Full-Scale Monitoring of Form Pressure While Casting Bottom-up with Self-Compacting Concrete

Abstract

The question remains open on how the form pressure develops when casting from the bottom up especially with high flowable self-compacting concrete. This article presents a result of full-scale long-term monitoring of the form pressure using state-of-the-art pressure sensors that can send the data every minute. A 7 m wall with a 4 m width and cast from the bottom using a concrete pump with a valve opening in the formwork while the casting rate was maintained between 0.5 to 0.7 m/h. Pressure gauges were mounted on the form surface as part of a real-time system for monitoring the pressure, and the transformed data was broadcast and gathered in the cloud. The sensors were situated in different locations. The results showed that the actual pressure exerted by the concrete is far less than the hydrostatic pressure even when the concrete is pumped from the bottom. The results also showed that, the form pressure reduction depends on the properties of concrete particularly setting time.

Keywords: full scale, cast in place, self-compacting concrete, form pressure, bottom-up

Introduction

Casting the concrete from the bottom up has been a method that is practiced especially when casting large elements that are congested or in civil engineering underground structures such as tunnels, basements, and dams, the method reduces the need for access to the structure. Self-compacting concrete (SCC) is commonly used in these types of structures due to its high flowability to flow between the rebars with no or minimal need for vibration (Khayat & Omran, 2009; Perrot, 2015). In these types of structures, doubt still endures on the form pressure, especially when casting with SCC at the same time as the pressure required to push the concrete from the bottom up. The uncertainty is on the maximum pressure that is required for the form design and also the reduction of the pressure over time (Hurd, 2007; Proske, Khayat, Omran, & Leitzbach, 2014). Having prior estimation of the form pressure can help to design a steadfast form and safe for the workplace (Proske & Graubner, 2010), while knowledge of pressure reduction helps to propose a faster pouring rate (Assaad & Khayat, 2006; Henschen, Castaneda, & Lange, 2018).

The international standards suggest designing the form with full hydrostatic pressure such as ACI 347R-3 (ACI347R, 2005) which then promotes expensive design and hinder the speed of pouring (Khayat & Omran, 2009). However, studies over the past tend to disregard the hydrostatic pressure assumption and proved the pressure is far less than the hydrostatic more details are addressed in the review article by (Gamil, Nilimaa, Emborg, & Cwirzen, 2021). The German standard (DIN18218) has also suggested a different model design for the form pressure based on the concrete setting time and stated when the old concrete has been in the form more than the setting time it tends to have no pressure deemed (DIN18218, 2010).

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