

# Air-Void Clustering: A Rare Problem Explained

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## Laboratory study links air-void clustering to certain types of air-entraining admixtures and late additions of water to concrete.

Air-void clustering (AVC) in concrete is a randomly occurring phenomenon that can result in a significant decrease in compressive strength. As the name implies, AVC is the concentration of entrained air voids around coarse aggregate particles at the paste/aggregate interface, creating a localized zone of weakness. Lower compressive strengths occur because applied loads cannot be effectively transferred between the paste and aggregate particles. Examples of air-void clustering are shown in Figure 1.

A research project conducted by CTLGroup (Kozikowski, et al. 2005) focused on two potential causes: late additions of water, and admixture type. Other factors were varied systematically between mixes to evaluate their influence on the phenomenon. Concrete specimens from each mixture were tested for compressive strength and visually evaluated.

### Visual Rating System

The visual reference shown in Figure 1 was created based on various levels of clustering severity witnessed. This reference standard is composed of four categories to differentiate between no clustering, minor, moderate, and severe air-void clustering. A rating of 0 implies that no clustering exists. Minor clustering (Rating 1) involves the intermittent occurrence of clustering of entrained air voids around the periphery of coarse aggregate particles. For moderate clustering (Rating 2), most or all of the aggregate is surrounded by a layer of entrained air voids. Severe clustering (Rating 3) is defined as several layers of entrained air voids surrounding a single aggregate.

Concrete cylinders were cut and lapped for evaluation. Cylinders were rated by assigning each coarse aggregate (larger than 6 mm or 0.25 in.) to one of the four numeric categories of 0 to 3. The number of coarse aggregates corresponding to each category was multiplied by the corresponding category number. These values were then summed, and an average clustering rating was obtained by dividing the sum by the total number of aggregates evaluated.

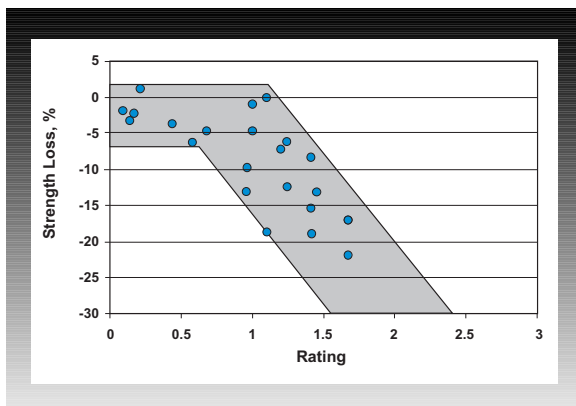


Figure 2. Relationship between compressive strength loss and clustering rating.

### Clustering Tied to Compressive Strength

Correlations between clustering ratings and compressive strength losses are presented in Figure 2. There is an apparent compressive strength loss with increasing average clustering rating. The potential for compressive

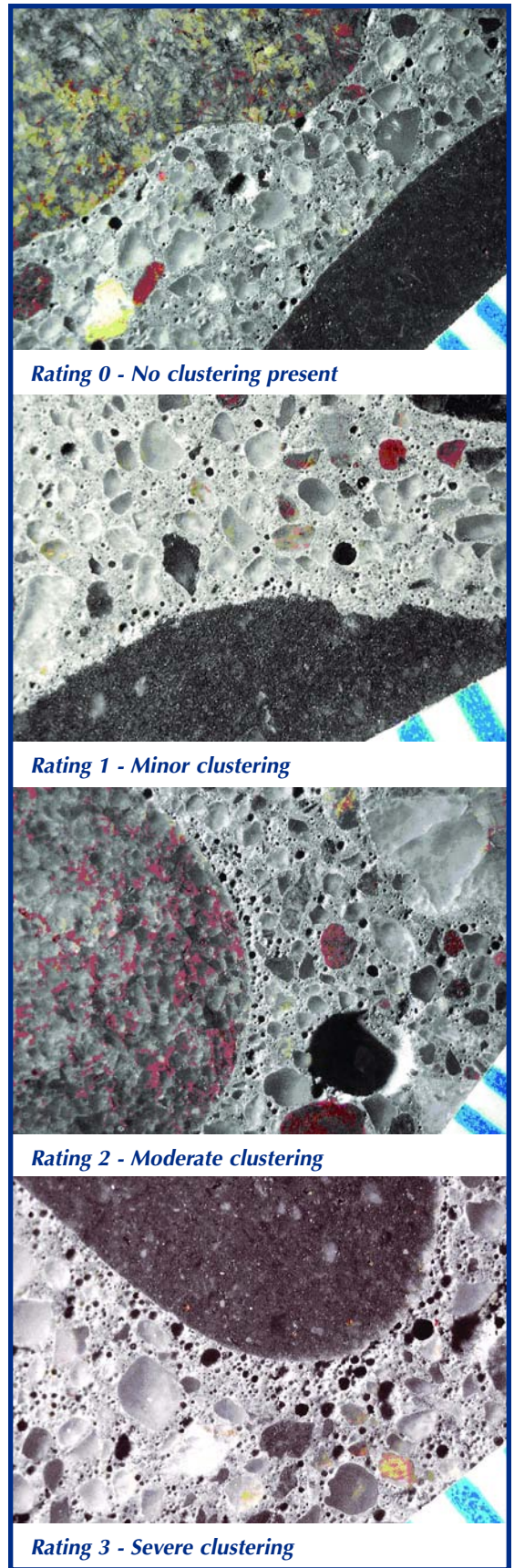


Figure 1. Rating scale for entrained air-void clustering observed at paste-coarse aggregate interfaces. Millimeter scale. (IMG17954, IMG17955, IMG17956, IMG17957)

strength loss due to clustering increases as the average clustering rating exceeds 1.0. For ratings exceeding 1.5 there is a definite association to compressive strength loss.

## Conclusions

Based on the use of the visual rating system and the variables examined in this study, the main findings are as follows:

1. Air-void clustering did not occur in concrete mixes made with vinsol resin-based admixtures.
2. A late addition of water to concrete mixtures containing non-vinsol resin admixtures regularly caused clustering to occur. Special care should be taken not to retemper concrete mixes containing these types of air-entraining admixtures. The practice of holding back water at the batch plant to be added at the jobsite (and not exceed the specified w/c) would also constitute a late addition of water.
3. Different air-entraining admixture formulations were found to produce similar clustering ratings, but exhibited significant variations in strength loss.
4. The severity of air-void clustering increased when the retempered concrete was mixed for a longer period of time.
5. Aggregate shape/mineralogy had a significant impact on the level of strength loss.

### For more detailed information on this study see:

Kozikowski, Ronald L. Jr.; Vollmer, David B.; Taylor, Peter C., and Gebler, Steven H., *Factors Affecting the Origin of Air-Void Clustering*, SN2789, Portland Cement Association, Skokie, Illinois, USA, 2005, 22 pages.