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-

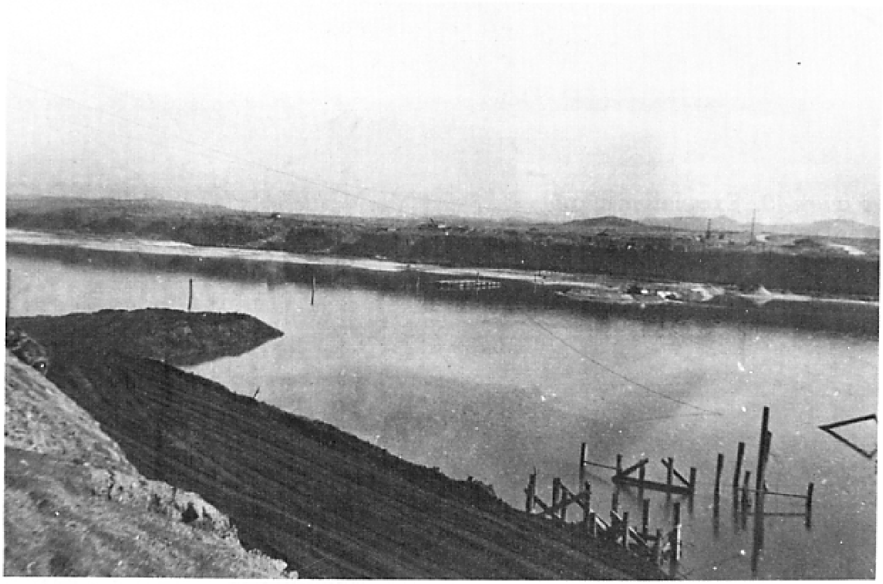


Figure 38. The Imjin River at the X-Ray site, showing early progress on the construction causeway and test piles driven in November 1952 to determine the depth of bedrock.

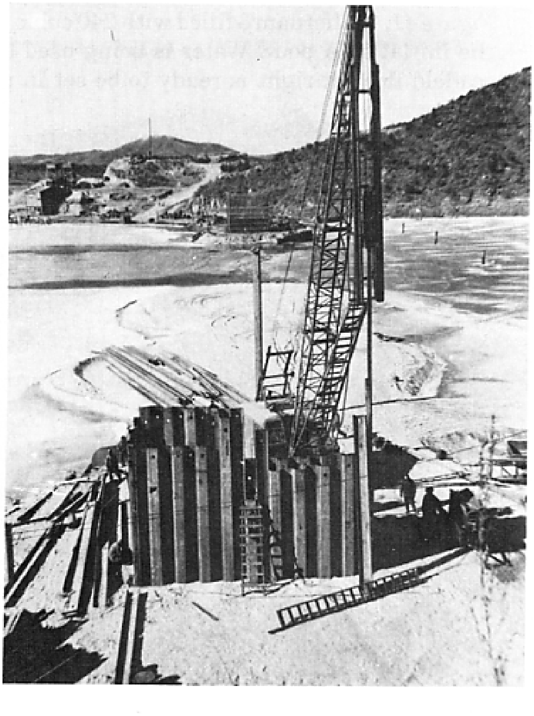


Figure 39. Pile driving on cofferdam 1 during February 1953. View shows curing cabin on pier 6 on far causeway and the concrete batch plant on the far shore.

