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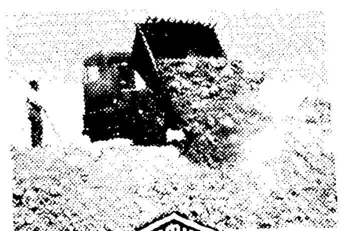

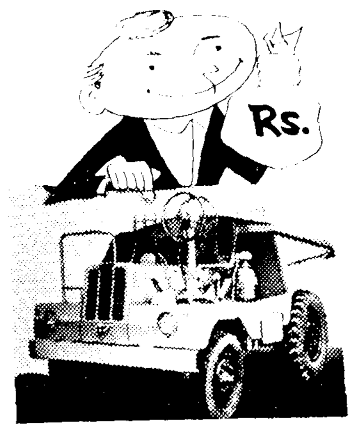

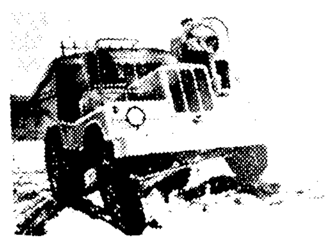

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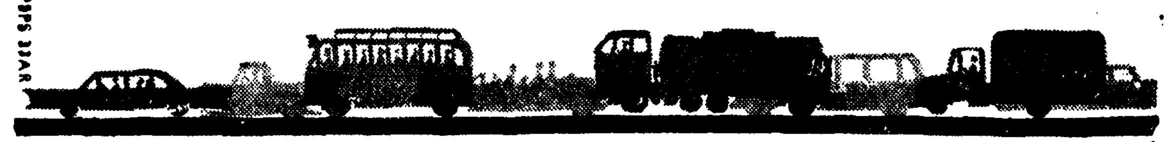

TRANSPORT-COMMUNICATIONS MONTHLY REVIEW

A REVIEW OF
ROAD ENGINEERING, DEVELOPMENT & TRANSPORT

JANUARY 1961

ROADS AND THE THIRD FIVE-YEAR PLAN

MORE and better roads are no longer a matter of administrative convenience but are an imperative economic necessity today. Adequate investment in roads is, therefore, essential if the objectives of our planned economy aiming at the rapid development of our industry, commerce and agriculture have to be achieved fully. Increased production would be of no value unless there are sufficient facilities for distribution. Roads must be provided to carry agricultural commodities to the markets, to ensure smooth flow of goods required for industry and commerce, and also to meet other transport requirements. A vigorous drive is, therefore, necessary to accelerate both the expansion and improvement of the road system of the country.

The Draft outline of the Third Five-Year Plan envisages a total outlay of Rs 10,200 crores which is nearly twice the provision included in the Second Five-Year Plan. This means more outlay on agriculture, more on industries and more on irrigation. But how much for roads? They get Rs 250 crores only which is nearly the same amount as that provided in the Second Five-Year Plan. One wonders why this lack of appreciation in regard to road requirements of the country!

That roads are a basic social necessity and, as such, a primary charge on the public exchequer is already recognised by all and hardly needs any special emphasis. Even in terms of economic-worthiness, roads have proved themselves to be a sound proposition and are contributing through road transport to the national exchequer much more than what is being spent on road communications at present. The total revenue expected to accrue from road transport in the Second Five-Year Plan is likely to be of the order of Rs 660 crores as against the total provision of Rs 248 crores included for road development in the current plan. It is estimated that the revenue from road

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transport may go upto nearly Rs 900 crores in the Third Five-Year Plan, which is nearly two and a half times the expenditure incurred on the development and maintenence of roads in the Third Five-Year Plan.

Judged from the point of view of employment potential also, roads and road transport, present a formidable case for a higher allocation. Recent studies made in this connection have revealed that roads and road transport provided direct and indirect forms of employment for 2.4 million persons in 1959. This employment is widely dispersed regionally and occupationally, particularly in the lower income groups. It is significant that out of 2.4 million persons referred to, road construction and maintenance account for no less than 0.97 million, i.e., nearly 41 per cent.

As the country develops in productivity and prosperity, it is faced with a staggering problem of keeping pace with the traffic growth. So rapidly is the vehicular traffic increasing both in respect of volume and load carrying capacities—and this is bound to increase in future in the country—that even the substantial highway improvements that have been made shall not be enough to meet the requirements of future road transport.

Production of commodities in 1965-66 requiring long distance transport is expected to be of the order of 300 million tons against 182 million tons in 1960-61. At the end of the Second Five-Year Plan, the railways are expected to carry 162 million tons. There will, thus, be a gap of 20 million tons which has to be carried mainly by road transport. The share of goods traffic to be carried by road transport in the Third Five-Year Plan is expected to increase much more than this volume and on that score also roads more than justify an increased provision.

A recent review of the road requirements of the country has revealed that even for meeting the absolute minimum requirements of our national highways only, which constitute the main arterial roads of the country, a sum of Rs 120 crores is required for developing the existing National Highway system alone in respect of the improvement of road surface and the construction of missing links and bridging of unbridged river crossings. The amount required for meeting the minimum requirements of the country as a whole will work out to nearly five times the amount required for national highways which brings out the palpable meagreness of the proposed provision of Rs 250 crores.

It is time that serious thought is given to this vital problem and Immediate action taken to bring home to the authorities concerned the gross inadequacy of the proposed provision for roads and the dire urgency of increasing that provision commensurate with the needs of our expanding economy lest it is too late to retrace the steps. Let us not forget that a country pays for roads whether it has them or not—and it pays more for those it does not have.

THE REASONS FOR ROADS

By

R. G. HENNES *

MOST road construction is undertaken because some existing facility is clearly inadequate to serve its traffic. This is wrong. Highway transportation is much too important to be regarded through a simple market-place concept of supply and demand. Road improvement which is undertaken in blind reaction to the prevailing pressures of the moment is apt to be extravagent; early obsolescence may make it expensive according to any realistic annual-cost basis of reckoning; absence of long-range planning may make it highly imprudent if all true social costs are considered.

The value of good roads will never be fully realized unless highway engineers and administrators pause to consider the many purposes which good roads serve directly in a modern society, as well as the many indirect social and economic consequences of road improvement. If we can achieve some meeting of minds on what goals a society can hope to attain by its investment in highways then we can resolve how these goals can best be reached. Until we are satisfied that we understand why we build roads we cannot be sure where roads should be located, to what standards they should be improved, what limitations should be placed on vehicle size and weight, what expenditures are justified, how road costs should be financed.

These philosophical concepts are not academic; they are thoroughly practical; and they are violated daily because modern highway engineers and traffic engineers have been trained to design roads to meet predetermined traffic patterns, rather than to design roads which will create socially desirable traffic patterns. The usual approach tends to confirm and strengthen lines of communication which were established in response to the needs of ancient and outmoded cultures. Primitive paths and trails were laid out by the feet of hunters, who in turn were following the trails of wild animals wandering to water holes in Gaul or to salt licks in Kentucky. Other routes were established by caravans engaged in the spice trade, or by emissaries of barbaric kings to more primitive tribes in the borderlands. These indeed were rationally located routes, but the circumstances which justified their location have been buried by centuries of time. But once in existence these ancient routes induced further traffic, and traffic-serving settlements sprang up along their ways. Villages at the cross roads became cities. Many European capitals grew from river ports—close enough to the sea to serve a maritime commerce of galleys and barges, but far enough upstream to discourage piratic forays. Thus the ultimate determinant of city planning and highway location would seem to be the thirst of buffalos or the rapacity of Norse pirates.

Routes thus established now control where tomorrow's population will live and work, worship and play. There is

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a growing store of factual data regarding the extent and manner in which roads affect social and economic development. After reaching some critical stage in their growth, urban areas feed on themselves, sprawling out into the countryside in everwidening fringes along the main highways radiating from the central city. It is unnecessary to expand upon the urban problem—slums, traffic congestion, worsening problem of home-to-work transportation, inadequate facilities of all sorts—but as cities exist for the interchange of goods and services, and as transportation is an integral part of all such commerce, so we may confidently affirm that transport is at the root of all basic urban problems, and at the same time offers our best hope for their alleviation. We cannot undo all that has been done in the past, but we can resolve that future highway expenditures shall be far-sighted investments for the betterment of the whole society.

Nor can we design pavements properly without due consideration for ultimate social objectives. A road to serve only the national defense would be built to different standards than one designed for recreational travel; a road built to provide access to commercially valuable forests, would look quite different from one built to bring farm products to the railhead. These special purpose roads will differ in width, in surfacing, in curvature and gradient. They will differ in unit cost. If we are not quite clear on what purpose the road is to serve we will waste money.

A closely aligned question concerns the imposition of legal restrictions on the size and weight of highway vehicles. After a nation has substantially completed the improvement of its highway network it no longer has unlimited [illegible]dom of choice in this matter. The axle load must be that for which [illegible]ghway system was built. When [illegible] grade is saturated after the rains, [illegible]e passage of a grossly overweight vehicle may destroy the whole pavement. A few years ago the Western American states collaborated in observing road damage done by various types of vehicles operating over a test road in Idaho. 90 per cent of the damage occurred during those few months of the year when the moisture content of the subsoil exceeded its mean value by only 2 per cent. Whatever economic advantage heavier vehicles might give to the highway user is offset by the overwhelming necessity of protecting the total highway investment, once it has been made. The problem can be faced only at the outset of a major program of highway expansion or reconstruction. At such a time the highway engineer or administrator should inquire, "what is the economic size of highway vehicle, all costs considered?" Studies of this problem in the logging industry of the Pacific Northwest of the United States disclosed that optimum vehicle size depended not only upon lorry and road costs, but also upon length of haul and other aspects of vehicle operation. Any regulatory action in this matter must also take account of the extent of competition existing or desired between highway transport and rail, water-carriers, or pipeline. Other investigations have indicated that motor freight and rail freight become competitive at hauls greater than 200 or 300 miles in the U.S.A.; the break point would vary from nation to nation, and from time to time in the history of the same nation. Whether or not to design roads for the use of longer haul freight movements requires a policy decision based upon consideration of total transportation costs by each transport agency. If long distance highway hauling is to be encouraged the optimum vehicle size will increase, and a stronger highway surface will have to be built and paid for.

Paid for by whom? Highway finance is an integral part of the whole transportation complex. When and where and how roads are to be built or improved are questions [illegible]

to the availability of funds for road-building purposes. This is less simple than it sounds: it is complicated by the fact that the allocation of responsibility for road costs involves questions of joint use, and further complicated by problems of pricing the facility so as to maintain neutrality of treatment accorded to the various transport agencies (rail, air, water, etc.). With respect to the former point it should be noted that much road use occurs in the exercise of accepted functions of government: national defense, maintenance of internal law and order, development of natural resources, and so on. Presumably to the extent that road costs reeflct this sort of usage, roads should compete with education, welfare and other objects of governmental concern for a share in the general funds of government, apportioned according to the wisdom and discretion of legislative bodies and public administrators. But there are active and dormant public demands for road improvement to standards much higher than those which are essential to the exercise of normal governmental functions; this incremental highway usage is an aspect of personal consumption of the facility (for individual recreation or convenience) or it is a part of the overall process of production and distribution. These incremental costs should be charged against the private users of the highway facility in proportion to the incremental or marginal costs entailed by this usage, so that the pricing of the highway facility will influence demand and encourage the rational allocation of the national resources. These considerations merge with the second factor mentioned earlier: the problem of achieving maximum productive efficiency by minimizing transportation costs through the maintenance of neutrality in the treatment of competing transportation agencies. This latter requirement also can be realized through the allocation of tax responsibility according to the incremental cost entailed by each class of highway user.

If basic highway costs only are charged against general governmental revenues, and if all the incremental costs of road improvement are fairly collected from the various classes of highway users, more funds will be made available for justifiable road expenditures. If, then, available funds are expended according to the dictates of long-range planning, there would be reason to expect that the highway investment would become highly profitable to the whole community. An enlightened highway policy will reduce overall production costs, increase the gross national product, and in the long run encourage the selection of land uses for the betterment of the common weal.

The development of national highway policy along the lines suggested in the foregoing pages calls for a vast amount of data, some regarding the national and regional economies; and some dealing with technical aspects of motor vehicle operation, its influence on road design, and its influence on economic and social activity. In the former category India is fortunate in possessing its Five-Year Plans and the body of economic data upon which they are based. In the balance of this paper I want to discuss a massive effort, now nearing completion, to collect factual information on the benefits conferred by highway improvement, the effect of roads on land values, the effect of roads on the economic activity of the community and nation, the effect of roads on agriculture and the development of natural resources, the economics of vehicle size and weight, the incremental costs of road improvement attributable to various sizes and classes of highway vehicles, the effects of road improvement on the costs of motor vehicle operation, and the rational design of road surfacing and highway structures to sustain various axle loadings and gross vehicle weights. Many of the results of these investigations will be applicable to roads everywhere, and all of the findings should be of interest to all who are concerned with highway policy and design.

There are two major parts to this total research effort, differing both in sponsorship and in substance.

The test road at Ottawa, Illinois (U.S.A.), was sponsored by the American Association of State Highway Officials, and supervised by the Highway Research Board of the National Academy of Science (U.S.A.). The total cost of this enterprise, in excess of 30,000,000, dollars is being defrayed by contributions from the individual American states, assisted by grants from the federal government and from industry. Test vehicles covering a wide range of gross weight, axle loading, and axle distribution have been in continuous operation, each type on its own test loop. Each test highway loop is composed of contiguous sections of rigid and flexible pavement, involving many variations of total thickness, surfacing thickness and base thickness. Special care was taken to obtain uniformity in the subgrade soils. A number of short span bridges of varying types are part of the set up. Elaborate instrumentation is characteristic of the entire operation. The tests are carried through to destruction of the weaker sections, and necessary maintenance of all sections is carefully recorded. From the resulting data analysts should be able to resolve many presently evasive uncertainties regarding the design standards corresponding to various traffic conditions. There are obvious implications regarding tax responsibility of different vehicle classes that undoubtedly will be inferred by those who study the test findings. Nothing approaching this monumental research undertaking has ever before been attempted in the highway field, and it is not likely that any more exhaustive study of this particular problem will ever be undertaken in the future. I assume that at least a preliminary report on the project will be presented at the January 1961 annual meeting of the Highway Research Board in Washington D.C.

A second research effort of comparable importance is now being completed by the U.S. Bureau of Public Roads. You may know that the 1956 and 1958 Highway acts of the American Congress committed the Federal Government to much heavier participation in an enlarged road building program. Most importantly, these acts authorized a federal contribution of 90 per cent of the cost of constructing a 41,000 mile network of limited access inter-regional highways connecting all the major population centres of the nation. This contrasts with a previous 50 per cent contribution toward a much less ambitious program. The funds for the heavier road expenditures are collected entirely from highway user imposts, the revenues from which are deposited into a Highway Trust Fund. The higher taxes necessary to finance the enlarged program naturally evoked considerable testimony at Congressional hearings from highway user groups and affected industries. To secure equity in financing, Sec. 210 of the 1958 Highway act requires the Bureau of Public Roads to conduct a study of highway cost allocation; a report on their findings is scheduled for presentation to the 1961 Congress. I feel confident that the forthcoming report will make good use of available data from the AASHO test road, but in addition to that body of information the Bureau of Public Roads has contracted with universities and research institutes for dozens of studies on many subjects: highway benefits accruing directly to the user, to the owner of adjacent land, to the business activity of affected communities. Major reliance is placed upon the incremental cost method of allocation, but consideration of other theories also is stipulated in the act. The report should make a massive addition to our knowledge of the social and economic consequences of highway improvement.

(Continued on page 11)

ENGINEERING AND CIVILIZATION

(Abstract of a lecture* given by SIR HUGH BEAVER†

K.B.C., M.I.C.E., M.I.CHEM. E., M.E.I.C.)

IT particularly falls to the engineer, the applier of science, to see himself as part of a service to his country and to mankind, and to condition his thinking accordingly. Thus it is that it is one of our greatest problems to see how, in spite of specialisation in so many directions, we engineers may still recognise and have some common purpose and some ultimate worth-while objective as being the real heart and final justification of all engineering effort.

The greatest danger that we face in the world today is that science and technology should not realise or should ignore what they owe to humanity; and that the arts, whatever that is taken to cover, should seek to or seem to maintain, wittingly or unwittingly, the wall that from time to time—but not always—has been erected round them. We cannot afford and we cannot risk this division between the so-called humanities on the one side and science on the other; and it is in my opinion wholly meaningless.

The meaning of civilization

Whatever setbacks and difficulties there have been and will be, whatever bright flowerings and black eclipses, civilization is a continuous motion steadily and relentlessly pressing forward all the time. That is the sense in which I use the word civilization.

A crisis of history

The population of the world is advancing at a staggering rate. It is now not very much short of 3,000 million and at the present rate of increase will or could be 4,000 million in 20 to 25 years time and 5,500 million by the end of the century. There are now new civilisations like that of Russia or old civilisation like China or Asia pushing into the forefront and obviously going to take dominant place in the picture and tomorrow there will be Africa also. To add to all this, science and technology have brought us to the very edge of potential world destruction; advanced scientific research has brought us perhaps just to the threshold of the secret of the artificial or synthetic creation of living organization.

It is certain that our own country and the Western world are at a critical point in history—whether the next stage is our further advance or the overwhelming of our civilisation, using the word in Professor Toynbee's sense. This is the situation, which engineers have done so much to create, and in which they now find themselves faced with the problem whether they can save it.

The special responsibility of engineers

Engineers have a special long-term responsibility because it is they who

* Delivered at a Joint Meeting of The Institutions of Civil Engineers, of Mechanical Engineers, and of Electrical Engineers, at The Institution of Electrical Engineers, Savoy Place, on 3 March, 1960.

† Managing Director, Arthur Guinnes, Son & Co.

have built this modern world of convenience and comfort; and who all through the ages have not only been improving conditions of life but have also produced all the means and machines of destruction.

Some looked on engineering as just a development from the crafts, and have said that only in the last 200 or 300 years has there really been any science to apply. Others have looked on engineering as essentially being the ability to get machines and instruments to do the job of manual workers, and so have considered that engineering is only the product of recent centuries when shortage of labour began to be the ruling factor.

I do not think either view is tenable. It is in my opinion both incorrect and dangerously misleading to think that the basis of developed engineering ever was or is shortage of manpower. In fact today we in this country are, in a way, proving, or perhaps trying to prove, the very opposite—that manpower is the basis of engineering and not the shortage of manpower. For in this most highly developed age of engineering, with a far larger proportion of our people engaged industrially, and therefore in engineering, than in any other country, and with all the inventions and labour-saving devices in use or foreshadowed, it is likely that we in these islands may eventually find ourselves outdistanced by our competitors, simply because of their greater sources of manpower—and for no other reason.

As Sir Maurice Bowra has said, we must certainly admit that, without engineering, civilization is impossible; and even though, as he thought, it was not always of first importance, yet without engineering a civilization is doomed. China and Greece and Rome in turn, as he sees them, paid the price for treating engineering as of secondary importance and lost their leadership in the world of their days.

Education in an age of technology

The question then that again faces us here is not what are the proper proportions of our manpower to be directed or attracted to this discipline or that; but how we are best to educate this and future generations in which inevitably the preponderance of the educated output must for ever be scientific and engineering.

I accept the terms, arts and humanities, as describing a side of life which has in the past been often and insistently distinct from science or the applications of science, that is to say, engineering. I do not consider that can be accepted today.

Establishing the ends

Much thought is being given by many educationists to the problem of producing the adequate citizen for the new world, for furnishing citizens who can deal with the problems of a scientific world whether they approch them from the side of arts and the humanities or from the side of science and engineeing; and in particular to produce the scientist and the engineer as full educated citizens of their country and of the world.

But how much thought is being given to it by engineers themselves? The engineer is responsible for all the physical basis and development of civilization, it is he who sooner or later translates into action every discovery of science; he lives much closer to life as it is lived by the ordinary man than does the scientific researcher. Here then are both his responsibility and his opportunity.

Here too we have another aspect to be considered. Engineering has never, as Sir Maurice Bowra sees it, been revolutionary in the political sense. "If we regard politics as the struggle for power, engineering is", he says, "not a political activity". I think it would be difficult to be quite certain that this has always been so; but, by and large, I belive we must accept the charge. But no one has the right to disclaim or "opt out" of politics, least of all the engineer. The Greeks had for such a one—as for other types—a name. They called the citizen who took no active interest in politics—a private person—an ideiorns. Hence our word idiot!

Is this then not something to which the great institutions should give continuous—and not just occasional—thought? They have in their combined membership a great body of practical people. They can have profound effect on education. Moreover, education goes on all through one's working life, and if it seems difficult—although I personally do not accept this—to see how schools and universities can at the same time produce in the same person both the scientist and technologist and the man of wide vision, then is it not possible for the institutions to see how far they can in part at least rectify this omission in the post-university life—in the working life; looking on themselves not solely as platforms for technical discussion but as providing the means of studying how there can be greater contribution by engineers of the future to the civilization of the future?

(*From "Journal of the Institution of Civil Engineers, U.K.", August 1960*)

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(*Continued from page 8*)

The location of roads, the design of roads, and the financing of roads are, or should be, closely related to a fundamental understanding of why roads are built, and what a nation stands to gain from highway expenditures. The AASHO test road and the Highway Cost Allocation study of the Bureau of Public Roads together should provide more information on these points than has been available ever before. As an adjunct to a comprehension of the economic goals and resources of any specific nation or area, these reports should be helpful anywhere in the establishment of highway policies that would confer maximum benefits on the community and the nation, in the short run and in the long run.

"I consider the existence of good roads as a vital factor in determining whether our society can become an equilitarian homogeneous one or will continue merely as a conglomeration of social groups leading their own separate lives and maintaining different levels of social and economic development."

— Dr. Rajendra Prasad

ROAD DEVELOPMENT IN RAJASTHAN

By

KISHORELAL*

THE State of Rajasthan, as reconstituted on the 1st November 1956 under the States Reorganisation Act, 1956, has come into existence through seven different stages of merger of the nineteen erstwhile princely States and the former Part 'C' State of Ajmer as well as the transfer of small enclaves from one State to another. The State's population of 15.97 millions (1951 Census) is spread over an area of 1,32,148 sq. miles. The density of population per sq. mile works out at 121. It is the most sparsely populated State in India next only to the State of Jammu and Kashmir, whose density of population is 54. On the Northern and North-Eastern boundaries of Rajasthan lie the States of the Punjab and Uttar Pradesh, on the South-Eastern boundary lies the State of Madhya Pradesh and on the South-Western boundary lies the Gujerat State. On the South-Western and North-Western boundaries lies West Pakistan. The Arravali Range runs from North-East to South-West almost across the entire State, dividing it into two parts—the North-Western, which comprises 3/5th of the total area and the South-Eastern which covers about 2/5th. The North-Western region is on the whole a sandy, ill-watered and unproductive area; it improves gradually when one moves from West to East and in the extreme West, it is a mere desert, while towards the East it is comparatively fertile and habitable.

At the time of formation of Greater Rajasthan in March 1949, the State inherited a poor system of communications. Even the five main cities, viz., Jaipur, Jodhpur, Bikaner, Kota and Udaipur were not connected with each other. Except for Delhi-Jaipur-Ajmer-Sirohi Road, there was no inter-state road. The construction of bridges over rivers was considered an expensive affair and by no means within the means of individual princely States. Each princely State lived in an isolated existence and cared only for its own development within its own frontiers and did not encourage inter-connection between the adjoining States. In 1949, we had only 4,000 miles of metalled and gravelled roads and another 4,000 miles of Fair Weather tracks. The incidence of road mileage was the lowest amongst all the States of India both on population as well as area basis.

After 1949, the Rajasthan Government took upon itself the responsibility for the construction of missing road links, improving old existing roads and construction of new roads, but very little progress was made in the two years preceding the commencement of First Five-Year Plan owing to the limited resources of the State. The break-up of different categories of roads at the beginning of the First Five-Year Plan (i.e., as on 31-3-51) is indicated below:

1. Cement concrete	...	14 miles
2. Black-topped	...	525 ,,
3. Metalled	...	2,833 ,,
4. Gravel roads	...	2,041 ,,
5. Fair weather roads	...	5,357 ,,
Total	...	10,770 miles

*Chief Engineer (B & R), Rajasthan, Jaipur.

The above roads are marked on the map of Rajasthan below.

First Five-Year Plan

The first phase in the planned development of road system started with the launching of the First Five-Year Plan. The main principles kept in view were to connect various centres of administrative units, viz., the Divisional, District and Sub-divisional Headquarters and also other commercial centres of the State. The plan involved an outlay of about Rs 7 crores, out of which an amount of Rs 551 lakhs was provided under the State Plan, Rs 54 lakhs against Central Road Fund and another sum of Rs 75 lakhs on the improvement of N.H. No. 8 passing through Rajasthan. In terms of physical targets, the Plan provided for the construction of 1,861 miles of new roads and improvement of 1,369 miles of existing roads. Actual progress of the Plan was rather slow during the initial two years of the Plan-period and the total expenditure during this period was only about 10% of the total outlay. This was due to the impediments, which usually come up at the initial stages of execution of the Plan. The State came into existence in 1949, i.e., only two years before the beginning of this Plan and was required to fall in line with the older and well-established States with highly developed economy and efficient administration. Political, administrative and financial problems had also to be faced by the State Government. All these difficulties were surmounted and the tempo of work was accelerated during the later years. As against an outlay of Rs 605 lakhs on road sector including grants from Central Road Fund, the total expenditure during this Plan-period was about Rs 535 lakhs. During this period, 1,304 miles of new roads were added and 1,026 miles existing roads improved. Besides, 69 miles of roads were up-graded under centrally sponsored schemes and 177 miles of N. H. No. 8 improved. About fifteen bridge-works including three major bridges were completed. The road mileage at the end of First Five-Year Plan is shown in Table 1.

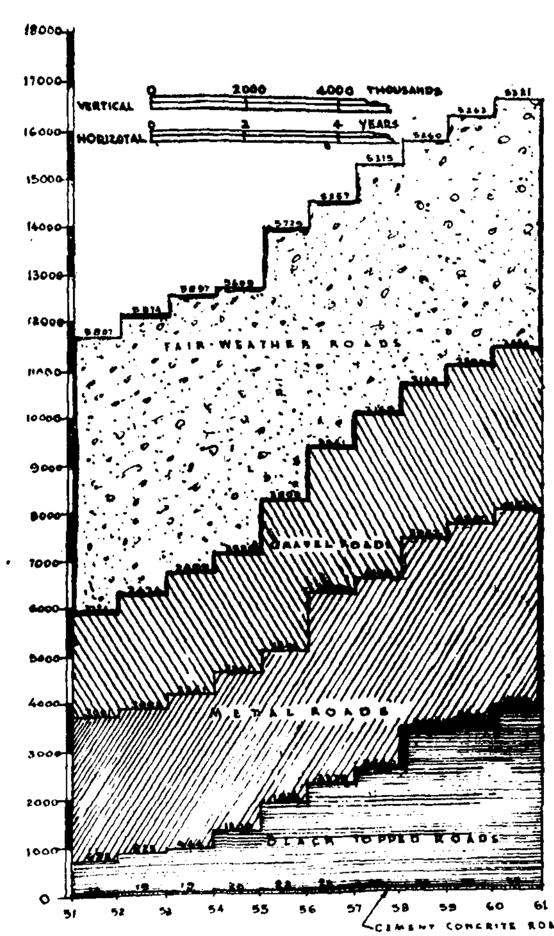


Chart 1 showing mileage of different types of roads maintained by Rajasthan P.W.D. (1951 to 1961)

Second Five-Year Plan

The second phase in the road-development started with the Second Five-Year Plan. The objectives in framing this plan were the same as out-lined in the Nagpur Plan, but as the Planning Commission allocated only Rs 8.99 crores for Road Sector in the State Plan against the requirement of Rs 35 crores, the programme envisaged originally had to be drastically curtailed. The sanctioned allotment of Rs 8.99 crores was increa sed by a sum of Rs 42.50 lakhs after the merger of former Ajmer State in Rajasthan. Thus the total outlay in the State Plan has increased to a figure of Rs 9.41 crores. Against this, the anticipated expenditure during the plan period is expected to be Rs 9.87 crores.

In addition to this amount, works on the National Highway costing Rs 1.30 crores will be completed during the Second-Plan period and Rs 72 lakhs will be utilised under the scheme for the construction of Roads of Economic and inter-statal importance. The State's annual share under the Central Road Fund is about Rs 12 lakhs and it is expected that a total sum of Rs 60 lakhs will be available during the Second Plan-period. This will be fully utilised.

The total expenditure on roads during this Plan, therefore, is expected to be about Rs 12½ crores. The following physical targets are likely to be achieved during the Second-Plan period :—

Construction of new roads : 2,656 miles
Improvement and up-grading: 1,972 „
C.D. Works (Aggregate linear waterway) : 3,500 R.ft.

The progress of the plan-works during the first four years has been very satisfactory and the expenditure during the first four years amounts to Rs 708 lakhs. It is anticipated that a sum of Rs 279 lakhs would be spent during the last year of this Plan. The anticipated road-length in the State at the end of Second Plan is shown in Table 1 below.

TABLE 1.

S. No.	Type of road	Total length of roads at the end of First Plan in miles	Anticipated lengths at the end of Second Plan in miles
1	Cement concrete ...	22	25
2	Black-topped ...	1,936	3,826
3	Metalled roads ...	3,501	4,154
4	Gravelled roads ...	2,800	3,444
5	Fair Weather roads ...	5,729	5,321
	Total	13,988	16,770

This includes 1,284 miles of Municipal and other roads that were transferred to to the Public Works Department during the First Five-Year Plan period.

The position of the different types of roads, anticipated at the end of the Second Five-Year Plan is shown in *Chart No. 1* enclosed. The *Chart No. 2* indicates annual expenditure on Original Works—Communication, for the whole State from financial year 1951-52 to 1960-61. Perusal of the Chart will reveal that there has been a gradual increase in the yearly expenditure.

Bridges

Since the formation of Rajasthan, construction of bridges over the unbridged crossings on existing roads is being

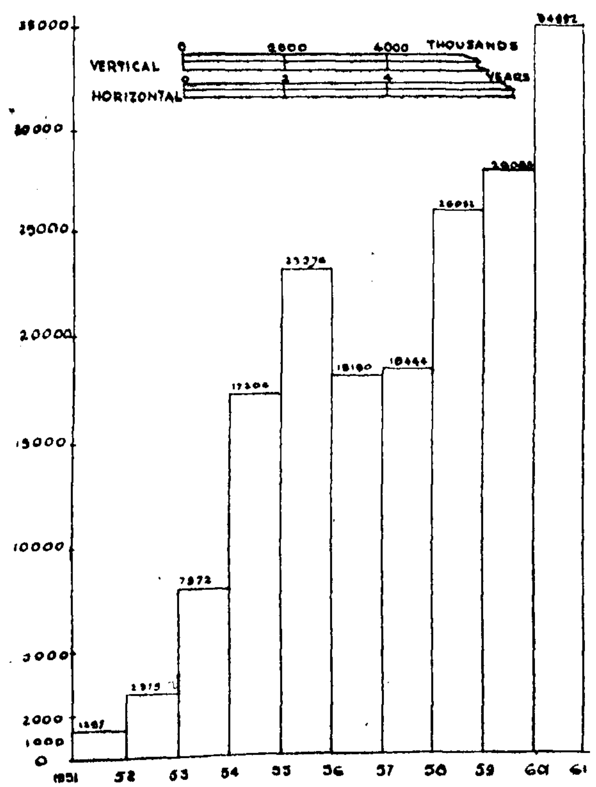


Chart 2 showing expenditure on original works—communications.

given top-most priority. A large number of bridges have been completed during the last 10 years. Some of the important bridges are listed below:

1. **Achrol Bridge**: Superstructure consists of one span of R.C.C. arch of 60 ft and three spans of masonry arches each of 36 ft.
2. **Som River Bridge**: Superstructure, 2 spans of 60 ft R.C.C. arches and 7 spans of 30 ft masonry arches.
3. **Khari River Bridge**: 18 spans of 36 ft each.
4. **Banas River Bridge**: 12 spans of 60 ft each.
5. **Manoharpur River Bridge**: 4 spans of 42 feet each.
6. **Bandi River Bridge**: Raft foundations—24 spans of 20 ft each.
7. **Berach River Bridge**: 4 spans of 60 ft clear R.C.C. arches and 3 spans of 40 ft stone masonry arches.
8. **Dhoond River Bridge**: Raft foundations—53 spans of 12 ft each.
9. **Bharna Nallah Bridge**: 3 spans of 40 ft each; masonry arches.
10. **Ahu River Bridge**: 9 spans of 40 ft each; masonry arches.
11. **Submersible Bridge over Mahi River**: 14 spans of 20 ft each.
12. **Submersible Bridge across the Hiren River**: 18 spans of 20 ft each.

For photographs and other particulars, the readers are requested to peruse Annual Report 1959 of Indian National Group of the International Association for Bridge and Structural Engineering, New Delhi.

Special Problems: The work on road construction in some parts of Rajasthan presented peculiar problems. In Bikaner—Ganganagar areas, there are no hills and mountains worth the name. Even kankar of good quality is not available. In the beginning of the First Five-Year Plan, there was practically no road in this area, except the half-completed Bikaner-Rajgarh-Delhi road. A search was made for suitable clay and experiments were made to construct road with burnt-brick soling and Jhama ballast. This technique was very successful and about 200 miles of roads have already been constructed in Ganganagar District with this type of specifications. Cost of construction with this method is rather high and slack coal for burning bricks has to be brought by rail over a distance of about 1,000 miles from Coal mines in Bihar. Experience has shown that slack coal is not available in abundance. In order to obviate these difficulties and to effect economy in construction-cost, we are now working on the soil-stabilised road construction and few miles of this type have already been laid. This is expected to bring down the cost by 30 per cent in comparison to the brick and jhama construction.

Third Five-Year Plan

Though very steady and satisfactory progress has been made by the State in improving means of communications during the last 10 years, the network of roads' system can by no means be called adequate. The Third Five-Year Plan for road development had been formulated in accordance with the "20 Year Road Development Plan for India" recently drawn up by the State Chief Engineers, but owing to the paucity of funds, it will not be possible to undertake the development of roads in the Third Five-Year Plan, at the pace envisaged in the 20 Year Plan. An amount of only Rs 13 crores has been provided for road sector in the State Plan as approved by the Planning Commission, Government of India against our requirements of 43 crores of rupees worked out on the basis of 20 Years' Road Development Plan.

The following objectives have been kept in view in the formulation of the Third Plan:

1. To connect all villages with a population of 5,000 and over by surfaced roads.
2. To connect all Tehsil head-quarters, the Panchayat Samiti head-quarters and most of the Police stations, with the District Head-quarters.
3. To connect important mining areas and quarries with the general road-system or with rail heads.
4. To provide an adequate road-system in the newly developed Bhakra Canal area and the Rajasthan Canal and the Chambal areas.
5. All State Highways and all Major District Roads would be fully bridged.
6. To provide black-topped surface to important State Highways and Major District Roads.

The Plan envisages the construction of 2,896 miles of new roads and improvement of 1,063 miles of existing roads as detailed below:

Construction of new Roads	*Miles*
(a) Metalled roads	1,780
(b) Painted roads	428
(c) Gravelled roads	688
	2,896
Improvement of existing Roads	*Miles*
(a) Bitumen treatment of metalled roads	685
(b) Metalling of gravel or fair weather roads	253
(c) Gravelling of fair weather roads	125
	1,063

It has been decided that the construction of the approach roads to towns and villages will be entrusted to the Panchayat Samitics. Out of the total outlay of Rs 13.00 crores a sum of Rs 1.05 crores has been earmarked for being granted to the Panchayat Samities for the construction of such approach roads. The Panchayat Samities will augment this amount by their own contribution of an equal amount, either in cash or by way of voluntary labour.

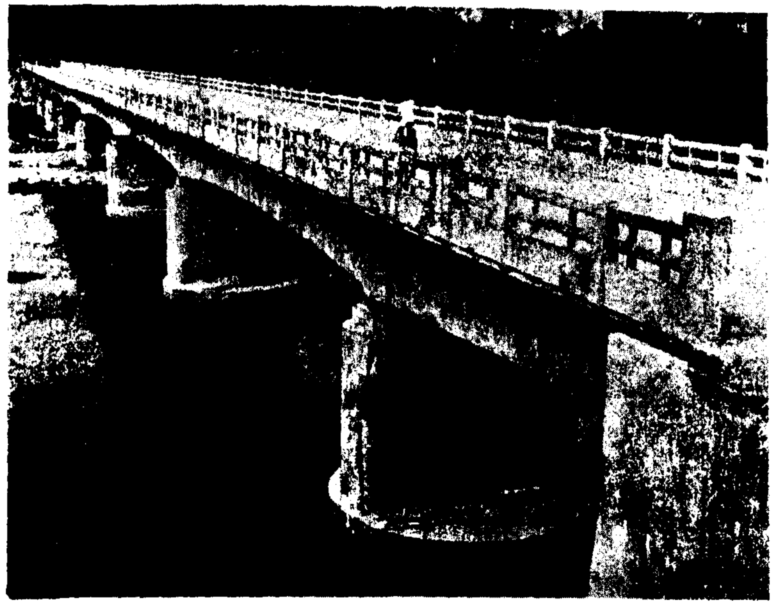
Such is the fascinating story of the development of roads in Rajasthan. It is true that we have yet to cover considerable grounds to come up to the level of neighbouring States but we are certainly on a more firm footing today than ever before. With the interest shown by the people in the Plan and with the participation of Panchayat Samities in the execution of works, the Third Five-Year Plan can truly be termed as the "Peoples' Plan" and it is certain that the benefits of the Plan will reach the millions of people inhabiting the sprawling State of Rajasthan.

BRIDGING ACTIVITIES IN ASSAM

By

K. BARUA*., B.E., M.C.P. (Calif.) M.I.E. (Ind.)

BESIDES the mighty Brahmaputra flowing majestically through the entire length of Assam, the easternmost state of India, there are innumerable tributaries having their source from the lower reaches of the Himalayas and from the Southern hill ranges of Assam feeding this mighty river. Bridging of these rivers including the Brahmaputra to afford uninterrupted movement of traffic is a stupendous task involving huge financial commitments. There were about 300 unbridged rivers in the road system of Assam at the time of Independence, aggregating to a length of about 58,000 R. ft.



DIKRONG-BRIDGE

A bridge over the Brahmaputra, which has not yet been bridged in its entire length, is under construction by the Railways. This will be a rail-cum-road bridge and when completed will afford uninterrupted rail and road

*Chief Engineer and Secretary, P.W.D. (R & B Wing), Assam, Shillong.

communication between north and south of Assam.

Practically, only after the Independence, serious attempt has been made to construct major bridges over the rivers which were crossed by ferries. Since 1947 upto the end of the First Five-Year Plan period, eight major bridges (total length 2,969 ft) were completed at a cost of Rs 33.5 lakhs.

In the First Five-Year Plan, provision was made for the construction of eight major bridges at an estimated cost of Rs 432 lakhs, which spilled over to the Second Five-Year Plan as given in the following paragraph.

In the Second Five-Year Plan provision was made for the following twenty major bridges (total length 9,759 ft) at an estimated cost of Rs 178.04 lakhs. This includes the eight bridges spilled over from the First Five-Year Plan.

Spill over from the First Five-Year Plan:

Name of the River	*Length* ft	*Estimated cost* Rs in lakhs
(1) Barak	1,532	27.42
(2) Dhansiri	660	13.88
(3) Dikhu	499	11.62
(4) Jhanji	282	6.48
(5) Desang	315	7.43
(6) Gaurang	420	8.42
(7) Buroi	1,056	24.10
(State Government's share 50 per cent of the cost).		
(8) Dikrong	725	5.19
(State Government's share 50 per cent of the cost).		

New works taken up in the Second Five-Year Plan:

Name of Bridge	*Length* ft	*Cost* Rs in lakhs
(1) Bridge over Kapili on the 5th mile of Nokhola-Bhakatgoan road	550	9.78
(2) Suffrai bridge on Desang on Sepon-Safrai road	510	8.66
(3) Bridge over Jhanji at Tamulisinga on Hahsora road	300	5.30
(4) Bridge over Dhansiri on Barpathar road	280	5.09
(5) Mangaldai bridge on Mangaldai-Patherighat road	300	4.10
(6) Adabari bridge on Hajo-Mukalmua road	300	4.10
(7) Maranadi bridge	250	4.50
(8) Sonai bridge on Matinagar-Didarkosh road	300	5.30
(9) Construction of bridge over Longai on Chandkhira-Isabeel road	280	3.86
(10) Construction of bridge over Matijhuri on Silchar-Hailakandi road	450	8.50
(11) Construction of bridge over Kapili at Kampur	500	8.50
(12) Construction of Amraghat bridge over Sonai river	250	5.81

Of the above twenty (8 + 12) bridges, the following seven bridges have been completed.

(1) Bridge over Dhansiri

(2) Bridge over Dikhu

(3) Bridge over Jhanji

(4) Bridge over Desang

(5) Bridge over Gaurang

(6) Bridge over Buroi

(7) Bridge over Dikrong

Of the remaining thirteen bridges, work has started on the following eight bridges:

(1) Bridge over Barak.

(2) Bridge over Kapili on Nokhola-Bhakatgoan Road.

(3) Saffrai bridge on Desang on Sepon-Safrai road.

(4) Bridge over Jhanji at Tamulisinga.

(5) Mangaldai bridge on Mangaldai-Patherighat road.

(6) Bridge over Longai on Chandkhira-Isabeel road.

(7) Bridge over Kapili at Kampur.

(8) Bridge over Dhansiri on Barpathar road.

Short notes on completed bridges during the Second Five-Year Plan:

Bridge over Dhansiri

A balanced cantilever R.C.C. Bridge over the Dhansiri river on the 5th mile of Orang-Routa Road in Darrang District. Clear width of roadway is 22 ft

Bridge Over the River Buroi on North Trunk Road In Assam
Overall Length—1,056 ft.

between inside faces of wheel guards. Substructure consists of R.C.C. wells and R.C.C. piers. Overall length is 660 ft made up of three central spans of 133 ft each and two end spans of 99.75 ft each (centre to centre). Total cost is Rs 13,88,000.

Bridge over Dikhu

A R.C.C. balanced cantilever type bridge with well foundations and R.C.C. piers, clear roadway is 24 ft between wheel guards. Overall length is 499 ft made up of three middle spans of 110 ft each centre to centre and two end spans of 82½ ft each between centres. Total cost is Rs 12,63,336.

Bridge over Jhanji

A R.C.C. bridge with well foundation and R.C.C. piers consisting of three simply-supported spans of 65 ft 6 in. each between centres of piers and one 65 ft 6 in. span with a 20 ft cantilever arm at one end. Clear roadway is 24 ft between inside faces of wheel guards. Overall length is 282 ft. Total cost is Rs 6,48,000.

Bridge over Desang

A R.C.C. Bridge with well foundation and R.C.C. piers total length is 315 ft made up of three central spans of 65 ft each centre to centre and two end spans of 60 ft each centre to centre. Clear roadway between wheel guards is 24 ft. Total cost is Rs 7,28,101.

Bridge over Gaurang

A R.C.C. balanced cantilever cellular bridge with well foundation and R.C.C. piers over the Gaurang river at 36th mile of Phutkibari-Garubhasa Road in Goalpara District. Overall length is 420 ft between centre of bearings on abutments made up of three middle spans of 95 ft each centre to centre and two end spans of 67.5 ft each between centre of bearings. The clear roadway is 22 ft between kerbs. Total cost is Rs 7,53,119.

Bridge over Buroi

This is a prestressed concrete bridge over Buroi river on North Trunk Road East in Darrang District. Overall length is 1,056 ft made up of eight intermediate spans of 106 ft each and two end spans of 104 ft each, substructure consisting of R.C.C. wells and piers. The clear roadway is 22 ft between inner faces of R.C.C. kerbs. Total cost is Rs 16,30,500.

Bridge over Dikrong

This is a balanced cantilever R.C.C. bridge with well foundations and R.C.C. piers over the Dikrong river at Harmutty on the diversion of the North Trunk Road East in Lakhimpur District (North Lakhimpur Sub-division). Overall length is 725 ft made up of seven central spans of 90 ft each and two end spans of 47.5 ft each from centre to centre of wells. Clear roadway is 22 ft between kerbs. Total cost is Rs 14,08,700.

Bridge over Jia-Bhorolia

River Jia-Bhorolia is the largest tributary of Brahmaputra. The work for construction of a bridge over this river with the following particulars is being commenced shortly:

Length	...2,053 ft
Span	...Two end spans of 51 ft 6 in. each and fifteen intermediate spans of 130 ft each
Foundation	...R.C.C. well foundation.
Superstructure	...R.C.C. decking 24 ft wide between kerbs with R.C.C. beams over R.C.C. piers.
Estimated cost of the bridge proper	...Rs 56,30,200.
Estimated cost of the river training and protection works	...Rs 21,91,500

THE MANGALAPUZHA BRIDGE

By

P. V. JOSEPH,* B.SC., B.E.

Introduction

OPENING of the Mangalapuzah Bridge over the right arm of the river Periyar on National Highway No. 47 between Alwaye and Desam replaced a ferry which was inadequate to meet the present-day requirements and thus fulfilled a century old cherished desire of the people. This bridge has got great commercial importance.

The Mangalapuzha bridge is the first road bridge on the right arm of the

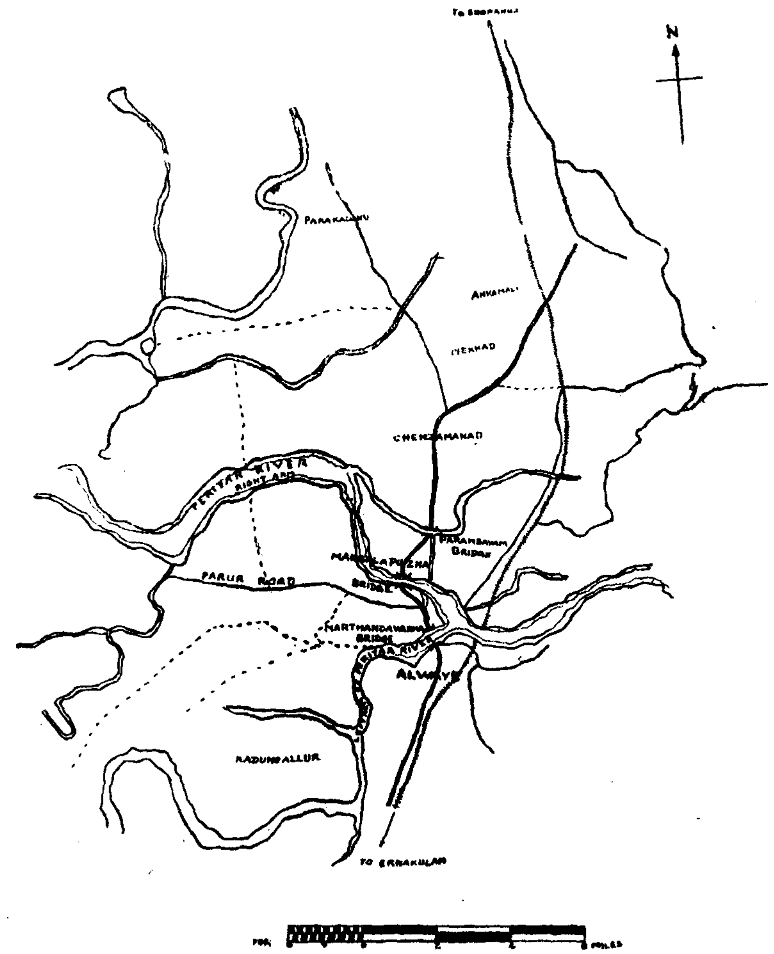
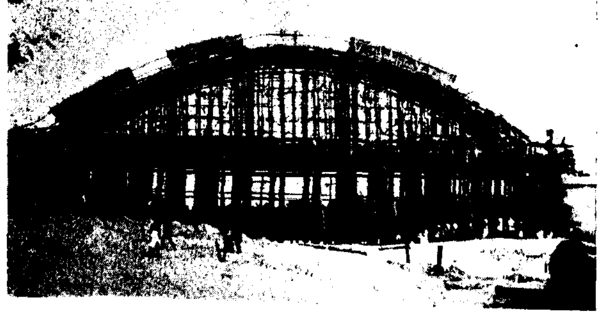


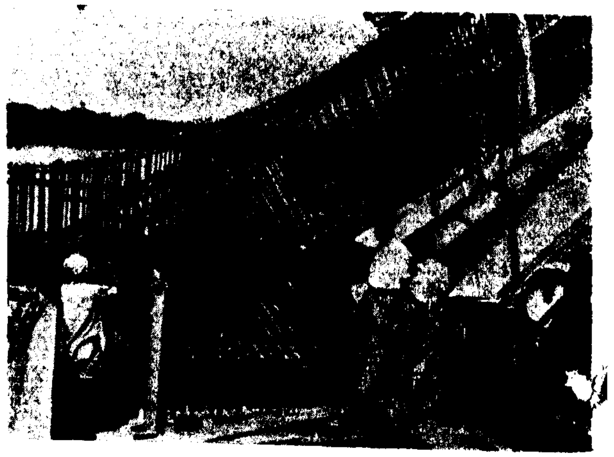
Fig. 1 KEY MAP
Mangalapuzha Bridge on N. H. No. 47

* Executive Engineer, Bridges Division, Alwaye, Kerala State.

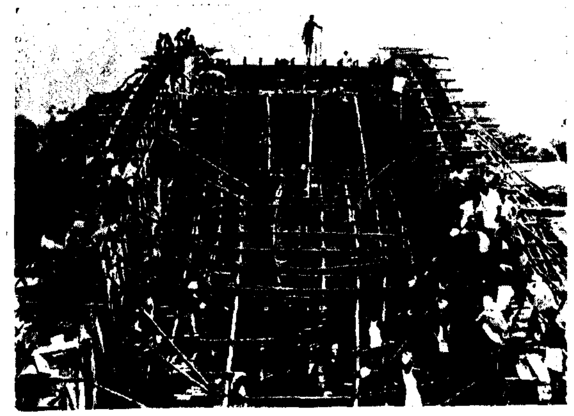
A view of the completed bridge



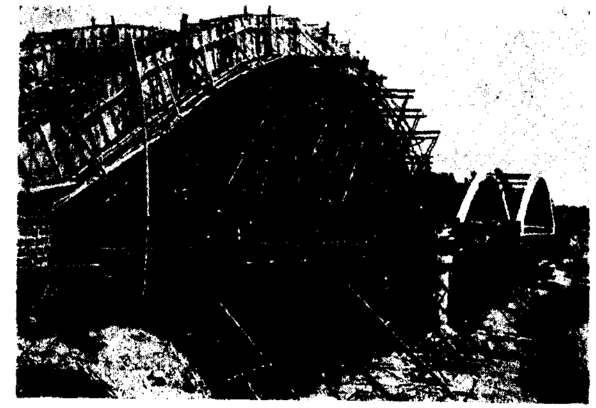
Details of scaffolding and centering



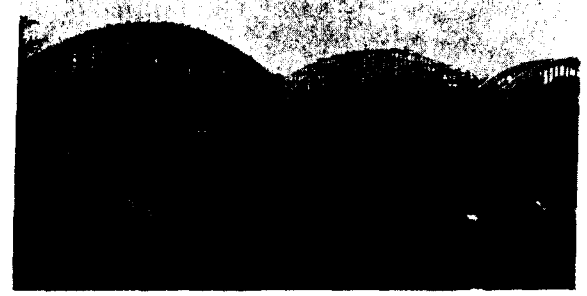
Reinforcement details of springing of arch



Concreting of the arches in progress



Formwork for the left end span nearing completion



River being diverted through the completed right end span. Formwork for the other two spans in progress

river Periyar. The bridge is located about four furlongs downstream of the ferry crossing where the river has got the narrowest section and well-defined banks.

Waterway

Periyar river has perennial flow. The variation in the discharge during the dry season and during the rains when the river is in flood is considerable. It was therefore decided to provide a high level bridge.

The following justify that the ventway of the bridge need only be 450 to 480 ft.

The railway bridge which spans the river immediately upstream of the point of bifurcation into right and left branches consists of 9 spans of 80 ft. The clear distance between the abutments is 784 ft. It could be safely assumed for the purpose of the bridge design keeping in view that the right arm of the Periyar river discharges directly into the sea, and the left arm discharges into the back waters through tortuous channels, the discharge through the right arm will not exceed 60 per cent of the total. This indicated that the ventway of the bridge need be only 720 × 0.6 = 432 ft. The width of the river at the bridge site is 460 ft, maximum observed velocity during floods at the site is only 7 ft per second. Hence a bridge with 3 spans, each having a length of 162 ft, was considered ample to pass the maximum flood. This is the longest span so far adopted in Kerala State.

Consideration in the Bridge Design

Core boring results proved existence of good rock bed at 55 to 60 ft depth below the bed level of the stream. Above the rock bed there was a layer of boulders over which the soil was mostly sand mixed with clay. It was, therefore, decided to provide well foundations for piers and abutments. The site conditions indicated that foundation and substructure work would be costly and this influenced the decision to limit the number of spans to three, each 162 ft. For such long spans, steel trusses could probably be cheaper but due to the acute shortage of structural steel and non-availability of foreign exchange for high tensile steel for prestressed concrete work, it was decided to provide bowstring girders.

General Features of Design

The structure consists of a bowstring bridge with three spans each having a length of 162 ft out to out. The deck has a length of 491 ft. The clear roadway between kerbs is 24 ft, the overall width of the bridge being 30 ft 6 in. The bridge is designed to carry one lane of Class 'AA' or two lanes of Class 'A' IRC loading whichever produces the worst effects. The working stresses adopted were 750 lb per sq. in. for 1 : 2 : 4 cement concrete and 18,000 lb per sq. in. for mild steel. Wind pressure was assumed as 20 lb per sq. ft. The bottom of decking was 3 ft above the highest flood level.

Important Particulars at a Glance

Number of spans	... 3
Length of bridge proper	... 491 ft
Loading	... One lane of Class 'AA' loading or two lanes of Class 'A' loading whichever creates worst effects.
Clear width of roadway	... 24 ft
Overall width	... 30 ft 6 in.
Type of foundations	... Well foundation for piers and abutments.
Maximum depth of foundation below well cap	... 53 ft
Height of the crown of the arch above the deepest foundation	... 115 ft
Height of piers	... 24 ft $3\frac{1}{2}$ in.
Type of superstructure	.. R.C.C. bowstring type.
Maximum clearance above O.F.L.	... 9 ft 6 in.
Bearings	... Cast steel rocker and roller bearings.
Wearing surface	... 3 in. thick cement concrete.
Total quantity of cement used	... 1,100 tons.
Total quantity of steel used	... 500 tons.

Levels

High flood level	... (+) 25.00
Ordinary flood level	... (+) 19.00
Lowest bed level	... (−) 28.00
Bank level	... (+) 32.14
Dry season low water level	... (+) 0.84
Top of wells	... (−) 1.66
Top of capping slab	... (+) 0.84
Top of road level	... (+) 33.00
Level of soffit of girders	... (+) 28.62
Lowest foundation level	... (−) 54.00

Foundations

Well foundations have been provided both for the piers and abutments. The foundation for the piers consists of two wells each with external diameter of 16 ft and internal diameter of 10 ft. For each abutment, 3 wells are provided, the internal diameter of each was 8 ft. The wing walls on either side have open foundations.

The wells were provided with steel cutting edges and R.C.C. curbs. The cutting edge consisted of 8 in. × $\frac{1}{2}$ in. M.S. plate rivetted to 4 in. × 4 in. × $\frac{1}{2}$ in. angle crew. The mix of the concrete was 1 : 2 : 4.

The well steining was constructed with rubble masonry in cement mortar 1 : 4. The thickness of steining of the wells under the piers was 3 ft and 2 ft 3 in. in the case of wells under abutments. Nominal bond rods were provided for the well steining. For each well 16 Nos. of 7/8 in. steining rods were used, these rods were taken into the well curbs at the bottom and into the well cap at the top. After the pier wells were seated on hard foundation, the bottom 7 ft 11 in. was plugged with 1 : 2 : 4 concrete with $1\frac{1}{2}$ in. guage granite metal under water and the rest of the cavities were filled with sand and 4 ft thick 1 : 3 : 6 cement concrete at top and 2 ft 6 in. thick reinforced concrete capping slab was provided over the wells.

During construction, all the wells of the Alwaye abutment after reaching about 20 ft depth developed a lean towards downstream with the kerbs going towards the land side. All the wells were filled with 1 : 4 : 8 cement concrete. In addition, $1\frac{1}{4}$ in. diameter rods at 1 ft centres were provided along the inner periphery of the wells. The abutment masonry was shifted 4 ft 9 in. towards land to move the point of application and cause the resultant to fall within safe limits. The rear side of the abutment was packed well with rubble so as to offer least side thrust. Consequent on this, the left end span was increased to 166 ft 9 in.

Each pier consists of two circular R.C.C. columns 12 ft external diameter and a 9-in. diaphragm wall in between. The shell thickness of the circular pier is 12 in. The reinforcement for the shell consists of $1\frac{1}{8}$ in. dia. vertical rods at $4\frac{1}{2}$ in. centres and $\frac{1}{2}$ in. dia. circular links at 6 in. centres. The R.C.C. pier column cap over each column is 12 ft 6 in. in dia. and 2 ft in thickness.

Abutments

The abutments are of coursed rubble masonry in 1 : 4 cement mortar. These are 7 ft 6 in. wide at top with a front batter of 1 in 12. Stepped footings are given in the rear. 2 ft thick R.C.C. bed blocks are provided over the abutments. An R.C. curtain wall 12 in. thick and 8 ft 6 in. high is provided to retain the earth.

Bearings

Cast steel rocker and roller bearings are provided over the piers. For each span, there are 2 Nos. of rocker and 2 Nos. of roller bearings. The top and bottom bearing plates are 5 in. thick at the centre. The roller has 15 in. diameter.

Superstructure

The superstructure is of the reinforced concrete bowstring girders with vertical suspenders. The arch is parabolic in shape. It is 7 ft 6 in. x 3 ft at the springing, 5 ft x 2 ft 6 in. at the haunch and 4 ft x 2 ft 6 in. at the crown. All joints in the reinforcement were welded.

The main reinforcement of the arch consists of 8 Nos. of $1\frac{1}{4}$ in. dia. rods both at top and bottom at the haunch section and the same is reduced to 6 Nos. of $1\frac{1}{4}$ in. dia. both at the top and bottom at the crown section. At the springings where the arch is in contact with the Rocker or Roller bearing plates, the concrete has to take a high compressive stress of nearly 1,520 lb per sq. in., for this $1 : 1\frac{1}{2} : 3$ cement concrete with a water cement ratio of 0.38 and graded granite chips was used. The remaining portion of the arch rib was concreted with 1 : 2 : 4 cement concrete.

The tie beam is channel shaped and is 30 in. x 63 in. The top and bottom beams are 30 in. x 15 in. and the central portion 18 in. x 33 in. The main reinforcement for this beam consists of 1-3/4 in. dia. M.S. rods. The main rods are anchored at ends to M.S. plates 30 in. x 10 in. x 1/2 in.

