JERSEY DOT'S

"Turning Problems into Solutions"

Tech Brief

Effects of Synthetic Air Entraining Agents on Compressive Strength of Portland Cement Concrete – Mechanism of Interaction and Remediation Strategy

FHWA-NJ-2002-025 December 2002

SUMMARY

This tech brief is a summary of a research project that was undertaken in order to determine the cause for loss of compressive strength for concretes using synthetic type air entraining admixtures. The research program involved four different brands of admixtures and two different types of admixtures (Synthetic and Vinsol resin) per brand. The experimental program involved determination of compressive strength, measurement of air content at fresh state, detailed determination of air void parameters at the hardened state, and measurement of surface tension of admixtures in water and cement filtrates. The results of research indicated that, concretes produced by the synthetic air entraining admixtures, in general exhibited lower compressive strengths than those produced by Vinsol resin agents. The primary reason for the strength loss associated with the Synthetic air-entraining admixtures was creation of larger air bubbles (voids) by these admixtures. In general, but not in all cases, the synthetic air entraining admixtures increased the surface-tension-reduction capability of the cementitious mixture, giving rise to creation of larger bubbles.

BACKGROUND

Nearly all of the concrete employed in construction is air entrained. Besides improving freeze-thaw durability, air entraining increases the workability of concrete, and therefore allows for a reduction in water to cement ratio (*w/c*). However, introduction of additional void space with air entrainment will have a detrimental effect on strength. A strength loss of 10 to 20 percent can be anticipated for most air-entrained concretes. This reduction in strength is anticipated and is compensated for during mix proportioning of concrete by reducing the amount of required sand and water. Water content can be generally reduced by 30 to 50 lbs/yd^3 for a 5 percent increase in air content.

This partially offsets the strength reduction that accompanies air entrainment. However, recent experiences of NJDOT with synthetic air entraining admixture have indicated larger than anticipated decreases in compressive strength. According to NJDOT observations, this decrease in strength has been isolated independently of parallel contributions from varying air content, ambient temperature, Portland cement quality control and differing alkali contents in Portland cement. Such losses in strength were not observed with Vinsol resin type air entraining agents. The objective of this work was to find the reason for the compressive strength loss.

RESEARCH APPROACH

To achieve the stated objectives of the research, the experimental program included the following tests, analysis, and measurements:

1. Compressive Strength Tests.
2. Air void analysis.
3. Surface tension measurements.

The project required air void analysis of multitude of samples. This necessity led to the development of an automated linear traverse system based on image processing methodologies (figure 1). Details of the system are given in the full report. Four different brands of air entraining admixtures, namely: Brand-A, Brand-B, Brand-C, and Brand-D were employed in the study. Both Synthetic and Vinsol resin types of admixtures per manufacturer were examined.

Figure 1. Automated linear traverse system

FINDINGS

General findings pertaining to the analysis of results are summarized below:

1. Synthetic air-entraining admixtures created more air bubbles than their Vinsol resin counterparts.
2. More air bubbles do not necessarily result in lower strengths. The reduction in strength at the same level of total air is associated with the production of larger bubble sizes.
3. The extent which synthetic air entraining agents affect the air void characteristics and therefore the compressive strength are brand sensitive. Depending on the brand, Synthetic agents influence the air void system in two ways. Some increase the total number of air bubbles; others increase the number of very large bubbles; and the third category does both.

Typical results indicating the size and distribution of air bubbles is shown in figure 2.

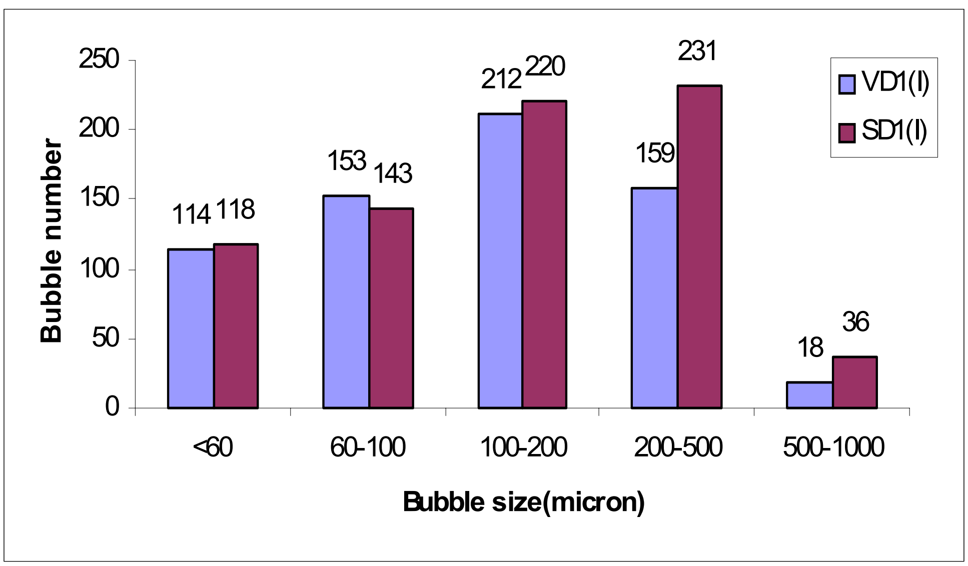

Fig.2 Comparison of air void sizes for concretes with Vinsol and synthetic air entraining agents

CONCLUSIONS

In general, synthetic air entraining admixtures increase the surface-tension-reduction capability of the cementitious mixture, giving rise to creation of larger bubbles and therefore lower compressive strengths. Although the majority of strength losses were associated with the Synthetic agents, the effect and severity of air entraining admixtures on strength loss, and air void distribution is brand sensitive. Generalization in terms of strength loss and air void distribution for synthetic admixtures will lead to erroneous results.

RECOMMENDATIONS

1. Under equal circumstances and availability Vinsol resin admixtures are more favorable due to the established compatibility of mixtures with Vinsol resins.

2. With the limited number of brands tested here, and if the price and availability dictates the use of synthetic admixtures, certain brands (brand-B in the present study) shall be used as it did not cause any compressive strength losses.

FOR MORE INFORMATION CONTACT:

NJDOT PROJECT MANAGER:	Nicholas Vitillo
PHONE NO.	(609) 530-5966
e-mail	Nick.Vitillo@dot.state.nj.us
UNIVERSITY PRINCIPAL INVESTIGATOR:	Dr. Farhad Ansari
UNIVERSITY:	University of Illinois at Chicago
PHONE NO.	(312)996-2437
e-mail	

A final report is available online at
http://www.state.nj.us/transportation/research/research.html

If you would like a copy of the full report, please FAX the NJDOT, Division of Research and Technology, Technology Transfer Group at (609) 530-3722 or send an e-mail to Research.Division@dot.state.nj.us and ask for:

Effects of Synthetic Air Entraining Agents on Compressive Strength of Portland Cement Concrete-Mechanism of Interaction and Remediation Strategy

NJDOT Research Report No: FHWA-NJ-2002-025