



GUIDE DESIGN SPECIFICATIONS FOR BRIDGE TEMPORARY WORKS

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ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
AIISI	American Iron and Steel Institute
AITC	American Institute of Timber Construction
ANSI	American National Standards Institute
APA	American Plywood Association
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
BOCA	Building Officials & Code Administrators
FHWA	Federal Highway Administration
NAVFAC	Naval Facilities Engineering Command
NDS	National Design Specifications for Wood Construction
NFPA	National Forest Products Association
OSHA	Occupational Safety and Health Administration
PCI	Precast/Prestressed Concrete Institute
SSFI	Scaffolding, Shoring and Forming Institute
UBC	Uniform Building Code

GENERAL NOTATION

in.	inches
ft	feet
plf	pounds per linear foot
psi	pounds per square inch
ksi	kips per square inch
psf	pounds per square foot
ksf	kips per square foot
tsf	tons per square foot
pcf	pounds per cubic foot
fps	feet per second
hr	hour

SI* (MODERN METRIC) CONVERSION FACTORS									
APPROXIMATE CONVERSIONS TO SI UNITS					APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol When You Know		Multiply by	To Find	Symbol	Symbol When You Know		Multiply by	To Find	Symbol
LENGTH					LENGTH				
in.	inches	25.4	millimeters	mm	mm	millimeters	0.039	inches	in
ft	feet	0.305	meters	m	m	meters	3.28	feet	ft
yd	yards	0.914	meters	m	m	meters	1.09	yards	yd
mi	miles	1.61	kilometers	km	km	kilometers	0.621	miles	mi
AREA					AREA				
in. ²	square inches	645.2	square millimeters	mm ²	mm ²	square millimeters	0.0016	square inches	in ²
ft ²	square feet	0.093	square meters	m ²	m ²	square meters	10.764	square feet	ft ²
yd ²	square yards	0.836	square meters	m ²	m ²	square meters	1.195	square yards	yd ²
ac	acres	0.405	hectares	ha	ha	hectares	2.47	acres	ac
mi ²	square miles	2.59	square kilometers	km ²	km ²	square kilometers	0.386	square miles	mi ²
VOLUME					VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL	mL	milliliters	0.034	fluid ounces	fl oz
gal	gallons	3.785	liters	L	L	liters	0.264	gallons	gal
ft ³	cubic feet	0.028	cubic meters	M ³	m ³	cubic meters	35.71	cubic feet	ft ³
yd ³	cubic yards	0.765	cubic meters	m ³	m ³	cubic meters	1.307	cubic yards	yd ³
NOTE: Volumes greater than 1000 l shall be shown in m ³ .									
MASS					MASS				
oz	ounces	28.35	grams	g	g	grams	0.035	ounces	oz
lb	pounds	0.454	kilograms	kg	kg	kilograms	2.202	pounds	lb
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "T")	Mg (or "T")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact)					TEMPERATURE (exact)				
F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	C	C	Celsius temperature	1.8C + 32	Fahrenheit temperature	F
ILLUMINATION					ILLUMINATION				
fc	foot-candles	10.76	lux	lx	lx	lux	0.0929	foot-candles	fc
fl	foot-lamberts	3.426	candela/m ²	cd/m ²	cd/m ²	candela/m ²	0.2919	foot-Lamberts	fl
FORCE AND PRESSURE OR STRESS					FORCE AND PRESSURE OR STRESS				
lbf	poundforce	4.45	newtons	N	N	newtons	0.225	poundforce	lbf
lbf/in. ²	poundforce per square inch	6.89	kilopascals	kPa	kPa	kilopascals	0.145	poundforce per square inch	lbf/in. ²

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised September 1993)

PREFACE

Background

In 1991, a study was initiated by the Federal Highway Administration (FHWA) to identify the current state of practice in the United States and abroad for designing, constructing, and inspecting the temporary works used to construct highway bridge structures. This study was known as the FHWA Bridge Temporary Works Research Program. One of the documents produced from this study was FHWA Publication No. FHWA-RD-93-032, *Guide Design Specification for Bridge Temporary Works*, which was subsequently adopted by the American Association of State Highway and Transportation Officials (AASHTO) in 1995.

There have been several initiatives since original publication of the AASHTO *Guide Design Specifications for Bridge Temporary Works* that have advanced the design and construction of the temporary works used in bridge construction. The Structural Engineering Institute of the American Society of Civil Engineers (ASCE) developed SEI/ASCE 37-02, a standard for design loads on structures during construction. Based upon the period of time that has elapsed since the development of the original *Guide Design Specification*, and the development of other related standards over this period of time, the reassessment and updating of the guide design specification seemed appropriate and necessary.

Summary of Changes

This 2017 Second Edition of the AASHTO *Guide Design Specifications for Bridge Temporary Works* has been updated to reflect current codes and practice. The organization is generally the same as the First Edition, but the construction provisions have been moved to the AASHTO *LRFD Bridge Construction Specifications*. The format was also changed so the commentary is adjacent to the specification (two column format) similar to the *AASHTO LRFD Bridge Construction Specifications*. The loads in Section 2—Falsework have also been significantly revised and both ASD and LRFD design specifications are included.

Acknowledgments

The AASHTO *Guide Design Specifications for Bridge Temporary Works* was revised under NCHRP Project 20-07/ Task 294 by Wiss, Janney, Elstner Associates, Inc., Northbrook, Illinois. John F. Duntemann was the Principal Investigator. This project was directed by the NCHRP Task Group, which consisted of the following representatives:

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Ramon Cook, *The Burke Company*
Robert Desjardins, *Cianbro Corporation*

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2020 INTERIM REVISIONS INSTRUCTIONS AND INFORMATION

General

AASHTO has issued proposed interim revisions to the *AASHTO Guide Design Specifications for Bridge Temporary Works*, Second Edition (2017). This packet contains the revised pages. They are designed to replace the corresponding pages in the book.

Affected Articles

Underlined text indicates revisions that were approved in 2019 by the AASHTO Committee on Bridges and Structures. ~~Strikethrough text~~ indicates any deletions that were likewise approved by the Committee. A list of affected articles is included below.

All interim pages are displayed on a pink background to make the changes stand out when inserted in the second edition binder. They also have a page header displaying the interim publication year. Please note that these pages may also contain nontechnical (i.e., editorial) changes made by AASHTO publications staff; any changes of this type will not be marked in any way so as not to distract the reader from the technical changes.

2020 Changed Articles

2.3.5.2

APPENDIX C

APPENDIX E

INTRODUCTION

1.1—SCOPE

This Guide Design Specification has been developed for use by state agencies to include in their existing standard specifications for falsework, formwork, and related temporary construction used to construct highway bridge structures. The specification should also be useful to bridge engineers, falsework designers, contractors, and other engineers. Sections within this specification address falsework, formwork, and temporary retaining structures. Related publications and definitions are identified below.

C1.1

The AASHTO *Guide Design Specification for Bridge Temporary Works* was first published in 1995. This specification was originally developed by Wiss, Janney, Elstner Associates, Inc., of Northbrook, Illinois with the FHWA and directed by the Scaffolding, Shoring and Formwork Task Group of the FHWA. These specifications provided unified design and construction criteria that reflected the best practices at the time the specifications were developed.

Since 1995, there have been several initiatives that have advanced the state of practice related to the design and construction of the temporary works used in bridge construction. ASCE developed SEI/ASCE 37, *Design Loads on Structures during Construction*.

