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Madras Highways

Jan 1956

MADRAS HIGHWAYS

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MADRAS STATE HIGHWAY ENGINEERS

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MADRAS HIGHWAYS

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SRI SHANMUGA RAJESHWARA SETHUPATHI
Raja of Ramnad,
Minister for Public Works, Madras.

Messages

R. Shanmuga Rajeswara Sethupathi
Minister for Public Works

FORT ST. GEORGE
MADRAS
22nd Novr. '55.

Today we are quite conscious of the importance of roads and road transport as never before. Appropriately the Second National Five Year Plan has included a large programme of road developments; and to implement this, all the available resources and technic must be brought to play. It is gratifying to note that the Association of Madras State Highway Engineers, with this object, is bringing out "Madras Highways," a quarterly dealing with the developments in Highway Engineering. I wish the journal every success and trust that the "Madras Highways" will help considerably in fostering the increased highway activity in the State.

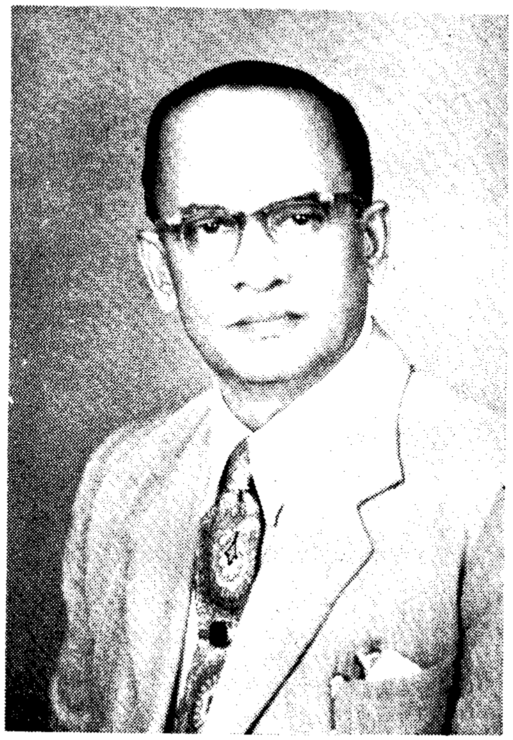
(Sd.) ***R. S. Rajeswara Sethupathi.***

I congratulate the Association of the Madras State Highway Engineers in bringing out the inaugural number of the 'MADRAS HIGHWAYS.'

It is a matter of gratification that the Association has undertaken this task of publishing important matters relating to their work. Such a journal is a real necessity. It not only helps in the exchange of ideas between technical men, but brings in appreciation from the layman. Civilisation has always advanced wherever there were transport facilities, either by road or by river. Farsighted statesmen of ancient India had always laid the greatest emphasis on the importance of road-making to further the prosperity of the country. The word 'road-making' to-day probably does not convey to the poor man that it is for his benefit. Road-making does not consist of only of cement, black-topping or of importing expensive foreign machinery. It embraces also road-making in the villages with the resources available to the villagers. Research is certainly necessary in the matter of providing the rural areas with cheap roads which involve the use of local material, man power and resources.

I am sure that the journal 'Madras Highways' will serve a usefull purpose and I send my very best wishes for its success.

(Sd.) **R. M. Sundaram,** I.C.S.



SRI K. K. NAMBIAR,
B. E., M. I. E. (Ind.), F. Inst. H. E. (Eng.), M. I. Mun. E. (Eng.), M. Am. Soc. C. E.,
Chief Engineer (Highways) Madras.

The Science of Highway Engineering has undergone extraordinary developments all over the world since the dawn of this Century when the Internal Combustion Engine came to be harnessed for road transport. The developments have been particularly spectacular during the past two decades. New techniques like soil stabilisation, prestressing of concrete etc., have brought about revolutionary changes in Highway Engineering practice.

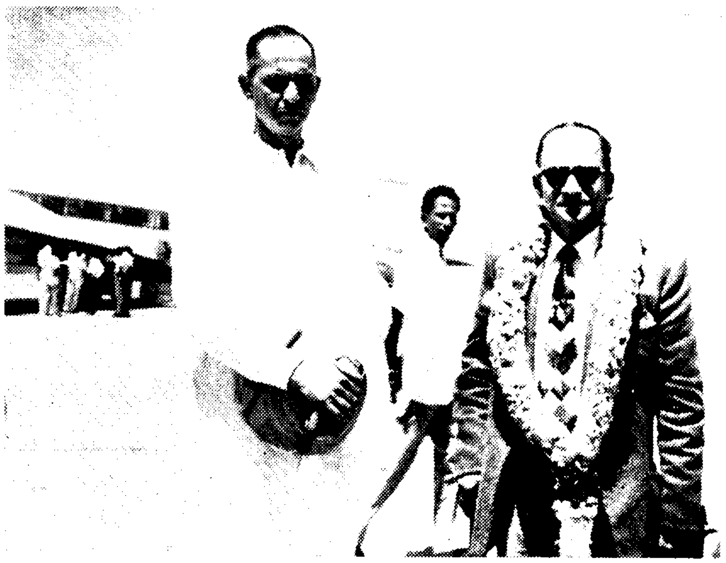
There are, no doubt, several publications already dealing with the latest developments in Highway Engineering setting forth research notes and technical papers on works projected and executed, and so on. It may be argued whether it is necessary to add to their number by publishing this journal of the Association of Madras State Highway Engineers. The reply to such criticism is this.

There always arises something new in practice which one does not anticipate in a purely theoretical study of the subject. One cannot be a successful Engineer if he allows himself to be surprised by one of these unexpected snags that might confront him in the process of execution. It is in such contexts, that a journal of this nature which is intended to pool the experience of several Engineers of this State and disseminate information on practical aspects of the construction and maintenance of roads and bridges will be found most useful. The fundamental relationship between theory and practice can only be secured by exchange of information through the medium of such journals.

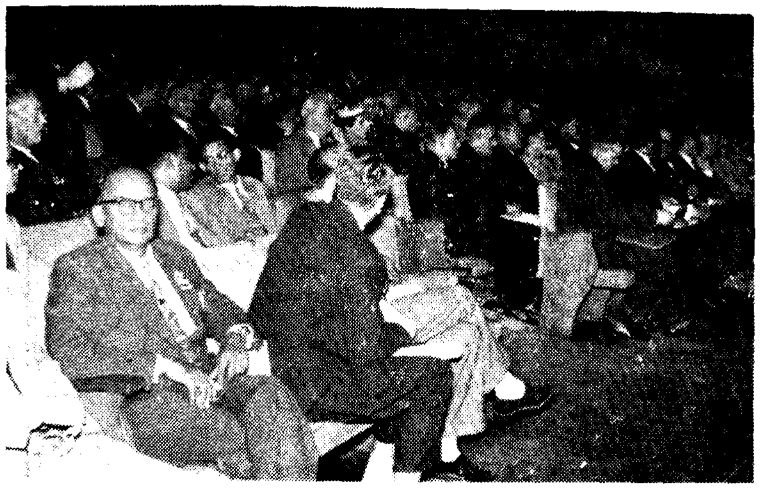
I have no doubt that "The Madras Highways" will be fully patronised by the members of the Highway Engineering profession by sending valuable contributions setting forth their experience and will thus reflect the best current thought and practice in the Science of Highway Engineering leading ultimately to the cherished objective of the general advancement of the road system in the State.

21-11-'55

(*Sd.*) ***K. K. Nambiar,***
CHIEF ENGINEER (HIGHWAYS).



Reception at Meenambakkam airport on return of
Sri K. K. NAMBIAR from Istanbul.



A view of the concluding session of the Congress.

Ceremonial procession of the Guards at the opening of the International Road Congress at Istanbul.

Ourselves

It is nearly ten years since the Madras Government formed a Highway Department using for that purpose a body of men who for nearly sixty years before that had been primarily working on roads and bridges. This gave statutory recognition to the fact that work on the Highways was a wholetime job requiring its own special skills and experience.

Last year this body of men got together and have formed the Association of Madras State Highway Engineers. This year they are bringing out this Journal to serve as a common pool of experience.

Our work is normally measured in terms of expenditure. Starting with Rs. 316 Lakhs in 1946-47 it had risen to 987 Lakhs in 1952-53 i.e., more than trebled in 7 years. It consists of every type of work on roads and bridges; ranging from cement concrete pavements to simple earthern village roads and mighty structures with a hundred & fifty feet spans designed on the latest lines and built of prestressed concrete to simple foot bridges.

Work on this scale and of this variety necessarily involves a large variety of experience and problems at all levels of design and execution and it is our hope to put all such experience on record in this journal so that each may benefit by the experience of every other.

Acknowledgments: The need for such an exchange of experience has been recognized not only by us but also by them, who have the direction of our work as their responsibility. Sri Shanmuga Rajeshwara Sethupathi, Hon. Minister for Public Works, Madras, Sri R. M. Sundaran, Secretary, Public Works Department and our Chief Sri K. K. Nambiar have sent us kind

messages of encouragement and good wishes for which we are grateful indeed.

Events: Two events of great significance have occured recently. One is the International Road Congress Meeting at Istanbul in October last at which our country was represented by Sri H. P. Mathrani, Consulting Engineer for Roads, Government of India and our Chief Engineer Sri K. K. Nambiar. We hope that the deliberation of the leaders of our profession all over this world will give useful pointers to hand our work can become more widely useful to our people. We wish to greet also the Indian Road Congress now meeting at Nagpur and look forward to receiving guidance and information from their deliberations. That this session is presided over by Sri K. K. Nambiar our Chief Engineer is a proud distinction which we would share without sacrificing modesty.

The other event we refer to is the cyclone disorder in the Southern part of this State. The calamity caused by this unprecedented cyclone is of vast proportion. A part of the work of rehabilitation will necessarily fall on our members. We wish to convey our sincere sympathy to all who have suffered and to wish good-speed to their working on the restoration of their area to normalcy. We expect to give in a subsequent number some details of the work done by our department in this great task.

We hope that we will be able to fulfil the modest role we have set ourselves and serve to bring together the large and varied experience of all our members and others working in this field.

H. P. MATHRANI & K. K. NAMBIAR

at the Pyramids in Egypt, enroute to Istanbul to attend the International Road Congress

A Talk on the Tenth International Road Congress at Istanbul

Sri K. K. Nambiar

I must at the outset make it clear that it was not with the idea of explaining to you the details of all the technical subjects discussed at the Conference that I have ventured to speak to you this evening, nor will it be possible for me to bring within the compass of a talk like this, even a fraction of all the technical problems discussed at a Conference extending over several days at which delegates from all parts of the world discussed their respective problems regarding the latest trends in construction and maintenance of roads. All that I hoped to do was, to give you an idea as to what this International Road Congress is, its constitution, managements and a general picture of the Conference, the problems discussed therein and the nature of conclusions arrived at, without going into any intricate technical details. You might also be interested to hear something about the venue of the Congress viz. Istanbul, the arrangements made for the deliberations of the Congress, the excursions arranged for the benefit of the delegates as also some idea about the road problems of the country itself, where the Congress happened to be held.

The International Road Congress, as the name implies is an assembly of people engaged in the construction, maintenance and administration of roads in all the countries of the world. The birth place of this Congress was Paris which is the Headquarters of the Permanent International Association of road Congress. The first Congress was held in Paris in 1908. At that time, Paris was rightly chosen as the centre for inauguration of this Association, as the road system in France was comparatively, more developed than all the other countries in the world. Since then, several sessions of the Congress had been held in other countries of Europe, once every 4 years. This is the Tenth Session of the International Road Congress and it is the first time it is being held in a comparatively undeveloped country viz. Turkey. Since the inception of the Congress at

Paris in 1908, many other countries have made remarkable and striking advances in the development of their Highways. The Autobahns of Germany and the Inter-regional Highways of U. S. A. are all later developments. There have been revolutionary changes in the methods of construction and maintenance of roads with the introduction of new materials, plant and machinery in the field of Highway Engineering enabling rapid and economic execution of road works.

Turkey was chosen as the venue of the Tenth Congress, not because that country could claim any leadership in the matter of road development; nor is it a place where Engineers from all parts of the world could see the latest developments in materials and technique of road construction and maintenance. But the authorities must have thought it necessary to hold such Congresses in under-developed countries also, so that their problems could be spotlighted at the Congress and a fillip given to road development in such under-developed countries also, so that they may catch up with other advanced countries in the matter of improving their road systems. It is also to be stated that in recent years Turkey has made some progress and is now geared up to go on with large scale development works to improve the road system of the country.

Since 1948, some progress has been made in Turkey in the matter of road construction and improvement, largely due to the arrangement made between Turkish Ministry for Public Works and the American Mission for Aid to Turkey. A team of Highway Engineers from United States Bureau of Public Roads has been co-operating with the Turkish road Engineers in this matter. The General Directorate of Highways, a semi-autonomous organisation was set up under the Ministry of Public Works on the pattern of the American Highway Administration. The present General Director of Turkish Highways, Mr. Danis Koper was the President of the Turkish Organising Committee of this Roads Congress. Under the Director General, there are 3 departments viz. (i) for technical and economic research, (ii) for construction and maintenance and (iii) for administrative affairs. These departments are again sub-divided into several divisions. The department of

technical and economic research has divisions dealing with (a) planning and programming, (b) design and plan, (c) traffic and operations, (d) laboratory and research and (e) bridge design. Similarly, the Department of construction and maintenance has divisions dealing with (a) road construction, (b) bridge construction, (c) maintenance and (d) equipment. The Directorate has its Head-quarters in Ankara with 11 field divisions, each division covering several provinces of the country. These divisions execute Highway works, partly on contract and partly by direct labour, using departmental plant and machinery.

As referred to earlier, this re-organisation of Turkish road activities has been brought about mainly by American Aid. Their chief problem was to find the required technical personnel for carrying out the improvement to the Highways. This has been successfully tackled by a series of training courses held in Turkey for training Engineers to hold various positions in the new administrative set up and by giving refresher courses to the existing members of the staff in the matter of new methods and techniques adopted in America. This training course became so successful and popular that the United Nations Organisation decided to open a Highway Engineering Centre in Ankara last year, under the auspices of the General Directorate of Highways, Turkey. Some of you might remember that Madras Government got an enquiry from the United Nations Organisation, whether we would like Engineers from this country to be sent to Ankara to receive training at this refresher course. Madras did not think it necessary to avail of this opportunity of receiving training at Ankara. A second training course has also been started this year, at which 25 Engineers from 9 countries in Asia and elsewhere are receiving training.

Now, coming to the arrangements of the Session itself, I must state, that the Turkish Government spared no pains to make this Conference a grand success. Istanbul, the old capital of Turkey, a very picturesque city on the Bhosphorus, was eminently fitted to be the venue of this grand Session. About a thousand delegates, ladies and gentlemen from all parts of the world took part in this Session. You can visualise the tremendous effort and organisation necessary to receive and accommodate this vast number of delegates from various climes and countries, speaking different languages, to arrange for their transport not only to the numerous committees and conferences during the Session, but also during the inspection and excursion trips. The whole thing was worked out to the minutest detail, so that the Conference and other fixtures during the Congress could go on without a hitch or delay. The Session itself was held at the Yildiz Palace, which was once upon a time the residence of the Turkish Emperor. Situated on top of a hillock, overlooking a large garden resorted to only by the Turkish Royalties in early days, this beautiful Palace offered a welcome setting for the deliberations of the Congress. The formal opening Session of the Congress was held at the Dolmabahce Palace, another magnificent building situated on the banks of the Bhosphorus. The majority of the delegates were accommodated in First Class hotels in Istanbul, the spill-over being housed in cabins of two steamers berthed nearby. The top-ranking among the Hotels is the Hilton Hotel, recently opened by Mr. Conrad Hilton, the multimillionaire who owns the famous chain of hotels of Waldorf Astoria and Statler fame. You should have read a short description of this hotel and its opening function held in last June in the latest issue of "The Readers' Digest".

You might like to know the arrangements made for translation of the proceedings of the Congress as delegates from various countries not conversant with the Turkish languages, would find it difficult to follow the proceedings if they were conducted only in Turkish language. The proceedings were arranged to be simultaneously translated in three languages viz. English, French and Turkish. About a thousand earphone receiver sets were made use of on the occasion. The set consists of a pair of earphones which could be worn around the head attached to a small receiver set about the size of an ordinary spectacle case, which could be clipped on to the coat pocket of the delegate. The set has a switch which could be adjusted to three points corresponding to the languages, English, French and Turkish respectively. All that one needed to do was to take hold of a set, put it inside the pocket or clip it outside and then to put the earphone around the head after switching on the language desired on the set. This was a very convenient arrangement and members could move about from place to place and follow the proceedings in the language of their choice. You know that similar arrangements are made for translation at other International Conferences and at the meetings of the United Nations, where people speaking different languages participate. I had myself occasion to visit the United Nations at Lake Success in New York in the year 1946 as the guest of Sri K. P. S. Menon. The arrangements adopted there at that time were somewhat different. The members had to sit in their chairs to make use of the translator. The device adopted at the United Nations Organisation then was known as the Filene Finlay Translator, attached to the chair, where you could switch on any of the five languages marked on the translator and put on a similar earphone over the head. The device used at Istanbul has the advantage that the delegate could fasten the set on his dress and could move about from place to place as he liked without the necessity of being confined to the chair to follow the proceedings.

