



Designation: E2954 – 15 (Reapproved 2022)

Standard Test Method for Axial Compression Test of Reinforced Plastic and Polymer Matrix Composite Vertical Members¹

This standard is issued under the fixed designation E2954; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the evaluation of vertical members in axial compression for “full-sized” specimens with various end conditions with constant cross-sections throughout the length.

1.2 This test method is limited to reinforced plastic and polymer matrix composite materials and covers the determination of the compressive properties of structural members. The method is intended primarily for members of rectangular cross section, but is also applicable to irregularly shaped studs, round posts, or special sections.

1.3 This test method covers short-term axial load testing under standard indoor atmospheric conditions. It does not address: sampling, the ability of the material to carry a sustained long-term load, design load derivations, temperature effects, performance under freeze/thaw or salt spray exposure conditions, chemical/UV exposure effects, or engineering analysis/modeling needed to extrapolate the results to conditions other than those tested. Each of these factors, and potentially others, need to be considered by the design professional or product standard development committee before using the information generated by this test method to assess structural adequacy.

1.4 Short sections are not covered in this test method and should be tested using a material test standard such as Test Method **D6108** or Test Methods **D198**.

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appro-*

priate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*²

D198 Test Methods of Static Tests of Lumber in Structural Sizes

D883 Terminology Relating to Plastics

D2915 Practice for Sampling and Data-Analysis for Structural Wood and Wood-Based Products

D3878 Terminology for Composite Materials

D6108 Test Method for Compressive Properties of Plastic Lumber and Shapes

E4 Practices for Force Calibration and Verification of Testing Machines

E6 Terminology Relating to Methods of Mechanical Testing

E83 Practice for Verification and Classification of Extensometer Systems

E575 Practice for Reporting Data from Structural Tests of Building Constructions, Elements, Connections, and Assemblies

E631 Terminology of Building Constructions

3. Terminology

3.1 *Definitions*—Terminology **D3878** defines terms relating to high-modulus fibers and their composites. Terminology **D883** defines terms relating to plastics. Terminology **E6** defines terms relating to mechanical testing. In the event of a conflict between terms, Terminology **D3878** shall have precedence over the other standards.

3.1.1 For definitions of terms in this standard, see Terminology **E631**.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard’s Document Summary page on the ASTM website.

¹ This test method is under the jurisdiction of ASTM Committee **E06** on Performance of Buildings and is the direct responsibility of Subcommittee **E06.11** on Horizontal and Vertical Structures/Structural Performance of Completed Structures.

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3.2 Definitions of Terms Specific to This Standard:

3.2.1 *full-sized specimen*—full-sized specimens (meaning full cross-sectional area) tested with standard lengths with various end conditions and bracing conditions about the weak and strong member axes. The end conditions addressed include: eccentricity, fixed, pinned.

3.2.2 *short sections* (not considered in this test method)—compressive test sections having a maximum length, L , less than 17 times the least radius of gyration, r , where $r = \sqrt{I/A}$.

3.3 Symbols:

3.3.1 σ = compressive strength.

3.3.2 σ' = compressive stress at proportional limit.

3.3.3 E = compressive modulus of elasticity.

3.3.4 E' = apparent modulus of elasticity.

3.3.5 A = cross-sectional area.

3.3.6 Δ_L = change in length from original gage length at proportional limit.

3.3.7 L_G = gage length of compression column.

3.3.8 P_{max} = maximum load borne by column loaded to failure.

3.3.9 P' = applied load at proportional limit, lbf (N).

4. Summary of Test Method

4.1 The structural member is subjected to a compressive force distributed on the contact surface of the specimen in a direction generally parallel to the longitudinal axis. The specimens are either loaded to failure or proof loaded. The test method is intended to determine the axial compressive strength of standard full-size specimens tested with various end conditions including: built-in eccentricity, pinned, fixed, or as required to accomplish the experimental objective. Lateral bracing may be installed as required to accomplish the experimental objective.

5. Significance and Use

5.1 The compressive properties obtained by axial compression will provide information such as: modulus of elasticity, stress at proportional limit and compressive strength for the end support, and lateral bracing condition tested.