This 2017 Second Edition of the AASHTO *Guide Design Specifications for Bridge Temporary Works* has been updated to reflect current codes and practice. The organization is generally the same as the First Edition, but the construction requirements have been moved to the AASHTO *LRFD Bridge Construction Specifications*. The loads in Section 2—Falsework have also been significantly revised and both ASD and LRFD design specifications are included. These documents—the design and construction specifications—complement each other. The AASHTO *Construction Handbook for Bridge Temporary Works* has also been updated and serves as a useful reference on this subject.

1.2—RELATED PUBLICATIONS

American Association of State Highway and Transportation Officials, AASHTO *LRFD Bridge Construction Specifications*, Third Ed., with 2010, 2011, 2012, 2014, 2015, and 2016 Interim Revisions, Washington, DC, 2010.

American Association of State Highway and Transportation Officials, AASHTO *LRFD Bridge Design Specifications*, Seventh Ed., with 2015 and 2016 interim revisions, Washington DC, 2014.

American Association of State Highway and Transportation Officials, *Construction Handbook for Bridge Temporary Works*, Second Edition, Washington, DC, 2017.

American Association of State Highway and Transportation Officials, *Standard Specifications for Highway Bridges*, 17th Ed., Washington, DC, 2002.

American Society of Civil Engineers, *Minimum Design Loads for Buildings and Other Structures* (ASCE 7-10), Reston, Virginia, 2010.

American Society of Civil Engineers, *Design Loads on Structures During Construction* (ASCE 37-02), American Society of Civil Engineers, Reston, VA, 2002.

Duntemann, J.F., Dunn, L.E., Gill, S., Lukas, R.G., and Kaler, M.D., *Guide Design Specification for Bridge Temporary Works*, Report No. FHWA-RD-93-032, Federal Highway Administration, Washington, DC, November 1993.

Duntemann, J.F., Calabrese, F., and Gill, S., *Construction Handbook for Bridge Temporary Works*, Report No. FHWA-RD-93-034, Federal Highway Administration, Washington, DC, November 1993.

Duntemann, J.F., Anderson, N.S., and Longinow, A., *Synthesis of Falsework, Formwork, and Scaffolding for Highway Bridge Structures*, Report No. FHWA-RD-91-062, Federal Highway Administration, Washington, DC, November 1991.

United States Department of Transportation, Federal Highway Administration, *Accelerated Bridge Construction—Experience in Design, Fabrication, and Erection of Prefabricated Bridge Elements and Systems*, Report No. FHWA-HIF-12-013, Federal Highway Administration, East Hartford, CT, 2011.

U.S. Department of Transportation, Federal Highway Administration, *Certification Program for Bridge Temporary Works* (FHWA-RD-93-033), Federal Highway Administration, Washington, DC, 1993.

U.S. Department of Transportation, Federal Highway Administration, *Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects*, FP-03, Washington, DC, 2003.

1.3—DEFINITIONS

For the purposes of this specification, the following definitions apply:

Cofferdam—A watertight structure that allows foundations to be constructed under dry conditions.

Engineer—Used with a capital “E” refers to the owner’s engineer.

Falsework—Temporary construction used to support the permanent structure until it becomes self-supporting. Falsework includes steel or timber beams, girders, columns, piles, and foundations, and any proprietary equipment including modular shoring frames, post shores, and horizontal shoring.

Formwork—A temporary structure or mold used to retain the plastic or fluid concrete in its designated shape until it hardens. Formwork must have enough strength to resist the fluid

pressure exerted by plastic concrete and any additional fluid pressure effects generated by vibrations.

Scaffolding—An elevated work platform used to support workmen materials and equipment, but not intended to support the structure being constructed.

Shoring—A component of falsework such as horizontal, vertical, or inclined support members. For the purpose of this document, this term is used interchangeably with falsework.

Temporary Retaining Structure—For the purpose of this document, refers to both earth-retaining structures and cofferdams.

1.4—METRIC CONVERSIONS

Conversion of equations from U.S. Customary units to S.I. units is provided in Appendix G.

FALSEWORK

2.1—FALSEWORK DRAWINGS

All elements of the falsework system shall be shown on working drawings, hereinafter referred to as falsework drawings. The falsework drawings shall include the information and details necessary to construct the falsework without reference to any supplemental drawing, calculation sheet, design standard, or other source or reference document.

The falsework drawings shall include all design-controlling dimensions, including beam length, beam spacing, post location and spacing, vertical distance between connections in diagonal bracing, height of falsework bents, and similar dimensions controlling falsework design and erection.

The falsework drawings shall include a superstructure placing diagram, which shall show the concrete placing sequence, placement rate, and all construction joint locations, if not included in or different from contract plans.

When footing-type foundations are to be used, the soil-bearing value assumed in the design shall be shown on the falsework drawings.

When pile-type foundations are to be used, and the vertical distance between the ground line and the top of the pile will equal or exceed four times the pile diameter at the ground line, the falsework drawings shall show the maximum horizontal distance that the top of a falsework pile may be pulled to its position under the cap, and the maximum allowable deviation of the top of the pile, in its final position, from a vertical line through the calculated point of fixity of the pile or the unloaded pile alignment.

The anticipated total settlement of the falsework and forms shall be shown on the falsework drawings. The anticipated settlement shall include both foundation settlement and joint take-up, and shall not exceed 1 in.

The falsework drawings shall show the method by which the falsework may be adjusted vertically and the locations where such adjustments will be reinforced.

Where openings through the falsework are required to permit the passage of public traffic, including pedestrian traffic, the falsework drawings shall show the location of the all such openings, including horizontal and vertical clearances and the location of temporary railing.

Where temporary bracing is to be used during erection and removal of falsework over or adjacent to public traffic, the falsework drawings shall show the sequence of erection and removal and details of the temporary bracing system to be used.

Table 2.1-1—Minimum Mechanical Properties of Structural Steel by Shape, Strength, and Thickness

AASHTO Designation	M 270M/ M 270 Grade 36	M 270M/ M 270 Grade 50	M 270M/ M 270 Grade 50S	M 270M/ M 270 Grade 50W	M 270M/ M 270 Grade HPS 50W	M 270M/ M 270 Grade HPS 70W	M 270M/ M 270 Grade HPS 100W	
Equivalent ASTM Designation	A709/ A709M Grade 36	A709/ A709M Grade 50	A709/ A709M Grade 3650S	A709/ A709M Grade 50W	A709/ A709M Grade HPS 50W	A709/ A709M Grade HPS 70W	A709/ A709M Grade HPS 100W	
Thickness of Plates (in.)	Up to 4.0 incl.	Up to 4.0 incl.	Not Applicable	Up to 4.0 incl.	Up to 4.0 incl.	Up to 4.0 incl.	Up to 2.5 incl.	Over 2.5 to 4.0 incl.
Shapes	All Groups	All Groups	All Groups	All Groups	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Minimum Tensile Strength, F_u , (ksi)	58	65	65	70	70	85	110	100
Specified Minimum Yield Point or Specified Minimum Yield Strength, F_y , (ksi)	36	50	50	50	50	70	100	90

Conversion: 1 ksi = 6.89 N/mm²

The falsework drawings, when submitted to the owner, shall be accompanied by one set of the design calculations. The calculations shall show the stresses and deflections in load-supporting members. The drawings and calculations shall be stamped and signed by a Licensed Professional Engineer, registered in the state where the falsework is to be erected.

2.2—MATERIALS AND MANUFACTURED COMPONENTS

2.2.1—General

Falsework design may be based on the use of either new or used materials and manufactured components, or a combination thereof.