In between meetings of the Congress, members were taken round for seeing the sights of Istanbul. A cruise was also arranged one evening in a luxury ship S. S. Tarsus, when the delegates were delightfully entertained by Turkish folk dances and similar interesting items. There were several social functions such as banquets, receptions etc. arranged in honour of the delegates by the Mayor of Istanbul and the Minister for Public Works.

After the Congress Session, excursions were arranged to Ismir and Ankara. Delegates could chose either of these excursions. Mr. Mathrani and myself, who were the two official Indian delegates to the Congress availed of the Ankara trip. As you know, Ankara is the new capital of Turkey, which is situated about 500 kilo meters to the east of Istanbul. Ankara is on the continent of Asia, whereas Istanbul being on the opposite side of the Bhosphorus, is located in Europe. The bridging of the Bhosphorus which is about a mile wide would connect Europe with Asia by land. At Ankara, the programme included a visit to famous Ataturk's Mausoleum, and other historic parts of the city.

Coming to the deliberations of the Congress, the programme was divided into two main sections. Section (1) dealing with construction and maintenance and Section (2) dealing with roads in relation to traffic—administration and allocation of funds. I shall now briefly explain to you the working of the Congress. Under the two headings mentioned above, six questions were framed on the following subjects:—

First question:	Surfacing of roads and runways
Second question:	Soils
Third question:	Low cost roads
Fourth question:	Roads in relation to traffic
Fifth question:	Allocation of funds and economic justification of road works
Sixth question:	Urban roads and traffic in cities.

Each of these questions is further expanded. For example, the First question, "Surfacing of roads and runways," is divided into three items: (a) Concrete roads and runways, (b) Surfacings made with plastic binders and (c) Questions common to various surfacings. Similarly, the question 'Soils' is subdivided into (a) bearing capacity, (b) stabilisation of soils etc. Each of these sub-questions is again further broken down to several sub-headings. To give a particular instance, the item "Concrete roads and runways," occurring under the first question, "surfacing of roads and runways," is broken up into new methods of construction, increase in size of slabs, joints, prestressed concrete, air entrainer and plasticised concrete. Having posed these questions, headings and sub-headings under them, all the participating countries are requested to send up what are known as National Reports to the Congress. On receipt of these National Reports, general reporters are appointed for each of these questions to study and sift these reports carefully and draft conclusions on each of these questions. Several countries had sent up National Reports. All these are printed and published. Obviously it will not be possible for the delegates of the Congress to study all the reports and discuss them at the Session. Therefore, the conclusions drafted by the general reporters only are brought up for discussion at the Session of the Congress. When these conclusions are formally presented to the Congress, the delegates discussed within the brief time allowed to each speaker some of the conclusions on which they wished to comment. Afterwards, drafting panels are appointed to examine these draft conclusions in the light of the comments raised at the plenary Session, and to finalise the conclusions giving effect to the amendments considered necessary. One drafting panel is constituted for each of the six questions. Mr. Mathrani was included in the drafting panel for Soils, whereas I was made a member of the drafting panel for low cost roads, because I happened to make several comments on the draft conclusions on this subject. The conclusions as finalised by these drafting panels are again brought up before the full Session of the Congress and voted upon and adopted making only the minimum changes as found necessary.

In view of the procedure described above, you can realise that the conclusions have to be necessarily of a general nature applicable to all the participating countries and cannot take cognizance of individual problems in any country. A great deal of difficulty is also experienced in coming to unanimous decisions in view of the vast divergence of conditions prevailing in the various countries participating at this Congress.

Referring in particular to the question of low cost roads, with which I happened to be associated most during the Session of the Congress, I must say that there was a great deal of difficulty in coming to unanimous decisions regarding the geometric and structural standards of low cost roads, owing to difference of opinion regarding the scope and definition of what a low cost road is. The underdeveloped countries of Asia, Africa, South America etc. were in a large majority at this Conference and decisions being arrived at by consent of the majority do not necessarily mean that they are the most authoritative from a purely technical or factual point of view. This you will realise is an inherent handicap when technical matters are to be settled by majority votes in democratic conferences like this.

As already stated by me at the commencement of my talk, time will not permit me to go into the details of the decisions taken in the Congress or the technical problems brought out in the numerous National Reports presented by the participating countries. But you might be eager to know what exactly are the things of interest to Highway Engineers that we had occasion to see in Turkey during this Congress. I must at the outset disabuse you of any idea that the roads in Turkey are of a very much higher standard than those in India. On the contrary, our roads, speaking generally are much better than, the roads in Turkey.

Till the end of 1947, the standard of road maintenance in Turkey was indeed very low. It was only after the advent of the American Aid, that there was a countrywide awakening with regard to road developments and considerable improvements were carried out to their road system. With equipments obtained under the American Aid and with the American technical assistance, the tempo of work on road construction and maintenance has been on the increase since 1948. In the current year, the budget for road works in Turkey amounts to 362 million Turkish Liras, which is 22 times the amount they spent in 1947 for the same purpose. A Turkish Lira is valued at present, at 1·7 rupees. Turkey has to-day a road net consisting of over 28,712 kilo meters of surfaced and 22,412 kilo meters of non-surfaced roads. The programme for the current year calls for a total length of 1,300 kilo meters of blacktop surfacing. You will see that the programme for blacktopping in the whole of Turkey is far below what is being achieved in a state like Madras. It is true that they have programmed for increasing this provision for blacktopping to 1800 kilo meters in 1956, 2300 in 1957, 2350 in 1958 and so on. And yet, the tempo of work in the country is nowhere near what is being achieved in India, with our Five Year programmes. Even the main Highway from Istanbul to Ankara which is about 500 kilo meters in length has not yet been completely blacktopped. The work of re-aligning this highway adopting modern geometric standards is in full progress and as soon as upgrading of a particular stretch is completed, the surface is being blacktopped. When the main Highways are yet to be blacktopped as stated above, it is needless to say that the interior roads should be of far lower geometric and structural standards.

Yet it must be admitted that Turkey has made a sound beginning in having a properly constituted administrative set up. The Directorate of Highways with the several departments and the numerous divisions under its control, is fully organised to deal with an everincreasing tempo of Highway programme and will no doubt accomplish a great deal in the matter of road development in Turkey if sufficient funds are made available for the purpose. Madras too could take credit for having a separate Highway Department devoted solely to the task of improving the Highway net work of the State and adding to its mileage by constructing branch roads to the numerous villages wherein the bulk of its population live and work.

Effective Operation of Existing Street and Highway Systems

R. Thillaianayagam,
Assistant Engineer, Highways.

INTRODUCTION

Safe, free flowing, convenient movement of vehicles and pedestrians is the most important measure of success in all vehicle and highway development effort. Human weaknesses do not permit the realization of completely accident-proof highway transportation, but our most serious operating losses those of accidents and congestion, can be substantially reduced. The wider application of proven techniques in traffic operation and control and the adjustment of physical facilities to fit traffic requirements will do this.

Measures to promote safe and efficient traffic operation may be either restrictive or constructive. For economic and other reasons, some restrictive traffic control measures will always be required. Even when the most optimistic road construction programme materializes, however, such new construction can never be expected to solve all traffic problems. When more and better road facilities are provided, they inevitably generate or induce much new traffic. This new traffic, combined with the expected increase in traffic volumes, indicates that some new facilities, as well as existing facilities, will in most areas be loaded to volumes approaching maximum capacity.

Furthermore, new roads will serve only a very small part of the average city. Many areas will continue to depend for transportation service on existing roads. Basic city patterns usually change very slowly, and to provide proper and social adjustments slow changes are usually necessary. New facilities would not unduly accelerate this evolution.

The effective operation of existing street and highway systems is thus highly important to gain a maximum fluidity of traffic and safety. This involves utilizing to the best advantage existing streets and highways, through

I. Application of control measures.
II Judicious installation and operation of traffic control devices.
III. Localised structural changes in the streets and highways.
IV. Other factors.

I. CONTROL MEASURES

(1) Main Road

The Main Road ahead sign, (Figure 1) which may be applied to all cross streets along a designated main road, or to individual intersection gives the operator of the vehicle on the more important highway a provisional right-of-way over vehicles on the side street.

The main road rule is set forth in the Motor vehicle rule (The tenth Schedule) as follows:

The driver of a motor vehicle shall on entering a road intersection, if the road entered is a main road designated as such, give way to the vehicles proceeding along that road, and in any other case give way to all traffic approaching the intersection on his right hand.

In the practical application of this rule certain habit factors of the driving public must be recognized. The custom of yielding the right-of-way to the vehicle first in the intersection or to the vehicle on the right is definitely altered and a different set of rules is imposed. The degree of observance of the main road regulation depends upon community habit and the degree of enforcement.

Main road judiciously selected can greatly expedite the flow of traffic, becoming in fact a traffic routing system. Certain conditions, however, should govern their selection. Generally speaking, only fairly wide major arteries of considerable length, without jogs and bottlenecks, should be so designated. Care should be taken, too, in the formation of the pattern of main road for a given community so that the radial and circumferential routes are well established. Main roads should not be closely parallel to each other, since the requirement of frequent stops for cross traffic leads to irritation and disobedience on the part of the motorist. In general the designation of main roads should be limited to those conditions where the volume, speed, and continuity of traffic flow make the regulation more or less self-enforcing.

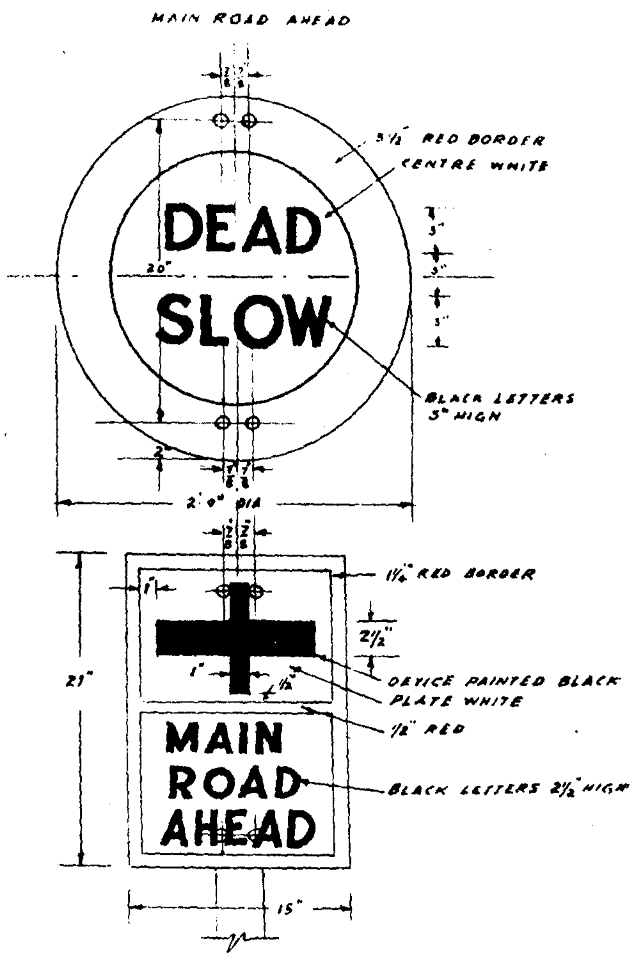


Fig. 1.

(2) Speed Control

The basic speed rule of the road in the Motor Vehicle Act (*Section* 116, Motor Vehicle Act) is that no one shall drive a motor vehicle at a speed (*or in a manner*) which is dangerous to the public, having regard to all the circumstances of the case including the nature, condition and use of the place where the vehicle is driven and the amount of traffic which actually is at the time or which might reasonably be expected to be in the place.

The basic rule imposes upon each driver the task of deciding what is the appropriate speed under all conditions, such as when he is approaching or crossing an inter-section or a railway crossing, when he is travelling on any narrow or winding road, when he is approaching and going around a curve or over a hill crest, when any special hazard exists with respect to pedestrians or other traffic in the roadway, or when there are any other unusual road or weather conditions.

It is difficult for even the most experienced motorist to determine what are appropriate speeds for all given conditions. For example, no motorist can tell the maximum safe speed of a curve until he has actually negotiated the curve.

A basic principle in efficient traffic operation is that motorist must be permitted to go to their destinations at a reasonably rapid rate consistent with safety. Speed Zoning is the establishment of safe and reasonable speed limits, based on engineering studies, for certain special zones or sections of rural highways and city streets.

Among the more common types of locations where speed zoning is generally found to be advisable are approach to inter-sections, curves, individual points of hazard and high-accident sections along rural highways, no-passing zones and entrances to municipalities from rural highways.

The computation of normal safe approach speeds at inter-sections with obstructed view across the corner is rather detailed in character and depends upon accurate engineering measurements of such factors as sight distance across the corner, radius of curvature, grades, pavement friction, and character of traffic. Where these physical conditions alone are not the sole factors, studies should be made of actual prevailing speeds. Representative speed checks (Figure 2) taken at such locations should be considered in determining the proper numerical limits for speed zones. The figure set on a section of highway should take into account the 85 percentile speed (the speed at or below which 85 per cent. of the traffic moves) since this shows what all but a few motorists consider reasonable. Too large a reduction in zoned speed below the 85 percentile speed may therefore involve enforcement difficulties. Nevertheless, where there are hidden or unrealized hazards of an exceptional nature as revealed by an accident experience study of the location it may be wise to post a zoned speed considerably lower than the 85 percentile speed.

Proper speed zoning, therefore, calls for investigation into accident occurrence, speed studies, measurement of physical conditions such as degree of curvature, super-elevation, sight distances, roadside development, etc., and evaluation of these in the light of past experience. After a new speed-zone limit has been established, studies of speed, accidents, public opinion, enforcement, speed trends, and similar matters should be made in order to evaluate the results.

A single department in the State, preferably the State Highway Department, should have authority for speed zoning on all State Highways, to assure a uniform policy and a single responsibility therefor.

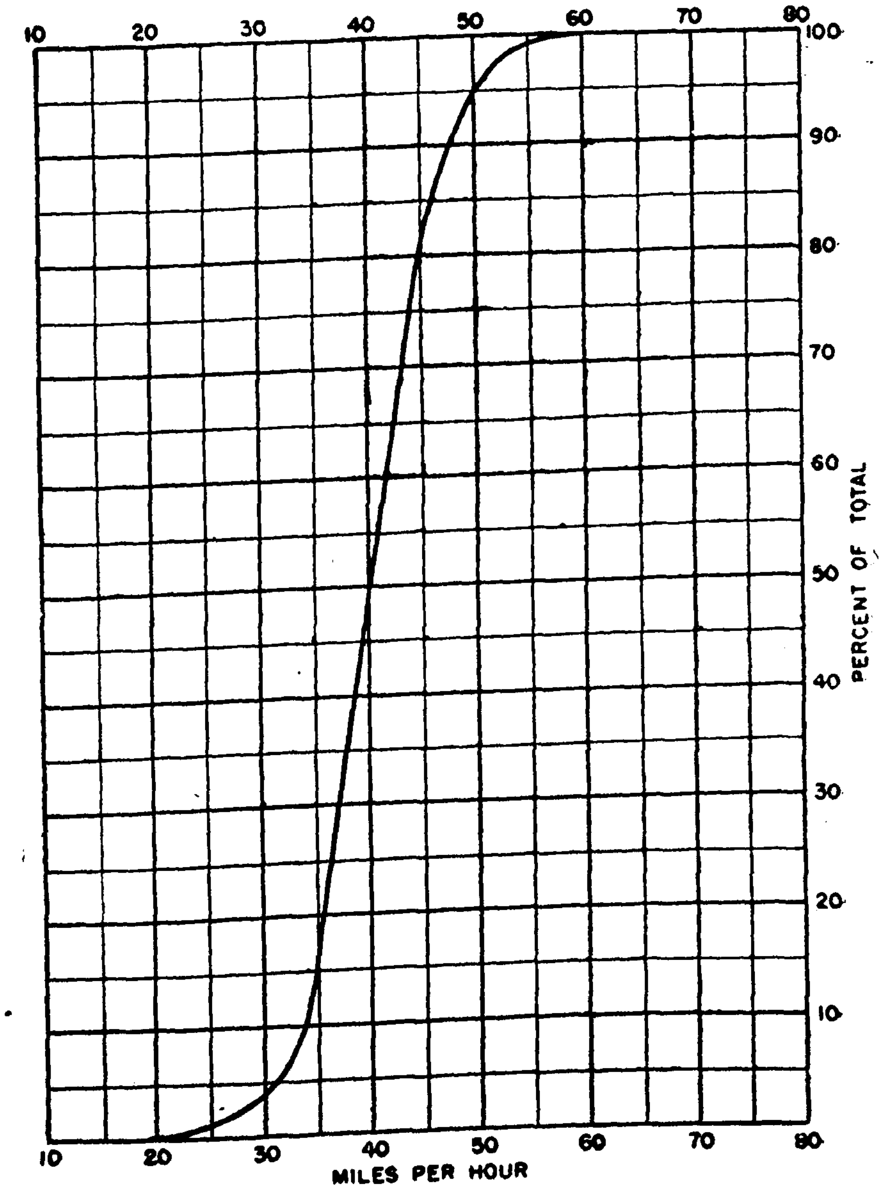
(3) Turning Regulations

If all vehicular traffic moved in straight lines, control of conflict at intersections would be comparatively simple. Turning movements, both to the left and right, are an important cause of conflict, accident, and delay at crowded intersections, right turns interfere with vehicular traffic from the opposite direction, and with the pedestrian movement. Left turn, generally speaking are much less disturbing to vehicular traffic flow, but interfere with pedestrian movement. Obviously U-turns may impede vehicular traffic in both directions. These difficulties have frequently led to enact regulations barring turns (Figure 3) over considerable distances and at many intersections.

