# REPORT ON

# RESISTANCE COEFFICIENT TESTS

# CAST-IN-PLACE CONCRETE PIPE

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in cooperation with

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ABSTRACT

Because of the need for engineering design criteria for unreinforced concrete cast-in-place pipe, a cooperative agreement, Contract No. 14-06-300-1373, was drawn between the United States Bureau of Reclamation and the Salt River Project to make studies to determine the coefficient of roughness for this type of pipe.

The Salt River Project is an irrigation and electric power project serving a large area of Central Arizona. It was established in 1905, the first Reclamation venture in the United States. During recent years it has installed over 100 miles of cast-in-place pipelines in its irrigation system.

Seventeen different field locations with pipeline reaches of various lengths, diameters and ages were selected for testing. Test data was collected in the summers of 1964, 1965, and 1966 during the normal irrigation season. A total of 281 tests were made on pipes ranging in size from 24 to 54 inches in diameter. The roughness coefficient, "n" in Manning's formula, was calculated for each set of test measurements. The "n" values derived ranged from 0.008 to 0.018, but 241 of the tests or 86% had values of 0.013 or less. Only 26 tests, 9%, gave values higher than 0.014, the recommended design "n" factor.

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## PART I INTRODUCTION

Contract No. 14-06-300-1373, dated July 15, 1963, calling for "studies and investigations of operation and maintenance problems and water conservation facilities in irrigated areas", was drawn between the Bureau of Reclamation, the United States Department of Interior, and the Salt River Project, Phoenix, Arizona. A specific objective of the contract was to establish a program of studies and investigations to determine the coefficient of roughness for continuous, unreinforced concrete cast-in-place pipelines.

Consultations were held in late 1963 between representatives of the Chief Engineer's Office, Regional Office, and the Phoenix Development Office, Bureau of Reclamation, and the Salt River Project to plan the study program. During these conferences, the extent of the tests and studies were established, and decisions made on the equipment and instrumentation needed, test standards, and the techniques to be applied. In November, 1963, test sites, pipeline inspection and the installation of test equipment were determined. Field test data were collected during the summer months of 1964, 1965, and 1966.

The Salt River Project has used two types of cast-in-place unreinforced concrete pipe since 1955 as low-head irrigation conduit. They are classified in this report according to their method of construction -- more specifically, according to the kind of internal forming used. One type uses metal forms, while the other uses an inflated rubberized fabric tube. Reference will be made hereafter to these types as "metal form" or "inflated tube."

METAL FORMS -- They are made of sheet aluminum, approximately four feet long. When placed in the casting machine, they overlap slightly and are hooked together to provide a continuous form. The forms require a truss-type spreader bar for support of the upper three-fourths of the pipe. Some 2 to 4 hours after pouring a pipeline, following the initial set of the concrete, workmen remove the spreader bars, break the metal forms loose, and remove them from the pipe for re-use in the next day's operation.

INFLATED TUBE -- The tube is placed in the prepared pipe casting trench, inflated to a specific pressure, and inserted into the casting machine to provide the entire support surface for the internal circumference of the pipe. After the concrete begins to set, the tube is deflated and removed for re-use.

Both types of pipe have the same dimensional and material specifications as used in the Salt River Project irrigation system.

## PART IV CONCLUSIONS AND RECOMMENDATION

### A. Conclusions

1. A valid "n" value in Manning's formula for unreinforced concrete cast-in-place pipe is 0.013 for new pipes and those having an age to 10 years.

2. The type of internal form used in the construction of cast-in-place pipe has an effect on the roughness coefficient. Pipelines constructed with the inflated form have at least 0.001 lower "n" value than those constructed with metal form--provided their construction quality is equal.

3. The maintenance of high standards for material and workmanship during the construction of the pipeline is necessary to produce smooth flow surfaces and a minimum resistance to flow. Inferior standards and/or the malfunction of the pipe construction machinery or equipment is very apt to result in pipelines with greater roughness and resistance to flow.

4. The length of the test period is insufficient to show that aging is a factor affecting the roughness coefficients of cast-in-place pipe. The values derived at 12 of the 16 test locations showed no change in the second or third year values over those of the first year. At each of the other four locations, the change in values was believed to be caused by physical features other than age. There was not any significant difference between the values in the older and the more recently installed pipe of the same construction type.

5. Pipe diameter or quantity of flow did not affect or alter the "n" values. Pipe diameters ranged from 24 to 54 inches and flow quantities varied from 2.2 to 62.5 cubic feet per second in the tests; there was no apparent correlation of either the pipe diameter or the flow quantity with the "n" values derived.

The analysis of the total group of 281 test results gave an average "n" value of 0.01152 and a standard deviation of 0.00175. Significantly, 91% of all the values were less than 0.0140 and 86% were less than 0.0130.

The standard deviation values for the total group of tests and for the metal-form pipe were comparable in magnitude. The value for the inflated-form pipe, however was considerably lower indicating a lesser degree of variation and spread in these results.

6. Sediment in the pipelines apparently increases the flow resistance. In those locations where considerable sediment quantities were encountered during pipeline inspection, namely Sites 13, 15, and 17, there also the "n" values were inconsistent and generally higher. The average of the test values from these three sites was 0.01393 compared to 0.01152, the average of all tests.

B. Recommendation

Because of the relative newness of cast-in-place concrete pipe, it is recommended that the study be repeated, in whole or in part, in 1970-72. This would serve to corroborate the findings on "n" values and determine if any change in the physical characteristics of the pipe occurs over a longer period of time.