2.2.2—Structural Steel

2.2.2.1—Identification and Properties

New structural steel shall conform to the AASHTO or ASTM specifications designated in Table 2.1-1. The

most recent date of issue shall apply to each of these specifications.

Certified material test reports (CMTR) or certified reports of tests made by the fabricator or a testing laboratory in accordance with ASTM A6/A6M or A568/A568M, as applicable, and the governing specification shall constitute sufficient evidence of conformity with one of the above standards. Additionally, the fabricator shall, if requested, provide an affidavit stating that the structural steel furnished meets the requirements of the grade specified.

For new structural steel, the design working stresses shall not exceed those specified in the *AISC Steel Construction Manual*. For structural steel design, the modulus of elasticity, E , shall be assumed as 29,000 ksi.

2.2.2.2 — Salvaged Steel

Used structural steel, which satisfies ASTM A6/A6M criteria for surface imperfections, may be used at the allowable working stresses for new material, provided the grade of steel can be identified to the owner's satisfaction.

C2.2.2.2

The specification allows the use of both new and salvaged structural steel. Salvaged (used) steel is subject to the same ASTM A6/A6M criteria for surface imperfections as new steel. For reference, some of the more common steel designations predating ASTM A36 are provided in Table C2.2.2.2-1.

Table C2.2.2.2-1 Early ASTM Steel Specifications

Date	Specification	Remark	ASTM Requirement	
			Tensile Strength (ksi)	Minimum Yield Point (ksi)
1924–1931	ASTM A7	Structural Steel	55 to 65	$\frac{1}{2}$ T.S. or not less than 30
		Rivet Steel	46 to 56	$\frac{1}{2}$ T.S. or not less than 25
	ASTM A9	Structural Steel	55 to 65	$\frac{1}{2}$ T.S. or not less than 30
		Rivet Steel	46 to 56	$\frac{1}{2}$ T.S. or not less than 25
1939–1948	ASTM A7-A9	Structural Steel	60 to 72	$\frac{1}{2}$ T.S. or not less than 33
1939–1949	ASTM A141-39	Rivet Steel	52 to 62	$\frac{1}{2}$ T.S. or not less than 28

2.2.2.3—Welding

All provisions of the *Structural Welding Code, ANSI/AWS D1.1/D1.1M*, of the American Welding Society, as appropriate, apply to work performed under this specification with exceptions as noted below:

- *AISC Steel Construction Manual* Section J1.6 in lieu of ANSI/AWS D1.1/D1.1M Section 5.17.1
- *AISC Steel Construction Manual* Section J2.2a in lieu of ANSI/AWS D1.1/D1.1M Section 2.3.2
- *AISC Steel Construction Manual* Table J2.2 in lieu of ANSI/AWS D1.1/D1.1M Table 2.1
- *AISC Steel Construction Manual* Table J2.5 in lieu of ANSI/AWS D1.1/D1.1M Table 2.3

C2.2.2.3

While it is recognized that many provisions of the *Structural Welding Code, ANSI/AWS D1.1/D1.1M* may not be applicable to falsework construction, the intent of Section 2.2.2.3 is to require the same quality of workmanship for temporary works as for permanent construction. The noted exceptions are the same as those found in the *AISC Steel Construction Manual*.

- *AISC Steel Construction Manual* Appendix 3, Table A-3 in lieu of ANSI/AWS D1.1/D1.1M Table 2.4
- *AISC Steel Construction Manual* Section B3.9 and Appendix 3 in lieu of ANSI/AWS D1.1/D1.1M Section 2, Part C
- *AISC Steel Construction Manual* Section M2.2 in lieu of ANSI/AWS D1.1/D1.1M Sections 5.15.4.3 and 5.15.4.4

2.2.3—Wood

2.2.3.1—Allowable Stresses

All species and grades of wood to which allowable unit stresses have been assigned in the *National Design Specification (NDS) for Wood Construction* are acceptable for use in falsework.

Design working stresses for new lumber shall not exceed the design values for visually graded dimension lumber and visually graded timbers as tabulated in the *National Design Specification (NDS) for Wood Construction*. The listed values are for normal load duration and dry service conditions (unless noted otherwise), and shall be modified as provided herein.

2.2.3.2—Modification Factors

Modification factors for service conditions and duration of load shall be as prescribed by the NDS. All modification factors are cumulative.

Load duration factors shall not apply to values for modulus of elasticity or compression perpendicular to the grain.

2.2.3.3—Used Lumber

Subject to the owner's concurrence, used lumber of known species may be used in accordance with the following:

- (a) Where the grade is known or can be established, the stress level for used lumber, in good condition and without obvious defects, shall not exceed the adjusted allowable stress for new lumber of that grade and species.
- (b) Where the grade is unknown and cannot be established, the stress level for used lumber, in good condition and without obvious defects, shall not exceed the adjusted allowable stresses as listed in Appendix A.
- (c) The stress level for used lumber of lower quality or showing evidence of abuse shall not exceed the stress values for the species as listed in Appendix A. The listed stress values are maximums and shall not be increased by size factors.

C2.2.3.2

Since falsework is seldom subjected to maximum loading for more than seven days, a load duration factor of 1.25 will be applicable to most falsework designs. In the case of loads of shorter duration, such as wind, a larger factor is appropriate. The load duration factor for connections is limited to 1.6 in the NDS. Connections resisting impact loading, such as the connection at the base of a falsework post adjacent to a traffic opening, shall not use a load duration factor larger than 1.6.

C2.2.3.3—Used Lumber

The maximum design values for ungraded structural lumber tabulated in Appendix A are based on the lowest stresses for each size classification. These are applicable only for normal load duration and dry surface conditions, unless noted otherwise. Refer to the *NDS Supplement—Design Values for Wood Construction* for a description of applicable adjustment factors and species designation.

Unless otherwise permitted by the owner, the allowable stress values for lumber of unknown species shall not exceed the lowest allowable stress values of any species listed in Appendix A for a particular size classification. Said stresses are maximums and shall not be increased by application of load duration or other stress-adjustment factors. The owner may require any lumber proposed for use under paragraphs (a) or (b) above to be regraded prior to use.

2.2.4—Other Materials

The design of materials other than structural steel and timber shall conform to the applicable design standard or specification for such material.

2.2.5—Manufactured Components

2.2.5.1—General

As used herein, manufactured components include the following classes of proprietary products:

- Vertical shoring systems including tubular welded frame shoring, tube and coupler shoring, and components thereof.
- Manufactured assemblies including single-post shores, brackets, jacks, joists, clamps, and similar devices manufactured for commercial use.

2.2.5.2—Maximum Loadings and Deflections

The maximum load to be used on any manufactured component, under any load sequence or combination, shall not exceed the manufacturer's recommendations.

When requested by the owner, a manufacturer's catalog, technical bulletin, or similar publication shall be furnished with the falsework drawings showing the use of manufactured components. The information furnished shall include, but not be limited to, test data and limitations and conditions governing the use of the component.

The dead load deflection of a manufactured component designed for use in a horizontal or inclined position shall not exceed $1/240$ of the span length under the weight of the concrete only.

The use of a manufactured assembly for which no engineering data is furnished will not be permitted, unless the assembly has been tested under the falsework design.

C2.2.5.1

Vertical shoring systems consist of individual components that may be assembled and erected in place to form a series of internally braced steel towers of any desired height. Safe working loads for these shoring systems are generally determined empirically by full-scale load tests, where the ultimate capacity is based upon uniform and concentric loading of the tower legs. Therefore, the shoring capacity published by the manufacturer should be considered the maximum load that the shoring is able to safely support under ideal loading conditions. Horizontal loads, eccentricity due to unequal spans or an unbalanced pouring sequence, and uneven foundation settlement generally will have an adverse effect on the vertical shoring assembly and warrant special consideration.

