ENGINEERING TECHNICAL INFORMATION SYSTEM

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Field Notes

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ENGINEERING FIELD NOTES

This publication is a monthly newsletter published to exchange engineering information and ideas of a technical or administrative nature among Forest Service personnel. The text in the publication represents the personal opinions of the respective author and must not be construed as recommended or approved procedures, mandatory instructions, or policy, except by FSM references.

This publication is not intended to be exclusively for engineers. However, because of the type of material in the publication, all engineers and engineering technicians should read each issue.

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Material submitted to the Washington Office for publication should be reviewed by the respective Regional Office to see that the information is current, timely, technically accurate, informative, and of interest to engineers Service-wide (FSM 7113). The length of material submitted may vary from several sentences to several typewritten pages. However, short articles or news items are preferred. The Washington Office will edit for grammar only. All material submitted to the Washington Office should be typed double-spaced, and all illustrations should be original drawings or glossy black and white photos.

Each Region has an Information Coordinator to whom field personnel should submit both questions and material for publication. The Coordinators are:

R-1	Bob Hinshaw	R-6	Kjell Bakke
R-2	Allen Groven	R-8	Ernest Quinn
R-3	Dan Roper	R-9	Ron Pokrandt
R-4	Fleet Stanton	R-10	Bill Vischer
R-5	Jim McCoy	WO	Al Colley

Coordinators should direct questions concerning format, editing, publishing dates, etc., to Fran Owsley, Editor, Division of Engineering, Forest Service, USDA, Washington, D. C. 20250.

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FIELD NOTES

ROAD PERSPECTIVE AND COMPUTER GRAPHICS

By Jerry Larsen
Staff Engineer, Geometronics, Region 2
and
Jerry Leonard
Civil Engineering Technician, Region 2

Man has always desired to be able to graphically display the effects of his development of facilities prior to the actual construction of these facilities. Over the years, various ways to accomplish this have been developed, such as artists' renderings, plans, engineering drawings, scale models, etc.

In developing highway designs, many different design parameters and effects must be evaluated as they interrelate to one another. A designer must be able to communicate the relationship between the horizontal and vertical alignment and the manner in which it will fit the landscape. The usual graphic presentation of this design is through plan and profile drawings, with computer printouts providing the detailed information.

This method of display, with its exaggerated scales, is normally difficult to comprehend by those not familiar with engineering drawings. Today, with the concern for the effect of major construction on ecological and environmental factors, there are people from all disciplines, representing a myriad of lay pressure groups, entering into the decision-making process on all engineered facilities. The United States is experiencing an acute awareness of the impact of public works projects upon the total environment. Conservation of natural beauty is a major decision factor in highway location.

As a result of this awareness, it is becoming increasingly necessary to evaluate more thoroughly the interrelationships between the actual physical design parameters as well as the impact of the design and associated construction activities on the environment. The designers and planners must be able to communicate their thoughts and ideas to people in all walks of life who have a real interest in the consequences of the proposed actions.

With this in mind, the Federal Highway Association (FHWA), formerly the Bureau of Public Roads, embarked on a program to develop a means to present the highway designer and various other interested groups with the ability to evaluate design features of a proposed highway. The FHWA's research developed two very interesting systems. One is a 16-millimeter movie sequence about a given road, ordinated with a computer-driven cathode ray tube. By using a flash technique, it is possible to get a sensation of driving along the existing road and then the road as it is proposed. This system has great potential but is expensive. The other system is much the same but uses still photography, and an electronic digital plotter is used in place of the cathode ray tube.

After reviewing these systems, we in Region 2 think that the still photo system has the potential (with certain existing equipment) of being economically practical. A road currently under design was selected as a pilot study and the necessary on-the-ground photographs were taken (see Figures 1, 2, and 3). Certain basic criteria must be determined before the system is operable. These are:

- Focal length of camera being used.
- Road with X, Y and Z coordinates on road stationing.
- Road design data in RDS system (1108 Computer).
- A target or range finder in the camera to sight and center the photo view (center of photo) on a known point with X, Y and Z coordinates.

The following photographs and computer plots demonstrate our first attempt at highway design graphics.

