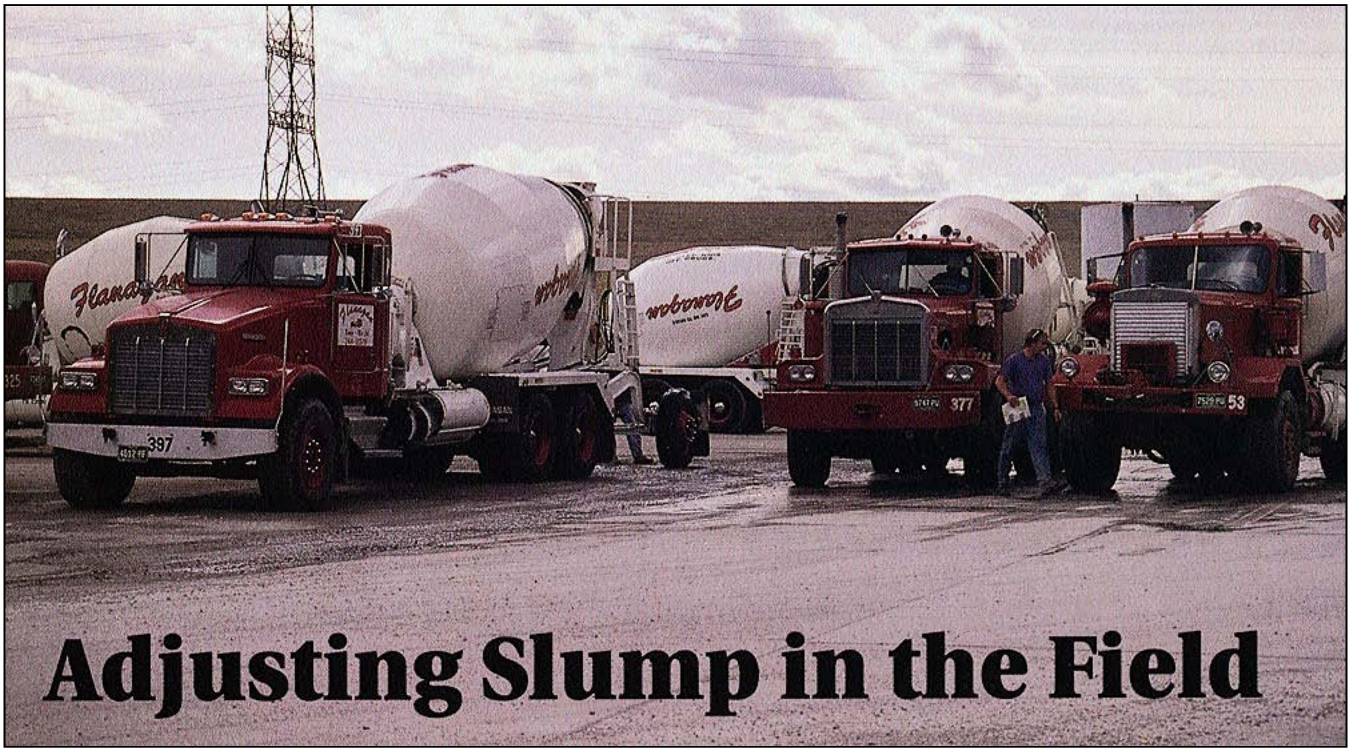



# Adjusting Slump in the Field

*Slump adjustment is a fact of life for concrete contractors, but they should follow these guidelines for its use*

**Variations in slump between trucks can be the result of many factors. Long delivery, waiting, and unloading times, for example, can decrease slump. Add water, if necessary, in accordance with ASTM C 94. Turn the drum an additional 30 revolutions at mixing speed.**

**BY BRUCE A. SUPRENANT**

A ready mix truck arrives on the jobsite. The concrete sliding down the chute looks dry, a worker asks for 5 gallons of water, and the fight begins. Water-paranoid specifiers and inspectors may not allow any water to be added on-site. Water-happy contractors, on the other hand, consider adding water to a truck a birthright. Both parties have a vested interest in the quality and performance of the concrete.