Manufactured assemblies are commercial products such as jacks, hangers, brackets, and similar items, the use of which is governed by conditions or limitations imposed by the manufacturer. When approved for use, these products become an identifiable component of the falsework system.

C2.2.5.2

The specifications limit the load or the deflection or both, of any commercial product to the maximum recommended or allowed by the manufacturer. The manufacturer's recommendation should be shown in a catalog or design manual published by the manufacturer, or in a statement of compliance pertaining to a particular project.

The working load for such assemblies shall not exceed 40 percent of the maximum load sustained during the test.

2.2.5.3—Factor of Safety

The factor of safety for vertical shoring systems shall not be less than 2.5. This shall be clearly evident from a catalog or other engineering data furnished by the manufacturer.

The factor of safety for jacks that are not a part of a shoring system, and all types of manufactured assemblies, shall not be less than the minimum factor of safety required by the industry standard for the particular device, and in no case shall the factor of safety be less than 2.0.

2.3—LOADS

2.3.1—General

The falsework design load shall consist of the sum of the dead and live vertical loads and a horizontal load.

The vertical design load shall consist of the sum of the dead and live vertical loads, including live load impact where appropriate.

The horizontal design load shall consist of the sum of any actual horizontal loads due to equipment, construction sequence, or other causes, excluding the specified wind load, but in no case shall the horizontal design load be less than 2 percent of the total dead load to be supported at the point under consideration.

Pursuant to the provisions in Section 2.3.2, the vertical and horizontal design loads shall be increased as necessary to account for the effect of load redistribution due to prestressing, shrinkage, or other causes.

If the effect of a particular loading condition cannot be determined at the falsework design stage, the design shall be based on an assumed loading condition. In such cases the assumptions shall be reviewed when the actual conditions become known, and the falsework design revised if necessary.

2.3.2—Loads and Load Combinations

2.3.2.1—Loads and Load Designation

The following loads shall be considered:

<i>D</i>	=	dead load
<i>C_D</i>	=	construction dead load
<i>C_{FML}</i>	=	fixed material load
<i>C_{VML}</i>	=	variable material load
<i>C_P</i>	=	personnel and equipment loads
<i>C_H</i>	=	horizontal construction load
<i>C_R</i>	=	equipment reactions
<i>C_C</i>	=	lateral pressure of concrete
<i>EH</i>	=	horizontal earth pressure load
<i>PS</i>	=	secondary forces from post-tensioning
<i>SH</i>	=	force effects due to shrinkage
<i>LL(or LS)</i>	=	live load
<i>I</i>	=	impact load

C2.3.1

The minimum lateral load is intended to ensure that sufficient horizontal load capacity is available so that the falsework remains stable under normal conditions, when environmental lateral loads are not present. The horizontal design load should be considered separately in both the transverse and longitudinal directions.

For post-tensioned construction, it is generally recognized that redistribution of gravity loads occurs after the superstructure is prestressed. The distribution of load in the falsework after post-tensioning is dependent on factors such as spacing and stiffness of falsework supports, foundation stiffness, superstructure stiffness, and tendon profile. The amount of load redistribution can be significant and may be a governing factor in the falsework design.

Overall temperature variations result in contraction or expansion. The induced forces must be resisted or the movement accommodated by the falsework.

C2.3.2.1

The loads are only defined by name and symbol in this section. The definition of each load is in subsequent sections. Additional construction and environmental loads may include (and be accounted for in the load combinations) such items as prestressing, rib shortening, buoyancy, and others as appropriate.

<i>CE</i>	=	centrifugal force
<i>TG (or TU)</i>	=	thermal loads
<i>WS</i>	=	wind load
<i>EQ</i>	=	earthquake load
<i>S</i>	=	snow load
<i>R</i>	=	rain load
<i>WA</i>	=	stream flow
<i>IC</i>	=	ice load
<i>WI</i>	=	wind load on ice
<i>SE</i>	=	force effect due to settlement

The specified loads are nominal loads which are intended to be suitable for use in either Load and Resistance Factor Design (LRFD) or Allowable Stress Design (ASD), provided that appropriate load factors and combinations are used.

2.3.2.2—Load Combinations and Load Factors

The total factored force effect shall be taken as:

$$Q = \sum \gamma_i Q_i \quad (2.3.2.2-1)$$

where:

Q_i	=	force effects from loads specified herein
γ_i	=	load factors specified in Table 2.3.2.2-1

C2.3.2.2

The selection of load factors is intended to be compatible with ASCE 7. Since little independent research has been done, the load factor 2.0 is suggested for those loads that may vary substantially, or about which we have little information.

The loads suggested herein for consideration in load combinations are not all-inclusive; therefore, their selection will require judgment in many situations. Design should be based on the load combination causing the most unfavorable effect. In some cases, this may occur when one or more loads are not applied simultaneously. Furthermore, the critical load effect may result from the application of one or more loads on only part of the structure. Finally, concentrated loads may be applied in place of or in addition to the assumed uniformly distributed loads.

Load combinations should be considered based on the specific type of construction and procedures. Consideration should be given to construction loads which may be mutually exclusive, strongly correlated, or which occur with such a low probability that they may effectively be neglected.

Environmental loads are considered in a similar way as in ASCE 7. However, the following differences for environmental loads during construction must be kept in mind: (1) modifications to the design load values for the possibility of a reduced exposure period may be appropriate, (2) certain loads may be disregarded for most practical purposes because of the generally very short reference period associated with typical construction projects, and (3) certain loads in combinations may effectively be ignored because of the practice to shut-down construction sites during these events (i.e., snow and wind, snow and certain equipment forces, extreme winds and personnel loads, etc.). Regional and project-specific conditions should be considered when deciding which combinations of environmental and structural loads to use.

2.3.2.3—Load and Resistance Factor Design

Loads shall be combined to obtain the maximum design load effects for members and systems.

The most unfavorable effects from both wind and earthquake loads shall be considered, where appropriate, but they need not be assumed to act simultaneously. Similarly, C_H need not be assumed to act simultaneously with wind or seismic loads. Lateral earth pressure, environmental loads, and other construction loads shall be considered when applicable using the load factors in Table 2.3.2.2-1.

Where the effect of one load is partially or wholly resisted by another load, the factor on the resisting load shall be taken as zero for variable loads and 0.9 for controlled loads.

A controlled load is a material that is placed in a specific location to counteract the effect of a specific load.

C2.3.2.3

The load factors provided herein are intended to reflect the relative uncertainty in the particular action. This uncertainty can arise from: (1) inherent or natural variability, (2) range of applications, and (3) possibilities for misuse or error. It may therefore be reasonable to make certain modifications to load factors in the presence or absence of additional information.

Factors on heavy equipment reactions are for maximum load values only. The load factor is much lower (1.6) when the equipment is rated such that the reactions are specified by the manufacturer or is otherwise known. Also, in the event any equipment is used which generates dynamic loads (i.e., pumps, unbalanced rotors), the load effect must be determined separately first and then multiplied by a factor of 1.3.

OSHA requires that “each scaffold and scaffold component shall be capable of supporting, without failure, its own weight and at least four times the maximum intended load applied or transmitted to it.” ANSI has a similar requirement. In order to satisfy this OSHA criterion, the load factor for personnel and equipment load, C_P , fixed material load, C_{FML} , and variable material load, C_{VML} , should be 4.0 and the load factor for construction dead load, C_D , should be 1.0. However, assuming $C_D = 1.0$ may be unconservative in cases where the dead load is high relative to the total load. Also, capacity reduction factors (ϕ factors) used with these load factors should be 1.0.

