COUNTRY ROADS BOARD
VICTORIA

LECTURES IN HIGHWAY ENGINEERING

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FOREWORD BY THE CHAIRMAN OF THE BOARD.

D. V. DARWIN, M.M., M.C.E., M.I.C.E., M.I.E.(Aust.), C.E., F.A.P.I.

Within those large sections of Civil Engineering dealing with transportation and structures the place and importance of roads has greatly increased in the first half of the present century. It is proper, therefore, that the Country Roads Board, the central road authority of the State, from its inception in 1913 should have assisted educational Institutions in Victoria in presentation of the knowledge of the art and science of road engineering.

At Melbourne University from 1914 to 1920 lectures were given in the fourth year of the civil engineering course by the first Chairman of the Board (Mr. W. Calder, M.I.C.E., M.I.E.(Aust.)) or the engineering member (Mr. W. T. B. McCormack, M.I.C.E., M.I.E.(Aust.)) or by the first Chief Engineer, Mr. A. E. Callaway, C.E., who became part-time lecturer in 1921. This lectureship has since been held continuously by engineering members and chief engineers of the Board. Other engineering officers have similarly assisted in the diploma courses of the Technical Colleges. More recently it has become necessary to extend considerably the treatment of the subject at Melbourne University and to draw upon the specialized knowledge of additional senior engineers to assist in the preparation and delivery of lectures.

Lecture notes cannot completely cover every aspect of a complex subject, but furnish at least an essential outline. Besides the traditional subject-matter dealing with the art of construction and maintenance, Highway Engineering to-day depends increasingly on a careful scientific analysis of both material and human factors. The community has come to depend more and more upon road transportation, so that in recent years "Traffic Engineering" has merged, a section of the subject applying scientific methods to the study of road usage. This has given dynamic emphasis to the conception of the duties and responsibilities of the highway engineer. However, of no less importance are the other applications of science, e.g. to surveys, plans and construction processes, to development of machines, and to the many materials of construction, including the soils of foundations and earthworks so fundamentally important in road behaviour. Again, in exercising his skill, economy is ever in the mind of the engineer and year by year fresh advances are being made in discovering and assessing what are necessary and sufficient standards for economical road design and performance.

Those preparing the notes have special knowledge of the most recent techniques. They have also inevitably drawn upon the work of previous lecturers and upon their own and other contributions contained in the volume issued by the Board in 1947, entitled "Road Construction and Maintenance". For that volume and for these lectures the co-ordination of the treatment has been in the hands of the present Deputy Chairman, Mr. C. G. Roberts, M.C., B.Sc. (Eng.), M.I.E.(Aust.), A.M.I.C.E.

The formulation of policies in road and bridge administration, including technical matters, frequently involves adjustment of details to suit particular circumstances. In publishing the present volume, the Board as a body is not responsible for statements made or opinions expressed, which must always be considered in their context and could naturally bear much more detailed consideration. The notes should, however, provide assistance, not only to engineering students in the course of training, but also to practising engineers whose work from day to day always provides a profitable field for continued study and investigation. The courtesy of the Faculty of Engineering in allowing publication of the lectures by the Board is gratefully acknowledged.

SUBJECT INDEX.

LECTURE 1.

PLACE OF ROADS IN THE COMMUNITY AND ROAD PLANNING.

C. G. ROBERTS, M.C., B.Sc.(Eng.), A.M.I.C.E., M.I.E.(Aust.).

1. General Considerations.

Fundamentally, the object of a road is to connect two fixed points in the best possible manner, having regard to the interests to be served and traffic considerations involved. Whatever the ultimate nature of the road pavement, the location, and particularly that of bridges, is a feature which has a lasting influence on the usefulness and safety of the road. The choice of a suitable route is, therefore, a matter of great importance, and much care and thought should be given to it.

A clear idea of the ultimate purpose of the road must be obtained. It may be—

(i) A road destined only to bring settlement in contact with a market or railway town.

(ii) A trunk road joining important towns, generally serving settlement as well.

(iii) Portion of an existing or future main arterial road.

In the first case, it is essential to give reasonable service to individual members of the settlement, without great regard to directness or alignment generally.

In the second, economy of distance and higher standard of alignment must be given more weight while serving the needs of the rural community adjacent to the road.

In the third case, the general economy demands directness and high standards of alignment, and grade to allow fast, safe travel, with spur roads, if necessary, to serve settlement or small towns.

