USE OF GRAVEL ARMORPLATE IN DROP STRUCTURE DESIGN

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The fields of irrigation and soil conservation are continually confronted with the problem of controlling the erosional forces of water in irrigation and drainage systems. As a result, many different types of drop structures have been developed to prevent erosion on steep slopes and to lower the water at abrupt drops. Most of these structures, however, are too costly for general use by irrigation companies and farmers.

This paper is a presentation of the recent developmental work at Colorado A&M College on an economical drop structure utilizing gravel armorplate in the scour hole. The goal of the study has been to develop design criteria for a gravel armorplated stilling basin. This type of structure reduces considerably the cost of construction.

After studying the mechanism of scour and how it is influenced by various factors such as height of drop, tailwater depth, discharge, and sediment characteristics, there remained the problem of how to prevent the high rate of scour in a sand bed.

On the basis of previous tests, gravel armorplating material was chosen as a possible means of controlling the rate of scour.

The use of armorplating materials decreased considerably the rate of scour. Four different size-ranges of armorplating gravels were used, each decreasing scour with increasing amounts of armorplating material applied to the scour hole. Pound for pound, however, the larger-sized particles alone decreased the rate of scour less than the smaller-sized particles, see Fig. 1. By using a graded mixture, a greater decrease in the rate of scour was obtained than for any of the separate sizes tested alone. This scour phenomenon can be explained by the size of the openings between the particles and the size of the supporting

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material between the particles. The particles having the larger openings permitted the fine bed material to be forced upward and ultimately to be eroded from the scour hole. With the graded mixture, these openings were filled with larger material, which resulted in less change of this material being forced upward through the armorplate.

As the amount of armorplate was increased, the scour decreased to a point where any further increase in the amount of armorplate would not give a sufficient decrease in scour to be economically practical. When the rate of scour approached zero (Fig. 1), the amount of armorplate necessary to control the scour completely became very great. For practical use, a predetermined rate of scour must be chosen, and then the proper size and the economical amount of armorplate can be determined.

The following conclusions were reached in this study:

(1) Only a relatively small amount of armorplating material is necessary for a relatively large decrease in the rate of scour.

(2) The rate of scour increases with an increase in the size of the armorplate material when the armorplate material remains larger than the largest particle size of the bed material.

(3) The rate of scour decreases with an increase in the amount of armorplate placed in the scour hole.

(4) Graded armorplate material decreases the rate of scour much more effectively than uniform material.

This study has indicated the feasibility of a gravel armorplated stilling basin. Furthermore, by proper selection of armorplate a control of the scour rate may be obtained.

From this basic research work, drop structures using the principles involved have been built and have operated satisfactorily. The cost of construction for these structures was greatly reduced. At the same time, maintenance of these same structures has either been the same or, in some cases, has been less than the maintenance of other drop structures on the same system.

A still greater decrease in cost and increase in effectiveness of this type of drop structure may be accomplished with further research in the laboratory and the field.

