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USE OF BELT CONVEYORS TO TRANSPORT MASS CONCRETE

Kenneth L. Saucier

Army Engineer Waterways Experiment Station  
Vicksburg, Mississippi

September 1974

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# USE OF BELT CONVEYORS TO TRANSPORT MASS CONCRETE

by

Kenneth L. Saucier

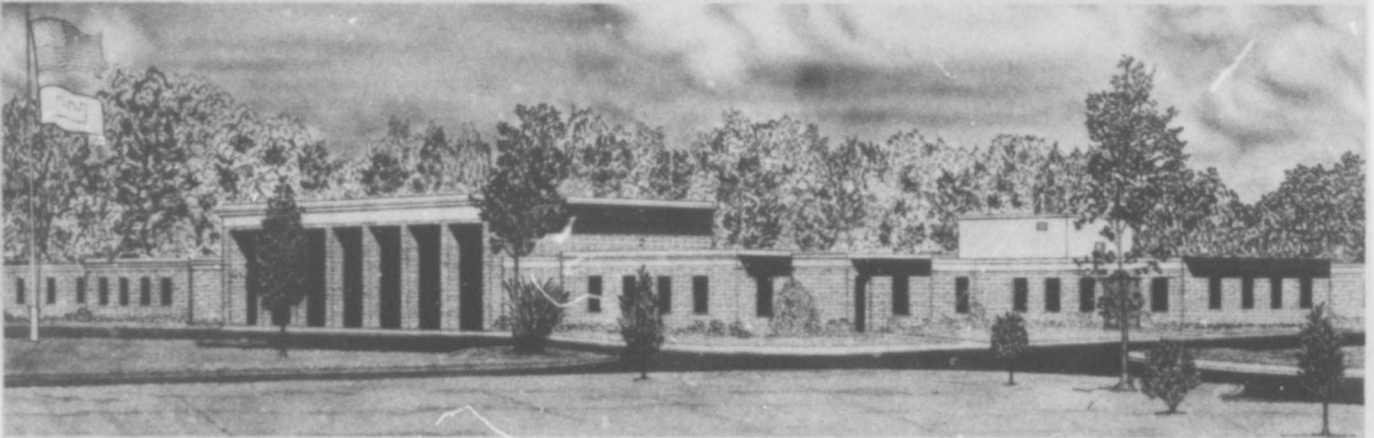
Concrete Laboratory

U. S. Army Engineer Waterways Experiment Station  
P. O. Box 631, Vicksburg, Miss. 39180

September 1974

Final Report

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A series of tests was conducted to determine the effects of using conveyor belts to transport concrete. Concrete mixtures containing aggregate up to 6 in. in nominal maximum size were mixed, placed on conveyors arranged in a triangular pattern, transported up to simulated distances of 6000 ft, and tested for changes in temperature, air content, and workability (slump). The results indicate: (a) no change in temperature of the concrete results due to conveying, per se; (b) less than 0.5 percent loss of air may be expected (Continued)		

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20. ABSTRACT (Continued)

from concrete containing approximately 5 percent air; (c) slump loss of approximately 1-1/2 in. may be expected when conveying for 1500 ft or less within 10-15 min; (d) comparative tests of idle concrete showed a 1-1/2-in. slump loss at 20-25 min; (e) indications are that slump loss is increased with (1) increased belt travel time and (2) for a given travel time, greater belt speed; and (f) when conveyor belts are kept full, no segregation due to conveying is apparent.

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## PREFACE

The study reported herein was conducted as part of Civil Works Investigation - Engineering Studies Item ES 617, and was authorized by first indorsement from the Office, Chief of Engineers, U. S. Army, dated 11 December 1972 to a U. S. Army Engineer Waterways Experiment Station (WES) letter dated 8 November 1972, subject: "Project Plan for Investigation of Belt Conveyors for Use in Transporting Mass Concrete."

The study was conducted at the Concrete Laboratory, WES, during the period September 1973 through December 1973. The research was conducted under the general supervision of Messrs. B. Mather, Chief of the Concrete Laboratory, J. M. Polatty, and W. O. Tynes, and under the direct supervision of Mr. K. L. Saucier, who prepared this report.

Director of WES during the conduct of this study and preparation and publication of this report was COL G. H. Hilt, CE. Technical Director was Mr. F. R. Brown.

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI)  
UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
inches	0.0254	metres
feet	0.3048	metres
square feet	0.09290304	square metres
cubic feet	0.02831685	cubic metres
cubic yards	0.7645549	cubic metres
pounds (mass)	0.4535924	kilograms
pounds (force)	4.448222	newtons
pounds (force) per square inch	0.00689476	megapascals
feet per minute	0.3048	metres per minute
miles per hour	1.609344	kilometres per hour
Fahrenheit degrees	5/9	Celsius degrees or Kelvins*

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\* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula:  $C = (5/9)(F - 32)$ . To obtain Kelvin (K) readings, use:  $K = (5/9)(F - 32) + 273.15$ .

# USE OF BELT CONVEYORS TO TRANSPORT MASS CONCRETE

## PART I: INTRODUCTION

### Background

1. The placement of concrete into forms by conveyors is permitted in both civil and military guide specifications; however, inclusion of the use of conveyors in the job specifications for civil projects is optional with the District preparing the specifications. CE 1401.01,\* July 1973, states:

Belt conveyors may be used when approved. Such conveyors shall be designed and operated to assure a uniform flow of concrete from mixer to final place of deposit without segregation of ingredients or loss of mortar and shall have a speed of travel in excess of 500 ft/min\*\* and be provided with positive means for preventing segregation of the concrete at the transfer points and the point of placing.

2. CE 204,† September 1970, states:

Chutes and conveyors: Chutes shall be of steel or steel-lined wood, rounded in cross section, rigid in construction, and protected from overflow. Conveyors shall be designed and operated, and chute sections shall be set, to assure a uniform flow of concrete from mixer to final place of deposit without segregation of ingredients, loss of mortar, or change in slump. The discharge portion of each chute or conveyor shall be provided with a device to prevent segregation. The chute and conveyor

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\* Office, Chief of Engineers, "Civil Works Construction Standard Guide Specification for Concrete," Guide Specification CE 1401.01, Jul 1973, Government Printing Office, Washington, D. C.

\*\* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 4.

† Office, Chief of Engineers, "Military Construction Standard Guide Specification for Concrete for Building Construction," Guide Specification CE 204, Sep 1970, Government Printing Office, Washington, D. C.

shall be thoroughly cleaned before and after each run. Waste material and flushing water shall be discharged outside the forms.

3. ACI Standard 301-72\* states:

Belt conveyors shall be horizontal or at a slope which will not cause excessive segregation or loss of ingredients. Concrete shall be protected against undue drying or rise in temperature. An approved arrangement shall be used at the discharge end to prevent apparent segregation. Mortar shall not be allowed to adhere to the return length of the belt. Long runs shall be discharged into a hopper or through a baffle.

The ACI Manual of Concrete Inspection\*\* states that:

- a. Conveying concrete must not result in nonuniform concrete at the forms.
- b. The method of conveying should not require a wetter consistency than required for placing nor should it induce segregation or result in excessive drying and stiffening.
- c. The direction of fall should always be vertical to prevent segregation--use pipe or trunk. Baffle plates alone may not be satisfactory.

4. With the increasing use of conveyor belts to transport concrete and the advent of larger and higher capacity belts, questions have arisen relative to the performance of belts for use with mass concrete. Among the questions were whether conveying concrete by belt results in temperature rise and air and slump loss. Segregation would appear to be of primary concern with large-aggregate concrete moving at slow speed. Faster conveying speeds (>500 ft/min), higher belt tension, improved wipers, and smaller pulleys (<6 in. in diameter) appear to be desirable.

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\* American Concrete Institute, "Specifications for Structural Concrete for Buildings," Manual of Concrete Practice, Part 2, 1973, Detroit, Mich., paragraph 8.2.2.2.

\*\* American Concrete Institute, ACI Manual of Concrete Inspection, 5th ed., Special Publication SP-2, 1967, Detroit, Mich.

### Objectives

5. The objectives of this study include:
- a. Determining if belts now available are adequate for transporting mass concrete.
  - b. Determining problem areas, such as charging and transferring concrete from belt to belt, and possible remedies and belt wipers.
  - c. Determining whether the use of belt conveyors results in temperature rise, slump loss, segregation, and air loss in freshly mixed concrete.

### Scope

6. Typical freshly mixed mass and structural concrete was placed on belts and transported simulated distances up to 6000 ft at different rates of speed and under different temperature conditions. The belts were stopped periodically, and tests were conducted to determine if the characteristics of the fresh concrete had been appreciably altered during movement. Slump, air content, and temperature tests were conducted. The final discharge was observed in order that the extent of segregation in the concrete could be determined.

## PART II: MATERIALS, MIXTURES, AND EQUIPMENT

### Materials

7. Type I portland cement (RC-670), natural fine aggregate (WES-1 S-4(51)), and a solution of neutralized vinsol resin (AEA-918) for entraining air, all from Mississippi, were used in this investigation. Physical and chemical properties of the cement are given in Table 1. Limestone coarse aggregate from Alabama (CRD G-40(3)) was used in four mixtures; natural coarse aggregate from Louisiana (NO-29 G-4(10)) was used in mixture 2. The physical properties and gradings of the aggregates are given in Tables 2-6. Fly ash from Alabama (AD-474) was used in mixtures 4 and 5.

### Mixtures

8. Five mixtures were used in the study as indicated below:

<u>Mix- ture</u>	<u>Nominal Maximum-Size Aggregate in. (mm)</u>	<u>Type of Coarse Aggregate</u>	<u>Fly Ash % by Volume</u>	<u>Table Giving Physical Properties and Gradations</u>
1	1-1/2 (38.1)	Limestone	0	2
2	1-1/2 (38.1)	Natural	0	3
3	3 (75)	Limestone	0	4
4	4-1/2 (113)	Limestone	35	5
5	6 (150)	Limestone	35	6

All mixtures were proportioned to have a slump of  $3 \pm 1/2$  in. and an air content of  $5-1/2 \pm 1$  percent. During the investigation, individual batches were varied by the addition of mixing water so that the slump determinations immediately after mixing ranged up to 6 in. The air content remained essentially within the desired range.

### Equipment

9. Belts of two different sizes were studied in this investigation.

Both types of belts were constructed of smooth, hard rubber. Type A belt, shown in Figure 1, was 50 ft long and 24 in. wide. One section of type A belt was obtained and used only with 6-in. maximum-size aggregate concrete (mixture 5). The belt was supported on a tubular steel frame and was driven by the head pulley, i.e., the discharge end pulley. Idlers, or support pulleys, were spaced at distances of from 1 to 3 ft along the belt length. The charging hopper (Figure 1) had a capacity of approximately  $1/2 \text{ yd}^3$  and a discharge opening of approximately  $1 \text{ ft}^2$ . Belt A was tightened by means of screw threads on the charging end shown in the lower right-hand corner of Figure 1.



