ENGINEERING TECHNICAL INFORMATION SYSTEM

FIELD NOTES • TECHNICAL REPORTS • TEXTS
DATA RETRIEVAL • CURRENT AWARENESS

VOLUME 7 NUMBER 8

Field Notes

Red Mountain Creek *Soil Bridge*

Engineering Survey/Design Programs on the 720 WANG-701 Output Writer

Log Stringer Bridge Inspection and Analysis in Alaska

Washington Office Engineering News

FOREST SERVICE AUGUST 1975

U.S. DEPARTMENT OF AGRICULTURE

ENGINEERING FIELD NOTES

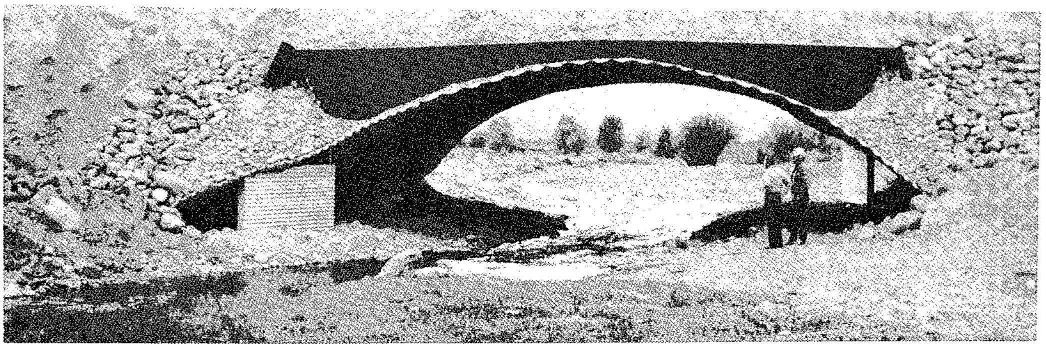

Figure 1. *Completed 50 ft. x 10 ft.* ***U.S. Steel Reinforced Soil Bridge*** *across Red Mountain Creek. Note the end diaphragm protruding through the fill.*

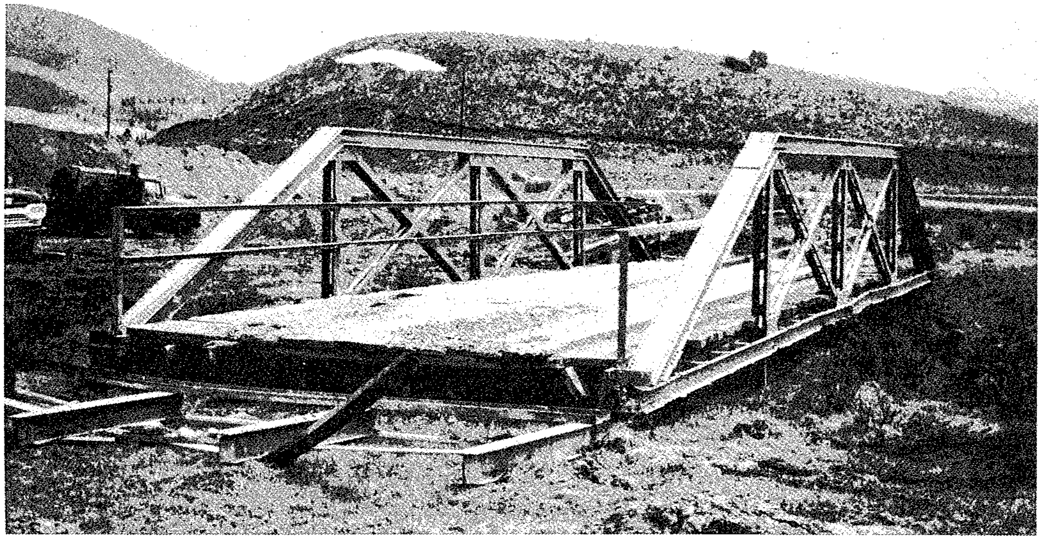

Figure 2. *Original steel truss bridge across Red Mountain Creek. Inventory rating for HS loading is 3.3 tons.*

RED MOUNTAIN CREEK *SOIL BRIDGE*

Robert M. Willis
Civil Engineer

Leland Fansher
Civil Engineer

Rio Grande National Forest
Region 2

For many years, structural plate steel arches have been available as an alternate to bridges for use as stream crossings. Until recently, steel arches have been limited to spans not exceeding 25 feet. Several steel manufacturers have now developed modified arches with spans greatly exceeding previous limits.

During the fall of 1973 and the spring of 1974, the Rio Grande National Forest, in cooperation with Douglas Studs, Inc. (the timber purchaser) and Mineral County constructed one of these long span arches manufactured by U.S. Steel under the trade name *Reinforced Soil Bridge.* At the time of its construction, the Red Mountain Creek *Soil Bridge* (fig. 1) was unique; with a 50-foot span and a 10-foot rise combination, it was the first such low-rise-to-wide-span structure.

Plans for the *Soil Bridge* were developed after a safety inspection showed the existing steel truss bridge (fig. 2) to be unsafe for legal truck loads. Several alternatives, such as a new truss bridge, multiple arch installations, and the *Soil Bridge* were investigated; analysis indicated that the *Soil Bridge* would be the most economical.

Hydrologic investigations indicated a required waterway of 340 square feet. Consequently, an arch size with a 50-foot span and a 10-foot rise was selected. In addition, the concrete footing walls were raised 3 feet to mold to the waterway. The following is a comparison of the Red Mountain Creek structure with the previous maximum steel arch:

	Red Mountain *Soil Bridge*	Maximum Steel Arch[1]
Span	50 ft.	25 ft.
Rise	10 ft.	8 ft. 6½ in.
Ratio, Rise ÷ Span	0.2	0.34
Arch Radius	435 in.	160 in.
Waterway	344 sq ft.	155 sq. ft.
Steel Thickness	0.215 in. (5 ga.)	0.280 in. (1 ga.)

