Appendix B

Engineering Report on Bridge Study and Design, Teal Site, Imjin River, 2D Engineer Construction Group, 14 September 1952, With Selected Attached Documents

HEADQUARTERS
2D ENGINEER CONSTRUCTION GROUP
APO 971

Engineering Report on Bridge Study and Design,
Teal Site, Imjin River

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*Not reproduced

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14 September 1952

Engineering Report on
BRIDGE STUDY AND DESIGN
At the Teal Site, Imjin River, Korea

I. INTRODUCTION

1. If the Imjin River is viewed for the first time during normal weather conditions, a picture is revealed of a small mountain stream surrounded by rugged mountainous terrain lazily winding itself into the distance. The active channel is relatively small in comparison to the overall width of the river bed. It can easily be forded in most places. The almost vertical rock cliff banks, approximately 75 feet above low water, the wide dry river bed of about 1200 feet width, and the shallow active channel of about 150 to 200 feet width indicate that the Imjin River is approaching a state of old age. There is no indication during normal times of the monstrous force that the Imjin River actually develops during floods.

2. The Imjin River, fed by its tributaries and many small mountain streams, reaches flood heights of 48 feet above mean level and a velocity of 15 feet per second and discharges nearly six million gallons of water per second. The rapid runoff of approximately 95% of precipitation during flash floods has caused the Imjin River to rise more than six feet per hour. There is no specific information on what action occurs in the sand and gravel overburden in the river bed during a flood. However, experience with scour action and the floating out of piling which had 12 to 15 feet of penetration indicates that the overburden of sand and gravel in this fast-moving stream is unstable to a depth perhaps equal to the depth of the flood water in the stream, or to bed rock, which ever is less.

3. In the preparation of this report, extensive use has been

made of available technical data, reports, tests, drillings, and studies of other Korean river projects and studies made by Japanese engineers during their 36 years of occupation of Korea. Advice and assistance of technically qualified Korean engineers who worked with the Japanese engineers during their occupation has also been utilized (see Inclosure 1 for acknowledgments). This information together with knowledge gained by the U.S. Army Engineers during the two years of U.S. operations in Korea has been used to the maximum extent possible in preparing the analysis, designs, and recommendations contained in this report.

4. Attached as inclosures and referenced hereunder are copies of core drilling tests by Japanese engineers, hydrographic data obtained from Japanese records, and design calculations made by this headquarters, all of which have been used in this bridge design report. The flood conditions, which have not abated since 30 July 1952, have prevented accomplishment of core drilling at the Teal site, although contractors, equipment, and personnel have been available to start that work. Seismograph equipment and crews have not been found available to make quick profile studies of the river bed subsurface. A sheet-piling caisson will be sunk at the bridge site and soil samples taken for analysis as soon as the flood waters recede. Until this river bed exploration is completed, the soil structure of the river bed and its bearing capacity can only be assumed from geological studies and from interpretation of known data at downstream sites, which sites were studied by the Japanese engineers. It is believed that this interpretation is sufficiently accurate to provide basic design criteria and to allow construction estimates within about 15% accuracy.

5. Designs of two different basic types of bridges have been developed for the purpose of this report. A high-level, class-50 two-way, permanent type bridge for all-year use is our consideration of the only feasible structure that will insure uninterrupted year-around use and be able to withstand normal annual and expected floods on the Imjin River. Its design is restricted to materials generally available in Korea. Due to the cost in materials and construction effort and length of time required for construction of a permanent bridge, an alternate type design for a low-level fixed bridge is offered for consideration. The low-level

bridge is considered stable against flood damage but it will not be usable during high floods.

6. Design drawings and construction estimates for the high-level permanent bridge and the one-way low-level and two-way low-level bridges are attached as separate plans. It is considered that the results of the core drilling (yet to be performed) will not affect the bridge design, but will only indicate the depth to which piers will have to be sunk.

7. Time has not permitted the development of detailed specifications and construction schedules for each of the bridge plans submitted herewith. Preliminary estimates of time and construction effort required for each type of bridge are included in the report. Upon notice by higher headquarters of the design approved for construction, the specifications and construction schedule for that design will be prepared and submitted for approval.

