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THE FUTURE OF SLAB-ON-GROUND DESIGN

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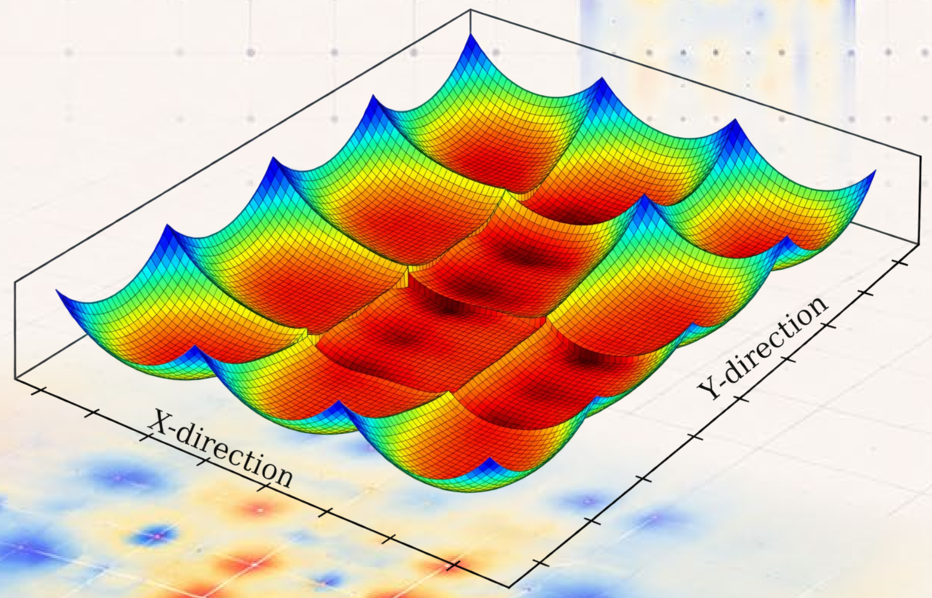

SLABS™ | The Future of SOG Design

Dr. Jeff Roesler

Dr. Lev Khazanovich

Juan Pablo Covarrubias

Nigel Parkes

THE SLAB DESIGNER.

Robert Rodden

THE SLAB DESIGNER.

Jorge Olavarría Bastidas

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Noon – 12.10	Nigel Parkes | **Introductions & The Need**
12.10 –12.30	Juan Pablo Covarrubias | **The How & Proof of Concept**
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2.00 – 2.30	All | **Questions & Answers**

