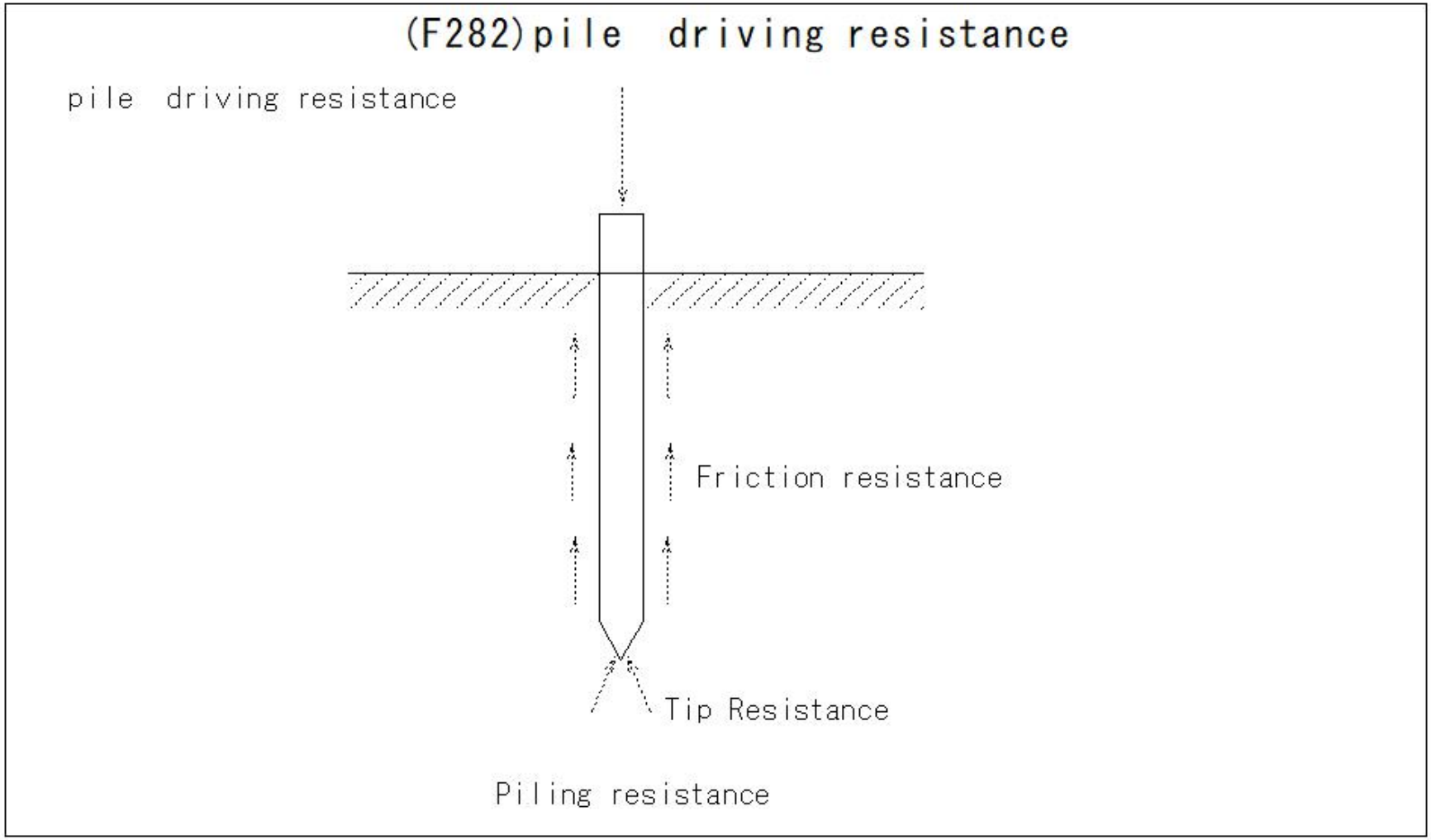
(F280)strut



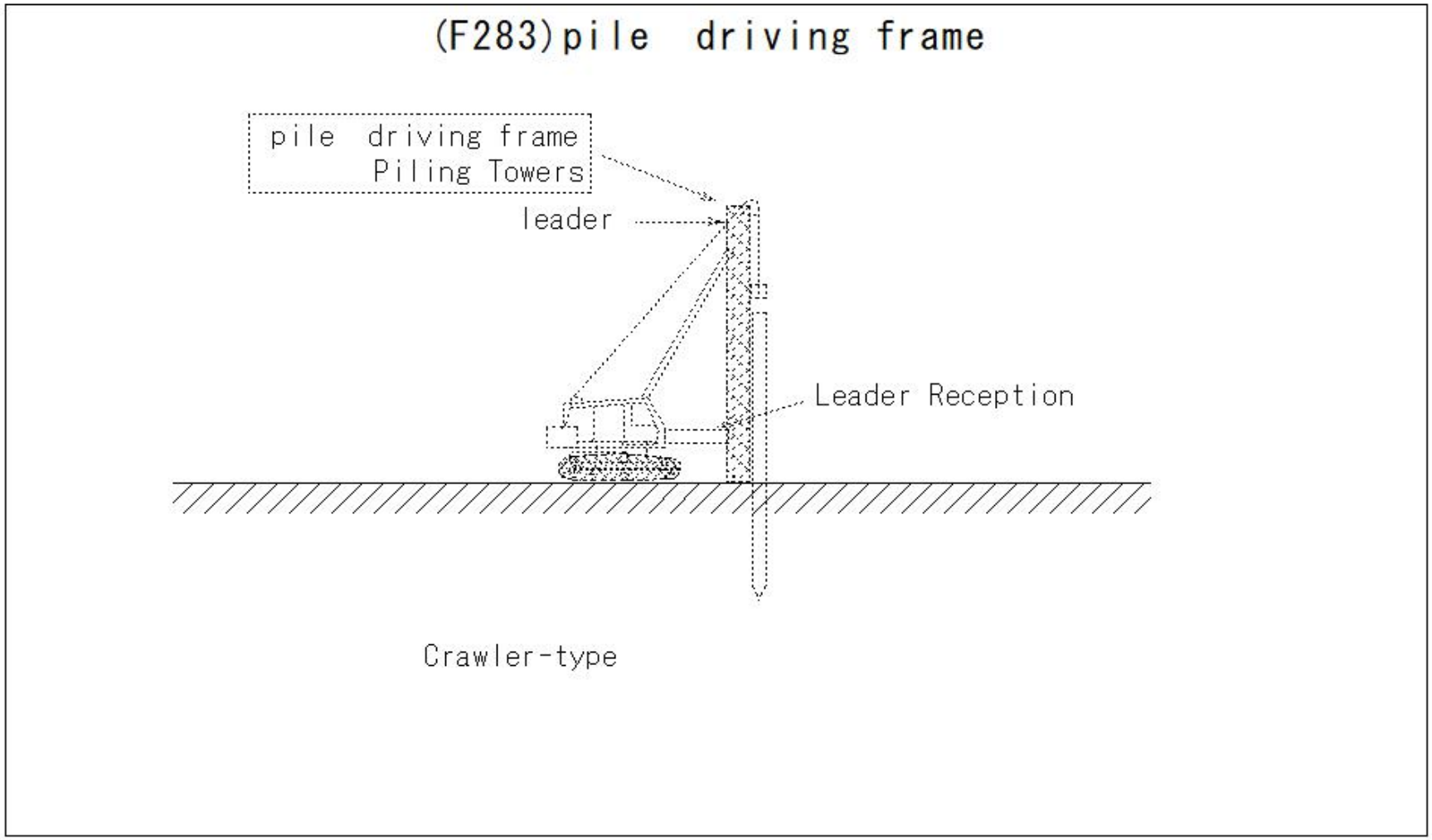
(F281)tip of pile



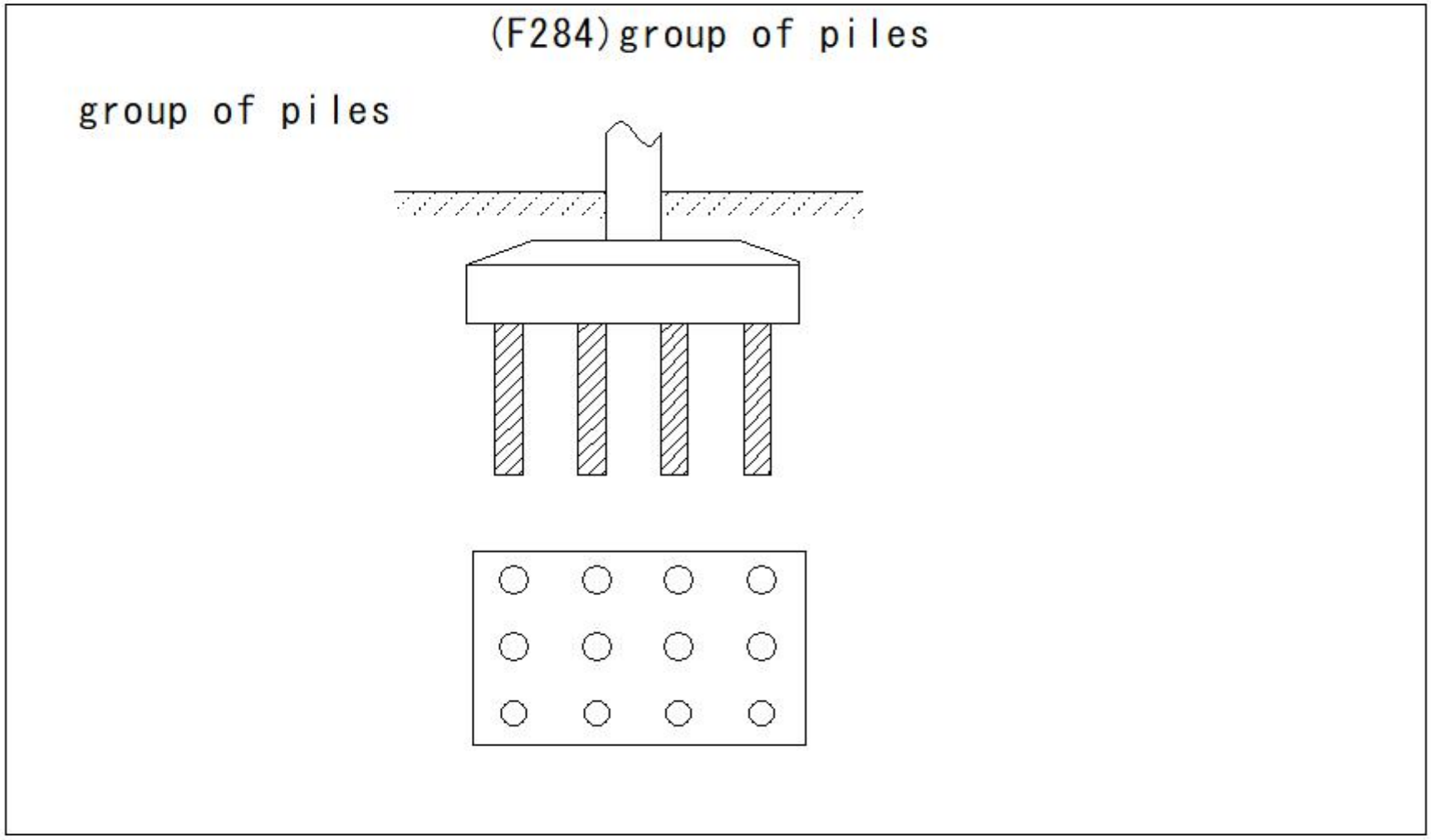
(F282)pile driving resistance



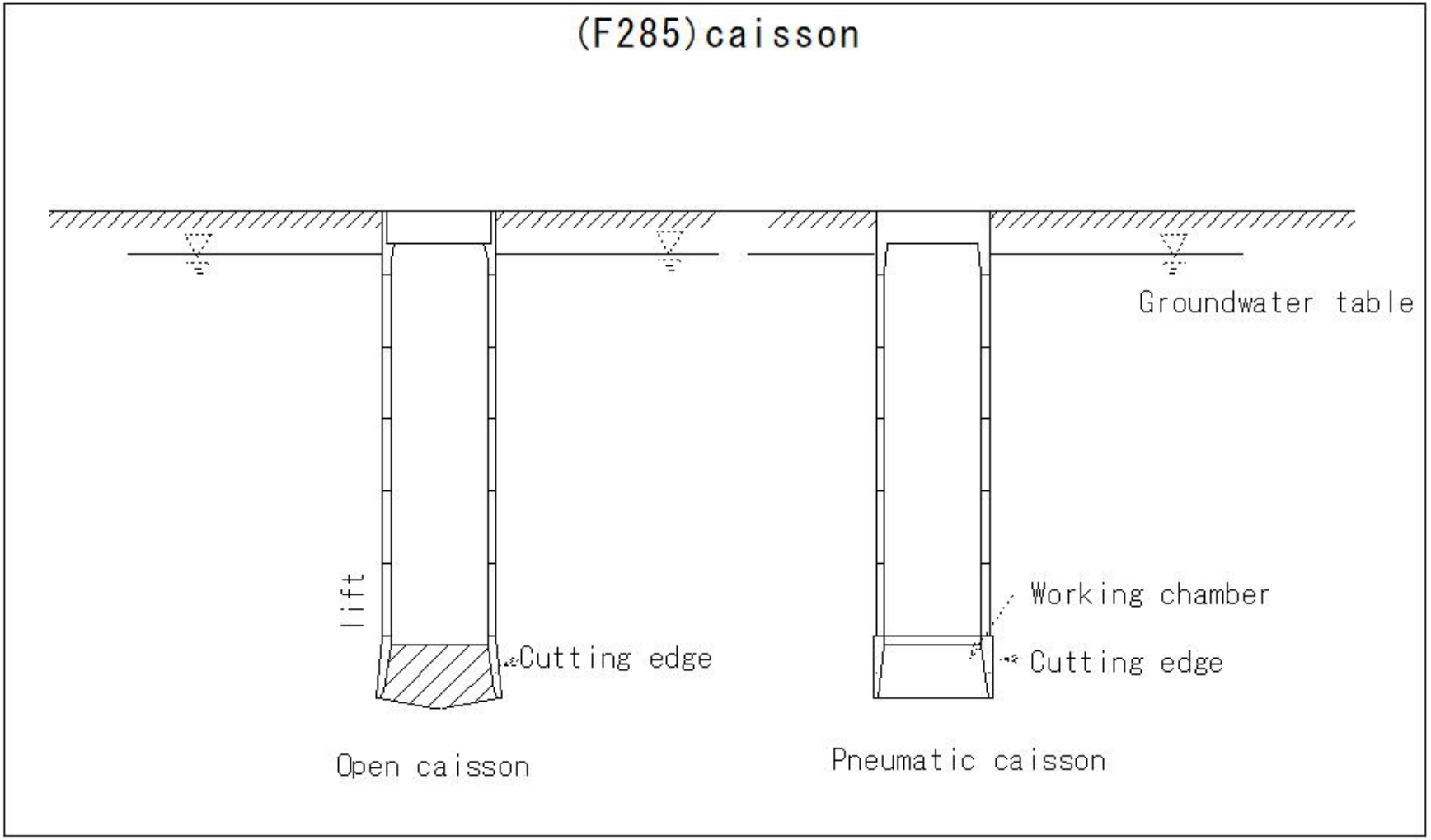
(F283)pile driving frame



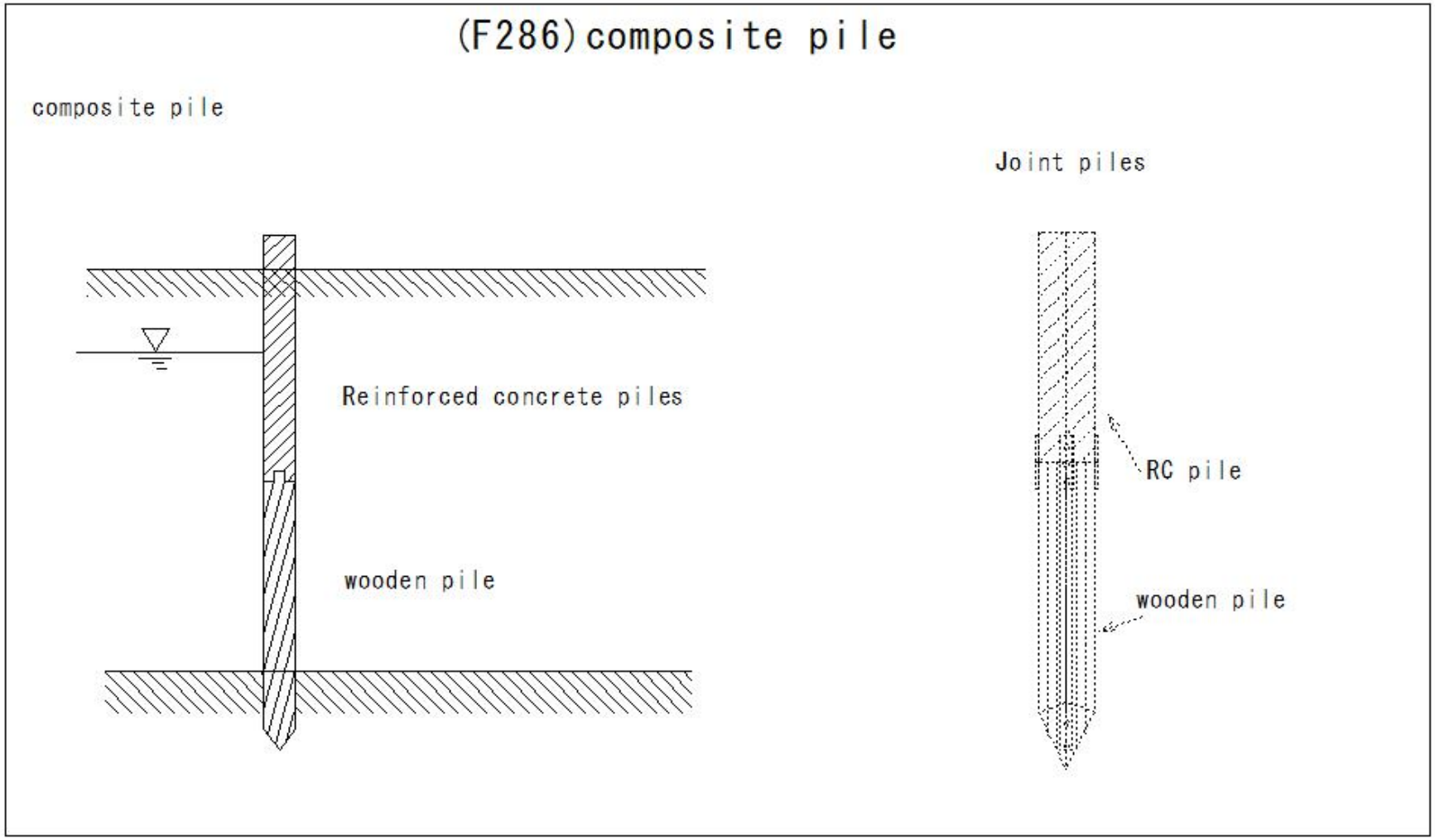
(F284)group of piles



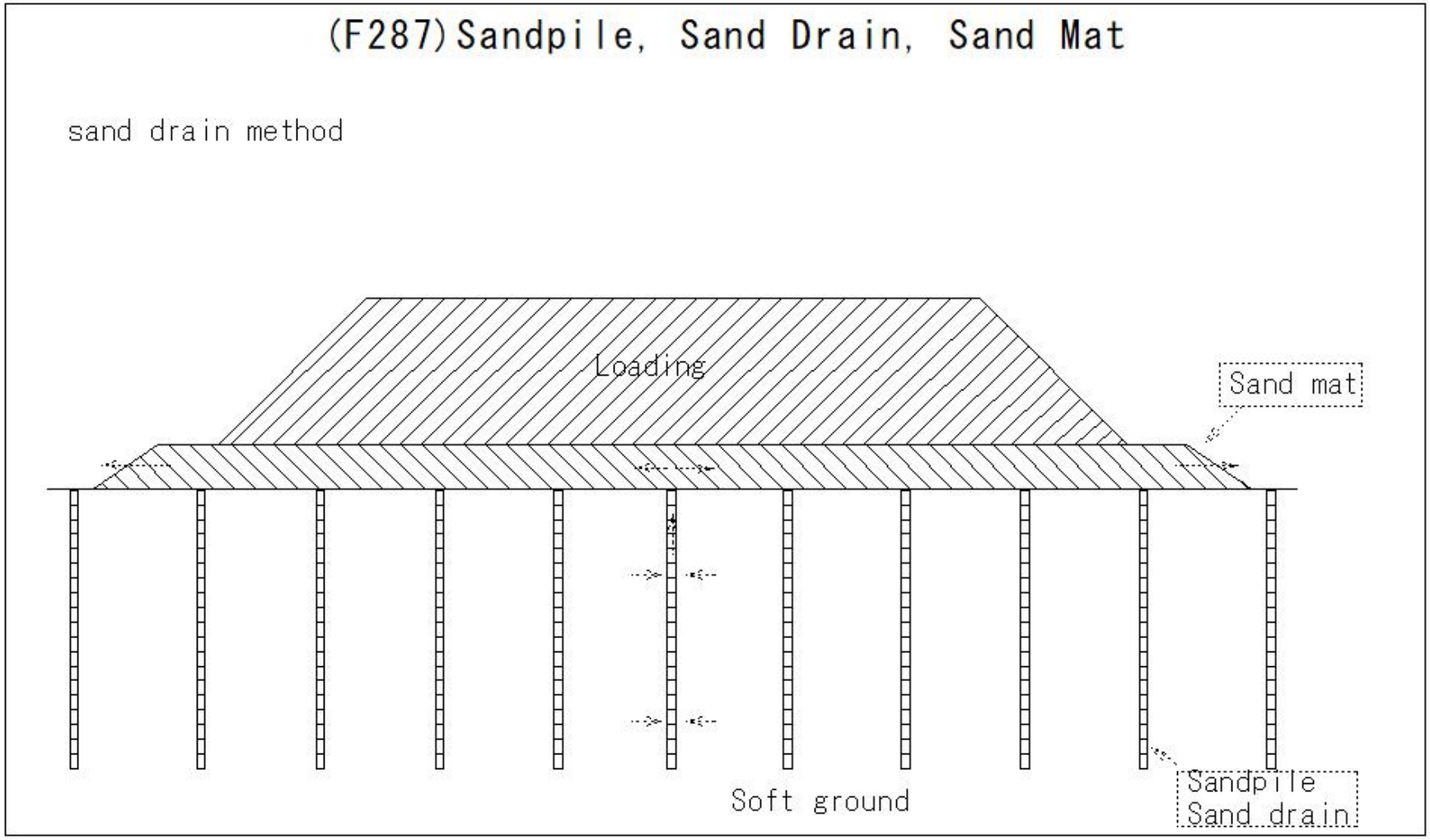
(F285)caisson



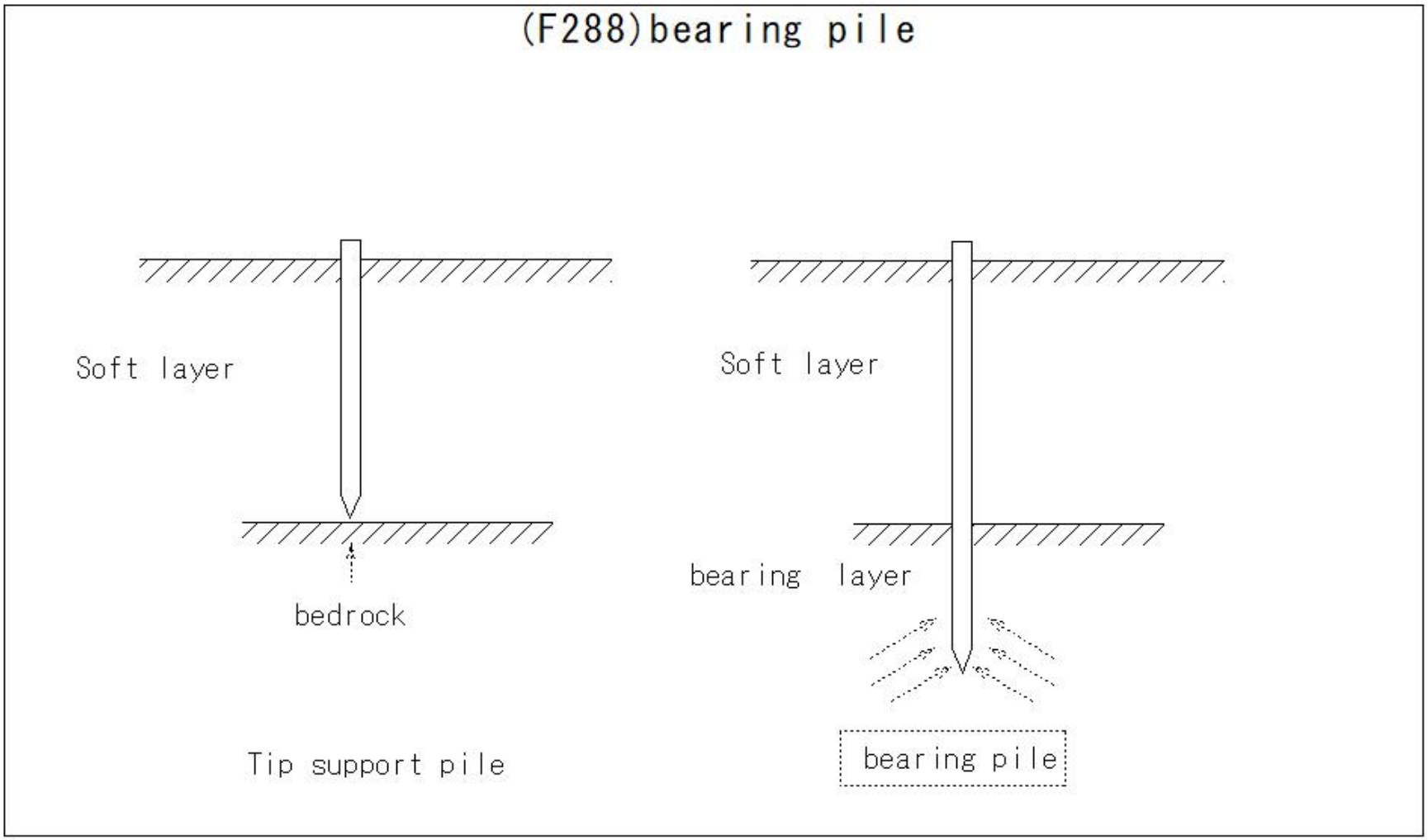
(F286)composite pile



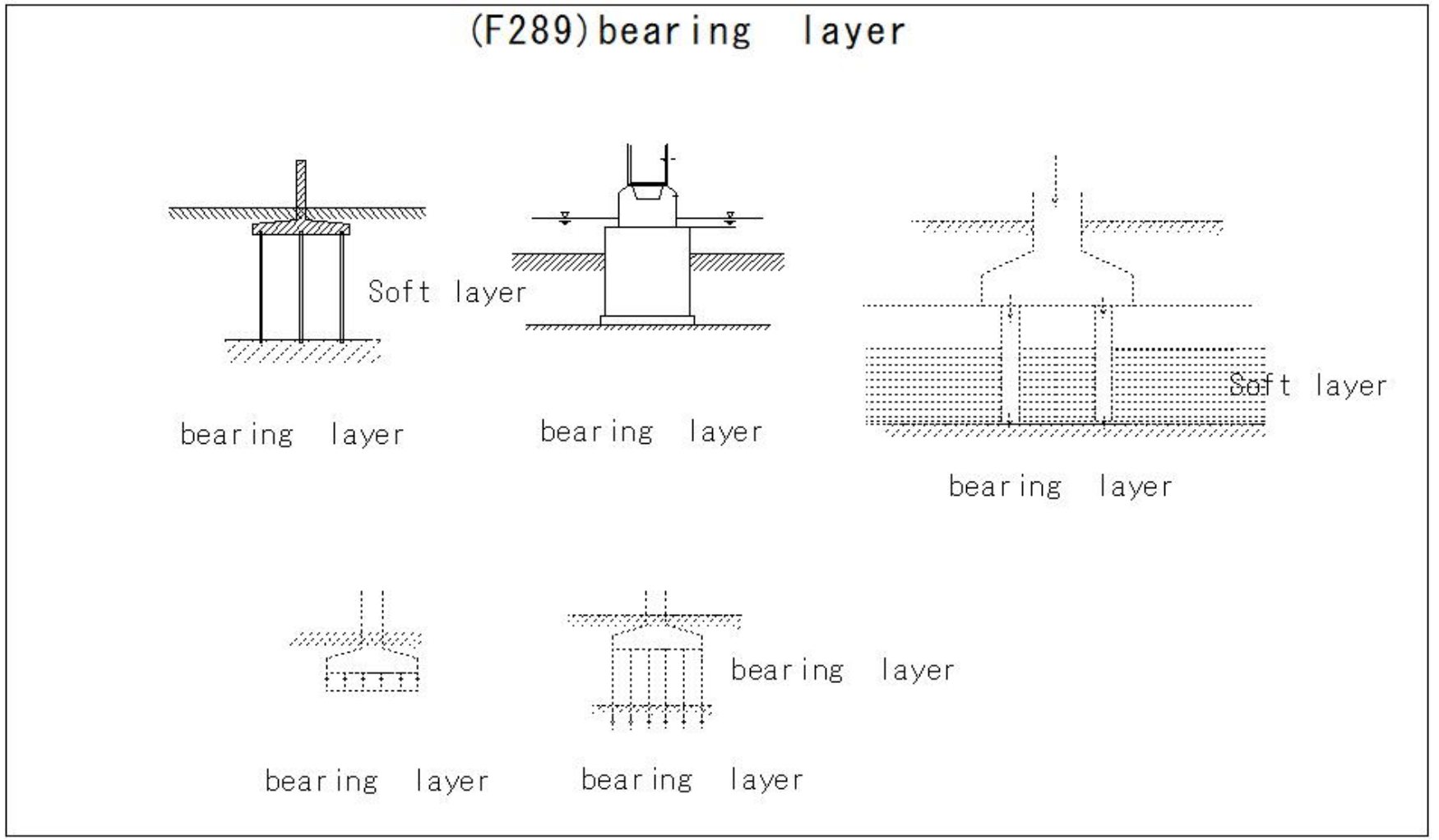
(F287)Sandpile, Sand Drain, Sand Mat



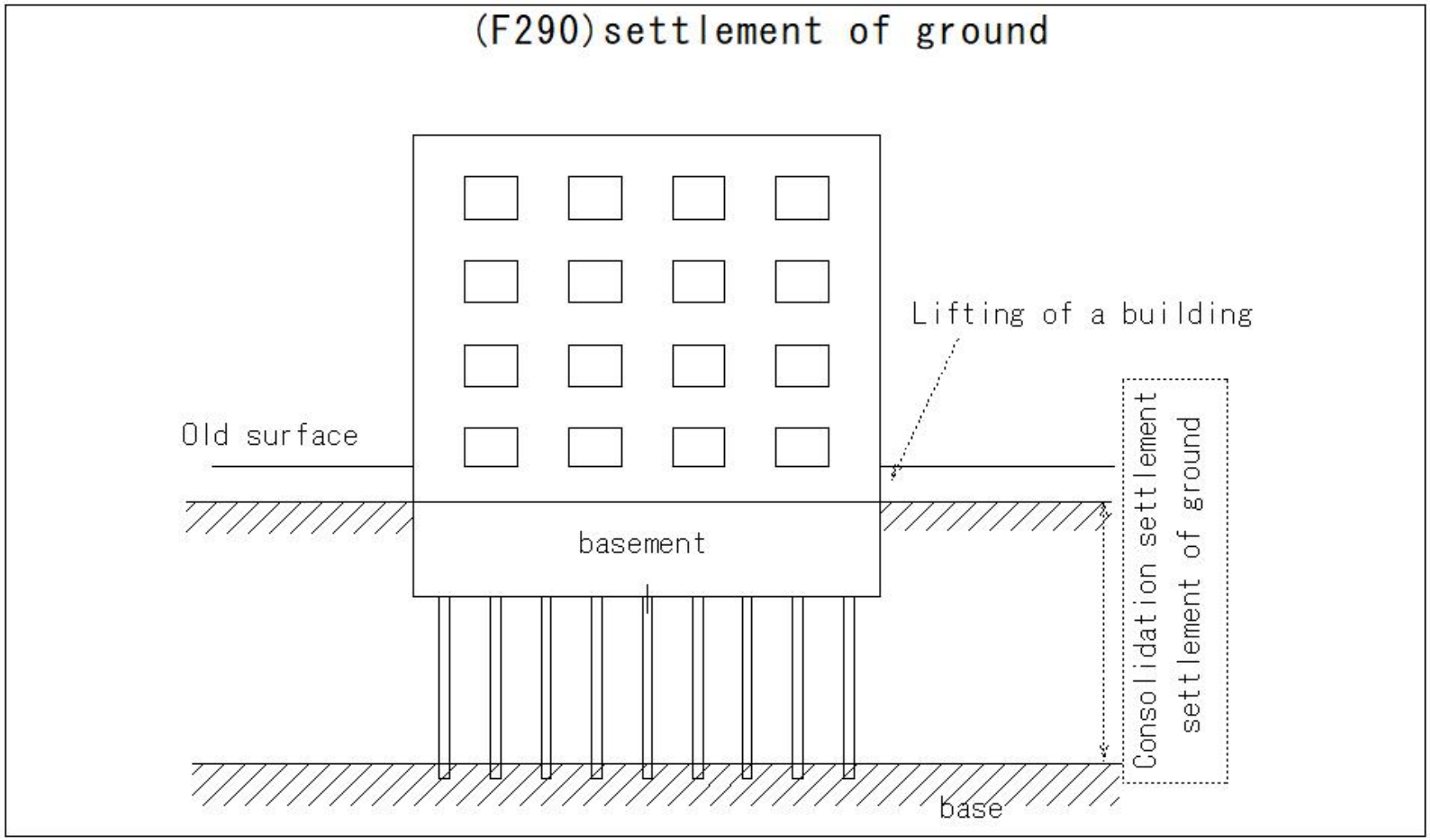
(F288)bearing pile



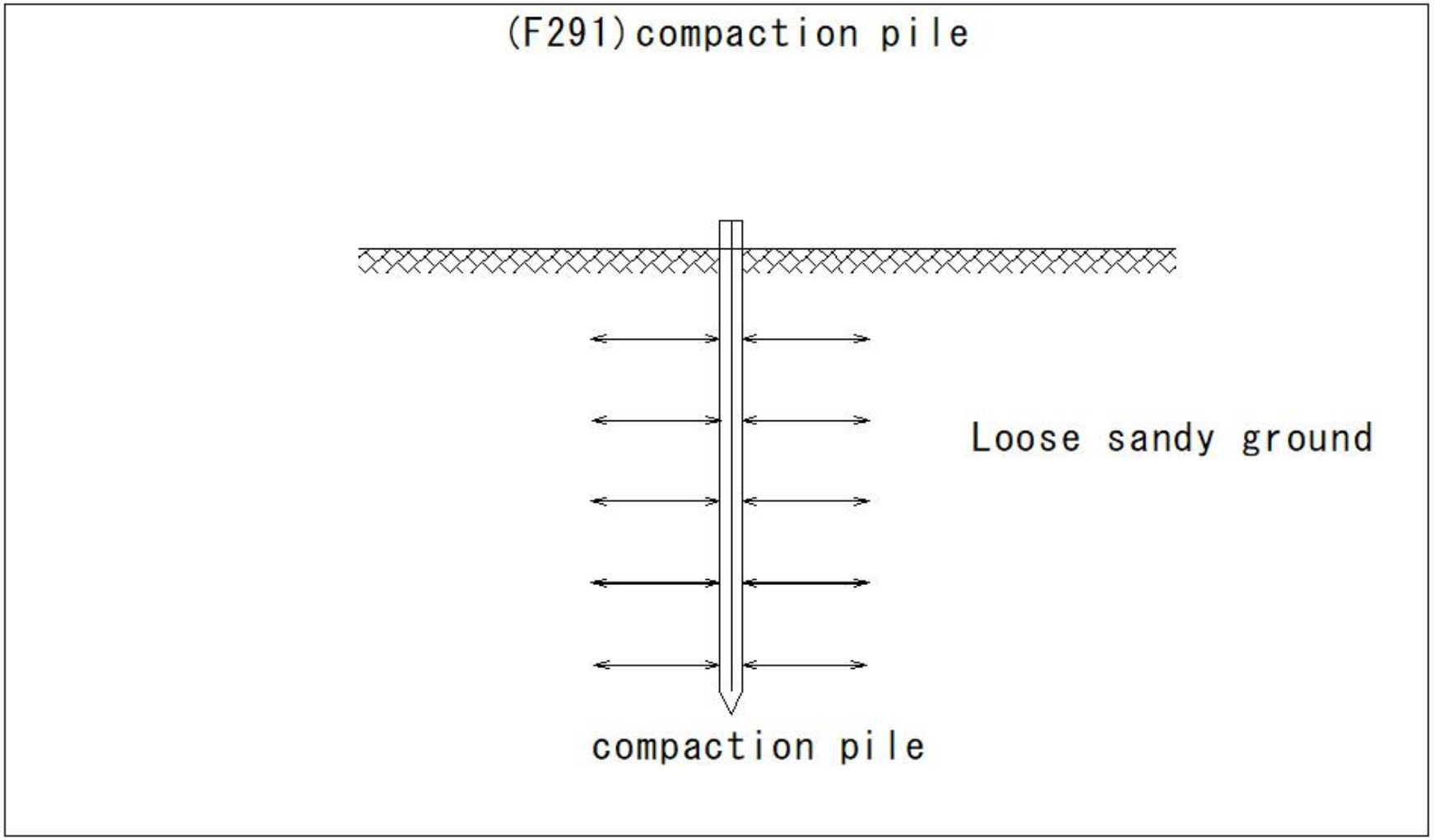
(F289)bearing layer



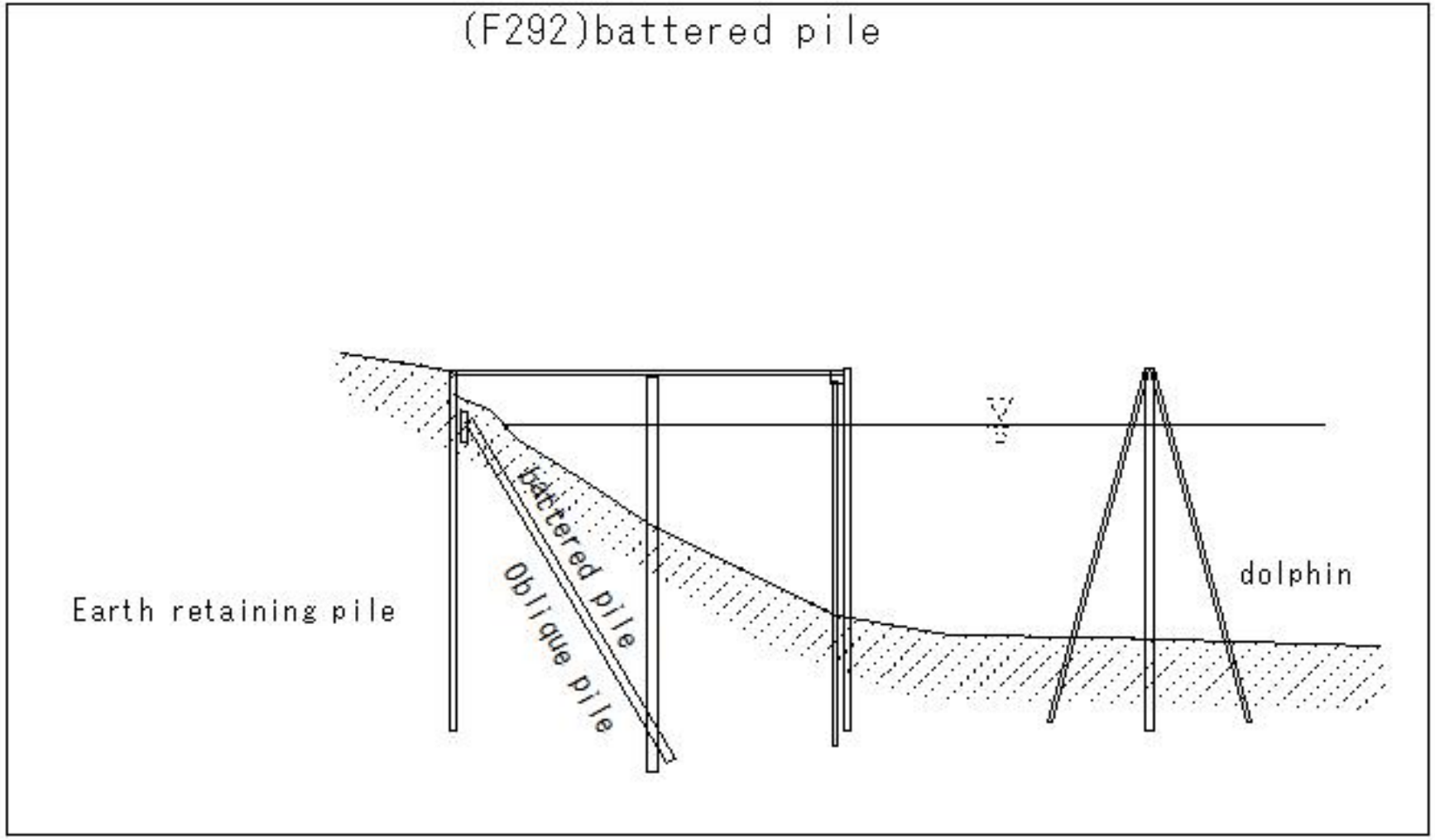
(F290)settlement of ground



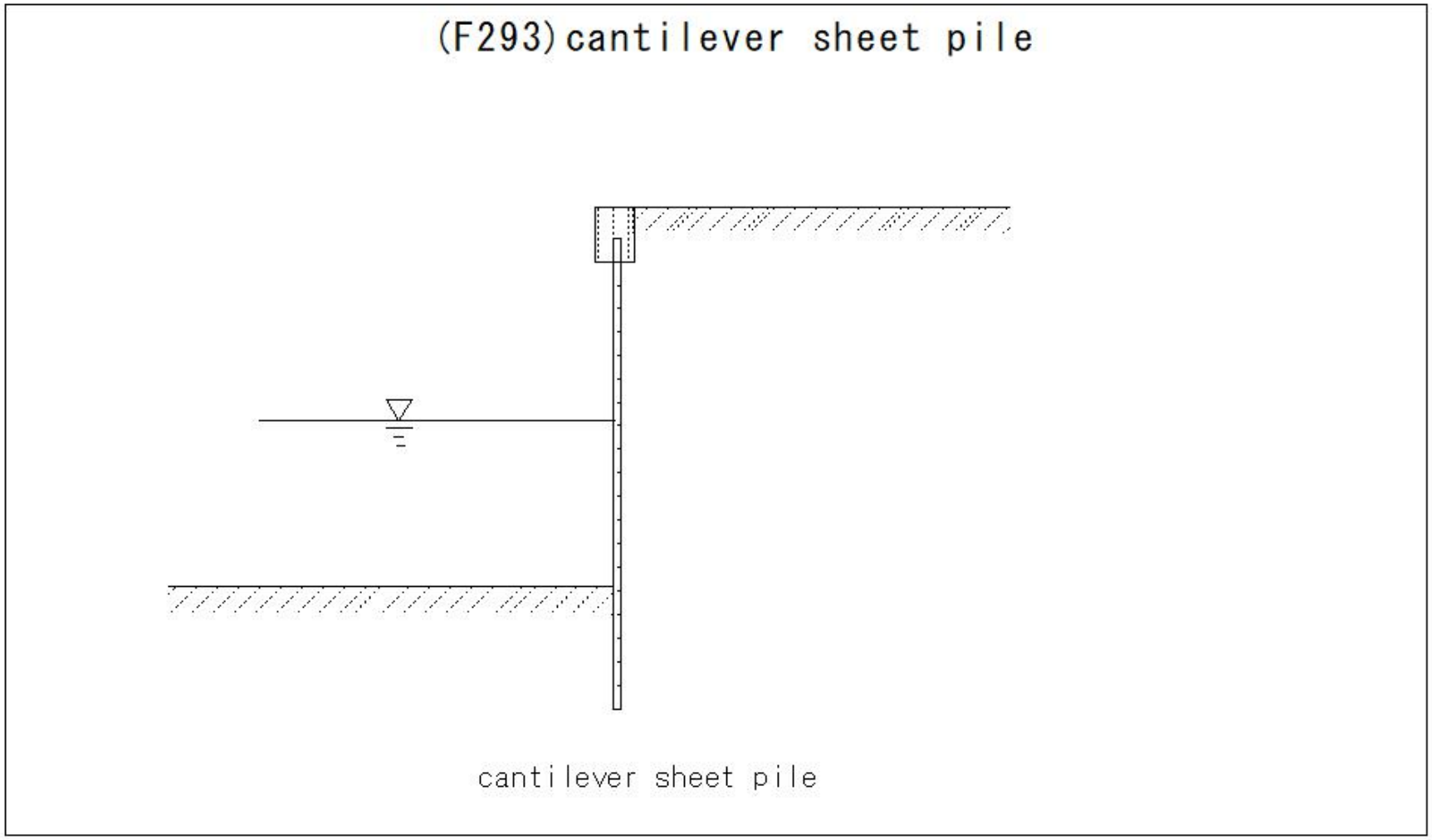
(F291)compaction pile



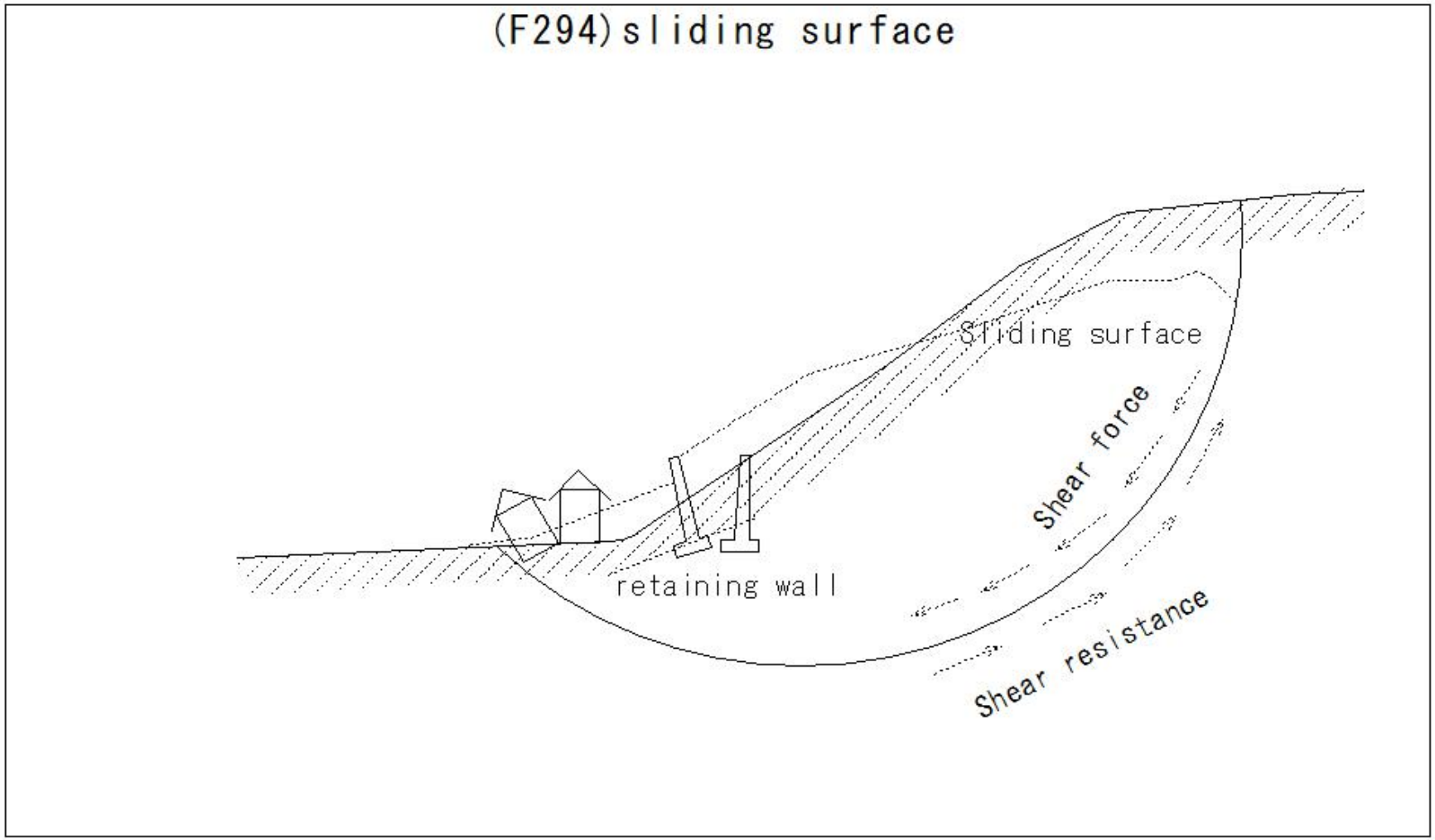
(F292)battered pile



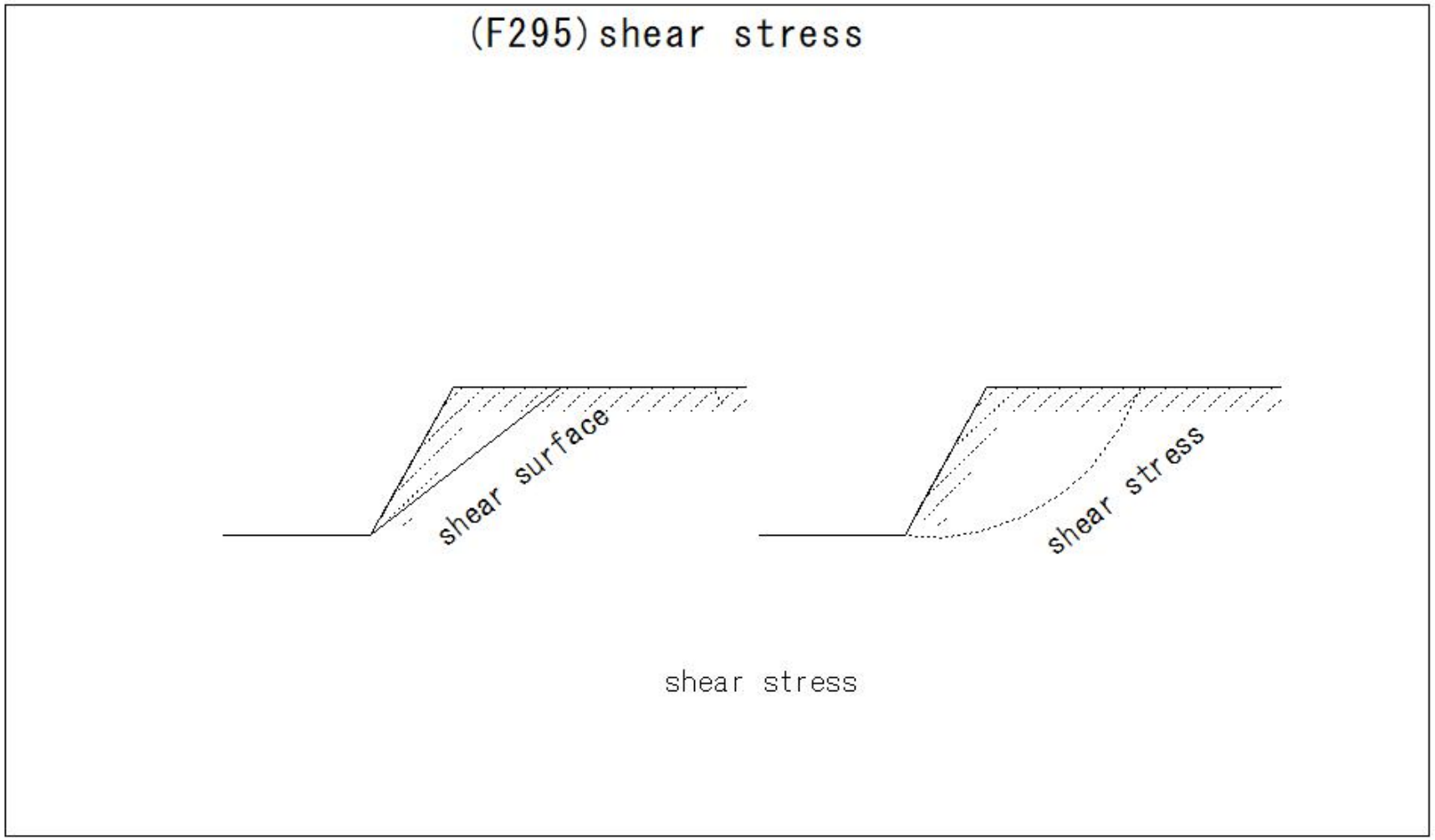
(F293)cantilever sheet pile



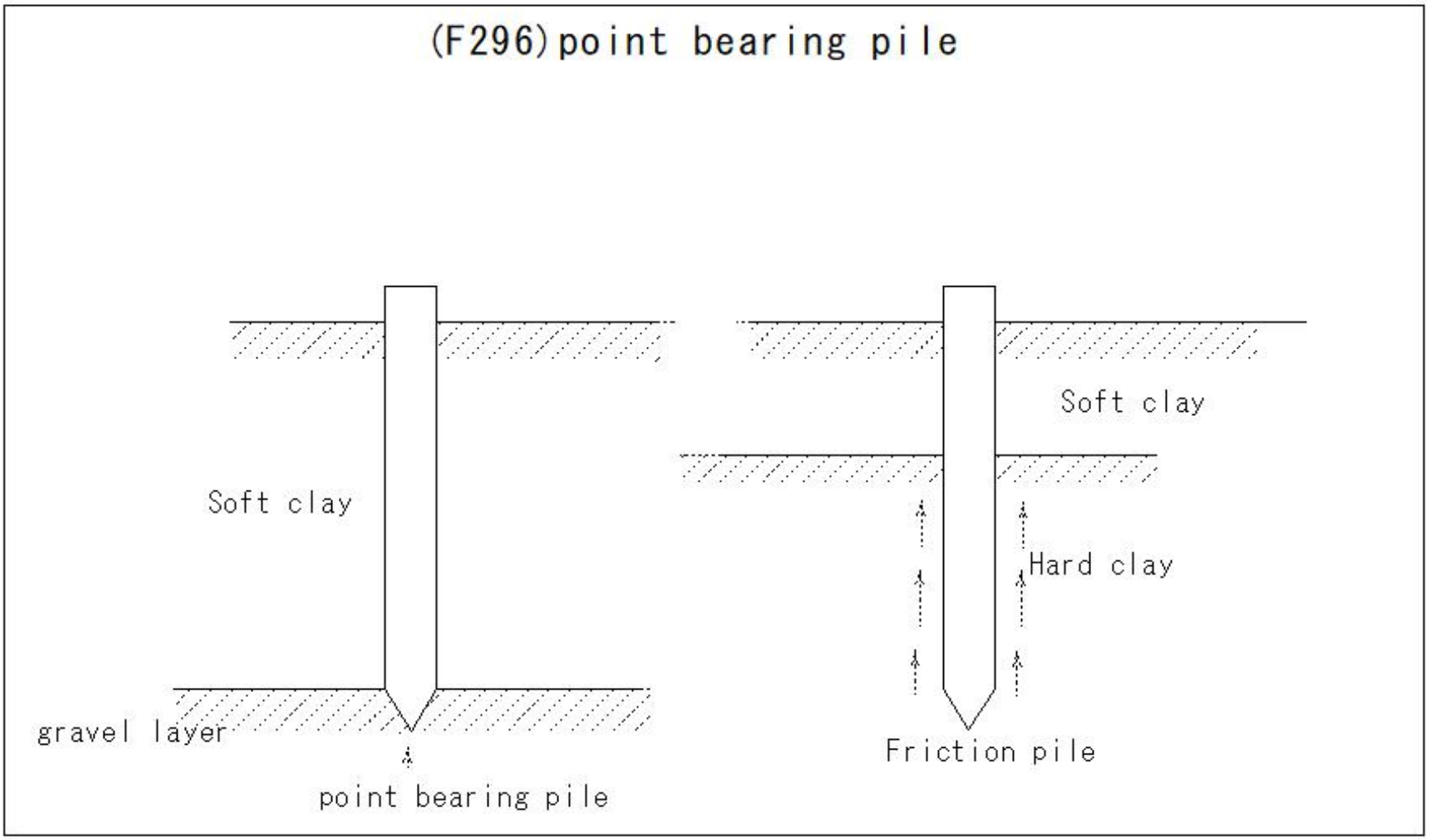
(F294)sliding surface



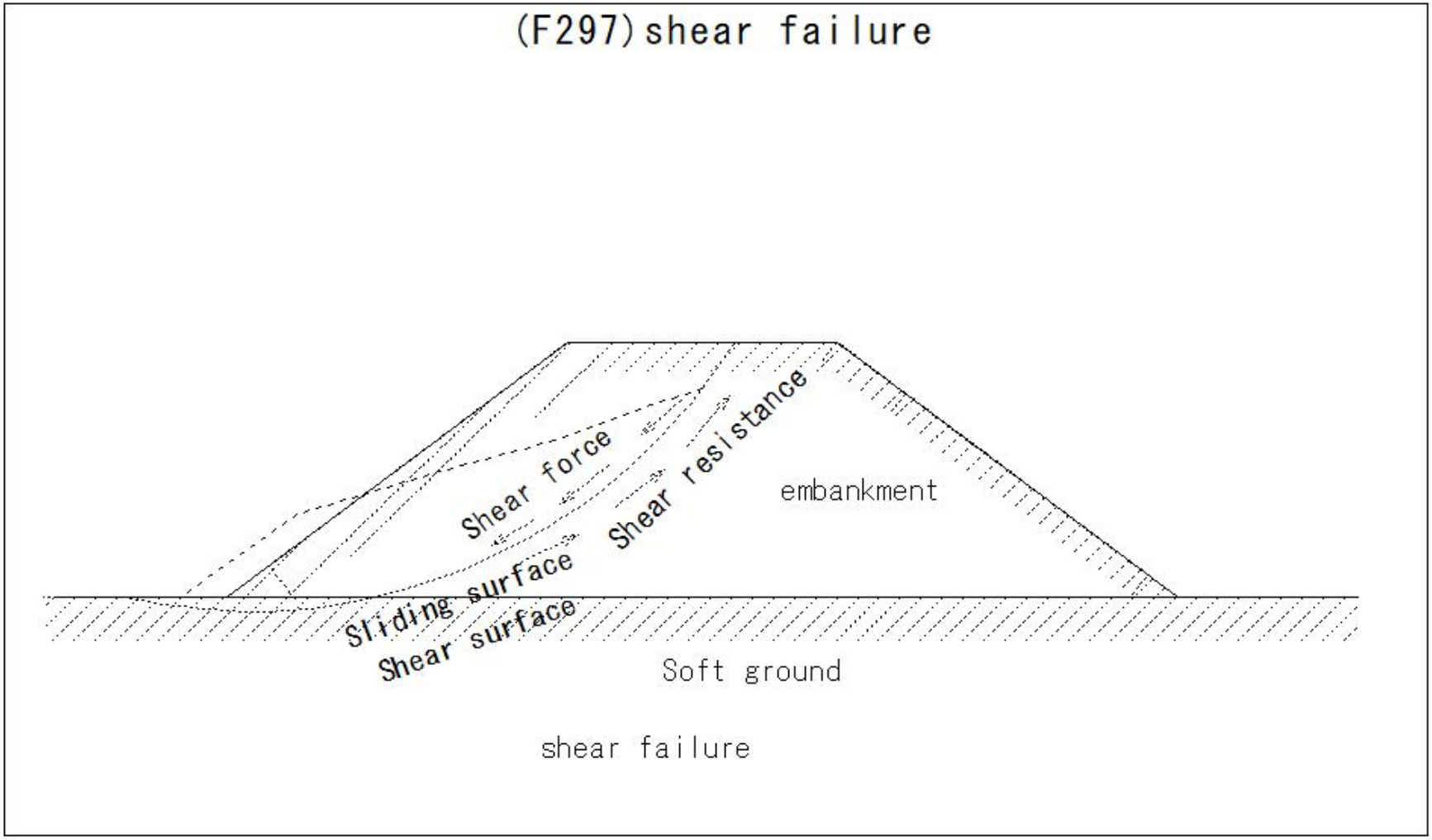
(F295)shear stress



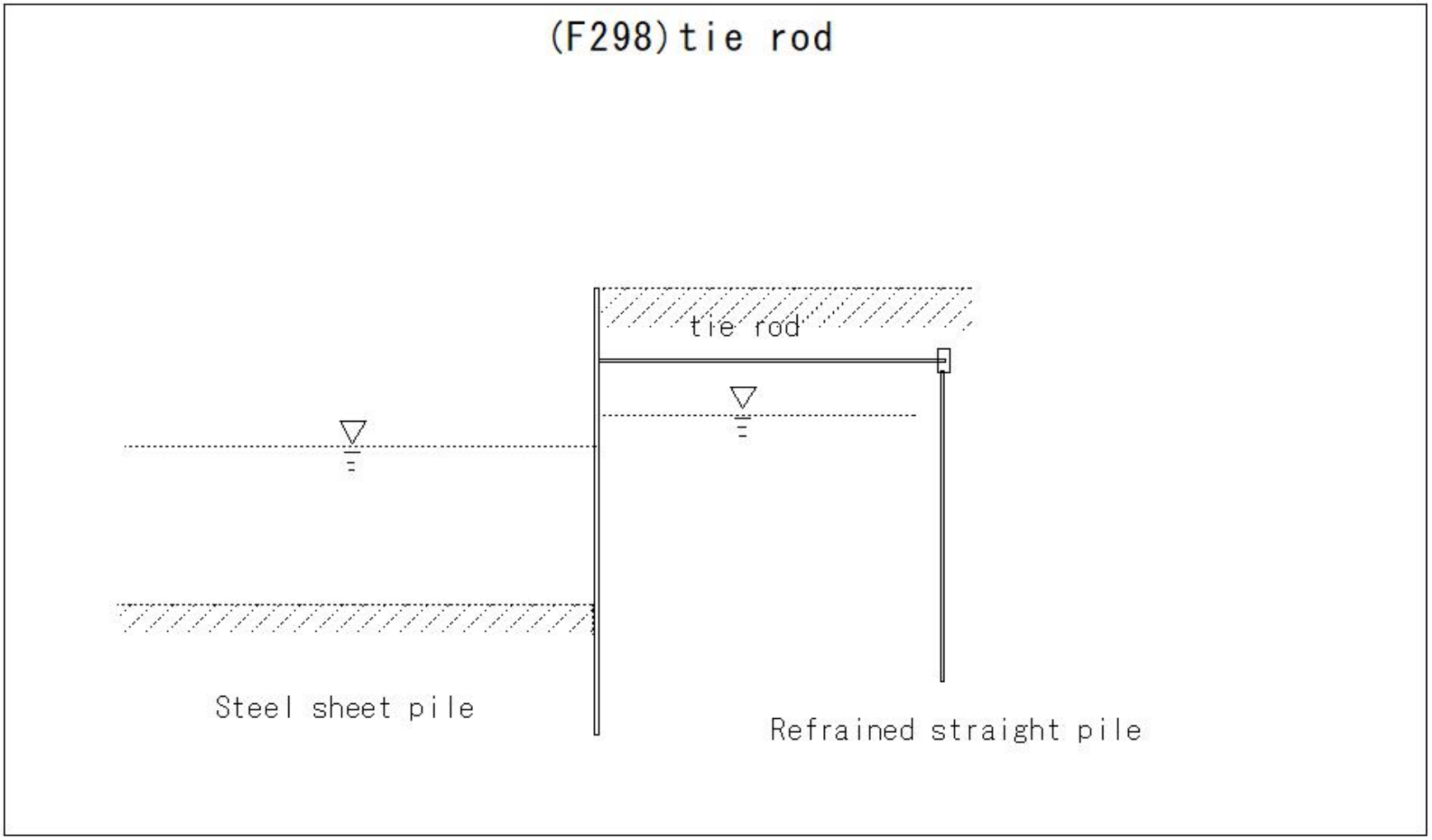
(F296)point bearing pile



(F297)shear failure



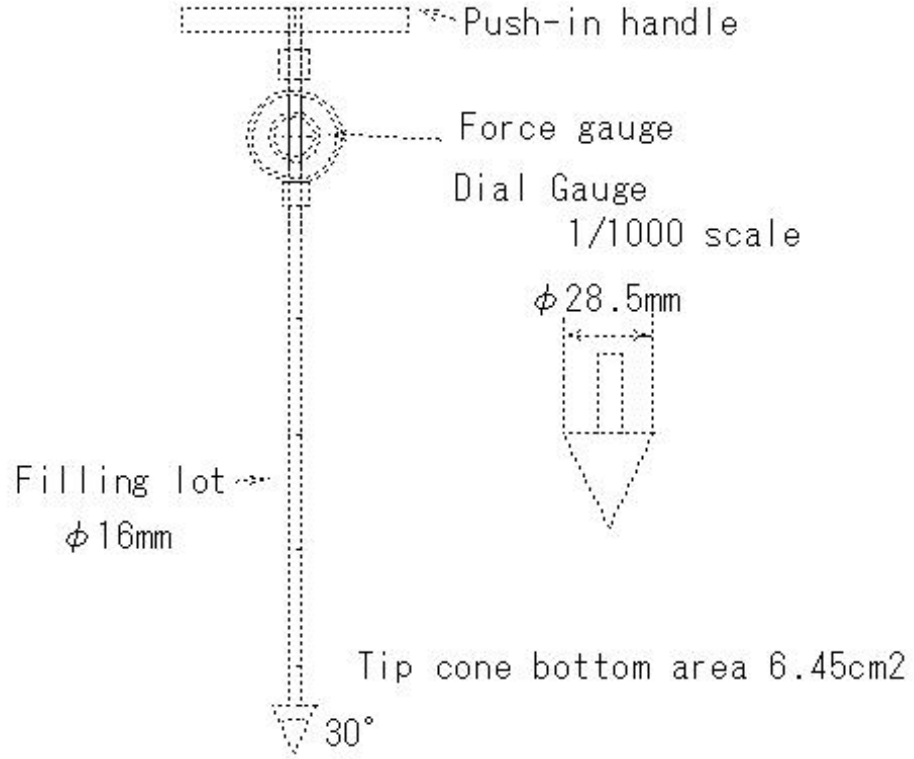
(F298)tie rod


(F298)tie rod
tie rod
Steel sheet pile
Refrained straight pile

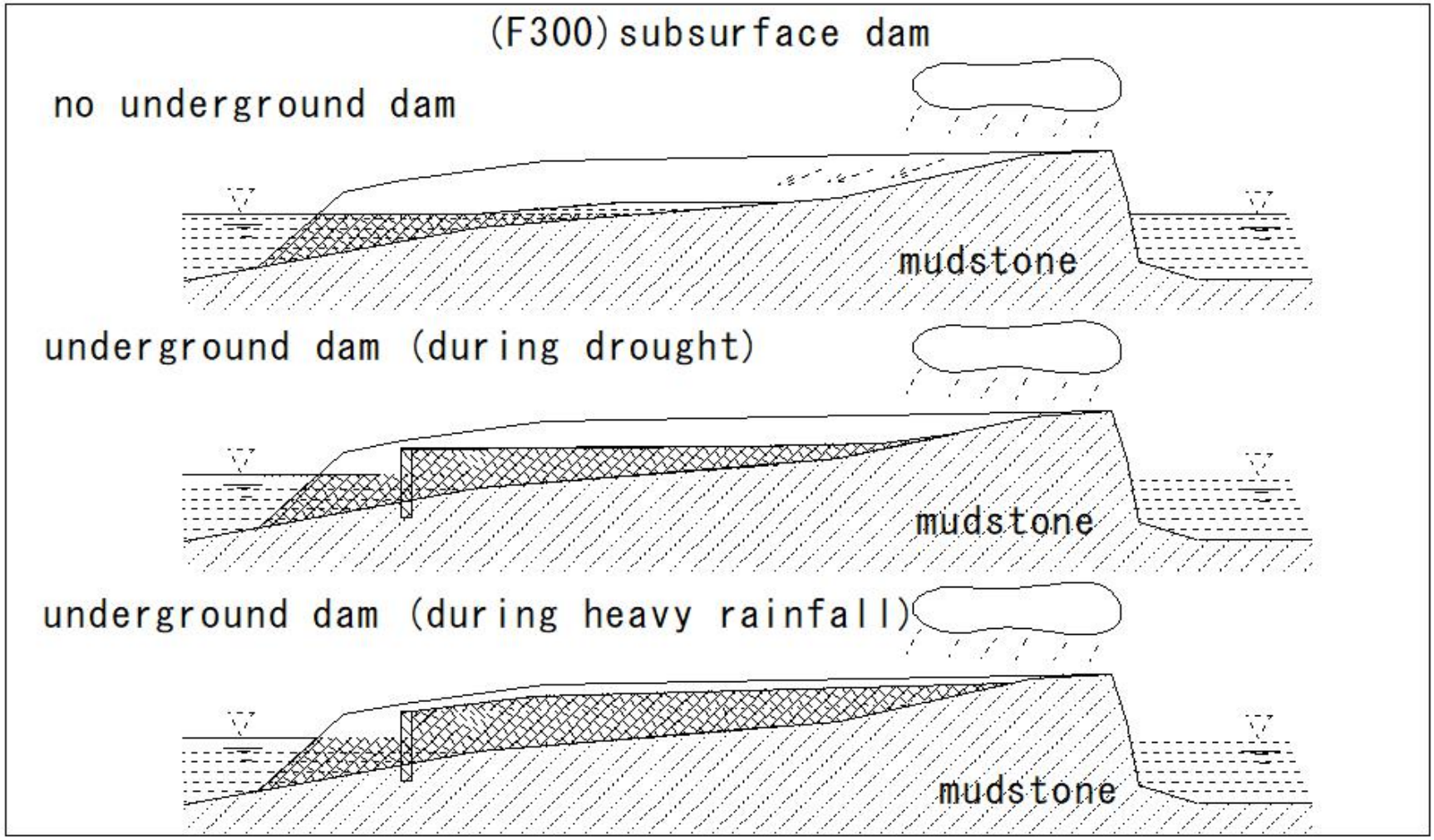
