SOME MEASUREMENTS OF VELOCITIES AND SCOUR AT A MISSISSIPPI RIVER BRIDGE PIER

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SYNOPSIS

A study of scour resulting from the construction of two piers in the channel of the Mississippi River was made during the construction of the bridge at Baton Rouge, Louisiana. This study included soundings taken at high and low water stages on ranges extending about 1,000 ft up and down stream from the bridge centerline and velocity readings on two ranges, one on the bridge centerline and the other upstream, at one of the piers. This paper reports the result of this field study and points out the effect of the construction on the stream bed and the channel cross section.

The example cited brings to attention the danger of damaging scour in streams having alluvial beds and shows the velocity at varying depths at a flood height that resulted in a cutting out of the stream bed adjacent to the channel obstructions and affected the river cross section materially up and down stream.

The data reported is to encourage the further study of a problem on which little responsible data is available and to call attention to the need for coordinating knowledge of stream flow and soils characteristics toward a sound basis on which scour effects at bridge piers might be predetermined within reasonable limits.

It is the purpose of this paper to bring to attention the possible nature and extent of scour at bridge piers constructed in streams having alluvial bottoms by pointing to an actual experience where depth and velocity measurements were taken. While there is a considerable volume of literature available on the hydraulic properties of bridge piers as affecting stream flow and resulting turbulence, height of back-water, etc. based on laboratory research and field studies, there is little if any authoritative data directly concerning the phenomenon of scour resulting from the effects of the high velocities and eddies created by such channel obstructions. It is to bring out the need for study of the scour problem, as affecting bridge piers that this paper is presented.

With each flood in the rivers and streams, especially in our alluvial valleys, there is somewhere a bridge failure, caused by scour, which results in a breakdown in our highway transportation system and much economic loss. It is believed that there can be developed means by which probable scour depths in the various erodable materials which make upstream beds, can be approximated with reasonable accuracy, provided that sufficient research with this end in view is carried out.

These observations were made in the spring of 1938 in connection with the construction of the channel piers for the Mississippi River Bridge at Baton Rouge, Louisiana. In this case two obstructions in the form of cylinders 111 and 121 ft in diameter, used to retain sand islands through which the pier caissons were sunk, were placed in the main river channel 660 ft apart. Protection of the stream bed to permit the placement of the cylinders was provided in the form of mattresses upon which ballast and riprap stone was placed.

Surveys of the river cross-section on the bridge centerline shown in Figure 1 give some indication of scour effects observed at various water elevations. Those soundings, made from Sept. 15, 1937, about the time the cylinders were placed in the channel through Jan. 31, 1939 after the effects of two high water periods, show the effect on the river section of the channel obstructions. Also to be noted is the adjustment of the channel section to the obstructions. The subsequent effects of the reduction in the size of the obstructions by the removal of the sand islands from around the permanent pier sections is evidenced by the soundings of July 1940. Soundings made on seven ranges extending about 1,000 ft upstream and down stream from bridge centerline taken at low water stages from 1937 to 1940, show changes in the channel cross section of major dimensions (Fig. 2 and 3). It was found that above the piers the stream bed built up as much as 20 ft on the 1,000-ft downstream range.

