United States
Department of
Agriculture

Forest Service

Engineering Staff

Washington, DC

Engineering Field Notes

Volume 20
January-February
1988

Engineering Technical Information System

Engineering Field Notes

Administrative Distribution

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.

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Field personnel should send material through their Regional Information Coordinator for review by the Regional Office to ensure inclusion of information that is accurate, timely, and of interest Service-wide.

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Inquiries

Regional Information Coordinators should send articles for publication and direct any questions, comments, or recommendations to the following address:

FOREST SERVICE-USDA
Engineering Staff-Washington Office
Attn: D.J. Carroll, Editor
M. J. Baggett, Assistant Editor
P.O. Box 96090-Washington, DC 20090-6090

Telephone: (703) 235-8198

1987 *Engineering Field Notes* Article Awards

It is January again—time to poll our readers on their choices for the best *Engineering Field Notes* articles published during 1987. Each year, based on a survey of our readers, we reward the authors of the three articles receiving the most favorable response.

Engineering Field Notes tries hard to provide useful information to those of you in the field as well as those of you who manage or supervise projects from the office. Did you find any articles especially informative or useful this year? Did any articles help you to develop more effective methods for doing your job? Did any articles help your office save money—or time?

If you have benefited from any of 1987's *Engineering Field Notes* articles in any way, please complete the rating sheet on the following page. To do this, choose the three (3) articles you found most informative, beneficial, or just plain interesting, and rate them from 1 (highest) to 3 (lowest). And—if you believe an article helped the Forest Service save money, please indicate the amount you believe was saved or could be saved.

Remember, do *not* rate more than three (3) articles.

After you have voted, cut out the rating sheet along the dotted line, fold and staple it closed, and mail it to the Washington Office. To be counted, *all rating sheets must be delivered to the Washington Office by January 31, 1988.*

Wait! Before you get back up, why not start writing *your* article for 1988's Engineering Field Notes?

1987 *Engineering Field Notes* Awards

Article	Author	Choice (1, 2, 3)	$ Saved
January/February			
Technology Transfer in the Rocky Mountain Region	Royal Ryser	______	______
An Overview of the Federal Land Highways Coordinated Research & Development Program	Chris Schwarzhoff	______	______
Comparative Evaluation of Micro Road Design Software	Ted Zealley	______	______
A Plastic Ford—You've Got to Be Kidding	Lester M. Pence, Jr.	______	______
Timber Bridges: A Manual to Detail Easily Built, Long-Lasting Structures	Gary Peterson	______	______
Placerville Nursery Biomass Furnace	Dan Totheroh, Joe Olson	______	______
NAP (Network Analysis Program)	Robert Sutton	______	______
Using Fabric to Pave Over Wood Bridge Decks	Allan A. Johnson	______	______
Aggregate Surfacing Acceptability	Skip Coghlan	______	______
March/April			
Some Thoughts on Professionalism	Ted Zealley	______	______
Buffalo Pass Turnkey	Jerry Lancaster, Wayne Hamilton	______	______
Valle Vidal Global Positioning System (GPS) Demonstration Project	Dennis J. Mouland	______	______
Engineering Systems Guidelines & Standards	Jerry D. Bowser	______	______
PAIRWISE, A New Decisionmaking Tool Available to Forest Service Engineers	Robert J. Hrubes	______	______
Heart Bar Hybrid Photovoltaic System	Robert Ota, Audie Nishida, Joe Olson	______	______
Rehabilitation of Hume Lake Dam—First Concrete Multiarch Dam in the United States	Darrel B. Cherry	______	______
May/June			
Yakutat Global Positioning Project	Dave Wood	______	______
Mount Whitney Solar Toilet	James G. McDonald, Robert Stanley, Dave McCauley	______	______
An Empirical Evaluation of Network Analysis Models Used by the Forest Service	Thomas L. Moore	______	______
Skyline Thinning Cost Comparison for Three Yarding Systems	Peter H. Hochrein	______	______
HP-41C Estimate of Uncertainty for Conventional Ground Method Closed Survey Traverses	Al Kayser	______	______
A Primer on Satellite Sensors	Jerry D. Greer	______	______
Central Tire Inflation Program—Boise National Forest Field Evaluation	Deborah J. Taylor	______	______
July/August			
Black Butte Cadastral Survey Using Global Positioning (GPS) & Photogrammetric Technologies for Control	H. Mike Harbin	______	______
Getting Ahead Using the Multi-Year Schedule Program	John T. Chesley	______	______
An Analysis of Space Shuttle Large Format Camera Coverage of National Forests in the United States	Jerry D. Greer	______	______
ROad Analysis & Display System (ROADS)	Chris Schwarzhoff	______	______
Computer Speadsheets in Geotechnical Design	Michael D. Remboldt	______	______
September/October			
A Comparison of Travel Time Prediction Models Used by the Forest Service	Randall K. Nielsen	______	______
Log Truck Performance on Curves & Favorable Grades	Ron Jackson	______	______
Road Program Costs: Continuing Efforts Addressing the Issue	Billy J. Reed	______	______
An Evaluation of Timber Sale Scheduling Using the TRANSHIP Computer Model	Tom Moore, Randall Nielsen, Don Studier	______	______
Acoustic Emission Testing of Wood Products	Marcia Patton-Mallory	______	______
A Procedure for Analyzing Double-Lane Versus Single-Lane Roads	Randall K. Nielsen	______	______
November/December			
Roads Program Costs—Continuing Efforts Addressing the Issue	Editor	______	______
Productivity Gains from Computers	Jerry Bowser	______	______
Another Look at Bidtab	Edmund C. Tarver	______	______
Epoxy Injection Repair of Crane Lake Dam	Jack Mielke	______	______
North Boat Ramp—Diamond Lake, Oregon	Robert Nixon	______	______
Continuous Belting Trail Drainage Structures	L.T. Kocmic	______	______
Multiple Resources Historic Evaluation—Lookout Tower Study, Pacific Southwest Region	John Grosvenor	______	______
Fish Habitat Improvement Using Photovoltaic-Powered Lake Circulation and Aeration	Mark Shaw	______	______
Airfield Expert System	Fong L. Ou	______	______
Winter Travel—A Safety Reminder	NFAP	______	______