From the conception of this project, our goal was to keep the process simple. One of the limitations of this procedure was that the observer was required to occupy a centerline station with known coordinates, which allowed him a view only along the centerline of the road. To be able to see the improvement from different views – i.e., from across a drainage, the top of a cut bank, etc. – two methods were used:

- An independent survey to establish relative coordinates of the camera point.
- A computer program to resection the location of coordinates of the camera point.

The inputs for this program are three identifiable points on the photo, with known coordinates and the focal length of the camera being used. A fourth known point can be substituted for the focal length of the camera. Technical requirements can be found in Report No. FHWA-RD-72-7.

Figure 1. – The camera was positioned over station 6+51 on a horizontal plane looking at the range pole at station 7+01. A 135 mm press camera was used.

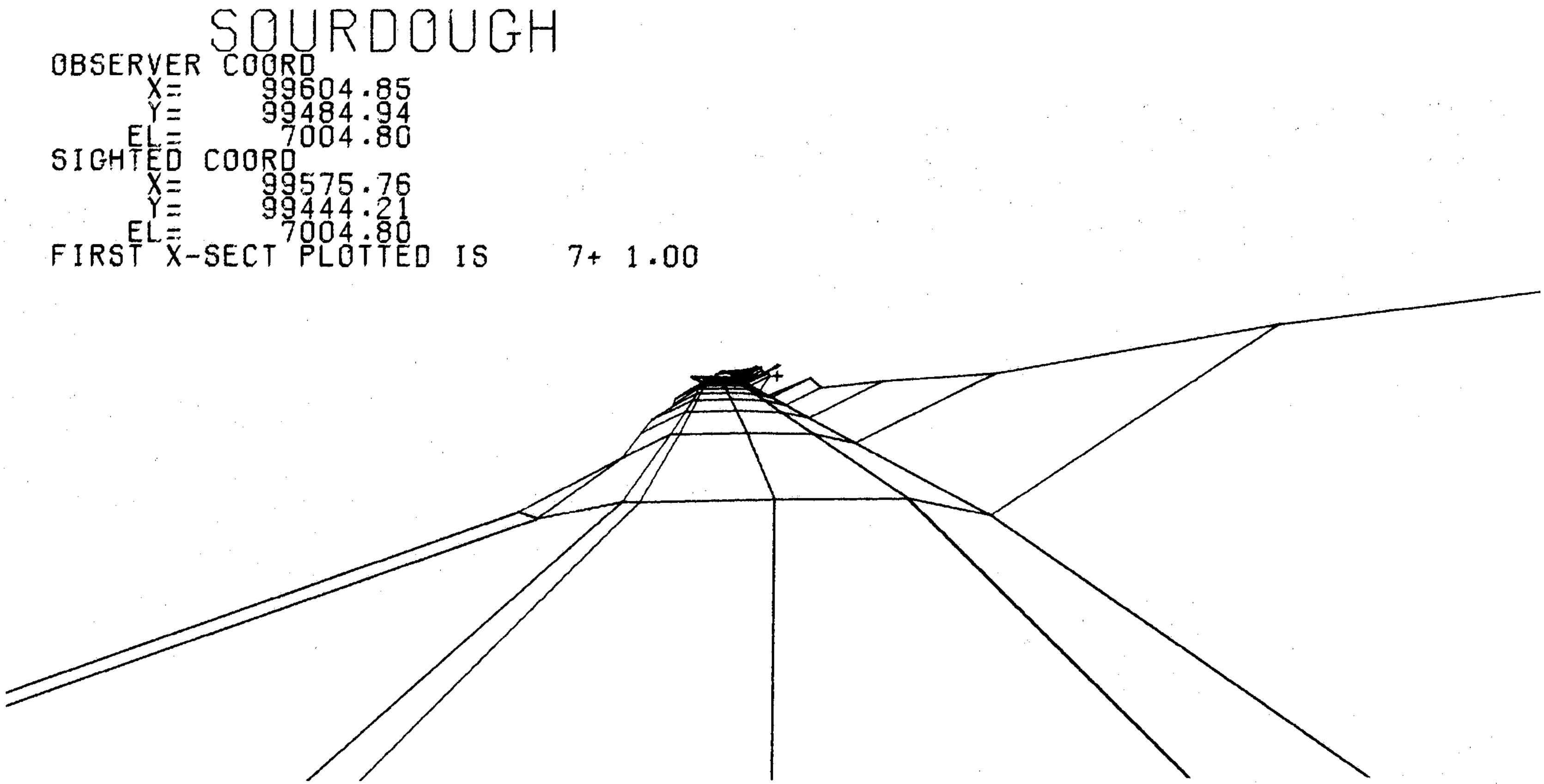

***Figure** 2. – This plot was generated from the RDS design data. The input for the perspective was the X, Y, Z coordinates for the occupied point, observed point and the focal length of the camera. These plot routines are available to those regions who are using the Univac 1108. For more detailed information, see report No. FHWA-RD-72-6 (Rev.).*

