



**SILVER JUBILEE
NUMBER**
January **1960**

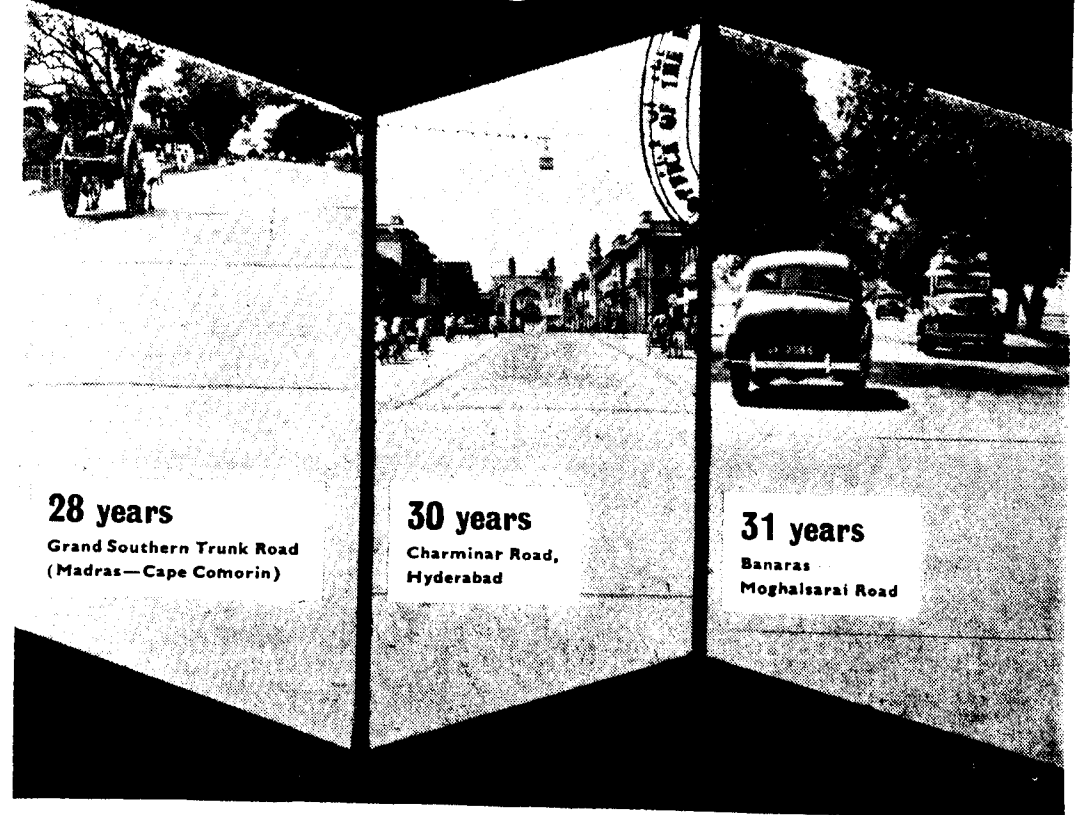
625.706
Ind -

**AN ROADS CONGRESS
NEW DELHI**

Long life *plus* Economy

... that's the story of

Concrete ROADS



28 years

Grand Southern Trunk Road
(Madras—Cape Comorin)

30 years

Charminar Road,
Hyderabad

31 years

Banaras
Moghalsarai Road

**Specify
Concrete roads for**

- Low maintenance cost
- Uninterrupted Service
- Better visibility
- Greater safety

Build to last with

ACC
cement

THE ASSOCIATED CEMENT COMPANIES LIMITED • The Cement Marketing Company of India Private Limited, Bombay I

Please mention this journal when replying to advertisements.

JWT JCM. 9006-2

**McKenzies' Sphere of Operations:
CONSTRUCTION DEPT.**

Construction of:

**Industrial Buildings—Roads—Bridges—Dams—Canals and
Irrigation Works—Heavy Foundations and Specialized
Concrete Work including Pile Foundations.**

Sole Licencees for:

India, Burma and Ceylon

for

**Vibro Type Cast-in-Situ Piles and Marine Works
MECHANICAL DEPT.**

Construction of:

1. Railway Wagons, Railway Carriages and Components.
2. Trailers—Agricultural, Industrial Trailers, Municipal Garbage Units, Water and Night-soil Tanks.
3. Jeep Type Trailers, etc.
4. Motor Bodies such as Vans, Station Wagons, Load Bodies, Omnibuses and Coach-building Work of all description.

McKENZIES LTD.,

Head Office: SEWRI, BOMBAY

Telephone: 61862-3-4

Madras Office: 2-A, TAYLOR'S ROAD, KILPAUK, MADRAS.

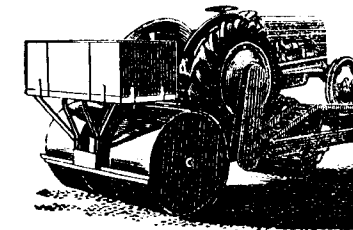
Calcutta Office: 30, CENTRAL AVENUE, CALCUTTA-12.

Please mention this journal when replying to advertisements.



REVOLUTION IN ROAD MAKING

THE
KAMANI-TWASE
'TRACTAMOUNT' ROLLER



Which converts a Wheel type Tractor into a
5 to 8 ton Road Roller on less than
10 minutes.

for constructing:

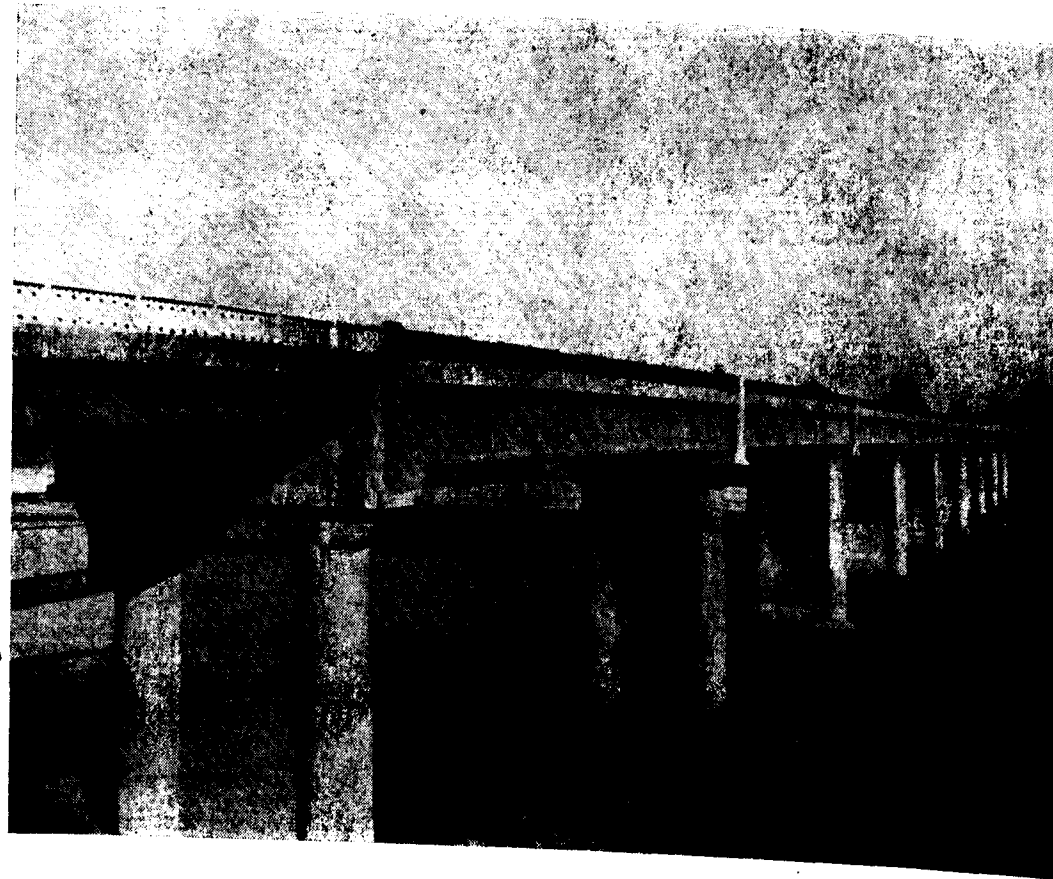
- Tar Macadam in Cities
- Roads in Community Project Areas
- Foot-Paths
- Roads for Coffee and Tea Estates
- Football and other Play grounds.

Manufactured under Licence in India by

KAMANI ENGINEERING CORPORATION LTD.

**AGRA ROAD, KURLA,
BOMBAY-70**

Please mention this journal when replying to advertisements.



BRAHMANI BRIDGE AT PANPOSH.

Built for Orissa P.W.D., the Bridge consists of 9 spans of 160'-0" and one end span of 68'-6". The decking is in Prestressed Concrete using the world-famous Freyssinet Prestressed Concrete System. The roadway is 24'-0" between kerbs and is flanked by 5'-0" wide footpath on each side. The substructure consists of hollow R.C.C. piers, about 55'-0" high and the same are founded on mass concrete footings laid on rock.

GAMMON INDIA PRIVATE LIMITED

CIVIL ENGINEERS & CONTRACTORS

HAMILTON HOUSE - BALLARD ESTATE - BOMBAY-1

Telephone: 264511 (5 lines)

Telegrams: "GAMMON"

Please mention this journal when replying to advertisements.

MILLARS'

ROAD AND BUILDING PLANT

Concrete Mixers—Asphalt Mixers—Roller Pan Mixers—
Builders Hoists—Wellpoint Pumping Equipment—
Merton Overloaders—Marsden Stone
Crushers, Granulators, Sand
and Gravel Washers and Screening
Plant—Ammann Spreader Finisher, Rotor
Loaders, Articulating Conveyors—Universal Mixers, Road
Rollers, Excavators, etc.

TIMBER

For Marine and Construction Purposes. Sleepers,
Railway Carriage and Wagon Scantlings,
Bridges and Crossings, etc.

MILLARS' TIMBER & TRADING COMPANY LIMITED

BOMBAY 27

Please mention this journal when replying to advertisements.

FARGO

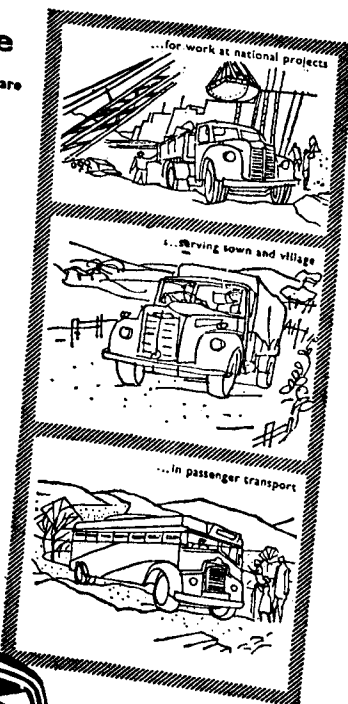
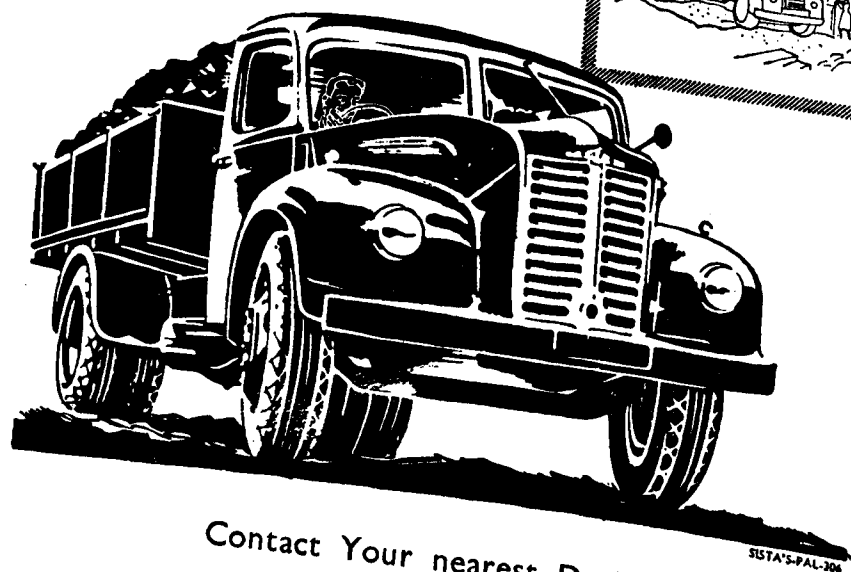
DIESELS in national service

Fargo diesel trucks are doing more than their fair share of work at projects because of their rugged construction and ability to carry more loads at less cost per trip. No matter what the load and however tough the going, they are first-class for service, performance and economy

FARGO DIESEL TRUCKS

Now available with new, more powerful and economical engines

PROGRESSIVELY MANUFACTURED BY
THE PREMIER AUTOMOBILES LTD.
BOMBAY



Contact Your nearest Dealer.

Please mention this journal when replying to advertisements.
vi

TRANSPORT- COMMUNICATIONS MONTHLY REVIEW

JANUARY 1960—No. 153

SILVER JUBILEE NUMBER

LIST OF CONTENTS

	Page
EDITORIAL	
Time to Ponder	1
ROAD DEVELOPMENT IN INDIA	
National Highways of India by H. P. Sinha	4
Road Development in Mysore State by G. S. Ganapathy	13
Roads in West Bengal by R. C. Roy	21
Road Development in Madras State by S. C. Nayak	29
Development of Roads in Bihar by B. Prasad	38
Road Development in Assam by Debeswar Sarma	45
Road Development in Assam by K. Barua	47
Some Facts Relating to the Economics of the Road System of the Punjab by G. C. Khanna	53
Road Development in Himachal Pradesh by J. Mukand	57
Road Development in Andhra Pradesh by N. Durrani	62
Road Development in Uttar Pradesh by Jagdish Prasad	66
Road Development in Madhya Pradesh by P. V. Devatia	73
ROADS IN OTHER COUNTRIES	
Phased Development of Asian Highways by M. S. Ahmad	76
Better Roads for Britain by J. F. A. Baker	86
Highway Development in Canada by G. W. Gilchrist	93
Ontario's Highway System by W. J. Fulton	103
Highway Engineering Problems in France by R. Coquand	109
The French Highway System by M. A. Rumpier	114
The Road System in Libya by Sir Arthur Dean	118
Highway Development in the United States of America by Bureau of Public Roads, U.S.A.	123
Developing Road-Building in the U.S.S.R. by P. A. Egorov	127
The Planning and Construction of Roads in West Germany by Dr. Ing. H. Kunde	134

ROAD TRANSPORT		Page
Road Transport Needs under the Second National Plan and some Suggestions for its Effective Augmentation by E. A. Nadirshah	...	142
Operating Costs of Nationalised Road Transport Undertakings in India by Dr. M. K. Ganguli and K. C. Saxena	...	151
Road User Behaviour and Methods for Improving the Same by Indrakant Patel	...	161
ROAD CONSTRUCTION		
Resurfacing of Concrete Pavements by K. K. Nambiar	...	166
The Design of Bituminous Pavements by T. M. Coulter	...	175
The Inter State Highway System in the United States by N. S. Surya	...	188
River Training for Protection of Bridges by D. V. Joglekar	...	193
ROAD RESEARCH		
Road Research in Great Britain by Sir. W. H. Glanville	...	206
Road Research in India by S. R. Mehra	...	213
Recent Research in U. K. on Concrete Road Construction by N. R. Srinivasan	...	220

ALSO :— Always on the road— Angelic Caution —

TRANSPORT-COMMUNICATIONS MONTHLY REVIEW

A REVIEW OF
ROAD ENGINEERING, DEVELOPMENT & TRANSPORT

SILVER JUBILEE NUMBER

JANUARY 1960

TIME TO PONDER

IF twenty-five years is a significant period in the life of an individual, it is much more so in the life of an institution like the Indian Roads Congress. For the latter, it means attainment of a certain maturity out of an eventful existence of a quarter of a century which confers a privileged status on the Society in the galaxy of learned institutions of the country. This status not only nobly enshrines the Society's professional attainments of the past but also symbolises its warm aspirations for the future.

For the celebration of its SILVER JUBILEE, the Congress appropriately meets in the beautiful city of Bangalore, the capital of a State long since known not only for its God-given gifts but also for its man-made works of great genius and magnitude. This is not the first time the Congress is meeting in Bangalore. Just a year after its inauguration, it met here in 1936 and so the period between these two meetings in this City practically encompasses the whole life span of the Institution.

The moment is, indeed, one for jubilation and we are happy to find that our intense feelings on this occasion are shared by the highest dignitaries of the State and other well-wishers of the Society whose messages of goodwill and encouragement, which we are proud to publish in the Souvenir brochure issued on this occasion, provide so much inspiration and incentive in the pursuit of our task ahead. The echo of the messages does not recognise any geographical boundaries but spreads over the corners of the world, unmindful of the limits both in space and time. To all our well-wishers we record our most profound respect and gratitude. To our distinguished contributors and, in particular, to those from overseas, whose interesting articles on road development in their countries are published in this Review, go our deep sense of appreciation and cordiality.

Transport - Communications Monthly Review is published on the 25th of each month by the Indian Roads Congress, New Delhi.

This Review is sponsored by the Roads Wing of the Deptt. of Transport, Ministry of Transport and Communications, but the Government of India accept no responsibility for any views or opinions expressed.

Subscriptions. Annual subscription including postage is Rs. Fourteen. Single copy including postage is Rs one and Twenty-five naye Paise.

To members of the Indian Roads Congress, Engineering Personnel below the rank of an

S.D.O. and Engineering students, a special reduced subscription rate of Rs eight per annum is offered. Students are required to apply through the Principal of their College.

Advertisements.	Advertising rates per insertion.	
	Full Page	Half Page
Inside front cover	Rs 100/-	—
Inside back cover	100/-	—
Outside back cover	120/-	—
Ordinary position	75/-	45/-

Detailed rate card can be had on application to the Secretary, Indian Roads Congress, Jamnagar House, Mansingh Road, New Delhi-2.

The consideration of time makes us reflect the past for a while for it has borne so much influence on the present. The high ideals and noble aspirations of the Society so effectively voiced by the past Presidents of the Congress are an unfaltering beacon of light to guide the future path. They form a proud tradition to be dearly treasured and emulated and we are glad those voices are with us today giving encouragement in our journey along the path which they so nobly trod. We are indeed very thankful to all our past Presidents for the kind expressions of their sentiments.

On the fairly large scale map of time in which the Indian Roads Congress has now been in existence, it is possible to discern clearly the useful role it is playing in the cause of road development in India. Briefly, this has been twofold: pooling of knowledge and experience from all over the country, and adoption of uniform standards and practices in road construction. Given the vast dimensions of this sub-continent with a variety of physical features and a diversity of problems, the necessity for the former needs no special emphasis. An appreciation of the latter follows from the realisation that road development has to be viewed from the point of national requirements in their broader concepts rather than any immediate or narrow considerations. The Indian Roads Congress has played an effective part in both these directions and it is heartening to note that its advice and recommendations have been largely accepted and acted upon both by Central and State Governments. The discussion and dissemination which have emanated from its forum not only has been a useful co-ordinating and unifying factor but has also led to economical results in road construction.

The Nagpur Plan truly laid the foundation of road development in India on a sound and comprehensive basis. The First and Second Five-Year Plans which followed have seen the realization of this modest ambition and a clear view of the task ahead is now provided by the recently drawn Second Road Development Plan (1961—81), which is to get a start from the Third Five-Year Plan. Let us hope this will be commensurate with the transport demands of the future in consistence with the contemplated agricultural and industrial development of the country. There is no doubt that roads have to make a substantial contribution in this direction. We know how true are the words of the late Thos. H. MacDonald about his own country:

“We were not a wealthy nation when we began improving our highways,.....But the roads themselves helped us create a new wealth, in business and industry and land values.....So it was not our wealth that made our highways possible. Rather, it was our highways that made our wealth possible.”

In this connection, we may also recall the memorable words of Dr. Rajendra Prasad, President of India, from his Inaugural Address to the 22nd Session of the Indian Roads Congress, which are so true of our country:

“This social and cultural aspect of roads is not in any way less important than the economic aspect. After all, it is not human beings alone who travel by roads. It is not goods or commodities of various kinds alone which are transported through roads. The traffic of ideas also takes place through social intermingling which is made possible by roads. This last aspect of roads is, in my opinion, of fundamental importance, particularly for a country like ours which is populated by communities and groups belonging to varying levels of economic and social development.”

In India, the foundations of road development have been well and truly laid and a good deal of progress already made. Road research is now a valuable guide for economy and soundness in road construction. Trade and industry are also playing their complementary role in road construction and their valuable contribution and association with the Indian Roads Congress has indeed been very helpful.

And so on this memorable occasion when we cross an important milestone in the long and arduous journey of road building in the country, let us in all humility pledge to dedicate ourselves to our tasks with renewed confidence and courage to go ahead with our journey towards the building of a strong and prosperous nation.

“I consider the existence of good roads as a vital factor in determining whether our society can become an equalitarian 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



H. P. SINHA, I.S.E.
Consulting Engineer (Road Development) & Jr. Secy. to the Govt. of India.

NATIONAL HIGHWAYS OF INDIA

ONE of the most important factors for the unification of a country is her communication system. This is true in the case of India as of any other country. Roads form an integral part of the communication system. Evidence is available to show that their importance in this country, which is vast in area and inhabited by people having different customs and speaking various languages, had been very well recognised even in ancient times.

Arterial Roads in the Past

Major trunk roads received particular attention during the time of Chandra Gupta Maurya and Ashoka and later during the Pathan and Mughal periods. Sher Shah's role in the building of main highways is particularly important. Four of his roads are well known, one running from Sonargaon in East Bengal through Agra, Delhi, Lahore, on to Kabul, was known as **Sarak-i-Azam** (G. T. Road). The second ran from Agra to Burhanpur, the third from Agra to Jodhpur and Chittor, and the fourth from Lahore to Multan. All the roads connected important towns of the country through which they passed. Qanungo rightly observes that these "roads and sarais" were the arteries of the empire.

Roads appear to have been properly looked after during the Mughal period

but after the disintegration of that empire, the roads went into neglect until the British appeared on the scene.

British Period

To the British, the main roads were important strategically. The East India Company had placed the roads in charge of Provincial Military Boards. Later, Lord Bentinck took keen interest in the development of roads.

Means of communications were still not easy in those days, and there were few good roads connecting one part of the country with another. To Mr. Thomason, Lt. Governor of the N.W. F.P. from 1843 to 1853, is given the credit of having perceived the importance of good roads and of taking the initiative in the construction of metalled roads to connect different large cities throughout his jurisdiction. A trunk road to connect Calcutta with Upper Provinces was undertaken about the same time, and Lord Dalhousie who realised the value of good roads as few people then did, on military and on other grounds, pushed on vigorously the development of roads.

In 1855, a special Deptt. of Public Works was created by the Govt. of India, under Civil Administration with subordinate departments for Madras and

Bombay. The expenditure on public works then increased steadily.

roads, little attention was paid to inter-state and other roads.

Advent of Railways

Works of great magnitude like the G. T. road were undertaken by the new Deptt.; but, with the advent of Railways, such works were relegated to the background and attention was concentrated mainly on the construction of feeder roads to railways. In some cases, the trunk roads were allowed even to go out of repairs.

Gradually, roads came to be looked upon as a subject of local interest and

Jayakar Committee

The condition of roads deteriorated further. The Local Bodies with their limited financial and technical resources could not cope with the situation. As a result of strong public opinion, the Govt. of India appointed the Indian Road Development Committee under the Chairmanship of late Dr. M. R. Jayakar to examine the whole question. On the recommendation of this Committee, the Central Road Fund came into existence in 1929, which represents



GREAT SOUTHERN TRUNK ROAD, MADRAS

A view of mile 9 of the Great Southern Trunk road; built in 1931, it is still in excellent condition

importance only. The culmination of this process was reached in the Govt. of India Act, 1919, when the responsibility for roads was transferred from Central Govt. to Provincial Govts. which, in turn, placed the greater part of road mileage in the charge of Local Bodies. The result was that except for strategic

the first major step taken by the Central Govt. to promote road development in India.

Economic depression between the two World Wars, particularly during the thirties, slowed down road development from Provincial and Local revenues.

There was a time when the Road Fund became almost the main source of finance for road development. The deterioration of roads became so serious that, in some instances, the Road Fund had to be used, even for normal maintenance.

Trunk Road System

Discussions then took place between the Central and State Govts. regarding the development of a trunk road system and, in the middle of 1933, the Govt. of India proposed to the Secy. of State that provision might be made specifically in the Constitution Act then under contemplation to permit national trunk roads becoming, in some measure, a federal charge. Although it was recognised that eventually it might be necessary for the future federal legislature to enact a Federal Roads Act, no specific provision was made in the Govt. of India Act 1935 to cover Central interest in the development of arterial roads because of the emphasis on provincial autonomy at that time.

World War II, however, brought home the need and urgency of all-round development of roads, particularly the main highways. Lack of well-developed through routes, absence of bridges at important crossings and the fact that there was a limit to what the railways could carry, emphasised that the trunk roads could be properly developed only if the Centre took over their development and maintenance. That co-operation between the Centre and the States, and States and Local bodies each functioning in its own sphere, was productive of excellent results was also evident from the history of road development in other countries, notably in the U. S. A., France and Australia.

Nagpur Plan

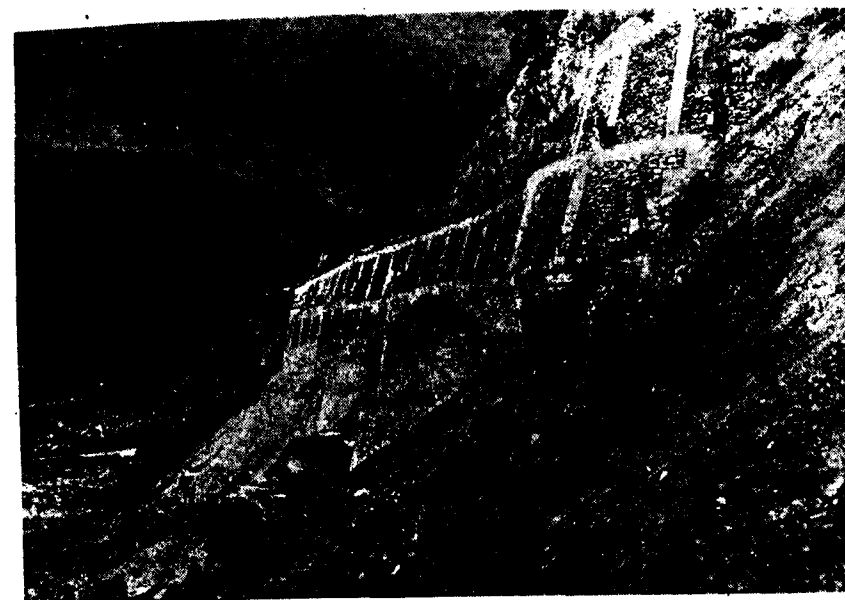
Towards the end of the Second World War, the Indian Roads Congress considered the post-war planning for road development and their Council passed a resolution classifying roads on an All-

India basis for the first time. At the instance of the Govt. of India, the Chief Engineers in charge of roads in the Centre and the States met in Dec. 1943 at Nagpur and drew up a Post-War Road Development Plan for India, popularly known as the Nagpur Plan, for catering to the needs of the country during the following 20 years. The main recommendation made in the Plan was the classification of roads into four broad categories, viz., National Highways, State Highways, Distt. Roads and Village Roads, the National Highways being defined as main highways running through the length and breadth of the country, connecting major ports, foreign highways and capitals of States. It was also recommended that the Central Govt. should assume complete financial liability for the construction and maintenance of roads accepted as National Highways.

National Highways

Fully conscious of the need for a major trunk road system in the country to integrate the various parts and to serve the national interests, in April 1947, the Govt. of India assumed complete financial liability for a network of roads provisionally accepted by them as National Highways. Under the new Constitution of India, national highways have become a Central subject. Accordingly, in 1956, the Govt. of India enacted the National Highways Act and statutorily took over the roads classified by them as National Highways. This legislation marks a great landmark in the history of National Highways in India.

The total mileage of roads in the present N. H. System is about 13,900. It includes the G. T. Road running from Calcutta to Amritsar via Banaras, Kanpur, Agra and Delhi, the Agra-Bombay road, the Bombay-Bangalore-Madras road, the Madras-Calcutta road, the Calcutta-Nagpur-Bombay road, the Banaras-Nagpur-Hyderabad-Bangalore-Cape Comorin road, the



A hill road under construction



Another hill road under construction

Delhi - Ahmedabad - Bombay road, the road from Ahmedabad to Kandla port with a branch road to Porbandar, the birth place of the Father of the Nation, the Hindustan - Tibet road from Ambala to Tibet border via Simla, the road from Delhi to Lucknow, Gorakhpur and

Muzzaffarpur with a branch road to the Nepal border, the Assam Access road, the Assam trunk road on the south bank of the Brahmaputra, and the road branching off from the Assam trunk road towards the Burma border through the State of Manipur.

When these roads were taken over as National Highways, there were not only long lengths of missing links but most of the big rivers were unbridged. The first need was to fill the gaps and to construct the missing bridges and the second was to improve the road surface which was generally earth or waterbound macadam. It was also found necessary to make provision for widening the carriageway, where urgently required, to meet the increased traffic needs.

Achievements

At the time of Independence in 1947, the National Highway routes had 1,600 miles of missing links, and thousands of missing culverts and bridges. Including about 150 major unbridged river crossings. About 9,000 miles of the road had low grade surfaces..

Upto the end of the first 5-yr Plan, a sum of Rs 34 crores was spent on the development of national highways. As a result, 746 miles of missing links and 33 major bridges were constructed, nearly 5,000 miles of existing sections improved and about 400 miles of improved sections widened to two-lane carriageway.

The second 5-year Plan as drawn up in 1956 included a provision of Rs 55 crores for the development of national highways. This has, however, been reduced to Rs 45 crores as a result of the re-appraisal of the plan resources. The targets proposed to be achieved against the revised provision are the construction of 700 miles of missing links, bypasses, etc., and 40 major bridges and the improvement of 3500 miles of existing sections.

Among the important works completed on national highways so far, mention may be made of the Barakar and Poon Poon bridges and the rail-road bridge over the Ganga near Mokameh, in Bihar, the Kathjuri and Kuakhai bridges in Orissa, the Mahi bridge in Bombay, the Pennar and Champavati

bridges in Andhra Pradesh, Pugalur and Palar bridges in Madras, Beyne and Ghagger bridges in the Punjab, Gheesh and Leesh bridges in W. Bengal, Bygool, Bhakra and Betwa bridges in U. P., the Chambal bridge near Dholpur in Madhya Pradesh.

Important works in progress include the construction of a motorable road from Narkanda to Chini on the Hindustan-Tibet Highway, an all-weather road from Bombay to Ahmedabad and road bridges over the Gautami-Godavari in Andhra, and Garhmukteshwar in U. P. Estimated to cost over a crore of rupees, the bridge over the Gautami-Godavari is one of the biggest prestressed concrete bridges under construction in India at present. It has 48 spans of 160 ft and the foundations go 100 ft below the bed level.

One important feature of the national highway scheme is the provision of bypasses around congested cities and towns for the benefit of through traffic. Such bypasses are under construction at Wellington (Calcutta), Ahmedabad, Ludhiana, Mathura, Kurnool and Madurai.

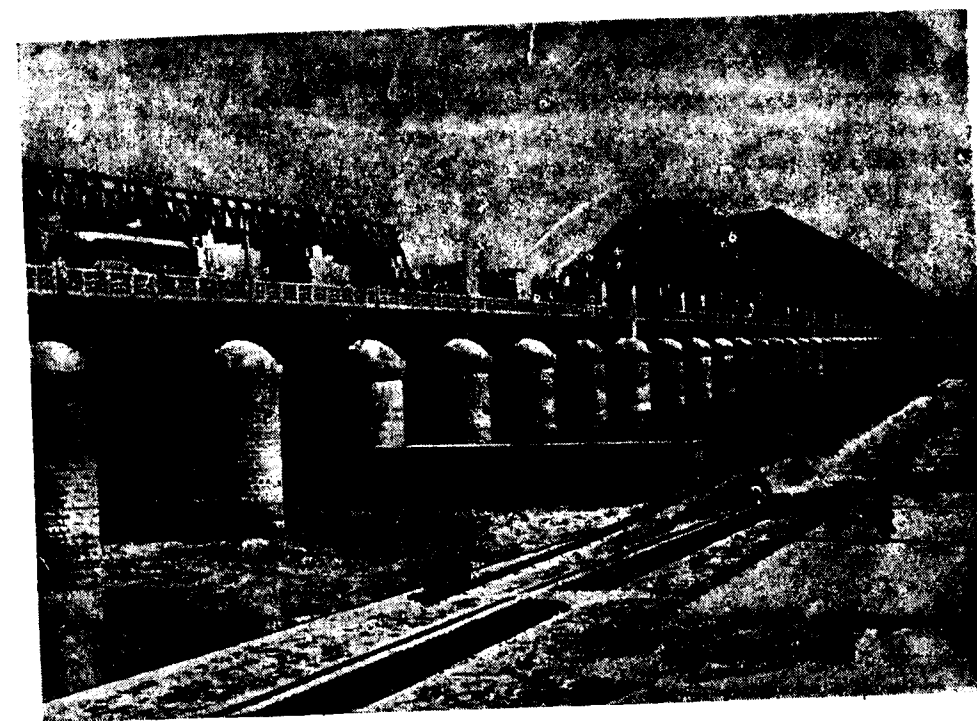
Another important work in progress on National Highways is the Jawahar Tunnel on the road to Srinagar. Estimated to cost nearly Rs 5 crores, the tunnel is intended to provide all-weather communication facilities between the Kashmir valley and the rest of the country. The western tube of the tunnel was thrown open to public in December 1958. Work on the eastern tube is expected to be completed by 1960.

Encroachment & Ribbon Development

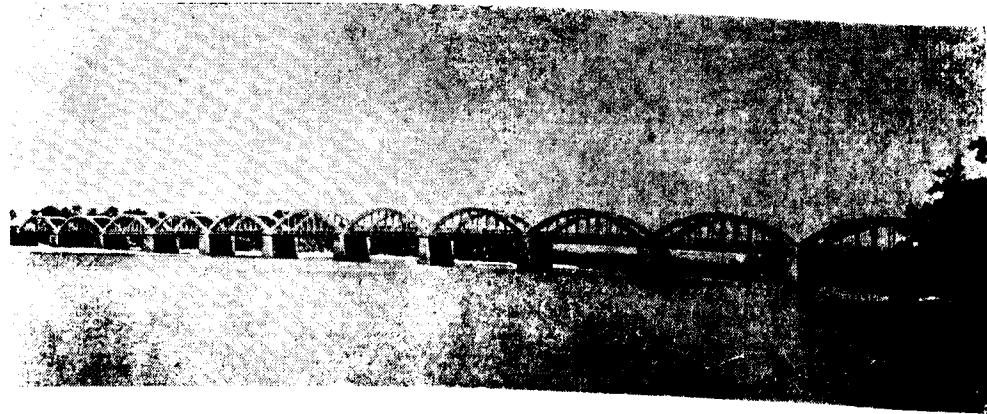
Problems relating to the prevention and removal of encroachments and restriction of ribbon development along National Highways are no less important than the construction of missing links and road bridges and the improvement of road surfaces. With the increase in the speed and intensity of traffic, both



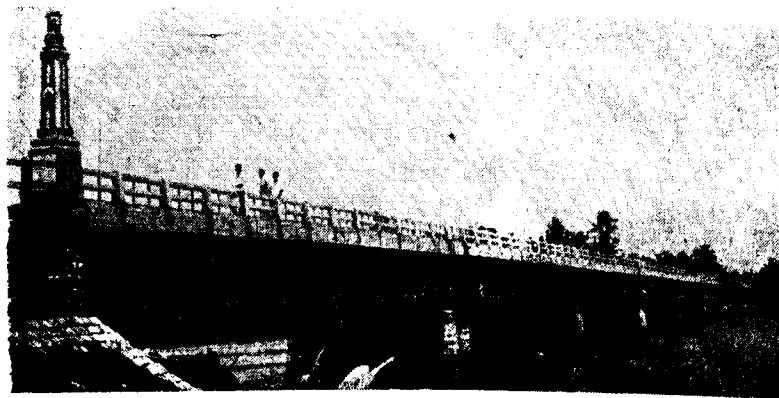
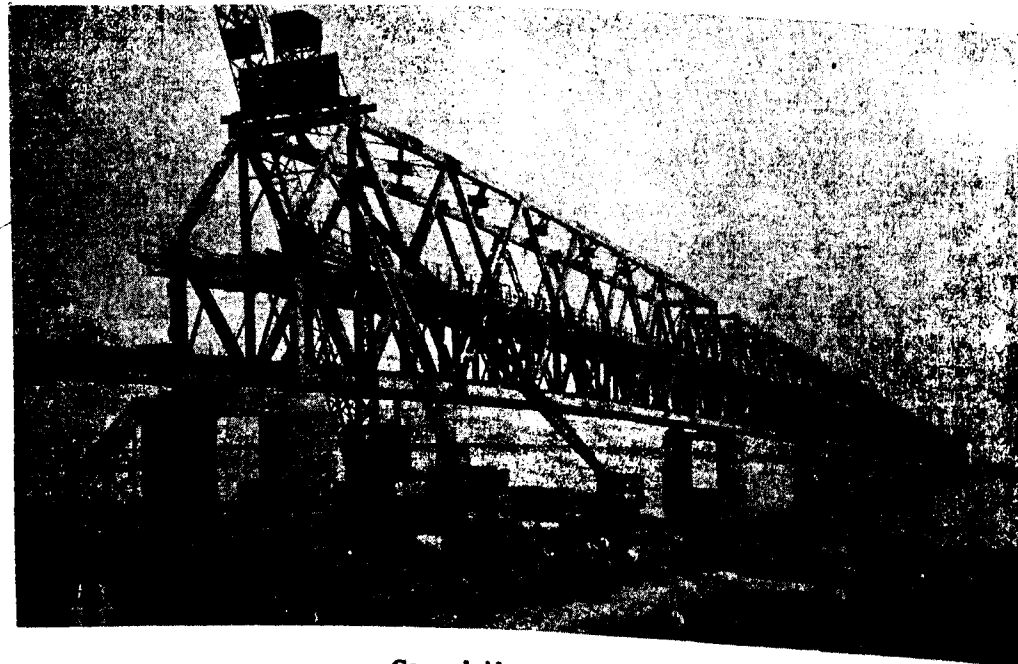
Mahanadi bridge at Sambalpur



Krishna bridge at Bezwada on N. H. No. 5—Madras-Calcutta road



Bharathapuzha bridge on West Coast road

Udyavar bridge at
mile 3/35 of
Mangalore-Balndur
Coast road

Ganga bridge at Mokameh



Kitchinia Bridge on Patna-Ranchi road

these problems need immediate attention. It is proposed to undertake Parliamentary legislation to tackle these problems. A departmental draft bill for the removal and prevention of encroachments on national highways has already been prepared and is now under the active consideration of Government. The subject of ribbon development falls under the State sphere of activities. In order, however, to ensure uniformity throughout the country, it is proposed to enact a Central legislation in this behalf under Article 252 of the Constitution. A departmental draft bill in this connection has been circulated to States for their comments and passing the necessary resolution as required under the Constitution.

Expansion of the N. H. System

The need for the expansion of the National Highways system, which is at present of an aggregate length of about 13,900 miles, has been keenly felt for

some time past in order to meet the growing needs of the country, the changed administrative requirements arising from the partition of the country, the integration of the former Princely States and the recent re-organisation of States. Owing to financial limitations, however, it has not been possible so far to expand the N. H. system in the current 5-year Plan. Let us hope that it will be possible to make a sizeable progress in this direction during the Third 5-Year Plan.

Twenty-Year Plan

Vast changes, political, economic and social have taken place since the Nagpur plan of 1943 was formulated. A new long-term road plan for catering to the needs of the country during the next 20 year period ending 1980-81 has now been prepared again by Chief Engineers in charge of roads in the Centre and States. Estimated to cost Rs 5,200 crores, the new plan envisages increasing

the present road mileage of about 28 miles per 100 sq. miles of area to 52 miles per 100 sq. miles of area in 1980-81. Such an expansion in the road system is absolutely necessary for providing communication to the remotest parts of the country. At the same time it cannot be ignored that the demand for road transport, even for long distance traffic will continuously increase with the result that all the arterial roads will require timely improvement and up-grading so as to cope with the growing traffic. The National Highways, being the primary artery, will receive most of this traffic. It has, therefore, been proposed to have an increase from 13,900 miles to 32,000 miles in the length of national highways in the country. This will provide a grid system over the entire country such that no place is at a distance of more than 40 to 60 miles from a National Highway. It is also envisaged that the entire length of the national highways proposed in the new Plan should be provided with minimum two lanes of black topped or other improved surface with bridges thereon designed to highest loading standard. The total N. H. length envisaged in the plan includes 1,000 miles of what are designated as "Expressways" intended to cater to heavy and fast-moving traffic in the highly industrialised and thickly populated areas. The plan is under the active consideration of Government.

Organisation

National Highways being a Central subject are being administered by the Government of India themselves. The execution of the work is, however, being done by the State P.W.Ds and, in some cases, by the Central P. W. D. The Govt.

of India control these works through the Roads Wing of the Department of Transport and help the State Govts. in solving the technical problems and other difficulties.

Apart from the combined Sectt. and Technical Organisation at the Centre, the Roads Wing has Liaison and Inspectorate Organisation consisting of Engineer Liaison Officers attached to Chief Engineers of various States. These officers make frequent inspections of road works in States financed by the Centre and these inspections are supplemented by other senior officers of the Roads Wing from time to time.

To Sum Up

This is thus a broad picture of the evolution of our N. H. system. It is true that we have yet to cover considerable ground, but we are certainly on a more firm footing today than ever before. We have today the largest National Highway network in the whole of Asia and this is a living monument to our unity and common culture. Nearly 80 per cent of the missing links and more than 50 per cent of the major bridges have already been constructed and over 80 per cent of the existing low grade surfaced sections improved. It is expected that, by the end of the Third 5-Year Plan, the entire length of the existing National Highways will be fully black topped and at no place the pavement width will be less than 12 feet. Let us hope that in years to come as our economy grows and our national income increases, more and more funds will become available for the development and expansion of our N. H. system and we will be able to provide an ideal arterial road system for the service of the country.



G. S. GANAPATHY
Chief Engineer,
(General)
Mysore state

ROAD DEVELOPMENT IN MYSORE STATE

INTRODUCTION

THE New Mysore State, as formed on the re-organisation of States, takes into its fold the scattered areas of Karnataka among different administrative units. It now consists of (a) the four Kannada districts of former Bombay State, (b) three Kannada districts of former Hyderabad State, (c) the South Kanara district and Kollegal Taluk of the former Madras State, (d) the Coorg district of former Part C State and (e) the whole of the former State of Mysore. It has nineteen revenue districts. The total area of the State is 74,860 sq. miles. The State is rich in natural resources, mineral, forest and water.

The State has a total road mileage of about 26,000 giving an intensity of 0.35 miles of road per sq. mile of area. It compares very favourably as regards road mileage with most of the other States in India. The Public Works Department of the State has about 17,000 miles of road, the local bodies like District Boards have about 8,000 miles of roads and the Forest Department has about 1,000 miles of roads (Fig. 1.). The State has 3,800 miles of road with either concrete or black topped surface, 12,400 miles of road with water-bound macadam surface and 10,000 miles of road with moorum or gravel surface. (Fig. 2 & 3.)

Though, on the whole, the State can boast of fairly good mileage of roads, the degree of development of different regions of the State is not quite satisfactory. The region of former Mysore State is the best developed area. Under the benevolent ruler of the State, the former State of Mysore was known for its progress in many fields. The intensity of road mileage in this region is about 0.50 miles per sq. mile of area which is almost equal to the target for the whole of India at the end of the Second All-India Road Plan (1961-81). The regions of South Kanara District and Coorg are fairly well served with roads, but the major need in this area is of cross drainage works. The regions of Bombay Karnatak and Hyderabad Karnatak are comparatively poor in roads, the Hyderabad Karnatak being the poorer of the two.

Geographically, the State can be broadly divided into two regions: (a) Malnad region and (b) Maidan region. Malnad region has generally heavy rainfall. It comprises the Western Ghat section and the coastal region of the State. The rainfall intensity of the region varies from 60 in. to 250 in. at the peaks of Western Ghats. The heavy rainfall, the swiftly flowing rivers, the uncongenial climate of the area and the sparse population present a number of problems in the area. The soil is rich

Acc No. 1650
Dt 20.12.77

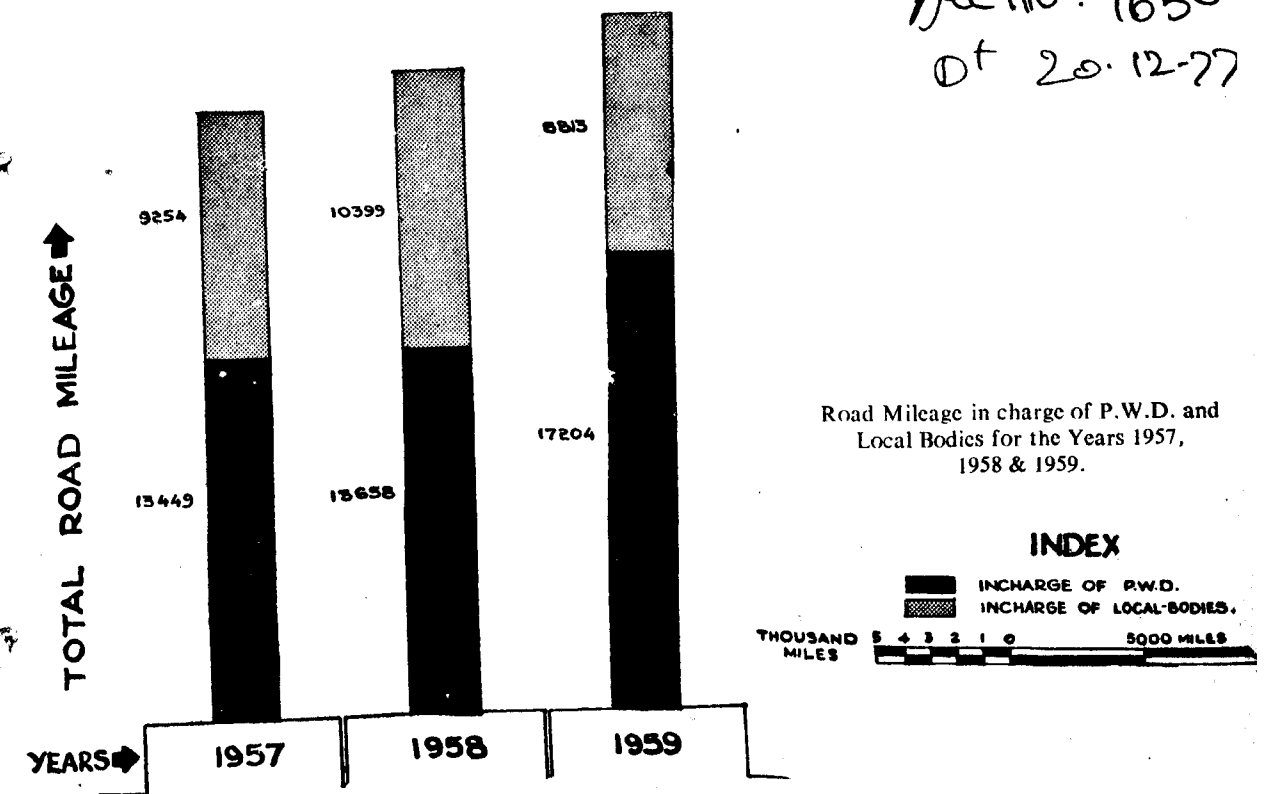
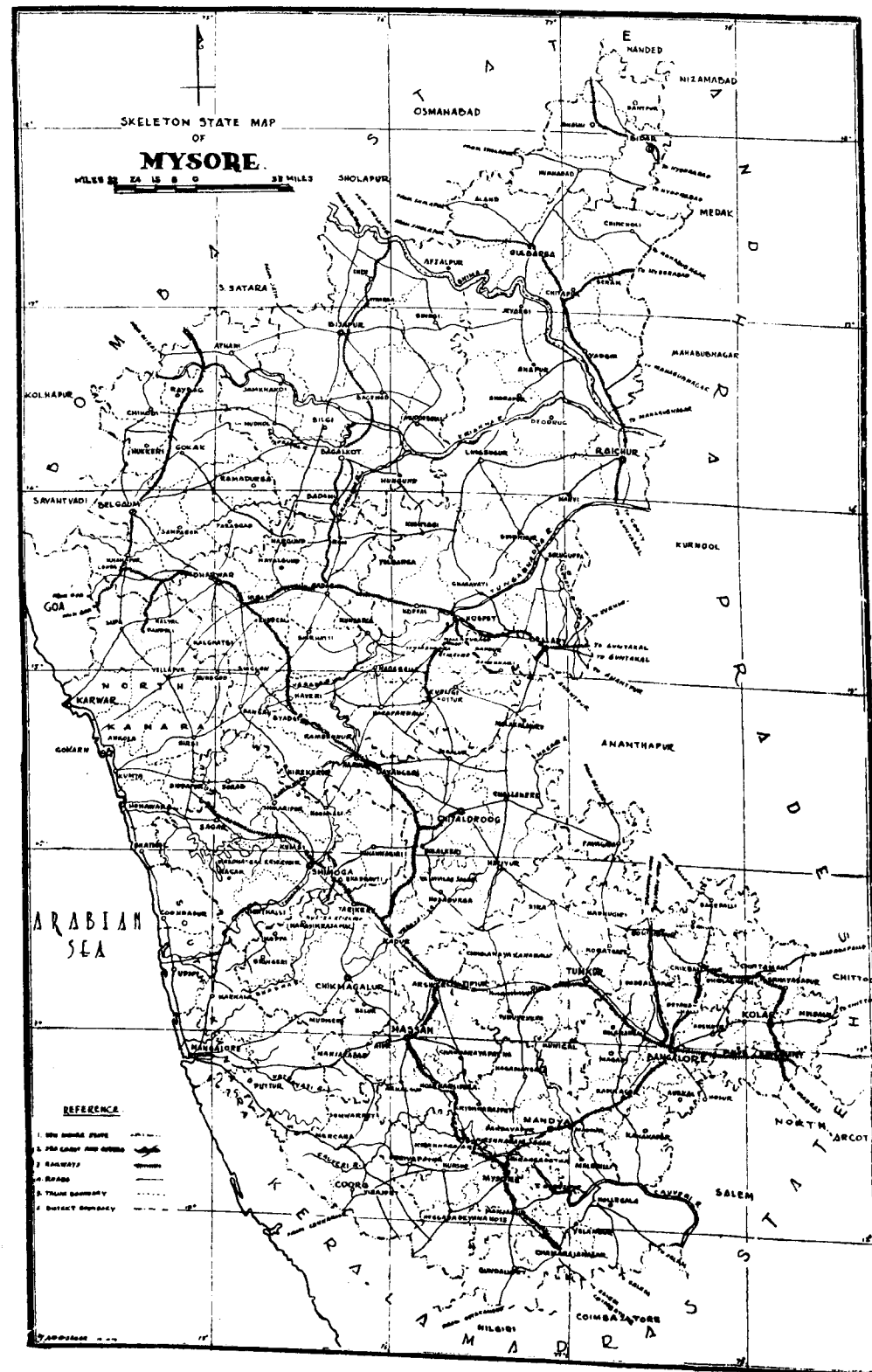


Fig. 1.

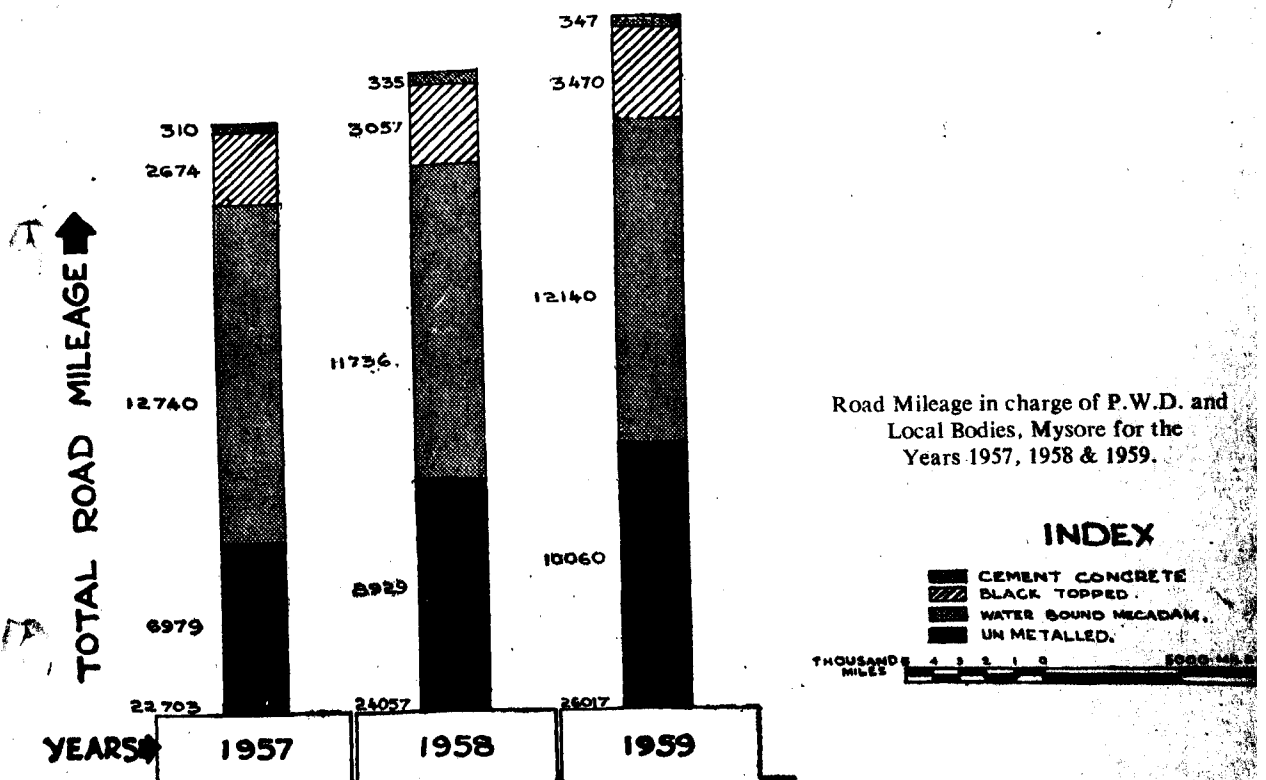
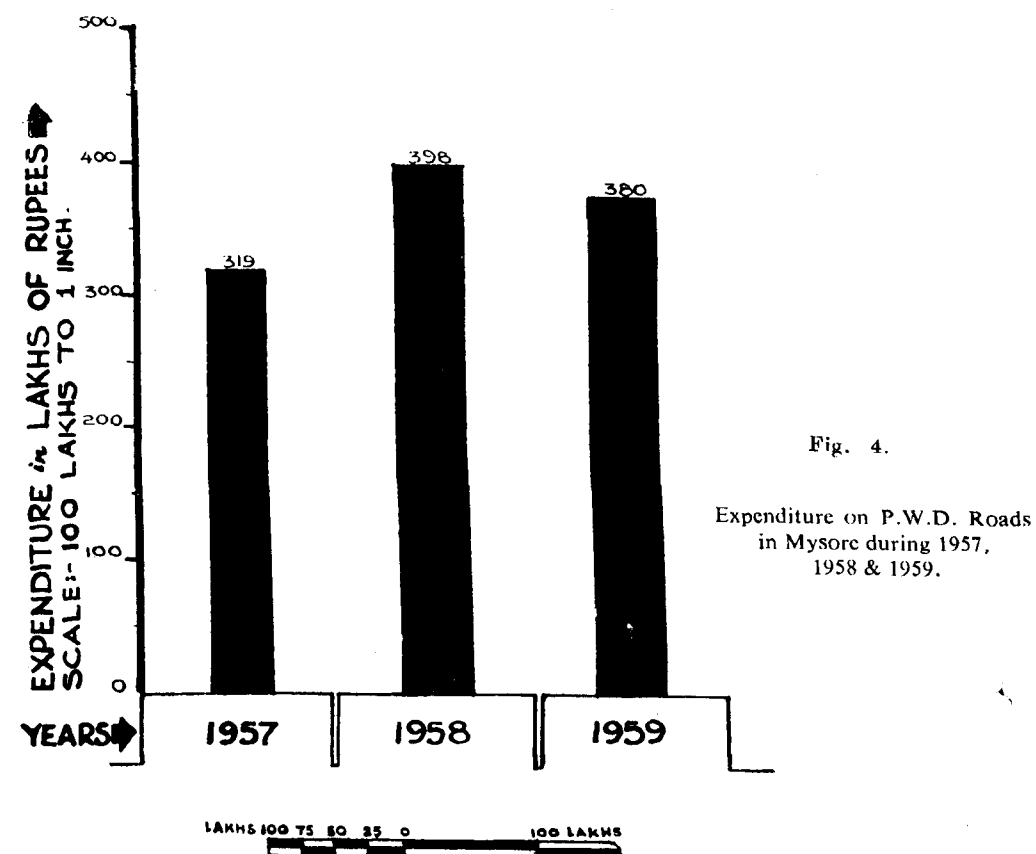
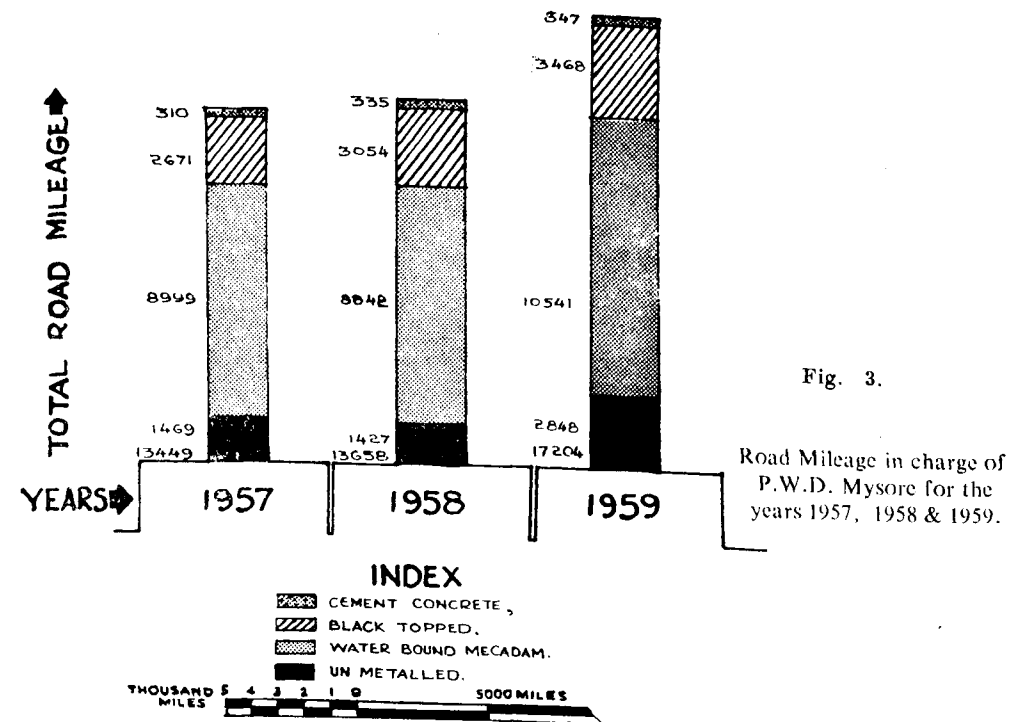
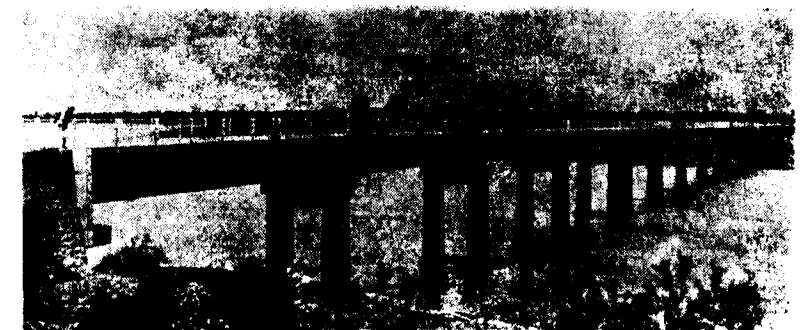


Fig. 2.



Bridge across the river Cauvery near Bannur



Bridge across the river Bhima near Jewargi

and the forest wealth is immense. The roads in this region have two main needs : (a) cross-drainage works on the roads and (b) proper maintenance of roads under conditions of heavy rainfall. The region of Maidan is mostly flat country cut across by major rivers like the Krishna, the Tungabhadra and the Cauvery. Nearly half of this area has black cotton soil.

PLAN PROGRAMMES

The Second Five-Year Plan of Mysore State was considerably affected by the re-organisation of the State. A portion of the Plan of the different regions had to be recast to reorientate the Plan to the changed conditions of the State.

The re-organisation of the State brought in a number of administrative problems. Now most of the problems are solved and considerable progress is made in the Second Plan programme. (Fig. 4). The State Plan provides about Rs 700.00 lakhs for roads, of which about Rs 500.00 lakhs will be spent by the end of 1959-60. It is expected that at least 90 per cent of the programme will be fulfilled in the Plan period.

The Third Plan proposes an outlay of Rs 12.00 crores on roads, of which Rs 3.00 crores are for bridges, Rs 3.00 crores are for providing black-topped surface to roads and Rs. 3.00 crores for rural roads including those in the

Malnad region of the State and the areas under major irrigation schemes.

The recast Second Plan and the draft Third Plan endeavour to improve the road facilities in the regions of the State which are poor in communication. A large number of roads and bridges are under construction to connect District Headquarters to the State Capital at Bangalore and to connect Taluk Headquarters to District Headquarters and to important centres of economic, social and religious activities.

Special efforts are being made to improve the roads by providing black-topped surface of $\frac{3}{4}$ in. premix carpet to roads. Not only all available savings in Plan programme are diverted for this programme, but 25 per cent of repair grants are also diverted for this purpose. Each Circle has a programme for black-topping the roads; out of this 25 per cent is for repair grants. In this programme also, as in other programmes, the regions of the State with poor mileage of black-topped roads, are given special consideration.

Along with other States, Mysore is also working on the twenty-year Road Programme within the frame work of the All-India Road Plan, 1961-81. It is estimated that this programme will cost about Rs 75.00 crores.

The roads in the Mysore State are not yet classified in all the regions according to the classification adopted in the "Nagpur Plan." The roads in the four Districts of Bombay Karnatak and the roads in South Kanara District are classified according to the "Nagpur Plan." The organisation created for the preparation of District Road Maps on the lines decided by the Conference of Chief Engineers in Hyderabad in January 1959, is also entrusted with the task of re-classifying the roads. The work is making good progress.

The State has, as in other States, its

own programme under various Central aids, such as the Central Road Fund. The outstanding programmes are (1) West Coast road and (2) improving the roads connecting mineral ore areas to ports on West Coast.

The West Coast road is a part of the programme of improving the West Coast road from Bombay to Kanyakumari. The State has about 150 miles of West Coast road, parallel and close to the West Coast. It starts from Ankola in North Kanara District and ends in South Kanara District at Mysore-Kerala border.

The programme consists of improving the road to have 32 ft of formation width with 12 ft wide black-topped surface of $\frac{3}{4}$ in. premix carpet, providing high level bridges designed for I.R.C. Class 'A' load. This road crosses some very wide rivers, the bridges on which pose a number of technical problems.

The road has 14 major bridges, of which (1) the bridge across Sharavathi river near Honavar in North Kanara District (Rs 60.00 lakhs), (2) the bridge across Gangoli river near Coondapur in South Kanara District (Rs 100.00 lakhs), and (3) the bridge across the Netravati river near Mangalore in South Kanara District (Rs 60.00 lakhs) are the biggest. The other bridges range from Rs 8.00 lakhs to Rs 25.00 lakhs in cost. Besides, there are some major bridges which are weak and need reconstruction.

The West Coast road programme is estimated to cost Rs 5.00 crores—Rs 3.30 crores for bridges and Rs 1.50 crores for roads. The works in this programme are in full swing, except the above three big bridges. The works on Netravati bridge is likely to start before the end of 1959-60 and that on Gangoli river by November 1960-61. The proposal of Sharavathi bridge is under investigation.

The programme of improving the roads connecting mineral ore areas to ports on West Coast is a Central Aid Programme, sponsored by the State Trading Corporation of India. There are large and rich deposits of iron and manganese ore in the eastern part of the State. These ores are now a rich source for earning much needed foreign exchange. The ore is transported by road to the ports on West Coast from which place they are exported abroad. At present four roads are selected—(1) Londa Karwar Road (Rs 96.00 lakhs), (2) Hubli Karwar Road (Rs 7.00 lakhs), (3) Jog Honavar Road (Rs 39.00 lakhs) and (4) Banasandra Mangalore Road (Rs 45.00 lakhs). The works on different sections are in progress. The roads are to be improved to have a 32 ft wide formation width, 12 ft wide blacktopped surface of $\frac{3}{4}$ in. premix carpet. The weak cross-drainage works are to be strengthened to carry a prescribed 8-ton laden weight of traffic. The programme is estimated to cost about Rs 2.00 crores in which the Centre will assist to an extent of Rs 186.00 lakhs. The programme is proposed to be completed by end of 1960-61.

RURAL ROADS

Civilization, it is said, spreads with roads. The saying underlines the importance of rural roads in the overall communication plan. In this country with the bulk of its population living in villages, the necessity for rural roads cannot be overstressed.

Since Post-Independence period, there is considerable popular activity in the development of rural areas. Several miles of roads are built by Shramadan and under the Community Development and National Extension Service Schemes. Sometimes, the roads were incomplete and had missing links. It is the experience of all the States that no agency was fixed for maintenance of these roads. The Government of Mysore have recently

taken policy decisions regarding the agency for maintenance of such roads and have also decided that the incomplete roads be completed and missing links provided by the Public Works Department as a part of the Plan Programme. A programme is prepared and is under implementation this year. It is estimated to cost about Rs 30.00 lakhs.

There are several villages in the State which need roads to connect them to the main highways. Government have recently decided to construct these rural roads in the next five years (from 1959-60) at an estimated cost of Rs 1,200 lakhs. A programme for 1959-60 and 1960-61 has been prepared and is being implemented.

There are a large number of roads in the State in the charge of local bodies like the District Boards. The financial resources of the local bodies are too poor to maintain the roads to proper standard and to improve them further. As a first step to improving these roads, the Government have recently transferred about 3,600 miles of important roads from the District Bodies to the Public Works Department for maintenance as State Roads. These roads are to be improved comprehensively in three stages, viz., (1) improvements to surface, (2) constructing culverts and minor bridges and (3) constructing major bridges.

It has been decided to abolish District Boards and form Village Panchayats and Taluk Boards. As a result of this scheme, another about 3,000 miles of important roads, will be taken over from the Local Bodies by the State.

Besides, in order to improve non-P.W.D. roads, the Government have decided that all bridges (cross-drainage works with linear waterway of 20 ft and more) on non-P.W.D. roads should be constructed by the Public Works Department. A programme of Rs 3.00 crores

has been prepared and will be taken up for implementation shortly as a part of the Plan Programme.

Another important scheme for improving communication facilities in the rural areas is the Malnad Development Scheme. As already stated, Malnad has problems peculiar to the region. The Government is advised by the Malnad Development Board on the needs of Malnad. As a part of this programme, a scheme is prepared for communication in Malnad area. The various rural road programmes draw upon this scheme for Malnad Area. Specific provision is also included in the draft Third Plan for communication in this area.

Besides these major schemes, there is a scheme of improving communications in the Sugar factory areas in the State from Sugarcane Cess Fund. The Government have decided that about 75 per cent of the nett realisation of the Fund should be allocated for communications.

ORGANISATION

The State Public Works Department is entrusted with all the Civil works of the State. It executes all building works required for the administration of other Departments also. The Department was recently reorganised. The State now has

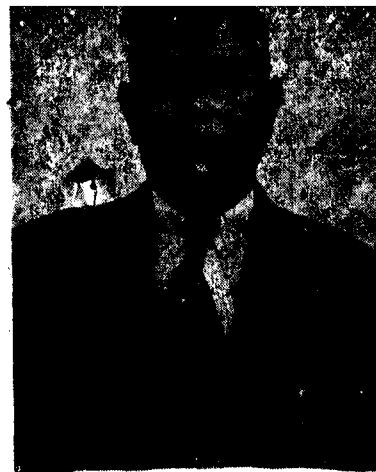
three Civil Chief Engineers—Chief Engineer for Roads and Buildings, Chief Engineer for Irrigation and Public Health, and Chief Engineer, Irrigation Projects. Each Chief Engineer has, since very recently, a Design Section. The Circles and Divisions execute all the Civil works—of course there are Special Divisions for schemes wherever work-load demands. All Divisions and Circles are in charge of roads, buildings, irrigation and public health engineering works. An average work-load for a Division is fixed at Rs 40.00 lakhs and an average work-load for a Sub Division is fixed at Rs 8.00 lakhs. The Executive Engineer of a Division, the work-load of which exceeds Rs 45.00 lakhs, is assisted by a Personal Assistant of the rank of Assistant Engineer.

The State spends about 14 per cent of the total State Budget on works executed by the Public Works Department. Of this, about 33 per cent is spent on roads. The allocation of roads is increasing year by year.

The State has an Irrigation Research Station. Recently, Government have approved of the creation of a Roads Wing in this Research Station. This Wing is expected to work in close collaboration with the Central Road Research Institute.

"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 out vast areas of this country which are closed up to day and which you cannot reach unless you walk or ride...I give roads first priority."

—SHRI JAWAHARLAL NEHRU.



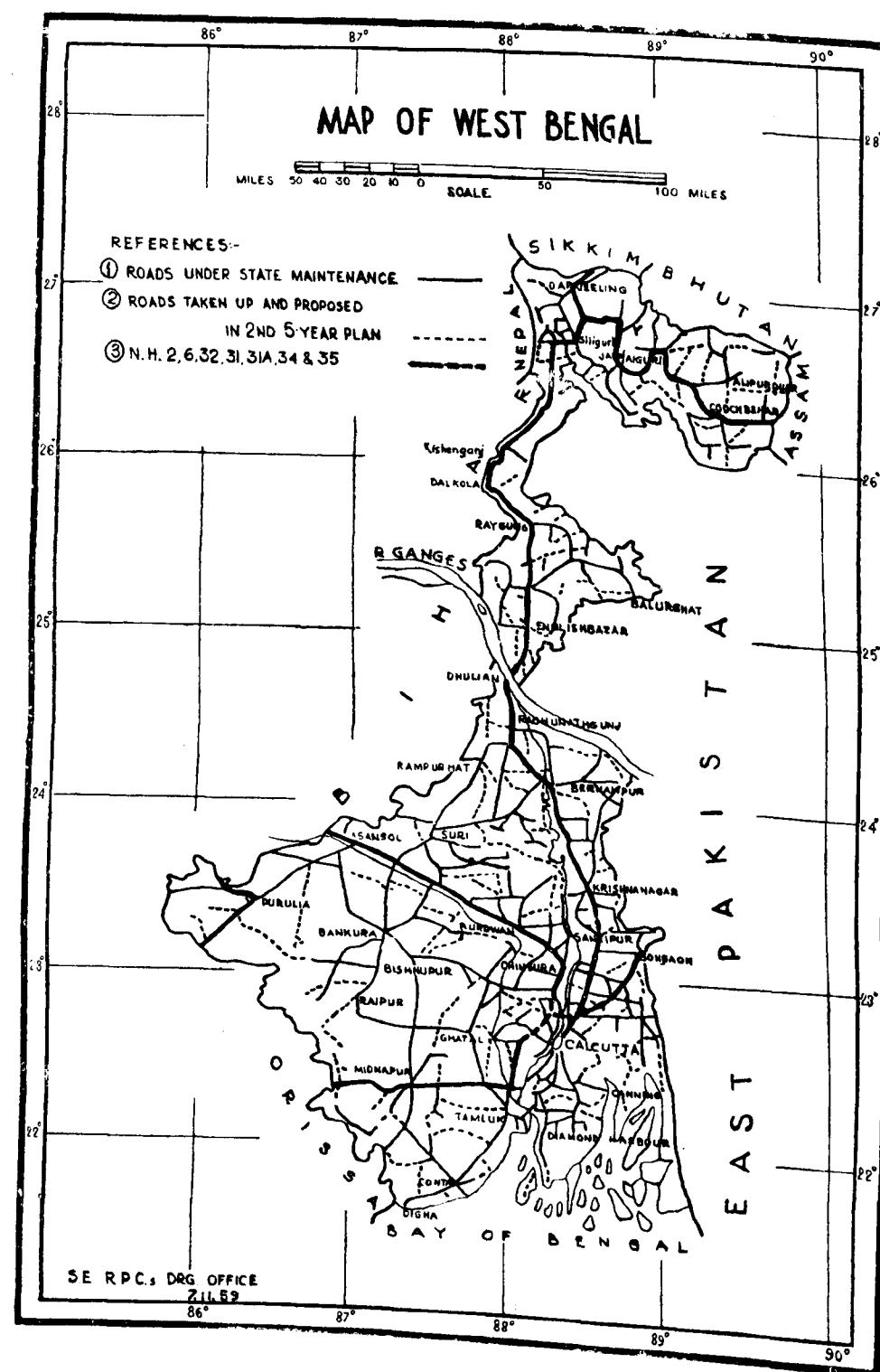
R. C. ROY, B.Sc., B.E.,
Chief Engineer (Road Development),
West Bengal.