CHOOSE ONLY THREE ARTICLES

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FOREST SERVICE—USDA
ENGINEERING STAFF (1113 RP-E)
P.O. BOX 96090
WASHINGTON, DC 20090-6090

FOREST SERVICE—USDA
ENGINEERING STAFF
ATT. D.J. CARROLL (1113 RP-E)
P.O. BOX 96090
WASHINGTON, DC 20090-6090

(FOLD HERE)

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Fourth International Conference on Low Volume Roads

Jerry Bowser
Chief Engineer
System Operation, Analysis, and Development

The beautiful campus of Cornell University, in Ithaca, New York, was the site of the Fourth International Conference on Low Volume Roads, held August 16 through 20, 1987. The previous conferences, held quadrennially, were in Boise, Idaho, Ames, Iowa, and Tempe, Arizona. Cosponsors for the Ithaca program were the Federal Highway Administration, USDA Office of Transportation, and USDA Forest Service. The conference was conducted by the Transportation Research Board and hosted by Cornell University's Local Roads Program.

The importance of low-volume road systems was indicated by the diverse attendance at the conference; 46 States and 26 countries were represented in the more than 280 attendees. The Forest Service was well represented by a cross section of professionals looking to discover new ideas and to share innovations. The value of this conference to the Forest Service was underscored by the presence of Larry Henson, Associate Deputy Chief, who gave the opening statement for the agency.

Conference technical papers have been published in *Transportation Research Record 1106: Fourth International Conference on Low Volume Roads*, copies of which have been procured for each Forest Service Region and Forest Supervisor's Office. (Papers from the first three conferences can be referenced in *Special Report 160, Low Volume Roads* (1975); *Transportation Research Record 702, Low-Volume Roads: Second International Conference* (1979); and *Transportation Research Record 898, Low-Volume Roads: Third International Conference* (1983).)

There were 89 papers brought to the conference. In selecting these papers, the steering committee placed importance on the following:

(1) More effective methods of correlating and disseminating technical and management information in both developed and developing countries.

(2) Program management systems to aid in designing, constructing, and managing low-volume roads and to provide information that can be used for justifying appropriate funding levels and establishing appropriate engineering standards.

(3) Greater understanding of the mechanisms of damage to low-volume roads, particularly the effects of heavy loads on lightly paved or unpaved roads.

(4) Characterization of marginal, substandard, or unconventional materials and documentation of their use in low-volume roads.

Although many papers may be of value to Forest engineers, papers authored or coauthored by Forest Service engineers may be of particular interest to Engineering Field Notes readers wishing to get detailed technical information. Copies of these papers can be obtained from the author or reviewed in TRB Record 1106. The papers are:

(1) *Equipment Rental Road Construction*, Brenda Styer, John Bowman, Richard Lidell, Don Mockler, Sandy Peterson, and Al Schoch.

(2) *The Use of Wood Chips for Low Volume Road Construction in the Lake States*, John Bowman, Richard Lidell, and Gary Schulze.

(3) *Paper Mill Sludge for Stabilization of Sand Roads*, Richard Lidell, Dale Higgins, and John Bowman.

(4) *Consideration of Seasonal Pavement Damage for Timber Haul Roads*, Hannes Richter and Frederick Hsia.

(5) *Using Central Tire Inflation Systems on Low Volume Roads*, Edward Stuart III, Ed Gililland, and Leonard Della-Moretta.

(6) *Determination of Pavement Layer Structural Properties of Aggregate Surfaced Roads*, T. Rwebangira, R.G. Hicks, and Mark Truebe.

(7) *Use of Clegg Impact Tester in Managing and Designing Aggregate Surfaced Roads*, Tej Mathur and Gerald T. Coghlan.

(8) *Efforts to Reduce Construction Costs of Logging Roads in Muskeg in Southeast Alaska*, Melvin Ditmer.

(9) *Using Jersey Barriers as Ford Walls in Low Water Crossings*, John Barksdale and Rodney Mendenhall.

(10) *Computer Model for Developing Road Management Strategies in Underdeveloped Areas*, Sara Baldwin, Martin Hanson, and Michael Thompson.

(11) *Operation of Highway Logging Trucks on Steep Low Volume Roads*, Paul Anderson, Marvin Pyles, and John Sessions.

(12) *Travel Speeds on Curves and Favorable Grades for Logging Trucks on Single Lane Roads*, Ronald Jackson and John Sessions.

(13) *Protection of Wooden Bridge Decks on Aggregate Surfaced Roads,* Richard Faurot and Donald Mockler.

The conference did produce a valuable interchange among concerned roading experts from a variety of perspectives. Since most roads in the United States and in the world are low-volume traffic carriers, technical developments and improvements that will enhance the quality and durability of these transportation systems at a reduced cost are of interest to us all. Costs are of particular import to the Forest Service because of the continuing initiatives to cut unit road costs. Many new and proven ideas were presented and discussed that gave the Forest Service renewed resolve that there are still cost-savings potentials yet to be tried and utilized.

The success of this conference can be credited to a lot of effort by many people. We appreciate the long hours of work required to pull this off. A special thanks to conference steering committee member John Pruitt, Regional Engineer in Region 3, and to Chairman of the TRB Committee on Low Volume Roads, Adrian Pelzner, retired Forest Service Chief Geotechnical Engineer.

