Paneltech
TECHBULLETIN
paneltechintl.com | APR 2012

Additives can increase plywood concrete form pressures

An understanding of the lateral pressures exerted on concrete formwork is critical to the successful design of a concrete structure. These pressures are highest at the base of a pour and are influenced by a number of commonly understood factors. The following article gives an overview of the critical factors with a focus on those that are changing with recent variations in concrete chemistry.

In a recent issue of ***Concrete International,*** the American Concrete Institute's technical magazine, one of their "Landmark Series" articles from 1958 listed the key variables affecting the lateral pressure of concrete on concrete formwork:

1. Rate of placement
2. Consistency of concrete
3. Weight of concrete
4. Maximum aggregate size
5. Temperature of concrete mix
6. Ambient temperature
7. Smoothness and permeability of forms
8. Cross section of forms
9. Effect of consolidation by vibration
10. Placing procedures
11. Pour water pressure
12. Type of cement
13. Depth of placement

Some of these factors, such as form smoothness and maximum aggregate size are probably less important.

The APA has provided a concise publication on concrete forming that includes a procedure for estimating the pressures applied on the formwork at the base of the pour.

They cite some equations developed by the ACI for calculating form pressures and summarize those formulas in a convenient chart (see below).

Should you need a more complete description of the process, the APA's ***Concrete Forming Guide*** contains a complete description of the for design process including a complete set of equations covering other pour rates.

Some of the more recent trends in additive use have affected the pressure that concrete forms are designed to resist. In particular, additives that increase the workability of the concrete by their nature will also increase the pressure on the form base.

The use of these additives has led to a fast growing mix type known as Self-Consolidating Concrete (SCC). Self-Consolidating Concrete mixes have resulted in form pressures as high as 3000 lb/sq ft, as cited by a recent article in **Concrete Construction**.

Self-Consolidating Concrete is highly flowable concrete that can spread into place, full the formwork and surround the rebar without vibration or other mechanical consolidation. It commonly uses a poly-carboxylate super plasticizer that combines high water reduction, cohesiveness improvement and no set retardation.

SCC can flow as far as 130 feet from the point of placement, making it valuable where access is difficult.

Another strong advantage of SCC is the

continued on page 2

~~ Examples ~~

For the mathmatically inclined—the formula recommended for pour rates between 7 and 15 feet of wall height per hour is expressed as:

$$P_{max} = C_w \, C_c \, [\, 150 + 43400/T + 2800\, R/T \,]$$

This equation adjusts for the pour temperature (T) and the pour rate (R) as well as the unit weight of the concrete and the chemistry used. The term C_w is a unit weight coefficient that adjusts the pressure by a recommended ratio for unit weights other than 150 lb/cu ft. The term C_c is a chemistry coefficient that ranges from 1.0 for Type I, II or III mixes without retarders, to 1.4 for blends containing over 70% slag or 40% fly ash.

The upper bound of pressure, also used for pour rates over 15 ft/hour is a much simpler equation:

$$P_{max} = w\,h$$

where the w is the weight per cubic foot of the concrete and h is the height of the pour. The latter equation is commonly used in hydraulics for fluids with no internal cohesion. The implication is that the pour rate is so high that there is no time for the concrete to develop enough set to hold up its own weight.

TECHBULLETIN

APR 2012

Additives can increase plywood concrete form pressures

continued from page 1

excellent architectural finish that can be obtained as a result of its use (Concrete Construction).

Because there has been very little empirical data on SCC, the recommended practice has been to use the conservative full liquid head (P = w h) when estimating form pressures, fly ash, other pozzolans or high-range water reducing ad mixtures.

A recent study at Purdue reported in **Concrete International** produced data that indicate SCC form pressures considerably less than full liquid head. Nonetheless, the variability produced between repetitions in the laboratory using the same mix caused the authors to recommend further study before implementing design changes that would reflect lower than full liquid head pressures.

While using full liquid head will cause the formwork to cost more, the cost of a formwork failure is obviously not worth the risk. The authors recommend prototyping the mix and measuring the pressure as a potential approach on projects where the savings would warrant the research.

SCC is new, but its growth has been rapid. Formwork designers should continue to monitor the technology as more people gain experience with it.

References ~~

- **Concrete Forming**
Design Construction Guide, APA: The Engineered Wood Association
- **Pressures on Formwork,**
in Concrete International, November 2004, pp 62-92
- **Formwork for Self-Consolidating Concrete,**
in Concrete Construction, October 2004, pp 32-36
- **Formwork for Self-Consolidating Concrete,**
in Concrete International, October 2004, pp 32-37

Overlaid plywood panels give better performance under high pour pressures.