Chapter 3: Design Considerations

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3-1 Introduction

Loading for temporary structures varies depending on the type of structure and the requirements specified in the contract specifications. The *Contract Specifications* can require minimum horizontal and vertical design loads; however, in some cases, the design loads are determined by the design engineer. This chapter will address typical loads and load combinations that may be encountered in the submittal review of temporary structures, but not all loading conditions will be discussed. Each unique structure will require the loading be applied according to the contract specifications, if available, or loading in compliance with design criteria or codes appropriate for the facility involved.

3-2 Contractual Requirements

Contract Specifications Section 7-1.04, *Legal Relations and Responsibility to the Public - Public Safety,* states:

> *Temporary facilities that could be a hazard to public safety if improperly designed must comply with design requirements described in the Contract for those facilities or, if none are described, with standard design criteria or codes appropriate for the facility involved. Submit shop drawings and design calculations for the temporary facilities and show the standard design criteria or codes used. Shop drawings and supplemental calculations must be sealed and signed by an engineer who is registered as a civil engineer in the State.*

Loading for most temporary structures is addressed in the *Contract Specifications* Section 48, *Temporary Structures,* or as shown on the contract plans. When loading is not described, best industry practice should apply.

3-3 Cal/OSHA Requirements

Requirements from Cal/OSHA's Construction Safety Orders vary depending on the type of structure being considered. Most temporary structures require the design to be by a qualified person or licensed engineer. Some structures, such as scaffolding, are required to conform to listed loading and load combinations. Note that the Construction Safety Orders are found in the California Code of Regulations, Title 8, Division 1, Chapter 4, Subchapter 4.

3-4 Structure Categories

Many structures are similar in design but have unique loading and design requirements associated with their use. Some typical temporary structures are listed below, along with the associated design considerations.

Falsework is typically associated with the construction of cast-in-place concrete structures, particularly bridge structures. In this type of construction, falsework provides a stable platform upon which the forms may be built and furnishes support for the bridge superstructure until the members being constructed have attained sufficient strength to support themselves. Section 48-2, *Temporary Structures – Falsework*, of the *Contract Specifications* contains specific loading and design criteria for falsework. The *Falsework Manual* is another source for the design criteria for falsework.

Temporary supports are similar to falsework and are typically used to provide support for permanent structures during retrofit, reconstruction, erection, and removal activities. Many accelerated bridge construction (ABC) projects require some form of temporary support during erection. Section 48-3, *Temporary Structures – Temporary Supports*, of the *Contract Specifications* contains specific loading and design criteria for temporary supports which are discussed in detail in Chapter 9, *Temporary Supports and Jacking,* of this manual.

Trestles and work platforms are used to support equipment loads and other construction activities. The design criteria and loading for these structures are typically provided by the temporary structure designer. These types of structures are discussed in detail in Chapter 4, *Temporary Access Trestles,* of this manual.

Scaffolding, as defined by Cal/OSHA, is any temporary elevated platform and its necessary vertical, diagonal, and horizontal members used to support workers and materials. Chapter 7, *Bridge Scaffolding*, discusses the design of bridge scaffolds in more detail.

Protective covers are associated with bridge removal operations to collect debris. Chapter 5, *Design Considerations*, of the *Bridge Removal Manual* addresses protective covers. Loading for protective covers is typically provided by the design engineer. Protective covers are also required when pedestrian routes pass beneath work areas such as falsework.

Some temporary structures are used for more than one purpose and should be designed to the most restrictive requirements. For example, scaffolding is often used as a protective cover in addition to providing a platform for workers.

3-5 Dead Loads

The dead load is typically the self-weight of the supported structure in place at any time in the construction sequence. The construction dead loads include the weight of any forms, shoring, or other temporary structures in place during the construction sequence. The total dead load for temporary structures is typically the summation of the two loads described above.

Similar to values used in falsework analysis, the weight of the concrete, forms, and reinforcing steel is:

- 160 pounds per cubic foot (pcf) for normal concrete.
- 130 pcf for lightweight concrete.

As a proportion of concrete weight, the weight of forms and rebar for typical concrete bridges may be estimated as:

- 15 pcf

The densities of other common building materials can be found in Table 17-12, *Densities of Common Materials*, of the *AISC Steel Construction Manual* or in other references.

Other items considered as dead load in design of temporary structures, in addition to the weight of the temporary structure or the in place supported structure, can be demolition debris, stored materials, and construction equipment.

3-6 Live Loads

Live loads are determined by the design engineer unless specified in the contract documents. Minimum live loads are determined by the type of temporary structure and the intended use. The minimum live load for falsework is 20 psf and this value is also appropriate for other temporary structures. Scaffolding requires higher minimum live loads and is discussed elsewhere in this manual. Live loads due to equipment such as cranes are determined by adding the actual equipment weight plus the maximum loads it will support. Live loads from equipment are moving loads that must be analyzed in the position that produces the maximum stresses to the supporting structure.

3-7 Environmental Loads

3-7.01 Wind Loads

There are many methods available to calculate wind loads. The method used for calculating the wind load must be appropriate for the type and shape of structure being analyzed. This section will discuss a few of the more common methods for calculating wind loads. If the method for calculating the wind loads is not specified in the contract documents, then it is the responsibility of the design engineer to select the appropriate method. The design method used for calculating wind loads, along with any assumptions, should be noted on the shop drawings.

The simplest method for determining the wind pressure on a temporary structure is the load tables found in the *Contract Specifications* Section 48-2.02B(2), *Temporary Structures –Falsework – Materials – Design Criteria – Loads*. The wind pressure values in this section are applicable to falsework but can also be applied to other temporary structures that are similar to falsework. The wind pressures are applied to the projected area of the structure.

