# Guide to Tilt-Up Concrete Construction

Reported by ACI Committee 551

ACI 551.1R-14

American Concrete Institute
Always advancing

First Printing
November 2014
ISBN: 978-0-87031-956-3

**Guide to Tilt-Up Concrete Construction**



The technical committees responsible for ACI committee reports and standards strive to avoid ambiguities, omissions, and errors in these documents. In spite of these efforts, the users of ACI documents occasionally find information or requirements that may be subject to more than one interpretation or may be incomplete or incorrect. Users who have suggestions for the improvement of ACI documents are requested to contact ACI via the errata website at http://concrete.org/Publications/DocumentErrata.aspx. Proper use of this document includes periodically checking for errata for the most up-to-date revisions.

ACI committee documents are intended for the use of individuals who are competent to evaluate the significance and limitations of its content and recommendations and who will accept responsibility for the application of the material it contains. Individuals who use this publication in any way assume all risk and accept total responsibility for the application and use of this information.

All information in this publication is provided "as is" without warranty of any kind, either express or implied, including but not limited to, the implied warranties of merchantability, fitness for a particular purpose or non-infringement.

ACI and its members disclaim liability for damages of any kind, including any special, indirect, incidental, or consequential damages, including without limitation, lost revenues or lost profits, which may result from the use of this publication.

It is the responsibility of the user of this document to establish health and safety practices appropriate to the specific circumstances involved with its use. ACI does not make any representations with regard to health and safety issues and the use of this document. The user must determine the applicability of all regulatory limitations before applying the document and must comply with all applicable laws and regulations, including but not limited to, United States Occupational Safety and Health Administration (OSHA) health and safety standards.

Participation by governmental representatives in the work of the American Concrete Institute and in the development of Institute standards does not constitute governmental endorsement of ACI or the standards that it develops.

Order information: ACI documents are available in print, by download, on CD-ROM, through electronic subscription, or reprint and may be obtained by contacting ACI.

Most ACI standards and committee reports are gathered together in the annually revised ACI Manual of Concrete Practice (MCP).

**American Concrete Institute**
**38800 Country Club Drive**
**Farmington Hills, MI 48331**
**Phone: +1.248.848.3700**
**Fax: +1.248.848.3701**

**www.concrete.org**

# ACI 551.1R-14

# Guide to Tilt-Up Concrete Construction

## Reported by ACI Committee 551

Jeff Griffin, Chair

James R. Baty II, Secretary

Iyad M. Alsamsam
William R. Braswell
Jerry D. Coombs
Darryl E. Dixon
Michael Fulton
John G. Hart
Robert P. Hirsch

Brent E. Hungerford
Anthony I. Johnson
Philip S. Kopf
Kimberly Waggle Kramer
James S. Lai
John W. Lawson
Ed T. McGuire

Andrew S. McPherson
Trent C. Nagele
Craig J. Olson
Lance Osborne
Jayendra R. Patel
J. Edward Sauter
Nandu K. Shah

Joseph J. Steinbicker
Jason A. Swagert
Gerry J. Weiler

*Consulting members*
Hugh Brooks
David L. Kelly

*Tilt-up concrete construction is commonly used in low- to mid-rise building construction. This guide reviews the many issues related to the planning and construction of tilt-up buildings to produce a quality tilt-up project. Major topics include preconstruction planning, foundations, special considerations for slab-on-ground construction, wall panel forming and casting, panel erection, connections and repairing, and painting. This guide also contains sections on sustainability and insulation systems, as well as references to the relevant codes and standards including updated Occupational Safety & Health Administration (OSHA) safety regulations.*

**Keywords:** forming; finish; inserts; insulation; panel; precast; release agent; sandwich panel; site cast; sustainability; tilt-up.

### CONTENTS





ACI 551.1R-14 supersedes ACI 551.1R-05 and was adopted and published November 2014.