Cross girders are placed at 10 ft 4 in. centres. The cross girder is 20 in. wide $29\frac{1}{2}$ in. deep from the bottom of the deck slab. The main reinforcement for the cross girder consists of 18 Nos. of $1\frac{1}{4}$ in. dia. M.S. rods, $\frac{3}{8}$ in. dia. four-legged stirrups are provided for this beam, spacing varying from $4\frac{1}{2}$ in. to 12 in.

Hangers are 18 in. x 12 in. in section with 12 Nos. of $1\frac{1}{4}$ in. dia. rods. The main rods of the hangers are anchored at both ends to M.S steel plates 17 in. x 14 in. x $1\frac{1}{4}$ in., 4th and 6th hangers from either end are wind braced. The section of the wind brace of the 4th hanger is 18 in. x 36 in. and that of the 6th hanger is 18 in. x 30 in.

The deck slab is $9\frac{1}{2}$ in. thick. The reinforcement for the slab consists of 5/8 in. dia. main rods at $4\frac{1}{2}$ in. centres and 5/8 in. dia. distribution rods at 10 in. centres.

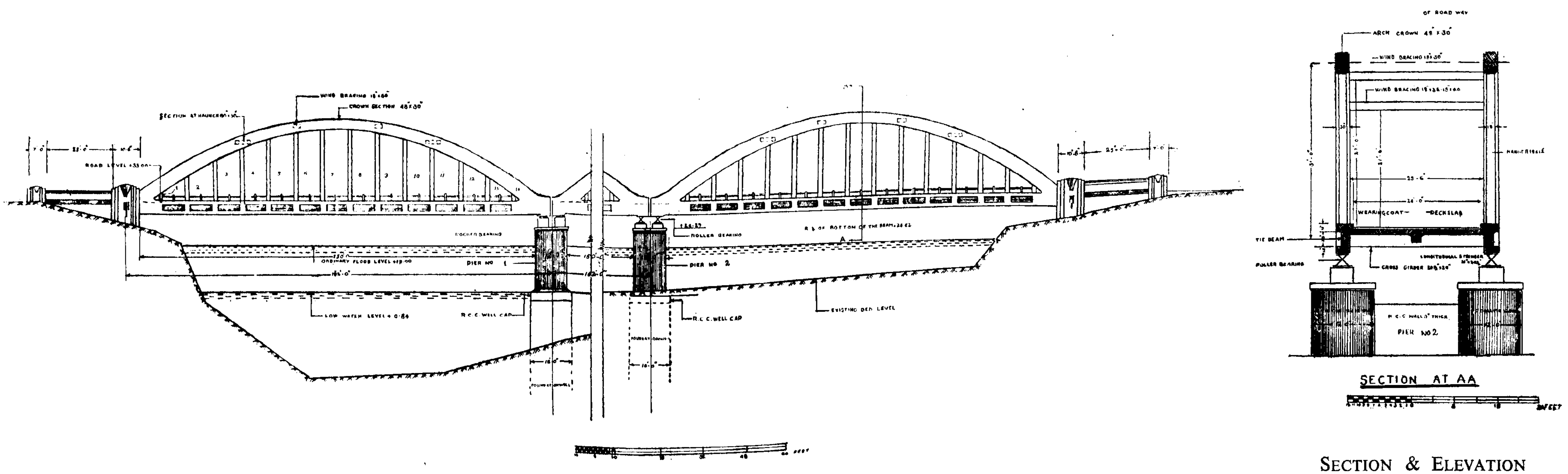
Expansion Joints

The superstructure of each span is separated from the adjoining span by 2 in. wide expansion joints. T iron 4 in. x 4 in. was placed in this gap over which bent copper plates 1/16 in. thick was placed between the slab and wearing coat. The gap over the copper sheet in the wearing coat is filled with resilient joint fillers.

Approaches

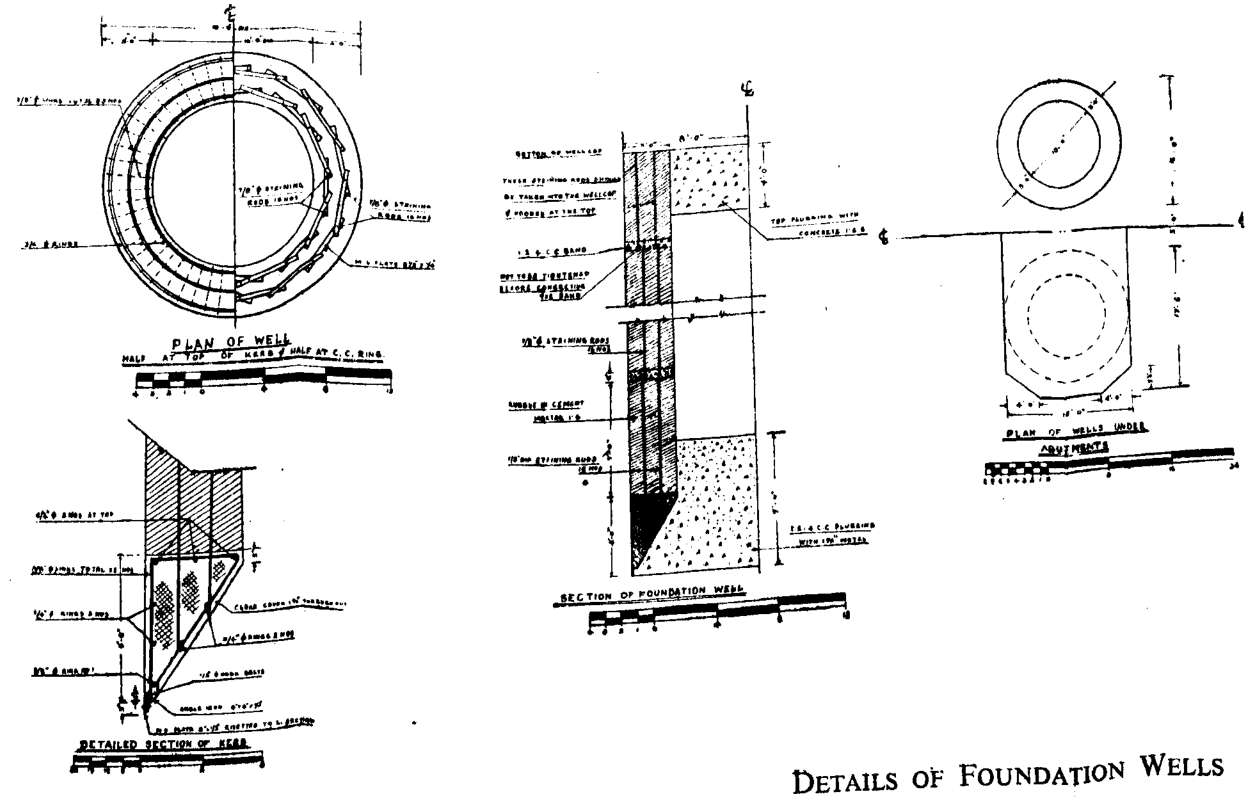
The approaches with formation width of 40 ft with 22 ft carriageway run mostly on high embankments. The length of the approach road on the Alwaye side is 4 furlongs and that of the Desam side is 5 furlongs. The cost of forming approaches is about Rs 1.2 lakhs.

PLATE I-A

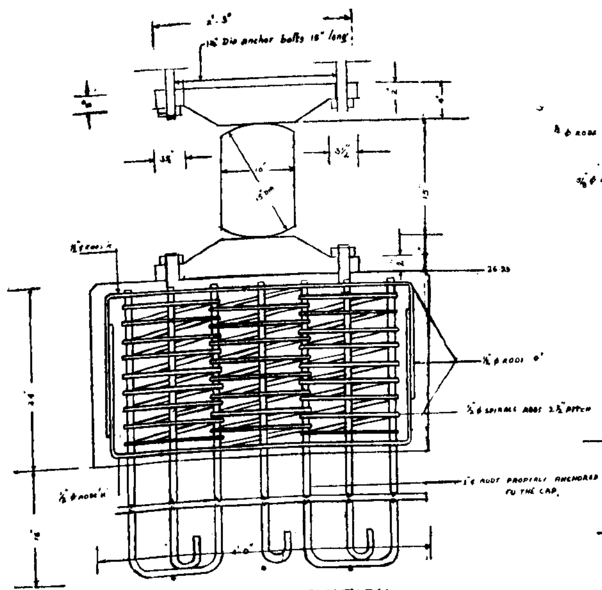


SECTION & ELEVATION

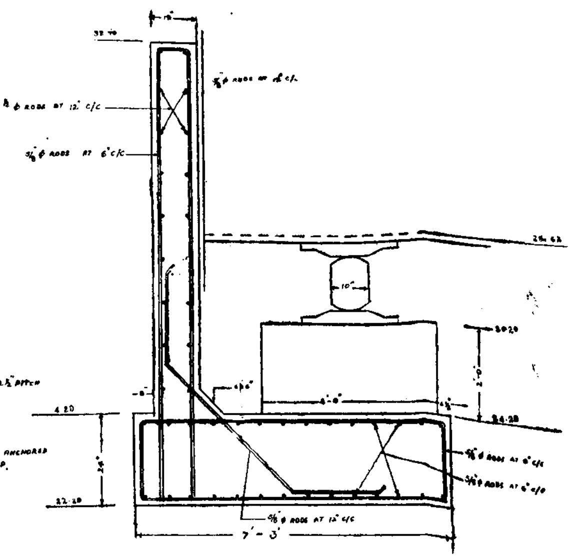
PLATE I-B



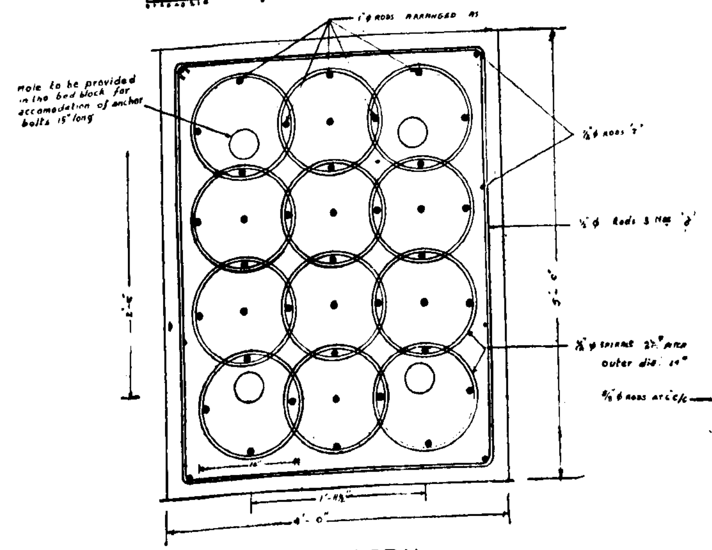
DETAILS OF FOUNDATION WELLS



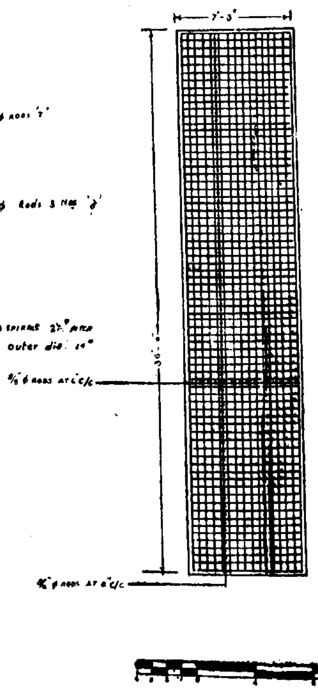
DETAILED SECTIONAL ELEVATION OF BED BLOCK (UNDER THE ROLLERS)



REINFORCEMENT DETAILS OF ABUTMENT CAP.



PLAN OF PEDESTAL

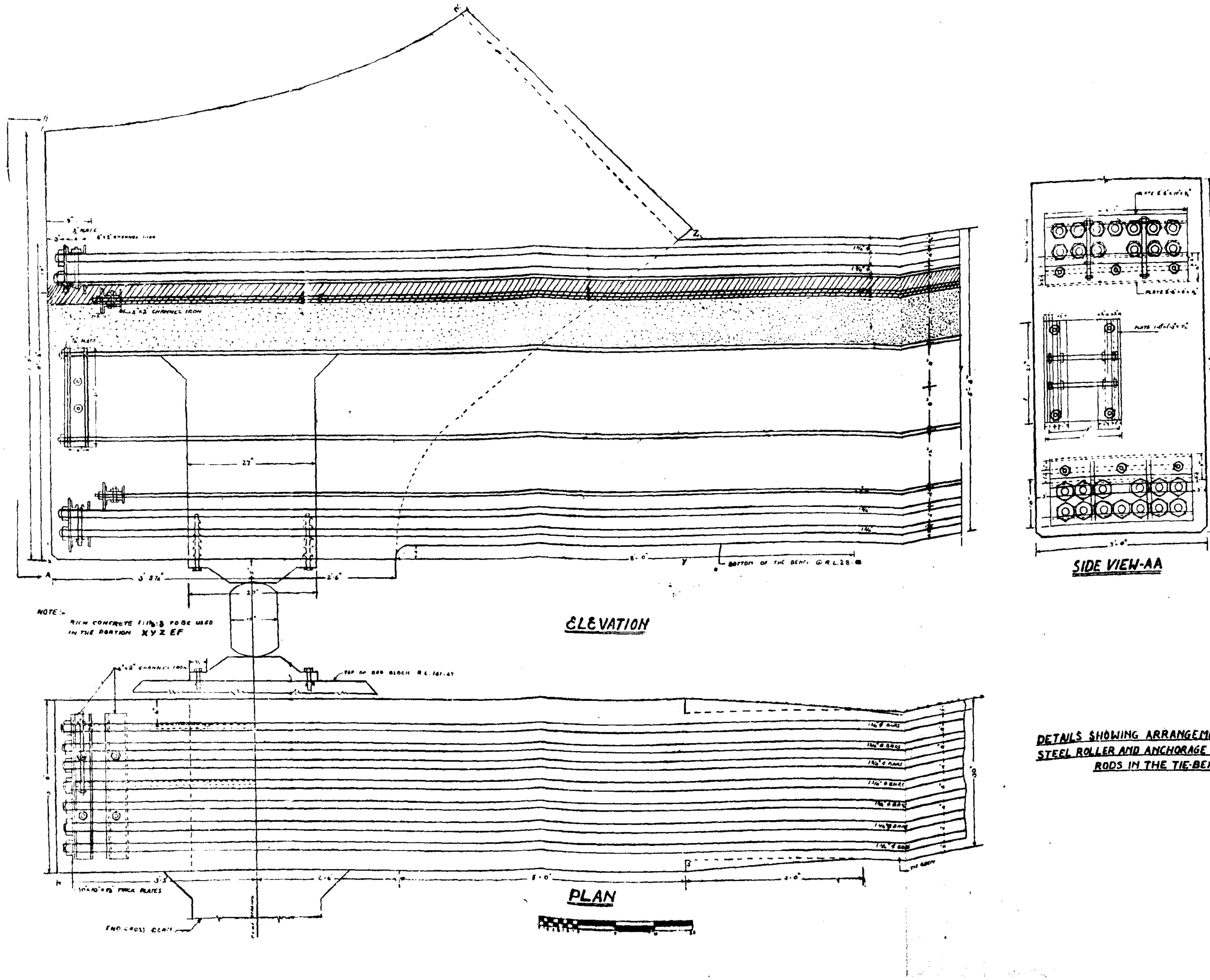


NOTES.

1. 1:1½:3 Mix vibrated concrete shall be used for the bed blocks.
2. Holes may be left out in the bed blocks for proper anchorage of the foundation bolts, the holes may be grouted after bearings are properly arranged.
3. For the pedestal under the rocker plates, the same arrangement of spirals etc. may be adopted, the only difference is that the thickness of the block is 3'-3" instead of 2 ft.

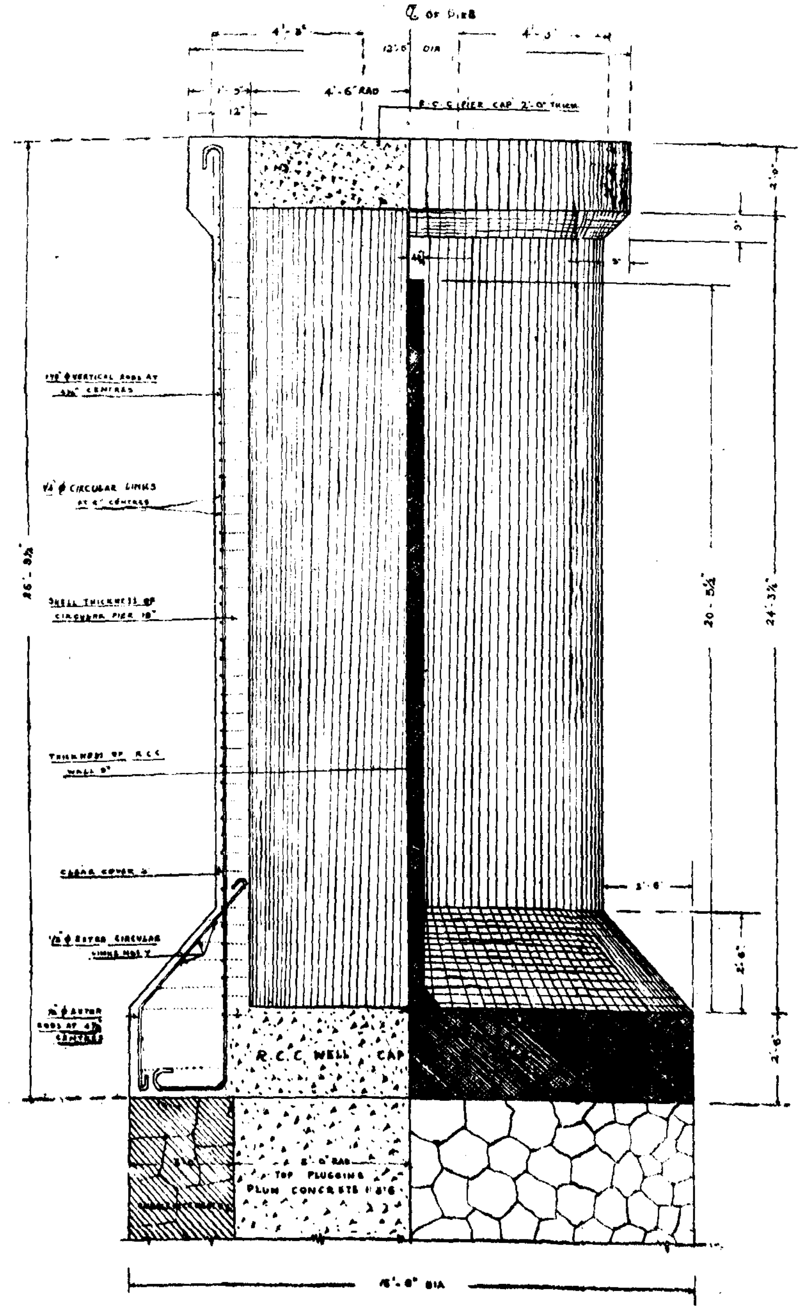
REINFORCEMENT DETAILS OF PEDESTAL AND ABUTMENT CAP

PLATE IV



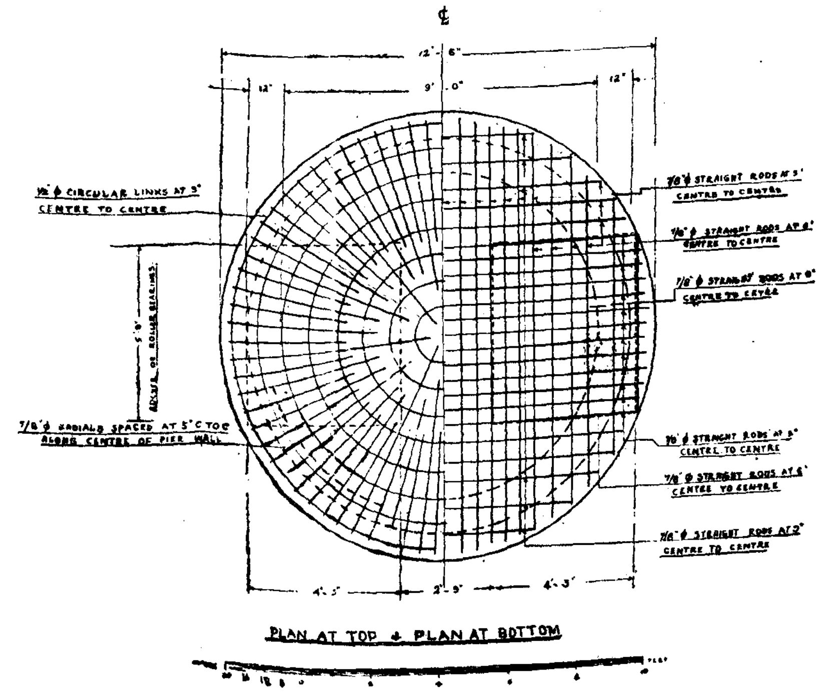
DETAILS SHOWING ARRANGEMENT OF CAST STEEL ROLLER AND ANCHORAGE OF ENDS OF RODS IN THE TIE-BEAM

PLATE II



HALF SECTION & HALF ELEVATION

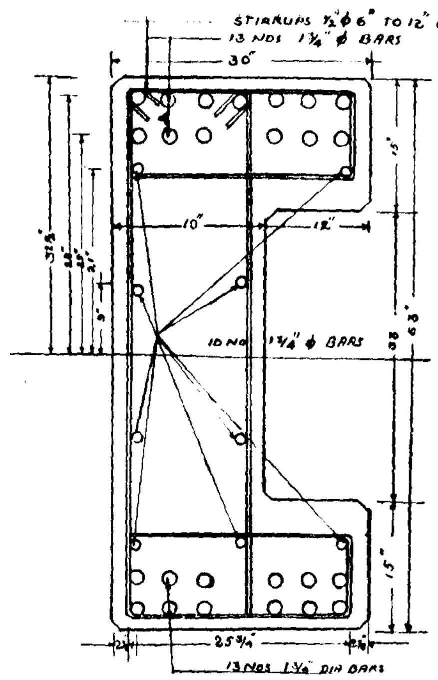
DETAILS OF PIER CAP



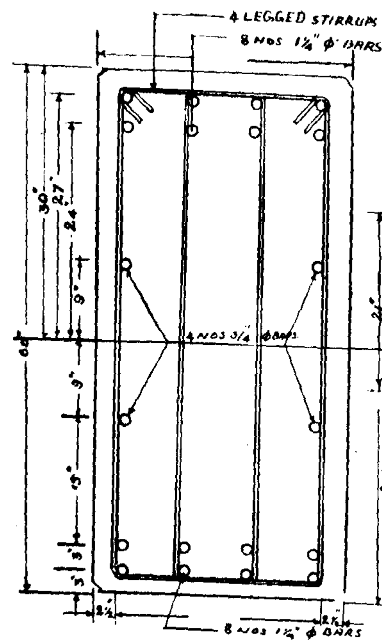
PLAN AT TOP & PLAN AT BOTTOM

DETAILS OF PIER & PIER CAP

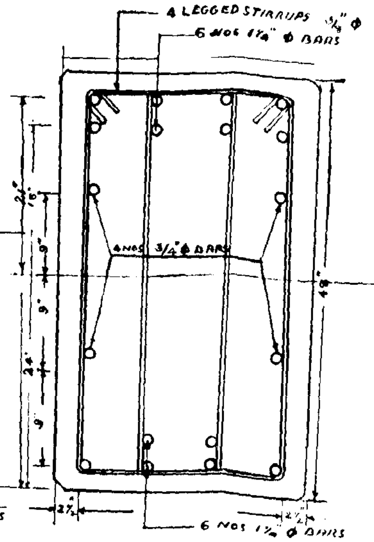
PLATE VI-A



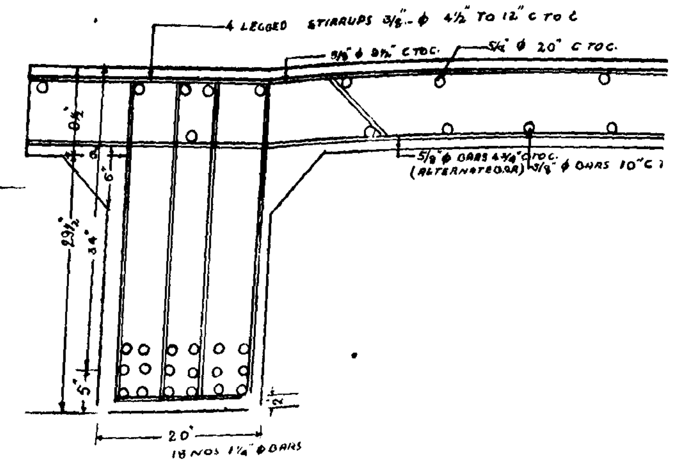
SECTION OF TIE BEAM



SECTION OF ARCH RIB
AT HAUNCH

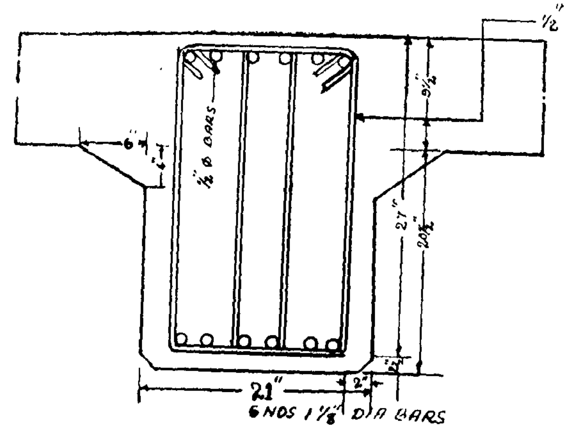


SECTION OF ARCH RIB
AT CROWN

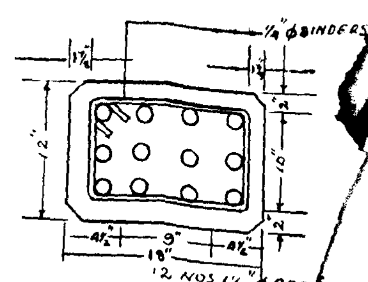


CROSS GIRDER

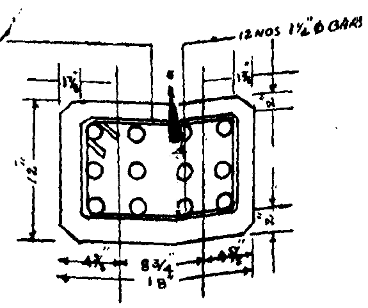
PLATE VI-B



LONGITUDINAL STRING

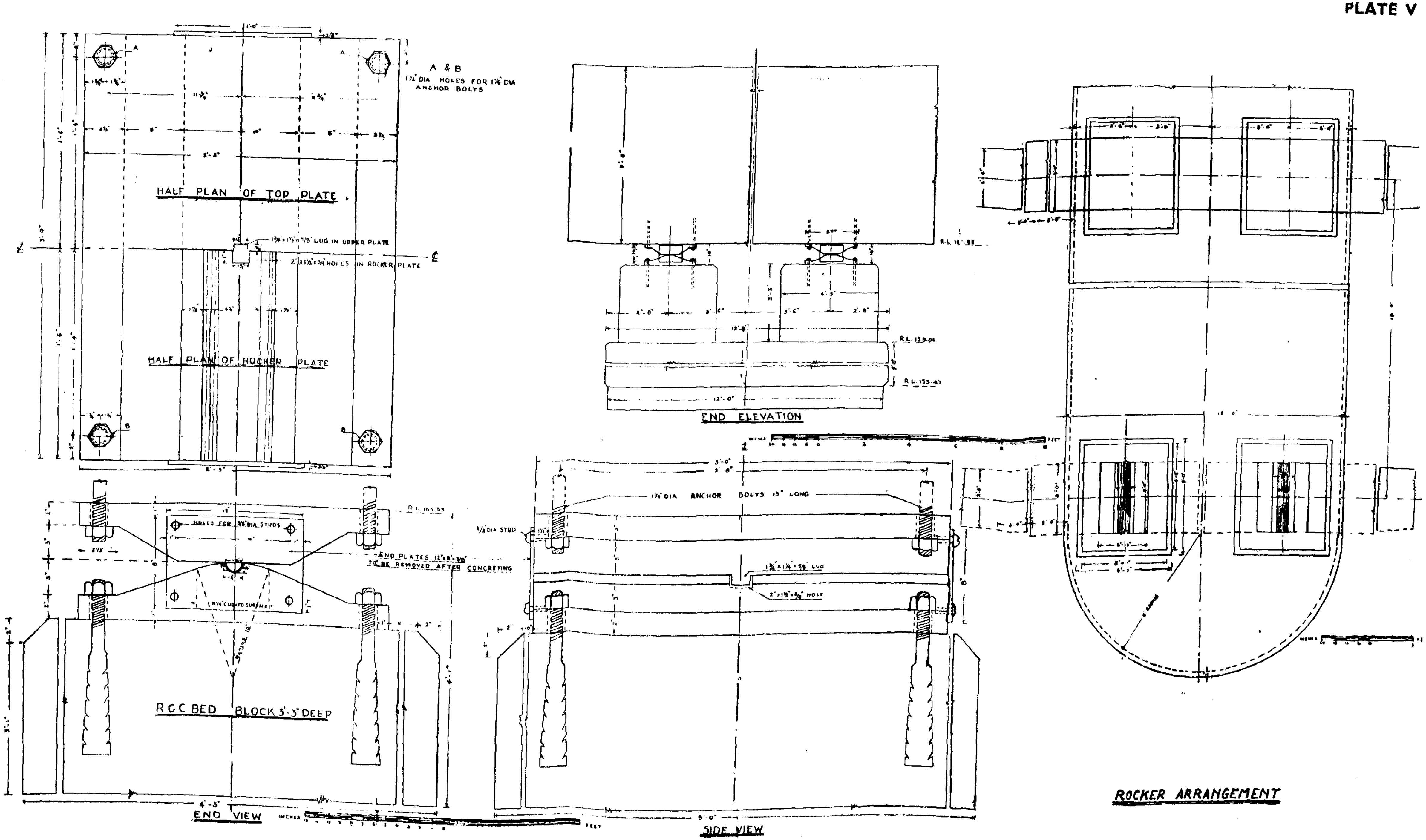


SECTION OF HANGERS
(WIND BRACED)



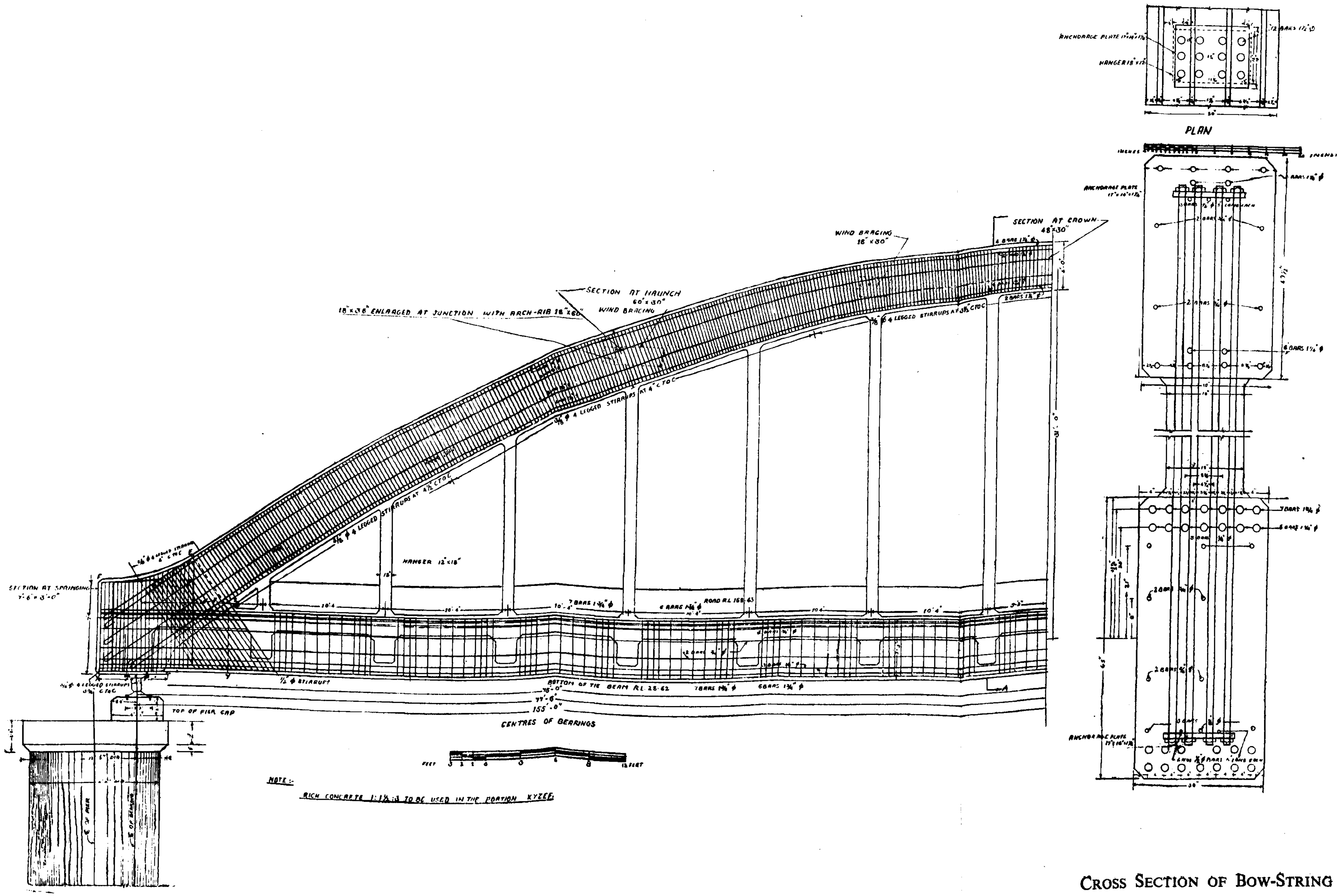
SECTION OF 7TH HANGER

PLATE V



ROCKER ARRANGEMENT

PLATE VII



CROSS SECTION OF BOW-STRING GIRDER & ANCHORAGE OF HANGER

Substructure

The piers were raised in stages of 5 ft, using steel *shuttering.* Abutments and wing walls were in coursed rubble 2nd sort masonry. Abutments and wing walls were got executed through piece contractors.

The foundation stone was laid by President, Dr. Rajendra Prasad in February 1956. The construction was taken up in April 1956 by the State P.W.D. Work was delayed due to the unexpected floods, shortage of material and construction difficulties. The work was completed in May 1960 and the bridge was opened to traffic on 25-9-60 by Dr. P. Subbarayon, Minister for Transport and Communications, Government of India.

Cost

Analysis of the cost of the bridge is given below:

		Rs
Foundations	...	4,50,000
Piers and abutments	...	1,35,300
Superstructure	...	7,95,000
Approach roads	...	1,20,000
Land acquisition charges	...	1,00,000
Total	...	16,00,000

	Rs
(a) The cost per running foot of the bridge.	3,258
(b) The cost per sq. ft. carriageway.	135
(c) The cost per sq. ft. of the entire elevation area enclosed between the line connecting the lowest part of the foundation and a line connecting the uppermost points of superstructure.	29
(d) The cost per cu. ft. of the enclosed volume.	0.95

"Among the social services, I put communications first since I do not see how it is possible to effect any great improvement in health and education in the villages of India unless they can be reached surely and quickly at all times."

— LORD WAVELL

BRIDGING INDIA'S RIVERS

THE NARMADA BRIDGE AT MORTAKKA

By

L. H. BHATIA*, AND B. B. AGARWAL *

A R.C.C. arch bridge across Narmada river in mile No. 41 of Khandwa-Indore road was opened to traffic in 1958.

Before construction of this bridge the traffic used to cross this river over the rail-cum-road bridge of Khandwa Ajmer Meter Gauge Railway of the B.B. and C.I. Railway. In 1939, when the Railway decided to remodel the bridge, the question of sharing the cost by the Railway, Central Provinces and the Holkar State arose. The Holkar State expressed their inability to meet their liability resulting in failure of negotiations. The Railways remodelled their bridge omitting the roadway. Thus through road communication between old Central Provinces and the Holkar State (Indore) was dislocated; since then upto the completion of this bridge the traffic used to cross by a ferry (maintained by both the States) in fair weather only.

General view of the bridge

The necessity of the permanent road bridge for Inter State traffic was keenly

* P.W.D., B. & R., Madhya Pradesh.

felt and a proposal to construct a bridge was finally approved in the year 1951, cost to be shared by the various States as given below:

a. Government of India—50 per cent.

b. Old Madhya Pradesh State—25 per cent.

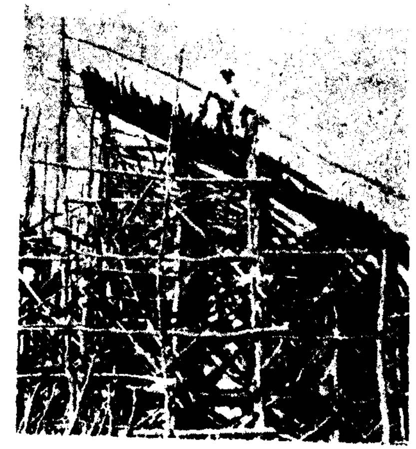
c. Old Madhya Bharat State—25 per cent.

With the high banks on either sides, difference of 25.12 ft between ordinary and the highest flood level, it was decided for reasons of economy to construct a high submersible bridge which may get submerged once in about 5 to 10 years for a few hours in case of extra-ordinary flood.

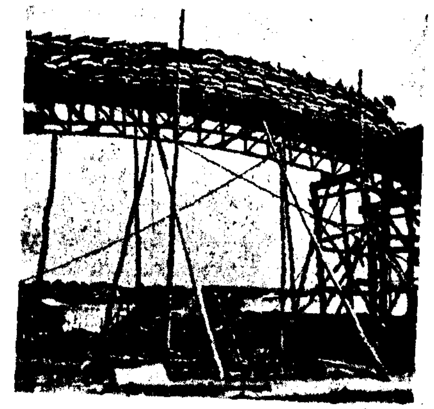
Hydraulic Data

From the hydraulic observations for

Concreting of arch 12 during flood



Details of wooden centring



Testing steel centring

Concreting in progress

the last 100 years available with the Railways the following were arrived at:

A. Highest flood level R.L. 487.12 (in the year 1941).

B. Ordinary flood level R.L. 462.00.

C. Summer water level R.L. 418.83.

Investigation of site and type

The site selected was 1,000 ft up-stream of the existing railway bridge, here the river had a fairly straight reach, well-defined banks and rocky bed almost throughout its width.

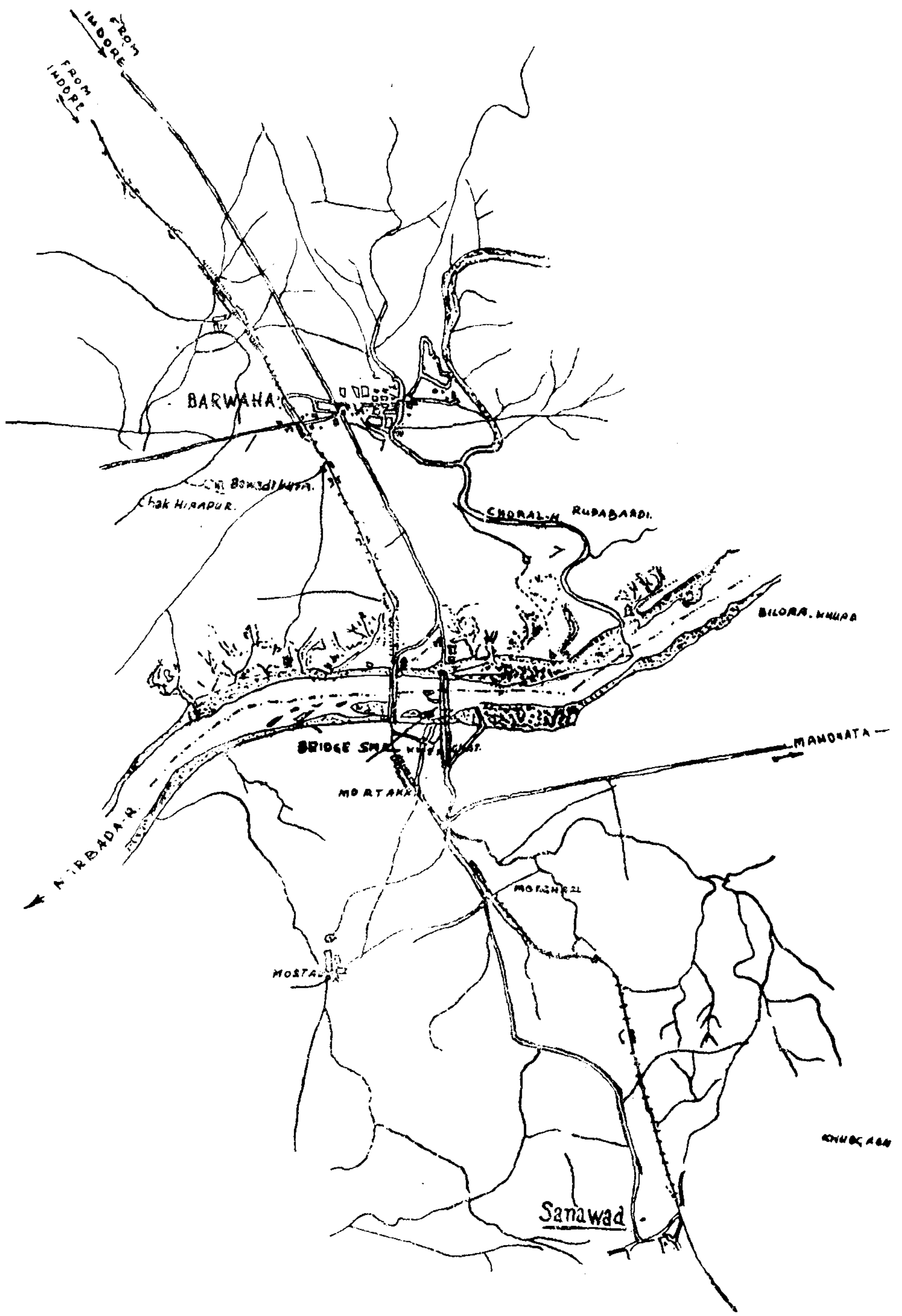


Fig. 1. **Index plan**

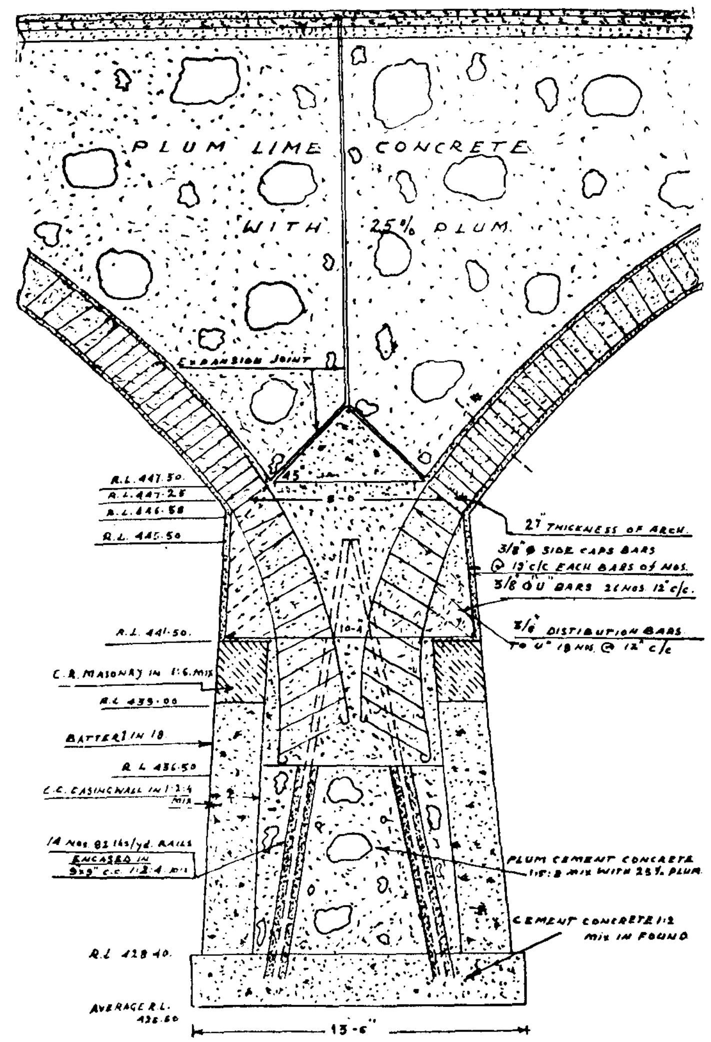


Fig. 2. **Details of arch reinforcement**

D. Maximum flood discharge 10,79,000 cusecs.

E. Average bed level 413.00.

F. Catchment area 8,686 square miles.

Note :—Assumed B.M. at top of the railway bridge pier (on Khandwa side) was taken as 500 R.L.

General Features of Design

This is a high level submersible, spandrel-filled reinforced concrete arch bridge of 22 spans each 90 ft (clear) and 3 spans of 53 ft 8 in. (clear). The total length of the bridge is 2,424 ft, 22 ft carriageway was provide for two traffic lanes. Road level wa kept 5 ft above the ordinary floo level.

The superstructure (arches) wei designed for two lanes of I.R.C. Cla 'A' standard loading, 20 lb per sq. f were allowed for wind pressure.

The working stresses adopted fc concrete and steel were as follows :

1. Concrete 750 p.s.i.
2. Steel 18,000 p.s.i.
3. m = 15.

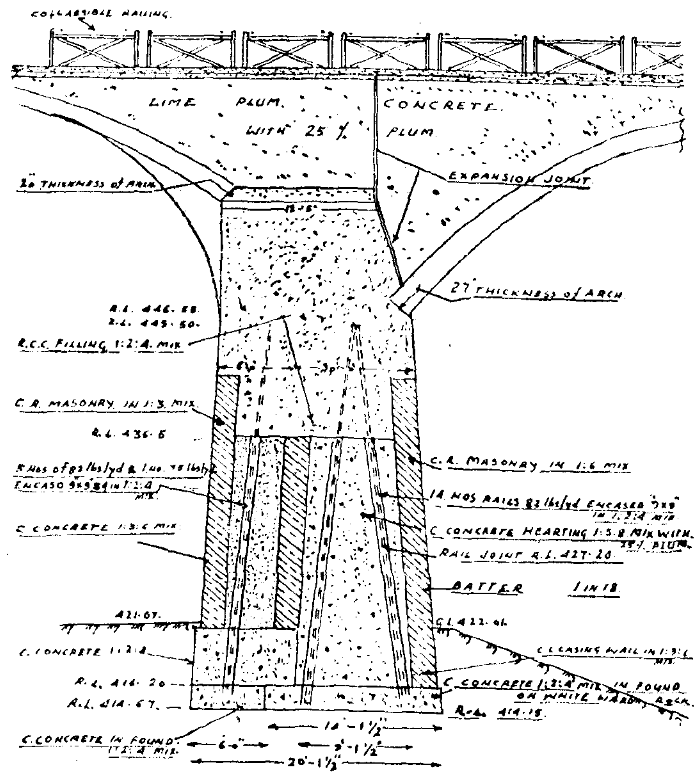


Fig. 3. Details of abutment pier on Narmada bridge at Mortakka

Foundations

Trial bores taken at the site of the bridge revealed good and sound rock at 5 to 10 feet below the bed. As such, open foundations were proposed, taking the foundations at least 2 ft in the hard rock, 2 ft thick 1 : 2 : 4 cement concrete foundation was provided over which masonry piers were built.

Piers and Abutment Piers

Piers were designed to resist the moment, shear, and horizontal thrust and the resultant to remain within its middle third. The pier faces had batter of 1 in 18, and semi-circular cut waters on both the ends. The top width of pier was 9 ft 9 in. Every pier was reinforced with 14 No. 75 lb or 82 lb old rails, 1 ft length of the vertical rail was embeded in the foundation concrete. The details of piers and abutments are given in Figs. 2, 3 and 4.

Arches

Following conditions were assumed, in the design of arch :

a. Fixed ends.
b. Filled spandrel.
c. I.R.C. Class 'A' standard loading for two lanes.
d. Cover over crown 6 in. cement concrete over 1 ft. 6 in. lime concrete.
e. Effective span 90 ft (axial).
f. Ratio, rise/span = 1/5.
g. Impact factor 15/(20 + span).
h. Temperature variation = 30 degrees F.

The sections of arch at crown and springing worked out to be 18 inches and 27 in. respectively; 1 per cent steel was provided giving 1 in. dia. bars at 9 in. centre to centre throughout and extra $1\frac{1}{2}$ in. dia. bars at 9 in.

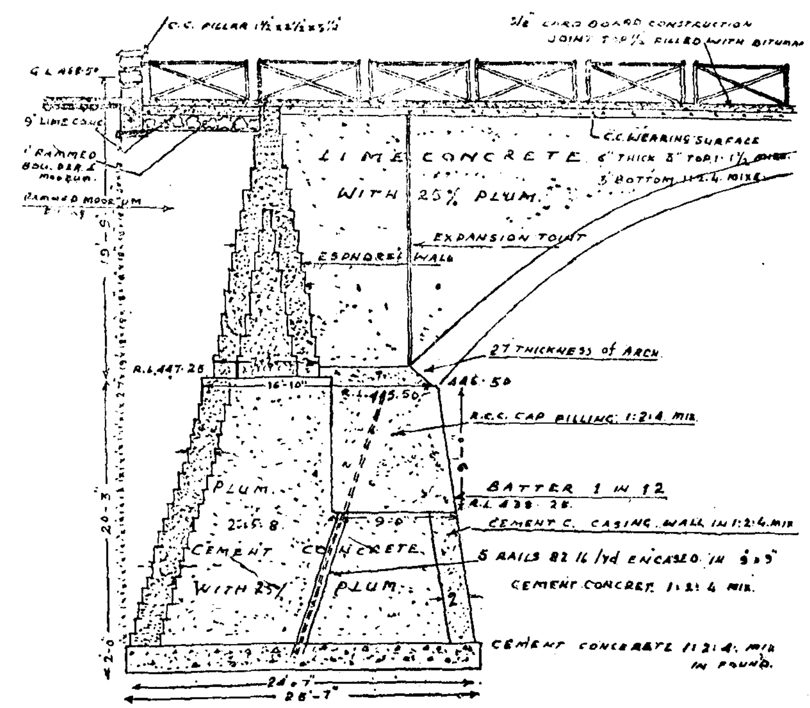


Fig. 4. Details of end abutment.

centre to centre running from springing upto 1/10 of the arch, which was found sufficient. The distribution reinforcement at the rate of 20 per cent of the main reinforcement was provided. The arch was reinforced both at the top and the bottom. The reinforcement was taken down upto the bottom of the nominally reinforced cap. The haunches were filled with lime concrete containing 25 per cent plums.

Roadway

The road crust consists of 3 in. cement concrete 1 : $1\frac{1}{2}$: 3 wearing coat, over 3 in. cement concrete 1 : 2 : 4 over 1 ft 6 in. lime concrete.

Railings

Collapsible railing of standard design 3 ft 6 in. in height was provided.

Centring

Concrete pillars $1\frac{1}{2}$ ft × $1\frac{1}{2}$ ft were laid on the bed with their top partially above water level. These pillars were spaced at 5 ft along the span and 3 ft across. Over these, wooden sleepers 1 ft × 8 in. size were placed across the span, over the sleepers, the main vertical ballies of not less than 8 in. dia. on wooden wedges 12 in. square × 6 in. high were erected. These were braced bothways along and across the span and also diagonally (as shown in Fig. 5). On these were placed the bearing rafters 5 in. × 8 in. in size. On these rafters, in rows of 3 ft interval, curved wooden beams of $3\frac{1}{2}$ in. × 8 inches deep size, in required curvature of the arch were placed. Wooden planks 2 in. thick and 6 in. wide were nailed so as to give a smooth and plane surface on the top. The framework of ballies was load-tested before concreting.

Change in Design

During the course of excavation of pier No. 4 from Khandwa side a very

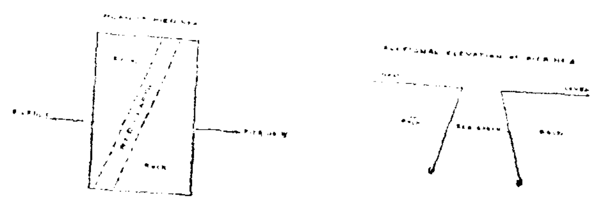


Fig. 5. Showing details of wooden centering.

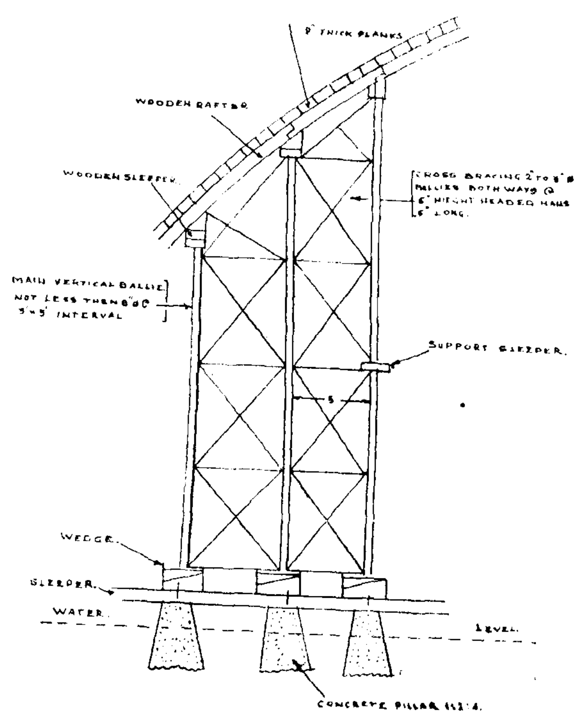


Fig. 6. Showing red earth pocket in pier 4.

treacherous cross-section of the bed was met with. When the top skin of the rock was excavated it was found that the rocky strata below was not continuous and was separated by a 15 ft wide diagonal red earth cleavage diverging downwards, as shown in Fig. 5. This necessitated further detailed investigation of this strata for which 5 borings—one on each of the four sides and one in the centre, were made, these proved the existence of red clay upto 50 ft depth. This created a complicated problem because the adjoining piers 3 and 5 were already constructed. It was therefore decided to put three 53 ft 8 in. arches instead of two 90 ft span arches and thus avoid a pier being put at the original site of pier No. 4. The new pier Nos. 3 and 5 were strengthened by increasing the sections to take into account the uneven stresses and strains produced due to unequal arches. In order to keep the crown level same, the springing level of these smaller arches was raised. To give a touch of symmetry, apron arches 2 ft wide were given to make these small arches appear in line with the normal arches.

Materials

Each 90 ft arch span consumed 7,800 cu. ft. of concrete requiring 72 tons of cement, and 20 tons of steel. Concreting of arch was done by winch machine, lifting concrete to a maximum height of 70 ft and placing it in an adjustable sloping chute and finally vibrating it at site. The concreting was done in 3 shifts of 8 hours each, five days were required to concrete an arch.

Erection of centering of a 90 ft arch with average height of 40 ft took about 15 days. The cost of centering was Rs 18,000 per span and it required 21,420 r. ft. of teak ballies and 3,350 sq. ft. of planks.

The quantities of various materials used in the construction of the bridge were as follows :

a. Cement	... 4,125	tons
b. Lime	... 50	,,
c. Steel	... 875	,,
d. Coarse aggregate (metal)	7,91,000	cu.ft.
e. Boulders	1,46,000	,,
f. Sand	4,27,000	,,
g. Masonry stones	1,27,000	,,
h. Wood for centering and other works	54,140	,,

Costs

a. Foundations ...	Rs 2,40,000
b. Piers and abutments	,, 6,40,000
c. Arches and superstructure including railings	,, 23,00,000
d. Approaches (including retaining wall)	,, 1,20,000
e. Miscellaneous such as staff quarters, work establishment, etc.	,, 1,00,000
Total cost ...	34,00,000

Cost Analysis

a. Cost per running foot of bridge.	Rs	1,400
b. Per square foot of entire area enclosed between the line connecting the lowest part of the foundation and the formation level.	,,	25
c. Per cubic foot of the bridge from bottom of foundation to top of roadway.	,,	1

DEFINITIONS

Husband sued by wife in court for desertion was asked by the Judge: "Have you deserted this lady?"

Husband with folded hands: "My Lord, you do not know my wife. I am not a deserter, I am a Refugee."

NATIONALISED TRANSPORT UNDERTAKINGS AND NATIONAL INCOME

By

H. C. GUPTA* AND K. C. SAXENA*

NATIONAL Income Committee in its Final Report† in February 1954, commenting on the inadequacy of the available statistics for Transport sector stated "data regarding employment and income are not available even in regard to motor transport undertakings of State Governments," and the Committee recommended that "an annual report should be prepared by the Central Ministry of Transport bringing together all available statistical data regarding State Transport Undertakings".

A set of proformae prepared by the Central Ministry of Transport was supplied to every State Transport Undertaking and they were required to supply information in those proformae every quarterly. Data are received by the Statistical Unit of the Central Ministry of Transport are tabulated and published yearly, reviewing the progress made by all the Nationalised Transport Undertakings in the country.

In the paragraphs that follow an effort has been made to estimate the contribution by the Nationalised Transport Undertakings towards the total National Income of the country. The data utilised for the purpose are those received from Nationalised Transport Undertakings and the figures relate to the years 1957-58 and 1958-1959.

National Income

National Income may be defined as the total of such goods and services received by individual members (by virtue of acting as owners of factors of production) in return for their assistance in producing commodities and services. It may also be defined as the total of commodities and services (economic goods) produced by the people comprising a nation. Defined in any of the two ways National Income is the end product of a country's economic activity.

Motor transport may be categorised as a service which assists production of goods and services by delivering raw materials, capital, labour, etc., where they can be more productive and also in delivering final (or finished) goods and services where they are required for consumption. In this context the law of utility applies to a great extent. The utility of goods or services can be enhanced if they are transported to one area where they have higher utility from an area where they have lower utility. Motor Transport is a service which transports goods and services from places of lower utility to areas of higher utility. In this process of transportation, it means, that it adds utility to goods and services. If the costs involved in transporting goods and services are higher than the increase in utility (which can also be measured in terms of money) then the goods and services would not be transferred. It is only in the case where the value added by transferring goods and services from one place to another, is higher than the costs of transport that the movement will be justified.

* Ministry of Transport and Communications, Roads Wing, New Delhi.

† National Income Committee, Final Report, Feb., 1954, p. 130.

Motor Transport service costs

Use of motor transport service does not contribute directly towards production and income. It is an intermediary service which helps and speeds up the process of production by bringing in contact the spread over factors of production. Unless the factors of production which are necessary to produce a goods or service are brought together and are applied in appropriate combination, output would not result. Similarly it carries finished goods and services to market centres where they would be purchased for consumption by final consumers. In both the cases, namely, production and distribution the use of motor transport has enhanced the utility (or value) of goods and services. Without the use of this intermediary service the production and distribution of goods and services would not have been possible.

