SERIES 4, ISSUE 5 – MATH FOR PRESTRESSED CONCRETE: CONCRETE YIELD

Concrete is ordered by volume (per cubic yard) and batched by weight. If concrete ingredients are not accurately batched and combined, the materials may produce either more or less than the desired volume.

Yield refers to the actual volume of concrete produced from the batched materials.

- *Over yield* occurs when the weight of the materials batched provides a volume of concrete that is more than what was originally calculated and ordered. An over yield of concrete can increase the risk that the concrete may be rejected because it fails the project acceptance criteria for fresh concrete, strength, or durability requirements. If over yields are due to batching inaccuracy, that can also cause problems with inventory control of ingredients.
- *Under yield* occurs when the weight of the materials batched provides a volume of concrete that is less than what was originally calculated and ordered. An under yield of concrete can negatively affect the resulting properties of the mixture. For example, 2% under yield may result in 2% more cementitious material content per cubic yard than what was ordered. Under yield can also increase the standard deviation of strength, thereby reducing the quality of the concrete and increasing the cost of all concrete produced. An under yield can also lead to the need to order an additional, partial load because there is insufficient concrete to complete the casting operation.

Calculating Density (ASTM C138/C138M) (see Note 1)

- Select a container whose volume is known.
- Weigh the dampened, empty container.
- Fill the container with concrete, as described in ASTM C138/C138M.
- Weigh the full container; record the value to nearest tenth (0.1) of a pound
- Subtract the empty container weight from the full container weight to get the weight of the concrete.
- Divide the weight of the concrete by the known container volume to get the density (unit weight) of the fresh concrete.

Calculating Yields

Calculate the following using the total weight of all materials batched (aggregate, water, cement, etc.):

- Yield per batch in cubic feet = Total weight of all materials (lb) / Fresh density (lb/ft^3)
- Yield per batch in cubic yards = Total weight of all ingredients batched (lb) / [Fresh density (lb/ft^3) × 27]
- Yield per cubic yard in ft^3/yd^3 = Yield per batch in ft^3/Number of cubic yards delivered
- Yield as a percentage = (Actual volume of concrete/Reported volume) × 100

Example Problem

Assume a concrete batch with the following properties:

Volume of concrete targeted = 4 yd^3

Weight of materials batched = 15,930 lb

Cementitious materials = 2800 lb

Sand = 5520 lb

Stone = 6627 lb

Water = 118 gal x 8.33 lb/gal = (983 lb)

Density (unit weight) of the concrete = 147.52 lb/ft^3

Yield = 15,930 / (147.52 × 27) = 3.99 yd^3 in the actual batch

Yield per batch = 15,930 lb/147.52 lb/ft^3 = 107.98 ft^3

Cubic yards delivered = 4

Yield per cubic yard = 107.98 ft^3/4 yd^3 = 26.99 ft^3/yd^3

Yield (%) = (3.99 yd^3 4 yd^3) × 100 = 99.8%

Gravimetric Air Content Calculation

ASTM C138/C138M provides a method for calculating the air content of freshly mixed concrete using the gravimetric method.

The formula for calculating gravimetric air content is as follows:

$A = (B - C) \times 100/B$

where

A = air content as a percentage by volume

B = theoretical air-free density of the concrete in pounds per cubic foot

C = density (unit weight) of the fresh concrete in pounds per cubic foot

For example, if the theoretical air-free unit weight is 151.7 lb/ft^3 and the measured density (unit weight) is 141.4 lb/ft^3, the air content would be 6.8%:

$A = (151.7 \text{ lb/ft}^3 - 141.4 \text{ lb/ft}^3) \times 100/151.7 \text{ lb/ft}^3 = 6.8\%$

Notes

1. This is a summary of the steps involved. Be sure to review ASTM C138/C138M for a full description of the process and requirements.
2. The suggested tolerance for yield is ±1% for non-air-entrained concrete and ±2% for air-entrained concrete. (NRMCA TIP-8, Concrete Yield)

Note: Please complete this form and return to the Quality Control Manager. All crew members should be observant and report to their supervisor anything out of the ordinary on a project. See something, say something.

NOTES	ATTENDEE SIGNATURES
_____ DATE _____ PRESENTER	_____ _____ _____ _____ _____ _____