HAHN READY MIX

# Aggregates for Concrete

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## What do we need from aggregates to make quality concrete?

For many, rocks are just rocks and sand is just sand. For a concrete producer or a concrete finisher, this couldn't be further from the truth. Aggregates make up 60-75% of the volume of a concrete mix and therefore the properties of those aggregates can literally make the concrete or break it.  Aggregate properties can influence strength, workability, finishability, water demand, durability, and yield. So what does a Ready Mix Producer look for in a quality concrete aggregate?

**Mineralogy** - Aggregates can be made from many different types of stones, sands, or gravels. Different materials have different properties that can influence concrete behavior. In the eastern Iowa/western Illinois region, common coarse aggregates are crushed limestones and fine aggregates are natural river sands.  In other areas of the country, less desirable substances such as granites and manufactured sands have to be used due to local availability.

**Gradation** - The “Gradation” of an aggregate is the distribution of particle sizes within a sample of that aggregate. This is critical because

good concrete has many different sizes of aggregates within the mix to interlock most effectively.  We'll discuss optimized aggregate gradations in a future technical bulletin, but it's essential to know that we aren't looking for rocks that are all the same size or sands that have the same size grains. Aggregate gradations with too much material on a single sieve or that is too coarse can lead to finishing and placement issues. Aggregates that are too fine can lead to strength problems.  We assess sands using a metric called the “fineness modulus” (FM), which is essential a value determined by the cumulative addition of the weight retained on each successive sieve in a gradation test.  The target FM for the best compromise between strength and workability is 2.7, but sands should not be outside the range of 2.3-3.1. The top size of an aggregate is also important as different sized aggregates are appropriate for different types of jobs. Sands are typically referred to as “Fine Aggregates", while stone is referred to as “Coarse Aggregates” or “Intermediate Aggregates”, depending on size.

**Cleanliness** - One might hear horror stories about “dirty rock”. What this really means is that the aggregate has too much material passing the #200 sieve. Often this very fine material is silt, clay, or dust and can cause serious issues with paste bond to the aggregate, an increase in water demand, and difficulties entraining air. This results in negative effects on strength, durability, freeze-thaw durability, and workability. This super-fine material should not exceed 3% for fine aggregates and 1.5% for coarse aggregates.

**Free of Deleterious Substances** - Clay lumps, chert, coal and lignite would be considered deleterious substances. These unwanted materials sometimes found in aggregate deposits can cause popouts or other surface blemishes that are undesirable in concrete.  ASTM C33 sets limits on how much deleterious substances can be present in an aggregate.

Aggregate Popout

Courtesy PCA

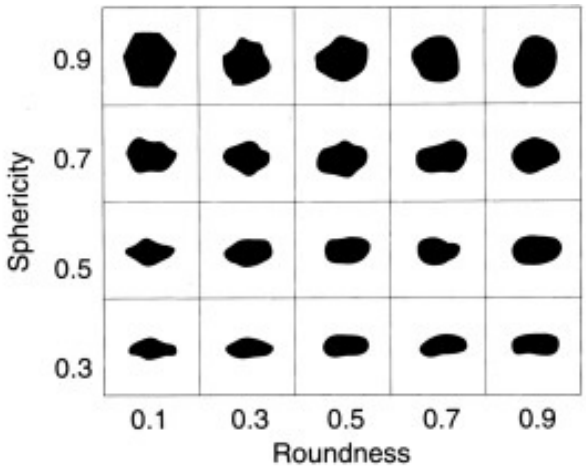
**Free of Organic Impurities** - Some sands can have organic impurities such as tannic acid that can interfere with the hydration of cement. This phenomenon is typically not present in our area.

**Soundness and Freeze-Thaw Durability** - Aggregates in concrete must be able to withstand aggressive actions to which the concrete containing it might be exposed. Soundness refers to the ability to resist those forces. Freeze-thaw durability is of particular importance, as aggregate that cannot withstand freeze-thaw stresses can result in concrete with popouts, d-cracking (below), or even the total collapse of the concrete structure.

**Abrasion Resistance** - Abrasion resistance is an aggregates ability to resist being worn away by rubbing and friction. This is important for the surface wear of in-place concrete but also an aggregates ability to resist

degradation in a stockpile or during the mixing process.

