THE

SANTA CRUZ

HARBOR

Building the Santa Cruz Harbor

By George N. Wagner. Branch manager, (retired) Granite Construction Co.

George Wagner

To: Abe and all my Grandchildren and Great Grandchildren. [1]

HOW IT BEGAN. A few months ago, Abe (Abe is a Grandson) you visited the Santa Cruz Harbor. You and Teresa (his wife) walked out on the west jetty. You saw the various sized stone used in its construction. You also saw the tetrapods. (Cast concrete shapes) used for the outer protection against the violent northwesterly seas. You asked, "Grandpa, how was this harbor built? Where did the stone come from? Where did the jacks (tetrapods) come from? Did you build them?" You said, "Why don't you write something about this and tell us how the harbor was built. Tell everything from the start to the end." Well, Abri, after thinking about this for some time I think I will try. It will probably take me several months. The following is my endeavor.

Abe, the harbor was built over 40 years ago and this is a long time for me to remember that far back about how it was done. However, with the help of others, particularly the harbor director, Brian Foss and his staff and some of the people who worked on it, I will be able to put together enough information to come up with some kind of a descriptive story. I will write this article with much detail, keeping in mind, my high school age grandchildren and great grandchildren in grammar school. Also included are some pictures that will be helpful.

HISTORY. Here, I should give you a little history. After World War II, the talk in the community was that a harbor was needed on the north side (the Santa Cruz side) of Monterey Bay as a refuge for fishing boats and other small craft that made their homeport, Santa Cruz. In 1950, an election was held that officially created the Santa Cruz Port District. The Woods Lagoon area was chosen for the location of the harbor. Woods Lagoon was a low-lying area on the ocean side, behind Twin Lakes Beach and just inside the easterly city limits of Santa Cruz. There was a small stream, Arano Gulch Creek, flowing into it, and the lagoon had an opening to the ocean. In the winter, Arano Gulch Creek developed enough water flow from the rains and runoff to keep the mouth open. However, in the summer, a sand bar would build up and close the ocean entrance. During high tides the waves would break over the sand bar and keep the lagoon filled with seawater. Arano Gulch Creek would dry up in late summer or fall. Therefore, the water in the lagoon was at times very brackish. Some years mallard ducks would nest in the upper area. Apparently, the upper water sometimes remained fresh enough to be occupied by ducks and land birds.

For the next 10 or 11 years, the Commissioners worked hard and diligently to obtain the land and the funds needed to build the harbor. About 1961, the commissioners were successful and the harbor became a reality. Because this was a harbor with ocean going boat traffic, it came under the jurisdiction of the U.S. Army Corps of Engineers. By law, the Corps must design it and oversee its construction. In early 1962, the design was complete. With the cooperation and under the direction of the Port District Commissioners, the U.S. Army Corps of Engineers advertised for bids to construct the Santa Cruz Harbor. Here is where we (Granite Construction Co.) came in.

Figure 2. East Cliff Drive before the Harbor. Bridge is a Corrugated Metal Arch attached to a Concrete slab on footings, with headwalls.

Figure 3. Blown up picture of corrugated metal arch culvert, which is the Woods Lagoon outlet. A log is floating in the culvert.

THE HARBOR WAS CONSTRUCTED IN FOUR PHASES.

PHASE 1. The outer works. Opening the entrance. Constructing the stone jetties and the Dredging.

PHASE 2. The inner harbor: Construct the bulkheads, docks and floatation units.

PHASE 3. The upper harbor. Construction of, the entrance roads, parking lots, and dredging.

PHASE 4. The floatation units for Phase 3.

Each of these phases was a separate and individual contract.
Phase 1 was designed by and constructed under the direction of the U.S. Army Corps of engineers.
Phase 2,3,and 4 was designed by and constructed under the direction of Earl and Wright, a private engineering firm located in the bay area. Granite Construction Company built the first three phases.

BIDDING THE PROJECT: The Santa Cruz Branch of Granite Construction Company, of which I was the manager, was elected to bid and build the project. The plans, specifications and bid documents for the project were obtained. Corporate signatures on the proposal and a bidder's bond were obtained. The Corps of Engineers sets the bid opening date and time, usually 30 days after the date of the advertisement. At that time, bid openings, for U.S. Army Corps of engineer's work, for this district, were held on Wednesdays at 2:00 PM at the District Engineer's Office in San Francisco and they are always open to the public. The specifications contain the engineer's estimate of the quantities of work and materials for the project. Each bidder bids on the engineer's quantities so that a realistic comparison of bids can be made. The unit quantities obtained from plans at the Harbor Office and from memory are as follows:

Item No. 1. Lump Sum Clearing and grubbing.
Item No. 2. X tons A1 stone. Avg. 15 tons. Min. 12 tons, each.
Item No. 3. X tons A stone. Avg. 10 tons. Min. 7 tons, each.
Item No. 4. X tons B1 stone. Avg. 3 tons. Min. 2 tons, each.
Item No. 5. X tons B2 stone. 2 1/2 to 3 1/2 tons, each.
Item No. 6. X tons C stone. Quarry run to 2 1/2 tons
Item No. 7. X tons Filter Blanket. 2 1/2" x 3/4" crushed rock.
Item No. 8. 900 each 25 ton Tetrapods.
Item No.9. 375, 000 Cu. Yd. Dredged Material
Item No.10. Construction of the launching ramp 2nd contract
Item No. 11. Construction of the east bulkhead. 2nd contract
Item No.12. Construction of the boat repair area. 2nd contract
Item No.13. Construction of the docks. 2nd contract.

The first 9 of the above items composed the Corps of engineer's project. I do not remember the quantities for the various sizes of stone. All sizes together totaled 250,000 tons. Items No. 10, 11, 12 and 13, were a part of the second contract, phase 2, not under the jurisdiction of the Army Corps of Engineers, but these last four items were designed to be built at the same time as phase 1. A private engineering firm, Earl and Wright, with offices in the Bay Area, designed phases 2, 3, and 4. Along with Phase 1, Phases 2 and 3 were built by Granite. Phase 4 was built, by Troutwine Bros., a contractor specializing in constructing small harbor floating units. Items No.11, 12, and 13 were constructed in part along with the corps of engineer's project and these had to be completed before the dredging, a part of phase 1, could begin. The launching ramp, the interlocking sheet piles bulkhead, construction of the docks and construction of the boat repair area all were a part of the second phase.

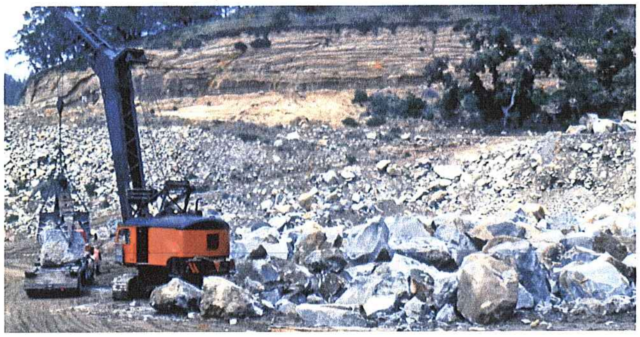


Figure 4. The Quarry. Large stone 12 ton.

Figure 5. Quarry. 2 ½ to 3 ½ ton.

<u>SOURCE OF STONE</u>. You asked? Where did the big rocks come from? In the latter 1950s Granite Construction company was hired by Pacific coast aggregates, the forerunner of Lone Star Cement Co. of Texas, to remove over burden; that is, to remove or strip off the unsuitable material from an area overlying their limestone deposits at their limestone quarry at Davenport, Calif. Davenport is on the Coast Highway about12 miles north of Santa Cruz, Calif. The stripping job was about three miles easterly, off the highway in the mountains. This job was under my cognizance as well. From samples taken by core drilling, the material to be stripped was from 200 feet to 250 feet thick, overlaying the limestone deposit. The material to be stripped contained about two million cubic yards. The top consisted of a layer of common earth, about 50 feet thick. The next layer was a lens of rock, called Franciscan Sandstone, (it is a conglomerate) 100 to 125 feet thick. Under that was a layer of material called blue stock, a soft rock material. The top area contained about 250,000 cubic yards of common earth. The common earth on top was removed with Caterpillar tractors and scrapers (dirt haulers) and bulldozers. About 250,000 cubic yards was removed by this method. When sandstone lens was reached, the material was too hard and could not be rooted with tractors. Here the project was turned into a drill, blast, shovel and truck operation. Over one 1,100,000 cubic yards was removed by this method. The bottom blue stock material, containing about 650,000 cubic yards was also moved by shovel and truck and hauled to a waste dump within 1200 to 2500 feet from the cut. The shovel could dig this material without blasting. However, it was hard on the shovel and it was slow going. Down holes were drilled for blasting at a larger spacing than those for the sandstone. These holes were lightly loaded with blasting powder and shot. Then the material was not only easier to dig, but the production increased by 25 to 30 percent.

Figure 6. Sorting & loading "A1" stone, 15 tons. Note: 20 ton Semi truck.

The City of Santa Cruz, for their West Cliff Drive revetments, used much of this Franciscan sandstone. The Half Moon Bay Harbor Project took 800,000 tons of the material for the construction of the harbor outer breakwater. The rock for the construction of the Santa Cruz Harbor also came from this source. This rock passed all the tests for jetty stone, required by the U.S. Army Corps of Engineers, for the Half Moon Bay Harbor breakwater. We knew the rock was acceptable for the Santa Cruz harbor because the specifications were the same for both. Our bid to remove two million cubic yards of overburden and haul it to a disposal site was $0.50 per cubic yard. At today's 2004 dollars my guess is, it would cost $5.00 to $6.00

Figure. 7. A stockpile of 2 ½ x 3 ½ Ton stone.

SUBMITTING A BID FOR THE PROJECT: Well Abe, now that we have the plans and specifications, the work begins, estimating the cost and scheduling the work to complete the project within the time set up. Quantities have to be surveyed from the plans and compared to the engineer's quantities. In order to have a fair comparison of bids; the engineer's quantities must be used by all contractors to set their bid prices. Most projects are bid by the unit, the number of units times a price. (Example 350 units x $2.75) If any appreciable difference in quantities is found in an item, it will affect the unit bid price for that item. Therefore, if the quantity is found to be much less than the engineer's, the unit bid price would be more; if found to be more than the engineers the unit price would be less. We find all the quantities in order, except the tetrapods. The bid item, 900 Tetrapods, 25 ton each is OK, but an ambiguous difference is found in the size of the 25-ton tetrapod. The bid item, along with the specifications, calls for a 25-ton size tetrapod. Calculations from the dimensions of the tetrapod on the drawings show it to be larger than 25 ton. It calculates to weigh 27 ton.

A tetrapod is a concrete shape similar to the child's jack that is played with by bouncing a ball, and then the child picks up the jack again before the ball hits the ground. A tetrapod has four legs all meeting at a central hub. Three legs project outwardly, horizontally from the central hub like the spokes of a wheel without a rim. They are 120 degrees apart. One leg projects upward (vertically) Each leg is 5 feet long and tapered. The horizontal legs are tapered both ways. At the ends, they are round with a diameter of 3 foot 6 inches. At the hub, they are oblong. The vertical diameter at the hub is 4 feet and the horizontal diameter at the hub is 4 foot 8 inches. It is 9 feet tall. (See sketch)

TETRAPOD DIFFERENCE. I think a reason for the difference in the weight of a tetrapod described in the paragraph above is probably because the weight of the ingredients in the concrete varies in different locations in the U.S. Concrete meeting the Corps of Engineer's specifications, made from aggregates native to this area weighs 150 pounds (in round numbers) per cubic foot. At that weight, a 25-ton tetrapod would contain 333 cubic feet of concrete or 12.33 cubic yards, which would be smaller than the dimensions shown on the detailed plans. Calculating the volume from the measurements on the detailed drawings, a tetrapod contains 360 cubic feet or 13.33 cubic yards of concrete. Then at 150 pounds per cubic foot the actual weight of a tetrapod is 27 ton. The tetrapod weighs 2 ton more and contains one cubic yard more concrete than the one called for in the bid items. Therefore, it will cost more than the 25-ton tetrapod. If the contractor did not check the volume and set the price for the 27ton tetrapod he would be required to build the 27ton tetrapod and be paid for the 25-ton tetrapod. Now you understand why the contractor should always check the engineer's quantities. This is an unusual case and does not happen very often.

On the other hand, the contractor could take advantage of this situation. He could place his bid with the construction for a 25-ton tetrapod. Then if he was awarded the contract, claim an extra payment for the extra cubic yard of concrete contained in the designed tetrapod. Using this method would change the price of his total about $14000.00 less than by using the 27-ton tetrapod. That could win him the job. Doing this would be risky. He may be successful but it would be a hard battle. During the survey of quantities, it seemed very clear to me and the person taking off the quantities that the contractor must build the tetrapod shown on the drawings regardless what it states in the unit bid items.

After casting the first one, the actual amount of concrete, for one tetrapod, measured at the mixer, was 13.75 cubic yards. At that time, on the corner diagonally across the road, from where the tetrapods were being manufactured, there existed a Feed and Fuel business, with a large truck scale. During the hauling and placing, one truck, loaded with a tetrapod, was run across that truck scale and weighed. The completed and cured tetrapod weighed a little less than 28 ton. (55,700 lbs.) When they are placed, Pell Mell style, the legs point in all directions. As you can imagine, Abe, it would be difficult for an ocean wave to roll one.

CONTINUE THE ESTIMATE: So now Abri at this point we know what the quantities are. We know where they go. We have the source of materials, excepting forms to cast the tetrapod. They have to be designed and a source found from which to obtain them. For ease of handling and reuse, the forms must be made out of sheet metal. Because the shapes are round and the hubs are curved, the sheets have to be rolled. I am thinking of 8-gage sheet metal. (The gauge is the thickness of the metal. The thickness of an 8-gauge sheet is 0.165 inch or approximately 1/6 of an inch.) They have to be made in two pieces so they can be stripped, coming apart or split at the spring line, or at the center, 1/2 the vertical height, of the bottom legs. It is going to be hard to explain this method to you without a drawing, so we made some drawings, consisting of four pages. (See drawings at the end of the story.) The top half of the forms will contain the form for the vertical leg and the upper half of the hub and the lower legs all in one piece. The lower half will contain the lower half of the legs and half of the hub in one piece. They are not really half pieces, but I will call them halves. At the connecting edges of the 8 gauge sheet iron forms, both top and bottom, and all of the way around, will be welded, a 1 1/2 inch x 1 1/2 inch x 1/4 inch angle iron. To the bottom angle iron, will be welded uprights, at certain equal intervals. The uprights will be1 1/2 inch wide x 1/4 inch thick x 4 inch high. At the same intervals, slots will be cut in the upper angle iron. The uprights will protrude through the slots in the upper angle iron. In the uprights will be another slot to receive a wedge. After the forms are together and the uprights protrude through the slots in the upper angle iron, the wedges are driven into the slots of the uprights to tightly hold the forms together. With wedges, the forms can be taken apart and reassembled much faster than with bolts and nuts. Two sheet metal companies were interested in making the forms. Drawings of the form design and copies of the plans were mailed to them and a price requested for eight top halves and 40 bottom halves. The lowest price received was $65,000.00, delivered, which was accepted. In today's dollar value (year 2004) the forms would cost about $300,000.00

ANALIZING THE JETTY STRUCTURES: We have all the materials calculated and know where it all goes and how to place it. During the estimating, the first thought was a system to place all the material in the jetties with a large crane, placing the rock in front of the crane, building out as you go. Some of the tetrapods to be placed on the slope of the jetty go out 90 feet from centerline. This would take a huge crane to swing 27 ton 90 feet out from the crane. The top of the jetty was 18 feet wide and a crane on crawler tracks large enough for the job would be 26 or 28 feet wide. Too wide for the 18 foot jetty.

Another idea was to use barges, as it was done at the Half Moon bay breakwater. Granite construction Co. and Healy Tibbits, a joint venture, held this Half Moon Bay contract. The 800,000 tons of stone, for that project, came form the same source at Davenport. If barges were used for the Santa Cruz Project, to be efficient, two five thousand-ton ocean-going barges would have to be bought at $400,000.00 each. (In 1962 dollars.) A tugboat would have to be rented. If the City of Santa Cruz's Wharf could be used, barge-loading facilities would have to be built. The wharf would have to be beefed up to haul over and rebuilt after the project was completed. This method was prohibitive as too costly. One thought was to build our own wharf and loading dock at Davenport and transport the rock to the job by water. Moreover, with this scheme the hauling and handling of the tetrapods would not fit into the plan. All this was also too costly. Using either of these two methods would put us out of competition. We go back to the original plan. Use a crane.

In those days, large cranes were not equipped with outriggers. To explain, Abri, an outrigger on a crane uses the same principle as those on a Hawaiian canoe. Without outriggers, it would require a crane with tracks 26 to 28 feet wide. The jetties were 18 feet wide on the top. So how to overcome this problem? One morning sitting in the office, looking at the cross section, dreaming about finding a method to place the tetrapods, it hit me. Why, all the tetrapods that go out from 40 to 90 feet are under water. Using the buoyancy of the water, a pressure of 62.5 pounds per cubic foot, solves the problem. Underwater the tetrapod would weigh a little less than 16 ton. It could be done with a smaller crane. Duck Soup. We have the answer.

To explain a little more about crane lifting capacities, let us visualize a crane, like the one we are considering, with it's boom all the way down, flat, horizontal. The boom is 110 feet long. I do not think it could lift 5 ton in this position, without the crane tipping over. Raise the boom to where it is at 45 degrees, it will lift more. Now when it is as high as it will go, about 87 degrees (Do not raise it anymore because the boom will fall over backwards on the crane.) the crane can lift 28 ton. Now slowly boom down with this load, it soon reaches a point where the crane would tip over. That is what we are talking about. I lost the formula used to calculate crane-lifting capacities.

CRANE, SEARCHING. We instructed our people to search the country for a crane to fit this job. One was located working in an iron mine in northern Minnesota. It was an American Crane made by the American Crane Company, and it was available. It was equipped with a dragline front. We needed to know the length of the boom if the boom were strong enough to be used as a lift crane, (The corps of Engineers are very particular about the safety of crane booms. requirement is that booms are to be inspected weekly.) We needed to know the width of the tracks, outer edge to outer edge. We found the boom was strong enough and was 110 feet long, perfect. If I remember correctly, the manufacture's lift rating was 27.5 ton. Any equipment can usually perform a little better than the manufacturer's rating. The width of the tracks was 22 feet, 4 feet wider than the top of the jetty, too wide. The corps of engineers was contacted requesting permission to widen the jetty top from 18 to 22 feet, 2 feet on each side by changing the side slope from the 1 1/2 to 1 designed slope, to a 1 to 1 slope in the upper 8 feet of rise. They gave their approval. The company certainly would not commit to a purchase of any used equipment sight unseen. Clem Molina, the company's equipment superintendent, (maintenance) was sent to look at the crane. He found it to be in very good condition, with not much wear and recommended an OK to purchase.

TIME FOR COMPLETION: All public works projects, as well as many private projects that are bid on a competitive basis, have a time for completion. The time for completion is usually expressed in a number of working days. A working day is every day except Saturdays, Sundays and Holidays. Sometimes due to inclement weather or unworkable ground conditions caused by inclement weather when the contractor cannot perform his work, is not considered a working day. I do not remember the number of working days that were set up for this project. I think it was approximately 300 working days. If the contractor does not complete the job in he allotted number of days, he is penalized by X dollars per day. The amount for the penalty is covered in the specifications. I do not remember the amount set up for this project.

Now we have to compute the rate of production we would have to make to complete the project in time set up. The two salient items were the construction of the jetties and the manufacture and placing of the tetrapods. The construction of the jetties was the controlling item. Abri, I wish I had saved my estimate for the project. It has all the information on it. The number of days allowed building the project, productions calculated, material costs, bid prices, etc. Now Abri, we have all the information and the know how to effectively build the project. All we have to do now is to figure the rate of production and the costs, including the costs for the large crane. A hold was put on the crane, subject to Granite being awarded the job. The bid was complete and we had a dollar number for which we could build the job, but we expected some of the material prices to change that would affect the bottom number

COMPLETING AND CLOSING THE BID. Anyhow, the estimating was finished; the bid document items were all filled in (always in ink) with the prices and total. Two bid items and the total were filled in with a pencil, so to be able to erase them to make last minute changes. This bid is to be closed in at the office of the Corps of Engineers in the Federal Building, San Francisco. All bids are to be opened at 2:00 PM. The person taking the bid (the bid runner) arrives at the Corps' office an hour or so before bid opening time. When he arrives, he contacts our office with the information he arrived safely and is calling from the nearest telephone. He informs that he is at a public telephone, one-minute's walking time from the bid opening office. That is a good location, only one-minute away. I direct him to call us at 20 minutes before two and hang on to the line and keep open so none of our competitors will get that telephone. One of our office lines could be tied up, as there were eight main telephone lines into our office. I also instruct him to attend the bid opening and when it is over call us with the bid results. We anticipated a price change in three items. 1. The interlocking steel sheet piling, 2. The pressure treated wood piling and 3. The dredging, which is being subcontracted. At 8 minutes before two o'clock three phone calls came in, 2 from companies furnishing the steel piling and one from the company furnishing the wooden piling. Lower prices were received from all three companies. No call was received from any dredging company. We selected the lowest price for the piling, calculated the price changes in the office, and conveyed them to our man in San Francisco. He then replaced the penciled fill ins, with the new prices, ran to the bid opening office and turned in the bid at 3 minutes before two.

At fifteen minutes after two, our man in San Francisco called with the results. There were five bids submitted. Granite was the low bidder. The second lowest bid was just under $50,000.00 over Granite's. The price was under the engineer's estimate. We felt we had a good bid. It was good for everybody. If I remember correctly the bid was about $2,575,000.00, in 1962 dollars. My guess is in today's 2004 dollars the bid would be, in the range of, 8,000,000.00 to10, 000,000.00 million dollars.

PROJECT SUPEINTENTENT. At this point James "Jimmy" Gaither, the intended project superintendent was brought in. A set of the plans and specifications were turned over to him. The main items, schedules, productions and equipment were briefly discussed. The first order of work was, "Find a good location to set up a job office, equipped for a telephone." There was a house, near the shore of he harbor, owned by the Harbor District. This house was obtained for a project office.

LEGAL WORK DONE: A few days afterwards our labor, material and performance bonds, which were, submitted the project was awarded to Granite Construction Co.

PATENT INFRINGEMENT. After the award the local resident engineer, for the Corps of Engineers notified us, not to do any work or spend any money on the tetrapods, because there was an infringement of patent rights, A South African country held the patent for the shape of these tetrapods. It was anticipated that in a few weeks this matter would be resolved. A few weeks later we received the order to proceed with the construction of the tetrapods.

THE CRANE: The deal for the purchase of the crane, dismantled and loaded on railroad flatcars by the seller, was closed, and the crane was shipped to Capitola, Ca. The day of arrival came but no crane arrived. I put a tracer on it. It was found in Phoenix Arizona. We were told it would be routed through Denver, but had to be rerouted. Why? Because some of the tunnels on the northern route, over the Rocky Mountains, were not wide enough to take the load. Remember the crane is 22 feet wide. Also, there are tunnels too narrow on the Tehachapi grade and it was routed further south through San Bernardino. The day came when it arrived at Capitola. It was loaded on five railroad flatcars. The house, loaded on one, special width car, contained the engine, the winches, hoists, cable and all the operating machinery. It weighed 30 ton. On another car was loaded the undercarriage, sometimes called the draw works. It contained the ring gear that rotated the machine, the roller bearings it rides and rotates on, the drive gears and steering mechanism, and running tracks that move it along with all the cast iron, enough to hold it together. That part weighed 20 ton. The next car, loaded with the counterweights and parts of the boom, weighed 12 ton. The other two cars had the smaller, bulkier parts of the boom, cable, drums, spare parts, and miscellaneous pieces. Altogether, the machine weighed about 70 ton.

UNLOADING CRANE: Now we have to unload and assemble it. We had a mechanic that was experienced with big cranes of this type. Granite did not have a crane large enough to lift the 30-ton house, but they have two truck cranes that together can lift it. These cranes are mounted on trucks and are within the legal weight limits required by the State Department of Highways and can travel over all roads without obtaining an overload permit. These cranes were equipped with outriggers and could each lift 20 ton, so together they could lift the 30-ton house. The railroad cars were spotted on the main line in Capitola for unloading, as there was no spur track there anymore. It was where the old depot is today, on Monterey Drive and Escalona. The assembling area was on East Cliff Drive across from Lake Drive. There was a problem with spotting and leaving the cars on the main line. The one daily train hauling cement out of Davenport and sand out of Felton could not get around the spotted cars. The closest sidetrack or railroad wye was in Santa Cruz. A railroad siding or railroad wye was needed to bypass these railroad cars. Each time the daily train came along the cars would have to be taken to Santa Cruz, about 5 miles north, bypassed and then returned. This happened two times during the unloading.

One the first day using two cranes and Granite's two low bed trucks, three cars with the miscellaneous equipment, were unloaded. One crane was at the railroad offloading the railroad cars onto the trucks. The other crane was at the assembly site offloading the trucks. Late that afternoon the train returned. The train took the entire cars load and unloaded back to Santa Cruz, by passed them, and on the way home dropped off the loaded cars. They took the three empties back to Watsonville. The next morning our crew started early to have the undercarriage unloaded before the train returned by approximately 10:00 AM. We have arraigned to rent a specially constructed low bed truck from the Biggie Trucking Company that was large enough and had enough wheels to haul the 30-ton load over the roads without damaging them. An overload permit was still required from the division of Highways to move the load.

Two truck cranes were used to unload the undercarriage. One crane could have handed the job, but in the interest of safety the two were used. Why not they were both on the job. The two cranes lifted the draw works. A D6 Caterpillar (Cat) tractor pulled the cars from under the load. Biggie's truck backed under the load onto the truck. It was hauled to the assembly site and unloaded the same way. The two cranes lifted and the truck drove out from under it. It was then lowered and set on the ground. In the meantime the daily SP train took the two cars to Santa Cruz, bypasses them, and returned the loaded car, with the house, back to Capitola. The two cranes unloaded the same way as the undercarriage. It was hauled to the site and the truck with the house was backed up against the undercarriage. The cranes lifted the house. The truck drove out from under it. The D6 tractor pulled the undercarriage under the house. The truck drove out from under it. The D6 tractor pulled the undercarriage under the house. The two cranes let it down over the kingpin, onto the rolled bearings and the job was done. No it wasn't. Now came the finishing work to make it run. The booms assembled and attached, the counter weights were attached. And the cables were strung and hooked up. One truck crane remained and lifted all the heavy pieces into place. The counter weights weighted 10 or 15 ton. The operating levers had o be connected to their respective, air boosted controls and many other little things had to be done, the airlines hooked up, etc. It took another week to complete the job

Figure 8. Assembling the crane. It takes a small one to lift the parts onto the big one.

