Annex E (normative)
Piles

E.1 Outline

This Annex specifies Group I and Group II of piles which are used mainly for the foundation piles among the PC products specified in this Standard.

E.2 Classification

The classification of piles shall be as specified in table E.1.

In addition, Group I shall be as specified in table E.2.

Table E.1 Classification of piles

Major division	Minor division
Piles	Prestressed concrete pile (PC pile, ST pile, knot pile)
	Prestressed reinforced concrete pile (PRC pile, PRC knot pile)
	Others

Table E.2 Classification of Group I of piles

Classification	Division by external diameter mm	Division by effective prestress N/mm^2	Detail
Prestressed concrete pile (PC pile, ST pile, knot pile)	300 to 1 200	4.0 to 10.0	See recommended specification E-1.

— The effective prestress shall be obtained by calculation. The calculated value shall be in the range of ± 5 % of each value.

— The PC pile has the same cross section over the entire length. The ST pile is a PC pile having the cross section which enlarges toward on one end. The knot pile is a PC pile of which the body is provided with knots.

NOTE : The piles of external diameter exceeding 1 200 mm may be adopted. In this case, performance values shall be according subject to the agreement between the parties concerned with delivery.

E.3 Performance

E.3.1 Performance of body of piles

The performance of body of piles shall conform to the provisions of table E.3.

In addition, the performance items of Group II shall be subjected to the agreement between the parties concerned with delivery.

Table E.3 Performance of body of piles

Performance item	Performance	Performance check method
Service stage performance	Shall be safe to the regular load assumed at the time of use, and crack width shall be less than the permissible value.	See design document or **E.6**.
End stage performance [a]	Shall not break due to the load assumed at the time of end stage.	See design document or **E.6**.
Durability [b]	Durability shall be secured against deterioration assumed.	See design document or actual results.
Workability	Workability for transportation, installation, assembly, etc. shall be secured.	See design document or actual results

Notes [a] Confirmation of the end stage performance shall be made when requested by the purchaser.

[b] Durability may be confirmed by the actual results of such similar products as are equivalent in terms of water-cement ratio and/or covering of reinforcing bar, etc.

E.3.2 Performance of joint part

The performance of joint part shall be as follows.

a) **Bending strength of joint part** The joint part shall not break when it is subjected to the break bending moment of the end stage performance for the body specified in **E.3.1**.

b) **Connectivity (squareness of joint end face)** The joint end face shall be at right angles with the pile axis line within the deviation of 1 mm per 300 mm.

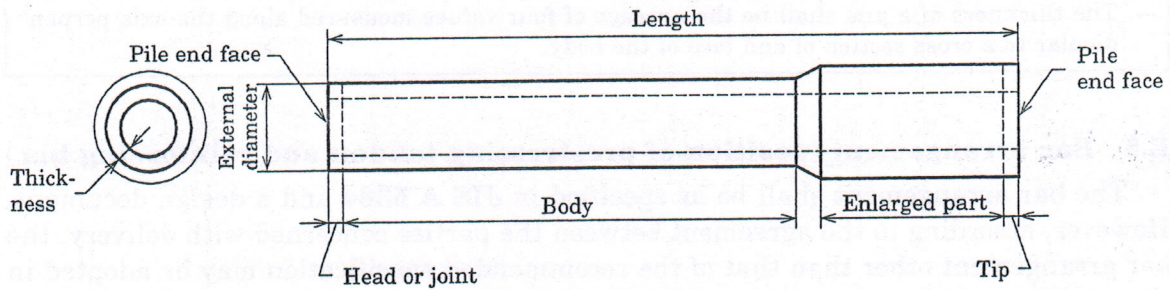### E.4 Shape, dimensions and dimensional tolerances

The shape, dimensions and dimensional tolerances of piles shall be as follows. As to Group I, if the design concept is not different, and if the performance (quality) and the performance (quality) check method are the same, the reference dimension may be changed within ±10 % in response to the purchaser's demand, provided that the necessary performance (quality) is satisfied.

a) **Shape** An example of shapes of piles is shown in figure E.1.

A PC pile and a PRC pile have a hollow cylinder body, having a suitable tip, a joint or a head, if needed. An ST pile has a diameter enlarged part at its end. The maximum length of the diameter enlarged part shall be twice the external diameter of the diameter enlarged part. Also, an ST pile may be provided with a suitable tip, a joint or a head, if needed. Moreover, a knot pile is a PC pile of which the body is provided with knots. The outside diameter of the knot part shall be in the range in which the performance of the body is not compromised. Also, the knot pile may be provided with a suitable tip, a joint or a head, if needed.
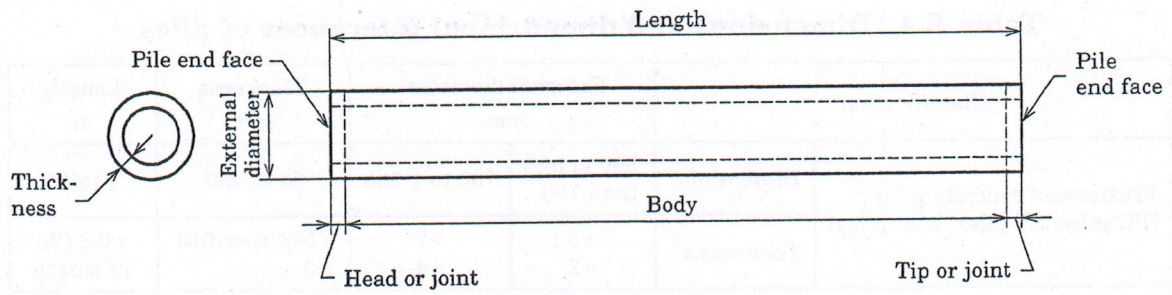
a) **PC pile, PRC pile**

