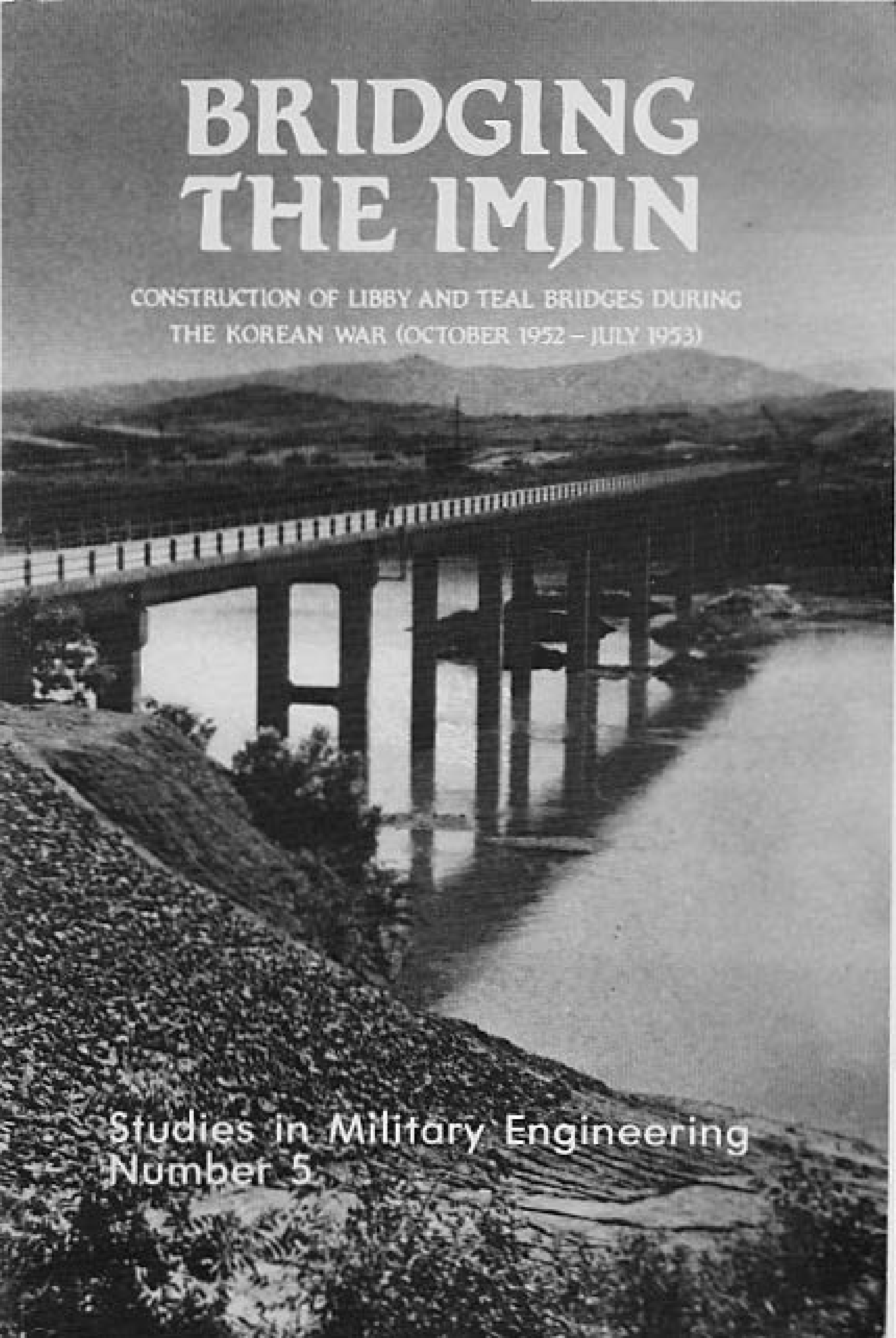
BRIDGING THE IMJIN

CONSTRUCTION OF LIBBY AND TEAL BRIDGES DURING THE KOREAN WAR (OCTOBER 1952 – JULY 1953)



Studies in Military Engineering
Number 5

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. **THE COVER**

View of the Libby bridge from the west bank of the Imjin River soon after the bridge's completion in June 1953.

BRIDGING THE IMJIN

CONSTRUCTION OF LIBBY AND TEAL BRIDGES DURING THE KOREAN WAR (OCTOBER 1952–JULY 1953)

by

William R. Farquhar, Jr.

and

Henry A. Jeffers, Jr.

edited and with an introduction by

Charles Hendricks

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Foreword

As the 40th anniversary of the Korean War approaches, we in the Corps of Engineers should reexamine how our predecessors overcame the engineering challenges posed by the rugged and unforgiving environment in which that war was fought. A number of memoirs and studies have evaluated Korean War combat in some detail, but thus far little has been published about the U.S. Army engineers' wartime efforts to conquer the Korean terrain with highways, bridges, ports, and pipelines. ***Bridging the Imjin*** represents a beginning in the effort to fill that gap.

During the last two years of the Korean War, the flood-prone Imjin River, whose waters could quickly rise 40 feet, flowed just a few miles behind a long stretch of allied battle lines. Army engineers thus faced a critical requirement to construct secure bridges across that water barrier. This book examines the efforts of one engineer unit, the 84th Engineer Construction Battalion, and its superior command echelons to overcome the serious challenges posed by the unpredictable waters of the Imjin. The battalion's story is spiced with interesting examples of creative engineer responses to deficiencies of equipment, building materials, and trained manpower, circumstances that are so typical of wartime field construction. The 84th Engineer Battalion more recently served seven years in Vietnam and now is stationed in Hawaii.

An important contribution of this volume is the publication for the first time of a 1953 report on the construction under difficult field conditions of two durable bridges across the Imjin. This historical report and the attached documents and photos assembled by its authors lay largely unnoticed in federal repositories until unearthed by our staff historians. Combined with an introduction that places the report in context, this history provides an instructive example of imaginative engineering in the face of challenging wartime requirements.

ALBERT J. GENETTI, JR.
Colonel, Corps of Engineers
Chief of Staff

Editor's Preface

Korea's monsoon rains and the floodwaters they spawned posed some of the most difficult technical challenges faced by the United States Army engineer units serving in the Korean War. Nowhere were those challenges more pressing than along the lower Imjin River, where tides, ice, and summer floods repeatedly threatened to break critical supply lines to United Nations forces which for two years manned defensive lines just ten kilometers northwest of the river. After struggling for more than a year with mixed success to span the lower Imjin with bridges that could survive the stream's fury, American military engineers finally conquered this river in the last year of the war with two modern bridges erected at sites where earlier spans had failed.

A report prepared in Korea by the military history staff of the 8086th Army Unit tells the story of the construction of these two successful spans, known as the Teal and Libby bridges. Majors William R. Farquhar, Jr., and Henry A. Jeffers, Jr., drafted the narrative report in 1953 and attached to it copies of a number of related documents. The U.S. Army Center of Military History holds a typescript copy of that report. Farquhar and Jeffers provide an instructive account of the accomplishment of a difficult wartime engineering assignment, one which required considerable imagination, determination, and perseverance. Innovative techniques developed by officers and enlisted men of the battalion served to overcome the difficulties imposed both by the physical problems involved and by the shortages of equipment and trained manpower. As my introduction to their report explains, U.S. Army engineers found that it was no easy task to overcome the wartime challenges of the, Imjin River.

In editing Farquhar's and Jeffers' valuable narrative, I have attempted to modernize or correct the spelling and grammar, and, in several instances, I have corrected minor misstatements of fact in order to avoid discrepancies between the report and contemporary documents. I have also amended the footnotes of the original study. I selected for publication 46 photographs drawn from the 57 included with the original report and 31 others taken from the collections of the National Archives, the Defense Still Media Records Center, the Office of History of the Corps of Engineers, and the Combined Field Army (ROK/US). The book contains four maps, which I prepared using information contained on contemporary maps found in unit history records in the National Archives.

I selected for this publication the documents contained in three of the eleven appendixes attached to the original report and added a fourth appendix drawn from a contemporary document. Appendix A, taken from Tab 3 of the original study, contains the official correspondence in which I Corps asked for the replacement of the failed high-level Teal and X-Ray bridges, and Eighth Army approved imaginative plans for new crossings there. Appendix B contains the engineering report of Eighth Army's 2d Engineer Construction Group that illustrates the manner in which the Teal site was evaluated prior to the decision to build a low-level bridge there. This appendix was at Tab 1 of the original study. Appendix C reproduces the section entitled "General Description" of the four-page mimeographed document "Libby Hi-Level Highway Bridge," which was prepared by the 84th Engineer Construction Battalion in 1953 and signed by Major William C. Carter, Jr., the battalion's operations officer. A copy of the document is contained in the Papers of William Clarence Carter, Jr., at the Office of History, Headquarters, U.S. Army Corps of Engineers. The last and longest of the appendixes is the "Log of Libby Bridge," written by Majors Carter and Sam E. Fairchild, his predecessor as operations officer of the 84th Engineer Battalion.

I have made every effort to preserve or, when required, to restore the integrity of the documents printed in the appendixes. The first three of these appendixes consist of documents that were copied manually from the originals by Major Jeffers. I have corrected copying errors found in the documents in Appendix B by comparing Jeffers' manual copies with carbon copies of the same documents drawn from Box 1 of the Papers of Frank Otto Bowman at the Hoover Institution Archives, Stanford, California. I have not found any other copies of the documents in Appendix A, and thus they appear substantially as copied in the 1953 report. I simply rearranged the sections of this appendix to put them in chronological order and corrected errors of spelling, grammar, and punctuation. I have not altered the hastily written "Log of Libby Bridge" except to correct spelling and punctuation, to add letters obliterated at the edges of the typed version of the log copied at Tab 7 of the original study, and to add explanatory notes. In doing this and in making the few factual changes required in the original narrative, I was greatly assisted by the late Colonel William C. Carter, Jr., who was the primary author of the log and the project superintendent of the construction of Libby bridge. I owe a special debt of gratitude for his help.

Sincere thanks are also due to the editors who have assisted my work on this publication—Chris Hardyman, Joyce Hardyman, and Diane Arms. Archivists Morris Izlar and Fred Pernell of the National Archives and Elena Danielson of the Hoover Institution on War, Revolution and Peace provided valuable assistance with documentary research and photo and map collection. Army cartographer Arthur S. Hardyman advised me on military map making. Robert R. Weekes prepared the cover.

CHARLES HENDRICKS

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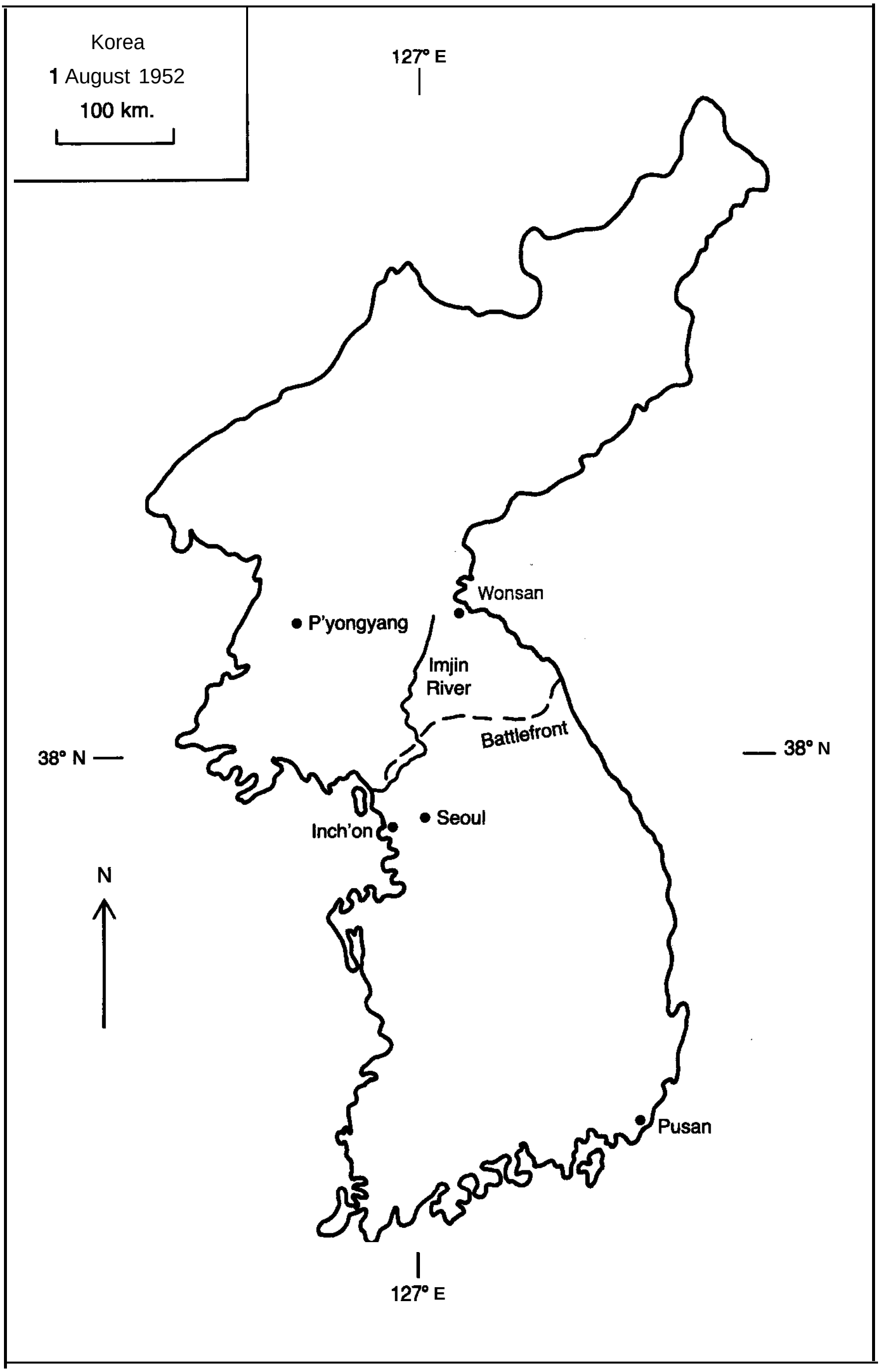
BRIDGING THE IMJIN

CONSTRUCTION OF LIBBY AND TEAL BRIDGES DURING THE KOREAN WAR

(OCTOBER 1952–JULY 1953)


Korea
1 August 1952
100 km.
127° E
P'yongyang
Wonsan
Imjin
River
Battlefront
38° N
38° N
Seoul
Inch'on
N
Pusan
127° E

MAP 1

Introduction

by Charles Hendricks

The Imjin River rises high in the Taebaek range along Korea's eastern coastline. *(Map 1)* Starting its journey less than 20 miles west of the important North Korean port of Wonsan, it flows south through the rugged central portion of the Korean peninsula, gathering with it the waters of the Komit'an, Yokkok, and Hant'an rivers before turning southwest at the 38th parallel to join the Han River as it approaches the Yellow Sea. While the Imjin appears no more than a sluggish stream during much of the year, the monsoon rains that mark the Korean summer regularly transform it into a mighty torrent during July and August.

The lower reach of the Imjin, stretching from the confluence of the Yokkok to the Han, gained considerable military significance during the last two years of the Korean War. In this period the western end of the main battle line between the United Nations and Communist forces stabilized along the plains and hills a few miles west and north of the river. From the crossing of the lower Imjin by American-led U.N. forces in June 1951 until the signing of the armistice on 27 July 1953, the vagaries of the Imjin's summer floods, autumn calms, winter freezes, and spring thaws posed continuous challenges to the Army engineers responsible for maintaining passage across its waters.

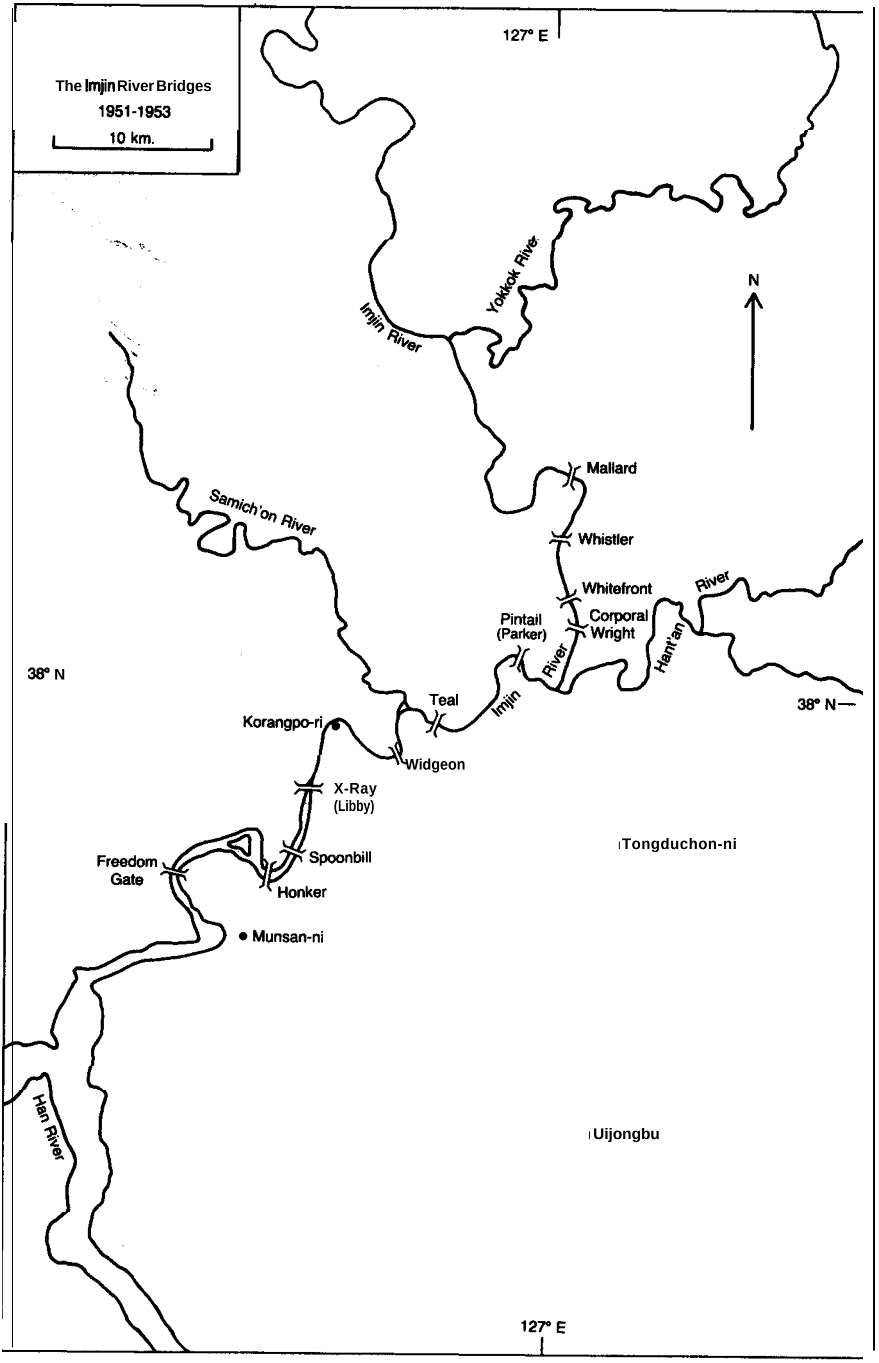
This volume tells the story of the construction during late 1952 and early 1953 of two bridges across the Imjin. Both represented innovative approaches to the problems posed by the river. The modern, high-level Libby highway bridge supported on concrete piers and abutments and the submersible, low-level Teal bridge built on 16-inch steel piles were novel solutions to bridging requirements located so near a battlefront. The building of these bridges climaxed a preliminary 15-month contest between the Army engineers and the Imjin, during which the engineers learned the devastating power of the river and began to devise solutions to its challenges.

The engineer confrontation with the Imjin began after the 1951 Communist spring offensive ground to a halt short of Seoul in May. United Nations forces on the western side of Korea led by Major General Frank W. Milburn, commander of the U.S. Army's I Corps, quickly resumed their advance, retook Uijongbu on 6 May, and reached the Hant'an River on the 25th. Three days later, I Corps' 58th Engineer Treadway Bridge Company bridged the Hant'an near where it flowed into the Imjin. The 408-foot floating bridge built by the company supported the advance of the 1st Cavalry Division.[1]

The same company, aided by elements of I Corps' 1092d Engineer Combat Battalion, began on 6 June to construct a 492-foot M-2 floating treadway bridge across the Imjin roughly 3½ miles to the northwest. Designed to support the drive of the British 28th Independent Brigade, then attached to the 1st Cavalry Division, the bridge's ponton rafts had to be assembled one-half mile downstream from the bridge site and then towed there by amphibious trucks (DUKWs), utility boats, and manpower. Construction was interrupted by enemy mortar fire around dark and was not completed until early the next afternoon. It was named the Corporal Wright bridge in honor of Corporal Theodore Wright of the 58th Engineer Company, who died of wounds received during its construction.[2] *(Figure 1) (Map 2)*

During June, United Nations troops pressed their advance in the mountains east of the Imjin and north of the Hant'an but undertook only raids and patrols west of the Imjin. In making these raids, the U.N. forces relied upon floating treadway bridges, 50-ton capacity ferries, and footbridges installed at three sites on the lower Imjin. The Corporal Wright bridge was replaced by a ferry and a footbridge on 26 June; another ferry and footbridge were installed 3½ miles north at what would become known as the Whistler site; and during 20-22 June the 58th Engineer Company and Company A, 14th Engineer Combat Battalion, installed a second M-2 steel treadway bridge 16 miles southwest of the Corporal Wright bridge at what the Americans would later call the Honker site. This last bridge stood astride the main road from Munsan-ni to Kaesong, Korea's medieval capital, and it enabled a tank and infantry force of the Republic of Korea's 1st Division to stage a successful raid on Kaesong.[3]

Because of the danger of a new enemy offensive, I Corps engineers removed the Honker bridge only four days after its


The Imjin River Bridges
1951-1953
10 km.
127° E
Yokkok River
Imjin River
N
Mallard
Samich'on River
Whistler
Whitefront
River
Pintail
(Parker)
Corporal
Wright
River
Hant'an
38° N
Imjin
38° N
Teal
Korangpo-ri
Widgeon
X-Ray
(Libby)
Tongduchon-ni
Spoonbill
Freedom
Gate
Honker
Munsan-ni
Han River
Uijongbu
127° E

MAP 2

completion and replaced it with a ferry. Even farther downstream, the Korean division in late June blew a 234-foot gap in the Chinese-built railroad bridge on the main rail line from P'yongyang to Seoul. The Koreans acted on the orders of the I Corps engineer, Colonel Emerson C. Itschner, a man who would later become Chief of Engineers. But when the Communists proposed to hold peace talks at Kaesong, the companies that had constructed the June bridge at the Honker site built another floating bridge there on 2 July to accommodate U.N. delegates to the forthcoming conference.***(Figure 2)*** This time they employed a mobile crane and a platoon of dump trucks to build up the north shore approach road to protect it from high water.[4]

The United Nations forces were thus operating three crossing points on the Imjin when the 1951 rainy season began in earnest on 19 July. I Corps measured 5.22 inches of rain in the *48* hours beginning at noon that day, and by 21 July the Imjin had risen to 11.8 feet. The 1st Cavalry Division's 8th Engineer Combat Battalion attempted to remove the Whistler footbridge, but began too late and lost one-third of it. The footbridge at the Corporal Wright site washed out completely. One section of footbridge slammed into the ferry at the latter site and sent it a mile downstream. Together with a disabled DUKW and other debris, the runaway footbridge then floated all the way down to the Honker site where it hit and bent the floating bridge, putting it out of service for three days. Colonel Itschner observed, "A lesson learned during this latest period is that no floating equipment is dependable under heavy flood conditions with large quantities of debris."[5]

American engineers constructed a new footbridge and ferry at Whistler in late July, but more high water on 1 August washed them out. Nevertheless, corps engineers began the more ambitious task of building a floating treadway at the Whistler site on the very same day. Although they had to suspend work for a time because of the flood, they managed to complete a 600-foot-long bridge by the morning of 3 August, when tanks of the 1st Cavalry Division rumbled across in an offensive drive. ***(Figure 3)*** The fate of this bridge was typical of I Corps' problems with the Imjin that August. High water two days later forced the engineers to swing the bridge to shore, and the receding river left it high up on the bank. Rebuilt on 6-7 August, the bridge was finally dismantled on 9 August during a new flood?

The flood of 1 August also swept away the Honker floating treadway. American engineers rebuilt it over the next two days and then swung it to shore during the floods of 5 and 9 August. But the bridge broke loose from its anchorage at 11 AM on the 9th and floated all the way down to the Yellow Sea, despite the efforts of amphibious engineers to recover it. Eighth Army's 84th Engineer Construction Battalion rebuilt this bridge during 12-16 August but took it down three days later in the face of typhoon warnings. After the storm turned away from Korea, the battalion rebuilt the bridge again on the 26th and 27th. A day after its completion, new floodwaters once more destroyed the bridge.[7]

Fortunately for the engineers, enemy action that summer did not match the ferocity of the river. Observing again that "keeping floating bridges intact during heavy flood periods is an impossible task," Itschner was grateful that "the seriousness of the floods [was] reduced greatly by the quiet tactical situation; during a more active and operational period such floods could have proven disastrous to the UN troops."[8]

Shortly after the 1951 flood season ended in late August, I Corps pushed major elements across the Imjin River. The offensive began 7 September when a battalion of the 1st Commonwealth Division advanced to Chalmul. Two more battalions of this division and elements of the 1st Cavalry Division crossed the river the following day, advancing to a new Line Wyoming that ran west of the Imjin from Korangpo-ri northeast through Chalmul and Kangso-ri.[9]

The 58th Engineer Treadway Bridge Company and the 14th and 1092d Engineer Combat Battalions built three M-2 floating treadways across the Imjin on 8 and 9 September to support this advance. The 396-foot Pintail bridge just 2% miles below the Imjin's confluence with the Hant'an and the 456-foot Teal bridge 4 miles farther southwest supported the advance of the 1st Commonwealth Division. At Whitefront, 1¼ miles north of the old Corporal Wright site and 3 miles northeast of Pintail, the engineers completed a 540-foot floating bridge just before midnight on 9 September. These engineer units built a fourth floating treadway across the Imjin, the Widgeon bridge, on 20 September. While this bridge was only two miles southwest of the Teal bridge, the broad northwesterly bend in the Imjin between Widgeon and Teal jutted so close to Line Wyoming that supplies could not be safely transported on the Imjin's west bank between the two bridges.[10]

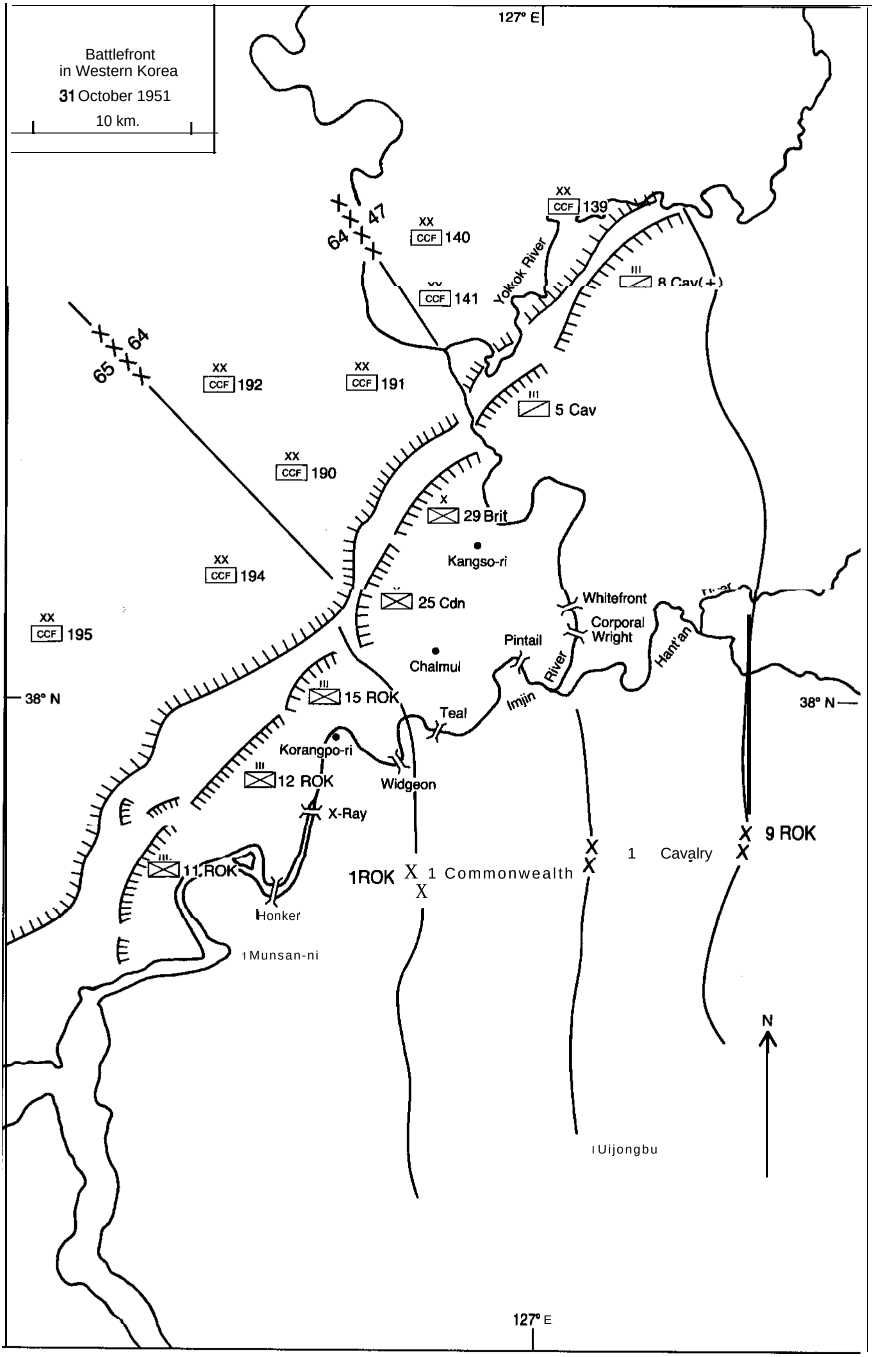
After a brief respite, I Corps pushed its limited advance forward another three to four miles to Line Jamestown in October. (*Map* 3) This new advance moved the Republic of Korea's 1st Infantry Division across the river and pushed the 1st Commonwealth Division comfortably beyond it. The Korean division's movement created a need for more bridges across the lower Imjin. I Corps engineers built a footbridge at Korangpo-ri, three miles downstream from Widgeon, in early October and replaced it with a causeway later in the month. They built a floating treadway at the X-Ray site three miles farther south and a floating footbridge six miles below Korangpo-ri on 18 and 19 October?

