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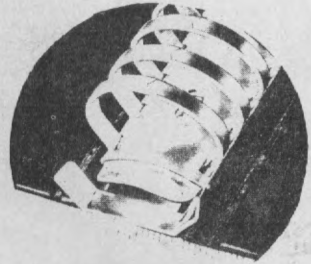

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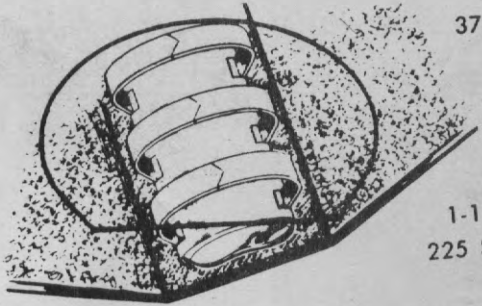

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INTRODUCTION

The objective of this publication is to make available to the Naval Construction Force an accumulation of information pertaining to specific problems that have occurred and the solutions that have been applied. Some of these problems have occurred more than one time and the solutions applied have varied depending upon the unit involved or the specific conditions encountered. The information contained in this publication is not to be considered as the only solution to a specific problem, rather it is a compilation of what were considered to be the best engineering and practical solutions applied under the circumstances by the units solicited for information. Although many of the problems and solutions may be related to other deployment areas, these "Lessons Learned" were all gleaned during the Vietnam contingency.

This publication will be expanded and updated as additional useful information is made available. The binder is such that changes can be readily accomplished. Units of the Naval Construction Force are therefore encouraged to make contributions to this manual on a continuing basis. The information requested is experience related subjects, including both the problem and the solution, that will be helpful to others in the future. It is expected that the majority of the contributions will be successful applications; however, applications that have not proved successful are also solicited. The experience gained from these applications is as valuable as the more successful solutions.

Problems, solutions and/or recommended changes to the manual should be sent to:

Naval Construction Battalion Center
Seabee Systems Engineering Office
Code 15
Port Hueneme, California 93041

Reviewed and approved October 1970 in accordance with SECNAV Instruction 5600.16.

D. L. CONNER

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SECTION 1.0

CONSTRUCTION

1.1 EARTHMOVING

1.1.1 Survey Markers

Problem. Prior to the start of construction, survey markers are sometimes altered or removed by storm waters or by indigenous personel who desire the markers for firewood. Occasionally, markers are relocated by infiltrating forces to confuse the construction force.

Solution. Surveyors should stake out the job no earlier than one day prior to the commencement of construction, particularly in heavily populated areas. Additionally, survey crews should check the grade and alignment of stakes continually to insure that they have not been purposely or inadvertently moved.

1.1.2 Surface Drainage

Problem. The construction of facilities alters the previous conditions by removing the area from available percolation surface, by concentrating the roof drainage into a potentially damaging flow, and by allowing water to run faster over a smoother surface. Normally an occupied area will continue to have improvements upstream. Additional structures, paved surfaces, and ditches will continually channel more surface water through downstream drainage facilities.

Solution. The following actions are recommended:

a. Drainage structures must be designed with adequate capacity and should be made comspicuous to provide a psychological deterrent against neglect and inadvertent blockage during the dry season.

b. Drainage channel requirements should be based on the experience of local residents in heavy and prolonged rain under saturated soil conditions. Large drainage structures, being conspicuous by nature, may afford infiltration paths for hostile forces and therefore caution must be exercised in determining the size of the structures.

c. Drainage structures should be cleared of all vegetation and foreign matter prior to the rainy season, and adequate provisions for the escape of discharge from culverts must be made to prevent problems of backwater and silt depositions.

d. On slopes steeper than 1 1/2:1, the fill supporting completed facilities and primary drainage ditches should be riprapped with rocks, sacked concrete or gunite. Riprapping lends itself to accomplishment by indigenous personnel and is therefore less likely to be postponed.

e. Each battalion should keep several 30-foot lengths of made-up culvert in 18-, 24-, and 30-inch sizes for emergency placement as the new monsoon season's rains make their mark on construction of the previous summer. Other desirable emergency culvert sizes are 36-feet long in 36-,48-,60-, and 72-inch diameters.

f. Grass seed and fertilizer should be carried as a pre-expended item for use in stabilizing graded slopes. Grass must be established early enough to be firmly rooted, and culverts should be in the ground before the advent of heavy rains.

g. Special consideration must be given to the construction of headwalls in areas where the soil condition consists mainly of sand and laterite. Improperly constructed headwalls will eventually wash out causing failure of the drainage structure. At Chu Lai, MCB-8 noted that the headwalls were constructed on a flat concrete slab at the end of the drainage structure. Many of them were failing due to scouring around the end of the wall as water flowed over the tops of the culverts during heavy downpours. New headwalls were constructed, shaping them so that wing walls protruded out from both sides of the structures providing support in front of the culvert as well as diverting the water around the sides of the headwall.

h. Utilization of natural water courses provide one of the best drainage systems.

1.1.3 Land Clearance

Problem. Construction progress is occasionally halted due to delays encountered while clearing uncharted mine fields. Although EOD teams may report that uncharted mine fields have been cleared, many mines go undetected thereby hazarding construction personnel.

Before topsoil could be removed to place laterite fill, it became necessary to clear an uncharted French and Vietnamese mine filed.

Solution. The blade was removed from an International TD-20 bulldozer. Shielding the cab and motor with 1/2 inch steel plate welded and braced to the trunion arms, the bulldozer was used to push a sheepsfoot roller into the mine area. Several mines were detonated during the operation, resulting in only minor equipment damage and no injuries to personnel.

1.1.4 Excavation

Problem. Clearing and excavating operations in areas containing pipelines or communications lines in indefinite locations have caused unnecessary delays when the lines were struck and damaged by moving equipment.

Solution. Local Marine and Army mine sweep teams have been used to spot these lines with mine detection equipment thereby avoiding accidental striking of a line.

1.2 BUILDINGS

1.2.1 Bunkers, Poured-in-Place Versus Tilt-Up

Problem. Two large reinforced concrete bunkers were constructed for the 3rd Marine Division at Dong Ha. The COC Bunker was a 24- x 50-foot structure while the Communications Bunker was 30- x 70-feet. Both bunkers were covered with approximately five feet of earth.

Solution.

a. The COC Bunker was of conventional poured-in-place construction utilizing precast roof beams. The Communications Bunker, which was of tilt-up type, proved to be more efficient. Not only was there a significant savings in the amount of material used for forms, but also a much higher quality finish was attained on the tilt-up wall and roof panels. The tilt-up method could be used to a significant advantage for a number of in-country Seabee projects.

b. Considerable emphasis should be placed on training crews to build forms properly, especially for wall pours. Crews must learn from experience correct forming procedures and must be thorougly aware of the importance of form strength.

1.2.2 Hut Foundations

Problem. A problem was encountered in the sandy areas of Chu Lai in building tropical huts for cantonments. Huts with supports placed directly on the sand were quickly undermined by the erosive action of wind and water on the sand. Both sandbagging and underpinning were unsuccessful in preventing the erosion.

Solution. To preclude such undermining of huts place in sandy areas, they should be erected on compacted laterite or rock pads which resist the erosive action of wind and provide the required bearing strength for hut support. Spraying the area around the hut with crude oil or cut back asphalt will also stop erosion.

1.2.3 Construction on Sand

Problem. Construction of buildings on a less than optimum soil base.

Solution. Depending upon the type of structure and weather conditions, several satisfactory foundation techniques can be employed. Large rigid frame buildings should be erected on a prepared compacted laterite base. All strong-back huts should be placed on piers resting on treated wood footer blocks or precast concrete footer blocks. To prevent wind erosion from undermining the footings, place the footer blocks below grade or pile sand bags around them. Quonset huts should be constructed either on concrete strip footers or concrete slabs. These slabs can be placed on laterite pads in the dry season and on sand during the rainy season, as laterite loses all stability when wet. As a further deterrent to erosion, soil cements can be added to the base.

1.2.4 Scaffolding

Problem. Scaffolding for overhead plumbing or electrical work is generally built over concrete decks, and wheels for the legs are often unavailable. Moving the scaffolding may result in scored concrete and bent scaffold legs.

Solution. Attach sheet-metal skids to the bottoms of the legs to allow the scaffolding to be moved with less effort with no damage to the deck or the scaffolding. However, the ABFC has a new assembly 1135, Portable Scaffold with 8-inch wheels. The scaffold assembly is now shown on NAVFAC Drawing 1109771 and is included in the MCB-TOA Part III for Battalion use.

1.2.5 Pre-Engineered Steel Buildings

Problem. The erection of pre-engineered steel buildings can create difficulties.

Solution. The most difficult phase of construction is the assembly of the roof vent, a project in itself. Two methods of vent assembly were utilized. In the first method, the entire vent was assembled on the ground in 20-foot sections, and then raised in palce by a crane. In the second method, the angles were assembled on the ground and hauled in place on the roof; the sheet metal was then installed on the roof. Both methods worked well, however, the first required the use of a crane, and the second did not. The manhours involved were practically the same.

Two different methods were used in erecting the structural frame. One method was to assemble the entire structural frame work, and then to square the building. In the other method, the end walls were assembled on the ground, raised into place, and each bay erected and squared one by one. The first method gave quicker results without requiring a crane for a long period.

No problem was experienced in applying the side sheeting if the building was squared. End-wall gable sheeting was field cut. Time could possibly have been saved by shop cutting the panels, and the use of an oxyacetylene torch in the field would not have been required. When shop cutting is employed, care must be taken during erection to achieve proper wall clearances.

1.2.6 Strongback Tents

Problem. It was discovered, after precutting strongback tent materials, that there is a design difference between the Army 16-x32 foot tent and the Marine Corps tent.