b) **ST pile**
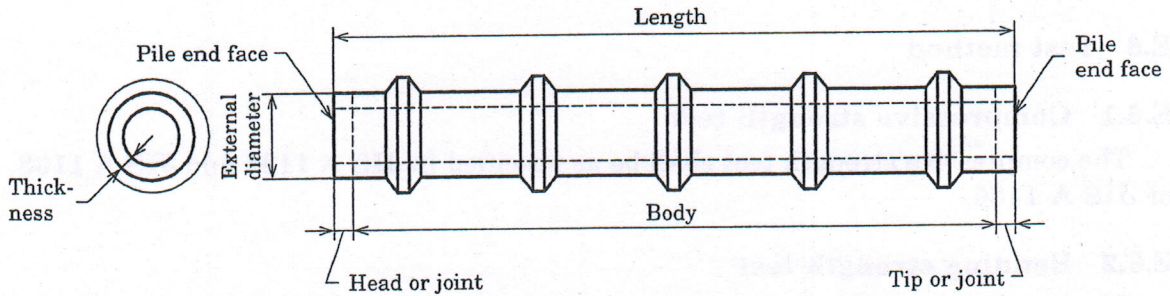
c) **Knot pile**

Figure E.1   Example of shapes of piles

b)   **Dimensions and dimensional tolerances**   The dimensions and dimensional tolerances of the products classified into Group I shall be as specified in table E.4. The dimensions and dimensional tolerances of the products classified into Group II shall be subjected to the agreement between the parties concerned with delivery.

Table E.4 Dimensions and dimensional tolerances of piles

Classification		External diameter mm		Thickness mm	Length m
Prestressed concrete piles (PC piles, ST piles, knot piles)	Dimensions	300 to less than 700	700 to 1 200	60 to 230	4 to 15
	Tolerances	+5 −2	+7 −4	+Not specified −0	±0.3 (%) of length

- The length of a pile shall be designated in increments of 1 m.
- The outside diameter of a pile shall be the average of two values measured along the axis perpendicular to a cross section of the body.
- The thickness of a pile shall be the average of four values measured along the axis perpendicular to a cross section of end face of the body.

E.5 Bar arrangement (position of prestressing tendon and reinforcing bar)

The bar arrangement shall be as specified in **JIS A 5364** and a design document. However, according to the agreement between the parties concerned with delivery, the bar arrangement other than that of the recommended specification may be adopted in the range in which the product performance (including the provisions of **E.3**) is not compromised. For the bar arrangement of the piles, the manufacturer shall define the bar arrangement so as to satisfy **E.3** for each product.

E.6 Test method

E.6.1 Compressive strength test

The compressive strength test shall be as specified in **JIS A 1132** and **JIS A 1108**, or **JIS A 1136**.

E.6.2 Bending strength test

The bending strength test shall be as specified in **JIS A 5363** and as follows.

The tester shall be of Class 1 or superior specified in **JIS B 7721**, or shall be at least equivalent in allowance thereto.

a) The bending strength of body shall be tested as shown in figure E.2. The length of 3/5 of pile length L shall be supported as a span B, the force F shall be applied at the centre of the span, and the loading force F shall be calculated from the bending moment according to the following formula.

If there is a possibility that a local break is likely to occur at the loading point or the fulcrum before the bending break occurs on a pile, countermeasures shall be taken.
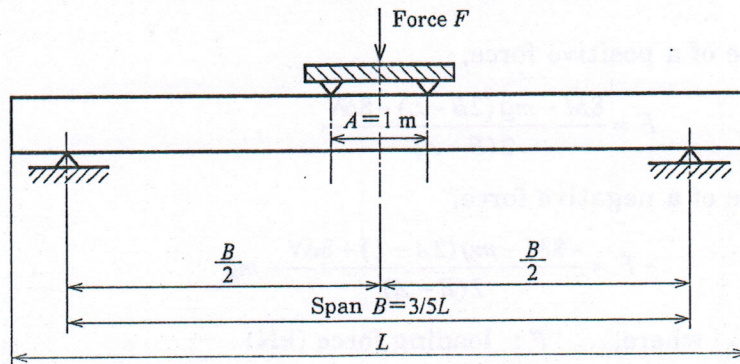
$$F = \frac{40M - mgL}{6L - 10A}$$

where, F : loading force (kN)

N : bending moment (kN·m)

m : mass of pile (t)

g : standard acceleration of gravity (9.81 m/s^2)

L : length of pile (m)

A : bending span (m) $A = 1.0$

Figure E.2   Loading method of bending strength test

When the effect of a shear force seems to become large at the time of the bending strength test, the length of span B may be made larger than 3/5 the length L of a pile. In this case, the loading force shall be calculated from the bending moment according to the following formula.

$$F = \frac{8M - mg(2B - L)}{2(B - A)}$$

where, F : loading force (kN)

M : bending moment (kN·m)

m : mass of pile (t)

g : standard acceleration of gravity (9.81 m/s^2)

B : span (m)

L : length of pile (m)

A : bending span (m) $A = 1.0$

b)   The pile shall be confirmed that it does not break when it is subjected to the force F equivalent to the break bending moment.

c)   For the bending strength test of joint, the seam of joint shall be made coincident at the centre of span, then, the procedure of **a)** and **b)** shall be conducted.

E.6.3 Axial-tension bending strength test (positive/negative alternating repetition axial-tension bending strength test)

The axial-tension bending strength test shall be as follows.

The tester shall be of Class 1 or superior specified in **JIS B 7721**, or shall be at least equivalent in allowance thereto.

a)   For the axial-tension bending strength test of the body, as shown in figure E.3, the span part of B of the pile with the axial-tension N shall be supported, and the

force F shall be applied at the centre of span. According to the following formula, the loading force F shall be calculated from the bending moment.

If there is a possibility that a local break is likely to occur at the loading point or the fulcrum before the bending break occurs on a pile, countermeasures shall be taken.

In the case of a positive force,

$$F = \frac{8M - mg(2B - L) - 8\delta N}{2(B - A)}$$

In the case of a negative force,

$$-F = \frac{-8M - mg(2A - L) + 8\delta N}{2(B - A)} - mg$$

where,

F : loading force (kN)

M : bending moment (kN·m)

m : mass of pile (see values in of recommended specification E-1 table 5) (t)

g : standard acceleration of gravity (9.81 m/s^2)

L : length of pile (m)

B : span (m) $B \geqq 7.0$

δ : relative deflection of centre part (m)

N : axial-tension (kN)

A : bending span (m) $A = 1.0$

b) The axial-tension N, loading force F, and positive/negative alternating number of cycles shall satisfy the following conditions.

1) The axial-tension N shall be secured constant till the completion of test.

2) The axial-tension N shall be either of three steps, N_1, N_2, and N_3, which are shown in recommended specification.