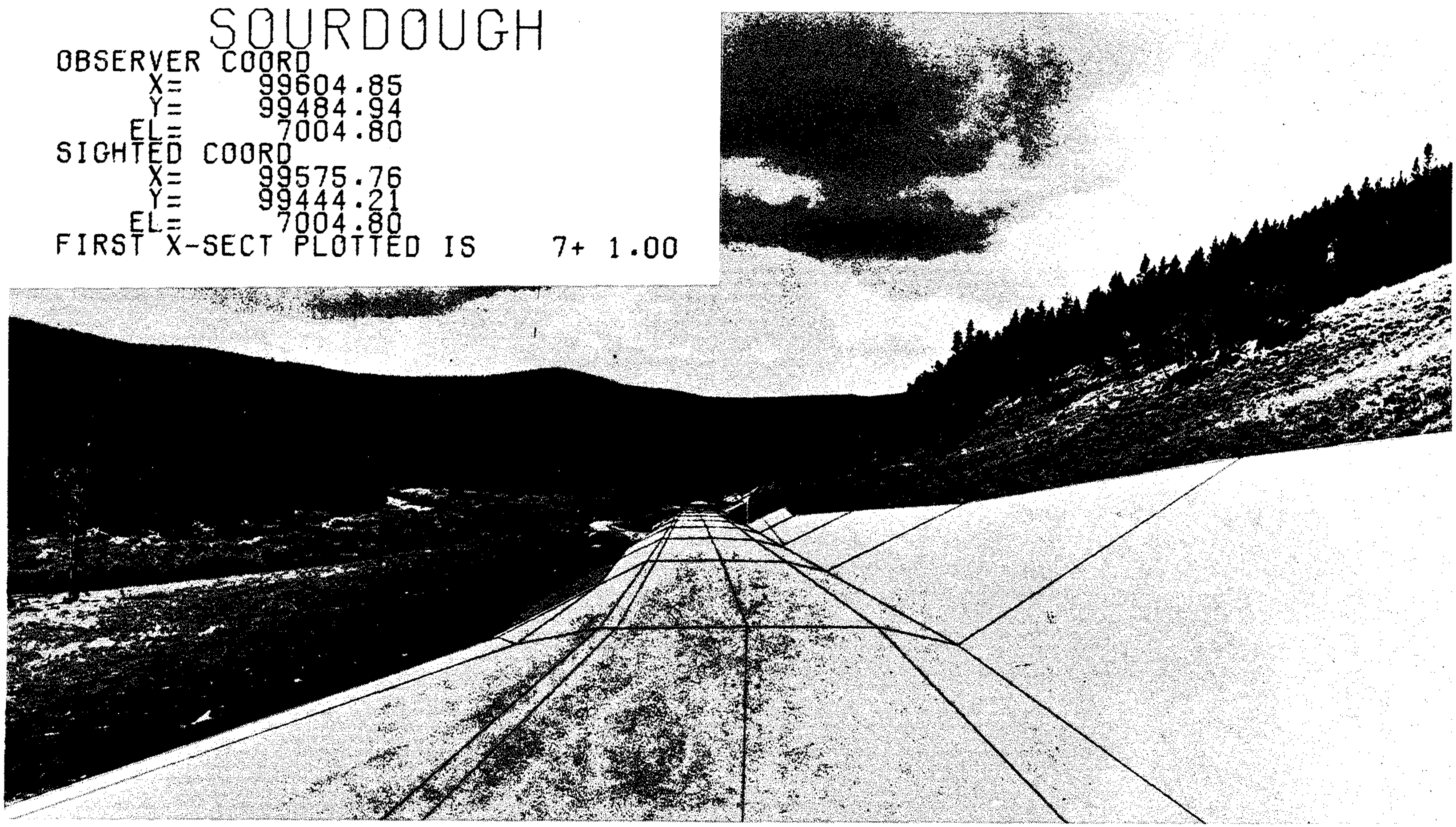

Figure 3. – *The plotted perspective drawing includes tie marks corresponding to the known points to aid in matching the two images (photo and plot) and to act as a check on scale and on distortion (see report No. FHWA-RD-72-3). When these were fitted, a picture of the montage was taken with a reliable copy camera. This last step could be eliminated by making the plot on clear film and using it directly as an overlay on the controlled photo.*

With careful use of a good camera and having access to the 1108 version of RDS, anyone can produce a graphic presentation of a proposed highway design. Although we have not had enough experience to establish cost, we feel that the expenditures for the process will be relatively small.

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LIMITING VEHICLE VELOCITIES AROUND CIRCULAR CURVES

By John Sessions
Logging Engineer, Region 2

An assumption often made when determining the design velocity around circular curves is that a vehicle is limited by the velocity which causes it to slide under centrifugal force. In all standard highway engineering texts the equation

$$\frac{V^2}{gR} = f + e$$

is used to express the relationship between curve radius, velocity, coefficient of friction, and superelevation.

This paper will define under *what* conditions sliding does control, and when the overturning moment becomes the critical factor.