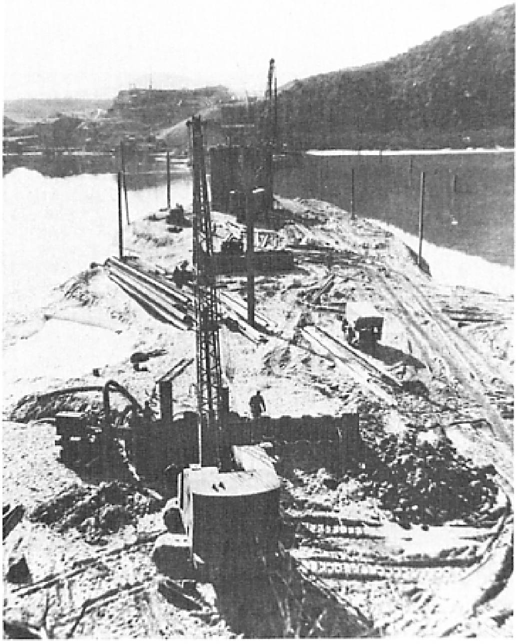
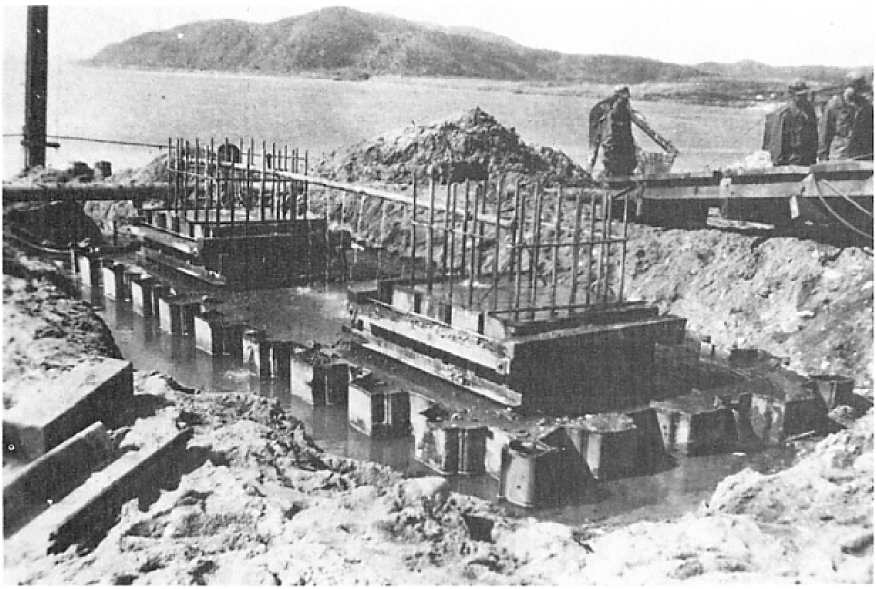


Figure 40. Excavation of cofferdam 1 and pile driving on cofferdam 3. Pier 7 is visible on the far shore.

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.



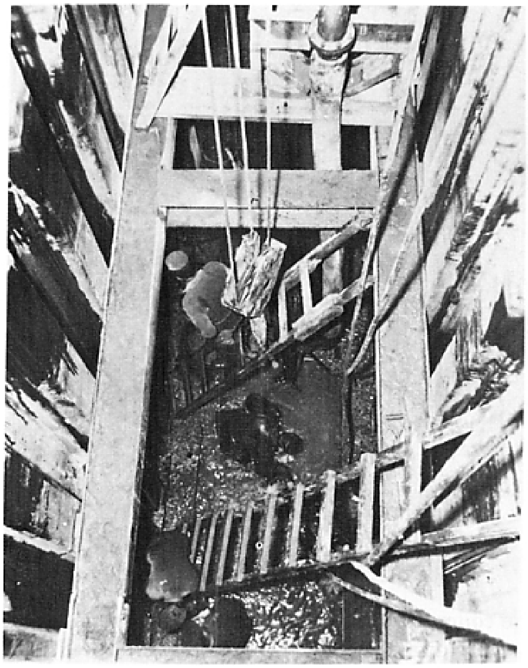


Figure 42. Interior view of a cofferdam showing 12-inch H-beams, or whalers, which enabled it to withstand outside pressure. Buckling of the H-beam is visible at the upper left.

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.

