Improving the Design and Construction of Concrete Slabs-on-Ground

Honoring Bruce Suprenant Concrete Construction Contributions
Part 3 of 4

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Bruce Suprenant

Tolerances for Cast-in-Plac
Concrete Buildings
A Guide for Specifiers, Contractors, and

by Bruce A. Suprenant, PhD, PE, FACI
and Ward R. Malisch, PhD, PE, FACI

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CONCRETE CON

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ACI

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Concrete materials and methods of concrete construction/Test methods and standard practices for concrete

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American Society of Concrete Contractors

Position Statement #46

Water-Cementitious Materials Ratio for Concret to Receive a Trowel Finish

ode, Table 19.23.2.1, requires
titious materials ratio (*w/cm*)
e with the severity of the
for each exposure category:

d
rcement (C).
de varies from N/A (not
nd 0.40, depending on the
concrete to receive a trowel
in an exposure category for
num *w/cm*. Unfortunately,
ximum *w/cm* for interior
hich results in undesirable
sh.
low *w/cm* increases abrasion
esults in a faster drying time
e-sensitive floor covering.
ence of Construction
ce," SP-100: *Concrete*
) showed that repeated power
sion resistance and decreased
gn by providing a lower
due to the troweling.
oncrete Slabs that Receive
erials," Section 9.4,
best compromise between
ance. Further, specifying a
crete workability is not
5, "Guide to Concrete Floor
8.4.4: "The amount of water
ixture is generally determined
bined aggregate material used

in the mixture and is not effectively controlled by spec
w/cm." And specifying a maximum *w/cm* may be harm
stated in NRMCA Publication 2PE004-21, "Guide to
Improving Specifications for Ready Mixed Concrete,"
2.11: "Including a maximum *w/cm* for concrete where
essential can adversely affect the ability to place and f
concrete and the concrete performance because of pos
increased paste content, elevated concrete temperature
increased propensity for cracking."
If *w/cm* must be specified, ACI 302.1R-15, Section
recommends a *w/cm* in the range of 0.47 to 0.55 for co
floors to receive a trowel finish. However, concretes w
same specified strength but with a different *w/cm* will
have identical workability and finishability. For examp
consider the difference in water content for the concre
a compressive strength, f'_c, of 4000 psi (28 MPa), whic
contains 500 lb/yd³ (297 kg/m³) of total cementitious
materials, with a *w/cm* of 0.40 and 0.50. The water co
are 24 and 30 gal./yd³ (119 and 149 L/m³), respectivel
6 gal./yd³ (30 L/m³) difference can dramatically affect
concrete placing and finishing properties.
In addition, ACI 302.1R-15, Section 8.3, states that
troweled concrete, "a minimum amount of water is rec
produce a workable, finishable mixture with predictab
uniform setting characteristics. Currently available wa
reducing admixtures perform best when they are mixe
concrete that has enough water to produce a water-ind
slump of 3 to 4 in. [75 to 100 mm] if no admixture wa
If this water slump is not achievable with the admixtu
setting times and finishability can vary when the conc
subjected to normal variations of ambient temperature
time between batching and discharge. The slump enve
results in predictable setting times and the required se
of finishing operations."

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Direcator - [də rə kāt tər] **noun** A person who consistently accomplishes what Bruce Suprenant accomplished throughout a career.

