

PROGRESS REPORT, COMMITTEE ON SURFACE DRAINAGE OF HIGHWAYS

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C. F. IZZARD, *Chairman*

The third annual meeting of the Committee on Surface Drainage of Highways was held on December 1, 1947 with nine members present and three others reporting by letter. The major part of the meeting was devoted to discussing the Drainage Guide prepared by the Ohio Department of Highways and to reports on progress of research projects in which the Committee is interested.

Ohio Drainage Guide - The Ohio Drainage Guide is part of a Plan Preparation Manual and is intended primarily as a tool to facilitate hydraulic design of culverts and small open channels. It does not deal with waterways for bridge structures. The Guide includes 23 pages of text and examples demonstrating how to use the 24 charts, four of which deal with estimating peak rates of runoff, 12 with flow in open channels, and eight with culvert and pipe flow. The basic principle followed is that of designing culverts as hydraulic structures to carry a design discharge estimated in cubic feet per second. The charts enable determination of the depth of ponding at the entrance for any given discharge depending on the head loss through the structure measured from the tailwater elevation in the outlet channel or, in the case of barrels on steep grades, on the size and shape of the entrance.

The Committee reviewed the Ohio Drainage Guide thoroughly and recommends that other highway depart-

ments give consideration to developing similar guides for use by their design engineers. It is recognized that the weakest point in the method is the estimation of the peak rate of runoff in cubic feet per second but as more data become available from hydrologic studies of the Soil Conservation Service, U.S. Geological Survey and other agencies, this deficiency is gradually being removed. The runoff chart in the Ohio Guide is identical to that published in Part II, Roadside Development Report, Highway Research Board, April 1940, which has been found to be reasonably in line with the most recent runoff data available on small drainage areas. It is suggested that each State contact the Soil Conservation Service - Research, Washington 25, D.C., for latest available bulletins on peak rates of runoff on small drainage areas in that State.

With suitable charts at hand hydraulic analysis of a culvert can be made quickly for a range of discharge rates, and for alternate types of pipes, or boxes, either single or in multiple. The designer can then select the most economical layout meeting the limitations on cover over the culvert and for freeboard against overtopping the embankment or submerging valuable improvements on the upstream side of the roadway. The final selection of the design discharge may be made with reference to the probability of excessive damage if exceeded.

Handbook formulas which give only the required waterway area in square feet permit no analysis of the hydraulic effect of these many variables which ought to influence the final design.

The widespread application of hydraulics to design of culverts depends on reducing the involved mathematical formulas to relatively simple charts, giving results within practical limits of accuracy, which field engineers can use quickly and confidently. The Ohio Guide takes a long step in this direction but some of the committee members feel that the procedure is still too complicated for general use. Further simplification and clarification is undoubtedly possible. On the other hand it must be recognized that the field engineers ought to be given more training in the elements of flow in open channels and through culverts so that they may be able to apply the working charts more intelligently.

Hydrologic Data - The U.S. Geological Survey reported that a number of State highway departments are entering into cooperative agreements with the Survey, among these being Ohio, Missouri, and Georgia. These agreements vary in their provisions. Some provide for statistical analyses of existing streamflow records to provide data on magnitude and frequency of peak flows. Some provide for installation of additional gaging stations on small drainage areas each selected as being representative of a physiographic area of uniform runoff and climatic characteristics. In several States agreements provide for studies by the Survey regarding magnitude and frequency of floods and stages of such floods in the vicinity of proposed bridge sites for use by the State in designing the bridge waterways and highway gradelines. Special studies of thunderstorms are being made in

Ohio. In New York State studies are being made of floods to obtain data for use by the Department of Public Works in contesting claims by property owners for damages caused by such floods.

The Committee invites attention to Bulletin No. 7 of the Ohio Water Resources Board entitled "Floods in Ohio--Magnitude and Frequency". This bulletin, compiled in cooperation with the U.S. Geological Survey, includes tabulation of peak flows at 44 gaging stations, from which are plotted graphs of the recurrence intervals of these floods. This type of graph enables good estimates of the magnitude of probable floods for frequencies not greatly in excess of the period of record for the stream gaged. By comparing floods of a given frequency on drainage areas having similar physiographic and climatic conditions but varying in size, it is usually possible to make fairly good estimates of probable floods on streams which are not gaged located in the same region.