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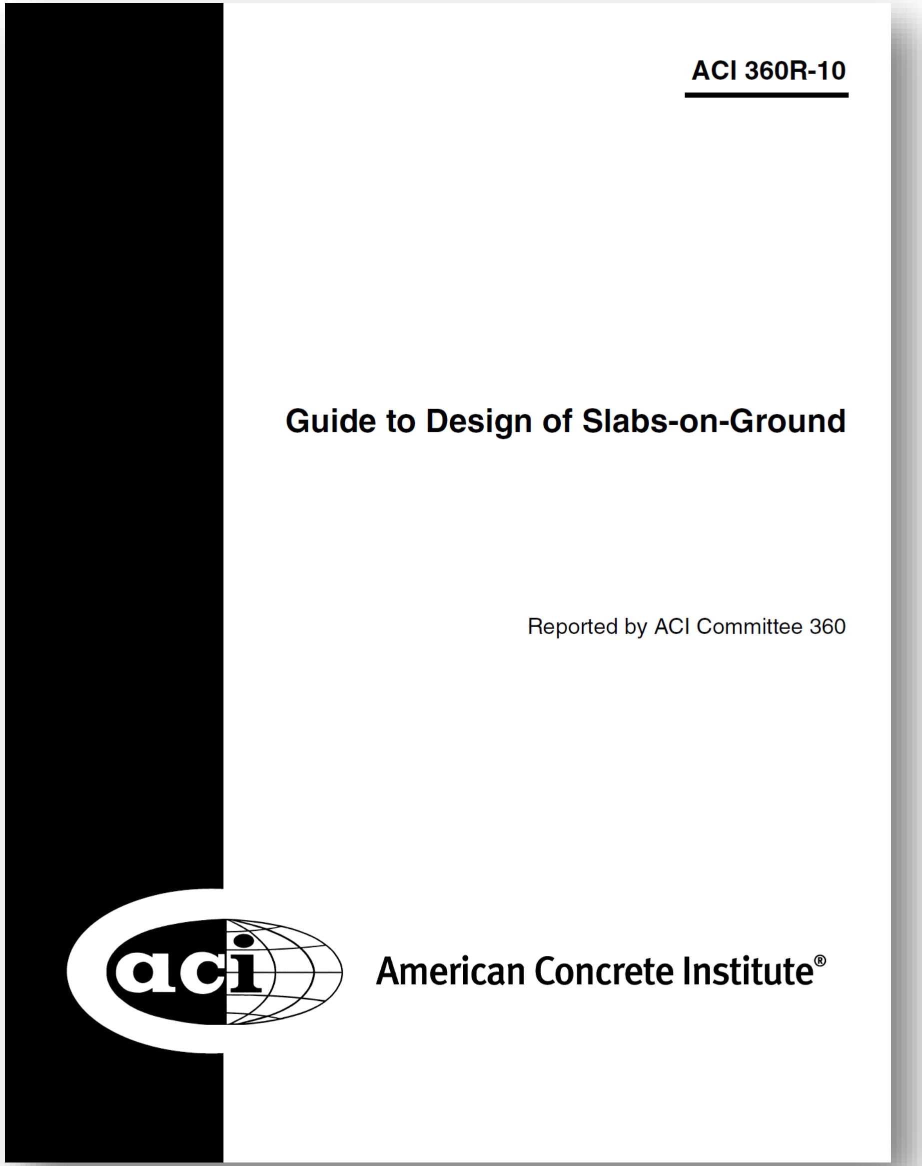
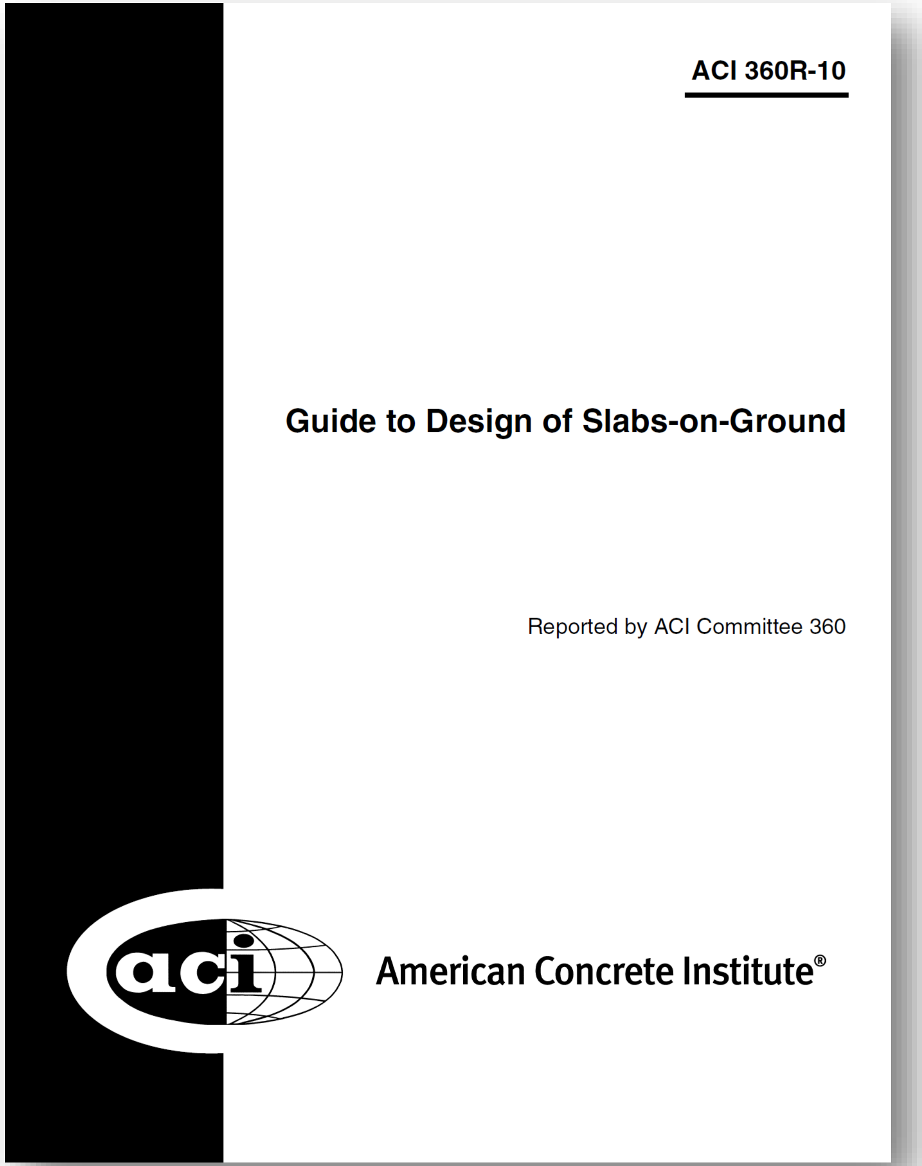