# CHAPTER 1—INTRODUCTION AND SCOPE

## 1.1—Introduction

Tilt-up concrete construction is a unique form of site-cast precast construction where building elements commonly referred to as panels are constructed in job-site conditions and set in place within the building design. The conditions of casting location and positioning within the building design, therefore, necessitate tilt-up's own specialized set of design parameters and construction techniques. Tilt-up panels are generally handled only once. They are lifted or tilted from the casting slab and erected in their final position in one continuous operation.

ACI defines tilt-up as "a construction technique for casting concrete elements in a horizontal position at the job site and then tilting them to their final position in a structure." ACI 318 further states that tilt-up concrete construction is a form of precast concrete. Several features make the tilt-up construction method unique.

Tilt-up panels serve as many functions for building design as markets in which they are constructed. Panels, or perhaps better described as tilt-up elements are constructed with and without openings, sometimes consisting of only a grid of monolithic beams and columns. Wall panels are found flat, ribbed, curved (with broad to tight radii), and even biaxially curved. Elements have been constructed freestanding and cantilevered, simply supported, and connected in a variety of configurations. Elements have been taller than 96 ft (30 m) (Lucky Street Parking Garage, Hollywood, FL) and building façades have been stacked as high as 138 ft (42 m) (ASU Student Housing, Phoenix, AZ). Not all tilt-up elements are building panels, however. Although the majority produced annually are designed as either load- or nonload-bearing building envelope panels, tilt-up elements have also been featured as signs, monuments and art, walkways, stadium seat supports, spires, tanks, tunnels, and bridges.

## 1.2—Scope

This guide presents the basic concepts, techniques, and procedures used in tilt-up construction. The design of tilt-up wall panels, although not addressed in this guide, is addressed in the companion design guide ACI 551.2R, which is beneficial in content to both licensed design professionals and contractors. This guide includes a brief history of tilt-up concrete and a discussion of planning; foundation and floor slab construction; and wall panel forming, casting, and erection. It briefly describes typical connections used to attach the panels to the rest of the structure, and options for panel finishes are briefly described.

# CHAPTER 2—DEFINITIONS

ACI provides a comprehensive list of definitions through an online resource, "ACI Concrete Terminology," http://www.concrete.org/Tools/ConcreteTerminology.aspx. Definitions provided herein complement that resource.

**bolster strip**—continuous reinforcement support device for wire mesh or mat in a concrete slab or wythe element.

**cribbing**—wood blocking set under crane outriggers to spread the point load over a larger area to prevent damage to the supporting surface.

**densifier**—chemical applied to a concrete surface to fill pores, increasing surface density.

**elastomeric paint**—paint consisting of a polymer with elasticity, generally having low Young's Modulus and high yield strain compared with other materials that behave as a rubber-like membrane on the concrete surface to span cracks and decrease permeability.

**hygrothermal analysis**—analysis of the movement of heat and moisture through buildings, particularly a building envelope, component, or system.

**membrane bond breaker**—nonchemically active release

agent that prevents the bond of fresh concrete to the casting surface that dissipates with time.
**penetrating bond breaker**—chemically active release agent that prevents the bond of fresh concrete to the casting surface that requires cleaning methods to remove from substrate.
**polyisocyanurate**—thermoset plastic typically produced as foam and used as rigid thermal insulation.
**polystyrene**—rigid or foamed synthetic aromatic polymer made from the monomer styrene, a liquid petrochemical for use in extruded shapes or insulation boards.
**polysulfides**—sealants designed for joints that need to withstand prolonged immersion in liquids. Typical applications include swimming pools, fountains, cooling towers, fuel and chemical storage tanks, wastewater treatment, and petrochemical plants.
**reentrant**—inward corner of a concrete element that is typically recognized at windows and doors.
**reveal**—longitudinal recess in the surface of a concrete element.
**spud vibrator**—vibrator with a vibrating casing or a vibrating head used to consolidate freshly placed concrete by insertion into the mass. Also commonly referred to as a stinger.
**thermal transmittance**—measure of the rate of heat loss of a building component expressed as watts per square meter, per degree Kelvin, $W/m^2K$; U-value is calculated from the reciprocal of the combined thermal resistances of the materials in the element, air spaces and surfaces, also taken into account is the effect of thermal bridges, air gaps, and fixings (commonly known as the U-value).
**urethanes**—thermosetting polymer formed by reacting an isocyanurate with a polyol, used in the manufacture of flexible, high-resilience foam seating, caulks, and rigid foam insulation panels.
**wythe**—each continuous vertical section of a concrete wall in monolithic thickness.