(F299)dutch cone

(F299) dutch cone

Portable conical penetration test
Soft formations
N value 1-30
Cone bearing capacity qc=kgf/cm2
Sandy ground foundation
qc＝4N



(F300)subsurface dam



(F301)electric resistivity survey

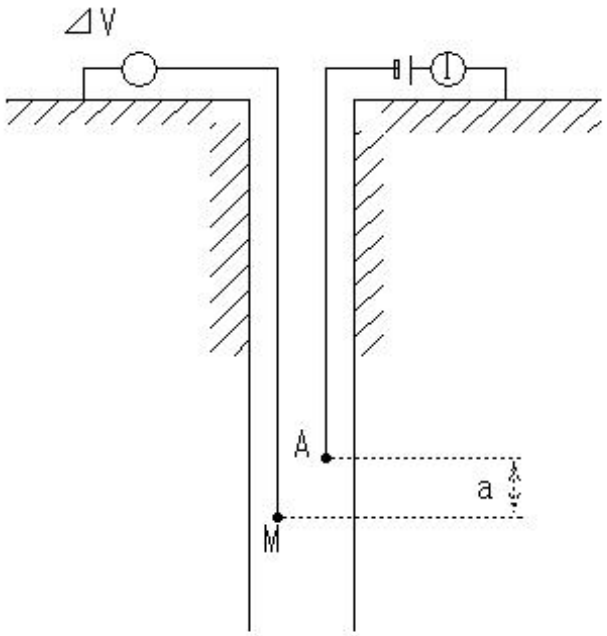
(F301)electric resistivity survey

electric resistivity survey

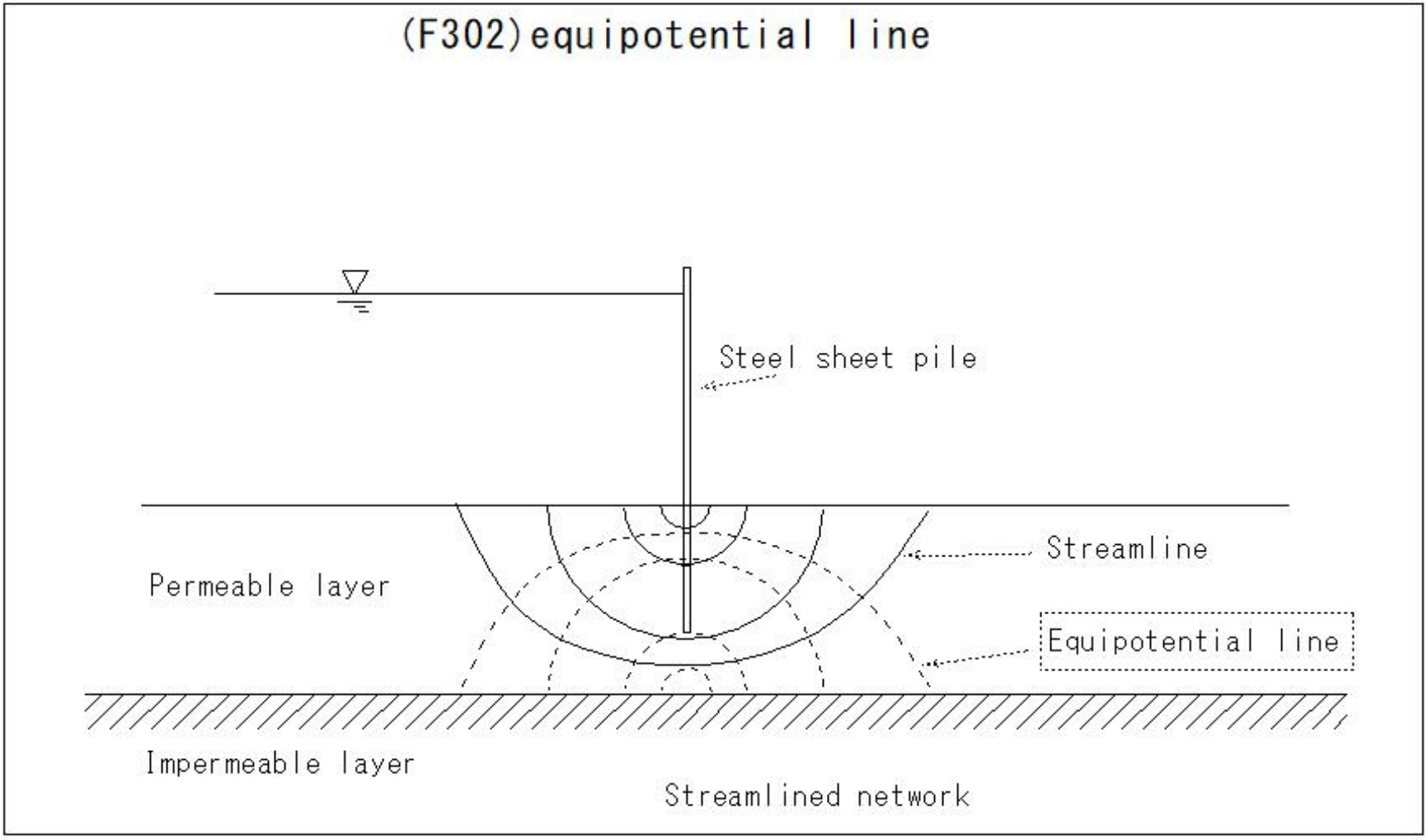
Electrical properties of formations

Comparative resistance of geological formations - measurement

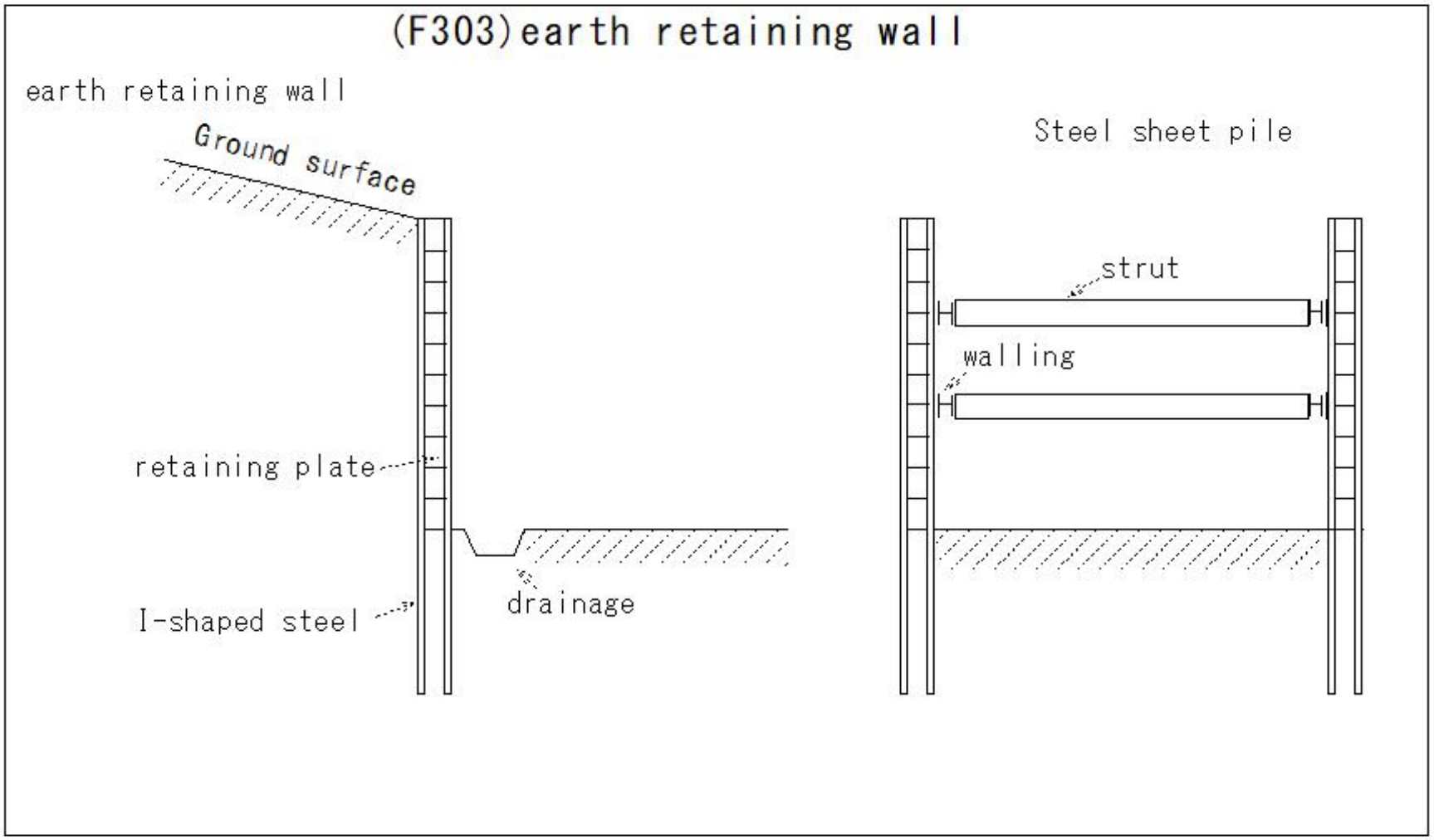
Ground composition



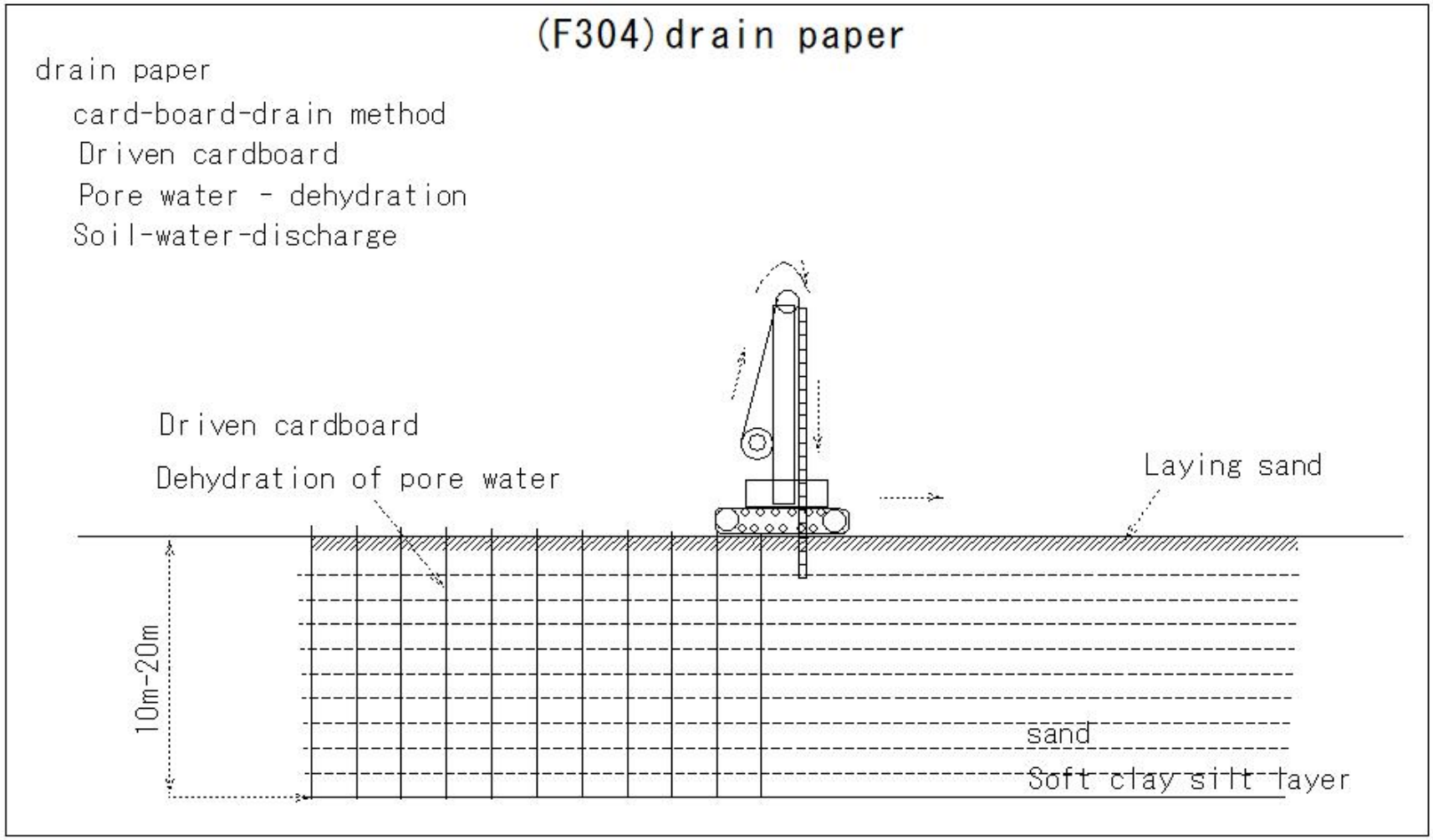
(F302)equipotential line



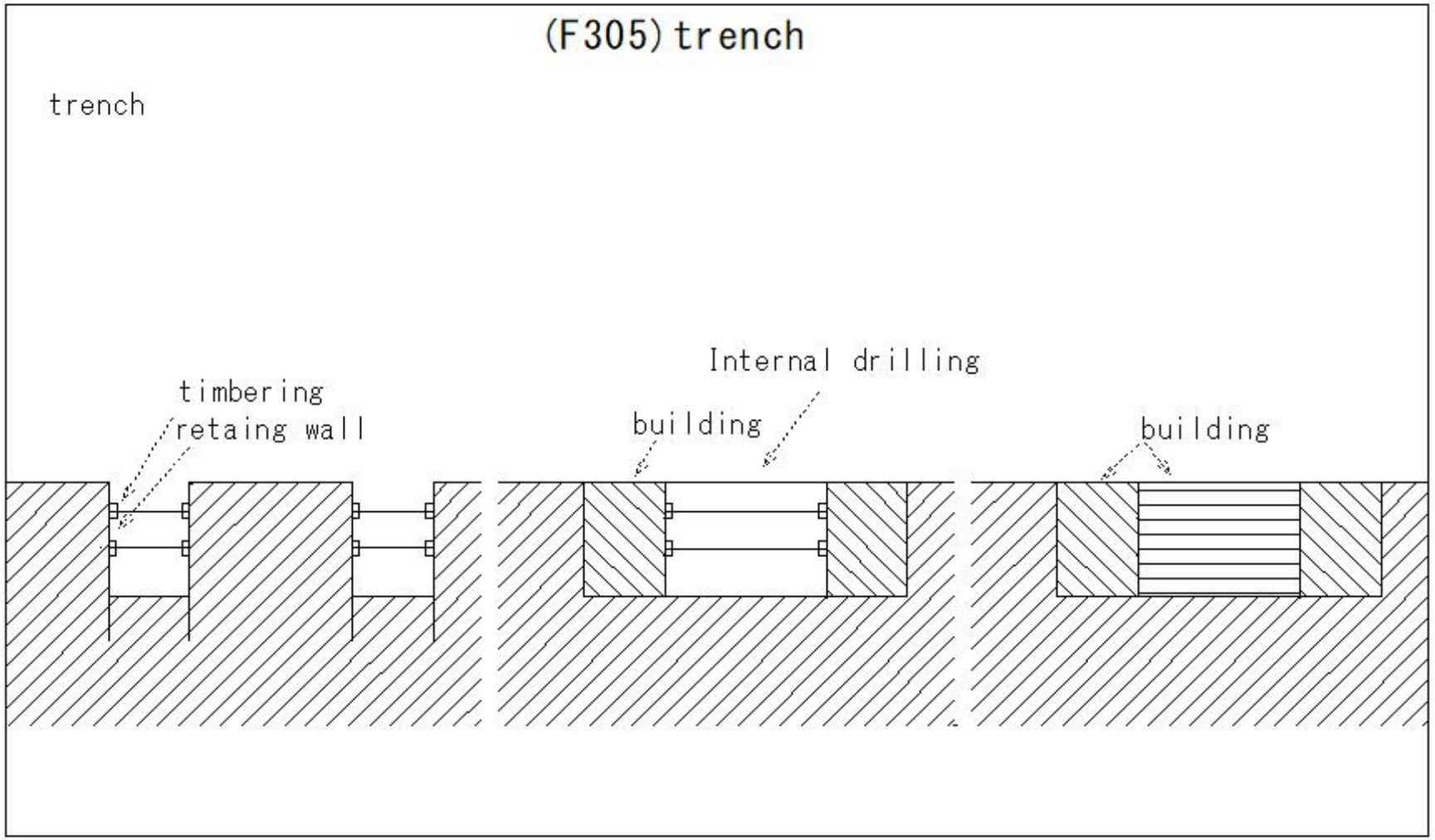
(F303)earth retaining wall



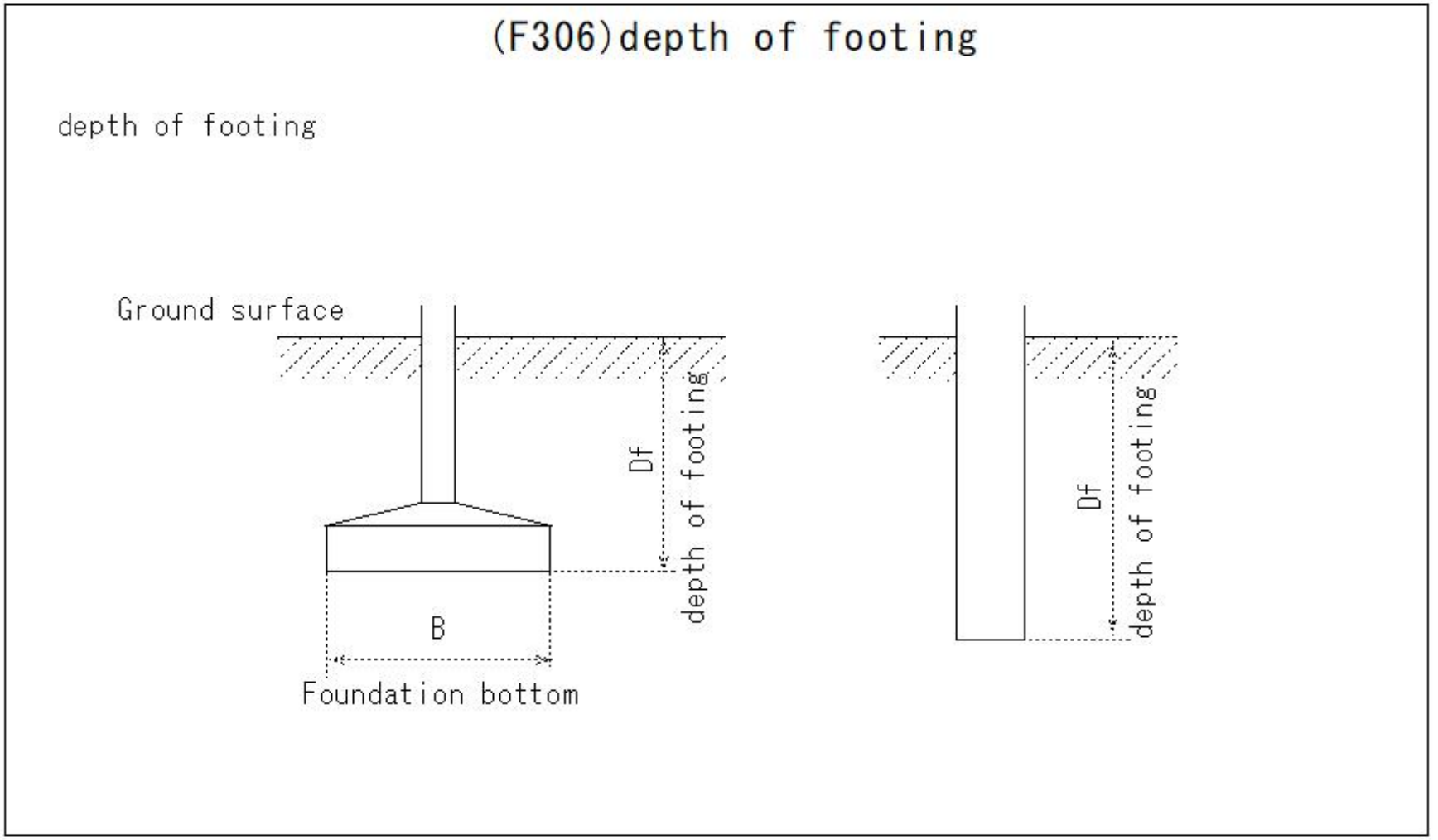
(F304)drain paper



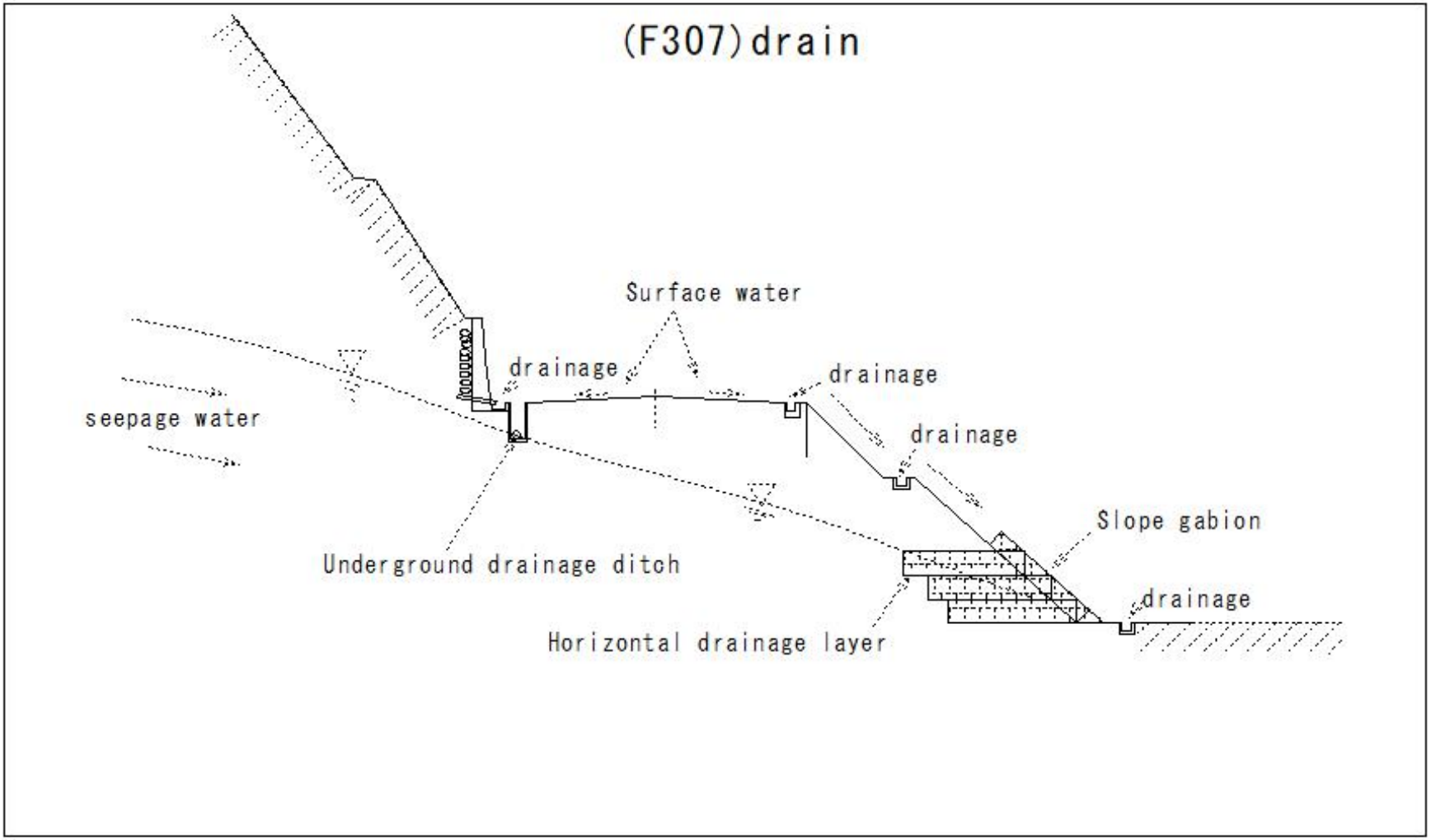
(F305)trench


(F305) trench
trench
timbering
retaing wall
Internal drilling
building
building

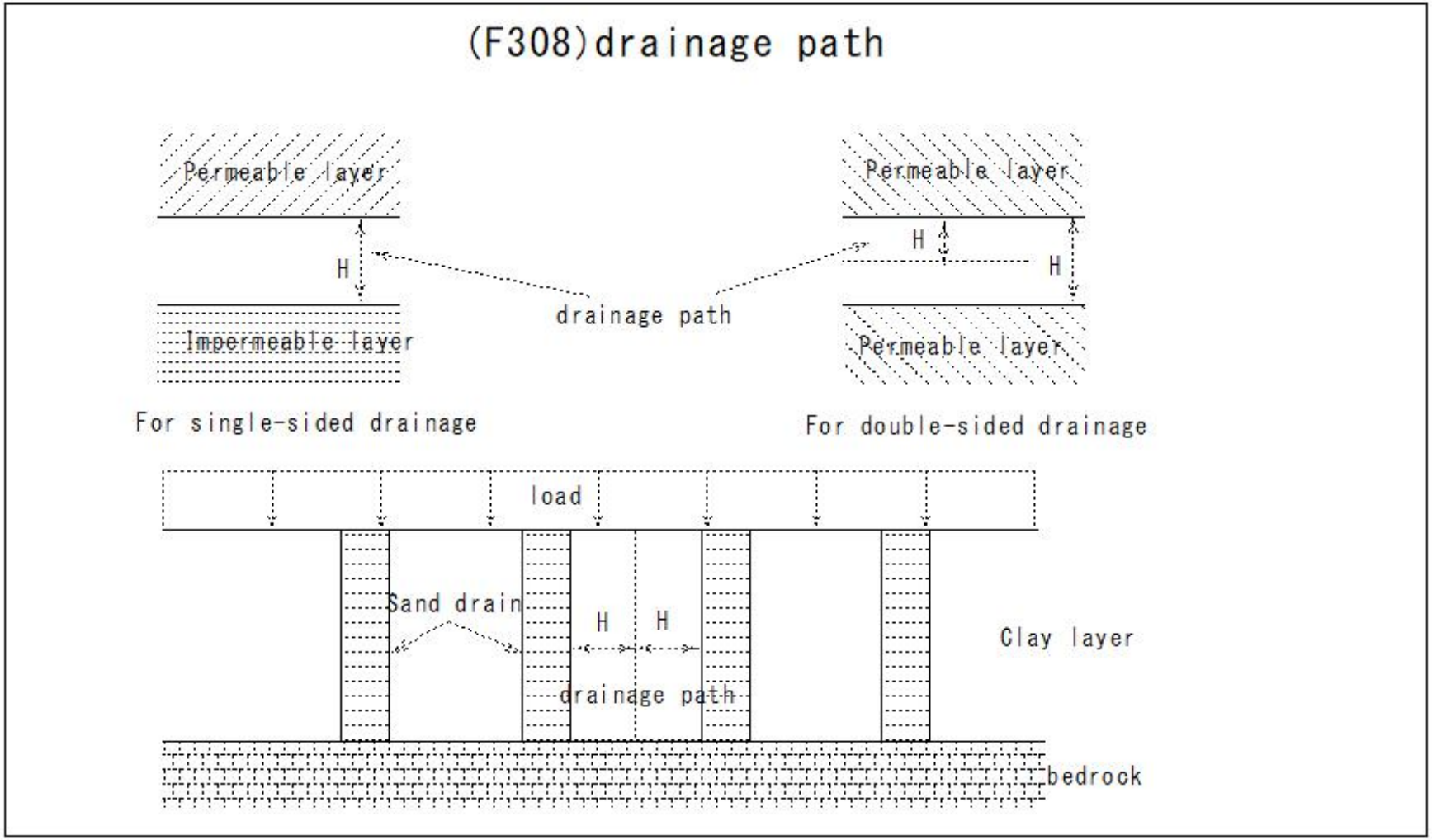
(F306)depth of footing



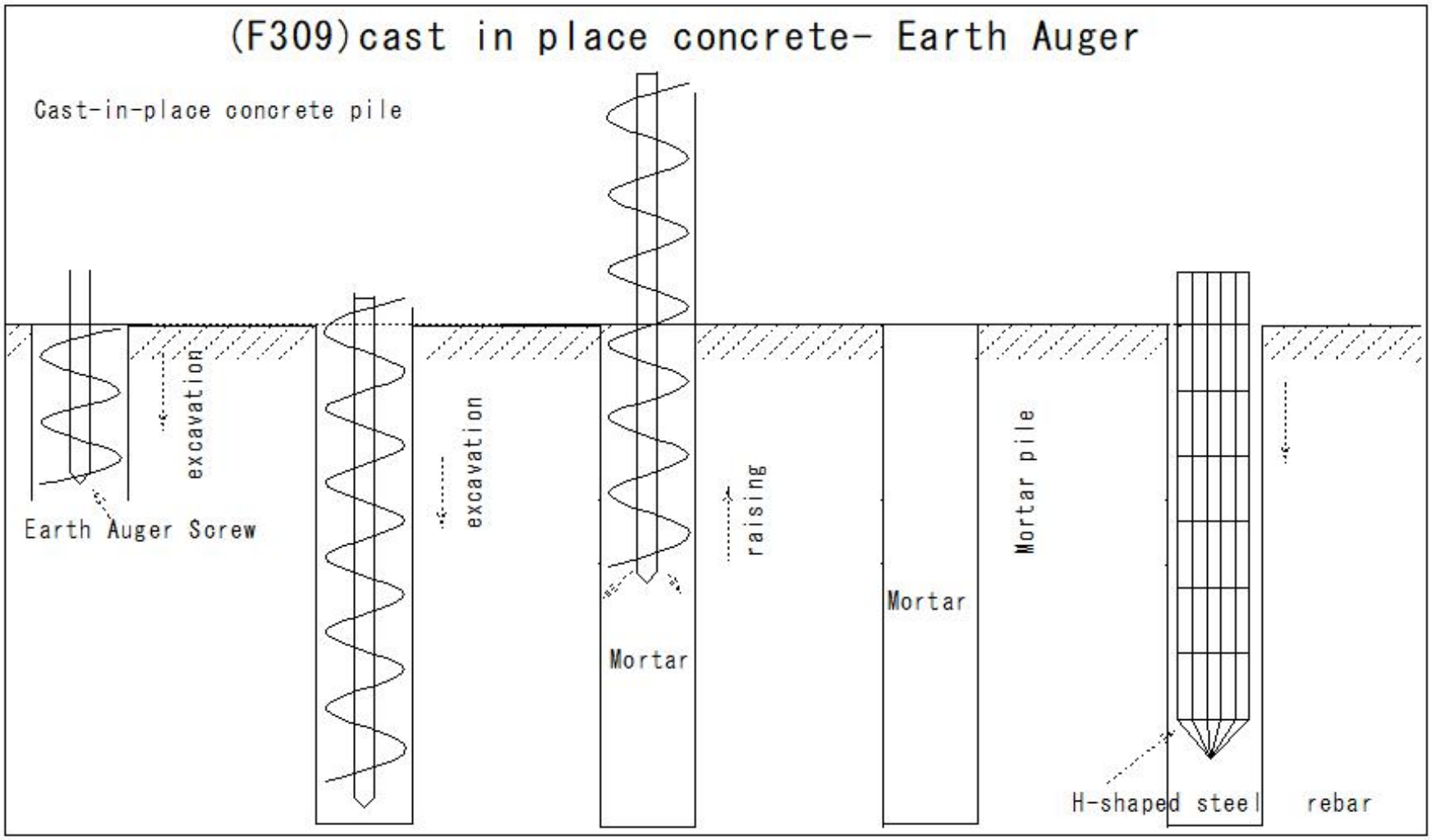
(F307)drain


(F307)drain
Surface water
drainage
drainage
drainage
seepage water
Slope gabion
Underground drainage ditch
drainage
Horizontal drainage layer

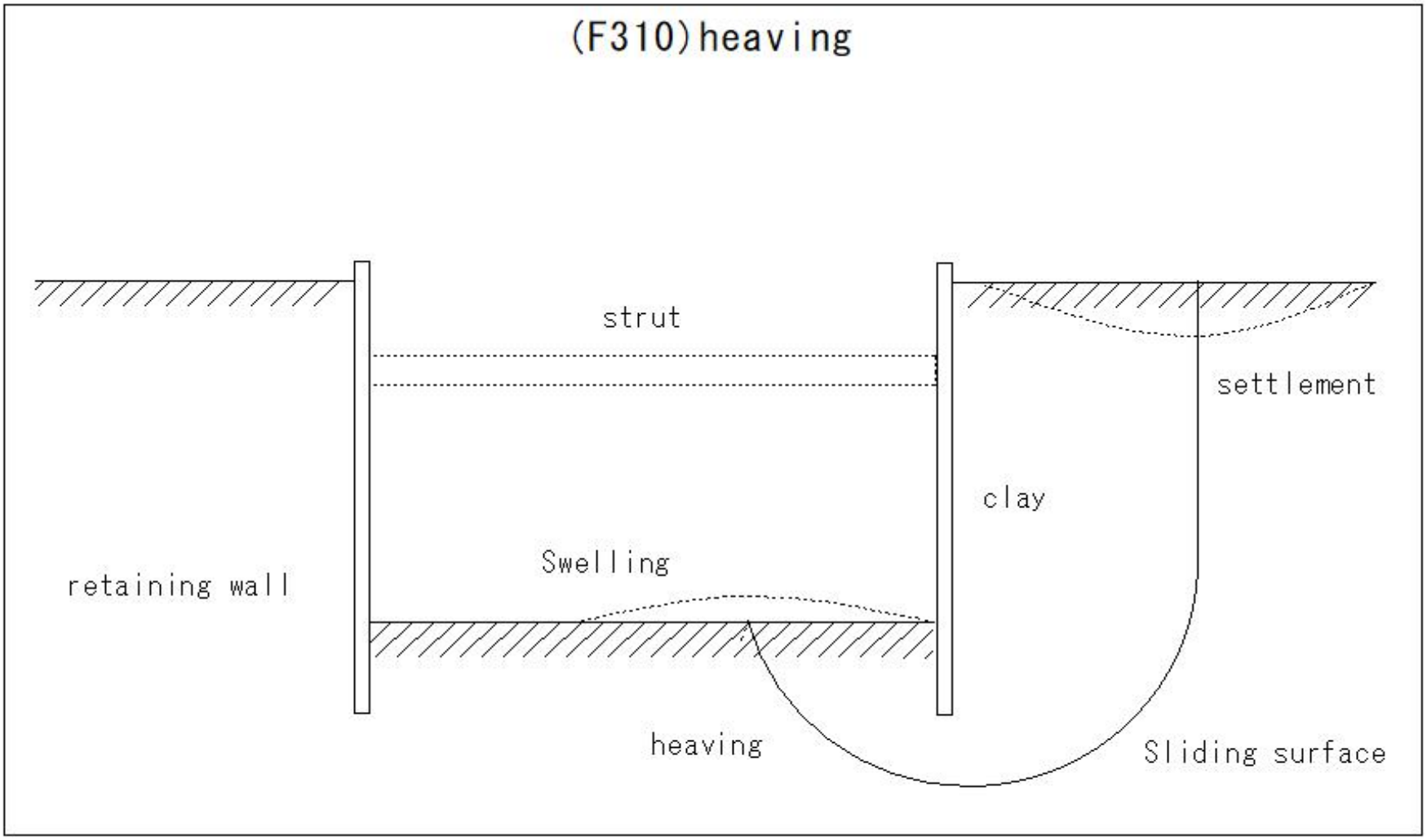
(F308)drainage path



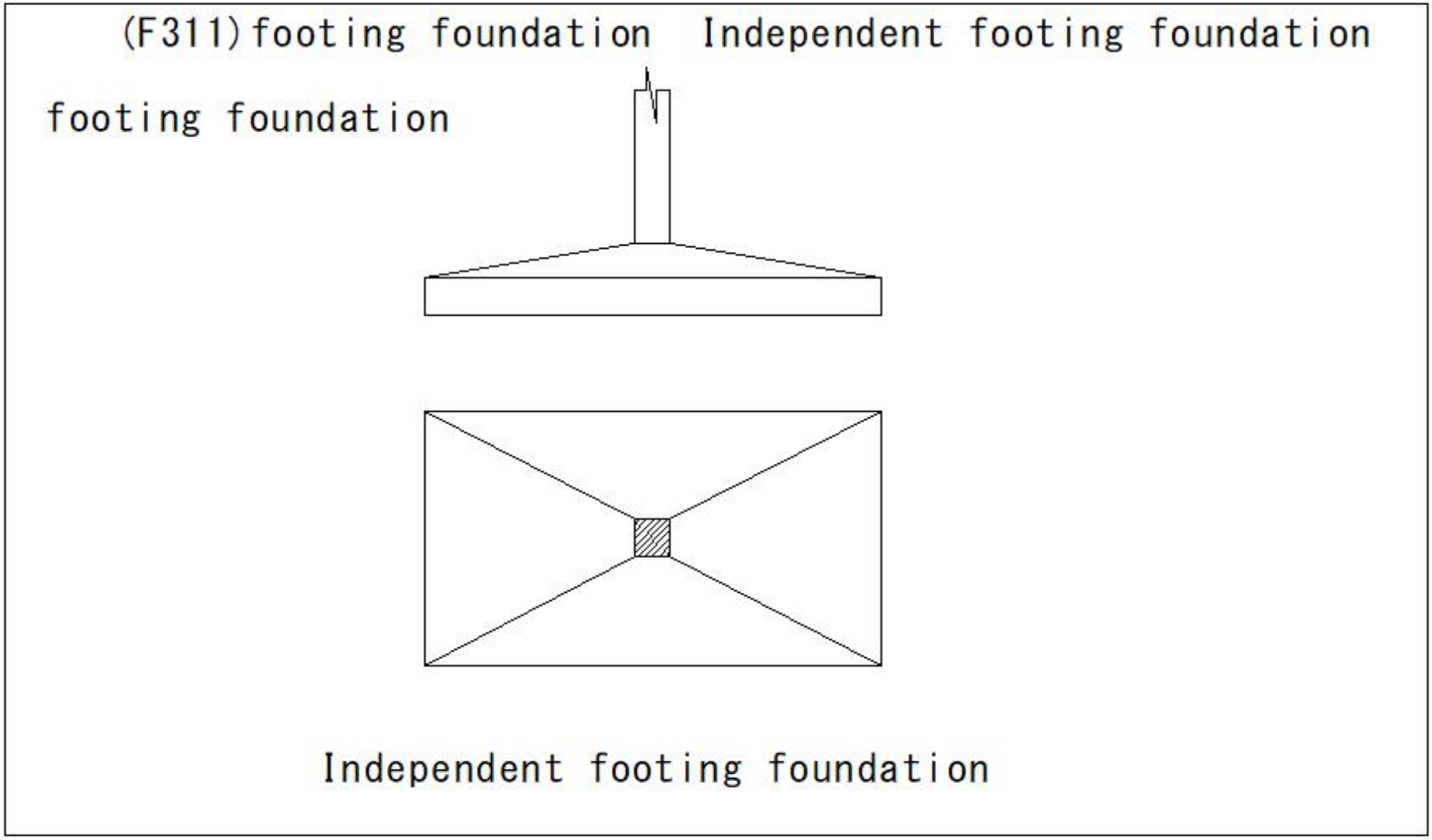
(F309)cast in place concrete- Earth Auger