1.6—Further research

There are many areas that need additional research. Some of these areas are:

- Developing concrete mixture proportions that have low shrinkage characteristics and are workable, finishable, and provide a serviceable surface;
- Flexural stress in slabs with curl and applied loads and how curling stresses change over time due to creep;
- Base restraint due to shrinkage and other volume changes and how this restraint changes over time;
- Provide dowel recommendations based on loadings (lift truck, rack post, and uniform storage) rather than slab thickness;
- Provide plate dowel spacing recommendations for plate dowel geometries;
- Provide design guidance for slabs with macrosynthetic fibers;

> These are some pre-2010 “future research” needs that we can now incorporate into design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Guide to Design of Slabs-on-Ground

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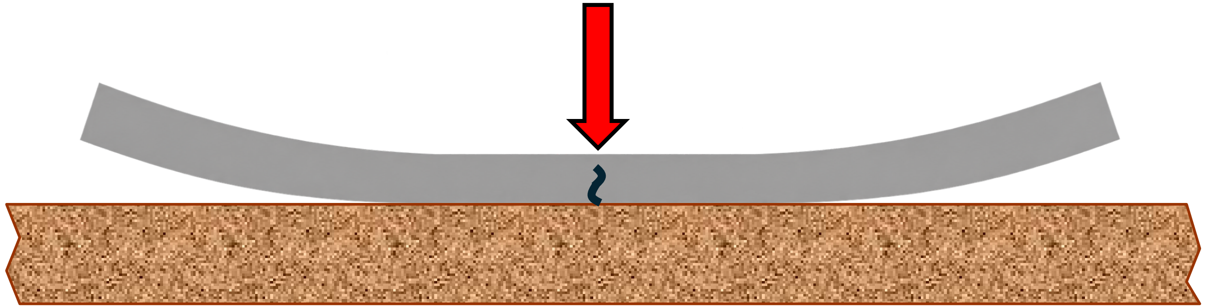
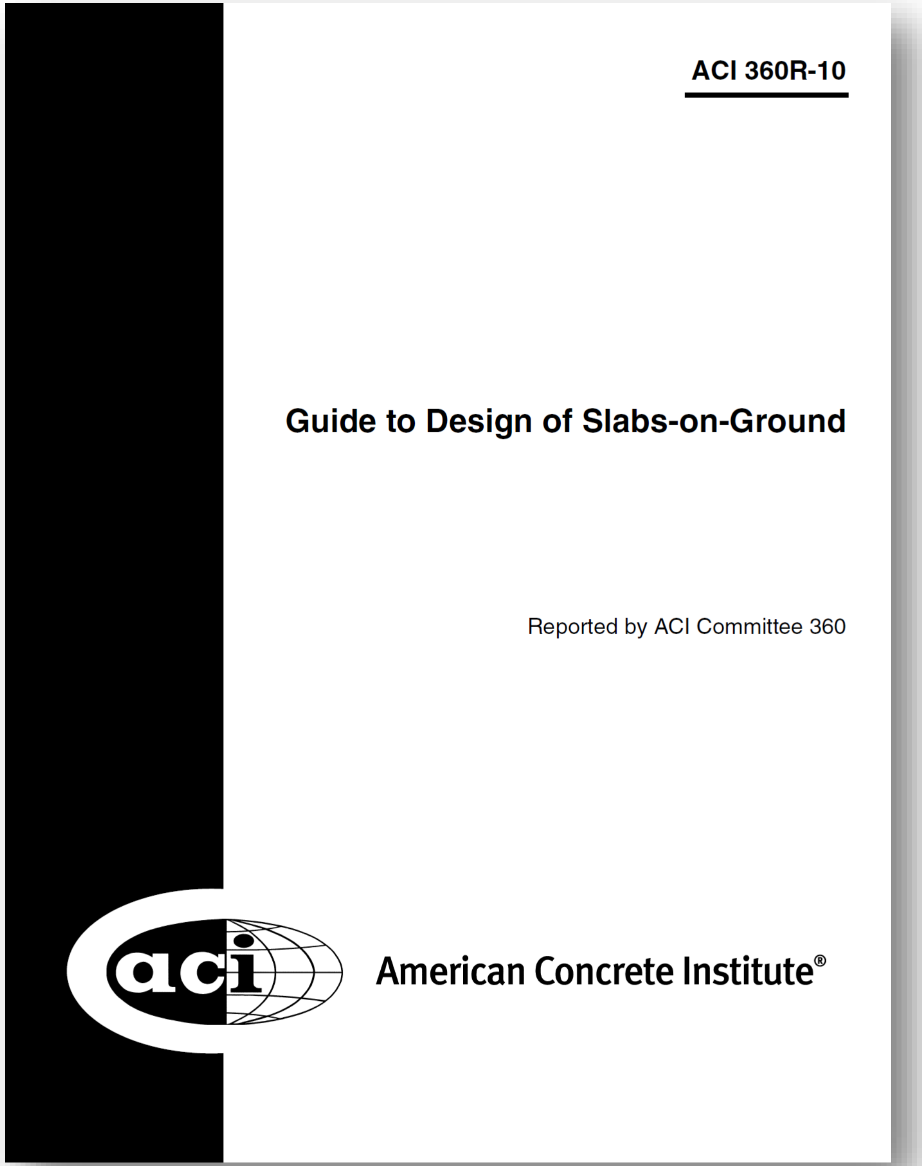
Generally accepted thickness design methods for unreinforced slabs-on-ground are the:

- PCA method (Section 7.2.1);
- WRI method (Section 7.2.2); and
- COE method (Section 7.2.3).

Each of these methods, described in Chapter 1, seek to avoid live load-induced cracks through the provision of adequate slab cross section by using an adequate factor of safety against rupture. The PCA and WRI methods only address live loads imposed on the slab's interior, whereas the COE method only considers live loads imposed on the slab's edges or joints. All three methods assume that the slab remains in full contact with the ground at all locations. Curl-induced stresses are not considered. Design examples in Appendixes 1, 2, and 3 show how to use all three methods.