There is, of course, no clear cut division into these three general groups. Cost is a vital consideration.

Factors to be considered when deciding on the standards of a road include:—

(1) Settlement. (Local roads.)

(2) Local commerce. (Regional, or sub-arterial roads.)

(3) Arterial commerce.

(4) Segregation of motor traffic.

(5) Tourists.

(6) Forestry.

(7) Streets.

(8) Defence needs. (Strategic, tactical, encampments.)

(9) Special industrial developments.

LECTURE 2.

ESTIMATION OF TRAFFIC.

H. P. GEORGE, A.M.I.E.(Aust.), C.E., F.A.P.I., C.H.T.(Yale), A.M.I.T.(London).

1. The Need for Traffic Estimation.

The highway planner is conscious of the importance of the traffic service function of a road network or of a traffic facility such as a bridge, tunnel or a particular section of a road.

He is required to estimate the demand for traffic service and this, when established, is translated into a location and design that aims to provide the maximum benefits to the most people, fitting the new facility effectively and pleasingly to the topography, land development and to the highway system.

Planning and design looks to the future and it is therefore necessary to predict. Formerly, forecasting traffic flows and traffic demands, was stigmatized as an unavoidable and somewhat haphazard task, but now it has become an accepted routine planning function and a pre-requisite to sound design, both geometrically and structurally. A good deal of research is being conducted in the U.S.A. on the analytic side of traffic estimation relative to the many factors affecting traffic movement such as—

trip purpose and trip length;
opportunity;
freedom of movement;
traffic generators;
economic level of vehicle ownership.

At the present time in Australia traffic forecasting for specific highway projects is virtually limited to the projection of hindsight into the future. This is a mechanical rather than an analytical approach.

In addition to the projection of past trends, the traffic planner must recognize and appreciate the shape of things to come including development in all its varied forms in urban and rural areas and probable trends in technologies likely to affect road transportation.

2. Methods of Traffic Estimation.

The several methods of traffic estimation which have been developed fall into two basic classes—mechanical and analytical.

The mechanical procedures project forward the composite past trends assuming that future experience is directly related to or is a simple function of past experience.

Analytical techniques of traffic estimation classify and analyse the related factors that have formed the trend patterns and take into consideration traffic generators and other anticipated traffic stimuli which are expected to become significant in the future.

For the Princes Highway at Oakleigh, the 30th highest hour is about 12.5 per cent. of the annual average daily traffic, or about 16 per cent. of the average 12 hour week day count.

3. Speed Studies.

Speed studies are carried out for the following reasons:—

(*a*) To determine the magnitude, range and distribution of speeds under the prevailing conditions of the roadway and operative regulations.

(*b*) To correlate speed and accidents.

(*c*) As a guide to the use of traffic control devices (signs, signals and pavement markings).

(*d*) To measure the effect of speed control measures and to determine the need for such measures.

Methods used.

(*a*) *Enoscope.*—An "L" shaped box (mounted on a tripod) with a mirror set at 45 degrees to the open ends. Passage of a vehicle is registered by a flash. Time of passage between two boxes is measured with a stop watch.

(*b*) *Pressure Contact Device.*—Two rubber tubes placed across the road. They are connected by an air switch to an electrically operated timing device.

(*c*) *Radar Meter* (*Micro-wave Speed Detector*).—A portable device which operates on the principle that the difference in frequencies of an incident radio wave and the wave reflected from a moving object is proportional to the speed of the object.

Presentation of Results.

The information is usually presented graphically as a speed distribution curve or as a cumulative frequency distribution curve. The distributions are usually essentially "Normal" or Gaussian.

Measures most commonly used are:—

Average speed (arithmetic mean)
98 percentile speed.
85 percentile speed.

Pace (The speed range which contains the greatest number of vehicles for some arbitrary increment—usually 10 m.p.h.)

4. Speed and Delay Studies.

These studies are carried out to determine the amount, causes, location, duration and frequency of traffic delays as well as the running speed between specified points on a route.

Delay studies are also conducted at intersections to determine the nature and extent of delays due to treatment and the efficiency or otherwise of traffic control devices and channelization. Before and after studies are useful in determining the benefits accruing from remedial action.

LECTURE 4.

GEOMETRIC DESIGN OF ROADS.

G. J. DEMPSTER, A.M.I.E.(Aust.), C.E., M.A.P.I.

References.