The structural principle of the *Soil Bridge* is that the arch of compacted soil over the steel plate carries most of the load. The steel plate acts as a liner, preventing soil movement and permitting construction of the soil arch. It must resist buckling and ring compression. In conventional design, the steel carries most of the load and the soil primarily prevents excessive steel deflection.

To prevent failure during backfill and to form a soil keystone, the *Soil Bridge* design provides for steel bins on the top of the arch as illustrated in figure 3.

Due to right-of-way problems, it was not possible to realign Red Mountain Creek. Thus the *Soil Bridge* had to be constructed on a 15 degree skew, with the end sections beveled for aesthetic effect. This bevel and skew caused some construction problems which were solved through design modifications.

The original design envisioned arches without skew and bins fabricated square with both the arch and road centerlines. For the Red Mountain project, U.S. Steel fabricated the center bins square with the arch and added diaphragms, parallel to the road centerline on the ends, forming two triangular bins (fig. 3). These end diaphragms were not designed with end treatment in mind and they protrude through the fill slope (fig. 1). The original bins are galvanized and appear brighter in the photo than the added bins and end diaphragms, which are not galvanized (fig. 3).

[1]***Handbook of Steel Drainage and Highway Construction Products, New York, NY,** American Iron and Steel Institute, 1971, p. 62: Max. Span x Min. Rise.*

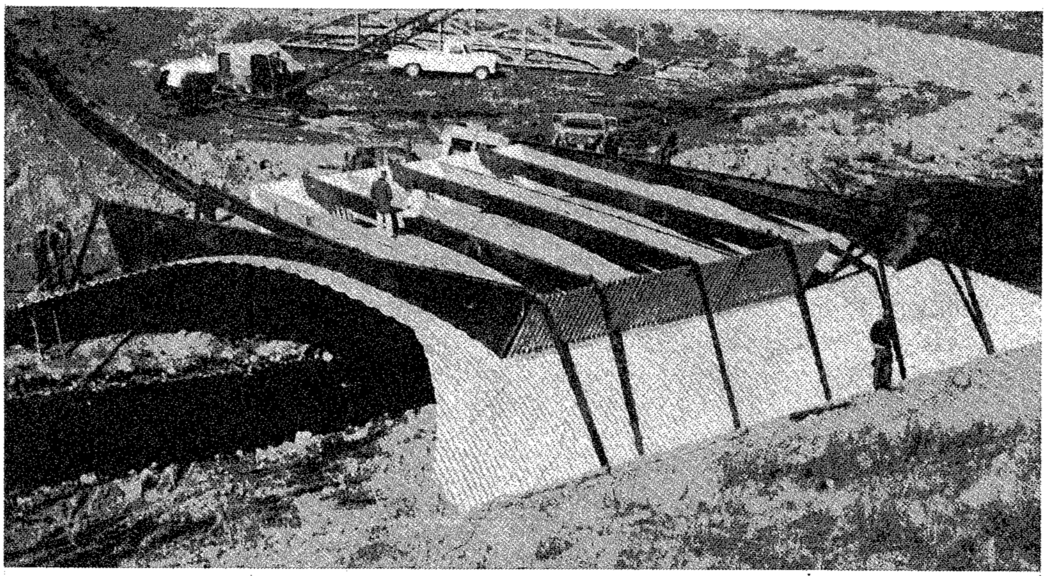

Figure 3. *Steel completely erected showing skewed diaphragms and triangular bins at the ends.*

Figure 4: *Stiffeners added as a safety factor to stiffen the structure during backfilling. Backfill lifts alternate from side to side, and are placed in approximately one foot lifts.*

To reinforce the structure during backfill, stiffener angles were added from the top of the bins to the footing with midpoint ties to the arch (fig. 4). The effect of these stiffeners and the added bins is to form a truss which supports the arch during construction. After backfilling is complete, the truss is no longer functional. If rust destroys the truss, the finished structure will not be damaged. It is understood that U.S. Steel is adding this feature to all *Soil Bridges* designed to span 35 feet or more.

The design and construction of the concrete footings was conventional. The arch shell was erected with the aid of a 20-ton crane and native timber posts for shoring (fig. 5). Bins were bolted in place, completing the steel portion of the structure.

Because the steel arch is designed for minimum lateral loading, backfilling was critical. The procedure was to alternately backfill and compact the sides in shallow lifts (fig. 4), while monitoring peaking in the center. When the soil in the center rose one inch, the top and bins were loaded with earth, literally pushing the arch back down to the original shape (fig. 6). This alternating sidewall and crown loading was continued until backfill was complete. This procedure, while requiring care, proved satisfactory. The only instruments used were a surveyor's level and several plumb bobs.

The backfill soil was a local silty fine sand. Occasional rocks larger than 6 inches were removed from the backfill soil near the steel. Compaction averaged only about 90 percent of AASHTO T-99 maximum density, but was deemed acceptable by the bridge designer.

Problems were encountered at the corners where the bevel and skew formed acute angles. The unsupported partial arches at these corners deflected downward and actually formed reverse curvature at the edges (fig. 7).

Three steel columns were erected under the two opposite critical corners (fig. 8) and were covered with metal plates to prevent accumulation of debris (fig. 9). These columns detract from the appearance of the bridge and also restrict the waterway to some extent. Figure 9 shows part of the riprap in place. More was added since then, and the exposed diaphragm of the end bins was painted.