In the world of to-day the resources may be found in different areas while its actual utilisation may be many hundred miles away. They must be transported increasingly and freely if the processes of production are not to be hindered and stocks of finished products are not to lie in stores. The speed of the transport used must correspond to the need of the economy.

The motor vehicles are of different types and are used for personal as well as for productive purposes. A vehicle when plied for pleasure excursion cannot be said to contribute towards production. Motor transport when used for carrying passengers or goods or both will be productive if the passengers and goods carried will contribute towards production, and or distribution. It will simply mean that such type of goods and passengers carried by motor vehicles are on job or on their way towards production. That is, their movement is adding to the utility of the goods and services that would be produced and the costs involved in their movement are less than the utility added. These costs are in the form of fares for passengers and freight on goods that are transferred. Naturally it is a current expenditure on production and this will have to be added at the time of calculating total cost of output to be finally realised from the consumers.

Motor Transport viewed as an industry

Like any other industry motor transport is organized and run on a certain set of principles. The need of motor transport service is of prime importance and large amounts of goods and services are to be transferred through this means to facilitate the industry and trade. The service must be available regularly and should be elastic to meet the emergencies. There is need to organise it on large scale and a minimum level of efficiency must be maintained. For this it must have a sound organization and must make investments in vehicles, furniture, building, repair tools, machinery and fuels, etc. It should also have labour both skilled and unskilled as required.

A particular Motor Transport Organization will select such routes, carry such passengers and goods, charge such fares and freights which cover the entire cost of running the organisation and yet leave surplus for expansion and development. The total receipts must exceed total costs. If it is not so, the unit of industry will become uneconomic and the service will have to be closed. No industry or unit of industry can afford losses for an indefinite period.

Methodology

There are two approaches for the calculation of National Income suitable for our study, namely, Money Income approach and Money Output approach. Being essentially two aspects of the same thing, each will add up to the same total. In some professions and industry it is not possible to evaluate income through the Money

Output approach. Similarly in others this approach is most suitable.

Money Income approach

Approaching the problem from the first direction, we may say that National Income is the sum total of income earned by owners of the various productive factors. That is, in order to arrive at estimates of the total flow of income accruing to the factors employed, we must carefully collect data on (1) wages, salaries, and supplements earned by all employees, (2) net income of unincorporated business, (3) net interest paid on bonds, mortgages, and other loans, (4) net rents, (5) net corporate earnings (dividends, reserves, corporate income-taxes, etc.).

From the above details it is evident that expenditure on purchase of raw materials, repairs, etc., and contribution to depreciation fund are not to be accounted for and added. It is so because raw material is by itself a product and the price of it is paid to its producer. The producer must have obtained services of certain factors of production whom he had employed and he shall pay them in return for their services and their incomes will form part of total National Income. If we add up this item then it will be doubly counted. Thus the payments made for raw materials utilised are not to be taken into consideration. Similarly, the contribution made to the depreciation fund is in lieu of the fixed inventory such as machinery, buildings and furniture, etc., used in the production of current output of goods and services. Fixed inventories when used for production wear and tear. An amount calculated in relation to the life of the inventory is deducted every year out of total revenues and is contributed towards the depreciation fund account. This fund is meant to replace the inventory.

In calculating National Income contribution of Nationalised Road Transport, through "this approach", all the items under the sub-heading "current expenditure" will have to be included. "Current expenditure" includes rates, taxes and insurance, cost of departmental vehicles, general contingencies, miscellaneous expenditure and interest on capital. Items such as payments in the form of rates, taxes and insurance charges are regarded as 'service costs' similar to the costs involved in employment of factors of production and should necessarily be included in the calculation of National Income contribution. But items such as, general contingencies and miscellaneous expenditure should be treated as operational costs and excluded. The available statistics with the undertakings, however, are not detailed enough to separate out expenditure on these two items and, therefore, it is not possible to take the above into account. Since the sums involved under these two items are very nominal, any further refinement in the calculation will not give significantly different result.

Money Output approach

Another way of looking at National Income is the net value of all goods and services produced in a year. In this method we will have to take into account the value of services which do not result into tangible goods along with the services which result in tangible commodities. The difficulty arises as soon as we are required to add up diverse goods and services to form a meaningful total. To mitigate this problem will be to find a common denominator that can be applied to both effectively. One of the yardsticks is psychological or welfare based on satisfactions enjoyed as a result of consumption of goods and services. It would not be theoretically inconceivable that some one might draw up a definition of "psychological utility" or "psychic income", where million and one different goods and services produced could be combined. But the result in practice would be somewhat arbitrary

and might depend a great deal on how we weigh different individual tastes, for psychological income for the same goods or service would be different for different persons. Consequently it is preferred to use a second kind of yardstick or common denominator, namely, money value or market price. Even this is not a perfect solution.

Some of the best things in life cannot be measured in money. Perfectly accurate market prices are even hard to define for such ambiguous services such as doctors' appointment. Besides, there is a great danger of double counting in this method. It would be wrong for example to count bread in the net national product and also at the same time to count the flour that went into that bread and the wheat. In this approach we must count only the final goods or services.

If we insist upon this approach then we will have to decompose the final product into the contributions of the different stages of production. We can always do so by concentrating on the so-called "value added" at each stage of production. This is nothing but a return to our first way of looking at National Income—i.e., from the standpoint of costs of production paid out at each stage as earned incomes to the owners of factors of production. Our final product equals the sum of value added at each stage of production. This value can be evaluated in money units as it is paid.

In calculating National Income through the Money Income approach we add up the incomes received by the various factors of production employed in the Nationalised Transport Undertakings. The Money Output approach involves evaluation of value added at each stage of production. This complex problem can be solved if we make the following assumptions which are very much close to reality and would eliminate the complexity of this approach.

(i) Instead of calculating value added by each factor of production at every stage of production process, we take into account the value added by them from first to the last stage of production. That is we take the total value added by a factor of production in the whole process of production of goods and services. This will eliminate double counting, etc.

(ii) The payments received by the factors of production in the form of wages, rents, interests and profits, etc., are just equal to the contribution made by them towards the value of total output (in money terms).

(iii) All values can be measured in terms of common denominator 'money.' Meaning that the value added by each factor of production at various stages of production of goods and services can be resolved into common measure of money and the sum of the value (in money unit) added by all the factors of production would be equal to the total value (in money units) of the entire output of goods and services produced. It also means that the psychological utility or psychic income can be reduced to the measure of money.

Resolving the complexity of the second approach we in the following pages shall endeavour to calculate National Income contribution of the Nationalised Transport Undertaking through this method.

Motor Tranport Statistics

It is evident from the above that availability of adequate statistical data concerning Motor Transport Industry regarding costs and revenues is essential to calculate the National Income this industry contributes towards the total. Such complete information, as required, is not available for private sector both for passenger and goods service and for goods service in the public sector. However, detailed information, as required for our study, is available for passenger traffic of the various Nationalised Transport Undertakings in the country. These data are utilised for the present case study in the calculation of National Income, by Motor Transport service in the public sector.

A Case Study

For the sake of convenience we have taken all the State Transport Undertakings including Corporations for our analysis. The details of cost and revenue figures required for our study can be broadly outlined as under:

Components of Total Payments and Receipts

(MONEY OUTPUT APPROACH)

	1957—58 (Rs in '000)	1958—59 (Rs in '000)
@ Depreciation ...	49,842	68,447
£ Operational costs ...	1,32,351	1,51,833
" Gross revenue ...	4,46,719	5,17,017

On the basis of above figures National Income has been worked out below:

National Income = Money value added by Labour, Land Capital, Enterprise and Organization
= Gross Revenue (operational costs plus depreciation)

(a) National Income for 1957—58 = 4,46,719 – (13,235 + 49,842) thousands of rupees.
= Rs 26.45 crores.

(b) Similarly for 1958—59 = 517017 - (151833+68447) thousands of rupees.
= Rs 29.67 crores.

The National Income contributed by the Nationalised Transport undertakings towards the total National Income of the country in the years 1957-58 and 1958-59 was Rs 26.45 and Rs 29.67 crores respectively.

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@ Depreciation on vehicles and other assets.

£ Includes fuel, lubricants, tyres and tubes, batteries, stores spares, tools consumables, etc.

" Includes traffic and others.

PROPOSED CODE ON A UNIFORM SYSTEM OF ROAD SIGNS, SIGNALS AND MARKINGS AND SIGNS FOR ROAD WORKS

By

M. S. AHMAD*

WHEN mechanically driven vehicles made their appearance on urban roads, it became evident that, to avoid unnecessary interruptions, detentions, congestions and accidents, particularly at street intersections, some sort of traffic regulation was necessary. A few devices for traffic control were introduced. With the growth of road traffic, particularly in large cities, the situation became more acute, and was further aggravated by the fact that road improvements could not always keep pace with either the increase in the volume of traffic or mechanical developments in automobiles in power, speed, and size. It thus became more imperative to evolve a proper and adequate system of traffic control by signs, signals, road markings and other means for a safe, speedy and smooth traffic flow. In the course of the years and after intensive studies and analyses of the data available, a system of traffic control was evolved, and road signs and signals introduced. Since then, there has been a continual improvement.

Road traffic, particularly in large cities, is a complex problem. It includes road users, from pedestrians to drivers, of both slow and fast moving vehicles with a wide range of performance, and involves men, women and children, people of all ages. It operates on roads with all kinds of surfaces, grades, widths, alignments and intersections under varying weather conditions. Hence, traffic control signs and signals and road markings—so essential for regulating and guiding traffic have been receiving special attention during the last few decades. From time to time, efforts have also been made to standardize all these signs, either on a regional or on a global basis.

On 28 August 1948, the Economic and Social Council passed a resolution 147B (VII) and requested the Secretary-General of the United Nations to convene a conference of Governments, not later than August, 1949, with the object of agreeing on a new world-wide convention on road and motor transport superseding the two world-wide conventions of 1926 namely:

(a) International Convention relating to road traffic; and

(b) International Convention relating to motor traffic.

and the Convention of 1931 concerning the unification of road signals, which was later revised in 1938 and 1939 by a Committee of Experts appointed by the League of Nations for the codification of road law. In accordance with the above resolution, the UN conference on road and motor transport was convened in Geneva in August/September 1949. The draft text of the Inland Transport Committee of the Economic

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Commission for Europe, and the text of the 1943 Convention on the Regulation of Inter-American Automotive Traffic served as working papers for the conference. On the basis of its deliberations, the Conference, besides preparing a Convention on road traffic, prepared and opened for signature a Protocol on Road Signs and Signals (1949). The provisions relating to road signs and signals had been divided into two parts:

(i) general principles, which presumably would be acceptable to all countries were included in the body of the Convention;

(ii) detailed provisions, embodying the revised system of the 1931 Convention were placed in the Protocol on Rood Signs and Signals.

During this period two main systems of road signs and signals, viz., the International or European system and the American system had been developed in the world and a number of countries had included portions of both systems in their national systems. But the 1931 Convention had embodied more or less the international or the European system. The question of standardization of road signs and signals had also been discussed at the Pan American Highway Congresses in 1929 and again in 1939. This question was also taken up by the Inter-American Travel Congress in 1949, and this Congress recommended the adoption of a single American system based on the United States Manual on Uniform Traffic Control Devices, and proposed the preparation of a continental convention relating to :—

(a) basic traffic regulations, and

(b) signs or instructions for directing traffic.

Such a Convention, however, was never prepared. It was not desirable to leave the countries a choice to adopt any one of the two entirely different systems. The hope was therefore expressed during the discussions that an amalgamation of the two systems would be possible. Consequently in 1950, in accordance with the Economic and Social Council's resolution 272 (X) supplemented by resolution No. 10 of the fourth session of the Transport and Communications Commission, the Secretary-General, in consultation with the Chairman of the Transport and Communications Commission, appointed a group of experts on road signs and signals who were to devise a unified world-wide system of Road signs and signals and prepare a draft Convention embodying such a system.

As a result of its deliberations and field inspections, the group of experts submitted a draft Convention on a uniform system of road signs and signals. The Convention, however, was not universally accepted.

The subject of road signs, signals and markings was taken up for discussion at the ECAFE Seminar on Engineering and Traffic Aspects of Highway Safety in 1957, and certain recommendations were made.

The Expert Working Groups on International Highways, at their first series of zonal meetings in November/December 1959, felt that it was essential to work out a uniform system of road signs and signals designed to ensure safety and a smooth flow of traffic over the International highway network. They also felt that, as a number of countries in Asia and the Far East had not as yet well-developed systems of road signs and signals, these countries could more easily adopt a system acceptable to the countries of the region as a whole. It further felt that unless some measure of uniformity was not agreed upon now, the task of unification would become increasingly difficult if systems in different countries were allowed to develop on divergent lines. The Expert Working Groups on International Highways, therefore, at their second series of their zonal meetings in June/July 1960, took up the question of road signs, signals and markings, and signs for road works. As a basis of discussion the Experts Working Groups had before them the Protocol on Road Signs and Signals 1949, the draft Convention on a Uniform System of Road Signs and Signals (1952) and the recommendations concerning Road Signs and Signals of the ECAFE Seminar on Engineering and Traffic Aspects of Highway Safety of 1957. The Experts Working Groups at the outset realized that in order to overcome the problem of diversity of languages in the ECAFE region, the adoption of the use of symbols as far as possible would be advantageous. It also felt that in order to reduce expense in changing the existing signs and signals, alternative solutions would have to be permitted. The groups further recommended that the traffic signs should be divided into three categories according to the message that they would require to convey :

(a) warning signals,

(b) regulatory signs, and

(c) information signs.

As a result of their deliberations, a Code on a uniform system of road signs and signals, pavement markings and signs for road works has been prepared and has been unanimously recommended for the adoption in the ECAFE region by them. The recommended Code is now being forwarded to the Governments of the ECAFE region with the recommendation that it be adopted. If the Code is accepted by the countries of the ECAFE region, as is hoped will be the case, there will at least be a uniform system of road signs and signals and pavement markings and signs for road works. The resulting uniformity in this region will no doubt greatly facilitate international road traffic and increased safety on roads. The Code is reproduced below.

CODE ON A UNIFORM SYSTEM OF ROAD SIGNS AND SIGNALS, PAVEMENT MARKINGS AND SIGNS FOR ROAD WORKS IN THE ECAFE REGION

Part I—General Provisions

Article 1

Each adopting State shall take appropriate measures to ensure the application of the system of road signs and signals and pavement markings described in this code, as soon as practicable, and gradually if necessary.

Article 2

When this Code comes into force, the adopting States shall, in accordance with Article 1 hereof, and as a matter of urgency take measures to replace or to supplement in order to avoid confusion any signs, signals, or markings which, although they have the distinguishing features of those belonging to the system provided in this Code, are used with different meanings.

Article 3

1. It shall be prohibited to add or display on any sign or other traffic control device anything not related to the purpose of such sign or device.

2. Any boards, notices and installations which might be confused with the signs or other traffic control devices or make them more difficult to understand shall be prohibited.

Part II—Road Signs

Chapter I—General

Article 4

This system of road signs shall comprise three classes of signs, namely :

(a) danger warning signs

(b) regulatory signs

(c) informative signs

Danger warning signs are intended to warn the road user of the existence and nature of danger on the road.

Regulatory signs are intended to inform road user of certain limitations, prohibitions and restrictions governing the use of the road, violation of which constitutes, a statutory offence.

Informative signs are intended to guide the road user in the course of his travel and give him such other information as may be of interest or use to him.

Article 5

1. Where adopting States consider it necessary to modify the symbols prescribed in this Code, these modifications shall be such as not to alter the essential character of the symbols.

2. For the purpose of facilitating the interpretation of the symbols additional information may be given on a rectangular plate below the sign.

3. In order to educate road users in the use of the uniform signs prescribed by this Code, these signs may be supplemented during the initiation period by the signs previously used in the country concerned.

4. Additions to the lists of symbols for signs shown in the Table of Symbols for Warning Signs of Article 13, and additions to the list of symbols for signs shown in the Table of Symbols for Regulatory Signs of Article 20 may be proposed in accordance with the adopted procedure.

5. Additional Symbols for signs of local importance created by adopting States, to serve local needs, shall be communicated to the Executive Secretary of the United Nations, ECAFE.

Article 6

The colours of the signs shall be those prescribed in this Code.

Article 7

Reflecting devices, reflectorization or illumination used on signs should not dazzle the road user nor impair the legibility of the symbol or inscription and the sign should retain the same essential characteristics by night as obtained by day.

Chapter II—Warning Signs

Article 8

Warning signs shall have a white or yellow back ground with red borders. Symbols shall be black or dark colour.

Article 9

Warning signs shall have one of the following shapes: (1) an equilateral triangle with one point upwards, (2) a diamond consisting of a square with one diagonal vertical or (3) an equilateral triangle with a point upwards surmounting a rectangle or a diamond. No shape other than one of these three shall be used on signs of this class by the parties to this agreement.

Recommendation: In view of the importance of arriving at uniformity of all elements of the insignia of danger, it is recommended that the retention of three alternative shapes for warning signs be regarded as transitional for a country where more than one alternative is being followed and that the authorities in all countries should subsequently aim at the adoption of warning signs in the shape of one of the three alternatives as soon as possible.

Article 10

1. The dimensions of sign plates shall be such that the sign can be readily discernible and understandable.

2. For warning signs the standard size shall be;

(a) for signs having the shape of a triangle, the length of each side of the triangle 90 cm (36 in.)

(b) for signs having the shape of a diamond, the length of the side 60 cm (24 in.)

(c) for signs having the shape of a triangle surmounting a rectangle or diamond the length of each side of the triangle or diamond and the height of the rectangle 60 cm (24 in.)

Reduction of the standard size shall be permissible only in built-up areas if use of the standard size should be impracticable.

The size may be increased above the standard size as required.

Article 11

The competent authorities of the countries concerned shall determine the distances in advance of danger points at which danger warning signs should be placed so as to ensure, both by day and by night, the best possible efficiency of these signs, taking into account the particular conditions of the road and of the traffic, provided that such distances shall not be less than 90 m (300 ft) or more than 200 m (656 ft) unless the conditions prevailing so demand.

Article 12

1. Warning signs shall be placed facing the traffic and on the same side of the carriageway as used by the traffic concerned. Under special circumstances the signs may be placed or repeated on the opposite side of the carriageway.

2. Warning signs shall be placed at an appropriate distance from the edge of the carriageway.

3. In this code the height of signs above the ground shall mean the height of the lower edge of the signs from the level of the crown of the road.

As far as possible a uniform height shall be observed particularly over the same route.

The height of warning signs shall be not more than 2.40 m (8 ft) nor, except in built-up areas or where other special circumstances demand otherwise, less than 0.60 m (2 ft).

Article 13

The adopting States shall accept the symbols listed in the following table for the indicated signs. The signs containing these symbols may, where necessary, for the education of road users, be accompanied by plates bearing inscriptions.

Table of Symbols for Warning Signs[1]

(i) "Dangerous Curve" or "Dangerous Curves". This series of signs may be completed by each of the adopting States by the addition of symbols which are illustrative of other types of curves.

(ii) "Road Intersection of equal importance".

(iii) "Intersection between a Major and a Minor Road". When this sign is placed on the minor road a "Stop" sign may also be placed on the minor road at the junction.

(iv) "Uneven Road". Each adopting State may elect to substitute for the above sign, signs giving a clearer indication of the type of danger. These alternative signs are:

- (a) — "Bump" (sharp rise in the profile of the road)
- (b) — "Dip" (sharp depression in the profile of the road)
- (c) — "Rough Road" (a succession of irregularities in the profile of the road).

(v) "Dangerous Hill". On signs "Dangerous Descent" the silhouette of an automobile will be shown facing downwards on the hypotenuse,

[1] The list of symbols is included in Table 1.

TABLE OF SYMBOLS FOR WARNING SIGNS (Table No. 1)

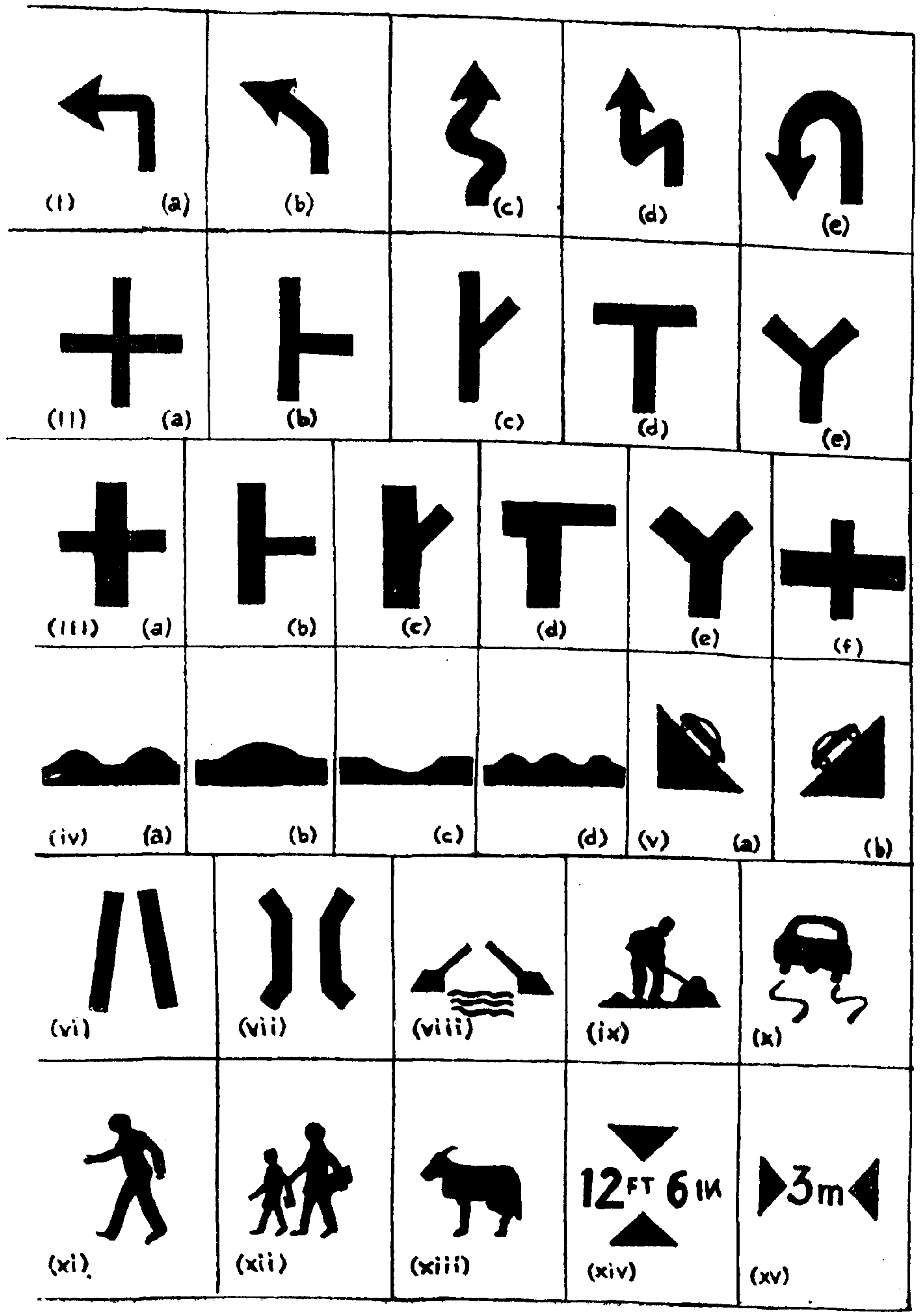
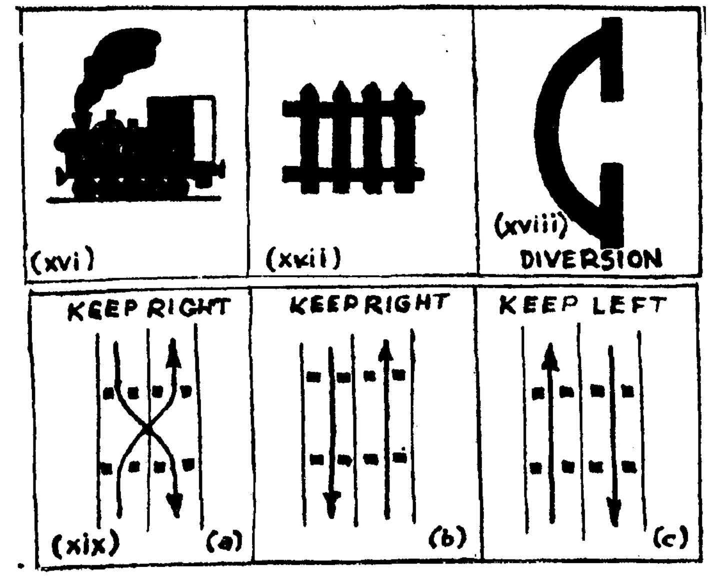


TABLE OF SYMBOLS FOR WARNING SIGNS (Contd) (Table No. 1)



which will be inclined from the upper left to the lower right. On Signs "Dangerous Ascent" the silhouette of an automobile will be shown facing upwards on the hypotenuse, which will be inclined from the lower left to the upper right.

(vi) "Road Narrows"
(vii) "Narrow Bridge"
(viii) "Opening Bridge"
(ix) "Road Works"
(x) "Slippery Road"
(xi) "Pedestrian Crossing"
(xii) "Children"
(xiii) "Beware of Animals"
(xiv) "Low Clearance"
(xv) "Narrow Clearance"
(xvi) "Level-crossing unguarded". When this sign is placed, a 'stop' sign shall at the same time be placed.
(xvii) "Level-crossing guarded by gates"
(xviii) "Road Diversion"
(xix) "Rule of Road". This sign showing the left-hand drive or right-hand drive is to be exhibited at each country frontier.

Article 14

Where automatic signals with flashing lights are installed at level-crossings they shall give warning of the approaching train by two alternately flashing red lights.

Recommendation: It is recommended that the two flashing lights be placed on a horizontal line 0.60 m to 0.90 m (2 ft to 3 ft) apart.

Article 15

1. When barriers to traffic are used in connection with road works, such barriers shall be of a colour or colours suitably contrasting with the surrounding and where necessary reflectorized or illuminated.

2. Warning signs indicating hazards of a temporary nature shall be devised in accordance with the design standards of the warning signs.

Chapter III—Regulatory Signs

A. Stop Sign.

Article 16

1. The stop sign shall be round in shape. The colour of the ground shall be white, light yellow or yellow with red border. The English word 'STOP' and its equivalent in the language of the country if desired by the adopting State shall be inscribed in red colour.

Article 17

1. The stop sign shall be placed facing the traffic and on the same side of the carriageway as used by the traffic concerned. It may be repeated on the other side of the carriageway.

2. The signs shall be placed in the immediate vicinity of the point where the vehicle is required to stop.

B. Other Signs

Article 18

1. Regulatory signs shall be round in shape with a white, light yellow or yellow background with red borders and symbols black or dark colour.

2. The uniform symbols for signs listed in this Code shall be shown on the disc.

3. An oblique bar drawn from the upper left quadrant of the ring to the lower right quadrant at an angle of 45° with the horizontal, shall indicate prohibition. Signs indicating limitation or compulsion shall be without such an oblique bar. The oblique bar may be drawn from right to left on signs used in countries where the left-hand traffic rule applies.

4. Where the end of regulation or prohibition is to be indicated by a de-restriction sign, the sign shall take the form of the general insignia of regulatory signs accompanied by a suitable inscription. The border of the disc and the inclined bar, where prescribed, should be red in colour.

Article 19

For regulatory signs the standard diameter of the disc shall be

(a) 40 cm (16 in.) in cities of built-up areas, or 60 cm (24 in.) in rural areas;

(b) the height above road surface shall not be more than 2.40 m (96 in.) and not less than 0.60 m (24 in.)

Article 20

The symbols listed in the following table shall be accepted by the adopting States as the symbols for the indicated signs. The list of symbols set out below may progressively be added to in accordance with the adopted procedure:

Table of Symbols for Regulatory Signs[1]

(i) "Direction Prohibited"

(ii) "Turning to the Right (or the left) Prohibited"

(iii) "About-turn (U-turn) Prohibited"

(iv) "Overtaking Prohibited"

(v) "No Entry for Vehicles having an Overall Width exceeding..............metre (feet)"

(vi) "No Entry for Vehicles having an Overall Height exceeding ....metres (feet)"

(vii) "No Entry for Vehicles exceeding..............tons laden weight"

(viii) "Speed limit"

(ix) "Direction to be followed"

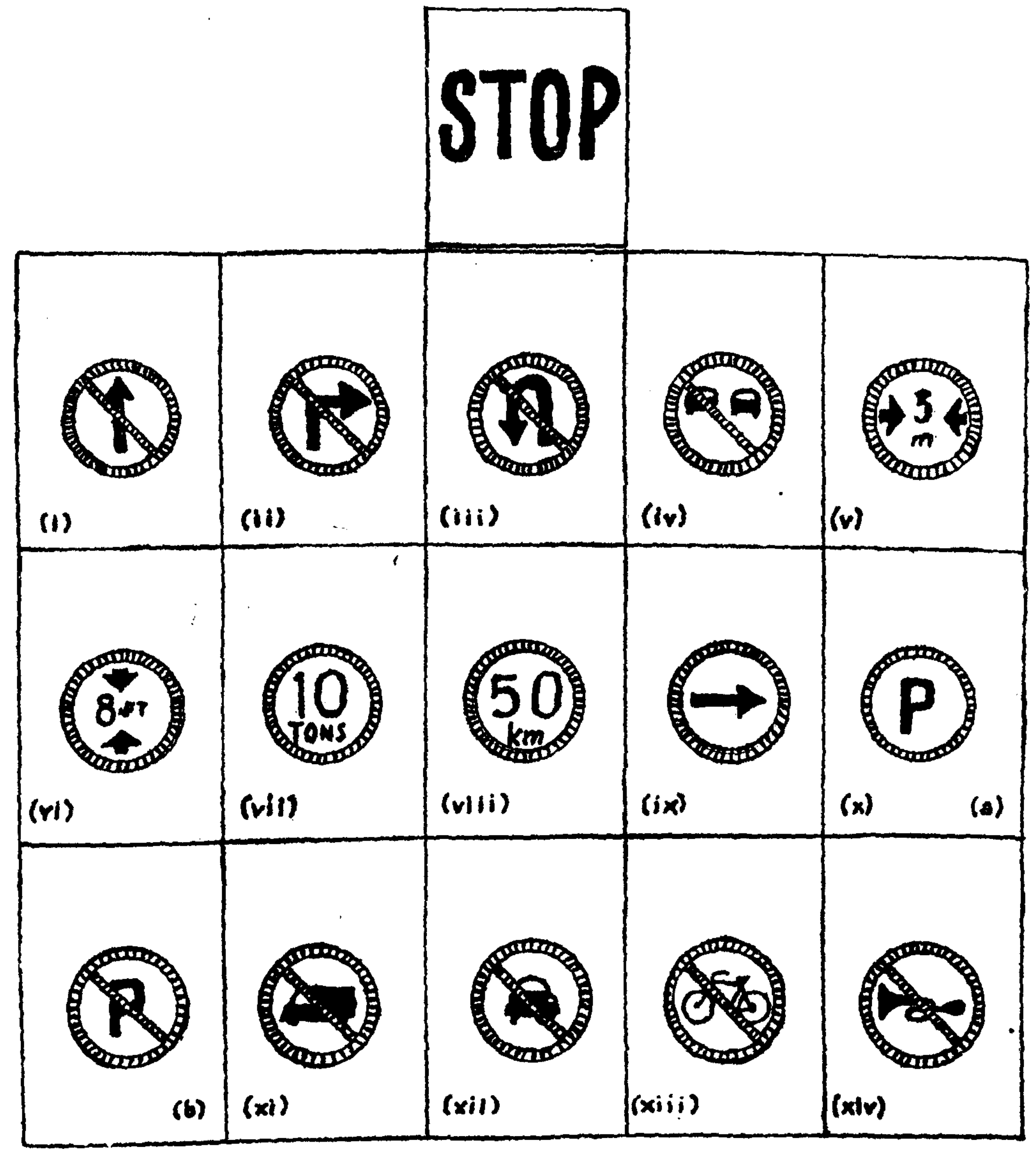
(x) "Signs to indicate restricted or prohibited parking"

(a) Restricted Parking

The sign shall be accompanied by an indication of the limitations or restrictions imposed.

[1] The list of symbols is included in Table 2.

TABLE OF SYMBOLS FOR REGULATORY SIGNS (Table No. 2)



(b) Parking Prohibited

The sign may be accompanied by an indication relative to the duration of the prohibition.

(xi) "No Entry for Goods Carrying Vehicles"

(xii) "No Entry for Motor Vehicles"

(xiii) "No Entry for Bicycles"

(xiv) "Horn Blowing Prohibited"

Article 21

1. Regulatory signs shall be placed facing the traffic and on the same side of the carriageway as used by the traffic concerned. They may be repeated on the opposite side of the carriageway.

2. The signs shall be placed at the point where the prohibition starts and if necessary at further points where the regulation continues. Nevertheless, signs prohibiting turning or showing the direction to be followed may be placed at a suitable distance in advance.

Chapter IV—Informative Signs

Article 22

1. Informative signs shall be subdivided as follows:

(a) Advance direction signs
(b) Direction signs
(c) Route markers
(d) Signs giving general information.

2. Informative signs shall be rectangular in shape with white background and black lettering.

A. Advance Direction signs

Article 23

The advance direction signs shall be rectangular in shape.

B. Direction Signs

Article 24

Direction signs shall be rectangular with the longer side horizontal and shall bear an arrow or arrows, or shall be rectangular, with the longer side horizontal, with one side terminating in the form of an arrow head.

C. Route Markers

Article 25

Route markers shall bear numbers or letters or a combination of numbers and letters. These signs shall be rectangular in shape.

D. Signs giving General Information

Article 26

1. Signs giving general information shall be rectangular in shape.

2. Signs indicating a locality or other geographic feature shall be of the same colour combination as the direction signs.

Part III—Traffic Light Signals

Article 27

1. A three coloured light signal system shall be used. It will have the following meaning:

Red—indicates that vehicular traffic must not pass beyond the prescribed point;

Green—indicates that vehicular traffic may pass the signal;

Amber—shall be used only after the green signal. It indicates that the vehicle shall not proceed beyond the signal unless it is so close to the signal when the amber signal first appears that it cannot safely be stopped before passing the signal.

2. (a) When a single amber flickering light is used, it shall indicate "Proceed with caution".

(d) When single red intermittent light is used, it shall indicate "Stop then proceed with caution".

3. The lights on traffic light signals shall always be arranged vertically except where used for special purposes or where the clearance is limited. The red light shall be placed at the top, the amber light in the middle and the green light at the bottom.

4. When traffic light signals are placed on or at the side of the carriageway, the height of the lower edge of the lowest light above the carriageway shall normally be not less than 2 m (6 ft 6 in.) (and not more than 3.50 m (11 ft 6 in.) When those signals are suspended over the carriageway the lower edge of the lowest light should be placed as low as possible consistent with the height of vehicles operating on the road.

5. More than one signal face may be used to ensure so that at least one

signal face may be clearly visible to traffic approaching from each direction. The casing of traffic light signals should be painted in black or a dark neutral colour.

Part IV—Pavement Markings

Article 28

(a) Pavement markings are markings indicated by lines, studs, or in any other manner, on the surface of the travelled way or on its ancillary works, such as kerbs, footpaths and shoulders, for the control, warning, guidance or information of road users.

(b) Pavement markings on the surface of the travelled way are called "surface markings" and shall be classified as follows:

(i) Longitudinal markings;
(ii) transverse markings;
(iii) other markings.

Types of marking at present included in each category are given in section A of this Code.

Article 29

(a) Longitudinal markings shall consist of continuous lines or broken lines.

(b) When a longitudinal marking consists of a continuous line, it restricts traffic to the extent that no vehicle should cross or straddle such a line. Conditions for its use are given in Section A of this Code.

(c) When a longitudinal marking consists of a broken line, vehicles are allowed to cross it, provided that this can be done with safety. These markings serve as a guide to drivers and to facilitate the movement of traffic in lanes. Conditions for their use are given in Section A of this Code.

(d) A continuous line may be used adjacent to a broken line. If so used, in countries where traffic moves to the right (left) a vehicle should not cross the continuous line adjacent to and to the right (left) of a broken line on the left (right) of the lane in which it is moving. A vehicle may, however, cross the continuous line if that line, at the left (right) of the lane in which the vehicle is moving is to the left (right) of, and adjacent to, a broken line.

Article 30

(a) Transverse markings shall consist of a continuous or a broken line. Types of such markings are given in Section A of this Code.

(b) Where a continuous line is used across one or more of the approach lanes of an intersection, it indicates the line behind which drivers should stop when complying with a STOP or HALT sign, an indication given by a traffic signal or a police officer, or any other traffic regulation.

Article 31

(a) Other markings, such as arrows painted on the travelled-way, oblique parallel lines or words painted on the travelled-way, may be used to supplement other signs or to give appropriate indication or guidance to road users.

(b) Recommended types of such markings are given in Section A of this Code.

Article 32

Markings on ancillary works of the roadway, notably kerbs and shoulders, may be used to improve the visibility, especially at night, of the kerbs or of obstacles in the roadway. They may also be utilized to indicate areas where waiting is forbidden, bus-stops, or to give other similar indications.

Article 33

(a) Each adopting country shall keep the same colour or combination of colours for all road markings having the same meaning.

(b) Road surface markings shall be yellow and/or white, the latter including shades of silver and light grey. When both colours are used, one colour must be reserved for markings other than border lines, intended to control or guide moving vehicular traffic, and the other colour must be reserved for pedestrian and cycle crossings, border lines and markings indicating existing parking or waiting regulations.

Article 34

Each adopting State shall establish standards (visibility, slipperiness, maximum height above the surface), to which the materials used for roadway markings shall conform.

Article 35

The adopting countries shall endeavour to apply, at the time of the placing or the renewal of the road markings on their roadways, the recommendations contained in Section A of this Code.

Section A.
Detailed Specifications for Uniform Pavement Markings

1. Function

Road surface markings are generally used to show the limits of the travelled way and the parts of the travelled-way reserved for the different directions of traffic or for certain types of road users, or to indicate to the motorist where and how he should drive. They are sometimes used with other traffic control devices in order to reinforce or make more specific the indication given by such devices.

2. Type of pavement markings

The types included in the three categories of pavement markings consist of:

(a) Longitudinal markings indicating: centre lines, border lines, lane lines, restricted overtaking, change in width of the travelled way, or approach to obstacles.

(b) Transverse markings indicating: stop lines, pedestrian crossing or cyclist crossings.

(c) Other markings (arrows, oblique parallel lines, words, etc.), used to give further indications to road users.

3. General recommendations

Pavement markings may be either painted or indicated by some equally or more effective means. Materials used for this purpose should not be slippery. Any material adopted for use should be given a reasonably long trial on the road before final adoption.

Studs or other similar devices at present in use are not generally suitable for marking continuous lines. When used for broken lines or to supplement other road markings, they should not, in relation to the level of the roadway, project more than 1.5 cm or more than 2.5 cm in the case of studs incorporating retroreflectors.

4. Reflectors

The use of reflector material or reflector devices or road markings serves to render them more visible by night on unlighted roads. Their use is therefore recommended on such roads.

5. Detailed specifications[1]

(a) Longitudinal markings:

(i) Dimensions

The width of lines for longitudinal markings, whether continuous or broken lines, should be at least 10 cm (4 in.) and should not normally exceed 15 cm (6 in.).

PAVEMENT MARKINGS (Table No. 3)

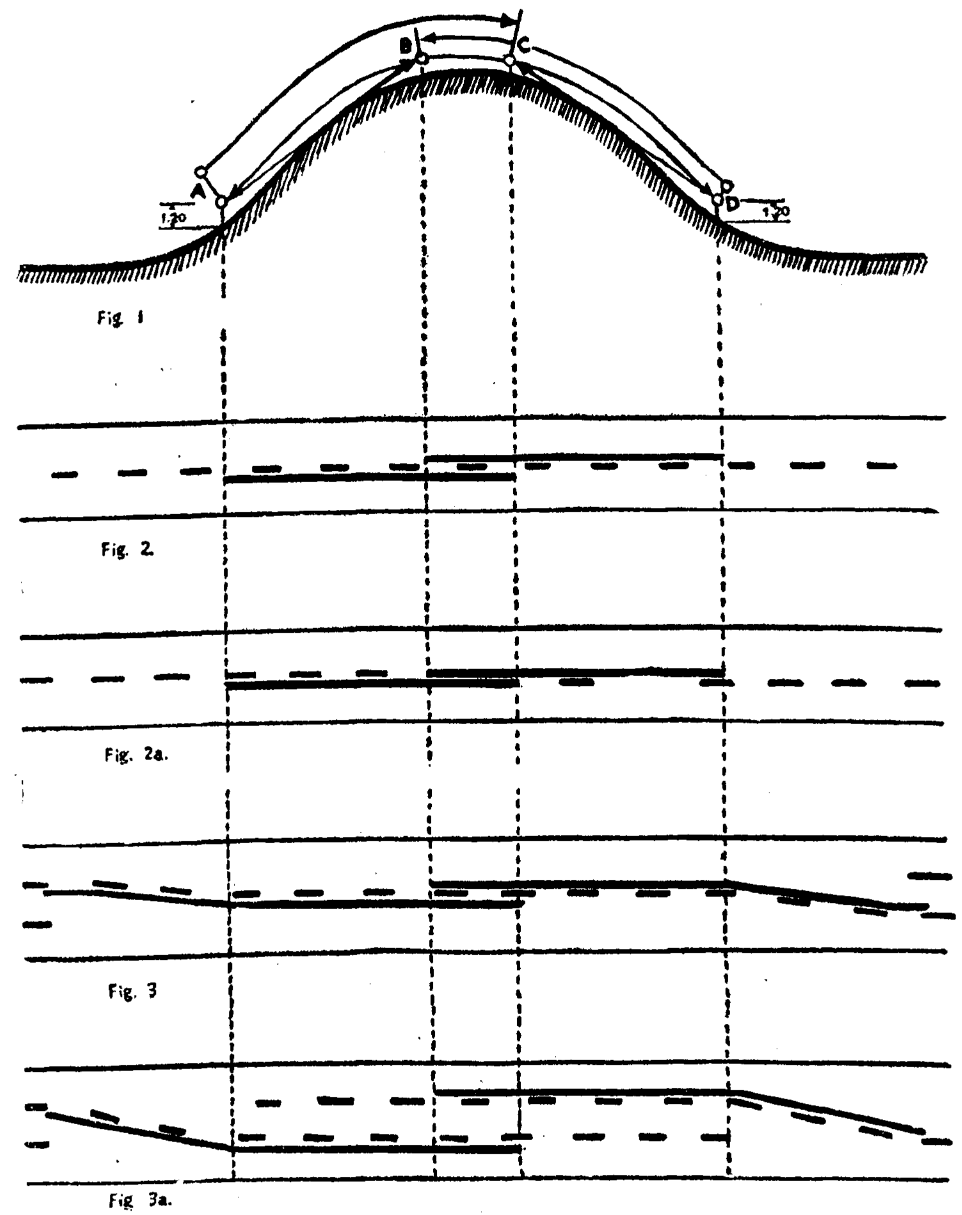


Fig. 1 **Profile of sight distance**
Fig. 2. 2a. **Design of traffic lines for a two-lane road**
Fig. 3. 3a. **Design of traffic lines for a three-lane road**

[1] Graphic representation is shown in Table 3.

PAVEMENT MARKINGS (Contd.) (Table No. 3)

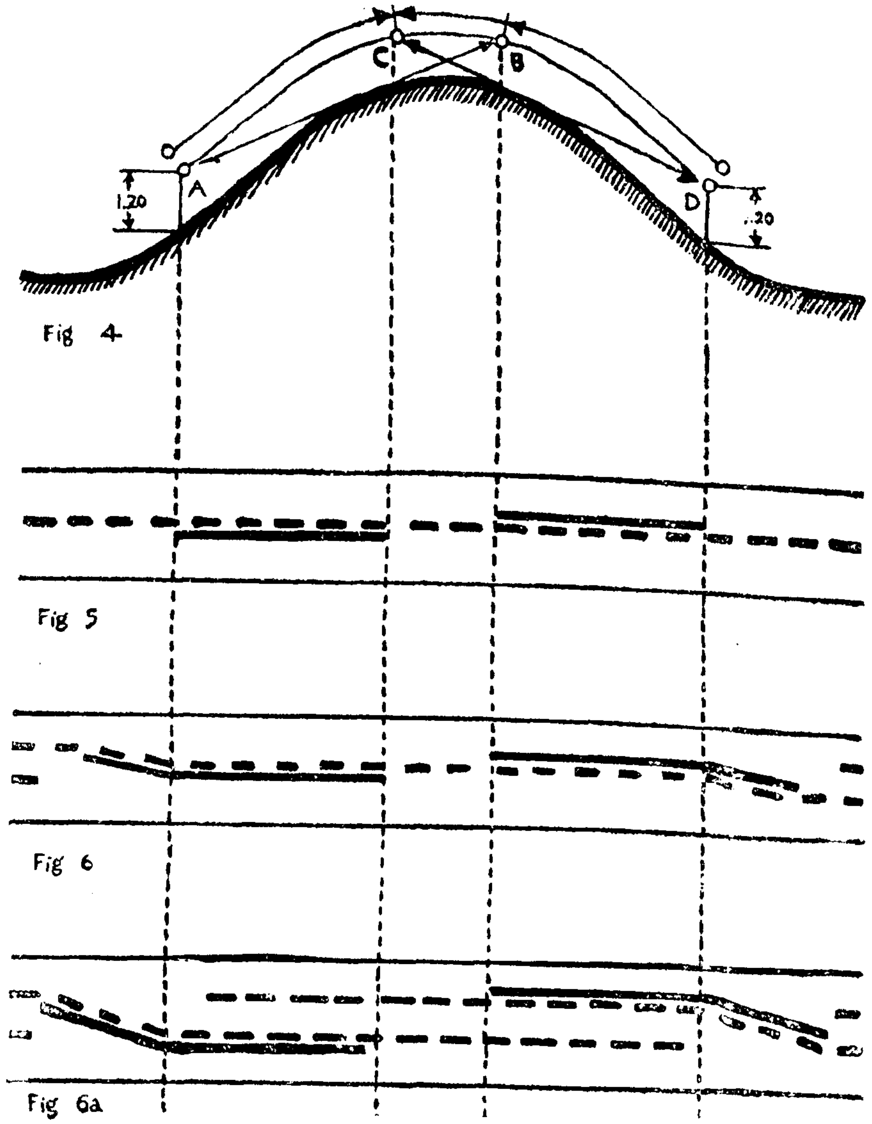


Fig. 4, 5, 6, 6a. Working traffic lines when sight distances from opposite directions overlap

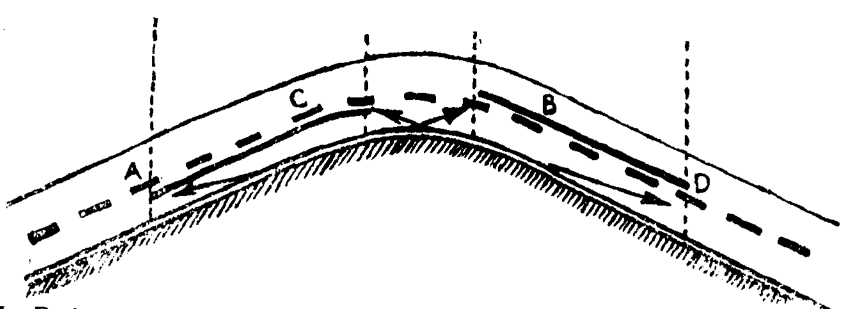


Fig. 7. Design of lines on a curve with restricted sight distance on a two-lane road

When a continuous line is used alongside a broken line or another continuous line, the distance between the lines should not be greater than 15 cm (6 in.) nor less than 10 cm (4 in.).

The broken lines consist of alternate stripes and gaps, each of uniform length. The speed of vehicles on the section of road or in the area concerned should be taken into account when choosing these lengths.

In normal traffic conditions in rural areas, the broken line should be divided into stripes of between 2 and 10 m (6.5 to 32 ft). The distance between two successive stripes should not be less than the length of one stripe nor more than 10 metres.

Where traffic is slow, the size and spacing of the stripes should be less than those in open country. They may be as little as 1 m (40 in.) long but the gap should then not exceed 5 m (16 ft).

On main urban arteries with fast-moving traffic, however, the features or longitudinal markings should be the same as in rural areas.

(ii) Marking traffic lanes

If traffic lanes on either a two-way or a one-way road are to be indicated, this should be done by means of broken lines.

Open country

It is recommended that, on two-way roads with two lanes, the centre of the roadway should be indicated by a longitudinal marking when the traffic volume is large or when fog is prevalent or in special cases. The road marking for this situation is normally a broken line. Only in special circumstances and under the conditions specified below, should continuous lines be used.

The lanes of three-lane roads, on sections of normal visibility, should be indicated by broken lines.

Marking of lanes on a multiple-lane roadway is recommended.

Built-up areas

Marking of traffic lanes is recommended on roads carrying at least two lines of traffic in each direction, and on one-way streets carrying at least two lines of traffic.

At the approaches to major intersections (especially controlled intersections) where sufficient width is available for two or more lines of vehicles, it is recommended that traffic lanes should be marked as shown in Figure 17. In such cases, the lane lines may be supplemented by arrow markings [see section (c) below].

It may also be desirable to mark traffic lanes at points where the width of roadway is reduced by kerbs or islands.

(iii) Markings at particular locations: use of continuous lines

In order to improve the flow of traffic, it may be advisable at some intersections to replace the broken centre lines by a continuous line, or supplement them in this manner (as shown in Figures 14, 15 and 16).

Measures restricting overtaking are desirable on two-way roads at places where sight distance is restricted (hump-backed bridge, a bend in the road, etc.) or where the travelled-way becomes narrow, or because of some other peculiarity.

These restrictions should be imposed on sections where the sight distance is less than a certain minimum (M), by means of a continuous line used in accordance with the figures indicated below[a]. The value to be adopted for M varies with road conditions. Figures 2 and 3 show, for a two-lane and three-lane road respectively, the design of

[a] The definition of sight distance used in this detailed specification for Uniform Pavement Markings is the distance at which an object placed on the roadway at 1.2 m (4 ft) above the roadway can be seen by an observer on the road, whose eye is also 1.2 m above the roadway.

the lines at a summit with restricted sight distance. These figures correspond to the profile shown in Figure 1, where M represents the length defined above, A (or D) is the point where the sight distance becomes less than M, while C (or B) is again more than M[b].

Where the sections AB and CD overlap (Figure 4), that is, when forward visibility in both directions occurs before reaching the top of the summit, the lines are arranged in the same way, but the continuous barrier lines alongside the broken centre line do not

PAVEMENT MARKINGS *(Contd.)* (*Table No. 3*)

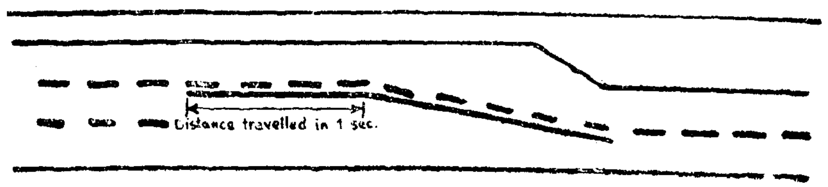


Fig 8

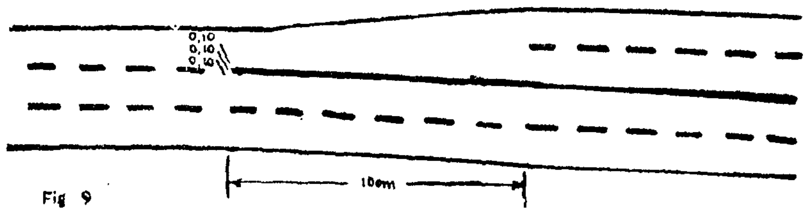


Fig 9

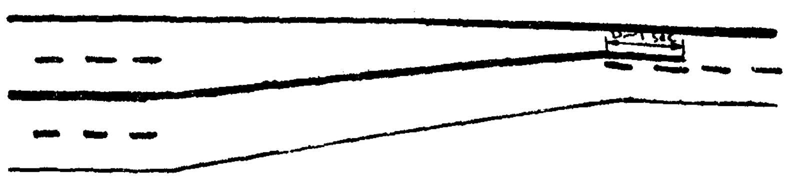


Fig 10

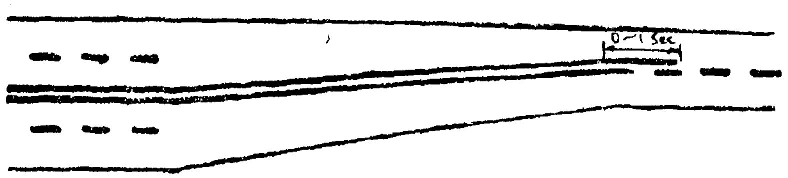


Fig 10a

Fig. 8, 9, 10, 10a. **Methods of indicating changes in the width of the roadway**

[b] On narrow roads with little traffic, where the layout shown in Figures 2 and 3 might reduce the width of the traffic lanes, Figure 2 could be changed between A and D by a single continuous centre line, without a broken centre line alongside, preceded by a broken centre line divided into at least three parts. This would certainly be less expensive and last longer than Method I. Nevertheless this simplified plan should be used with care and only in exceptional cases, since it prevents the driver from overtaking over a certain distance even though there is adequate sight distance. Wherever possible, it is essential to avoid using both methods on the same route or in the same region, as this may lead to confusion.

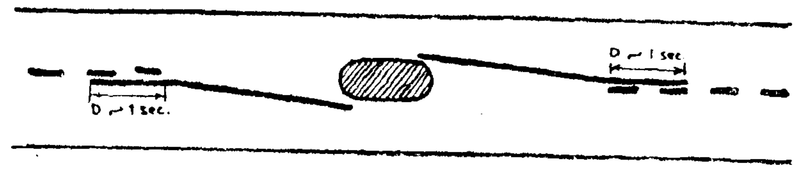


Fig 11

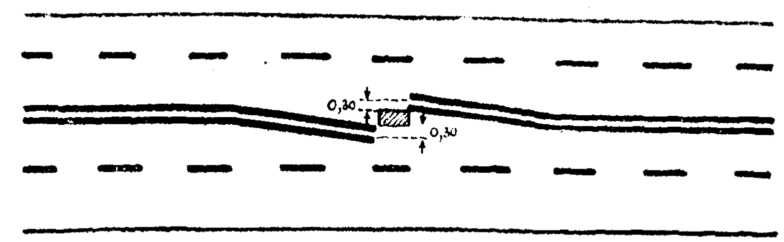


Fig 12

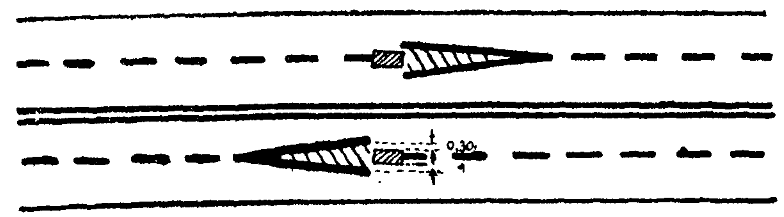


Fig 13

Fig. 11, 12, 13. **Lines indicating the approach to islands or obstacles on the roadway**

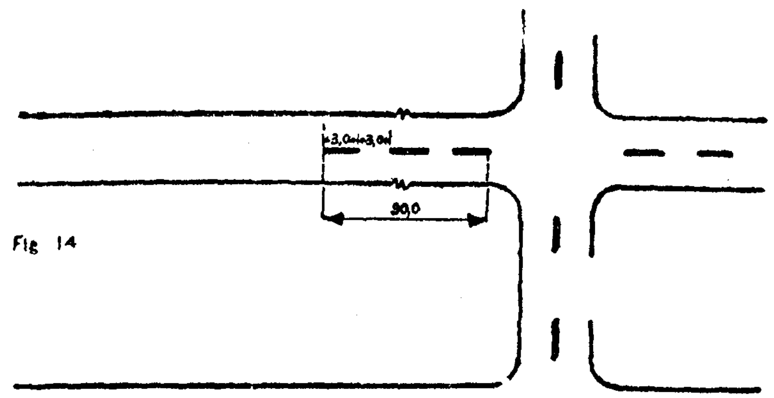


Fig 14

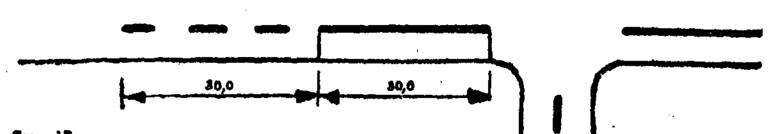


Fig 15

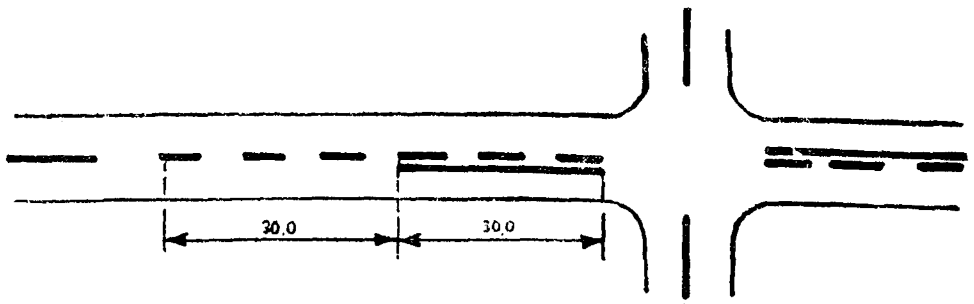


Fig 16

Fig. 14, 15, 16. Use of continuous lines at intersections for improving traffic

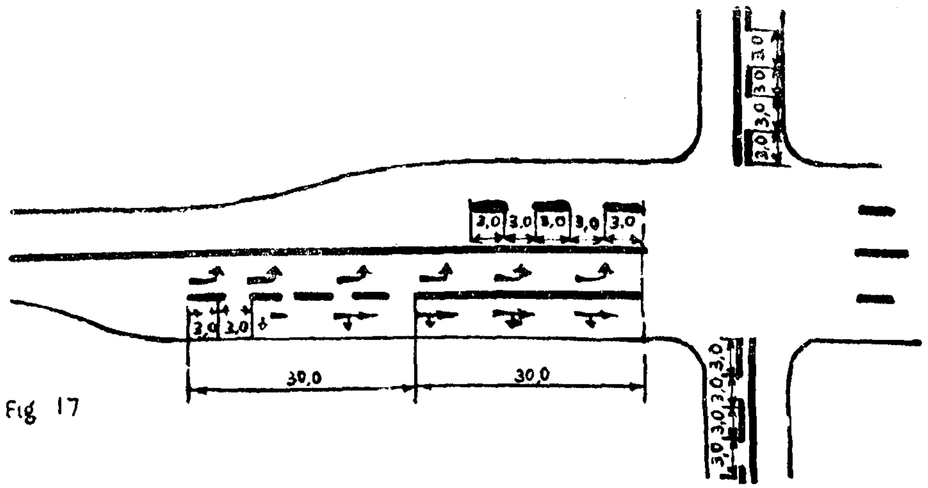


Fig 17

Fig 18

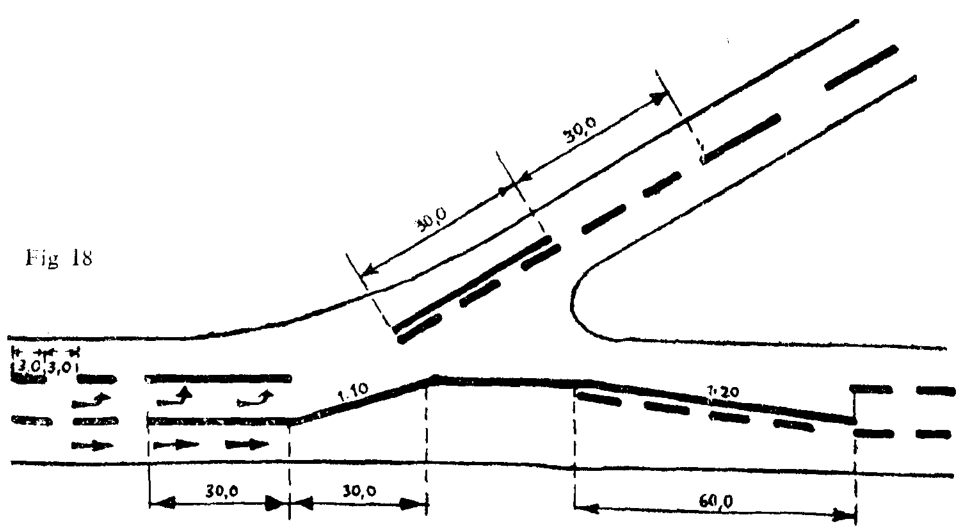


Fig. 17, 18. Arrow markings showing traffic approaching on intersection

overlap. This is shown in Figures 5 and 6.