Road Program Costs: Continuing Efforts Addressing the Issue

The Road Maintenance Management Information System (RMMIS)—A Viable Tool for Controlling Road Costs

David Badger
Road Maintenance Engineer
Washington Office Engineering

Our 340,000-mile Forest Development Road system has an estimated replacement value of about $19 billion. We estimate that about 1.5 percent of this value should be expended annually for maintenance. Currently, the total value of all maintenance work financed or accomplished by all sources, including federally appropriated funds, commercial users, permittees, other local, State, and Federal Government agencies, and volunteers, is only about half this needed amount. During the past several years, appropriations for road maintenance have not kept pace with inflation or with the growth in the road system. As a result, some badly needed maintenance work has been deferred. Our system is in a gradual state of deterioration. We estimate that a backlog of $350 million in restoration work now exists because of unperformed maintenance.

What can we do about this situation? Certainly we could wish for more money, but that would not be very fruitful. We can, however, learn to use the resources we have more wisely. We can sharpen our skills in prioritizing, advance planning, financial and program management, and decisionmaking processes to ensure that limited resources are used where they will achieve the highest payoff results and to help reduce the rate of investment loss. The Forest Service Road Maintenance Management Information System (RMMIS) was developed as a tool to help us meet these goals.

Our Forest road system is unique among transportation systems; it differs from other systems in the following ways:

(1) It is basically a low-volume, low-standard system, with most roads being either unsurfaced or gravel-surfaced.

(2) It includes five different maintenance levels.

(3) Some roads may be closed for all or part of the year.

(4) Maintenance may be accomplished in many different ways, including force account; formal contract; requirements on timber purchasers,

permittees, commercial users, and cost-share cooperators; cooperation with counties, local governments, or other Federal agencies; and volunteer organizations.

(5) Forest roads are located in a diversity of soil types, climatic zones, elevations, and vegetative types.

The operation and maintenance of our system presents a tremendous challenge. The possible combination of maintenance activities, road management techniques, and funding sources are almost endless. To make the wisest choices of these possible combinations, the Forest Service formally adopted a Maintenance Management System (MMS) with the publication of the Road Maintenance Handbook (FSH 7709.15).

The basic concept of our MMS is essentially the same as that of most States and counties. It is an activity-based system that provides a systematic process for planning, budgeting, scheduling, reporting, and evaluating road maintenance work. Depending on the complexity of individual road systems and the many variables involved, maintenance management processes are usually most easily implemented and provide more beneficial results when combined with computerized data management capabilities. Accordingly, an interregional task force was assembled to develop design parameters for RMMIS. Task force representatives included personnel from National Forests, Regional Offices, and the Washington Office. Design parameters developed by the task force were later validated by all Regions.

System Overview

RMMIS is a subsystem of the National Transportation Information System (TIS). It has both program-planning and accomplishment-reporting capabilities and provides either general or detailed data as specified by the user. Work may be tracked by individual maintenance activity, by maintenance activity group, or by maintenance level. Data may be displayed by individual road, by grouping of roads (for example, by maintenance level), or by a combination of individual roads and grouping of roads at the same time. RMMIS can identify work financed or accomplished by the Forest Service, timber purchasers, cost-share cooperators, local governments (counties, townships, and so on), permittees, human resource and volunteer programs, and other Federal agencies. The method of work accomplishment (that is, force account, contract, cooperative agreement, and so forth) is also identified.

At first, RMMIS may seem to be overly complicated. It is a sophisticated system that provides the capability and flexibility to accommodate the many unique situations associated with our road system. One major attribute of RMMIS is that it can easily be tailored to fit the specific management needs of individual units. Individual users determine the amount of detail and report parameters.

The following sections describe data that are entered into the computer at the beginning of the year and remain constant unless updated. These data are basic when operating most RMMIS programs.

Activity Standards

An activity standard that defines work force, equipment, and material requirements must be developed for each maintenance activity included in a maintenance program. Individual units determine the detail of the work included in each activity. For example, data can be tracked by a specific work process (grading, culvert cleaning, brushing); by activity group (travelway activities, drainage activities), representing a summary of work included in an activity group; or by maintenance level (M.L. 1, 2, 3, 4, 5), representing a summary of work for the specific maintenance level.

Labor Rates

This category is the series-grade rate of pay for each employment classification listed in the activity standard or included in your work force. The average wage rate for each series-grade is all that is required.

Equipment Rates

This is the fixed ownership and use rate, by equipment classification code, for each equipment classification listed in the activity standards or used in performing road maintenance work.

Materials Costs

This is the unit cost for each type of material listed in the activity standards or used in performing road maintenance work. Each type of material is identified by a code number.

Work Planning

The work-planning phase of RMMIS provides for the development of the annual road maintenance plan. The work plan identifies, on a road-by-road or grouping-of-roads-by-maintenance-level basis, or combination thereof, the quantity of work to be accomplished, the cost of work force, necessary equipment and materials, and other relevant data. Work plans may be developed for several different budget levels for current as well as future fiscal years. Also included is an option that can determine the effects that proposed modifications would have on the preliminary program. This could be of significant value as an aid in determining which modifications to implement when developing the final program.

Data that are necessary for development of annual work plans include a maintenance work prescription for each road or group of roads, which identifies:

(1) Work activities to be accomplished.

(2) Number of units of work to be accomplished.

(3) Who will perform the work.

(4) How the work will be financed.

(5) Proposed date to begin work.

These data are merged with the activity standard and rate table data already in the computer to develop the annual work plan.

Accomplishment Reporting

The accomplishment-reporting phase of RMMIS provides a series of accomplishment reports displayed in a variety of formats. Standard accomplishment reports include:

(1) Force Account Accomplishment.

(2) Contract Accomplishment.

(3) Other Performance Accomplishment.

(4) Combined All Methods Accomplishment.

(5) Accomplishment by Source of Funds.

(6) Accomplishment by Surface Type.