The cost of the structure, including footings and backfill, was $55,470 versus an estimated cost of $75,000 for a concrete bridge with the same span. This does

Figure 5. *Native timber post shoring used during erection of the steel shell.*

Figure 6. *Control of crown rise by loading top of structure with earth.*

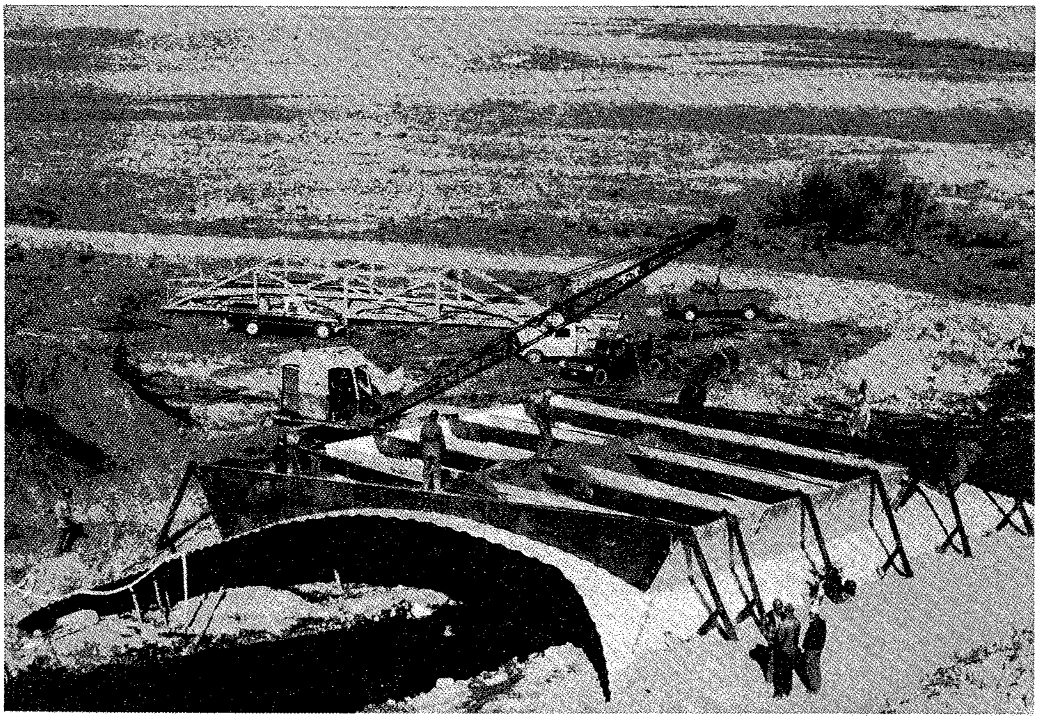

Figure 7. *Failure of unsupported corner of structure. Failure occurred at both acute angle corners of this beveled and skewed structure.*

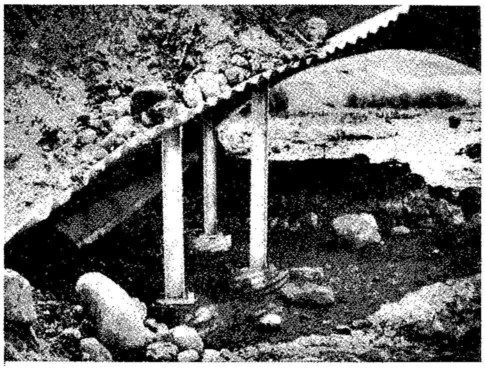

Figure 8. *Steel column supports placed under failure at corners.*

Figure 9. *Steel support columns partially covered with steel plate to prevent accumulation of debris.*

not include costs incurred by Mineral County in removing the old bridge, constructing and removing a detour, riprapping the new structure, and final grading of the roadway.

At the present time, it appears the *Soil Bridge* principle is sound and that the Red Mountain Creek Project is a success. The completed *Soil Bridge* has been carrying timber and construction traffic during the summer and no movement or deflection can be determined with a transit and rod; however, the structure should be observed for several years before final conclusions are reached.

Constructing this bridge was a valuable experience for all concerned. The designer made several improvements in his overall concept which will permit even larger spans to be built in the future. Most design and construction problems can be attributed to the beveled and skewed ends on this structure. Region 2 would definitely consider constructing another *Soil Bridge* but would hesitate to try one with either a beveled or a skewed end. The Region would not consider another structure of this size with ends that were both beveled and skewed.

J. D. Adams Company, Colorado Springs, Colorado, was responsible for steel erection and backfill. Southwest Forest Industries, South Fork, Colorado, is the timber purchaser. The structural design was guaranteed by U.S. Steel Corporation, Pittsburgh, Pennsylvania. Steel fabrication was by Syro Steel Company of Provo, Utah. Construction was supervised by Professor Reynold K. Watkins, Associate Director, Engineering Experiment Station, Utah State University, Logan, Utah, who developed the *Soil Bridge* concept and designed this structure.

Pictures of the bridge were used in recent national advertising by U.S. Steel.

ENGINEERING SURVEY/DESIGN PROGRAMS ON THE 720 WANG - 701 OUTPUT WRITER

Robert Lane
Civil Engineering Technician
Eldorado National Forest
Region 5

The preconstruction section on the Eldorado National Forest has compiled and written a number of engineering programs for the 720 Wang desk top computer.

This computer has provided the Survey/Design Section with a means of checking survey data while the survey crew is still on the project. The solar program can check out a set of solar observations in a very short time. The traverse programs can run the traverse very quickly, allowing the survey crew time to correct any errors in field work while the crew is still on the project.

Our designers have found the 720 Wang to be a handy tool in the road-design process. As they became more familiar with the capabilities of this computer, they found the need for a higher performance computer lessening. Only about 60 percent of our new construction design is completed on the Fort Collins computer. Of this 60 percent, a large amount of preparatory work, which otherwise would have to be performed on the Fort Collins computer, can be done on the Wang.

The traverse, contour reduction and initial horizontal alignment can be run and checked before submitting the design to Fort Collins for the first earthwork run. This has sped up the process and reduced the number of input errors to the Fort Collins computer.