3) While the axial-tension N is applied, the repeated loading force F shall produce the moment of 1/1.2 each of the crack bending moment and the break bending moment. The number of cycles shall be 10 or more.

One cycle is defined as one positive/negative sequence.

c) It shall be confirmed that the pile does not break when it is subjected to the force F equivalent to the break bending moment after the completion of positive/negative alternating repetition.

In addition, the loading force F shall be calculated according to the formula specified in a).
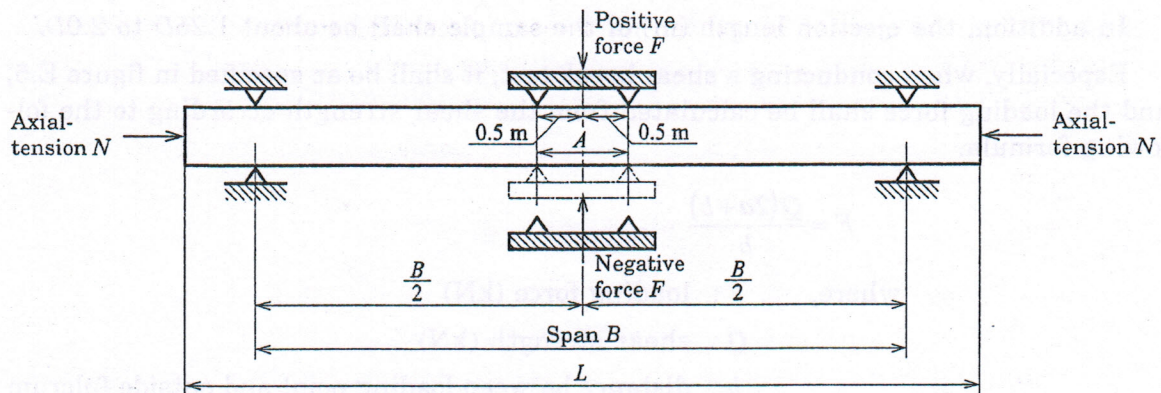
Figure E.3   Loading method of axial-tension bending strength test

E.6.4   Shear strength test

The shear strength test of body shall be as specified in **JIS A 5363** and the following.

The tester shall be of Class 1 or superior specified in **JIS B 7721**, or shall be at least equivalent in allowance thereto.

The shear strength test of body shall be conducted using the method shown in figure E.4 or figure E.5. When using the method shown in figure E.4, the loading force shall be calculated from the shear strength according to the following formula.

If there is a possibility that a local break is likely to occur at the loading point or the fulcrum before the shear break occurs on a PC pile, countermeasures shall be taken.

$$F = 2Q$$

where, F : loading force (kN)
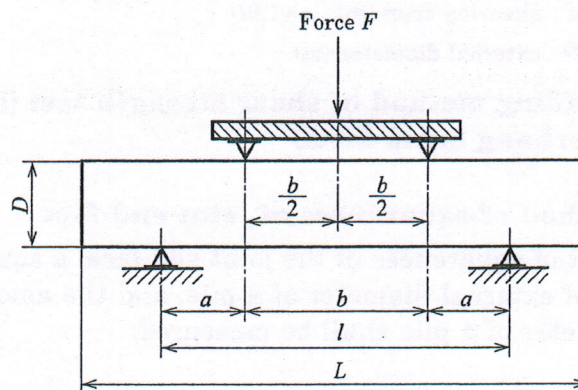
Q : shear strength (kN)

b : bending span (loading span) (m) $b = 1.0$

a : shearing span (m) $a = 1.0D$
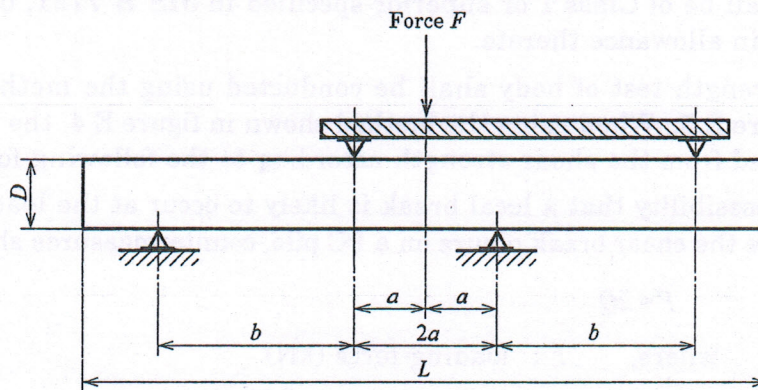
D : external diameter (m)

Figure E.4   Loading method of shear strength test (loading by simple beam form)

In addition, the ejection length (m) of the sample shall be about 1.25D to 2.0D.

Especially, when conducting a shear break test, it shall be as specified in figure E.5, and the loading force shall be calculated from the shear strength according to the following formula.

$$F = \frac{Q(2a+b)}{b}$$

where, F : loading force (kN)

Q : shear strength (kN)

b : distance between loading point and outside fulcrum (m)

a : shearing span (m) $a = D - t/2$

t : thickness (m)

D : external diameter (m)

Force F

b : bending span (loading span) (m) $b = 1.0$

a : shearing span (m) $a = 1.0D$

D : external diameter (m)

Figure E.5 Loading method of shear strength test (loading by overhang beam form)

E.6.5 Measuring method of squareness of joint end face

For the measurement of squareness of the joint end face, a square shall be set as it in line with the axis of external diameter of a pile, and the amount of inclinations about the external diameter of a pile shall be measured.

E.7 Quality of concrete

E.7.1 Material and production method

The material for concrete and the production method shall be as specified in **JIS A 5364**.

E.7.2 Compressive strength

The compressive strength of concrete shall be verified by the compressive strength of the sample which has been processed by the same curing as the product or the compressive strength which has been controlled properly. When the predetermined material aging is finished, the strength shall be 80 N/mm^2 or more for the effective prestress of 4.0 N/mm^2, and the strength shall be 85 N/mm^2 or more for the effective prestress of over 4.0 N/mm^2. Moreover, the compressive strength at the time of prestress introduction shall be 40 N/mm^2 or more.

In addition, products of Group II shall be subjected to the agreement between the parties concerned with delivery and the compressive strength of concrete may be as specified in Annex A of **JIS A 5364**.