Figure 1. Type A belt used for transporting six-in. maximum-size aggregate concrete to test block

10. Type B belt was 50 ft long and 18 in. wide. Three sections were obtained and arranged in a triangular pattern, as shown in Figure 2, to provide means for circulating the concrete to any simulated distance. The major part of the study was conducted using mixtures 1-4 on type B belts. The belts were supported by aluminum channel (Figure 3) and driven by a 15-hp electrical motor connected by chain to

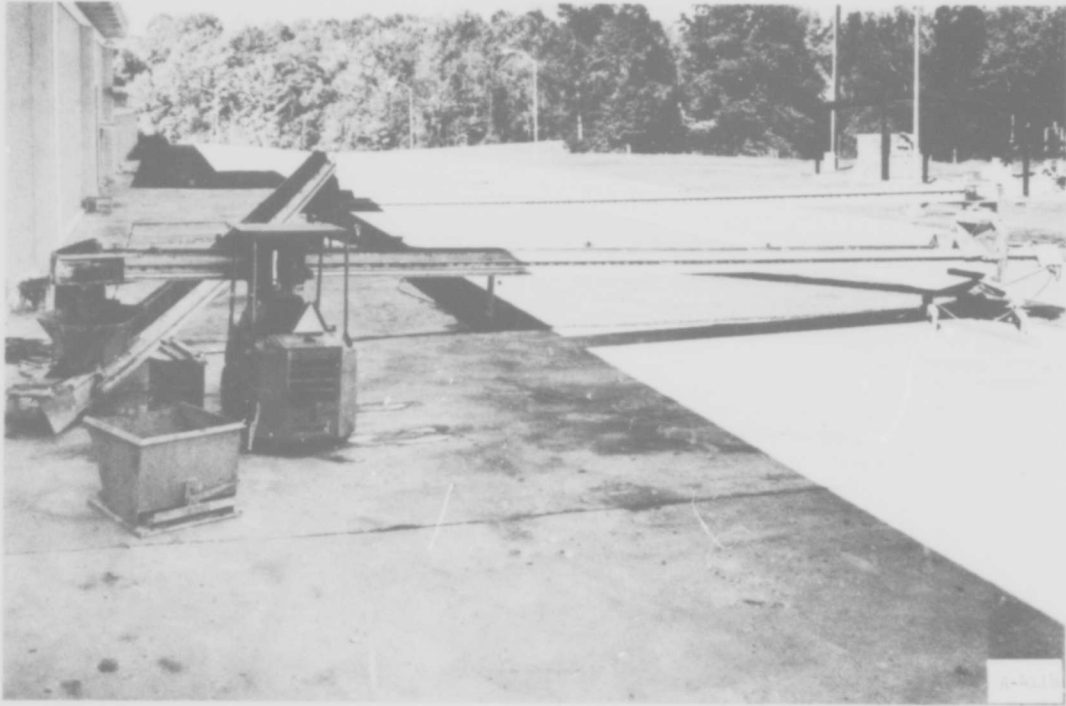


Figure 2. Triangular arrangement of type B belts

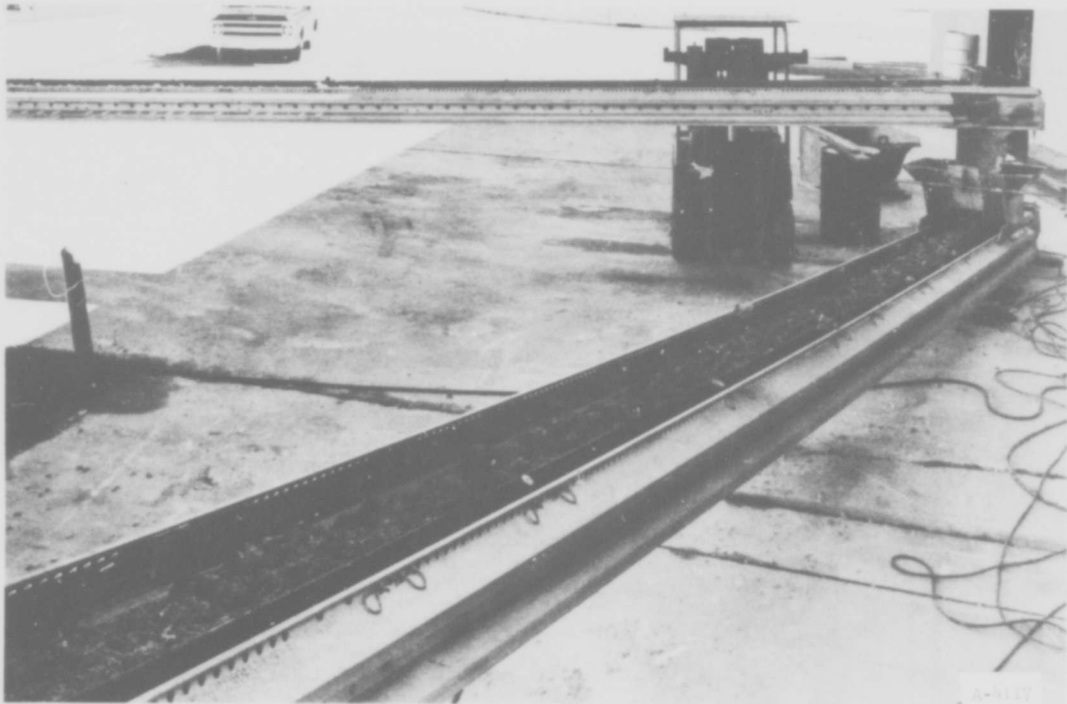


Figure 3. Type B belts loaded with concrete

the tail pulley at the charging end. The charging hopper (Figure 3) had a capacity of approximately  $1/2 \text{ yd}^3$  and a discharge opening of approximately  $1/2 \text{ ft}^2$ . Type B belts were tightened by means of demountable hydraulic jacks that could be moved from belt to belt to provide predetermined belt stress. Dimensions of type B belts and the charging hopper are given in Plate 1. The type A belt was used horizontally; the type B belts were used at a slope of 12:1.

#### Transfer Apparatus

11. Use of three type B belts provided an opportunity to study the apparatus used to transfer concrete from one belt to another. The apparatus, shown in Figure 4, consisted of a tubular frame, which supported the charging end of the outgoing belt at the lower level and the discharging end of the incoming belt at the upper level. Each belt could be rotated in both horizontal and vertical planes to provide complete freedom of movement. The upper gathering shroud was lined with hard rubber, and the discharge hopper was constructed of metal. The minimum inside dimension at the discharge point was 9 in. Rubber side curtains prevented concrete from spilling off the outgoing belt during transfer.



Figure 4. Transfer apparatus for type B belts

## PART III: TESTS

### Type A Belt

12. Type A belt was used to move 6-in. maximum-size aggregate concrete into a form located in a limited-access area as part of another investigation. Seven batches of 16 ft<sup>3</sup> of concrete each were loaded individually onto the belt and moved at a rate of 500 ft/min into the form. No definitive tests of type A belt were conducted. However, observations indicated that satisfactory conveyance was achieved. A baffle at the discharge end, shown in Figure 5, reduced segregation. The belt wipers apparently were functioning properly as very little mortar loss was experienced. Due to the use of only one belt, no transfer operations were observed.

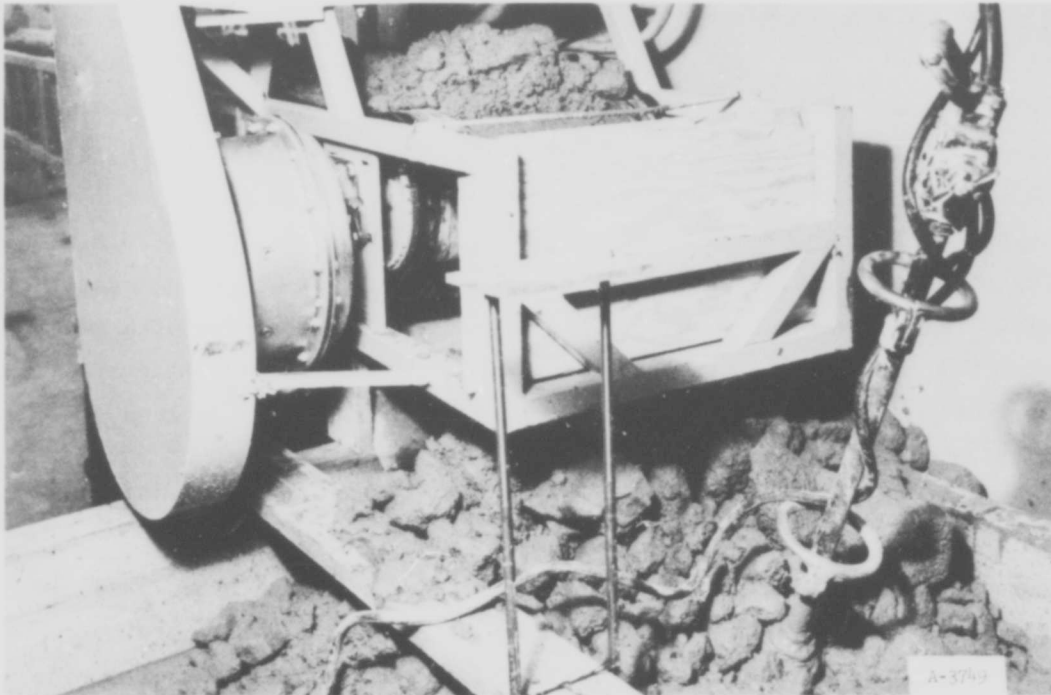


Figure 5. Six-in. maximum-size aggregate concrete at discharge end of conveyor prior to consolidation, type A belt

### Type B Belt

13. The quantitative portion of the investigation was conducted on the type B belts using four mixtures using up to 4-1/2-in. maximum-size aggregate. The usual procedure was to (a) mix a 16-ft<sup>3</sup> batch of concrete; (b) discharge a portion into a self-dumping hopper; (c) test for slump, air content, and temperature; (d) place the remainder of the batch on the conveyor belts and run a specified distance; and (e) stop, test, and run again. The procedure was continued, stopping at various intervals, until no slump occurred. The work, of necessity, was conducted outside. However, during the rest periods when plastic tests were being conducted, care was taken to stop the idle concrete in a shaded area (see Figure 2), thereby protecting it from direct sunlight.

14. Forty-three batches of concrete and one batch of grout were tested during the study of the type B belts. The tests were conducted during the late summer and fall months in order to secure a range of ambient temperatures. Test results for all batches are given in Table 7. The time was calculated from the instant that the water-cement contact was made in the mixer. The time required to complete the mixing, make the tests, and get the concrete on the belt was normally between 10 and 15 min. Subsequent tests were made at intervals of 10-20 min, depending on the time used for stoppages, sieving of large aggregate, etc. Temperature was measured in the concrete by insertion of a stem thermometer into the concrete. Ambient weather information was obtained from the National Weather Service office in Jackson, Mississippi.

