AMERICAN NATIONAL STANDARDS INSTITUTE/ STEEL DECK INSTITUTE

ANSI/SDI AISI S921-2019 (R2024)

Test Standard for Determining the Strength and Stiffness of Cold-Formed Steel Truss Assemblies and Components

Approved American National Standard

ANSI

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First Printing, December 2024

PREFACE

(This Preface is not part of the ANSI/SDI AISI S921-2019 (R2024), *Test Standard for Determining the Strength and Stiffness of Cold-Formed Steel Truss Assemblies and Components*, but is included for informational purposes only.)

This Standard is a reaffirmation of ANSI/AISI S921-2019.

This Standard has been developed as a consensus document for the design of cold-formed steel members and structures. The intention is to provide criteria for routine use and not to provide specific criteria for infrequently encountered problems, which occur in the full range of structural design. The Symbols and Appendices to this Standard are an integral part of the Standard. A non-mandatory Commentary has been prepared to provide background for the Standard provisions and the user is encouraged to consult it. Additionally, non-mandatory User Notes may be interspersed throughout the Standard to provide concise and practical guidance in the application of the provisions. The user is cautioned that professional judgment must be exercised when data or recommendations in the Standard are applied, as described more fully in the disclaimer notice preceding this Preface.

AISI S921-19

American
Iron and Steel
Institute

AISI STANDARD

S921-19

Test Standard for Determining the Strength and Serviceability of Cold-Formed Steel Truss Assemblies and Components

2019 Edition

Approved by
the AISI Committee on Specifications for the Design of
Cold-Formed Steel Structural Members

DISCLAIMER

The material contained herein has been developed by the American Iron and Steel Institute Committee on Specifications for the Design of Cold-Formed Steel Structural Members. The organization and the Committee have made a diligent effort to present accurate, reliable, and useful information on testing of cold-formed steel members, components or structures. The Committee acknowledges and is grateful for the contributions of the numerous researchers, engineers, and others who have contributed to the body of knowledge on the subject. With anticipated improvements in understanding of the behavior of cold-formed steel and the continuing development of new technology, this material will become dated. It is anticipated that future editions of this test procedure will update this material as new information becomes available, but this cannot be guaranteed.

The materials set forth herein are for general information only. They are not a substitute for competent professional advice. Application of this information to a specific project should be reviewed by a registered professional engineer. Indeed, in most jurisdictions, such review is required by law. Anyone making use of the information set forth herein does so at their own risk and assumes any and all resulting liability arising therefrom.

1st Printing – January 2020

PREFACE

The American Iron and Steel Institute Committee on Specifications developed this Standard to establish procedures for confirmatory and performance testing of the strength and serviceability of cold-formed steel truss assemblies and components.

The Committee acknowledges and is grateful for the contributions of the numerous engineers, researchers, producers and others who have contributed to the body of knowledge on this subject.

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AISI S921-19
TEST STANDARD FOR DETERMINING THE STRENGTH AND SERVICEABILITY OF COLD-FORMED STEEL TRUSS ASSEMBLIES AND COMPONENTS

1. Scope

1.1 This Standard establishes procedures for *confirmatory* and *performance tests* for the strength and serviceability of cold-formed steel trusses.

1.2 This Standard is applicable to roof and floor trusses, whether built as *component assemblies* or fabricated on site.

1.3 This Standard is applicable to laboratory or in situ testing.

1.4 This Standard is composed of Sections 1 through 13 inclusive.

2. Referenced Documents

The following documents or portions thereof are referenced within this Standard and shall be considered as part of the requirements of this document.

a. American Iron and Steel Institute (AISI), Washington, DC:

AISI S100-16, *North American Specification for the Design of Cold Formed Steel Structural Members, 2016 Edition*

AISI S240-15, *North American Standard for Cold-Formed Steel Framing, 2015 Edition*

b. ASTM International (ASTM), West Conshohocken, PA:

A370-15, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

E6-15, *Standard Terminology Relating to Methods of Mechanical Testing*

IEEE/ASTM SI10-10, *American National Standard for Metric Practice*

3. Terminology

Terms not defined in Section 3 of this Standard, AISI S100, AISI S240, or ASTM E6 shall have the ordinary accepted meaning for the context for which they are intended.

4. Units of Symbols and Terms

Any compatible system of measurement units shall be permitted to be used in this Standard, except where explicitly stated otherwise. The unit systems considered in this Standard shall include U.S. customary units (force in kips and length in inches) and SI units (force in Newtons and length in millimeters) in accordance with IEEE/ASTM SI10.

5. Precision

5.1 The load-measuring device or devices used shall be capable of measuring loads to an accuracy of ±2% of the ultimate load.

User Note:
The capacity (range) of the load-measuring device should be appropriate to the expected maximum tested load. The use of a measuring device with a calibrated capacity greatly exceeding the anticipated load is inappropriate. A target ratio of the load cell capacity to specimen strength of no greater than three is recommended.