E.8 Inspections

Inspections shall be as specified in **JIS A 5365** and the following.

a) **Final inspection** The final inspection of piles shall be conducted for the appearance, performance, shape and dimensions, and shall be as follows.

  1) **Appearance** For the appearance, it shall be a 100 % inspection or a sampling inspection in consideration of the characteristics of product, manufacturing method, production quantity, etc.

  2) **Performance, shape and dimensions** For the performance, shape and dimensions, the inspection shall be a sampling inspection.

  When the performance is inspected by a sample as alternative characteristics, the correlation between the sample and the product shall be established.

  3) **Size of inspection lot** The size of inspection lot shall be determined by the manufacturer in consideration of the characteristics of product, manufacturing method, production quantity, production period, ordered quantity, etc.

  Any product in the inspection lot shall have the same characteristics, and shall be manufactured using the same materials, concrete mix proportion and manufacturing process, etc.

b) **Delivery inspection** The delivery inspection of piles shall be conducted for the appearance, shape and dimensions. The size of inspection lot and the sampling method shall be subjected to the agreement between the parties concerned with delivery, and shall be specified by the purchaser. The delivery inspection may be omitted subjected to the agreement between the parties concerned with delivery.

E.9 Marking

The marking items on piles shall be the following as specified in **JIS A 5361**. Moreover, the PC pile, ST pile and knot pile among the piles manufactured by centrifugal force compaction shall be marked as PHC.

a) Classification or its abbreviation

b) Manufacturer's name or its abbreviation

c) Date of manufacture or its abbreviation

E.10 Others (recommended specification)

Group I of covered conduits is shown in table E.5.

Table E.5 Recommended specification

Structure-specific product group standard		Recommended specification
JIS A 5373	Annex E Piles	Recommended specification E-1 Prestressed concrete piles

Recommended specification E-1
Prestressed concrete piles

E-1.1 Outline

This recommended specification describes the prestressed concrete piles in Group I of piles (hereafter referred to as "PC piles") in Annex E. The pile with diameter enlarged part at its end (ST pile) and that provided with knots on the body (knot pile) are included.

E-1.2 Classification

PC piles shall be classified, by the external diameter, into 300 mm, 350 mm, 400 mm, 450 mm, 500 mm, 600 mm, 700 mm, 800 mm, 900 mm, 1 000 mm, 1 100 mm and 1 200 mm. Moreover, they shall be classified, by the magnitude of effective prestress, into Class A, Class B, and Class C (hereafter referred to as "A, B and C", respectively).

In addition, the effective prestress of A, B and C of PC piles shall be 4.0 N/mm^2, 8.0 N/mm^2 and 10.0 N/mm^2, respectively.

E-1.3 Performance

E-1.3.1 Bending strength

The bending strength of the pile body and the pile joint shall be as follows.

a) **Pile body** The PC pile body shall be subjected to the bending strength test as specified in **E-1.6.2**. When it receives the crack bending moment specified in recommended specification E-1 tables 1 and 2, it shall not produce any crack. Also, the PC pile body shall not break with the value of break bending moment specified in recommended specification E-1 tables 1 and 2.

b) **Pile joint** The PC pile joint shall be subjected to the bending strength test specified in **E-1.6.2** and shall not break with the value of break bending moment specified in recommended specification E-1 table 1.

E-1.3.2 Shear strength

The PC pile body shall be subjected to the bending strength test as specified in **E-1.6.4**. When it receives the shear crack strength specified in recommended specification E-1 table 3, it shall not produce any crack. Moreover, it shall not break with the value of shear break strength specified in recommended specification E-1 table 3.
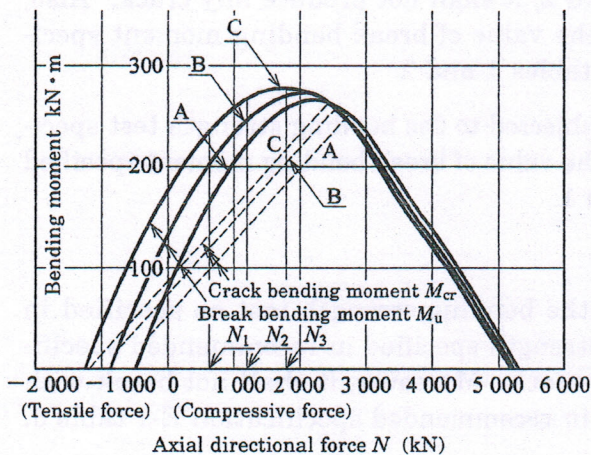
E-1.3.3 Connectability (squareness of joint end face)

The joint end face shall be at right angles with the pile axis line within the deviation of 1 mm per 300 mm.
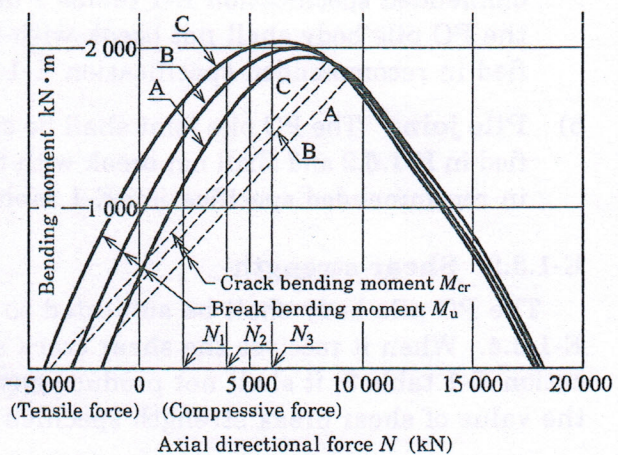
Recommended specification E-1 Table 1 Dimensions and bending strength (at application of axial-tension $N = 0$ kN)