PROGRAM LIST

- PLANE SURVEY VOL. 2 #700/701
- SOLARS #14865
- TRAVERSE #15353
- % GRADE AND ELEVATION #2309
- CONTOUR REDUCTION %/ SLOPE DISTANCE #7291
- LEVELS (MILE POST) #2519
- BIN WALL ANALYSIS #15778
- HYDRAULIC RADIUS (ARCH PIPE) #11244
- CONSTRUCTION CLEARING #2743
- AGGREGATE BASE COURSE #8565
- HAND LEVELS #1831
- SURFACE AREA #3331

PROGRAM LIST—Continued

P-TRAVERSE #4997

HORIZONTAL ALIGNMENT #18480

TRANSIT NOTES/TANGENT OFFSET #14009

EARTHWORK (END AREA) #4690

RECONSTRUCTION CLEARING #3248

AGGREGATE BASE COURSE #5465

ASPHALT CONCRETE #8793

LEVEL CIRCUIT #3786

SURFACE AREA #3226

AGGREGATE BASE COURSE #6015

MANNING'S EQUATION #6265

EXCAVATION COST ESTIMATE #18083/2215

WRITING TRIG PACK #10705

EXTENDED SURVEY VOL. 94 720/701

SUN SHOT #14524

VERTICAL CURVE ELEVATION #2530

P-TRAVERSE #5206

TRANSIT NOTES/CURVE DATA #9527

AS STAKED QUANTITIES #8575

COORDINATE GEOMETRY #720/701 #13456

SURFACE AREA #3398

SLOPE AREA #4290

CALIFORNIA NOMOGRAPH #6579

EARTHWORK QUANTITIES #4631/13677/676

FLOOD-FREQUENCY ANALYSIS #6876

CLEARING COST ESTIMATE #14379

CONTOUR REDUCTION ROD/DISTANCE #6453

STADIA REDUCTION (SIGHT SURVEY) #11496

% ABNEY CROSS SECTION REDUCTION #2700

COST ESTIMATING PROGRAM/ENGR. ESTIMATE, A-10 WORK SHEET, A-10 (WITH C5-202), A-11, A-12

Many of our low-standard timber roads are designed from chain-flag (field alignment) surveys. Approximately one mile of this type design can be performed on the Wang in one hour. Output includes earthwork quantities, mass ordinates, clearing quantities, and slope stake notes.

The newest program, "Cost Estimating/Engineering Estimate, A-10, A-11, and A-12," performs all of the computations for these tables in the sale contract. Results to date have shown that the program will eliminate many hours of computation and checking work and greatly reduce human-error probability.

Anyone wanting copies of these programs can obtain them by sending seven 25 foot blank cassette tapes to the Eldorado National Forest, 100 Forni Road, Placerville, California, 95667; Attention: Bob Lane.

LOG STRINGER BRIDGE INSPECTION AND ANALYSIS IN ALASKA

Robert Willis
Civil Engineer
Tongass National Forest
Region 10

The problems associated with inspecting and analyzing bridges have confronted every bridge engineer. Log stringer bridges located on the islands of the Alexander Archipelago of southeastern Alaska pose several problems not normally encountered in bridge engineering. Figures 1 through 3 are examples of log stringer bridges.

The current knowledge of log stringer bridge analysis and design is somewhat limited. Our team had to make several critical assumptions prior to anaylsis. The allowable bending stress of Sitka Spruce was assumed to be 1600 psi; a similar value for western hemlock was also used. These values were recommended by the Forest Products Laboratory, Madison, Wisconsin.[1] These two species are the only ones currently being used for bridge construction in the National Forests of Alaska. Another assumption was the live-load distribution factor applied to the stringers. Preliminary testing by the Forest Products Laboratory has indicated that 30 percent of the vehicle load is the recommended distribution to each stringer. Testing to determine live-load distribution factors was also required because of the unique way log bridges are constructed in Alaska.

Construction is simple, but functional. Stringers are placed side by side to form a continuous mat. Filler poles are then placed to chink between the stringers, with 6 inches to 3 feet of cover material (broken rock) placed to form the running surface. A cable is wrapped around the stringers for stabilization under load. Brow logs are added as curbs on most bridges. The stringer logs are alternated small end to large end when constructed. This construction method gives approximately the same cross-sectional area throughout the bridge. Of the 150 log bridges that our team analyzed, all but one was composed of Sitka Spruce logs. The one exception was a bridge on Baranof Island which was constructed of western hemlock.

[1] *A field testing program is now underway to correlate this data, as well as live-load distribution factors for this type of bridge.*

The field inspection of the Alaska bridges was a very interesting and challenging assignment. Getting the necessary equipment to bridge sites was a problem in logistics. Moving from logging camp to logging camp can only be accomplished by float plane or boat, and in remote areas helicopters are used. This method of transportation severely restricts the choice of equipment. In the first area the inspection team flew to, we felt confident that everything needed was on hand. In fact, we had more than was needed. Three people and all of our gear could only fit into the largest float plane available. Our week of initiation quickly showed us which equipment was impractical. The first week we used a portable generator with an electrical drill to bore the stringer logs. This electric drill was quickly abandoned in favor of a 16-inch hand-operated increment auger. The auger was as fast as the electric drill and made it easier to locate decayed or damaged wood.

There are other problems associated with bridge inspection in Alaska. The weather is very often rainy, which means that all equipment used must be weatherproof or protected. Waders and rain gear are a necessity. Steel tapes were used, but frequent oiling was required. The increment augers were also oiled often. All of the inspection forms were printed on "write-in-the-rain" paper.

On bridges over 40 feet long, the stringer diameter was measured and each stringer was drilled adjacent to each abutment. A core was taken at each end of the stringer to locate decayed wood. Any decayed or damaged wood found was subtracted from the diameter of that stringer. Thus, an effective diameter of sound wood was determined. The average of all effective diameters was used in the calculations. On bridges 20 feet to 40 feet in length, only selected stringers were drilled. A pick was used on the remaining stringers to check surface decay. The diameter and soundness cores of these shortspan bridges was measured at midspan.

