

Improving Concrete through Optimizing Aggregate Gradation

Findings from the FHWA Mobile Concrete Trailer

Findings from FHWA's Mobile Concrete Trailer (MCT) from field visits across the country indicate that many state agencies specify limits on individual aggregate sieve sizes used for concrete production. For concrete performance in service, it's **the final combined gradation from all the aggregates used in the mixture that is of importance**. Advantages of using the combined gradation include:

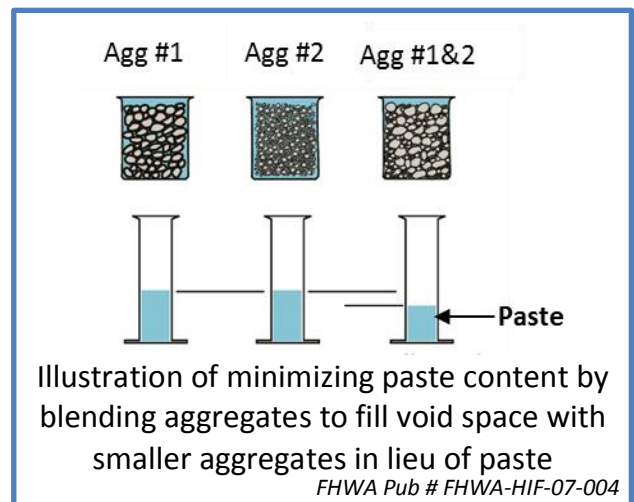
- 1) Not rejecting an acceptable aggregate just because a few sieve sizes are not met.
- 2) Saving time and effort by focusing on assuring the combined gradation meets the specification, as opposed to focusing on each individual sieve.
- 3) Considering the performance of the combined gradation from all aggregates to enhance mixture performance.

Optimizing Aggregate Gradation:

Finding the best combination of aggregates used in the concrete mixture involves **minimizing the paste content while still producing a workable mixture**. Optimizing aggregate gradation offers advantages for both fresh and hardened concrete properties. It's a balancing act; mixtures should contain a minimum amount of paste to fill all the voids between aggregate particles and to separate aggregates slightly, acting as a lubricant to make the mixture workable. Excess paste beyond this amount does not offer any benefit and may, in fact, be detrimental to performance (cracking, higher permeability etc.).

Benefits of Optimizing Aggregate Gradation

- Increased workability / constructability
- Lower Cracking Potential
 - Reduced thermal and drying shrinkage
- Increased Durability (lower paste content)
 - Lower permeability and ASR potential
- Lower Cost
 - Reduced cementitious content
- Promotes sustainability
 - Better utilization of the aggregates
 - Decreased production of CO₂ emissions



Tools to Reduce Paste Content and Optimize Gradation for Workability:

Focus on optimizing the combined aggregate blends (instead of individual aggregates) to achieve a mixture with the minimum paste content that is also dense, workable, and easy to place.

- **Paste Content:** Use spreadsheets to calculate the paste content based on trial batch proportions (should be less than 25% by volume).
- **Tarantula Curve:** Optimize combined gradation from a workability stand point using the Tarantula Curve (<https://www.fhwa.dot.gov/pavement/concrete/pubs/hif15019.pdf>). For a given set of aggregates, the blend percentages can be adjusted to obtain the best proportion that meets the Tarantula Curve criteria (for the spreadsheet tool, contact michael.praul@dot.gov)
- **Intermediate Aggregate:** For certain mixtures, it is beneficial to include an intermediate aggregate, in addition to the traditional rock and sand, to improve aggregate packing. Costs associated with the intermediate aggregate may be offset by reducing cement content and increasing the concrete quality.