Posted on: January 09, 2014

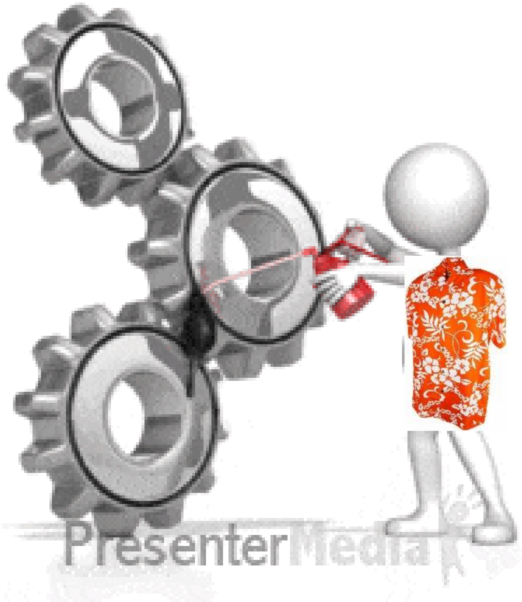
2014 INFLUENCER: BRUCE SUPRENANT

American Society of Concrete Contractors, St. Louis

There aren't too many engineers who have dedicated so much of their lives helping contractors both through education and direct consultation. "I've tried to interpret between the engineer and the contractor," he says. "To help each understand what the other can and can't do and to find some simple changes that can make everyone happy. A lot of this was spent educating engineers about construction. It seems like I helped to define this gap."

For many years, Suprenant was a fixture at the World of Concrete, often appearing as the master of ceremonies for the Mega-Demos in jeans, work boots, and a tuxedo shirt

"For being an advocate for contractors and helping the entire design and construction team understand one another"



Why Slabs Curl

Part II: Factors affecting the amount of curling

BY BRUCE A. SUPRENANT

Slabs curl due to differences in moisture distribution that create a shrinkage profile. This induces an applied curling moment within the slab. The amount of curling for a given moisture distribution may, however, not be unique. Some research and field experience helps us estimate the amount of curling deflection as affected by differences in:

- Amount of drying shrinkage;
- Modulus of subgrade reaction;
- Concrete compressive strength and modulus of elasticity;
- Reinforcement ratio;
- Slab thickness;
- Joint spacing; and
- Curing.

Not all of these factors affect curling deflection to the same degree.

Drying shrinkage

Drying shrinkage is considered to be one of the most important factors affecting the amount of curling deflection. Many references suggest ways to minimize drying shrinkage,[1-3] but the exact relationship between drying shrinkage and curling deflection is unclear.

Tremper and Spellman[4] developed a figure that related slab-curling deflections of full-size test slabs to the shrinkage of laboratory specimens made with the test-slab concrete. Although this figure provides information on only one project, their paper includes data on slab curling versus drying shrinkage for two other projects. The data for all three projects are shown in Table 1 and arranged in the order of the percent of drying shrinkage, from lowest to highest.

The table shows that it's difficult to relate drying shrinkage to curling deflection for projects with differing variables such as subgrade or subbase stiffness and drying environments. However, Fig. 1, which graphs the Tremper and Spellman data by project, suggests that a relationship exists on a project-by-project basis. As the graph shows, curling deflection increases as drying shrinkage increases, though the ratio of drying shrinkage to curling is unique for each project. As Table 1 shows, the average curl, in inches, is three times the drying shrinkage, in percent. Thus, in some cases, reducing drying shrinkage by a given percent would result in a much greater percentage decrease in curling deflection.

American Society of Concrete Contractors

Position Statement #35

The Effect of Curling on Floor Flatness

ACI 117-06 and ACI 117-10, “Specification for Tolerances for Concrete Construction and Materials,” require F-numbers to be measured within 72 hours after slab concrete placement. This was not always the case. ACI 117-90 included no time requirement for the measurement of floor flatness, F_F, and the commentary stated the reason: “Since neither deflection nor curling will significantly change a floor’s F_F value, there is no time limit on the measurement of this characteristic.”

The statement in the commentary indicating that curling will not significantly change a floor’s F_F value has since been shown to be incorrect by measurements published in “The Concrete Floor Tolerance/Floor Covering Conundrum,” *Concrete International*, July 2003. This is why ACI 117-06 and ACI 117-10 now require that F_F measurements be made within 72 hours.