Figure 7 shows the design of the lines, on the same hypothesis, on a curve with restricted sight distance on a two-lane road. On three-lane roads two methods are possible. These are shown in Figures 3 and 3a. Figure 3 should be used where there is a substantial proportion of two-wheeled vehicles and Figure 3a when traffic is mainly four-wheeled.

In figures 3, 3a, 6 and 6a, the angle of the oblique transition lines in relation to the centre line of the road must be less than 1 : 10, and preferably 1 : 20. In Figures 8, 9, 10 and 10a, which illustrate

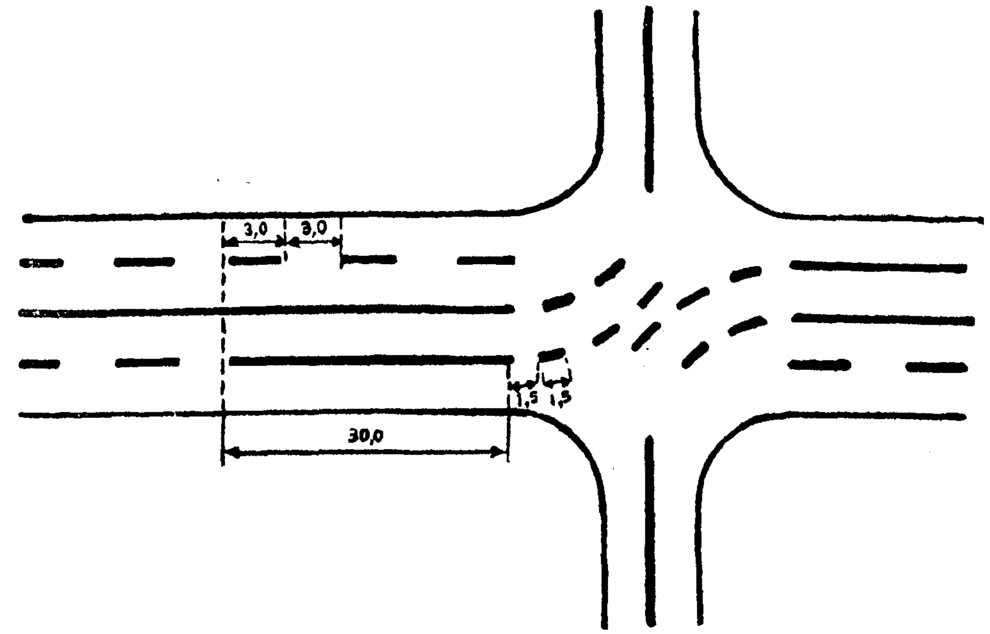


Fig. 19. Guide lines for turning

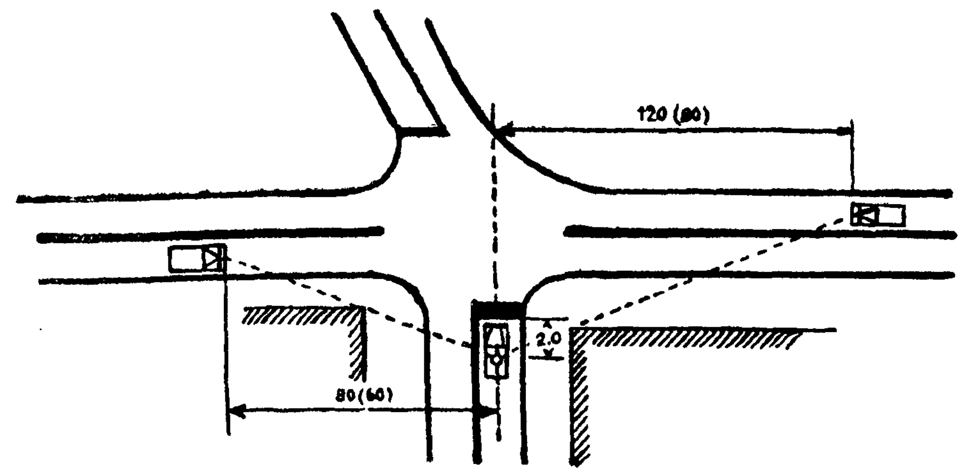


Fig. 20. Continuous longitudinal lines marking traffic lane

Note: In sketches No. 14 to 20 the figures given for dimensions of dotted lines and intervals should be regarded only as mere indications.

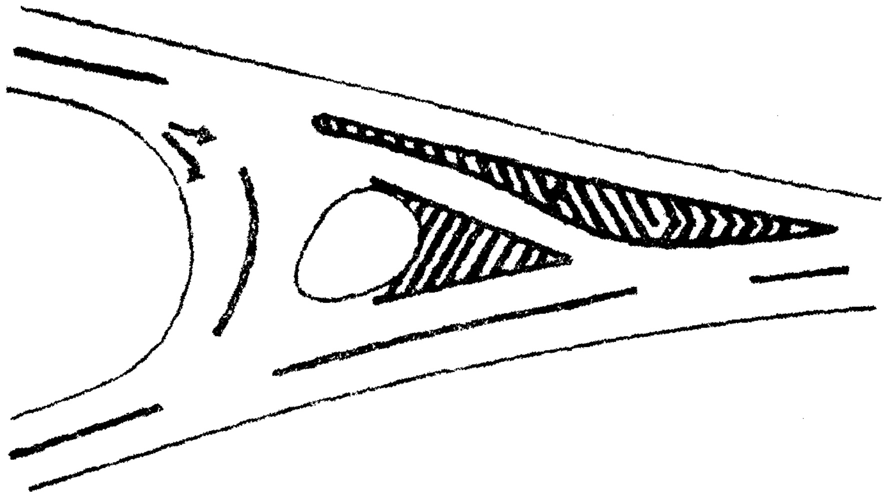


Fig. 21. Oblique parallel line markings

the methods to be used to indicate the changes in the width of the roadway, this angle should be between 1 : 20 and 1 : 40. In addition, the oblique continuous line should be preceded, in the direction to which it applies, by a continuous line parallel to the centre of the roadway, the length of which corresponds to the distance travelled in one second at the operating speed adopted.

When it is unnecessary to mark the lanes by broken lines on a normal section of road, the broken centre line should precede the continuous lines which accompany it, over a distance of at least 50 m (165 ft), and preferably 75 m (247 ft).

(iv) Use of double continuous line

On wide roads, a single continuous line may be replaced by a double continuous line, in order to improve its visibility.

(v) Conditions for use of continuous (barrier) lines

The distance and circumstances which allow the driver of a vehicle safely to overtake the vehicle in front depends on several factors, but mainly on the relative speed of the two vehicles, the speed at which oncoming vehicles are approaching and the volume of traffic.

If the longest overtaking distance is used as a basis for marking barrier lines (that is, corresponding to overtaking in the most unfavourable circumstances), the lines which are then marked are a guarantee of safety, provided all drivers observe them. However, they greatly restrict the use of the travelled-way, for the most unfavourable circumstances do not occur frequently. Indeed, lines determined on this basis might well prove more harmful than useful, if they encourage impatient drivers to cross a barrier line whatever the situation. If, on the other hand, there is no barrier line on a section where visibility is not sufficient for overtaking, the driver is free to decide for himself whether he can or cannot overtake safely, a decision he may not always be able or willing to make.

For these reasons the choice of sight distance to be used in determining the desirability or otherwise of marking a continuous barrier line, and also in determining the desired length of the line of necessity involves a compromise. The following figures show the recom-

mended range of values of M for various speeds of approach:

Approach speed (per hour)		Range of values for M			
		Minimum		Maximum	
Kilometres	Miles	Metres	Feet	Metres	Feet
100	60	250	800	450	1,500
80	50	160	530	300	1,000
65	40	110	365	180	600
50	30	60	200	150	500

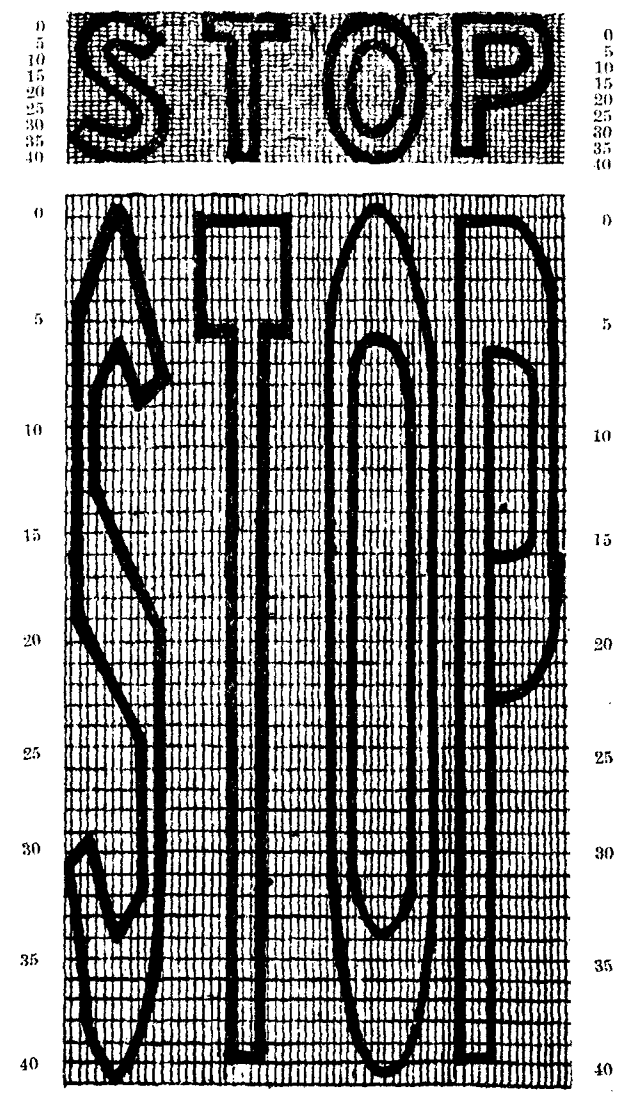


Fig. 22. Word markings on road surface for "stop" indication

[c] The approach speed which should be used in this calculation is the speed below which 85 per cent of the vehicles travel, or the design speed if it is higher.

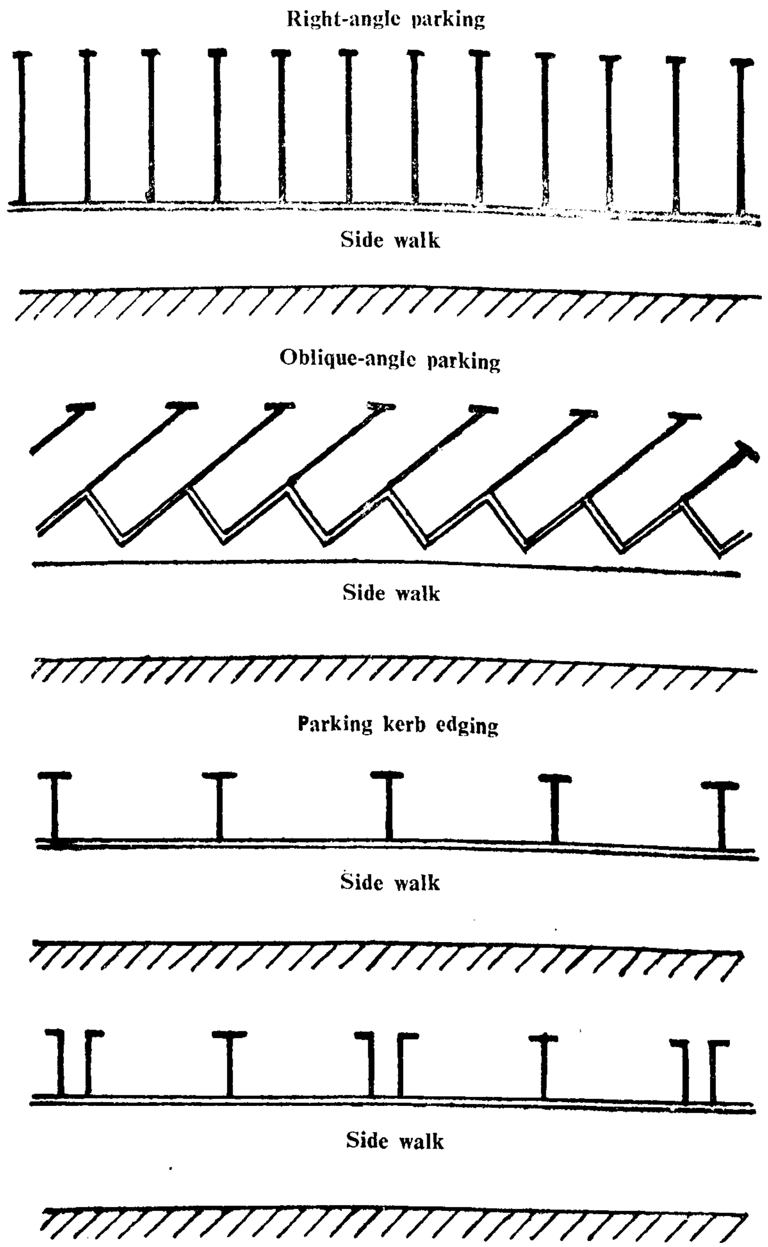


Fig. 23. **Lines indicating parking space limits**

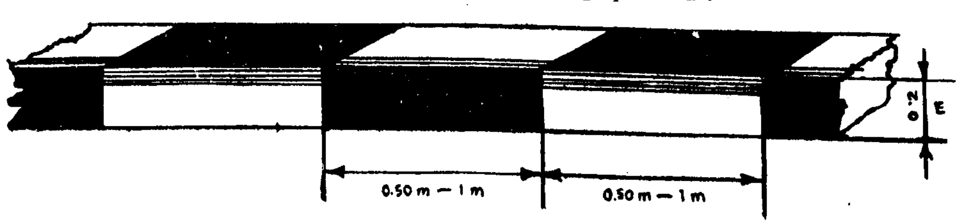


Fig. 24. **Kerb markings**

(vi) Border lines marking the edge of the travelled-way

Border lines marking the edge of the travelled-way are especially useful when there are no raised kerbs. The marking may be a broken line or a different pattern from that used for lane markings, or a continuous line of a different width or colour from that used for barrier lines. Studs, buttons or reflectors may be used in conjunction with the line, or as an alternative.

(vii) Marking obstacles

Figures 11, 12 and 13 show the lines to be used near an island or some other obstacle on the travelled-way.

(viii) Guide lines for turning vehicles.

At some intersections it is desirable to show drivers how to turn left (right). Figure 19 is a suggestion for these guides, which should be broken lines; they may be supplemented by arrows. Because of the great variety of layouts at intersections, it is very difficult to standardize such markings.

(b) Transverse markings

(i) General

Owing to the angle at which a driver sees markings on a road surface, transverse markings have to be wider than longitudinal ones if the same visibility is to be obtained.

(ii) Stop lines

The minimum width of a stop line should be 20 cm (8 in.) and the maximum 50 cm (20 in). A width of 30 cm (12 in.) is recommended.

When used with a STOP sign, the stop line should be placed in such a position that a driver who stops immediately behind the line has the best possible view of traffic on the other arms of the intersection, consistent with the requirements of other vehicular and pedestrian traffic. The indication given by the STOP sign and the line may be supplemented by marking the word STOP or HALT on the travelled-way (see Section C, below).

Stop lines may be supplemented by continuous longitudinal lines marking the traffic lanes (see figure 20).

(iii) Pedestrian crossings

Zebra markings are visible from a greater distance than other forms of road marking and are therefore, especially useful for delineating the position of pedestrian crossings. The space between the stripes should be equal to the width of the stripes and should be between 50 and 60 cm (20 to 24 in.). The stripes should be parallel to the direction of traffic. The minimum width which is recommended for a pedestrian crossing is 2.5 m (8 ft).

Pedestrian crossings may also be indicated by studs, buttons or broken lines. Studs and buttons are not recommended, however. Broken lines marking pedestrian crossings should consist of stripes of 50 cm (20 in.) long and at least 15 cm (6 in.) wide. The gaps should be 20 cm (8 in.) long. The space between two broken lines should be at least 2.5 m (8 ft) wide. When studs or buttons are used to mark pedestrian crossings, they should be between 40 and 60 cm (16 to 24 in.) apart.

(iv) Cyclist crossings

Zebra markings are also recommended for cyclist crossings but these should be distinguished from pedestrian crossings by stripes of a different width from those for pedestrian crossings.

Cyclist crossings may also be indicated by studs, buttons or broken lines of a different pattern from those used for pedestrian crossings. Studs and buttons are not recommended however. The width of the crossings should be not less than 2.5 m (8 ft).

(c) Other markings

(i) Arrow markings

On roads where sufficient traffic Lanes are available to segregate traffic approaching an intersection, the lanes which traffic should use may be indicated by arrow markings applied on the road surface (see figures 17 and 18). They may also be used on a one-way road to confirm the direction of travel.

Arrow markings should not be longer than 5 m (16 ft). They may be supplemented by word markings.

(ii) Oblique parallel markings (see figure 21)

Such markings may be used to delineate areas of the road surface, or areas raised slightly above the road surface, which vehicles should not enter. They are especially useful at the approaches to obstacles in the travelled-way, such as islands.

(iii) Word markings

Word markings on the road surface may be used for the purpose of guiding warning or regulating traffic. The words used should preferably be place names, route numbers or words which are easily understood internationally such as "stop", "bus" and "taxi". The letters should be greatly elongated in the direction of traffic movement because of the low angle at which they are viewed by approaching drivers. A method of achieving this is illustrated in Fig. 22.

Where traffic speeds are greater than 50 km per hour (30 miles per hour), lettering should be at least 2.5 m (8 ft) in height.

(iv) Parking space limits

Parking space limits may be indicated on the road surface by appropriate lines (see figure 23).

(v) Marking indicating parking restrictions

Kerb or road surface markings may be used to show where parking is prohibited. The marking should be a continuous line covering the top of the kerb or on the road surface close to it. If desired, the face of the kerb may be similarly marked.

(vi) Kerb markings to improve visibility

Kerb markings as shown in figure 24 may be used where necessary to enhance the visibility of a kerb (especially at night).

(vii) Bus stops

The continuous line on the kerb used to denote "parking prohibited" may also be used to advantage to indicate the length of kerb which should be reserved for buses. This marking may be supplemented if desired by word markings on the road surface, or by an area of distinctive road surface.

DEFINITIONS

Pedestrian—A married man with a grown up daughter and possessing only two cars.

TRAFFIC LINE MARKING

POLICY ON MAIN ROADS IN NEW SOUTH WALES

(By the courtesy of the Department of Main Roads, New South Wales, Sydney)

THE Department of Main Roads establishes and maintains traffic lines to divide traffic streams on those proclaimed Main Roads which are suited to such marking. Traffic lines are covered by Traffic Regulations, and the Department's policy in so far as it relates to the regulatory aspect of these lines conforms with Police views. The cost of line marking is met by the Department on those roads where the Department has full responsibility. Elsewhere, it is shared with the Council concerned on the same basis as other works.

Responsibility for the marking on roadways of pedestrian crossings, parking zones, and other markings for traffic control purposes rests with the Police and the Department of Motor Tr... ...port.

Traffic lines normally define the centre line of two lane or multi-lane road pavements, thus separating streams of traffic proceeding in opposing directions, and may also be used as lane lines on a multi-lane road to divide a stream of traffic proceeding in one direction. Lines assist in securing orderly movement of traffic and reduce the risk of "head-on" and "side-swipe" collisions by reminding drivers to keep within the marked lanes or on the correct side of the road. In wet or foggy weather, lines also serve as a valuable guide to drivers.

Centre Lines

Centre line marking usually comprises a single broken line marked at or near the centre of the road pavement to indicate the normal dividing line between opposing streams of traffic.

A two-lane pavement is not marked with a centre-line if its width is less than 18 ft. To mark pavements less than 18 ft wide is considered liable to give rise to discomfort or hazard and to cause excessive pavement edge wear.

Separation Lines

These are special types of centre line markings and usually consist of two unbroken lines side by side or a broken and an unbroken line side by side. In some circumstances, a single unbroken line may be used as a separation line.

The **double line markings** are mainly used to separate opposing traffic streams at situations where it could be hazardous to cross the centre line, i.e., the double line assists in indicating the presence of a hazard. Locations for their use are as follows:

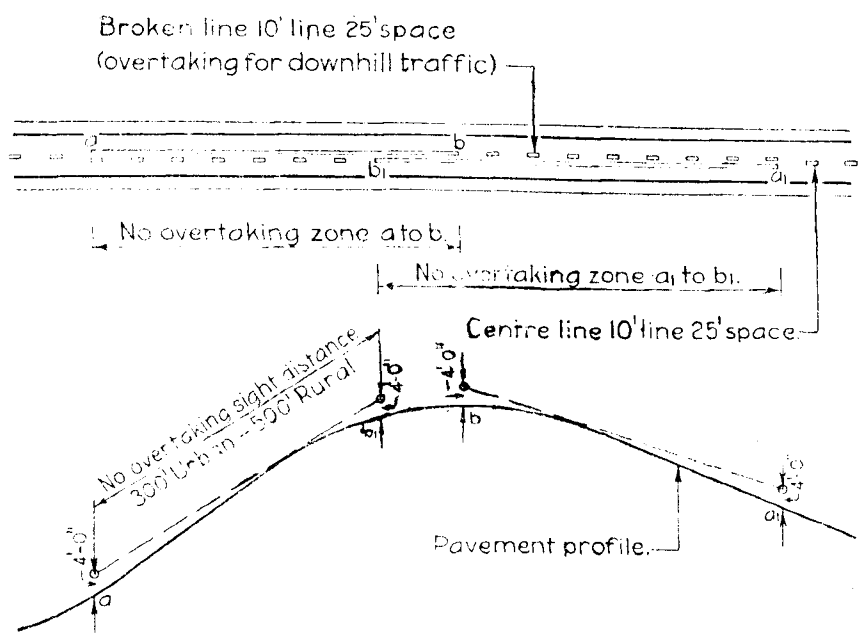
On sections of road where visibility is restricted to the extent that overtaking could be hazardous.

The double line consists of either

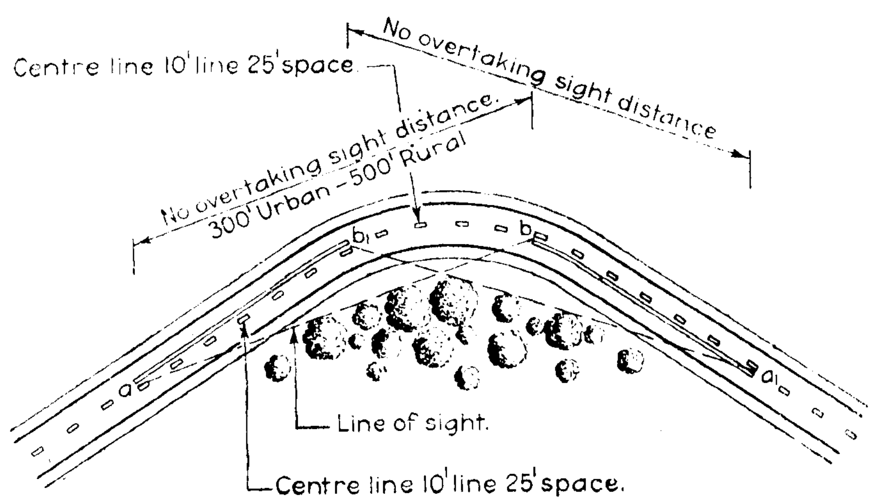
(a) two unbroken lines where visibility is restricted in both directions, or

(b) a combination of unbroken line and broken line where visibility is restricted only in one direction, the unbroken line being on the side of the traffic with restricted visibility.

Uses of the double line in these circumstances are illustrated in Fig. 1.



(a) VERTICAL CURVE WITH RESTRICTED VISIBILITY



b) HORIZONTAL CURVE WITH RESTRICTED VISIBILITY

Fig 1.

LINE MARKING

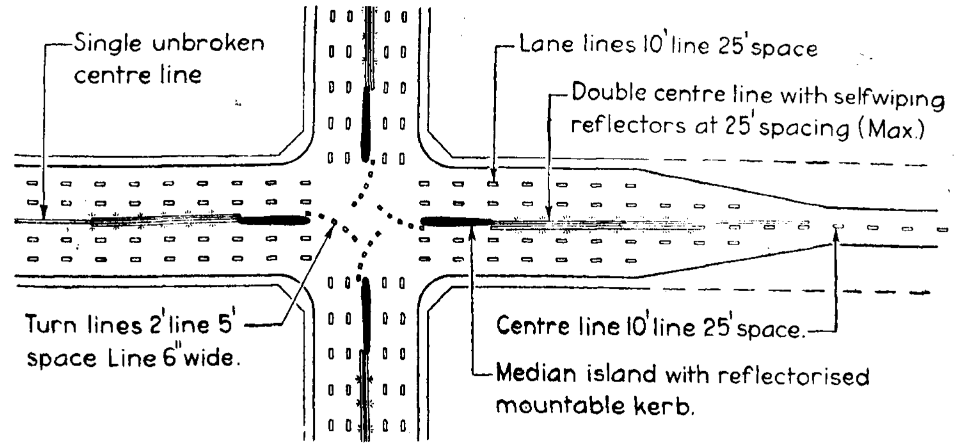


Fig. 2 **Line marking at crossroad intersection with median islands intersection of two Major roads**

Showing: (a) Approach to median island.
(b) Transition lines where pavement narrows.
(c) Turn lines at "Diamond" intersections.

Note: Selfwiping reflectors only where considered necessary.

On approaches to medians or islands separating opposing streams of traffic.

The general minimum length of such lines is 200 ft and they are so located as to guide traffic smoothly past the left-hand side of the island. In some circumstances, a broken and unbroken line combination may be used, with the unbroken line on the side of traffic approaching the island. Use in approach to islands is illustrated in Fig. 2.

On approaches to obstructions in the road.

Double lines are used in approach to obstructions, e.g., bridge piers, in the roadway in a similar manner to those in approach to islands or medians.

On approaches to railway level crossings with half-arm boom gates.

If more than two lanes are available for each direction of travel, medians are generally used to divide opposing streams and enable the half-arm boom gate completely to control traffic. On two-lane roads, double unbroken lines are used to emphasise the "no crossing" aspect of the separation line. This use is illustrated in Fig. 3.

On climbing lanes for slow-moving vehicles on hills.

Double lines are used throughout the length to emphasise the separation between opposing flows, the line on the side of uphill traffic which will have two lanes available to it, being unbroken. Downhill traffic is restricted to one lane by double unbroken lines where visibility is restricted. Elsewhere double lines consist of an unbroken and a broken line, with the broken line on the side of downhill traffic to permit overtakings when safe to do so. This use is illustrated in Fig. 4.

On transitions from wide to narrow road, and vice versa.

Double lines are used to keep traffic to the correct side of the road where there is a change in road width, i.e., where the number of

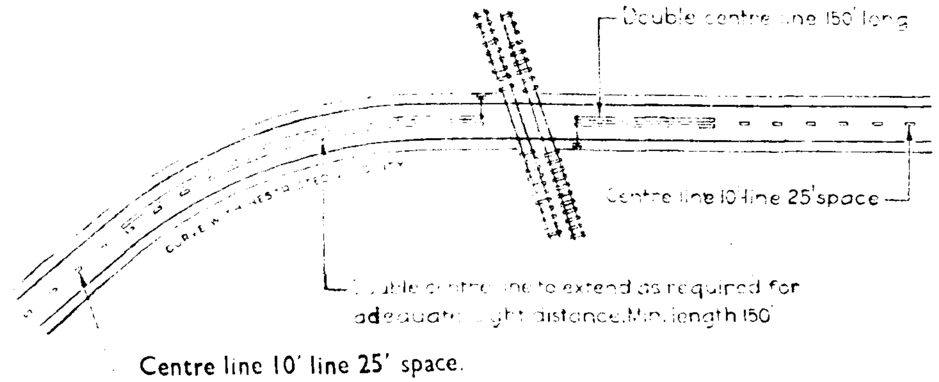


Fig. 3 Line marking at railway level crossings provided with half Boom Gates

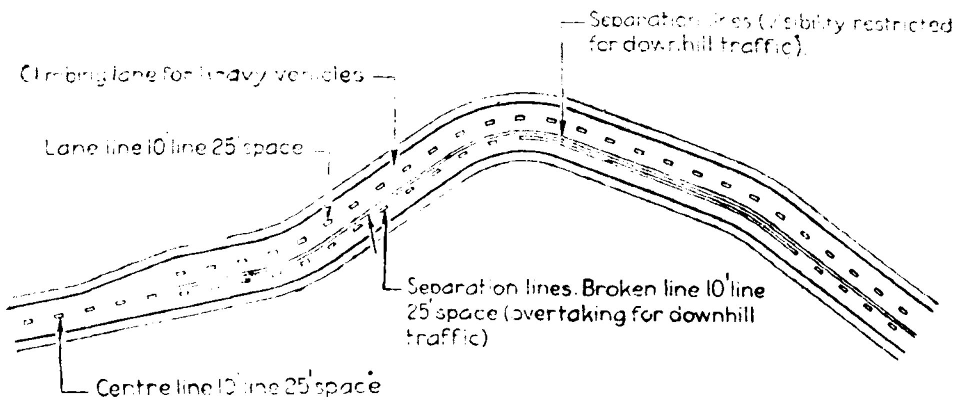


Fig. 4 Line marking at climbing lane for heavy vehicles

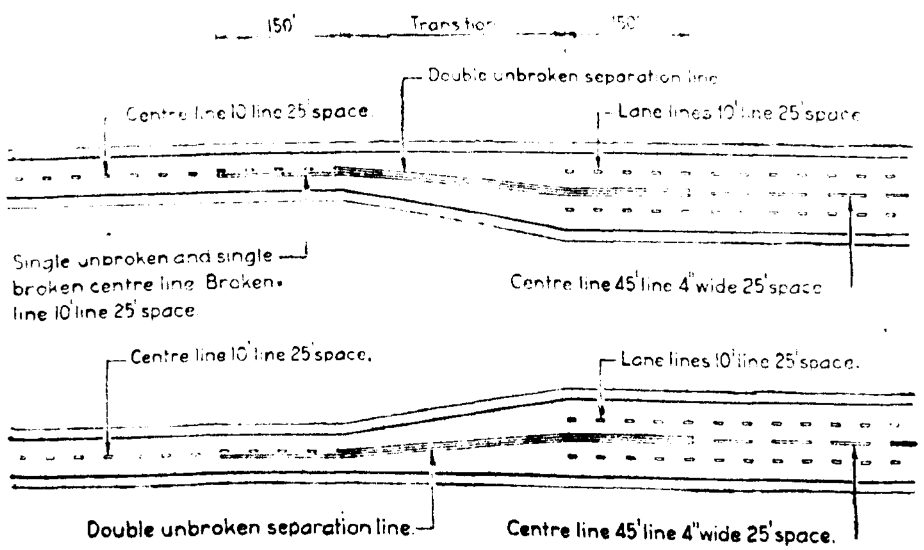


Fig. 5 Line marking at transition from four lane to two lane pavement

lanes is decreased or increased. This use is illustrated in Fig. 5.

On approaches to intersections.

Double lines are used to mark the separation between opposing streams of traffic either:

(a) where there is a change in road width, i.e., a change in the number of lanes, or

(b) where more lanes are available in one direction than the other.

This use is illustrated in Figs. 6 and 7.

This use is illustrated in Fig. 9.

As a centre line on a six-lane carriageway in locations where visibility is not restricted but it is desirable that traffic should keep to the correct side of the centre line at all times. In such cases, the separation line is usually a temporary expedient pending construction of a median.

This use is illustrated in Fig. 8.

Lane Lines

The lane line marking is usually a single broken line, similar in appearance

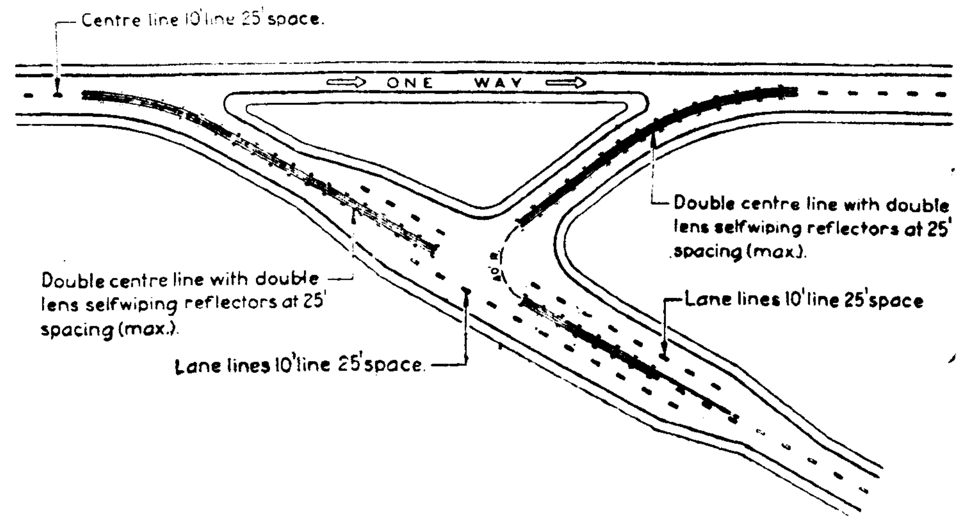


Fig. 6 Line marking at intersection where double line acts as median

Note: Selfwiping reflectors only where considered necessary.

A *single unbroken line* may be used as a separation line in the following circumstances:

On a two-lane road in approach to a traffic dome at an intersection or junction.

This use is illustrated in Fig. 7.

As a centre line on a four-lane bridge, or on a four-lane road if standing is not permitted at any time and it is desirable that traffic should keep to the correct side of the centre line at all times.

to the normal centre line marking, and is used to divide streams of traffic proceeding in the same direction. A single unbroken line is used as a lane line where lane changing is prohibited.

In general, lane marking is restricted to roads where two or more travelling lanes are available for each direction of traffic flow.

The Department's policy provides for lane marking as follows:—

1. Four-lane undivided roads.

In general, a road of sufficient width to provide for only four

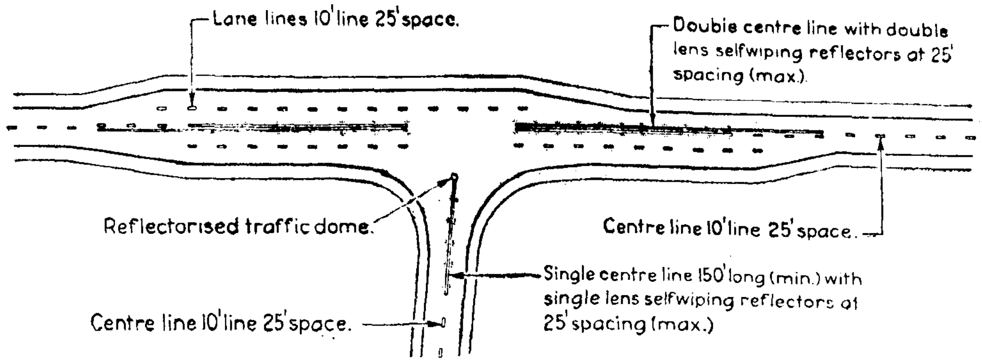


Fig. 7 **Line marking at "T" intersection without median zones intersection of major and minor road**

Showing: (a) Double centre line at widened intersection.
(b) Single centre line at approach to a traffic dome.

Note: Selfwiping reflectors only where considered necessary.

lanes of traffic (i.e., two moving lanes and two parking lanes) will be marked with a broken centre line only, except where "no crossing" lines are required at sections of restricted visibility, etc. However, if stopping or standing is prohibited for a part or the whole of the day to permit of two moving lines of traffic in one direction, then the road is marked in four lanes. In these circumstances, a longer and wider stripe is used for the centre line marking to emphasise the centre line and distinguish it from the lane lines. An illustration of the lane marking and this special type of centre line marking is shown in Fig. 9.

2. Four-lane divided roads are marked in four lanes.

3. Six-lane roads.

   Whether divided or undivided, all six-lane roads are marked in lanes.

   Where a six-lane road is not required to carry three lanes of moving traffic in one direction of flow, only the division between the lane alongside the road centre line and the next adjoining lane is marked. Thus there is a wide kerbside (outside) lane which may have both a row of standing vehicles and a lane of moving traffic.

   Where six-lane roads are required to carry three lanes of moving traffic either continuously or at certain times, e.g., during peak periods, the division between the kerbside (outside) lane and the next adjoining lane should also be marked.

   Fig. 8 illustrates these forms of lane marking.

4. At channelised intersections.

   A single unbroken line may be used as a "no crossing" lane line where lane changing is undesirable, and therefore prohibited, in approach to channelised intersections.

5. At intersections where additional lanes are provided.

   Lane lines are marked at intersections where the pavement has been widened to provide additional (speed change) lanes.

   Figs. 6 and 7 illustrate this use of lane lines.

6. The width of lanes to be marked is dependent on the carriageway width

available. Desirable lane widths are 11 ft and 12 ft, with an absolute minimum of 9 ft. Where possible, kerbside lanes should not be less than 10 ft wide. To determine lane widths and best location for lane lines, the Department of Main Roads carried out studies of the lateral placement of vehicles in the traffic stream. As a result, it is believed that markings, as described, will conform as nearly as possible with the paths desired by drivers.

confused by turn markings, the turn line extends from the start of the turn indicated across only one opposing traffic lane.

Types of Markings

1. **Dimensions**: The broken lines used for normal centre lines and lane lines are marked by a painted stripe 3 in. wide and 10 ft long with a gap of 25 ft between stripes.

   The single unbroken line is 4 in. wide.

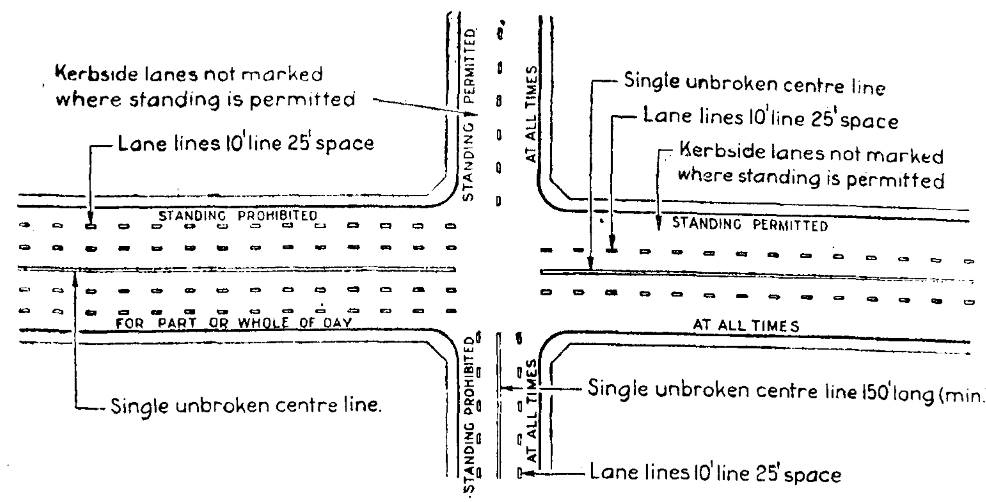


Fig. 8 **Line marking six lane roads not provided with medians**

Showing: (a) Six lane roads where standing is prohibited and where standing is permitted
(b) Four lane roads where standing is prohibited and where standing is permitted

Turn Lines

Where there is an apparent need to provide guidance for traffic making right turns, in those cases where "diamond"* turns are permitted, turn markings should be as illustrated in Figs. 2 and 10.

A special type of broken line, with short stripes and gaps, is used for turn markings so that these markings can be readily distinguished from other broken lines used as lane or centre lines. Also, in order that other traffic should not be

In double line markings, either as two unbroken lines or a combination of one broken and one unbroken line, the lines are 3 in. wide and spaced 3 in. apart.

Turn markings consist of stripes 6 in. wide and 2 ft long with a gap of 5 ft between stripes.

Exceptions to the general practice are:

(a) Centre line on four-lane roads where lanes are marked.

* By "diamond" turns is meant the making of right hand turns in a natural curve which keeps the vehicle to the right of the centre of the intersection.

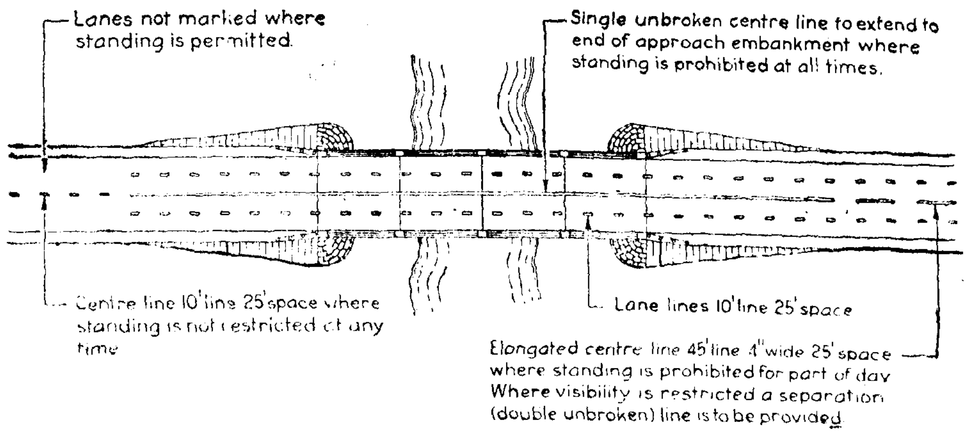


Fig. 9 **Line marking at bridge with four traffic lanes**

Showing: (a) where standing is prohibited for part or whole of day

(b) where standing is not restricted at any time

To differentiate between the centre line and lane lines, the centre line is marked by a 45 ft long stripe, 4 in. wide, with a 25 ft gap.

(b) On the Sydney Harbour Bridge, where upto six lanes are used for traffic flow in one direction during peak periods, a different form of marking is used. Changes from standard are:

(i) Having regard to the heavy volumes of traffic on the bridge and the fact that peak periods in winter can occur in darkness and in bad weather conditions, it was considered desirable to shorten the gaps in broken lines to provide greater continuity of line than applies with the standard marking. Accordingly, while retaining the 35 ft length of cycle for the line marking operation, the stripe on broken lines, except as referred to in (iii) below, has been increased to 17 ft 6 in. long and the gap shortened to 17 ft 6 in.

(ii) The line between the fourth and fifth lanes from the western side of the bridge carriageway is marked as a single unbroken line. This line is the separation line between opposing flows of traffic in off-peak periods. During peak periods, when traffic is flowing in the same direction on both sides of this line, lane changing is prohibited and the line, therefore, retains its "no crossing" significance.

(iii) The stripes in the line between the second and third lanes from the western side of the bridge carriageway are lengthened by filling in each alternate gap, i.e., the stripe on this line is 52 ft 6 in. long and the gap 17 ft 6 in. This line serves as a separation line in the morning peak and is then marked, in addition, by traffic markers (flaps) placed along the line.

All lines on the bridge are marked 4 in. wide.

2. **Colour**: Until recently, the colour of all pavement markings in New South Wales was yellow, but white paint is now being used by the Department of Main Roads for marking all broken traffic lines on Main Roads. The use

of yellow for unbroken lines will be continued.

The main reasons for changing the colour of broken lines are:

(a) To obtain greater uniformity in practice throughout Australia.

The unbroken yellow indicates the lines which are not to be crossed, except in specified circumstances, and which assist in warning of conditions where particular care is needed. The broken white indicates the lines provided principally to guide traffic and which may be crossed when it is safe to do so.

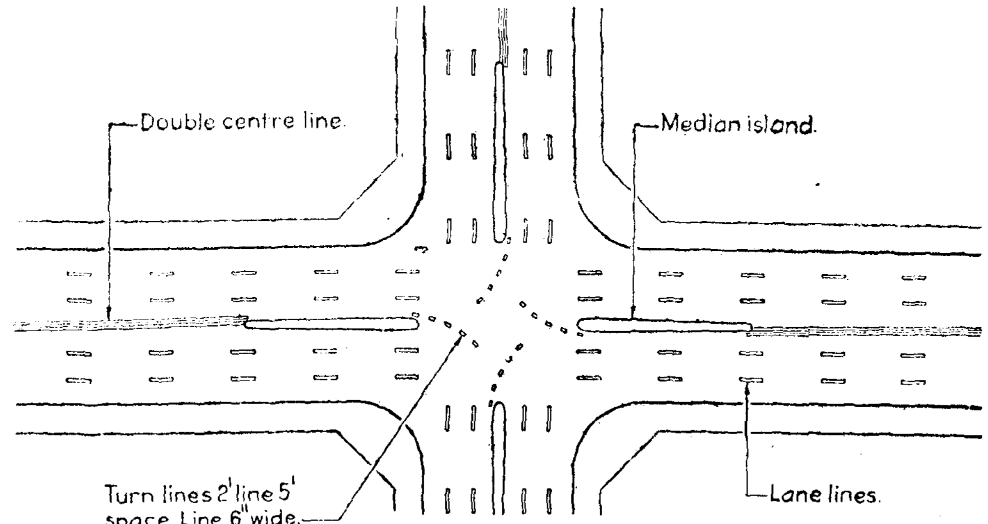


Fig. 10 **Line marking at diamond intersection**

Note: For further details see Fig. 2.

The use of white or yellow is permissible for pavement markings in Australia. Four of the six States use white only and, until the change to two-colour line marking in New South Wales, the other two States used yellow only. The change to white for broken line markings in New South Wales brought the practice in this State more closely in conformity with that in the majority of Australian States.

(b) To provide a better contrast between the traffic lines used for guidance purposes and those used for warning or control purposes, and so emphasise the meaning of the lines as prescribed in the Motor Traffic Regulations.

The use of two colours for traffic line marking is in accordance with the practice now recommended by the American Association of State Highway Officials and which has been adopted by the majority of the States in the United States of America.

3. **Visibility at Night**: To improve visibility of traffic lines at night, particularly in adverse weather, the Department of Main Roads is now using glass beads on pavement markings. The beads are spread on the wet painted line and reflect the light from vehicle headlamps back to the driver.

The Department is making increasing use of self-wiping pavement reflector studs to emphasise lines having regulatory significance, i.e., single and double unbroken lines, particularly in approach to islands and obstructions in a road.

TRAFFIC CONTROL IN NEW YORK CITY

By

R. A. B. SMITH, A.M.I.C.E., M.I.STRUCT.E., M.INST.T.

IN view of the proposals submitted to Parliament by the Minister of Transport, designed to improve the traffic situation in London, it is of interest to examine the type of traffic authority set up in New York.

This I was able to do as a member of the A.A. Committee visiting New York on my way back from Jamaica.

The whole of New York City, which consists of five boroughs, is for traffic purposes under the control of the Traffic Department at Police Headquarters.

The Commissioner of Traffic is appointed by the Mayor for a period of five years. Once the Commissioner is appointed he is practically a dictator during his period of office. This power makes it essential that he should make no regulation without very careful investigation and consultation with interested organisations such as the American Automobile Association. Once a regulation is approved by the Commissioner, it is published in the Daily Record and from that day becomes an active instrument. Every Commissioner and the heads of various departments must be engineers and no politician can be appointed; as very few engineers are politicians, it is not thought likely that a politician will ever be appointed. This very definite object of keeping traffic out of politics has proved of great value and is a point not to be lost sight of in our own country.

Under the Commissioner are various bureaus which have been set up as the need has been seen. Probably finality has not yet been reached, but they are at present roughly as follows:

Traffic Lights and Controls

This department decides on the siting and phasing of traffic lights. The positioning of pedestrian crossings, the posting of Police required to control intersection and all similar matters.

Parking

The necessity for on or offstreet parking, the regulations governing parking space on the streets, etc.

In general, the objective is to persuade long-term parkers to park on the inner fringe of the largest cities and encourage them to use public transport for the rest of the journey. In smaller towns the reverse is the case and the long-term parker is to be given every facility to complete his journey to the centre by car as it is considered that the public services cannot fulfil the public requirements except in big cities where a number of p.s. vehicles can be provided to meet the need especially during peak hours.

Thus in a big city all day parking in the centre is expensive and scarce especially as short-term parkers are given preferential treatment in offstreet parks and garages whereas in a smaller town the long-term parking is not so expensive in relation to the cost of short-term parking.

It is an accepted fact that the centre of a large city cannot retain its land

and rateable values when the facilities are not available for customers and clients for unloading and loading, and should therefore take precedence over facilities for the office workers. There seems to be much merit in this attitude.

Every endeavour is made to get garages built, first of all, on the inner fringe.

These may be built by private enterprise or by the authority. Two were visited which had been constructed by the authority.

The first was a multi-story garage. This was on the continuous ramp principle, that being the type most attractive to the public, especially the feminine element who are prone to have accidents on the steep ramps, but enjoy the gentle slope of $2\frac{1}{2}$ to 4 per cent, the former so slight that it is barely noticeable. Parking is at right angles on either side of the ramp which is about 23 ft wide whilst the total width is nearly 60 ft.

The second was a two-storey underground garage on the same principle fitted up with central control in the Manager's Office of all lighting, ventilating and other systems. Built by the authority it is leased for a term of years to private enterprise on a basic rental with a proportion of any additional profits.

The running costs are low and there were no petrol pumps, but in the case of the built-up garages there was shop space which is let off.

This bureau settles the necessity for a built-up garage in any area and chooses the location, but does not design; consultants are called in for that purpose.

The position and width of approaches are however governed by the bureau as also is the number of cars for which provision must be made. This depends on the width, etc., of roads around the site.

Fire resistance is not the nightmare over there that it appears to be in this country, generally sprinklers are considered a wasted expense and many get stolen; it is thought better which can be rushed to the scene of the fire and used more effectively than hand sprinklers or those fixed in the ceiling.

Parking Meters

These are in great numbers, but not used at all in the very centre which is almost entirely a no-waiting area except for loading and unloading.

Up to recently Police have enforced the proper use of meters but too many had to be detached from other duties and an alternative had to be sought.

The system now introduced is that of traffic wardens, both male and female. The men are given plain blue uniforms and a badge whilst the women are dressed in a similar fashion to air hostesses. Both look smart.

The girls are provided from a Civil Service list after having been tested as to education and personal suitability. Both men and women are trained in the duties by policemen who used to do this work, and also taught how to treat the public and the type of circumstances which may mitigate the offence (in which cases they need not issue a ticket). The fine varies according to the nature of the street, from 5 to 15 dollars.

The first 50 girls started whilst I was in the city and they impressed me as being a very good type and very smart. All receive good pay and the job is pensionable.

Design of intersections, etc.

This is another bureau which studies intersections, regulates the position of bus stops, the limit of parking spaces, facilities for loading and unloading and makes one-way street regulations.

Money from meters and excess charges is allocated as follows :

(a) Maintenance

(b) Cost of traffic wardens

(c) Cost of street parks

Speed Limits

Speed limits are set after close investigation and calculation by the engineers and according to the density of traffic, number of intersections, etc.

These limits are either 25, 35 or 45 m.p.h. A speed exceeding these by 10 per cent is assumed when setting the limit and the police do not necessarily issue a summons unless the 10 per cent is exceeded.

On the whole our 30 and 40 m.p.h. seem a more realistic approach and not so confusing.

The Safety Division of the Police is staffed by 1,900 men. Work schedules are so arranged that maximum man-power is on the streets during the famous New York "exodus", the five o'clock rush hour. They are particularly charged with keeping traffic flowing smoothly and with minimum hazard.

The use of posters reminding drivers to drive carefully is regarded, after much experience, as useless and is almost entirely dropped. It is felt that drivers regard these posters as meant "for the other fellow". Instead the courtesy police force has been enlarged. Frankly, the better driving which appears to be the case is largely due to this

The courtesy police (in uniform) generally travel in pairs but in ordinary cars without gongs—not police cars. Their duty is to stop offenders and warn them, but only rarely do they issue a summons. The name of the warned driver goes into the police files.

The investigation undertaken, on which this report is made, may be of some use in view of the setting up of a traffic authority in London, which may be followed by the same in other cities.

(From "Highways and Bridges and Engineering Works," July 6th, 1960)

"When a road is once built, it is a strange thing how it collects traffic, how every year as it goes on, more and more people are found to walk thereon, and others are raised up to repair and perpetuate it, and keep it alive; so that perhaps even this road of ours may, from reparation, continue to exist and be useful hundreds and hundreds of years after we are mingled in the dust. And it is my hope that our far-away descendants may remember and bless those who laboured for them to-day."

—R. L. STEVENSON

THE INTERSTATE HIGHWAY SYSTEM IN THE UNITED STATES

By

B. D. TALLAMY *

THE United States is constructing a National System of Interstate and Defence Highways, 41,000 miles long, which will join the principal cities in the 48 contiguous States and will connect with important highways of Canada and Mexico at the international borders. The highways are designed to carry the kinds and volumes of traffic forecast for 1975.

Development of the system is a joint undertaking of the Federal Government and the States, with the former providing 90 per cent of the cost. The States let the contracts to private construction companies on the basis of competitive bids, and meet 10 per cent of the cost. Plans, contract terms and construction are subject to approval by the Federal Government, which acts in highway matters through the Bureau of Public Roads, part of the U.S. Department of Commerce.

Nearly 9,600 miles of the System are already open to traffic. This total includes 4,235 miles built or improved to the standards of 1975 and 3,076 miles that will need further improvement but are adequate for present traffic demands. It also includes 2,268 miles of toll roads, tunnels and bridges previously built and incorporated in the System in accordance with the law.

Many of the Interstate routes are parallel to or coincide with existing roads. The work is therefore partly the construction of highways, bridges and tunnels on new locations and partly the reconstruction and improvement of those already built. All the newly-built roads are free—that is, there will be no collection of tolls on them.

For the benefit of readers who have not visited the United States it may be useful to summarize certain basic facts affecting highways in the country.

There are in the United States today a total of about 3.5 million miles of roads and streets. It is possible to drive from Seattle, in the State of Washington, in the Pacific North west, to Miami, Florida, at the South-eastern corner of the country, all the way on paved roads. The need now is not so much for more roads as for better roads with greater capacity, to carry the enormous and growing volume of traffic.

In recent years there has been a migration from rural to urban areas, and from city centres to the suburbs. This suburban living has been made easier by the automobile, of which there are now more than 61 million in the country. Including trucks and buses, motor vehicles of all kinds number nearly 74 million.

In addition to the Interstate System, about 790,000 miles of other primary highways, secondary roads and their urban extensions are eligible for Federal aid if the States apply. In the improvement of such roads, the Federal Govern-

*Federal Highway Administrator, Bureau of Public Roads, U.S. Department of Commerce.

60-485—Ohio—I-280—Toledo Expressway—Showing interchanges and structure over Maumee River—Lucas County—U-1052 (6) thru (12) 10/1/58

ment and the States meet construction costs in equal shares. This is often called the ABC program. Since passage of the Federal-Aid Highway Act of 1956, which authorized completion of the Interstate System and expanded the ABC program, contracts have been completed on more than 100,000 miles of ABC roads. In the main, this work has consisted of rebuilding existing roads to higher standards, although some have been built on new locations.

Many roads are of course built by the States, counties and other Governmental units without any Federal-aid. The States maintain all the Federal-aid roads and regulate the traffic on them. Except on certain Federal property, the National Government does not let contracts for the construction of highways, maintain them, or police them.

The Interstate System will be the framework of the United States National Highway network. It is expected to carry 20 per cent of the country's total traffic.

The high standards required for the Interstate System were drawn up by the American Association of State Highway Officials and approved by the

Bureau of Public Roads. They incorporate all known features of safety and utility, and are aimed at safe and relaxed driving, at economy of vehicle operation, and at pleasing appearance.

An important feature is the control of access from adjoining property and from intersecting roads. All entrances to and exits from routes of the System are at planned locations only, selected to enable vehicles to enter and leave the highway with safety to themselves and to the stream of traffic. American roads that had developed without

Grade separations generally carry cross roads over or under the routes of the Interstate System. In sparsely settled rural areas, where traffic volumes are low, intersections at grade are permitted under stated conditions and if no appreciable hazard is created. No railroad grade crossings are permitted.

Sweeping curves, easy grades, and long sight distances provide driving in safety and comfort, at reasonable speeds and without interruption.

