United States
Department of
Agriculture

Forest
Service

Engineering Staff

Washington, D.C.

Engineering Field Notes

Engineering Technical Information System

Volume 15
July - September
1983

"Put 'Er Back in Shape, Boys!"

Welded Wire Retaining Walls: A Solution to a Diversity of Retaining Wall Needs

Naches Pass Road Reinforced Earth Walls

Curve-Widening Simulator

In-Place Preservative Treatment of Deteriorating Wood Bridges

Engineering Field Notes

Administrative Distribution

- Professional Development
- Management
- Data Retrieval

This publication is an administrative document that was developed for the guidance of employees of the Forest Service—U.S. Department of Agriculture, its contractors, and its cooperating Federal and State Government Agencies. The text in the publication represents the personal opinions of the respective authors. This information has not been approved for distribution to the public, and must not be construed as recommended or approved policy, procedures, or mandatory instructions, except by Forest Service Manual references.

The Forest Service—U.S. Department of Agriculture assumes no responsibility for the interpretation or application of this information by other than its own employees. The use of trade names and identification of firms or corporations is for the convenience of the reader; such use does not constitute an official endorsement or approval by the United States Government of any product or service to the exclusion of others that may be suitable.

This information is the sole property of the Government, with unlimited rights in the usage thereof and cannot be copyrighted by private parties.

Please direct any comments or recommendations about this publication to the following address:

FOREST SERVICE—USDA
Engineering Staff—Washington Office
Att: G.L. Rome, Editor (Room 1112 RP/E)
P.O. Box 2417—Washington, D.C. 20013

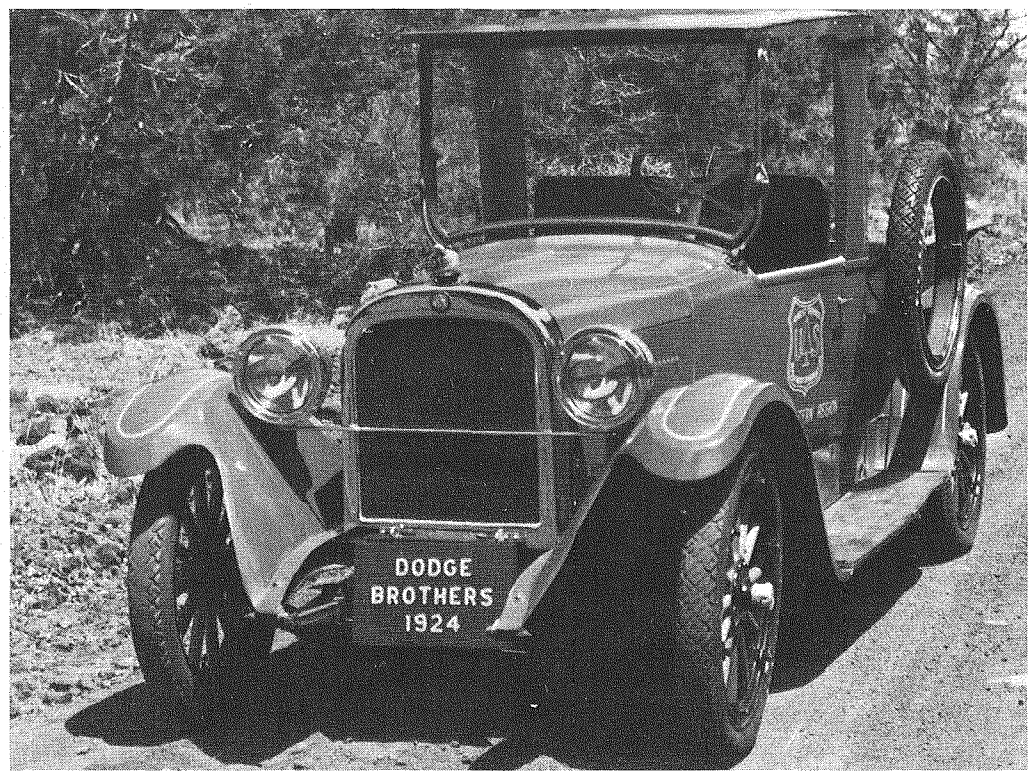
Telephone: Area Code 703—235-8198

"Put 'Er Back in Shape, Boys!"

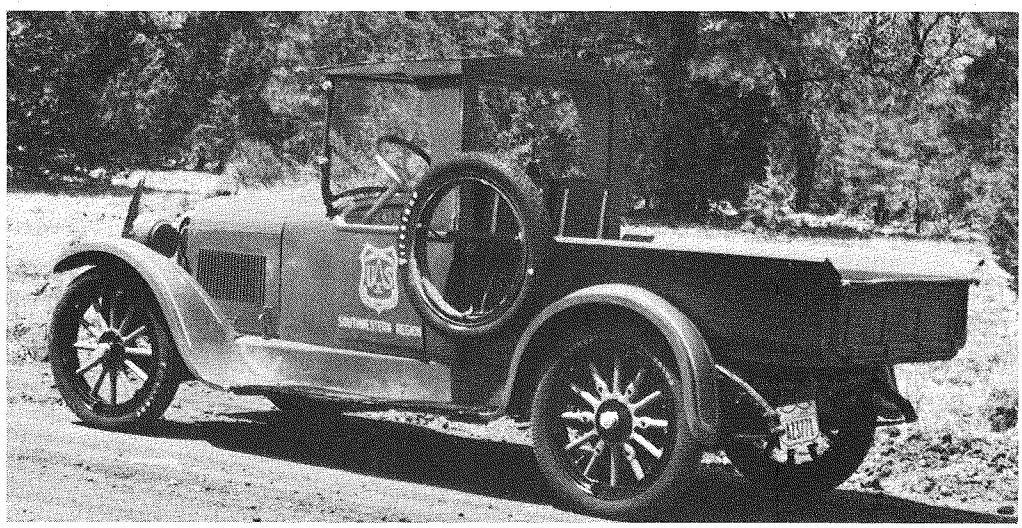
In 1969, the Forest Service recovered an ancient pickup truck from the bottom of Rattlesnake Canyon in the Galiuro Mountains of southeastern Arizona. The 1924 Dodge had been a mainstay of the Klondyke District until about 1933, when it was left in the bottom of the canyon . . . and how this came about is as interesting as the story of its retrieval and restoration.

James W. Girdner, born in Dennison County, Texas, worked for the Forest Service from its earliest years; he was called "Old Timer" before World War II. Ranger Girdner was well known all over Arizona by the ranchers and conservationists he served.

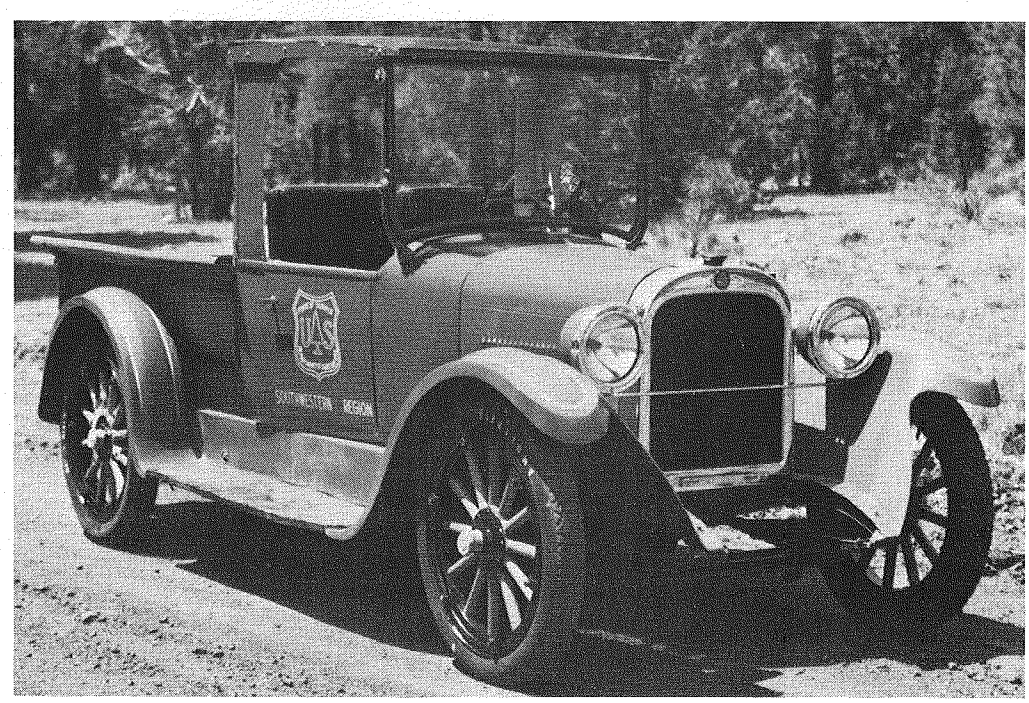
During the middle-to-late '20's, Girdner needed transportation--other than his horses. He went into Safford to find out what "headquarters" could do to help him. Pickups were scarce (money was tight then, too), but he found a 1924 Dodge that had been turned in for salvage.



Since no purchase was required, the Forest headquarters probably felt that giving the salvage to Girdner was an economical move. With whatever tools and materials could be scrounged, with Forest Service people's energy, and with assistance from Mr. Merrill Haby (who still lives in Klondyke, across from the General Store), Girdner set about to "put 'er back in shape."

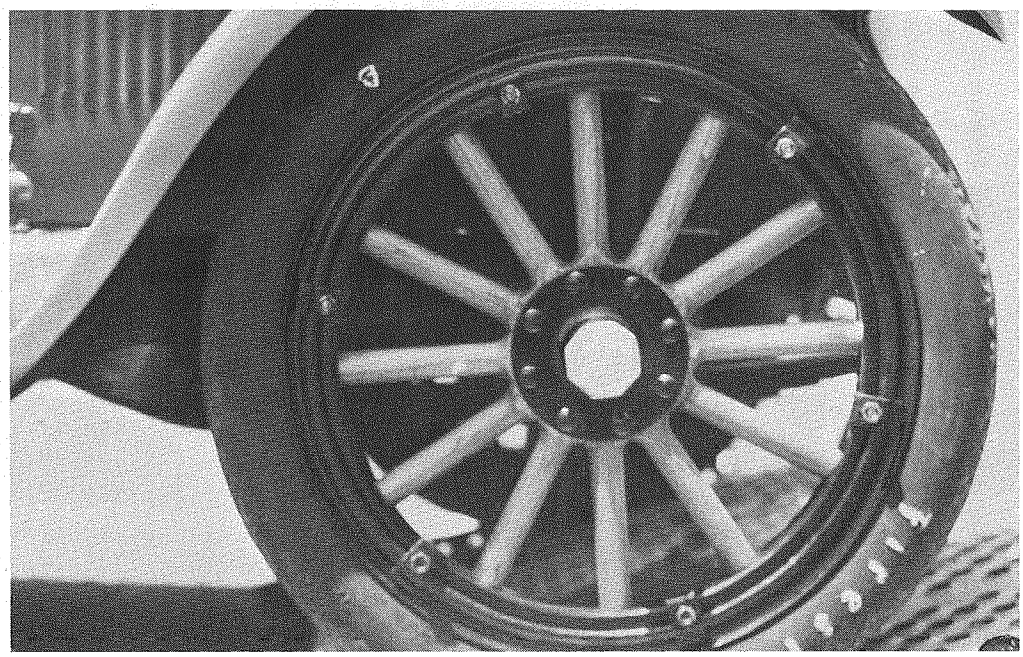


The resurrected Dodge served Girdner well for some 5 or 6 years. In fact, it did so well that he was given no consideration when other Rangers were getting new pickups . . . until 1933, that is.



Telephone lines were going through Power Garden into Rattlesnake Canyon and on to the back country. Girdner and his '24 Dodge had pulled all sorts of loads over the mountain roads; using the Dodge to haul telephone poles was as natural as all spades with no wild ones. From the bottom of the canyon to the top of Powers Hill was a 47-percent grade; Girdner skidded and bumped the Dodge to the bottom.