The applicable resistance factors can be determined in the related codes and standards. The designer should be aware that temporary structures used repeatedly are subject to abuse and loss of capacity, and that ϕ factors may need to be lower than those used for ordinary strength design to compensate for this loss of capacity.

Table 2.3.2.2-1—Load Combinations and Load Factors

Load Combination Limit State			<i>D</i>	<i>C_D</i>	<i>C_{FML}</i>	<i>C_{VML}</i>	<i>C_R^a</i>	<i>C_C^b</i>	<i>LL LS I CE C_P C_H</i>	<i>PS SH</i>	<i>TG TU</i>	<i>EH^c</i>	<i>WS</i>	<i>EQ</i>	<i>S</i>	<i>R</i>	<i>WA</i>	<i>IC</i>	<i>WI</i>	<i>SE^d</i>
Load and Resistance Factor Design	LRFD	1	1.4	1.4	1.2	1.4	1.6/2.0	1.3/1.5	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	1.0/0.0
	LRFD	2	1.2	1.2	1.2	1.4	1.6/2.0	1.3/1.5	1.6	1.0	1.0	γ_{EH}	0.0	0.0	0.5	0.0	1.2	0.0	0.0	1.0/0.0
	LRFD	3	1.2	1.2	1.2	1.4	1.6/2.0	1.3/1.5	1.6	1.0	1.0	γ_{EH}	0.0	0.0	0.0	0.5	1.2	0.0	0.0	1.0/0.0
	LRFD	4	1.2	1.2	1.2	1.4	1.6/2.0	1.3/1.5	1.6	1.0	1.0	γ_{EH}	0.0	0.0	0.5	0.0	1.2	0.2	0.0	1.0/0.0
	LRFD	5	1.2	1.2	1.2	1.4	1.6/2.0	1.3/1.5	1.0	1.0	1.0	γ_{EH}	0.0	0.0	1.6	0.0	1.2	0.0	0.0	1.0/0.0
	LRFD	6	1.2	1.2	1.2	1.4	1.6/2.0	1.3/1.5	1.0	1.0	1.0	γ_{EH}	0.0	0.0	0.0	1.6	1.2	0.0	0.0	1.0/0.0
	LRFD	7	1.2	1.2	1.2	1.4	1.6/2.0	1.3/1.5	0.0	1.0	1.2	γ_{EH}	0.5	0.0	1.6	0.0	1.2	0.0	0.0	1.0/0.0
	LRFD	8	1.2	1.2	1.2	1.4	1.6/2.0	1.3/1.5	0.0	1.0	1.2	γ_{EH}	0.5	0.0	0.0	1.6	1.2	0.0	0.0	1.0/0.0
	LRFD	9	1.2	1.2	1.2	1.4	1.6/2.0	1.3/1.5	1.0	1.0	1.0	γ_{EH}	1.0	0.0	0.5	0.0	1.2	0.0	0.0	1.0/0.0
	LRFD	10	1.2	1.2	1.2	1.4	1.6/2.0	1.3/1.5	1.0	1.0	1.0	γ_{EH}	1.0	0.0	0.0	0.5	1.2	0.0	0.0	1.0/0.0
	LRFD	11	1.2	1.2	1.2	1.4	1.6/2.0	1.3/1.5	1.0	1.0	1.0	γ_{EH}	0.0	0.0	0.5	0.0	1.2	1.0	1.0	1.0/0.0
	LRFD	12	1.2	1.2	1.2	1.4	1.6/2.0	1.3/1.5	1.0	1.0	1.0	0.0	0.0	1.0	0.2	0.0	1.2	0.0	0.0	1.0/0.0
	LRFD	13	0.9	0.9	0.0	0.0	0.0	0.0	0.0	1.0	0.0	γ_{EH}	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0/0.0
	LRFD	14	0.9	0.9	0.0	0.0	0.0	0.0	0.0	1.0	0.0	γ_{EH}	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0/0.0
	LRFD	15	0.9	0.9	0.0	0.0	0.0	0.0	0.0	1.0	0.0	γ_{EH}	0.0	1.0	0.0	0.0	0.9	0.0	0.0	1.0/0.0
Allowable Stress Design	ASD	1	1.0	1.0	1.0	1.0	1.0/1.2	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0/0.0
	ASD	2	1.0	1.0	1.0	1.0	1.0/1.2	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	0.7	0.0	1.0/0.0
	ASD	3	1.0	1.0	1.0	1.0	1.0/1.2	1.0	0.0	1.0	1.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0/0.0
	ASD	4	1.0	1.0	1.0	1.0	1.0/1.2	1.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	1.0/0.0
	ASD	5	1.0	1.0	1.0	1.0	1.0/1.2	1.0	0.0	1.0	1.0	1.0	0.0	0.0	1.0	0.0	1.0	0.7	0.7	1.0/0.0
	ASD	6	1.0	1.0	1.0	1.0	1.0/1.2	1.0	0.75	1.0	1.0	1.0	0.0	0.0	0.75	0.0	1.0	0.0	0.0	1.0/0.0
	ASD	7	1.0	1.0	1.0	1.0	1.0/1.2	1.0	0.75	1.0	1.0	1.0	0.0	0.0	0.0	0.75	1.0	0.0	0.0	1.0/0.0
	ASD	8	1.0	1.0	1.0	1.0	1.0/1.2	1.0	0.0	1.0	1.0	1.0	0.6	0.0	0.0	0.0	1.0	0.0	0.0	1.0/0.0
	ASD	9	1.0	1.0	1.0	1.0	1.0/1.2	1.0	0.0	1.0	1.0	1.0	0.0	0.7	0.0	0.0	1.0	0.0	0.0	1.0/0.0
	ASD	10	1.0	1.0	1.0	1.0	1.0/1.2	1.0	0.75	1.0	1.0	1.0	0.45	0.0	0.75	0.0	1.0	0.0	0.0	1.0/0.0
	ASD	11	1.0	1.0	1.0	1.0	1.0/1.2	1.0	0.75	1.0	1.0	1.0	0.45	0.0	0.0	0.75	1.0	0.0	0.0	1.0/0.0
	ASD	12	1.0	1.0	1.0	1.0	1.0/1.2	1.0	0.75	1.0	1.0	1.0	0.0	0.53	0.75	0.0	1.0	0.0	0.0	1.0/0.0
	ASD	13	0.6	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	1.0/0.0
	ASD	14	0.6	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.7	0.7	1.0/0.0
	ASD	15	0.6	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.7	0.0	0.0	1.0	0.0	0.0	1.0/0.0

Notes:

a. For LRFD, $C_R = 1.6$ for rated equipment and $C_R = 2.0$ otherwise; for ASD, $C_R = 1.0$ for rated equipment and $C_R = 1.2$ otherwise.b. For LRFD, $C_C = 1.3$ for full fluid head condition and $C_C = 1.5$ otherwise.c. Where the effect of EH adds to the primary variable load effect, $\gamma_{EH} = 1.6$; where the effect of EH resists the primary variable and the load is permanent, $\gamma_{EH} = 0.9$; for all other conditions, $\gamma_{EH} = 0.0$.

d. Load Cases which include settlement shall also be applied without settlement.

e. OSHA requires that scaffolds shall be capable of supporting, without failure, "their own weight and at least four times the maximum intended load." Where required to satisfy this criterion, $C_F = 1.0$, $C_{FML} = 1.0$, $C_{VML} = 2.0$, and $C_E = 1.0$. See C2.3.2.3 for additional information.