The equations expressing the two possible modes of failure are presented on pages 8 and 9. Also see the Force Diagram on page 8. Comparing the forms of the velocity equations for the two modes (Equation 6 and Equation 12) indicates a simple decision rule exists to predict the critical mode of failure.

If $f > (\bar{x} / \bar{y})$ the overturning case controls;

If $f < (\bar{x} / \bar{y})$ the sliding case controls;

where f is the coefficient of friction and $(\bar{x} / \bar{y})$ is the ratio of the distances to the center of gravity of the vehicle. The decision rule is independent of the superelevation and curve radius.

The sliding case controls passenger cars with their low center of gravity; but loaded logging trucks, having a higher center of gravity, can affect the mode of failure on paved surfaces.

The following example illustrates how to determine whether a vehicle will slide or overturn and what the controlling velocity will be.

If we assume:

coefficient of sliding friction	=	0.50
$(\bar{x} / \bar{y})$	=	0.35

Then since

$$f > (\bar{x} / \bar{y})$$

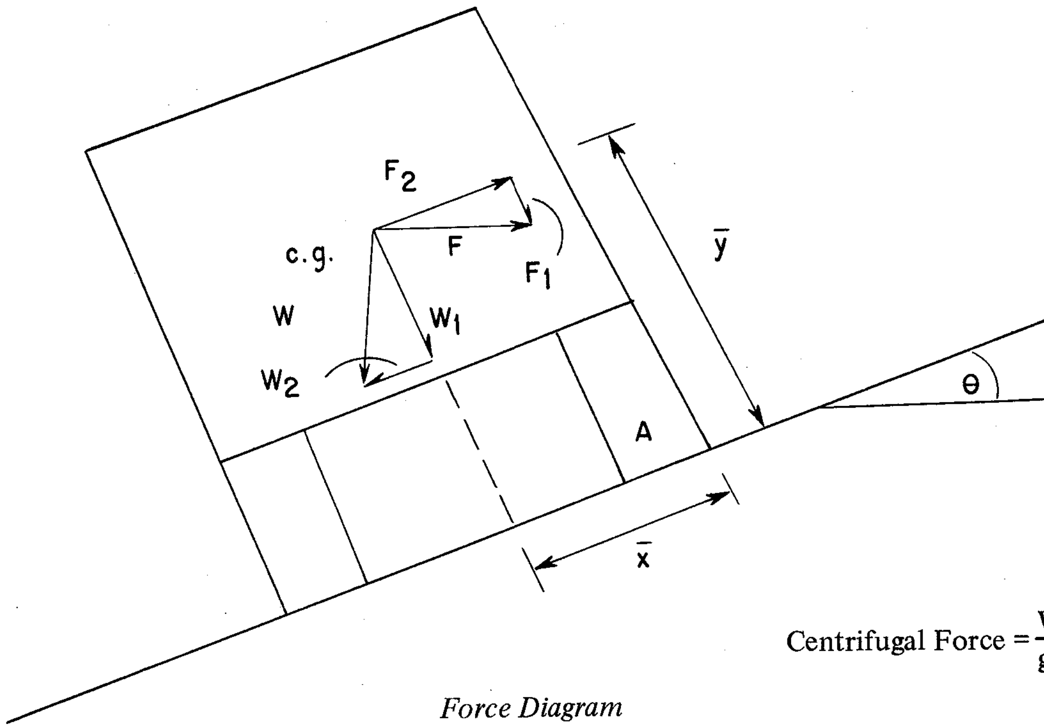
we would expect the vehicle to overturn before it would slide. If we further assume a curve radius and superelevation, then the limiting velocities can be calculated from Equation 6 and Equation 12 and compared.