(7) Accomplishment by Maintenance Level.

In addition, most planning and accomplishment-report outputs can be tailored to display data by Ranger District, road, activity code, functional classification, service life, surface type, lanes, or maintenance level. Report outputs also can display data by who financed or accomplished the work, or by any combination of the categories. If both the planning and accomplishment phases of RMMIS are being used, the accomplishment data will be displayed next to the plan data for comparison purposes.

Data that are necessary for developing accomplishment reports include a listing by road of the following:

(1) Work completed by maintenance activity number.

(2) Amount of work completed.

(3) Work force, equipment, and materials used to accomplish the work.

(4) Contract unit price (for contract work).

Again, these data are merged with the activity standard and the rate table data already in the computer to produce the accomplishment reports.

The RMMIS programs run on the UNIVAC computer system at the Fort Collins Computer Center. These programs may be accessed through the Data General system, thus making RMMIS available to all potential users. The system was designed to be user-friendly and accessible to persons with only a minimum of data processing expertise. Although the process of data manipulation may be detailed and complex, most operations are automated and transparent to the user. Region 6 staff have been pilot-testing the RMMIS programs and should have completed their work by the time this article is published.

The value of the Forest Service's annual road maintenance program, which includes federally appropriated funds; timber sale allowances for road maintenance; work performed by cost-share cooperators, permittees, States, counties, and other local governments; other Federal agencies; and volunteer programs is approximately $125 to $150 million. The management of this program has a direct effect on all activities occurring on the National Forests and on the service provided to the public. Therefore, to make the wisest use of these limited resources, it is essential to consider and evaluate alternative actions before making final program decisions. RMMIS is one tool that can assist in this effort. Contact Regional Operations and Maintenance and System Management Engineers for detailed information on system availability and detailed operating instructions.

Bob Harris—Forest Service Engineer of the Year, 1987

Robert (Bob) Harris, Assistant Regional Engineer, Region 5, has been selected as the 1987 Forest Service Engineer of the Year. He received this honor because of his leadership in providing cost-effective facilities management in Region 5, as well as his ability to work with others to implement many complex projects. With this distinction, Bob also becomes the Forest Service nominee for the National Society of Professional Engineers' Federal Engineer of the Year award.

As Assistant Regional Engineer for Facilities, Bob is Region 5's Engineering Program Leader for Facility Construction and Maintenance, Geotechnical Engineering, Architecture, Engineering Computer Operations, and Water & Disposal Engineering. Known for his energy and drive, Bob has executed an unusually large number of projects through coordinating and leading

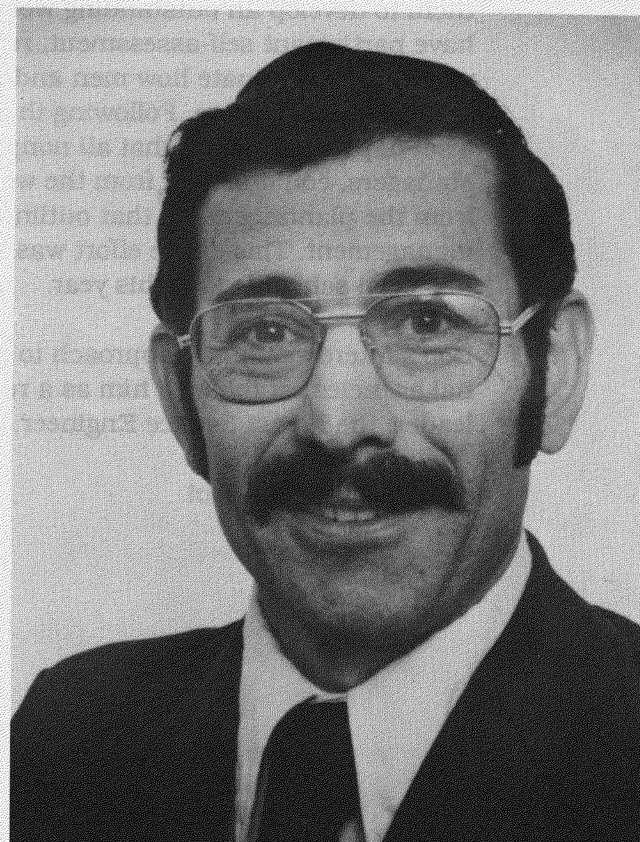


Figure 1.—Bob Harris, Forest Service Engineer of the Year for 1987.

others. He excels at group problem solving; given a task objective, he calls together the appropriate persons, internal or external, to solve problems. Using exceptional facilitation skills, Bob is able to lead groups in focusing on important issues. He then draws on the skills of those present to effect successful outcomes of which everyone feels a part.

Bob has been on the forefront of Region 5's effort to eliminate high-cost leases of administrative sites. In 1986, he instituted a Regional committee to implement land exchanges for administrative facilities. He included staff from Administrative Services, Programming & Budgeting, Lands, and Engineering. Under his leadership, Region 5 has opted out of 8 high-cost leases, resulting in significant cost savings. He has 18 more leased sites approved for shift to Government ownership.

Bob played leadership roles in three technical advisory committees to coordinate interagency agreements for the development of economical, mutual-use administrative sites. These projects are the Northern California Service Center in Redding, a joint firefighting center with the California Department of Fire (CDF); the Big Sur Multi-agency Administrative Site, with CALTRANS and the California Department of Recreation; and a Joint Fire Dispatch Center on the Tahoe National Forest, with CDF.

In 1987, Bob created a workshop titled "Women in Engineering." He selected a planning cadre of female Engineers and Technicians and worked with them to develop an outstanding workshop. Objectives of the session were to have participant self-assessment, review women's issues, discuss Forest Service culture, evaluate how men and women work together, strategize careers, and design the future. Following the session, Bob oversaw the publication of a set of proceedings so that all nonparticipants, particularly Engineering Managers, could benefit from the workshop. He then coordinated a letter from the planning cadre that outlined concerns and recommendations to management. This entire effort was so successful that a followup workshop has been scheduled for this year.

