ASTM INTERNATIONAL

Designation: E 455 – 98

Standard Test Method for
Static Load Testing of Framed Floor or Roof Diaphragm Constructions for Buildings[1]

This standard is issued under the fixed designation E 455; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers procedures designed (*1*) to evaluate the static shear capacity of a typical segment of a framed diaphragm under simulated loading conditions, and (*2*) to provide a determination of the stiffness of the construction and its connections. A diaphragm construction is an assembly of materials designed to transmit shear forces in the plane of the construction.

1.2 No effort has been made to specify the test apparatus, as there are a number that can be used as long as the needs of the testing agency are met. If round-robin testing is to be conducted, test apparatus and testing procedures shall be mutually agreed upon in advance by the participants.

1.3 The text of this standard contains notes and footnotes that provide explanatory information and are not requirements of the standard. Notes and footnotes in tables and figures are requirements of this standard.

1.4 *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 appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see Section 5.

2. Terminology

2.1 *Symbols*:

E = modulus of elasticity of flange or web material, depending upon which material is held constant in a transformed section analysis, psi (or MPa)

G = shear modulus of the web material, psi (or MPa)

G' = shear stiffness of the diaphragm obtained from test (includes shear deformation factor for the connection system), lbf/in. (or N/mm)

I = moment of inertia of the transformed section of the diaphragm based on webs or flanges, in.^{4} (or mm^4)

L = total span of a simply supported diaphragm, in. (or mm)

P = concentrated load, lbf (or N)

R_u = maximum diaphragm reaction, lbf (or N)

S_u = ultimate shear strength of the diaphragm, lbf/ft (or N/m)

a = span length of cantilever diaphragm, in. (or mm)

b = depth of diaphragm, in. (or mm)

t = thickness of web material, in. (or mm)

w = uniform load, lbf/in. (or N/mm)

Δ_b = bending deflection of diaphragm, in. (or mm)

Δ_k = empirical expression for that portion of the diaphragm deflection contributed by the shear deformation of the connection system, in. (or mm)

Δ_s = pure shear deformation of diaphragm, in. (or mm)

Δ_s' = apparent total shear deformation of the diaphragm based on test (see section 8.1.2.2), in. (or mm). This factor includes both the pure shear deformation and that contributed by distortion of the connection system.

Δ_t = total deflection of diaphragm, in. (or mm)

$\Delta_{1,2,---}$ = deformation measured at Point 1, 2, _ _ _, in. (or mm)

3. Summary of Method

3.1 The general purpose of this test method is to evaluate the shear forces that can be carried by the web of a framed floor or roof diaphragm assembly by testing a simulation of the construction. The test method outlines basic procedures for the static load testing of these constructions using simple beam or cantilever-type test specimens. Suggested specimen and test

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setup details are provided, along with loading procedures, instrumentation, and evaluation methods.

3.2 *Construction*:

3.2.1 *Diaphragm Performance Assumptions*—These diaphragm assemblies, assumed to act as plate girders, span between shear walls, moment bents, or other constructions that furnish the end or intermediate supports to the system. The chord members of the assembly perpendicular to the line of applied load act as the flanges of the girder, and the plate or panel elements act as the web. A schematic drawing of a simple span diaphragm is shown in Fig. 1.

3.2.2 *Connections*—The performance of the diaphragm is influenced by the type and spacing of the panel attachments and perimeter anchorage. It is necessary to ensure that the type of connection system used and its application as nearly as possible duplicate the system intended for use in the prototype structure.

3.3 *Deformations*—The in-plane diaphragm deformation(s) shall be recorded. The total in-plane deformation of a diaphragm consists of bending and shear deformation plus any additional deformation caused by distortion of the connection system. Table 1 contains some useful deflection equations.

4. Significance and Use

4.1 Framed floor and roof systems are tested by this test method for static shear capacity. This test method will help determine structural diaphragm properties needed for design purposes.

5. Apparatus

5.1 *Test Assembly*:

5.1.1 *General*—The diaphragm test assembly consists of a frame or framing system on which the elements comprising the web of the diaphragm are placed. The elements are fastened to the frame in a manner equivalent to their attachment in the field. The assembly may be tested horizontally or vertically.

Either a cantilever or a simple span diaphragm assembly may be used, with concentrated or distributed loading.

