Utility Regulation

Regulating Tree Trimming (Pennsylvania). (Regulations governing trimming and removal of trees on or along state highways) (Including copy of permit form) (11-10-43)

Regulations Governing Clearing for Construction or Maintenance of Utility Lines Along State Highways in North Carolina. (Adopted by N. C. Utilities Coordinating Committee) (Also suggestions for clearing practices on utility rights-of-way) (3-10-44)

Control of Utilities along Highways (Indiana). (Includes copy of law and copies of tree trimming and tree removal permit forms) (4-25-44)

Regulation of Tree Trimming by Utilities (Kansas). (Including laws and permit forms) (6-28-44)

AERIAL SURVEYS FOR NEW HIGHWAYS AND ROADSIDES

By Wilbur H. Simonson, *Public Roads Administration, Chairman, Subcommittee on Design, Right-of-Way and Border Control Committee on Roadside Development*

SYNOPSIS

The paper outlines use of aerial photographs and maps in locating and designing highway and roadside areas to fit the terrain and to conserve natural and developed features. Tables are included to give a record of progress in highway use of aerial photographic surveys and to show the relationship of map-scales, contour intervals, topography, and land-use in preliminary and final stages of highway location and design. Advantages of aerial survey methods for obtaining complete topographic information on a belt or zone of land are summarized. A list of recent photogrammetric references is included.

In his book, "American Highway Practice," Dr. L. I. Hewes states two principles that may well be kept in mind by locators and designers of every post-war highway. These are first that "the reconnaissance should cover a belt of country rather than a line"[1] and, second, that "better designs result if the line is first studied carefully on paper and the mistakes rectified there."[2]

The best of possible engineering aids toward carrying out these principles in practice are aerial photographs and aerial survey methods. By combined use of aerial and ground survey methods, complete topographic information on a wide belt of terrain can be obtained at relatively low cost in time and money. Only when complete and accurate topographic information is available, can errors in location be prevented and mistakes that may otherwise be made in design and construction be avoided or rectified in the preliminary stages of highway development. And in the long run, only when complete topographic information is at hand can highway locators and landscape architects work out simultaneously the highway design requirements for traffic and driver services. Mapped topography is needed to fit new highway locations into the terrain and to design roadway cross sections and roadside areas to conserve natural and developed features in that terrain.

[1] See Volume 1, page 30.

[2] See Volume 1, page 39.

Early beginning of aerial survey methods

The use of aerial highway surveys probably began when a location engineer first flew in an airplane over a proposed route and was quickly able to find control points such as gaps in mountain ranges or edges of bad ground indicating where the best highway location lay. Oblique or vertical photographs taken on these flights recorded such control points so that ground survey crews could be directed to them without loss of time.

Aerial mosaics were next obtained by assembly of two or more overlapping vertical photographs to serve as a map on which to make initial studies of a proposed highway location. In flat terrain, such a mosaic was a reliable map for reconnaissance use. In hilly or mountain topography, however, uncorrected mosaics made without the benfit of a framework of ground control points did not permit of adequate measurement for preliminary location purposes.

