IN-LB	Inch-Pound Units
SI	International System of Units

Measurements of Workability and Rheology of Fresh Concrete—Report

Reported by ACI Committee 238

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Measurements of Workability and Rheology of Fresh Concrete—Report

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This report presents insights related to the understanding of a workable concrete for a given application, and consists of four main parts: 1) definitions related to rheology and workability; 2) critical review of the tests available to measure different aspects of workability and rheological performance of fresh concrete; 3) discussion of the factors affecting the performance of fresh concrete; and 4) examples that illustrate the application of rheology and material science to predict or improve the performance of fresh concrete in the field.

Adequate workability can range from no flow (zero-slump) to liquid flow-like (self-consolidating concrete), depending on the application.

Keywords: fresh concrete; measuring; rheology; slump; testing; workability.

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CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

Fresh concrete properties are imperative not only in obtaining the desired hardened state properties, but also can affect the constructability including mixing, transporting, placing, consolidating, and finishing of the concrete. For example, when considering concrete with relatively lower workability, poor placement or consolidation may lead to defects such as honeycombing, which reduces compressive strength and increases permeability, thereby leaving the concrete open to chemical attack. On the other hand, poor placement or consolidation for concretes with relatively higher workability (for example, self-consolidating concrete) may lead to other issues such as segregation and bleeding, which can also result in reduced strength and poor surface quality.

Nevertheless, fresh concrete properties are not always properly measured or predicted during the mixture proportioning design process or through a quality control program. Although originally developed as a consistency test (to quantify batch-to-batch variability), the slump test is one of the most commonly specified test methods to access the workability of the concrete. It is important to understand that because the same slump value can be obtained for concretes with very different workabilities, slump is not always the most applicable test method. Over the years, hundreds of tests have been developed to measure the workability of concrete. The question is how to select the proper test for the application at hand, and how to interpret the results obtained to predict the performance of the concrete in the field in the fresh state.

1.2—Scope

To address these questions, it is necessary first to define workability in terms of fundamental physical entities, as described in the science of rheology. Therefore, this report has four main parts:

1. Definitions related to rheology and workability
2. Critical review of the tests available to measure different aspects of workability and rheological performance of fresh concrete
3. Discussion of the factors affecting the performance of fresh concrete
4. Examples that illustrate the application of rheology and material science to predict or improve the performance of fresh concrete in the field

This report presents insights related to the understanding of a workable concrete for a given application. Adequate workability can range from no flow (zero-slump) to liquid flow-like (self-consolidating concrete), depending on the application.

CHAPTER 2—NOTATION AND DEFINITIONS

2.1—Notation

c = second order parameter in modified Bingham model, Pa·s^2 (psi·s^2)
d = depth of penetration
g = gravity, m/s^2 (ft/s^2)
h = height of slump cone mold, m (in.)
K = consistency factor, Pa·s^n (psi·s^n)
n = consistency index or power index representing deviation from Newtonian behavior
s = slump, m (in.)
V = volume of slump cone, m^3 (in.^{3})
W = cone mass
α = time-dependent parameter in DeKee and Yahia and Khayat models
$\dot{\gamma}$ = shear rate, s^{-1} (sometimes referred to as shear strain rate)
ϕ = concentration of solids

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