In addition to the measured field data, it’s possible to calculate the effect of curling on floor flatness as shown in Chapter 8, Floor Flatness and Levelness, of *Tolerances for Cast-in-Place Concrete Buildings* published by the American Society of Concrete Contractors in 2009. The calculation method was also included in “The Effect of Curling on Floor Flatness,” *Concrete Contractor*, April/May 2010. This is important because ACI 302.1R-04, “Guide for Concrete Floor and Slab Construction,” states:

> Application of present technology permits only a reduction in cracking and curling, not elimination. Even with the best floor designs and proper construction, it is unrealistic to expect crack-free and curl-free floors. Consequently, every owner should be advised by both the designer and contractor that it is normal to expect some amount of cracking and curling on every project, and that such occurrence does not necessarily reflect adversely on either the adequacy of the floor’s design or the quality of its construction.

Design professionals should consider how curling is to be dealt with on each project so that the specifications address this issue. Curling occurs because of differential moisture loss that is a time-dependent process; thus, the initial floor flatness produced by the concrete contractor will decrease with time. The table below shows how an initial F_F of 51 can decrease to 45, then 35 and finally to 22 as curling occurs and slab edges raise from 1/16, to 1/8 and 1/4 in.

Calculated effect of curling on floor flatness

Amount of curl	F_F Number		
Initial F_F—no curl	51	40	25
1/16 in.	45	40	25
1/8 in.	35	35	23
1/4 in.	22	23	18
Percent decrease from initial			
1/16 in.	12%	0%	0%
1/8 in.	31%	13%	8%
1/4 in.	57%	43%	28%

To deal with changes in floor flatness with time, design professionals can use an allowance for floor grinding and leveling as described in “Division 3 versus Division 9 Floor Flatness Tolerances,” ASCC Position Statement #6, *Concrete International*, June 2003. An additional resource is “Responsibility for Controlling Slab Curling,” ASCC Position Statement #30, *Concrete International*, January 2010.

ASCC concrete contractors will meet the F_F specification requirements when measured within 72 hours. The effects of a decrease in floor flatness with time must be addressed by the design professional with respect to the work of follow-up trades.

If you have any questions, contact your ASCC concrete contractor or the ASCC Technical Hotline at (800) 331-0668.

This position statement from the American Society of Concrete Contractors is presented for reader interest by the editors. The opinions expressed are not necessarily those of the American Concrete Institute. Reader comment is invited.

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The Design of Slabs to Receive Moisture-Sensitive Floor Coverings

Design of Slabs that Receive Moisture-Sensitive Floor Coverings

Part 2: Guide to Specification Issues for Architects and Engineers

BY BRUCE A. SUPRENANT

When preparing construction documents for concrete slabs that will receive moisture-sensitive floor coverings, specifiers must consider both the benefits and liabilities of any decisions they make regarding:

- Vapor retarders;
- Concrete materials and properties;
- Concrete surface properties; and
- Protection of the floor surface.

The decisions require compromises—as do most design decisions.

VAPOR RETARDERS

Vapor retarder location is a critical decision, but material, thickness, and installation methods also must be considered.

Fill under Concrete Slabs."[1] This standard requires specifications for vapor-retarder materials to include the following:

- This specification number (E 1745);
- Class A, B, or C, or alternatively, specific performance requirements for each of the properties (water vapor permeance, tensile strength, and puncture resistance); and
- Performance requirements, if any, for special conditions (flame spread, permeance after soil poison petroleum vehicle exposure, and permeance after exposure to ultraviolet light).

Class A, B, and C vapor retarders must all have the same 0.3-perm water vapor permeance but have to meet differing tensile strength and puncture resistance requirements. Class A has the highest strength and puncture resistance and Class C has the lowest.

