AWS D1.7/D1.7M:2024
An American National Standard

Guide for Strengthening and Repairing Existing Structures



American Welding Society®



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An American National Standard

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American National Standards Institute
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Guide for Strengthening and Repairing Existing Structures

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Prepared by the
American Welding Society (AWS) D1 Committee on Structural Welding

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This guide provides information on strengthening and repairing existing structures. Included are sections on weldability, evaluation of existing welds, testing and sampling, heat-straightening, and damage repair.

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This standard is subject to revision at any time by the AWS D1 Committee on Structural Welding. It must be reviewed every five years, and if not revised, it must be either reaffirmed or withdrawn. Comments (recommendations, additions, or deletions) and any pertinent data that may be of use in improving this standard are requested and should be addressed to AWS Headquarters. Such comments will receive careful consideration by the AWS D1 Committee on Structural Welding and the author of the comments will be informed of the Committee's response to the comments. Guests are invited to attend all meetings of the AWS D1 Committee on Structural Welding to express their comments verbally. Procedures for appeal of an adverse decision concerning all such comments are provided in the Rules of Operation of the Technical Activities Committee. A copy of these Rules can be obtained from the American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166.

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Foreword

This foreword is not part of this standard but is included for informational purposes only.

The first edition of AWS D1.7, *Guide for Strengthening and Repairing Existing Structures*, was issued in 2010. This guide has been developed to assist in the task of strengthening and repairing existing structures. This guide is intended to provide Engineers and Contractors with general guidance and direction as it relates to weld repairs, weld strengthening, and other procedures to correct challenging issues faced while repairing existing structures.

The second edition of AWS D1.7, has been extensively revised to further assist in the task of strengthening and repairing existing structures.

Informative Annexes. These annexes are not part of this guide but are provided to clarify the guide's recommendations by showing examples, providing information, or suggesting alternative good practices.

Errata. All errata to a standard shall be published in the *Welding Journal* and posted on the AWS website.

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, AWS D1 Committee on Structural Welding, American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166.

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Guide for Strengthening and Repairing Existing Structures

1. General Requirements

1.1 Scope

This guide contains basic information pertinent to the strengthening and repair of existing steel structures. This includes welded repairs, heat-assisted straightening, fatigue improvements, and nonwelded but related repairs such as partial or complete member replacement. The information contained in this guide provides direction and guidance for both Engineers and Contractors. Specifically, it contains background information that will be useful to the Engineer who is obligated under the "Strengthening and Repair of Existing Structures" clause of AWS D1.1/D1.1M or other contract provisions to provide a comprehensive plan for strengthening and repairing steel structures. Various repair strategies may be developed using the information provided herein and welding procedures may be developed based upon applicable AWS D1 codes.

This guide applies to existing structures made of the following materials:

(1) Carbon or low-alloy steel with a minimum specified yield strength of 100 ksi [690 MPa] or less,

(2) Cast iron, and

(3) Wrought iron.

Strengthening and repairing of existing structures may include modifications to meet new serviceability or strength requirements as well as conditions requiring repair. The Engineer should prepare contract documents for the work, including requirements for design, base and weld metals, workmanship, inspection, field requirements (traffic routes, temporary support, hazards, utilities, etc.), and documentation.

Although this guide is not written with mandatory requirements, mandatory language, such as the use of "shall," will be found in those portions of the document where failure to follow the instructions or procedures could produce inferior, misleading, or unsafe results.

1.2 Limitations

This guide is not intended to provide detailed procedures to accomplish specific strengthening or repair operations; instead, information supplied herein is intended to provide users with an overall approach for the assessment and repair of steel structures. This includes determining the cause of the observed or calculated deficiencies, documenting and quantifying those conditions, determining the appropriate repairs, preparing contract documents, and implementing the repairs when necessary.

Repair and strengthening activities may require guidance to address situations that may be encountered. This guide is not comprehensive in the guidance that is offered. In addition to unlisted subjects, the following are not addressed in this guide:

(1) Structures made of steels less than 1/8 in [3 mm] thick,

(2) Pressure vessels and pressure piping,

(3) Seismic upgrades,

(4) Seismic damage (FEMA 352 is recommended for such applications),

(5) New construction (applicable D1 code is recommended for such applications), and

(6) Abatement of asbestos, lead, or other safety hazards as may be required by applicable regulatory agencies.

1.3 Approval

All references to "approval" should be interpreted to mean approval by the Authority Having Jurisdiction, the Engineer, the Original Equipment Manufacturer (OEM), or other contractually responsible parties.

1.4 Units of Measurement

This standard makes use of both U.S. Customary Units and the International System of Units (SI). The latter are shown within brackets ([ ]) or in appropriate columns in tables and figures. The measurements may not be exact equivalents; therefore, each system must be used independently.

1.5 Safety

Safety and health issues and concerns are beyond the scope of this standard, and therefore, are not addressed herein.

