IOWA STATE HIGHWAY COMMISSION

Materials Department

Special Investigations

FINAL REPORT OF R-234

A STUDY OF THE RELATIVE DURABILITY AND DRYING SHRINKAGE OF CONCRETE USING VARIOUS RETARDERS

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by

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A Study of the Relative Durability and Drying Shrinkage of Concrete using Various Retarders

INTRODUCTION:

A number of concrete admixtures are presently used in various concretes principally for water reduction, retardation, or air entrainment. Whereas the use of these admixtures in concrete placement is well documented, there is limited information showing their effects on durability and drying shrinkage. Since the durability and the shrinkage of concrete can have a pronounced effect on a structures longevity, wear characteristics, and reaction to loading, it is desirable to know the relative effects of different admixtures prior to concrete placement.

PURPOSE:

The purpose of this study is to provide information which could be used to establish durability and shrinkage criterion for evaluating the admixtures currently in use and those whose use may be proposed.

MATERIALS:

1. Aggregates
   The coarse aggregate was taken from the following:
   Alden Limestone - Weaver
   White Materials Corp., Gravel - Des Moines
   Bentye Stone - Roverud
   The fine aggregate was from Hallett Construction Company's Ames Pit; and complying with section 4110 of the standard specifications.

2. Cement
   The cement was a blend of seven cements commonly used in Iowa complying with the requirements of type I cement and tested under Lab. No. AC7-5638.

3. Admixtures

   The air entraining admixture was Ad-Aire Lab. No. ACA6-20.
   The retarders used were the following:

   A. Pozzolith 100R
   B. Daratard 40
   C. Protex PDA 25R
   D. Plastiment
   E. Sugar
   F. Pozzolith 200R
   G. Pozzolith 8 Improved

4. Concrete
   The concrete was proportioned to comply with the requirements of a D-57 structural mix. The slump was adjusted to 2 1/2 ± 1/2 inches. The amount of air entraining agent was adjusted to yield 6±1% air content as measured by ASTM C-231.

PROCEDURE:

Since it was required that the effects of both drying shrinkage and durability be studied, it was imperative that two sets of beams be made and tested. The procedure of each was as follows:

1. Drying Shrinkage Specimens
   A. Three 3"X3"X11" beams were cast for a control as well as for each concrete containing an admixture.
   B. All concretes were consolidated by external vibration.
   C. The specimens were cured initially in molds under polyethelene film and wet sample bags.
   D. The beams were removed from the molds 23 1/2 ± 1/2 hours after casting.
   E. The specimens were then placed in water at $73.4^{\circ} \pm 1^{\circ}$F for 1/2 hour.
   F. The beams were wiped with a damp cloth upon removal from the water storage and measured for length.
   G. The beams were then placed in water at $73.4^{\circ} \pm 3^{\circ}$F for 28 days and remeasured after 1/2 hour storage in water at $73.4^{\circ} \pm 1^{\circ}$F.
   H. The specimens were stored in air at $73.4^{\circ} \pm 2^{\circ}$F and relative humidity of 50 to 80%. Length determinations were made after periods of air storage of 4, 7, 14, and 28 days and of 8, 16, 32, and 64 weeks.
   I. A final measurement was taken on the beams after 128 weeks in air and after being placed in a 300°F oven for 72 hours.

2. Durability Specimens
   A. Three 4"X4"X18" beams were made for each retarder mix. Beams containing no retarders were also made as a control.
   B. All concretes were consolidated by external vibration.
   C. The beams were molded and covered with a polyethelene film for 20-48 hours.
   D. Curing was completed by allowing the specimens to stand 90 days in the moist room followed by one day in a 40°F water cooler.
   E. Testing was done under freeze and thaw conditions in accordance with ASTM C-291 with the following exceptions:

      1) Specimens were 18" in length.
      2) Beams were not randomly replaced after reading.
      3) Beams were not weighed.