On 23 October, two days before the resumption of armistice talks at Panmunjom, the 84th Engineer Construction Battalion rebuilt the Honker floating treadway bridge to facilitate access to the truce talks. The Honker bridge was located just 1% miles below the footbridge that the Republic of Korea's 901st Light Ponton Company had installed 6 miles south of Korangpo-ri. Honker adequately served the area.[12]

As there were no bridges intact downstream from Honker, I Corps ordered the Korean company to remove the footbridge and transport it 3½ miles west of the Honker crossing to what would be called the Freedom Gate site. There, alongside the remains of the low-level railroad bridge that their countrymen had severed in June and the high-level rail crossing that had been broken earlier in the war, the 901st Company at the end of October twice more laid the footbridge across the Imjin. Each time, the powerful currents of a ten-foot tide washed it out. Colonel Edward Daly, the new I Corps engineer, finally conceded the impossibility of maintaining a floating bridge there.[13]

With winter approaching, I Corps engineers considered alternatives to the floating bridges. Beginning in September, they looked for appropriate sites for pile bridges. They knew that "if I Corps was successful in staying across the Imjin River, that these permanent bridges would be required to reduce the danger of flood and ice destroying the M-2 bridges."[14]

Not enough permanent pile bridges could be constructed before ice filled the Imjin, however. So in early November the engineers decided to replace the floating bridges with low-level fixed bridges that could be constructed quickly. In shallow water, rock-filled crib piers would support the span. The engineers would use pile piers where the river was at least three feet deep. In either


Battlefront
in Western Korea
31 October 1951
10 km.
127° E
XX CCF 139
XX CCF 140
CCF 141
XX CCF 192
XX CCF 191
XX CCF 190
XX CCF 194
XX CCF 195
64 47
65 64
Yokok River
III 8 Cav(+)
III 5 Cav
X 29 Brit
Kangso-ri
25 Cdn
Whitefront
Corporal
Wright
Pintail
Chalmul
Hant'an
River
Imjin
III 15 ROK
Teal
Korangpo-ri
III 12 ROK
Widgeon
X-Ray
III 11 ROK
Honker
Munsan-ni
1 ROK
1 Commonwealth
1 Cavalry
9 ROK
38° N
38° N
N
Uijongbu
127° E

MAP 3

case, the bridges would have a modified M-2 treadway deck suitable for tanks and a minimum clearance of five feet above low water. The approaches might include causeways to reduce the length of the bridge.[15]

The 72d Engineer Combat Company built the first bridge of this type. This five-span, 150-foot crib-pier bridge attached to a longer causeway crossed at the northernmost Whistler site, where only a ferry had operated since the removal of the floating treadway bridge during the flood of 9 August. Corps and army engineers installed other low-level fixed bridges at the Whitefront, X-Ray, and Widgeon sites in late November and December 1951. (*Figures* 5 *and* 6) The 62d Engineer Construction Battalion completed the new X-Ray bridge on 26 December, only five days before ice damaged the floating bridge there and forced its removal.[16]

Spanning the Imjin at the Freedom Gate site closest to its mouth proved to be difficult. After the effort to install a floating footbridge there failed at the end of October, the 1092d Engineer Combat Battalion proposed a suspension bridge connecting diagonally the two high-level railway spans, the central portions of which had been demolished. I Corps instead ordered the battalion to build a 1,450-foot-long and 20-foot-high pile footbridge just upstream from the destroyed railroad bridges. But as Lieutenant Colonel Andrew Inge of the 1092d complained during construction, "The design [of this footbridge] had been cut to the bone to reduce the number of piles and materials.... This resulted in practically no safety factor."[17]

Work on this pile footbridge proceeded slowly during November until an embarrassing mishap interrupted construction on the 30th. That evening a work crew left a raft, bearing a crawler crane that it used as a pile driver, anchored in shallow water. The receding tide beached the raft on the sloping riverbed, and the crane, which was not securely fastened, slid off into the muck. A five-day recovery effort, assisted by Navy divers, retrieved a virtually useless piece of equipment. Work resumed under stricter operating procedures on 10 December with a crawler rig borrowed from Eighth Army, and the footbridge was completed on 2.1 December. By then ice had begun to appear on the Imjin, and on 4 January heavy floes carried by a strong tide destroyed a 160-foot section of the bridge?

A week before the destruction of the Freedom Gate footbridge, ice had broken the Honker floating treadway in two. The two losses left a considerable stretch of the lower Imjin without a bridge and provoked a flurry of activity among corps and army engineers. The I Corps engineer immediately had a 400-pound expedient cableway installed at the Freedom Gate site and ordered the 14th Engineer Combat Battalion to build a diagonal quarter-ton capacity suspension bridge between the broken high-level railway spans there. The Eighth Army engineer ordered his 84th Engineer Battalion to construct a low-level steel- and timber-pile bridge nearby. The bridge would stand on 30 steel bents in the main river channel and 66 timber bents on the river's edges and tidal flats. The battalion was required to build a deck suitable for both highway and rail traffic.[19]

Assigning two companies and devoting over 140,000 man-hours to this project, the battalion made rapid progress and was able to open the bridge on 15 February. (*Figure* 7) Six days later friendly aircraft mistakenly bombed the bridge and damaged seven bents. The 84th replaced all of the damaged bents except one which stood dangerously close to an unexploded 1,000-pound bomb that could not be removed. That area was spanned by a 36-inch I-beam supported on specially braced bents.[20]

The bridge-building success of the 84th at Freedom Gate led the I Corps engineer to suspend work on the light suspension bridge there on 4 February 1952, when it was 61 percent complete. Toward the end of that month, I Corps built one more bridge across the Imjin farther north than the other available crossings. This was a 168-foot-long rock-crib bridge three miles north of the Whistler bridge at the Mallard site.[21]

Although well suited for the river's ice, neither the low-level bridges on rock-crib piers nor the one atop pile piers at the old Freedom Gate railway crossing could be expected to withstand the Imjin's summer floods. The September 1951 surveys had been designed to locate sites for permanent high-level crossings, and by the end of October, planning had advanced sufficiently to permit the 84th Engineer Construction Battalion to begin work at Pintail on a timber-bent bridge supported on pile piers that would stand 43 feet above mean low water. The river was only about 420 feet wide at this point, but the bridge was designed to have a length of about 1,000 feet to connect the river's banks at its own height.[22]

After the 58th and 72d Engineer Companies moved the Pintail floating treadway to make way for the new high-level crossing, the 84th Engineer Battalion found that the rocky river bottom there prevented the sinking of timber or steel piles. Seeking a secure crossing of the Imjin without delay, Eighth Army engineer officers quickly ordered the battalion to construct at the Teal site a bridge very similar to the one planned for Pintail. The Teal bridge was a one-way, 50-ton-capacity timber-trestle bridge that was 1,175 feet long and 48 feet high. *(Figure 8)* Timber piles supported the ten southernmost bents while steel piles carried the weight of the three bents to the north. The battalion finished the bridge on the last day of 1951, after investing 137,000 man-hours in its construction.[23]

In order to prepare more adequately for the summer floods, Eighth Army in February 1952 assigned its 62d Engineer Construction Battalion to widen and raise the X-Ray bridge and to build a new high-level bridge on concrete foundations at Pintail, where the 84th's earlier efforts had been aborted. Company C of the 62d undertook both assignments in March after the river's ice melted. Driving new piles and constructing timber bents, the company made rapid progress at the X-Ray site. In mid-April it installed the 24-inch I-beams that would carry the decking. The bridge opened to traffic on the 27th.[24]

The Pintail bridge progressed more slowly. Company C of the 62d poured the concrete foundations in late April and installed the steel pile and reinforcing rods in early May. The company launched the bridge's 48-inch I-beams in late May and June and poured the concrete decking in July. The bridge opened on 24 July, just days before the disastrous flood of 30 July 1952. Like the X-Ray bridge, Pintail was designed to have a 50-ton capacity as a two-way bridge or to support 80 tons one way.[25] *(Figure 9)*

As the 62d began work on the new X-Ray and Pintail bridges, the 84th Engineer Construction Battalion began a high-level bridge of similar capacity at the Whitefront site. The bridge was 1,184 feet long and stood 44 feet above low water on 13 timber trestle bents supported by steel piles. *(Figure 10)* Timber piling was tried, but it would not penetrate adequately even when a pile shoe was used. Company B of the 84th completed the bridge by the end of May, investing 111,000 man-hours in its construction.[26]

After reopening the low-level railway bridge at the Freedom Gate site, the 84th also began building a high-level Imjin crossing adjacent to it. The new bridge utilized the remains of the more

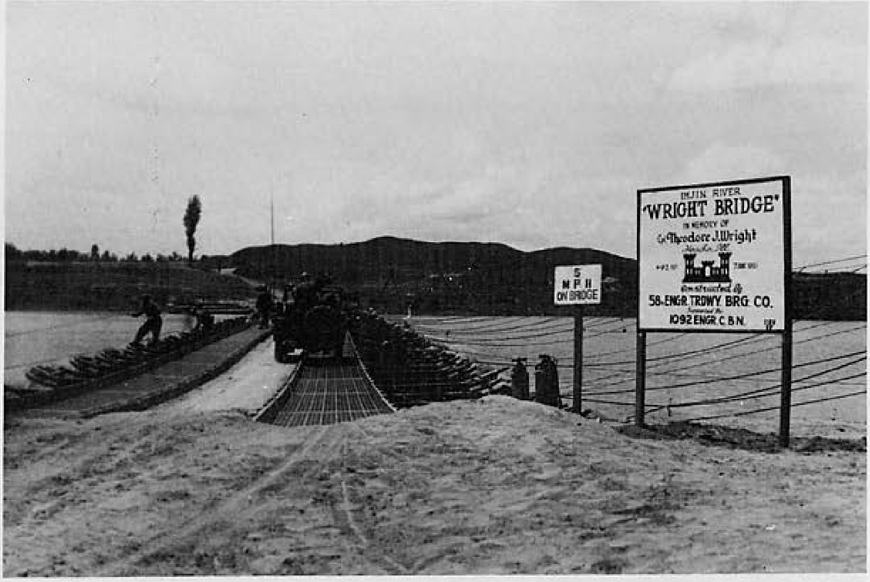


Figure 1. Jeep crossing the Corporal Wright ponton bridge on 13 June 1951.

Figure 2. U.N. delegates and newsmen crossing Honker ponton bridge on 15 July 1951 en route to an early peace conference session at Kaesong.

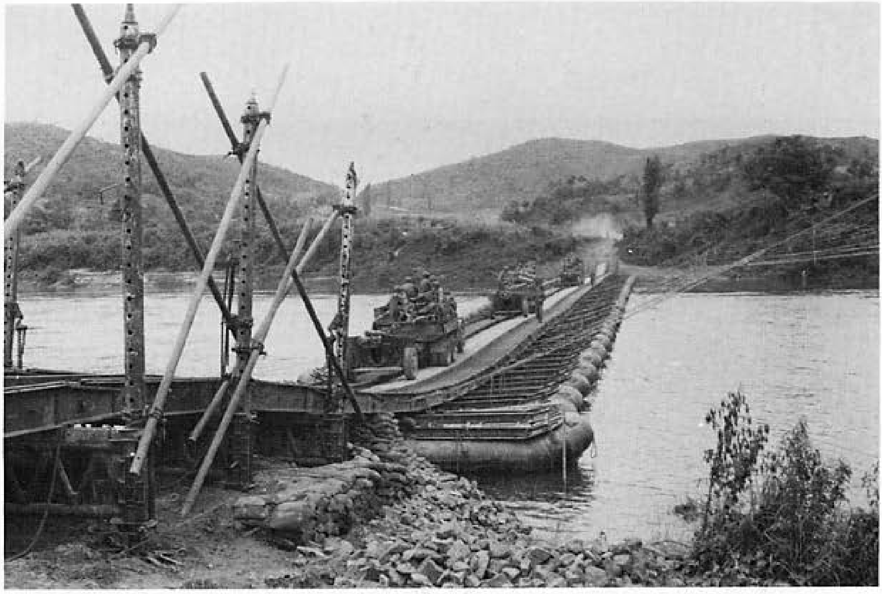


Figure 3. Artillerymen of the 1st Cavalry Division crossing the floating treadway bridge at the Whistler site in early August 1951.

Figure 4. High water on 6 September 1951 covering the site of the Honker ponton bridge, which had been washed away in a flood nine days earlier.

Figure 5. Jeeps crossing the M–2 treadway bridge that the 72d Engineer Combat Company built on rock-filled crib piers at the Whistler site in November 1951.

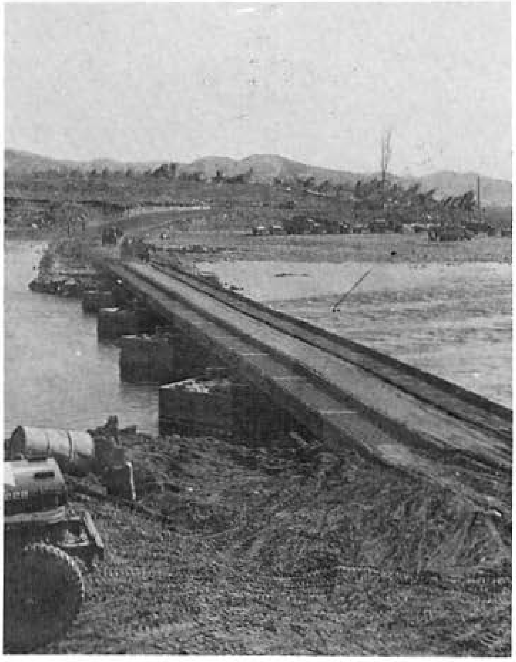


Figure 6. Construction of the Whitefront rock-filled crib-pier bridge in November 1951.

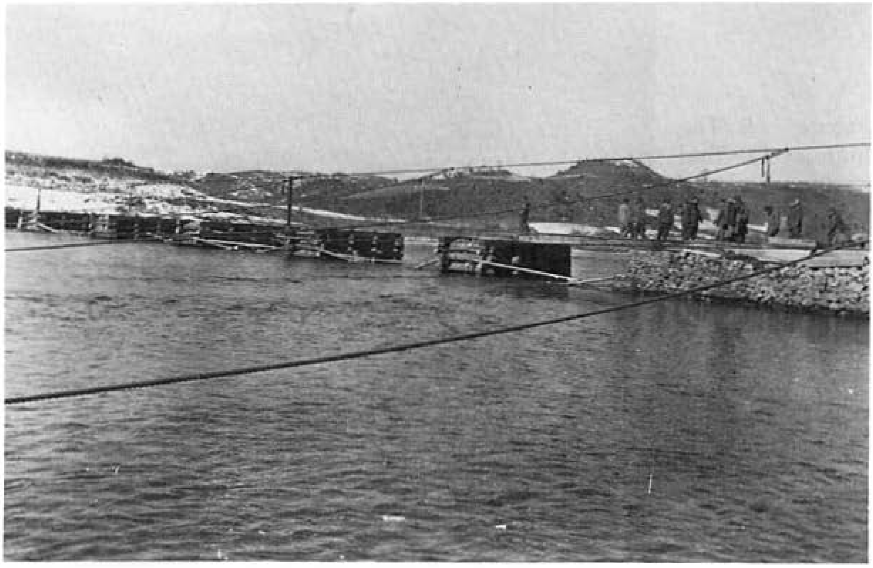


Figure 7. The low-level pile bridge at the Freedom Gate site that the 84th Engineer Construction Battalion erected in January–February 1952 between two destroyed railway spans. The shadow cast by the more southerly of the railway bridges, which the 84th would reopen in July 1952, is visible at the right of this 10 March 1952 photo.

Figure 8. The high-level Teal bridge, photographed on 27 July 1952.

Figure 9. The high-level Pintail bridge on 27 July 1952, just three days after the 62d Engineer Construction Battalion had opened it.

Figure 10. The high-level Whitefront bridge on 27 July 1952.

Figure 11. Construction under way to reopen the more southerly railroad bridge at the Freedom Gate site. The low-level pile bridge is visible at the right of this 9 July 1952 photo.

Figure 12. The high-level Teal bridge collapsing under the pressure of floodwater on 30 July 1952.

Figure 13. Pier from the collapsed high-level Teal bridge lodged against protective fender piles at the reopened span of the Freedom Gate bridge on 30 July 1952.

Figure 14. The high-level Teal bridge in early August 1952, showing damage done by floodwater on 30 July.

Figure 15. The high-level Teal bridge after the flood of 24–25 August 1952.

Figure 16. A survivor: the high-level Whitefront timber-pile bridge in September 1952 with damage largely limited to the fender piles.

Figure 17. Spoonbill bridge on 20 June 1953.

Figure 18. South Korean artillery convoy crossing Libby bridge on 23 May 1983.

southerly of the two earlier railway bridges at the site. One of the concrete piers of this bridge had been destroyed, and the battalion had to replace it with a pier comprised of a wooden-pile bent cluster and prefabricated steel trestle. In addition the westernmost span had to be replaced and another span jacked and rebraced. The engineers contracted with the Korean National Railway to assist in the work. On 5 July the battalion launched a 206-foot-long, 48-inch I-beam across the new pier from one original concrete pier to another. (*Figure 11*) Completed soon after, this second high-level bridge was opened and dedicated on 17 July, just before the start of the 1952 flood season.[27]

After their exertions of the previous months, the engineers were shocked by the destructive intensity of the 1952 floods. The flood season began early as April precipitation exceeded that recorded in the fourth month of any of the previous 30 years. Floodwaters on 13 April wrecked the northerly Mallard and Whistler rock-crib pier bridges, and nearly topped the low-level Widgeon bridge well downstream. I Corps engineer troops replaced the Mallard crossing with a new 300-foot-long bridge that was six feet higher than the old. They raised the Widgeon bridge by four feet and drove railroad rails above it for an upstream fender and anchor system.[28]

Heavy rains at the end of July raised the level of the Imjin by 13 feet on 27 July, causing the new Mallard bridge to collapse and forcing the removal of the Honker floating treadway. The rains continued for the next three days, and by 30 July the Imjin at Pintail had risen 38 feet. At noon that day, after river currents as fast as 15 to 20 feet per second had exposed the base of some of the piles supporting the Teal bridge, two of the bridge's spans washed out. Debris from Teal washed downstream to X-Ray, where it struck a bridge that had already been moved about four feet downstream by the floodwaters. Two piers of the X-Ray bridge failed at 1:30 PM. (*Figure* 12) Debris also lodged against the high-level Freedom Gate bridge near the river's mouth, leading the engineers to close it for four hours on 31 July while they removed the debris with a crane.[29] (*Figure* 13)

The low-level Widgeon bridge submerged on 27 July and remained intact under some 20 feet of water. It reappeared on 3 August after the floodwaters passed, requiring only minor repairs. The success of the Widgeon bridge impressed Colonel Merrow Sorley, I Corps engineer, who concluded that "this type of bridge has future potentialities. ... [It] is not an equal substitute for a permanent high-level bridge over which traffic at all seasons will be as assured as it is tactically indispensable; but as a relatively cheap bridge, which may prove usable much of the year with only minor periodic damage and repair, it appears from this recent test to have demonstrated value as a supplemental bridge."[30] This lesson was instrumental in determining the design of the submersible Teal bridge constructed that autumn.

An even greater flood roared down the Imjin on 24 and 25 August, fed largely by rains that fell in North Korea. Raising the Imjin 40.5 feet in ten hours at Pintail, these waters destroyed the Widgeon bridge and swept away additional piers of the Teal and X-Ray bridges. ***(Figure 15)*** This was the year's last significant flood on the Imjin. At the end of the 1952 flood season, the I Corps engineer observed with some satisfaction that three high-level bridges-at Whitefront, Pintail, and Freedom Gate-had survived the summer unscathed, and each supported a different division across the river. ***(Figure 16)*** But more than 16 miles separated the Freedom Gate and Pintail bridges, and this stretch of open river could have threatened the U.N. forces if the enemy had launched a serious offensive in August 1952.[31]

The need for bridges in that reach of the Imjin led I Corps to install new floating treadway bridges at the X-Ray and Teal sites in September and to build a rock-crib pier bridge at the naturally defiladed Spoonbill site three miles south of the X-Ray crossing. ***(Figure 17)*** With its piers strengthened by piles made from railway rails, the Spoonbill bridge opened to traffic on 30 October.[32] But these bridges too would be temporary, and the need to construct permanent bridges to replace the two high-level crossings that had been destroyed by the summer floods of 1952 remained. Eighth Army's 84th Engineer Construction Battalion undertook the job, constructing a submersible, low-level bridge at the Teal site and the high-level, steel and concrete Libby bridge at the X-Ray site. Standing 49 feet above mean low water, the Libby bridge remains in use today. ***(Figure 18)*** The Teal bridge provided eight years of useful service before it was removed in late 1961. It was replaced the following spring by a new low-level bridge made of reinforced concrete. These superb wartime bridges were responses to a river-crossing problem that had faced the American engineers for more than a year. Enriched by their experience, they finally resolved that problem in the last months of the war. For two years the Imjin proved itself a worthy opponent to the American military engineers.

CONSTRUCTION OF LIBBY AND TEAL BRIDGES, IMJIN RIVER, OCTOBER 1952 TO JULY 1953

by
William R. Farquhar, Jr.
and
Henry A. Jeffers, Jr.

Preface

Between October 1952 and July 1953 two bridges of unusual design were built over the Imjin River in central Korea within range of the enemy's light artillery. One was a high-level highway bridge which would be a credit to any state highway system in the United States; the other was an experimental "low-water" bridge which is expected to survive being submerged by the river which it spans. This monograph explains why these bridges were built, and presents some of the problems which had to be solved, obstacles overcome, and hardships endured by the 84th Engineer Construction Battalion that built them.

The narrative is written to be understood by the professional soldier who may have little or no knowledge of engineering and its special language. For the engineer, however, who might be interested in the technical aspects, many of the engineering details are included in the supporting documents. In addition, completed "as-built" tracings of the high-level bridge (Libby) have been forwarded to the Engineer School, Fort Belvoir, Virginia, by the 84th Engineer Construction Battalion. [1]

The initial research and rough draft of the narrative were done by Major William R. Farquhar, Jr. After his departure from this organization the project was completed and put in final form by Major Henry A. Jeffers, Jr.

When this project was reviewed by the Commanding Officer, 2d Engineer Construction Group, he suggested that a resume of the designing phase of the two bridges might be of interest to other Army Engineers. This informal resume was prepared by his headquarters and is attached.

Seoul, Korea
21 September 1953

CHAPTER I

Background

The Imjin River, a tributary of the Han, flows in a meandering course a short distance south of a 25-mile-long stretch of the stabilized main line of resistance of the United Nations Forces in western Korea. Its presence close behind the line, between the front line troops and their sources of supply (and in some cases their artillery), greatly enhances the importance of the crossings available.

Seen for the first time during normal weather conditions, the Imjin is not a particularly impressive river; it can be forded easily in many places. Its active channel utilizes only about 150 to 200 feet of the 1,200-foot width of the dry riverbed, which is bordered by almost vertical rock cliffs standing approximately 75 feet above the mean low water level. It gives no indication in normal times of the tremendous power it develops when in flood.

During the Korean rainy season of July and August, the Imjin becomes a raging torrent, largely confined by its steep rocky banks. Fed by its larger tributaries and many small mountain streams, it reaches flood heights of 48 feet above mean water level and a velocity of 15 to 20 feet per second. The rapid runoff of approximately 95 percent of precipitation during heavy general rains has caused the Imjin, on occasion, to rise at a rate of more than six feet per hour.[1]

In addition to these extreme variations in the amount and speed of the water, the riverbed itself shifts and changes with each seasonal flood. The sand, gravel, silt, and boulders, which form the movable material (overburden) in the river bottom, are scoured out of their resting places by the force of the flood and deposited again wherever the eccentricities of the river currents dictate. Specific information as to the degree and nature of the movement of the Imjin River's overburden is not available. However, the experience of Japanese and Korean bridge builders, and that of the Corps of Engineers after two years in Korea, indicates that the overburden is unstable to a depth equal to the depth of the water in the stream, or to bedrock, whichever is less.[2]

During the severe Korean winter, icy winds sweep down the Imjin; the sub-zero temperatures cause thick ice to form on the river. Fluctuations in the level of the river, particularly tidal action in the lower reaches, break up this ice, and large amounts of floe ice pile up against any obstacle in the channel. The destructive force exerted by the floods and ice of the Imjin has made the task of the engineers responsible for building and maintaining bridges on the Imjin a most difficult one.

During the flood season (1 July to 15 September) and the ice season (15 December to 25 March), floating bridges cannot be used because they cannot stand the unusually strong force of the water or the pressure of the ice. Neither can ordinary military bridges of the rigid type withstand the pressure of the Imjin flood plus the impact of tons of debris, including parts of our own and enemy washed-out bridges which come floating down at high speeds.[3]

In July of 1952 there were five high-level bridges on the Imjin which were expected to provide communications with the I Corps front during the flood season.[4] These were, from north to south:

(1) Whitefront—a two-way, high-level bridge supported by timber bents on steel piles (CT 260133, Map: Korea 1:25,000).

(2) Parker Memorial (Pintail)-a two-way, high-level bridge supported by steel piers on concrete bases (CT 231097).

(3) Teal-a one-way, high-level bridge supported by timber-pile bents (CT 175057).

(4) X-Ray-a two-way, high-level bridge supported by timber-pile bents (CT 097012).

(5) Freedom Gate (Munsan-ni)—a reconstructed high-level railway and road bridge on concrete piers and one, light, steel-trestle pier (CS009955).

There were also in the I Corps sector several floating bridges and one low-level bridge; these were not expected to be usable during the flood season. Widgeon, the low-level bridge (CT 151035), is of interest, however, in that it was expected to survive the floods even though submerged. It was a treadway bridge supported by rock-filled cribs; this was the first attempt to build a cheap low-level bridge that would survive being submerged by the floods and provide a crossing during the rest of the year.

I Corps Headquarters was fully cognizant of the threat that the Imjin presented to the lines of communication to the front in its sector. An operational flood plan was prepared "which assigned responsibility to individual units for communications and procedures for reporting river rises, for facilities necessary to protect bridges such as debris booms, LCM's [landing crafts, mechanized] and utility boats, for searchlight illumination to aid in night removal of debris, and for tanks or automatic weapons fire to break up floating debris."[5]

The flood season was late in getting started in the summer of 1952. It was on the 27th of July that the first of the Imjin floods came, a minor rise which overtopped Widgeon bridge and washed out its approaches but did not otherwise damage it. However, heavy general rains on the watersheds of the Imjin and the Hant'an, the Imjin's major tributary, during the night of 27-28 July and on 28 July presaged a more formidable rise. At Parker Memorial bridge the river rose 38 feet during the period 5 AM on 27 July to 3 PM on 30 July. Complete data as to flood heights at all bridge sites are not available due to the fact that flood gauges were in many instances affixed to the bridges and thus went down the river with them; but of particular interest is the following from the "Flood Report, 1 July-15 September 1952," Office of the Engineer, Headquarters, I Corps, 26 September 1952:

> After a rise of 27 feet at Teal ... two spans failed and were washed out at 1200 hours on 30 July. Failure of the bridge occurred when little debris was present in the channel, none hung on the piers, and when no previous observable displacement of the structure had occurred from the striking of debris. Debris was not a primary or secondary cause of failure within the observation of spectators. Previous pile penetration of ten feet had been reduced to as little as two feet on some piers by scour action. Nine piers were scoured at the base but otherwise still in good condition. Three piers were completely destroyed by the flood. Maximum velocities observed upstream were as great as 15-20 feet per second in the deepest part of the river?
>
> At 1330 hours 30 July 1952 the X-Ray two-way high-level bridge failed when two piers went out. Striking of debris was a contributing cause of failure of X-Ray, when it was struck by large floating segments of crib and floor debris from the failure of Teal. This occurred slightly before the cresting of the flood at X-Ray, at a river stage about one foot below crest height. At this time, however, a portion of X-Ray bridge had already been displaced downstream about four feet from a primary cause which might have caused failure even in the absence of debris, and which was presumably sliding of pile bents.'

Freedom Gate (Munsan-ni bridge) and Widgeon held up well during this flood. Freedom Gate was closed to traffic for only four hours on 31 July so that a crane could be moved onto the bridge to remove debris lodged against the piers. Widgeon, overtopped by the flood, reappeared intact when the water subsided and was reopened to traffic on 3 August after minor repairs.

The Imjin remained fairly quiescent until 24 August when considerable rain fell to the north and east of the I Corps sector prior to 6 AM. At that time both the Imjin and Hant'an rivers started rapid rises where they entered U.N. territory. At the Parker Memorial bridge the river rose 40.5 feet between 7 AM and 5 PM. During this flood Widgeon bridge was almost completely destroyed and X-Ray bridge lost five more spans. "At various times ... Parker, Whitefront, and Freedom Gate bridges were closed to traffic for short periods to enable debris removal operations to be facilitated. Accumulation of debris against the timber pile piers combined with high river velocities constituted a continual hazard necessitating debris removal. The content of the debris indicated that the enemy had suffered damage to his installations and also that the neighboring Corps had some losses in bridge and ferry equipment."[8]

In early September floating bridges were placed at Teal and X-Ray sites, and a ferry was operated at Widgeon site as necessary. (*Figure* 19) The Imjin flood season of 1952 was over, and the central portion of the I Corps sector was left without bridges that could withstand the ice season which would begin in December.

The Commanding General, I Corps, felt that replacement of Teal and X-Ray bridges was an urgent military necessity and so informed the Commanding General, Eighth Army.[9] He also recommended that more substantial structures be built, rather than restoring the structures which had proved inadequate in the face of high water. In a later communication, it was pointed out that the floating bridges at these sites would have to be removed about 11 December to prevent unnecessary loss of equipment during the ice season and that it would be highly desirable that permanent structures be completed at these sites prior to that time in order to provide continued satisfactory support of the forward elements of I Corps.[10] The Eighth Army Engineer instituted an extensive study and research program to provide a basis for design and construction of bridges capable of withstanding the floods and unusual river conditions encountered on the Imjin.[11]

Armed with the basic data and specifications furnished by

Eighth Army and supplementing this with research of its own, the 2d Engineer Construction Group proceeded with the designing of suitable bridges to meet these needs.[12] Conferences between the Eighth Army and I Corps Engineers led to an informal agreement on the construction of a two-way, high-level bridge at X-Ray site and a two-way, low-level bridge at Teal site.[13] The formal concurrence of the Commanding General, I Corps, to this plan was obtained in late September, and construction at Teal began almost immediately.[14]

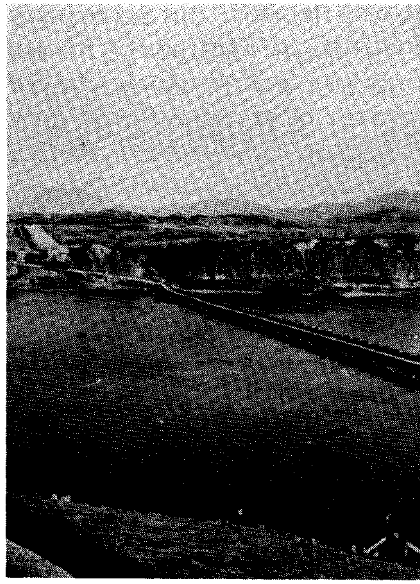


Figure 19. X-Ray site in October 1952 showing newly erected ponton bridge and perpendicular volcanic rock banks.

The result of the research program, which combined 36 years of Japanese and Korean observation with two years of American experience, was a firm conviction in the minds of all concerned that it would be useless to replace the washed-out bridges with ordinary structures. It was decided that only a high-level bridge resting on concrete piers extending down to or securely anchored in bedrock would have any potential of withstanding the extreme flood conditions of the Imjin River and providing a year-round crossing. It was further believed that there was an urgent military requirement for such a bridge at X-Ray site in the center of the I Corps sector, whether the current tactical situation continued, UN. forces advanced, or an armistice was signed. In the case of either an advance or an armistice, the Freedom Gate bridge (Munsan-ni) would probably have to be limited to rail traffic, and thus it would become imperative to have a highway crossing between Munsan-ni and Kaesong.