Why should slump be adjusted in the field? How should slump be adjusted in the field? Prepour conferences must settle these two important questions before the concrete arrives.

## Factors Affecting Slump

Rarely will a laboratory mix be entirely suitable under the variable field conditions facing a concrete contractor. Adjustments to the amount of water and admixtures are commonly required. These adjustments aren't necessarily due to poor quality control or material variations. Variations in slump between trucks can be the result of other factors.

**Batching tolerances.** Even with sophisticated computer-controlled batch plants, batching tolerances can affect slump control. Tolerances for the individual batching of each mix ingredient are given below (Ref. 1). Examples of how each tolerance affects the batch weights of a typical 3500-psi concrete mix also are shown.

- Cementitious materials - 1% (5 pounds of cement per cubic yard)
- Water (by volume or weight) - 1% (2.5 pounds or ⅓ gallon of water per cubic yard)
- Aggregates - 2% (60 pounds of aggregate per cubic yard)

Water-cement ratios can vary by about 0.01. However, with uniform mixing, batching tolerances shouldn't affect slump by more than ½ inch.

ASTM C 94 (Ref. 2) requires the total mixing water, which influences both slump and water-cement ratio, to be measured within ±3%. Besides the water added at the plant, the total mix water includes free water in the aggregates and, if applicable, water added on-site, residual mixer wash water, and ice. If the ±3% requirement is met, the water content can vary by about 1 gallon, the water-cement ratio can vary by about 0.02, and the slump can change by 1 inch per cubic yard of concrete.

Most batch plant operators work

on the "dry" side (batch water a little short), which produces concrete with a safe water-cement ratio while allowing, if necessary, some field water additions to adjust slump. Some batch plant operators hold back as much as 5% of the batch water. Check the batch ticket to determine how much water has been added at the plant.

**Aggregate moisture content.** Measuring and correcting for fine aggregate moisture content can significantly change slump. Assuming a sand content of 1,200 pounds per cubic yard, a 1% variation in sand moisture causes a variation of about 1 ½ gallons of water per cubic yard. Many ready mix producers measure sand moisture contents in the morning; as the temperature rises during the day and the aggregate dries, more water is absorbed, reducing concrete slump.

To indicate changes in sand moisture content, producers should use a properly maintained and calibrated sand moisture meter. Moisture-compensating equipment can be set to automatically reproportion sand and water batch weights for a change in aggregate moisture content. Typically, moisture meters aren't sufficiently accurate to warrant interlocking them with moisture compensators for automatic operation. Even with sophisticated equipment, it's difficult to prevent slump variations due to changes in sand moisture content.

**Concrete temperature.** Even slight variations in concrete temperature can affect slump. A rise in temperature usually decreases slump because cement hydrates faster at higher temperatures. For instance, a 10°F increase in concrete temperature demands an additional gallon of water to maintain the same slump the concrete had at the lower temperature.

**Mixing.** To achieve a uniform concrete batch, ASTM C 94 requires a minimum of 70 to 100 revolutions at mixing speed. Because it's difficult to obtain uniform concrete in an overloaded mixer, the volume of mixed concrete should not exceed 63% of the total drum volume. When the truck arrives on-site, turn the drum another 30 revolutions at mixing speed to reduce any segregation that may have occurred during the haul.

**Delivery, waiting, and unloading times.** Prolonged delivery, waiting, and unloading times can cause a decrease in slump. ASTM C 94 requires the producer to have concrete within the permissible slump range for 30 minutes starting either on arrival on-site or after initial slump adjustment, whichever is later. The first and last ¼-cubic-yard discharges are exempt from this requirement. The contractor is responsible for slump changes due to prolonged waiting and unloading times.