Solution. It is highly advisable to learn beforehand, exactly what type of tent is to be utilized prior to construction of the frame.

1.2.7 Strongback Huts

Problem. Prefabrication of hut components saves time. Prefabricated components must be utilized as soon as possible after assembly because they will deteriorate rapidly in open storage. Screening becomes clogged with dust and dirt.

Solution.

a. Care must be taken when loading prefabricated components for hauling to the job site to ensure that forklifts do not puncture the screening and that pieces are securely tied to the bed of the truck or trailer.

b. Use of bent sheets of metal roofing rather than a pre-formed ridge cap, results in a more weatherproof structure and simplifies construction. Care must be exercised in the sheet metal shop when bending metal roofing to assure that the corrugations on the bent sheets will match those of a new shipment of metal roofing to be used on the remainder of the huts.

c. Prefabricating jacks work well as long as the ground is relatively level. Otherwise, the jacks must be built in place.

d. It takes less time to build a new hut than is required to convert a tent strongback to a hut. Side and end walls of the strongback must be remodeled to conform to the hut's configuration. Part of the lumber in the side and end walls can be utilized.

1.2.8 Strongback Tents versus S.E.A. Huts

Problem. The majority of the Camp Haines berthing huts were initially constructed as 16- x 32-foot strongback tent frames with 6-foot sidewalls. All tent frames were eventually converted to tin roofed SEA huts of the same size. The largest reason for this conversion was the lack of durability of the tents when subjected to the weather conditions predominant in Northern I Corps. It was found that sufficient damage to render the tents unusable was sustained when they were exposed to winds not exceeding 35 knots. In addition, tents proved to be a great deal less habitable during both the dry and wet seasons.

When constructing a new camp, three alternatives are available. One is to construct a tent frame at a cost of $312 and cover it with a tent valued at $430. Since a tent remains servicable no longer than six months it must be replaced at six months intervals through the life of the facility. Ignoring interest rates, over a two-year cycle, this facility has a total cost of $2,032 or an annual cost of $1,016. If the facility wereused for four years, the total cost would be $3,752 or an annual cost of $938.

The second alternative is to construct strongback tent frames and cover them with tents, then convert to SEA huts after six months. This alternative costs $984 per hut which is $492 per year if the hut is used two years and only $246 if the hut is used for four years.

The third alternative is to construct an SEA hut at an initial cost of $560 which is $280 or $140 per year for a two-year or a four-year use respectively.

Solution. The comparison of these three alternatives shows that building an SEA hut originally is the most economical. Maintenance of each structure and habitability emphasize this point even more. It is therefore suggested that the NMCB tent allowance be used for temporary detachments where no strongbacks are built and that strongbacks be superseded by the cheaper, more durable, and more habitable SEA hut in base-camp construction.

1.2.9 Sheet Metal Fabrication

Problem. The fabrication of large sheet metal work i.e. ducts, sinks, vent hoods, etc., at facilities where long distance shipment to the construction sites is involved.

Solution. The extensive damage that resulted to the sheet metal fabrications during shipment from Camp Haskins to Camp Haines could have been avoided if a stock of sheet metal and the required tools had been sent to the construction site for fabrication.

1.2.10 Concrete Block Manufacture

Problem. Fabrication of quality 35-pound 8- x 8- x 16-inch concrete blocks can be difficult to achieve.

Solution.

a. The quality of the block depends on the cleanliness of the aggregate and condition of the cement. Aggregate should be clean and the cement must be hydration free.

b. The moisture content of the mix is the most important factor in the production process because it controls the quality and compressive strength of the end product; moisture content should be that which produces a 2-to 3-inch slump.

c. New blocks should be immediately stored in metal or wooden curing racks, air cured for three hours.

d. Block should be palletized only after a minimum of 24 hours of water curing to prevent stress cracks under load.

e. Pallets of blocks should be banded for all but the simplest moves. Breakage of blocks was negligible with banding, after reportedly having been as high as 50-percent.

1.2.11 Customer Liaison

Problem. One recurring problem throughout the deployment was customer liaison. Projects were often received with little or no design, and the Battalion asked to make customer liaison and coordinate design with him. The customer always wanted a better facility than was authorized and very often could not decide exactly what he did want. Sites were often changed, and a few times buildings had to be moved. Customers had little engineering concept of building construction, and their design concepts were sometimes impossible to build. When a plan was finally agreed upon, an MTO was made and submitted to the Regiment, only to have material requests returned because plans exceeded funds available. This served to delay the start of the project even further.

Solution. Plans and detailed MTOs should not be developed when the customer's desired scope is beyond that authorized until Regimental approval has been obtained. Funding limitations must be considered as a constraint of scope and consequently detailed project planning should be limited until the scope and funding relation is clarified.

1.3 CONCRETE

1.3.1 Batch Plant

Problem. Batch Plant Operations. For the final five-and-one-half months of the deployment, the Battalion was tasked with the operation of the Da Nang East batch plant. Production from this plant varied from less than 100 to over 1,100 cubic yards per week. A total of 2,063 man-days of Seabee labor and 204 man-days of indigenous labor were required in the operation of this plant resulting in an inefficient combined labor average of 19.5 man-days per one-hundred cubic yards of concrete produced.

The batch plant facility had been constructed by a previous Battalion and consisted of a small sand and aggregate combination hopper and a small cement hopper mounted on an elevated wood structure. The combination hopper was charged by a crane with clam shell which was permanently assigned to the plant. The cement hopper was loaded manually by personnel on a bin platform with cement bags delivered by fork-lift. Due to the size of the bin and platform, only a limited number of bags could be available at one time resulting in the requirement for a full time fork-lift assignment and continual bag breaking by personnel. Water for the transit mixers was obtained from a 100-barrel tank mounted on a separate elevated tower and charged by a permanently assigned water truck which drew its supply from the nearest water point.

Solution. Based on the Battalion's experiences with the less-than-satisfactory plant facilities assigned, it is recommended that Seabee batch plant operations consider the following:

a. The establishment of a batch plant component centrally located to Battalion projects. The facility should be provided with adequate sand, aggregate, and cement storage bins and hoppers with measurement control and with its own water well and storage tank for quick and measurable water charging.

b. The batch plant should be designed and constructed with concrete slabs under the charging hoppers to facilitate the movement of transit mixers and cleaning of the area and should be provided with a covered concrete slab for cement storage preferably at the same level as the top of the cement storage bin.

c. It is recommended that both batch plant operations personnel and transit mix drivers be assigned as one crew under one supervisor. It is considered that the operation of this facility could be assigned to any of the four line companies depending on the Battalion work load or situation. However, it is highly recommended that the plant supervisor be a BU1 or a BUC who understands the complexities of batching and mixes.

d. It is highly desirable that the plant be provided with one of the commercial radios recently provided the Battalions and that the plant supervisor be provided with a radio vehicle to permit his checking of mixing times, water addition, job site placement conditions, transit mixer breakdown, etc.

1.4 ASPHALT

1.4.1 Asphalt Heater and Drum Opener

Problem. Work pace is frequently set by time required for heating asphalt and removing it from drums.

Solution. NMCB FORTY developed a completely reliable method of opening drums and rapidly heating liquid asphalt that was used in large quantities for spraying the sand berms on the ASP project. A previously unused "Rapid Fire Car Heater" was adopted to eliminate the excessive time required to transport and heat the asphalt with a distributor truck. The entire system, which can be hitched to a truck and pulled to almost any site, consists of the heater, a trailer mounted pneumatic operated barrel opener and tank, and an air compressor. After the barrels of asphalt are drained into the tank, one cycle through the heater heats the asphalt to a temperature in excess of 200 degrees. The "Rapid Fire Car Heater" is operated by a Ford industrial engine which runs the asphalt pump, the diesel pump for the heater, and the blower. The asphalt is circulated at the rate of 250 gpm through the casings over which the burner is blowing, and with an asphalt inlet temperature of 75 degrees, in approximately six minutes 1,400 gallons can be heated to a temperature of 220 degrees. After passing through the heater, the asphalt can either be pumped into a distributor truck or back into the storage tank if no truck is ready to be loaded. With this ingenious innovation, approximately 25,000 gallons of asphalt can be properly heated and discharged in a 10-hour period vice the 5,600 gallon capability using the distributor truck heater. The mobility of this unit plus its speed and efficiency of heating asphalt greatly enhanced the continuing progress toward the completion of the ASP project.

1.5 AIRFIELDS

1.5.1 M8A1 Matting; Installation of

Problem. The working surface is particularly critical. Slighting the earthwork final grade is fatal.

There are several different manufacturers of M8-A1, and apparent specification tolerances result in lengths and widths of matting varying as much as one inch. Unlike brands may match-up for a row or two, but eventually all "play" in the tabslot arrangement is used up and different makes refuse to fit together.

Driving the locking pins and bending of the locking tabs is a back breaking, time consuming job if done with a pry bar.

The matting damages easily in handling.

Solution. Give the EO's time to prepare a level working surface before the matting starts going down. Recommend holding grade to .02 feet. Before putting the first piece of matting down, pull a straight line along the direction of laying, turn 90-degrees with a transit, and start with a square corner.

Do not start pounding pins until it is relatively certain that all is going well. But don't let the pin pounding fall too far behind if time is a factor. Pounding with the same size crew which is laying matting, it will take 150% of the laying time to drive all the pins.

Recommend all matting of one manufacturer be installed before utilizing another, i.e., matting should be stacked according to manufacturer on the job site. Some matting dimensions vary within a single manufacturer.

Forklift operators must be impressed with the necessity to exercise utmost care in staging the bundles. The top and bottom pieces invariably take a beating, and it is advisable to keep several men set aside to repair those that are repairable before turning them over to the laying crew.

To simplify driving locking pins the following expedient was developed. An H-frame, from which an air-hammer was hung by a chain, was mounted on a pallet and the pallet placed on a forklift. A man sat on the pallet with the air-hammer suspended in front of him. As he finished driving the pins in on one sheet, the forklift would carry him to the next.

