CRD-C 62-69

METHOD OF TESTING CYLINDRICAL TEST SPECIMENS FOR PLANENESS AND PARALLELISM OF ENDS AND PERPENDICULARITY OF SIDES

1. Scope

1.1 This method of test covers procedures for determining the planeness and parallelism of the ends of cylindrical test specimens and the perpendicularity of the sides to the ends. It is intended for use in connection with the preparation of test specimens of concrete, mortar, rock, and similar materials for test for compressive strength or other properties.

1.2 In many, or most cases, compliance with established tolerances on planeness and parallelism of ends and perpendicularity of sides and ends can adequately be established by the use of the carpenter's square, precision mechanics level, and feeler gage qualitative procedure described in Section 3.1. However, when a procedure for specimen preparation is being evaluated or when quantitative data on the departures from planeness, parallelism, and perpendicularity are sought, the quantitative procedure described in Section 3.2 using apparatus as described in Section 2.4 may be used.

1.3 Quantitative data on departures of specimens from planeness, parallelism, and perpendicularity are needed in connection with research on the effects of such variations. Available data suggest that closer tolerances on such departures may be needed as specimen size decreases, as compressive strength and modulus of elasticity increases, and when specimens are tested under multiaxial states of stress.

2. Apparatus

2.1 A carpenter's square with one arm longer than the specimen to be tested, the 90-degree angle accurate within 0.1 degree, and the outer edges machined straight within 0.001 in. (0.025 mm) along their entire length.

2.2 A precision mechanic's level having a length at least equal to the width of the test specimen.

2.3 A set of feeler gages for measuring thicknesses between 0.001 and 0.010 in. (0.025 and 0.250 mm).

2.4 A measuring device similar to that shown in Fig. 1. This device

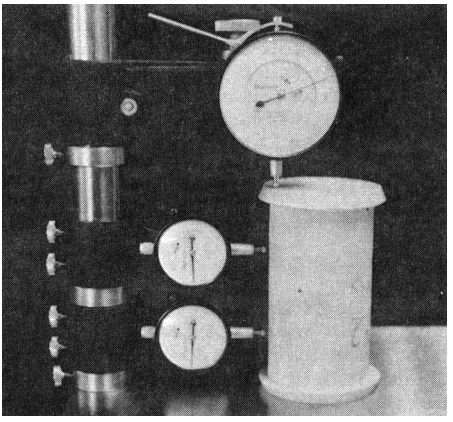


Fig. 1. Apparatus for determining planeness, parallelism, and perpendicularity of cylinders and cores of concrete and rock

shall have a rigid metal baseplate with its top surface machined so that it will not depart from plane more than 0.0005 in. (0.012 mm). At one side, a rigidly mounted metal rod having a diameter of at least 1-1/2 in. (4 cm) shall extend upward from the base at an angle of 90 ± 0.1 degrees. Three gages shall be mounted on the upright rod, as indicated in Fig. 1, each with a metal collar under it, and graduated to 0.0001 in. (0.0025 mm). The upper gage shall be mounted so that its measuring foot moves up and down in a direction perpendicular to the base. All of the gage mountings and collars shall be provided with set screws to lock them in a selected position so as to prevent horizontal or lateral movement after they have been positioned.

2.5 A circular metal plate approximately 1.5 in. thick, having a diameter approximately equal to the end of a ground test specimen, or the cap on a capped specimen. The metal plate shall conform to the following requirements and have scribings as indicated. The flat surfaces shall not depart from plane more than ± 0.0005 in. and shall be parallel within 0.05 degrees. The sides of the metal plate shall be scribed with eight equispaced lines perpendicular to the flat ends. Letters A through H, respectively, shall be marked at one end of these lines around the plate in a clockwise direction, and the end nearest these letters shall be designated as the top end of the plate as used during the testing of the specimens.

3. Procedures

3.1 Qualitative evaluation.- Place a suitable metal plate on a table or bench and level it up so that it is horizontal. With the square, check the perpendicularity around the test specimen, with the end of the specimen on the leveled baseplate. Slight departures from perpendicularity may be measured with the feeler gages or larger departures with a suitable rule or other measuring device. Check the two ends with the level for parallelism, and with the square and feeler gage for planeness.

3.2 Quantitative evaluation of planeness.-

3.2.1 Marking the metal plate.- With a sharp pencil connect the tops of the scribed lines as shown in Fig. 2a so that the four lines intersect at the center of the top of the metal plate. Each of the eight center angles will be a 45 degree angle. Then letter the outer end of each line as shown as shown in Fig. 2a, A through H. Locate the measuring points one through five on each line with three being the center point, points one and five located 1/4 in. from the edge, and points two and four halfway between points three and one or five (Fig. 2a).