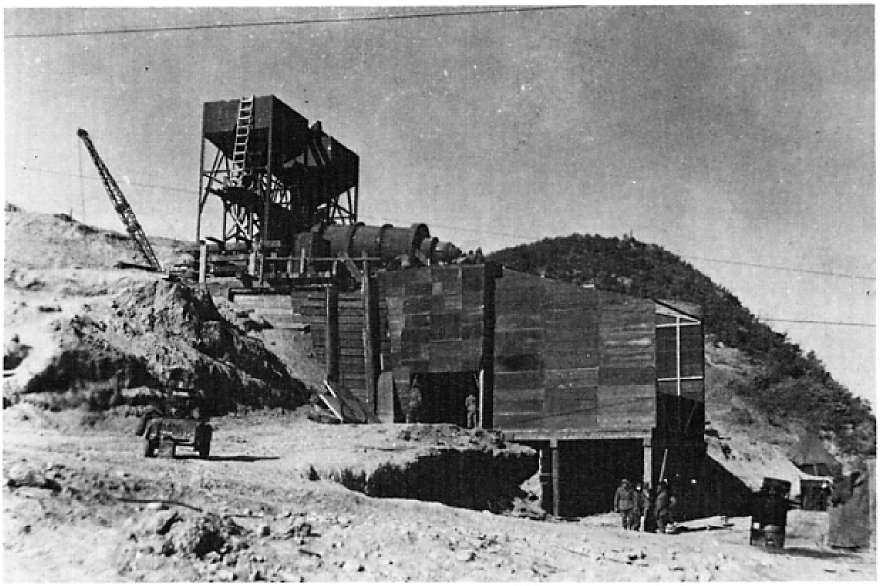
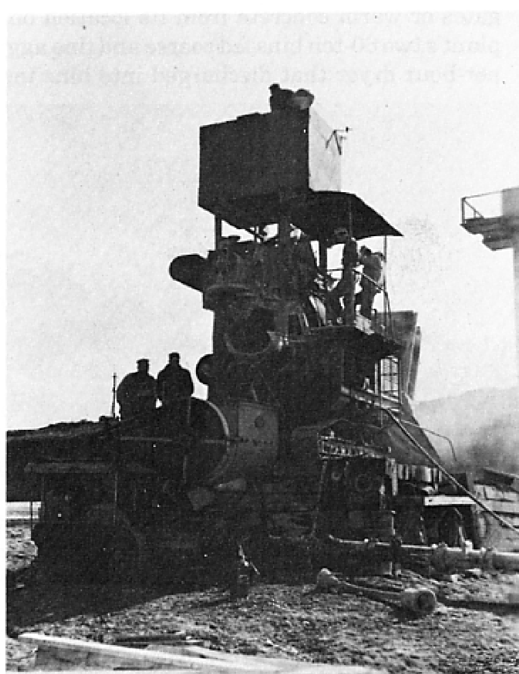


Figure 44. Close-up view of the concrete batch plant showing aggregate bins and, at bottom, locations where dump trucks and mixers were filled.

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.



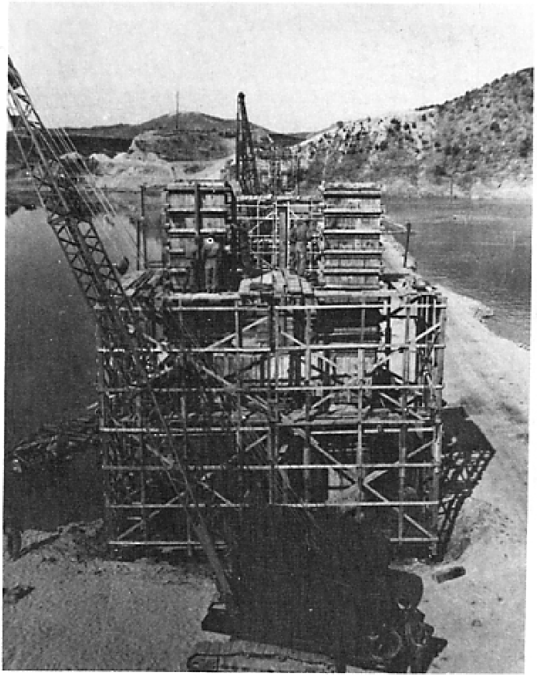


Figure 46. Forms for D pour that had been put together on the ground, raised, and then lowered onto the C pour pedestal. The curing cabin being used as scaffolding is ready to be raised into position and clamped.

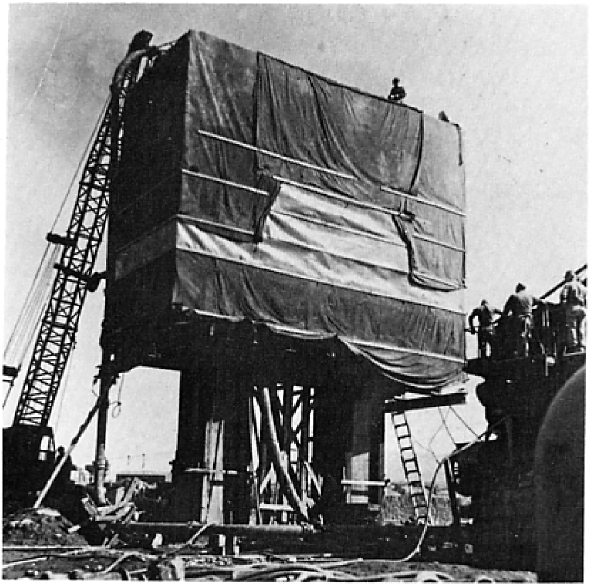


Figure 47. The curing cabin on pier 7 in position for the final or E pour. The canvas pipe, center, provided heat for curing. The 34 E paver and the pumpcrete machine, right, mixed cement and pumped it to the pouring location through the pipe, left, that ran over the curing cabin.