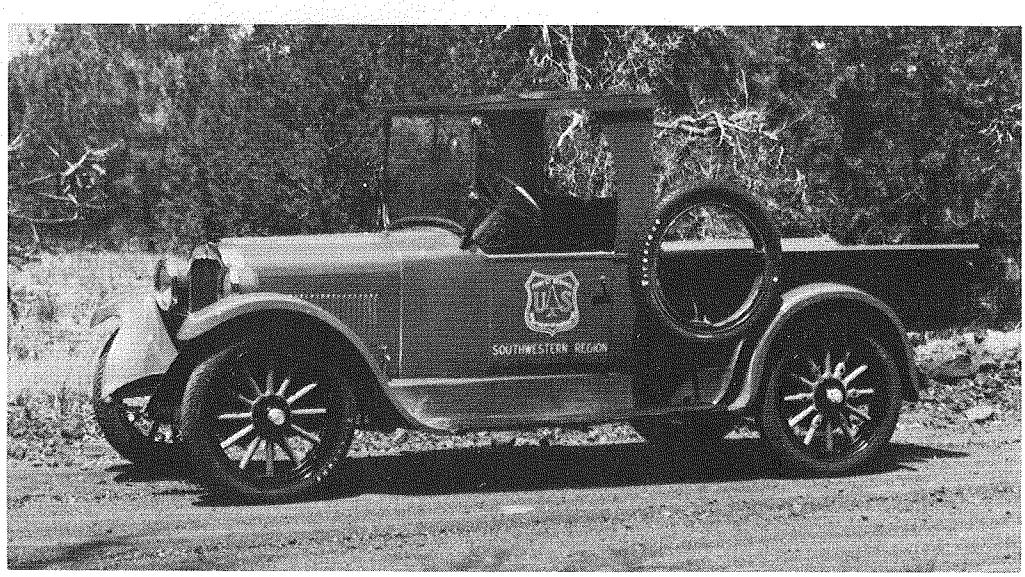
In a few weeks, they had hauled the 4-inch pipe poles to the head of the canyon, and the line was completed. Girdner and his crew clambered out of the canyon, but it was next to impossible to get the Dodge out. Arriving back in Klondyke, Girdner sent word to the Safford Office that he "couldn't get that [bleep] pickup out of Rattlesnake" and he'd just have to get a new one--and soon.



In due time, a brand new 1934 Dodge pickup arrived at the station. Girdner's smile was just a little smug; he had outwitted the man that held the money, and he had a "new pickup like all the other Rangers." Before long, Girdner regretted losing his reliable '24 truck; the "new-fangled '34 Dodge wouldn't pull your hat off, much less a loaded horse trailer up those mountain grades." But he was too stubborn to admit his mistake, or try to pull the old '24 out of the canyon, according to his family and friends.

So there it stayed until 1969, when the Forest Service took it out and restored it for Forest Service historical interest. The '24 Dodge pickup

is hauling again . . . now for such events as the Santa Cruz County Fair, where kids can ride in the treasured pickup. Twice, the Forest Service Ranger has said, "Put 'er back in shape, boys!"



The information for this historical note was furnished by Robert R. Girdner of Sierra Vista, Arizona; he is the son of James W. Girdner, who served as a Forest Service Ranger from about 1925 to 1939. Ranger Girdner served at the Baseline-Clifton Ranger District and was District Ranger on the Aravaipa in Bonita, Arizona.

Ray St. Pierre on the Prescott National Forest and Gene Smith and Tom Hooker on the Kaibab National Forest recently provided information about the truck's restoration. Cecil Thompson, a Forest Service retiree, originally restored the truck in 1969. In more recent improvements, Tom Hooker made the wooden spokes; Robert Dockerty (former employee, now in the "Older American Program") painted the truck and made the wooden roof; and Fred Avila, on the Kaibab, painted the pin stripes, Forest Service shield, and license plate. The truck, when not being driven in parades, can now be seen in the Sharlot Hall Auto Museum in Prescott, Arizona.

Welded Wire Retaining Walls: A Solution to a Diversity of Retaining Wall Needs

Ted Fitzgerald
Construction Engineer
Manti-LaSal National Forest
Region 4

BACKGROUND

Since November 1980, four welded wire retaining walls have been constructed on Forest Development Roads on the Manti-LaSal National Forest. A fifth wall was under construction as this article was being written, with completion anticipated by July 1983. This article discusses the applications, advantages, problem areas, and construction techniques associated with these walls.

The wire mats and wire mesh screens used in all the installations were manufactured by Hilfiker Retaining Walls, P.O. Drawer L, Eureka, California 95501. Specific design criteria, other typical installations, and installation procedures are contained in literature available through that company.

COMPOSITION of WELDED WIRE WALLS

Welded wire walls are composed of five basic elements (see figure 1):

(1) Welded wire mats of varying horizontal lengths. The horizontal length of the mat is determined by the wall height and the type of backfill material to be used.

(2) Backing mats. Backing mats are placed behind the vertical face of the wire mat. Both the wire mat and the backing mat are made of 9-gage galvanized welded wire fabric (2-inch by 6-inch rectangular pattern). (For walls higher than 15 feet, wire mats placed below 15 feet are made of 7-gage wire.) The long axes of the openings in the backing mats are perpendicular to the long axes in the vertical face openings. When properly placed, a 2-inch square pattern develops.

(3) Galvanized wire mesh screen with 1/4-inch openings. The screen is manufactured in rolls and is placed behind the backing mat, forming a

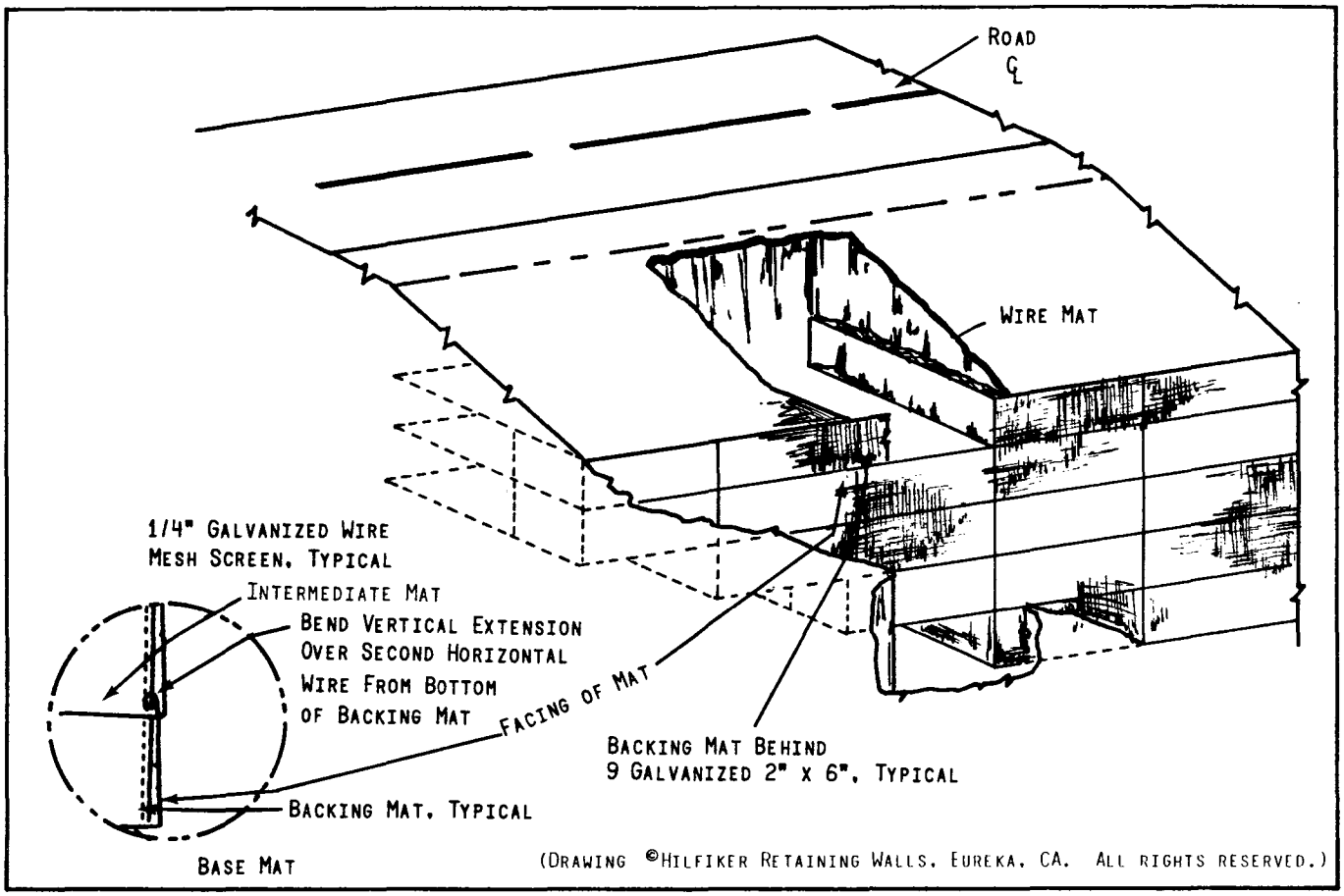


Figure 1.--Typical welded wire retaining wall.

composite face section of three separate wire panels. Clips secure these panels until the backfill is in place.

(4) Granular soil backfill material. This material, commonly available at or near the construction site, is spread over several wire mats placed side by side and is compacted, forming one step along the length of the wall at that elevation. (Wall lengths usually vary at different elevations to fit terrain conditions.)

(5) Facing gravel--either pea gravel or 3/4-inch concrete aggregate. These gravels normally are manufactured aggregates and must be hauled to the construction site. They are used to backfill the outer 6 inches to 2 feet of the panel face. After the next overlying mat is in place and secured, the aggregate is dribbled through the 2-inch by 6-inch screen and consolidated by rodding.

The process of combining these five basic elements to form incremental steps in the wall is repeated until the desired wall height and configuration are achieved.

OIL & GAS INSTALLATION

The first welded wire retaining wall on the Forest was constructed by Sulenta Construction Company, Inc., of Pinedale, Wyoming, for American Quazar Petroleum Company in Deep Creek Canyon on the Sanpitch Section of the Uinta National Forest. These Forest lands are administered by the Sanpete Ranger District of the Manti-LaSal National Forest.

Previous seismic investigation had identified a geologic structure characteristic of potential petroleum-bearing formations some 16,000 feet below Deep Creek (Section 16, R1E, T15S, Salt Lake Base and Meridian). The selected well site (figure 2) was not the best location for testing the structure, but it was chosen because of terrain constraints and environmental considerations. Although it was the most environmentally acceptable, the site presented the contractor with some challenging construction problems.

The proposed total depth of the exploratory well was 16,500 feet. To drill to this depth, a large rig was required, and a drill pad measuring 200 feet by 300 feet had to be constructed. Construction of the welded wire wall to contain the embankment and prevent it from affecting the Deep Creek riparian

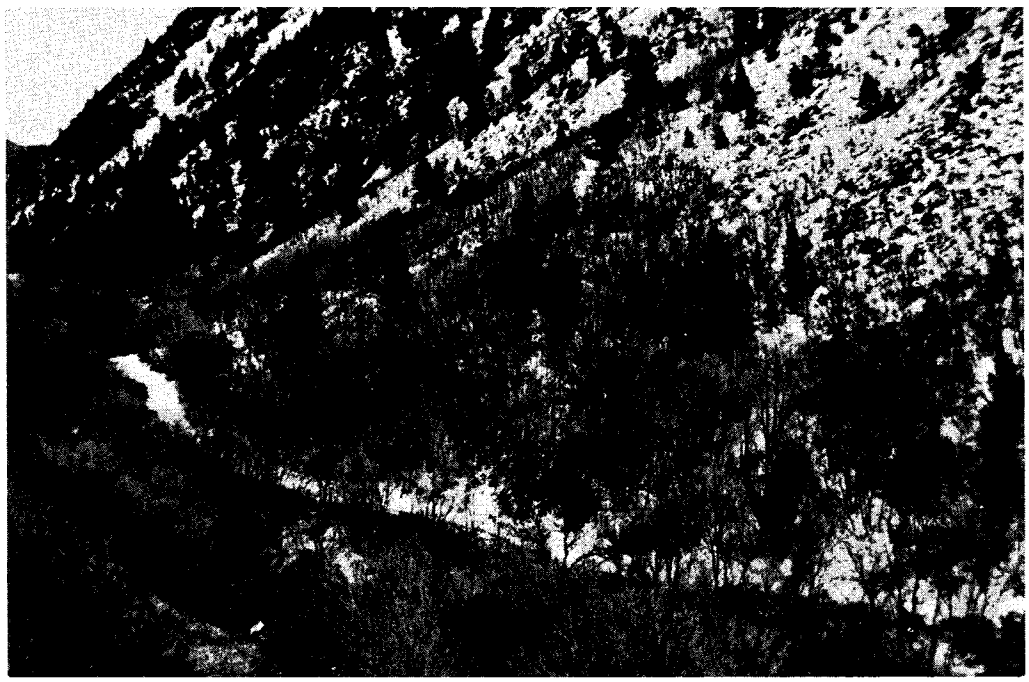


Figure 2.-- Proposed site for American Quazar's wildcat oil well.

zone allowed the pad to be moved closer to the stream and reduced the excavation from 80,700 cubic yards to 38,000 cubic yards. This also reduced the disturbed area from 2.92 acres to 2.26 acres. The reduced area would have consisted primarily of 1:1 cut slopes reaching heights of 200 feet or more.