TABLE 1
A RECORD OF PROGRESS IN HIGHWAY USE OF AERIAL PHOTOGRAPHIC SURVEYS

Year	State	Types of Photographs Or Maps				Scale, Feet to 1 inch	Use—Stage of Plan Prepations			
		Mosaics	Paired Prints	Enlarged Photos	Contour Maps		General Area Study	Reconnaissance of Atler-nate Routes	Preliminary Location and Design	Final Surveys and Plans
			ft.	*ft.*			*ft*	*ft.*	*ft.*	*ft.*
1924	New York, Westchester Co.	Uncontrolled				Small				
1926	New York, Erie Co.	Controlled				Small				
1927	Michigan	Controlled				1,667	1,667	1,667		
1927–29	Mt. Vernon, Mem. Hwy., Virginia	Controlled 330	500	200	Plus Plane-Table Topo	500 330 200	330	500 and 330	200 and 100	100 and 50
1930	Idaho, Mountainous				10-ft. intervals	1,000	X	1,000		
1930–1940	17 States[a]		Contact prints			1,667–660	1,667	660		
1937–1939	Michigan	Controlled	Contact prints			1,667–1,000	1,667	1,000		
	Michigan	Controlled		40					40	40
1941	New York		1,000		5-ft. intervals	1,000–200	X	1,000	200	100
1941–42	Ontario, Canada		900	400	Plus Plane-Table Topo	900–400	X	900	400	100
1943–44	Mass.-Conn. and New England		500			200	X	500	200	100
1944–45	Kansas	Controlled 100	200	100	2 intervals, 100 scale overlay	200 and 100	X	200	100	100
1945	Rhode Island		500		5-ft. intervals 200 ft. scale	200	500	500	200	100

[a] Arkansas, California, Idaho, Illinois, Indiana, Kansas, Michigan, Minnesota, Ohio, Oregon, Rhode Island, Tennessee, Texas, Utah, Virginia, Washington, Wisconsin and others.

Another stage in the evolution of aerial survey methods began when two consecutive photographs of a highway route, taken at a measured distance apart on a "line of flight" with the same camera at the same altitude, were examined under the stereoscope. This is an improved optical instrument with two eye-pieces which is used to aid the observer to combine the images of paired aerial photographic prints and thus get the effect of solidity or depth. These "stereopaired prints," when examined under the stereoscope, showed not only the location of ridge tops, points on the floors of valleys, existing roads, buildings, and other topographic details but, also, the relative differences in elevation between such points. That is, areas of terrain could now be studied in relief by stereoscope methods. All three dimensions of length, breadth, and height or elevation were revealed as a spatial model of the topography of the area under study by use of the stereoscope. With such additional information readily available to him, the engineer could make tentative location studies to fit the highway into the terrain.

The final stage in the evolution of aerial survey methods was reached about 1924 when precision equipment was first developed which made it possible to compile accurate contour maps from aerial photographs with a few selected ground control points located by survey crews on the area covered by each photograph. It was not until some years later, however, that photogrammetric survey methods began to be applied to highway location and design problems. (See Table 1.)

The stereoscope and paired aerial photographic prints are the foundation of the photogrammetric map-making equipment operations. Most forms of precision mapping equipment from the simple stero-comparator and KEK plotter to the complex equipment used in the Multiplex, Brock, and comparable systems, are based on similar optical and mathematical principles. Details of these typical methods of aerial map-making will be found in War Department reference No. 1 appended. A concise comparison of various methods now in use is given in the magazine reference No. 3. The most detailed and authoritative description of photogrammetry now available is presented in the manual reference No. 6.

Stages of aerial surveys

Assuming that aerial photographs have been taken of a zone of land to include all feasible location lines of a new highway, a complete aerial survey may consist of three stages:

1. A mosaic of matched and numbered photographs taken on one or several flight lines over the highway route will be made available for initial location studies. These matched photographs might be at a scale of 1,000 ft., but preferably should be at a scale of 500 ft. to 1 in. (See Fig. 1.)

2. Sets of "stereopaired prints" at a scale of 500 ft. to 1 in. will be found most useful for stereoscopic study of the area to be traversed by the highway.

3. An accurate topographic map of the whole proposed route may be prepared with 5-ft. contour intervals at a scale of 200 ft. to 1 in. In the case of rough mountain or urban terrain, such a map may be at a scale of 100 ft. to 1 in. In flatter terrain, the contour interval may be made at 2-ft. spacing. (See Fig. 2.)