2.3.2.4—Allowable Stress Design

Loads shall be combined to obtain the maximum design load effects for members and systems.

The most unfavorable effects from both wind and earthquake loads shall be considered where appropriate, but they need not be considered simultaneously. Similarly, C_H need not be assumed to act simultaneously with wind or seismic loads.

When structural effects due to two or more variable loads in combination with dead load are investigated in load combinations of Section 2.3.2.2, the combined effects shall comply with both of the following requirements: (a) the combined effects due to the two or more variable loads multiplied by 0.75 plus effects due to dead loads shall not be less than the effects from the load combination of the dead load plus the load producing the largest effects; and (b) the allowable stress shall not be increased to account for these combinations.

Where the effect of one load is partially or wholly resisted by another load, the factor on the resisting load shall be taken as zero for variable loads and 0.60 for controlled loads.

2.3.3—Dead and Live Loads

2.3.3.1—Dead Load

The dead load, for the purposes of this standard, is the weight of the permanent construction in place at the particular time in the construction sequence that is under consideration. The dead load includes all construction in place that is temporarily shored or braced. It includes construction whose primary structural system is complete, but which is being used to support construction materials and construction equipment. The weights of scaffolding, shoring, concrete forms, runways for construction equipment, and other temporary structures are not included; these loads are considered to be construction dead load, C_D , as defined in Section 2.3.4.1.

The combined weight of concrete, reinforcing and prestressing steel, and formwork shall be assumed to be not less than 160 pcf for normal concrete or 130 pcf for lightweight concrete.

2.3.3.2—Live Load

The live load may vary at different stages of construction. The live loads shall include impact, longitudinal forces from vehicles, centrifugal forces from vehicles, and wind loads on vehicles, as applicable.

C2.3.2.4

Designers are cautioned against mixing ASD and LRFD load combinations.

OSHA requires that “Each scaffold and scaffold component shall be capable of supporting, without failure, their own weight and at least four times the maximum intended load applied or transmitted to it.” ANSI has a similar requirement. ASD ordinarily provides for safety factors somewhat less than 2; thus, in order to satisfy the OSHA criteria, the superimposed design loads effectively need to be more than doubled.

The designer should be aware that temporary structures used repeatedly are subject to abuse and loss of capacity and that safety factors may need to be higher than those used for ordinary ASD to compensate for this loss of capacity.

C2.3.3.1

The contractor usually controls the sequence of construction and thus controls what loads will be on the structure at the various construction stages. The design of temporary shoring and bracing must include these dead loads as well as the temporary loads described in this specification.

C2.3.3.2

The live loads during construction may be different than the live loads applied on the completed structure. For example, during reconstruction of a bridge designed for trucks, a lane may be restricted to cars, resulting in a lower live load. Reduction of the live load from the final design value shall not be made unless the actual loads are strictly monitored and enforced.

The partially completed structure should expose the occupants or users to no greater risk than inherent in the codes and standards of practice that pertain to the completed structure.

2.3.3.2.1—Construction Live Load

The construction live load shall consist of the actual weight of any equipment to be supported applied as concentrated loads at the points of contact, plus a uniform load of 20 psf applied over the area supported, plus 75 plf applied at the outside edge of deck overhangs.

2.3.3.2.2—Impact

When impact can occur, the design load to be applied to steel members and manufactured components shall be increased as provided herein.

- For members and components subject to impact during placing operations, the design dead load shall be increased by an impact factor of not less than 30 percent of the weight of the material being placed.
- For members and components subject to impact during lifting operations, the static load due to the payload shall be increased by not less than 30 percent for mechanically operated lifting equipment and not less than 15 percent for manually operated lifting equipment.
- If motorized carts are used, the uniform live load shall be increased an additional 25 psf.

2.3.3.3—Minimum Vertical Load

The minimum total design vertical load for any falsework member shall be not less than 100 psf for the combined dead and live load, exclusive of any increase for impact, regardless of slab thickness.

2.3.4—Construction Loads

Construction loads are loads imposed on a partially completed or temporary structure during and as a result of the construction process. Construction loads include, but are not limited to, materials, personnel, and equipment imposed on the temporary or permanent structure during the construction process.

2.3.4.1—Construction Dead Load

The construction dead load shall consist of the dead load of temporary structures that are in place at the stage of construction being considered. The dead load of the permanent structure, either partially complete or complete, is not included.

C2.3.3.2.1

Construction live loads are inherently transient and, therefore, for a given falsework scheme the potential combinations of these loads should be considered.

In bridge deck construction, a concentration of live load generally occurs at or near the edge of the bridge deck during concrete placement and finishing. The guide specifications include a 75 plf live load applied along the outside edge of all deck overhangs to account for this loading. In the case of long falsework spans, however, the application of 75 plf to falsework components below the overhang support system may be unduly conservative. Therefore, it is recommended that the 75 plf be applied as a moving load over a length of 20 ft. and positioned to produce the maximum stress in the underlying falsework component being considered.

C2.3.3.2.2

The allowance for impact assumes normal care in the placing of structural elements. It is not intended to cover excessive impact loads resulting from dropping materials onto the falsework or dragging structural elements into position.

The dead load of the permanent structure is defined in Section 2.3.3.1.

2.3.4.2—Material Loads

The material dead loads consist of two categories:

- Fixed material loads (C_{FML})
- Variable material loads (C_{VML})

Fixed material loads (C_{FML}) are loads from materials that are fixed in magnitude. Variable material loads (C_{VML}) are loads from materials that vary in magnitude during the construction process. If the local magnitude of a material load varies during the construction process, then that load shall be considered as a variable material load.

C2.3.4.2

This section separates material dead loads into two categories: C_{FML} and C_{VML} . C_{FML} and C_{VML} are separated to permit the use of an appropriate load factor for each category in strength design. This approach recognizes the difference in the variability of the load between the two categories.

This section addresses the loads from materials and is not intended to apply to equipment loads. Personnel and equipment loads are considered separately in Section 2.3.4.3.

Material loads may be either distributed or concentrated loads. The designer must consider the pattern of uniformly distributed loads and the location of concentrated loads that create the most severe strength and/or serviceability condition.

The designer must determine whether the superimposed material load during the construction process is essentially fixed in magnitude, is variable, or can be adjusted during the construction process. For example, the load from formwork becomes a C_{FML} once it is installed, while the load created by the concrete during fresh concrete placement is considered a C_{VML} . The load due to concrete placement is considered a variable material load since fresh concrete can be piled higher than the finished thickness of the slab.

The distinction between a C_{FML} and a C_{VML} is not location or position on the structure, rather it is the variability of the loading magnitude.

The stockpiling of any material is considered a variable material load. Some materials, such as scaffold or forms, are considered variable material loads when stockpiled but may be considered fixed material loads when placed in their final end use position. Engineering judgment must be used to determine whether the stockpiled material should be considered as a uniformly distributed or a concentrated load.

2.3.4.3—Personnel and Equipment Load

2.3.4.3.1—General

Personnel and equipment loads shall be considered in the analysis or design of a partially completed or temporary structure. The design or analysis of the structure shall be governed by either a uniformly distributed and/or a concentrated personnel and equipment load, whichever creates the most severe strength and/or serviceability condition.

The personnel and equipment loads used in the design or analysis of a partially completed or temporary structure shall be the maximum loads that are likely to be created during the sequence of construction.

