Edgewise compressive strength of corrugated fiberboard using the clamp method (short column test)

1. Scope

1.1 This method describes procedures for determining the edgewise compressive strength, parallel to the flutes, of a short column of single-, double-, or triple-wall corrugated fiberboard.

1.2 The method includes procedures for cutting the test specimen (saw cutting and knife cutting), one procedure for specimen support (spring support clamp fixture), and two procedures for applying the compressive force (constant strain rate, or constant load rate). Studies have shown that any combination of these procedures will yield similar test results.

2. Significance

2.1 Research has shown that the edgewise compressive strength of specimens with flutes vertical, in combination with the flexural stiffness of the combined board and box dimensions, relates to the top-to-bottom compressive strength of vertically fluted corrugated fiberboard shipping containers (1,2).

2.2 This method may also be used for comparing the edgewise compressive strength of different lots of similar combined boards or for comparing different material combinations (3,4).

3. Apparatus

3.1 Compression testing machine meeting the requirements of either 3.1.1 or 3.1.2, 3.1.3, 3.1.4, and 3.1.5.

3.1.1 Rigid Support Compression Tester. Two platens, one rigidly supported and the other driven. Each platen shall have a working area of approximately 100 cm² (16 in²). The platens are to have not more than 0.050 mm (0.002 in.) lateral relative movement, and the rigidly supported platen not more than 0.150 mm (0.006 in.) movement, perpendicular to the surface, within a load range of at least 0 to 2224 N (0-500 lbf). Within a 100 cm² (16 in²) working area, each platen shall be flat within 0.0025 mm (0.0001 in.) of the mean platen surface, and the platens shall remain parallel to each other within 1 part in 2000 (.0125 mm/25 mm, .0005 in./1.00 in.) throughout the test.

3.1.1.1 Within a range of platen separations necessary to cause compressive failure of the test specimen, and within a load range of at least 0 to 2224 N (0-500 lbf), the speed of the driven platen shall be controllable at 12.5 ± .25 mm (0.49 ± 0.01 in.) per minute. (For convenience, the test machine should be capable of rapid return and automatic, settable positioning).

1Names of suppliers of testing equipment and materials for this method may be found on the Test Equipment Suppliers list in the bound set of TAPPI Test Methods, or may be available from the TAPPI Information Resources Center.
Flexible Beam Compression Tester. Two platens, one flexible beam supported and the other driven. Each platen shall have a working area of approximately 100 cm\(^2\) (16 in.\(^2\)). Within the specimen contact area, each platen shall be flat within 0.0025 mm (0.0001 in.) of the mean platen surface, and the platens shall remain parallel to each other within 1 part in 2000 throughout the test. The platens are required to have not more than 0.05 mm (0.002 in.) lateral relative movement.

Within a range of platen separations necessary to cause compressive failure of the specimen, and within a load range of at least 0 to 2224 N (0-500 lbf), the speed of the driven platen shall be controlled so that the rate of force increase (without considering specimen deformation) is 111 ± 22 N/s (25 ± 5 lbf/s).

The driven platen shall be moveable to achieve an initial platen separation of at least 60 mm (2.36 in.).

A capacity of at least 2224 N (500 lbf).

A means for measuring and indicating the maximum load sustained by the test specimen with an accuracy of 0.5% of that load or 2.2 N (0.5 lbf), whichever is greater.

A means such as a saw or other device for cutting specimens having clean, parallel and perpendicular edges within the tolerances specified in 6.2 and 6.3. Opposite edges shall be parallel to each other and perpendicular to adjacent edges.

Knife cutter, single knife device with guides, or a twin-knife device with guides to cut the test pieces according to the specifications in Section 6. The knives must be sharp and arranged in the device so that it/they are at 90° ± 30° to the specimen's surface.

Saw, circular, equipped with a sharp, no-set (hollow ground or taper ground is desirable) saw blade. The saw blade shall be 90° ± 30° to the table supporting the specimen, and have the ability to consistently hold specimen size to ± 0.8 mm (± 0.03 in.).

Test fixture (Figs. 1 and 2) consisting of,

- Clamps, upper and lower to secure the test specimen. One side of each clamp must be fixed and so aligned that the test specimen is held exactly perpendicular to the base of the fixture. The moveable side of each clamp is actuated by a spring or springs having a total rating of 231 ± 22 N (52 ± 5 lbf), such that the test specimen is held by a uniform pressure between 55 kPa and 83 kPa (8 and 12 psi). The surfaces of the clamp must have a coefficient of friction high enough to prevent slippage of the specimen within the clamp during testing (120 - 180 grit). Each clamp side must be at least 50.8 mm (2.00 in.) wide by 19.8 mm ± 0.25 mm (0.78 in. ± 0.01 in.) tall.