Use of aerial photographs and maps—the aerial mosaic

Alternate preliminary lines for two or more practicable road locations may be laid down on the small-scale mosaic map. At scales ranging between 1,000 and 500 ft. to 1 in., the most prominent control points and topographic features can be identified for study. Ridges, stream crossings, existing roads, edges of cleared fields, and bridges, for example, will be clearly visible. With a reading glass we might be able to find details such as rock outcrops or areas of swamp and marsh. However, at this stage, the ground is seen, except for shadows and light contrast features, as a flat area in one plane although in areas of rough topography where extreme differences in elevation occur sufficient shadows are cast to make some relief apparent to the observer. Governed by the objective controls established for the project, the line of a proposed highway traced out on a small-scale mosaic will be useful as a preliminary outline for reconnaissance studies. From such a map, survey crews might be able to find and fix control points and connect them by running out preliminary location lines on the ground. But until each alternate preliminary line is staked out on the ground, with necessary clearing of brush and timber on each of the several lines, and the contours over a selected width of highway strip along each alternate location plotted, we should have insufficient data as a basis for choosing the best location. In other words, the aerial mosaic is not an adequate map on which preliminary locations can be satisfactorily studied and completely compared without field staking. To be fully useful the mosaic should be supplemented by stereoscopic paired prints and contour maps. Further uses of the mosaic are brought out in the references listed.

Paired prints and the stereoscope

Now we may take the paired photographs at a scale of 500 ft. to 1 in. covering the same highway strip or belt of terrain and place them in oriented position under the stereoscope. We are now seeing the ground, not as a flat plane, but in three-dimensional relief as a spatial model of the ground surface as it appears in nature. Each depression and low knoll is clearly seen. Slopes appear to slope, and a stream is seen not only as a line but as a line with a gradient or slope. Tree growth, low trees and brush land, grass land or cultivated fields and farms can be clearly distinguished, fence and property lines may be identified, major structures may be located and the types and sizes of structures interpreted in a general way. Areas of watershed can be traced out and estimates of surface run-off can be readily calculated. This particular map at a scale of 200 ft. to 1 in. showing let us say 5 ft. contour intervals. All essential culture and topographic details will have been accurately plotted on this map. By use of a set of draftsman's curves, or preferably the