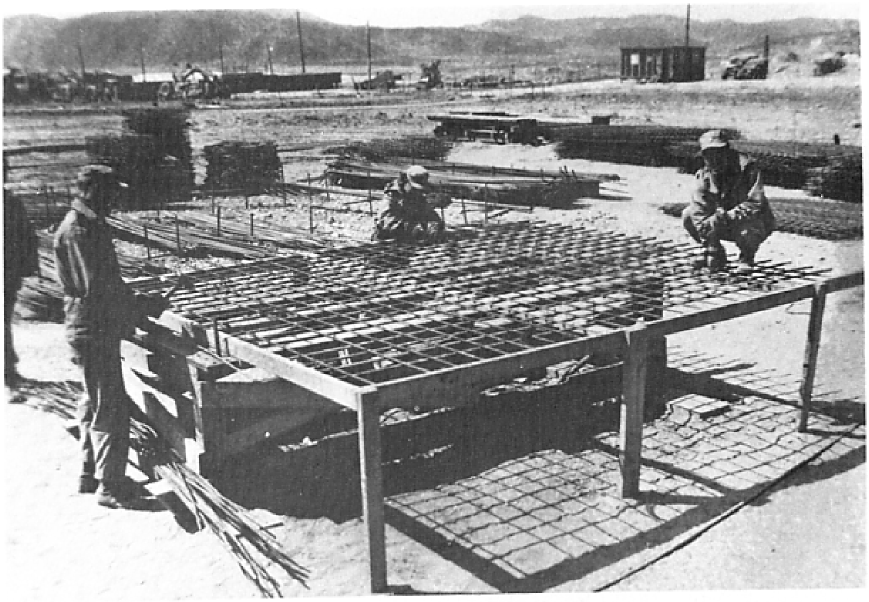


Figure 48. Steel mats that would reinforce the bridge decking being fabricated in the central work yard.

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

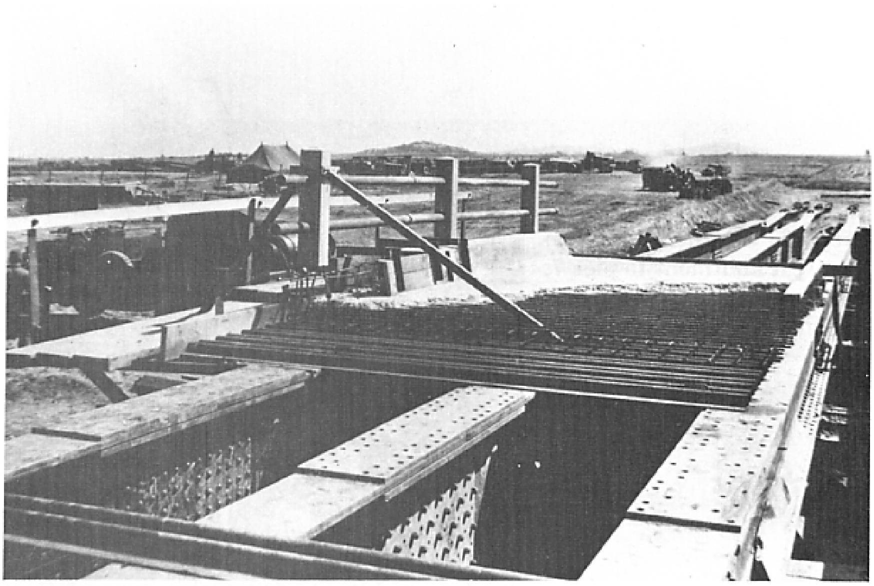
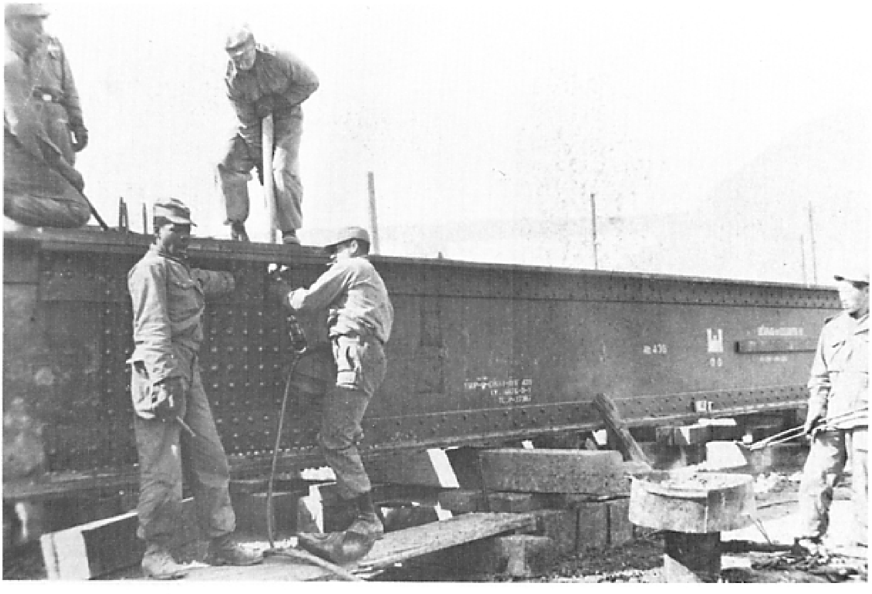