(*a*) A Policy on Geometric Design of Rural Highways. (American Association of State Highway Officials 1954.)

(*b*) Policy for Geometric Design of Rural Roads. (Conference of State Road Authorities of Australia 1955.)

1. Geometry of Road Design.

The geometry of road design is the combination of all elements which form the road layout and dimensions, i.e., alignment, both horizontal and vertical, widths of pavement and formation, crossfall, sight distance, clearance at structures, and the layout of intersections.

(*a*) *Three major requirements to be met are*—

Safety,
Efficiency and convenience,
Over-all economy.

The general basis of good geometric design is to know the conditions under which traffic must operate, and the needs of traffic to satisfy the above requirements.

Since topography, and land use have a pronounced effect on highway location and geometry and the determination of the type of highway, information regarding these factors should be obtained in the early stages of planning and design. This information together with traffic and vehicle data form the major controls for the geometric design of roads.

The general factors which form the theoretical and mathematical basis for a design standard are fundamentally:—

Traffic volume.
Nature or type of traffic.
Speed of traffic.

(i) *Traffic Volume* is the number of vehicles passing a given point on a road in a given period of time. This factor, together with the average speed of travel of the vehicles determines the number of traffic lanes required.

The period of time used in analysing traffic volume varies according to the nature of the road. For most Australian rural highways, use of the average daily traffic (A.D.T.) is of sufficient accuracy for design purposes. In U.S.A., the A.A.S.H.O. policy indicates that A.D.T. is used only for relatively low volume highways.

On heavily trafficked American highways, the 30th highest hourly volume (30 H.V.) is generally used as the design hourly volume (D.H.V.). On tourist highways with highly seasonal traffic, the 80th to 100th highest hourly volume might be applicable.

See "Policy for geom. design of roads" gives a table of volume & widths. Width of road will increase when visibility decreases or prevailing conditions are usually bad. Can have 16' roads (before trucks were common). Min for 2-lane = 18'0". (100-200 vehicles/day, speeds up to 50mph).

LECTURE 7.

IMPROVEMENT OF EXISTING FACILITIES TO OBTAIN MAXIMUM USE.

H. P. GEORGE, A.M.I.E.(Aust.), C.E., F.A.P.I., C.H.T.(Yale), A.M.I.T.(London).

Traffic Inefficiencies.

An important task of a road authority is to achieve the maximum traffic service out of existing facilities by—

(*a*) increasing the traffic capacity and so reducing congestion, delay, discomfort and inconvenience;

(*b*) improving the quality of traffic flow and removing hazardous elements.

Many of the methods used come within the domain of the traffic engineer.

Typical Physical Improvements.

(*a*) *Climbing Lanes.*—It is often found that the presence of steep grades on roads carrying a significant proportion of heavy vehicles materially reduces the capacity of sections of the road. Heavy vehicles are slowed down to crawl speeds which in addition to affecting the capacity creates conditions where drivers of passenger cars and other light vehicles are tempted to undertake dangerous overtaking manœuvres, even though the road may be regulated as a "no-passing" zone by pavement striping with double lines. The provision of climbing lanes removes the heavy vehicle from the path of the faster vehicles, restores capacity and makes for safer operation.

(*b*) *Pavement Widening.*—For optimum traffic capacity the width of traffic lanes should be 12 feet. As the traffic volume increases additional capacity becomes necessary and this can be obtained by suitably widening narrow two-lane carriageways. For example the practical capacity of an 18-ft. two-way pavement can be increased by as much as 40 per cent. by widening to 24 feet, providing the proportions of heavy vehicles is low. With increasing percentages of heavy vehicles, the increase in capacity by widening is diminished.

(*c*) *Improvement of Visibility.*—Poor visibility severely reduces the capacity of two and three-lane carriageways as well as being a traffic hazard. It is to be noted that sub-standard visibility for a three-lane pavement can have the effect of reducing the road to a two-lane facility. Improvement of both horizontal and vertical visibility restores capacity and minimizes the hazardous element associated with two-way three-lane roads.

(*d*) *Intersection Treatments at Grade.*—Intersections at grade, particularly in urban areas, are the cause of congestion, delay and hazard and reduce the capacity of the road. Improvements at grade fall in the following classes:—

(*a*) Signalization.

(*b*) Flaring to provide additional carriageway.

(*c*) Channelization.

(*d*) Rotary or roundabout treatment.

LECTURE No. 14.

BITUMINOUS SURFACE TREATMENT.

