Concrete Dam Faces and Spillways

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GOMACO WORLD

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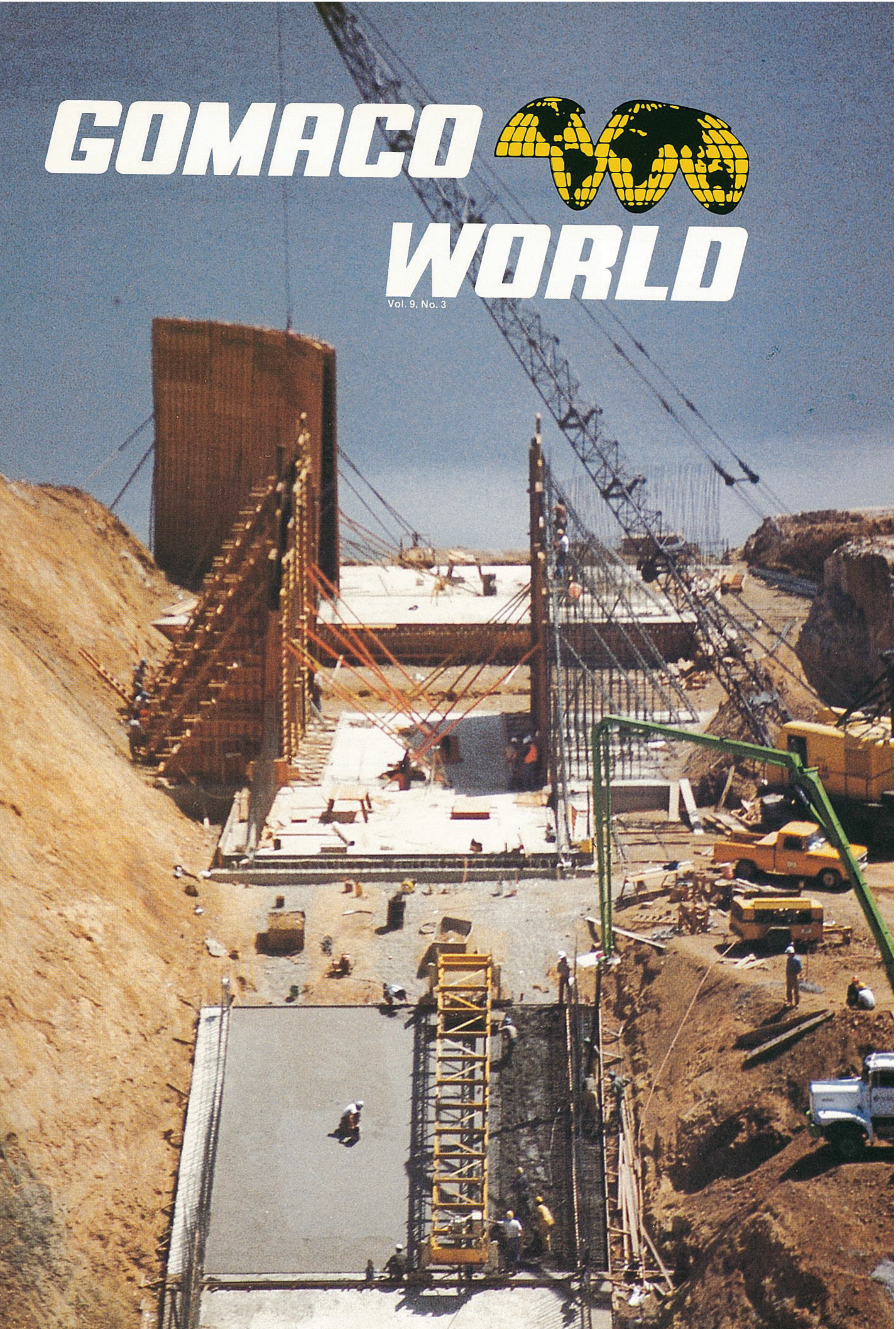
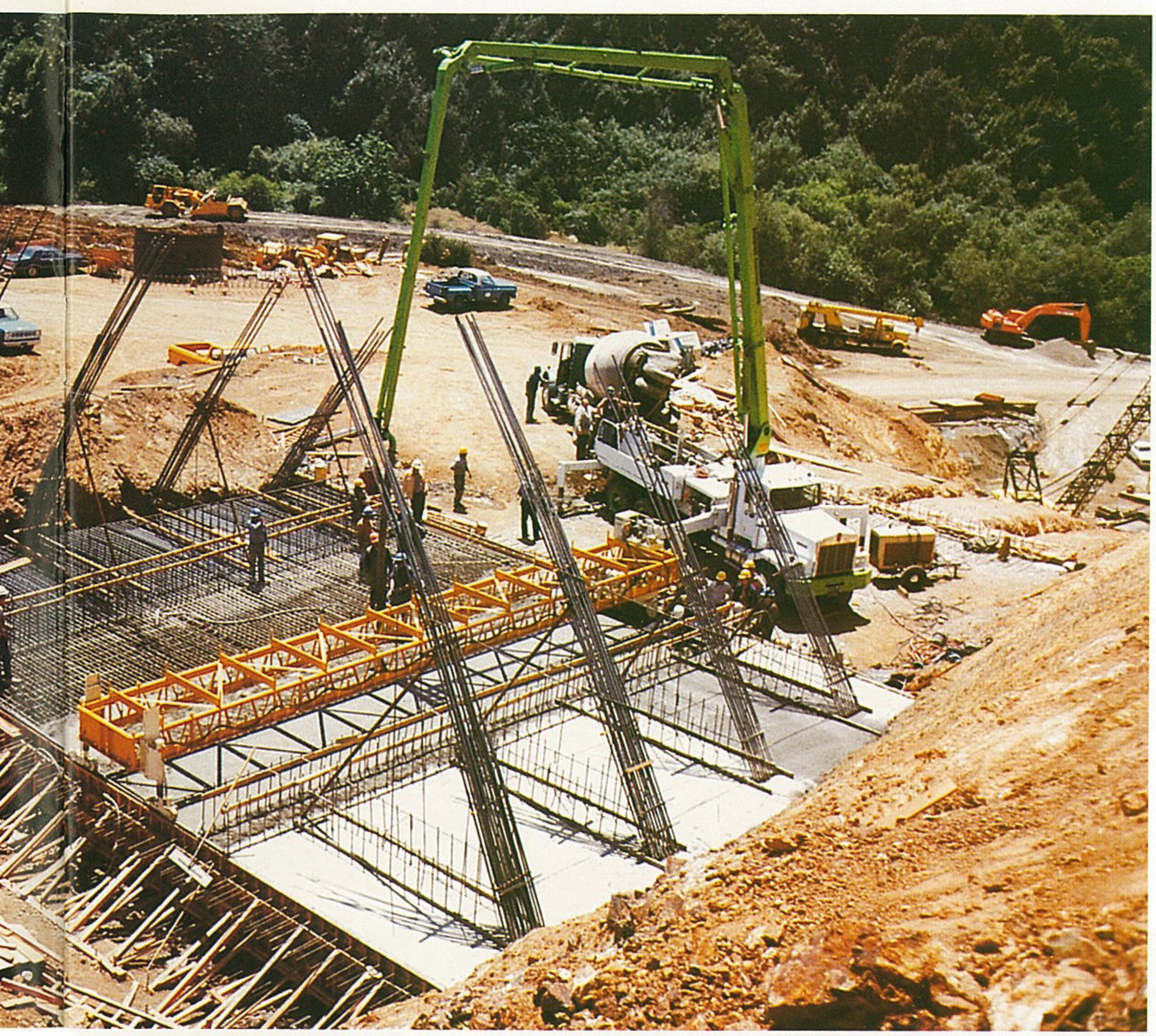