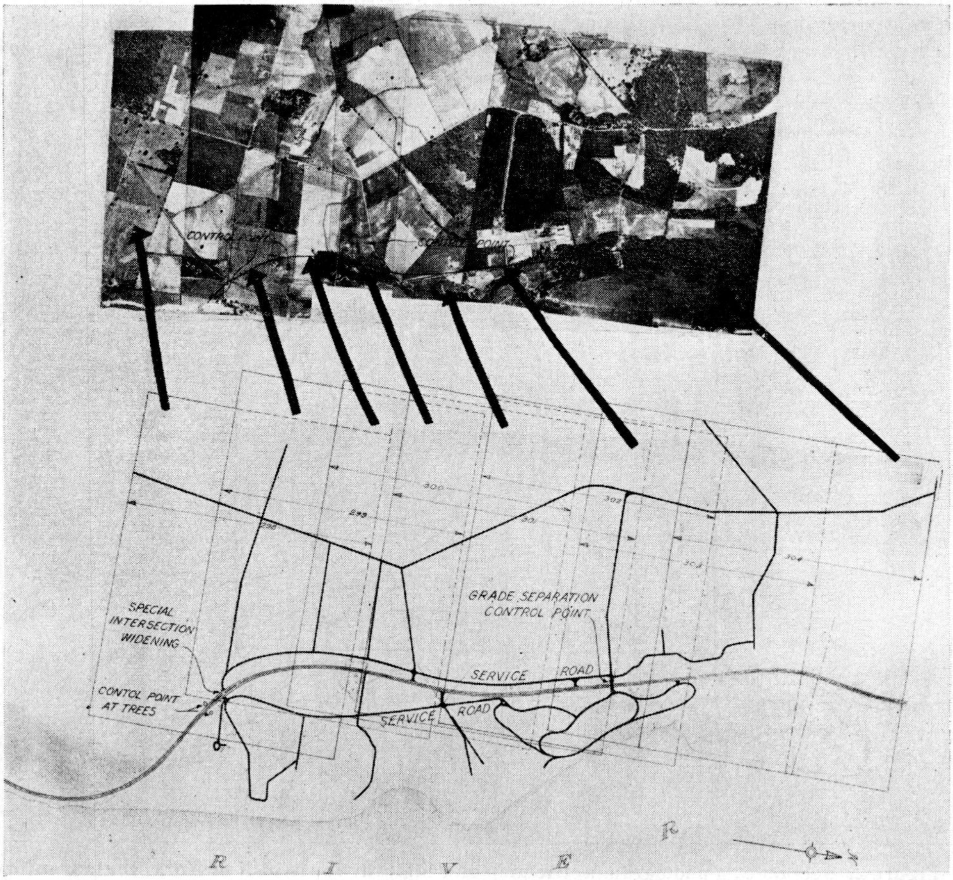

Figure 1. Consecutive photographs taken on a strip along a line of flight over a proposed highway route are the first stage of a complete aerial survey. Here is a series of overlapping 7 by 9-in. prints assembled in a rough mosaic and used for general reconnaissance and as a control plan for general development. Taken at an original scale of 500 ft. to 1 in. these photographs in stereopairs made possible detailed examination of the ground under the stereoscope in relief. From such a series of photographs corrected to scale in correcting printers, and supplemented by ground survey location of control points on each photographed area, an accurate contour map can now be supplied by a number of contracting companies by use of precise photogrammetric mapping equipment.

use for estimating drainage requirements is outlined in reference No. 2 of the appended list.

Use of aerial photogrammetric map

Finally, we may project the several selected alternate road location lines on the contour more flexible "spline-line" location study method (Fig. 3), the proposed alternate center-lines can be readily adjusted to the selected ground control points and a flowing alignment fitted. The same flowing alignment can be actually staked on the ground by transit and chain method to within a few feet of position accuracy, both horizontally and vertically. By looking at the topographic map and at sections of it viewed in the paired prints under the stereoscope, we can clearly see and adequately plot the following important details within the normal limits of accuracy determined by the scale of the map being used.