5.1.2 *Frame Requirements*—The frame is a part of the test assembly and shall consist of members of the same or similar materials as those intended for use in the prototype construction. The test frame members shall be of equal or less strength than those intended for use in the prototype construction. If the test objective is to force failure to occur elsewhere in the assembly, make the test frame members stronger and note the modification in the test report. The frame shall be calibrated to establish its load-deformation characteristics before attaching the diaphragm elements. If the frame has a stiffness equal to or less than 2 % of the total diaphragm assembly, no adjustment of test results for frame resistance need be made. However, if the frame stiffness is greater than 2 % of the total assembly, the test results shall be adjusted to compensate for frame resistance.

5.1.2.1 *Cantilever Frame* (see Fig. 2)—A pinned frame reaction at corner (*C*) shall be provided to transfer the horizontal force (*P*) through the diaphragm into the support system. The pin shall be located as close as possible to the diaphragm-to-frame contact plane to minimize warping of the diaphragm surface. A vertical reaction roller or rollers shall be provided in the diaphragm plane at corner (*H*). The frame shall be laterally supported at adjacent corners (*D*) and (*E*) on rollers and at other locations as necessary to prevent displacement of the diaphragm from the plane of testing, but not to restrict in-plane displacements.

5.1.2.2 *Simple Span Frame* (see Fig. 3)—In-plane reactions shall be provided at points (*E*) and (*H*) as shown to resist the applied test load or loads. The frame shall be supported with rollers at points (*C*), (*D*), (*E*), and (*H*), and under each loading point. Hold-downs with rollers shall be provided to prevent displacement of the specimen from the plane of testing but not to restrict in-plane displacements. The diaphragm can also be
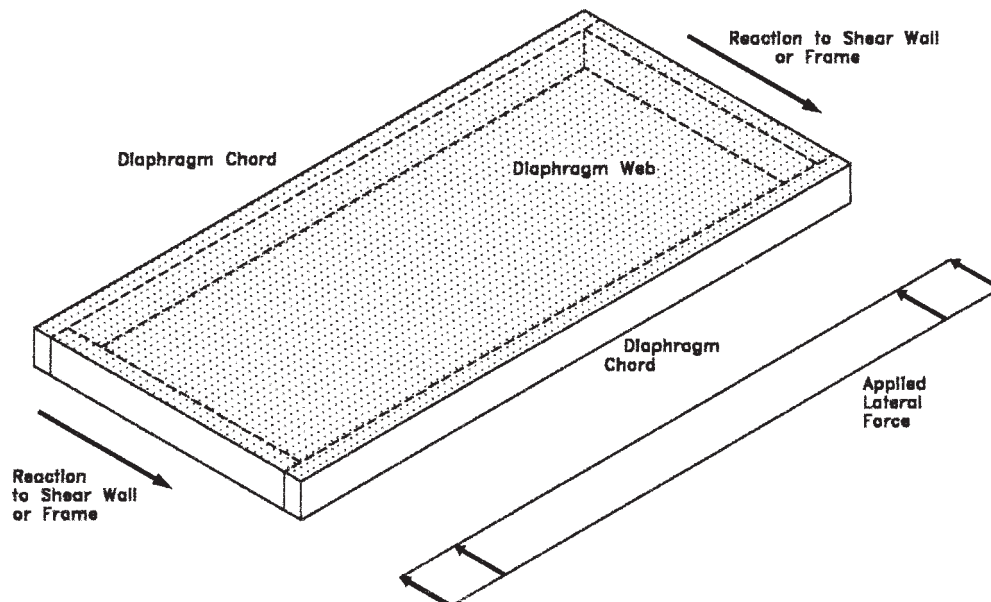

FIG. 1 Schematic of Simple Span Diaphragm

TABLE 1 Useful Deflection Equations

NOTE 1—Other equations may be applicable depending on the number of load points used.