15. Most of the tests were conducted at belt speeds of 480, 600, or 720 ft/min. Seven batches were tested at a speed of 240 ft/min. Due to the fact that it was not possible to distinguish between the effects of time and belt action on an individual sample of concrete, separate undisturbed samples were secured from many batches and allowed to remain idle while the belt tests were conducted. The "idle" sample was then tested, thereby providing a means of separating the effects on concrete of time and movement on belts--sampling error neglected. Some

difficulty was encountered with the first few batches: a loose belt on batch 1 resulted in the loss of concrete and termination of the test. Equipment malfunction on batches 2, 3, and 4 caused a delay in testing, but useable data were obtained.

16. Weather conditions during the study provided relatively severe drying conditions for most of the tests. High temperatures, low humidity, and wind all contributed to drying since the belts were not covered during the tests. For the purposes of this report, excellent drying conditions were considered obtained when two of the three following requirements were met, and good drying conditions were considered obtained when one of the three was met: temperature  $\geq 70^{\circ}\text{F}$ , relative humidity  $\leq 50$  percent, and wind velocity  $\geq 10$  mph. For several batches, the belts and transfer hoppers were dampened immediately prior to conveying to determine if wetting would significantly alter the results obtained with dry belts. In these tests, free water was not allowed to mix with the concrete; the belts were wetted to essentially saturated-surface-dry conditions.

17. Compressive strength tests at 7 days age were conducted on specimens cast from batches 15, 18, 23, and 36. Three specimens from each batch were cast using an internal vibrator for consolidation and tested at a specified conveyed distance. The results, given in Table 8, indicate a rather wide variation in strength between batches. However, the variation was not a consideration in this study. Actually, the water content was allowed to deviate at random, by not correcting for free moisture in the aggregate, in order to secure a wider range of consistency for each mixture studied.

## PART IV: RESULTS AND DISCUSSION

### Segregation

18. Quantitative tests to determine the extent of segregation imparted by the belts were not conducted. Rather, observations made during the charging, conveying, and discharging of the concrete provided information on the separation of the large aggregate. No serious segregation problems were observed on any of the mixtures during transfer between belts, including the limited amount of work with the 4-1/2-in. aggregate concrete. Early in the study, it was discovered that the large aggregate in mixtures 3 and 4 segregated during mixer discharge. When placed on the conveyor belts as discharged and conveyed for 500 ft or more, the large aggregate tended to separate even more behind the mass, especially if there was an empty section of belt immediately behind the last portion of the batch. Expectedly, this condition was compounded by the higher belt speeds (600 and 720 ft/min). When the last part of the batch as discharged was placed in the center of the conveyed mass, the problem was partially eliminated. When all three belts were kept full, no segregation due to conveying, per se, was observed. The discharge from the last conveyor into the form or bucket, of course, provided the greatest opportunity for the concrete to segregate. This problem was not within the scope of this investigation. The ACI has effectively documented\* the requirements necessary to prevent separation at the end of conveyor belts.

### Belt Size and Speed

19. For any particular job, the maximum size of aggregate used will dictate the belt size (width). Since the belt assumes an exaggerated "U" cross section during use, as shown in Plate 1, the effective

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\* ACI Manual of Concrete Inspection, SP-2, American Concrete Institute, 1967, Fifth Edition, Detroit, Michigan.

width is somewhat less than the specified width. The nominal 24-in.-wide belts (type A) proved satisfactory for conveying 6-in. maximum-size aggregate concrete (Figure 1). Unless the belt was overloaded at the charging hopper, no spillage was observed. The 18-in.-wide belts (type B) were satisfactory for conveying 3-in. maximum-size aggregate in the range of 0- to 6-in. slump. Although the manufacturer recommended type B belts for conveying 3-in. maximum-size aggregate concrete, the 18-in.-wide belts also proved satisfactory for conveying 4-1/2-in. maximum-size aggregate concrete in the range of 0- to 4-in. slump except through the transfer hoppers. Stoppages occurred within the hoppers with each tested batch (7, 11, and 38) of mixture 4. Apparently, the hoppers were too restrictive for the transfer of 4-1/2-in. aggregate concrete. The side curtains effectively prevented loss of material at the transfer points.

20. In addition to the effect of belt speed on aggregate distribution near the end of the conveyed batch (paragraph 18), one other effect of speed was noted. Apparently, there are two design approaches for concrete conveyors. Type A belts are designed using the assumption of closely spaced (3 ft) belt support idlers and lower belt speeds (250 to 500 ft/min), while type B belts are designed using the assumption of greater idler spacing (6 ft) and higher belt speeds (600 to 750 ft/min). At the slowest speed (240 ft/min), type B belts tended to sag on the idlers when fully loaded. Although not observed in this study, such sag might cause excessive belt wear and possible spillage of the large aggregate. Apparently, slow speeds require somewhat tighter belts and/or closer idler spacing.

#### Apparatus

21. The apparatus comprising the support system for the belts appeared adequate for both types of belts. Due to the use of belt B for most of the work, more can be said about that apparatus. Very early in the program (batch 1), it was discovered that loose belts would ride up on the side idlers and dump the concrete off the side. Thus,

sufficient belt tension is necessary for successful conveying. However, since the belts are spliced, excess tension could conceivably reduce belt life. In the past, belt wipers and fasteners have been the most troublesome aspects of the conveyor system. Belt A used a mechanically fastened splice and a resilient belt wiper. Belt B used a vulcanized belt splice and a hard carbide belt wiper. The wipers and fasteners provided with the two type belts tested herein appeared to be an improvement over the older models. With proper maintenance and cleaning of the wipers, little mortar loss was observed under the belts. Approximately 100-lb tension evenly distributed between the two wiper springs was required for effective scraping. However, the location of the wiper blades, under the belt and inside the transfer hopper, made cleaning difficult. Allowing wash water on the belt to strike the scrapers did not remove mortar next to the blades. This mortar then hardened and caused ineffective wiping on subsequent batches. For good cleaning, it was necessary to brush the mortar away from the leading wiper edge manually; but time spent on such effort prevented poor wiper action on later tests.

#### Temperature

22. Temperature determinations made in the concrete on the belts during stops for slump and air content tests did not indicate that conveying necessarily either increased or decreased the temperature. Results of temperature determinations of all batches that experienced no problems during transport are plotted with ambient temperatures in Plate 2. With very few exceptions, the concrete temperature tends to move toward the ambient temperature over the time period required for testing the batch. If the concrete temperature is initially higher than the ambient temperature, it tends to decrease during transport; if the concrete temperature is initially lower than the ambient temperature, it tends to increase (Plate 2). Furthermore, the rate of increase or decrease is dependent on the initial difference in temperature, i.e., a large initial difference causes a more rapid movement of concrete

temperature toward ambient temperature (note especially batches 20, 30, 32, 33, and 37). If the initial temperature difference is small, as in batches 6, 12, 17, 29, and 31, little change in concrete temperature will occur.

#### Air Content

23. Air content data for 31 batches that experienced no stoppage problems and on which tests of idle concrete were conducted are given in Table 9. For the conveyed concrete, the maximum and average air content losses are tabulated for the individual batches. Normally, only one test per batch of idle concrete was conducted, as shown in column 5. The data indicate that on the average the conveyed concrete lost a maximum of about 1 percent air and averaged approximately 0.75 percent loss. However, the idle concrete averaged a loss of about 0.5 percent. Significantly, the batches that lost the most air, batches 8, 17, 23, 34, and 36, had the highest initial air contents: 7.0, 7.5, 8.5, 7.5, and 7.2 percent, respectively. Therefore, loss of air is apparently greater for concretes containing relatively high amounts of air, i.e., >7 percent.

24. In order to isolate and compare the effects of belt speed and travel times, data for all batches on which a test of idle concrete was conducted were plotted as shown for batch 26 in Plate 3a. Using this information, a plot of air loss versus duration of belt travel was developed. The results, given in Plate 4, are inconclusive. Some air loss was sustained in most instances; however, definitive relationships between belt speed and travel time and air loss are not evident.

#### Workability

25. Probably the most important area to be studied is the effect of belt transport on workability. In this study, the slump test was used to determine the workability of the concrete tested. Some degree of change in workability can logically be expected during movement of

concrete on any type of equipment, i.e., bucket, pump, truck, etc. In order to determine the effects of conveyor belt movement and the resulting agitation on concrete, slump tests were conducted after each conveyor test on fresh portions of the concrete ribbon. Therefore, some sampling error was introduced. The slump data are given in Table 7 and Plate 5a. Companion tests of concrete allowed to remain idle were also conducted on many batches, and the results are given in Plate 5b. Although there is considerable scatter in both data sets, the relationship between slump loss and time appears to be linear. Time is closely related to conveyed distance in Plate 5a, since more time is required to convey greater distances especially when intermediate stops are made. The results indicate that approximately twice as much slump loss occurred in the conveyed concrete as in the idle concrete at an extended length of time, e.g., 4 in. versus 2 in. at 50-min age.

26. Again, to isolate the effects of belt speed and travel time, data for all batches on which a test of idle concrete was conducted were plotted as shown for batch 26 in Plate 3b. A plot of slump loss versus duration of belt travel was thus developed (Plate 6). Although there is considerable scatter in the data, indications are that slump loss is increased (a) with increased travel time and (b) for a given travel time, greater belt speed. Since zero time in Plate 6 actually corresponds to about 10 min of actual time with no belt transport, a slump loss of approximately  $3/4$  in. is indicated prior to any belt movement.

27. To differentiate between the effects of time and conveyed distance, results of those tests that could logically be compared, i.e., the first test only of batches that experienced no trouble and on which the first test was conducted within a time span of 10 to 20 min, are presented in Table 10. Unfortunately, much more data are available for the lower conveyed distances. However, the results indicate little difference in slump loss between conveyed distances up to 1500 ft, the average loss being approximately 1-1/2 in. At the greater distances ( $\geq 3000$  ft), slump loss was more pronounced (2 in. or more) although the

time required to complete the tests averaged only 5 min more than that required to complete the shorter conveying tests.

28. No data were available from idle tests below 20 min; therefore, only test results for 20 and 25 min are presented in Table 10. It can be seen that the idle concrete experienced an average slump loss of almost 1-1/2 in. It follows then that the increased agitation of movement on the conveyor belts produced sufficient additional drying to cause slump loss of approximately 1-1/2 in. in 10-15 min rather than in 20-25 min as with idle concrete. On a linear basis, the 10-min time difference might be equated to about 1/2-in. slump loss. Therefore, for relatively short conveying operations, i.e.,  $\leq 1500$  ft accomplished within 10-15 min from time of mixing, slump loss would not appear to be significant.