To start the job

At the beginning of the spillway project, the C-450 was used to finish a flat slab prior to the machine's uphill climb. The total job of finishing the 600 foot long spillway required 800 tons of grade 60 steel for reinforcement.

Some of the most challenging construction work through the years has been done in California because of its great variety of geological conditions. And, a California construction firm with a reputation for tackling the really tough jobs recently faced a challenge to build a concrete dam spillway in the state.

The challenge was within the specified construction method. It led the firm to Canada in a combination of transcontinental expertise to find a proven method that was used successfully on the job.

The $4.2 million project for the East Bay Municipal Utility District was awarded to Piombo Corporation of Belmont. It involved raising the level of an earth-filled dam and excavating an existing spillway at Lake Chabot near San Francisco Bay. A new modified spillway was constructed to accommodate the overflow of water for Oakland's supplemental drinking water supply.

The original specifications for the 600 foot long spillway called for the use of conventional slipform paving equipment to complete the 25 degree sloping waterway.

"The State Division of Safety of Dams was concerned about concrete consolidation," Alan Rabe, company project engineer, explained. "You have to have good consolidation with an even concrete surface where water flows at a high velocity.

"We did not believe that it was practical or feasible to slipform the spillway," he continued. "The job would require a specially-built slipform paver and then we would need a special crane to handle it."

Thinking that there must be a more practical method of building the spillway, Rabe began a search for other tried and tested methods. He needed a cost-effective piece of equipment which yielded good concrete consolidation and an even concrete surface.

In a letter to the East Bay Utility District, Rabe wrote:

"We felt that it was necessary to look into other methods of placing concrete in the spillway slabs and contacted GOMACO Corporation, specialists in slipform pavers and finishers. They recommended a GOMACO Model C-450, which is a lattice panel, single auger, cylinder

Spillway

type concrete finisher which simultaneously compacts and finishes the concrete while spreading it."

The letter continued, *"It is our belief that the GOMACO Model C-450 will give the desired results on these spillway slabs."*

Rabe found that a Canadian firm has used the GOMACO C-450 to finish a 35 degree sloping concrete headwall for a major dam at a hydroelectric project in Quebec. The firm, Hydro-Quebec, had won Canada's Montgomery Award for 1979 for innovation in construction methods on the job.

Hydro-Quebec endorsed the use of the C-450 in a letter to the utility district, which read:

"We confirm that we encouraged Piombo Company to use a GOMACO C-450 concrete finisher for the concrete structure.

"We realized an economy of more than $750,000 using this method. We cannot foresee any reason why the method could not be used on your spillway chute slab."

Hydro-Quebec had made a film of the job,* and with the film in hand and support information supplied by the firm and GOMACO, Rabe presented the method to the utility district and the State Division of Safety of Dams. After futher evaluation, Piombo Corporation was allowed to use the C-450 to construct the spillway.

A letter from the Division of Safety of Dams to the utility district confirmed the matter.

"Approval to demonstrate the C-450-X slope finishing system at Chabot spillway is given. Approval to use the system is contingent upon your requirements that the method results in a good job of consolidation and finishing."

The utility district also confirmed the use of the machine, provided that the district *"take several six inch diameter test cores to a four inch depth in the initial slab placed."*

During the spillway construction, the core tests were taken with acceptable results in concrete consolidation.

"The machine was successful," Rabe noted. "We were very happy. The GOMACO was both a cost savings and the quality of work it turned out was acceptable."

"By using the concrete finisher, we saved $150,000 on the job. The machine alone, saved us up to $80,000 right there over the cost of a slipform paver.

"It would have been impossible to pave the spillway by slipforming because of the many different configurations which required the machine to conform so closely to the wall," he added.