ROADS IN WEST BENGAL

THE State of West Bengal emerged after the Partition of 1947 in three separate geographical blocks unconnected with one another. Two-thirds of old Bengal went to Pakistan and a number of administrative districts on the border were themselves partitioned. Age-old routes of trade and traffic were thus disrupted, presenting difficult problems of communication. In 1956, however, as per recommendations of the State Reorganisation Committee, a narrow strip connecting the northern-most block to that of the central one was awarded to West Bengal. Similarly, a part of the Purulia District was transferred to West Bengal from Bihar. The area of West Bengal, after the transfer of some territories from Bihar, stands at 34,169 sq. miles. The present population is a little over 237 lakhs.

On account of the wide variety in the composition of the soil of West Bengal as also the differences in annual rainfall and annual flood levels in various regions, techniques in road construction and the types of materials used in road-building have to be altered to suit local conditions. In the hilly highlands of the Northern region, stone, gravel and shingle are locally available in large quantities. Consequently, stone boulders are used for the foundations, stone metal and shingle are laid as interme-

mediate course and the surface is dressed with bitumen or road tar. In the alluvial plains of the Central region, traversed by many rivers generally flowing from north to south, high embankments are necessary to keep the road above the flood level. Brick is the only material available for the construction of roads in this region, though small quantities of boulders, stones and shingle can be carried from the northern region or from Rajmahal side. The Southern region of the State comprises the high lands in the western border and the deltaic area of new alluvium deposits. The soil in the highlands is hard and contains a high percentage of moorum. Here road construction is not a very difficult or costly problem. But in the deltaic area, the soil is made up of silt and clay. There is very little sand admixture and this makes the soil plastic-hard when dry and muddy and soft when wet. Road construction in such soil is expensive as the roads here would require thick pavements and foundations to bear traffic. High embankment is also essential to keep the foundations free from water. Besides, the whole area is criss-crossed by many big rivers and their tributaries and distributaries to such an extent that it may be well termed a net-work of waterways. Consequently, "through" roads have to make provision for a large number of



bridges, major and minor. Large openings and waterways for culverts and the like have also to be provided to ensure proper drainage in the country-side.

ROAD PLANNING

Planning for road development in this State dates back to the time of Mr. A. J. King, a Superintending Engineer under the Government of Bengal. In the thirties of this century, Mr. King made a detailed investigation into the conditions of road communication then existing in Bengal. Thereafter, he formulated a plan for a complete and continuous road system in the province. His scheme took into consideration the necessity for making use to the greatest possible extent of the existing roads, both metalled and unmetalled, and providing other roads to act as feeders to existing trunk and metalled roads. His scheme also avoided, as far as possible, selection of roads likely to compete with railways and steamer services. Mr. King envisaged four different classes of roads to make a complete system for the whole province on integration: (A)—The Trunk Roads to provide through communication by reasonably direct routes across the entire area of the province connecting the headquarters of all districts; (B)—Inter-district Main Roads to connect headquarters of neighbouring districts by routes more direct than those provided by the Trunk Roads; (C) and (D)—The District Main and the District Secondary Roads to provide communications further into the interior. His plan also included construction of independent feeder roads connecting railway and steamer services. Mr. King submitted his complete report to the Provincial Govt. early in 1939. But before Government could have sufficient time to examine the financial and administrative implications of Mr. King's plan, the War came and shelved everything for the time being.

The entire road system of the

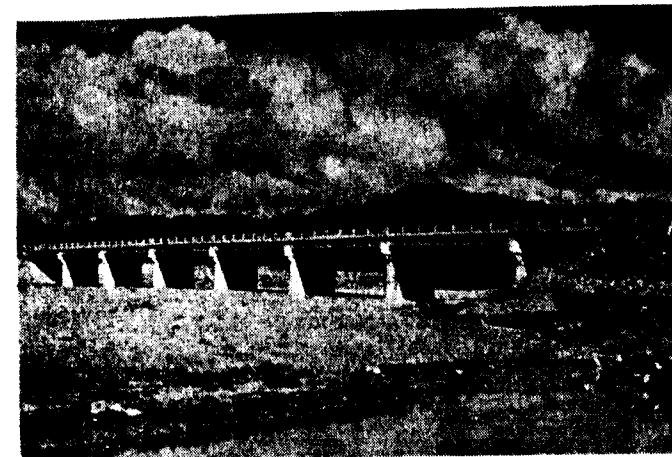
province was subjected to severe strain during the War period and its defects were exposed. The Government of India had now decided to assume a direct role in the formulation of a comprehensive road-plan for the country as a whole and the Conference of Chief Engineers convened by the Government of India in December 1943 produced the famous Nagpur Plan.

The classification adopted in the Nagpur Plan was substantially the same as Mr. King's. The Trunk Roads and Inter-district Main Roads of Mr. King were analogous to the National and Provincial Highways; and the District Main and the District Secondary Roads to the Major and Other District Roads. Mr. King's plan for Bengal was then subjected to revision in the light of the Nagpur Plan, and in 1946 the finalised Plan of an integrated road-system in the State was ready. The impending constitutional changes, however, held up further progress and things remained at a standstill until after the Partition of 1947.

The partition of Bengal brought additional problems for certain areas bordering on East Pakistan which were virtually cut off from the rest of the State for want of proper road communications. Quick integration of these areas with the normal trade channels of West Bengal became necessary. Administrative problems were equally intriguing. The task of policing a 600 mile long border on East Pakistan for enforcement of land customs to prevent smuggling of dutiable and contraband goods across the frontiers cropped up. Police stations on the border areas had to be connected with each other and with the subdivisional and district headquarters by a net-work of all-weather roads. The management of ferries by private contractors was inefficient. Proposals were, therefore, included in the Government's programme for the gradual taking over of ferries butting on roads and making necessary arrangements for

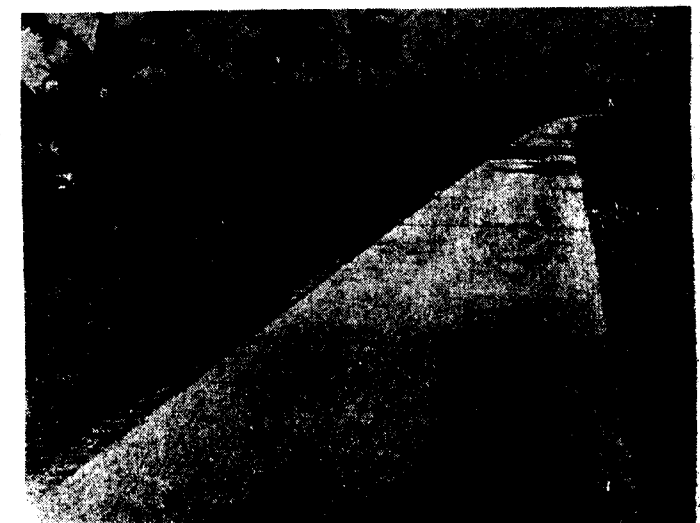


Gheesh bridge in the
district of Jalpaiguri

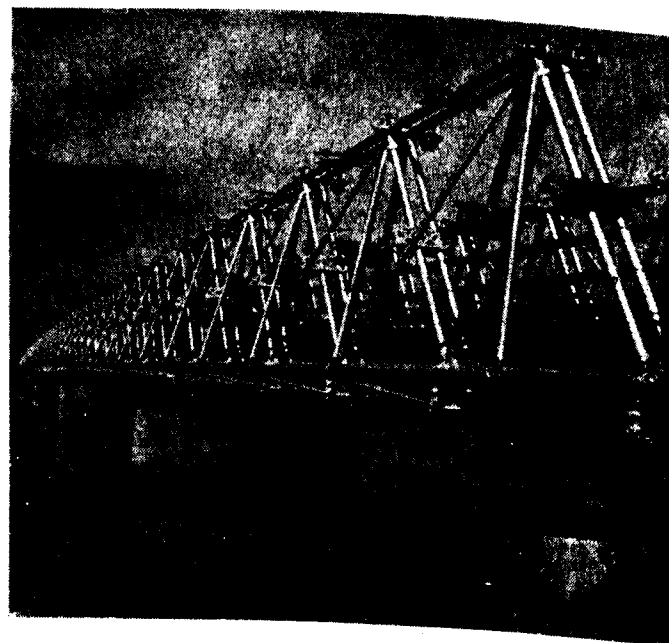


Leesh bridge (in prestressed
concrete) in the district
of Jalpaiguri

Cement Concrete Roadway
—Krishnagar Berhampore
Section



Punarbhava bridge
in the district of
West Dinajpur



Bridge over the Darakeswar
in the district of Bankura,
(West Bengal)

improving the approaches and providing boats of adequate capacity for ferrying cars and lorries fully loaded. All these requirements had to be incorporated in the Post-Partition Road Plan adopted by the Government of West Bengal.

At the time of Partition in 1947, the State Government had only, 1,181 miles of roads under its direct control. All other roads were in charge of the "local bodies". The District Boards had in their charge 2,079 miles of low-grade metalled roads and 15,890 miles of unmetalled roads. Another 2,300 miles, half of which were metalled roads of low specifications, belonged to the municipalities. The Union Boards were in charge of the residuary mileage of *kutchha* roads. Repairs and maintenance of these roads, with bridges and ferries falling on them, have been the statutory responsibility of these "local bodies"; and they have also been responsible for the construction of new roads, bridges, etc., in their respective fields of operation. These "local bodies" with their meagre and inelastic resources were never equal to the task.

FIRST FIVE-YEAR PLAN

The Government, therefore, undertook a direct programme for road development under the Five-Year Plans. During 1948-51, before the formal commencement of the First Five-Year Plan, the Government took over a large number of roads from the "local bodies" and a total amount of nearly Rs 7 crores was spent for their development. When the First Five-Year Plan was finalized in 1951, the works programme under this Plan included new construction and/or improvement of 1,724 miles of State Roads within a ceiling of expenditure of Rs 13.85 crores for the five-year period, 1951-56. Besides this programme for State Road Development under the First Five-Year Plan, works were simultaneously taken up for the development of 251 miles of National Highways directly financed

by the Government of India and of 310 miles of other roads financed from the Cooch-Bihar Development Fund, from the State's share of allocations from the Central Road Fund and from other allotments made from the State's own revenue resources. As works proceeded, the Plan was adjusted and expanded within the limit of funds available, and new mileages were added. Additional works were taken up with the help of new accruals from the Central Road Fund, and grants-in-aid were received from the Government of India for the improvement of some roads in the Sundarvans and, later, for the improvement of a number of roads of inter-State or special economic importance.

Starting with a modest programme, road development works were gradually expanded, till at the end of 1955-56, the programme in West Bengal, under the First Five-Year Plan and various other schemes, covered a total of nearly 3,000 miles of roads including the National Highway sections. Every year, nearly 350 miles of completed sections of roadways with black-top or cemented surface are being made available for community use. Other mileages completed upto the water-bound macadam stage are also being thrown open to traffic, even while further works for surface-dressing continue on these roads. Still others are being improved up to the *kutchha* stage awaiting further improvement. In this way at the end of 1955-56, 1,531 miles of roads were completed with black-top or cemented surface, 662 miles up to the water-bound macadam stage, while nearly 800 miles of other roads were in various stages of construction. All these part-finished roads were carried over for completion during the Second Five-Year period side by side with new roads included in that Plan.

SECOND FIVE-YEAR PLAN

The Second Five-Year Plan commencing from 1956-57 embraced a

programme of road construction estimated at Rs 26.50 crores. Out of this, the spill-over work accounts for Rs 5.33 crores and the balance for new works. In addition, a supplementary plan estimated at Rs 61.66 lakhs has been drawn up for the improvement of road-system in the territories transferred from Bihar to West Bengal. The ceiling of expenditure for the plan-period 1956-61 has, however, been fixed at Rs 17.48 crores (including Rs 37.69 lakhs for the transferred territories). The plan provides for the construction and improvement of 3,700 miles of roads including 1,400 miles carried over from the first plan for completion. The mileage of new roads taken up in the second plan thus stands at 2,300 of which 108 miles are in respect of the transferred territories. This is exclusive of 35.6 miles of National Highways taken up during the period. Simultaneously, other roads have been taken up out of the allocations to this State from Central Road Fund. In the first three years of the second plan, about 1,200 miles of State roads and 100 miles of National Highways were completed to surface-stage in addition to other mileages at various stages of construction. About 10,000 rft of bridges, some of which are major works were also completed during this period. The total mileage of roads under the control of Government at the end of 1958-59 was 5,500. This figure is expected to go up to 7,200 miles at the end of the Second Five-Year Plan period.

BRIDGES

A large number of bridges and culverts both on the National Highways and State roads have been completed or are under construction. The more important of these are: bridges over the Raidak, Gadadhar and Kaljani in Cooch Behar district; over the Gheesh and Leesh and Buri Teesta in Jalpaiguri; over the Kulik, Gandhar, Nagar, Buri Mahananda, Tangon, Punarbhaba and Atrai in West Dinajpur; Bhagirathi, Tutia-

nala, Pagla and Behula in Malda; over the Akheri, Falgu and Sealmar in Murshidabad; the Mayurakshi, Chandra-bhaga, Deucha and Bakreswar bridges in Birbhum; the Ajoy and Khari bridges in Burdwan; the Dwarakeswar, Beril and Sali bridges in Bankura; the Jallangi and Paglachandi bridges in Nadia; the Gaighata and Diamond Harbour bridges in 24-Parganas; the Satmile and Dulong bridges in Midnapore; the Saraswati and Kunti bridges in Hooghly and the Damodar bridge in Howrah district.

SPECIAL PROBLEMS

The peculiar and diverse geographical and geological pattern of this State has presented a number of problems from the view point of establishment of communications, some of which are indicated below:

- (i) Poor bearing capacity of the subsoil;
- (ii) Too many active streams, many of which change their courses too frequently;
- (iii) Submergence of the country for several months in a year;
- (iv) Low lying pockets in the country-side which do not dry up at all;
- (v) Excessive rainfall;
- (vi) Non-availability of hard stone suitable for road-metal in major portion of the State;
- (vii) High density of population with innumerable non-acquirable plots, such as, cremation and burial grounds, temples, and mosques, dotted all over the country;
- (viii) Location of the northern half of the State in the seismic zone.

All these problems make comprehensive road-planning very intricate and

construction highly expensive. Bridges are to be made not only very long but must also be provided with deep foundations, adequate protective works and training of the rivers. Provision of high road-embankment needs proper compaction and soil treatment. On account of high density of population, road alignments have to pass generally through built-up areas, requiring acquisition of homestead lands and structures. This makes land acquisition not only very costly but also a lengthy process. In many cases, observance of proper geometrics in fixing alignments has been rendered difficult owing to presence of many non-acquirable plots of land on the route. In certain urban areas, large habitations have grown up along old important roads. The Grand Trunk Road, for example, from Howrah to Burdwan has become congested by buildings constructed all along the roadside. This hampers the scope of widening to suit the needs of modern traffic and increases the risk of accidents. Some effective steps are essential for the control of the building lines, road-land boundaries, prevention of encroachment, traffic regulation in rural areas and the like. The attention of Government has been attracted in this direction and they are actively considering the ways and means to solve the problem.

The soil in West Bengal being silty clay and in some parts mainly clay, it is difficult to maintain earth roads for service in all weathers. But now the technique of "soil stabilisation", both mechanical and with cement or lime, is being progressively used mainly as a

base course for the present. With a view to carrying out experiments on these lines, a Research Institute has been functioning in West Bengal. The results obtained at the Institute through laboratory tests and field experiments are encouraging. A "Road Test Track" is also run for conducting experiments on different specifications which can be adopted in the field. This is financed by the Government of India. The results of experiments have helped in effecting great savings in the cost of road construction in the State. It is hoped that this Test Track will continue to play its useful role in future.

The role of communications in an integrated plan of development can hardly be over-emphasised. An improved road system which quickens the correspondence between production and exchange is the vital, activating principle of an advancing economy. Large increase in production envisaged by the various plans of development can be pressed to the service of an expansive economy only through the help of improved transport arrangements, operating on an improved system of road communications. It is, therefore, natural that road development has been assuming an increasingly important position in the five-year development plans. It is also a good sign that the people are becoming more and more road-conscious and, appreciating the limitations under which the road programme is being implemented in this State, are extending their hands for co-operation wherever necessary.

"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



S. C. NAYAK, M.I.E. (Ind.)

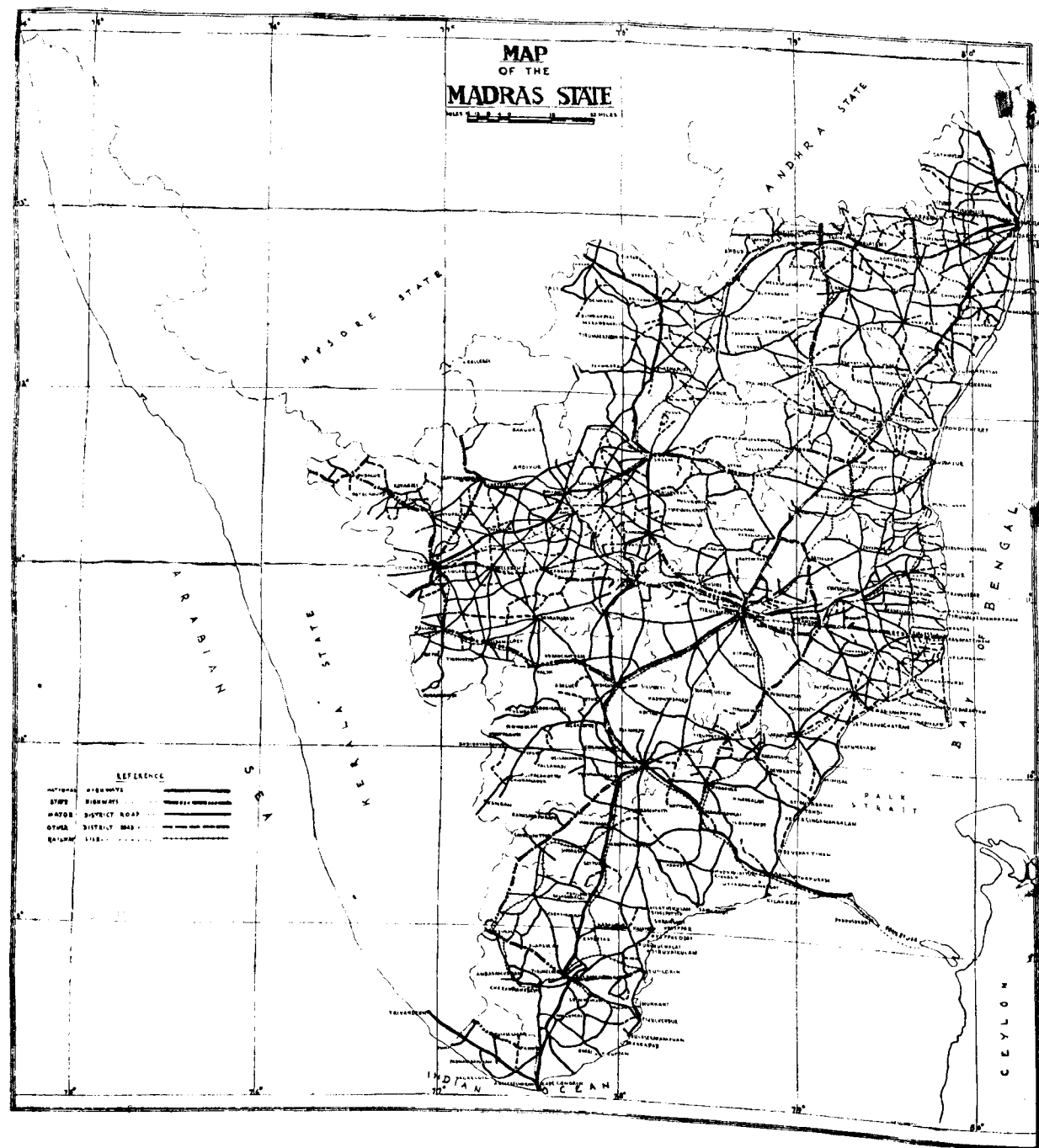
Chief Engineer (Highways), Madras.

ROAD DEVELOPMENT IN MADRAS STATE

NATURE in its inscrutable language reveals from time to time a few of its secrets in some of its manifestations and man follows them up and endeavours to master them. It has been a race between man and nature through the ages. It is in this race that man, in his urge for movement, wore out a trail in the course of his quest for food. The worn out path helped him in his subsequent endeavours and man took the hint from nature. The footpath came to stay. But the urge in man to strive for better and safer living led him to movement by vehicles and the cart tracks came into being. Having indicated the scope for improving society through means of communications, nature again set before man the task of maintaining the routes against ravages of weather, etc. Thus the need for thinking in terms of maintenance of the routes took shape. As nature revealed more and more of its wealth for the prosperity of man, systematic development of communications emerged as the inevitable result. We stand today on the threshold of an era of intensive development of roads, which alone can assure prosperity to every man in a Welfare State.

Looking back through the last few centuries, the roads developed through strategic necessities. Gradually, however, civilian and commercial interests

also came to be cared for and, in Madras, the Revenue Board, which was in sole charge of the roads, was relieved of its responsibility in the field of communications which were transferred to a new department known as the 'Trunk Road Department', which again was abolished within a few years of its existence, after the formation of the Public Works Department in 1858. When the then Government felt the importance and advantage in assisting the States to maintain through communications to a comparatively higher standard, the system of annual grants was instituted. However, as the grant doled out by the Centre and the revenue raised from local sources were exceedingly inadequate, a bill known as District Road Cess Act of 1866 was passed authorising the collection of a cess not exceeding half an anna in a rupee on the rental value of occupied land. It was not until the creation of the Local Fund Board in 1871 that any appreciable development was discernible. There were about 21,019 miles of roads, exclusive of village roads, under the care of Local Fund Department, the annual outlay on them being about 50 per cent of the total Local Fund expenditure. The formation width varied from 15 to 24 ft and the metalled width was not more than 8 ft. It is interesting to note that many bridges were taken up during this period with the munifi-



cence of big philanthropists, one notable example being the Sulochana Mudaliar bridge across the Tambaraparani in Tirunelveli district.

Consequent on the abolition of tolls

in 1930, the resources of the District Board funds could not manage the proper upkeep of roads and deterioration was inevitable. Hence, thoughts were turned to a scientific assessment of the existing conditions and precise

planning for the future. Accordingly, certain important stretches of roads were designated as Trunk Roads and Government assumed responsibility for reimbursing the cost of their upkeep to the District Boards; some other roads were classified as Second Class Roads and Government agreed to pay 50 per cent of the expenditure on their maintenance. Later on, Central Road Fund was also constituted out of receipts from petrol tax.

When the preliminary attempts at rationalising the road development phases were undergoing the test of time, the World War II broke out. This war was a forceful reminder of the inadequacy of the roads vis-a-vis the nation's needs of defence and trade. It was at this juncture that the year 1943 saw the formulation of the Nagpur Plan, suggesting a 20-year road development programme for the country as a whole. Consistent with the recommendations of that Conference, Madras took the lead over other States in organizing a separate Highways Department on 1-4-1946. This constituted the first major step in the right direction.

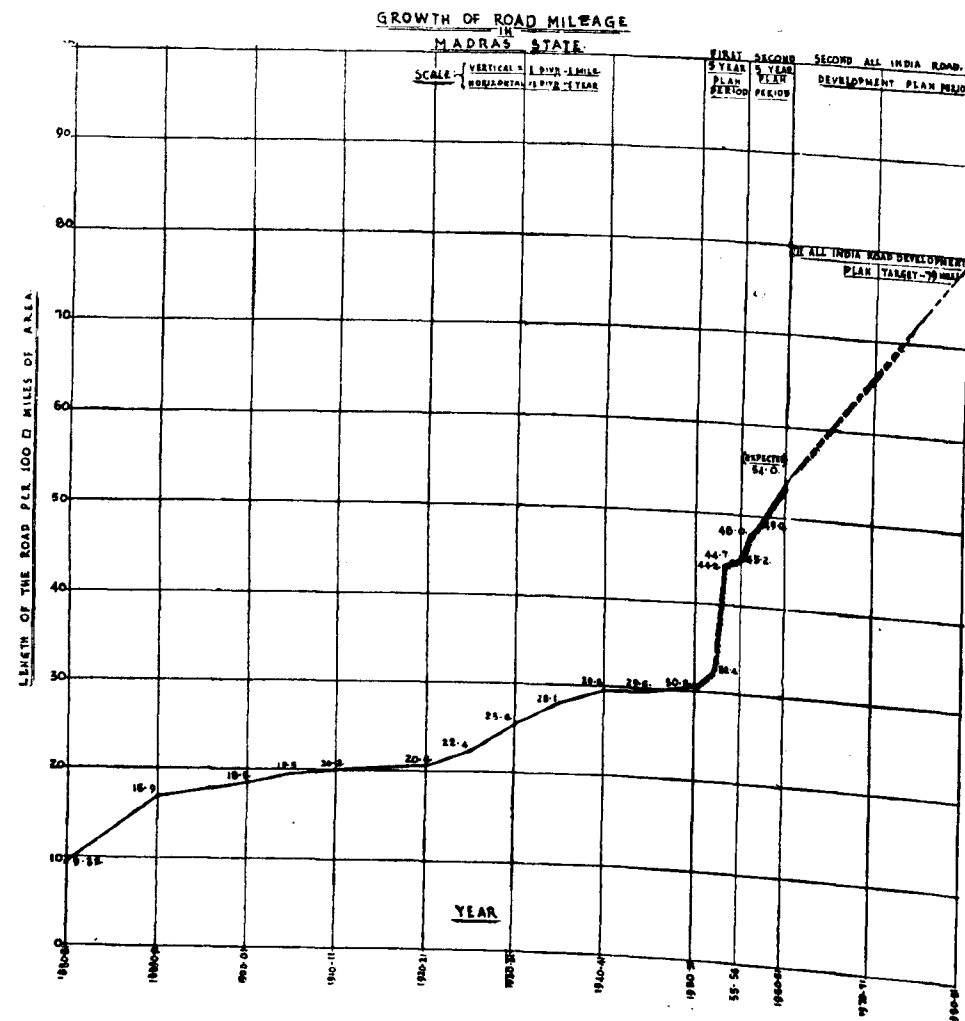
The undivided and specialised attention by this Department has had the desired effect in the addition of a large mileage of roads since its formation. This State which was having only 29.6 miles of roads per 100 sq. miles of area in 1946, now has 49 miles of roads for every 100 sq. miles. A comprehensive plan for post-war road development for the composite Madras State, which envisaged 1,229 miles of cement concreting, 1,237 miles of black-top and construction of major and minor bridges to a tune of Rs 13 crore, in addition to new roads, was drawn up. This plan was proposed to be executed in phases divided into a series of five year plans commencing from 1947 onwards. An expenditure of Rs 2.62 crore was incurred up to April 1951, when the Madras Post-War Road Development Plan was

merged with the national Five-Year Plan.

A provision of Rs 5 crore, inclusive of about Rs 2 crore of spill-over works from the Post-War Road Development scheme, was made for the first Five-Year Plan. After the separation of Andhra, the share of Madras was Rs 3.58 crore. The achievement was about 100 miles of concrete and bituminous roads, formation of 1,400 miles of new roads in addition to the construction of 175 major bridges and 255 minor bridges. A striking achievement in this period was that almost the entire mileage of National Highways in the State was provided with dustless surfacing, and at the end of the Plan period, Madras had about 5,000 miles of black-top roads.

In spite of the headway made in the field of communications, the road system began to find itself unable to meet the growing volume and speed of traffic of all kinds. Motor vehicles with their high speeds and heavy loads brought in their wake a multitude of complex problems which called for a more comprehensive planning and reorientation of the programmes for arriving at quicker results. The answer was the Second Five-year Plan. This was on a much larger scale at a cost of Rs 16.23 crore for roads other than National Highways with an expenditure ceiling of Rs 8.5 crore. After successive prunings, the expenditure ceiling has been fixed at Rs 6.77 crore, consisting of Rs 3.7 crore for State Roads, Rs 2.32 crore for District Boards and Rs 0.75 crore for tools and plant. The Second Plan envisages 86 miles of concrete roads, 740 miles of black-top surface and formation of 2,300 miles of new roads.

Today, Madras possesses a good network of nearly 25,000 miles of roads, out of which only less than about 1/3rd is unsurfaced; when compared with any other State in India, it has to its credit the largest mileage of roads. Madras



State has so well extended its network of feeder roads into the rural areas that no village in an agricultural or otherwise well developed area lies at a distance of more than two miles from any road and in the under-developed and hilly regions not more than 6 miles from any road. The interior village roads have been formed mostly during the last few years under the Firka Development, Community Development and National Extension Services, apart from those formed by Panchayats and District Boards. The element of public participation has been utilised to the utmost extent in this State.

The salient features of the road activities that have earned for Madras State the pride of place among the States of India, can be set out as :

- (i) Codifying the road specifications;
- (ii) Low cost surface construction with local materials;
- (iii) Modern bridge designs;
- (iv) Introduction of mechanisation with locally manufactured implements;
- (v) Establishing a Highway Research Station.

(i) Standardization has been a long felt need in the field of road development. The Madras Detailed Standard Specification introduced in 1931 contained very limited information with regard to road works. After an intensive study, extending over a couple of years, a Highway Manual laying down the Standard Specification for roads and bridges, in addition to contract conditions, constructional details, standard forms and data, type designs and administrative procedure, has been published in four volumes. This Manual was released in time for adoption in works of the Second Five-Year Plan and has ensured uniform standards of construction throughout the State besides serving as a useful guide for the young Engineers.

(ii) It has been established that soil stabilization for wearing course is quite a success in countries with no iron tyred traffic; but where the narrow iron tyred traffic continues on the roads, stabilization has to be restricted to foundation courses. The first soil cement road to be constructed in India was the Ramnad-Mandapam road in 1951 and since then several schemes have been executed. Only two types of stabilization, viz., soil-clay stabilization and soil-cement stabilization, have been found suitable and economical. Deviations from conventional American Specifications in grading were boldly ventured upon and the successful performance of the roads has clearly demonstrated the need to base the design mixes with due reference to local conditions. Recently, experimental stretches of surface treated soil-stabilized roads have been put into execution in Coimbatore and Ramnad districts with the assistance of the Central Road Research Institute and it is hoped that experience gained in these works may go a long way in perfecting the techniques of soil stabilization and finding a satisfactory solution to the problem of providing a base for all-weather surface for the vast network of village roads.

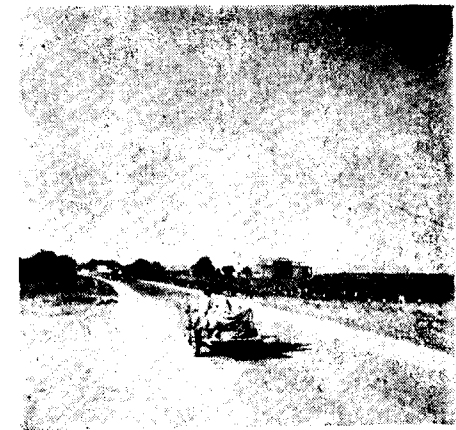
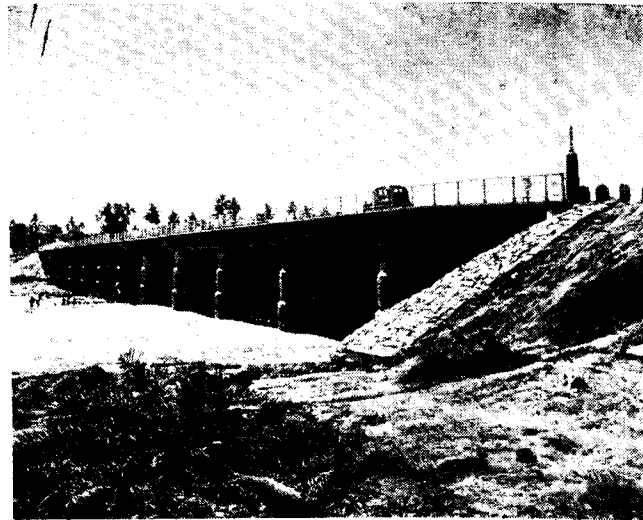


Photo 1.

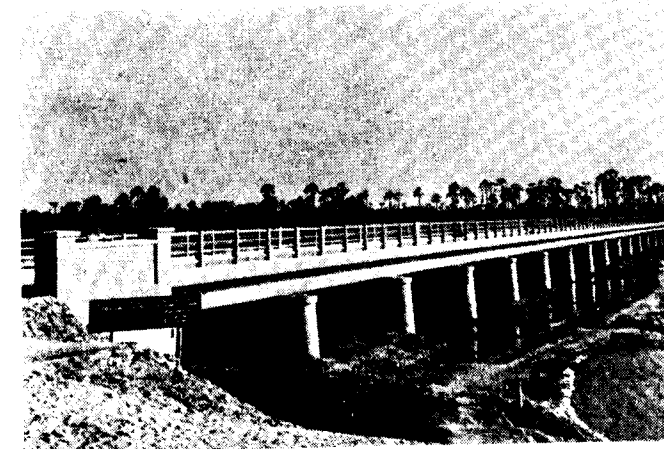
G. S. T. Road showing conphalt surface near Meenambakkam Air Port, Madras

(iii) Modernisation of existing weak and narrow bridges and provision of bridges at river crossings were commenced with proper organization almost with the inception of the Highways Department. Complex designs have been conceived and put into execution. In the matter of foundations, circular or rectangular wells depending on the depth continue to be popular and in superstructure design, a wide variety of construction practices has been resorted to. Flanged Tee-beams, Bow-string girder multiple box culverts, parabolic slabs cantilevered and suspended, multiple box girders of the simply supported and continuous type, have all been successfully adopted to meet the structural and aesthetic needs. Almost all types of bearings such as mortar pad, rubber pad, cast steel roller and plate bearings have been adopted. The 22 ft lift span fabricated in the Highways Department workshop and utilised in the construction of a bridge in Nagapattinam is the first of its kind in this State.

A new era in bridge construction for this State dawned with the completion of the first prestressed concrete road bridge in India across the river Palar at Chingleput on National

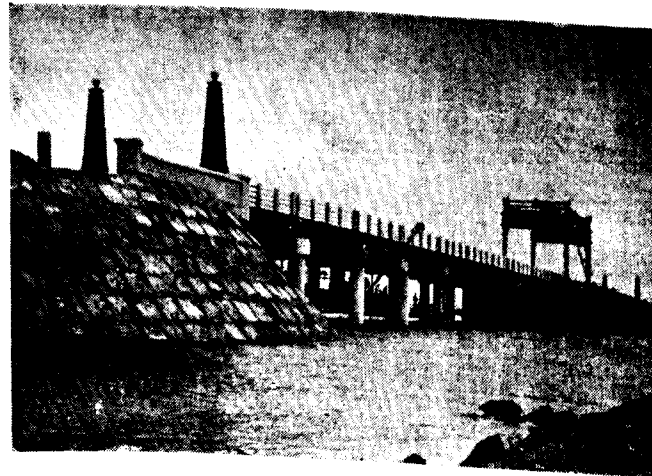


Kaveripatnam bridge at
166/4 Banaras Cape Comorin
Road (N. H. 7)

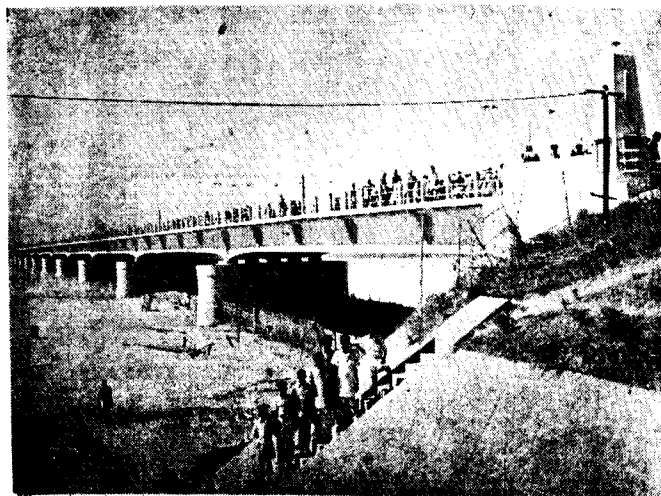
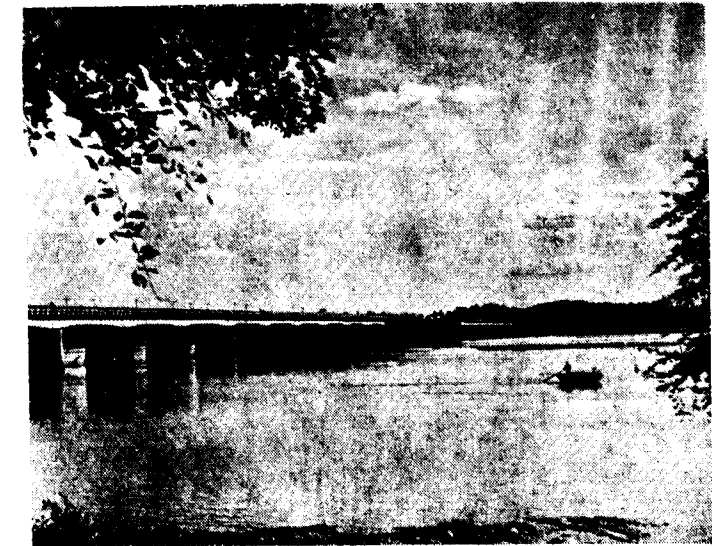


Manapad bridge near
Kulasekarapatnam
Tinnevely Dt.

Kaduvayar bridge with
lift span near Nagapattinam



Bridge across the
Cauvery near Pugalur
in Banaras-Cape
Comorin Road



Prestressed concrete bridge
across river Coleroon
near Chidambaram



Load test on a beam of prestressed
concrete—bridge across Palar
near Chingleput

Highway 45, using Magnel-Blaton system of prestressing. This bridge with 23 spans of 90 ft each was constructed at a cost of Rs 25.75 lakh. Load tests conducted on a beam to destruction and on a full span for design load on this bridge have clearly established the soundness of the technique and indicated a factor of safety of 2 against cracking and more than 6 against failure.

Encouraged by the economy and speedy execution of the above bridge, another bridge using Freyssinet system has been constructed across the river Coleroon with 14 spans, each of 150 ft the bridge being of unbalanced cantilever type. A third bridge, using the same system of prestressing, is under execution across the river Cauvery near Tiruchirappalli on N.H. 45. Madras State has thus begun to utilise progressive methods of bridge design and construction and it is expected that prestressed concrete will find its right place in the many projects that are to be taken up in the coming plan periods.

(iv) Even though mechanisation has proved worthy of adoption in western countries, in a country like ours, where labour is cheap and plenty and resources are slender, a cautious approach is needed. The policy of this Department has always been one of self-help in the matter of manufacture of as many of its requirements as possible, as well as in the maintenance of all the plant owned by the Department.

Created along with the Highways Department in 1946, the Transport and Machinery Organization has today expanded vastly in its field of activity; it has established a central workshop at Guindy in Madras, two regional repair shops at Pudukottai and Coimbatore and several small repair yards in the headquarters of all maintenance divisions. The Central Workshop is now fully equipped for the manufacture of borrow mixers with geared wheels, oil-fired bitumen boilers of various capacities, bitumen drum mixers, diving sets,

bridge bearings, hand bore sets, etc. The production of sheepsfoot rollers, pneumatic consolidation device and other equipment for soil stabilization has also been completed.

This Department was owning machinery worth Rs 300 lakh by the end of the First Five-Year Plan and has earmarked a sum of Rs 75.15 lakh for new purchase under the Second Plan. With the completion of the extension building to accommodate a part of the expanding workshop, it is hoped to produce all equipment required for road making except perhaps some complicated machinery.

(v) Road construction and maintenance has passed the age of craftsmanship based on trial and error and experience without systematic research. As stated earlier, the race for unravelling the mysteries of nature in the engineering field goes on and man's application to that end takes the form of research. This has been recognised in this State and the construction of a Highway Research Station at a cost of Rs 17 lakh in 1957 fulfilled the need in this direction. The activities of the Highway Research Station are mainly:

- (i) physical problems involving the characteristics of road materials and their behaviour in the road separately and in combination, and
- (ii) problems associated with effects of traffic and climatic conditions affecting the road structures and the capacity of the structure to resist them. The organisation functions under four sections, viz., soils, concrete, bitumen and traffic. Each of the four sections has its own laboratory and arrangements for undertaking field studies, and recent additions are a well equipped Photostat apparatus and a good library.

It has rightly been held that highway planning should not run alongside the execution programmes but must precede them. Accordingly, a special unit has been formed in this Department to examine the existing layout of roads in each district and formulate plans for the future.

The targets of road mileage envisaged in the Nagpur Plan for achievement in 20 years had already been achieved by Madras in about half the time by the end of the First Five-Year Plan. But the over whelming growth of traffic in post-war years, the inadequacy of the railway

system and the enormous capital outlay required to undertake the distant haulage of goods, have all indicated that the time is ripe for a fresh spurt in road development.

In the Second 20-Year Road Development Plan commencing from 1961, it is roughly computed that a sum of Rs 300 crore may be required for Madras State for achieving the targets stipulated under development. The existing and targetted mileages of each class of road under the Second 20-Year Plan for Madras State are as follows:

	Mileage as on 31-3-1957	Mileage as expected on 31-3-1981
Group I Roads		
National Highways	1,084	2,002
State Highways	1,087	2,980
Major District Roads	7,889	12,061
	10,060	17,043
Group II Roads		
Other District Roads	5,184	12,664
Village Roads Classified	8,777	12,219
	13,961	24,883
Total	24,021	41,926

The phasing of the plan is proposed to be in four stages of five years each, and the first stage which is only 1/10th of the total plan provision envisages a capital expenditure of Rs 6 crore per annum on an average. Even this projected development may be found to be inadequate for the actual conditions in the course of the 20-year plan period.

To quote H. Belloc, "the road is one of the great fundamental institutions of mankind; we forget this because we take it for granted." It will be the aim of Madras State Highway Engineers to ensure that this fundamental institution will be of the highest achievable standards.

DEVELOPMENT OF ROADS IN BIHAR



B. PRASAD,
Chief Engineer, P.W.D. (B & R), Bihar.

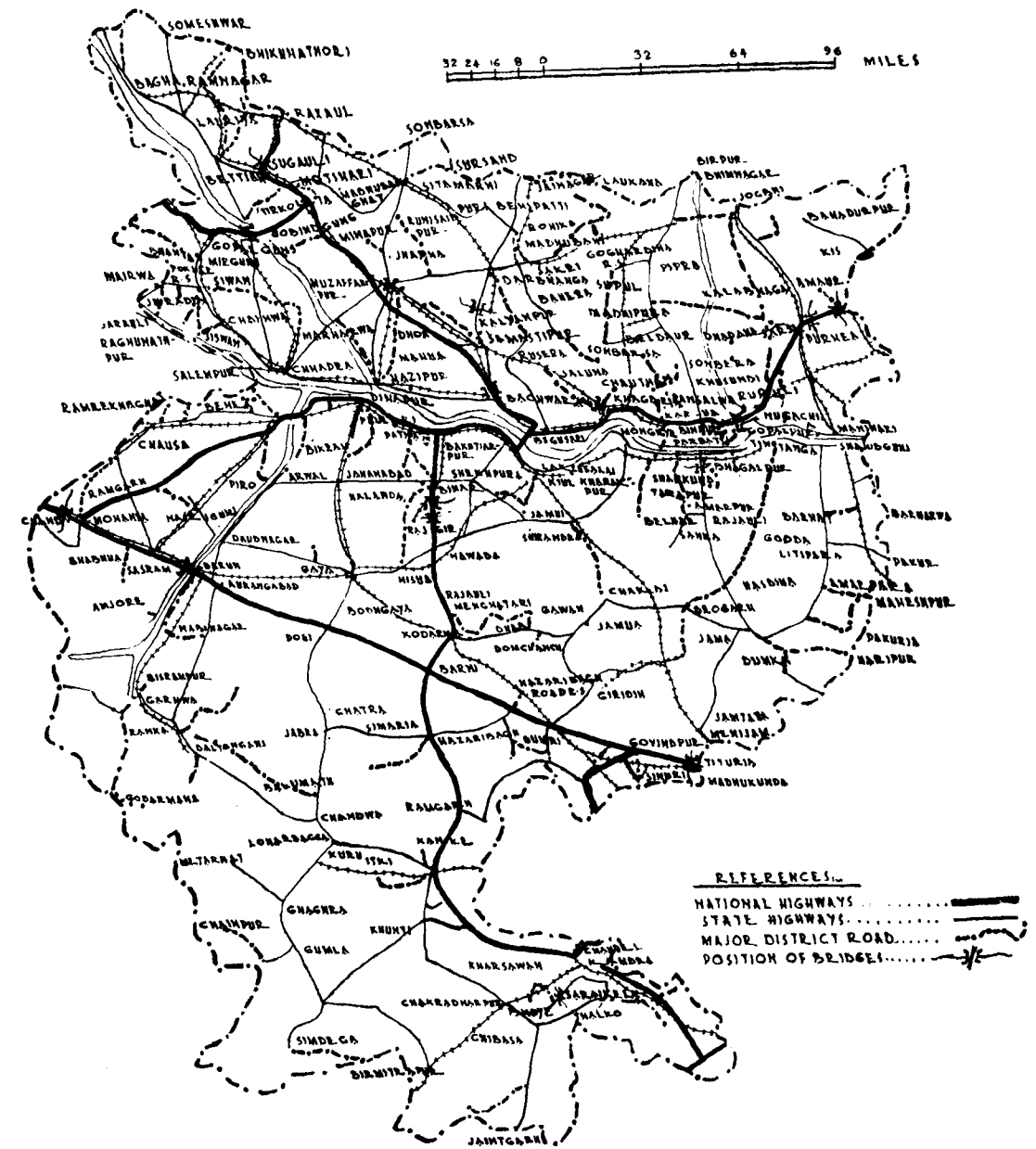
GOOD roads are an essential pre-requisite to the economic and all-round development of the country. They are the arteries through which the economic and cultural life of the country flows. Prior to independence, roads were constructed mainly from the administrative point of view, to maintain law and order and not much importance was attached to the planning and development of roads to foster the economic growth of the country and the people. The rail-road competition in which the Railways had an upper hand also prevented, to some extent, the growth of main arterial roads, and only feeder roads were constructed. But no community can try to develop without good roads. Railways and ships can move large loads from terminal to terminal. Airplanes can speed passengers and certain kinds of freight. But only roads can knit a community into an economic whole. Only roads can move products from isolated villages to towns and to marketing centres.

Bihar has an area of 67,113 square miles and it had about 35,000 miles of roads, mostly kutchha with unbridged gaps and most of them could be called foot tracks only. The total length of the metalled roads was 1,500 miles only but even these roads had unbridged

gaps at major river crossings. Some of the important roads which existed 25 years ago were the portion of the Grand Trunk Road from Karamnasa to Chirkunda, the Patna-Ranchi Road, the Arrah-Patna-Monghyr-Bhagalpur road, the Monghyr-Jamui-Barbigha-Biharsharif road, etc., but none of these roads had black-topped surface. North Bihar had practically no surfaced road at that time.

ROADS DURING 2ND WORLD WAR AND NAGPUR PLAN

The roads at that time were generally in the charge of the District Boards. The Public Works Department had only 1,315 miles of roads in its charge at the time of independence. The District Boards used to be financed partially by the grants from the then Provincial Government, as well as from the road cess collected by the District Boards, which was their major source of revenue to finance the maintenance of roads and bridges. New construction or additions in the length of new roads and construction of bridges were very few and far between. During the Second World War from 1939 to 1945, the revenue of the District Boards was diverted towards military expenditure and the Govt. grants which dwindled



DEVELOPMENT OF ROADS IN BIHAR

down to the bare minimum were spent only on roads of strategic importance. The District Board roads never recovered from this set back and, after being deprived of maintenance for over six long years, their condition became extremely bad. The war activities, on the

other hand, generated new demands towards transport of materials and passengers by road. The need of developing and improving the road system as speedily as possible was keenly felt from every quarter. Prompted by this feeling, the Chief Engineers of the then

Provinces and major States and officials of the War Transport Department met at a conference at Nagpur in 1943 and evolved a road plan known as the famous "Nagpur Plan."

POST WAR ROAD DEVELOPMENT SCHEMES

In accordance with the Nagpur Plan, the Post-War Road Development schemes were drawn up and launched in 1946-47. Very soon India became independent. The advent of independence changed the entire concept of Government. Economic development and welfare of the people determined all Governmental activities. The law-and-order-concept of the road communication was not now the main determining factor and more emphasis was given to development works to bring in general prosperity to the country. The State P.W.D. was selected to be the major agency to execute the road development programmes for obvious reasons. The District Boards followed different specifications in the different districts, their personnel were subordinate to the District Boards and they did not have many trained engineers. Thus the growth of roads in charge of the P.W.D. has been phenomenal during the last ten years.

FIRST FIVE YEAR PLAN

At the time of independence, there were 1,315 miles of roads in charge of the State P.W.D., out of which 905 miles were metalled including 201 miles in North Bihar. A sum of Rs 1.88 crores was spent on the Post-War Road Development Schemes till March 1951 when the First Five Year Plan was launched. At that time, the mileage of roads in charge of the State P.W.D., rose to 3,025, out of which 894 miles were in North Bihar and 1,938 miles only were metalled. During the First Five Year Plan, a sum of Rs 7.75 crores was originally provided in the State Plan. The achievement, both in terms of expenditure and physical

target, was much ahead of the schedule. The Plan ceiling was, therefore, raised to Rs 10.50 crores. The targets laid down in the First Five Year Plan of the State were fully achieved. During this Plan, a sum of Rs 1.81 crores was spent on the National Highways and Rs 1.40 crores on the Central Road Fund schemes, in addition to Plan expenditure. Some of the important routes improved and constructed under these schemes were the Ganga-Darjeeling Road and the Assam Access Road, which provided the only link to Assam with the rest of the country. At the end of the First Five-Year Plan, there were 5,544 miles of roads in charge of the Department, out of which 1,804 miles were in North Bihar and 3,698 miles were metalled.

SECOND FIVE-YEAR PLAN

The increase in vehicular traffic requires sufficient mileage of good surfaced roads. The State Government had prepared the Second Five-Year Road Plan for Rs 44.70 crores but this was drastically curtailed to Rs 16.80 crores. This made it difficult to attain even the average target of the all-India figure. It is hoped that the target laid for the Second Five-Year Plan would be achieved before time and this may be ultimately raised. Under the National Highway programmes, 86 schemes have been included in this Plan. Some of the important schemes are construction of Barauni-Purnea and Barauni-Kasia roads. When constructed, they will provide through communications between U.P. and Assam or West Bengal through a trunk road passing all along north of the Ganges. This will remove a long felt want of the area. Fourteen road projects and 3 major bridge projects are also included in the Central Road Fund scheme. At the end of the Second Five-Year Plan, there will be about 6,830 miles of roads in charge of the State P.W.D., out of which about 2,542 miles will be in North Bihar and 5,100 miles will be metalled. This brings

out the changes that have been brought about in the last 12 years. The overall mileage in the State would be increased by about five times. In North Bihar, the increase will be over twelve and a half times.

BRIDGES

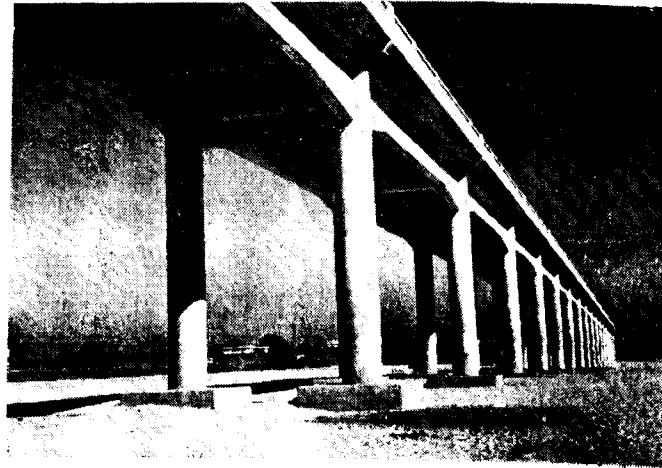
The District Board roads were particularly deficient in the matter of bridging of gaps. Thus building of a large number of bridges was, therefore, the special responsibility of the P.W.D. The difficulty in obtaining steel has been a great hinderance in speeding up the progress; still, the achievement has been well marked. During the last 10 years, the P.W.D. have completed construction of (i) 903 ft long R.C.C. Burhi Gandak bridge at Muzzaffarpur, (ii) 1,198 ft long R.C.C. Kiul bridge at Jamui, (iii) 1,350 ft long R.C.C. bridge at Lakhisarai, (iv) 200 ft and 260 ft long R.C.C. bridges over river Durgawati, (v) R.C.C. bridges at Chiraijore, Kailash, Bela and Mani rivers, (vi) 300 ft long Poon Poon bridge on the G.T. Road, (vii) 607 ft long Barakar bridge on the G.T. Road, (viii) 416 ft long R.C.C. bridge over river Kitchania, (ix) R.C.C. bridge over river Bhakra, (x) Prestressed R.C.C. girder bridge over river Ullai, (xi) Prestressed R.C.C. girder bridge over river Nagi, (xii) Prestressed R.C.C. girder bridge over river North Koel at Garu, (xiii) 1,000 ft long prestressed R.C.C. girder bridge at Phusro over river Damodar, (xiv) 1,600 ft long R.C.C. bridge over river North Koel at Rehla. Besides these, a number of other major and minor bridges have been constructed, strengthened or remodelled. In the hilly areas, numerous causeways have been constructed. Some of the major bridges scheduled to be constructed are the Rs 250 lakh bridge over river Sone at Dehri, the Rs 50 lakh bridge over river Mahananda at Bingra-ghat and bridges over Burhi Gandak at Khagaria, over Kosi at Kursela, over rivers Sikrahna and Tilaway, etc. The construction of the Rail-cum-Road

bridge over river Ganga at Mokameh is a landmark in the history of road development in this State, particularly for North Bihar. The construction of this bridge will greatly facilitate the movement of men and materials from South Bihar to North Bihar and also to the northern parts of West Bengal and Assam. The total number of major bridges constructed is 53, submersible bridges and minor bridges—125 and culverts—3,000.

SPECIAL PROBLEMS

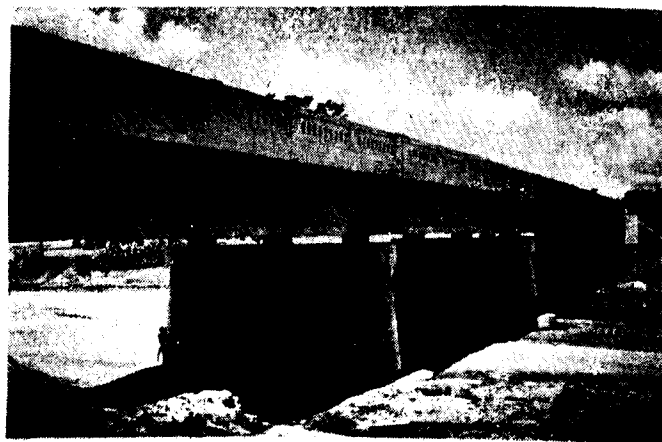
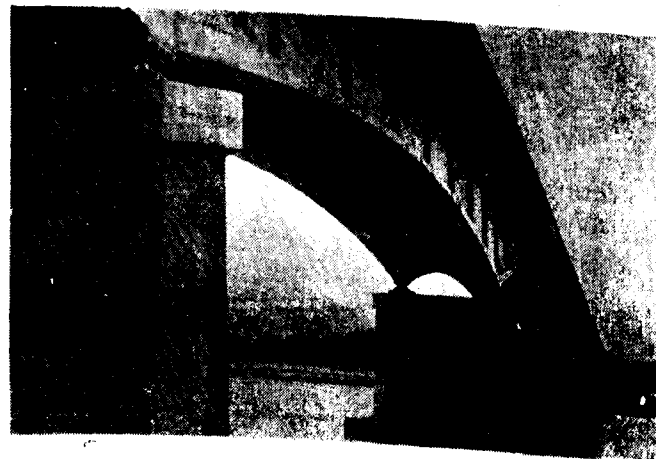
So far as North Bihar is concerned, it presents great difficulty for the quick development of an efficient road system. Stone metal for base course is not available in the area except at a few localised spots in the form of river boulders and shingles. The transportation of stone metal and chips involves very considerable cost. To reduce the cost of road construction, brick soling is used and Jhama metal is also provided under stone metal. North Bihar is a huge drainage basin for a large number of rivers and streams originating from the hills on the North and also from the Himalayas, involving construction of a large number of costly drainage structures. The non-availability of screw piles at present is also a difficult problem. To get over this difficulty, attempt is being made to construct submersible bridges with raft foundations. A large number of such type of bridges have been constructed in South Bihar and Chotanagpur and they are functioning successfully. Before the construction of the protective embankments of the river Kosi, a large number of channels in Saharsa and Purnea Districts used to get the spill discharge of this river and their courses were always shifting. Now with the construction of the Kosi embankment, their channels are getting stabilised and it would now be possible to provide bridges over them.

Detailed surveys are being done and

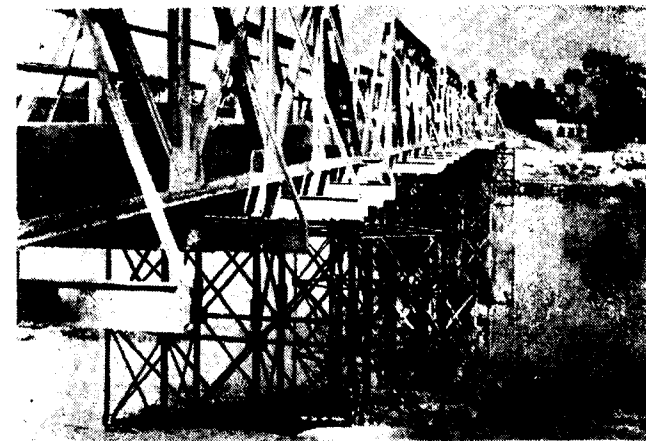


R. C. C. bridge over river
North Koel at Rehla in
Palamau Dist. in Bihar
(1615 ft long)

R. C. C. bridge over river Kiul
at Lakhiserai (1350 ft long)
in Monghyr Dist. in Bihar



Prestressed concrete bridge over
river Nagi on Jamui-
Chakai road in Bihar



Screw pile and steel girder bridge
at Magardehi in Darbhanga
Dist. in Bihar

Prestressed concrete bridge over
River Damodar at Phusro
(10 spans of 100 ft each clear)



hydraulic data collected for construction of a large number of bridges. It is expected that the bridging programme will be in full swing within a year. The difficulty of foreign exchange for getting high tensile steel still persists, due to which the construction of major bridges has received some set back. It is hoped the position will ease within a year or so when it will be possible to go ahead with the construction of prestressed concrete bridges.

Chotanagpur area in this State is the industrial and mineral centre of the country and, to cope with the rapid expansion and development of coal fields, mines, industries and the projected Fourth Steel Plant at Bokaro and the Heavy Machine Building Plant at Ranchi, the State P.W.D. had to construct some important roads and bridges in a very short time.

Efforts are being made to reduce the

cost of road construction by constructing soil stabilised or gravel stabilised roads with a top wearing course where there is very low intensity of traffic.

A large number of old bridges and culverts have been damaged due to plying of heavy loads, for which they were not designed. Their reconstruction or remodelling will throw a great strain on the State's resources.

PERSONNEL

One of the most important points which will accelerate road development is a good team of engineers and other personnel to carry on the work. We have made efforts to train our engineers as far as possible and to provide specialised training for as many of them as possible.

TARGET

The Nagpur Plan launched in 1943

was a 20-year plan. The mileage target laid in this Plan was of pre-independence era and did not envisage the tempo of development obtaining now. Bihar should have had 10,211 miles of main roads and 26,381 miles of 'Other Roads'. But, we have to-day only 8,069 miles of main roads, i.e., only 62 per cent of the target. The target of 'Other Roads' has been achieved but this includes 10,042 miles of such roads which are never motorable and are, at best, tracks. In 1956, the mileage of surfaced road per lakh of population in this State was 122 against 312 miles in the country. On area basis, the mileage of surfaced roads per 1000 square miles was 70.7 against 104.0 miles in the country. The task to be fulfilled is, therefore, of a large magnitude. The State P.W.D. is pledged to hard work and devotion to this cause for the uplift and economic growth of the State.

The most beautiful thing we can experience is the mysterious. It is the source of all true art and science. He to whom this emotion is a stranger, who can no longer pause to wonder and stand rapt in awe, is as good as dead.

—ALBERT EINSTEIN.

ROAD DEVELOPMENT IN ASSAM

By

DEBESWAR SARMA, Minister, Govt. of Assam.

COMMUNICATIONS are the main arteries of civilization. If we go back into the history of human civilization, it will be seen that every seat of civilization is connected in some way or the other with the development of means of communication. Our ancestors rightly realised that through means of communication help build the growth of a nation towards its economic development. The Romans, too, realised the importance of roads for properly administering their vast empire.

In this country, also, as far back as the 4th century B. C., our great Emperors like Asoka, realised the usefulness of good means of transportation for the welfare of the country. It was during his time that a network of roads was spread over whole of India. Later, Sher Shah built the Grand Trunk Road and the important part it is playing even now in the economy of the country hardly needs to be reiterated.

Of course, during those days, the main traffic using the roads comprised pedestrians, animal drawn vehicles and pack animals and those roads were not of modern standards. Fast moving road traffic was also unknown in those days.

During the British regime, the Railways came into being in this country. More attention was paid towards the construction of new railways and that, too, in the interest of administrative convenience and strategical importance rather than for helping the economic progress of the country. Very little was done towards the building of new roads and improving the existing ones. Assam, however, could not be properly served by Railways

or water transport due to its difficult configuration, and neglect in the field of road making has badly told upon her economy.

It was during 1943, when the war came to our doors, that we realised the importance of roads in a country's economy and strategy. At a conference of the State C. E's that year at Nagpur, a plan was evolved known as the Nagpur Plan. This plan recommended an increase in the road mileage of the whole country to 3,85,000, of which 2,90,000 would be motorable. According to this plan, Assam's requirement of motorable roads, including National Highways stood at 13,200 miles.

During the war, a few roads in Assam were taken up hurriedly but there came again a period of slackness with the cessation of hostilities. Some of the roads were again taken up during the post-war development period but these could not be pushed much further owing to the shortage of funds.

Assam is a frontier State surrounded almost on all sides by foreign territory and her link with the rest of the country is also very poor. The problem of transport became even more acute after the partition of the country. The economy of the people living near the border and hilly regions mainly depending upon their local produce, was badly shattered due to the loss of nearby markets to Pakistan.

The first real step towards a systematic road development came with the First Five Year Plan. During this Plan, road projects were taken up in Assam

covering an approximate mileage of 461 under Art. 275 of the Constitution and 205 miles under the State Revenue Programmes at an estimated cost of Rs 256.2 & Rs 42.50 lakhs respectively. Later on, during 1954-55, an expanded programme was prepared which included five new road projects. This meant an increase of 152 miles at an estimated cost of Rs 86 lakhs. Thus the total mileage of roads proposed to be taken up in Assam during the First Five Year Plan stood at 613 under Art. 275 and 205 miles under other schemes. Out of this a total of about 320 miles of all-weather roads and 300 miles of jeepable roads were completed during this period.

The difficulties which had to be faced in the implementation of the First Five Year Plan were many. Local labour was not sufficient for the purpose and labour from other parts of the country was not keen to work in the Hill Districts where majority of roads planned were to be built. There was also the difficulty in the transporting of materials. The link railway line which was the main means of contact with the rest of India is very unstable and not capable of coping with the heavy traffic. The dearth of technical personnel for the survey and execution of the works was another problem. In the face of all these difficulties the targets achieved, as indicated in the preceding para, is by no means a mean job.

Besides the incomplete projects from the First Five Year Plan, some more roads have been proposed during the Second Five Year Plan. In addition to the construction of new roads, improvement of about 600 miles of existing low standard roads, metalling and black-topping of 184 miles of existing roads and reconstruction of many bridges and culverts, which were either weak or below standard in other respects, have been taken up.

Assam is a State which is criss-crossed with the mighty Brahmaputra and its many tributaries. Even now we have

got more than a hundred ferries in our road system. Importance was, therefore, given to spanning the unbridged rivers during the First Five Year Plan. The total length of bridges taken up during this period under different schemes totalled approximately 11,600 ft at an estimated cost of Rs 26.6 lakhs. The Barak bridge in Silchar is the most important of these. As per original design, this bridge was to be of 1532 ft length with a central navigable span of 400 ft. But owing to various difficulties, including non-availability of foreign exchange, the bridge could not be completed till now. Attempts are, however, being made to complete the same by changing the design so as to utilise indigenous materials as far as possible. Other minor bridges taken up under the two Plans and completed up-to-date are Ranganadi, Dikrong, Dhansiri, Dikhu, Desang, etc. The Burai bridge on N.T. Road is in progress and a number of other major bridges totalling about 4000 Rft are being taken up during the current plan.

There are a few very important works which have been taken up outside the Plan. After the partition, the districts of Cachar, Lushai Hills and Tripura State were cut off from the rest of India. The construction of the Jowai-Badarpur road, 296 miles in length, will form an important road link, and it is estimated to cost Rs 126 lakhs when completed. The formation work of this road is nearly complete. It is expected that by 1960-61, with the completion of the remaining two bridges, this road will be rendered all-weather motorable one.

The river Brahmaputra practically cuts the whole of Assam into two. There are as many as five important river crossings besides smaller ones. The traffic at these crossings is now being maintained by steam ferries or motor launches which are both very slow and quite inadequate to cope with the volume of present day traffic. The

(Continued on page 52)



SHRI K. BARUA, B.E., M.C.P.,
Chief Engineer, P.W.D.,
Assam.

ROAD DEVELOPMENT IN ASSAM

THE road communications in the State are administered both by the State P.W.D. and Local Bodies. While roads of National, State and District importance, as also important village roads, are improved and maintained by the P.W.D., roads of local importance are under the control of Local Boards (since abolished and being replaced by Panchayats). The Municipalities and Town Committees administer roads in the town and municipal areas. Expenditure on road development (other than National Highways and centrally aided schemes) is met out of the normal resources and allocations to the State from the Central Road Fund, as also from a portion of the revenue derived from the Motor Vehicles Tax. The expenditure on maintenance (except National Highways) is entirely borne out of the State's revenues.

The main problem in the construction and improvement of roads in Assam is the existence of numerous ranges of hills of varying heights, and rivers and streams with changing courses, heavy rainfall, etc. The major portion of the plain districts being low, is subjected to frequent flooding. The roads are, therefore, required to be kept at a higher level than the surrounding area.

For construction of motorable roads

in the hills, long and circuitous distances are to be covered. The stone metal required for improved types of roads is generally available in the hills and the cost of its carriage to the plains is very high which influences the cost of the projects. The road development may conveniently be divided into the following phases:

FIRST PHASE 1912-26

With the formation of the new province of Assam in 1912, the Chief Commissioner felt the necessity of improving the road communications in the State and accordingly drew up a road development programme in consultation with the leading personnel of the State. This marks not only the first phase of road development in the State but also the beginning of the public co-operation in the matter of development of communications in the State. A sum of Rs 41½ lakhs, contributed by the Government of India, was spent in the execution of this programme which included the following:

1. General improvement to existing roads — 640 mile
2. Construction of new roads — 240 „
3. Metalling — 96½ „
4. Construction of bridges 4845 Rft.

5. Construction of temporary bridges — 150 Nos.
6. Construction of culverts — 400 Nos.

SECOND PHASE, 1926-33

The second stage in the development of roads started with the introduction of the motor transport in the country which necessitated the improvement of roads to a higher standard. In 1926, the first Road Board of Assam was constituted according to a resolution of the then Assam Legislative Council. As per recommendation of this Board, a programme for Rs 17 lakhs which included metalling of 76½ miles of roads was taken up and completed by 1930-31.

The second Road Board, with a view to ensure improvement and construction of roads in a systematic manner, prescribed in 1927 a classification of roads into various categories, viz., Metalled, Gravelled and Kutcha (earth roads). Accordingly, road maintenance machinery viz. tractors, caterpillars, graders, planers, and rollers were purchased and the year 1928 marked the beginning of a new era in the execution of bridge and road works in Assam with the introduction of mechanized methods of road construction and road maintenance.

The third Road Board in 1929 drew up a programme consisting of 49.1 miles of metalled roads costing Rs 15,45,000 and 617.46 miles of kutcha (earth) roads estimated to cost Rs 52,61,000/- but on account of the general economic depression of 1929 the programme could not be implemented to the extent desired. Only 16 roads and 31 bridges estimated to cost Rs 16,92,431/- were undertaken and completed by 1930. This programme was however, almost completely carried out at a cost of Rs 33 lakhs by the year 1932-33 covering improvement of 97 miles of roads and replacement and upgrading of 190 bridges. As a

result of this many of the roads in Assam were gravelled by this time and many bridges were constructed permanently.

In 1928-29, the Government of India sanctioned a "Bridge Loan Fund" for construction of major bridges. Out of this fund, a 560 ft screw pile bridge over Dhansiri on the Assam Trunk Road at Numaligarh, the Chalkhowa bridge at Borpeta (540 Rft in length) at a cost of Rs 1,50,324/- were built. Simultaneously, the construction of Shillong-Sylhet road was undertaken in 1929 out of a "Special Loan Fund" from the Government of India and was completed by 1933 at a cost of Rs 20,64,620/- which included a sum of Rs 1,84,993/- spent on the construction of a 350 Rft suspension bridge at Dawki. This bridge, near India Pakistan border, is one of the longest and most spectacular suspension bridge in Assam.

In the year 1927, a special "Tea Cess Road Fund" was created to finance construction of roads primarily to facilitate the transport of commodities to and from the tea gardens as well as the development of the areas near about the gardens. Out of receipt, in this fund, 130 miles of roads and 10 bridges were improved and reconstructed at a cost of Rs 13 lakhs. It is worth mentioning that the first black-topped road in the State, viz., Jorhat-Mariani Road, was built out of the amount made available from this fund.

The creation of the Central Road Fund in 1929-30 by the Government of India is another landmark in the sphere of road development in the State. During the period 1930-1933-34, a total sum of Rs 14,43,335/- was received from Reserve and General Fund and utilised for development of road communications.

The Assam Highways Act was placed on the statute book during the year 1928-29.

THIRD PHASE 1933-45

The Assam Road Board was converted into Assam Communication Board in 1934-35. In 1935, a road improvement programme amounting to Rs 30 lakhs provided for improvement of 345½ miles of roads and construction of 30 bridges was sanctioned by Government of India to be financed from the Petrol Tax Reserve Fund. This programme was completed by 1938.

The total amount received from the Central Road Fund during the period from 1933-34 to 1944-45 was Rs 107.04 lakhs including Rs 31.84 lakhs from the Reserve Fund. The most important works done from the Reserve Fund are the construction of some major bridges, viz., Dehing, Dikhow, Ranganadi, Desang, Nanoi suspension bridge, Kopili, Borgaon, etc., and improvement of Assam Trunk Road, Dhodar Ali, North Gauhati, Jhangaon Road, Sibsagar-Desangmukh Road, etc.

The second World War made the north eastern frontier of India a war zone, and the needs of defence necessitated a speedier system of road communications throughout the State. These works were mostly carried out by the P.W.D. as the agent of the Defence Department. Some of the important works done as a part of defence works are (1) widening South Trunk Road from Bongaigaon to Saikhowaghat via Goalpara and Gauhati and construction of Numaligarh-Dimapur-Imphal Road, Imphal-Palel Morch Road to Burma Border and Makum-Lekapani Road.

FOURTH PHASE 1945-51

With the cessation of hostilities, an extensive scheme for development of the country in the post-war period was formulated by the Government of India and a programme of road development for the State of Assam estimated to cost Rs 773 lakhs was drawn up with a view to construct—improve 558 miles of district roads and 1400 miles of village roads and for the construction of major

bridges to a total length of 48,100 Rft. The work was started on 1,040 miles of roads of which 210 miles were practically completed. Due to sudden reduction of post-war grants in 1949-50, work on 830 miles of roads in progress had to be kept in abeyance.