Figure 50. Full-scale model of a section of decking that was built in the work yard for practice and testing purposes.

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.



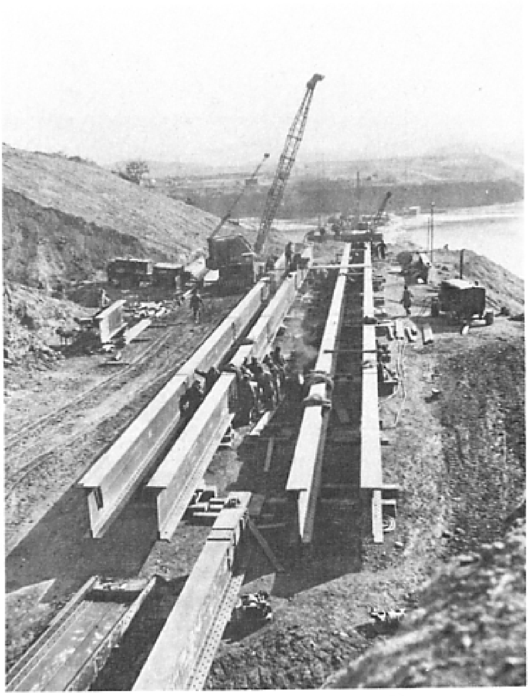
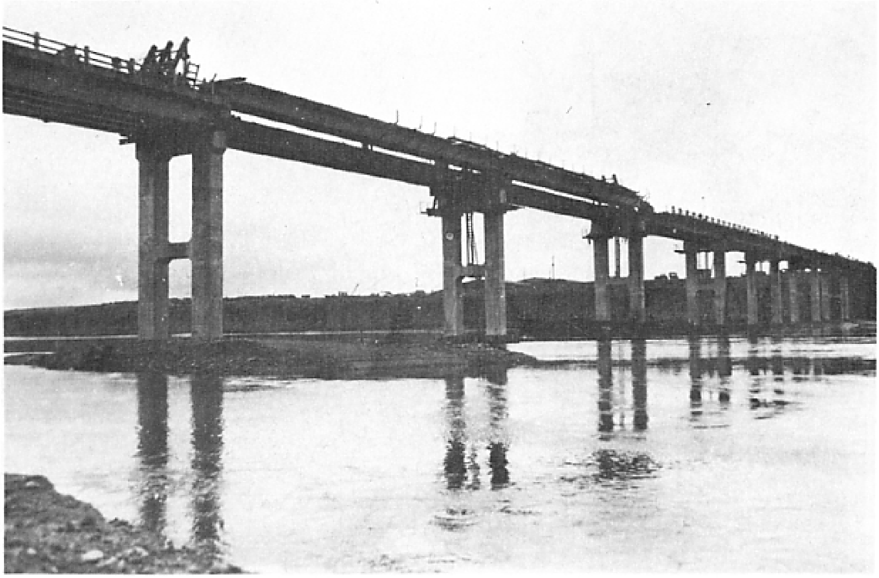


Figure 52. Steel beams being prepared for the span from the west abutment to pier 7, while riveters received training on the beam at left center.