RESULTS:

The results of the durability test are shown in table I and are pictured in figures 1, 2, and 3. An examination of the data and the graphs shows the effects of the various retarders to be very erratic and somewhat unexplainable. For example, a comparison of the graphs indicates that the retarders change positions of relative durability with the three different coarse aggregates. However, the graphs do show that there is a recovery in durability when a good quality coarse aggregate is used. Although this fact has been proven in previous studies, the experimental data does not show an overall superiority or rejection criterion for any one retarder without first specifing a coarse aggregate.

The results of the drying shrinkage test are also shown in table I. The graphs of drying shrinkage (figs. 4, 5, and 6) indicate that the better quality coarse aggregate will reduce the air shrinkage with all retarders. However, no retarder exhibited the least drying shrinkage with all aggregates. Thus, there is still no basis for considering a retarder generally better. The uneven nature of the shinkage curves is thought to be due to the change in humidity in the cement lab. Since accurate control of humidity is impossible with the present facilities, the specimens shrunk during dry weather and actually showed a growth in very humid weather (32nd week measurement, not shown on graphs). Also, the concrete mixing facilities left possibilities for unaccounted variables to enter into the test results.

SUMMARY

This study has shown that:

1. The coarse aggregate has a far greater influence on durability than any influence due to a retarder. There is no concluding evidence to justify considering any single retarder tested to be generally best. Any durability and shrinkage criterion taken from this study would be purely speculation because of the erratic and inconsistant data obtained.

2. There must be a complete investigation as to the dependability and repeatability of the freeze and thaw test procedure before projects of this magnitude can be conducted in the future.

   Possible areas of more stringent control might be:

   A. Mixing atmosphere
   B. Vibration time
   C. Frequency determination
   D. Humidity control

Table I
Durability and Drying Shrinkage Results

Coarse Aggregate	Retarder	% Air in Mix	Durability		Shrinkage, 128 Weeks in Air, In.
			D. F.	% Growth	
Weaver - Alden Lab No. AAC8-422	None	5.8	96	0.012	0.0071
	Pozz. 100R	6.3	96	0.011	0.0057
	Daratard 40	5.7	99	0.011	0.0044
	PDA 25R	5.1	97	0.013	0.0040
	Plastiment	6.4	96	0.012	0.0069
	Sucrose	6.5	95	0.012	0.0056
	Pozz. 200R	6.2	98	0.010	0.0056
	Pozz.-8 Imp.	7.5	98	0.011	0.0052
Keefner - Des Moines Lab No. AAGA-284	None	5.3	87	0.018	0.0077
	Pozz. 100R	5.4	83	0.029	0.0078
	Daratard 40	5.0	92	0.020	0.0077
	PDA 25R	4.8	86	0.036	0.0080
	Plastiment	5.1	92	0.015	0.0071
	Sucrose	5.3	94	0.011	0.0069
	Pozz. 200R	5.3	93	0.012	0.0066
	Pozz.-8 Imp.	5.6	93	0.009	0.0062
Roverud - Bentye Lab No. AAC8-446	None	5.7	94	0.015	0.0057
	Pozz. 100R	5.5	89	0.026	0.0061
	Daratard 40	5.3	94	0.019	0.0057
	PDA 25R	5.7	93	0.020	0.0061
	Plastiment	5.2	87	0.051	0.0058
	Sucrose	5.6	82	0.062	0.0061
	Pozz. 200R	5.8	96	0.012	0.0056
	Pozz.-8 Imp.	5.0	95	0.009	0.0061