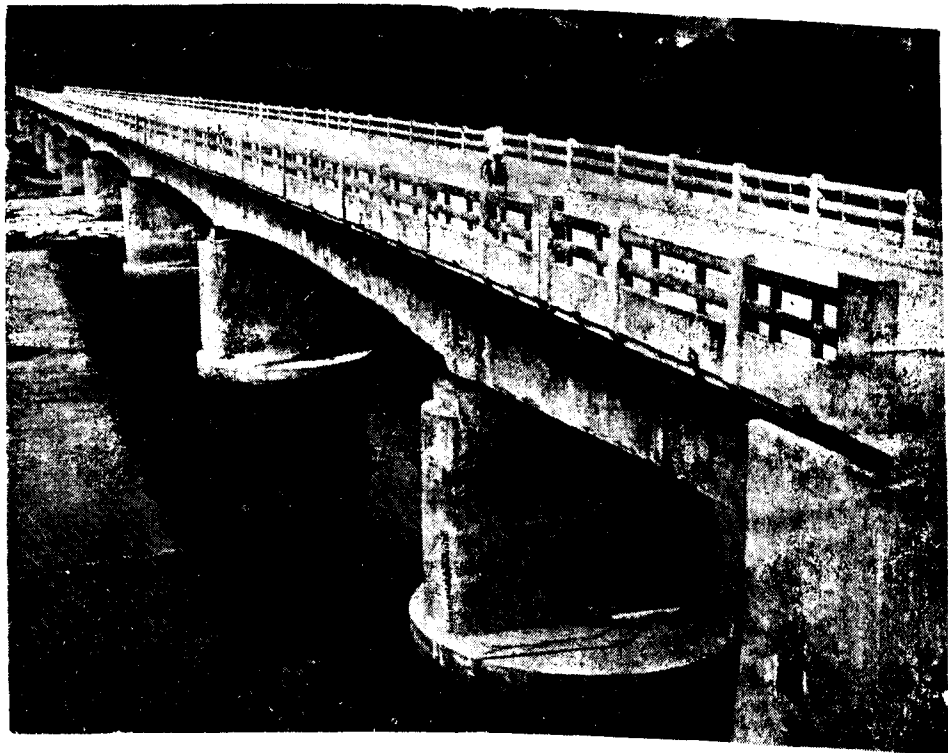
The partition of India snapped off communication between Garo Hills and the rest of Assam, and also of Cachar district with the Assam valley and consequently with India. In order to remove these disadvantages, three roads, viz. Shillong - Jowai - Haflong - Silchar Road, Medhipara-Phulbari-Tura Roads and Lowairpowa - Churaibari Road in Cachar Hills were constructed. The first one covering 222 miles and costing Rs 1,30,00,000 is a fair weather road beyond Garampami to Haflong.

A programme of sixty roads covering 586 miles and estimated to cost about Rs 56 lakhs had been undertaken in 1950-51 from Assam's allocation from the Central Road Fund. These are mainly incomplete works of Post War Development Programme kept in abeyance due to reduction of grant.

A few more programmes financed from Cess Procurement funds, State's revenue and Motor Vehicles Tax, etc. were also taken up during this period. About 309 miles of roads were improved/constructed at a cost of Rs 61 lakhs approximately.

FIFTH PHASE, FIRST PLAN PERIOD

Under the First Five Year Plan Development Schemes, construction and improvement of 1373 miles of roads and 10 major bridges totalling a length of 4300 Rft were taken up at an estimated cost of 423 lakhs with an expenditure target of Rs 265 lakhs. A sum of Rs 274 lakhs was spent on these schemes as against the target of Rs 265 lakhs. Approximately 50 per cent of the roads were completed. No major bridge could be completed due to delay in the finalisation of the First Five-Year Plan



Dikrong bridge, Assam

and difficulties in getting materials, etc. The balance of the works have been provided for in the Second Five Year Plan as spillover work.

In addition to the above, programmes for improvement of road communications in the autonomous districts of Assam and plain tribal areas with a view to raise their standard to that of the rest, have also been taken up out of funds sanctioned under Article 275 of the Constitution. About 300 miles in the hills and 80 miles in the plain tribal areas were completed under these programmes.

During this period, construction of a very important road, viz., Shillong-Jowai-Passi-Badarpur Road (portion from Passi to Badarpur) has been taken up with a view to provide better road link for Tripura State and southern part of Assam with the rest of the country. The length of the road from

Shillong to Badarpur is 130 miles and major part of it has already been completed. The cost of constructing the portion from Passi to Badarpur, 82 miles, has been entirely financed by the Government of India.

In order to make the North Trunk road an all-weather road, the Government of India have contributed 50 per cent of the cost of construction of 3 important bridges over Buroi, Dikrong and Ranganadi. The bridge over Ranganadi had already been completed during the first plan period.

SIXTH PHASE, SECOND PLAN PERIOD

Considerably bigger road development programmes have been taken up during this period. Under "Road Sector of the State Plan", construction of 650 miles of road, 22 major bridges including those carried over from the

First Plan, improvement of 600 miles of low standard roads, metalling and black topping 184 miles and reconstruction of 10,240 ft of bridges and culverts have been taken up. Eight major bridges have already been completed. An important target is the metalling and black-topping of about 100 miles of North Trunk road mainly falling in the areas not served by the Railways. The expenditure target under this sector is Rs 665 lakhs.

Under Article 275 sector of the Plan, a sum of Rs 345.82 lakhs has been provided for road development in the hills. About 200 miles of roads are expected to be completed during this period. Another 200 miles of roads are also expected to be completed in plain tribal areas with an expenditure of Rs 85.84 lakhs.

From the State's share in the Central Road Fund, programmes amounting Rs 137.00 lakhs have also been approved and works have been taken up on most of the projects. They envisage metalling and black-topping of 13 miles of North Trunk Road and construction of about 480 miles of village roads.

At the instance of the Government of India, another important programme for improvement of roads of economic

and inter-state importance submitted by State Government has also been approved by the Government of India. The total cost of the programme is Rs 169.5 lakhs and it includes some very important projects, viz., construction of a bridge over Jia-Bhorali, length 2050 Rft., estimated to cost Rs 86.53 lakhs, improvement of North Trunk Road from Baki to Sankosk, metalling and black-topping major part of Karimganj-Patharkandi-Churaibari road. With the completion of the bridge over Jia Bhorali, the North Trunk Road between Tezpur and North Lakhimpur will be an all-weather road. The improvement of of Karimganj-Patharkandi-Churaibari road will provide a better road link connecting the road system in the Tripura State.

OVERALL POSITION

With the completion of the programmes in hand, Assam will have about 8000.29 miles of road including 729.29 miles of National Highways, the break-up of which by type is given below:

(1) Black-topped	...	1273.29
(2) Metalled	...	141.50
(3) Gravelled	...	4425.50
(4) Earth	...	2160.00
		8000.29 Miles.

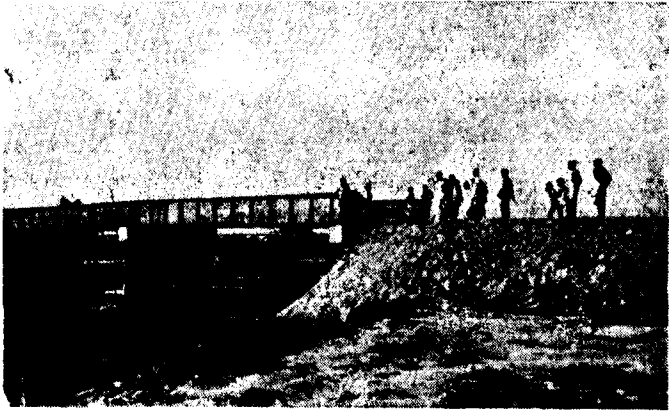


Photo 2. Gabru bridge under construction



R.C.C. Bridge over Kullong River at Nowgong (Assam) (under construction)

Adding to the above miles the length of motorable roads under Local Boards (which is approximately 1000 miles), the total road mileage in the State will stand at 9,000 miles against 12,585 miles according to the Nagpur Plan. The achievement in the sphere of development of roads in the State after independence will be observed from the fact that the State had only 2500 miles of road before independence against about 8000 miles envisaged to be completed under programmes in hand.

There are now altogether 483 major bridges (100 ft or over in length). Out of these, 116 Nos. are between 200 ft 500 ft in length and 12 bridges over 500 ft.

It is expected that far bigger strides will be taken in the field of road development in this strategic State during the future plans and thereby the State will be served by more and better roads to cater to her various needs in spite of her difficult terrain and various other difficulties.

(Continued from page 46)

construction of a Rail-cum Road bridge over this river at Pandu is a step forward towards the removal of traffic bottleneck, though completion of this bridge will not mean a complete solution of this big problem. This bridge, approximately 4,600 ft in length and estimated to cost over Rs 12 crores, is expected to be completed by 1962.

By the end of the Second Five Year

plan, when all the schemes outlined above are expected to be completed. Assam will have approximately 8,500 miles of roads against 13,200 miles, which is the total requirement of the State as envisaged under the Nagpur Plan. Thus there is still a long way to go, but if the progress of the last few years is maintained and with proper organization of the resources in man-power, material and talent, goal cannot be very far off.

SOME FACTS RELATING TO THE ECONOMICS OF THE ROAD SYSTEM OF THE PUNJAB

BY

G. C. KHANNA, Chief Engineer, Buildings & Roads, Punjab.

THE economic and commercial performance of the road system of a country can be gauged like that of an industrial concern. An industrial enterprise invests money on buildings, plants and machinery for the production of goods at economic costs. The investment of capital by a State on construction of roads is of a similar nature. Traffic generated on the road system can thus be assessed on the analogy of the output of a commercial undertaking. If the traffic operates at commercial rates and gradually increases, investment is termed 'productive' and the yield increases progressively.

The metalled road mileage of the Punjab on 31st March 1959 was approximately 5,400 miles. On present day rates, the total cost of road system, i.e., investment of the State, would be about Rs. 50.00 crores.

The traffic intensity on different roads of a system varies in all countries. The average traffic on state roads of the Punjab, as per census taken by the P.W.D., is about 1,200 tons per day. Fig. 1 gives the intensity of traffic on different parts of the road system of the Punjab.

Total traffic carried on P. W. D. roads in the Punjab is about 2,400 million ton miles per annum.

The average cost of operation of a vehicle on a metalled road, carrying 5 ton load, is about Re 1 per mile or 20 nP per ton mile. Turnover for 2,400 million ton miles of traffic on the

road system of the Punjab would thus be Rs 48.00 crores per annum.

All vehicle operators run their vehicles on profit motives. If 10 per cent net profit is assumed, the profit to vehicle operators, if all vehicles are run on commercial basis, would be about Rs 4.8 crores per annum.

If a vehicle plies on a katcha road, the extra cost of transport would be at least 20 per cent more on account of higher depreciation of vehicle parts and increased propulsion charges. The extra cost per ton mile of traffic could thus be 4 nP.

If there were no metalled roads in the Punjab and the traffic of 2,400 million ton miles was to be carried on katcha roads, the extra cost of transport would be Rs 9.6 crores. By metalling the road system, the people of the Punjab, therefore, save about Rs 9.6 crores per annum on transport of goods.

- (a) Assume that the Punjab State had floated a loan of Rs 50.00 crores for the construction of the road system. If interest is assumed at $4\frac{1}{2}$ per cent and the entire loan had to be paid in a period of 60 years, the annual re-payment of loan by annuity including principal and interest would be:

RELATION-SHIP BETWEEN TRAFFIC INTENSITY AND COST OF ROAD PER TON MILE OF TRAFFIC

SCALE: VERTICAL 1 IN. = 5 nP.
HORIZONTAL 1 IN. = 200 TONS

ANNUAL COST OF ROAD PER MILE = Rs 8,500/-
COST PER TON MILE OF TRAFFIC IF TRAFFIC INTENSITY IS 1200 TONS PER DAY } = Rs $\frac{8500 \times 100}{1220 \times 365} = 2.0$ nP

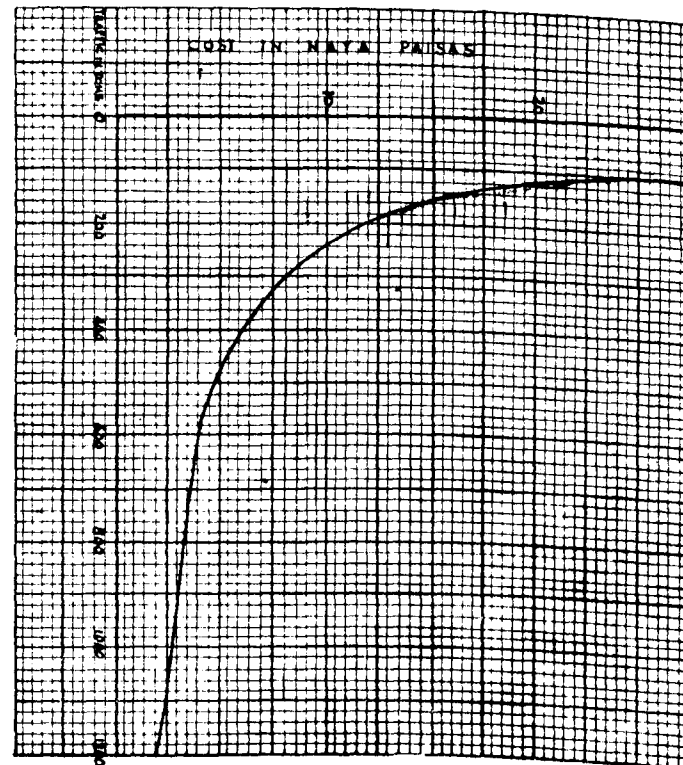


Fig. 1

(Taken from Archers Table for Loan and Compound Interest)

Rs $50 \times .0484 =$ Rs 2.42 crores

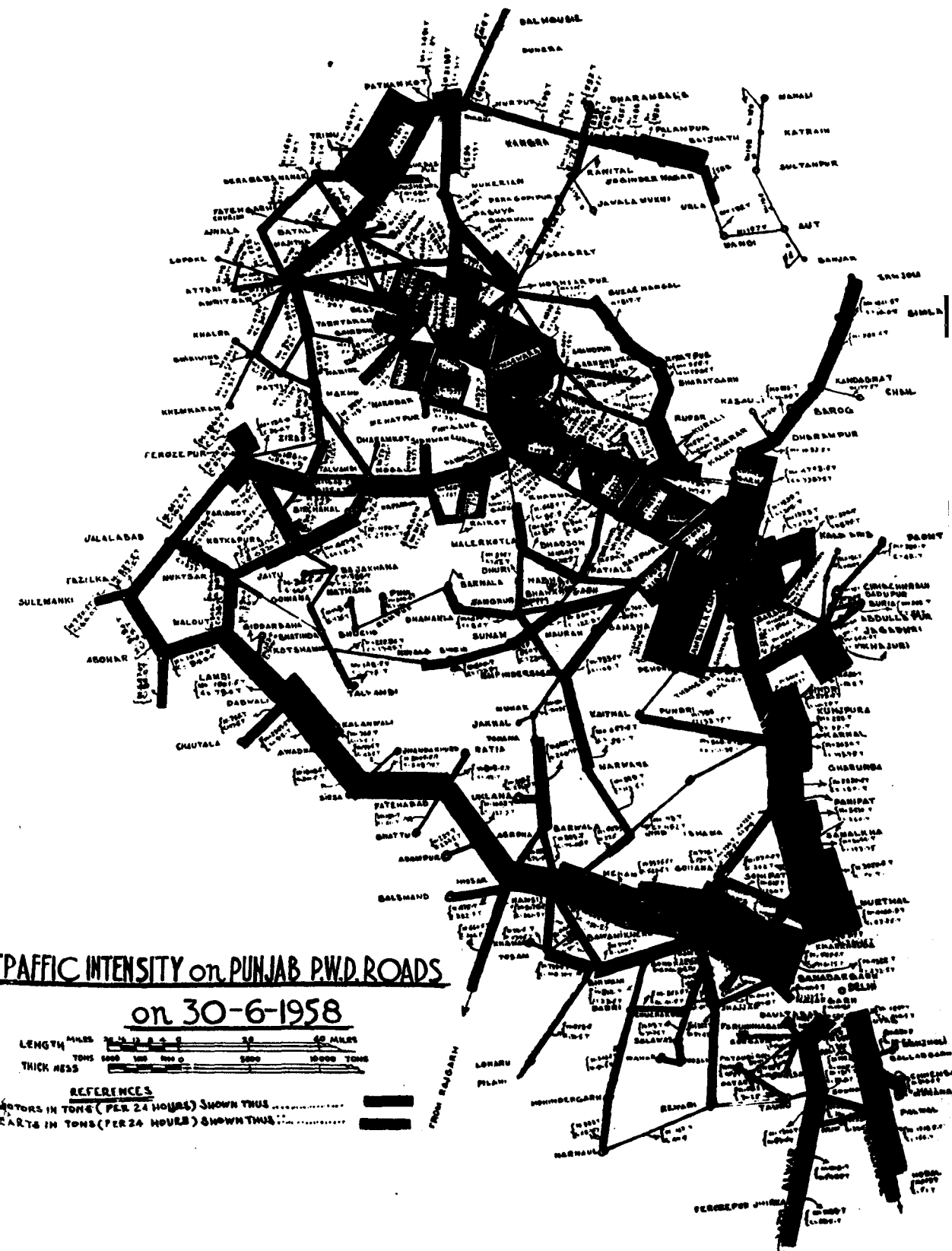
It has been assumed that salvage value of the road system will be zero at the end of 60 years. This assumption errs on the side of safety, as the road system will still have some value.

(b) Average expenditure on the maintenance of the road system is = Rs 1.50 crores

(c) If the road crust is provided additional 4 in. metal every 20 years, average cost per annum = Rs 0.67 crores

Total annual expenditure = Rs 4.59 crores

Net saving per annum (Rs 9.6—4.59 crores) = Rs 5.00 crores



With an investment of Rs. 48.00 crores, there is a net saving of Rs. 5.00 crores, which yields a return of 10 per cent. In this calculation the amount realized by Government in taxation, i.e., taxes on petrol and diesel oil, taxes on motor vehicles and parts, passengers and goods tax, toll tax, income tax paid by operators have not been taken into account.

The average annual cost per mile of the road works out to be $\frac{4.59 \times 10^7}{5400} =$ Rs. 8,500/-. If the traffic intensity on the road is about 1200 tons per day, the cost of road service per ton mile of

traffic is $= \frac{8500 \times 100}{1200 \times 365} = 2 \text{ nP}$. The cost of road plant including its maintenance is approximately 10 per cent of the cost of vehicle operation per ton mile of traffic. The relationship between the traffic intensity and cost of road per ton mile of traffic is shown in Plate.

This note gives an outline of the method for assessment of commercial aspect of a highway system of a State.

The analysis of road costs per ton mile of traffic and figures of yield on the investment will convince even a layman that the highway system of a State is both *productive* and *profitable*.

Will governments cooperate to apply science to promote the welfare of the peoples of the world, or, in rival groups, apply it to their mutual destruction? If moral and ethical principles were the guide to foreign policy there is no doubt what the answer would be.

—JOHN BOYD ORR

Opposition is not a hindrance to life, it is the necessary condition for the becoming of life.

—HAVELOCK ELLIS

ROAD DEVELOPMENT IN HIMACHAL PRADESH

BY

J. MUKAND, CE., (Roorkee), Chief Engineer, Himachal Pradesh.

FIRST FIVE-YEAR PLAN

HIMACHAL Pradesh is situated on the foothills of the Himalayas between north latitude 30 deg.—30 min. and 33 deg.—10 min. and east longitude 75 deg.—55 min. and 79 deg.—50 min. The State has an area of 10,904 sq. miles and a total population of 11.09 lacks. The terrain is almost throughout mountainous and a large number of big rivers such as, Ravi, Beas, Sutlej and Giri criss-cross the region. The main wealth of the State consists of produces such as potatoes and fruits of great variety. The Himachal Pradesh forests contain a large quantity of coniferous timber and it is possible that considerable mineral potential lies latent in the bosom of its hills.

But this vast potential cannot be exploited in the absence of adequate means of communications. Transportation is required to increase production, to distribute surpluses, to exchange ideas and services and to extend the cultural and economic benefits of the modern age to the remotest corner of the State. In the absence of any other acceptable mode of transportation such as Waterways, Railways, etc., the planners of the economy of Himachal Pradesh have had to pay particular attention to the rapid development of roads as without these roads no scheme for development can be either initiated or implemented in this rugged hilly State with very large inaccessible areas. According to the modified "Grid & Star" formula set forth in the Road Development Plan for India (1961—81), Himachal Pradesh requires an overall length of 4,700 miles of roads for the optimum utilisation of all its resources. This corresponds to a figure of 0.43 miles of road per sq. mile of area.

Prior to 1947, the area now known as Himachal Pradesh was a conglomeration of Princely States large and small. These States were separate political and administrative entities and this precluded the possibility of any co-ordinated, systematic approach to the planning and construction of roads in this hilly area. At the beginning of the First Five-Year Plan, Himachal Pradesh had only 219 miles of roads, i.e. a road mileage of 0.02 miles per sq. mile of area. Even these few roads were not correctly designed and satisfactorily constructed and the volume of traffic that they carried was negligible. In order to appreciate the magnitude of the problem faced by the Engineers charged with the responsibility of providing the State with enough roads and making even the remote areas accessible, it is only necessary to compare this figure of 0.02 miles per sq. mile with the corresponding figures of 0.45, 0.41, 0.30 and 0.23 for Bihar, West Bengal, Uttar Pradesh and Bombay respectively.

A systematic review of the road requirements of the State was made for the first time in 1951 when an overall network of roads for the entire State was planned. It was accepted that in order to open up all remote areas at the earliest and to provide benefits to large areas quickly, the construction of roads should be phased. The phasing proposed consisted in spreading the development programme over a number of years and in constructing roads in stages of 2 ft track, 9 ft track, 16 ft width and 24 ft width. The First Five-Year Road Development Plan for Himachal Pradesh

was framed and a sum of Rs 235.00 lakhs was allocated for road construction. This figure was 41.6 per cent of the total outlay during the First Plan period for the State. The fact that the corresponding percentage in the All India Plan was only 5.5 per cent testifies to the great stress that was laid on the development of roads in Himachal Pradesh. By the end of the First Plan, the State had 881* miles of roads. This gave a road mileage figure of 0.08 mile per sq. mile of area against the corresponding All India figure of 0.23 mile per sq. mile.

SECOND FIVE-YEAR PLAN

The State's Second Five Year Road Development Plan began where the First Plan had left off. The works which were not completed during the First Five-Year Plan stage were carried over to the Second Plan and a number of new schemes were also initiated. The entire programme, however, was kept within the framework of the proposed construction of the road net-work as envisaged earlier. In the Second Plan the State proposes to spend Rs 804 lakhs on road development in order to achieve the construction of a total length of 1,328 miles of roads. This will correspond to a road mileage of 0.12 mile per sq. mile, which is six times the mileage figure for the State in 1951.

Himachal Pradesh has now prepared a draft Third Five-Year Road Development Plan for Rs 1,312 lakhs. This Plan has been framed to achieve the construction of 2,631 miles by 1966. This will give a figure of 0.24 miles per sq. mile of area against the ultimate target figure of 0.43 mile per sq. mile. By the end of the Third Five-Year Plan Himachal Pradesh will have linked all its Tehsil headquarters and important administrative outposts by a network of motorable roads and this will have effectively opened up the remote areas.

*All mileage figures indicated in this note pertain to road width of 9 ft and above

BRIDGES

As most of the roads in Himachal Pradesh prior to 1951 were meant only for mule and pedestrian traffic the crossings over the nallahs were normally either dry stone scuppers or simple timber bridges. For crossings with spans of 100 ft and above light suspension bridges existed over a few well established routes while over the subsidiary routesmen and materials had often to be transhipped by means of simple pulley rope devices. Now that the State is to have a net-work of motorable roads the construction of permanent bridges across all perennial streams and rivers is very necessary.

A well organised bridge construction programme has been launched in Himachal Pradesh to ensure free all-weather flow of traffic along the road network. The State P.W.D. has finalised proposals for the construction of 35 bridges planned and designed as per I. R. C. standards. Of these, 7 bridges costing Rs 17.94 lakhs have been completed, 11 bridges are in progress and the construction of 17 bridges is expected to be taken in hand very shortly. The draft Third Five-Year Road Development Plan provides for the construction of a further number of 41 bridges at a cost of Rs 98.78 lakhs. The permanent bridges designed and proposed for construction in Himachal Pradesh include suspension bridges, R.C.C. single and multiple span arch bridges, R.C.C. T-beam and slab bridges, R.C.C. suspended cantilever bridges and prestressed concrete bridges.

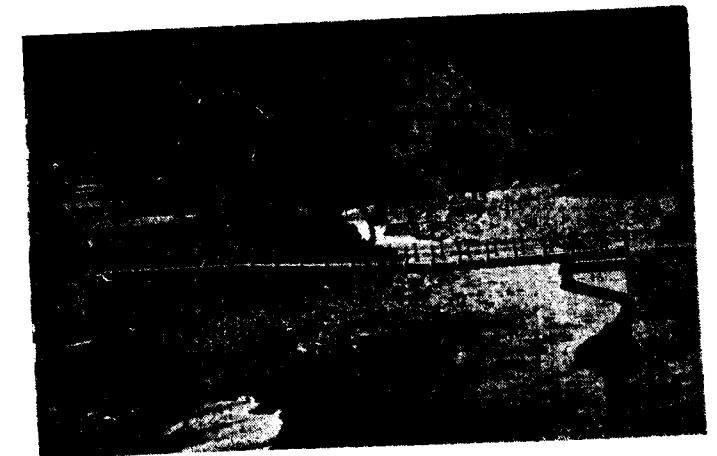
DESIGN STANDARDS

The bridges are being designed for live loads and dead loads as laid down in the I.R.C. Code of Practice.

The design standards prescribed for road construction are governed to a



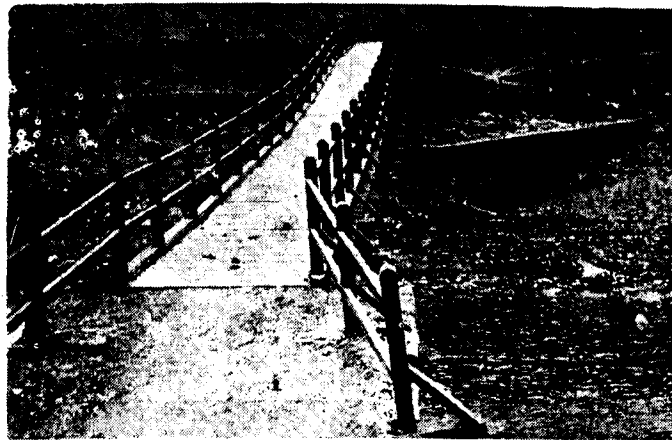
Folk dances of Himachal Pradesh



A temporary wooden cantilever bridge



Rock cutting in half tunnelling



Roadway over a wooden bridge

Rock cutting for the construction of a road



large extent by the nature and category of the road and the volume of traffic that it is expected to handle. In Himachal Pradesh, however, considerations of volume and speed of traffic, etc., are all subordinate to the topographical conditions of the area where the terrain is so difficult that it alone governs the design standards. The standard widths to which roads are being constructed in Himachal Pradesh are 2 ft, 9 ft, 16 ft and 24 ft. These are the formation widths in straight reaches. On curves, the formation is being suitably widened to a width depending upon the radius of the curve. The minimum radius for all horizontal curves is normally kept as 100 ft, but in exceptional cases radii as sharp as 75 ft and even 50 ft have to be provided. The minimum length of the transitions is kept as 75 ft but, where the conditions make it absolutely necessary, transitions of 50 ft at either side of the curves have been proposed. The super-elevation for horizontal curves varies from 1 in 15 for curves of radii sharper

than 200 ft to 1 in 33 for curves having a radius of 500 ft.

The road construction is being planned to a ruling gradient of 1 in 20, a minimum gradient of 1 in 15 for a maximum length of 1 furlong with level stretches of 200 ft on either side, and an exceptional gradient of 1 in 12 for lengths not exceeding 300 ft. In very difficult areas even these standards have, in a few cases, had to be relaxed. The hill side cutting is normally done to slopes which depend upon the nature of the soil and which vary from 1/2 : 1 in the case of ordinary soil to 1/16 : 1 for medium rock. Where hard rock is met, vertical cutting is being resorted to for heights upto 25 ft and half tunnelling is being adopted for heights greater than 25 ft. The road side structures i.e., retaining walls, breast walls, side drains, culverts, etc., are being designed as per latest design practice.

The surface treatment for roads in Himachal Pradesh consists of a first wearingcoat of 4½ in. thickness, a 2nd wearing coat of 3 in. thickness and two coats of surface painting, on a base of 6 in. stone soling. This stone soling is provided only at places where the natural subgrade itself is not hard enough to serve as a base course. Where the formation is either hard or soft rock, stone soling is being dispensed with.

SPECIAL PROBLEMS

Himachal Pradesh has problems in the design and construction of roads and bridges unique to itself in view of its topographical conditions, its climate, and its resources in men and materials. These problems have to some extent impeded the progress and have increased the cost of construction per mile of road as compared to that in the other States of the Union. These problems briefly stated are as follows:

1. The difficult nature of the terrain makes all investigations and surveys very difficult and

time consuming.

2. Roads have, in considerable lengths, to be hewn and blasted through long strata of hard rock. This work is slow, costly and hazardous.
3. In a number of areas the working season is restricted to 4 months in a year while in a few more it is no better than 6 to 8 months in a year.
4. In the remote areas labour is not locally available and has to be imported from outside. Himachal Pradesh is also faced with shortages in manpower, materials and equipment.
5. The remoteness and inaccessibility of various sites of construction is, at present, further accentuated by the inadequacy of the existing roads and the almost complete absence of bridges that can be used for transporting labour and equipment.
6. The maintenance of the existing lines of communication requires a great deal of time and expenditure because of erosion, hill slips, etc.

A concerted effort is being made by the State to overcome these handicaps. In spite of these bottlenecks, however, the progress made upto date is satisfactory and continues to improve.

Himachal Pradesh now stands on the dawn of an era of development and prosperity. Among the many factors which will be responsible for ushering in this new age, highway construction will surely rank as one of the most important. Some work has been done and a lot remains to be done. The State faces the future programme of road development with confidence as it is now far better equipped in men, materials and the know-how of hill road construction than it was 8 years ago.



Sri N. DURRANI, B.Sc., B.E.
M.I.E. (Ind.), M.Am.Soc.C.E.,
Chief Engineer, (Highways),
Andhra Pradesh.

ROAD DEVELOPMENT
IN
ANDHRA PRADESH

THE important role communications play in the development of any tract of land is very well known. No form of development in any walk of life can be achieved unless adequate means of communications are provided. Road communications occupy a unique position in relation to other forms of transport, viz., rail, water, aerial, etc. None of these is complete by itself; they have to be supplemented by road communications.

The State of Andhra Pradesh comprises 20 revenue districts and has an area of 1,06,041 sq. miles, which is 8.4 per cent of the total area of the country, and a population of 313 lakhs.

The State has a total road mileage of 19,236 made up region-wise as follows:

Coastal Andhra	9,392 miles
Rayalaseema	6,199 „
Telengana	3,645 „

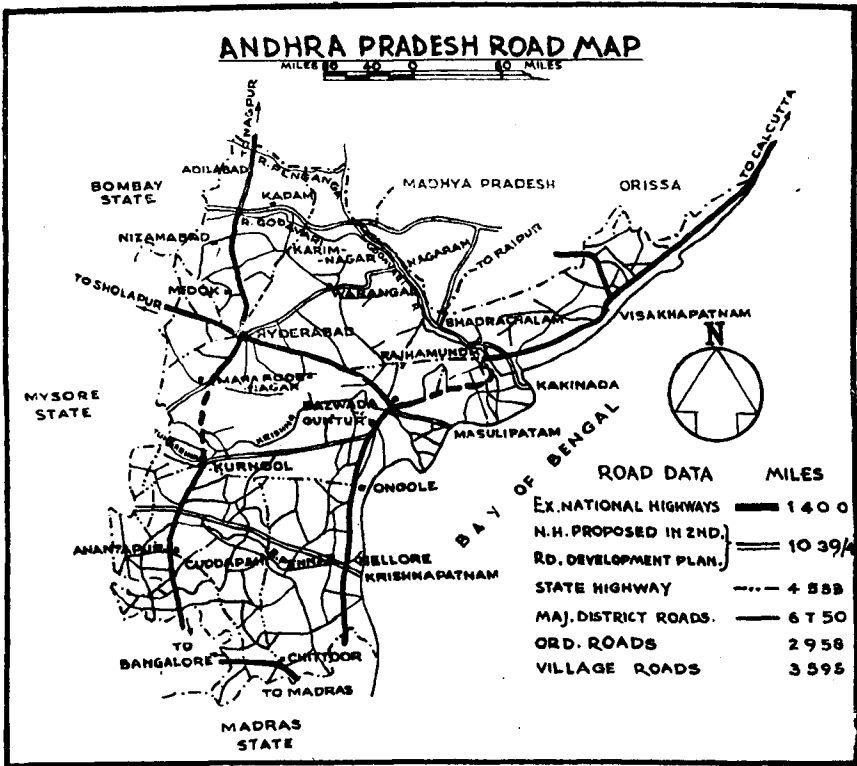
The mileage of roads works out to 0.19 miles per sq. mile of area and 65 miles per lakh of population.

Till after the First World War, there was no systematic road development or planning in India. The little activity

that came later was halted with the declaration of the Second World War. Even the nominal maintenance of roads then existing in an unconnected manner could not be done satisfactorily. The first attempt to unify the road system on all-India basis was made at the Chief Engineers Conference held at Nagpur in December 1943. The Table below gives the targets of road milage in Nagpur Plan pertaining to the Andhra region of the State (Nagpur Plan does not cover the princely State of which the Telengana region of Andhra Pradesh formed part):

	Andhra Pradesh as in 1943 (miles)	Nagpur Plan targets (miles)
National Highways	937	937
State Highways	396	424
M.D.Rs.	1,968	2,612
O.D.Rs.	3,551	6,060
Village Roads	7,740	13,886

To implement the proposals of road development, the Madras State took the lead and created a Highways Department in 1946 to look after the roads. The highways department was continued in the newly formed State of Andhra Pradesh and, in 1956, was recognised as



a separate department exclusively in charge of roads in Andhra and Telengana wings of the State. The implementation of the Nagpur Plan was commenced with the recast Five Year Plan (1947-52) and received keen attention during the subsequent first and second Five Year Plans of India in the years 1951-56 and 1956-61 along with other developmental activities since attainment of India's Independence.

FIRST FIVE YEAR PLAN

By the end of the First Plan in 1956, 732 miles of new roads had been constructed in the Andhra region of the State. Upgrading of 864 miles and construction of 45 bridges was also done in Telengana during the same period, and 210 miles of roads were constructed including masonry works. The expenditure on road development during the First Five Year Plan was Rs 238.69 lakh in Andhra and Rs 99.972

lakh in Telengana. Notable among the works completed during the First Plan are the construction of major bridges on Madras-Calcutta road (N.H. 5) with bridges across the river Pennar at mile 109/1-4 at Nellore (cost Rs 34 lakh) and across the river Champavathi at Nathavalasa in mile 520/3 in Visakhapatnam district (cost Rs 19.47 lakh), cement concreting the same road for about 17 miles in Guntur district and 19 miles in Visakhapatnam district at a cost of Rs 22.50 lakh. Black-topping of 132 miles of the same road in Nellore, Guntur, Krishna, West Godavari and Visakhapatnam districts at a cost of Rs 25.06 lakhs and Banaras-Cape Comorin road for a length of 107 miles in Kurnool and Anantapur districts at a cost of Rs 22.55 lakh was also completed. Upgrading the same road for a length of 51 miles in the upper reaches of Mahaboobnagar and Medak districts in Telengana at a cost of Rs 8.97 lakh

was done. In Telengana area, three major roads: (1) Medak-Papannapeta-Alladurg road at a cost of Rs 10.62 lakh, (2) road from Bhangir to Jugdevpur at a cost of Rs 10.29 lakh, and (3) Alladurg-Metalkunta road at a cost of Rs 6.34 lakh, were newly constructed. Metalling the road from Kovvur to Tallapudi on Godavari flood bank (Rs 12.25 lakh) and cement concreting Koduru-Nellajerla road, miles 24/3 to 34/0 (Rs 12.31 lakh) were among the important works carried out in Andhra. On State roads also, many major crossings were bridged in Andhra area. Several other rivers like the Pennar have been provided with causeways to give facilities to traffic at all seasons.

SECOND FIVE YEAR PLAN

During the Second Plan, the targets proposed for achievement are construction of 593 miles of new roads (both in Andhra and Telengana) and 223 bridges, besides upgrading 778 miles of State roads and 175 miles of National Highways. By the end of the Plan period, if all the schemes are successfully carried out, the mileage of different types of roads would be:

	Mileage
National Highways	1,400
State Roads	10,244
District Board Roads	9,939
Total	21,583

In the approved Second Five Year Plan, new works on State roads costing Rs 722 lakh for the State are programmed to be taken up, actual expenditure proposed being Rs 561.34 lakh, leaving the balance as spillover into the Third Plan. Incomplete works of the First Plan, costing Rs 171.30 lakh, are proposed to be taken up and completed during this plan. Works on National Highways to the tune of Rs 681.07 lakh, consisting of Rs 436.94 lakh of new

works and Rs 244.13 lakh of incomplete works of the First Plan, are also proposed in the Second Plan.

The important works taken in hand during the Second Plan are: the construction of the prestressed concrete bridges, 7669 ft long, across Gowtami branch of river Godavari at a cost of Rs 171.71 lakh on the proposed diversion of N.H. 5 in East and West Godavari districts; the bridge across Vasista river on the same diverted route at an estimated cost of Rs 100 lakh which has been sanctioned and the work will commence shortly; construction of bridges on Banaras-Cape Comorin road (N.H. 7) across the Krishna river at Rangapur at a cost of Rs 36.29 lakh and its diversion at a cost of Rs 26 lakh, and across the river Tungabhadra at Kurnool at a cost of Rs 26.17 lakh and forming a diversion road at a cost of Rs 35.21 lakh including the appurtenant works such as K.C. Canal bridge, Handri bridge, Sunkesala subway, etc., have also been taken up. The Tungabhadra bridge is nearing completion while the K.C. Canal bridge and Sunkesala subway have already been completed. Progress on other works is considerable. The regulator-cum-road bridge across the river Krishna near Vijaywada on N.H. 5 was completed at an estimated cost of Rs 39.08 lakh towards road's share. Approach roads costing about Rs 19 lakh to the regulator bridge, including the bridge across Bandar canal at a cost of Rs 5.60 lakh are in progress. The work of forming a diversion road in mile 83/1 to 85/7 of N.H. 5, including bridge over Upputeru at a cost of Rs 14.52 lakh, is also completed and will be opened to traffic soon. The prestressed concrete bridges across Yeleru river near Yerravaram at mile 391/1-3 of N.H. 5 in East Godavari district at a cost of Rs 9.60 lakh was thrown open to traffic in April 1958. Another prestressed concrete bridge across the river Paleru on S.H.-V. road at an estimated cost of Rs 5.80 lakh was also completed in a record time of

8 months and opened to traffic in September 1958.

Construction of bridge across Pennar at Pamidi on N.H. 7 at a cost of Rs 23 lakh and diversion of N.H. 5 at Visakhapatnam including construction of bridges across Mahendragedda and its spillways, at an estimated cost of Rs 27.85 lakh, are included in the programme.

With the completion of all these bridge works, the existing barriers on National Highways throughout the length and breadth of the State will be removed, providing scope for free flow of traffic from one end to the other.

On State roads, three prestressed concrete bridges, viz., across Upputeru river on Gudivada-Bhimavaram road at Rs 8.66 lakh, across river Gostani at mile 14/6 of Vizianagaram-Bowdara road at Rs 3.96 lakh, and at mile 6/3-5 of Vizianagaram-Kothavalasa road at Rs 6.20 lakh, which were started in the First Plan, have been completed and thrown open to traffic in 1956, 1957 and 1958 respectively. Another prestressed concrete bridge across Buradakalva at mile 17/3-4 of Rajahmundry-Gokavaram road at an estimated cost of Rs 3.85 lakh has been completed and thrown open to traffic on 29.5.1959.

Other important bridges taken up for execution during the Second Five-Year Plan are the bridge at Nellimerla on Vizianagaram-Palakonda road across river Champavathi at a cost of Rs 6.76 lakh and construction of bridges across Irrigation and Navigation canals and bypassing Duggirala at a cost of Rs 5 lakh. Remodelling the bridge at mile 9/1 of Anakapalle-Madugula road at Rs 3.63 lakh has also been taken in hand.

Approval has been also accorded for the construction of a high level bridge costing Rs 57 lakh across the river Godavari near Bhadrachalam in order to provide an all-weather crossing to tens of thousands of pilgrims visiting

the sacred shrine of Sri Bhadrachalam. For this work, Government of India have extended Rs 20 lakh. Tenders for the work have been invited and the work is likely to be commenced shortly.

During the Second Plan, 54 miles of District Board roads are to be taken over by the Department in stages, about 15 miles have already come under their control. Their condition being poor, they are to be improved gradually.

Besides the above mentioned works, several works have also been undertaken from grants received from Govt. of India.

	Rs in lakh
(1) C.R.F. State allocations	154.68
(2) C.R.F. Ordinary reserve	41.071
(3) Other grants	150.00

SECOND ROAD DEVELOPMENT PLAN

In order to provide the transport needs of the expanding economy of the country, the Chief Engineers in their meeting held at Bombay in August 1958 prepared the Second Road Development Plan for the country for the period 1961-81. The targets proposed for achievement by the end of this Plan for Andhra Pradesh are given below:

Classification	Miles
National Highways	1,039
State Highways	2,405
Major District Roads	15,400
Other District Roads	16,861
Village Roads	18,665
Total	54,370

According to the All India Road Development Plan, the target for the next 20 years for National Highways in respect of Andhra Pradesh comes to Rs 86 crore and the quota for the

(Continued on page 75)



AGDISH PRASAD,
C.E. (Roorkee), A.M.I.E.,
Chief Engineer,
P.W.D., B & R., U.P.

ROAD DEVELOPMENT IN UTTAR PRADESH

ROADS play a vital role in the progress of a country and civilization in general.

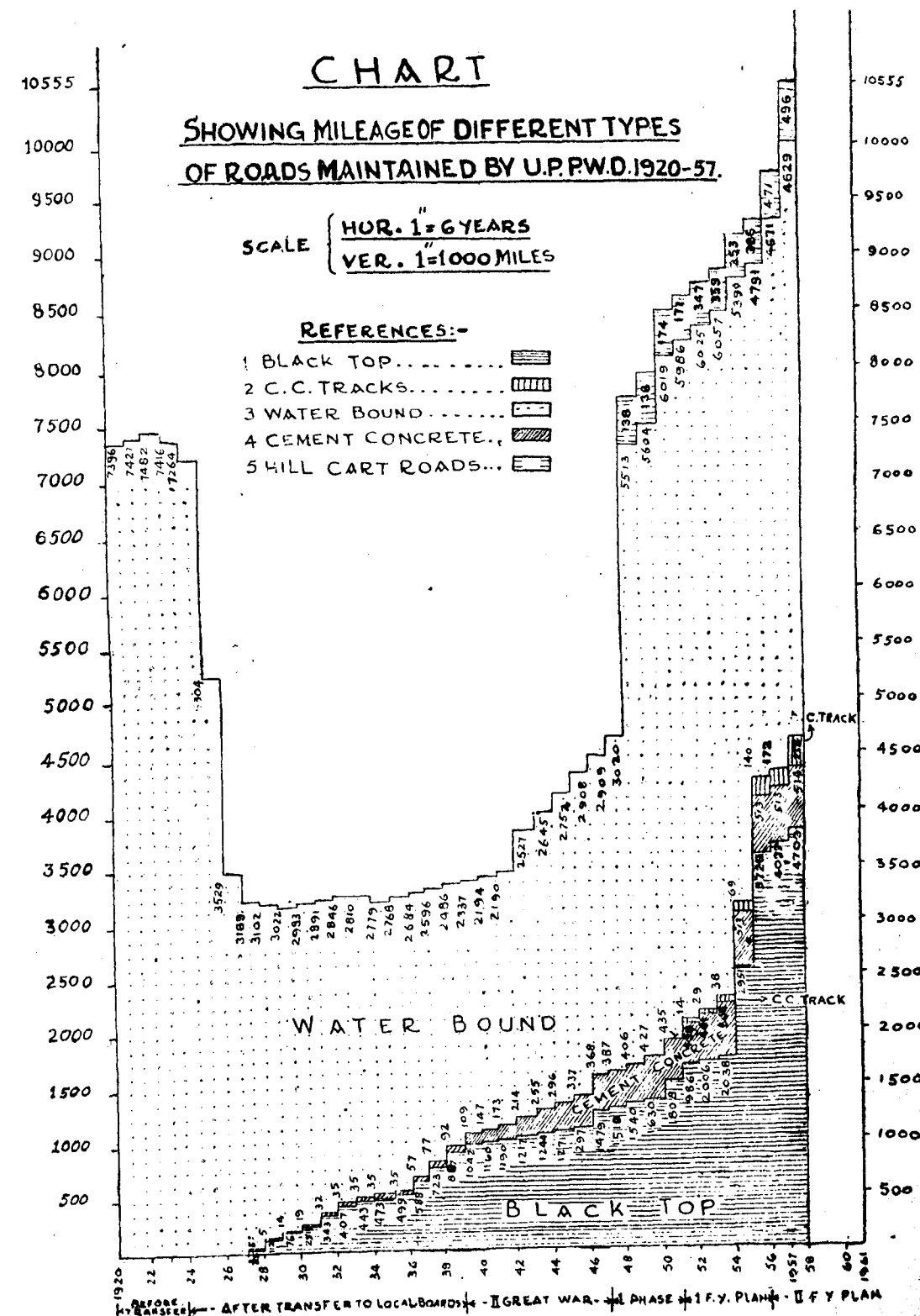
In India, roads have existed in some form or the other from ancient times. Excavations carried out by the Archaeological Department of the Government of India established the existence of roads as far back as 3500 B.C. In the reign of Chandra Gupta Maurya, roads connected the north-western frontiers of India to the capital town of Pataliputra (modern Patna). The Grand Trunk Road of the Moghul Kings is a fine specimen of roads.

However, today there are thousands of acres of cultivable land in India which lie waste and vast areas which are inaccessible. The country is faced with a constant acute problem of food for the ever-increasing population and the danger of famine looms large on the country. Thousands of villages are today far away from modern civilization and are devoid of modern amenities of life. Let these villages be connected by some kind of roads and it will be no wonder if the problems of food, clothing, unemployment, etc., find an automatic solution in a very short space of time.

With the attainment of Independence, the country was astir with zeal and enthusiasm to banish poverty, starvation unemployment and ignorance from the teeming millions of India by launching development and reconstruction programmes in all the fields of national life. A lot has happened since then and we can always look upon our achievements with a sense of pride.

In relation to size and population of India, road development in general is far behind the other advanced countries of the world. As regards Uttar Pradesh in particular the State is backward with regard to mileage of metalled roads. According to the population, area and agricultural productivity, this State should have a much greater mileage of roads. The following figures will indicate the magnitude of disparity which exists in respect of road mileage between this State and other States in the country.

State	Road mileage per hundred square miles of area (1955)
Madras	29.9
Andhra Pradesh	20.7
West Bengal	15.3
Bombay	13.1
Uttar Pradesh	10.3



Thousands of villages in the State remain isolated and even the bare necessities of life never reach them. These areas have to be opened up to solve the problem of food and unemployment in the State.

NAGPUR PLAN TARGETS AND ACHIEVEMENT

The first bold step in the direction of making up leeway in roads was taken in the year 1943 when for the first time the historic Nagpur Plan was evolved by the Chief Engineers of all States covering a period of 20 years. According to this Plan, U.P. should have 16,500 miles of metalled and 42,307 miles of unmetalled roads. At the end of 1946-47, the State had 9,387 miles of metalled roads and 25,953 miles of unmetalled roads under the management of the State P.W.D. and Zila Boards. It is expected that at the end of the Second Five Year Plan, the State will have about 14,000 miles of metalled roads, leaving a gap of 2,500 against the target set in the Nagpur Plan.

This deficiency has, therefore, to be made good in subsequent plans.

POST-WAR ROAD DEVELOPMENT SCHEME AND FIRST FIVE YEAR PLAN

Soon after the end of the Second World War, a post war road development scheme costing Rs 68.70 crores at 100 per cent above pre-war schedule of rates was drawn up to be completed in 10 years. The first phase programme for 15.5 crores was drawn up in 1946-47. Due to addition of some works and the increase in prices, a revised programme costing Rs 20.53 crores was reported to Govt. in 1950.

In the year 1949, when the works were in full swing, a financial crisis set in the State and the programme had to be kept in abeyance. With the start of the National Five Year Plans, this State also prepared its First Five Year Plan which included works left over from Phase I of the Post War Road

Development Scheme and certain additional works necessitated due to the merger of certain states in U.P. This Plan was to cost Rs 783.10 lakhs with a total expenditure of Rs 522.36 lakhs up to the end of 1955-56 and a spill over of Rs 260.74 lakhs to be met during and from the Second Five Year Plan.

During the plan period, necessity of sanctioning some additional works was felt and several works, outside the plan, were also sanctioned.

A general appreciation of the works taken up during the First Five Year Plan is given below.

SECOND FIVE-YEAR PLAN

At the end of the First Five-Year Plan the total cost of incomplete work was valued at Rs 620 lakhs. Due to rise in prices this figure has now risen to Rs 708 lakhs. These incomplete works now form part of the Second Five-Year Plan as continuing schemes. These are now nearing completion.

The Second Five-Year Plan now comprises new works costing about Rs 1,550 lakhs (revised figure) in addition to the spill over of Rs 708 lakhs from the First Plan. The size of this Plan including establishment charges is Rs 2,404 lakhs. Due to restrictions in annual budget allotments, the targets originally fixed for physical completion are not being realised with the result that the size of the next Plan is bound to go up. The salient features of the Second Five-Year Plan and achievements up to March 1959 are given below.

Apart from the road development schemes being executed under the second Five-Year Plan, several schemes financed by Govt. of India subsidy, loan or Central Road Fund have also been taken up as under:

(a) Unemployment relief scheme	Rs lakhs.
...	254.84
(b) Scheme for roads in border areas	54.00

Achievements till the end of First Five-Year Plan

Items of works	Plan works 1951-56.		Works outside plan 1951-56		Unemployment relief scheme costing Rs. 2.5 crore	
	Target in miles	Achievement up to 3/56	Sanctioned lengths	Completed length	Sanctioned length	Completed length by 3/56
1. Reconstruction						
(a) Local metalled roads	329	324	76	50	57	9
(b) Unmetalled hill bridle roads	70	91	257	178	121	19
(c) C.C. on P.H. routes	32	35	5	8	—	—
2. New Construction						
(a) Metalled roads	541	894	320	80	380	79
(b) C.C. Tracks and painted roads	180	148	76	2	—	—
(c) O.D.R's and V.R's.	(2000)	(1346)	—	—	—	—
3. Miscellaneous Items						
(a) Improvement and reconstruction of:						
(1) Metalled roads	104	88	491	133	—	—
(2) Unmetalled roads	35	93	136	136	—	—
(b) Metalling O.D.R's.	80	150	246	37	—	—
(c) New metalled roads	41	49	—	—	—	—
4. Decking of Rly. bridges	2	—	—	—	—	—
5. Construction of new bridges	9	7	61	19	—	—

Second Five-Year Plan

Sub-head of works	Continuing schemes				Total provision		Plan Schemes Plan targets		Achievement up to March 1959		Remarks
	Provision in the plan		Achievement up to March 1959								
	Length	Cost	Length	Cost	Length	Cost	Length	Cost	Length	Cost	
A. Reconstruction											
(1) Local metalled roads	68	37.48	61	37.03	412	131.17	215	69.12	68	28.00	
(2) Hill bridge roads	167	11.32	111	5.50	434	18.45	260	10.13	45	2.80	
(3) Modernization and improvement	212	72.65	180	54.57	464	188.83	245	102.32	87	63.27	
Total	447	121.45	352	93.10	1310	338.25	720	181.57	200	94.07	
B. New Construction											
(a) New metalled roads	324	193.12	415	204.52	958	493.14	351	192.45	272 (A)	164.36	Note: A includes progress on item B also
(b) Metalling O.D.R's	312	114.85			811	321.80	376	148.60			
(c) C. C. Tracks	329	94.90	108	30.00	—	—	—	—	—	—	
(d) Unmetalled roads	68	13.31	48	8.84	300	24.40	260	15.31	77	5.51	
(e) Shramdan roads	—	—	—	—	100	27.50	60	17.50	(B)	—	
(f) Govt. Estate roads	—	—	—	—	25	10.00	10	5.00		—	
(g) Maintenance of Shramdan roads	—	—	—	—	300	7.50	300	7.50	—	1.02	
Total	1043	416.43	571	243.36	2593	884.34	1357	386.36	349	170.89	
C. Bridges											
(i) Major bridges	41	130.30	32	99.79	57+8	333.84	15+8	141.19	2}	66.80	.80 are for improvement of ferries
(ii) Suspension bridges	8	.61			36	22.00	26	12.81			
Total.	49	132.91	32	99.79	92+8	355.84	41+8	157.00	2	66.80	
D. Other Works	L.S.	37.16	—	15.79	L.S.	79.54	L.S.	46.00	—	15.78	
Grand total.	—	708.00	—	452.04	—	1657.93	—	770.93	—	347.54	
Less expenditure not debitable to plan	—	—	—	—	—	21.93	—	21.93	—	21.93	
Net.	(708.00)	A	—	—	—	(1636.00)	B	749.00	—	325.61	
Establishment and maintenance	—	—	—	—	—	Est. (123.00)	(C)	77.00	—	52.73	
						Maintenance (107.50)	...	80.00			
						(A) Reduced to		696.94			
						(B) Reduced to		1610.30			
						(C) Reduced to		121.01			
						Revised plan					
						Total		2428.25			
						Plan expenditure		1523.54			
						Spill over		904.71			

(c) C.R.F. schemes ...	Rs 122.08 lakhs
(d) C.C. Tracks or painted roads round sugar factories on contributory basis ...	247.00 „
(e) Development of backward areas...	99.50 „
Total	777.42 „

NATIONAL HIGHWAYS

The State P. W. D. maintains 1397 miles and 3 furlongs length of roads classified as National Highways (excluding portions lying within Municipal limits) at the expense of Government of India at a recurring cost of about Rs 52 lakhs on an average. A number of development schemes are being carried out on National Highways in U.P. as under :

	Rs lakhs
(a) Widening the carriageways	217.15
(b) Improving geometrics	21.29
(c) Providing bypasses	91.37
(d) Construction of bridges including Pontoon bridges	751.85

Approximately 25 per cent financial progress has been achieved on these development schemes to end of March 1959.

BRIDGES

The State is crossed by three big rivers, viz., Ganga, Yamuna and Ghagra, apart from a large number of smaller streams. They flow in all directions north-south, south-north, east and west. To make the road system all-weather, it is absolutely necessary to construct a large number of bridges, major and minor, both in the plains and hills. Top priority is given to bridges. A katcha road with bridges is more useful than a metalled road without bridges.

It is proposed to construct 79 major bridges of all types in the State at a

total cost of Rs 945.796 lakhs provided under various schemes. Out of these, 20 bridges have been completed and work on 59 bridges is in hand.

Some of the most important bridges are :

(1) Ramganga Bridge (State Highway, Bareilly-Mathura Road)	Length: 2210 ft Cost: Rs 60 lakhs
(2) Bridge at Garhmukteshwar over River Ganga	Length: 2308 ft Cost: Rs 77.97 lakhs
(3) Bridge over Sarju at Ayodhya	Length: 3354 ft Cost: Rs 182 lakhs
(4) Bridge over Rapti at Gorakhpur	Length: 1353 ft Cost: Rs. 41.43 lakhs
(5) Bridge over Yamuna at Mathura	Length: 1050 ft Cost: Rs 28.81 lakhs

Border Area Roads

The State has a long border common with Tibet or Nepal in the north. The border common with Tibet is at a very high altitude. Recent events have brought the problem of roads in these areas to the fore front and it is hoped speedy action will be taken in the near future to construct more roads in the border areas.

THIRD FIVE YEAR PLAN

In view of the rapid changes that are taking place in the country and their consequential impact on the growth of road traffic, the Committee of Chief Engineers of the State P.W.Ds. has considered essential to revise the standards laid down in the Nagpur Plan and the 20 Year Road Development Plan recently finalised by them lays down revised standards.

According to this Plan, the State of U.P. should have the following mileages:

Target anticipated at the end of the 2nd Five Year Plan :

1. Metalled roads 48,700 miles
14,000 miles.
2. Unmetalled roads 32,900 miles
25,000 miles.

This leaves a gap of 34,700 miles of metalled roads and 7,900 miles of unmetalled roads to be removed within a period of 20 years. Besides this addition of new mileage, reconstruction of existing local metalled and unmetalled roads, upgrading and widening of heavy traffic miles, raising of road formations and providing additional waterways to the existing culverts and bridges, construction of missing bridges on new as well as existing roads and improvement of road geometrics, etc., are also necessary. It has been estimated that the cost

of all the above items of work will be roughly 565 crores. An expenditure of Rs 500 crores is anticipated in the next 20 years in four successive five year plans in the following order.

Period	Cost of Plan in crores	Expenditure in crores	Spill over crores
1961-66	90	60	30
1966-71	135	100	35
1971-76	210	150	60
1976-81	255	190	65
Total	565	500	65

This expenditure follows the same pattern as suggested in the 1961-81 Plan in respect of the all India figure of Rs 5,200/- crores.

"The search for truth is in one way hard and another easy. For it is evident that no one can master it fully or miss it wholly. But each adds a little bit to our knowledge of nature and from all the facts assembled there arises a certain grandeur".

—ARISTOTLE.

ROAD DEVELOPMENT IN MADHYA PRADESH

P. V. DIVATIA, B.E., (Civil)
Chief Engineer, PWD., B. & R. Madhya Pradesh

THE reorganized Madhya Pradesh, comprising 43 districts, was formed on the 1st November 1956 with the merger of Madhya Bharat, Vindhya Pradesh, Bhopal and Mahakoshal, and has an area of 1,71,052 sq. miles, i. e., 14.6 per cent of the area of India. (See Map, Annexure I). The population of Madhya Pradesh as per 1951 census is computed as 2,60,71,654.

This new State is a conglomeration of numerous States, large and small, with its attendant lag in all types of communications. There were very few through or inter-state roads and hardly any bridges in the constituent units of the State because construction of bridges was costly and there was no common agency to construct them for mutual benefit. So, the new M. P. inherited greatly dis-connected portions with many enclaves of adjoining States like Rajasthan, Uttar Pradesh, Bihar, Orissa, Bombay through which one has to pass for reaching other parts of Madhya Pradesh. The capital of new Madhya Pradesh at Bhopal has no direct road links with different parts of the State as in Bombay and Uttar Pradesh.

Thus, in 1956, the new Madhya Pradesh started with initial shortage of roads, missing links and almost no connections with the new capital. This State also suffers from insufficient Railway mileage, absence of water communications and even air connections. From 1st December 1959, only Indore, Bhopal and Gwalior have been brought on the air map of India.

On the formation of the State in 1956, the position of road mileage was as follows :

Cement concrete	—	28 miles
Black topped	—	1,680 "
Water-bound macadam	9,649	"
Unsurfaced, motorable	5,573	"
Municipal roads	—	678 "

Total 17,608 miles

Thus, surfaced roads were 12,035 miles and unsurfaced 5,573 miles. (These figures do not include the Irrigation, Forest, Janpad Sabha, Private, and Community Development Block roads).

By 1958, Madhya Pradesh had 18,192 miles of road (surfaced 11,095 and unsurfaced 7,097 miles), excluding C. D. Block Roads, Forest, Irrigation, and Janapad Sabha roads. The roads under Community Development were as much as 13,297 miles (1800 miles pucca, 5,252 miles katcha and 6,245 miles improved or repaired katcha). The following table gives comparative intensity figures for Madhya Pradesh and India as a whole :

Particulars	Madhya Pradesh		All-India	
	1956	1958	1956	1958
Road mileage per 100 sq. miles.	10.30	12.69	21.70	29.20
Population per mile	1,482	1,507	1,220	1,134

The Nagpur Plan had envisaged 26 miles of roads per 100 sq. miles by

1960, according to which M. P. should have a total of 44,836 miles of roads (16,692 miles surfaced and 28,194 miles unsurfaced). Madhya Pradesh had thus initially a large leeway to make up before it came in line with the general conditions in India and also further to improve and considerably increase its road progress from year to year.

Since the present M. P. has been formed after merging 4 units and the large unit of old C. P. and Berar (or old M. P.) has been truncated and shorn of 8 districts, it will be difficult to give correct picture of the First Five Year Plan of these units, their targets and achievements.

In the Second Five Year Plan of Rs 190.90 crores, the provision for roads was Rs 12.0787 crores whereas the estimated cost of the schemes was nearly double, that is, Rs 23.992 crores, which has since increased considerably. But expenditure till the end of the Plan will be about Rs 9.281 crores.

The physical targets against the expenditure are as follows:

- (a) New road construction (Metalled) 1,828 miles.
- (b) New Road construction (F.W.R.) 862 "
- (c) Improvement of existing roads 1,805 "
- (d) Construction of bridges and Culverts 2,706 Nos.
- (e) Construction of rest houses. 20 Nos.

During the 3 years of the plan, physical achievements attained so far are:

- (a) New road construction (Metalled) 882 Miles.
- (b) New road construction (F.W.R.) 400 "

- (c) Improvement of existing roads 745 Miles.
- (d) Construction of Bridges and Culverts 376 Nos.
- (e) Construction of rest houses. 3 Nos.

THIRD FIVE YEAR PLAN

As already indicated above, the heavy leeway inherited has to be made up, which is about 14 miles per 100 sq. miles of the area, and which forms the main objective of the Third Five Year Road Plan of Madhya Pradesh. The financial outlay of the Third Road Plan of Madhya Pradesh to fulfill this objective would be of the order of Rs 75 crores.

The objectives of the Third Five Year Plan of Roads in Madhya Pradesh conforming to the above mentioned financial limits will be as follows.

(a) The physical targets:

S. No.	Items	Figures by the end of Plan		
		1st Five Year Plan	2nd Five Year Plan	3rd Five Year Plan
1.	Length of metalled roads in miles	12,035	13,572	16,072
2.	Length of roads asphalted (in miles)	1,690	1,900	3,700
3.	Road mileage per 100 sq. mile	10.30	13.00	17.00

- (b) Improvement of all existing roads and bridges and asphaltting of all important roads.

- (c) Construction of culverts, causeways and bridges on existing roads with a view to increase their utility.
- (d) Connecting Bhopal (Capital of M.P.) with all divisional headquarters.
- (e) Construction of roads for industrial development particularly Coal, Iron Ore, Bauxite and Manganese.
- (f) Construction of security roads.
- (g) Connecting all district, tehsil and block headquarters to existing metalled roads.
- (h) Construction of missing links of the former interstatel roads.
- (i) Asphaltting of roads leading to places of tourist interest and metalling of roads leading to places of pilgrimage.
- (j) Roads of economic interest like in sugar cane areas.
- (k) Completion of metalled roads constructed under Scarcity Relief Programme where 80 per cent work has already been completed.
- (l) In the overall programme, every district has to get a proper share depending on its area, population and needs.

Madhya Pradesh is situated in the heart of India with rich forest and mineral wealth and abundance of food-grains rice, etc. This State thus needs to be opened out more and more by better roads accessible from all parts of India quickly to develop its potentials for the benefit of the country. Third Five-Year Plan of the State is, therefore, ambitious.

(Continued from page 65)

Third Five-Year Plan works out to Rs 21.50 crore. The All India Plan envisages the upgrading of 1,000 miles of National Highways as "Expressways" by the end of the Plan period, viz., 1981. So far as this State is concerned, 45 miles in all are proposed to be upgraded as "Expressways." The cost of conversion of these two stretches into Expressways comes to Rs 720.00 lakh at Rs 16 lakh per mile as indicated in the All India Plan.

The All India Road Development Plan also contemplates upgrading some of the State roads to the standards of National Highways and the expansion of the mileage of National Highways. Under this scheme, nearly 1,040 miles of roads are proposed for classification as National Highways for Andhra Pradesh. 330 miles are proposed to be so classified in the Third Five-Year

Plan according to their importance. The balance of 710 miles will have to be taken up in subsequent plan periods. A further sum of Rs 2,200 lakh has been proposed for upgrading the extended portion of S.H.-V. road up to Masulipatnam to National Highway standard with two lane traffic and cement concrete pavements wherever necessary.

The overall cost of the Third Plan as proposed for the State is Rs 45.07 or Rs 45 crores. This provision, though not fulfilling the entire requirements of the State, will form the nucleus for development of a harmonious and larger road grid for the future. It is hoped that, with the co-operation of all, it will be possible to put through successfully the road development plans which will contribute in a large measure to the welfare and prosperity of the State.



M. S. AHMAD

Chief, Transport &
Communications Division,
ECAFE, Bangkok

PHASED DEVELOPMENT OF ASIAN HIGHWAYS

"THE World has shrunk" would be a comment on the obvious. Thanks to the phenomenal development of transport facilities during the last decade, the remotest parts of the world can now be reached in days, if not in hours: As no nation is now completely isolated, it cannot live or prosper in seclusion.

In the distance-annihilation process land transportation has played an important role. Highways across international borders have greatly increased the opportunities for economic, cultural and tourist exchanges between countries. They have facilitated balanced development among peoples and have brought them prosperity to which they aspire and to which they are entitled.

Realizing the important role an adequate system of international land communications can play in the economic social and cultural development of Asia, the Highway Sub-Committee of the Inland Transport and Communications Committee of the United Nations Economic Commission for Asia and the Far East (ECAFE) at its fourth session held in Bangkok in November 1958, stressed the urgency for early action on the part of governments to develop international highways in the ECAFE region. The Sub-Committee felt that the time had come for the ECAFE secretariat to undertake comprehensive studies of all

aspects of the problem of developing an international Asian Highway system and to initiate such action as might serve to stimulate governmental interest and facilitate development of international road communications.

While reviewing the state of the highways in the countries of the ECAFE region, the Sub-Committee appreciated that it would not be possible to develop immediately the entire network falling within each country to the full accepted standards of international highways due to the high cost and other factors involved. It, therefore, recommended that a few standards for development by stages should be prepared and recommended that improvements, at least to the minimum standard, should be the immediate objective. The higher stages of development should follow as funds permit and volume of traffic justifies. The immediate aim should be the consideration of linking existing road systems across borders.

As the ECAFE region is vast in area, connected by land extending from Iran in the West to Viet-Nam in the East, the Sub-Committee felt that many problems linked with the development of international highways could best be considered by dividing the area into three zones and examining the special problems of each zone by convening meetings of

expert working groups for each zone.

The first working group is scheduled to meet in Bangkok to consider the road network in the area covering Viet-Nam, Cambodia, Laos, Thailand, Malaya and Burma. The second working group will meet in New Delhi to cover Burma (western connections), East Pakistan, India, Ceylon, Nepal and connections of West Pakistan. The third will meet in Lahore to cover West Pakistan, Afghanistan and Iran. The terms of reference of the working groups have been laid down as follows:

1. To consider the proposals submitted by countries within the zone covered and recommend:
 - (a) the routes to be followed,
 - (b) the standards to be adopted for such routes, and on
 - (c) any other pertinent factor.
2. To consider and recommend priorities of highway construction and rehabilitation.
3. To consider and make recommendations on any other factors which would facilitate international traffic.

In pursuance of the above recommendations the ECAFE secretariat has prepared some standards after careful study of the standards for roads and bridges adopted by the countries of the region for submission to the zonal meetings. While fixing standards, the following factors were kept in view:

- (a) traffic density and its composition
- (b) assumed design speed.

The traffic density will indicate the number of vehicles (expressed in transport units) which are expected to use the roads within the next ten years. To convert the number of vehicles using the road into transport units, the total of which would be a decisive factor in highway classification, the following

coefficients are proposed to be used:

- | | |
|--|-----|
| (i) Cars and motor vehicles | 1 |
| (ii) Light commercial vehicles (with axle load up to 5 tons) | 1 |
| (iii) Medium and heavy commercial vehicles (with higher axle load) | 3 |
| (iv) Buses and coaches | 3 |
| (v) Bicycles | 0.5 |

The main factors determining the design speed are the topography and the volume of traffic. These two factors will have to be examined in every case.

In view of the above considerations, five classes of highways for international traffic have been proposed. These five classes can be considered as consisting of two series: I, II, V for all cases where doubling of the carriageway (separate lanes) is feasible without incurring a disproportionately high cost (flat or rolling topography, cheap land, etc.) and I, II, III, IV for cases where progressive widening of the road is the only economically acceptable solution.

Class I. The simplest type of road—for a traffic density not higher than 10 transport units per hour in both directions.

Minimum design speed:

60 kilometres per hour in flat topography

50 kilometres per hour in rolling topography

40 kilometres per hour in mountainous topography

Carriageway:

Single-lane used for two-way traffic.

Class II. The ordinary type of road—for a traffic density not higher than 600 transport units per hour in both directions.

Minimum design speed:

70 kilometres per hour in flat topography

60 kilometres per hour in rolling topography
50 kilometres per hour in mountainous topography
Carriageway:
Two-lane for the two-way traffic.

Class III. The higher type of road—for a traffic density not higher than 1,000 transport units per hour in both directions.

Minimum design speed :

80 kilometres per hour in flat topography
70 kilometres per hour in rolling topography
60 kilometres per hour in mountainous topography
Carriageway:
Three-lane for the two-way traffic.

Class IV. The higher type of road—for a traffic density not higher than 2,400 transport units per hour in both directions.

Minimum design speed :

90 kilometres per hour in flat topography
80 kilometres per hour in rolling topography
60 kilometres per hour in mountainous topography
Carriageway:
Four-lane for the two-way traffic.

Class V. The motorway for automobile traffic only for a traffic density higher than 2,400 transport units per hour in both directions.

Minimum design speed :

100-120 kilometres per hour in flat topography
100 kilometres per hour in rolling topography

80 kilometres per hour in mountainous topography

Carriageway :

Two separate ones, each having at least two lanes and being used for one-way traffic only.

The above proposals are summarized in tabular form in *appendix* together with other design specifications proposed with regard to width of lanes, horizontal and vertical curves, sight distances, gradients, width of shoulders, and so on.

The expert groups will also consider at their zonal meetings other aspects such as, road signs and signals, preparation of detailed highway maps, frontier formalities (passports, visas and customs regulations), entry of private cars and other motor vehicles, dimensions and weight of vehicles in international traffic, international driving licences, facilities of through transit for freight traffic, etc. In this connection considerable work has been done by the United Nations on frontier formalities (passports and visa regulations, health regulations, temporary importation of private motor vehicles, currency regulations, etc.) A protocol on road signs and signals was also prepared by the United Nations and came into effect on 20 December 1953. The following countries of the ECAFE region are signatories to the various protocols and conventions:

1. Convention on Road Traffic—Geneva, 1949

Entry into force: 26 March 1952.....Cambodia, Ceylon, China (Republic), Federation of Malaya, Laos, Philippines and Viet-Nam.

2. Protocol on Road Signs and Signals—Geneva, 1949

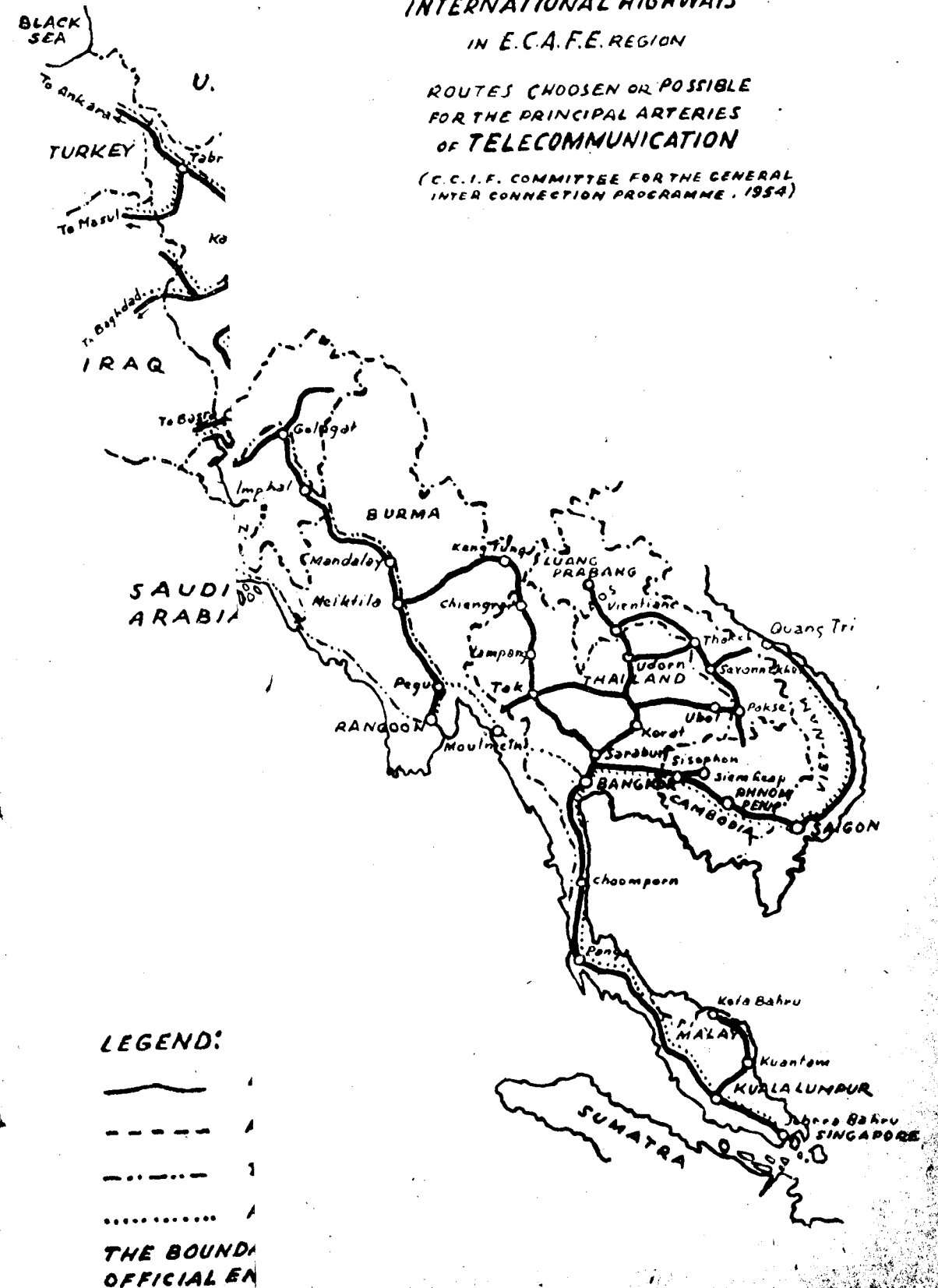
Entry into force: 20 December 1953.....Cambodia.