Weather CLEAR
Surface CONCRETE
Condition CLEAR

Direction EAST-WEST

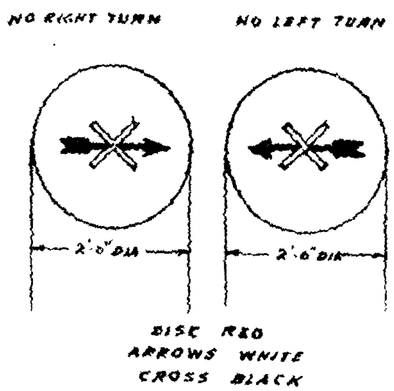
SPEED ACCUMULATION CURVE



Modal Speed 40.4 M. P. H.
85 Percentile 46 M. P. H.

Fig. 2.

Total Observations 201



PROHIBITION OF BUSES STOPPING TO SET DOWN OR TO TAKE UP PASSENGERS

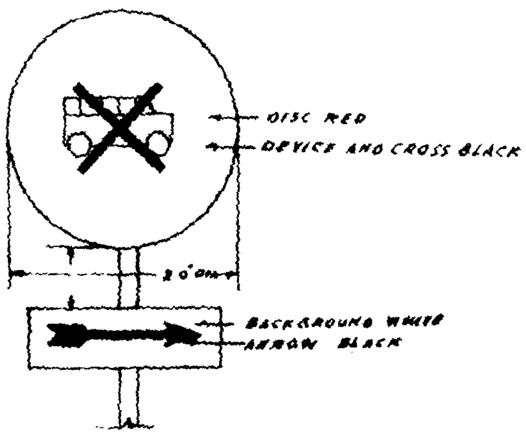


Fig. 3.

NOTE: The limits of places where stopping is prohibited can, if necessary be, shown by the use of definition plates with arrows.

Under favourable conditions, where it is possible for a driver to select his route before entering a restricted area, the relief afforded by the prohibition of turns sometimes more than compensates for the comparatively minor diversions of traffic movement thus required. Every turning movement, however, possesses a degree of utility to the driver making it, taking him presumably along his most direct route. Traffic should be permitted to flow with a minimum of unnecessary diversion, and there is a presumption, therefore, against prohibition of either left or right turns except under conditions where the requirements are very pressing and the restrictions will not result in too great diversion of flow.

Thoughtful analysis should be the basis for the prohibition of any turn. The added number of car-miles, adverse effects at other locations, and any other losses which would be induced by the prohibition should be carefully weighed against the advantages of eliminating the turning conflict and the reduction of hazard which might occur. Evaluation of these matters depends upon the number and frequency of turning movements, the number of pedestrians, the delays to flow and counterflow the routing which must be undertaken by the diverted traffic in creating additional turns at adjacent intersections, together with the ability of such adjacent points to accommodate the additional turning movements thus thrust upon them.

(4) One way streets

The movement of traffic to and from areas outside of cities, coupled with the increased use of automobiles within the cities, has created loads which in many instances exceed street intersection capacities. Widening roadways within cities is very costly because of land values, and such widening usually intensifies the intersection problem.

Properly designated and controlled one-way streets can greatly alleviate traffic conditions, providing increased capacity and average speed and reducing conflicts at intersection and midblock, the hazards due to speed variations, parking difficulties, and signal problems. The need for adequate marking of one-way streets, with suitable provision for night effectiveness.

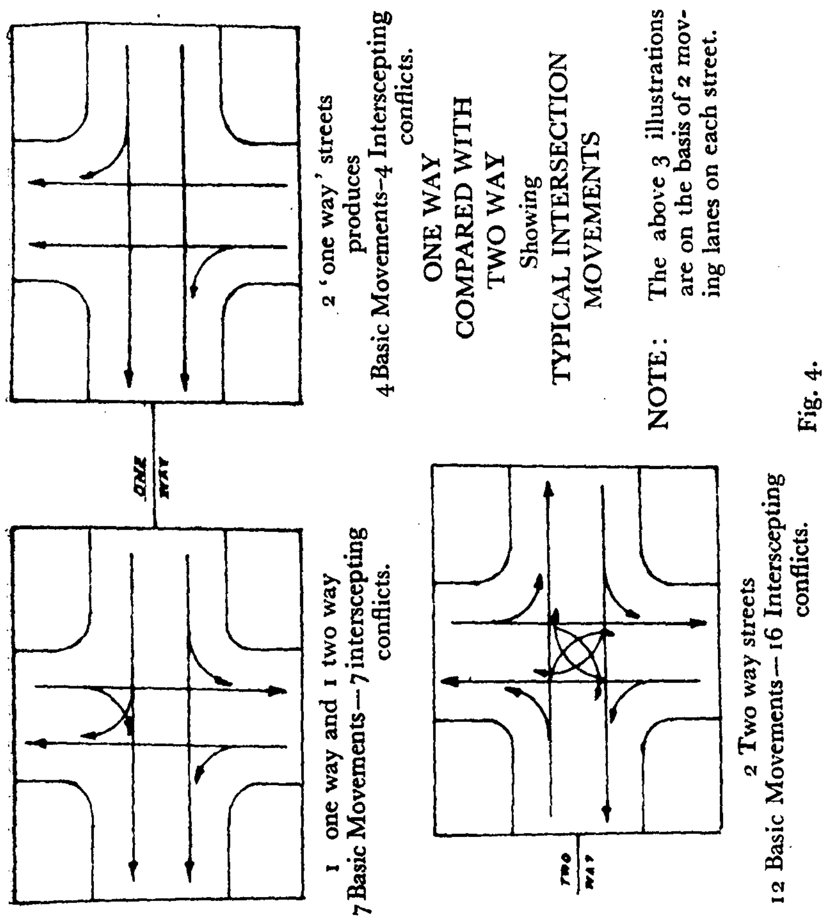


Fig. 4.

through illumination or otherwise, cannot be stressed too strongly.

There are several disadvantages of one-way regulations. Motorists may have to travel farther to reach a definite destination, this disadvantage increasing in proportion to the number of one-way streets in a given area. One-way signs must be erected at every intersection, and it usually takes a month of enforcement before even local motorists become thoroughly acquainted with these one-way rules. Visiting motorists cannot of course, be expected to know one-way rules.

If, as is desirable, the one-way streets are in pairs, there is likely to be some added congestion due to cross traffic and redistribution in the cross streets forming the termini of such one-way streets. If the one-way operation is of short length, particularly in central business districts, the additional congestion in the termini of such streets may more than offset the gains.

Introduction of the one-way rule entails factors which must be recognized. There is a severe upsetting of community habit and before the rule can be effectively applied considerable 'selling" and public education are necessary.

(5) Parking and loading regulation

Until such time as adequate offstreet facilities can be provided for vehicle parking and for loading and unloading, the use of curb space will continue on many streets. Curb parking and loading should therefore be so regulated (Figure 5) as to cause a minimum of hazard and interference with the movement of vehicles. Curb or centre-of-the street parking will not solve the parking problem, but making the best use of curb space reduces the amount of offstreet parking needed.

Curb parking decreases the effective width of the street for moving traffic and tends to produce congestion and accident. Where parking is allowed on densely travelled streets, cars should be parked parallel to the curb; angle parking accommodates more cars along a given length of curb, but causes more delay and hazard.

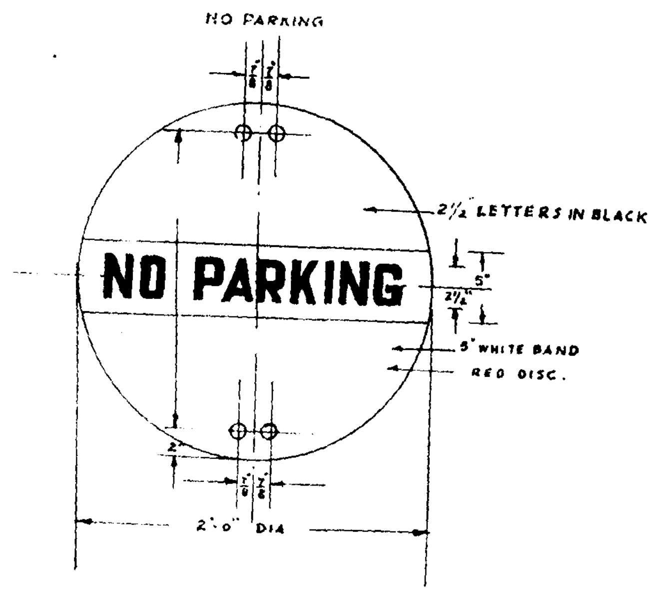


Fig. 5.

NOTE: Sign as here set forth may be amplified by instructions inscribed upon a definition plate placed below it as in the general arrangement set forth in sign No. 1 of this plate. Upon the definition plate may be set forth the times during which parking is prohibited. In like manner an arrow head inscribed on the definition plate will indicate that parking is prohibited on that part of the street or road lying to the side of the sign to which the arrow head points.

The eapacities of streets on which centre-of-the street parking is permitted are also adversely affected. The hazards to persons entering and leaving such vehicles, however, is greater because they must cross lines of moving traffic, frequently in midblock, to reach the sidewalks.

The ultimate solution of the parking problem in congested areas depends on the provision of offstreet parking facilities, by surface parking lets either the enclosed or open air type. As these facilities are planned, it should be kept in mind that the location, design, and control of entrance and exits has much to do with the safety of their operation.

II. TRAFFIC CONTROL DEVICES

Mechanical aids in the form of signs, signals, markings, and islands have come to play an important part in modern systems of traffic regulation. Many regulatory provisions are not enforceable unless at the time and place of any alleged violation a sign or other mechanical device is in proper position and sufficiently legible to be seen by an ordinarily observant person. In other instances it is necessary to post information to warn or guide street users to the end that there be facility and safety of traffic movement.

Good, clean, well-designated, properly applied, and well-maintained traffic control devices are an essential adjunct in the intelligent regulation of street traffic flows. In urban areas, the provision of needed mechanical aids has all too frequently been allowed to drift along, primarily because their importance in traffic control work has never been sufficiently impressed.

Uniformity in traffic control devices is highly desirable and indeed essential for maximum efficiency in their use. Uniformity as to design, location, and application is very valuable in attaining compliance and proper use by drivers and pedestrians.

While full and proper use of signs, signals, and markings is of great benefit to the control and regulation of traffic, the misapplication or excessive use of such control devices not only wastes public funds, but also often results in delay, confusion, and disorder in the traffic stream. The application of traffic control devices should not be based on guess work or inexperience. It should be based on sound engineering principles, established by factual studies of types and flew of traffic, accidents, speeds, delays and physical conditions which will show the exact nature of the difficulty and indicate what particular devices or methods of control are needed.

(1) Signs

Traffic signs are divided in the Motor Vehicles Act into three classes—Mandatory, Cautionary and Informative.

Mandatory signs:

These signs (Figure 6) make it obligatory for drivers of vehicles to take the particular course of action indicated by the signs. Failure to do so may result in prosecution. These signs consist of or include a circular disc displaying a device, word or figure and having a red ground or border. These signs announce a prohibition of parking, or of loads or speeds in excess of specified figures or of right or left turns; or of overtaking, or the use of sound signals; also the exclusion of certain form of traffic or of all traffic, from particular road-entries. Main road Ahead sign is a very important sign of this class.

Cautionary signs:

These signs (Figure 7) call attention to hazardous condition that otherwise would not be immediately apparent. It is always well to notice them, and to take good advice, although disregard of them cannot end in prosecution. A rectangular plate on which the lettering and symbols are shown is surmounted by a red triangle. These signs relate to rough-roads, turns, school, steep hills, ferries, hair pin bends, narrow bridges, roundabouts, dip, humped bridge etc.

Informative signs:

These signs (Figure 8 and 9) include direction and informational signs. They are of rectangular shape. These signs include, flood gauges, advance road approach, end of speed limit, parking place, Hospital, Bus stand, Bus stop and Ghaut Road Signs.

HEIGHT AND LATERAL LOCATION OF SIGNS
RURAL INSTALLATIONS

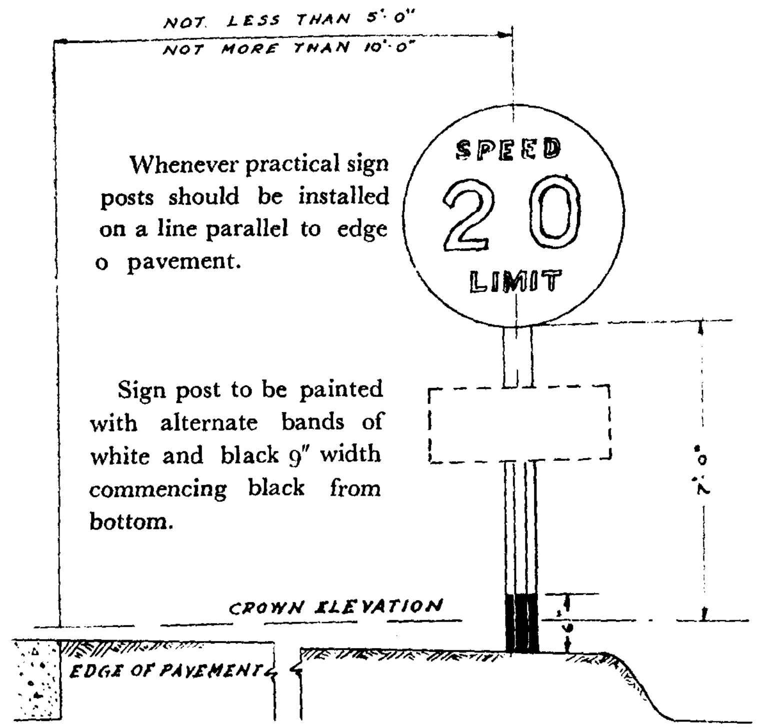
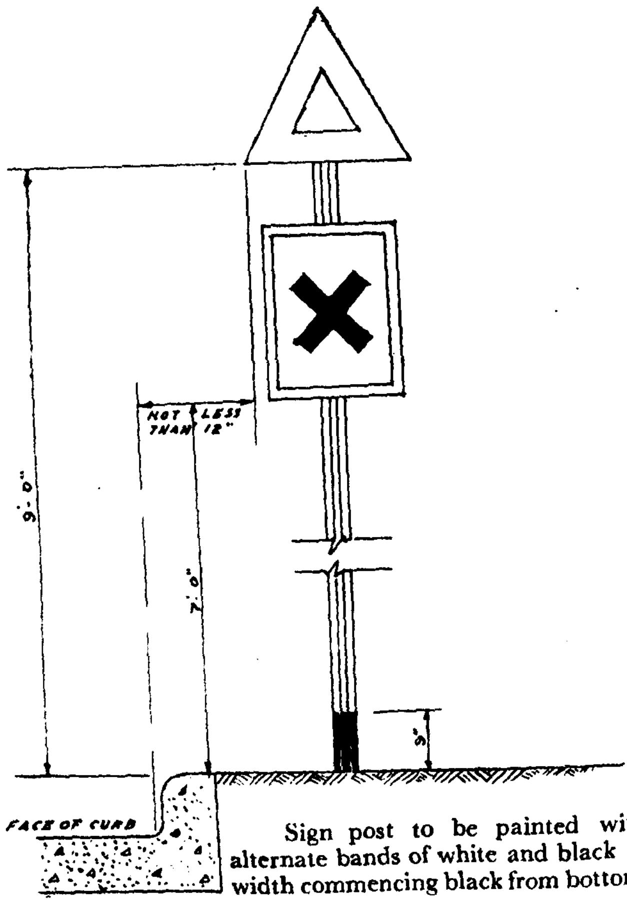


Fig. 6.

To be used in placing signs in rural sections.

HEIGHT AND LATERAL LOCATION OF SIGNS URBAN INSTALLATIONS



Sign post to be painted with alternate bands of white and black 9" width commencing black from bottom.

Fig. 7.

To be used in placing signs in urban sections.