FIGURE 1 THE INFLUENCE OF RETARDERS ON DURABILITY USING ALDEN STONE

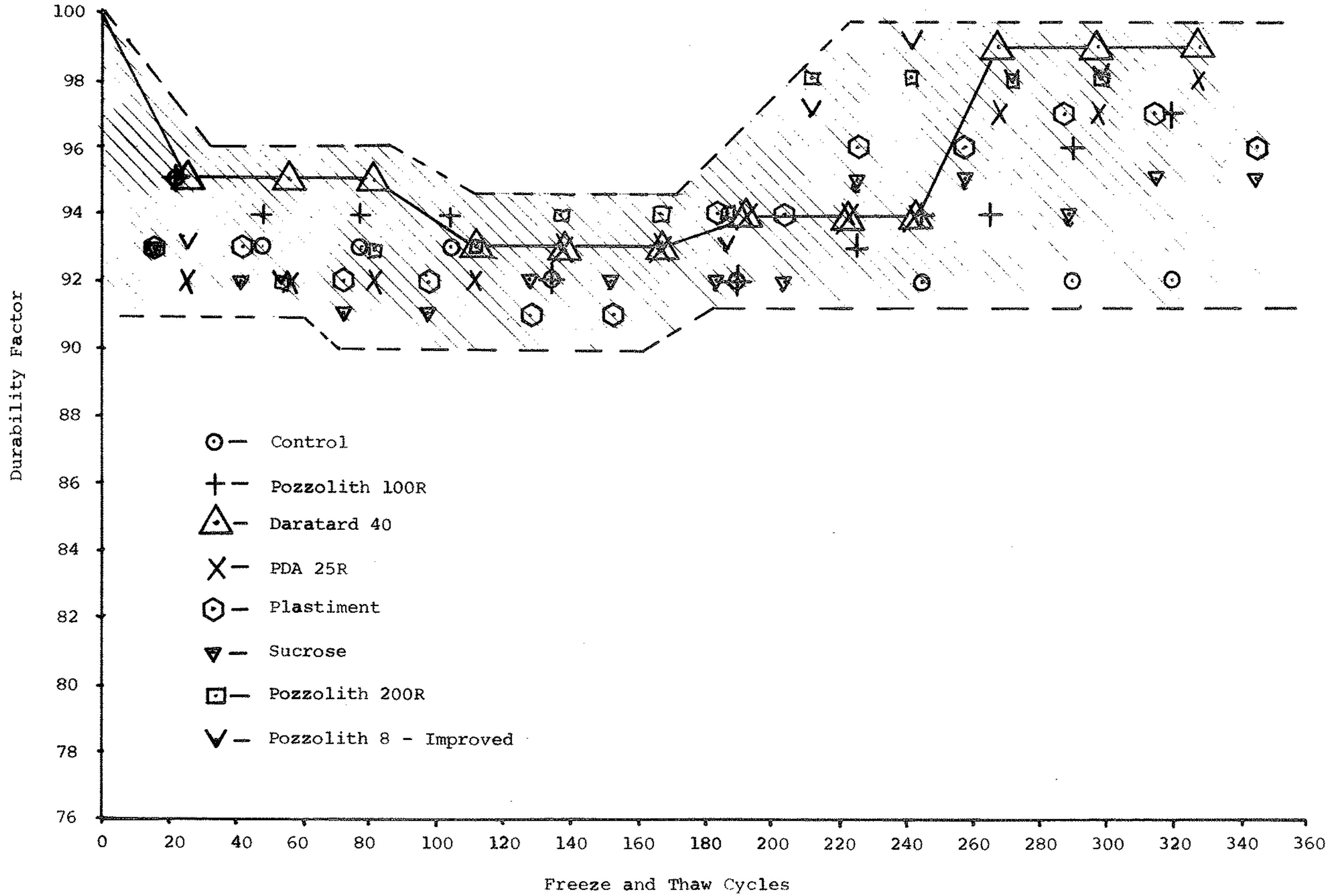

FIGURE 2 THE INFLUENCE OF RETARDERS