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.



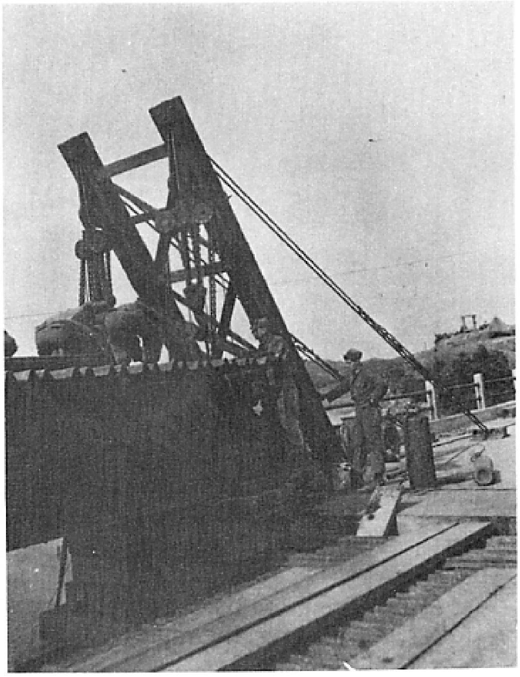
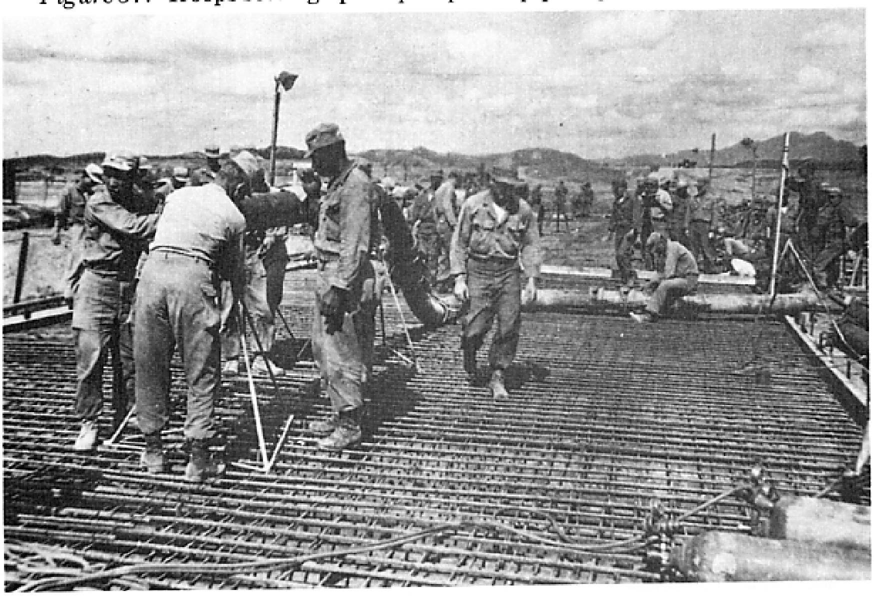


Figure 56. Close-up view of chain hoist lowering downstream girder across piers 7, 6, and 5. This girder was lowered in 22 hours, a much shorter period than the eight days required to lower the corresponding girder from the west abutment to pier 7 with jacks.