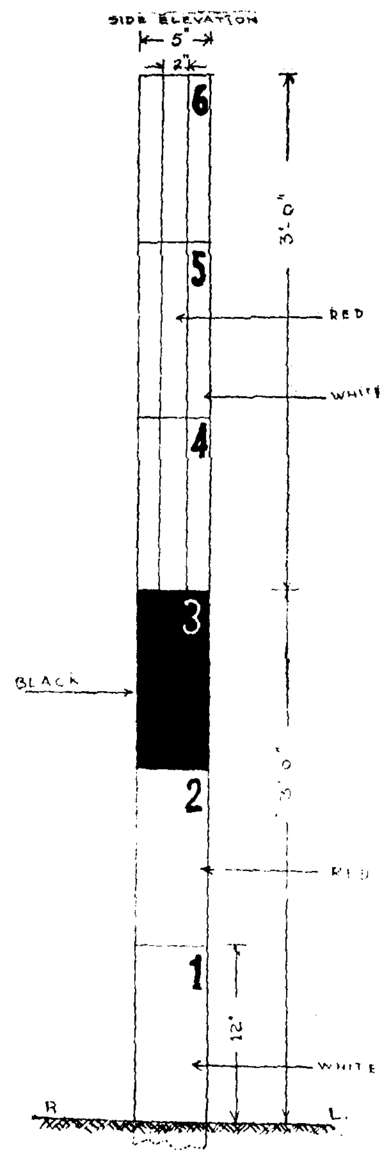


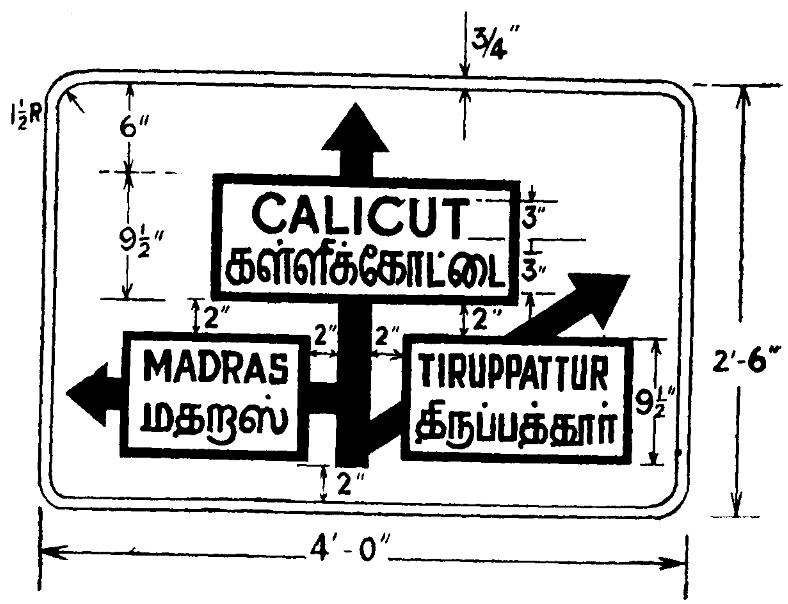
Fig. 8.

FLOOD GAUGES FOR CAUSEWAYS ETC.

The gauges should be placed on the upstream side of Irish Bridges or Causeways. They should consist of Iron rails or, preferably some wider section. They should be 6 ft. in height from the deepest part of the gap, the bottom 1 ft. should be white the second foot red, the third black and from the top of the black, that is from 8 ft. above zero to the top the gauge should be white and have a red line 2" wide running up the centre.

R. L.—Road level at lowest point of Irish Bridge or causeways, etc.

ADVANCE DIRECTION SIGNS



Background — Yellow

Letters, Borders, Arrows } Black

NOTE:

1. This sign is intended for use at approaches to important road junctions and should indicate the name of the nearest important towns on each of the roads branching off from the junction and also the angle of bifurcation of the roads.
2. The lettering in the above design is illustrative only.
3. The sign shall be fixed so that the bottom edge is at a clear height of 4 ft. above level of shoulder edge.
4. The sign shall be erected on a wooden or R. C. post 5" × 5" painted in 9 inch black and white bands.

Fig. 9.

In nearly every phase of traffic control improvement it is essential to give full consideration to the application of traffic signs. Many unnecessary signs have been placed that the average motorist has an inclination to disregard all signs. Therefore, a careful survey of existing signs may be needed. A complete inventory and subsequent removal of undesirable signs and the relocation of many others are needed. There is also need for a thorough renovation of signs which have received little or no maintenance in recent years.

Mandatory and Cautionary Signs should be used sparingly and only where needed, so that their effectiveness will not be destroyed by excessive frequency. Informative Signs, however, should be used freely, where they can contribute to the convenience and facilitation of traffic.

The proper location of a sign is important. Signs warning of hazards or signs giving necessary information, such as directional signs and markers, should be placed sufficiently in advance of the point to which they apply to allow the driver time to complete the maneuvre required of him. The distance at which a sign must be legible includes not only the distance for deceleration or other control of the vehicle but also allowance for the driver's perception, reading, and reaction time.

The signs shall be placed on the left side of the road appropriate to the direction of the traffic. Normally the signs shall be placed at not less than 400 feet and not more than 600 feet, from the hazard unless this is impracticable on account of local conditions.

Outside built up areas (Figure 6) the centre line of the sign shall be not less than six feet and not more than ten feet from the nearest edge of the pavement unless special circumstances render this impracticable. In built up areas (figure 7) and mountainous country the distance between the edge of the sign nearest to the pavement and a vertical line drawn from the edge of the pavement shall be not less than 12 inches.

The height of the lower edge of the signs from the level of the crown of the road shall be seven feet.

When both a warning sign and a guide sign are necessary at approximately the same location, the Warning sign shall precede the Guide Sign. They shall be separated by a distance of not less than 100 feet, and the warning sign shall be located so as not to obscure the informatory sign.

If a sign indicating an actual or potential hazard, or directional information at a critical point, is not of sufficient importance to require that it be as visible and legible at night as in daylight, it ordinarily has no place on the highway. Such signs are more important at night than in the daytime. All signs that mark potential hazard should be reflectorized or otherwise illuminated. Signs having daylight application only, such as school, parking regulations, etc. need not be reflectorized or illuminated.

From the standpoint of designs, all traffic signs applicable to the same type of conditions or conveying the same kind of information should be uniform with respect to shape, colour and message. They should also have reasonable consistency as to size and illumination. Modern highway speeds and increasingly complex intersections require that traffic control signs be recognized and understood at a glance. Uniformity and simplicity of design are of the greatest importance in aiding recognition.

Traffic control devices should also be so located that the view of them is not obstructed by curves, dips in the road, foliage or other obstructions to sight distance.

(2) Bridge piers and Abutments Marking

This marking shall be used on the ends of all piers and obstructions which are within the pavement area and which exceed 5 inches in height and on all abutments and constructions that constitute a definite hazard outside the pavement, but within 3 feet of pavement edge-except those that can be marked by other methods. The edges facing the approaching traffic shall be painted white with black stripes sloping downward at a 45° angle toward the lanes of approaching traffic. The width of the black stripes shall be 4 inches and the white stripes 6 inches. Not less than two black stripes shall be used on any obstruction.

On all obstructions where the sides of such abutment or pier are exposed to approaching traffic because of roadway alignment, the exposed wall shall be stripped the full length for a height of approximately 6 feet. The stripes shall be sloped at a 45° angle downward in the direction of traffic. In the event a wall is exposed to both directions of traffic such as on a curve, the stripping for one traffic stream shall be in the direction of fiew to the mid-point of the wall and then changed to the opposite direction for opposing traffic stream.

(3) Clearances marking for Overhead Structures

This marking (Figures 10 and 11) shall be used on all overhead structures that have a roadway clearance over the pavement of less than 16 feet 6 inches and may be used on other overhead structures when deemed necessary. The face of the overhead obstruction shall be painted white for a height of 18 inches over the roadway that is accessible to approaching traffic. The clearance in feet and inches shall be painted in 12 inch black numerals at the critical locations, and the remaining part of the white shall be stripped vertically with black. The black stripes shall be 4 inches wide and spaced at 10 inch intervals center to center.

(4) Pavement Markings

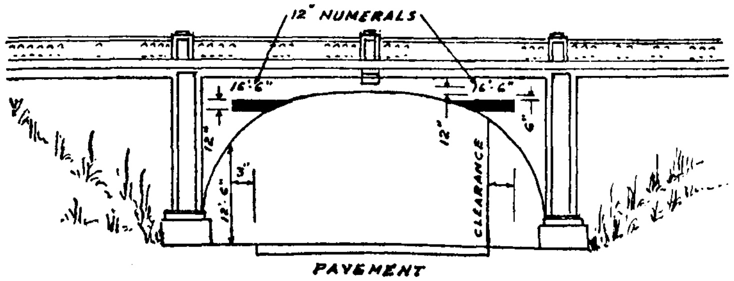
Pavement markings are lines, words, or symbols applied to, or integral with, the pavement surface for the purpose of conveying to motorists regulatory or informational messages which assist in driving conduct. They are closely allied to symbolic signs and are preferable to signs for certain conditions requiring the transmission of warning or information to the vehicle driver without diverting his attention from the roadway.

Proper and judicious application of pavement markings can be very helpful in safeguarding and expediting traffic, center lines tending to prevent collisions at horizontal and vertical curves, and lane lines on wide pavements tending to promote the orderly flow of traffic.

4 (a) Centre or medial lines

All centre lines, when required, shall be either black or white, depending on the type of pavement. Except when the

STANDARD UNDERPASS VERTICAL CLEARANCE MARKING ARCH TYPE UNDERPASS



Mark structure when the clearance is 12′-6″ or less at a point 3′-0″ from the pavement edge.

STANDARD UNDERPASS VERTICAL CLEARANCE MARKING LOW CLEARANCE STRUCTURES

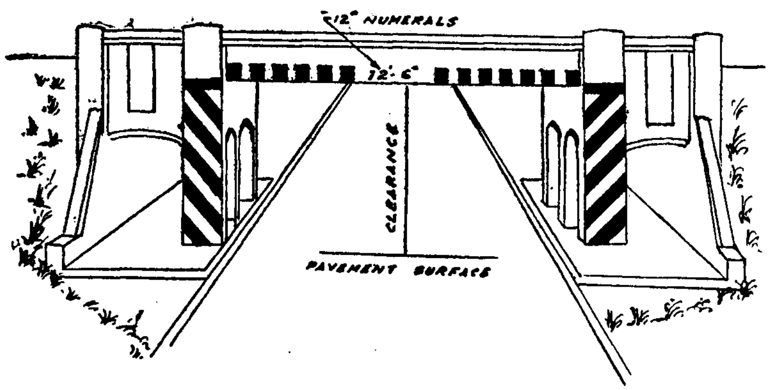


Fig. 10.

All overhead structures having a vertical clearance of less than 16′-6″ must be marked with the vertical clearance.

STANDARD UNDERPASS VERTICAL CLEARANCE MARKING

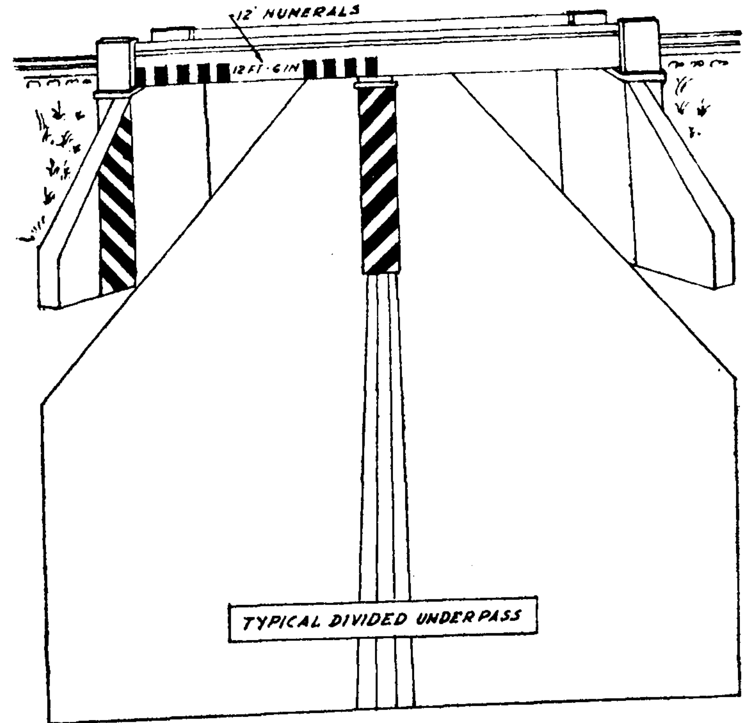


Fig. 11

All overhead structures having a vertical clearance of less than 16′-6″ must be marked with the vertical clearance.

No passing zone marking to be carried a sufficient distance either side of the structure to protect approaching traffic adequately.

pavements are badly darkened, the black centre lines shall be used on all concrete pavements. The white centre line shall be used on bituminous pavement. Marking should consist of lines from 4 to 5 inches wide with 3 feet mark and 9 feet gap.

4 (b) No passing zone Markings

The 'no passing' marking at zones (Figure 12 & 13) where overtaking and passing is hazardous shall consist of a continuous white or black line, depending on the type of pavement, four to five inches wide extending 100 feet in each direction beyond the hazardous point.

4 (c) Night visibility of paint Markings

Pavemeut markings made with paints of a dull or rough finish have much better night visibility than paints with a gloss finish, due to the specular reflection from the smooth surface of paint, which means that light from an automobile headlamp is reflected away from the driver instead of being returned to him. The most effective means of increasing the night visibility of traffic markings used on both horizontal and vertical surfaces is to employ special paint or material in which small transparent spheres or beads have been imbedded.

(5) Traffic signals

Traffic control signals should be located at intersection only when the conditions of traffic justify their use. Among the considerations of traffic which are highly significant in the application and use of traffic signals are vehicular volume, turning movements, pedestrian movement, speed control, and the requirement of safety. While traffic control signals are installed to improve the flow of vehicular and pedestrians traffic along a given route, and to decrease accidents, they intermittently stop the flow of traffic, and below certain minimum values of traffic their use is not justified and they become a hindrance to traffic flow. It is very important to avoid such delays to traffic where it is apparent to the motorist that they are due to the routine operation of a signal for which there is no justification.

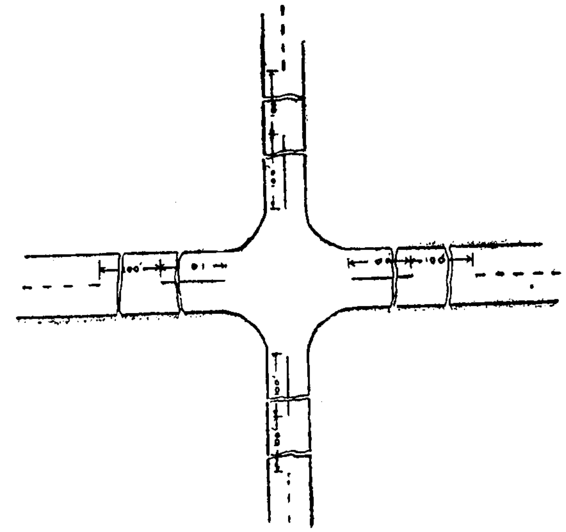
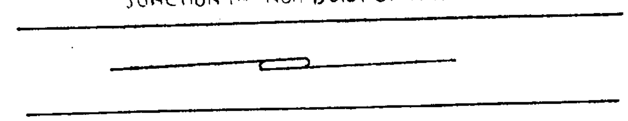
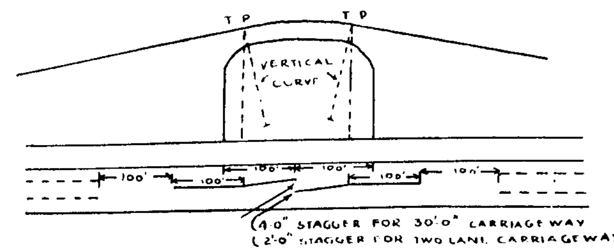


DIAGRAM SHOWING WHITE LINES ON APPROACHES TO UNCONTROLLED JUNCTION IN NON BUILT UP AREA

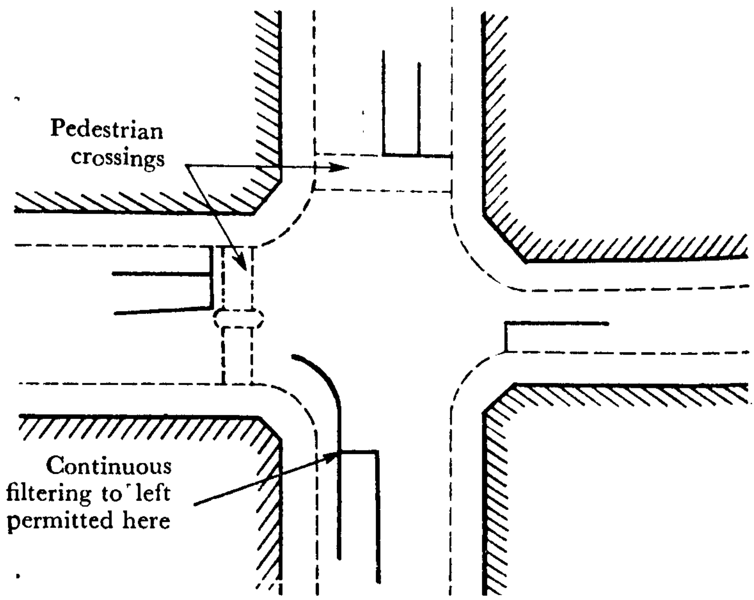


LAYOUT OF WHITE LINES AT CENTRAL REFUGES



LAY OUT OF WHITE LINES AT SUMMIT OF TWO GRADIENTS WHERE VISIBILITY IS BELOW STANDARD

Fig. 12



COMPOSITE DIAGRAM SHOWING TYPICAL LAYOUT OF WHITE LINES ON APPROACHES TO POLICE OR SIGNAL CONTROLLED JUNCTION

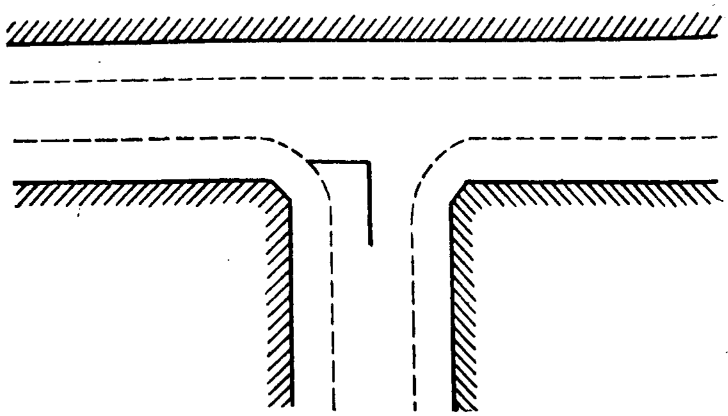


Fig. 13.
STOP LINE AT "MAIN ROAD AHEAD" SIGN

Properly installed and operated signals will provide for the orderly movement of traffic at busy intersections by alternately assigning right-of-way. Compared with the manual types of controls, traffic signals represent a considerable economy. When properly installed and operated they reduce certain type of accidents such as the rightangle and pedestrian-crossing variety. Signal installation, however, tends to increase rear-end collisions and often makes turns more difficult.