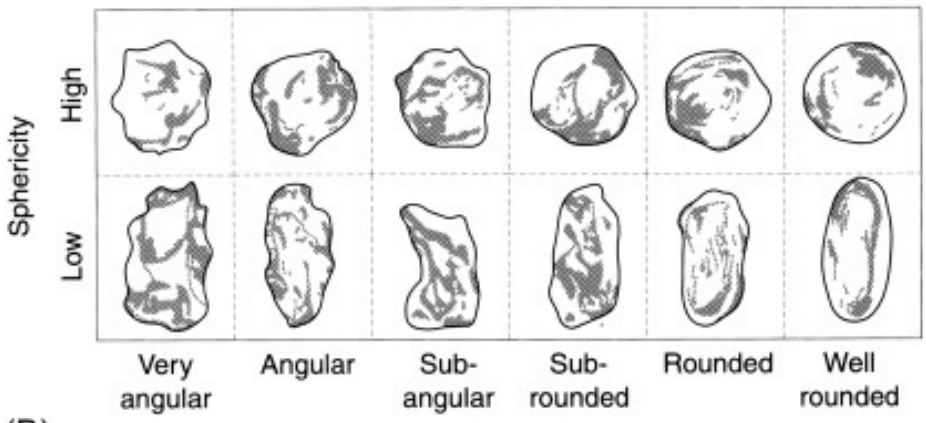
**Particle Shape & Texture** - Not only is the gradation of the aggregates important, but the shape and texture of those particles are as well. Long & elongated particles in the coarse aggregate can be very difficult to finish, may not fit through rebar or even be longer than the depth of a pour and potential stick out the top if orientated vertically. Angular fine aggregate will result in a much higher water demand and can be very difficult to pump and finish. The resulting higher water demand can have a massive effect on in-place strengths and durability. An ideal fine aggregate is rounded, and an ideal coarse aggregate is sub-angular or sub-rounded with a high sphericity. This slight angularity promotes paste bond and interlock in the concrete mix.




Sphericity = nominal diameter/maximum intercept

Roundness = average radius of corners and edges/radius of maximum inserted circle

(A)

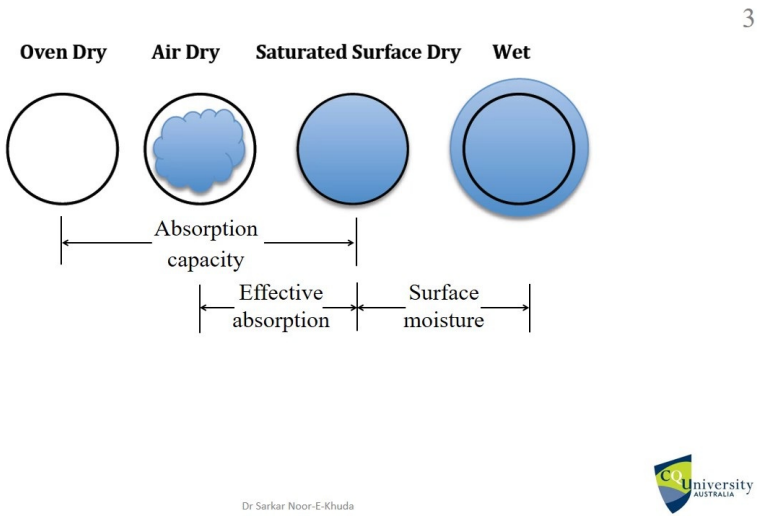



(B)

**Free of Akali-Aggregate Activity** - We'll discuss this topic in more depth in a later technical bulletin, but aggregates with a high silica in the sand or carbonate in the rocks can react with the alkalis in cement to form an expansive gel which can destroy concrete from the inside after it has hardened.

**Consistent Specific Gravity** - Specific Gravity (also known as Relative Density) of an aggregate is how much a given volume of the aggregate weighs in comparison to water. An aggregate with a constantly changing specific gravity will result in concrete mixes with inaccurate yields, and contractors may end up shorted. This is also why it's important to adjust mix designs if an aggregate change is made, as it is possible the new aggregate has a different specific gravity.

**Low & Consistent Absorption** - Many aggregates have a bit of internal porosity that can hold water. This potential for holding water is called “absorption”. Aggregates with a high absorption are less likely to be internally saturated, causing  the aggregate to pull free water out of the mix in transit or when going through a pump. The loss of water promotes extreme slump loss or plugging of a pump. If you've ever had a driver tell you he left the yard with a 5" slump but arrived with a 1", it's likely the aggregate was in an absorptive state.




Overall, our region is particularly blessed with nearly ideal aggregates for concrete. Much of the mitigation measures that suppliers from other regions have to utilize to make good concrete with poor aggregates do not even need to be considered for concrete in our area. As always, in selecting an aggregate for use, Hahn Ready Mix is diligent is considering the above factors to make the highest quality concrete.

**Feedback - This Tech Bulletin marks a whole year of information about concrete. We have many more topics prepared to share with you, but we'd love to hear from you which topics you'd like us to cover. Email us at Sales@hahnrmg.com and let us know if there's something you want to learn about. Thanks!**

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