# Bridge Design - Concrete Decks

**Course Number:** CE-02-408

**PDH:** 2

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# Module 10: Concrete Decks

## Learning Objectives

By the end of this section, you will be able to:

- **Identify** the structural characteristics and application requirements for cast-in-place and precast concrete bridge decks.
- **Calculate** factored design moments and required reinforcement for both positive and negative flexure using the Approximate Method of Analysis.
- **Evaluate** deck designs for compliance with AASHTO LRFD crack control, serviceability, and minimum reinforcement standards.

*Executive Summary:* Bridge decks are essential structural components that provide a riding surface and transfer traffic loads to the main load-carrying members. While cast-in-place reinforced concrete is most common, design must account for "internal arching" behavior where membrane stresses, rather than pure flexure, often govern structural capacity. This chapter establishes a comprehensive framework for deck design, moving from material selection and limit state definitions to a detailed design example compliant with AASHTO LRFD and California Amendments.

## Introduction

Bridge decks are an integral part of the bridge structure, providing the direct riding surface for motor vehicles and transferring load from moving traffic to the major load-carrying members. This chapter covers various concrete deck types, basic structural behavior, and major design and detailing considerations. All examples and standards are provided in accordance with the AASHTO LRFD Bridge Design Specifications (2012) and California Amendments (2014).

## Concrete Deck Types

Selection between the two main types of concrete decks depends on location, traffic, cost, seismicity, schedule, and aesthetics.

### Cast-In-Place Concrete Decks

A cast-in-place concrete deck is a thin concrete slab, usually between 7 and 12 inches thick, utilizing normal reinforcement or prestressing steel.

- **Advantages**: Low cost, ease of construction, and extensive industry use.
- **Disadvantages**: Susceptibility to cracking, rebar corrosion, and tire noise.

⚠️ **Safety Constraint**: Lack of deck crack control can lead to rebar corrosion and increased life cycle costs.

## Precast Concrete Decks

These consist of precast reinforced or prestressed concrete panels that can serve as the final surface or as temporary stay-in-place forms.

💡 **Design Tip**: The primary advantage of precast concrete decks is the acceleration of the construction schedule.

# Design Approach

## Structural Behavior of Concrete Decks

The primary structural behavior of a concrete deck is defined by **internal arching** rather than pure flexure.

- **Mechanism**: As cracks develop in the bottom of the slab and the neutral axis shifts upward, compressive membrane stresses develop above the neutral axis to resist further crack opening.
- **Failure Mode**: As load increases, the section becomes overstrained, leading to a cone-shaped section of failed concrete; therefore, the primary failure mode is **punching shear**.

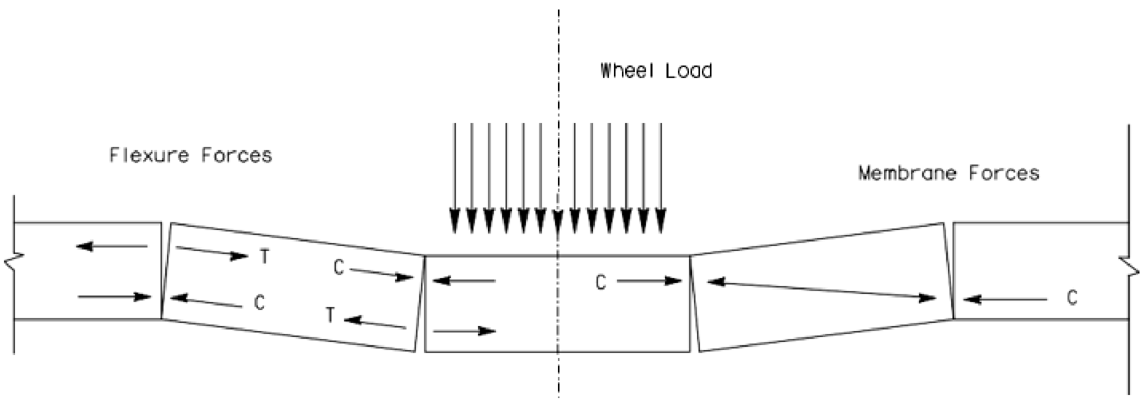



**Figure 10.3-1**. Concrete Deck Showing Flexure and Membrane Forces

# Limit State

## Service Limit State

Decks are designed to meet Service I limit state requirements to control deformation and cracking.