1.5.2 Revetments

Problem. When MCB-10 undertook the job of erecting 5,880 feet of 8-foot-high bin-type revetments for protection of Marine Air Group 36 helicopters at Quang Tri Airfield, Vietnam, they encountered five problems caused by the helo pad's being in constant use. They were:

a. Only a small part of the pad may be used.

b. Saftey of the men must be insured while on the pad.

c. Not being able to use manufacturer - furnished spud wrenches for matting alignment.

d. Misalignment.

e. Filling revetments with sand.

Solution. These problems were solved simultaneously by the use of a pre-assembly area located off the pad. Not only was total time reduced on the mat, but rapid assembly of like sections and easy access to all component parts was allowed.

a. Revetment assembly was broken down into a three-step operation. First, column pieces were connected with the column splice and the connecting channels attached. Second, the pieces were joined with the spacers to form the end and center sections, which were then staged in their proper locations on the pad by a small forklift. Their location was accurately fixed by bolting a stringer on each side of the column for the entire length of the revetment. Third, the remainder of the stringers were assembled on location. By using this three-step procedure and a crew of only five men, it was possible to complete step three on a 60-foot-long, 8-foot-high revetment in only 90 minutes.

b. The spud wrenches provided by the manufacturer were too long and did not have a great enough taper to allow easy alignment of holes in matting parts. This problem was solved by turning alignment pins from tie rods used in packaging AM2 matting. These pins greatly speeded assembly of the columns.

c. The problem of part misalignment solution was to align the sections using the in-line holes and then making the matting holes with a cutting torch.

d. As the only available fill for the revetments was sand, and since the revetments were placed on M8A1 matting, it was necessary to seal the bottom and sides to prevent leakage. A top seal was also required to prevent sand uptake by the helicopter engines. This situation was taken care of by the use of soil cement for the top and bottom, and burlap for the sides. A layer of about three inches of soil cement provided an adequate seal. These procedures may seem expensive, however, they resulted in a greatly reduced amount of free-blowing sand and should help reduce helicopter maintenance. Since sand has no cohesiveness and continually leaks out through the smallest openings, laterite fill is recommended for metal revetments. For securing cracks, two-inch or four-inch masking tape works better than felt roofing paper. Also metal revetments are highly susceptible to being blown over when built higher than four feet without filling to the four foot level. Building above this level without filling should be done only when absolutely necessary or adequate safety precautions are taken.

1.5.3 AM-2 Matting

Problem. Installation and maintenance of AM-2 matting.

Solution. When placing AM-2 matting, facing the direction lay, a string line should be set on the side to the right by the surveyors so the matting can be installed in a straight line. Any excessive crown should be removed before starting the job.

a. Spacers should be placed into the joints after the sheets are laid to keep the sheet spacing uniform. The locking keys can be used for spacers.

b. When picking up the AM-2 matting, if the keys do not pull easily with vice grips, place a spud wrench (with the end ground down) into the hole in the locking key and hammer wrench to drive the keys out.

c. Due to the nature of placing AM-2 matting, it was found that a ten-hour day is the longest that the men can work effectively without resulting in carelessness and injuries.

d. The matting is delivered in crates. When the matting crates have been disassembled, the crate parts must be kept in case the matting has to be picked up and stored. The most efficient manner of handling the crate parts is to place each different part of the crate together on a wooden pallet and band them.

e. Extra locking keys should be kept so they will be available for necessary repairs. A georgia buggy worked best for keeping the keys together while on the project site, and metal ammunition containers work best for storage.

f. A project of this magnitude requires close control and coordination at all times. Usually the project has a short time table and it is imperative that all personnel be aware of their performance of a specific task and its affect on others scheduled to follow.

g. If usage and wheel loads to be encountered require the personnel and expense to install AM-2, then adequate sub-base preparation is also required. It is considered that in no case should an AM-2 runway, installed over laterite with no sub-base preparation, be expected to support C-130 traffic (4 cycles per day) for over two to three months without requiring removal, regrading, and re-installation.

h. One method for cutting AM-2 matting is to use a Skil saw. The best blade appears to be the Skil combination blade (for both ripping and cutting). This blade has five teeth per inch and about 3/8-inch deep. However, it is recommended to use plenty of oil on the blade to keep it cooled, and to wear goggles for protection against flying chips.

i. Action has been initiated to include NAVAIR 51-60A-1 "Handbook Installation, Maintenance, Repackaging and Illustrated Parts Breakdown AM-2 Airfield Landing Mat and Accessories" of 1 July 1967 in Section 0917, Forms and Publications of the MCB TOA.

1.5.4 SATS Wiring

Problem. Installation of SATS

Solution.

a. All SATS wiring should be buried whenever possible in order to reduce damage by vehicles, planes, flare pots, etc.

b. All shoulder traffic must be eliminated to reduce damage to wiring and lights.

c. On soil cemented shoulders, where it may be impractical to bury wire, it should be tucked along the edge of the matting and held in position with bent pieces of No.3 rebar.

d. Use phone pole butts to support approach lights. Bomb racks rust rapidly and should not be used.

e. The centerline lights were made by both MCB Four and Forty to prevent tail hooks from catching the plate over the lamp.

f. In sandy or dusty areas, all runway lights should be covered with 1/8-inch plexiglass to prevent sand or dirt from clogging the light.

g. Runway lights should not be installed within 250 feet of the arresting gear.

h. Vaults and regulators should be kept in a ventilated shelter.

i. Circuit breakers must be cleaned weekly to prevent severe rusting.

j. The battalion assigned to maintain SATS lighting system should have additional training in vault and regulator maintenance.

k. For splicing wire, Scotch cast splices are recommended in lieu of tape in order to provide water tight joints.

l. Spare SATS parts must be ordered well in advance, as lead times are exceptionally long.

1.5.5 Soil Cement

Problem . Soil cementing processes.

Solution. Cement spreading can be accomplished from dump trucks using a spreader, scrapers, or by hand using the bag or grid method. Whichever method is used it is important that the amount of cement spread be sufficient to provide a uniform mixture based on mix design best suited for soil conditions. To achieve best results it is necessary that fresh lump-free cement be used. If a large amount of lumps are present it may be necessary to build a screening tower so that cement falls through the screen into a waiting truck and lumps fall off to the side into a waste truck. In all cases test samples should be made to make sure that required strengths are maintained.

Recommended procedure. Two separate soil cementing projects were undertaken by NMCB-3. A 23,200 square yard parking apron was laid for the 131st Aviation Company, U.S. Army during an early deployment and a 90,000 square yard parking apron for MAG-36, early in December 1969. The second task yielded very favorable results.

The procedure outlined below is highly recommended for any soil cement project:

Make a study of the job.

Ensure that the size of the entire project is fully understood.

Establish a fixed goal for each day's production, rather than having a variable goal for each day.

Attempt to adhere to the established daily goal regardless of how many hours are required.

Estimate the number of men and pieces of equipment required to perform the job.

Check the availability of a sufficient capacity water source as near as possible to the job site.

Attempt to keep cement staged at least one day in advance on the job site to preclude shortages which may tend to impede progress.

Utilize a night crew, if possible, to stage pallets on the actual area to be cemented the following day.

The night crew should remove all crating and banding so that the day crew can begin laying bags immediately in the morning.

All rough grading, hauling of sand and finish grading for each daily section should be completed the day before bags are laid.

Bags should be laid by the bag laying crew at intervals specified by Engineering.

Bags should all be laid out before being broken to ensure proper spacing.

Part of the bag laying crew should begin breaking bags when those laying bags are far enough ahead so that spacing is not jeopardized.

The bag laying crew should remove all broken bags and other foreign materials.

These materials should be hauled away by whatever means available (MRS scraper and end dumps were used).

Use pulva-mixers to distribute the mounds of cement.

Hand raking is unnecessary.

Lower the blades so that the tines or teeth are about one (1") inch above the grade.

A uniform spreading of cement should normally be achieved with one pass.

Another pass should be made with the pulva-mixer dropped to its maximum to thoroughly mix the sand and cement.

Forward speed should be regulated so that homogeneous mixing is achieved.

A second pass should be made only if lean and rich spots remain.

When thoroughly dry mixed, apply water with a tanker truck (more than one may be required if the job is a large one).

Water should be applied cautiously; more water can always be added but excess water cannot be removed.

Excess water causes bad spots which normally have to be patched.

Water should be applied with a controlled distribution system; either a spray bar or fan type outlet under pump pressure.

Make two passes with the mixers to thoroughly mix the water with the dry mix.

More water may have to be added in some areas.

Excessive mixing causes aeration of the cement and should be avoided.

Check consistency of mix and moisture content by the hand "squeeze test".

Squeeze a handful of the soil cement tightly in the hand.

Break the sample into two pieces.

If the cement is properly mixed and has correct moisture content, the break will be clean with no "crumbs" falling away.

When this condition is achieved, the cement is ready for rolling.

An additional mixing pass may be necessary to achieve the proper consistency.

Roll the entire area one time with a roller. A pneumatic tire roller is recommended.

Next, use a motor grader to shave the pad, smoothing out high spots.

Roll the pad once more to complete the job.

Additional rolling causes cracking.

Finish up by using a grader to cut off the edge of the pad, thereby leaving a straight edge from which to gain a start for the next day's work.

The pad should be shot with asphalt the next morning.

Additional notes:

When laying cement bags next to an old joint, it is recommended that the bags be laid closer than the specified interval. The results are that you have a richer mix at the joint and you reduce the chance of failure at the joint.

When making adjacent passes with the pulva-mixers, it is recommended that an 8-inch lap be made across the track left by the hood on the previous pass. If this is done, the tines of the mixer will actually lap into the previous pass about two to four inches and a homogeneous mix is achieved. This results in a homogeneous pad, rather than a series of well mixed strips.