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



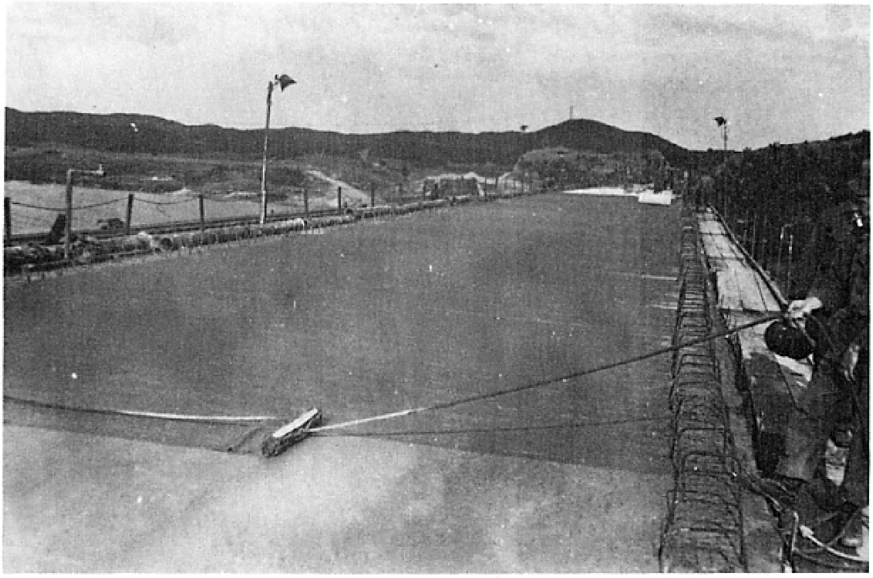


Figure 58. A burlap drag being used to give the deck surface the desired rough texture perpendicular to traffic. Reinforcing steel for curbing is visible.

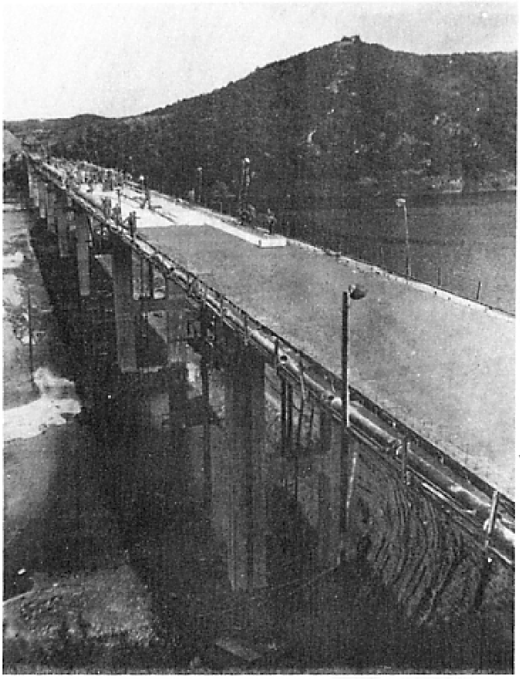


Figure 59. Concrete deck being covered with burlap, at center, prior to receiving a seven-day water cure. A flood gauge is visible on pier 1 in foreground.

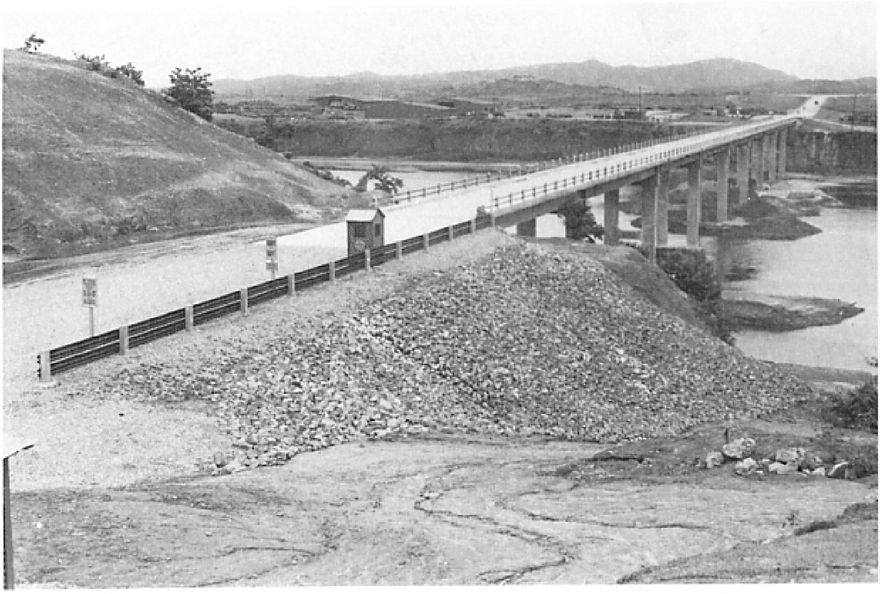


Figure 60. Completed Libby bridge from the west bank on 4 July 1953.