2.3.4.3.2—Individual Personnel Loads

Individual personnel loads consist of a concentrated load of 300 lbs that includes the weight of one person plus equipment carried by the person or equipment that can be readily picked up by a single person without assistance.

C2.3.4.3.2

Individual Personnel Load is defined differently in ANSI 10.8 as 250 lbs per person plus 50 lbs of equipment per person; however, the load totals are the same.

2.3.4.3.3—Uniformly Distributed Loads

Uniform loads shall be selected to result in forces and moments that envelope the forces and moments that would result from the application of concentrated loads that could occur and which are not separately considered.

Table 2.3.4.3.3-1—Classes of Working Surfaces for Combined Uniformly Distributed Loads

Operational Class	Uniform Load ^a (psf)
Very light duty: sparsely populated with personnel; hand tools; very small amounts of construction materials	20
Light duty: sparsely populated with personnel; hand operated equipment; staging of materials for lightweight construction	25
Medium duty: concentrations of personnel; staging of materials	50
Heavy duty: materials placement by motorized buggies; staging of materials for heavy construction	75

Note:

- a. Loads do not include dead load, D , construction dead load, C_D , or fixed materials loads, C_{FM} .

2.3.4.3.4—Concentrated Loads

The personnel and equipment concentrated loads shall be the maximum loads expected in the construction process, but shall be no less than given in Table 2.3.4.3.4-1. The concentrated load shall be located to produce the maximum strength and/or serviceability conditions in the structural members. The designer shall consider each category of minimum concentrated personnel and equipment load that is likely to occur during the construction process.

Concentrated loads from equipment shall be determined in accordance with Section 2.3.4.5.

Table 2.3.4.3.4-1—Minimum Concentrated Personnel & Equipment Loads

Action	Minimum Load ^a (lbs)	Area of Load Application (in. ²)
Each person ^b	300	12×12
Wheel of manually powered vehicle	500	Load divided by tire pressure ^c
Wheel of powered vehicle	2000	Load divided by tire pressure ^c

Notes:

- a. Use actual loads where they are larger than tabulated here.
 b. Need not be less than 18 in. ctr-to-ctr
 c. For hard rubber tires, distribute load over an area 1 in. by the width of the tire.

C2.3.4.3.3

Construction loads, except for material loads, will rarely be distributed uniformly. However, design for equivalent uniformly distributed loads is a long standing practice that has stood the test of time. The designer must select a uniform load that will adequately capture the effects of real anticipated construction loads. Table 2.3.4.3.3-1 presents a tabulation of traditional minimum uniformly distributed loads that include personnel, equipment, and material in transit or staging.

C2.3.4.3.4

Concentrated loads from equipment are a serious concern. The type of equipment to be used for each construction operation, its location (on or off the structure), and its loading must be considered. Loads for different types of construction equipment have been tabulated. See also Section C2.3.4.5.1 for precautions in using tabulated data.

Many specifications require temporary or permanent structures to be designed for a uniform load and/or a concentrated load. If the source of the concentrated load can be clearly identified, such as wheel loads, axle loads, or equipment reactions, that specific load should be distributed as determined by its source.

Problems arise in determining the distribution areas of unidentified, but specified, loads. To determine the distribution area for an unidentified concentrated load, assume that the load will be generated by the densest material normally available on a construction site. That material is arbitrarily chosen to be concrete at 150 pcf.

The specified concentrated load in Table 2.3.4.3.4-1 is assumed to be the total load, including dynamic forces.

2.3.4.4—Horizontal Construction Load, C_h

One of the following horizontal load criteria, where appropriate, shall be applied to temporary or partially complete structures as a minimum horizontal loading, whichever gives the greatest structural effects in the direction under consideration:

- For wheeled vehicles transporting materials, 20 percent for a single vehicle or 10 percent for two or more vehicles of the fully loaded vehicle weight. This force shall be applied in any direction of possible travel, at the running surface.
- For equipment reactions as described in Section 2.3.4.5, the calculated or rated horizontal loads, whichever are the greater.
- 50 lbs/per person, applied at the level of the platform in any direction.
- Two (2) percent of the total vertical load. This load shall be applied in any direction and shall be spatially distributed in proportion to the mass. This load need not be applied concurrently with wind or seismic load.

This provision shall not be considered as a substitute for the analysis of environmental loads.

2.3.4.5—Equipment Reactions, C_r

The equipment reactions shall include the full weight of the equipment operating at its maximum rated load in conjunction with any applicable environmental loads unless the use is restricted and revised reactions are developed.

2.3.4.5.1—Rated Equipment

The minimum equipment loads for design shall be those provided by the equipment manufacturer or supplier.

Unless equipment, such as front end loaders or fork lifts, are intentionally restricted from tipping on one axle, the loader self-weight plus tipping load shall be applied to the front axle.

The designer shall verify the basis of the rating and the rated reactions given by the equipment supplier. If the basis of the rating is different than the conditions under which the equipment will be used, then the more severe reactions shall be used in design.

2.3.4.5.2—Non-Rated Equipment

The equipment loads for non-rated equipment shall be determined by analysis.

C2.3.4.4

The intent of this provision is to provide a minimum lateral load resistance mechanism and a minimum lateral stiffness in all temporary or partially complete structures. Due to unavoidable eccentricities, vertical superimposed loads may produce some horizontal loading. Also, horizontal loads can be created from personnel and equipment operations.

The designer should be aware that the actual horizontal loads may exceed the minimum specified in this section, particularly if more than one construction activity is being conducted at the same time.

The 50 lbs/person load in Criterion 3 represents a conservative estimate of the lateral force that could be generated from the activities of personnel.

Criterion 4 is intended to provide a minimum lateral load resistance and to assure lateral stability for the entire structure during construction. Generally, it is not expected that this criterion will result in forces during construction that exceed the capacity of the permanent lateral load resisting system of a structure below the level where the permanent lateral load resisting system has been completed; however, the permanent lateral load resisting system needs to be checked for this criterion.

Wind and other phenomena that produce horizontal loads must be considered separately from the requirements of this section, as specifically provided in Criterion 4.

C2.3.4.5

Rated equipment is that for which reactions are given by the equipment or supplier. For non-rated equipment, the designer is to determine the reactions by analysis. *Crane and Derricks* (Shapiro) provides examples of calculations for reactions from lifting or hoisting equipment that include assessments of environmental loads.

C2.3.4.5.1

Care should be exercised when using the tabulated values for equipment, such as loaders, from references or from any manufacturer's data. Axle load distributions at maximum load do assume that all of the axles are touching the ground and with a certain load distribution. Unless special precautions are taken, such as limiting bucket size and floor or deck obstacles, it is a common occurrence that the loaders, in attempting to pick materials for transport, will either catch an element of the deck or try to pick more than their rated load. In this instance, the entire vehicle picks up and pivots about its front axle. This load could create axle and wheel loads more than 30 percent greater than the manufacturer's rated wheel load.

2.3.4.5.3—Impact

The reaction of equipment shall be increased by 30 percent to allow for impact, unless other values (either larger or smaller) are recommended by the manufacturer, are required by the authority having jurisdiction, or are justified by analysis.

2.3.5—Environmental Loads

The basic reference for computation of environmental loads is the 2010 edition of ASCE 7. The requirements of ASCE 7 shall apply except as modified herein.

2.3.5.1—Risk Category

Unless otherwise required by the authority having jurisdiction, the Risk Category, as defined in ASCE 7, shall be taken as Risk Category II for all environmental loads during construction, regardless of the Risk Category assigned for the design of the completed structure.