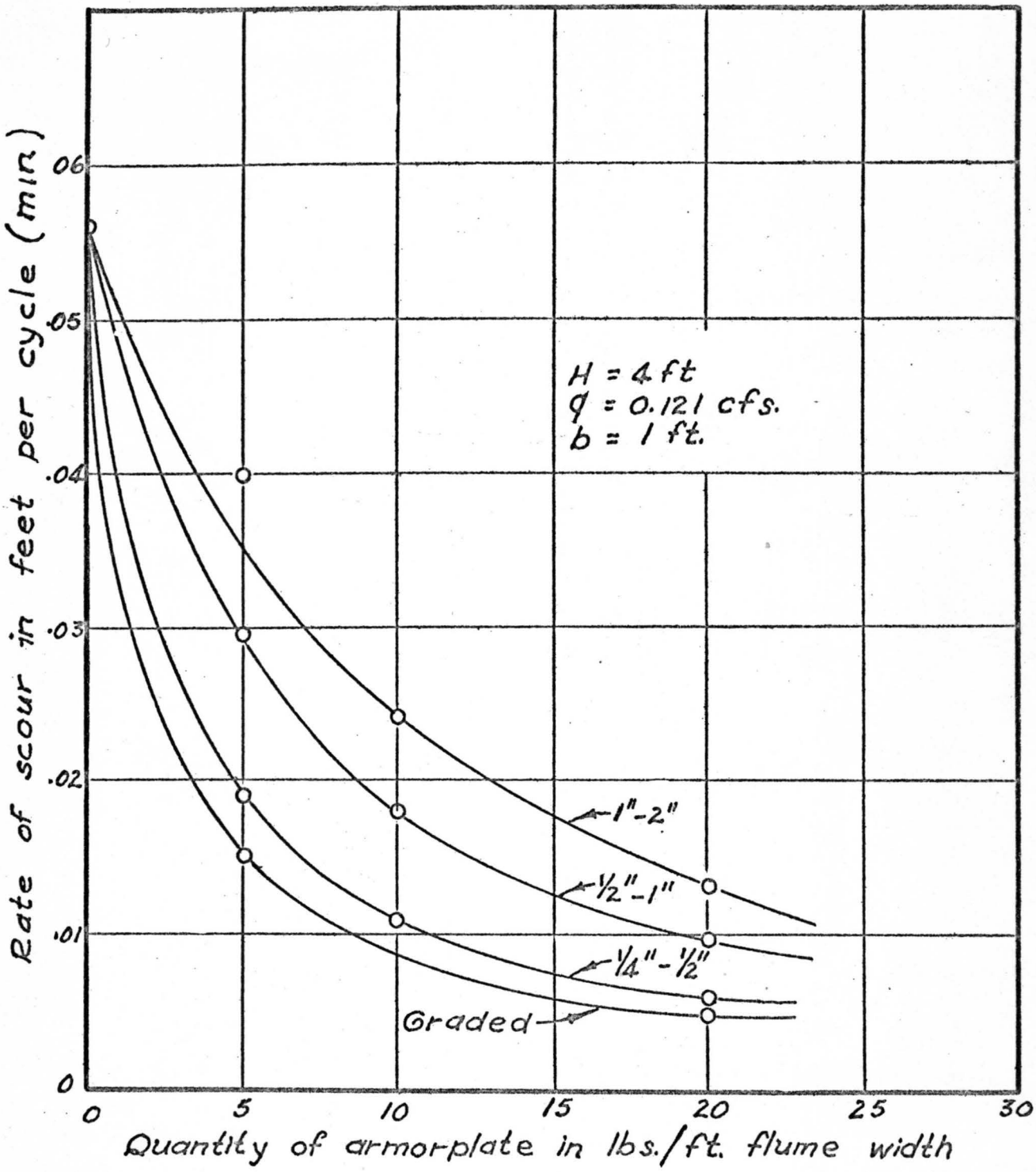
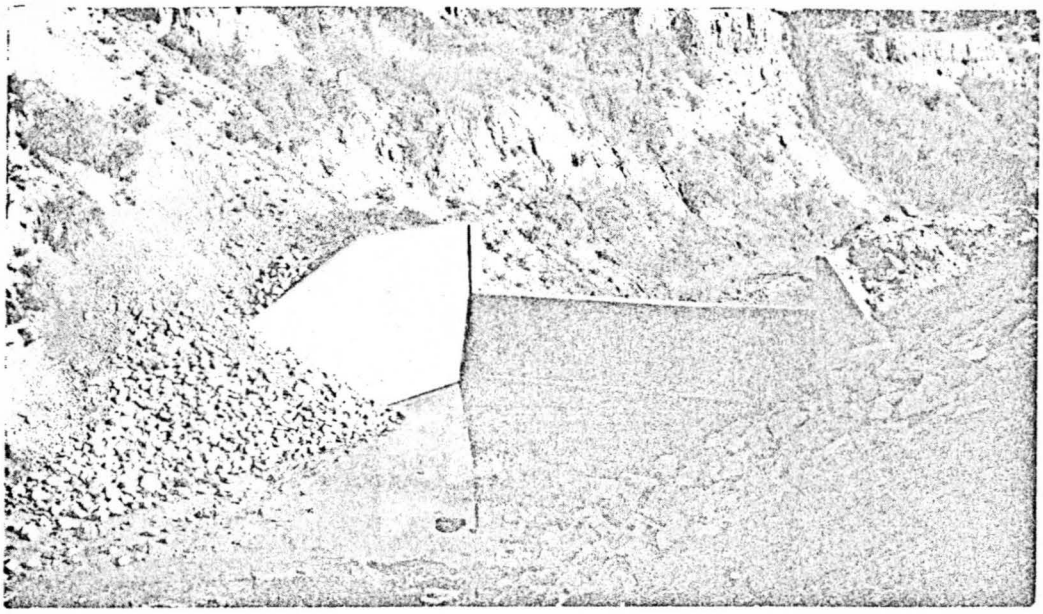


Fig. 1. Effect of armorplate on rate of scour.



Looking upstream

Looking downstream

- Field structures on the Windsor Reservoir and Canal System using a gravel armorplated stilling basin.