REPORT

FIELD TRIP TO PALMER, ALASKA

JULY 1965

WITH RECOMMENDATIONS CONCERNING
FIELD STUDIES OF THE BRIDGE SCOUR PROBLEM

by

H. W. Shen

Prepared for
U.S. Department of Commerce
Bureau of Public Roads
Division of Hydraulic Research
under Contract CPR11-8022

Civil Engineering Department
Engineering Research Center
Colorado State University
Fort Collins, Colorado

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ABSTRACT

Reported herein is the report of a field trip to the Knik River Bridge near Palmer, Alaska. Methods of field data collection were tested during the annual flood of the Knik River. Based on this experience and laboratory observations, recommendations concerning field studies of the bridge scour problems are made.

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Chapter I

1. Place — Report on the field trip to Knik River Bridge, near Palmer, Alaska

2. Date — July 11-14, 1965

3. Bridge Site

Knik River (See attached map -- Fig. 1) obtains its water from Lake George through a narrow five-mile-long gorge. One side of the gorge is formed by glacier and the other side is a steep mountain cliff, as shown in Fig. 2. During the winter season, the glacier advances and makes several contacts with the mountain on the other side of the gorge. These natural ice dams prevent water from flowing to the Knik River. In early summer, large pressures resulting from the high level of the lake break the ice dams. After the collapse of the ice dams, water rushes downstream from Lake George, thus causing a dependable, annual, short-duration summer flood of the Knik River. The width of the gorge during the summer is about two hundred feet.

As shown in Fig. 3, a natural river bend exists approximately two miles upstream from the Knik River Bridge. Because of this natural bend, a relatively deep channel near the eastern river bank is formed under the bridge.

The Knik River bridge has eight 500 feet spans of steel trusses and a long approach section near its western bank as shown in Fig. 4.

4. Data Collected

a. From the bridge pier:

(1) Water surface elevation at the upstream face of the bridge pier was read directly from the scale painted on the pier as shown in Fig. 5. Water surface profiles along the pier during medium flood stage are shown in Figs. 6 and 7. Even at this stage, it was difficult to control the boat very close to the pier.

Several hours later, the water surface profile became almost horizontal along the pier, as shown in Fig. 8.

(2) River bottom elevations immediately upstream from the pier were recorded continuously by a depth sounder mounted on the pier.

b. From the boats:

Two aluminum boats, A and B, with their measuring instruments, as shown in Figs. 9 and 10 respectively, were used.

(1) Boat A - The only function of this boat during that day was to measure the profile of river bed with a depth sounder. The measuring procedure used:

(a) Bed profiles of the river - markers were set at the center of each bridge span, (midway between any two piers) and at one thousand feet intervals along the eastern river bank.

The pilot of this boat attempted to move the boat with a constant speed along the center line of one of the bridge spans, as shown in Fig. 11.

The depth sounder started to record the river bottom profile at approximately five thousand feet upstream from the bridge. The operator of the depth sounder marked the recorder chart when the boat passed one thousand feet interval posts on the eastern river bank. This procedure was repeated for the center line of each bridge span.

(2) Boat B - The main functions of boat B were to measure velocity distribution and to collect suspended sediment samples upstream from the bridge piers.

5. Discussion of Results

a. Scour around bridge piers:

Since large amounts of rocks were dumped around all bridge piers, no noticeable change of bed elevation adjacent to the piers was found by the depth sounder mounted on the pier. However, a drop of 4 to 6 feet in bed elevation occurred at a distance of 5 feet from several piers. It was concluded that riprap was probably dumped within 5 feet of each pier.

b. Bed profiles:

Dunes on the order of one-third to one-half flow depth occurred frequently on the river bed. Figure 12 gives the bed pattern near the western bank after the high flood peak has passed. By holding the boat stationary, it was found that the dunes did not move within a 10-minute period.

The distances between every thousand feet interval, marked on the chart of depth sounds, were not equal. Both the speed and the direction of the boat probably varied. Actually, piloting the boat was a very difficult task, and therefore, better horizontal control on the position of the boat is necessary.

6. New Bridge Sites on the Knik River

Figure 13 shows the new bridge on Knik River that will be used for the scour study in 1966, and Fig. 14 shows the Sun Shine bridge which could be used for another site of scour study. However, as pointed out by Mr. Murray L. Correy of the Bureau of Public Roads, the bed sediment size near the Sun Shine bridge appeared to be too coarse for bridge scour study.