MIXED WORK.

J. MATHIESON, M.C.E., M.I.E.(Aust.).

Read this chapter.

1. General Description.

The previous lecture described the materials used in bituminous surface treatment work, and dealt in some detail with sprayed work in which the binder is distributed uniformly over the road surface and subsequently the aggregate is incorporated into this by rolling and/or traffic. In general the operation is relatively rapid. One spraying unit can average about 1½ miles per day.

The subject of this lecture is "mixed" work in which the binder is mixed with the aggregate in relatively small quantities and these batches are spread on the road surface by some form of mechanical spreader. In certain cases, the spreading may be carried out by hand, but apart from patching, this is a very unsatisfactory procedure, because quite apart from cost, it is very difficult to get a true surface. Practically all work of this nature is done by mechanical spreaders of one type or another.

This is one real difference between the two types of work. Surfacing carried out with mixed material is or should be appreciably truer than the old surface, while the shape of a new sprayed surface is substantially the same as the old one.

2. Types.

There are two main types of mixed material:—

(*a*) Hot mix, in which the aggregate is dry and hot and the binder is hot. The binder is usually straight bitumen.

(*b*) Cold mix, in which the aggregate is cold and preferably dry and the binder hot. The binder is usually medium curing cutback.

Both of these may be divided into five general kinds classified in accordance with the grading of the aggregate, namely:—

(i) Macadam,

(ii) Graded,

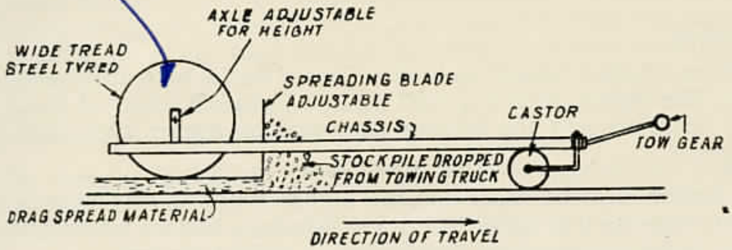
(iii) Close graded,

(iv) Open or gap graded,

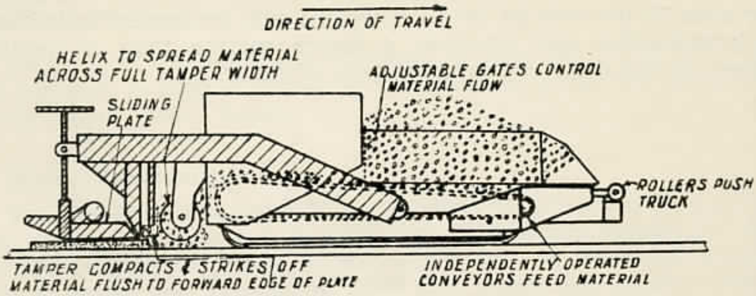
(v) Dense graded.

Premixed macadam may be said to be the lowest type of mixed work. Coarse material is employed and mechanical interlock is relied upon for stability. The surface area to be coated per unit volume of aggregate is low and consequently the quantity of binder required

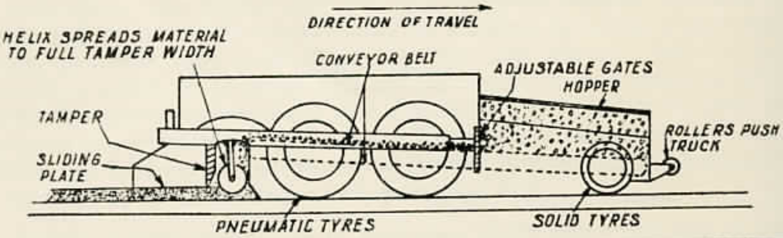
DRAG SPREADER



BARBER–GREENE SPREADER



BLAW KNOX SPREADER



3 AXLE ROLLER

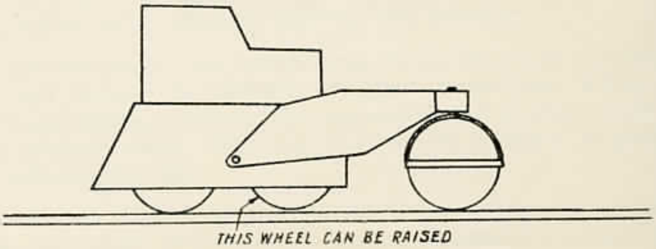


Fig. 14·1.