Abutments were checked for undermining and decay. Notched abutment logs consistently exhibited more decay than abutments which were not notched. A notation was made on the inspection form whether or not abutment logs were notched. Whether or not they were cabled was also recorded.

Several things became apparent after the field inspection was completed. It was thought that stringers with the bark removed had greater resistance to decay. Organisms that cause decay were expected to thrive under the bark, attacking the logs. In fact, bridges with the bark remaining consistently showed less surface decay than stringers with bark removed. Stringers with the bark removed appear to be more readily dried and, conversely, stringers with bark always showed a high degree of saturation. This high moisture content was thought to be the reason that a number of older bridges (8 to 12 years) were in relatively good shape. High moisture content appears to inhibit the growth of decay-causing organisms. Low average annual temperature is also an influencing factor, but to what extent we could not determine.

Another interesting finding concerned the use of stabilizer logs. Stabilizer logs are used on some bridges to better distribute the loads to the stringers (fig. 4). Stabilizers are particularly important on bridges exceeding a span length of 40 feet. Observation showed that bridges in this category, or longer, seemed to exhibit more individual stringer deflection without a stabilizer than those that were stabilized. Curiously, even those bridges which had no cables or stabilizer log acted as a unit when loaded. However, cabled logs showed less individual deflection on long spans, and stabilized bridges produced even better distribution.

The rock used as a running surface was another deciding factor in the relative strength of a bridge. Three to four feet of cover on a bridge is not uncommon. One 20-foot bridge was found to have 22 feet of cover. This particular bridge had 26 stringers and was over 60 feet wide. This tapered to a roadway width of around 16 feet. Under normal calculations, this bridge would be greatly overstressed with the cover material. However, the bridge did not show any deflection. We felt that the deadload was being distributed by the soil in such a manner that the effective load on the bridge was much less. The material may be forming a "soil bridge." However, it is good design policy to keep cover material to a minimum; 12 inches is the suggested maximum. Figure 5 illustrates an excessive rockfill as a running surface.

Failures were observed in some of the structures; however, these were relatively few. The most common failure was due to abutment undermining. Most of the failures of this type were caused by improper design of the required waterway. Abutment failures are most common on smaller waterways. Flows on this type of stream vary significantly from season to season; for instance, an overnight rise of 3 feet in water elevation is not uncommon. (In the Ketchikan Area, 42 inches of rain fell in October 1974. In already saturated terrain, this rain becomes runoff.)

Observation of stringer failures was uncommon. No complete failure of any bridge was observed, but individual stringers had failed in some bridges. Typically, these bridges were not cabled or had cables which were loose. The failed stringers almost always were located under the wheel lines of traffic on the bridge. There were a number of bridges that were composed of several layers of logs (fig. 6).