The final embankment configuration consists of four sections: two sections of retaining wall and two sections of fill slopes. The first section, the lower retaining wall, is 12 feet high and was constructed of panels with 12-inch vertical face increments. From the top of this wall, a slope embankment approximately 15 feet high was constructed of select material containing a high percentage of rock that is from 6 inches to 1 foot in diameter. The upper wall was then constructed to a height of 15 feet, using panels with 18-inch vertical face increments. The last section consisted of an embankment approximately 8 feet high placed on a 1:1 slope.

The construction of the welded wire retaining walls began the second week of November 1980. The contractor worked two shifts daily to expedite construction of the walls. Although work was hampered by winter storms, the lower wall was completed by November 25, 1980, and the upper wall by December 8, 1980. The drill rig was in place and drilling began on December 20, 1980. Figure 3 shows the completed pad construction with the drill rig in operation.

Shortly after construction of the upper wall, some of the face panels began to deform. The first panels to buckle were along the bottom of the wall, where compressive loadings are the greatest. By April 1981, panels only 3 feet from the top of the wall also had buckled. Examples of the initial buckling are shown in figure 4.

On December 19, 1980, Eugene D. Hansen and Bruce C. Vandre of the Region 4 Geotechnical Materials Engineering Staff and I inspected the condition of the wall. We were interested specifically in the surface deformation and concluded that several elements contributed to the buckling of the face panels. The most significant factor was that the contractor did not follow precisely the manufacturer's recommended installation procedures. The contractor backfilled the outer 1 to 3 feet of the wall with crushed aggregate base material instead of with the uniformly sized pea gravel or 3/4-inch concrete aggregate recommended by the manufacturer.

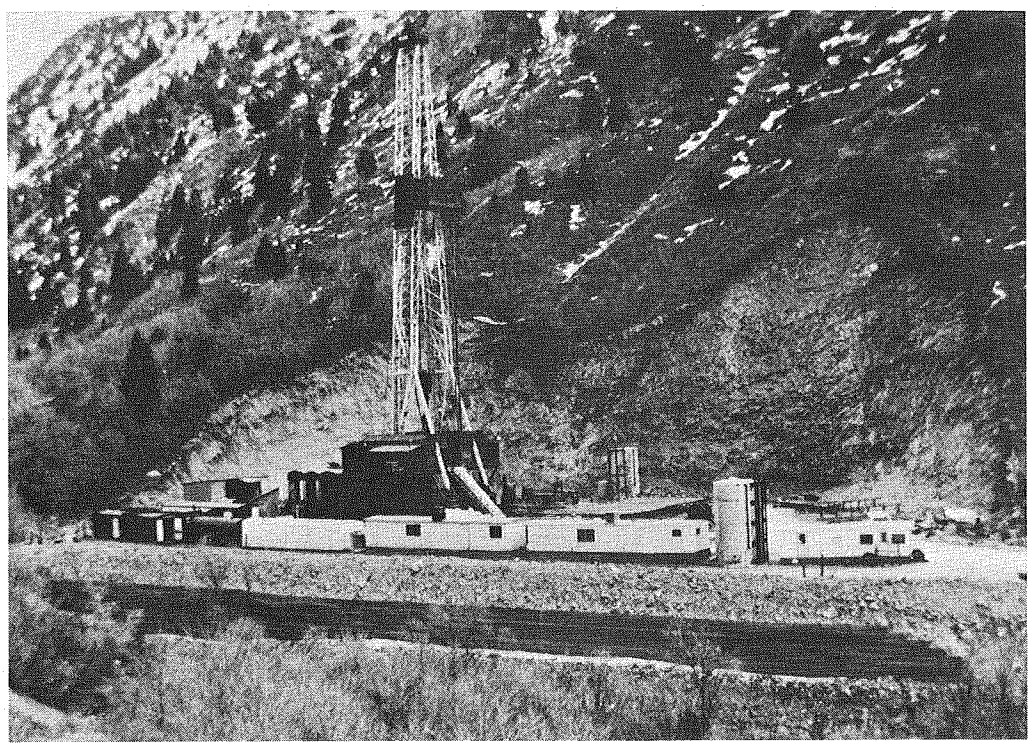


Figure 3.--Drill site during drilling operations. Note location of welded wire retaining walls below pad elevation.

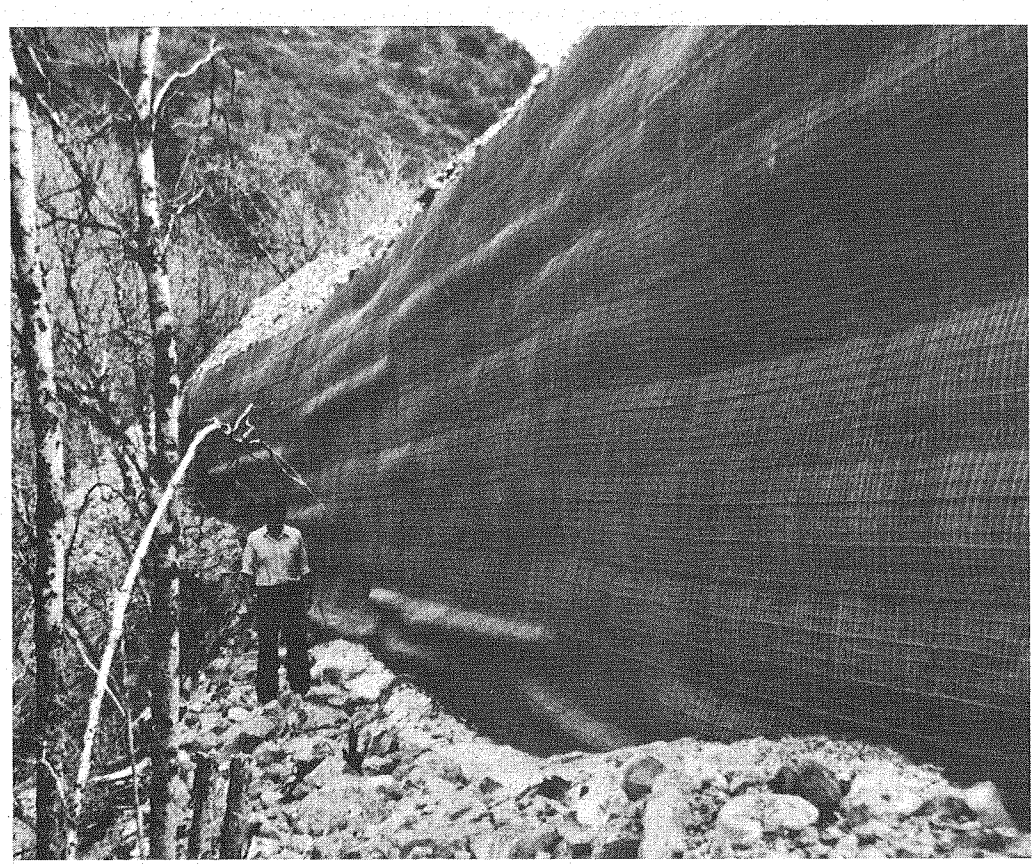


Figure 4.--Surface deformation in upper wall. Note areas void of facing gravels in the lower right-hand corner.

In addition, the aggregate used in backfilling the face should be rodded to prevent bridging and the development of large voids. Apparently this was not done properly, because voids the size of baseballs--and larger--were visible throughout the wall face. Furthermore, the aggregate used by the contractor consolidated and compacted under load, placing compressive stresses in the face wires. Because no appreciable strength exists in the 9-gage, 2-inch by 6-inch wire mesh, any consolidation of the materials contained within the walls resulted in the buckling of the face panels. Although the surface deformations marred the appearance of the upper wall, the structural integrity and stability of the wall were not jeopardized.

Drilling of the well was completed to a depth of 13,515 feet by September 1981. The Forest Service determined that it would be in its best interest, as well as the public's, to retain the drill pad once specified reclamation was performed around the perimeter to enhance the pad for use by campers, picnickers, and other visitors. The walls continue to function as intended.

The lower wall has remained relatively firm, with no significant signs of buckling or deformation. The probable reason for the lower wall's superior appearance compared to the upper wall is that the lower wall was constructed with 12-inch face panels. With the thinner lifts, there is less opportunity for the facing gravels to "bridge"; and because the overall volume of facing gravel is reduced, there is less opportunity for consolidation under load.

A second factor that could have contributed to the differences in the walls' performance is that the construction crew did not know the installation procedures on the first wall, and therefore they followed the manufacturer's recommendations. By the time the second wall was installed, the crew had gained enough experience that they developed their own installation procedures, possibly shortcutting some of the more tedious and time-consuming operations, such as rodding the facing gravel.

COAL MINING INSTALLATION

The second and third welded wire walls constructed on the Forest were built by Genwal Coal Company. Genwal purchased a Federal coal lease in Crandall Canyon, which is located on the Price Ranger District. Before Genwal's involvement, a primitive road existed in Crandall Canyon, but that road was unsatisfactory for the company's proposed use. The

Forest Service and Genwal Coal Company developed design criteria for the new facility, and a consultant engineering firm employed by Genwal designed the new roadway with a 26-foot surface width for Crandall Canyon. The design included three bin-type retaining walls in narrow, steep sections of the canyon where normal roadway embankments would have encroached upon or buried Crandall Creek.

During construction, Genwal proposed changing the retaining walls to the welded wire type. The Forest Service approved this change, and in August 1981 construction of the first wall commenced. A subsequent alignment modification eliminated one wall from the design.

The two walls constructed by Genwal Coal Company are comparatively simple installations, approximately 50 feet long and 13.5 feet and 19.5 feet high. These walls were constructed using 18-inch face panel increments. Material common to the site was used for backfill, but facing gravels were imported. The work force consisted of four men, one dozer, and one loader.

The operator initially used crushed aggregate base material for facing gravel. We first reviewed the wall construction after several lifts were installed, and we informed the operator of what would occur if he continued to use those aggregates for facing gravel. He was required to provide the proper material for the remainder of the work, though the panels already in place were allowed to remain.

The stability and durability of welded wire retaining walls were put to a severe test in Crandall Canyon. The walls were completed before drilling and shooting of the sandstone cliffs directly above the walls, which was necessary as part of the road construction. The contractor followed this sequence of operations hoping that the retaining walls would provide an area onto which the shot rock would fall and stop before entering Crandall Creek. One completed wall and a nearby 50- to 70-foot sandstone cliff are shown in figure 5.