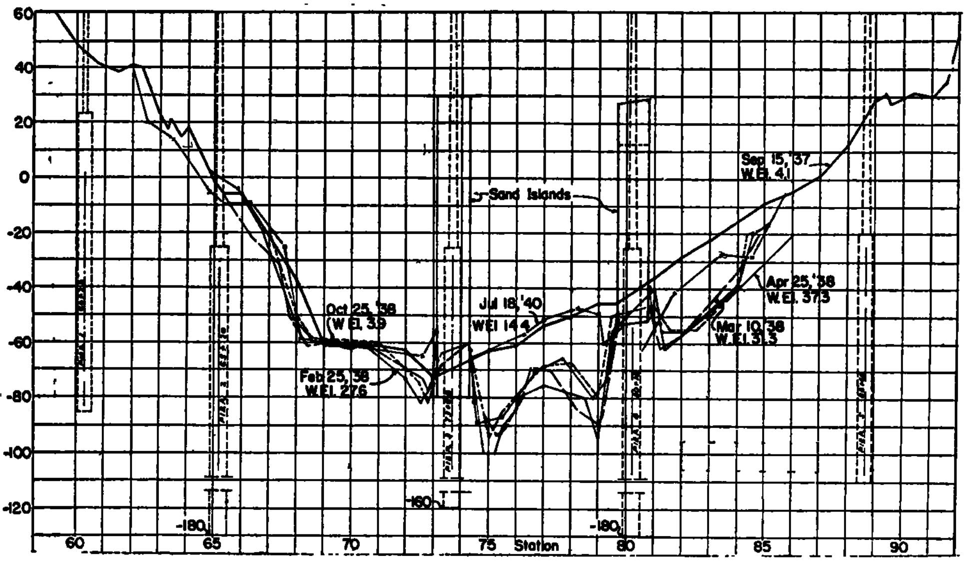

Figure 1. River Cross Sections at Mississippi River Bridge—Baton Rouge, La.

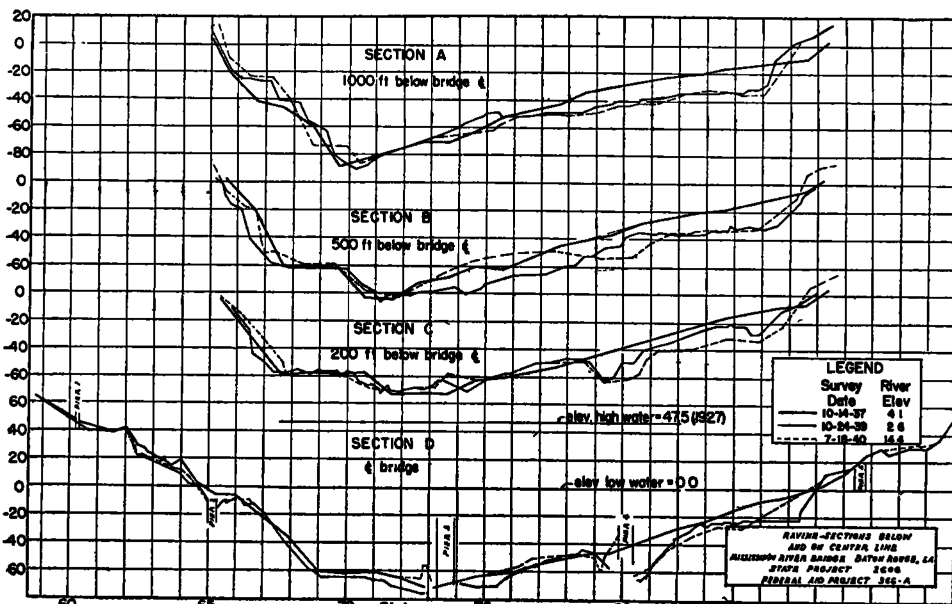

Figure 2. Ravine Sections Below and On Center Line of Bridge

During the high water period of 1938, when scour at the piers to great depths was indicated by soundings, velocity readings were made on two ranges in the vicinity of the east channel pier with the cooperation of the Water Resources Section of the U. S. Geological Survey. One range was just upstream of the east channel pier and the other was on the bridge centerline. It was intended to run an additional range downstream and also similar ranges in the vicinity of the west channel pier, however, the work was found to be extremely hazardous, therefore, it was concluded with the completion of the readings in the vicinity of the east pier.

From the velocity study (Fig. 4) backwater effects of the channel obstructions are clearly indicated on the upstream range by the reduced velocities recorded especially at the greater depths. Velocities on the centerline range are increased to an extent, resulting in the sand bottom adjacent to the obstruction cutting out to the depth of more than 40 ft even though protected by mattress-work. This scouring action was caused by a bottom velocity of about 6 ft per sec with a flood height of 37 ft. The horizontal velocity diagram indicates that the velocity increases along the sides of the obstruction, and by comparing these with the sections shown in Figure 1, the drop in speed is clearly indicated in the effect on the river bottom as can be seen by the high ridge left between the two piers. The vertical velocity and vertical factor curves are of particular interest in that they show the relatively small difference from surface to streambed adjacent to the obstruction and the relatively wider velocity range up-stream where back-water effects scour. These observations further show that in this case the higher velocities adjacent to the piers resulting from back-water vary as the depth of the channel.