5.2 This test method addresses only full-sized specimens for determination of compressive strength and compressive modulus of elasticity intended for application to actual length members with end conditions and lateral bracing as intended.

NOTE 1—The effective length of the column with respect to buckling is affected by the end conditions. A fixed end condition results in an effective length for buckling that is less than the actual length of the column, by as much as 50 %.

6. Apparatus

6.1 *Drive Mechanism*—A drive mechanism for imparting to a movable loading head a uniform controlled velocity with respect to the stationary base.

6.2 *Load Indicator*—A load-indicating mechanism capable of showing the total compressive force on the specimen. This force-measuring system shall be calibrated to ensure accuracy in accordance with Practices E4. A schematic representation of the typical test set up is shown in Fig. 1.

6.3 *End Conditions*—The end conditions used for the test shall be chosen to satisfy the experimental objectives. Options include:

6.3.1 *Fixed*—With a fixed end condition as conceptually depicted in Fig. 2(a), a spherical bearing block may be used at either end of the column to ensure uniform contact. When spherical bearing blocks are used, the radius of the sphere shall be as small as practicable, in order to facilitate adjustment of the bearing plate to the specimen, and yet large enough to provide adequate spherical bearing area. This radius is usually one to two times the greatest cross-section dimension. The

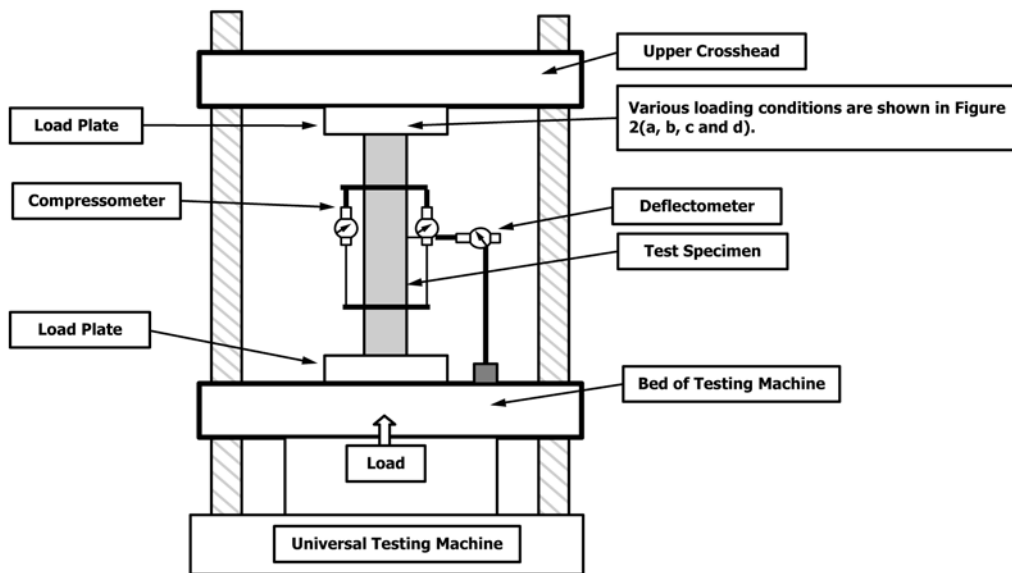


FIG. 1 Test Set-Up

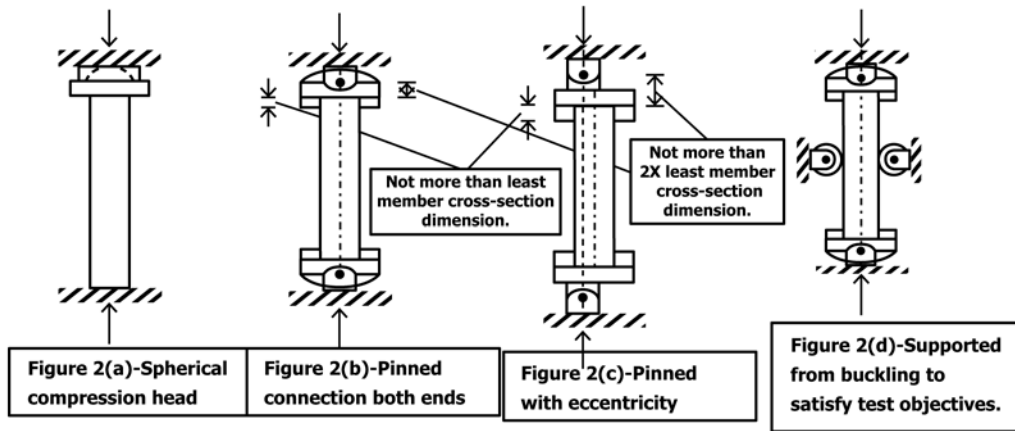


FIG. 2 Various Loading Conditions

center of the sphere shall be on the plane of the specimen contact surface. The size of the compression plate shall be larger than the contact surface. It has been found convenient to provide an adjustment for moving the specimen on its bearing plate with respect to the center of spherical rotation to ensure axial loading.

6.3.2 *Pinned*—As conceptually depicted in Fig. 2(b), a pinned end condition shall use a fixture capable of rotating about an axis perpendicular to the column length. The size of the compression plate shall be larger than the column contact surface. The pivot point of the fixture shall be aligned with the centerline of the test column. Depending upon the experimental objectives, the pivot(s) shall be positioned to permit rotation about the weak column axis, the strong column axis, or both. The pivot locations shall be positioned as close to the column bearing surface as practical, but at a distance of not more than two times the smallest column cross-sectional dimension. The pivot points of the fixtures shall consist of greased bolts, knife edges, ball-bearings, or other details that minimize the frictional rotation restraint of the fixture. Retainer blocks, angles, clamping fixtures, or other attachments may be used to ensure that the column does not slide off the bearing fixtures under load. However, these devices shall not protrude along the column length a distance greater than the minimum cross-sectional dimension of the column.