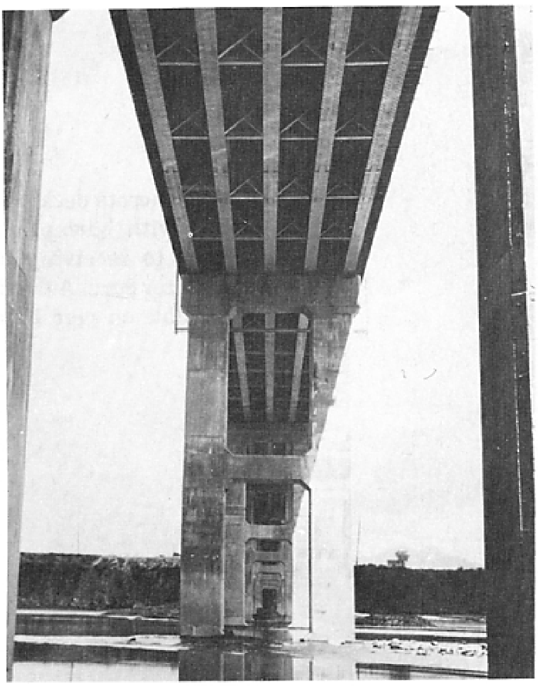


Figure 61. View looking east at the completed piers and superstructure of Libby bridge.

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

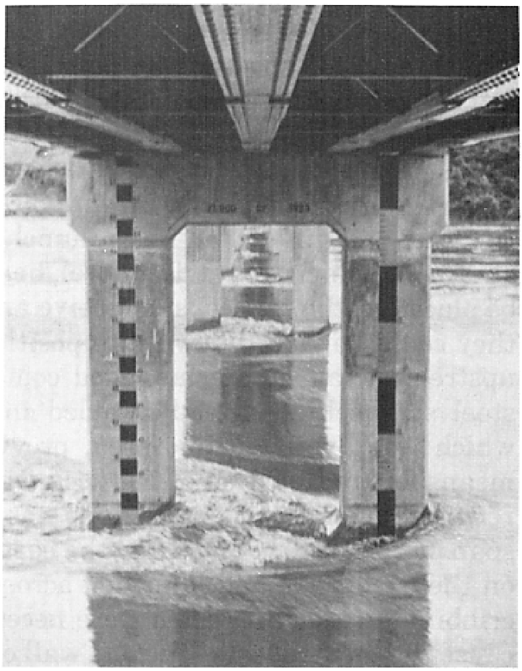
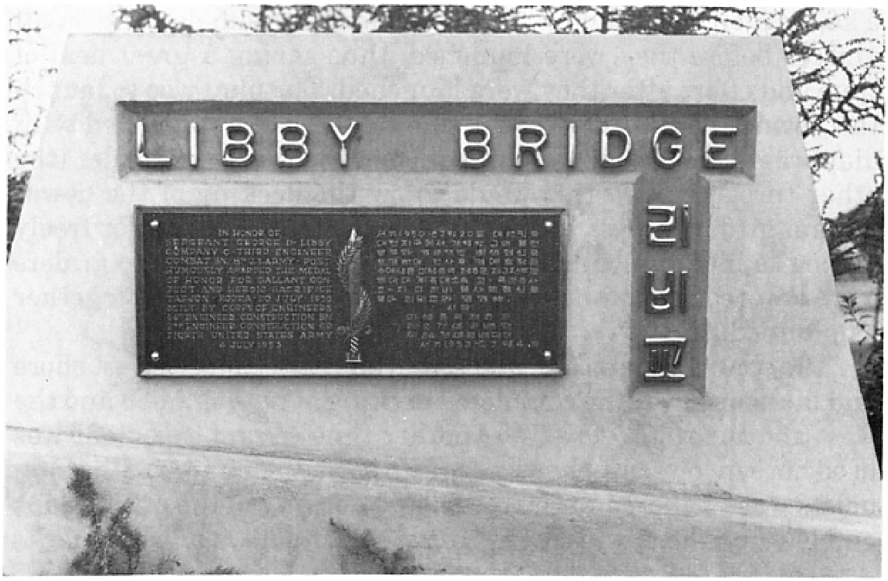


Figure 63. Plaque erected at the east end of the bridge as a memorial to engineer Sergeant George D. Libby.



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)* Cleanup 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.