- Means to open the jaws against the spring load so as to be able to insert the test specimen (e.g., thumb screws).

Suspension system, consisting of frictionless bearings to allow the jaws to move freely up and down. Structure must be of rigid design to guarantee test load is applied to specimen in absolute vertical direction (90° ± 10°) to base of fixture.
4. **Sampling**

Samples shall be obtained in accordance with TAPPI T 400 “Sampling and Accepting a Single Lot of Paper, Paperboard, Containerboard, or Related Product.”

5. **Conditioning**

Precondition and condition the sample in accordance with TAPPI T 402 “Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets, and Related Products.”

6. **Test specimens**

6.1 From each test unit, accurately cut at least 10 or any other required number of specimens (Rule 41 only 6 specimens are required) with the knife or circular saw to cut clean, parallel, and perpendicular edges. If the test specimens are to be taken from corrugated shipping containers, they should be taken from areas away from scorelines, joints, and closures. Specimens should not be taken from obviously damaged areas and areas not representative of the container as a whole.

6.2 The width edges shall be parallel to each other and perpendicular to the axis of the flutes. Cut specimens to a width of 50.8 ± 0.8 mm (2.00 ± 0.03 in.).

6.3 Specimens to be tested using this procedure shall be cut to a height 50.8 ± 0.8 mm (2.00 ± 0.03 in.) for A, B, and C-flute and for all double- and triple-wall board.

7. **Procedure**

7.1 Perform all tests in the conditioning atmosphere.

7.2 The rate of platen movement required for a flexible beam compression machine has been determined to be 111 ± 22 N/s (25 ± 5 lbf/s). Record the platen movement rate actually used. On most machines this rate of platen movement will be 13-51 mm (0.5 - 2.0 in.) per minute depending on the load range at the beam.

7.3 The rate of platen movement for each rigid support compression machine should be set to 12.5 ± 0.25 mm (0.49 ± 0.01 in.) per minute.

7.4 Using the thumb screws open the upper and lower jaws of the test fixture and place the specimen centrally in the jaws with the flutes oriented in the vertical direction. Allow the fixture to fall into place so that the specimen rests between the fixture's base and top. Release the clamps so that the springs hold the jaws on the specimen.

7.5 Center the test fixture on the machine platen.

7.5.1 Apply a compressive force to the specimen. Verify the platen movement rate as described in 7.2 or 7.3.

A test is considered valid when one or both liners have buckled in the center portion of the specimen. Occasionally samples will fail at a loaded edge. These results may be less than samples buckled in between the jaws. It is recommended that an additional sample be taken.

7.6 Record the maximum load (newton or pounds-force), the specimen width, and whether or not the specimen exhibited a valid failure.

8. **Report**

8.1 For each test unit, report:

8.1.1 Average maximum load per unit width for valid tests calculated from average maximum load from specimen lot (10 specimens or 6 for Rule 41) and specimen width (kilonewtons per meter or pounds-force per in.).

8.1.2 Standard deviation among valid determinations (kilonewtons per meter or pounds-force per in.).

8.1.3 Number of valid test determinations.

8.1.4 A description of material tested.

8.1.5 A statement that the test was conducted in compliance with this test method and a description of any deviations.
9. Precision

9.1 For the maximum expected difference between two test results, each of which is the average of 10 test determinations.

Repeatability (within a laboratory) = 5%.
Reproducibility (between laboratories) = unknown.

In accordance with the determinations of these terms in TAPPI T 1206 “Precision Statement for Test Methods.”

9.2 While corporate converting labs have done extensive testing, no round robin program has been performed. Reproducibility is not known because data is not available.

10. Keywords

Corrugated boards, edge crush resistance.

11. Additional information

11.1 Effective date of issue: October 12, 1995.
11.2 This method could provide a referee procedure for measuring edgewise compressive strength of corrugated fiberboard.
11.3 Related methods: TAPPI T 811, ASTM D-2808, ISO 3037, all of these methods are technically identical except for specimen size and preparation. This method differs from the other methods in that a test holding fixture is used and the test specimen's edges are not reinforced. Failures at the loaded edges sometimes occur, but the test results are usually close to those obtained with edge reinforcement. With this method, a single specimen size is used for all board constructions.

References

Appendix A: Calibration

A.1  Crush tester. Calibrate the flexible beam instrument in accordance with TAPPI TIP 0304-20 (Calibration of Flexible Beam Crush Tester). Calibrate the rigid support instrument in accordance with the manufacturer’s instructions.

A.1.1 Periodic calibration must be performed to assure test results are accurate. The test instrument’s accuracy must be certified periodically (minimum of once per year).

Your comments and suggestions on this procedure are earnestly requested and should be sent to the TAPPI Technical Divisions Administrator.