#### Strength Tests

29. In order to determine the effects of slump loss on strength, 6- by 12-in. cylinders were cast from four batches of mixture 1 and tested for compressive strength at a nominal 7 days age. The results, given in Table 8, indicate a definite increase in strength with a decrease in slump, and, to a lesser degree, in air content. The loss in workability would, therefore, appear to be predominantly the result of drying of the concrete during transport, thereby decreasing the effective water-cement ratio and increasing the indicated strength. The argument might then be advanced that, if the amount of slump loss could be established for a given set of conditions and maintained relatively consistent from batch to batch, the slump could be controlled at the discharge end of the conveyor and loss of slump would become irrelevant. However, closer study of the problem would appear desirable before full acceptance of such a premise. Determinations of (a) successful achievement of a consistent, batch-to-batch slump loss figure for field control purposes and (b) the extent and effects of hydration should be made prior to appreciable relaxation of slump maintenance requirements for belt transport of concrete.

## PART V: CONCLUSIONS

30. Based on the results of this investigation, the following conclusions appear justified:

- a. When conveyor belts are kept full of concrete, no segregation due to conveying, per se, is apparent.
- b. Eighteen-in.-wide belts are satisfactory for conveying 3-in. maximum-size aggregate concrete. Twenty-four-in.-wide belts are needed for transporting 6-in. maximum-size aggregate concrete.
- c. Belt speeds in the range of 250-700 ft/min are satisfactory for moving concrete. At the slower speeds, there is a tendency for belts to sag somewhat between idlers spaced 5-6 ft apart.
- d. Maintenance of proper tension in the belts is required to prevent spillage of concrete. Belt scrapers are available that will satisfactorily clean the fresh mortar from the returning belt. Thorough cleaning after each placing operation is recommended.
- e. Apparently, belt conveyance per se has no effect on temperature of concrete. Rather, the concrete tends to approach ambient temperature whether ambient temperature is higher or lower than initial concrete temperature.
- f. Little air loss (<0.5 percent) is attributable to conveying concrete containing approximately 5 percent air. Loss of approximately 1 percent air may result in concrete with an initial air content above 7 percent.
- g. Change in workability, as measured by slump loss, amounts to approximately 1-1/2 in. in 10-15 min at conveyed distances of 1500 ft or less. Comparative tests of idle concrete showed a 1-1/2-in. slump loss at 20-25 min. Indications are that slump loss is increased with (1) increased belt travel time and (2) for a given travel time, greater belt speed.
- h. Strength tests indicate that proportionally higher compressive strength is obtained with conveyed concrete that has sustained slump loss, due apparently to the effect of lower water-cement ratio. The extent and effect of hydration of the cement should be determined prior to any attempts to control concrete consistency at the discharge end of the conveyor belt.

Table 1

Chemical and Physical Properties of  
Portland Cement, RC-670

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Chemical Properties

SiO <sub>2</sub> , %	20.6
Al <sub>2</sub> O <sub>3</sub> , %	5.1
Fe <sub>2</sub> O <sub>3</sub> , %	4.1
CaO, %	64.6
MgO, %	1.7
SO <sub>3</sub> , %	2.3
Ignition loss, %	1.1
Insoluble residue, %	0.1
Na <sub>2</sub> O, %	0.12
K <sub>2</sub> O, %	0.22
Total alkali, as Na <sub>2</sub> O, %	0.26
C <sub>3</sub> A, %	6.6

Physical Properties

Fineness, air permeability, cm <sup>2</sup> /g	3680
Compressive strength, psi	
3 days age	3180
7 days age	4420

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Table 2

Mixture Proportions and Aggregate Data for Mixture 1

Material	Mixture Data	
	Solid Volume ft <sup>3</sup> (m <sup>3</sup> )	Weight, Saturated- Surface-Dry lb/yd <sup>3</sup> (kg/m <sup>3</sup> )
Portland cement	1.857 (0.053)	365.0 (216.6)
Fine aggregate	7.663 (0.217)	1262.4 (749.0)
Coarse aggregate	12.503 (0.354)	2118.6 (1257.0)
Water	3.627 (0.103)	226.3 (134.3)
Air	1.350 (0.038)	-- --
Total	27.000 (0.765)	3972.3 (2356.9)

Physical Properties of Fine and Coarse Aggregates  
and Gradings of Coarse Aggregates

Test	Fine	Size Range		Combined Coarse Aggregate*
		No. 4 to 3/4 in. (4.75 to 19.0 mm)	3/4 to 1-1/2 in. (19.0 to 38.1 mm)	

Physical Properties

Bulk specific gravity, saturated-surface-dry	2.64	2.72	2.71
Absorption, %	0.2	0.5	0.5

Cumulative Percent Passing

Sieve	No. 4 to 3/4 in. (4.75 to 19.0 mm)	3/4 to 1-1/2 in. (19.0 to 38.1 mm)	Combined Coarse Aggregate*
2 in. (50 mm)		100	100
1-1/2 in. (38.1 mm)		98	99
1 in. (25.0 mm)	100	30	69
3/4 in. (19.0 mm)	97	1	54
1/2 in. (12.5 mm)	67		38
3/8 in. (9.5 mm)	35		20
No. 4 (4.75 mm)	5		3

\* The two size ranges of coarse aggregates were combined in the following proportions: 56%, 3/4 to 1-1/2 in.; and 44%, No. 4 to 3/4 in.

Table 3

Mixture Proportions and Aggregate Data for Mixture 2

<u>Mixture Data</u>		
<u>Material</u>	<u>Solid Volume</u> <u>ft<sup>3</sup> (m<sup>3</sup>)</u>	<u>Weight, Saturated-</u> <u>Surface-Dry</u> <u>lb/yd<sup>3</sup> (kg/m<sup>3</sup>)</u>
Portland cement	1.772 (0.050)	347.8 (206.3)
Fine aggregate	7.898 (0.224)	1294.1 (767.8)
Coarse aggregate	12.352 (0.350)	1946.9 (1155.1)
Water	3.628 (0.103)	225.0 (133.5)
Air	1.350 (0.038)	-- --
Total	27.000 (0.765)	3813.8 (2262.7)

Physical Properties of Fine and Coarse Aggregates  
and Gradings of Coarse Aggregate

<u>Test</u>	<u>Fine</u>	<u>Size Range</u> <u>No. 4 to 1-1/2 in.</u> <u>(4.75 to 38.1 mm)</u>
	<u>Physical Properties</u>	
Bulk specific gravity, saturated-surface-dry	2.64	2.55
Absorption, %	0.2	2.4

Cumulative Percent Passing

<u>Sieve</u>	
2 in. (50.0 mm)	
1-1/2 in. (38.1 mm)	100
1 in. (25.0 mm)	98
3/4 in. (19.0 mm)	90
1/2 in. (12.5 mm)	64
3/8 in. (9.5 mm)	42
No. 4 (4.75 mm)	10

Table 4

Mixture Proportions and Aggregate Data for Mixture 3

Material	Mixture Data	
	Solid Volume ft <sup>3</sup> (m <sup>3</sup> )	Weight, Saturated- Surface-Dry lb/yd <sup>3</sup> (kg/m <sup>3</sup> )
Portland cement	1.674 (0.047)	329.0 (195.2)
Fine aggregate	6.480 (0.184)	1067.5 (633.3)
Coarse aggregate	14.422 (0.408)	2438.4 (1446.7)
Water	3.269 (0.093)	204.0 (121.0)
Air	1.155 (0.033)	-- --
Total	27.000 (0.765)	4038.9 (2396.2)

Physical Properties of Fine and Coarse Aggregates  
and Gradings of Coarse Aggregates

Test	Fine	Size Range			Combined Coarse Aggregate*
		No. 4 to 3/4 in. (4.75 to 19.0 mm)	3/4 to 1-1/2 in. (19.0 to 38.1 mm)	1-1/2 to 3 in. (38.1 to 75.0 mm)	
<u>Physical Properties</u>					
Bulk specific gravity, saturated- surface-dry	2.64	2.72	2.71	2.70	
Absorption, %	0.2	0.5	0.5	0.3	
<u>Cumulative Percent Passing</u>					
<u>Sieve</u>					
4 in. (100.0 mm)				100	100
3 in. (75.0 mm)				93	97
2 in. (50.0 mm)			100	47	81
1-1/2 in. (38.1 mm)			98	14	68
1 in. (25.0 mm)		100	30	3	43
3/4 in. (19.0 mm)		97	1	2	32
1/2 in. (12.5 mm)		67			21
3/8 in. (9.5 mm)		35			11
No. 4 (4.75 mm)		5			2

\* The three size ranges of coarse aggregates were combined in the following proportions: 36%, 1-1/2 to 3 in.; 32%, 3/4 to 1-1/2 in.; 32%, No. 4 to 3/4 in.

Table 5  
Mixture Proportions and Aggregate Data for Mixture 4

Mixture Data		Weight, Saturated-Surface-Dry
Material	Solid Volume ft <sup>3</sup> (m <sup>3</sup> )	lb/yd <sup>3</sup> (kg/m <sup>3</sup> )
Portland cement	0.933 (0.026)	183.4 (108.8)
Fly ash	0.502 (0.014)	68.3 (40.5)
Fine aggregate	5.930 (0.168)	976.9 (579.6)
Coarse aggregate	16.033 (0.454)	2718.7 (1613.0)
Water	2.622 (0.074)	163.6 (77.1)
Air	0.980 (0.028)	--
Total	27.000 (0.764)	4110.9 (2439.0)

Physical Properties of Fine and Coarse Aggregates and Gradings of Coarse Aggregates

Test	Size Range		Combined Coarse Aggregate*
	Fine	Coarse	
Bulk specific gravity, saturated-surface-dry	2.64	2.74	2.74
	0.2	0.3	0.3
Absorption, %	2.72	2.70	2.70
	0.5	0.3	0.3
Sieve	Cumulative Percent Passing		
	No. 4 to 3/4 in. (4.75 to 19.0 mm)	3/4 to 1-1/2 in. (19.0 to 38.1 mm)	1-1/2 to 3 in. (38.1 to 75.0 mm)
5 in. (125.0 mm)	100	100	100
4-1/2 in. (112.5 mm)	97	97	97
4 in. (100.0 mm)	67	93	94
3 in. (75.0 mm)	35	47	81
2 in. (50.0 mm)	5	14	64
1-1/2 in. (38.1 mm)	1	3	53
1 in. (25.0 mm)	0	2	33
3/4 in. (19.0 mm)	0	1	24
1/2 in. (12.5 mm)	0	0	16
3/8 in. (9.5 mm)	0	0	8
No. 4 (4.75 mm)	0	0	0

\* The four size ranges of coarse aggregates were combined in the following proportions: 25%, 3 to 4-1/2 in.; 25%, 1-1/2 to 3 in.; 26%, 3/4 to 1-1/2 in.; 24%, No. 4 to 3/4 in.