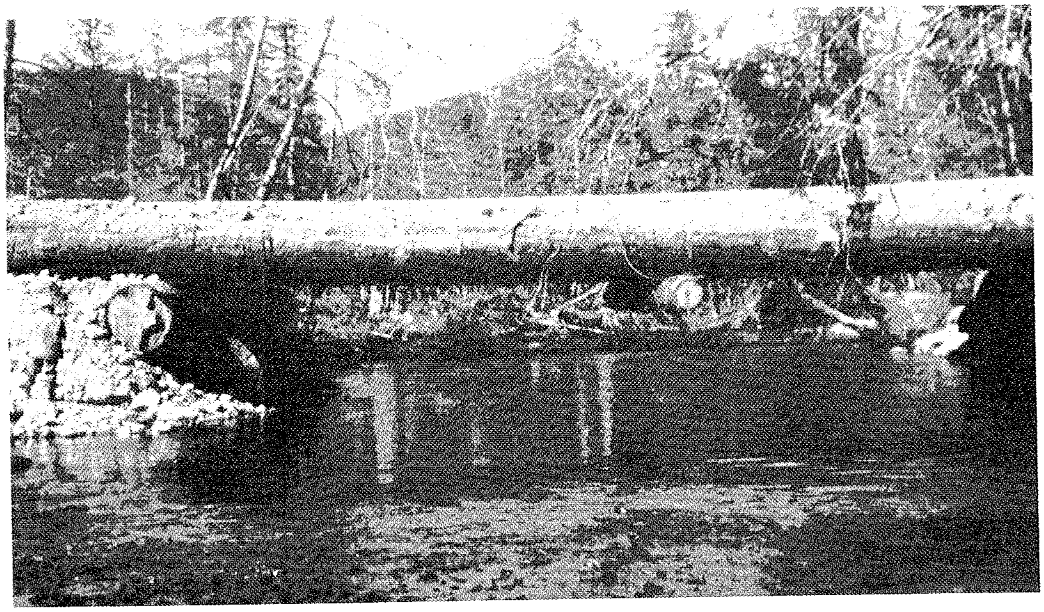

Figure 1. *Log stringer bridge.*

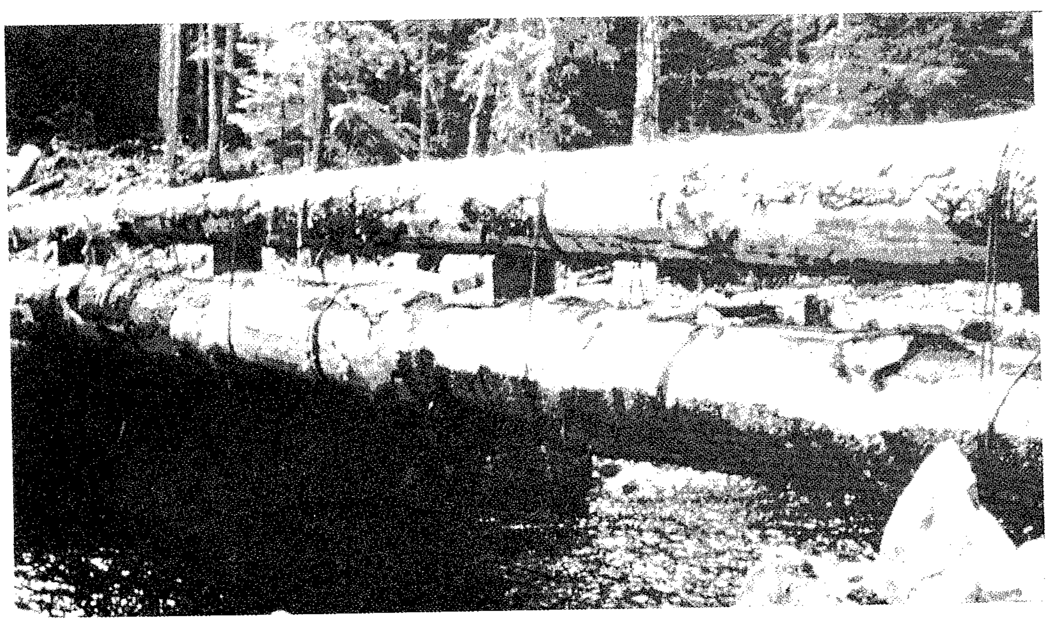

Figure 2. *Staney Creek Bridge – 94 ft. simple span.*

Figure 3. Short-span log stringer bridge.

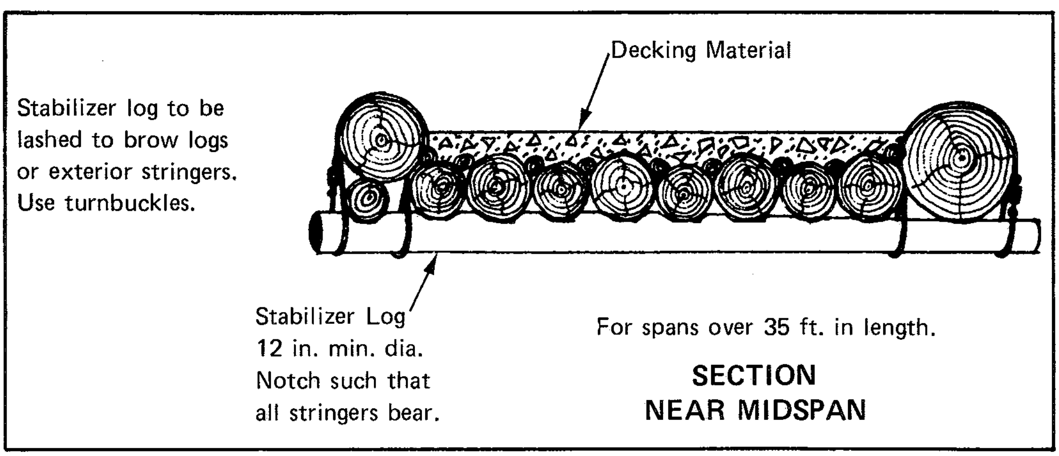

Figure 4. Stabilizer logs used to distribute load.