When the crane was assembled and ready for work it was first used perform the long reach work and underwater excavations. The launching ramp excavation was excavated. The boat repair area and the dock area excavations were made. The wooden piles for the boat launching area were installed with the big crane. Then it went on to excavate the beginning of the west jetty

Figure 9. The Dry lagoon.

<u>EARLY ITEMS OF WORK:</u> During the time the crane was being unloaded, the first item of work, Bid Item No.1, Clearing and Grubbing was going on. This item did not consist of a lot of work. East Cliff Drive was closed for good. The new concrete bridge over the harbor was under construction by another contractor, The Murphy Pacific Company, a contractor from San Francisco. The Arch Culvert, serving as a bridge on East cliff drive, was removed; three or four eucalyptus trees were removed as well as some flotsam, wood and floating logs washed in by the rough seas. There was an old dump with car bodies. All this junk was hauled to the County dump.

Figure 10. Access Road on East Side.

Figure 11. Access road & working pad for the Murray St. Bridge.

START CONSTRUCTION WEST JETTY: Now we begin construction of the west jetty. At the shore end, an excavation is made. The big crane was used for this. The dragline bucket was put on. It had a capacity of five cubic yards. The excavation had to be made down to datum, that is elevation 0+00 sea level. The grade had to be carried all the way back to the bank there the cut was 10 feet deep. The excavated material was top loaded into Cat DW 20 scrapers and hauled to the fill in the automobile parking lot on the west side of the harbor.

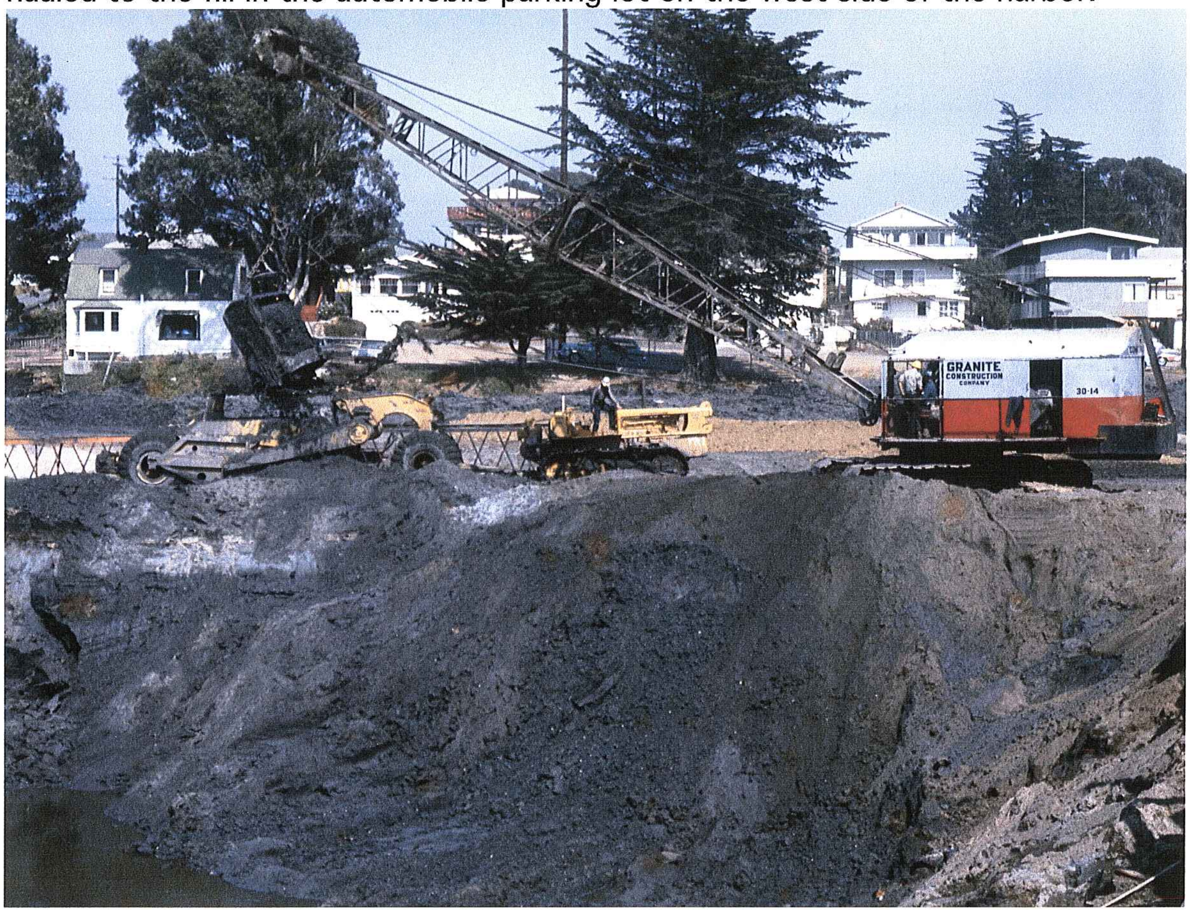


Figure 12. Excavating for the start of construction for the West jetty.

ENGINEERING. Abe, I should tell you that the Corps of Engineers does not provide the engineering for any of their projects like the State and Counties do. They give you an elevation point and a base line to work from, that's all. The contractor has to take it from there. We hired a private professional engineering firm, Bowman and Williams of Santa Cruz, to do the laying out. That firm established the centerlines for the jetties; the lay out for the launching ramp; located the line for the sheet pile bulkhead; the location for the shop structure, elevation points, etc. We did our own grade checking and minor measurements, etc. In addition, when we talk about elevations and sea level, the Mean Lower Low Water elevation is used. This is the real datum or elevation 0+00. The tide tables you see in the newspaper are at Mean Sea Level that is 2.9 feet above datum.

There are two jetties projecting out into the ocean. These are to protect the mouth of the harbor and keep the channel open. However, the opening of the channel is hard to control, because of the out and in movement of the sand in this area. As in many small harbors, the opening has to be dredged out from time to time. Both jetties are built with large pieces of stone. The individual stone pieces weighs from 2 ton to 18 ton each. These are sometimes called jetty stone. The west jetty is the larger because the prevailing storms come in from the northwest. Both jetties are constructed the same way. The west jetty will be described because it is the larger. Both have a core built out of the "C" stone (a uniform gradation of quarry run material to 2.5 ton pieces) (C stands for core.) Each jetty begins at the bank or bluff.

In these jetties, the first layer of stone was the filter blanket. The filter blanket runs through the sand portion of the beach. It consists of crushed rock graded from 3/4 inch pieces in size to1 1/2-inch pieces. The layer is three feet thick. It is laid through the sandy beach area to keep the sand from washing out from beneath the jetty stone. A special bucket, made out of an old half worn out semi dump truck body, was built to handle this stone. The bucket was designed to handle the core or C stone also, but was not used for that, as you will see later in the story. The mechanics went to work to rebuild it. The tailgate was cut out to leave one end open. The sides were widened from six feet to eight feet, so a semi dump truck could back into it and dump its load of 20 ton. For strength and wear, the bottom of the bed was lined with 3/8 inch steel plates welded in. At the closed end a bail (like on a bucket) was made out of 3/4-inch wire rope with a spreader bar between the cables that were attached to the corners of the old truck bed. A spreader bar had to be put in to keep the wire ropes from pulling the sides together. At the open end, a piece of steel channel iron, 2 inches deep, 6 inches wide and 6 feet long, was welded to the underside of the bed to reinforce it at that point. In the middle of the bed opening, a hole was drilled through the bed and the channel iron. A 3/4-inch wire rope cable was fed through the hole and attached to the underside. On the topside inside of the bed a cable clamp was attached to the cable, so the cable could not slide up or down through the hole, the cable could be laid to one side when a truck backed into the bed and dumped its load. With this homemade bucket a semi dump truck could back into the beefed up dump bed, dump its 20 to 24 ton load, and drive out. Then the crane with it's two lines would lift the load, swing out over the area where it is to be placed, release the single front line and dump it like you would dump sand out of a bucket.

Now laying the jetty stone started. Remember Abri, there were six different sizes of jetty stone. The four larger sizes, those from2 1/2 ton up to the largest, 18-ton, was handled as individual pieces with a rock grapple. For the larger rock unloading, the grapple picks the rocks off the flat bed trucks. This rock grapple alone weighs six-ton. The bedding stone or filter blanket is laid through the beach and sandy area, where there is a lot of wave and breaker action. The jetty is porous, and the water surges in and out through the rocks of the jetty. This water action takes place through the jetty at the breaker area. The filter blanket ends when deep water is reached where there is not so much movement of water.

SORTING THE STONE: Before beginning to lay the rock for the jetties, the selection, sorting and loading operation of the stone must be described. As mentioned earlier in this story, Pacific Coast Aggregates the forerunner of Lone Star Cement Co. of Texas hired Granite Construction Company to remove overburden from their limestone deposits. Pacific Coast Aggregates designated areas on which the overburden was to be wasted or deposited. Several areas were designated for waste areas. Each one was 5 acres, more or less, in area. With the approval of Pacific Coast Aggregate Co., Granite Construction turned one of these areas into a staging area for the sorting and loading the rock for their various jobs. Abe, as I mentioned above this stripping was a drill, blast shovel and truck operation. Granite had three wagon drills drilling blast holes for blasting, a 3 1/2 cubic yard P & H power shovel loading 30 ton, off the highway, rock trucks, which hauled the rock to the staging area. On the staging area a ramp was constructed, over a hundred 23ramp had a 50-foot high bank over which the rock trucks dumped their loads. Two locations were set up over which to dump. The drivers were instructed to dump the 8-ton and over rocks over one location and all the other rock over the second location. Abe, imagine a truckload of rocks rolling down a 50 foot bank. The larger rocks roll clear to the bottom, out into the flat area. The medium sized rocks stop at the toe of he bank and the finer material hangs higher up on the slope of the bank. By this method, the rock almost sorts itself into the various sizes required. It was at the toe of this slope on the flat area, that all of the sorting and loading took place. Don Granger was the Foreman in charge of the sorting, loading and weighing.

SORTING AND LOADING: Loading was done with two machines, a Caterpillar Model 966 front end loader with a 2.5 cubic yard bucket and a Northwest 80D, 2 1/2 cubic yard, crawler crane with a lifting capacity of 20 ton. A dial scale was installed in the lifting line of the crane, facing the operator. The operator could see at all times the weight of the stone he held in his tongs. These rock tongs were lighter than the ones being used on the jetty. They weighed four tons. The dial line scale was an important tool. It kept us within legal weight limits. It helped the operator to get the maximum load on a truck without being overloaded. Among the first things done was to weigh and set out a row of stone for all to see. As the operator lifted and weighed a stone, a helper with spray paint can painted the weight on it. They ranged from the approximate weights of 500 lbs., 1000 lbs., 1500 lbs., 1 ton, 1.5 ton, 2 ton, 2.5 ton, 3 ton, 3.5 ton, 5 ton, 7 ton, 10 ton, 12 ton and 15 ton. This line of set stone was very helpful. By being mindful of the size of these stone, everyone had an idea about what a certain size stone looked like. This line of stone was used up near the end of the job.

Figure 13. Excavating the cut in the bank for beginning the west jetty.

Figure 14. Loading an "A" stone in the quarry, 10 tons.

Figure 15. Loading "B2" stone, minimum 2 ½ to 3 1/2 tons each.

Between trucks, when the crane was not loading, it sorted the rocks to size. When the crane lifted a rock, the operator read the scale and the oiler spray painted the weight on it. It would then be set aside among the rocks of about equal size. Doing this helped speed up the loading. For example, if a 20-ton capacity truck had a part of a load of 17 ton, the cane operator could easily find a rock of about 2.5 or 3 ton to fill out the load without going over the weight limit.

<u>WEIGHING</u>: On the out road a 60 ton 70 foot, long truck scale was installed. The trucks all had to tare in the first thing each morning and again at noon. On the way out each loaded truck had to stop and be weighed. This was very important for several reasons. The trucker or hauler was paid by the ton for the hauling. The contractor was paid by the ton for finished rock in place. Do not forget Abri, just because Granite was doing the stripping, Granite did not own the rock. It was bought from the Lone Star Cement Co. Lone star was paid by the ton. If I remember correctly, the price paid was 0.50 per ton. A licensed weigh master operated the scale.

Figure 16. Weighing a truck loaded with stone.

<u>HAULING</u>: For the hauling over the highways to the jetty, there were three sizes of trucks used. Semi dump trucks, 20 to 22 ton capacity, hauled the “C” stone (quarry run to 3 ton.) Truck and trailer units hauled the “A” stone, the “B1” stone and the “B2” stone. The capacity of the truck and the capacity of the trailer were 12 ton each, together they hauled 24 ton. Semi flat beds, with a capacity of 20 to 24 ton, hauled the 15 to 18 ton pieces

<u>JETTY TRAFIC</u>: The jetty being only 22 feet wide was a one-way road. A truck coming on to the jetty had to get to the crane, be unloaded or dump its load, and get off the jetty, before another truck could get on. Semi dump trucks had to back on loaded, dump its load, and drive off forewords. Flat bed semi trucks had the option of going on foreword or backing on, because the crane lifted the stone off individually. Usually the driver chooses to drive on loaded and back off empty. The truck and trailer units had to drive on foreword. There was no place for them to turn around. The way these were handled, after lifting off the rock, the trailer was unhooked; the crane loaded it on the truck then the truck backed off. When the truck arrived back at the quarry, the crane there would lift off the trailer.

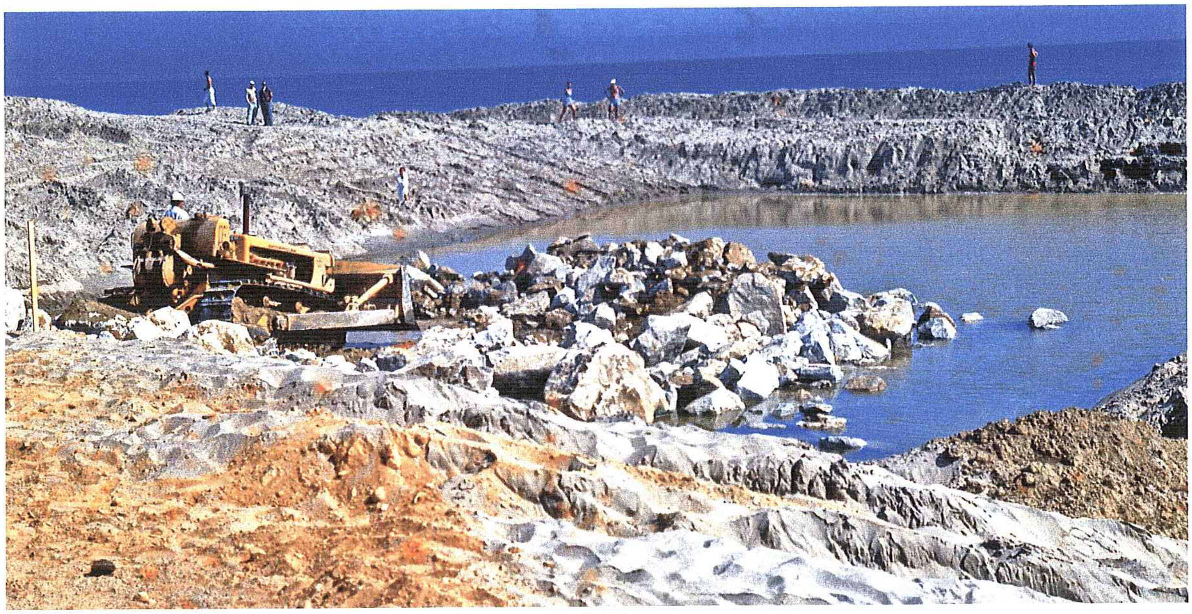


Figure 17. Start constructing the West Jetty.

START PLACING THE JETTY ROCK: After the excavation was complete, at the bluff end, placing of the jetty stone began at the bank. The crane lifting lines were connected to the homemade truck bed bucket. Filter blanket stone, 3/4 inch x 1 1/2 inch, bought form the Granite Rock Co, Quarry at Aromas, hauled in 20 ton semi trucks was dumped into the truck body bucket and swung out over the area in which it was to be placed and dumped. The filter blanket was built out as far as the crane could reach, approximately 100 feet. Over the filter blanket, core stone was placed.

Figure 18. Dumping and placing rock on the west jetty

<u>CONTROL OF LINE AND GRADE</u>. As construction of the jetty proceeded outward, line and elevation points were set. Grade and line stakes were driven into the roadway fill along the edge. From these control points, the jetty was kept at the right grade and line. For underwater checking, an engineer's transit was set up on the side slope. A small boat with an outboard motor was always available for this work. A 1-inch by 3 inch by 20-foot long surveyors rod was made. The rod had graduations at 1-foot intervals. Two men in the boat would go out in front of the jetty. They would put the rod into the water on top of the rocks. The engineer with the transit would read it. From this information, he could determine the line and grade thus keep the structure going in the right direction and at the right height.

Figure: 19. Unloading an 18-ton stone. The largest stone in the jetty.

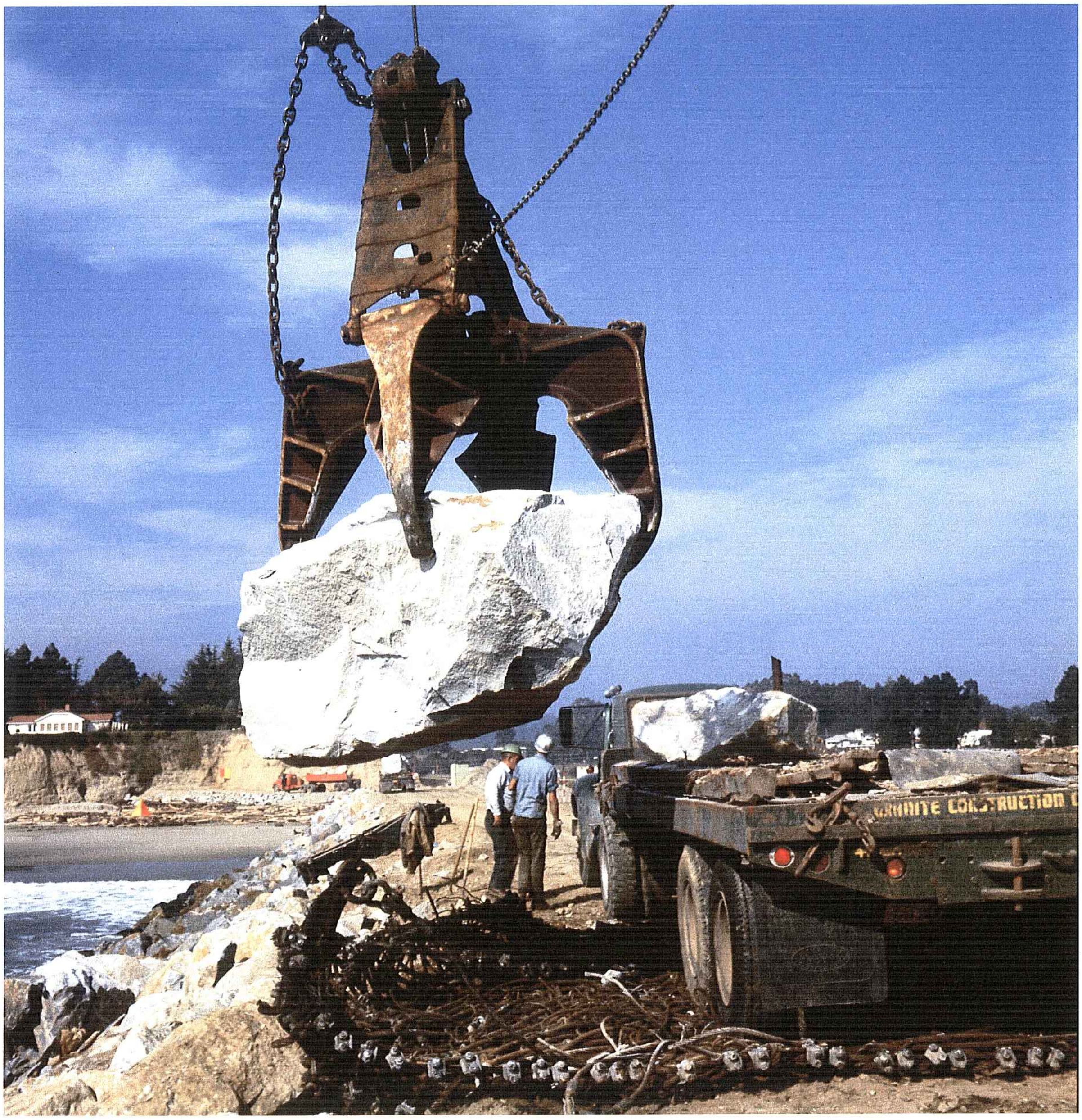


Figure: 20. Unloading a 12-ton stone.

Figure: 21. Loading a trailer of a double truck & trailer unit onto the truck to back off the jetty. A truck & trailer unit cannot turn around on the jetty.

THE NET: At the start of laying the C stone, a problem appeared. This was bringing in the fine material to finish the haul road on top of the jetty. The top of the jetty was finished with C stone and further out it will finish with A and A1 stone. The crane could fill in the larger voids with C stone but there were not enough fines to finish over the C stone. How would you like to drive over 2 and 3-foot stones? The top of the jetty was a one-way road. Fine material was obtained from the quarry to fill the voids and finish the road. However when a truck loaded with fine material came in, the operation stopped until the truck dumped its load, the load was spread, leveled, and the truck got off the jetty. This caused about a ten-minute delay in the production.

A net came to mind. If a net was built, to place the “C” stone which net had 6-inch openings, I believe enough fines would screen through the mesh, to finish the roadway A net was built. A wooden frame 16 feet wide and 20 feet long was nailed together out of 3 inch x 8-inch fir lumber. 3/4-inch wire rope cables were stretched across the wooden frame, both ways; each six inches apart and attached. 3/4-inch wire rope clamps were used to clamp the two cables together at those 6 inch crossing points. A one-inch diameter wire rope cable was laid around the perimeter; the 3/4-inch cables were looped over it and clamped. A 4 inch by 12 inch 18-foot long I beam (eye beam) was found and attached to one end to keep the net spread out when lying on the ground. A wire rope sling was attached to the I beam and at the open-end a simple wire rope sling was attached to both ends of the net. The crane would lay the net down, flat; the truck would dump its 20-ton load of C stone on it. When the crane lifted the net, enough fines filtered through the openings to make all the fines needed to finish the top road. After dropping the fines needed, the crane would swing around and dump its load. There was always a laborer spotter at the construction end of the jetty to direct the crane operator where to dump the load. The I beam bent into a V with the first load, but it continued to work satisfactorily. The net weighed one ton.

Figure 22. The net picking up a 20-ton load of quarry run material.

Figure: 23. The net, swinging a load.

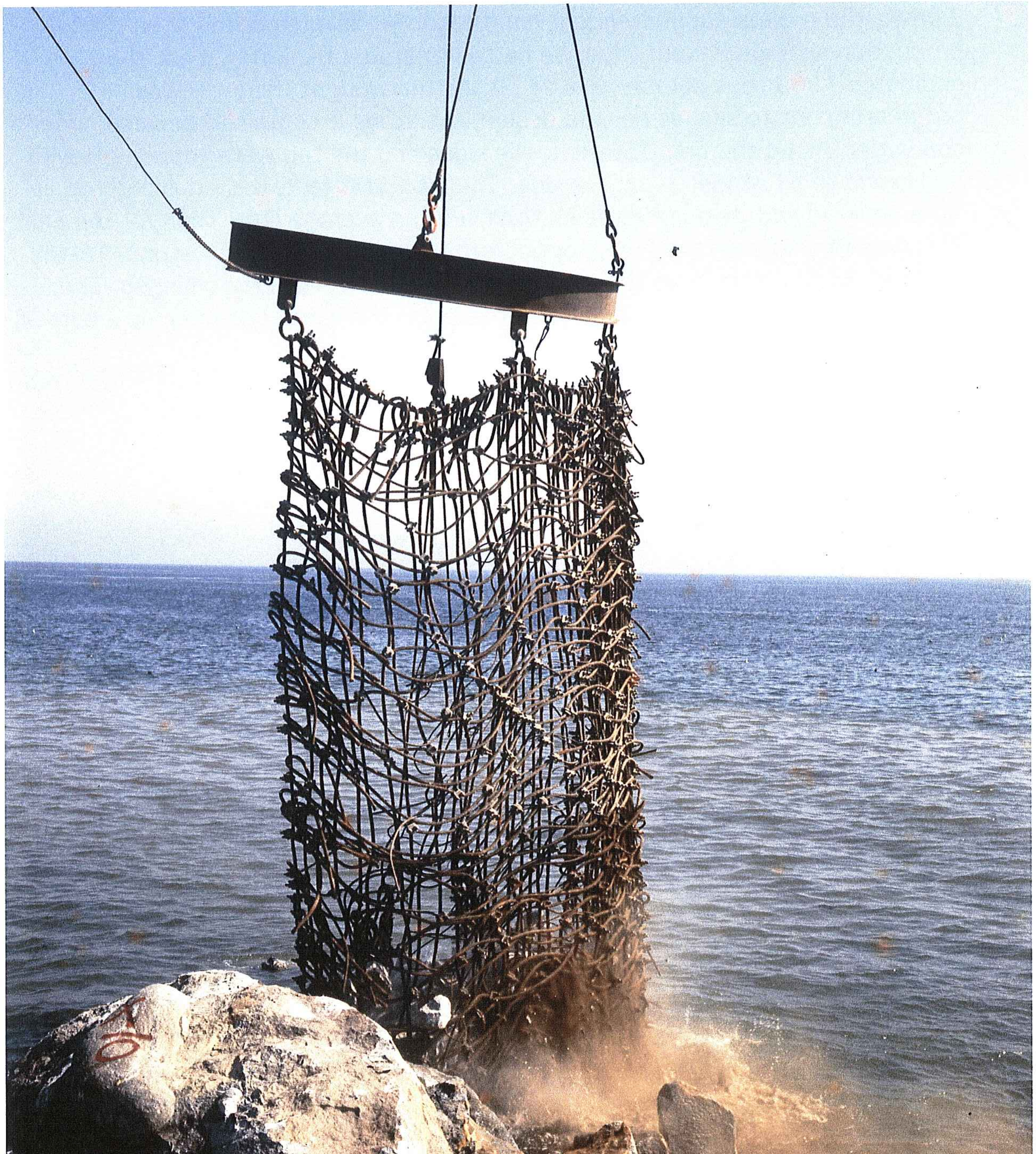


Figure: 24. The net dumping a load.