(6) Other Devices

While a sound system of traffic signals, signs, and markings is required and must be considered as fundamental in each community, there are numerous other traffic control devices which should be developed and given further application.

6 (a) Lighting

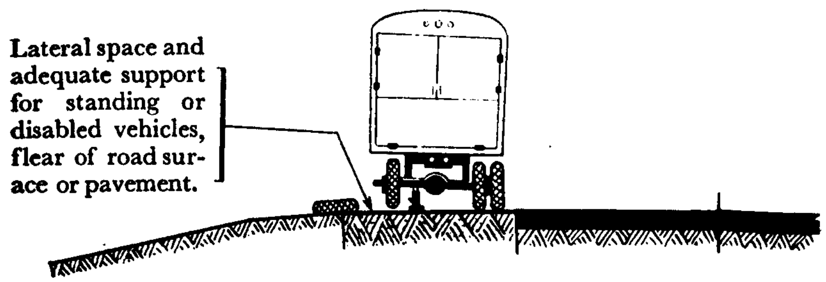
The ability to see quickly and clearly is a highly important factor in traffic safety. This is especially true at night. Impaired visibility at night creates a serious hazard to motorists and pedestrians alike. Experience shows that modern street lighting can produce such an improvement in visibility as to aid traffic flow greatly and to effect very substantial reductions in night accidents. It is most desirable therefore, that measures be taken to increase night visibility where conditions require, particularly on city streets and at points of potential night time hazard, on rural highways.

To obtain the maximum usefulness from street and highway lighting, there should be control of the extraneous light from flashing signs, stores, and other establishments along the highway. Otherwise the driver's vision may be handicapped by glare, his attention may be distracted, and misleading and confusing situations may arise.

6 (b) Shoulder

A primary function of the roadway shoulder (Figure 14) is to provide an emergency area for use in the event of an unusual traffic situation or vehicle disability. Sufficient width should be available to permit such operations as the changing of tyre etc.,

SHOULDER AND PAVEMENT-STRUCTURAL DESIGN



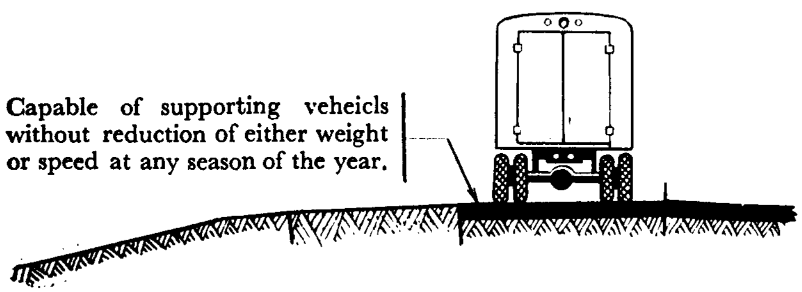


Fig. 14

without undue hazard to the driver from vehicles moving on the pavement. Other characteristics of good shoulders include a smooth, even surface substantially flush with the pavement edge, and ability to support satisfactorily occasional moving vehicle which, by traffic circumstances or otherwise may be required to leave the main travelled portion of the roadway.

A vehicle stopped on the shoulder should be clear off the pavement edge to the right by atleast a foot. If working space is needed, as for tyre change, a 2 foot space to the left outside the vehicle is none too large. Thus a usuable shoulder width of 9 feet is desirable for passenger vehicles and 11 feet for uses of trucks. This has led to the adoption of 10 feet as the shoulder width that should be provided along high types facilities. In difficult terrain and on low volume highways shoulders of this width may not be feasible, but in general the 10 feet section is recognized as the desirable minimum.

6 (c) Guardrail

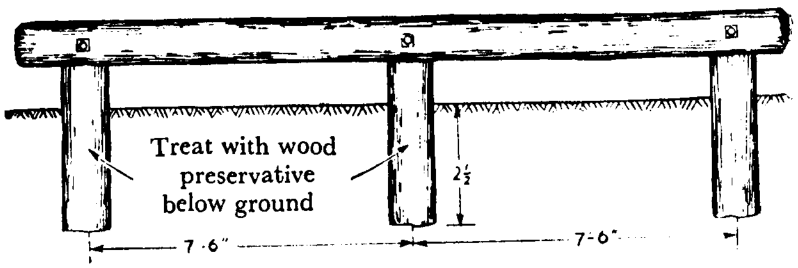
The use of guardrail (Figure 15) is advised at points of extreme danger. Generally such points are considered to be fills ever 6 feet in height at location where topographic or other conditions, such as sharp change in alignment, force a material reduction in speed. It may be omitted where it is practicable to provide a slope of 1 in the 4 or flatter because a driver forced on to such a slope has a chance of regaining control of the vehicle.

Guardrails are made of wood, squared or undressed, or of metal, supported on posts. Metal ones are, and wooden ones always should be, fastened to the face of the post rather than on top of it, with no bolt head, nut or other object prejecting from the vertical face,

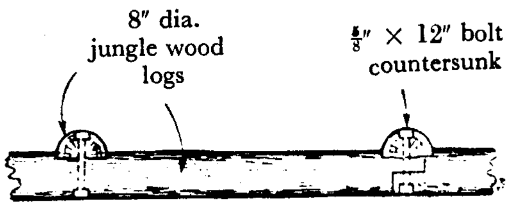
Guardrails should be easily visible and should have sufficient strength to deflect a car back into the road with a minimum of damage.

Metal guard rails are of three principal types, which may be classified as follows: (a) steel plate guards of the beam or non-tension type; (b) steel strip guards of the tension type;

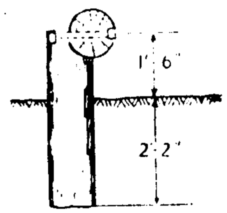
RUSTIC GUARD RAIL



ELEVATION



PLAN



SECTION

Fig. 15

NOTE: Rustic guard rail may be used on high embankments of roads through forest areas and ghat sections where hardwood may be obtainable cheaply. Rustic guard rail shall be painted with a bituminous paint.

(c) guards of wire cable, wire mesh or other multiple elements held in tension.

Posts which support guard rails are set firmly into the ground at least 12 inches from the outside of the shoulder. The posts are generally of wood, concrete or steel.

6 (d) Guide Stone

Guide stones are effective aids for night driving. Guide stones are to be considered as guide signs rather than warning devices. They may be used on long continuous sections of highway or through short stretches where there are changes in vertical or horizontal alignment, particularly where the alignment might be confusing.

Guide Stones are necessary also

1. At the curves and approach to curves when the radius of the curvatures are below the standard prescribed for the class of road appropriate to the design speed.

2. Limited by the maximum standard cross-slope of 1 in 15, when the super elevation or banking speed at curves is below the calculated amount for the design speed and radius of curvature.

3. When sections are hazardous, where accidents are frequent and when sections are favourable for high speeding.

Guide stones (Figures 16 and 17) shall be installed at a height such that the top is 2′–3″ above the edge of near pavement or roadway. In no case it may be more than 10 feet nor less than 2 feet outside the roadway or pavement edge, the most desirable location being uniformly 8 feet wide, to allow a clear shoulder wide enough for the parking of a vehicle. On roadways with shoulders less than 8 feet wide, Guide Stone if used, shall be installed at the shoulder edge. Along curbed sections of roadway, Guide Stones, if used, shall be placed not less than 2 feet, nor more than 5 feet, from the curb face.

Guide Stones should not be placed more than 66 feet apart, where such spacing is interrupted by driveways, cross roads, etc., and where, under the normal spacing, a Guide Stone would fall within such an area, that Guide Stone may be moved in

STANDARD GUIDE STONES

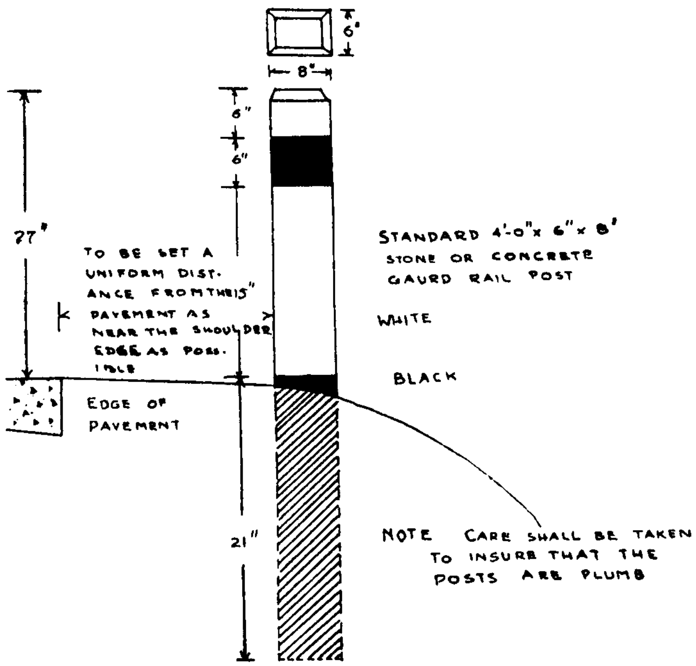
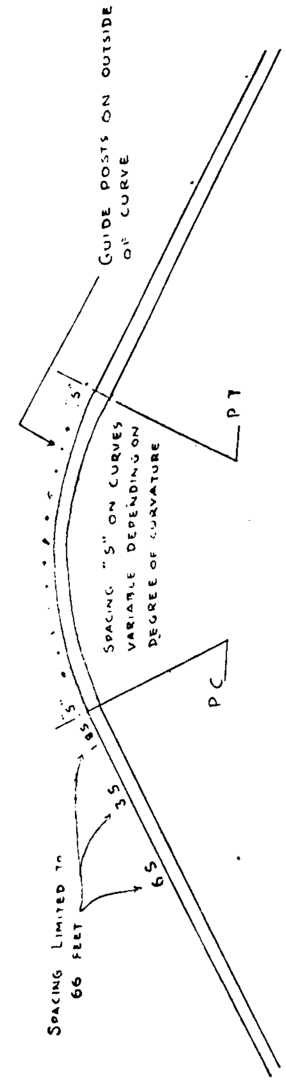


Fig. 16

TYPICAL SPACING OF GUIDE STONE IN CURVES



1 Guide Posts if on inside of curve be placed radially opposite to those on outside of curve.

Spacing $S=1.2\sqrt{R+18}$

Where R = the radius of the curve in feet.

Fig. 17

either direction a distance not exceeding one quarter of the normal spacing. If such Guide Stone still falls within that area, it should be eliminated.

On the approaches to and throughout horizontal curves the spacing should be sueh as to make five Guide Stones always visible to the left of the centre line of a two-lane pavement. The spacing 'S' on the curve is found from the formula $S = 1 \cdot 2\sqrt{R+18}$, where R is the radius of the curve in feet. The spacing to the first Guide Stone in advance of and beyond the curve is 1·8 S, to the next guide stone 3 S, and to the next 6 S, but not to exceed 66 feet.

III. LOCALIZED STRUCTURAL CHANGES

There are numerous types of structural changes in the roadway itself which the Highway Engineering Department can devise to improve traffic conditions. They may involve little expense, as in the placing of small channelizing islands or the cutting back of curbs at intersection or they may involve substantial expense, as in the elimination of jogs requiring the razing or alteration of buildings. In either case they are measures to increase the efficiency of existing streets or highways as distinguished from the creation of new throughfares or the complete rebuilding of existing ones. Except in the case of extensive street widenings or shoulder improvements they extent only short distances, mainly at or near intersections.

Localised structural changes may contribute greatly to increasing the traffic capacity and efficiency of the street system. The capacity of a given highway or street in an area having frequent crossroads is governed largely by the layout and capacity of its intersection, and furthermore these intersections are among the most serious accident points. Intersections are thus key points in dealing with the problems of accidents and congestion.

(1) Lane width

In the early days the road widths generally ranged from 8 to 16 feet to provide for one and two lanes of traffic. But the majority of the traffic in those days were only bullock carts with very few motor cars or buses.

In the evolution of modern design, increases in traffic volume, wider commercial vehicles, and higher operating speeds have brought successively wider traffic lanes. Ten feet has been the standard width. But the modern trend has been to provide a lane width of 11 to 12 feet. The more liberal lateral clearance conduces directly to the avoidance of sideswiping accidents; its benefits are also manifest in an increase of the case and comfort of driving with consequent lessening of fatigue which itself contributes to many accidents. Where mixed, traffic is prevalent it is the usual practice in India to provide a lane width of 8 feet to accommodate bullock carts and a lane width of 10 feet for fast moving motor vehicles. But on account of the shyness of the motorist to travel close to the slow moving vehicles, it is considered that a lane width of 10 feet should be adopted in the case of bullock cart traffie also.

(2) Road Widening

Roadway widening is usually very expensive and as such most careful consideration should be given to the extent of lasting relief which will be obtained, by such widening. All too often such improvements have been made at great cost without traffic gains justifying the expense. On the other hand, there are numerous instances where wide sidewalks or grass strips make substantial widening of the roadway feasible at relatively little cost. There are also many cases where widening the roadway 3 to 6 feet without altering the boundary lines of the street or highway may produce another usuable traffic lane. Obviously such limited widening, should not be made unless they will result in an additional lane or bring existing lanes to adequate width. Another important application of street widening is the cutback alongside a leading island or adjacent to an intersection. Transit loading islands frequently reduce the number of effective traffic lanes. The integral number of lanes is more important at intersections, than in midblock. Constancy in the number of lanes for movement opposite to loading islands can be provided by cutting back the curbs at such points, with appropiate transitional approach radii. This practice will not only increase the capacity of the intersection but also avoid congestion, reductions in speed and reduce accidents. Even where there are no loading islands, widenings are highly desirable at the approaches to intersection where there is considerable turning movement, to permit vehicle operators desiring to turn to move into and, if necessary, wait in the proper lanes without Impeding through traffic. Such-intersection widenings are also desirable to provide additional reservoir space in a signalized area where the traffic is so heavy as to back up seriously or block the intersection behind.

(3) Elimination of Bottlenecks

Frequently the roadway for one or a very few blocks of an important traffic route, or one that would be important, is a lane or two lanes narrower than the remainder, of the route. Correction of these conditions would greatly improve traffic flow.

(4) Correction of Jog or Offset Intersections

Jog or offset intersections (Figure 18) are frequently bottlenecks, in that they throw an additional burden of traffic on the intersected street and complicate the signaling and control of traffic. While channelization may in some cases be helpful the only complete remedy is elimination of the jog through the acquisition of right-of-way so that the offset streets can be deflected to create a direct crossing.