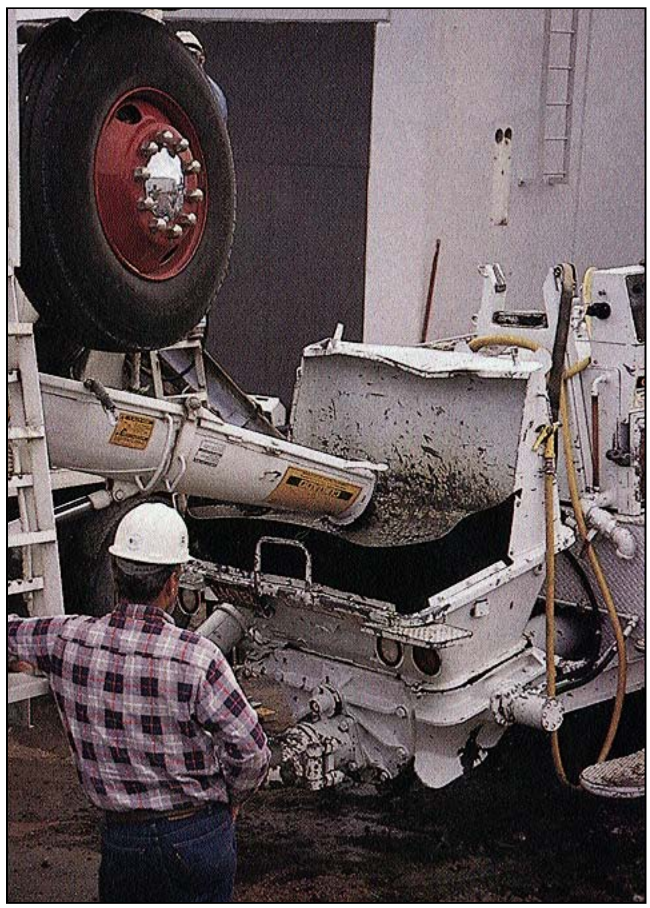
**PROLONGED DELIVERY, WAITING, AND UNLOADING TIMES CAN CAUSE A DECREASE IN SLUMP**

## Adding Water to Increase Slump

ASTM C 94 is the most frequently cited specification that permits and controls on-site slump adjustment. Section 11.7 allows for a slump adjustment if the truck arrives on-site with a concrete slump less than specified. The water addition, however, must not increase the water-cement ratio above the maximum permitted by specifications.

When using water to increase slump, it must be added to the entire batch. Don't add water to the middle or end of a batch. It's impossible to accurately guess the amount of concrete remaining in the truck. The common practice of hitting the drum with a fist and listening to the resulting sound to guess the remaining cubic yards isn't accurate. The amount of water to add to a partial batch of concrete to stay within the maximum water-cement ratio can't be calculated. Also, you can't add water to increase slump to bypass the 1 ½ hour or 300 revolution criteria of ASTM C 94.

Make sure on-site water is added correctly. Introduce water into the batch at the head section of the drum or by dual injection into the head and discharge section of the drum. Don't use a hose to spray additional mix



**Concrete to be pumped usually requires a high slump. Adding superplasticizers on-site, instead of water, can obtain a pumpable mix without increasing the water-cement ratio.**

water into the discharge end of the drum. This method doesn't adequately distribute the water throughout the mix and the amount of water added is only a guess.

ASTM C 94 requires an additional 30 revolutions at mixing speed when water is added to the truck. Water can't be added to the truck when the combined revolutions from a long haul or waiting time exceed 270.

Check that the ready mix truck has a Truck Mixer Manufacturers Bureau rating plate attached to the body indicating its conformance to truck mixer and agitator standards. These standards require the truck to have a mixer water system with a working, visible sight gauge and an automatic measuring device accurate to 1% of the total capacity of the water tank.