When the drilling and shooting occurred, the amount of rock displaced simultaneously far exceeded the storage capacity of the primitive road above the walls. The amount of dynamic loading exerted onto the walls by blasting the rock and having it drop onto the roadway is unknown, but it is estimated that as much as 1,250 tons of rock fell directly onto the top of the wall. As seen in figure 6, some

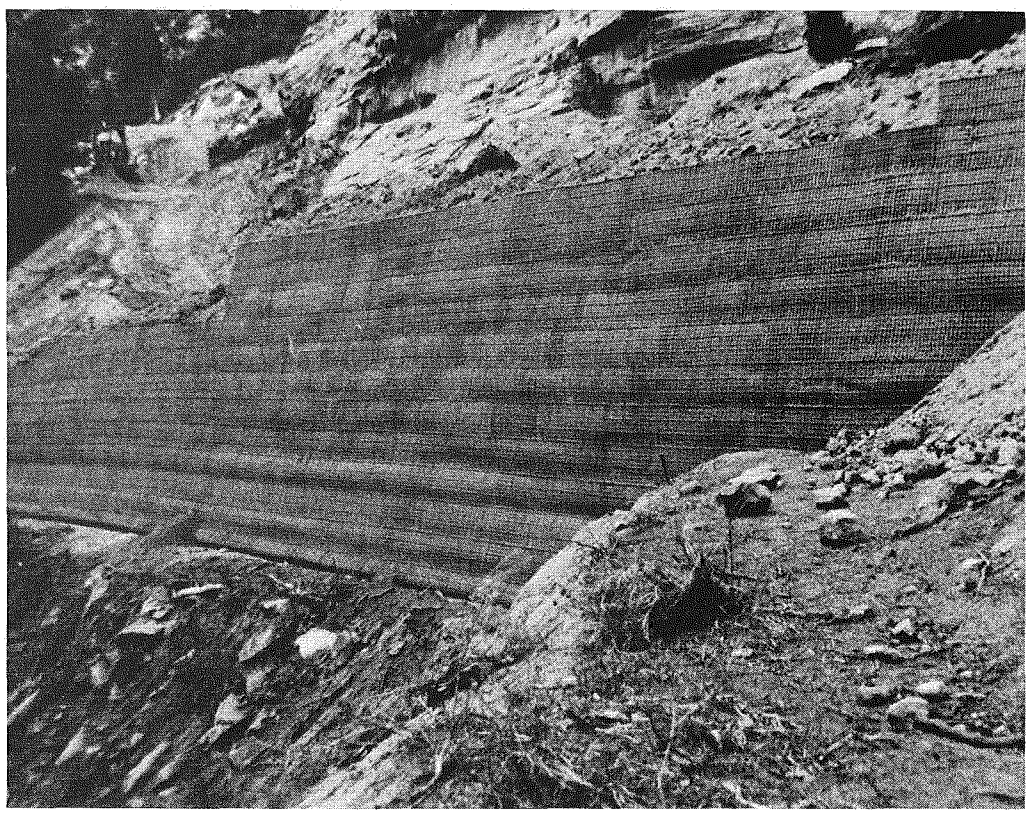


Figure 5.--Completed wall in Crandall Canyon. Note the sandstone cliff above wall.

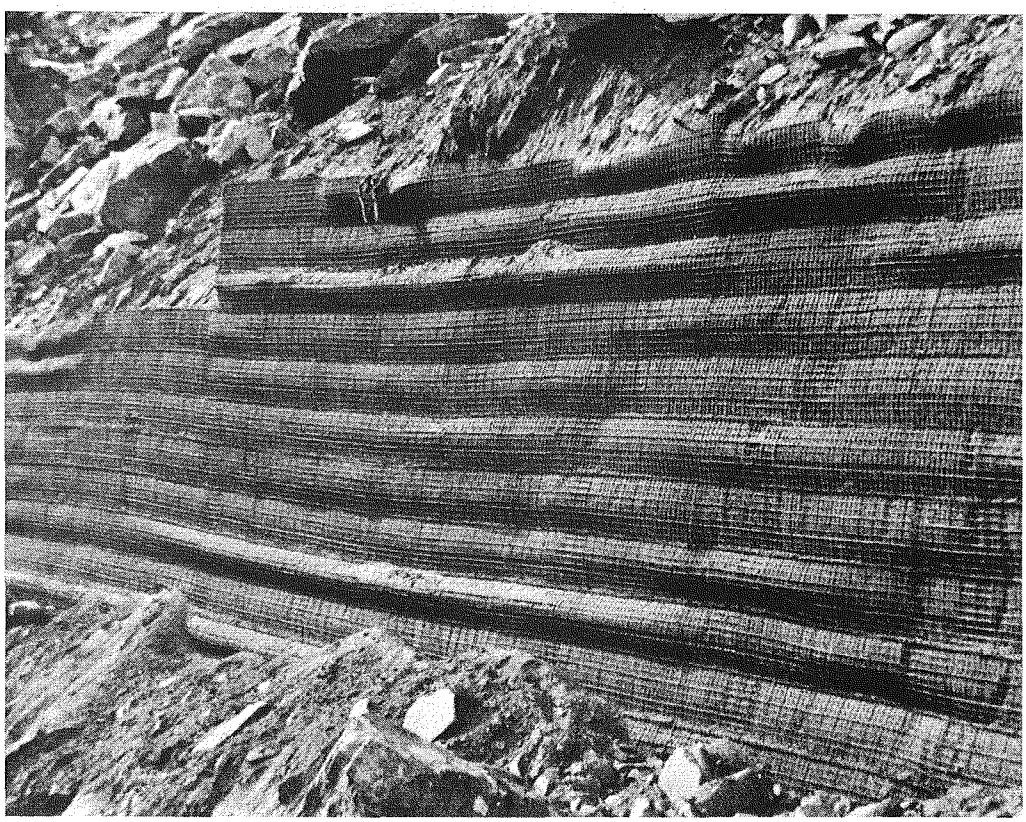


Figure 6.--Crandall Canyon wall after blasting operations.

damage to the wire occurred at the upper edge of the wall. However, the structure is flexible and, even under this tremendous loading, only minor surface deformation developed below the upper panel. Other wall types of rigid construction might have sustained considerably more damage. The welded wire retaining wall performed extremely well when subjected to this test of strength and stability.

PUBLIC WORKS INSTALLATION

One of the major public works activities in Region 4 from 1979 to 1982 was the reconstruction of Forest Development Road 50062, LaSal Loop Road, on the Moab Ranger District of the Manti-LaSal National Forest, which included construction of the Mill Creek Bridge by Severance Construction of Eden, Idaho. This project involved constructing a poured-in-place concrete bridge and a 350-foot, gravel-surface roadway. The roadway design called for 248 feet of welded wire retaining wall, of which 163 feet were to be built on an 80-foot radius. The wall varied in height from 6.5 feet to 25.5 feet, with 19 different wall heights along its length.

Two factors dictated that a retaining wall be constructed at the east approach to the bridge. The mountainside above the road in this area has a natural side slope of about 50 percent and consists of 10 to 20 feet of colluvial material underlain by uplifted sandstone formations. The overlying soil materials are extremely wet and unstable, particularly from May to July of each year. Benching into the hillside would have reactivated numerous slumps and hummocks located just above the road and possibly created massive land movements extending 1,600 feet up the mountainside to the top of the ridge. These conditions precluded any cutting into the hillside.

Mill Creek is located approximately 70 feet below the roadway elevation. To develop the desired road width, construction of conventional embankments would have encroached into the stream. The stream and terrain geometrics precluded realigning the stream with channel changes. Therefore, retaining the embankment with some type of wall was necessary.

Practically the full gamut of wall types was considered before determining that a welded wire retaining wall best met Forest Service needs at this location. The dominant factors in making this decision were the cost of the wall, the flexibility of wall construction, the working area required for construction, and the esthetic quality of the completed installation.

The final, in-place construction cost of the wall, including excavation, select backfill, facing gravel, and wall materials was $113,491.70. For 4,980 square feet of wall face, this computes to a unit price of $22.79 per square foot.

The configuration of the wall--an 80-foot radius on the face panels, 19 changes in wall height because of foundation conditions and roadway grade, and a maximum height of 25.5 feet--was easily accommodated by a welded wire retaining wall. Most other wall types were unable to meet these specifications without extraordinary fabrication and erection techniques, which would have increased their already higher costs. Although the working area requirements for the volume of material to be handled in welded wire wall construction exceeded the requirements of some other wall types, they did not exceed the area available for this project.

Some other wall types were considered esthetically superior to the welded wire retaining wall, particularly in light of the irregular surfaces that developed on those walls previously constructed on the Forest. However, it was felt that the appearance of the welded wire retaining wall could be improved by proper construction engineering inspection and strict adherence to the manufacturer's recommended installation procedures. Surface treatments can be applied to the walls if a particular appearance is required. At the Mill Creek location, the facade material was considered unnecessary. Considering all these factors, along with others not discussed here, the welded wire retaining wall was determined to be the best structure for this installation.

Excavation for the wall began on October 8, 1981. The first wall panels were emplaced on November 5, 1981, after 1,800 cubic yards had been excavated and 1,300 square yards of filter cloth with 250 feet of underdrain pipe had been installed. Work continued on the wall until December 21, 1981, when a winter suspension halted construction. Work resumed on April 12, 1982, and the wall was completed by May 1, 1982 (see figure 7). Approximately 270 man-days of construction labor were used to construct the wall. Figure 8 shows a section of the completed wall and the degree of wall face uniformity that can be achieved by following the manufacturer's installation recommendations. In figure 9, the wall's adaptability to field conditions is evident. The

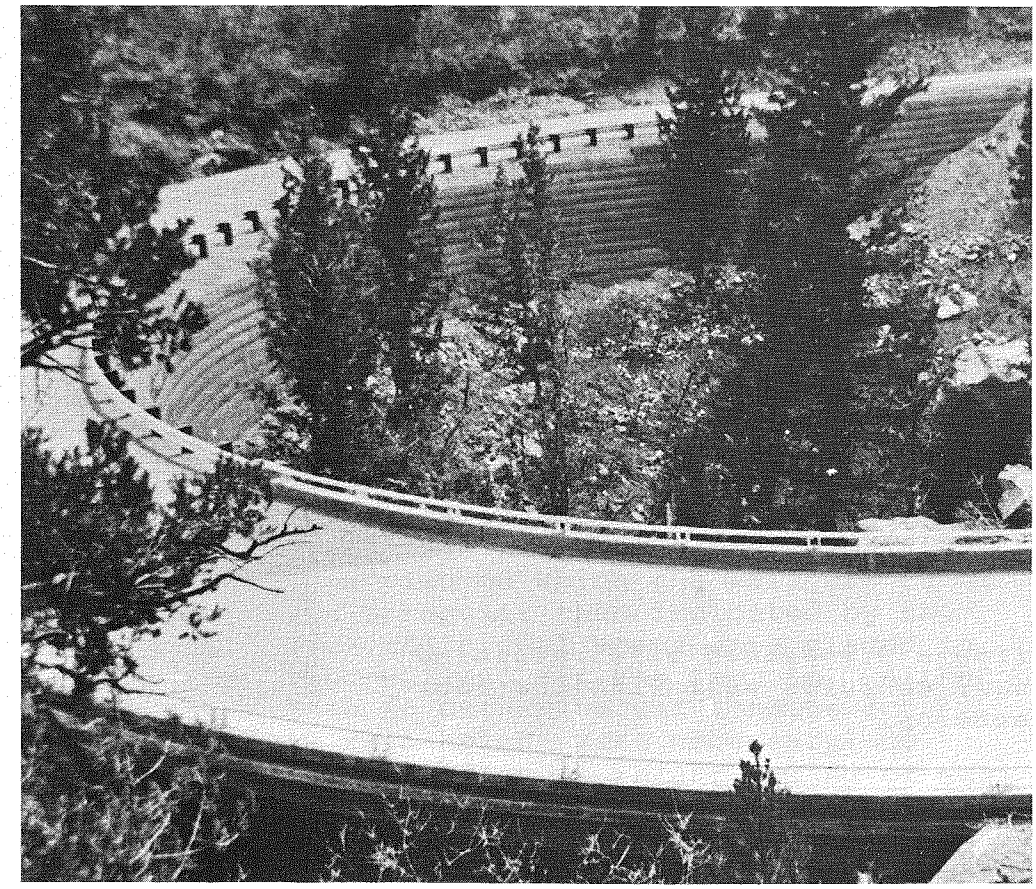


Figure 7.--Completed LaSal Loop welded wire retaining wall.

