# Heavy Load Concrete Floor Slab Design

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# Module 1: Introduction

## Learning Objectives

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

- **Identify** the specific criteria that classify a floor slab as "heavy loaded" versus "light loaded."
- **Distinguish** between various load types and their roles in the design of concrete slabs on grade.
- **Evaluate** the fundamental design basis used for military construction of heavy-duty floor slabs.

*Executive Summary:* This chapter establishes the mandatory criteria and definitions for designing concrete floor slabs on grade subjected to heavy loads in military facilities. It distinguishes heavy loads from light loads based on specific weight thresholds for vehicular, stationary, and wall loadings, and introduces a design methodology rooted in empirical working stress concepts rather than limit state design.

## Design Purpose

The criteria presented in this course govern the design of concrete floor slabs on grade specifically for buildings supporting **heavy loads**. This guidance is applicable to all elements responsible for military construction. In typical building environments, such as warehouses, these heavy loads are categorized into three primary types:

- **Moving loads**
- **Stationary live loads**
- **Wall loads**

## Scope and Application

This module covers theoretical concepts, practical applications, the design basis, and specific procedures for heavy-load scenarios. Note the following boundaries for this criteria:

- **Light-Loaded Areas:** For office spaces or similar environments, refer to TM 5-809-2/AFM 88-3, Module 2.
- **Vibratory Loadings:** For areas subjected to significant dynamic or oscillatory loads, refer to TM 5-818-1/AFM 88-7, Module 1.
- **General Standards:** For design criteria falling outside these specific scopes, use industry-standard engineering practices.

## Technical Definitions

The following definitions are foundational to the application of the design procedures:

## Load Classification

- **Light Loads:** Loads characterized by a forklift axle load of **5 kips or less** and stationary live loads less than **400 pounds per square foot (psf)**.
- **Heavy Loads:** Any load condition meeting or exceeding one of the following:
    - Moving live loads exceeding a **5-kip forklift axle load**.
    - Stationary live loads exceeding **400 psf**.
    - Concentrated wall loads exceeding **600 pounds per linear foot (plf)**.

## Load Types

- **Slab on Grade:** A concrete slab supported directly on the foundation soil.
- **Wall Load:** Concentrated loads imposed by walls or partitions.
- **Dead Load:** Permanent materials of the structure, including fixed equipment and permanent walls.
- **Live Load:** Loads from use and occupancy, further divided into:
    - **Moving Live Load:** Vehicular traffic (e.g., forklift trucks).
    - **Stationary Live Load:** Movable stored materials.
- **Vibratory Loads:** Dynamic or oscillatory loading of significant magnitude.
- **Design Load:** The combined effects of stationary live, dead, wall, and moving live loads.

⚠️ **Safety Constraint:** When calculating the **Design Load**, the dead load of the floor slab on grade itself must be ignored.

## Soil and Slab Types

- **Special Soils:** Soils with undesirable properties such as high swell potential or high compressibility.
- **Nonreinforced Slab:** A slab with minimal distributed steel (usually welded wire fabric) intended only to limit crack width from shrinkage and temperature.
- **Reinforced Slab:** A slab containing either welded wire fabric or deformed reinforcing steel bars for structural capacity.

## Design Fundamentals

The design of concrete floor slabs on grade is an iterative process focused on different loading conditions.

# Design Methodology

1. **Determine Slab Thickness:** Initial thickness is calculated based on expected **moving live loads**.
2. **Check Adequacy:** The determined thickness is then verified against the requirements for **stationary live loads**.
3. **Wall Load Analysis:** The thickness of the slab under wall loads is determined as a separate design step.

💡 **Design Tip:** The entire procedure is based on the **working stress concept**. Environmental stresses, such as those from temperature gradients, are not calculated separately; instead, they are accounted for in the pre-established empirical working stresses derived from roadway and airfield performance data.

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*Checkpoint Quiz*

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**1. Which of the following conditions would classify a floor slab as "Heavy Loaded"?**

a) A stationary live load of 350 psf.
b) A forklift axle load of 6 kips.
c) A concentrated wall load of 500 plf.
d) A total dead load including the slab weight.

**Answer:** (b). A forklift axle load exceeding 5 kips is one of the three specific triggers that define a "heavy load" classification.

**2. In the design of heavy-duty floor slabs on grade, how are stresses from temperature gradients handled?**

a) By adding a 10% safety factor to the dead load.
b) By performing a separate finite element analysis for thermal expansion.
c) They are inherently included in the empirically assigned working stresses.
d) By increasing the minimum reinforcement ratio by 0.0018.

**Answer:** (c). The design uses a working stress concept where environmental and temperature effects are accounted for within the assigned working stresses.

**3. According to the design procedure, what is the first step in determining the required slab thickness?**

a) Calculating the stationary live load capacity.
b) Evaluating the soil compressibility of "special soils."
c) Determining thickness based on moving live loads.
d) Summing the weight of the slab and the fixed equipment.

**Answer:** (c). The procedure dictates determining thickness based on moving live loads first, then checking for stationary load adequacy.

# Module 2: Basis Of Floor Slab on Grade Design

## Learning Objectives

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

- **Evaluate** the primary structural variables that control stress development in concrete slabs on grade.
- **Analyze** the impact of moving vehicular loads versus stationary live loads on slab design.
- **Apply** theoretical concepts, such as Westergaard's analysis, to determine bending moment stresses in heavy-loaded floor systems.

*Executive Summary:* The structural integrity of a concrete floor slab on grade is primarily governed by tensile stresses induced by moving live loads. Design procedures focus on limiting these critical stresses by correlating vehicle configurations with standard loadings. Stationary live loads and wall loads introduce additional complexity, requiring analysis of both positive and negative bending moments to ensure the slab thickness is adequate for all loading conditions across its service life.

## Design Stresses

The structural design of a concrete floor slab on grade is primarily controlled by stresses caused by **moving live loads** and, in specific cases, **stationary loads**. These stresses are a complex function of several interrelated variables:

- **Slab Parameters:** Thickness, modulus of elasticity ($E$), and Poisson's ratio.
- **Vehicle Characteristics:** Total weight, weight distribution, and wheel or track configuration.
- **Support Conditions:** The modulus of subgrade reaction ($k$) of the supporting foundation material.
- **Traffic Volume:** The frequency of loading over the design life, which is critical for fatigue considerations.

## Vehicle-Imposed Loads

Military vehicles are categorized into three general classifications for floor slab design:

1. **Forklift trucks**
2. **Other pneumatic and solid tired vehicles**
3. **Tracked vehicles**

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