When applying water, the amount required will depend on the existing moisture content in the ground. Weather will also be a factor; some days will be too wet and the operation will have to be delayed.

It is advisable to have a qualified mechanic at the job site at all times in case of equipment breakdown.

The man in charge should have competent supervisors to assist in each phase of the work. One man cannot adequately keep up with the bag laying crew, the mixing crew, and the rolling crew.

Alertness in every phase is a must. Conditions change rapidly and the supervisor has to be aware of them so that corrective action can be taken immediately.

Soil cementing is largely a matter of sound judgment and constant attention. The above procedure was very successful and is recommended for consideration by others who may be assigned such a project.

1.6 WATERFRONT DOCKS

1.6.1 Sheet Piling

Problem. Driving piling received in short lengths and pile capping.

Solution. Sheet piling received at Dong Ha was in 20-foot lengths. Two methods were employed in driving sheet piling:

a. The 40-foot lengths were prewelded and driven.

b. A 20-foot section was driven almost to the ground level and then another section was welded on and driven. The second method proved to be the most efficient due to the comparative ease of handling the shorter lengths of sheet piling. Two types of sheet pile caps were employed - concrete and timber. The concrete cap proved to be far superior in terms of wear and deterioration, while the timber cap shortened construction time.

1.6.2 Dewatering Procedures

Problem. Throughout the deployment numerous facilities were constructed at or near the water. These included the PACV or Hover-Craft facility, two LCU ramps, and repairs to a concrete causeway. The problem of dewatering the construction site using coffer-dams and pumps was critical to the successful and timely completion of this type of facility.

Solution. Emphasis should be placed on the thoughtful and deliberate execution of a satisfactory dewatering scheme for each job. During the homeport training cycle, personnel should be trained in the purpose and techniques of dewatering. Keeping pumping equipment operating properly was also found to be critical during construction, and the use of an EO or CM as pump operator on a project is good insurance to keep the equipment functioning.

1.6.3 Fuel Safety.

Problem. During this work, the Battalion personnel learned the importance of ensuring that no fuels are in an area where welding or cutting is accomplished. While working at night, cutting for the barge mooring assemblies, the river flow carried into the working area a quantity of AVGAS that had accumulated in the surrounding water in the construction area. The resultant fire was extinguished without incident, but considerable damage could have occurred had the fire reached the ammunition loaded LCU's in the area or the ammunition staged on the off-loading area.

Solution. No fuels should be in the area where welding or cutting operations are in operation. Adequate fire protection is a necessity in critical areas where explosives are stored snd the potential exists for fire.

1.6.4 Ammi Pontoon Installation

Problem. NMCB-9 was tasked with the construction of a waterfront facility utilizing Ammi Pontoons. The project was located 50 miles south of Saigon, Republic of Vietnam in the Mekong Delta at Dong Tam.

The Ammi Pontoons, the first to be installed in Vietnam, were side carried by LST from Japan to Vung Tau. At Vung Tau they were off-loaded and transported by tug-boat down the My Tho River and anchored in mid-stream until they could be positioned in the boat basin at Dong Tam. The Ammi's were to provide mooring space along three sides of the boat basins for a RAG (River Assault Group). The Ammi's were to be placed parallel to the bank far enough off shore to remain afloat when the tide was out. Each pontoon was held in place by two 20-inch-diameter steel piles driven through the end pile wells.

Solution.

a. If sections are not loaded equally, come-alongs must be applied to lift the lower connector so that the connector chain may be pinned in place. This procedure could take as long as two hours with an inexperienced crew.

b. When maneuvering the Ammi Pontoons into place in still water, manpower rather than equipment should be used to eliminate danger of damaging the sections. Two lines with two men on each end is sufficient.

c. The connector chain should protrude from the male connector, and the loose end of the chain should have a small ring on the last link to pass a line through.

d. A line should be tied to the middle of the protruding connector chain to assist in lifting the chain when it is run through the female connector.

e. If the Ammi's are to be raised out of water on piles, a complete rigging kit must be provided.

f. Normally each Ammi section has a side-carry rail on one edge and over 20 eyelets on the other. These serve as good tie-down fixtures and also provide the means for lashing down any deck loads required during transport.

1.7 ELECTRICAL POWER GENERATING DISTRIBUTION

1.7.1 Location of Generators

Problem. During the windy summer months, dust caused clogging of the ventilation ducts in generator housings, malfunctioning of breaker panels, and fouling of the filtering systems for the engines. In many cases, it is difficult to prevent blowing dust from affecting the generators.

Solution. The ingestion of dust can be minimized by locating the generators away from heavily traveled roads.

1.7.2 Use of Concrete Utility Poles

Problem. There are many round precast concrete utility poles being used in pole-line construction in Vietnam.

Solution. From 1-1/2 to 2 times as many man-days per pole should be allowed for construction with this type of pole, as compared to wooden poles. The poles are more difficult to set as they are heavier and cannot easily be lifted. Climbing the poles requires screwing in steps above and below the climber. Hardware for the poles should be prefabricated to fit the poles. Also, they are easily broken in shipment. It is recommended that the use of these poles be avoided.

1.7.3 Installation of Concrete Utility Poles

Problem. Installation procedures for precast concrete poles.

Solution. The normal method of setting poles in firm soil was to bore an 18-inch diameter hole with an auger, approximately eight feet deep. The pole was then positioned by crane and the hole was backfilled.

a. In areas where surface water would fill a bored hole, a 24-inch diameter bit was used. Two 55-gallon drums were welded end-to-end and inserted into the hole. The pole was then positioned by crane, and concrete was poured into the drums, displacing the water.

b. In swampy areas where a hole could not be bored, a jetting method was employed to displace sand as the pole was set. An auger started the hole and the pole was positioned by a crane. A hose and nozzle connected to an air compressor was then used to jet the set around the pole. As the sand was displaced, the crane operator lowered the pole.

1.7.4 Power Distribution System

Problem. Electrical distribution systems were encountered in Vietnamese cities with a 220-volt secondary, in which no ground lead could be distinguished.

Solution. The following method was used to convert this power supply to the 220/110 volts, single-phase, three-wire system with grounded neutral as required for electrical circuits. Since the available transformers were designed to convert from primary distribution voltage to utilization voltage (or vice versa), two transformers were procured for each installation with characteristics as follows:

Each with sufficient capacity rating to supply the load
Each with the same high-voltage (primary) rating
Each with two low-voltage windings suitable for 110/220 volts connection

The respective high-voltage leads of the two transformers were connected as indicated in the diagram (Figure 1). The low-voltage windings of each transformer were connected for 220-volts as indicated. The midpoint (junction of the two low-voltage windings) for the supply (input) connection was not grounded. The midpoint for the load-side transformer was grounded and connected to the neutral for the 110/220-volt single-phase, three-wire circuit to the load. This system was successfully used with 2-10 KVA transformers, and should work with larger or smaller units.

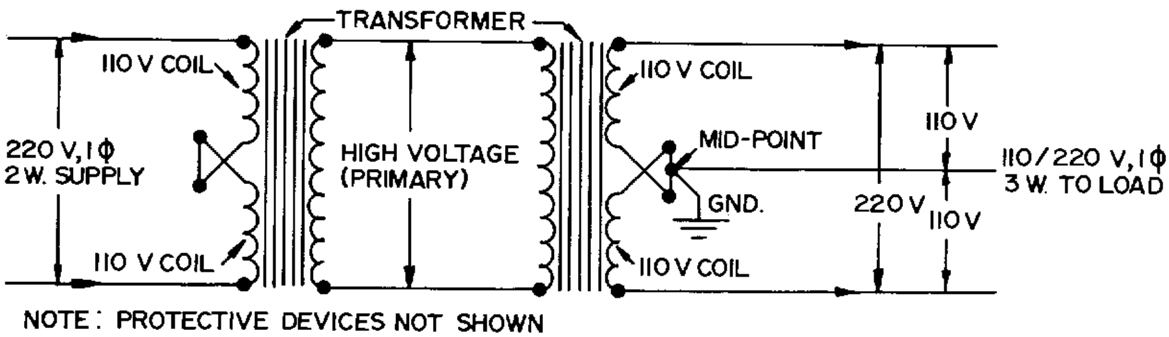

Figure 1

1.8 CAMP DEVELOPMENT

1.8.1 Remote Construction Sites

Problem. One constant problem at all remote construction sites was the difficulty in maintaining the cooperation of and contact with nearby friendly operating units. In areas that were patroled by Vietnamese National Forces, the language was a problem. Often nearby units would change radio frequencies almost daily, complicating radio contact immensely.

Solution. Frequent personal contact with units equipped with mortar, artillery, and air-support capabilities was necessary to ensure that they understood the exact location of the detachment's site and work areas. It was necessary that fall-back and contingency plans be kept up-to-date with nearby units in the event of massive enemy action.