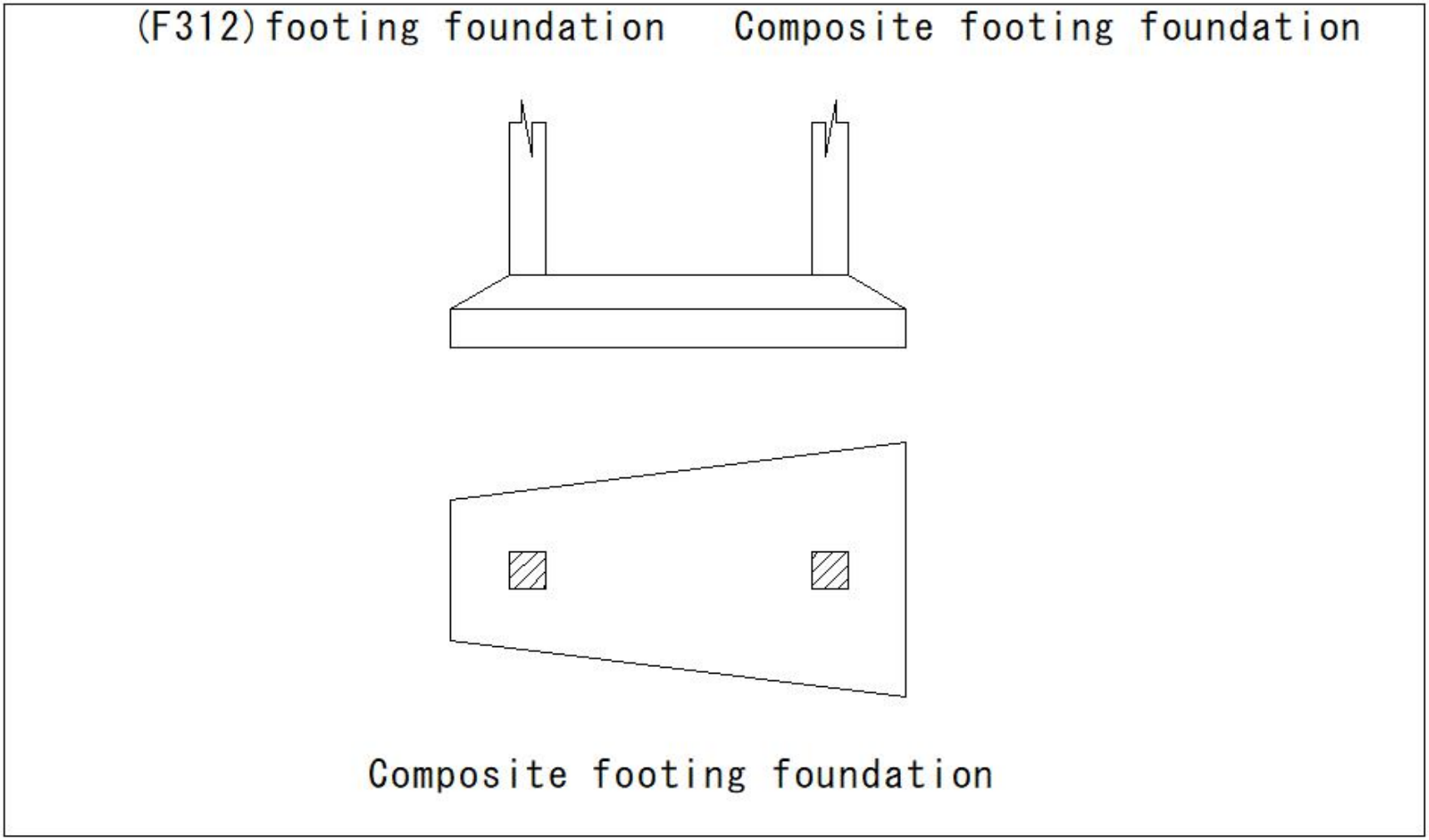
(F310)heaving



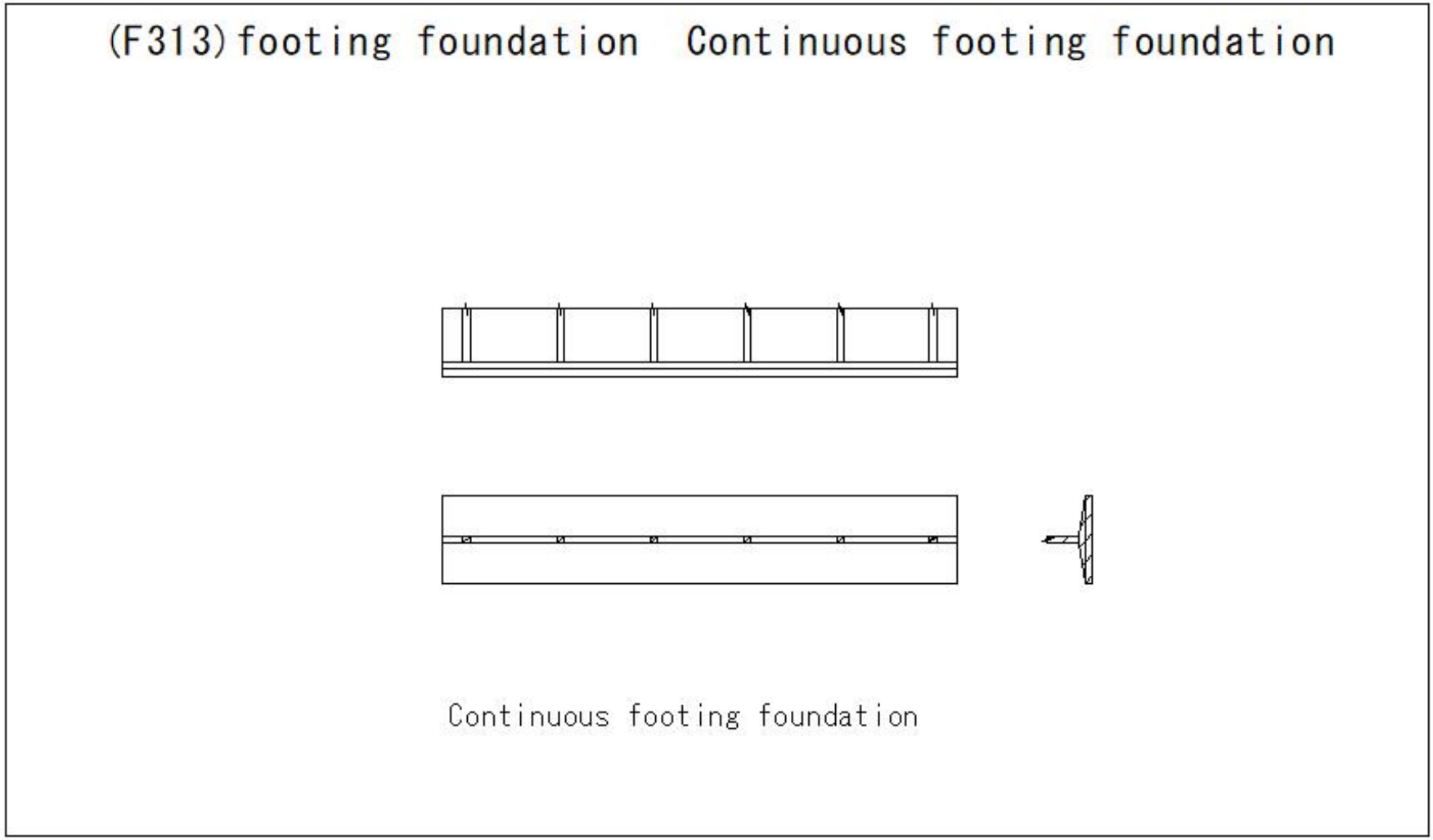
(F311)footing foundation Independent footing foundation



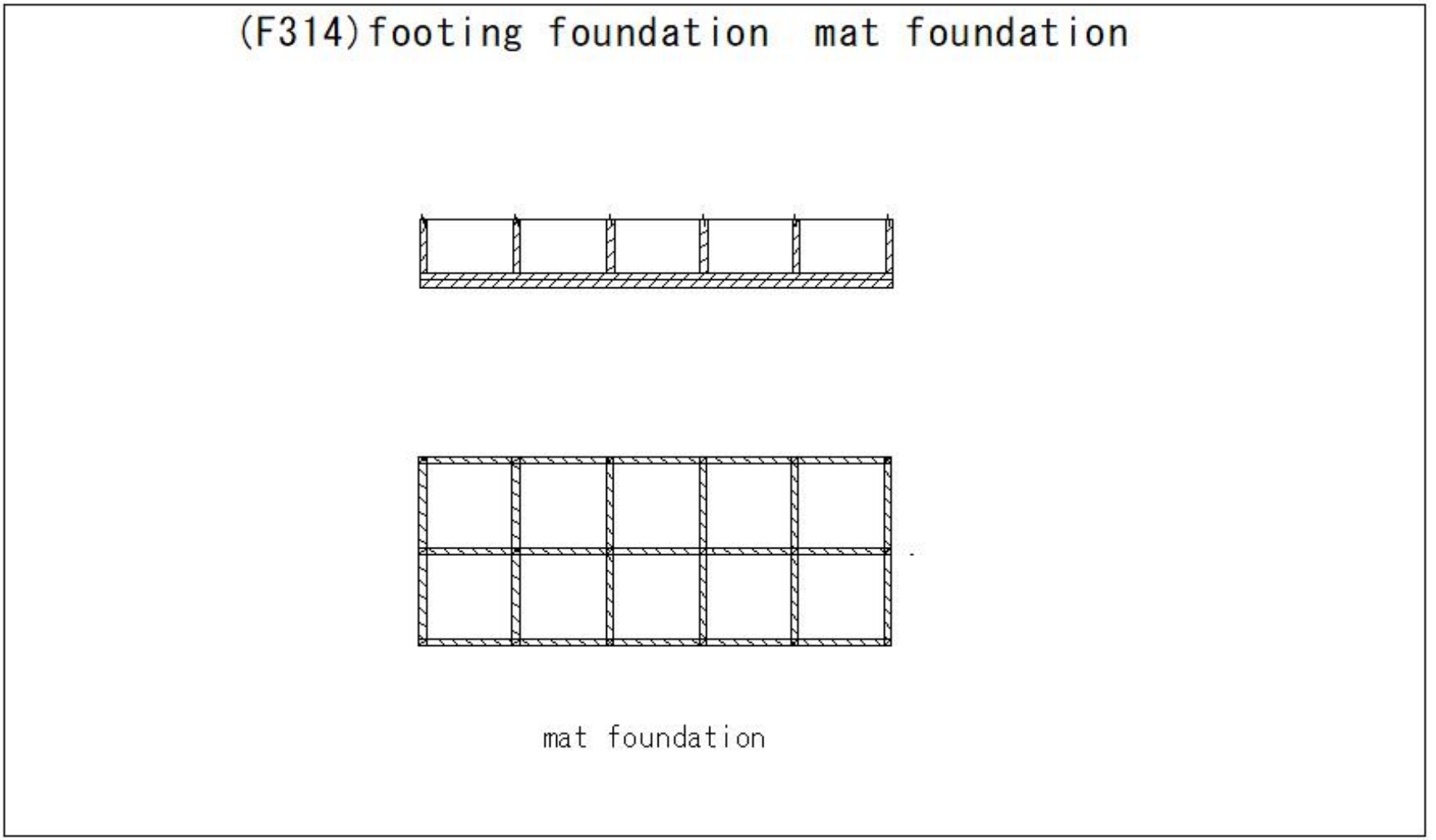
(F312)footing foundation　Composite footing foundation



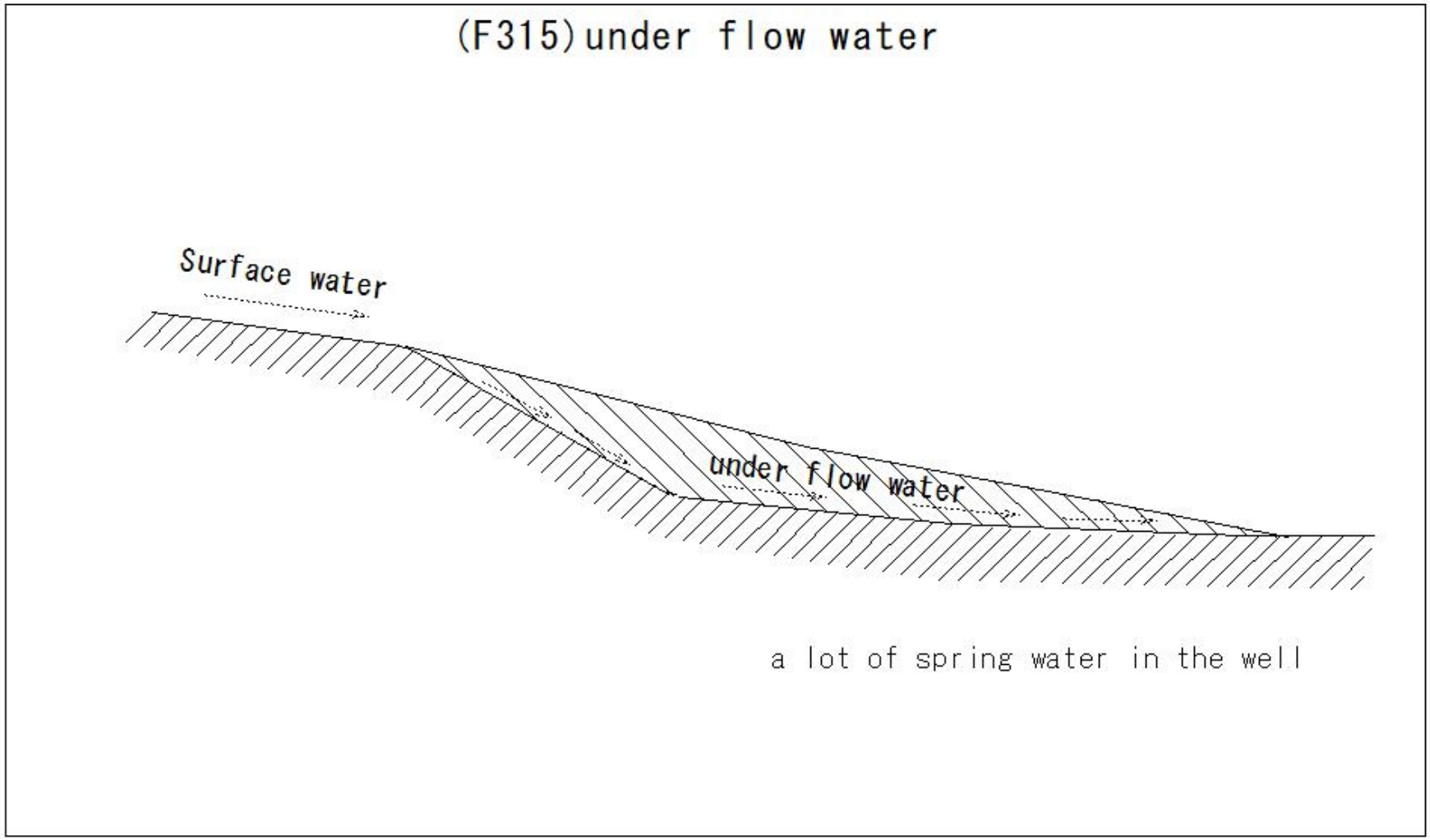
(F313)footing foundation Continuous footing foundation



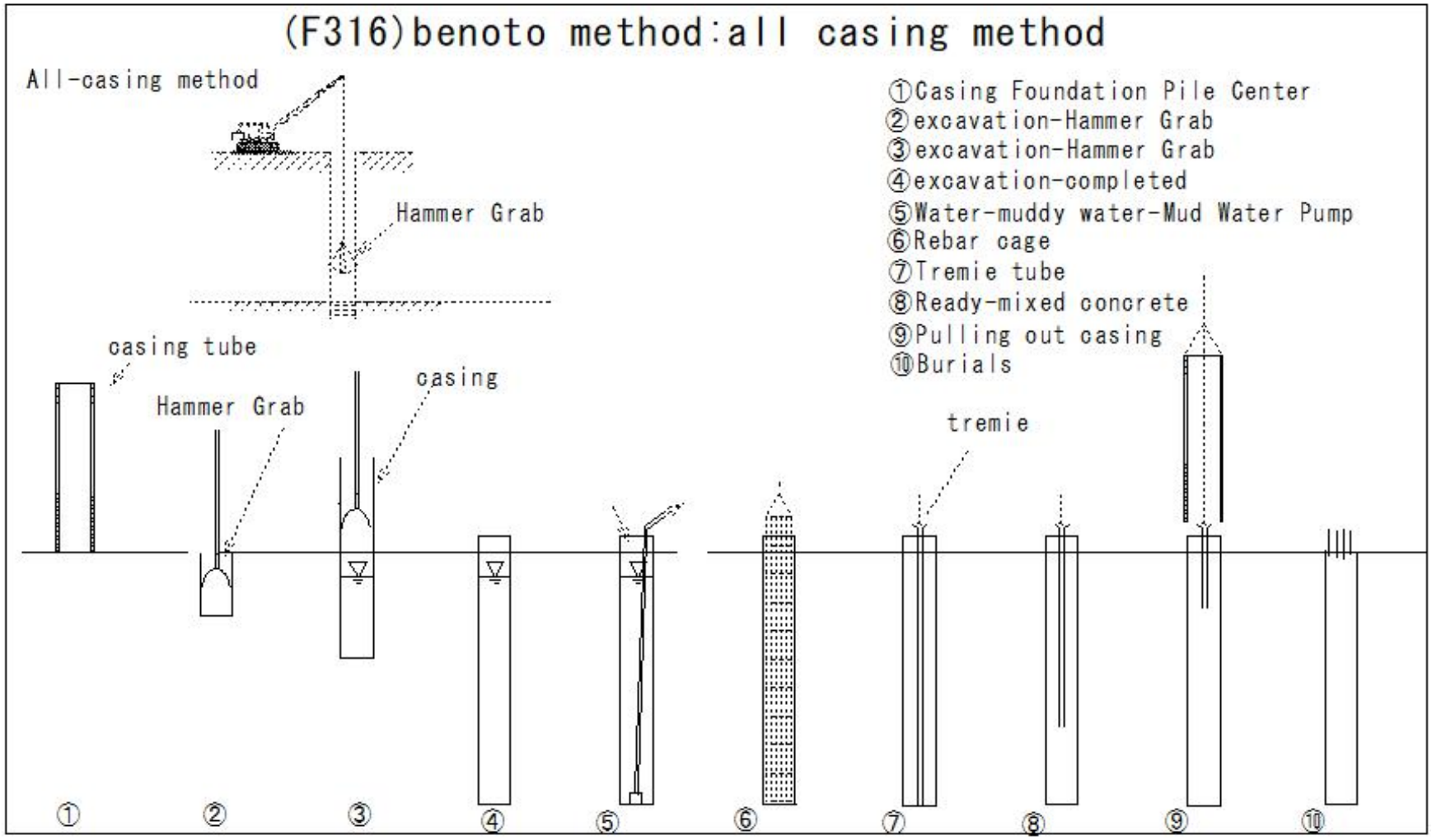
(F314)footing foundation mat foundation



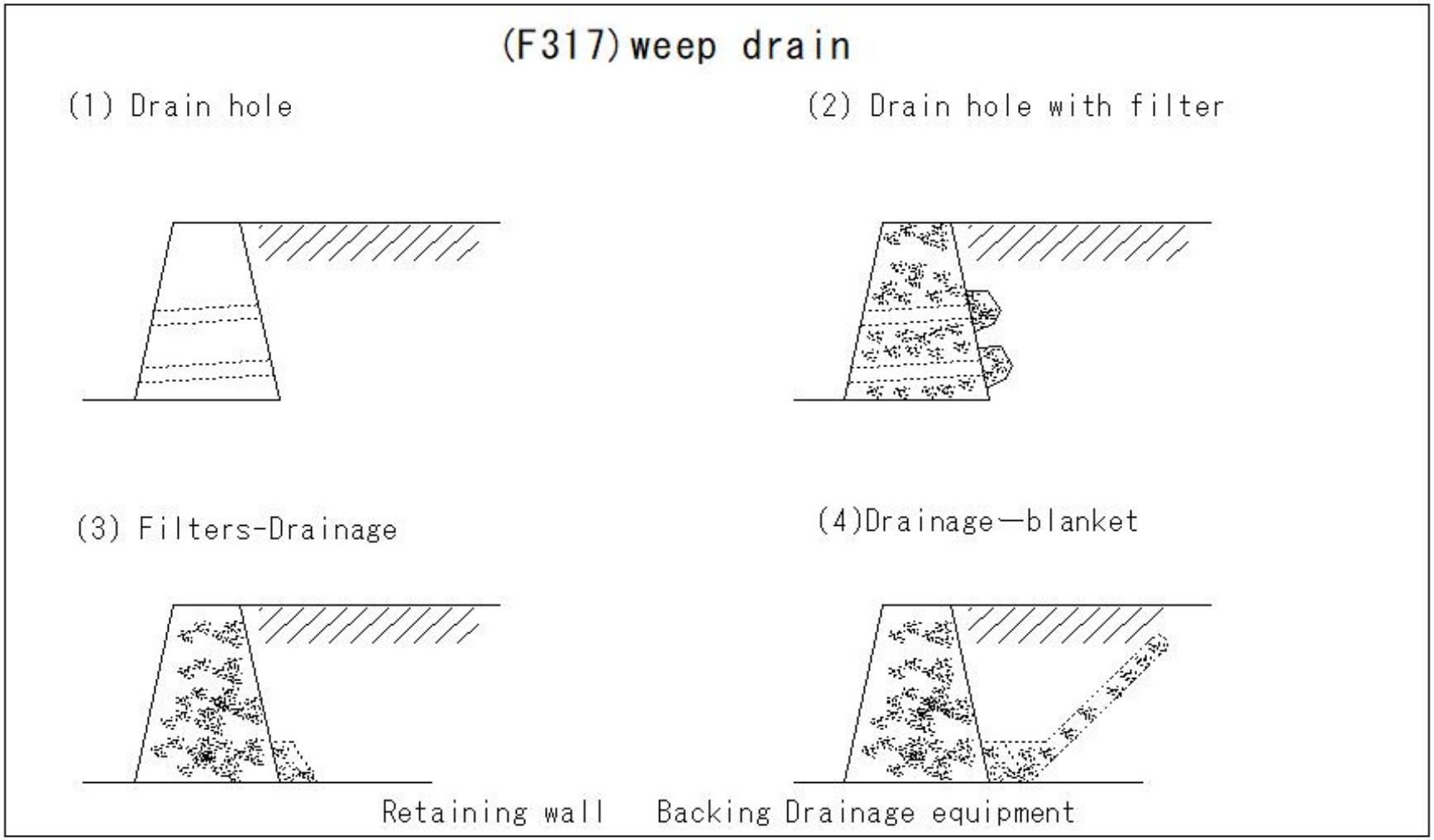
(F315)under flow water



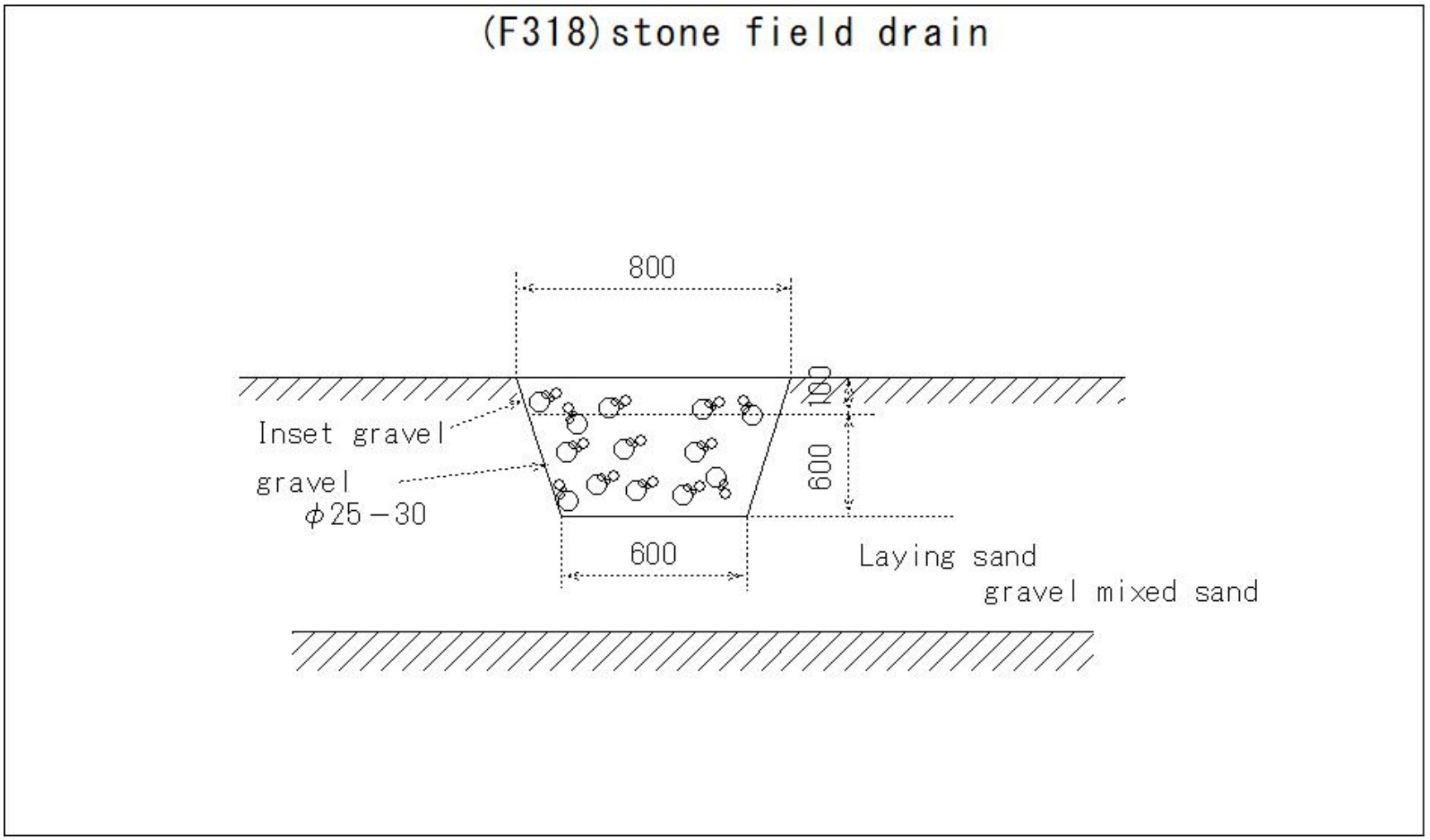
(F316)benoto method :all casing method



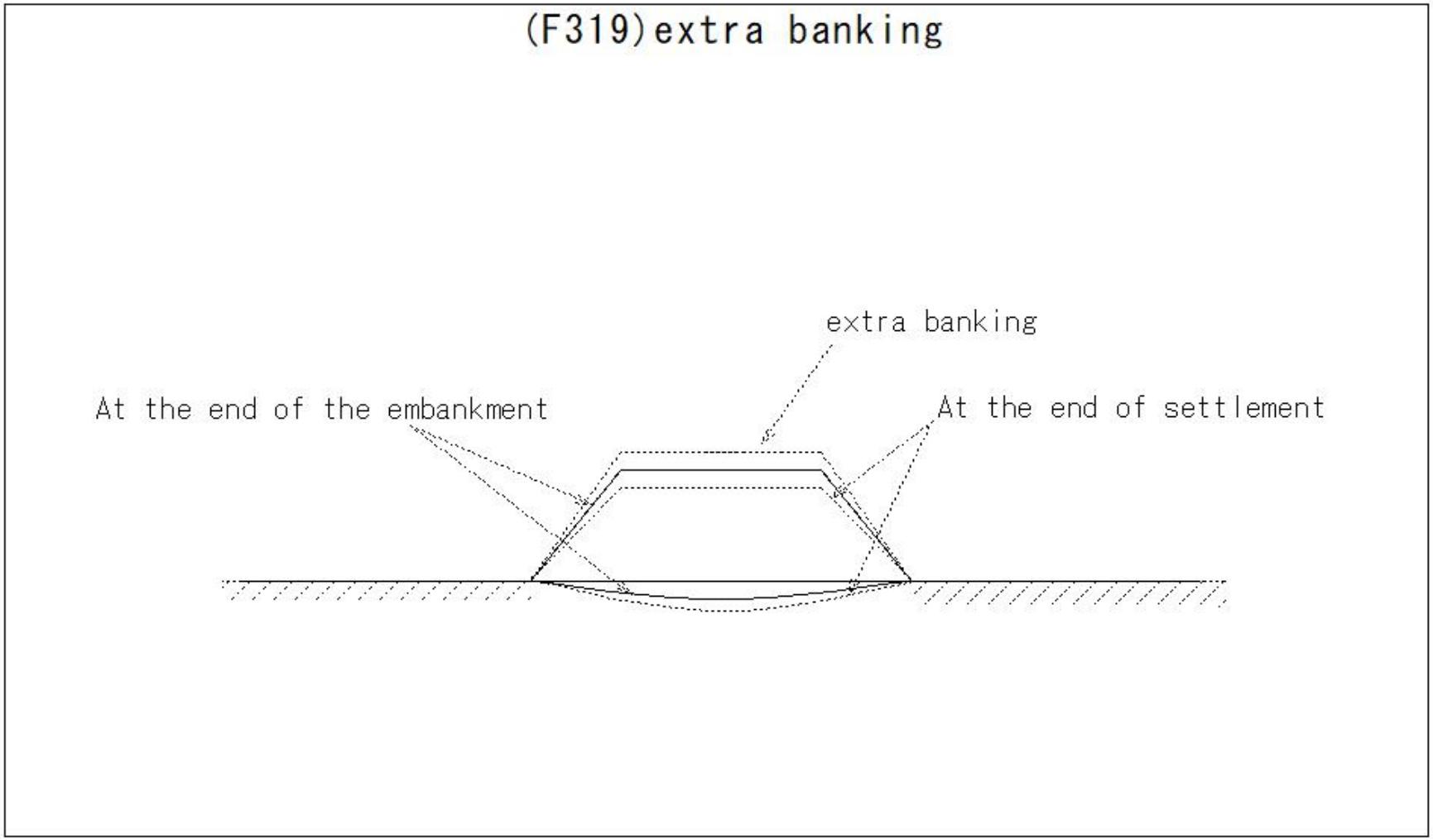
(F317)weep drain



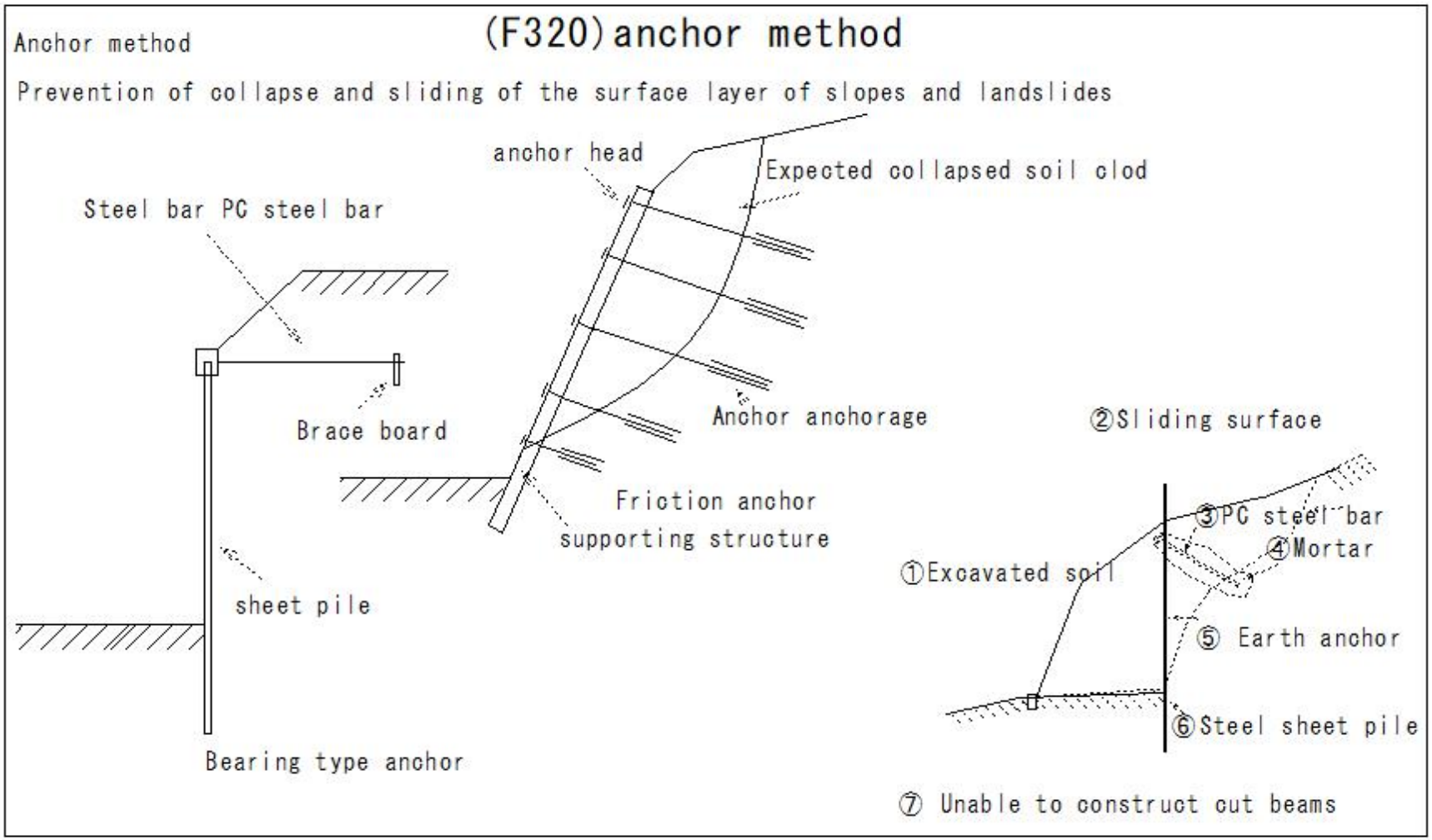
(F318)stone field drain



(F319)extra banking



(F320)anchor method



(F321)pile foundation

pile foundation

1 pile foundation method

2-place cast pile method

3 Ready-made piles

4 Embedded pile foundation

5 Driven pile foundation

6 Pre-boring method

7 Hollow excavation method

8 rotation injection

9 jet method

10 blow method

11 Earth removal method

15 Earth removal method

17 Auger earth removal method

21 Cement milk injection

22 No treatment

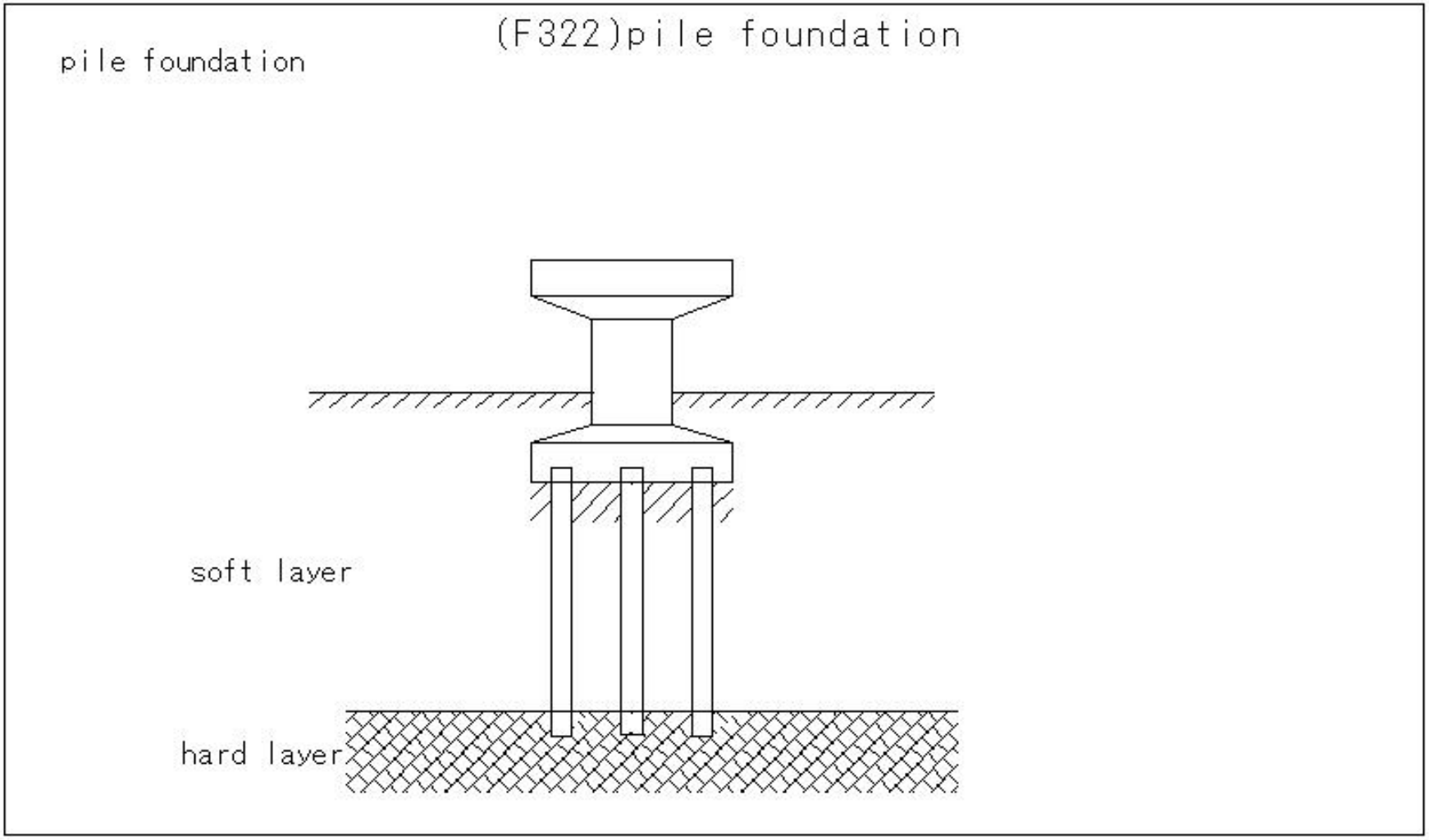
23 Hydraulic press-fit milk injection

24 stroke milk

25diesel hammer blow

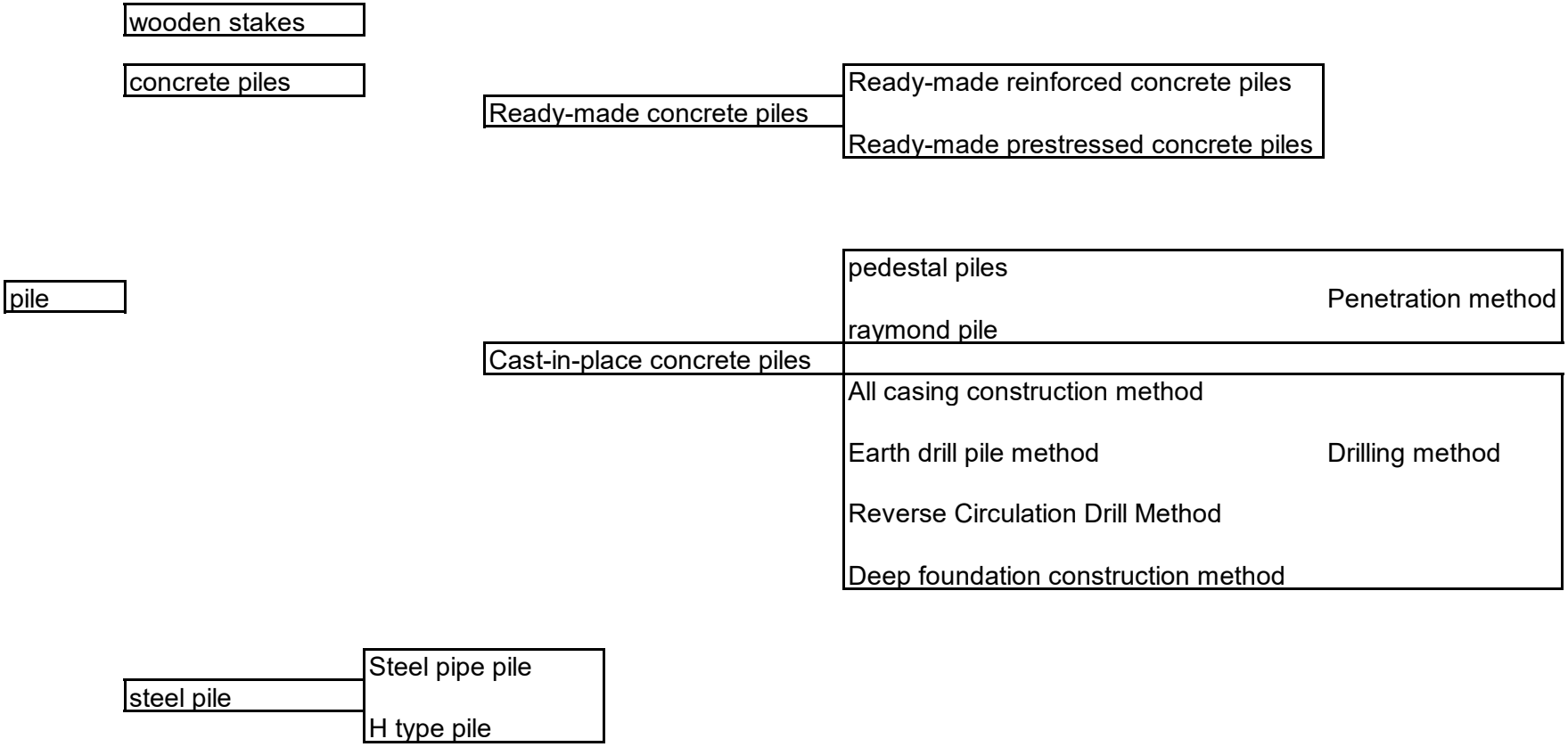
26 hydraulic hammer blow

(F322)pile foundation

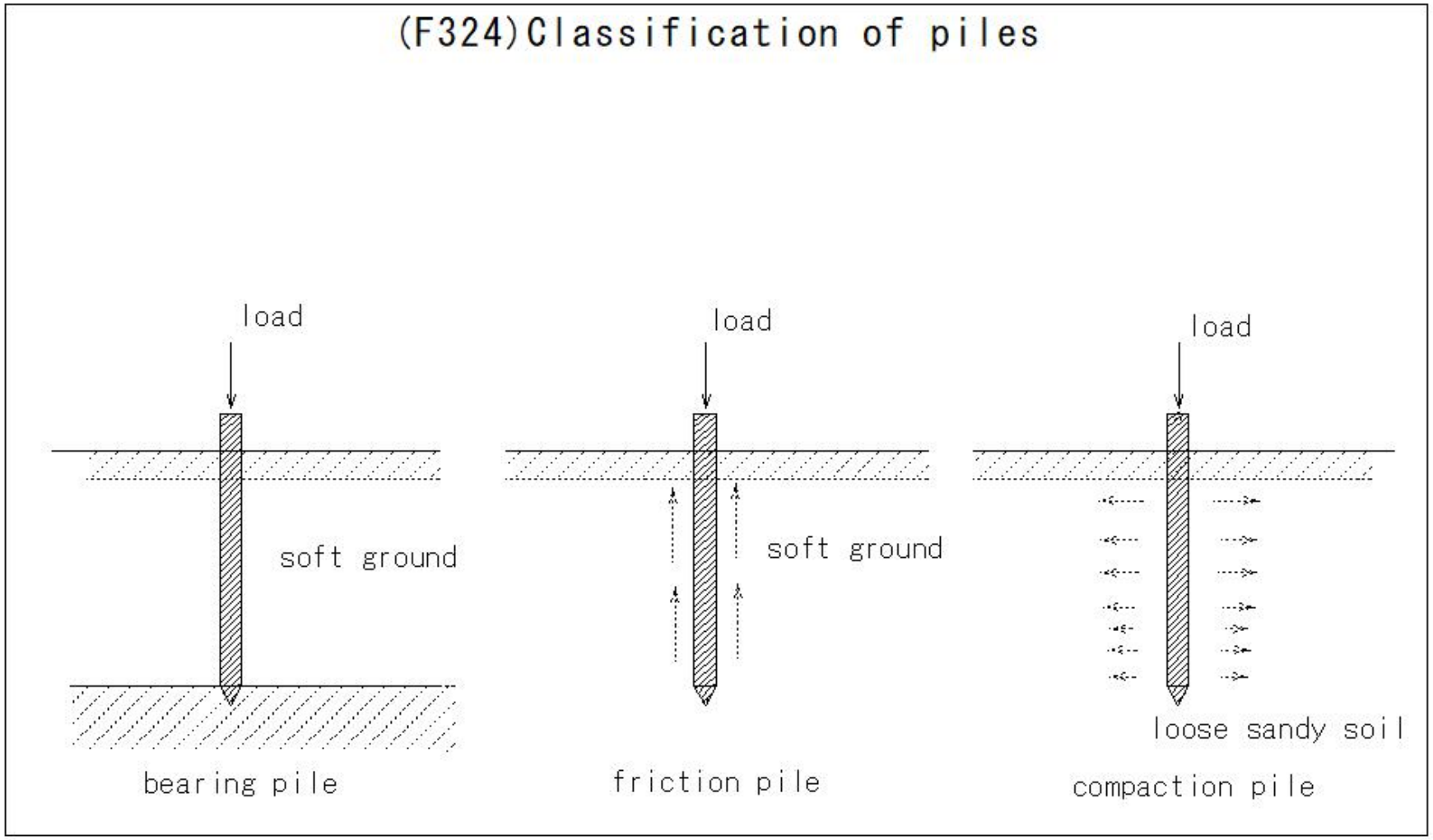


(F323)pile foundation

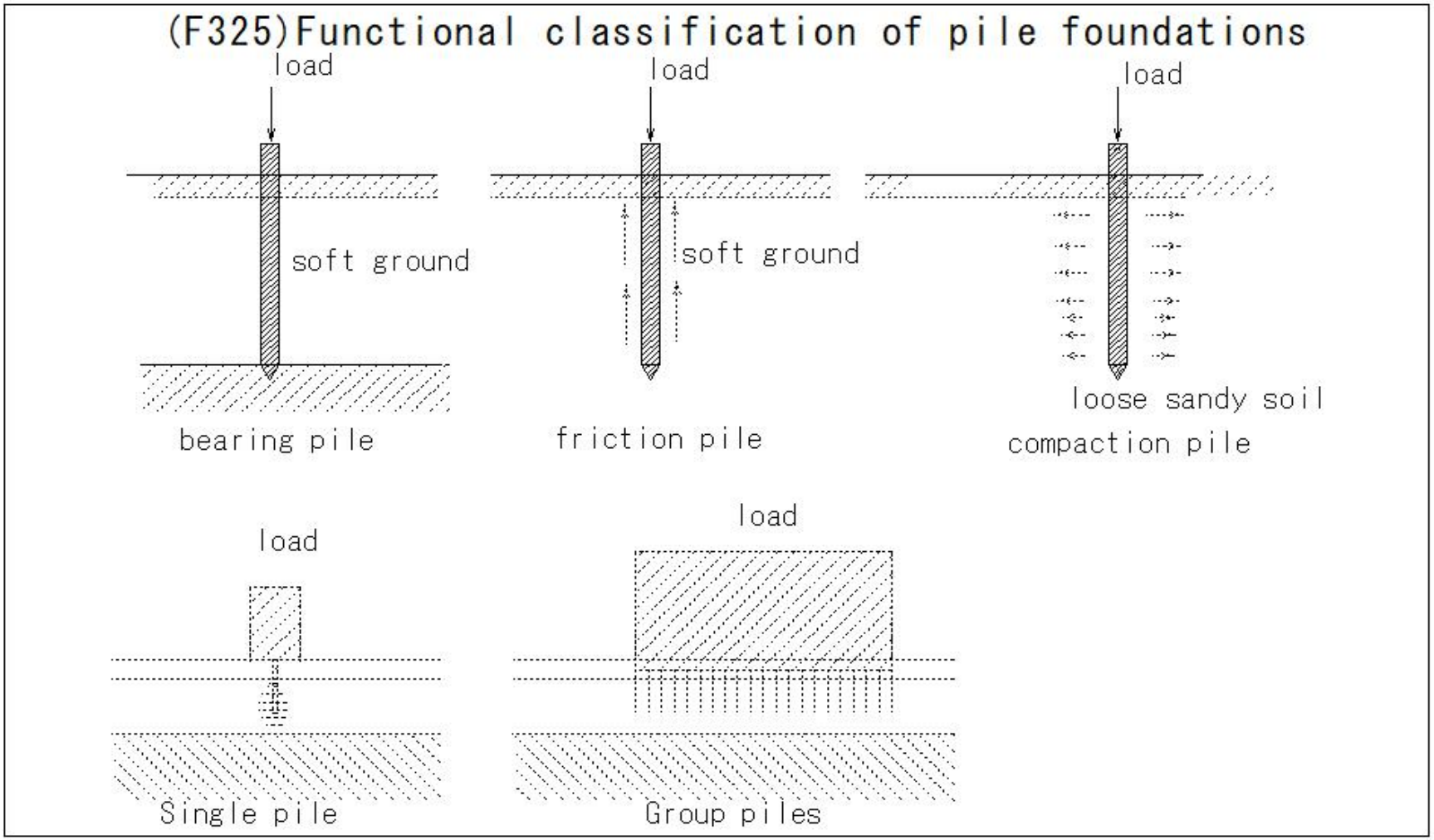
(F323)pile foundation



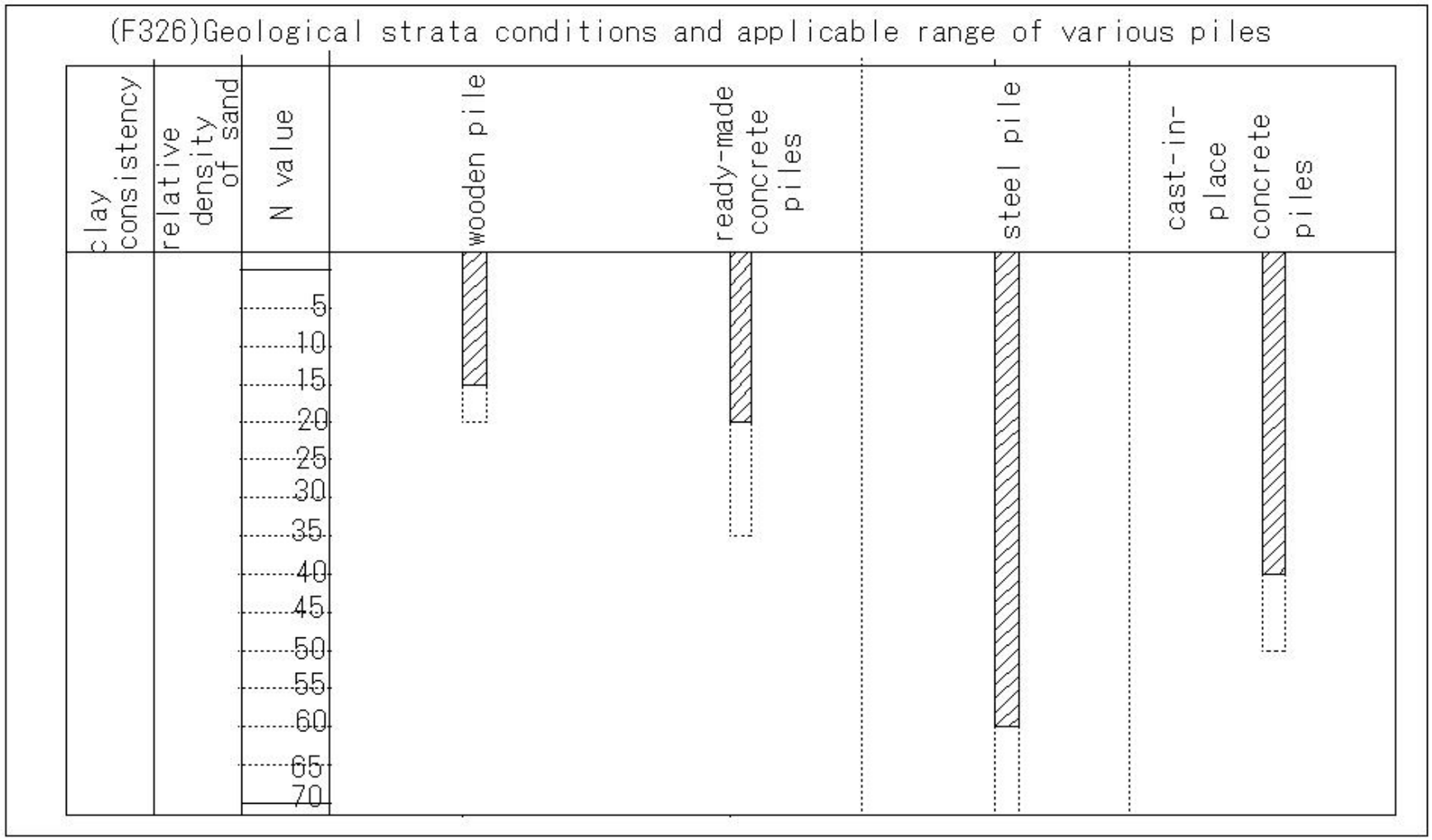
(F324)Classification of piles



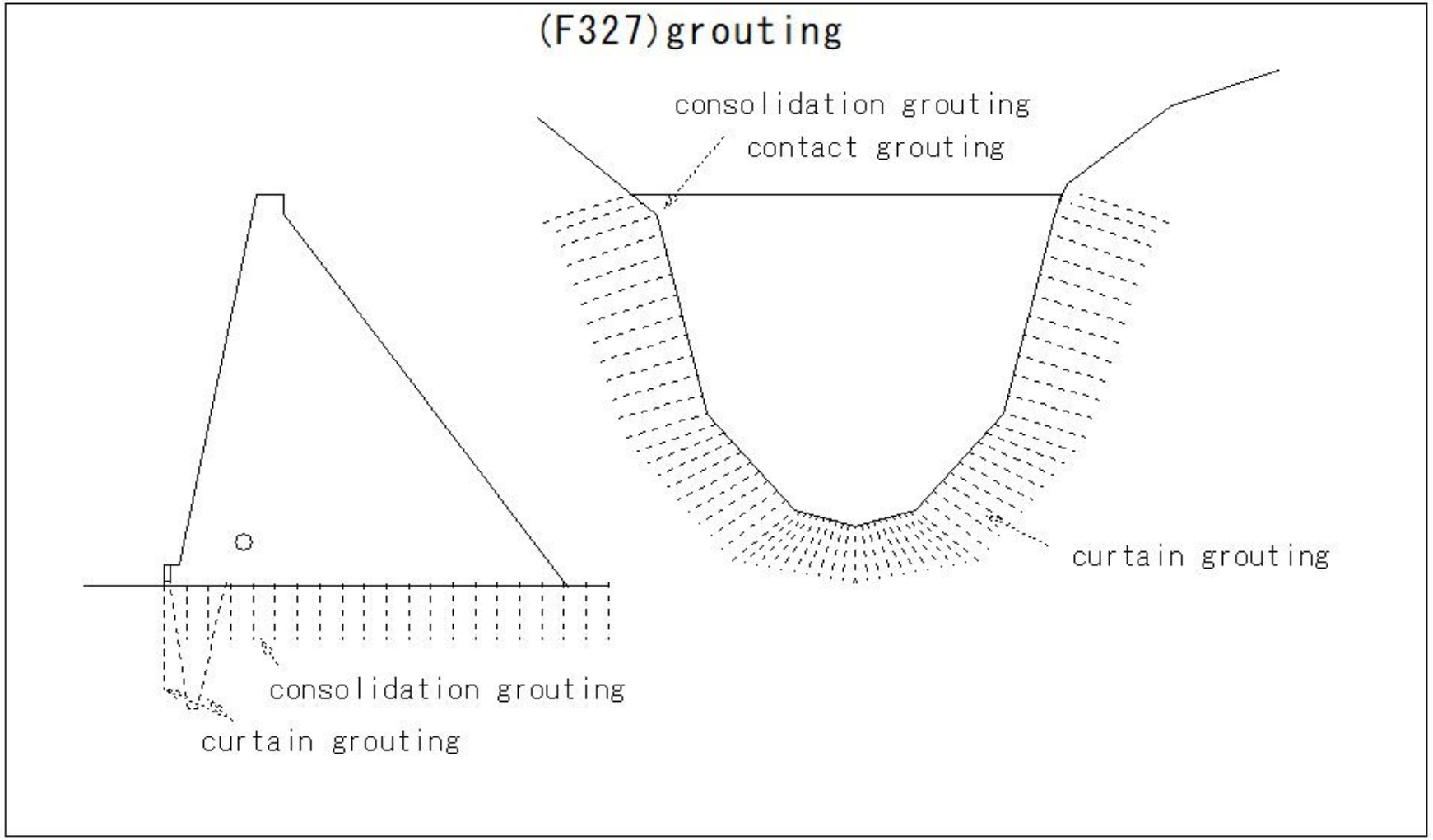
(F325)Functional classification of pile foundations



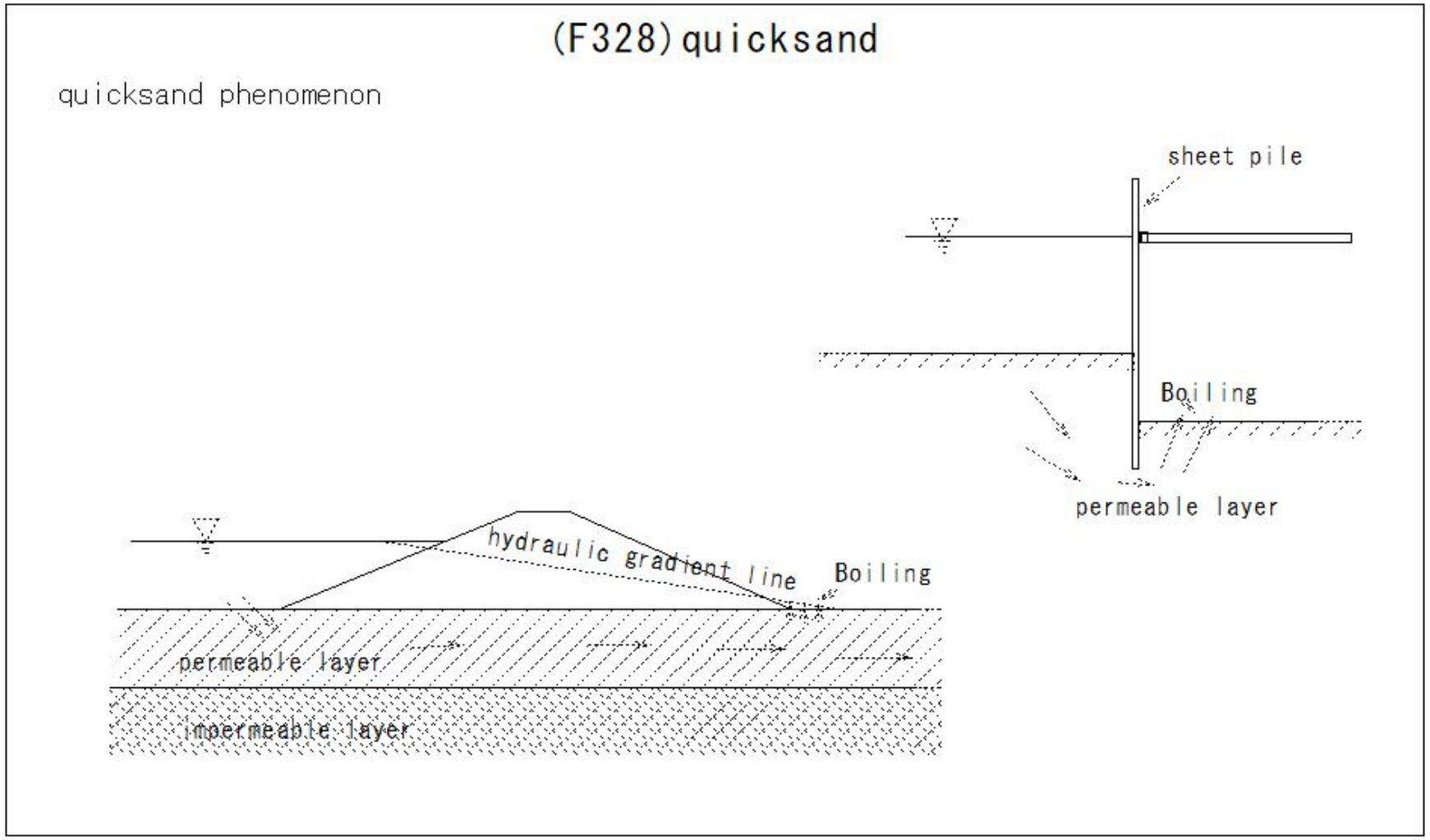
(F326)Geological strata conditions and applicable range of various piles