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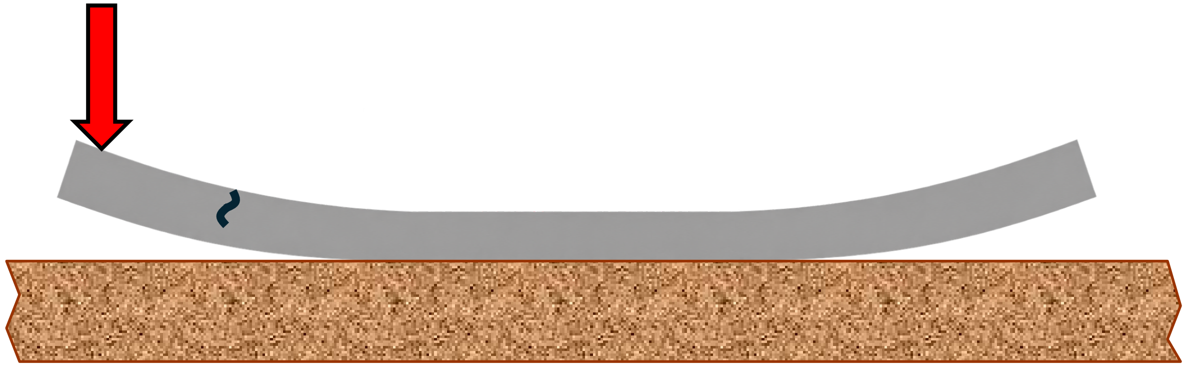
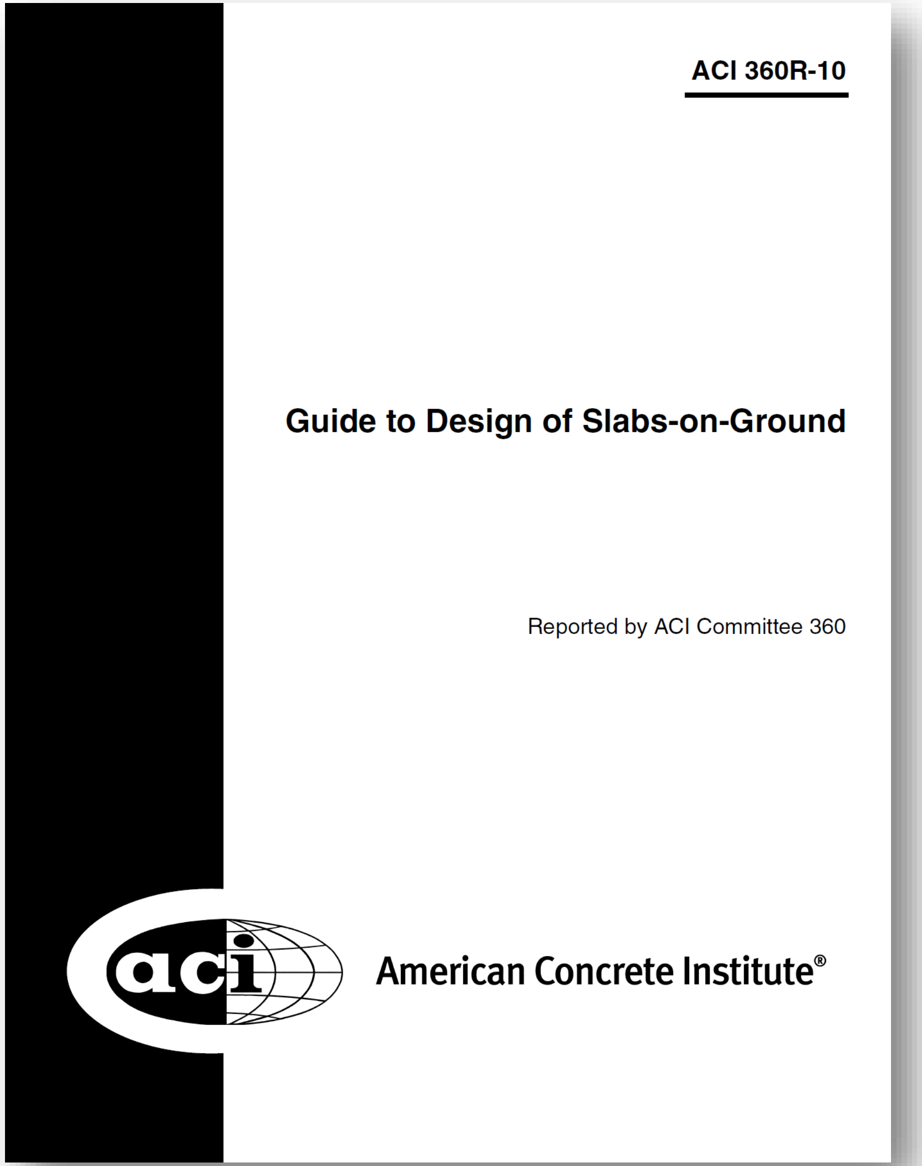
Ytterberg's 1987 paper documents the conflict between the Westergaard assumption of a fully supported slab-on-ground and the reality of either unsupported slab edges or supported slab centers. Because the three commonly used slab thickness design methods (PCA, WRI, and COE) all are based on Westergaard's work and the assumption that slabs are always fully supported by the subgrade, they give erroneous results for slab thickness where the slab is not in contact with the subgrade. This is called the cantilever effect. The thickness