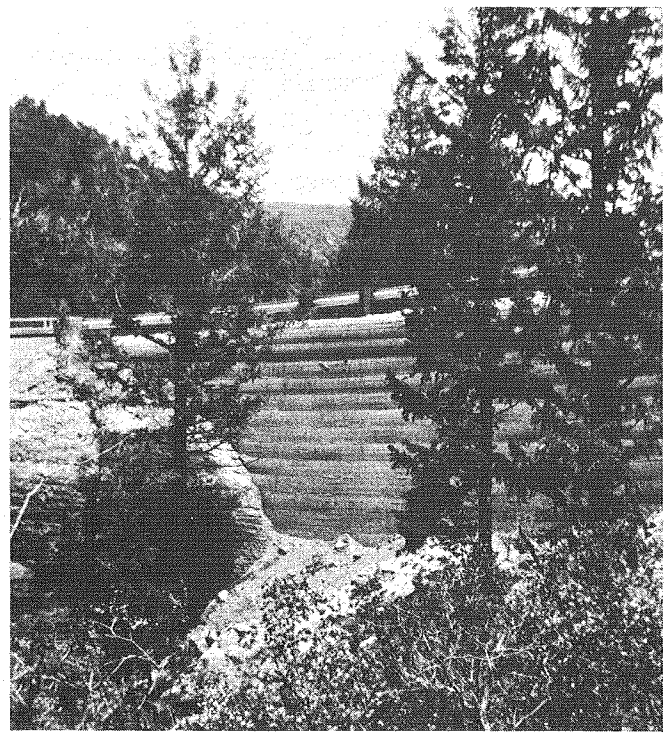


Figure 8.--Example of surface uniformity achievable with welded walls.

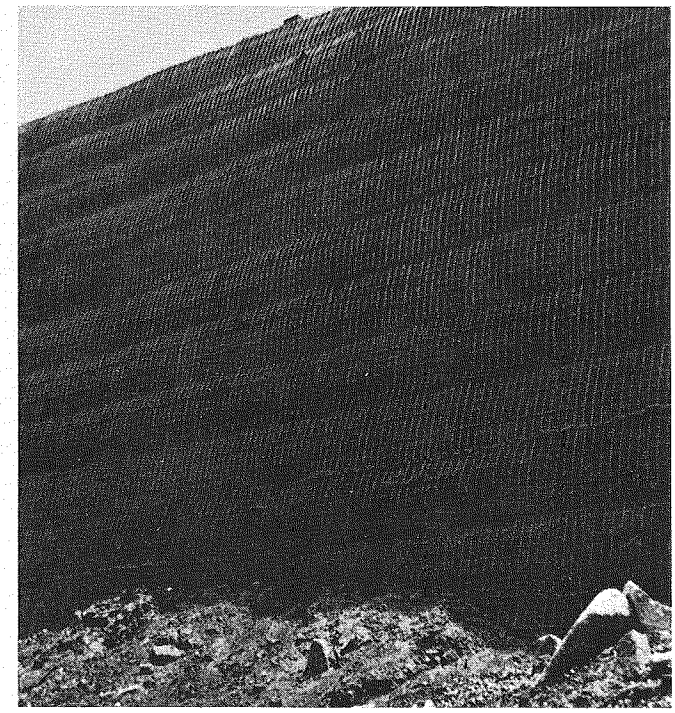


Figure 9.--Welded wire retaining wall conforms well with the rock outcrop.

wall is tightly butted up against an irregular rock outcrop, a result that was achieved by cutting and "tailoring" the wall panels to match the rock line.

UTAH DEPARTMENT of TRANSPORTATION INSTALLATION

A new State highway is being constructed between Scofield and Fairview, Utah. Three projects are currently under construction within the Forest boundary, with a combined length of 13 miles. The Carbon County line to Skyline Mine project, being constructed by H. E. Lowdermilk Company of Helper, Utah, requires construction of a continuous welded wire retaining wall 1,250 feet long. The purpose of this wall is to prevent roadway embankments from encroaching on the Eccles Canyon stream and to reduce the overall disturbed area associated with the highway construction. The wall height varies from 7.5 feet to 19.5 feet, with 15 steps in the bottom of the wall and is to be constructed of mats having 18-inch facing panels.

The uniform sustained grade of the road in the wall area is 7.84 percent. Unlike the walls previously discussed, this wall will not be constructed using panels set on a level grade with vertical steps in the upper panels to achieve the desired road grade. Instead, the wall panels will be placed on the 7.84-percent grade; there will be no steps in the top of this rather long wall. The exposed face of the wall will parallel the roadway centerline, which

includes a 515-foot, 10-degree curve to the right and a 60-foot, 10-degree curve to the left, with the wall located on the right side of the road. The remainder of the wall is in a tangent section.

Plans also call for installing two 24-inch cross-drain culverts within the wall. The wire mats will be cut and folded back along the culverts, with some wire mesh wrapped around the mat and culverts to retain the backfill material.

Construction began in September 1982, but after four or five panels approximately 200 feet long were installed, the project was suspended for the winter because of heavy snows. Although very little had been accomplished on this wall, one of the advantages of the welded wire retaining walls was immediately apparent. The terrain on which the wall was to be located was more irregular than indicated by the wall design. Two additional steps were placed in the bottom of the wall to fit the terrain. Although some calculations to determine mat lengths for the appropriate wall height were necessary, no major design modifications or refabrication of wall components were required.

CONCLUSION

All our experiences with welded wire retaining walls have been positive. The walls have performed very satisfactorily at each installation, even though some were not constructed in compliance with the recommended procedures and some have borne excessive dynamic loadings. Additional applications of welded wire retaining walls on the Forest in road maintenance, recreation facility development, and other situations requiring almost vertical embankments will undoubtedly be forthcoming.

Naches Pass Road Reinforced Earth Walls

Stephen Wood
Supervisory Civil Engineer
and
Roger Henderson
Civil Engineer
Wenatchee National Forest
Region 6

PROJECT

The Naches Pass Road, Forest Service Road #197, on the Wenatchee National Forest was a single-lane, aggregate-surfaced road that had to be widened to provide for a double-lane, paved surface. The design for this 5.5-mile project was started in 1979. The road lies between the Little Naches River and tall vertical rock bluffs of columnar basalt. Retaining walls in two areas on the project had to be constructed to allow the widened road between the river and the bluffs. The walls minimized encroachment on the river and permitted us to leave the scenic bluffs untouched.

A hydrologic study of the river was made, geotechnical data were gathered, and alternative retaining wall designs were investigated. Value analysis techniques were applied to the assembled data, and through this process a Reinforced Earth[1] wall was selected as the retaining structure that would best satisfy our needs at the least cost (see figure 1). A contract to construct the road was awarded to E. R. Fegert, Inc., of Othello, Washington, on September 29, 1981.

The specifications and bid costs for Reinforced Earth walls #1 and #2 are presented in table 1.

CONSTRUCTION

Construction of Reinforced Earth wall #1 began by diverting the river into a temporary channel with an earth diversion dike. Next, pumps were stationed to dewater the trench where the structure's precast

---

[1] A trademark of Reinforced Earth Company, Rosslyn Center, 1700 North Moore Street, Arlington, Virginia 22209.

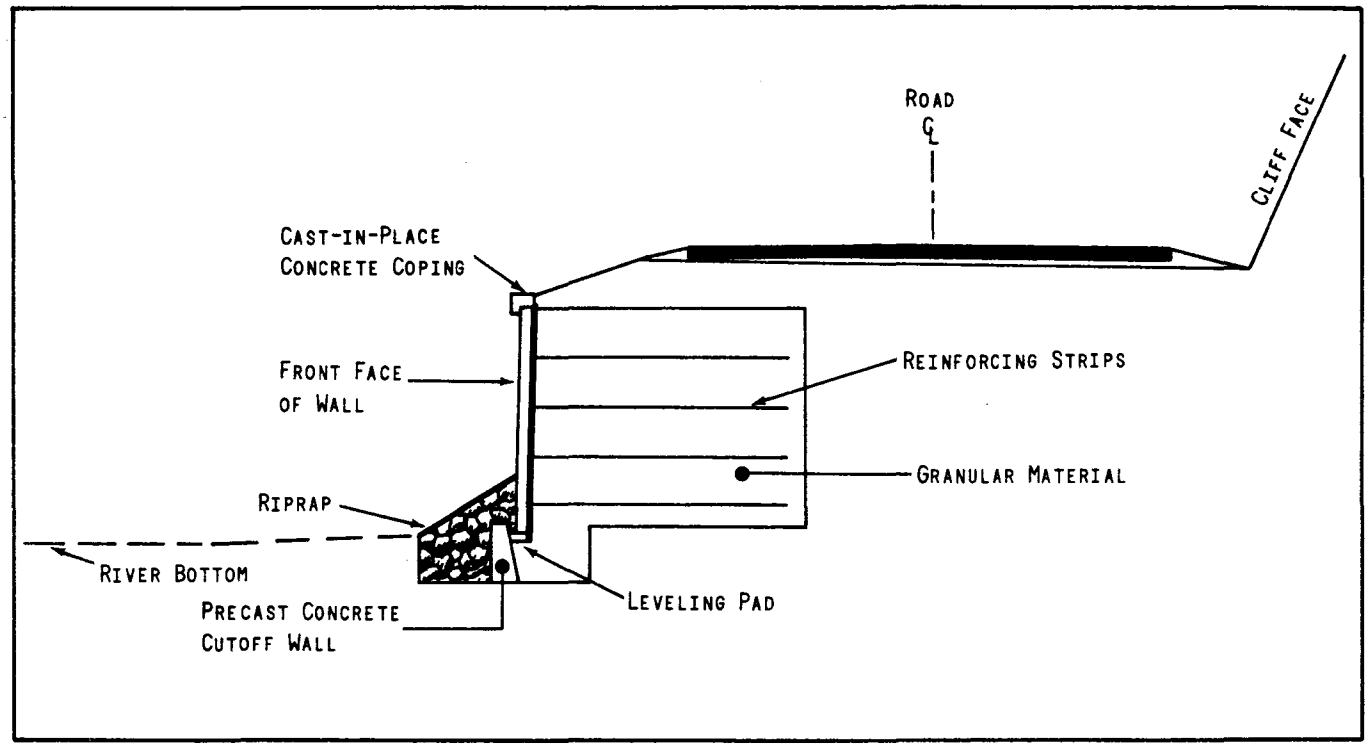


Figure 1.--Reinforced Earth wall, typical section.

concrete cutoff walls and cast-in-place leveling pad were to be placed (see figures 2 and 3). This trench was excavated between 3 and 4 feet deep below the river bed. The cutoff walls were set, riprap and a select backfill were placed on either side of these walls, then the leveling pad was cast behind the cutoff wall (see figure 4). Because the contractor was careful to ensure that the cutoff walls were installed to the correct line and elevations, no major problems were encountered in building the Reinforced Earth wall to the required construction tolerances.

The wall was constructed as described by the Reinforced Earth Company's construction manual. The first level of panels was installed under the supervision of a Reinforced Earth Company engineer, who was on the project for 2 days. The next level of panels was erected on top of the lower level. Dowels in the panels were inserted into holes in the adjacent panels. Each panel had numerous tie strips cast into it. These tie strips were bolted to galvanized steel reinforcing strips that extended back into the granular material. This material was layered above each row of reinforcing strips to form a "reinforced volume." The crew installed an average of 850 square feet of wall panels per day.

Table 1.--Specifications and bid costs for Reinforced Earth walls #1 and #2.

	Wall #1	Wall #2
	Specifications	
Height	Varies, averages 13 feet	Varies, averages 13 feet
Length	835 feet plus 2 end walls at 12.5 feet each	378 feet plus 2 end walls at 12.5 feet each
Wall Area	6,741.0 square feet	3,191.7 square feet
	Bid Costs	
Staking	$ 500.00	$ 500.00
Cuttoff Walls ...	29,156.00	11,623.00
Panels (including erection)	116,551.89	55,184.49
	Bid Costs for Both Walls	
Structural Excavation	$20,466.00	
Structural Excavation, Solid Rock	35,000.00	
Leveling Pads ...	4,323.20	
Select Granular Backfill	21,808.00	
Riprap	9,582.09	
Miscellaneous ...	36,624.18	
	Totals	
Cost	$230,947.00	$110,372.00
Average Cost	$34.36 per square foot of wall area	

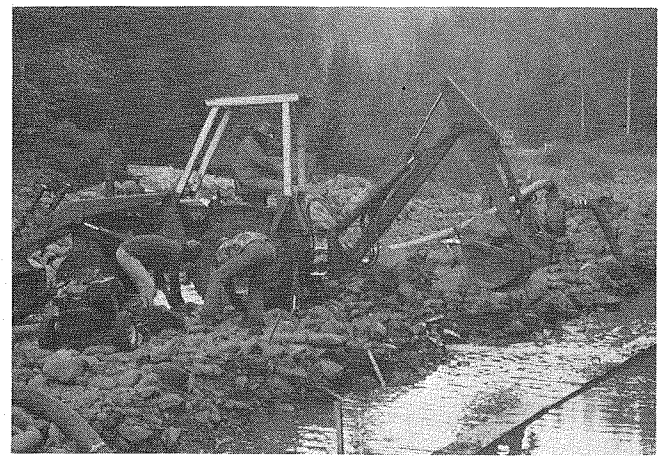


Figure 2.--Installation of pumps to dewater trench before placement of precast concrete cutoff walls and cast-in-place leveling pad.

