POROUS PLATE STUDIES
(SUMMARY)

by

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INTRODUCTION

This report consists of a brief summary of the work being done in connection with porous plate screens at the University of Washington. The work is being conducted with the objective of extending the present knowledge toward more definitive design criteria by a careful study of the hydraulic variables which govern the flow over such a screen. Some of the geometries for the study were chosen so as to be similar to the field installations at the Stanfield Canal at Echo, Oregon.

Before a design criteria for porous plate screens can be utilized it is necessary to know the inter-relationship of such variables as the screen porosity, screen length, and the slope angle as defined in figure 1. Although there are many field installations of screens or porous plates, the few general studies which have been made leave many design parameters only vaguely defined. A reasonably good analysis has been made only for a slope angle of 0^{o}. It is to be expected that the relationships will change as the angle is altered from that of 0^{o} to say 5^{o} or 10^{o}. The theoretical relationships involved become very cumbersome, and in order to make any use of them at all it is necessary to make a number of assumptions. The exact nature of these assumptions can be accurately made only through use of quantitative laboratory results.

For this purpose a model was constructed to simulate a porous plate screen. The model is now being tested.

DESCRIPTION OF MODEL

The model used in the study is shown in operation in figure 2. It is constructed primarily of plexiglass, to aid in visual analysis of the flow, and is attached to an existing flume of one foot width. The test section is four feet in length. The floor of the screen is made out of tee-sections constructed of 3/8-inch-thick plexiglass and 1[illegible]inch wide. These are placed in a direction transverse to the flow. The tee portion is added to provide extra strength. The present sections in use are shown in figure 3. During the second phase of the test program the downstream edge of these sections, or the upstream edge of the openings, will be rounded for reasons which will be explained. This is shown in figure 4.

There are several reasons for using the tee-sections. These floor sections slide into grooves cut in the inside of each wall and the desired opening width is maintained by spacers

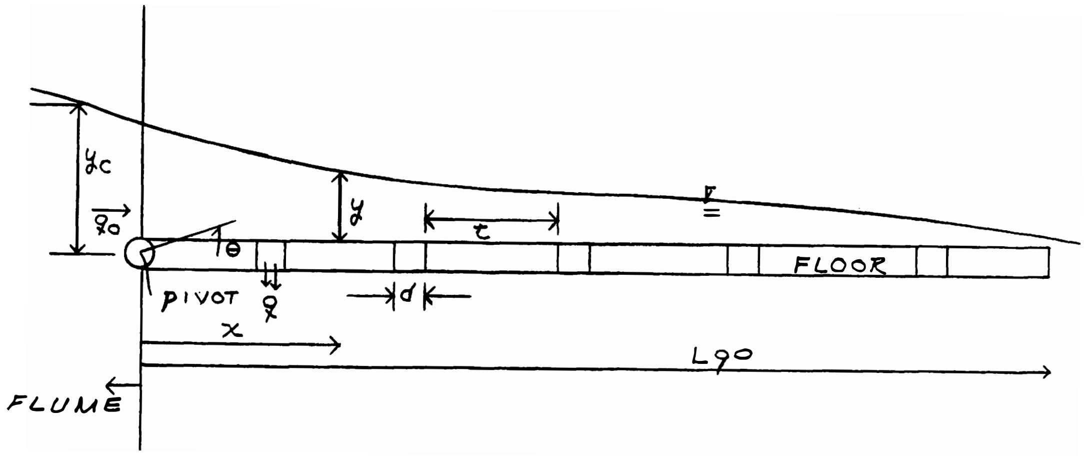

Figure 1.--Elevation view of test model.

q_o = initial flow.

q = flow through a single opening.

p = porosity = $\frac{\text{area of openings}}{\text{gross area}} = \frac{d}{t + d}$

L_{90} = length at which 90% of the initial flow has passed through the plate.