3. Convention concerning Customs

SCHEMATIC MAP OF PROPOSED INTERNATIONAL HIGHWAYS IN E.C.A.F.E. REGION

ROUTES CHOSEN OR POSSIBLE FOR THE PRINCIPAL ARTERIES OF TELECOMMUNICATION

(C.C.I.F. COMMITTEE FOR THE GENERAL INTER CONNECTION PROGRAMME, 1954)



Facilities for Touring—New York, 4 June 1954

Entry into force: 11 September 1957.....Cambodia, Ceylon, Federation of Malaya and Japan.

4. Additional protocol to the Convention concerning Customs Facilities for Touring, relating to the importation of Tourist Publicity Documents and Materials—New York, 4 June 1954

Entry into force: 28 June 1956Federation of Malaya, India and Japan.

5. Customs Convention on the Temporary Importation of Private Road Vehicles—New York, 4 June 1954

Entry into force: 15 November 1957.....Ceylon, Federation of Malaya, Viet-Nam.

6. Customs Convention on the Temporary Importation of Commercial Road Vehicles—Geneva, 18 May 1956, effective on 8 April 1959.....Cambodia.

The zonal meetings will ascertain as to what action is proposed to be taken by other countries who are not signatories to the international conventions.

The zonal meetings, at a later stage, will also consider the question of developing telecommunications facilities (along the international highways) where they do not exist.

In Geneva in 1954, and later in Rome

in 1958 and in Tokyo in May 1959, the Consultative Committee of International Telephone (CCIF) and the Consultative Committee of International Telegraphs and Telephones (CCITT) prepared a general inter-connection plan for linking the various countries of Asia by metallic circuits. This plan is superimposed on International Highway routes and is shown in the map reproduced. It will be noted that the International Telecommunication routes, in many cases, follow the International Highways. Telecommunication facilities provided along the International routes would no doubt be of great benefit to highway transportation. During the Second World War, when telecommunication facilities were expanded, a large number of important telecommunication routes in India were constructed along the National Highways. It is understood that the new coaxial cable for telecommunications in India is also taken along the highways.

It is expected that the experts attending the Zonal Meetings would give due regard to the requirements of telecommunications in the development of Asian Highways. Recommendations such as the provision of ducts over new bridges for cables and minimum separating distances for telecommunication circuits for different standards of roads will have to be made. Such co-ordinated action will not only provide essential facilities for highway traffic but will also facilitate international telecommunication linkage.

APPENDIX

Minimum Geometrical Design Standards for International Highways in the ECAFE Region

1. Class of highway	I	II	III	IV	V
2. Density of traffic: veh/h	10	6-300	201-353	250-600	more than
per one line	(in both directions)				600

3. Design speed: km/h

(a) flat topography	60	70	80	90	100-120
(b) rolling topography	50	60	70	80	100
(c) mountainous topography	40	50	60	60	80
4. Number of lanes	1	2	3	4	4 divided
5. Width of lane (m) desired	3.50	3.50	3.50	—	—
not less than	3.00	3.25	3.25	3.50	3.75

6. Radius of horizontal curves (m) for design speed km/h

v km/h	minimum R m
40	100
50	100
60	100
70	150
80	200
90	250
100	300
120	500

7. Length of transition curves (m) should not be less than indicated in table below:

V km/h Rm	1500	1000	500	300	250	200	150	100
120	50	75	100	—	—	—	—	—
100	30	40	80	140	—	—	—	—
90	20	30	60	100	120	—	—	—
80	15	25	45	75	90	110	—	—
70	10	15	30	50	60	75	100	—
60	X	10	20	30	40	50	60	100
50	X	X	10	15	20	25	35	50
40	X	X	X	X	10	15	20	30

8. Superelevation on curves necessary when

9. Maximum superelevation

10. Extra width on curves with radius less than

11. Minimum extra width on two lane pavements for the curves with radii

R below 1,000 metres

8 per cent

750 metres

	extra width (m)
700-550	0.40
500-400	0.50
350-250	0.60
200-150	0.75
125-100	1.00

12. Minimum radii in vertical curves:

	I	II	III	IV	V
(a) convex curves	1,000	2,000	3,000	4,000	V km/h R min
					120 8,000
					100 6,000
					80 4,000
(b) concave curves	500	750	1,000	1,200	120 2,000
					100 1,500
					80 1,000

13. Non-passing sight distance (m) V km/h Minimum sight distance surface Vehicles in both directions

V km/h	Minimum sight distance surface	Vehicles in both directions
40	50	—
50	60	100
60	85	120
70	100	170
80	110	200
90	135	220
100	150	270
120	180	—

14. Increase in metres by down-grades in non-passing sight distances

V km/h	Increase in metres by grades		
	3 per cent	6 per cent	8 per cent
40	—	3	3
50	—	4	5
60	3	5	6
70	3	7	10
80	4	9	12
90	5	11	18
100	6	12	21
120	10	24	40

15. Decrease in metres by up-grades in non-passing sight distances

V km/h	Decrease in metres by grades		
	3 per cent	6 per cent	8 per cent
40	—	2	2
50	—	3	3
60	3	3	6
70	3	4	7
80	4	6	9
90	5	7	12
100	6	9	15
120	10	15	21

16.	Maximum gradients in per cent	I	II	III	IV	V
	(a) flat topography	3	3	3	3	3
	(b) rolling topography	5	5	5	5	4
	(c) mountainous topography	8	8	8	6	5
17.	Minimum width or shoulders (m)					
	(a) flat topography	2.50	2.50	2.50	2.50	3.00
	(b) rolling topography	2.00	2.50	2.50	2.50	3.00
	(c) mountainous topography	1.50	2.00	2.00	2.00	2.50
18.	Width of road bed in m					
	(a) flat topography	8.00	11.50	14.75	19.00 ^f	
	(b) rolling topography	7.00	11.50	14.75	19.00	
	(c) mountainous topography	6.00	10.50	13.75	18.00	
19.	Side slopes	The side slopes not steeper than 2 : 1 in cuts (except in solid rock or other special soils) and in fills. In fills of 3.00 m or less, the side slope shall not be steeper than 4 : 1				
20.	Minimum width of right-of-way	I	II	III	IV	V
		20	20	25	35	40
21.	Cross-fall of carriageway	Maximum 3 per cent				
22.	Maximum length of portions with great grades in metres	Grades 3-4 per cent 1000 metres more than 4 per cent 500 „ cent				
<i>Note</i> :—If longer portions are necessary every 500 metres, a portion should be introduced with the maximum grade of 1 per cent and the minimum length in metres:						
		I	II	III	IV	
		100	100	150	200	
23.	Minimum distance between break points of grades in metres	I	II	III	IV	V
		100	100	150	200	250
24.	Minimum distance between two serpentine (hairpin curves) in metres	I	II	III	IV	
		100	100	250	250	
25.	Design standards for hairpin curves:	I	II	III and IV		
	minimum radius of basic curve m	15	20	30		
	minimum cross-fall in per cent	6	6	6		
	minimum length of transition curve m	20	25	30		
	extra width of carriageway in m	3.00	2.50	2.00		
	maximum grade in per cent	4	3.5	3		
	maximum speed in km/h	15	20	30		
26.	Minimum clearance					
	(a) horizontal	At least 1.00 metre from the edge of carriageway. For class I at least 1.50 m.				
	(b) vertical	4.50 m.				

27. Railway crossings

Separation regardless of volume of traffic where railway operation involves two or more main line tracks. Where the railway operates six or more regular train movements on a single track, separation may be justified regardless of traffic volume. Where the railway has five or less regular train movements per day on a single track, separation shall be made when an economic analysis indicates justification. Where there is no separation, adequate protective devices are necessary.

28. Crossroads

Separation only for class V highway.

29. Special paths

For classes II, III and IV for pedestrians and cyclists whenever a daily volume of 500 pedestrians or cyclists is reached.

For classes II, III and IV roads, whenever the hourly volume of slow-moving vehicles (animal-drawn vehicles) exceeds 40, adequate lanes for this traffic should be provided.

For classes II, III and IV roads, whenever the hourly volume of animal drawn traffic exceeds 100, adequate lanes for this traffic should be provided.

30. Trams and railways

For classes II, III and IV excluding carriageway, for I and V excluded within formation.

31. Structures

(a) Culverts

(Length between abutment 6.00 metres or less) Width of culvert shall not reduce pavements, median strip and shoulders.

(b) Bridges

No modification of the characteristics of the carriageway, if appropriate, of cycle or footpaths should be allowed over and under minor structures. The clear margins should be retained.

Bridges should have a carriageway of 7 metres or more according to the requirements of the highway.

Major bridges may initially be built for one traffic lane only (i.e., 3.5 metres between kerbs). Long bridges should always be built for at least two traffic lanes (i.e., 7 metres).

The minimum overhead clearance for new or rebuilt structures should be 4.5 metres.

Note: Extension of the alignment on the approaches should not be less than 10, 20, 40, 60, and 80 metres for classes I to V respectively.

32. Special measures

Stopping and parking should be prohibited on the carriageways of motorways. In order to reduce stopping and parking on the carriageways of the IV class of roads, the following should be provided off the carriageway for the roads carrying more than 1,500 vehicles per hour in both directions:

(a) lay-bys; their spacing being governed by local factors such as the number of adjoining properties and the volume of traffic.

(b) draw-ins for buses.

Lighting on sections carrying heavy night traffic should be uniform and adequate for motorized traffic to travel without headlights.

BETTER ROADS FOR BRITAIN

Rapid Progress Under the Current Programme

By

J. F. A. BAKER, C.B., M.I.C.E., M.I.Mun.E.

Chief Engineer, (Highways) Ministry of Transport and Civil Aviation, U. K.

THE Minister has recently pointed out that we are now engaged on what is probably the greatest road-building programme the country has ever seen.

Let me say at the outset how exciting and stimulating are the opportunities which, after the lean years from 1939 to 1954, now present themselves to civil engineers and all others in Great Britain who are concerned with the vitally important field of highway engineering and construction, whether they be with the Ministry of Transport and Civil Aviation, Local Highway authorities, or with consulting engineers.

Contractors for their part have been very ready to tackle the constructional problems involved and have shown considerable resource and enterprise in conforming to, and sometimes beating, the rigorous contract times despite the handicap of unfavourable weather during the past summer.

OBVIOUS TO ALL

The traffic problems created by the remarkable increase in the number of vehicles on our existing highway system are obvious to all and the justification for the Government's present road programme cannot be denied.

The need for central administration and control of the most important of the country's through traffic routes to ensure that the plans for the maintenance and improvement of these roads were based on a national policy was realised as long ago as 1936 when the first Trunk

Roads Act was passed. This was followed by a further Act in 1946 and, as a result of these two Acts, the Minister became directly responsible for about 8,000 miles of highways called trunk roads forming a national system of through traffic routes. The Special Roads Act of 1949 was a further legislative step forward which gave highway authorities, including the Minister of Transport, powers to build special roads which could be restricted to particular kinds of traffic. The motorways being built at present are examples of these special roads.

There still remains, however, with local highway authorities in Great Britain a total of 180,000 miles of public highways of which nearly 20,000 miles are Class I roads of substantial traffic importance, as well as 18,000 miles of Class II and 49,000 miles of Class III roads, also carrying through traffic. The Minister still continues to help local authorities financially with grants of 75 per cent to Class I roads, 60 per cent to Class II roads and 50 per cent to Class III roads. With these substantial mileages of important traffic routes, it will be seen how formidable is the problem of comprehensive improvement and how necessary it is that an agreed system of priorities be adopted based on traffic need.

The various Acts mentioned above laid down provisions which must be complied with before the Ministry can build a new motorway or trunk road. The line of route has to be advertised,

details of the effect on side roads, etc., also published, and the necessary land bought. There is provision in the Acts for objections to be made to all these things, and, if necessary, for the holding of public inquiries. These statutory processes are very time-consuming but they have been designed to protect the rights of private individuals, and, for the most part, the time spent on them could not be reduced except at the cost of curtailing those rights.

LENGTHY BUSINESS

The long time needed to undergo these processes does mean, however, that the preparation of trunk road schemes is a lengthy business; in the case of a large scheme it can take up to three years or more. Some progress has, however, been made with the speeding up of land acquisition. Unlike most other commodities, land cannot be bought in bulk at a lower cost, or with less effort, than in small quantities. The Ministry of Transport, as Highway Authority for Trunk Roads, now has approximately 20,000 interests in land at various stages of negotiation, each one of which has to be the subject of individual attention.

The lengthy legal process of conveyancing has been dropped in cases where the value of the interest is small. Entry on the land is also now being obtained by using compulsory powers at an early stage, while negotiations for compensation may still be in progress. Despite this, very little opposition has been offered by landowners. There is widespread recognition of the urgency of the need for improving our road system even among farmers and landowners generally whose interests are adversely affected.

The need for lengthy preparatory work limited the amount of constructional work which could be started quickly in 1954, and the consequent relatively slow early growth of the programme largely obscured its real scope. But the programme is now in full swing, and important road works are in hand

all over the country. In terms of money, trunk road schemes in England and Wales authorised in 1954-55 were estimated to cost 8.6 million pounds, while it is expected that trunk road schemes authorised in the current financial year will cost about 50 million pounds. In terms of work being done, in trunk road schemes each costing over 100,000 pounds about 50 miles of new or improved roads have been finished since the present programme started, and about 200 miles are under construction. To maintain the tempo in spite of lengthy preparatory work it is essential to plan well ahead, and this is being done, schemes totalling some 850 miles of new or improved trunk road, being under preparation at the moment. In addition, local authorities are getting on with and preparing classified road schemes for which the Minister will contribute a financial grant.

STRIKING A BALANCE

The programme has to strike a balance between various conflicting road needs. First, there are large-scale works to modernise the whole network of through routes; then the problem of urban congestion must be tackled; finally, as much money as can be spared must be devoted to small, unspectacular schemes needed all over the country, but which, in the aggregate, make a big contribution to the free flow and safety of traffic.

The Minister of Transport has already announced the pattern of the first part of this programme. This is based on the following five major projects:

- (1) An improved trunk road from London to the north-east based on the present Great North Road.
- (2) A new motorway from London to Birmingham and then the north—west.
- (3) Improvements of the two existing trunk roads from London to the south-east, by-passing

the Medway Towns (A2) and Maidstone and Ashford (A20).

- (4) A road from the Midlands to South Wales.
- (5) A road from London westwards to London Airport, the west of England and South Wales.

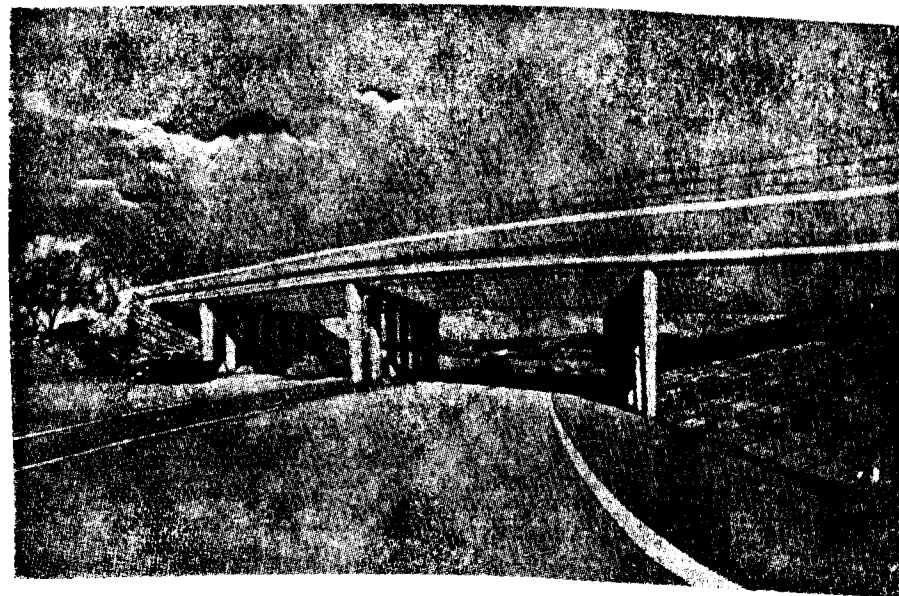
It will be seen that projects (2), (4) and (5) connect the important centres of London, South Wales and the Midlands by a triangle of roads, for the most part motorways, while the industrial north west is joined to it by a motorway leading from the vertex in the Midlands. Some of this network is at present being built, some is in an advanced stage of preparation, while some will have to wait for the future.

Being built at present is the London-Birmingham motorway, which includes the Dunchurch by-pass at one end and the St. Albans by-pass at the other, and constitutes some 70 miles of motorway—the first long stretch of motorway to be built in this country, although work

previously started on other relatively short pieces built to this standard (Preston, Lancaster and Stretford-Eccles by-passes, all in Lancashire). At the Birmingham end the Dunchurch by-pass will run into A, 45, which will be dualled all the way to the Birmingham boundary, while there will also be dualling improvements at the London end. Altogether, there will be some 110 miles of connected dual carriageway between London and Birmingham. This is one side of the triangle.

SOUTH WALES LINK

Another side of the triangle is the connection between the Midlands and South Wales. A key stretch is the Ross Spur motorway, of some 20 miles, being built from Ross to near Upton-on-Severn. At the Welsh end, the roads into South Wales will be improved, including the costly improvements to the Heads of the Valleys road A, 465 where consideration is being given to utilising a closed railway line. No further stretch of motorway, however, is planned.



Design for the Sittingbourne road bridge over the Maidstone By-pass (architects: Ansell and Bailey, consulting engineers Scott and Wilson, Kirkpatrick and Partners)

At the other end, the Ross Spur will join the projected Bristol Birmingham motorway, completing the connection with the Midlands. The northern part of this motorway from the end of the Ross Spur northwards to Lydiate Ash, and by-passing Worcester and Broomsgrove, is in an advance stage of preparation.

The connection to the triangle from the north-west consists of the Birmingham-Preston motorway. The northern part of this, from near Stafford northwards to join the Preston by-pass, is in an advanced stage of preparation, and it is hoped to start work on some of the viaducts involved shortly. A motorway link between the Preston and Lancaster by-pass is also planned. Preparation on the southern part of the motorway is not as advanced, and the line has not yet been established. It is hoped to join it on to the top of the Bristol-Birmingham road, and also eventually to connect it by a motorway link running north of Birmingham to the London-Birmingham motorway. This lies in the future.

Base of Triangle

The base of the triangle is the projected new London to South Wales road. For the most part this lies well in the future, but detailed preparatory work is going ahead at the two ends, London and South Wales. At the Welsh end, preparation of the Severn Bridge is in hand, but no date can be fixed for the start of constructional work on the bridge. This will have to be phased with progress on the Forth Bridge. At the London end, two major schemes are planned. The first is the Slough-M Maidenhead by-pass to be built as a motorway and the second a motorway from the Chiswick flyover at the end of the Cromwell Road Extension to join this by-pass. It is proposed that part of this should be built as a two tier road along the Great West Road for, length of about one and a half miles, and that further west it should have a connection

to London Airport by means of a tunnel under the Bath Road.

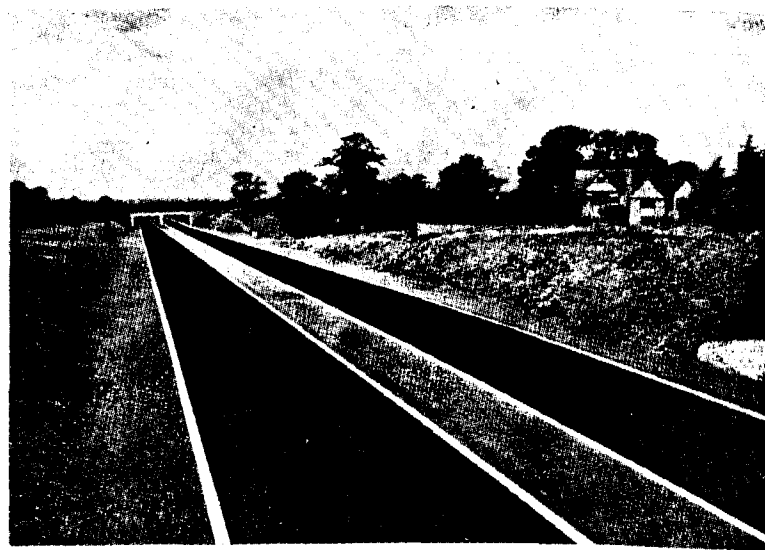
Work is rapidly going ahead on project (1), the Great North Road, and in a very few years it is expected that the whole of the 267 miles between London and Newcastle will be dualled, including many new by-passes, except for about 35 miles of existing three-lane single carriageway. Ultimately, it is planned to dual this also.

The biggest scheme on project (3) is the Medway motorway, some 25 miles long. The line of this has been advertised, but there are more statutory processes to be undergone before work on this scheme can start. A2 on either side of the motorway will be improved, but will remain general purpose.

The second part of the programme, the removal of urban congestion, is also going ahead. Road construction is only part of this campaign but is the only one discussed here.

LONDON SCHEMES

In the London area, much work is in evidence. The important Cromwell Road Extension is an obvious example and will provide an urgently needed new road from central London to London Airport and the West. Dual carriageways have been constructed on Western Avenue and the underpass being built at Hanger Lane at the junction of Western Avenue and the North Circular Road will speed traffic flow at this extremely busy intersection. On the Kingston by-pass work has started on the underpass at the junction with the Leatherhead Road at the Ace of Spades. In the L. C. C. area, schemes under way or planned are the reconstruction of the junctions at the Elephant and Castle, Notting Hill Gate, St. Giles Circus, Holborn/Kingsway, Harrow Road/Edgware Road/Marylebone Road and Gardiner's Corner. In the City, bombed sites have been cleared



Meriden By-Pass

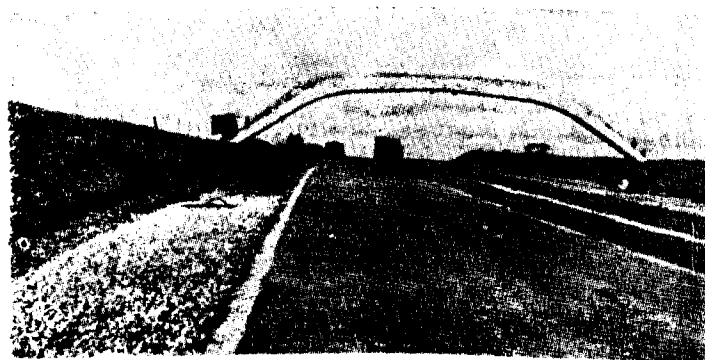
and work has begun on a wide thoroughfare, which is part of the new east-west Route 11, and which will incorporate a large underground car park. Work on the Dartford-Purfleet Tunnel is progressing steadily, and planning is well advanced on a second Blackwall Tunnel.

HYDE PARK CORNER

Several schemes are being prepared to improve the route across London from Western Avenue to the City and the east. Flyovers and underpasses are to be built at congested junctions where this is

possible. An underpass is being designed at the Blackfriars Bridgehead, and another for the most ambitious scheme of all in London, the reconstruction of Hyde Park Corner, Park Lane and Marble Arch. This underpass will run in two tunnels between Piccadilly and Knightsbridge and accommodate two lines of traffic in each direction. The whole scheme will cost about 5-1/3 million pounds.

The provinces are not being neglected. Many important cities and towns have begun work, or hope to do so in the next year or two, on inner ring roads,



A three-pin arch type, reinforced concrete footbridge over the motorway

relief roads and bypasses at a cost of many millions of pounds. Most notable of these are Birmingham, Manchester, Nottingham, Huddersfield, Newcastle, Leicester, Wolverhampton and Swansea.

Local highway authorities are primarily responsible for these urban schemes, the Minister helping financially. These schemes need careful planning, and it is the Government's policy to try to keep the highway authorities informed two or three years in advance of the schemes which are likely to be accepted for financial grants. In this way, work can be carried out steadily and smoothly and highway authorities are enabled to forecast their outlay and their employment of staff and labour.

In other areas as much work as possible is being done on both trunk and classified roads with smaller schemes designed to remove bottlenecks, improve traffic flow and provide greater safety, while minor widenings in conjunction with resurfacing works are undertaken whenever practicable. It is realised, however, that, with first priority being given to the projects mentioned earlier, authorities elsewhere have important

schemes which they are anxious to tackle as soon as it is possible, but for which funds are not at present available.

A road programme of the present magnitude which is now looking so far ahead makes great demands on trained engineers, particularly in the preparation stage. County councils, who normally act as the Minister's agents for trunk road works, and highway authorities generally, are doing splendidly in keeping to the stringent time schedule needed to keep the programme moving. But there is no doubt that they are, in many cases, heavily taxed. The Minister is making some use of consulting engineers, particularly on large projects such as the London-Birmingham motorway where the road passes through a number of counties and for the Medway towns motorway and also on big bridges such as those at Queenhill on the Rose Spur. Local authorities are also using consultants occasionally on their own schemes where the volume of work is too heavy for their own staff.

MODERN THINKING

The standards of design and layout of the new and improved roads of the new



Laying Cem-Mix by Barber-Greene Spreader in the forest section of the Ross-Tewkesbury Motorway (Contract No. 1)



Ross By-pass — Wye Flood Plain. Four of the flood arches under construction over which the embankment will be built up

and improved roads are in accordance with the best current thought and practice. On the motorways there will, of course, be complete grade separation by underpasses or flyovers at all road intersections and a total prohibition of direct access to the motorway. On some of the trunk road by-passes, the opportunity will also be taken where practicable to provide grade separation. This has been done, for example, on the Ashford by-pass, which was opened to traffic over a year ago. In rural areas particular attention is paid to the need to obtain suitable alignment and treatment of the new roads so that they will be in harmony with the landscape. Close liaison is maintained with the Landscape Advisory Committee on these matters and they are consulted on all motorway and trunk road schemes. The aesthetic features of bridge design also receive particular attention and the designs of all important bridges are submitted to the Royal Fine Art Commission for their approval.

The design, specification and type of construction for the carriageway work will depend on site conditions and the availability of local materials, the appropriate specification being selected from the Ministry's comprehensive revised Standard Specification recently published and which was prepared in consultation with the Road Research Laboratory, the Federation of Civil Engineering Contractors and many other interested bodies. This arrangement ensures that the methods of construction accord with the latest practice to suit modern traffic needs and will be as economical as is possible. Tenders are frequently invited on alternative specifications before a final decision is taken.

SPEEDY METHODS

Present-day methods of highway design are directed to making the most effective use of modern plant and equipment and differ substantially from those in use before the war. There have been great advances in mechanisation at the quarries, at the mixing and batching plants, in earth-moving equipment and in paving machinery for the carriageway construction. All these developments enable construction to proceed with greater speed and at a higher standard of quality and efficiency than ever before. Whether the carriageway construction is in concrete or "black top" surfacing, the latest machines ensure riding quality of a far higher standard than was possible, with the methods available, 20 years ago.

So far, this country has had no direct experience of motorways, although the movement of traffic on such roads abroad has been studied with care. The first stretch of motorway here to be finished will be the Preston by-pass at the end of this year and experience will be gained of driver behaviour and in such matters as lighting, signposting, safety markings, etc. The opportunity is also being taken to impose special regulations for a year to see how they work.

When all these proposed motorways, and other road schemes now being prepared, are finished in the next few years, there will be hundreds of miles in this small island of new and improved roads providing free flow and safe conditions for traffic which will compare favourably with anything existing in other countries.

(From "The Financial Times, November 10, 1958)



C. W. GILCHRIST, O.B.E.

Managing Director, Canadian
Good Roads Association

HIGHWAY DEVELOPMENT IN CANADA

CANADA today is in many respects unique among the countries of the world. Its 10 provinces and two territories extend over an area larger than that of any other nation except its neighbour across the polar regions—the U.S.S.R. Its history, dating back to the arrival of John Cabot, in the late 15th century, is only a brief hour in the years of Asian or European civilisation; yet it is, in this mid-twentieth century, one of the leading middle powers of the world.

To a much greater extent than most, Canada depends for its economic development and political unity on efficient communication and transportation. The earliest exploration of the country was made possible by the presence of vast systems of inland waterways. Settlers followed in the wake of explorers, established their homes on the shores of Canada's Great Lakes and the rivers flowing into them. Even today most of the major metropolitan centres are situated on large bodies of water. The largest city of all—Montreal—has grown up on an island in the St. Lawrence River. It is the largest inland seaport in the world.

In the 19th century railways became the chosen instrument of colonization.

The Canadian Pacific Railway crossed the flat prairie lands, climbed the Rocky Mountains and descended into the Province of British Columbia. Wave after wave of colonists followed the railways, settling on the homestead lands provided by the recently created federal government.

At the beginning of the present century, man devised another means of transportation—the motor vehicle. The Cinderella of the Canadian transportation story, motor transportation has, within the past decade, threatened the supremacy of both its predecessors.

Today there are 4,500,000 cars, trucks and buses on Canadian roads and streets—more than twice the number at the close of the Second World War. This year these vehicles will travel 40 billion miles. Canadian drivers will add more miles to their speedometers than any drivers in any other country in the world except the United States.

The waterways and the railroads broke down the formidable geographic barriers of Canada, consolidating the five totally different economic regions of the country. The Canadian transportation system now serves as one of the most potent factors in uniting this nation of

17 million people scattered over an area of almost four million square miles.

Building and maintaining this vital network of roads, streets and bridges has imposed a heavy financial burden on Canadians. This year Canadian governments together will spend a total of 1 billion dollars, 44 million dollars on improvements to the road systems of the nation. The total is a new record in the history of Canadian and represents an expenditure of about 250 dollars for every family in Canada.

Among the countries of the free world, Canada and West Germany vie for second place in the amount of their annual expenditure on road and street improvements. In the first place is Canada's neighbour to the south, the United States.

The Act of Confederation left virtually the entire responsibility for roads and streets to the provincial and municipal governments. In the last century all rural roads were built, maintained and financed locally, with the exception of a few military works.

Around 1910 the burden on rural municipalities became too great, and roads became so important to the economy that some provincial aid and technical assistance was begun. In the 1920s, provincial highway departments were formed, taking over responsibility for the most important roads linking major population centres. However, a vast mileage of low-volume roads was still left to the municipal governments. The burden of this responsibility was very great and the tax resources of the municipalities inadequate. Hence, over the years provincial aid has been given to the municipalities for road construction purposes.

In five of the provinces all of the rural roads have now been taken over by the provincial highways departments, thus removing the rural municipalities from the road building business in those

regions. In general, throughout Canada urban municipalities have maintained complete financial and jurisdictional responsibility for their street systems. However, in every province the urban municipalities receive some sort of financial assistance from their provincial governments.

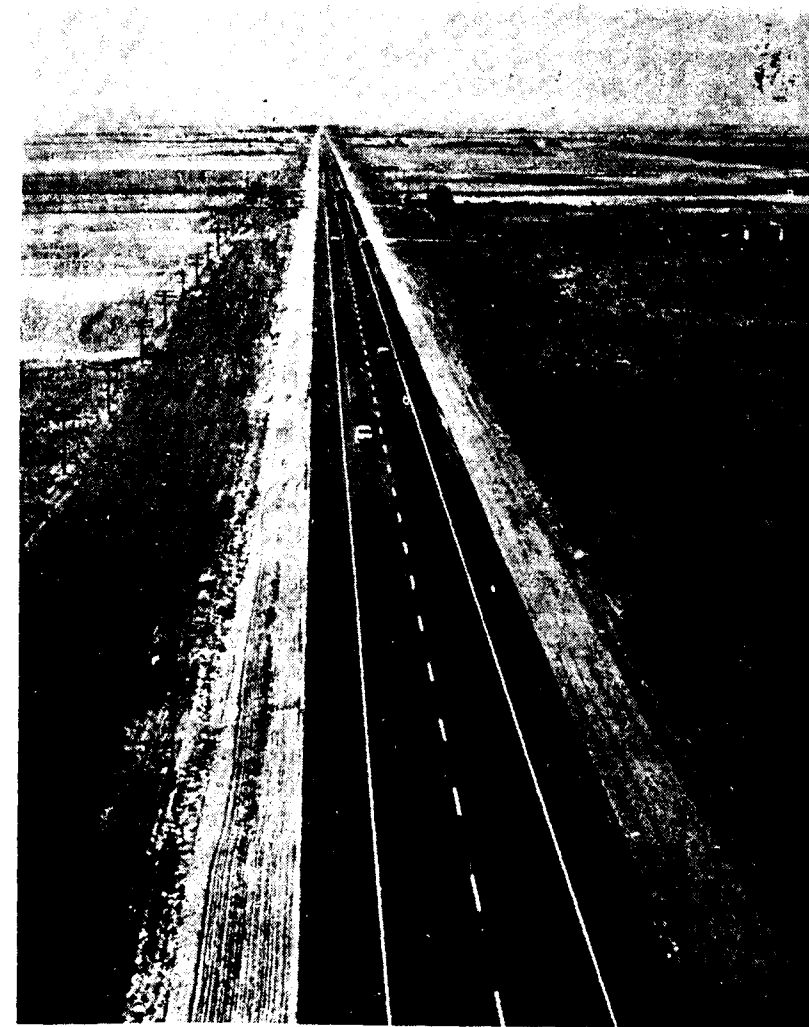
The federal government constructs and maintains roads in national parks and in the North-west and Yukon Territories. With these exceptions, the federal government has never entered the road building business except to make financial contributions towards certain specific projects of national interest. These will be discussed in greater detail in a moment.

The provincial governments, then, are the major road builders in Canada. Combined, the municipalities are next, followed by the federal government. This year the total expenditure of all governments on roads in Canada—federal, provincial and municipal—is estimated at a new record high. For the first time in history it will go over the 1 billion dollar mark.

Only two categories of government expenditure are higher than the outlay for roads and streets—national defence, and what is generally termed social welfare. The latter category is composed of a wide range of welfare expenditures such as labour and unemployment insurance, relief, old age pensions, family allowances and others. The road and street expenditures are considerably larger than any of these single items.

This year the 10 provincial governments will spend 64 per cent, or 660 million dollars, of the nation's total expenditure on roads and streets. Municipal governments will spend 260 million dollars, roughly one-quarter of the total. The federal government in Ottawa will spend the remaining 11 per cent, or 116 million dollars.

In the past, the expenditures of provincial—and to a lesser extent federal—

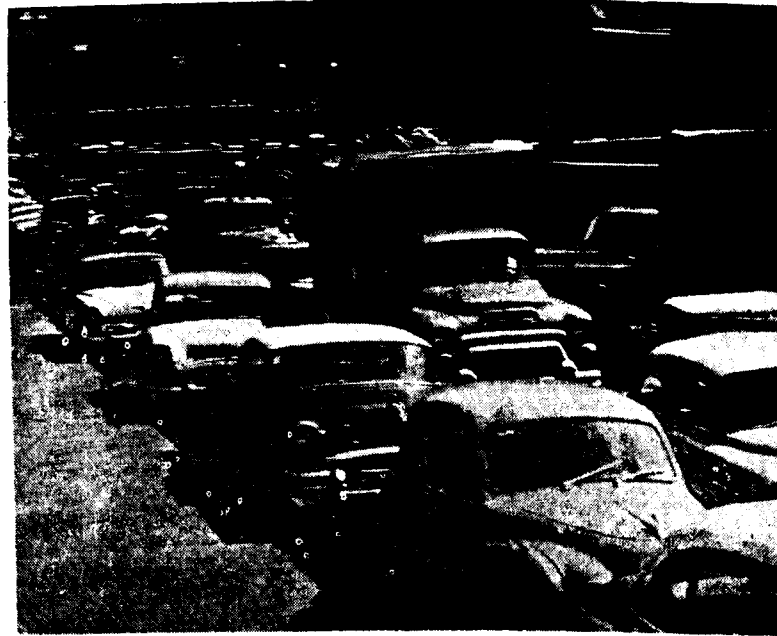


In the Canadian prairies highway construction is relatively simple, the terrain flat. This vista from a helicopter in the Province of Saskatchewan sweeps to the horizon. The highway is typical of most of the three prairie provinces.

government funds have invariably been concentrated on the construction of inter-city rural highways. This preference has arisen, naturally, from the wide dispersion of the Canadian people over the great area and the correspondingly great distances between the principal urban centres. The results of this concentration are now apparent in the generally high quality of the rural highway systems throughout the nation.

Persistent increases in the number of vehicles using these highways, and in the speed of these vehicles, seem likely. This will ensure the continuation and even acceleration of the rural highway construction program.

Until recently, the urban street problem has not been particularly acute. However, in our major cities we now find that the street systems are incapable



Congestion on city streets has become one of the most complex and pressing problems of Canadian governments. Here, road traffic gluts one of the old streets in Montreal, Canada's biggest city

of accommodating the large volumes of traffic which have developed in recent years, and the pavements are failing under the heavy loads. Inadvertently, we have neglected our urban street systems by not foreseeing the problems and providing for them.

Two factors have contributed to this neglect. The first of these is the urgency of building intercity highways, which I have already mentioned. The second is the relatively weak financial position of the municipalities in comparison with the other two levels of government.

Although approximately half of the 40 billion miles Canadians will drive this year will be on urban streets, only one quarter of the national aggregate expenditure will be made on these heavily travelled thoroughfares. The municipalities, whose only source of revenue is a tax on real property, are severely restricted in their financing of

street improvements by the growing demand for other municipal services.

Traffic congestion in most Canadian cities is a relatively recent phenomenon. Larger centres such as Montreal, Toronto and Vancouver seek a solution of the problem in expressways cutting through the heart of the city and in municipal parking lots which clear the streets of parked cars. Smaller centres, into which congestion is slowly creeping, look forward to a steadily worsening condition. The Royal Commission on Canada's Economic Prospects predicted, in its recent report to the federal government, that Canada's urban population will double within the next 25 years.

In the light of that forecast, the piecemeal construction programs providing correspondingly temporary relief from congestion, which municipalities are now undertaking, are entirely inadequate. If

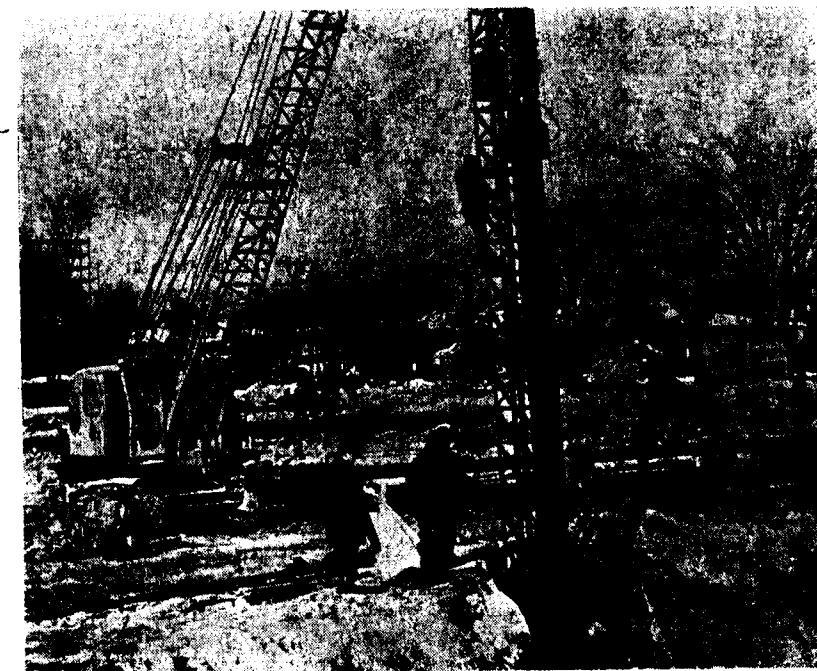
urban congestion continues to increase, as it almost inevitably will, the cost of meeting even the lowest standards of driving and parking convenience will soar beyond the realm of economic possibility for the municipalities.

A third factor in the planning of the Canadian road budget is the growing necessity of providing road transportation into the unexplored regions of the northland. The need for inter-city highways and relief from urban congestion is felt in most of the countries represented here today. Few countries, however, are faced with the problem of providing roads for an undeveloped region as rugged as the Canadian northland.

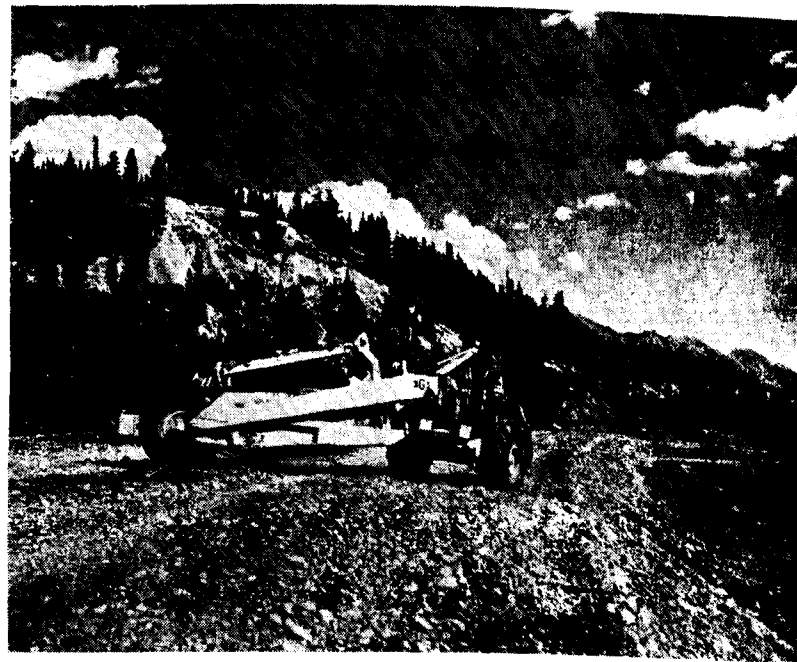
Frontier roads into the Yukon and Northwest Territories will provide the means for tapping great natural resources of timber, oil, lead, zinc, coal and

other minerals. A pattern for the future development of this region, which represents 39 per cent of the total area of Canada, is now emerging. The federal government, which has jurisdiction over the Yukon and North-West Territories, has greatly increased its expenditures in these areas during the current year.

Of the three levels of government sharing authority for the provision of roads in Canada, the federal government has always been the least active in the field. The power granted it by the Act of Confederation to provide for "other than local undertakings" is capable of extremely broad interpretation. Nevertheless, the Canadian Government has never seen fit nor found it desirable to assume the aggressive leadership in the road transportation



Winter construction makes Canadian road construction costly and a challenge to engineering skill. In the City of Ottawa, the nation's capital, temperatures range from 40 degrees below zero Fahrenheit to 90 degrees. Here, a construction crew is in the initial phases of bridge construction in the capital city in the dead of winter



More roadbuilding equipment is being used on the 5,000-mile Trans-Canada Highway than on any single construction project in Canadian history. Here work proceeds on the Highway in Banff National Park, just two miles east of the resort town of Banff, Alberta, in the Rocky Mountains.

field that the central governments of some other nations have shown—most notably the Government of the United States.

This lack of participation in the highways programs by the federal government has probably resulted in the fact that in 1958, almost 100 years after the joining of the provinces into the Dominion of Canada, we are still working on the construction of our first trans-continental highway.

The first coast-to-coast journey across the Dominion in a standard passenger car was not made until 1946. Today, although less than half of the Trans-Canada Highway is completed to specified standards, it is possible to make the journey in comparative comfort by making use of alternate routes.

The Trans-Canada Highway has

stood, until now, as the most notable of the federal government's contributions, in the roadbuilding field. Direct federal expenditures have been limited to the construction of roads within national parts, in the Yukon and Northwest Territories, and to the maintenance of the Canadian section of the Alaska Highway.

In 1919 the federal government began a series of grants-in-aid for the construction of primary provincial highways. Nine years later, when the sum of 20 million dollars set aside for this purpose had been paid to the provinces, the grants were abandoned. More recent grants, including those for the Trans-Canada Highway (to cost about three-quarters of a billion dollars and to be shared by the federal and provincial governments), have been limited to a few specific projects.

Within the past few months the position of the Dominion Government with respect to highways has shown signs of an approaching transformation. The demand for increased federal participation in roadbuilding is growing. The political party now in power in Ottawa, headed by the Prime Minister, the Right Honourable John Diefenbaker, assumed office with a backlog of pre-election promises of more substantial aid. Since then it has moved towards implementing this program by introducing a scheme whereby it would share with the provinces the cost of constructing development roads into areas of proven natural resources. This roads to resources program has already resulted in a 49 per cent increase in the federal roads budget.

The matter of delineating federal, provincial and municipal responsibility in roadbuilding, or in any other field, is an extremely controversial one in Canada, as it is in most nations with a federal system of government. Those who advocate increased financial responsibility on the part of the federal government point out the need in Canada for planning on a national level of a co-ordinated network of high-standard highways.

They stress the necessity of relieving the provinces of the great financial burden placed upon them by the motor age by making the vast tax resources of the federal Government accessible to them. Federal aid, they say, would also tend to make the growth of the road systems across the country more uniform by equalizing the financial burden among all areas, some of which are less prosperous than others.

Those who oppose the expansion of federal aid fear the spread of federal influence into the spheres of secondary roads and the loss of regional authority which might result. They argue that centralization would remove the problem too far from those familiar with it for efficient solutions and might,

at the same time, result in a considerable increase in construction costs because of possible administration delays and duplication of effort. In spite of these and other difficulties that can be foreseen, it now seems that the federal government will probably become an increasingly important factor in the development of the Canadian road and street systems.

These are encouraging signs for all in Canada who are anxious to see the financial and jurisdictional roles of the federal, provincial and municipal governments in the roadbuilding sphere clarified.

The constitutional tangle created by the Act of Confederation has been the cause of considerable difficulty. Most of all, it has been one of the chief deterrents to the establishment in Canada of a comprehensive, co-ordinated, national transportation policy. A second factor contributing to this deficiency has been the extremely rapid growth of the motor transportation industry itself.

This lack of a national transportation policy embodying provisions for guiding or fostering the orderly development of highway transportation has also helped to create several anomalies within the highway industry itself.

Not the least distressing of these is the absence of accurate and meaningful data on the nation's highway systems. Little knowledge of the full extent to which roads and streets are contributing to Canadian social and economic achievements can be obtained from the statistics now available. It is only within the past 13 years that special reports have been made on Canadian road and street mileage and on government expenditures on these roads. These highway reports are now published annually by the Dominion Bureau of Statistics, Canada's clearing house for all statistical information. This has come about through the close

co-operation and assistance of the Canadian Good Roads Association.

The latest report indicates that there are some 453,000 miles of rural roads in Canada. The significance of this figure is, however, somewhat limited because it probably includes upwards of 50,000 miles of unimproved or unused road allowances provided for in the land surveys of the provinces of Saskatchewan and Alberta.

While the report provides a classification of Canadian roads and streets according to their surface type, it makes no distinction between the various functions which these roads fill. The situation is changing, however. This year the Dominion Bureau of Statistics will distribute new reporting schedules, prepared in co-operation with the Canadian Good Roads Association, to provincial and municipal governments. In these schedules eight categories of roads and streets, distinguished primarily by their economic purpose in the provincial or national scheme, will be recognized. The information gained from these reports will contribute immeasurably to the assessment of the road transportation picture across Canada. At the same time, these reports will undoubtedly prove useful in planning the future development of roads and streets in all provinces.

There are many problems arising in Canadian roadbuilding which require a Canadian solution. Inevitably, the proximity of the United States has contributed to the parallel development of highway transportation in the two countries. The mechanization of the road construction industry in Canada, for example, has proceeded apace with similar progress in the United States.

There are, however, striking differences between the highway industries in the two countries. The Canadian climate and geography have, in fact,

created problems which are encountered in few other countries.

There is, for example, no region in Canada entirely free from the problem of snow clearance. The amount of snow that may fall in a single year varies widely—anywhere from 144 inches at Goose Bay, Newfoundland, to 10 inches at Victoria, British Columbia—but regardless of its depth, cities and towns find it necessary to maintain equipment for its removal. Within the past decade, improvements in this equipment have made winter travel in Canada almost as reliable as at any other time of the year.

This feat is not accomplished without considerable expense. The annual expenditure on snow ploughs, blowers, sand and chemical stockpiles cuts heavily into the Canadian highway dollar, reducing the amount which can be spent on the construction of new roads. Almost one-third of the total national budget for the current year will be spent on the maintenance of existing roads. A large part of this sum will be used to keep roads and streets free of ice and snow.

Other problems peculiar to Canada arise from geological conditions. The dominant feature of Canadian geography is the Laurentian, or Canadian, Shield, an area of hard igneous rock with scant soil cover. This land-form covers one-half of the country's entire area. Within this, the road builder is faced with extremely heavy and expensive construction, including rock excavation and areas of muskeg. This muskeg consists of decaying organic matter underlaid by either bedrock or frozen ground and saturated with water. Because of its prevalence, muskeg is a source of constant trouble to Canadian roadbuilders as it must generally be removed and replaced by suitable foundation material.

A second Canadian problem, that of frost heave and frost action in soils,

presents even more serious difficulties. The conditions for frost action are present in every part of Canada. This creates great technical problems in recognizing and treating such conditions, and the special designs for pavements and structures necessitated by these conditions are extremely costly. In developing our north we must cope with the permafrost conditions in road-building. These again necessitate different design practices and costly construction.

All these are essentially Canadian problems and their prevalence in Canada makes their solution by Canadian agencies imperative, although they do occur in other countries.

Road research as a highly developed, nationally co-ordinated activity is in its infancy in Canada. The pace of Canadian research, however, has accelerated. This year it is estimated that 1 million dollar will be spent by Canadian agencies on the advancement of knowledge in the highway field. The total—one-tenth of one per cent of the national outlay on roads and streets this year—is not large in comparison with the amount which other industries spend on research, but it is far larger than had been thought possible a few years ago, when the Canadian Good Roads Association first began to advocate increased research, and it is increasing steadily.

A second advancement in road building, which is closely related to research, is the increased emphasis which is being placed on long-range planning. Provincial and municipal governments alike are beginning to appreciate the need for planned development of their road and street systems. Experts in the highway field have predicted that a continually increasing population, earning substantially higher incomes, will own and drive more than twice as many vehicles in 1980 as in 1958.

In anticipation of these demands for road service, two provincial govern-

ments have created special planning branches within their highway departments. A leader in this field is the Province of Ontario which is now entering its second year of a 20-year planned program for road and street development. The province of Saskatchewan is also preparing to embark upon a similar scheme.

The larger municipalities have also recently begun to plot the course of future urban roads during five and 10-year periods rather than on a year-to-year basis. Many of these cities, including the two largest—Montreal and Toronto—and the national capital of Ottawa, have invested heavily in developing plans for the future redevelopment of the entire urban area.

If the roads and streets, not only of Canada but of all other nations, are to prove adequate for the traffic they will carry 15 or 25 years from now, this process of applying all the technical resources at our disposal to their planning must be accelerated.

Planning will be no less vital to the development of the Canadian northland than to the more heavily populated southern regions of the country. The opening of this great storehouse of wealth will proceed in an entirely different fashion from highway development or redevelopment in the populated regions. New planning criteria will be used to realise the maximum potential of the Canadian north.

In the first place, a balance will have to be achieved between all forms of transportation—water, air, rail, road and pipeline—before exploration and exploitation can become economically feasible. In this area, where the economy is based on non-renewable assets, roads can be expected to play a particularly important role. To accommodate the quickly changing patterns of exploration and settlement these

roads will undoubtedly be built at as low a cost and to as low standards as possible. The day when modern highways cross the Canadian Arctic, if it ever arrives, is a long way off.

There still remains a great deal to learn about the north—its geography its economic potentialities and the means of conquering and living with that somewhat forbidding country. Already enough is known, however, to realise that Canada stands on the edge of a new economic era.

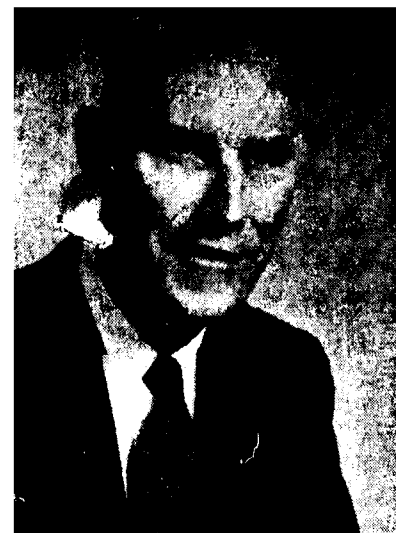
A somewhat tardy beginning has been made in the co-ordination and integration of the nation's highway

systems. Although it is not yet complete, the Trans-Canada Highway has greatly helped this situation and has definitely stimulated the flow of motor vehicle traffic from east to west across the nation—indeed, is already contributing greatly to national unity.

The provincial highway systems of Canada will soon be a co-ordinated network of transportation arteries to serve the entire nation. With the research and planning now going into these roads, I have every confidence that they will serve our nation efficiently and will play the leading role in Canada's economic development in the years to come.

As professional men we must believe that truth will inevitably prevail. If our cause is true, if we prepare our submission with sincerity adhering only to facts and sound arguments, if we make it to the proper authority in the proper manner, and if we have patience to persist in spite of initial setbacks, we will be successful. This has been the experience of the Institution.

—"THE JOURNAL OF THE INSTITUTION OF ENGINEERS, AUSTRALIA," DECEMBER 1958.



W. J. FULTON, P.Eng.,
Deputy Minister of Highways, Ontario

ONTARIO'S HIGHWAY SYSTEM

Mr. Fulton is the chief executive officer in charge of the 11,400 miles of rural highways constructed and maintained by the Province of Ontario, Canada. Mr. Fulton joined the Department of Highways in 1921 and before attaining his present position was in charge of location surveys and director of planning and design.

ON behalf of the Ontario Department of Highways, I wish to extend most cordial congratulations to the members of the Indian Roads Congress on the completion of 25 years of constructive activity in the interest of better public transportation.

In Canada, as in many other parts of the world, great progress has been made in the construction and maintenance of better roads and streets during the past few decades. This is particularly true of Ontario which is the most central of Canada's ten provinces and with a population of 5,800,000 people, has one-third of the population of the entire country. There are 1,900,000 motor vehicles registered in the province.

Ontario has a total area of 413,000 square miles and extends for 1,000 miles from east to west and from south to north. Some 88 per cent of the population lives in the southern part of the province which comprises only seven per cent of the total area. Most of the primary and secondary industrial production and practically all of the agricultural production are centralized in that area. The larger urban centres, of which Metropolitan Toronto with a population of 1,500,000 people is the largest, generate large volumes of traffic

which may reach a peak of 65,000 vehicles per day. In Northern Ontario which is rich in minerals, forests and water powers, the population is widely scattered except in a few urban centres and limited areas of soil suited to agriculture.

The great disparity in population and in area, between Southern and Northern Ontario, poses unique problems to the highway engineer. The densely settled southern region with its large cities and concentrated traffic volumes requires and can support a closely knit network of modern highways. But the balance of the population, widely dispersed over the vast expanses of Northern Ontario, must also be provided with road services.

The extremes of climate in Northern Ontario, the thinness of soil cover over hard granitic rock, the profusion of lakes that must be skirted or crossed, and the wet muskeg areas of the clay belt, all create exceptional road building difficulties. In many cases, settlement and economic development follow directly on the establishment of new routes, so that expenditures on road construction, in the northern areas of Ontario, may be regarded as a long-term investment in the future. As a

result, some 45 per cent of the provincial highway system of the province will be located in Northern Ontario.

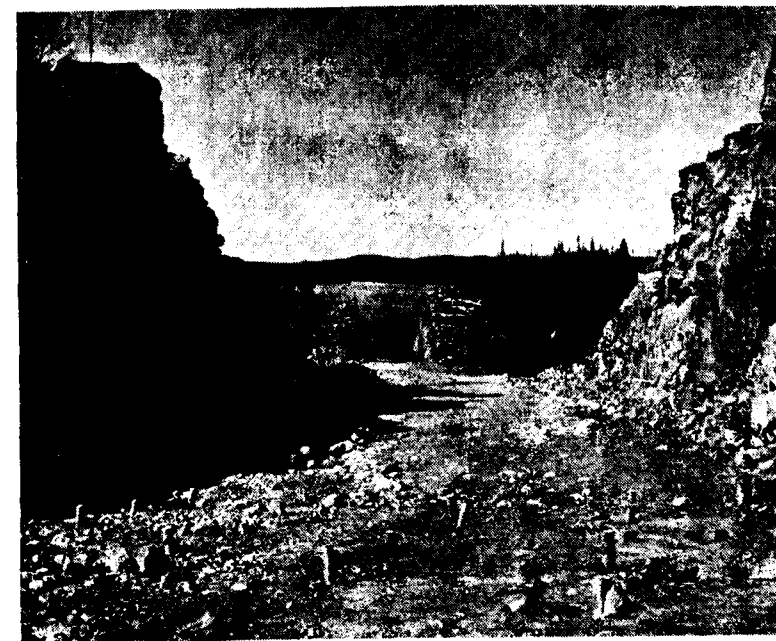
To serve the province we have a system of 11,400 miles of main and secondary rural highways which carry some 40 per cent of the total traffic volume. These are the highways which link the several economic areas and carry the large volumes of inter-urban traffic. The entire cost of construction and maintenance of these highways is a charge on the provincial treasury. In addition, there are 65,200 miles of rural roads and 8,400 miles of urban streets which are the responsibility of the municipalities. These municipalities receive provincial aid which amounts in total to slightly more than half of their total expenditures

on the construction and maintenance of municipal roads and streets.

With the exception of the Trans-Canada Highway, of which the 1,453 miles in Ontario will be completed in 1960, and some relatively minor northern roads, the province of Ontario receives no aid for highways from the Federal Government. In the present year our Department budget provided for a record expenditure of 273,257,000 dollars of which 55 per cent is for capital construction, 16 per cent for maintenance, 26 per cent for subsidies on municipal roads and streets and the balance for main office expense. Including expenditures made by the 1,000 municipalities the total cost of all highways, roads and streets in the province



Ontario is developing a series of dual-lane, controlled access highways which are designed to most modern standards to serve large volumes of traffic moving between major cities and economic areas. Above, Highway 400 is in operation for 53 miles north of Toronto and is being extended. Another highway will span the southern part of the Province over a distance of 500 miles and will by-pass all urban centres. Rights-of-way on controlled access highways are 300 feet wide and usually the two lanes of traffic are separated by a depressed median strip. All routes are clearly signed and a maximum speed limit of 60 miles per hour is now in effect. A high standard of highway maintenance is required and all King's highways are kept open throughout the year regardless of weather conditions.



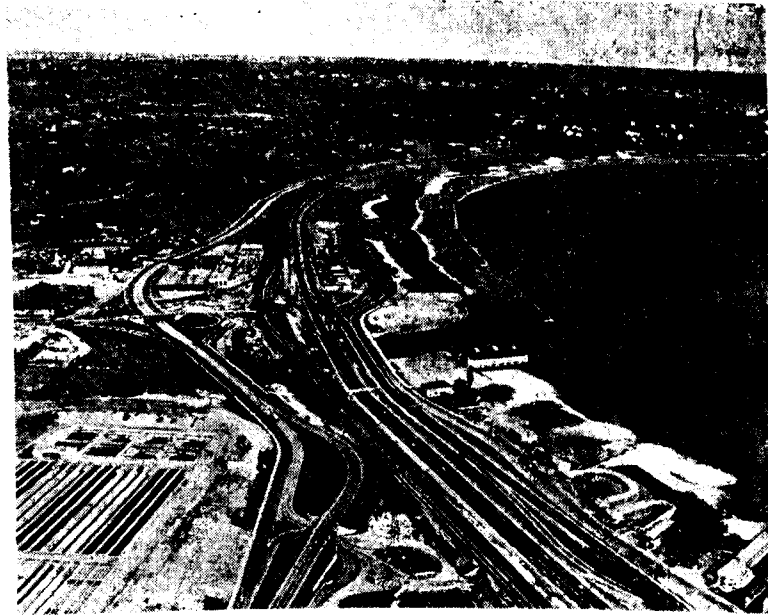
Highway construction in Northern Ontario presents special problems due to the hard granitic rock of the Laurentian Shield, wet muskeg and the large number of rivers and lakes. The greater part of the 1,453 miles comprising Ontario's section of the Trans-Canada Highway is located through rugged terrain. Above is shown a 75 foot rock cut necessary to provide a reduced grade on one of the steepest sections of the Trans-Canada Highway. This is on the north shore of Lake Superior.

will be some 320,000,000 dollars this year. All of the Department's expenditures are made out of the consolidated revenue fund of the Province which receives all revenues from motor vehicle registrations, drivers' licence fees and gasoline taxes. Over the long term highway expenditures have been about equal to highway revenue but we are now in a period when expenditures exceed receipts.

The growth of Ontario in population and in economic development has been at a more rapid rate than most other parts of the North American continent in recent years and it is expected that this rate of progress will continue until, by 1975, we will have a population of over 8,000,000 with the prospect that there will be more than 4,000,000 motor vehicles within the province. In anti-

cipation of this development we have conducted economic and engineering studies of our provincial highway system and, with the co-operation of the municipalities, of municipal roads and streets.

These studies have provided us with an up-to-date inventory of our highways and streets which have been classified according to their relative importance. Standards have been established for each classification and costs have been estimated for reconstruction of our present highway system to meet future traffic requirements. The result is that we are able to plan our highway construction programme on the basis of facts and for the past five years this programme has been stepped up each year. At the present rate of progress our entire provincial highway system



At the western entrance to Toronto, provincial rural highways merge with modern expressways at bridges over the Humber River where traffic reaches a peak of 55,000 vehicles daily. Toronto, the capital of the Province of Ontario, is part of a metropolitan area with a population of 1,500,000 and a 59-mile system of expressways is projected in order to handle the heavy volume of urban traffic. New sewage disposal plant is shown at lower left.

will have been reconstructed within the next ten years.

Our provincial highways are divided into three main classes, Freeways, Trunkline highways and Feeder highways. The freeways are the main international and interprovincial routes connecting metropolitan centres and having the highest traffic volumes. The trunkline highways are routes having relatively large traffic volumes and which complete the network of highways that connect all other large cities and important areas of the province. Our most modern freeways now in operation or under construction in Southern Ontario are dual-lane, controlled-access highways on 300-foot rights-of-way. These highways have a design speed of 70 miles per hour although the present maximum speed limit is 60 miles per hour. Maximum curvature is 3 degrees and maximum grades are 3 per cent

while stopping sight distance is 600 ft. These highways have four to six lanes, each 12 ft in width, and 10-ft shoulders. We use a depressed median strip between the two asphaltic concrete pavements to improve drainage and provide the maximum of safety. There are now two highways of this type in the province of which one will extend east and west for 500 miles from one end of Southern Ontario to the other. Our present plans call for a total of some 800 miles of this type within the next few years to serve an annual average daily traffic of 6,100 vehicles.

Next in importance to the Freeways are the trunkline highways which will total 4,900 miles and, together with the freeways, will carry two-thirds of the total traffic using the provincial highway system. All municipalities with a population of 4,000 or more are served by a feeder or a trunkline highway but in the

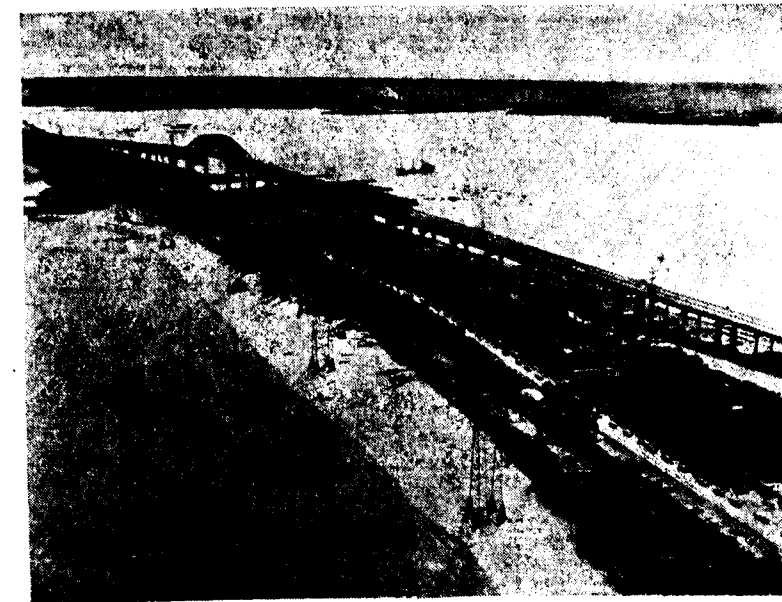
case of the larger urban centres we are constructing by-passes which will carry through traffic around the cities and thereby relieve the congestion on city streets. Major trunkline highways approach the freeways in their design standards although in the majority of cases the trunkline highways are only two or three lanes in width. In Southern Ontario major trunklines will carry an average of 3,800 vehicles per day as compared with 800 per day in Northern Ontario.

The provincial system is completed by some 2,900 miles of feeder highways carrying smaller volumes of traffic and constructed to lower standards. Our classification of provincial highways follows the principle that any rural areas should have a provincial highway as convenient as the service rendered any

other rural area of similar development. All communities with a population of 2,000 or more have at least a feeder highway and many smaller communities also benefit directly.

At the present time more than 85 per cent of our main highways are paved and the remainder are of gravel and crushed stone. Over the next few years most of these gravel roads will be paved and further paving will be done on secondary provincial highways most of which are now gravel. The secondary highways are located principally in Northern Ontario and serve as access roads to isolated communities off of the main travelled routes.

While we are well under way on a planned programme of reconstruction of provincial highways, we believe that all



The Burlington Bay Skyway is the largest single structure completed by the Ontario Department of Highways. Opened in October 1958, the Skyway and its approaches provide four-and-a-half miles of four-lane, controlled access highway along the shore of Hamilton Harbour. The three central spans provide a clearance of 120 feet over the entrance to the harbour shown above with the City of Hamilton in the background. The Skyway exclusive of approaches is 8,400 feet in length and consists of 75 spans supported by 76 piers. The Skyway is lighted with fluorescent lamps on aluminium standards. Total cost of the Skyway was 19,000,000 dollars and a small toll charge is made—the only toll on any Ontario highway or structure

of the 76,638 miles of rural highways and roads throughout the province should be fully integrated into one system. This requires the co-operation of a great many municipalities and, in order to secure the full facts upon which policies and future action could be based, we have recently completed an engineering study of all municipal roads and streets in the province which has been issued under the title "Ontario's Roads and Streets." This study has supplied information which most of our municipalities did not have before and, through the experience gained by co-operating in this study, municipal engineers and other officials have become more familiar with modern highway engineering techniques. As far as possible, the Department of Highways will assist the municipalities in the solution of their particular problems but such problems continue to be the primary responsibility of the municipality.

As an outgrowth of our municipal needs study, the Department has initiated several special studies of selected urban areas for the purpose of determining the long-term needs for provincial highways serving those areas. These studies should be of great value to the local authorities in planning their street programmes and they also bring the Department, which has heretofore been concerned mainly with rural highways, more closely in touch with urban traffic problems.

It is in our larger cities that the traffic problem is most acute. The municipal needs study classified urban streets in three main classes; (1) urban extensions of provincial highways, (2) arterial streets which, with urban extensions, form the main traffic arteries within the urban centre, and (3) local streets used

mainly for direct access to residential, business and industrial areas. Our four largest cities will require some 96 miles of expressways on which access will be controlled in order to channelize large traffic flows within and around city areas. Because of their extreme importance every mile of urban extensions should be improved and the mileage of arterial streets should be increased by some 326 miles, or 16 per cent, over the next few years.

While we consider our provincial highway system to be comparable with the best on the North American continent we are fully aware of present inadequacies and future needs. We have a planned programme of construction based on present and future needs and we are proceeding to put that programme into effect. The results of this programme are already apparent as highways built to modern design standards replace the old, many of which were quite adequate as little as ten years ago. As progress is made on provincial highways we anticipate that the municipalities will take action on their own roads and streets so that throughout the province we will have a completely integrated system of modern highways, roads and streets which will be adequate to take care of the increased volume of traffic, which is materializing year by year.

During the past two years the Ontario Department of Highways has been glad to welcome Messrs S. R. Pillai, K. Prasad, Ram Bilas, B. M. Das, D. C. Panda and R. N. Bannerjee, all students from India under the Colombo Plan. We trust that their all-too-short stay with us has been profitable and will contribute to the progress that is being made toward solution of highway problems in India.

HIGHWAY ENGINEERING PROBLEMS IN FRANCE

By

R. COQUAND

Chief Engineer, Roads and Bridges Professor, National Institute of Roads and Bridges, France

(Translated from the original in French)

THE rapid expansion of automobile traffic, the all round progress of engineering techniques, the necessity to introduce new and economical methods of construction suited to the present needs, have all led to an appreciable development in the technique of highway engineering in France.

CHARACTERISTICS OF HIGHWAY SYSTEM

The French network of 80,000 km of national roads, besides 600,000 km of local roads, is not suited to the needs of modern traffic on main crossings where the intensity of traffic would be of the order of 10,000 vehicles per day. A network of 2,000 km of motor roads has been therefore planned, certain sections of which are under construction especially for bypassing big centres.

In respect of geometrical features of roads, France is a signatory to the Geneva Declaration of 16th September 1950, which has been modified in 1957. The new French standards published in 1958 conform to the international regulations.

The new provisions pertain essentially to the characteristics of motor roads and roads of dual carriageways, improvements of junctions, and the design of stopping and sight distances. Further, they furnish precise information as regards capacity of roads.

Side by side with study of the geometrical features of roads, studies of traffic conditions have developed in two main directions: the study of accidents and the investigation of traffic. Statistics

relating to the location of accidents and their causes have been improved and their systematic use has been undertaken in order to locate the particular points and, what is most difficult, the continuous sections where defects in the road constitute a major cause of accidents. On the other side, studies on the improvement of roads in the vicinity of cities or on sections of heavy traffic require frequent investigation of traffic more or less heavy to provide information not only as regards intensity of traffic on any one of the intersecting roads, which is determined by traffic counts, but also the direction of the traffic flow, which is indispensable for the correct understanding of the complex road problem.

Finally, the increasing importance of road transport in the national economy leads to more and more emphasis on the problem of road improvement in terms of economics. The execution of road works and the choice between different solutions for the same project has to be decided in relation to the advantages accruing to road users and to public economy. The Public Works Ministry has stipulated such investigations for all important projects and in 1954 formulated provisional regulations for this purpose; in liaison with the Commissioner General for Planning, the financial administration and the economic study groups of national or private societies, it has striven to enforce its recommendations, fully taking into account the liberal principles accepted in the whole public sector in matters of investment.

The necessity of such studies is parti-

cularly obvious when a large undertaking has to be covered by self-financing, particularly when it requires payment of tolls as in the case of Tancarville bridge, the Mont Blanc tunnel or fly-overs over motorways.

We may thus conclude that the characteristics of road projects are determined not only with reference to certain geometric standards to be adopted but also with a view to obtain maximum return for investment made.

METHODS OF CONSTRUCTION

The development in road construction from traditional roads has tended towards soil stabilization with graded soil and this tendency has not ceased to assert since 1952 when a Ministerial circular defined the principles of construction of this type of roads.

Naturally, as this method was employed more and more, its modes of application have been refined and perfected. The engineers have acquired in this field a rich experience by which they have largely profited and which they have shared with their colleagues; the diffusion of this valuable information has been made in the largest manner possible by articles published in technical journals, by study circles promoted by Roads Directorate, the conferences and symposia organized by the Highway Engineering Association, the International conferences, etc. An effective factor in the progress made has been the setting up of regional laboratories directed and controlled by the Central laboratory of the Deptt. of Roads and Bridges which have set up for the engineers a most useful task not only of carrying out very important and useful tests but also of giving advice and disseminating results of investigations made and experiences acquired elsewhere.