3.2.2 Marking the specimen.- Center the metal plate on top of the specimen, and using the markings on the side of the metal plate make marks with a sharp pencil around the top of the side of the specimen. Remove the metal plate and connect these marks across the top as shown in Fig. 2a and as was done on the metal plate. Then letter the outer edge of each line, A through H, and locate and number the measuring points, one through five as shown in Fig. 2a. Using a square, project one of the points on the top of the side of the specimen onto the bottom of the side of the specimen. Reverse the specimen and use the metal plate to mark the bottom end in a manner similar to that of the top end. Letter the lines on the bottom A through H and locate points one through five on these lines in such a manner that the bottom numbered points are directly above the top numbered points and the letters above and below are the same. Then with the sharp pencil draw lines along the side of the specimen connecting corresponding ends of bottom and top lines indicated by A-A, C-C, E-E, and G-G, as shown in Fig. 2b.

3.2.3 Measuring planeness of the ends of the specimen.- Place a sheet of paper or thin plastic of uniform thickness on the baseplate of the measuring apparatus (Fig. 1). Place the test specimen on its base on this paper or plastic. Center the metal plate, top up, on the specimen and make sure that the markings on the plate and specimen are properly matched. Secure the metal plate to the specimen by taping or other means of holding it in place. Center this specimen and metal plate under the top dial of the measuring device, make a measurement down to point 3. Lock the top dial in position, and by moving the specimen with the metal plate on top around make measurements down to the plate at the remaining points 1, 2, 4, and 5 across each line. It is recommended that the dial gage point be raised slightly while moving the specimen and then lowered when the specimen is positioned to measure the next point. Recordall measurements. Table 1 is a suggested form with data properly recorded. Next, take the metal plate off the top of the specimen and place it, top up, beneath the specimen. After proper alignment and

securing the specimen to the metal plate, bring the metal plate and specimen into positions under the fixed top dial and measure and record measurements down to the center point 3 and points 1, 2, 4, and 5 on each line on the top of the specimen. Then, turn the specimen upside down, and fix the metal plate first above and then below the specimen making measurements at each numbered position respectively along each line, recording all measurements. Care must be taken during this procedure not to disturb the apparatus since very slight movement will affect the sensitive dial gages.

3.2.4 Calculating planeness values.- The above measurements will give values at each numbered location along each line for the following conditions: (1) specimen with top end up, (a) metal plate on top of the specimen, and (b) metal plate under the specimen. (2) Specimen with its bottom end up, (a) metal plate on top of the specimen, and (b) metal plate under the specimen. For the determination of the departures from planeness on the top surface of the specimen subtract the (1)(b) measurements at each point along each line on the top of the specimen from the corresponding (1)(a) measurements at each point along each line on the top of the metal plate. For the determination of the departures from planeness on the bottom surface of the specimen subtract the (2)(b) measurements at each point along each line on the bottom of the inverted specimen from the corresponding (2)(a) measurements at each point along each line on the top of the metal plate on the inverted specimen.

3.3 Quantitative evaluation of perpendicularity.-

3.3.1 Adjusting the side dials of the measuring apparatus.- Set the side dials of the apparatus in Fig. 1 so that when the specimen is placed on the metal plate on paper or plastic on the base of the measuring apparatus the dial contact points will be at levels approximately 1/4 in. from the top and bottom, respectively, of the specimen. With the square and level, line up the contact points in a line perpendicular to the baseplate of the apparatus and adjust the dials to the same reading.

3.3.2 Measuring perpendicularity.- Center the specimen on the metal plate and fix it in position. Move it into position and make upper and lower readings along lines A-A, C-C, E-E, and G-G. Invert the specimen on the metal plate and again make upper and lower readings along lines A-A, C-C, E-E, and G-G. Record all readings. Determine the difference between upper and lower readings for each of the four lines in each of the two specimen positions. The difference between upper and lower readings divided by the perpendicular distance between the contact points is the tangent of the angle of departure from perpendicularity. Determine the angles from their tangents by using standard mathematical tables, and select the greatest angle of departure.

3.4 Quantitative evaluation of parallelism.- The departure from parallelism in direction A, Fig. 3, is the sum (Note) of the two angles along a given line as determined in the two orientations of the specimen. Determine this value αA for line A-A and αC for line C-C. The maximum departure from parallelism (tilt) and direction of tilt are determined as follows:

Note.- Taking proper account of algebraic signs.

$$\text{Tan } \alpha = \sqrt{\tan^2 \alpha A + \tan^2 \alpha C}$$

$$\text{Tan } \phi = \frac{\tan \alpha C}{\tan \alpha A}$$

where

α = maximum angle of convergence of planes against which the ends of the specimen might rest.