- **Exposure**: Deck slabs shall be designed for Class 2 exposure.
- **Exposure Factor**: g e = 0.75.

## Strength Limit State

Concrete decks must be designed for Strength I limit state.

- **Resistance Factor**: f = 0.9 (tension-controlled components).
- **Permit Loads**: Strength II typically is not checked as permit vehicle axle loads do not usually control deck design.

## Extreme Event Limit State

Deck overhangs with concrete barriers must meet Extreme Event II requirements.

- **Design Case 1**: Transverse and longitudinal forces specified in AASHTO Appendix A13.2.
- **Design Case 2**: Vertical forces specified in AASHTO Appendix A13.2.
- **Design Case 3**: Strength I occupancy loads specified in AASHTO Article 3.6.1.

## Fatigue Limit State

Concrete decks supported by multi-girder systems are not required to be investigated for fatigue.

# Methods of Analysis

## Approximate Method of Analysis

This traditional Caltrans method treats the deck as transverse strips acting as flexural members supported by girders. The width of an equivalent strip depends on the deck type and traffic direction.

## Refined Methods of Analysis

Refined methods (e.g., finite element) are acceptable but typically reserved for complex deck structures requiring detailed analysis.

## Empirical Method of Analysis

Based on internal arching action, this method is currently **not permitted** for concrete bridge deck design in California until further durability testing is completed.

**AASHTO Table 4.6.2.1.3-1 Equivalent Strips**

| Type of Deck | Direction of Primary Strip Relative to Traffic | Width of Primary Strip (in.) |
|---|---|---|
| Concrete: | | |
| • Cast-in-place | Overhang<br>Either Parallel or Perpendicular | $45.0 + 10.0X$<br>$+M$: $26.0 + 6.6S$<br>$-M$: $48.0 + 3.0S$ |
| • Cast-in-place with stay-in-place concrete formwork | Either Parallel or Perpendicular | $+M$: $26.0 + 6.6S$<br>$-M$: $48.0 + 3.0S$ |
| • Precast, post-tensioned | Either Parallel or Perpendicular | $+M$: $26.0 + 6.6S$<br>$-M$: $48.0 + 3.0S$ |
| Steel: | | |
| • Open grid | Main Bars | $1.25P + 4.0S_b$ |
| • Filled or partially filled grid | Main Bars | Article 4.6.2.1.8 applies |
| • Unfilled, composite grids | Main Bars | Article 4.6.2.1.8 applies |
| Wood: | | |
| • Prefabricated glulam | | |
| ○ Non interconnected | Parallel Perpendicular | $2.0h + 30.0$<br>$2.0h + 40.0$ |
| ○ Interconnected | Parallel Perpendicular | $90.0 + 0.84L$<br>$4.0h + 30.0$ |
| • Stress-laminated | Parallel Perpendicular | $0.8S + 108.0$<br>$10.0S + 24.0$ |
| • Spike-laminated | | |
| ○ Continuous decks or Interconnected panels | Parallel Perpendicular | $2.0h + 30.0$<br>$4.0h + 40.0$ |
| ○ Non interconnected panels | Parallel Perpendicular | $2.0h + 30.0$<br>$2.0h + 40.0$ |

$S$ = spacing of supporting components (ft)
$h$ = depth of deck (in.)
$L$ = span length of deck (ft)
$P$ = axle load (kip)
$S_b$ = spacing of gird bars (in.)
$+M$ = positive moment
$-M$ = negative moment
$X$ = distance from load to point of support (ft)