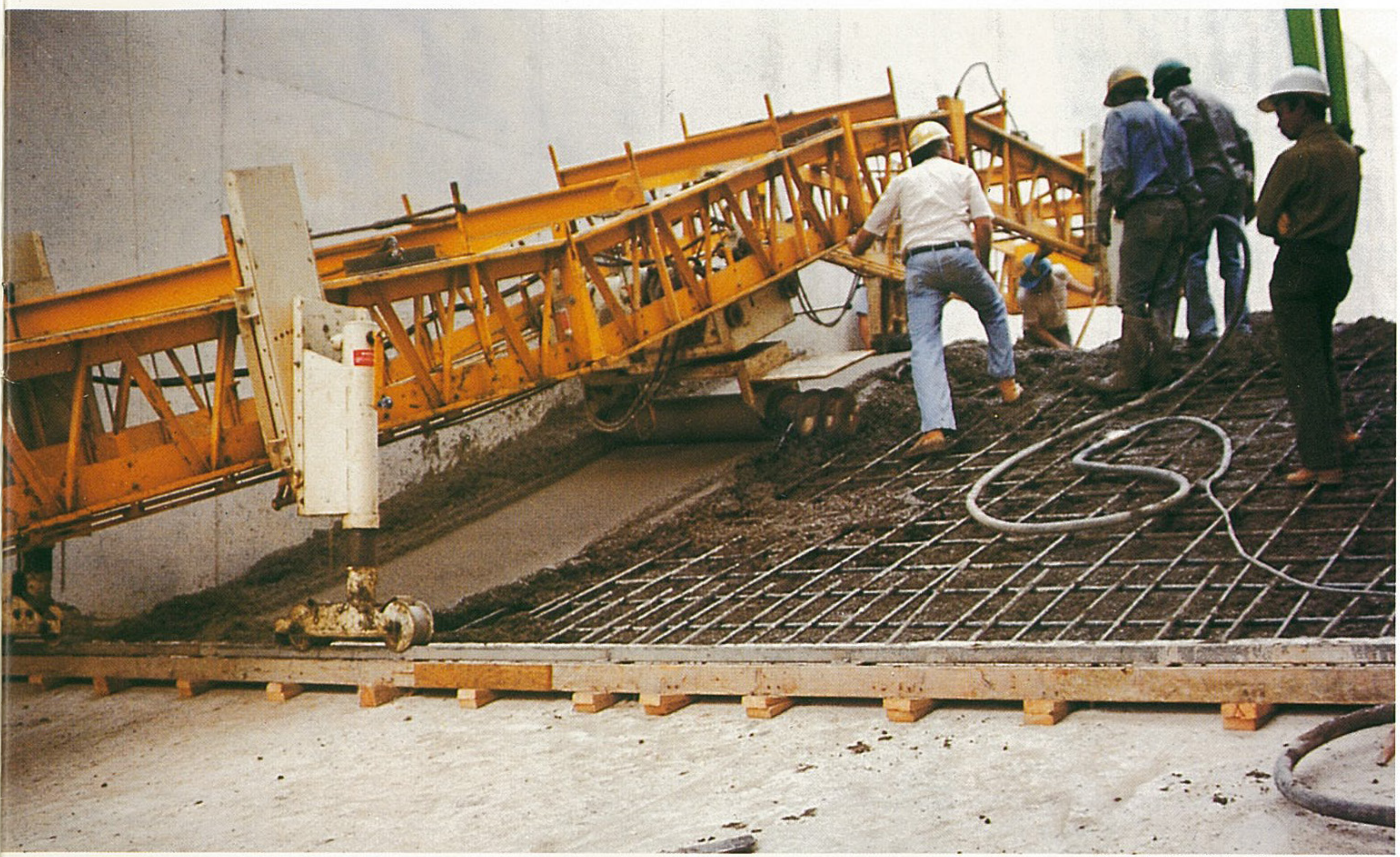
Since the project's completion in October, Piombo Corporation

*The Hydro-Quebec project film is available for viewing through the GOMACO Corporation.

Finishing method

The C-450 rolls over the spillway to finish the concrete across the 40 foot wide slab.

Dennis Ernst



Photos by Alan Rabe, Piombo Corporation

Slope over finishing

Because the dam spillway must carry waters overflowing from the dam, the structure rolls down the slope. The C-450 concrete finisher machine frame conformed to the profile with adjustable lattice panels to give the machine a snake-like look.

Spillway

has plans to use the finisher on similar slope paving applications, according to Rabe. In addition, the C-450 can be used as a flat slab finisher.

"The GOMACO is lightweight which makes it easy to handle and maintain. And, it's simple. There's nothing complicated about it," Rabe noted.

"It makes our work so much simpler, and the finisher does the job. That's what we're after. It saves both time and labor.

"The job was made easier with the help of GOMACO," he continued. "Their engineering knowledge and consulting turned a tough project into one that could be done without major problems."

To Rabe's knowledge, the Lake Chabot project was the first time that the machine and the construction method had been used in California for a water project, he said.

"What we did at Chabot really set the pace for future projects." ■

Project capsule

Project: Concrete dam spillway for East Bay Municipal Utility District
Contractor: Piombo Corporation
Belmont, CA
Alan Rabe, project engineer
GOMACO machine: C-450 concrete finisher
GOMACO distributor: California Performance Diesel, Inc.
Fresno, CA
Spillway: 600 feet (183 m) long
2:1 slope or 25 degrees
13 slabs total averaging 40 feet (12.2 m) wide
1½ to 2 feet (.46 to .6 m) thick
Steel reinforcing: 800 tons (726 tonnes), grade 60
Concrete slump: 3 inches (7.6 cm)

Alan Rabe, Piombo Corporation

Up the spillway

As work progressed toward the top of the spillway, the C-450 concrete finisher moved across each slab to finish concrete down the 25 degree slope. The thirteen slabs of the spillway varied in size from 90 to 600 cubic yards of concrete. For the slabs, 1½ to 2 feet thick, concrete was pumped up the slope with a maximum slump of three inches. The walls of the spillway were formed after each slab was completed. The total job required 10,000 cubic yards of concrete.

NTF Construction & Trading Ltd. continue to work with their GOMACO C-700 finisher on a spillway project in Dalaman, Turkey.

Spillway Finishing At Yacyreta Dam

The Parana River is the second largest river in South America, and a massive dam project is currently underway on the river between Argentina and Paraguay to harness the water for hydroelectric power.

When completed, the Yacyreta Dam will affect an area of 88 kilometers (54.7 miles). In the first phase of the project, the main dam is being built between Yacyreta Island and Argentina crossing the navigable arm of the river and affecting an area 20 kilometers (12.4 miles) long. When the first phase is complete, work will start on the second phase in which a dam will be built connecting Yacyreta Island and Paraguay.

Once the project is finished, the resulting artificial lake will have a surface area of 1,720 square kilometers (663.9 square miles) and cover two river islands.

The two dams will have a total of 20 turbines and through each turbine, 203 million liters (53,627,093 gallons) of water will pass every hour generating a total of 18 gigawatts (1 gigawatt = 1 billion watts) of hydroelectric power per hour.

The water level at the turbines of the main Yacyreta hydroelectric dam will have a variation of 58.5 to 64 meters (191.9 to 209.9 feet). The flood gate will be 24.4 meters (80.1 feet) higher than the water level.

On the overall project, 3.8 million cubic meters (4,970,185 cubic yards) of concrete will be used, and the embankment will have 81 million cubic meters (105,943,420 cubic yards) of material.