Chapter II

SELECTION OF SITES FOR FUTURE FIELD STUDIES
(For local scour only)

Since each bridge site is slightly different, it is difficult to suggest a set of rigid general rules for all field studies. In the following discussion, the reasons for requiring each type of data are briefly given so that field engineers may use their judgment for any necessary modification.

1. Selection of Bridge Sites

a. Armoring should not be a factor in determining maximum scour. With this in mind, the bed material composition should be reasonably uniform in size and cohesionless. If the largest bed material in the neighborhood of the pier can be moved by the flood, the maximum scour depth should be independent of the sediment gradation. Bed material consists of the grain sizes of which the channel bed is normally composed. This is the most important requirement

b. The net flow area under the bridge may not vary more than 10% from the upstream approach area to avoid constriction effects. This maximum allowable deviation was suggested by E. M. Laursen and A. Toch (22).

c. During flood stages, the direction of the velocity of the water in front of the pier must not deviate more than six degrees from the axis of pier. This limit was determined by T. Ishihara (17).

d. It is desirable to have a relatively large, dependable annual flood. It would be uneconomical to set up the instrument and wait for the occurrence of the 50-year flood.

e. The site should be easily accessible.

2. Data Before Flood

a. Necessary data: (without these, the field study will be meaningless).

(1) Bed elevation adjacent to the pier should be measured. The difference between elevations before, now, and during the flood is the amount of scour caused by the flood. This is just to be certain that no large scour hole caused by the last flood, or by any other phenomenal reason, already existed.

b. Desirable data

(1) Three to five bed sediment core samples around the pier are desirable. It is useful to compare sediment compositions at different depths before and after the flood in order to study the armoring and deposition effects.

(2) Vertical velocity distribution: Measured at three or four different depths and average flow depths at a hundred feet upstream from the pier would be desirable. With these data, one can obtain (a) the correlation between the hydraulic condition and the scour depth near the pier for the base flow; and (b) the constants that determine the vertical velocity distribution. From past experience the vertical velocity distributions in rivers vary logarithmically with flow depth, but the constants must be determined in each river.

3. Data During Flood

a. Necessary data:

(1) At about 100 to 150 feet upstream from the pier velocity measurements at 0.2, 0.4, 0.6, and 0.8 flow depth should be made at points A, B, and C (see Fig. B-1) during peak discharge. Results from laboratory indicated that the scour action was caused by the difference of stagnation pressures at different depths in front of the pier, and the variation of stagnation pressures was caused by the vertical velocity distribution of the flow.

(2) Average flow depth of points, A, B, and C (see Fig. B-1) during peak discharge should be recorded. When large bed irregularities exist, several readings may be necessary to determine the average flow depth.

(3) The magnitude of dunes or other bed forms on the river bed should be determined. Scour depth around the bridge pier will fluctuate considerably if large bed irregularities exist.

(4) A continuous record on the development of scour hole around the pier by a depth sounder (or comparable instrument) should be taken. Time scale should be recorded on the chart so that one can correlate the variation of scour depth with the changing approach flow conditions. Scour depth within the arc of DEF (see Fig. B-1) and also the slope of scour hole should be measured.

(5) A continuous river discharge record for the flood should be obtained. It is highly desirable to know the variations of the approach velocity and flow depth at B with the river discharge.

(6) Depth integrated suspended sediment samples should be taken at point B (see Fig. B-1) during the following three conditions: (a) when the river discharge reaches its maximum; (b) when the scour depth around the bridge pier reaches its maximum; and (c) when the sediment concentration in the river at point B reaches its maximum. The above three conditions may or may not occur at the same time and are often rather difficult to predict. The second condition is the most important of the three because the amount of sediment entering the scour hole is equal to the capability of the flow to scour in the scour hole during the maximum scour condition. Sediment samples under the first and third conditions will give us information on the above stated development of the scour hole. Thus, are highly desirable.

(7) Water temperature should be measured as it has been shown by Hubbell, Karaki, and Ali[1] that the sediment transport varies with temperature. This would effect both the sediment inflow and outflow from the scour hole, but not necessarily in the same way. The kinematic viscosity also varies widely with temperature.

b. Desirable data:

(1) It is desirable to determine the two constants in the vertical velocity distribution of the river when the river discharges are about 15% and 30% less than the peak discharges, both before and after the passage of flood peaks.