External diameter mm	Division	Thickness mm	Length m	Crack bending moment kN·m	Break bending moment kN·m	External diameter mm	Division	Thickness mm	Length m	Crack bending moment kN·m	Break bending moment kN·m
300	A	60	4 to 13	24.5	37.3	700	A	100	4 to 15	264.9	397.3
	B	60	4 to 15	34.3	61.8		B	100		372.8	671.0
	C		4 to 15	39.2	78.5		C			441.4	882.9
350	A	60	4 to 13	34.3	52.0	800	A	110	4 to 15	392.4	588.6
	B	60	4 to 15	49.0	88.3		B	110		539.6	971.2
	C		4 to 15	58.9	117.7		C			637.6	1 275
400	A	65	4 to 15	54.0	81.4	900	A	120	4 to 15	539.6	809.3
	B	65	4 to 15	73.6	132.4		B	120		735.8	1 324
	C		4 to 15	88.3	176.6		C			833.8	1 668
450	A	70	4 to 15	73.6	110.8	1 000	A	130	4 to 15	735.8	1 104
	B	70	4 to 15	107.9	194.2		B	130		1 030	1 854
	C		4 to 15	122.6	245.2		C			1 177	2 354
500	A	80	4 to 15	103.0	155.0	1 100	A	140	4 to 15	932.0	1 398
	B	80	4 to 15	147.2	264.9		B	140		1 324	2 384
	C		4 to 15	166.8	333.5		C			1 521	3 041
600	A	90	4 to 15	166.8	250.2	1 200	A	150	4 to 15	1 177	1 766
	B	90	4 to 15	245.2	441.4		B	150		1 668	3 002
	C		4 to 15	284.5	569.0		C			1 962	3 924

Informative example

External diameter 400 mm axial force, bending moment relationship diagram

External diameter 800 mm axial force, bending moment relationship diagram

Recommended specification E-1 Table 2   Axial-tension bending strength

External diameter	Divi-sion	Bending strength at application of axial-tension N_1			Bending strength at application of axial-tension N_2			Bending strength at application of axial-tension N_3		
		Axial-tension N_1	Crack bending moment M_{cr}	Break bending moment M_u	Axial-tension N_2	Crack bending moment M_{cr}	Break bending moment M_u	Axial-tension N_3	Crack bending moment M_{cr}	Break bending moment M_u
mm		kN	kN·m	kN·m	kN	kN·m	kN·m	kN	kN·m	kN·m
300	A	392.4	44.1	77.5	784.8	64.7	105.9	1 177	84.4	122.6
	B		54.0	95.2		74.6	117.7		94.2	127.5
	C		58.9	106.9		79.5	123.6		99.1	130.5
350	A	490.5	64.7	111.8	981.0	96.1	156.0	1 472	126.5	181.5
	B		79.5	140.3		109.9	173.6		141.3	188.4
	C		89.3	159.9		119.7	184.4		151.1	192.3
400	A	588.6	97.1	163.8	1 177	139.3	223.7	1 766	182.5	259.0
	B		116.7	201.1		158.9	249.2		202.1	269.8
	C		130.5	234.5		173.6	266.8		215.8	277.6
450	A	735.8	134.4	228.6	1 472	195.2	312.9	2 207	256.0	361.0
	B		168.7	291.4		229.6	353.2		290.4	379.6
	C		183.4	329.6		244.3	375.7		305.1	389.5
500	A	882.9	183.4	304.1	1 766	263.9	421.8	2 649	345.3	496.4
	B		227.6	392.4		309.0	483.6		389.5	527.8
	C		247.2	447.3		328.6	518.0		409.1	543.5
600	A	1 275	309.0	522.9	2 551	452.2	723.0	3 826	594.5	839.7
	B		388.5	671.0		530.7	823.1		673.9	886.8
	C		427.7	765.2		570.9	877.0		713.2	909.4
700	A	1 766	498.3	832.9	3 532	731.8	1 151	5 297	965.3	1 312
	B		606.3	1 034		840.7	1 282		1 074	1 366
	C		673.9	1 185		906.4	1 355		1 139	1 387
800	A	1 962	692.6	1 143	3 924	991.8	1 579	5 886	1 292	1 855
	B		839.7	1 446		1 140	1 796		1 440	1 967
	C		935.9	1 679		1 235	1 936		1 534	2 027
900	A	2 452	966.3	1 598	4 905	1 394	2 226	7 358	1 821	2 601
	B		1 165	2 009		1 595	2 516		2 024	2 748
	C		1 264	2 277		1 696	2 679		2 127	2 827
1 000	A	2 943	1 306	2 159	5 886	1 876	3 004	8 829	2 446	3 502
	B		1 598	2 750		2 167	3 403		2 736	3 697
	C		1 745	3 143		2 314	3 633		2 882	3 810
1 100	A	3 434	1 652	2 821	6 867	2 372	3 943	10 300	3 092	4 597
	B		2 030	3 646		2 735	4 538		3 440	4 907
	C		2 218	4 163		2 916	4 846		3 612	5 041
1 200	A	3 924	2 080	3 555	7 848	2 982	4 983	11 770	3 885	5 852
	B		2 552	4 598		3 435	5 754		4 319	6 272
	C		2 834	5 331		3 706	6 208		4 578	6 471

When the performance check of the PC pile body involves the axial-tension bending strength test and the positive/negative alternating repetition axial-tension bending strength test, the representation external diameter shall be around the middle diameter of piles which are usually manufactured. The axial tension at this time shall be N_3.

In addition, the length of PC pile used in this case shall be 8 m or more.

Recommended specification E-1 Table 2 (concluded)

Symbol	Explanation
N_4	Axial-tension which almost equivalent to each break bending moment of A, B, and C in axial-tension and bending moment relationship diagram
N_3	Axial-tension of $N_4 \times 3/4$
N_2	Axial-tension of $N_4 \times 2/4$
N_1	Axial-tension of $N_4 \times 1/4$

Symbol	Explanation
M_{cr}	Crack bending moment
M_u	Break bending moment

Recommended specification E-1 Table 3 Shear break strength

External diameter mm	Thickness mm	Division	Shear break strength kN	
			Shear crack	Shear break
300	60	A	99.1	125
		B	126	160
		C	136	175
350	60	A	119	149
		B	150	190
		C	163	209
400	65	A	148	187
		B	187	234
		C	204	259
450	70	A	181	225
		B	228	293
		C	248	316
500	80	A	229	276
		B	288	359
		C	314	395
600	90	A	311	388
		B	392	506
		C	428	554
700	100	A	406	514
		B	512	677
		C	557	739
800	110	A	512	661
		B	647	863
		C	704	936
900	120	A	631	820
		B	797	1 063
		C	867	1 153
1 000	130	A	762	990
		B	961	1 289
		C	1 047	1 400
1 100	140	A	905	1 202
		B	1 142	1 561
		C	1 244	1 687
1 200	150	A	1 059	1 413
		B	1 337	1 823
		C	1 457	1 979

When the performance check of the PC pile body involves the shear test, the representative external diameter shall be around the middle diameter of piles which are usually manufactured.