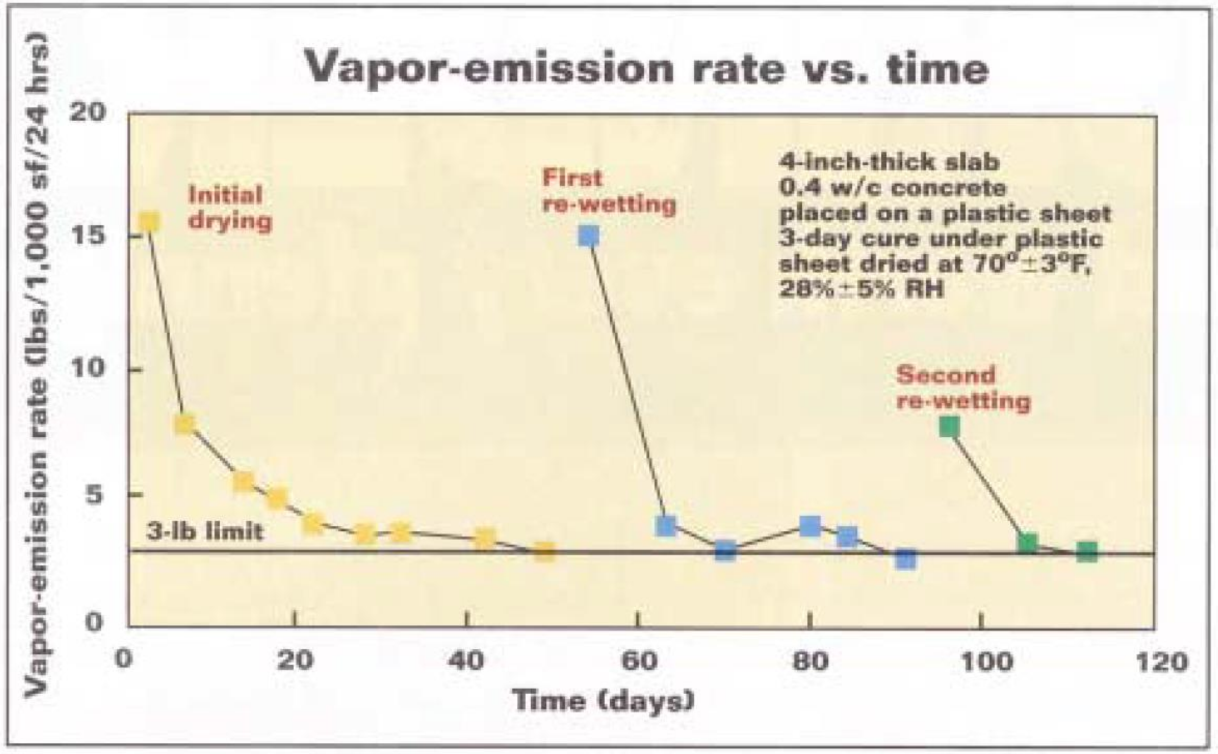
Thickness

ACI 302.1R-96, "Guide for Concrete Floor and Slab Construction,"[2] gives the following recommendation for vapor retarder thickness:

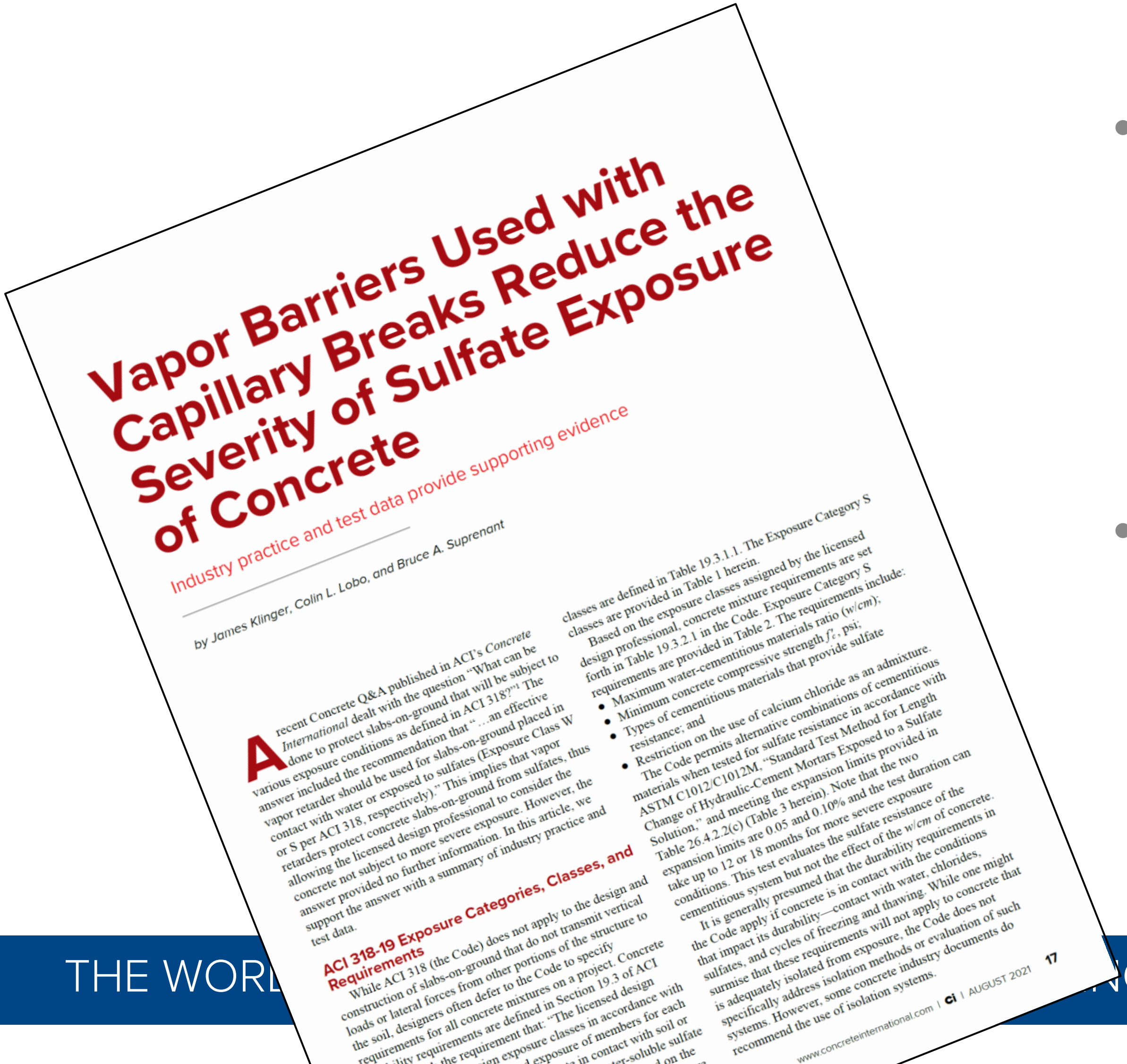
Concrete international / APRIL 2003 85

- Vapor Retarder
- Drying Time
- Concrete Mixture
- Slab Thickness
- Concrete Finish
- Curing

The Design of Slabs to Receive Moisture-Sensitive Floor Coverings



Sulfate Exposure of Concrete Slabs



Vapor Barriers Used with Capillary Breaks Reduce the Severity of Sulfate Exposure of Concrete