ON DURABILITY
USING
BENTYE STONE

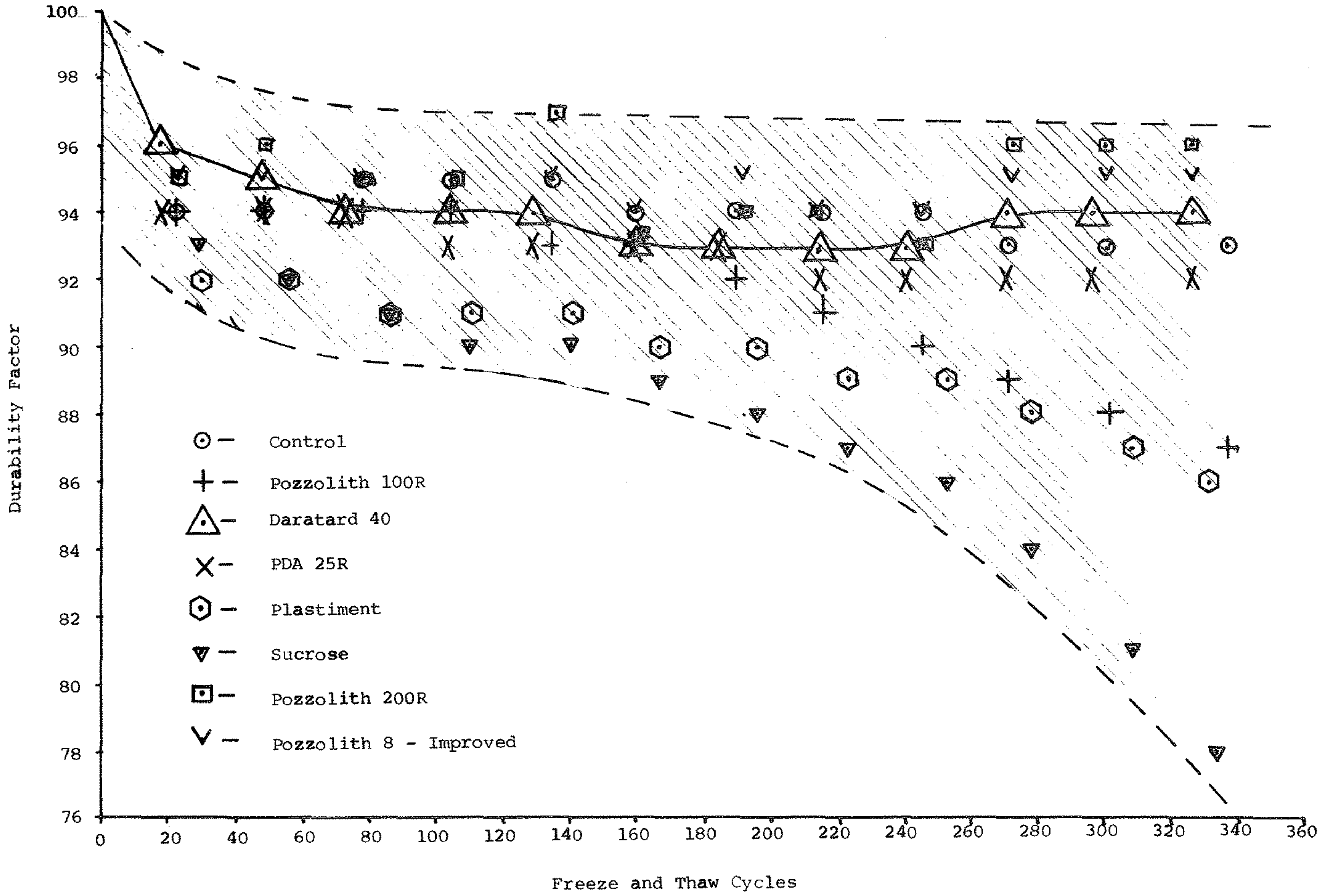

FIGURE 3 THE INFLUENCE OF RETARDERS