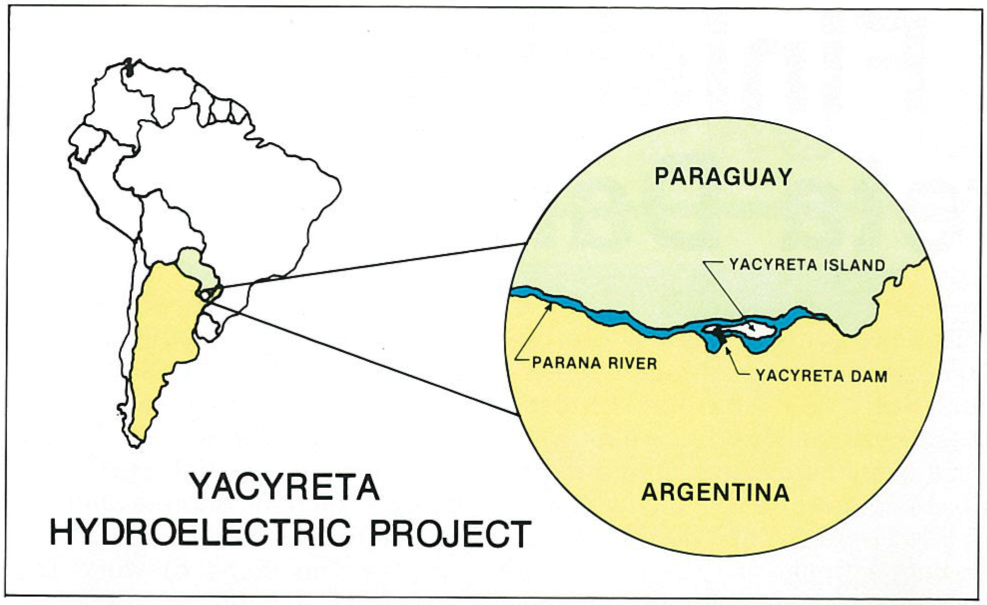
A group of European and South American companies, E.R.I.D.A.Y. U.T.E. (Empresas Reunidas Impregillo Dumez y Asociados para Yacireta - Union Transitoria de Empresas), is using a 24.38 meter (80 foot) long GOMACO C-450 concrete finisher for flat slabs and slope paving of a concrete spillway on the project.

In the first stage of work, the C-450 is finishing 96 concrete slabs for the compensation pool at the bottom of the spillway. Each slab measures 20 meters by 20 meters (65.6 by 65.6 feet) and is one meter (3.3 feet) thick with a slope of five degrees.

Each slab requires 400 cubic meters (523.17 cubic yards) of concrete for a total of 38,400 cubic meters (50,225 cubic yards). The spillway when completed will be more than 400 meters (1312.4 feet) long and 80 meters (262.5 feet) wide.

The concrete for the com-

Photos courtesy of Frederico Irrgang, SELL-MAQ S.A.



pensation pool is being placed atop a 2 to 2.5 meter (6.6 to 8.2 foot) thick concrete foundation placed on solid rock. Before laying the foundation, three 33 millimeter (1.3 inch) iron bars are forced 9 meters (29.5 feet) into the rock, and tied together above ground and bent as an anchor. Each set of three bars is spaced every 1.5 meters (4.9 feet), and provides reinforcing to prevent the concrete slabs from slipping or overturning when the water spills into the compensation pool.

After the placement of the concrete foundation, a wood frame is built one meter (3.3 feet) high for each slab, and rails are installed atop the frame for the C-450. Two sheets of steel mesh are also set in place for additional reinforcement in the slab. The wood frame is then cleaned by water pressure, and the C-450 is set on the rails for the finishing operation.

The slab is completed in three layers which are all vibrated and consolidated together. As the first layer is put down, work begins on the second layer with the C-450 finishing the final top 30 centimeters (11.8 inches). The entire process for each slab takes 9 to 10 hours.

All concrete being used in the spillway includes cement with a low hydration temperature. Different size aggregate was used for the concrete in each layer with 3.5 centimeter (1.4 inch) aggregate used in the bottom layer, 7.6 centimeter (3 inch) aggregate in the middle layer and 1.9 centimeter (¾ inch) aggregate in the top layer.

The slump of the concrete in the final layer varies from 3 to 6 centimeters (1.2 to 2.4 inches) depending on the ambient temperature throughout the day. Because the average high temperature of the area in summer is 40 degrees Celsius (103 to 104 degrees Fahrenheit), ice is added to the concrete to maintain a constant temperature of 10 degrees Celsius (50 degrees Fahrenheit).

Specifications require that each

concrete slab meet a tolerance of 4 to 6 millimeters (.16 to .24 inches) in one meter (3.3 feet). The C-450 has been consistently maintaining a tolerance of 3 millimeters (.12 inches) in one meter while finishing the slabs.

The crew working with the C-450 includes a machine operator, three laborers distributing concrete in front of the machine, two hand finishers along the slab edges and three finishers working from a powered Spanit workbridge behind the C-450. In addition, five workers hand vibrate the concrete in front of the machine.

Following the finishing of each slab, wet burlap covers the new concrete surface. The burlap must be kept wet because any fracture or fissure resulting from the surface setting too fast could produce serious erosion problems when the Parana River overflows the spillway.

Because of heavy rains in the area and the amount of concrete involved in each slab, a moving awning was built to sit on rails and cover the C-450 and the slab to prevent rain from damaging the concrete.

After each slab is completed, the C-450 is lifted off the slab and moved to another, with the slabs being finished in a chess board sequence. When all the flat slab work is done, the C-450 will be outfitted with a slope conversion kit to finish the final 45 degree sloping downfall of the spillway.

The C-450 was purchased specifically for use on the spillway. The machine is equipped with optional electric engines in lieu of the standard gasoline engines, and the machine also has a pan vibrator for vibration during concrete finishing.

The spillway job on the main dam is expected to be completed by June of 1989. At that time, the Parana River will be channelled out onto the spillway. The first turbine at the Yacyreta Dam is scheduled to begin operation in 1990.■

The SL-750 uses automatic advance which allows the machine to automatically move forward to any pre-set distance at the end of each carriage pass, as it moves along the rails to pave the new canal.

A GOMACO SL-750 paves a concrete lining on a reservoir in Kazakhstan.

Photos courtesy of GETKATE CONSTRUCTION (1976) LTD.

Dream, challenge and doors of opportunity

Last year, a dream came true, a challenge was met, and doors of opportunity were opened for GETKATE CONSTRUCTION (1976) LTD. of Lethbridge, Alberta, according to John Getkate, company vice president and operating manager.

The dream - to own a new GOMACO SL-450 slope finisher. The challenge - concrete slope paving of a new 15-degree spillway for the Oldman River Dam reservoir 6.21 miles (10 km) northeast of Pincher Creek, Alberta. The doors of opportunity - future canal and irrigation-related slope paving projects.