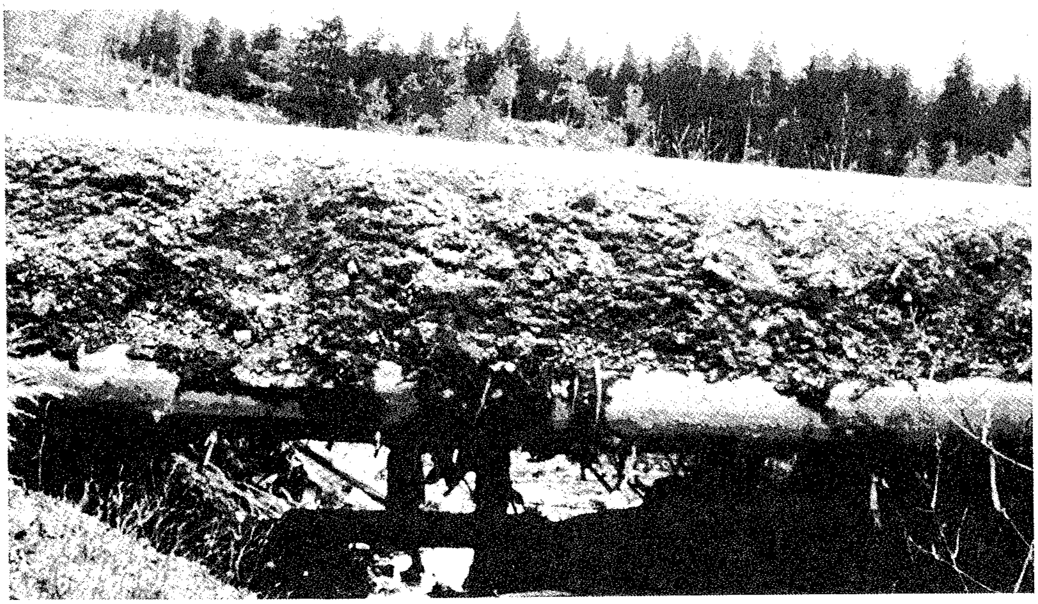

Figure 5. *Excessive blast-rock fill on stringers.*

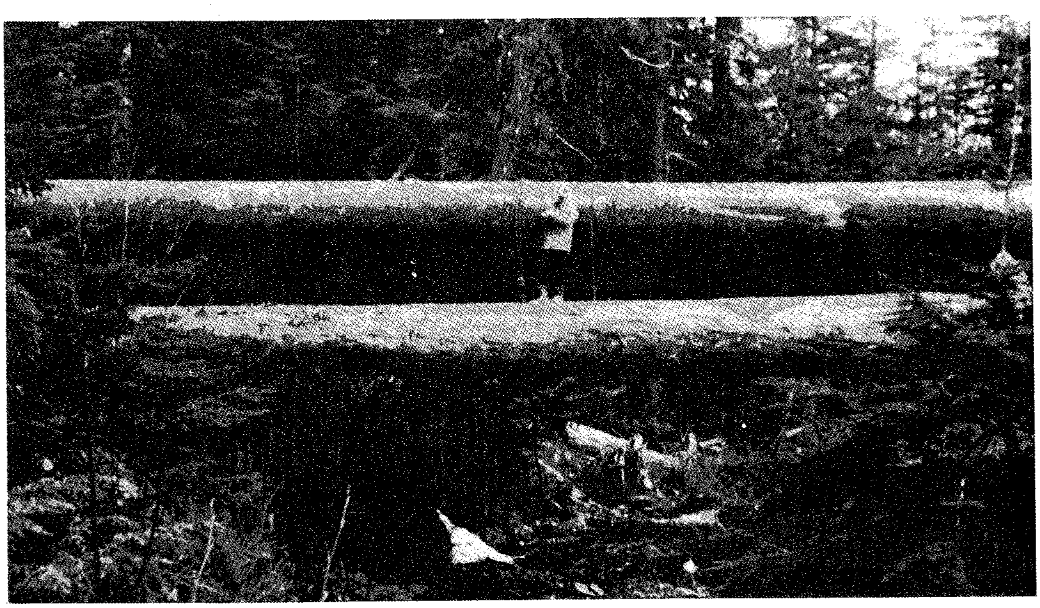

Figure 6. *Multiple-layer log stringer bridge.*

In most cases, a stringer had failed on the original bridge, and rather than replace one stringer, another bridge was constructed over the top of the original. However, the original bridge was not removed. One bridge inspected was composed of three layers. Over the years, the road grade on this bridge had apparently changed upward about 10 feet.

The data gained by our inspection will be used in several ways. Analysis has been made on the relative strength of existing bridges for a signing program. A design guide for log stringer bridges was initiated. The need for additional information was generated in several areas, and procedures for inspecting log stringer bridges were developed.

Our conclusion is that log stringer bridges are simple to construct, economical, and have relatively good design life for southeast Alaska.

AUTHOR'S CORRECTION

From *Field Notes,* Volume 7, Number 7, July 1975, P. 12

Gasvoda's Design

The circuitry of Gasvoda's unit differed from that of any of the units that had previously been examined; however, the advantages made the risk worth taking. Power consumption was one-forth that of GCO's best unit and the range was doubled (50 feet). A timing circuit to insure count-accuracy had been added, which enabled the counter to reject spurious events. The reduction in power requirement permitted use of dry cells that lasted up to 60 days under continuous operation.

WASHINGTON OFFICE ENGINEERING NEWS

OPERATIONS

Harold L. Strickland
Assistant Director

FOREST SERVICE REMOTE SENSING MANAGEMENT COMMITTEE (FSRSMC)

Recognizing the rapid evolution of remote sensing technology and the need for prudent application of such technology in the Forest Service, the Chief and Staff established a Forest Service Remote Sensing Management Committee (FSRSMC) on June 2, 1975. The executive core group for the FSRSMC comprises one or more representatives from each Deputy area in the Washington Office; those now active in remote sensing are providing Staff support for the committee.

The executive core group members are:

1. T. C. Nelson, Deputy Chief for NFS, Chairman
2. NFS: M. R. Howlett, Director of Engineering
3. S&PF: R. K. Smith, Director of FI&DM
4. P&L: G. S. Bergoffen, Director, Situation Analysis
5. Research: J. M. Hughes, Director, FE&MR, Vice Chairman
6. AM: L. Lundberg, Director, Administrative Management
7. H. L. Strickland, Executive Secretary

As soon as possible, the FSRSMC will submit a detailed implementation plan, for carrying out its charter, to the Chief and Staff for approval. As a minimum, the plan will cover the following areas of responsibility:

1. Continuous evaluation of the need for and the development of alternative methods for managing remote sensing activities in the Forest Service.

2. Coordination of all remote sensing activities within the Forest Service and with USDA agencies, other Federal agencies, and the private sector.

3. Development of a series of training sessions on the state-of-the-art and applications of remote sensing for Forest Service personnel throughout the country. The first session will be designed for the WO staff and will lead to the development of subsequent sessions at field locations. Two or three major sessions at universities with well-developed facilities, staff, and programs will be considered. These sessions are to be cooperative ventures with the universities and they shall be long enough to provide hands-on experience with materials and systems.

4. Providing executive counseling service to the Chief and Staff on remote sensing matters.

Any suggestions you might have for action by the committee will be appreciated.

TECHNOLOGICAL IMPROVEMENTS

Heyward T. Taylor
Assistant Director

INTERACTIVE ROAD DESIGN SYSTEM (IRDS)

In April 1974, a group of engineering and computer personnel met at Fort Collins Computer Center to discuss the feasibility of using a conversational Road Design System compatible with the newly-acquired Univac 1108. Prior to this, both economic and equipment constraints prevented introduction of this concept, although the need for the system had been recognized. The group agreed upon the feasibility of the road design approach with the availability of the Univac 1108, and began to develop the specification of the working environment and system configuration, which they termed Interactive Road Design System (IRDS).

From April until June 1974, Regional personnel worked to develop the portion of the system assigned to their respective Regions. In July, preliminary testing of the first phase of the IRDS was done on the Medicine Bow National Forest. The results of this test were favorable, but they pointed out several weaknesses in the RDS data storage and retrieval system. RDS personnel met and agreed to modify the system equipment which was used for RDS data storage to accommodate timely retrieval of the RDS data.

After the Engineering Design Support Group (EDSG) moved to the Fort Collins Computer Center in the following September, Region 2 decided that development on IRDS was sufficient for proper data maintenance to put three forests on IRDS production for the 1975 design season. It was recognized that the system needed additional operational features, but these were known and were being developed for incorporation in the program.