Table 6  
Mixture Proportions and Aggregate Data for Mixture 5

Material		Mixture Data		Weight, Saturated-Surface-Dry	
		Solid Volume		lb/yd <sup>3</sup>	(kg/m <sup>3</sup> )
Portland cement		0.933 (0.026)		183.0	(108.6)
Fly ash		0.502 (0.014)		78.0	(46.3)
Fine aggregate		4.904 (0.139)		814.0	(482.9)
Coarse aggregate		17.389 (0.492)		2932.0	(1739.6)
Water		2.435 (0.069)		162.0	(96.1)
Air		0.837 (0.024)		--	--
		Total 27.000 (0.764)		4169.0	(2473.5)

Test	Fine	Physical Properties of Fine and Coarse Aggregates and Gradings of Coarse Aggregates		Combined Coarse Aggregate*
		Size Range	Size Range	
		No. 4 to 3/4 in. (4.75 to 19.0 mm)	3/4 to 1-1/2 in. (19.0 to 38.1 mm)	3 to 6 in. (75.0 to 152.5 mm)
Bulk specific gravity, saturated-surface-dry	2.64	2.72	2.71	2.69
Absorption, %	0.2	0.5	0.5	0.3
<u>Cumulative Percent Passing</u>				
Sieve		100	100	100
6 in. (150.0 mm)		97	98	87
5 in. (125.0 mm)		67	30	65
4 in. (100.0 mm)		35	1	35
3 in. (75.0 mm)				8
2 in. (50.0 mm)				2
1-1/2 in. (38.1 mm)				
1 in. (25.0 mm)				
3/4 in. (19.0 mm)				
1/2 in. (12.5 mm)				
3/8 in. (9.5 mm)				
No. 4 (4.75 mm)				

\* The four size ranges of coarse aggregates were combined in the following proportions: 40%, 3 to 6 in.; 18%, 1-1/2 to 3 in.; 20%, 3/4 to 1-1/2 in.; 22%, No. 4 to 3/4 in.

Table 7  
Test Results for All Batches

Batch No.	Belt Speed ft/min	Time After Mixing min	Conveyed Distance ft	Slump in.	Percent Air	Temperature, °F		Relative Humidity Percent	Drying Condition	Remarks
						Concrete	Ambient			
<u>Mixture 1</u>										
1	480	0							Excellent	Belt too loose; lost considerable concrete off sides
		10	0	3-1/2	7.0	71	79	53		
		25	300	3	6.0	73	80	51		
		90	Idle	1-3/4	6.0	74	83	49		
2	480	0						Excellent	Wipers not working properly	
		10	0	2-3/4	6.5	71	85			49
		25	3000	1	6.0	78	85			49
3	480	0						Good	Two stoppages due to electrical malfunction	
		10	0	2	4.5	73	79			65
		30	Idle	1/2	3.5	80	80			60
		55	1500	0	3.0	80	81			58
4	480	0						Excellent	Three stoppages due to equipment malfunction	
		10	0	3-1/2	5.9	73	85			50
		45	Idle	2	--	--	86			49
		75	1500	3/4	3.8	82	87			48
10	480	0						Good	Prewet belts and transfer hoppers	
		10	0	3-3/4	5.8	75	85			70
		20	150	1-3/4	5.2	78	86			69
		30	1500	1-1/4	4.7	81	87			65
		40	3000	1	4.7	82	87			63
12	480	0						Good	Prewet belts and hoppers	
		10	0	3-3/4	5.0	90	83			60
		20	450	1-3/4	4.0	90	84			58
		30	Idle	2-1/4	4.4	88	84			58
		40	1500	1/2	3.6	89	84			58
		50	Idle	1	4.2	82	85			56
15	480	0						Good	Prewet belts and hoppers	
		10	0	4-1/4	6.2	89	82			66
		20	1500	2-1/4	6.0	87	83			63
		30	3000	1-1/4	5.7	87	84			60
		90	Idle	1/2	5.5	82	85			53
17	600	0						Excellent	Wind velocity was 12 mph	
		10	0	3-3/4	7.5	92	85			54
		20	1500	2	6.4	89	85			54
		30	Idle	2-1/2	7.0	90	85			54
		40	3000	1/2	5.8	89	85			54
		50	Idle	1-1/2	6.3	89	85			54
18	600	0						Excellent	Wind velocity was 18 mph	
		10	0	3-1/2	6.4	92	81			64
		30	3000	1-1/2	5.8	86	81			64
		45	6000	0	5.2	85	82			63
		55	Idle	1	5.6	89	82			63
20	600	0						Excellent	Wind velocity was 11 mph	
		10	0	2-1/2	6.6	73	54			38
		25	1500	1-1/2	5.2	68	55			38
		40	3000	1	5.0	66	56			38
		50	Idle	2	5.8	65	57			38
23	600	0						Excellent		
		10	0	4-1/2	8.5	66	73			33
		25	450	2-1/2	6.6	67	74			33
		35	3000	1-1/2	6.5	70	74			33
		50	6000	0	5.9	71	75			32
		55	Idle	2-1/2	7.5	65	75			32
27	600	0						Excellent	Wind velocity was 10 mph	
		10	0	3-1/2	6.7	69	59			46
		25	450	1-1/2	5.5	65	59			46
		40	1500	1	6.0	63	60			46
		55	3000	0	5.4	60	60			46
		65	Idle	2-1/4	6.5	60	60			46
34	240	0						Good	Wind velocity was 14 mph	
		10	0	3-1/2	7.5	66	49			61
		20	450	1-1/2	5.7	63	49			60
		30	1500	1	5.5	56	50			59
		40	3000	3/4	5.5	53	50			58
		45	Idle	2	7.2	61	50			56

(Continued)

(Sheet 1 of 4)

Table 7 (Continued)

Batch No.	Belt Speed ft/min	Time After Mixing min	Conveyed Distance ft	Slump in.	Percent Air	Temperature, °F		Relative Humidity Percent	Drying Condition	Remarks
						Concrete	Ambient			
<u>Mixture 1 (Continued)</u>										
36	240	0								
		10	0	3	7.2	66	56	42	Excellent	Wind velocity was 11 mph; prewet belts and hoppers
		20	450	2	5.7	63	56	42		
		30	1500	1-1/2	5.7	59	56	42		
		40	3000	1	5.4	57	56	42		
50	Idle	1-3/4	6.2	58	56	42				
42	720	0								
		10	0	4-1/2	5.8	64	44	47	Excellent	Wind velocity was 13 mph; prewet belts and hoppers
		25	3000	2-1/2	5.3	55	44	47		
		35	6000	1/4	5.2	51	45	46		
		40	Idle	2-1/2	5.4	57	45	46		
<u>Mixture 2</u>										
39	240	0								
		10	0	3	5.5	67	57	35	Good	Prewet belts and hoppers
		20	450	1-1/2	5.0	63	58	30		
		30	1500	0	4.2	61	58	30		
		35	Idle	1	5.0	64	58	30		
43	720	0								
		10	0	4-1/2	5.9	64	45	46	Excellent	Wind velocity was 12 mph
		20	450	2-1/4	4.3	56	45	46		
		30	1500	1-1/4	4.3	55	45	46		
		40	3000	1/2	4.3	51	46	45		
		50	6000	1/4	4.7	48	46	45		
		60	Idle	2	5.2	52	46	45		
<u>Mixture 3</u>										
5	480	0								
		10	0	3	5.0	73	82	67	Good	Segregated sample Segregated sample
		25	1500	1-3/4	4.7	76	83	65		
		40	3000	1-1/4	5.5	80	84	63		
		60	6000	3/4	5.4	82	85	61		
		90	6000+	0	4.4	81	86	59		
6	480	0								
		10	0	3-1/4	5.6	86	87	56	Good	
		30	3000	1-3/4	6.0	87	87	56		
40	Idle	1-3/4	5.6	86	87	56				
8	480	0								
		10	0	3-3/4	7.0	90	81	77	Good	
		30	1500	2	6.3	90	81	77		
		35	Idle	2	6.0	86	81	77		
		50	3000	1/4	5.2	86	82	75		
9	480	0								
		10	0	3-3/4	6.5	90	78	88	Good	
		20	150	2-1/2	5.7	87	78	88		
		30	1500	1-1/2	6.0	87	79	85		
45	3000	1/4	5.2	85	79	85				
13	480	0								
		10	0	6	5.3	90	82	69	Good	
		20	450	5	5.3	89	82	68		
		30	1500	2-1/2	5.3	89	83	66		
		45	Idle	3-1/4	4.8	84	84	65		
		55	6000	1	6.0	85	84	63		
14	480	0								
		10	0	2-3/4	5.4	73	75	83	Good	
		20	150	1-1/2	4.7	74	76	81		
		30	450	1/2	4.4	74	78	79		
		45	1500	1/4	5.0	75	79	77		
16	600	0								
		10	0	3	6.0	89	81	71	Excellent	Wind velocity was 14 mph
		25	1500	1	5.7	87	81	71		
		30	Idle	1-3/4	5.7	87	82	68		
		35	3000	0	4.3	82	82	68		
19	600	0								
		10	0	2-1/2	4.8	89	83	60	Excellent	Wind velocity was 18 mph
		20	1500	1/2	4.5	86	83	60		
		30	3000	0	4.3	85	83	60		
40	Idle	1	4.2	84	83	60				

(Continued)

(Sheet 2 of 4)

Table 7 (Continued)

Batch No.	Belt Speed ft/min	Time After Mixing min	Conveyed Distance ft	Slump in.	Percent Air	Temperature, °F		Relative Humidity Percent	Drying Condition	Remarks
						Concrete	Ambient			
Mixture 3 (Continued)										
21	600	0								
		10	0	4	5.0	73	71	37	Excellent	Wind velocity was 10 mph
		20	1500	3	4.9	70	71	37		
		35	3000	1-1/4	4.8	68	71	37		
		50	4500	0	4.5	68	70	37		
		60	Idle	2-1/2	5.0	66	70	37		
22	600	0								
		15	0	3-1/2	5.5	70	62	52	Good	
		40	1500	1-1/4	5.2	65	63	49		
		60	3000	0	4.9	66	64	46		
		75	Idle	1-3/4	5.0	65	65	43		
24	600	0								
		10	0	3	5.5	72	67	78	Fair	
		20	450	1-1/2	5.2	72	68	75		
		30	1500	1-1/4	5.5	72	69	72		
		45	3000	0	4.2	72	70	69		
		55	Idle	1-1/2	5.0	72	71	66		
25	600	0								
		10	0	3-3/4	5.8	74	78	48	Excellent	
		25	450	2-1/2	6.0	74	78	47		
		35	1500	2-1/2	6.5	75	79	46		
		50	3000	1-1/2	6.4	75	79	45		
		65	4500	1/4	5.7	75	80	44		
		70	Idle	2-1/4	6.4	70	80	43		
26	600	0								
		10	0	3-1/2	7.0	70	49	68	Good	Wind velocity was 10 mph
		20	450	2	6.5	66	49	68		
		30	1500	1-1/2	6.0	63	50	64		
		45	3000	0	5.5	60	50	64		
		50	Idle	2-1/2	6.3	61	51	60		
28	600	0								
		10	0	3	5.6	73	61	58	Good	Wind velocity was 11 mph
		20	450	2	5.6	68	62	58		
		30	1500	1-1/2	5.4	68	63	58		
		45	3000	1/4	4.8	67	63	56		
		50	Idle	2	5.5	68	64	55		
29	600	0								
		10	0	3-1/2	5.4	71	70	43	Excellent	Wind velocity was 12 mph
		25	450	2	5.4	70	71	42		
		35	1500	1-1/2	5.4	70	71	40		
		45	3000	1	5.2	69	72	38		
		55	Idle	2-1/2	5.4	67	72	37		
30	600	0								
		15	0	3-1/2	5.3	90	58	41	Good	
		25	3000	1-1/2	5.2	73	59	40		
		35	6000	0	4.8	68	60	38		
		45	Idle	2	5.4	83	61	35		
31	600	0								
		10	0	3-1/2	6.2	69	67	29	Good	
		20	150	2	5.4	67	67	28		
		25	3000	0	5.4	67	67	27		
		35	Idle	2	5.4	68	67	26		
32	600	0								
		10	0	3	6.2	89	68	25	Good	
		25	6000	0	6.5	72	69	25		
		30	Idle	2	5.7	81	69	25		
33	240	0								
		10	0	4	6.5	69	45	68	Good	Wind velocity was 14 mph
		20	450	1-3/4	5.3	63	45	67		
		30	1500	1-1/4	6.0	57	46	66		
		45	3000	0	6.0	53	47	65		
		50	Idle	3	6.5	59	47	64		
35	240	0								
		10	0	3	6.6	66	54	48	Excellent	Wind velocity was 10 mph; prewet belts and hoppers
		20	450	2-1/2	6.6	61	54	46		
		30	1500	1	5.7	60	55	45		
		40	3000	1/2	6.6	56	55	44		
		45	Idle	1-1/2	6.6	59	55	43		