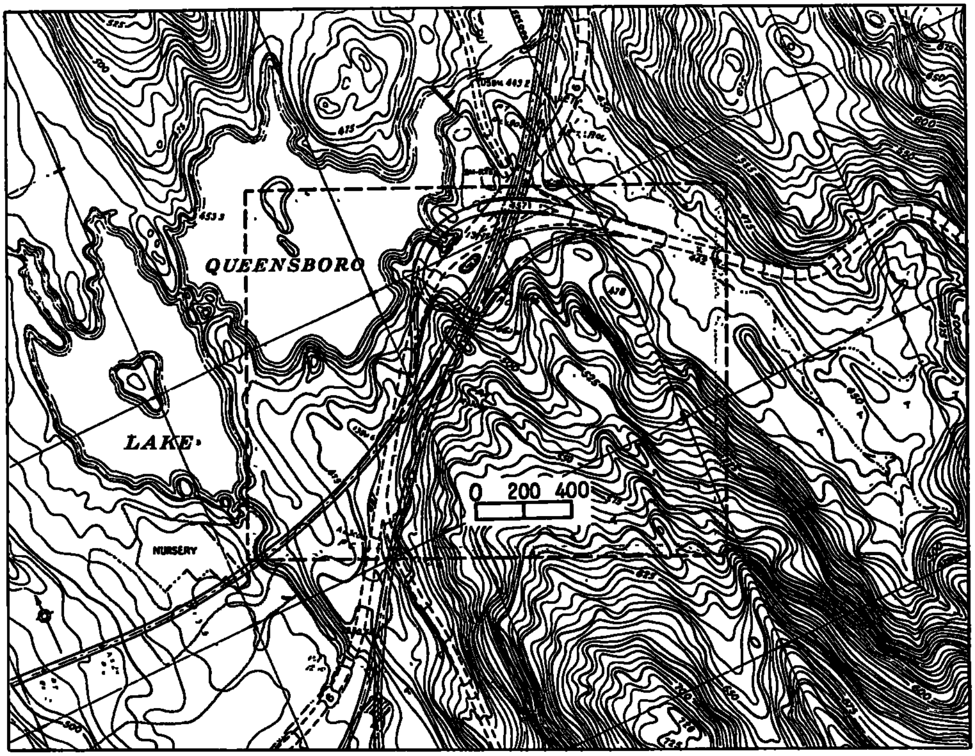

Figure 2. Section of a photogrammetric map of a highway route in New York, contour interval 5 feet, original scale 200 feet = one inch. The preliminary spline line shown permitted yardage estimates from the contours which checked within 5 per cent with the yardage measured after the line was staked out on the ground. This map met contract requirements of vertical accuracy to within one-half the contour interval, and horizontal accuracy to within the nearest 10 feet on 90 per cent of the area mapped. NOTE the grid system essential for accurate plotting of planimetric details. For uniformity in practice, the grid control should be based on the State plane coordinate system.

1. All primary and secondary "control points" through which the road location lines must pass in order to fit the terrain and to conserve the natural or developed features.

2. Critical soil and drainage conditions, such as unstable sandy or clay soils which may produce slides, sloughage or settlement if included within construction areas. Certain types of tree growth, for example, will only be found on sandy soils, other trees and vegetation grow only where subsurface water is close to ground surface. Muck soils in particular will always be covered by distinctive types of vegetation.

3. Locations which will avoid excessive land-damage claims. For instance, various types of industrial and commercial areas, large-scale public or semi-public institutions such as hospitals, schools or universities, cemeteries, housing developments, etc., in urban and suburban areas; and fine crop lands, groups of large trees, blocks of heavy timber, developed farm or garden areas, and precipitous palisades or cliffs, can be identified and avoided in the preliminary location stages.

4. All natural drainage channels and

watershed areas draining into them can be clearly outlined and types of surface involved in run-off measurements classified for culvert calculations.

5. Areas suitable for safety and scenic turn-outs. Stream shores, lake shores and points with outstanding views of hills and valleys are examples of such sites.

6. Preliminary property acquisition maps can be plotted for right-of-way requirements without trespass on private lands by survey crews in advance of construction, a time-saving procedure favorable to a possible reduction in land purchase costs.

7. Roadside areas likely to be developed in an undesirable manner by private individuals can be studied for possible acquisition.

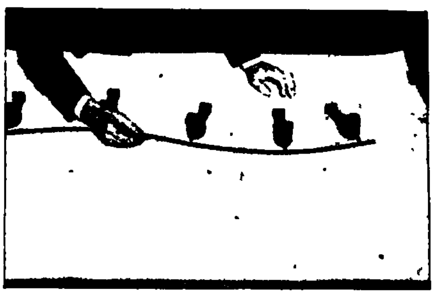

Figure 3. Use of spline in study of alternate routes and in fitting route location to selected controls on working topography sheet.

For example, land should often be acquired bordering on road intersections to avoid gas station and similar development which will interfere with sight distance. Border or service road requirements can also be analyzed in relation to existing and potential roadside development and driver service needs, present and future.

8. The best of several alternate preliminary location lines can be selected by use of the stereoscope, and accurately plotted on a large scale photogrammetric contour map without the usual staking of trial lines on the ground. The scale of this map may be 200 ft. to 1 in. or larger. Reasonably accurate yardage estimates can be made from the contours and location lines plotted on such a map. For example, on a recent major highway project preliminary yardage estimates from 5-ft. contours on a photogrammetric map in hill topography checked within 5 per cent of the yardage on the same line accurately staked out as a final location line on the ground.