The tests should be conducted on a testing machine that complies with the requirements of ASTM E4-16, *Standard Practices for Force Verification of Testing Machines*.

5.2 The deflection-measuring devices, if employed, shall avoid magnification of deflection readings due to a movement of supports during loading. When deflection-measuring systems that do not compensate for support settlement are used, measurement of support displacement under load shall be required in order to obtain an accurate load-deflection response. Deflection readings and measuring devices shall have an accuracy of 0.01 inches (0.25 mm).

6. Test Apparatus

6.1 The load delivery system shall consist of a test rig utilizing hydraulic or pneumatic cylinders, test chamber, dead weight, or any other means capable of achieving the objectives of the test.

6.2 When loads are applied using a test chamber, the test chamber shall be capable of supporting a positive or negative pressure differential.

6.3 When loads are applied using dead weight, such as sand, masonry units, or water, the loading material shall be positioned to prevent arching action.

6.4 When loads are applied using water, the water shall be compartmentalized into cells to prevent a non-uniform load as the truss deflects.

7. Test Specimen

7.1 For the purpose of this test, a test specimen shall consist of a full-scale truss assembly representative of those intended for use in the final product.

7.2 The materials contained within the test specimen shall be representative of those intended for use in the final product. For *performance tests* and *confirmatory tests*, the mechanical properties of the steel shall be determined in accordance with Section K2.3 of AISI S100.

7.3 Fabrication of the test specimen shall be representative of that intended for the finished product.

8. Test Setup

8.1 A test shall consist of a single truss, pair of trusses, or multiple trusses.

8.2 A single truss shall be tested in either a vertical position (normal or inverted) or in a horizontal position. A pair of trusses or multiple trusses shall be tested in a vertical position (normal or inverted).

8.3 Reaction supports shall provide clearance above the ground or restraining frame to allow for normal displacements, ease of loading and instrumentation, and to provide room for observations and measurements. Supports shall have strength and stiffness to resist deformations during tests.

8.4 Support reaction hardware shall be typical of that planned for use in the completed structure or as required to satisfy the intent of the tests.

8.5 Lateral support shall be provided beneath a single truss when tested horizontally to keep the test truss flat and to minimize any adverse lateral displacement caused by gravity. Lateral support shall be provided for single, paired, or multiple trusses when tested vertically to properly restrain the top chord, bottom chord and web truss members as designed, and to minimize adverse lateral displacement and prevent buckling of the assembly. Where lateral support is used, it shall not interfere with the free in-plane displacement of the truss or truss assembly. The components of the test truss shall not be laterally supported in a manner that will exceed that intended in a representative installation.

9. Test Procedure - General

9.1 Loading of the test specimens shall be achieved either using an incremental loading or a continuous loading method.

User Note:
Care should be exercised to avoid non-uniform loading of a pair of trusses or multiple trusses.

10. Test Procedure - Full-Scale Confirmatory Load Test

10.1 A full-scale *confirmatory test* is permitted to consist of a single test specimen in accordance with Section K2.2 of AISI S100.

10.2 When loading incrementally, the applied load shall be increased in increments not exceeding 1/5 of the test load until the test load is reached. The test load shall be held for not less than 5 minutes, and then the *confirmatory test* shall be considered complete.

10.3 When using continuous loading, the applied load shall be increased uniformly until the test load is reached. The speed of loading shall not exceed 1/10 of the test load per minute. The test load shall be held for not less than 5 minutes, and then the *confirmatory test* shall be considered complete.

10.4 Tests to Confirm Deflection

a. When a test to confirm deflection is required, the applied load shall be increased up to the test load, at which time deflections shall be measured.
b. When loading incrementally, the applied load shall be increased in increments not exceeding 1/5 of the test load until the test load is reached. When using continuous loading, the applied load shall be increased uniformly until the test load is reached.
c. When testing a pair of trusses or multiple trusses, the deflections of the trusses at corresponding locations are permitted to be averaged. Support displacement under load shall be measured to obtain an accurate load-deflection response when deflection-measuring systems that do not compensate for support settlement are used.

11. Test Procedure - Full-Scale Performance Test

11.1 The minimum number of test specimens shall be in accordance with Section K2.1 of AISI S100.

11.2 When loading incrementally, each of the increments of the test load shall not exceed 1/5 of the estimated ultimate load. If structural failure has not occurred at the estimated

ultimate load, additional load is to be applied until failure occurs.

11.3 When using continuous loading, the applied load shall be increased uniformly until structural failure occurs.

11.4 When using continuous loading, the speed of loading shall not exceed 1/10 of the estimated ultimate load per minute.