Bob's interdisciplinary approach to problems and his interaction with external agencies established him as a recognized outstanding Forest Service leader: the Forest Service Engineer of the Year.

Congratulations, Bob!

Modified Aggregate Surfaces & Bituminous Surface Comparisons in Region 8

Douglas E. Scholen
Staff Engineer
Region 8

Ozark Class "C" Fly Ash Project

In 1980, New Zealand had reported success in stabilizing low-grade aggregates, including shales, with the addition of 3 percent Portland cement, indicating that a substantial increase in aggregate durability had occurred. To test potential benefits for Region 8, the Ozark National Forest agreed to construct a 1,000-foot test section of modified shale surfacing on the heavily traveled Sorghum Hollow road in August 1984, using Class "C" fly ash from Little Rock. A fly ash content of 10 percent was selected following lab testing of shale specimens and noting that the content of the fly ash is about 30 percent, giving a total addition of 3 percent. During construction, two 24-ton loads of fly ash were blade mixed with shale imported from a nearby borrow pit, watered to optimum moisture, and compacted to T-99 density. During the next 3 years, this section has remained essentially unchanged in condition and without blading or other maintenance, while adjacent sections surfaced in 1984 with crushed aggregate have suffered from severe potholing and have required frequent blading to support the mixed traffic in excess of 50 vehicles per day (vpd).

More recent experience has indicated that the lab procedure used on this project is too severe—with its 4-day soak required before testing the cured specimens in unconfined compression. At the recent Fourth International Conference on Low Volume Roads at Cornell University, New Zealand displayed a lab procedure requiring only 48-hours curing at 70 °F and unconfined compression testing without soaking, followed by an observation period with a specimen in a water bath. All this indicates that similar performance of the shale surface might be obtained with considerably less fly ash, perhaps as little as 3 percent.

North Carolina Pozzalime Projects

In 1985, North Carolina agreed to construct a test section on the Davidson River road using a very small percentage of pozzalime with crushed rock containing about 25 percent fines. Twenty-four tons of pozzalime were spread over 2 miles of 18-foot road, disked into 4-inch depth, watered, and compacted to T-99 density. This amounted to about 0.6 percent additive overall and 2.4 percent in terms of the fines only.

Blading on this road was reduced from nine to two times per year following this construction, and the surface performed satisfactorily during the subsequent 18-month period. Grader operators noted substantial hardening on the treated sections during 1986. An unusually warm winter occurred during 1986-87, resulting in many cycles of freeze-thaw in this area (estimated one per day through the winter). During a recent inspection, it was not possible to discern any difference in hardness between the treated and untreated sections. Whether or not this loss of strength will be regained remains to be seen. The acquisition of a Clegg testing hammer this year will provide a better means of evaluating the condition of this and other road projects.

Pleased with the improved performance of the modified gravel surface, the Pisgah National Forest currently has 4 additional miles of road under contract on the Yellow Gap road in the vicinity of the test section. Construction was completed in October 1987. In this contract, the bid on the pozzalime construction was nearly $5,000 per mile, possibly reflecting mobilization cost spread over only 4 miles of road.

The Bio-Cat Option

The concern with the effects of freeze-thaw in the Appalachian forests has led to a search for a more effective stabilizer. Recently the Soil Stabilization Company in Merced, California, has been marketing a complex organic molecule (something like an asphalt) under the name of Bio-Cat. This material is added to the compaction water in small amounts (about 1 gallon per 960 cubic feet of soil or aggregate). Following compaction, full strength is reached in 7 days. A dense elastic cake with a hard surface is obtained, according to the manufacturer. The company recently offered to supply enough material for a 1/2-mile test section in North Carolina, and subsequently shipped a 55-gallon drum of Bio-Cat to the Pisgah District in mid-September. The test was completed October 23, 1987.

Mississippi Pozzalime Projects

Following the initial success with stabilizing a crushed aggregate surfacing on the Davidson River road in North Carolina, it was decided to try other types of surfacing materials in the Region to learn whether similar improvements in performance could be obtained. Mississippi had been searching for some method of binding its clay gravels for better performance and had a particularly serious problem on Forest Development Road 202 on the Chick District near Laurel, where the annual gravel loss approaches 1 inch per year, and blading every 2 weeks throughout the year is required to maintain a passable road. Truck traffic on 202 averages 25 vpd.

Although lab testing of pozzalime-treated samples from 202 had shown negligible strength gains, it was felt that the testing procedure was too severe and not typical of field conditions for a well-drained road surface. Therefore, a test section was proposed to the Desoto National Forest. Clay gravel in the area generally has about 35 percent rounded gravel, the remainder being a sand-silt mixture of low plasticity. Because of the increased fines in the clay gravel as compared with the crushed aggregate, the proposed test section was 1 mile long with similar width, half the area of the Davidson River road, providing a pozzalime application rate of approximately 1.5 percent of the total mix and 2.3 percent of the fines only.

Construction of the 202 test section, consisting of the first mile of road east of State Highway 15, was completed under contract in early October 1986. Performance has exceeded all expectations. Nearly a year later and following some extremely heavy rains, including storms exceeding 10 inches of rainfall, the condition of the road surface remains essentially unchanged. During that period, the only maintenance performed consisted of two light bladings, both when adequate moisture was present to ensure recompaction of the loosened material. Throughout that period, the truck traffic continued without interruption.