FLEXIBLE PAVEMENTS

It has been admitted since long that a flexible pavement laid over a terrain

should have a minimum thickness depending not only on the characteristics of the terrain (C. B. R., Group Index, Westergaard's modulus of subgrade reaction) and the incidence of load permissible on the road, but also on the structure of the road itself.

It is very vital that not only the value of the wheel load but also the number of load repetitions should be taken into consideration to provide sufficient thickness of the road pavement which is meant to carry the intensity of heavily loaded traffic.

But, as already pointed out, the control of thickness independent of the structure of road pavement constitutes only a first approximation. A large number of tests conducted in different countries, notably the American W.A.S. H.O. tests, have shown that certain materials like bituminous concretes are endowed with considerable rigidity (at least under loads applied by running wheels for short duration so as not to produce any yield) and under such conditions they effect a wide distribution of loads on the underlying layers; when such materials are employed in wearing surfaces or when they form the base layers they can, therefore, rightly reduce appreciably the total thickness of the road crust without any risk of disturbing the supporting soil. This property is denoted by the term "layer effect".

Taking into account the effect of layered systems in as precise a manner as possible, how is one to calculate the reduction in thickness? Messrs Jeuffrey and Bachelez, Engineers of Roads and Bridges Deptt. (France) have given an excellent solution of this problem, the application of which concurs very satisfactorily with the results of W.A.S.H.O. tests. Their design curves have actually been utilized in a number of concrete cases.

On the whole, it is indispensable to understand well that the "effect of layered systems" has for its counterpart

a perceptible resistance of a rigid layer to appreciable deformations that can be produced in the substratum, say by loads or due to consequence of variations of thermo-moistural conditions. One cannot afford to provide a rigid layer over a yielding substratum at the risk of rapid cracking. Hence the practice now common for some years of measuring deflection of roads which have to receive a layer of bituminous concrete or dense coated mixtures. These deflections measured under the most unfavourable conditions, particularly in wet season, should not exceed a few tenths of a millimetre since it would otherwise cease to be a rigid pavement and become a flexible overlay.

COMPACTION OF SOILS

Obtaining a sufficient dry density, varying from 90 per cent of the normal Proctor value for embankments to 95 per cent of the modified Proctor value for road materials, remains the principal aim to be achieved in the mechanical stabilization of roads. Fortunately, side by side with the evolution of this principle, use of vibrating machines has been developed for compaction of soils predominantly sandy. In fact, the laws of compaction and especially those relating to optimum moisture content are seen to be appreciably different when one uses vibration and when one has recourse to different types of rollers. The progress made in this field of study will probably involve revision of Proctor's rules for vibrated soils.

Moreover, the classical Proctor's test is not entirely applicable to materials of small size; it is at present being used in the case of compaction of coarse material of variable nature. Following this trend one can envisage the use of the test on a truly large scale in trial sections to judge the effect of different appliances on different materials.

Regarding measurement of compaction and moisture content, it is convenient to avail of the possibilities opened

by the use of nuclear densitometry (determination of density by nuclear means) based on the diffusion of gamma rays for the measurement of moisture content by apparatus based on the absorption of slow neutrons by the hydrogen atoms of water. The development of this apparatus has provided considerable facility for the indispensable controls at site.

CHEMICAL STABILIZATION

Chemical stabilization consists, besides compaction and other purely mechanical operations, of the addition of a product such as cement, bitumen, tar, synthetic resins, etc. It is used especially to utilise certain soils very rich in fine materials which cannot be treated by simple mechanical stabilization.

During the last few years a clear trend is visible of keen interest on the part of engineers in the use of cement in flexible pavements.

This is covered by the technique properly named "Soil-cement" which imparts to the pavement composed of fine elements a special cohesion partly due to the setting of cement without destroying its flexibility. Experience in England in this respect gives some empirical rules which simplify and largely facilitate its application and which have been found to be very useful. Base courses have been constructed in soil cement in different regions devoid of rocks and rich in fine materials (loamy sand, chalk, etc.). Nevertheless, the surface resistance of soil cement is small and roads which have been thus treated should receive surface treatment.

Let us say that one uses (and this is done very frequently) soils improved with cement in small percentage (3 to 10 per cent), the role of cement being simply that of reducing the effect of highly plastic soils, or facilitating the use of fine moist materials late in the season when one cannot hope for drying it by the sun. Mon. Dariez, Inspector

General has shown that in this respect cement as compared to lime has some indisputable advantages*.

Stabilization with bitumen remains a rather costly technique for the construction of main part of the pavement considering the relatively large quantities of bitumen required and the difficulties of using the material at work site. Consequently, the efforts of research workers tend towards reducing these difficulties on the one hand while, on the other, use is made of special products like binder which secure stabilization of moisture content in the interior of the soil, as bitumen has the effect of making the soil impermeable when used in small quantities. As regards the first part, certain binders having a very high wetting power have come in the market which are capable of rapid dispersion in the very fine soils by means of spontaneous emulsion; these binders can simplify considerably the problems of mixing and thus increase the list of sensitive soils which can be stabilized with bitumen.

As regards research on new methods of chemical stabilization, these are directed, on the one hand, towards resins having long molecular chains, factors of stability and flocculation and, on the other, towards surface active products. The latter, modifying totally the phenomenon of capillarity in treated soils, render them hydrophobic and impermeable. At extremely small dosage (0.5 per cent, for example) this technique which has already been tested in practice could prove to be extremely fruitful.

COATED MATERIALS

Progress has certainly been made during the last few years in the manufacture and use of coated materials of all kinds, and although it relates to confirmation of results already obtained between 1952 and 1955, this is a new step forward. The researches have

tended, above all, to the diversification of the technique for its economical and efficient application to the needs and resources which vary according to each case.

Investigations are inclined, in particular, toward numerous types of surfacings intermediate between open-textured carpets and dense carpets to assess the advantages of one type over another. It is still too early to evaluate the results. In the same way, it is not possible to summarise here all the experiments actually conducted for promoting the new techniques of manufacture to enlarge the scope of using different kinds of materials. To state it briefly, considerable progress has been achieved in the manufacture of tar concretes, tar macadam with small percentage of voids, and various types of hot and cold micro-bituminous concretes.

In connection with what has been indicated earlier about the effect of layered systems, one should pay attention to the manufacture of binders of reduced susceptibility, increased ductility which would be stiff at high temperatures without becoming brittle at low temperatures. In this regard, the effect of addition of rubber to bitumen has been the subject of highly interesting investigations.

MACADAMS AND SURFACE DRESSINGS

The age old technique of water-bound macadam or continuous penetration has been largely used where hard materials are available at site. It is, however, hardly capable of any further improvement except in regard to the process of spreading the material and its mechanical gradation.

The same is the case as regards the technique of surface dressing which has benefitted largely by the steady progress made in the application of black top materials, in the manufacture of various types of binders (tar and bitumen) and

by improved methods of construction adopted in each particular case.

Further, it is well known that the grain size distribution of materials of the framework (macadam or gravel) is transformed slowly towards a continuous graded material under the effect of traffic. This development does not present any inconvenience provided it is very slow and takes place by successive stages in which the road remains in equilibrium both mechanically and chemically. If, on the contrary, the change is very rapid, it would result in the disintegration of the road, for example, if the materials get crushed or altered.

Stress has been particularly laid by the Central Laboratory of Roads and Bridges Deptt. on the necessity of taking care against the possibilities of this development resulting in great friability of aggregates or instability of the chemical structure (kaolinisation). The "Deval Wet Test" has been devised with a view to eliminate the softening of the aggregate taking into account the action of water.

With regard to gravel, significant tests have been made with material classified according to its thickness so as to give uniform coating and very good appearance.

RIGID PAVEMENTS

A very important development has been recorded in the technique of rigid pavements

The new specifications recommend concretes a little less dry than before; the slight decrease in strength is compensated by increased safety and much easier workability. Insistence on this act, however, does not mean sole

preference of dry concrete to fluid concrete.

There has been a marked tendency to decrease the number of expansion joints even amounting to their total elimination. In an actual case, a cement concrete road which had been constructed in 1957 has been provided for many kilometres with only flexible contraction joints.

The technique of dowelling remains still in force, although its range of application would diminish. In France, the present tendency is rather to avoid the incidence of such joints and improve the behaviour of slabs in general by placing the latter on thick foundation courses of selected materials.

USE OF PRESTRESSED CONCRETE

Use of prestressed concrete for air strip pavements has already been made in numerous constructions, the most prominent being the take-off strip at Alger-Maison-Blanche.

Use of prestressed concrete for road pavements appears less favourable in view of smaller width in the case of roads, highly rough profile and limited thread of wheels of vehicles as compared to runway pavements. But this technique would hold immense possibilities for construction of concrete roads of reduced thickness. An experimental road is under construction using various methods for prestressing and for maintaining the prestress after construction. The steps that have been taken under the direction of the Central Laboratory of Roads and Bridges Deptt. would undoubtedly furnish valuable information for the advancement of knowledge in this matter.

* See Duar, the stabilization of base courses and foundations, the Monitor of Public Works 2 & 9 February, 1957.

THE FRENCH HIGHWAY SYSTEM CONSISTENCY—ORGANIZATION—FUNDS

By

M. A. RUMPLER,*Director, Division of Highways, Public Works Ministry, France*

FRANCE possesses a highway system whose density, homogeneity and structure are as many elements contributing to make it one of the most representative factors of her economic system. In large lines, its general outline has remained the same as in the times of Colbert and Napoleon but the interconnections have developed so much during the course of the centuries that its length has now attained a million kilometres (621,000 miles), divided into national and departmental highways and communal and rural roads. Counting only the first two, the total French road system represents 120 km of highway per 100 square kilometres of area (75 miles per 38.6 sq. miles), a proportion larger than in any other country.

The national highways provide communication between all parts of the country which they cover in an immense spiderweb with Paris in the center. Their total length amounts to over 50,000 miles of which 125 miles are four-lane, 3,100 miles are three-lane with roadways 29-1/2 to 32-3/4 ft wide, and 46,600 miles are two-lane with roadways 19-1/2 to 23 ft wide.

Before 1930, they constituted a total of 24,850 miles. At that time, traffic began to cover greater and greater distances on the departmental highways so that they became of inter-departmental importance and were integrated into the national highway system, thereby doubling the latter. Under an overall plan, certain of these highways have been transformed into "through-highways"

which provide rapid transportation across France, still with Paris as their centre, by means of wide and straight roads built to safely permit high average speed for the user.

Superhighways have not yet been greatly developed by reason of the general excellence of the French road system, in particular the through-highways which have until now been able to satisfy traffic requirements, at least in the open country. In general, it is only at the exits from large cities that they are becoming inadequate and, since the end of the last war, such congestion in the most populous cities has been relieved through the Superhighway to the West in Paris, the Superhighway to the North in Marseilles, the Croix-Rousse tunnel in Lyons and the Superhighway of Lille. In the near future, the Superhighway to the South from Paris will make rapid contact between Paris and the Orly Airport and the heavy traffic on the Cote D'Azur will be absorbed by the wide and fast Esterel-Cote D'Azur Superhighway between Nice and Frejus.

As a whole, the French road system is under the control of the State department or community and the national highways are controlled administratively by the Division of Highways and Highway Traffic in the Public Works Ministry, and technically by the engineers of the Points-et-Chaussees (the highway and bridge engineering division created in 1716) who are assisted by the public works engineers of the State. The Points-

et-Chaussees engineers also supervise the departmental highways for the departments and communities but the latter are responsible for the rural roads.

Cost of maintenance of national highways is provided for by budgetary appropriations on the basis of such factors as mileage, density of traffic, topographic and subsoil characteristics, etc. Funds for new construction came for many years from a special item in the budget and were distributed according to previously established programs. In the period following the last war, reconstruction of the road net damaged by the war was the primary concern of the engineers and included the rebuilding of more than 6,000 destroyed bridges.

These arrangements approximately covered the existing highway needs but with the renewal of automobile traffic and its subsequent intense growth in France, it became necessary to plan on new measures and establish programs for which the funds would not be subject to the hazards of budgetary decisions. In 1951, a law created the Highway Construction Fund which receives the moneys collected from a percentage on automotive fuel taxes and destined to finance the program of highway modernization.

Subsequently, two five-year plans were established of which the first was constituted by some of the most urgent work, the improvement of the international and economic through-highways, the construction of superhighways to relieve congestion, highway access construction in the large urban and industrial centres, the elimination of the most dangerous level railroad crossings, the reconstruction of over-age or inadequate bridges, road construction in war-damaged communities, the development of scenic highways for tourist travel, the preparatory work for the Mont Blanc highway tunnel to Italy, and the work required to improve or reconstruct points on the highways where the statis-

tics indicated a recurring and excessive number of accidents.

The second five-year plan continued with the objectives of the first and simultaneously began the modernization of the road system, made necessary by the increasingly rapid rise of traffic density, through inter urban superhighways. The Public Works Ministry laid out a program of 1,250 miles of superhighways in 1955 for establishing rapid and direct highway connections between the following cities:

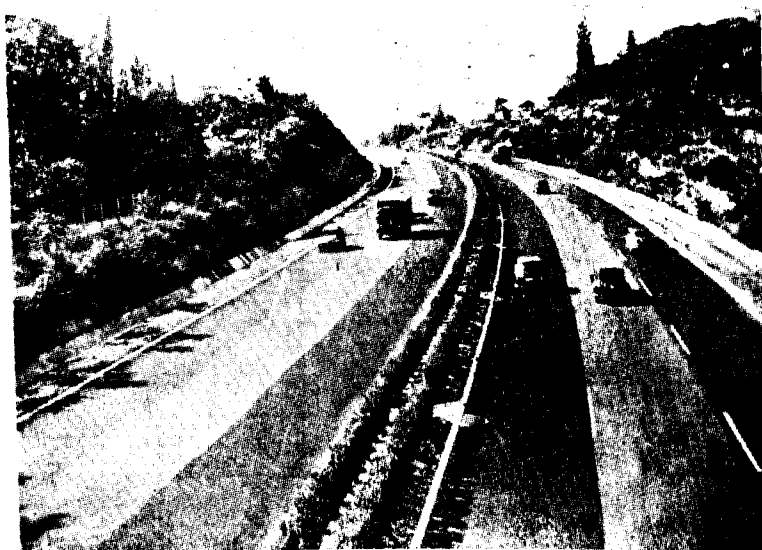
— Paris	— Lille
— Paris	— Lyons - Marseilles (Superhighway to the South)
— Paris	— Normandy
— Paris	— Chartres
— Metz	— Thionville
— Metz	— Nancy
— Metz	— Sarrebruck
— Strasbourg	— Basel
— Frejus	— Nice (Esterel-Cote D'Azur Superhighway)

Work on the new highways was to be terminated between 1960 and 1970 as far as the available funds made this possible. Imperative financial considerations, however, have interfered with the planned scheduling and made it necessary to divert some of the moneys from the Highway Construction Fund to other purposes. In August 1957, it was decided to temporarily suspend all new construction in view of this but to continue actively with all construction already begun. In the meantime, the situation has improved and permits have been issued again to undertake new work within certain limitations.

In any event, the Highway Construction Fund has made it possible to bring the French road system as a whole up to present-day requirements. From its inception until the end of 1958,

162,500 million francs were appropriated for scheduled programs and 137,600 million francs of credits were allotted for large-scale construction. The first five-year plan is nearly completed and execution of the second five-year plan has gotten under way.

of 80 per cent in the number of accidents at the points where such improvement has been carried out and such work will be continued at the same rate of intensity. In addition, approximately 60 more miles of bicycle paths will be provided in suburban areas.



Superhighway to the north from Marseilles

Since the first of July 1957, 1,500 miles of roadway have been improved and 570 miles of new roadways as well as 125 miles of bicycle paths have been newly built. Construction or improvement was carried out on 596 new and 338 existing bridges. The main effort has been concentrated on such industrial or populous areas as Paris, Marseilles, Lyons, Lille, Grenoble and others where either bypasses, through-roads or superhighways have been created. At the same time, the development of scenic itineraries as in the Alps, the Pyrenees and the Cote d'Azur has been continued.

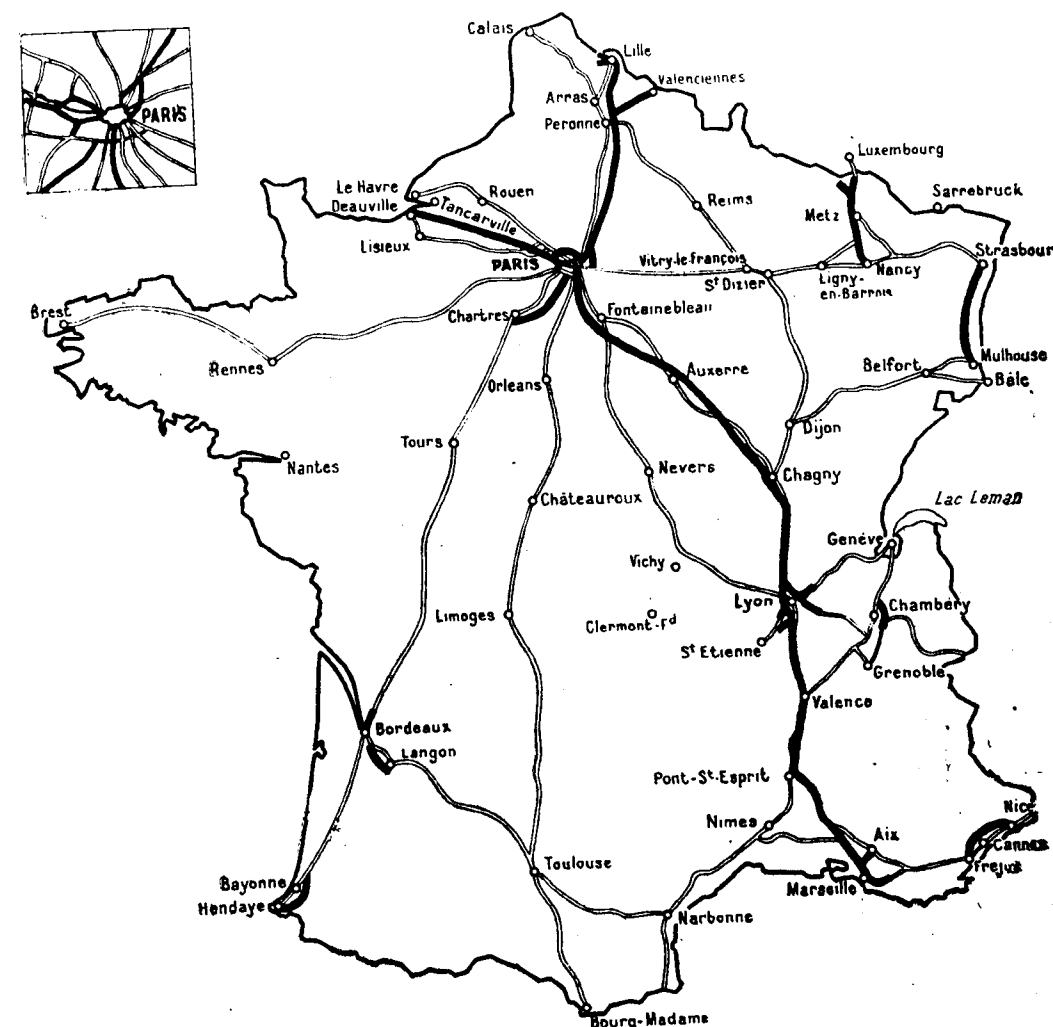
Safety of highway traffic has been served by the elimination of 250 danger points (curves, humps, intersections, level RR crossings). This has been so successful that the statistics show a drop

Part of the large-scale projects undertaken by the Highway Construction Fund will be financed by tolls to be collected from the user. These projects include the Tancarville Bridge over the Lower Seine, the largest suspension bridge of Europe with a center span of 1,995 ft to be opened for traffic in 1959, the Esterel Cote d'Azur Superhighway, and the highway tunnel under the Mont Blanc with a length of 7½ miles which will be the only large-scale project to be undertaken this year.

Our brief review of the situation shows that the French road system is keeping in step with the growing production of cars and trucks and the increasing density of traffic. The present period of "suspension" is being put to profit by the responsible authorities by research on the flow of arterial traffic,

Part of the large-scale projects undertaken by the Highway Construction Fund will be financed by tolls to be collected from the user. These projects include the Tancarville Bridge over the Lower

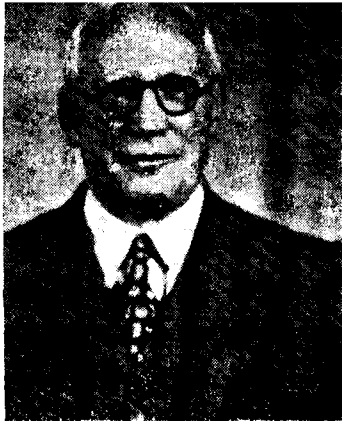
PLANNED SUPERHIGHWAYS



the development of projects of primary necessity and the preparation for acquisition of right-of-way in definitely adopted construction plans. This will

make it possible to immediately start work on some of the latter when funds become available so that planning on future programs can then be resumed.

(From: "French Economic And Technical Bulletin", No. 4, 1959.)



Sir Arthur Dean,
General Manager, Libyan Public
Development and Stabilization
Agency, Libya.

THE ROAD SYSTEM IN LIBYA

FROM the most ancient times and until the early decades of the present century, Libya has had practically no roads at all. Except for the narrow coastal belt, and a few scattered areas which can be made suitable for human settlement, the country is a large arid wasteland of sand dunes, rocks and mountains. It is against this geographic background that man has had to shape his mode of existence. For several centuries the only means of land communications have been the horse or the camel, and they followed either a natural course or a route opened by the feet of men and beasts. The Phoenician settlers who came to Libya about 800 B.C. established a number of trading posts, the "Emporia", along the coast. As a seafaring people they were only concerned with maritime trade and paid little or no attention to communications with the hinterland.

The Romans in Tripolitania and the Greeks in Cyrenaica made attempts to connect the various inhabited centres by an organised system of land routes marked at regular intervals by milestones. This in Tripolitania was established within the "Limes Tripolitanus", the defensive line of fortifications built to protect the coastal cities, while the vast desert beyond it was still intersected by traditional caravan routes, used by the nomads of the interior. One of these

routes was followed by Cornelius Balbus in 19 A.D. in his military expedition into Phasania (Fezzan) when he reached Cydamus (Ghadames) through the desolate Hamada Desert. Even at the peak of the glory of Leptis Magna, the industrious Romans did not build metalled roads because this was almost impracticable on account of the desert nature of the terrain, and the considerable distances. The Arabs who invaded North Africa after the collapse of the Roman Empire found the ancient Greek and Roman cities destroyed and pillaged by the marauding tribes of the desert. The land routes became unsafe. Advancing from Egypt the Arab armies overran Cyrenaica and Tripolitania during the seventh century under the leadership of Omar Ibn Al-As, and although fiercely opposed by the Berbers, they were able to thrust themselves westward as far as the Atlantic and later to cross the Straits of Gibraltar into the Iberian Peninsula.

As desert dwellers and desert experts, the Arabs opened only desert tracks suitable for the horses and dromedaries of the caravans which followed the invading armies. Indeed the primitive and rudimentary economy of Libya, after the destruction of the Ancient Phoenician, Punic, Greek and Roman centres, did not require well established means of communication. For succeeding long centuries the traffic consisted

only of the shifting of nomads from one area to another searching for their living and the movement of flocks of sheep and camels, mainly in the Sirte area. The centuries old desert tracks of the pre-desert and desert were more than sufficient for this purpose.

If a road became impassable, or was obliterated by the elements, a new one was traced by caravans and followed by father and son through generations. When interruptions occurred, because of floods or other causes, communications came to a standstill without serious repercussions on a pastoral economy. Localities with water constituted the staging points and distances had only a relative importance. Thus a caravan often had to march a very long distance before halting at the next well in order to replenish its supply of water and find rest for men and beasts.

During the period of the second Ottoman administration, which began in 1835 and ended in 1912, the most important caravan routes followed four directions from Tripoli. Two along the coast, westwards to Zuara through Zanzur, Zavia and Agelat and eastwards to Misurata via Homs and Zliten. The remaining two pushed southwards, one to the Gebel of Garian and the other to the Gebel of Jefren. These four roads were described as carriageways because in general the nature of the soil permitted the transit of horse drawn vehicles. The minimum of improvement with an occasional light macadam surface in soft patches and a few causeways on large wadis to help traffic in the rains was all that was attempted.

Nine other tracks were essentially caravan routes for camels since the difficulties of the terrain they crossed, masses of large stones (gargaf) and pebbles (serir), high sand dunes (zellaf) made them impassable for draught animals such as horses and donkeys; mules were then unknown in Libya. These routes fanned out from Tripoli in the direction of Sirte, Nalut, Ghadames and

as far as Mourzouk and Ghat and thence to Bornu and further on to Zinder and Kano in Northern Nigeria. Tripoli was then the sea outlet of an active trade with the Sudan and Central Africa, when camel caravans laden with gold dust, ivory, spices and other tropical products made their way to the coast, and returned to central Africa to sell European manufactured products. The slave trade, of which Morzuk was the main centre, was also prosperous. A journey between Tripoli and Kano took normally about six months and followed two routes, one departing from Tripoli through Garian, Mizda, Geheriat, Shueref, on to Morzuk and thence to the Sudan, or from Ghadames to Ghat and directly to Kano. The second route departed from Misurata through Bu Ngem, Hon, Sebha, Morzuk, to reach Bilma and Bornu.

In Cyrenaica, there were at least ten different caravan routes. These largely ran inland from the small ports of Benghazi, Apollonia, Derna and Tobruk. The most important extended from Benghazi to Agedabia and thence to Sirte, Misurata and Tripoli. From Benghazi to Tocra, Tolmetta, Merg or Barco, from Apollonia to Cyrene and Derna, from Derna to Tobruk, Bardia and the Egyptian frontier. Another from Derna southwards to Giaghub. Agedabia was in the past the key centre of the traffic to the south. From here a route leads to Kufra and another to Marada, Zella, Morzuk, Ghat and on to the Sudan.

With the outbreak of the Turkish-Italian war in 1911 and the landing of Italian troops in Libya, communications became an urgent problem for the conduct of military operations and for the requirements of a modern European army.

Italian road engineers repaired old tracks, and where necessary built ways through mountain passes and laid bridges over wadis, but all these works were of an essentially military nature. As far as the Turks were concerned,

their small garrisons, backed by irregular Arab forces, continued to use the old routes. Their supplies of arms from Egypt came by the way of a caravan route known as Trigh Enver Bey, a straight desert path running like a thread across the arid plain of the Marmarica as far as south of Derna. The same route was followed by Rommel when his Afrika Corps detoured to strike south on Bir Hakeim and El Adem during the battle of Ain Gazala. Contraband arms from Algeria and Tunisia was carried through the open desert to shorten distances. During the first decade of their administration, the Italians embarked on the building of motor roads, which, however, did not go much beyond the areas of Tripoli and Benghazi and did not exceed a total of more than one hundred kilometres. The real programme for the building of a modern road system, aiming at solving the problem of both military and civilian communications, was not started until the latter part of the 1920's and the beginning of the 1930's. For the first time Libya had bitumen roads which were able to support heavy traffic across sandhills. The Tripolitania and Cyrenaican Jebels through which mountain passes were carved are admirable examples of skilful road engineering for which the Italians bore a well-deserved reputation. The road network of Libya now extends to 2,054 kms., of which 1,600 had been bitumenised with bridges, road signs, etc., leaving 454 kms. of metalled tracks. Additional tracks, adapted to the transit of motor vehicles brought the total to about 2,830 kms.

Tripolitania and Cyrenaica were for a long time after the Italian conquest two separate administrations under governors, one residing in Benghazi and the other in Tripoli, but when the two territories were merged to form one single Colony of Libya under Marshal Balbo at the beginning of 1934, the linking of the two major Libyan towns, and opening a road through the two

territories and to run from the Egyptian to the Tunisian frontier, became essential.

Up till then practically all traffic, military and commercial, had been maritime, coastal shipping in small vessels. The large Sirtic area was passable only along a primitive track which put a heavy strain on both men and machines who ventured through it. It was also frequently interrupted by gangs of the Arab resistance movement.

The coast road, or "Litoranea", known also as Via Balbia, after Marshall Balbo, was inaugurated by Mussolini in the Spring of 1937. It is 1,822 kms. long from the Egyptian to the Tunisian frontier, running along the Mediterranean. At regular intervals the road is supplied with 65 road maintenance depots (Case Cantoniere). This colossal project cost 103,000,000 Italian (prewar) Lire, including the road maintenance depots, bridges, road signs, milestones and the Marble Arch, or "Arcae Philaenorum", a monument erected to commemorate the opening.

"Marble Arch", the name was given by British troops of the liberating army and has stuck, and which was meant to be a symbol of the revival of Roman greatness, emerges as a colossus in the desert emptiness. It was an outstanding feature during the war in North Africa, and carries the inscription quoted from Horace, "Alme sol possis nihil urbe Roma visere maius"—"Oh, great sun, never you will see a greater thing than the city of Rome". This was an expression of Mussolini's ambition to rebuild the Roman Empire. The Litoranea had, in fact, two aims; first to be a symbol of pride for Fascist Italy, and secondly to serve the military requirements of Libya; becoming a large military base, the springboard for Italy's expansion in Africa. Just before the war, Italy had a standing army of 200,000 men stationed in Libya. During

the war, the Litoranea carried the traffic of at least three large, modern mechanised armies and suffered considerable damage, especially in the tract from Agheila eastwards, as the tide of the war went forward and backward.

Extensive repair work has been carried out in recent years all along this coast road which is now part of the Federal Road System of the Libyan Government. Whole sections which were heavily damaged have been completely rebuilt, and the road is efficiently maintained under the Federal Roads Department.

THE NEW FEZZAN ROAD

The Fezzan, the southern province of Libya, which has so far been considered as a remote region because of difficulties of communication, is now being opened up by a modern road. The Fezzan covers an area of about 400,000 sq. km., a desert country for the most part, consisting of large Ergs (sand dunes) and rocks. It has always been an area of transit for the caravans between Sudan and Chad and the Mediterranean from the days of the Garamantes till the present time. Indeed the history of the Fezzan is closely linked with its geographical position as a centre of communications, not only between north and south but between east and west. In fact, caravans came from Egypt, and in Cairo there is still a gate called "The Gate of Zouila", a reference to the village of that name about 200 kms. east of Murzak. At present the Fezzan is crossed by the Federal road, so far only a trace on the map and a track on the ground, which runs from 125 km. to the east of Misurata to Ghat at the southwest corner of Libya on the Algerian border. This road passes through Bunjen, Hon, Sebha, "The Historical Way of the Garamantes", Ubari, Serdeles and Ghat, a total of about 1,100 km. It has been selected as the route for modernization. The other track running north to south by Mizda,

El Gheriat and Brak (520 km.) has now been abandoned except as a caravan and landrover route. This Fezzan road was traced along the least difficult tracks and is purely a surface road. This surface is no longer able to support the heavy strain of rapidly increasing traffic arising largely from the opening of the country to the search for oil in which many companies are now engaged with every prospect of successful results. At present a truck of 7 tons takes at least 36 hours hard driving from Tripoli to reach Sebha, 18 to 20 hours is taken by a Land Rover. In order to bring the province of the Fezzan closer to the other two Libyan territories, it is essential that communications with it are made easier and to open it up so that its agricultural and mineral resources can be developed. With this in mind, the Libyan Government, through the Federal Ministry of Communications, Roads Department, has started, early this year, the construction of a modern road to the Fezzan, the course following approximately the existing track. The new road will be 697 km. long, 6 metres wide with bitumen laid on a foundation of stabilized soil and hard core. When completed it will do much to assist the development of the Fezzan, it will open a regular traffic for the export of local products and will permit the transit of the traffic of the oil companies which are now engaged in prospecting for oil in this part of Libya.

Libya, like India, has a Federal Constitution, and the road system is in part a Federal and in part a Provincial responsibility.

Except for the two major trunk roads, the Coast road and the Fezzan road, the other land communications in Libya come under the respective provincial Governments, though streets within their boundaries are administered by Municipalities. The Federal Roads Department, a branch of the Ministry of Communications, is responsible for

maintenance and improvement as well as new construction of the Federal highways, a task which is being efficiently performed. The Provincial Governments have also carried out extensive road works and are regularly improving the existing road system to make it suitable for the ever increasing road traffic. Many of the roads which were built 30 years ago are now too narrow for the increasing traffic carried by modern vehicles, the eight ton truck with a ten ton trailer is common. Hence widening of metalled width and improving curves and gradients, with, in some instances, the introduction of dual carriageways, is becoming necessary to an increasing extent. Having been liberated from Italian rule by the victory of British and American arms, Libya was set up as an

Independent Kingdom in 1951 under King Idris I, who as the Emir of Cyrenaica, had been the spearhead of the resistance movement. Since then a great deal of money has been spent by the Federal and Provincial Governments on roads. There is, however, still much left to be done for the roads in Libya, which in view of its great distances and sparse population are a vital aspect of the social and economic development of the country. Libya has today a good network of road communications, one of the best in the Middle East and practically speaking there is no centre of population throughout this vast country, however remote it may be, that cannot be reached by motor car, certainly be Land Rover or similar four-wheel-drive vehicles.

The only man who behaves sensibly is my tailor; he takes my measure anew every time he sees me, whilst all the rest go on with their old measurements, and expect them to fit me.

—G. B. SHAW

HIGHWAY DEVELOPMENT IN THE UNITED STATES OF AMERICA

THE BUREAU of Public Roads., [U.S.A.]

TRANSPORTATION, the movement of people and goods, has played a major role in shaping many civilizations. In countries with large land masses, road or highway transport has been especially important.

This is notably true of the United States of America, where the era of modern road building began with the invention of the gasoline automobile in 1893. By 1900, there were 8,000 motor vehicles in the country; 20 million by 1925, and in 1959 registrations reached 70 million.

The U.S.A. now has about 3.4 million miles of roads and streets. This total necessarily includes a wide variety of highway types, from 2-lane unsurfaced roads that are little more than wheel tracks to great multi-lane thoroughways linking huge metropolitan areas.

As motor vehicle registration and mileage mounted steadily, as vehicle weights increased year by year, highway engineers and officials were faced with a wide array of problems. This was particularly true of our State highway departments, which have the major responsibility for the construction and maintenance of main rural highways throughout the United States.

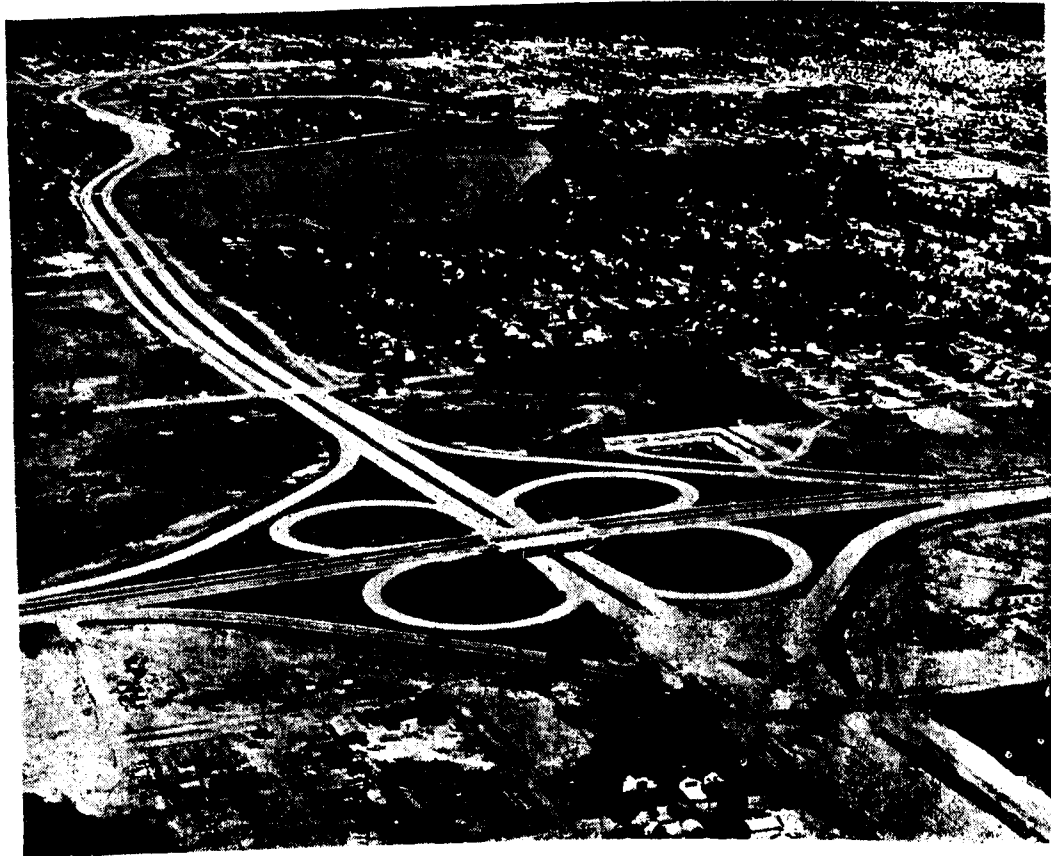
Federal aid to the States for highway construction began modestly in 1916. From 1921 such aid was limited to a system of major roads selected by the States and joined at State lines to promote a connected highway network. Beginning in 1944, Federal aid was extended to urban highways and to secondary or farm-to-market roads.

About 789,000 miles of roads are now eligible for Federal aid, 256,000 miles on the primary system, and 533,000 miles on the secondary. Federal aid for these systems (including urban extensions) is divided among the States according to formula which weigh the relative area, population, and rural mail route mileage of each State. Federal aid is used only for construction and right-of-way acquisition—maintenance and operation of Federal-aid roads is up to the States. The States select the roads to be improved, decide what projects to build, prepare the plans and let the contracts and supervise the construction—all subject to approval by the Federal Government.

Federal highway functions are carried out by the Bureau of Public Roads of the Department of Commerce. In addition to administration of Federal aid, the Bureau carries on extensive research dealing with highway planning, construction, economics and use. Much of this research is conducted in co-operation with the State highway departments.

At present the Highway Research Board of the National Academy of Sciences in co-operation with the American Association of State Highway Officials, the Bureau of Public Roads, and other organizations, is carrying out by far the most extensive and costly highway research project ever undertaken.

Known as the AASHO Road Test, the basic purpose of the project is an exhaustive study of the behaviour of both rigid and flexible pavements of



59-305—In right foreground—1 A35-2(104)098 a 4 mile grading and bridge project from Minnesota River to TH 100 In middle—U 024-1(1) grade and surfacing of roadway going across picture (TH 100) now I C94) in A35-2(101) 102 old no. IN 394-1(1) for highway-highway bridges.

Background U 049-1(2) grade and gravel base for 2.5 miles on TH 65 (now Interstate at Rt. A35) TH 100 across picture is open to traffic and now carries 18,000 ACT TH 65 (I A35) is not yet complete. A paving project was recently authorized which will complete I A35 within the area pictured. Traffic is expected to be about 14,000 ADT.

known thickness under dynamic loads of known magnitude and frequency.

Behind this simply stated objective lie more than five years of study and preparation. Actual construction of test road was begun in 1956. A high degree of uniformity in the embankment support was achieved before the actual sections of pavement were laid.

The 4-lane divided highway consists of four basic loops, including dual straightways 6,600 feet long, with half

circles for a turn around at each end. There are two smaller loops, one of which will not be subjected to test traffic while the other will be used for light loads.

Each basic loop contains a series of test sections, some of rigid (Portland cement concrete) pavement and others of flexible (bituminous) pavement. These sections vary in thickness of pavement, base, and sub-base. The test sections will undergo axle loadings

varying from 2,000 to 30,000 pounds on single axles, and from 24,000 to 48,000 pounds on tandem axles. The test loading and driving will proceed for 16 hours a day, 6 days a week during a period of two years. The highway loops also include sixteen test bridge spans of varying strength and four overpass bridges.

An elaborate system of instrumentation has been designed and installed to take the measurements of strain, deflection, and other phenomena under study. Full use will be made of electronic equipment, including computers and punch-card equipment for data analysis.

Some 70 test vehicles of 18 different makes will be used. Driven by a 300 man army contingent assigned by the Department of Defence, the range of vehicles and drivers should assure operation representative of normal highway traffic.

The actual road test got under way on October 15, 1958, when the first loaded trucks began to roll. Since then the test vehicles have been driven more than 2 million miles and several more million miles are scheduled before the test ends in the fall of 1960. By April 30, 1959, no less than 100,000 applications of each axle loading had been applied in each of the ten test lanes.

The wide range of axle loadings, combined with an equally wide range of pavement structure depths and layer components, gives great scope to this research. In each test lane the sections of pavement range from well below to somewhat above the generalized design which would be regarded as adequate for the load. As expected, some of the thinner pavement sections and several of the overstressed bridges have shown signs of distress—thus the test already is developing the type of data for which it was conceived.

Thanks to the broad scope of this project, the careful preparation, and the scientific manner in which it is being carried out, it is hoped that the results

will be of lasting value to highway designers and engineers the world over.

The ever-increasing importance of highway transport, the mounting tide of motor-vehicle use, and an unmistakable trend toward urbanization in many areas, all underscore the imperative need for better roads.

In the U.S.A., regular Federal aid to the States for highway construction has risen from a token 5 million dollars in 1917 to authorizations of 875 million dollars for 1959; 900 million dollars for 1960, and 925 million dollars for 1961. The money is divided 45 per cent for the Federal-aid primary system, 30 per cent for the secondary system, and 25 per cent for their urban extensions. These funds must be matched in equal amount by the States.

In spite of these substantial sums and even greater additional funds spent directly by the States and by local, county, and municipal governments, highways in the United States have not been adequate to handle the constantly increasing volume of traffic. This problem was especially acute in many urban places and on main travelled roads serving large metropolitan areas. Congestion, delay, and traffic accidents took a steadily mounting toll.

The Federal-Aid Highway Act of 1944 introduced a new system concept and called upon the State highway departments, in co-operation with the Bureau of Public Roads, to designate a 40,000 mile Interstate System network linking important cities from coast to coast. This was an important step, but since this Act did not provide special aid funds for the network, progress was slow. Meanwhile, traffic congestion, delays, and accidents continued to mount.

The Federal-Aid Highway Act of 1956 came to grips with the problem. Federal funds totalling over 25 billion dollars were authorised for the years 1957-69 to complete a 41,000 mile National system of Interstate and

Defence Highways. Though comprising only 1.2 per cent of the total road and street milages in the United States, it will serve 20 per cent of the total traffic when it is completed. Congress recognized the national importance of the system by providing that the States would put up only 1 dollar for every 9 dollars of Federal aid.

By definition, the Interstate System is a part of the Federal-aid primary system, thus the States have selected the routes and are planning and arranging for construction of the projects on the Interstate System. By the end of 1958, 4,700 miles had been built and opened up to traffic. An additional 6,800 miles were under way, and planning or right-of-way acquisition had started on another 16,800 miles.

This new network is being built to design standards which will be adequate for the traffic expected in 1975 a 60 per cent increase over 1956. Most of the system will be divided four-lane highway, but 6 lanes or more will be needed in and near large cities. Lanes will be at least 12 feet wide, the dividing strip generally 36 feet or more. Grades, sight distances, and curvatures will provide optimum conditions for safe, efficient traffic movement, consistent with sound engineering practice and economy.

A most significant feature of the Interstate System is access control. This means that vehicles entering and leaving the main traffic streams will do so only at planned intersections having grade separations and ramps which will permit safe orderly exit and entrance, with no direct interference from abutting property, driveways, roads or places of business.

Planned access of this sort is essential to preserve the traffic capacity of heavily travelled highways, to permit the smooth, orderly flow of traffic and to

offer the maximum in safe, efficient motoring.

Many consider that the safety factor alone is decisive, for controlled access cuts highway fatalities and accidents by half or more. It is estimated that completion of the Interstate System will save at least 4,000 lives annually.

Highway finances in the U. S. A. are now compatible with the contribution which motor cars make to our way of life. Total expenditures for roads and streets in 1959 came to 10.5 billion dollars. Of this sum, 7.1 billion dollars went for capital outlay—construction and purchase of right-of-ways—and 2.3 billion dollars were for maintenance, the remainder went for administration, highway police and safety activities, and interest on debt. The total included 7.1 billion dollars spent for State highways and 1.7 billion dollars for county and other rural roads, with 1.4 billion dollars going for city streets.

Total highway revenues, which reached 10.8 billion dollars in 1959, included 3.0 billion dollars of Federal funds, 5.6 billion dollars from State governments, 808 million dollars from county and other local rural governments, and 1.4 billion dollars provided by cities and other urban places. The Federal funds derive originally from the Federal excise taxes on highway users. In addition, 4.4 billion dollars annually came from State gasoline taxes, motor vehicle registration fees and the like, toll charges supplied 450 million dollars, 1.5 billion dollars came from property taxes and general revenue, and 177 million dollars came from miscellaneous sources.

In the first three years of the greatly enlarged highway program which began July 1, 1956, construction was completed on more than 75,000 miles of Federal-aid highways and 15,000 bridges.



P. A. EGOROV

Chief Engineer of the Communal Service and Urban Facilities Department, Ministry of Communal Economy of the Russian Federation of Soviet Socialist Republics.

DEVELOPING ROAD-BUILDING IN THE U.S.S.R.

RAPID industrial development in the USSR, reconstruction of old and construction of new cities was accompanied by an immense road-building program.

In cities of the Russian Empire in pre-revolution days, there were almost no improved roads.

Inter-city communication was carried out by means of unpaved badly maintained "post" roads and some access stretches leading to the cities had cobblestone or coarse broken stone pavements. In the cities proper only the main streets had pavements, but even those were of the simplest types.

Large-scale road-building over the immense territories of the Soviet Union began to develop in 1925. After the second world war large-scale road construction assumed great proportions. The Republican, province and local administrations throughout the Soviet Union allocated huge sums of money and large material resources for road-building. To cope with this problem, the USSR industry manufactures a large quantity of diverse road-building machines and equipment.

All highways and city roads in the USSR are classified according to their designation and anticipated traffic volume.

Thus, cross-country arterial roads of the I class are those designed for a traffic volume of over 1000 motor cars per 24 hours. The speed of traffic on such roads may reach 140 kilometres per hour.

Roads of the II class comprise those where traffic density reaches 500-1000 cars per 24 hours, and where provisions are made to secure traffic speed up to 100 km per hour.

Roads of the III class have a traffic capacity of 500 motor vehicles per 4 hours, with speeds up to 70 km per hour.

In addition to highways of the I, II, III classes there are also local approach roads.

The width of the subgrade and carriageway is established by calculations depending on traffic flow density, the road-lane width being equal to 3.5 metres for two and four lane traffic, and 3 metres—for a bigger number of lanes. Radii of curves, gradients and vertical

curves are assumed depending upon the class of the road and its topography.

Thus, for I class roads the radii of curves in the horizontal plane are about 3500 metres, for II class roads—from 2000 to 2500 metres and for the III class roads—between 1000 and 1500 metres.

The gradients are:—for the I class roads not exceeding 3 to 4 per cent, for those of the II class—5 to 6 per cent and for III class roads—7 per cent.

Modern I class highways have crossings with other highways, as well as with rail road lines arranged at different levels, with over-bridges and one-way traffic ramps. Every 200—300 kilometres of roads of this class (as for instance the Moscow-Minsk, Moscow-Simferopol, Kharkov-Rostov and other highways) are provided with service stations which cater for the passengers and their motor cars, and comprise repair-shops, hotels, restaurants and filling-stations.

To provide protection against snow-drifts, shrubbery and trees are planted in strips 10 to 20 metres wide that border the highways.

In mountainous regions dimensions of roads under construction are established by taking into consideration local conditions.

Urban construction in the USSR is carried out in accordance with plans based upon long-term planning of layout of housing and communal facilities. These plans and schedules are approved and authorised by appropriate governmental agencies and are mandatory for all administrative and economic organizations, as well as for private citizens, engaged in any kind of building activities within city boundaries.

The most important element in the planning of city building layout and construction is a proper solution to the problem of an urban transportation system (principles underlying traffic

organization), of layout of road networks, determination of basic dimensions for highways, thoroughfares and terminals.

According to the classification used in the USSR the urban road network falls into 4 groups: arterial city streets, district arterial streets, local streets and inter-block lanes.

The width of the street carriageway in cities is set depending on the traffic volume and the types of vehicles used, with proper attention given to existing and planned future city area layout.

The construction of streets is, as a rule, accompanied by the construction of a gutter system and, in a number of cases, of a drainage system designed to lower the level of underground waters.

In connection with an increase during the past years in the number of motor cars now used in towns—in some of the large cities of the USSR (as, for instance, Moscow), work has been initiated for the reconstruction of congested crossings and for arranging vehicle and pedestrian passageways at different grades.

An example of a reconstructed street is the recently completed traffic relief arrangement at the Kutuzeff avenue in Moscow, Photo 1.

Carriageways for both roads and streets have different types of upper courses: cement-concrete, asphalt-concrete, also metal and gravel, sometimes treated with binding agents, rectangular stone blocks or cobblestones.

Due to a very high level of crude oil production and refining in the USSR—one of the most widely used materials in road construction is asphalt-concrete. Upper courses made of this material have the necessary mechanical strength and plasticity, and ensure a high degree of adhesion between the automobile tyres and the road surface, are easily cleaned and washed and, if necessary the worn surfaces can be quickly restored.

In addition to this, the employment of asphalt-concrete permits complete mechanization of all construction work processes.

Under conditions prevailing in the USSR the service life of asphalt concrete varies from 10 to 25 years and depends, in the first place, upon the thoroughness of the asphalt concrete, traffic density and on maintenance of the road surface

throughout its service period.

In recent years the road building industry is increasingly using for upper courses—cement concrete.

On the II and III class roads, crushed-stone and gravel highways with bituminous macadam upper courses prevail.

Figs. 1 and 2 are illustrative of the upper course structures of roadways

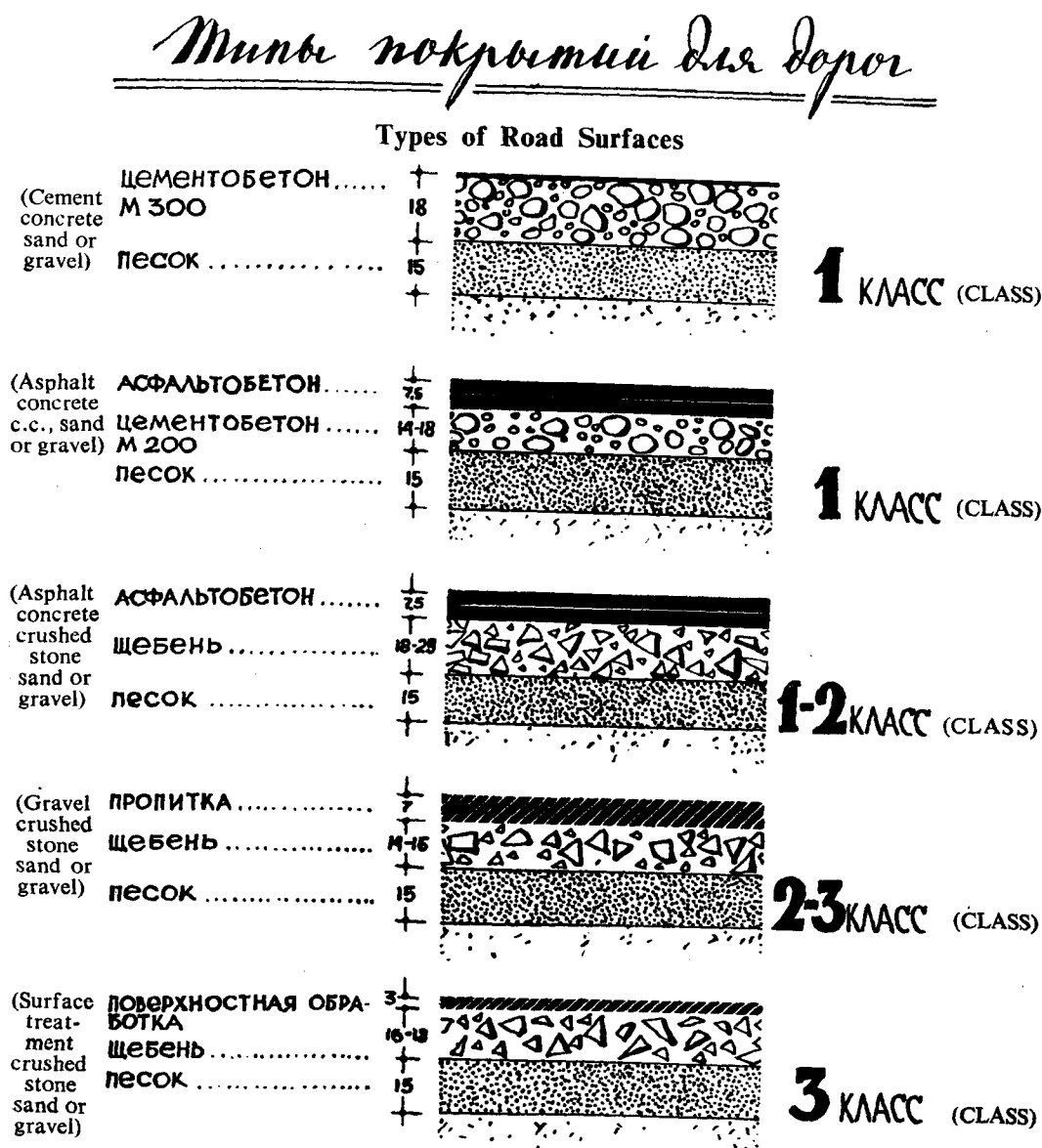


Fig. 1

Применение покрытий на дорогах местного значения

Application of local materials for road pavements

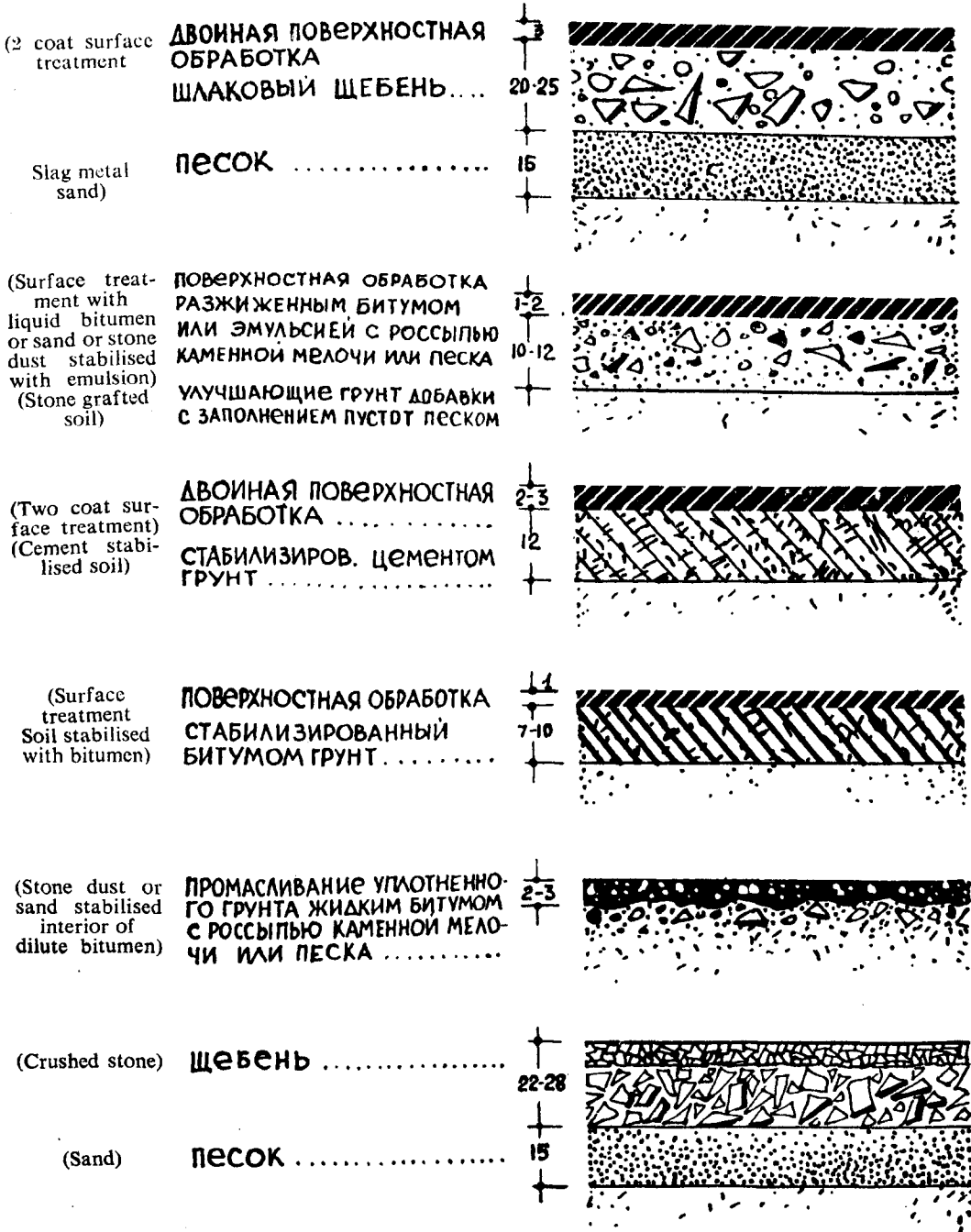


Fig. 2
130

(dimensions are given in centimetres). Photos 1 and 2 are examples of modern arterial street construction and represent avenues traversing the zone of newly constructed housing blocks in Moscow.

Photo 3 illustrates the arrangement of a city street of local importance. All operations connected with the construction and repairs of roads and

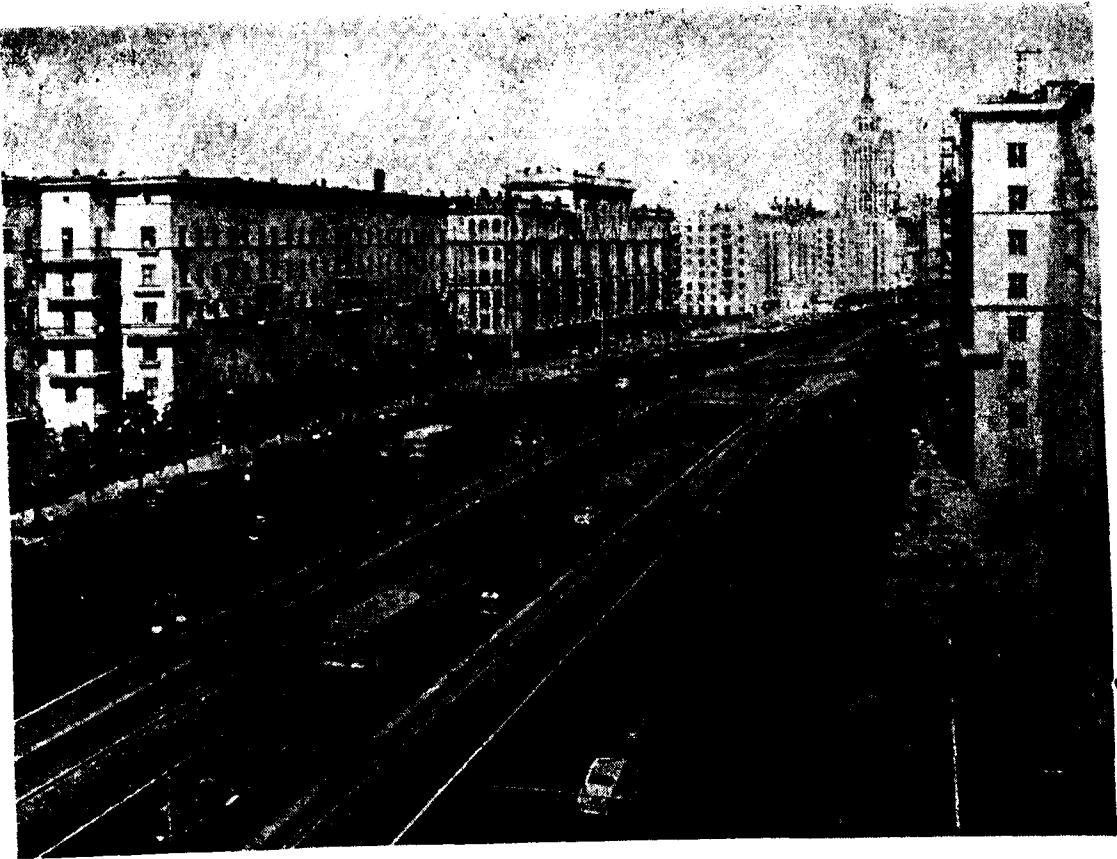


Photo 1. Avenue Katuzoff



Photo 2. Perspective of Lenin-Avenue and Lomonosoff-Avenue



Photo 3. The road of local importance

streets, with the exception of the laying of stone-blocks and cobblestones, are mechanized. This involves an extensive use of power showels, bulldozers, power scrapers, motor rolls (including vibratory types), stone crushers, rippers, bitumin pavers, concrete mixers, auto-cranes, tractor leaders and other equipment.

Inter-city roads of all classes and streets are built by specialised organizations who own road building plants, machinery and equipment.

Until quite recently, highway bridges were built either of steel or wood, reinforced concrete and concrete structures being rarely used.

In 1952 the attitude toward using reinforced concrete in the construction of bridges has radically changed and preference is given to reinforced concrete and concrete structures.

In the construction of small and medium span bridges, over-bridges, and ramps, only standard design and pre-

fabricated reinforced concrete structural members are used, these being manufactured at stationary and open-air mixture plants.

Reinforced concrete is now also a key material for the construction of large bridges spanning big rivers.

There are some of such large bridges now under construction. The arch triple-articulated reinforced concrete bridge across the river Enisei in the vicinity of the Krasnojarsk is 2.5 km long, 24 metres wide and each span is 156 metres long. The spans are made of pre-fabricated reinforced concrete structural members. Arch blocks, each weighing 1600 tons, are fabricated directly on the shore then being placed upon special floats, are brought up to the bay of the bridge substructure. Such a method of arch erection, without intermediate supports is being used for the first time. It considerably speeds up erection of structures, enables to eliminate temporary, and ancillary labour-consuming structures, ensures continuous industrial,

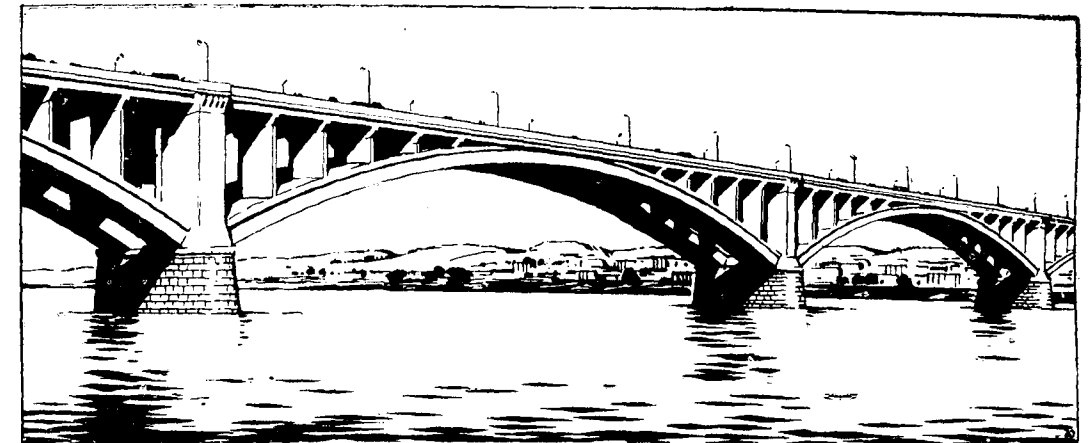


Photo 4. Bridge across the Enisei river at the city of Krasnoyarsk

all-year-round fabrication of structural members and thus reduces over-all cost of construction work.

The town bridge across the Viyatka river in the city of Kirov, which is of the girder-cantilever system, is also being built of prestressed reinforced concrete members, with individual spans 84 metres long. The total length of the bridge is 540 metres and its effective

width is 16.5 metres. The concreting of the bridge framework is effected with the aid of suspended arrangements.

The USSR has begun the realization of the huge tasks of further development of all branches of national economy planned for the 1959-1960 period. In this connection the construction of roads and amenities will gain a new impetus.

Mysticism keeps men sane. As long as you have mystery you have health; when you destroy mystery you create morbidity.

—G. K. CHESTERTON.

THE PLANNING AND CONSTRUCTION OF ROADS IN WEST GERMANY

By

Dr.-Ing. H. KUNDE *

SINCE the volume of motor traffic and the number of motor vehicles are steadily increasing (400,000 to 500,000 motor vehicles per annum for the past ten years), road construction has become a vital problem in the German Federal Republic. Although the automobile and motorcycle were invented here by Daimler and Benz more than 70 years ago, Germany is not as thoroughly motorized as most of the neighbouring countries of the western hemisphere,

and this fact must be taken into consideration. A considerable increase in traffic in the future must thus be anticipated. This is a fact which compels the responsible authorities of such a densely populated country to undertake special road construction measures.

On March 31st, 1958, the West German road network, according to its statutory structure, comprised the following:

2,260.3 km or 1,404 miles of Federal autobahnen	= 1.7 per cent
24,395.3 km or 15,158 miles of Federal highways	= 18.5 per cent
56,700.9 km or 35,233 miles of Rural roads	= 42.9 per cent
48,672.2 km or 30,243 miles of Secondary roads	= 36.9 per cent
132,028.7 km or 82,038 miles	

The Federal government is responsible for the maintenance of the first two groups, which together form the network of Federal arterial highways. The third group is composed of roads belonging to the 9 Federal counties. They serve regional traffic mainly. The last group comprises the roads of the 418 districts which serve short-distance and district traffic if it does not use other roads also, because a distinct separation of the various types of traffic according to the type of roads over which it moves is impossible. The arterial highways must accommodate the most dense and heavy traffic, while the district roads are used by smaller vehicles and considerably lighter traffic.

The knowledge gained from systematic traffic surveys is one of the most important prerequisites, and is the basis of road construction planning. When this is borne in mind, it becomes perfectly clear that the Federal government must prepare the most complete and expensive plan if it is to supplement its road network in such a manner that it will accommodate a steadily increasing traffic volume for the next 20 years.

The development plan, which became law on July 27th, 1957, comprises the development of approximately half of the Federal arterial road network. Approximately 17½ billion DM will be

* Chief of the Department of Road Construction at the Federal Ministry of Transport (Bonn), Germany.



Photo 1. Autobahn between Bayreuth and Nuremberg, Berlin-Munich section

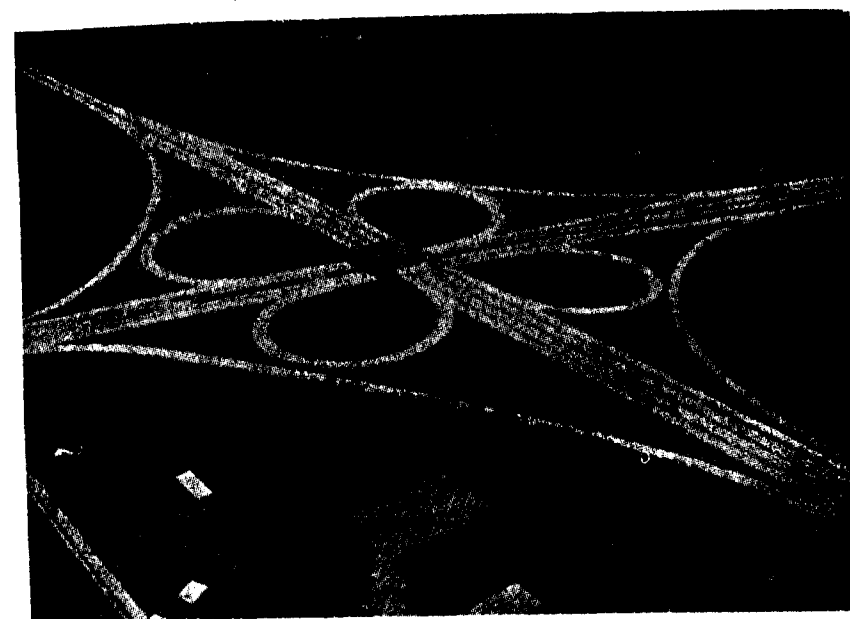


Photo 2. Autobahn clover-leaf near the Frankfurt Cross, at the intersection of the Kassel-Mannheim, and Cologne-Wurzburg autobahnen



Photo 3. Wiedbachtal bridge along the Cologne—Frankfurt autobahn

spent during the next 10 to 12 years for this programme, including construction of 2,000 km or 1,243 miles of autobahnen, 1,050 km or 652½ miles of Federal highways and 3,000 km or 1,864 miles of town by-passes for Federal highways. This sum will be supplemented by running expenses for maintenance and administration, as well as for certain subsidies to large and medium-sized towns which are responsible for administration of through-

roads which are part of the Federal highway system. It is expected that the financial basis will be provided during this year by passage of a special road construction financing law to cover approximately 1/3 of the construction programme, which is to be completed in the next four years.

Several Federal counties also have prepared plans for developing their roads and commenced construction. In the same manner, the authorities of various districts where the financial means vary greatly, but on the whole are considerably lower than those available to the Federal or county governments, are attempting to increase the development of their secondary road network, or at least to lay modern road surfaces on

existing roads as rapidly as possible.

All in all, approximately 50 to 60 billion DM will be required during the coming 10 to 12 years to improve at least half of the roads, including municipal roads, to the point where they can accommodate the increasingly heavy and dense traffic. The present development programmes will be supplemented later by other programmes which will deal with remaining roads of all types. This programme will provide for the necessary extensions, auxiliary roads and modernization projects which are impossible to consider at the present time. For these reasons, it can be expected that the financial requirements for road construction will continue to be urgent for several decades to come.

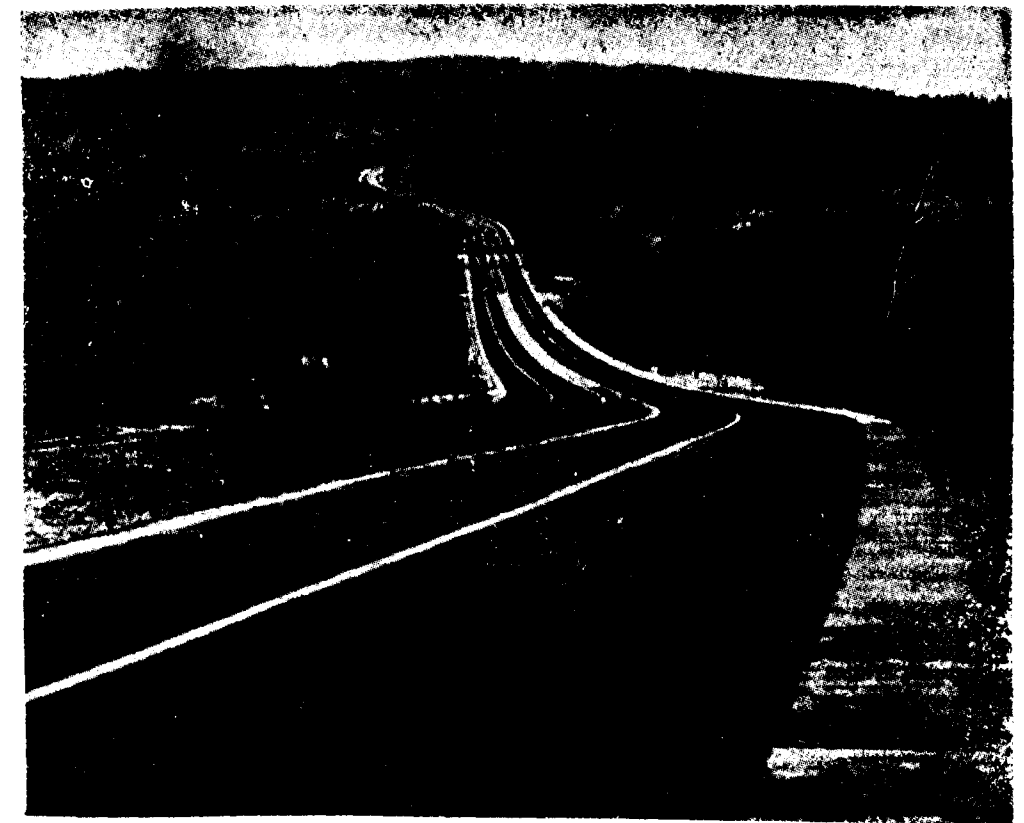


Photo 4. Crossing where the Kassel—Hanover autobahn crosses the Werra river near Hudemunden

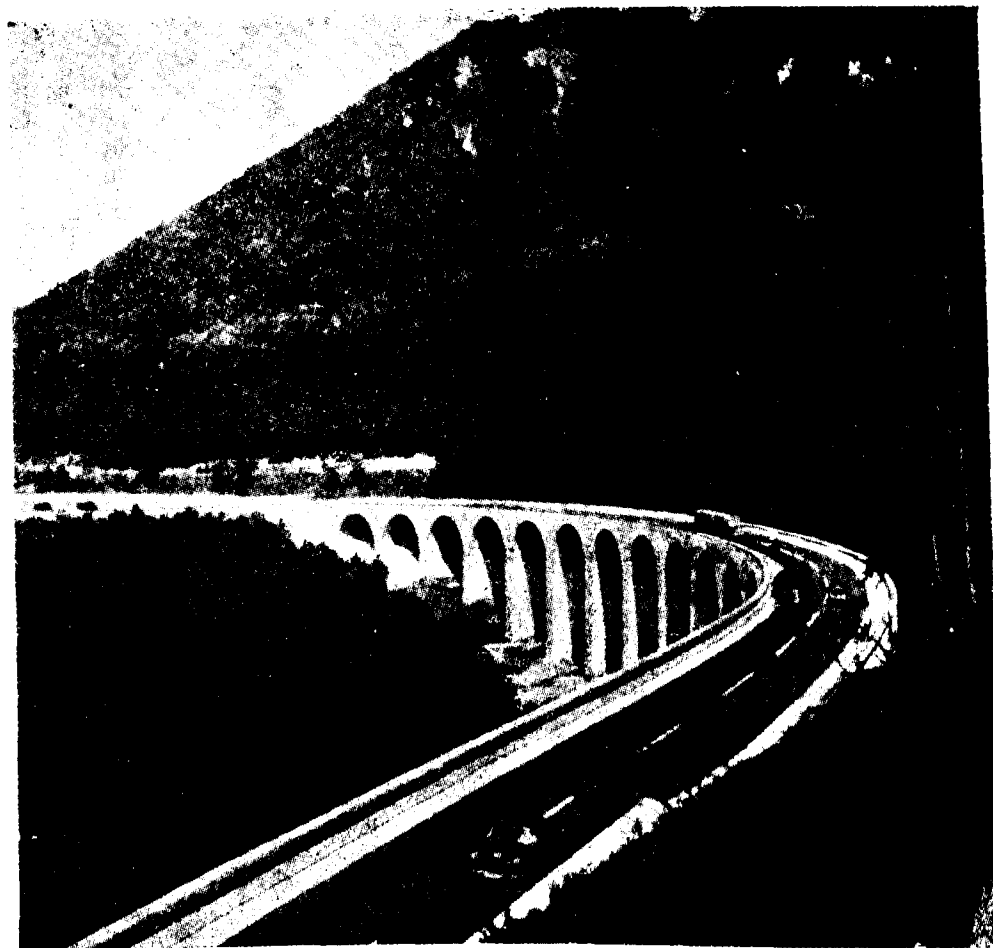


Photo 5. Alb rise of the Stuttgart—Munich autobahn (showing the route to Schontalblick and the Todsburg bridge) Traffic in the opposite direction travels over another route for several miles due to the terrain. The second route is not visible in this picture

Actually, Germany's roads have already been modernized since 1924/25. In view of the size of the network, the necessary work cannot be completed in one year, or even 10 years. During the first decade, attempts were made to combat the dust caused by the relatively small volume of motorized traffic which travelled over the old macadam surfaces. Only during the thirties were the road foundations and surfaces reinforced to any great extent by modern building methods, mainly by using

bitumen and road-building tar as binders for the stone and gravel used in road construction. Ninety per cent of the auto-bahnen, commenced in the autumn of 1933, were paved with concrete.