II. THE PROBLEM

8. A high-level one-way timber bridge was constructed over the Imjin River at the Teal site (CT 174057) during the winter of 1951–1952. That site is within three miles of the present front line (MLR). Timber piling and timber bents were used for all piers except the three piers adjacent to the north bank of the river, which piers had steel H-beam piling. During the floods of July and August 1952, the bridge was lost due to damage by flood action. Report of this headquarters to the Engineer, EUSAK [Eighth United States Army, Korea], 20 August 1952, subject: "Preliminary Analysis of Damages to Imjin River Bridges during the Flood of 30 July 1952," provides information on damages suffered to that time. The flood of 24 August 1952 washed out about one-half the structure then remaining. The Engineer, Eighth Army, subsequently ordered the remaining structure removed and salvaged.

9. In Operations Order No. 33, 13 August 1952 (Incl 2), the Engineer EUSAK directed this headquarters to submit design data, specifications, and construction plans for a "class-50, two-lane Hi-level Highway Bridge over the Imjin River in the vicinity

of the Teal site." Such bridge is proposed to replace the original Teal bridge and is desired to provide a river crossing to be used in support of combat units located north of the Imjin River in that vicinity. The purpose of this report is to meet the requirements of Operations Order No. 33.

III. DISCUSSION

10. The report of 20 August 1952, referenced in paragraph 8 above, reflects the opinion of this headquarters concerning the unstable overburden in the river bed above bed rock. It is appreciated that this opinion cannot be proven until the river bed exploration is completed and the soil is analyzed. However, evidence now available is so strongly indicative of the instability of the overburden in the river that it appears necessary to base the bridge design on that assumption. From an analysis of the Honker bridge design, it appears that the Japanese engineers apparently reached the same conclusion during the time of their occupation of Korea. (See report referenced in paragraph 8 above.) The best qualified Korean engineers (who also worked with the Japanese engineers) were recently consulted on this matter and were found to be firm in the same conviction. Records of core drillings at the Honker site (CS 086968) (Incl 3) provided by Korean engineers from Japanese records, indicate an average depth of overburden of about 20 feet.[1] A geological study furnished by the Engineer FECOM [Far East Command] (Incl 4) indicates that the overburden may be somewhat less upstream from the X-Ray site (CT 095013), perhaps about 15 feet in depth. For the purpose of this study and until core drillings are obtained, an average depth of overburden is assumed as 20 feet.

11. Hydrographic data (Incl 5) was obtained from records compiled by Japanese engineers during their occupation of Korea. Those records are now in the files of the Bureau of Public Works, ROK [Republic of Korea]. This data agrees generally with the data provided by FECOM in the report referenced in paragraph 10 above (Incl 4). A surveyed cross-section of the Imjin River channel at the Teal site, together with high water records plotted thereon, is included at Incl 6.

12. The high-level bridge proposed for consideration is designed for use of construction materials and equipment normally available through supply channels in Korea.. There may be some necessary items of materials and equipment in short supply, and if actually found to be not available (and no suitable substitutes), their shortage may be the deciding factor in selection of the bridge design. A listing of these suspected critical items is included with the inclosure for each separate type design. There are not believed to be any critical items required in construction of the low-level bridges proposed for consideration, although special supply action may be necessary to procure some of the materials and equipment required.

13. Simplicity of design for early construction of a bridge in Korea is necessary due to lack of construction skills, lack of special handling equipment, speed of construction desired, and economy in use of construction forces and materials. Several alternate sites were studied, and several alternate designs and combinations were made and preliminary cost estimates prepared of each for comparison. Two basic types of bridges are developed in the designs offered for consideration, and all of the other alternates considered have been eliminated without inclusion in this report. The original Teal site (or possibly 50 feet upstream depending on results of core drillings) was found to be the most economical site for construction of a high-level bridge, and a slightly further upstream site was found to be the most feasible for construction of a low-level bridge.

14. The high-level bridge is a design using four 48” I-beams, continuous section over two spans, with 121' 4" spans. The decking is corrugated metal sheets 5/32″ x 13″ x 13' with a 4" concrete wearing surface. Wood decking is offered as an alternate for consideration. The piers finally selected, after studies were made of several different designs, are reinforced concrete with a solid base (tied into bed rock) extending to approximately mean low water level, with two vertical columns (essentially forming a bent) 5′ × 4’ at base and tapering to 3’ × 4’ at the cap. Construction details are shown on the attached drawings, Plan A. Design computations, cost estimates, and a listing of suspected critical items of materials and equipment are included at Incl7. Assuming that work can be started on the high-level bridge by 1 October

1952, and that all necessary supplies and equipment can be made available without undue delay, the bridge should be completed by June 1953; although a tremendous workload will be required after the spring thaw. This construction schedule assumes that concrete work, except the base of the piers, will not be feasible during the winter from about 15 December 1952 until 1 April 1953. The construction effort will be about eight Battalion months. The estimated total cost is $1,167,366.00.