ON DURABILITY USING KEEFNER STONE

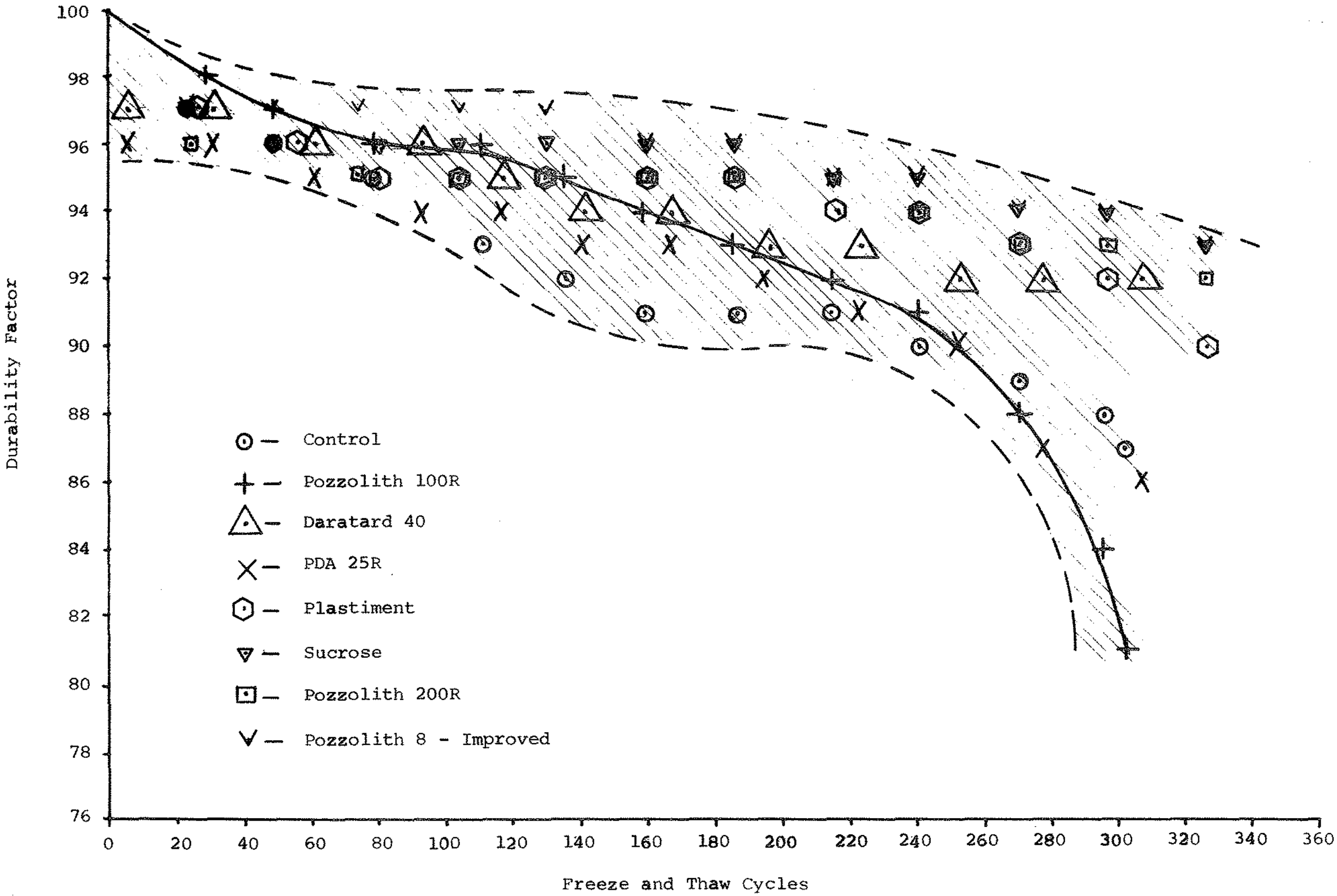

FIGURE 4 THE INFLUENCE OF RETARDERS ON DRYING SHRINKAGE