What Makes Moist Clay Behave as It Does?

Vince Pitelka, 2021

Moist, workable clay behaves as it does for three primary reasons. First, clay platelets are submicroscopic in size, averaging less than two microns. A micron is $\frac{1}{1000}$ of a millimeter, and simple calculations reveal that a cubic inch of clay contains at least 2 trillion platelets. Second, clay platelets are flat, thin, and smooth. Third, they have a natural affinity for water and tend to form a water hull or lubricating layer between platelets. These three conditions result in particles that tend to stick together and slide smoothly over one another when wet. Some other phyllosilicate minerals like talc and mica break down to very fine, flat particles, but only clay has the combination of submicroscopic size, flat, smooth particle shape, and affinity for water that gives the quality of plasticity.

Why do Different Clays Behave Differently?

Different clays behave differently for two primary reasons. First, the natural circumstances of geologic origin, metamorphosis, weathering, and movement by wind and water determine platelet size and thus plasticity. Second, a variety of contaminants affect plasticity, color, texture, drying and firing shrinkage, and maturing temperature.

Effects of Particle Size on Clay Performance

The range of clay particle sizes present in any clay or clay body is critically important and affects five primary performance characteristics: 1) plasticity/adhesion, 2) working structure, 3) drying shrinkage, 4) body strength at bone dry and bisque fired states, and 5) firing shrinkage.

1. ***Plasticity and Adhesion***—The plastic and adhesive qualities of clay depend on the fineness of the clay particles—the finer the particle, the more water layers present, and thus more lubrication and greater plastic and adhesive qualities. Exactly the opposite occurs with larger particle sizes—less water layers, less plasticity and adhesion.
2. ***Working Structure***—The ability of clay to hold its form while wet depends on contact points between particles and interference to movement provided by larger particles. The water hull lubricates the surfaces but doesn't prevent particles from physically touching each other, and the friction of those contact points creates working structure. Less water content gives more friction, producing stiffer clay. More water content reduces friction, and enough water eliminates friction, producing a slurry or slip. With appropriate water content, very small clay particles give many contact points, high plasticity, and good working structure, but if the average particle size is too small, the high number of water layers gives problematic drying shrinkage. If the clay particles are uniformly large in a clay body, drying shrinkage is reduced, but plasticity is also reduced and the number of contact points decreases, giving poor working structure.
3. ***Drying Shrinkage***—The loss of water layers by evaporation causes drying shrinkage, and the finer the average particle size, the more the water layers, and thus the higher the

drying shrinkage. High shrinkage during drying causes cracking and warping. The larger the average particle size, the less water layers, and thus less drying shrinkage.

4. ***Dry/Bisque Strength***—Fine particle size mean more adhesion contact points between particles as the clay dries, giving greater strength in dry greenware and in bisqueware. Inversely, larger average particle size gives less contact points between particles and thus lowers strength at bone dry and bisque fired stages.
5. ***Firing Shrinkage***—When any clay is fired above lowfire temperatures, glass begins forming within the platelets and seeps into the intervening spaces or voids. As this happens the platelets shrink, causing firing shrinkage. The larger the average particle size, the more space between to fill with glass, and thus the greater the firing shrinkage, which if excessive can cause cracking and warpage.

To Sum This Up: The advantages of clay with very small platelet size are high plasticity and adhesive qualities, fair working structure due to friction from many contact points, high dry/bisque strength due to many contact points, and low firing shrinkage due to few large voids. The disadvantages are drying shrinkage so high as to make the clay unusable, and no larger particles to increase working structure. The only advantage of clay with larger average platelet sizes is low drying shrinkage, while the many disadvantages include low plasticity due to few water layers, poor working structure due to few contact points, low dry/bisque strength due to few contact points, and high firing shrinkage due to large voids between particles.

For more information, see the handout “Green-Packing Density and the Effects of Particle Size on Clay Performance.”