Industry practice and test data provide supporting evidence

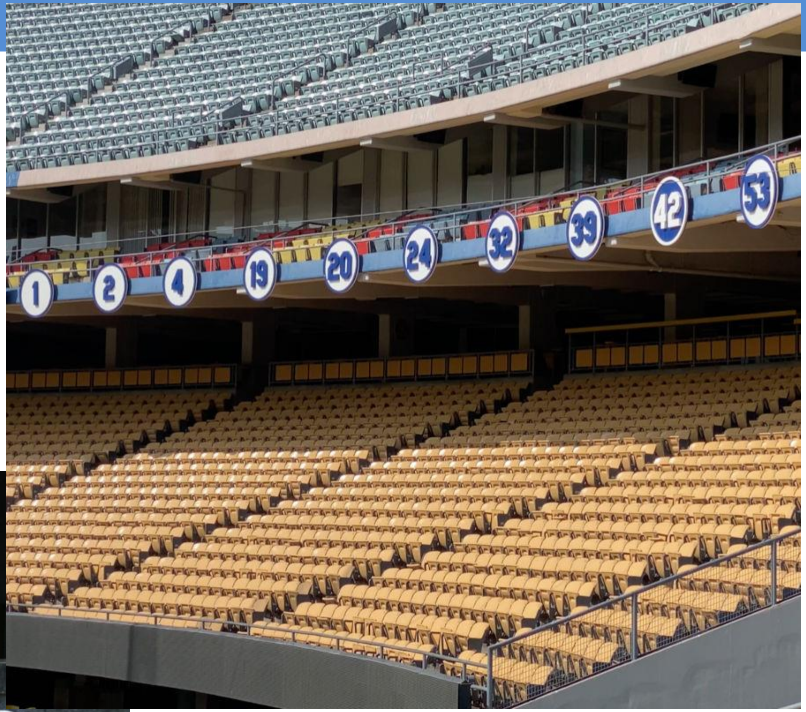
by James Klinger, Colin L. Lobo, and Bruce A. Suprenant

A recent Concrete Q&A published in ACI's *Concrete International* dealt with the question "What can be done to protect slabs-on-ground that will be subject to various exposure conditions as defined in ACI 318?"[1] The answer included the recommendation that "…an effective vapor retarder should be used for slabs-on-ground placed in contact with water or exposed to sulfates (Exposure Class W or S per ACI 318, respectively)." This implies that vapor retarders protect concrete slabs-on-ground from sulfates, thus allowing the licensed design professional to consider the concrete not subject to more severe exposure. However, the answer provided no further information. In this article, we support the answer with a summary of industry practice and test data.

ACI 318-19 Exposure Categories, Classes, and Requirements

- ACI 318 Requirements
  - Lower w/c
  - Higher Strength
  - Sulfate Resistant Cement
- Separation Layer to Prevent Concrete from Contacting High-Sulfate Soils

Retired Numbers



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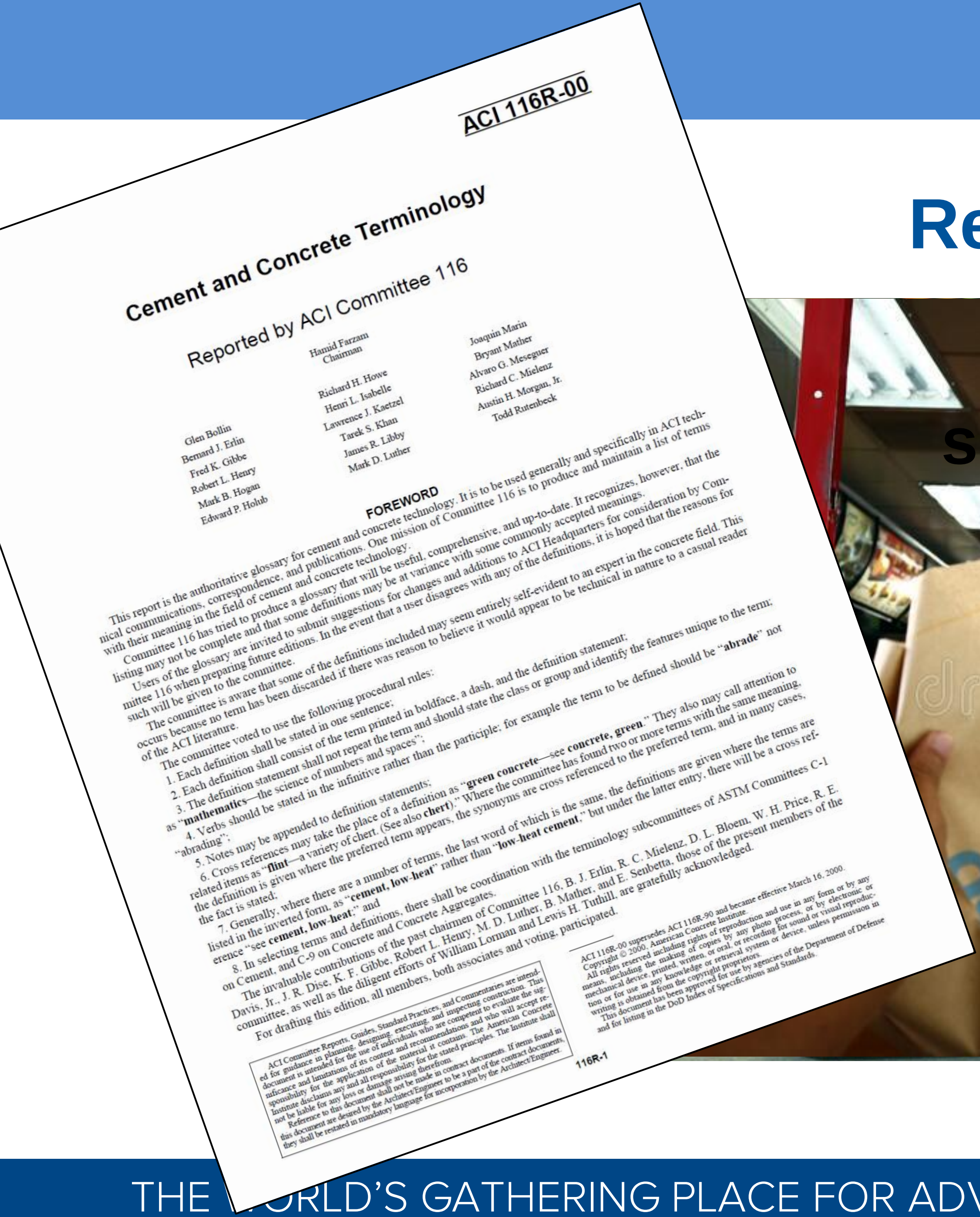
ACI 116R-00