ϕ = angle in the horizontal plane, measured clockwise from OA, of the maximum convergence.

O = center of the specimen.

4. Figure 3 illustrates departures from planeness, perpendicularity, and parallelism. Table 1 indicates a work sheet, filled out.

5. Report

5.1 The report shall contain information identifying the test specimen, the group performing the tests, the dimensions of the specimen, the greatest departure from plane on a bearing surface to the nearest 0.001 in., (0.25 mm) the greatest angle of departure from parallelism between bearing faces to the nearest 0.1 degree, and the greatest departure from perpendicularity of the side to the base to the nearest 0.1 degree.

TABLE 1. WORK SHEET RECORDING PLANENESS, PARALLELISM, AND PERPENDICULARITY TEST DATA

Planeness

Test Point	Test Specimen, Top Side Up				Test Specimen, Bottom Side Up			
	AE	BF	CG	DH	AE	BF	CG	DH
	Readings on Plate, in. (Plate on Top)							
1	0.0198	0.0225	0.0259	0.0280	0.0196	0.0191	0.0210	0.0246
2	0.0217	0.0230	0.0247	0.0258	0.0216	0.0213	0.0223	0.0241
3	0.0236	0.0236	0.0236	0.0236	0.0236	0.0236	0.0236	0.0236
4	0.0255	0.0241	0.0224	0.0214	0.0256	0.0259	0.0248	0.0231
5	0.0274	0.0246	0.0213	0.0192	0.0276	0.0281	0.0260	0.0226
	Readings on Test Specimen, in. (Plate on Bottom)							
1	0.0196	0.0222	0.0259	0.0269	0.0190	0.0184	0.0210	0.0246
2	0.0216	0.0228	0.0243	0.0253	0.0212	0.0208	0.0220	0.0235
3	0.0235	0.0234	0.0234	0.0234	0.0232	0.0232	0.0232	0.0232
4	0.0252	0.0239	0.0220	0.0213	0.0250	0.0250	0.0242	0.0220
5	0.0263	0.0242	0.0213	0.0186	0.0275	0.0275	0.0259	0.0219
	Difference, in. (Test Specimen Departs from Plane)							
1	-0.0002	-0.0003	-0.0	-0.0011	-0.0006	-0.0007	-0.0	-0.0
2	-0.0001	-0.0002	-0.0004	-0.0005	-0.0004	-0.0005	-0.0003	-0.0006
3	-0.0001	-0.0002	-0.0002	-0.0002	-0.0004	-0.0004	-0.0004	-0.0004
4	-0.0003	-0.0002	-0.0004	-0.0001	-0.0006	-0.0009	-0.0006	-0.0011
5	-0.0011	-0.0004	-0.0	-0.0006	-0.0001	-0.0006	-0.0001	-0.0007

Greatest Departure from Planeness -0.0011 in.

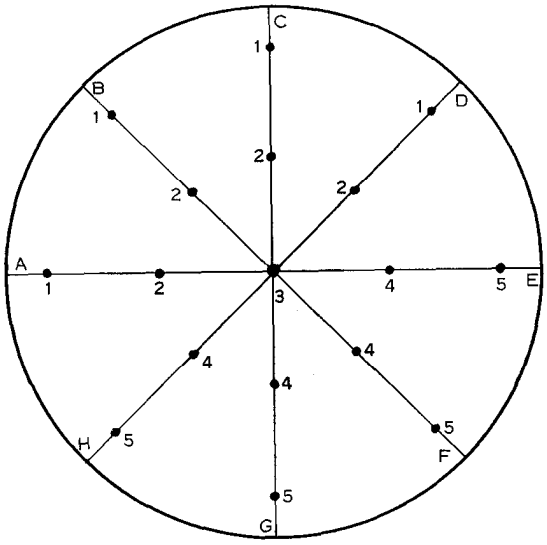
Perpendicularity

Line	Readings, in. T-Up	L-Dn	T-Dn	L-Up	Span in.	Tangents T-Up	T-Dn	Max Angle
AA	0.0021	0.0027	0.0000	0.0000	5.5	0.00011	0.00000	0.0
CC	0.0014	0.0013	0.0005	0.0001	5.5	0.00002	0.00007	0.0
EE	0.0000	0.0004	0.0014	0.0013	5.5	0.00007	0.00002	0.0
GG	0.0000	0.0000	0.0028	0.0022	5.5	0.00000	0.00011	0.0