Rainfall intensity-frequency duration data compiled by Yarnell and published in Miscellaneous Publication No. 204 of the U.S. Department of Agriculture included only storms through 1933. Since that time many additional first order weather stations have been installed and 14 more years of record obtained from the original stations. The Committee believes that the Weather Bureau ought to analyze the data now available and publish a new bulletin on intensity-frequency relations. Data of this kind are particularly valuable in the design of storm drains for urban highways and airports.

Some runoff data are being obtained by installation of crest stage recorders, a simple device which leaves ground cork particles adhering to a staff, placed in a vertical pipe, at the maximum elevation reached by the flood waters.

An observer records the maximum stage and resets the gage for the next flood. These gages are inexpensive, and if supplemented by current meter measurements to establish stage-discharge curves, can yield valuable information on flood discharges. Used in pairs or in series on a carefully selected reach they enable slope-area determinations of discharge.

The committee noted that a series of Regional Hydrologic Conferences is being planned by the Subcommittee on Hydrologic Data of the Federal Inter-Agency River Basin Committee for the purpose of compiling recommendations from all interested Federal agencies as to additional hydrologic measuring stations needed. The Public Roads Administration will cooperate with the State highway departments in preparing listings of stream-gaging stations which would be useful in connection with future road and bridge construction.

Stormwater Drainage for Urban Highways - A Subcommittee on Stormwater Drainage for Urban Highways has been formed and is preparing a list of problems on which research is believed to be needed.

Experimental work on inlet capacities is in progress at the University of Illinois, and at the University of Minnesota, as reported elsewhere in this bulletin. Research at the University of Illinois will also include statistical analysis of data for about 15 recording rainfall gages in the vicinity of Chicago to provide intensity-frequency duration curves and related information for use in design of stormwater drainage on express highways.

Hydraulic Research on Culverts - A fundamental investigation of the hydraulics of culverts is underway at the St. Anthony Falls Hydraulic Laboratory of the University of

Minnesota as a cooperative project of the Minnesota Department of Highways and the Public Roads Administration. The first phase of this investigation is a thorough search of engineering literature to learn what has been done previously. An annotated bibliography covering about 100 of the more important articles is in preparation. The second phase of the project is the construction of a tilting channel in which model culverts may be installed for testing on various gradients. The plans for this apparatus have been approved and construction is expected to start soon. The third phase will be measurement of flow through model culverts with various approach and outlet channel conditions simulating the situations commonly encountered in the field. One of the initial objectives will be to develop entrance and outlet sections for pipe culverts which will operate efficiently over a wide range of flows, decreasing the headwater elevation for peak flows, and minimizing the erosion at both inlet and outlet. The resulting designs will be modified as necessary to facilitate mass production by precasting, or prefabrication, thereby eliminating the need for cast-in-place concrete headwalls and securing greater economy in first cost as well as lowered maintenance costs.

The hydraulic model tests at the St. Anthony Falls Hydraulic Laboratory will also enable further experimental verification of the theory of flow through short tubes as developed by Dr. Keulegan. The analytical study by Dr. Keulegan, abstracted in this bulletin, will be of great interest to research engineers since it reveals clearly the inadequacies of the empirical formulas previously developed from limited experimental data.

Proposed Research on Underscour at Bridge Piers and Abutments - The

committee endorses the proposal made by the Joint Committee on Floods of the American Society of Civil Engineers for a fundamental investigation of the mechanics of scour around bridge piers and abutments. In many sections of the country it is necessary to build bridge foundations in alluvial stream beds. At flood stages deep scour occurs around these obstructions placed in the stream and occasionally a pier or abutment will fail by undermining. A more fundamental understanding of the forces involved in the scour phenomena, particularly the effect of local eddies, will make it possible to design substructures which will be safe against scour without excessive cost for either construction or maintenance.

(Editors Note: Since the committee meeting a research project has been financed by the Iowa State Highway Commission and the Public Roads Administration for model investigations of scour around bridge piers. The work will be done by the Iowa Institute of Hydraulic Research of the University of Iowa at Iowa City, under the direction of Dr. Hunter Rouse.)

The committee is gratified with the widespread interest now being shown on surface drainage of highways. Substantial progress is being made on the research problems endorsed by the committee. No new objectives were set forth, it being felt that efforts for the next year should be devoted to support of projects underway.

The committee will welcome suggestions as to research needed in the field of highway drainage.