(5) Increasing kerb radii at intersections

Longer vehicle wheel bases and larger buses, trucks, and trailer combinations more than ever emphasise the importance of adequate turning radii at street intersections. Many intersections in built up areas are not operting at reasonable efficiency because the radii of the curbs are such that turns cannot be made without encroaching on other traffic lanes. Many accidents and much congestion can be traced to inadequate curb radii necessitating awakward turns. The radius of kerbs at intersections should normally be 35 feet in order to enable large vehicles to keep close to the kerb when turning. In residential streets used mainly by light cars, a kerb radius of 15 feet should be regarded as the minimum. (Figure 19) Where there is substantial pedestrian traffic, however, excessive

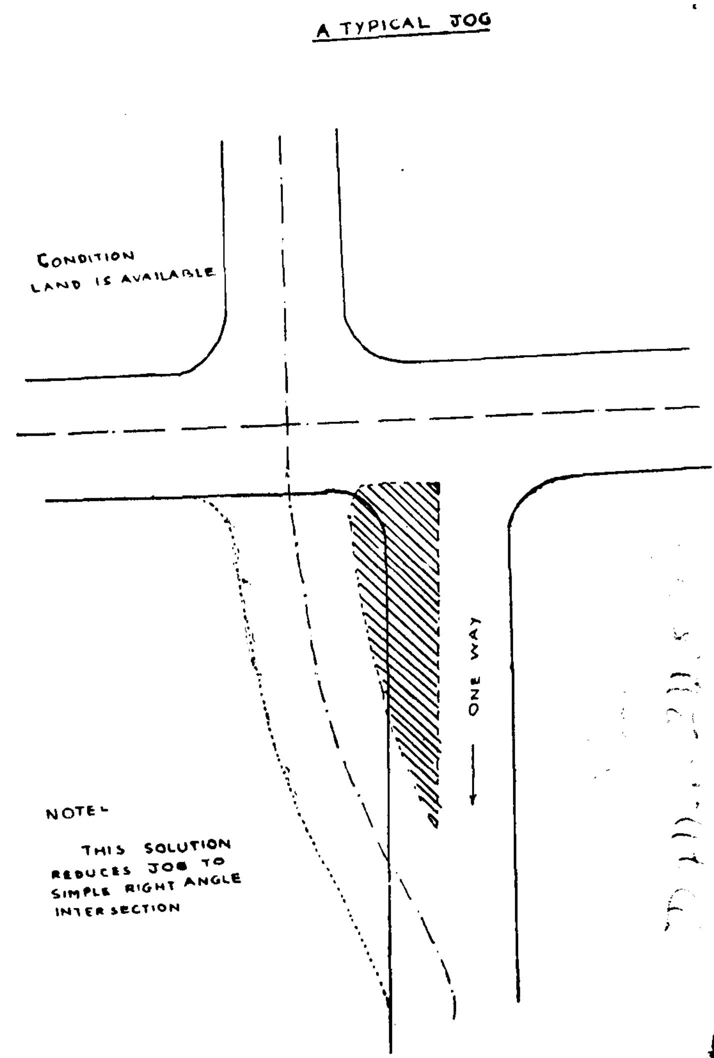


Fig. 18

NON-CIRCULAR CURVES FOR KERBS AT CORNERS

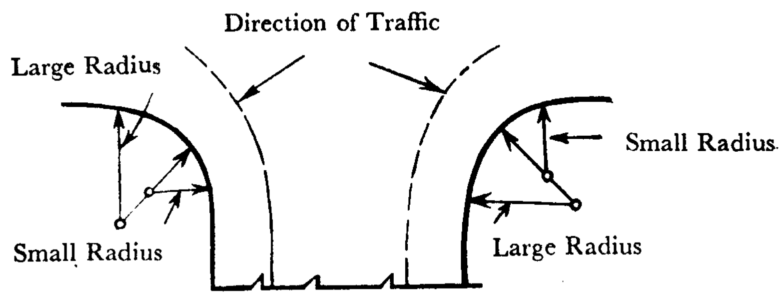


Fig. 19

1. When the kerb radius is less than 15 ft. it is advisable to adopt a curve laid to two different radii rather than use a cireular curve and the smaller curve at the commencement of the turn and the larger curve at the end of the turn, vehicles will avoid the sharp curve in a manner which will ensure that the rear wheels will not grind on the larger or flatter curve and (2) that the two curves could in practice, be merged into an elliptical curve.

increase of radii should be dealt with cautiously. If extremely heavy left- turn movements are in demand, consideration shod be given to the creation of a separate left-turn channel in conjunction with a refuge island, so that the turns can be accommodated with facility and yet pedestrians will not have unduly wide intersection throats to cross without a place to stand with complete safety.

(6) Channelization

The objective of channelization (Figures 20, 21 and 22) is to promote safe and orderly movement of traffic. This is accomplished by means of islands, divisional curbings, or by other means so adapted and placed in a roadway that opposing movements of traffic are divided, improper or hazardous movements are blocked, and correct movements are confined to definite paths which seem natural, attractive, and convenient to the driver. Channelization also provides islands of refuge for pedestrians.

When channelization is correctly applied, drivers and pedestrians move confidently and in an orderly manner. Needless conflicts and confusions are eliminated. The results are safe operation and optimum utilization of roadway space by vehicle traffic and pedestrians. The principle of channelization which applies to both rural and urban areas, should be employed where necessary in the design of new highways and is often readily adaptable to existing roadways. Channelization treatment must be carefully designed to fit the circumstances of each case. Channelization improperly applied may result in awkward or even hazardous traffic movements, delays, and conflicts. Preliminary tests of proposed treatments are often desirable. These can be made by the temporary use of stanchions, sandbags, or other devices the positioning of which can be modified if change is found desirable.

(7) Provision of Pedestrian aids

Provision of aids to facilitate and safeguard the movemen of pedestrians across roadways or to and from streetcars and other transit vehicles loading and unloading in the centre of the roadway is a vital part of any traffic improvement programme.

THE SIX BASIC TYPES OF INTERSECTIONS

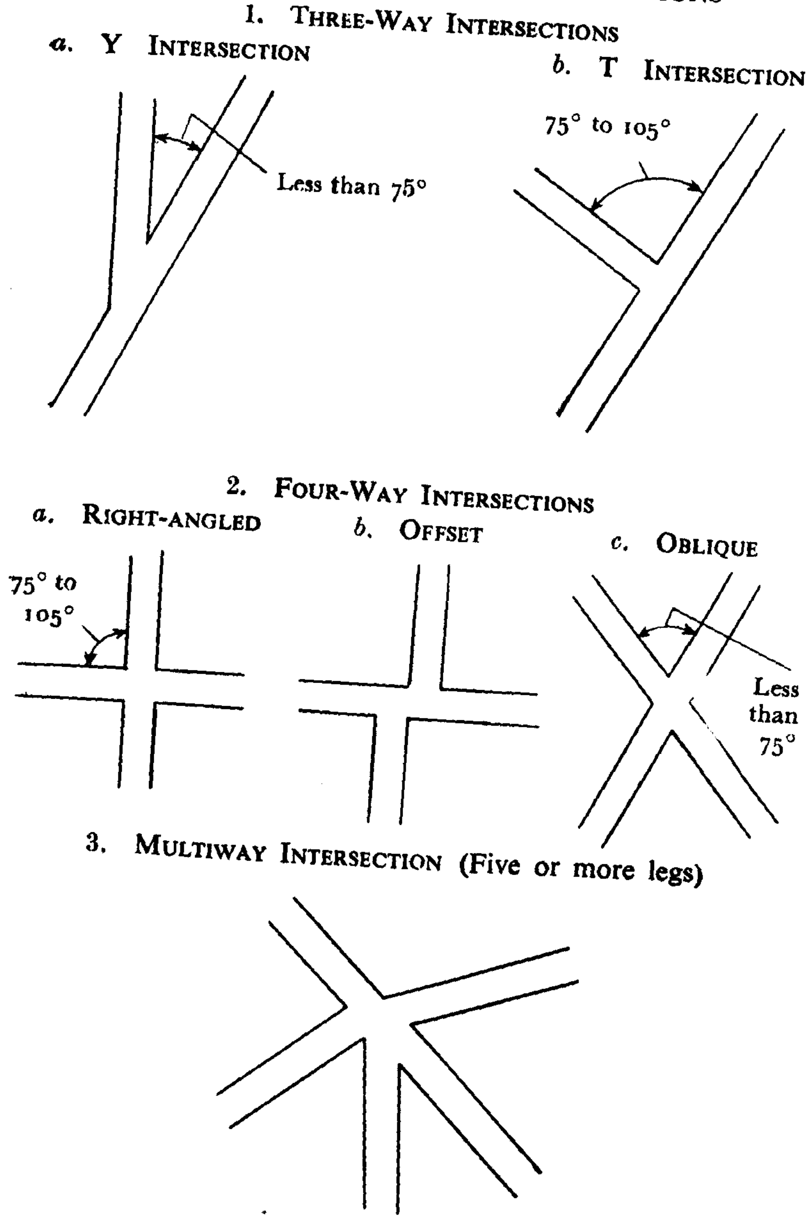
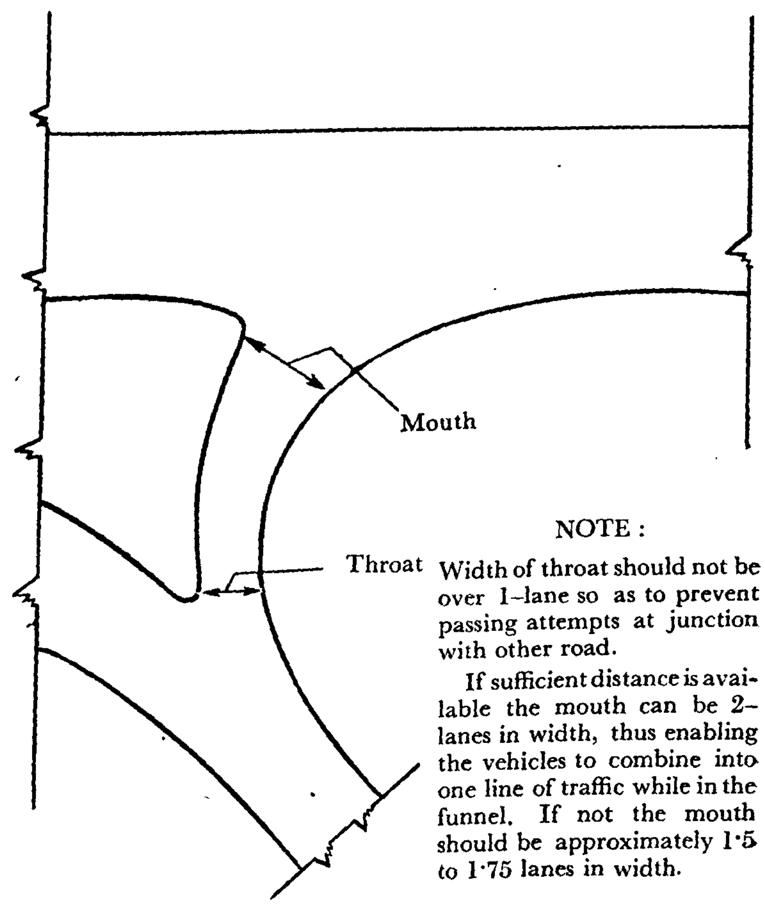


Fig. 20

ELEMENTS OF INTERSECTION DESIGN FUNNELING



NOTE :

Width of throat should not be over 1–lane so as to prevent passing attempts at junction with other road.

If sufficient distance is available the mouth can be 2–lanes in width, thus enabling the vehicles to combine into one line of traffic while in the funnel. If not the mouth should be approximately 1·5 to 1·75 lanes in width.

Fig. 21

A TYPICAL "Y"

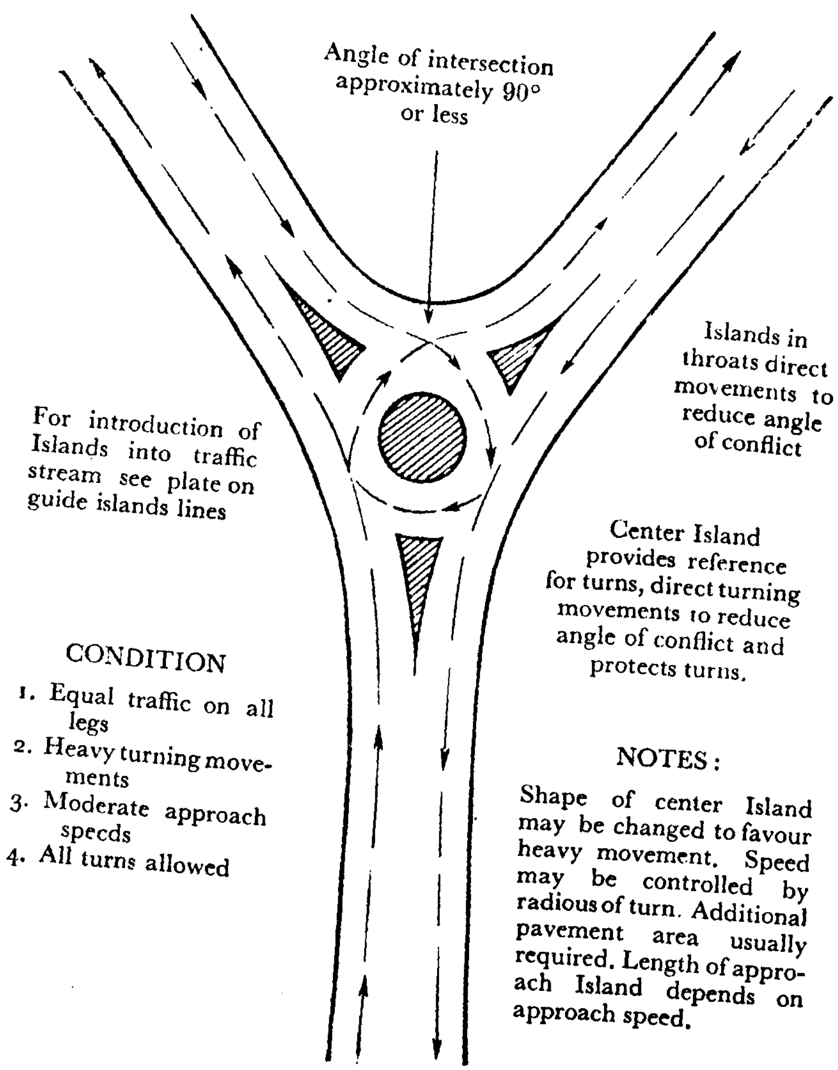


Fig. 22

The principal needs are for more and better designed pedestrian islands—loading and refuge—for more and better marked cross walks, and in some cases for pedestrian barriers or barricades.

Another important pedestrian need is the provision of footpaths or sidewalks along highways in suburban areas immediately adjacent to cities. Studies have shown that many pedestrian accidents occur in such areas where there is a lack of sidewalks to segregate pedestrian traffic from vehicular traffic.

The width of a footpath will be determined by the volume of pedestrian traffic anticipated but should not be less than five feet even in rural areas. In principal shopping streets a minimum width of fifteen feet should be adopted. If the number of pedestrians per 24 inch width (after deducting the "Dead" width) is less than 20 per minute, the footways can be regarded as having adequate capacity.

The widening of the carriageways of narrow roads should not be effected by encroaching upon the grass verge or footpath unless adequate space can be left for pedestrians. Footpaths are provided for the safety and convenience of pedestrians. They should be kept clear of obstruction from Mail Boxes, Telephone kiosks, bus shelters, transformer boxes etc. as far as possible. At junction, where conditions are specially dangerous for pedestrians it is essential that no obstructions other than those necessary for control of traffic should be permitted.

Experience also shows that to ensure use of sidewalks their surface must be atleast as smooth in all kind of weather as the roadway. For Indian conditions, where the major portion of the pedestrians do not use any footwear, the surfacing of the footpaths should be of either brick or edge or wooden setts Concrete footpaths become extremely hot and bitumen footpaths hot and sticky and are very uncomfortable to walk on during summer. Means of access (Figure 23) which are essential to enable vehicles to cross footpaths should be suitably paved and graded to the channel.

(8) Removal of obstruction to view

Frequently obstruction to view are temporary in character and can, therefore, be easily removed. Traffic operation at

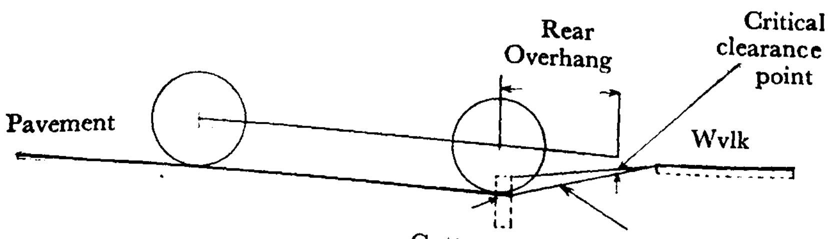


Fig. 23

MAXIMUM SIDEWALK HEIGHTS ABOVE GUTTER

Distance rom face of curb to sidewalk	Maximum height of walk above gutter	Distance from face of curb to sidewalk	Maximum height of walk above gutter
	7½" (0·62')	9'	1'-4½" (1·38')
2'	7½" (0·62')	10'	1'-6½" (1·54')
3'	7½" (0·62')	Beyond a point 10' from the gutter, the drivevay grade may be steepened, but in no instance shall the slope meeting the sidewalk exceed 30%.	
4'	7½" (0·62')		
5'	9¼" (0·77')		
6'	11" (0·92')		
7'	1'1" (1·08')		
8'	1'2¾" (1·23')		

In the design of private entrances, consideration must be given to the fact that where the grade of a drive becomes too steep between the pavement and sidewalk, certain vehicles will not clear. The critical clearance point is the rear bumper guard or exhaust pipe.

Measurements of a number of 1948–1949 passenger vehicles show an under-clearance of 10·5 to 15·5 inches at the lowest point in the rear of the vehicle. The table given above is based on the lowest (10 5 inches) under clearance, less a chassis deflection of 3 inches caused by an assumed load of 450 lbs. in the rear seat.

The table shows an allowable difference in elevation between gutter grade and sidewalk from 7·5 inches where sidewalk abuts curb to 1·5 feet where the sidewalk is 10 feet from the face of the curb. Where the grade cannot be established within these limits, it is necessary to lower the sidewalk.

intersections can sometimes be materially improved by cutting back or moving shrubs or other landscaping. At other points, however, substantial physical alterations may be needed which will prove expensive but are nonetheless warranted in any long-range programme of traffic improvement.

(9) Kid resistance surface treatment

Another important matter in traffic design is skidresistant pavements. This is but one of the ways in which improved pavement surfaces can be employed to bring about a safer and more efficient use of existing roadways. Provision of skid resistant surface eliminates large number of accidents.

IV. OTHER FACTORS

(1) Central Accident Records Bureau

A first essential, in the factual approach to the traffic problem is the gathering of accident facts. This should embrace required accident reports made by operators involved, and reports of police officers.

