Proper design was presented by Feldmann and Schambach (2016). Proper construction is addressed in this article and includes proper site preparation, quality concrete, and careful concrete placement and curing. Also discussed are impacts of building fabrication sequence and weather conditions on slab-on-grade construction.

Site Preparation
Site preparation for slab-on-grade construction typically consists of removal of topsoil and other undesirable soils near the surface, grading of the remaining native soil (a.k.a., subgrating), and placement and compaction of a subbase. Very wet and frozen soil conditions will generally delay these site preparation activities. The extent to which existing soil should be removed depends on soil expansive characteristics (i.e., the change in soil volume with a change in soil moisture content) and the frost susceptibility of the soil. The extent to which existing soils could be problematic may require on-site soil testing. The subbase should be constructed using a clean, graded granular material since such a material minimizes wicking of water upward from the soil subgrade (i.e., it serves as a capillary break), provides drainage and frost protection, provides good strength and support to the overlying slab, prevents settlement (when properly compacted), and keeps workers out of the mud. Adding the thickness of the subbase and concrete floor to the subgrade elevation establishes the final building floor elevation.

Construction Sequencing
Casting the slab during the construction process largely depends on the details of the post-frame building and concrete floor. The slab is always cast first where posts are to be mounted atop the slab or attached to a wall resting on the slab. In buildings featuring embedded posts, the construction sequence often hinges on whether or not the posts are continuous. Continuous posts are those with the embedded and above ground sections delivered as one piece to the building site. Non-continuous posts have separate embedded and above ground portions. Many non-continuous posts are comprised of an embedded concrete pier attached above grade to a wood post. For post-frame buildings using non-continuous posts, only the embedded portions of the posts need to be placed prior to slab casting. Since most post-frame building piers only extend a foot or so above the subbase, interference of piers with concrete pumping equipment and other slab placement equipment is a non-issue. Once the concrete floor is adequately cured, the remainder of the post-frame building can be completed. The advantage of this
sequence is that the slab provides a smooth, hard, and level work surface for building completion. For post-frame buildings using continuous posts, it is generally best to complete the entire building shell prior to floor slab casting. This ensures that posts are exactly positioned prior to slab casting (important when the slab is cast against the posts), and in most cases, protects the casting operation from precipitation, direct sun, wind, and temperature extremes. This construction sequence is often desired because it enables all or a large portion of both above- and below-slab utility work (i.e., electrical, plumbing and mechanical equipment installation) to be completed at the same time (i.e., prior to slab placement). The downside of this construction sequence is that it often limits the type of equipment that can be used in slab placement. More specifically, a lack of head clearance and/or unobstructed access to the entire floor area may eliminate certain concrete pumping options and limit direct placement via concrete truck.

**Under-Slab Vapor Barriers/Retarders**

Vapor barriers/retarders placed in direct contact with the underside of a slab-on-grade will ebb the flow of water vapor from the subgrade up into the slab and can also help prevent soil gases from permeating into the slab. Vapor barriers/retarders should not be placed under the subbase material since any water that leaks into the subbase material after the slab has been placed will be held and distributed under the slab by the vapor barrier/retarder (picture a swimming pool under your slab). Captured water will actually enhance instead of ebb the movement of water vapor into the slab. Placing a vapor barrier/retarder under the subbase material also makes it difficult to deal with rainwater and other precipitation that accumulates in the subbase prior to slab placement. When placing concrete directly on a vapor barrier/retarder, an adjustment in the concrete mix design is generally required to reduce the amount of bleed water for routine finishing. To avoid damage to the barrier/retarder during construction, use a thicker barrier/retarder. A minimum 10 mil thickness is common with 15 mil recommended when laser screeds or heavy placing equipment will be on the barrier/retarder. A more complete discussion on vapor barrier/retarder installation is found in ACI 302.1 R-15.

Photo 1: Concrete being deposited for a reinforced floor slab with two mats of steel reinforcement bars.
**Under-Slab Insulation**

Specific details regarding insulation installation is beyond the scope of this article. However, concrete placement must integrate with the installed insulation. For example, if insulation is to be installed under a concrete slab floor with in-floor heating, the concrete placement procedures must not damage the under-floor insulation and in-floor heating system.

A concrete pump is often used for placing concrete over insulation. Construction of the building shell prior to slab placement will typically eliminate use of a boom concrete pump but should still enable use of a truck- or trailer-mounted line pump.

**Steel Reinforcement**

Steel reinforcement should be properly secured in place prior to concrete placement. Thought should be given to concrete delivery as some reinforcement may need to be left out temporarily to enable concrete truck access to some parts of the floor area.

Photo 2: Reinforcement positioned above a prepared slab on grade base with a vapor barrier located directly under the final slab position.