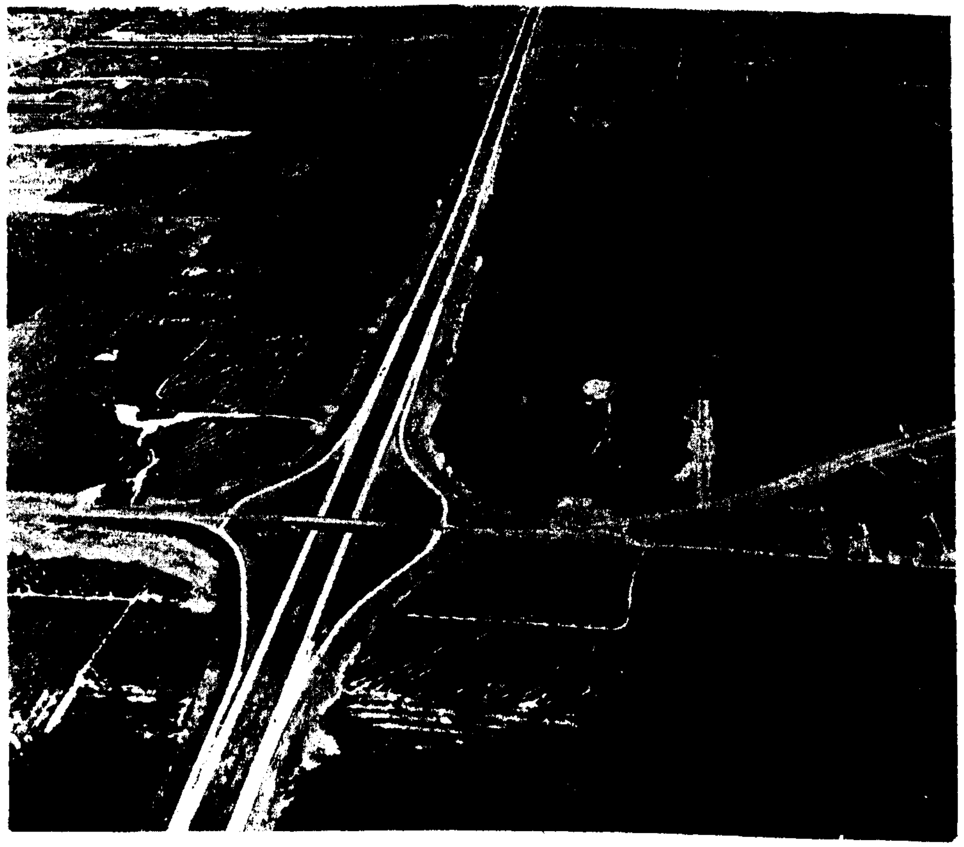
Nearly all of the System will consist of divided highways with four or more

60-354—Jones Point Bridge during construction from Virginia side from Virginia to Maryland over Potomac River near Washington DC

control of access were recognized sources of danger in permitting vehicles to run on and off the road at business places, residences, and minor side roads, many making left turns.

No gasoline stations, restaurants or other service facilities are permitted directly on the Interstate right-of-way, but may be on connecting roads or frontage roads on one or both sides of the highway.

traffic lanes. The lanes must not be less than 12 ft in width. In flat country, where drivers can see for great distances at all times, two-lane highways are permitted if the traffic expected in 1975 is less than 5,000 vehicles daily, but in such cases the roadway is normally built on one side of the right-of-way so that an additional pavement, to provide a divided highway, can be added if needed.



60-487—Ohio—I-90-2 (5) 52—Three miles south of Geneva, Ashtabula County—
Interchange with S. R. 534—9/14/58

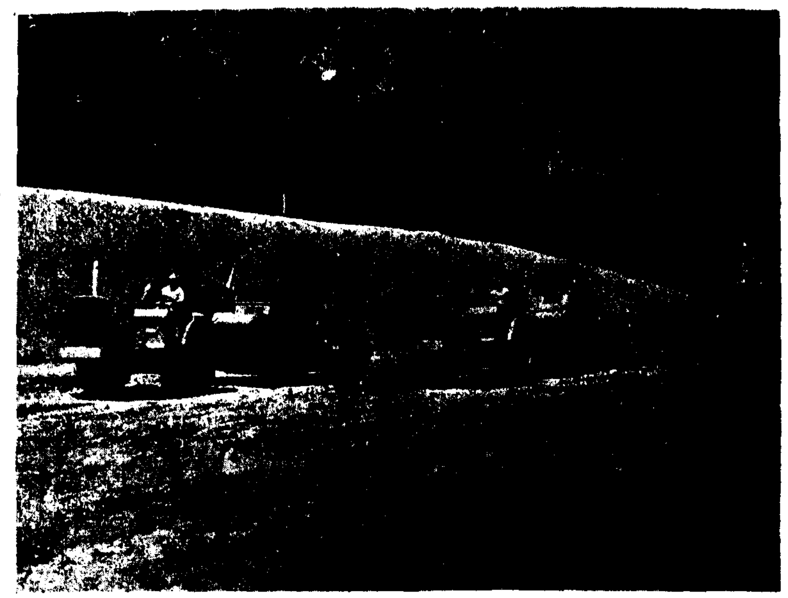
Median areas between the two roadways of divided highways must generally be at least 36 ft wide, but in urban and mountainous areas a minimum of 16 ft is permitted. Under unusual conditions of terrain or right-of-way, the median may be reduced to not less than 4 ft.

Shoulders at least 10 ft wide (6 ft in mountainous terrain), usable in case of emergency by all classes of vehicles in all weather, are provided on the right of traffic.

Wide rights-of-way are required, but need not be of constant width. Construction often takes advantage of terrain, and opposing roadways may be placed on opposite sides of a stream or hill. Minimum right-of-way widths required in rural areas range from 150 ft for a two-lane road to 300 ft for an eight-lane divided highway with a frontage road on each side. In urban areas land cost and building demolition are important considerations, but the right-of-way must be wide enough to accommodate the roadways and necessary slopes, walls, and frontage streets.

Bridges and overpasses are preferably of deck type, with no overhead obstruction. Through bridges and underpasses on at least one route through or around a city and on certain other selected routes must have at least 16 ft vertical clearance—elsewhere 14 ft. The full width of traffic lanes, median, and shoulders is carried across bridges

South Carolina—60-51—Interstate Route I-21—Richmand County



57-1365—Maryland—Caterpillar D. W. 21 scraper 21 yard capacity working on road construction job. U. S. 240
Photo by courtesy U. S. Bureau of Public Roads.

of 150-foot length or less, and through underpasses. On long and costly bridges, the median width may be reduced to not less than 4 ft. Where curbs or parapet walls are used, the pavement is several feet wider than on the approach traffic lanes.

Large and clearly visible signs giving route numbers and directions to interchange facilities with principal connecting roads are required.

The high standards and the large volume of traffic forecast necessarily make construction of the Interstate System expensive, especially in urban areas. The average cost is about one million dollars a mile.

The Federal share of the cost of the Interstate System is at present derived from taxes on highway users—taxes on motor fuel, excise taxes on tires, tubes, and large vehicles, and a use-tax on large vehicles. The States derive funds for their share of the construction from fuel taxes and various other taxes.

It is expected that the United States Congress will determine in 1961 a long-term policy for financing the Federal share. For its information, the Bureau of Public Roads and the States are preparing a revised estimate of the cost of completing the Interstate System, and a highway cost allocation study indicating the benefits derived by direct users of the roads and others deriving benefits from them.

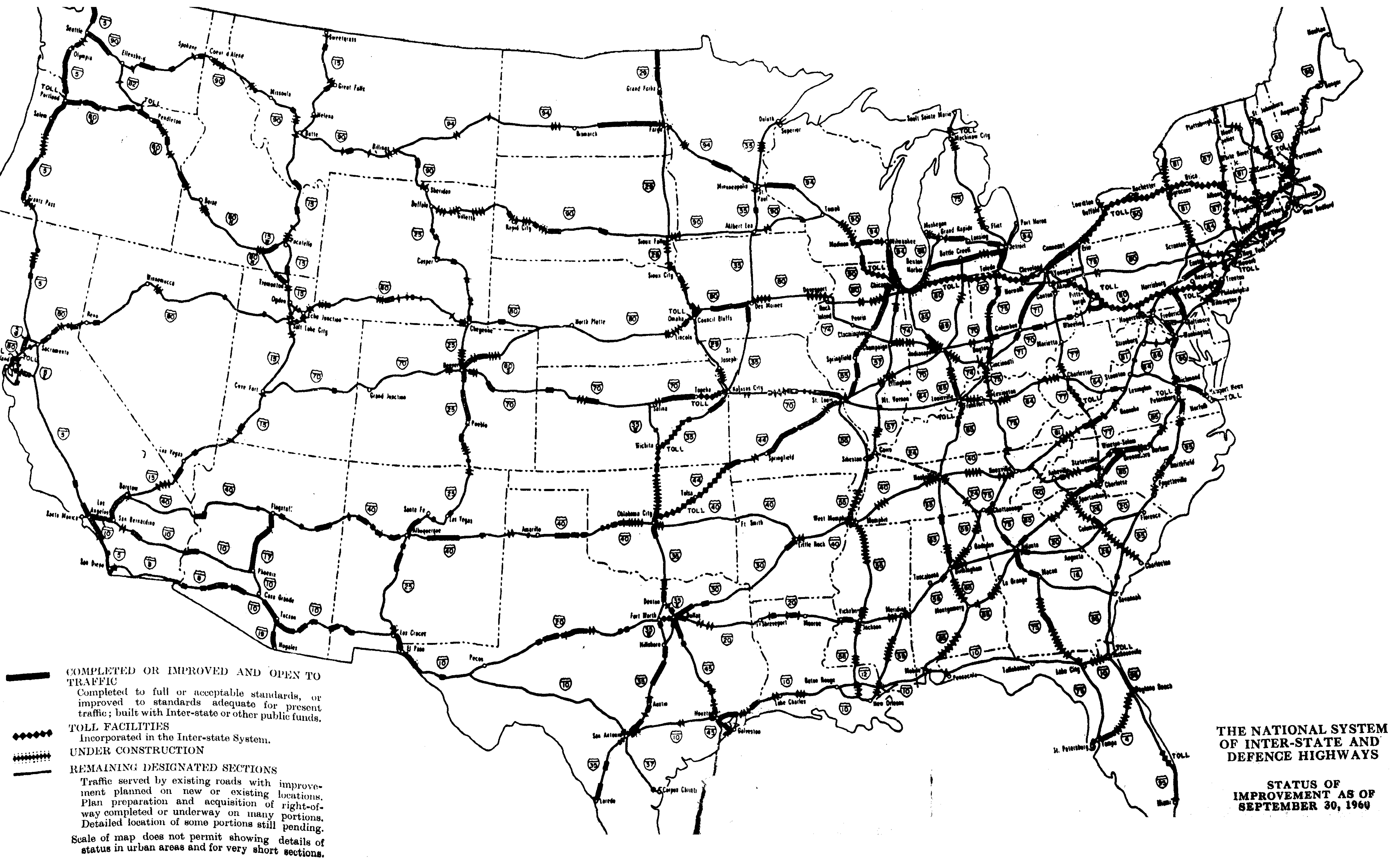
The 1956 legislation contemplated completion of the Interstate System by 1972. Subject to provision of the necessary funds, I believe that this goal can be realized.

An official was inspecting a newly completed portion of a highway. He grumbled at everything. The crown was not high enough, the shoulder was too steep. The ditches not deep enough, and so on.

The foreman bore it all patiently. Then he straightened upto his full height and looking the inspector in the eye, he asked, "How is she for length?"

It is a good example of living in a "fools's paradise" to substitute costly maintenance for needed Capital improvements.

—THOMAS MACDONALD.



THE NATIONAL SYSTEM OF INTER-STATE AND DEFENCE HIGHWAYS

STATUS OF IMPROVEMENT AS OF SEPTEMBER 30, 1960

THE COST AND PLANNING OF NEW ROADS IN BRITAIN

By

JOHN ROBINSON*

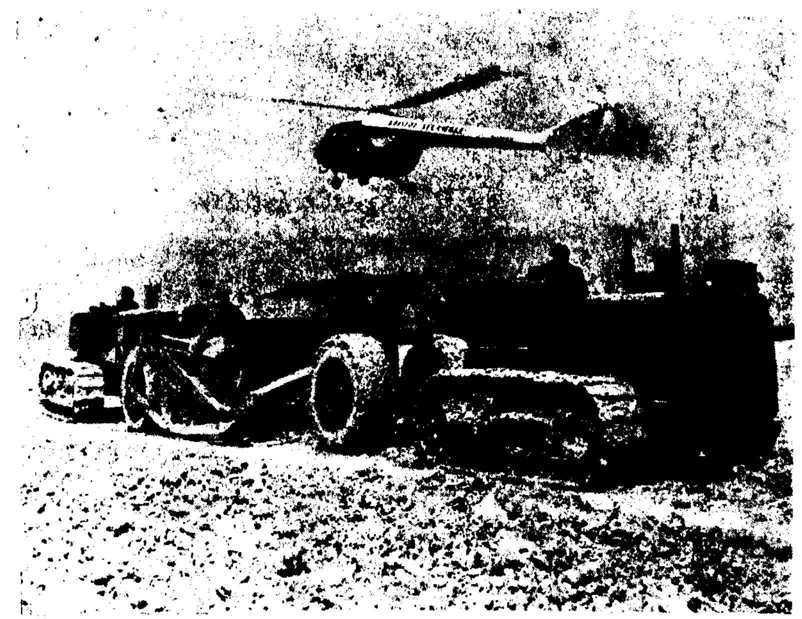
BRITAIN was a late starter in the creation of a modern highway system, but a comprehensive scheme of new works and improvements is now in hand, and the opening last year of the country's first motorway caught public imagination and has given impetus to the driver for better roads.

As early as 1946 a modernisation programme involving the construction of 800 miles of new roads was announced, but the troubled economic climate of the post-war years frustrated the development of the scheme. In 1955, however, a Four-Year Plan was introduced, costing £212,000,000, and two years later another Four-Year Plan was announced by the Minister of Transport, bringing the total cost allowed to £240,000,000.

The increasing pace of new construction work on roads (excluding minor improvements) is indicated by the amount of money which the Government has already made available out of the £240,000,000 estimate. In 1955 it was £3,500,000, in 1956 £6,500,000, in 1957 £13,500,000, in 1958 £26,500,000, and in 1959 (estimated) £52,500,000. The estimate for this year is £65,000,000. The amount spent by local authorities on new construction also rose from about £4,000,000 in 1955 to about £8,000,000 last year. In addition, some £90,000,000 is spent every year by local authorities on maintenance of existing roads.

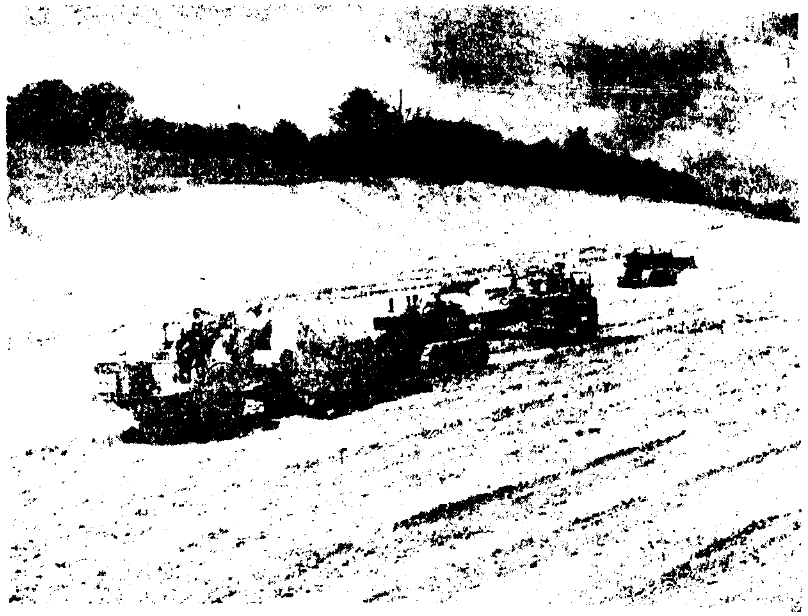
Road Fund Change

Government grants are voted annually through the Civil Estimates, and local

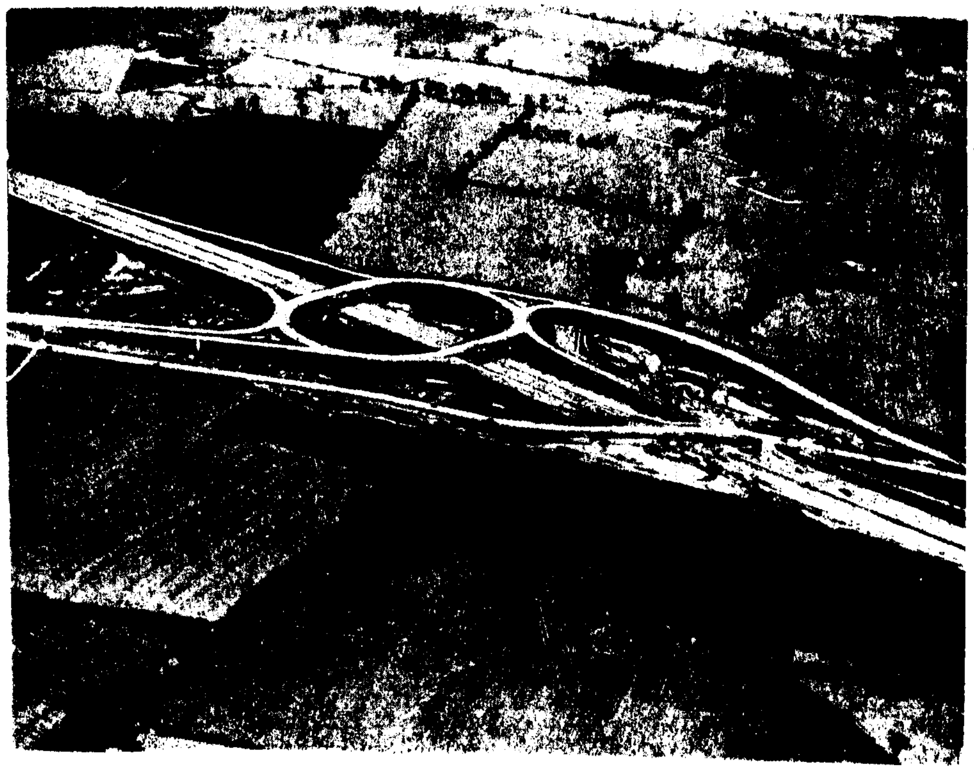


London/Birmingham Motorway. A Helicopter in use to co-ordinate work on the construction of Britain's new motorway from the northern outskirts of London to Birmingham in the Midlands.

* Editor of the " National Builder ", London.



London/Birmingham Motorway. Tractors and scrapers in use during the construction of Britain's new motorway to the Midlands



One of the fly-over roundabouts on the new motorway to the Midlands of Britain

authority expenditure on road works comes from the local rates. The Road Fund, which originally received revenues from motor vehicle licence duties, and paid out each year grants for road work, was abolished in 1956. The Exchequer now receives all former revenues of the Fund, and grants for new work are made as separate items, as well as included in the block grants paid to local authorities.

The revenue from motor licences and from the motor fuel tax has increased considerably over the years in pace with the increase in the number of vehicles

A new trunk road is being constructed through the heart of the City of London, forging its way over some of the worst bomb blitzed areas. It will be a dual-carriageway with three-line traffic in each direction. Garages for several hundred cars are being built below the road. Not the least part of the cost of many millions of pounds has been that of acquiring the land

licensed, and the increased vehicle mileage. Last year these revenues from road users (including purchase tax on cars) amounted to £564,000,000, compared with the £84,700,000 actually spent on all road works by the Central Government in England, Wales and Scotland. As the organisations of road users in Britain point out, the money is in the "kitty"; it is merely a question of putting road works in their allotted place in the queue waiting to use the country's available constructional resources, both labour and material.

Stage-Coach Designs

It is not to be supposed that the road schemes now under construction will be sufficient to solve Britain's road traffic and transport problems, which are considerable, but at least it is a beginning. Motor vehicles have trebled since 1939, and the number continues to rise. The country possesses a network of complicated but, generally speaking, well-constructed and well-maintained roads, a number of which were modernised between the two World Wars. They were, however, designed in the days of the stage coach and many are now out-of-date. Britain's Road Research Laboratory found, in a survey, that present traffic on 62 per cent of trunk roads, 23 per cent of class I roads, and 6 per cent of class II roads, exceeds their designed capacity. Another finding was that 1 per cent of the road system carries 25 per cent of traffic, and 10 per cent carries 60 per cent of the traffic. This does indicate that the most urgent work involves the main roads and through routes.

The Ministry of Transport is responsible for the trunk roads, that is certain designated through routes, and has complete financial liability for them, although local authorities are employed as agents to carry out work on them to Ministry specification. An Act of Parliament recognised the principle of motorways and other special purpose roads, and provided the necessary powers for their construction. The Minister reports to Parliament every year on road works in England and Wales, and the Secretary of State for Scotland does the same for Scottish roads.

Three-part Plan

The present Plan for road modernisation falls into three parts:

1. The initiation of a network of fast motor through routes, such as the London-Birmingham motorway opened to traffic last year.

2. The elimination of bottlenecks in the cities and big towns to give free passage to traffic coming off the main roads.

3. Improvement to existing roads, such as realigning cross-roads or improving visibility, and schemes which do not cost a great deal but make a big difference to the traffic flow.

The main roads planned include the improved Great North Road from London to the North-East, work on which is progressing steadily: a motorway from London to the North-West, the first part being the London-Birmingham motorway already in use, to be followed later by a motorway from Birmingham to the Preston-By-pass, already in use, and giving access to Lancashire and the North-West; improvements to two existing trunk roads from London to the South-East, with by-passes to the busy midway towns in Kent and at Maidstone and Ashford, the last-named already in use; a new route from the Midlands to Bristol and Wales in the West, including the Ross Spur motorway now in use, and linking up with Birmingham at the Midlands end; and a road from London westwards via London Airport to South Wales.

Other important projects are the London to Yorkshire motorway, which will run from near Rugby to Doncaster, linking with the Great North Road; and the Doncaster By-pass and Stevenage By-pass, both of which will form

parts of the improved Great North Road.

Mile-Long Viaduct

Typical of the road works now under construction for the elimination of bottlenecks in the cities is the Cromwell Road Extension, London, which includes a mile-long viaduct over the existing Great West Road. Another is the so-called Hyde Park Boulevard in central London, and in the provinces the ring roads at Birmingham, Manchester, Sheffield and Gloucester all fall under this heading.

The first full-length motorway, the section from London to Birmingham gave Britain much valuable experience in the construction of fast through roads of this type. The 73-miles stretch from the outskirts of London to Birmingham was the largest single road scheme ever commissioned in Britain, and it was executed by three contractors in the scheduled time of 10 months.

Britain's Engineers are not lacking in technical skill. They have had wide experience on airfield construction, and on road building in the Commonwealth. The largest of the London-Birmingham motorway contractors, John Laing and Son Ltd., of London, had already carried out considerable road construction in Central and Southern Africa, and its Canadian company was concerned with a section of the Trans-Canada Highway. What makes the Birmingham motorway so remarkable is not so much the techniques employed, but the organisation and planning which enabled the company to drive an entirely new road through a densely-populated and highly developed countryside, and to do so, despite some severe weather, within the tight time-scale laid down.

Planning Time Lag

The whole problem of building motorways in Britain is epitomized in the fact that on the 53-miles stretch of motorway built by Laings, no less than 52 major road bridges, eight railway bridges, several canal and river bridges, and numerous small bridges for public and farming use were a necessary part of the contract. In all, 129 bridges were constructed in order to give the new road unrestricted passage.

Before work begins there is a protracted period of negotiation, surveying, land acquisition, appeals, and planning. Much patient and time-wasting work has to be carried out before the engineers and consultants can get down to design and planning. This period is variously estimated at between two to six years, but in close-packed Britain it is a necessary and laborious preliminary to the inauguration of a new road system.

A great deal of this necessary but unrewarding work has been done in recent years, and everything points to a great new surge in road-building in Britain over the next decade. The British have lagged behind the European Continental countries in this respect, but the need for new roads is widely recognised and has been accepted by the political parties. The revenue from road users greatly exceeds that spent on roads, the engineers have the experience and skills, other construction projects such as housing and power stations become less urgent as priority programmes come to an end—there seems no reason why road-building should not increase considerably in the next few years.

Great attention is being given to the problem of pressing new roads through industrial areas, and two imaginative projects are reaching the practical stage, one for taking a motorway on a viaduct over an existing all-purpose road for about a mile, and another for taking a motorway link on the outskirts of Birmingham over a railway.

In rural areas disused railway sites are being used to take roads where practicable.

BRITAIN'S NEW MOTORWAY SPEEDS WAY TO THE WEST

By

PAT GREGORY*

BIRMINGHAM stands, geographically, in the very heart of England, the "capital" of a Midland conurbation which served as the cradle of the industrial revolution. To the West, in South Wales, is another important

Kempley Viaduct—view eastward through forest

*London Journalist and feature writer

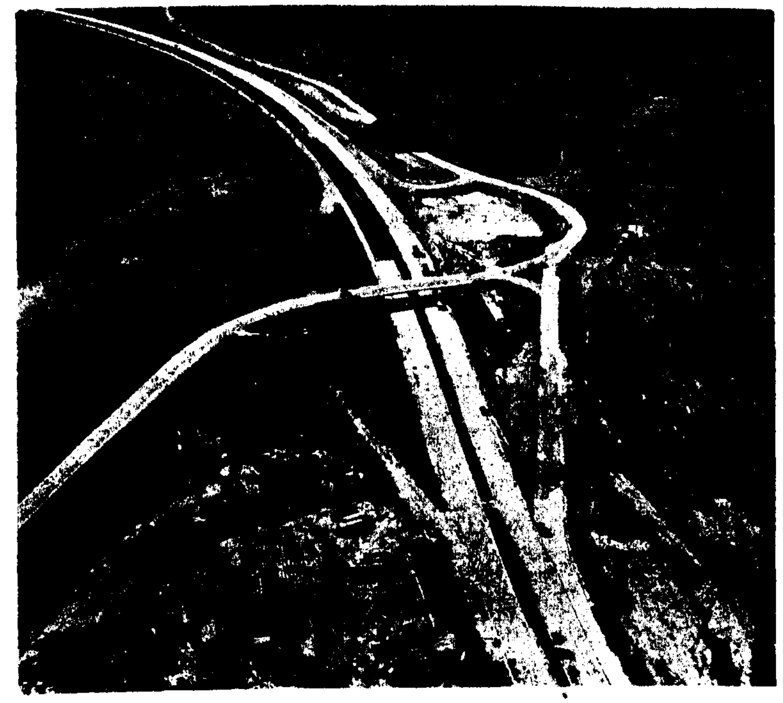
centre of Britain's heavy industry, whose coal and steel are key components in the country's economy. Between the two lies a belt of rich, hilly farm-land bisected by the rivers Severn and Wye. The narrow, twisting roads, legacies of the horse-traffic age, that traverse this agricultural strip, have always been a tedious barrier to modern commercial road communication between the two vital industrial centres.

For Industry and Pleasure

At the end of 1960, however, a new motorway is to be opened through this rural countryside where England and Wales meet, to provide not only a fast, safe link for industrial purposes, but also a pleasant ride for tourists between the Midlands and the West.

Constructed at a cost of £6,000,000, the 22½ miles (36 kilometres) long Ross Motorway takes its name from the old town of Ross, with its narrow streets, which stands on a rocky pinnacle above the River Wye looking across to the mountains of Wales. The new highway effectively by-passes the town, and provides a vital artery in Britain's National Road Plan, connecting with other major trunk routes stretching West and North.

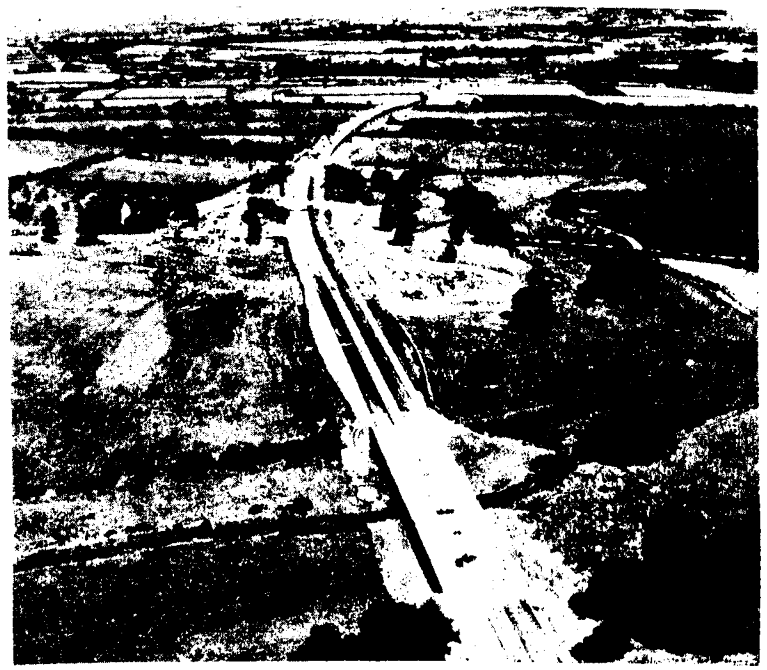
Within its effective width of 88 ft (26.82 metres) the Ross Motorway has dual 24 ft (7 metres) wide carriageways and a central reservation 15 ft (4.5 metres) wide. The maximum gradient is 1 in 25, and it is designed for speeds of upto 70 miles (112 kilometres) per hour. In places there are embankments 40 ft (12 metres) high and cuttings 37 ft (11 metres) deep. About 2,250,000 cubic yards (1,720,000 cu. metres) of rock and soil have been excavated during its construction, which provided work for more than 1,200 men.



View of interchange with Gloucester-Ledbury road, A. 417 at Bury Court.

A notable feature of the scheme has been the building of two major bridges, one over the River Severn at Queenhill and the other over the River Wye at Bridstow. The Queenhill Bridge, together with its approach viaducts, covers a total length of 2,466 ft (752 metres) and cost more than £1,000,000. It is a three-span continuous steel girder bridge with a centre span of 240 ft (73 metres) (headroom 44 ft—13 metres) and two side spans of 130 ft (40 metres) each. It is of dual construction 73 ft (22 metres) wide overall, each half width having two pairs of girders with reinforced concrete decking.

(610 metres) long over the river's flood plain. The embankment has a maximum height of 33 ft (10 metres), through which seven flood relief arches are pierced. Each flood arch is itself a considerable structure, being more than 80 ft (24 metres) long and having a span of 18 ft (5.48 metres). The Bridstow Bridge is a graceful three-span structure with a total length of 353 ft (107 metres). It has a 203 ft (62 metres) clear span in the centre and two approach spans each 75 ft (23 metres) long. The bridge



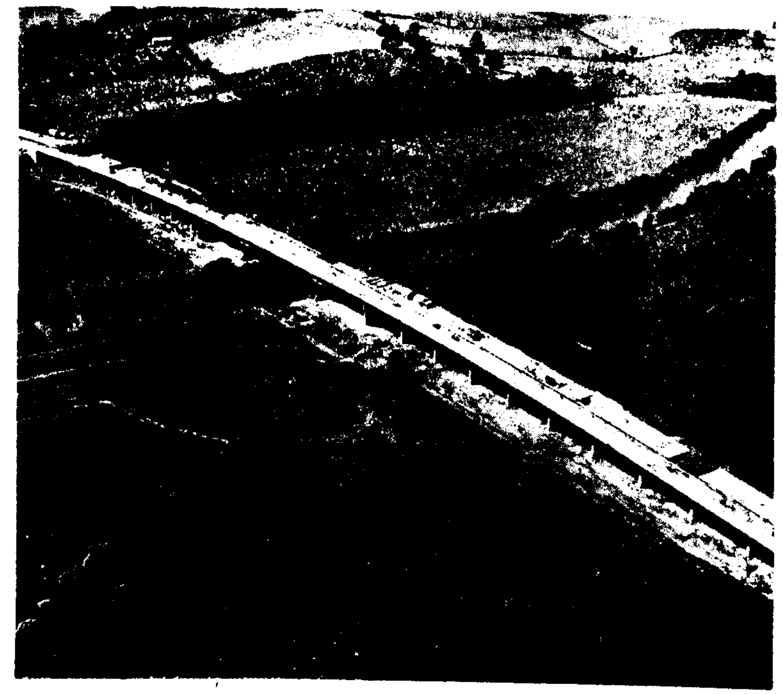
View eastward of Queenhill Bridge and Viaduct with Bushley Viaduct in foreground

The bridge and viaduct piers were carried down to rock marl by means of 54 steel caissons using compressed air, the depth below ground varying between 28 ft (8.5 metres) and 47 ft (14 metres).

Long Embankment

At the western end of the motorway, near Ross itself, the road is carried over the River Wye by the Bridstow Bridge, with its associated embankment 2,000 ft

structure carries dual carriageways and is supported by two reinforced concrete piers and abutments which also terminate the structure at either end. The deck consists of pre-stressed concrete approach and cantilever spans supporting the prestressed concrete suspended centre span. Nine main beams support the concrete deck slab. The mass concrete pier foundations are continuous, and extend some 16 ft (4.87 metres) below the river level down to sandstone.



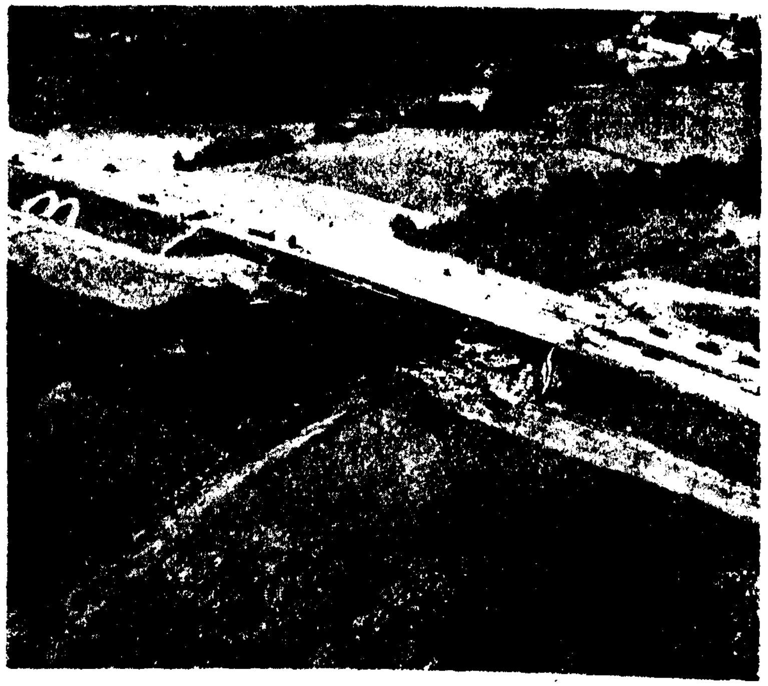
Queenhill Bridge and Viaduct from the south

The motorway passes either under or over other existing roads athwart its course by a series of 36 other bridges of varying size and importance. Its construction was divided into four main contracts.

Starting from the east, the first portion included extensive bridgeworks and viaducts over the River Severn, including the major Queenhill undertaking. The accepted foundation was of crushed stone in a constant thickness of eight in. (20 centimetres) using two-inch (5 centimetres) single size stone with a gravel sub-base six in. (15 centimetres) to nine in. (23 centimetres) in thickness. The base course consists of a three-inch (7.6 centimetres) layer of bitumen macadam, followed by a one-and-a-half inch (38 millimetres) hot asphalt final running surface. The edges of the carriageways are marked by twelve in. (30 centimetres) wide concrete marginal strips, flush with the carriageway.

Extensive Excavation

In the next section there were no junctions with the existing road system. Here the soil is mainly Keuper Marl, with an overlying cap of clay varying in thickness from about two to six ft (61 centimetres to 1.82 metres). The form of construction adopted for the carriageway foundation is soil-cement, for which Keuper Marl has been found to be a very suitable medium. Two-layer construction has been adopted. The lower layer is four in. (10 centimetres) to six in. (15 centimetres) thick, depending on site tests, with seven per cent of cement (mix-in-place), and the top layer six in. (15 centimeters) thick with ten per cent of cement (using suitable soil brought in from bulk excavation in adjoining cuttings). The base course consists of four in. (10 centimetres) of bitumen macadam in two layers, followed by a final surface of one-and-a-half in. (38 millmetres) of hot asphalt. The twelve-inch (30 centimetres) concrete



Bridstow Bridge showing two flood arches

margins are finished flush with the final running surface.

The third contract covered slightly more than six miles (9.65 kilometres) of Motorway. The roadworks involved construction of 25 culverts and a pedestrian underpass. The carriageway foundation is of limestone gravel on waterbound stone, with a hot rolled asphalt running surface. Finally, at the western end to the termination of the Ross Bypass, the fourth contract included Bridstow Bridge.

The undulating nature of the country entailed "cut and fill" to such an extent that, over the whole length, the average difference in level between the new road and the former ground level is 20 ft (6 metres). Excavation amounted to nearly 1,000,000 cubic yards (764,550 cubic metres) half of it in rock. Here the carriageway foundations are of crushed stone and cement-bound granular base, with hot rolled asphalt running surface.

The Ross Motorway is a salient link in Britain's highway construction programme. Even the staunchest supporter of Britain will concede that the United Kingdom has lagged rather sadly behind other nations in the provision of generously broad motorways to speed her traffic and commerce from coast to coast.

New Roads Scheme

Immediately after World War II a traffic count conducted by Britain's Ministry of Transport showed that ten per cent of her roads carried about 60 per cent of the country's cars and lorries. From this analysis it was readily apparent that a comparatively small milage of really first-class modern roads could produce enormous improvements in traffic flow. In 1946 tentative plans were drawn up for building 800 miles (1,280 kilometres) of British Motorway, but unfortunately the bleak economic position of the country at that time caused

the programme to be shelved for more than a decade. As Britain's finances have improved, it has been possible to re-introduce the scheme in rather less ambitious, piecemeal fashion.

Britain's first true Motorway, a 72-miles (116 kilometres) long length of the proposed fast road from London to Yorkshire, was opened about twelve months ago. It has proved to be a tremendous success.

Now, with a greatly improved prospect commercially, the United Kingdom Government plans to spend during the present financial year an all-time record of £115,297,000 on general road improvement schemes. During the past six months major undertakings totalling £39,000,000 have been started.

More than half of this sum is being spent on three schemes. First, 28 miles (45 kilometres) of the Bristol to Birmingham Motorway, which is due for completion in October 1961, at a cost of £ 8,580,000; secondly, a duplication of Blackwall Tunnel, London; and thirdly, the new Park Lane, also in London.

WORDS OF WISDOM

If we were all given by magic the power to read each other's thoughts, I suppose the first effect would be to dissolve all friendships. The second effect, however, might be excellent, for the world without friends would be intolerable, and we should learn to like each other without needing a veil of illusion to conceal from ourselves that we did not think our friends absolutely perfect.

—BERTRAND RUSSELL

NO COMPROMISE

The fundamental principles of scientific work is unbending integrity of thought, following the evidence of fact wherever it may lead, within the limits of experimental error and honest mistake. On this there can be no compromise.

—PROF. A. V. HILL.

ROAD DEVELOPMENT IN FRANCE

(By the courtesy of Public Works, Transport and Tourism, France)

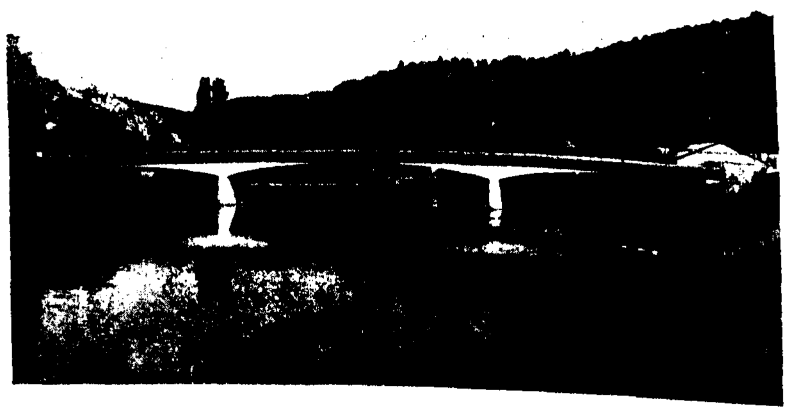
THE French road system has been organised during the course of several centuries of experience. Its excellence is indisputable and is one of the most homogeneous and densest of the world.

Its length, in a condition fit for traffic is of the order of 800,000 kilometres, of which nearly four hundred thousands are surfaced which gets for the road system a dense milage of roads in good condition. The total milage of important roads without taking into account the urban roads (45,000 km) works out to 120 km of roads per 100 km^2.

The parish roads are those which are built on the land owned by the communes.

In short, the total length of urban roads is of the order of 45,000 kilometres which connect together the streets of towns and villages.

The roads in their entirety, form part of the public property of the State, of the province or of the communes, according to the category of the road design. It results in a very important consequence in right, that is, the highways and roads are inalienable and that the actions in claiming them as property of estate are indefeasible.



Pont de Velotte N.W. le Doub at BESANCON

The road system comprises of:

The total milage of National Highways which concerns the entire country is at present 81,508 kilometres.

The length of provincial roads which connect different points of some of the provinces is 269,904 kilometres.

Confining oneself to the National Highways which are important part of French National network of roads, one distinguishes the National Highways from the grand itineraries and the motor-ways.

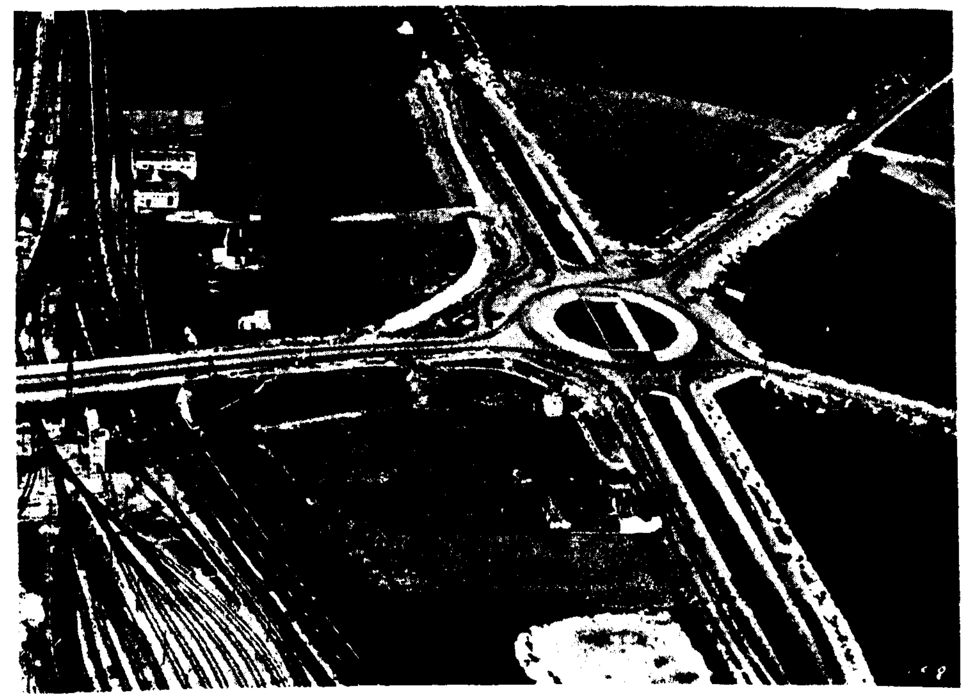
The National Highways are 812 in number and the important ones start

from Paris. Every one of them has its own peculiar characteristics, depending upon the region it traverses.

During the course of 19th century and the outset of the 20th century, the National Highway system has grown in about a steady manner; it has increased from 27,000 km to 40,000 km in 1930; but now it has reached 80,000 km by integration of 40,000 km of roads which till then

three lanes (9 or 10.50 m. width of carriageway), 15,000 have two lanes (7 m. width of carriageway).

The important itineraries which comprise of about 7,000 km, amongst the National routes, are those which have Paris as the principal centre of the system and permit the rapid travel towards the outside countries. These have been designed in a manner to assure



N.H.5. Pompadour Circle (circus)

was classified as provincial roads. In fact, the increase of more and more traffic on the secondary roads has been responsible of this expansion of National Highways. The provincial roads had never been conceived to sustain so heavy a traffic and the total local resources have not permitted of setting apart of funds that would have been necessary for their upkeep.

At present, of a little more than 80,000 kilometres of the National Highways, 200 kilometres have four lanes, 5,000

have rapid and comfortable travel. The cities are in principle connected outside of the alignment, the crossings at level are avoided as much as possible and if these are unrealizable, priority is assured for automobiles travelling on the grand itineraries, at crossings of wide lateral roads.

To complete this list, it would be fit to say a word about the motorways. In France, taking into consideration the density and the quality of the road system, the need for motorways would be and is still much less imperative than in other countries, such as Italy or Germany.

Nevertheless, the incessant increase of the traffic on one side, the necessity of avoiding congestion at the approaches to the big cities and all industrial centres and increasing the safety on the other part, have led the administration to undertake the execution of a network of motor roads which in fifteen years will cover over 2,000 km, comprising the following links: Paris-Lille,

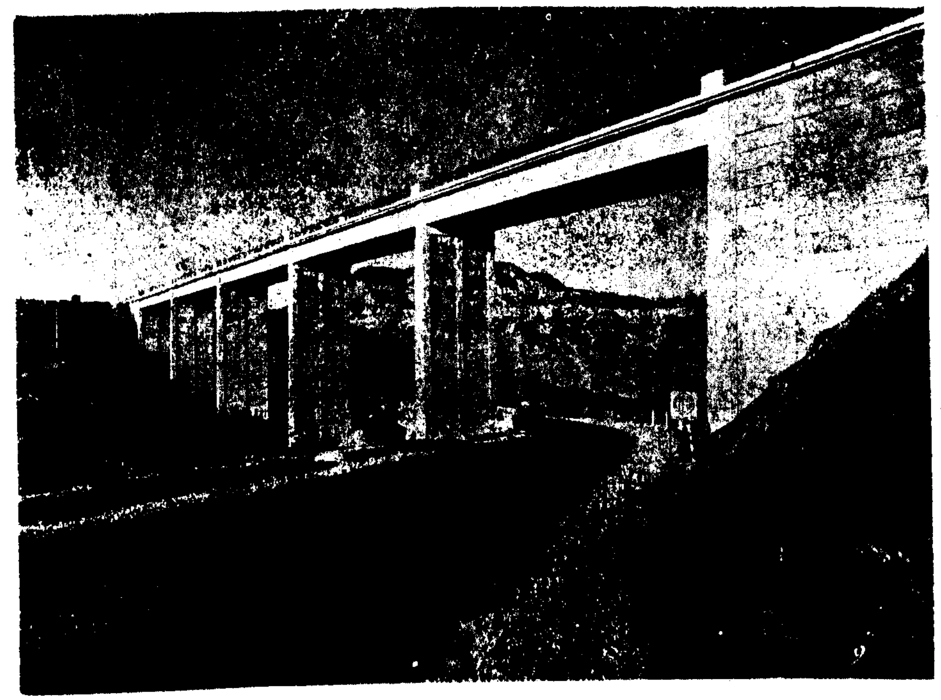
Fig. 3-Cunnel de la Croise-Routse at Syon Entiee cote Saone

Lenouveau Pont Sur l' Yonee

Paris-Lyom-Marseille, Paris-Normandie, Paris-Chartres, Metz-Thionville, Metz-Nancy, Metz-Sarrebruck. Strasbourg-Bale, Frejus-Nice. Basque-Coastal Motorway (Biarritz-Spanish frontier.

The road system represents one of the principle elements of national heritage; it has been estimated at present at 100 milliards of new francs. This is to say about the importance of the problem which confronts its administration.

has been divided into two sub-directorates of Works and Road Traffic. The first has the task of construction and maintenance of National Highways, their classification and numbering, the laying down of programmes and plans, statutes, the administration and working of motor roads and grand itineraries, the construction of works and all that would be treated as public responsibility regarding matters relating to roads. The second sub-directorate is concerned principally with the control of traffic,



A recently constructed bridge in France

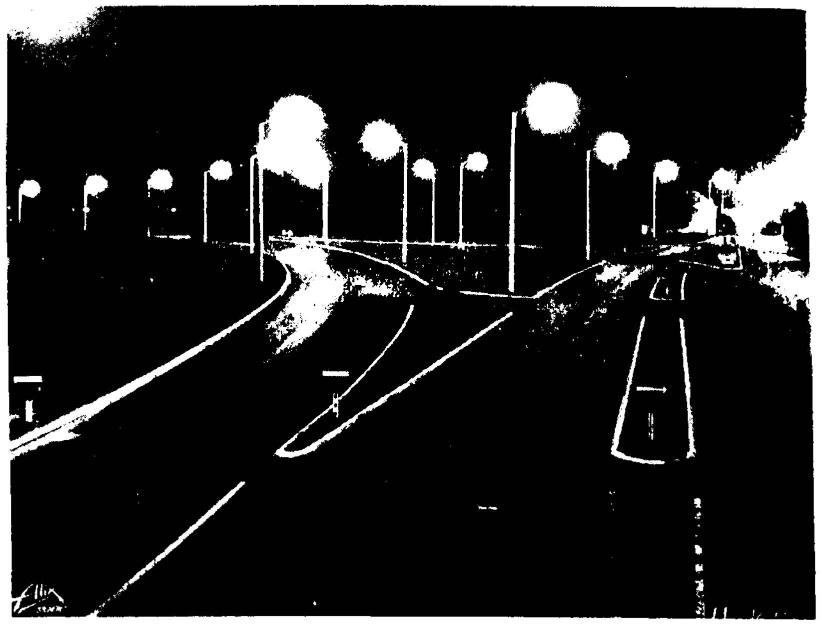
The authorities responsible for the roads are of two categories, one the administrative represented by the interested ministerial department, the other technical having as its head the Corps of Engineers of Bridges and Roads.

At the centre, the Directorate of Roads and Road Traffic of the Ministry of Public Works, Transport and Tourism

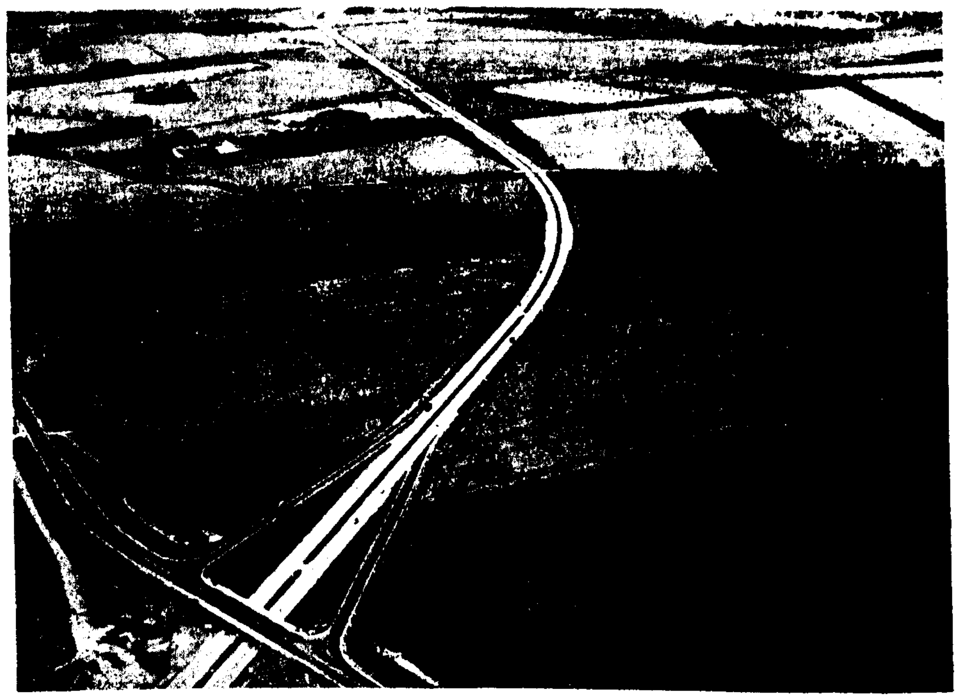
the safety, signalisation, roadside advertisement.

The central echelon equally, it is to be pointed out, is the council of the Department of Roads and Bridges, presided over by the Minister of Public Works, Transport and Tourism and one of its sections studies particularly the projects relating to National Highway system.

The other category of roads are under



N.H-21—Lourdes by-pass. At night fall-(Tarbes side)



Motor Road to the South of Paris. View towards Paris
—Semi-junction with N.H. 446.
—Overbridge on C.V.2.
—Junction with C.D. 153. 26th July 1960.

the competence of local authorities, Departments or Communes in whose area such of these roads fall, it being specific that the community is concerned, in the matter and they under the control and protection of Ministry of Interior.

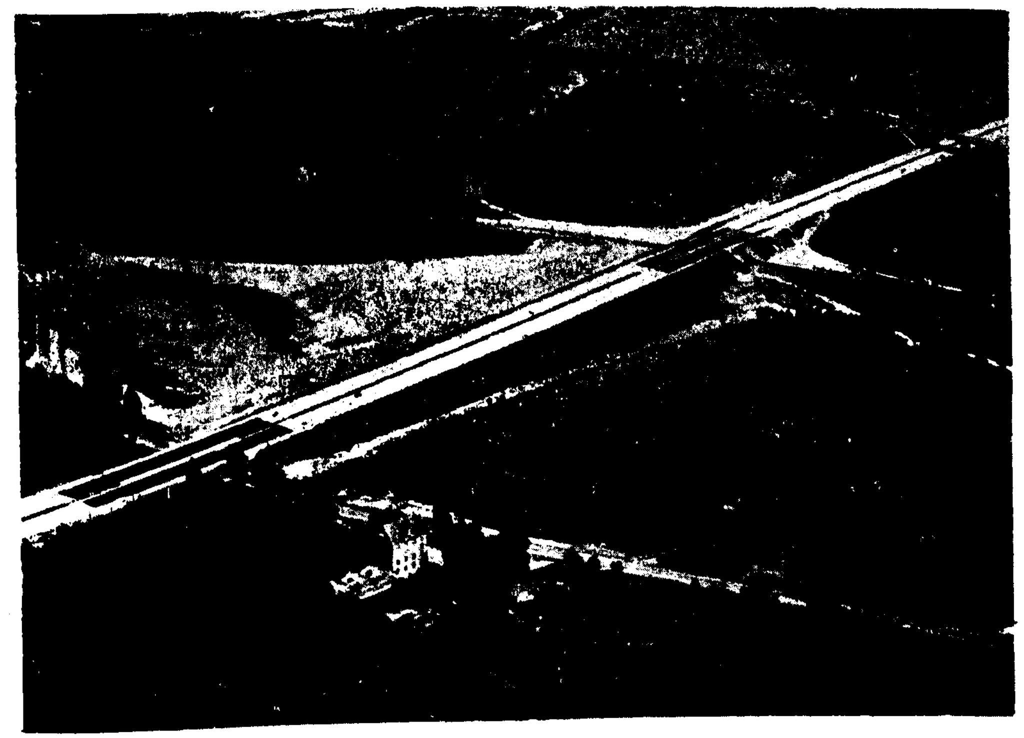
In regard to the financing of works, the credits sanctioned to the road fittings and construction are managed by the Directorate of Roads and Road Traffic.

With regard to national roads, the credits for the construction, which are the budgetary endowments, are distributed according to the area basis by the Department in relation to certain criteria which can vary from one year to other, e.g., kilometrage of roads, average traffic, etc.

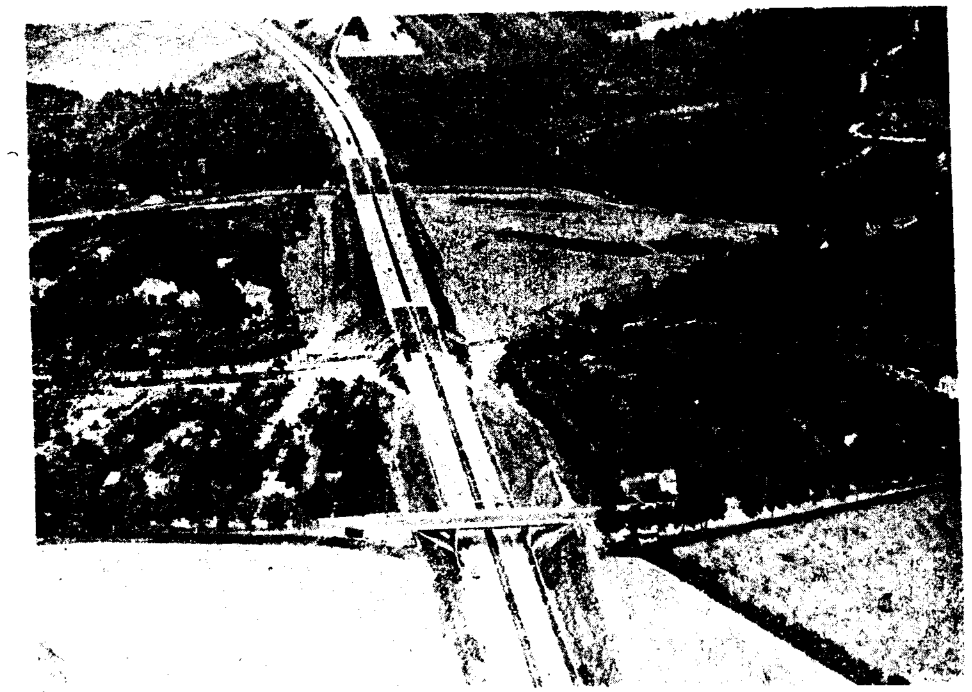
The credits are provided by F.S.I.R. created by an Act of 30th December 1951 and fed by a fraction of the taxes on the road fuels (7.7 per cent) which for 1961 would be 430 millions of N.F.

The funds are distributed under four heads (National, Provincial, Communes and Urban). The works which are financed from such funds are planned in stages and spread over years and conceived in a fashion to permit the progressive improvement of the entire system.

The financing of works carried out on the Provincial and Communes roads are operated by the Provinces and Communes with the aid of corresponding sections of F.S.I.R. Besides this, the communes can raise loans whose



Motor Road (Autobahn) to the South of Paris. Crossing of the Essonne Valley—from Left to Right
—Bridge over the Essonne river S.N.C.F. work.
Paris-Montargis and crossing of CD 137.
—Overbridge on R.N. 191. 26th July 1960



Motor road to the South Paris. Crossing of the Essonne Valley.
View taken in the direction of Paris.