Each city or State, should have a centralized traffic accident bureau, which should collect, analyse, and interpret accident data. This work requires special skill and special technicians trained in traffic accident analysis. It will lead inevitably to certain engineering, enforcement, and educational measures. The bureau should serve the police department, the engineering or Highways Department, the schools, and all official agencies that have responsibilities in dealing with the traffic problem, so that a particular analysis required by any agency can be carried on either by the bureau or by the agency itself from data the bureau collects.

In addition to comprehensive traffic accident analysis, there is need for studies of population, topography, land use, and other basic community characteristics, studies of traffic volumes, speed and delay, origin and destination, routings, cordon counts, parking practices and facilities, and other special investigations as may be required from time to time.

It is on the basis of the factual information collected and analysed that a sound program of traffic control can be developed which will be in keeping with the needs of the community.

(2) Traffic Police

The police have always been, and will continue to be, the principal agency for the enforcement of traffic laws. A well-organised traffic police bureau should be designed to exercise the three primary functions of traffic police work. First, traffic police should afford a directing and expediting service to traffic at those points where unusual opportunities exist for confusion and traffic friction. Second the police, have important functions of education and prevention of accidents and delays. The third function of the traffic police is the punitive function.

Traffic police can also be helpful in calling attention to conditions which they cannot correct, but which properly require the service of the Highway engineer. Police can be readily trained to recognize such situations.

(3) Public opinion

In the final analysis litttle or nothing can be done to secure traffic improvements without crystallized public opinion and support. Greatly increased effort should be exerted to cause the public generally to recognize that they have their responsibility not only of being safe highway users themselves, but also of seeing to it that their public officials give traffic conditions and traffic problems the consideration they require and deserve.

There is need, therefore, for the organization in each community of some concerted plan of action. The activities and plans of all individuals and groups dealing with the traffic problem should be properly coordinated.

Acknowledgement

The author acknowledge with thanks the valuable suggestions given by Sri K. Ramaswamy Reddy, Director, Highway Research Station, in writing out this paper. The article is published by permission of the Chief Engineer (Highways).

An Easy Method for Getting the Influence Line Ordinates for Moments at any point in a Simple Beam

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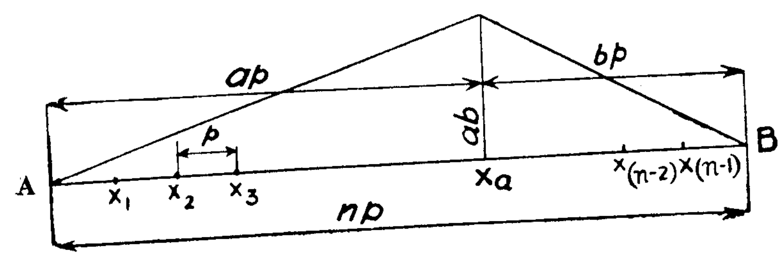
Assistant Engineer (H)

The influence line for moments at any point in a beam is generally obtained by calculating the ordinates at various points in the beam by the ordinary methods of statics. This involves a series of calculations, though simple, for getting the influence line for each point.

The following rule gives an easy method of simply writing down the influence line ordinates at any point, in integers, without any calculations.



Let the beam AB be divided into any number of equal parts say 'n', the length of each division being 'p' and the points of division being X_1, X_2, X_3 etc.

Required to find the influence line ordinates for moments at any point, say X^a.

Now $AX_a = ap$; and $X_aB = (n-a)\,p$

or bp

The ordinates may then be written down as follows:

At A $=O$

,, $X_1= b$

,, $X_2=2b$

,, $X_3=3b$ and so on in arithmetic progression till at

$X_a=ab$.

Beyond X_a it will decrease in arithmetic progression with the common difference a;

that is; coming from the other end B,

At B $= O$

,, $X_{(n-1)}= a$

,, $X_{(n-2)}=2a$ and so on till $X_{(n-b)}$ or $X_a=ab$.

These ordinates are in integers and the absolute moments are got by multiplying each by p/n.

ILLUSTRATIVE EXAMPLE 1

A beam 20 ft. long is divided into 10 equal parts of 2 ft. each. Required to get the influence line ordinates for moments at the sixth point *i. e.*, at X_6.

Here $a=6$ and $b=4$.

Hence the ordinates from A to B are as follows:

0, 4, 8, 12, 16, 20, 24, 18, 12, 6, 0.

ILLUSTRATIVE EXAMPLE 2

In the above beam it is required to get the influence line ordinates at the third point *i. e.*, at X_3.

The ordinates from A to B are

0, 7, 14, 21, 18, 15, 12, 9, 6, 3, 0.

Similarly for any point.

The absolute moments in the above cases can be obtained by multiplying each ordinate by 2/10.

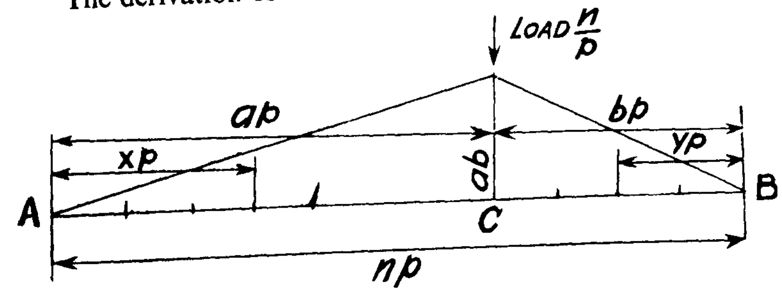
The ordinates for influence lines for moments at all the nine points in the above beam may be written down in the form of a statement as follows and plotted in order to get the enveloping diagram for moments. The figures in the statement will be in arithmetic progression four ways.

Load at	Moments at X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
X_1	9	8	7	6	5	4	3	2	1
X_2	8	16	14	12	10	8	6	4	2
X_3	7	14	21	18	15	12	9	6	3
X_4	6	12	18	24	20	16	12	8	4
X_5	5	10	15	20	25	20	15	10	5
X_6	4	8	12	16	20	24	18	12	6
X_7	3	6	9	12	15	18	21	14	7
X_8	2	4	6	8	10	12	14	16	8
X_9	1	2	3	4	5	6	7	8	9

The above method will be particularly useful for getting the M/EI diagrams for beams of varying Moments of Inertia since EI will be constant for a particular point, and the ordinates will still be integers.

DERIVATION

The derivation of the above is simple as follows:



AB is the beam divided into n equal parts of length p each. Let the moving load be n/p.

Required to get the influence line ordinates at C where

$AC=ap$ *i. e.*, at division no. a.

$CB=(n-a)p$ or say bp.

The moment at C will be maximum when the load is at C. The moment will then be,

$$\frac{n}{p}\times\frac{ap}{np}\times bp=ab$$

Between A and C, when the load is at any point, say, xp, moment at C is

$$\frac{n}{p} \times \frac{xp}{np} \times bp = xb$$

As x varies from 1 to a, the moment will be b, $2b$, $3b$ etc., in arithmetic progression up to ab at C.

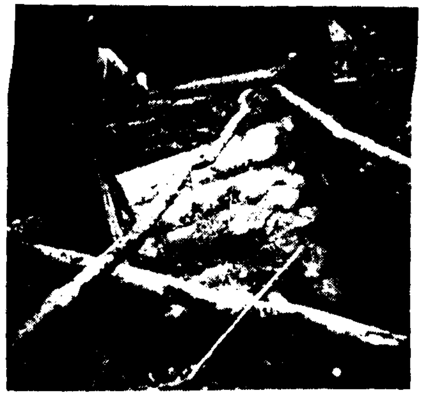
When the load is at any point between C and B, say, at yp from B, moment at C is,

$$\frac{n}{p} \times \frac{yp}{np} \times ap = ay$$

As y varies from 1 to b, the moments will be a, $2a$, $3a$ etc. in arithmetic progression up to ab at C.

These are in integers and are for a load of n/p. The absolute moments for the influence line are for a load of unity. Hence each of the above ordinates have to be multiplied by p/n.

1



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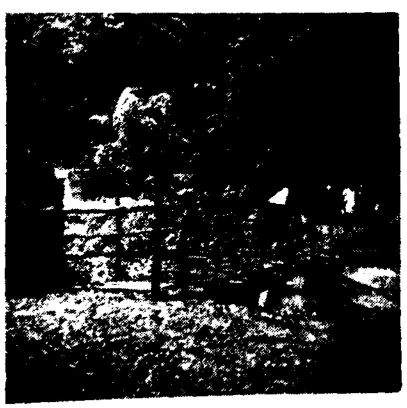

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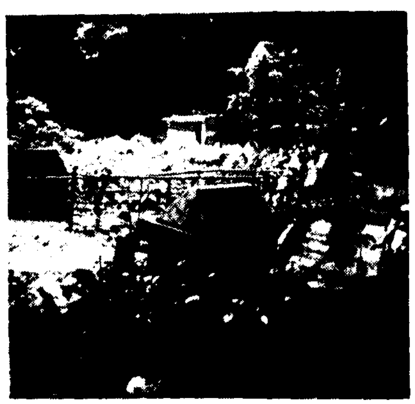

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A Repair Job

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The Manimanjarabad Road is one of the important roads leading from South Kanara District into the Mysore plateau. It branches from Mile 22/4 of the Mangalore Mercara Road and reaches the Mysore border 39 miles further away in what is called the Shirady Ghaut on one side and the Maranahalli Ghaut in the Mysore side. It is the shortest road from Mangalore to Bangalore and passes through Sakaleshpur and Hassan and has a number of lorries and buses running on it.

At mile 59/6 of this road there was a bridge of a single span of 35′ of a wrought iron lattice girder and rivetted curved deck plate carrying a metalled road. The width of the road-way was 14′ and the abutments were at good solid granite masonry.

On June 1954 a Dupa tree standing on the bank about 10′–15, above the bridge on their North Eastern side fell right acros the bridge and crumpled the superstructure like match wood. The tree was about 40′ tall and 10′ girth and the weight may be taken as about 10 tons.

The site was inspected the next day. It was found that even pedestrian could not get acros the ravine without very great inconvenience. Photograph Nos. 1 and 2 show the condition of the bridge then.

The first thing to do was to make a footbridge so that people could go across and transport at least of passengers could be continued by transporting from one brim to another across the damaged bridge. This was done in a day by using local jungle wood. Photos 3, 4 & 5 show the footbridge.

The next thing was to clear the debris of the old bridge from the site. It was found that the pieces were too large to be taken out as they were and that the tree which destroyed the bridge had not completed the severeance of the pieces. An oxy Acyteline gas plant was borrowed from the Shankar Vittal Motor Co. of Mangalore who also lent their operator. With the aid of this equipment the damaged girders were cut into convenient section. Photo 6 shows this operation in progress. These were hauled out by means of a 3½ ton differential pulley borrowed from the Electricity Department as shown in photographs 7 and 8.

While this was being done a method of erecting the bridge was thought out. It was found that at M 49/3 of Mangalore Agumbe Road about 120 miles away from the site of the damaged bridge we had girders on an old bridge of 30 ft. span where a new bridge had been put up to replace the week old bridge. This bridge had R. S. griders and floor of trough plates. These latter had become badly worn and damaged and were not useful any-longer. The job of dismentling these ginders was taken up. The flooring was seemed and the griders were taken out. In taking out the end girder they were moved close to the central girders across which roller of jungle wood had been laid. The end girders were lifted on to them and pulled across without much difficulty. One of central girders was laid flat and the others pulled on it similarly though with some more difficulty. The remeval of the last girder required the erection of two small trestles of jungle wood. Photographs 9 & 10 show the process of dismantling.

It was found, however that one of the abutments had a sort of screen wall in front for a height of about 4′ and that when this was raised to the height of the abutment we could reduce the span to 31′. On inspection this wall was found to be built of stone in mud pointed with cement. It was therefore dismantled and a new wall built of C. R. masonry in cement mortar 1 : 5 and bed blocks of cement concrete 1 : 3 : 6 were laid.

The R. S. girders were erected using the foot bridge to pull the first one and putting the other across it. A metalled road was laid over the deck plate and the road restored to traffic just one month after the bridge had collapsed. The last photograph shows the completed bridge.

The cost of the work excluding the cost of departmental material was Rs. 2473.

The work was supervised by Sri A. Shivaji Shetty B. E., Junior Engineer, Puttur, who put in heroic efforts to get the work done expeditiously. The Assistant Engineer was Sri D. A. Vishwanathan.

The girders were loaded on to a lorry for transport. While loading we found at a certain stage we did not have enough men to haul the girder to the lorry. A stout post was driven into the ground to keep the lower end of the girder without movement along the ground and the lorry was backed into the girder to complete the loading. Of course a roller had been inserted when the girder was mounted on the lorry. Photos 11 & 12 show the loading and transporting of the girder.

The floor plates of another damaged bridged which had been left handy at Someshwar about 10 miles from for the site of the bridge from which we took the girders came in handy and these were also transported to the bridge on the Manimanjarabad Road.

While the damaged lattice girder had a span of 35′ the R. S. girders available were only 34′ being the span of the bridge from which they had been taken being only 30′.

Construction and Behaviour of Soil Cement Base under Cement Concrete Surface in Chidambaram Bhuvanagiri Road

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I. INTRODUCTORY

1. **Location.** Chidambaram Bhuvanagiri Road is a major district road of South Arcot District and all road traffic from the different parts of Madras State bound for the great pilgrime centre of Chidambaram and the University of Annamalai Nagar pass through this bit of highway – 3 miles 5 furlongs in length.

2. **Soil particulars.** Irrigation channels are running on either side of the road for the entire length and the water table also is fairly high for most part of the year. The subsoil of the road is clay, with a very low plastic limit of about 11% and a high plasticity index, getting softened quite early in the wet season and remaining soft for a long period after that. During the time the clay in the subgrade is in soft condition, it works up through the interstices of the soling by the combined action of capillarity and vibration of traffic, gradually allowing the metal crust to go down, and forming pot holes, thus necessitating frequent renewals. The cost of the metal for this road lying in the deltaic taluk of Chidambaram, is very high since it has to be transported by rail. Hence the maintenance of this road was causing perpetual headache to the road authorities of the district, until soil stabilisation solved the problem. The proximity of river Vellar, the main sandsourse for the area, running parallel to the road, suggested the adoption of sand cement process of soil stabilisation. Tests made with different varieties of sand revealed that medium type would suit best.

II. CONSTRUCTION DETAILS

1. **Experimental measure.** Reach $\frac{1}{6}$–$\frac{3}{6}$ of the road was taken up for stabilisation by sand-cement process. The latter half of furlong $\frac{2}{8}$ was tried first as an experimental measure. The compaction strength was tested by means of a penetrometer. Waterbound macadem construction was made over it and the behaviour of the structure under full traffic conditions observed. The satisfactory results of the field experiment recommended the application of the method for the whole reach.

2. **Soil Cement Base.** The construction technique adopted was to remove the metal crust completely with soling etc. and rebuild the road with bases of soil cement laid to a width of 20 ft. in two courses of 4″ each with 2% and 4% cement respectively over a blanket course of 4″ of pure sand spread and consolidated to a width of 36 ft. (vide Fig. 1). The process involves trenching and shaping to correct gradient and

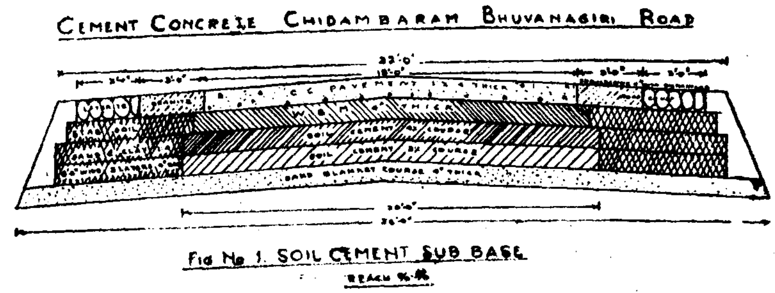

Fig. 1

camber, collection of sand, spreading and consolidation of the same at optimum moisture content for sand blanket course. Over this base course, sand was spread to correct level again and mixed with 2% of cement by volume for the first course and 4% of cement for the second course and consolidated at optimum moisture content. Pneumatic tyre rolling was done first, by means of a Tractor with a drag attached to the rear, levelling the impressions of the tyres. Consolidation was done next by means of a 10 ton power roller and final finishing was effected with a Tandom roller. Curing was done with water sprinkled from rose cans, the surface being covered with a layer of sand blindage to prevent direct heat of the sun and barricaded to traffic, cattle etc. for all the time. Over the 4% cement course, water bound macadeansubgrade was constructed for a thickness of 4" and width of 19'.0" over which cement concrete surfacing, 1 : 2 : 4 mix 4" thick and 18'.0" wide was laid. The total thickness of the new construction came to 20" the level of the road surface being raised by about 1'-0" over the previous one thus keeping it well above the water table.

About 170 tons of cement were used for the sand. Cement process of the two mile reach

3. **Stab-soil base for shoulders.** The picked up metal of the dismantled road crust was used with economy for metalling the shoulders on either side, the base for the same having been formed with the soil (clay) at the site mixed with sand in the ratio of 1 : 4 and consolidated at optimum moisture content as detailed before.

4. **Behaviour of surface under traffic.** The stabilisation and laying of subgrade for the reach $\frac{1}{0}$–$\frac{3}{0}$ was completed by August 1950, and concreting over it by December 1950. No traffic was allowed over any layer until waterbound macadem was completed. After a minimum ironing period of 1 month (and even up to 3 months in some furlongs) the concreting was done. The surface was found to be fairly level after being subjected to a heavy traffic during the monsoon months of September to December.