x = distance from start of plate

y = water depth

y_c = critical depth of initial flow

θ = angle of the floor with the horizontal, measured counterclockwise

C_d = discharge coefficient = $\frac{q}{A \text{ opening} \sqrt{2gh}}$ where $h = y$

t = bar width = 1"

d = opening width

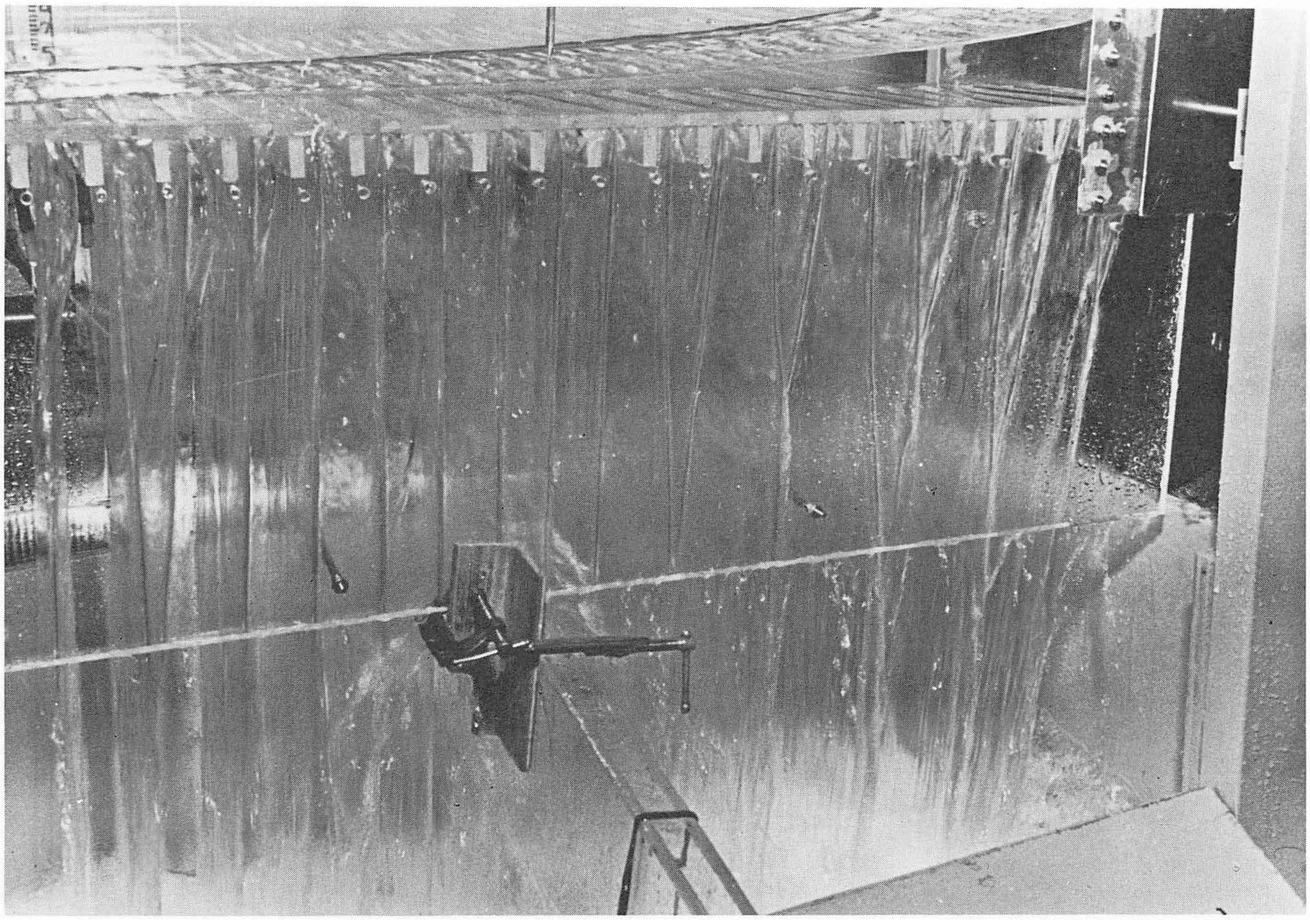

Figure 2.--View of test model in operation.