Another commonly used method for determining wind loads is found in the American Society of Civil Engineers (ASCE) *Minimum Design Loads and Associated Criteria for Building and Other Structures.* Discussions and examples used in this manual will assume the most recent version is used, which is ASCE 7-16. The methods found in ASCE 7-16 are much more complicated than the pressure tables found in the *Contract Specifications*. The procedures in ASCE 7-16 are primarily developed for building design, and care should be taken that the proper procedure is used for temporary structures. The wind pressures are applied to the structure as directed in the ASCE 7-16.

The procedures found in the American Association of State Highway and Transportation Officials (AASHTO) *Guide Design Specifications for Bridge Temporary Works* (GSBTW) are similar to the procedures in ASCE 7-16, but are based on the procedures found in the AASHTO *Bridge Design Specifications* (BDS). The BDS methods are currently based on ASCE 7-10, but pending revisions will adopt the procedures in the current ASCE 7. The GSBTW has simplified the determination of the variable used in the wind pressure calculations for temporary structures. The wind pressures are applied to the projected area of the structure.

See Appendix A Example 1*, Wind Loads,* for sample calculations and a comparison of the wind pressure methods described above.

3-7.02 Seismic Loads

Seismic loads are typically not applied to temporary structures due to the short duration the temporary structure is in service. Some minimal lateral loads are increased, such as for temporary supports, to account for the statistical probability of a seismic event based on anticipated service life.

When seismic loads are applied to temporary structures, the loads are typically based upon a 50-year seismic event (2 percent probability event).

Procedures for calculating seismic loads can be found in ASCE 7. The AASHTO GSBTW provides modifications to the ASCE 7 procedure that are applicable to temporary structures.

3-7.03 Stream Flow

When temporary structures are placed in flowing water, the water pressure applied to the temporary structure is:

$$\mathbf{P_W = Kv^2} \qquad (3\text{-}7\text{-}1)$$

P_w = pressure (psf)
v = water velocity (ft/s)
K = 1.375 for square faces
0.67 for circular piers
0.50 for angular faces

The formula above is based on Section 2.3.5.5, *Stream Flow*, of the AASHTO GSBTW.

If significant drift buildup is anticipated, the potential increase in loading should be investigated.

3-7.04 Soil Pressure

Soil pressure can be determined using the methods and guidelines found in the Caltrans *Trenching and Shoring Manual*.

3-8 Load Combinations

Temporary structures are typically designed using Allowable Stress Design (ASD); however, in some circumstances the designer may elect to use Load and Resistance Factor Design (LRFD). The load combinations discussed in this section will be based on ASD. For LRFD combinations, refer to AASHTO GSBTW Table 2.3.2.2-1, *Load Combinations and Load Factors*. The typical ASD load combinations considered for the design of temporary structures (except falsework) are as follows:

$\mathrm{DL+LL}$
$\mathrm{DL+0.75LL+0.75WL}$
$\mathrm{DL+WL}$
$\mathrm{0.6DL+WL}$

DL – Dead Load
LL – Live Load
WL – Wind Load

The combinations above represent the typical loading conditions and are not all-inclusive. The effect of one or more loads not being applied should be considered to determine the most unfavorable loading condition.

Assumed minimum horizontal loads, such as the 10 percent minimum load used in temporary support design, are not reduced when combined with dead or live loads.

When calculating wind loads using the methods found in ASCE 7, it should be noted that these wind loads are based on LRFD and should be reduced by 0.60 for ASD. The combination above with the 0.60 factor applied would be as follows:

$$\mathrm{DL+LL}$$
$$\mathrm{DL+0.75LL+0.75(0.6)WL}$$
$$\mathrm{DL+0.6WL}$$
$$\mathrm{0.6DL+0.6WL}$$

When stream flow or horizontal earth pressure is applied, the typical combinations for ASD are as follows:

$$\mathrm{DL+LL+WA+EH}$$
$$\mathrm{DL+0.75LL+0.75(0.6)WL+WA+EH}$$
$$\mathrm{DL+0.6WL+WA+EH}$$
$$\mathrm{0.6DL+0.6WL+WA+EH}$$

WA – Stream Flow
EH – Horizontal Earth Pressure

3-9 Traffic Openings

Whenever an operation will reduce clearances available to public traffic, the *Contract Specifications* Section 7-1.04, *Legal Relations and Responsibility to the Public – Public Safety,* requires the Contractor to notify the Resident Engineer within a specified timeframe before the anticipated start of the operation. Moreover, the *Contract Specifications* Section 12-4.02A(3)(b), *Temporary Traffic Control – Maintaining Traffic – Traffic Control Systems – General – Submittals – Closure Schedules*, requires the Contractor to submit a closure schedule request within a certain timeframe before the anticipated start of any job site activity that reduces horizontal or vertical clearance of traveled ways.

Referring to BCM C-6, *Required Documents to be Submitted During Construction*, the Structure Representative completes Form TR-0019, *Notice of Change in Clearance or Bridge Weight Rating,* or Form TR-0029, *Notice of Change in Clearance or Bridge Weight Rating,* as applicable. The form is submitted to the Resident Engineer as notification of the change. The Resident Engineer notifies the Transportation Permits

Branch. After erection of the temporary structure, the Structure Representative verifies the clearance.

The minimum width and height of each traffic opening to be provided through the temporary structure will be shown on the structure contract plans or in the special provisions.