5. **Analysis of cost.** The cost of construction for building up the subgrade comes to about Rs. 50,000 per mile, nearly three-fifths of which goes for the waterbound macadam construction. The following table will give an idea of the cost of the different items incurred for the 2 mile reach $\frac{1}{0}$–$\frac{3}{0}$.

TABLE I

No.	Item	Cost Rs.	As.	Ps.	Remarks
1	Trenching	800	0	0	Soil Cements Base 38,300
2	Sand blanket course	8,000	0	0	
3	2% Cement	12,200	0	0	
4	4% Cement	17,300	0	0	
5	Waterbound macadem	59,000	0	0	WBM 59,000
6	Laying Concrete	1,20,000	0	0	CC 1,20,000
7	Stab soil base for berms	7,200	0	0	Berms 10,700
8	Picked up metal Berms 3'-0" granite & 3'-0" laterite	3,500	0	0	
	TOTAL	2,28,000	0	0	

Total Cost of Construction including Concreting } Rs. 1,14,000 per mile for a total riding width of 30'-0", with 18'-0" concrete pavement in the middle and 6'-0" metalled berms on either side.

6. **Plants and Machinery.** The whole subgrade construction from trenching to waterbound macadam construction was done departmentally and the following plants were used:

Marshal Tractor	1 No.
Aveling Barford Roller (10 Ton)	1 No.
Galion Tandom Roller	1 No.
Dodge Tippers	2 Nos.
Water Lorries	2 Nos.
Oradinary Lorries	2 Nos.
Water Pump Set	1 No.

Testing apparatus, scarifying discs and other ordinary tools and implements.

III. A COMPARATIVE STUDY WITH OTHER REACHES IN THE PRESENT CONDITION

1. **Maintenance.** Maintenance on the road has chiefly been confined to providing mastic to construction and expansion joints of the concrete slabs, patching up pot holes in WBM shoulders, earthwork for berms etc. and only a nominal amount of about Rs. 500 has been spent over this for a year.

2. **Present condition:** More than five years have elapsed since the construction over this reach was done. The surface has withstood the traffic intensity of more than 2000 tons, about half of which is iron tyred, for all these years. The surface is fairly alright except for a few transverse cracks that have developed in the concrete slabs, as is liable to occur however careful the work is executed. A thorough investigation of the nature of cracks indicates, that almost all of them have developed only on the approaches of reconstructed culverts thereby indicating that the work had been executed without allowing sufficient time for the made up earth on the approaches to settle properly.

3. **Comparison with other methods.** A comparison of the behaviour of the surface of this reach with the adjoining reach of $\frac{0}{6}-\frac{1}{0}$, wherein the design of construction adopted was, "widening the metalled width with laterite soling and laying the concrete after making up for the extra camber of the water-bound macadem by building up the metal crust" (vide fig. 2) reveals, that the number of cracks in the reach in which soil cement sub base has been constructed is much less than those in the other.

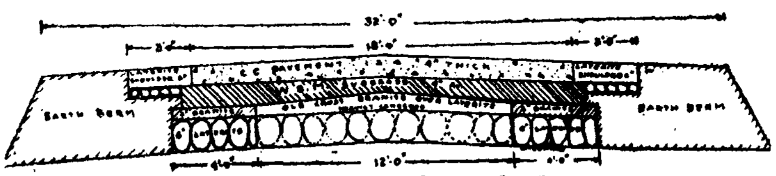

Fig No 2. LATERITE SOLING BASE

Fig. 2

Though the subsoil of reach $\frac{0}{6}-\frac{1}{0}$ is clayey loam with a plasticity index higher than that of the soil of reach $\frac{1}{0}-\frac{3}{0}$ (plastic clay), yet the concrete surface over the latter (stabilised reach) has withstood traffic better than the other. The following table shows the comparative cost of the two types of constructions adopted.

TABLE II

ITEM	COST	
	Concreting with soil cement base/mile	Concreting with Laterite soling/mile
	Rs.	Rs.
1. Sub-base	19,000 (for full width)	5,500 (for widening by 8'-0")
2. W B M	29,500	29,500
3. Laying C.C.	60,000	60,000
4. Berms	5,500 (6'-0" on either side)	7,500 (3'-0" on either side)
Total Cost/mile	1,14,000	1,02,500
Width of Riding Surface (including metal shoulders)	30'-0"	24'-0"

4. **Conclusion.** On the above considerations, soil cement may well be taken to have offered a permanent solution for maintenance of roads in deltaic areas, where the cost of road metal is highly prohibitive, and keeping the roads in a fit condition for traffic for all weather, is a problem.

A Few Useful Points on New Formation of Roads Including their Accessaries such as Road Dams, Culverts and Bridges

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GENERAL

Formation of roads, like any other public amenity follows the rule of supply and demand. The demand arises in the needs and claims of a growing community and the supply follows consistent with and controlled by the availability of funds. What the community wants and can pay for, the engineer, as a member of the community, helps to secure with his instincts of enterprise, economy and efficiency. To help him in achieving the results of these instincts, the following salient points pertinent to the formation of roads may be cited.

I. RECONNAISANCE ETC.

(1) Proper, patient and sufficient reconnaisance and looking into details at the very beginning will ensure a satisfactory job and avoid that waste which haste entails.

Between any two places to be connected by a road there are several alignments possible and the selection of the most serviceable and economical one will be possible only after all available information is collected, studied and intelligently acted upon. Hence the collection and collaboration of data have to be done carefully.

The ordinance tope maps published by the Government of India, on scales 1" to 1 mile and 4" to 1 mile, showing contours, topographical features and several other useful points of information, is a valuable help and should, therefore, be first secured and studied. Aerial photography is a sure and a cheap guide in reconnoitering for formation of roads in dense hilly and in accessible areas.

The completion of the office work on plotting and mapping should closely follow the field work so that discrepencies, if

any, may be detected and corrected before the field workers shift from the field work.

The general location and alignment will depend upon the following considerations.

1. **The minimum length of road:** The shortest route being desirable not only to economise on cost of formation and subsequent maintenance but also for the convenience of the users of the road.

2. **Access to places on the route:** A little deviation, at the risk of making the route longer, is desirable if commensurate with the service rendered to a place enroute and lying away from the shortest route.

3. **The nature of the land traversed:** If there are costly lands or structures, or topographical difficulties such as steep hills, lakes, nasty river crossings, boggy or marshy areas, the comparative costs of the shortest route and the by-passing routes should be roughly estimated before arriving at a decision.

4. Public opinion on the above three points and individual representations which may deserve consideration or may require persuasion.

A careful assessment of the local materials should be made by means of trial pits. This is a point sorely neglected in very many cases, resulting in costly hauling of materials for formation of the casing (gravel, Kanker etc.) while a few feet below, on the very alignment, suitable material is available but is blindly ignored. The trial pits may be made in such a manner as to be later on used as avanue pits for the road.

Where roads are to be formed in sparsely inhabited and undeveloped areas, the forecast of future traffic which will develop after the formation of the road will have to be carefully assessed after searching enquiries about the possibilities of future development of the area with regard to its fertility, arablity and the varieties of crops the area can produce whether consumer produce or cash produce.

II. TRAFFIC CENSUS ETC.

In certain areas where there is demand for formation of a road there may be cart tracks already, serving for transfort of goods, and in such cases the census of the traffic which may be seasonal and needs keen enquiry, should be collected and a forecast should be made of the possibilities of expansion of trade and transport.

The "Peak" load is an important consideration as it may be several times larger than the average load, as a road designed for the average load (arrived at by dividing the total load of an year by 365, or the total load of a day by 24) may fail to serve the traffic needs or to stand up to the impact of the traffic load, when the peak load comes in traffic lanes and road widths are to be designed as per the latest decisions of Highways authorities. Now the Indian Roads Congress has formulated certain suggestions on this question. The road width will include the traffic lane and the berms. Classifications of roads and standard widths are prescribed by local and Central Governments from time to time and these instructions have to be kept in view.

While the exploiting section of the public like bus owners and lorry owners wish to mount up the load on roads and shout that roads should be built to the traffic, the road Engineer supported by the administrative authority in charge of roads, and the reasonable members of the public, has to insist on the limitation of load to that for which it is designed, unless the public are prepared to foot the bill on upgrading of the road. Hence for formation of roads, certain anticipation of increase in traffic has to be made for arriving at the traffic for which the formation is made.

III. MATERIALS OF CONSTRUCTIONS ETC.

The materials available from trial pits along the alignment and in the near vicinity have to be studied and tested, if necessary before deciding up on the materials to be used on the formation of the roads.

The trial pits should reach as far deep as hard rock or heavy springs preclude further exploration for suitable subsoil materials like kankar and gravel. This is specially necessary in black cotten areas where suitable gravel is scarcely found on the surface. A simple calculation taking into account the fact that a pit $10' \times 10' \times 10'$ gives not merely 1000 cft. but 1250 cft. of slacked material would show that gravely materials dug out from pits as

deep as fifteen feet into the supervering black soil, is cheaper than gravel carted from a distance of 3 to 4 miles. Further this gravel taken out wet from the pits consolidates better when laid on the road formation than any amount of watering and consolidation of carted gravel. Hence deep trial pits lead to a valuable use of large borrow pits after taking out the gravel from these deep inner pits, the black earth spoil taken from the top layer is thrown back into the pits, to remove the danger of their depth in proximity to the road. Such pits with the filled loose earth make very good avenue pits. A few of the pits are however at intervals, left sufficiently guarded by a spoil bank to prevent surface drainage filling it, so that the inner pit may continue to serve as a quarry for further quantities of gravel for use on maintenance of the road. A few pits are also maintained likewise for rain water storage for road work. Such maintained pits are located as faraway from the edge of the road embankment as is necessary to remove danger to traffic.

The use of the stabilized soil for the sub grade will be very economical wherever the soil and sub-soil are unsuitable (like clay) and even treacherous (like black cotton soil). Screening of gravel to reduce the mud content will be found worth while for securing a satisfactory material for the wearing coat of light-traffic roads.

IV. DESIGN OF ROAD FOR LOADS

The road-rupee-ratio is a phrase invented by the Indian Roads Congress to denote the importance of maintaining a reasonable parity between the cost of a road and the rupee-return the road gives to the public. To secure the highest possible rate for the public, the cost of the road needs to be kept down to the minimum while at the same time its utility is increased. This end should be achieved by careful design which is an expression depending up on factors like design-load, available materials and methods of construction, apart from careful alignment mentioned above.

The foundation is the most important as its weakness will bring on quick failure of the road and entail an eternal waste in maintenance. The commonest mistake in this particular aspect is the excessive height of embankment and added to it the use of unsuitable or treacherous material in the formation of such high embankment.

The causes for this common but disastrous mistake are:

1. The saying "high and dry" in which the "high" is unfortunately taken literally by some unthinking and inexperienced designers while, really, the 'dry' is the essential part which should attract the road designer.

2. Failure on the part of the road designer to observe the disastrous effects of unnecessarily high embankments, on the road surface and side slopes.

3. 'Earthwork' is the cheapest part of the road formation estimate and the tendency of the designer to revel in an impossingly high cross section for the road, without appreciably swelling the cost of the estimate.

4. The erroneous idea that whatever earth is taken out of the trenches formed for side drainage must be used up on the earthwork formation.

5. Lastly and perhaps the practically happening part is that played by the contractor who finds such profit in doing earth work when the wet season is propitious and cheap labour forth coming.

Hence unless a high embankment is absolutely necessary as on tank bounds and across tanks to keep the road surface about 2 feet above the M. W. L. or across paddy fields which require the road surface to be about 2 feet above the field level, it would be a folly to have a bank more than a foot high. In fact in gravelly soils, there are good surfaced roads barely three inches above the level of the natural ground at sides. In other words the less the embankment the better. Even where capillary rise of water from the side drains or adjoining fields is feared as likely to wet and soak the formation-foundation, this fear should be over come by the use of a compat gravel base or better, by a stabilized-soil sub-grade, additionally strengthened by a non-porous casing in the side slopes.

Cuttings should be freely resorted to wherever feasible as cuttings provide the following advantages:

1. Cuttings improve the gradients and sometimes visibility as in the case of cutting auto-humps.

2. Cuttings secure for the road a harder foundation from out of the harder inner soil.

3. Cuttings afford good material for filling up adjoining dips. The thickness of the base course (subgrade) will depend upon the material of which it is to be constituted, and again the choice of the material will depend up on the considerations of economy arising from the proximity of the source or quarry. The thickness of the base course should be designed for the load the road is to carry. The manner in which the base course is laid will determine its efficacy and not the mere thickness.

Illustratively, a 6" gravel base course laid in well compacted layers of 3", the second layer quickly succeeding the laying of the first layer, i.e. before the first layer is damaged by weather or traffic, will act as a compact slab and be far more effective than even a foot thick layer of gravel laid loose, haphazard and deprived of all opportunity to consolidate into a slab. Hence the design should specify the material, thickness and also the method of construction, before the guarantee of its ability to bear the road load can be assumed for design purposes. It is safer to assume the 60° dispersion of load for the comparatively looser base course while for the compactor wearing coat, 45° dispersion may be assumed for purposes of design.

The choice of the materials and type of the wearing coat will largely depend upon the rules laid down by Governments and road associations. But what the designer can do for this part is the choice of the best stone considering its suitability and lead which largely determines its cost. One should not succumb to the usual fallacy that always the harder stones (like granite) are better than the softer stone like gneiss or lime stone. The softer stone provides its own binder and presents a smoother surface which lets the vehicle life longer while at the same line keeping the road maintenance cost low enough.

V. LAND ACQUISITION

1 & 2. The road roller mentality of providing for acquisition of the maximum possible width of land irrespective of the high (Productive) value of the land is a pit fall from which the road designer should abstain. In areas where paddy lands are a common feature and one will notice the narrow widths of road land. The things called paddyflats (narrow road across paddy lands) are noticiable where a road which has wide margins while passing through dry areas, suddenly contract where the paddy lands come and again widen in the dry lands. This is sensible.

3. Where a road is to be formed on the outskirts of a town and there is the likelihood of houses of shops being built along side the new road, steps have to be taken in the design stage against "ribbon development."

4. Against possibility of crowding on the road and croenaching on its margins in the future.

5. The best step against this possible nuisance is to acquire sufficiently wide (say 100') strips of land on either side of the actual road land required for the road-purpose and let this extra strips be controlled and allowed to be built upon in the future. Even as a profitable financial proposition this method is advisable as the land will fetch good prices with the betterment effects of the road and justify the lay out.

VI. METHODS OF CONSTRUCTION Etc.

The proper and efficient methods of construction should be thought out in the design stage itself and incorporated in detail in the estimate without leaving anything to haphazard construction. This, of course, does not take away the responsibility of the Engineer in charge of the execution, in the matter of exercising all diligence and precaution on the plea that he is following the estimate implicity even when it occurs to him that a better method is indicated by circumstance. The points touched on require attention both in the design stage and during execution. Log books showing the labour employed daily, the materials brought to site, the materials used up on the works, the turnover and other interesting particulars about the work, should be maintained as they serve important purposes like correct assessment of cost, data and watching progress so as not to go slack below programme and avoiding the raising of unnecessary and vexatious claim. When earth work is in progress for formation of the road embankment, it is advantegious to (1) keep the section cancave to retain rain water (2) and make the coolies proceed with the dumping earth from the edges to the centre so that their tread may consolidate each layer.

VII. CULVERTS Etc.

During the survey for first-road formation it will be difficult to correctly ascertain the maximum flood level either from information by the local people or from marks left by the flood. This is especially in the plains and the lack of correct information in the black cotton plains raises a problem to decide the location and ventway of culverts. A number of small culverts distributed across a low lying area is better than a single large culvert as it is futile to expect the rain drainage to collect and flow in road side drains towards a central culvert. Pipe culverts are very convenient in such cases. In several instances of doubt in arriving at probable discharge in black cotton area, it is advisable to provide road dams so as to enable a correct gauging in succeeding years, and construction of a culvert or bridge in later years to replace the road dam if necessary. R. C. Box culverts have their floors and decking monolithically connected by steel reinforcement and so function as strong units against cross drainage. The legs of the box offer facility to skew flow of the stream and therefore gain greater stability than culverts with piers which obstruct cross flow.

VIII. BRIDGES Etc.

The most important feature is the decision about the waterway. The catchment area as found in the topo maps and verified during reconnaisance and survey should be the most dependable datum while the selection of the co-efficient in the Ryver and Dicken's formula should be made carefully with reference to the nature of the country and the shape of the catchment area;

4

for, obviously, a rectangular catchment with its longer side in the direction of the flow of the river should be expected to yield a greater discharge, for the same extent of rainfall, than a square catchment of the same area, and even more than a rectangular catchment with its shorter side along the flow of the river.

Reconciliation of the discharge as calculated from the catchment area, with the discharge—ascertained through Kutters formula applied to the results of longitudinal and cross sections of the field work has to be carefully and honestly done before arriving at the reconciled figure for the discharge for which ventway is to be provided.

The scour calculations require great attention as the correct ascertaining of this, decides the depth of foundation in loose soils.

IMPORTANT

MEMBERS ARE REQUESTED

TO NOTIFY THE SECRETARY

AT ONCE

ANY CHANGE OF ADDRESS

OR OF DESIGNATION