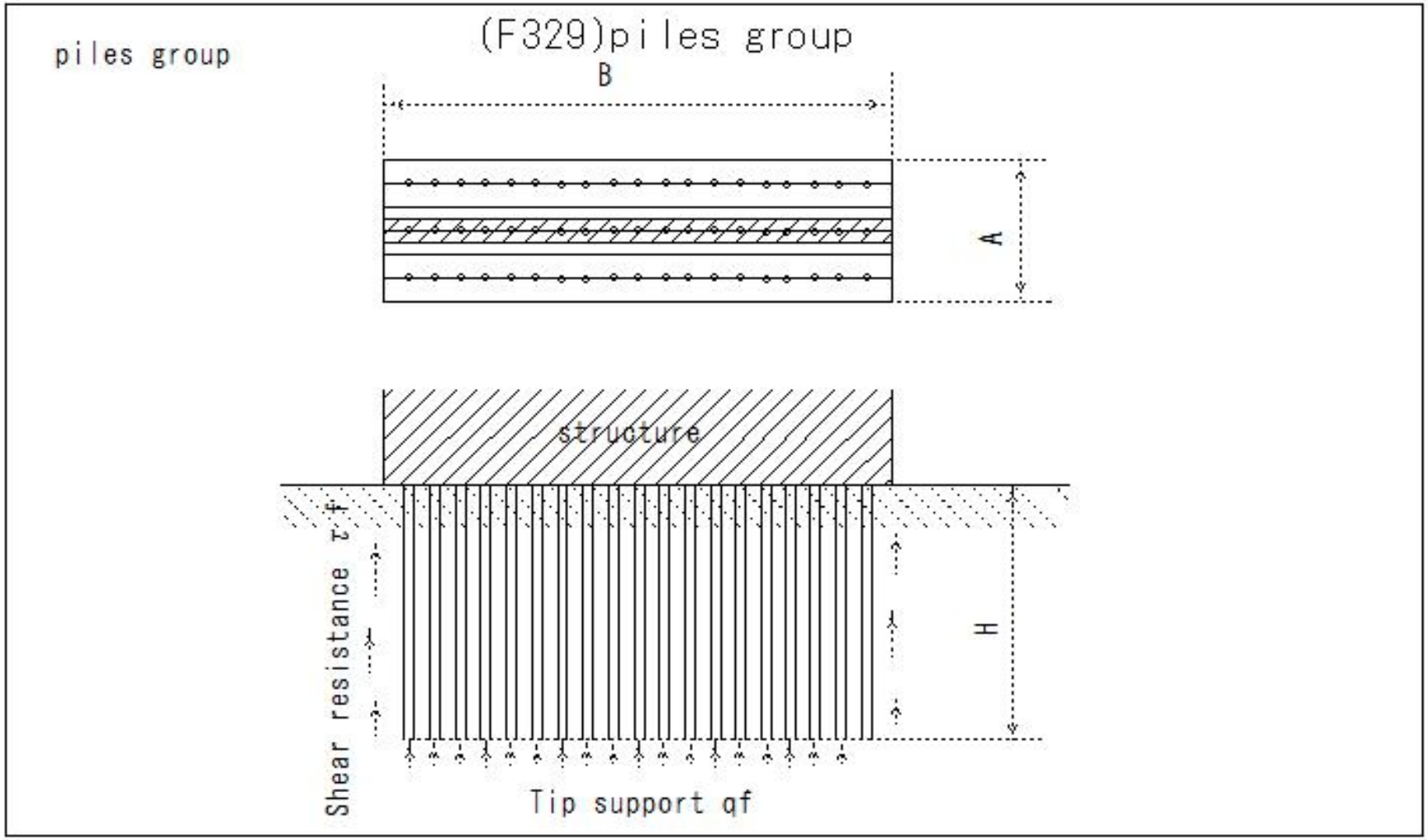
(F327)grouting



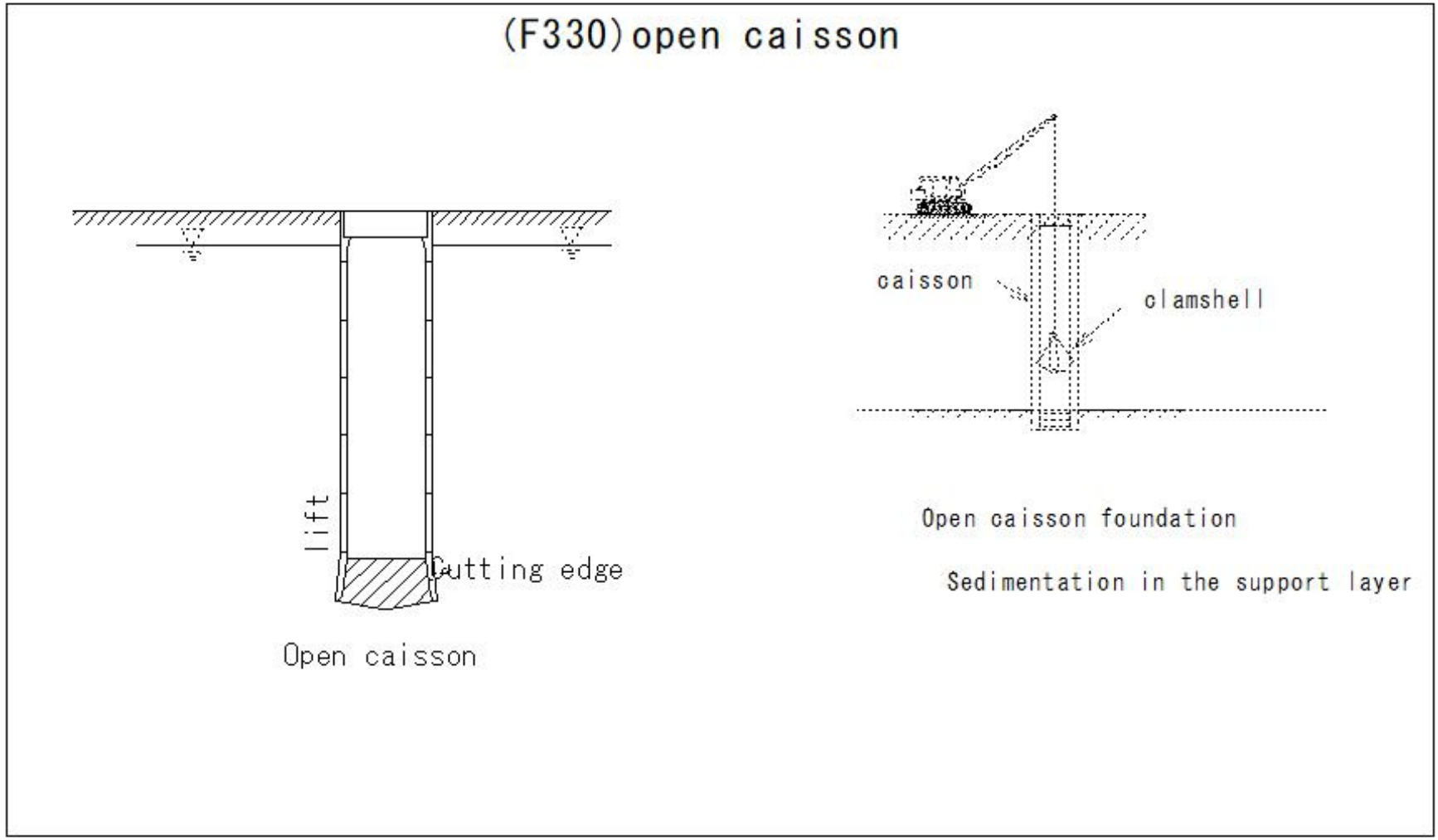
(F328)quicksand



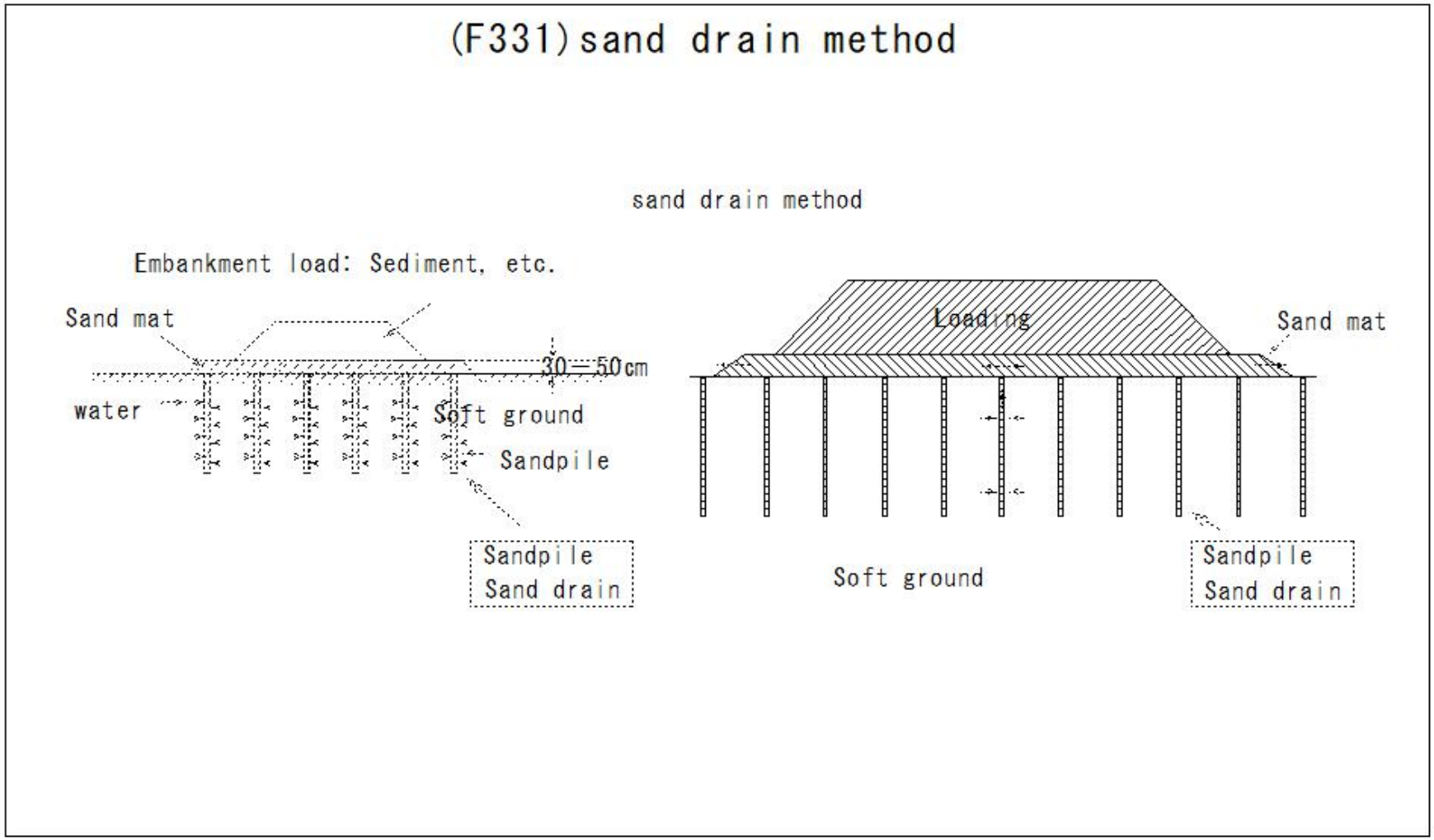
(F329)piles group



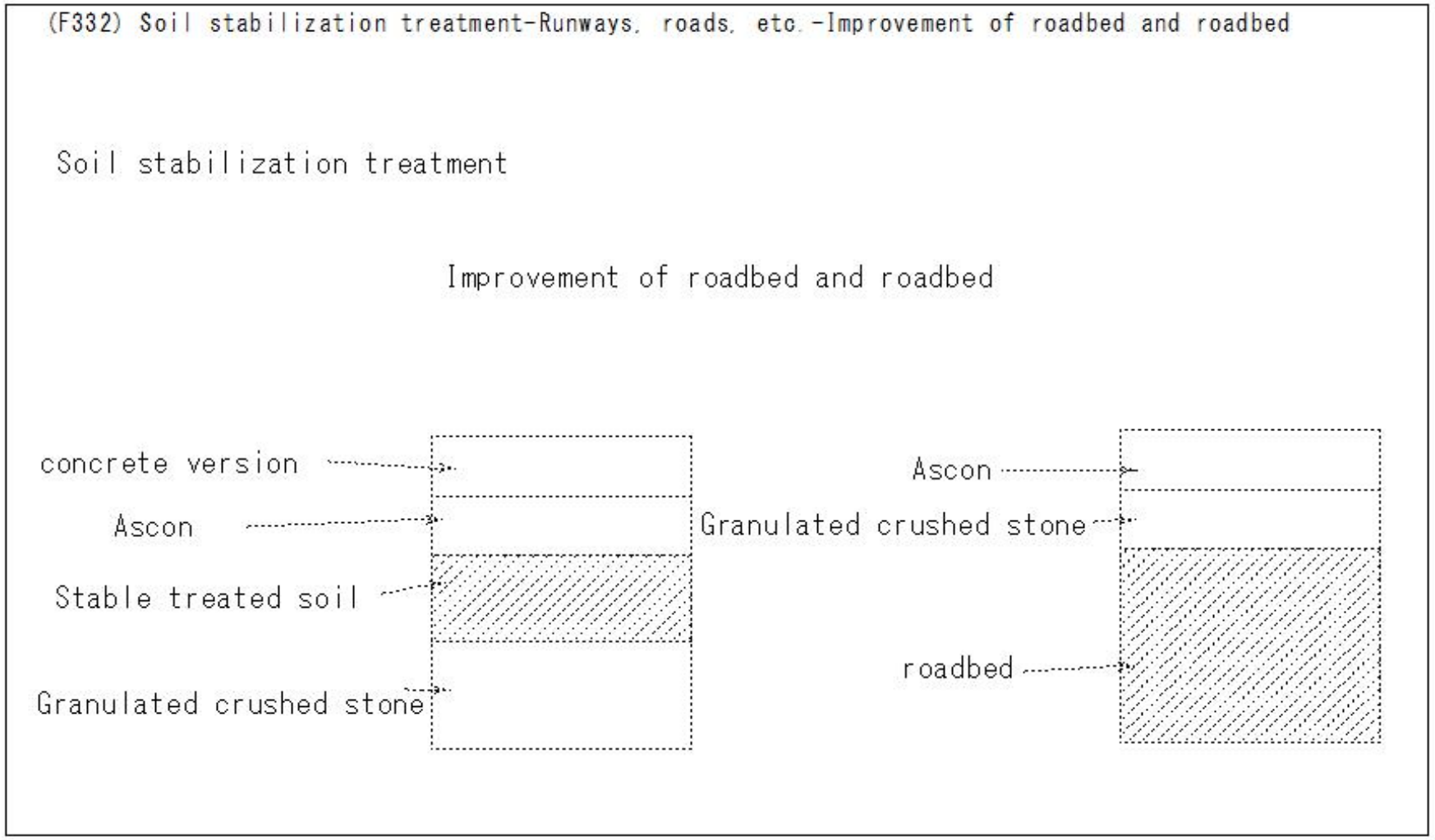
(F330)open caisson



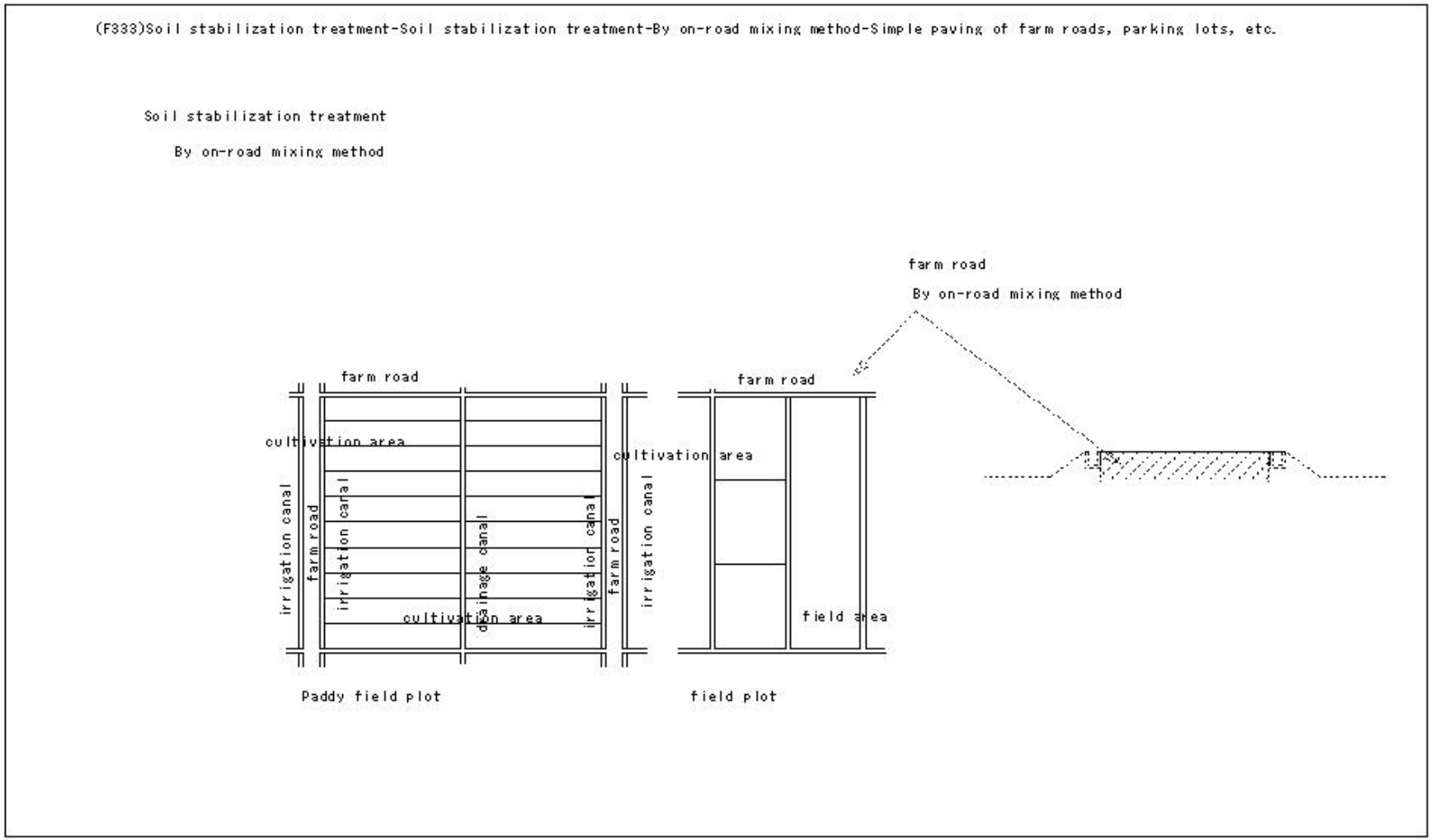
(F331)sand drain method



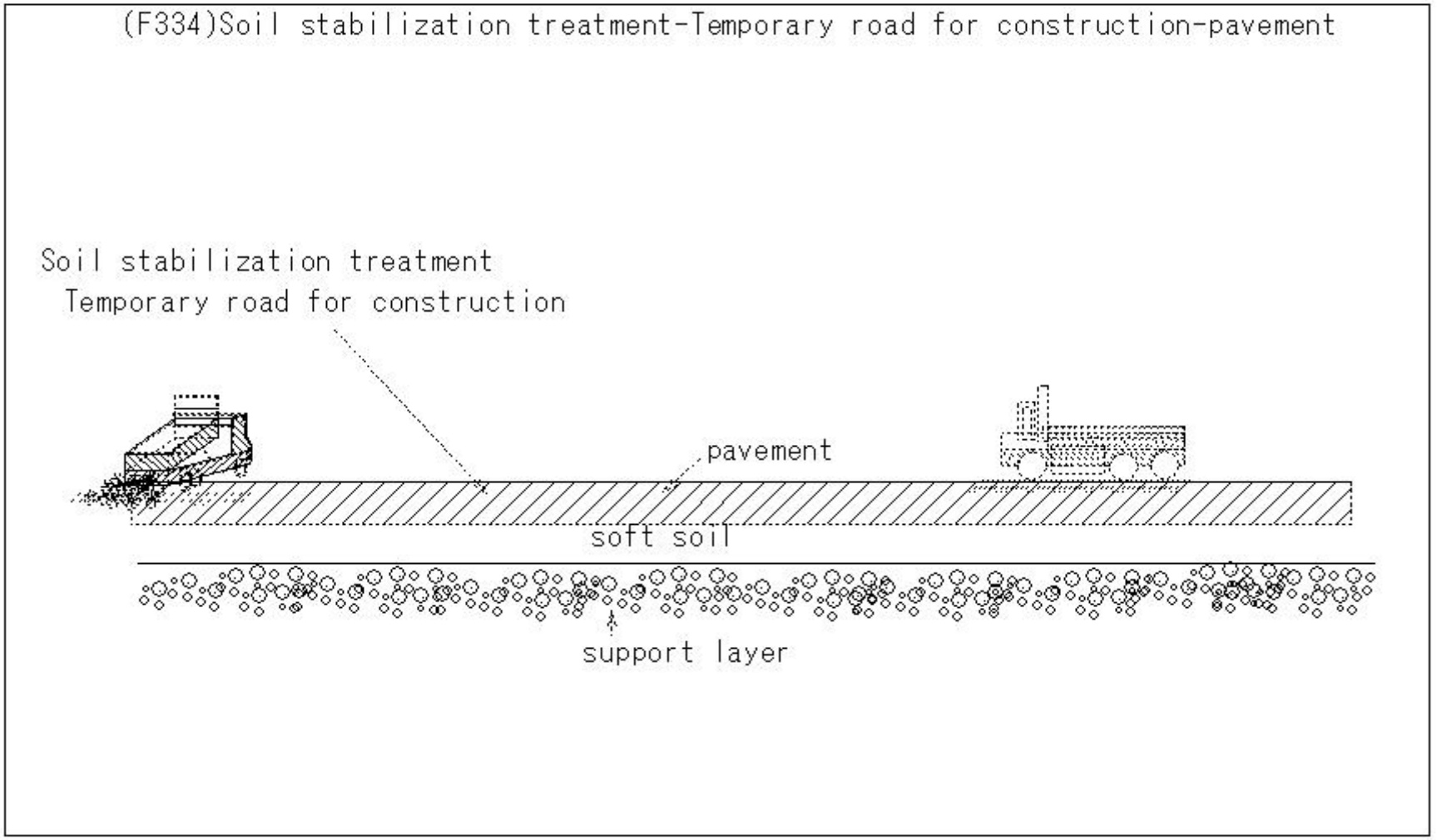
(F332) Soil stabilization treatment-Runways, roads, etc.-Improvement of roadbed and roadbed



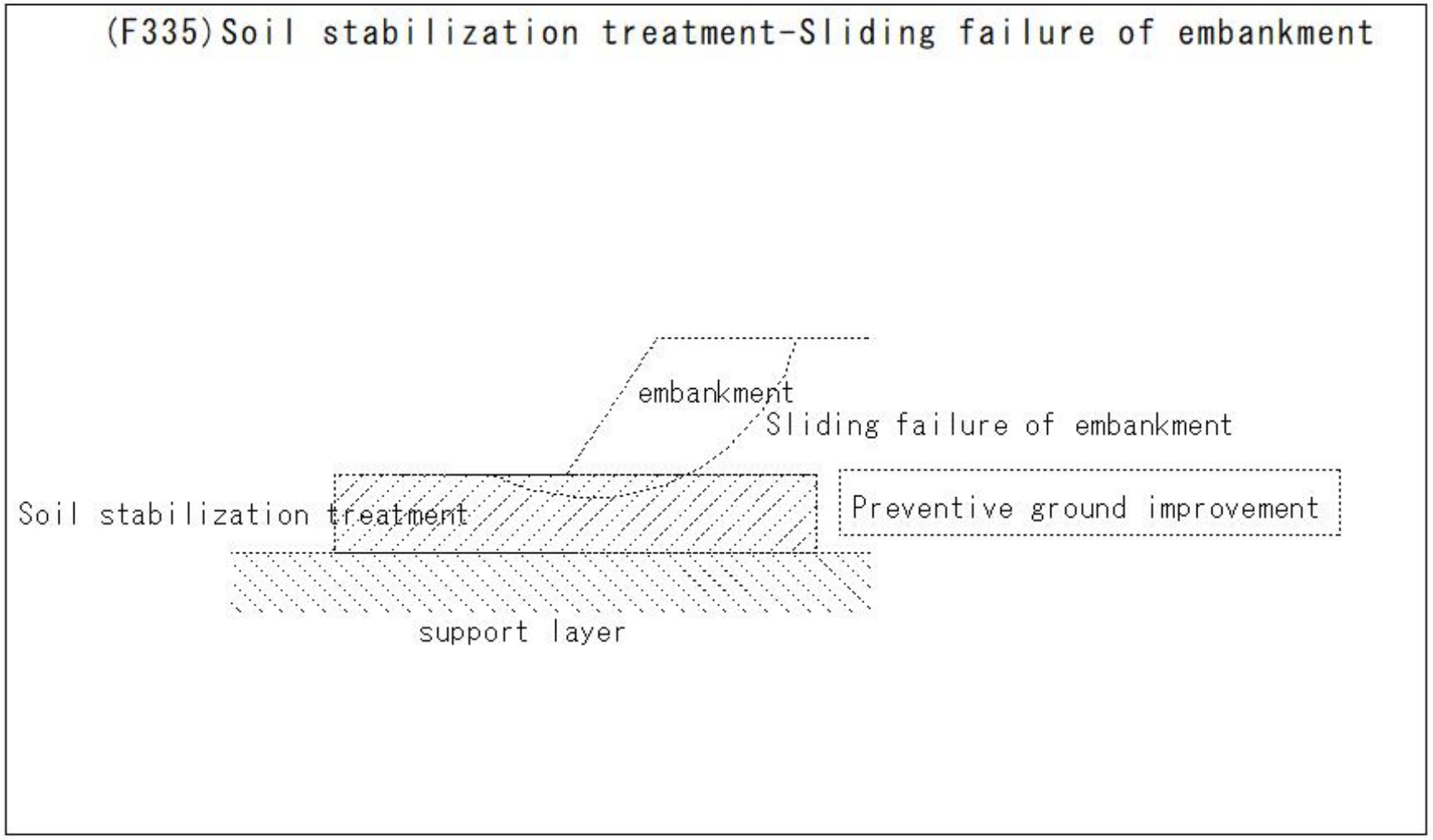
(F333)Soil stabilization treatment-Soil stabilization treatment-By on-road mixing method-Simple paving of farm roads, parking lots, etc.



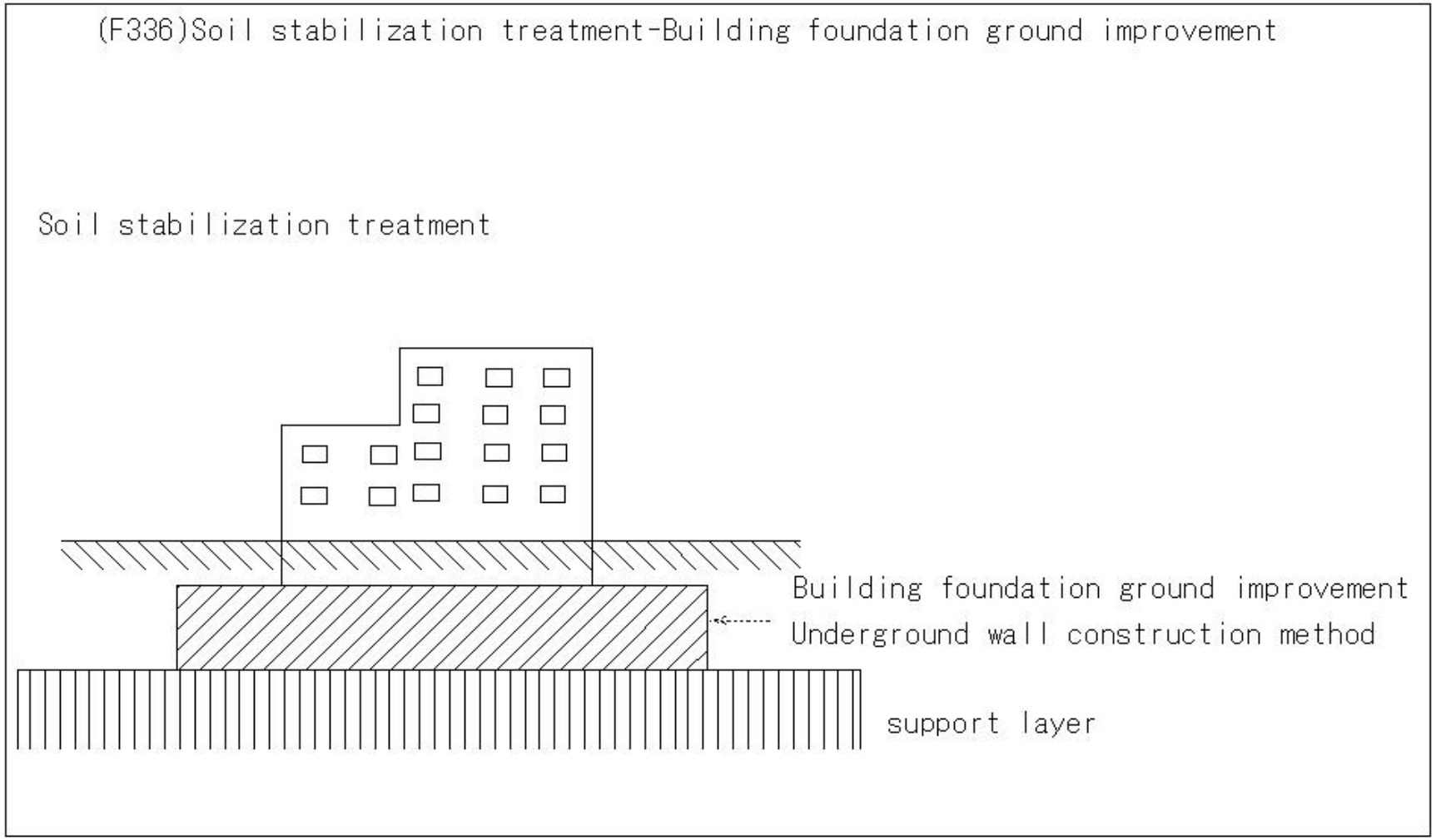
(F334)Soil stabilization treatment-Temporary road for construction-pavement



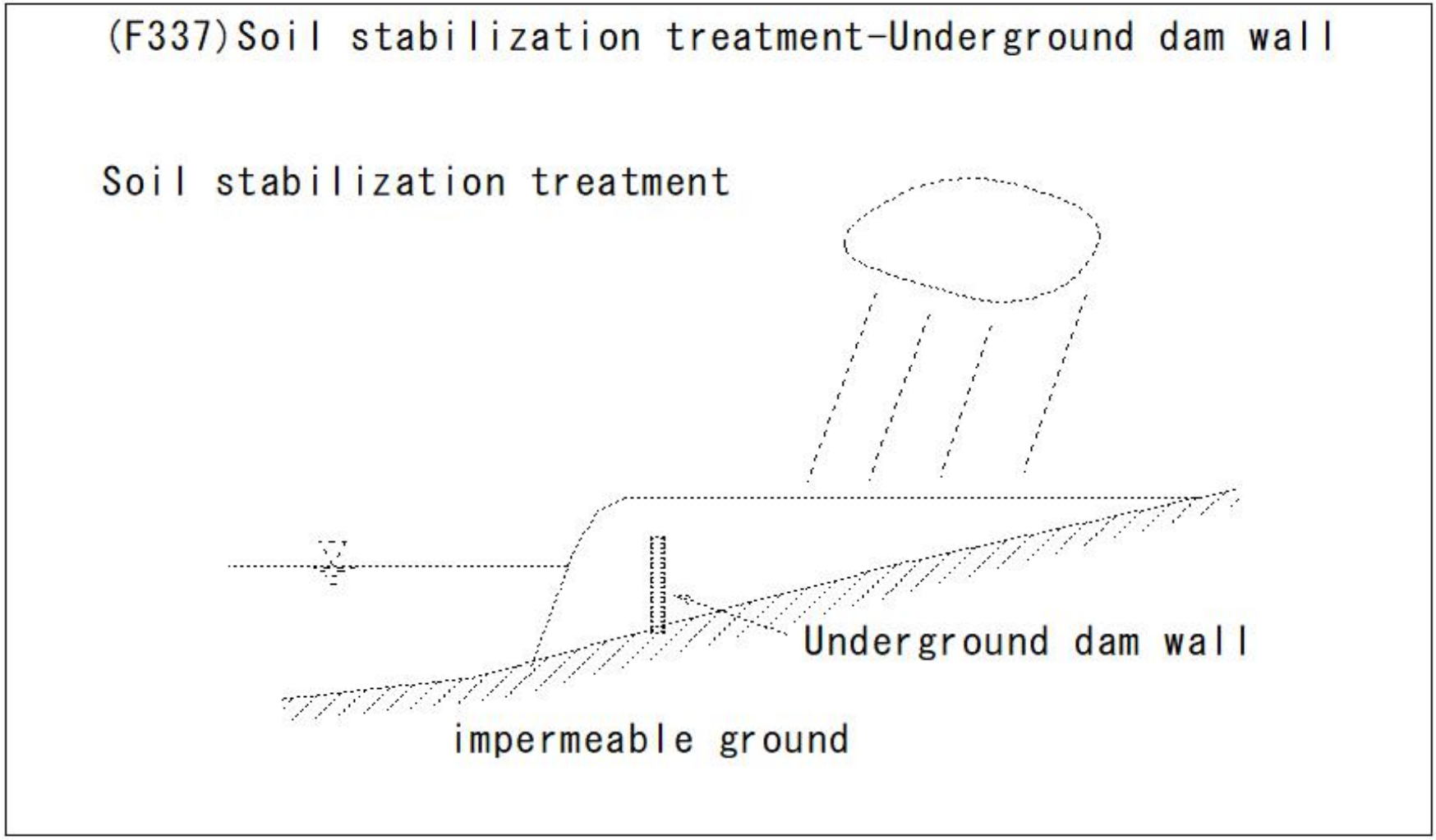
(F335)Soil stabilization treatment-Sliding failure of embankment



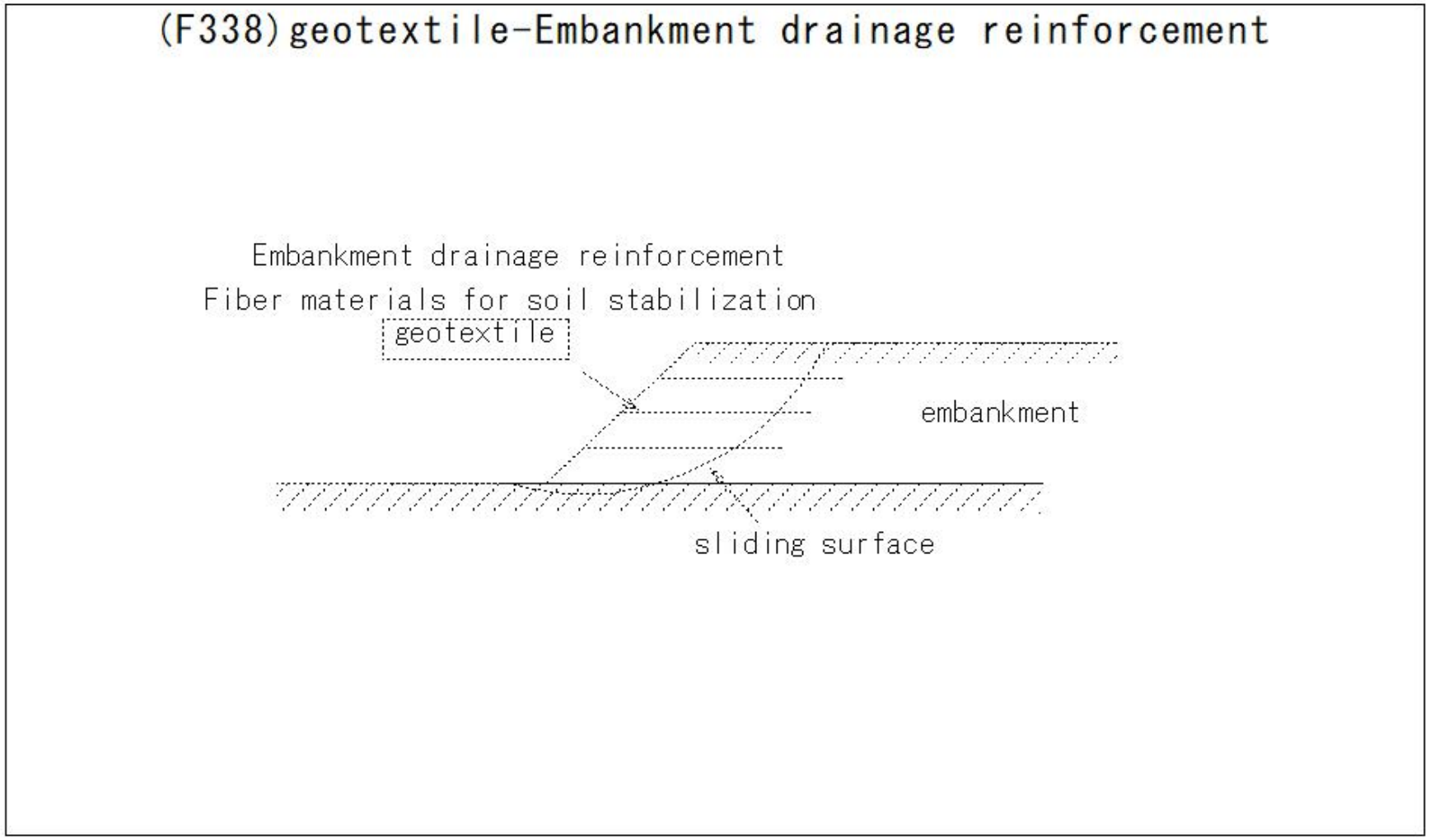
(F336)Soil stabilization treatment-Building foundation ground improvement



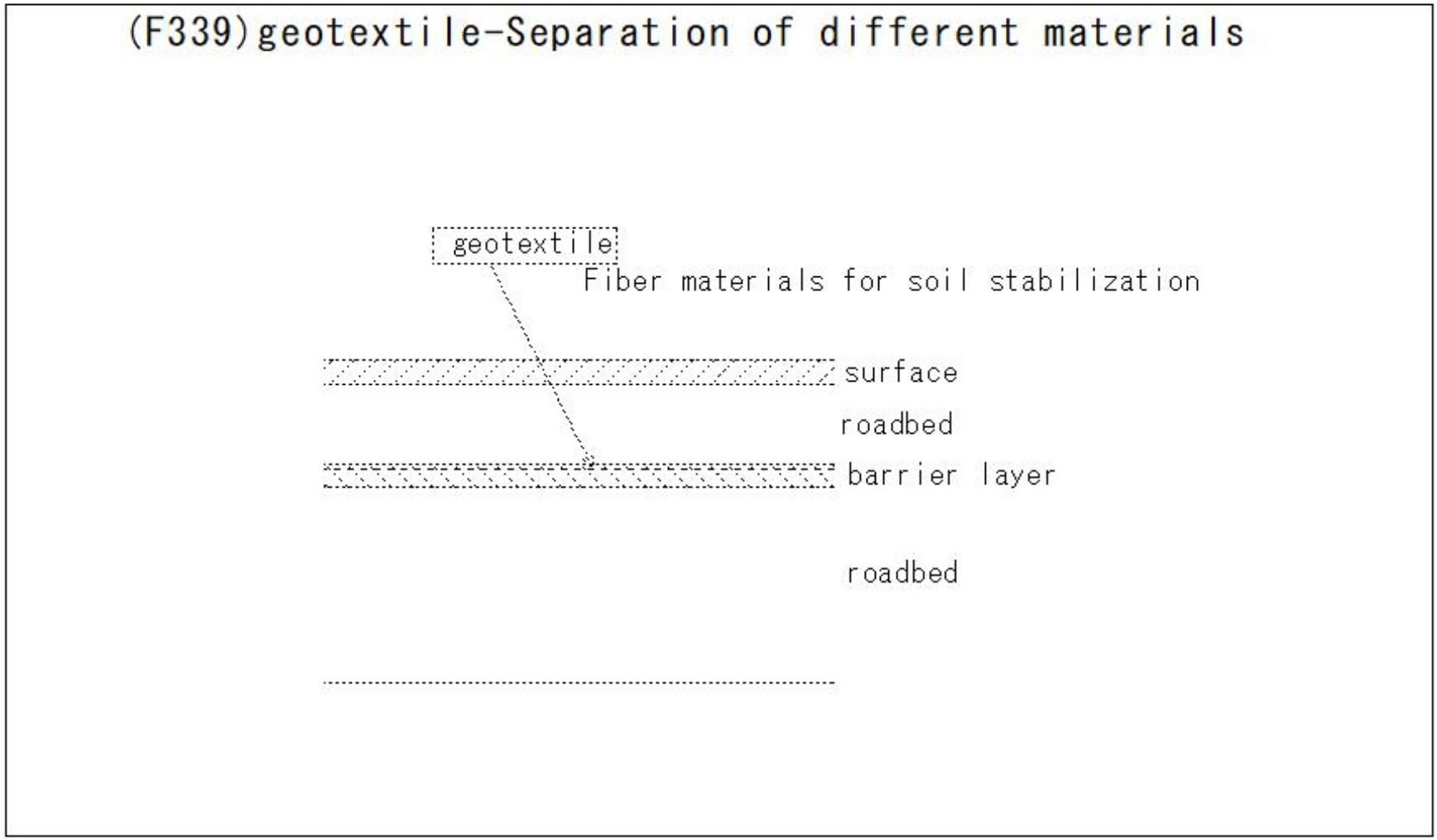
(F337)Soil stabilization treatment-Underground dam wall



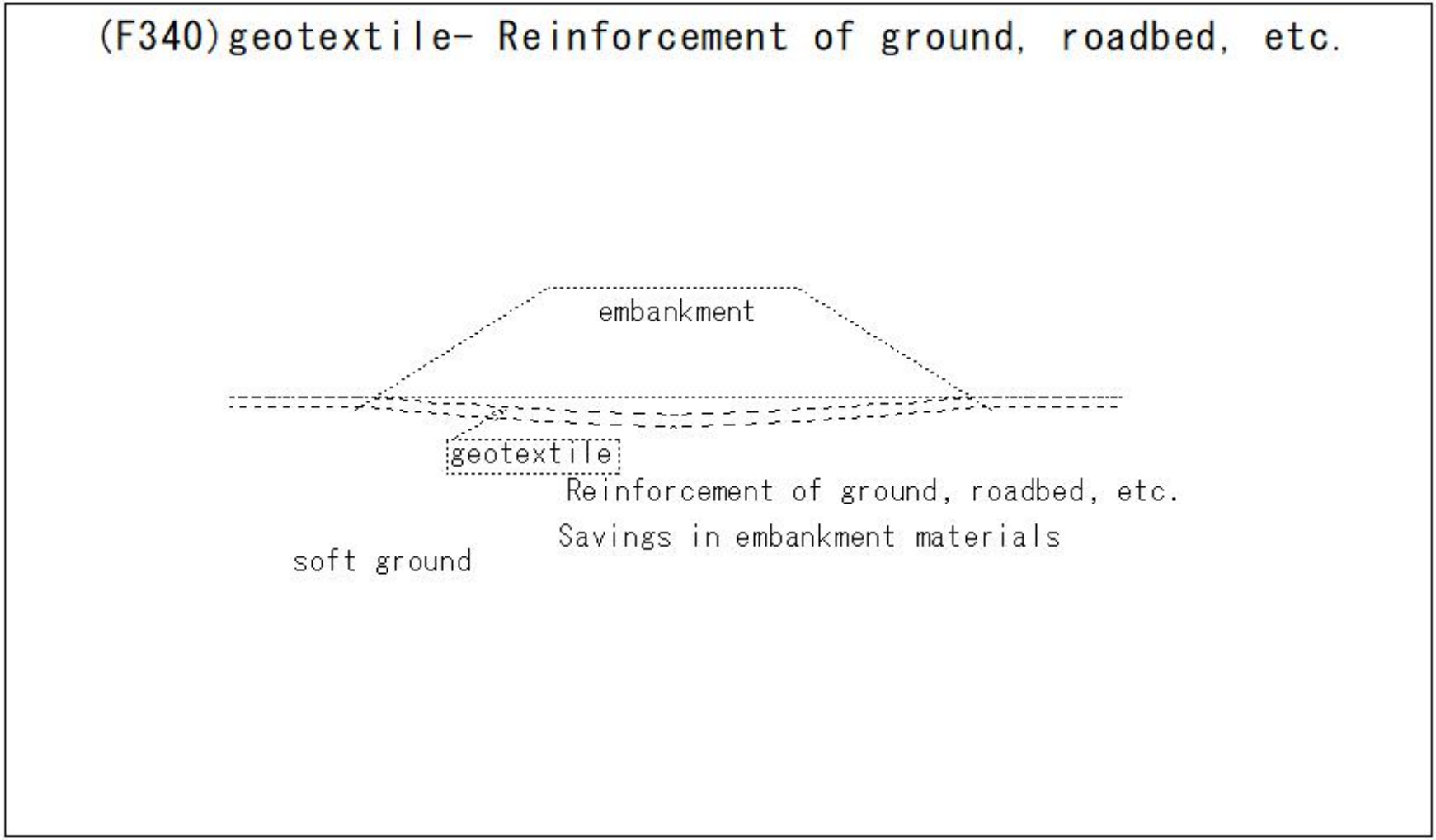
(F338)geotextile-Embankment drainage reinforcement



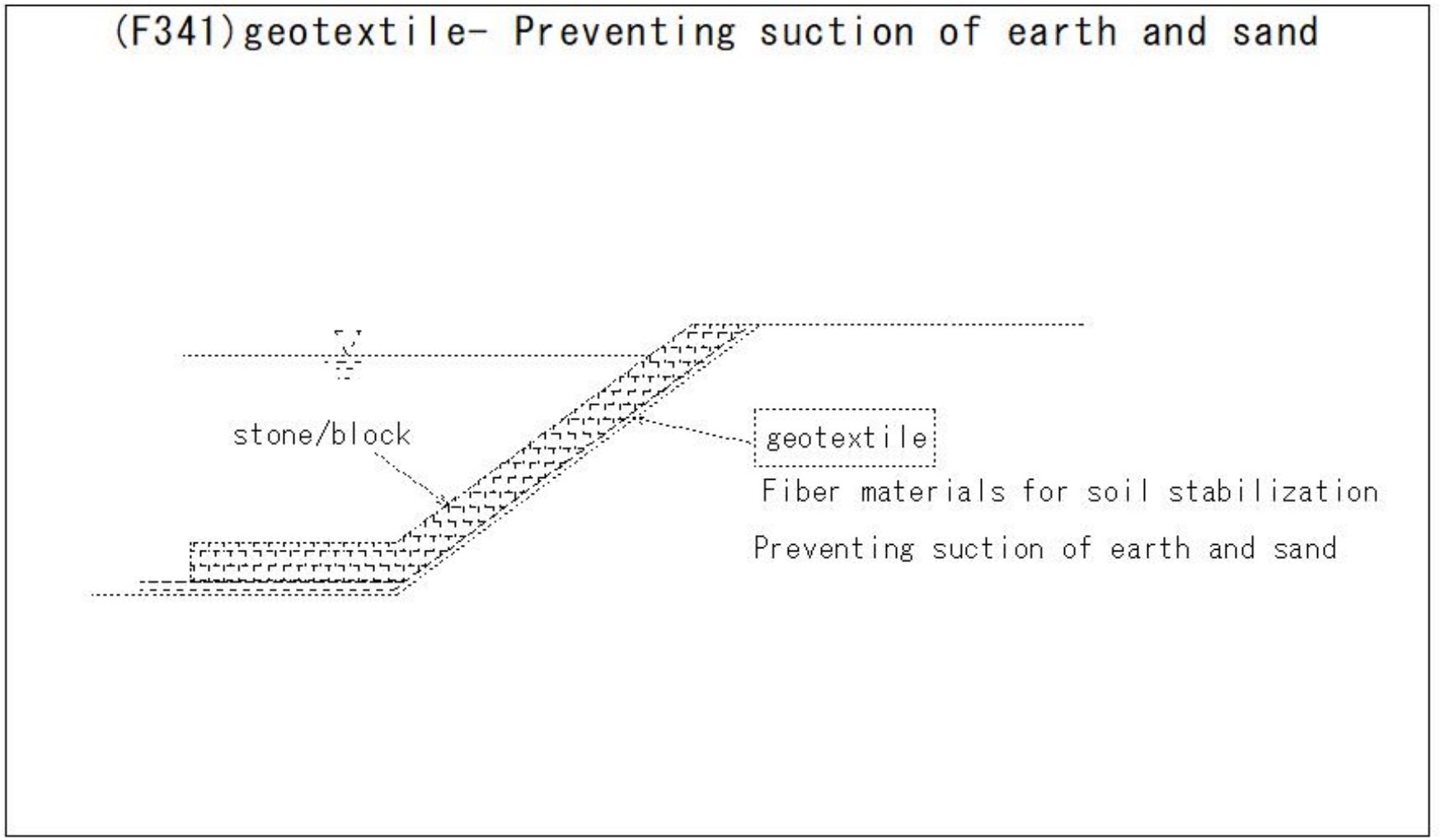
(F339)geotextile-Separation of different materials



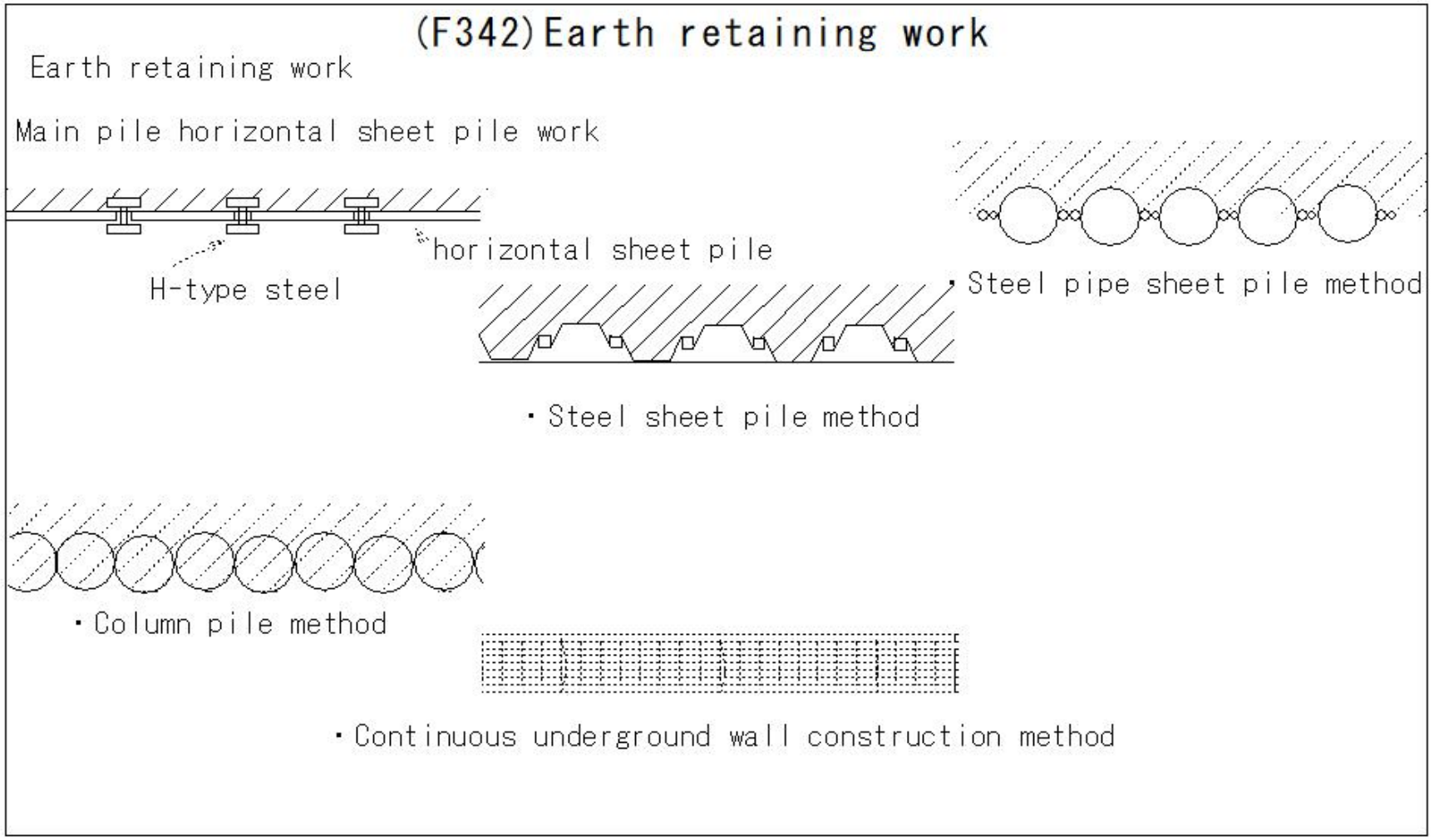
(F340)geotextile- Reinforcement of ground, roadbed, etc.