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[1] Hubbell, D. W., S.S. Karaki, and Khaled Al-Shaikh Ali. Flume studies of the effect of temperature on the mechanics of flow in alluvial channels, - studies of flow in alluvial channels. USGS WSP 1948, Chapter F, November 1961.

(2) A second method (not an alternate method) to record the scour hole development with changing river discharges is highly desirable. The basic idea of this method is to dump quantities of different colored particles into the scour hole at various flood discharges. After the flood, boring samples would be taken to find the vertical distribution of these colored particles. From the vertical distribution, an attempt can be made to reconstruct the development of the scour hole. The particles can be dumped through a 2 - 3 inch pipe attached to the pier. A readily available flourescent paint is an ideal coloring material.

For instance, if there are five different colors available which are denoted as colors A, B, C, D, and E, respectively. Depending on the type of flood expected, the engineer would select various points along the hydrograph at which the colors would be inserted. One possibility might be to insert a color at a preselected percentage of the expected peak discharge. Table B-1 illustrates this.

The purpose of this method is to study the development of the scour hole and cannot be used as a substitute for the continuous scour depth record.

TABLE B-1

When discharge is	Insert color
w% of expected peak	A
x% of expected peak	B
at the peak	C
Y% of peak	D
Z% of peak	E

(3) Depth integrated suspended sediment samples should be taken in front of the pier from the water surface to a depth of approximately 1.1 times the upstream approach flow depth at point B (See Fig. B-1). Comparing this data with the depth integrated suspended sediment sample taken at point B, at the same time, will indicate the funding for the suspended material deposit in the scour hole.

4. Data After the Flood

a. Necessary Data:

(1) Sufficient bed material samples should be taken to a depth greater than the greatest scour depth during the flood. The main purpose of taking these samples is to investigate the sediment size distribution of the bed sample to determine the degree of armoring. If sufficient large particles exist at a certain depth, armoring effect might have occurred, and thus, the maximum scour depth was distorted by the deposition of these large particles.

b. Desirable Data:

(2) It is desirable to record the variation of scour depth with the decreasing river discharge. This will aid us in understanding the complete development of scour hole.

Fig. 1 - Map of the bridge site

Fig. 2 - View of the gorge with the glacier on the left and a steep mountain cliff on the right