E-1.4 Shape, dimensions and dimensional tolerances

The shape, dimensions and dimensional tolerances of PC piles shall be as specified in recommended specification E-1 figure 1, and recommended specification E-1 tables 1 and 4.

If the reference dimension is changed within the range as specified in **E.4**, the manufacturer shall present the data indicating that PC piles conform to **E.3** by the design document or the performance test when requested by the purchaser.

A PC pile has a hollow cylinder body, having a suitable tip, a joint or a head, if needed.

An ST pile is a PC pile having a diameter enlarged part at its end. The maximum length of the diameter enlarged part shall be twice the external diameter of the diameter enlarge part.

A knot pile is a PC pile of which the body is provided with knots. The external diameter of a knot part shall be in the range in which the performance of the body is not compromised, and for that whose external diameter is 450 mm or less, it shall be not more than the said external diameter + 150 mm, and for that whose external diameter is 500 mm or more, it shall be not more than the said external diameter + 200 mm. Moreover, the interval between knot parts shall be 1 m.

A tip, a joint and a head are included in the length of PC pile. A metallic fixture, which is attached to the tip after manufacture, is not included in the length of pile. There are a closed edge and an open edge. A tip may be attached to a upper pile or a middle pile to make a lower pile.
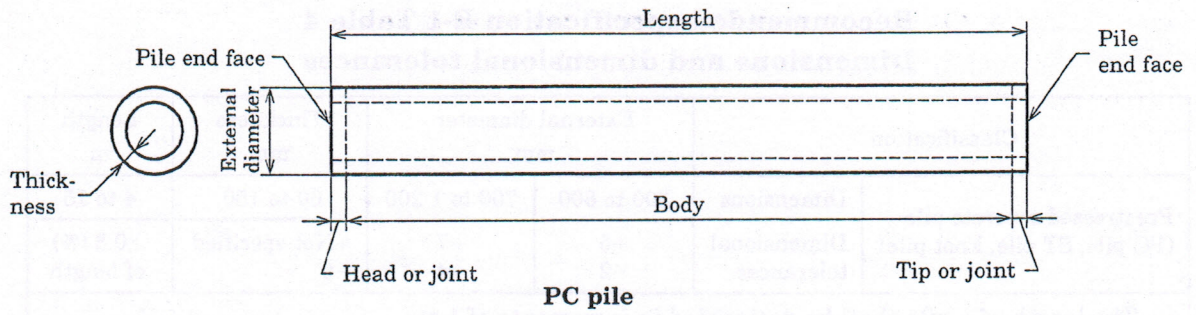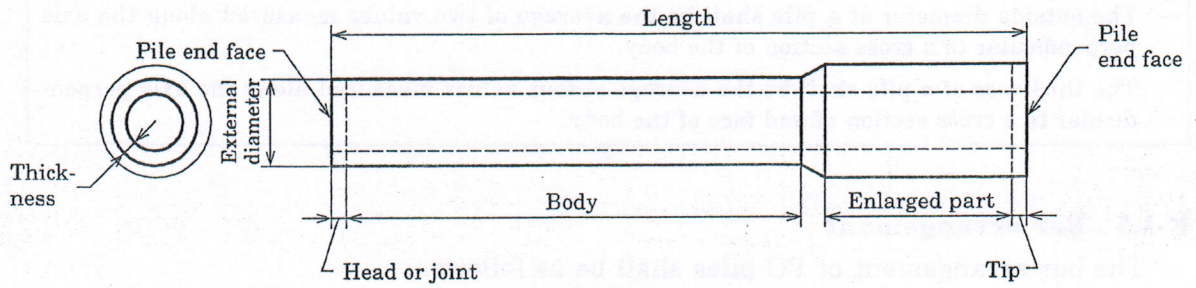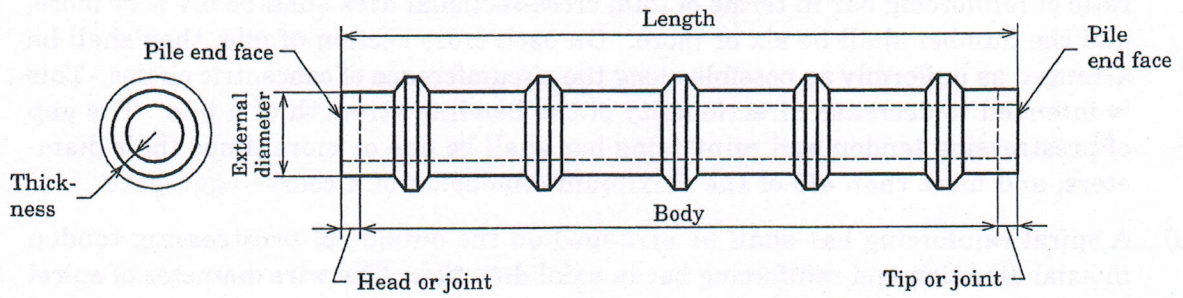
Recommended specification E-1 Figure 1   Shape of pile

Recommended specification E-1 Table 4
Dimensions and dimensional tolerances

Classification		External diameter mm		Thickness mm	Length m
Prestressed concrete pile (PC pile, ST pile, knot pile)	Dimensions	300 to 600	700 to 1 200	60 to 150	4 to 15
	Dimensional tolerances	+5 −2	+7 −4	+Not specified −0	±0.3 (%) of length

— The length of a pile shall be designated in increments of 1 m.

— The outside diameter of a pile shall be the average of two values measured along the axis perpendicular to a cross section of the body.

— The thickness of a pile shall be the average of four values measured along the axis perpendicular to a cross section of end face of the body.