Since gravel replacement and renovation of 11 additional miles of 202 was already planned for 1987, the Forest decided to include pozzalime treatment in the project. A 20-year design at 9,000 18-kip single axle loads per year required 5 inches of pozzalime-treated gravel over 4 inches of untreated gravel. Assuming an annual surfacing loss of 1/8 inch, sufficient surfacing will remain throughout the 20-year life to support traffic without further gravel replacement. The project was completed under contract in early September 1987. The cost of the pozzalime treatment was $3,000 per mile, compared to $7,000 for the initial 1-mile test section. When compared to the $5,000 per mile for the 4 miles of the Yellow Gap road in North Carolina, it seems that the length of project has an important effect on the unit bid price.

Bituminous Surface Comparisons

During recent years, considerable interest has developed in using bituminous surfacing on heavily traveled collector roads to avoid costly gravel replacement needs that tax the Regional budget each year— on the premise that the high initial cost of bituminous pavement would more than pay for the gravel replacement and frequent bladings over the life of the pavement. Using data from these two projects in North Carolina and Mississippi, together with cost figures from a recently completed paving contract for the Coleman Lake road in Alabama, it was possible to make an analysis of four types of construction and compare their costs: gravel, pozzalime-treated gravel, Bio-Cat-treated gravel, and asphalt concrete pavement.

As shown in table 1, the bituminous option in Mississippi is more economical when compared with untreated gravel. Note, however, that because of the poor quality of the clay gravel base material, it must be treated with the pozzalime before it will support a bituminous surface. Note also that the cost of the pozzalime-treated gravel alone is only about 25 percent of the cost of the bituminous pavement over the 20-year life period. Of course, little is known of the actual maintenance requirements of the pozzalime. The Bio-Cat option is similar to the pozzalime but slightly higher in cost, since the material cost is approximately $3,000 per mile higher than pozzalime.

Table 1 shows a similar analysis for the road in North Carolina. There, because of the better quality aggregate, the aggregate loss is half of that in Mississippi, and modification is not required prior to placing asphalt concrete, but the advantage remains for bituminous over gravel, and the modified gravel is still about 25 percent of the bituminous. While the problem of freeze-thaw in this area may increase future costs of pozzalime modified-surface maintenance, bituminous pavement maintenance will also be

Table 1.—Mississippi and North Carolina cost comparisons.

Mississippi

Surface type	*Gravel*	*Pozzalime*	*Bio-Cat*	*Bituminous*
Gravel base	100,000	90,000	90,000	45,000
Pozzalime		33,000		33,000
Bio-Cat			66,000	
Bit. $30/ton				352,000
Gravel repl. 1"/yr	387,000			
Blading	158,000	22,000	22,000	
Slurry				116,000
Totals	645,000	145,000	178,000	550,000

North Carolina

Surface type	*Gravel*	*Pozzalime*	*Bio-Cat*	*Bituminous*
Gravel	34,000	34,000	34,000	34,000
Pozzalime		20,000		
Bio-Cat			32,000	
Bit. $30/ton				128,000
Gravel repl. 0.5"/yr	190,000			
Blading	36,000	8,000		

substantially greater than in Mississippi. If the Bio-Cat proves to be effective and resistant to the effects of freeze-thaw, maintenance costs for both the modified-surface and bituminous-surface roads (using a modified gravel base) should be similar to the costs in Mississippi.

This cannot be considered a final note until more is known about the maintenance needs of the modified surfaces. It does, however, place a large question mark over the economic feasibility of bituminous pavement in locations where chemical modifiers are practical.

Green Book Survey/Design Program for the HP-71B Computer

Richard A. Rasmussen
Civil Engineering Technician
Bighorn National Forest

Introduction

The computer program GREENBK was written to fill a void in the Bighorn National Forest's road surveying practices. In the past Forest staff have been doing the major part of the road surveys in the "RSDS format" (for RSDS design) and a minor portion in the "RDS format." The field book was the primary storage device for the survey data. With the trend to construct lower standard roads, it became unnecessary to put as much effort into the survey and design of some of the roads, particularly those in gentle terrain, those constructed by the "Station" or "Mile," or those constructed to tolerances of plus or minus 2 to 3 feet.

In the "good old days" before computer design, there was a system in which a road was surveyed and construction was staked at the same time. It was fondly called a "Green Book Survey" and was used where cross slopes were fairly uniform and where end haul was at a minimum. The cross slope was measured, the figure was looked up in the book for the proper road width and template shape, and a figure was given for the distance to the catch point of each section. A field book was used to record each cross slope and the station of each stake. In the office, the quantities could be arrived at by returning to the "Green Book" where the tables provided additional figures to get end areas, clearing and grubbing quantities, and seeding areas. The cover of this book was a dark green. Later publications came out with a tan cover, but by then the name "Green Book" identified a type of road survey.

Last spring, the Forest purchased two Hewlett-Packard HP-71B hand-held computers to be used as electronic notebooks for our timber road surveys. It was decided that the hand-held computer could be used to perform the same functions– looking up each cross slope in the "Green Book" and recording the cross slope, percent slope, slope distance ahead, and any needed remarks in the field book.

Program Description

The GREENBK program consists of three two-dimensional arrays where the survey information and calculated information are stored and another two-dimensional array where the data tables from the "Green Book" are stored. When the program is first loaded into the computer, the data tables must be loaded into the array. The program was designed this way because our low-standard roads are constructed using a road surface 12 feet wide, an almost vertical backslope (0.25:1), and a 1.5:1 fill slope. Other locations may have a different minimum-standard road. If other users wish to change the program to fit their needs, all they have to do is change the Data Statements.

When the program is run, the operator is asked for the same standard information that would normally be put into a field book, such as date, weather, and temperature. It asks for the name of the crew chief, beginning station, road name, and number. The program then goes into the actual road survey routine where it asks for the slope distance ahead, percent slope ahead, azimuth ahead, cross slope (a single shot), and any remarks. The computer display then provides the section number and station for the back of the construction stake, then the vertical cut and the horizontal distance from centerline to the top of the cut, and the slope distance from centerline to the downhill clearing flag.