15. An alternate plan of construction for the same high-level bridge is under consideration and will be studied in more detail if the high-level bridge is authorized for construction. The major change in design would be constructing skeleton bents of 24" I-beams (cross-braced), with the beams set in the base of the concrete pier. The concrete base could be constructed during the cold weather period but it would not be feasible to pour the concrete columns during the winter months (on either of the two designs). The superstructure could then be constructed on the skeleton bents and should be completed by the end of the extremely cold weather. About April when warmer weather arrives, the bents could then be encased in reinforced concrete, the concrete decking poured, and the bridge would then be ready for traffic. This method would be more expensive in total steel used, but would require about 25% less reinforcing steel. It would allow a more balanced work schedule by taking the maximum workload off of the final two to three months and allowing a balanced or full work schedule during the cold weather months, thus insuring completion on schedule, barring serious accidents.

16. A low-level fixed bridge is offered as a less expensive solution to provide a river crossing before the winter ice season. This bridge is designed to withstand damage by floods and would allow traffic at all times when the river is below a 10-foot level. The piers, on 69-foot centers, consist merely of a sheet metal piling caisson driven to bed rock, excavated and tied in to bed rock with a reinforced concrete slab, refilled and compacted with rock and gravel, and sealed with a reinforced concrete cap. Two 36” I-beam girders, with 12” I-beam saddles to support M-2 treads, will suffice for a one-way traffic class-50 bridge. Construction details are shown on the attached drawings, Plan B. Design computations, cost estimates, and a listing of items of materials

and equipment that may require special supply action are included at Incl 8. About six to seven weeks construction time by one Construction Company reinforced is estimated for completion of this bridge. The estimated total cost is $498,053.00. All materials above the piers can be salvaged if it is desired to remove the bridge at a future date.

17. A restricted two-way class-50 low-level bridge, 20' 2½" width, basically similar to the one-way bridge described in paragraph 16 above, is offered for consideration. A wider pier, addition of a third 36" I-beam girder and a third M-2 tread, with wider fill between treads, is the only difference. This bridge will allow two-way traffic for all military vehicles except those exceeding a width of about 100", and provided a maximum load of 90 tons per span is distributed between the three 36" girders (30 tons allowable load per girder). Construction details are shown on attached drawings, Plan C. Design computations, cost estimates, and a listing of items of materials and equipment that may require special supply action are included at Incl 9. About ten to twelve weeks' construction time by one Construction Company reinforced is estimated for completion of this bridge. The estimated total cost is $672,843.00.

18. An unrestricted two-way class-50 low-level bridge, 24' in width, basically similar to the one-way bridge described in paragraph 17 above, is also offered for consideration.[2] Four 36" I-beam girders will be required. A corrugated sheet metal decking with 4" concrete wearing surface, similar to the decking designed for the high-level bridge, is proposed for the unrestricted two-way traffic bridge. A schematic drawing with cross section and elevation is attached as Plan D. Design computations, cost estimates, and a listing of materials and equipment that may require special supply action are included at Incl 10. About twelve to fourteen weeks' construction time by one Construction Company reinforced is estimated for completion of this bridge. The estimated total cost is $702,093.00.

19. If bed rock could be reached at depths less than 20 feet below the river bed, and if the overburden allows an easy penetration of the sheet piling, it is possible that the construction time can be reduced for the type of bridges shown on Plans C and D.

However, such assumptions cannot be considered at this time, particularly with knowledge that some H-beam piling previously driven at the Teal site has reached penetrations of 17 feet.

IV. CONCLUSIONS

20. In view of the short construction time available before ice season starts, it is important to obtain early approval of the bridge design to allow maximum use of the good construction period prior to mid-December.

21. From information presently available, it is our opinion that the only type of high-level bridge capable of withstanding the force of an Imjin River flood is a permanent type structure embedded in bed rock, designed to shed debris and of sufficient strength to withstand normally expected impact loads with the river in flood stage. Reinforced concrete piers on a solid mass reinforced concrete base appear to provide the only feasible and economical solution to meet these criteria.