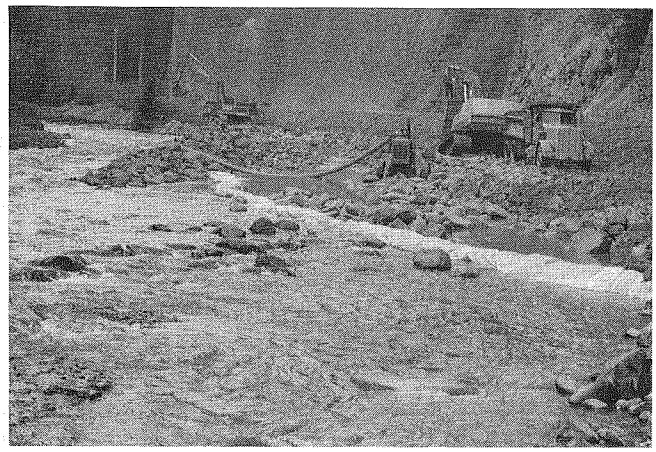


Figure 3.--Trench, after pump installation.

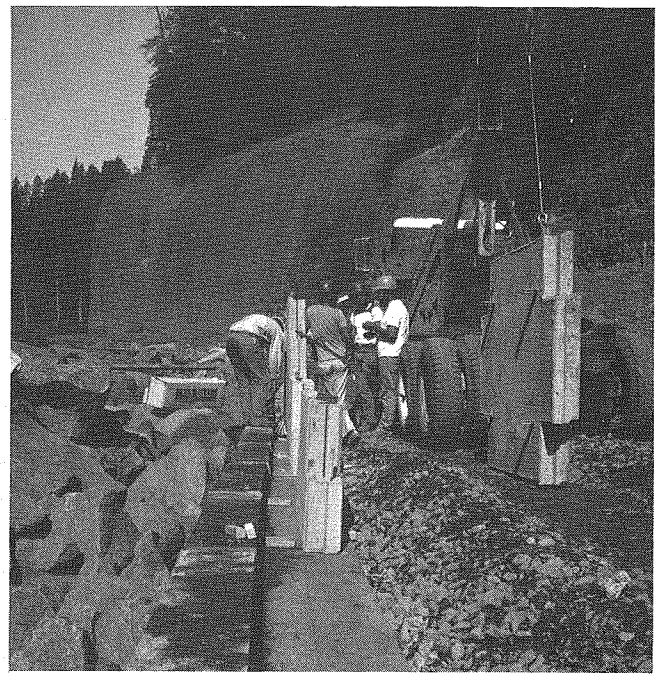


Figure 4.--Leveling wall is cast behind cutoff wall.

The only item that limited a more rapid construction was the hauling of granular material from the stockpiled source.

The one change made in the wall design that differed from standard Reinforced Earth walls was the installation of filter cloth behind all vertical and horizontal joints. This was required because the river runs against the wall. Water flows in and out of the backfill, so filter cloth was used to trap the fines. The fines are needed to maintain the structural integrity of the wall by providing friction for the reinforcing strips that hold the "reinforced volume" and wall panels together in a mass--similar to the function of steel in reinforced concrete. Construction of Reinforced Earth wall #1, except for the coping, took 8 working days. A crew of three men placed the panels and reinforcing strips, one man operated a truck-mounted boom, one man operated a grader, one man operated a steel-wheeled roller, and one man operated a small dozer (see figures 5 and 6). They were supervised by one foreman.

CONCLUSION

The erection of Reinforced Earth wall #1 was successful, and the structure blends well with the surrounding terrain (see figures 7 and 8). In addition to being the most feasible and economical alternative, this Reinforced Earth wall met land management objectives involving esthetic quality, hydrologic considerations, and fisheries habitat criteria. The Reinforced Earth construction accomplished the following:

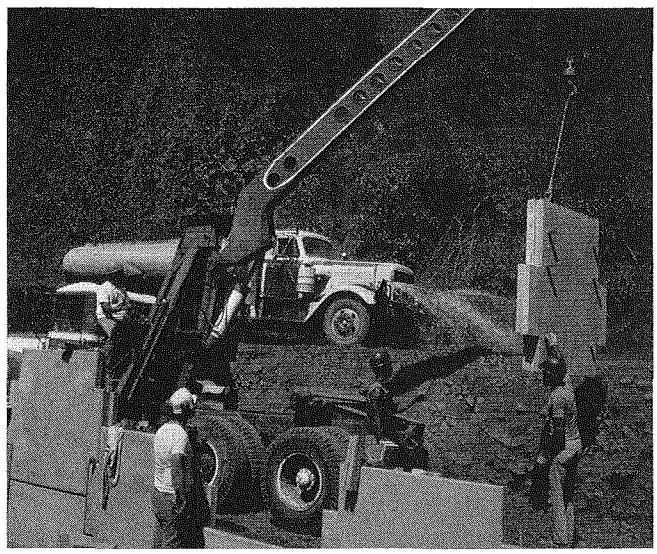


Figure 5.--Three-man crew places panels on Reinforced Earth wall #1.

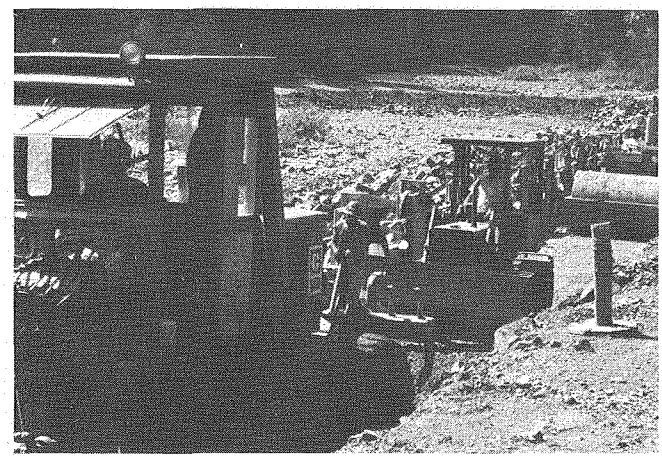


Figure 6.--Truck-mounted boom, grader, and steel-wheeled roller are used to construct Reinforced Earth wall #1.

Figure 7.--Successful erection of Reinforced Earth wall #1.

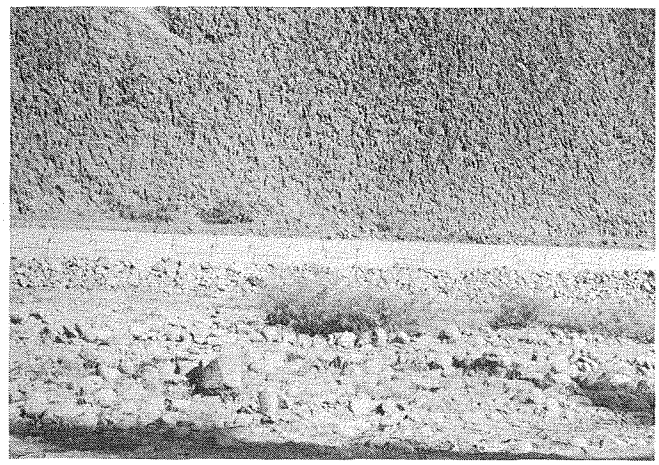


Figure 8.--Reinforced Earth wall #1 blends well with surrounding terrain.

(1) Work was completed faster than a cast-in-place concrete retaining wall could be built. This was critical because of a mandate from the Washington State Department of Fisheries to return the stream to its natural channel by September 1, 1982.

(2) Traffic was maintained on the existing roadway adjacent to the construction area.

(3) The finished retaining wall provides an interesting and attractive appearance. The panels and coping can be painted with a concrete waterproofing stain, which will allow the structure to blend into the environment.

(4) No pollution of the river was caused by "live" concrete entering the river because the concrete was entirely precast, except for the leveling pad and the coping.

(5) Construction of the wall did not require a solid rock foundation into which footings had to be dowelled.

(6) A smooth, thick concrete wall provides greater resistance to damage by debris in the river than would alternate structures.

(7) Reinforced Earth construction is a relatively simple procedure, so construction problems were minimal.

Curve-Widening Simulator

Jim Bassel
Staff Engineer, Transportation
San Dimas Equipment Development Center

In the fall of 1978, Gary Bergstrom (logging specialist) and Ken Perreard (engineer) of the Rogue River National Forest in Oregon developed and built a curve-widening simulator. This is a handy tool for determining the extra width needed, because of "offtracking," by long-wheelbase vehicles on forest roads. The curve-widening simulator essentially is a tricycle having a long wheelbase that produces the movements of a long-wheelbase vehicle. The usefulness of the device and its cost-saving features have resulted in Gary and Ken already being awarded a little more than $2,000 for their idea.

A second curve-widening simulator was constructed for Brian W. Kramer of the Olympic National Forest in Washington. He reported on his findings with this device at a September 1982 American Society of Agricultural Engineers regional meeting in Corvallis, Oregon.

When faced with determining whether long-wheelbase vehicles (for example, yarders, lowboys, and similar equipment for logging, construction, or hauling) can make all turns on a forest road,the current standard practice is first to have a trained observer indicate where difficulties may be encountered. Then, each questionable curve is surveyed and plotted to simulate the vehicle's actual movement on the road. This is a tedious and expensive procedure. By using the simulator, only those curves that cannot accommodate the simulator need to be surveyed and plotted.

More recently, engineers and shop technicians at the San Dimas Equipment Development Center (SDEDC) were asked to look at the Region 6 device and refine its design. SDEDC produced an updated simulator (see figure 1), and it was debugged during trial runs--first on a forest road in the foothills of the San Gabriel Mountains in California and then by Region 6 personnel on Rogue River National Forest roads.

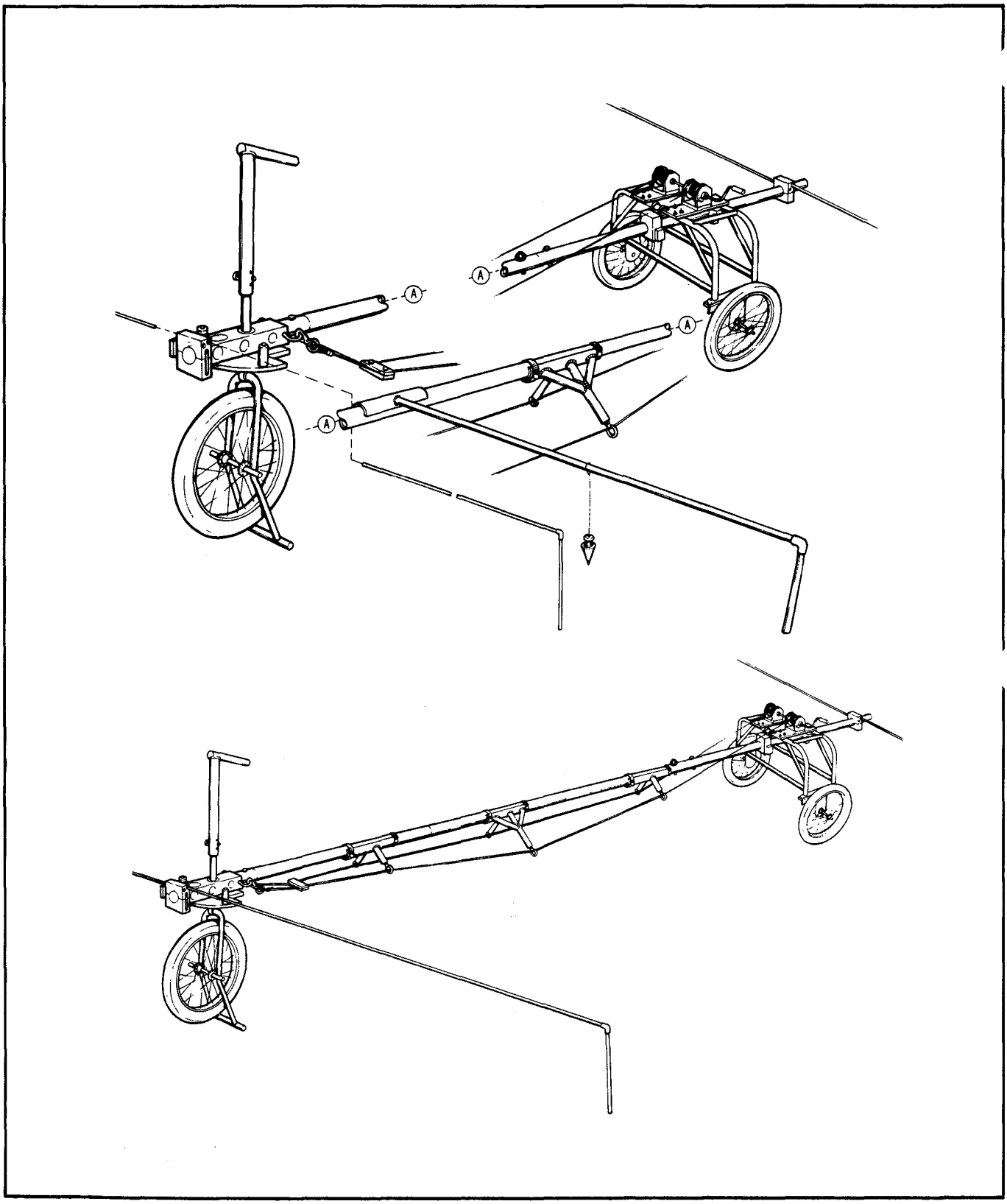


Figure 1.--Updated simulator produced by SDEDC.