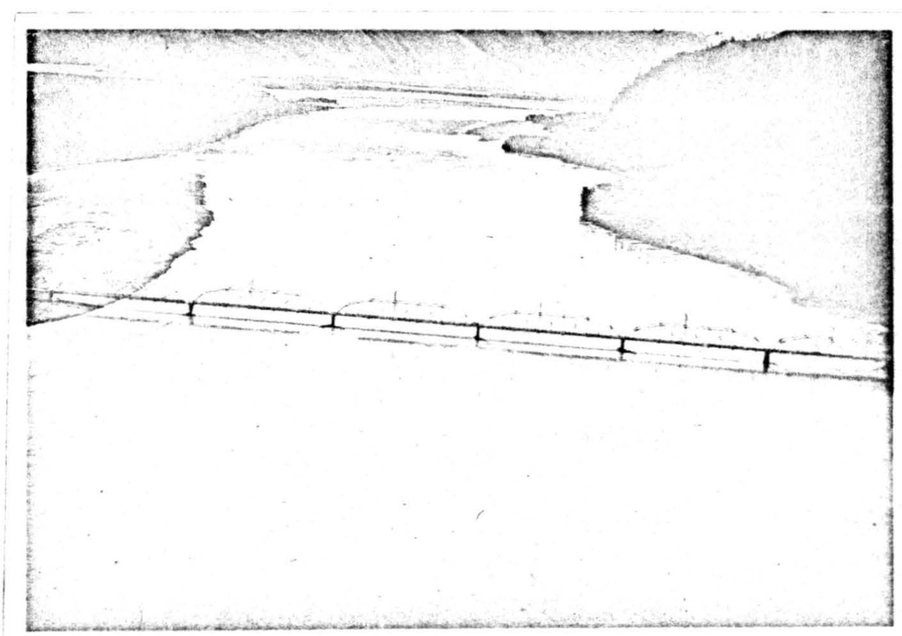

Fig. 3 - River bend two miles upstream from the Knik River bridge

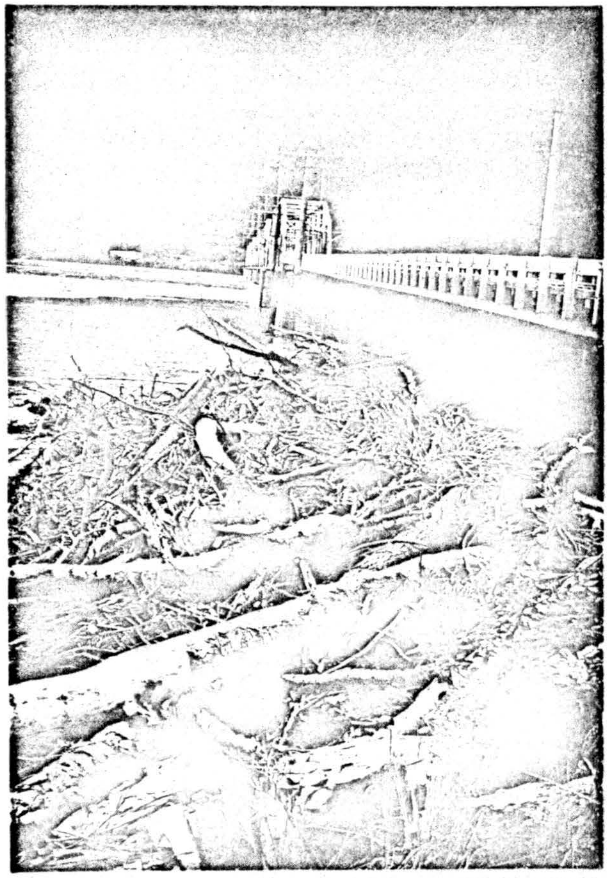

Fig. 4 - Overall view of the bridge

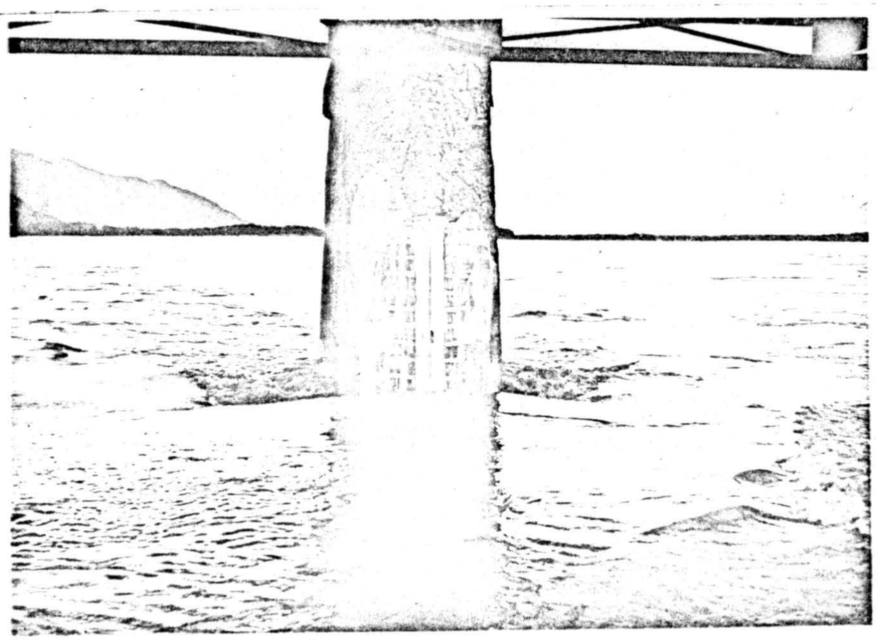