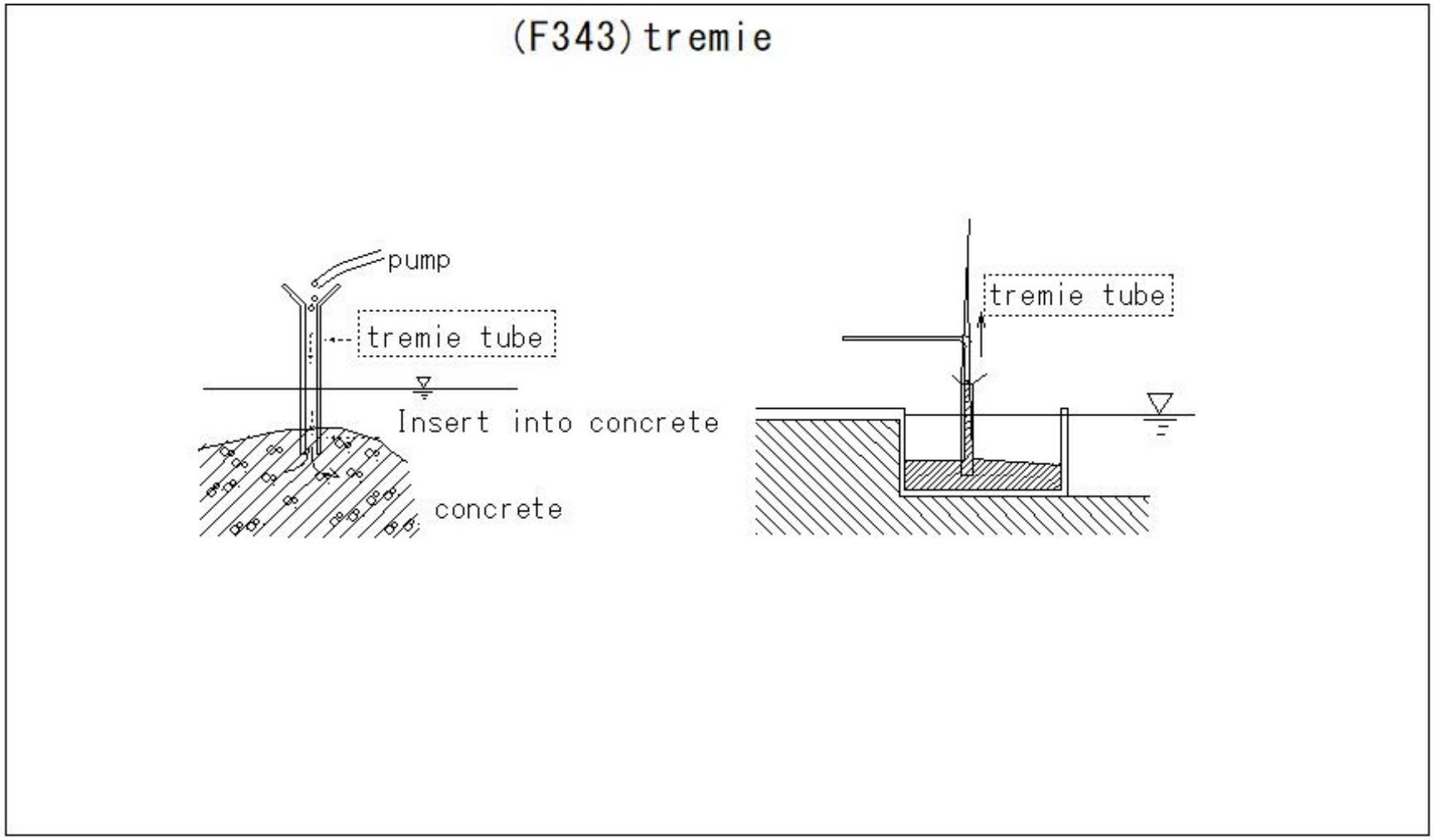
(F341)geotextile- Preventing suction of earth and sand



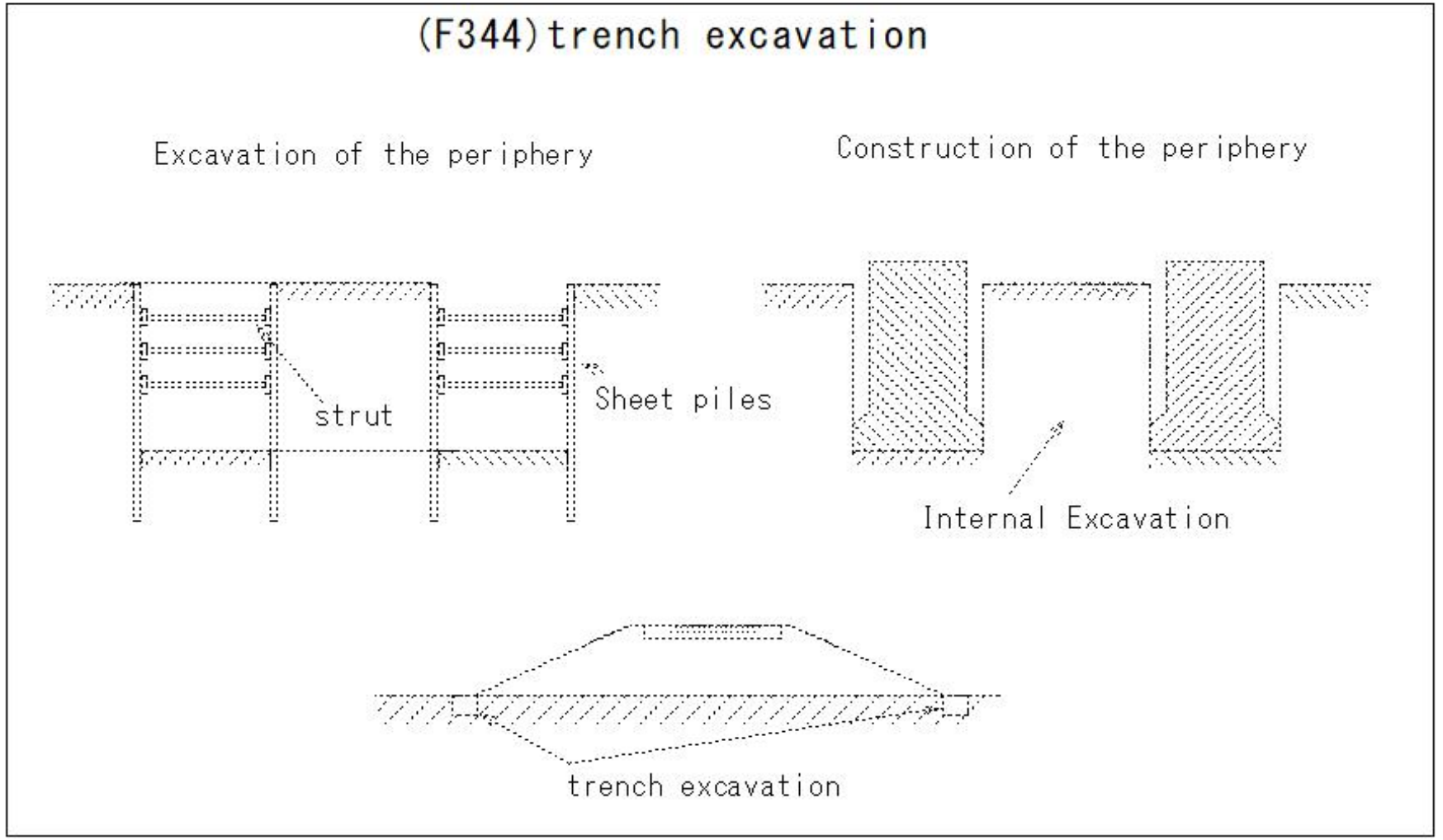
(F342)Earth retaining work



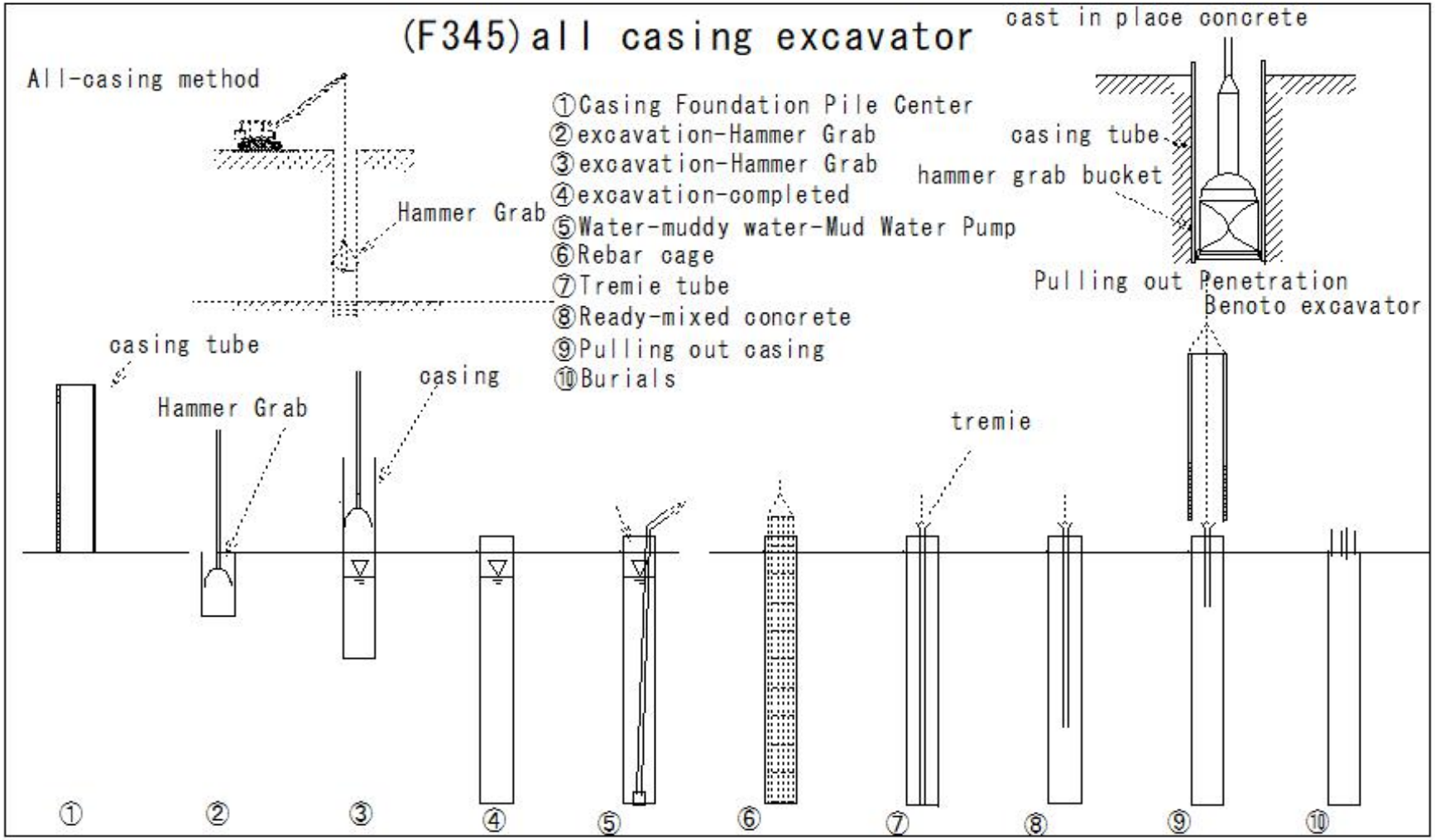
(F343)tremie


(F343)tremie
pump
tremie tube
Insert into concrete
concrete
tremie tube

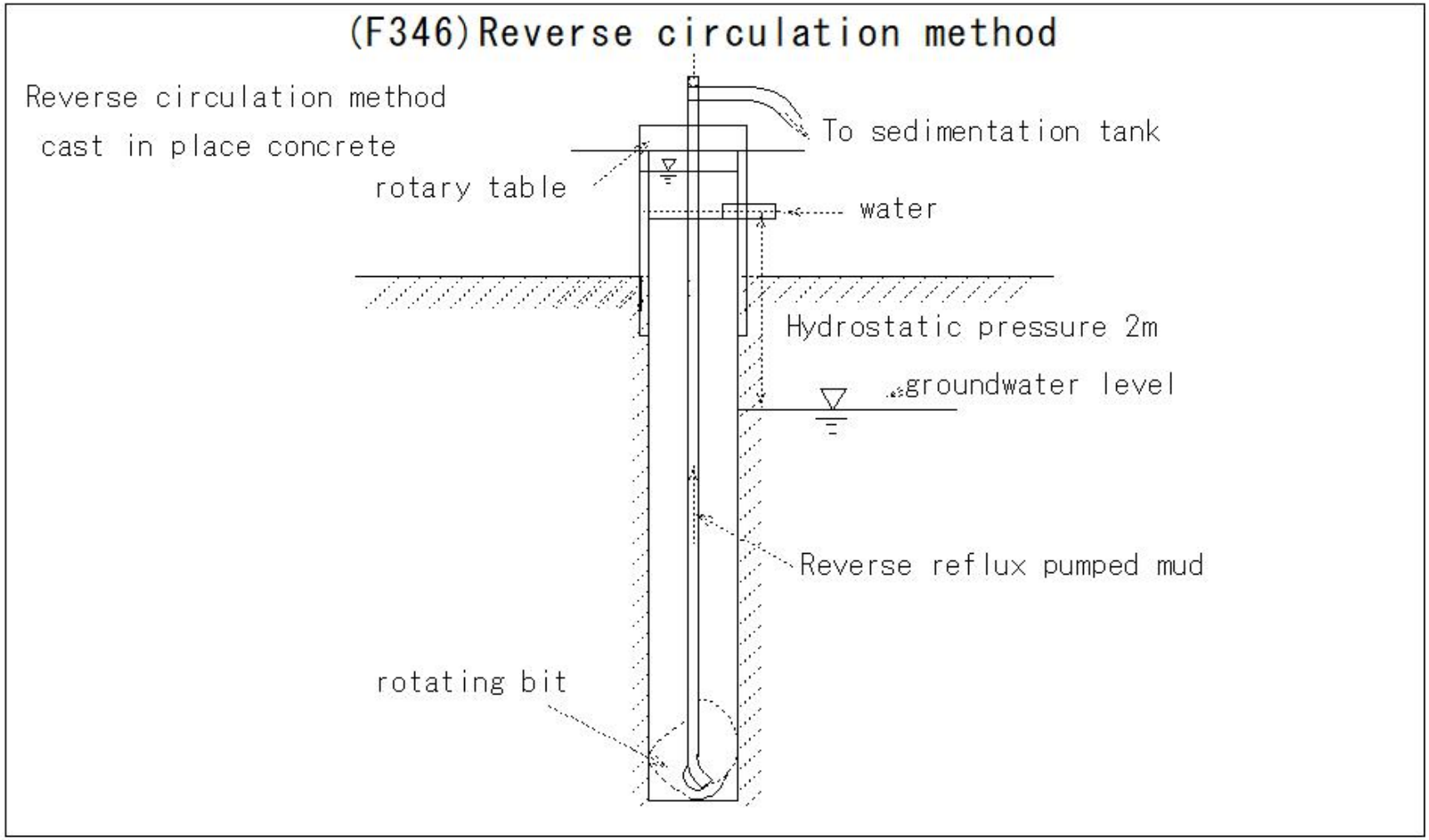
(F344)trench excavation



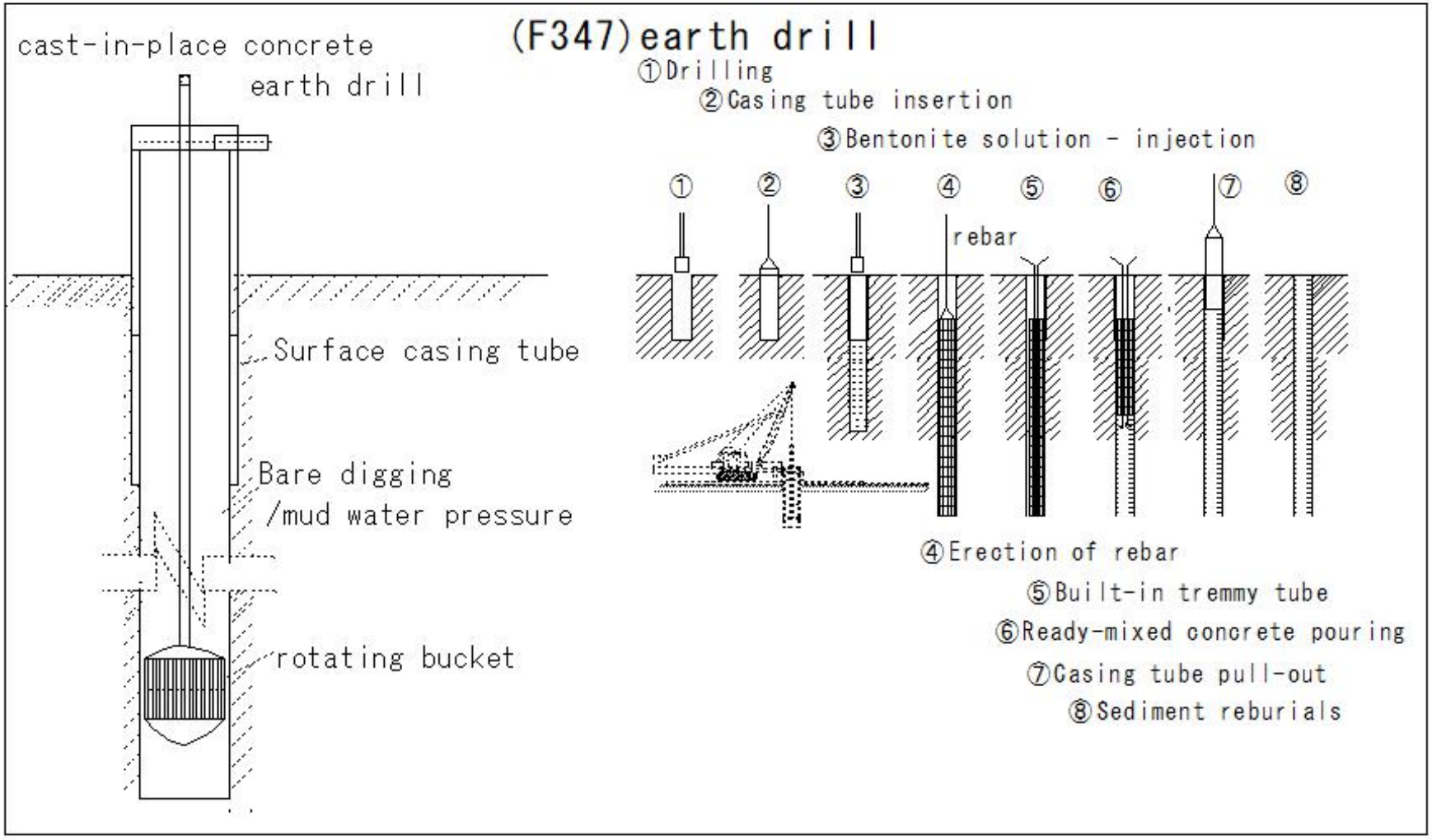
(F345)all casing excavator



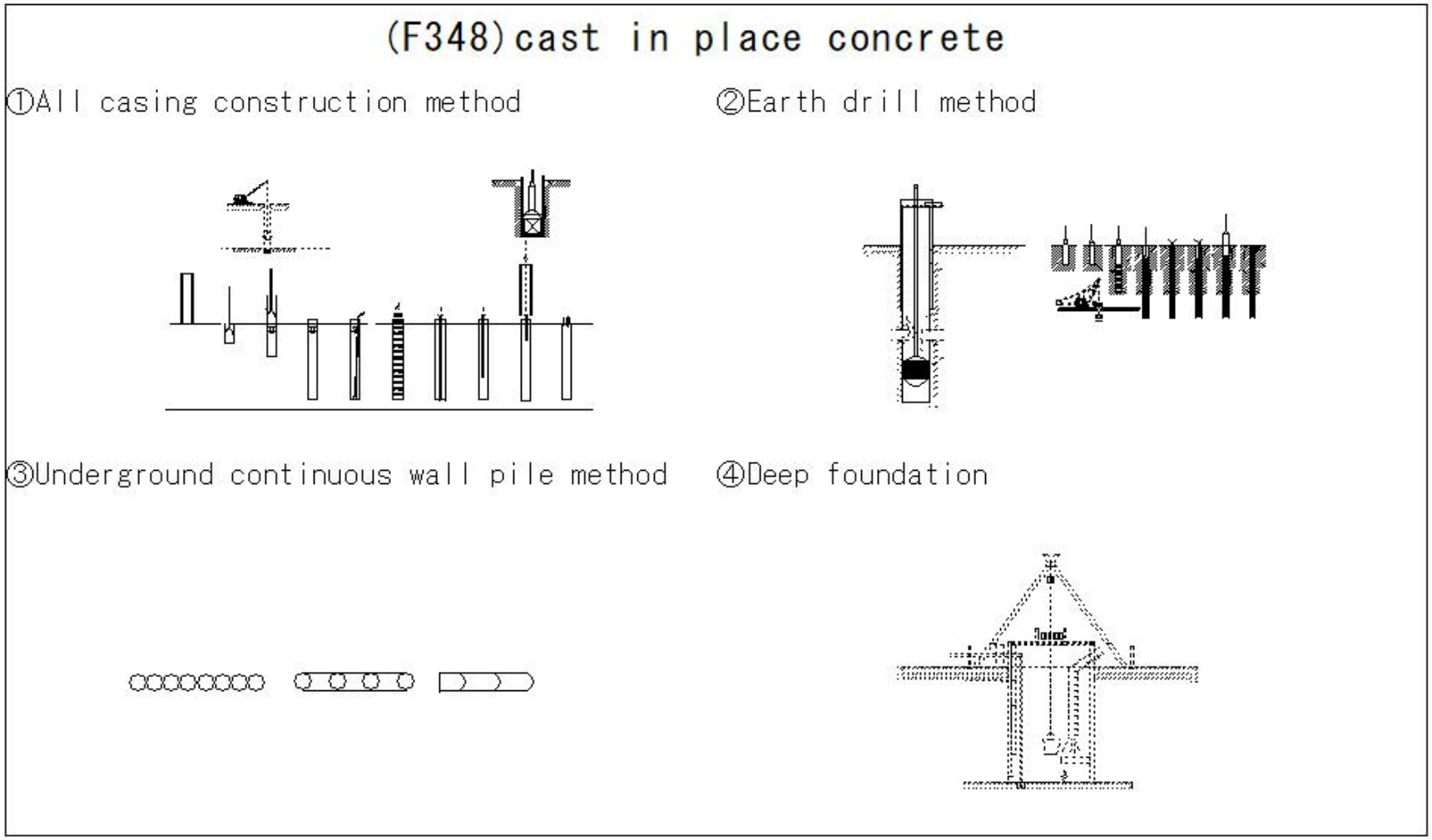
(F346)Reverse circulation method



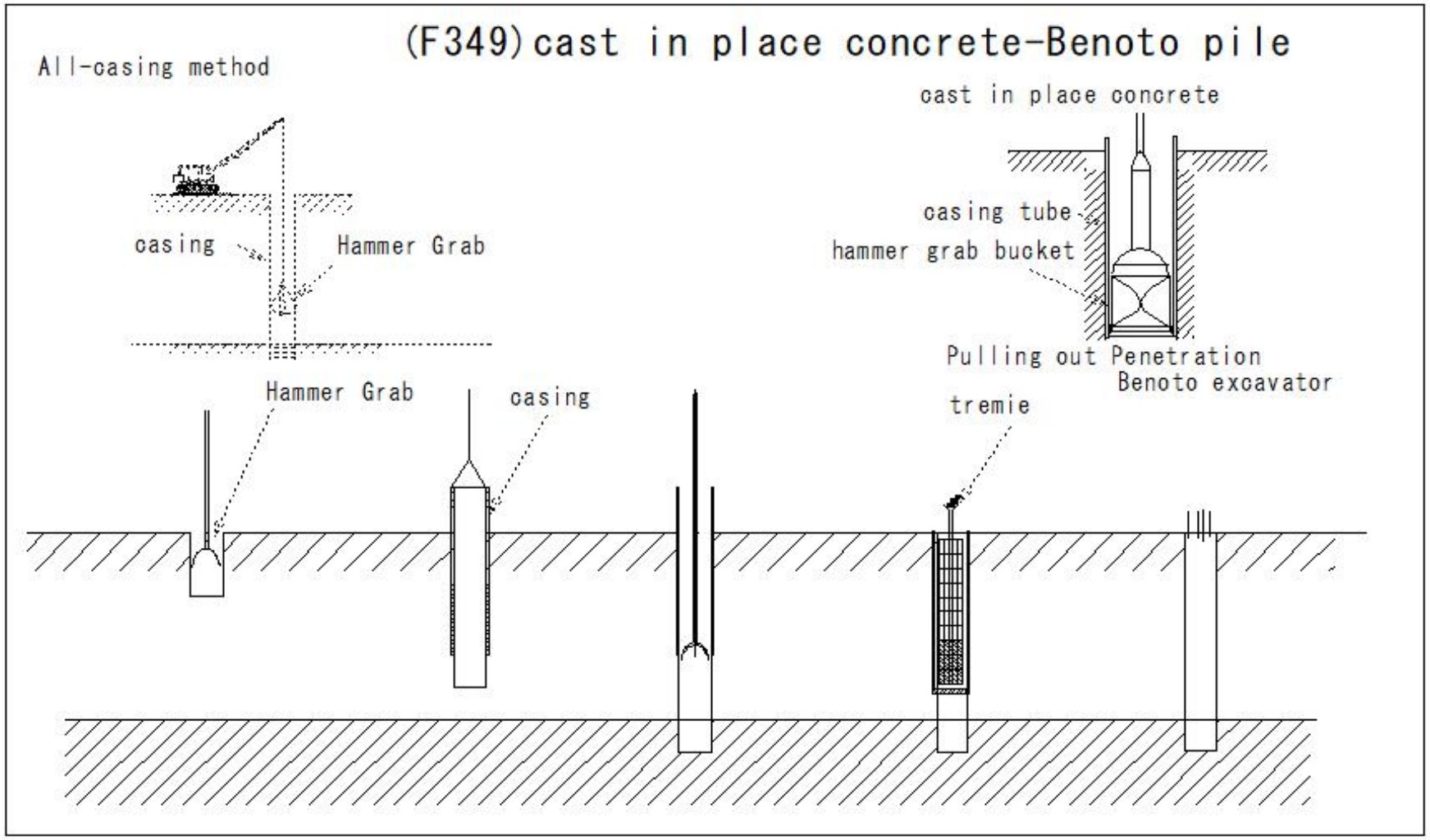
(F347)earth drill



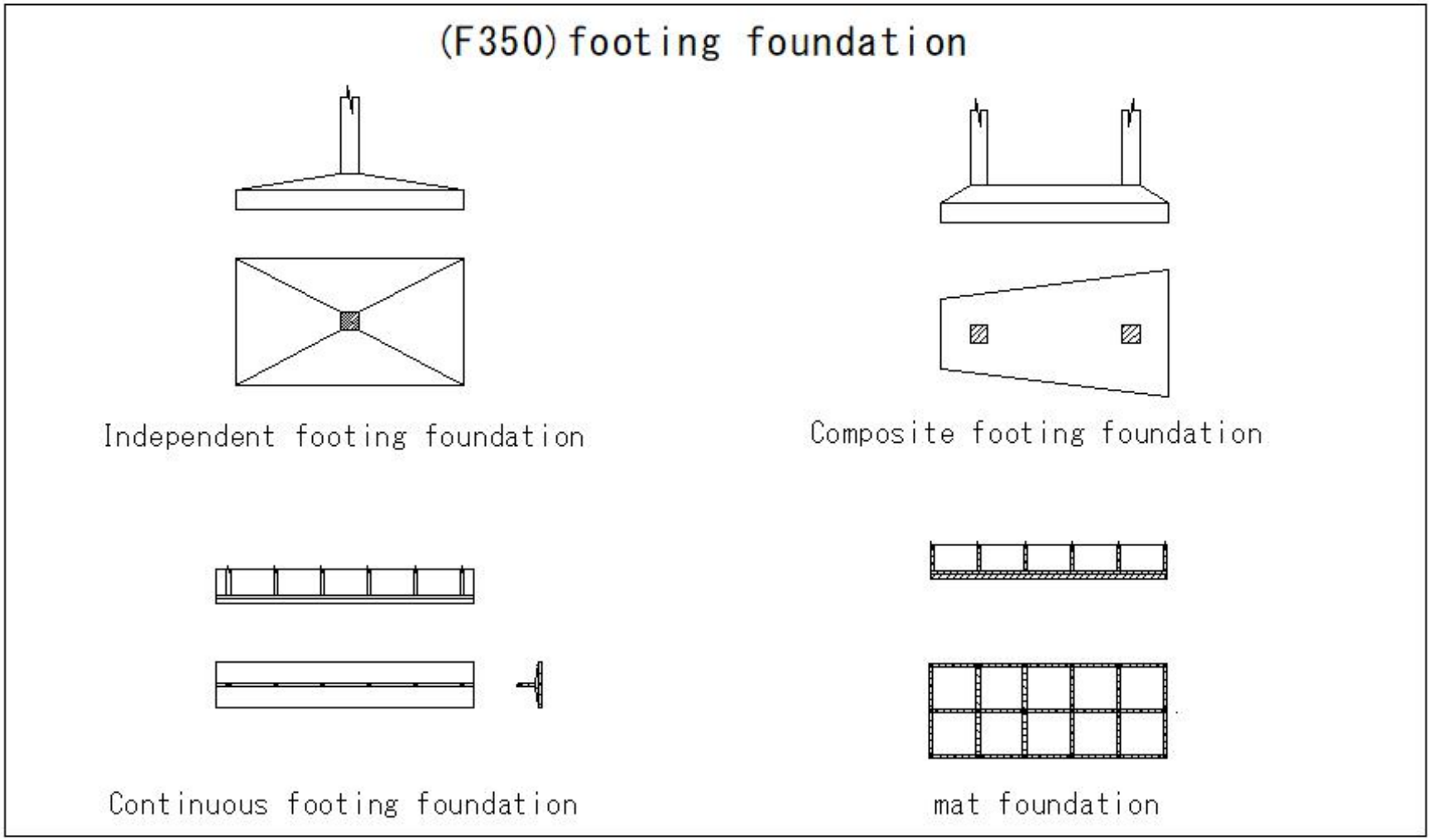
(F348)cast in place concrete



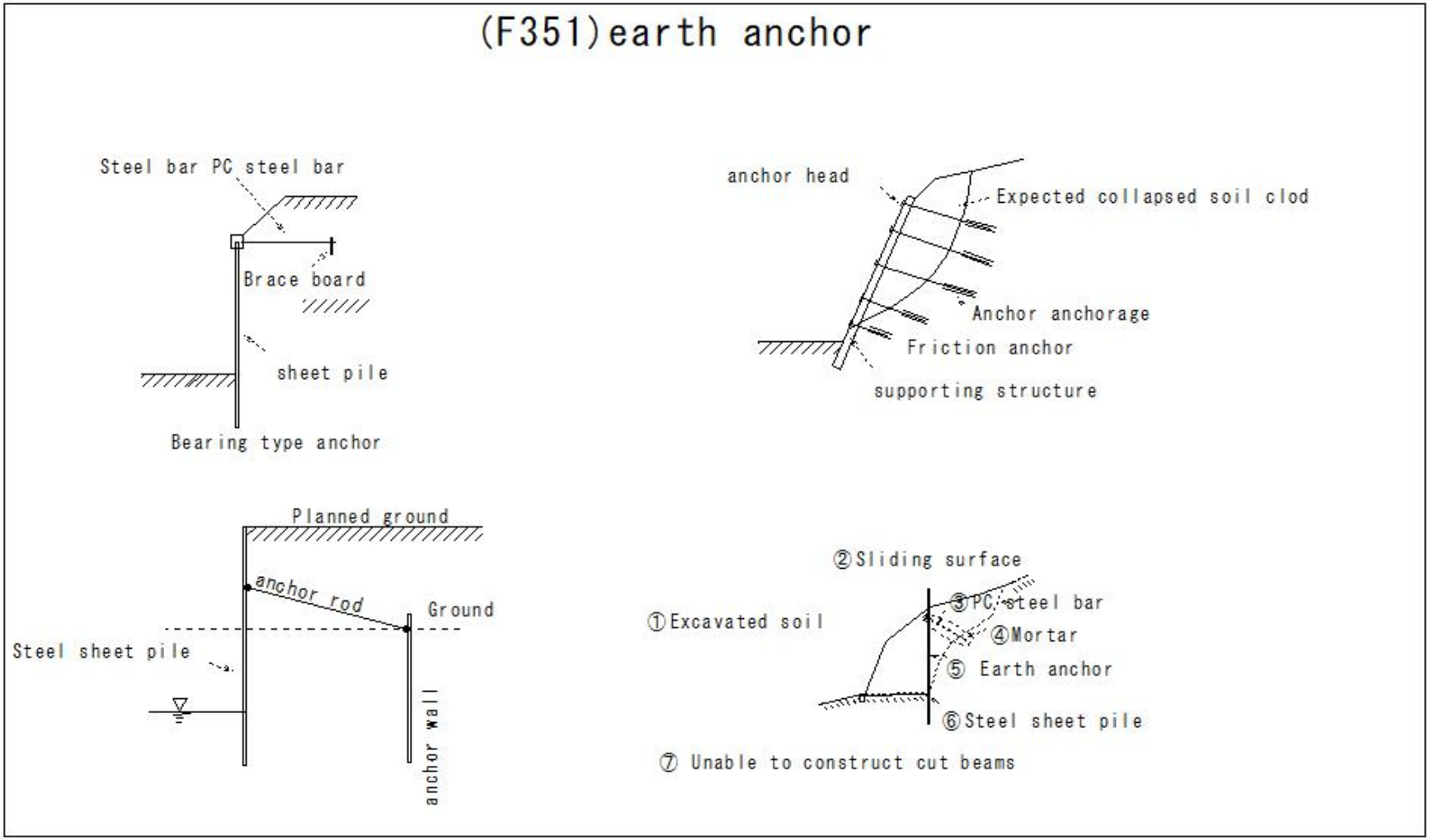
(F349)cast in place concrete-Benoto pile



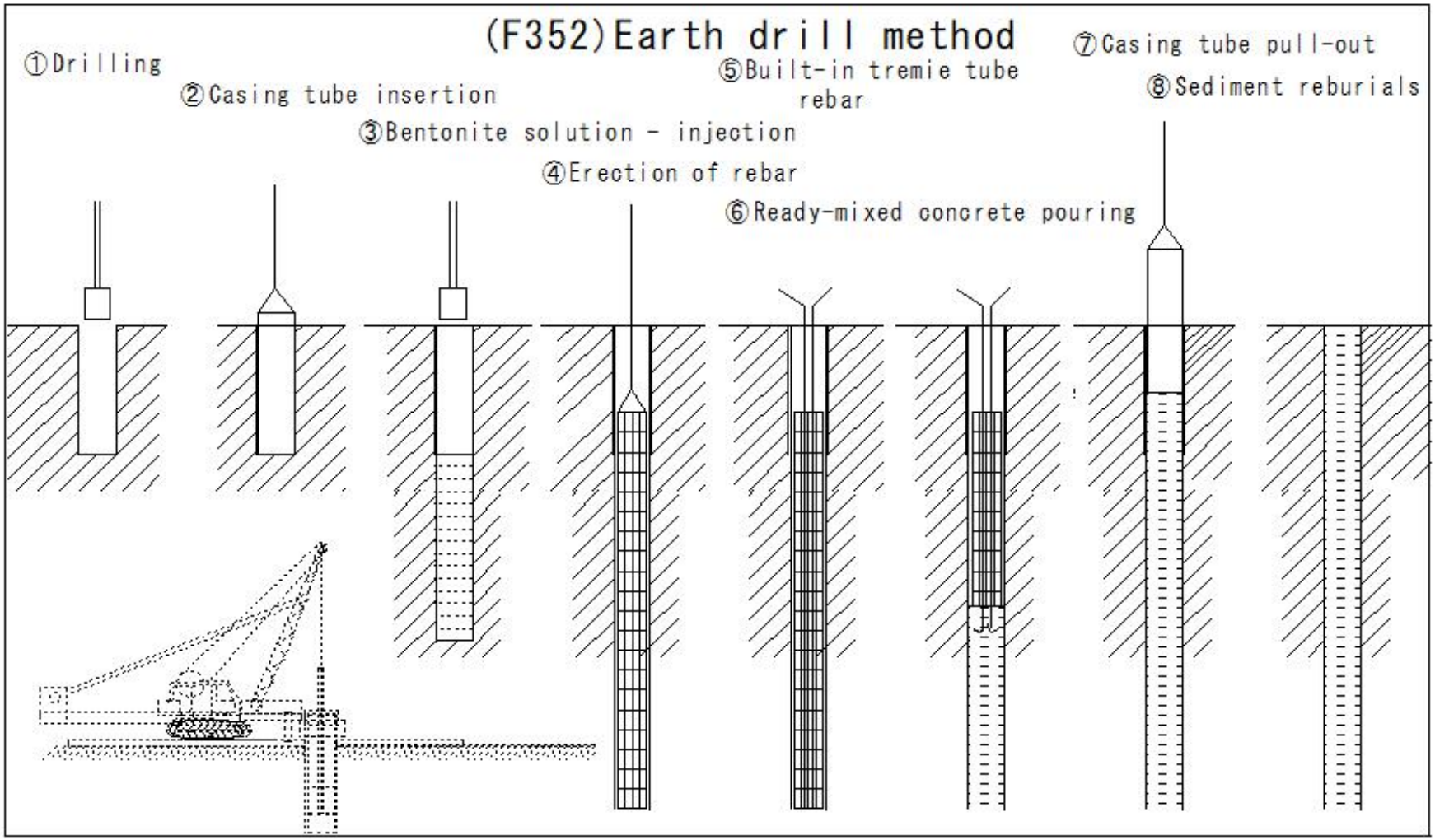
(F350)footing foundation



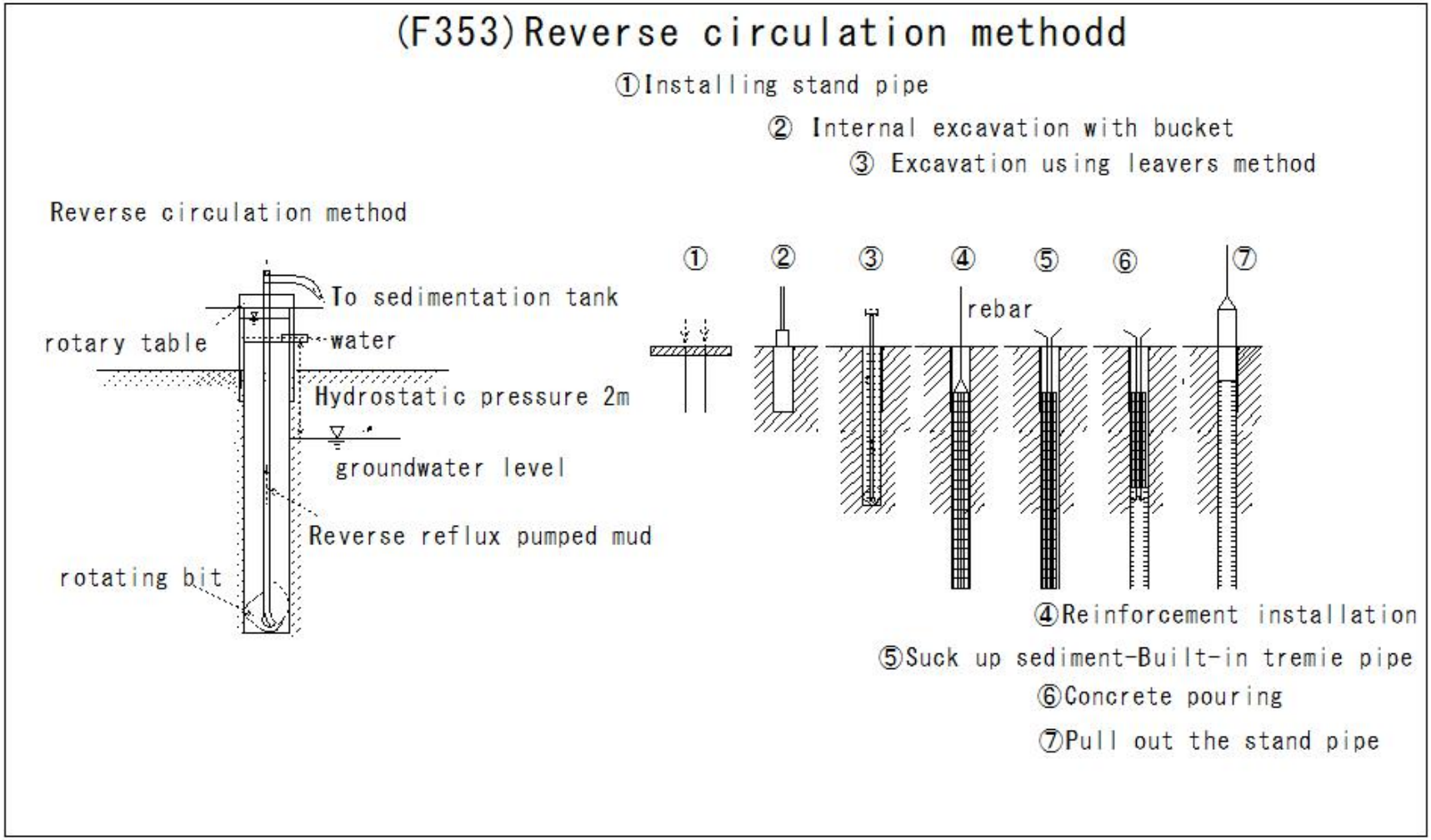
(F351)earth anchor



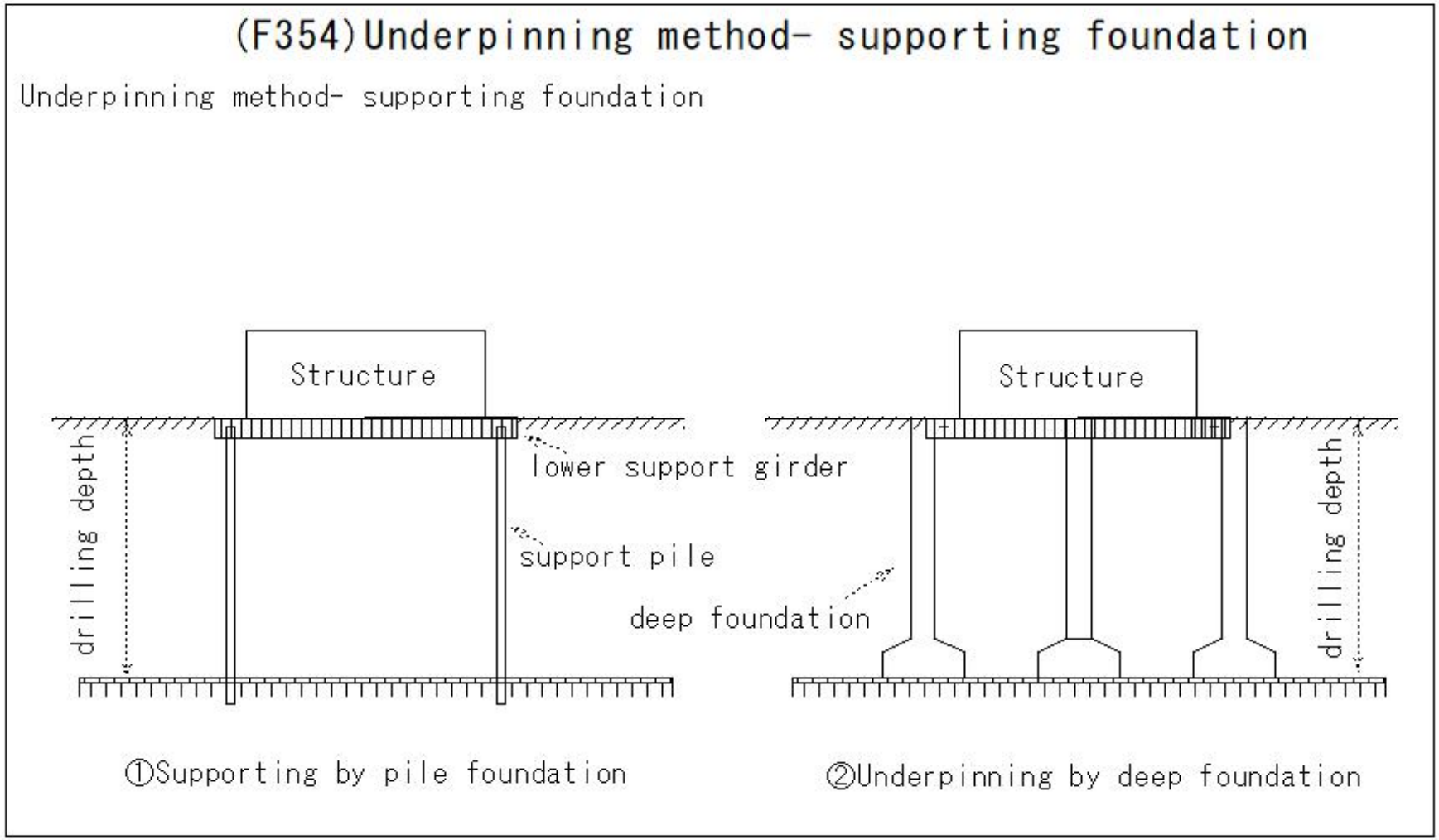
(F352)Earth drill method



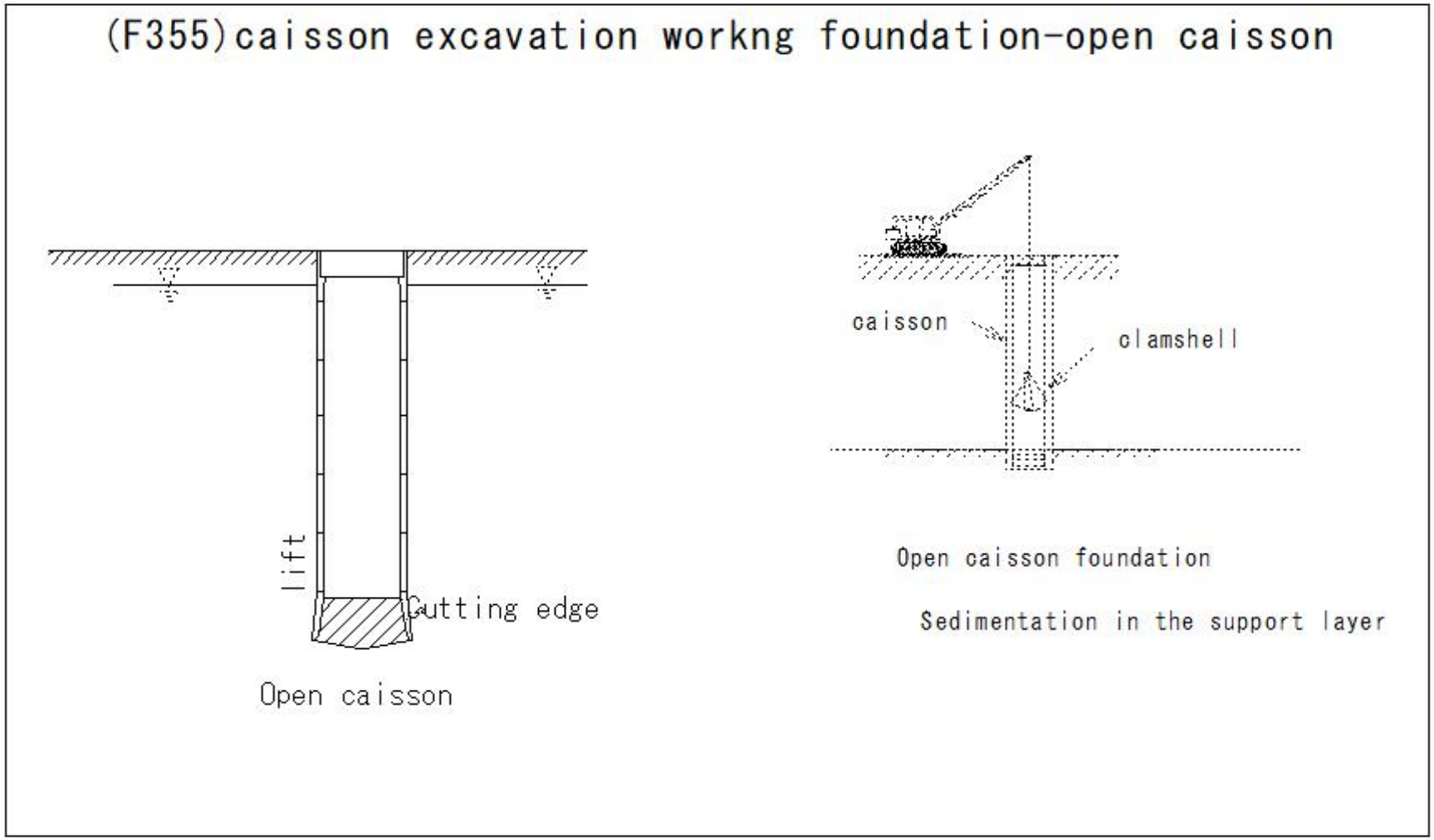
(F353)Reverse circulation methodd



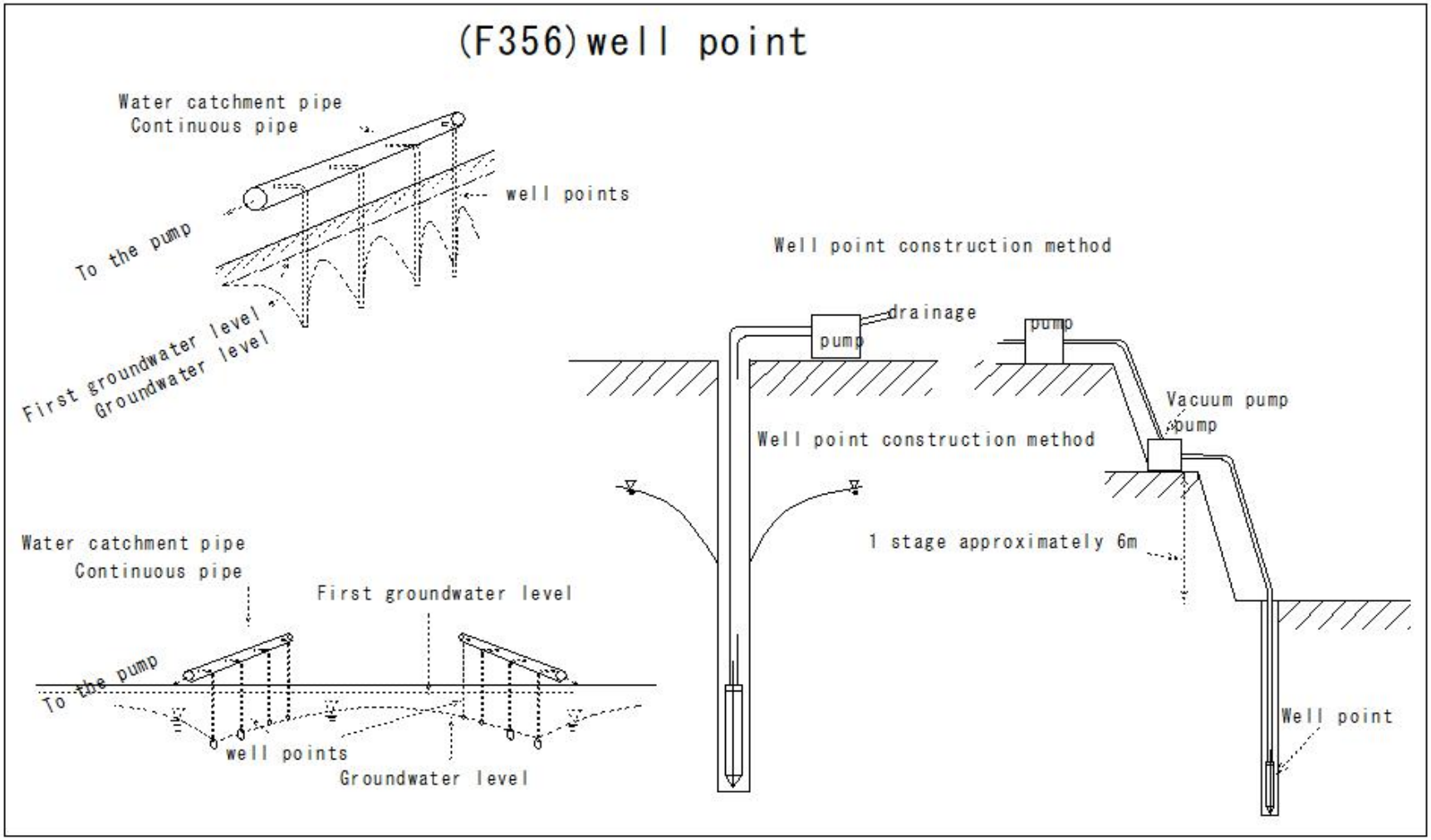
(F354)Underpinning method- supporting foundation



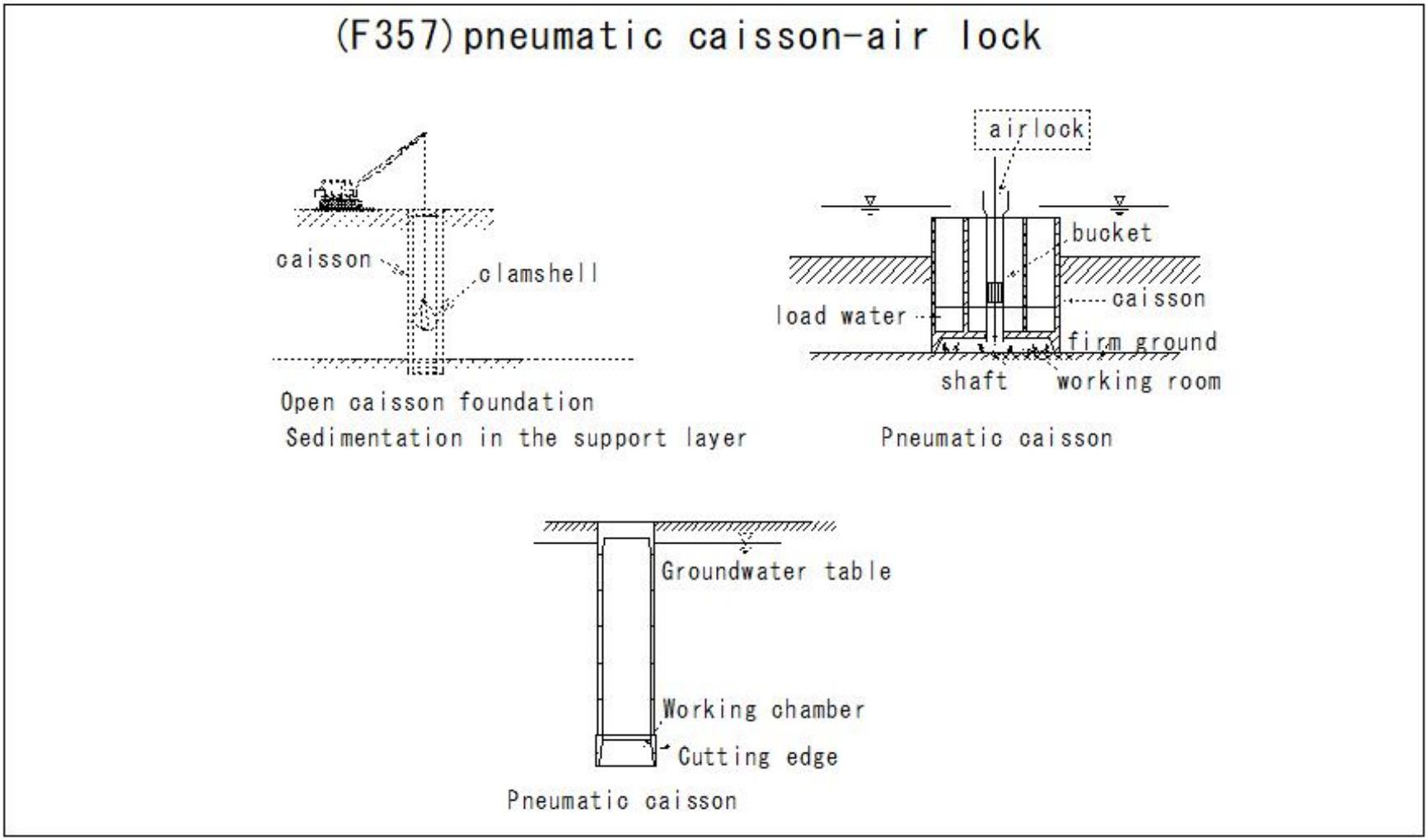
(F355)caisson excavation workng foundation-open caisson