Assuming:

superelevation	=	0.06
curve radius	=	200 ft

By Equation 6, the vehicle would begin to slide at 61 fps or 42 mph. By Equation 12 the vehicle would overturn at 52 fps or 35 mph. The vehicle is clearly limited to that velocity at which overturning would occur.

As highway research is developing pavement surfaces with higher coefficients of friction, and we increase the paving of forest roads, it is necessary to know under what conditions our design guides apply.



Centrifugal Force $= \frac{WV^2}{gR}$

Force Diagram

MODE 1 – SLIDING CASE

$$\text{Normal Force} = F_1 + W_1$$

$$= \frac{WV^2}{gR}(\sin\theta) + W(\cos\theta) \qquad \text{(Eq. 1)}$$

$$\text{Sliding Force} = F_2 - W_2 \qquad \text{(Eq. 2)}$$

$$= \frac{WV^2}{gR}(\cos\theta) - W(\sin\theta)$$

To prevent sliding,

$$\text{(Normal Force) (Coefficient of Friction)} \geqslant \text{Sliding Force} \qquad \text{(Eq. 3)}$$

Substituting Equation 1 and Equation 2 into Equation 3,

$$\frac{WV^2}{gR}(\cos\theta) - W(\sin\theta) = f\left[\frac{WV^2}{gR}(\sin\theta) + W(\cos\theta)\right] \qquad \text{(Eq. 4)}$$

Dividing by W (cosθ) yields,

$$\frac{V^2}{gR} - (\tan\theta) = \left[\frac{V^2}{gR}(\tan\theta) + 1\right] f \qquad \text{(Eq. 5)}$$

Solving for V and substituting superelevation = $\tan\theta = \frac{e}{1}$,

$$V \leqslant \left[\frac{e + f}{\frac{1}{gR} - \frac{fe}{gR}}\right]^{1/2} \qquad \text{(Eq. 6)}$$

MODE 2 – OVERTURNING CASE

$$\text{Resisting Force} = F_1 + W_1$$

$$= \frac{WV^2}{gR}(\sin\theta) + W(\cos\theta) \qquad \text{(Eq. 7)}$$

$$\text{Overturning Force} = F_2 - W_2$$

$$= \frac{WV^2}{gR}(\cos\theta) - W(\sin\theta) \qquad \text{(Eq. 8)}$$

Summing moments about Point A in the Force Diagram,

$$(F_2 - W_2)(\bar{y}) = (F_1 + W_1)(\bar{x}) \qquad \text{(Eq. 9)}$$

$$\left[\frac{WV^2}{gR}(\cos\theta) - W(\sin\theta)\right]\bar{y} = \left[\frac{WV^2}{gR}(\sin\theta) + W(\cos\theta)\right]\bar{x} \qquad \text{(Eq. 10)}$$

Dividing by W (cosθ) yields,

$$\left(\frac{V^2}{gR} - \tan\theta\right)(\bar{y}) = \left[\frac{V^2}{gR}(\tan\theta) + 1\right](\bar{x}) \qquad \text{(Eq. 11)}$$

Solving for V and substituting superelevation $= \tan\theta = \frac{e}{1}$,

$$V \leqslant \left[\frac{e + (\bar{x} / \bar{y})}{\frac{1}{gR} - \frac{e}{gR} (\bar{x} / \bar{y})} \right]^{1/2} \qquad \text{(Eq. 12)}$$

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REGIONAL DIVISION OF ENGINEERING NEWS

REGION 5

FACILITY MAINTENANCE

Submitted by John Grosvenor, Region 5

During the last two years, the California Region has been conducting forest-wide building and utility condition surveys. These surveys are a management tool to better aid the Line Officers (District Rangers and Forest Supervisors) in establishing priorities for money and personnel concerning construction, operation and maintenance of the facilities. One-half of the National Forests in California have now completed their surveys.