Fig. 5 - The scale painted on the pier used to read the water surface

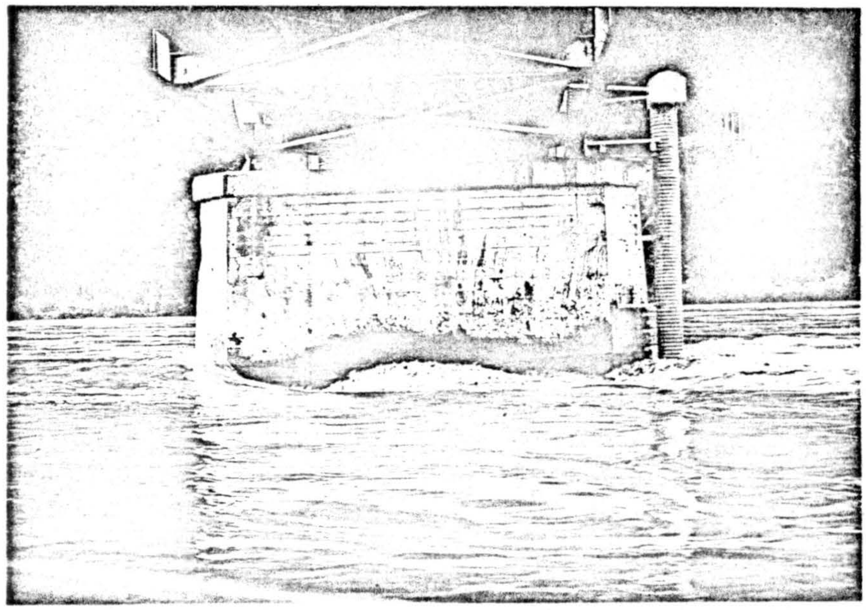

Fig. 6 - Water surface at medium flood stage

Fig. 7 - Upstream water surface profile at medium flood stage

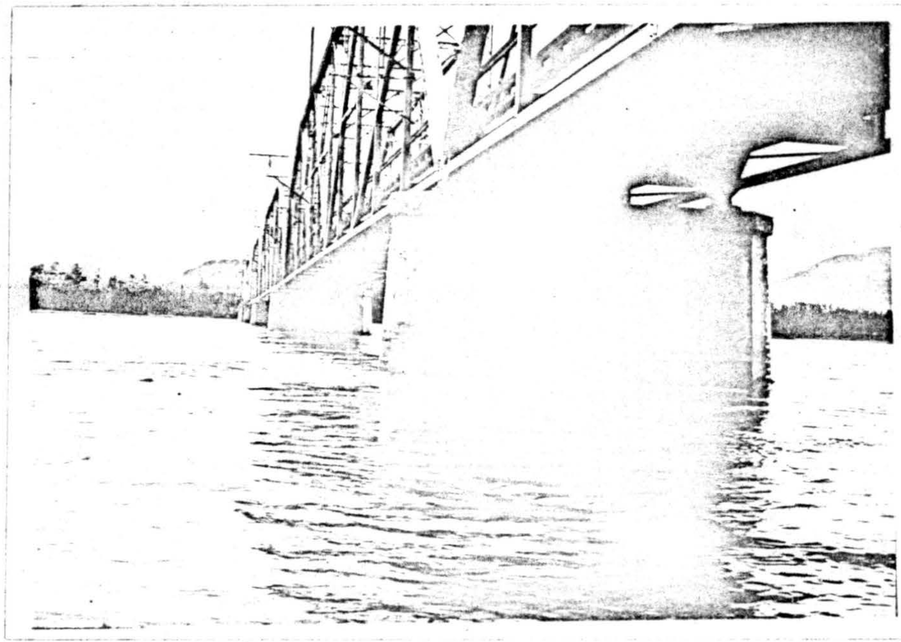

