ACI 318 Floor Slab Design

Role of Tests, Observations, and Mete Sozen

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Mete

- Friend
- Colleague
- Mentor
- Thinker
Investigation of Multiple-Panel Reinforced Concrete Floor Slabs

Design Methods—Their Evolution and Comparison

By METE A. SOZEN and CHESTER P. SIESS
The Sozen and Siess paper provided—
• an introduction to the historical background of the design methods for floor slabs permitted in ACI 318-56
• the over-all results of tests on five structures tested at the University of Illinois.
Some historical background:

*Methods of design for flat slabs and two-way slabs were very different.

*Two-way slab looked like traditional timber or steel construction.

*Flat slab had to be invented and was assigned some "special" attributes.
Weight of steel required in the interior panel of a flat slab in 1910
Flat Slabs

• 1906 C.A.P. Turner

Load tested his first flat slab design. By 1913, over 100 flat slab buildings were built around the world. There were fights over patent rights and the way in which load was carried. Turner wrote on many topics.

(MAS Footnote: A book published in 1934 had comments on—
• the quirks of the English language
  ("Wormwood is unrelated alike to wood and worms.")
• disproved Einstein
• welcomed the F. D. R.’s New Deal
• The book was intended for reinforced concrete design.)
Flat Slabs

- 1914 J. R. Nichols
Most engineers classified the flat slab as "beyond the range of pure analysis," but Nichols proposed a simple approach--

\[ M_A + M_B = M_O = WL/8 \]

Paper was short (10 pages) but had over 50 pages of discussion. (MAS “Newtonian mechanics stood very much condemned.”)
Flat Slabs

- **1921 Westergaard and Slater**
  Showed that moments in slabs were not as small as measured from strains

![Diagram showing the effect of tension in concrete](image)

**Effect of tension in concrete**
• Moments in a flat slab

Westergaard and Slater 1921

• Napoleon’s 1812 Campaign to Moscow

Charles Joseph Minard 1791-1870
Design Moments

Flat slabs—Separate sections

• 1916
  \[ M_o = 0.107WL (1 - 2c/3L)^2 \]
  85% of Nichols' analysis (statics)

• 1920-1956 ACI Building Codes
  \[ M_o = 0.09WL (1 - 2c/3L)^2 \]
  72% of statics

• 1963 ACI Code
  \[ M_o = 0.10WL (1 - 2c/3L)^2 \]

Two-way slabs—included in sections on flexure

• 1916 Both slab and beams were designed for full load and pattern loadings. Beams were designed using ACI Moment coefficients.
  \[ M_o > \text{Moment from statics of panel} \]

• 1936 Method 1
• 1947 Method 2 added
• 1963 Method 3 added

No wonder designers were confused!
University of Illinois test program began in 1956--40 years after Talbot suggested a test program was needed.

¼ scale test structures

Flat plate 2 Flat Slabs 2 Two-Way Slabs
Test of Flat Slab reinforced with WWF

Instrumented reaction tripod

1950’s state-of-the-art data acquisition system
### Comparison of Ultimate to Design Load (using ACI 318-56)

<table>
<thead>
<tr>
<th></th>
<th>T1 Two-way slab</th>
<th>T2 Two-way slab, modified design</th>
<th>F1 Flat plate</th>
<th>F2 Flat Slab</th>
<th>F3 Flat Slab WWF</th>
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<tbody>
<tr>
<td><strong>Test load</strong></td>
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<tr>
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1/16 scale tests at U of I

3/4 scale test at PCA Labs
The Building of a Building Code

The tension between theory and observation

BY METE A. SÖZEN
“There is no absolute truth that governs …..a building code. A building code is doomed to vacillations between theory and test. No prescription for developing a building code can be guaranteed to be successful, but there are simple rules, derived from experience, that deserve mention:”

• Don’t change the code unless dangerous practices or failures occur.
• Test results must be confirmed by field observations.
• No revisions in less than 7 years.
• Keep the code committee small (< 12 members)
ACI 318-71
CHAPTER 13-SLAB SYSTEMS WITH MULTIPLE SQUARE OR RECTANGULAR PANELS

\[ M_0 = \frac{wl^2l^2}{8} \]

\[ M^- = 0.65M_0 \]
\[ M^+ = 0.35M_0 \]

Col. Strip 0.75M-
Mid. Strip 0.25M-
Col. Strip 0.6M+
Mid. Strip 0.4M+

Beam \leq 0.85
Col. Strip M

Beam \geq 0.85
Col. Strip M

Typical Interior square panel

Col. Strip
Mid. Strip
Mete Sozen

• Influenced virtually all aspects of design of concrete structures
• Influenced a large number of researchers and designers all over the world
• Stressed the importance of observation
• Taught us to ask the right questions