22. Working under weather conditions normally expected in this country and with equipment, material, and construction forces available to this command, a satisfactory high-level bridge cannot be completed until June 1953. About eight Battalion months of construction effort will be required for its construction.

23. A low-level fixed bridge can be constructed that will be available for traffic by December 1952 (prior to the ice season). Such bridge is expected to be able to withstand the forces of the Imjin River in flood without suffering damage, but it will not be usable when the river is more than 10' above mean low water. Cost in materials and construction effort is relatively inexpensive in comparison to the high-level bridge. Data are not available in this headquarters as to the average number of days per year such low-level bridge would not allow traffic, but from knowledge of recent floods, it is believed that traffic would be closed for less than a total of three weeks out of each year.

24. A choice of three different types of low-level bridges is offered. The most economical type for two-way traffic is Plan C

(restricted two-way traffic). It does not appear economically feasible to plan for two-way maximum loads. Such traffic could be easily controlled, and besides it would be unusual to expect such allowance on Korean bridges. Superstructure on this bridge is salvageable.

25. It is not considered economically feasible to complete a bridge as shown on Plan D (unrestricted two-way traffic) until after the thaw season, due to difficulties that will be encountered in laying a surfacing material on the bridge during the ice season. Use of timber decking would allow completion in January 1953 of a similar type bridge, provided construction is authorized without delay.

26. A permanent bridge over the Imjin River at the Teal site is not presently foreseen as of material value to the permanent Korean transportation system. The civilian needs are for a road system between Seoul and Kaesong; the appropriate location for an Imjin River crossing for that route would be at the Honker site (CS 086968). A second preference would be at the X-Ray site (CT 095013). The Teal site is considerably upstream from a desirable crossing for permanent value to the Korean transportation system. Hence a permanent bridge at the Teal site would be primarily of military value only. And if an armistice is signed on the presently understood terms, the Imjin River will probably be in the neutral zone.

V. RECOMMENDATIONS

27. Construction of a low-level fixed bridge over the Imjin River at the Teal site is recommended. It is further recommended that a bridge be approved which is basically similar to the design shown on Plan C (two-way restricted traffic).

HEADQUARTERS
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APO 971

ACKNOWLEDGMENT

Acknowledgment is made of the valuable assistance rendered and technical data furnished for preparation of the engineering report by the following Korean engineers:

Mr. Chae Kyong Yol, formerly Chief, Bureau of Public Works, ROK

Messrs. Han In Sun and Rim Bon Kun, Seoul Bureau of Public Works

Mr. Chang Young Sheng, Chief Engineer, Kyong Gi Do [Kyonggi] Province

Mr. Kim Y. K., Chief Engineer, Korean National Railway.

HEADQUARTERS
EIGHTH UNITED STATES ARMY KOREA (EUSAK)
OFFICE OF THE ENGINEER
APO 301

OPERATIONS ORDER NUMBER 33

13 August 1952

1. 2d Engineer Construction Group:[3]

* * *

H. Submit design, data, specifications, and construction plans for class-50, two-lane Hi-Level Highway Bridge in the vicinity of Teal bridge, CT 175057. The information to include:

(1) Data compiled on river bottom soil structure and bearing capacity.

(2) Profile of river stages listing low, high, and mean water levels.

(3) Cross-sectional plot of river bed elevations.

* * *

FOR THE ENGINEER:

s/W. J. Himes
t/W. J. HIMES
Lt Col CE
Operations Officer

OFFICE OF THE CHIEF ENGINEER
GHQ, FEC

22 August 1952

FROM: Maj. Anderson
TO: Maj. Pusey, EUSAK Engr Sec[4]

Recently, someone from your office requested information on river bed conditions for a specific location. We had nothing readily available and were unable to give you any data then. Subsequent research revealed some data from which the attached study was prepared by a geographer in our Foreign Map Library and edited by a geologist. I don't know if this will help you at all at this date, but am sending it to you in hopes that it will. Please let us know if examination in the field reveals errors or omissions in this report. If we can help you in any way again, please let us know.

s/Andy
t/E. G. ANDERSON[5]
Chief
Research and Analysis Branch
Intelligence Division