JOB UNDERWAY: After a few more small kinks were ironed out, Jimmy Gaither, the project superintendent had the job working smoothly. The production averaged about what we had estimated. I think they beat the estimated 1500 tons per day, a little bit. As the work of the jetty was progressing out to sea, as per the design, the stone it contained became larger and larger. Along the first 350 feet, the sides and the top were topped off with two layers of B1 stone, 3-ton average. The next 300 feet, the sides and top were covered with two layers of A stone, 10-ton average size. Then for the next 200 feet the sides and top was topped off with two layers of A1 stone, 15-ton average. At 850 feet from shore the configuration of the jetty changed. The spine was added to the section and at this point the tetrapods became a part of the jetty.

Figure 25. Beginning construction of the spine.

THE SPINE: The spine is a block of concrete grout and stone, 340 feet long. It sits on top of the B1 jetty stone, on the harbor side of the jetty, at elevation +2.0. It is 18 feet wide and 14 feet high. The first 12 feet in height consists of (B1 stone 3-ton avg.) and the voids between the stone are filled with concrete grout. Grout is a mixture of six sacks of cement to one cubic yard of sand and mixed in a transit mixer. Enough water is added to make a 3-inch slump. (Concrete slump is described on Page 20, Par. 3.) The top two feet of the spine is all regular concrete. The spine begins 860 feet (Station 8+60) from shore. At this point, a turnout is constructed for the trucks to pass each other. The jetty also makes a 50-degree turn to the east at this point. The spine runs on top of the jetty, along the harbor side and ends at the end of the jetty, 1200 feet from shore. (Station 12+00) It has a volume of more than 85,680 cubic feet, or 3172 cubic yards of concrete grout and stone, and weighs approximately 6225 tons. The top of the spine is at elevation +16, that is 16 feet above datum, 0.00. 15-ton average sized stone are placed on the harbor side of the spine and tetrapods are placed on the ocean side.

<u>CHANGE IN THE METHOD:</u> Because of the spine, the configuration of the jetty changes at this point. The method of construction also changes. The spine has to be built together with the stone part of the structure. The forms for the construction of the spine are wooden panels and are used to contain the grout. The dimensions of the panels are 20 feet long and 14 feet high. The timber used is douglas fir in 2 inch by 12 inch by 20-foot long planks bolted to 4 inch by 4 inch by 16-foot long studs, or uprights, at 3-foot centers. The 4x4 studs extend above the boards by two feet, so they can be tied together with steel rods or wire rope. The wire rope is not encased in the concrete. Eight of these panels are built, enough for about 50 feet of the spine structure to be built at a time. The panels are reused seven times. The panels are too big and heavy for the workers to lift. They weigh about 1500 pounds each. The crane lifts and sets them in place. The tops of the forms or panels are carefully set to finished grade, which is plus 16, the final top elevation of the finished jetty. Abe, can you visualize setting the panels on the top of rough irregular stone. They have to be chinked up with smaller stone to get them level and to grade. The openings under the forms have to be filled with stone. This is slow work. There is no reinforcing steel in the structure. Because the steel, rusting, if saltwater reached it, will break the concrete. No steel rods, tie wires or spreaders are permitted. The forms are set on top of the B1 stone in which there are many voids. On the inside and two feet from the bottom of the forms, 4-inch by 4 inch by 18 foot long wooden spreaders are used to temporarily keep the panels apart. On the outside of the forms at the bottom large pieces of stone are lifted with the crane and placed against the forms, opposite of these spreaders. Then enough grout is poured to penetrate the voids in the layer of B1 stone below the forms. Pouring the grout is continued until it reached to one foot above the bottom of the forms to keep the forms apart when the 4x4 spreaders are removed. Then B1 stone is placed between the forms one foot away from the sides, and the voids are filled with grout, 12 feet high, to elevation 14.0 for a distance of

about 50 feet. On the inside the stone is kept away form the sides, one foot, to create more strength around the outside of the stone and also to make it easier to strip the forms. In addition, it is kept down two feet from the top. The top two feet of the spine receives regular concrete. After the concrete reaches its initial set, about one hour, the stones placed along the outside of the forms and any spilled grout on the outside is removed. If this is not done, the grout will harden and lock in the forms, so they cannot be removed, without the use of a jackhammer. The end of the section of stone and grout, where construction stops is left on a 45 or 50-degree slope. Stone is left protruding from the grout. This is done in order to make a strong bond with the next section.

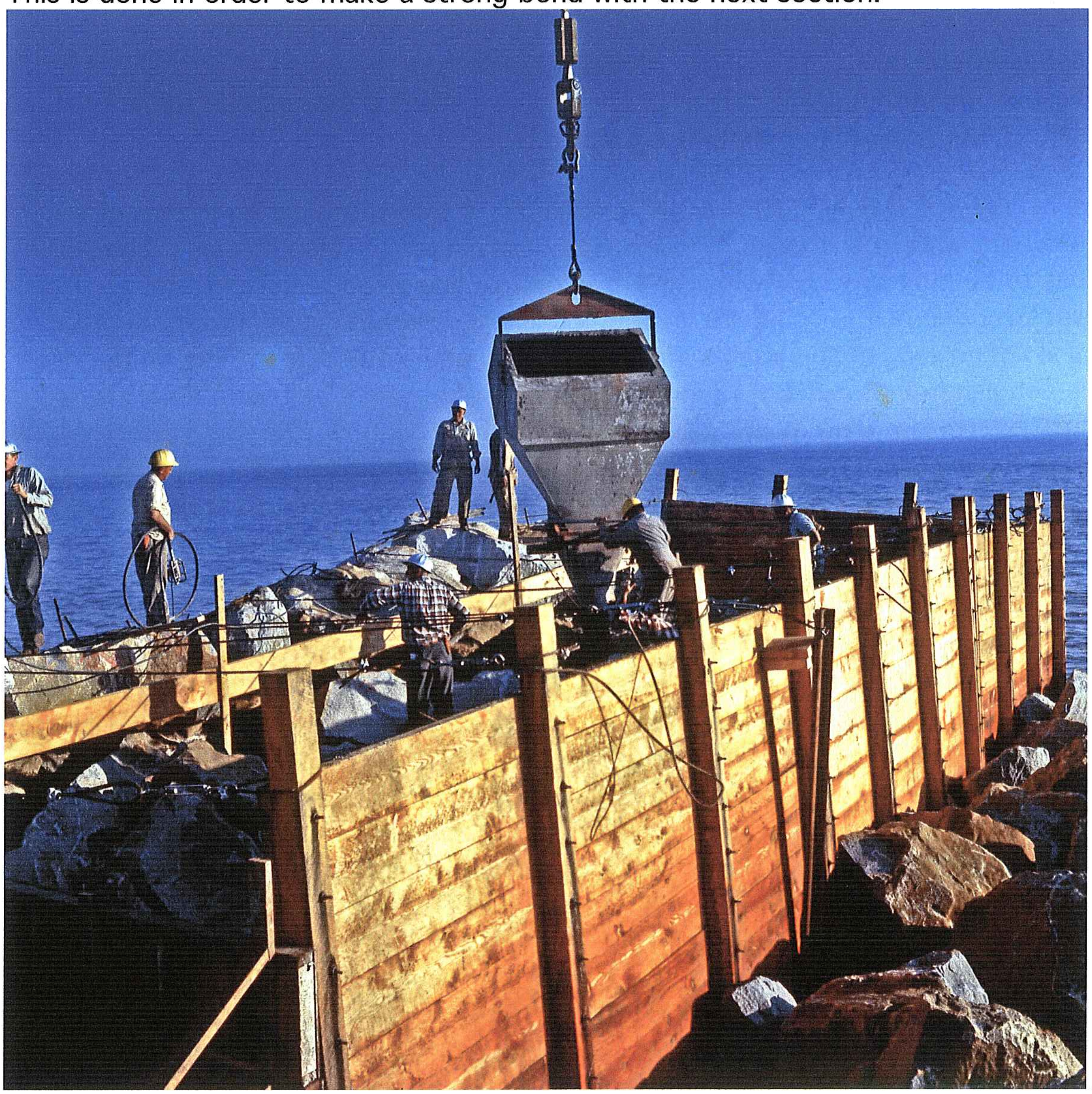


Figure: 26. Pouring grout into the spine forms

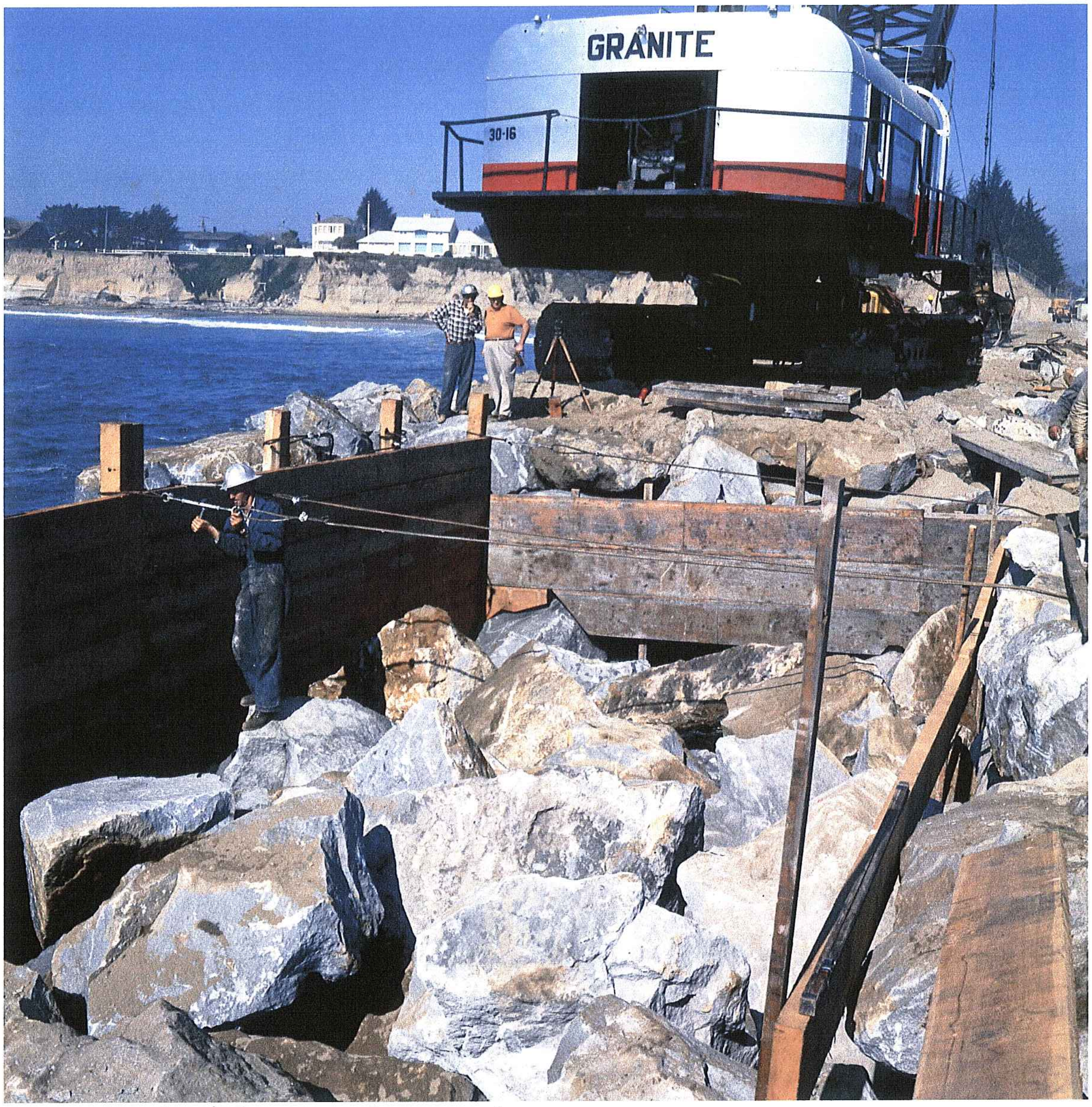


Figure: 27. Spine forms ready to receive concrete grout

The following morning the panel forms are stripped and laid to one side on the finished slope. C stone is then placed against the spine on the ocean side to make the extra width needed for the crane. On the channel side, A-stone, (average 10 ton pieces) is placed in two layers, to the finished grade. The tetrapods are not placed at this time for it is more efficient for this part of the job to be a separate and a continues operation; also because the temporary fill, built for the crane has to be removed. And also, if it were done at one time, the engineers would be able to place the tetrapods in places where they are most needed. Throughout the construction the crane always worked from the top or the finished elevation of the jetty.

Construction of the jetty now continues outward. The “C” stone core is laid to elevation -4, then six foot of B2 and B1 stone is laid with the top at elevation +2, which is the bottom of the spine. Besides 50 foot of spine, about 7500 tons of stone is laid for every 50 foot stretch, which takes seven days to complete, so the spine along with the jetty will take two and one half months to complete.

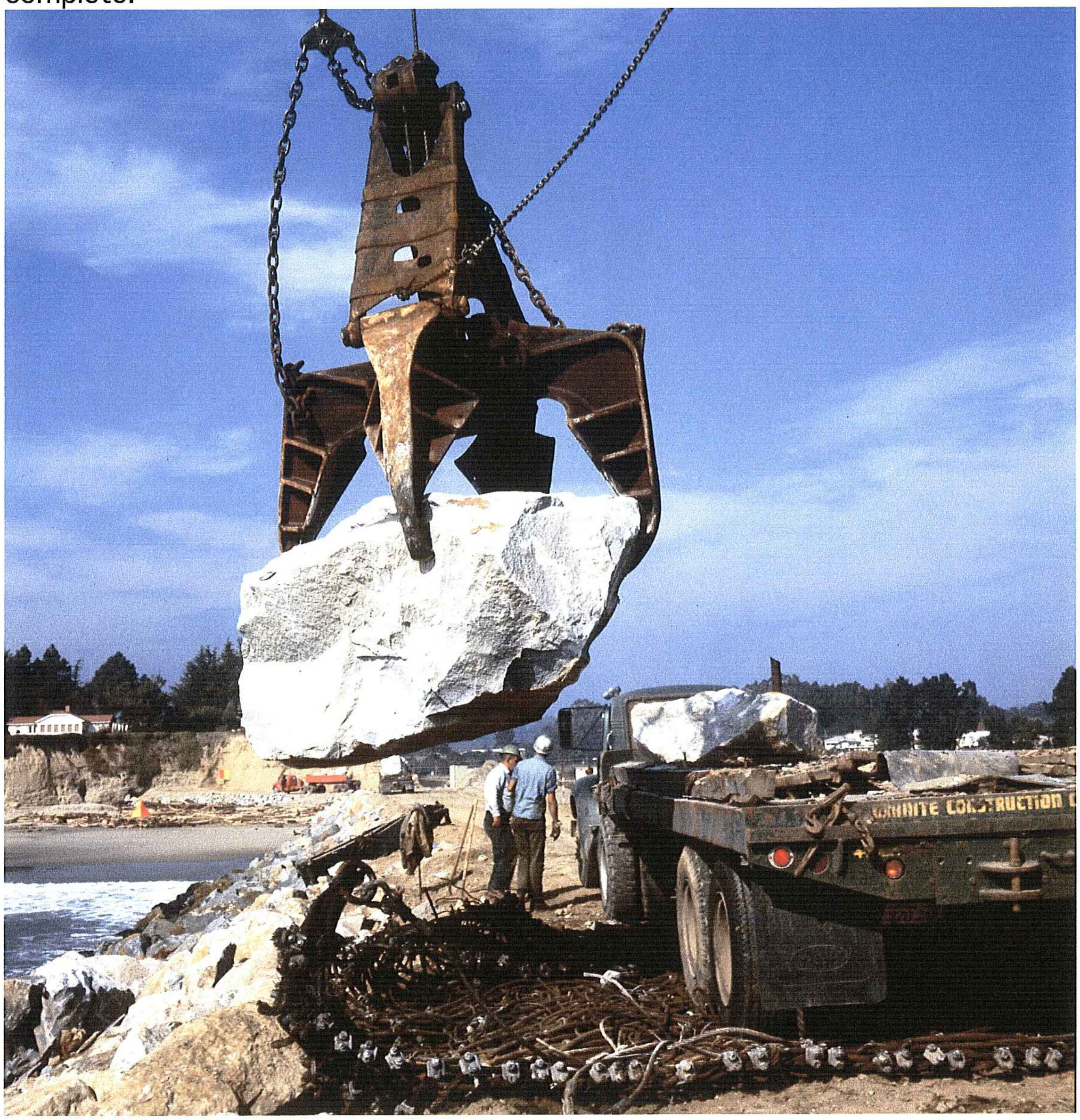


Figure: 28. Placing a12 ton stone.

Figure: 29. Placing a 10-ton stone.

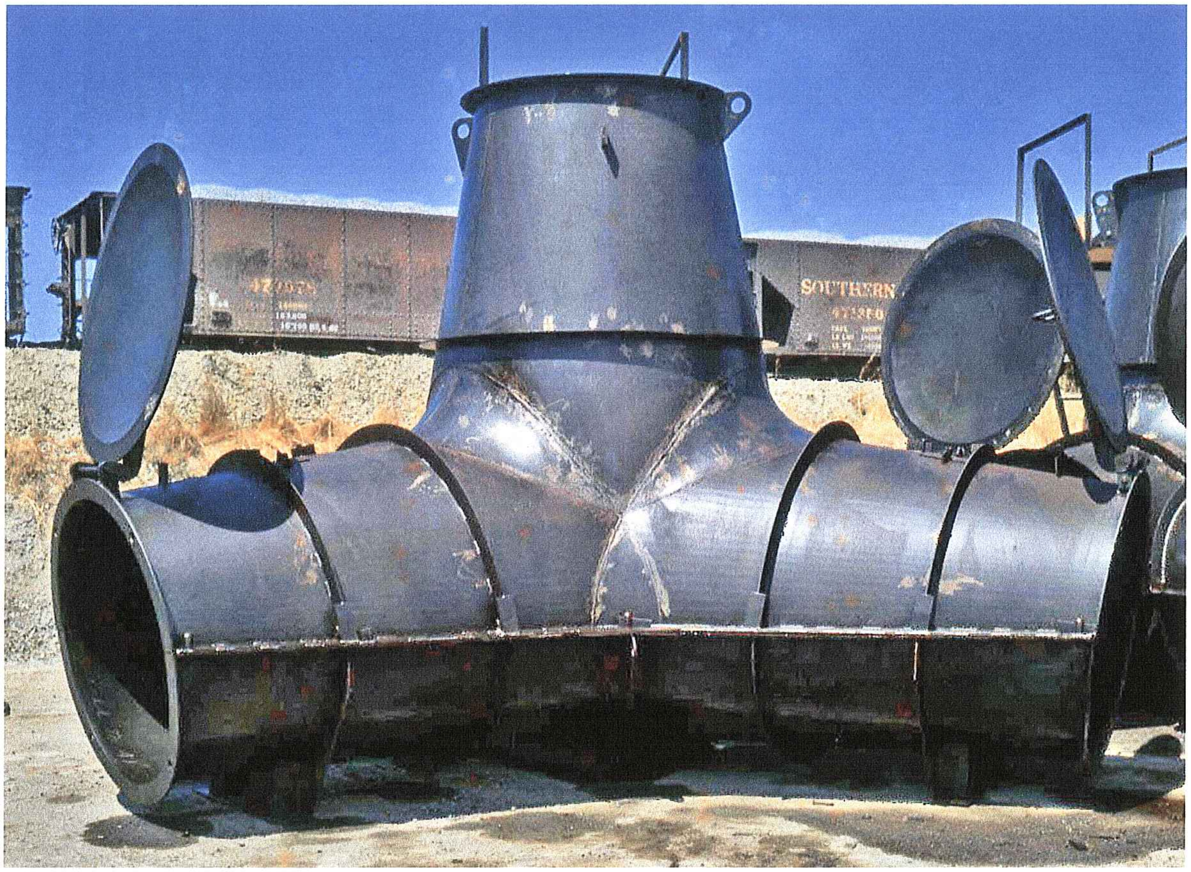


Figure 30. Sheet metal tetrapod forms. One of eight tetrapod forms.

MANUFACTURING TETRAPODS: In a paragraph, beginning on page 4 above, the design and building the forms for the tetrapod was described. Here the manufacturing of the tetrapods will be described. The tetrapods were manufactured on property owned by GraniteRock Company located at the southwest corner of 7th Ave. and the Southern Pacific Railroad Co. At that time, GraniteRock Co. owned and operated a satellite concrete batching plant at this location and also had a Southern Pacific Railroad spur into the location delivery of the materials, aggregates, sand, etc. GraniteRock Co. was gratuitous and permitted Granite Construction Co. to use the property, free of charge, for the time needed to manufacture the tetrapods. These savings helped to keep down the cost of the project. To manufacture the tetrapods and to install them within the time limit set for the project, it was planned to make eight per day and to complete 40 per week. Mentioned in the paragraph on page 4 we are going to buy the forms in 8 top halves and 40 bottom halves. The reason for this is because the bottom forms will not be stripped or removed until the compressive strength of the concrete reached at least 1000 pounds per square inch. We learned from experience that most of the time the compressive strength of concrete containing 5 sacks of cement per cubic yard reached the1000 pounds in seven days. The tetrapods did not contain any reinforcing steel. The reason being that, should the seawater reach the reinforcing steel within the tetrapods through a crack or seepage, it would cause a rusting which would expand the steel and break the tetrapod. Because the tetrapods contained no reinforcing steel, we would have to leave the tetrapods in the bottom forms for 7 days before they could be removed or stripped, therefore the reason for the 40 bottom halves. To be the most efficient, the rate of production is timed to be completed at the same time the spine is completed. This operation can be completed in more or less time by buying more or less forms.

Figure 31. Set up to pour the first 8 tetrapods.

Figure 32: Removing tetrapods from bottom forms.

CASTING TETRAPODS. To begin with, the first row of forms was set out on a Thursday, and the concrete poured on Friday morning. For the start, the first round, and the first time for stripping them would be on a Monday morning. They would have two more days than planned for the curing time of them. On that first Monday, all went well except for one. The top half would not come off. The crane could not pull too hard the first time for fear it would break off the leg. Wedges were driven in at the split between the forms and along with the pull of the crane it popped off. It was found the form of the vertical leg had a slight inward bulge, about 1/4 or 3/8 inch inward, just in deep enough so the budge would not clear the concrete. When the top popped off, it left a gouge in the concrete, not hurting anything. The manufacture of the forms was informed. They sent a technician down to check it. He pounded out the bulge and ground it smooth. The next pour was stripped after setting for 18 hours. All went well. In all the 900 tetrapods, not one was broken, either in the manufacturing or in the placing.

Possibly, I am going into a lot of detail here, but you asked for it, so I will tell you about the design, the pouring and the curing. The Corps of Engineers designed the mix. It consisted of three sizes of aggregate, (1) sand, (2) 1/8 inch to 3/4-inch granite rock, and (3) 3/4 inch to 1 1/2-inch granite rock. Each ingredient was individually weighed into the mixer separately according to the design. All together, the three aggregate ingredients weighed about 3550 pounds. Then the cement was added, five sacks or 470 pounds. These combined ingredients at this weight make a volume of one cubic yard. Then just enough water was added to the batch for it to mix and for the mixed concrete to come out of the mixer. The less water used the stronger the concrete. The mix was designed for the concrete to reach a compressive strength of 2000 pounds per square inch after aging for 28 days. The compressions always tested over 2000 pounds. To reach this strength was easy because the mix did not need much water; it was massive concrete, contained no reinforcing steel to work around, and was easy to place in the forms. It was not like pouring a 6 inch or 8 inch wide concrete wall full of reinforcing steel. This concrete would have to contain more water to flow around the reinforcing steel, thereby loosing strength. There are many different mixes for concrete. You may want stronger concrete. For example, you can get stronger concrete by adding more cement. You can get stronger concrete by using a mix with harder and larger rock like 3 inch and 4-inch diameter rock, etc.

In the above paragraph, a concrete vibrator is mentioned. Here I will describe one. The concrete vibrator used in the tetrapods is a large heavy duty one used for mass concrete. It is a cylinder 3 1/2 inches in diameter and about 14 inches long. It has a threaded cap on one end, which comes off to reach the mechanism inside. Inside is a shaft with weights on one side and high-speed bearings on each end. It is driven by an air motor that drives the shaft at the rate of 2000 to 3000 revolutions per minute causing the dong to vibrate. When inserted into the concrete the vibration makes the concrete flow. It makes the concrete fill in the finest cracks and crevices. In addition, it makes the concrete denser.

The eight tetrapods together take 102 cubic yards of concrete, total. GraniteRock Co. assigned two (6-cu.yd. capacity) transit mixers to the job. The tops of the forms were over 9 feet high. Too high to pour into them directly out of the chute of the transit mixer. A crawler crane is used full time throughout the manufacturing of the tetrapods. The crane was to handle the forms, the bucket for pouring the concrete and to move the tetrapods when necessary. A two cubic yard lay down concrete bucket was used. The transit mixer would fill the bucket with two or more cubic yards of concrete. The crane would lift it up. The bucket becomes vertical when lifting and swinging over the tetrapod form; a laborer pulls the handle and the 2 yards of concrete drops into the form. While the bucket was being refilled the laborer would insert the concrete vibrator and vibrate the mix. This vibration would not only push the concrete into the corners and crevices but it would also compact the concrete to make it dense as possible.