Moreover, by combined use of accurate topographic maps with stereopaired prints, preliminary highway location and design studies can be carried into the final staking and plan stages. Often, recognized errors are thus largely eliminated in the office before field staking and actual construction are started.

Relative scales of topographic maps

Table 2 shows the general relationship of map-scales, contour intervals, topography, and land-use in preliminary and final stages of highway location and design. In the application of the principles and operations of photogrammetric map-making equipment, the selection of the contour interval predetermines the scale to which a map may be prepared for a given kind of topography. The map-scales and contour intervals indicated for each class of topography are based on a 0.1-in. minimum spacing of contour lines on the map sheets. The balanced relationship shown in the table should be considered as a general guide in the selection of map-scales to meet the requirements of working accuracy in drafting and design.

Cooperation in the use of aerial photographs and maps

The landscape architect, with experience in highway design, will find aerial photographs and maps of great assistance in developing grading and planting plans for highway and roadside areas. He will have no difficulty in interpreting photographs by reason of his professional training in the recognition of all forms and types of vegetation, and the relationship between natural land forms and existing types of soil and rock. Cooperation between the highway location engineer and the landscape architect in use and interpretion of aerial photgraphs under the stereoscope and in the final photgrammetric topographic map should be the objective. Highway and roadside design being essentially a single design problem, aerial surveys can be the means of making such cooperation even more effective than in past years, in getting new highway location fitted to the lay of the land,

and in conserving as far as possible the natural and developed features of new highway routes.

Summary—Advantages of aerial survey methods

To make a short summary of a subject on which volumes have been written it is evident that the complete aerial survey should be used to get complete topographic information on a belt or zone of land, through which any-one of a number of alternate routes of a new highway must pass.

Small scale aerial mosaic maps are of service in general route reconnaissance. Paired photographic prints at scales of 500 ft. to 1 in. or larger for stereoscopic examination, and aerial photogrammetric maps at scales of 200 ft. to 1 in. or larger, have the following uses and advantages:

1. A wide strip or belt of terrain containing all practicable highway locations can be photographed in a few hours of clear weather at anytime of year. Wet ground or light snow do not delay the field work of aerial photography. Topographic survey by ground crews covering an equivalent belt of land 3,000 ft. wide or wider may require months. In most States wartime shortages of trained personnel will not permit plane table mapping on such a scale in any case.

2. Accurate photogrammetric contour maps can be developed in the drafting room with precision drafting equipment in much less time and at corresponding lower cost than a topographic map of equivalent accuracy made by traditional survey and drafting methods.

3. By the combined use of complete sets of aerial photographs with the accurate photogrammetric contour maps made from them:

Difficult, arduous and time-consuming ground reconnaissance can be largely eliminated. (Reference No. 2, p. 4, Col. 3.)

Alternate preliminary lines can be located and yardage estimates of work accurately obtained without staking out several alternate preliminary lines on the ground. (Reference No. 4, part II, New York.)

Right-of-way maps can be developed satisfactorily for preliminary purchase agreements without sending ground survey crews across private land. (Reference No. 2, p. 5.)

Drainage watersheds can be analyzed, plotted and measured for runoff and culvert design calculations. (Reference No. 2, p. 6.)

Soils may be classified generally from existing forms of vegetation and from evi-

TABLE 2

RELATIONSHIP OF MAP-SCALES, CONTOUR INTERVALS, TOPOGRAPHY, AND LAND-USE IN PRELIMINARY AND FINAL STAGES OF HIGHWAY LOCATION AND DESIGN

Kind of Topography	Type of Land Use	Preliminary Location Plans		Final Staking-Plan Stage	
		Scale of Contour Map	Contour Interval	Scale of Plans	Contour Interval
		ft. per in.	*ft.*	*ft. per in.*	*ft.*
Level to rolling (8:1)	Open country	500–400	5[a]	100	a
	Built-up areas	400–200	5–2	50	2
Rolling to hilly (4:1)	Open country	400–200	5–2	100–50	2
	Built-up areas	200–100	5–2	100–50	2
Hilly to (2:1)	Open country	200–100	5–2	100–50	2
Light mountainous	Built-up areas	100– 50	5–2	50–20	2
Mountainous (1:1)	Open country	100– 50	10–5	100–50	5
	Built-up areas	50– 20	5–2	50–20	2

Rolling terrain is here classified as smooth topography with prevailing slopes flatter than 8 to 1.