(Continued)

(Sheet 3 of 4)

Table 7 (Concluded)

Batch No.	Belt Speed ft/min	Time After Mixing min	Conveyed Distance ft	Slump in.	Percent Air	Temperature, °F		Relative Humidity Percent	Drying Condition	Remarks
						Concrete	Ambient			
<u>Mixture 3 (Continued)</u>										
37	240	0								
		10	0	3-1/4	5.3	68	46	74	Fair	Prewet belts and hoppers
		20	150	2	5.5	65	47	70		
		30	1500	1	5.8	58	48	65		
		40	3000	0	5.3	54	46	60		
45	Idle	2	5.8	62	49	55				
40	720	0								
		10	0	2-3/4	5.8	67	37	73	Fair	Prewet belts and hoppers
		25	3000	0	5.0	52	37	70		
35	Idle	1-3/4	5.4	62	38	66				
41	720	0								
		10	0	5	5.9	64	40	60	Fair	Prewet belts and hoppers
		25	3000	2	5.8	53	40	57		
		35	6000	1/4	5.6	49	40	54		
45	Idle	4	5.7	55	41	52				
<u>Mixture 4</u>										
7	480	0								
		10	0	3-1/2	7.0	74	82	69	Good	Stopped three times due to blockage in transfer hopper
40	1500	1-3/4	6.4	79	84	61				
11	480	0								
		15	0	3-1/4	4.5	75	74	91	Good	Five stops due to hopper blockage
30	1500	1/4	4.3	77	75	85				
38	240	0								
		10	0	3	2.7	67	52	40	Good	Prewet belts and hoppers; three stops due to hopper blockage
		30	450	1/2	2.2	59	52	38		
		45	1500	0	1.8	54	53	37		
50	Idle	1-3/4	2.6	54	53	37				
<u>Grout</u>										
44	600	0								
		10	0	6	--	73	66	37	Good	
		20	450	5-1/4	--	72	67	37		
		30	1500	4	--	72	67	37		
		35	3000	3	--	70	68	37		
		40	4500	1-3/4	--	70	68	37		
45	Idle	5	--	69	68	37				

Table 8

Compressive Strength Test Results

Batch No.	Belt Speed ft/min	Conveyed Distance ft	Age days	Elapsed Time		Slump in.	Air Content %	Strength psi**
				After Water/Cement Contact*	min			
15	480	0	7	10	4-1/4	6.2	2560	
		1500	7	20	2-1/4	6.0	2840	
		3000	7	30	1-1/4	5.7	2990	
		Idle	7	90	1/2	5.5	3320	
18	600	0	7	10	3-1/2	6.4	2520	
		3000	7	30	1-1/2	5.8	3090	
		6000	7	45	0	5.2	4020	
		Idle	7	55	1	5.6	3530	
23	600	0	7	10	4-1/2	8.5	1710	
		450	7	25	2-1/2	6.6	2330	
		3000	7	35	1-1/2	6.5	2750	
		6000	7	50	0	4.9	3780	
		Idle	7	55	2-1/2	7.5	2530	
36	240	0	8	10	3	7.2	3070	
		450	8	20	2	5.7	3730	
		1500	8	30	1-1/2	5.7	4250	
		3000	8	40	1	5.4	4240	

\* Prior to molding cylinders.

\*\* Each value represents average of three individual cylinder tests.

Table 9  
Air Content Loss Data on Batches That Experienced No  
 Complications During Conveyance

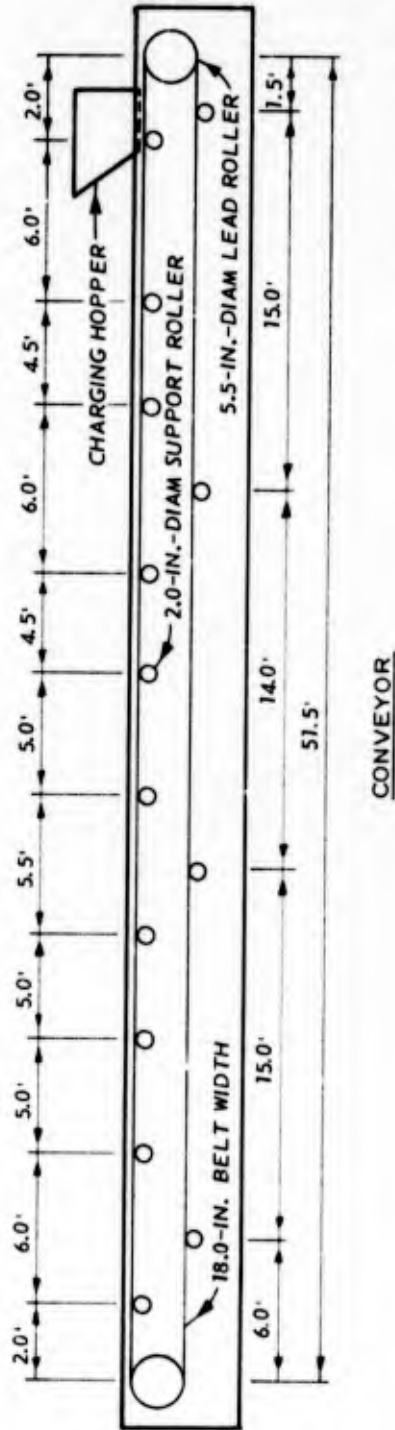
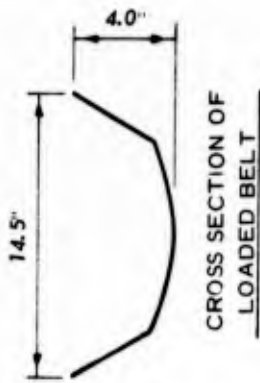
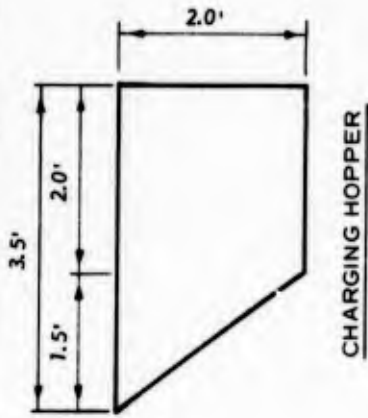
Batch No.	No. of Conveyance Tests	Loss in Air Content, %		
		Conveyed Concrete*		Idle Concrete
		Maximum	Average	
6	1	+0.4	+0.4	0.0
8	2	1.8	1.2	1.0
12	2	1.4	1.0	0.7
13	3	+0.7	+0.2	0.5
15	2	0.5	0.4	0.7
16	2	1.7	1.0	0.3
17	2	1.7	1.4	0.9
18	2	1.2	0.9	0.8
19	2	0.5	0.4	0.6
20	2	1.6	1.4	0.8
21	3	0.5	0.3	0.0
22	2	0.6	0.5	0.5
23	3	2.6	2.2	1.0
24	3	1.3	0.5	0.5
26	3	1.5	1.0	0.7
27	3	1.3	1.1	0.2
28	3	0.8	0.3	0.1
29	3	0.2	0.1	0.0
30	2	0.5	0.3	0.0
31	2	0.8	0.8	0.8
32	1	+0.3	+0.3	0.5
33	3	1.2	0.7	0.0
34	3	2.0	1.9	0.3
35	3	0.9	0.3	0.0
36	3	1.8	1.6	1.0
37	3	0.5	0.3	0.0
39	2	1.3	0.9	0.5
40	1	0.8	0.8	0.4
41	2	0.3	0.2	0.2
42	2	0.6	0.6	0.4
43	4	1.6	1.5	0.7
Avg	2.4	0.97	0.73	0.45

\* Plus sign indicates gain from original test.