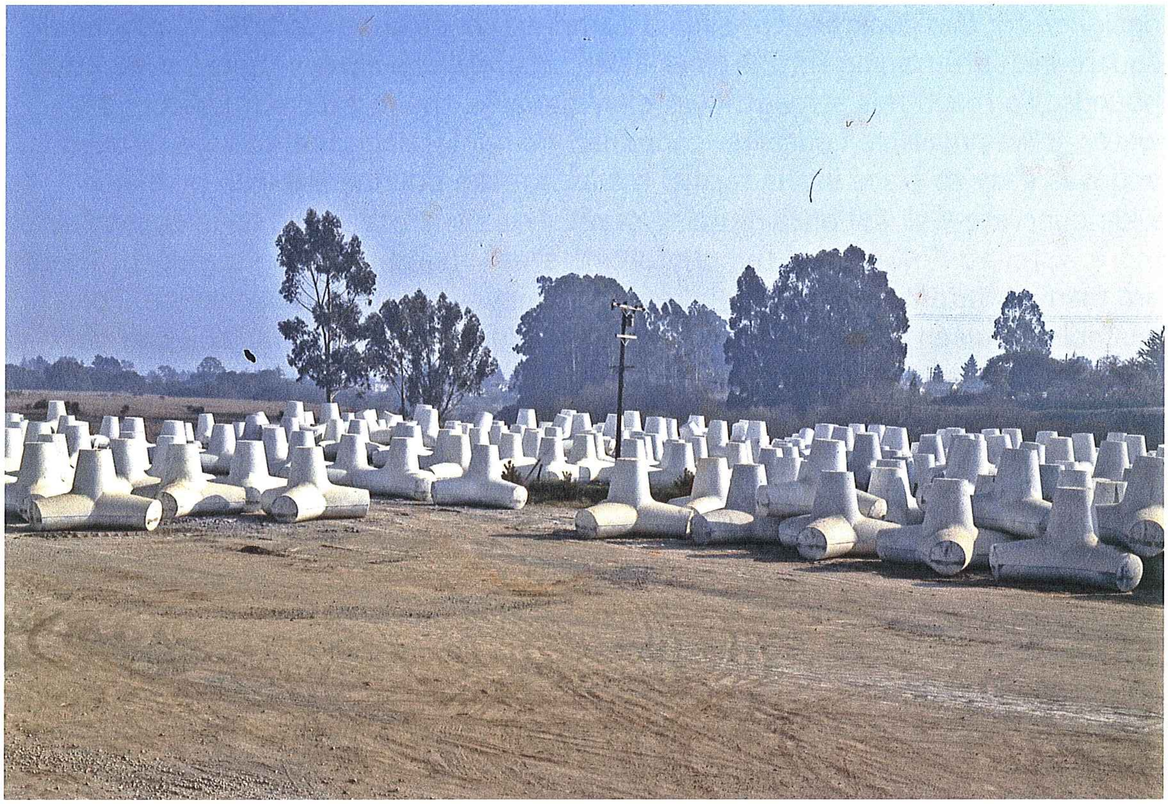


Figure 33: Tetrapod storage and curing area.

TESTING CONCRETE. During the pouring an engineer inspector periodically, took samples of the concrete for two tests. 1. A slump test. 2. Several samples for compression tests. For the slump test, the inspector has a slump cone. It is a cone made from heavy gauge sheet metal, about 12 inches tall. If my memory serves me right, the big end is 6 inches in diameter and at the small end, is 2 501/2 inches in diameter. At the big end, a stirrup is welded on each side of the cone, for the person taking the sample, to stand on. The slump test is done to estimate the amount of water contained in the mix. The less water used in the mix the stronger the concrete will get. The cone is placed, big end down, on a flat surface, usually a piece of plywood. The tester stand on the stirrups to keep the cone from raising up while filling it through the two and one half inch opening on the top, roding it to compact it well. Then he slowly lifts off the cone. The concrete slumps. If the mix contains a lot of water, it slumps down to a pile about three inches high. This is called a nine-inch slump. If it contains the minimum amount of water, it will slump down 1 1/2 inches, called a 1 1/2 inch slump. For the compression test, the inspector will have several empty cylinders. The cylinders have a tin bottom and cardboard sides. They are six inches in diameter and 12 inches high. The inspector fills four or more cylinders with concrete fresh out of the mixer. It is tamped into the cylinders well rodded. They are marked so they can be identified. The cylinders are then placed with this day's manufacture of tetrapods so they will receive the same curing method and time that the tetrapods receive. They are broken at ages of 7 days, 21days, and 28 days or at ages determined by the inspector, but always one or two are broken at 28 days old. A special hydraulic press made for this purpose, is used to break them. First the cylinder is placed in a machine that trues up the ends to be exactly at 90 degrees with the centerline of the cylinder. An epoxy or resin of quick hardening material is used to true up the ends. Then they are placed under the hydraulic press that has a pressure gage with a large dial. At the first crack of the cylinder, the pointer on the dial locks up; showing the exact pressure at the instant the concrete first begins to break. After that the inspector would come every few days or a week or so, unannounced, and take the samples from the mixer unloading at that time. He never took a slump test anymore because this concrete was massive and we poured it very dry. We would pour the mix just wet enough so it would come out of the mixer. A large 3-inch diameter, 12 or 14 inch long, concrete vibrator was used. A 60 cubic foot per minute air compressor powered it. We never failed a test.

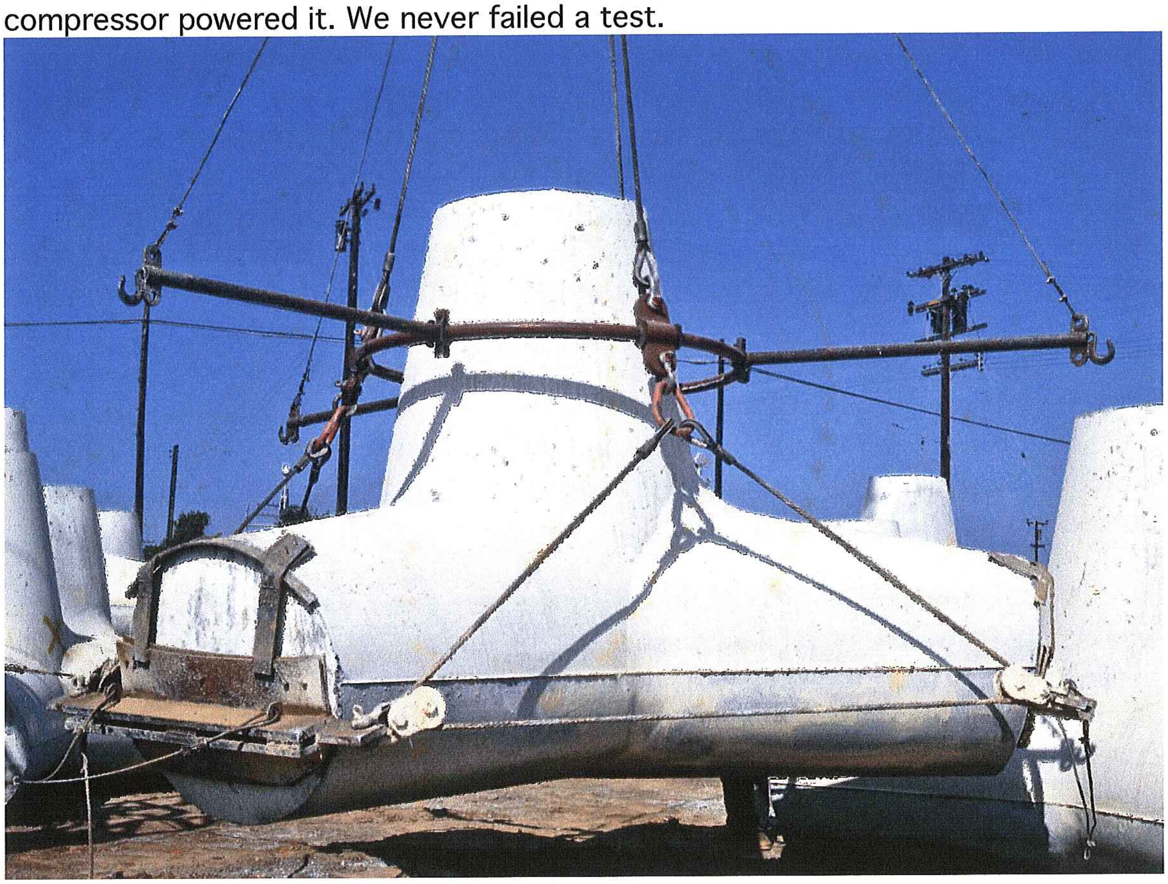


Figure 34. A tetrapod in its carrying sling.

After the first 5 days, the operation becomes routine. 1. In the morning, the first item of work is to remove (called strip) the top halves of the forms from the tetrapods poured the previous day. The crane would lift them off and then put them together again with the second row of bottom halves laid out the previous afternoon. After each pour the forms are cleaned and sprayed with form oil to keep the concrete from sticking to them. 2. The eight tetrapods altogether held 102 cubic yards of concrete and the pouring of them takes until noon. 3. In the afternoon, the crew strips the bottom halves of the forms from the tetrapods that are 7 days old. This operation is a little more complex. The tetrapod has to be lifted up to remove (strip) the bottom halves. Can you visualize this Abe? A wire rope sling could not be wrapped around the tetrapod because it would surround or include the form as well. The tetrapod could not be lifted by attaching the sling around the vertical leg, because the concrete, being too green, the leg might break off. A special wire rope harness was designed to wrap around the ends of the three horizontal legs. When the crane lifted, it put the tetrapod into compression. Instead of lifting by tension, it lifted with compression. At the end of the legs three round plates made out of 3/8-inch steel plates welded to 3, I inch cross pieces were which were made to fit the ends of the horizontal legs. A ring with a 3/4-inch wire rope sheave (pulley) was welded to each side of the three 1-inch pieces. The plates were lined with old rubber conveyor belting so they would not slip off. Approval was obtained from the Corps of Engineers to deflect the face of the leg end, inward at the bottom, about 3 degrees off the vertical. This was also done to keep the steel plates from sliding off. A wire rope sling was fed through each of two sheaves on each side of the three plates, ends facing upwards. Iron rings were attached to the ends. A three-part sling was attached to the lifting line of the crane each with a hook. The rings at the end of each of the three slings were hooked on to one of the three hooks of the sling from the crane. The crane then could lift the tetrapod out of the bottom form, which would then drop off. (See the drawings herewith.) The crane then would walk with the tetrapod and place it in a line in the curing yard. The crane with a 20-ton lifting capacity, walking, (about 200 feet,) with a 28-ton tetrapod, kind of made her grunt, groan and walk on her tiptoes but she would make it.

Now comes the curing of them Abe keeping them wet for about three weeks, the following method was used. On the day they were poured and just before quitting time, a laborer wet them down with a hand hose. The next days after the top forms were removed, they were covered with blankets and kept soaked by sprinkling two or three times during the day, for the seven days. After the seventh day they were stripped out of the bottom forms and moved to the curing yard. Here again they were covered with blankets. (Note: we bought every used blanket existing in the second hand and surplus stores in Santa Cruz.) There were three or four water hoses; all attached to a timer. Each had 8 or 10, fine mist sprinklers in the line, 20 feet apart and each hose could be turned on or off independently. The finished tetrapods were stacked together close enough so this number of sprinklers could cover quite a number of them. They were turned on for short periods during the day, by a timer, to keep the blankets wet, but not at all during the night. They were cured by this water method for about 24 or 25 days. GraniteRock Company furnished the water.

Figure 35. Another Tetrapod Store & cure Area.

PLACING THE TETRAPODS: When it came time to place the tetrapods, another problem arose. At 28 ton each, which is an overload for a standard semi low bed trailer, it would take a special trailer, with enough wheels, to haul them. In the estimate it was planned to use the company's (Granite's) two low bed equipment movers, but they could not be tied up for the four or five weeks it would take to move and place them. Our equipment superintendent Clem Molina came up with the idea to use U.S. army low bed semi trailer tank movers. The beds of these semi trailers could not be over four feet high; if they were, the tetrapods being nine feet high may not go under the overhead electric and telephone wires crossing the streets. He found two that fit our specifications, in an army excess equipment pool and bought them for, if I remember right, $2500.00 each. Nobody wanted them because they were too heavy. They were almost over the legal load limit when they were empty. They were brought to the shop in Watsonville and completely checked over. They were found to be in, a nearly new condition except the tires. The rubber was old and undependable for those loads. New tires were put on, two semi dump truck tractors of Granite's were assigned to pull them and we were in business.

Figure 36. Unloading a Tetrapod.

Equipment that was required to move them from the casting yard into their final position. A 20-ton crane at the casting yard was used to load them. Two laborers were required to put on the sling. Three, 3/4 inch wire rope slings were used. Two low bed semi trailers with enough capacity hauled them. Two pilot cars were needed. A crane on the site to unload and place them. A spotter and la laborer on the jetty. Since many of the tetrapods were placed under water a special unhooking device was required. A regular hemp rope was attached to the device. When the tetrapod was in place, the rope was pulled unhooking the device, whose sling then could be pulled from under the tetrapod and retrieved.

The routing for hauling them, approved by the division of Motor Vehicles was: leaving the casting yard on 17th Ave. go south on 17th Ave. to East cliff Drive, west on East Cliff Drive to Lake Ave., north on Lake Ave. to Eaton, west on Eaton across the bridge on Murray to Sea bright, south on Sea bright to Atlantic, down Atlantic and onto the jetty. A pilot car, pickup truck, equipped with a large sign, "Wide load following", was required ahead of each truckload.

The tetrapods at the ocean end of the jetty and the wrap around were laid first. As the crane backed off, the fill placed for widening was removed. Tetrapods were laid on and up the slope to against the spine. This operation went on until reaching the beginning of the spine, where the job finished. The placing of the tetrapods took 2 1/2 months. This was the last work done on the west jetty. The jetty was complete. The crane crossed the harbor channel area to the East Side. The sand bar across the harbor channel had not been dredged out. The crane now equipped as a dragline began excavation for the east jetty. The excavated material, all sand, was cast to the East Side of the East jetty.

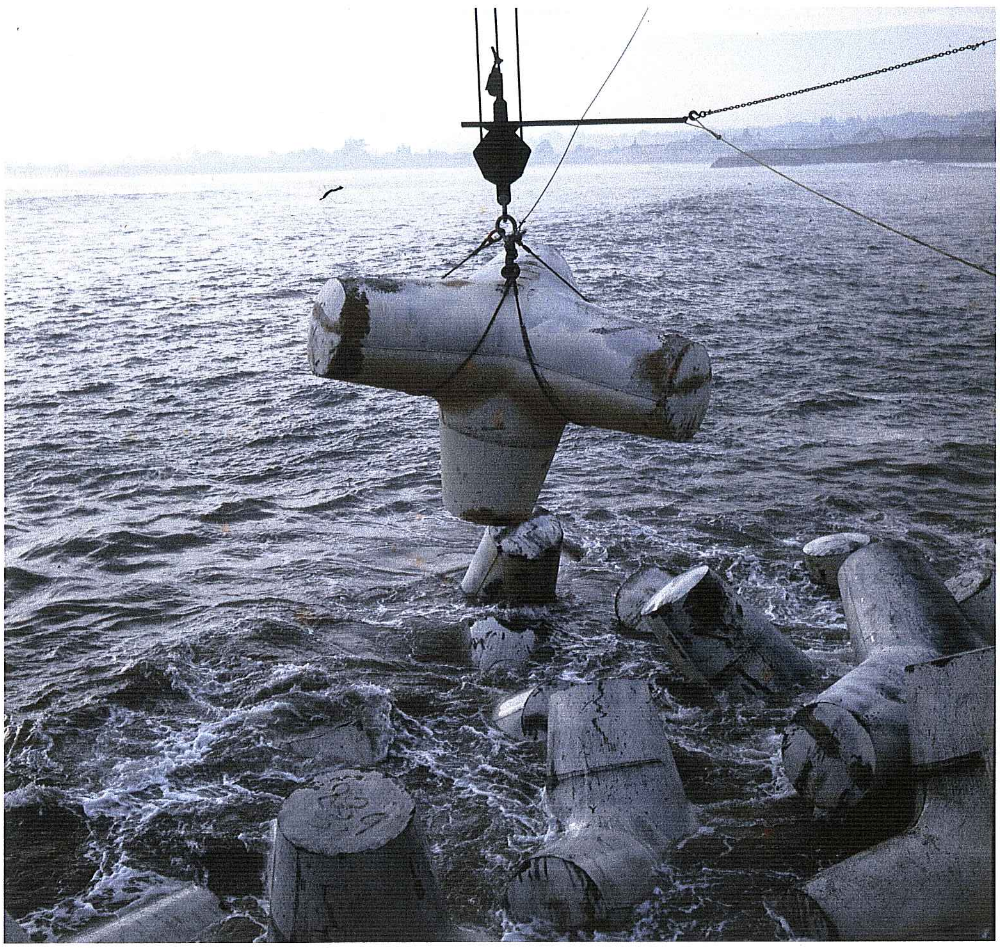


Figure 37. Placing a tetrapod.

EAST JETTY. The east jetty is 800 feet long, not nearly as big as the west jetty. It also had to be widened from 18 feet to 22 feet to accommodate the crane. Beginning at the bank and for the first 700 feet, the jetty was constructed with a filter blanket over the sandy bottom. On top of the filter blanket, the core was laid with "C" stone. The core was topped off with two layers of "B1" (3 ton Stone.) The last 100 feet and the wrap around contained the core stone, covered with 6 foot, 2 layers of "B1" stone (10 ton) and that was all.

Figure 38. Crane on the East Jetty

THE CRANE COMPLETED ITS JOB. It had completed 10,000 cubic yards of excavation, laid 250,000 tons of stone and placed 900 tetrapods without a major breakdown. At that time Granite had no use for such a big machine. Granite's equipment all had to be portable. It was immediately put up for sale and it wasn't long before the company had a buyer. Granite's people dismantled it and loaded it on five flat railroad cars, the same way that it came. Then a big R.R. engine took it away. I do not know where it went.

Figure 39. During the storm.

Figure 40. Crane completes the West Jetty.

Some of the other items of work were started before the jetty work started. Some items were completed during the time the jetties were under construction.

Items of work completed before dredging.
5. The boat-launching ramp.
6. The west bulkhead, sheet pile wall.
7. The boat repair pier.

Items of work after dredging.
8. The public pier.
9. The commercial fishing pier.
10. The floatation units. See page 32.

Figure 41. Crane with dragline bucket excavating Boat Launching Ramp

<u>5. THE BOAT LAUNCHING RAMP</u> <u>is</u> a reinforced concrete slab six inches thick and is sitting on a number of rows of wooden piling. It is on a slope into the water. A pickup truck with a boat trailer can back down this slope into water deep enough to float the boat. The boat would be unloaded and the pickup with trailer drives away. It is so reinforced that the slab will stand alone on top of the piles, like the deck of a bridge. The big crane was used to make the excavation and drive these piles, before it started the work on the jetty, not because of the weight of the pile and hammer but because of the reach. The piles were located out over the muddy area; so soft it would not hold equipment, and the smaller cranes could not reach out over the muddy distance. The piles were driven to a resistance of 20 ton; in other words, each could carry a 20-ton load. The ground was graded off, the reinforcing steel placed. Forms, (2 inch x 6 inch boards) were placed around the outside; screeds and strike off forms were installed. The concrete was poured and finished in one day, with the big crane, using a two cubic yard concrete bucket.

Figure 42. Installing reinforcing steel for the concrete launching ramp.

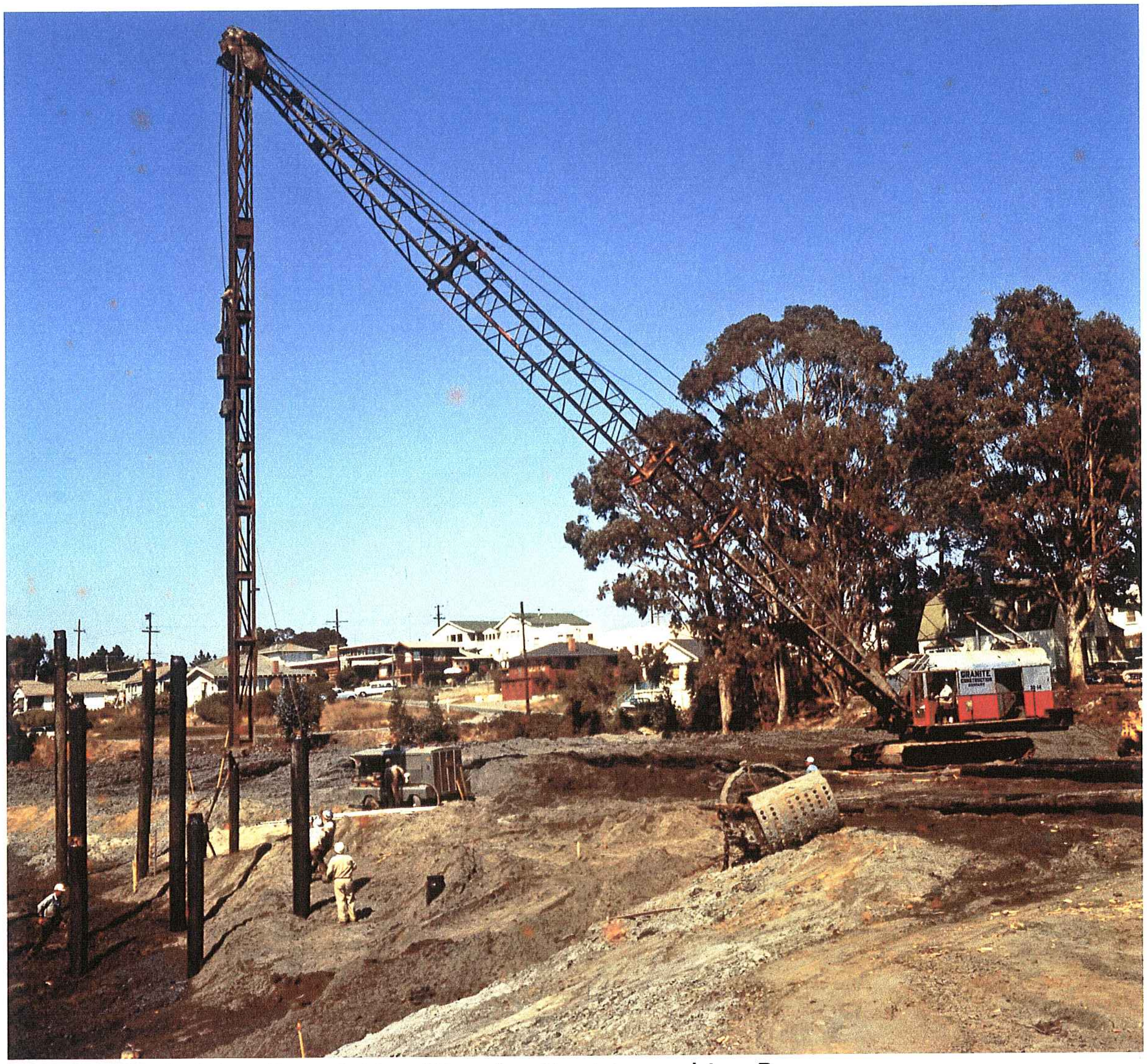


Figure 43. Driving foundation Piles for Boat Launching Ramp.

<u>6. THE WEST BULKHEAD</u> is an interlocking steel sheet pile wall about 1,200 feet long. The individual sheet pile is 40 feet long and 14 inches wide. The piles have a profile like a wide stretched out letter U. The sides of the U (about 3 inches long) slanted outwards about 1 inch. The center is 12 inches wide and over all makes up 14 inches. I do not remember the wall thickness or the weight of these piles. The piles go together similar to a zip lock plastic bag, only they have to be started from their ends. One cannot slip them together sideways. The steel will not give like plastic. The purpose of this bulkhead is to retain the earth from sliding into the berthing area. (Boat parking area.)

Figure 44. Laying out Sheeetpiles for West Bulkhead.

For driving the piles, first a vibrating sheet pile hammer was tried. It had a hydraulically operated clamp that clamps on to the top of the pile. Then it fiercely vibrates the pile into the ground. This did not work very well. It was the wrong type of ground for a vibrating hammer. In addition this system needs two hoses, one for the hydraulic clamp and one for the air. The two hoses, always in each other's way, are a nuisance. After that a regular steam powered sheet pile-driving hammer was tried. It worked very well. Instead of using steam power, 500 cubic feet per minute capacity air compressor was used. The piles were driven into the ground 34 feet, leaving 6 feet extending above ground. This six-Foot area is to be backfilled with excavated material from the harbor side of the bulkhead.

Figure 45. Beginning to drive sheet piles for the west bulkhead.

It is very important when starting a sheet pile wall or bulkhead, that the first piles be driven perfectly plumb and true to line. If this is not done the entire wall will not be true and will not be plumb. In order to be sure and positive that the bulkhead wall is started right, a wooden starter frame is built to hold the first 10 or 15 piles. When driving, these first piles are carefully watched with strings set to the line and plumb bobs for the vertical checking. If any one of them begins to drift out of line or out or plumb it can easily be pulled back into line and correction made. Here I learned that you couldn't drive the type of steel sheet piling used on this project, unless at least 85% of the length of the pile is in its interlocks. If not, you will drive it out of the interlocks. Then you have a problem. You have to pull six or seven of the previously driven piles and start over. Therefore, Abri, whenever you see sheet piles driven in a wall, bulkhead or cofferdam and you see them in steps of four five or six feet, you will know the reason why.

Figure 46. Driving Sheet piles for the West Bulkhead.

After all the sheet piles are driven to grade, a reinforced concrete cap is built on top of the sheet piles. The purpose of this cap is not only to reinforce the sheet pile bulkhead, but also to hold the steel rod tiebacks that connect the wall to the dead men. . A so-called dead man is actually an anchor. It could be a log, a piece of timber or concrete. In this case, they were poured concrete. The cap is about16 inches wide and 12 inches high. Imbedded in the concrete cap are steel rods, 1inch in diameter, which extended back into the earth bank a distance of six or eight feet, and connected to concrete dead men. The steel rods from the cap are connected to the dead men, to tie back the wall to help keeping it from tipping or bending over into the harbor. When all this is done, earth from the harbor side of the wall is excavated with a crane and dragline bucket and cast over the wall to make the fill to the top of the wall. From my memory, these rods and dead men were about 8 feet apart.

