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MICHIGAN

STATE HIGHWAY DEPARTMENT

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USE OF VINSOL RESIN CEMENT IN BRIDGE STRUCTURES

Research Project 44 B-17

Report 63

RESEARCH LABORATORY
TESTING AND RESEARCH DIVISION
November 24, 1944

USE OF VINSOL RESIN CEMENT IN BRIDGE STRUCTURES

A question has arisen in the Department concerning the use of Vinsol resin cement in bridge structures. Since it is anticipated that this question will eventually develop into a matter of Departmental policy, an attempt has been made in this report to present pertinent facts based on available information from reliable sources.

In general it may be stated that the evidence supports the use of an air-entrained concrete in structures provided proper precautions are taken in the design and control of the concrete mixture to insure satisfactory bond and compressive strengths. In this respect it is imperative that the air content shall be controlled within definite limits and that full advantage be taken of the possible reduction in water-cement ratio and sand-aggregate ratio made possible by the greater plasticity of air-entrained concrete.

The study includes such essential features as effect of Vinsol resin on bond, effect of Vinsol resin on strength, and control of air content.

Effect of Vinsol Resin on Bond

Tests conducted at the Central Concrete Laboratory of the U. S. Corps of Engineers (1)* and at the Research Laboratory of the Portland Cement Association (2) indicate that the bond between concrete and steel is not seriously affected by the entrainment of air up to the optimum amount found desirable in pavement construction to prevent scaling. This optimum has been found to correspond to a drop in unit weight of from 3 to 6 pounds per cubic foot from that of a standard cement concrete carrying the same aggregates. To prevent excessive decrease in strength this drop in weight

should in no case exceed 6 pounds and should preferably be maintained near the lower limit.

Buerpel (6), after further numerous tests at the Central Concrete Laboratory makes the following statement - "In cases where the mixture design is made to take proper advantage of reduction in water-cement ratio and sand-aggregate ratio in mixtures with Vinsol resin and the air content of the resulting mixture does not exceed a total of 5 per cent as determined by A.S.T.M. method C 138-44, the bond between concrete and steel can be expected to be not less than 90 percent of that obtained with a well-designed mixture not containing an air-entraining agent". It should be pointed out that a 5 percent total air content would represent a drop in weight of about 5 to 6 pounds per cubic foot since the volume of air in standard portland cement concrete usually amounts to around 1 or 2 percent. The actual test data indicated a bond resistance of Vinsol resin treated cement of from 90 to 113 percent of standard portland cements, and in most of the tests amounted to 100 percent.

Similar results were obtained by the Portland Cement Association. Cements conforming to A.S.T.M. Specification ES-C150 in Vinsol resin content produced concrete conforming to the desirable weight reduction of 3 to 6 pounds, and caused no appreciable loss of bond strength.

Effect of Vinsol Resin on Strength

Considerable experience in the use of Vinsol resin treated cements has demonstrated that the compressive and flexural strengths of the concrete are somewhat reduced by the incorporation of excess air in the mix over the amount normally present when a similar untreated cement is used. This reduction in strength may be kept at a minimum by proper design of the mix and by the exercise of rigid field control during construction. Tests by

this Laboratory (3), Bumeister (4) and others (5) (6) show that 28 day compressive strengths of 80 to 90 percent of those of comparable portland cement concretes may consistently be expected of Vinsol resin cement concretes, and in some cases may equal or exceed those of the untreated type. As a matter of fact, Vinsol resin concretes often exhibit no wider reduction in strength than the variations found in ordinary portland cement concrete during construction. Specimens of Vinsol resin concrete from the Michigan Test Road molded in standard 6 inch by 12 inch cylinders developed 28 day compressive strengths of 84 and 87 percent of standard portland cement concrete, the actual strength values being in excess of present specification requirements for grade A concrete.

According to Goldbeck (7) the reduction in flexural strength is less than that of compressive strength for air contents within the permissible working range, modulus of rupture values showing a decrease of 6 to 13 percent against a corresponding loss of 10 to 20 percent in compressive strength. In general, it may be said that the strength of the concrete is not appreciably impaired when the drop in unit weight does not exceed 3 percent, or about 4 to 5 pounds per cubic foot in a well designed mix.

Control of Air Content

The amount of air entrained in a concrete mix depends upon a number of factors, each of which must be controlled within fairly narrow limits to achieve optimum results. These factors may be grouped roughly under two headings; (a) laboratory design, and (b) field control.

Laboratory Design. Concrete mixtures in which air-entraining agents are employed should be designed individually for the particular brand of cement and types of aggregates to be used on the job. Both the strength

of the concrete and volume of air entrapped in the mix vary with different brands of cement having the same Vinsol resin content (3) (7), and proportioning will be affected accordingly. It will usually be necessary to reduce the ratio of sand to total aggregate and of water to cement from that required when using standard portland cement. In some cases it may be desirable to reduce the amount of total aggregate (4). When the cement content is increased, or the water decreased, larger amounts of air-entraining agents are required for a given drop in weight, since the volume of air included is greater with lean, wet mixes than with rich, dry ones. Practically, the air content is generally controlled by adjusting the amounts of sand and water in the mixture.

Field Control. One salient fact should always be borne in mind when working with concretes containing air-entraining agents - that it is the volume of air in the mix that determines the properties which we are trying to control, regardless of the means by which that air content is obtained. The amount of air taken into the concrete depends not only upon the particular characteristics of the cement and proportions of the mix, but also upon the time and vigor of mixing. In addition, there is always the matter of adjusting the amount of mixing water in the field to maintain the proper consistency while using aggregates of varying moisture content. In some cases it may be necessary to adjust the amount of sand in the mix to obtain the desired result under existing conditions of construction and equipment. In any event, field control of the air content is essential for the production of uniformly high grade concrete of this type. This may be done most conveniently and satisfactorily by regulating the drop in weight to conform to the specified limits of 3 to 6 pounds per cubic foot.

For the reasons just mentioned, transit mixed concrete presents difficulties in the control of air content and, therefore, would not be satisfactory for this type of work.

It has been found recently (10) that, due to the variation in alkali content among cements of different manufacture, more uniform and predictable results may be obtained by first neutralizing the Vinsol resin with sodium hydroxide to form the sodium soap before intergrinding with the clinker; and better still, by separating the air-entraining agent from the cement entirely and adding it at the mixer, providing the hazard of the personal equation in this kind of operation may be overcome.

Summary

Pertinent facts concerning the use of Vinsol resin cement in reinforced structures may be summarized as follows:

1. Strength of bond between concrete and steel is not materially affected by the addition of Vinsol resin to the cement, provided the mix is properly designed and the air content kept within limits corresponding to a drop in weight of 3 to 6 pounds per cubic foot.

2. Compressive and flexural strengths of concretes containing air-entraining agents may be made to closely approach or equal those obtainable without the use of such agents, with the same provisions stipulated in the previous item.

3. The concrete mix must be designed to take advantage of reduction in water-cement ratio and sand-aggregate ratio, in order to secure maximum strength.

4. Close control of unit weight must be exercised in the field to insure uniformly high strength and durability.

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