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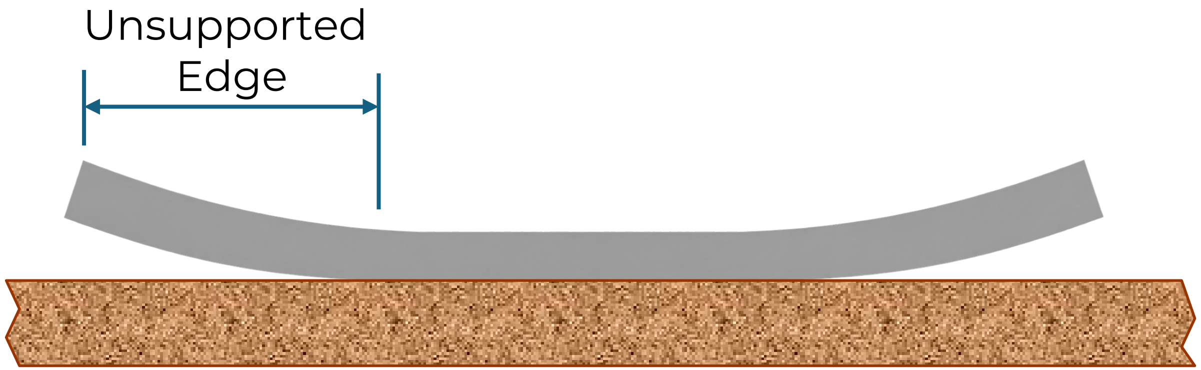
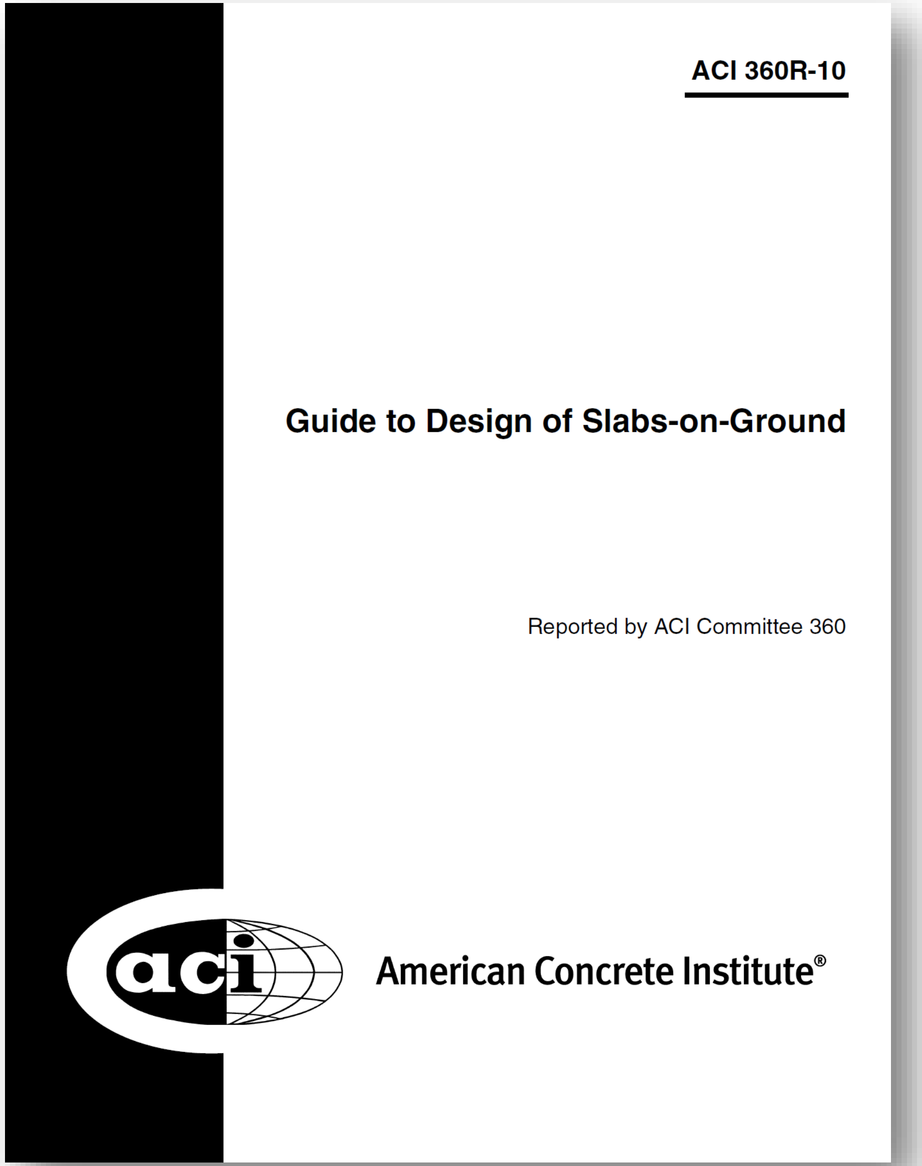
Another anomaly is that the three slab thickness design methods permit thinner slabs as the modulus of subgrade reaction increases. A higher subgrade reaction modulus actually increases the length of unsupported curled slab edges because the center of the slab is less able to sink into the subgrade. Thus, curling stress increases as the subgrade stiffens, and resultant load-carrying strength decreases for edge loadings; however, higher *k* with loadings away from the edges allows thinner slabs. Designers should consider these factors.