Figure 47. Top of a completed Bulkhead Wall. Before the damage. Facing north.

After the wall is complete, remember Abe, the top of the finished wall is about six feet above original ground. This area behind the wall had to be filled. The specifications called for the backfill material to be obtained from the harbor side of the wall, thereby decreasing the amount of material that had to be dredged or pumped out and save the cost of trucking the material in from an unknown source. Here we run into another problem. The material on the harbor side of the bulkhead consisted of silt and fine wet sand that acted somewhat like quicksand and would not hold up equipment such as a crane, dragline, scrapers or bulldozers. Any of these would sink in that soft material. I know from experience this material would carry a load of 100 to 200 pounds per square foot, allowing for the vibration, it was decided to use a small crawler crane with a 3/4 cubic yard dragline bucket. The footprints of this crane compressed more than 200 pounds per square foot. Mats would have to be built. The crane would set on mats, dig out a bucketful, and cast it over the wall into the area to be filled. Mats were made using 12-inch by 12 inch by 20 feet long, douglas fir timbers. Four sets of six timbers each were bolted together; making four mats six feet wide and 20 feet long. A bolt with a chain and a ring was installed in the center of each mat. A hook was welded onto the side of the bucket. With this setup the crane would hook onto a mat, pick it up, swing it around and place it behind itself, and then dig another six feet, or swing around two mats and dig 12 feet. (Note here Abe: The mats contained enough lumber to build a small house) Then Abe, picture the crane sitting on mats inside the harbor digging the dirt and casting it over the wall. The crane was digging in the direction of the new bridge, away from the ocean. When it had dug up enough dirt, placed it behind the wall to make the fill, the first mat was hooked onto the bucket and placed behind the crane, in the direction in which the crane was digging. The crane would move ahead six feet, fill behind that section of wall, move ahead six feet swing the mat behind, dig and fill, and so it went down the line. Enough material was dug from he harbor to fill behind the wall in one lift of six feet. Moving one or two mats with each move could do this.

Figure 48. West Bulkhead. Steel sheet piling in place. Before the damage. Facing south.

BULKHEAD PROBLEM. One day Jim Gaither, the superintendent, called and informed me the wall is moving, tipping inwards towards the harbor. Boy Oh! Boy Abe, if this is true, that the wall would bend over. I could see $100,000.00 out the window. We set three tattle tail markers, that is, stakes to ascertain if the wall was moving. With a chisel, a fine line was cut into the concrete cap on the wall and stakes set perpendicular to the wall line, back about 50 feet into solid ground. Then using a steel tape the distance between the stake and the chiseled mark was measured and periodically monitored. The wall was tipping toward the harbor at the rate of 1/4 inch per hour. Not only that, but the movement was continuing down the line towards the beginning of the wall. It had a sort of domino affect. When the strain was released on one deadman it transferred more strain to the next one down the line and it started moving, etc.

Fig.49. The damaged bulkhead wall.

A Company truck crane working on one of our jobs in Santa Cruz, equipped with a clamshell bucket, was immediately ordered out to the harbor. It began to (unload) dig out the fill dirt from behind the wall, well ahead of where the movement was taking place. After some of the fill dirt was removed the wall movement stopped.

The engineering firm Earl and Wright of San Francisco the designers of the wall were notified of the problem. Two engineers came down from their office, studied the situation, did a lot of probing and digging, with the crane and clamshell bucket, around the wall and made some tests. They decided the bulkhead wall had no structural damage. The reinforced concrete cap on top of the bulkhead was bent in a curve but was intact. It was not broken or cracked anywhere. (Before this, I never experienced concrete that would bend without breaking.) The engineers determined placing the earth back fill too fast caused the outward movement and by placing it in one four to six foot lift. The fill material taken from the harbor was a silt, sandy material saturated with water, which together is a lot heavier than dry sand or plain earth. The engineers decided that the bulkhead needed more structural strength built into it. This was done with the construction of a four-foot wide by six inches thick reinforced concrete sidewalk on top of the bulkhead just over that length of wall that moved. The sidewalk was anchored to the concrete cap on top of the bulkhead by drilling a series of two-inch diameter holes into the cap, 5 inches deep and 18 inches apart. (I believe my memory is right about this.) Pieces of 3/4-inch diameter by 12 inches long reinforcing steel were bent into a 90-degree angle. Each one had an eight-inch leg and a four-inch leg. The eight-inch legs were dry packed into the 5 inch drilled holes. The material used for dry packing is pure cement with a wee but of water added to make damp. Then use this material to pack around the 90 degree bent steel bars, held in the center of the two-inch hole. After the dry packed cement sets up, reinforcing steel in the sidewalk is tied to the four-inch legs. This additional installation not only increased the structural strength of the wall; it hides the crooked wall as well. Whew!! Abry. That was close. I do not see the 100,000 bills flying away anymore.

THE BOAT REPAIR DOCK: The bulkhead for the boat dock is also constructed with interlocking steel sheet piling. These piles had a different profile than those of the west bulkhead. Their profile was an elongated Z and they were longer and stronger piles. Two piles made up a segment of the wall. They had to be stronger because the dock extended out into the harbor, deeper water and retained a higher earth backfill. A concrete cap was constructed on top of the wall connected to deadmen, the same way as the west bulkhead. The earth backfill was hauled in with trucks, compacted and brought up to the designed grade.

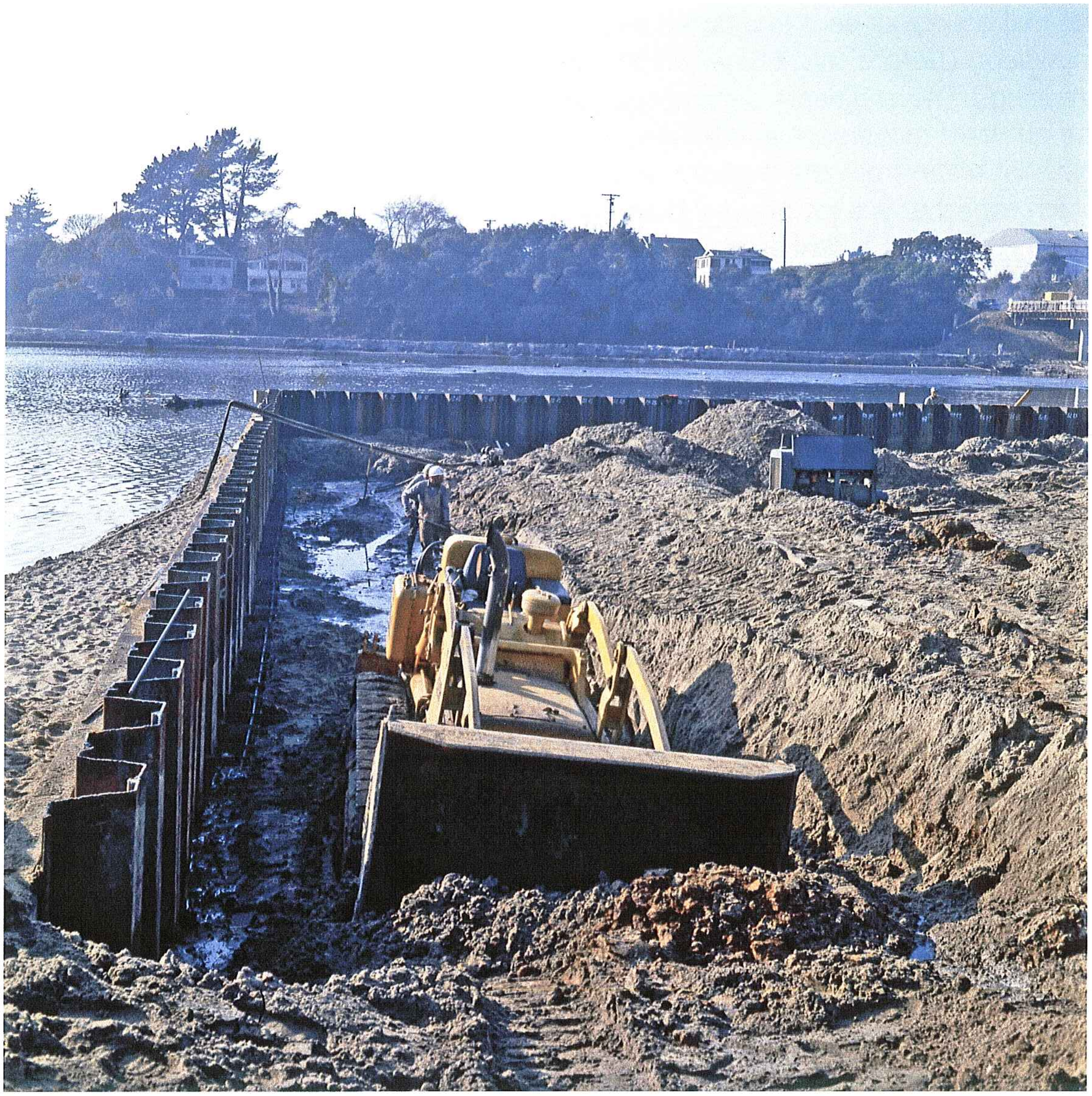


Figure 50. Sheet Pile bulkhead for the Boat Repair Dock. Excavating for tiebacks.

<u>THE PUBLIC PIER</u>. The public pier and the commercial fishing pier are adjacent to each other. They are located on the West Side of the harbor, near the south end of the west bulkhead and near the entrance to the west jetty. The structures are similar. Both are standard wharf like structures. It appears that Aldo's is built on a portion of the commercial fishing pier. Pressure treated timbers are used throughout the structures. The wooden piles are pressure treated with creosote preservative. All the other timbers were pressure treated with another wood preservative. The piles were driven on a line in a North South direction. 12 inches x 12-inch timber caps were placed on top of the piles. 6 inches x 12-inch stringers at 18-inch centers were placed from cap to cap. On top of the stringers is placed the 4 inch 12 inch deck timbers. All this material was handled and placed by the barge-mounted crane.

Figure 51. Installing Caps and Stringers for the public pier.

Figure 52. Constructing the Public Pier.

Figure 53. The Public Pier complete. Anchor piles in place for floatation units in the distance.

DREDGING: Dredging is excavation underwater. Most dredging is done to deepen or widen a harbor. Some dredges are used for mining. There are various type of dredging machines, such as digging buckets, bucket wheels, elevator buckets on a boom, scooping dredges, suction dredges and more. Granite Construction Company does not do dredging work. Because an approved disposal area, for the dredged material, was set up for this job, the designer expected the contractor to use a suction dredge. The suction method was also the most economical. The dredging of the project was subcontracted. Bids were obtained for the dredging. Shellmaker Dredging Company of San Francisco submitted the low bid to us. There was another bid. I do not remember the Company's name. Anyway, that company's bid was considerably more than the Shellmaker Company.

Figure 54. Shellmaker's Dredge. The Vagabond.

I will give you a description of Shellmaker's dredge named "The Vagabond." It was built on a hull 40 or 50 feet long and 12 or 14 feet wide. I do not know if it was manufactured elsewhere or home built. It appeared to be a home built one. The front is called the digging end and the rear is called the discharge end. On the front are the suction pipe and the cutter head. These are mounted on a boom that can be raised up or lowered. The cutter head is shaped like a sphere or like the shell of half an orange. It is 36 inches in diameter with the cutting blades about six inches apart. The cutter head revolves and the blades do the cutting. The main engine drives the cutter head with a drive shaft running down the boom. Within the lower half on the cutter head is the inlet end of the suction pipe. This is a 12-inch diameter pipe. As the cutter loosens the material it drops down in front of the suction pipe and is immediately sucked up along with gobs of water (5000 gallons each minute.) It goes through the pump and is discharged into the 12-inch transportation pipe to the disposal area.

At the back, the discharge end, there are two spuds, one at each corner of the dredge. A spud is a round, heavy, thick walled, steel shaft 6 or 8 inches in diameter and 40 to 50 feet long. It weighs several tons. It is mounted vertically at the extreme rear corners of the hull. Each spud is raised with a vertical tower cable hoist setting in front of them. They are raised with an electric motor driving the hoist. When they are lowered they are dropped, hard, the intent being for the spud to penetrate the ground as deep as possible, to serve as an anchor or a pivot. When the dredger is working it pivots on the one spud as it swings back and forth. Two engines supply the power for the dredge. I do not know the make or size of the engines. The main engine drives both the cutter head and a 12-inch diameter centrifugal water pump; this size pump will pump 5000 gallons of water per minute. Five thousand gallons equals 42,000 pounds or 21 tons. Imagine, Dillon, this pump will lift 42,000 pounds (5000 gallons) of water from the bottom of the harbor (about 20 feet deep) every minute push it through a 12 inch pipe 1200 feet, dump it into the ocean at a disposal area. This takes power. My guess is the engine had to have 375 or 400 horsepower. The second engine drives a 15 or 20-kilowatt generator (Dillon, a kilowatt is one thousand watts, but you knew that. Dillon is a great grandson.) This generator supplies the power to six electric motors of various sizes that drive the swing cable winches and hoists, plus the lights and minor electric powered tools, etc; The two larger electric motors are at the front of the dredge and power the winches that pull the swing cables. There are two smaller motors on the fore and aft, power boom hoists, and there are two on the aft spud lifting hoists. The swing cable winches and motors are the workhorses of the dredger. Anchors are placed on the banks, one on each side right and left. Attached to these anchors are sheaves (pulleys). The swing cables (1/2-inch diameter wire rope) are attached to the cutter head boom, one on each side, underwater. From there, the cables are led to the sheaves on the anchors and fed through the sheaves then back to the swing cable wenches on the dredge. With this setup the operator, from his high seat on the dredger swings the dredge back and forth as it pivots on the spud pivot on the rear of the dredge. The boom with he cutter head and suction pipe is lowered to the bottom and starts cutting and sucking up the water with the dirt. It is pumped into the transportation pipe, one thousand five hundred (1500) feet long. This pipe transports the pumped water with the solids to a disposal area. The pipe comes in mostly 40-foot lengths. There are some 10 and 20-foot lengths used to fit around curves.

The pipe was delivered and unloaded on the beach east of the east jetty. It was mostly in lengths of 40 feet. Here it was laid out; two or three lengths were put together and attached to especially designed floats at the joints. When together, these pipe joints deflected enough to withstand the rough swells of the ocean when floating in the waves. The discharge end of the pipe lies on a special float equipped with rings and wire rope cable to be attached to permanent anchors lying on the ocean floor over the disposal area. The pipe was put together, on shore, by putting two 40-foot pieces together and attaching them to a float making an 80-foot section of line with a float. A Cat. D6 bulldozer, rented from Granite, was used to move the pipe around on shore. The workboat managed to get close enough to shore to shoot a rope to shore, which was attached to the float carrying the outlet pipe. The 80-foot section of pipe with the float was attached to the outlet pipe on the raft and together with the tug pulling and D6 bulldozer pushing the first 160-foot section was pulled out and was afloat. After this another 80 foot section was attached and pulled out and so on and on until the outlet end was over the disposal area. This was about 1000 to 1200 feet from the beach. After permanently (for the duration of the job) anchoring the floats for the outlet pipe, the workboat was hauled back to the harbor. Here the same crew put together the rest of the pipe from the beach running on shore northerly along the east side of the harbor, to about the middle of the harbor and into the water. Here it is connected to the dredge. Six or eight lengths of pipe are left floating in the harbor to be used for adding or removing pipe from the floating line as the dredge works up and down the harbor.

The dredge needs a workboat, sometimes called a tender, to service it and take care of its needs. One that ferries supplies, between dredge and shore, as it works. That is a real necessity as the dredge is not self-propelled. The workboat transports the crew from shore to the dredge and back. It brings on supplies, fuel, oil, and water; moves the dredge, when it is in a long move, acts as a tugboat. The work boat also places, moves and maintains the transportation pipeline, floating in the harbor, which is connected to the dredge.

Within the harbor, the bottom of the channel is elevation minus 14 feet (-14), that is 14 feet below sea level. (Mean Lower Low Water MLLW). In the berthing areas the elevation is -10 and -12 feet MLLW. A rough measurement from the plans by one of the engineers calculates there is approximately 375,000 cubic yards of sand and silt to be pumped out of the harbor. This material will be pumped through the transport pipeline to a disposal in the ocean selected by the Army Corps of Engineers. An area is selected where the pumped in material will cause the least amount of environmental damage.

To start, the workboat moved the dredge to the upper part of the harbor, near the new bridge. The transportation pipeline was attached to the discharge pipe on the dredge. The swing cable anchors were set out, one on the left bank (facing downstream towards the ocean) and one on the right bank. The swing cables are connected. Everything is ready to go. The operator starts the engines, lowers the cutter head boom with the suction pipe to the ground. The cutter head is turning; the suction pipe is sucking, gulping up 5000 gallons of water per minute along with some solids, (sand & silt) and spills all out into the ocean 1200 feet from shore. The operator raises the right spud and locks it up. The left one is left in for a pivot pin. With the swing cables in place the operator slowly swings he dredger to the left about 60 degrees. He stops the dredge and swings back to the right the 60 degrees plus another 60 degrees to the right, making an arc of 120 degrees.

Figure 55. Dredge refueling at the public pier.

When the dredge has dug down two feet below designed grade, it moves ahead. The operator swings the dredger to the left so that the right spud is two to three feet ahead of the left one. Then he drops the right spud and raises the left one. Now the dredge is two to three feet ahead and starts the digging again. The dredge has developed a cut face under water. As the dredge pumps out the material, the sand keeps flowing in towards the dredge, it develops a cut face, approximately on a 4 to 1 slope. The dredging contractor Bill-------? I do not remember his last name, told me it was normal to dig or cut two feet below designed grade because the dredger cannot finish to a finer grade. Some places the finish is at the designed grade and other places it is two feet below the finished grade. In addition, there are some small ridges between the cuts, other material moves in from the sides, and solids move in from rainwater runoff. Under water currants will smooth out the ridges and irregularities. I asked Bill how much earth; sand and silt the dredge will pump out every day. He told me from about 250 to 350 cubic yards per hour depending on the type of material the dredge is digging. If the material is lighter silt, it will probably move 350 cubic yards per hour and if the material is heavy gravel it will pump about 250 cubic yards per hour. Calculated by weight and if my calculations are correct that is 2000 to 2800 cubic yards of solids per day.

Figure 56. Dredging through for the harbor opening, the first time.

All went along fine, the engines were moaning away (they were housed in soundproof shelters) day after day, month after month. After the first few weeks of pumping, I walked on the beach, down the coast from the disposal area and I could not see any signs of dirt or pollution in the water or sand.

Figure 57. Set up installed to pump ocean water back into the harbor

Pumping water out at 5000 gallons a minute would lower the water level in the harbor. There was a sand bar across the opening of the harbor. After a few days dredging one could see dredging had lowered the water in the harbor. During the spring and early summer, about every high tide, ocean waves would break over the sand bar and refill it with water. The elevation of the beach sand outside of the harbor was at plus three or four and if that sand bar would break when the water in the harbor was low, there would be a catastrophe. The incoming surge would wash back in a 100,000 cubic yards of sand in just hours. One could not let the water in the harbor get too low. When the days got to the end of summer, the waves were not breaking over the sand bar and there was not enough water in the harbor to perform the daily work. So then, what do they do? It was critical that the water inside the harbor and the water outside the harbor be kept at the same level; plus the harbor had to contain enough water for the dredge to be able to work. What did the subcontractor, Shellmaker, do? They pumped ocean water back into the harbor.

Figure 58. Ocean water being pumped back into the Harbor.

On the East Side of the west jetty and on the ocean side of the sand bar, a platform was built on stilts, partially over water. The top of the platform was at about elevation plus10. From this platform, a 12-inch suction pipe was jutted into the ocean. On top of the platform a 12-inch pump (the same size as the one on the dredge) driven by a diesel engine, was installed. The discharge end of the pump was connected to a 12-inch pipe running on top of the jetty back to and spilling into the harbor. The outlet pipe was installed on a little downhill slope to take advantage of gravity. The last excavation to be made was to dig through the sandbar. The dredge had somewhat of a hard time dredging through the sandbar. It had to work in the waves and breakers a good part of the time and took quite a beating. It was not long until the sand bar was all dugout and the harbor was ready for sea going small boat traffic. The Coast Guard from Monterey came and set the buoys outlining the sidelines of the channel. The harbor was ready for use, but not finished.

This is the story of the construction of the first phase of the Santa Cruz Harbor.

PHASE 2. Phase 2, Index also called the inner harbor consisted of constructing the west bulkhead wall and the boat repair area, both consisting largely of driving interlocking steel sheet piling. Both of these structures had to be complete before dredging could begin. After dredging was complete the construction of the floating units and berthing stalls was constructed. As Granite did not own any floating pile driving equipment, the driving of the woodpiles, anchoring the floating units was subcontracted. Earl and Wright Co. an engineering firm with offices in the bay area designed phase 2 of the harbor project. Granite's bid for constructing phase 2 was, One Million Nine Hundred Seventy Thousand ($1,970,000.00) Dollars. (In 1963 dollars)

PILE DRIVING. The pile-driving contractor moved in with four semi truckloads of equipment all part of a portable floating barge. Each load was loaded with one large tank, about five or six feet in diameter and 20 feet long. The tanks were alike and appeared to have a capacity of about 5000 gallons. Also on the truck with them were a number of steel beams of various lengths, shapes and sizes. One of Granite's truck cranes was rented to help unload and to assemble the barge. The tanks were the floating units for the homemade barge. Abe, I will describe this barge to the best of my ability. Eight of the beams, about 30 feet long, were made with cradles on the ends to fit the tanks. One tank was set into the cradles of two beams. The second tank was set into the cradles on the beam opposite the first. The other two tanks were assembled the same way. The tanks were spread apart about 30 feet. The beams with the cradles were underneath the tanks. The beams under the tanks were braced and cross-braced. These tanks in a steel skeleton were pushed and pulled down the launching ramp and floated. Similar steel beams were then put across the top and fastened onto strong brackets welded to the tanks, which now looked like large clamps holding the tanks. All the steel beams connecting the tanks were braced and cross-braced. Then girder like steel beams was place on the top of all this, which appeared to be about 10 feet apart. The next day other trucks came with the wooden deck made in panels. These panels appeared to be 8 feet wide and 20 feet long, made from 3 inch by 12-inch planks and I think these planks were double (laminated) making a 6-inch thick deck. These wooden panels were bolted or attached to the steel girders, making the deck of a floating barge. A small crawler crane was run up onto the deck of the barge. The crane was about the size of one that could handle a 3/4 cubic yard bucket. It is then called a 3/4 cubic yard crane. The crane was chained down to the barge. Granite's crane swung the pile driving leads to the barge and helped connect them to the boom of the crane. The leads hang from the boom like two legs of 8 inch by 8-inch timbers, about 30 or 40 feet long, held together and parallel with a number of heavy trough like U shaped steel brackets. The leads are lined on the inside with steel runners in which the pile driver hammer was pulled up and down with a cable from the crane.

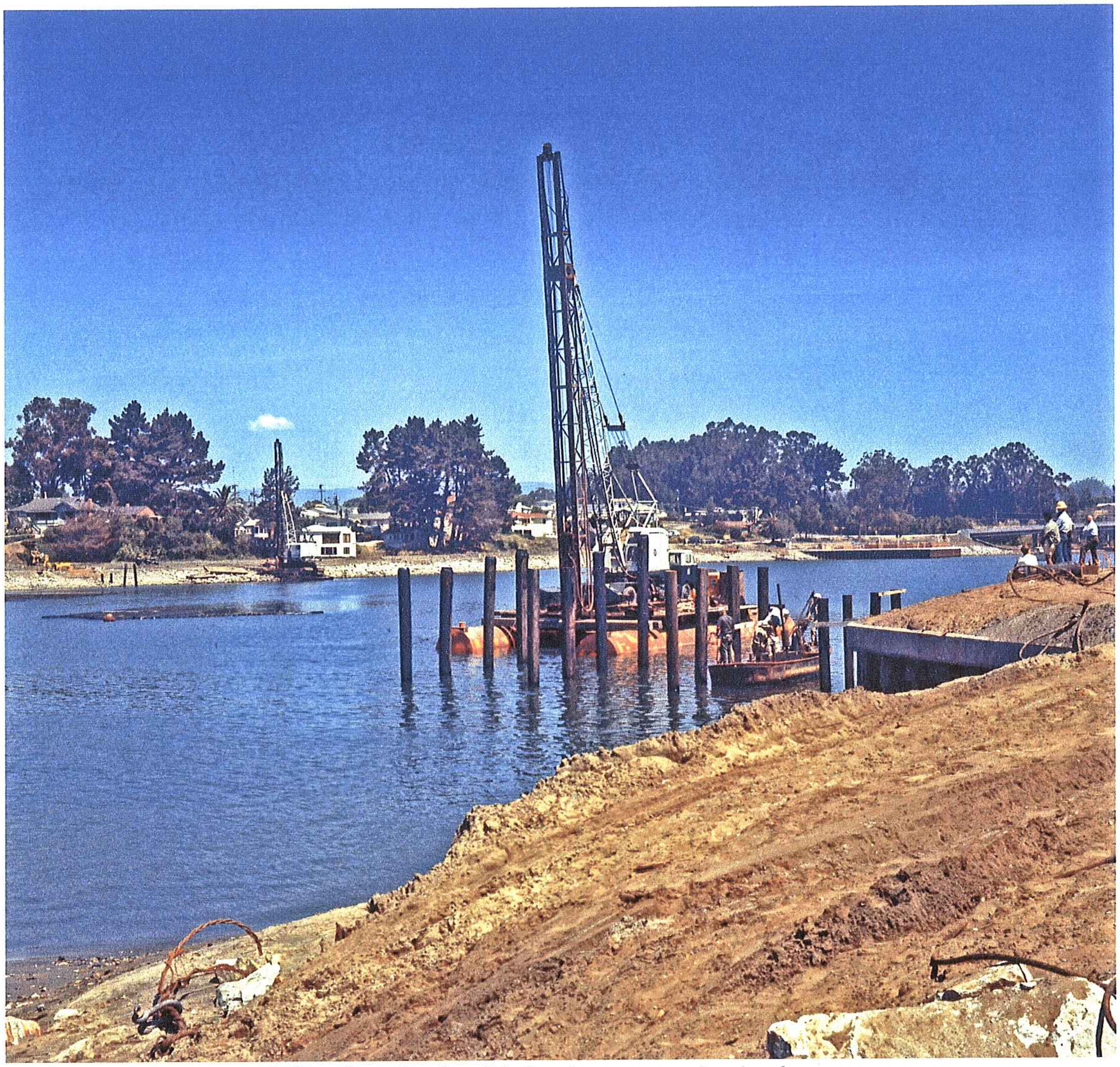


Figure 59. Driving piles for deck off the boat repair dock.