## CHAPTER 3—HISTORY, TRENDS, AND SUSTAINABILITY

### 3.1—History of tilt-up construction

Although precasting building elements is sometimes considered an innovative concept in engineering, origins can be traced to as early as 4700 BC to a small village in Jarmo, Iraq, where the villagers made walls for their dwellings from touf, a pressed mud. As cementitious materials became available, the quality and durability of these precast materials improved. The Romans produced pozzolan cement, which they used extensively in their building projects around 25 BC. It was not until the nineteenth century and the development of portland cement that concrete structures became integral to the construction process. By 1890, portland cement was widely accepted as the standard cementing material.

Early structures using portland-cement concrete were usually cast-in-place. By 1914, cast-in-place concrete reinforced with mild steel reinforcing bars was second only to structural steel as a building material.

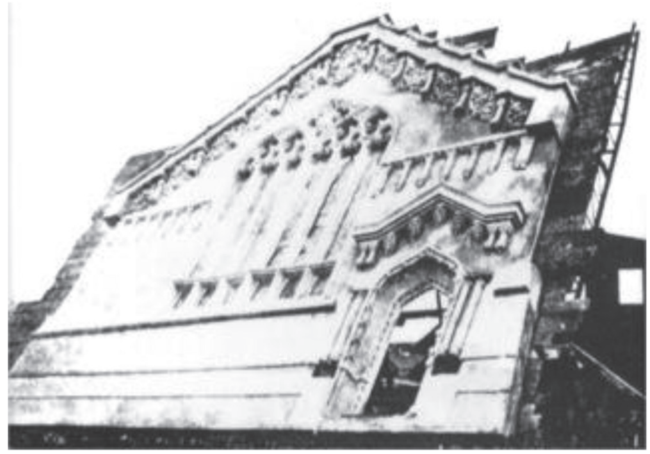

*Fig. 3.1a—Front wall panel of Memorial United Methodist Church on tilt table.*

Some builders in the United States developed an early form of tilt-up construction in which a tilting platform was used. Aiken (1909) described the innovative method where walls for a building were constructed on a structural platform, then rotated or tilted upward by means of specially designed mechanical jacks, setting the panel in its final position. This tilt table method was used on the Jewett Lumber Company in Des Moines, IA, between 1906 and 1912, and on several Army facilities, factory buildings, and churches. The tilt table method was also used on the Memorial United Methodist Church in suburban Chicago. The church construction incorporated decorative precast elements that were embedded in the tilt-up panels (Fig. 3.1a and 3.1b).

Collins (1958) states that railroads during the period before World War I developed a technique for precasting large sections of bridges from reinforced concrete and setting them in place with their heavy cranes. The cranes, however, were mounted on railroad cars and required additional track to be laid to access the site.

The idea of precasting large structural units using reinforced concrete cast into molds or forms was hastened by World War I. The shortage of steel and labor caused by the war and the subsequent increase in building prices challenged engineers and contractors to develop new methods of building. Most improvements in precasting methods were developed in England and Western Europe. Precast elements, however, were small and easily handled without heavy equipment. In Russia, precast building elements developed using alternative casting methods due to more difficult conditions for fabrication and construction. There, larger sections were constructed using techniques similar to those now used in the United States. Erection was accomplished with stationary cranes.

In the United States, there was little advancement in the use of precast concrete elements until World War II. Three technological innovations, attributed to this era, made the erection and connection of site-cast elements more practical. The first two of these developments were the heavy-duty