1 Incl
Study

RIVER BED CONDITIONS
AT
YONGSAN-NI FERRY, IMJIN RIVER, KOREA

FOREIGN MAP LIBRARY
INTELLIGENCE DIVISION
OFFICE OF THE ENGINEER
HQ FEC
AUG 1952

FOREIGN MAP LIBRARY
OFFICE OF THE ENGINEER
HQ FEC

River Bed Conditions at Yongsan-ni Ferry,[6] Imjin River, Korea

The Imjin valley is located in a region of low mountains, formed on a bedrock consisting principally of metamorphosed sediments of pre-Cambrian age. These meta-sediments are widely distributed in the drainage area and consist of quartzite, limestone, phyllite, and amphibolite with admixture of mica schist and schistose gneiss. Also, some porphyry, granite, and basalt are found locally in the district. Among these rocks, only the more resistant materials, such as quartzite, phyllite, etc., are transported and deposited in the streams, though some basalt may come from local areas of outcrop.

At an earlier stage, the Imjin River cut its valley in approximately its present location, and that valley formed the avenue of movement for a series of basalt flows, partially filling it. These basalts now extend to the village of Yongsanni on the west side of the valley and to Kumgong-ni on the east side. The present Imjin flowed on this basalt surface and has since cut through the existing valley, showing cliffs of basalt as far as Yongsanni on the west side and farther downstream on the east. Terraces, indicating several stages of downcutting, have been formed along the stream.

The influence of the tide acts on the water level of the river as far as Korangp'o-ri. Changes of level at the Yongsanni ferry are as follows:

Rise of level at spring high tide	+ 0.9 meters
Mean level of the river	0
Fall of level at low tide	– 0.5 meters

Floods of the Imjin are notable and may raise its level about 15m. above the mean. Below are data for several past floods:

Date	Water level above sea	Precipitation (in millimeters) During	At I'chon	At Yonch'on
22-23 Aug 1922	15.67m.	18–23 Aug	600-700	300-350

Date	Water level above sea	Precipitation (in millimeters) During	At I'chon	At Yonch'on
1 Aug 1933[7]	15.63m.	17 Jul-1 Aug	550–600	400-450
21 Jul 1924	16.09m.	11-27 Jul	750–	550-600
18 Jul 1925	16.37m.	15-27 Jul	600-	550-600

In this part of the stream, rapids are found at two places: to the north (upstream from Yongsan-ni) at Chajip'o, and to the south (downstream) near Changsan-ni. While bedrock is not reported visible in the stream at these points, the situation is suggestive of bedrock control. The lack of alluvial terraces or of broad alluvial plains at any point along the river in this sector plus the presence of rapids indicate a stream actively engaged in downcutting, a condition which does not allow for accumulation of any appreciable alluvial mantle. Furthermore, upstream from Chajip'o, bedrock is exposed along the stream bed; at Seoul, in the same geomorphic region, bedrock is exposed in the bed of the Han River. These factors indicate a lack of any general alluviation of stream valleys in this part of Korea. It should be noted, however, to the west of the Imjin, tributary valleys are apparently alluviated to some depth. This is probably only as a result of one-time damming of these local tributaries by the basalt flow in the main valley.

The longitudinal section is from a reconnaissance of the River Dept., Korean Government General's Office, 1929. Between the rapids of Chajip'o and Changsan-ni, three deep points in the stream bed are indicated: Korangp'o-ri, 3.5 meters below mean water level; a point 900 meters above Yongsan-ni ferry, 5.7 meters below mean water; and near Imjin-ni, 10.5 meters below mean water. As these occur at the apexes of several meander curves, they are the points of most active stream erosion and, in an actively downcutting stream, may be assumed to be on bedrock. By connecting these deep points in the profile, we have what may be assumed to be the ***maximum*** depth to bedrock beneath the river surface.

Though the actual river bed at Yongsan-ni is masked by alluvium, this is considered to be thin. At the ferry, the river is 2.4 meters deep. As bedrock is assumed to be 5.7 meters below the surface, 900 meters upstream, there is a difference of 3.3 meters representing the maximum probable depth of alluvium in the axis of the stream. This figure may probably prove to be high, as the bedrock surface generally rises in the straight stretches of a stream, for there the effective stream erosion is not so great as at the apex of the meander curve. On the west bank of the Imjin at Yongsan-ni ferry, alluvium may be slightly thicker than on the east, this especially below the mouth of the small tributary just south of the ferry.