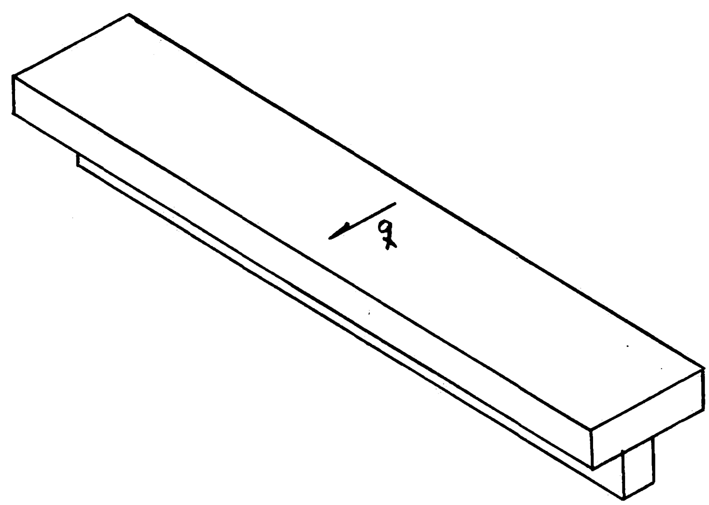

Figure 3.--Square edge tee-section.

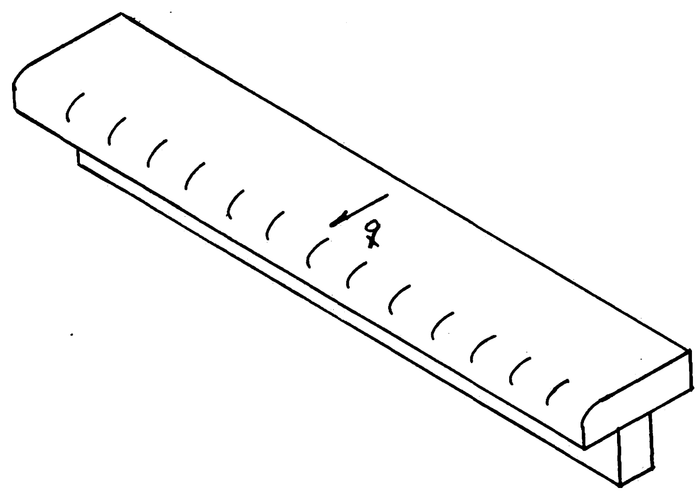

Figure 4.--Rounded edge tee-section.

which are easily changed. This arrangement enables the changing of the porosity and length. The porosities being used in the present series of tests are 0.197, 0.261, and 0.333.

Another advantage of the bar arrangement over that of a true porous plate is the relative ease with which the discharge through the openings can be defined and measured. With the punched hole openings there occurs a three-dimensional effect which leads to uncertainty in the definition of the porosity. Not only is the effective opening area of the bar arrangement more readily visualized and analyzed, but the actual opening area is more easily defined and measured.

In the present series of tests the incremental flows are being measured to enable some determination of the relationship of the discharge coefficient to some of the other variables, such as t/d, slope, depth, and initial flow.

The entire test section is pivoted so that the floor can be tested at any angle from zero to twenty degrees. By varying the number of tee-sections in use at a time the length can vary from zero to four feet. The tests run to date have been in the range of from one to three and one-half feet. The maximum available flow for the one foot of width is about 1.1 cubic feet per second.

The test program has been divided into two separate parts. The first part was run with the sharp edge sections. The second part will be run with the rounded edges on the downstream edge of the tees. It is believed that the rounded edges will increase the discharge per foot, maintain a smooth, uniform approach flow, and more nearly represent a field installation fabricated from commercial tee-sections.

The first part of the program was run to provide background information to be used to compare with existing studies and with subsequent changes in the test model. The data which has been taken includes the water surface profiles, the incremental discharge through the plate, and the pressure on the surface of the plate.

In order to compare the data from tests made with various lengths, angles, porosities, and flows, it is necessary to compare them on a dimensionless basis. The terms are defined in figure 1 with L_{90} being the length at which 90 percent of the initial flow has passed through the plate.

RESULTS

The flow over the plate can be either sub-critical or super-critical depending both upon the angle of the plate with the horizontal and the porosity. In the first phase tests have been run at 0°, 5°, 10°, and 15°. At 0° and 5° the flow was super-critical over the plate, and at the 10° and 15° angles the flow was sub-critical over the plate, at the porosities at which these angles were tested. At the angle at which critical flow occurs the flow is unstable. This angle is of course dependent upon the porosity. This region should be avoided in any field installation as the flow is highly variable and non-uniform. At the lower porosity of 0.197 this angle was found to be about 7° -8°. More testing will be done in the second phase to try to determine the influence of the parameters upon the location of the critical flow region.

Typical water surface profiles for each of the angles and porosities tested will be found in figure 5. Also, in figure 6, will be found a dimensionless representation of the discharge as a function of the dimensionless length.