The land managers reported that the completed IRDS projects output provided ample time for review and follow-up of the project design in their file offices prior to contract awards. One forest estimated savings of $1,500 in travel costs, and an estimated reduction of between $5,000 and $10,000 per project in reduced earth-work volumes costs.

Presently, IRDS has been introduced to field personnel in Regions 1, 2, 3, 5, 6, 9, and 10. The system was designed by engineers and adheres strictly to field users' specification; consequently, comments from the field have been consistently favorable.

CONSULTATION AND STANDARDS

Charles R. Weller
Assistant Director

POSTER AND SMALL METAL SIGNS CATALOG

The much talked about "Posters and Small Metal Signs" catalog is in distribution. This catalog includes all of the posters and small metal signs that are currently available.

Posters display short-term messages along roads, in campgrounds or wherever people congregate. Poster messages cover a wide array of messages including Fire Prevention, Rules of Use and Conduct in Developed Areas, and Environmental Messages. However, managers should carefully plan and select only posters that are applicable in their particular situation. It should be remembered that card-board posters are presentable for only a few weeks, after which they should be removed before they become faded, wrinkled, or torn.

Small permanent metal signs are available with messages regarding land surveys, closing gates, and recreation developments.

One problem that has come up repeatedly is the improper ordering of posters and small metal signs. Non-reflectorized posters are available only from Central Supply in Landover, Maryland; reflectorized and vinyl posters are available from FPI in Atlanta, and small metal signs are available only from GSA in Denver, Colorado. Non-reflectorized posters must be ordered on the Standard Form AD-14, and small metal signs on the Federal Strip. Please be sure that your orders are properly filled out and sent to the proper address. Many times we have heard of ordering units who have been trying for months to get a particular small metal sign. After considerable delay, it is often discovered that it was ordered improperly from Central Supply who does not stock them.

NEW PUBLICATIONS

Aerial Tramways, Ski Lifts, and Tows – EM 7320-1, 116 pp. illus. Revision of the March 1967 publication. This publication is a primer on the subject of aerial passenger tramways for Forest Service personnel who are newly assigned to activities associated with these transport systems. The text is general and nontechnical, containing a description of the types of tramways and their components; it contains terminology used in manufacture, installation, and operation of aerial passenger tramways, ski lifts, and tows. For sale by the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. Available in August 1975.

The Smith River Highway Visual Analysis Study – EM 7700-3, 142 pp. illus. Revision and expansion of original 1973 publication. This publication presents a study of a visual analysis system designed to translate raw data into recommendations about highway construction. The system is a complete package of visual information ranging from broad-scale interpretation of the entire study area to very small scale evaluations of existing scenic conditions along Highway 199. For sale by the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.

NEW OPTICAL SENSOR DEVELOPED

Heyward T. Taylor
Technological Improvements

Charles R. Weller
Consultation and Standards

The Forest Service, U.S. Department of Agriculture, today announced the successful operation of an experimental surveying system through which a pulsed laser beam can be detected visually for a distance of up to one mile.

This new equipment is a companion detector to the Forest Service's Laser Range Pole system for property line location, which has been in operation for the last two years. Both systems use a pulsed laser beam in place of the standard surveyor's range pole.

The electro-optical sensor system can zero-in on the laser beam electronically. Unlike the visual system, it is operable in bright daylight, but has a slight margin for error that the visual system does not have. When the electro-optical sensor malfunctions in locating the laser beam, the error cannot be detected until the line is projected between points. The visual receiver provides positive, precise alignment of the connecting line.

The new visual receiver was developed by the Forest Service at San Dimas, California, acting on information supplied by engineers from our Southern Region who first observed the pulsed laser through a night vision scope. It was fabricated by the Stans-Optic Division, Sacramento Army Depot. It is operable only in subdued light such as late evening, at night, or in early morning. This presents some disadvantages over our present Range Pole system because of the nighttime operation. The visual receiver, attached to a modified transit, acts much as a television receiver, gathering the light, magnifying it, then transferring the image to the eyepiece. The visual receiver was originally designed by the Army to enhance night vision.

This innovative and sophisticated surveying apparatus is vital to the Forest Service to accomplish the immense amount of surveying required on government forest lands. There are 187 million acres of National Forest System land in 46 States and Puerto Rico, bounded by more than 272,000 miles of property lines adjoining three-quarters of a million neighbors. The lands are often intermingled in complex patterns with lands in private ownership. A big percentage of the property lines between National Forest System land and adjoining lands have not been adequately located and marked on the ground.

Many of the surveys controlling the property lines are as much as 150 years old. Many miles of line and their controlling property corners have been obliterated or lost. With conventional methods (about 2,000 miles of property lines are located each year) as much as 24 years would be required to bring the property line surveys up to date between corners now established at a cost of more than $100 million. With the new system, it is estimated the job can be done in 12 years at about a third the cost. Using conventional methods, more than 200 years would be needed to complete all corner and property line surveys.

One significant benefit from the new laser equipment, according to Forest Service Chief John R. McGuire, is the sighting directly between two points a mile apart, no matter how rough the terrain or how dense the forest. It is accurate to within 6 inches per mile.

With the laser sender at one point, a vertical beam is pulsed, perhaps as high as a mile above ground. At the other point, the operator sees the pulse through the receiver. The transit is locked in the exact direction and the scope is lowered to ground level where a stake is marked on the projected line of sight. This line is then extended by the regular sighting and marking methods to the point where the laser beam was fired.

With conventional methods in mountainous or heavily forested terrain, it is necessary to make many sightings with surveying instruments and many calculations before the true property line can be established.

Chief McGuire explained that the importance of more rapid property line establishment is the increasing use of land and its resources by the Forest Service and neighboring owners–ranging from timber harvesting to condominium and summer home development. The dangers of trespass on both sides are increasing and the consequences are more severe, he said.

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