These forest-wide surveys serve as a *ground zero* for the yearly required condition surveys, as well as providing the current needs to correct health and safety items (items that create unsafe occupancy or hazards to the general public). In order to provide validity, continuity and credibility to these surveys, a multidisciplinary team approach is being used. The team is made up of professionals and technicians with expertise in buildings and structures; water and sewer systems; roads and drainage systems; and electrical systems. A C&M representative of each district who has historical knowledge of the facilities shall be a part of the team. The size of the team depends on the size of the forest, skill levels available and the time available to do the survey (the teams have ranged from 4 to 9 persons).

Once the survey is completed the station, district and forest data are compiled. A meeting is then held with the Forest Supervisor, District Rangers and appropriate forest staff officers. This strong managerial approach insures that the priorities identified are consistent with the forest's program of work, volume of business and available funds. The time and effort spent on these surveys and inventories can be justified only if the overall maintenance and operation of the facilities on the forest are performed economically and efficiently in support of the forest program.

As an outgrowth of these surveys, the Region is conducting a training program for those individuals who maintain the stations. Many of the problems found in the surveys were caused by either actions or inactions by the Forest Service C&M personnel.

Each session consists of 2 ½ days of training given in four geographic areas of the state. The emphasis is on what our people can and cannot do, and how to get the work accomplished. The subject areas covered include heating and air conditioning systems; electrical, plumbing, water and sewer systems; structural modifications and architectural changes; and protection and treatment of wood. The instructors are all Forest Service employees (three from the R.O. and two from a forest) and are all extremely competent in their specific areas.

This is the first get-together session of the facility maintenance personnel in this Region. Within the geographic areas the maintenance people are getting to know one another – discovering who the regional specialists are, and how to get assistance. They are also being provided a forum to discuss their particular problems and to air grievances.

These training sessions are being video-taped and will be available for future training of Region maintenance personnel. For further information regarding either the surveys or the training, you can contact John Grosvenor, Regional Staff Engineer for Facility Construction, Operation and Maintenance, (415) 556-3984.

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OPERATIONS

Harold L. Strickland
Assistant Director

DIGITAL TERRAIN INFORMATION SYSTEM

The Digital Terrain Information System (DTIS) is a family of computer programs designed to meet multidiscipline needs. From various input data, terrain models can be measured, analyzed, and displayed in various forms -- contours, profiles, perspectives, slope. aspect, etc.

The system has been under development and pilot demonstration for the past 3 years. Results have been favorable. Although additions and improvements will be made in the future, it is now time to fully document the system and make it available to all interested users. The pending Fort Collins Computer Center provides a unique opportunity for assisting technology transfer. The target date is July 1, 1974.

At the present time, this digital terrain information is obtained by means of three different systems. One involves the numerical representation of the terrain based on imagery read in a stereomodel. This engages the use of a digitized stereoplotter to define the terrain with digital X, Y, Z output on either cards or magnetic tape. With the use of a computer, this data is transformed into ground coordinates and stored in a grid format from which individual terrain profiles are generated. In the production of orthophotos, a precision XY plotter is employed to scribe these profiles which are used directly to control the projecting motions of the GZ-1 orthophoto projector.

The second system involves digital data taken from topographic map sheets. This is done with the use of an XY graphic digitizer with vertical recording capabilities. This digitizing unit, with proper computer software application, can store terrain information onto magnetic tape which then can be plotted on an XY plotter in any format which has been programed.

The third system entails the use of the DMA TopoCenter's 1:250,000-scale numerical map data file, all of which has been digitized. This terrain data is systematically stored in a grid format on magnetic tape. Through a series of developed computer software programs, direct retrieval of this terrain data in different graphic forms is proving very valuable because of the wide geographic range it encompasses.