DIESEL PILE DRIVER. A diesel pile-driving hammer was swung over, installed in the leads, and attached to the cable from the crane. A diesel pile-driving hammer needs no steam or compressed air to run; therefore it eliminates a steam boiler or a compressor on the barge. This pile driver runs by itself, almost like a robot. (Note here, Dillon. Great grandson Dillon is into robots.) I think you would like to know how this works. Here is how. It runs like a two-cycle diesel engine. A small hammer, like the one used on this job, looks like a long cylinder about two feet in diameter and six feet high. On the bottom is a steel cap about the right diameter to fit the diameter size of a standard wooden pile. It sets down on top of the pile. On top of this cap and all in one piece with the cap is the firing chamber of the pile driver. Protruding into the firing chamber is the fuel injector. In the same cylinder, is a free running piston, with piston rings, not unlike the piston in an automobile engine. It is free running and not connected to anything. It is solid steel and a lot heavier and longer than an automobile cylinder. In guessing, the piston in this hammer weighed about 1000 to 1500 pounds. To start the driver running, the piston is raised with a line from the crane. When it gets to the top, a trip releases it and the piston drops. On the way down, it passes the exhaust and air intake valve ports and so closes them and compresses the remaining air in the cylinder. When the piston reaches the bottom and at the right mille-second a charge of fuel (either diesel or kerosene) is squirted under pressure into the firing chamber. The heat from the compressed air explodes the fuel. The explosion in the chamber not only drives the pile downwards but also drives the piston up to start the cycle over again. As the piston travels upward it passes the exhaust port and discharges the exhaust fumes. Now as the piston is still traveling upward the intake port opens and it sucks in clean air. When it reaches the top it no longer needs a trip to release its downward motion. This cycle is repeated over and over, the pile driving hammer runs until someone pulls a rope that holds a valve open. A diesel pile-driving hammer runs at about 40 to 50 cycles per minute. One can see the piston from the outside when the piston comes out of the top after each firing. (Dillon, is this a robot?) I have seen diesel hammers where the piston weighs 5 tons or more. The pile driver needs resistance to create enough pressure in the firing chamber to set off the fuel. When starting, the tip of the pile is setting in mud or a soft earth material; the fall of the hammer will not create enough pressure when it hits the firing chamber. The weight and fall of the piston does drive down the pile some. Sometimes the crane operator has to raise and drop the piston 5 or 6 times, before enough resistance is built up to create enough pressure causing the heat to set off the explosion.

SOURCE OF PILES. The piles and lumber (prefabricated) for the flotation units was bought from The Neidermeyer Martin Co. in Portland Oregon. This company specialized in pressure treating wood with preservative. The piles were impregnated with creosote. The lumber for the flotation units was impregnated with a different material, because the lumber had to be handled, put together, nailed etc., to make up the units. I think it was a liquid preservative called coppernate. (Note: Creosote preservative is very hard on the human skin. Workers would put on gobs of ladies cold cream on their hands and faces to protect their skin.) This company in Portland has long pressure tanks, over 100 feet long, to treat the piles. For the lumber, they have shorter tanks. As I understand the process, used at that time, the lumber or piles were placed into the respective tanks and submerged in the liquid preservative. Then the tanks were pumped up with air pressure and held for a predetermined period of time. More or less of the preservative would be impregnated into the fibers of the wood, determined by the length of time it is under pressure. No doubt, by this time, there have been many improvements made in both the preservative material used and the method of impregnating the wood.

The barge-mounted pile driver now drives all the piles that are in the harbor, the piles for the dock and those for the flotation units. A surveyor's transit on shore and a tape on the barge spot the positions for each pile. It also drives the piles for the Public pier and the Commercial fishing pier.

FLOTATION UNITS. The lumber for the flotation units came by truck from Portland Oregon in lengths cut to fit and were modular. Ray Tallman, the foreman here, set up a long table, an assembly line, where they would be put together. They were nailed, bolted and otherwise fitted with connectors, rings and other hardware, as called for in the specifications. The plastic foam floating blocks were installed on the under side. Attached also was the conduit that the electrical wiring supplied the boats with lights and power. The Adams Electric Company of Santa Cruz installed the electrical work on the units and made all the connections after the units were afloat. Potable water service was installed by Granite. After all this they were tipped into the water, floated into their respective positions, and connected. Large rings about 18 inches in diameter were slipped over the piles and connected to the floats, to keep them from floating away. The rings allowed them to raise and lower with the tides.

There was one problem. The boat owners tied up next to or near the piles did not like the piles as they were. They were all cut off flat on top, which made an ideal perch for a seagull and you know what, a sea gull can do a lot of damage to anything under him. Granite under an extra work order was instructed to obtain sheet metal dunce caps and install them on all piles. The seagulls could not sit on those pointed dunce caps.

Abe, I must mention here, there is also a railroad bridge crossing the Woods Lagoon. It was located near the ends of Eaton St. and Murray St. The new highway bridge built across the harbor connected Eaton St. and Murray St. The railroad bridge is up stream, just north and adjacent to the new highway bridge. Before Phase 3 of the harbor was put into use, the Southern Pacific Railroad Co reconstructed the railroad bridge. This needed to be done to allow boats to pass through and underneath it.

Figure 60. Installing reinforcing steel for Murray St. Bridge piers.

PHASE 3. Sometimes called, "The Upper Harbor", which was that part of the harbor up stream from the two bridges. The upper harbor consisted of: 1. Construct the entrance roads and parking areas, 2. Lowering a Pacific Gas & Electric Company's high-pressure gas main, 3. Underwater excavating, dredging.

1. Constructing the entrance roads and parking was no problem as we do that type of work every day.

2. Lowering the Pacific Gas and Electric Company's high-pressure natural gas line under the harbor was of some concern, as we do not do that kind of work every day. The existing water level was at elevation 4. The ground or mud was at elevation 2.The existing pipeline was at elevation minus 6 and was to be lowered to minus 14 or minus 16. (I am not sure about these elevations, but they are approximate.) That meant a trench 18 feet deep had to be dug and all under water. There was no way a trenching machine or a backhoe could get into that water and mud to dig a trench and the work was too little to bring in a

trencher or backhoe on a barge. A dragline system was the best way to do this chore.

One of Granite's truck canes was set up on the north shore. At that time, the width of the lagoon was about 200 feet. A dead man for a haul back line was buried in the ground about 300 feet away from the crane. That meant over six hundred feet of wire rope line would be required. These cranes used 1/2-inch diameter wire rope. The drums holding the wire rope, for ordinary work, only held 150 feet of cable. It was necessary to change the drums to a larger size to hold over 600 feet of cable. The new line was to be installed upstream or to the east of the existing line. P.G. & E. Co. had an established plan. The new pipe line came off the existing line at an angle to the north, then down the east bank and into the water continuing down at that same slope to elevation minus 16, then at that level across the width of the harbor and up to the top of the west bank, then at an angle to the south and connecting back into the existing line.

This was an all welded pipeline. P.G. and E required certified welders on all their high-pressure gas lines. Fortunately, Granite had some certified welders working on a pipeline job for P.G.& E. in the Taft Bakersfield area. Three of these men were brought to Santa Cruz to weld together this pipeline. Due to their skill, they were all highly paid men. The pipe was laid out in a U shape, with the sides of the U laid back at about 50 degrees, to fit the trench.

The excavation was started. The going was very slow. About 100 cubic yards was excavated on the first day. Under ideal conditions a dragline set up like this one, would excavate 600 cubic yards per day. The mud from each side kept running into the trench and the crane dug and dug and dug. Finally the mud stopped running in. I guess there was no more mud. A boat and a surveyor's wooden rod, was used to check the grade of the trench. New pipe was bought and the welders were put to work welding the pipe together. All the welds were x-rayed. No bubbles or voids were found in the metal. All welds passed OK. When the pipe was welded together in the shape to fit the trench, and the trench dug to grade, lines from the crane were attached to the pipe. The dragline was attached to the front end and the haul back line attached to the back. The pipe was pulled in the water over the trench. It was filled with water to make it sink in properly in place. After the pipe was in place and checked that it was at the proper depth, the crane with the clamshell bucket back filled the trench. The water was pumped out of the pipe. P.G. & E connected the pipe to the live line at each side of the harbor. The old pipe was dug out, cut into 20-foot lengths and hauled to the P.G. & E's corporation yard.

PHASE 4. Phase 4 consisted of the flotation units for phase 3, the upper harbor. Phase 4 was a separate contract. Granite was not the low bidder for this part. Another contractor, Troutwine Bros. was the successful bidder. This company specialized in constructing flotation units for small craft harbors.

CORPS OF ENGINEERS. There was six Corps of engineers personnel, engineers and inspectors, working on the project full time. They are the representatives of the government and the people to see that the work is done with good quality material and good workmanship. A job requirement was to hold monthly safety meetings with the engineers and inspectors. The job superintendent chaired their meetings. All of these engineers were willing and helpful at all times. They were a good bunch to work with. It was so long ago I cannot remember any of their names.

Santa Cruz Harbor is one of the best. It must have spaces for nearly 1000 boats. It is a boon to the entire area. It is well managed, is well maintained and is always clean and neat. Much credit must go to Brian Foss and his team.

Almost all of the trade unions were represented in the work of constructing the harbor. They are the following:

Operating engineers,
Carpenters,
Construction laborers,
Teamsters,
Pile Drivers, and
Concrete finishers.

There was never a large crew of people working on this project at one time, only 20 to 25 men. The number needed varied. Some men, at different times, would be taken off the Harbor job to work on another job, and then replaced again when needed. Granite Construction Company always has a number of local jobs under construction, on a continuing basis. These jobs are of various sizes, from a sidewalk patch to a multi million-dollar job. Men and equipment can be dispatched and exchanged between jobs, which makes steadier work for the employee, the work more efficient, and better use of the equipment, which all results in a lesser cost. Many good men of all trades worked on this project, the names of which I cannot remember. Some of the employee's names are:

Cliff Skinner, Foreman concrete work
Earl "Doc" Petrick, Carpenter foreman, small structures.
Ray Tallman, Foreman pile driving and flotation units.
Brian Kelly, Project engineer, #1. A few months after the beginning of he project, Brian was removed and sent to engineer another project and replaced by:
Bob Burick, Project engineer #2

James Gaither, Project superintendent.
Jim Browne, Chief estimator and assistant branch manager.
Orville Smith, Crane operator.
George Ponza, General superintendent and dispatcher, Santa Cruz Branch.
The one and only George Ponza, a rare guy, kept us all on our toes.

Figure 61. Working late to finish a section of the concrete spine before the storm.

Index. Paragraph Titles. Santa Cruz Harbor.

INDEX OF DRAWINGS

INDEX OF DRAWINGS

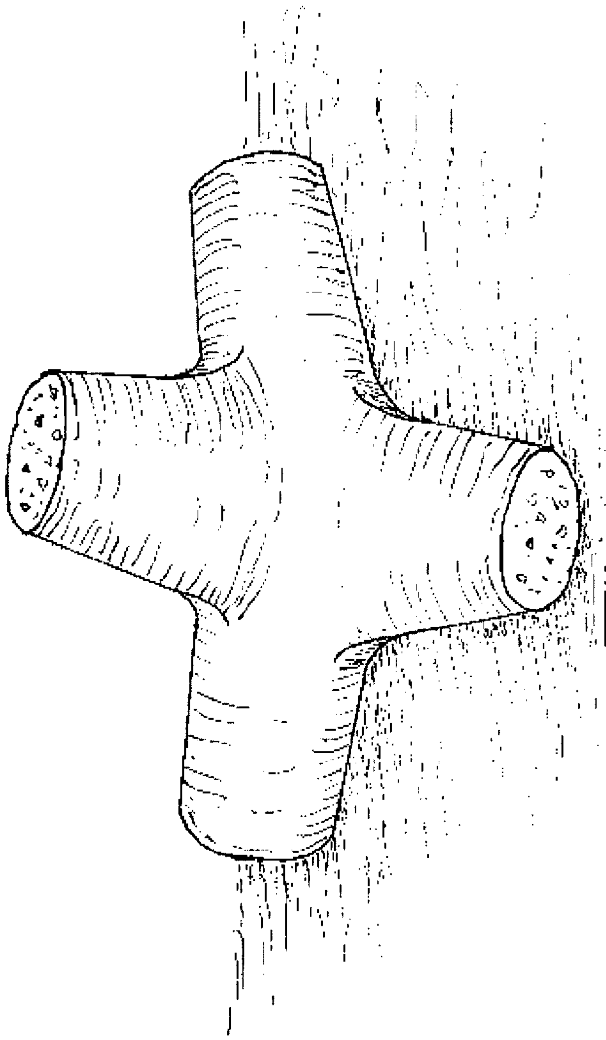
OVER

OVER

OVER

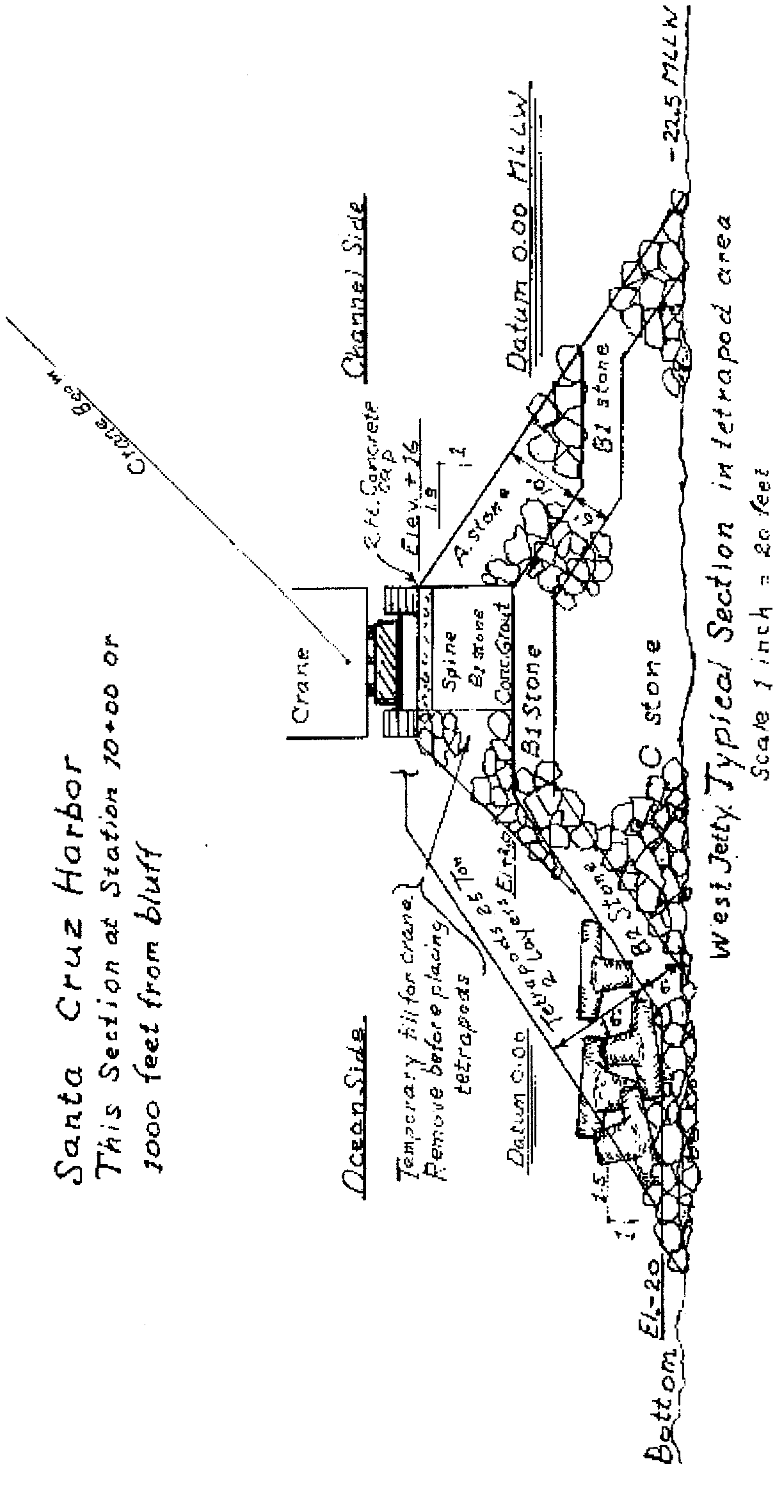
OVER

Santa Cruz Harbor



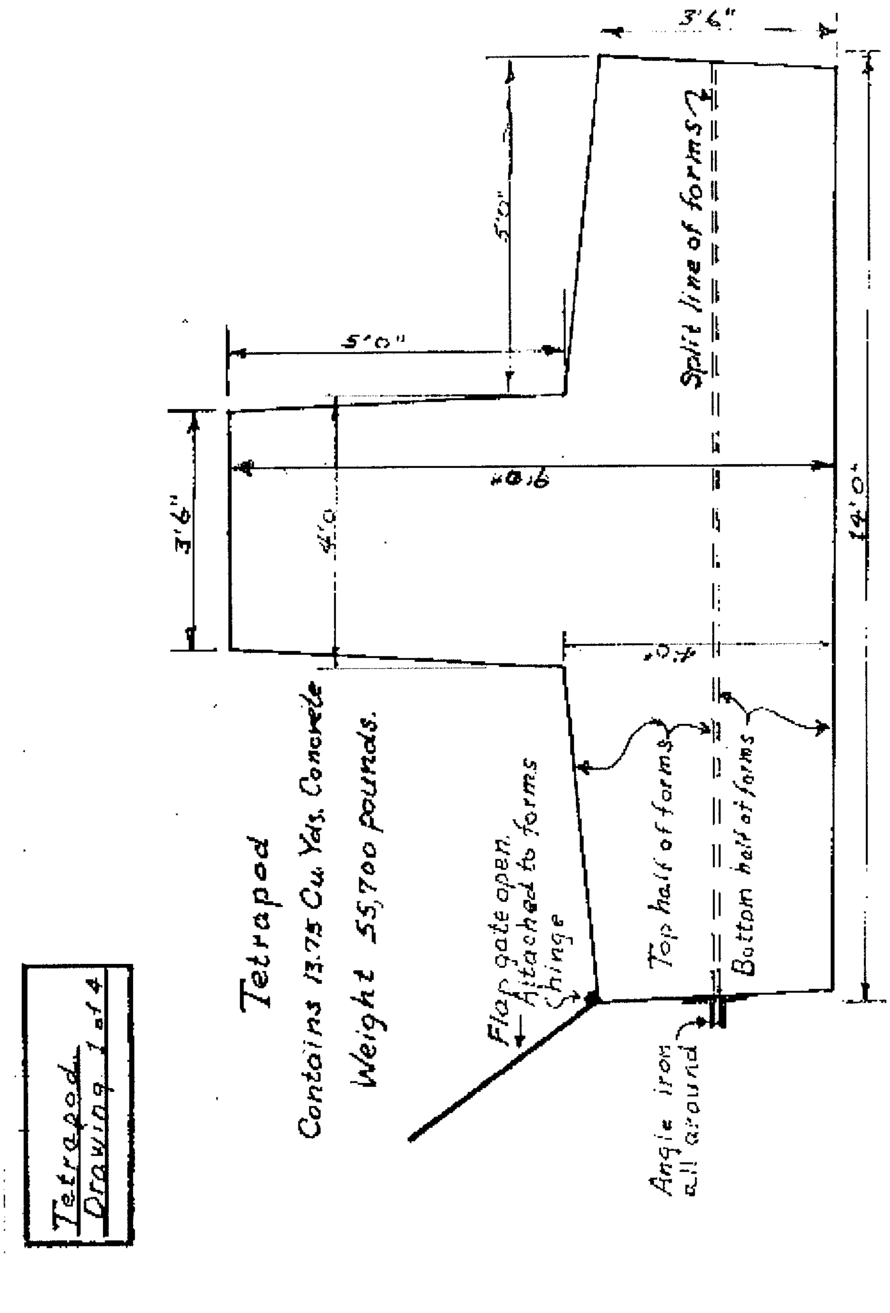
Sketch of a Tetrapod

Fig. 1



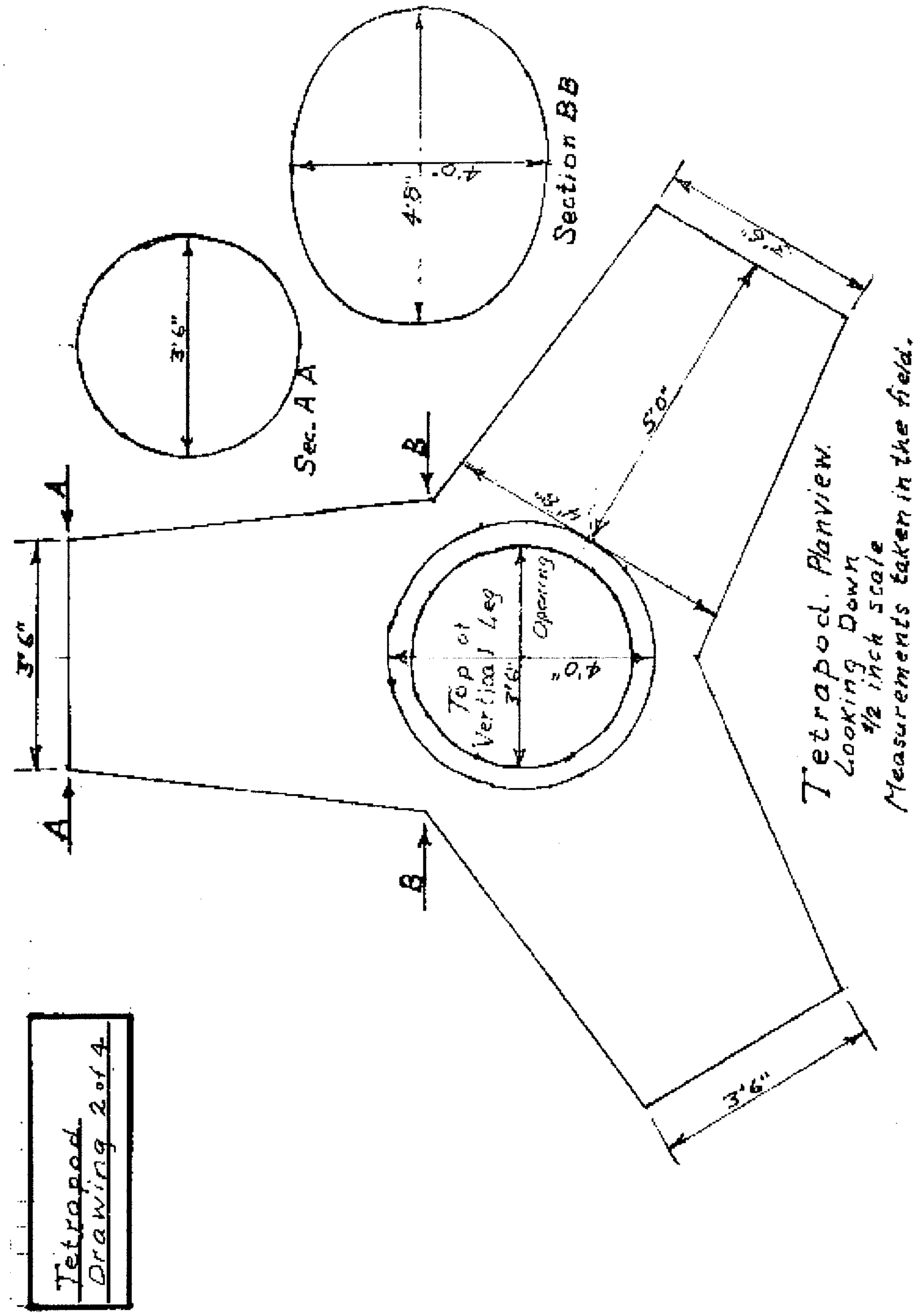
West Jetty Typical Section in tetrapod area
Scale 1 inch = 20 feet