USING ALDEN STONE

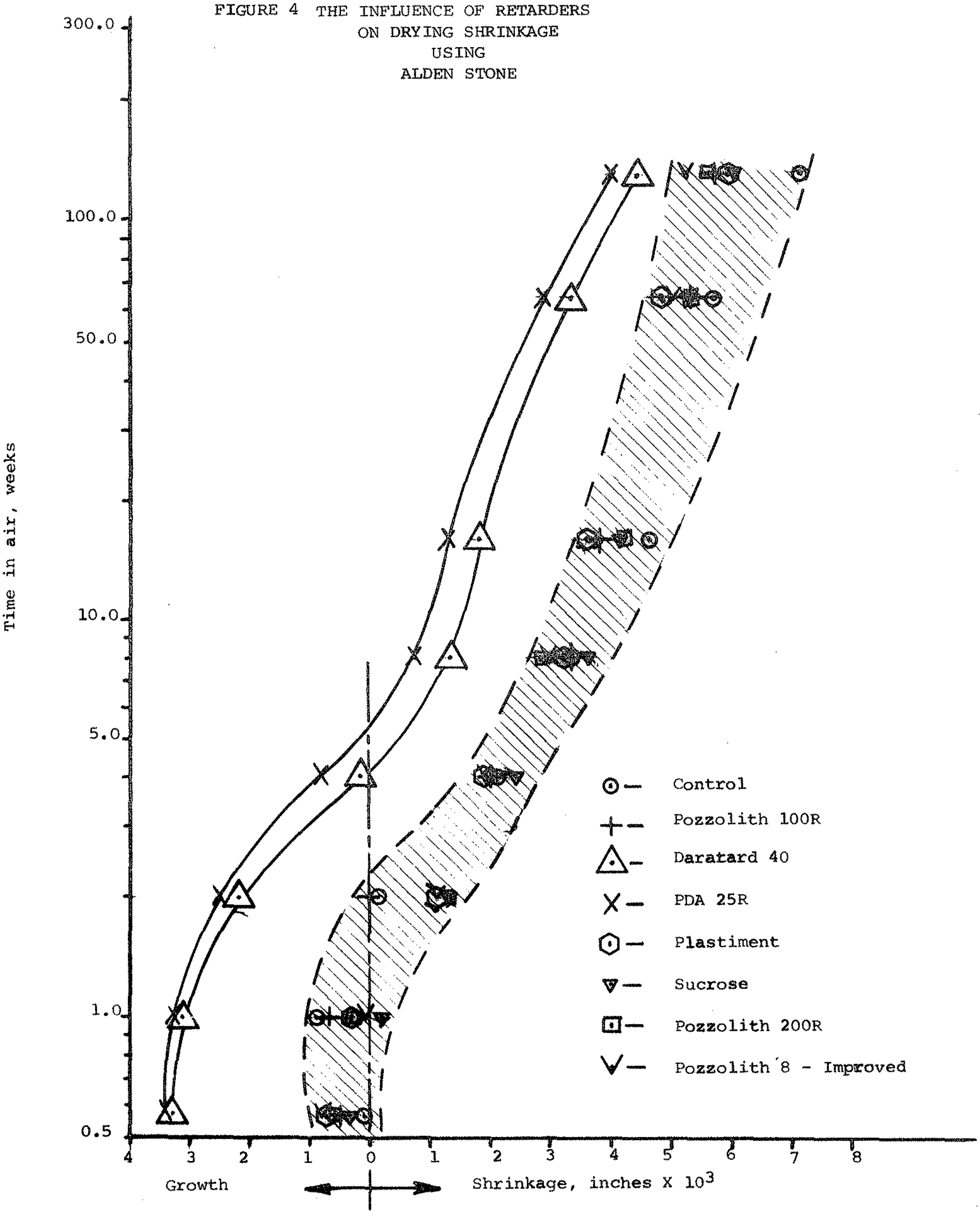

FIGURE 5 THE INFLUENCE OF RETARDERS ON DRYING SHRINKAGE USING BENTYE STONE