The problem confronting bridge engineers daily is how deep shall a pier or abutment footing be placed in a material known to be erodable and yet be safe against possible scour. At the present time this question is being answered by the individual's experience since little if any data on this subject are to be had. In the comparatively recent past there has been considerable study of the hydraulic efficiency of bridge pier sections such as the investigation of Nagaler at the University of Michigan and Yarnell at the University of Iowa. However, these studies were made in laboratory flumes with fixed bottoms so that the formulae developed for determining back-water heights do not necessarily apply to streams having bed material that will adjust itself to the pier obstructions.

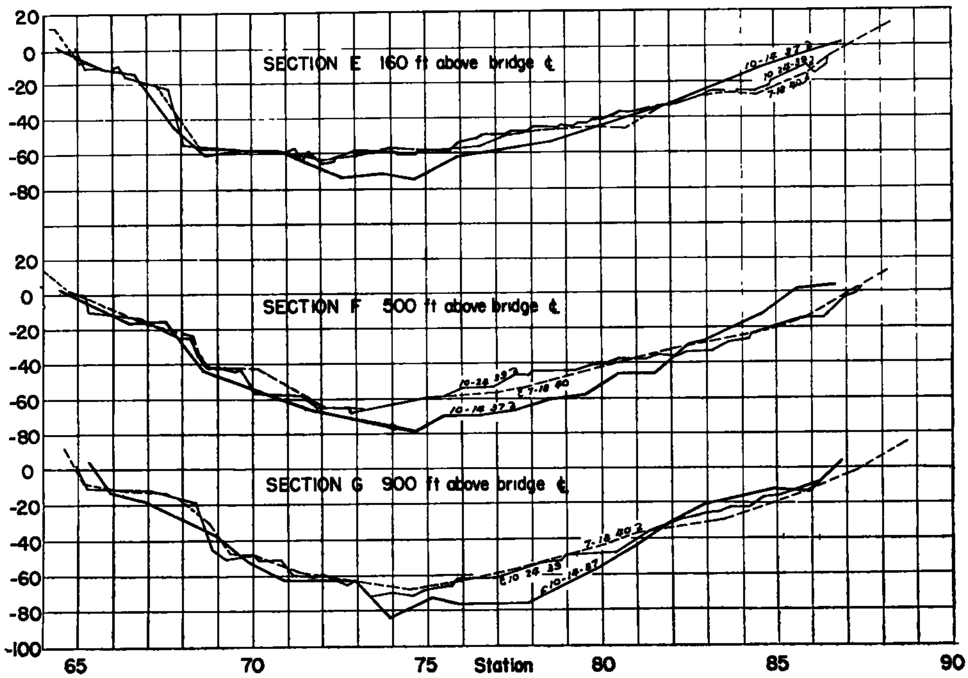

Figure 3. Ravine Sections Above Bridge

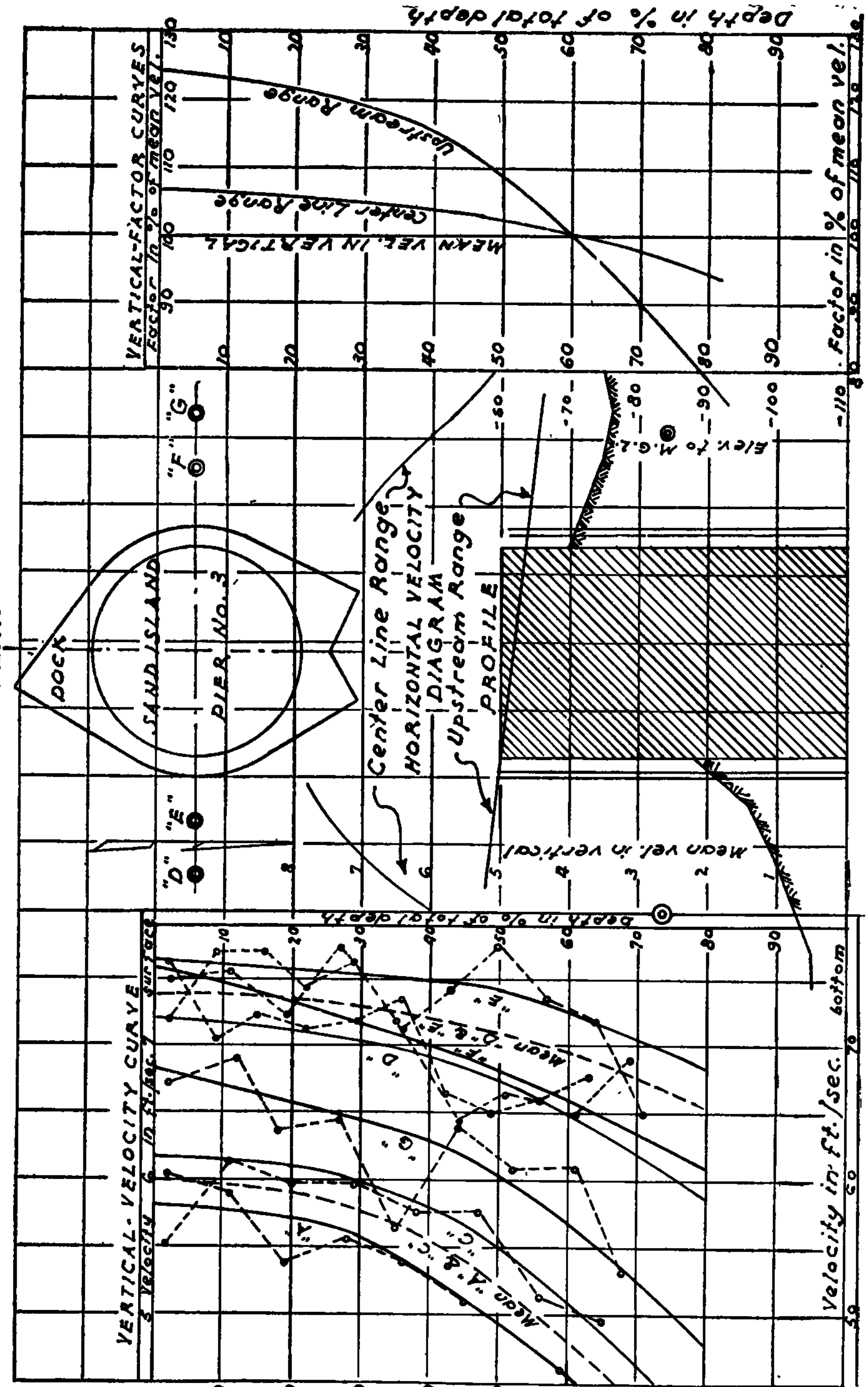

Figure 4. Velocity Study

It is recognized that scour is the direct effect of the increase in the hydraulic grade and current velocity due to backwater effect from the obstructions placed in the channel but we have little or no data as to what velocity will be required to erode a material of known physical analysis. The engineer does know that scour to great depth has and does occur as in the case described herein and often times dependence for the safety of the structure is placed in protective works which are not always successful.

It is hoped therefore that interest in the phenomena of scour around bridge piers can be aroused sufficiently to bring about research in the laboratory and in the field whereby the knowledge of stream flow and soils characteristics can be coordinated so that before too long the designing engineer shall have sufficient responsible data from which to determine within reasonable limits the amount of scour to be expected around bridge piers in the various classes of materials making upstream beds when subjected to water currents of known velocities.

DISCUSSION

PROF. D. P. KRYNINE, *Yale University:* The question, how to estimate possible scour from the water table fluctuations and given topographical, geological and structural conditions, apparently interests engineers all over the globe. Some time ago I received a letter from a French engineer working in Madagascar where he has to deal with some stormy streams. He has accumulated many data along these lines and asked me a question similar to that posed by Mr. Erickson. I sent him all the literature on the subject I knew, and asked him to write an article for some American journal. I understand that observations exist connecting fluctuations of the water level in the Colorado River with the corresponding values of the scour. Perhaps the Geological Survey possesses some information on this and similar subjects which could be of help to bridge designers.