## Other Ways to Increase Slump

It's important to understand that concrete properties can change when water is added to the mix. Adding just 1 gallon of water per cubic yard can:

- Increase slump 1 inch
- Decrease compressive strength 150 to 200 psi
- Waste about ¼ bag of cement
- Increase shrinkage by 10%

But water isn't the only way to adjust slump. Consider adding a water reducer or superplasticizer at the site to increase slump. Using admixtures maintains the water-cement ratio, but provides a workable slump. If the concrete is at the maximum water-cement ratio, an admixture may be the only acceptable method of increasing slump.

It's best to add a superplasticizer to concrete of a constant slump. For instance, use water to raise the concrete slump to 4 inches, then add a superplasticizer to raise the slump to 6 inches or more. If the concrete has a lower slump, it's difficult to determine the correct dosage to achieve the desired slump.

Some manufacturers make prepackaged powdered admixtures (superplasticizer or water reducer) that come in convenient per-cubic-yard dosages. Throw in the required number of bags, then mix to achieve the desired slump. Admixture costs per cubic yard of concrete vary from $1 to $3.

## Decreasing Slump

Sometimes, slump needs to be decreased. For instance, the slump of the first ¼ cubic yard of concrete is 4 inches, but it's for a slipform paver that needs concrete with a maximum 2-inch slump.

Ready mix drivers typically use a couple of extra sacks of cement to try to dry up the mix. This may lower slump, either due to the cement or to the increased heat and grinding action of the additional revolutions. But the process is time-consuming and usually not very effective.

If a high air content causes a high slump, an air detrainer can be added. Reducing air content by 1% reduces slump by ½ inch. Trucks with high air contents are usually sent back to the plant.

An effective method for reducing slump is to add powdered silica fume. Prepackaged powdered silica fume, without superplasticizer, dries up a concrete mix. However, it also will darken concrete, which may not be acceptable. One contractor reports that adding 6 pounds of silica fume to a cubic yard of concrete lowers the slump by 1 inch. The cost of silica fume is about $3 per cubic yard.

## Testing Slump

Most contractors use two slump tests—one for checking the initial slump of the concrete and the other for acceptance criteria.

Initial slump tests are used to determine how much water is needed, if any, to increase slump. To measure initial slump, fill a wheelbarrow with concrete from the first part of the truck and take a slump test on this first ¼ cubic yard. Water additions based on initial slump usually are conservative, since the first ¼ cubic yard of concrete out of the truck typically is wetter, with a higher slump, than the remaining concrete.

The slump test on the first ¼ cubic yard can't be used for acceptance or rejection of concrete. ASTM C 94 requires tests for acceptance to be taken from concrete representing about 15% to 85% of the load. The test also must be taken after all water is added to the entire batch.

Though the initial slump test often is used in the field, it's not in strict accordance with ASTM C 94 since some concrete (the 4 cubic feet needed to fill a wheelbarrow) is removed before water is added. Not accounting for the 4 cubic feet won't make any practical difference at the site, but it does violate the strict interpretation of ASTM C 94. Still, initial slump tests provide a more accurate reading than the alternative—guessing the slump while standing on a ladder looking down into the drum, watching the concrete move.

## Prepour Conference

At the prepour conference, it's important for the ready mix producer, contractor, engineer, architect, owner, and inspector to agree on why and how slump is to be adjusted in the field. Make sure specifications are clear for slump tolerances and maximum water-cement ratios for each concrete mix. Also discuss the permitted slump adjustments, who authorizes slump adjustments, and when water is appropriate or when admixtures will be used. Place controls and limits on the use of water and admixtures.

### References

1. ACI 304R-89, "Guide for Measuring, Mixing, Transporting, and Placing Concrete," American Concrete Institute, Detroit, Mich.

2. ASTM C 94, "Standard Specification for Ready-mixed Concrete," ASTM, Philadelphia, Pa.

PUBLICATION #C940038