Overbridge over N.H. 191.
—Crossing of the lines S.N.C.F.—Paris-Montargis and of CD 137.
—Bridge over the river Essonne

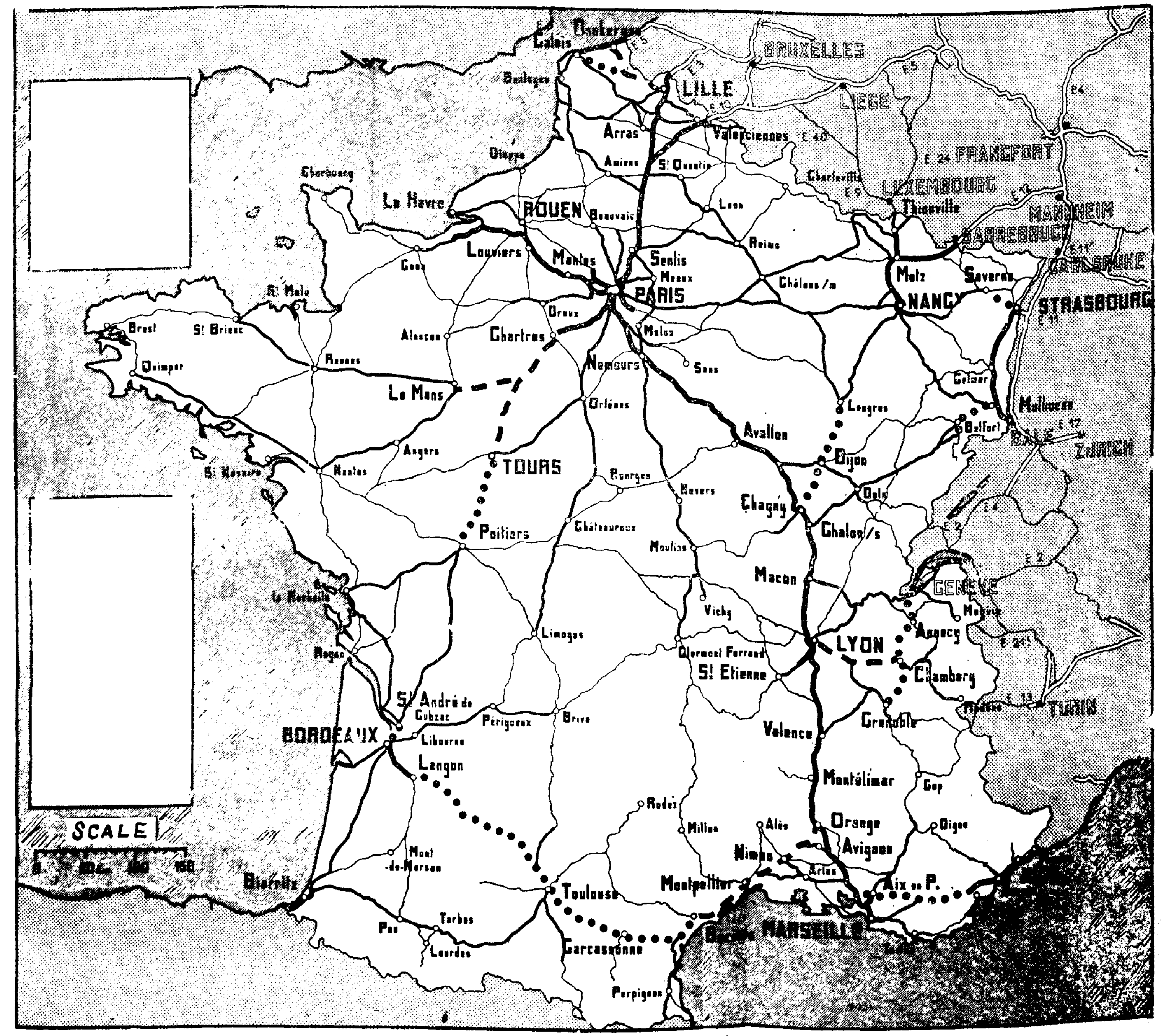
proceeds are earmarked for the roads which are under their charge.

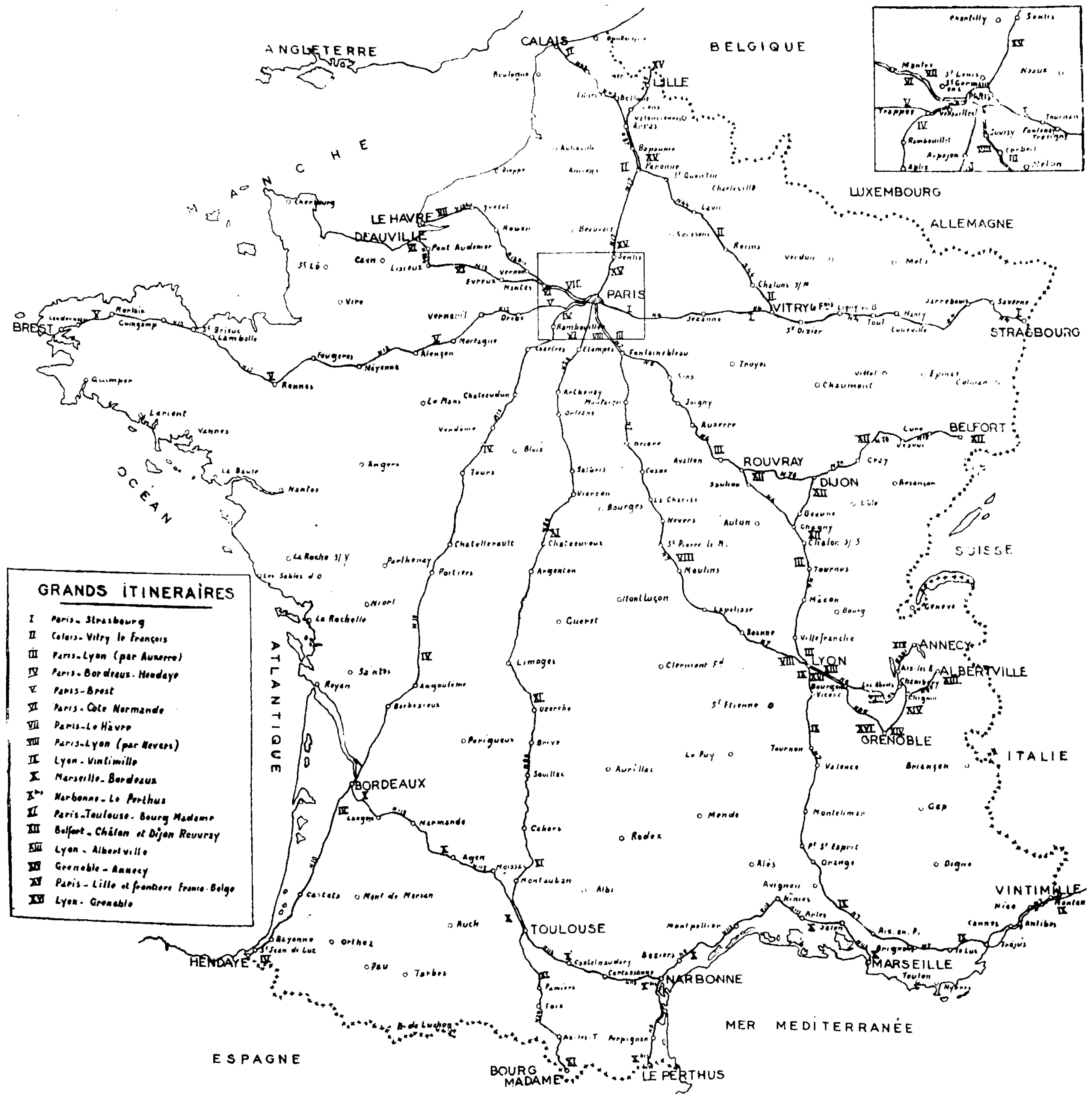
Nevertheless, these loans need the prior approval of the proper authorities, the Minister of Interior.

[The above has very kindly been translated from French to English by Shri S. K. Rajgopalan, Divisional Engineer-Consultant, Ministry of Transport and Communications (Roads Wing), New Delhi.]

CHILD SAYING HIS PRAYER AT BED TIME

"And I pray God to put vitamins in Pudding and Pies instead of in Cod Liver Oil and Spinach – Amen."





SWITZERLAND'S 20-YEAR ROAD PROGRAMME

By

M. DE BUSSY

The Swiss National Road Plan drawn up late last year, covers the period to 1980. In this article, the author, recently Director of Roads at the Rijkswaterstaat, at The Hague, describes the traffic studies on which it was based and the design standards recommended.

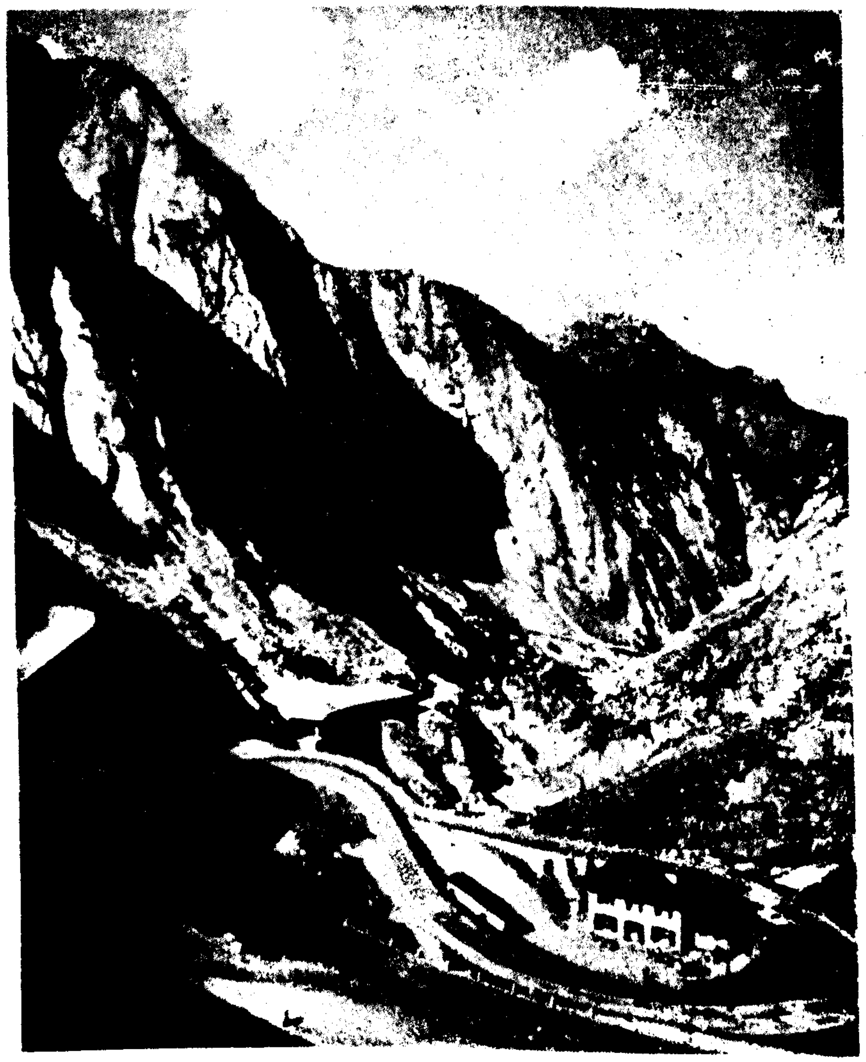
NOTWITHSTANDING its fairly high degree of motorization and the importance of tourist traffic, Switzerland has, as yet, done little for the benefit of its road traffic. In general, the autonomous cantons only have improved sections of existing roads, although south of Lucerne is a short stretch of motorway. But the report of the Commission appointed in 1954 to study the road traffic problems and to advise on a national road plan is most comprehensive and thorough, consisting of six splendidly executed volumes of 100 to 200 pages each, with a wealth of tables, graphs and maps.

Switzerland can be divided into two parts. The undulating and hilly area north of the Alps, with its dense population, industry and commerce, stretches from Geneva in the West to the Bodensee in the east over a length of some 170 miles, while its width is nowhere more than 35 miles. It occupies considerably less than half of the national territory. South of this area are the high mountains with a very low density of population, except in a few penetrating valleys (of the Rhine, the Rhone and the Aar) and in the region of Lugano and Locarno, and here the main tourist resorts are to be found.

The road problem follows this division, the northern area presenting the same requirements and possibilities as most western densely populated countries (dense, economically important traffic, with the possibility of constructing roads of normal standards) whereas the Alps do not permit, nor require, the building of high speed roads.

The traffic problems in the Alps are discussed separately in the fifth volume of the report. The other volumes refer to: general matters, project of a motorway system in general, projects in detail of motorways, urban express roads to connect motorways (not yet published), programme costs and financing and legal procedure. From the data and opinions given, the following may be cited.

According to an investigation in 1956 concerning approximately 13,000 vehicles, small cars averaged 11,500 miles a year and heavy cars and lorries 13,000 miles each. An estimate shows that in the same year 2,000 million Swiss francs (170 million pounds) were spent on vehicles, fuel, repairs, etc., which was 8 per cent of the national income. 1,037 persons were killed in traffic accidents, which is equivalent to 0.19 killed to one million vehicle-kilometres, whereas the same relation is only 0.08 on German motorways. In 1957, Switzerland's 5,117,000 inhabitants had cars at 81.2 per 1,000 inhabitants, 415,000 in total. But 2,458,000 foreign automobiles



The new St. Gotthard Pass. Hairpin bends at Schollenen Gorge

entered the country in the same year. This explains partly the very high percentage of light vehicles (cars and light vans) on the roads; an average of from 88 per cent and rising to 95 per cent on alpine roads in summer.

A general traffic census as part of an all-European census in 1955 is the main source for traffic analyses. But on six primary roads automatic counters give the traffic density continuously hour by hour. On the alpine passes separate counts determined the Swiss cantons or the countries of origin of traffic. Cordon censuses around 17 cities, and investigations in five cities provided detailed information on urban traffic, and tables and graphs give traffic distributions throughout the year, week and day. In accordance with American data the 30th hour traffic in Switzerland is two-thirds to four-fifths of the absolute maximum. The relation between the highest hourly volume and the daily average on roads was found to be: 0.203 for entrances to

The new road at Schollenen Gorge with the old road below.

cities; 0.225 for rural roads with mostly business traffic; 0.261 for rural roads with important tourist traffic, and 0.414 for alpine roads with preponderant tourist traffic.

Graphs give lengths of trips of vehicles leaving Basle and for the relation between the distances to various cantons and countries, and the number of vehicles originating from them observed on the alpine passes. Roughly, a hyperbolic curve can be drawn through the diagrams, but the points are rather widely scattered. In general, it can be said that the main currents of business traffic follow a direction south-west to north-east in the oblong densely populated part of the country north of the Alps. Perpendicular to this direction are the streams of tourist and recreational traffic.

Predictions of future traffic are based on an extrapolation of the curve of the number of vehicles with a gradual decrease of the rate of growth: from 1960 to 1980 the number of automobiles is supposed to increase from approximately 500,000 to 800,000. In the same time the population will only rise from 5.3 to 5.5 million.

Design Standards

The proposed national roads are classified in three categories. First class roads will be 'motorways' in the full meaning of the word. Second class roads will be also exclusively for motor-traffic with limited access, but they will not necessarily have hard shoulders nor a central reserve, and they may have less than four lanes. Grade separation at intersections is recommended, but not required. Third class roads have fewer requirements, that is lower standards.

The design standards proposed for the three classes of roads are given in the table below:

Design speed	75	62½	50 m.p.h.
Radius of horizontal curves			
normal minimum	2,300	1,500	900 ft
absolute minimum	1,500	900	600 ft
Radius of vertical summit-curves			
normal minimum	10	5.5	2.5 miles
absolute minimum	7.5	3.8	2.5 miles
Lane width	11½	11½	11½ ft
Free height	14½	14½	14½ ft
Gradients	3 per cent (at the most 5 per cent)	3 per cent	8 per cent
Stopping distance	800	570	380 ft.

Sight distances must be double the stopping distances on two-way carriageways.

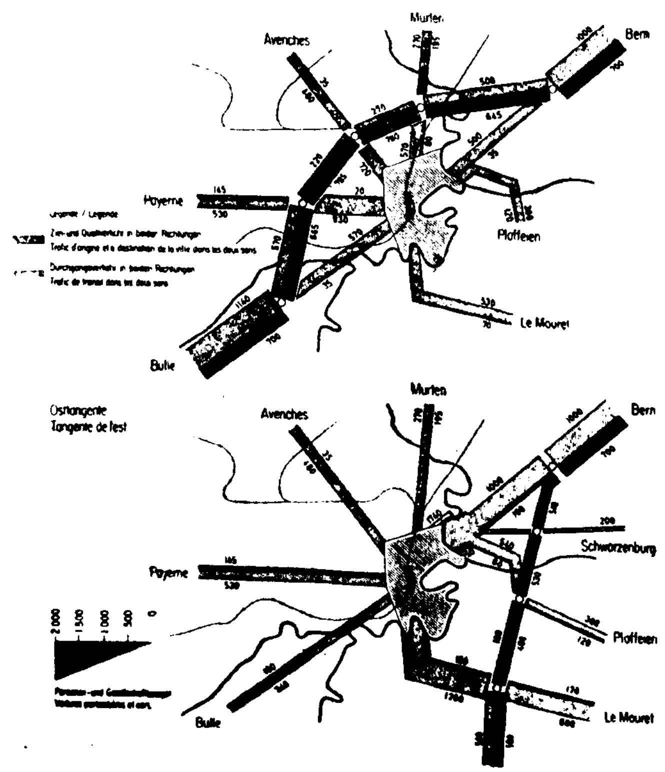


Fig. 1. An example of the detailed studies on which the Swiss Road Plan was based, it shows the calculated traffic distribution near Fribourg by two alternatives (west and east) of a motorway. Shaded: traffic for or from the town; black: through traffic. Figures refer to traffic in both directions, based on a census of 11th July, 1955

The capacity of the roads is evaluated at 2,000 passenger-car-units per hour for two lane roads, 3,000 p.c.u. for three lane roads, and 8,000 p.c.u. for four lane roads with a central reserve. The traffic densities to be admitted in practice are, however, respectively put at 1,000, 1,500 and 4,000 p.c.u. per hour (i.e., for the 30th hour a year in density) or 4,000, 6,000 and 25,000 per average day. Reductions for impediments, etc., are to be applied according to the American Highway Capacity Manual.

Three lane two-way carriageways are not rejected in good visual conditions, i.e., on mostly straight alignments. Experience shows that head-on collisions on the centre lane are rare. Due to the topography straight alignments are seldom possible; but especially for two-way carriageways they are recommended up to a length of three miles. Transition curves in the form of clothoides are recommended.

The design for a normal cross-section for motorways is two carriageways of 23 ft, each flanked on both sides with a marking ribbon 1 ft 7 in. wide and on the outside with a hard shoulder of 8 ft 2 in. and a green shoulder of 1 ft 7 in. The central reserve is 13 ft wide. The total width of the crown of 85 ft may be diminished to 62 ft in difficult conditions, the carriageways being kept at the same width. Perhaps the fact that many big cuts and fills are necessary influenced the decision not to make the crown widths too ample or to recommend wider central reserves. It should be remembered that the Swiss value their agricultural ground very highly.

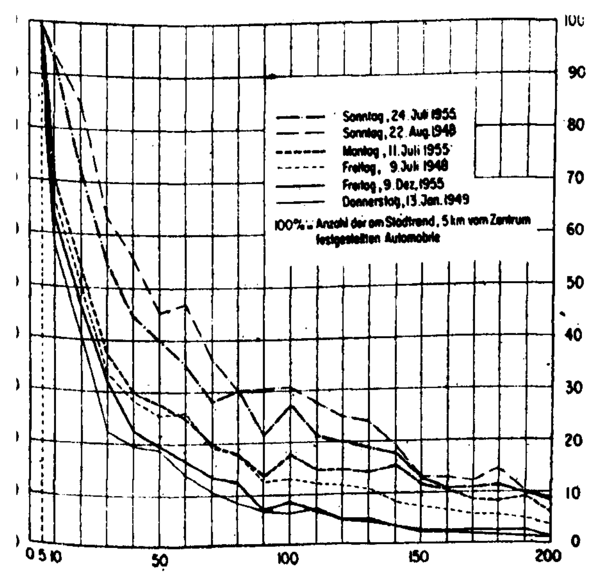


Fig. 2. Trip lengths of cars leaving Basle on six days. Horizontal: length of trip from centre of Basle. Vertical: percentage, 100 per cent is the number counted on city border, 5 kilometres from the centre. The two top curves refer to Sunday traffic.

With only slight deviations the cross-sections of European motorways are getting standardized. This is a pity, for in this way the roads will have a very similar aspect, which threatens to give rise to monotony. It would be advisable to stress the desirability of a variation in the widths of the central reserves and of the green shoulders; this will also give the possibility of fitting the road in a pleasant way into the landscape. And moreover, the far from hypothetical danger of head-on collisions with vehicles cutting through the central reserve will disappear, and blinding by headlights at night will be totally excluded. In many cases the value of the extra land required is negligible and even in agricultural regions a short calculation shows that the extra loss of area does not amount to very much, considering what is gained by it for millions of travellers year after year.

Tunnels proposed for motorways are to consist of two one-way tubes, of vaulted cross-section, 29 ft between kerbs in short tunnels and 24 ft in long tunnels; the latter having on the outside a distance of 3 ft 3 in. between kerb and wall supposedly for inspection, etc. This distance is in the other cases 1 ft 8 in. to 2 ft.

In order to make a plan for a net of motorways, very extensive studies have been made. The country has been divided into sections in each of which a committee has investigated numerous possible itineraries of roads and combinations of them. Some of them could be rejected after a first inspection; where alternative alignments remained comparisons have been made taking into account among other items estimated costs, traffic properties (rise and fall, etc.), expected amount of traffic, traffic diversion from existing roads, regional benefits and disadvantages, national advantages, and an economic assessment of a motorway. Sometimes the problem was easy to solve, e.g., from Geneva to Lausanne one location for a motorway follows practically directly from the topography and the report gives ten pages to it. But for the motorway between Lausanne and Berne four alternatives had to be compared, which takes 40 pages of the report. The costs of the motorways are estimated to be from 250,000 pounds to 500,000 pounds a mile; those of (double) tunnels an average $1\frac{1}{2}$ million pounds a mile.

To give the comparisons as much as possible a mathematical character, certain standards have been developed. In order to take account of the difference of rise and fall in alternative locations, a 'virtual' length has been introduced, based on fuel consumption and on travel time. It is stated that for passenger cars rise and fall compensate each other practically if gradients are not more than 5 per cent. As to time loss, an 8 h.p. car, the Opel-Rekord, travelling at 62 m.p.h. can be taken as representative, with up to 3.5 per cent gradient no decrease of velocity assumed. A 5 per cent gradient lowers the speed to 50 m.p.h., or 20 per cent. But since motorways are not supposed to have steeper inclines than 3 per cent, a 'virtual' length has not to be applied with regard to passenger cars. For commercial vehicles, being of more divergent types, the problem is more complicated and use is made of some data from other countries. The result is that for fuel consumption and travel time combined virtual lengths of upward gradients of 2.5 to 3 per cent are to be put at 116 per cent and for gradients of 5 to 5.5 per cent at 167 per cent of the real length.

Origin and destination counts have been available only in some cases to estimate future traffic on the alternative itineraries. But the general traffic census in 1955 taken at 400 points, during which on four days the cantonal licence plates were noted of the vehicles from the seven largest cantons, gave a basis as to inter-cantonal traffic. For traffic inside the cantons the same census was used and analysed with the help of what the report calls the Lillsche law:

$$Q = c\,\frac{A1.A2}{r^n}$$

in which Q is the number of vehicles moving between two places having respectively A1 and A2 vehicles; r the distance between these places and n = 1.5, whereas c is a coefficient dependent

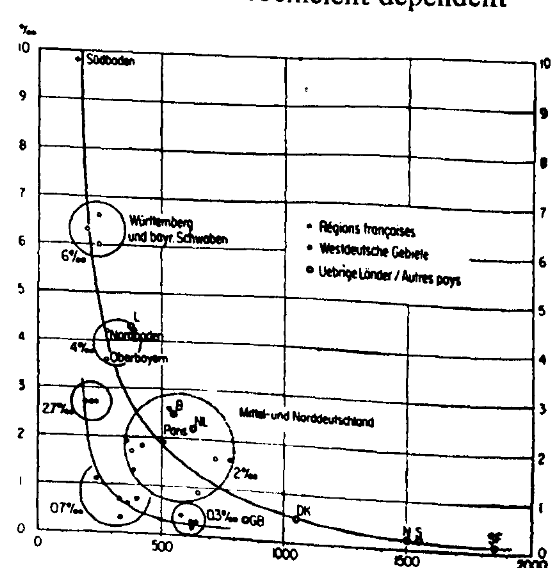


Fig. 3. Automobiles from different regions and countries on Swiss passes on four days; August 1953. Horizontal: distance to point of origin. Vertical: cars counted, expressed as 1/1000th of number in different regions and countries. Full dots: French region. Open dots: German regions. Dots and circles: other countries.

on conditions, on average of the order of magnitude of 0.001 (with r in kilometres), and to be found by checking with the observed traffic volumes.

How much of the future traffic will stay on the old roads and how much will use an available motorway will depend on the relation of travel distances as well as of travel time along the two itineraries. Use is made of American observations on the Shirley Highway (near Washington, D.C.); in most cases 70 to 90 per cent of the traffic is expected to prefer the motorway. The calculations are based on speeds of 53 m.p.h. on motorways, 31 (sometimes 38) m.p.h. on existing rural roads and 22 m.p.h. on urban roads. It should be remembered that motorways are only envisaged in the lower non-mountainous, part of the country.

The results based on the census of 1955 are multiplied by 2.5 to account for the expected increase of the number of automobiles in the country and abroad. The report however explicitly does not add a percentage for 'new' traffic, as a result of the greater ease of traffic along motorways, which it states will certainly enhance their use, because an estimate of this increase cannot be given with any security.

Estimated Savings

Regional benefits of the construction of motorways result from the fact that a given region of the country, or of a canton, will be in easier reach of the economical centres of the country. Where the choice of alternatives for a motorway was difficult this factor was taken into account with the help of elaborate computations. The report contains a number of maps giving in different shades the zones where the saving in travel time between cities will be 0—10, 10—20, etc., upto 50—60 minutes. Based on the above mentioned formula, an estimate of the number of vehicle-hours per day that will be saved is derived.

Fig. 4. Number of foreign automobiles on the St. Gotthard Pass according to country of origin: total of four days in August, 1953.

A point system has been developed to compare the values for neighbouring cities and villages of their proximity to a motorway. According to the report the traffic-behaviour of people varies widely with the size of the town or village they live in: citizens of the larger cities generate per capita four times as much motor traffic as inhabitants of small agricultural settlements, towns with some industry and smaller cities lying between. This seems to be supported by data from the railways. A second factor is the size of the considered town or village and a third is its distance to the nearest motorway access point, a greater distance giving a rapidly decreasing relation with the motorway, approaching zero at 20 miles.

Crossing the Alps

Volume 5 of the report is dedicated to road connections across the Alps. In this volume of almost 200 pages a very thorough and comprehensive study is made of traffic crossing the Alps from in and outside Switzerland, its origins and destinations, the traffic relation between regions to the north and the south of the mountains, the seasonal and daily fluctuations, the estimated development of traffic up to 1980, etc. Special observations have been made about queue-building, velocities and capacities on mountainous roads. Moreover meteorological data are assembled.

To meet traffic demands three possibilities have to be studied:

(a) Improvement of the roads over the passes. Since in practically all of the cases it is not possible to keep them free from snow in winter time this solution is not a total one;

(b) improvement of the transport of cars by train through the St. Gotthard and Simplon Tunnels to take up winter traffic and to divert a certain amount of summer traffic from the road over the passes;

(c) driving of new tunnels at such an altitude that it is possible to keep their access roads open during the entire year, as is being done between France and Italy through Mont Blanc.

For the St. Gotthard route (the most important trans-alpine connection and the historic background of the Swiss confederacy) the Commission comes to the conclusion that the improvements at present envisaged by the railways management will suffice up to 1980; also the pass-road itself (Goschenen-Airolo) will be sufficient for a long time after the present improvement works have been carried out. Hourly traffic densities up to 800 or even 1,000 passenger car-units are possible with a reduction of speed to 20 or 25 m.p.h. due to the steep gradients. But the accesses at both sides (from the Vierwald-stattersee to Goschenen, and from Airolo to Bellinzona) will have to be improved by construction of a new two-lane second or third class road, separate from the existing road and by-passing built-up areas. In time it can be decided which solution is to be preferred for a further increase in capacity; either the construction of a second railway tunnel with provisions for the transport of cars or the construction of a special road tunnel.

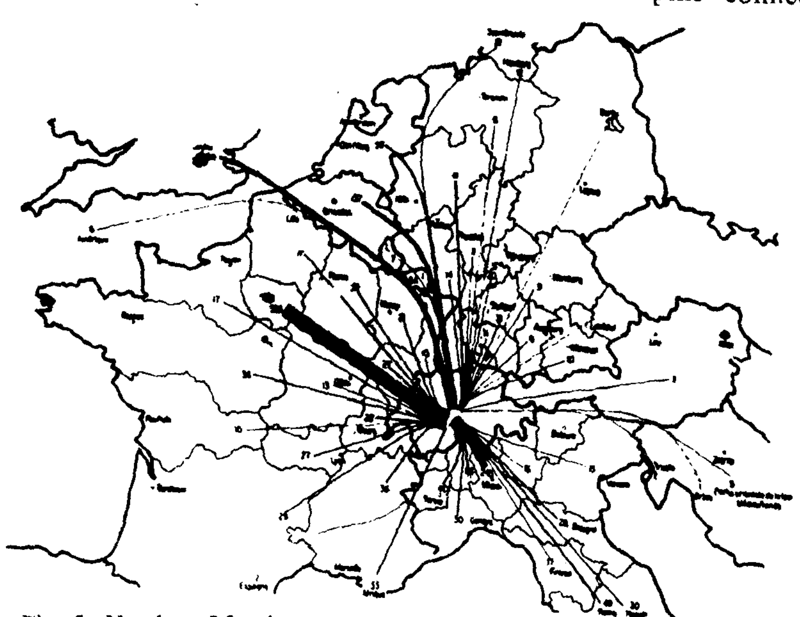


Fig. 5 Number of foreign automobiles on the Simplon pass according to country of origin: total of four days in April, 1953.

The Simplon railway tunnel does not at present make as good a provision for the transport of cars as the St. Gotthard tunnel, but according to the report it can be improved in such a way that it will meet winter demands up to 1980, even if no Mont Blanc tunnel nor a Great St. Bernard tunnel is constructed. The road over the pass should be improved to two-lane third class standards and snow clearing services should be organized to keep it open, except in January, February and March. Here also the Commission does not recommend a special road tunnel.

Such tunnels are however advocated on two itineraries: the connection of the upper Rhine valley (Chur) with Bellinzona, Lugano and Locarno over the San Bernardino, and the connection of Berne via Thun with the upper Rhone Valley and the Simplon pass. A Great St. Bernard tunnel is calculated not to be economically justified due to the close proximity of the Mont Blanc tunnel. The report gives an elaborate comparison of normal ventilated road tunnels and tunnels with transport of cars on railway wagons. The latter solution should be considered when the length of the tunnel exceeds six miles.

National Roads Programme

In the last volume of the report the Commission comes to its final proposals for a network of national roads, a programme for its construction, its financing and its economic justification. With the financial slow down in sight the Commission lowers slightly its target as to the motorway scheme. It introduces the idea of 'semi-motorways', two-lane two-way roads of the second class, built in such a way that a second carriageway can easily be added so as to form a real motorway. This would give a saving of about one-third and the eventual completion would not incur other than very slight loss of what has been built. Funds are limited and the amount saved can be put to better use on other objects. Roads of this kind in view of their good alignments could carry easily 6,000 passenger-car-units per average day, which density is not predicted for 1980 on a number of sections of the initially proposed motorways. These sections are, therefore, put in the second class. This reasoning seems sensible but doubts may arise whether in this prosperous densely-populated country traffic volumes will not surpass far earlier the prognosis, e.g., on the above-mentioned road Lausanne-Berne of which a part is brought down to the second class and which will constitute the main artery for the connection of Berne with Lausanne and Geneva all of them sizeable towns. However, construction of the second carriageway is always possible at the moment when it is needed and if traffic grows faster than predicted more money will be available.

Final Proposals—Financing the cost

The final proposal for the national road network gives a total length of

360 miles of class 1 (motorways) 350 miles of class 2 (including 'semi-motorways') and 340 miles of class 3 (including the three trans-alpine routes totalling 260 miles). The construction programme is divided into two parts; the first part to be concluded in 1969 is estimated to cost 240 million pounds and the second part to end in 1980 will cost 71 million pounds. The report proposes that the roads of this national network be financed and designed by the Federal Government, and that construction and maintenance be the duty of the cantons. Financing is a great problem. A toll system is rejected. With toll-booths on all of the 180 projected access points, cost of collection would approximate 1,200,000 pounds a year. Also part of the traffic might then avoid the new roads by continuing to go through the built-up areas. Suggestions have been made, but not accepted, for a system by which vehicles obtain the right to use the roads by paying an annual lump sum. Even for the tunnels no tolls seem to be recommended. An elaborate study leads the Commission to the following financial system. Of the revenue of the present petrol-taxes, 20 per cent would be used for the national roads (the cantons receive now 40 per cent and will continue to do so according to the proposal; the rest goes to the treasury); moreover an extra tax of 2½ d. a gallon would be added to the petrol-tax exclusively for the new road system. Loans would be issued to be repaid by the same sources after the completion of the work; according to whether an optimistic or a pessimistic view is taken of the growth of the motorization the repayment would cease either in 1994 or in 2021.

Economic Benefits

A chapter is added to evaluate the economic benefit of the proposed road system. Running and maintenance costs of motor vehicles are put at about 4½ d. a mile, of which 25 per cent would be saved on motorways, giving in 1980 a total saving of almost 6 million pounds annually. To this must be added the saving in time, in so far as it is of economic importance, to which is attributed a value of 8½ million pounds per year in 1980. The reduction of accidents that can be expected accounts for a further benefit of 1.3 million pounds per year. The sum of these benefits is only slightly less than the annual costs of rents, amortization and maintenance, which the report concludes, justifies the investment. Attention is also drawn to other benefits that are difficult to calculate, e.g., for industry, trade, agriculture and tourism in more easily attainable districts, and on account of the greater tranquillity and safety on old roads, particularly in built-up areas. The report ends with a project of law to realize the proposals.

References

'Die Planung des Schweizerishchen Nationalstrassennetzes', Eid-genossische Drucksachen-und-Materialzentrale, Bern 1959. The photographs are reproduced by courtesy of the Swiss National Tourist Office.

(From "Traffic Engineering and Control," Vol. 2, No. 4, August, 1960)

THE TRANS-CANADA HIGHWAY

By

G. B. Williams

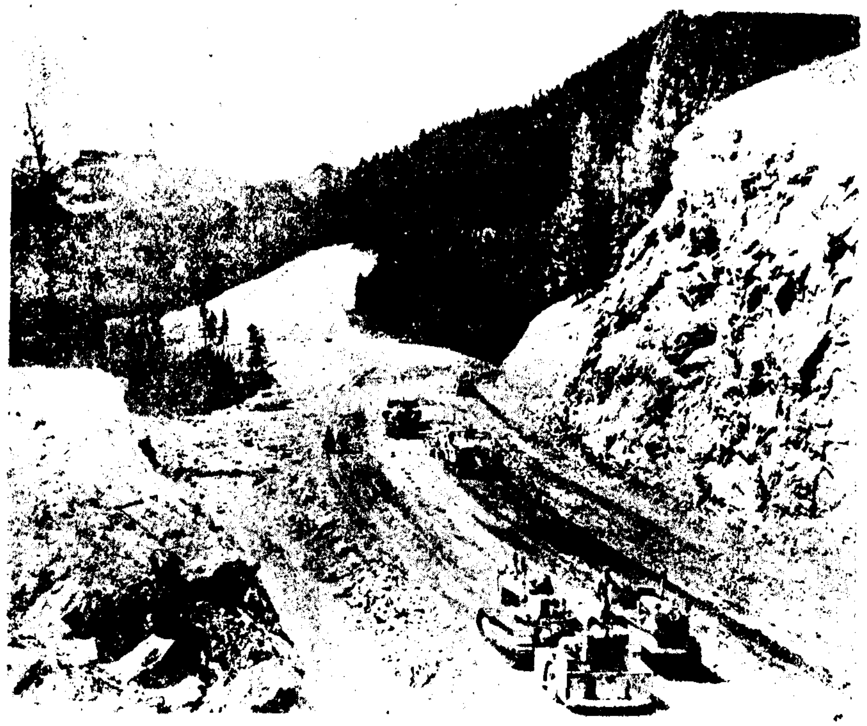
(An abstract of an article)

TRANSPORTATION across Canada has always been a formidable problem. The terrain is such as to make mass transportation easiest in a north-south direction.

the Canadian Pacific Railway was completed. Perhaps the first organized effort directed in this way was the formation of the Canada Highway Association in 1910 which advocated

ALBERTA—Mile 37.4 north of Kootenay River crossing on the Trans-Canada Highway

In a review of the History leading up to passing of the Trans-Canada Highway Act by the Government of Canada in 1949, it would almost appear that discussions on the possibility of the Trans-Canada road began as soon as a highway across Canada. From that time, various automobile associations and good roads associations, with varying degrees of enthusiasm, have advocated the construction of this road.



Grading operations T. C. H.—Banff National Park

It was only after the Second World War the provinces assumed the task of reconstruction of their highway plans to meet the needs of the heavier vehicle registration, increased loadings and the established freight trucking, the Trans-Canada Highway received immediate attention.

In 1948, judging the time to be right for such an undertaking, the Federal Government convened a meeting with the provinces to discuss the project. Based on this meeting and subsequent liaison between the Federal Government and the provinces " An Act to encourage and assist in the construction of the Trans-Canada Highway" was passed unanimously by Parliament in 1949 and given Royal Assent on 10th December of the same year.

With this same specific purpose in mind, a second Federal-Provincial Conference was held on 15 and 16th December 1949 to prepare for the agreements authorized under the Trans-Canada Highway Act and under which the highway would be built. Previous agreements had resulted in highway construction to a variety of standards; routes were not necessarily well connected at provincial boundaries and the vigour with which construction was undertaken varied greatly between provinces. At this 1949 meeting, a set of minimum standards was mutually agreed upon, a time schedule and operating procedure outlined.

The general concept was that the project would be a two-lane highway with the basic geometric standards and design criteria as given in Table I. The design was not elaborate but would provide an adequate highway for anticipated volumes and character of traffic to move within the limits of legal speeds

with complete safety in so far as design could provide it. On short sections where local traffic conditions warranted additional traffic lanes, the Federal Government's participation was limited to the equivalent of the two lanes plus shoulders. Conversely the Federal Government agreed to consider deviations from the standards on short sections where the terrain was such that the design standards could not be met within good engineering practice and economy. The time set for the construction of the highway was seven years dating from 10th December 1949.

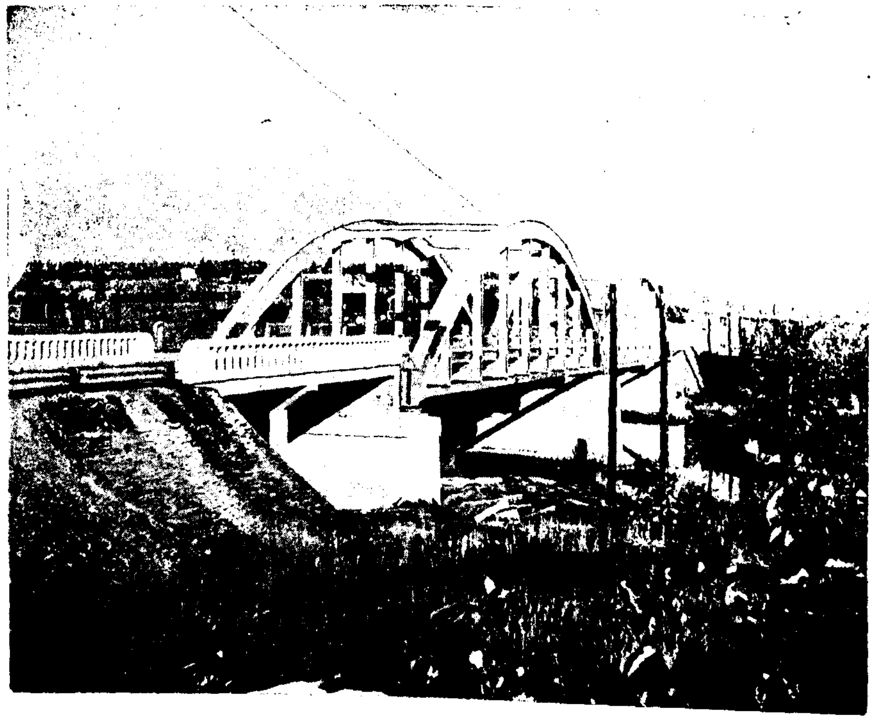
Table I

Standards For Trans-Canada Highway

Right-of-Way —		Minimum	100 ft width
Curvature —		Desirable	Maximum 6 degree
Gradient —		—	Maximum 6 per cent
Sight Distance —	Vertical Horizontal	Min. 600 ft Min. 600 ft	—
Pavement —	Width Depth Loading 18,000 lb axle —	Min. 22 ft Min. 3 in. Repeating	Maximum 24 ft —
Shoulders —	Width	Min. 5 ft	Maximum 10 ft
Bridges —	Loading	H20-316	
	Overhead Clearance	Min. 14 ft-6 in.	
	Width —	For length 30 ft or less	Width of pavement plus shoulders
		For length 30 ft—100 ft—	Minimum 27 ft
		For length over 100 ft	Minimum 24 ft

In general, under the Act, the Federal Government was to pay 50 per cent of the cost of construction of the Trans-Canada Highway to the agreed Standards. Provision was made for the acceptance of existing road along the approved route which was constructed to Trans-Canada Highway standard or for work which could be incorporated to advantage in the reconstruction. In such cases, the provinces could be reimbursed to the extent of 50 per cent of their prior expenditures.

The route was to be designated by the provinces subject to the approval of the Government of Canada and was, in general, to be the shortest practical east-west route through each province consistent with the needs of the provinces and the interest of Canada as a whole. The provinces would undertake the construction of the road. Both their design and construction procedures would be subject to review and approval of the Federal Government as a partner and arrangements were made for federal



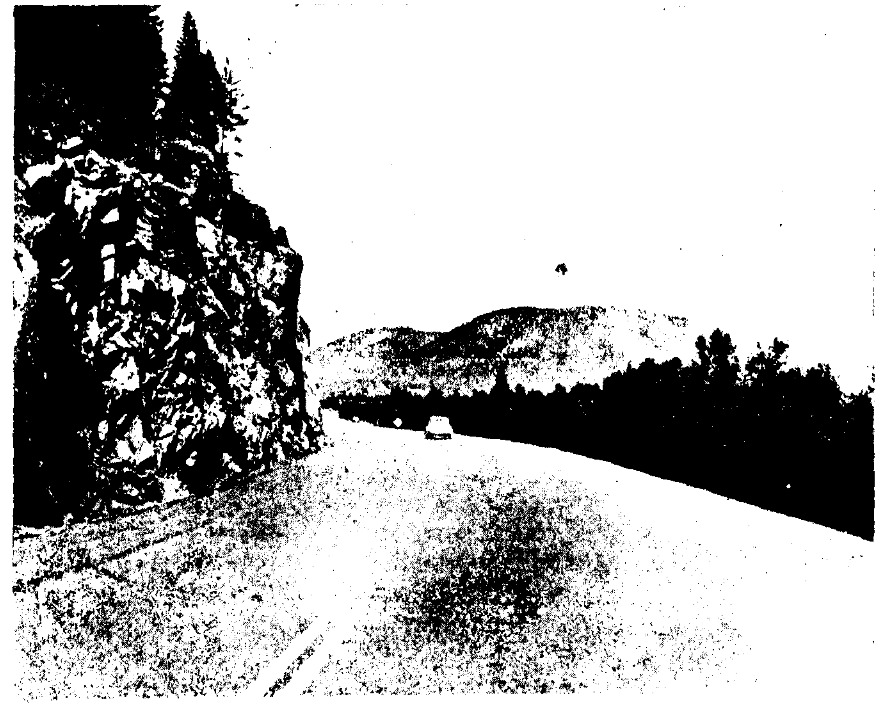
NEW BRUNSWICK—Trans-Canada Highway bridge at Cole's Island across the mouth of the Salmon River. This is a 50-50 section. September 1957

engineers to inspect the work during construction.

At the time of signing agreements with the provinces, the designated route of the Trans-Canada Highway was 4,497 miles in the participating provinces, and eighty three miles in Banff and Yoho National parks. Since that time, there have been revisions in location and consequently in mileage. The estimated figures to date are given in Table III, subject to further revision on completion of detailed surveys. The estimated federal share at the time of signing was 150,000,000 dollars.

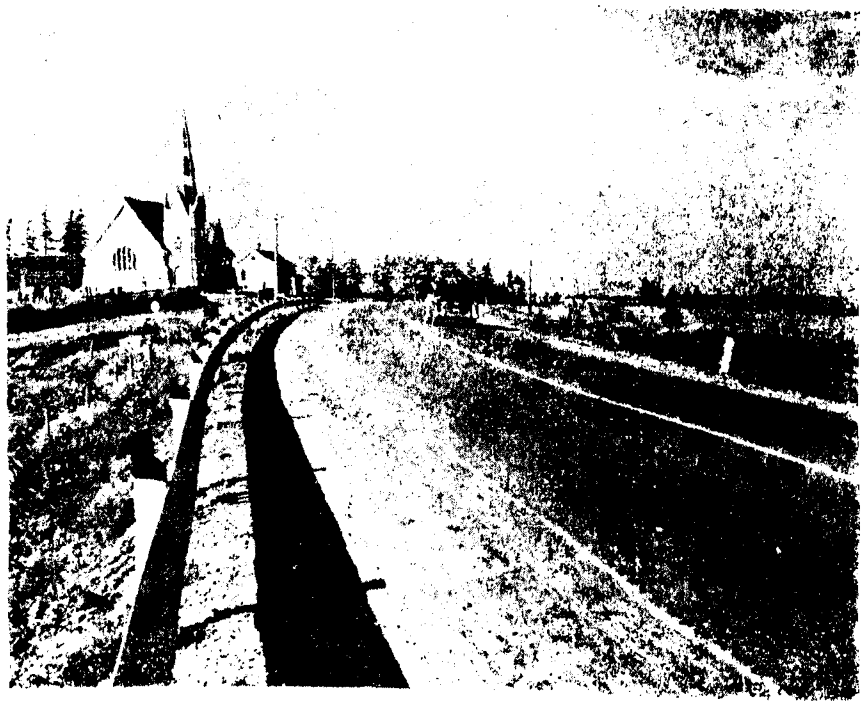
Table II shows the total mileage of designated route, passable mileage and paved mileage by provinces at the time of signing the agreement, and the statistical summary of what has been done is given in Table III showing the mileage by provinces.

The provinces which have made most progress are those where the Trans-Canada traversed the province in ar area where they needed and wanted a highway prior to the Agreement and, ir most cases, had started some construction. That is not to say that the other provinces did not desire the highway All did, as was evidenced at the 194' Conference and all, with the exceptio of Quebec, have participated. Th problem for the provinces with les progress is, however, that while the wanted the highway, the period in whic it was required to be built coincide with a period in which the demands fc other highways were also at their peal For some of the provinces, demand elsewhere were such that they coul not, by virtue of their own loc: emergency, provide their share of th cost of the Trans-Canada Highwa This is particularly true of tho provinces where there was an existi



BRITISH COLUMBIA Salmon Arm to Tappen Hwy. near Salmon Arm

Section of finished pavement along Sask. section T. C. H.



PRINCE EDWARD ISLAND—In the village of Crapaud, the Trans-Canada Highway passes beautiful St. John's Anglican Church

paved road serviceable but below Trans-Canada Highway standards.

In other provinces, the problem was simply one of insufficient funds to proceed at the rate they originally anticipated. This problem is emphasized by the fact that financial commitments to date are very much in excess of those originally contemplated for the present stage of completion. In other words, the project has turned out to be a much greater one than was originally realized.

It was to meet this problem that the Federal-Provincial Conference on the Trans-Canada Highway was convened at Ottawa by the Honourable Robert Winters in November 1955. The emphasis of the conference was on dealing with the gaps where there was no highway of any kind which, at that time, approximated 250 miles, and on an additional 1,477 miles which were not paved.

In considering the gaps, a review of the highway under construction showed that in no province was there more than 10 per cent of the mileage on which there was no road of any kind and, in fact, in most provinces there was a continuous road but not all completed to standard. To ensure a speedy closing of the gaps and in general to speed up reconstruction, the Federal Government proposed that it would pay 90 per cent of the cost of construction of 10 per cent of the mileage in each province. On the remaining 90 per cent of the mileage, the contribution would remain as formerly, at 50 per cent of the cost.

Table II

Total mileage of designated route, passable mileage and paved mileage by Provinces at the time of signing the agreement

Participating Provinces		Total mileage	Approximate* Passable mileage	Paved* mileage
Newfoundland	...	610	450	40
Prince Edward Island	...	74	74	30
Nova Scotia	...	310	310	223
New Brunswick	...	388	388	306
Ontario	...	1,412	1,250	456
Manitoba	...	305	305	154
Saskatchewan	...	414	414	139
Alberta	...	292	292	142
British Columbia	...	692	692	427
National Parks	...	83	83	47
Total	...	4,580	4,258	1,964

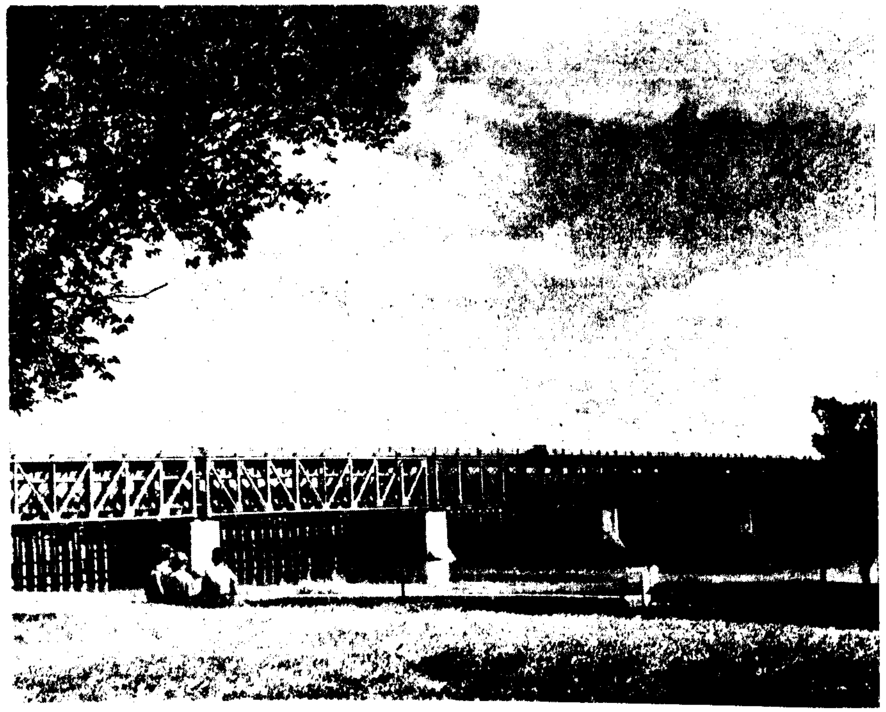
* Not necessarily on designated route.

Table III

Status of Construction on Trans-Canada Highway to 30 September, 1960

	Nfld.	P.E.I.	Nova Scotia	N.B.	Ont.	Man.	Sask.	Alta.	B.C.	National Parks Yoho, Glacier, Banff, Revelstocke, Terra Nova	Total
Estimated total mileage	554	71	311	390	1453	309	406	282	568	140*	4,477
Grading											
Mileage approved for contract	375	71	119	197	977	250	406	281	537	140	3,353
Equivalent mileage completed	288	71	119	196	938	249	406	281	505	137	3,190
Paving											
Mileage approved for contract	169	71	119	197	977	300	406	281	503	122	3,145
Equivalent mileage completed	167	71	119	190	904	300	406	281	446	106	2,990
Structures											
Number approved for construction	44	5	28	39	136	38	15	38	99	39	481
Number completed	39	4	27	30	119	38	15	38	74	39	423

* Total mileage in National Parks: Banff 51; Yoho 29; Glacier 29; Revelstocke 8; Terra Nova 26.



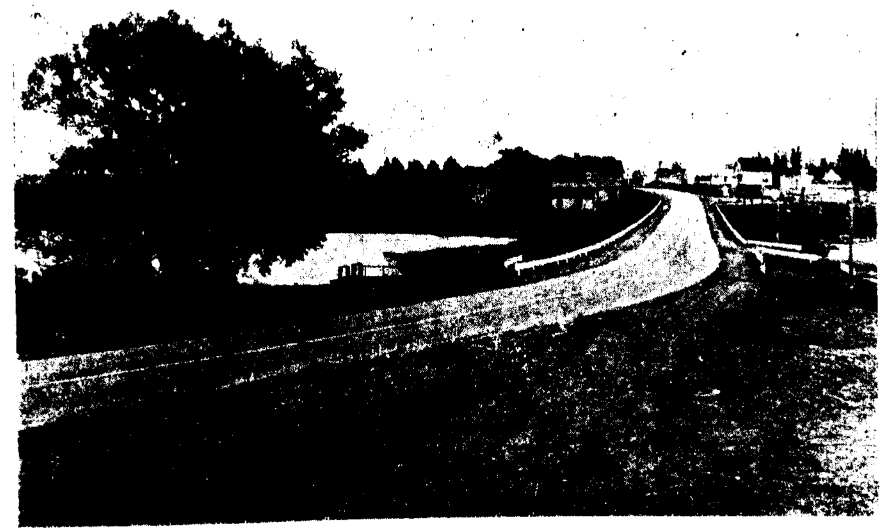
Bridge and locks over the Red River on the Trans-Canada Highway at Lockport, Manitoba

Further, to permit the provinces to concentrate on the unpaved sections, it was proposed that existing paved highway on the route, though below Trans-Canada Highway standards, could be left for later reconstruction. All new work participated in by the Federal Government would be to the previously agreed standard and the aim would be to provide as much mileage of this class as was within the capacity of each Provincial Government.

With these proposals, it was felt that an earlier completion of a paved highway across Canada could be achieved than was otherwise possible. These proposals were discussed in detail at the conference and a completion date for construction was set at 31 December 1960. The necessary amendments to the Trans-Canada Highway Act, providing for the increased Federal contribution, were passed by Parliament and assented to on 7 June 1956.

Since the Conference, each province has been re-appraising its own situation and considering mileage on which it felt the existing pavement would satisfy the demands of traffic for some time to come. It is evident that all provinces are interested in preparing a realistic, if in some cases, a very tight schedule, to achieve a maximum of reconstructed highway, as well as a fully paved highway across their province by the end of 1960.

In the gap-closing operations, the Province of Ontario has established special engineering districts to speed the surveys and has let several contracts reducing the gap mileage. In Newfoundland, two grading contracts have been let reducing the untravelled portion of the route. The Prairie Provinces



PRINCE EDWARD ISLAND—At the little fishing village of Vernon a causeway carries the Trans-Canada Highway across the Vernon River

(Alberta, Saskatchewan and Manitoba), as well as prince Edward Island, will have no difficulty in fully completing the highway to standard by 1960, whereas Nova Scotia, New Brunswick and British Columbia are carefully scheduling their work to achieve a maximum of benefit to their provinces and Canada as a whole.

Because of geographical position, terrain, population distribution and variations in economy of the provinces, the achievement of a national highway is difficult; however, much has been done and now with a co-operative effort it should be fully completed in 1960.

Husband—After honeymoon to annoyed wife ; " Darling ! you said there is one thing you like about me."

Wife—" Yes and you have spent it all."

BRIEF HISTORY OF THE DEVELOPMENT OF ROAD TRANSPORT IN THE FEDERATION OF MALAYA

(By the courtesy of the Ministry of Transport, Federation of Malaya)

PRIOR to 1st January, 1938, the control of motor vehicles, such as existed, was effected in the 4 Federated Malay States by the Police in Perak and Selangor, the Chief Sanitary Inspector in Negri Sembilan, and by 6 District Officers in Pahang; this function was not carried out, save in a perfunctory manner, in the Unfederated Malay States.

The motor vehicles in use, in particular, for passenger services and haulage of goods, were generally in a dilapidated condition. Public passenger vehicles were of the small 7 to 9 seater type; the home-made bodies, which were known as "mosquitos", consisted of a narrow wooden trough with seats, and had a wooden canopy. Spare parts and puncture repairing outfits were seldom carried and breakdowns and delays were frequent.

In the operation of passenger services, little attempt was made to adhere to time-tables, and, as a result of this and the cut-throat competition which was a consequence of the virtual absence of any limitation on the number of such vehicles licensed, the services were erratic and unreliable. As a further consequence of inadequate control, the maximum fares which were laid down in some parts of the country were not generally observed, and the fares charged more commonly depended upon the whim of the operator.

Apart from the 4 Federated Malay States mentioned above there were 11 separate administrations which were empowered to impose motor vehicle licence fees, and many different methods of application, and scales of licence fees, were in force until, on 1st January, 1938, the new Road Traffic Enactment of 1937 came into force, after which considerable progress was made in the standardization of the registration and licensing, construction, weight, equipment, lighting, maintenance and use of vehicles, the licensing of drivers including "learners", the law regarding offences by drivers, and the general control of all road users. Under the provisions of this Enactment, a Road Transport Board was set up to control goods and public service vehicles, and co-ordinate road transport with other forms of transport.

When the future administration of Malaya after the Second World War was planned, it was decided that all the functions and duties of the Transport Board and the various Registration and Licensing authorities throughout the country should be taken over by a department under a Commissioner for Road Transport, and when Malaya was liberated in September, 1945, a Road Transport Department was formed under the British Military Administration; on 1st April, 1946, this became a department of the Civil Government. The department consists of a headquarters with a Commissioner for Road Transport, Deputy Commissioner, administrative and technical staff, and 9 registration areas, of which the three more important are controlled by Senior Registrars and Inspectors of Motor Vehicles and the remainder by Registrars and Inspectors of Motor Vehicles.

At the same time the B.M.A. Road Transport Proclamation No. 17 of 1945

came into force; this was based on the Road Traffic Enactment, 1937, with necessary revisions and additions to meet current conditions.

In the following years, progress was made in the drafting of a Road Traffic Ordinance and connected Rules, with the object of dispensing with the Road Transport Proclamation, 1945, and the numerous subsidiary regulations and amendments which had been made; owing to the Emergency in connection with the fight against Communist terrorists, consideration of this new Ordinance was deferred and it was not until 1st July, 1959, that the bulk of it and the Rules made thereunder came into force, only Part V, relating to the regulation of commercial transport, remaining to become effective on 1st January, 1960.

The Road Traffic Ordinance, 1958, and subsidiary legislation, contained many necessary revisions and additions to the law which it replaced; it also included additional Rules providing for a Highway Code, copies of which would be made available to the public, a more comprehensive control of road users and the fitting of taxi-meters on taxis.

Of particular interest in the provisions of the new Road Traffic Ordinance is the setting up of one Central and nine Regional Licensing Boards to deal with all aspects of commercial licensing. The Federation is divided into nine traffic regions; the Central Licensing Board, of which the Commissioner for Road Transport is Chairman, deals with commercial licensing matters where two or more traffic regions are involved, and Regional Licensing Boards, of which the Registrars and Inspectors of Motor Vehicles are Chairmen, where only one particular traffic region is concerned. These Licensing Boards do not, themselves, operate any transport, but supervise and regulate, by licence, the operation of all goods and public service vehicles, with the object of ensuring that a stable, efficient, safe and economical system for the carriage of merchandise and passengers is available throughout the country and that full co-operation exists between the different forms of transport in the country.

Rules governing the international circulation of motor vehicles and drivers were also included in the new Ordinance; these were a revised form of the law previously existing, modified where possible to assist in the promotion of the tourist industry by easing the requirements connected therewith as far as motor vehicles and drivers are concerned.

The Road Transport Department is responsible, for the registration and licensing of all motor vehicles, the testing and licensing of motor vehicle drivers, including drivers of public service vehicles, the licensing of bus conductors, and the collection of all revenue derived from such activities; in addition, it is responsible for the mechanical inspection of all commercial vehicles at regular intervals, and all other vehicles where particular circumstances, such as accidents, render this necessary.

