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

Form Pressure Exerted by Self-Consolidating Concrete: Primary Factors and Prediction Models—Report

Reported by ACI Committee 237

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Given the high flowability and relatively fast casting rate of self-consolidating concrete (SCC), such concrete can exert high form pressure. Accurate assessment of form pressure is necessary from safety and economic points of view. The maximum form pressure and pressure decay are dependent on the structural buildup of the concrete at rest following placement, as well as on the placement parameters. The structural buildup at rest is affected by the thixotropy of the mixture. This report presents information on key parameters, including constituent materials, mixture proportioning; and casting parameters such as the casting rate, concrete temperature, and reinforcement percentage, affecting thixotropy and SCC form pressure. Prediction models available for estimating SCC form pressure are presented. Findings from two round-robin field studies conducted to validate these models are also discussed. This report should be of interest to concrete professionals, including concrete suppliers and formwork designers, because it covers: 1) the influence of SCC proportions and casting parameters on form pressure; 2) means to estimate formwork pressure with examples; and 3) techniques to measure formwork pressure in field applications.

Keywords: form pressure; lateral pressure; self-consolidating concrete; structural buildup at rest; thixotropy.

CONTENTS

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CHAPTER 1—INTRODUCTION

1.1—Introduction

Self-consolidating concrete (SCC) is highly flowable non-segregating concrete that can spread into place, fill the formwork, and encapsulate the reinforcement without any mechanical consolidation. SCC is designed to have a relatively low yield stress compared to conventional concrete to ensure high flowability without segregation. Yield stress corresponds to the critical shear stress value beyond which the material starts to flow. SCC can have slump flow values typically in the range of 22 to 30 in. (560 to 760 mm). Due to the high fluidity of SCC, formwork systems are often designed to sustain full hydrostatic pressure. Accurate estimation of form pressure for field application of SCC is necessary for the economical design of formwork and to ensure safety during and after casting. Field and laboratory investigations involving the measurement of lateral pressure exerted by SCC on formwork systems indicate that form pressure can be considerably lower than hydrostatic pressure (Assaad and Khayat 2005c; Assaad et al. 2003b; Billberg et al. 2014; Gardner et al. 2016). This is illustrated in Fig. 1.1 for SCC used for the rehabilitation of wall elements that measure 20 ft (6 m) in height, 23 ft (7 m) in length, and 7.5 in. (0.19 m) in width (Assaad 2004; Khayat et al. 2005b). The casting rate was approximately 21 ft/h (6.5 m/h). The pressure distribution envelopes exerted by a representative SCC mixture determined at the end of the placement and then after 1 and 3 hours are shown in Fig. 1.1 (left). The variations in the maximum lateral pressure with time for five different SCC mixtures that were proportioned with different thixotropic values are illustrated in Fig. 1.1 (right).

Form pressure is affected by structural buildup; structural buildup increases with rest time, hence reducing form pressure (Assaad et al. 2003b; Assaad and Khayat 2005c). The rate of structural buildup is dependent on the concrete mixture characteristics, including:

(a) Binder constituent (Assaad et al. 2003b)
(b) Type and dosage of chemical admixtures (Assaad et al. 2003b; Khayat and Assaad 2006)
(c) Water-cementitious materials ratio (*w*/*cm*) (Khayat and Assaad 2006)
(d) Maximum aggregate size and the total aggregate content (Assaad and Khayat 2005a)

For a given casting rate *R*, lower form pressure can be observed for concrete with a higher rate of structural buildup at rest (Assaad and Khayat 2007). The structural buildup of the concrete corresponds to an increase in shear strength when the material is left at rest due to flocculation—a physical effect that is reversible—as well as hydration of the cement-based materials, which is irreversible. At very early age, the flocculation component is dominant, and the structural buildup is reversible and can be broken down if the mixture is agitated. However, as hydration progresses with time, the structural buildup gradually becomes less reversible (Roussel et al. 2012). The placement of SCC mixtures with a high rate of structural buildup, at relatively low to moderate casting rates—for example, approximately 7 to