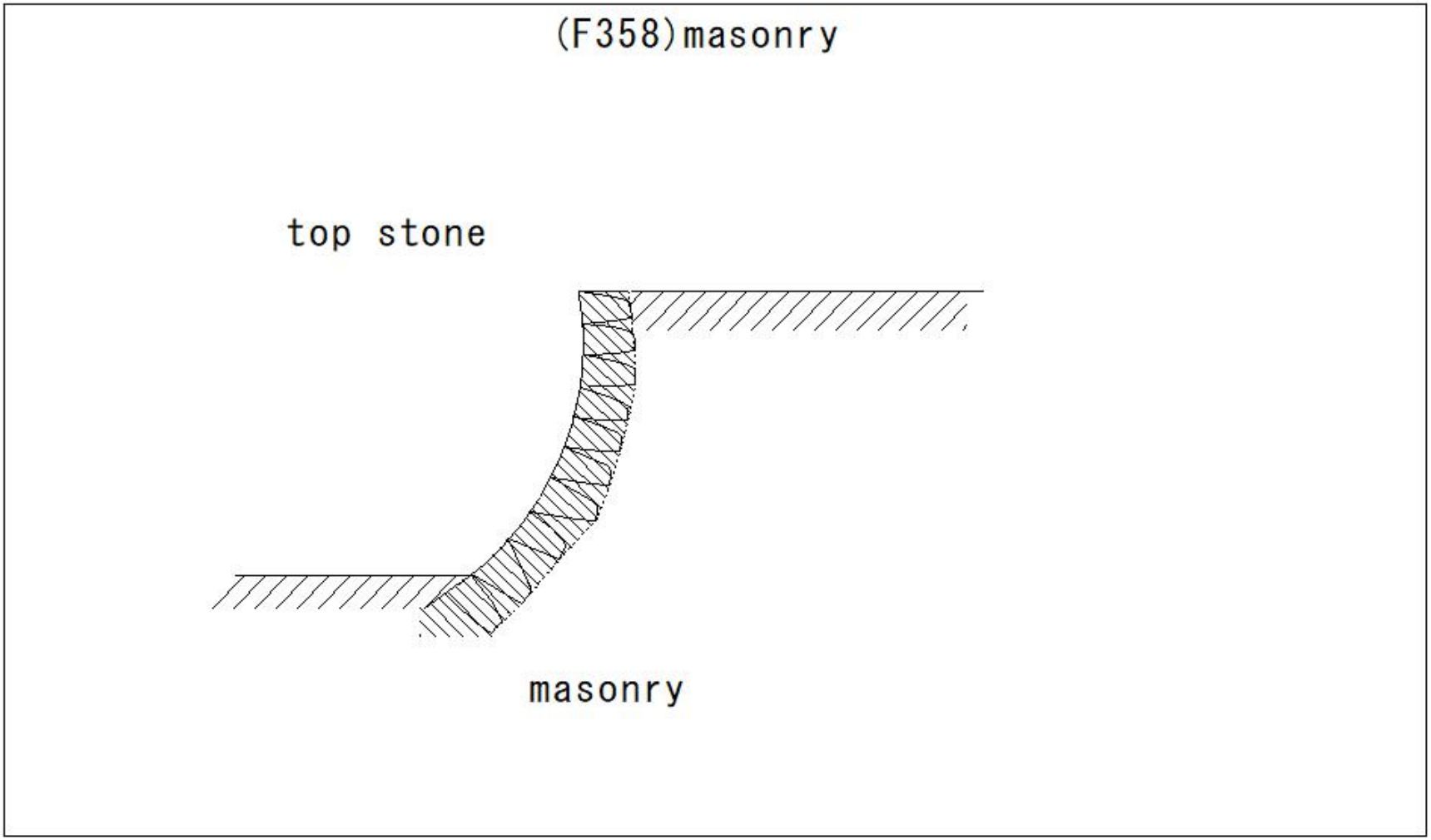
(F356)well point



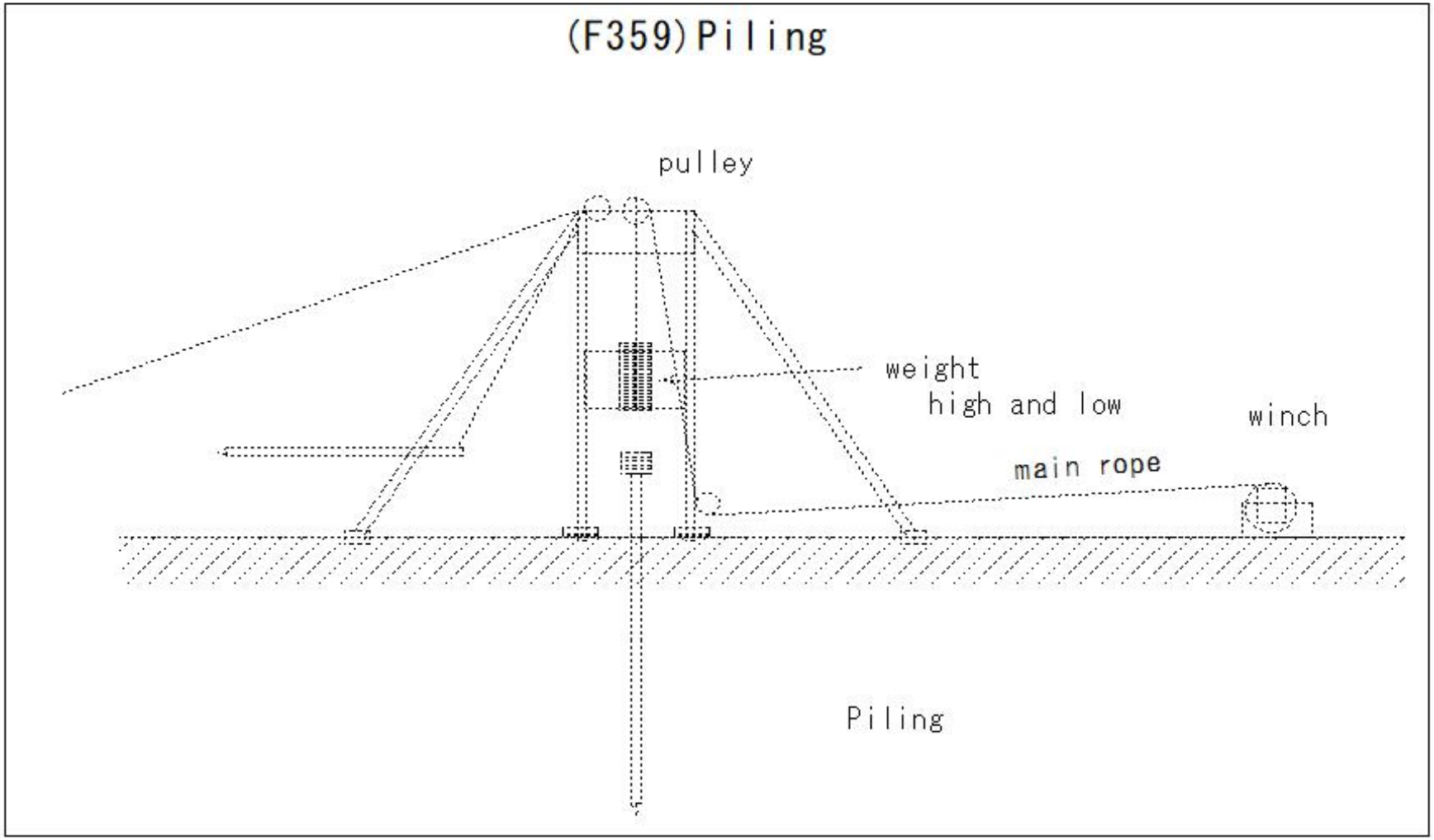
(F357)pneumatic caisson-air lock



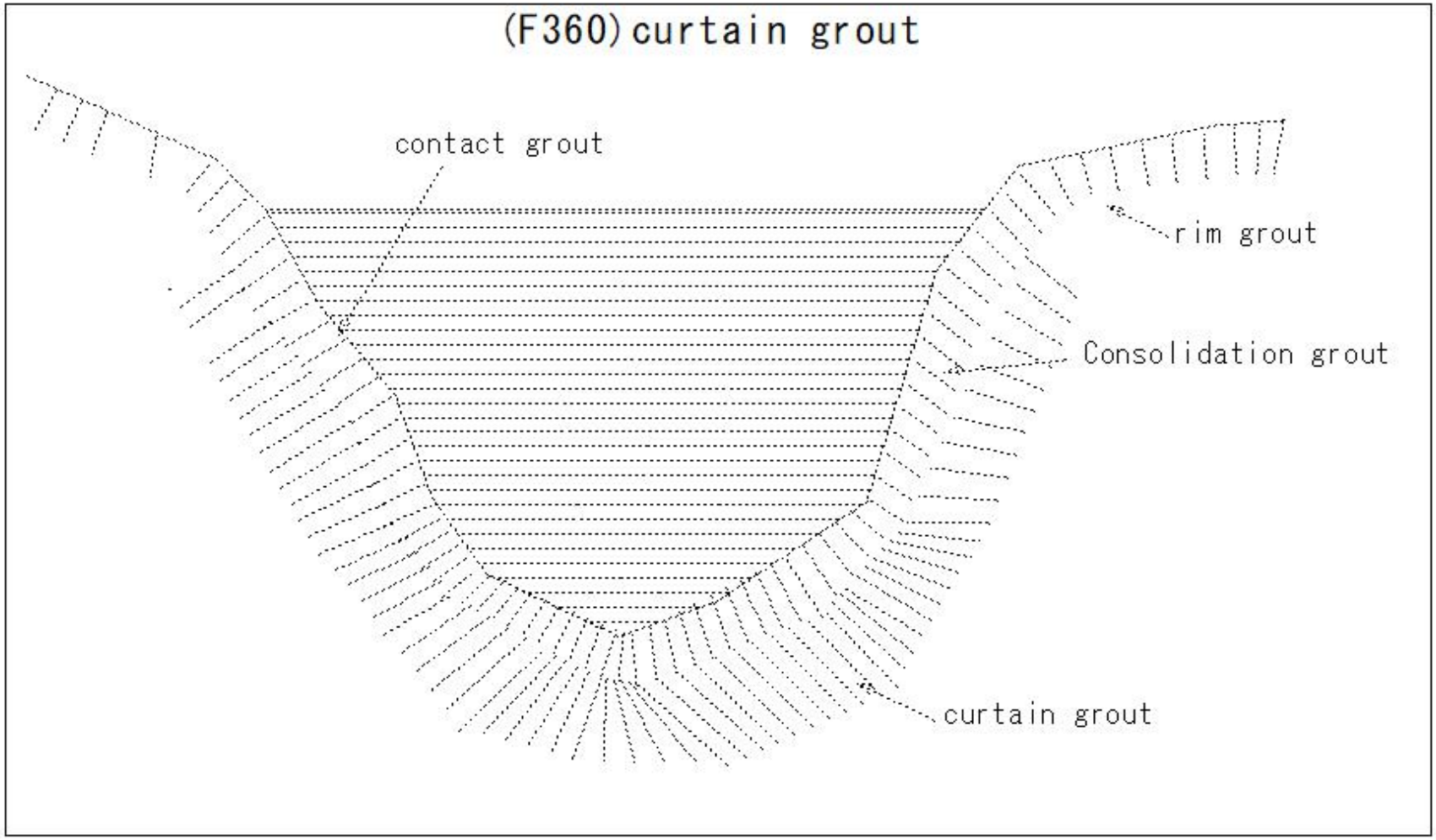
(F358)masonry



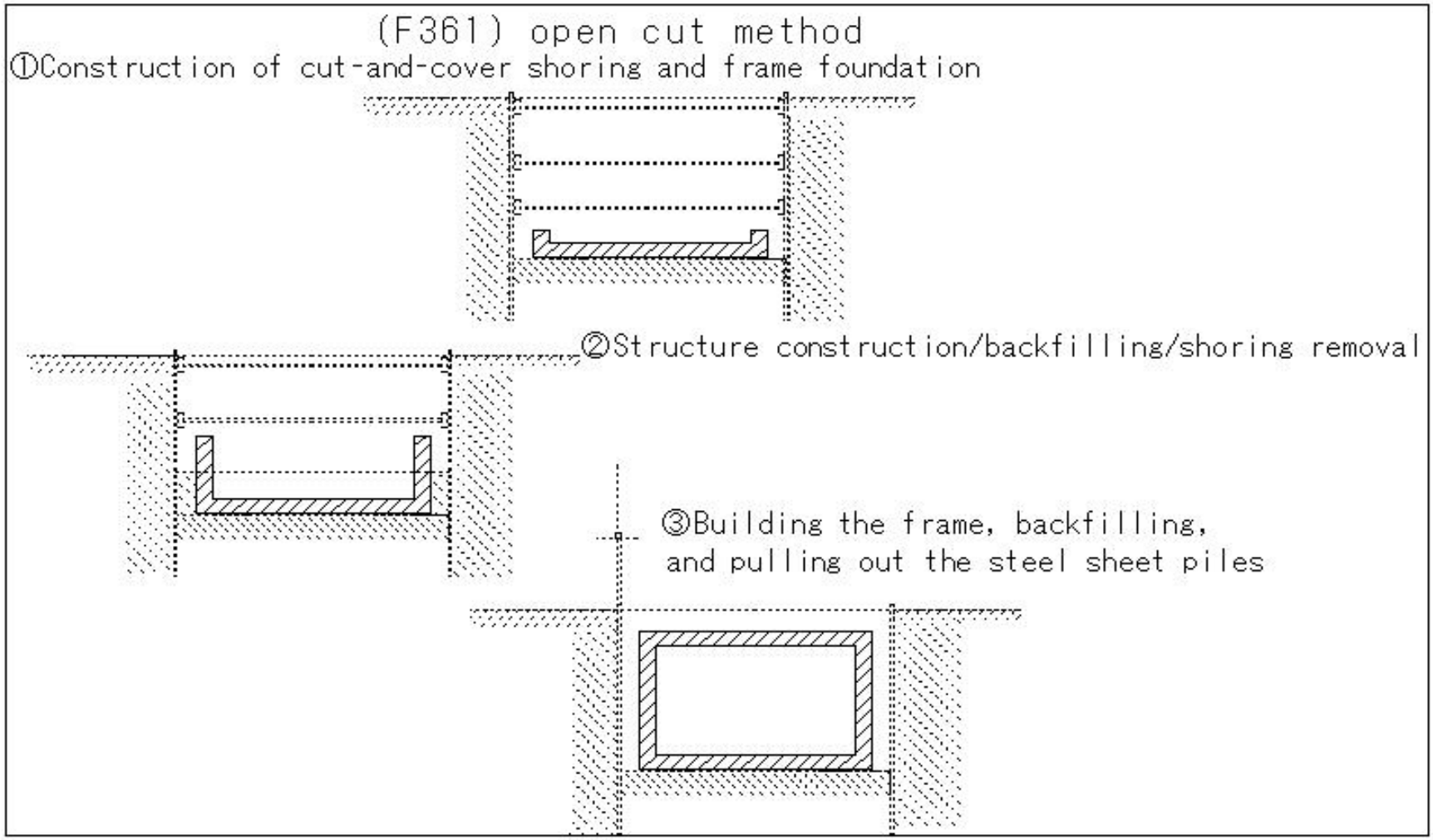
(F359)Piling


(F359)Piling
pulley
weight
high and low
winch
main rope
Piling

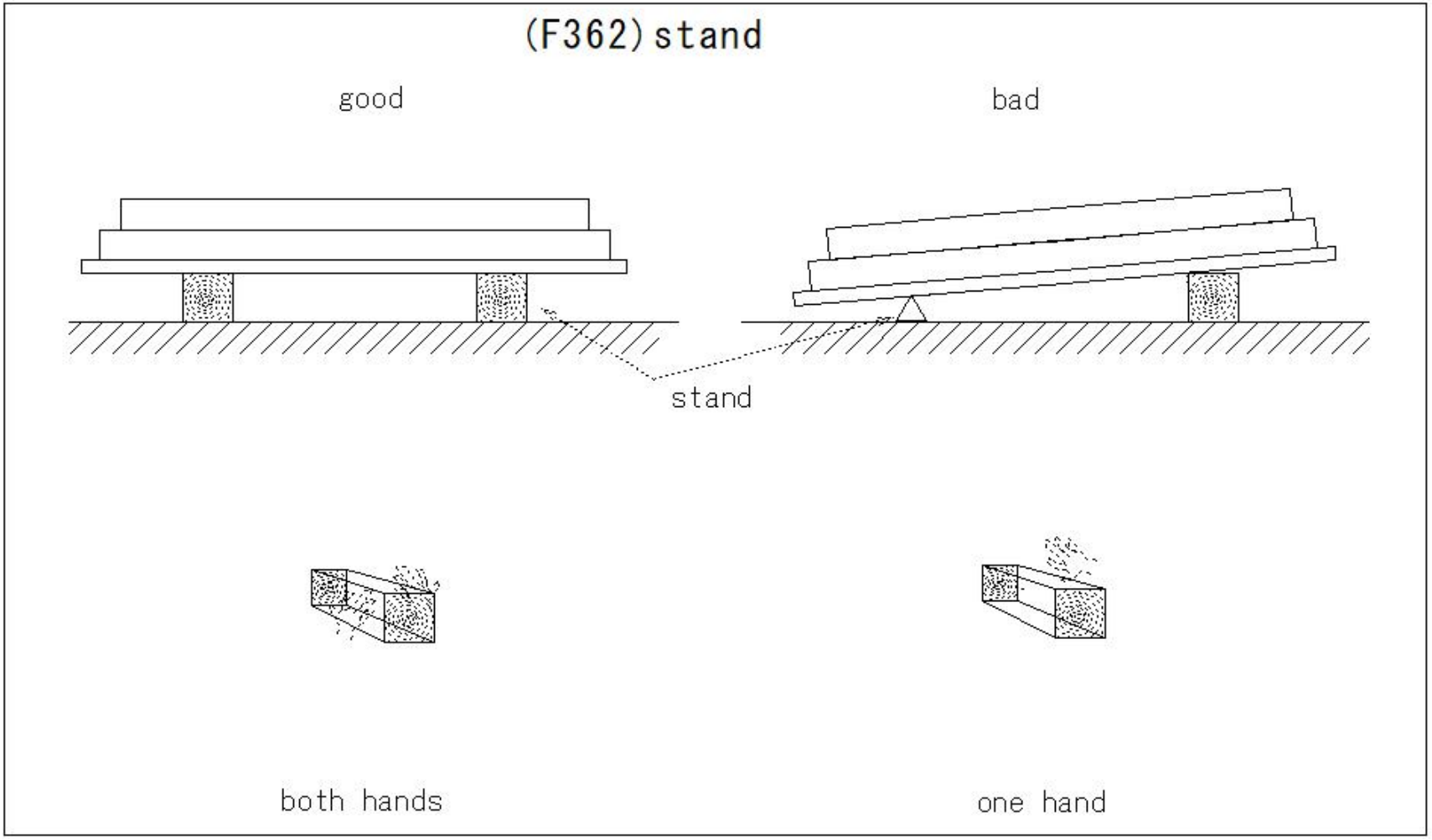
(F360)curtain grout



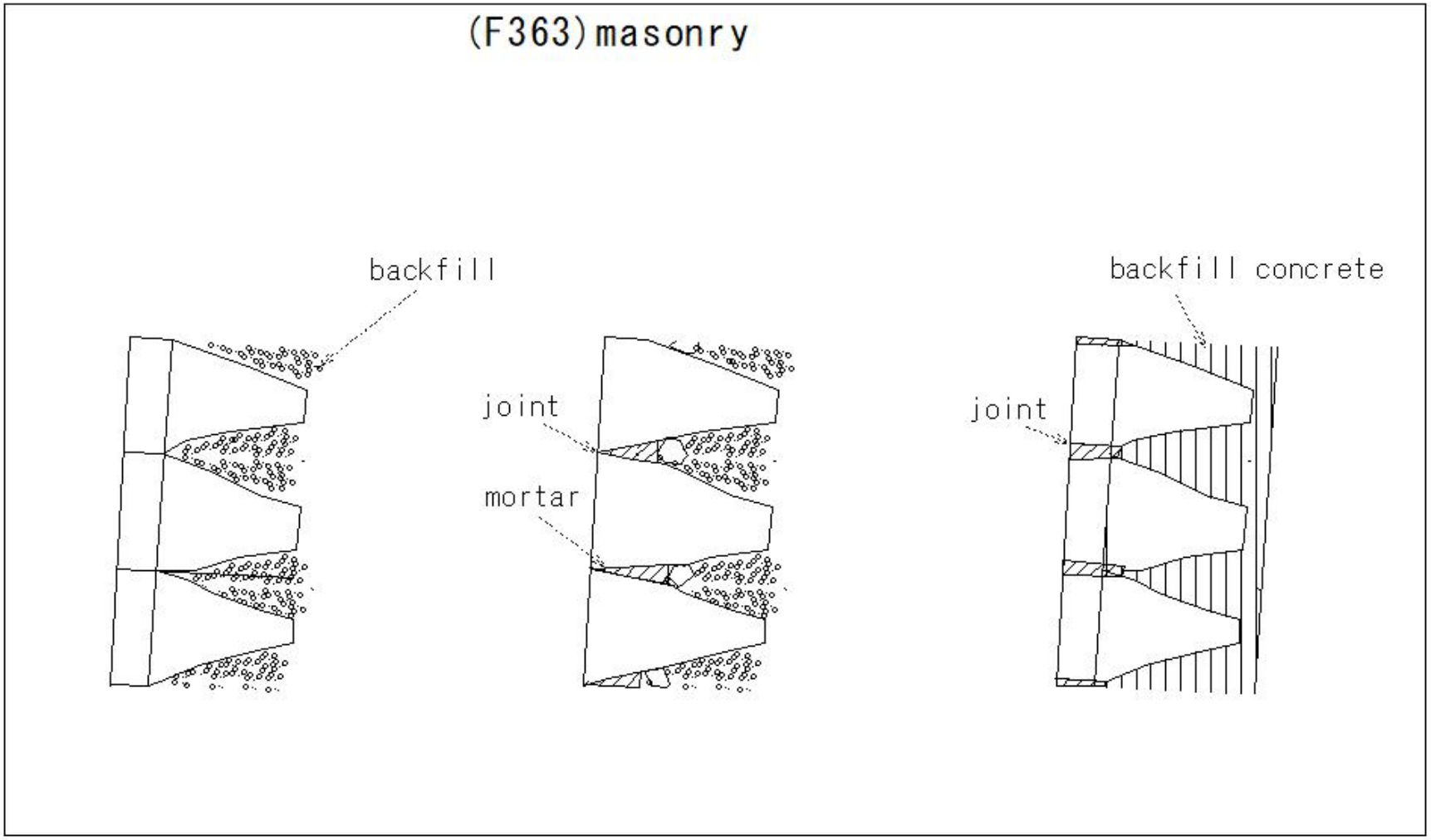
(F361) open cut method



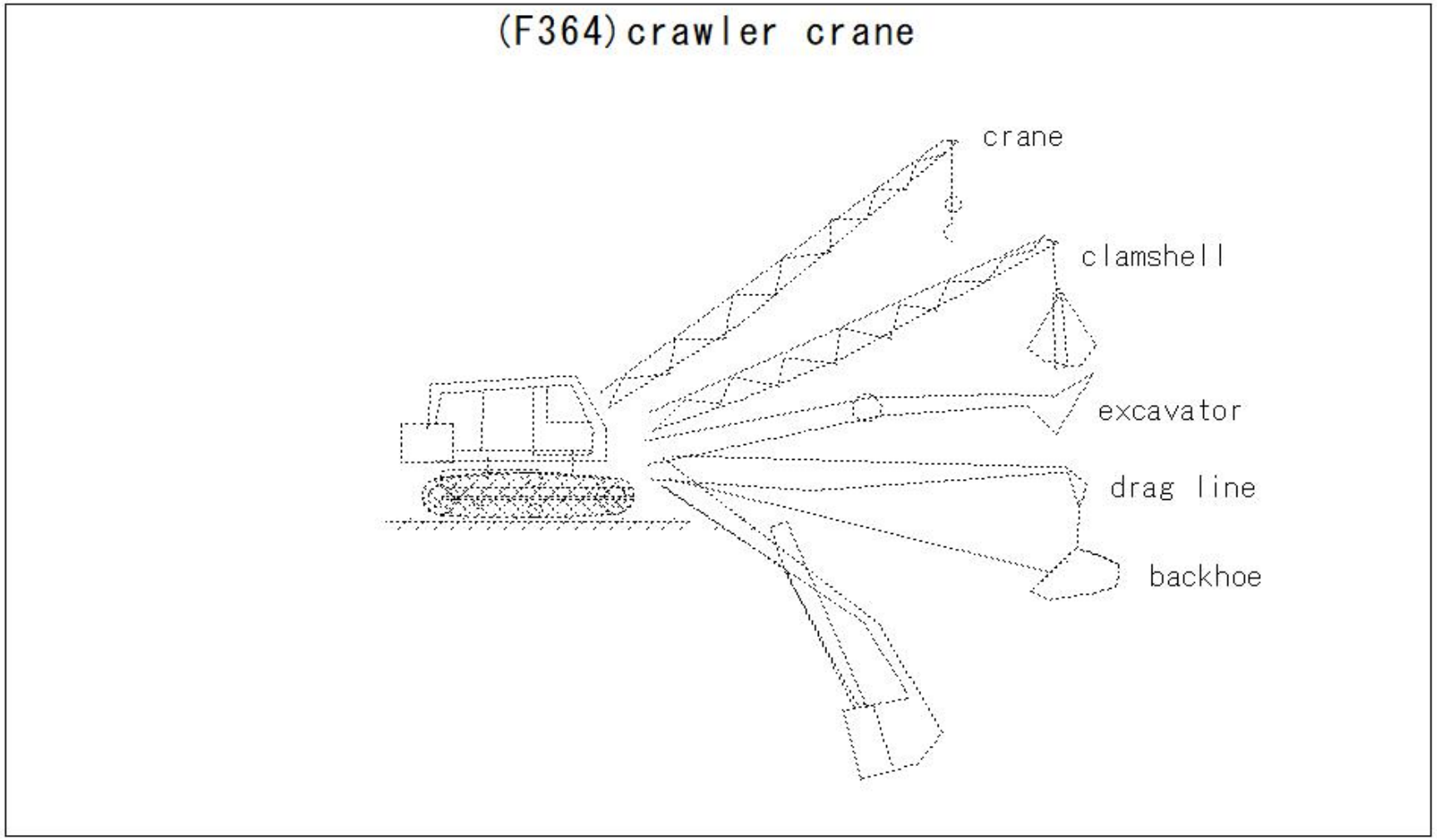
(F362)stand



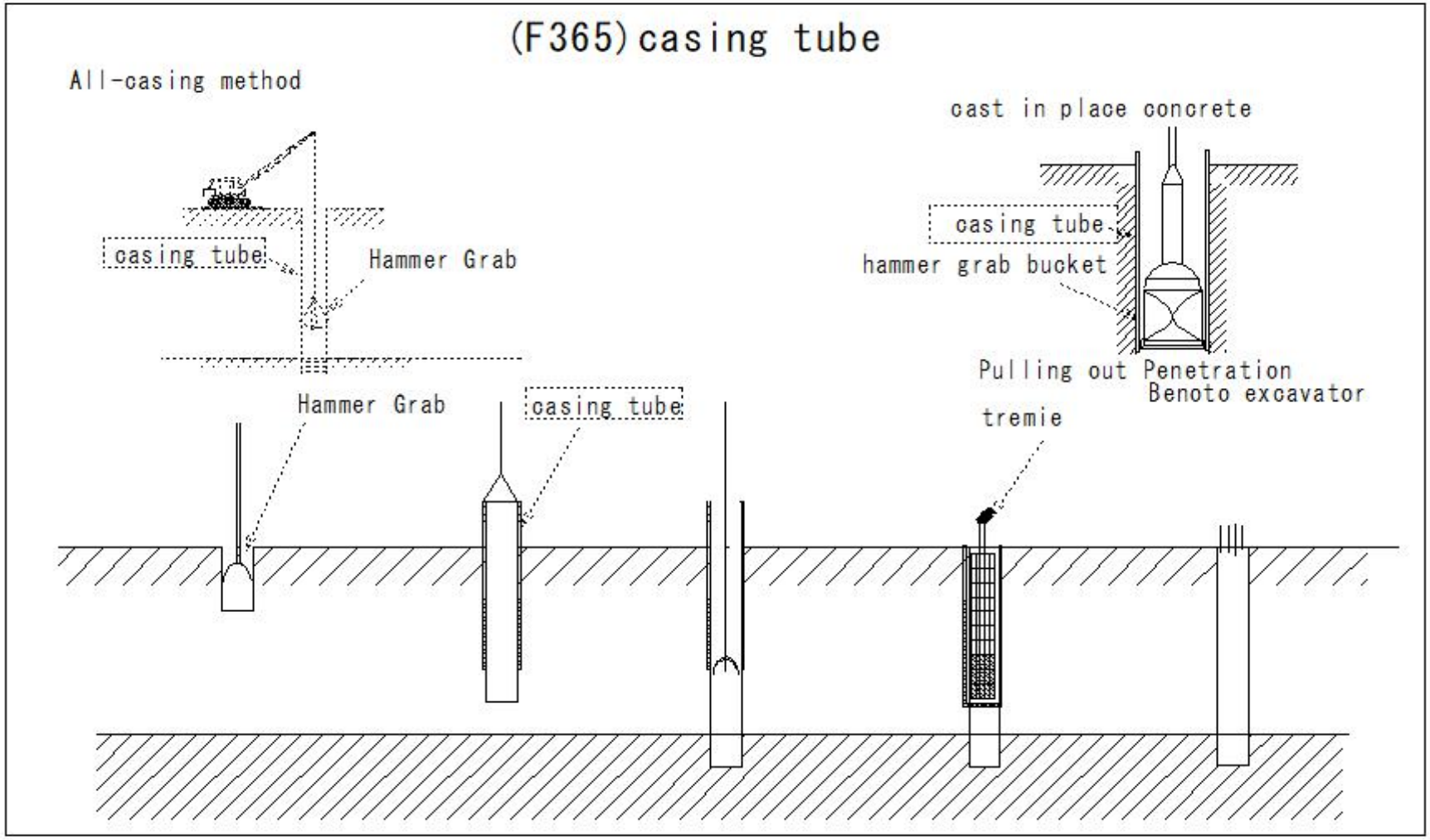
(F363)masonry



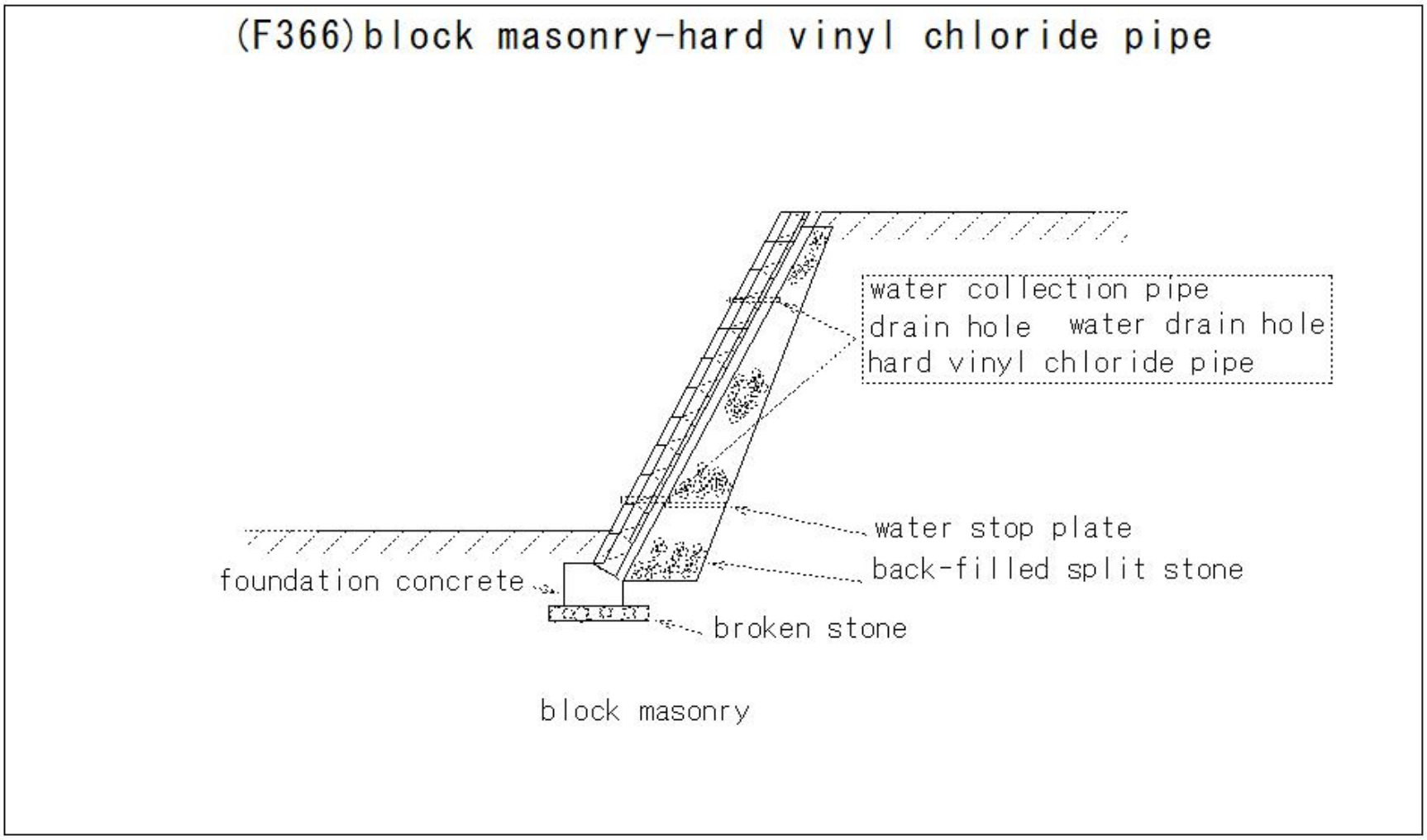
(F364)crawler crane



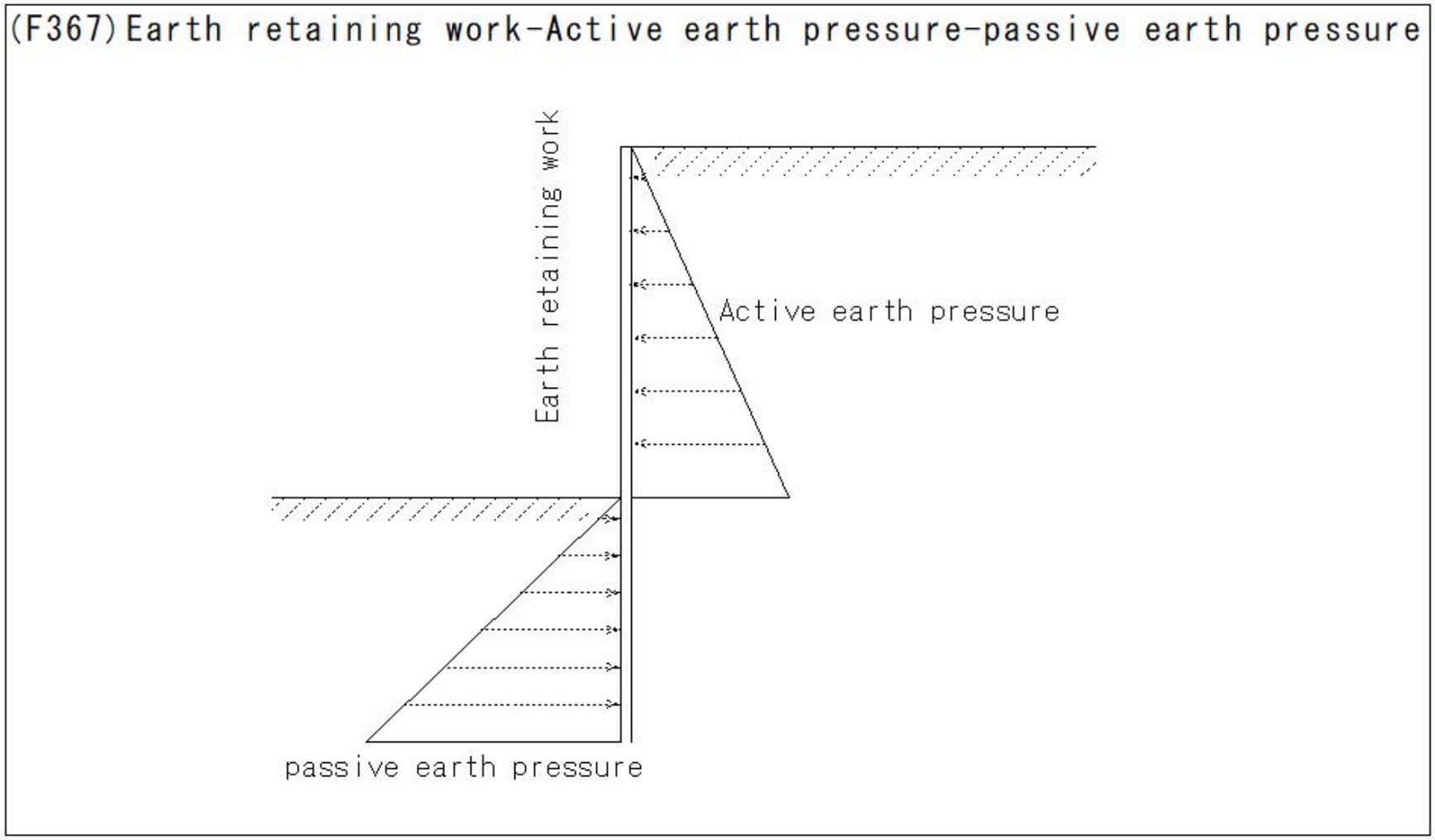
(F365)casing tube



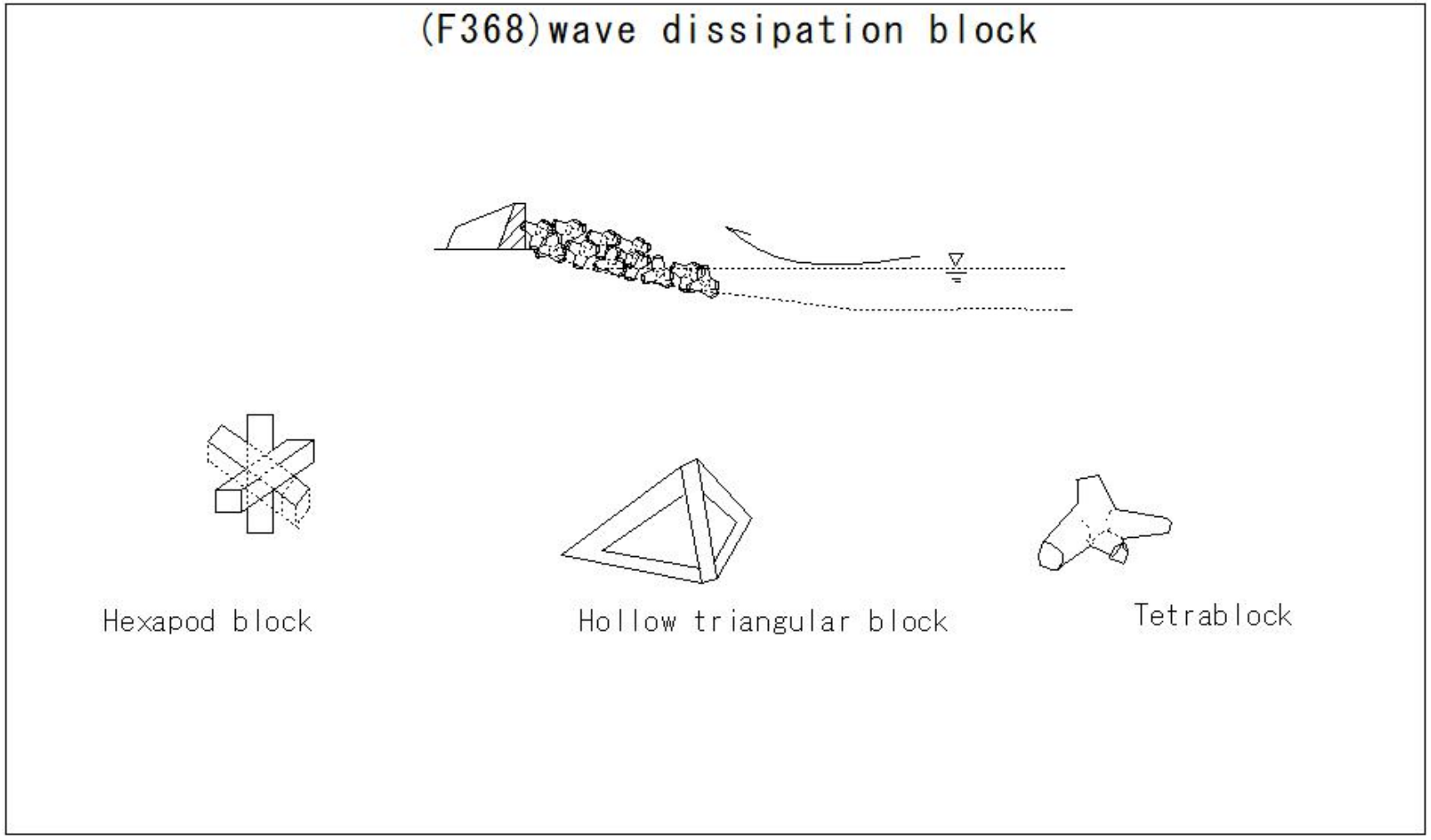
(F366)block masonry-hard vinyl chloride pipe



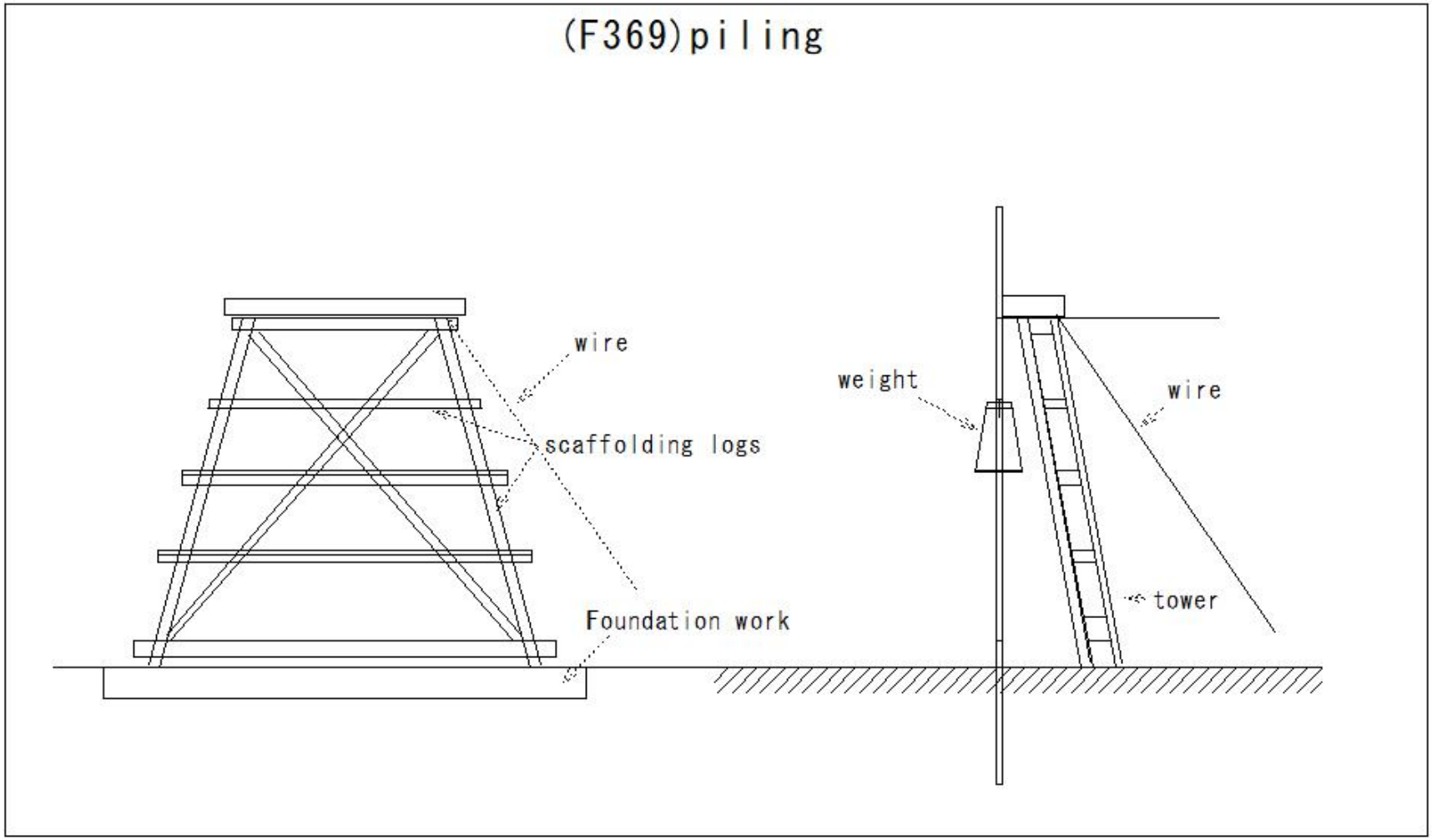
(F367)Earth retaining work-Active earth pressure-passive earth pressure



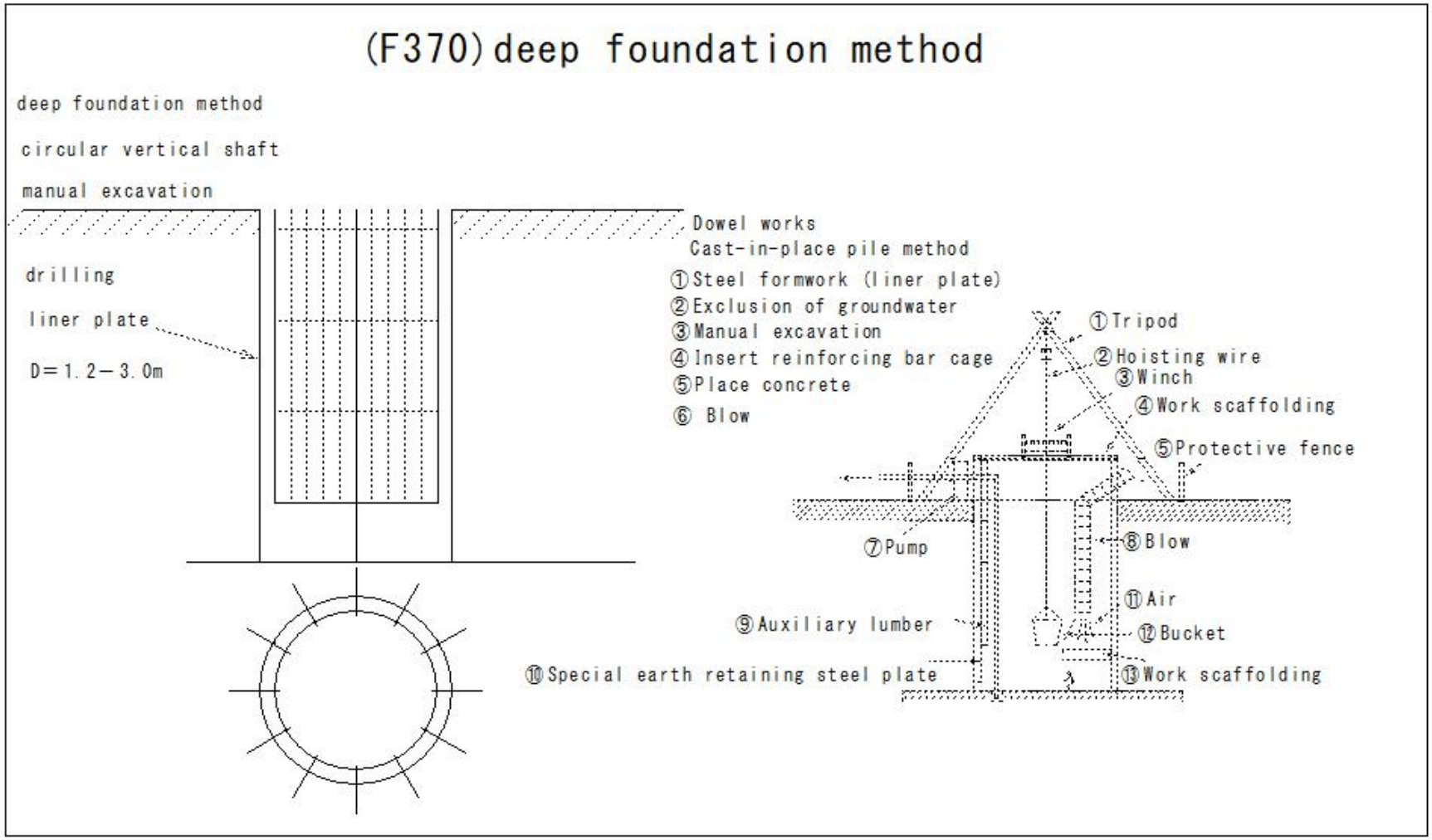
(F368)wave dissipation block



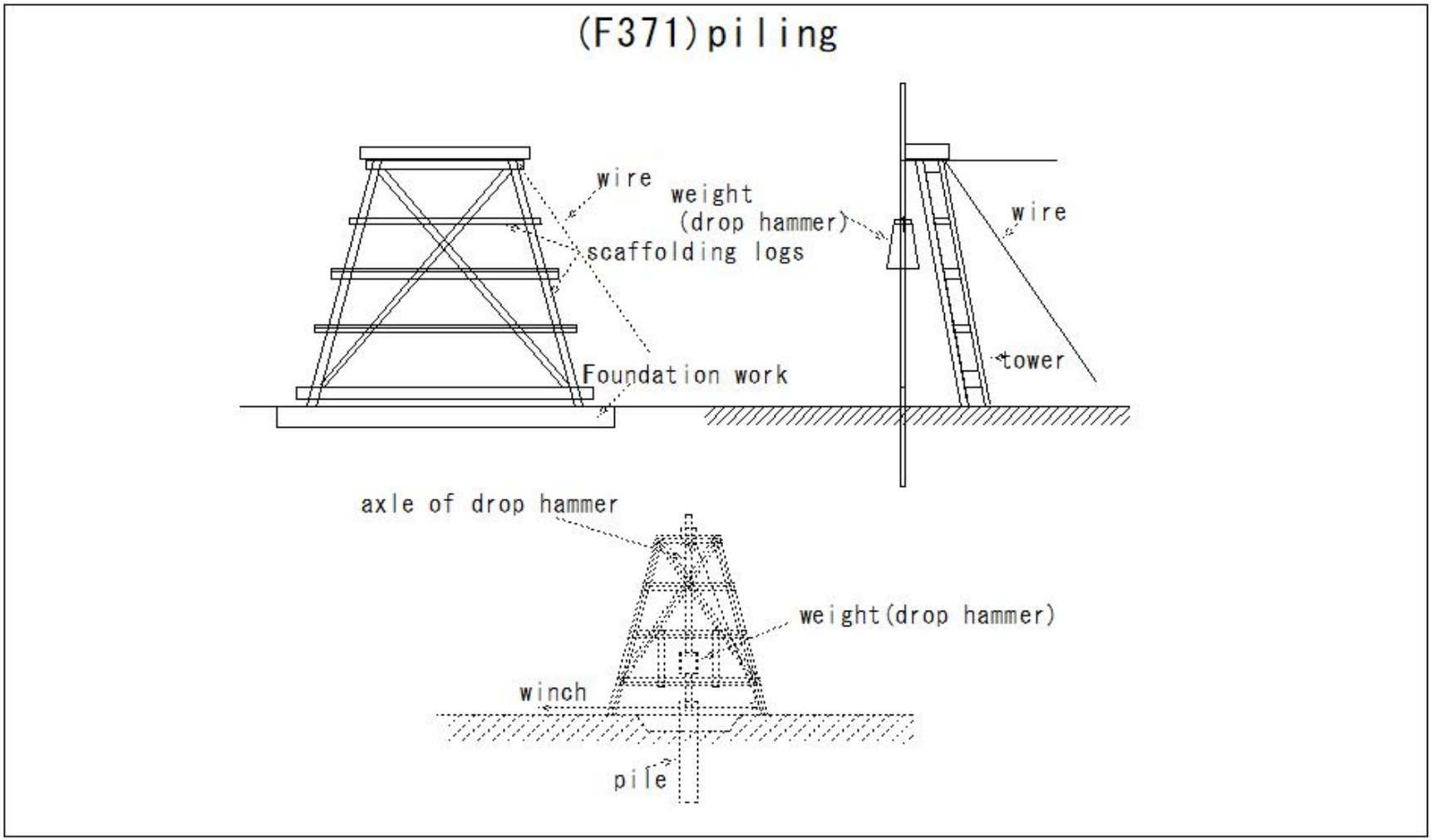
(F369)piling


(F369)piling
wire
scaffolding logs
Foundation work
weight
wire
tower

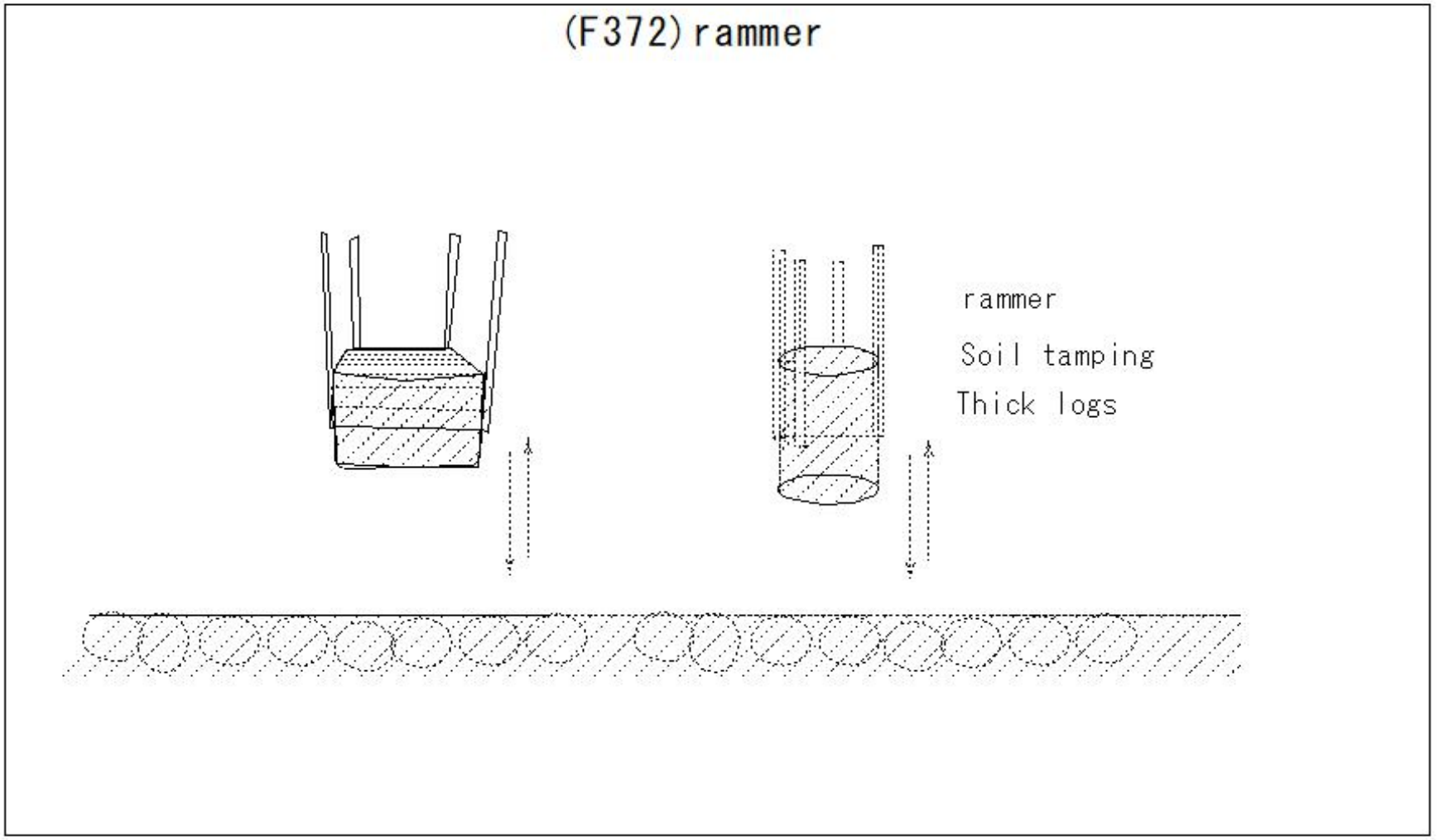
(F370)deep foundation method



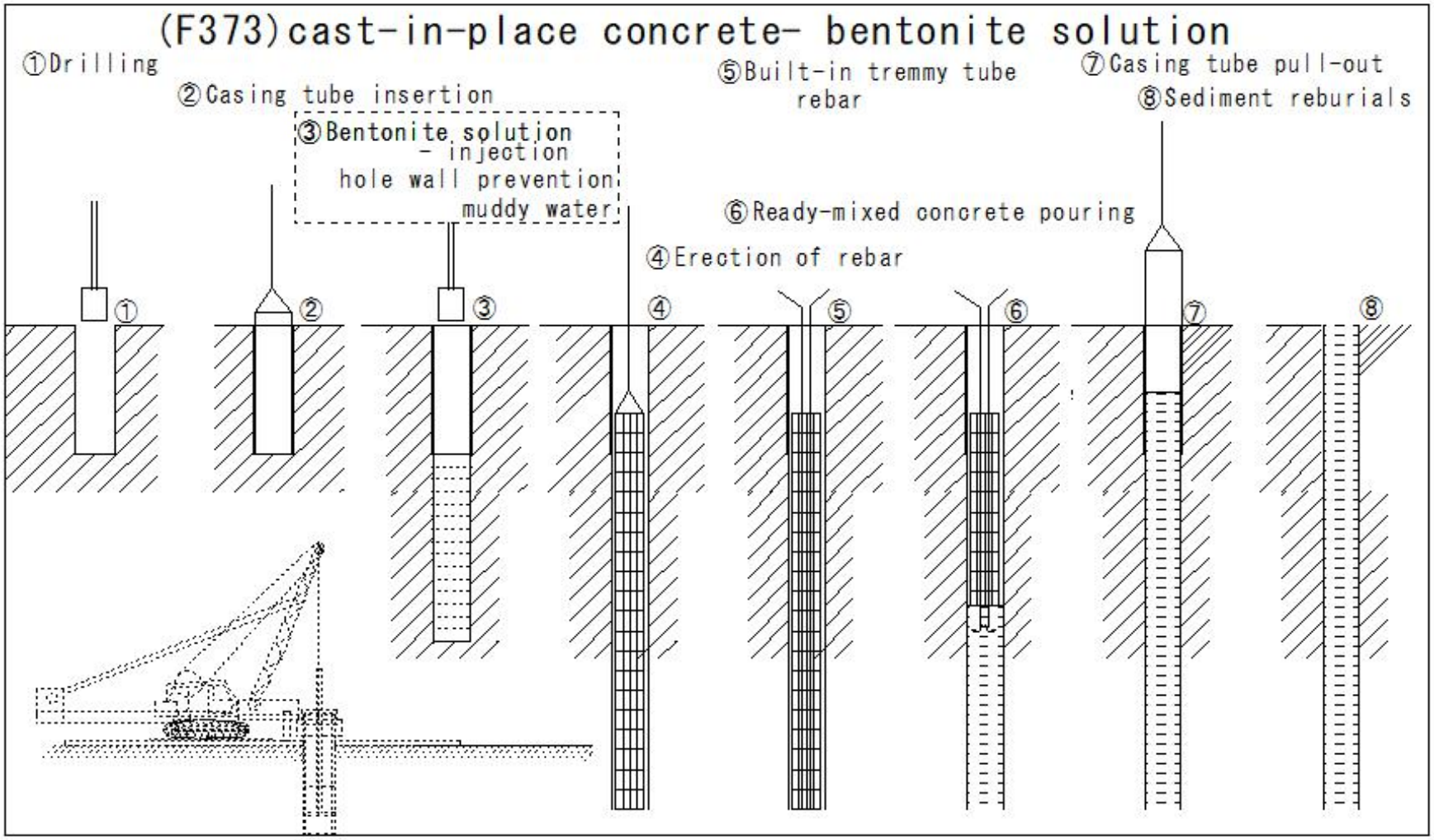
(F371)piling


(F371)piling
wire
weight
(drop hammer)
scaffolding logs
wire
Foundation work
tower
axle of drop hammer
weight(drop hammer)
winch
pile