SDEDC has prepared engineering drawings and instructions for assembly, disassembly, calibration, and use of the latest-design curve-widening simulator. These plans and instructions are available by request from SDEDC.

Being essentially all aluminum, a typical assembled simulator weighs approximately 90 pounds. The simulator components can be fabricated for approximately $3,500--less when the items are mass produced. Two people who are familiar with the components can assemble the simulator in less than 15 minutes. They should use those components that correspond to the type, wheelbase length, and width of the vehicle to be simulated.

A two-person crew uses an optical mirror and plumb bob to calibrate the simulator by setting the maximum turning angle to match that of the vehicle being simulated. The simulator is then walked around curves on a forest road to trace the exact path of the long-wheelbase vehicle that the simulator has been assembled to match. Even vehicle backing and "jockeying" can be simulated. Thus, the road curves that will need to be surveyed and reconstructed so that the long-wheelbase vehicle can use the road are identified with certainty before the actual equipment is brought to the forest site.

In-Place Preservative Treatment of Deteriorating Wood Bridges

Edgar E. Hedgecock
Civil Engineer
National Forests in Florida
Region 8

INTRODUCTION

In-place treatment of deteriorating wood bridges has been used for decades by the railroads, but there has been little use of the procedure elsewhere.

The following are pertinent points concerning this procedure:

(1) Treated material normally starts to decay after about 35 years.

(2) In-place treatment can be considered when decay is under way on not more than 25 percent of the structural members.

(3) Waiting until a greater percentage of members are decaying will normally necessitate replacing some structural members. Experience shows that when decay has attacked 40 percent of the members, 2 percent will have to be replaced; when decay is in 80 percent, 14 percent will have to be replaced.

(4) Pressure injection of preservative into structural members arrests decay for 12 to 15 years, and the treatment must be repeated at 12- to 15-year intervals.

EXAMPLE

In 1982, the decision was made to arrest internal deterioration and surface decay by undertaking an in-place preservative treatment of the existing 391-foot-long Bay Creek Bridge, #120-6.0, on the Apalachicola National Forest. The in-place treatment included replacing defective sections of structurally deficient piles.

The National Forests in Florida contracted with the Osmose Wood Preserving Company to do the in-place treatment of the Bay Creek Bridge. The work was done over a 9-day period in the fall of 1982. The

cost for the in-place treatment was slightly more than $28,000 ($72 per linear foot). Replacing the bridge would have cost about $450,000.

MATERIALS

All the chemicals used in treating the Bay Creek Bridge are intended to arrest fungus infection, decay, and rot. In addition, the treatment is supposed to retard any new fungus infection, decay, or rot for 12 to 15 years.

The following wood-preserving chemicals produced by the Osmose Company were used on the bridge:

Tie-Gard®. Tie-Gard® cartridges control decay caused by water; they were placed in drilled holes at the groundline or waterline of all the bridge piles. The cartridges are solidified preservatives consisting of 37.5 percent sodium fluoride, 37.5 percent potassium bifluoride, 19 percent sodium dichromate, 5 percent 2.4 dinitrophenol, and 1 percent inert material.

Timber Fume®. This chemical is a highly poisonous fumigant solution that arrests internal wood decay. Vials of the solution were placed in holes between the cartridges and the tops of the piles. The solution consists of 99 percent chloropicrin and 1 percent inert ingredients.

Osmose 24-12® Solution. The 24-12 solution prevents wood molds and fungus decay. The solution was injected under pressure into the caps and into the top area of piles. The solution is composed of 4.48 percent pentachlorophenol, 0.52 percent other chlorophenols, 5.16 percent aromatic petroleum solvent, 46.52 percent aliphatic petroleum solvent, and 43.32 percent inert ingredients.

Osmoplastic-F®. A wood preservative that kills existing fungus organisms and inhibits new fungus growth, the solution was injected into predrilled holes in all bridge stringers from 5-gallon buckets using a hand pump. The preservative is 20 percent sodium fluoride, 8.9 percent pentachlorophenol, 1.1 percent other chlorophenols, 15 percent creosote, and 55 percent inert ingredients.

PROCEDURES

Although the contractors had years of experience in treating wood railroad bridges and powerline poles, they had not treated any bridges like the Bay Creek unit. The company used a standard operating plan,

with only a few minor changes, that generally followed this order:

(1) Drill inspection holes.
(2) Inspect for internal decay.
(3) Establish a treatment pattern for piles, caps, and stringers.
(4) Develop environmental protection measures.
(5) Replace sections ("posting") of piles.
(6) Treat pilings.
(7) Treat caps.
(8) Treat stringers.
(9) Remove and dispose of all protective material and waste.

Details of Procedures

Each of the procedures involved specific steps to ensure maximum efficiency in the treatment.

1. Drill inspection holes. The contractor made a preliminary inspection of the bridge to determine the extent of treatment or requirements for replacement of pieces. The contractor sounded all members with a hammer and drilled 3/8-inch holes into piles, caps, and stringers at points of suspected decay. The results of this inspection were used to develop a cost estimate on which to base a contract price.

As part of the contract, the contractor drilled a predetermined pattern of 3/8-inch holes into the piles, caps, and stringers (figure 1). The patterned holes permitted us to look at the critical areas near the groundline and at the pile-cap-stringer connection. The contractor modified his standard railroad pattern to better fit the bridge's condition and the location of its structural members.

2. Inspect for internal decay. The structural condition of each member was determined by using the inspection holes and a special metal probe. The contractor estimated the sound and bad wood in each member, and these figures, for "shell" and "void," were marked beside the respective inspection holes.

3. Establish treatment pattern. A treatment pattern based on inspection data and water conditions at the bridge site was established. A variety of chemicals were used because of the water table at the site and the size of structural members of the Bay Creek Bridge.

4. Develop environmental protection measures. A special effort was made to prevent any pollution or

Figure 1.--Typical investigative borehole pattern, before treatment.

contamination of water. Highly toxic chemicals were used, and extra care was required during the treatmen near the water. Plastic draping around and under caps caught any spillage or leakage during injection; also, a funnel collar attached to the base of each pile collected any chemicals that ran down the pile.

A two-man crew performed all treatment operations. One crew member made the treatment while the other acted as a guard to control any spills or leakage. The crew's attitude and care during this part of the work can make the project a success or failure.

5. "Post" rejected piles. The contractor has developed methods and equipment to replace decayed piles and to match the replacements to the original piles' alignment and batter; further, the contractor can replace a section of pile rejected because of extensive structural decay or rot above the waterline or groundline instead of having to drive a new pile.

On Bridge #120-6.0, two piles were rejected because of decay, and sections of them were replaced from

just above the ground to the cap (see figures 2 and 3). Replacement was made with a creosote-treated pile section, which was "welded" in place with Osmoweld® epoxy resin and eight fluted steel pins, each 3/8 inch by 16 inches (see figure 4).

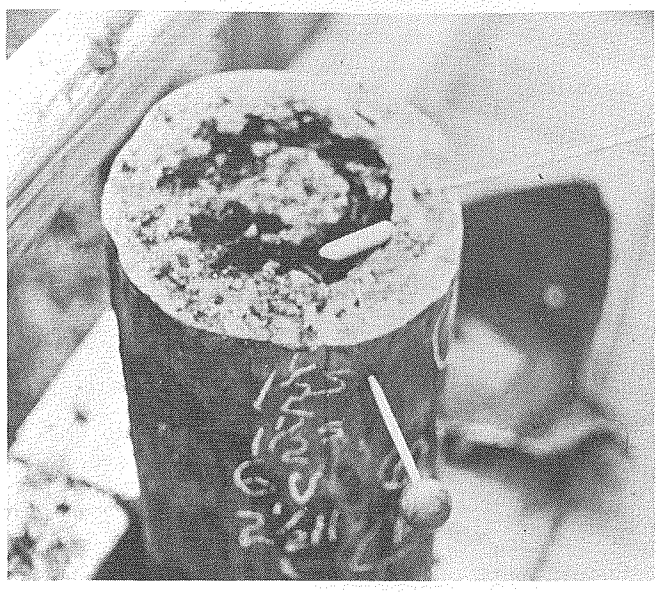


Figure 2.--Defective pile removed.

Figure 3.--Repairing the cut pile section, using the Osmose Company's specially designed pile cutter to replace the defective pile.

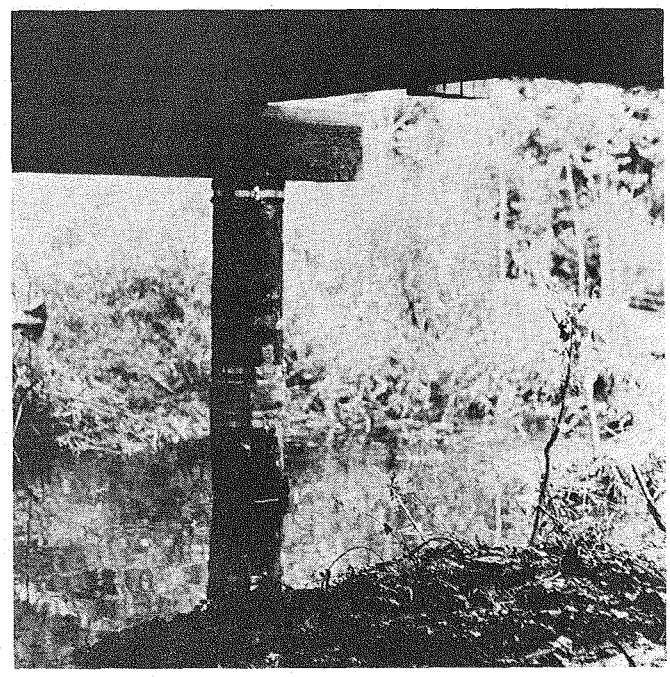


Figure 4.--Completed pile posting with Osmoweld® and protective plastic in place.

Normally, the contractor has a separate crew to do the posting; however, because the bridge was a relatively small job, the treatment crew performed the piling repairs.

6. Treat piling. Treating the piling was complicated by the high, fluctuating water level of Bay Creek. To achieve maximum effectiveness in the treatment, the contractor decided to use a combination of three products: Osmose 24-12®, Timber-Fume®, and Tie-Gard®. The following procedure allowed the maximum treatment of wood with the least risk of any material getting into the water:

(a) Extra holes (in addition to the inspection borings) were drilled at the groundline; Tie-Gard® cartridges were inserted and the hole was plugged (see figures 5 and 6). The cartridges will dissolve over a period of time and saturate the pile by capillary action.