Such a justification did not appear to exist at Teal site; in fact, it was believed that although an urgent military requirement existed for a crossing at Teal as long as the current situation continued, either an advance or an armistice would remove the requirement for any crossing at all at this site. For these reasons it was decided that an expensive high-level bridge could not be justified at Teal site. The alternative adopted was a low-level highway bridge which would be available for use except during periods of extreme floods and was designed to permit use with minimum delay after the flood waters receded. Thus, a bridge which was expected to be available for use perhaps 50 weeks out of the year was to be built for less than half the cost, construction time, and engineer effort that would be required for the X-Ray bridge.[15]

The bridges designed for these sites created problems of construction which Army Engineers had not experienced before in an active theater. Teal bridge, for instance, was designed to duplicate the relatively inexpensive "low water" bridges so numerous in the southwestern United States. These bridges are sturdy enough to withstand being overtopped by flash floods and yet can be put back into service as soon as the waters recede. In order to duplicate this strength of construction, Teal was designed to be supported on piers composed of 16-inch, hollow, open-end steel piles, driven to bedrock and filled with concrete. This 16-inch Armco piling was available in the theater but had not been used for this purpose before. Other low-level bridges had been built in Korea, but none had been built with the permanent-type materials and strength of the proposed Teal.

X-Ray bridge, on the other hand, was a complete departure from military bridge construction. The Corps of Engineers has designed and supervised the construction of larger, wider, and higher bridges, but in most cases these bridges were actually built by civilian contractors or by skilled civilian labor under Engineer supervision. This was the first time that an all-new-construction bridge was to be built with sheet-pile cofferdams and reinforced concrete piers by troop labor. It was to be, in fact, a commercial rather than military type of bridge, which any state would be proud to have as part of its highway system.

Both bridges were to be built within easy range of the enemy's light artillery. As it turned out, although enemy artillery rounds fell near both bridge sites during construction, there was no indication that the enemy made a deliberate attempt to interfere with the building of the bridges?

CHAPTER II

The Construction of Teal Bridge

When the 2d Engineer Construction Group received the directive to go ahead with construction of Teal bridge, the job was assigned to the 84th Engineer Construction Battalion, a unit which has come to be known as "The Conquerors of the Imjin." Lieutenant Colonel James R. O'Grady, commanding officer of the battalion, appointed Captain A[rlton] W. Hardin, his Assistant S-3, as project officer and designated Company B, commanded by Captain Edward H. Goldsmith, to do the construction.

Pile penetration tests were made with open-end Armco piles, pointed Armco piles, and 12-inch I-beams. Using a 5,000-pound hammer with 160 blows per minute, it was possible to drive the I-beams to a depth of a little over 18 feet, the pointed piles to a depth of 22 feet, and the open-end piles to a depth of 27 feet and to bedrock. An attempt was made to pull up an open-end pile with two D–8 hyster winches in order to inspect it for splitting or other damages, but it was impossible to extract it.

The first preparatory work was begun on 2 October 1952 when Company B began construction of a causeway from the south shore out to the site of pier 11. The piers were numbered 1 to 16 from south to north. On 10 October the excavation of the approach on the north shore was begun. When the approximate grade level of the approach road was reached, two springs which put out water at the rate of about 350 gallons per minute were uncovered. To correct this situation it was necessary to excavate six feet below the grade level, dig a V-shaped trench with the apex of the "V" at the springs and the points at either side of the abutment, and fill it with rock to make a French drain to carry off the water. By the time the north approach was finished, some 14,800 cubic yards of earth had been excavated; some of this earth was pushed out to make the causeway on the north side of the river and later caused some difficulty in the use of heavy equipment when it became boggy.[1]

The first of the 128 piles in the bridge was driven on the 16th of October as the beginning of pier 11.[2] Considerable difficulty in driving the piles was encountered due to the presence of large boulders in the riverbed; piles were observed to "walk" as much as eight inches to the side while being driven vertically. This caused a problem when it was time to cap the piers with the 12-inch H-beams, as the piles were out of line. This misalignment was corrected by pulling the piles back into line as much as possible with a tractor and block and tackle. Colonel O'Grady allowed a maximum sideways pull of 2.5 inches on the piles, due to the danger of bending or snapping the pile.[3] (*Figures* 20 *and* 21)

On 20 October work was begun on the south approach; the riverbank on this side was of volcanic rock which was cracked and fissured. The fissures were filled with clay, a condition which made blasting the rock out very difficult. A set of charges would loosen the rock and open up the fissures, but, when a bulldozer tried to push out the rock, the fissures would close up so that the clay again bound the rock in place.[4] Water, from springs and occasional thaws, also added complications to drilling holes for charges as, in the extreme cold, bits and drills would actually freeze tight in the holes. In all, 14,200 pounds of dynamite were used to blast out 12,320 cubic yards of rock.[5]

Colonel O'Grady recommended to the 2d Engineer Construction Group that diagonal bracing be added to the pier design to strengthen the bridge against overturning. *(Figure 22)* This consisted of a diagonal brace of 12-inch channel iron, running from the top of each pile to the bottom of the next downstream pile, bolted and welded in place. The four piles in each of the two rows in the pier were connected seven feet down from the bottom of the H-beam cap (approximately at causeway level) with 12-inch channel iron bolted in place, and the lower ends of the diagonal brace were welded to this. The purpose of this bracing was to transmit the shock of debris and pressure of the water from the top of each pile to the bottom of the next downstream pile, thus actually exerting downward pressure rather than horizontal pressure which might overturn the pier. This recommendation was accepted, and this feature was added to the bridge design.[6]

Despite cold weather and high winds, welding continued on the capping and bracing of the piers already driven. Cold, and the bulky clothing it made mandatory, made welders clumsy as they climbed around on the piers. High winds made it very hard to

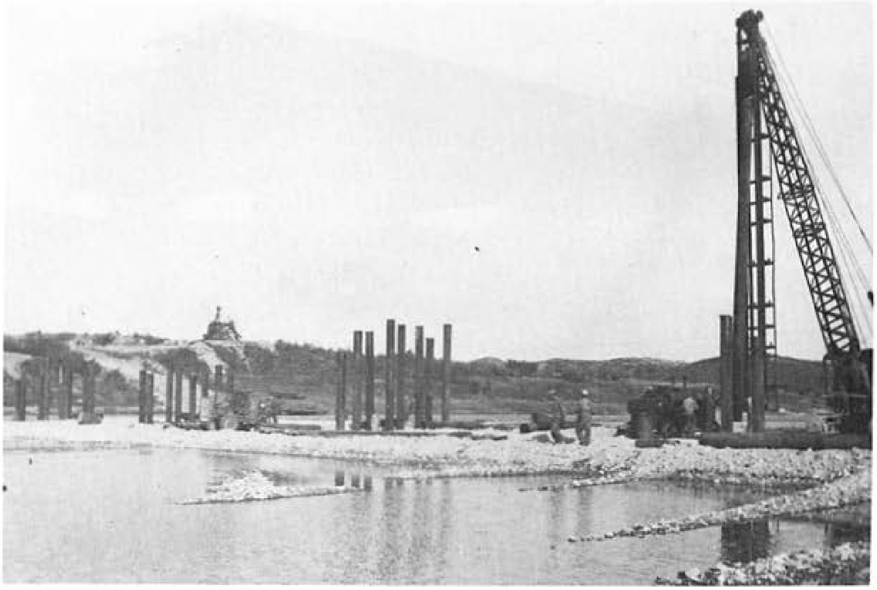


Figure 20. Engineers driving 16-inch Armco steel–column piles for the low-level Teal bridge in October 1952.

Figure 21. Cables used to align piles that had "walked" when driven against large boulders in the riverbed.

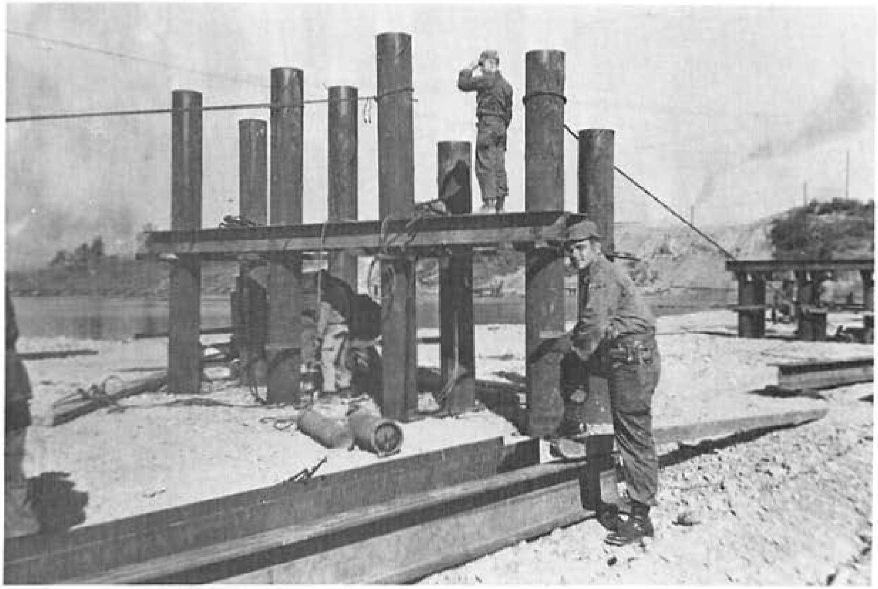


Figure 22. A nearly completed pier featuring diagonal channel-iron bracing.

Figure 23. Troops constructing blackout shelters for night welding that could double as curing cabins in cold weather.

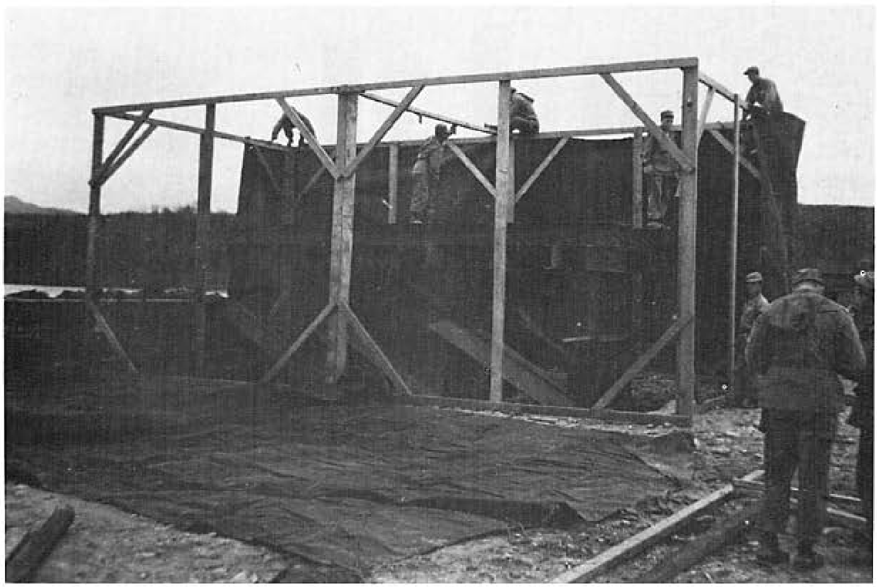


Figure 24. Troops filling the hollow Armco piles with concrete, with 36-inch I-beam girders in the foreground.

Figure 25. Anchor bolts set in a concrete-filled pile capped by 12-inch H-beams.

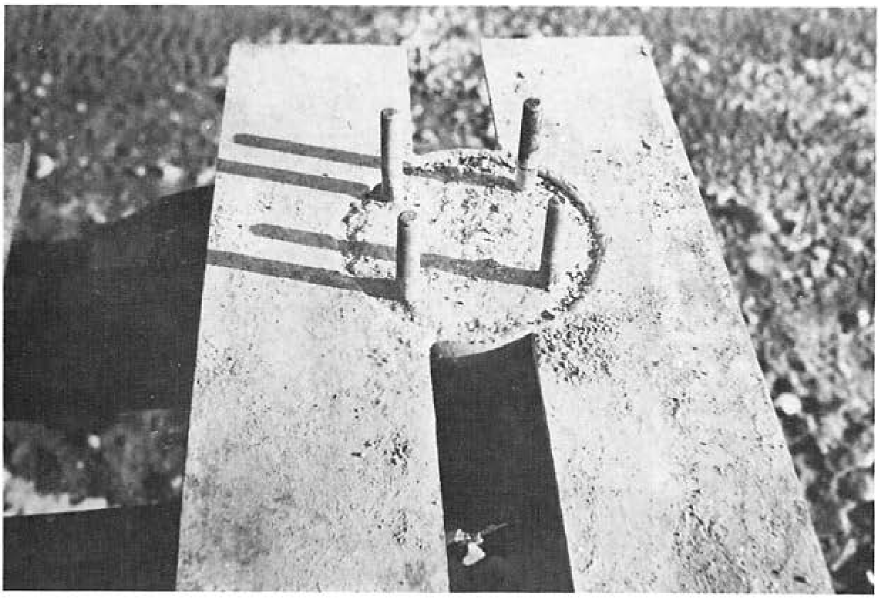


Figure 26. Teal site on 26 November 1952 showing completed piers at south end of bridge, left, and others still under shelters. I-beam girders and the Imjin River flowing north of the causeway are visible at right.

Figure 27. Thirty-six-inch I-beams in place on bridge with a pile driver, in background, working on one of the northernmost piers.

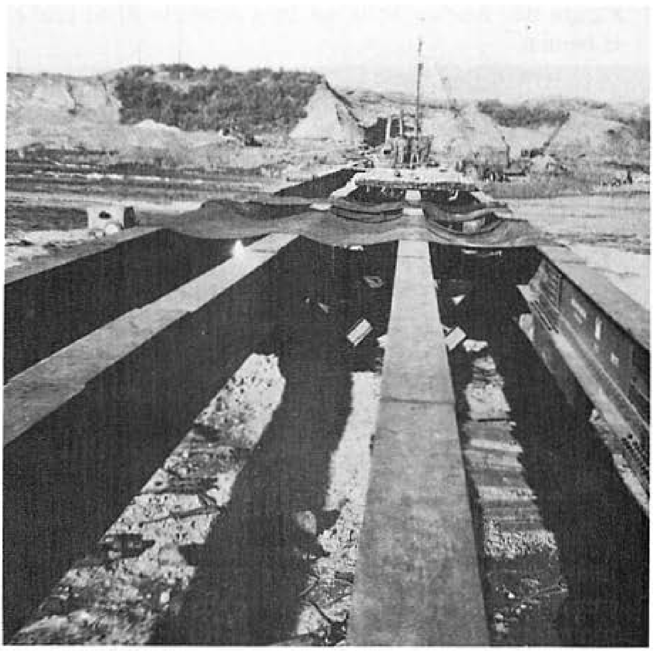


Figure 28. Side view of girders in place. Crew on right is placing decking.

Figure 29. Troops placing decking from pier 16 to the north abutment. This was the only span which used six 24-inch girders. Note angle-iron diaphragming between girders. Visible at center is two-inch by six-inch laminated sub-decking and beyond that is three-inch by twelve-inch diagonal decking.

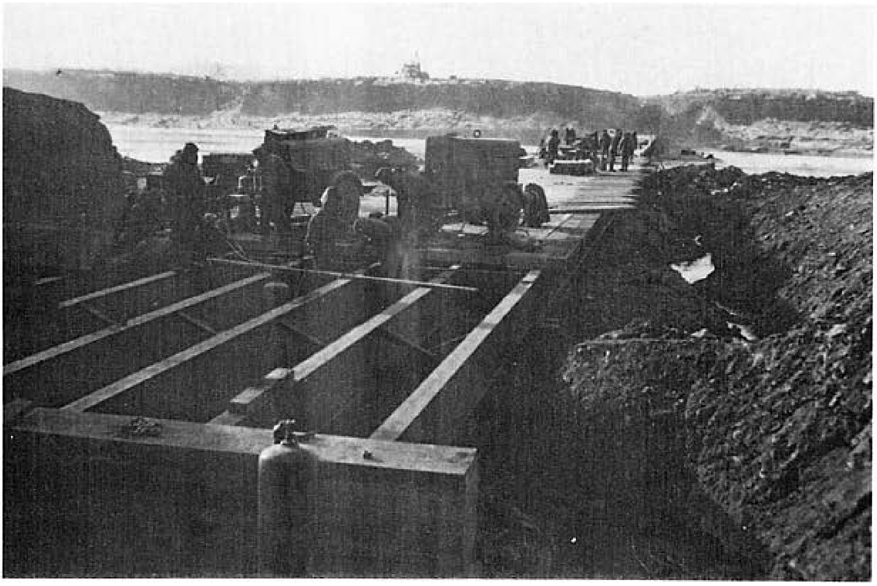


Figure 30. Girders in place on piers 8 through 11 allowing the passage of water below these spans and the construction of a causeway to pier 11 from the north bank.

Figure 31. Teal bridge from the south shore on 7 January 1953 as troops place decking on the north end.

Figure 32. Teal bridge from the north shore on 16 January 1953 when almost completed. This view shows the removable guardrail.

Figure 33. Army vehicles crossing the completed Teal low-level bridge at the end of January 1953.

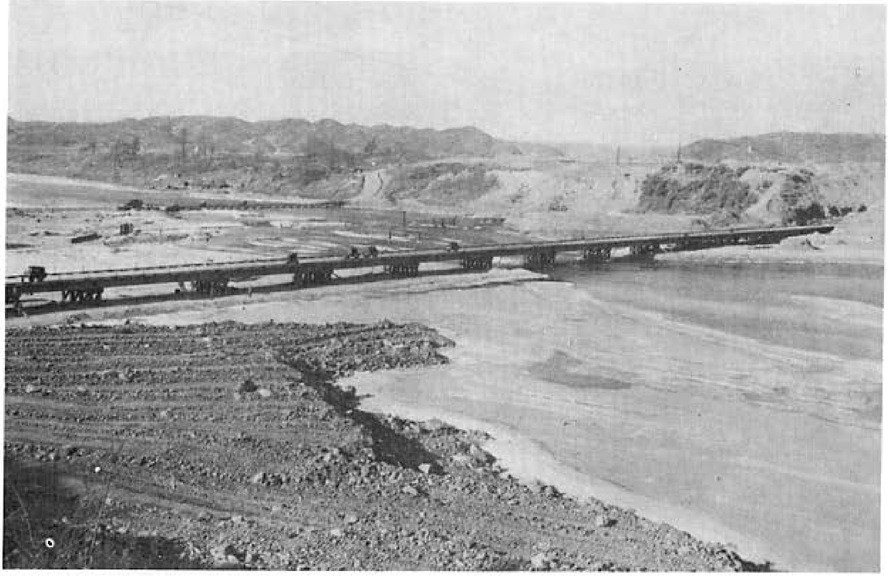
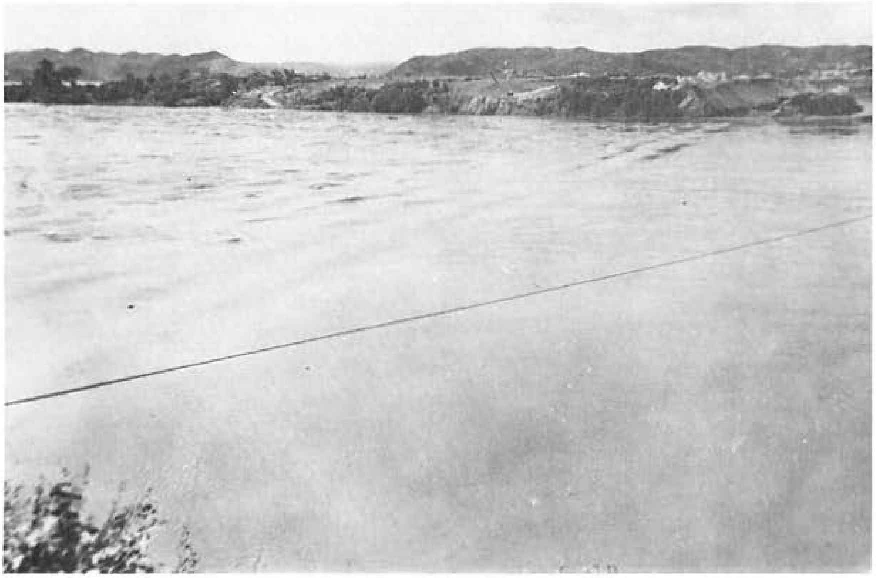


Figure 34. Teal bridge underwater on 15 July 1953, viewed from the south approach road.

Figure 35. The Imjin River flowing 12 feet over the Teal bridge on 15 July 1953.



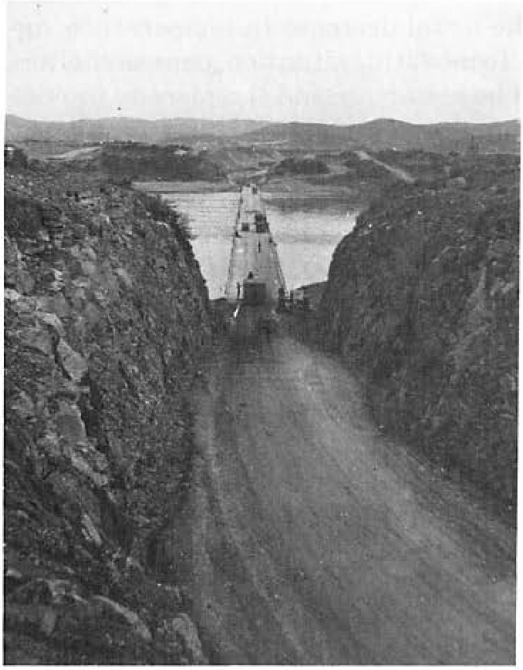


Figure 36. Teal bridge in operation on the afternoon of 16 July 1953 after floodwater receded.

Figure 37. Teal bridge after the flood of 15 July 1953 showing the damage to the removable guardrail, which was not removed due to the rapid rise of the river.

keep an arc. Nighttime, with the necessity for working in as much blackout as possible and the usual decrease in temperature, aggravated these difficulties. To meet this situation, canvas shelters were designed which could be set up around the piers to provide both shelter from the cold and wind and blackout at night. The frames of these shelters were so constructed that they could be taken down and moved as required.[7] *(Figure 23)*

On *20* November the welding on pier 11 was completed, and concrete was poured into the piles. *(Figures 24 and 25)* The canvas shelters were put to a new use at this time, as it was necessary to provide heat to keep the concrete in the piles from freezing before it cured. *(Figure 26)* A shelter was set up around the pier, and a hot-air blower maintained a suitable temperature, about 60°, until the concrete was cured.[8]

On 29 November, when the tops of the piles were sealed with asphalt and the bearing plates set in place, the first girders were lifted into place in span 11 with cranes. The I-beams used as girders were of three different types: ten spans were made up of four 36-inch, rolled-steel I-beams; six spans were of four 36-inch, built-up (bolted splices) steel I-beams; and the remaining span, from pier 16 to the north abutment, was made up of six 24-inch, rolled-steel beams. *(Figures 27, 28, and 29)* The first two types were salvaged from the old Teal bridge.

In normal bridge construction, to allow for expansion, spans are fixed at one end and rest free on bearing plates at the other end with a small guide welded onto the bearing plate to prevent sideward movement of the span. This is not true in the case of Teal bridge, which will have to resist the force of the Imjin's floods. Both ends of each span are bolted in place; however, at one end of the span the holes for the anchor bolts are round, and at the other end the holes are slotted and will allow the span to expand lengthwise.[9]

As soon as the steel was in place from pier 11 to pier 9, the causeway was cut between them to allow passage of water, and the causeway from the north shore was pushed out to pier 11. *(Figure 30)* It was then possible to drive the piles for the last four piers (12 through 16). Penetration, to bedrock on all piles, varied from 15 feet to 32 feet, 8 inches; average penetration was around 27 feet.[10]

It was planned to excavate all the way to bedrock for the abutments so that concrete could be poured directly on bedrock, but seepage of water into the excavation made this impracticable. A key to bedrock was achieved by driving four 12-inch H-beam piles to bedrock in the excavation, capping these with another H-beam, and pouring the concrete abutment around these capped piles.[11]

On 11 December the two-by-six-inch laminated wood sub-decking was started at pier 11 and worked to the south shore; on 22 December the diagonal three-by-twelve-inch decking was started and nailed down to the sub-decking at a 45° angle to the center line. (See *Figure 29.*) The decking had an overall width of 22 feet, which, with six-inch curbing on either side, left a 21-foot running surface for vehicles.

By 10 January, the decking, curbing, and guardrail were in place on all of the bridge except span number one, which had to await the completion of the south abutment. The guardrail on Teal consisted of half-inch wire rope strung through pipe posts which were set in sockets bolted to the outside of the curbing.[12] *(Figure 32)* The guardrail was so designed that it could be removed quickly before floods topped the bridge, thereby allowing freer flow of water and debris over the bridge.

All construction work on the bridge was completed by 27 January, and it was pressed into service prior to the official opening, because the division occupying that sector of the front was being relieved and the bridge was needed.[13] *(Figure 33)* The official opening and dedication of Teal bridge took place on 31 January 1953, when Major General M. M. A-R-West, Commander of the Commonwealth Division, cut the engineer tape at the south end of the bridge.

Teal got its first baptism and trial in the flash flood of 15 and 16 July 1953. The water covered the bridge during the early hours of 15 July, and at the crest of the flood Teal was under 12 feet of running water. The guardrail was not removed as planned because of the speed of the river's rise and the danger of working on the wet structure, which might be overtopped at any moment in the darkness. The flood receded on 16 July, and by 3 PM Teal was free of water and in service again; the only damage was to the removable guardrail.[14] *(Figures 34-37)*

CHAPTER III

Construction of X-Ray (Libby) Bridge

Late in October 1952, the commanding officer of the 84th Engineer Construction Battalion was advised by the 2d Engineer Construction Group that his battalion was to construct the high-level bridge at the X-Ray site. "The Conquerors of the Imjin" were scheduled for another bout with their old foe. This time the plan called for the river to be completely overcome before the next flood season began on 1 July 1953.

On 1 November work began on driving test piles and developing fuller information on the overburden and bedrock conditions. Plans for the bridge were received on 9 November, and the battalion began to see the type of task it had been assigned.[1] It was to build, in seven months, a bridge that was completely outside its experience, a bridge that would probably have required a civilian construction firm a year to build in the states. It could not wait for warm spring weather and ideal working conditions; the bridge was needed at once. During most of the next seven months the battalion would be working in the sub-zero cold of the extreme Korean winter.

The enlisted men of the battalion came from all walks of life, and most had no experience in construction work. However, every operation on the bridge was broken down into the simplest tasks possible, and the men learned rapidly what was required of them. Simplified forms, jigs, and instructions enabled them to turn out workmanlike results with a minimum of formal instruction. Some Korean civilians were employed on the job: approximately twenty welders, four divers, two riveters, and others as carpenters, sign-painters, tire-repairmen, etc. The Korean welders needed some additional training, particularly in overhead welding, before they could be used; however, roughly 50 percent of the welding was done by U.S. soldiers. The battalion also had approximately 155 KATUSA [Korean Augmentation to the U.S. Army] personnel, who proved to be excellent construction workers.[2]

At the time the work on X-Ray began, the battalion was minus

Company B, which was building the new Teal bridge; Company A, which was constructing troop facilities in the Seoul-Inch'on area; and Company C, which was replacing a weakened span of the Freedom Gate bridge. As these companies completed their projects, they joined the battalion's work on X-Ray. Company B did not arrive until 1 February 1953.

Preparatory work proceeded through November and most of December-assembling equipment and supplies and erecting an equipment maintenance shop, a carpenter shop, a material storage building, and an open storage yard. Causeways were pushed out into the river from the east shore past the site of pier 3, and from the west shore beyond pier 6. A source of aggregate (sand and gravel to be used in concrete) near the site was tried and found unsuitable due to an excess of silt. Another source was found upstream near Teal that offered clean washed gravel and sand, and stockpiling of aggregate at the X-Bay site began.

The basic plan was to construct piers 6, 7, and 8 and the west abutment, using a central concrete batch plant located on the west bank of the river. Actual construction began on 26 December with the driving of the first pile for pier 6. Pile driving continued through piers 7 and 8 on the west side and piers 1, 2, 3, 4, and 5 on the east side, in that order.[3] *(Figure 39)* The greatest difficulty in the construction of X-Bay bridge was with these pier bases: driving the pile, excavating the cofferdams, and placing the concrete. Each of the eight caissons presented a separate and distinct problem requiring its own solution.

The pier bases were constructed by driving grooved sheet piles to form a rectangular caisson which was then excavated to bedrock and filled with concrete. *(Figures 40 and 41)* The tolerance allowed in rolling the sheet piling in Japan was too great; in some cases it varied as much as three-quarters of an inch in width. Some of the piles were painted with red lead and some were not. The tolerance was less on the painted piles, and most of the splits in the piling were found at junctures of the two types. Also the corner piles had ball-and-socket joints, while the side piles had thumb-and-finger joints; this again made it very difficult to fit properly. The tolerance in the grooves caused leaks all up and down the joint. Lead wool was used to pack the joints, but this did not stop the water. Eventually soft wooden wedges, driven into the joints, proved to be a fairly effective means of stopping the flow.[4]

The poor quality of the sheet piling greatly increased the difficulties of dewatering the cofferdams to permit excavation down to bedrock. In addition, the rough, irregular surfaces of the bedrock made it almost impossible to get a tight seal between pile and rock. Blowouts under the piles inevitably occurred before the final clean-up could be completed. Frequently the sheet piles split near the bottom, with the result that backfill (filling up the excavation), pile extraction, and redrive were necessary, as many as three times for one of the cofferdams. Unfortunately, when cofferdam 6 was excavated, the pile extractor had not arrived yet, and it was necessary to make the initial concrete pour completely under water. On the other cofferdams, as excavation proceeded, it was possible to remove boulders that obstructed full pile penetration, extract and replace bent piles, and then drive the piles all the way to bedrock. In excavating cofferdam 1, it was found that the piles at one corner had struck a layer of basalt; however, it was possible to backfill, extract the bent piles, replace them, and drive on down to bedrock.[5]

Sub-zero weather greatly handicapped the operation of the dewatering pumps, which required constant supervision. During operation, ice would form on the outlets and connections, plugging up the pumps. When a pump was not in operation, water would freeze inside the pump mechanism. It was necessary to apply heat externally to these points to get the pumps operating and to repeat the application of heat frequently to keep them going.

It was found to be a general rule that the more water that was pumped out of a cofferdam, the more likely a blowout was to occur under the pile. This was due to the decreasing inside pressure.[6] *(Figure 42)* In the later stages of the cofferdam work, divers were used to great advantage to overcome this. The cofferdam was allowed to fill with water when the bulk of the excavation had been accomplished, and divers were used to clean the bottom of all sand, gravel, and loose bedrock. Following this, an initial pour of three to four feet of concrete was made, keying the pier to bedrock and sealing off the bottom of the cofferdam. The cofferdam could then be dewatered and work continued "in the dry." Only cofferdam 8 was poured completely in the dry.

In these excavations to bedrock, Major William C. Carter, battalion S-3 and project officer, found evidence to refute, at least partially, the theory advanced in the preparatory studies for the bridge that the overburden (mud, sand, gravel, and other material covering bedrock in the bed of the river) along most of the length of the Imjin is moved completely by the scouring action of the river during flood season. The appearance (corrosion of rocks, etc.) of samples of the overburden procured in the excavation of the cofferdams led Major Carter to conclude that the lower overburden at X-Ray had not been moved by scouring for many years. The bedrock itself did not appear to him to have been eroded by scour action for several hundred years.[7] If this is the case, Libby bridge will have an even greater possibility of surviving the floods due to the additional protection afforded the caissons by the overburden.