Hilly topography includes terrain with areas of steepest slope flatter than 4 to 1.

Light mountainous includes those areas wherein the steepest slopes are generally of 2 to 1 character or less steep.

Mountainous includes those areas of rough topography wherein the slopes are generally steeper than 2 to 1 and where 1 to 1 slopes are common.

Rugged mountainous topography would naturally require special consideration if the slopes are generally steeper than 1 to 1, thus being outside limits of contour intervals shown.

Preliminary location plans—Larger scale and smaller contour interval shown above should be used so that the contour interval of preliminary plans is the same as that shown for final plans in the last column at the right. For example, a 200-scale map with 2-foot contours used as a preliminary plan may be enlarged to 50-scale with same contour interval for use in final plans.

[a] In flat, unwooded country, plane-table topographic surveys for precision in elevation control can be made at a low cost in a minimum of time. There is some question as to the advantages of aerial photogrammetric surveys over ground survey methods under such favorable conditions. On the other extreme may be found most complicated highway situations in built-up areas of rough topography in cities like Pittsburgh or San Francisco.

dences of erosion and geological formations readily seen in paired photographs under the stereoscope. (Reference No. 5, p. 590.)

Bad drainage conditions and various control points to be followed in location may be recognized.

Bridge sites and approaches can be selected and preliminary grading studies made, permitting comparative cost estimates. (Reference No. 4, p. 4.)

Possible sources of stone, gravel, and other local materials needed for construction can be located. (Reference No. 5, p. 594.)

Sites suitable for wayside development and for safety and scenic turnouts and other driver service areas can be selected for design and acquisition before construction begins.

Some twenty years ago small-scale photographs and aerial mosaic maps were being used in general planning of highway location and design on parkway and other high-type highway construction in eastern metropolitan areas. A number of aerial survey companies are now available who will take contracts for the development of large-scale photogrammetric maps of highway routes at costs which are usually less than those for an equivalent topographic map by ground survey, and in a fraction of the time required for ground survey mapping. By the end of the war we shall have still better equipment for aerial mapping and map-making and trained personnel to use it in designing and developing better highways and roadsides.

REFERENCES

(1) U. S. War Department, Technical Manual 5-240, Aerial photography print off., 1944. 111 p. (Technical manual 5-240). A complete concise manual covering the principles, methods, materials, and equipment used in making aerial photographs, establishing ground controls, projecting maps by radial plotting methods, and in making aerial mosaics and photogrammetric maps by tri-metrogon and multiplex systems. A glossary and list of references concerning aerial photogrammetry is given in the appendix. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C.

(2) Junior, F. E., "Post-War Highways and Photogrammetry," *American Highways* 23 (3) July 1944, p 3-6, 114. A general outline of the subject with excellent illustrations showing, a typical aerial mosaic and photographic index, a property map compiled on an aerial mosaic, a mosaic on which drainage areas are outlined for culvert design purposes.

(3) Ask, Raymond E., "Fundamentals of Photogrammetric Engineering," *Engineering News-Record* 133 (24, 25) November 30, 1944, p. 694-699; December 14, 1944, p. 748-753. Part 1—Aerial photographs and their use in planimetric mapping. Part 2—Aerial photographs in topographic and military mapping. Part 2 is of special interest—describes main details of, and principles on which use is based of various types of photogrammetric equipment.