Safety and health information is available from the following sources:

American Welding Society:

(1) ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*

(2) AWS Safety and Health Fact Sheets

(3) Other safety and health information on the AWS website

Material or Equipment Manufacturers:

(1) Safety Data Sheets supplied by materials manufacturers

(2) Operating Manuals supplied by equipment manufacturers

Applicable Regulatory Agencies

Work performed in accordance with this standard may involve the use of materials that have been deemed hazardous, and may involve operations or equipment that may cause injury or death. This standard does not purport to address all safety and health risks that may be encountered. The user of this standard should establish an appropriate safety program to address such risks as well as to meet applicable regulatory requirements. ANSI Z49.1 should be considered when developing the safety program.

2. Normative References

The documents listed below are referenced within this publication and are mandatory to the extent specified herein. For undated references, the latest edition of the referenced standard shall apply. For dated references, subsequent amendments, or revisions of the publications may not apply since the relevant requirements may have changed.

A list of informative documents is provided in Annex A, including those published by AWS, AISC, AASHTO, and AREMA.

American Welding Society (AWS) standard:

AWS A3.0M/A3.0, *Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying.*

3. Terms and Definitions

AWS A3.0M/A3.0, *Standard Welding Terms and Definitions*, provides the basis for terms and definitions used herein. However, the following terms and definitions are included below to accommodate usage specific to this document.

alternating current field measurement (ACFM). An electromagnetic technique for nondestructive testing (NDT), detection, and sizing of surface breaking cracks. It was derived from the methods used in eddy-current testing and works on all metals, ferrous or nonferrous.

bloom. A semi-finished steel product produced by continuous casting or rolling from an ingot.

coefficient of thermal expansion. An alloy-specific numerical value (with units of in/in/°F [mm/mm/°C]) which can be used to calculate the change in unit length or the change in volume of a solid when its temperature is changed.

cold-working. Process of increasing yield strength of metal by plastic deformation, typically at ambient temperature.

condition evaluation. Determination of the condition of a structure or component. This can include analysis, visual inspection, NDT, destructive testing, etc.

Contractor. Any company, or individual representing a company, responsible for fabrication, erection, manufacturing or welding, in conformance with the provisions of this guide.

deterioration. Degradation of the structure due to erosion, corrosion, etc.

distortion. Alteration of the original structure or structural element's geometry, often due to impact, overload, fire damage or welding-related shrinkage.

elastic modulus. Ratio of the stress in a body to the corresponding strain. Also referred to as modulus of elasticity or Young's modulus.

Engineer. Designated individual who acts for, and on behalf of, the Owner on all matters related to the evaluation and repair of steel structures. The Engineer's responsibilities may include specifying repair materials; preheat, interpass temperature control and postweld heat treatment; inspection requirements; and quality requirements.

hardenability. Property that determines the depth and distribution of hardness in response to heating and cooling.

heat shaping. The application of heat, below the austenite formation temperature, in a controlled, repetitive pattern to produce upsetting in a restrained section. With restraint present (either internal or external), the heated portion of the material expands and thickens, or upsets. During the cooling phase, the material then contracts, resulting in a gradual deformation of the member. The heating and cooling process is repeated until the desired movement is achieved.

heat-straightening. A specific application of heat shaping to repair or correct steel that has been distorted by welding, damaged, or otherwise plastically deformed.

hot mechanical straightening. The application of an external force after heating below the austenite formation temperature in order to straighten a deformed member. The applied force yields the member and results in a large movement in a single cycle, rather than the gradual movement associated with the repetitive heating and cooling of heat-straightening.

hydrogen diffusion. The process of dispersing excess hydrogen trapped in solidifying weld metal to areas of lower hydrogen.

hydrogen diffusion postheat. A thermal treatment applied to an assembly after welding for the purpose of releasing diffusible hydrogen.

ingot. A casting of simple shape, suitable for hot working or remelting.

Inspector. Designated person responsible for inspection and quality matters.

killing. Process of deoxidizing steel by the addition of an agent prior to solidification.

notch. A V-shaped indentation, often occurring during fabrication or erection due to impact or improper cutting.

Original equipment manufacturer (OEM). A Contractor that assumes some or all of the responsibilities assigned to the Engineer.

Owner. The individual or company that exercises legal ownership of the final product or structural assembly produced to this guide.

postweld heat treatment (PWHT). Any heat treatment after welding.

quenching. Rapid cooling to achieve desired material properties.

section loss. Reduction in the cross-sectional area of a component, often due to wear or corrosion.

strain. Ratio of change in length to original length for a specific stress. Units are in/in [mm/mm].

tempering. Heating metal to below the minimum temperature for austenite formation, typically to increase toughness.

transformation range. The range of temperatures within which a phase forms during heating and transforms during cooling.

yield strength. The stress that causes permanent, plastic deformation.