From the beginning of the project in November until late in April, work was carried on through periods of extreme cold, sleet, and snow storms; very few times was the work stopped, day or night, on account of the weather. Flash floods and spring high tides eroded the causeways and on 20 March and 13 May 1953 went completely over them. The water and the need for immediate repair of the causeways made the evacuation of men and equipment necessary on several occasions!

Motors became practically impossible to start without the use of special warming devices, and it was finally decided to keep the motors of key vehicles and equipment running 24 hours a day. Condensation of water in the pneumatic hoses would freeze at the connections and plug the hose; this could only be solved by applying constant heat to all such connections. The same difficulty of welding in the extreme cold which was experienced at Teal was present at X-Ray.

Mixing, pouring, and curing concrete in freezing weather, often below zero Fahrenheit, presented a whole new series of problems to Major Carter and to First Lieutenant Donald W. McKenzie, commander of Company A, who was in charge of all concrete operations. An aggregate dryer, capable of handling 50 to 180 tons per hour, was used to heat the aggregate to an acceptable temperature, and a 24-head shower unit, permitting temperature control from 37° to 180°F, heated the water for mixing. *(Figures 43 and 44)* Once the concrete was poured, it would soon lose its heat and freeze unless some means was found to maintain a constant above-freezing temperature until it was cured. Unique curing cabins covered with canvas were designed which served the double purpose of maintaining heat and providing a work platform. These cabins could be raised and clamped in place as the pier rose, and they also served as overhead support for the pipe which would deliver concrete in the later pours. The temperature inside the cabins was maintained at 60° by Herman Nelson hot-air blowers; in addition, spray bars were used to keep the curing concrete moist with warm water.[9]

In early February 1953, the first pouring of concrete--in cofferdam 6, which was full of water-was accomplished with concrete buckets and a crane. This procedure proved too slow and created a great deal of wash and wave action, which tended to wash the cement out of the mix. After about 20 buckets of concrete were placed, placement was stopped and a new means was adopted. A 16-inch Armco pile with a hopper attached was used as a tremie to carry the concrete down to the bottom of the cofferdam; the lower end of the pipe was kept about one foot below the surface of the concrete already poured in order to prevent washing of the mix. The remainder of pier 6 was placed in this manner.[10]

There were still doubts as to the quality of the concrete in pier 6, and further pouring on this pier was halted until tests could be made. An attempt was made to obtain samples of the concrete by coring, but this did not prove successful as only about two inches of core were ever obtained. On 4 March an order to blast out the concrete came down from the Eighth Army Engineer. The pier was blasted out down to bedrock, and the concrete, except for the three and four feet at the bottom, was found to be unsatisfactory. On 16 March the pier was repoured using a pumpcrete machine which produced better results?*(Figure 45)*

Excavation of cofferdam 8 was completed on 13 February, and the concrete placement was begun using concrete buckets and cranes. This was the only pier poured completely in the dry. With the other piers it was necessary to place a three- or four-foot blanket of concrete at the bottom to reduce water leakage and the danger of a blowout, then dewater and drill through the concrete to bedrock to test it, before placing the rest of the concrete.

By late February a pumpcrete machine had arrived and was operating; this unusual device was capable of pumping wet concrete for long distances and to considerable heights. The time required for concrete pouring was greatly reduced due to the speed with which the pumpcrete could deliver concrete to the spot where it was needed.

Five pours or lifts were made on each pier, and they were given alphabetical titles for ease of reference. "A" pour was an average of 240 cubic yards of concrete in the caisson; "B" pour was the two lower 16.5-foot vertical columns, the lower part of the H-shaped pier. "C" pour was the horizontal middle stiffener, and "D" pour was the two upper vertical columns above the stiffener. "E" pour formed the cap across the top of the "H". After it was in operation, all pours were made with the pumpcrete. *(Figures* 46 *and* 47) To complete pier 5, for instance, concrete was pumped 700 feet horizontally and 48 feet vertically.[12]

Wherever possible, components of the bridge were completed and assembled on the shore before being placed on the bridge. Reinforcing steel was prefabricated into mats of the required size in the central work yard and hauled to the point of use when needed. *(Figure 48)* All forms were made in the carpenter shop under the supervision of Second Lieutenant Harry H. Nishikimoto and, whenever possible, were so designed that they could be taken down and reused. A curb form was designed that would use the same bracket that held the deck slab form. The superstructure operation was geared to placing 242 feet of deck a day, and the curb placement was similarly geared, using the same forms. Guardrail posts were cast in batches of 66, using the same forms over and over.[13] *(Figure 49)* A full-scale model of a section of the deck was built in the work yard to give to all concerned practice and training in the procedures which were to be used. *(Figure 50)*

Steel fabrication and placement raised many problems. The Japanese-manufactured 48-inch I-beams, which were to be used as girders, had to be riveted together with splice plates in order to form girder spans of the required length. Fabrication began in February and continued through 5 June with First Lieutenant Curtis W. Badman, assisted by Warrant Officer Harry Cooley, in overall charge of all steel construction.

On the day riveting began, the only man in the battalion who had civilian experience as a riveter departed for home. However, a week's schooling and the help of two Korean riveters soon turned out good crews. The rivet hammers available through Army supply channels were too light for the seven-eighths-inch rivets used, and suitable hammers had to be rented from a Korean contractor.[14] *(Figures 51 and 52)*

In early April the beams which were to span from the west abutment to pier 7 were completed. The two downstream beams were then spaced at the required distance apart and braced (dia-

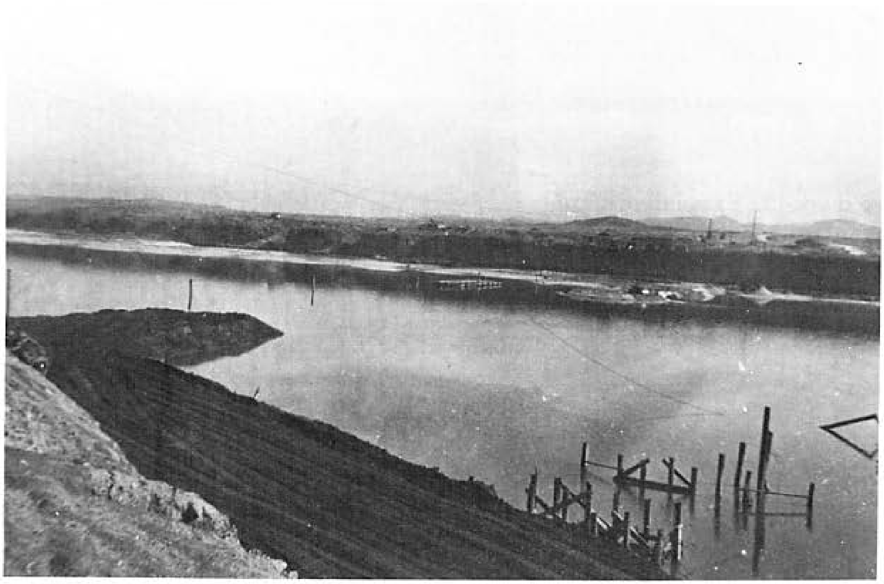


Figure 38. The Imjin River at the X-Ray site, showing early progress on the construction causeway and test piles driven in November 1952 to determine the depth of bedrock.

Figure 39. Pile driving on cofferdam 1 during February 1953. View shows curing cabin on pier 6 on far causeway and the concrete batch plant on the far shore.

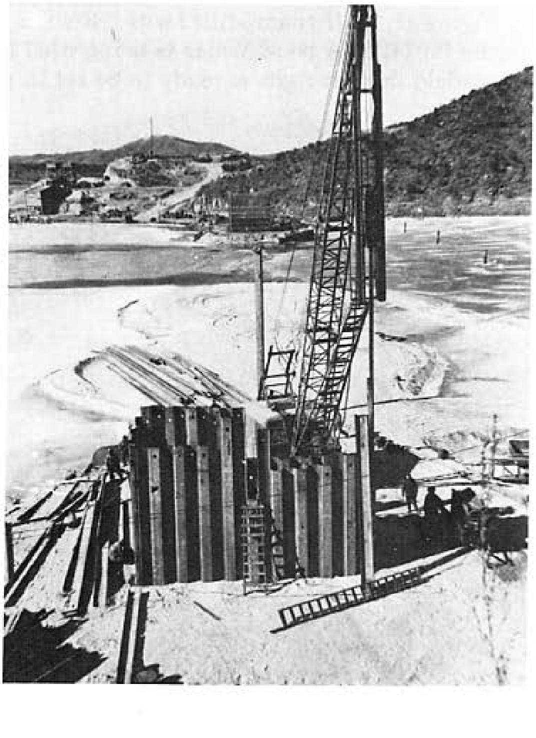


Figure 40. Excavation of cofferdam 1 and pile driving on cofferdam 3. Pier 7 is visible on the far shore.

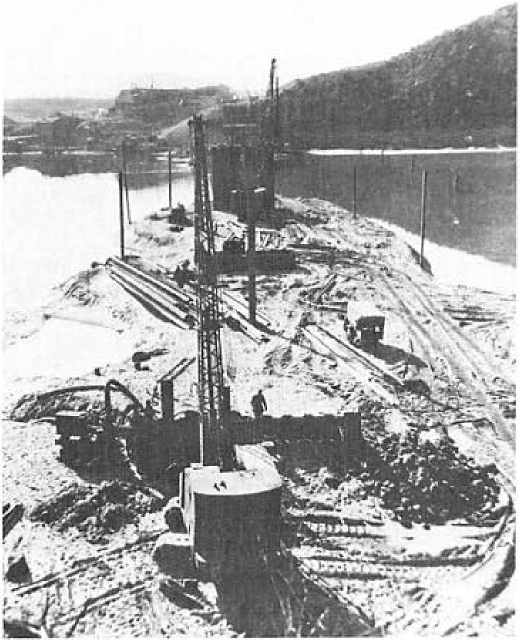


Figure 41. Cofferdam 3 filled with 240 cubic yards of concrete constituting the initial or A pour. Water is being used to cure the concrete, and the scaffold floor at right is ready to be set in place.

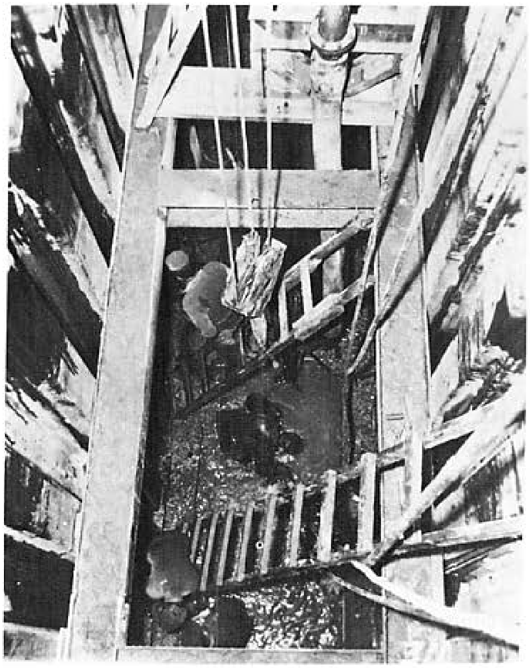
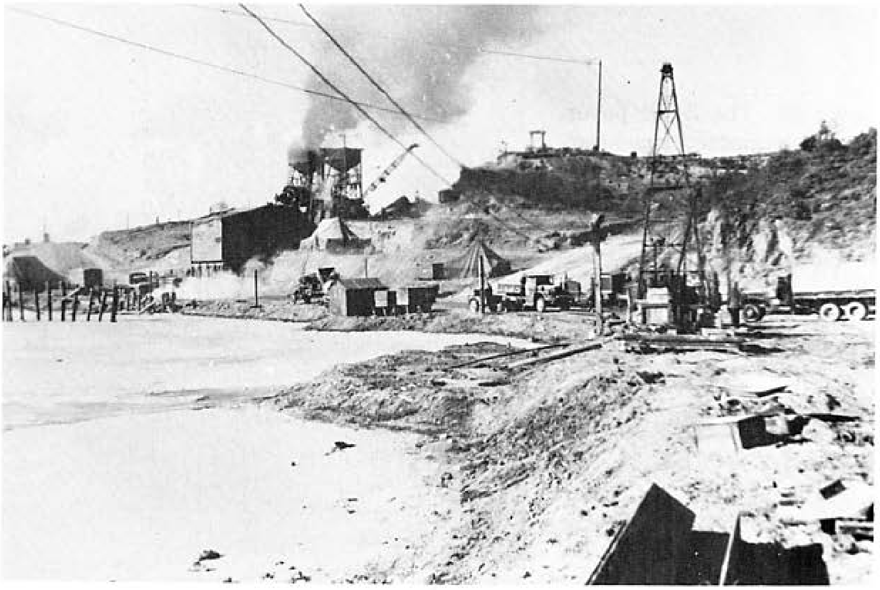


Figure 42. Interior view of a cofferdam showing 12-inch H-beams, or whalers, which enabled it to withstand outside pressure. Buckling of the H-beam is visible at the upper left.

Figure 43. The central concrete batch plant, which furnished hot aggregates or warm concrete from its location on the Imjin's west bank. The plant's two 60-ton bins fed coarse and fine aggregate to the 80- to 150-tons-per-hour dryer that discharged into bins inside the plant.



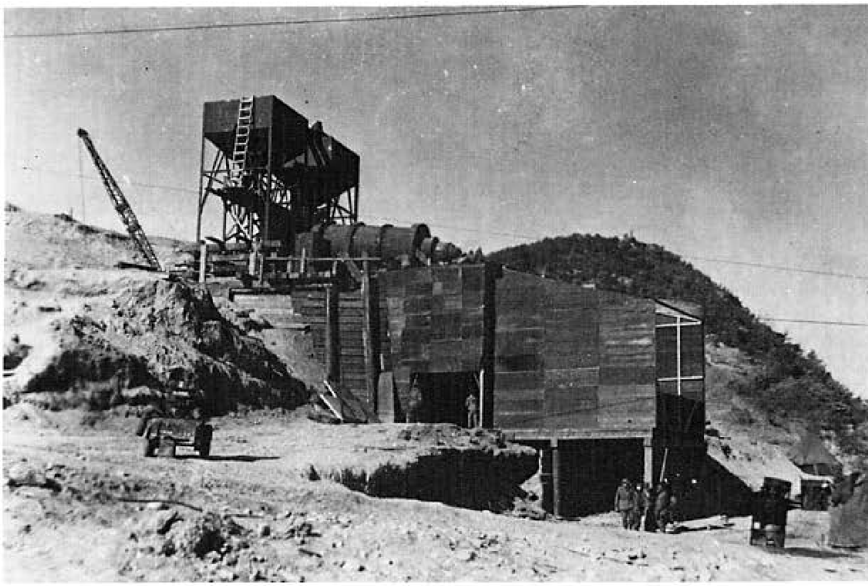
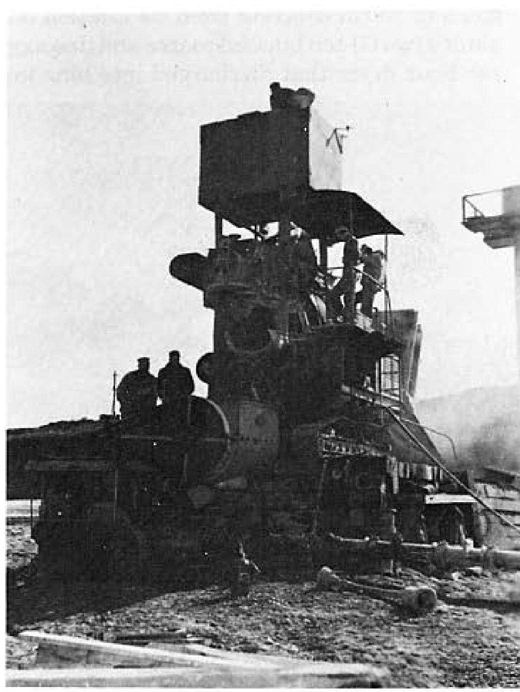


Figure 44. Close-up view of the concrete batch plant showing aggregate bins and, at bottom, locations where dump trucks and mixers were filled.

Figure 45. The 34 E paver and Rex pumpcrete machine, which together proved remarkably successful in mixing cement and moving it to the pouring site.



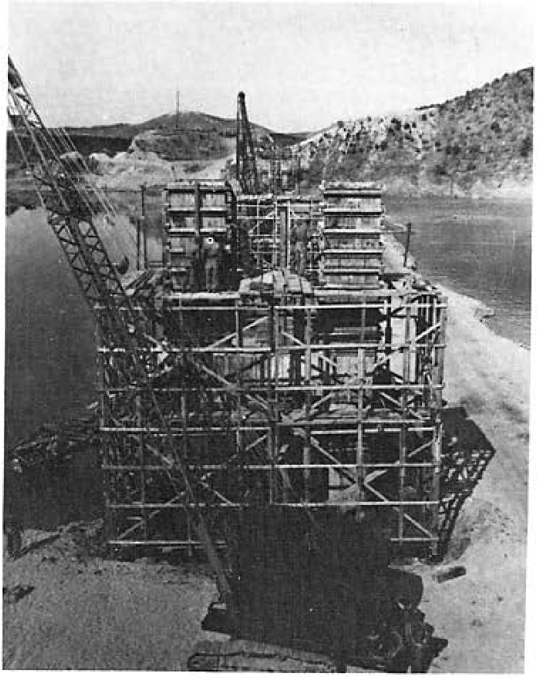


Figure 46. Forms for D pour that had been put together on the ground, raised, and then lowered onto the C pour pedestal. The curing cabin being used as scaffolding is ready to be raised into position and clamped.

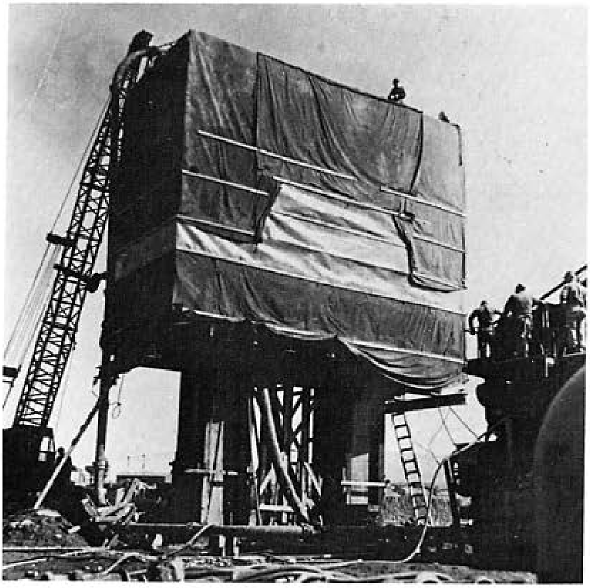


Figure 47. The curing cabin on pier 7 in position for the final or E pour. The canvas pipe, center, provided heat for curing. The 34 E paver and the pumpcrete machine, right, mixed cement and pumped it to the pouring location through the pipe, left, that ran over the curing cabin.

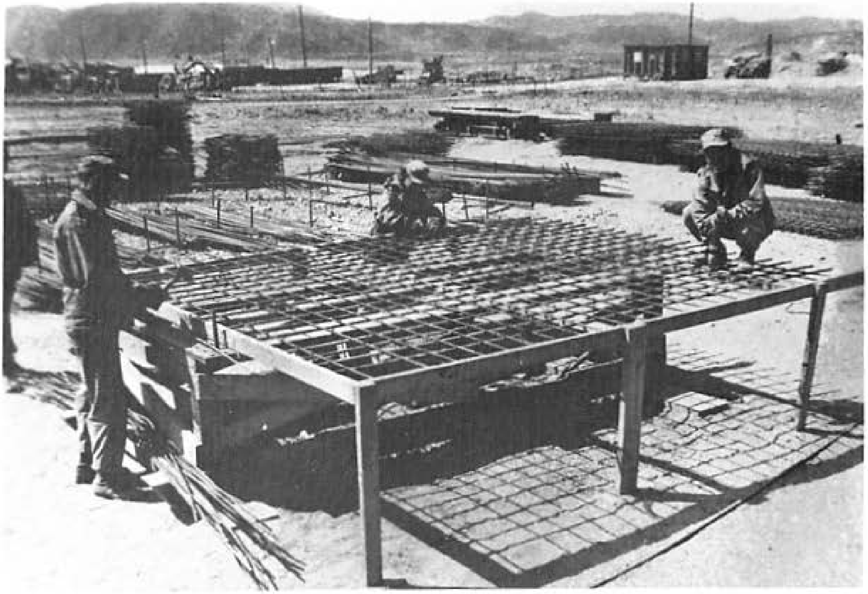


Figure 48. Steel mats that would reinforce the bridge decking being fabricated in the central work yard.

Figure 49. Soldiers casting guardrail posts. The reusable forms shown could cast batches of 66 posts at once.

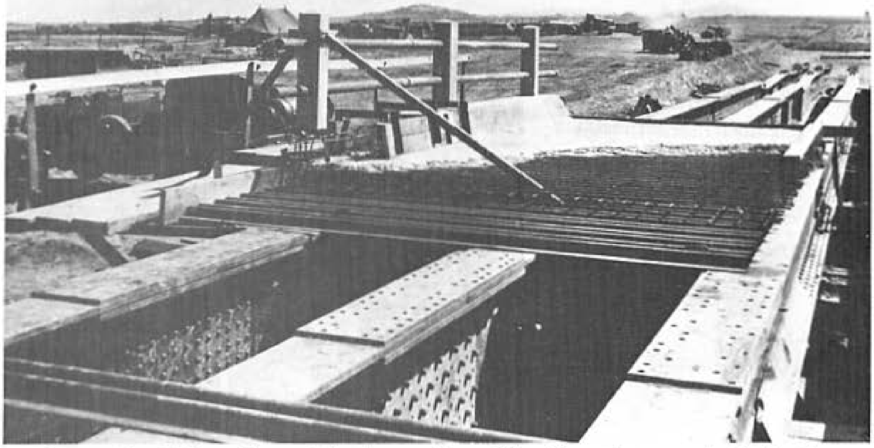


Figure 50. Full-scale model of a section of decking that was built in the work yard for practice and testing purposes.

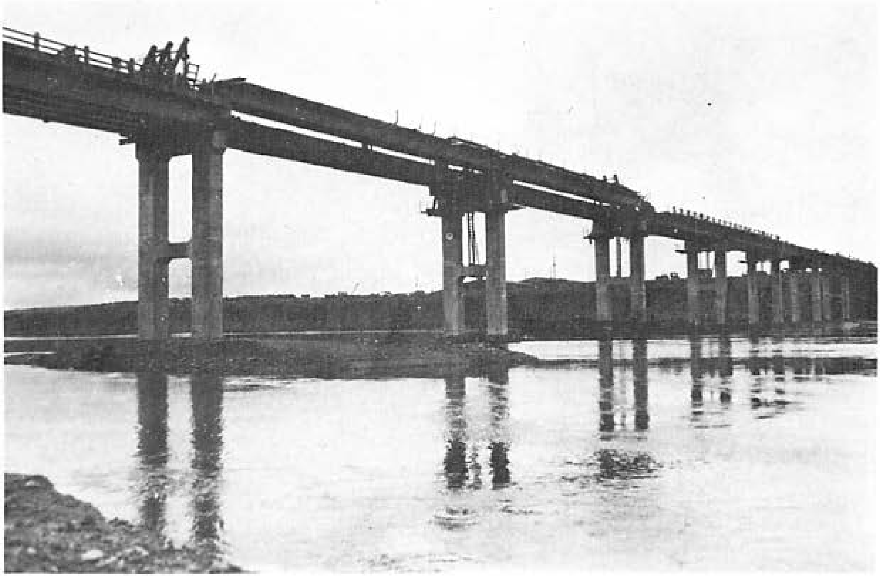
Figure 51. Riveters at work on steel beams. Newly trained American and Korean riveters developed their skills so quickly that a 121-foot span was launched with a deflection of only 17 inches.

Figure 52. Steel beams being prepared for the span from the west abutment to pier 7, while riveters received training on the beam at left center.

Figure 53. Steel beams in place from the west abutment across pier 8 to pier 7. The 30-foot launching nose may be seen beyond pier 7.

Figure 54. Launching the span across piers 7, 6, and 5. Launching noses extend both east and west into the gap between piers 5 and 6.

Figure 55. Chain hoist lowering girder complete with sub-decking across piers 7, 6, and 5.



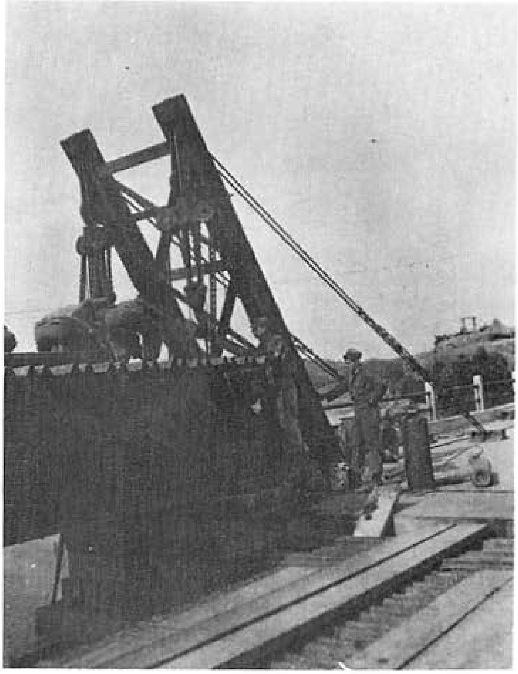


Figure 56. Close-up view of chain hoist lowering downstream girder across piers 7, 6, and 5. This girder was lowered in 22 hours, a much shorter period than the eight days required to lower the corresponding girder from the west abutment to pier 7 with jacks.

Figure 57. Troops setting up the pumpcrete pipe to pour concrete decking.

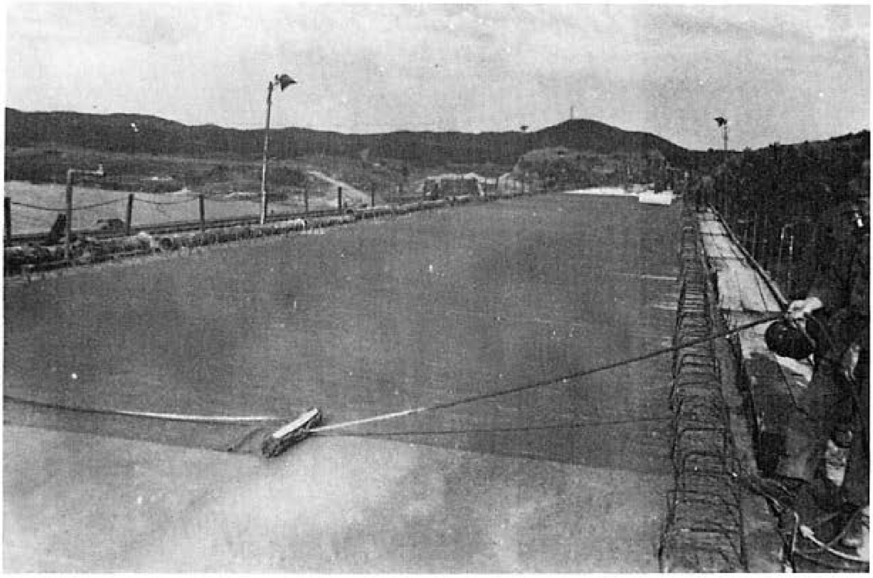


Figure 58. A burlap drag being used to give the deck surface the desired rough texture perpendicular to traffic. Reinforcing steel for curbing is visible.

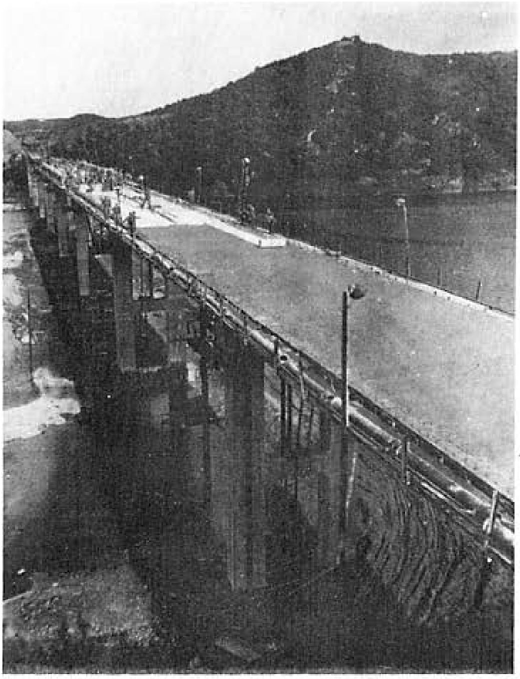


Figure 59. Concrete deck being covered with burlap, at center, prior to receiving a seven-day water cure. A flood gauge is visible on pier 1 in foreground.

Figure 60. Completed Libby bridge from the west bank on 4 July 1953.

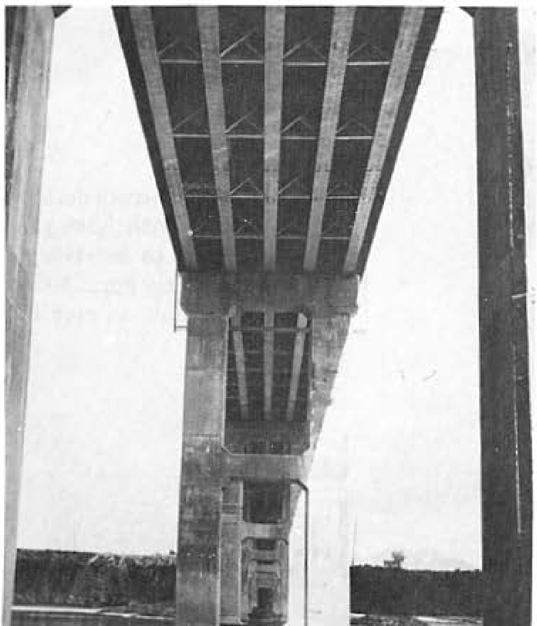


Figure 61. View looking east at the completed piers and superstructure of Libby bridge.