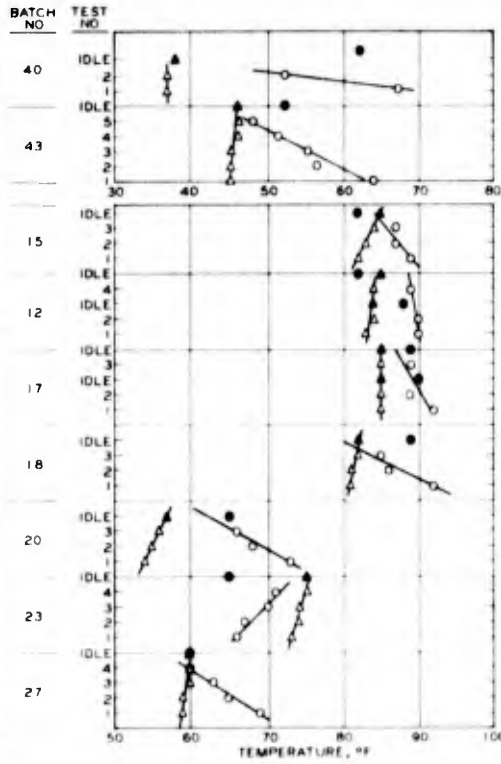
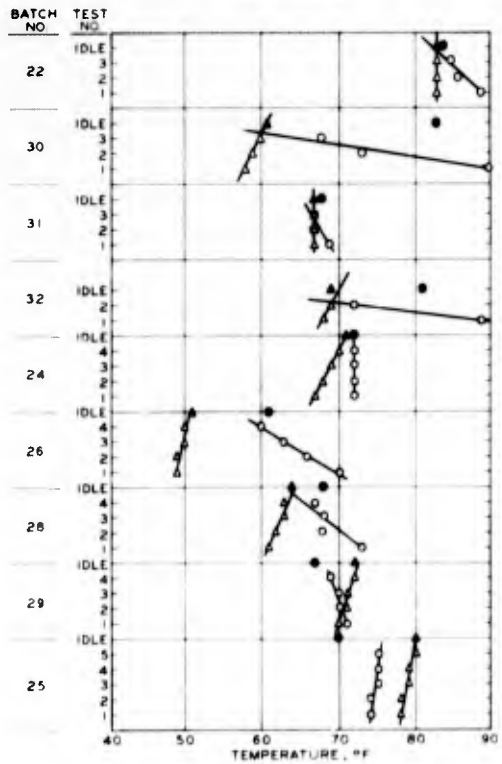
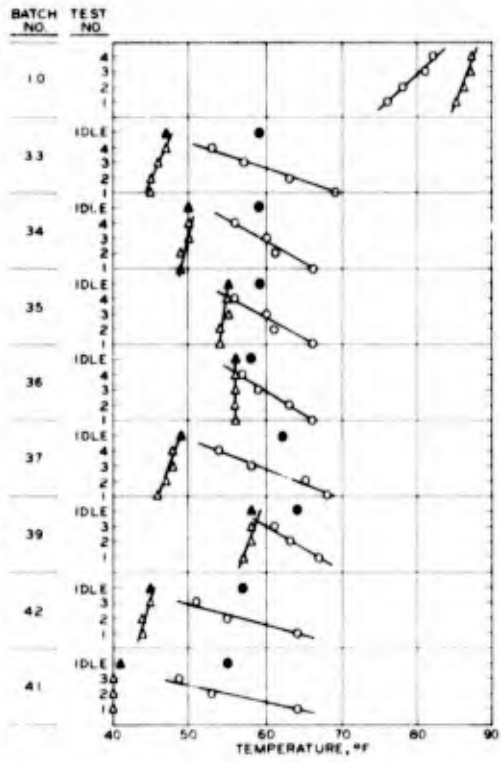
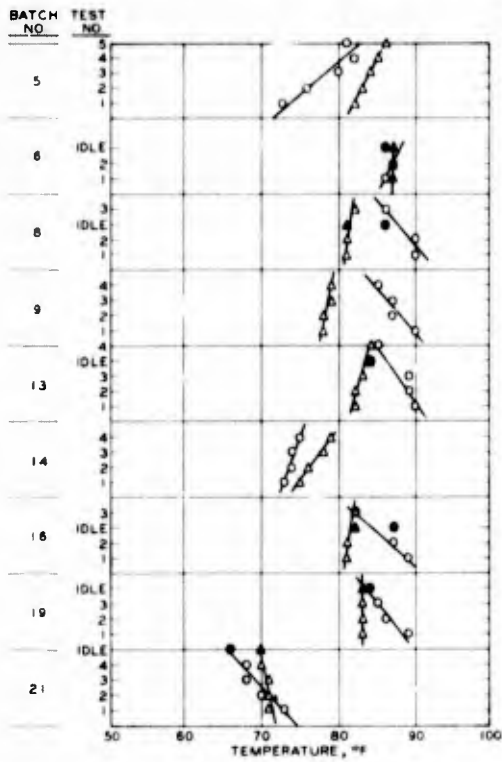
Table 10

Effect of Conveyed Distance on Slump

Batch No.	Time After First Test min	Conveyed Distance ft	Slump Loss in.	Batch No.	Time After First Test min	Conveyed Distance ft	Slump Loss in.
9	10	150	1-1/4	16	15	1500	2
10	10	150	2	17	10	1500	1-3/4
12	10	450	2	19	10	1500	2
13	10	450	1	20	15	1500	1
14	10	150	1-1/4	21	10	1500	1
23	15	450	2	Average	13	1500	1.6
24	10	450	1-1/2	6	20	3000	1-1/2
25	15	450	1-1/4	18	20	3000	2
26	10	450	1-1/2	30	15	3000	2
27	15	450	2	32	15	6000	3
28	10	450	1	40	15	3000	2-3/4
29	15	450	1-1/2	41	15	3000	3
31	10	150	1-1/2	42	15	3000	2
33	10	450	2-1/4	Average	16	3430	2.3
34	10	450	2	8	25	Idle	1-3/4
35	10	450	1-1/2	12	20	Idle	1-1/2
36	10	450	1	16	20	Idle	1-1/4
37	10	150	1-1/4	17	20	Idle	1-1/4
39	10	450	1-1/2	31	25	Idle	1-1/2
43	10	450	2-1/4	32	20	Idle	1
Average	11	375	1.6	39	25	Idle	2
5	15	1500	1-1/4	40	25	Idle	1
8	20	1500	1-3/4	Average	23		1.4
15	10	1500	2				

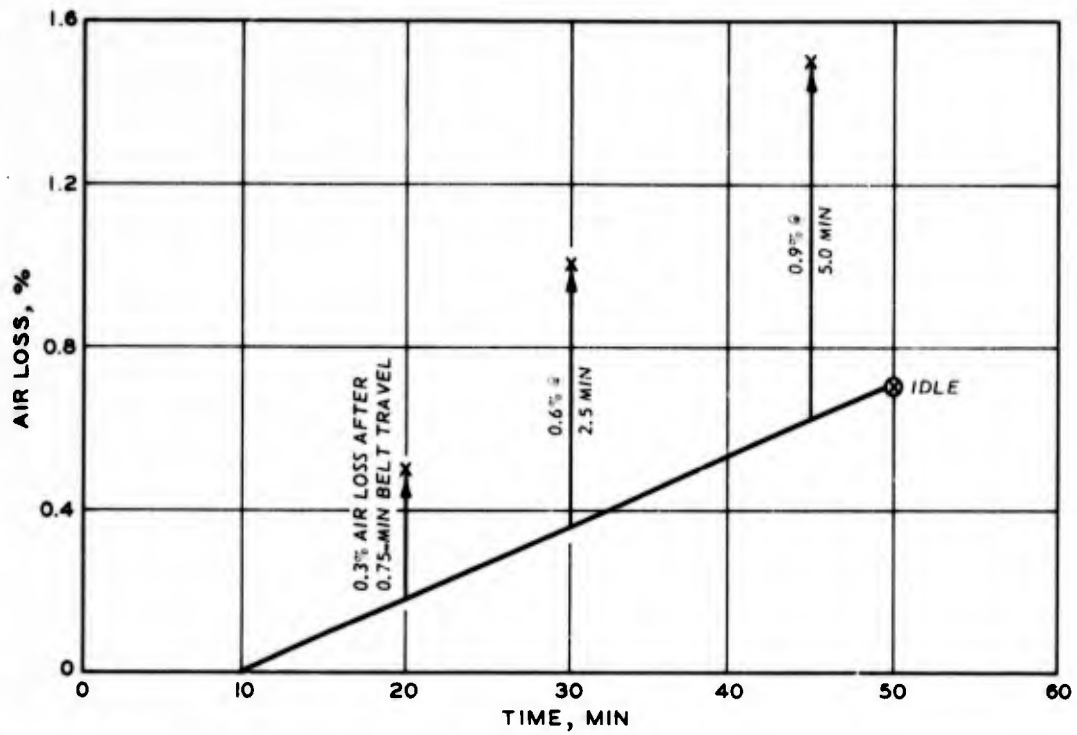


TYPE B BELT AND  
CHARGING HOPPER DIMENSIONS

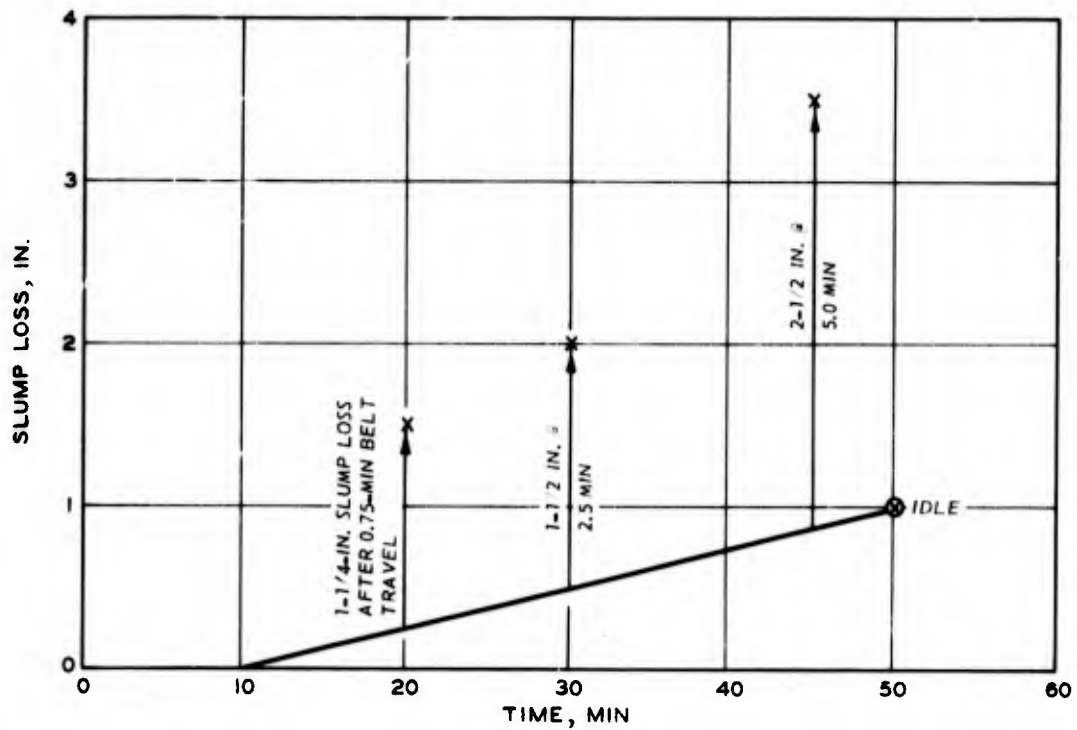


LEGEND  
 O CONCRETE TEMPERATURE      NOTE CLOSED POINTS INDICATE TEMPERATURES DURING TESTS OF IDLE CONCRETE  
 Δ AMBIENT TEMPERATURE