Aside from a very few exceptions, the dusty carriageways of old are no longer to be found in today's Federal highway system. Urban roads and secondary roads, however, have not been improved to such an extent. Nevertheless, in the 5 years between

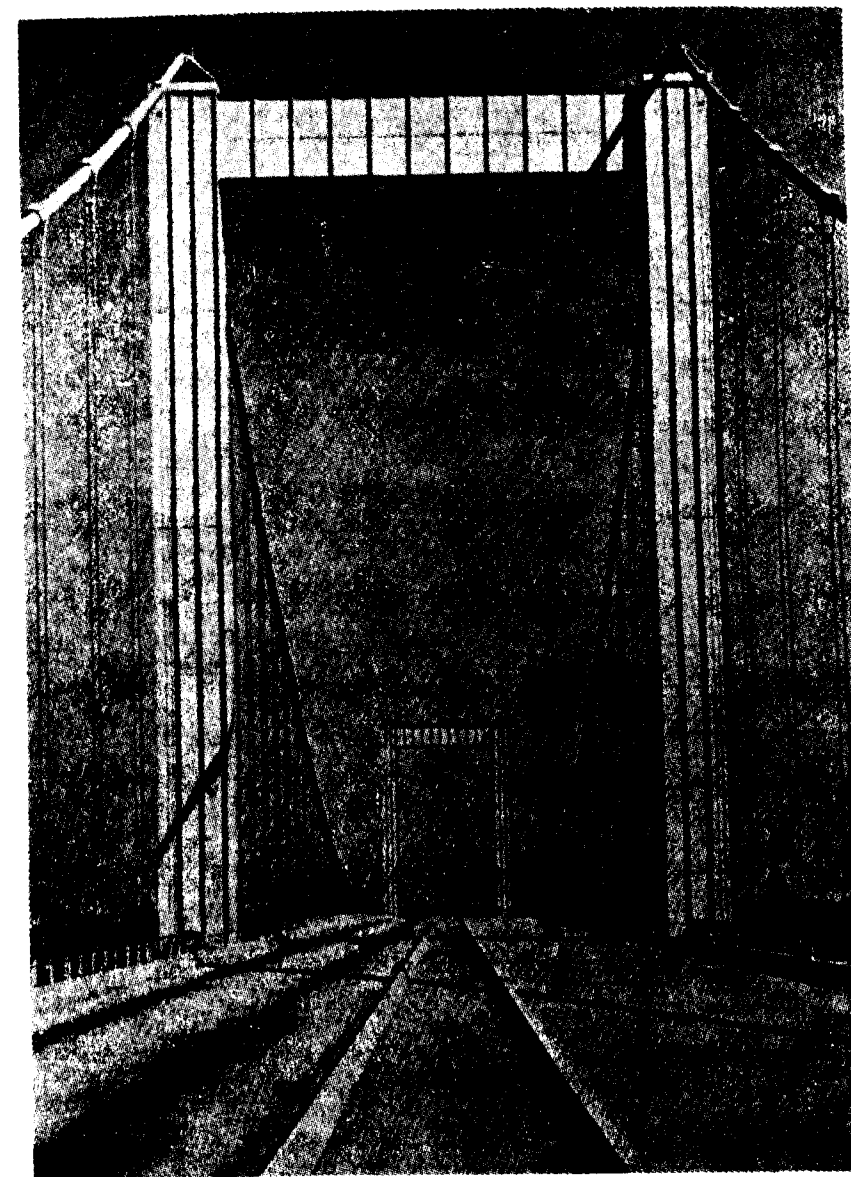


Photo 6. Autobahn bridge across the Rhine river near Cologne—Rodenkirchen

1951 and 1956, approximately 20,000 km (12,427 miles) of such roads were surfaced with bituminous pavements, which may be regarded as remarkable progress, and may lead one to expect that urban roads also will be made dust-free during the next few years.

Between 1940 and 1949, road const-

ruktion generally came to a halt in Germany because of the war. None but the most essential construction work could be done at that time, and even maintenance was restricted to scanty repairs because of the lack of materials, conveyances and manpower.

With the more recent increase in

motor vehicle traffic and the accompanying increase of special taxes—auto licence fees, and petroleum taxes during 1951, 1953 and 1955, the revenues available to the Federal government and its counties for road construction also increased. As a result, more and more roads were built or improved each year. The total expenditures of the regional public corporations for this purpose increased four-fold between 1950 and 1958.

To-day, the alignment of roads must be improved, and they must be widened, reinforced and rendered frost-resistant. First of all, the danger of accidents which accrues from the construction of older type roads, such as narrowness, poor visibility, too many curves, crossings and intersections, cambered roadbeds, slippery surfaces, steep grades, etc., must be eliminated.

High-speed traffic, as well as an attempt to adapt roads harmoniously with the landscape, have led to the selection of new routes. By means of suitably engineered curves, perfect dynamic alignment is ensured, and with the aid of perspective the road is blended with the landscape in such a manner that it conveys a natural and light impression.

Modern bridge construction is similar. During the last phase of the war, 14 to 15 years ago, approximately 1,500 bridges within the Federal arterial net work were destroyed. Most of these were bridges with wide spans. With only a few exceptions, all of these have been reconstructed. This represents an important accomplishment of the bridge builders within the past decade. At present 160 bridges are under construction, including several new ones which are being

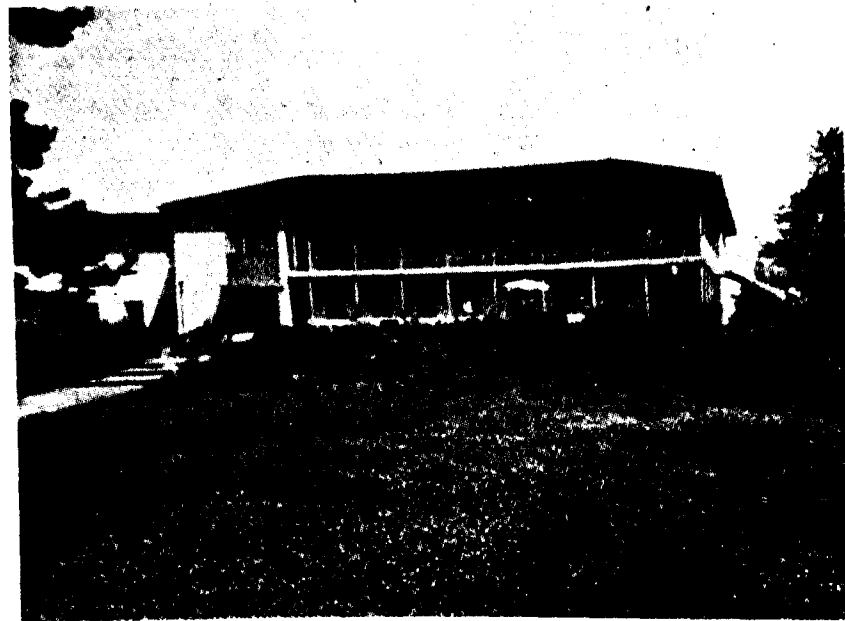


Photo 7. Service station ("Rasthaus") at Hanover—Garbsen, on the Hanover—Cologne autobahn. The German Federal autobahn network offers many special services, not only for vehicles (repair shops, petrol stations, etc.) but also for the personal comfort of the autobahn traveller (service stations, restaurants, hotels, and even an autobahn church, completed this year

built as a part of the Federal autobahn, the length of which has been increased since 1950 by 12.8 per cent. According to the development programme, the widening of many bridges—approximately 1,400—will become necessary.

If one compares the structure of bridges built during recent years with older structures which remain intact, a great change in design and construction becomes evident. This is influenced by the latest knowledge regarding route selection, the development of new construction methods and the availability of improved building materials.

Among the developments which influence bridge construction, the most

conspicuous innovations are the use of prestressed concrete and the composite construction method. (This periodical has published detailed reports of these methods in previous issues.) Both methods make possible almost complete utilization of the cement, concrete and steel employed in building. The quality of such materials recently has been improved to a very great extent. The new construction methods encouraged the development of much lighter and more attractive superstructures with greater load-carrying capacities combined with increased economy. Thus, the most essential aims of modern construction methods are fulfilled.

(From: "Trends", 30th June, 1959.)

Nothing fails like worldly success

—ARNOLD TOYNBEE



E. A. NADIRSHAH,
Concrete Association of India

ROAD TRANSPORT NEEDS UNDER THE SECOND NATIONAL PLAN AND SOME SUGGESTIONS FOR ITS EFFECTIVE AUGMENTATION

THE Second National Plan envisages increase in production from 151.672 m. tons in 1955/56 to 228.40 m. tons in 1960-61 excluding items like automobiles, machines, etc., which cannot be listed in tons, i.e., the increase in production was estimated at 77 m. tons by 1960-61. On account of reduced allotment and increasing cost this figure may now work out to about 80 per cent of the original target, i.e., the increase in production may be taken at about 62 m. tons. Taking into consideration the back log of about 5 m. tons left over from the first Plan, the total additional goods traffic that would develop will be 67 m. tons.

The Planning Commission had made an appraisal of financial resources and the likely industrial development, which indicated that the Railways will have to carry an additional 53 m. tons of freight traffic by 1960/61 as against 47 m. tons provided. If this is taken into consideration, then out of 67 m. tons of increased production by 1960/61 the Railways will carry or cater for 53 m. tons leaving a gap of about 14 m. tons, say about 15 m. tons to be catered for by other forms of transport.

The gap of the country's long distance haulage of as much as 15 m. tons per year which the railways cannot tackle due to various reasons, can be tackled by road transport as :

- (a) the roads are not used to their full extent as they should be, as in 1955-56 the number of motor vehicles on our roads was only one per mile against 25 in Britain, 21 in U.S.A., 13 in Malaya and 8 in Ceylon;
- (b) the investment on roads which is expected to reach a figure of Rs 700 crores in 1960-61 is not made full use of in spite of the fact that road transport has greater speed and flexibility than the railways. Taking the speed factor, it is stated by Mr. B. V. Vagh, Executive Vice-President, of the I.R.T. D.A. in an article in an issue of the "Capital" that a road truck covers about 150 miles per day as against 48 miles covered by a railway wagon
- (c) in addition, the road transport's potential of providing employment to our teeming poor population is far greater than of the railway. Only in January 1958, the President of the I.R.C. mentioned in his presidential address that against about 1 million hands employed in the railways, the number employed by road transport was about 3 million.

FACTORS ADVERSELY AFFECTING ROAD TRANSPORT CAPACITY

Much has been said during the last few years about the prolonged restrictive Government policy on the growth of road transport in this country and without restating the causes for such a policy the resulting handicaps may be summarised as follows :

Inadequate number of vehicles: The number of motor vehicles in this country is very limited and if road transport is to play its legitimate share in moving the increased traffic, the number of vehicles should be greatly increased. That the rate of increase is not adequate can be seen from the following figures :

The number of motor vehicles in the country in 1943-44 was 1,62,247 which increased to 4,18,067 in 1955, which works out to about 89 vehicles per million of population. This is hardly 1/10 of our neighbouring country like Ceylon, 1/100 of U.K. and 1/410 of U.S.A. The deficiency in these numbers, causing bottlenecks in transport for the moving of goods, has resulted in losses and damage to perishable foods. We have 1/2 a truck per mile of road as against 5 to 10 trucks per mile in other parts of the world; taking only surfaced roads in the country and mechanised transport for comparison with U.K., our roads carried 1½ trucks and 2 other vehicles (motor) per mile against 9 and 27.7 respectively in U.K.

For the traffic required by 1960-61 the Road Transport Committee of the Indian Roads Congress estimated two years ago that about 2.25 lakhs of motor trucks will be required, besides another 1.25 lakhs trucks being required to replace the over-age and worn out trucks in the country. For the reduced output now expected and without providing additional passenger capacity to relieve over-crowding in the railways, the minimum number may be taken at 1.8 lakhs with at least 60,000 vehicles for replacements, making in all 2.4 say 2½ lakhs.

The plant manufacturing capacity in the country for commercial vehicles is expected to be about 45,000 in 1960-61. Starting with 15,000 vehicles in 1956-57, the total number of trucks likely to be available works out to about 1½ lakhs by 1960-61. Against this figure the number of commercial vehicles produced in 1957 and 1958 was 16,248 and 14,557 respectively, i.e., the production of these 2 years was 30,805 as against 52,000 planned, i.e., 40 per cent less.

Thus the gap of about one lakh of trucks or more would have to be made good by raising the targets of our production of vehicles, failing which, by importing the required number of motor trucks. At a minimum of Rs 25,000 per truck about Rs 375 crores will be required to purchase the one and half lakhs of extra trucks. Government will have to come forward with loans and make them available to operators through finance corporations and banks as only a very small portion of funds is likely to come from private sources.

Inadequate size ranges of vehicles: The economics of road-haulage are considerably dependent on the maximum permissible weights of vehicles, as the larger the capacity of a vehicle to carry, the less will be the cost per ton. Though the gross laden weight of the medium sized vehicles has been upgraded to 18,000 lb in the Motor Vehicles Act amended in 1956, the absence of any reference to maximum axle loads prevent the use of articulated vehicles. With lesser axle loads of such vehicles it is possible to carry gross laden weights of a much larger magnitude without exceeding the axle load limits of the medium sized vehicle and without in any way increasing the damage to the road, which is the main reason for limiting the sizes of motor vehicles. It may be worthwhile to point out that while the public demand for increased axle loads in this country is for the Indian Roads Congress limit of 18,000 lb for single axle and 32,000 lb for twin axles, many

of the recently built heavy duty highways in United States are designed upto 32,000 lb axle load to permit the efficient use of road transportation. The weight permitted should be related to number of axles. The law should stipulate a safe axle load and not a safe vehicle load. The National Highways being under the control of the Central Government, at least on these roads a uniform limit of 12 tons on two axled vehicles should be prescribed.

Truck trailers: The absence of these vehicles is a disadvantage to our Road Transport. They not only distribute loads over a larger number of axles and lessen the wear and tear of roads for the same load but bring down the cost of transport and reduce the number of vehicles required. In U.K., the cost of running an articulated combination with a load capacity of 11 tons is roughly 30 per cent less than that of a 6 ton truck.

Limited zonal operation: The present system of regulation of motor truck transport by the Regional Transport Officers in narrow jurisdictional limits and the need to obtain countersignatures on permits required for operation in different regions even inside a State has limited the zone of operation of trucks to very uneconomical distance limits.

Uneconomic burden of taxation: The various States under whom the administration of the motor vehicles is left, have for long considered motor vehicles as an item of luxury and they have been levying taxes with a view to reimburse the general revenues without any particular regard for the economics of the operation of motor transport. This is reflected in the high rates of overall taxation, which work out in the case of petrol driven trucks to about 7.5 nP. per ton mile and 4.28 nP. per ton mile on a diesel truck. This excludes import duty on vehicle component. For an annual turnover of about 94,000 ton miles, this means over Rs 6,500 per annum per truck. A 5 ton petrol

truck operating 25,000 miles, pays an annual tax of Rs 7000. A diesel truck operating 30,000 miles in Bombay pays Rs 4,800 per year. In addition to this, municipalities levy wheel tax, octroi, etc. and several states levy passenger and goods tax. In some States the licence fee is heavy. A fee of Rs 200 is levied in Manipur for a public carrier permit and fees ranging from Rs 50 to Rs 3,500 are charged for permits on certain roads in Assam. Besides, Road Transport Industries lose annually crores of rupees through detention at octroi posts. The total octroi income is estimated at about Rs 11 crores and the cost of collecting amounts to 14 anns. in a rupee according to the Masani Report. No other country in the world taxes the motor vehicles so heavily.

Damage to roads due to bullock carts: We are all aware that there are about 10 million bullock carts in the country moving a load of about 125 million tons per year as against 115 million tons handled by railways in 1955/56 and 125 in 1956/57 respectively. These carts cause maximum damage to the roads but they do not contribute anything towards the construction or maintenance of roads.

Small number of viable units of operators: In the limitations placed by the narrow zonal operations of vehicles and the uneconomical burden of taxation, the incentive to operate large number of vehicles has been curbed to the maximum and the majority of truck operators are owners of single or few trucks, which is responsible for the poor conditions of their operation and maintenance. Nearly 90 per cent of our vehicles are owned by single unit operators.

Lack of inter-State reciprocity: Barring a few exceptions till, lately, the inter-State movement of motor trucks was very largely restricted in view of the duplicate taxation and other permit regulations.

Inadequate resources of operators: In view of the high cost of operating vehicles, due to various causes such as taxation, restrictive measures, etc., the resources of the operators for enlarging their fields of operation are very limited and very rarely the small operator has been able to profit enough by his operation to enlarge his field of business.

Poor and non-uniform structural standards of roads: The mileage of roads by the end of the Second Five-Year Plan is expected to reach 3,79,000 miles, of which 1,44,000 will be surfaced with water-bound macadam, black topped or concrete, thus leaving nearly 2/3 rds of 2,35,000 miles of unsurfaced roads. According to New Road Plan, the mileage of roads in India is proposed to be increased by 1980-81 to 6,57,000 of which 2,52,000 miles will be surfaced with water-bound macadam, black topped or concrete and the remaining 4,05,000 will be minor district and village roads. Since a large part of the movement of agricultural products are from the interior of the country, large portions of the journeys have to be made on unsurfaced roads adding to the high cost of operation. Besides, the limiting of the sizes of vehicles due to inadequate strengths of bridges, etc., also adds considerably to the cost of haulage.

Higher operative cost of vehicles: Poor condition of roads adds considerably to the operation cost of vehicles on account of wear and tear of vehicles and tyres and high fuel consumption not counting waste of time through stoppages and reduced vehicle speed and higher cost of insurance. Though roads in U.K. are of far better and of higher standards than those in India (in fact, no comparisons can be made) yet it was estimated in 1947 that if proper standards of roads was promised possible saving in vehicle operation cost would be over 60 million pounds i.e., Rs 800 million which is equivalent to about 10 per cent saving

in vehicle operation cost. Mr. N.D. Daftary, General Manager, State Road Transport Corporation proved that operation of vehicles on a good surface like that of cement concrete resulted in a saving of about 17 per cent. He has further stated that "State Transport cost of operation on average bad and katcha roads in 1953-54 amounted to Rs 5.80 crores. If all our vehicles were operating on modernised roads our saving in operating cost would have been Rs 98 lakhs approximately. If the vehicles in the entire State are considered, the amount will be approximately Rs 9 crores. In Bombay State, we have 21,988 miles of metalled (W.B.M.) and katcha roads and the cost of concreting the entire surface would come to approximately Rs 130 crores. Thus, if Government decides to float a loan for the amount the saving in operation cost will not only cover the interest but sinking fund charges also. Resulting benefits due to comfortable travel, etc., are not taken into consideration in computing this."

One of the past Presidents of the I.R.C. (Shri R.K. Batra) estimated that the loss of motor transport on account of the bad and inadequate roads in this country was of the order of Rs 38 crores per annum.

Limited roadside services and other facilities: Without organised road transport operators and adequate number of vehicles it has not been possible upto now to organise roadside facilities for efficient servicing of the vehicles, such as even for towing of vehicles, and it is not an uncommon sight to find a driver and a cleaner undertaking even a major repair job on the roadside by trial and error method.

Uncertain policies of nationalisation: Added to the above handicaps, the road transport in the private sector has also been working under the constant fear of nationalisation which has damped the enthusiasm of planning on a long term

basis for plying of road transport vehicles even along the profitable routes lest their investment should result in capital losses at the time of nationalisation.

Preferential treatment for railways: All these restrictions and handicaps in the development of roads and road transport could, to a very large extent, be attributed to the attitude of railways which unfortunately has not been at all encouraging or helpful.

Foreign exchange: In foreign exchange railways have been getting the lion's share. A sum of Rs 377 crores has been allotted to the railways in the Second Five-Year Plan against about Rs 90 crores for road transport and about Rs 42 crores for water transport.

Foreign aid: In regard to foreign aid also the railways' share is predominant and in the case of U. S. A. alone, according to published information, out of a total of about 78 million dollars (Rs 39 crores) allocated to our country under Transportation, the railway share is some 75 million (Rs 37.5 crores) while that of highway transportation is only 30,000 dollars (Rs 1.5 lakhs = 0.015 cr.)

More allotment of funds: During the First Plan, the railways were allotted Rs 140 crores by the Central Government out of central resources for increasing their haulage capacity by 23 million tons per year, i. e., Rs 6.1 crores per 1 m. ton. During the Second Plan an allotment of Rs 700 crores has been made for carrying out additional traffic of 53 million tons per year, i. e., Rs 13.21 crores per 1 m. ton; though the allotment is increased by about 5 times, the additional load carrying capacity was increased by $2\frac{1}{4}$ times only, at double the cost than in the First Plan.

In the Masani Report it is pointed out that in spite of more allotment of funds, it is calculated that in 1955/56 the Government lost about Rs 4.5 crores

because goods which could not be transported by railways remained unhandled as there were no trucks to do the job. The handling of the freight would have required 10,000 trucks and provided employment for about 60,000 persons. This goes on from year to year imposing loss on everybody.

Return on capital spent on transport: The railways give a return of about Rs 40 crores a year against an investment of about Rs 1,000 crores (1955-56). In Road Transport, there is an investment of about Rs 1,400 crores from public as well as private sectors and it pays to the exchequer a net return of 8 per cent on investment in roads and 10 to 12 per cent on investment in vehicles besides paying income and other taxes from which the railways are evidently exempted.

Railway representation on road transport matters: In spite of the fact that Road Transport has never asked for any representations on bodies dealing with Railway Transport, Railways have been granted representation on bodies dealing exclusively with Road Transport matters and a further attempt was made to put Railway representatives on State Transport Authorities in all States but it did not succeed as it was pointed out that such appointments were ultra vires of M. V. A.

Transport trend in other countries: Throughout the World, road transport is overtaking railways as it is the most advantageous form of transport in many ways. In Italy, between 1938 and 1954, the traffic on railways declined from 68.8 per cent to 31 per cent whereas that of road transport rose from 31 to 69 per cent. In Sweden, between 1925 and 1956 railway coaches increased by 16 per cent but motor buses increased six fold—Railway wagons declined from 59,000 to 56,000 while trucks increased from 10,000 to 11,200. In U. S. A., between 1929 and 1953 goods traffic on the railways increased 83 per cent but

that on the roads increased by 289 per cent. Railway passengers increased by 35 per cent but road passengers went up by 118 per cent. We cannot go against world technological trends and try to reverse the wheels of progress in our own country.

Further, it is more economical to build a road than a railway line. The cost of constructing a new national highway with bridges and culverts to a carriage-width 22 feet ranges from about Rs 1.57 to 1.98 lakhs per mile, while a single track rail-line costs about; Rs. 7 lakhs per mile.

Corrective steps in policies: But there is a silver lining to every dark cloud. The above listed handicaps of the road transport industry have of late received sympathetic consideration of the Central Government through the persistent efforts of the organisations like the Indian Roads Congress, the I.R.T.D.A., Institute of Road Transport etc., and the paramount importance of road transport has been accepted uniformly alike by the Government, the industry and the public. Views have been very vehemently expressed calling for road transport to fill in not only the gap in transport capacity for long distance haulage but also for establishing progressive measures and policies. The following measures may be noted with interest:

M.V.T.E. Committee and T. E. Commission: The following findings of the Motor Vehicles Taxation Enquiry Committee have received full endorsement from the Taxation Enquiry Commission:

- to adopt inland transport policy as enumerated by the International Chamber of Commerce
- to establish a rational basis of motor vehicles taxation at a reasonable level
- to establish a single point taxation for motor vehicles and
- to have reciprocity in move-

ment of the vehicles from one State to another.

Study Group: The main findings of the Study Group constituted under the Transport Ministry are for liberalising licensing policy, reducing taxes by 20 per cent, etc., leading to the Motor Vehicle Act Amendment Bill in 1956.

National Planning Commission: The pronouncement by the Planning Commission that the States should not undertake nationalisation of the goods transport till after the end of Third National Plan.

M. V. Amendment Act (1956): The passing of the Motor Vehicles Amendment Act (1956) which removed certain restrictions in road transport. The New Motor Vehicles Act has liberalised the provisions of the old Act of 1940 and there will be no distance limit on motor transport but the Railway Board does not accept interpretation of Motor vehicles act. There has also been some relaxation in respect of permissible loads. This along with some relief in taxation will reduce the operation cost to some extent.

State Bank Amendment Act: The passing of the State Bank Amendment Act (1957) which authorised the State Bank to advance money for the hire purchase of lorries.

T. C. & C. Conference: The calling of the Transport Commissioners and Controllers Conference in Mussorie (October 1958) which considered a number of measures to implement the provisions of the Motor Vehicles Act and matters pertaining to taxation, licensing, etc., such as (i) suspend Code for 5 years, (ii) a 100 per cent increase in goods transport by road (iii) issue a permit to any one who produces a vehicle.

I. R. T. Commission: The setting up of the Inter-State Transport Commission by the Central Ministry of Transport of the Government of India (March 1958).

for the administration of permits for inter-state movements of vehicles with over-ruling powers over the States.

T. C. on M. V. Industry : The findings of the Tarrif Commission on the Motor Vehicles Industry and their suggestions for the rationalisation of measures for improving the increased manufacture of indigenous motor vehicles and control of prices have received the approval of the Government.

Separate Ministry for Transport : A separate Ministry constituted by the Centre with a Minister of the Cabinet rank in charge to manage all transport other than railways.

T. D. C. and C. T. C. Committee : The formation recently by the Government of India Transport Development Council and Central Transport Co-ordination Committee. These bodies will advise the Central and State Governments in matters pertaining to development of highways, waterways, transport etc., to secure a co-ordinated uniform policy between different States.

Second Road Development Plan : The formation of a Second Road Development Plan for India (1961-80) for accelerating the road development in the country which aims at nearly doubling the mileage of roads during the above period and at the same time attempts at a modest provision for the construction of expressways to meet the special needs of motor transport. It is proposed to bring the mileage of metalled roads to nearly 40 per cent of the total mileage and nearly 25 per cent will be provided with modern surfaces with concrete or bitumen. Expenses are estimated at Rs 5200 crores as against Rs 700 crores for the Nagpur Plan.

R. & I. W. T. A. Committee : The appointment of a Road and Inland Water Transport Advisory Committee with representation to non-officials. The recommendations of this Committee are: (A) Appointment of an expert Committee to draw up the broad outlines of a national policy covering all modes

of transport, (b) Fixation of ceiling on motor vehicles taxation and consolidation of various motor vehicles taxes and elimination of indirect taxation, (c) Adoption of single point taxation by all States (d) Liberalisation of the licensing policy of State Governments and adoption of measures to increase the number of vehicles on the road (e) Adoption of measures for popularising truck-tractor trailer combinations (f) Freedom of movement of vehicles used by tourists (g) Printing of upto-date regional road maps of India (h) Placing the subjects of I. W. T. and Road Transport under one Minister for development of I. W. T. (i) Adoption of measures necessary for the prevention of (a) country boat disasters and (b) motor vehicle accidents.

The Economic Mission of the International Bank : The Economic Mission sent to India by the International Bank recommended development of road transport instead of railway, suggested the removal of restrictions on intra-state and inter-state road transport and reducing the taxation on vehicles. It emphasised that we must resist the temptation to develop Railways "at enormous cost and the large foreign exchange" they require.

Recommendations of the Recently appointed Masani Committee : Among the recommendations made by this Committee are a series of measures to overcome the inhibitory factors which have hitherto retarded road transport in India, the upgrading of weight limits on roads, encouragement of truck-trailer combinations, the grant of all-State validity to public carrier permits at the option of the applicants, liberal issue of permits for inter-State operation, elimination of procedural delays in issuing permits, appointment of full fledged Transport Ministries and full time Transport Authorities throughout the country, etc.

Action suggested for future : Though all the policy changes in the preceding

paras reflect trends towards improvement of road transport in years to come, certain vigorous action (a) to effectively bridge the divided authority between the Centre and the States in the matter of motor transport administration and (b) for tiding the economic crisis facing the industry would be necessary on an emergency basis, as if we are on War basis. Though the priorities for the implementation of these suggestions listed below, according to the author's opinion may be questioned, there is no likelihood of two opinions being expressed as to the urgent need for all these steps.

Financial facilities : Pending reduction of taxes quick and suitable financing arrangements should be created for operators to bring more vehicles on the road even under the limitations of permits, etc. The amendment to the State Bank of India Act to enable the advances of money to hire purchase organisation with a view to assist the road transport undertakings should be fully exploited by a liberal consideration from the Bank authorities.

Encouragement of inter-State movement : The States should co-operate in liberalising the inter-State movement by extension of the duration of permits and also permit R. T. Os to issue multiple region permits.

Stipulation of axle loads and articulated vehicles : Amend the gross laden vehicle weight limit of Motor Vehicles Act by stipulation of axle load limits and provide scope for articulated vehicles such as semi-trailers, tractor-trailers and truck - trailer combinations within the axle load limits.

Liberalisation of axle loads on highways : Liberalise axle load limits on highways upto the capacity of the major sections of the highways and resort to strengthening of weak bridges and culverts on an emergency footing to develop economical long hauls. Also, where this latter possibility is limited

due to delay in the construction of bridges, etc., the road transport should be aided by piggy back operation of trucks on railways.

Increasing of vehicle manufacture : Raise the target of vehicle manufacture in the country and liberalise the import policy to permit import of more vehicles or their components from abroad. In this context, it would be desirable to examine the utilisation of the U. S. Export Import Bank loan of 150 million dollars amongst other things for industrial projects dealing with the automobile industry.

Lowering of taxation and establishment of single point taxation : Pursue active negotiation through the States at the highest levels to obtain an uniformly lower level of taxation by the Centre in lieu of licensing or registration fees, customs and excise sales tax in motor fuel, oils, spare parts, tyres etc. and the amount collected from States taxes be redistributed to States on the basis of vehicles registered and operated in each State for expenditure on Construction and maintenance of roads. In fact the President of I. R. C. had suggested in January 1959 that in addition to the above, the States would be required to match the share thus received by equal allocation from other general resources.

Development of Co-operatives : Development of co-operatives of transport operators to create owner interest in the operation.

Extra funds from fuel to be credited to C. R. F. : The price structure of motor fuel is under investigation by the Central Government and it is estimated that an extra amount of Rs 10 crores per year is likely to accrue to the exchequer and it is suggested that at least half the amount of saving be credited to the Central Road Fund.

Taxation of bullock carts : A small tax, as suggested by the President of the

I. R. C. in January 1959 on bullock carts, say, Rs 12 per cart per annum may be levied. This will, according to him, bring in something like Rs 10 crores to the national exchequer and might be devoted exclusively to the construction and maintenance of rural roads to the great benefit of draught animals as well as the monetary gain to the owner.

Provide missing bridges and culverts and strengthening of existing ones: We should give top priority to the provision of missing bridges and culverts and to make them fit to carry heavy loads on all traffic bearing roads. Unless this is done the operation of truck trailer combinations and an increase in the permissible laden weights of vehicles as per Government's recent circular will prove ineffective.

Correct disparities in road and road transport development: The Government to take active measures to correct the disparities already mentioned so that road transport may have a fair chance to develop adequately i.e. (a) allot more share in foreign exchange (b) arrange to get or allocate more

foreign aid for road construction by modern methods (c) increase the allotment of funds in the remaining period of II Plan and in III Plan to accelerate the tempo of road construction and (d) no representation should be given to railways on bodies exclusively dealing with road transport methods.

Improvement in physical and geometrical standards of existing roads: With a view to fully utilise the existing road system, the roads should be modernised by upgrading of road structure and of surface and improving its geometrics whenever possible.

Separate departments of highways: A large road development plan can be executed smoothly only if it is undertaken by an efficient and good organisation. Such an organisation can give individual attention to the task in hand if not burdened by other types of public works. Only two States in the whole of India can boast of separate department of highways, viz., Madras and Andhra. It is high time other States follow their example.

We are mortal persons responding to the advance of perhaps immortal ideas. We are not ourselves only; we are also part of human experience and thought.

—H. G. WELLS

OPERATING COSTS OF NATIONALISED ROAD TRANSPORT UNDERTAKINGS IN INDIA

By

Dr. M. K. GANGULI and K. C. SAXENA†

OUT of 20 States including centrally administered areas in India, 17 States/Union Territory have nationalised road motor transport in varying proportions and operate passenger services for the most part. Some of these undertakings run under the provisions of the Road Transport Corporation Act, 1950, others function under statutory authorities constituted for the purpose. There is yet another class of these undertakings which supply services under departmental control. The Tripura and Andaman and Nicobar Islands Administrations do not have such services and Aminidive, Laccadive and Minicoy Islands have no motor vehicles.

All State Road Transport Undertakings taken together operate a fleet of over 12,000 buses against about a fleet of about 45,000 for the whole of the country. The fleets belonging to the Bombay State Road Transport Corporation, U.P. Roadways, Mysore Government Transport and Himachal Government Transport include goods vehicles as well. But the number of such vehicles is very low as compared to the fleet of goods vehicles for the whole of the country. As regards the passenger transport, the undertakings operate services in hill and plain regions (both city and rural services) covering various geographical parts of the country and their experience can be regarded as fairly representative of the whole 'population*' although it does not bring

into its orbit the observations of Private Operators.

COST OF OPERATION DATA

All the State Transport Undertakings are required to furnish cost of operation statistics on quarterly basis to the Ministry of Transport and Communications in the prescribed proforma (Annexure 1). For the purpose of analysis, it will be noticed that the cost of operation data has been broadly classified as under:

1. Cost of personnel
2. Cost of material
3. Depreciation
4. Overheads
5. Interest on capital

Several factors influence the above items of cost. Operating costs in hilly areas and in plains are apt to be at variance. Traffic requirements in towns also play an important role in influencing the cost of operation of city services. Except under very controlled circumstances the effect of all these factors in isolation is not possible to study. The following paragraphs discuss briefly the various aspects of the cost of passenger transport as revealed from the statistics furnished by the different undertakings for the quarter ended 31st March, 1958.

Table I will show that the total cost per vehicle mile varies between 61.0 nP and 143.2 nP for the various

† Ministry of Transport and Communications, Department of Transport, Roads Wing, New Delhi.

* 'Population' refers to the general body of individual units out of which the sample is taken.

TABLE I
Operating Cost of Passenger Transport

Sl. No.	Name of the undertaking	Cost per vehicle mile in nP	Average seating capacity	Cost per seat mile in nP
1.	Andhra Pradesh State Road Transport Corpn.	108.5	36	3.0
2.	Bihar Rajya Transport	116.1	40	2.9
3.	Bombay State Road Transport Corpn.	134.5	40	3.4
4.	B. E. S. T.	143.2	60	2.4
5.	Kerala State Transport	84.4	35	2.4
6.	Kutch State Road Transport Corpn.	125.4	32	3.9
7.	Madras State Transport	111.1	56	2.0
8.	Marathwada State Road Transport	90.4	38	2.4
9.	Mysore Govt. Road Transport	108.0	38	2.4
10.	Orissa State Transport Service	105.3	35	3.0
11.	P.E.P.S.U. Road Transport Corpn.	61.0	44	1.4
12.	Provincial Transport Service, Nagpur	81.0	38	2.1
13.	Punjab Govt. Transport Services	69.1	45	1.5
14.	Rajasthan State Road Transport	116.0	N.A.	N.A.
15.	Saurashtra State Road Transport Corporation	119.6	42	2.8
16.	U.P. Roadways	105.6	44	2.4
17.	West Bengal Transport	118.8	42	2.8
18.	Delhi Transport Undertaking	106.0	55	1.9
19.	Himachal Govt. Transport	127.0	25	5.1
20.	Assam State Transport	120.0	25	4.8

N. B. Cost statistics for C.P.T.S. Jabbalpur, Madhya Bharat Roadways and Undertakings of J. & K. and Manipur are not available.

undertakings. The figures of cost of operation per vehicle mile have been derived by dividing total cost incurred by effective mileage performed in each case. It is known that apart from other considerations, in an organisation like B.E.S.T. Undertaking, where the cost per vehicle mile is highest, the permitted average seating capacity is of the order of 60. This will obviously influence the cost structure and, therefore, to have an effective comparison, the cost of transport has been expressed in terms of seat mile in col. (5) of Table 1. The relatively low cost of road transport for Punjab Govt. Transport or Pepsu Road Transport comes out prominently in both the cases but the

high cost of hill motor transport comes into better relief only when calculated in terms of seat mile.

The State Road Transport Undertakings shown in Table I can be broadly classified into the following categories according to the services they operate:

- Undertakings operating hill services
- Undertakings operating city services in plain areas
- Undertakings operating rural services in plain areas
- Undertakings operating composite services in city as well as rural areas.

Assam State Transport and Himachal Govt. Transport fall under category (i). Under (ii) can be bracketed the services operated in the cities of Delhi, Bombay, Calcutta and Madras. Category (iii) will cover the services operated by the Corporations in Bombay, Saurashtra and Kutch regions of the Bombay State, the Provincial Transport Service, Nagpur, services operated in Marathwada, Madhya Pradesh, Bihar,

Orissa, Punjab and Rajasthan. Composite services under (iv) are operated in Andhra Pradesh, Uttar Pradesh, Kerala and Mysore. For the purpose of the above groupings, small overlapping to the extent of 10 to 15 per cent has not been taken into account.

The variations in the operating cost for different types of services are given below :—

TABLE II

Type of Service	Average cost per vehicle mile in nP	Average cost per seat mile in nP
Hill Services	123.5	4.9
City „	119.9	2.3
Rural „	100.2	2.6
Composite „	101.8	2.7

TABLE III
Itemised Share of Operating Cost

	Hill services		City services		Rural services		Composite services	
	Cost in nP	per cent	Cost in nP	per cent	Cost in nP	per cent	Cost in nP	per cent
A. Vehicle mile basis								
Cost of personnel	36.0	29	46.5	39	25.2	25	32.5	31
Cost of material	47.5	39	35.1	29	35.0	35	36.0	36
Depreciation	19.0	15	19.5	16	17.7	18	13.8	14
Overheads	14.5	12	14.5	12	17.5	17	14.2	14
Interest on capital	6.5	5	4.3	4	4.8	5	5.0	5
	123.5	100	119.9	100	100.2	100	101.5	100
B. Seat mile basis								
Cost of personnel	1.44	29	0.89	39	0.65	25	0.85	31
Cost of material	1.90	39	0.67	29	0.90	35	0.95	36
Depreciation	0.76	15	0.37	16	0.45	18	0.36	14
Overheads	0.58	12	0.28	12	0.45	17	0.37	14
Interest on capital	0.26	5	0.08	4	0.12	5	0.13	5
	4.94	100	2.29	100	2.57	100	2.66	100

It will be observed from the above table that there are significant variations in the cost of operation of the various services. The cost is highest in the hilly regions. In terms of the vehicle mile, the average cost of city services is also quite high. But seat mile cost in city services is lowest. This is mainly because city services can profitably employ passenger vehicles with higher payload and enjoy an advantage over all other services in the matter of road surfaces as well. As regards the cost of transport in composite services and rural services, there appears to be hardly any difference. The composite services include operations in hilly regions and city and rural services in plain regions. Thus there are interplay of various forces. Some times composite services include goods and scheduled taxi services as well. At present it is hardly possible for these undertakings to run scheduled goods and taxi services because these services are not so remunerative. They tend to inflate total cost of operation.

In order to have a clearer picture it would be necessary to study the variations with reference to the various items of cost.

Table III shows that the cost of personnel is highest in case of city services. This is understandable. City services operate normally for 16 hours a day as compared to about 8 hours per day for other services. On account of longer hours of duty the operational staff has to work on split duty basis, as it is difficult to do steering duty continually for 6 to 8 hours. City buses require more staff on this account. They also require better paid staff with considerable experience as it is comparatively difficult to handle bigger vehicles on congested routes, with more frequent faults. The cost of personnel for the rural services comes lowest. The composite services are hardly of a standard type and the cost in their case greatly depends upon the components of the composition, namely allocation of vehicles for the various services.

Cost of material and cost of personnel together account for nearly 70 per cent of the total operating cost. The percentage share of cost of material is higher than the cost of personnel for all services excepting city services. This is because in case of city services the consumption of spare parts and other material is relatively less due to better

TABLE IV-A
Share of cost of material — Vehicle-mile basis

Items	Hill services		City services		Rural services		Composite services	
	in nP	Per cent	in nP	Per cent	in nP	Per cent	in nP	Per cent
Fuel	30.90	65	17.40	49	15.51	44	15.69	44
Lubricants	2.37	5	2.30	7	1.61	5	1.84	5
Tyres & tubes	14.23	30	5.97	17	7.31	21	6.26	17
Batteries			0.63	2	2.42	7	0.98	3
Spare parts			5.11	14	7.79	22	10.91	30
Tickets & ticket equipment			3.73	11	0.36	1	0.32	1
Total	47.50	100	35.14	100	35.00	100	36.00	100

TABLE IV-B
Share of cost of material — Seat-mile basis

Items	Hill services		City services		Rural services		Composite services	
	in nP	Per cent	in nP	Per cent	in nP	Per cent	in nP	Per cent
Fuel	1.24	65	0.33	49	0.40	44	0.41	44
Lubricants	0.09	5	0.04	7	0.04	5	0.05	5
Tyres & tubes	0.57	30	0.12	17	0.19	21	0.16	17
Batteries			0.01	2	0.06	7	0.03	3
Spare parts			0.10	14	0.20	22	0.29	30
Tickets & ticket equipment			0.07	11	0.01	1	0.01	1
Total	1.90	100	0.67	100	0.90	100	0.95	100

road facilities. In case of the vehicles plying in hilly regions, the cost of material both in terms of vehicle mile and seat mile comes out highest as the consumption of fuel, lubricants, tyres, tubes and spare parts etc., in hilly regions hardly bears a comparison with the services in plains. Tables IV-A, IV-B give a further break-up of the cost of material bringing out in detail the relative share of various items in different services.

The comparisons made above bring out clearly that though the overall cost of material in city services is lowest, their expenditure (percentage share) on fuel and lubricants stands very high. Frequent stoppages in congested cities explain to a great extent this differential pattern. The above figures also show the dominant share of fuel expenditure in all the services and the close competition between tyres and tubes and spare parts for securing the second position. The additional expenditure incurred by city buses on fuel is to a great extent offset by the saving on spare parts as already stressed. The hill services having large proportion of petrol buses incur highest amount of expenditure on fuel.

For a majority of the undertakings the cumulative effect of the depreciation costs and interest charges varies from 20 to 25 per cent of the total per vehicle operating cost (Table III). Manufacturers generally stipulate both the age of the vehicle and the mileage each vehicle should give. But experience has shown that each unit behaves in a different way and the actual amortisation periods are different under different conditions. The Undertakings, therefore, work out depreciation costs according to their own formulae. In general, however, it appears that the overall share of depreciation cost to the extent of about 15 per cent furnished by the different undertakings may be considered to be adequate.

Overhead costs would be influenced by rents, rates and taxes prevailing in different States. Further, welfare and superannuation benefits included in the overhead cost are dependent upon the age of the undertaking and the rates of salaries, etc., prevalent therein. These are likely to be higher in old undertakings and especially those operating city services. Since undertakings of various standings have been grouped together in Table III

the fluctuations have been, to a large extent, minimised and the range of overhead cost of the different types of services comes to 12-17 per cent.

Hitherto the study of cost differentials is confined to the groups operating on the various classes of services. A detailed table showing the cost of operation for each individual undertaking is given in Appendix II. The following paragraphs discuss briefly some special features observed in case of individual undertakings.

The higher cost of personnel for city services in Bombay and Calcutta is mainly on account of heavier expenditure on traffic staff. Otherwise the expenditure incurred on personnel engaged in administrative or maintenance and repairs in city services is comparable with those operating in rural areas. The low cost on personnel in case of Rajasthan is on account of the fact that this State operates only 10 vehicles and the number of vehicles in scheduled services put by them would be about 6. Operating such a small fleet they hardly require any top level managerial personnel. The figure of 16.0 nP quoted for PEPSU Corporation is a low figure and is indicative of the operational efficiency of the Corporation.

Coming to the cost of material, apart from the type of services, the composition of the fleet is an important factor which influences the consumption of fuel. Some of the State Transport Undertakings possess vehicles operating on H.S.D. oil. Others operate on petrol. Another class owns mixed fleet (Appendix III). Diesel oil gives better mileage at lower costs. The undertakings, viz., B.E.S.T., Delhi Transport Undertaking, Directorate of Transportation, West Bengal and Madras State Transport are having mostly diesel vehicles and that is why in spite of their operating city services on congested routes the fuel consumption cost has been kept at not too high

a figure. The high cost of spare parts for Rajasthan State Road Transport appears to be due to the age of their fleet operating rural services.

The provision for depreciation made by undertakings like Provincial Transport Service, Nagpur, or the Kutch State Road Transport Corporation appears to be inadequate and this aspect requires a further study in detail. Similarly, allowance has also to be made for the fact that some undertakings like P.T.S., Nagpur, or Rajasthan State Road Transport are not at present making any provision for interest charges on capital at charge.

The high rates of taxation on motor vehicles in Madras State are reflected conspicuously under over-head charges of the Madras State Road Transport. Over all it appears that the direct taxation constitutes only about 5 per cent of the total cost of nationalised transport undertakings. In the form of cost of materials, however, these undertakings are paying about another 15 per cent of the total cost as indirect taxes. The data further suggest that if effective control is exercised general contingencies and miscellaneous expenditure can perhaps be reduced to some extent in certain cases.

PASSENGER MILE COST

The total number of passenger miles performed by the different undertakings is not generally available. It would, therefore, be necessary to arrive at some reasonable estimates of the load factor to calculate the cost per passenger mile. According to the experience of undertakings like B.S.R.T.C. & U.P. Roadways, the load factor varies between 60 and 80 per cent. In Appendix II cost per passenger mile has been calculated on the basis of 70 per cent load factor. It will be seen that the cost per passenger mile in plains varies between 2.0 nP. and 5.0 nP. while in case of hilly regions it comes to about 7 nP. The ave-

rage rate charged (for III class) per passenger per mile by railways in 1957-58 for B.G. is 4.87 pies (about 2.4 nP.) and for M.G. it is 5.15 pies (about 2.6 nP.)

It is, therefore, clear that the cost per passenger mile of well organised road transport does not compare unfavourably with that of railways.

Appendix I

COST STATISTICS FOR THE QUARTER ENDED.....

Name of undertaking.....State.....

(Note: Please read the Foot Note carefully before filling)

FACTOR	Current year amount	
	Actual in Rupees.	Per vehicle mile.
A. GROSS REVENUE		
(a) Traffic		
(b) Others		
(c) Total		
B. COST OF PERSONNEL		
(i) Administrative		
(ii) Traffic		
(iii) Maintenance & repairs		
(iv) Total cost on personnel		
C. COST OF MATERIAL (Operational)		
(i) Fuel		
(ii) Lubricants		
(iii) Tyres & Tubes		
(iv) Batteries		
(v) Stores-spare parts, small tools, consumables		
(vi) Ticket & ticket equipment		
(vii) Total-cost of Material		
D. DEPRECIATION		
(i) Vehicles		
(ii) Other Assets		
(iii) Total		

E. OVERHEAD COST (Excluding personnel)

- (i) Rents, Rates, Taxes & Insurance
- (ii) Cost on running of departmental vehicles
- (iii) Welfare & superannuation benefits
- (iv) General contingencies
- (v) Miscellaneous
- (vi) Total overhead cost (excluding personnel)

F. INTEREST ON CAPITAL**G. TOTAL OPERATING COST (B TO F)****H. NET OPERATING PROFIT****I. TOTAL DEFECTIVE MILEAGE OPERATED**

- Note: (1) Should include revenue earned even if not received and cost incurred even if not paid.
- (2) Rate of depreciation adopted in item D for different assets shall be indicated.
- (3) This form should be sent to the Ministry of Transport, Government of India, New Delhi, within two months following the quarter to which it relates.

takings**Appendix II**

Items	Andhra Pradesh State Road Trans- port Corporation	Saurashtra State Road Transport Corporation	U.P. Roadways	West Bengal Transport Directorate	Delhi Transport Undertaking	Himachal Pradesh Transport	Assam State Transport
A. Cost of Personnel							
(a) Administrative ...	8.38	2.56	3.30	4.17	6.00	6.00	36.00
(b) Traffic ...	20.15	14.63	18.30	35.33	24.00	22.00	
(c) Maintenance and repairs	14.50	4.30	9.90	8.69	7.00	8.00	
Total (Item A) ...	43.03	21.49	31.50	48.19	37.00	36.00	36.00
B. Cost of materials							
(a) Fuel ...	10.93	14.43	22.30	22.15	18.00	34.85	42.00
(b) Lubricants ...	1.80	0.95	1.90	2.49		2.67	
(c) Tyres and Tubes ...	6.41	11.55	4.90	4.58	9.00	16.05	
(d) Batteries ...	0.41	0.30	0.40	0.64			
(e) Spare parts ...	13.30	17.50	15.60	2.56	6.00		
(f) Tickets ...	0.44	—	0.70	8.17	1.00		
Total (Item B) ...	33.29	44.73	45.80	40.59	34.00	53.57	42.00
C. Depreciation							
(a) On vehicles ...	13.21	36.20	12.90	13.85	19.00	14.00	23.00
(b) Other assets ...		0.77	0.50		1.00	1.00	
Total (Item C) ...	13.21	36.97	13.40	13.85	20.00	15.00	23.00
D. Overheads							
(a) Rent, rates & taxes	4.09	3.56	6.00	9.59	5.00	4.00	14.00
(b) Cost at running departmental vehicles	0.12	—	—		—	0.65	
(c) Welfare and Superannuation	7.42	5.24	0.10		1.00	—	
(d) General contingencies	0.61	2.45	3.00	4.00	6.80		
(e) Miscellaneous ...	2.08	0.54	2.10			4.04	
Total (Item D) ...	14.32	11.79	11.20	9.59	10.00	15.53	14.00
E. Interest on Capital ...	4.62	4.60	3.70	6.58	5.00	6.90	5.00
E Total operating cost	108.47	119.59	103.60	118.80	106.00	127.00	120.00
Average pay load permitted carrying capacity (In Nos.)	36 ^A	42	44	42	55	25	25
Net carrying capacity assuming load factor as 70 per cent	25 ^A	29	31	29	39	18	81
Cost per passenger mile taking load factor as 70 per cent (In nP.)	4.3 ^A	4.1	3.4	4.1	2.7	7.05	6.7

* Figures of Central v
 @ Combined passenger
 N. A. Not available.



INDRAKANT PATEL

ROAD USER BEHAVIOUR AND METHODS FOR IMPROVING THE SAME

Mr. Indrakant Patel is a Member of the Managing Committees of W.I.A.A., Indo-German Cultural Society and Social Centre and a Member of the Senate of the Sardar Vallabhbhai Vidyapeeth University at Anand. He was till recently a Member of the Government of Bombay's Traffic Advisory Committee.

THE last world war has resulted in increase in speed and volume of transportation between continents, countries, cities and towns and indeed within cities themselves and the speed and volume of traffic have multiplied themselves almost out of proportion with other operations. The increase in speed and volume of traffic has created new problems which at once engage the attention of all concerned.

I have travelled far and wide before and after the war. I have seen traffic problems in the major cities of Europe and America, of Japan and of India. But traffic problems exist everywhere; only they are different in nature and must therefore be solved by different methods.

Before the war, I used to be greatly fascinated by the smooth flowing traffic in most of the major cities of the world. However, in recent years I have watched with pain traffic everywhere emerge from a small but orderly position to a very voluminous and disorderly traffic which demands major consideration today. There is a terrific congestion in the streets which causes loss of millions of valuable manhours everywhere. Hundreds of people are being killed on our streets. Yet why do we seem so unconcerned about it? I am indeed glad

that ECAFE have at last taken up the challenge. I hope their efforts will change the situation in due course.

In general, traffic operations involve movement of people and of vehicles. Traffic congestion occurs when the movement of people or of vehicles is unduly retarded or stopped. Accidents happen when a road user fails to follow the rules of the road. Accidents increase as congestion increases. Congestion increases as obstacles to traffic increase. Only when every user of the road concentrates on clearing his share of traffic congestion, will traffic flow smoothly and with speed and safety.

There are two factors that create traffic problems: the road and the people. Road conditions greatly affect the traffic. A wide road with a good surface with proper grading, minimum number of curves, gentle curves, and proper illumination has the least amount of traffic congestion and accidents. A narrow road with bad surface, improper grading, several sharp curves, bad illumination, obstacles, etc., naturally has more traffic problems. The road should have capacity to handle the volume and speed of traffic problems.

The second factor is the people or the road users. No matter how good a

road is, unless every user of the road follows the traffic rules, traffic must come to grief. The speed and volume of traffic will decide the volume of trouble. On a road on which several lanes of traffic move at a high speed, a single indisciplined road user can cause the death and destruction of several men and vehicles.

Improvement of traffic in a city can be brought about by redevelopment of the city, which would include widening of roads, resurfacing roads, installation of automatic traffic signals, construction of two-level grade separated road inter-sections, turn-pikes, expressways, freight-ways, subways, tunnels, bridges, elevated double decker roads and an improved system of road illumination. Improvement can also be brought about quickly and with less expense by improving road user behaviour. I would any-time give greater importance to this aspect of the problem because it introduces the human element and a very desirable aspect of human life.

The first requisite for any intelligent action to improve road user behaviour, I believe, is a study of his behaviour on the road and the causes that lead to his behaviour, for, some of these causes can possibly be removed and solutions found for the other causes.

Population everywhere has increased and so has the pressure on the roads, particularly in industrial towns. There are far too many people on the road. And far too many vehicles, fast vehicles. The tempo of traffic has risen. Time has suddenly become more valuable, speed has gained importance and the value of human safety has dropped.

We find ourselves in an entirely unhappy situation. Road-sense is conspicuous by its absence, there is no courtesy on the road; traffic congestion and traffic jams are taken for granted. Accidents are no longer accidents. They don't even make news. Traffic deaths do not attract sustained sympathy.

Why this change? Why this unhappy state of affairs?

Why is there so much traffic congestion, so many accidents?

Why are so many people being killed on our streets and valuable national wealth being destroyed by road accidents?

The answer is obvious. We have failed to develop ourselves with the development in our traffic. Today's tempo of traffic demands more and better roads, better city planning, better lighting, better traffic control. Above all, we need a better understanding of today's traffic needs.

Why does the road user behave as he does? Why? Why does the pedestrian risk his life by walking on the road instead of on the footpath? Why does the motorist overtake on the wrong side? Why does the truck driver drive in the middle of the road and obstruct other traffic? The hand-cartman insists on pushing his cart with one wheel on the tram track. Why?

I think I know why: If you don't well; analyse the cause in each case. You will find the answer without much difficulty. The behaviour of the road user, call it misbehaviour if you like, is due to one or the other of the following reasons:

1. Compelling factors
2. Ignorance
3. Lack of traffic sense
4. Intoxication, anger, nervous tension, etc.
5. Plain carelessness
6. Lack of preventive measures
7. Lack of traffic education.

Let us consider these factors, briefly, and one by one. Let us consider some compelling factors. In perhaps five cases out of ten, what behaviour is attributed to a road user is not really

his. A pedestrian may walk on the road because the municipality has sold his foot-path to vendors or the footpath is too narrow and most often too dirty. The motorist overtakes on the wrong side because the truck driver ahead drives in the middle of the road. And the truck driver drives in the middle of the road because the edge of the road is too full of pits and pot-holes and pedestrians. That is also why you find the push cart fellow on the tram tracks. The tram tracks have no pot-holes, they are smooth, they are level, they are away from intruding pedestrians. You so often find a car suddenly swerve, hit against a lamp post or another car or knock down a pedestrian. Why does the motorist behave like that? Well, ask the road repair man. He had not placed the caution signal right ahead of the repair job. It is his behaviour that should be questioned, not the road user's! If the street lighting is not good enough, a motorist must use bright head lamps and dazzle the on-coming traffic or take the risk of killing a jay-walker. Jay-walkers are never in short supply and they are never wrong. These are just a few examples of factors which compel the road user to behave as he does. I can cite a hundred more. Let us improve the road user behaviour by removing these compelling factors.

Ignorance is another cause. A lot of road users misbehave on the road because they are ignorant. Ignorant about what they should or should not be ignorant of the consequences. In fact, a number of cases which appear to be due to carelessness are really due to ignorance about the consequences. A person who crosses a road without watching traffic often does it because he does not know that his safety is his own responsibility. And he doesn't know that an in-coming car may have faulty brakes, inexperienced driver or other reasons due to which it cannot stop in time. And he doesn't know that even with the most efficient brakes, a car needs

a certain distance before it can come to a dead stop. The car's head lamp may dazzle him but perhaps they are not bright enough to make the road crosser in his dark clothes visible to the driver from a distance. There are many other ways in which the road user behaviour is not right because he is ignorant of what he should or should not do. I do not think I should burden you with more examples.

Then we come to road user behaviour due to lack of traffic sense. This is quite distinct from misbehaviour due to ignorance. The fellow who drives in the middle of the road and obstructs other traffic does it purely out of lack of traffic sense. So does the pedestrian who crosses against red light. You often find cars zigzagging from one traffic lane to another trying to gain advantage over the other cars ahead, driving with dazzling lights, swerving or turning or stopping suddenly without giving a proper signal, and doing hundred other things which they know are wrong and are likely to cause obstruction to traffic. They do it because they have no traffic sense. You may say they have no civic sense.

And there are people who you think are neither ignorant nor devoid of traffic or civic sense, yet their behaviour on the road is highly irregular. These are perhaps people who are worried, unhappy or angry, under the influence of intoxicating drinks or in nervous tension. They are usually absent-minded and out of balance on the road. The high pressure businessman is in a terrible nervous tension due to a complicated deal he is negotiating. He is in a hurry and in no mood to wait. He must get ahead, right or wrong, red or green. He subconsciously thinks how he behaves on the road is nobody's business. These are among the most dangerous road users. And they are incurable. You have to be careful with them.

Then of course there is a distinguished

class of road users, who may or may not have paid the road tax but they are mighty sure that not only the road but all the people on the road belong to them. They can deal with them just as casually or carelessly as a millionaire's daughter deals with her father's coppers. Out of modesty, they allow themselves to be called just plain careless people. You can expect any kind of behaviour from them, they treat everybody as equal and they will not spare anybody. They will behave just as they like on the road. They are not licensed to do so but they ultimately pay for it, so who are you to question their behaviour on the road?

But I find that a whole lot of bad road user behaviour is due to lack of adequate preventive measure to stop or curb it. Overtaking on the wrong side is an offence, but how many offenders are really brought to book? When such an offender is punished, does anybody care to also punish the other fellow who forced him to overtake him on the wrong side? More severe punishment should be prescribed for obstructing traffic. Municipal authorities and others who cause unauthorised road obstructions should be severely dealt with. Traffic control authorities should be made answerable for not taking action against jay-walkers and other offenders. Only when such steps are taken will the bad road user behaviour improve. After all, traffic is a matter of habit. If good habits are encouraged, traffic will improve. If bad habits are not checked traffic conditions must steadily deteriorate and traffic must come to grief.

However, I am convinced that the most outstanding need of the hour and for all time is better and wider traffic education which alone can contribute more than all other factors combined towards improvement in road user behaviour and ultimately save many valuable lives and national wealth. By traffic education I do not mean merely teaching children how to cross the road

or teaching driving signals to drivers. This education has to be on a much wider basis and must include educating city planners, municipalities, road-builders, traffic control authorities, all types of road users, school children, school teachers, housewives, busy bodies, in fact all men, women and children, young and old, sane and insane, literate and illiterate, even dogs and cats and pets and people in all walks of life, whether in school or college, in business, or service, in commerce or industry, builders, guardians and users of the road, in short every-one who has anything to do with any road at all. For, each of them, if not properly educated in traffic needs, can be a cause of disturbance or irregularity in traffic or even cause a fatal accident.

Traffic education should be both intensive and extensive. Every thinking person has to play an important role in this. This education can be effectively imparted by our schools and colleges, churches and social welfare institutions, civic organisations, automobile, taxi and truck owner and operator Associations, by writers and editors, through films and documentaries, by newspaper advertisements, cartoons, stories, and articles and through many other mediums. Films and radio can play a very effective role in this, particularly in India, where these two mediums reach more people than any other medium. Our social workers and public leaders can also contribute greatly to this educational drive.

In one town in Germany, I saw a children's garden where miniature streets are constructed and children are allowed to operate miniature cars and learn traffic rules and acquire traffic sense.

I can spend hours telling you how this education can be spread but I think it would be wiser to leave that to your imagination,

From what I have said here, it is quite obvious that if we want to improve road user behaviour we must find remedies that will remove the causes of this behaviour. Among remedies that come to my mind are construction of better roads, better road maintenance, improved street illumination, provision of wide and clean footpaths free from vendors, beggars, and road repair materials, safety islands for pedestrians, better trained and more co-operative traffic constables. These remedies will minimise the compelling factors of bad road user behaviour. To remove ignorance and lack of traffic sense, I have already suggested an extensive as well as intensive traffic educational drive. Cases of bad behaviour due to intoxication can be reduced by Prohibition and severe punishment for drunkenness but much

more by education and propaganda.

Better business conditions and general rise in the standard of living will gradually reduce nervous tensions, anger and unhappiness which cause bad road user behaviour. And a more alert and vigilant traffic control system will rapidly eliminate bad road user behaviour due to carelessness. More severe punishment should be prescribed for careless behaviour and for repeated offences. Preventive measures of this type will show immediate results and road user behaviour will greatly improve.

These in general are the remedies I whole-heartedly recommend. There may be others too. We must study road user behaviour in greater detail and search for remedies that will produce the required results.

ALWAYS ON THE ROAD

A healthy man once went to a doctor ; the latter asked him the secret of his good health.

The man replied : " Doctor, when I married I entered into a pact with my wife that when I became angry she was to laugh and when she became angry, I had to leave the house. So, doctor, I am always on the road and that is the reason of my good health."



K. K. NAMBIAR,
Chief Engineer, Concrete Association
of India, Bombay

RESURFACING OF CONCRETE PAVEMENTS

INTRODUCTION

ALTHOUGH concrete construction has been in vogue in this country for over 5 decades, in this special field of resurfacing concrete pavements, our experience is very limited. Hence, every engineer who is confronted with this problem, has to depend on experience obtained abroad, and, in the absence of ready availability of authentic literature on the subject, several doubts remain unanswered. In this article an endeavour has been made to discuss the theoretical and practical aspects of this problem and the techniques evolved by experience in other countries.

Amongst all the countries, U.S.A. rates first in the experience record of widespread use of resurfacings. In 1957, in a survey conducted of 300 projects spread over 28 States in U.S.A., covering a period of no less than 43 years, it was found that the ratings were 40 per cent excellent, 40 per cent good, 18 per cent fair and 2 per cent poor. The design of resurfacing in that country has been based on the experience of these projects. Of late, this experience has also been supplemented by extensive laboratory tests which have further confirmed that the assumptions made so far are quite sound and suitable for a general application.

TYPES OF RESURFACINGS

In general, the problems of resurfacing can be broadly classified into two categories:

(1) In this category, the resurfacing is called for to strengthen the existing pavement, which may or may not suffer from surface deterioration and may or may not show any structural distress such as cracks, settlement, etc. In this, the remedial measures would have to account for the degree of strengthening required allowing for conditions of existing pavement. Consideration would also be necessary in this case for the alternative possibilities of the additional layer to act monolithically or otherwise, and provide for a condition wherein the new layer or the old layer would not be liable to failure on the application of the loads.

(2) In this category, the resurfacing is called for to correct the surface deterioration, due to wear, weathering, etc., and the existing pavement does not show any structural distress, such as cracking, settlement, etc. The remedial measure called for under this category is purely of addition of a thin veneer of concrete to restore the surface and primarily the considerations are of a practical nature.



Spreading the diluted acid on the existing concrete surface and brooming the same evenly by a light brush to produce a good effervescence

A close up of the treated surface after surface-drying was complete



DESIGN FORMULAE

Till recently there has been no rational analysis of the stresses in the concrete slabs, when one was superimposed on the other as in the case of single slabs by Westergaard's theory, etc. One of the common assumptions made was that

the two slabs were equivalent to a single slab, the square of whose thickness was equal to the sum of the squares of the thickness of the two slabs, i.e.

$$T^2 = T_0^2 + T_R^2$$

where T_0 = Thickness in inches of the old slab



Pouring cement-sand grout (1 : 1 mix)
on the treated surface and spreading
the same uniformly by a brush, prior
to laying the resurfacing



Spreading the concrete and
tamping the same

T_R = Thickness in inches of the
resurfacing slab

T = Thickness in inches of the
equivalent single slab
having a structural
capacity equal to that
of thickness T_O and T_R .

The limitations of this assumption
were that the two slabs will have
the same stiffness and that no friction
will exist to cause them to act to some
degree as an integral unit and thus
reduce the stresses below what they
would be, if the slabs acted independent-

ly. Therefore, in practice, to allow for
this factor, as well as for the variation
in properties of concrete in old and new
slabs, empirical correction factors were
employed and the formulae took the
following forms:

$$T^2 = CT_O^2 + T_R^2 \dots \dots (1)$$

$$T^{1.87} = CT_O^{1.87} + T_R^{1.87} \dots \dots (2)$$

formula (1) being applicable where con-
siderable friction existed between the
two slabs and formula (2) being employ-
ed where a separating course was
employed to eliminate or reduce the
friction between the 2 slabs and coeffi-
cient C to evaluate the condition of the
old slab.

C being 1 if old pavement was in good
condition.

.75 if old pavement has a few
corner breaks but no
progressive breakage.

and .35 if old pavement is badly
cracked or shattered.

These formulae were extensively employ-
ed by the U.S. Army Corps of Engineers,
but after an extensive series of loading
tests on pavements in Lockbourne Air-
force base in Ohio in 1947 and 1948, the
formula was modified as follows to suit
the actual observed results.

$$T^{1.4} = CT_O^{1.4} + T_R^{1.4} \dots \dots (3)$$

This formula gives slightly higher
values for resurfacing than formula (2)
but less than that required by formula
(1).

Recognising the empirical basis of
these formulae, attempts at rational
analysis have been made and those
developed by Henry Marcus of U.S.
Navy, and L.A. Palmer have received
some attention. These formulae allow
for the variation in the quality of con-
crete in the two layers and ensure tensile
stresses within safe limits in both the
layers. The use of these formulae in-
volves application of the better known

Westergaard's theory for the supporting
capacity of old and new slab, had they
been laid directly on the subgrade and
are as follows:

$$f_1 = f_0 \frac{E_1 h_1^3}{E_1 h_1^3 + E_2 h_2^3} \dots \dots (4)$$

$$f_2 = f_3 \frac{E_2 h_2^3}{E_1 h_1^3 + E_2 h_2^3}$$

where

f_1 = Maximum tensile stress in the
upper (new) slab under a given
applied wheel load when the
new slab rests on the underlying
slab.

f_0 = Maximum tensile stress in the
upper (new) slab under the
same applied wheel load under
the condition that the new slab
rested directly on the subgrade
without the old slab between it
and the subgrade.

f_2 = Maximum tensile stress in the
lower (old) slab resulting from
the same wheel load applied to
the upper (new) slab which
rests on the lower (old) slab.

f_3 = Maximum tensile stress in the
lower (old) slab resulting from
the same wheel load being
applied directly to it without
the interposition of the upper
(new) slab between it and the
load.

L_1 = thickness of the upper (new)
overlay slab.

L_2 = thickness of the lower (old)
slab.

E_1 = modulus of elasticity of con-
crete of the upper (new) slab.

E_2 = modulus of elasticity of con-
crete of the lower (old) slab.

Again, these formulae presuppose the
condition of no friction between the
two slabs and in normal cases when no
separating courses are provided, would
result in higher stresses. The method
also permits use of different working

stresses for each slab if considered necessary. The experimental evaluation of these formulae is still awaited.

FIELD OBSERVATIONS

Besides the design aspect, several findings of a conclusive nature would require to be provided for in resurfacing. It has been observed that joints and cracks in old pavements will be reproduced as cracks in resurfacing when very thin or no separation courses are employed and as such it would be essential to match the joints in the resurfacing with those of the old slab, though the type of joints such as expansion or contraction may be varied in location after proper observation of the actual functioning of those joints in the old pavements. It is not customary to provide special joints against the locations of cracks. Where cracking in the old slabs is extensive, distribution steel has been freely employed so that the reproduced cracks do not form points of weakness in the new slabs, as they are held tightly together, though these may sometimes be considered objectionable from the point of view of appearance. Measures to reduce such cracks are discussed separately under separation courses.

DESIGN OF REINFORCEMENT

Generally, the principles governing the estimates of distribution steel requirements follow the same lines as new concrete pavements. The formulae commonly employed in calculating the steel requirements are as follows:

Distribution steel:

$$A_s = \frac{LFW}{2S}$$

Where

A_s = area of steel in sq. in. required per foot width or length of slab.

L = distance in ft between free transverse joints when the

equation is used to calculate longitudinal steel or between free longitudinal joints or edges when calculating transverse steel.

F = coefficient of friction between slabs.

W = weight in lb/ sq. ft. of slab.

S = allowable working stress in p.s.i. in steel.

In using this formula, it must be remembered that steel is estimated on the basis of thickness of resurfacing only, provided no wide cracks existed in the old pavement. If, however, there are wide cracks either by themselves or associated with breakage of distribution steel in the old pavement, then the steel reinforcement in the resurfacing has to be based on the combined thickness of the two slabs.

SEPARATION COURSES

In the use of separation courses, there appears to be wide disagreement amongst the authorities and the criterion for their use would be guided by the following considerations. Many studies indicate that there is a greater structural capacity for the construction when no separation courses are employed. However, it is also borne out that repetitive cracking in the upper layer could be substantially reduced or even eliminated by separating courses of substantial thickness. Therefore, in view of the additional cost both of extra thickness of concrete as well as the cost of separation course itself, their use would be justified only in such cases where either raising the level of concrete or making up of excessive irregularities are called for and not from aesthetic considerations.

BONDING OF RESURFACING

Of late several construction techniques employed are found to develop adequate bond between the old and new concrete

and they have been mostly employed to correct an unsatisfactory surface condition where no strengthening of the old slab was necessary. Therefore, there seems to be ample justification to reckon for structural capacity the thickness of such construction as the combined thickness of old concrete plus the resurfacing. All the above considerations in the design of resurfacing presuppose that the underlying subgrade has not failed. Where such failure is noticed, it would not be overcome by an additional layer of concrete and would necessitate the breaking up of the old slab, making up the subgrade and construct a new pavement thereon.