"We always wanted a GOMACO machine," Getkate said. "Ten years ago, we would put in half the cost of one in our tenders. Our introduction to GOMACO came five years ago by purchasing an older C-450 cylinder finisher."

Spillway challenge

The $50 million spillway contract was just a portion of a $400 million project for Alberta Public Works Supply and Services involving the construction of the new dam. The general contractor was Piggot Project Management Ltd. of Hamilton, Ontario.

At the time the spillway paving subcontract came up, it was the first of its kind for the firm. They were using their older C-450 for two bridge decks in conjunction with the massive dam project. That led the general contractor to seek their subcontracting services on the spillway and the purchase of the new slope paver.

"There were fairly tight tolerances on the spillway," Getkate explained. "And the general contractor figured cylinder finishing was the best way to obtain them. When they asked us to help, we ordered a new slope paver."

The 15-degree sloping spillway serves as an emergency overflow and regulates the water level of the reservoir behind the dam. If there is an excess of water or an early spring run-off, water can be discharged through the structure and down into the Oldman River below.

The spillway is approximately 1100 feet (335.28 m) long with a tapering width which narrows from 150 feet (45.72 m) at the bottom to 400 feet (121.92 m) at the top.

The overall area of the spillway is approximately 17,103 square yards (14,300 m^2). The concrete thickness is two feet (609.6 mm), according to Getkate.

The new SL-450 slope finisher was used to pave the flipbucket section at the bottom of the spillway, the sloping chute floor, and the curved ogee at the top. The spillway included about 21,189 cubic yards (16,200 m^3) of concrete placed in 27 pours.

Flipbucket at bottom

The first paving operation for the SL-450 was in a concave configuration for the flipbucket at the bottom of the spillway.

The flipbucket design allows for a slowing of the speed of water flowing down the spillway, shooting water up into the air as it travels beyond the end of the flipbucket.

"The flipbucket was on a 65.62 foot (20 m) radius so it was just a constant curve," Pete Braak, company foreman, explained. "At the very top of the flip, it was sharper than 45 degrees."

The SL-450 was used in two operations to complete the new flipbucket, according to Braak. First, concrete was placed in the required profile with the use of the finisher. Then, the auger and float pan were removed from the finisher, and the cylinder alone applied a steel trowel finish on the surface.

Sloping chute floor

After the flipbucket was completed, paving work moved up the slope on the chute floor. Two mats of reinforcing steel made of 3/4 inch (19.1 mm) bars were set at one foot (.3 m) centers for reinforcement. The general contractor installed formwork and set up two-inch (50.8 mm) round pipe rails for upward travel of the SL-450.

The width of the chute tapered with five machine passes required at the bottom and seven passes at the top, with each pass ranging from 16 to 50 feet (4.88 to 15.24 m) wide, according to Getkate.

Because access was required for work at the top of the spillway, paving of the chute floor progressed from one wall to the other.

"The original intent was to pave the full 1100 foot (335.28 m) length of the spillway, but that was split in half for pours of 550 feet (167.64 m) at a time," Braak said.

Flipbucket

Spillway chute

Because a side discharge conveyor used with the SL-450 had fixed wheel assemblies at 48 1/2 feet (14.78 m), according to Braak, the slope finisher was forced to ride the same width.

"Even though I had the option of self-widening, the wheel assemblies didn't move," he explained. "I just increased the distance the carriage would move."

The SL-450 was equipped with incorporated console drive because the pipe rails were set up for the full length of the spillway at a fixed width. The incorporated console drive was adjusted from the operator's console on the SL-450 for the continual varying paving widths.

Going with an all-wheel drive option on the SL-450 made for a smoother paving operation, according to Getkate.

"We set up the SL-450 perpendicular to the slope and used the all-wheel drive alternative with four hydraulically powered bogie wheels," he explained. "We did that just to make sure we didn't have problems climbing the grade and moving concrete.

"For this project, we thought it would be beneficial to have a new machine with more horsepower, all-wheel drive and features to accommodate the slope. That was our biggest concern," he continued.

"Nobody thought the machine could climb the grade with those wheels. They figured there would be some slippage so going with all-wheel drive assisted in the paving operation."

Concrete slump averaged between 3 1/2 and 3 3/4 inches (90 and 95 mm), according to Braak. He added that the concrete was almost unworkable because of 1 1/2 inch (38.1 mm) coarse aggregate and a large amount of fly ash in the mix.

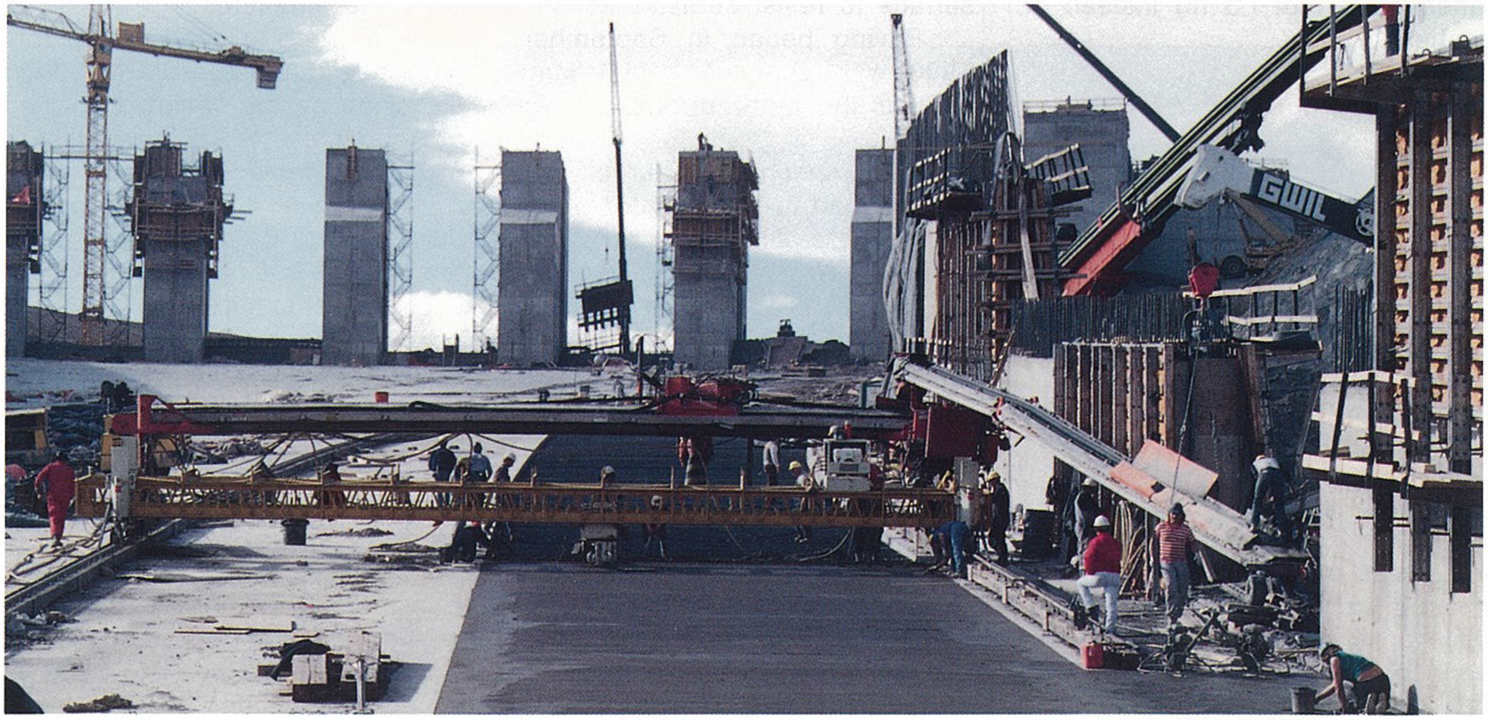
Behind the SL-450 slope finisher, power trowels were used for a tight consolidated finish on the new concrete surface. The tolerance was 1/4 inch in 9.84 feet (6 mm in 3 m).