1.8.2 Refrigeration Equipment

Problem. The following comments concern three problem areas encountered at the refrigerated food storage installation at Dong Ha, erected according to Y&D 603290 and 603291.

a. The 2- x 6-inch boards used as support for the refrigerated storage boxes run longitudinally to the long axis of the concrete slab. The provision for under-the-box drainage is a 2-inch gap provided by the 2- x 6-inch supports and a 1/8-inch-per-foot slope on the slab perpendicular to the 2- x 6-inch boards. The method used at Dong Ha for flushing food drippings from under the boxes was to force water under the ends of the boxes with a fire hose. The 2- x 6-inch arrangement does not permit easy flushing of the slab since the clearance under the box is only 2-inches and because the majority of the water and waste has to be pushed by pressure of the water hoses the full length of the slab. The slope on the slab, perpendicular to the 2- x 6-inch boards, running from the center of the slab to the outside,does nothing to facilitate drainage under the boxes. In order to improve the drainage and to permit easier flushing with water hoses, the existing supports were removed and replaced with 6-inch concrete curbs laid under the boxes parallel to the direction of the slope on the concrete slab. A curb was placed under each box seam, however, on a new installation 4-x 4-inch supports could be used in lieu of the 2- x 6-inch supports shown on Y&D drawing 603290 and these could be elevated on 4-inch-thick timbers or concrete curbs running perpendicular to the longitudinal axis. It is considered advisable to have the boxes elevated at least 6-inches for ease of cleaning and ventilation under the boxes.

b. The problem of draining spoiled food and food drippings away from the slab merits consideration. At Dong Ha, a simple open concrete lined drainage culvert was constructed along both sides of the slab to ensure that food drippings did not pond and stagnate at any one location.

c. The third problem was one of lack of ventilation under the boxes and in and around the refrigeration unit condenser units. The refrigeration units were mounted back to back with the condenser unit drawing their cooling air from the space between the boxes and discharging the hot air back into the same space causing a recirculation of hot air. Thia obviously reduces the efficiency of the units and overworks the compressors. The Dong Ha installation was revised to provide better ventilation by elevating the boxes; by elevating the roof and providing openings between the eve end of the roof and the boxes themselves; and by constructing a roof ventilator.

Solution. Y&D drawings 603290 and 603291 will be revised. An interim solution should be used as recommended.

1.8.3 Camp Closure

Problem. NMCB-71 was leaving RVN without being relieved by another Battalion. Camp Miller, in Chu Lai, was to be completely closed down and put in a "mothballed" status. All camp component equipment, communications gear, pre-positioned camp components (tent city), construction equipment, spare parts, and project materials had to be disposed of, transferred, or shipped out. The camp was to be left structurally intact but otherwise devoid of any materials, utilities, or personnel support facilities. Additional complicating factors were due to the limitation on the overall number of Seabees in RVN,NMCB-71's redeployment was to be phased in an accordion fashion and NMCB-71 was not centrally located at one camp.

Solution. A comprehensive CPM (Critical Path Method) Schedule for camp closure was a very useful tool used as a basis for estimating crew sizes and time required for all delay party functions.

a. Continuous updating of this CPM diagram, as well as of the man-day estimates for each activity, allowed all concerned to grasp the interdependence of the many tasks required and the importance of completing them on time. The most important general area of concern was the following set of broad policies under which the entire evolution was accomplished.

Maintain productive work at any site up to the last possible minute prior to a unit move from that site.

Maintain a strong umbilical cord of support from the central battalion or delay party command to each detached detail. The battalion command must provide backing and support since no one else will feel the same degree of commitment to the welfare of a detached unit.

The predominant difficulty facing the battalion early in the planning cycle is uncertainty concerning the desired action and timing of the camp close out and unit moves.

b. At this point it is quite helpful for the battalion to develop the scenario as it appears most likely and appropriate, and to develop from this group of assumptions, the proposed actions to be taken and their timing. The results of this planning can then be promulgated to all commands concerned as a "concepts letter." Feedback from the various levels in the chain of command then serves to conform and/or define the direction to the battalion and ensures that those questions which concern the battalion most are answered.

c. Publish written, detailed OP-ORDERS for each segment of a complicated move as soon as possible. If the attempt is made to wait until the entire evolution can be set forth, it will be too late. The redeployment described above was accomplished by five separate OP-ORDERS published as the various phases of the move firmed up.

d. Communicate as much as possible to the crew, even if the only word is "We still don't know." With the uncertainties of an evolving situation, rumors are rampant, and rumors on something as vital as the date of getting home and who is on the delay party can undermine morale amazingly fast. Frequent meetings attended by all officers and chiefs are essential in keeping everyone up to date on the developing situation.

e. Be aggressive and persistent in efforts to satisfy requirements of the battalion that are not within the ability of the battalion or the Seabee Chain of Command to control. Examples of such requirements are in-country airlift, assumption of area security by other units, or equipment support. Most service organizations are more than willing to help if you can set forth clearly what you need and why, but it sometimes takes a great deal of looking to find the right organization that can solve the problem.

f. When making determinations as to the disposition of camp gear that is not otherwise controlled, always act in the best interests of the overall Seabee Community (e.g. special services gear, the project material yard "gold pile", etc.).

g. The application of these seven broad policies superimposed on the normal precepts of battalion command, served to provide the necessary framework for everyone concerned with NMCB-71's redeployment to accomplish the mission smoothly.

h. Another major area of potential interest to other battalions is the closing down of a functional, semi-permanent Seabee camp. This is no small task. The first step is to make a complete inventory of all camp equipment that is not owned by the battalion itself or by individuals in the battalion. The importance of this inventory cannot be overemphasized, since it forms the basis of the disposition instructions which the battalion will receive from the Type Commander (COMCBPAC), via Commander, THIRD Naval Construction Brigade. The inventory will be marked to show the directed disposition of each item of equipment, and becomes a most valuable document.

i. Other disposition instructions will be received as well, such as Commander, THIRTY-FIRST Naval Construction Regiment instructions for disposition of organic equipment and spare parts. Commander, THIRD Naval Construction Brigade instructions on the disposition of augment equipment. COMCBPAC instructions on the disposition of the prepositioned camp component (tent city), and instructions from the appropriate Regiment on transfer of project materials from the Material Liaison Officer's yard. In addition to the preparation of all of these items for shipment, staging for shipment, or hauling to another battalion site, a major effort is also required to clean up the camp, board up the buildings, and remove installed equipment so that it can be turned over to shipping and receiving. MCB-71 found that a crew of 25 men was required full-time for 30 days as a camp close-out team. This team was primarily made up of builders and non-rated men, but a utilities-man crew and a crew of construction electricians is a necessity for equipment removal from the galley, shop areas, and even from the battalion clubs.

j. The major lessons learned on camp close-out fall in to five general areas:

It is absolutely necessary to obtain camp component inventories and disposition instructions on all items as early as possible. Planning is seriously hampered until this is known.

It is important to arrange berthing and messing for the camp close-out detail with another unit outside of camp to permit materials to be removed and shipped in the easiest manner as well as to avoid retaining a large group of support personnel carried as overhead. At least 20 days should be allowed for breaking down the galley equipment, laundry and boiler plant.

Security of the camp must be tightened to an extreme degree. No one should be allowed on the base unless escorted, and no material should be allowed off base without a written chit from a Chief or Officer. When the word gets out that a camp is to be closed, scavengers appear as if from nowhere and their ingenuity and singleness of purpose is unsurpassed. Extreme security measures are warranted when it is taken into account that the camp component is valued at over $4,000,000, and spare parts, project materials and tools add another $1,300,000 to the value of the camp.

Each man in the battalion should be made personally responsible for his 782 gear, and it should be turned in or removed from the camp prior to the start of the close out operation. Cots, mosquito nets, mess gear, and other items that may have been acquired in the camp over several years, can be unnecessarily lost unless tight control is exercised. If lockers are to be shipped out of the general area, each man should be required to dismantle his own locker before leaving camp, as this is a tedious and time consuming job when some 600 must be done at once.

Do not underestimate the almost unbelievable amount of refuse that must be disposed of before the camp can be left clean and presentable in all respects.

1.9 ROCKS AND GROUND MAINTENANCE

1.9.1 Culverts

Problem. Culverts - The installation of corrugated metal culverts in the fine, cohesionless, sand fill posed certain problems.

Solution. It was determined that the culvert should be as water tight as possible. The proper fitting of sections, the complete installation of all bolts and sealing joints with asphaltic mastic was necessary to prevent fine-sand backfill from being washed out from around the culvert during heavy water flows.

Gunite would be ideal for fine-flow sand. (ABFC Assembly 7059 has greater capability than what is needed for the culvert problem.)

1.9.2 Sand Berms; protection of

Problem. Construction of sand berms at slopes steeper than 3:1 in the fine-grained Chu Lai sands should not be attempted as the earth structure produced would be unstable. Earth vibrations from passing equipment and explosion shock waves might cause slides to occur.

Solution. Steep-sloped sand berms stabilized by direct application of asphalt over the sand are subject to severe erosion during heavy rains at any point where there exists the slightest break in the asphalt membrane. To construct ASP berms primarily of sand which will survive monsoon weather, application of a laterite cap on the exterior surfaces of the berms is essential. MCB-40 developed the following rapid and effective method for placing and compacting laterite on sand berms before placing the asphalt erosion-inhibiting membrane.:

a. Sand was hauled and spread by motorized scrapers to form the long common side up to a height of approximately five feet.

b. When the height of the common side was approximately five feet high, bulldozers began pushing the sand out for the fingers.

c. The process of hauling and spreading sand on the long berm and pushing out the fingers with dozers was continued until the height of the berm was approximately eleven feet.

d. The side slopes of the berms were formed by allowing the sand to seek its natural slope as it was piled and spread.

e. A six-inch cap of laterite was added by placing the laterite on the top of the berms and pushing it out on the fingers in the same fashion as the sand.

f. When the entire berm was capped with laterite, the slopes were dragged and smoothed using a jury-rigged harrow on a dragline.

g. A 12-foot long roller was constructed using three 40-gallon barrels filled with concrete and mounted on a frame to which a hoist and drag chain were connected. The roller assembly weighed approximately 2,000 pounds. After watering to obtain approximately optimum moisture content, the berms were rolled with this assembly using a crawler crane with the roller connected in the same fashion as a drag bucket. The roller was pulled up the slope using the hoist cable and down it using the drag cable.

h. To form an erosion-inhibiting membrane, a coat of MC-250 was applied to the laterite for penetration. A second coat of RC-3 was applied to form a hard surface.

i. MC-250 Asphalt was found to be the most effective, both in terms of penetration and surface hardness, for application as an erosion-inhibiting membrane on the berms.