Another important relationship which needs to be determined is that of the discharge coefficient. In the past this has been assumed to be constant along the length of the plate. From figure 7 it can be seen that there is considerable variation. It is interesting to note, however, that it remains more nearly constant for the sub-critical flow cases. This would tremendously simplify a design procedure for this type of flow and is one point in favor of using such angles. It is also interesting to note that the discharge coefficient does depend upon the plate porosity.

FUTURE PLANS

As stated earlier, the next step is to round the edges of the tee-sections. In the series of tests already completed most of the attention was given to flow over the plate at an angle of 0° to the horizontal. This was to compare results with the somewhat limited results presently available.

It is realized, however, that most fish screen installations would be on angles of greater than that of 0°; partially for economic reasons, as the length required to pass a given amount of water decreases rapidly as the angle with the horizontal increases.

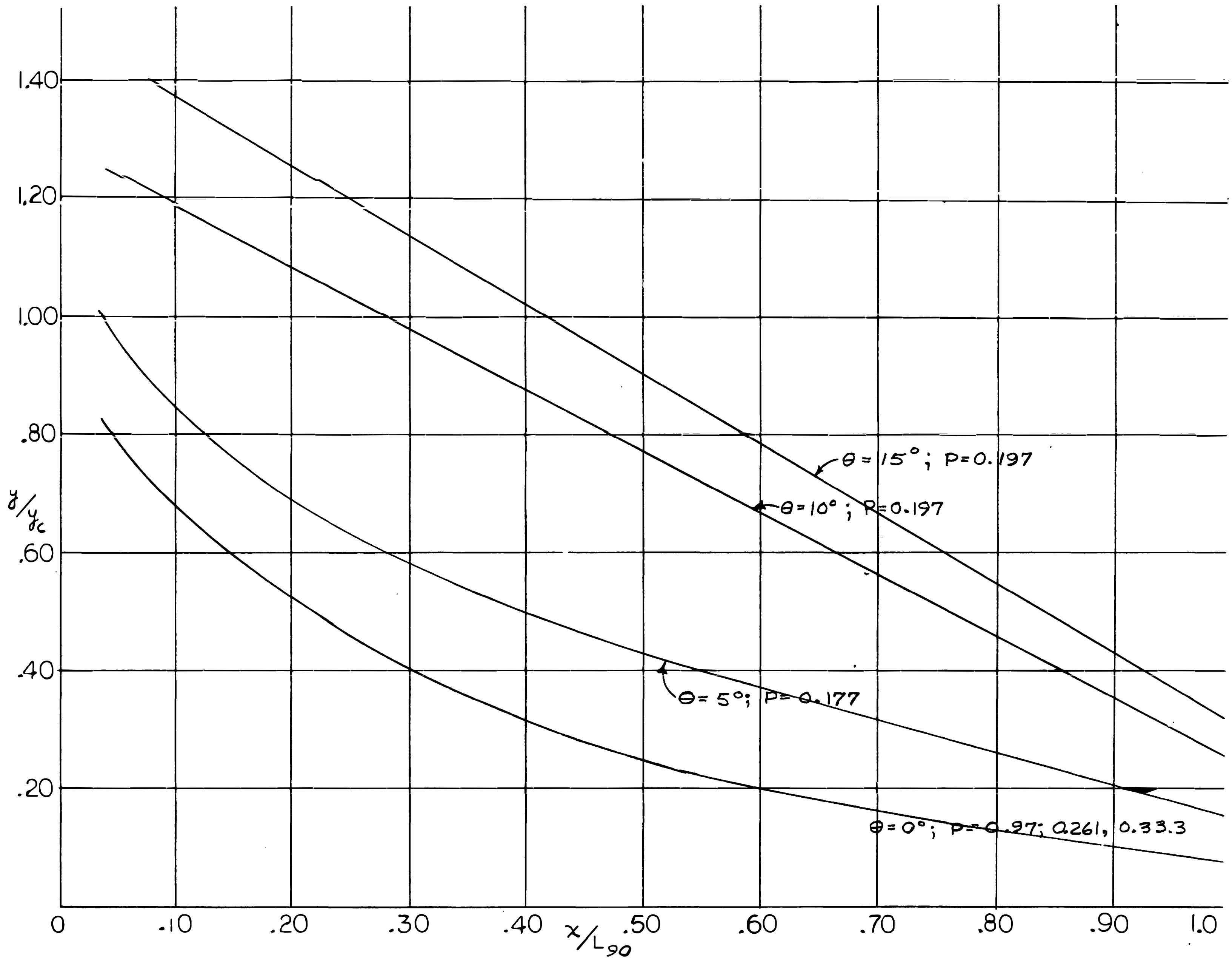

Figure 5.--Water-surface profile.