Holders of provisional driving licences, i.e., "learners", are required to take a test of competency to drive the motor vehicle for which they wish to acquire a competent driving licence, before the latter can be issued, and these tests are carried out by Driving Testers attached to the offices of the Registrars and Inspectors of Motor Vehicles; during the year 1959, 56,062 persons were tested throughout the country, as a result of which 35,851 passed the tests and obtained competent driving licences, and 20,211 failed. Mechanical inspections of motor vehicles are carried out by Vehicle Examiners, who are also attached to the offices of the Registrars and Inspectors of Motor Vehicles; all commercial vehicles are subjected to an initial mechanical inspection before being licensed for use, and thereafter they are inspected at regular intervals, the aim being to limit these intervals to 6 months. During 1959, 5,251 initial and 30,808 routine inspections were carried out throughout the country; in addition, 5,127 vehicles, which had been involved in accidents, were inspected, at the request of the police.

The total number of motor vehicles registered in the Federation on 31st December, 1959, was 153,377, comprising 2,499 omnibuses, 4,013 hackney carriages, 128 hire and drive vehicles, 21,799 commercial load-carrying vehicles, 77,945 private cars, 32,194 motor cycles, 5,961 road-rollers, tractors and trailers, etc., and 8,838 Government-owned vehicles of various types. There are 628 omnibus routes in the Federation, and during the year 1959 omnibuses travelled 103,845,340 miles over them and carried 270,993,440 passengers.

In recent years there has been a marked trend in favour of diesel power, particularly as regards commercial vehicles; in the past five years the percentage of diesel-engined vehicles has increased from 11½ per cent to 23 per cent.

The load-carrying capacities of the commercial vehicles operated by the haulage industry vary from 3 cwts in the case of the smallest to 20 tons in the case of the largest, but the backbone of the industry comprises vehicles with load capacities between 3 and 8 tons.

The most common types of bus used for public services are the 24/32 and 32/44 seater, although smaller vehicles are operated where they are found to be more economical in use; in addition to the normal stage bus services, express services operate between Kuala Lumpur and Malacca, Singapore, Butterworth and Kuantan, Malacca and Singapore, Johore Bahru and Mersing and Johore Bahru and Singapore, and a certain number of "Charter" buses and "School buses" are operated to meet particular requirements.

Stage buses serve all the roads in the Federation where services can be safely operated and are required; certain services, which are not remunerative, are, of necessity, being operated for public interests; only in cases of new road developments is any considerable expansion of existing facilities likely.

The road haulage industry and bus services have advanced to the stage where they are generally considered to have reached a high level of efficiency and, in progressing to that stage, have assisted to a considerable degree in the opening up of undeveloped areas in the country.

"I have come to the conclusion that one thing to which we must give topmost priority is roads—roads of all kinds, not only very up-to-date bitumenized or cement roads, but roads of any kind, to open vast areas of this country which are closed up today and which you cannot reach unless you walk or ride.........I give roads first priority."

— SHRI JAWAHARLAL NEHRU

THE DAVAO-AGUSAN ROAD

(By the courtesy of the Development Projects Division, Department of Public Works and Communications, Bureau of Public Highways, Philippines, Manila)

THE Davao-Agusan road is a 290-kilometre land route from Davao Gulf in the south to Butuan Bay in the north, connecting the capital cities of the Provinces of Davao and Agusan. The highway traverses along the Agusan river valley. The land is rich in timber, minerals and other natural resources. It is suitable for raising abaca, cacao, rice and other agricultural products.

In this vast valley, transporation was by water through the river, its lake and tributaries in native dugouts. Settlements were established only along the banks of the rivers. Houses on log or bamboo pontoons in inundated areas made up the so-called floating villages. There were the muddy foot-trails in the virgin forests through which products and consumer goods were carried on back-packs. Travel was not only slow and inadequate but also tedious and expensive. The area thus remained long underdeveloped. The aboriginal Manobos and Mandayas remained backward or primitive. The few Christian settlers did not make much more progress either.

The need for a highway through this extensive valley had long been recognized. The construction of this road was started in the early thirties in the province of Davao. In 1941 at the outbreak of the war, 106 kilometres of road was already completed from Davao City to Barrio Bankerohan on the west bank of the Manat river, a branch of the Agusan river. The proposed remaining location was to follow the west bank of the Manat and Agusan rivers up to Sta. Josefa, a municipal district in Agusan Province.

Before 1937, while road construction began in Davao, preliminary investigation was started in Agusan. The first location was surveyed from the outskirts of Butuan along the west side of the valley to join the Davao line at Sta. Josefa. On this location a 13-kilometre section was completed from Butuan to the Bitos hills.

Work on this line was suspended in 1937. The location on the west side of the Agusan valley was abandoned in favour of another on the east side. The north terminus of the new location was established at Barrio Ampayon, seven kilometres from Butuan, while the southern terminus remained at Sta. Josefa. With this termini determined, the new route was officially designated as the New Agusan-Davao road. The proposed route was in a southerly direction passing the settlement of Afga and Nuevo Sibagat to the proposed Wawa river crossing. From this crossing, the line went south-easterly through thickly forested hills and valleys to the proposed junction to Lianga; then southward through the old settlement of San Francisco, then across the Bunawan and Simulao rivers to the municipal district of Trento. From Trento the line went south-westerly to connect to the Davao location at Sta. Josefa.

The last war halted construction on this road. No new construction was undertaken immediately following liberation pending restoration of pre-war facilities to their former usable conditions.

The restoration of the pre-war roads was not adequate to satisfy the needs for development of the Agusan and Davao hinterlands. Hence the Mindanao Development Roads Program in 1952 under the joint auspices of the National Economic Council and the International Co-operation Administration. This program is implemented by the Philippine Bureau of Public Highways with the technical assistance of the United States Bureau of Public Roads.

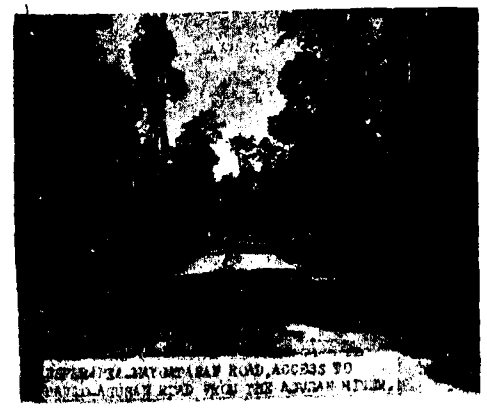
The approved route relocated and finally constructed followed the general alignment of the pre-war locations except for two major deviations. Instead of following the west banks of the Manat and Agusan rivers on the Davao side all the way down to Sta. Josefa, a new line crossed the Agusan river at Camp Kalaw, thereby transferring the location to the east side. This relocation traversed some settled areas and shortened the route by seven kilometres. The second deviation involved a change in the Wawa river crossing to a site three kilometres below the Barrio of Nuevo Sibagat instead of the downstream crossing at Maygatasan. This relocation provided a better bridge site, traversed richer agricultural lands and shortened the route by four kilometres.

The Davao-Agusan road under the NEC-ICA program was divided into ten sections for obvious practical reasons. Each section comprised a project. The projects were advertised and awarded to the lowest complying bidders.

The first project started under this program was the Nabunturan-Banlag Section, which consisted of two parts, the widening and resurfacing of the 13-1/2-kilometre section from the Nabunturan Poblacion to Bankerohan and a new 10-kilometre construction from Bankerohan to Banlag Creek. Bids were called on October 10, 1952, but were all rejected for being unreasonably high. A rebidding was held on November 18, 1952, in which the lowest bidder was L. S. Sarmiento & Co. to whom the contract was awarded effective January 8, 1953. With adequate equipment and favourable weather, the contracting firm performed this contract at a very fast rate, completing the work on January 8, 1954, much ahead of schedule.

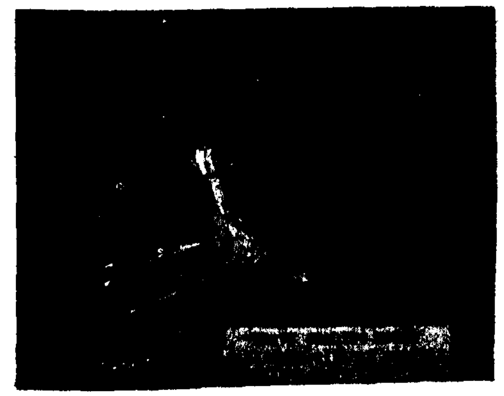
When this first section was about half-way completed, a 3-1/2-kilometre section including all drainage structures from Banlag Creek to the Camp Kalaw bridge site was added to the contract under a supplemental agreement effective August 13, 1953, at the same unit prices as most items in the original contract. The construction of the Camp Kalaw Detour Bridge was further added to the first contract at negotiated prices under another supplemental agreement effective September 29, 1953. The Camp Kalaw Detour was completed and accepted on November 30, 1953, in time for use as access in the construction of the first unit of the Camp Kalaw bridge proper and the Camp Kalaw-Pasian section which were bidded simultaneously. The Banlag-Camp Kalaw Bridge section was completed and accepted only on June 16, 1954, but was already passable when the next projects were started.

The construction of the Camp Kalaw Bridge proper was divided into two units. Unit I, for the substructures, the 3-15 meter RCDG approach spans and the road embankment at the abutments, was awarded to L.S. Sarmiento & Co. on November 30, 1953 and completed on September 30, 1954. Unit II, for the erection of the 60-foot Pony Steel Trusses, including RC. slabs and sidewalks, was also awarded to the same contracting firm on October 17, 1954. The steel truss members were furnished free by the ICA. Cement for this unit was also furnished to the contractor.

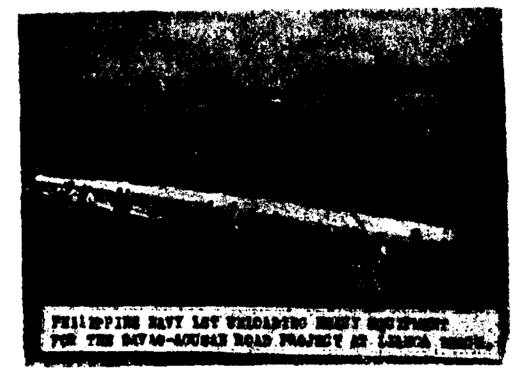


Esperanza-Maygatasan Road, access to Davao-Agusan Road from the Agusan River

Typical Finished Road Section, Davao-Agusan Road



Heavy grading works, Taligaman-Sibagat Section, Davao-Agusan Road



Philippine Navy LST unloading heavy equipment for the Davao-Agusan Road Project, at Lianga Beach

Typical BPE Engineer's camp, Davao-Agusan Road

Grading work, camp Kalaw-Pasian Section, Davao-Agusan Road

Grading work Pasian-Bunawan Section, Davao-Agusan Road

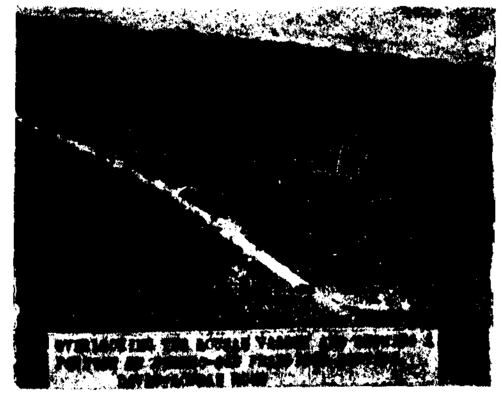
Completed camp Kalaw-Pasian Section, Davao-Agusan Road

Clearing Gibong Bayugan Section, Davao-Agusan Road

ICA heavy equipment being unloaded in Sasa Wharf Davao-City from a ship which came direct from U.S.A. (July, 1952)

Heavy clearing camp Kalaw-Pasian Section, Davao-Agusan Road

Family of Homeseekers enter the jungle following the clearing gang in search of new home during construction of Gibong Bayugan Section, Davao-Agusan Road (Taken in June, 1954)



Overlooking the Agusan Valley and showing a portion of Gibong San Francisco Section, Davao-Agusan Road

Bureau of Public Highways Survey Crew at work in San Francisco - Bunawan Section, Davao-Agusan Road

Typical Finished Road Section, Davao-Agusan Road

Davao-Agusan Road Base Course in Place, Davao

Camp Kalaw Detour Bridge and Engineer's Camp, Davao-Agusan Road

Contractor's and Project Engineer's camp in San Francisco (Taken in January, 1955) This is now a part of the new organized town of San Francisco

The bridge was completed and opened to traffic on January 3, 1955.

The Camp Kalaw-Pasian project, a 13-1/2-kilometre section from the Camp Kalaw Bridge to the Pasian Creek, with five R.C. bridges and minor structures of R.C. box and pipe culverts, was likewise awarded to L.S. Sarmiento & Co., effective December 1, 1953. Construction progress on the whole was satisfactory. This project was completed on November 25, 1955.

Soon after the start of construction on the Davao side of the route, preparations were being made to begin work in Agusan.

Taligaman-Sibagat project was the first advertised on the Agusan side, a 15-kilometre section from Taligaman to the Barrio of Nuevo Sibagat. The contract was awarded to the Poblete Construction Company.

Organizational difficulties, unfavourable weather conditions and the occurrence of embankment failures were the main causes of delay in the completion of the section. The project was completed on August 27, 1956.

Due to the delay in the completion of the Taligaman-Sibagat section, the calling of bids for the Sibagat-Bayugan section was deferred pending construction of the Maygatasan-Esperanza spur road which was to serve as access road to the second project. This access road was constructed by force account by the Highway District Engineer of Agusan.

The Sibagat-Bayugan project, an 18-kilometre section starting from Nuevo Sibagat, included the Wawa and Andanan Bridges, four other bridges and permanent minor structures. Bids were called on December 28, 1954, and contract awarded to the Poblete Construction Co., which submitted the lowest bid, effective May 10, 1955. The contracting firm, with the experience gained in the preceding section, had improved considerably in its operations. Construction was in both directions from the Maygatasan-Esperanza junction. By the time the Taligaman-Sibagat section was partially usable by the company, it also started operations at Sibagat, from which end work was started on the Hupas and Wawa Bridges. For almost two years, operations were confined on the Andanan, Taglatawan, Hupas and Wawa Bridges and the roadway sections in between. Meanwhile progress of the contract was hampered by floods and the poor condition of the access and pilot roads. The completion of the Taligaman-Sibagat section in the middle of 1956 enabled the construction firm to abandon its expensive supply line via the Agusan river. It could operate from the Butuan side. The project was completed and accepted on November 20, 1957. Of particular interest in this section, the 120-metre Wawa Bridge is on a $1° - 30'$ curve and has a superelevated deck.

When this program was initiated, it was decided to commence construction at several points along the route by providing access or feeder roads to the main highway. Two such spurs were constructed from the town of Lianga, Surigao. The Azpitia-Los Arcos section of the Azpitia-Lianga road was constructed and at the same time the Los Arcos-Lianga section was improved. The construction and improvement of this road made possible the start of work on the Bayugan-Gibong section.

To provide access to the Gibong-San Francisco and San Francisco-Bunawan sections, the Lianga-San Francisco spur road was repaired and completed.

In September and October, 1953, construction equipment intended for the construction and improvement of the spur roads were landed at Lianga Beach from the Government barge "ROAD BUILDER", a Navy IST and chartered commercial vessels. Both spur roads were constructed by force account with Lianga as the base of operations. The

Azpitia-Los Arcos spur road was started from Los Arcos on October 11, 1953 and completed on October 30, 1954. The San Francisco-Bahi section of the Lianga-San Francisco spur road was started from Bahi on February 1, 1954 and completed on November 11, 1954.

While the two access roads from the coast were under construction, the three sections of the main highway were advertised in rapid succession. Bids for the Gibong-San Francisco section were received on March 30, 1954, for the Bayugan-Gibong section on May 25, 1954 and for the San Francisco-Equation-Bunawan section on June 24, 1954.

The Bayugan-Gibong project was a 21-kilometer section from the Bayugan creek to the Gibong river. Work included construction of the Gibong Bridge and seven smaller bridges and all reinforced concrete box and pipe culverts.

The Gibong-San Francisco section is 15 kilometers long and started from the bank of the Gibong river to San Francisco. The project included the construction of three bridges and all R.C. box and pipe culverts.

The San Francisco-Equation-Bunawan project, a 43-kilometer section, was the longest under contract in the entire route. It included construction of twelve bridges and R.C. box and pipe culverts.

The contract for the Gibong-San Francisco section was awarded to the Manila Investment and Construction, Inc., effective June 7, 1954. Some of the equipment used in the construction of the access roads were leased to the company. From the start its progress on this contract was unsatisfactory. It was particularly slow in the construction of the bridges and minor structures. After contract work operations were practically in a state of abandonment due to financial and other difficulties of the contracting firm, the contract was rescinded on August 17, 1956. The remaining work was done by administration and completed on September 26, 1957.

The lowest bidder for the Bayugan-Gibong section was the Mindanao Construction Co., Inc., to whom the contract was awarded effective July 11, 1954. This outfit did very well at the start. Progress of work was satisfactory during the first year of the contract particularly in grading and surfacing. The weakness of the outfit showed when work on the structures started. Because of organizational deficiencies only the Awa and Labao bridges and nine box culverts were completed by the company.

Late in 1955 the company transferred most of its equipment and operators to its Cotabato projects, expecting that in the period from December 1955 to March 1956 weather conditions in the Agusan area would be unfavourable. It was intended to shift back these equipment and men as soon as better weather conditions would prevail in Agusan. The proposed shuttling did not materialize as planned, and was deferred even after the weather became favourable. It was not until after it had practically completed all earthmoving in its Cotabato projects, that the company started returning equipment to Agusan. The project was on a virtual standstill the whole of 1956 and the first half of 1957.

Under such conditions, with no prospects of improvement in sight, the project was recommended for rescission about the middle of 1957. This recommendation was approved by the Secretary of Public Works and Communications and the work was suspended pending final taking over by the Government. After a strong appeal by the contracting company, the rescission order was reconsidered on its promise of better performance to complete the project within a new time-limit. Resumption of contract work was authorized on August 7, 1957.

After a brief period of increased activities following the order of resumption of operations, rate of progress on the project soon started to skid downward again. As before, work on the structures remained far behind the grading work. The overall accomplishment rate was far below normal. By this time, the problem of the company was chiefly financial, with wages in arrears for several months.

Due to the contracting firm's failure to comply with the conditions set forth in the reconsideration of the rescission order, the contract was ordered rescinded for the second time on May 10, 1959. At the time of this rescission, nine-tenths of the grading work and one-half of the surfacing work had already been completed.

Work was resumed by administration forces on June 12,1959. Grading, surfacing work and all structures except the Gibong bridge were completed on September 30, 1959. The entire project was completed and accepted on October 11, 1960. The Gibong bridge was finished earlier.

The construction of the Gibong bridge could be considered a special project in itself. The structure as designed consisted of two centre spans of one hundred-foot reinforced concrete box girder with four 1,500-metre deck girder end spans.

Work on this bridge by the contracting company had been very slow. It was not until the middle of 1955 that it started activities on the piers. Excavations were made for Pier 1 at the same time that wooden sheet piles were being driven as cofferdam for Pier 3. Meantime a craneway was constructed to enable driving of test and bearing piles at Pier 2. The craneway was washed out during the first big flood in December 1955.

Since then practically no work was done on this bridge for more than one and a half years to about the time of the reconsideration of the first rescission order. After the resumption of operation following the first rescission, preparations were immediately made to complete Pier 3. Concreting of the footing for Pier 3 was done in November 1957 after completion of the cofferdam. This pier was completed before the December 1957 floods. The second RCDG span on the San Francisco side of the bridge was completed in February 1958. Operations were then shifted to Pier 1A and Abutment "A", with no efforts made to start the centre pier. Work on this bridge was done intermittently through the year 1958 and the first few months of 1959 while the contract was still in effect. During the more-than-one-year period, only Pier 1A and Abutment "A" and the first RCDG span were completed.

Not much activity was undertaken on this bridge immediately upon taking over by force account. Necessary equipment had to be used first on other structures so that after their completion all efforts could be concentrated on this bridge. The 45-day pre-election ban and the floods that followed soon after further delayed the start of operations.

The construction of the craneway and detour bridge was started in January 1960. The driving of the steel piles for the cofferdam of the centre pier was begun in February. The driving of the bearing piles followed. The concrete seal was poured in May and the entire pier completed in early June. While the centre pier was being constructed, the Bailey-panel falseworks and the timber supports for the two R.C. box girder spans were being erected. The Gibong bridge was completed and opened to traffic on September 10, 1960.

The San Francisco-Equation-Bunawan section was the fourth project awarded to the L. S. Sarmiento & Co., Inc. The contract went into effect on September 11, 1954 but work, was actually started on August 23, 1954. Operations were con-

fined at the San Francisco end, the other side being inaccessible.

Due to the floods that occurred in 1954, 1955 and 1956, a ten-kilometre section of the line was under water. A major relocation was made from the Lagcogangan creek to bypass the marshy section and bring the road to higher ground. In order not to delay the project, work on this new location was permitted as soon as the design for the relocation was completed.

The contracting company as early as March 1957 was encountering financial difficulties especially in the payment of wages and procurement of essential spare parts. Operators were reluctant to work due to non-payment of wages. Work was also hampered by the frequent breakdown of equipment, repair of which could not be done in time. By the middle of 1958, work showed very little progress.

Due to the unsatisfactory progress of the contract work during 1958 and 1959, the 10½-kilometre section from Ko-o bridge to Bunawan was deleted from the original contract on January 8, 1960. The administration forces started actual operations on the deleted portion from the Bunawan side on December 7, 1959.

Meanwhile little or no progress was made on the remaining portion of the contract work. Contract operations on road and bridges were practically in a state of abandonment. Finally, rescission of contract was ordered on February 4, 1960.

To speed up construction operations by administration, the remaining box culverts were replaced by ARMCO multiplate pipes and pipe-arches of various sizes both in the deleted portion and the rescinded contract section. Only one R.C. box culvert had to be constructed by administration. Since the start of operations, grading work was greatly hampered by continuous rains and the presence of unsuitable materials. The placing of selected borrow base course immediately following grading work was a special operating procedure strictly followed in the force account work in this wet area.

The rescinded contract was completed on October 31,1960, while the deleted portion was finished on November 15, 1960.

The Pasian-Bunawan section was the last contract on this road to be awarded. This 30½-kilometre project, from Pasian creek to the Bunawan National Agricultural School site, included six bridges and the RC box and pipe culverts. Bids were called on January 25, 1955 with the Manila Investment and Construction Co., Inc. as the lowest bidder to whom the contract was awarded. Contract went into effect on June 18,1955.

This project was accessible only via the Camp Kalaw-Pasian section which was not yet completed when the contract for this project took effect. The contracting form constructed seven kilometres of pilot road to bypass the unfinished portion of the Camp Kalaw-Pasian section.

Right from the start, this project was beset by bad weather. From September to November 1955 and from February to August 1956 there were short periods of good weather. The construction company failed to take full advantage of such good weather due to lack of equipment and other causes, resulting in unsatisfactory progress. The gap between percentage of time elapsed and the percentage of work accomplished kept on widening. The contracting firm finally requested rescission of its contract on November 3, 1956. By then it had stopped construction operations in this project. The contract was then rescinded for reason of abandonment of the work by the contracting company.

A new set of construction equipment and personnel from completed force account projects in Cotabato and Zamboanga had to be brought in to start work by force account. A good number of the personnel formerly employed in the contract work joined the administration work. Construction procedures were improved. A new schedule of work was adopted. The pilot road was repaired and extended upto the Lankila—a bridge site to facilitate movement of equipment and materials for the first two bridges. Construction of the structures was given top priority as heavy grading work depended upon their completion. Work immediately followed on two box culverts at Tagdalican and Tagauma creeks which were completed in September 1957. Pipe-laying was accelerated. Day and night operations were ordered whenever weather conditions permitted.

In order not to delay progress of grading work, the drainage structures had to be placed far in advance. ARMCO multiplate and pipe arches of various sizes, furnished free by ICA, were installed in lieu of reinforced concrete box culverts.

Construction of two major bridges, the Bunawan bridge and the Simulao bridge, presented special problems for the adminstration forces. Work had to be carefully programmed taking into consideration the characteristics of the weather in the area. Detour bridges had to be constructed across these major waterways.

A redesign of both structures was made to take care of the observed flood flow. The Simulao bridge was raised and extended by a 15-metre RCDG span at each end. The centre span of the Bunawan bridge was increased from 23 to 27 metres.

In June 1959, the roadway and structures from the beginning of the project to the south approach of the Simulao bridge were completed, and a 26-kilometre road section was opened to traffic. On July 31, 1959, all grading and surfacing operations on the rest of the project were completed, except the approaches of the two bridges still under construction. Thenceforth all operations were concentrated on these two structures until works were temporarily stopped during the 45-day ban preceding the 1959 elections.

Work on both bridges was immediately resumed after the election to take advantage of the good weather then prevailing. Fortunately, the floods came rather late that season. Even then, sufficient safeguards were instituted to prevent damages to the structures by floods.

The Bunawan bridge was completed in May 1960 and opened to vehicular traffic since then.

At the time the Simulao detour bridge was damaged by flood in January 1960, all the piers had already been completed. The end box girder spans and the RCDG approach spans were completed in April 1960. Only the centre spans remain unfinished. The detour bridge was then dismantled and the Bailey panels were used as falsework for the centre box girder span. The centre box girder span was finished in July 1960. The whole Pasian-Bunawan section was completed, accepted and turned over to the Highway District Engineers concerned for maintenance on September 13, 1960.

Conclusion and Recommendation

The opening of the Davao-Agusan road, with 183-kilometre new construction costing £ 25,000,000.00, puts in service one of the major routes in the net work of trunk roads needed for the development of Mindanao. Immigrants started to settle along the road even before its completion. Communities sprang up where formerly there were only impenetrable jungles. The older settlements grew and improved.

This road enhanced agriculture, commerce and industry in the areas traversed. It benefited also the southern Surigao towns of Lianga and Hinatuan which became accessible through the Aspitia-Lianga and the San Francisco-Barobo spur roads.

The road as constructed is wholly on the east side of the Agusan valley from the Camp Kalaw bridge to Butuan City. About two-thirds of this great valley west of the Agusan river still remain inaccessible. In order that this vast region could also be made available for settlement and exploitation, it is necessary that a second trunk road of 200 kilometres in length, of which 180 kilometres will be new construction, be likewise constructed in the near future on the west side of the valley, together with one or two cross-roads to connect with Bukidnon province.

Taking a cue from the road just completed, this second trunk road may be located at the foothills of the mountain ranges separating the Agusan and Davao provinces from Bukidnon province. The route starts from Buenavista in Agusan, follows the Buenavista-Ma-asin road up the valley, crosses the low hills at the Agusan-Davao boundary to Sto. Tomas, joins the Davao Penal Colony road and continues to meet the present Davao-Agusan road at Panabo. This proposed road, including all permanent drainage structures, will cost £ 26,000,000.00.

QUALITIES NEEDED FOR RESEARCH

In research we want men who are insistent on self-discipline, men who are meticulously curious and observant of small distinctions—with a natural call to study and an inborn spirit of enquiry, never those not suited to its continual disappointments.

—DR. PEREY DUNSHEATH.

GOOD MANAGEMENT

"The things that really count in good management are the ones you can't put on an organization chart.........the feelings and attitudes which men have within themselves about their jobs and their organization".

SOME RECENT GERMAN VIADUCTS AND BRIDGES

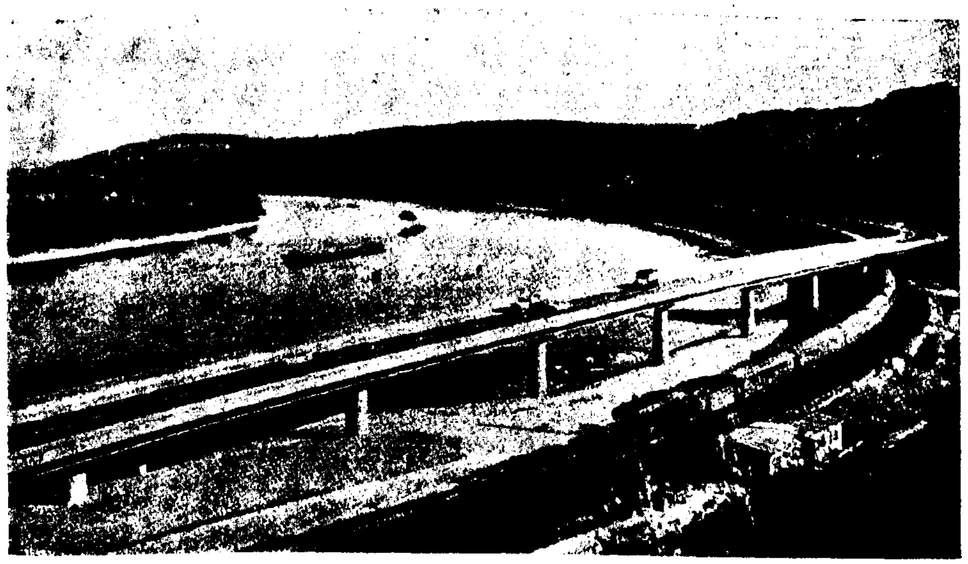
VIADUCTS IN THE RHINE NEIGHBOURHOOD

THE Rhine valley in autumn is at its loveliest; the woods and the gently rounded, castle-crowned hills are exquisite in subtle browns golds, and the blue of river and sky has an opalescent quality. The great attraction of this area for tourists at any time is easily understood—and particularly so at this time of the wine-harvest!

The Rhine itself is, of course, a major tourist highway. Nevertheless, the nearby roads must take a great deal of the traffic its beauty creates. Federal Highway B9, which runs from Worms through Mainz, Koblenz, and Cologne to Dusseldorf, on the left bank of the river, is the main tourist road, and is very overburdened for much of the year. Considerable improvements to this route are necessary to cope successfully with the traffic; some have already been made, among them some notable concrete elevated roads.

The first of these, the Unkelstein viaduct, had a more than local significance. The Federal Minister of Transport, in authorising its building, considered that, in addition to alleviating a specific 'black spot', it would also serve as a preliminary exercise for the elevated roads which would inevitably be required in city centres in the near future.

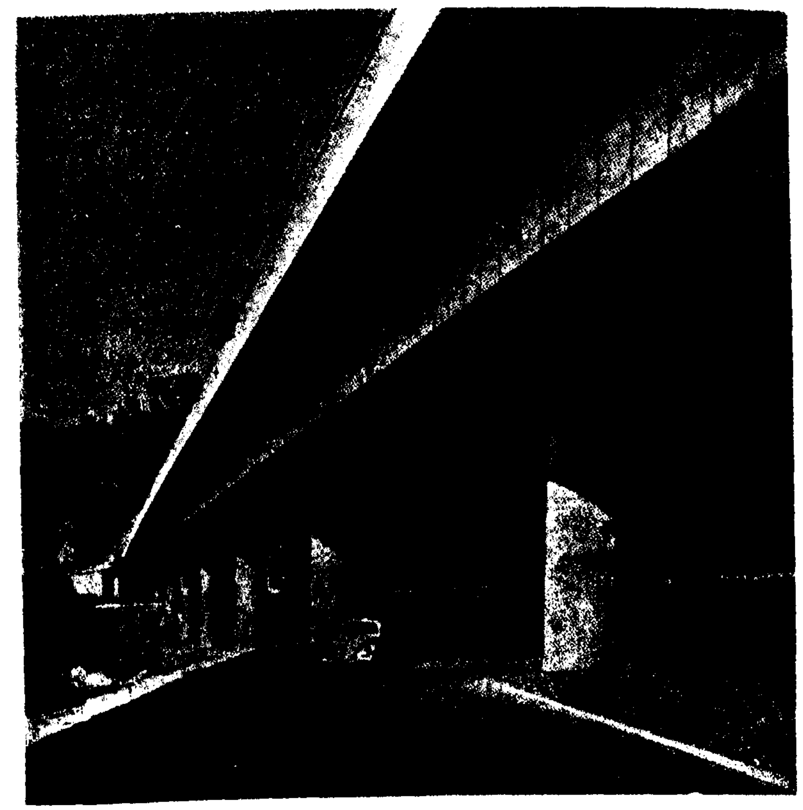
The road conditions at Unkelstein were in particular need of improvement. Running north from Remagen, B9 passed here under a narrow railway bridge in a sharp 'S' bend, with very poor visibility. The road itself was only 24 ft wide, and the bridge clearance only 12 ft. In addition, at every high water the road was flooded to a depth



The fine sweep of the Rhine at Unkelstein echoed by that of the new viaduct.

of three yards, forcing motorists into a detour of 15 miles over the mountains. The highway authority, the 'Land' of Rhineland-Pfalz, considered two solutions: either a short overpass approximately 100 yards long, with a connecting embankment 270 yards long, or an elevated road 370 yards long. The latter solution was chosen as preferable on all grounds—economic, technical and aesthetic. The landscaping committee had the opportunity to say beforehand which solution they preferred and condemned the overpass, even allowing for the ameliorating effects of planting.

The elevated road runs beside the Rhine for its full length after crossing the double railway track at a very acute angle. The superstructure, which has an overall width of 49 ft 6 in., is cantilevered from a prestressed concrete box beam, carried on a single row of columns; this method of support was chosen as both the most practicable and the most attractive. Certainly, the general effect of the viaduct against the wood behind it is elegant as well as strong and, in detail, the quality of the finish of the untreated concrete, especially on the columns, is excellent.



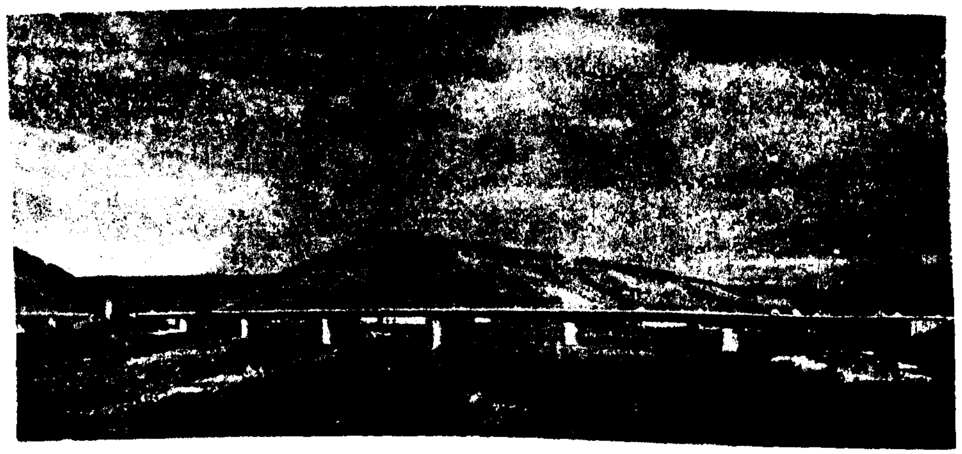
The Mushroom—headed supports carrying the Unkelstein viaduct.

There are eight mushroom-headed columns in all, founded on groups of piles, each pile having a bearing capacity of 100 tons. The spans between the columns vary between 107 ft and 134 ft, and the columns themselves vary in height between 15 ft and 38 ft 6 in., measured from the base to the underside of the superstructure. The hollow shafts of the columns have a diameter of 8 ft 3 in. immediately below the head; the heads themselves are 16 ft 6 in. in diameter. Seven of them have four multi-roller bearings, permitting longitudinal movement of the structure; the eighth, near the centre, is a fixed support.

The box beam is prestressed on the Dywidag system and is continuous over its whole length. It is 6 ft 6 in. deep and 31 ft 6 in. wide, with the cantilever extending 9 ft either side.

In April 1959 another elevated roadway was opened to traffic further south on B9, at Bingen, where the river Nahe and the Rhine meet. The B9 traffic used to cross the Nahe by the old Roman Drusus bridge. This bridge, main road, a double-track railway line, and the River Nahe at a sharp angle of skew. Similar in general appearance to that at Unkelstein, it fits admirably into the lie of the land. It balances well with the strongly defined Rochusberg and the round medieval Sturme tower, and in no way destroys the effect of the groups of rose and gold steep-roofed, timbered houses. In fact, it is an added pleasure to the eye, since the finish of the concrete, straight from the forms, is outstanding, and the combination of its cool grey with the eau-de-nil coloured hand-rails is very agreeable.

This viaduct also has structural features in common with that at Unkel-



The viaduct at Bingen crossing the River Nahe, with the Rochusberg in the background, and the Stu:me tower on the left.

partially destroyed during the war, was restored with the help of reinforced concrete, and remains as a monument, but is totally inadequate to carry current traffic. It was therefore decided, in 1952, to build a by-pass road for B9 around Bingen and the Rochusberg, the hill rising behind it. This by-pass, five miles long and free from frontage access, joins the existing B9 route at Gaulsheim.

The 402 yard long elevated roadway which forms part of the by-pass lies near Munster-Sarmsheim, crossing a stein, again consisting essentially of a prestressed concrete box beam combined with cantilevered side slabs, carried on a single row of six centrally placed cylindrical columns of 16 ft 6 in. diameter, spaced at irregular span lengths which vary between 67 and 40 yards. The columns themselves are not round, but of 30-angle polygonal section, a feature which greatly enhances their appearance and counteracts any effect of too great solidity.

Some of these columns and the north abutment were founded on natural rock,

and the south abutment and the remaining columns on bored piles of 90 tons bearing capacity per pile. The box-section superstructure is 21 ft wide at the soffit and 8 ft 6 in. deep throughout. It is continuous, with thick internal diaphragms at the columns and thinner diaphragms at the one-third points of each span and is prestressed longitudinally and transversely on the Dywidag system. It is supported on movable bearings, except for a fixed bearing on the third column.

The cantilevered slabs project 19 ft on either side, so that the overall width of the superstructure is 59 ft. It comprises a four-lane carriageway 47 ft wide, two 5 ft wide footways and a 1 ft wide strip on each side to take the hand-rails.

The third elevated roadway on B9 is still under construction. It lies at Kettig and forms part of the Weissenthurm-Andernach by-pass, north of Koblenz. This viaduct, 547 yards long, differs very considerably from the other two, most notably in the supports. They consist here of pairs of tall slender octagonal columns varying in height from 52 ft to 82 ft, and at 130 ft centres. These

The fine quality of the concrete finish clearly shown on the polygonal columns and superstructure at Bingen.

columns are hollow with reinforced concrete walls approximately 1 ft thick, and in general effect they are very striking. The 59 ft wide roadway is cast integrally with the two supporting box beams, and cantilevers out from either side of these beams, which are prestressed on the B.B.R.V. system.

For this viaduct the contractors have developed a special method of constructing the superstructure, particularly applicable with tall columns. The formwork is carried on four trussed girders which advance, after the completion of a span, by means of a steel girder device which moves over rollers at the column head. Using this system the rate of construction has been 256 ft of deck a month.

The Wuppertal Motorway and its Bridges

The completion of the Leverkusen-Wuppertal-Kamen motorway is among the top priority jobs on the German motorway construction programme. Fifteen miles, running northwards from the Leverkusen interchange on the Cologne-Dusseldorf motorway, were in service before the war and, after repairs to the bridges, were put into commission again in 1953. The remaining ten miles in the Rhineland province will be completed this year, and part of this stretch is already open, greatly improving the traffic flow from the Cologne-Hanover motorway to Wuppertal-East.

This new section is one of the most beautiful as well as one of the most modern of the German motorways. The

Kettig viaduct under construction, showing the girder support for the formwork, with the device for moving it over the foremost columns.

The Rhineland-Pfalz is the highway authority responsible for all these viaducts, under its President, Dr. E. F. Wahl. The architect for all three was Dip.-Ing. Gerd Lohmer. The engineering design and construction of the Unkelstein viaduct was carried out by Dykerhoff and Widmann K. G., that of the Bingen viaduct Wayss and Freytag A. G. and that of Kettig, by Strabag-bau A. G.

hilly landscape is naturally delightful and good design and good man-made landscaping have resulted in a road of noble sweeps and unfussy detailing which lives most harmoniously with its setting.

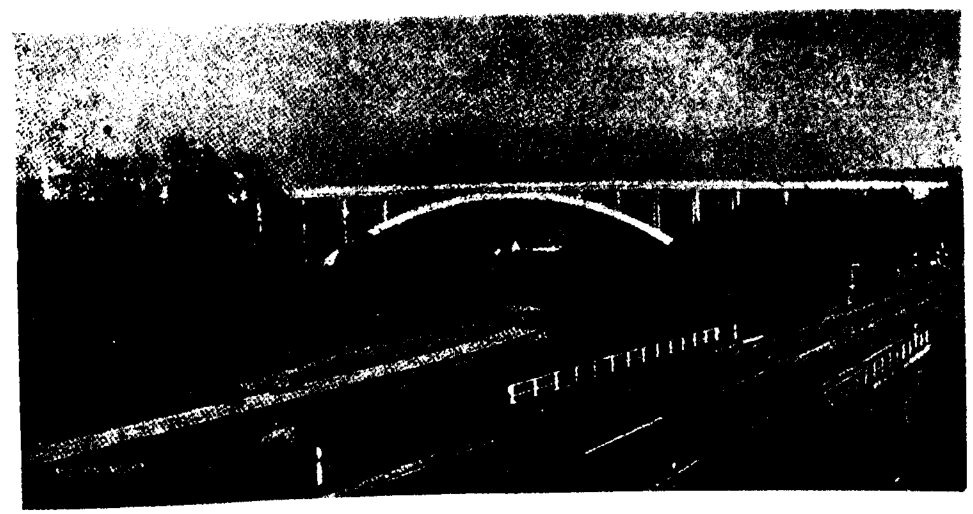
This kind of country has, of course, vastly added to the construction problems, and sixteen bridges have been necessary, together with a large number of deep cuttings, high embankments and

long retaining walls. At Kupferhammer, for example, large rock excavations had to be made and the Federal highway moved over to the hill-side before a start could be made with the retaining wall between it and the motorway. Again, the narrowness of the Blombach valley necessitated separating the carriageways over a two-mile stretch, and running them along the valley sides 500 ft apart —economical technically, and visually very pleasing.

The concrete road itself gives a ride as smooth as butter, an up-to-the minute proof of the excellence of concrete surfaces to-day. The pre-war design for the road was revised to eliminate all gradients steeper than 4 per cent, and greater attention was paid to the frost resistant road base, which in this case varies bet-

Of the sixteen bridges on the Rhineland section of the motorway, the four most important are the Blombachtal, Schwelme, Langerfeld and Wuppertal bridges. The Blombachtal, a reinforced concrete arch bridge of unusual and daring dimensions carrying a provincial road over the separated carriageways of the motorway and the railway, is far and away the most striking of them; 358 yards long, it marches splendidly across the valley, dominating the view as the road rises to it, the great arch and the slender columns which support the deck carrying the eye upwards.

The full span of the arch is 490 ft with a rise of 82 ft and a maximum height of 165 ft above the valley floor at the crown. In cross-section the arch is a hollow box 38 ft wide, increasing



The Blombachtal bridge bestrides the railway and the separated carriageways of the Wuppertal motorway.

ween 22 in. and 30 in. in thickness; its top 7 in. are cement- or tar-stabilized. The concrete slab is 8 in. thick, placed in two layers of 6 in. and 2 in. The road is dual-carriageway, each carriageway having two 24 ft wide lanes, and there are 2 ft wide marginal strips on each side. These marginal strips are painted white as a safety precaution, and there is a 5 ft 6 in. wide central reservation, increased in some stretches to 7 ft, and densely planted as an anti-dazzle hedge.

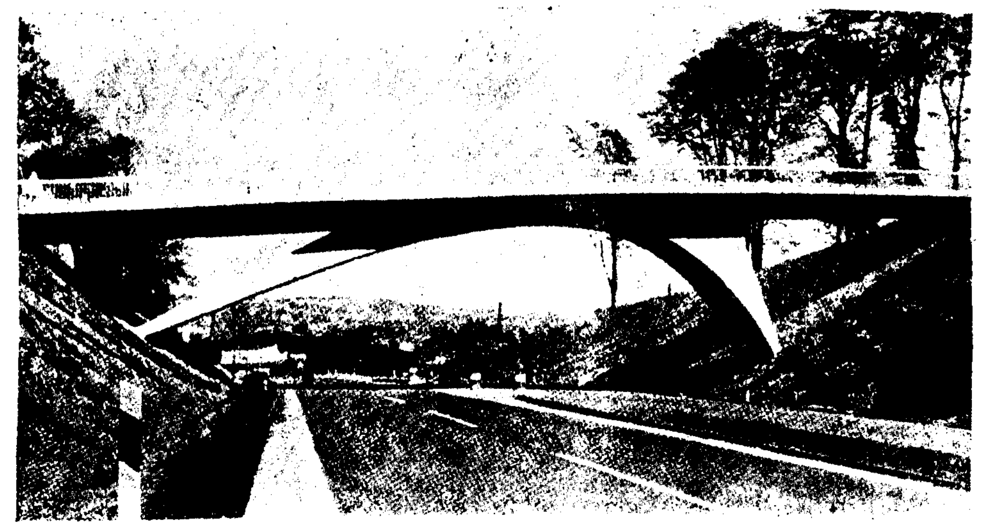
the depth from 7 ft 6 in. at the crown to 11 ft at the springings, while the wall thickness correspondingly increases from 1 ft 4 in. to 2 ft. It is stiffened by both longitudinal and transverse diaphragms.

The deck structure, 50 ft wide overall, consists of a five-webbed box-section with a 10 ft 6 in. wide cantilevered deck slab on each side. Its supporting columns vary in section from the slenderest, 2 ft 6 in. by 2 ft, to the 5 ft by 4 ft portal columns at the springing. The finish of the concrete is remarkable throughout, but particularly so on these slim columns.

The design of the more northerly Schwelme bridge, which carries the motorway over two roads, the railway and the river Schwelme, is dictated by the need to allow clear visibility for the railway. It is a continuous three span concrete structure, 226 yards long, with two rows of four slender columns. As it incorporates the acceleration and deceleration lanes of the motorway access point, it is 100 ft wide in all. The prestressed superstructure consists of two separate halves, each made-up of two box sections connected by the deck slab and by diaphragms. In view of foundation difficulties caused by the cavities in the limestone formation, both this bridge and the Langerfeld bridge are founded on 13 ft diameter reinforced concrete caissons.

The prestressed concrete Langerfeld bridge, which carries the motorway over two subsidiary roads, was designed to fit in with the industrial outskirts of Wup-

The Blombach valley framed by the bridge's slender supporting columns.



The 'Picasso' bridge outside Wuppertal; on the right can be seen the brushwood temporary retainer for the embankment, its diamond pattern a pleasing feature of the motorways in this area.

pertal. It is continuous over its eight spans, with an overall length of 345 yards and it lies in a curve of the motorway with a radius of 656 yards. The superstructure consists of two separate box sections with 12 ft cantilevered slabs on both sides.

One of the most attractive stretches of the motorway is the point at which it sweeps over the Wupper valley on a 460 yard long viaduct more than 100 ft above the river. This viaduct, the Wuppertal bridge, is continuous over seven spans, with stone-faced concrete supporting piers which vary in height from 46 ft to 92 ft. The superstructure is interesting in that it consists of a prestressed concrete deck slab acting compositely with a trapezoidal steel box beam and cantilevered out 13 ft each side of it.

The most unusual bridge on the motorway, and, after the Blombachtal, the most attractive, is the asymmetrical bridge not far outside Wuppertal which carries the Ehrenberger Strasse over the motorway. Not among the most important and without an official name, it is known as the 'Picasso' bridge because of its strange shape. A portal-frame design, with the columns placed at different angles of inclination deliberately to emphasize its asymmetry, was chosen on grounds of appearance. An arch or box-section bridge would have looked wrong, in the highway authority's opinion, in view of the steep longitudinal gradient (1 in 10) of the Ehrenberger Strasse.

The portal frame has been designed as a solid slab with two end bearings permitting longitudinal movement, and two pin-jointed feet. The end bearings are 178 ft apart and there is a distance of 110 ft between the feet. The actual carriageway is 20 ft wide, with two 5 ft wide cycle tracks and two 4 ft wide footpaths.

Herr Landesrat Meyer, head of the Rhineland highway authority, has been in charge of all work on the motorway and its bridges in his province. The Blombachtal bridge was designed by Professor Dr. Ing. Pirlet and the 'Picasso' bridge by Dr. Ing. Heinz Grandenz.

(From "Concrete Quarterly," (45), April-June 1960)

THE NEW AUTOROUTE TO THE SOUTH OF FRANCE

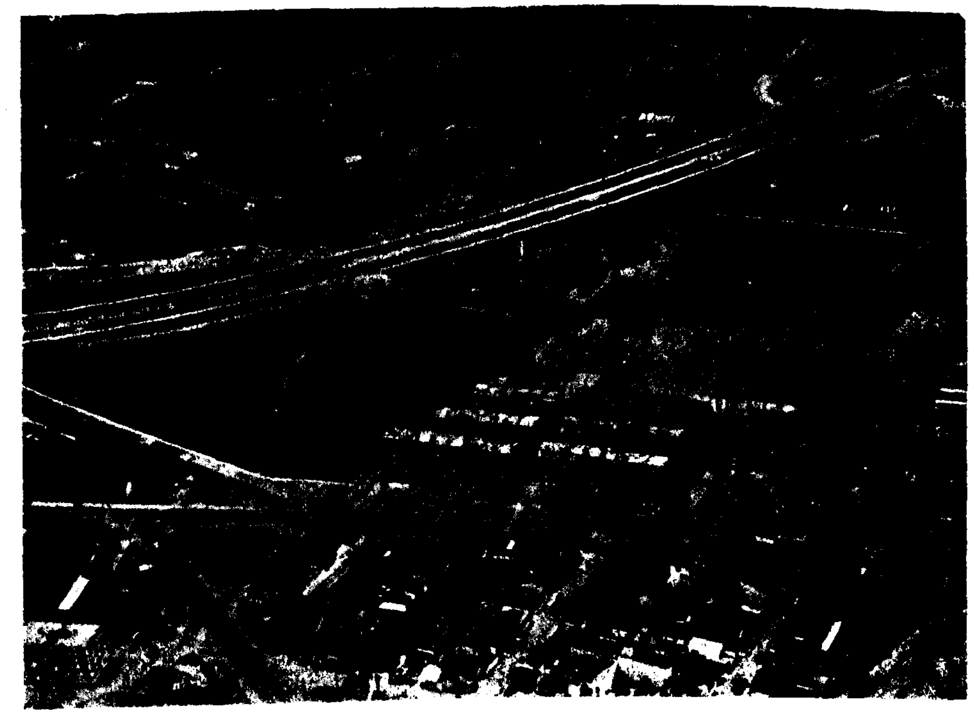
THE first major stretch of the Autoroute to the South from Paris had already been included in the general improvement plans for the Paris Area before the war but not until the adoption of legislative amendments in December 1952 was its final trace approved in order to relieve as soon as possible the growing congestion on the two main arteries, the National Highways Nos. 7 and 20, leaving Paris in the direction of the South of France.

History and Function

Traffic statistics on the two national highways began to show the increasing density of utilitarian and pleasure vehicles almost immediately after the war and soon became the mathematical expression of interminable files of cars crawling along on weekends and holidays within the outer confines of the city. Hence the plan for channelling long-distance traffic (including that to the Orly Airport) by an autoroute midway between the two highways and reserving the latter for the heavy local traffic. On that basis, estimates anticipated an average daily density of about 40,000 vehicles immediately upon completion which it was believed would increase to 50,000 vehicles within a very short time.

The Autoroute to the South would then constitute the major channel for the fast flow of traffic across the southern suburbs of Paris, give direct and rapid access to the Orly Airport and the

Model of the Gentilly Clover-Leaf Terminal at Paris of the Southern Autoroute



Viaduct of the Southern Autoroute over the Bievre Valley at Arcueil

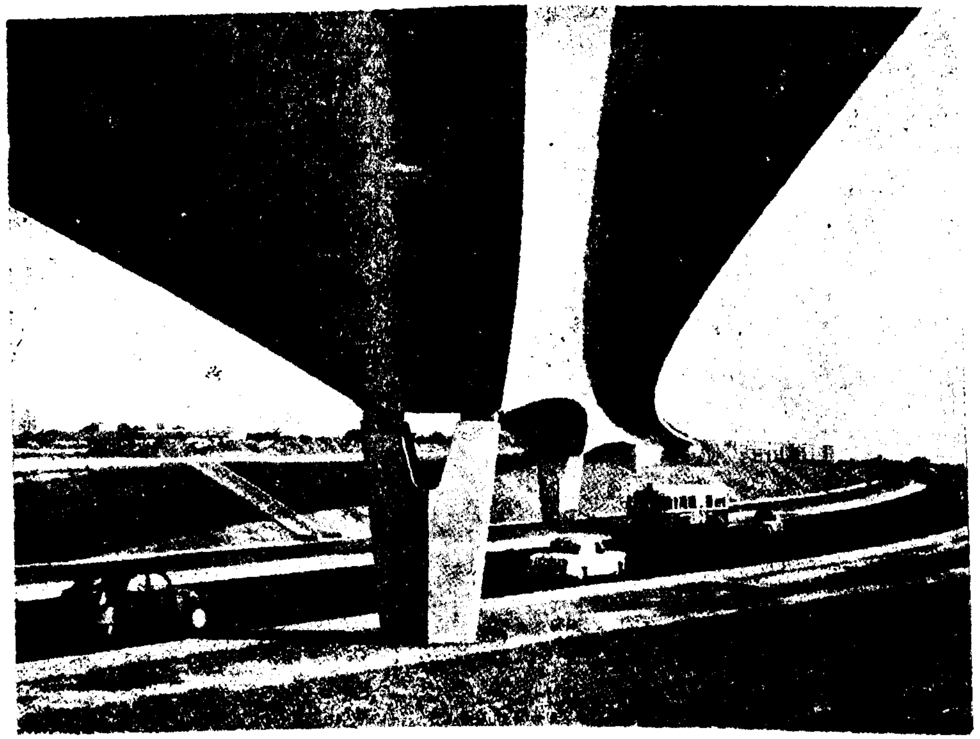
national highways to Fontainebleau and Orleans and relieve the latter for short-haul transportation in the encumbered suburban areas. The residential communities beyond the limits of the greater Paris Area would benefit quite as much as from the new autoroute as from improved conditions on the main highways and the first completed stretch would be the beginning of the future throughway from Paris via Lyons to Marseilles.

Trace and Characteristics

The Autoroute South starts at the Boulevard that girdles the city of Paris. After crossing the valley of the Bievre at Arcueil, a first branch takes off in the direction of the Orly Airport at Chevilly-Larue and at that point the autoroute deflects in a wide sweep to the west in order to by-pass the airfield area at Orly.

Shortly thereafter, the main stem divides into two branches, one very short which connects up with National highway No. 20 to Orleans, and one very much longer which joins up with National Highway No. 7 to Fontainebleau, just south of Plessis-Chenet, by a short section constructed in the manner of a standard inter-departmental highway in view of its essentially provisional character. Eventually, the autoroute will be continued from here in a general southern direction immediately after crossing the Departmental highway No. 448 from Malesherbes to Corbeil.

Designed for a basic speed of 60 miles (100 km) per hour, the present total length of the Autoroute South amounts to 26 miles which include the main stem (6 miles = 9.5 km), the Orly branch (2.8 miles = 4.5 km), the Orleans branch (1.5 miles = 2.1 km) and the Fontainebleau branch (15.7 miles = 25.2 km) but does not include the Plessis-Chenet connection (1 mile = 1.5 km).



Bridge No. 10 at the Orly Airport where east roadway of Southern Autoroute crosses Fontainebleau Highway.

Except for junctions and forks, minimum radius of curves is 2,000 ft (600 m) on the main stem with the exception of the first curve after the start; 2,300 ft (700 m) on the Fontainebleau branch as far as Departmental road No. 29 and 5,000 ft (1,500 m) thereafter; and 3,300 ft (1000 m) on the Orly and Orleans branches. Entrance and exit junctions are at angles of between 3 deg. and 4.5 deg.

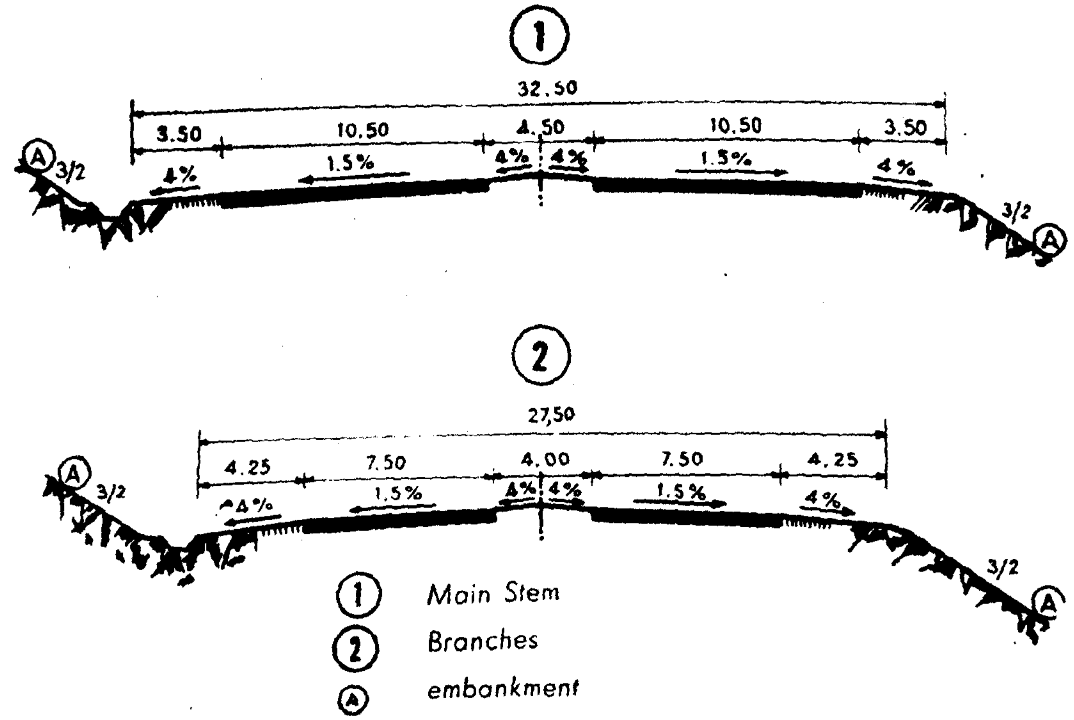
Again except for junctions, grades in general do not exceed 4 per cent with the exception of very short stretches (1,000 ft) with 5 per cent where additional lanes for slow vehicles have been provided for two-lane sections. Minimum radius of rise and fall along the trace was set at 16,000 ft (5,000 m) and frequently is 24,500 and 33,000 ft (7,500 and 10,000 m) for rises. Divided by a centre strip, the main stem has three-lanes and the branches two-lanes in both directions.

Entrances and Exits

Not including the terminal junctions, eight entrances and exits between Paris and Plessis-Chenet connect the autoroute to the general road network of the area. The first three are exits only for traffic travelling towards Paris (or Orly) and the last two are entrances only for cars coming from the country. The three remaining junctions provide both entrance and exit for local and long-distance traffic in the intermediate area.