Fig. 8 - Water surface at low flood stage

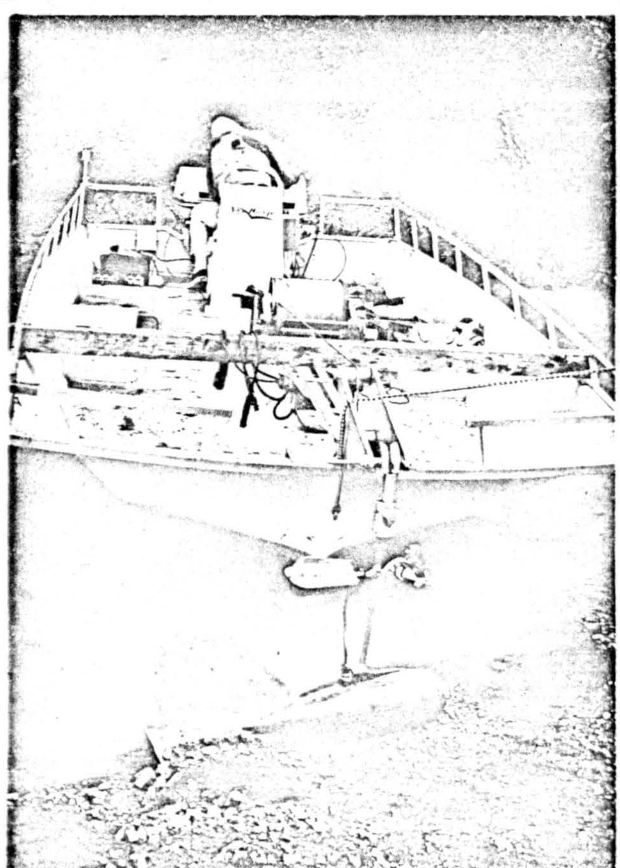

Fig. 9 - Aluminum boat A

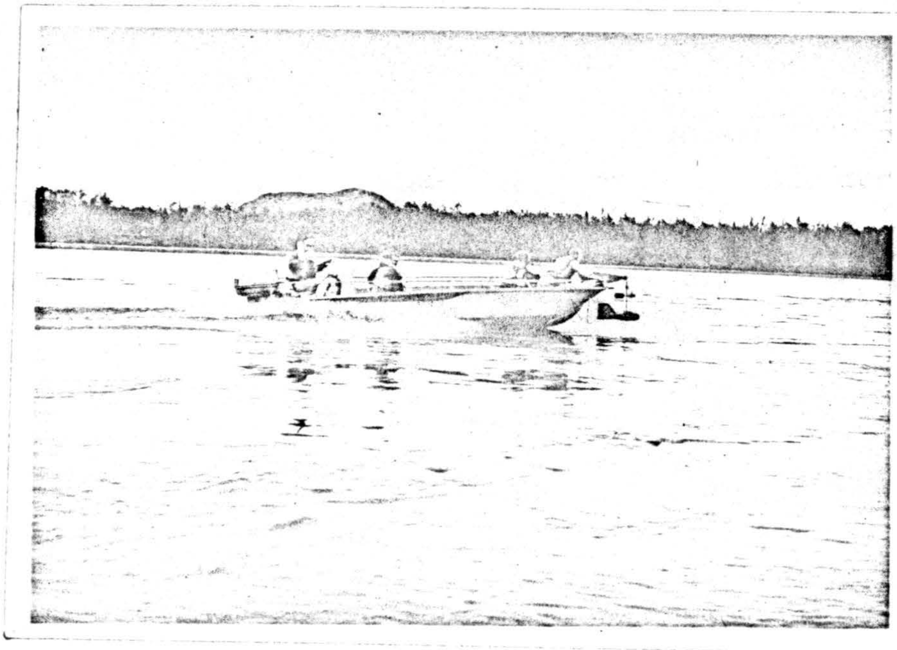

Fig. 10 - Aluminum boat B

Fig. 11 - Pilot attempts to move the boat at constant speed along the center line of one span