Type of Beam	Loading Condition	Maximum Deflections[A]		
		Δ_b	Δ_s	$\Delta_s{'}$
Simple beam	uniform load	$5wL^4/384EI$	$wL^2/8Gbt$	$wL^2/8G'b$
Simple beam	third-point load[B]	$23PL^3/648EI$	$PL/3Gbt$	$PL/3G'b$
Cantilever beam	uniform load	$wa^4/8EI$	$wa^2/2Gbt$	$wa^2/2G'b$
Cantilever beam	concentrated load at free end	$Pa^3/3EI$	Pa/Gbt	$Pa/G'b$

[A]At midspan of simple beam and free end of cantilever beam. Make appropriate adjustment in units as required for compatibility when SI units are used.
[B]For bending deflection at the load points under a third-point load, use the following equation:

$$\Delta_{b(at\ L/3)} = (5PL^3/162EI)$$
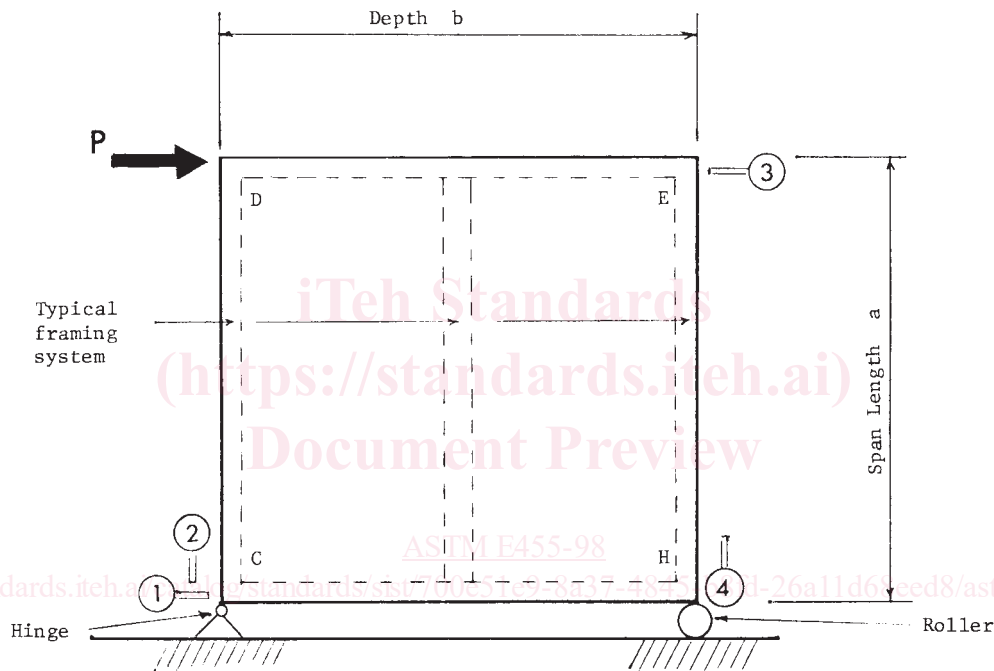
NOTE 1—|sr◯ Dial gage or other deflection measuring device.
NOTE 2—Lateral restraint devices are not shown, and should not restrict movement in the plane of the diaphragm.
FIG. 2 Plan of a Cantilever Beam Diaphragm Test with a Concentrated Load

supported by tension reactions at points (*C*) and (*D*) instead of reactions shown at points (*E*) and (*H*) in Fig. 3.

5.1.3 *Diaphragm Size*:

5.1.3.1 *Cantilever Diaphragm*—The diaphragm shall be tested on a span length *a*, as shown in Fig. 2, equal to or greater than the typical support spacing likely to be used in the building. The test assembly shall not be less than 8 ft (2.4 m) in either length or width; nor shall it contain less than four elements if the diaphragm consists of individual elements. The diaphragm shall contain typical end and side joints for the elements.

NOTE 1—When the web of the diaphragm is made of individual elements, they might not be equally effective for the same span length if laid perpendicular or parallel to the load direction.

5.1.3.2 *Simple Beam Diaphragm*—The diaphragm length and depth shall be as shown in Fig. 3, where the dimensions *a*

and *b* have the same connotation as above with a minimum dimension in either case of 8 ft (2.4 m). The diaphragm shall contain typical end and side joints for the elements.

6. Safety Precautions

6.1 Tests of this type can be dangerous. Equipment and facilities must be designed with ample safety factors to ensure that it is the specimen that fails and not the test apparatus or facilities. Observers and sensitive instrumentation must be kept away from diaphragms when loading to failure or in a load range where performance is unknown.

7. Number of Tests

7.1 A minimum of two specimens shall be tested to determine the value of a given construction. If the plan of the diaphragm is unsymmetrical, the second test shall be run with