Smaller pours were about 680 cubic yards (520 m^3) and larger pours were about 1308 cubic yards (1000 m^3), according to Getkate.

Normal paving production averaged from 98 to 105 cubic yards (75 to 80 m^3) an hour. A 1216 cubic yard (930 m^3) pour was completed in 13 hours, according to Braak.

"Getting concrete to the GOMACO was always a challenge," Getkate noted. "There were different phases of construction all around where walls were being poured on the outside so getting the mix to the side discharge conveyor was a challenge in itself."

Braak added, "In order to keep



up with the placing, I increased the skew on the carriage. Normally, on bridge decks, I run it at five degrees. To roll the concrete out of the way, I increased the skew to 15 to 20 degrees. I was getting a good finish and able to move ahead one foot (.3 m) instead of inches."

Curved ogee at top

At the top of the spillway, the SL-450 finished the ogee structure where water is transitioned from the inlet to travel down the sloping chute.

The SL-450 was set up in a configuration with a downward convex curve and a backward concave curve. The typical ogee width was 35 feet (10.67 m).

"Just looking at the ogee section, it is unbelievable what that machine actually did," Getkate stated. "It took time setting up the finisher for an ogee section, but it met the tolerances."

The tolerance on those sections was .12 inch in 9.84 feet (3 mm in 3 m).

"Concrete consolidation is very important, especially the top finish," Getkate said. "Because there is a vast amount of water and suspended silt, they require a dense surface to resist abrasive action."

Paving began in September, 1990 with completion last May, staging the work throughout the winter.

"With spring peak run-off, the spillway had to be ready for water, and we were able to do that," Braak stated. "The water came over the top of the spillway in the middle of June."

Doors of opportunity

Now that the spillway has been completed, the slope paver replaces the firm's older C-450 which now acts as a standby paver, according to Getkate.

"We do a lot of irrigation work and cross sections of canals," he said. "We wanted the opportunity to have a slope paver available in case that work comes up in the future.

"This was a pretty substantial project, and it was a challenge. We also want to get more exposure in concrete finishing on tight tolerance structures.

"We were excited about this project and the new GOMACO. With the slope paving option, it excited us to get the SL-450 and find a niche in the market.

"We never considered competitive pavers. We were happy with the older C-450, and it was in our best interest to stick with GOMACO with this slope paving option.

"That was just a stepping stone," Getkate concluded with regard to the spillway. "We're happy with the results, and this slope paver is opening doors of opportunity for us down the road."

UMA Engineering Ltd. of Edmonton, Alberta was the engineering firm on the spillway job. Concrete was provided by LaFarge Construction Materials.♦

Photos courtesy of Getkate Construction Ltd. SL-100001-D #1

St. Mary's Spillway

Alberta Environmental Protection in Alberta, Canada, was facing a huge problem. What were they going to do with an aging and failing dam? The St. Mary's Dam, located approximately 25 miles (40 km) southwest of Lethbridge, Alberta, was built in 1951 and officials felt the structure could no longer be relied upon in its present condition.

"The old one was not up to the new dam safety standards. The under-slab drainage system was not performing properly, a lot of freeze-thaw action was occurring and it was becoming a big maintenance headache for Alberta Environmental Protection," Dave Lapins, resident engineer for AGRA Earth & Environmental, said. "We went through a lot of investigations to determine if we should rehab it or if it was cheaper just to build a new one. Ultimately, the decision was made to build a new one adjacent to the old one."

Alberta Infrastructure administered the $47 million project and hired NAC Constructors in Campbellford, Ontario, as prime contractor. NAC turned to an experienced spillway paver, Getkate Construction Ltd., to slipform the flip bucket and chute slab.

"They hired us because of our experience on the Old Man River Dam project from 1990," John Getkate, president of Getkate Construction, said. "They looked us up and asked me to look at the profile of the spillway to see if I thought our equipment would work and we went from there."

> "They hired us because of our experience on the Old Man River Dam project from 1990," Getkate said.

Getkate had previously used a GOMACO C-450 on the Old Man River Dam project. For the St. Mary's job though, due to the length of the spillway, Getkate used his C-700.

"We went to the C-700 because the flip bucket was approximately 108 feet (33 m) long," Getkate said. "The C-450 would have provided the same finish on the regular chute slabs, but since we had the equipment on site already, we just used the C-700 for the whole job."

Concrete had to be placed in front of the C-700 with a crane and bucket. The 5076 psi (35 MPa) mix with 1.5 inch (38 mm) aggregate couldn't be pumped. The slump of the concrete was approximately three inches (76 mm). Concrete was placed over heavy steel reinforcing.

"There were two mats of reinforcing," Getkate said. "It was anywhere from .6 to one inch (15 to 25 mm) rebar and ranged from six inches (150 mm) on centers each way to 12 inches (300 mm) on center each way between the two mats."

The concrete slab averaged 24 inches (610 mm) thick.

The flip bucket was poured longitudinally and the slope and all the chute slabs were poured transversely at a 3:1 and a 5:1 slope.