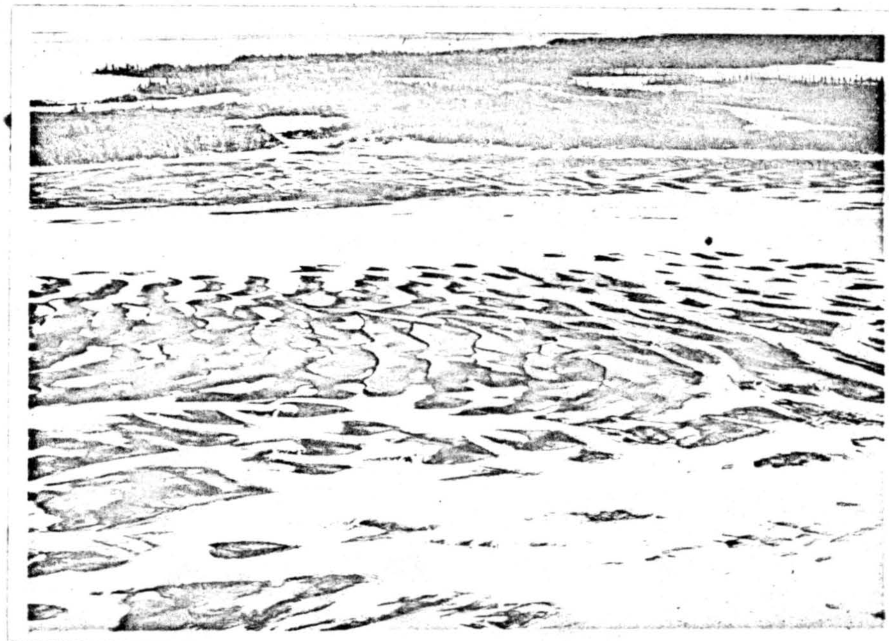

Fig. 12 - Bed form near the western bank after the flood has passed

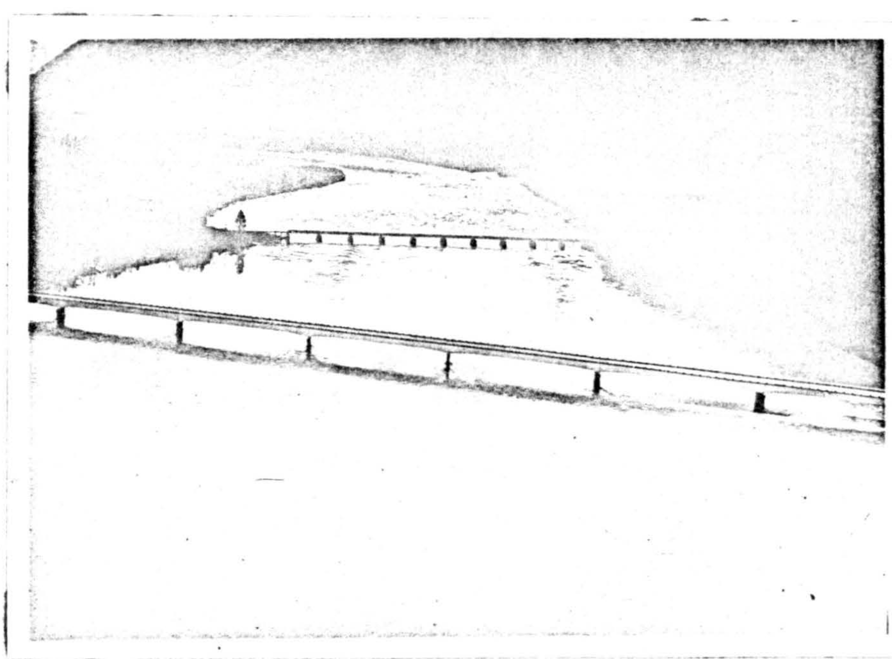

Fig. 13 - Knik Arm Bridge - new bridge on the Knik River which will be used for the scour study in 1966

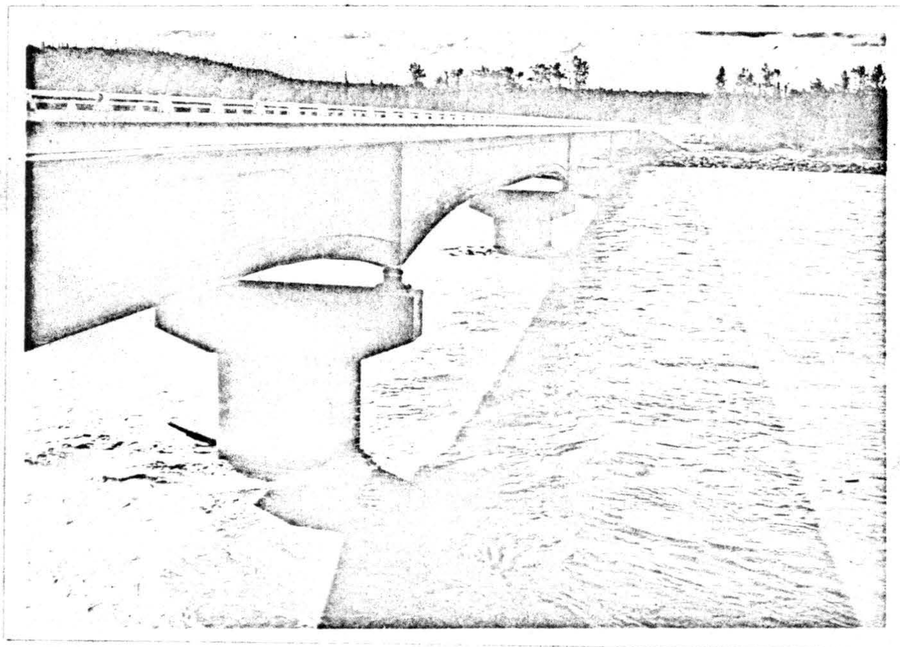

Fig. 14 - Sun Shine Bridge on the Knik River