The field data can be "dumped" to either magnetic cards or to cassette tapes using the Hewlett-Packard tape drive. A hard copy of the survey notes and the reduced staking notes can be made using a Think-Jet printer. The field data can be edited, corrected, recalculated if an error is discovered, and redumped to the magnetic cards or tape; then another hard copy can be made. The hard copy of the staking information gives the section number, station, individual quantities of clearing and grubbing, excavation, and seeding, plus a grand total at the bottom of the printout for each category.

Equipment Needed

Users will need to upgrade the HP-71B computer from its original configuration with an IL interface and a card reader if they wish to use magnetic cards instead of cassette tapes. The system also will need additional RAM memory. We were unsure of exactly how much RAM would be needed, so we installed two 32K RAM chips into ports 1 and 2. It seems to be more than adequate as we can now put an entire day's survey into the 80K RAM. At this time, the program is set up to allow 200 sections or points before it needs to be dumped. Users also need a Think-Jet printer to obtain a hard copy of the day's information and the staking notes.

Savings

It required about 4 hours per mile of survey to reduce the old "GREEN BOOK" survey notes that are recorded in a field book and to arrive at a total volume for clearing and grubbing, excavation, and seeding. The GREENBK program eliminates this time because the printout for staking notes has this information on it. There is no appreciable amount of savings during the survey since the keyboard input time is about the same as writing in the field book. Errors in the survey can be found quite easily by examining the survey and staking note printouts.

For additional information, contact Richard Rasmussen at (307) 672-0751 (or Data General at D.RASMUSSEN:RO2FO2A).

Safety in the Office

Many Forest Service employees spend the majority of their time in an office. Although the hazards in an office environment are not as dramatic as those in the field, they are still hazards.

Accident reports have been submitted for every conceivable happening. Many office and warehouse accidents result from improper lifting and moving of heavy boxes or furniture. These accidents are easy to avoid. If it is too big for you to move, get help. If it is very big, get professional help. If you have a serious back problem, do not attempt to do any lifting without the advice of your doctor.

Most office accidents that occur are not of the life-threatening kind. This is in contrast to the field situation, where automobiles, aircraft, falling trees, heavy equipment, and severe weather all add up to higher risks for field-going personnel. The things that we must contend with in the office are not as dangerous as those in the field, but that does not mean that they may be casually ignored.

Opening more than one drawer of a filing cabinet can bring the entire cabinet down on you and break your arm or leg as easily as some field accidents can. Piling boxes on top of cabinets poses a hazard to people who may try to get them down for use. Chairs can unexpectedly tip over, and the knot on your head is as real and as painful as one sustained in the course of firefighting. Discarded razor blades that are not properly wrapped pose a serious hazard. In some ways, they are more dangerous than a sharp axe used to clear brush. They should always be taped heavily so that a janitor or anyone else who may be poking around looking for that very important note (which was "here a minute ago") will not get cut.

Carpets can have bumps or ridges that will trip you just as easily as a branch on a sidewalk. Extension cords that are laid out in walkways will trip people just the same as a vine growing over a trail. Used improperly, a simple paper cutter can do the same damage that a log chipping machine can; both will remove fingers! There is as much dust in most offices as there is in the air on many field projects. Eyes in the office and eyes in the field react the same way; they can hurt and often require medical attention.

Hammers, stapling machines, electrical equipment, and many other things found in the office can cause lost-time accidents as easily as field hazards can. A staple inadvertently driven into your finger can cause an infection as severe as one resulting from a cut by a barbed wire fence.

So, regardless of the place where we work, safety is something that should always be on each of our minds. Think safety. Live safety. If there are things on your mind, such as work or family problems, take an extra moment when you do your work. This extra time may just save you the pain of an accident. Remember, accidents can be avoided. We must all work toward maintaining an accident-free workplace.

EFN thanks the Nationwide Forestry Applications Program for submitting this safety message.

Techline Notes

Engineering Field Notes *(EFN) has "borrowed" the following information from* Techlines*— one-page documents published by the Forest Products Laboratory in Madison, Wisconsin.*

In an effort to help Forest Service units share information and to foster an atmosphere conducive to technology transfer, EFN, from time to time, will be including information extracted from Techlines. *We hope this section will provide readers with usable information sources and individuals to draw on to get their jobs done.*

Engineering Field Notes *editors appreciate FPL's desire to share information, and hope that this sharing will benefit all concerned.*

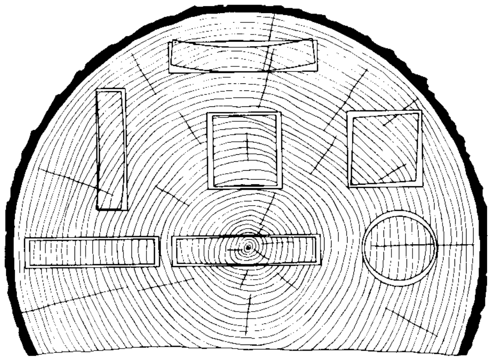
Wood Handbook

The Forest Products Laboratory was established in 1910 as the first institution in the world to conduct general research on wood and its use. The vast accumulation of information that has resulted from the Laboratory's engineering and allied investigations of wood and wood products over 7 decades, along with knowledge of everyday construction practices and problems, provide the basis for the U.S. Department of Agriculture's most recently revised *Wood Handbook.*

The purpose of the *Wood Handbook* is to serve as an aid to more efficient use of wood as a construction material. The handbook is designed to give engineers, architects, and builders an authoritative source of information on the physical and mechanical properties of wood and how these properties are affected by variations in the wood itself.