**Subbase Moisture and Temperature**

Moisture and temperature conditions of the subbase during concrete placement are critical and need to be considered. Excess moisture on site can increase the water to cement ratio of the placed concrete. The difference between the lower temperature of either the subbase material or ambient air and the expected temperature of the concrete material should ideally be no more than 20 F but could be as much as 30 F. If this difference will be greater than 30 F, the ambient air temperature or base material temperature should be warmed so concrete setting times are not reduced due to cold temperatures. Concrete should not be placed on frozen base material.

**Concrete Procurement**

A comprehensive 11-page discussion of concrete materials and mixture proportioning is found in ACI 302.1 R-15. The selection of materials and mixture proportions are similar for normal concreting as well as for cold and hot weather concreting. The major difference between the...
hot and cold weather concreting is the desired target temperature of the mixture when delivered to the job site. Usually, normal concreting (ambient temperatures ideally between 50 and 70°F and up to 90°F) does not require any temperature modification of mixture because the materials available at concrete plant are not that much different than the temperatures at the job site. During cold weather concreting, concrete materials should be at least 50°F when delivered to job site. A discussion focused on heating concrete materials is found in ACI 306 R-16. Heated mixtures are achieved by heating water to 140°F and/or heating aggregates to 60°F to ensure frozen lumps are removed. No maximum temperature limit is needed for a hot weather concrete mix as long as other steps of proportioning, production, delivery, placing, consolidating, finishing, and curing are satisfactorily completed (ACI 305 R-10).

Concrete Placement
Concrete placement includes delivery, placement, consolidating and finishing. General placing, consolidating, and finishing information is found in ACI 302.1 R-15 as Chapter 10. Specific cold weather concreting information is found in ACI 306 R-16. Specific hot weather concreting information is found in ACI 305 R-10. The elapsed time between the addition of water to the concrete mixture and when concrete finishing needs to occur is very temperature dependent. This time period is difficult to predict because it depends upon job site ambient temperature, relative humidity, and wind conditions. Final finishing generally begins when bleed water on the concrete surface has evaporated. A ‘rule of thumb’ exists that says this time period reduces by about one-half when the temperature increases by 20°F. Similarly, a 20°F ambient temperature decrease doubles the time period. So, in general, the placement needs to be much faster during warm and hot weather concreting while the placement and final finishing of concrete in cold weather will take much longer.

One of the major challenges with hot weather concreting is the very rapid evaporation of bleed water from the fresh concrete. Sometimes bleed water will evaporate so quickly that the concrete surface will begin to dry before finishing has been completed. Water needs to be added to keep the surface moist during the consolidation and

Photo 3: “The timing and equipment used for finishing varies by project based on weather, concrete specifications, and desired final effects.”
finishing activities. Since water evaporates so quickly during hot weather concreting, cracking of the fresh concrete while the concrete is still in the plastic stage is a common problem. Adding reinforcing fibers to the concrete mixture generally helps reduce plastic concrete cracking.

Photo 3: The timing and equipment used for finishing varies by project based on weather, concrete specifications, and desired final effects.

**Concrete Curing**

Concrete gains strength via a chemical reaction called hydration. During hydration, major compounds in cement are chemically bonded to water molecules to form the hydration products that bind aggregates in place. In the absence of water, hydration stops and concrete no longer gains strength. For this reason, if water is allowed to evaporate too quickly from the surface of fresh concrete, a lower final concrete strength will result. It follows that hot weather concreting can result in a weak concrete floor if concrete is not kept moist during the curing process and kept as cool as possible while it cures. Cold weather concreting has a different set of challenges. The cold temperature will significantly slow the curing process. Concrete needs to cure for 24 to 36 hours so it can reach a 500-psi strength before it is allowed to freeze. If cold weather concreting is done inside a building and the building is heated to keep the concrete from freezing, water can evaporate too quickly for the concrete resulting in weak concrete due to lack of hydration as with hot weather concreting.

**Summary**

Slab on grade floors need to be both designed and constructed properly to obtain a quality result. This article focused on construction sequencing when concrete slabs are part of post-frame building. Concrete construction during normal weather was presented with additional aspects included to address adjustments needed during cold and hot weather concreting. Much more information on concrete construction is available in the various Guides from the American Concrete Institute.

**References**

- ACI 302.1 R-15; American Concrete Institute. “Guide to Concrete Floor and Slab Construction” 76 pages.
- ACI 305 R-10; American Concrete Institute. “Guide to Hot Weather Concreting” 23 pages.
- ACI 306 R-16; American Concrete Institute. “Guide to Cold Weather Concreting” 23 pages.
- ACI 308 R-16; American Concrete Institute. “Guide to External Curing of Concrete” 36 pages.

**More information regarding the Guides from ACI:**

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