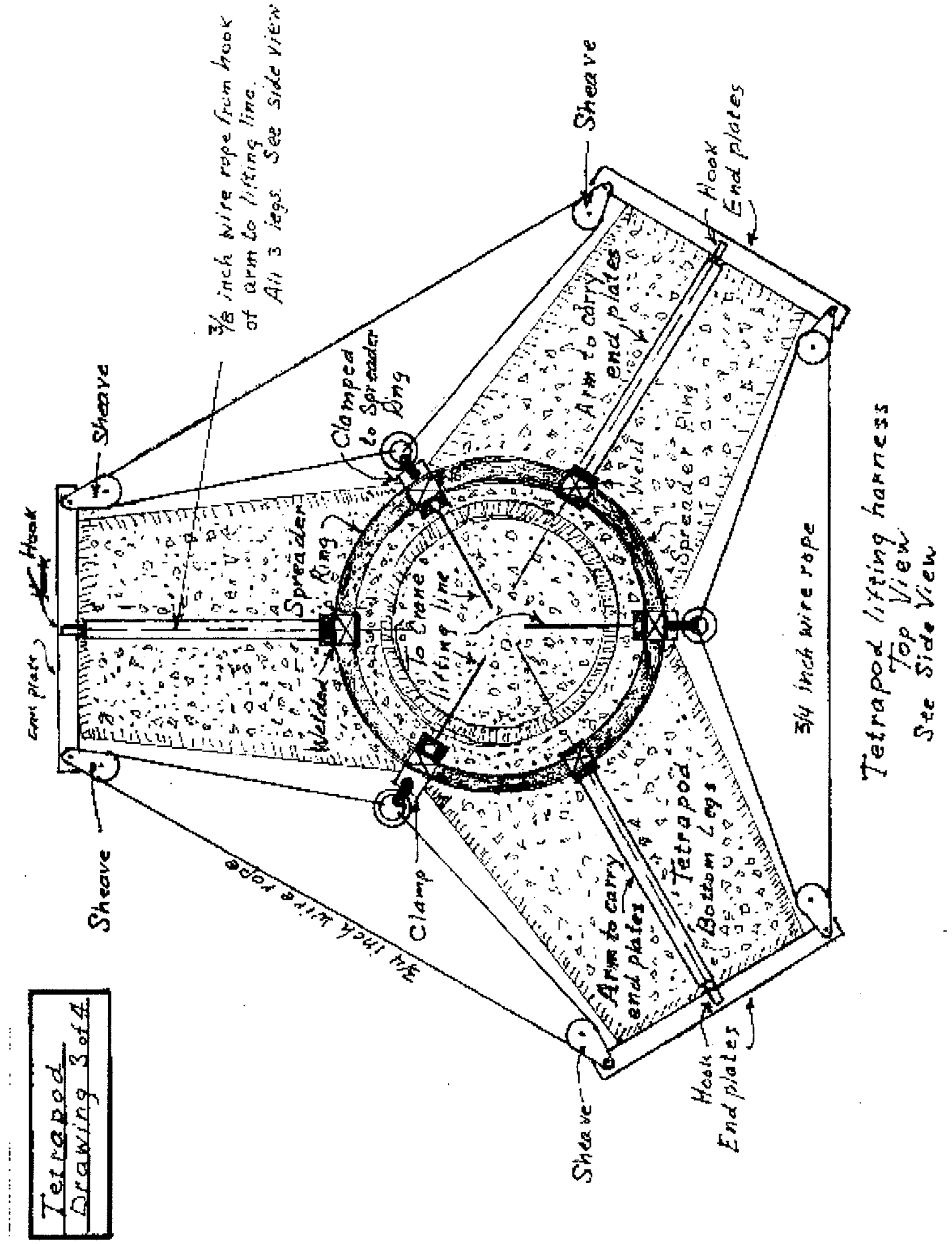
Fig. 2

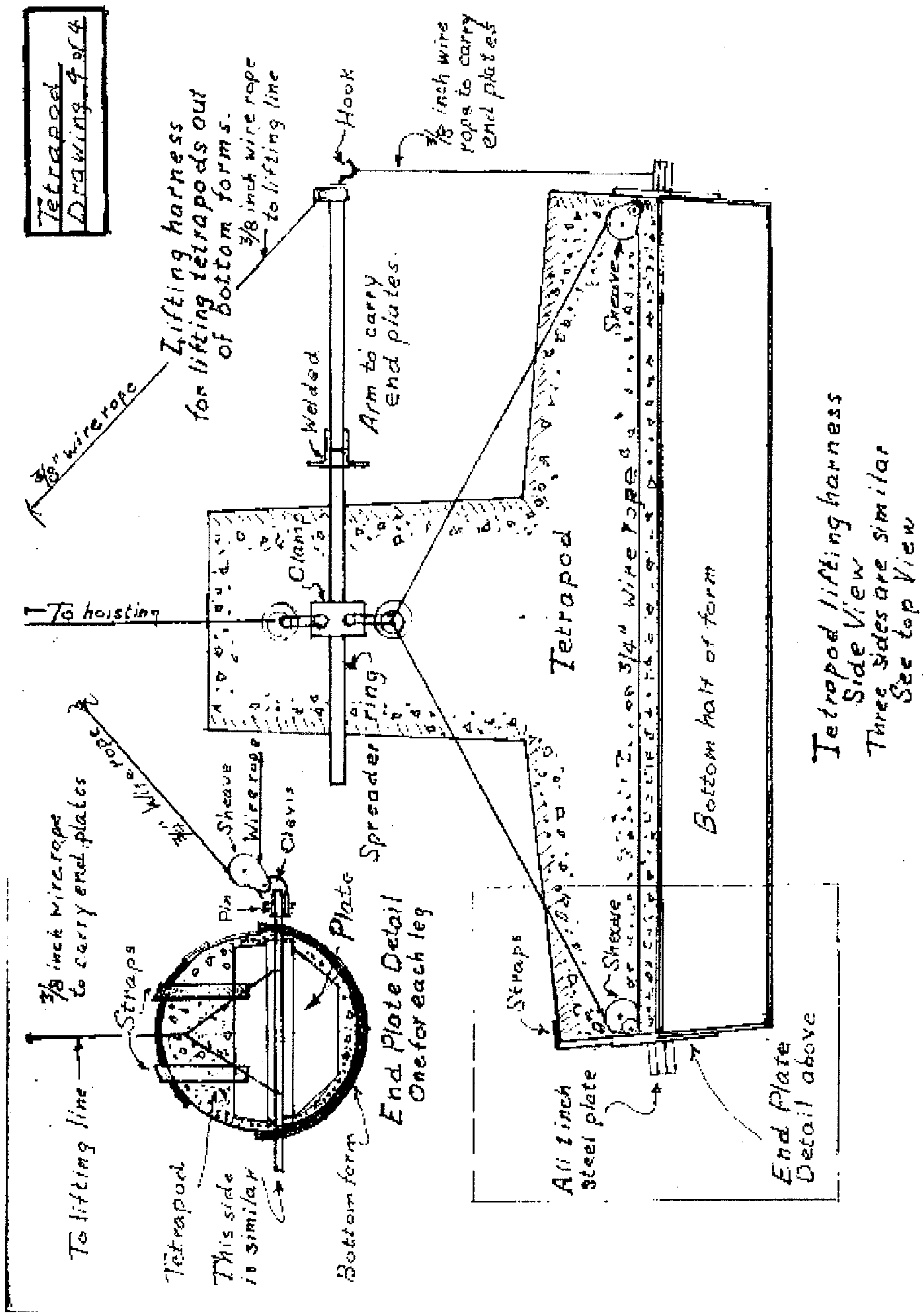


Tetrapod Side view
not to scale.
see plan view
Measurements taken in the field;
approximate only

Fig. 3


Section BB
4'8"
4'0"
Sec. A A
3'6"
A
A
B
B
3'6"
5'0"
3'4"
3'4"
Top of Vertical Leg
3'6"
Opening
4'0"
3'6"
Tetrapod. Planview.
Looking Down
1/2 inch scale
Measurements taken in the field.
Fig. 4
Tetrapod
Drawing 2 of 4


Tetrapod
Drawing 3 of 4
3/8 inch wire rope from hook of arm to lifting line. All 3 legs. See side view
Sheave
Sheave
Sheave
Sheave
Sheave
Hook
End plate
Hook
End plates
Hook
End plates
Clamped to Spreader Ring
Spreader Ring
Weld
To Crane lifting line
Arm to carry end plates
Arm to carry end plates
Weld
Spreader Ring
Clamp
Tetrapod Bottom Legs
3/4 inch wire rope
3/4 inch wire rope
Tetrapod lifting harness
Top View
See Side View


Tetrapod
Drawing 4 of 4
Lifting harness
for lifting tetrapods out
of bottom forms.
3/8 inch wire rope
to lifting line
Hook
inch wire
rope to carry
end plates
wire rope
Welded
Arm to carry
end plates
Clamp
To hoisting
Spreader ring
Tetrapod
Sheave
3/4" wire rope
Bottom half of form
Straps
Sheave
All 1 inch
steel plate
End Plate
Detail above
3/8 inch wire rope
to carry end plates
Straps
Sheave
Wire rope
Clevis
Pin
Plate
End Plate Detail
One for each leg
To lifting line
Tetrapod
This side
is similar
Bottom form
Tetrapod lifting harness
Side View
Three sides are similar
See top View
Fig. 6

Page 1. Index of Figures

Page 2. Index of Figures.

APPENDIX.

Santa Cruz Harbor.

This is a continuation of the story showing photos taken before construction and photos taken after completion.

The present day pictures are those of today (5/26/07) and are the prominent picture on the page. A comparative picture of the same location taken during construction is the smaller picture on the page.

Index. Present Day Photos

Before and after photos.
Before photos were taken during construction
After photos were taken 40 years later on 4/28/07

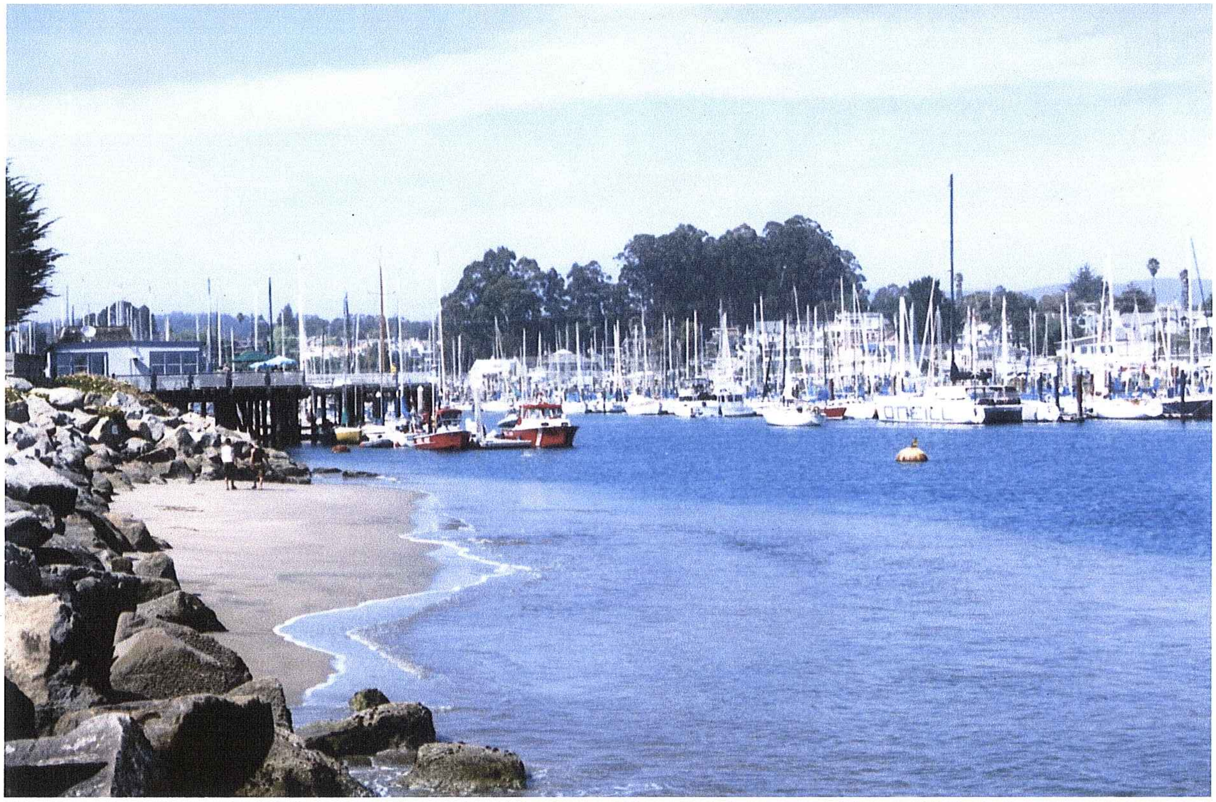


Figure 2a. East Cliff Drive after the Harbor. The bridge and East Cliff Drive are removed.

Figure 2. East Cliff Drive before the Harbor. Bridge is a Corrugated Metal Arch attached to a Concrete slab on footings, with headwalls.

Figure 8a. Location of the assembling of the crane. Near the Crow's Nest.

Figure 8. Assembling the crane. It takes a small one to lift the parts onto the big one.

Figure 9a. After the dry lagoon is filled with water. This view is from the east end of the Murray St. Bridge.

Figure 9. The Dry lagoon.

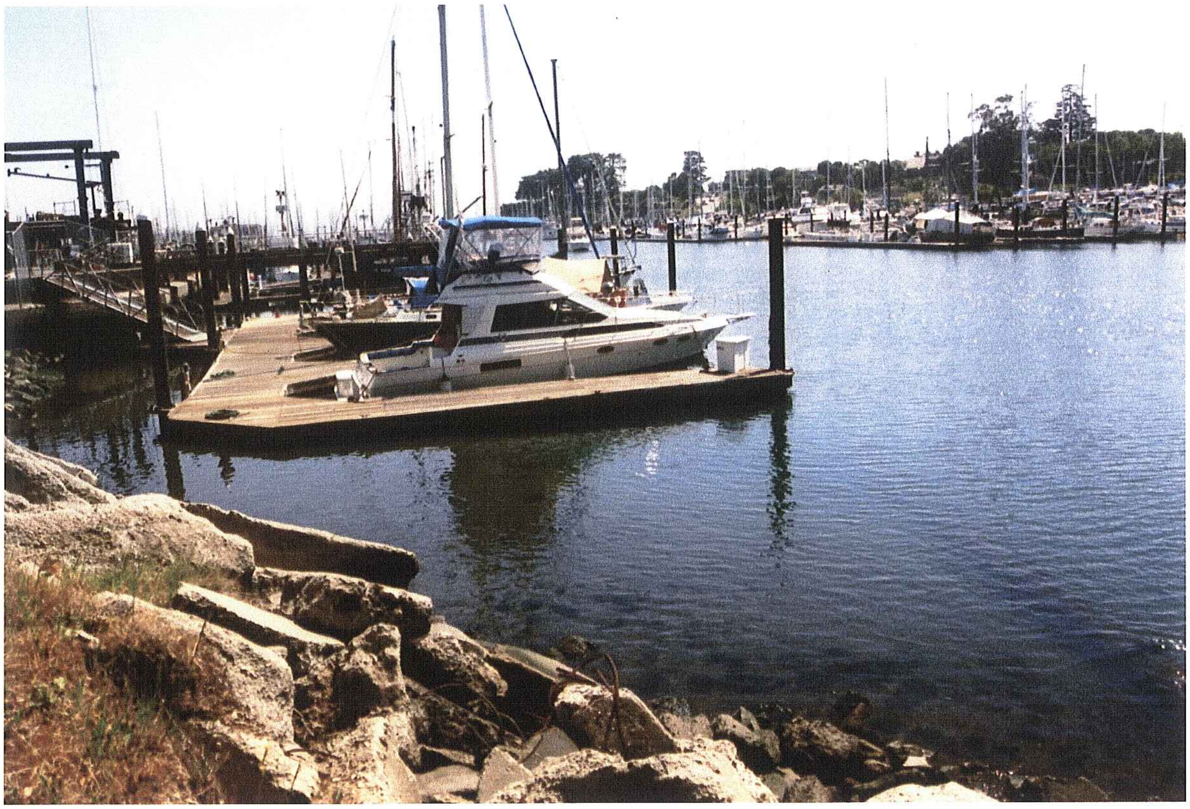


Figure 10a. Access road on the east side, after construction.

Figure 10. Access road on the east side.

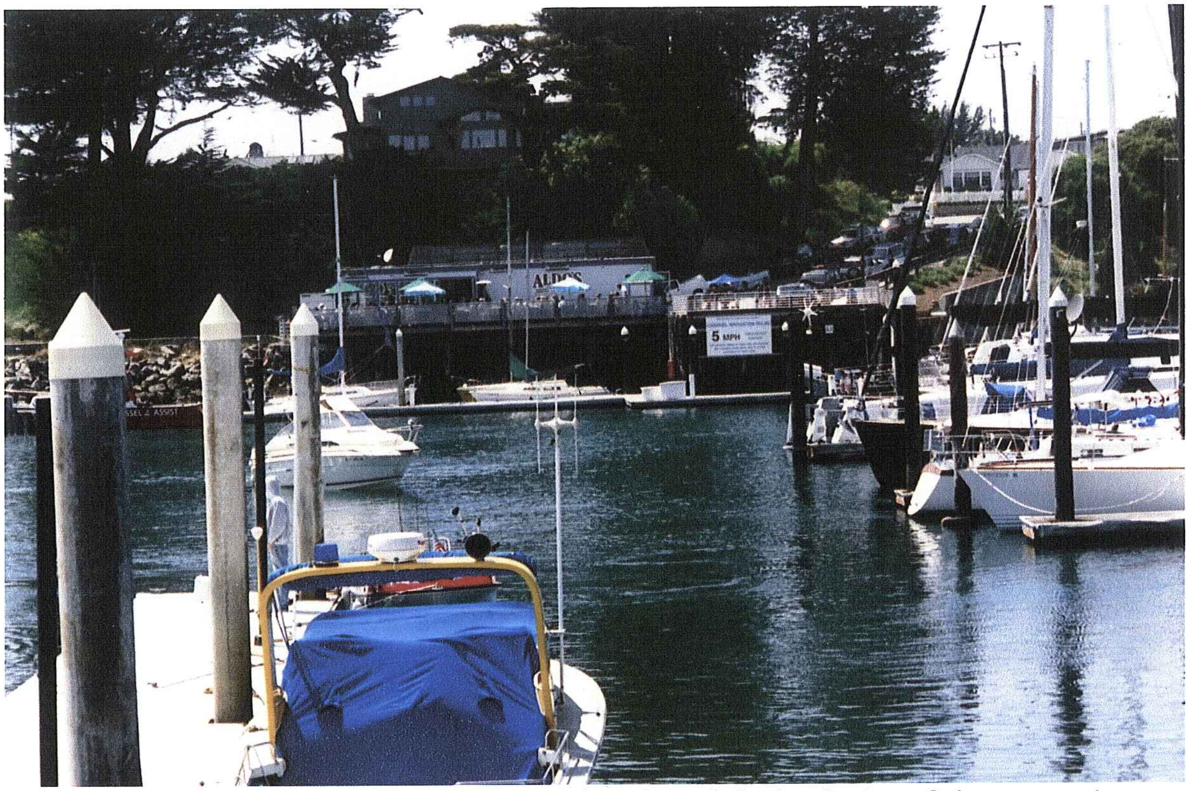


Figure 12a. West of Aldo's Restaurant. Near location of the beginning of the excavation for the west jetty

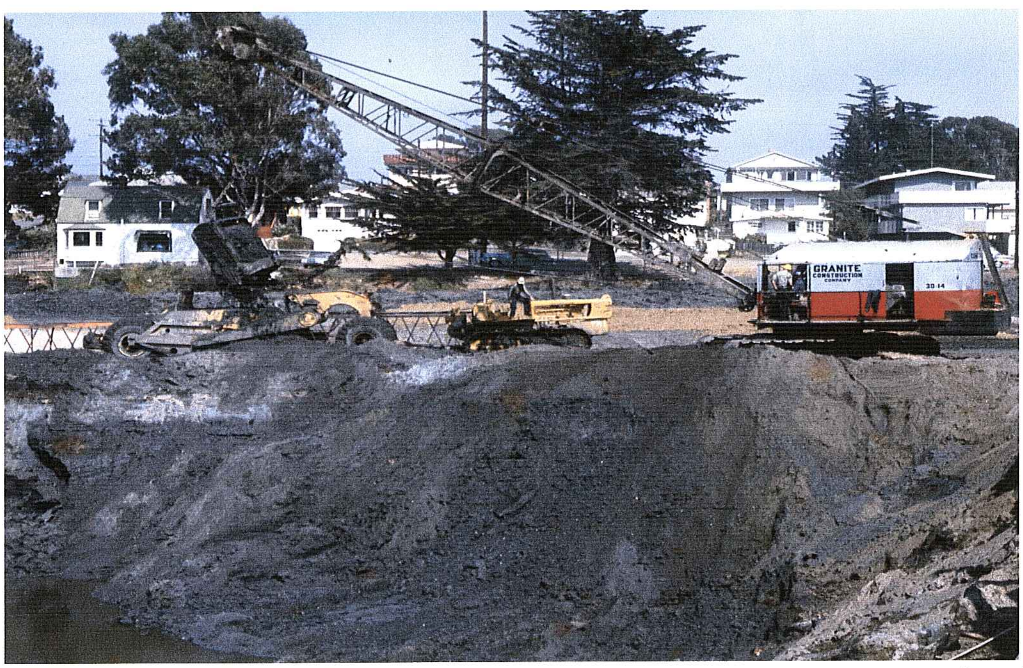


Figure 12. Beginning excavation for west jetty. Near present-day Aldo's.

Figure 29 a. Approximate location of the 10-ton stone. Here the west jetty is complete.

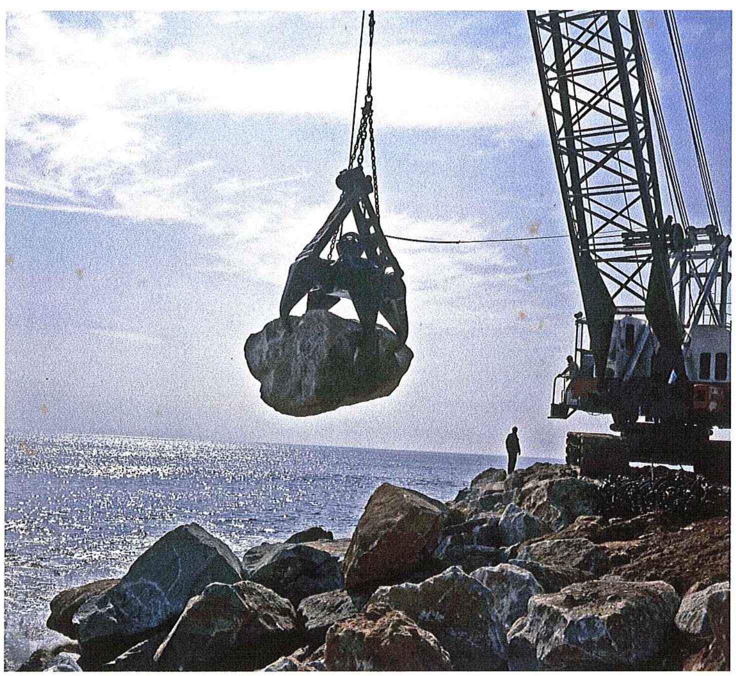


Figure 29. Crane unloading a 10-ton stone. Before the west jetty is complete.

Figure 40a. Southerly half of the west jetty after completion

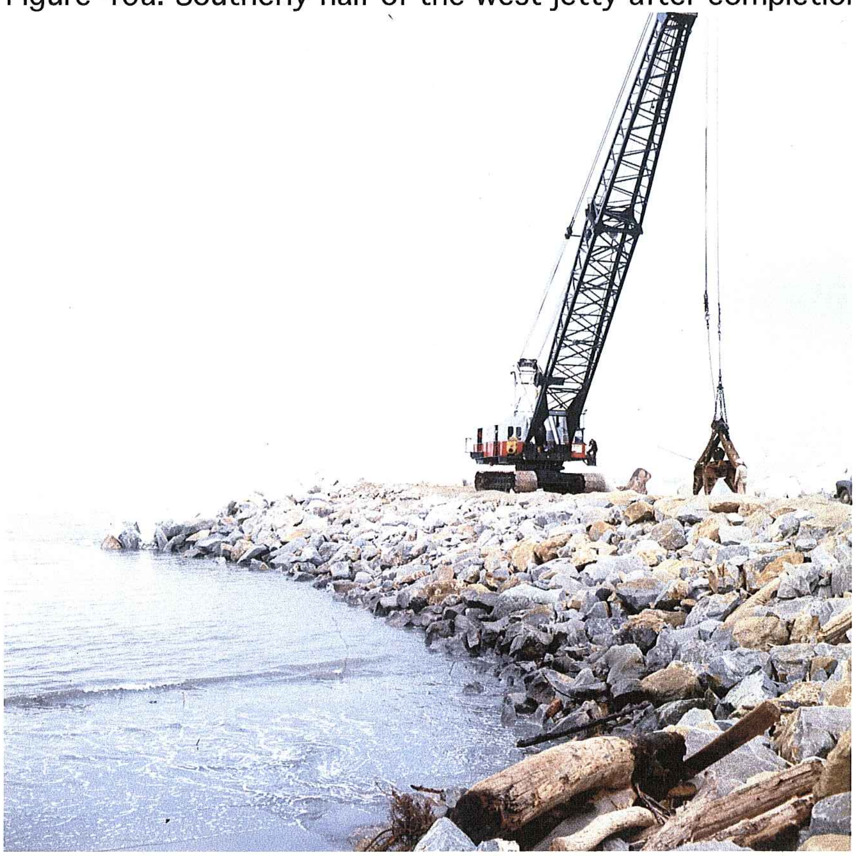


Figure 40. West jetty complete. Crane moves off

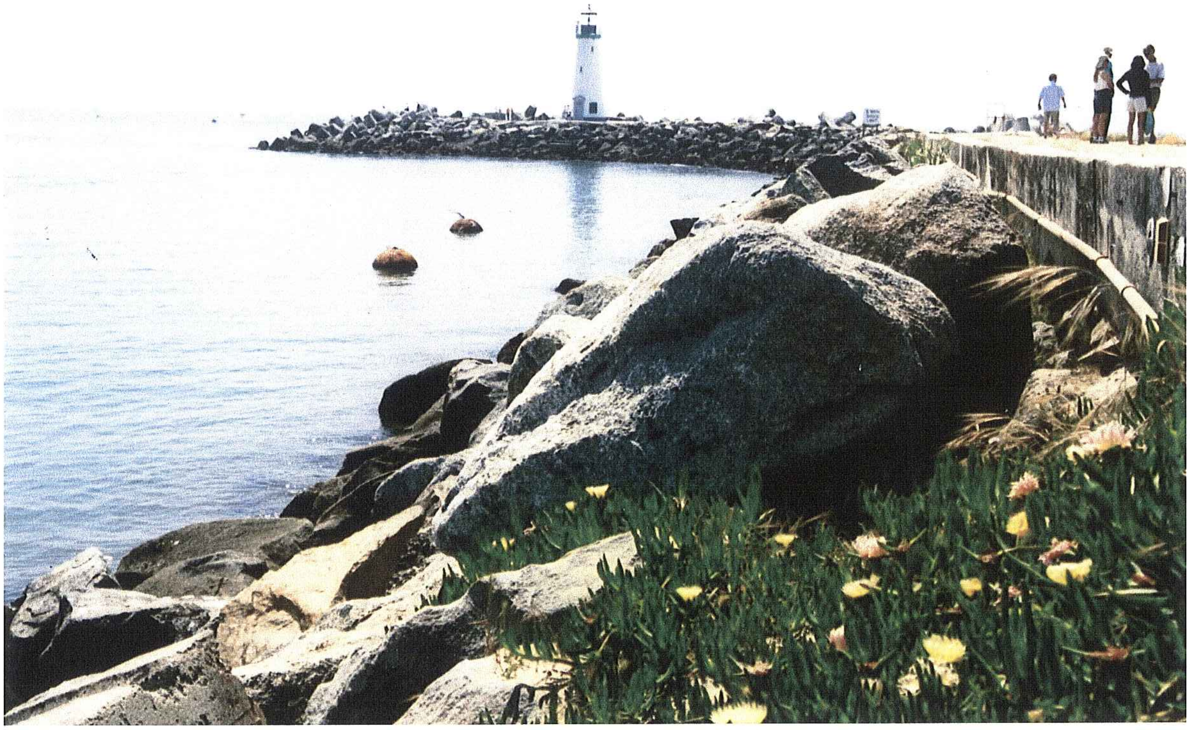


Figure 19a. Approximate location of the largest stone in the jetty. (18 ton)

Figure 19. Unloading an 18 ton stone

Figure 27a. The first grout section finished.