(b) Vials of Timber-Fume® were inserted into holes that were drilled in the middle section of all piles (figure 7). The chemical becomes a gas in a short time and works its way throughout the pile. Timber-Fume® is not effective when water is present. It is a highly toxic substance, so extra care was used in preparing and placing the vials (see figure 8).

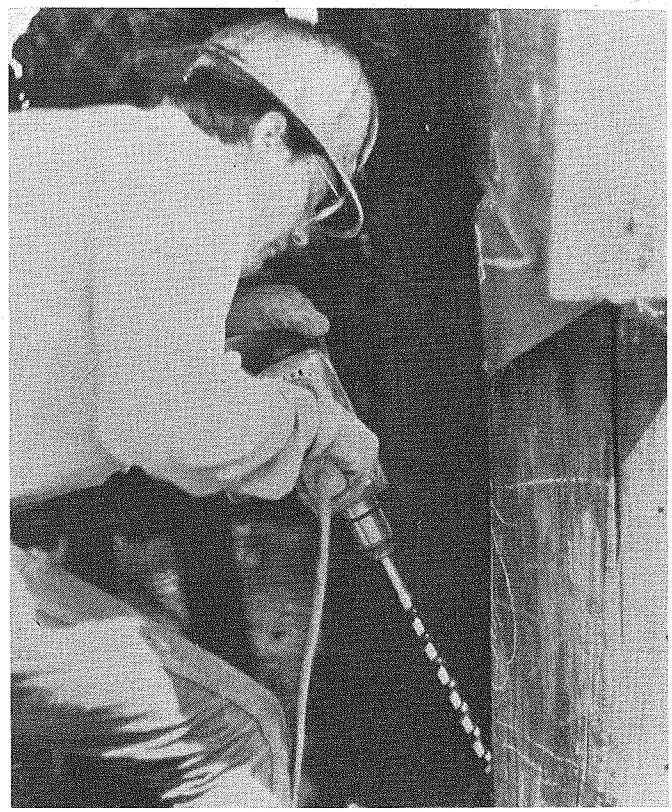


Figure 5.--Drilling holes for Tie-Gard® cartridges.

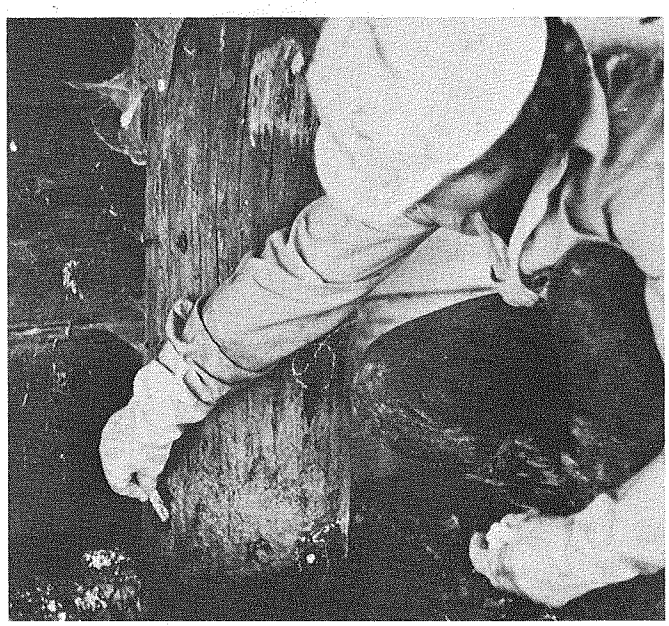


Figure 6.--Insertion of Tie-Gard® cartidges. Note the use of rubber safety gloves.

(c) For extra protection against decay, Osmose 24-12® was injected into the inspection holes at the top area of each pile (figure 9). The chemical will work its way through any voids in the wood.

7. Treat caps. Osmose 24-12® was injected under pressure into all the inspection holes in the bridge

Figure 7.--Timber-Fume® vial in wood-plugged hole, with location tab visible.

Figure 8.--Preparing Timber-Fume® vials. Note the required safety mask and gloves.

caps. A treated wood plug was driven into each hole to seal the chemical in the wood after injection. Plastic draping was used to catch any chemical that seeped out of cracks during injection and appeared to work satisfactorily (see figures 10 and 11).

In the injection process, a relief valve and catch bucket were used to suppress back pressure spills; the two-man crew worked well in preventing spills (see figure 12).

Figure 9.--Injection of Osmose 24-12® solution into piles and caps.

Figure 10.--Typical individual cap and pile draping, and funnel for protection against Osmose 24-12® leakage.

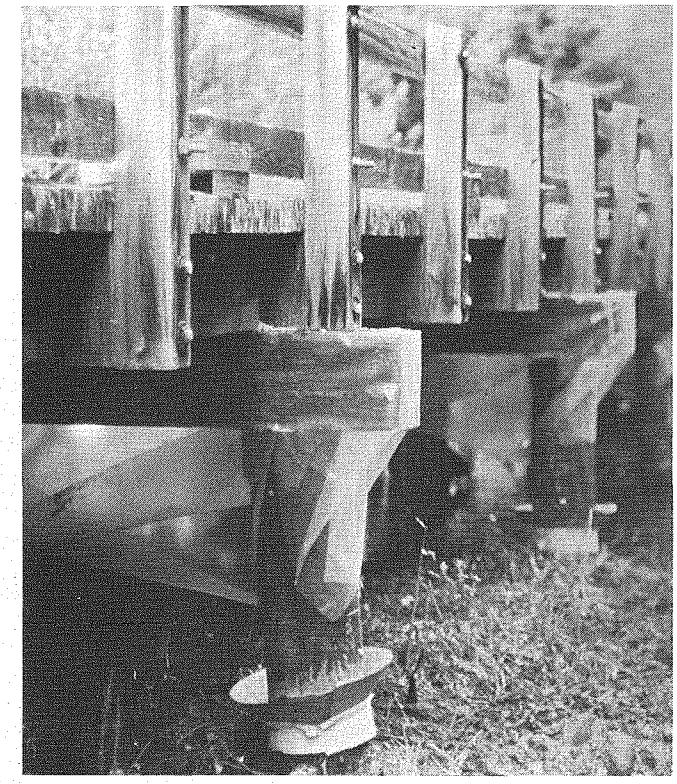


Figure 11.--Bridge draping for spillage protection, in place and ready for Osmose 24-12® injection.

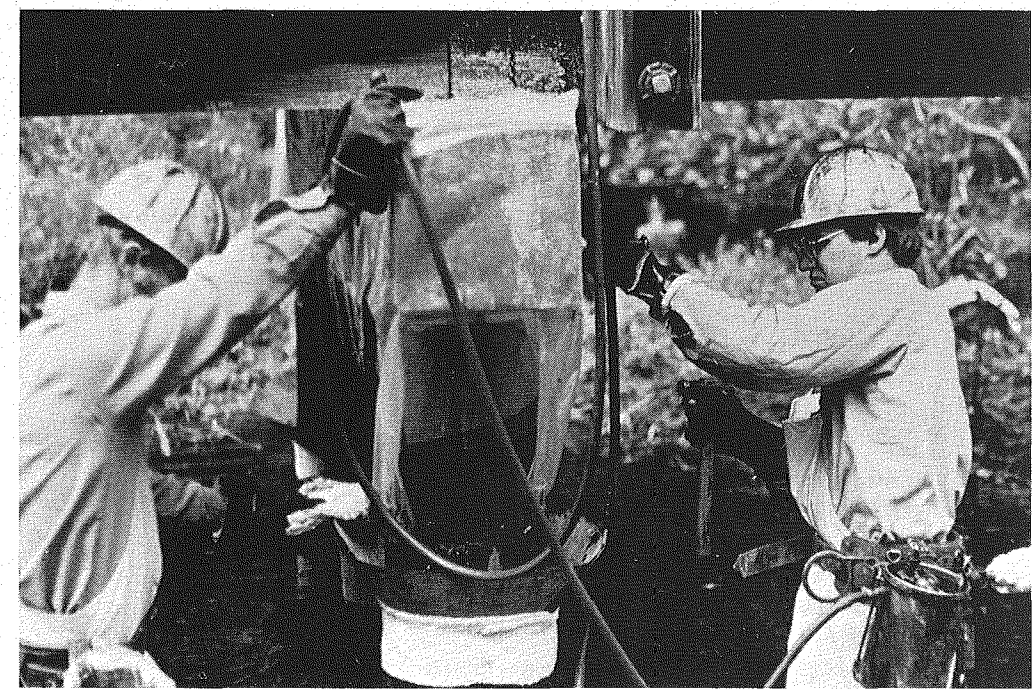


Figure 12.--Two-man crew injects Osmose 24-12® solution into piles and caps. Note the safety backflow valve on the worker's belt.

8. Treat stringers. The treatment of the stringers caused the contractor some problems. The narrow (3-inch-wide) stringers and the high water condition ruled out the use of liquid Osmose 24-12®; therefore, the contractor used a grease gun to inject Osmoplastic® into the stringers. However, the high sodium fluoride content of Osmoplastic® caused the rubber seals in the grease gun to disintegrate and forced the contractor to switch to Osmoplastic-F®, which contains ingredients that are less active. With this compound, the contractor was able to maintain pressure and properly inject the compound into the inspection holes.

9. Clean up. The contractor waited 2 to 3 hours after treatment before removing the spill-protection plastic draping. All plastic, waste rags, and containers were carefully rolled and placed in plastic trash bags for removal from the site.

WATER MONITORING

The Forest monitored the water quality of Bay Creek during the bridge treatment. Water samples were taken before starting treatment to establish a typical quality level. During the operation, samples were taken from above and below the bridge, and sent to the Florida Department of Environmental Regulation for testing. Results from all tests for any traces of chemicals used in the treatment operation were below detectable levels; further, there was no noticeable variation in water quality between the pretreatment samples and the later ones.

CONCLUSIONS

The contractor did an excellent job on the Bay Creek Bridge. The personnel were knowledgeable and proficient in their work and were careful to avoid spillage of toxic chemicals, thereby ensuring a complete treatment with minimum environmental risk in fulfilling the contract.

This was the first contract awarded by the Forest Service in the Southern Region for this particular service. If experience of the Forest Service with this method is as satisfactory as was that of the railroads, we will be able to save considerable maintenance and reconstruction funds.

☆U. S. GOVERNMENT PRINTING OFFICE: 1983/661-625/56

Engineering Technical Information System

The Series:

THE ENGINEERING FIELD NOTES SERIES is published periodically as a means of exchanging engineering-related ideas and information on activities, problems encountered and solutions developed, or other data that may be of value to engineers Service-wide. Articles are usually less than six pages, and include material that is not appropriate for an Engineering Technical Report, or suitable for Engineering Management publications (FSM 1630 and 7113).

Distribution:

Each Field Notes edition is distributed to the Engineering Staff at Regional Offices, Forests, Stations, and Area Headquarters, as well as to Forest Service Engineering Retirees. If your office is not receiving the Field Notes, ask your Office Manager or Regional Information Coordinator to increase the number of copies for your location. Copies of back issues are available in limited quantities from the Washington Office.

Submittals:

Every reader is a potential author of a Field Notes article. If you have a news item or short description about your work that you wish to share with Forest Service Engineers, we invite you to submit the article for publication. Field Personnel should send material to their Regional Information Coordinator for review by the Regional Office to assure inclusion of information that is accurate, timely, and of interest Service-wide; short articles and news items are preferred. Type the manuscript double-spaced; include original drawings and black-and-white photographs (if only color photographs are available, send transparencies or negatives), and two machine copies of the manuscript.

Inquiries:

Regional Information Coordinators should send articles for publication and direct questions concerning format, editing, publishing schedules, etc., to:

FOREST SERVICE—USDA
Engineering Staff—Washington Office
Att: Publications Specialist (Room 1112 RP/E)
P.O. Box 2417—Washington, D.C. 20013

Telephone: Area Code 703—235-8198

Regional Coordinators:

R-1 Larry Bruesch
R-2 Mike Clinton
R-3 Jerry Martinez
R-4 Ted Wood
R-5 Phillip Russell
R-6 Kjell Bakke
R-8 Tom Poulin
R-9 Mujeebul Hasan
R-10 Mel Dittmer
WO Al Colley

ENGINEERING TECHNICAL INFORMATION SYSTEM

Volume 15
July - September 1983

Engineering Field Notes