2.3.5.2—Wind

~~Except as modified herein, wind loads shall be calculated in accordance with procedures in ASCE 7. Select provisions from ASCE 7 10 have been reproduced in Appendix C. Design wind pressures shall be based on design wind speeds calculated in accordance with Section 2.3.5.2.1. The basic wind pressure shall be increased by 5 psf for falsework members over or adjacent to traffic openings.~~

~~2.3.5.2.1—Design Wind Speed~~

~~The design wind speed shall be taken as the basic wind speed in ASCE 7. Basic wind speed maps from ASCE 7 10 have been reproduced in Appendix C.~~

~~2.3.5.2.2—Frameworks without Cladding~~

~~Structures shall resist the effect of wind acting upon successive unenclosed components.~~

~~Treatment of staging, shoring, and falsework with regular rectangular plan as trussed towers in accordance with ASCE 7 shall be permissible. Unless detailed analyses are performed to show that lower loads may be used, no allowance shall be given for shielding of successive rows or towers.~~

~~For unenclosed frames and structural elements, wind loads shall be calculated for each element. Unless detailed analyses are performed, load reductions due to shielding of elements in such structures with repetitive patterns of elements shall be as follows:~~

- ~~• The loads on the first three rows of elements along the direction parallel to the wind shall not be reduced for~~

C2.3.5.1

During construction, the primary occupancy of a structure is by construction personnel. As such, the risk to loss of human life is comparable to that for Risk Category II buildings as defined in ASCE 7. Circumstances in which the engineer may consider a higher Risk Category, or in which some authorities have required such consideration, include construction work immediately adjacent to essential facilities in which a construction failure would imperil operation of the essential facility.

~~C2.3.5.2~~

~~If local conditions so dictate, and for certain hazardous construction operations, it may be appropriate to apply a minimum strength level wind pressure, such as 16 psf, to design.~~

~~C2.3.5.2.2~~

~~Even though the design wind speed during construction may be lower than that for the completed structure, the total wind load may actually be higher due to the cumulative effect of wind acting on many more surfaces and often with higher drag coefficients than in the fully enclosed structure. For common arrangements of elements in typical open frames and temporary structures, shielding effects are small. Considering the changing nature of the bridge silhouette and the arrangement of construction materials on the structure, it is prudent not to assume that loads will be reduced due to shielding, except in certain specific cases:~~

~~For open structures with regular patterns of elements, the direction of maximum force on the structure usually is not parallel to the principal axis of the structure. Shielding effects are minimized, and therefore loads are at their~~

shielding.

- The loads on the fourth and subsequent rows shall be permitted to be reduced by 15 percent.
- Wind load allowances shall be calculated for all exposed interior partitions, walls, temporary enclosures, signs, construction materials, and equipment on or supported by the structure. These loads shall be added to the loads on structural elements.

Calculations shall be performed for each primary axis of the structure. For each calculation, 50 percent of the wind load calculated for the perpendicular direction shall be assumed to act simultaneously.

2.3.5.2.3 Accelerated Wind Region

Structures placed near building edges and corners shall resist the higher pressures and suctions that will exist in such regions. The design wind speed shall be factored upward from the basic wind speed by the square root of the suction coefficient for cladding as given in ASCE 7. The calculated wind speed shall be used with appropriate drag factors to calculate loads on structures. At building corners, the resulting pressures shall be assumed to act on adjacent staging structures in horizontal directions parallel to and perpendicular to the enclosure surface. At top edges of enclosures, pressures shall be assumed to act upward as well as horizontally.

2.3.5.2.1 General

The wind load provisions presented herein shall be used with conventional bridges in typical settings.

The latest edition of the ASCE 7 shall be used for the design of temporary bridge works used for the construction of:

- Conventional bridges adjacent to cliffs or building edges and corners.
- Cable-stayed, suspension, and arch bridges.
- Any other nonconventional bridges.

Wind loads on the superstructure that are transmitted to bridge falsework shall be determined in accordance with Article 2.3.5.2.5.

2.3.5.2.2 Design Wind Speed

The design 3-second gust wind speed, V , used in the determination of design wind loads on bridge temporary

highest, when the direction of the wind is not parallel to the column lines. For this reason, the most severe loads on an open structure include components of load in both principal directions of the structure.

For guidance on shielding effects and loads on open structures, refer to *Crane and Derricks* (2000), *Wind Loading on Falsework, Part I* (1975), *Wind Loading on Open Framed Structures* (1981), and the *Low Rise Building Systems Manual* (1996).

C2.3.5.2.1

Structures placed near building edges and corners are required to be designed to resist the higher pressures and suctions that will exist in such regions. The design wind speed must be factored upward from the basic wind speed by the square root of the suction coefficient for cladding as given in ASCE 7. The calculated wind speed should be used with appropriate drag coefficients to calculate wind loads on such structures. At building corners, the resulting pressures should be assumed to act on adjacent staging structures in horizontal directions parallel to and perpendicular to the enclosure surface. At top edges of enclosures, pressures should be assumed to act upward as well as horizontally.

works shall be taken as the 3-second gust wind speed specified for Strength III load combination in the AASHTO LRFD Bridge Design Specifications.

2.3.5.2.3—Wind Load

2.3.5.2.3a—General

The wind loads on bridge temporary works shall be determined using the procedure specified in the AASHTO LRFD Bridge Design Specifications modified as shown in Articles 2.3.5.2.3b, 2.3.5.2.3c, and 2.3.5.2.3d.

The amplification of wind load due to successive unenclosed components shall be determined using Article 2.3.5.2.4.

2.3.5.2.3b—Wind Pressure

The design wind pressure on temporary bridge works shall be determined as:

$$P_z = 2.56 \times 10^{-6} V^2 K_z G C_D K_d \quad (2.3.5.2.3b-1)$$

where:

P_z = design wind pressure at a height, z , above ground (ksf). The height, z , to be determined using Table 2.3.5.2.3b-1.

V = design 3-second gust wind speed as determined in Article 2.3.5.2.2 (mph)

K_z = pressure exposure and elevation coefficient to be taken as specified in AASHTO LRFD Bridge Design Specifications Article 3.8.1.2 for Strength III load combination

G = gust coefficient factor to be taken as 0.85

C_D = drag coefficient to be taken from Table 2.3.5.2.3b-2

K_d = wind directionality factor to be taken as 0.95

The design wind pressure calculated using Eq. 2.3.5.2.3b-1 shall be increased by 5 psf for falsework members over or adjacent to traffic openings.

For each axis of the structure, wind load shall be determined using Articles 2.3.5.2.3c. For each primary axis of the structure, 50 percent of the wind load calculated for the perpendicular direction shall be assumed to act simultaneously.

C2.3.5.2.3b

The wind load provisions presented herein are formatted to follow the format of the wind load provisions in AASHTO LRFD Bridge Design Specifications and AASHTO Guide Specifications for Wind Loads on Bridges During Construction. This is the reason the following differences exist between the provisions presented herein and those in ASCE 7-2010 which form the basis for these provisions:

- The “Force Coefficient” in ASCE 7, C_f , was renamed to “Drag Coefficient”, C_D , to match AASHTO documents.
- The gust effect factor, G , and the force coefficient, renamed to drag coefficient, were moved from the equation for the wind force in ASCE 7-10 (Eq. 2.3.5.2.3c-1 herein) to the equation for wind pressure (Eq. 2.3.5.2.3b-1 herein).

The value of the wind directionality factor varies with the configuration of different elements. The specified value is an upper bound of the values used for typical components.