The Orly branch terminates in front of the passenger terminal. An overpass joins the Orleans branch to the national highway in order to eliminate cross-traffic and the Fontainebleau branch is an ordinary level-grade junction because it will lose its present importance as soon as the autoroute is extended.

CROSS SECTION OF STANDARD ROADWAY



Cuts and Fills

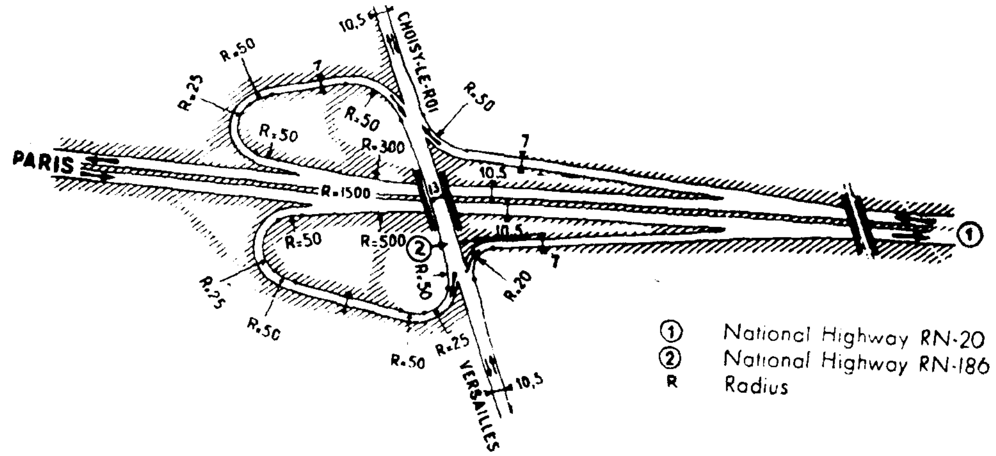
Construction of the trace required earthwork amounting to a total of 5,232,000 cubic yards (4,000,000 m^3) and the major part of this was necessitated where the autoroute crosses the relatively deep valleys of the region. Fills had to be placed to a height of 56 ft (17 m) in the valley of the Essone River and of 46 ft (14 m) in that of the Bievre and Orge Rivers and the adjoining cuts are never less than 33 ft (10 m) deep. Work on the junctions also required movement of large masses of earth. The centre roadway of the autoroute terminal in Paris has a height of 46 ft (14 m) and its construction, combined with that of the subsequent cut which leads into the Bievre Valley, alone necessitated excavation and movement of 655,000 cubic yards (500,000 m^3) of soil materials.

Some of the cuts traverse the instable sandy soils and others the limestone rock and dense clay of the geologic layers of the area. Placement of fill required careful preparatory work at some points. In the Essone Valley, the swampy bed and borders of the Ormoy Lake needed to be dredged to a depth of 16½ ft (5 m) and a foundation bed of fine sand to a height of 3¼ ft above mean water level before the necessary fill could be placed. Minor difficulties arose from the necessity of plugging abandoned underground limestone quarries near the start of the autoroute and of filling up open-face clay pits in the Chevilly-Larue region.

Overpasses and Underpasses

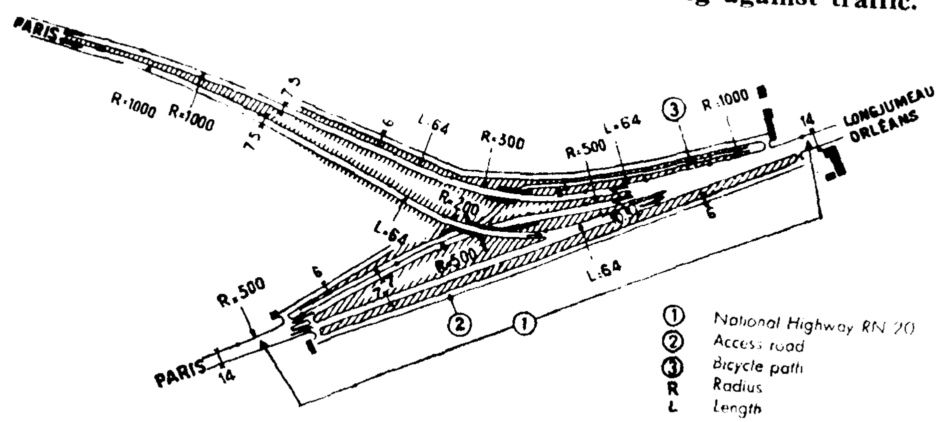
The entrance to the autoroute at Paris consists of the Gentilly Terminal, a complex three-level structure of separated roadways which joins the autoroute south to the Ring-Boulevard at Paris and will eventually make it possible to extend the autoroute terminal directly into the heart of the city. It required the installation of 56,250 cubic yards (43,000 m^3) of concrete and 1,700 metric tons of reinforcing steel,

JUNCTION OF RN-186 MAIN STEM AT FRESNES-TYPICAL JUNCTION TO ROADS CROSSED BY THE AUTOROUTE



TERMINAL JUNCTION TO RN-20 AT MASSY TYPICAL TERMINAL JUNCTION

Cars enter and leave both roads without crossing against traffic.

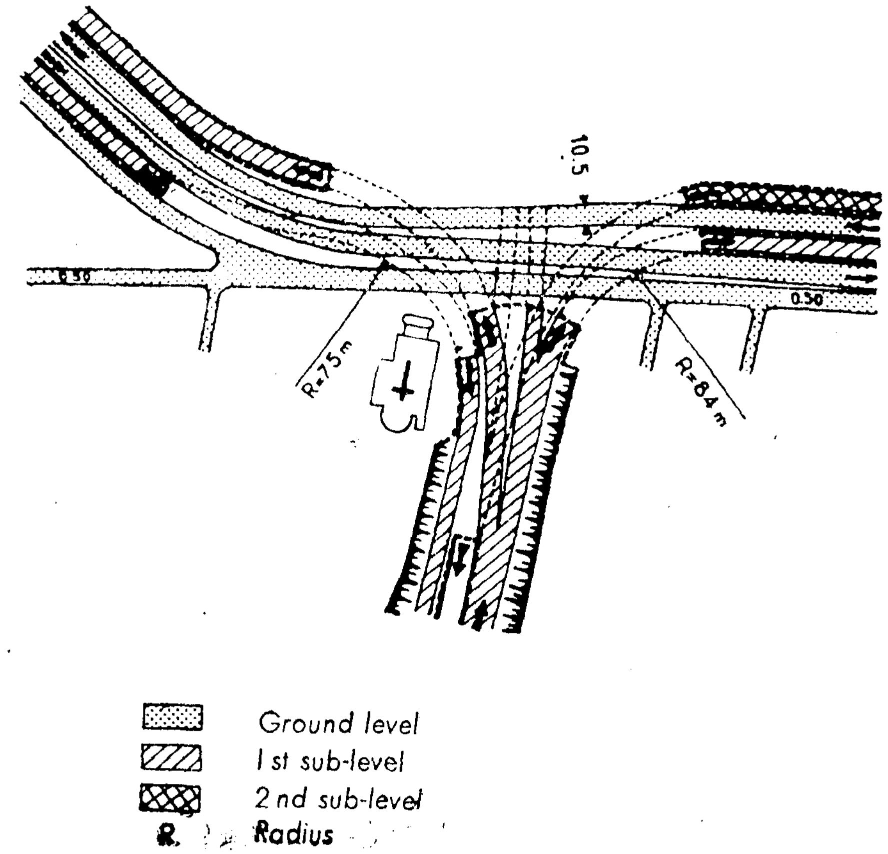


quantities comparable to those absorbed by the construction of a large-sized hydro-electric project or such a vast building as the new National Industrial and Technical Exposition Center in Paris.

The Gentilly Terminal is only one of the seventy Civil Engineering structures encountered along this first stretch of the autoroute. Their construction absorbed an aditional 87,600 cubic yards (67,000 m³) of concrete and 6,900 metric tons of reinforcing and structural steel for 29 overpasses and 22 underpasses across city and suburban streets and roads; 7 railroad bridges or underpasses; 3 bridges over the Orge, Yvette and Essonne Rivers; 4 clover-leaf overpasses at branch and terminal junctions; and 5 other structures of various kinds.

The overpasses for roadways crossing the autoroute generally consist of simple reinforced-concrete girder bridges with four continuous spans supported by three pillars and two buried abutments. Where the autoroute crosses over streets and highways, the overpass generally is designed as a twin-bridge, divided by a screen-covered interval. The latter provides for the admission of daylight to the roadway crossed and at the same time assures the security of users of the autoroute. Most often, they consist of a reinforced-concrete slab in three spans

Diagram of Gentilly Clover-leaf Terminal at Paris, Representation of Levels



resting on two piles and two buried abutments. The retaining walls of the approach ramps permit widening of the roadway crossed without increasing the length of the structure.

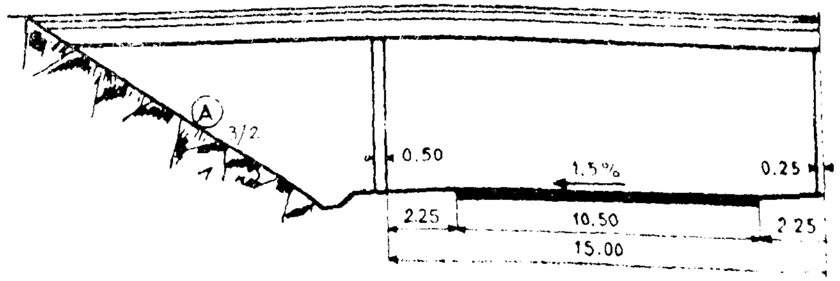
A certain number of these structures deserve special mention either by reason of their exceptional dimensions and their curved trace or because they superpose three levels of traffic at the same point.

The Bievre Viaduct at Arcueil forms a curve with a radius of 2,625 ft (800 m) for a length of 728 ft (222 m) and rises 46 ft (14 m) above the valley grade. It was constructed of prestressed-concrete girders with a length of 121 ft (37 m), each of which were precast and placed by being launched across the open spans.

Where the Orly branch crosses over the relocated section of the National Highway Paris-Fontainebleau, the prestressed-concrete crossover also forms a curve identical to that of the Arcueil Viaduct. Particularly remarkable by the bold lines of the design, the slender supports and the impeccable finish, it consists of a centre span of 175 ft (53.40 m) and two lateral spans of 128 ft (39 m) each.

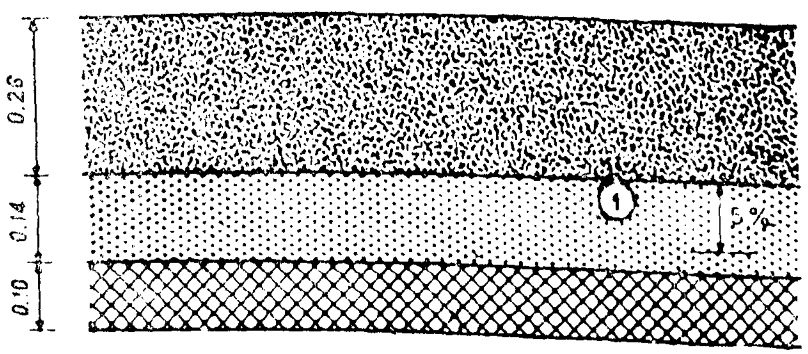
Special design features include the elimination of the centre support in the dividing strip of the autoroute which improves general appearance as is the case for the highway overpass at Corbeil; the set-back wall of the concrete arch with a span of 42-1/2 ft (13 m) over the Orge River; the influence of the bridge clearance on the character of the bridge deck as in the structural steel bridge of the Departmental highway which crosses the Yvette River on its junction with the autoroute; particular devices necessitated by the importance of skew as in the overpass of the Departmental High-

Over Passes—Main Stem



Ⓐ Talus

Cross section of Concrete Roadway



Pavement slab
Sand bed
Stabilized soil course
① Drainage layer

way No. 118 in which the beams have no bracing.

Total construction time for the seventy structures of the autoroute represents approximately 2.5 million man-hours of work.

Roadway Foundations and Pavements

Except as otherwise indicated hereafter, all the roadways have concrete pavements of three different types in accordance with the nature of the terrain and classified as A, B and C respectively for sandy, calcareous or argilaceous soils. That classification also corresponds to the geological layers. Pavement work was divided into a number of lots awarded on open bidding and the first lot of 2,700,000 sq. ft. (250,000 m^2) got started in 1958. The sand bed was stabilised in place at a rate of 5 per cent of cement to a depth of 4 in. (10 cm). Transverse drains and drain wells for the longitudinal drains below the road shoulders in cuts provide for drainage. A sand course of varying thickness (12 in. = 30 cm thick at the shoulders in poor ground) separates the concrete slab from the subgrade, except in the sandy soils of Fontainebleau where there is also no drainage layer.

The concrete slabs were poured to a width of 12 ft (3.75 m), for the 24-ft (7.50 m) roadways and to a width of 11-1/2 ft (3.50 m) for the 34-ft (10.50 m) roadways. Expansion joints are installed every 200 ft (60 m) and contraction joints have been provided every 16-1/2 ft (5 m). A longitudinal joint separates adjacent slabs.

Due to difficulties in the placement of the stabilised sand bed, this was replaced in the subsequent lots by a layer of 0/60 gravel from 5-1/2 to 7-1/2 in. (14 to 20 cm) deep in the different sections.

Flexible pavement was substituted for concrete in a few locations which include a stretch of 1¾ miles (2.4 km) at the start and consists of 3 layers of bituminous concrete (4¾ in. = 12 cm), 1 layer of 0/30 gravel (5¼ in. = 13 cm), 1 layer of 0/60 gravel (8 in. = 20 cm) with the upper half stabilised at 5 per cent of cement, and 1 foundation sand course (7¾ in. = 19 cm). Curbstones, 12 in. (30 cm) wide and painted white, border the 34-ft roadways. The same pavement of only slightly different types was provided for the fill across the Orge Valley, for the connecting stretch at Plessis-Chenet, for the approach ramps—to mark the transition—and for the paving of overpasses. Shoulders and the dividing strip are level with the grade of the roadway, except in curves where the inner edge is protected by curbstones. Shoulders have been compacted sufficiently to a width of 6-1/2 ft (2 m) to allow vehicles to pull off the autoroute in emergencies. The total pavement covers 8,100,000 sq. ft. (750,000 m^3).

Safety and Security

In view of the high speed of the traffic, the standard highway panels were modified to adapt them to changed requirements. Throughout, a series of three indicator panels has been employed at distances respectively of 6,500, 3,250 and 1,625 ft (2000, 1000 and 500 m) ahead of junctions. At the approach to forks in the autoroute, the indicator panels are mounted on gantries across the roadway.

On the main stem and on the Orly Branch, lighting is provided by 400-W fluorescent fixtures, mounted on double light poles in the dividing strip and spaced at intervals of 130 ft (40 m). The more important indicator panels in these sections are also illuminated at night.

Emergency telephones have been installed in pairs on either side of the roadway to prevent the users from having to cross the roadway and can be used for calling the police in case of breakdown or accident. The phone stations are spaced at intervals of 2,600 ft (800 m) on the main stem and about every 1-1/4 miles (2 km) on the branches where consideration was given to the fact that a telephone should be near every junction.

Landscaping and Planting

Various improvements have been effected to blend the trace of the autoroute harmoniously into the landscape and to offer an attractive and aggreable itinerary. The slopes of embankment have been carefully modelled to follow the contours of the terrain and have been covered with screened topsoil up to the road shoulders.

Decorative bush and tree groups have been planted on embankments, partly to form an attractive foreground of the surrounding landscape and partly to mask elements not in keeping with the character of the autoroute or to separate it from inhabited areas.

On the Autoroute to the South, the plantings constitute a necessary complement to well defined purposes. The brush-trees of the centre strip screen out the blinding headlights of cars going in the other direction. The trees and plantings of the slopes stabilise the soil and prevent erosion, mark out and at the same time blend the trace of the

(Continued on page 175)

EUROPEAN DEVELOPMENTS ON PRESTRESSED CONCRETE PAVEMENT

By

ARMAND MAYER*

IN a period when prestressed concrete is undergoing considerable development in the United States and tests on prestressed pavements are being carried out in various American laboratories and on test strips, it may be of value to make a survey of European experiments in this field.

Preliminary information on the subject was presented by the author at the International Concrete Road Conference at Rome in 1957. In this report more recent work and particularly the projects carried out in 1959 in Germany, Belgium and France are described.

It will certainly be of interest to collect data on the conditions of the different projects after these have been in use for sometime. It is hoped it will be possible to present this information at a future meeting of the Highway Research Board.

England

The lecture delivered by Mr. J.P. Stott, in charge of research work at the Road Research Laboratory to th' Institution of Civil Engineers on M..rch 1, 1955, gives a detailed account of the tests carried out in Great Britain up to 1954.

The writer obtained further details during a visit there some time ago. The tests carried out in Great Britain are listed in the Table below.

Tests were performed on individual slabs, prestressed by longitudinal cables without transverse prestresssing or by diagonal cables symmetrically arranged in two directions in relation to the centre line of the slabs, or by longitudinal and transverse cables at right angles to each other.

The South Benfleet test was particularly interesting on account of the fact that after the road was construtced, it became necessary to cut it open, th eliminating the longitudinal prestress a time. This experience showed that is not much more difficult to repair a prestressed concrete road than an ordinary concrete one.

Germany

The earliest prestressed concrete paving project in Germany was the tank testing platform constructed for the French corps of engineers at Spire in 1954. This platform consists of a series of slabs 50 to 70 metres long (164 to 229 ft). The pavement has a total thickness of 20 cm. (8 in.) including a 14 cm. (16 in.) sub-course and a 6 cm. (2 in.) wearing course. The slabs are laid on a 30 cm. (12 in.) river gravel base course with a 2 cm. (0.7 in.) fine sand topping. A layer of kraft paper was placed between the sand and the concrete pavement. The total length of the platform is 1,500 metres (4,900 ft).

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Date	Site	Length	Width	Thickness	Prestressing: Longitudinal	Prestressing: Transverse	System of prestressing	Present condition
1950	Crawley, Sussex	393′	19′	6″	210 lb per sq. in.	22.4	Diagonal cables	Good
1951	Wexham Springs Buckinghamshire	108′ 127′ 196′	10′ 10′ 11′	6″ 6″ 6″	182 126 252	— — —	Longitudinal cables only	Good
1951	London Airport	328′	118′	6″	560	560	Triangular slabs, Orly type	Good
1951	John Laing's Ltd.	50 × 164 = 8,200′	11′	6″	294	—	Longitudinal cables	Good
1952	Basildon, Essex	13 × 164 = 2,232′	15′	6″	280	—	Longitudinal cables	Good
1952	Woolwich	3,280′	16–26′	6″	252	28	Diagonal cables	Good
1954	Port Talbot	1,476′	19′	6″	280	Varying	Longitudinal diagonal cables with jacks	No information
1954	South Benfleet	328′	19′	4″	532	49	Flat jacks in longitudinal, cables in transverse direction	Good after reinstatement of the longitudinal compression

The prestressed system utilised is of the Leoba type with a stress of 30 tons per element. Each unit consists of 6 steel cables, the extremities of which are provided with threaded rods and bolts by which they may be placed under tension.

The total sectional area of the 6 cable consisting of 12 strands is 2.65 cm.^{2} Stress is equal to 80 per cent of the elastic limit. The slabs are separated by transverse joints with bituminous coated dowels at the base. The upper part of the joints is filled with a special joint compound.

This platform has been in use since 1954 and no appreciable wear has been noticed up to the present time. Because of the length of the slab elements, the joints are several centimetre wide, however, and variations in the width of the joints due to differences in temperature cannot be taken up by the joint compound.

This condition is not serious as far as tank traffic is concerned, but it has resulted in a certain spalling of the joint edges. Transverse prestress units exist only near the joints. On the whole the using services are very satisfied with the manner in which the platform has stood up under exceptionally heavy traffic.

Various tests performed in Germany in 1954 were described in the reports of the Concrete Pavement Committee of the German Pavement Association. Three systems were tested. The first, utilised in the slabs constructed at Mergelstetten I and II, included both longitudinal and transverse prestress cables. The slabs were 120 metres long (393 ft), 8 metres (26 ft) wide and 15 cm. (6 in.) thick. Longitudinal prestress values were 22 and 17 kg./cm^2. (308 and 238 lb/sq. in.) transverse prestresses 8 and 3 kg./cm^2. (112 and 42 lb/sq. in.) The fact that pavement continuity was interrupted at 120 metre

(393 ft) intervals made it necessary to provide special and costly cable holding devices and did not avoid the joint problem. At Mergelstetten, III cable prestressing was also used, but the cables were placed diagonally, thus partly avoiding the joint problem. Cable anchorages were set in prefabricated lateral strips which were necessarily costly.

As a result of these tests, the Government decided to construct a by-pass at Bingen with a 1,000 metre (3,280 ft) prestressed concrete section. Design specifications provided for a very wide safety factor, so that the pavement would stand up under any circumstances. The section is over-designed. The prestressed Pavement is 16 cm. (6 in.) thick; longitudinal prestressing is 50 kg./cm^2. (700 lb/sq. in.) with a total tension of 65 tons per cable; transverse prestressing is 15 kg./cm^2 (210 lb/sq. in.) with a total tension of 9 tons per transverse bar.

The slab is placed on a 3-course hot-laid bituminous concrete foundation 15 cm. (6 in.) in thickness. The upper course of the foundation has a very smooth surface and is composed of sand compacted in a bituminous binder. In order to reduce friction, the bituminous concrete was covered with two layers of talc-coated paper before the prestressed concrete was placed. The coefficient of friction was thus reduced to 0.35 in place of 0.8, the figure on which the design was based. In places, the paper is replaced by plastic sheets which give the same result.

An "anti-frost" base was provided under the bituminous concrete foundation. This base is 40 cm. (1 ft 4 in.) thick and consists of sand and gravel compacted by a vibrating roller to 98 per cent of the modified AASHO optimum corresponding to a dry density of 2.4, i.e., an extraordinarily high degree of compaction.

This base was placed on compacted unclassified Rhine Valley fill material.

The section consists of 150 metre (492 ft) long slabs separated by steel and rubber joints similar to those designed by Goodrich for the Jones and Laughlin Co. in America which were described in the proceedings of the 1958 meeting of the Highway Research Board.

Longitudinal prestress cables consist of jack-prestressed stands in thin sheet metal tubes. Transverse prestressing is provided by 7.50 metre (30 ft) bars fixed at one end and prestressed by jacks at the other. Prestress tension is maintained by a bolt which is tightened.

The by-pass at Bingen is in service at the present time. The metal plate and rubber joints appear to be standing up well and to be very slightly affected by traffic.

At the same time, under the influence of organizations, grouping together highway research specialists an[illegible]d, [illegible]crete and cement technicians, prest[illegible] concrete made great strides in the[illegible] of airfield runway construction.

In 1956 a test runway was constructed at Memmingen by the contracting firm of Dyckerhoff and Widman. It consists of 100 metre (328 ft) slabs, 7.70 metres (30 ft) wide and 14 cm. (5 in.) thick with an increased thickness at the edges bringing the total thickness to 20 cm. (8 in.). The ends of the slabs are spaced at a distance of 1 metre and the slabs are prestressed by single cables 10.2 mm. in thickness. Prestressing is both longitudinal and transverse. The transverse cables cross the entire 45 metre (147 ft) width of the runway. A special system was provided in the spaces between the slabs in order to ensure satisfactory tensioning of the cables. After the cables have been tensioned, concrete is placed so that a space of only 3 cm. (1.2 in.) is left for longitudinal movement of the slabs. The cables are inside metal tubes whose diameter is only slightly greater than that of the cables.

The tubes are left in the concrete at the time it is placed. The cables are then introduced into the tubes and tensioned. The space between the cables and the inside of the tube is then filled with grout injected so as to provide a strong bond between the cables and the slab.

The success of this runway led the contractor to include a prestressed concrete alternate with his bids for construction of runways at Wunstorff, Hopsten and Nordholtz. The alternates were accepted in all three cases as being both more economical and technically more satisfactory.

The proposed project was to be a bituminous concrete runway on a 20 cm. (8 in.) stabilised macadam foundation. The ends of the runway were to include 300 metre (984 ft) long sections of concrete 22 cm. (8.6 in.) thick on a stabilised macadam base. The alternate proposed by Dyckerhoff and Widman was a prestressed concrete runway 14 cm. (5.5 in.) thick and 20 cm. (8 in.) thick at the outer edges. The pavement was to be placed directly on a 45 cm. (1 ft 5 in.) thick anti-frost sand base with a 2 cm. (0.7 in.) thick fine sand topping covered with a double thickness of paraffined paper. Elimination of the stabilised macadam foundation, the materials for which had to be transported from a great distance and which the contractor found superfluous, if not actually harmful when utilised under a prestressed concrete slab, made up for the difference in cost between prestressed and ordinary concrete. The total cost per square metre of prestressed concrete was 27 DM. as compared with 22 DM. for a 22 cm. (8.6 in.) ordinary concrete slab. The saving on foundation costs largely compensates for the 5 DM. difference.

Since the slab rests directly on sand, compression of the latter was carried out with particular care. Vibrating crawler compactors were used and, at Hopsten, with a fine, slightly silty sand, a modulus of reaction of 14 kg./cm.^{3} was obtained, i.e., an extremely high value.

The critical point was to find a method of construction which would ensure pavement continuity between successive slabs and permit longitudinal cable prestressing and movement of the slabs caused by variations in temperature after prestressing. Calculations indicated that a space of 6 cm. (2.3 in.) would be required between slabs. Experience made it possible to reduce this width to 3 cm. (1.2 in.).

In addition, for longitudinal cable prestressing, jacks had to be placed between successive slabs and tension applied so that the required displacement could be obtained. The ends of all cables were stamped to provide a projecting screw thread, the diameter of the groove being equal to that of the cable. This made it easy to fix the cables to the jacks and is one of the patented features of the Dywidag system.

Placing the jacks, supporting them against fresh concrete surfaces with the use of metal elements to provide the required 3 cm. (1.2 in.) joint space, placing metal joint covers, fixing cables and filling the space between slabs with concrete would, at first, seem to be a rather complicated series of operations, but it is claimed that the work proceeds automatically when a trained crew is employed. In any case, the company, utilising this method of construction, has already built a two-section, 1,276 metre (3,828 ft) long runway at Wunstorff and a 3,000 metre (9,842 ft), 30 metre (98 ft) wide runway with a parallel taxiway of the same length at Hopsten, i.e., a total prestressed concrete paving area of 170,000 m^2. The firm has now begun designs of installations at the Nordholtz airfield near Cuxhafen. Construction will include a 2,900 m. (9,514 ft) long, 45 m. (147 ft) wide runway and additional paved areas bringing the total surface to 260,000 m^2.

These are NATO fields and pavements are designed for 20-ton wheel loads. The thickness thus remains at 14 cm. (5.5 in.). Concrete will have a compressive strength of 450 kg/cm². (6,300 lb/sq.in.) and a tensile strength of 60 kg/cm². (840 lb/sq.in.) Rhine Valley sand gravel will be used for aggregate as well as crushed rock. An air-entraining agent and a plasticiser will be used, as is customary. Under these circumstances, four 130 × 7.50 metre slabs (426 ft × 29 ft) can be placed per 12-hour shift which represents 450 m³. of concrete placed per day.

In addition to the fact that prestressed concrete presents certain advantages from the point of view of cost, the users feel that it presents considerable technical advantages. A thin prestressed slab placed directly on a layer of sand is highly elastic and is preferred by pilots. In addition, the wide spacing between joints and the fact that they are provided with a metal joint cover makes them imperceptible to the pilot as he runs over the pavement. The surface of the pavement is cleaner and free of loose gravel which, in the case of bituminous pavements, may damage jet engines on group flights. Prestressed concrete is now thoroughly accepted for use in airfield pavement construction in Germany as a technique offering unquestionable advantages. The Dyckerhoff and Widman company plan to apply their methods to highway construction. The reduction of pavement thickness as compared with the 14 cm. (5.5 in.) thickness of runway pavement cannot be very great, but the company hopes to be able to reduce thickness to 10 cm. (4 in.) and, at this figure, to provide an economically advantageous alternative.

Belgium

(1) Test Road: Belgium has shown a keen interest in prestressed concrete for several years. In 1957 the Centre L'Etudes Routieres proposed the construction of a test road and, with the agreement of Mr. Hondermarcq, Director-General of Roads, entrusted the design of the project to Professor Paduart of the University of Brussels.

The project was designed in 1958 and the necessary credits were obtained for the fiscal year 1959. The test road will consist of a section $3\frac{1}{2}$ kilometres long between Zwartberg and Meeuwen. The road will be 7 metres (26 ft) wide and will include two curves with radii of 1,000 and 500 metres (3,280 ft and 1,640 ft) respectively. The terrain is practically horizontal.

The characteristics of this test road are based directly on the experimental work conducted at Orly in 1957, i.e., a minimum of foundation and pavement thicknesses fixed at 8, 10 and 12 cm. (3 in., 4 in. and 4.7 in.) as was the case in the tests conducted in France. The prestress system is the same as that utilised for the runway at Maison-Blanche, i.e., flat jacks in active joints spaced at 270 metre intervals. Fixed abutments have been designed by Mr. Paduart for each end of the test road. The first will be an ordinary reinforced concrete slab anchored by 80 cm (2 ft 7 in.) piles driven into the ground. The other abutment will also be a thick reinforced concrete slab anchored in the soil by six thin parallel fins, each 1 metre (3 ft 3 in.) deep and 15 cm. (6 in.) wide.

The most original feature of the project is the system for preventing relative movement of the slabs at the active joints. These joints are constructed over tunnels 1.70 metres (5 ft) deep which may be used for cable and utility crossings.

The slabs rest on the vertical support of the tunnels. Upward movement of the slabs is prevented by bars grouted into the concrete at the bottom of the tunnel and bent and embedded in the concrete of the road pavement slabs. These bars are free-standing for their entire height and permit slight horizontal movement of the slabs through their elasticity.

This extremely original and very simple solution would appear to give results comparable to those obtained by the more complicated system adopted at Maison-Blanche.

The soil on the test road site is a slightly silty sand, easily compacted and of good quality. This sand will be utilised for the foundation. It will be compressed for a width of 8 metres, waterproofed by spreading cutback and covered with 2 cm. of sand to facilitate movement of the slabs. The thin layer of sand will be covered with kraft paper on which the concrete will be placed.

The designers have thus reduced foundation thickness to a minimum. Since the soil is not susceptible to frost and since it can carry truck and heavy equipment traffic in all weather conditions, this solution would appear to be a satisfactory one.

The pavement consists of 8, 10 and 12 cm. thick slabs prestressed by jacks placed in the active joints briefly described above.

Different prestresses will be adopted for longitudinal jack prestressing and for transverse prestressing. The latter may be replaced by reinforcement or eliminated altogether. A total of 26 sections with different characteristics are planned. Up to the present time, only the abutments and the tunnels for placing active joints have been constructed.

2. Runway at Melsbroek: Sometime after design was begun on the test road, the management of the Melsbroek Airport near Brussels decided to invite bids for construction of a 3.3 km. (10,830 ft) runway, 45 metres (148 ft) in width designed for jet planes.

The runway was to be constructed of ordinary concrete. Bidders learned, however, that they could present alternative designs for prestressed concrete. Mr. Paduart, who had just finished the design of the test road, accordingly proposed the construction of a prestressed concrete runway to be executed in collaboration with the Wegebo Company.

The ordinary concrete runway was to consist of a slab 45 cm. (1 ft 6 in.) thick composed of two courses 22.5 cm. (9 in.) in thickness, the lower course to be 325 kg. concrete and the upper 400 kg. concrete.

The base was to consist of a layer of 0.60 (0-$2\frac{3}{8}$ in.) quarry run aggregate laid on the natural soil, a sandy silt. The alternative proposed by Mr. Paduart was a prestressed 18 cm. (7 in.) slab placed on a 2 cm. (0.7 in.) layer of sand above a 20 cm. (7.8 in.) base course. The upper 10 cm. (4 in.) of the base course was to be 0-60 quarry run aggregate and the lower 10 cm. compressed sand.

The prestressed concrete proposal offered a saving of approximately 5 per cent, as compared with ordinary concrete and was selected by the airport authorities. Work got under way in the spring and the completed runway should be opened to traffic on December 15, i.e., after 6 months' work. Results seem, at the present time, to be quite remarkable. Five of the six 7.50 metre (24 ft 7 in.) strips have already been placed for the entire 3.3 km. length. Practically no cracks are noticeable and the joints covered with concrete will be imperceptible when completed.

Certain features designed by Mr. Paduart, which were to be tested on the test road before being utilised in permanent construction, were used on the Melsbroek runway before being tested. It appears, however, that the conditions under which they were desinged make it possible to anticipate that they will stand up well in use.

The original features which were described in connection with the test road have been utilised for the Melsbroek runway. The abutments are of the ribbed type and are ordinary concrete slabs 40 cm. (1 ft 4 in.) in thickness connected by reinforcement to fins 40 cm. (1 ft 4 in.) in width and 1.20 m. (4 ft) in height measured from the lower surface of the slab. The ribs were placed without forms in the natural soil which had been excavated by a specially designed machine like a mechanical trencher. The soil was sufficiently cohesive to permit trenching without shoring and placing vibrated concrete without caving in of the trench walls.

Contraction joints 5 cm. (2 in.) deep have been provided in the upper part of the abutments.

The abutments are extended by large ordinary concrete slabs which connect the main runway to the taxiways. In the event that the abutments should prove insufficient to absorb expansion of the runway in warm weather, measures have been taken so that they can be reinforced by uniting them to these end slabs.

The active joints above utility tunnels, described in connection with the test road, are also found at Melsbroek. Slab thicknesses have been increased 18 to 25 cm. (7 to 10 in.) at these joints. Active joints are spaced at 330 metre intervals (1,082 ft). Temporary joints were placed every 110 metres (360 ft) following the example at Maison-Blanche. These joints make it possible to compress the concrete 24 hours after placing and it is thanks to them that the 110-metre long slabs show no fissures due to contraction.

Transverse prestressing will be provided by cables spaced at 1.75 metre (5 ft 9 in.) intervals. Each cable will consist of twelve 7 mm. strands tensioned at 100 kg. per mm.² for a breaking strength of 150 kg. Cables will be placed directly in the slab without tubes. Passages for the cables were provided by setting pipes on concrete blocks at the time the slabs were poured.

These pipes were removed when the concrete had set sufficiently.

The different strips which go to make up the runway were successively placed, each of them serving as a form for the following one. It is anticipated that the fissures between the strips which were caused by contraction will be eliminated at the time of transverse prestressing.

At Maison-Blanche, the longitudinal joints were protected by strips of paper before transverse prestressing. The contractor at Brussels expects to obtain similar results by scraping out the interior of the fissure with a knife before applying compression.

The foregoing are the chief features of the Melsbroek runway. When opened to traffic, it will be the largest prestressed concrete runway in operation. It will be extremely interesting to see how it stands up to a climate which is appreciably different from that of Algiers.

3. Experimental Taxiway at Melsbroek. A prestressed concrete test taxiway section was constructed at Melsbroek in 1958.

This section is 350 metres (1,148 ft) long and 23 metres (75 ft) wide and 10 cm. (4 in.) thick. The pavement rests on a 30 cm. (12 in.) layer of compressed sand above the natural soil compressed for a thickness of 30 cm. The pavement consists of prefabricated slabs in the form of parallelograms 12 metres (39 ft) long and 1.24 metres (4 ft 1 in.) wide. These slabs are prestressed by grouted strands at the time they are manufactured. They are joined together in 18 strips to make up the total width of the pavement. These slabs are set directly on the sand base course and held together by transverse cables consisting of eight 7 mm. strands. The cables are spaced in openings provided in the slabs at 80 cm. (2 ft 7 in.) intervals. Each cable exerts a pull of approximately 26 metric tons. Transverse prestressing is approximately 33 kg. The oblique joints in the slabs are staggered from one strip to the other so that

each of the joints is crossed by one cable. Because the joints are oblique, the transverse stress transmitted by the cables gives a component perpendicular to the joints, thus ensuring a longitudinal prestressed bond between the butt ends of the slabs. There has not been sufficient time to determine how this taxiway section will stand up to traffic.

The fact that the Administration did not accept this system for the construction of the Melsbroek runway would appear to be an unfavourable indication, however.

Switzerland

We may mention the first two tests made in Switzerland by the Concrete Road Association. They include two sections each 500 metres (1,640 ft) long. In the first of these, longitudinal compression is obtained by means of flat jacks placed every 70 metres (229 ft) with a fixed abutment at one end and a natural rock abutment at the other. In the second section compression was obtained by means of wedges placed at 120-metre (393 ft) intervals. One end of the slab is held by a fixed abutment; the other end abuts against an existing road. The longitudinal prestresses are quite high; 60 kg./cm². and 70 kg./cm² (840 and 980 lb/sq. in.) respectively.

On the other hand, the transverse prestress has a low value. In the first case it is produced by single strand cables (7 mm. diameter) 1 metre (3 ft 3 in.) apart and tensioned so as to produce an initial compression of 4 kg./cm² (56 lb/sq. in.) in the slab. In the second case there is no transverse prestress but the slab is provided with light reinforcement. It should be noted that in both cases the slabs are narrow, viz., 2.5 metres (8 ft 2 in.) and 5.5 metres (18 ft) wide respectively. British experience has shown that in such circumstances transverse prestress may be eliminated. An interesting feature of the second test is that the slab included a curve in the road; this curved portion has behaved well upto now.

Spain

An experimental road is to be built in the Madrid area in the course of 1962 under the supervision of Mr. Escario, Professor of Road Technique at the Technical College for Bridges and Highways in Madrid. The necessary credits have been put at his disposal. This road will include a prestressed concrete section more than 1,000 metres (3,280 ft) in length. The methods which will be applied are still under study.

Italy

Part of a road has already been constructed under the supervision of Prof. Franco Levi and was the subject of a special report at the International Concrete Road Congress at Rome in 1957.

(To be continued)

(From " Roads & Road Construction ", July 1960)

(Continued from page 167)

autoroute into the surroundings, soften the outlines of the highway structures, frame the perspectives of the horizon and hide industrial activities.

Far from impractical utopianism, such a road is an important psychological element in relaxed driving over long distances and an important contribution to greater safety.

Together with its more direct considerations, it was conceived as such by the Special Division for Autoroutes in the French Ministry of Public Works and Transportation and constructed by the General Agencies of the Ponts-et-Chaussées of the Departments Seine and Seine-et-Oise.

(From " French Economic and Technical Bulletin " No. 6, 1960)

COLCRETE AND COLGUNITE METHODS AND THEIR USES

(Extracts from the Translation of the article published in German by Dipl. Ing. G. Brux. in the March-September issue of "Strassen—und Tiefbau")

(Translation by the courtesy of Messrs. Gammon India Private Ltd., Bombay)

I. Introduction

The network of highways and road in West Germany did not cater to the future needs of traffic because its pavements are insufficient and inefficient due to the overloading and necessitate renovation. This also applies to the roads and pavements made of concrete. The concrete pavement has not been in vogue for a long time. Still, as early as in 1890, at the time when concrete construction was still in its early stages, concrete pavements have been constructed with mostly plain concrete and the joints of the concrete slabs did not provide sufficient bondage, nor has an efficient frost protection layer been provided. Hence, it became the present highway engineer's main occupation to renovate or reconstruct the pavements of the existing highways. Also, according to the "Green plan", the pavements of roads serving forests and agricultural fields, are to be strengthened sufficiently and economically to withstand the traffic due to mechanisation of agriculture. Many pavements are to be constructed for special purposes such as for automobile test tracks, etc. The colcrete and colgunite methods have been used in this field in their earliest stages. These methods are being treated in the following article.

II. Colcrete and Colgunite methods and their specialities

The Colcrete system which was developed in England 20 years ago, is being used in Germany since 1954 and serves primarily the purpose of preparing mass concrete. The principle of this system is to use at first, large size aggregates and fill up the hollow spaces with a special type of cement mortar. The mortar used for this should have a good workability so that it can enter the smallest crevices and fill them up and should not decompose either during construction or after and also should

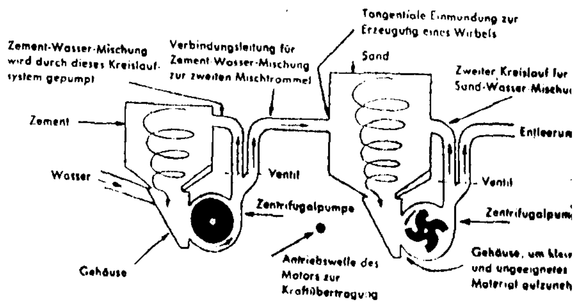

Fig. 1

Schematic sketch of a Colcrete two drum-mixer for Colgrout

not combine chemically with water. In the Colcrete system, these properties are attained through the patented method of mixing and preparing the mortar,* and through a special composition of mortar. (Adding additional materials like intrusion acid, Alficil.)

II. a. Method of Mixing and Properties of Mortar

The speciality of Colcrete system is the use of a special mixer in which the colloidal mortar Colgrout is prepared, and the Colcrete concrete thus cast possesses extraordinary properties. The process of mixing is carried out in two sections (see Fig. 1). At first, water and the binding material are pressed together through a narrow opening with

*The special mixer used for this purpose is based on an English patent of the year 1930, which was developed into an earliest patent of injection concrete by J. C. Gammon in the year 1932.

a high velocity (1500-2200 P.M.M). The frictional and cohesive forces occurring in this process influence a comparatively better mixing of the binding material, because the surface area coming into contact with the water in the "Colloidal Mill" is enlarged and the air and other gases are completely expunged from every film of material. The cement particles are hence very finely distributed in the fluid, whence the flaking of the cement and thereby occurring disadvantages are avoided.

Through the addition of sand of 0/3 mm. or 0/5 mm. fineness to this mixture, —which can be used advantageously for grouting purposes a very finely and thoroughly mixed uniform mortar of a high workability can be obtained, by following the same principle in mixing as in the first stage. Its components then remain finely distributed till setting occurs and it does not combine any more with water if a non-turbulent current of less than 1.4 m/sec. velocity is used. This permits its workability also during rain or under water. Due to its good workability, Colgrout can be pumped through thin tubes or hoses to great heights almost vertically. The binding quality of this mortar is considerably better than that of an ordinary mortar of the same composition, and also its strength and impermeability are higher than those of the normal mortar, after setting.

II. b. Use and Advantages

The Colcrete system is used in its country of origin and also other countries like U.S.A., Canada, India, Holland, France, Africa, etc., almost exclusively for mass concrete work for diverse purposes. However, in Germany it has been decidely developed further with success, in the field of grout-concrete, grouting mixtures (Colgunite) and grouting with Colgrout and other types of water cement colloidals.

The method of injecting Colgrout into the Colcrete depends upon size of aggregates, strength and the porosity.

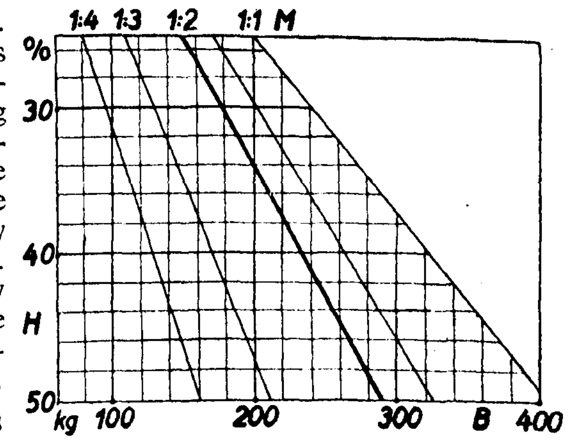

Fig. 2

Cement-Requirement B for colcrete mass concrete in relation to ratio of mix M and the porosity of large aggregates H.

If the depth of the layers is not much, and the size of large aggregates does not exceed 40 mm. dia.—as in the case of pavement construction—Colgrout is injected from above because it finds its way down to the hollow spaces by gravity and its fluidity, and displaces the air and water in the pores. In case of larger quantities and thicker layers, as well as underwater construction, the grouting is carried out from bottom to top through 1½ in. dia. pipes which are placed in position along with the large aggregates and these pipes will be withdrawn progressively downwards during the operation, so that the ends are always slightly above the Colgrout surface. (ex. retaining walls, tunnel bottoms, large foundations, etc.)

If the aggregates are smaller than 40 mm. the Colgrout is to be injected under pressure or one can ram or vibrate the members which have been filled at first with Colgrout (ex. casting of precast members) the porosity of the aggregates (H) and the ratio of the materials in Colgrout (M) are the deciding factors for the quantities of binding material and sand. The Colgrout preparing and conveying plant for Colcrete consists mostly of one or two Colcrete two drum machines, one sand silo with measuring and weighing equipment-conveyor belts and sand sieves for sieving the aggregates to the required fineness, water measuring and storage tanks or water rests in case of sufficient water pressure and section of pipe, and a Colmono pump (also Mohno pump) The efficiency of a twin plant with Colcrete two drum mixers of mark III (112 litres) depends on the extent of mechanisation of the sand and binding material supply. (8-12m ^{3}/h) in an 8-hour shift, a pavement area of more than 1200 m^2 of 20 cm. thickness can be poured.

III. Colgunite Process

The Colgunite process is a wet grouting process with Colgrout or alternatively with Colcrete-concrete. It is manufactured in a Colcrete Roller mixer, pumped through hoses and injected on to the contact surface with nozzles by the aid of compressed air. Mass concrete due to this process has, in addition to its qualities of compressive strength and impermeability to water, a high binding capacity and a good workability, which makes it suitable for the reuse of old brickwork, retaining walls and tunnels and has a very low back splash of 3-5 per cent during the injection through the nozzle. Finenesses of upto 15 mm. are being used nowadays for this injection process. Due to its low shrinkage, Colgunite is also being used for repairing damaged R.C.C. structures.

Water cement colloidals for Colcrete groutings are made in the Colcrete two drum mixer, and are injected depending on the pressure required, with Colmono, Mohno-Hany-or piston pumps for filling the gaps and binding together of floors, and other structures. These colloidals of the same water cement ratio as normal grout mixtures, have a better access and enter the smallest of the crevices (cracks, openings, porous aggregates, etc.). The water content required for the same fluidity is lesser and hence results in a reduction of shrinkage and an increase in the strength With the same water cement ratio and workability as a normal grourt mixture, one can also add fine sand or pulverized rock and reduce the shrinkage further.

IV. The Colcrete and Colgunite processes and their use in the construction of Highways and Roads, and repair work of the same

(a) Construction of new pavements—Material and Economy Considerations :

In cases like small and very irregular slabs which deviate considerably from rectangular shapes, arches, ramps, slopes, innumerable members, or where large aggregates are available in convenient sizes and quantities, Colcrete can be more economical than ordinary concrete even though more quantities of aggregates are used (1 m^3 aggregates and 0.5 m^3. sand for each cubic metre of finished concrete). The binding material requirements for Colcrete are, however, generally lesser than those for ordinary concrete. The Colcrete or Colgunite process is also very useful for the construction of runways—which require a thickness of 60 cm. or even more for heavy traffic—which would have necessitated considerable amount of compacting work if ordinary concrete had been used. With the Colcrete system, one is more independent of the weather because work can proceed under bad weather conditions also, i.e., rain or frost. The rainwater is driven out by the Colgrout and does not affect the work as it does not combine with Colgrout. For the progress of work it is advantageous since only 50 per cent of the quantities need go through the Colcrete mixer at a time and the Colgrout can be pumped through thin pipes to great distances.

This method of construction is specially suitable for test pavements for heavy trains of loads. The test tracks are composed of innumerable curves (H = 17.5 to 20 m), hairpin bends with a very small diameter (11—15 m)

and mostly without intermediate straight tracks, and they also consist of a steep transverse slope (2-20 per cent) and broadened pavements and steep longitudinal slopes. The use of precast members is almost impossible due to the small number of straight portions and is also very uneconomical. The heavy live load to which the pavement is subjected, necessitates larger thicknesses (in case of bad soil conditions, even 1 m. thickness) as well as stiffeners on the edges of the pavement. Also these types of constructions are easier by the Colcrete process of mass concreting.

Frost Protection:

To avoid the wastage of Colgrout through overflow due to unevenness, a sand layer of 5-10 cm. is to be laid under the large aggregates, which also serves at the same time as a frost protection layer, if the aggregates are properly graded.

Pavement slabs and their strength

Initially, colcrete system was used only for the blindage concrete, the pavement slab being made of ordinary concrete mix, and later on a mixture of Colgrout and gravel or grit was used for the same. Further, a system was developed by which the blindage concrete and the pavement slab are of the same composition and cast together.

By this method, the Colcrete mass concrete could develop a direct compressive strength of 500 kg./cm^2 (7150 lb/sq. in.) and 80 kg/cm^2 (1140 lb/sq. in.) tensile strength in bending. Thin Colgrout layers laid according to this method satisfy the specifications of DIN/100/c.

The fatigue strength of pavements cast according to this process is specially important in the case of test tracks.

Construction and interval of joints

In mass concrete construction, longitudinal joints are with or without dowels as in the case of transverse joints provided so far in the constructions of highways. One can increase the spacing of joints in mass concrete poured by this process, due to the low shrinkage. Experiments are being done in this field.

(b) Repairs and Renovations : Repairs of Joints :

In concrete pavements the joints cause most of the maintence expenditure. It is hence an advantage to reduce the number of joints. Depending on the extent of damage, joints in concrete pavements are repaired with the help of Colcrete. or Colgunite System using mass concrete. Colcrete has the advantage that it binds well with the old concrete and permits repairs in those parts where otherwise a complete renovations would have been necessary.

Repairs of pavement slabs and cracks:

Cracks occur in pavement slabs due to faulty construction (honeycombing), improper compacting, too much distance between joints, or external influences like uneven and too heavy loading (train of loads with change in direction). Depending on the cause of damage, one can carry out the repairs in different ways. The damaged pavement slab is removed (3-10 cm.) and Colcrete fluid concrete is provided in that place with the addition of grit or gravel. If necessary, cracks are provided with clams and closed completely by grouting with Colgrout or in they are too large, they could be built up to act as joints by the same process. This kind of repair work is more economical than a complete renovation and offers less hindrance to the traffic. The quality of repair work of this kind depends on the extent of care taken during grouting.

Lifting and replacing of pavement slabs:

In case of too large a settlement in the pavement slabs, they can be lifted and the underside provided with Colcrete and the pavement slabs can thus be brought back to position. This method is useful only for pavements subjected to light loads.

Renovation of concrete pavement slabs:

If the damages are of such extent that repairs even by the Colcrete or Colgunite method become uneconomical, or more number of adjacent pavement parts are to be repaired, i.e., when the damaged parts are too close to each other, renovation can be carried out with mass concrete by the Colcrete or Colgunite method.

(c) **Other uses:**

Colcrete and Colgunite methods are also used in the construction of tunnels, shafts, mines, bridges, underwater structures, etc.

V. Typical examples of work carried out by the Colcrete and Colgunite methods

The advantages of the Colcrete and Colgunite methods in the construction and repairs of roads have been described so far. In the following pages, technical data and characteristics of a few works carried out by these systems is given briefly.

Construction of a road for chain vehicles in Sandhofen near Mannheim

The cross-section of the road and the winding slabs (1500 m^2 area) consists of 15 cm. thick packing layer, 2 cm. thick sand layer for levelling, 20 cm. thick Colcrete mass concrete including the pavement slab, the surface of which has been sprinkled with porphyry grit 7/14 mm. dia. with Westphalhand concrete additional metal 3 mm. dia. and has been left without any further finishing. The grit for this purpose must be clean and dust-free or completely covered with the binding material so that it holds fast with the Colgrout. Grouting was carried out under temperatures around freezing point and also the mass concrete was strongly frosted. But no disadvantageous results due to this have shown up. No cracks have developed even though very large slabs upto 140 m^2 area in one piece have been cast. The required strength of 370 kg./cm^2 was exceeded.

Curves and crossings for chain vehicles at Hohenfels/Oberpfalz

Only that part of the road which was subjected to heavy stresses due to the change of direction of the chain vehicles, was made with mass concrete. For the curves and crossings, the cross-section consists of 22 cm. mass concrete with L.S. metal 40/120 mm. dia. and Colgrout with M = 1 : 2.5 by weight, pavement slab as in the previous example (quartz and chalk stone grit 7/14 mm. dia.). The crossing has been executed without transverse joints and the curves were executed with longitudinal and transverse joints.

Construction of a test-track pavement for heavy chain loads

Data of a 780 m long and 6.5 – 10 m. wide test track with many curves and ramps (6000 m^2), 15-20 cm. layer of compacted quarry gravel 0/50 dia., 15 cm. concrete B 160 (with gravel, as aggregates), 3-4 cm. bituminous insulation layer, 18 cm. Colcrete-mass concrete B 600 with Basalt metal 40/180 mm. dia. with H = 50 per cent Colgrout (M = 1 : 1.8 by wt. cement 275, quartz sand 0/3 mm. dia. with 0/7 mm gradation, W/c ratio = 0.42 – 0.45 including sand wetness). The pavement slab consists of 5 cm. Colcrete hard concrete B 650 with steel fabric reinforcements and rendered with plaster. The concrete for this was mixed in Colcrete mixer with Colgrout (M = 1 : 1.7 by wt. P.C. 275, Rhine sand 0/3 mm. dia. W/c ratio 0.38), with the addition of hard concrete metal (like Cuppros metal 0/30 mm. dia. 1.7 by wt.) and basalt grit (8/12 mm. dia. 0.6 by wt. and 12/25 mm. dia. 2 parts by wt.) and was brought to the site by trucks. The required compressive strength was exceeded (616 kg/cm^2). The surface in the joints was removed and dowels were provided at 30 cm. intervals with a transverse spacing of 12.5 m. Longitudinal joints were omitted. The progress of work was satisfactory.

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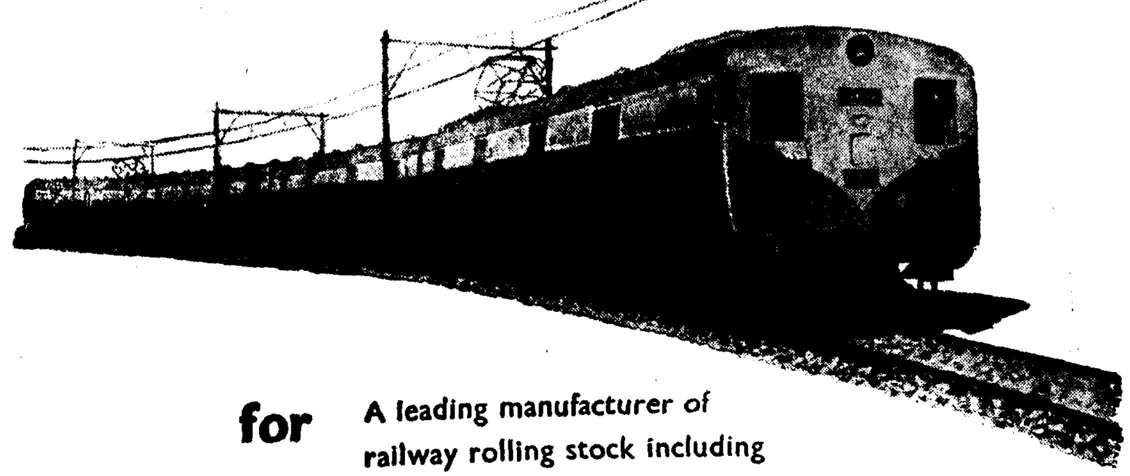

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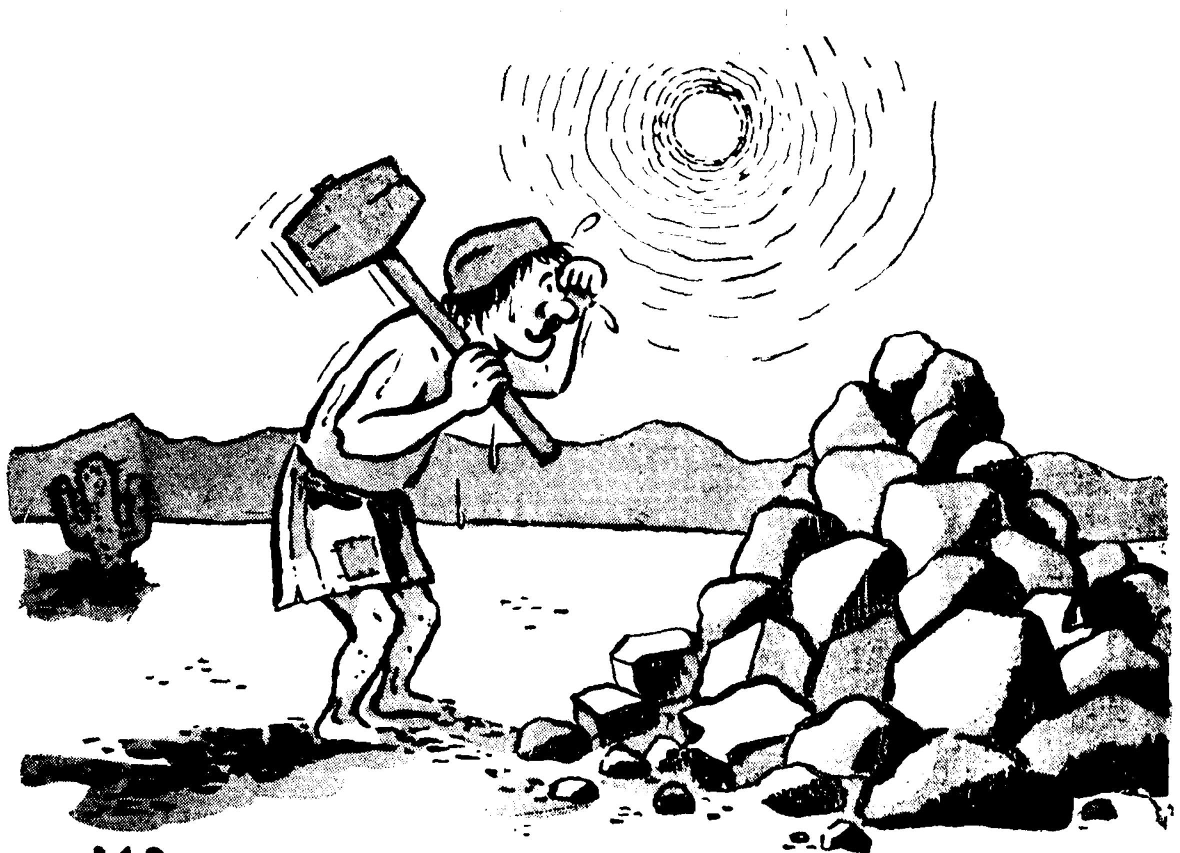

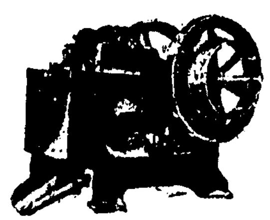

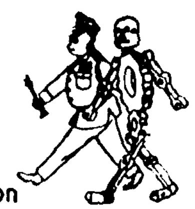

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