Cement and Concrete Terminology

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FOREWORD

This report is the authoritative glossary for cement and concrete technology. It is to be used generally and specifically in ACI technical communications, correspondence, and publications. One mission of Committee 116 is to produce and maintain a list of terms with their meaning in the field of cement and concrete technology.

Committee 116 has tried to produce a glossary that will be useful, comprehensive, and up-to-date. It recognizes, however, that the listing may not be complete and that some definitions may be at variance with some commonly accepted meanings.

Users of the glossary are invited to submit suggestions for changes and additions to ACI Headquarters for consideration by Committee 116 when preparing future editions. In the event that a user disagrees with any of the definitions, it is hoped that the reasons for such will be given to the committee.

The committee is aware that some of the definitions included may seem entirely self-evident to an expert in the concrete field. This occurs because no term has been discarded if there was reason to believe it would appear to be technical in nature to a casual reader of the ACI literature.

The committee voted to use the following procedural rules:

1. Each definition shall be stated in one sentence;
2. Each definition shall consist of the term printed in boldface, a dash, and the definition statement;
3. The definition statement shall not repeat the term and should state the class or group and identify the features unique to the term; as "**mathematics**—the science of numbers and spaces";
4. Verbs should be stated in the infinitive rather than the participle; for example the term to be defined should be "**abrade**" not "abrading";
5. Notes may be appended to definition statements;
6. Cross references may take the place of a definition as "**green concrete**—see **concrete, green**." They also may call attention to related items as "**flint**—a variety of chert. (See also **chert**)." Where the committee has found two or more terms with the same meaning, the definition is given where the preferred term appears, the synonyms are cross referenced to the preferred term, and in many cases, the fact is stated;
7. Generally, where there are a number of terms, the last word of which is the same, the definitions are given where the terms are listed in the inverted form, as "**cement, low-heat**" rather than "**low-heat cement**," but under the latter entry, there will be a cross reference "see **cement, low-heat**;" and
8. In selecting terms and definitions, there shall be coordination with the terminology subcommittees of ASTM Committees C-1 on Cement, and C-9 on Concrete and Concrete Aggregates.