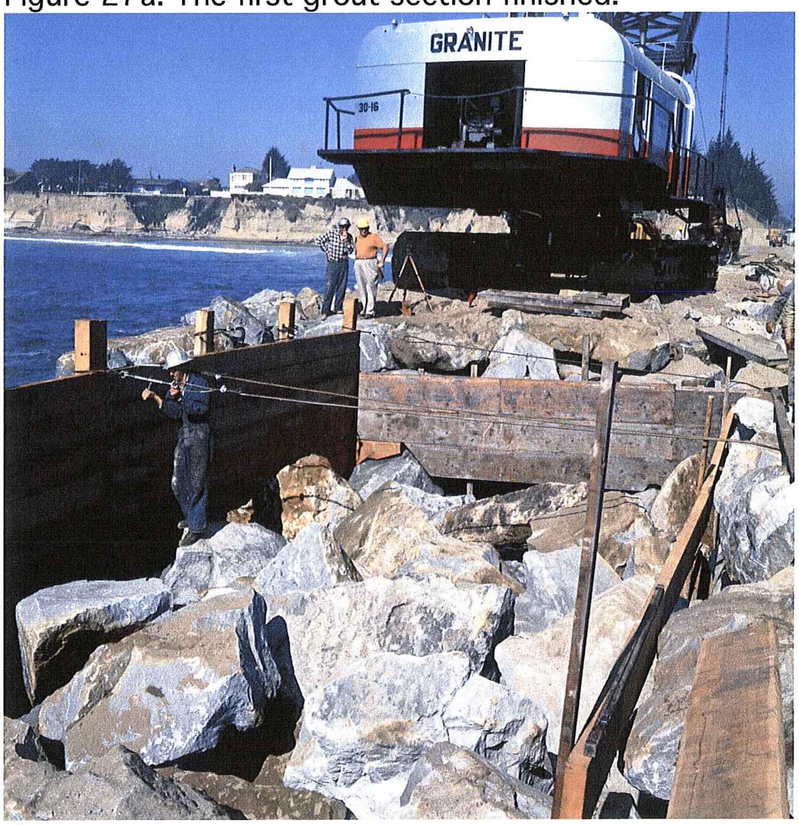


Figure 27. Forms ready to receive grout.

Figure 42a. Completed launching ramp.

Figure 42. Installing reinforcing steel in launching ramp.

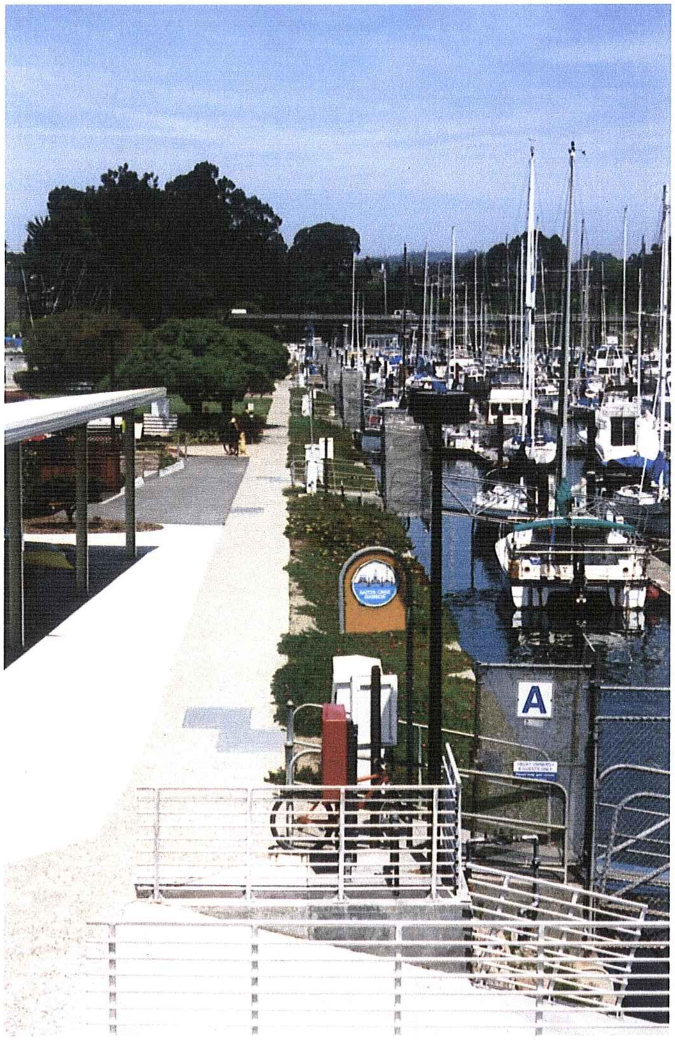


Figure 49a. Location of the completed bulkhead wall, present day. Facing North.

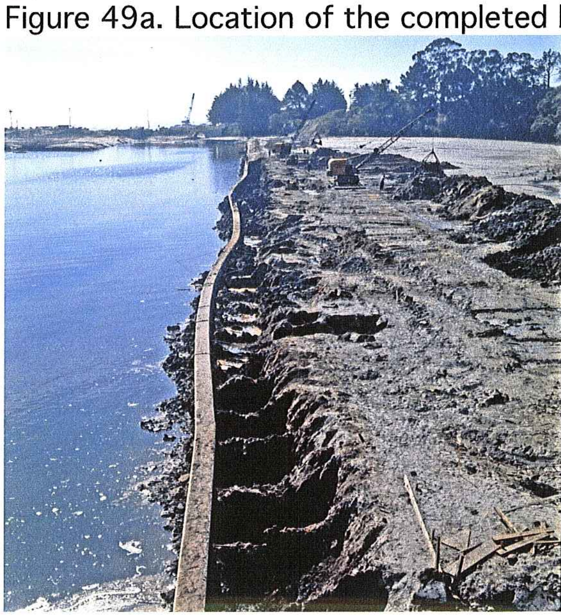


Figure 49. Exposed damaged bulkhead before repair. Facing South.

Figure 49 a. Damaged bulkhead with the conctete cap built over it.

Figure 49. Top of capped bulkhead before damage.

Figure 36a Location of the first tetrapod

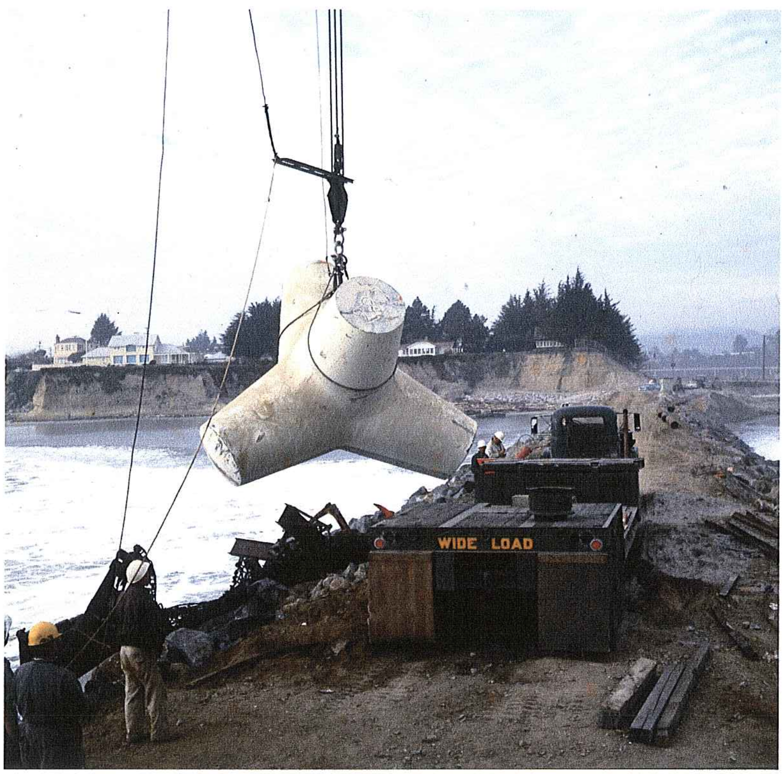


Figure 36. Unloading the first tetrapod.

Figure 39a. A pile of tetrapods.

Figure 39. During a storm.

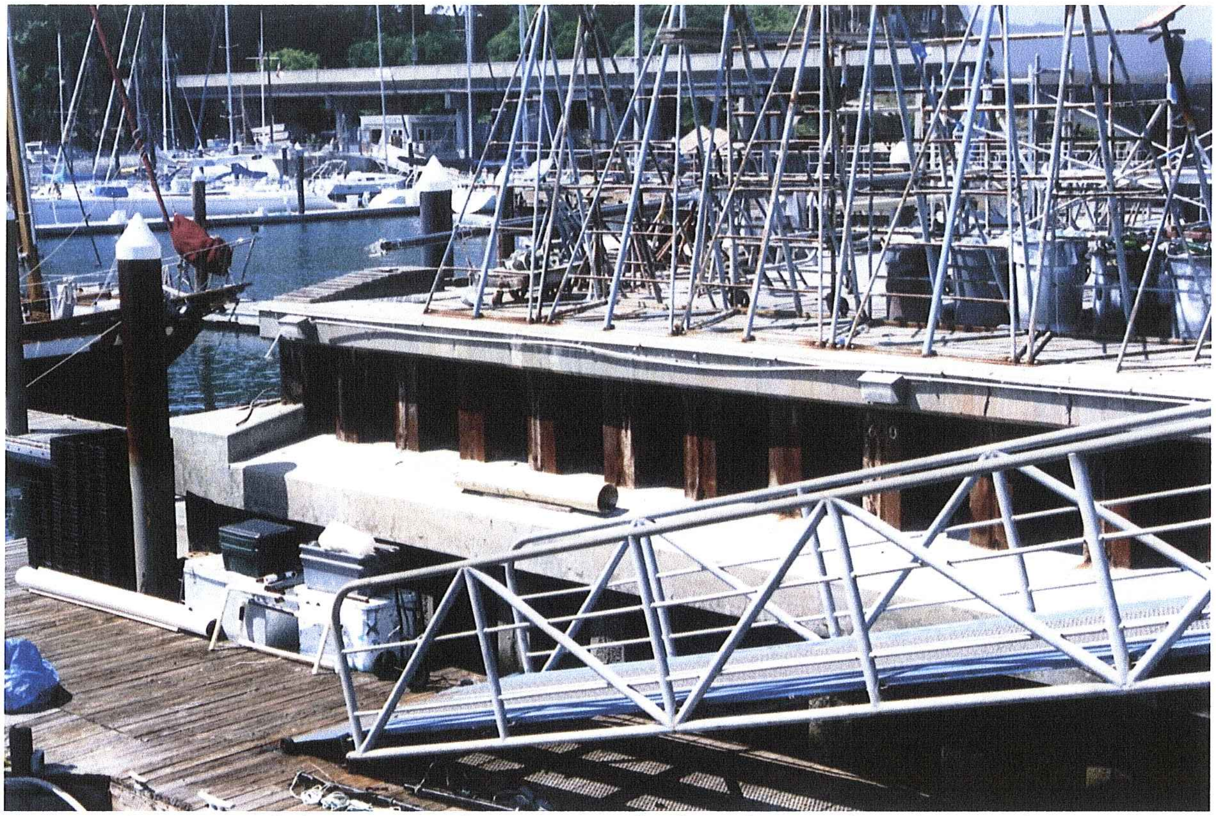


Figure 50a. View of the present boat repair dock with completed construction on the sheet pile bulkhead.

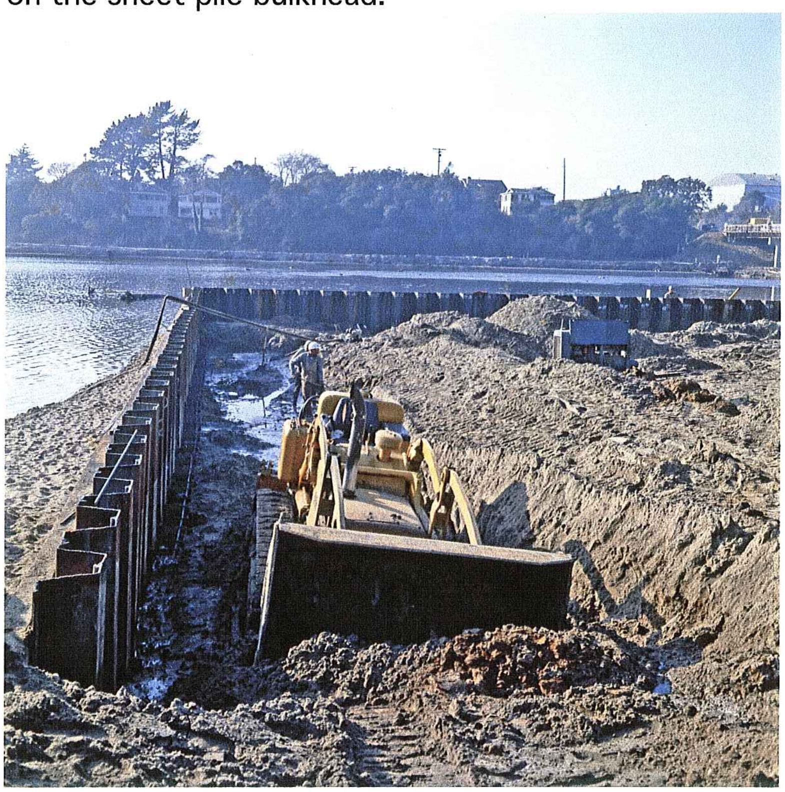


Figure 50. Sheet Pile bulkhead for the Boat Repair Dock. Excavating for tiebacks.

Figure 53a. Public pier near Aldos.

Figure 53. The Public Pier under construction. Anchor piles in place for floatation units, in the distance. Aldo's is now to the right of this pier.

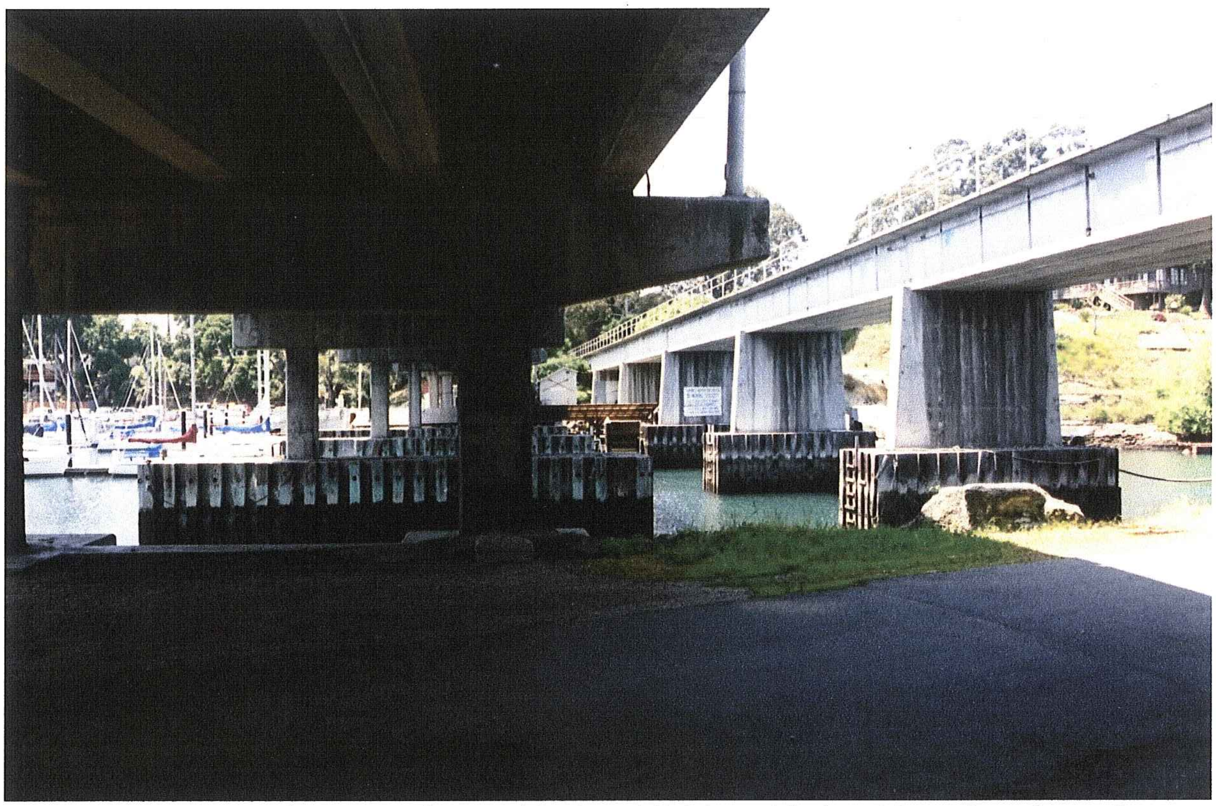


Figure 11a. Murray Street Bridge and Railroad Bridge side by side, taken from the east end.

Figure 11. Access road and working pad for Murray St bridge.

Figure 60. Installing reinforcing steel in piers for the Murray St. bridge.

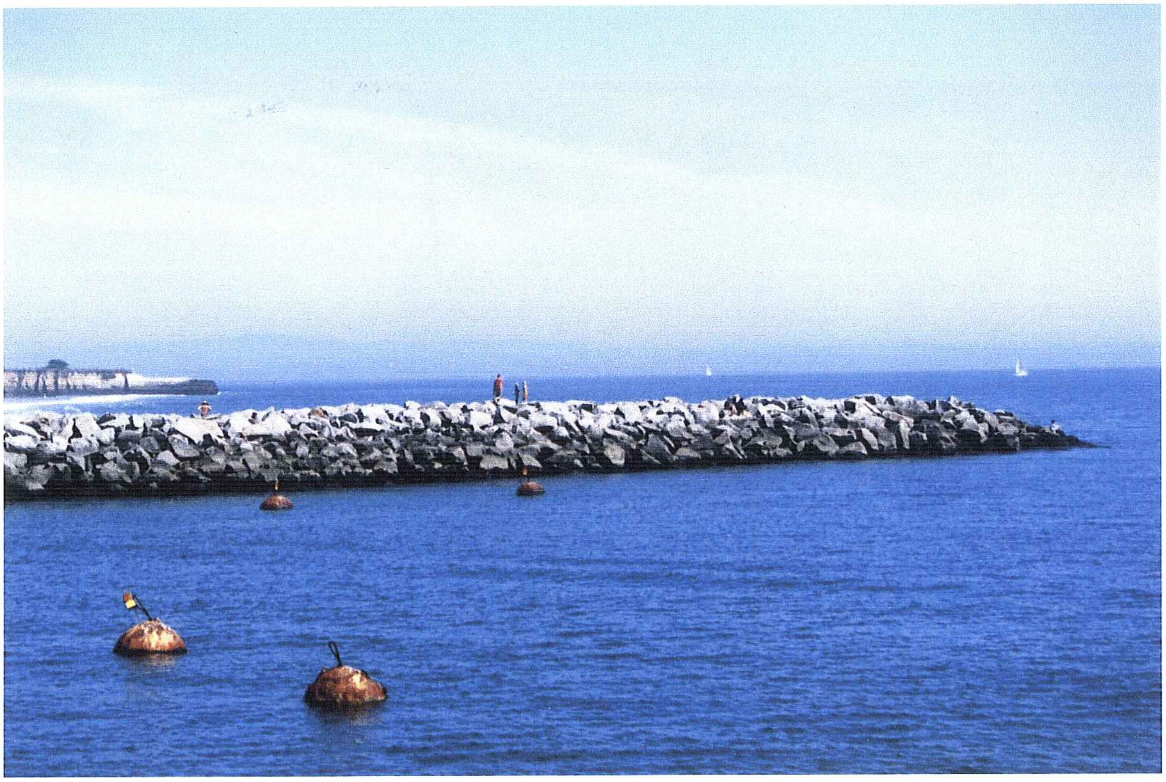


Figure 38a. Finished East Jetty. Harbor opening, notice buoys outlining channel.

Figure 38. Crane working on the East Jetty. Notice the sand, before the harbor mouth was opened.

Fig. 56a. Keeping the Harbor open today.

Figure 56. Dredging through the opening for the first time.

Figure 61a. Jetties today. We see the east jetty as well as the west jetty.

Figure 61. Waiting for the storm looking toward the west jetty, facing west, before the east jetty was built.

Harbor opening from the Murray Street bridge.

Additional photos not used in the body of the story.

Fig. No. 1. Section at end of spine, on west jetty filled with fresh grout.

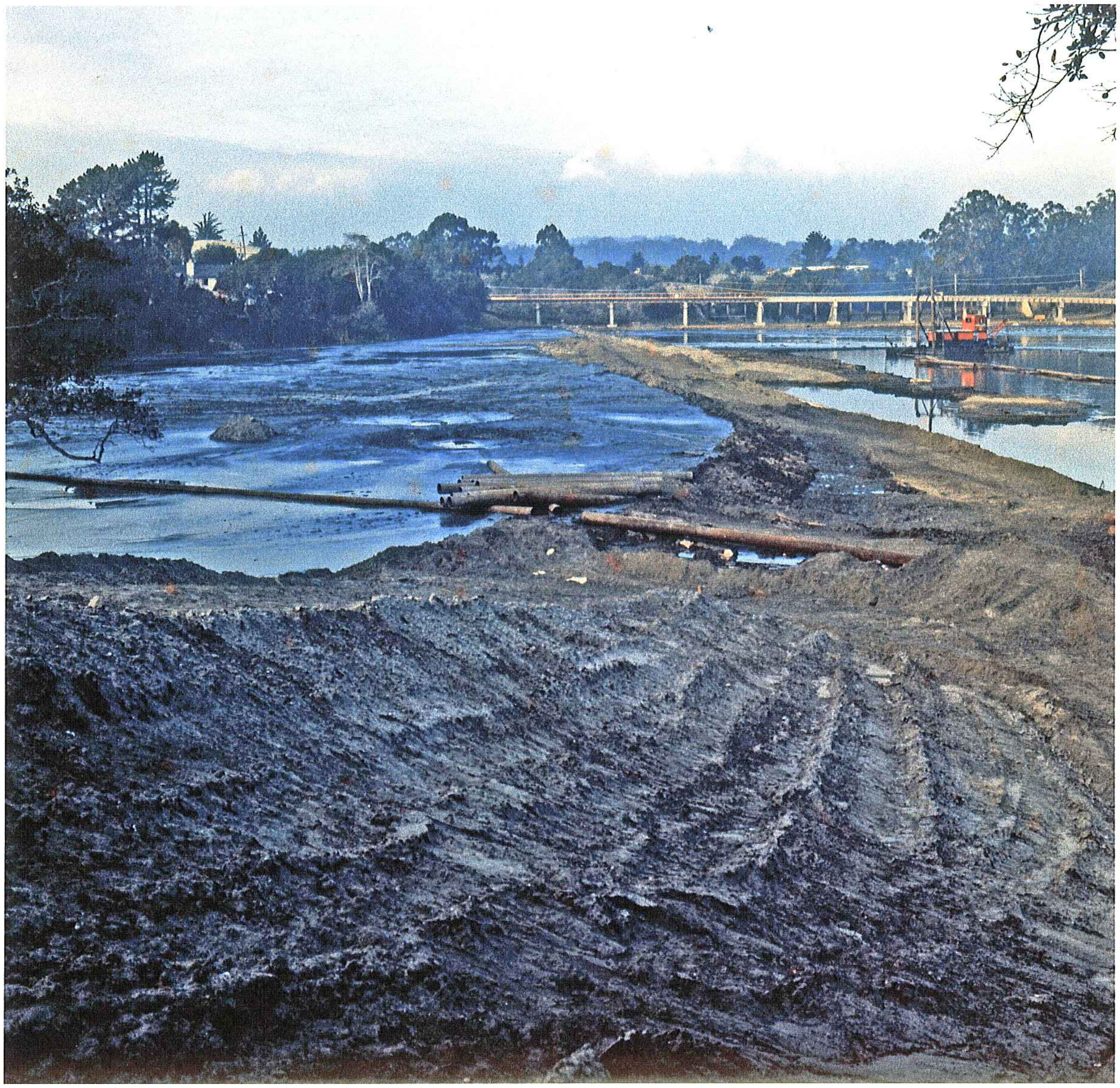


Fig. No. 2. Filling west parking lot with pumped in material. Shellmaker's dredge working in the distance.

Fig. No. 3. Top of the west jetty after the storm.

Fig. No 4. Pile trestle, remnants of Ocean Shore R.R. uncovered by the storm.

Fig. No. 5. West Jetty complete.

Fig. No. 6. West jetty is complete. Working on east jetty in the distance.

Fig. No. 7. Inner view. Working on the east jetty. West jetty on the right is complete.

Fig. No. 8. Dredge digging out the beach to open the channel, the first time.

Fig No. 9. Digging through the beach. Working in the breakers to open the harbor. (Taken from the end of the completed west jetty, facing north. (Bx7-SL10-img 125)

Fig. No. 10. Completing the opening, through the breakers.

Fig. No. 11. Coast guard boat laying the buoys to outline the channel.

THE END

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