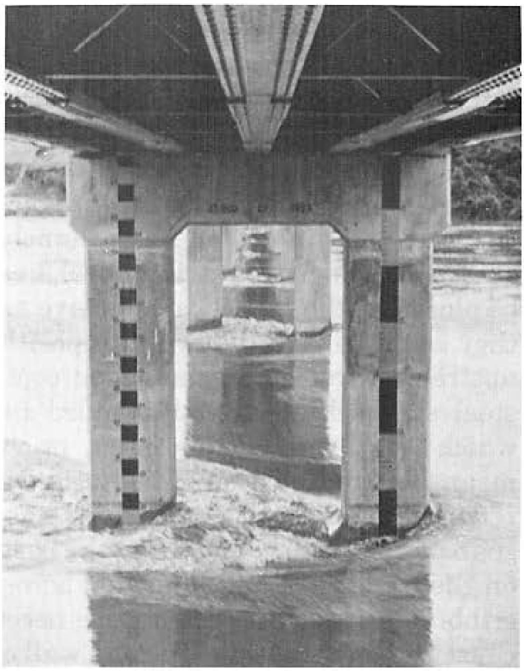
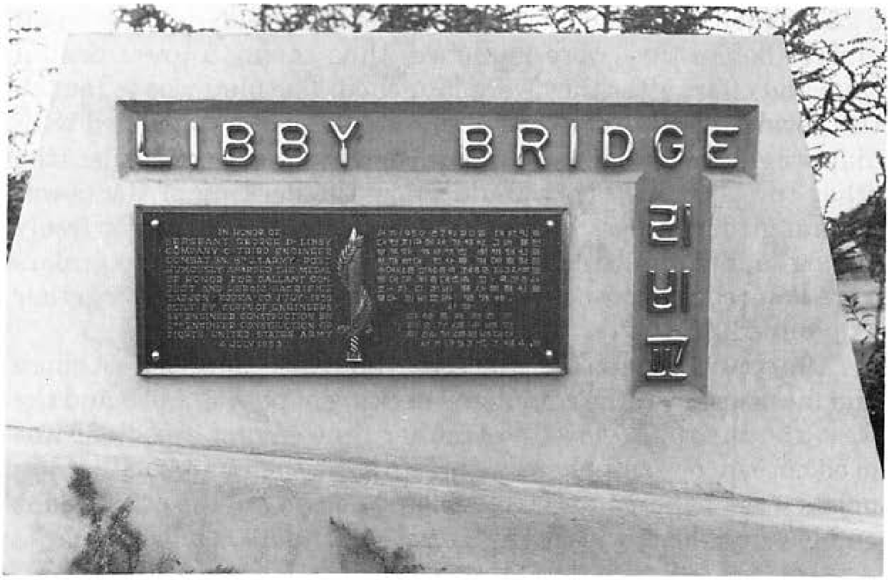


Figure 62. Libby bridge withstanding the flood of 15 July 1953 with more than 20 feet of clearance.

Figure 63. Plaque erected at the east end of the bridge as a memorial to engineer Sergeant George D. Libby.



phragmed) with six-by-six-inch angle iron and fifteen-inch channel iron between beams to form a pair of girders as a unit for launching. This downstream pair was then launched with a 30-foot launching nose fixed to the front at an upward angle to compensate for any downward deflection of the beam when it reached the pier, and a counterweight was added to the tail of the girder to prevent tipping. *(Figure 53)*

Since the girder had to be launched horizontally across the abutment, which was at deck level, heavy wooden cribbing had to be placed on the pier caps to receive and support the beams until they could be jacked down into position on the piers. The three upstream beams were launched complete with the corrugated steel sub-decking already welded in place. This sub-decking, which was available in Korea, provided a simple and speedy means for construction of the deck forms and did not have to be removed when the concrete deck was completed. The girders to span piers 1, 2, 3, 4, and 5 and the east abutment were fabricated on the east shore and launched across the east abutment. Less cribbing and jacking down were necessary for these girders because the top five feet of the end wall of the abutment had not yet been poured, and the girders could be launched just slightly above the elevation at which they were to rest. These girders were 606 feet long when launched, and moving them out to their position required a great deal of engineering skill?

Lieutenant Badman and Warrant Officer Cooley came up with a suggestion that made it possible to weld the sub-decking on all girders before they were launched, thus saving a great deal of time and effort after they were launched. The plan was to launch the downstream girder (two of the five I-beams connected with diaphragming) five inches higher than the upstream girder (the other three beams); this would allow the decking of the downstream girder to pass the decking of the upstream girder freely during launching, without scraping. Then when the two girders were lowered into position, the decking would tightly fit together as planned?

The span for piers 7, 6, and 5 was fabricated on the west shore and launched over the completed decking of piers 7 and 8 and the west abutment. *(Figure 54)* Another time-saving expedient was used here in lowering the girders into position; a frame with chain hoists was anchored to the completed decking of the other spans and lowered the downstream girder in 22 hours, while with jacks it required eight days to lower the corresponding girder of piers 7 and 8 and the west abutment. *(Figures 55 and 56)*

Superstructure operations had been proceeding rapidly wherever the girders were in place, but when the last girders were finally in place the decking operations went into high gear as the target date for completion drew near. The reinforcing steel mats were laid, and the concrete decking was placed with a discharge chute at the end of the pumpcrete pipe; a straightedge was used to obtain the desired plane, followed by a burlap drag to remove any excess moisture and to give the desired rough surface texture perpendicular to the flow of traffic. *(Figures 57 and 58)* The concrete was poured on 14 June, and seven more days of curing with water-soaked burlap were then required. *(Figure 59)* Clean-up operations, which consisted of scraping down all piers, painting the guardrails, removing all scaffolding and catwalks, sweeping down the deck and curb, painting the bottom flanges of all beams, and dressing down the approaches, continued for some time afterward.

An interesting feature of the bridge's construction, which was rather painful for all concerned, was the preparation for demolition should it become necessary. Two steel catwalks are suspended crosswise under the bridge between piers 6 and 7 with steel ladders leading down to them on both sides. Instructions as to the amount and placement of explosives are painted on the sides of the beams. The plan of demolition calls for cutting each of the five beams between piers 6 and 7, allowing this section of the bridge to drop into the river, which has its main channel at this point. Channel-iron brackets are welded to each beam to hold the explosive in place, and a yellow stripe is painted across the deck at each end of the span to show the proper placement of charges to break the concrete decking.[17]

The original target date for completion of the bridge was 1 July 1953. It was finished on time, but only because of a great deal of prior planning, hard work, and aggressive spirit on the part of all concerned to get the job done. From November through March, work proceeded on two ten-hour shifts; later in March, two eleven-hour shifts were put into effect; and after 1 June, two twelve-hour shifts were employed until the completion of the bridge.

F'reezing weather, high winds, floods, high tides, and even some enemy artillery, all contributed to slowing down construction. In the construction itself, the driving, excavating, and pouring of the caissons caused the most delay. Because of these difficulties most of the completion dates for the phases of construction were not met. As Major Carter remarked, "We didn't do anything on time except finish."[18]

Two men were killed during the construction of the bridge. KATUSA Corporal Kim Ho Duk was killed on 31 January 1953 when a boom failed on a three-quarter-yard Buckeye clam on pier 7. Private James E. O'Grady drowned on 16 April 1953 trying to help a Korean civilian worker who had become caught in ropes and was in danger of drowning when the boat in which he was working capsized. The commanding officer of the 84th recommended that the bridge be named for these personnel. However, the Commanding General, Eighth Army, directed that the bridge be named for Sergeant 'George D. Libby, 3d Engineer Combat Battalion, who was posthumously awarded the Medal of Honor for gallant conduct and heroic self-sacrifice at Taejon, Korea, on 20 July 1950.[19] *(Figure 63)* The Libby bridge was dedicated with appropriate ceremonies on 4 July 1953 by General Maxwell D. Taylor, Commanding General, Eighth Army, and was immediately put into service.

Appendix A

Correspondence Between I Corps and Eighth Army Leading to the Approval of the Construction of Teal Bridge

HEADQUARTERS I CORPS
OFFICE OF THE CHIEF OF STAFF
APO 358 U.S. ARMY

AG 823 CICS 2 August 1952

SUBJECT: Imjin River Bridges

TO: Commanding General
Eighth United States Army Korea (EUSAK)
APO 301

1. Recent floods in this sector have destroyed two of the five fixed bridges over the Imjin River which were available to the I Corps.

2. Whereas the Corps can and will be supported over the remaining bridges during the remainder of the flood season this year, it is considered that the replacement of the damaged X-Ray and Teal bridges is an urgent military necessity. It is further firmly believed that more substantial types [of] structures are indicated rather than restoration of those structures which have proven inadequate in the face of the high water.

3. It is deemed important that early consideration of this

matter be given with the specific object of providing replacement bridges at the earliest.

FOR THE COMMANDING GENERAL:

s/John K. Waters
t/JOHN K. WATERS
Brig Gen GS
Chief of Staff

AG 823 KEN-C 1st Ind
(2 Aug 52)
SUBJECT: Imjin River Bridges

HQ, Eighth U.S. Army Korea (EUSAK), APO 301, 11 Aug 52

TO: Commanding General, I Corps, APO 358

1. Replacement of damaged Imjin River bridges will be accomplished when present river conditions warrant and potential flood threat has terminated.

2. At the present time an extensive study and research program is being conducted to provide basis for design and construction of type structures capable of withstanding stage floods and abnormal river conditions encountered on the Imjin and its tributary streams.

BY THE COMMAND OF GENERAL VAN FLEET:

HEADQUARTERS I CORPS
OFFICE OF THE CHIEF OF STAFF
APO 358 U.S. ARMY

14 September 1952

SUBJECT: Imjin River Bridges

TO: Commanding General
Eighth United States Army Korea (EUSAK)
APO 301, U.S. Army

1 Reference: Letter this Headquarters, subject as above, dated 2 August 1952, and 1st indorsement thereto.

2. To provide adequate support for elements north of the Imjin River, the permanent bridge destroyed X-Ray site (CT 095012) and Teal site (CT 174056) during the flood season just terminating are being temporarily replaced with floating M-2 treadway bridges by Corps engineers.

3. Previous experience has demonstrated that floating bridges cannot be indefinitely maintained across the Imjin River during the winter months when ice conditions prevail. To prevent unnecessary loss of equipment, it is considered desirable to remove all floating bridges about 11 December 1952, the mean date of freeze-up on the Imjin. To provide for continued satisfactory support of the forward elements in the I Corps zone of action, it would seem highly desirable that permanent structures at the Teal and X-Ray bridge sites be completed prior to damaging ice conditions .

4. In order that this Headquarters may continue its planning for winter operations, it is requested that information relative to

permanent structures at X-Ray and Teal sites be furnished at the earliest practical date.

FOR THE COMMANDING GENERAL:

s/John K. Waters
t/JOHN K. WATERS
Brig Gen GS
Chief of Staff

KEN-C Imjin River Bridges 24 Sep 52

Engr

G-3 Concur ________ Nonconcur ________

G-4 Concur ________ Nonconcur ________

AG For signature and dispatch

1. Statement of the problem: To submit a plan to the Commanding General, I Corps, for replacing Imjin River bridges.

2. Facts bearing on the problem:

a. Equally spaced along the Imjin River serving the 1st Marine Division, the British Commonwealth Division, and the 3d U.S. Infantry sectors were, prior to 1952 flood season, five high-level bridges. Two of those (Parker and Whitefront) withstood the floods. One (Munsan-ni), potentially the best and most critical, has one temporary pier which was severely threatened. Two (X-Ray and Teal) were washed out leaving a large gap in the lines of communication over the river. (Tab A)

b. I Corps considers the replacement of the two bridges washed out with more substantial structures as urgent military necessity. (Tab B)

c. I Corps desires to be informed of the EUSAK plan for the replacement of those bridges. (Tab C)

d. A general plan has been approved for replacing the temporary span in the Munsan-ni railroad bridge. (Tab D)*

3. Discussion:

a. For these sites two general designs appear feasible. One is a two-way high-level bridge costing approximately $600,000 and requiring eight (8) months to build. The other is a two-way low-level bridge at about two-thirds the cost and one-half the time. The low-level bridge will be topped during floods. It is estimated that such a bridge would be impassable not more than two or three months during the year.

b. The sites of the old five high-level bridges are evenly spaced along the river and adequately serve the near and far shore road nets. From an Engineer point of view they are excellent permanent bridge sites. There are numerous floating bridge sites along the river which can be used during the intervals between the flood season, 1 July to 15 September, and the ice season, 15 December to 25 March, only. Previous experience has indicated conclusively that floating bridges cannot be maintained across the Imjin during these periods especially in the lower reaches where the river is affected by the tide.

c. A plan was discussed with Engineer of I Corps to replace the X-Ray bridge with the two-way high-level bridge to be completed before the 1953 flood season and to replace the Teal bridge with the limited two-way low-level bridge. This plan has been informally concurred in by the Chief of Staff, I Corps.

d. The high-level bridge at X-Ray appears justified on the basis that in addition to the I Corps requirement for a permanent bridge for the present situation there will be an all-year-around requirement including the flood season for such a bridge both after a possible armistice or an advance in that sector. After an armistice or an advance the Munsan-ni railroad bridge would probably have to be limited to rail traffic and thus a highway crossing is required between Munsan-ni and Kaesong.

e. Such a justification does not appear to exist at Teal. In fact, it would appear that, in any situation except for a continuation of the present one, the requirements for any crossing at all at Teal would cease to exist.

4. Conclusion:

a. That the plan informally presented to I Corps is feasible and justified.

b. That formal concurrence of the Commanding General, I Corps, is required.

5. Recommendations: Concurrence and dispatch of attached letter. (Tab E)*

___ LT COL HIMES[1]	___ COL DOWNING[2]	___ COL BAKER[3]
Sch Adv 315	Sch Adv 615	Sch Adv 615

*Not available for inclusion

HEADQUARTERS
EIGHTH UNITED STATES ARMY KOREA (EUSAK)
APO 301

AG 823 KEN-C 29 September 1952

SUBJECT: Repair of Imjin River Bridges

TO: Commanding General
I corps
APO 358

1. Reference letter your headquarters, dated 14 September 1952, subject: "Imjin River Bridges."

2. Past experience and results of studies of this headquarters have conclusively indicated that the only bridges which will have any potential for withstanding extreme flood conditions in the Imjin River are bridges resting on concrete piers extending down to or securely anchored in bed rock. Such structures are extremely expensive and will require both extensive engineer effort and time-consuming construction.

3. It is believed that there is an urgent military requirement for a safe, all-weather, all-year-around railroad crossing at Munsan-ni and a similar highway crossing in the Munsanni-X-Ray reach of the Imjin, whether the present tactical situation continues, whether our forces advance, or whether an armistice ensues.

4. To meet these requirements, it is planned that the temporary span in the Munsan-ni railroad bridge be replaced immediately by a permanent span with a planned completion date prior to 1 January 1953, and to construct at the X-Ray site a two-way class-60 high-level, all-weather highway bridge with a planned completion date some time between the ice season of 1952-1953 and the 1953 flood season.

5. It is believed there is also an urgent military requirement

for replacing the Teal bridge which washed out during the past flood season. To meet this requirement it is planned to construct a low-level limited two-way class-60 highway bridge which will be available for use except during periods of extreme floods and which will be of such design as will permit use with a minimum delay after flood waters recede. Present planning indicates that such a bridge can be completed by 1 January1953.

6. Request your comments and/or concurrence in the above plans.

BY COMMAND OF GENERAL VAN FLEET:

s/C. W. Burleson
t/C. W. BURLESON
Lt Col AGC
Asst AG

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

CONTENTS

6* Cross Section of Imjin River at Teal Site, with High-water Levels

7* Proposed High-Level Bridge Data
    Design Computations
    Cost Estimate
    Critical Items of Materials and Equipment

8* Proposed Low-Level, One-Way Bridge Data
    Design Computations
    Cost Estimate
    Critical Items of Materials and Equipment

9* Proposed Low-Level, Two-Way (Restricted Traffic) Bridge Data
    Design Computations
    Cost Estimate
    Critical Items of Materials and Equipment

10* Proposed Low-Level, Two-Way (Unrestricted Traffic) Bridge Data
    Design Computations
    Cost Estimate
    Critical Items of Materials and Equipment

*Attachments**

Plan A Drawings for Proposed High-Level Two-Way Bridge
Plan B Drawings for Proposed Low-Level One-Way Bridge
Plan C Drawings for Proposed Low-Level Two-Way (Restricted Traffic) Bridge
Plan D Drawings for Proposed Low-Level 'Iwo-Way (Unrestricted Traffic) Bridge

*Not reproduced

HEADQUARTERS
2D ENGINEER CONSTRUCTION GROUP
APO 971

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
2D ENGINEER CONSTRUCTION GROUP
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.

Appendix C

Excerpt From Libby Hi-level Highway Bridge, A Paper Signed About July 1953 by Major William C. Carter, Jr., Operations Officer, 84th Engineer Battalion

LIBBY HI-LEVEL HIGHWAY BRIDGE

General Description

Length and Spans: 1074.2 feet, with eight spans 121 feet and one span 104 feet.

Height: 49 feet to bottom of I-beams at mean low tide. 79 feet from bottom of caissons to top of deck.

Roadway: 22-foot traveled way; 25-foot overall.

Piers: Eight piers made of Yawata sheet pile, type #3—5 piles wide by 19 piles long, driven to bed rock (average elevation—15 feet) and cut off at elevation + 15.00 feet. Caisson mucked to firm bed rock and filled with concrete. Reinforcing temperature steel placed in the top 10 feet of caisson. Above elevation + 15.00 feet the piers rise 44 feet consisting of two reinforced concrete columns 4 feet wide by 5 feet long spaced 10 feet apart with an intermediate stiffener 4 feet wide by 3 feet deep, and a cap 4 feet wide, 4 feet deep, by 22 feet long.

Beams: Five 48-inch built-up beams spaced on 57-inch centers from bridge centerline.

Decking: 5/32-inch corrugated sheet metal subdeck, 25 feet wide, welded to beams, covered with 7 1/4 inches of reinforced concrete from top of 3-inch corrugation.

Approach roads: 30 feet wide covered with 12 inches of crushed basalt base and 4 inches of crushed one-inch aggregate.

Class: 60 ton two-way.

Appendix D

Log of Libby Bridge, Compiled by Major William C. Carter, Jr., Operations Officer, 84th Engineer Construction Battalion (22 November 1952–5 July 1953) and Major Sam E. Fairchild, His Predecessor in That Position

LOG OF LIBBY BRIDGE

9 October 1952

Notified by 2d Engineer Construction Group that the 84th Engineer Construction Battalion would build a high-level permanent-type bridge at X-Ray site on the Imjin River. Design and details forthcoming.

14 October 1952

A list of equipment and special materials is being prepared, that will be needed to build bridge. A reconnaissance of Battalion bivouac area is being made in the vicinity of X-Ray Bridge site. Plans are being made to move Company A, Company C, and H&S [Headquarters and Service] Company to this proposed location.

Submitted tentative equipment list to Group C.O., and he suggested that plans be made to utilize as much [as possible] of the equipment now in use or will be in use at Teal low-level bridge.[1] At present we don't know when the X-Ray Bridge job will start. Have not received any plans to date.

15 October 1952

Got O.K. from 1st Marine Division to occupy area near X-Ray site. Were told this battalion must construct "bug-out" road in rear of area. Now, have area swept for mines before starting preparation of area for quarters.

23 October 1952

Group shipped by rail 21 pieces of 60' sheet piling with different design from original type we had already received. Are unloading at Munsan[-ni] siding and holding for disposition.

25 October 1952

Got verbal notification from Gp.–4[2] that the following equipment was being shipped from Pusan:

2	Primary Rock Crushers	1	Aggregate Heating Plant
2	Secondary Rock Crushers	3	Shower Units
7	14 S Mixers[3]	18	20' × 40' Tarps
4	Dozers	4	Herman Nelson Heaters[4]
1	Two-compartment Aggregate Plant		

27 October 1952

Received plan #A-1-39, showing center line and plot plan of X-Ray site. Received profile, drawing #A-l--39 for proposed X-Ray [Bridge].

28 October 1952

Received Group Operation Order on X-Ray High-Level Bridge, #84–376.[5]

29 October 1952

Started assembling floats to drive Armco piles[6] upstream from piers to get bedrock profile and also to support cable fastening.

1 November 1952

Marines clearing mines in vicinity of near shore approach to bridge. Preparation being made to drive two Armco piles (one on each side) to support cable across river and to drive one pile opposite each proposed pier approximately 175 upstream to obtain bedrock profile in river bottom and also to be used as anchor piles to drive caissons.

9 November 1952

Completed driving two Armco cable anchor piles across river and strung anchor cable.

Received plans for permanent high-level bridge. The following questions came up: Is 3¼" enough thickness for concrete deck slab which uses 1" width of reinforcing rods? Whether or not the corrugated sheet metal on decking will be overlapped laterally? How many fixed and how many free ends of *36"* beams? A detail of free end of beam? The size of pier base? The height of column section? The number of reinforcing rods in section C–C' column? Whether or not the base of pier went to bedrock?

Also received bill of materials from 2d Group for bridge. This was returned to Group for correction.

10 November 1952

Drove test Armco piles 125' upstream opposite pier 7 and pier 6. These piles to be used as test for depth of bedrock and also [as] anchors for caisson construction. [We obtained the following results:]

	#6	#7
Length of pile:	*38* feet	*38* feet
Time:	1650	1140
Depth of river:	9 feet	6½ feet
Penetration below river bottom:	20 feet	17 feet
Total below water [surface]:	[29 feet]	23½ feet

[Additional results:]

	#3	#4	#5
Depth of river:	8½ feet	8½ feet	9½ feet
Penetration below river bottom:	20½ feet	21½ feet	18½ feet

11 November 1952

Received corrected (change 1) copy of 2d Group's BM [bill of materials] on X-Ray Bridge. This was checked by Battalion against plans and changes recommended to Group.

12 *November 1952*

Checked with Group on plans and BM. Refer to questions listed above on 9th and 11th Nov. No answer was given by Group on deck slab or corrugated sheet metal. They are trying to get more data on metal. Group issued another sheet of plans (profile) showing which joints were fixed and which were free. Didn't give a detail of free end joint.

It was O.K. by Group to use new dimensions for the base of the pier as resulted by actual measurements of type III sheet pile—giving 1 ft. increase in length and 1 ft. increase in width.

The heights of column sections were given and marked on the plans.

The number of reinforcing rods in cross-section of column C-C on plans was established as 22. Inserting 2 more on drawing.

The base of pier was to go to bedrock.

No decision was made on H-beams being used to anchor base of pier into bedrock.

No decision was made as to whether erection plates would be placed or just the bolts before pouring the base of the pier.

Group O.K.'d the additional changes of BM and issued a corrected copy (change II) of BM.

17 *November 1952*

Notified by Battalion S-4[8] that 45# 15" channel iron was not avail-able as called for on X-Ray BM. Called Maj. [Willard] Norris (Gp. [S-]3) and he said to go ahead and req[uisition] 15" channel leaving off weight. He said if 33.9# iron is substituted it would be O.K.

Capt. Long at Group is designing a sheet pile driving head that will drive 2 piles at a time. This may call for redesigning template for driving caisson.[9]

24 November 1952

Group notified Battalion last night that batch plant is not on hand at Pusan and 27 E mixers not available.

Major items now on hand include one 300 BBL [300 barrel] cement batch plant complete. One 80 to 150 [tons per hour] aggregate dryer arrived Munsan-ni this A.M. to be unloaded P.M. Sheet piling arriving on job. Work progressing on causeway, both banks.

A Company began erecting large maintenance building on 23 Nov. Area muddy due to freeze and thaw action. Trucks hauling rock base for X-Ray equipment yard, roads, and buildings.

25 *November 1952*

Aggregate dryer does not have UD 14A power. [generating] unit with the unit. Maj. Norris, Group S-3, [was] advised by phone, [by] Carter,[10] about 1730 24 November.

27 November 1952

Col. [Raymond W.] Beggs, Group Commanding Officer, visited Battalion 26–27 November returning 10 A.M. today. Discussed plans for executing X-Ray project w/general approval given for all plans except modification of aggregate loading into dryer and method of mixing and placing concrete in caissons. About 1730 26 November Col. Egglestan[11] informed Col. Beggs that a 34 E paver was expected in Inch'on from Yokohama 11 December.

Figure 64. Major William C. Carter, Jr., project manager for construction of the Libby bridge, in front of the completed structure.

Present plans are as follows:

Progress schedule as per drawing 376-1, sheet 2, dated 26 November 1952, approved verbally.

Plans [are] to construct straight-line gravity-follow concrete mix plant along cliff on west bank then move to east bank and remove on completion of piers and before spring high water.

Plan to batch aggregate in plant but to mix and place concrete in caissons from three ½-cu.-yd. mixers arranged near caisson. Haul batch in 3-compartment dump body. Place concrete in caisson from 1½ yd. clam bucket.

Corrall concrete curing cabins[12] will be used to both cure fresh concrete and as a work platform to place concrete. Also as a shelter when fitting forms and placing reinforcing steel.

20' x 54' shed for concrete storage arrived today by trailer.

10 December 1952

Col. Beggs visited during lunch 9 December and gave decision on caisson pile dimensions as follows: 19 piles length and 5 piles wide plus corner pile 4 corners.

At 1700 hrs. talked with Capt. Long, Gp. Equip. O.,[13] and was advised: UD 14A power unit for aggregate dryer being airlifted to K-16.[14]

Aggregate Elevator is on a boat from YED.[15] Rotary drill is coming-don't know where or when. Batch plant less scales is shipped via rail [from] Pusan. Sheet pile heads-3 ea.—adapter[16] ready 11 or 12 December.

10 December 1952

Aggregate plant at Marine Bridge consisting of one primary, two secondaries, went into effective production this afternoon after 4 days of trials and adjustments. Output indicated excellent coarse aggregate with doubtful fine aggregate due to unknown amount of fines and suspected silt and/or colloidal matter. Test samples picked off conveyor discharge this A.M. about 1130 and again about 1430 were taken back by 2d Gp. for sieve analysis along w/specimen from Imjin River sand.

Concrete batch plant in 3d day of erection on far shore. 20' × 54' cement shed going up on near shore. Equipment shop corn-pleted and roof going on carpenter shop. Materials yard about ½ laid out with approximately 8 trailer loads of lumber on hand.

Marine Bridge gravel appears unlimited with 20,000 cu. yd. take possible within easy 8 [cubic] yd. pan range of plant? Plant -is fed by dozer and ramp bulkhead. Shovel loading out gravel fill to. X-Ray yard.

Fender sheet pile on West causeway going in to protect channel erosion of causeway. X-Ray pontoon bridge removed 9 December.

17 December 1952

Staff visit by Col. Egglestan, Col. Norris,[18] Capt. [Edward P.] Klotch, Gp. Ex. Officer, S-3, S-4, respectively, was made 14-15 December. Conference concerning Teal, Freedom Gate, .and X-Ray problem was night of 14 December in Commanding Officer's tent. Among problems discussed concerning X-Ray were the following:

1½ [cubic] yd. [power shovel] now at Teal will be required there through January taking off slopes of North approach after bridge steel and piling are complete.

There was general discussion of aggregates for X-Ray. Initial sample from Marine Bridge plant taken about 8 December shows 8.5 fines passing #80 screen.[19] The sand appears to have an excess of clay and silt, and coarse contains a large quantity of sand and in addition is coated with some clay and silt. It was generally believed that material passing through dryer would burn off and blow off some of the fines. Washing is not desirable due to expected low temperatures. Aggregates at Teal are generally cleaner than those at Marine Bridge. Dump truck support was discussed. It was generally agreed that river sand from X-Ray would serve the purpose, but it tests out 62.9% retained on #40 and 31.2% retained on #60 screen.

Equipment forecast by Gp. as of 14 December was as follows: 34 E paver-Inch'on-24 December phoned in by Maj. [Leonard C.] Nash of Gp. Batch plant-have car number but don't know when it will arrive. Aggregate loader-conveyor on a boat from YED. UD 14A power unit for aggregate dryer was too big for airlift and is coming up by rail sometime. Rotary drill still at Pusan. Adapter heads for sheet piles will now be ready noon 16 December. Have had a one-two day ready report for more than a week now. The adapter head is necessary to set first pile and delaying the start of actual construction at X-Ray.

On 16 December a call to Capt. Long, Gp. Equipment Officer said pile adapters were to be ready at noon. Call back from Group says power failure has delayed completion to Thursday 18 December. Group Ex[ecutive] Officer informs that car number on batch plant turned out to be car number of car that brought up cement batch plant. No commercial batch plant will arrive in near future. Order given to Company A 16 December to proceed to construct our own plant. This has delayed concrete production several days.

17 ***December 1952,*** 1315 ***hrs.***

Just talked with Lt. Col. Norris, Gp. S-3, and request dump truck platoon (16 trucks with supporting mechanics and supervisors) to report 19 December. To be housed H&S Co.

Norris reports two hours' work remaining on sheet pile anvil head. Will call when complete. Requests redesign of steps and rerequisition of material to be changed to X-Ray.

17 ***December 1952, 1715 hrs.***

Group Ass't. S-3, Maj. Nash, has called and inform [ed us that] 16 dump trucks with drivers and support to arrive 19 December. Decision of Commanding Officer to move aggregate production plant from Marine Bridge to Teal. S-3 concurs. Marine Bridge aggregate has too heavy a coating of silt and clay. Company A's rock crusher crews to move up on 18 December.

18 December 1952

UD 14A power unit for aggregate dryer arrived at Munsan rail head yesterday. Today at 1630 checked rail yard and found six 60-ton aggregate batch bins had arrived.

Aggregate plant moved Marine Bridge to Teal on 17 December. 16 dump trucks to arrive tonight to haul aggregate from Teal to far shore X-Ray.

Adapter head for sheet piles arrived last night. Too big. Spent day cutting it with torch down to size. If it fits can begin first actual construction on caissons tomorrow.

20 December 1952

At 0845 hrs. the 1½ yd. Manitowoc crane rigged with leads, 5000# hammer, on West causeway near pier 6 picked up a 40' sheet pile. As crane swung from W to S the machine began to tilt to the S. Tracks were on E-W axis. Maj. Carter, Capt. [Willard T.] Pflueger, W/O [Harry] Cooley were observing operation; all hollered simultaneously, "drop the hammer." Operator attempted & stop swing a second then jumped. Rig toppled sideways to the S. Damage appears to be broken boom section, twisted leads, twisted and broken catwalk. Damage to machine unknown but believed slight. Immediate efforts began to remove damaged sections and upright machine.

30 December 1952

X-Ray project progressing slowly. Pier 6 sheet piling going in with 6 piles to 15 penetration as of 29 December. First pile driven to 30' penetration from causeway to bedrock. Remaining piles to be driven to 15 until all are connected then to bedrock.

Concrete mix plant erection proceeding. A total of six (6) aggregate batch bins arrived: two to feed aggregate dryer, two in mix plant to feed volume measure buckets for each mix, two to be returned to. Gp. S-4 as excess.

Coarse aggregate production at Teal is slow. 80 cu. yds. loaded out first day of operation. Frequent breakdown of crushing equipment. 595th [Engineer Dump Truck Company's] dump trucks (16) hauling aggregate from Teal to far shore X-Ray. Trucks as of today begin hauling sand from Spoonbill to far shore.

Excavation to elevation 53 [feet above mean sea level] proceeding on West abutment. Clay spades and pneumatic tools required for all excavation.

Carpenter shop completed and erection of concrete curing shelter underway. Materials storage yard laid out and organized. Operations Office carpenter work finished 29 December.

Company A and Company C hurting for manpower. Each company has men working to complete Teal.

Many items required for first concrete pour have not arrived. Gp. advised on 29 December of shortages.

11 January 1953

Status of project as of 1200 hrs. 11 January 1953 follows:

Sheet piles pier 6 all driven to within [at least] approximately 5' of bedrock with about 1/3 to bedrock. Penetration averages 30' below causeway which is at about plus 15' MSL.[20] 2100 GPM pump[21] with lowering attachments and hose is on site prepared to dewater. 3/4 yd. clam is on site prepared to excavate. Piles will be cut to elev. 15.00 per change in caisson design from elev. 10 to elev. 15 necessitated because elev. 10 would be under water much of the time. Well drill rig on hand to drill dowel holes if bedrock surface is not rough enough to prevent movement of caisson.

Central concrete mix plant is set up and awaits 34 E paver. Paver has been reported for more than two weeks as on the way, at Pusan, on water between Pusan and Inch'on, and in hold of ship at Pusan. Gp. S-4 advises as of an hour ago it is now on way via water to Inch'on. Aggregate dryer operated first time on 10 January. Water heater operated on 11 January.