(4) Simonson, Wilbur H., Part 1. "Aerial Photographic Surveys for Better Highways, *American Highways* 23 (4) October 1944, p. 3-4, 17. Outline of how aerial surveying has been developed for highway development, and how by aerial methods combined with ground survey and controls, essential topographic and design information may be obtained. Part II. Aerial mosaics and photogrammetric maps in highway location and design. Appears in the April 1945 issue.

(5) Belcher, Donald J., The Engineering Significance of Soil Patterns," *Proceedings*, Highway Research Board, Vol. 23, p. 569 (1943). The author brings out facts that, soil patterns recorded in aerial photographs have profound engineering significance. Climatic zones, vegetation, erosion characteristics, soil color; these and other factors combine to indicate to the trained interpreter of aerial views those soil conditions that most affect the location and construction of highways and airports.

(6) American Society of Photogrammetry, "Manual of Photogrammetry," Pitman Publishing Company, New York, Chicago. A complete text covering principles, methods, materials, equipment and practice used in obtaining and developing aerial photographs, mosaics, and photogrammetric maps. Articles and chapters are included by the leading authorities on the various phases of photogrammetry. A complete nomenclature and glossary of terms is given together with a list of references.

(7) Kingery, Robert, "Aerial Mapping Used in Regional Highway Planning," *Proceedings* Highway Research Board, Vol. 23, p. 555 (1943). The relatively large scale

of air maps and the breadth of the band covered by them give the highway engineer full information concerning the character of the neighborhoods being traversed. Air photographs (and mosaics) have proved an invaluable method of making reconnaissance surveys in urban areas within the Chicago region.

(8) "New Role of Aerial Photography," *Civil Engineering*, May 1945; Outlines combination of aerial and ground surveys for post-war highway plans.

PROGRESS REPORT, COMMITTEE ON DURABILITY OF CONCRETE

M. O. WITHEY, *Chairman*

F. B. HORNIBROOK
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SYNOPSIS

A reasonably rapid method for ascertaining the resistance of concrete to freezing and thawing has long been desired by materials testing engineers, but to date such procedures as have been stipulated in specifications have failed to obtain a large following. Since the previous Committee on Durability of Concrete as Affected by the Cement has made some tests in which the effects of different rates of freezing on resistance of mortars to freezing and thawing had been observed, it seemed desirable to study further this important subject.

The program of tests involved: (1) a comparison of the relative severity of a carefully specified coordinating freezing and thawing test as practiced in different laboratories, (2) a comparison of the effects of the freezing and thawing procedures commonly used in these laboratories (local procedures), (3) a comparison of the severity of the coordinating test procedure with the local laboratory procedures.

Tests were made in seven laboratories, and this report describes the testing procedures, discusses the results and arrives at a number of conclusions, among which are: The electronic vibrating devices used provided a convenient and rapid means of determining the change in the dynamic modulus of elasticity of the specimens tested; in these tests the average relation to the percentage decrease in modulus of rupture (R) to the percentage decrease in the dynamic modulus of elasticity (E) due to freezing and thawing was $R = 1.5E$; for the types of concrete tested the relation between the reductions in flexural strength and in dynamic modulus of elasticity was sufficiently reliable to measure the rate of deterioration of the flexural strength under the methods of freezing and thawing used; flexural strength is much more sensitive to the deteriorating effects of freezing and thawing than is the compressive strength; the relation of the reduction in the compressive strength to the reduction in the dynamic modulus of elasticity due to freezing and thawing was so variable in the tests conducted that the reduction in the dynamic modulus could not be used as a measure of the reduction in compressive strength; loss in weight does not provide a criterion of the early deterioration in flexural strength due to freezing and thawing; although there are exceptions, comparison of the load test procedures indicates that in general those procedures in which the rates of freezing from 32° to 15° F. were fast caused failure more quickly than those in which the rates were slow; those local test procedures having fastest rates of freezing and producing quickest failures did not discriminate clearly between the concretes made of satisfactory and those