1.10 BRIDGES

1.10.1 Liberty Bridges

Problem. Background. In October 1967, an unusually severe monsoon-generated flood caused extensive damage to roads and bridges in the lowlands south of Da Nang. The most seriously damaged major bridge was the 2,040-foot Liberty Bridge on the Thu Bon River at grid coordinates AT927531 (Army Map Series L7014, Sheet 6640IV). Nearly 800 feet of the bridge was totally destroyed and carried away by the flood. The bridge had been completed and open to traffic less than one month, having been constructed by Naval Mobile Construction Battalion-4 prior to their being relieved by NMCB-9 on 1 October. The bridge was located about one-half mile downstream from the confluence of two rivers, a wide area subjected to unpredictable current patternsduring high water.

The bridge was of standard timber construction, with 20-foot spans. A unique feature of its design, in addition to its tremendous length, was its height above the river bottom, a distance of 35-42 feet. NMCB-4's design elevation was based on criteria forwarded by the III Marine Amphibious Force, that the bridge be of sufficient height as to be usable during floods. The extreme height of the bridge, therefore, dictated the use of uncommonly long timber piles for its substructure. The bridge was constructed, in various locations along its length depending on the elevation of the river bottom, on 75- or 90-foot piles which required special procurement through the THIRD Naval Construction Brigade.

NMCB-9 was immediately tasked with the reconstruction of the bridge. An investigation of the conditions surrounding the bridge's destruction was conducted, and a failure analysis report was submitted to the Commander, THIRTIETH Naval Construction Regiment by NMCB-9 letter 3000 ser 1706 of 24 Oct 1967. The failure analysis, in summary, stated conclusions as follows:

a. The failure was due primarily to the buildup of water-borne debris on the upstream side of the bridge.

b. The longitudinal X-bracing in alternate spans, the catwalk beneath the bridge deck, and the remnants of a former upstream mine barrier were the major elements which caused the debris to accumulate.

c. The effect of scour was concluded to be minimal. (As further investigation was accomplished and as construction proceeded, however, scour was conceded to have played a much greater role in the bridge failure than previously estimated).

Solution.

a. Repair/reconstruction plan. The plan for reconstruction of the bridge included the following major steps:

(1) Clearing of debris from the remaining portions of the bridge.

(2) Repairing the south abutment of the 378-foot approach bridge, approximately 200 yards north of the main bridge. This abutment had failed at the bottom when the backfill became saturated by the rains. The collapse of the abutment resulted in the loss of the adjacent first span.

(3) Repairing or strengthening the remaining bents.

(4) Replacing the existing longitudinal bracing with a system of bracing to provide a more "open" bridge profile.

(5) Replacing 40 spans of the main bridge, incorporating several design modifications.

b. Site cleanup. The task of clearing away the debris from the remaining portions of the bridge was commenced on 15 October and was substantially completed by about 15 November. Clearing of the debris was complicated by the presence of poisionous snakes, several unidentified bodies, and the tangled barbed wire of the mine barrier. Concurrently with that work the repair crews removed the longitudinal portion of the horizontal bracing and X-bracing and the catwalks which had run beneath the bridge deck.

c. Repair of approach bridge. Repairs to the approach bridge were essential to the movement of pile driving cranes to the main bridge for its construction. As a first step in its repair, the collapsed south end span had to be removed, along with the materials from the collapsed abutment. It was here on 8 November 1967, that NMCB-9 learned an expensive lesson in construction precautions. While using an oxy-acetylene torch to cut the damaged drift pins of the first pile bent, a steelworker allowed a lingering spark to ignite the creosoted pile cap. The fire spread rapidly, and in spite of the tremendous efforts of the construction crew and nearby Marines to put it out by water, dynamite, and even mortar bombardment, it soon engulfed and destroyed the entire 378-foot bridge. This bridge was replaced by NMCB-9 during the remaining three months of the waiting period for 90 and 75-foot piles for the main bridge.

d. Repair of remaining bents. The damaged 2-inch x 12 inch (Transverse) diagonal bracing was removed from the pile bents and relaced by two or more 9-foot high tiers of 3- x 12-inch x-bracing, depending upon the space available at the time of construction between the superstructure and the water (or ground) level. Figure 2 shows schematically the "before and after" bracing patterns.

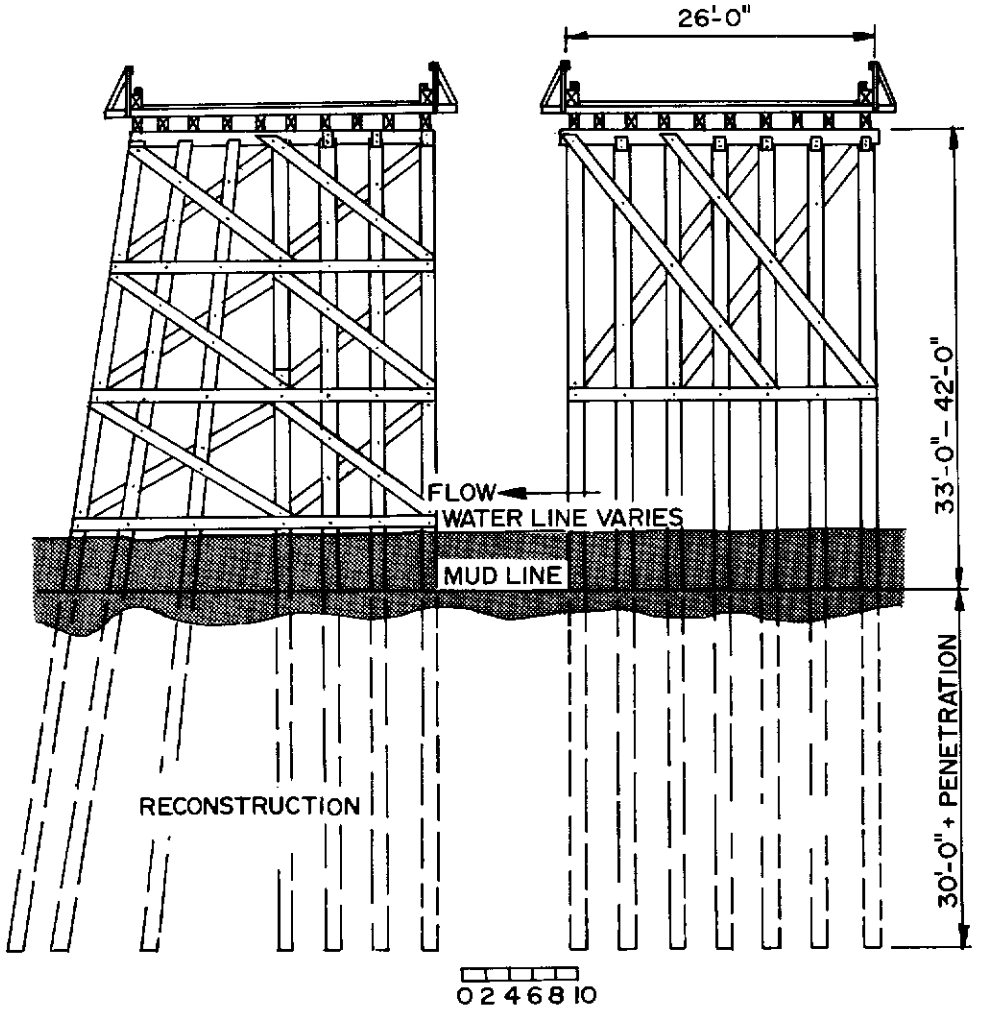
26'-0"
FLOW
WATER LINE VARIES
MUD LINE
33'-0" - 42'-0"
30'-0" + PENETRATION
RECONSTRUCTION
0 2 4 6 8 10

Figure 2

e. In order to achieve "unit action" in the resistance of the individual pile bents to horizontal loads such as those causing the destruction of the bridge, 3- x 12-inch timber scab plates were installed to bind the pile cap to the top of the piles and prevent their separation by uplift forces, and 6- x 12-inch blocking was installed on the underside of the 12- x 12-inch pile caps between adjacent piles. The scab plates and blocking produced a shear-resistant joint at the pile-pile cap intersection. See Figure 3 .