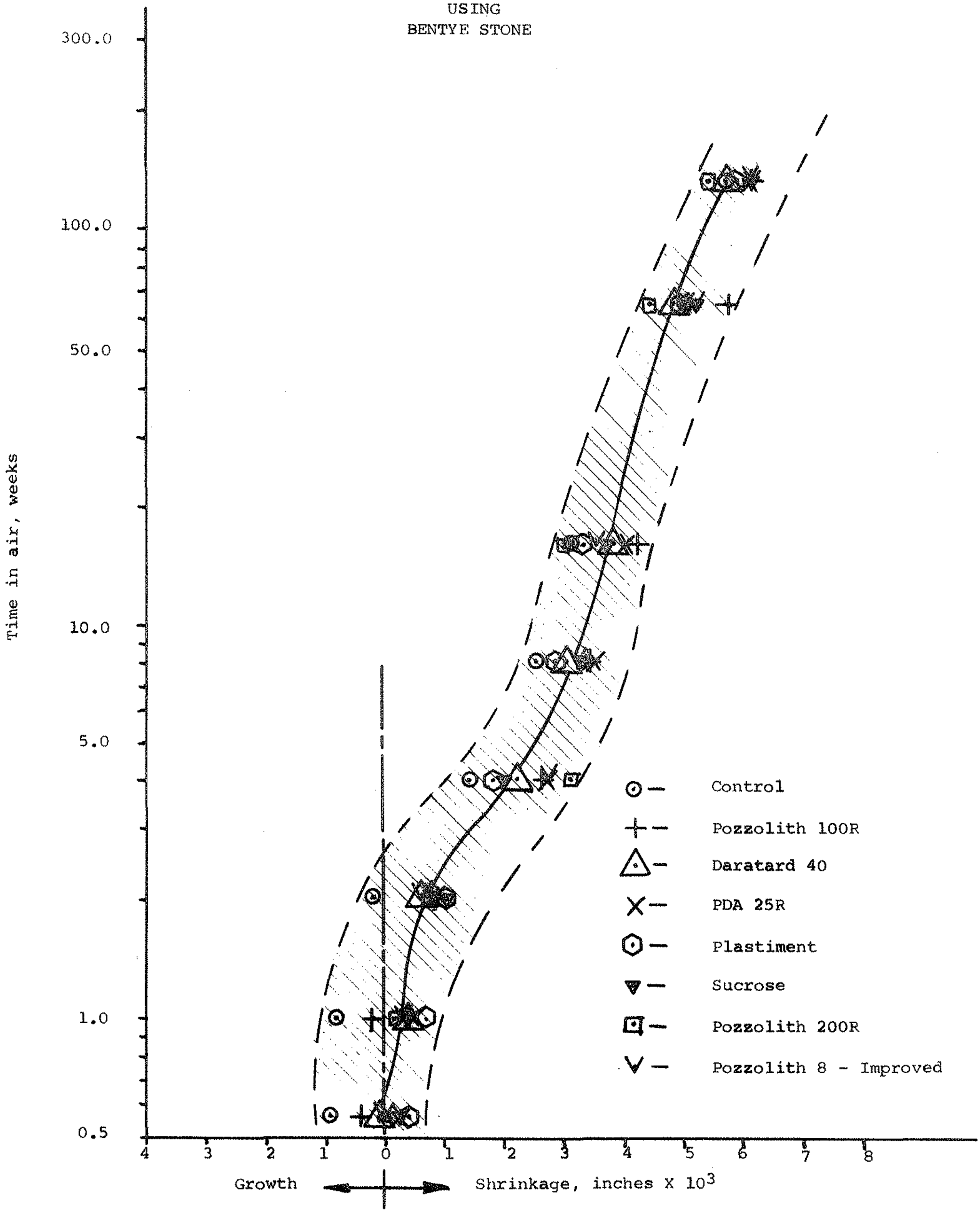

FIGURE 6 THE INFLUENCE OF RETARDERS ON DRYING SHRINKAGE USING KEEFNER STONE