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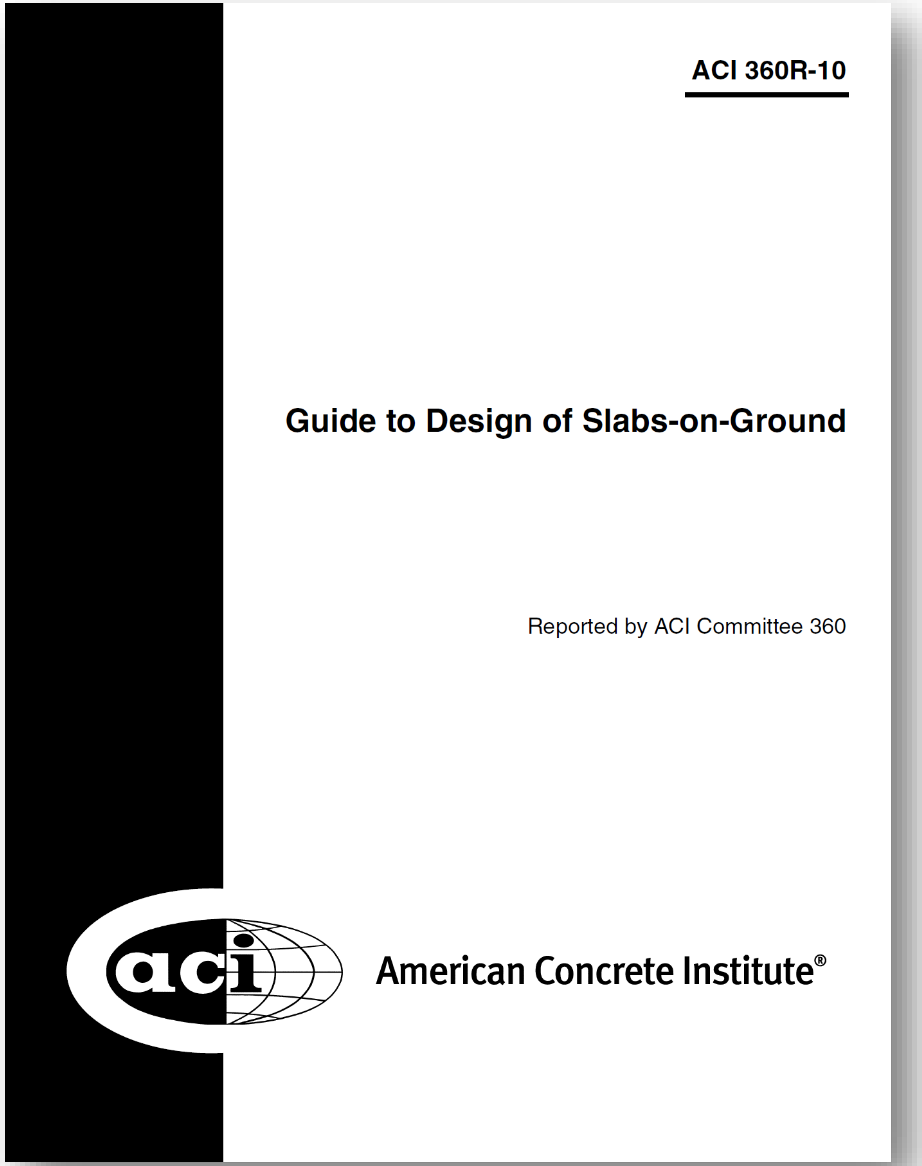
1.4.3 *Finite-element method*—The classical differential equation of a thin elastic plate resting on an elastic subgrade is often used to represent the slab-on-ground. Solving the governing equations by conventional methods is feasible for simplified models where slab and subgrade are assumed to be continuous and homogeneous. In reality, a slab-on-ground usually contains discontinuities, such as joints and cracks, and the subgrade support may not be uniform. Thus, the use of this approach is limited.