The invaluable contributions of the past chairmen of Committee 116, B. J. Erlin, R. C. Mielenz, D. L. Bloem, W. H. Price, R. E. Davis, Jr., J. R. Dise, K. F. Gibbe, Robert L. Henry, M. D. Luther, B. Mather, and E. Senbetta, those of the present members of the committee, as well as the diligent efforts of William Lorman and Lewis H. Tuthill, are gratefully acknowledged.

For drafting this edition, all members, both associates and voting, participated.

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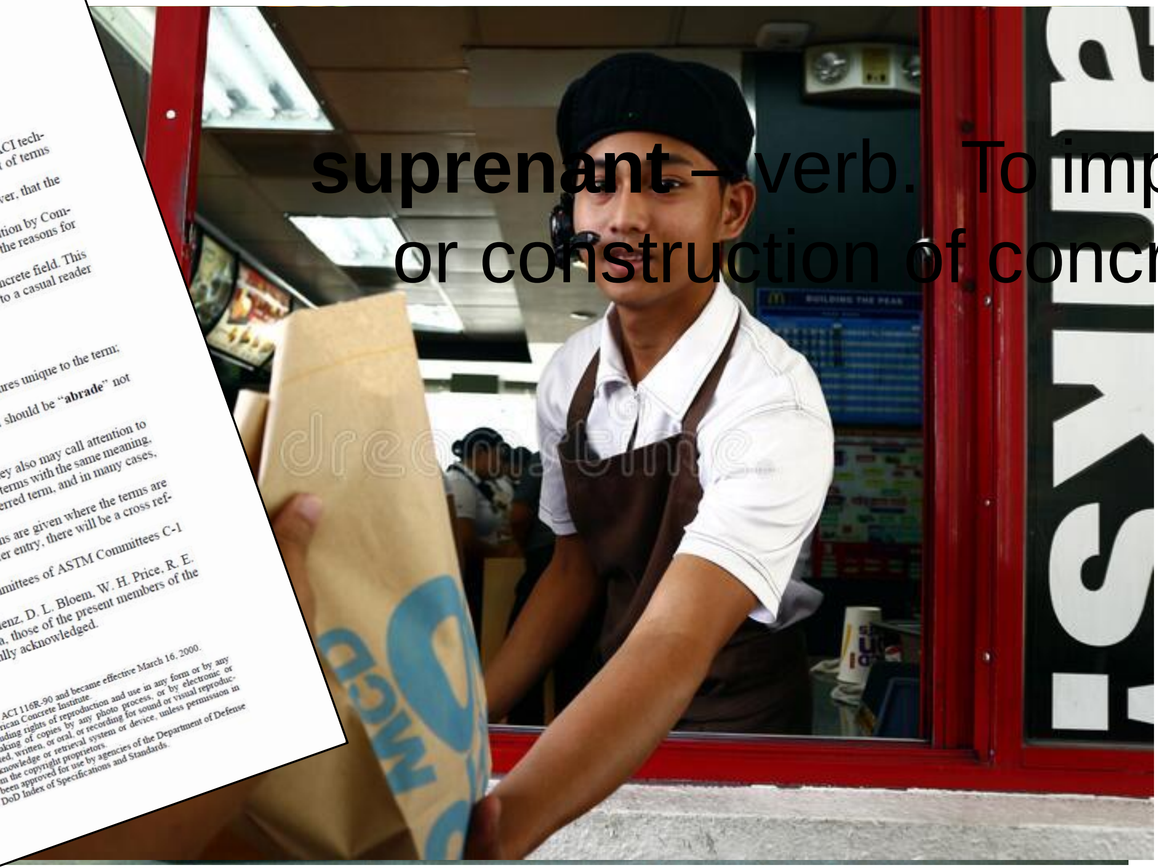

suprenant – verb. To improve the design or construction of concrete.

Thank You Bruce Suprenant!

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