Individual chapters of the *Wood Handbook* describe not only the wood itself, but wood-based products as well, together with the principles of how wood is dried, fastened, finished, and preserved from degradation in today's world. Each chapter is climaxed with a list of selected references to provide additional information. A glossary of terms is presented at the end of the handbook. The common and botanical names for different species mentioned in this volume conform to the official nomenclature of the Forest Service. Information on selected foreign species is included to reflect the increasing importance of imported species. English and metric systems of measurement are used for selected sections throughout the handbook. A conversion table is given inside the back cover.

Copies of the newly revised handbook are available from Superintendent of Documents, U.S. Government Printing Office, 710 N. Capitol Street, Washington, DC 20402; (202) 275-2091. Requests should include complete



The Wood Handbook *contains detailed information on wood properties. Illustrated is characteristic shrinkage and distortion of flats, squares, and rounds as affected by the direction of the tree's growth rings.*

title and stock number as follows: Agriculture Handbook No. 72, *Wood Handbook*, Stock No. 001-000-044-56-7. Current price is $27.00 (subject to change without notice).

Truss-Framed System Construction Manual

A *Truss-Framed System (TFS) Construction Manual* has been published by the National Association of Home Builders Research Foundation in cooperation with the Forest Products Laboratory. The manual includes sections on the design, detailing, and construction of TFS buildings. The TFS is an innovative new building system for residential and light-commercial construction. The new system offers substantial savings in both material costs and construction time, with improvement in structural durability and strength. TFS was conceived at the Forest Products Laboratory in the late 1970's to meet the need for less costly, high-quality home construction.

Truss framing was developed after field observations of building damage from natural disasters showed that roof-to-wall or wall-to-floor joints often failed before the structural members. These observations were confirmed by Forest Products Laboratory full-scale house tests. Since the unitized frame ensures structural continuity between the critical joints, TFS buildings are often sturdier than those constructed through conventional means.

The innovative system also requires about 30 percent less structural framing lumber than the conventional stick-built home. Because less onsite effort is needed to frame up a structure, the average size home can usually be erected in a few hours. As a result, builders have reported savings of about 10 percent of the overall costs by using the TFS building technique.

Copies of the construction manual are available from: National Association of Home Builders Research Foundation, Inc., P.O. Box 1627, Rockville, MD 20850; (202) 452-0200. Price is $5.00 ($4.00 for multiple copies).

Built with truss frames, this contemporary split-level house offers stylish architectural design and incorporates solar collector panels for increased energy efficiency.

Protecting Wood From Humidity

Whether used indoors or outdoors, wood is always affected by moisture and constantly changes dimensions because of changes in its moisture content. This happens regardless of the moisture form—rain, snow, dew, and even high or low humidity will cause wood to shrink and swell as it dries or wets. Protecting wood from these fluctuations in moisture requires effective finishes that are properly applied.

In a new Forest Products Laboratory publication, "The Moisture-Excluding Effectiveness of Finishes on Wood Surfaces," scientists report on the moisture-excluding effectiveness (MEE) of 91 commercially available surface treatments and finishes on wood. Results showed that only 16 finishes were more than 80 percent effective in slowing moisture vapor movement into wood over the relatively short time of 14 days, and then only when two or three coats were applied.

For a copy of FPL Research Paper 462, "The Moisture-Excluding Effectiveness of Finishes on Wood Surfaces," contact U.S. Department of Commerce, National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161; (703) 487-4650. Price is $9.95 hard copy, $5.95 microfiche, No. PB 86145026/AS. Complete technical data and descriptions of the finishes used can also be obtained from NTIS by the title: "The Moisture-Excluding Effectiveness of Finishes on Wood Surfaces—Support Data," No. PB 86147717/AS, $9.95 hard copy, $5.95 microfiche. (Prices are subject to change.)

Laminated Veneer Lumber

Parallel laminated veneer panels, when ripped into lumber widths, are called laminated veneer lumber (LVL). Researched extensively at the Forest Products Laboratory in the 1970's, this veneer processing technology combined existing plywood manufacturing methods with new laminated techniques to develop a product with greater uniformity and predictability than solid lumber. Tests have also shown that the strength of LVL specimens compares favorably with most high-strength lumber grades, and as a result, LVL offers a viable alternative to structural lumber.

Recently, more LVL has appeared in the marketplace because high quality, solid-sawn structural lumber has become more scarce and expensive. The markets for LVL appear limitless—it can be used for truss components, I-beams, bench seats, truck decking, door/window headers, scaffold planking, ladder stock, bridge stringers, and other interior and exterior applications.

Products made from LVL have several advantages over solid-sawn lumber. For example, the problems of warping and checking are practically eliminated because the veneer is dried before gluing. Also, because laminating disperses wood defects, most mechanical properties will be more uniform than those same properties in solid-sawn wood of comparable quality.

In the past 15 years, the Forest Products Laboratory has developed an extensive LVL data base that focuses on raw material options, processing alternatives, product performance levels, system and product economics, and alternative marketing opportunities. This data base has contributed significantly in several ways—an American Society of Testing and Materials (ASTM) task group is working on a general format for evaluating structural lumber substitutes, and two new U.S. standards have been or are being developed. The first, developed by the American Institute of Timber Construction (AITC), provides for LVL as a substitute for tension laminates in glued laminated beams. The other is a standard proposed by the American Plywood Association (APA). It will use performance ratings and will provide for trademarking based on the mechanical capabilities of the product. Thus, the future for this industry continues to look promising.

The importance of LVL products is expected to grow as the wood industry uses more smaller diameter trees. The versatility of LVL is a good example of how our renewable forest resources can provide a broad array of structurally efficient products to benefit manufacturers and consumers alike.

For more information, contact John A. Youngquist or Ted L. Laufenberg, USDA Forest Service, Forest Products Laboratory, One Gifford Pinchot Drive, Madison, WI 53705-2398; (608) 264-5796.

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Volume 20
January-February 1988

Engineering Field Notes