The finite-element method can be used to analyze slabs-on-ground, particularly those with discontinuities. Various models have been proposed to represent the slab (Spears and Panarese 1983; Pichumani 1973). Typically, these models use combinations of elements, such as elastic blocks, rigid blocks, and torsion bars, to represent the slab. The subgrade is typically modeled by linear springs (Winkler subgrade) placed under the nodal joints. Whereas the finite-element method offers good potential for complex problems, graphical solutions and simplified design equations have been traditionally used for design. The evolution of modern computer software has made modeling with finite elements more feasible in the design office setting.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11.3.3.4 *Nonlinear finite element computer modeling*—Proprietary finite-element modeling techniques can be used to model nonlinear material behavior. Such designs may include linear shrinkage, curling, and applied loads and are typically iterative. Once final stresses are determined, calculate a residual strength factor $R_{e,3}$ to determine the steel fiber quantity.

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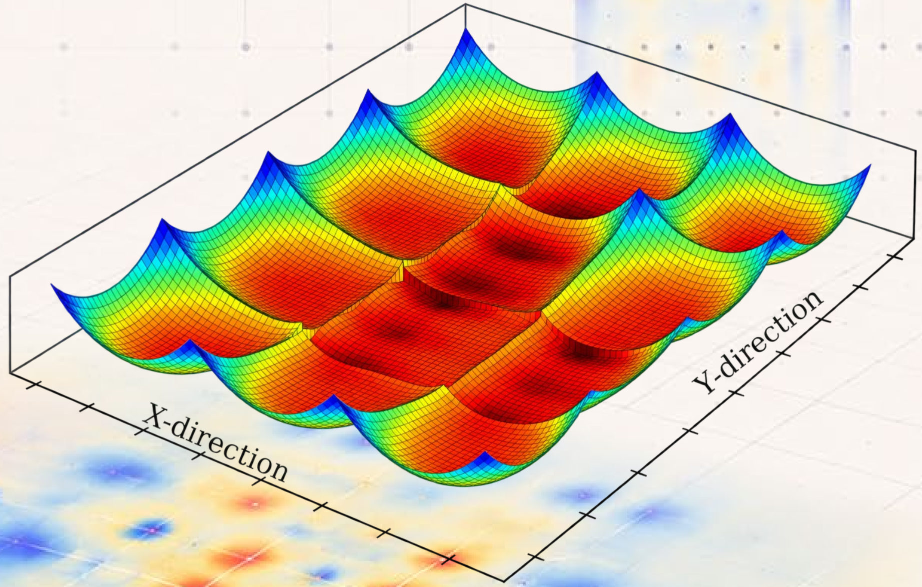

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