Concrete in Practice

What, why & how?

NRMCA®

CIP 8 - Discrepancies in Yield

WHAT is Concrete Yield?

Concrete yield is defined as the volume of freshly mixed concrete from a known quantity of ingredients. Ready mixed concrete is sold on the basis of the volume of fresh, unhardened concrete-in cubic yards (yd^3) or cubic meters (m^3) as discharged from a truck mixer.

The basis for calculating the volume is described in the ASTM C 94, *Specification for Ready Mixed Concrete.* The volume of freshly mixed and unhardened concrete in a given batch is determined by dividing the total weight of the materials by the average unit weight or density of the concrete determined in accordance with ASTM C 138. Three unit weight tests must be made, each from a different truck.

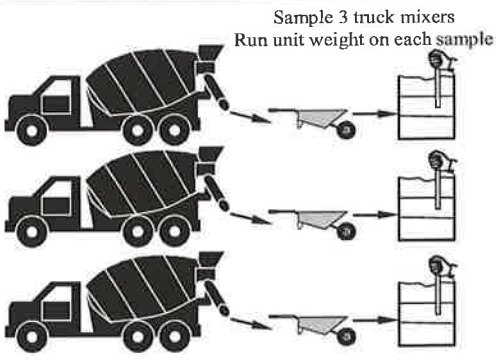
ASTM C 94 notes: *It should be understood that the volume of hardened concrete may be, or appears to be, less than expected due to waste and spillage, over-excavation, spreading forms, some loss of entrained air, or settlement of wet mixtures, none of which are the responsibility of the producer.*

Further, the volume of hardened concrete in place may be about 2 percent less than its volume in a freshly mixed state due to reduction in air content, settlement and bleeding, decrease in volume of cement and water, and drying shrinkage.

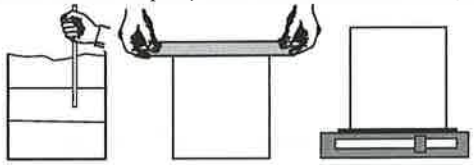
WHY do Yield Problems Occur?

Most yield complaints concern a perceived or real deficiency of concrete volume. Concerns about yield should be evaluated using unit weight measurements to calculate the yield. Apparent under-yield occurswhen insufficient concrete is ordered to fill the forms and to account for contingencies discussed below. If unit weight and yield calculations indicate an actual under-yield it should be corrected.

Apparent concrete shortages are sometimes caused for the following reasons:



ASTM C 138 - Test for Unit Weight
Fill unit weight container in 3 layers;
Rod each layer 25 times; tap sides with mallet;
Strike off with flat plate; Clean outside surfaces and weigh



$$\text{Unit Wt., lb/ft}^3\ (\text{kg/m}^3) = \frac{\text{Net concrete weight, lb (kg)}}{\text{Bucket Volume, ft}^3\ (\text{m}^3)}$$

$$\text{Avg. Unit Wt.} = \frac{(UW1 + UW2 + UW3)}{3}, \text{lb/ft}^3\ (\text{kg/m}^3)$$

$$\text{Batch Yield, cu.yd.} = \frac{\text{Weight of Batch, lb.}}{27 \times \text{Avg. Unit Wt., lb/ft}^3}$$

$$\text{Batch Yield, m}^3 = \frac{\text{Weight of Batch, kg}}{\text{Avg. Unit Wt., kg/m}^3}$$

a. Miscalculation of form volume or slab thickness when the actual dimensions exceed the assumed dimensions by a fraction of an inch. For example, a 1/8-inch (3-mm) error in a 4-inch (100-mm) slab would mean a shortage of 3 percent or 1 yd^3 in a 32-yd^3 (1 m^3 in a 32-m^3) order.

b. Deflection or distortion of the forms resulting from pressure exerted by the concrete.

c. Irregular subgrade, placement over granular fill, and settlement of subgrade prior to placement.

d. Over the course of a large job, the small amounts of

concrete returned each day or used in mud sills or incidental footings.

An over-yield can be an indication of a problem if the excess concrete is caused by too much air or aggregate, or if the forms have not been properly filled.

Differences in batched weights of ingredients and air content in concrete, within the permitted tolerances, can result in discrepancies in yield.

HOW to Prevent Yield Discrepancies?

To prevent or minimize concrete yield problems:

a. Check concrete yield by measuring concrete unit weight in accordance with ASTM C 138 early in the job. Repeat these tests if a problem arises. Be sure that the scale is accurate, that the unit weight bucket is properly calibrated, that a flat plate is used for strike off and that the bucket is cleaned prior to weighing. Concrete yield in cubic feet (m^3) is total batch weight in pounds (kg) divided by unit weight in pounds per cubic foot (kg/m^3). The total batch weight is the sum of the weights of all ingredients from the batch ticket. As a rough check, the mixer truck can be weighed empty and full. The difference is the total batch weight.

b. Measure formwork accurately. Near the end of large pours, carefully measure the remaining volume so that the order for the last 2 or 3 trucks can be adjusted to provide the required quantity of concrete. This can prevent waiting for an extra 1/2 yd^3 after the plant has closed or the concrete trucks have been scheduled for other jobs. Order sufficient quantity of concrete to complete the job and reevaluate the amount required towards the end of the pour. Disposal of returned concrete has environmental and economic consequences to the concrete producer.

c. Estimate extra concrete needed for waste and increased placement dimensions over nominal dimensions. Include an allowance of 4 to 10 percent over plan dimensions for waste, over-excavation and other causes. Repetitive operations and slip form operations permit more accurate estimates of the amount of concrete that will be needed. On the other hand, sporadic operations involving a combination of concrete uses such as slabs, footings, walls, and as incidental fill around pipes, etc., will require a bigger allowance for contingencies.

d. Construct and brace forms to minimize deflection or distortion.

e. For slabs on grade accurately finish and compact the subgrade to the proper elevation.

References

1. ASTM C 94, *Standard Specification for Ready Mixed Concrete*, American Society for Testing and Materials, West Conshohocken, PA.
2. ASTM C 138, *Standard Test Method for Unit Weight, Yield and Air Content (Gravimetric) of Concrete*, American Society for Testing and Materials.
3. *Ready Mixed Concrete*, Gaynor, R.D. NRMCA Publication 186, NRMCA, Silver Spring, Maryland.
4. *No Minus Tolerance on Yield*, Malisch, W. R. and Suprenant, B. A., Concrete Producer, May 1998
5. *Causes for Variation in Concrete Yield*, Suprenant, B. A., The Concrete Journal, March 1994
6. *An Analysis of Factors Influencing Concrete Pavement Cost*, by Harold J. Halm, Portland Cement Association Skokie, Illinois.

Follow These Rules to Avoid Under-Yield

1. Measure volume needed accurately. Reevaluate required volume towards the end of the pour and inform the concrete producer.
2. Estimate waste and potential increased thickness – order more than required by at least 4 to 10 percent.
3. To check yield use the ASTM C 138 unit weight test method on three samples from three different loads – yield is the total batch weight divided by the average unit weight or density.

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