6.3.3 *Eccentric*—An eccentric load may be applied by using a pinned end condition that is not aligned with the member centerline as depicted in Fig. 2(c). The degree of eccentricity about each member axis shall be selected to satisfy the experimental objectives and recorded.

6.3.4 *Other*—An alternate end condition may be chosen to specifically replicate a field application condition or other experimental objective. The details of the non-standard end conditions shall be fully described and reported.

6.4 *Bracing*—As conceptually illustrated in Fig. 2(d), lateral bracing shall be installed as required to satisfy the experimental objectives. The bracing fixtures employed for the test shall use a roller or other detailing to minimize friction to provide lateral restraint without imparting axial resistance to the column. The number, position, and details of the braces about each axis shall be reported.

NOTE 2—Bracing may be installed about the weak axis, the strong axis, or both.

6.5 *Compressometer*—A compressometer as shown in Fig. 1 shall be used. The measuring instruments shall conform to class D (or better) of Practice E83.

6.5.1 *Gage Length*—For modulus of elasticity calculations, a device shall be provided by which the deformation of the specimen is measured with respect to specific paired gage points defining the gage length. To obtain test data representative of the test material as a whole, such paired gage points shall be located symmetrically on the lengthwise surface of the specimen as far apart as feasible, yet at least one times the larger cross-sectional dimension from each of the contact surfaces. At least two pairs of such gage points on diametrically opposite sides of the specimen shall be used to measure the average deformation.

6.6 *Deflectometer*—A suitable device to measure out-of-plane deflection of the member as shown in Fig. 1.

NOTE 3—A dial gage or electronic displacement transducer mounted to the frame of the machine reacting at mid-height of the specimen is a satisfactory method.

7. Test Specimen and Sampling

7.1 The test specimen shall consist of a structural member commercially used in structural applications, that is, in sizes greater than 2 in. by 2 in. (51 mm by 51 mm) cross section.

7.2 *Identification*—Material or materials of the test specimen shall be identified as fully as possible by including the origin or source of supply, composition, manufacturing process and conditioning, chemical treatment, fabrication, and other pertinent physical or mechanical details that may affect the strength. Details of this information shall depend on the material or materials in the member.

7.3 The material being tested shall be representative of production. Where prototypes (non-production) are tested, the specimens shall be specifically identified as such.

7.4 The number of replicates shall be chosen to satisfy the experimental objectives. As a guideline, Practice D2915 can be used to determine the number of samples.