The digital data from these systems can be used interchangeably to produce various products of an infinite scope such as orthophotos, contour overlays at any interval, contour and density slope maps with any range of slope values, cross sections and seen area compilations. The future expansion of digital terrain data files and compatible software technology will enhance and increase the flexibility between the various data bases and the desired products which are obtainable from digital information. Remote terminal access to a central computer bank is truly a forthcoming reality.

CONSULTATIONS AND STANDARDS

Charles R. Weller
Assistant Director

POTABLE WATER SYSTEMS

Chapter 7420, Water Supply, of FSM 7400 has been published and was sent to the field just after the first week in the new year. In conjunction with its issuance, manual amendments or emergency directives are in the process of being issued for FSM 2331 and FSM 2540 to eliminate inconsistencies in our drinking water bacteriological sampling program.

The new FSM 7420 has been reviewed by the Water Supply Division of the Environmental Protection Agency, which formerly operated in the Public Health Service. The chapter includes recommendations made to Congress by the General Accounting Office (GAO) in its report #B-166506, *Improved Federal and State Programs Needed to Insure the Purity and Safety of Drinking Water in the U.S.*, November 15, 1973.

The Water Supply chapter initiates a new potable water supply inventory and monitoring system. Information for implementing the system is being prepared for field users. The two new forms involved, 7400-2 and 7400-4, are being printed. The computer monitoring program is being final-tested prior to sending it to the field. Our present plans are for the total package to reach you by the end of February 1974.

There are some errors in FSM 7420 which you may have already noted. These errors will be corrected as soon as possible by another amendment to the manual. The obvious errors or omissions are:

> FSM 7421.23, pg. 7421.23-2, *People Use table.* The word *Pay* in the left column table heading should be crossed out. The table heading should read "People Use Days [1/] Per Period of Use."

The second page of Exhibit 1, FSM 7421.25, was inadvertently omitted. That page follows:

Sample Size	If present sample contains	and previous sample contained	Then
10 ml	No portion	No previous sample	1/
	One portion	"	1/
	Two portions	"	1/
	Three portions	"	2/
	Four portions	"	2/
	Five portions	"	2/
100 ml	No portion	No previous sample	1/
	One portion	"	1/
	Two portions	"	1/
	Three portions	"	2/
	Four portions	"	2/
	Five portions	"	3/
Membrane filter technique	Colonies equal to or less than 3/50 ml, 4/100 ml, 7/200 ml, 13/500 ml	"	1/
	Colonies more than 3/50 ml, 4/100 ml, 7/200 ml, 13/500 ml	"	2/

TECHNOLOGICAL IMPROVEMENTS

Heyward T. Taylor
Assistant Director of Engineering

HANDBOOK CHAPTER ON FLEXIBLE PAVEMENT DESIGN

Chapter 50 of the *Transportation Engineering Handbook* (FSH 7709.11) has been rewritten and is in the process of being distributed. The title of the chapter has been changed from "Materials" to "Pavement."

A method for the design of structural sections for flexible pavements has been included in this chapter. The write-up of this design method is largely due to the efforts of Ronald

Williamson of Region 6. It combines the findings of the U.S. Army Corps of Engineers studies on unsurfaced and aggregate-surfaced roads with the findings of the AASHO Road Test at Ottawa, Illinois and later satellite programs. The format of the design guide is the same as may be found in *AASHO Interim Guide for Design of Pavement Structures, 1972* with modifications to include the Corps of Engineers material.

In the past, no single comprehensive method of design has been available that would apply to all of the structural section design problems encountered on Forest Service roads. Chapter 50 will now cover all except rigid pavement structures. This handbook chapter has been completed in response to many requests and comments by road design engineers who have been looking forward to its issuance.

GUIDELINES FOR THE DESIGN OF SUBSURFACE DRAINAGE SYSTEMS FOR HIGHWAY STRUCTURAL SECTIONS

A report entitled "Guidelines for the Design of Subsurface Drainage Systems for Highway Structural Sections" has been received from the Federal Highway Administration. A limited number of copies of this report have been forwarded to Regional Information Coordinators for distribution to the Forests. The report is a supplement to our recently issued handbook chapter on flexible pavement design (FSH 7709.11 Ch. 50).

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