11.5 Deflection readings shall be recorded at each load increment or continuously. When testing pairs of trusses or multiple trusses, the deflections of the trusses at corresponding locations are permitted to be averaged. Support displacement under load shall be measured to obtain an accurate load-deflection response when deflection-measuring systems that do not compensate for support settlement are used.

11.6 For incremental loading, the ultimate load shall be the load level before failure. For continuous loading, the ultimate load shall be the load at failure.

12. Test Evaluation

12.1 The self-weight of the truss shall be included in the total load applied to trusses that are tested in a vertical position to compensate for the effect of dead loads and gravity.

12.2 The *confirmatory test* for strength shall be deemed successful if the test specimen complies with the loading requirements in Sections 9 and 10.

12.3 The *confirmatory test* for deflection shall be deemed successful if the measured deflections of the test specimen do not exceed the design deflection limit.

12.4 The *performance test* is permitted to be used to determine the available strength [factored resistance] for the truss or truss component. For ASD, the available strength of the truss or truss component shall be the nominal strength divided by the safety factor; and for LRFD, the available strength [factored resistance] of the truss or truss component shall be the nominal strength [resistance] multiplied by the resistance factor. The nominal strength [resistance] of the truss or truss component is permitted to be taken as the average of the ultimate loads of the tested specimens. The resistance factor or safety factor for the *performance test* shall be determined in accordance with Section K2.1 of AISI S100 with the statistical data from Table K2.1.1-1 for the type of component and the corresponding failure mode.

12.5 The *performance test* is permitted to be used to determine the stiffness of the truss. The elastic stiffness, K_{truss}, of the truss is permitted to be determined by

$$K_{truss} = P_{0.4}/\Delta_{0.4} \qquad (Eq.\ 1)$$

where

$P_{0.4}$ = load at 40% of the ultimate load

$\Delta_{0.4}$ = deflection measured at load $P_{0.4}$

13. Report

13.1 The test report shall include a description of the test specimen configuration with drawings detailing all pertinent dimensions. The description shall define the size, geometric type, and strength of all truss components. Pertinent connector information shall include type and size.

13.2 The measured mechanical properties (including base steel thickness, yield stress, tensile

strength and percent elongation) of the truss components shall be included for *performance* and *confirmatory tests*.

13.3 The documentation shall include details of the test setup, load application, deflection-measurement locations, and drawings illustrating the test fixture.

13.4 The test report shall include the ultimate load, description of failure mode(s) and the corresponding component(s), and load-deflection curves (or the load-deflection measurements), as applicable.

13.5 The report shall include certification that the test program was performed under the direction of a registered design professional.

COMMENTARY ON AISI S921-19
TEST STANDARD FOR DETERMINING THE STRENGTH AND SERVICEABILITY OF COLD-FORMED STEEL TRUSS ASSEMBLIES AND COMPONENTS

1. Scope

This Standard is intended for use in the testing of truss assemblies fabricated using cold-formed steel structural members and connections.

A *confirmatory test* is performed with the intent to verify structural performance as defined by calculations in accordance with a recognized specification or standard.

A *performance test* is intended for use when calculation of the nominal strength cannot be made in accordance with recognized calculation design specifications or standards.

This Standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this protocol to establish appropriate safety and health practices and determine the applicability of regulatory limitation prior to use.

6. Test Apparatus

This Standard outlines the procedures to be followed in the static load testing of load-carrying truss assemblies. While the procedure provides direction on what to do, it does not direct the testing agency how to do it. This leaves the selection of the test fixture and loading medium to the discretion of the testing agency. It is the responsibility of the design professional to determine the appropriate loading rate.

Full-scale load tests of any large-size specimen such as a truss can be hazardous to the individuals performing or observing the tests, and can also damage the testing fixtures or the structure housing the test setup due to a sudden release of stored energy at failure. Care should be exercised in the preparation of the test setup to ensure that the failure of a test specimen will not result in a secondary collapse of a structural element not involved in the test.

The test fixture and load application means should be designed with adequate strength [resistance] and stiffness to ensure that it is the test specimen that is being tested and not the test fixture.

In a single truss test, frequently the support at one end will allow rotation but not translation (a rocker) and the other end support will allow both rotation and translation (a roller) so as not to induce additional unintentional secondary stresses into the test truss as it deforms under load.

The loading devices should result in the desired truss-loading situation regardless of whether uniform, concentrated, or a combination of both. The loading system should be such as to allow the application of loads during the test to approximate the overall intended in-service load distribution. Care should be taken to avoid eccentrically applied loads unless this type of loading is desired.

Depending on the truss type and shape, the truss test setup may vary. ASTM E73 (2013) shows static load testing of truss assemblies.

12. Test Evaluation

A full-scale truss *confirmatory test* is the test of a structural system as defined in Chapter K of

AISI S100.

Reference

ASTM E73-13, *Standard Practice for Static Load Testing of Truss Assemblies*, ASTM International, West Conshohocken, PA, 2013.