All coarse aggregate required [is now] on far shore[;] 900 [cubic] yds. [are there], only 700 [are] required. Hauling as of this date to stockpile near shore. Sand stockpiled on far shore, and source on river downstream far shore available for further requirements.

West approach road laid out with a curve to the right on north with 5%+ grade and curve to south on left with 8% grade. 36" culvert going in at station 12+51.[22] Slope stakes going in on approaches. Necessary stripping completed. Earth moving equipment must come from Teal on completion of that priority project.

West abutment nearing complete excavation to elev. 53 MSL. Gp. C.O., Col. Beggs says O.K. to not use form on abutment in view of rock condition of excavation. South wing wall will be stepped to suitable foundation. No wing wall necessary on N side.

Timbers laid to carry 1½ yd. Manitowoc which will drive pier 7 and for 1½ yd. P&H which is enroute this date from Teal to drive pier 8. Pile in place.

Carpenter shop is working on first set of forms. Reinforcing rod fabrication is underway. Materials storage is fully operational. 48" built-up beams to begin arriving coming week after rail embargo lifts on 13 January, 8 per day. Cement on hand.

We are needing welding equipment and cutting torches but must wait until Teal finishes.

Excess supplies and equipment are being moved daily from Teal. Company A and Company C manpower at Teal partially released on 10 January.

Weather past ten days has ranged from 42° to 2° F. Only one day of real warm weather.

16 January 1953

Plans have been changed by Army and Gp. in some particulars. Superstructure deck will be 8½" thick from steel deck valley to top of pavement, 7" at curb. Construction joint between slab and curb. Lifts on pours, as planned by 84th and for which initial set of forms had been built, were changed on column portions to below 45° chamfer of 1' under stiffener and under cap.

Major changes made in wing walls, and Gp., Lt. Dameran[23] has been promising new design for *3* days now. We could have poured concrete tomorrow if plans had been finished. A trip to Gp. yesterday produced half the information required but no call today on steel, which will have to be cut and bent and placed.

34 E paver, less drum, arrived at Inch'on yesterday. We are going ahead with one *16* S mixer in central plant.

Piling going in fast on pier *7* today. 1½ yd. P&H crane moved down from Teal requires several critical parts before driving operations on pier *8* can proceed.

26 January 1953

Equipment deadlined and lack of equipment due to Teal priority continues to delay seriously X-Ray job. During past week we have critically needed 1½ yd. crane for pile driving, one day was lost for lack of an operational air compressor when 500 cfm clutch[24] went out, and two days were lost limping along with a 210

Figure 65. Excavation of cofferdam 6, begun by a 3/4-yard clam bucket on 16 January 1953. Shower unit at lower left provided hot water for cement. Twelve inches of ice on the Imjin provided access to the far shore on foot.

cfm in lieu of 500. Teal is releasing equipment as fast as job permits.

Continuous problems arise with pumps. Ignition troubles due to lack of good spark plugs, points are main causes.

Three (3) ¾ yd. cranes are down for [piston] rod inserts. Passed by ¾ yd. Koehring day before yesterday just as inserts began to knock. Engine was full of oil. The clutch of the booster to boom hoist on 22B causes delays. Same crane needs new tracks. This machine has cost us valuable days in excavating caisson #6.

Lack of welding machines operational has held up completion of concrete batch plant. For a week only one welding rig at X-Ray and it was on pile driving rig or pier 6 most of time.

Steam rig 3 car heater[25] came up last Monday 19 January at night. Operator from 526th [Engineer Panel Bridge Company] had never seen the machine before and was useless. A bad tube has caused delay in proper use of rig. Believe it to be O.K. now.

Will place concrete in W abutment today if plant and ¾ yd. mobile Buckeye hold together. Buckeye broke down again last night. It will not travel due to clutch but can be thrown into gear.

Finished driving piling pier 7 yesterday to average penetration of 27'. Lack only one foot to refusal on average it is estimated. Gp. C.O. ordered Bn. C.O.[26] on 25th to drive only 5' all pile, excavate, place whaler,[27] drive again. This procedure will materially slow work over present procedure.

A bad crack in piling, pier 6, makes as much water as 2100 GPM can pump from elev. 4[28] support in hole. Attempting to seal crack with grout from outside caisson using well drill rig.

27 January 1953

Placed concrete in West abutment and wing-wall footings yesterday. Finished placing at midnight. Began placing at 1700 hrs. First bucket with 2% calcium chloride and running 110° set up in less than 30. min. 1–2–3 mix[29] used. Water was about 40°, cement 32°, rock 125°, sand plus 300°. Required 17 gal. water, at times 18 gal., to get 2" slump.

Diver explored pier 6 caisson and reports crack between 2" and 3" to bottom. Attempted to put corner pile in to cover crack but did not succeed. Plan is to pump neat cement grout with well drill rig from outside when differential is 3' water head flowing into caisson. Welder-diver to weld 2" angle iron over crack this P.M. Temperature of 9° this A.M. caused difficulties starting motors.

Gp. C.O., Col. Beggs, on job last night and today. Recommends keeping engines running at night.

Hurting for more cats[30] to fill east causeway, approach road from east and cut slopes for B Company's bivouac area. Need more welders, Herman Nelsons, and cranes.

28 January 1953

Diver worked in caisson pier 6 today. P.M. was spent setting 2" angle iron down to rock against and covering crack. At 0200 this morning diver finally completed tack-welding angle iron in place. Today he is to weld tight.

Attempted to grout with neat cement from 29' down using well drill. Pumped better than 30 [one-cubic-foot] bags down when pump quit, lost prime. Will try again.

Have 22B working caisson #6. 2100 GPM pump, welding machine, 4" diaphragm pump, 55 GPM pump, and well drill rig tied up on pier 6.

Mobile ¾ yd. Buckeye w/clam excavating on pier 7 beginning 26 January. 1½ yd. Manitowoc driving pile w/500 cfm pier 8.

Need more pumps, centrifugal, more welding machines and cranes. 1½ yd. P&H rigging on near shore causeway to drive piles.

30 January 1953, 0750 hrs.

Job has been stymied as a result of pier 6. On 29 January a concrete cap was placed through a tremie into a form to block off a flow coming from under one of the piles that split. Apparently little water is coming in through the crack. Diver cleaned out bottom, placed cap form, set tremie. Diver reports bottom uneven and leaks only under piling capped off on 29th. On 30 January we will pump grout adjacent to split piling.

On 31 January we will attempt to dewater. If successful we will muck out and pour. If unsuccessful we willget divers, muck out, and pour.

Col. Beggs returned [to] his Hq. on 29th. Visit made 29th by Col. Kelly,[31] 8th. Army Operations, and Col. Ribbs,[32] 8th Army Engineer Section.

Col. [Louis J.] Rumaggi, 8th Army Engineer, ordered concrete be placed around bottom of caisson night of 29 January. C.O. advised Gp. C.O. of conversation. Job needs more cranes. 1½ yd. P&H rigged to drive on east causeway and should begin driving. pier 1 today.

Rig pulled off of pier 8 on 29th and began driving pier 7 to penetration. Standard penetration accepted at 50 blows per quarter inch. This move was result of earlier Gp. C.O. order to drive down in increments and excavate and set whalers. This policy reversed on 29 January by Col. Beggs after a closer study of driving procedure and soil conditions.

Excavation of pier 7 will continue today after all piles reach penetration.

Army is vitally interested in depth of bedrock under caissons. Will drill down tomorrow when grouting [is] finished.

2 February 1953

The Army Engineer, Col. Rumaggi, and Col. Beggs visited the job yesterday. Col. Rumaggi, after having seen caisson, pier 6, remarked at noon to Col. Beggs, "We must consider all means necessary to fully investigate foundation conditions, at the risk of delaying the opening date [of the bridge], as neither you nor I wish to build a bridge such as this one that will fail."

Pier 6 was dewatered after time-consuming delays in getting

2100 GPM and 1000 GPM pumps lowered into hole and operational. Last night we stood on bottom of south end. Lots of water in split pile crack. Whaler now in bottom of pier 6. Col. Beggs says two Korean divers to come 2 Februaryto muck out bottom. A slab will then be placed on rock bottom, allowed to set up two to three days, then finish placing concrete. Man killed[33] night of 31 [January]–1 [February] by boom failure on 3/4 yd. Buckeye clam pier 7.

9 February 1953

Concrete was placed in pier 6 caisson beginning 5 February and ending 6 February at 1900 hrs. The hole continued to make water, and three large boils in the south end were evident when last mucking was completed. An air rock drill went 3' into rock near the southeast corner prior to placing concrete.

Before placing concrete 50 sacks of cement were emptied into the hole that was full of water at the time. The first 20 or so buckets of concrete were lowered with a 1½ yd. clam which proved time-consuming and created a great deal of wash-wave action. A rig mounted on four wheels running on the top 12" H-beam whaler holding a 15" pipe by a collar served as a movable tremie which speeded up placing operations.

Pier 7 was quickly excavated to a depth of about 26 feet, but remaining excavation is slow. Mucking by hand due to large boulders. No rock positively evident as of 2000 hrs., 8 February.

34 E paver arrived on job night of 8 February.

Considering use of a "pumpcrete plant" to place all concrete. "Bug out fever" prevails past three days.

11 February 1953

Col. Beggs, 2d Gp. C.O., visited job on 10 February, inspected caisson #7, and ordered a concrete blanket placed i-n the bottom, up to top of bottom whaler. A matter of 4' of concrete. Allow to set two days, dewater, and attempt to place remainder in the dry. Bn. C.O. and S-3 favored and recommended placing entire caisson but were overruled.

34 E paver is being readied for operation.

Excavation on pier 8 is slow, mostly by hand and air tools due to frozen ground. Now down to rock.

Placed West abutment wing wall. Vibrator sheared cable after ⅓ of pour placed. Rodded remainder into form increasing cement one bag per ½ cu. yd.

Job badly needs two additional cranes, 3/4 yd., to meet schedule. Vibrators are in critical category along with rivet hammer of 80–90 lb. size.

Bn. C.O. approved scaffold design incorporating 3” angle iron kicking against 48” beam with hook holding top member to 48” beam.

B Company platoon is placing 48" beams and beginning disassembly and assembly operations.

Adequate coarse aggregate is now on hand to finish job.

12 February 1953

Job was visited by Gen. Bowman, AFFE Engineer,% and party; Col. Kelly, 8th Army Engineer Section and party; and Col. Beggs, Gp. CO. Col. Beggs left instructions to attempt to dewater pier 7 after concrete blanket placed 11 February has “set” two days and finish placing concrete. 34 E paver was used to place concrete in pier 7, pour A blanket, and worked satisfactorily. Method of placing was through a hopper mounted on 15” Armco piling supported on a four-wheel expedient dolly. A “bung’ [plug] was placed in pipe at bottom to prevent water entering pipe on orders of Gp. C.O. Method does not work successfully unless ready means is available to keep elevation of bottom of pipe at exactly desired height.

Job badly needs generators for night lights, welding machines, cranes. A crane is needed to aid in fabrication of steel, a crane is needed to erect curing cabin, and a crane is needed for excavating near-shore caisson.

Pumpcrete plant less miscellaneous pipe and accessories arrived last night. Job had two welding machines operable as of last night. At least ten can be profitably used.

12 February 1953, 1300 hrs.

C.O. just informs that Gp. called and adds the fifth beam to bridge. This means loss of past weeks’ work in setting beams on far shore aligned for four-beam spacing.

13 February 1953

Gp. S-4 visited job with Gp. Equip; Officer and others. Discussed additional materials required as result of adding fifth beam to structure. Gp. S-4 says he has TWY’ed [cabled] Japan for items manufactured there.

Requested Gp. S-4 to ship all steel decking.

14 February 1953

Began placing concrete in dry hole, pier 8, about 2200 hrs., 13 February. As excavation proceeded on pier 8, rock was encountered at elevation from 8' to 10' down. The rock was rotten, fragmented, broken and weathered on top but moved out comparatively easily with clay spade. Sheet piles were undermined when bad material removed. On 13 February at about 1130 hrs. water broke through northeast corner in 200 GPM volume. Piles were tapped down with free 5000 lb. hammer, and 99% of leakage stopped. Foundation was mucked out again, washed down, and steel set. Foundation again washed down and all loose mud and muck removed. There appears a rough bedrock surface entire bottom. No slopes to the east are excessive or in a plane surface. The rock outcrops with an upward tilt to the south with the plane strata lying about 35° downward and level east and west. This gives an excellent key to prevent slippage to the south.

All concrete was placed in the dry. Seepage water was moved ahead of concrete. Pour completed 1655 hrs. 14 February.

15 February 1953

Gp. C.O. visited job on 14 February and observed dewatering of pier 7 where concrete blanket approximately 4' thick had been placed. The top of the surface is soft, material has very little cementatious material. The top 2" to 5" is cement settlings and is consolidated but not fully set up. On digging down we find the material much harder, and more cement is with aggregate.

Gp. C.O. orders excavation of all loose material. Pier 6 questioned. Hold up work on pier 6 until decision is made. Mucking crews worked P.M. 14 February and night shift cleaning out loose material.

Job badly needs three more cranes and more generators and welding machines.

Lowboy[35] dispatched to Gp. S-4 today to pick up KNR [Korean. National Railway] core drill rig to get core out of pier 6.

16 February 1953

Loose material free of required cement mucked out of pier 7. Material about 1' under surface found to be suitable concrete in opinion of Bn. C.O. and Bn. S-3. Gp. C.O. advised A.M. of 15

February and inspection requested, but Gp. C.O.could not come up until 16 February. Hole is heated and cleaned out awaiting approval.

Job is seriously delayed due to shortage of cranes. Cranes are needed to handle 48" beams, unloading and placing; crane is needed to load-aggregate bins; crane is needed to excavate pier 1; crane is needed to place concrete; crane is needed to assist in erecting forms, curing shelters, moving heavy objects, lowering pumps, and setting up for concrete operations. Available is 3/4 yd. trk. mtd. [truck mounted] crane used on causeway, all jobs in priority.

Small pumps, 55 GPM and 166 GPM, are badly needed. Riveting hammers supplied have been too small (60 size) or inoperative (KNR). Fabrication of steel is a full week delayed as result.

17 February 1953

Lt. Damron advised to bend 6 dowel bars in pedestals on piers 6, 7, and 8 since 20 dowels were used instead of 22 called for on plans.

18 February 1953

Gp. C.O. authorized placing concrete in cofferdam pier 7 on A.M. of 16 February. Placing commenced at 1100 hrs. and was completed at 0130 hrs., 17 February. Concrete was placed "in the dry."

[On] 17 February 1953, bulkhead was placed near pier 7 for 34 E paver to discharge into remixer hopper of pumpcrete plant.[36] Plan now is pump concrete into piers 6, 7, 8 from central location.

Gp. C.O. authorizes 5' fall from bottom of pipe to level of placing in the form.

Core drill from KNR thru Gp. S-4 did not arrive.

Forms going into pier 6, B pour, and steel being placed; curing cabin going up on pier 8. Shortage of operational rivet hammers and cranes is hurting job.

18 February 1953

Lt. Damron advised that all dowel bars to have 90° bend, 5" or 6" long, since, 7/8" rods used instead of 1" rods.

18 February 1953

Lt. Damron brought up plans for 78th job at Tongduchon-ni and delivered two sets of plans to Company B on location, also progress charts to be filled in and returned.[37]

20 February 1953

Gp. C.O. called Bn. C.O. this date and ordered us to cease placing concrete pier 6 until a core sample was obtained.

Downstream column, pour B, was placed successfully with pumpcrete plant on 19 February. Plant, pipe, forms, and steel are ready for upstream column. Waiting for core will seriously delay this pier's completion.

Parts of KNR drill rig arrived yesterday and are being assembled today. It appears that KNR used a primitive drill rig. The power unit is now present. It appears that chilled shot is used to obtain a core. Just how the 4" pipe drill will "pull" or retrieve a core once cut is a mystery to me. I've seen core drills in operation on several jobs, but the core tube was of American manufacture and possessed "dogs"[38] inside the tube to hold as the core obtained.

The job is seriously suffering for want of 3/4 yd. cranes. Cranes [are] needed to place 48" beams, unload piles and 48" beams, excavate pier 1, and aid in placing concrete, rigging, [and] forms in 6, 7, and 8.

Weather moderating today after a week of 0° to 10° weather.

21 February 1953

Gp. C.O. visited job briefly this A.M.

Two Korean drillers from a contractor's organization arrived to operate the KNR drill rig. Necessary parts missing from rig were determined by the drillers and Lt. Pak, KATUSA w/2d Gp., and 84th will dispatch a truck to pick up necessary parts at 0800 hrs., 22 February, from Lt. Lee of 2d Gp. Cores obtainable will be approximately 2" [in] diameter. This is not a desirable size for a concrete core but must suffice.

Forms [for] B [pour], pier 8, being installed. Bad concrete on pedestals, pour A, pier 7, being jackhammered out. Concrete bad due to vibrators not being operational at time of placing this portion, and insufficient rodding was apparent.

1 1/2 yd. Manitowoc is setting steel on W approach. Riveting school underway. Four 3/8" rivets were delivered and four 1/2" ordered. The 1/8" is sufficient to give a bad head, and rivets must be returned.

Job needs cranes, vibrators, small pumps. Pumps appear to be our next bottleneck in placing concrete.

24 February 1953

Col. Ribbs, 8th Army Engr Section, is visiting job today. Discussed rivets versus bolts in 48" beams due to poor quality of rivet stock and untrained crews w/no buckers.[39]

B pour, pier 8, completed in 2 hrs. 15 min. yesterday without incident using pumpcrete plant.

Drill rig is down 6'–8' and has produced 2" of core out of pier 6.

'Setting forms and curing cabin on pier 7.

Pier 1 excavated to elev. 3 and two piles E side are sprung and leak 400 GPM estimated.

Pile driving pier 2 proceeding nicely.

22B placed in operation last night w/new motor.

Ice too thin today for travel. Placed assault boat into service between causeways.

Began E approach today and had trouble breaking through frost.

East abutment excavated today w/dozer.

27 February 1953

Job was visited yesterday by Col. Beggs and Lt. Col. Parker, 34th Gp.[40] The KNR core drill barrel twisted off in the hole on 25 February and efforts to extract were futile. Side of curing cabin was removed and Failing[41] well drill was set into position to drill. Drill is down 3' as [of] 0800 hrs. today. Col. Beggs directs that we use rock bit to drill 20' taking sweepings every 5' and then attempt to take core rest of way. We will use an overshot with chilled shot to get core. If bottom is not consolidated, the plan as explained by Col. Beggs is to drill two holes inside caisson, drill holes outside caisson, pump grout. Redrill and if not consolidated we then drive piles 8' away from present piles, excavate, and fill w/concrete.

Split piles observed in pier *1* at elev. 0 on excavation were pulled. Pulled eleven piles on SE quarter, corner pile on SE and adjacent pile to corner. Resetting piles this A.M. Found piles warped on bottom as much as 18". Penetration blows cut back to 50 per 1/4".

Pour B, pier 7, placed yesterday, finishing at 1915 hours. Successful in' all respects.

Excavating to elev. 58 on near shore approach as work site for structural steel. Abutment is excavated.

28 February 1953

Last concrete aggregate loaded out of Teal on 27 February. Hauling scrap dirty aggregate to X-Ray roads.

Drill rig drilling in base of pier 6 hit soft digging between 10'–11' last night. Hole is down to 21' and lots of sand washes into hole. Ordered curing cabin removed and upstream column B form removed. Will drill two holes inside two columns and put down wagon drill holes next to pile and attempt to consolidate by grouting.

Col. O'Grady decided to jackhammer pier 6 out, remove all concrete and sand, gravel, [and] cement, and repour by putting in a blanket on bottom, then placing in the dry. Former plan to consolidate by grouting will not be followed.

Company A will be assigned the job. Causeway will be extended from near shore when 7 and 8 are complete.

3 March 1953

Gp. C.O. visited job 28 February and asked for another test hole before we blow caisson pier 6.

Gp. C.O. called 2 March and said Army Engr. has ordered caisson pier 6 be grouted.

KNR drill crew arrived late P.M. 2 March to retrieve core barrel and redrill hole. Riveters from KNR also arrived.

Rain night of 1–2 March left roads and work area very muddy.

C pour, pier 8, completed 1930 hrs., 1 March.

Job needs additional lights for night structural steel fabrication and generator for same.

4 March 1953, 0640 hrs.

Col. Rumaggi and Col. Kelly visited job 3 March. No positive decision on action to follow on pier 6. Wagon drill continuing.

Split piling pier 1 began pulling.

Four welding machines in 78th for repair badly needed on structural steel.

KNR could not retrieve core barrel until additional tools were brought up. Will try again today.

4 March 1953, 0725 hrs.

C.O. advised at breakfast that Col. Beggs called last night and said "blow" pier *6* and excavate.

5 March 1953

Pour C, pier 7, was placed on *4* March without incident. Curing cabin, pier 8, was raised 15½ feet.

Pier 6 was drilled, 40% dynamite used to blow top portion of caisson and downstream column at 2225 hrs., 4 March.

Pier 1 piles pulled on NE corner have been reset and driven to penetration. Excavation for third time underway. All piles noted split have penetrated a strata of rock 8"–10" thick at about elev. 2 MSL. All have been type.111 Yawata[42] unpointed piles that do not groove as well as those [of the] same type that come pointed.

Penetration driving continues on pier 2.

Shortage of operational welders is hindering progress on steel fabrication.

East access road fill continues.

Gp. C.O. advised 4 March that aggregate dryer could be removed.

Gp. S-3, Lt. Col. [Glenn J.] Allen, is on job in charge of demolishing pier 6.

7 March 1953, 0635 hrs.

Job progressing, but slowly with only two piers [ready for us] to work on placing concrete. Pumpcrete plant works fine. Curing cabin in raised position works out O.K., however no more will be built as weather is beginning to moderate.

Blasting, drilling, and breaking underway in pier 6 at depth of 6' down. Hole makes water at a slow seepage rate. Although some of the concrete 6' down is soft, there appears to be a reasonable grout mixed in with the aggregates.

Pier 1 excavation proceeding very difficult at elev.+ 2' MSL. Large rocks do not enter bucket of clam.

Should place D pour, pier *8,* today.

Beam fabrication continues with first diaphragming[43] begun yesterday. No bad shortage of cranes now. Aggregate bins and aggregate dryer removed yesterday and bins reset on near shore.

Jackhammer treatment given to downstream column pedestal of pier *7,* C pour, where 4" "suck" occurred due to vibrating stiffener lost? Repair will be monolithic with D pour.

10 March 1953, 0650 hrs.

Gp. C.O. inspected job yesterday. Lt. Col. Allen, Gp. S-3, is in personal charge of demolishing pier 6. They are nowabout 16 ft. down.

Gp. C.O.'s verbal O.K. received to make and launch a continuous beam from W abutment to pier 7, as a means of gaining continuity for riveting, decking, and diaphragming crews. Will launch to pier 5 from W shore and remainder from near shore.

Pier 7, pour D, placed yesterday.

Excavation continues on pier 1. It began to make 300-400 GPM last night.

Diaphragming to be the same as in plans. Gp. and Bn. C.O. will not buy X-bracing that does not butt tight to 48" beams.

Job is hindered for [lack of] cutting torches and arc-welding machines, Gp. C.O. and Gp. S-4 advised. Panic button pressed.

11 March 1953, 0645 hrs.

Rained all night. Roads were soft yesterday with increasing number of frost boils. Far shore causeway very muddy. Pile driving hindered yesterday due to wet conditions and shut down last night.

Pier 1 making 500 GPM, which required moving over 2100 GPM pump and installing. Rock holding up a high pile was jackhammered out. Pump-packing collar was broken when packing was tightened.

Forms going in E pour, pier 8.

Job needs cutting torches and welding rigs badly.

12 March 1953, 0645 hrs.

Hard rain and sleet continued until noon yesterday. All equipment and materials were evacuated from both causeways. Sunshine in P.M. helped dry up a bit, but there is 2" of snow on ground this morning. No productive work except in carpenter shop and setting forms pier 8 yesterday.

Far shore causeway will require extensive fill. River level is higher than normal by four feet and very swift, eating off near shore causeway upstream and on end.

13 March 1953, 0645 hrs.

Temperature at this hour is 22° F. Rain, sleet, sunshine, snow, and hail intermittent all day yesterday. Began moving equipment back on causeway far shore after removing some muck and filling with firmer material. Adding sand to roadway far shore.

Plan to place cap on pier 8 today. Carpenters setting forms for cap on pier 7. Pier 6 is excavated down below whaler and now close to bottom. Sump pump handled water until yesterday P.M.

Pier 1 excavation is hard and slow in hard-packed boulders. Excavation proceeding in sand in pier 2. Pile closure in #3 [was] expected last night as only two piles more were required. Plan to top down every 10th pile to hold against a washout if it comes.

River level from flood is not serious at this stage.

14 March 1953

Placed pour E, pier 8, last night. High tide of 25.9 [feet above mean sea level] at 1554 hrs. [at] Inch'on was at MSL 12.4 at 2005 hrs. on upstream edge of east causeway last night.[45]

15 March 1953

High tide at Inch'on 0459 hrs. 27.5' equaled high tide at X-Ray 0915 hrs. 12.75' MSL. This tide partially floods near-shore causeway.

Lack of welders and cutting torches seriously delaying diaphragming and cutting of sub-decking.

16 *March 1953*

High tide at Inch'on, 0543 hrs., 29.5' equaled high tide at X-Ray 0950 hrs., 14.25' MSL. This tide floods most of causeway.

Gp. C.O. inspected hole, pier 6, early and, after inspection of bedrock and bottom, gave orders to fill with concrete.

Placing began at 1100 hrs. and was completed at midnight. All placing was "in the dry." Approximately 5 GPM were pumped periodically from downstream end until all leaks in pile joints had been covered. A mix 8:12:20 was used. Quality of concrete in pier is superior to requirements.

17 *March 1953, 1710 hrs.*

Fair weather for a change with temperature above freezing all day. High tide at 1030 hrs. rose to elev. 15.2 MSL. *(Figure 66)* Highest tide of spring expected tomorrow morning. Tide flooded both causeways and badly eroded near shore. Timing of tide hinders hauling in sand for concrete and repairs as tide covers sand bar.

Figure 66. Work continuing on piers 1, 2, and 3 from submerged east causeway during high tide on 17 March 1953.

Job badly needs welding machines for steel prefab-[ricat]ing and cutting torches.

Moving to near shore from far shore is order of the day. Pumpcrete and 34 E are over and volume buckets for aggregate bins are being set on near shore.

Pier 1 whaler going in tonight. E side of pier 1 piling caving in at bottom.

Pier 2 down and whaler in bottom nearly finished. Lots of sand boils in hole.

Piles on #3 reaching rock at very irregular levels. Driving proceeding nicely.

Excavation of E abutment progressed today. Shooting for elev. 49.08 downstream and 50.08 upstream. Will hold to these elev[ations] for wing wall footer bottoms. Will take abutment proper to sound rock wherever located by drill test, probably about 49.0 + 6 inches. Cribbing for steel near shore out 300' now.

***19 March** 1953, 1430 hrs.*

Drizzly rain all day.

Pier 1 burst water under third pile from NE corner on E side at noon. Hole was kept dry with two sump pumps prior to break. Water now making about 400 GPM. High tide was at 1153 hrs.

Pier 2 sanded in 2'–3' in downstream side last night. Moving both pumps to upstream side on middle whaler so we can excavate sand with clam and find and remove boulder holding up pile where sand flowed in.

Piles on pier 3 are on rock and exceedingly erratic in depth pattern. Still more driving to rock all around.

Job delayed for lack of cutting torches and welding machines.

Will remove cabin on #8 Friday and on #7 on Saturday.

Mounted 50-cal. [machine guns] yesterday and day before, eight on bridge and four in area. Constructing emplacements for same.

34 E pumpcrete bulkhead nearly finished. Batch plant rigged for operation on near shore.

20 March 1953, 1500 hrs.

Rained harder as the day wore on yesterday and by 1600 hrs. the clutch on P&H pile driver was unsafe to operate due to wetness of brake. Shut down rig.

Night crew reported for work as usual, [but] rain was heavier by 1900 hrs. About 2000 hours Lt. Scott[46] received permission from C.O. to shut down job as all cranes were unsafe and rain was still heavy.

About 2100 Col. Beggs called and asked about weather and river. River was then at a low stage, 11.0' MSL at 2200 hrs. Gp. C.O. ordered causeway evacuated. Evacuation was completed at 0145 hrs.

At 0730 hrs. this date, river was low. Bn. C.O. ordered equipment to resume normal operations. Operations normal by 0930 hrs

*At about 1055 hrs. I looked out the window of the Operations Shack and noted water had risen rapidly during the past 20 minutes. Walking out of the shack, past the abutment, and down to causeway, a matter of 5–6 minutes, the water was noticeably rising. Secured Bn. C.O. permission to pull equipment. Equipment was evacuated in 20 minutes and water was more than 24" deep in low points on near-shore causeway and flowing (washing) rapidly. ***(Figure 67)*** At 1210 water was at elev. 16.7' MSL as judged by eye from bluff looking at pile cut at elev. 18. Water has dropped about 4 inches as of this hour. Work continues on abutment, steel, batch plant, and drainage of area. Area is sea of mud.

22 March 1953; 1615 ***hrs.***

River over causeway [on] near shore, ranging today from elev. 14.5 to 16.0. Cloudy and misty at this hour. Steel in E abutment and forms nearly ready [but] lack tie wire [for the steel] and bolting [to fix] wing walls [firmly in position], plus lots of clean up. Ditching main area road. Lowered both cabins 7 and 8 today. Roads very bad.

Figure 67. Storm water and a spring high tide combined to force an evacuation of the causeway on 20 March 1953. Piers 7 and 8 are in the foreground.

Figure 68. East abutment, completed on 25 March 1953, prior to stripping of forms.

360’ of footbridge constructed yesterday for use when needed from pier 6 to far shore.

Started filling near-shore causeway with clay from topside, this P.M. Drilling to blast rip rap on bluff south of bridge. Rip rap to be on causeway.

Marines closed roads and delayed work yesterday and day before.

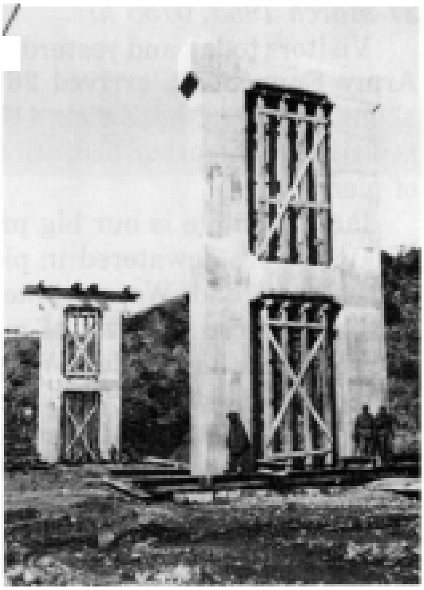


Figure 69. Completed piers 7 and 8 in late March 1953. The supports seen under the middle stiffener and the cap stayed in place at least 14 days.

25 ***March 1953***

Rained again last night and road between bivouac area and X-Ray is impassable again.

Placed concrete in E abutment and wing walls last night, finishing at 0100 hrs. today. ***(Figure 68)*** Used navy cube[47] for water w/34 E paver discharging into 2 yd. bucket hoisted by $1\frac{1}{2}$ yd. P&H.