WIDENING WITH RESURFACING

Particularly in highway work, resurfacing work in concrete is quite often associated with widening of the pavements and it has been the general experience that such work offers more advantages than difficulties. By construction of widening, integral with resurfacing, it is found that curling of the edges of resurfacing caused by loss of bond with old concrete is definitely eliminated; besides such construction has also facilitated design of form work for resurfacing jobs.

STRUCTURAL STRENGTHENING WITH RESURFACING

Construction of a 'thick' concrete resurfacing usually involves no great difficulties. If the old pavement is in an unsatisfactory condition at a few locations due to an unstable yielding subgrade those areas should be removed. The subgrade may then be corrected by placement of a sub-base and if necessary provision of drainage. Large areas of bituminous patches should be removed if the design is based on the absence of a separation course, i.e., formula(2). In case of extensive patching, which is undesirable to be removed, formula (3) should be used in estimating the thickness. Where the forms for resurfacing are supported on the subgrade, they are fixed in the usual manner, but where the

forms are to be set on the concrete, it would be necessary to drill holes for form pins in the existing slab. Concrete used for resurfacing should be placed with a minimum slump, since the subgrade will absorb little or no water at all. Where the resurfacing job involves widening, use of waterproof paper on the extended subgrade will prevent water absorption and permit use of concrete of same consistency throughout.

Distribution steel is placed in the same manner as in normal pavement construction by striking off the concrete at proper levels, placing the steel on fresh concrete and placing the second layer of concrete. Compaction, finishing and curing are carried out in the usual manner.

Thin bonded concrete resurfacing can be used to restore the surface of pavements that have been damaged by any cause. It should not be applied to concrete that is unsound or structurally inadequate for the condition of service.

PREREQUISITES TO THIN RESURFACING

It is difficult to make a general rule for the use of thin bonded resurfacing because each job must be evaluated on the basis of whether the new surface can be placed, jointed and constructed at reasonable cost to give satisfactory service. However, for thin bonded resurfacing, the following are some prerequisites that should be given consideration:

1. The resurfacing must be placed on concrete which is structurally sound below the surface disintegration or scale.
2. Scarification of the pavement to remove surface deterioration should be limited to a maximum of 1 in. and preferably 1/2 in. except in localised areas.
3. The old pavement surface must be clean, free of all dirt debris and loose material.

4. Joints in the resurfacing must be directly over the joints in the old pavement and of equal or slightly greater width.
5. Construction lane widths should be limited to about 25 feet.
6. Resurfacing thicknesses, should, if possible, be limited to 2 inches. They should never be less than 1 inch thick, except for patching and at ramps where grades have to be met.
7. The concrete mix used in the resurfacing should have physical properties matching as nearly as possible those of the concrete of the old pavement.
8. Maximum size of coarse aggregate in the resurfacing mix should be limited to 1/2 the thickness of the resurfacing.
9. Distributed reinforcement should be omitted from resurfacing thicknesses less than 3 inches.

METHODS OF BONDING

Amongst the above prerequisites, the preparation of surface to receive the resurfacing is the most important as the success of thin resurfacing depends primarily on the bond developed between the old and new concrete. Several methods have been tried out and broadly they fall into two groups.

(1) In the first method bond is developed primarily by roughening the surface by either grooving of the pavement or by denting the pavement with bush hammers or pneumatic chisels, to provide keying of the top concrete.

(2) In the second method, the roughness of the old surface is achieved by etching the same with commercial hydrochloric acid or glacial acetic acid. This treatment usually leaves the surface with a sand paper texture which is desirable for good bond. With the acid treatment, it is necessary that after the visible etching or foaming action has

ceased, the pavement surface should be flushed with water adequately till no acid traces are left as any acidity left impairs the bond as well as affects the concrete chemically.

PREPARATION OF SURFACES

In cases where the existing surface is heavily stained with oil, rubber or bituminous material, the surface is treated with a detergent which is highly alkaline such as sodium metasilicate. In such cases, it is very essential that this application is followed by flushing with water as in the case of acid application to neutralise the traces of alkalinity.

The next step in the preparation of surface following mechanical and other roughening of the surface and immediately preceding the placing of concrete is the application of a grout of cement and sand. This is essential to avoid air gaps between the old and new concrete impairing the bond.

ADMIXTURES

Amongst other developments in the field of thin resurfacing of concrete, the use of some admixtures to the grout and resurfacing concrete, are receiving considerable attention. Mostly used on an experimental basis, they are calcium chloride, polyvinyl acetate and epoxy resins. The two latter chemicals have been used in the field in U. S. A. and U. K. and the chief claims made are that in addition to improving the bond, they considerably enhance the tensile strength of the mortar or concrete and it is reported that thicknesses as small as 1/4 in. have been successfully bonded to old concrete. Though these techniques may prove to advantage in future, the existing practice of developing bond are quite satisfactory from a practical point of view.

LOCAL EXAMPLES OF THIN CONCRETE RESURFACING

During March 1959, a moderately sized thin resurfacing job was done in Bombay

using the following specification along the western carriageway of Sion-Matunga Road. The technique was easily applied with local labour and the results of its service to date show good promise for the future.

The area resurfaced was 400 ft x 10 ft (approx.) in two lengths of about 200 ft along the outer lanes of a 3-lane carriageway of 6 in. thickness and a resurfacing varying from 2 in. at one end to 1 in. at the other was laid. The mix for the thicker portions varying from 1-1/2 in. to 2 in. consisted of:

1 cwt of cement, 2-1/2 cu. ft. of fine aggregate and 4 cu. ft. of coarse aggregate (maximum size 3/4 in.) with 4 gallons of water

and for the thinner portion varying from 1-1/2 in. to 1 in.

1 cwt of cement, 2-1/2 cu. ft. of fine aggregate and 3 cu. ft. of coarse aggregate (maximum size 1/2 in.) with 4 gallons of water.

The preparatory treatment consisted of thoroughly cleaning the old slab by scrubbing with wire brushes, brushing off of dust, etc., and washing with water. This was followed by treatment of the surface with commercial grade hydrochloric acid diluted with equal quantity of water and applied at the rate of 1 gallon per 100 sq. ft. (8 lbs of commercial acid for 100 sq. ft.) by coir brushes rubbed down gently over the whole surface. After the bubbling had ceased, it was flooded liberally with water and brushed to remove all traces of the acid. Then the surface was left for air drying and where resurfacing was to follow quickly the surface was wiped with dry hessian bags. Then a cement sand grout of 1:1 mix and water cement ratio of 5-1/2 gallons per cwt, bag of cement was spread uniformly by means of a coir brush after which the resurfacing mix was laid to the specification described before, compacted, finished and cured as usual. The illustrations on

pages 167 & 168 show the various stages of this construction. The details of cost of this construction on a turnover of 900 sq. ft. in one shift worked out as follows:

1. (a) Materials		Rs
Hydrochloric acid	3 jars of 28 lbs each	18
Cement 32 bags @ Rs 6.75 per bag		
Fine aggregates 75 cu. ft. @ Rs 34 per 100 cu. ft.	}	216
Coarse aggregates 100 cft. @ Rs 55 per 100 cft.		
		25
		55
(b) Equipment		
Mixer including oil, grease etc. L.S.	}	10
Depreciation of forms, tools and water charges		
		6
Total		330

2. Labour		
Male coolies and bhisties 33 Nos. @ Rs 4 day	}	132
Female coolies, 9 Nos. @ Rs 4 a day		
Masons, 2 Nos. @ Rs 6 a day	}	12
Carpenter, 1 No. @ Rs 5/ a day		
Fitter, 1 No. @ Rs 5/a day	}	5
Supervisors, 2 Nos @ Rs 7/8/- a day		
		15
Total		205

Total of material plus labour Rs 535/-

∴ Cost per 100 sq. ft. = Rs 5950 nP say, Rs 60/-per. 100 sq. ft.

or alternatively, the break-up on the phases of the job was follows :

- | | | |
|--|---------|-----------------|
| (a) Preparatory work including acid treatment, washing, etc. | Rs 4/- | per 100 sq. ft. |
| (b) Grout application | Rs 8/- | per 100 sq. ft. |
| (c) Cost of concrete including curing joints, formwork, etc. | Rs 48/- | per 100 sq. ft. |
| | Rs 60/- | |

CONCLUSION

Preceding this experiment, a thick bonded resurfacing of 3 in. thickness with B. R. C. No. 9 fabric had been laid on the portion of a pavement about 20 ft x 100 ft at King's Circle in March 1954 on an existing 6 in. concrete slab. The preliminary treatment there included mechanical denting of existing pavement through picks and application of 1:1 cement grout. This stretch, lying on a curve, is carrying very heavy traffic and to date has showed no sign of separation of resurfacing from the old base and is behaving very well. Therefore, it may be concluded that resurfacing of concrete either for remedying

surface deterioration or for structural strengthening is a well proven technique and could be employed with confidence for economical rehabilitation of old concrete pavements.

ACKNOWLEDGMENTS

Acknowledgments are gratefully due to the following for much of the information contained in this article :

1. American Concrete Institute "Design of concrete overlays of pavements" report of Subcommittee VIII ACI Committee 325, Journal of the American Concrete Institute. Sept. 1958. Vol. 30, pp. 315.
2. Earl J. Felt. "Resurfacing and patching concrete pavements with bonded concrete" Proceedings of the Highway Research Board, U. S. A., 1956, Vol. 35. pp. 444.
3. R. I. T. Williams, "Thin bonded concrete surfacing applied to existing concrete road slabs" Roads & Road Construction, July 1959, Vol. 37, pp. 194.
4. "Design and Construction of Concrete Resurfacing" Indian Concrete Journal, Dec. 1958.

To command nature. we must obey her. The price of success in our personal, social and racial life is humble submission to the immutable nature of things.

ALEXIS CARREL



T. M. COULTER, B.C.E.,
Materials and Research Engineer,
Department of Main Roads,
New South Wales,

THE DESIGN OF BITUMINOUS PAVEMENTS — SOME FACTORS AFFECTING THE PREPARATION OF SPECIFICATIONS FOR BITUMINOUS SURFACING WORKS*

SYNOPSIS

FACTORS influencing the choice of the bituminous pavement to suit various conditions are discussed together with some details which need to be considered in the design of bituminous surfaces, with particular reference to dense-graded, coated aggregates and to sprayed surface dressings.

GENERAL CONSIDERATIONS

The commonest form of bituminous pavement in New South Wales is the light surface treatment, consisting of a sprayed film of bitumen or tar covered by aggregate uniformly spread to produce a coat one-stone thick. This type of surface is usually adequate for roads carrying light or medium traffic, say, up to 3,000 vehicles per day, depending on the nature of the traffic concerned. If traffic is heavy it is generally economical to construct a more substantial bituminous course such as penetration macadam or some form of coated aggregate pavement, either mixed in place on the road or in some form of premixing plant. However, in many cases it will not be practicable to adopt

a more economical type because of insufficient funds to meet the greater first cost.

Apart from considerations of finance and structural stability, other factors which govern the choice of surface course for any particular job include the safety and the convenience of traffic. For instance, some aggregates polish readily under the abrasive action of traffic and are not satisfactory for ordinary light surface treatments because of the tendency for the pavement to become slippery when it is wet. In such cases it may be necessary to use premixed materials and to include a proportion of aggregate which is not susceptible to polishing. Similarly a pavement carrying comparatively light traffic but having an excess of bitumen at the surface may need covering with a course of open-graded premixed material, not because it needs strengthening but to ensure adequate resistance to skidding; sprayed seals are generally ineffective in these conditions unless the excess bitumen is first removed by burning or scraping. In the same way, some old pavements, which are sound enough to be sealed

* (Paper presented to a joint meeting of the Civil Engineering Branch of the Institution of Engineers, Australia (Sydney Division) and the Local Government Engineers' Association on 25th March, 1958.)

with light surface dressing, may be so mis-shapen that they require corrective courses of premixed material to improve riding conditions.

For some years, penetration macadam was a fairly common form of construction in New South Wales; it was usually laid in courses about 3 in. thick, using bitumen or tar as the grouting material. Road-mix seals and reseals were also used extensively. At present, these forms of construction have been largely superseded by plant-mixed materials, either of the open graded type or of the dense-graded (asphaltic concrete) type. The open-graded materials, whether mixed hot, warm or cold, are pervious to water, and consequently they weather more quickly than the comparatively water-tight dense-graded mixtures and there is a growing tendency, in the interests of economy, to use the dense graded mixtures for strengthening, reshaping and skid-proofing the more heavily trafficked roads.

The two most important types of bituminous surface are, therefore, the dense-graded hot mixes used mainly on heavily trafficked roads in urban areas and the sprayed surface dressings used throughout the State under a wide range

of traffic volumes. It is for these two types only that the problem of design will be considered here in some detail.

DESIGN OF DENSE GRADED MIXTURES

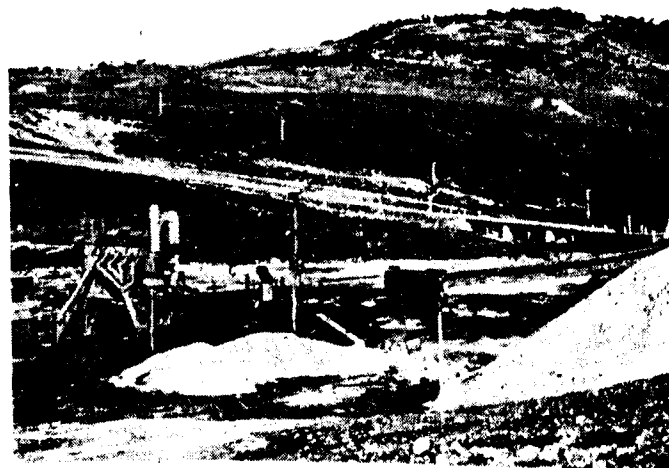
The design of dense-graded mixtures entails consideration of the following factors:

- (i) Thickness of course to be constructed.
- (ii) Maximum size of aggregate to be used.
- (iii) Quality of the separate materials used in the mix—aggregate, mineral filler and bituminous binder.
- (iv) Proportions in which the constituent materials are to be mixed.

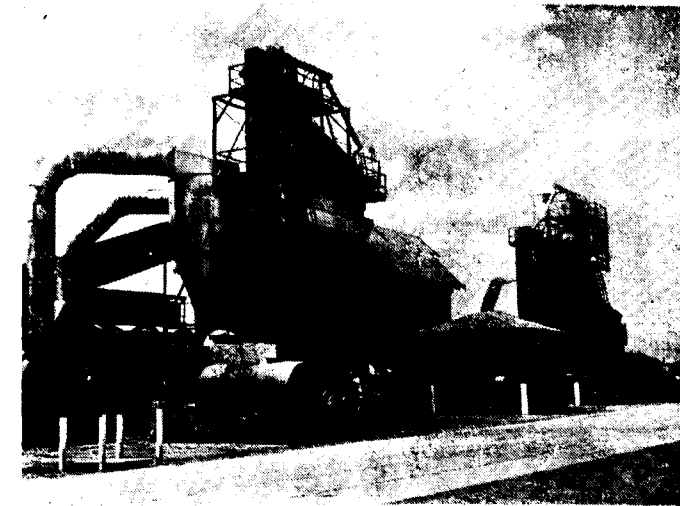
THICKNESS OF SURFACE COURSE

The thickness of surface course to be constructed will depend principally on the shape of the existing pavement, the amount of strengthening required and the cost.

If a pavement is grossly mis-shapen, large quantities of premix will be needed



Hot-mix plant on country work



Fixed hot-mix plant installation at Department of Main Roads, Metropolitan Maintenance Depot., Granville, N. S. W.

to restore smooth running conditions; it may, therefore, prove economical to break up the existing pavement and to reshape and recompact it before the bituminous surface course is applied. In such cases, due consideration would need to be given to the greater interference with traffic that would result from disturbing the old pavement. In the same way, a pavement which requires major strengthening could perhaps be built-up with an intermediate course of gravel or stone before the bituminous surface is applied, in preference to using a thick course of expensive hot-mixed material.

When the relative costs of various strengthening courses are being considered, it is generally assumed that dense-graded bituminous mixtures are more effective for pavement strengthening because of their comparatively high beam strength. However, temperature effects must be considered because high temperatures reduce the viscosity of the binder and so reduce the beam strength of the mix; on the other hand, very low temperatures can cause a tendency to brittleness, and failure by fatigue may occur if the underlying pavement is too flexible. It is not possible to calculate

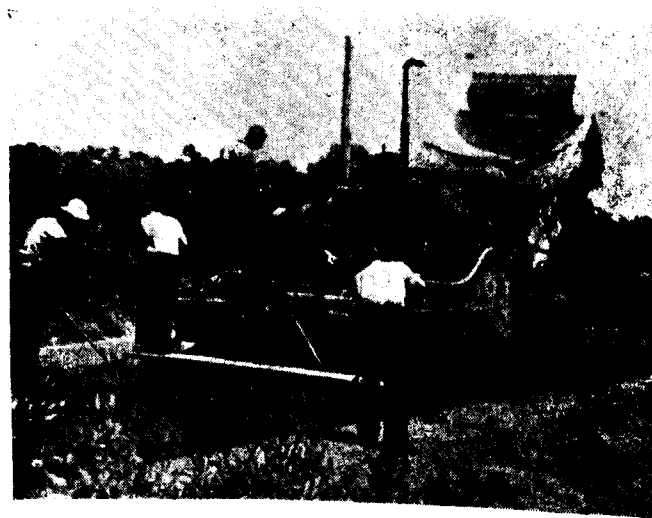
accurately what thickness of strengthening course is necessary but some indication may be obtained by constructing experimental sections and checking the amount of deflection under heavy loading. However, in road work it is usually economical to strengthen pavements progressively as and when they show signs of failure. This method also permits of continual improvement in shape and in resistance to skidding.

MAXIMUM SIZE OF AGGREGATE

Once the thickness of course has been decided it is usual to fix the maximum size of aggregate in the mix at not more than about six-tenths of the thickness of the course. If larger aggregate is used some difficulty may be experienced with spreading and compacting. The actual size of stone used will often depend on what material is readily available. Thick courses with large aggregate are usually covered by thin layers of finer material to provide running surfaces of better texture.

QUALITY OF AGGREGATE

The Los Angeles Abrasion Test (A. S. T. M. Designation C 131-51) is commonly used to check the quality of



Placing of bituminous mixture through mechanical tamper-spreader

aggregate proposed for bituminous work; the lower the abrasion loss the more resistant the aggregate. Aggregate in hot mixes is well protected by bituminous mortar and is not so vulnerable to damage and wear as cover aggregate in sprayed seal coats. For this reason it is not necessary to specify such stringent Los Angeles values as for cover aggregate. Values would ordinarily be in the range 25 to 40, depending on the intensity of traffic and the type of stone available.

SHAPE OF AGGREGATE

Many authorities require a proportion of the aggregate to be crushed. However, there seems to be no objection to the use of rounded gravel provided adequate stability can be obtained when the mix is tested by one of the standard procedures for determining stability, e. g., Hubbard-Field, Marshall, Triaxial Compression, etc. Crushed fine aggregates may give high stabilities but may require the addition of a natural rounded sand to provide better workability during spreading and compaction.

MINERAL FILLER

Ground limestone is the commonest type of filler used for hot-mix work in

New South Wales. Specifications generally require that not less than 85 per cent of the material should pass the No. 200 B. S. sieve.

BINDER

Although slightly softer and slightly harder bitumens are sometimes used, the commonest grade of binder used in asphaltic concrete in New South Wales is R. 90 residual bitumen. Tar is used extensively overseas for hot mixes but is not used in New South Wales except to a limited degree in open-graded mixes.

GRADING OF AGGREGATE

Most dense-graded mixtures approximate maximum density grading derived from curves such as suggested by Talbot, Bolomey, Wilhelmi and so on. In New South Wales it is often necessary to use coarse sand and fine sand to obtain a satisfactory fine aggregate grading for use in dense-graded bituminous work.

BASIC PRINCIPLES OF MIX DESIGN

The basic principles to be observed in designing a dense-graded bitumen aggregate mixture can be stated as follows:

- (a) The mixture must have suffi-

cient bitumen to bind the particles of aggregate together and to provide some resiliency in the mixture. Otherwise the pavement will fret or crack because it lacks cohesion.

Voids space should be sufficient to ensure that the voids are not overfilled when the mixture is progressively densified by the compacting effect of traffic and the expansion of the binder in hot weather. If overfilling does occur the mixture acts as a viscous liquid and deformation results.

- (c) Voids space should not exceed about 5 per cent in order to ensure that the mixture will be reasonably watertight. Some margin is necessary to allow for inevitable small errors in proportioning the ingredients on the work.
- (d) Internal friction of the coated aggregates must be high enough to prevent shear displacement under traffic.

LABORATORY PROCEDURE

Economic considerations usually decide what aggregates are to be used in a particular job. The problem of design then becomes a matter of determining the best proportion for mixing these aggregates with the binder to obtain a satisfactory mix.

The laboratory procedure used by the Department of Main Roads is briefly as follows:

- (a) Sieve the aggregates into various fractions and determine the proportions in which they should be combined to give a grading approaching maximum density. This is done graphically on charts specially prepared for each maximum size of aggregate.
- (b) Make up trial mixes at estimated optimum bitumen content and, say, one half per cent above optimum and one half per cent below optimum. Optimum bitumen content can be estimated from previous experience with similar mixes,



Bitumen spraying and aggregate spreading in progress

by formula based on particle size of the aggregates or by observing the cohesiveness of the mix while the binder is being added during preparation of the laboratory specimens.

- (c) Mould these mixes into test specimens in accordance with the standard procedure applicable to the chosen method of test and then determine void content and stability of each specimen.

(Stability testing may be done by a number of standard procedures including the Hubbard-Field and the Marshall methods.)

If the specimens fail to reach test requirements, adjustments are made to the proportions of the mix and more specimens tested until a satisfactory mix has been obtained. When these tests are being made consideration must be given to durability of the mix as well as its stability. In this regard it is necessary that the bitumen content should not fall below a certain minimum and it is desirable also that the filler/bitumen ratio (by weight) should not exceed about 1:2. It is usual to allow a little more bitumen and a corresponding reduction in filler in a very cold climate. It is generally found that the voids in the aggregate are of the order of 15 per cent and these voids are usually 75 to 85 per cent filled with bitumen.

The mix as designed in the laboratory becomes the job mix, and control testing is subsequently conducted at the mixing plant to ensure that subject to specified tolerances the mixed material conforms to the approved job mix.

In addition to laboratory testing it is generally necessary to check field densities to ensure that the void content of the completed pavement is in reasonable agreement with the design requirement.

LIGHT BITUMINOUS SURFACE TREATMENTS

Bituminous surface treatments, often referred to as surface dressings or seal coats are the commonest form of bituminous work in New South Wales. The technique is a relatively simple one but there is a need for careful design of various details of the work if consistently good results are to be obtained.

Surface dressings fall broadly into two classes—

- Single application of binder, covered with aggregate in one application or in two separate applications.
- Double application of binder and of aggregate.

Double coat dressings are sometimes used as a means of providing a more durable surface than a single seal in situations where the more expensive plant mix would not be warranted. However, single coat work is by far the most important type of surface dressing in New South Wales and the following discussion will be confined principally to this type of construction.

USE OF PRIMERS

Some form of bituminous primer is often applied to prepared pavements shortly before the main surface dressing is sprayed. Such primers are said to strengthen and waterproof the pavement and to provide good bond between the pavement gravel and the bituminous binder of the seal coat. While this is true in many cases, light primers may, in some instances, actually weaken the surface of the pavement material. Some engineers consider that money spent on priming would be better used in providing thicker coats of heavier bituminous material, so that in some cases conventional priming coats have given way to temporary seal coats of tar, road oils, bitumen emulsion, etc. In other cases, single-coat bitumen surface dressings

have been successfully applied direct to gravel pavements. If this process is used, it is necessary to ensure that the gravel conforms to specification and is thoroughly compacted in the pavement to provide a tight, even surface. This is not always practicable because of circumstances such as the following:

- Porous gravels (e.g., some limestone gravels) are often uneven in texture and it is not possible to estimate how much binder would be absorbed by the pavement if priming were omitted. In such cases, primers or light temporary seals are an advantage because in addition to making the surface denser, they provide a more even surface texture for the subsequent spraying of the bituminous binder.
- Some gravels have poor affinity for bitumen and an intervening coat of tar may improve the adhesion between the gravel pavement and the bitumen seal coat.
- It is often found expedient to hold a gravel pavement in shape for a few weeks or months prior to surfacing, either by priming in the orthodox way or by placing a light seal of tar, bitumen or bitumen emulsion.

TYPES OF PRIMER

Coal tar primers are the most commonly used in New South Wales. During the last two or three years petroleum tars have become available in grades suitable for priming. Cut-back bitumens, bitumen emulsions and water-diluted bitumen emulsions have also been used; in many cases, however, the coats laid with these materials, in

advance of the main sealing work, could more properly be termed light surface treatment rather than priming.

GRADES OF PRIMER

Primers can be obtained in a large range of viscosities. The grade best suited to any particular work will depend on the surface condition of the pavement and also on the intensity of traffic using the road. In case of doubt, a field trial on a small area of prepared pavement will assist in determining the most suitable grade of primer and will indicate what its effect on the pavement will be, what rate of application is suitable, how quickly it will dry, whether cover aggregate will be required and so on.

The commonest grades are those referred to in the Australian Standard Specification for Road Tars (A63-1947) as 0.35, 0.7, 1.4 grades, these figures representing the geometric mean over the permissible range of viscosity measured in seconds at 50°C. Heavier grades may be desirable in special cases but usually require a light covering of aggregate.

RATE OF APPLICATION OF PRIMER

The optimum rate of application will depend on the grade of primer used, the porosity of the pavement and the traffic conditions. The usual rate is between about 0.13 gallon and 0.20 gallon per square yard.

COVER MATERIAL ON PRIMER

If traffic cannot be kept off the primer while it is drying, it may be necessary to use coarse sand or grit as a protective cover. Care is required in using sand as a cover material; if it is applied too soon it may have a blotting effect on the primer and prevent it from penetrating into the gravel pavement.

QUALITY OF COVER AGGREGATE

Aggregate for surface dressing work must be sufficiently tough and hard to resist fracture and abrasion by the action of traffic. It should also be of such a nature that it is not prone to polish under the action of traffic and so cause skidding when the pavement is wet. There are several methods of testing to determine quality. The Department of Main Roads specifications rely principally on the Los Angeles Abrasion Test as an indication of the quality of an aggregate. This test has generally been found a fairly reliable guide to the performance of homogeneous stone but samples containing particles of different types may give unreliable results because the harder stones tend to protect the softer stones from being broken down to size on which the abrasion loss is measured. It is usual with such materials to make a selection of the weaker stones in the sample (say 10 per cent) and perform the test on these stones separately. The mixed sample is acceptable if its Los Angeles value is within the specification limit and the value for the weaker stones does not exceed the specified limit for the whole sample by more than 5 per cent. Aggregates of this type are weathered igneous rocks, river gravels which contain some stones harder than others, and blast furnace slags which usually contain some pieces that are vesicular and comparatively soft, some that are glassy and some that are tough and hard. Other stones which call for special attention are those which when dry give a reasonably good Los Angeles result but soften when soaked in water. This fault usually becomes apparent when the aggregate is submerged in the water bath for the adhesion test.

For surface dressing it is usual to specify a Los Angeles limit ranging from a little less than 20 per cent up to

35 per cent depending on the intensity of traffic on the particular work.

SHAPE OF AGGREGATE

Shape of aggregate is important because flaky particles interfere with the proper embedment of the stone in the bitumen film. The Department of Main Roads specification uses the British Standard Flakiness index test for control of shape; the limits allowed by the Department are a little more stringent than those used in British Standard specification—No. 63-1951.

GRADING OF COVER AGGREGATE

Surface treatment is aimed at building a layer of aggregate one stone thick so that an aggregate containing particles of uniform size is the most



Los Angeles abrasion machine



Shape-test of aggregate

suitable. Aggregates which contain oversize particles are difficult to embed properly and may result in flying stones. On the other hand, undersize stones are objectionable because they are liable to reach the bitumen film first and so prevent the larger stones from adhering. Specifications prepared by the Department of Main Roads provide for nominal gauge $\frac{3}{4}$ in. aggregate to contain not more than 5 per cent retained on $\frac{3}{4}$ in. B. S. sieve and not more than 20 per cent passing $\frac{1}{2}$ in. B. S. sieve. For $\frac{1}{2}$ in. aggregate the corresponding limits are 5 per cent retained on $\frac{1}{2}$ in. B. S. sieve and 30 per cent passing $\frac{3}{4}$ in. B. S. sieve. Better aggregate could be obtained by further limiting the fines but the cost would be increased.

In addition to specifying a one-size aggregate, some authorities take the additional precaution of removing grit and dust by passing cover aggregates over short screens as the stone is being loaded on to the spreading trucks.

SIZE OF COVER AGGREGATE

From the point of view of economy, the nominal size of the aggregate should be such that its effective life in the pave-

ment is commensurate with that of the binder. The optimum size for any particular work will depend on the amount of traffic and on the quality of the aggregate. If traffic is light, small aggregate ($\frac{3}{8}$ in. or $\frac{1}{2}$ in.) may be satisfactory for surfacing work whereas for heavy traffic $\frac{3}{4}$ in. aggregate is generally used. In special circumstances coarse sand may be a satisfactory cover aggregate. For resurfacing work $\frac{1}{2}$ in. nominal size is generally used but in some cases $\frac{3}{4}$ in. aggregate may be better, e.g., on the "Fatty" surface of a heavily trafficked road.

There is less tolerance in binder application when small aggregate is used and care should be taken to ensure that the application is well controlled to avoid either underspraying which will cause loss of stone or overspraying which will cause a fatty surface.

In order to reduce noise, vibration, and tyre wear, it is usual to apply a light course of filler aggregate after the main coat of aggregate has been rolled, particularly when the nominal size is greater than $\frac{1}{2}$ in. The filler aggregate should generally not exceed one half the nominal gauge of the coarser stone, so

that it can be embedded in the interstices of the larger aggregate without displaying it.

AVERAGE LEAST DIMENSION OF COVER AGGREGATE

With the assistance of rolling and traffic compaction, each particle of cover aggregate ultimately assumes a position in the pavement where one of its large faces is in contact with the binder and the least dimension is vertical or nearly so. The average mat thickness is therefore approximately equivalent to the average least dimension of the aggregate and the latter is therefore a useful parameter in calculating rate of spread of aggregate and rate of spray of binder.

The average least dimension may be determined in a number of ways including the following:

- (a) Measure the least dimension of each particle of a sample of the aggregate using calipers or slotted sieves; then calculate the average.
- (b) Spread a sample of the aggregate on a level tray with the least dimension of each particle vertical; pour water into the tray until it is judged that half of the particles have been covered. The depth of water will then approximate the average least dimension of the sample.
- (c) Calculate average least dimension from sieve analysis and flakiness index value, using curves previously developed by closely examining the relation between these three properties for a large range of typical aggregates.

RATE OF SPREAD OF COVER AGGREGATE

The optimum rate of spread is that which will produce a well compacted surface course one stone thick without

any surplus stone usually referred to as a "whip-off". If too little stone is used there will be a tendency for tyre to reach the binder and pick it up; if too much stone is applied it will interfere with proper embedment, cause traffic to throw loose stones in a dangerous manner and result in wasteful "whip-off." It is difficult to avoid a small "whip-off" on account of the impracticability of obtaining completely uniform spreading. Slight underspreading in the first instance followed by a small amount of hand spreading over the thinner patches is preferable to deliberate overspreading of aggregate to ensure complete cover.

It is not possible to calculate the optimum spread of aggregate with great accuracy. Several methods have been suggested for determining the rate of spread including the following:

- (1) F. M. Hanson in 1935 described a method of relating the rate of spread to the average least dimension of the aggregate and published a graph showing the average relation between these two variables (see "Bituminous Surface Treatment of Rural Highways" by F. M. Hanson).
- (2) J. P. Kearby, of Texas Highways Department, recommends a method of calculation based on the average mat thickness, the percentage of voids in the aggregate and the depth of embedment of the stone in the bitumen. (See "Thoughts and Theories on Bituminous Surface Treatments" by J. P. Kearby, World Construction, May-June 1953, p. 24).
- (3) W. P. Lovering, California Division of Highways, describes a method of calculating the rate of spread from the mean particle size of the aggregate, which is calculated as the weighted average of the mean

size of the largest 20 per cent, the middle 60 per cent and the smallest 20 per cent (See "Seal Coats—Economical Usage" by W. P. Lovering, Western Construction, April 1954, p. 60.)

Experiments conducted by the Department of Main Roads suggest that a reasonably close approximation to the optimum rate of spread can be obtained by measuring the Average Least Dimension of the aggregate and dividing the result into a constant which includes the gross effect of such factors as voids in aggregate, depth of embedment, unevenness of spreading, amount of compaction and so on. This constant has been found by laboratory and field experiments to approximate to 22, so that the rate of spread may be predetermined in square yards per cubic yard by dividing the Average Least Dimension in inches into the constant 22. This rate is a first approximation only and a close study should be made of the surfacing work in progress to determine whether some slight adjustment of the rate of spread is necessary.

A rough approximation to the optimum rate of spread can be obtained by loosely spreading a sample of the aggregate on a measured board, but considerable experience is necessary to obtain consistent results. Better results can be obtained by pressing the stones into a plastic film (such as fluxed bitumen) but in any case some correlation is necessary with actual field rates before the rate of spread can be predetermined with reasonable accuracy. Small scale tests of this nature can also be used to determine the amount of filler aggregate required to suitably fill the interstices in the coarser first application.

TYPE OF BINDER

Binders used in New South Wales include residual bitumen, coal tar, petroleum tar, bitumen emulsion and road oils. The commonest binder is R. 90

bitumen fluxed as required with varying amounts of kerosene or other flux oil.

Tars generally have a shorter life than bitumen and are usually not economical except under special conditions, such as (a) light seal coat to hold unprimed pavement for a year or two until arrangements are made for the main surface course; (b) reseal of pavement to improve skid resistance when wet; (c) reseal of pavement to minimise softening of pavement from oil and fuel spillage.

RATES OF APPLICATION OF BINDER

The quantity of binder sprayed on the pavement should be minimum required to hold the aggregate firmly in position. If too much binder is used it will rise to the top of the aggregate and cause a "slick" surface. The optimum rate of application of the binder is directly related to the Average Least Dimension of the stone and a simple rule for determining the approximate quantity of bitumen, in gallons per square yard, required on a primed surface or smooth (not fatty) pavement is to multiply the Average Least Dimension in in. by two-thirds, e.g., for $\frac{3}{4}$ in. stone with Average Least Dimension of 0.45 in. the base rate for binder application would be 0.30 gallons per square yard. This rate must obviously be adjusted to suit variable conditions of pavement texture, traffic, etc. These factors can seriously affect the rate of application and are not capable of accurate measurement. Experience is necessary in deciding what adjustments are needed to the base rate on account of changes in surface texture. The following figures give some indication of the range of these adjustments:

- (i) On unprimed surface—add up to 0.06 gallons per sq. yard.
- (ii) On rough and/or absorbent bitumen surface—add up to 0.05 gallons per sq. yd.
- (iii) On "fatty" bitumen surface deduct up to 0.05 gallons per sq. yd.

It is known that heavy traffic will compact the aggregate of a surface course after rolling has ceased and the bitumen may be forced to rise so high that the pavement becomes "slick". On the other hand, a lightly trafficked pavement, without the kneading effect of traffic, generally remains rugose so that additional bitumen can be used for durability without danger of causing slickness.

As a general rule it will be satisfactory to decrease the base rate for bitumen application by 10 per cent if traffic exceeds, say, 1,500 vehicles per day and to increase it by 10 per cent if traffic is less than, say, 200 vehicles per day.

Some adjustment of the calculated rate may be required during the course of the work and a close study of the surfacing work in progress is necessary to ensure that the rate of application is correct. However, if the aggregate approaches a "one-size" gauge (as it is generally required to do) and the Average Least Dimension has been measured, careful consideration should be given before any major departures are made from the calculated base rate.

FLUXING OF BITUMEN

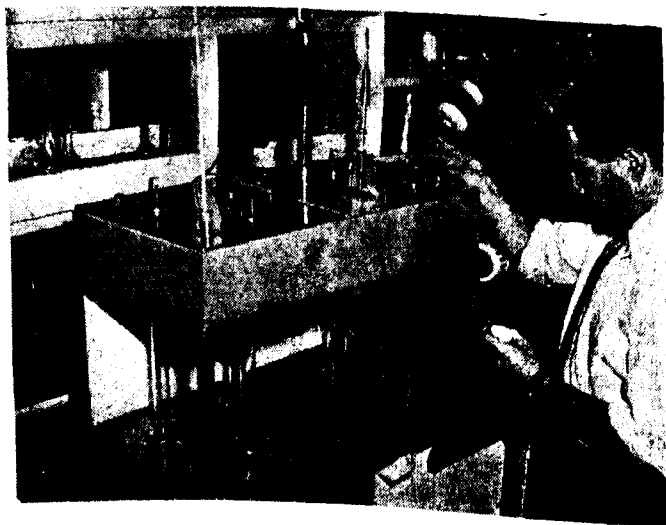
The binder in the completed work

should be at a suitable semi-solid consistency for the entire range of temperature to which the road surface will be exposed. This consistency is not sufficiently fluid for aggregate to be satisfactorily incorporated except at high pavement temperatures. It is usual, therefore, to add a fluxing agent to render the binder more fluid while the stone is being incorporated. This flux should escape from the binder as quickly as possible after achieving this purpose or otherwise it will have a subsequent undesirable softening effect on the pavement.

Power kerosene or similar light oil is generally used for fluxing bitumen but heavier oils are sometimes used in special cases where it is desired to retain the softening effect for a longer period, e.g., when work is being done on a lightly trafficked road towards the end of the normal spraying season.

AMOUNT OF FLUX

The proper amount of flux can be determined by studying the viscosity and adhesion properties of the fluxed binder at various temperatures. Curves and tables are available indicating the amount of flux required over a range of pavement temperatures and under other variable conditions.



Testing viscosity of bitumen

ADDITIVES

Many types of stone show poor affinity for bitumen in the presence of water. In such cases it is good insurance against wet weather damage to use an "anti-stripping" agent to improve adhesion. Materials which have been found satisfactory for this purpose include:

- Commercial anti-stripping agents supplied with directions for use.
- Creosote or petroleum tar, sprayed on the aggregate while it is being loaded from the stockpiles into the spreading trucks or at some time previously.
- Dehydrated tar (as per Department of Main Roads Specification No. 232) added to the bitumen.

Conditions over large areas of New South Wales are comparatively dry and the need for additives to give positive adhesion in wet conditions is not so urgent as in high rainfall countries. Usually the ability of an aggregate to resist stripping by water for a few days after initial adhesion has been effected is all that is required; after the aggregate has been well embedded in the binder for a few days, the risk of stripping is slight. In these circumstances, creosote and tar additives have been generally successful; they will not, however, ensure satisfactory adhesion on work actually carried out under wet conditions.

The creosote and tar have an economic advantage in that they act partly as fluxes as well as anti-stripping agents. Normal fluxing agents should be suitably reduced (usually by about 5 to 10 per cent of the binder) when these additives are being used. Tar added to bitumen may also improve the skid resistance of the pavement. However, these materials must be used with care when conditions are unusual. For

instance, a 10 per cent addition of tar (the usual minimum for protection against stripping) may produce too soft a binder for a heavily trafficked road in hot weather; on the other hand, 10 per cent of tar may provide insufficient fluxing of the binder if this method is used at low pavement temperatures.

Although the anti-stripping agents which are mixed in the binder are simpler to use, the precoating process has a compensating advantage in that it is more effective in securing initial adhesion of dusty aggregates, where the use of such material is unavoidable. In any case, careful consideration is necessary in determining whether an adhesion agent should be used and, if so, which agent would be the most suitable for the conditions obtaining on any particular work.

CONCLUSION

Standard specification forms, recently prepared by the Department of Main Roads to cover surface treatment work, are so arranged that it is necessary to consider carefully the design of any particular work before an adequate specification can be completed. The foregoing discussion may prove of some assistance in determining suitable detailed information for inclusion in this type of specification.

A sound specification is a major factor in successful surfacing work but consistently good results can be obtained only if the care exercised in designing the work is matched by similar attention to operational details.

ACKNOWLEDGMENT

The Author is indebted to the Commissioner for Main Roads for permission to use certain data included in this paper. The views expressed by the Author are his own and not necessarily those of the Department of Main Roads.

(From "Main Roads", December, 1958).

THE INTER STATE HIGHWAY SYSTEM IN THE UNITED STATES

By
N. S. SURYA *

THE National Highway system in India has several distinguishing features. The chief of these are:

- (i) their ownership vests with the Union Government;
- (ii) all expenditure on original works and maintenance on these highway is borne by the Union Government;
- (iii) their maintenance and improvement are usually carried out through the agency of the Public Works Departments of the States through which they pass;
- (iv) the State Public Works Departments in charge of the National Highways are paid agency charges (usually $7\frac{1}{2}$ per cent) for the work of maintenance and improvement;
- (v) the responsibility of the Union Government does not extend to urban lengths, that is, sections of National Highways through municipalities with a population of over 20,000 persons;
- (vi) the total length of the N.H. system in India is 13,800 miles which works out to (a) one mile per 90 square miles and (b) one mile per 26,000 persons.

(2) There is no highway system in the United States which has all or even

most of these features. The nearest approach is the National System of Inter-State and Defence Highways. The main characteristics which distinguish this system are:

- (i) their ownership rests with the States through which they pass;
- (ii) (a) Ninety per cent of the expenditure on original works is provided by the Union Government, the balance being found by the State;
(b) the expenditure on their maintenance is provided by the State;
- (iii) their improvement (and maintenance) is carried out through the agency of the Public Works Departments of the respective States;
- (iv) no agency charges are given to the States for carrying out improvement works;
- (v) the urban sections of the inter-State system are also eligible for the 90 per cent contribution from the Union Government;
- (vi) the total length of the system is about 41,000 miles which works out to (a) one mile per 70 square miles and (b) one mile for 4,400 persons.

The basic characteristics of the inter-

State system are those of a Freeway which is defined as an Expressway with full control of access. On all sections of this system, access is controlled by acquiring access rights prior to construction or by the construction of frontage roads. All 'at grade' intersections of public highways and private driveways are eliminated or the connecting road terminated, re-routed or intercepted by frontage roads. These characteristics will be clearer if a comparison is made of different classes of highways as in the table given below:

Characteristics of urban arterial highways

Design and control features	Major street	Expressway at grade	Freeway	Parkway
1	2	3	4	5
Types of vehicles	All	All	All	Passenger cars only.
Control of access	Usually none	Full or partial	Full	Full or partial
Minor cross streets	At grade	Terminated	Terminated	Usually terminated
Major cross streets	At grade	Preferably separated; some at grade	All separated	At grade or separated
Control of cross and turning traffic at grade	Stop signs or traffic signals	Preferably stop signs; some traffic signals	All separated	Stop signs, traffic signals or separated
Private driveways connecting to through lanes	Restricted; some right turns only	None or few	None	Restricted or none
Access connection treatment	Normal or flared	Channelised or ramp terminal	Ramp terminal	Usually channelised or ramp terminal
Frontage roads or equivalent	Usually none	Where needed	Where needed	Usually not needed
Median	Included where feasible	Included	Included	Usually included
Pedestrian crossings	Crosswalks	Crosswalks or separated	All separated	Crosswalks or separated
Parallel curb parking	Restricted or eliminated where feasible	Eliminated	Eliminated	Eliminated
Shoulders	Seldom applicable	Included	Included	Included

* Divisional Engineer (Consultant), Ministry of Transport & Communications, Department of Transport, Roads Wing, New Delhi-2.

Though the heading of this table prepared by the American Association of State Highway Officials indicates that it refers to Urban Highways, the comparison holds good in general for the non-urban sections also. It will be seen from this table that the Freeway is a far superior facility in comparison with the National Highway in India.

Before taking up the design of any interstate scheme, detailed surveys are made and traffic data collected. The following traffic data are invariably obtained:

ADT - Current average daily traffic.

ADT (1975) - future average daily traffic for the design year, this being 1975 for interstate schemes.

DHV (1975) - design hourly volume, two-way, usually equals 30th hourly volumes.

D - Directional Distribution, that is, the percentage of traffic in the predominant direction of travel during the design hour (varies from 50 to 80 per cent).

T - percentage of trucks during the design hour (varies from 5 to 12 per cent).

The ADT is the total traffic for the year divided by 365. This is required more for administrative purposes than for the design of the highway. The selection of the 30th hour volume for design requires some explanation. The graph on page 191 shows the relation between the highest hourly volumes and the ADT on several highways taken from analyses of traffic counts for 167 stations in the United States.

It will be seen from this graph that the curve steepens quickly to the left of the 30th hour and flattens to the right indicating that the design volume will have to be increased considerably to

accommodate a few more of the higher hourly volumes. It was found that on the average main rural highway 30 HV is 15.3 per cent of ADT. The directional distribution, D, is required because for the same DHV a highway with the higher percentage of traffic in one direction may require a wider pavement than a highway with lesser percentage. As an example let us consider the case of a highway with a DHV of 4000 vehicles per hour in both directions. If D is only 50 per cent, a multilane highway with two lanes in each direction will be adequate. But if D is 80 per cent, provision of 3 lanes in each direction will be required for a traffic volume of 3200 vehicles in each direction. The percentage of trucks, T, also affects the design of highways. Trucks being slower, heavier and occupying more space than passenger cars impose a greater traffic load on the highway than the latter. The overall effect of one truck on traffic movement is often equivalent to that of several passenger cars. It is interesting to note in this connection that the percentage of trucks is usually low during peak hours of traffic.

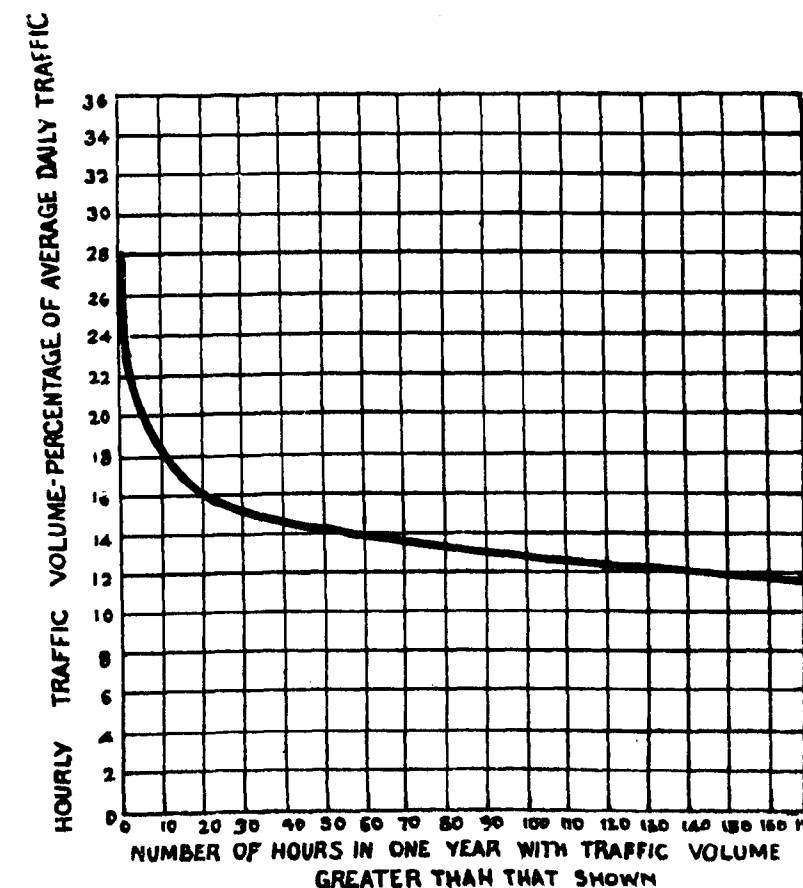
Though the interstate system forms only about one per cent of the Nation's total road and street mileage, it is estimated that it will carry 20 per cent of all traffic. It will connect 90 per cent of all cities of over 50,000 population. (The National Highway system in India connects only about 65 per cent of such cities). It is considered to be of vital importance to the economic welfare and defence of the nation. Hence the design of the system is planned very carefully. Access will be controlled throughout the entire system with entry only at carefully selected points. Traffic exchanges, overpasses and underpasses are provided in order to avoid all grade crossings, both highway and railway. It will be possible to drive from coast to coast without encountering a traffic light or stop sign.

The geometric design standards

for this system were specially worked out by the American Association of State Highway Officials which corresponds to the Indian Roads Congress in this country. The following are the more important of these standards:

- (i) **Design speed**—At least 70, 60 and 50 miles per hour for flat, rolling and mountainous country. In urban areas it should be at least 50 miles per hour.
- (ii) **Curvature, superelevation and sight distance**—These are to be correlated to the design speed in accordance with the "Policy of Geometric Design of Rural Highways" of the American Association of State Highway Officials.
- (iii) **Gradients**—Corresponding to the design speeds of 70, 60 and 50 miles per hour, gradients shall generally be 3, 4 and 5 per

- cent. Gradients 2 per cent steeper are permissible in rugged terrain.
- (iv) **Width and number of lanes**—Minimum width of traffic lanes is 12 feet. When the DHV (1975) is over 700 the section will be a divided highway.
- (v) **Medians**—In rural areas, in flat and rolling country not less than 36 feet. In urban and mountainous areas, it shall be at least 16 feet. In exceptional cases, it may be reduced to 4 feet. Kerbs should be set off at least one foot from the edge of the through traffic lane.
- (vi) **Shoulders**—Usable width of shoulder on the right of traffic should normally be not less than 10 feet. In mountainous areas, this can be reduced to 6 feet.



(vii) **Slopes**—Side slopes should be 4:1 or flatter where feasible, but not steeper than 2:1 except in rock excavation or other special situations.

(viii) **Right of way**—The following minimum widths are suggested as guides. Additional widths should be made for cuts and fills:

Type of highway	Minimum width in feet	
	Without frontage roads	With frontage roads
2-lane	150	250
4-lane divided	150	250
6-lane divided	175	275
8-lane divided	200	300

(ix) **Culverts**—Width should be sufficient to accommodate pavements, median and shoulders.

The completion of the network of 41,000 miles is expected to take 13 years. The estimated cost is about 28 billion dollars. In order to finance this programme, the Congress of the United States have increased the petrol and other motor vehicle taxes over a 16-year period. The extra cost to the average motorist on account of these taxes is of the order of 9 dollars (Rs 45/-) a year. This investment by the average motorist is small compared to the benefits from the system. Accident rates on freeways are about one third of those on other roads with similar volume of traffic. It is also claimed that one of the more striking benefits will be the saving of 4,000 lives a year.

The visiting American and his English friend were driving through London when the latter mentioned that his windscreen needed cleaning.

"Windshield," the American corrected him.

"Well, over here we call it a windscreen," was the answer.

"Then you're wrong," argued the American. "After all, we Americans invented the automobile, and we call this a windshield."

"That's all very well, old boy," snapped the Englishman, "but who invented the language?"

—GENERAL FEATURES CORP.

RIVER TRAINING FOR PROTECTION OF BRIDGES

By

D. V. JOGLEKAR, Adviser, Central Board of Irrigation and Power, New Delhi.

RIVER training is a very comprehensive subject and includes flood detention, reservoirs, flood control works, regional training of the river (such as Kosi, Ganga, etc.), local training of the river (for instance, protection of a railway or road bridge, town, etc.). Before we attempt to train a river, it is very essential to know its behaviour and considerable data such as flood hydrographs, gauges, type of bed material required, etc. No two rivers are alike and there are many types of rivers which can broadly be classified as (1) rivers in hilly regions, (2) incised rivers and (3) rivers in flood plains. The alluvial rivers can be subdivided as (a) stable, (b) aggrading and (c) degrading, depending upon the nature of hydrograph, the river can be flashy or may carry sustained floods as in the case of the Ganga, the Brahmaputra, etc. Sometimes rivers dry up before they join the sea; such rivers are common in Rajasthan. The river near its outfall is generally called a delta river and is characterised by several branches which multiply in number as it reaches the sea. In the last reach, the river also receives tidal water from tidal waves of the ocean. Training of these rivers has to be done very carefully as they are very sensitive to any obstruction. Rivers can also be classified as Himalayan rivers and non-Himalayan rivers. Himalayan rivers get their supplies from melting of the snow as well.

The river may be stated to be well behaving when it has a definite pattern of meanders. If the load which it carries on bed and in suspension is very great which it is unable to carry, it splits up into various small channels, building

up very steep slopes, for instance, near the foot hills of the Himalayas. In such cases the river is called a braided river and such rivers are rather difficult to control. As the load diminishes, the river moves within its own Khadir limits in meanders. From analysis of data carried out so far, it is found that meander length of a river is approximately equal to $30\sqrt{Q}$, where Q is the maximum discharge. The meanders move downstream, the rate of movement depending upon the load which the river carries and the bigger the load, bigger is the movement and in such rivers a repelling spur may, in course of time, become an attracting spur and great care is necessary to watch the movements of meanders in such rivers. As the rivers approach the sea, they drop their load and form a delta. The growth of delta depends on the tidal range. If the range is high, the tidal influx carries the load landwards, thus preventing a rapid formation of delta; instead the delta height increases as a result of more rapid deposits of silt. If the range is small, the growth of the delta is fairly rapid, but this may also be affected by littoral drift, as for instance, along the eastern coast of India.

The engineer entrusted with the design, maintenance and operation of various types of river training works, is required to know in the majority of problems, the complex relationships governing the flow area of water and the sediment load. The successful solution to his problem largely depends on his conception of phenomena and capacity to visualise the effects of various principal factors. In India, the growth

of knowledge in this field is closely associated with the expansion of irrigation.

Kennedy correlated the velocity of the canal to the average depth of flow based on observations on the Upper Bari Doab Canal. His formula is: $V = CD^m = 0.84 D^{0.64}$. Considerable work was done by Lacey who correlated the various factors taking into account the silt factor (f) which is $f = 1.76 \sqrt{m}$, where m is mean diameter of bed sand in mm. His formulae are:

$$P = 2.67\sqrt{Q}; \quad P = \text{wetted perimeter.}$$

$$R = 0.47 (Q/f)^{1/5}; \quad R = \text{hydraulic mean depth.}$$

$$S = 0.000547 \frac{(F)^{5/3}}{Q^{(1/6)}}; \quad S = \text{slope.}$$

$$V = \frac{1.3458}{N_a} R^{3/4} S^{1/2}; \quad V = \text{velocity in ft per sec.}$$

$$Q = \text{discharge in cusecs.}$$

$$N_a = 0.0225 f^{1/4}; \quad N_a = \text{rugosity coefficient.}$$

Lacey had developed his formulae from channels in regime. Considerable divergence is observed in actual practice and they cannot be strictly applied to rivers. As there are no other formulae, it is the practice in India to use these formulae to find out waterway for bridges in alluvial rivers, and depths of scour round the piers, noses of groynes and other rigid structures. The Research Station in Poona has done some work to introduce silt charge but much work still remains to be done in this field. These formulae, however, showed that variation of charge has a small effect on the area of channel and its mean velocity, but relatively great effect on slope, shape and channel width.

In designing the river training works, it is necessary to know the various characteristics of rivers such as bends, straight reaches, meanders, effects of cut-offs on river regime, sustained or flashy floods, earthquake, barrages and

weirs, etc. It has to be emphasised that it is the silt laden flow which is mainly responsible in moulding the behaviour of a river and creates a number of problems such as erosion of river banks, silting of reservoirs, outflanking of bridges and weirs, reducing the discharging capacity of canals taking off from alluvial rivers, etc.

As there are many factors which are still not known regarding the behaviour of rivers and there being no rigid mathematical formulae for designing training works, it is very desirable to test such measures in hydraulic models. Hydraulic models are a very useful aid in engineering practice provided the results are properly interpreted. It is, of course, very important to thoroughly understand the limitations of river models such as inability of models to reproduce silting and hence inability to reproduce changes from year to year, as most of the material moves along the bed of models which is just the opposite in rivers. Hence year to year reproduction is not possible in river models and training measures have to be tested against worst possible attack, which can be gauged after studying various courses of the river in the past.

FUNDAMENTAL FACTORS AFFECTING RIVER BEHAVIOUR

It is necessary to remember that there are two independent variables which cause the rivers to meander, or flow in braided channels, induce cut-offs, etc., one is the water discharge and the other is the silt discharge. So long as the river is able to carry its own load, no serious problem will arise. The trouble begins when the river has to carry bed and suspended load far in excess of its capacity. The Himalayan mountains are relatively young and due to the steepness of the hills huge landslides occur. Besides, the earthquakes shake the mountains leading to landslides; naturally the rivers have to carry huge quantities of debris. As the rivers are unable to carry this load, they

develop braided channels, meanders, etc. There is a misconception that the slope of the country is an independent factor controlling the behaviour of a river. The slope of the country is built by the deposition of the silt brought down by rivers and hence the slope is not an independent factor. So long as we remember this basic conception, we will be on the right track. The lateral movements of the rivers like the Kosi, the Indus, Manas in Assam, Torsa and Teesta in North Bengal are mainly due to the shifting of the flood plains from place to place. A river will go on raising its flood plain to such a level that the adjoining country is much below the level of the flood plains. When this happens, the river will try to leave its raised flood plain and flow towards a low level country side. This again, in its turn, will be built up to such a level that the river will again try to take another course and so on; so the real problem is to arrest the flow of sand at its source by building high dams, etc.; but these are very costly propositions and also not a permanent solution in the long run as the reservoirs upstream of the dams do get silted up and may lose their capacity in course of time. Besides, dams are never constructed for controlling the flow of sand on account of its high cost, unless they are built as multipurpose dams for irrigation, hydropower, etc.

VIOLENT MOVEMENTS OF HILLY STREAMS

An illuminating case of violent movements of Manas river in Assam which is a hilly stream has been described in the Railway Board's Technical Paper 334, 'River Engineering' by late K. B. Ray and is described below in brief:

The Manas is a north bank tributary of the Brahmaputra, which has several loops in the basin—Figures 1 and 2. In 1909, when the railway was constructed in Assam, the Manas loop drained the

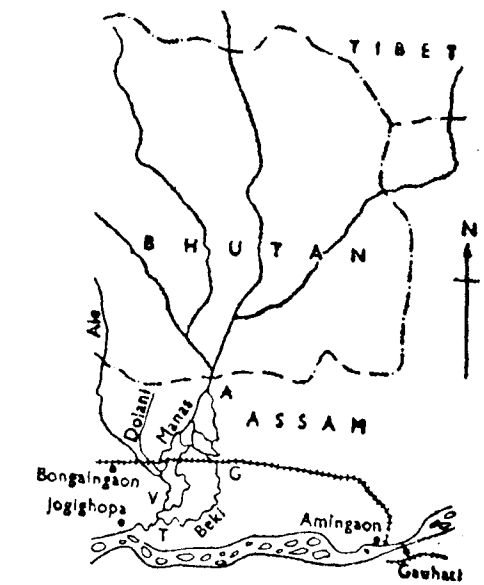


Fig. 1. Showing the Manas-Beki river basin

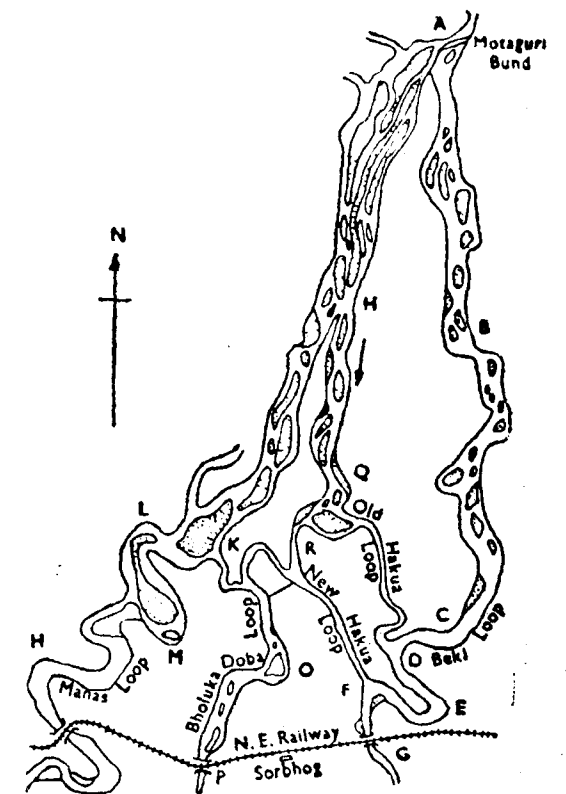


Fig. 2. Showing loop channels in the Manas basin north of the railway

major part of the waters of the Manas basin. The Bholookadoba was then a dying loop, while the Beki or Mara (dead) Manas was also a dying loop channel. The bridges provided in the railway line over these loop channels in 1909 were:

Manas	Bholookadoba	Beki
10 × 100 ft	2 × 75 ft	4 × 12 ft

The Manas emerges from the foot hills of the Himalayas at *A* (Figure 2).

In the reach *AHK*, the slope of the country is very steep, so that the velocity of flow in the river is high and hence its channel is more or less straight. Below *K*, the slope is flat and the river is not able to carry its load and hence there are several loops and meanders. The river channel is very wide and shallow; hence the discharging capacity of the river in this reach is very small with the result that the water is spilled submerging riverside lands. The high level of water found its way through the silted up shallower but straighter Beki loop channel to the latter's outfall into the Manas lower down at *T*, vide Figure 1, due to the great difference of levels, a cataract action started at *D* and worked its way back through the Beki loop. This process went on upstream to the railway bridge near *G* and ultimately to *A* on the Manas loop, thereby establishing a cut-off channel through the Beki loop.

More and more water flowed through the Beki loop whose channel went on improving. Consequently as less water flowed through the Manas loop the Manas channel went on deteriorating.

As the deepening of channel in the Beki loop from *T* reached the railway line at *G*, the 4 × 12 ft bridge having shallow open foundation was undermined and breached. Successive bridges with larger waterways were provided from 1909 to 1945 as under:

- (i) 4 × 12 ft
- (ii) 4 × 20 ft

(iii) 9 × 20 ft

(iv) 1 × 50 ft, 1 × 30 ft, 6 × 19 ft

(v) 1 × 50 ft, 2 × 40 ft, 6 × 19 ft

(vi) 2 × 40 ft, 3 × 100 ft

(vii) 7 × 150 ft

All these years, with lesser and lesser flow, the channel of the Manas loop went on deteriorating. In 1945, only 4 × 100 ft out of the 10 × 100 ft spans in the Manas bridge were effective. By 1945, the channel bed in the Manas loop had risen by 14 ft. In the meanwhile Beki deteriorated because it had to carry excessive charge of material and water level in the Beki went on increasing with the result that a part of the water flow found its way through the channel along *HQROP* of the Bholookadoba loop to its outfall lower down in to the Manas loop at *V* A cataract action started at *V* and worked upstream towards the railway bridge near *P*, and ultimately to *H* on the Manas Loop; a cut-off channel being thus established through the Bholookadoba loop its channel went on improving. The railway bridge on the Bholookadoba loop was subsequently undermined and breached. The successive bridges built on this loop were:

(i) 2 × 75 ft

(ii) 3 × 75 ft

(iii) 1 × 250 ft, 2 × 150 ft

In 1942, it was decided to divert the flow of water in the Manas basin from the Beki loop back into the Manas loop by building the Motaguri Bund across the offtake of the Beki at *A*. This, however, did not improve matters because the Manas channel was inadequate to carry the discharge and the load and finally a new channel was established called the Hakua loop along *HQRF*, having an outfall into the Beki loop at *F*. The big difference of water levels at downstream end of the Hakua loop and the Beki loop started a cataract action which worked backwards along

FROH and establishing cut-off channel with the Manas loop. More and more water went through the straighter channel *AHQRF* improving it while the Beki loop *ABCD* deteriorated.

This problem has still not been solved; but this example illustrates how cautious we have to be in evolving suitable training measures

ILLUSTRATION OF TRAINING MEASURES FOR PROTECTING RAILWAY BRIDGES

(i) Hardinge Bridge on the Ganga

This bridge, now in Pakistan, was constructed on the Ganga river, 200 miles north of Calcutta at a cost of Rs 5 crores on the Bengal-Assam Railway. Two long guide bunds were constructed on either side of the railway bridge to guide the flow, through the bridge. Till 1930, the river flowed along the left bank at the bridge. As the river was showing a tendency to shift, the Raita and Sara revetments were constructed, vide Fig. 3. By 1932, the river completely changed its course and began to

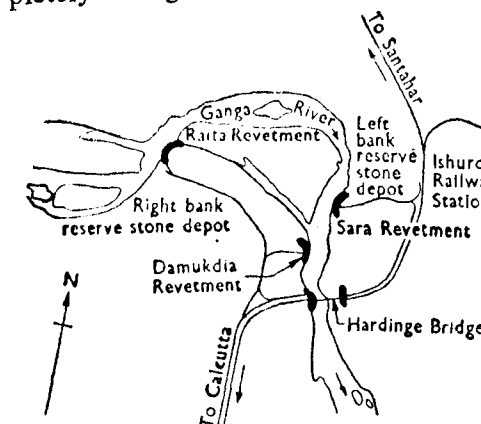


Fig. 3. Showing Ganga river near Hardinge Bridge

flow along the right bank at the bridge. The Sara revetment which was strengthened by stone protection threw the high velocity flow violently across towards the right bank and with the idea of guiding the flow through the middle of the bridge, the Damukdia revetment was constructed in 1932, the alignment

of which was towards the middle of the bridge. This, however, made conditions worse. Instead of the water being guided towards the middle of the bridge, the high velocity, swirling flow hit the head of the right guide bund and caused a serious breach. About a crore of rupees were spent in 2 years by dumping stones, but the tendency to outflank the bridge persisted.

The model tests done at the Poona Research Station clearly showed that the Damukdia guide bund should not have been constructed and that the maximum embayment which would have been caused behind the right guide bund would still have been sufficiently far away from the railway line. But as the Damukdia revetment was already there, it was decided, based on model results, to abandon the Sara revetment (i.e., not to strengthen it by dumping stones); because this would ease the flow of water at Sara and the main current would swing gradually away from the right guide bund. By adopting this measure, it was predicted that the attack on the right guide bund would cease in about 8 years by studying the movement of rivers in the previous years. This was off the mark by just one year—it took 9 years.

In this connection very important investigations were carried out, especially on falling aprons. It was found that the aprons do not launch satisfactorily unless:

- (i) The angle of repose of the underlying material is flatter than that of stones, and
 - (ii) The materials scour easily and evenly.
- (ii) **Failure of the railway bridge on Yashwantpur river (Andhra Pradesh)**

The railway bridge on Secunderabad-Kazipet section of the Central Railway collapsed on 27th September, 1954 due to the Yashwantpur river carrying exces-

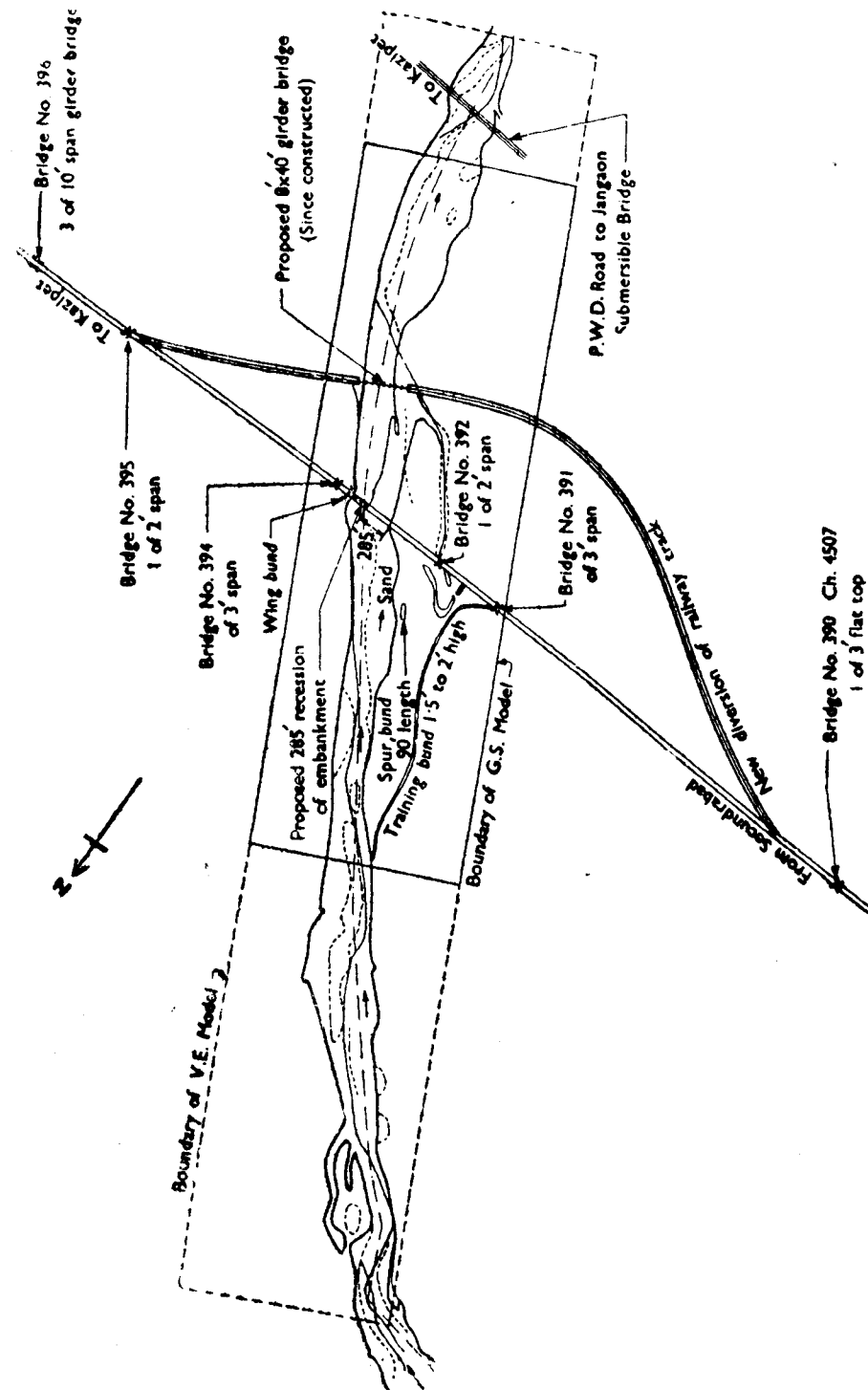


Fig. 4. Showing Plan of Yashwantpur river

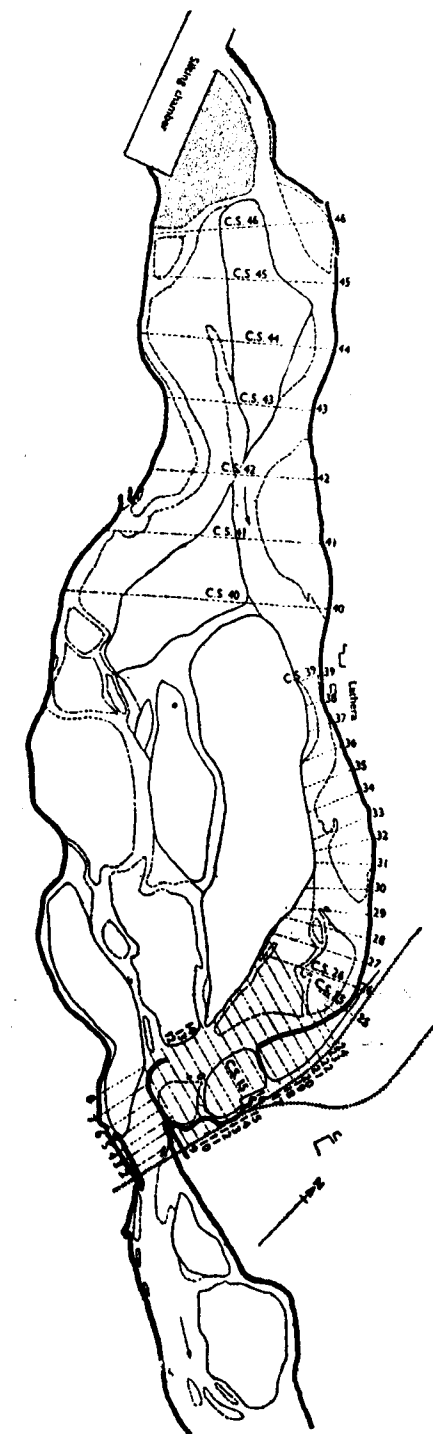


Fig. 5. Ganga river near Garhmukteshwar showing the extended left guide bund

sively high discharge of about 15,000 cusecs against the designed discharge of 8,000 cusecs. This bridge had 4 spans of 20 ft each. The river width in the vicinity of the bridge varied between 300 ft to 500 ft. The orientation of the bridge with respect to the river course was skew—vide Figure 4. It was found that the foundations of piers and drop walls were not sufficiently deep so as to be below the maximum depth of scour. The history of the bridge showed that it was constantly damaged in various years, since its construction in 1885; in 1954 the whole of the bridge was washed away, leading to a serious train disaster and loss of life. New bridge with sufficient waterway was subsequently constructed 800 ft downstream of the old bridge on the advice of the Poona Research Station.