SCABBING & BLOCKING OF EXISTING PILE BENT CAPS

No Scale

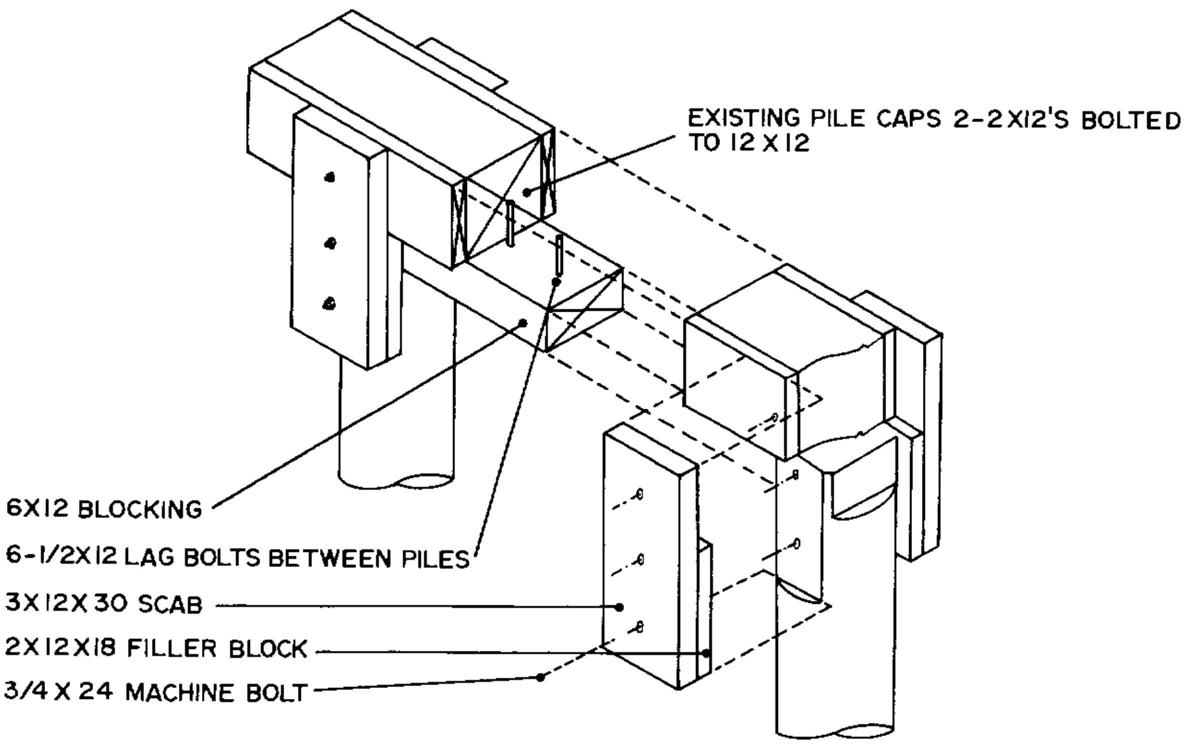

Figure 3

f. In the replacement of those bents which had been completely destroyed, 12- x 16-inch pile caps were used, and were notched four inches at the piles to eliminate the need for blocking. Scab plates were also used on the new bents to augment the shear resistance and hold-down strength of the drift pins.

g. The use of "TECO" spike-grid timber connectors was intended for the replacement of the original bracing and for the bracing of new bents. The connectors were placed on order in late January, but did not arrive in time to be utilized on the project. Their use would have greatly increased the joint strength between piles and cross bracing over that obtainable by a single thru-bolt.

(5) Replacement of longitudinal bracing. Knee bracing scheme was abandoned. In its place a system of horizontal bracing between adjacent bents (continuous over the length of the bridge to fixed anchorage points at each end) was developed to prevent longitudinal buckling of the piles. Such bracing, placed at an elevation determined to achieve a satisfactory column slenderness ratio, would be of a narrow vertical profile and, therefore, would not collect much debris. It would be a low enough level that when debris became a significant problem, the bracing would be well submerged, allowing the debris to float through.

The construction of the horizontal bracing was at first planned to be timber secondary members in compression. However the 20-foot span length would have dictated tertiary bracing in the horizontal plane due to the slender sizes of timber which were available. It was considered that the amount of material and labor that would be required for timber bracing would be prohibitive. Consequently, the longitudinal bracing design was finalized with the adoption of 3/4-inch-wire-rope tension bracing between pile bents. The individual braces extended only between adjacent bents and were equipped with an adjusting turnbuckle. Tension braces were placed only on the second, fourth, and sixth piles of each seven-pile bent; thus transverse pile bracing was depended upon to distribute the buckling resistance to the intervening piles.

(6) Replacement of main bridge spans. As the final major step in the reconstruction of the bridge, work commenced on driving piles for the 40 bents completely destroyed by the flood. The 75- and 90-foot piles had been placed on order immediately after the October flood, but due to the long lead time for their purchase in CONUS and the long transit time from the West Coast to Vietnam, they did not arrive until mid-February. It was planned to utilize two pile-driving crews, working from both sides of the river. A P and H 655 and a Northwest-6 crane were obtained and transported to the site. Two McKiernan-Terry De-20 diesel-activated hammers were used. By 3 February 1968 all was in readiness at the bridge site. However, the late arrival of the piles delayed the actual start of work until February. During the intervening two weeks, a change in tactical area assignments at the bridge site, a result of the enemy's lunar New Year offensive, resulted in the removal of the assigned Marine security force from the south terminus of the bridge. On 23 February Viet Cong forces set fire to a large stockpile of bridge timbers staged on the south shore, attempted to blow up the south bridge abutment, and attempted to set fire to the bridge in three places. Counter-fire from the north shore drove them away, however, and the damage to the bridge structure was minimized, although the material stockpile was a total loss. It was not until 11 March that the second crew could return to the south shore, repair the damage and proceed to drive the piles.

Figure 2 shows the original pile bent design and the design developed for the reconstruction. As can be seen, the principal difference in the battering of the three downstream piles is the redesigned bent. The battering of these piles served a dual purpose. First, it broadened the effective base of the pile bent, resulting in some increase in the bridge's resistance to overturning forces. But most importantly, it served to produce a counteracting force to the horizontal current loading. For every unit of live or dead load applied at the pile-cap level, a proportional horizontal component of force is developed by the batter pilea, in this case directed to the right, or upstream. Depending upon the angle of batter and the vertical loads applied to the pile cap, these forces can significantly reduce the net transverse load applied to the structure by the downstream-directed forces of wind and water.

The driving of batter piles presented a problem in the adjustment of the available leads to drive the piles at a uniform batter. To modify the fixed leads to easily adjust to and maintain the desired batter a universal joint connection between the catwalk and crane boom was developed. The universal joint allows the catwalk to rotate at its boom connection so as to allow the vertical leads to be inclined. The proper incline is maintained by adjustment of two chain hoists attached to the crane housing.

The firebreak scheme consisted of using the 20-foot-long, precast, bridge deck sections being manufactured at that time by NMCB-62. The installation of the concrete inserts could only be accomplished, however, after the bridge was otherwise completed, with temporary wooden spans having been installed to facilitate construction. The plan had been to install a concrete section in every tenth span of the bridge.

At the time of this report, the ultimate reconstruction of Liberty Bridge was suspended indefinitely.

(7) Recommendations. In view of the long and frustrating history of the Liberty Bridge project, ending with its almost total negation by a freak accident, perhaps the most valuable results of the entire undertaking was the deriving of "lessons learned". The following points are considered to be worth very close attention by an unit tasked with the design and/or construction of similar bridges.

(8) Location. Avoid river intersections and bends. Minimize the length of the crossing through prudent site selection. (The over-riding influence of tactical considerations is acknowledged).

(9) Elevation. Minimize the height of the bridge deck above the river bottom. Making use of the best flood data available, (which, in RVN, is quite scarce) establish a deck elevation consistent with a generalized probabilistic approach to the occurence of floods over the required tactical life of the bridge. Consider the feasibility of a lower bridge that could be specially designed to "flood over" during peak flooding periods.

(10) Longitudinal profile. For bridges on streams especially susceptible to flood-borne debris, keep the profile as open as possible. Maximize span lengths and avoid pier sections of broad profile. If bracing members must extend from bent to bent, try to place them low enough that surface-borne debris will float across without fouling.

(11) Transverse section. Design pile bents and superstructure in accordance with the Army Technical Manuals. Do not fail to design for all the horizontal forces which may be exerted on the bridge; current force on piles, current force on bracing, wind force on supersturcture, wind force on exposed substructure,

wind force on vehicles, and dynamic force of floating objects striking the bridge. Use batter piles downstream only, but don't forget to provide for counteracting their effect when the horizontal loading is reduced or not present at all. Design the pile to pile-cap connection for maximum shear resistance, incorporating such details as to provide unit action of all piles in the bent in resisting horizontal loads.

(12) Bridge materials. Construct the entire superstructure of untreated timber. For bridges having only a few years tactical requirement at the most, the resulting decrease in fire vulnerability more than offsets the hazards of insects and weathering. Include spiked-grid timber connectors in every timber design. Logistic support agencies should stock connectors as a shelf item.

(13) Fire protection. Include fireproof inserts at intervals along the bridge. Keep on hand the best available equipment and manpower for fire-fighting. Keep the substructure scrupulously clear of debris.

1.10.2 Rapid Repairs

Problem. On 25 August five bridges were destroyed by the Viet Cong. Work to replace bridges No.'s 9, 10, 11, 23 and 26 started immediately; tactical bridging kept traffic flowing. On the following two nights bridges No.'s 9, 10, and 11 were blown twice each.

Solution. Following the loss of the tactical bridging, which was in critical supply, a new plan was evolved for bridge replacement. It was determined that all five bridges could be replaced by culverts provided a method of rapidly constructing retaining walls could be conceived. Two retaining-wall methods were devised and prefabrication was accomplished inside the battalion camp. Bridges No.'s 9, 10, and 11 were replaced by CMP culverts utilizing a series of precast concrete block which were interlocked by No. 8 rebar pins. The blocks measured 4-feet x 6-inches x 6-inches and were also cast in 2-foot lengths. One-inch holes were cast into the blocks at four points to enable interlocking. A rapidly constructed headwall could be placed by this method and only required closing the road from 2 to 3 hours while the cover was placed over the culverts. The other method of headwall construction was used to repair bridge No. 23 which posed severe difficulty to normal construction because of a high steep dropoff beneath the bridge and a long span length. A No. 6 rebar net, tied to a similar net on the opposite side of the road was used to hold rock-fill over the culverts. After the fill was placed and traffic resumed, the rebar net was grouted to prevent rusting, and curbs were installed on the roadway. Both methods were proven successful when two culverts were blown on 9 September and one culvert on 5 October: The road was reopened in 3 to 6 hours without using tactical bridging.