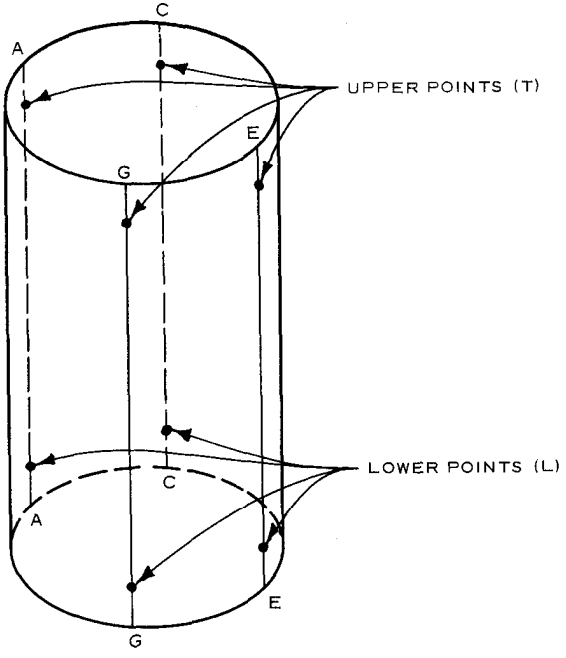
Parallelism

Tan αA	0.00011
Tan αC	0.00005
Tan α	0.00012
$\angle\alpha$, deg	0.0*
Tan ϕ	0.4545
$\angle\phi$, deg	24.4*

*Use standard mathematical tables to find angles corresponding to tangents.

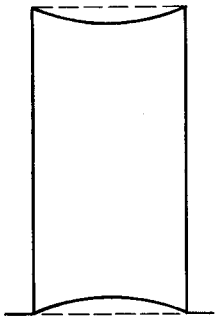


a. TOP SURFACES OF TEST SPECIMEN AND TOP OF CIRCULAR METAL PLATE (PARAGRAPH 2.5)



b. SIDE VIEW OF TEST SPECIMEN

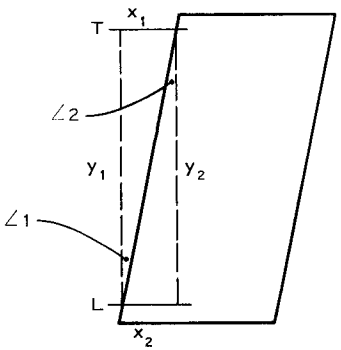
Fig. 2. Markings for test specimens



a.

PLANENESS

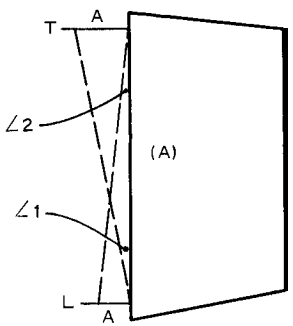
ONE PATTERN OF DEPARTURE FROM PLANENESS OF ENDS. DISTANCE BETWEEN DOTTED AND SOLID LINES TO NEAREST 0.0001 IN. SHALL BE MEASURED AT FIVE POINTS ACROSS EACH OF FOUR DIAMETERS. EACH SPECIMEN END IS REPORTED TO BE PLANE TO WITHIN THE LARGEST MEASURED DEPARTURE.



b.

PERPENDICULARITY

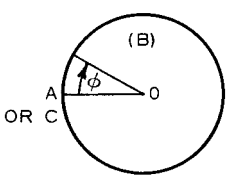
ANGLE BETWEEN DOTTED PERPENDICULAR LINE AND SIDE OF SPECIMEN IS MEASURED AT FOUR MARKED POSITIONS. GREATEST ANGLE WHOSE TANGENT IS x/y TO NEAREST 0.1 DEGREE IS REPORTED AS DEPARTURE FROM PERPENDICULARITY.



c.

PARALLELISM

ANGLE OF DEPARTURE FROM PARALLEL ALONG AA = $\angle 1 + \angle 2$ IN c. IN b ANGLE OF DEPARTURE = $\angle 1 - \angle 2$. ANGLES OF DEPARTURE ARE DETERMINED ALONG AA AND CC. MAXIMUM DEPARTURE FROM PARALLEL = α IN EQUATION $\tan \alpha = \sqrt{\tan^2 \alpha_A + \tan^2 \alpha_C}$. ANGLE OF MAXIMUM CONVERGENCE = ϕ IN EQUATION: $\tan \phi = \dfrac{\tan \alpha_C}{\tan \alpha_A}$.



END VIEW

Fig. 3. Some typical illustrations of planeness, perpendicularity, and parallelism