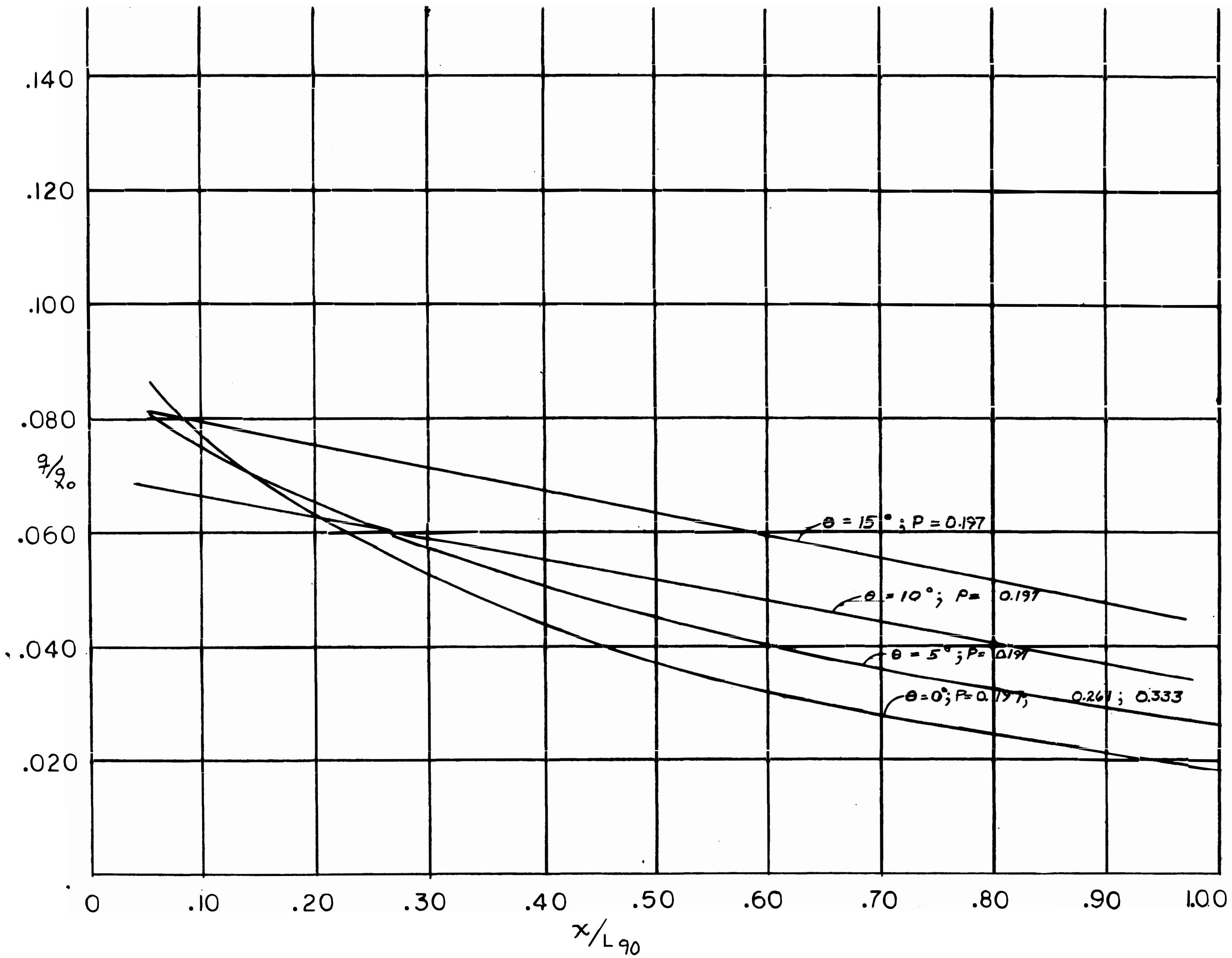

Figure 6.--Flow variation.