## Detailing Considerations

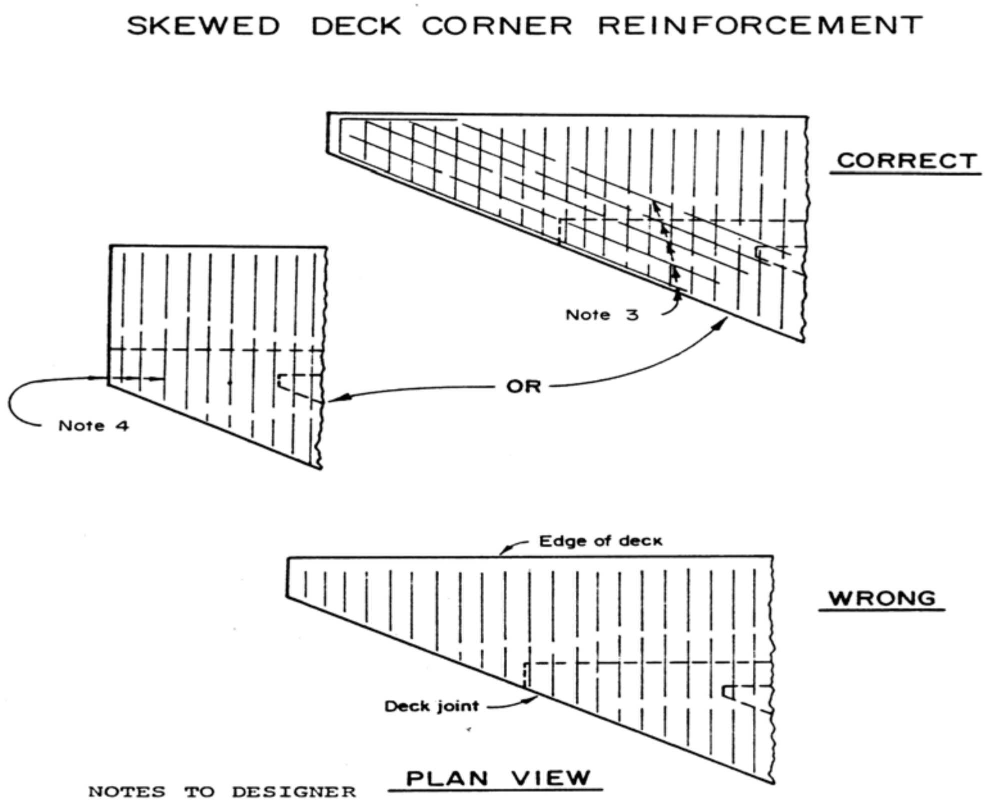
## Reinforcement Details

Designers must verify that main longitudinal reinforcement spacing and cover can fit within the specified slab thickness. Minimum reinforcement and spacing diagrams should follow MTD 10-20 and Standard Plan B0-5.

## Skewed Decks

Detailing varies based on the skew angle:

- **Skews < 20°**: Transverse reinforcement is parallel to the centerline of the abutment.
- **Skews > 20°**: Transverse reinforcement is normal to the centerline of the girder.




NOTES TO DESIGNER

1. Special consideration should be given to detailing the deck reinforcement in skewed corners of bridge decks.
2. Consider squaring off the deck at the end of the girder or placing reinforcing parallel to the abutment.
3. The designer should determine the amount and location of the reinforcement.
4. All reinforcement should be adequately anchored.

**Figure 10.5-1.** BDD 8-36 Skewed Deck Corner Reinforcement

## Deck Drains and Access Openings

Confirm drain assemblies fit specified locations; additional reinforcement may be required to secure the drain. **Deck openings are discouraged**; soffit openings are preferred for access.

Purchase this course to see the remainder of the technical materials.