Curing cabins on piers 7 and 8 are disassembled and H-beam bottom-frame remains to come out. ***(Figure 69)***

Set H-beam cap support for platform to launch steel on pier 8 yesterday P.M. Riveting and diaphragming continues on a two-shift basis. Additional welding machines received past three days bring us to five on far-shore steel. More cutting torches received yesterday and when more oxygen gauges are received we will be in good shape on welding rigs but can profitably use more arc welders. Moved nine civilian welders from B Company to X-Ray yesterday to take advantage of new rigs.

Water level yesterday and today is at a mean of ***12.5’*** MSL. Very little sand in sand bar available. Two $\frac{3}{4}$ yd. drag buckets pulling from upstream side of near-shore causeway and making money.

34 E platform disassembled yesterday and will be re-erected today. Mucking out began yesterday in #1 pier.

27 March 1953, 0755 hrs.

Visitors today and yesterday. Lt. Col. [Willard D.] Arnold, 8th Army Engr. Sect., arrived 26 March, 1400 hrs., and departed about 2130 hrs. Maj. Zwick, 417th Eng[inee]r [Aviation] Brigade, is visiting to report on bedrock and possible scour action at bottom of piers.

Pump trouble is our big problem. Early on 25 March about 0800 we were dewatered in pier 1 and bedrock was showing in downstream end. Water broke under two piles near center of E wall and forced removal of men and equipment. All efforts to dewater since have failed. Water was brought to within two feet of bottom the afternoon of 25 March and sand removed in upstream end, but at least 12" of sand remains that washed in under the piles. This morning the 2100 GPM is not operational and the 1000 GPM is producing less than 300 GPM. We will shut down pump and again hammer all piles in an attempt to close entry of water.

Pumpcrete and 34 E platform are in place. Causeway is about elev. 16 to within 20 ft. of pier 3. Dragline (1½ yd.) excavating causeway on far shore.

27 March 1953

Col. Beggs visited job and after inspecting hole pier 1, observing water coming in near boulder in NE corner, ordered divers sent up by Gp. to arrive tonight. Plan is to muck out, one of us to inspect hole after mucking, and then pour concrete around edges and over boulder. Dewater, cut out center of bottom to bedrock, and fill with concrete.

Gp. C.O. approved curb form and rail posts to set on slab, slab to be screeded 25' width, corrugated deck to ride up 1" on top flange splice plates. Method of placing slab to be by pumpcrete spotted near center of bridge and place W side first. Will shoot for 242' a day with curb to follow next day.

Pumps moving to pier 2. Causeway is out to pier 3, and we are hauling clay for fill up to elev. 12.

29 March 1953, 1700 hrs.

Visited at 1300 hrs. today by Col. Rumaggi and Col. [Ellsworth B.] Downing, 8th Army Engr. and Ass't. Pleased with progress and plans for future operations.

Col. Beggs came up yesterday and is pushing divers and work

Figure 70. View of the footbridge that enabled the pumpcrete machine to pump concrete from its location near pier 3, at center, to pier 6 across the river channel.

on #1 and #2. Divers made good progress today removing sand and report 1' sand on upstream end [of pier 1] remaining.

Gp. C.O. urged pouring of B and C pours, pier 6, via footbridge. B pour forms being set now and scaffolding half completed. Weather is smiling on us for a change.

Causeway extended barely past #3.

Rigging going up on pier 7 for launching and Manitowoc on last legs.

1 April 1953, 1745 hrs.

Clear this morning and cloudy this afternoon. Placed cap around edges of pier 1 yesterday P.M. up to bottom whaler. Diver says concrete is covering bottom and soft this P.M. Maj. Carter dived in shallow water suit to inspect bottom before placing in pier 1. Found edges 18" from sides and 36" from ends clean to bedrock. Sand heaped in center area.

Divers excavating in pier 2.

Placing B pour, pier 6, now using footbridge to span river. ***(Figure 70)***

Dragline between 6 and 7 has channel to sand bottom. Still

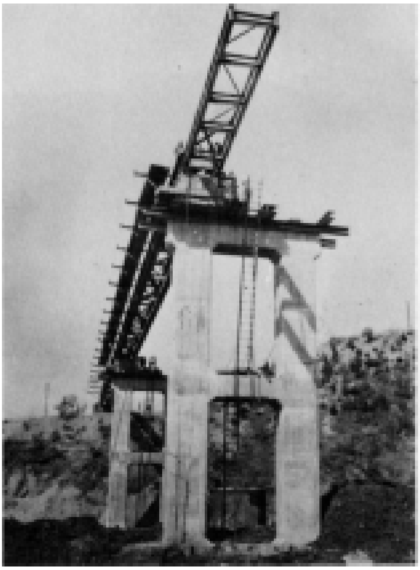


Figure 71. Downstream girder launched from the west abutment across pier 8 to pier 7 on 6 April 1953. The 30-foot launching nose extends beyond pier 7.

working, causeway is well past pier 3.

Second batch of 56 guard-rail posts pulled today and found well faced. New 1000 GPM pump delivered day before yesterday will help. No critical shortages, comparatively speaking.

Rigging for launching 7–W span progressing. Hope to launch next Monday, 6 April.

5 ***April 1953***

Yesterday divers completed cleaning bottom of pier 2 and removed all loose rotten bedrock from surface. 4' cap placed with pumpcrete successfully. Will dewater at midnight tonight, drill 4' hole in bedrock, and then complete A pour.

Pier 6, C pour this morning using footbridge.

Pier 1 cap excavated and sand previously piled in center by divers removed. Will pour today remainder of A pour in #l.

Rigging for launching downstream girder (2 beams) on far shore being completed today.

Dry weather is helping us get back to motor park.[48]

7 ***April 1953***

Placed A pour, pier 1, on Sunday successfully and on 6 April placed pier 2, A pour.

Excavation near bottom on pier 3 and all piles down except NW corner and adjacent piles.

Began driving piling #4 last night.

Causeway barely past #4.

Launched downstream girder from W to 7 yesterday. No trouble; #8 moved 1" with greatest movement occurring just before nose hit #7. #7 moved 3/8" maximum. Both piers always came back into position. ***(Figure 71)***

Col. Kelly visited job yesterday and was complimentary, accompanied by Maj. Eiler.[49] Weather warm and mornings foggy.

9 April 1953

Trouble in caisson #3. Last night as divers were measuring distance for cross members for bottom whaler, the ends measured 3′11″ and the center 3′9″. Measurements made inside piles to inside piles from N end to S were as follows:

1 — 79″	3 — 56″	5 — 49″	7 — 47½″	9 — 64½″
2 — 58″	4 — 61″	6 — 50″	8 — 64½″	10 — 64½″

Previous reports had indicated the W wall was toed in. This was supported by [the] fact [that] piles were away from top whaler. Last night divers said at first E wall was in but on recheck W wall was determined in. Piles are split near bottom of W side between 4-5 piles from N end and between 15–16 piles from N end. On S end piles are split on W side of center pile. Divers are rechecking measurements this morning. Divers reconfirmed 3 split piles this morning. Bn. C.O. decision to pull W half of piles. We will backfill to middle whaler which is crushed and attempt to dewater and remove.

Divers report sheet piles in NW corner are touching which is explanation why 30 minutes of driving failed to lower corner pile which is one meter high above. rock. All other aspects of job are progressing.

13 April *1953*

Weather is favorable but cold winds hurt. Job progressing and predicted schedule today is as follows:

Drive Pile:
- #3 — 15 April
- #4 — 17 April
- #5 — 25 April

Excavate:
- #3 — 21 April
- #4 — 23 April
- #5 — 1 May

Finish Concrete:
- #1 — 28 April
- #2 — 29 April
- #3 - 9 May
- #4 — 11 May
- #5 — 19 May

Launch Steel:
E-2 — 20 May
E-4 — 1 June
E-5 — 10 June
W-6 — 20 May
W-5 — 15 June

Finish Deck:
E-5 — 20 June
W-5 — 27 June

Present status: W-7 downstream girder jacked to within 1' of plates [that launching rollers rest on]. W-7 upstream will be finished on 15 April and then launched. Seven sticks [of] long steel being fabricated on near shore. B Company 90% effective as of today.

Pier 1, C pour, today.

Pier 2, B pour, complete, and forms for C pour going in.

Pier 3 piles pulled W half and all reset except three this A.M.

Pier 4 piles average 4' off rock.

Causeway half way out to #5.

Footbridge moved upstream between 5 and 6 to offset rapid current.

Channels between 7-8 and 6-7 are in.

Roads in dry condition and motor pool now in use. Bear of equipment shop still soft and impassable.

Gen. Tansey, G-4 D/A,[50] to visit today. Everyone hitting the ball and making money.

East approach road fill going in when pans not used on causeway or sand haul.

16 April 1953

Job progressing. Scaffolding on pier 1 and 2 is up, and steel going in for D pour. *(Figure 72)* High tide is holding up E pour on #6.

Pfc. James E. O'Grady, DS[51] to B Company from 74th Engr. Combat Bn., was drowned this morning at 0827 hrs. when a boat with Lt. Badman[52] and five men capsized in the channel between #6 and #7. Boat line to upstream cable gave way allowing boat to drift against a downstream cable and turn over. O'Grady dived in to help a Korean civilian welder that was caught in a rope. Swift current carried him downstream, and boat was 150 yds. approximately away from him when last seen above water. Grappling unsuccessful at 1500 hrs. from utility boat.[53]

Driving penetration to rock on #3 is slow. All piles to rock (no go) but another shift required to get penetration. Will launch far shore three beams Friday P.M. or Sat. depending on wind conditions.

21 April 1953, 0900 hrs.

Job progressing and the most difficulty is on caisson #3 and short 15 piles for #5.

Ordered 35 sheet piles on 9 April. Five of these arrived 20 April and were wrong type. Lowboys at ESP[64] yesterday were loaded out with non-critical materials, one pulled away from sheet piles. Schedule calls for finishing piles, #5, on 25 April. This will delay us.

Figure 72. Inside pier 2 during D pour showing the pumpcrete pipe at top and the base for the pneumatic vibrator, used to assure proper placement of cement, at right.

Pier 3 has a split pile on W side, one pile from SE corner, making 300 GPM approximately. Have set in a whaler at 12' down, have prefabbed two other whalers under this one; next lower 2" overall less in dimension and bottom one 4" overall less in dimension. Will lower these by measured cable to desired elev. as excavation proceeds. Have installed second whaler in #4 and dewatering with sump pump. ***(Figure*** 73)

Footbridge from causeway, #5, to far shore in operation yesterday P.M.

Three-beam girder 7-W down one foot and jacking proceeding nicely. ***(Figure 74)***

Poured E [pour] of #1 yesterday and will place E [pour] on #2 today.

Steel fabrication proceeding on near shore for three spans, ***5-4, 4-3, 3-2.***

Reinforcing steel prefabbing and carpenter shop deck and

Figure 73. The 4,100-gallon-per-minute pump used to dewater cofferdam 4 so that the lower whaler could be installed.

curb forms being prefabbed two shifts basis.

23 April 1953, 1440 hrs.

Clear, windy, sunny day. Warm this P.M. Work going nicely.

Deck and curb forms being prefabbed.

Reinforcing being prefabbed for deck.

Spans 5–4, 4–3, 3–2 are in process of riveting and diaphragming. Have finished 16 splices, four diaphragms X,"' and five sets of stiffeners on near shore. Setting bearing plates on #1 and curing #1, #2, and #6.

#3, divers are cleaning bottom of hole.

#4 has three whalers in position and fourth is now being set below the lower one. 1000 GPM pump is keeping water down about 24' from top. More clam work required when next whaler is set in.

#5, piles are down to within 10 ft. of rock, going O.K.

Three-beam girder, far shore, jacked down to within 30".

Pumpcrete set-up going in on far shore. Approach roads W side [are] to grade most places. Base and finish course for approach roads to be crushed from local cliff basalt.

25 April 1953, 0925 hrs.

Gp. C.O. visited job yesterday and ordered a bulkhead put in #3 about 3' from downstream end to hold concrete up 15' to seal off split piles. Remainder of bottom to get a 3'-4' cap when clean. Divers finished cleaning bottom yesterday P.M. This A.M. status is five piles hooked together with 12" H-beams resting on bottom, three whalers preventing pile movement upstream when filled with concrete. Timber laps or panels will cover space between piles and edges of caisson.

#4, high pile in SE corner allowed [to] cave in yesterday P.M. and pile rig moved over from #5 and redriven. Excavation by clam this A.M. proceeding nicely. Steel on far shore 7-W is about 14" from cap.

Two 2100 GPM pumps arrived yesterday.

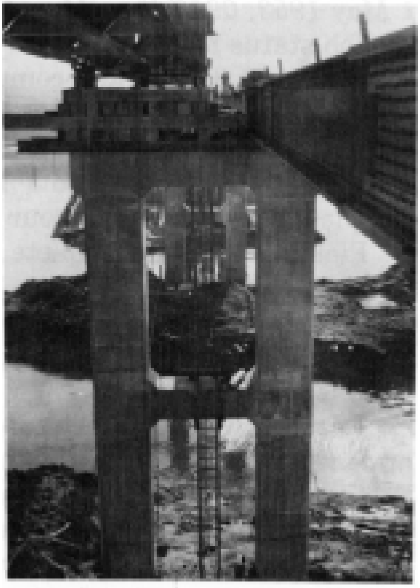


Figure 74. View showing cribbing used in launching upstream girder from the west abutment to pier 7.

26 ***April 1953, 1500 hrs.***

Placed concrete blanket in #3 this A.M. and [it is] up 20' on downstream side. Blowout in NE corner of #4 about 1500 hrs. Hole now has 3½'-4½' sand upstream end. Prior to blowout sand was 8" upstream and 20"-22" downstream. Tapped down pile, still in progress.

#5, second whaler going in now.

#4 has 4100 GPM of pumps making full pipe.

Weather fine. All other work continuing.

29 April 1953, 1800 hrs.

Just completed A pour on pier 3. Will pump down #4 after midnight, clean up blanket cap, and place A pour on #4 tomorrow.

Rain yesterday, last night and all today a slow rain. River not affected as yet. Watching closely. Night shift advised of precautionary measures to take in anticipation of possible high water.

#5, bottom (4th) whaler is hanging and clam is cleaning out. Pile on SW corner will not budge. Hole making about 2500 GPM with lots of aggregate coming under SW corner. Will muck out with divers.

Lack about two days riveting on near shore 3 spans, and one day more diaphragming on span 7-W. Deck going on downstream of 7-W.

Job on schedule to finish 27 June. A flood will hurt us bad.

1 May 1953, 0910 hrs. (Map 4)

Job status as of this hour:

Piers 1, 2, 6, 7, and 8 complete.

Pier 3, pour A complete, B pour forms and steel ready for concrete when A pour has set.

Pier 4, a blanket placed 3½′ and another pour averaging 15′ completed. Will finish A pour on 1 or 2 May.

Pier 5, expect to complete mucking and pour blanket 5′–6′ thick this date.

Causeway complete.

Abutments complete, except E abutment requires step after steel is launched.

East and west approach roads, sub-grade complete except 400' on E where steel fabrication is accomplished.

Steel 7–W launched and nearly sub-decked.

Spans from 5-2 will be riveted on near shore today or tomorrow. Diaphragming underway.

3 May 1953, 1820 hrs.

Just finished A pour of pier 5. The last one. Oh Happy Day!

7 May 1953

Have completed C pour, pier 3 and 4, and B pour, pier 5. Three spans of steel on near shore nearly ready for launching on 12 May. Decking on upstream will be finished tomorrow and downstream to follow. [Launching] Rollers are in place on pier 1 and 2 and rigging going in now.

Deck on 7–W is ready for concrete at 0500 hrs. tomorrow. Army issued a lot of changes via telephone from Gp. C.O. last night but resolved today. Contrary to previous agreement we will. pour monolithic from 7 to 8 to W abutment.

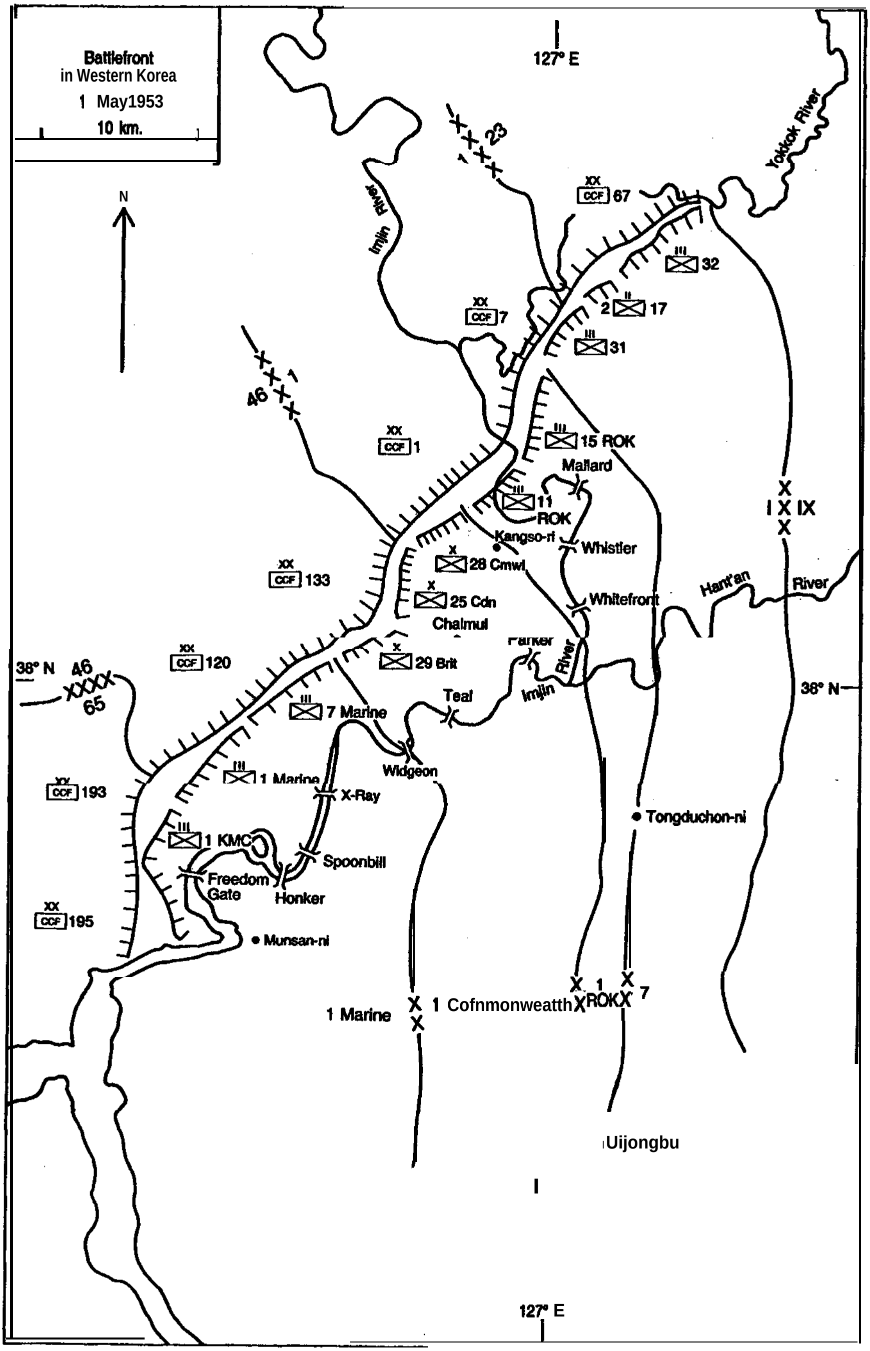
Forms ready on pier 3, D pour. Working tonight on D of 4 and C of 5.

Crusher broke gears last night for second time.

Pontoon bridge going in before Sunday will hinder operations of concrete work. Asked for 2MPs near shore to give us priority.

8 May 1953

Deck slab 7–W placed between 0720 hrs. and 1520 hrs. this date. Cracks occurred between 7-8 and 35–40 feet west of 8. Cracks are deep and occur more or less diagonally.


Battlefront
in Western Korea
1 May1953
10 km.
N
127° E
Imjin River
Yokkok River
Hant'an River
Imjin River
CCF 67
32
2 17
CCF 7
31
CCF 1
15 ROK
Mallard
11 ROK
Kangso-ri
Whistler
28 Cmwl
CCF 133
25 Cdn
Whitefront
Chalmul
Parker
CCF 120
29 Brit
Teal
38° N
7 Marine
Widgeon
CCF 193
1 Marine
X-Ray
1 KMC
Spoonbill
Freedom Gate
Honker
CCF 195
Munsan-ni
Tongduchon-ni
1 Marine
1 Cofnmonweatth
1 ROK
7
IX
Uijongbu
38° N
127° E

MAP 4

Figure 75. Troops laying the concrete deck. Two steel mats reinforced the concrete to provide an "antiartillery" safety factor beyond the necessary load-carrying strength. The concrete placing was monolithic and continuous.

Mix was 8:12:20. Concrete well vibrated and well placed, tamped, and screeded. Sun was hot after 1400 hrs. but not when cracks appeared at 1300 hrs. No cracks observed nearest abutment. My belief cracks were due to movement caused by reverse loading span 8–W with concrete. Wind was 15–25 MPH. Concrete is under sand bags and/or canvas and sand. Moist.

11 May *1953, 1630 hrs.*

Rain, a drizzle yesterday and this morning heavier. This P.M. rain was hard until 1600 hrs. Bn. C.O. ordered evacuation of all equipment from causeway about 1300 hrs. Evacuation complete except final removal of footbridge.

Pier 5 ready for concrete D pour.

Pier 3 and 4 lack E pour forms which are on scaffold but not in place. Schedule calls for D of 5 today and E of 3 and 4 tomorrow.

Curb upstream placed this morning, and about ⅓ of downstream, span 7–W. Rain prevents proper finishing.

12 May 1953, 1730 hrs.

Rains of two previous days hit us at 0915 hrs. when water began to go over causeway. All equipment removed. Men left working on forms, #3 and #4.

Finished placing curb this P.M. Spoonbill out and X-Ray pontoon out. Water now at 20.4 ft., highest this year.

Launched 3-beam upstream girder to #1 today. Lots of trouble due to cribbing sinking from rains.

Unloading cement from railhead.

Reinforcing prefab and corp [*sic*] prefab tonight. Steel near and far shore will be welding.

I Corps C.G.[56] visited job this P.M.

14 May 1953, 0820 hrs.

River flood readings, MSL, follow:

Date	*Time*	*Elevation*
12 May	1330	20.0'
12 May	1500	20.3'
12 May	1600	20.4'
-12 May	2100	20.4'
12 May	2200	20.0'
13 May	0700	19.0'
13 May	0800	19.4'
13 May	0900	19.6'
13 May	1000	19.1'
13 May	1100	19.0'
13 May	1200	18.7'
13 May	1300	18.6'

Date	*Time*	*Elevation*
13 May	1400	18.3'
13 .May	1500	18.2'
13 May	1600	18.0'
13 May	1730	17.9'
14 May	0700	14.1'
Causeway showing in spots.		
14 May	0800	16.8'
Tide coming in.		
14 May	0830	17.3'
HT at 0950.		

Causeway being extended pan wide[57] along rip rap upstream out to ramp. Men working on ramp for 34 E, badly eroded. New ramp near E abutment completed but water is too high to lay pipe. Believe quicker to repair old ramp between pier 2 and 3.

17 May 1953

Last pour of last pier completed at 2130 hours, 16 May 1953, on E pour, pier 5. D pour, pier 5, completed 0400 hrs., 15 May, and

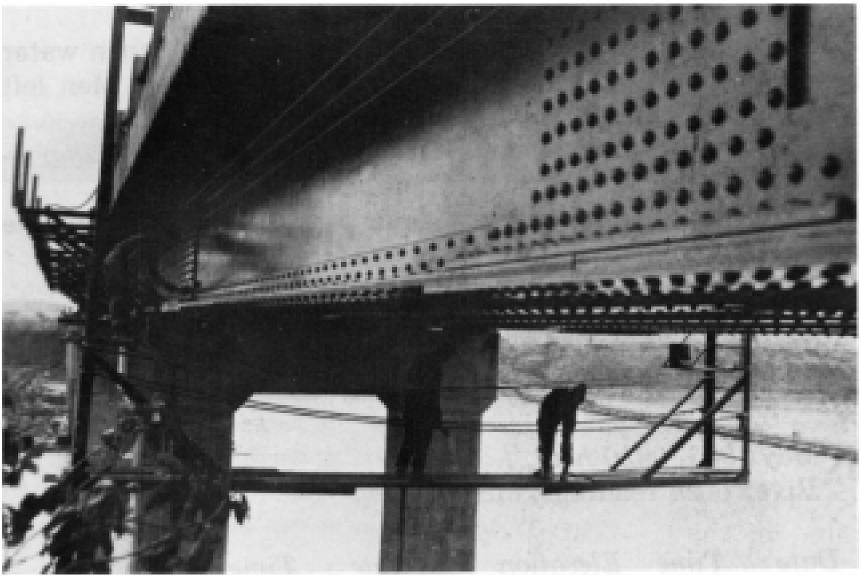


Figure 76. "Jackson's chariot," which could be rolled from the deck, providing scaffolding for bridge painters.

E pour of #4 and #3 during the daylight of 15 May. Only 15" of form removed from D pour of #5.

All steel is in place for final fabrication on both shores.

Carpenter shop is building more curb forms and deck slab forms. Also mess tables for H&S and C Companies.

Company C removing forms and building launching scaffolds.

Company A crushing road metal, prefabbing mats, cleaning and repairing pumpcrete, and policing job site. Have lots of hand dressing and rip rap to do on far shore approach.

1 platoon, C Company, at Whitefront fender pile job.

22 ***May 1953***

Misty rain this morning.

Four arc welders are at Teal repairing bomb damage that occurred on A.M. 20 May.

Jackson Chariot[58] transported to far shore yesterday and is now in process of erection to remove catwalks and [to] paint beams. ***(Figure 76)***

Far shore steel requires two splices to complete riveting of span 7–5. Near shore requires 27 splices to complete 2–1–E.

Foundation for monument placed 21 May. Carpenter shop fabricating monument forms.

Far-shore batch plant removed and disassembled. Road metal crushed on two-shift basis. Should finish all reinforcing prefab tomorrow.

Job now out of 6¼" rivets for three days. Crews continued with other sizes. Ten cutting rigs received yesterday. A big help. Will return all unit M/R rigs now.[59]

28 May 1953

About 1900 hrs. on 26 May three rounds exploded in the work area and to the north? The first was W of the material storage building and exploded about 3' below average ground level in the side of a ravine about 20 yds. from a quad 50 of 21st AA Bn., 25th Inf. Div.[61] No one hurt

The second round exploded to the north of the main road beyond the fence some 150 yds. The third was not located but said to be near the cliff W of #2 round.

Fuses and fragments were recovered from #1 and #2 rounds, and positive identification made at 25th Div. Arty.[62] as Russian *76* mm. Fuses were KTM-1 point-detonating type. Quad 50 chief reported an air burst at 0500 hrs. on 27 May upstream from bridge 200 yds. and on far shore. No verification.

Riveting will be complete today except last minute cut-outs? Welding of diaphragms nearly complete. Rigging of rollers on #6 complete with roller on top of #3 and #4. Decking still required on span E-2. Steel 5-7 practically complete. Stockpiling road metal on near shore. Approach roads up to steel fabrication sites complete, both shores.

Monument requires final top pour and walls. Setting wall foundation forms today. Cleaning piers down, and policing area. Hauling unused materials to railhead and ESPs. Weather is fine. Morale high.

3 *June 1953, 0750 hrs.*

Upstream girder E-1-2-3-4-5 launched by 1545 hrs. yesterday. Downstream girder E-1-2-3-4-5 launched by 0730 hrs. today. *(Figure* 77) Now jacking down, installing catwalk and readying for further superstructure work. Rain last evening and last night does not help.

On 2 June job was visited by Col. Davis,[64] Col. Ribbs, Col. Downing, and Col. Beggs.

Figure 77. View showing portions of the 606-foot girders that were launched from the east abutment to pier 5. These were the longest girders used on the bridge.

5 June 1953

Both upstream and downstream girders are jacked down. Seven diagonal diaphragms nearest #5 are in process of welding. Sub-deck complete except for loose areas over piers and diaphragms. Steel beams cut to proper length and in position. E abutment step forms going in. W approach slab being graded. Gp. ordered a 50' slab of 8" reinforced concrete on W approach with const[ruction] j[oin]t down centerline and expansion jt at 25'. E approach to be penetration asphalt.

Fill on E approach nearly to grade within 100 ft. of abutment.

Rock is on W approach.

Catwalk complete E to 5 up and downstream.

Slab forms nearly complete upstream.

Getting ready to launch 7-6-5.

9 June 1953

Job Status-Rain began about 0400 hrs., some 50 ft. before deck slab 5-4-3 was finished. Concrete completed to 3 and rough screeded, but left high near 3 expansion joint. We are reworking it now. Began pour about 2100 hrs. last night. Bridge girders were surveyed-in the day (5 June), jacking was complete, and we lost one shift as a result of wrong elev. on center screed and edge forms.

Diaphragms finished. from 3-2 and welding continuing with sub-deck coming along behind them fine. Reinforcing going in at 3 toward 2.

Gin poles are rigged on 5 and 7 and will be ready to lift with more welding. Can begin jacking down 7-6-5 this P.M.

Army yesterday asked for bridge to be finished on 13th. 16th with no more rain will be difficult. A lot depends on 5-6-7.

11 June 1953, 0820 hrs.

Finished deck slab 0400 hrs. from 3-2-1-E. Last night we removed curb form from 5-4-3 placed yesterday noon. Curb excellent. Now setting curb starting at 3 working toward 2-1-E.

Upstream girder from 7-6-5 finally in position 10 June, 1600 hrs. Moved gin poles and moved beams into E-W position last night on downstream girder. Beginning jacking down now. Weather clear after 0900 hrs. yesterday and last night. No air raid last night for a change.

Will try to finish off approach road E today.

Gin poles and chain hoists worked fine.

12 June 1953

Raining-Rains come almost daily now, of the shower variety instead of heavy mist. Very heavy this P.M.

Steel from 5-6-7 down on bearing plates at 0500 hrs. yesterday. Diaphragming continues.

Placed curb E-1-2-3 today.

Visited by two B.G.s, ROK Army AG and Engr., Gen. Um.[65]

Removed pump and crane and all property from causeways.

Knocked off all crews tonight except carpentershop and welding.

15 June 1953

Deck slab from 7-6-5 placed, finishing at 0400 hrs. this date. Deck slab from 5-4, west 30' placed 13 June at night. Curb from 5-4, 30' W placed night of 14 June.

Cleaning and policing job.

16 June 1953

Last concrete completed at 2345 hrs., 15 June, in curb span 5–6–7.

5 July 1953

The X-Ray project became the completed Libby Bridge yesterday at dedication ceremonies by Gen. Maxwell D. Taylor, Commanding General, 8th United States Army, attended by 35 stars and dignitaries. Good weather, good ceremony. Bridge opened to traffic, all except tanks, at 1200 hrs., 4 July. This log is hereby closed.

Notes

Introduction

1. John Miller, Jr.; Owen Carroll; and Margaret Tackley, *Korea, 1951–1953* (Washington: Office of the Chief of Military History, 1956), pp. 102–110; Command Report, Engineer Section, I Corps, May 1951, Narrative, pp. 12-13, contained in Box 1536, Entry 429, Record Group 407, Records of the Adjutant General's Office, National Archives, Suitland, Maryland. (All boxes listed in the notes to this Introduction are contained in the same record group, entry, and repository.)

