RUSSTECHNICAL NOTES

FACTORS WHICH MAY INFLUENCE AIR CONTENT

Air contents are an extremely important facet of today's concrete mix design criteria and subsequent in-place concrete performance and durability characteristics. A well designed concrete mix design with adequate air contents delivered by your company and placed by a knowledgeable professional will result in a quality durable finished concrete product that will last many years based on its intended design use. Inadequate air content can also have a negative effect on concrete quality; therefore regular routine concrete quality testing including air content should be an integral part of your quality control program as this is an item that can be controlled with knowledge of what is affecting the results. High or low air contents can be caused by a variety of material, in-house, and external factors; some of which are listed below.

I. Effects of Production, Construction Practices, & the Environment

- ✓ Batch Sequence – Always add air entrainment to the initial mixing water or apply directly on the sand. ***Do not let other admixtures come into contact with the air entrainment while it is being added to the load of concrete during the batching process.*** Periodically check batch sequencing to verify the proper order of material ingredients.

- ✓ Hot Water - Hot water will decrease air effectiveness and may negate its effectiveness completely.

- ✓ Ready Mix Truck Drum Capacities – Do not exceed the manufacturer's recommendations on load size. Optimum load sizes range from 6-9 cubic yards depending on mix design specifics; optimal load sizes usually mix the material ingredients the most efficiently. If proper mixing is an issue, consider adjusting load size. The air content of the concrete in the mixer drum may increase when the mixer load size is three cubic yards or less while air content may decrease in larger load sizes or if the mixer drum is worn or has concrete buildup on the fins.

- ✓ Mix Time – Expect longer mix times with larger load sizes. Smaller load sizes may be conducive to higher air contents and will normally mix more quickly. Inadequate mix times may decrease air content and adversely affect the air void system. Under mixing prevents air bubbles from spreading evenly throughout the load. In these cases air content may significantly increase on the way to the job because of additional mixing times enroute. Over mixing can actually decrease air content as air is "beaten" out of the plastic concrete. Establish an optimum mix time for each ready mix truck as drum and fin age, wear, concrete buildup, etc. all affect mixer drum performance. Some mixes simply take longer to mix thoroughly. ***Requiring each truck to mix adequately and within predetermined time frames for thorough mixing of material ingredients will help ensure that air contents remain consistent.***

- ✓ Drum Mixing Speed – All ready mix truck drums should mix at approximately the same mix speeds to maintain consistency between batched loads. Air contents typically increase with mixer speeds up to 20 rpm, higher mix speeds may decrease air content.

- ✓ Truck Drum Maintenance - Truck drums should be clean and well maintained. Concrete buildup and fin and drum wear can drastically affect the mixing and performance capabilities of any given mixer drum.

- ✓ Admixture Dispensers – Accuracy and consistency of the dispenser can affect air content uniformity. Make sure air entrainment dispenser is accurate, consistent, and discharging completely into the mixer. This is particularly important if air dosage requirements are low.

II. Effects of Transport

- ✓ Delivery – Air content is normally reasonably stable from the completion of adequate mixing through most delivery times. Typically, 1% – 2% of air content is usually lost during normal transport (more in hot weather, less in cold weather). Re-tempering with water will generally increase air content. If necessary, re-temper with air entraining admixture at the job-site or increase the air dosage rate at the plant to compensate for air loss during transport. Dramatic loss of air is often due to factors other than transport. Some examples would be if percent retained on the #30 and #50 sieve sizes on the fine aggregate are unusually low, entrained air bubbles may not have an adequate place to locate. This would result in higher than normal air losses. Also, pumped concrete (depending on boom configuration) can cause dramatic air losses from free fall of the concrete.

- ✓ Haul Time – Long haul times (and extended wait or pour times) may significantly reduce air content especially in hot weather. Try to optimize your delivery schedule and maintain satisfactory concrete temperatures.

III. Effects of Construction Practices

- ✓ Pumping Concrete – May result in air content reductions of 2%-3% at the discharge end of the pump boom. Higher air losses usually are the result of boom configuration causing free fall of the concrete and will sometimes actually create a vacuum in the pump boom.