"The design engineer determined where he wanted the construction joints and we put our machine transverse on the long length pours for the chute slabs," Getkate said. "Then we had to go parallel with the pour length for the flip bucket."

Paving on the spillway started from the bottom and worked its way up. Joints determined the width of the slabs.

"The paving widths were determined by the consultant and we poured no wider than 20 feet (6.25 m)," Getkate said. "We had some tapering pieces where we had to use the self-widening feature because it would taper out to a wider section at the ends. It was all variable.

"The biggest concern was keeping the tolerance on the flip bucket... and everything else for that matter."

Tight tolerances of .12 inch in 10 feet (3 mm in 3 m) had to be met. Getkate had no problems meeting the strict requirements.

The most difficult part of the project, according to Getkate, was slipforming the flip bucket.

"The flip bucket is on a radius and we had to set our C-700 to that curve," Getkate said. "We had to bend the carriage rail to that profile and since we were coming from a 3:1 slope and then flipping up, we had to make sure the legs on the machine were plumb.

"There was a lot of ingenuity on the part of my guys to make that profile work. It took a while to set it up, but once everything was in place, it went well."


SL-100001-D #2

The concrete slab averaged two feet (.6 m) thick with production averaging 246 to 262 feet (75 to 80 m) an hour.


SL-100001-D #4

The flip bucket was poured longitudinally, however the slope and all the chute slabs were poured transversely at a 3:1 and 5:1 slope.

A view down the spillway and into the flip bucket. Concrete had to be placed in front of the C-700 with a crane and bucket. The 5076 psi (35 MPa) mix couldn't be pumped.


SL-100001-D #5

St. Mary's Spillway, the new and the old.

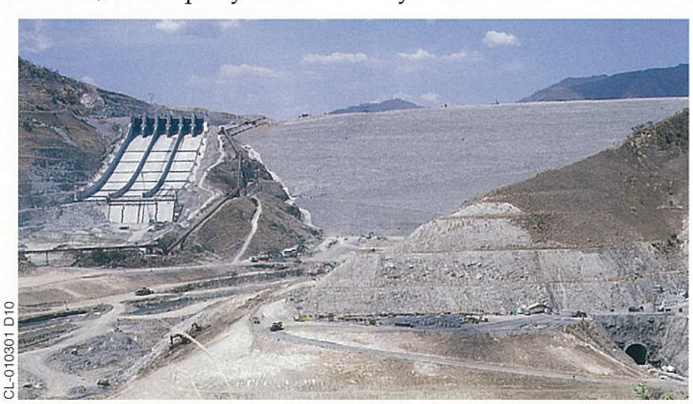

SL-100001-D #3

Photos courtesy of Alfredo Belen Jr. CL-010301 D1

Finishing the Spillway on the World's 12th Highest Earthen Dam

The San Roque Multipurpose Project involved the construction of an embankment dam along the Agno River in the Luzon island province of Pangasinan, Philippines. The San Roque Dam has a height of 656 feet (200 m) and is 3707 feet (1130 m) in length. At those dimensions, it's the 12th highest earth/rock-fill dam in the entire world, with a reservoir capacity of 1.1 billion cubic yards (850 million m^3). While at its peak, the San Roque Project was one of the largest on-going construction projects and employed over 5000 workers.

Raytheon Engineers and Constructors, a company that eventually merged with Morrison Knudsen to form Washington Group International, won the total design/build obligation from developer Sithe Energies, Inc. The huge responsibility of this massive undertaking was put into the hands of Raytheon project manager, Robert Resch.



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According to Resch, "The risk of significant rainfall and runoff during the wet seasons suggested a long completion time, but with an effective plan and constant coordination, we were confident we could mitigate most scheduling problems.

"The San Roque Dam was a Philippine flagship project and our contract included both the design and building," Resch explained. "Beginning with our engineering in March 1998, the fast-track project was completed just 58 months later."

For the job of concrete finishing the dam's spillway, Raytheon turned to GOMACO Corporation to develop a machine that would meet their specifications. After extensive testing, the GOMACO C-700 Cylinder Finisher proved to be that machine. Outside the GOMACO factory in Ida Grove, Iowa, a special ramp was built to simulate the spillway inclines. Resch, along with other managers from Raytheon, came to Ida Grove to observe the C-700 operating and have

The C-700 finishes an upper section of the spillway while excavation and other work is in progress further below.

The spillway's flip bucket has a 70 foot (21 m) drop to dissipate the force of the water flowing down the chutes.

The C-700 finishes a portion of the spillway. Some sections had slopes with 27 percent inclines.

The San Roque Dam is a 656 foot (200 m) high embankment dam al Philippines. Its spillway, in the upper left of the photo, is 1722 feet (5

meetings with the GOMACO design team to make sure the C-700 was equipped correctly and would produce the results required for the spillway. Upon completion of the tests in Ida Grove, the C-700 was delivered to the Philippines for further testing on site.

The spillway is located on the right-hand abutment of the dam and guides the flow of excess water supplied to the reservoir. At 328 feet (100 m) wide and 1722 feet (525 m) long, the San Roque Dam spillway is designed for a flow of 452,028 cubic feet (12,800 m^3) per second.

Approximately 800 laborers worked around the clock, 24 hours a day, seven days a week, in two shifts to complete the spillway's four main sections: the ogee, spillway walls, spillway chute slabs, and the flip bucket.

The spillway is separated into three sections by two 26 feet (8 m) high longitudinal walls. Each section is 98 feet (30 m) wide and runs the entire length of the spillway, from the ogee at the top to the flip bucket at the bottom. The C-700 was set up to finish each slab within each section in two 49 feet (15 m) wide passes.

The flip bucket runs the full 328 feet (100 m) width along the bottom edge of the spillway. Its 70 foot (21 m) drop dissipates the force of the water flowing down the chutes. Its reinforced concrete slabs are 33 feet (10 m) thick to withstand the constant pounding it takes from the force of the water flowing down the slope. The rail system the C-700 traveled on was formed to match the radius of the flip bucket.

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525 m) long.

CL-010301 D34

A view from behind the spillway shows the nearly completed spillway in late December 2002. The spillway's three sections were each 98 feet (30 m) wide.

One of the important design aspects of the San Roque spillway included the installation of six air duct galleries that run underneath and transversely across the entire width of the spillway. As you look at the pictures of the finished spillway, the galleries look like six steps going up the spillway chute. The purpose of the galleries is to inject a protective cushion of air into the water. The galleries are designed with natural ventilation and, as the water travels over them, a vacuum is created and injects the air right into the water. The air reduces the wearing of the concrete as the massive amounts of water flow down the chute, thereby extending the operating life of the spillway and reducing maintenance costs.