2. Command Report, Engineer Section, I Corps, June 1951, Narrative, pp. 3–5, Box 1543.

3. Ibid., pp. 7–10; Command Report, I Corps, Narrative Summary, June 1951, Box 1538.

4. Command Report; Engineer Section, I Corps, June 1951, Narrative, p. 10, and Annexes 22 and 23, Engineer Section Daily Journal, 22-23 June 1951; Command Report, Engineer Section, I Corps, July 1951, Narrative, p. 3, Box 1550; Walter G. Hermes, *Truce Tent and Fighting Front,* United States Army in the Korean War (Washington: Office of the Chief of Military History, Government Printing Office, 1966), pp. 15–18.

5. Command Report, Engineer Section, I Corps, July 1951, Narrative, pp. 9-12 and 15–19 with the quotation on page 15; Annexes 21-25, Engineer Section Daily Journal, 21-25 July 1951; and Annex 54, River Gauge Readings 19 thru 31 July 1951.

6. Command Report, Engineer Section, I Corps, August 1951, Narrative, pp. 3-9, Box 1557.

7. Command Report, Engineer Section, I Corps, August 1951, Narrative, pp. 3-5, 8–11, 15, 16, 20, and 25-27; Command Report, 84th Engineer Construction Battalion, August 1951, Box 5077.

8. Command Report, Engineer Section? I Corps, August 1951, Narrative, pp. 16 and 23.

9. Command Report, I Corps, September 1951, Narrative Summary, pp. 10-19, Box 1559.

10. Command Report, Engineer Section, I Corps, September 1951, Narrative, pp.. 9–10, Box 1564; Command Report, 1169th Engineer Combat Group, September 1951, Narrative, pp. 2-3, Box 5160.

11. Command Report, I Corps, October 1951, Narrative Summary, pp. 6-49, Box 1566. Command Report, Engineer Section, I Corps, October 1951, Narrative, pp. 2-4; Attachment 35, Engr Opn 0 131, 18 October 51, items 3b (11) and (12); and Attachment 38, Engr Opn 0 134, 28 October 51, item 3a (2), Box 1571. Command Report, Engineer Section, I Corps, November 1951, Attachment 38, Engineer Periodic Operations Report 183, 31 October-10 November 1951, item 3b, Box

1578. Command Report, 1169th Engineer Combat Group, October 1951, Narrative, pp. 3-4, Box 5161.

12. Command Report, 84th Engineer Construction Battalion, October 1951, Narrative, Box 5078; Hermes, *Truce Tent*, pp. 112–113.

13. Command Report, Engineer Section, I Corps, October 1951, Narrative, p. 4, and Attachment 38, items 3a (2) and (3); Command Report, 1169th Engineer Combat Group, October 1951, Narrative, pp. 3-4; Command Report, Engineer Section, I Corps, November 1951, Attachment 31, Engr Opn 0 135, 1 November 1951.

14. Command Reports, 1169th Engineer Combat Group, September 1951, Narrative, p. 3, and October 1951, Narrative, p. 1, containing the quotation.

15. Command &port, Engineer Section, I Corps, November 1951, Narrative, p. 3.

16. Ibid.; Command Report, 1169th Engineer Combat Group, November 1951, Narrative, p. 12, Box 5161; Command Reports, 1092d Engineer [Combat] Battalion, November 1951, Narrative, pp. 3 and 11, and December 1951, Narrative, p. 3, both in Box 5107; Command Report, 62d Engineer Construction Battalion, December 1951, Box 5058.

17. Command Report, 1092d Engineer Battalion, November 1951, Narrative, pp. 4-5.

18. Command Reports, Engineer Section, I Corps, December 1951, Narrative, p. 4, Box 1585, and January 1952, Narrative, p. 5, Box 1595; Command Report, 1169th Engineer Combat Group, December 1951, Narrative, pp. 3–4, Box 5161. A somewhat varying account is contained in Command Report, 1092d Engineer [Combat] Battalion, December 1951, Narrative, p. 3.

19. Command Reports, Engineer Section, I Corps, December 1951, Narrative, p. 5, and January 1952, Narrative, p. 5; Command Report, 84th Engineer Construction Battalion, January 1952, Narrative, p. 1, Box 5912.

20. Command Report, 84th Engineer Construction Battalion, February 1952, Narrative, p. 1, Box 5912; Command Report, Engineer Section, Eighth Army, March 1952, Narrative, p. 12, Box 1324.

21. Command Report, Engineer Section, I Corps, February 1952, Attachment 34, Engineer Periodic Operations Report 192, 31 January-10 February 1952, and Attachment 32, Engineer Periodic Operations Report 194, 20–29 February 1952, Box 1601.

22. Command Report, 84th Engineer Construction Battalion, October 1951, Narrative and Annex K, Pintail Bridge Plans.

23. Command Report, 1169th Engineer Combat Group, October 1951, Narrative, pp. 4-5; Command Reports, 84th Engineer Construction Battalion, November 1951, Narrative, and December 1951, Narrative and Annex L, As-Built Plans of the Teal Bridge, both in Box 5079.

24. Command Report, 24th Engineer Construction Group, February 1952, Inclosure 4, Extract of Operations Order Number 9, Engineer, Eighth Army, 24 February 1952, Box 6013; Command Reports, 62d Engineer Construction Battalion, March 1952, Narrative, Box 5884,

and April 1952, Inclosure 15, Engineer Periodic Operations Report 11, 9–18 April 1952, Box 5885; Command Report, Engineer Section, I Corps, April 1952, Narrative, p. 5, Box 1613.

25. Command Reports, 62d Engineer Construction Battalion, April 1952, containing Engineer Periodic Operations Report 12, 19–29 April 1952; May 1952, containing Engineer Periodic Operations Reports 13–15, 30 April-28 May 1952; June 1952, containing Engineer Periodic Operations Reports 16–18, 29 May-29 June 1952, all in Box 5885; and July 1952, containing Engineer Periodic Operations Reports 19–21, 29 June-28 July 1952, Box 5886. Command Report, Engineer Section, I Corps, July 1952, pp. 1 and 7, Box 1633. Command Report, 24th Engineer Construction Group, February 1952, Inclosure 4.

26. Command Report, Engineer Section, I Corps, May 1952, Narrative, p. 6, Box 1619; Command Report, 84th Engineer Construction Battalion, June 1952, Narrative, p. 1, Box 5914.

27. Command Reports, 84th Engineer Construction Battalion, February 1952, Narrative, p. 2, Box 5912, and July 1952, Narrative, p. 1, Box 5914; Command Reports, Engineer Section, I Corps, May 1952, Narrative, p. 7, and July 1952, Narrative, p. 7; Command Report, Engineer Section, Eighth Army, March 1952, Narrative, p. 13.

28. Command Reports, Engineer Section, I Corps, April 1952, Narrative, Box 1613; May 1952, Attachment 33, Engr Opn 0 159, 13 May 1952, Box 1619; and June 1952, Narrative, p. 5, Box 1625. Flood Report, 1 July-15 September 1952, Engineer Section, I Corps, p. 2, Box 1633.

29. Flood Report, 1 July-15 September 1952, Engineer Section, I Corps, pp. 2-4; Command Report, Engineer Section, I Corps, July 1952, Narrative.

30. Flood Report, 1 July-15 September 1952, Engineer Section, I Corps, pp. 3–5, with the quotation on page 5; Command Report, Engineer Section, I Corps, July 1952, Narrative, p. 1.

31. Flood Report, 1 July-15 September 1952, Engineer Section, I Corps, pp. 1 and 6.

32. Command Reports, Engineer Section, I Corps, September 1952, Narrative, pp. 4-5, Box 1645, and October 1952, Narrative, p. 3, Box 1651.

Construction of Libby and Teal Bridges, Imjin River, October 1952 to July 1953

Preface

1. As-Built Plans of the Libby Bridge, prepared on 3 July 1953, are contained in the Papers of William C. Carter, Jr., Office of History, Headquarters, U.S. Army Corps of Engineers, Kingman Building, Fort Belvoir, Virginia, and at Tab 11 of the typescript version of this study contained in file 8–5.1A/DK, Historical Resources Branch, U.S. Army

Center of Military History, Washington, D.C. A photocopy of the typescript study, less Tab 11, is contained in file XII-7-9, Military Files, Office of History, Headquarters, U.S. Army Corps of Engineers.

Chapter I

1. Engineering Report on Bridge Study and Design, Teal Site, Imjin River, 2d Engineer Construction Group, 14 September 1952, printed at Appendix B below.

2. Ibid. This is the official opinion based on studies made by Japanese and Korean engineers. Major William C. Carter, S–3, 84th Engineer Construction Battalion, found evidence indicating that this was not true of the Libby bridge site. See the interview of Major Carter by Major William R. Farquhar, Jr., 5 and 20 July 1953, a copy of which is attached to the original study at Tab 2. Japanese officials entered Korea after their nation's victory in the Russo-Japanese War, and Japan formally annexed Korea in 1910. It retained control of the peninsula until its surrender at the end of World War II.

3. Letter, Headquarters, 2d Engineer Construction Group, 20 August 1952, subject: Preliminary Analysis of Danger to Imjin River Bridges During the Flood of 30 July 1952.

4. Eighth Army Staff Study, Imjin River Bridges, 24 September 1952, printed in Appendix A below.

5. Flood Report, 1 July-15 September 1952, Engineer Section, I corps, p. 1.

6. Ibid., p. 3.

7. Ibid., p. 4.

8. Ibid., p. 6.

9. Major General (later Lieutenant General) Paul W. Kendall commanded I Corps, and General James A. Van Fleet commanded Eighth Army.

10. Brig. Gen. John K. Waters, Chief of Staff, I Corps, to Commanding General, Eighth Army, 2 August 1952; 1st Indorsement of above letter, Commander, Eighth Army, to Commander, I Corps, 11 August 1952; and Waters to Commanding General, Eighth Army, 14 September 1952, all printed in Appendix A below.

11. Colonel William C. Baker, Jr., was Eighth Army Engineer.

12. The 2d Engineer Construction Group, commanded by Colonel Henry J. Kelly, was attached to Eighth Army.

13. Colonel Merrow E. Sorley was I Corps Engineer.

14. Eighth Army Staff Study, Imjin River Bridges, 24 September 1952, and Lt. Col. C. W. Burleson, Assistant Adjutant General, Eighth Army, to Commander, I Corps, 29 September 1952, both printed in Appendix A below.

15. Engineering Report on Bridge Study and Design, Teal Site, Imjin River, 2d Engineer Construction Group, 14 September 1952; Eighth Army Staff Study, Imjin River Bridges, 24 September 1952; and Burleson to Commander, I Corps, 29 September 1952.

16. Interview of Lt. Col. James R. O'Grady, Commanding Officer, 84th Engineer Construction Battalion, by Major Farquhar, 20 July 1953, summarized at Tab 5 of the original study.

Chapter II

1. Interview of Lt. Col. James R. O'Grady; General Description, Teal. Low-Level Bridge [84th Engineer Construction Battalion, 31 July 1953], reproduced at Tab 6 of the original study.
2. General Description, Teal Low-Level Bridge.
3. Interview of Lt. Col. James R. O'Grady.
4. Ibid.
5. General Description,. Teal Low-Level Bridge.
6. Interview of Lt. Col. James R. O'Grady.
7. Ibid.
8. General Description, Teal Low-Level Bridge.
9. Ibid.
10. Ibid.
11. Interview of Lt. Col. James R. O'Grady.
12. General Description, Teal Low-Level Bridge.
13. Interview of Lt. Col. James R. O'Grady. The 2d Infantry Division relieved the 1st Commonwealth Division in late January 195% See Hermes, *Truce Tent and Fighting Front,* p. 389.
14. Interview of Lt. Col. James R. O'Grady.

Chapter III

1. Log of Libby Bridge, 84th Engineer Construction Battalion, entry for 9 November 1952, printed at Appendix D below.
2. Interview of Maj. William C. Carter, Jr. Much of the material contained in the summary of this interview also appears in a mimeographed article by Major Carter, "Freedom for all Peoples," a copy of which is in the Papers of William C. Carter, Jr.
3. Interview of Maj. William C. Carter, Jr.
4. Interview of Lt. Col. James R. O'Grady.
5. Ibid.
6. Ibid.
7. Interview of Maj. William C. Carter, Jr.
8. Log of Libby Bridge, 12 and 20 March and 11, 12, and 14 May 1953.
9. Interviews of Lt. Col. James R. O'Grady and Maj. William C. Carter, Jr.
10. Log of Libby Bridge, 2 and 9 February 1953.
11. Interview of Maj. William C. Carter, Jr., and Log of Libby Bridge, *3, 4,* and 16 March 1953. The Eighth Army Engineer was Colonel Louis J. Rumaggi. Colonel Rumaggi had replaced Colonel Baker in that position in October 1952.

12. Interview of Maj. William C. Carter, Jr., and Log of Libby Bridge, 14 and 15 February 1953.
13. Interview of Maj. William C. Carter, Jr.
14. Ibid.
15. Ibid.
16. Ibid.
17. Ibid.
18. Ibid.
19. Col. Louis J. Rumaggi, Engineer, Eighth Army, to Commanding Officer, 2d Engineer Construction Group, 24 April 1953, reproduced at Tab 8 of the original study.

Appendix A

1. Lieutenant Colonel William J. Himes, S-3, Engineer Section, Eighth Army.
2. Colonel Ellsworth B. Downing, Deputy Engineer, Eighth Army.
3. Colonel William C. Baker, Jr., Engineer, Eighth Army.

Appendix B

1. The coordinates stated are those of the Spoonbill site.
2. Paragraph 17 described a two-way bridge that it termed "basically similar to the one-way bridge described in paragraph 16."
3. The paragraph below contains the one relevant work order among the substantial number assigned to the 2d Engineer Construction Group in this document.
4. Major John D. Pusey was chief of the Technical Intelligence Branch, Engineer Section, Eighth Army.
5. Major Edward G. Anderson, Jr.
6. Yongsan-ni Ferry was located on the Imjin River near the X-Ray site.
7. Judging by its location in the chart, this entry apparently should be dated. 1 August 1923.

Appendix D

1. Colonel Henry J. Kelly commanded the 2d Engineer Construction Group. He would be succeeded by Colonel Raymond W. Beggs on 18 November 1952.
2. The Supply Section, or S-4, 2d Engineer Construction Group.
3. Concrete mixers and pavers were numbered to indicate their capacity in cubic feet. Thus the 14 S mixer had a capacity of 14 cubic feet, a 16 S mixer had a capacity of 16 cubic feet, a 27 E mixer had a capacity of 27 cubic feet, and a 34 E paver had a capacity of 34 cubic feet.
4. Herman Nelson produced gasoline and kerosene forced-air heaters.

5. A copy of Operations Order 84–376, 2d Engineer Construction Group, 25 October 1952, is at Inclosure 5 of the group's Command Report for October 1952, contained in Box 6001, Entry 429, Record Group 407, Records of the Adjutant General's Office, National Archives, Suitland, Maryland.

6. Each pile was a 16-inch diameter pipe manufactured by the Armco Steel Company.

7. A cross-section of the pier column indicated on the bridge plans.

8. Major Daniel 0. Stoudemire.

9. No template was actually used to drive the sheet piling.

10. Major William C. Carter, Jr., S–3, 84th Engineer Construction Battalion, joined the unit on 22 November 1952.

11. Lieutenant Colonel Howard K. Eggleston, Jr., Executive Officer, 2d Engineer Construction Group.

12. The concrete curing cabins used on the Libby Bridge piers were named for the enlisted man in the 84th Engineer Construction Battalion who developed them.

13. Group Equipment Officer.

14. Seoul Municipal Airfield.

15. Yokohama Engineer Depot.

16. Before sheet piling could be sunk, it had to be covered with a female-shaped sheet pile head, and an adapter had to be attached to the pile driver.

17. The &cubic-yard pan range of the plant was the area around it in which a D7 Caterpillar tractor pulling a trailer of that capacity could profitably operate.

18. Willard Norris had just been promoted to lieutenant colonel. He would leave the 2d Engineer Construction Group in late December 1952 to assume command of the 76th Engineer Construction Battalion at Yongdungp'o, near Seoul.

19. Eight-and-a-half percent of the aggregate was fine enough to pass through a number 80 screen.

20. Fifteen feet above mean sea level.

21. A 2,100-gallon-per-minute pump.

22. Station 12 + 51 refers to a location 1,251 feet west of the center of the bridge, or some 200 feet beyond the west abutment.

23. First Lieutenant Melford Dameron, Jr., is identified in a memorandum sent by Colonel Raymond Beggs, commander of the 2d Engineer Construction Group, to Brigadier General Frank Bowman, Engineer, Army Forces in the Far East, on 22 October 1953, as one of the officers in the group headquarters who should receive proper recognition for his role in designing and constructing Libby bridge. This memorandum is in the Papers of Rank Otto Bowman, Hoover Institution, Stanford, California. A "Lt. Damron" appears occasionally in the daily staff journals of the group contained in Boxes 60006004, Entry 429, Record Group 407, National Archives, Suitland, Maryland, and Major Carter sometimes spells the name that way subsequently in the log, but these apparently refer to the same Melford Dameron, Jr.

24. The clutch on a 500-cubic-foot-per-minute-capacity air compressor.

25. A steam-operated asphalt bath unit capable of heating up to three railway tank cars of asphalt.

26. At this time Colonel Raymond Beggs was the commander of the 2d Engineer Construction Group, and Lieutenant Colonel James R. O'Grady commanded the 84th Engineer Construction Battalion.

27. An internal bracing made from a ten-inch H-beam.

28. Four feet above mean sea level.

29. A concrete composed of a ratio of one part cement, two parts coarse aggregate, and three parts sand.

30. D7 Caterpillar tractors.

31. Colonel Henry J. Kelly, who had commanded the 2d Engineer Construction Group, became Operations Officer, S-3, Engineer Section, Eighth Army, on 8 December 1952. He replaced Lieutenant Colonel William Himes in that position.

32. Lieutenant Colonel Edward J. Ribbs.

33. KATUSA Corporal Kim Ho Duk.

34. Brigadier General Frank 0. Bowman, Engineer, Army Forces in the Far East.

35. Flatbed trailer.

36. The paver was able to park on the bulkhead right above the hopper on the pumpcrete.

37. On 10 February Company B, 84th Engineer Construction Battalion, moved from the Teal bridge site to Tongduchon-ni, a town some 12 miles east of the X-Ray bridge site, to construct living and operating facilities for the 78th Engineer Field Maintenance Company.

38. Teeth built flush against the inside of the drill.

39. A bucking tool, or bucker, was used to form a backstop for a rivet gun.

40. Lieutenant Colonel John R. Parker was in the 32d Engineer Construction Group stationed at Wonju, Korea, and he became its commander on 13 March 1953. The 34th Engineer Group was stationed at Camp Roberts, California, in this period.

41. Failing was a brand name.

42. The Yawata Steel Company was a Japanese manufacturer.

43. Installing cross braces to form girders.

44. In addition to the horizontal middle stiffener, C pour included a low pedestal, rising a short height above the stiffener, on each of the vertical legs of the pier. The pedestal on the downstream column of pier 7 was removed with-jackhammers due to bad concrete production.

45. Tides at Inch'on were derived from a published tide table and then compared with observed tides at the X-Ray site.

46. First Lieutenant James J. Scott, Jr.

47. A large steel box.

48. The motor park had for a period been mired in mud.

49. Major Keith E. Eiler was chief-of the Plans and Requirements Branch, Engineer Section, Eighth Army.

50. Major General Patrick Henry Tansey, a career engineer officer, was outgoing chief of the Supply Division, Office of the Assistant Chief of Staff, G-4, General Staff, U.S. Army.

51. Detached service.

52. First Lieutenant Curtis W. Badman was a platoon leader in Company B, 84th Engineer Construction Battalion.

53. Private O'Grady's body was recovered on 22 April 1953.

54. Engineer supply point.

55. Cross diaphragms.

56. Major General Bruce C. Clarke.

57. Roughly one lane in width.

58. This movable scaffold was named after the maintenance officer of the 84th Engineer Construction Battalion, Warrant Officer Peter Jackson, who designed it.

59. The receipt of ten oxyacetylene torches enabled the battalion to return the torches it had borrowed under Memos of Receipt from other units.

60. Chinese shelling of I Corps defensive positions near the X-Ray site increased beginning on 25 May as the enemy prepared for ground assaults on 28-29 May that netted it Outposts Carson, Elko, and Vegas. These outposts were located about four miles northwest of the X-Ray site atop hills forward of I Corps' main line of resistance.

61. The enemy round exploded near an emplacement of four .50-caliber machine guns manned by the 21st Antiaircraft Artillery Battalion, an element of the 25th Infantry Division. This division had relieved the 1st Marine Division on the western flank of the I Corps front on 5 May 1953.

62. Headquarters, Division Artillery, 25th Infantry Division.

63. The last minute cut-outs would replace bad rivets.

64. Colonel Hoy D. Davis, Jr., was an Engineer officer serving at Headquarters, Eighth Army.

65. The visitors from the Army of the Republic of Korea were Brigadier General Min Byong Kwon, the Adjutant General, and Brigadier General Urn Hong Sub, the Chief Engineer.

Photo Sources

Fig.

1. Photograph SC 370668, Department of Defense Still Media Records Center, Anacostia Naval Station, Washington, D.C. (hereafter cited as DSMRC).
2. Photograph SC 373544, DSMRC.
3. Photograph SC 376806, DSMRC.
4. Photograph SC 379406, DSMRC.
5. Command Report, 1169th Engineer Combat Group, November 1951, National Archives Record Group 407.
6. Ibid.
7. Photograph SC 410709, DSMRC.
8. Photograph SC 413381, DSMRC.
9. Photograph SC 413380, DSMRC.
10. Photograph SC 413379, DSMRC.
11. Photograph SC 406171, DSMRC.
12. "Construction of Libby and Teal Bridges, Imjin River, October 1952 to July 1953," figure 1, file 8–5.1A/DK, Historical Resources Branch, U.S. Army Center of Military History, Washington, D.C. (hereafter cited as "Construction of Libby and Teal Bridges," figure 1).
13. Command Report, 84th Engineer Construction Battalion, August 1952, National Archives Record Group 407.
14. Ibid.
15. Ibid.
16. Ibid., September 1952.
17. Photograph SC 435734, DSMRC.
18. Public Affairs Office, Combined Field Army (ROK/US).
19. "Construction of Libby and Teal Bridges," figure 3.
20. Command Report, 84th Engineer Construction Battalion, October 1952, National Archives Record Group 407.
21. "Construction of Libby and Teal Bridges," figure 5.
22. Command Report, 84th Engineer Construction Battalion, November 1952, National Archives Record Group 407.
23. "Construction of Libby and Teal Bridges," figure 9.
24. Command Report, 84th Engineer Construction Battalion, November 1952, National Archives Record Group 407.
25. "Construction of Libby and Teal Bridges," figure 8.
26. Command Report, 84th Engineer Construction Battalion, November 1952, National Archives Record Group 407.
27. "Construction of Libby and Teal Bridges," figure 13.
28. Ibid., figure 14.
29. Ibid., figure 15.
30. Ibid., figure 12.

Fig.

31. Ibid., figure 16.
32. Ibid., figure 17.
33. Command Report, 2d Engineer Construction Group, January 1953, National Archives Record Group 407.
34. "Construction of Libby and Teal Bridges," figure 18.
35. Ibid., figure 19.
36. Ibid., figure 20.
37. Ibid., figure 21.
38. Ibid., figure 22.
39. Ibid., figure.25.
40. Ibid., figure 26.
41. Ibid., figure 27.
42. Ibid., figure 28.
43. Ibid., figure 32.
44. Ibid., figure 33.
45. Ibid., figure 35.
46. Ibid., figure 38.
47. Ibid., figure 34.
48. Ibid., figure 40.
49. Ibid., figure 41.
50. Ibid., figure 42.
51. Ibid., figure 44.
52. Ibid., figure 43.
53. Ibid., figure 45.
54. Ibid., figure 48.
55. Ibid., figure 49.
56. Ibid., figure 50.
57. Ibid., figure 52.
58. Ibid., figure 53.
59. Ibid., figure 54.
60. Photograph SC 431293, DSMRC.
61. Papers of William Clarence Carter, Jr., photo 20, Office of History, Headquarters, U.S. Army Corps of Engineers.
62. Papers of William Clarence Carter, Jr., photo 25, Office of History, Headquarters, U.S. Army Corps of Engineers.
63. Photograph SC 435746, DSMRC.
64. Slide Collection, Box 46, Slide 1-16, Office of History, Headquarters, U.S. Army Corps of Engineers.
65. "Construction of Libby and Teal Bridges," figure 24.
66. Ibid., figure 30.
67. Ibid., figure 31.
68. Command Report, 84th Engineer Construction Battalion, March 1953, National Archives Record Group 407.
69. Ibid.
70. "Construction of Libby and Teal Bridges," figure 36.
71. Command Report, 84th Engineer Construction Battalion, April 1953, National Archives Record Group 407.

Fig.

72. "Construction of Libby and Teal Bridges," figure 37.
73. Ibid., figure 29.
74. Command Report, 84th Engineer Construction Battalion, April 1953, National Archives Record Group 407.
75. "Construction of Libby and Teal Bridges," figure 51.
76. Ibid., figure 55.
77. Ibid., figure 46.

Combat Forces Press, 1955) includes considerable discussion of engineer operations during the Korean War, some relating to bridge building, in a compilation of brief accounts of Army work behind the front lines. *The* Military Engineer published, in 1951–1958, articles by Army Engineer officers on bridges built during the Korean War over the Imjin (47: 116–118 and 50: 114–115), the Han (47: 333–336 and 48: 281–284), the Naktong (43: 96–100), the Pukhan (44: 86–87), and the Twinnan (44: 43–45) rivers and on railroad bridges in Korea (43: 332-333 and 47: 333–336).

While rivers have formed significant military barriers and military bridge building has played an important part in warfare since ancient times, no survey of this topic has been published in English since 1853. Bridge-building efforts are regularly discussed in accounts of specific wars and campaigns, however. A number of books discuss military bridging during World War II. The official history by Alfred M. Beck et al., *The Corps of Engineers: The War Against Germany,* U.S. Army in World War II (Washington: U.S. Army Center of Military History, Government Printing Office, 1985), treats U.S. Army bridge-building work in -Europe during that war in considerable detail. The most massive American bridge-building effort of the war, made on the Rhine River, is the subject of special reports by First, Third, Seventh, and Ninth Armies; XVI Corps; and the 1110th Engineer Combat Group, but these reports are generally available only in specialized collections on engineer operations and military history, such as those of the Office of History of the Corps of Engineers. Somewhat more widely available is the report by the 12th Army Group's engineer Patrick H. Timothy, *The Rhine Crossing: Twelfth Army Group Engineer Operations* (Fort Belvoir: Engineer School, 1946). A publication by the British Corps of Royal Engineers, *Bridging Normandy to Berlin* (n.p., 1945?), describes the bridge-building efforts of Field Marshal Sir Bernard Montgomery's 21 Army Group. *Engineer History, Mediterranean Theater, Fifth Army, 3* vols. (n.p., 1945?), contains detailed discussions of bridge construction in Italy amid reports of other engineer operations there. U.S. Army bridge building in Asia and the Pacific is discussed in Karl C. Dod, *The Corps of Engineers: The War Against Japan,* U.S. Army in World War II (Washington: U.S. Army Center of Military History, Government Printing Office, 1966).

Suggestions for Further Reading

The efforts of U.S. *Army* engineers to build durable bridges, across the Imjin River form both an episode in the history of military bridge building and a little understood aspect of the Korean War. Readers of this volume may want to pursue further reading in either or both of those subject areas.

The recently published book by Bevin Alexander, *Korea: The First War We Lost* (New York: Hippocrene, 1986), provides a superb overview of the military and diplomatic events of the Korean War, together with thoughtful insights into its political context. Walter Hermes' *Truce Tent and Fighting Front*, U.S. Army in the Korean War (Washington: U.S. Army Center of Military History, Government Printing Office, 1966), concentrates on U.S. Army operations during the last two years of the war, along with their diplomatic context, while Pat Meid's and James Yingling's *Operations in West Korea*, U.S. Marine Operations in Korea, 1950–1953, vol. 5 (Washington: Marine Corps Historical Division, Government Printing Office, 1972), discusses Marine operations near the Imjin River. Matthew B. Ridgway's *The Korean War* (Garden City, NY: Doubleday, 1967) and Mark W. Clark's *From the Danube to the Yalu* (New York: Harper, 1954) contain the memoirs of the successive United Nations commanders during the last years of the war.

More detailed operational accounts of the fighting near the Imjin River are provided by Cyril Barclay's *The First Commonwealth Division: The Story of British Commonwealth Land Forces in Korea* (Aldershot, England: Gale and Polden, 1954) and *The First Team: The First Cavalry Division in Korea, 18 July 1950–18 January 1952* (Atlanta: Albert Love, 1952). Lively accounts of Korean War combat told from the vantage point of the ordinary soldier are contained in a book by T.R. Fehrenbach, *This Kind of War: A Study in Unpreparedness* (New York: Macmillan, 1963), and in two works by one of the most popular military historians of the period, S.L.A. Marshall, *The River and the Gauntlet* (New York: Morrow, 1953) and *Pork Chop Hill: The American Fighting Man in Action, Korea, Spring, 1953* (New York: Morrow, 1956).

John G. Westover's *Combat Support in Korea* (Washington:

Prior to World War II, British engineers authored many of the leading English-language works on military bridge building. In 1816 Major General Sir Howard Douglas published one of the first works on this subject, *An Essay on the Principles and Construction of Military Bridges, and the Passage of Rivers in Military Operations.* The book was so popular. that Douglas substantially expanded it, and later editions appeared in 1832 and 1853. The book discusses many bridging operations in eighteenth and early nineteenth century warfare, and each edition includes more recent conflicts. *The Work of the Royal Engineers in the European War, 1914–19,* vol. 1, *Bridging* (Chatham: Royal Engineers' Institute, 1921), provides a detailed report on British bridging operations in World War I.

The American Civil War witnessed some very significant bridging operations. They are described in a long article by Corps officers Michael McDonough and Paul Bond, "Use and Development of the Ponton Equipage in the United States Army, with Special Reference to the Civil War," *Professional Memoirs, Corps of Engineers, United States Army, and Engineer Department at Large* 6 (1914): 692-758. Bridging was less important to American operations in fiance during World War I, but U.S. forces did build several significant bridges across the Aire and Meuse River&ward the end of that war. This bridge-building work is discussed briefly in *Historical Report of the Chief Engineer, Including all Operations of the Engineer Department, American Expeditionary Forces, 1917-1919* (Washington: War Department, 1919), primarily on pages 210–226. W.R. Ingalls, ed., *History of the 27th Engineers, U.S.A., 1917–1919* (New York, 1920), provides a detailed account of the work of a unit that served as a bridge regiment during the Meuse-Argonne campaign.

Map Symbols

Military Units—Identification

Cavalry (organized as infantry) . . . . 

Communist Chinese Forces . . . . 

Infantry . . . . 

Size Symbols

The following symbols, placed either in boundary lines or above the rectangle enclosing the identifying arm or service symbol, indicate the size of military organization:

Battalion II

Regiment III

Brigade X

Division XX

Corps XXX

Army XXXX

Examples

2d Battalion, 17th Infantry . . . . 

1st Korean Marine Corps Regiment . . . . 

195th Division, Communist Chinese Forces . . . . 

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* Roman page numbers refer to text; those in italics to photographs.

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