1.10.3 Pile-Driving Procedures

Problem. Pile-Driving Procedures

Solution.

a. When driving batter piles, it is best to have the benefit of a "moonbeam." However, batter piles, can be driven effectively without the use of a "moonbeam" provided the pile being driven is long enough to bind in the leads to help prevent the crane from swinging. A follower pile may be used if longer piles are not available. The toe of the pile is driven three feet, then tilted slightly toward the correct batter angle. The pile is driven another foot then brought to the correct angle. The pile may then be driven to the desired depth and bearing.

b. It was found desirable to point the toes of the piles for better control. Care must be taken to point them evenly and correctly to prevent the pile from drifting. The heads do not require chambering if a proper driving cap such as the McDermit head is used. Steel pile tips were fabricated for use in stiff bottom clays.

c. A straightening guide was employed to line up the pile bents. Furniture clamps of the long-bar type were used to tighten the guide. The straightening guide was supported by "T" bracing nailed to the piles.

d. A floating template was constructed as a guide for driving piles in the water. It was a standard floating template, modified to include a working platform utilizing 55-gal oil drums for buoyancy. A constant check must be maintained to prevent the piles, caps, and bents from getting out of plumb or square. Once they are out of square or plumb, a come-along may be employed for correct positioning.

e. Transverse bracing should be placed prior to positioning the crane over a bent, to prevent unnecessary racking of the structure while driving the batter piles.

f. When using 12- x 12-inch timbers for stringers with temporary decking and tread to support a crane such as the P&H 655, the crane must be positioned so that the treads are directly over as many stringers as possible to prevent excessive strain on the incomplete structure. Caution should be exercised when picking up loads from either side of the bridge with the crane. The crane should always be positioned over a fully braced bent when lifting side loads to prevent uneven stress on members.

g. When using trestle-type construction, NMCB-9 found that two-level operations proved to be the safest and most efficient method of approach. The crane worked on the lower level driving pile bents; temporary decking was then installed for the crane's advance. Concurrent with this operation, a second crew prefabricated the trestle and the preassembled trestles and permanent superstructure was installed.

CAUTION; Hazards to personnel

The crew should be made up of alert, agile, and well-conditioned personnel. All should be good swimmers; during phases of the job performed over the water they should wear life vests or jackets.

To avoid creosote burns, gloves and long-sleeve shirts should be worn when handling and working with creosoted timber. Soap should be available on the site at all times for removing creosote from the body as soon after exposure as possible.

A first-aid kit should be readily available for treatment of minor cuts, bruises, sunburn, etc.

Hard hats, steel-toed shoes, and flak jackets should be available to the crew.

Safety lines should be used since working over the water presents special hazards to personnel who are heavily weighted down with protective clothing.

1.10.4 Site Survey

Problem. The importance of a thorough reconnaissance and site survey of bridge sites was demonstrated when the Battalion commenced reconstruction of two destroyed bridges. The site survey conducted neglected to include soil borings or a detailed underwater exploration. Both sites contained steel truss bridges that had been blown into the river crossing and were lying in the path of the timber piling required for reconstruction. It was not until actual pile driving commenced that a previously destroyed concrete deck bridge that had preceded erection of the steel truss was located. The effort to clear and remove the concrete to allow pile driving to commence could have been programmed so as not to delay bridge reconstruction.

Solution. In retrospect it is believed that all steel truss bridges are, most likely, replacements of previously destroyed concrete spans and future bridge upgrading or reconstruction should be planned accordingly.

1.10.5 Bridge Work Safety

Problem. Two serious accidents occured during the pile driving operations in the main span reconstruction. The first, occurring on 10 March 1968, resulted in death. The second resulted in skull and wrist fractures. Both accidents were the result of falls from the superstructure.

The first man was tightening clamps on the pile straightening guides on a newly driven bent when a clamp slipped and the guides spread apart, causing the man to fall and strike his head on a raft approximately 35 feet below.

The second man was standing on an 8- x 18-inch timber stringer while another was being lowered into place by a crane. A gust of wind caused the stringer to swing around and knock the man from the bridge. His fall was partially broken by other men working below, but his head struck the raft on which the two men were working.

Solution. Three important lessons learned from the accidents were (1) to perform the pile straightening with the men working from a platform suspended by the crane, (2) to attach a tagline to long timbers being handled by the crane while on the bridge, and (3) to demand that men use lifelines whenever other means of protection cannot be provided.

1.11 ROAD CONSTRUCTION

1.11.1 Drainage

Problem. The problem of surface drainage is probably the most important consideration in almost all areas of construction and should be so considered. Never underestimate the Vietnamese monsoon rains. Drainage structures must be well overdesigned as to capacity. Drainage channel requirements should be based on experience in a heavy rain under saturated soil conditions. Almost every dry-season estimate will be severely undersized.

Perhaps the most striking example of the importance of proper drainage involved the roads. During the first month of the monsoon rains, those sections of Route #1 which were well compacted, well crowned and properly ditched (laterite surface only or perhaps rocked) survived remarkably well. Sections which turned into mud holes and required continual maintenance were obviously lacking in either a good crown, adequate ditches or both.

Drainage structures, particularly culverts, which were designed and installed during the dry season were sorely undersized when the monsoons arrived.

Solution. All roads as well as open storage or work areas should be well elevated if possible, well crowned, and provided with adequate drainage ditches and culverts. A tremendous amount of maintenance work could have been eliminated had more attention been given to the surface drainage problem during original construction.

1.12 TACTICAL

1.12.1 175mm Gun Platforms

Problem. On shifting unstable sands south of DaNang, an emplacement had been built for B Battery, 8th Battalion, 4th U.S. Army Artillery Regiment. This unit, outfitted with 175mm "Long John" guns, provided artillery support to U.S. Marines operating in the area.

It was discovered, however, that the guns could not be held on target. Braced only against an almost fluid sand, and standing on a heavy-timber platform designed for use on more stable soils, the "Long Johns" were sliding backward six inches with the recoil of each round fired. Six-inch errors introduced into a weapon hurling projectiles for miles made accurate fire impossible.

Solution. Faced with this problem, a modification to the original platform was developed. A rigid underground "fence" was constructed of heavy 12- x 12-inch timbers within which a bed of crushed rock was placed. A heavy wooden platform, built in the form of half an octagon from 12- x 12-inch timbers and 3- x 12-inch decking, was "floated" on the rock.

Navy Seabees and an Army Gun Crew were on hand 10 November as one of the massive, tracked guns rolled out into the platform and dropped its recoil spade into the rock bed. Twenty-two rounds were fired in rapid succession. The weapon's movement upon the sand was neglibile and well within the limits of accurate fire control. (See Figure 4).

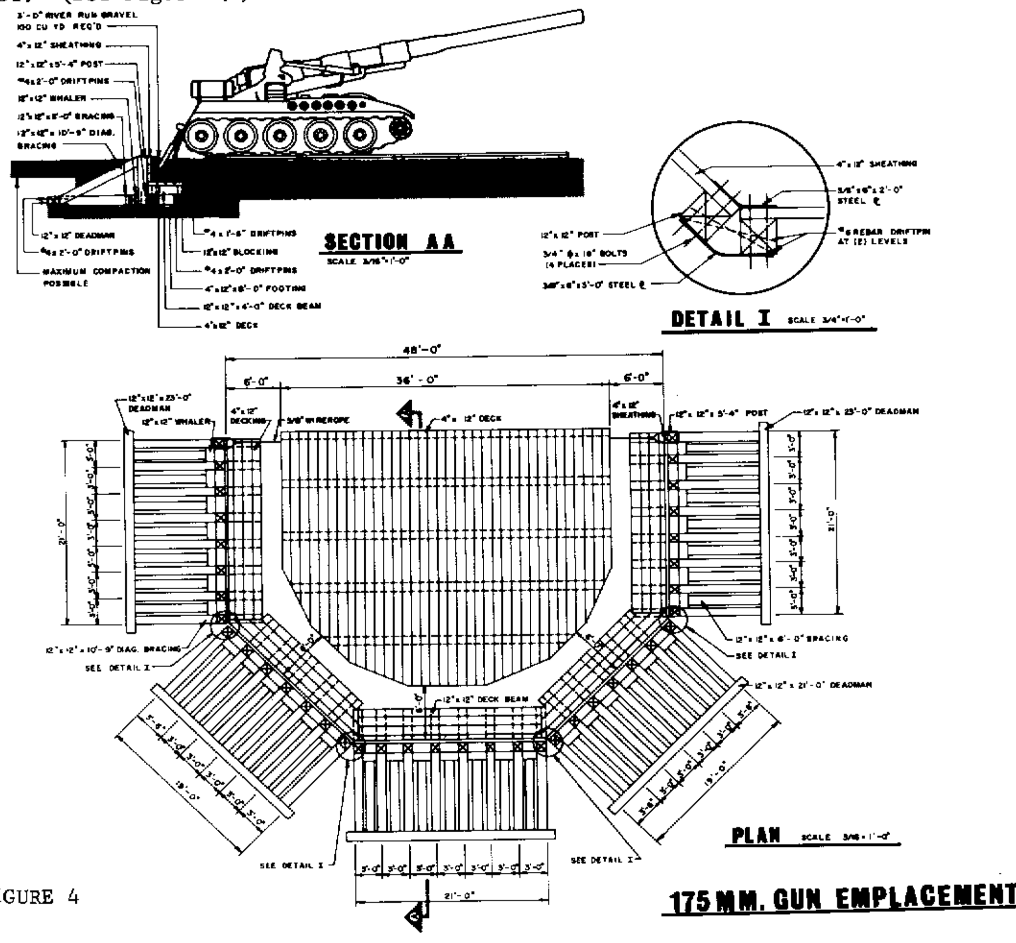

FIGURE 4

175MM. GUN EMPLACEMENT

1.13 FUEL, OIL, GREASE, SUPPLIES

1.13.1 Storage

Problem. Contaminated diesel and MoGas fuel is cause for numerous problems to fuel injector pumps and fuel transfer pumps. Diesel and MoGas fuel, which is handled a minimum of five times prior to arrival on board is often received containing water and solids.

Solution. It was necessary to construct fuel tanks separate from the tanks mounted on the generators. The tanks had to be piped so they would settle out solids and water, and could be drained regularly.

Dispensing equipment used in conjunction with water separator-filter units could also be used. Also a storage tank can be used for settling.