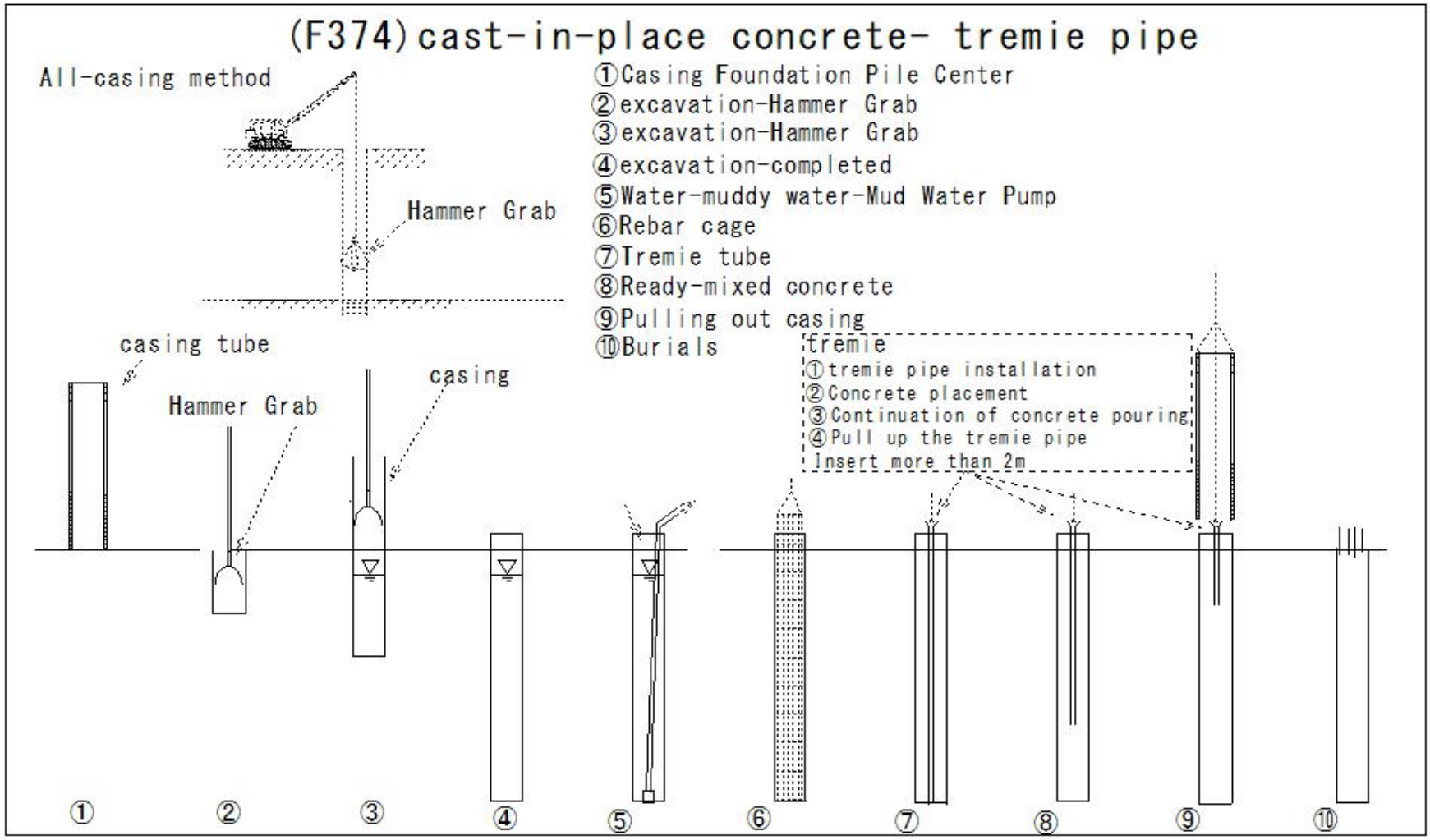
(F372)rammer



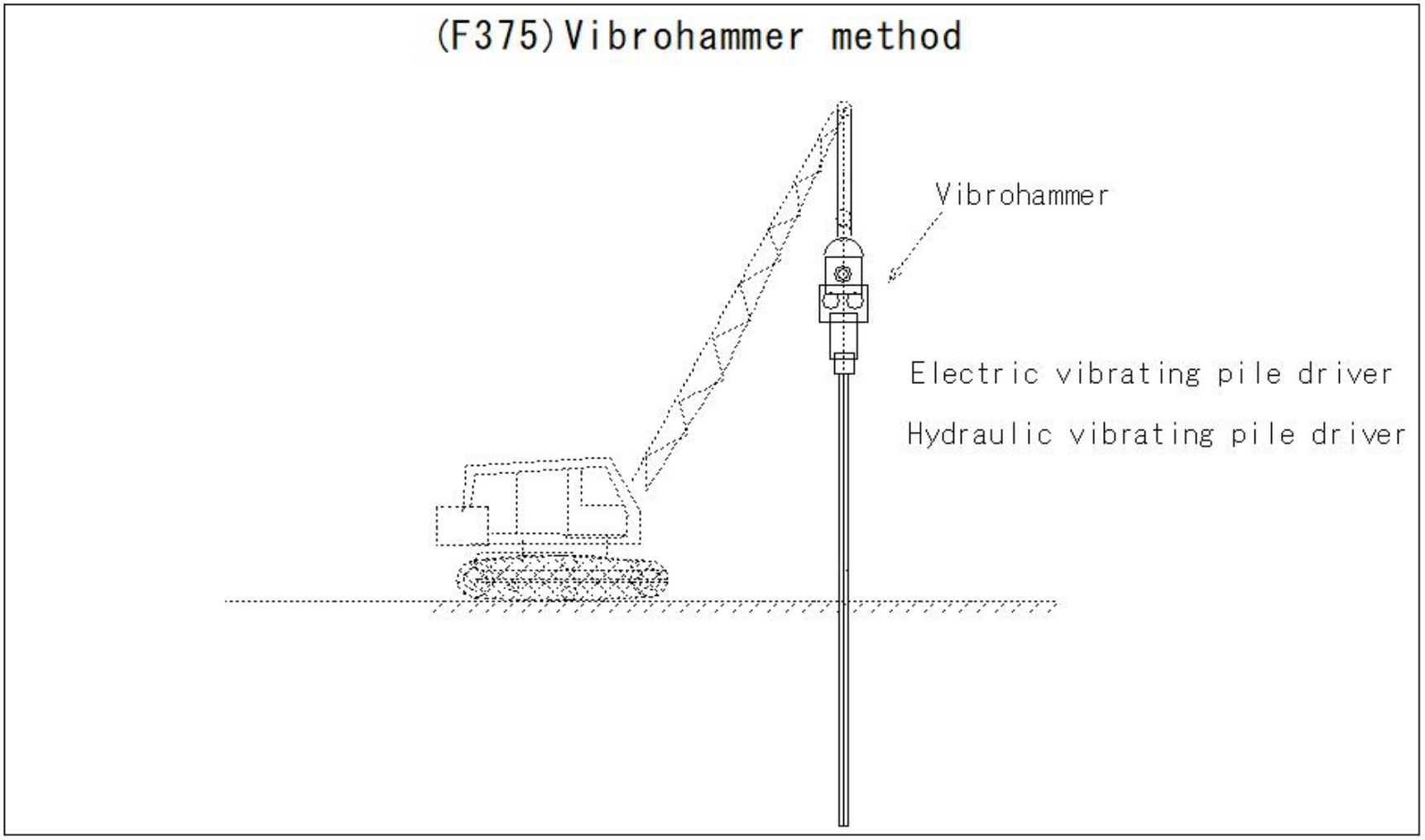
(F373)cast-in-place concrete- bentonite solution



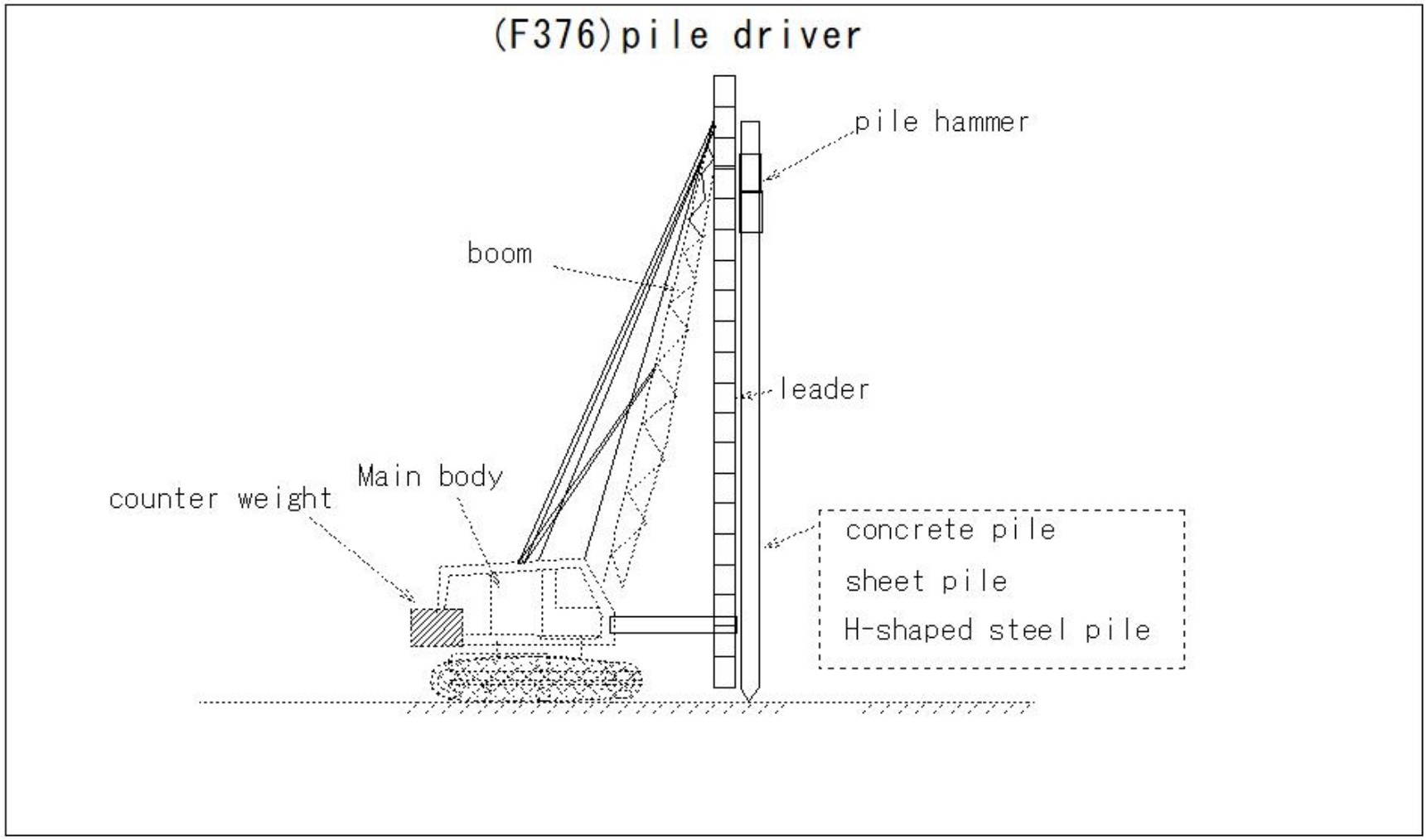
(F374)cast-in-place concrete- tremie pipe



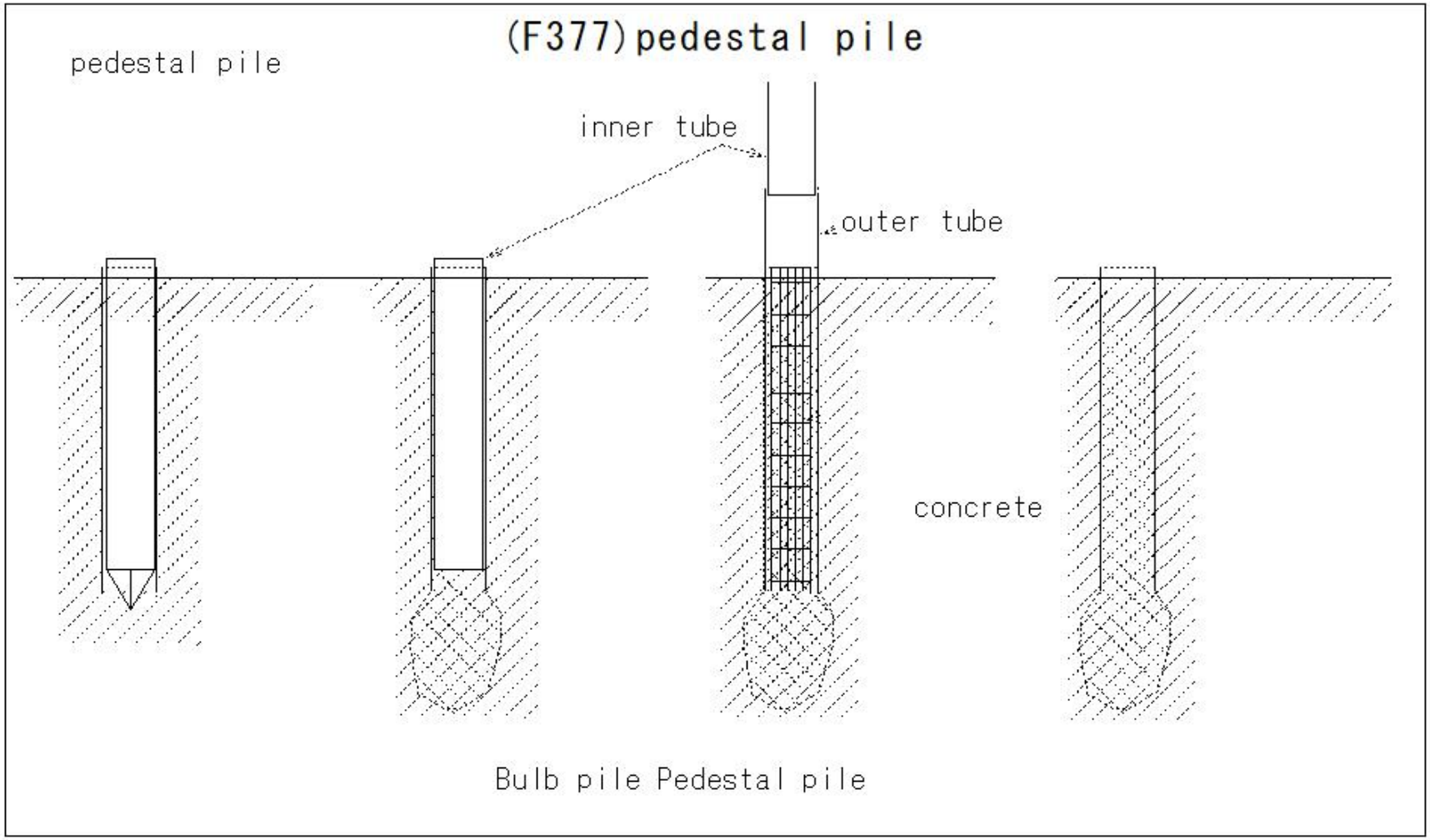
(F375)Vibrohammer method



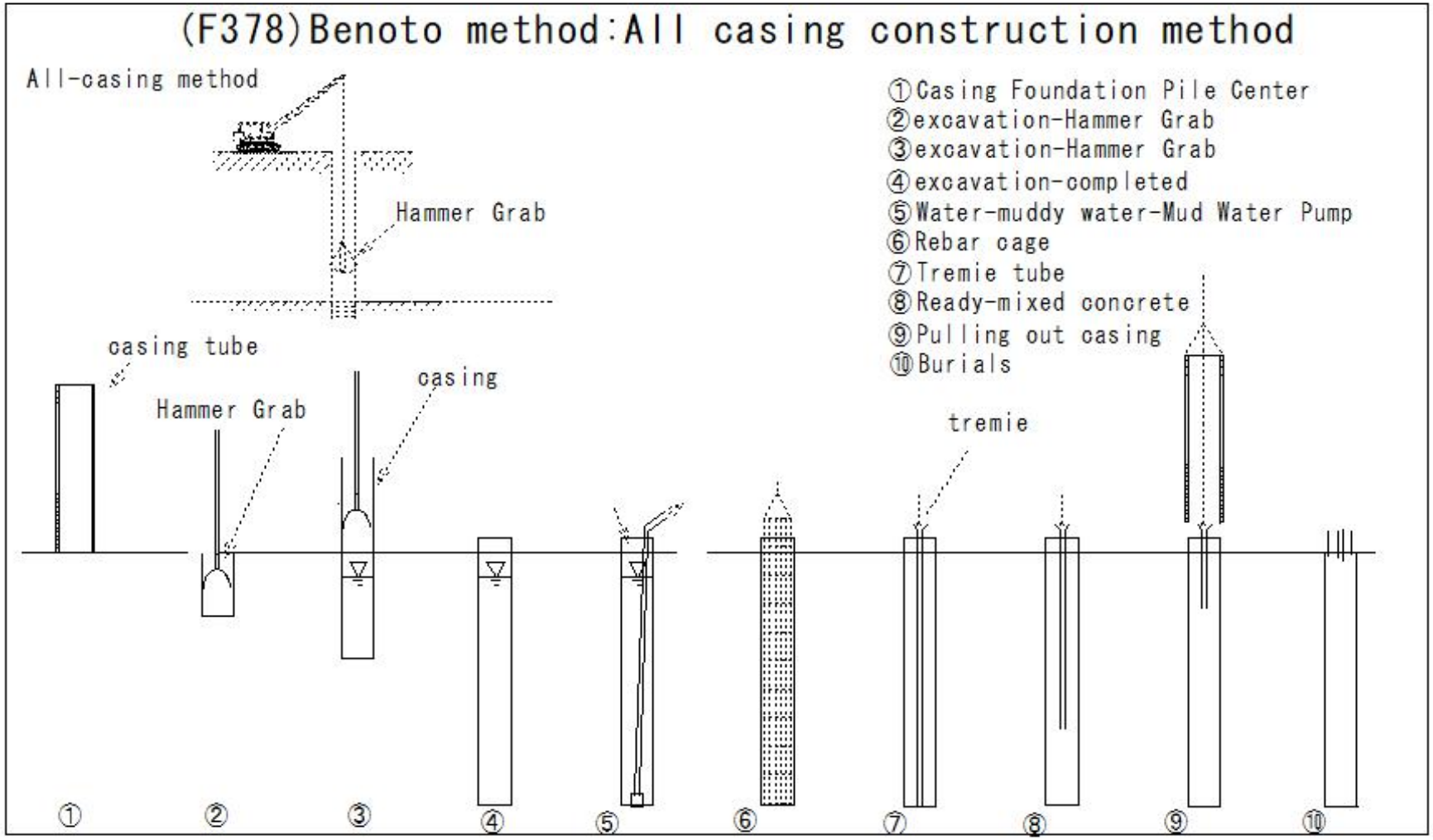
(F376)pile driver



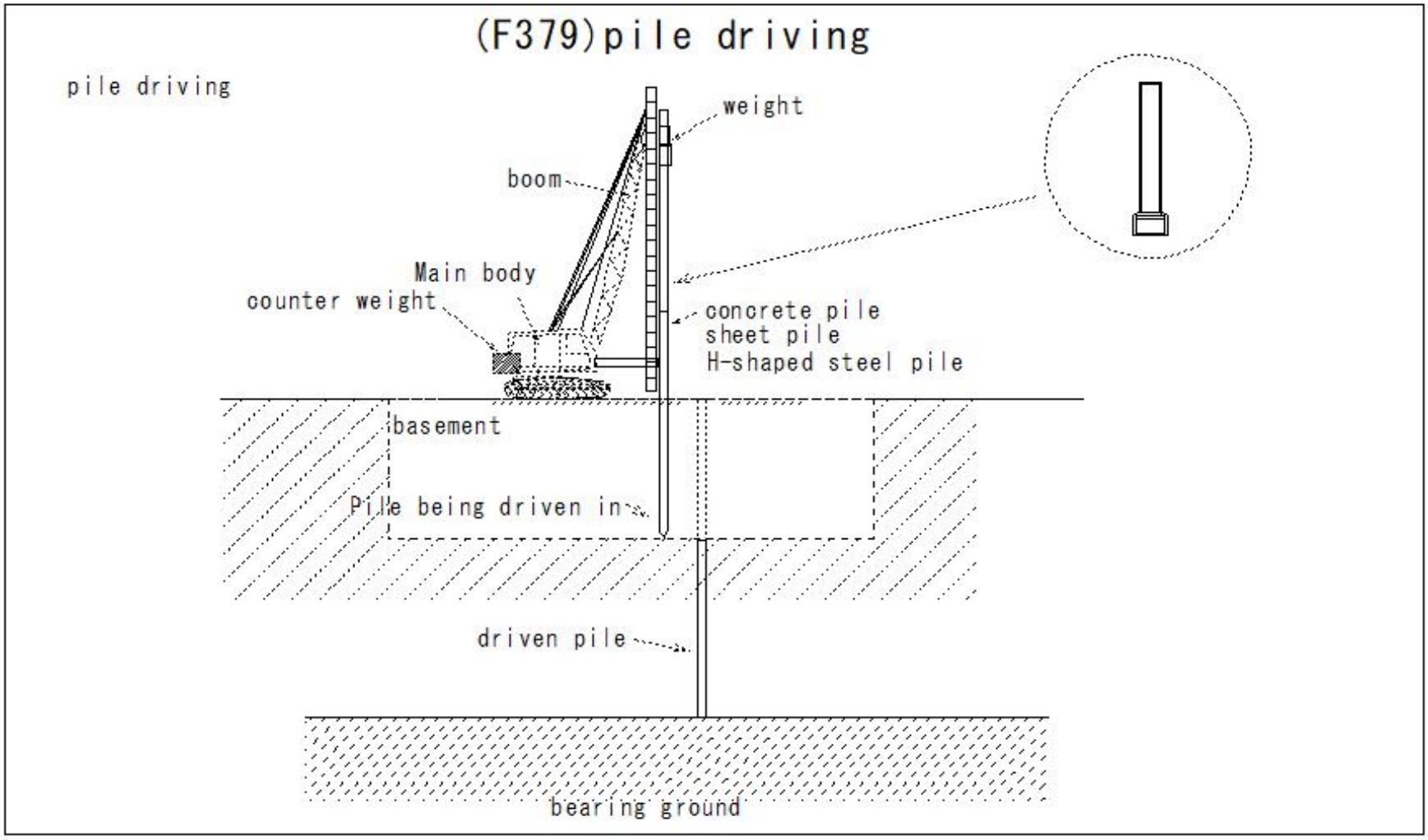
(F377)pedestal pile



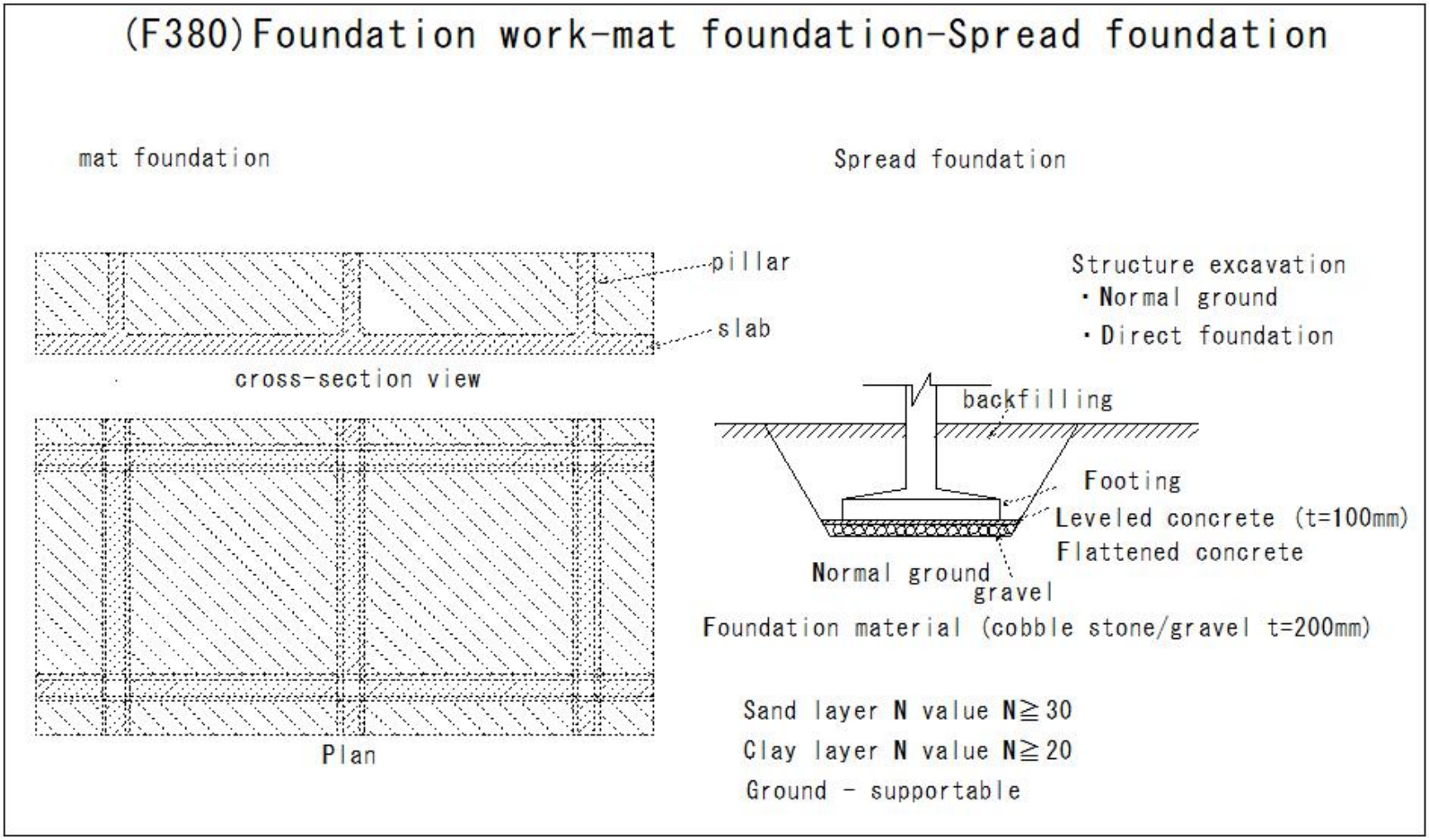
(F378)Benoto method:All casing construction method



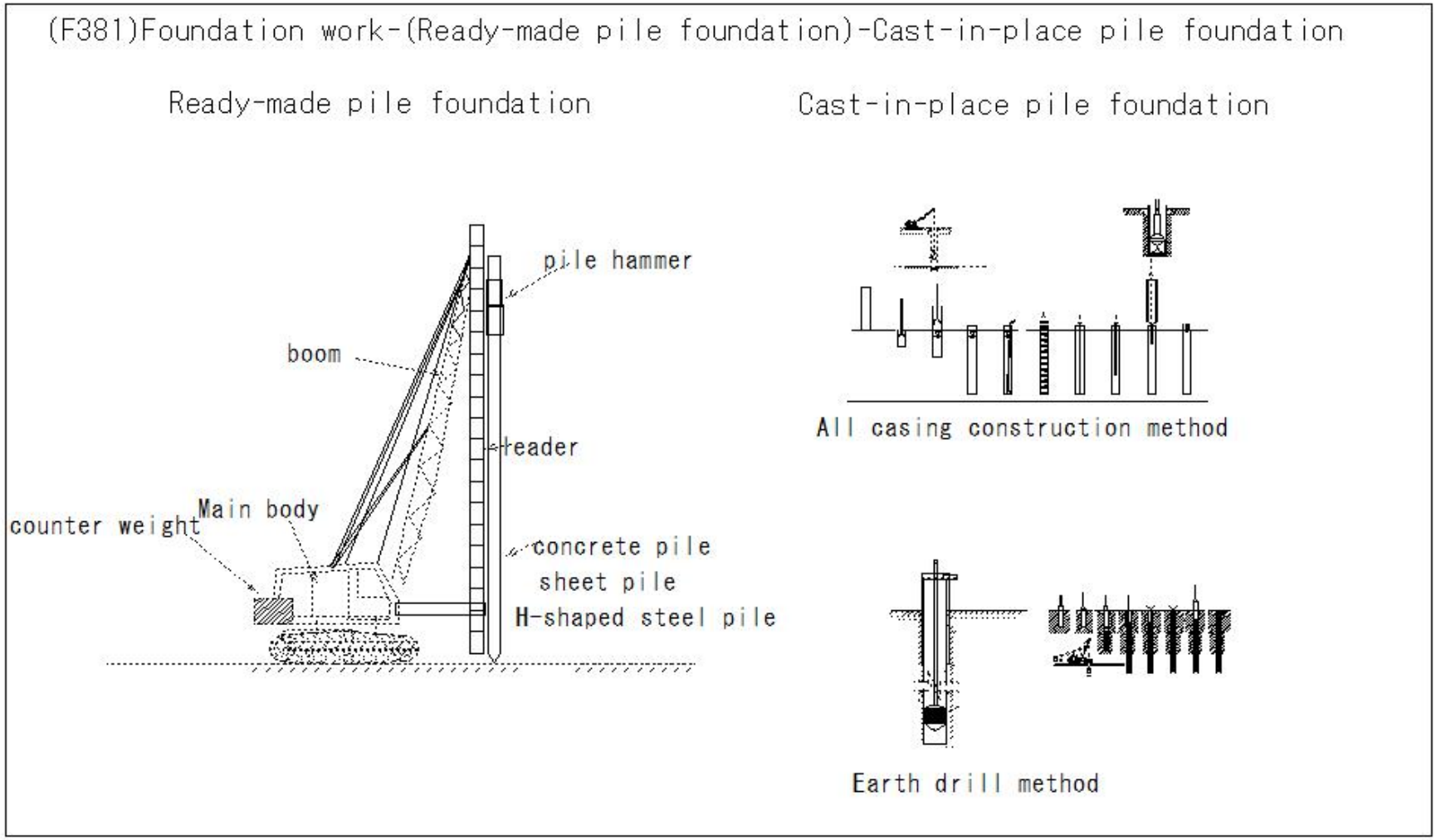
(F379)pile driving



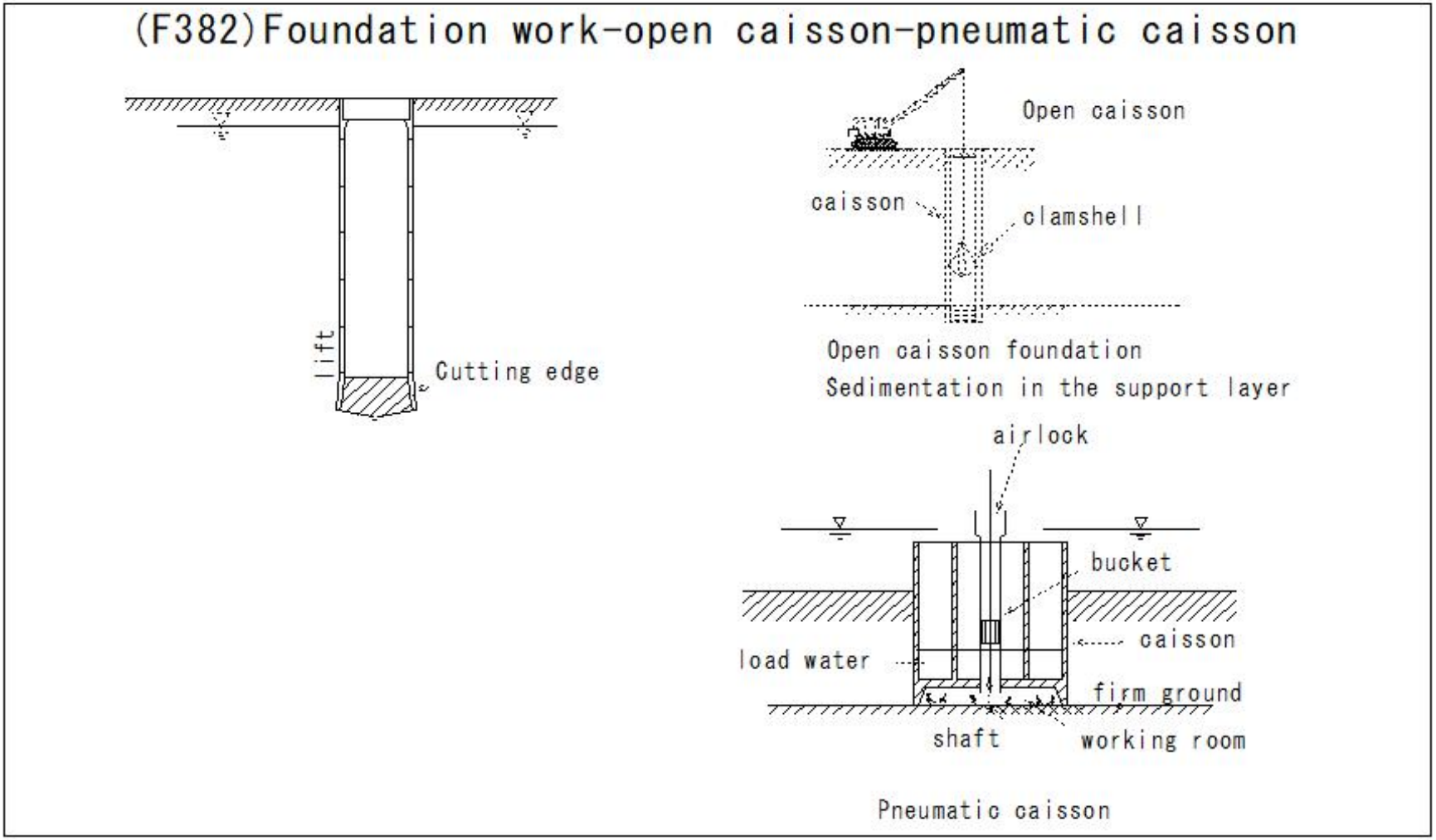
(F380)Foundation work



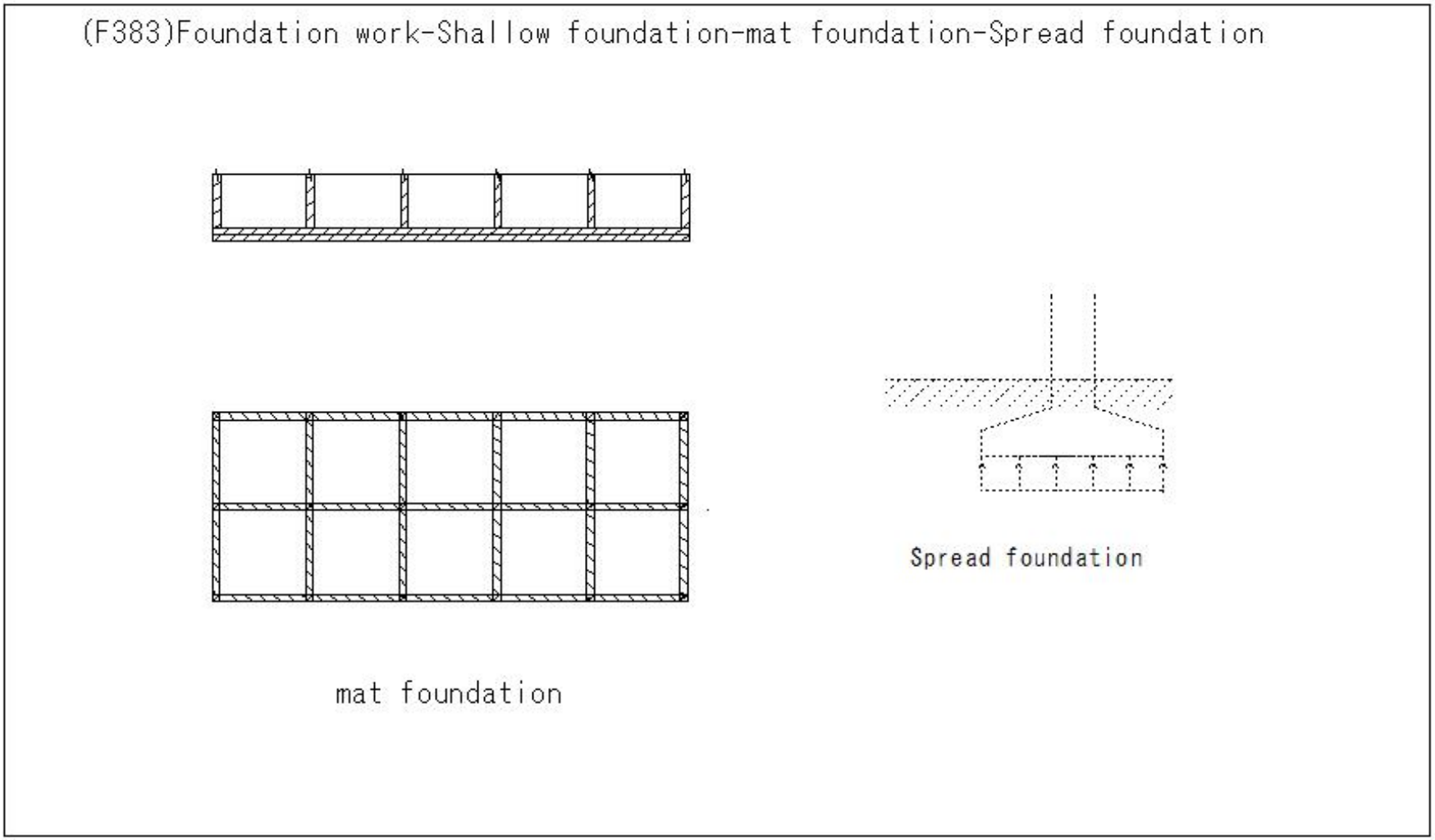
(F381)Foundation work-(Ready-made pile foundation)-Cast-in-place pile foundation



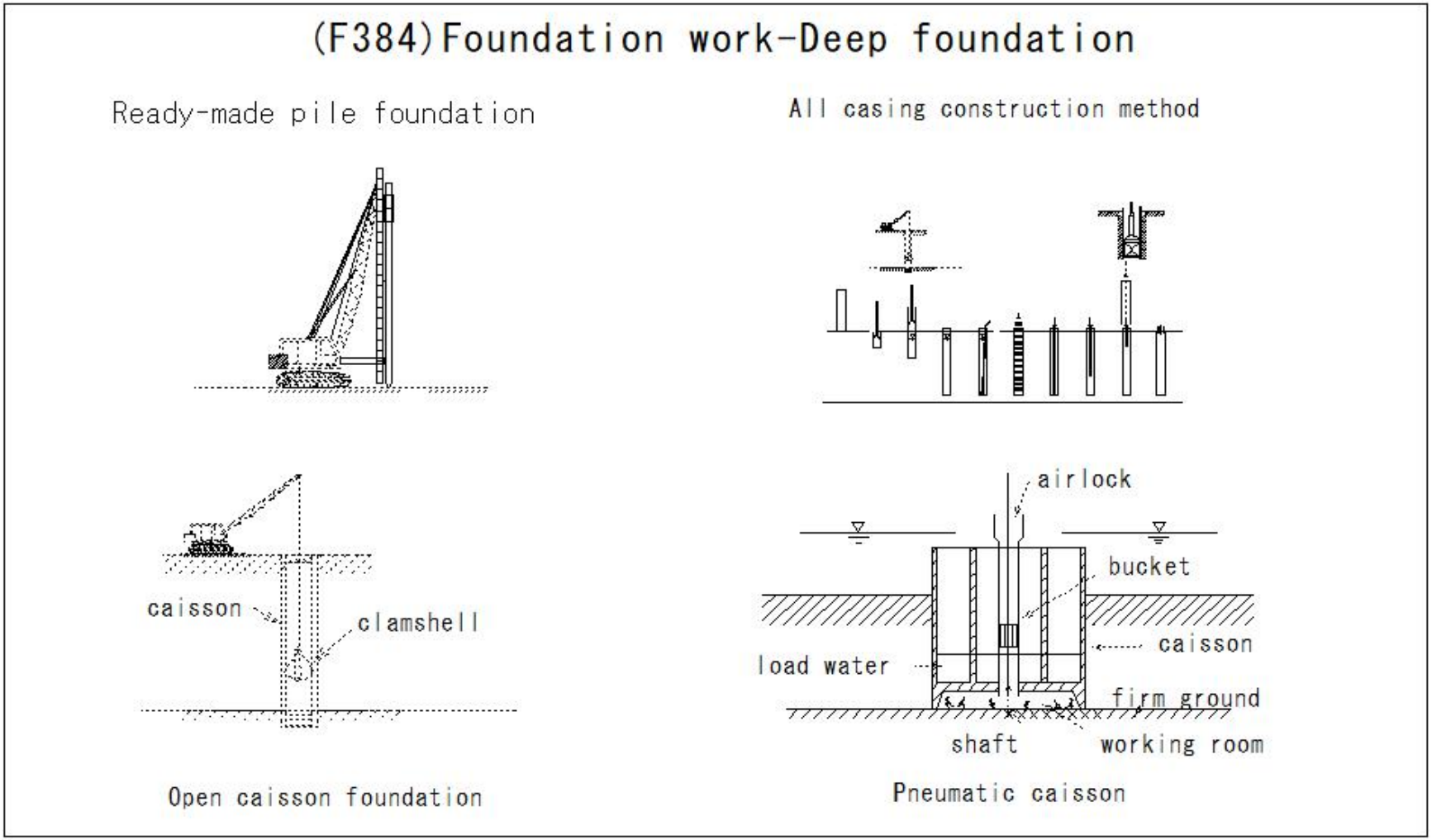
(F382)Foundation work-open caisson-pneumatic caisson



(F383)Foundation work-mat foundation-Spread foundation



(F384)Foundation work-Deep foundation

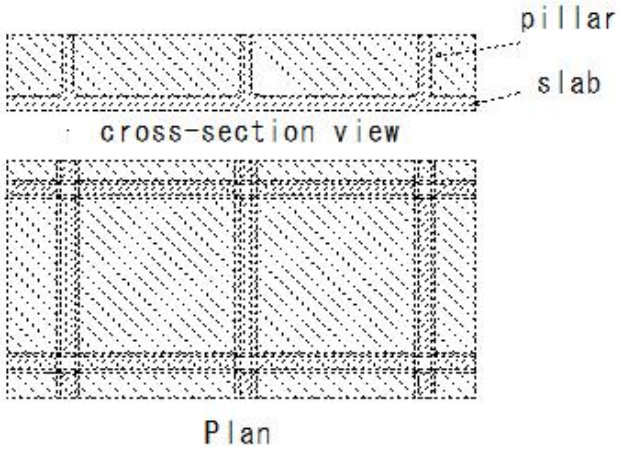


(F385)Foundation work-direct foundation

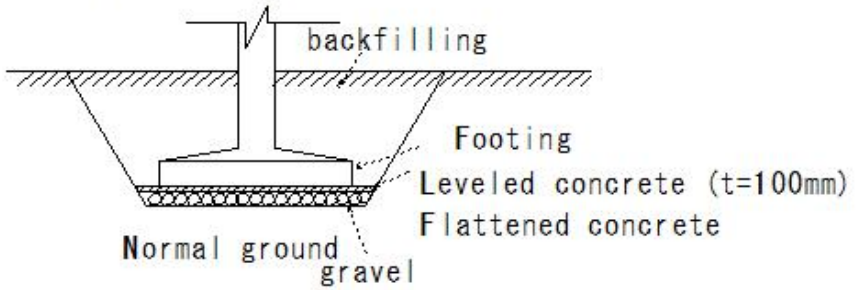
(F385)Foundation work-direct foundation

direct foundation

Direct basis
Soft ground
Uneven settlement



Structure excavation
・Normal ground
・Direct foundation



Foundation material (cobble stone/gravel t=200mm)

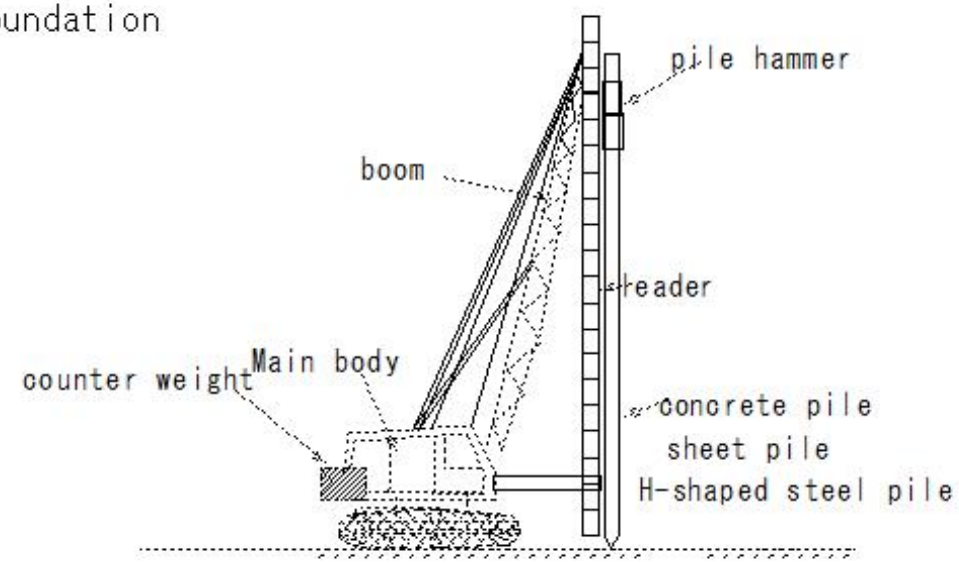
Sand layer N value N≧30
Clay layer N value N≧20
Ground - supportable

good points	bad points
minimum cost	Scope of application - limited
solid foundation	

(F386)Foundation work-pile foundation-ready-made piles

(F386)Foundation work-pile foundation-ready made piles

pile foundation

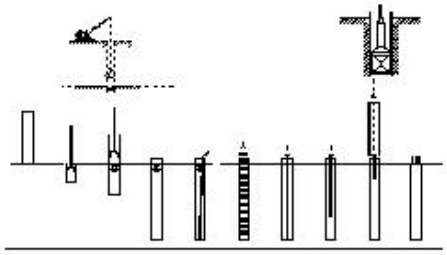


good points	bad points
Preparation - little	Geological confirmation - impossible
cost- cheap	Noise/vibration -loud
Construction period - short	Cobblestone - Difficult to construct

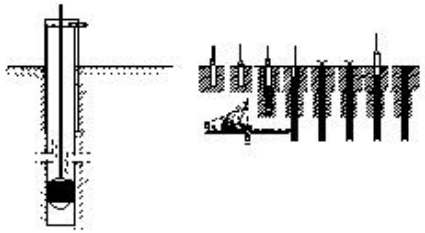
(F387)Foundation work-pile foundation-cast in place pile

(F387)Foundation work-pile foundation-cast in place pile

Cast-in-place pile foundation



All casing construction method

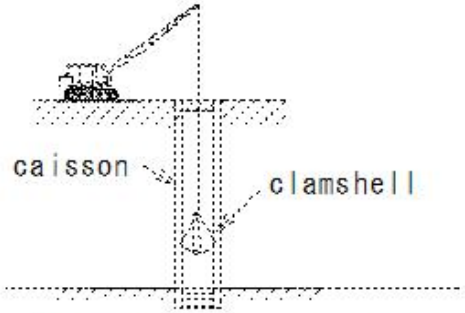


Earth drill method

good points	bad points
Noise/vibration - low	Preparation - big
Supporting capacity - sure	cost is high

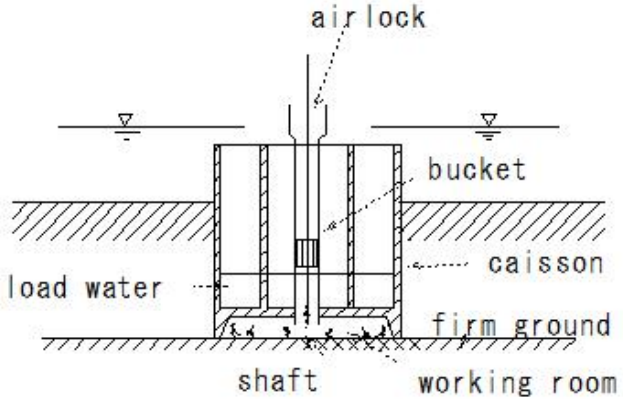
(F388)Foundation work-pile foundation-caisson foundation

(F388)Foundation work-pile foundation-caisson foundation



Open caisson foundation
Sedimentation in the support layer

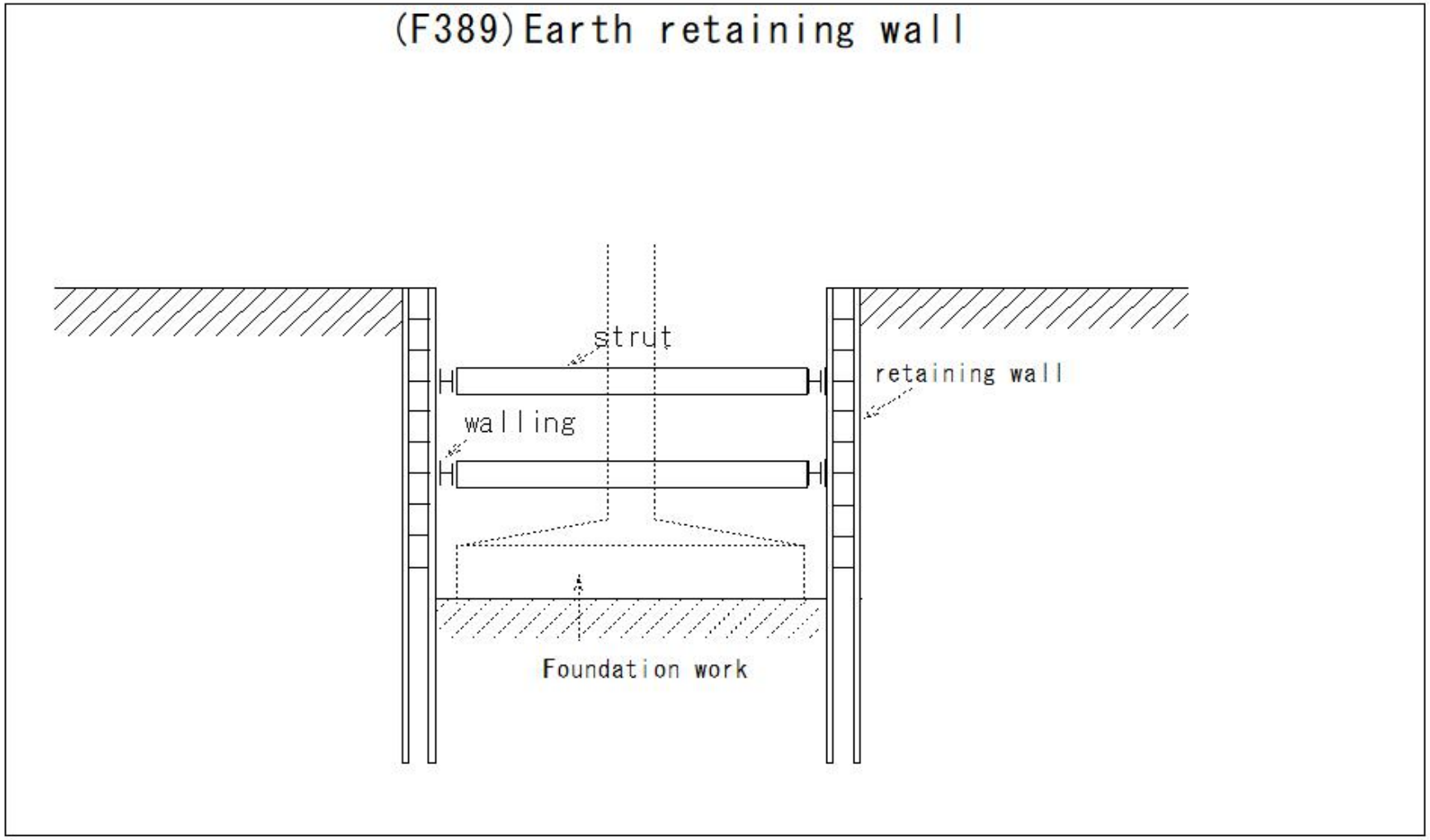
Open caisson



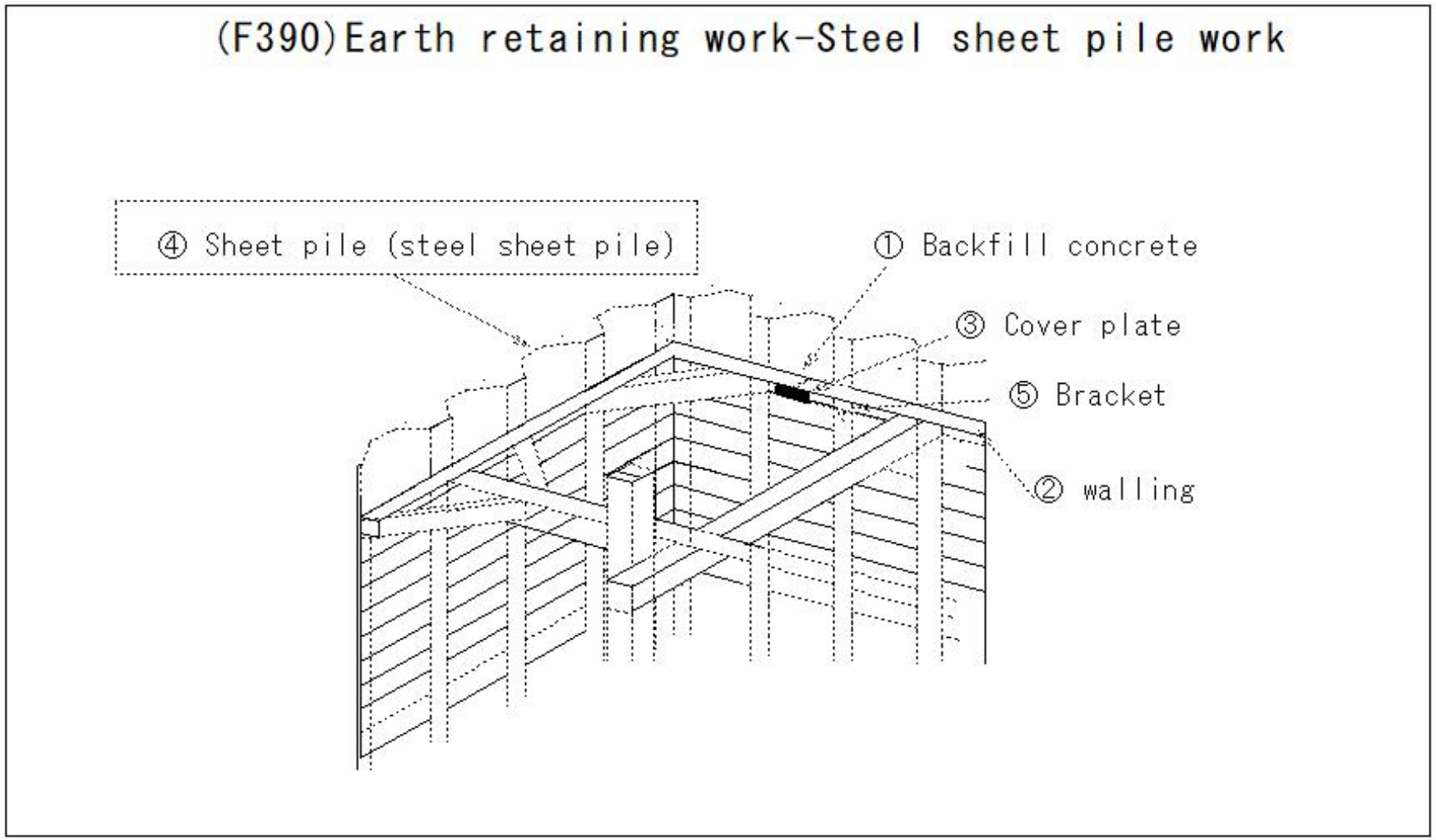
Pneumatic caisson

good points	bad points
Supporting capacity/horizontal resistance force - large Geology - confirmation - possible	Preparation - big cost is high