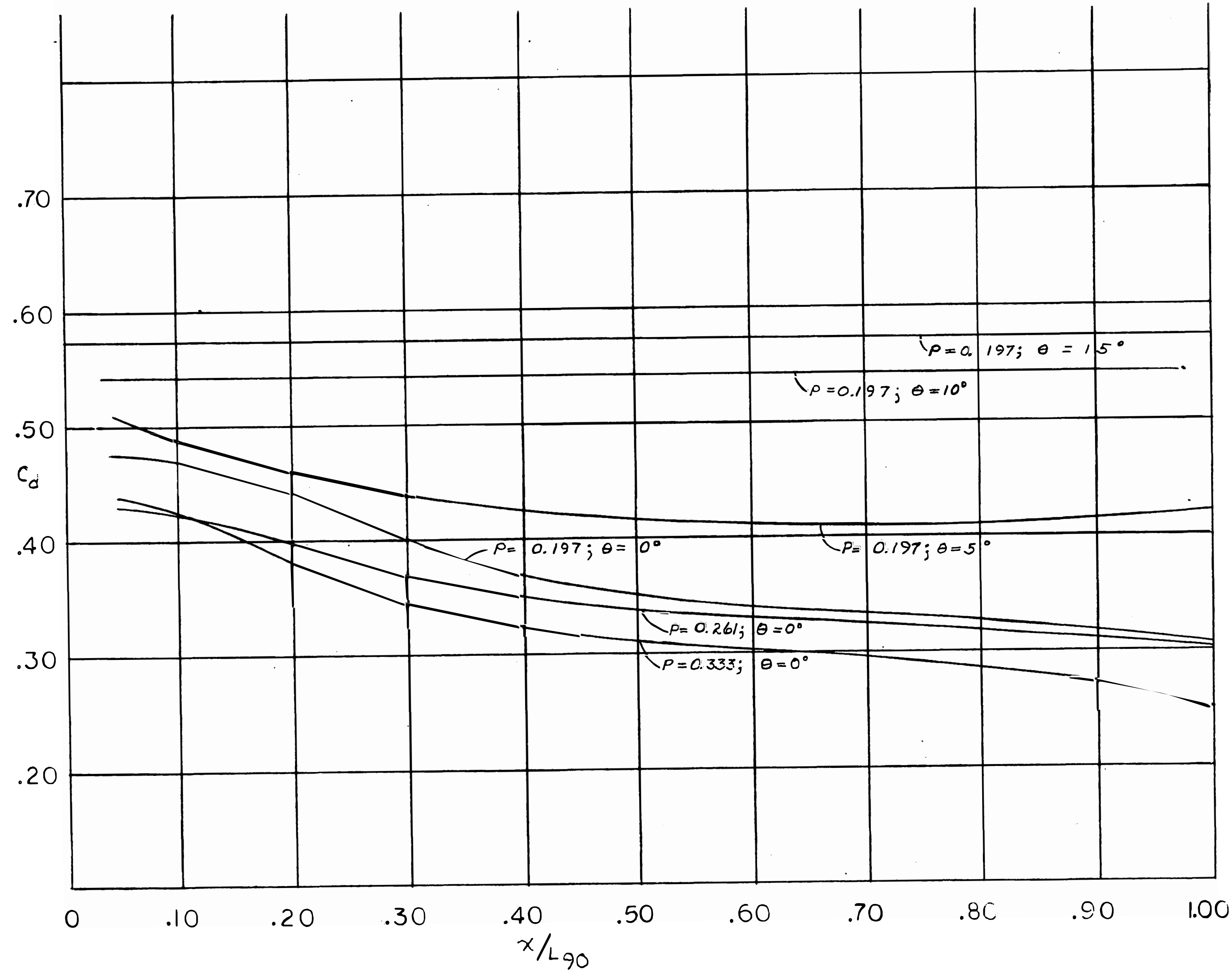

Figure 7.--Discharge coefficient.

In the next phase of the tests more attention will be given to the hydraulic characteristics at angles other than 0°, with some tests being run at 0° to compare with previous results. A number of tests will be run at 5° so that these data may be compared with that obtained at existing field installations. Also tests will be run at sub-critical flows, the advantage of the constant discharge coefficient being apparent at these angles.