The gallery steps in the chute slab required the C-700 be moved around the spillway in a criss-cross pattern, rather than starting each section at the bottom and continuing all the way to the top.

A special trolley was designed and built by Raytheon to remove the C-700 from its completed section, slide it over across the spillway and line it up into position for the next section to be finished.

The concrete slab depths for the spillway's top layer were 24 inches (610 mm) thick. An on-site concrete batch plant produced more than 261,589 cubic yards (200,000 m^3) of concrete for the spillway's construction alone.

Concrete was delivered by ready-mix trucks that fed concrete pumps with a telescoping pipe system for placing concrete in front of the C-700. Production averaged 55 cubic yards (42 m^3) per hour or approximately 654 cubic yards (500 m^3) during a 12-hour shift.

The concrete mix included a high-quality, low alkali, sulfate resistant Portland cement with a moderate heat of hydration. A Type II cement was specified because it generates less heat as it cures. More than 1.8 million bags of cement were used to produce the concrete for the spillway.

The mix design had a strength of 6000 psi (41 MPa). Concrete slump averaged between three to 3.5 inches (76 to 90 mm).

Different types of work were always happening on the spillway at the same time. As the high vertical walls were curing, the C-700 was set up for finishing slab sections at the top of the spillway while excavation work continued on the lower part.

Meetings between management and workers were held daily to keep everyone informed of what needed to be done and how work was progressing on the project. It was a monumental task just building the spillway, let alone keeping every aspect organized.

The final sections of the spillway were completed in July 2002. The San Roque Dam itself should be operational in the early months of 2003 and will have several benefits for the people in San Roque, including flood control, crop irrigation, quality water, power generation and water management.

Editor's Note: Special thanks to Alfredo Belen Jr., who provided the photography for this article. He has published a book detailing all of the project's aspects, "Images of the San Roque Dam." For more information, visit his web site at http://www.sanroquebook.com.

Spillways

CL-010301-D1

This GOMACO machine paves a spillway on the San Roque Dam in San Roque, Philippines.

CL-080203-D36

An RC Conveyor places the concrete ahead of the cylinder finisher.

CL-060101-#25A

The GOMACO equipment finishes a spillway in Dalyan, Turkey.

Canal Paving with the SL-750

SL-111007-D17

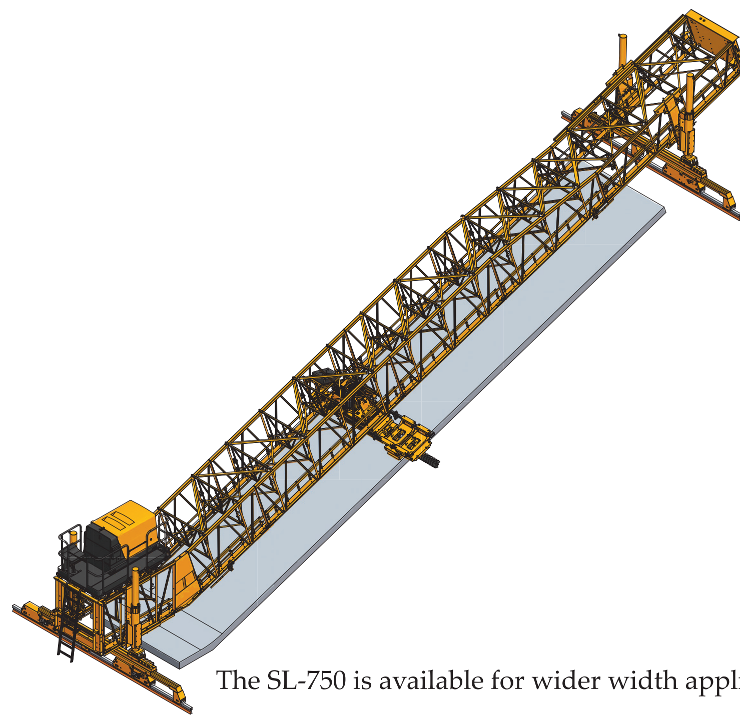
The SL-750 uses automatic advance which allows the machine to automatically move forward to any pre-set distance at the end of each carriage pass, as it moves along the rails to pave the new canal.

EG-060704-D9

GOMACO employees test an SL-750 on the testing pier at GOMACO facilities in Ida Grove, Iowa, U.S.A.

SL-111005-D8

The SL-750 paves a concrete lining on a reservoir in Kazakhstan.



The SL-750 is available for wider width applications

Highest Standards of Quality and Safety

GOMACO's quality management system is ISO 9001 and our products can be CE certified. Our manufacturing facility leads the concrete paving industry in computerization, robotics, and mechanization to provide precision from concept to finished product. The GOMACO manufacturing team is made up of three generations of personnel who build a product that has a worldwide reputation for quality, versatility, and dependability. Safety is the first consideration in the design process and we go beyond regulations and requirements with your team's well-being in mind.

EG-080901-D11

GOMACO work areas are large enough to accommodate the equipment required for your canal project.

Finite Element Analysis

Finite Element Analysis (FEA) consists of a computer model of the design and materials used which is dynamically loaded and then analyzed for maximum stress to achieve specific results. It is used in new product design and gives us the ability to verify that a proposed structure will be able to perform to your specifications prior to manufacturing.

Commitment to Canals

There is no question about our dedication to equipment needs for the waterways of the world. We have been involved with the largest projects and the most unique projects in the world. We are also proud of our partnership with those involved on smaller projects and providing efforts to make their accomplishments profitable. A testimony to our commitment is the building of a concrete testing pier on our proving grounds to provide the ability to assemble large slope machines for testing.

SL-020805-D15

GOMACO built a concrete testing pier at their facilities to test the canal equipment.

Commitment to Education

More than 17,000 students from around the world have received graduation diplomas from GOMACO University in Ida Grove, Iowa, U.S.A. Special classes have also been held in several countries throughout the world.

GOMACO has designed and conducted courses to better educate and aid equipment owners, operators, mechanics, and distributor service personnel in acquiring the knowledge and skills necessary to successfully operate GOMACO equipment. Classes are composed of informative lectures in the classroom and challenging "hands-on" preventive maintenance training. Study aids, including training and safety manuals and the latest information on product technology, are provided to the students for use in the classroom and on the job.

CV-041205-D3

GOMACO University is committed to educating equipment owners, operators, mechanics and distributor service personnel for successful operation.