TEMPERATURE DATA



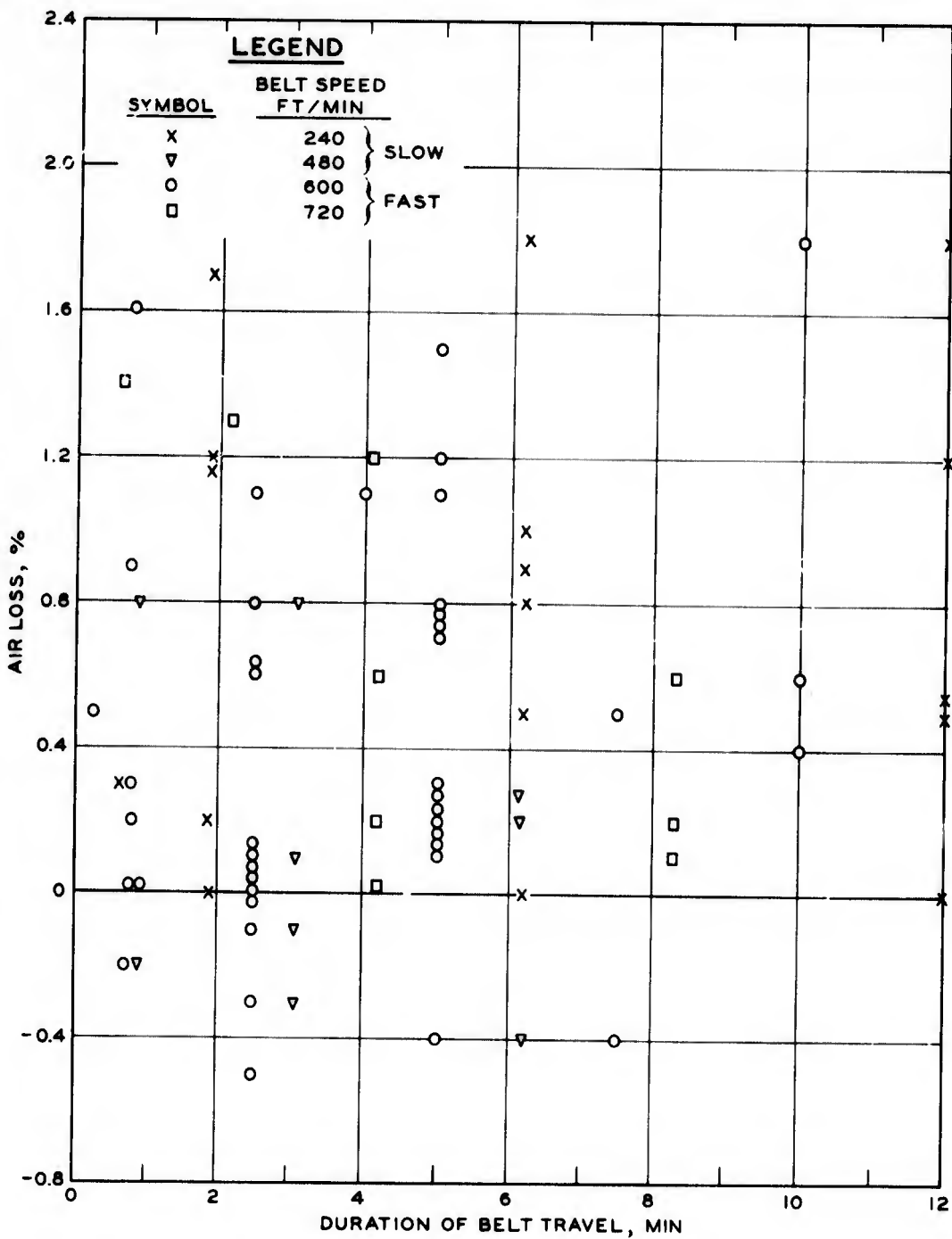
a. AIR LOSS VS TIME



b. SLUMP LOSS VS TIME

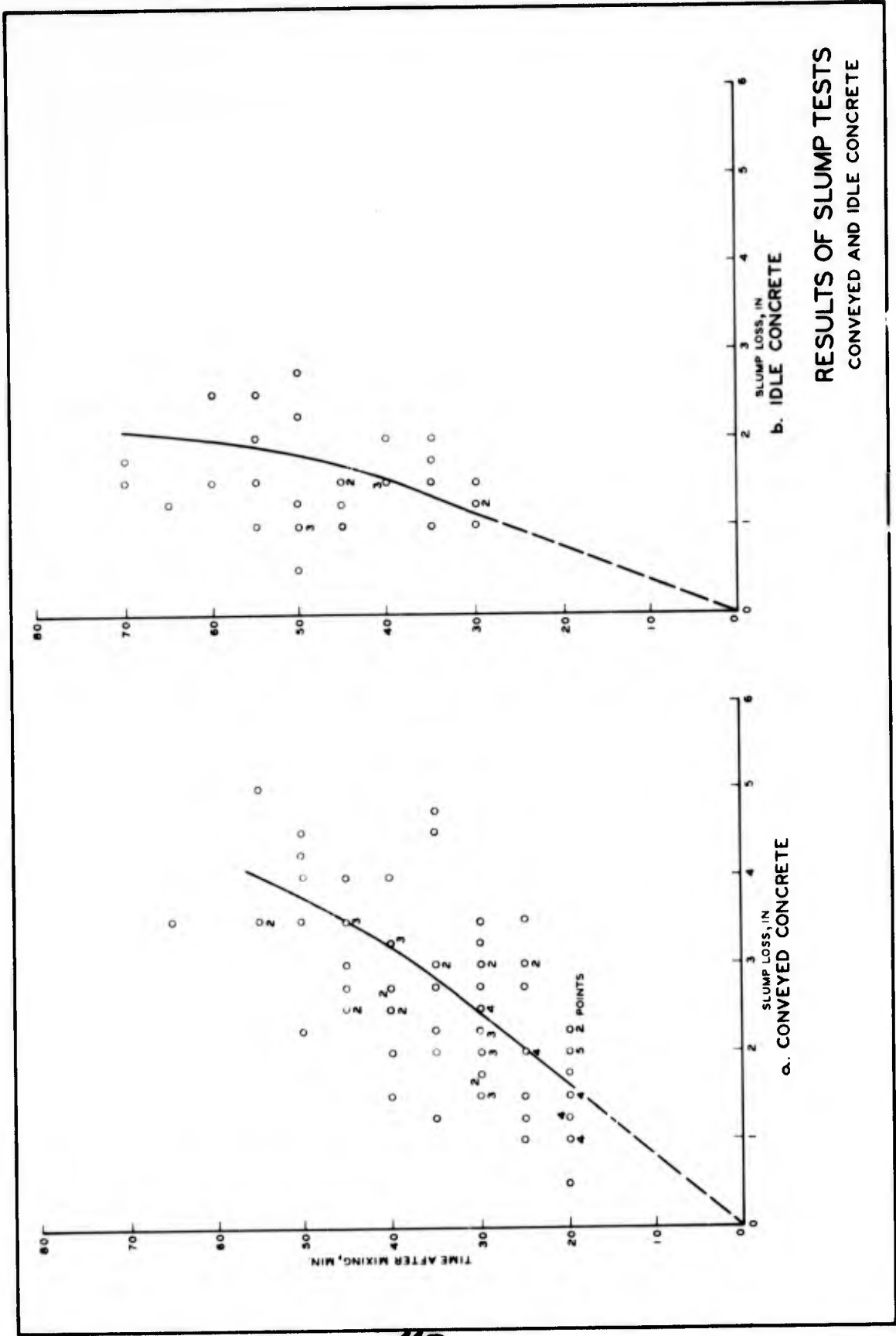
AIR LOSS AND SLUMP  
LOSS VERSUS TIME  
BATCH 26

NOTE BELT SPEED 600 FT/MIN

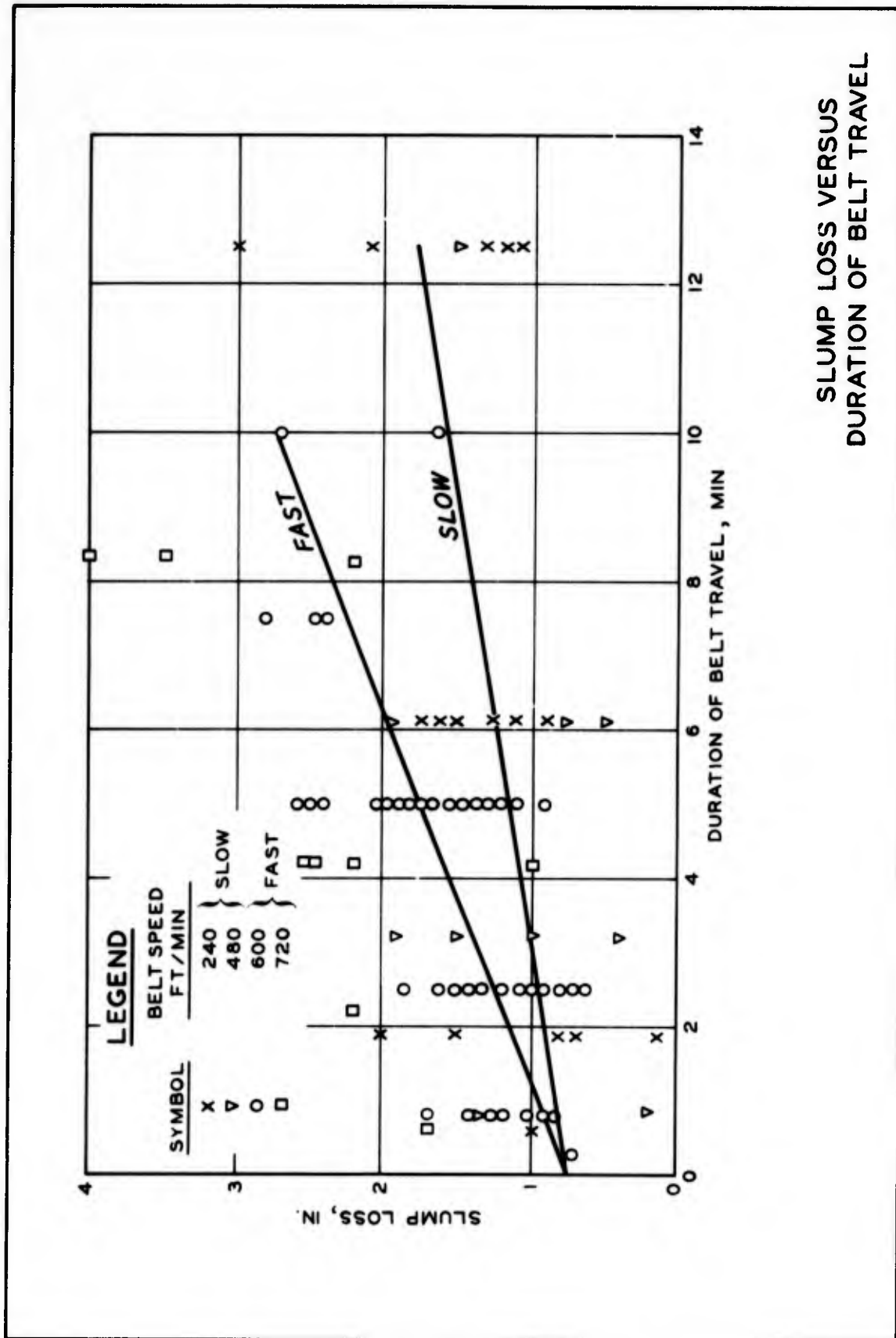


NOTE: MINUS (-) INDICATES AN APPARENT INCREASE IN AIR CONTENT

**AIR LOSS VERSUS DURATION OF BELT TRAVEL**



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