E-1.5 Bar arrangement

The bar arrangement of PC piles shall be as follows.

a) As to the prestressing tendon and reinforcing bar arranged in axial direction, the ratio of reinforcing bar in terms of total cross-sectional area shall be 0.4 % or more, and the number shall be six or more. On each cross section of pile, they shall be arranged as uniformly as possible along the circumference of concentric circles. This is intended to decrease directionality of the bending strength of a pile. The gap of prestressing tendon and reinforcing bar shall be one or more times their diameters, and more than 4/3 of the maximum dimension of a coarse aggregate.

b) A spiral reinforcing bar shall be arranged on the outside of prestressing tendon in axial direction and reinforcing bar in axial direction. The wire diameter of spiral reinforcing bars shall be 3 mm or more for the pile of 500 mm or less in external diameter, 4 mm or more for the pile of 600 mm to 1 000 mm in external diameter and 5 mm or more for the pile of 1 100 mm to 1 200 mm in external diameter. The pitch shall be 110 mm or less.

The required quantity of spiral reinforcing bar for improvement of the shear resistance and the deformation performance shall be subjected to the agreement between the parties concerned with delivery.

c) The covering of prestressing tendon and spiral reinforcing bar shall be more than 15 mm.

d) A reinforcing bar and prestressing tendon shall be free from loose scale, oil, etc. which damage adhesion of concrete, and shall be assembled and fixed to the right position.

E-1.6 Strength test

E-1.6.1 Compressive strength test

The compressive strength test of concrete shall be as specified in **E.6.1**.

E-1.6.2　Bending strength test

The bending strength test shall be as specified in **E.6.2**.

In addition, the mass of PC pile body used for calculation of a loading force may be as specified in recommended specification E-1 table 5.

E-1.6.3　Axial-tension bending strength test

The axial-tension bending strength test shall be as specified in **E.6.3**.

In addition, the mass of the body of PC pile used for calculation of a loading force may be as specified in recommended specification E-1 table 5.

E-1.6.4　Shear strength test

The shear strength test shall be as specified in **E.6.4**.

E-1.6.5　Measurement test of squareness of joint end face

The measurement test of the squareness of a joint end face shall be as specified in **E.6.5**.

Recommended specification E-1 Table 5　Mass of PC piles

External diameter	Mass [a] t											
	Length											
mm	4 m	5 m	6 m	7 m	8 m	9 m	10 m	11 m	12 m	13 m	14 m	15 m
300	0.470	0.588	0.705	0.823	0.940	1.058	1.176	1.293	1.411	1.528	1.646	1.763
350	0.568	0.710	0.852	0.994	1.136	1.278	1.421	1.563	1.705	1.847	1.989	2.131
400	0.711	0.889	1.067	1.244	1.422	1.600	1.778	1.955	2.133	2.311	2.489	2.667
450	0.869	1.086	1.303	1.520	1.737	1.954	2.172	2.389	2.606	2.823	3.040	3.257
500	1.097	1.372	1.646	1.920	2.194	2.469	2.743	3.017	3.292	3.566	3.840	4.115
600	1.499	1.874	2.248	2.623	2.998	3.373	3.747	4.122	4.497	4.871	5.246	5.621
700	1.959	2.449	2.939	3.429	3.919	4.409	4.898	5.388	5.878	6.368	6.858	7.348
800	2.479	3.098	3.718	4.338	4.957	5.577	6.196	6.816	7.436	8.055	8.675	9.295
900	3.057	3.821	4.585	5.349	6.113	6.877	7.642	8.406	9.170	9.934	10.698	11.462
1 000	3.693	4.617	5.540	6.463	7.387	8.310	9.233	10.157	11.080	12.004	12.927	13.850
1 100	4.389	5.486	6.583	7.681	8.778	9.875	10.972	12.070	13.167	14.264	15.361	16.459
1 200	5.143	6.429	7.715	9.001	10.287	11.572	12.858	14.144	15.430	16.716	18.002	19.287

Note [a]　For the purpose of convenience, the mass is calculated by the following formula assuming that the unit volume mass of PC piles is 2.60 t/m³, and the value of π is 3.14. The value of mass is rounded off to the third decimal place in accordance with **JIS Z 8401**.

$$m = \omega \pi t L (D - t)$$

where,　m :　mass of PC pile (t)

ω :　unit volume mass of PC pile (t/m³)

t :　thickness (m)

L :　length (m)

D :　external diameter (m)

E-1.7 Quality of concrete

The compressive strength of concrete shall be as specified in **E.7.2**.

In addition, Class A shall be 80 N/mm² or more, and Class B and Class C shall be 85 N/mm² or more.

E-1.8 Inspections

E-1.8.1 Inspection items

The inspection items of PC piles shall be as follows.

a) **Final inspection**   The final inspection items shall be as follows.

  1) Appearance

  2) Performance

  3) Shape and dimensions

b) **Delivery inspection**   The delivery inspection items shall be as follows. However, the delivery inspection may be omitted according to the agreement between the parties concerned with delivery.

  1) Appearance

  2) Shape and dimensions

E-1.8.2 Inspection lot

The size of inspection lot of PC piles shall be decided by the manufacturer for final inspection, and by the purchaser for delivery inspection according to the agreement between the parties concerned with delivery by considering characteristics of the product, production method, production quantity, production period, ordered quantity, etc. One inspection lot may consist of 3 000 units or fraction thereof.

E-1.8.3 Inspection method

The inspection method of PC piles shall be as follows.

a) **Final inspection**   The final inspection method shall be as follows.

  1) **Appearance**   For the inspection of appearance, the lot shall be subjected to 100 % inspection by visual observation, and those conform to the provisions of **5.1** shall be accepted.

  2) **Performance**   For the inspection of the bending crack strength of the body, two arbitrary piles per one lot shall be taken and inspected as specified in **E-1.6.2**. If both of the two conform to **E-1.3.1**, the lot shall be accepted. If neither of the two conforms, the lot shall be rejected. If only one of the two does not conform, the lot shall be re-inspected. In the re-inspection, four more piles shall be taken from the lot, and if all the four conform to the provisions, the lot shall be accepted after the first non-conforming product is eliminated. If one or more of them do not conform in the re-inspection, the lot shall be rejected. The bending break strength of the body shall be inspected as follows. One of the first two piles for bending crack strength inspection shall be inspected as specified in **E-1.6.2**.

When it conforms to the provisions of **E-1.3.1**, the lot shall be accepted. If it does not conform, two more piles shall be taken from the lot for re-inspection, and if both of them conform to the provisions, the lot shall be accepted after the first non-conforming product is eliminated. If one or more of them do not conform in the re-inspection, the lot shall be rejected.