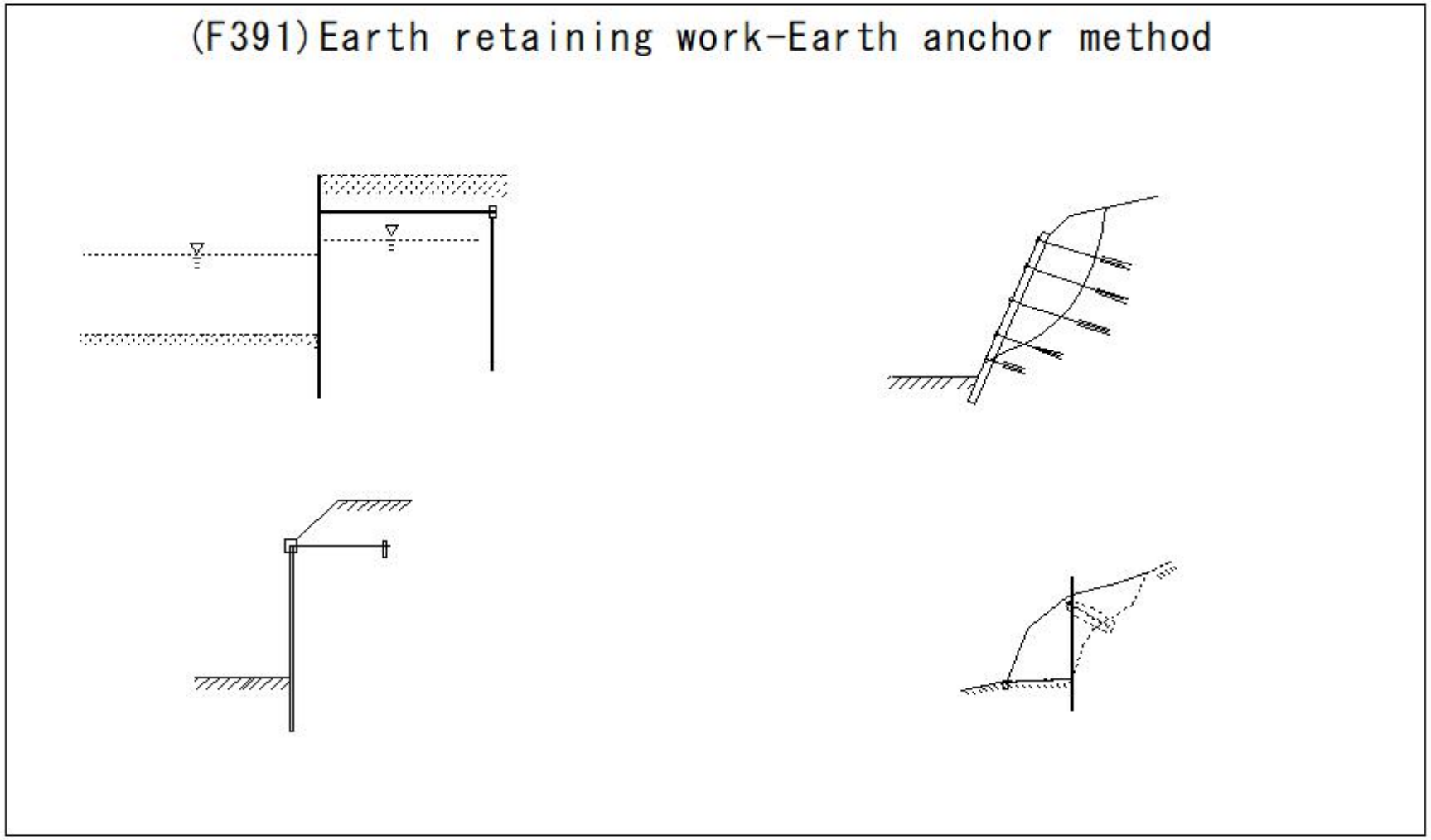
(F389)Earth retaining wall



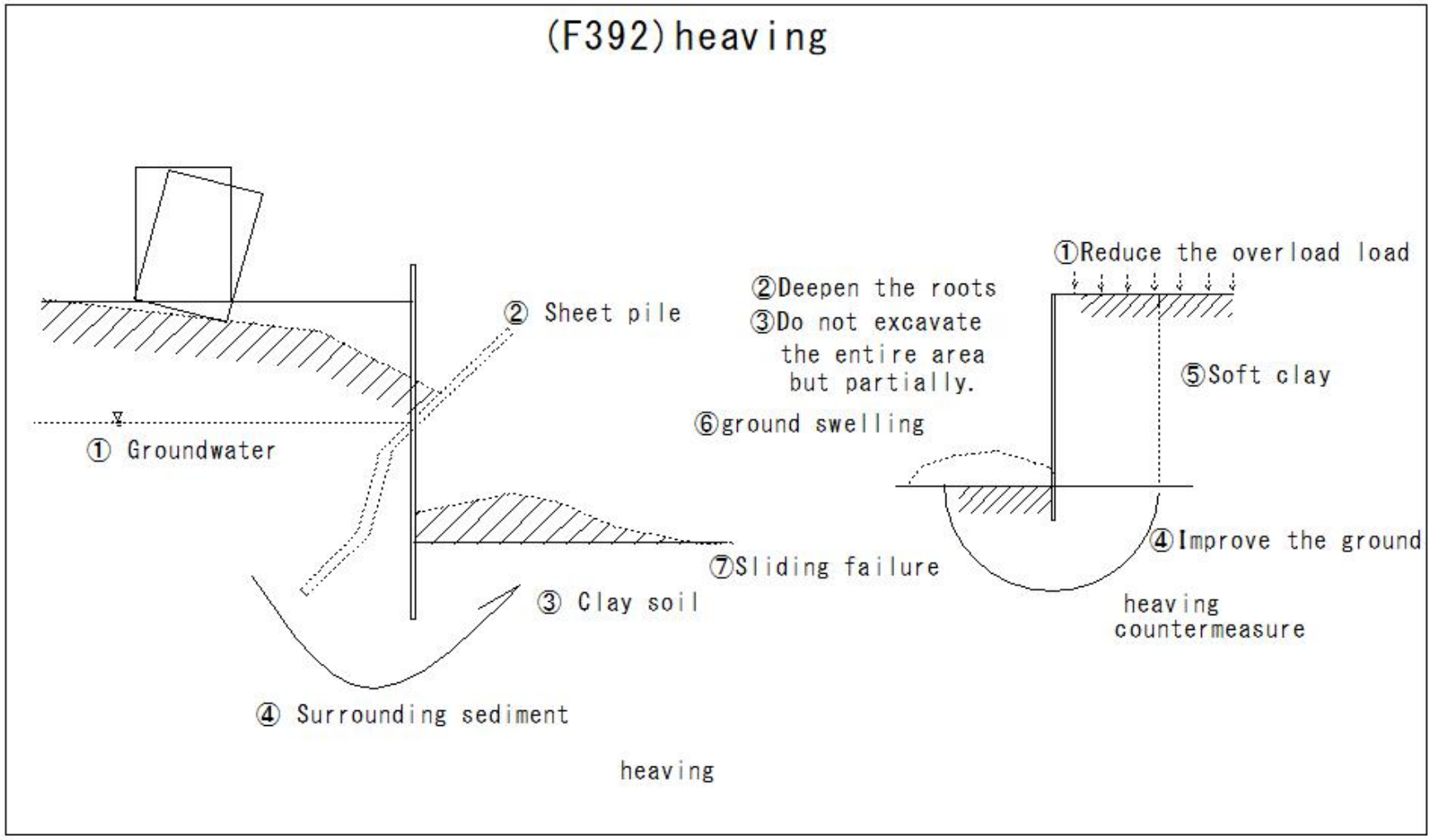
(F390)Earth retaining work-Steel sheet pile work



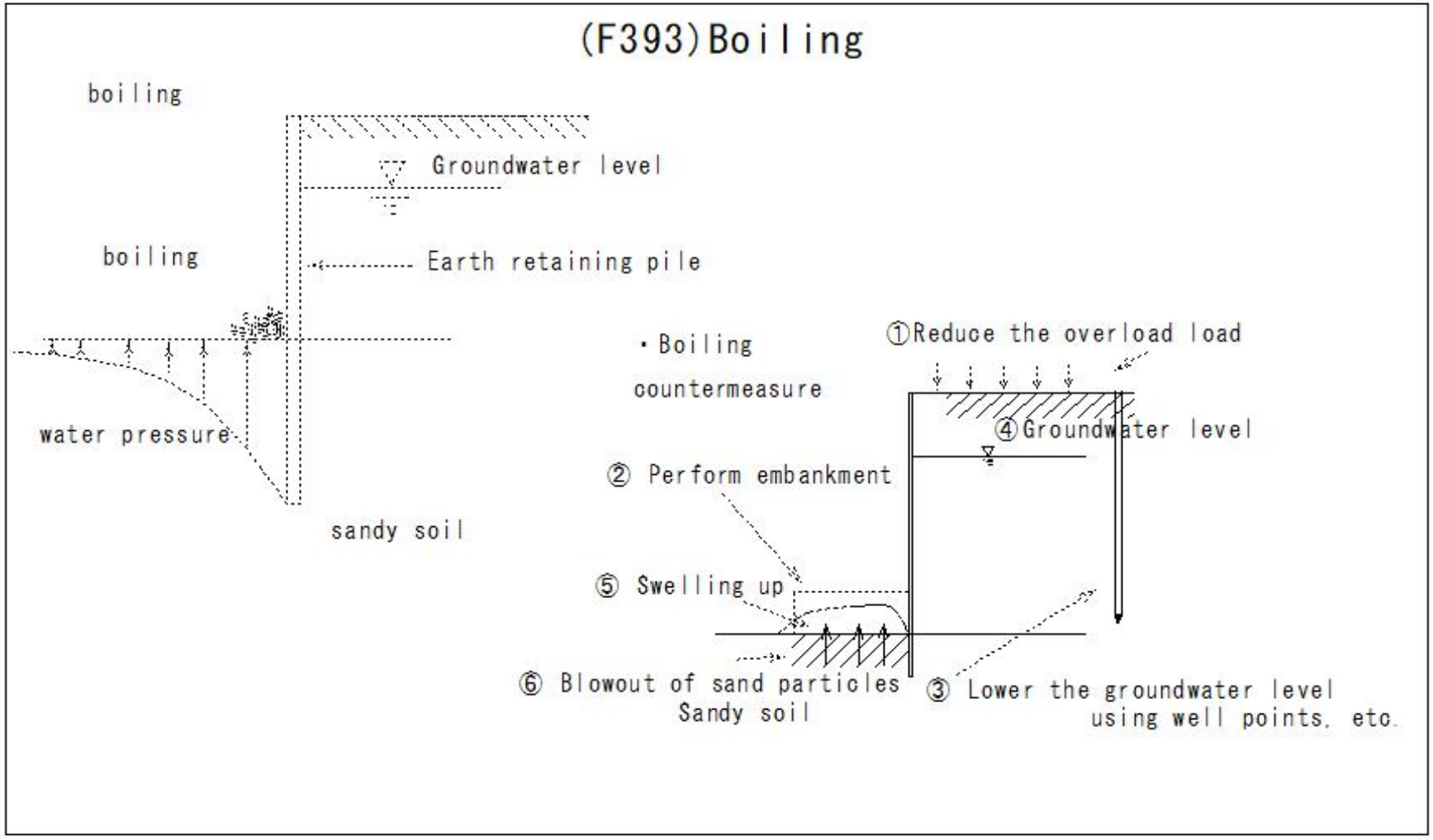
(F391)Earth retaining work-Earth anchor method



(F392)heaving



(F393)Boiling



(F394)Ground improvement work

(F394)Ground improvement work

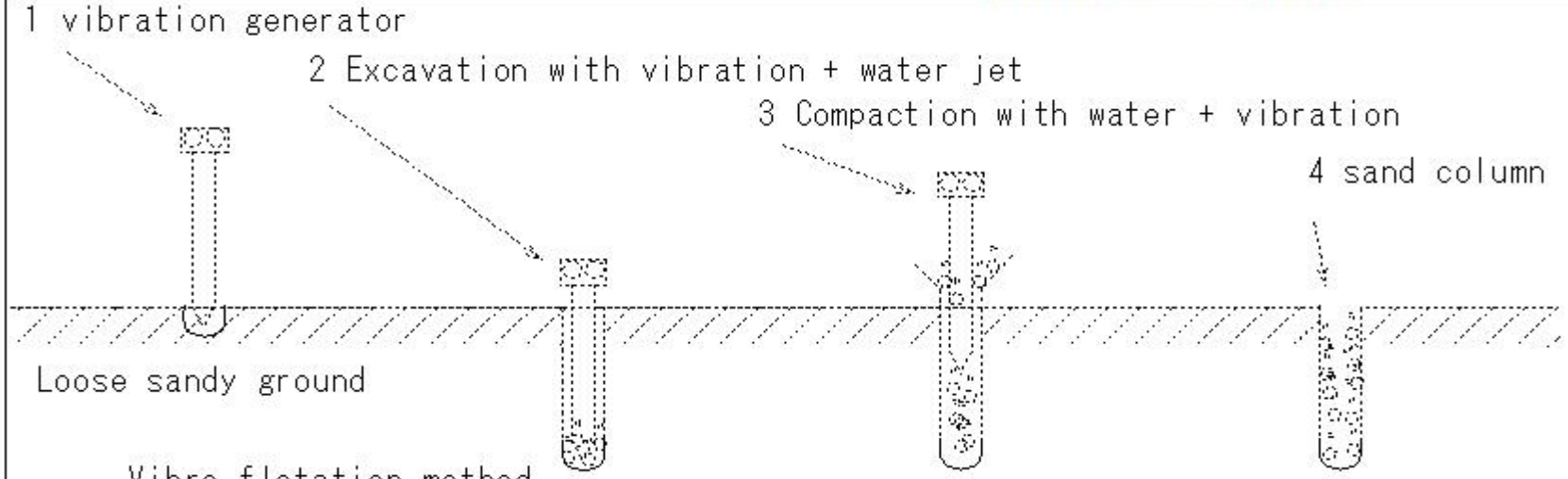
Ground improvement work
  Replacement method: Replacement with high-quality soil
  Surface treatment method: Improving soil strength
  increase soil density
    : Accelerate consolidation by loading
    : Groundwater drop due to pumping
    : Construction method using compaction
    :Method of consolidating soil
    : Consolidated with a bond

(F395)Ground improvement work-Vibroflotation method

(F395)Ground improvement work-Vibroflotation method

Sandy ground - ground improvement

construction method	improvement depth	Improved N value	Overview of construction method
Vibroflotation method	20m	10-15	vibration jet water
			Penetrating into sandy ground
			Sand supply - compaction



Vibro flotation method

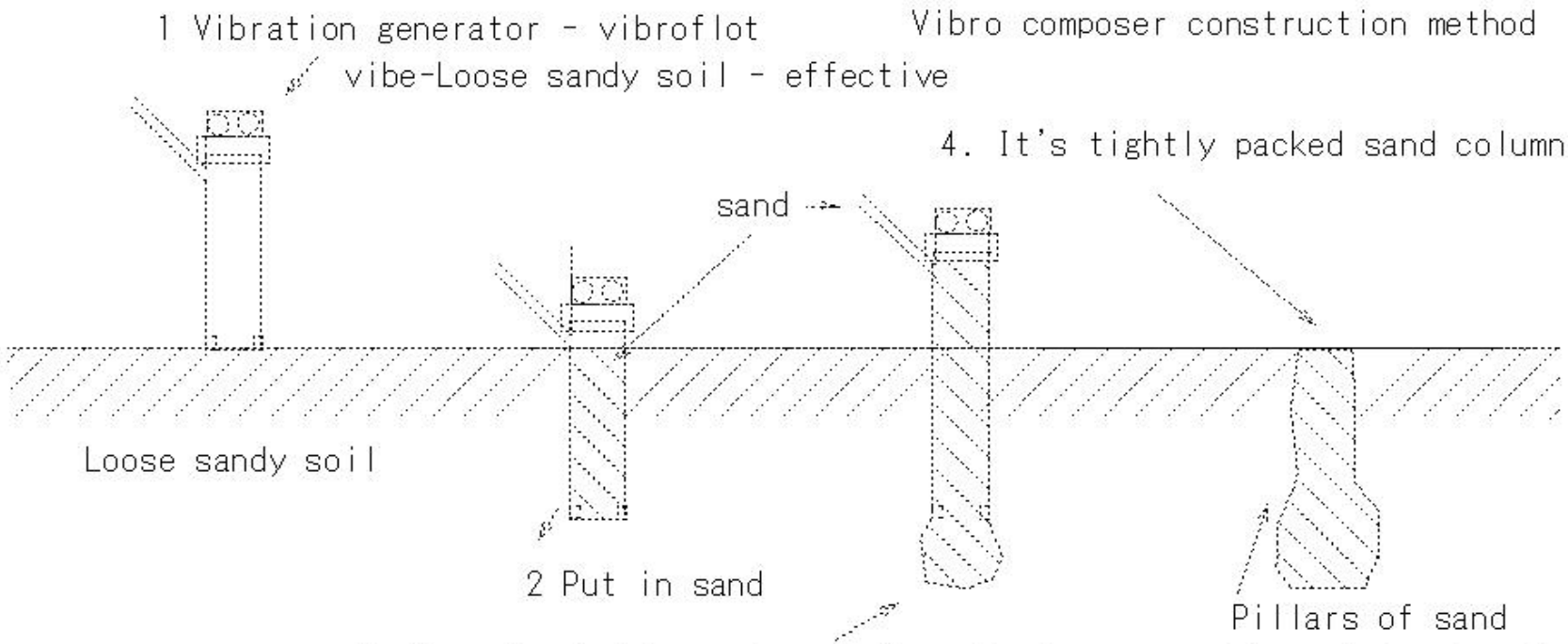
1 vibration generator - pile
2 Jet water and vibration - intrusion
3 Sand/gravel - input
4 Water tightening/vibration - compaction

(F396)Ground improvement work-Vibro Composer method

(F396)Ground improvement work-Vibro Composer method

Sandy ground - ground improvement

construction method	improvement depth	Improved N value	Overview of construction method
Vibro Composer method	30m	10-20	Vibration load - sand column



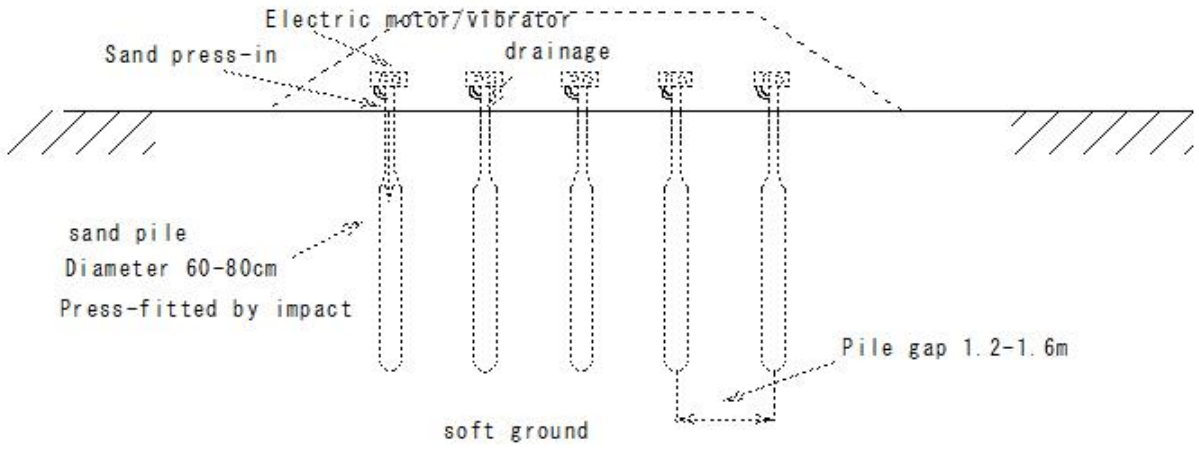
(F397)Ground improvement work-Sand compaction method

(F397)Ground improvement work-Sand compaction method

Sandy ground - ground improvement

construction method	improvement depth	Improved N value	Overview of construction method
Sand compaction method	15m	10-20	Shock/vibration - sandy ground
			- ground tightening

Sand compaction method



(F398)Ground improvement work-Preloading method

(F398) Ground improvement work-Preloading method

Improvement method for clay ground

construction method	Construction method overview	improvement depth
Preloading method	on soft ground large load	10-20m
	Accelerate consolidation settlement load removal	
	structure construction	

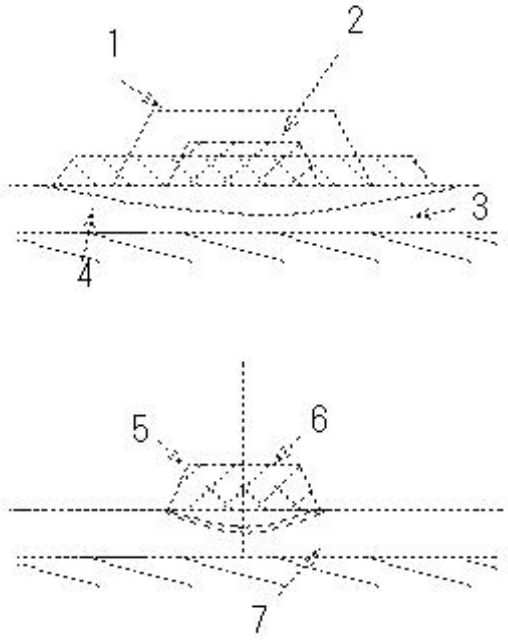
Preloading method

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



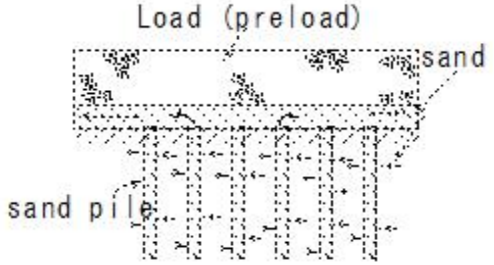
(F399)Ground improvement work-Sand drain method

(F399)Ground improvement work-Sand drain method

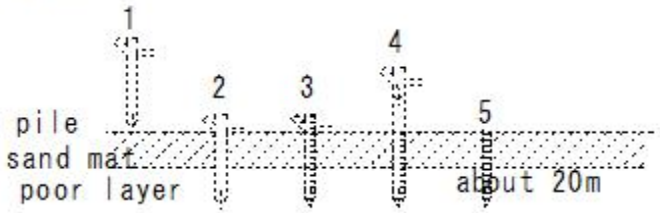
Improvement method for clay ground

construction method	Construction method overview	improvement depth
Sand drain method	drainage sand pillar Drive-in type	15-30m
	Vibro type Auger type Bagged type	

Sand drain method

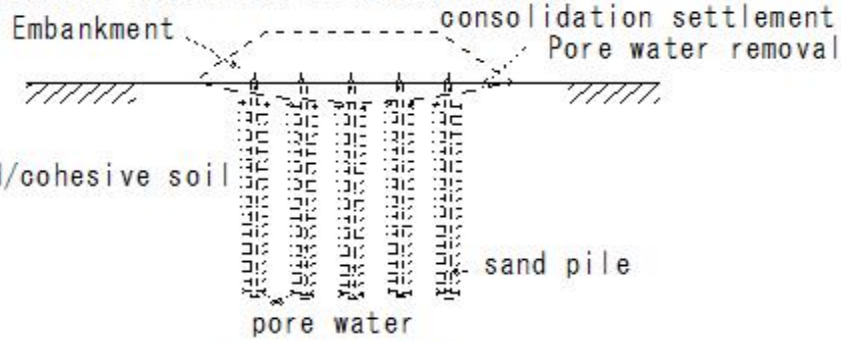


1 Mandrel
poor layer
Compressed air
2 Driving
3 Add sand
4 Compressed air
5 Pull out the sand pile
about 20m



Sand drain method

Eliminates pore water in cohesive soil
・Consolidation settlement in a short time



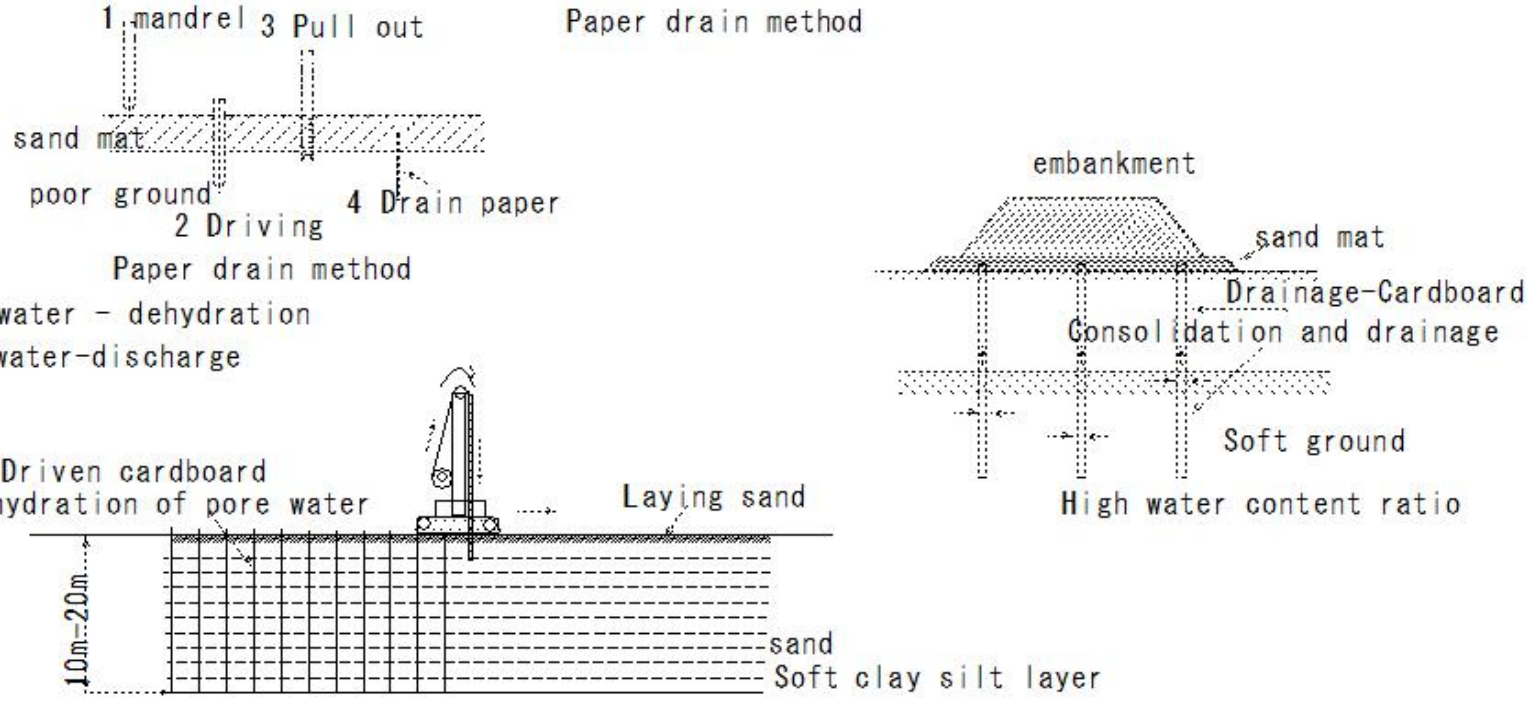
Sand drain method

(F400)Ground improvement work-Paper drain method

(F400)Ground improvement work-Paper drain method

Improvement method for clay ground

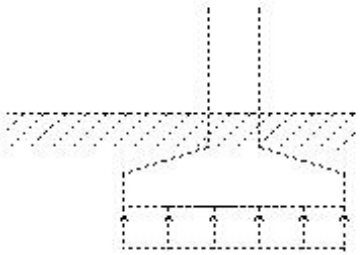
construction method	Construction method overview	improvement depth
Paper drain method	Drainage channel - cardboard card board	15-20m
	Construction speed - fast Construction cost - cheap	
	Construction management - easy	



(F401)spread foundation：direct foundation

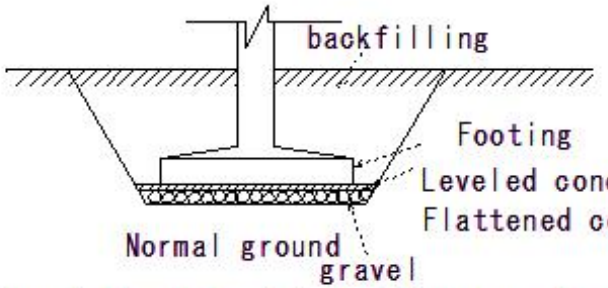
(F401)spread foundation：direct foundation

spread foundation：direct foundation



Spread foundation

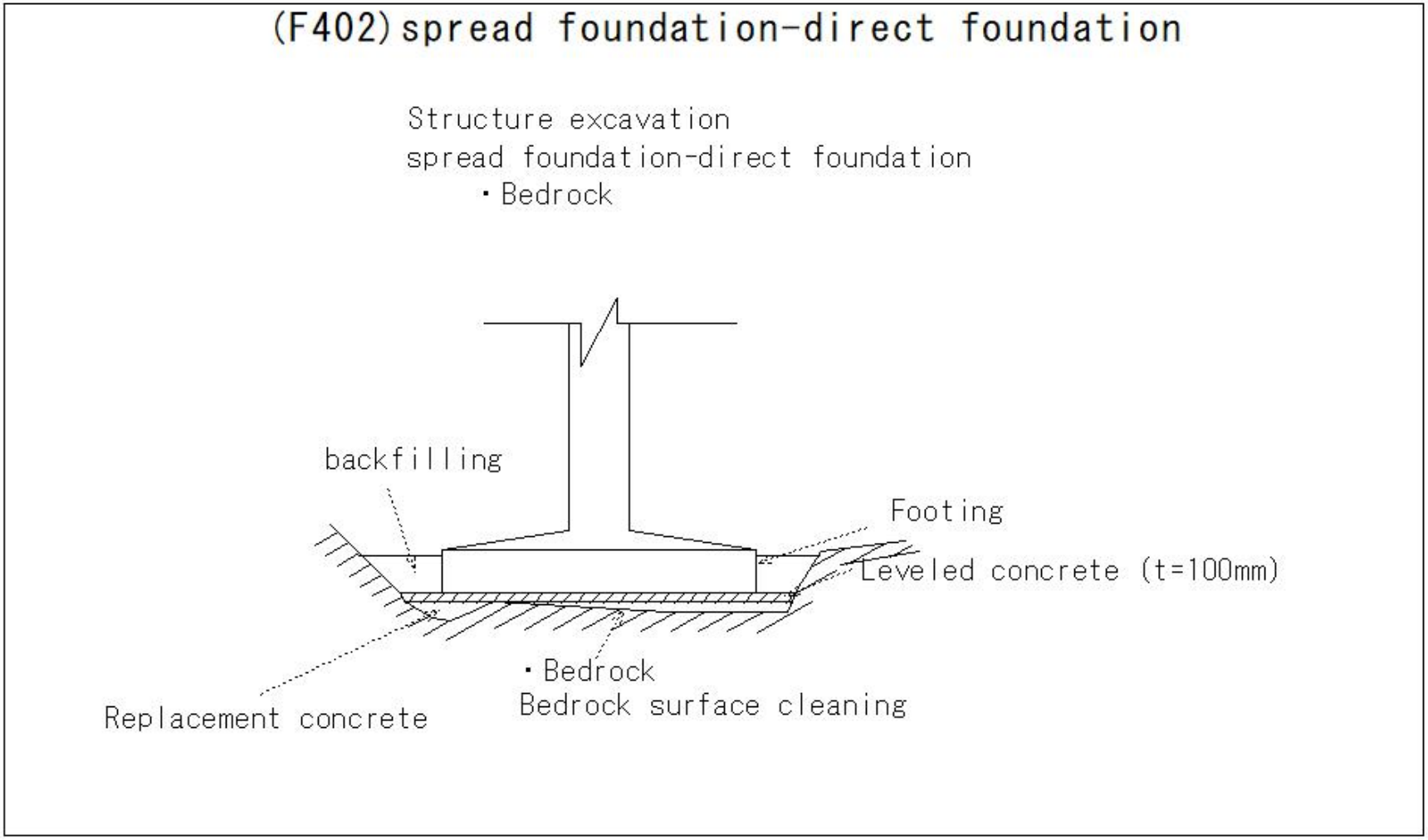
Structure excavation
・Normal ground
・spread foundation



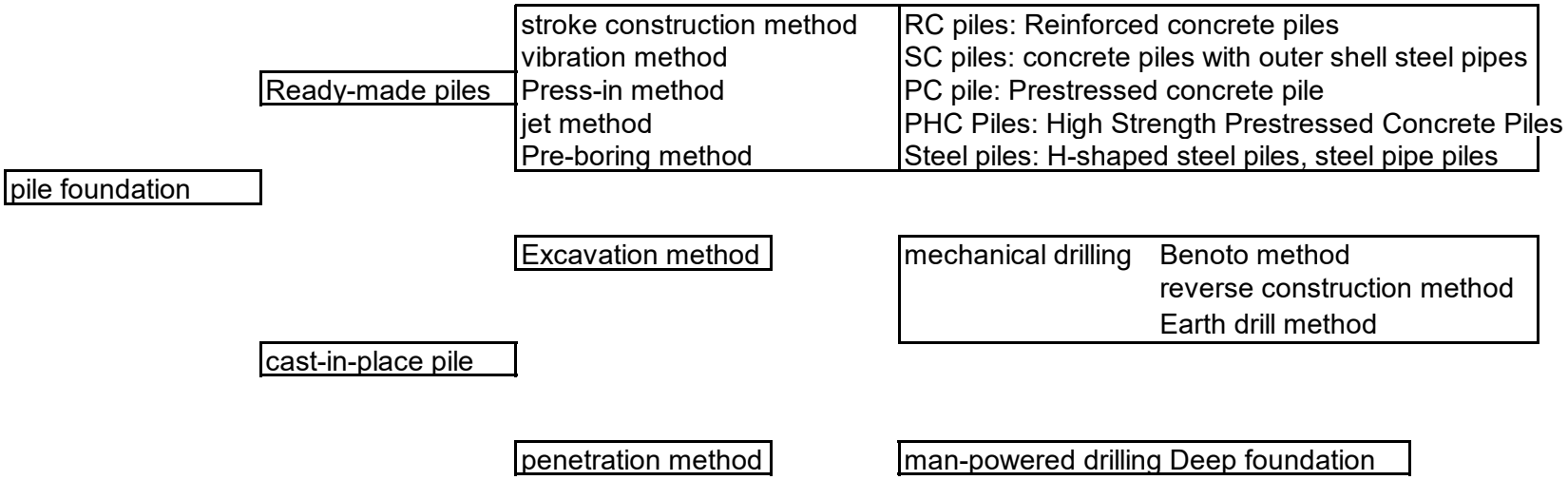
Foundation material (cobble stone/gravel t=200mm)

Sand layer N value N≧30
Clay layer N value N≧20
Ground - supportable

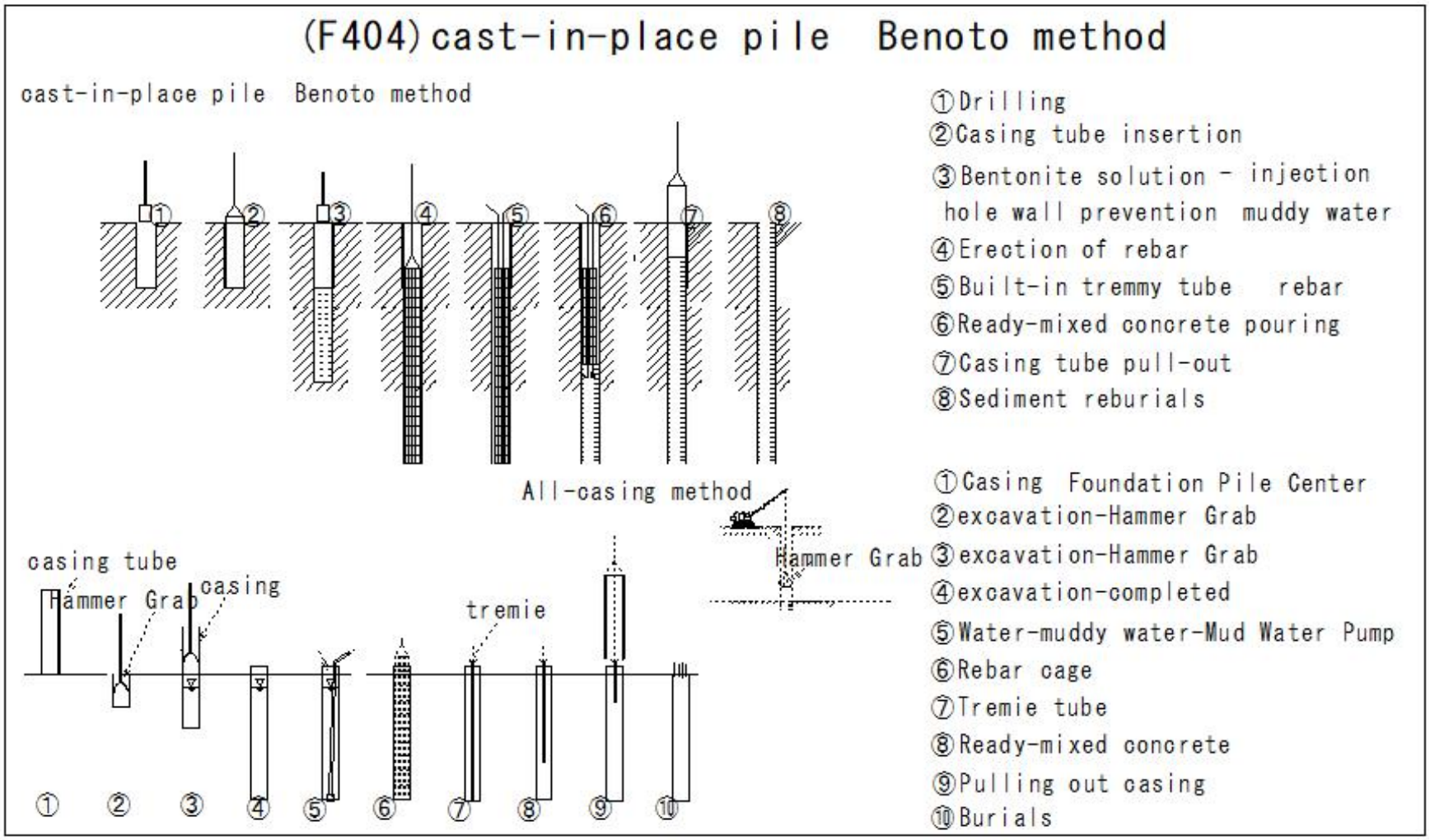
(F402)spread foundation-direct foundation



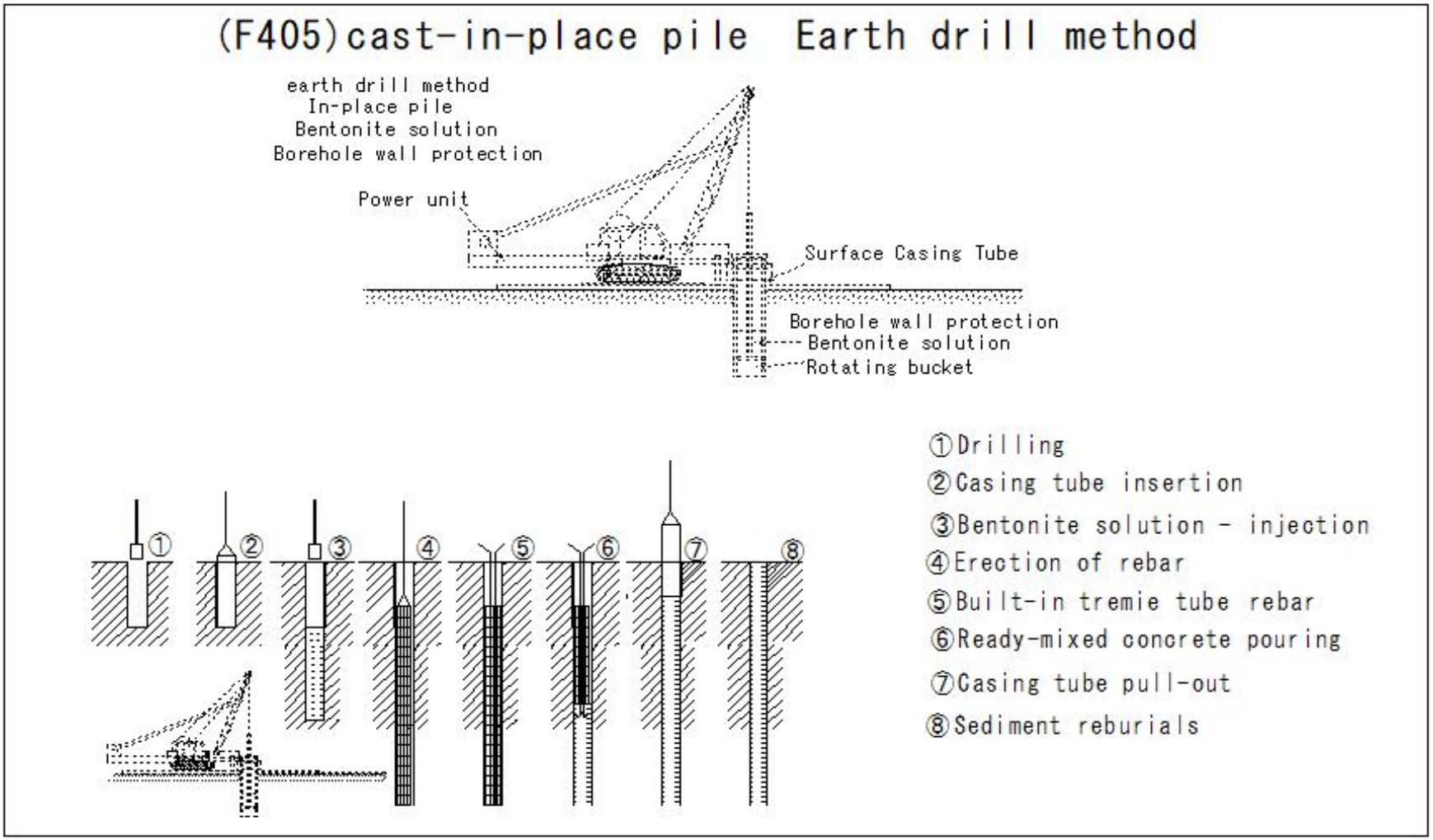
(F403)classification of pile foundation



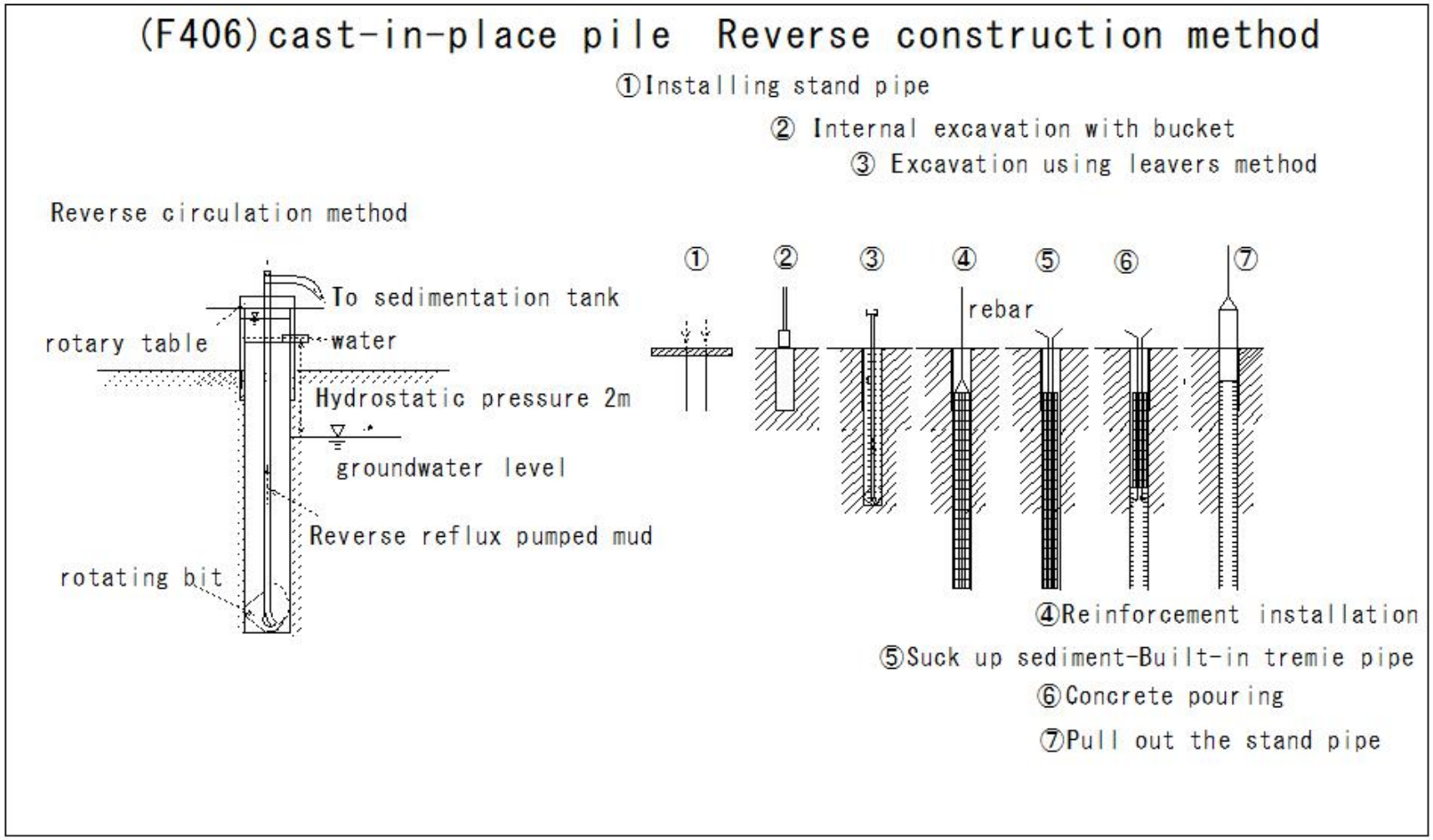
(F404)cast-in-place pile Benoto method



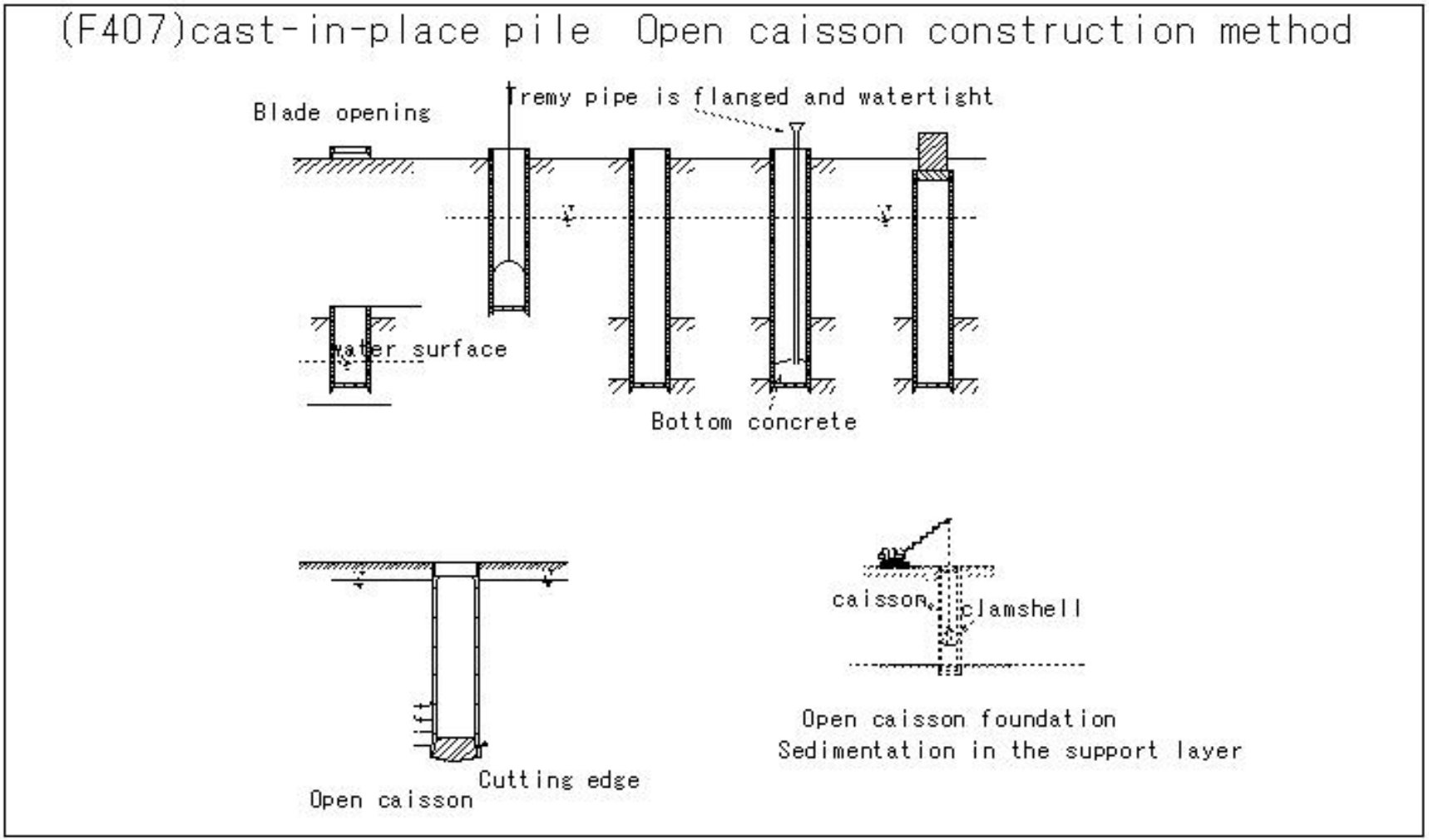
(F405)cast-in-place pile Earth drill method



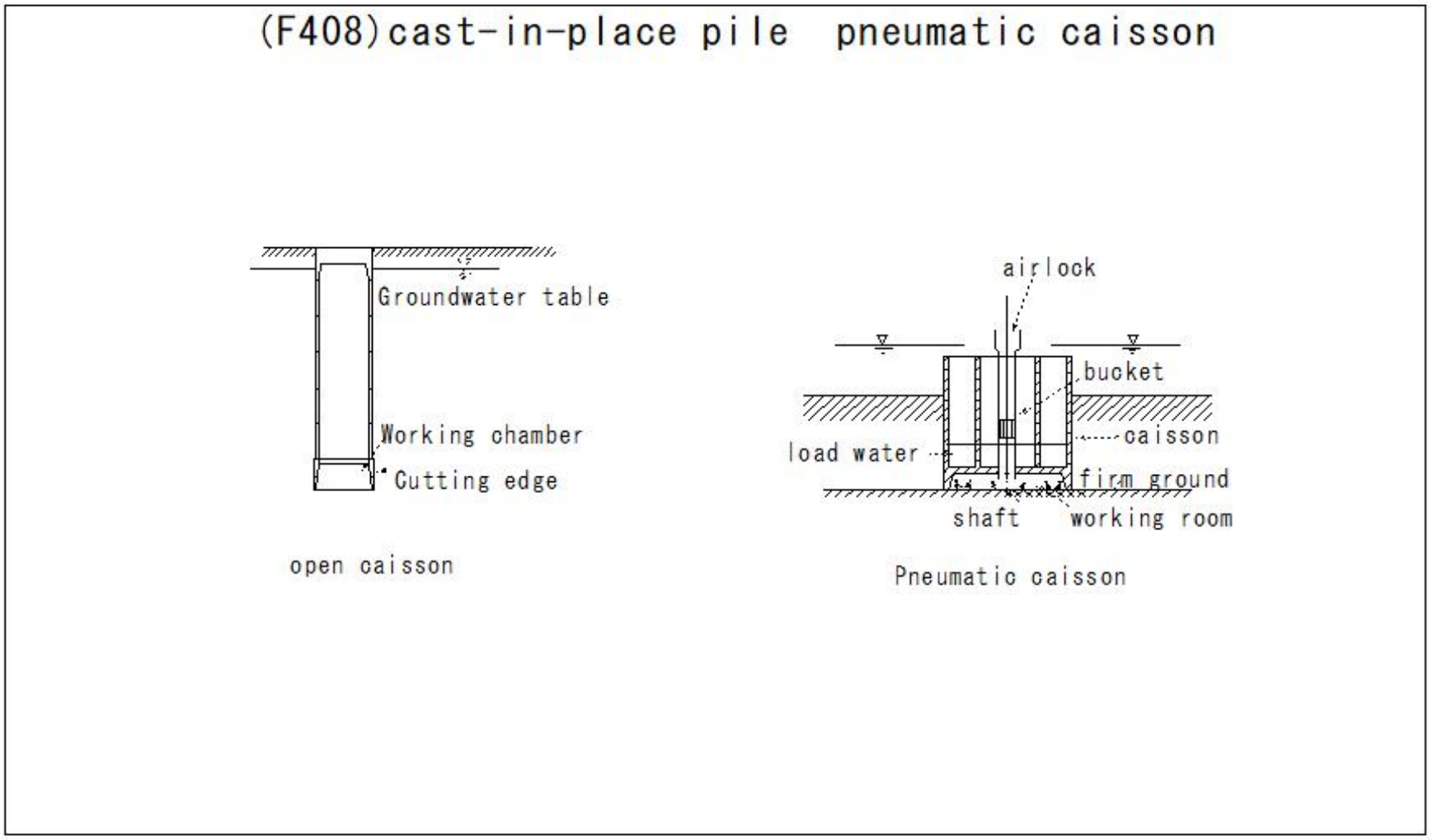
(F406)cast-in-place pile Reverse construction method



(F407)cast-in-place pile Open caisson construction method



(F408)cast-in-place pile pneumatic caisson



(F409)Foundation construction machinery(Pedestal method)