- ✓ Finishing – If concrete surfaces are excessively finished air content at the surface is decreased and disrupts the air void system sometimes causing durability issues on the surface of exterior concrete.

- ✓ Vibration – Excessive or incorrect vibration of the concrete decreases air content and may cause durability issues with in-place concrete.

- ✓ Re-Tempering Concrete – Water is commonly added on most job-sites to increase slumps. Re-tempering with water will generally increase air content but may cause loads to exceed slump, w/c ratio requirements, etc. and may not be able to be performed. If necessary, re-temper with air entraining admixture at the job-site or increase the air dosage rate at the plant to compensate for air loss during transport. Increasing the air content may regain the expected workability lost due to slump loss. Avoid excessive water additions – know your maximum w/c ratio.

Re-tempering with water does not usually affect the air void system but can on rare occasions result in a phenomenon called air void clustering which causes the air bubbles to cluster around the coarse aggregates causing the concrete to be structurally weaker. Re-tempering with air entrainment will restore the air void system. Higher admixture dosage rates are usually necessary for any additions performed after the initial load has been batched and mixed.

IV. Effects of the Environment

- ✓ Temperature – Air contents normally decrease when concrete or ambient temperature increase. In turn, air contents normally increase when concrete or ambient temperature decrease; both of which may require a dosage rate adjustment of the AEA. Changes in temperature usually do not affect the air void system. Air contents can change by 20%-30% with a 20F temperature change.

V. Effects of Ingredients and Mix Design

- ✓ Portland Cement - Air content can be affected by cement brand, cement type, alkali content, cement fineness, cement content, and contaminants.
    - AEA dosage rates may vary between cement brands.
    - Generally AEA dosage rates utilizing straight cement mix designs are approximately 40 – 50% of AEA dosage rates of mix designs which include fly ash.
    - Type III cement is finer than Type I and will normally decrease air content and require higher AEA dosages.
    - Air contents may increase with increased alkali contents.
    - There may be a decrease in air content as cement content is increased.
    - Air content can be affected by the cement manufacturing process resulting in contamination of cement with finish mill oil or grinding agents.

- ✓ Cementitious Supplementary Materials - Air contents are affected by fly ash, silica fume and granulated blast furnace slag. Metakaolin has no apparent effect on the air content.
    - Air contents generally decrease with the addition of fly ash. Air contents generally go down as LOI or carbon content in the fly ash increases.
    - Generally AEA dosage rates utilizing mix designs including fly ash are approximately double that of AEA dosage rates of mix designs which utilize straight cement.
    - Air content will normally decrease as you increase silica fume quantities.
    - Air content normally decreases as you increase ground granulated blast furnace slag (GGBF) quantities.

- ✓ Aggregates – Air contents can be greatly affected by certain changes in the aggregate top size, ratios, shape, and fineness.
  - Air contents generally increase as the top size decreases.
  - Air contents generally increase as sand content increases.
  - Air contents may increase when aggregate shape goes from irregular (crushed limestone) to round (river gravel).
  - Air content generally increases when sand grading in middle sieves increases.
  - Air content loss can result when sand grading in middle sieves decreases.

- ✓ Chemical Admixtures – Air contents are affected by different admixtures.
  - The addition of water reducers & retarders normally slightly increase air contents.
  - The addition of accelerators, both chloride and non-chloride decrease air content.
  - Superplasticizers & mid-range water reducers increase air content. Polycarboxylate-based admixtures increase air content considerably. AEA dosage rates must be reduced as compared to similar mix designs without these admixtures.

- ✓ Mix Water & Slump – Water chemistry and slump can have major effects on the air content of a mix design
  - Water that is very hard will normally decrease air contents.
  - Air contents decrease as water to cementitious ratios are decreased. Less mix water means less air content.
  - Slump – Air contents normally increase as slumps increase up to approximately 6”. Air contents usually go up approximately 0.5%. for each inch of slump gain. Air contents normally increase as water contents are increased. Air content decreases as slumps go down to approximately 2”. Very low slumps are difficult to entrain air and may require considerably higher AEA dosage rates. Very high slumps generated by water additions normally decrease air content.