3) **Shape and dimensions** For the inspection of shape and dimensions, two arbitrary PC piles per one lot shall be taken. If they conform to **E-1.4**, the lot shall be accepted. If one or more of them do not conform, the remainder of the lot shall be subjected to 100 % inspection, and those conform to the provisions shall be accepted.

b) **Delivery inspection** The delivery inspection method shall be as follows.

1) **Appearance** The appearance shall be inspected in the same way as **a) 1**).

When adopting the sampling inspection, if two arbitrary piles are inspected and conformed to the provisions of **5.1**, the lot shall be accepted. If one or more of them do not conform, the remainder of the lot shall be subjected to 100 % inspection, and those conform to the provisions shall be accepted.

2) **Shape and dimensions** The shape and dimensions shall be inspected in the same way as **a) 3**).

E-1.9 Marking

The PC piles, ST piles and knot piles which conform to all the requirements of this Standard shall be marked as specified in **E.9**. The piles manufactured by centrifugal force compaction shall be marked as PHC.

Current edition (JIS A 5373:2010)		Previous edition (JIS A 5373:2004)		Reason for revision
No. and title of clause	Content	No. and title of clause	Content	
Annex E (normative) Piles E.4 Shape, dimensions and dimensional tolerances	a) Shape ... Moreover, a knot pile is a PC pile of which the body is provided with knots. The outside diameter of the knot part shall be in the range in which the performance of the body is not compromised. Also, the knot pile may be provided with a suitable tip, a joint or a head, if needed.	Annex 5 (normative) Piles 4 Shape, dimension, and dimensional tolerance	a) Shape —	The shape of the knot pile is clearly specified.
	Table E.4 Dimensions and dimensional tolerances of piles Length m / 4 to 15 / ±0.3 (%) of length (Extracted from table) — The length of a pile shall be designated in increments of 1 m.		Annex 5 table 4 Dimensions and dimensional tolerance Length m / 7 to 15 / ±0.3 (%) of length (Partial excerpts) Remarks 1 The unit of length of a pile shall be 1 m unit. Piles are available in 4 m, 5 m, and 6 m according to the agreement between the parties concerned with delivery.	In keeping with demand trends, length of 4 m to 6 m which has been recognized according to the agreement between the parties concerned with delivery is added as the provision.
E.5 Bar arrangement (position of prestressing tendon and reinforcing bar)	However, according to the agreement between the parties concerned with delivery, the bar arrangement other than that of the recommended specification may be adopted in the range in which the product performance (including the provisions of E.3) is not compromised.	5 Bar arrangement (position of PC steel and reinforcement)	—	The provision in the case of change of bar arrangement according to the agreement between the parties concerned with delivery is added.
E.7 Quality of concrete	E.7.2 Compressive strength ... When the predetermined material aging is finished, ...	7 Quality of concrete	7.2 Compressive strength ... When the predetermined cure is finished, ...	Material aging that assures quality and performance is made clear.

Current edition (JIS A 5373:2010)		Previous edition (JIS A 5373:2004)		Reason for revision
No. and title of clause	Content	No. and title of clause	Content	
Annex E (normative) Piles E.9 Marking	Moreover, the PC pile, ST pile and knot pile among the piles manufactured by centrifugal force compaction shall be marked as PHC.	Annex 5 (normative) Piles 9 Marking	—	The marking of the product manufactured by centrifugal force compaction is made clear to be added.
Recommended specification E-1 Prestressed concrete piles E-1.3 Performance	E-1.3.1 Bending strength a) Pile body … Also, the PC pile body shall not break with the value of break bending moment specified in recommended specification E-1 tables 1 and 2. b) Pile joint The PC pile joint shall be subjected to the bending strength test specified in **E-1.6.2** and shall not break with the value of break bending moment specified in recommended specification E-1 table 1.	Recommended specification 5-1 Prestressed concrete piles 3 Performance	3.1 Bending strength a) Pile body … Moreover, the destructive bending moment shall exceed the value specified in recommended specification 5-1 table 1 and table 2. b) Pile joint The PC pile joint shall be subjected to the bending strength test specified in clause **6**. Then, it shall exceed the destructive bending moment specified in recommended specification 5-1 table 1.	Revised because the test method is made clear and it is dangerous to make the product broken by giving the load exceeding the break bending moment, when the product test is conducted.
	E-1.3.2 Shear strength Moreover, the PC pile body shall not break with the value of shear break strength specified in recommended specification E-1 table 3.		3.2 Shear strength Moreover, the shear destructive strength shall exceed the value specified in recommended specification 5-1 table 3.	Revised because it is dangerous to make the product broken by giving the load exceeding the shear break strength and the like, when the product test is conducted.

Current edition (JIS A 5373 : 2010)		Previous edition (JIS A 5373 : 2004)		Reason for revision
No. and title of clause	Content	No. and title of clause	Content	
Recommended specification E-1 Prestressed concrete piles E-1.4 Shape, dimensions and dimensional tolerances	A knot pile is a PC pile of which the body is provided with knots. The external diameter of a knot part shall be in the range in which the performance of the body is not compromised, and for that whose external diameter is 450 mm or less, it shall be not more than the said external diameter + 150 mm, and for that whose external diameter is 500 mm or more, it shall be not more than the said external diameter + 200 mm. Moreover, the interval between knot parts shall be 1 m.	Recommended specification 5-1 Prestressed concrete piles 4 Shape, dimension and dimensional tolerance	—	With addition of knot piles, the provision such as shape is added.
	Recommended specification E-1 Table 4 Dimensions and dimensional tolerances	Annex 5-1 table 4 Dimensions and dimensional tolerance		In keeping with demand trends, length of 4 m to 6 m which has been recognized according to the agreement between the parties concerned with delivery is added as the provision.
	Length m: 4 to 15 ; ±0.3 (%) of length (Extracted from table)		Length m: 7 to 15 ; ±0.3 (%) of length (Partial excerpts)	
	— The length of a pile shall be designated in increments of 1 m.		Remarks 1 The unit of length of a pile shall be 1 m unit. Piles are available in 4 m, 5 m, and 6 m according to the agreement between the parties concerned with delivery.	