(iii) Protecting the railway bridge on the Ganga River at Garhmukteshwar—Figure 5

When the railway bridge was constructed, the Ganga was flowing straight through the railway bridge. In course of time the river changed its course and swung over towards the left upstream of the railway bridge thus dangerously approaching the railway track. In order to safeguard the railway line, the left guide bund was extended 2,000 ft and was provided with a smooth curved head. The scheme was implemented and the river has now receded from the railway embankment and flows smoothly through the bridge.

(iv) Training works for the railway-cum-road bridge on the Ganga at Mokameh—Figure 6.

A railway bridge was proposed to be constructed at Mokameh to connect South Bihar with North Bihar and the Research Station was approached to make recommendations regarding the training works, depth of foundations of piers, waterway, etc. As the right bank of the river near the bridge site consisted of stiff clay, only one guide bund on the

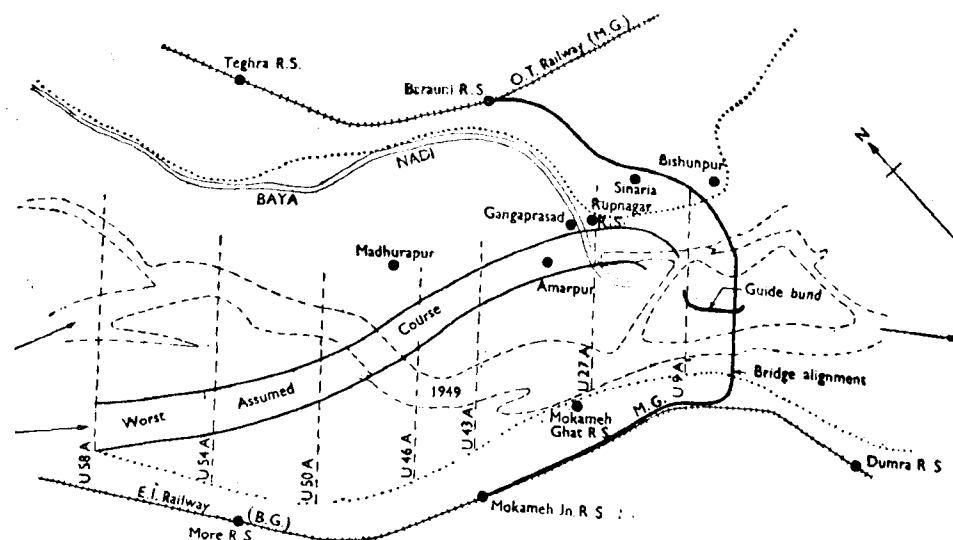


Fig. 6. Plan showing 1949 course and the worst assumed course with main channel near Madhurapur village—Model of river Ganga at Mokameh

left was proposed. The optimum length of the guide bund was determined by model experiments so that the high velocity flow through the bridge was away from the right bank. The guide bund was tested under worst possible course of the river. The maximum depth of scour at the pier was taken to be $2D$ as observed from proto type data of various bridges where $D=0.47$ (Q/f) $\frac{1}{3}$ rd (Lacey) and it was recommended that the bottom of piers should be taken $=3D$ below H.F.L. This would not require any stone pitching round piers, as $\frac{1}{3}$ rd the pier depth would afford a sufficient grip. Previous experience with shallow foundations had shown that to maintain this $\frac{1}{3}$ rd grip, piers have to be protected with stone pitching at fairly high levels, for instance, at Hardinge-Bridge on the Ganga river. This high pitching is a serious obstruction to flow causing dangerous scour downstream of the bridge into which stones round the piers slip requiring heavy annual maintenance. When piers are taken sufficiently deep, as in the case of Mokameh bridge, stone pitching is not required at all. It was also recommended that the work of the left guide bund with its curved head etc., and the railway approach bank connect-

ing the left guide bund and the left bank of the river should be done in one working season to avoid serious trouble. The above works were successfully completed in one season.

(v) Training the Rupnarain River at Kolaghat—Figures 7 and 8.

There is a railway bridge on the Rupnarain river at Kolaghat, about 35 miles from Calcutta. Due to very high floods in 1943, the river eroded the left bank and dangerously approached the railway embankment and there was every danger of the railway bridge being outflanked. Local officers suggested a series of short groynes to protect the left bank. The Station, however, objected to this proposal on the grounds that the river would be held permanently against the left bank, though the bank would itself be protected by such spurs at a high maintenance cost; instead, the Research Station recommended a long repelling spur 1,000 ft long facing upstream. This was constructed at a cost of about Rs 20 lakhs and has been found to be very successful as will be seen by comparing Figures 7 and 8. When the spur was constructed, there was a channel 20 ft deep flowing along the left bank. After the construction

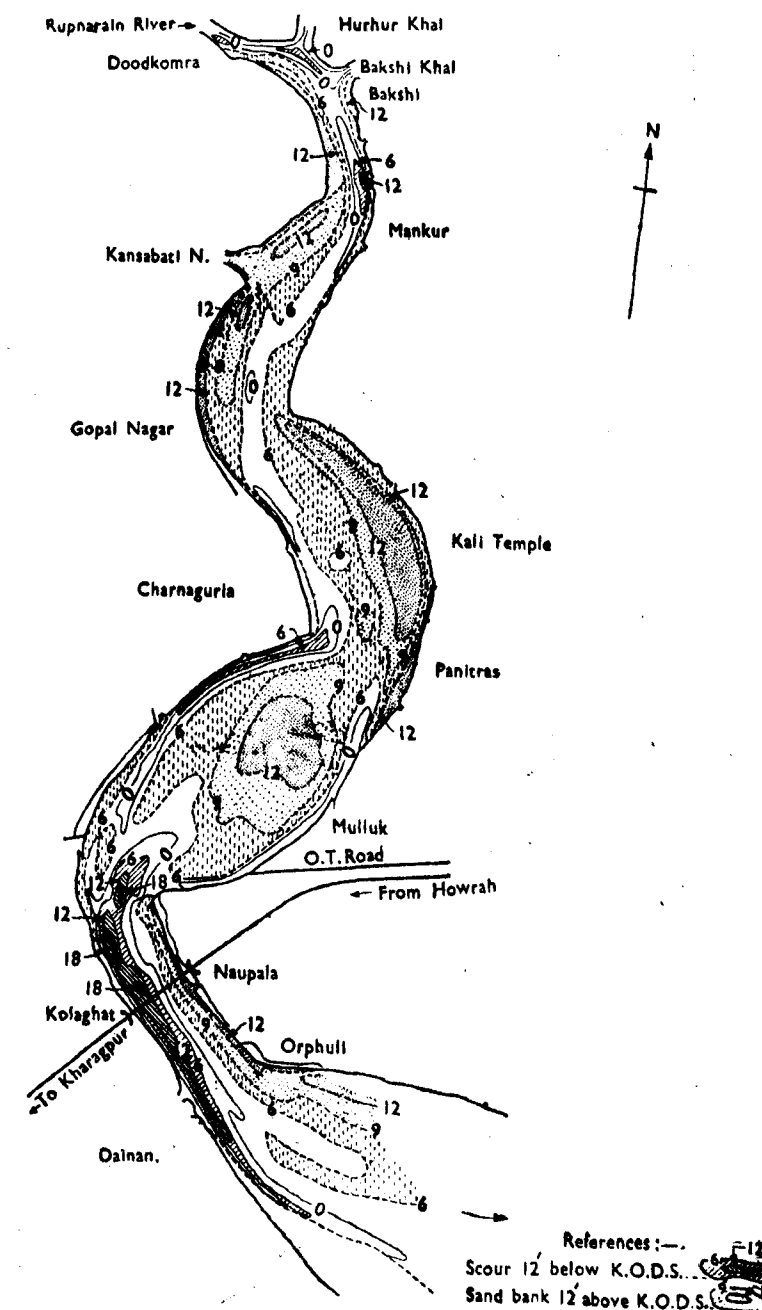


Fig. 7. Showing survey plan of Rupnarain river, Bakshi to Dainan, from 6th to 14th and 21st to 28th January, 1944 (Contours reduced to K.O.D.S. 7.759 ft below M.S.L.)

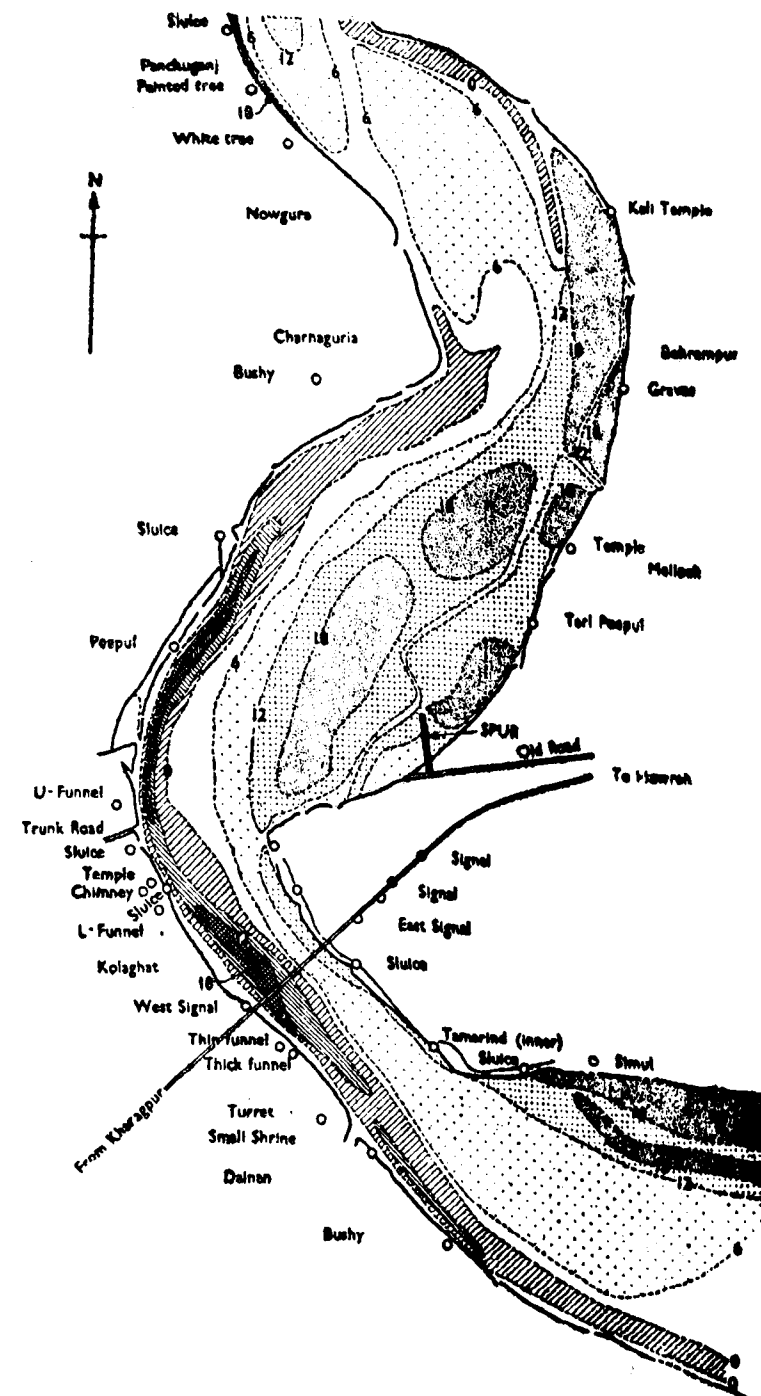


Fig. 8. Showing survey plan of Rupnarain river, Charnaguria point to Dainan, from 17th to 19th April 1946

f the spur, the river has been repelled
way from the left bank by about a mile
nd the spur is now buried in sand.
ncidentally the approach to the rail-
ay bridge also improved.

(vi) **Training the river Narbada at Broach (Gujarat)-Figure 9**

There is a road and the railway bridge on the Narbada river near Broach. A

straight sloping guide bund was constructed by the railway department on the left bank at right angles to the railway bridge, the nose of the bund nearly reaching the bed of the river. It was, however, found that during floods a big swirl formed due to water coming from behind the bund and meeting the high velocity flow of the river. This resulted in a very deep scour-hole just upstream

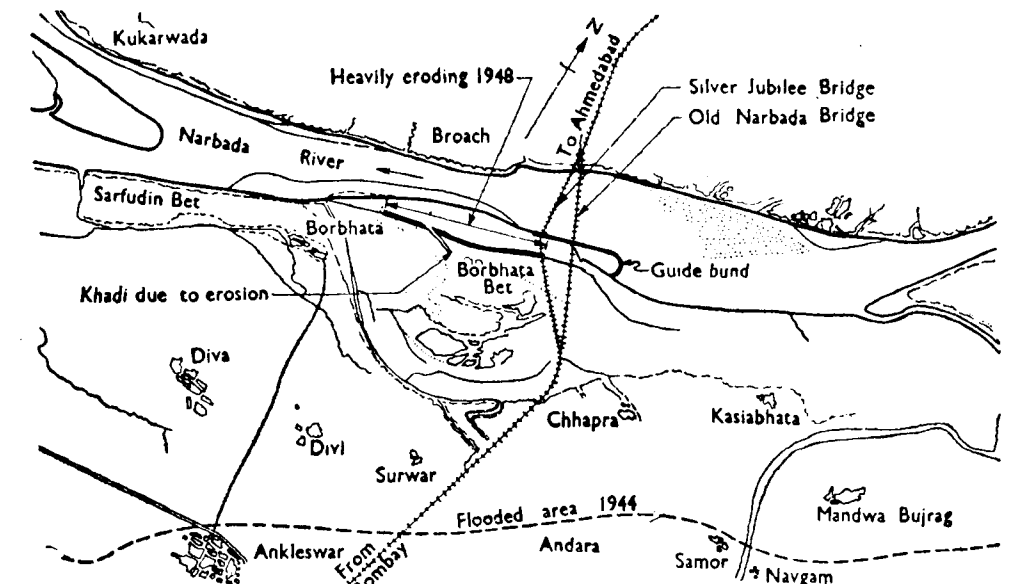


Fig. 9. Index plan showing erosion of the Narbada river at Broach and the low level lands on left bank susceptible to flooding

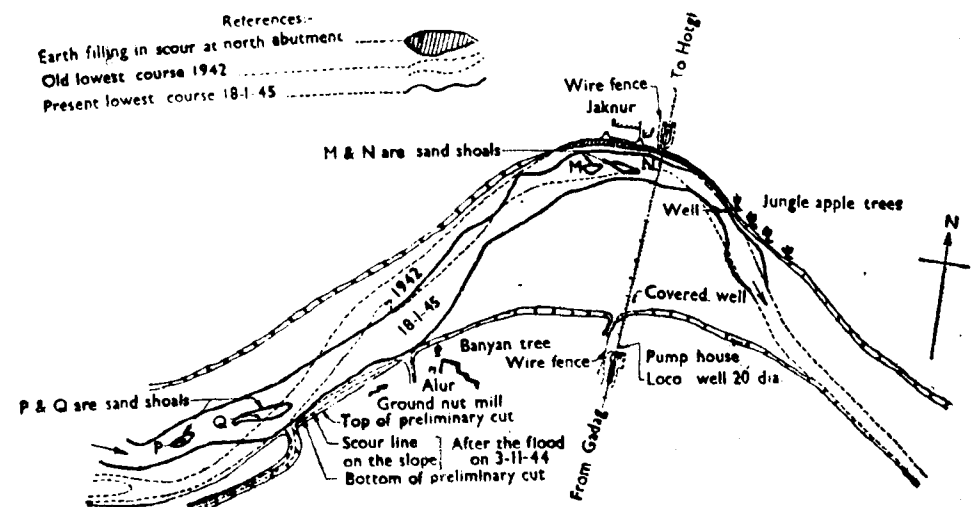


Fig. 10. M. & S.M. Railway protection to bridge No. 8 on the Malaprabha river near Hole-Alur. Plan showing course of river before and after preliminary cut at right bank mile 30/10-15 G.D.G.—S.U.R.M. Line

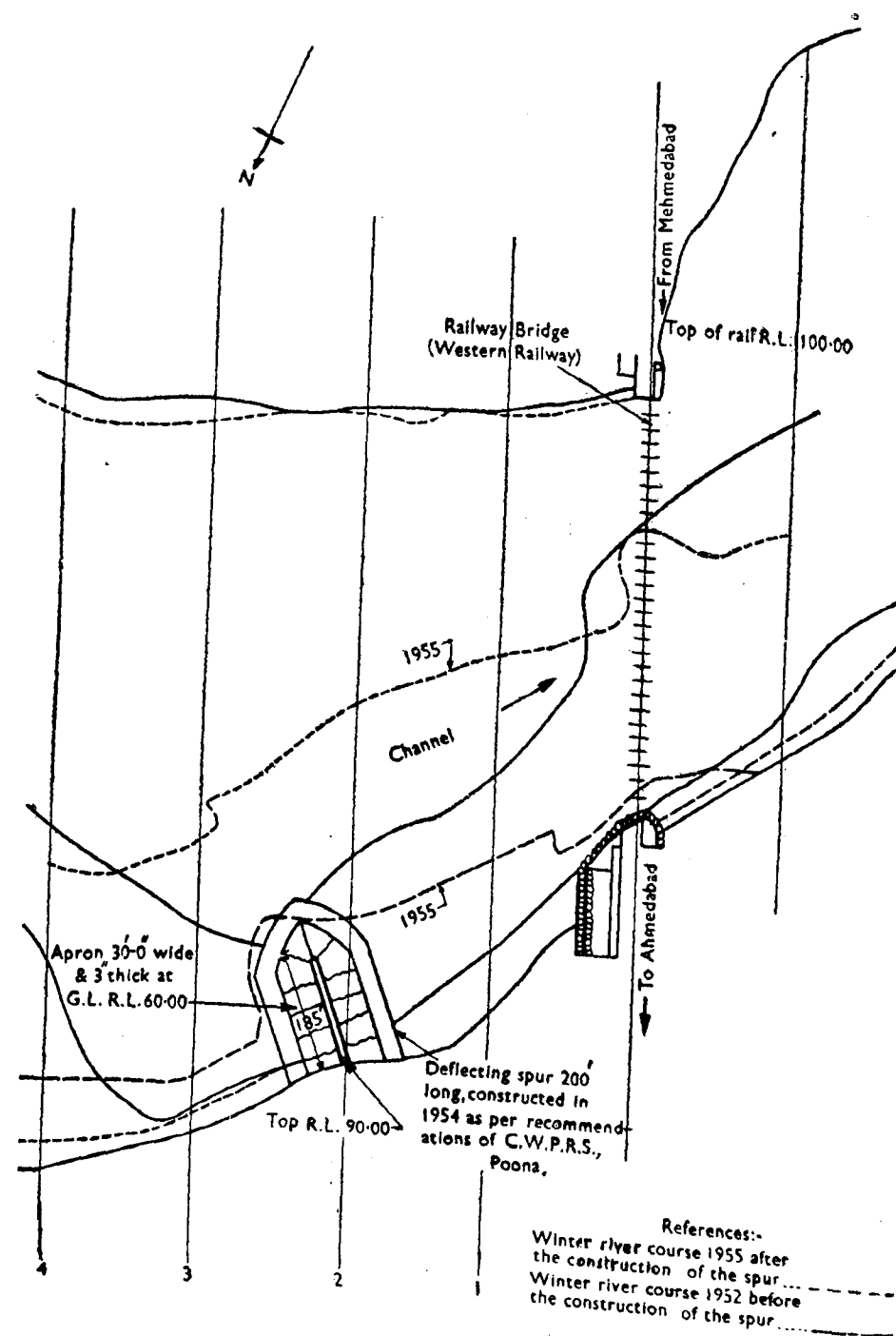


Fig. 11. Showing Western Railway Watrak bridge No. 695 at mile : 292—4173 ft.

of the bridge, thus endangering its safety. After model experiments it was recommended that the guide bund should be taken above H.F.L. and should be provided with a curved head. The scheme is being implemented.

(vii) Training the Malaprabha River near Hole-Alur-Figure 10.

The left abutment of the railway bridge on the Malaprabha river was subject to very severe action and the Research Station was asked to devise suitable training measures. Inspection of the site revealed that a natural cut-off had occurred about 10 miles downstream of the railway bridge. This cut-off induced a steep slope upstream causing severe action at the railway bridge near the left bank. It was recommended that the projection of the right bank upstream of the railway bridge should be cut so as to relieve attack near the left abutment. This has since been done and the river has completely swung away from the left abutment.

(viii) Protecting the right abutment of the railway bridge (Western Railway) on the Watrak river near Mehmedabad (Gujarat).

Upstream of the railway bridge, the river has a very sharp, right angle bend and the approach to the bridge is oblique, Figure 11. The river was eroding the right bank upstream of the railway bridge and there was a danger of the right flank of the bridge being out-flanked. The Poona Research Station was, therefore, approached to suggest suitable training measure to ensure the safety of the right abutment. Experiments revealed that it would be very difficult to train the river to make it flow centrally through the bridge. Therefore it was decided to give local protection. A short spur 185 ft long pointing upstream of the bridge was recommended, Figure 11.

This was completed before the 1955 flood season and the results achieved are very satisfactory in that silting has occurred near the right abutment and the flow has swung slightly away from the right bank.

To conclude, it will be seen that the training of rivers has to be done with proper discrimination after taking into account their characteristics.

(From "Irrigation and Power", April 1959).

ANGELIC CAUTION

When the congregation of an Ohio church left the service, they found the following notice posted in the parking lot: "While you were at services this morning, we blessed your nice cars. Still, it is necessary to drive carefully, because even the angels might jump out when you hit 80 mph."

—HERMAN E. KRIMMEL.



Sir W. H. GLANVILLE, Kt., C.B.,
C.B.E., D.Sc., M.I.C.E., F.R.S.
Director of Road Research,
Department of Scientific and Industrial
Research, United Kingdom

ROAD RESEARCH IN GREAT BRITAIN

ORGANISATION

IN Great Britain the Department of Scientific and Industrial Research is the government organisation entrusted with the task of carrying out research to meet the civil needs of the people: military research is the concern of other bodies.

This Department set up the Road Research Laboratory in 1933, a year only before the Indian Roads Congress came into being. At first the new Laboratory concerned itself with road materials and methods of road construction almost entirely but in 1946 a new division was formed to study traffic and safety problems: at the present time the Laboratory aims to find economical ways of reducing the frequency and severity of road accidents, of facilitating traffic flow and of designing, constructing and maintaining roads.

The work on materials and construction is carried out mainly to assist the many county and urban highway authorities and also to help the road making industry and the manufacturers of road contractors' plant. The work on traffic and safety is planned to assist those concerned with the administration, planning and layout of roads and also to be of value to vehicle manufacturers, street-

lighting engineers and other specialist groups. Much of the work of this Division is of importance also to all road users.

The Laboratory keeps in close touch with the Ministry of Transport and Civil Aviation and co-operates with them in all the experiments involving road construction, but other government departments use the results of the Laboratory's researches and invoke their aid from time to time, notably the Ministry of Housing and Local Government, the Home Office, the Air Ministry and the Ministry of Supply. Research on road problems in tropical areas is carried out by a Tropical Section and various co-operative research arrangements are maintained with the British Road Tar Association, the Road Bitumens Association, the Cement and Concrete Association, the Natural Rubber Development Board and the Chalk Lime and Allied Industries Research Association.

The total staff of the Laboratory is about 550, of these some 140 have university degrees or other professional qualifications and some 190 are graded as industrial workers, many of them in skilled specialist categories.

The total expenditure is somewhat under 600,000 pounds per year. At the

present time Great Britain is seeing a welcome revival in road building to meet the ever-increasing congestion on our roads caused by a steady growth since 1952 of some 7 to 8 per cent per year in the number of motor vehicles licensed. The annual expenditure on the Laboratory should be seen against this problem as a background, the cost of Britain's first motorway being some forty times this sum, viz., 23,000,000 pounds.

RESEARCH PROGRAMME

At the present time some 40 per cent of the Laboratory's research effort is devoted to traffic and safety problems and 60 per cent to problems concerned with materials and methods of construction. The main investigations can be briefly tabulated as follows:

Traffic and Safety

Traffic engineering: Study of traffic flow and accidents, influence on them of road layout, street lighting, road signs, traffic regulations and the characteristics of the road surface. Study of skidding resistance and surface irregularity of roads: study of parking and related problems. Assessment of priorities for road improvements.

The vehicle: Investigation of the features of vehicles and their equipment that influence the movement of traffic and the safety and comfort of road users. A prominent investigation in this group is concerned with lessening the risk of death or serious injury in an accident.

The road user: Characteristics of people as road users including their habits and patterns of behaviour, physical and psychological factors influencing perception and judgment. The effect of propaganda, education, training and legal regulations.

Materials and Methods of Construction

Soils: Studies of road foundations,

moisture movements and drainage, problems in the compaction of soil and the construction of earthworks, methods of soil stabilization.

Roadstones: The economical production of roadstones, methods of testing and assessing their significant properties.

The design of roads: Development of methods for designing roads as structures: measurement of the elastic properties of roads and subgrades including the dynamic stresses developed by traffic. Classification of traffic and measurement of its damaging power as a factor in road design.

Concrete: The design of the mix where the concrete is to be compacted by vibration; factors affecting the rheological properties of mixes: design of road slabs, design and construction of joints; mechanization of construction processes, field control of concrete quality: improvement of concrete kerbs and other concrete products.

Bituminous materials: Development of durable non-skid surfacings for roads carrying heavy traffic using local materials: methods of improving the durability of tars and bitumens and the development of better tests for the performance of these binders, improving methods for the control of materials and processes. Effect of adding rubber on the performance and life of bituminous surfacings.

Special problems: Development of methods of testing road materials non-destructively and of studying roads and subgrades as structures using techniques of vibration, propagation and radiation absorption: prevention of formation of snow and ice on roads by electrical heating and other means, removal of snow and ice from roads and control of drifting snow by "snow" fences. Development of improved methods of designing surface-water drains. Economic studies of the lives of surfacing

and bases and of the costs of materials and processes of road construction.

Full-scale road experiments. The design, construction and subsequent study of experimental lengths of road in many parts of Great Britain forms an important part of the Laboratory's work. Special attention is paid to the performance of plant.

IMPORTANT RESULTS OBTAINED

Traffic engineering: The results of fundamental investigations on the laws of traffic flow have been applied to estimate the value of various schemes put forward to relieve congestion at many of the main intersections in Central London and several other large cities. One investigation has been concerned with the correct setting of traffic lights to ensure that delays caused to traffic are a minimum.

Skidding: To measure the skid-resisting properties of roads, special test vehicles have been developed, including apparatus for measuring at up to 100 miles per hour. Two test cars are kept fully employed in assessing the slipperiness of various experimental road surfaces and in carrying out measurements to assist highway authorities all over the country.

The importance of "non-skid" road surfaces as a means of preventing accidents in wet weather is illustrated by "before and after" studies of the accident records of 55 short stretches of road where the skid-resisting properties of the road surface were improved because skidding accidents appeared to be unduly frequent. This change effected a saving of some 700 accidents during the period of some 2½ years after treatment. In monetary terms alone, this reduction in accidents probably represents a saving of about 100,000 pounds a year. Many other sites where similar savings are being obtained have come to light in the course of the Laboratory's work in recent years, and a simple

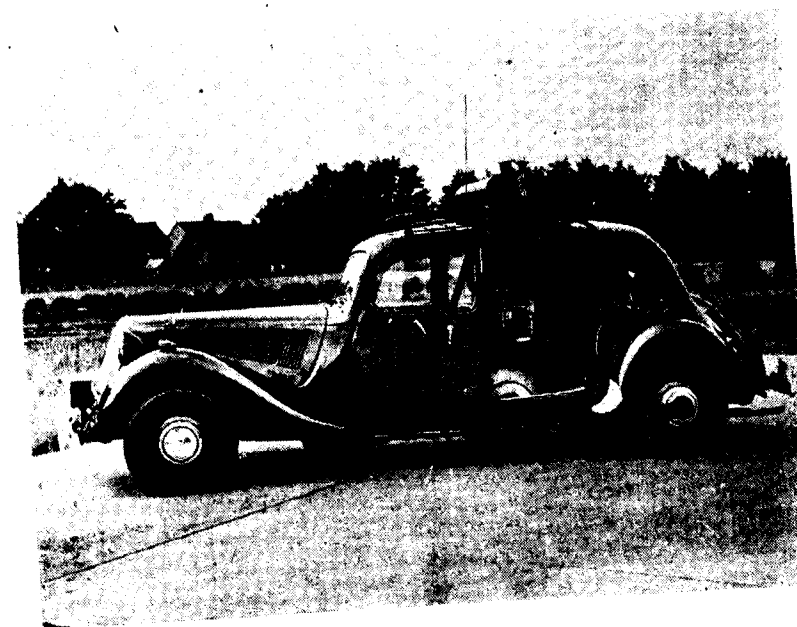
method for locating such sites promptly with the help of the police accident reports has been worked out. Work is also in hand to lay down the standards of skidding resistance required if frequent skidding accidents are to be prevented.

Under heavy traffic the polishing of road stones can be an important factor causing slipperiness. Stones differ in their ability to resist this polishing and a laboratory test has been developed to test their behaviour in this respect. Recent work which has thrown new light on the role of the tyre tread rubber in resisting skidding should also result in important improvements in the skid-resisting properties of tyres on slippery wet surfaces.

A small portable device has been developed for making rapid routine checks of the resistance to skidding of roads when wet. It is undergoing extensive trials with a view to its use by local authorities.

Statistics: A continuous watch is kept on traffic trends by the analysis of traffic census data, and the value of changes in road layout and other features are assessed by studies of accidents before and after the change. A similar analysis is made from time to time of the effectiveness of regulations and other forms of control: good street lighting in urban areas has been shown to be particularly effective in reducing accidents at night.

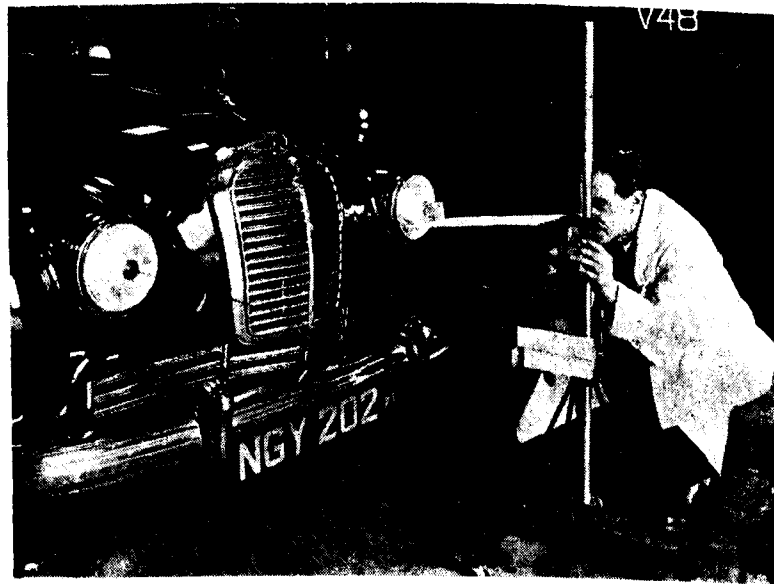
Vehicles: With the co-operation of the police in several neighbouring localities, teams from the Laboratory are called to the scene of each accident. They make particular note of any feature of the vehicle or vehicles concerned which contributed to the death or injury of those involved. In this way data are being collected together for the assistance of vehicle designers. Contacts have been developed in recent years with the manufacturers of motor vehicles and accessories. Here the findings of the Laboratory's researches have



Skidding test car for measuring skidding resistance of roads when wet



Portable device for making rapid check on the resistance to skidding of road when wet



Sample devices developed by Road Research Laboratory for directing headlamp beam

influenced the design of headlights, safety-glass windcreens, direction indicators and rear reflectors.

An extensive study of the dangers of poor rearlights was carried out in 1951. They were shown to be responsible for some 3,400 accidents a year representing an annual loss to the nation of some 2,000,000 pounds. In 1953 the Laboratory's recommendations were embodied in the Road Transport Lighting Act 1953. It empowered the Minister of Transport to prescribe the minimum intensity of rearlights.

When the use of rear reflectors became compulsory the question arose of testing the various types offered for sale to ensure that they reached an acceptable minimum standard. The Laboratory devised a compact photometer for this purpose and, by investigating the geometry of these reflectors, indicated the essential requirements for a reflector of high performance.

Crash helmets for motorcyclists: The Laboratory has taken the leading part

in the development of more effective crash helmets for motorcyclists and the experimental work carried out in the development of tests has formed the basis of the present British Standards Institution's Specification.

Zebra crossings: The well-known zebra pattern used in Great Britain to indicate the presence of a pedestrian crossing was arrived at as a result of experiments carried out by the Laboratory.

Road design: The full-scale road experiments cover in all several miles of trunk road carrying heavy traffic. Their main object is to provide data on the various alternative forms of road construction as regards first cost, maintenance costs and length of life. Techniques are being developed for measuring the properties of these roads as structures by studying the propagation of vibrations in them. In parallel experiments gauges buried in various layers of the road structure and in the subsoil are used to record the extent to which

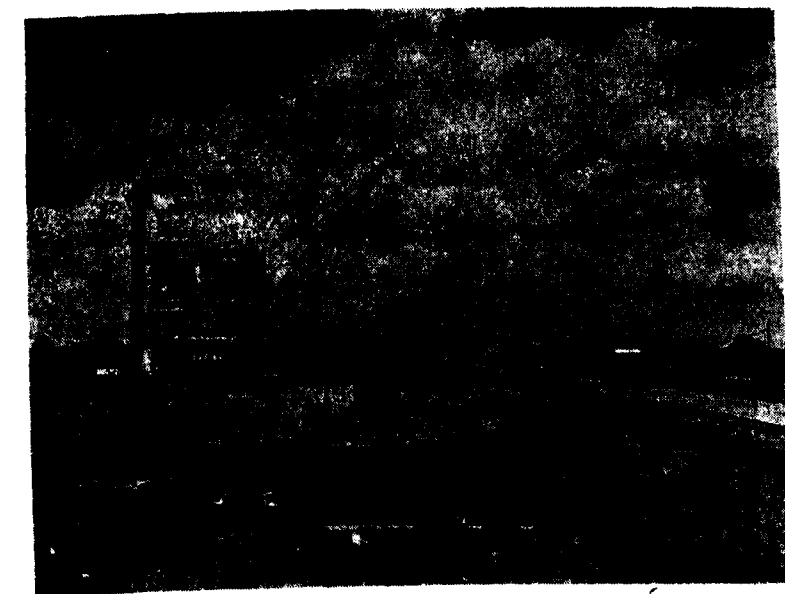
the loads due to traffic are reduced in intensity in the successive layers of the structure. All these measurements and others of dynamic strains, stresses and deflections in road structures are combining to yield a picture of the fundamental behaviour of a road as a structure. In this connection, a sustained vibration method is being developed for measuring the dynamic shear modulus of soil in-situ and the thicknesses of soil strata, it is being developed for site exploration to assess the bearing capacity of the soil forming the bed of a proposed road.

Soil stabilization: An economical road base can often be made by stabilizing the soil of the road bed with cement. The Laboratory has taken a leading part in research directed to extending the use of this process in Great Britain, and has co-operated with plant manufacturers in developing equipment for the construction of a soil-cement base. The use of the process in the last few years has saved more than 250,000 pounds in the construction

the roads needed in new housing estates and has reduced the cost of providing the runways for Southend Airport by 180,000 pounds.

Soil compaction: An immense amount of data has been collected regarding the performance of a wide variety of soil compaction plant on a wide range of soils; these data include the depth of the compacted layer and the increase in density achieved per pass at a selection of moisture contents within the working range. This information has been summarized in three Road Research Technical Papers which are now the standard works of reference in Great Britain and abroad on the compaction of soils to form road beds and earth embankments.

Concrete: The Laboratory's method of designing a concrete mix taking strength and workability into account, is now widely used. For very high strengths the mixes are on the dry side and this has introduced problems in the design of mixers so that the finer constituents of the mix are not left behind in



Full scale experiment on A. I. Great North Road, Great Britain.
Laying concrete sections

the mixer. A method has been developed of measuring the performance of a mixer in these respects which also gives an indication of the minimum time of mixing required; by its use and with the co-operation of manufacturers some improvements have been obtained in the design of modern mixers.

Non-destructive testing: Techniques have been developed for estimating the quality of concrete in-situ by measuring the velocity in it of pulses of ultrasonic vibrations. This velocity has been linked with the density and compressive strength of a particular concrete. This technique has provided a method of examining concrete structures without weakening them in any way such as by cutting out test specimens. It has been applied to the inspection of many structures notably to the concrete biological shield at the Atomic Energy Authority's works at Windscale, prestressed concrete hangers at London Airport and a reservoir at Mansfield in Nottinghamshire. Some 40 sets of test equipment to the Laboratory's design have been made by a commercial firm and sold to consultants, contractors and research organizations at home and abroad.

Surface dressing: Rather more than half the mileage of roads in Great Britain is of water-bound macadam which is kept waterproof and resistant to skidding by periodic applications of bitumen or tar and chippings. The Road Research Laboratory has determined the conditions to be observed for obtaining a long life for a dressing. It has helped to develop reliable machinery to carry out the dressing process with speed and economy and has carried out a great number of full-scale experiments to give precision to the specifications for surface dressings now in use. As a result,

surface dressings are now giving much longer service with an annual saving to the country of several million pounds.

Chemical agents have been developed at the Laboratory which can be used to prevent a freshly laid surface dressing from being damaged by rain before the tar or bitumen has hardened. This was a consequence of a fundamental study of the nature of the adhesion between a roadstone and a bitumen or tar. These agents are now used on a large scale with considerable savings to the country.

Bituminous carpets: The full-scale experiments carried out by the Laboratory have provided information of importance in drawing up the present-day specifications for asphalts and coated macadam; they have also led to the development of a new material, dense tar surfacing which has some of the characteristics of an asphalt but tar—a home-produced material—is used as the binder in place of imported bitumen. In addition, a bituminous surfacing material has been developed in which the aggregate is used wet and hydrated lime is added to the binder. This is particularly suitable for providing *low-cost roads in remote areas.*

In concluding this account of rather more than twenty five years of road research in Great Britain as carried out at the Road Research Laboratory, may I express my thanks for the many friendly and helpful contacts we have had during that time with Indian engineers and organizations, foremost among which is the Indian Roads Congress, you enter upon your next twenty five years of work with every good wish from us.



S. R. MEHRA, C.E., M.I.E.,
(Ind); M.I.C.E. (Eng); F.I.N.
Director, Central Road Research
Institute, New Delhi

ROAD RESEARCH IN INDIA

ORGANISATION

THE Council of Scientific and Industrial Research, New Delhi, has sponsored the work of carrying out research in various branches of science and engineering in India. The Council has established 23 national laboratories since the last 10 years or so, and the Central Road Research Institute, New Delhi, is one of them. The Defence Science Organisation working under the Ministry of Defence of the Government of India undertakes military research in this country. Apart from this, there are research laboratories for Rice, Agriculture, Medicine, Jute, Cotton and Forest, under the various Ministries of the Government of India and also some industrial research laboratories organised by the industrial concerns either individually or on a co-operative basis.

Organised road research in India, comparatively speaking, is of recent origin. Nevertheless, in the annals of the Indian Roads Congress, there were quite a few research papers presented from time to time either by individual engineers who happened to take interest in research or by some of the individual laboratories attached to PWD organisations. Because of limited finances available at the State level, the work in these laboratories was mostly confined to material testing and quality control of road construction.

Till the beginning of the Second World War, road design and construction followed the old patterns. Though some experimental field works on roads were carried out, systematic road research was limited. Since the last 12 years some road research laboratories have been established by the P.W.D's of States, such as the Punjab, U.P., West Bengal and Madras, where research on materials and construction according to their particular soil and climatic conditions has been organised.

The Central Road Research Institute was established in the year 1952. In the beginning, research was started in the Soils, Bitumen and Concrete Divisions for carrying out fundamental and applied research. Soon after, a Roads Division was formed for practical utilisation of the results of research carried out in the Soils, Bitumen and Concrete research divisions. The function of the Roads Division is to apply the results of research by constructing experimental test tracks inside the Institute and then pilot plant stretches of roads on a semi-field scale. The test track and semi-field scale trials are co-related with the findings of the laboratory results and when any particular processes are found to be successfully demonstrated, the Roads Wing of the Ministry of Transport, Government of India, sponsors full length experimental construction, with

a view to introduction of acceptable techniques.

In 1955, a new division—Traffic Engineering, Economics and Statistics—was started to investigate, among other things, into the problems of road traffic and safety in relation to the geometrics of highways and the psychology of road users.

The Institute maintains effective liaison with the Ministry of Transport and Communications, Public Works Departments of various States, C.P.W.D., the Engineer-in-chief, Army Headquarters, and Industrial concerns dealing with the road materials, as well as other road research institutes in different States in this country through the Indian Roads Congress.

This Institute, as it is constituted, is the premier research organisation in India dealing with road problems on an All-India level. While this work is done in many cases entirely with the available resources of the Institute, in quite a few cases, co-operative research is conducted with the co-operation of various public works departments and their research organisations, city corporations and private industry. In addition to the day to day design and construction problems some of the State laboratories are also taking up some problems on research level. The State laboratories act essentially as Testing and Control Laboratories and take up research on problems arising out of actual execution of work. Relevant data is used by the Central Road Research Institute for research on problems of an All-India nature.

The Institute's buildings consist of a three-storeyed administrative block, a technological block, a separate library wing, auditorium and canteen. At present the ground floor of the administrative block and the technological block are completed and in use, while construction of the other portions is in progress at present. The total estimated

cost of the buildings will be about Rs 30 lakhs.

The Central Road Research Institute has a total strength of about 400 at present, of which about 100 are engineering and scientific personnel engaged in research, about 200 in other technical services as aid to research, and about 100 in the administration, accounts and other sections.

The recurring expenditure of the Institute is about Rs 15 lakhs per year and this is expected to rise to about 22 lakhs per year in view of the great increase in the research activities of this Institute and the extra work that would be generated during the Third Five Year Plan period on account of a greater tempo in the road development programmes.

The important items of research and the results obtained so far in India are outlined in the following paragraphs.

SOILS

Stabilization of soils with soft aggregates

Brick ballast or naturally occurring soft aggregate such as laterite, kankar, moorum, soft stone, slate, etc., which would otherwise get crushed when used as water bound macadam can be considerably improved in strength by mixing it with twice its volume of graded soil, and compacting the mixture at optimum moisture. This results in a crust in which the soft aggregate is protected right round by a cushion of soil which prevents it from crushing and helps in maintaining the strength of the resulting road crust. About 250 miles of road constructed according to this method during the last many years have shown that such a specification after a thin bituminous surfacing can easily take a mixed traffic of about 200 tons a day. For a traffic of about 500 tons a day the same specification can be adopted after pro-

viding a stone graft on the surfaces prior to bituminous treatment.

In many areas, the cost will be almost half that of surface treated water bound macadam, which is supposed to be the cheapest conventional road. These roads are normally recommended for areas with water table lower than 6 ft. The adoption of this system of road construction will go a long way in considerably reducing the cost of roads in the coming development plans.

Soil cement

The work carried out so far in other parts of the world has shown that soil can be stabilized against weathering effect with a concentration of cement varying from 7-12 per cent. Making use of the facts that blending of soils is possible in the alluvial plains of India, and that frost conditions do not exist except in very limited areas, a concentration of cement as low as 2.5 per cent on the dry weight of soil has been very successfully used, though in a limited length in road bases. This result will greatly effect the economy of road construction in many areas.

Note: The use of 2.5 per cent soil-cement has also been tried in 1948 in India in the construction of walls of 4000 permanent houses. This is considered to be the biggest project of its kind in the world. The houses have since been watched and are giving satisfactory service.

Compacted soil as a part of the road pavement

An extensive study has been made of recent road failures and almost in every case, the cause appears to have been inadequate thickness of pavement, in relation to the heavily increased traffic (both in loads and in intensity), and the bearing value of the subgrade soil.

The obvious answer is to provide

increased thickness of hard pavement in future construction or re-construction which may, however, not be practicable due to the very heavy increase in cost. The study established a case for replacing the stone in a substantial portion of the designed thickness of pavement with compacted soil, provided a minimum density was specified to ensure a minimum C.B.R. value (saturated) which would be far higher than that of the natural subgrade. The cost of carefully controlled compaction would be hardly 10 per cent of the cost of stone it would replace.

Stabilization of soil with lime

There is increasing laboratory evidence that it is possible to considerably improve the bearing value of alluvial soils in soaked condition by using as small concentration of lime as 0.5 per cent to 1.0 per cent. There is a *prima facie* case for proper exploitation of this type of stabilisation by incorporating it in the top layer of embankment compaction, (which has already been advocated) with a view to further reduction in the thickness of the hard crust. Field trials on a progressively increasing scale are being planned.

In case of black cotton soils, it has been shown that the use of 5 per cent of commercial lime considerably reduces the plasticity index, thereby making them fit for use in base courses of road pavements as a cheaper substitute for stone soling. This will go a long way in reducing the cost of road construction as so far stone has had to be used throughout the entire depth of the road pavement which varies from 16-18 inches.

Study of soft aggregates

There are large deposits of soft aggregates in India which have so far been rejected for use in permanent road construction on account of their weak strength. A systematic study carried out on almost all the different types of such aggregates such as kankar,

moorum, laterite, shale, etc., collected from all over India shows that the aggregate impact values of a majority of samples vary from 15-50 which fully justifies their use in certain layers of a road pavement. It seems obvious that these materials are not only acceptable for use in the base course for which the limits of aggregate impact values are 40-50, but a large majority of them can also be used in the upper course of the water bound macadam. This will considerably reduce the cost of water bound macadam road construction in certain areas. The material which is still weaker and has an aggregate impact value varying between 50 and 60 can also be used according to Mehra's method of soil stabilization for light and medium traffic. The study has clearly shown that before any road project is undertaken, it is very necessary that a detailed survey of the area for location of naturally existing road material should be taken up to economise the cost of construction by scientific exploitation of local materials.

Subgrade moisture study

For economical design, it is necessary to know the worst moisture condition which the subgrade is likely to attain during the life time of the road so that design tests are carried out under conditions comparable with anticipated actuals. In the absence of such information the only alternative is to continue designing thickness "at saturation" irrespective of the fact whether the road is being constructed in wet or dry areas. This obviously leads to over designing in certain areas.

During the investigation of an extensive damage to roads in England due to drought conditions in 1947, it came to notice that moisture of the subgrades under surfaced roads remains constant and substantially below saturated condition. This fact has an important bearing on road thickness design in England.

Whereas in England the fact stated above is now accepted as a basis for pavement design, there is considerable doubt as to whether and to what extent, the phenomenon applies to tropical regions like India. It is obvious that in India, the moisture does not remain constant throughout the year as in England, but it is very probable that it does not reach saturation either, in many parts of the country.

To know the extent to which the subgrade is wetted during the year, an all-India survey was carried out immediately after the recession of the monsoon to find out the degree of subgrade saturation in different parts of India. For purposes of this investigation, India was divided into different zones based on the soil type and rainfall conditions. It has been found that the degree of saturation in different parts of India varies from 20 to 100 per cent. It appears that it should soon be possible to lay down factors for different regions, which could be applied to the thicknesses of crust calculated by the standard methods, to allow for the maximum saturation attainable by the subgrade in a particular area. This may not only make the design-work more rational but also result in economies on an overall basis.

CEMENT CONCRETE

Surkhi as pozzolana

Fundamental work carried out in India has revealed that the efficiency of burnt clays for use as pozzolanas depends upon the mineralogical composition of the clays, the temperature of calcination, the state of crystallinity of the burnt products and the fineness to which these are pulverized. It has also been established that the surkhis made from burnt bricks are generally not reactive.

Replacement of cement by properly prepared surkhi to the extent of 20 to 25 per cent (by weight) does not materially affect the strength or abrasive resistance

of concrete. On the other hand, the resulting concrete is more resistant to sulphate attack and alkali-aggregate reaction.

The problem of locating suitable major deposits of pozzolanic materials has been taken up in the form of an All-India survey of clay deposits that could yield reactive pozzolanas.

Design of concrete mixes

In India, the roads are subjected to mixed traffic of both iron and pneumatic tyred vehicles. Hence, it is imperative that design of concrete mixes should also take into account the abrasive resistance of the hardened concrete, in addition to the strength. An apparatus, known as "Pneumatic sand blasting cabinet" has been evolved to differentiate various concrete mixes in terms of their abrasive resistance.

To make full use of the locally available concrete aggregates, especially fine aggregates, which do not satisfy the accepted specification requirements in terms of their gradation, gap grading of coarse aggregates has been found to offer a solution in using these in concrete. A method of designing concrete mixes, based on gap graded principle, has been developed.

Air-entrainment of concrete

The work done on entrainment of air in concrete has revealed that by suitably adjusting the water/cement ratio and sand/aggregate ratio, it is possible not only to offset the loss of strength due to entrainment of air, but also to get higher strength and increased abrasive resistance of concrete. It has been found that air-entrained concrete is more workable, plastic and cohesive and shows increased resistance to sulphate attack and weathering action, consisting of heating and cooling, wetting and drying, as compared with plain concrete.

Work on determination of the relationship between water/cement ratio and strength of concrete for Indian cements, which is to be the basis of all concrete mix design, is well on its way.

Investigations on the utilisation of blast furnace slag and foundry slag for use as a road material, as well as the problem of laying concrete overlays on existing pavements to find out the possibility of stage construction of concrete roads are in progress.

TARS AND BITUMEN

Research programme

The following research problem are being handled :—

Analysis of Indian road tars with a view to improve their quality, utilisation of low temperature tars obtained from low temperature carbonisation of low grade coals; weathering and oxidation of road tars; design considerations of dense bituminous mixtures together with modified test procedures for carpet work for Indian climatic and traffic conditions; and introduction of modified techniques of surface dressing.

Results obtained

Some of the salient results that have been obtained so far both in the laboratory and in the field can be summed up as under :—

- (a) It is seen that the pitch anthracene ratio which goes a long way in the weathering and oxidation of tars is on the high side for Indian tars and can be reduced.
- (b) It has been proved in the laboratory that a low temperature tar can be utilised by blending it with the correct quality and quantity of asphaltic bitumen, thereby making the tar more viscous and also less resistant to oxidation.

- (c) Based on series of micro-viscosity tests on samples of tars weathered, it appears that the effect of ultra-violet radiation is much more than even pressure oxidation in the case of certain type of road tars such as RT-3.
- (d) By using an absorptiometer, the effect of overheating and even weathering and oxidation of tars on bitumen can be more easily studied.
- (e) It is possible to stabilise even fine sand by using a hard grade but rapid curing type of cut-back such as 30/40 mixed with solvent naptha.
- (f) As a result of the limited work done on design and laying of bituminous carpets, there is increasing evidence that the voids percentage required under Indian conditions may not have to be as low as that specified in the western countries. That being so, it may be possible to use crusher run stone as such with only a little modification.
- (g) A slight modification in the technique of surface dressing has been suggested in which two sizes of aggregates should be spread such that adequate interlock of the aggregates and less of traffic whip off can be obtained.

TRAFFIC AND SAFETY

Work on several aspects of road traffic flow and safety is being carried out. At present the work on hand is on road design aspects, economics of traffic flow, road users' behaviour, road signs, road markings, parking requirements, cycle traffic and road accidents. Work is also being carried out on statistics of traffic and flow for studying

traffic trends as well as for evolving more economical short count methods for traffic counts. Several "before and after" studies are being carried out with a view to study the effect of introducing, in actual practice, ideas emanating from research.

It has been found that maximum gradients for cyclists should not exceed 4 per cent to 5 per cent. For 5 per cent gradient length should not be more than 70 ft and for 4 per cent gradient it should not be more than 170 ft and 3 per cent gradient may be used upto a maximum length of 765 ft under Delhi area weather conditions. Relationship of different lengths for gradients under weather conditions of other regions has also been established.

Effect of bullock-carts on motor vehicles flow on a two-lane highway has also been studied. As a result of the study it has been recommended that when there are more than 4 bullock-carts per hour in either direction on a two-lane highway, they should not travel in singles but in caravans of 6 bullock-carts in each caravan. That would minimise the adverse effect of the presence of bullock-carts on roadway-carrying-capacity for motor vehicles.

Recommendations regarding horizontal sight distances and the width requirements for highways have also been made as a result of the field study under mixed traffic conditions. A method of timings of traffic signals for reducing delays under mixed slow and fast traffic conditions, has been suggested as a result of field study. This study indicated that bullock-carts should be prohibited through an intersection where the traffic is controlled by automatic light signals. If tonga traffic is permitted, minimum time cycle length must not be less than 55 seconds.

Origin-destination traffic study of Delhi, which was made by the road-side interview method has indicated

that cycle is the most common form of transport for people in income groups ranging up to Rs. 750/- p.m. Out of the total daily trips made by private conveyance in Delhi, 88 per cent is made up of cycle trips (i.e., 386,000 trips).

PAVEMENT DESIGN

With a view to have a better understanding on the applicability of some of the existing design procedures and to evolve suitable design criteria for the prevailing climate, soil and traffic conditions in India, special emphasis is being laid on pavement performance studies in the research programmes. Bullock-cart traffic, being a serious problem on Indian roads, is receiving special attention. With the aid of elastic theories and actual measurement of bullock-cart contact areas, a design criteria has been recently proposed for determining pavement thickness for this kind of traffic. Besides this empirical approach to the problem of pavement design, long range studies are under way on the pro-

blem of load transmission characteristics of different types of road materials with a view to rationalise flexible pavement design.

In relation to rigid pavement design, work is being done on evaluating accurately the temperature differentials in some of the existing pavements at different times of the year by means of thermocouples, with a view to estimate with reasonable accuracy, the probable order of temperature stresses occurring under local conditions.

Increasing emphasis is being given to the modification of existing methods of construction and maintenance, by utilising proved result of research. One of the most important functions of research, therefore, is to keep abreast of what is going on elsewhere and to examine latest acceptable ideas and techniques, with a view to their modification for adoption in India after necessary processing in the laboratory and in the field.

A fellow troubled by anxiety was advised to eat something whenever nervousness assailed him. He tried following the plan and found it had merit.

Then one morning, as his wife was driving him to his job, he noticed wisps of smoke curling above the hood of the car.

"Jump out and run for home, honey," shouted the nervous fellow to his spouse. "I'll fight the fire—you hurry back with a sandwich!"

—WALL STREET JOURNAL.

RECENT RESEARCH IN U.K. ON CONCRETE ROAD CONSTRUCTION

N. R. SRINIVASAN

Central Road Research Institute

INTRODUCTION

MECHANISED construction of concrete roads was first attempted in England in the middle of thirties¹. But soon the war intervened and put an end to the beginning. In the post war period, due to many other pressing problems, road development could not be given the place it deserved. There was hardly any concrete road construction worth the name due to the restriction imposed on the use of cement which was in force till a few years back². Only of late, a revival of mechanised construction of concrete roads has been attempted.

The period of apparent inactivity has, however, been well utilised by the research institutions in experimenting with the varied types of construction. The performance of different types of machinery and the final quality of the surface that results have been studied. The studies have permeated every aspect of construction to the minutest details. To-day as the country is re-embarking on a large scale road construction programme, the fruits of the researches of institutions like the Road Research Laboratory and the Cement and Concrete Association are already available to the county engineers and contractors.

PROBLEMS PECULIAR TO U.K.

Problems in U.K. have their own characteristics. Thus, for example, the frost problem which is given great importance in U.S. and the continental countries, has a secondary place in England³. The problem of riding quality on which great attention is paid in

U.K. hardly finds such stress in many other countries. In short, all the research in U.K. is aimed at laying a structurally sound road with a good riding quality using improvised mechanics and techniques. The future of concrete roads in England depends mainly on its riding quality. In cost, there is not that much of difference between a concrete and asphalt road, as we find in our country. But the riding quality of asphalt roads is better than that of the existing concrete roads and this is a vital factor in a country where the road sense of the public is high. In England, one finds a comparatively lesser proportion of large new luxury cars. There are a good number of small and medium British cars, stiffly sprung⁴. This makes the problem of riding quality all the more important.

The varied phases of research which have taken place in recent years towards the fulfilment of the aims outlined above, will be given in brief in the rest of this paper.

ALIGNMENT OF FORMS

It has been shown that the alignment of formwork has an important bearing on the surface characteristics of the finished road. Some experiments were carried out in the construction of Birmingham—Wolverhampton road. The forms were laid directly on the base of 6 in. thick ash or on bricks used as packing. They were adjusted to designed level by boring, using slate shims under each end of the 10 ft length of each form. Apparently, all the care needed in

aligning the forms appeared to have been taken.

The levels of the formwork were taken:

- (1) immediately prior to concreting
- (2) after the first pass of the finishing machine
- (3) after the final pass of the finishing machine

Results showed that even prior to concreting, the actual levels differed upto $\frac{1}{2}$ in. from the intended levels with this conventional method. The final levels after concreting showed settlements upto about $1\frac{1}{2}$ in. The cumulative errors due to form setting and settlement gave a difference of 1 in. to 2 in. between the final and designed levels. Under such conditions the crossfall might even be reversed as was actually observed in some cases. Of the errors due to settlement, 70 per cent of them took place during the first pass of the finishing machine. It was hence suggested that after the initial alignment of the form work, the finishing machine should be run over the forms a few times with

the vibrating beam freely vibrating before commencing concreting. The form levels should be again readjusted.

For the initial alignment of the forms, the R. R. L. has devised improvised boning rods which give better alignment.⁴ Aligning forms using taut wire was also found to give good results if proper procedures were followed⁵.

It was also found that rails, even when new, could have warped sections at the ends and hence required careful examination and repair^{6,7,8}. Besides the defects due to incomplete support given to the rails, the lack of support to the form base itself, due to the defective setting of forms, could result in increased deflections as the heavy machines pass over the rails fixed to the top of the form. Photo 1 shows a technique for the measurement of deflections of the rail. The proper alignment of the forms and rails carefully using a stretched line, the provision of a lean concrete base to support the form (Photo 2), employment of shims to give additional support to the rails and fixing the rails not to the top of the form work, but over stake housings attached to the form base (as in Photo 1) seem to be



Photo. 1

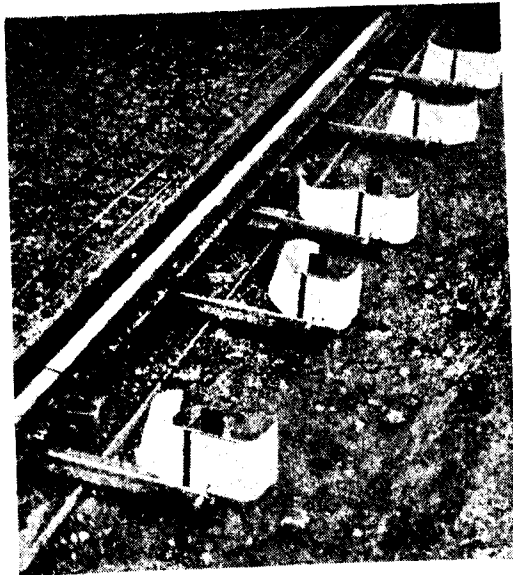


Photo. 2

the remedial measures to minimise the deflection in the rails.

Experiments were also conducted to study the effect of the position of the rail joints⁷. When the rail joint was between stake housings, there was a much greater deflection although the bolts in the fishplates were carefully tightened. It appeared desirable to have all rail joints over stake housings with some special fixing.

FOUNDATIONS FOR CONCRETE ROADS

One of the defects of Westergaard's theory is that it underestimates the stresses associated with the degree of support provided by the foundation. The theory postulates uniformity of support over the whole area of the slab, a condition rarely achieved in practice. Hence, not only the strength of the subgrade, but also the uniformity of support it affords to the slab should be taken into account⁸. Over subgrade of varying strength characteristics, this to some extent is achieved by the provision of the base⁹. However, experience and experiments in U. K. have shown that

it is not needed over very firm and stable soils or rocks. Even in poor soils, the usual concept that its thickness should be increased as the supporting power of the soil is decreased, is not held to be correct^{8,11}. It need be only thick enough to provide a smooth, hard working face over the formation so that during construction work, the subsoil is not deformed or otherwise damaged. On any but very poor soil, a base of 3 in. is held sufficient. Only for very poor soils with a C. B. R. of 2 per cent or less, it is advantageous to increase it to 6 in.⁸. Even this, because thinner sections are difficult to compact over such soils.

In soil compaction specifying in terms of dry density such as 95 per cent maximum density is not recommended, since experience has shown that this may under some conditions be impractical to obtain⁹. It has been suggested that the maximum air content should be specified such as 10 per cent for main part of the embankment fill and 5 per cent for the top 2 ft of subgrade soil or base⁹.

With clays, compaction at the natural moisture content is recommended since, if this is done, there is little likelihood of subsequent changes in moisture under the British conditions¹¹. For this, it is suggested that when constructing embankments the excavated clay should be compacted as early as possible after excavation.

Clay soils in cuttings are said to be usually close to saturation and hence their compaction is held to be unnecessary^{8,10,11}. In fact, heavy compaction could even be harmful as it may destroy the internal structure of the soil resulting in loss of strength.

To protect the subgrade or base from weather, before laying the slab it is now a practice to give a bituminous sealing coat as soon as the formation has been prepared.

SOIL CEMENT AND LEAN CONCRETE BASE

Experimentation is going on regarding the provision of soil cement and lean concrete bases. It had been observed that slabs laid on a rigid base have shown an unexpected tendency to crack. Hence it is feared that bases of stabilised soil and lean concrete may in certain circumstances be unsuitable for concrete roads^{2,11}. These bases cannot accommodate themselves to the warped shape of the slab which may crack due to non uniform support. Among the advantages, it could be mentioned that laying a lean concrete base does not require any special plant and may thus be cheap. It gives a stronger subgrade than pitching on poor subgrades. The less cement content is expected to result in less cracking than a normal concrete base. The lean concrete mix is usually of the order of 1 : 15 to 1 : 24 and the compaction is done by a vibratory roller.

Since compaction of road concrete is done by surface vibration the mix design is aimed at obtaining a fully compacted concrete using the machinery and materials available. Studies with an experimental vibrator in the laboratory have shown the desirability of restricting the amount of the 3/8 in. fraction in a grading with a maximum size of 3/4 in.¹³. Such a step also allows the use of a variety of sand gradings lying outside the limits of the present B.S. specification if the mix design is based on the specific surface of aggregates.

Recent experiments connecting surface area of aggregates and compactability have shown that there is an optimum range of S/A.¹⁴ within which the use of sands of varying finenesses yield concrete of good compactability with the minimum water addition. The cement content between 450-600 lb per cu. yd. has practically no effect on the optimum surface area for full compaction.

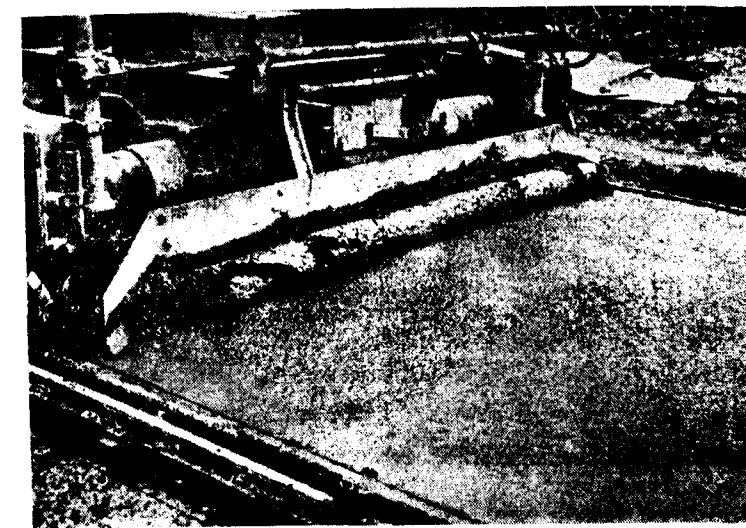


Photo 3.

RESEARCH ON MATERIALS

The problem of mix design is being viewed from new angles. The Road Note 4 is likely to undergo drastic chan-

The amount of water depends only upon the amplitude of vibration and the optimum grading. These are important findings and are likely to change radically the prevailing method of British

mix design. To design a mix it would, therefore, be necessary first to combine the available aggregates to give the optimum specific surface, then to determine the water content required to obtain full compaction with the compacting machine available, and finally to calculate the cement content needed to give the required water cement ratio and hence the required strength.¹⁴

Flexural strength is given greater weight in mix design and special clauses are introduced in the methods of mix design to take this also into consideration^{15, 32}. Experiments have also shown that concrete with crushed rock as aggregate gives better flexural strength than concrete with rounded aggregate¹⁵.

Since the frost problem is not a major problem in U.K., the main advantage sought to be derived through air entraining agents is not increased frost resistance. It is held doubtful whether the increased workability of the concrete could facilitate getting a good riding surface under even small gradients¹⁶. However, work in this direction is being carried out on a limited scale. Work in America and the continent is all in favour of air entrainment.

A number of simple apparatus have been designed for use in the field for giving quick results. The moisture content apparatus made by modifying a heavy duty balance is an example¹⁷. Quick methods for the analysis of fresh concrete^{12, 23} and quick methods for determining the density of hardened concrete using Gamma radiation^{18, 19} are further examples. All these have been of immense use in a number of investigations connected with the performance of machinery and quality control.

QUALITY CONTROL

Quality control has attracted increased attention and methods of effecting this in the field are being

investigated^{12, 20}. The control starts right from the stockpiling of aggregates. Single sized aggregates are stockpiled separately Photo 5. At least two sets of stockpiles are kept for each size so that any stockpile is kept unused for at least 16 hours from the time of delivery at site so that the moisture variations within the stockpile is reduced to the minimum (Fig 1). Checking the

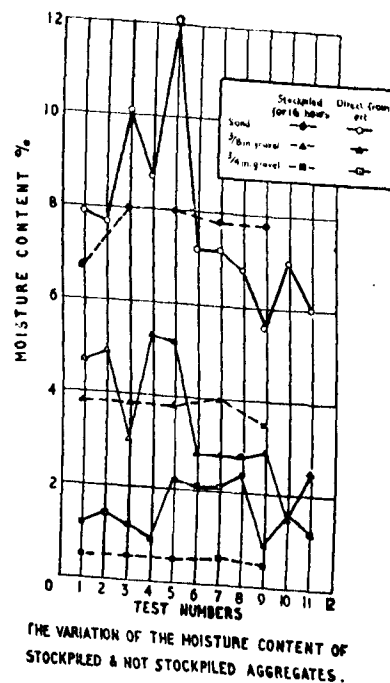


Fig. 1

moisture content of the aggregates is done at least once at the beginning of each day's work and for greater number of times where called for using the quick method of moisture determination. Checking the aggregate grading is also carried out. The workability of the concrete is being controlled by the automatic compaction factor apparatus²² which is directly calibrated to give the gallons of water to be added or subtracted at the mixer to get a concrete of a definite compaction factor. Greater importance is placed on getting a constant workability which is necessary for full compaction than to ensure a uniform

W/C whose variations for the same materials for a constant workability could only be slight^{12, 3}.

The importance of weigh batching in getting concrete of uniform quality is illustrated by Fig. 2. However, frequent check up and the proper upkeep of the weigh batchers are important prere-

quisites to weigh batching and without these very little benefit could be expected. In all works of any importance weigh batching has come to be used. Even in minor road works it is recommended that cement should be batched by weight assuming a bag to be one cwt³³. Since cement supplied in bulk encloses considerable quantity of air

Photo. 4

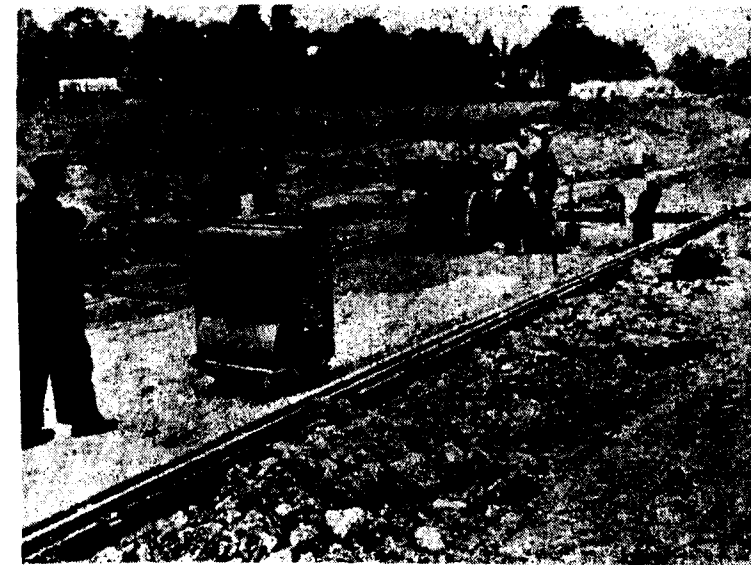
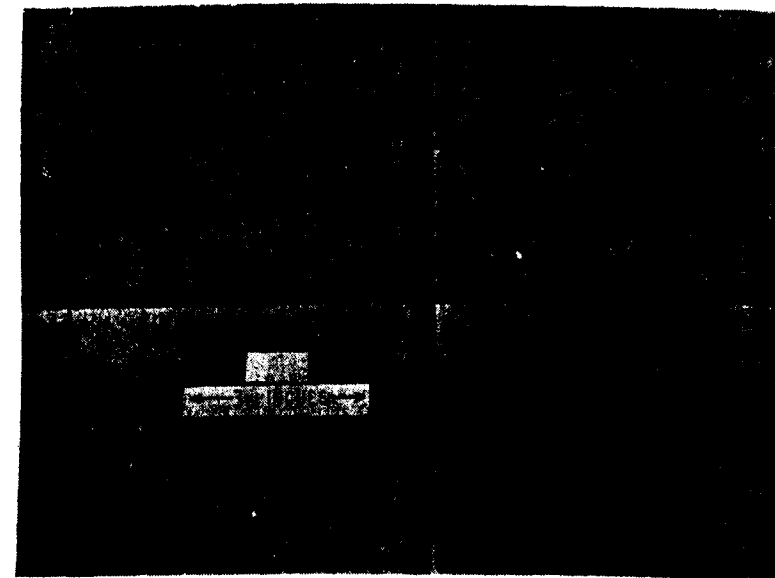
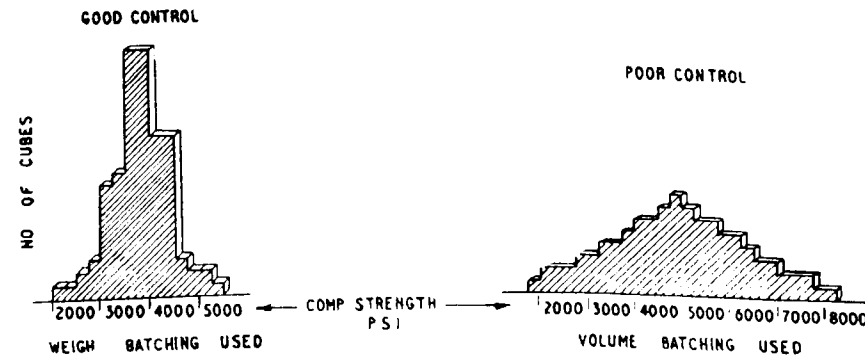


Photo. 5





FREQUENCY DIAGRAM OF WORK TEST CUBE RESULTS

Fig. 2

and may be as low as 60-70 lb/cu. ft., volume batching of bulk cement is prohibited³³.

Cubes are cast every day in the field and the mixed concrete analysed. The frequency of casting cubes depends upon many factors and no hard and fast rule could be prescribed. On large, important schemes, 15-20 cubes a day could be made during the early stages of construction which ultimately could be reduced to a few per week after the workmen have fallen in the groove. In any work, a standard deviation of 400 psi and below could be considered as 'excellent control'; 400-600, as 'good' and upto 800 as average. 1000 and above are considered as poor or no control²³.

Some data regarding the variation in cement quality:

- from the different consignments of the same factory, and
- from the different factories

has been collected and this has to some extent revealed the degree to which these factors affect the quality of the work³⁴. In these and in many other phases of quality control, the application of statistical methods is gaining ground^{35, 38}.

RESEARCH ON MACHINERY

Mixer: In the preparation of uniform concrete, the performance of the concrete mixer is a very important factor. It was found that none of the 3 usual types, viz., the nontilting, tilting or pan mixers is quite suitable for the type of dry, lean mixes used in Britain²⁴. Among these three, the N. T. type gives a more uniform concrete. Restricting the maximum size of aggregate to 3/4 in. results in more uniform mixes in all types²³. Lean dry mixes with larger size of aggregate are difficult to mix uniformly. The economy which is supposed to be achieved by the use of such mixes is hence rarely achieved in practice²³.

Mode of transport: Studies have also been made to measure the amount of segregation which occurs when concrete is transported in general purpose lorries^{12, 24}. Most of the segregation was found to occur at the time of loading from the mixer. Use of vertical chute and moving the lorry to and fro at the time of loading minimises segregation around the heap. Haul has very little effect on the fresh concrete. Mixes of very low workability are not changed by hauling over rough or smooth roadway while those of low workability undergo some precompaction during rough transit.

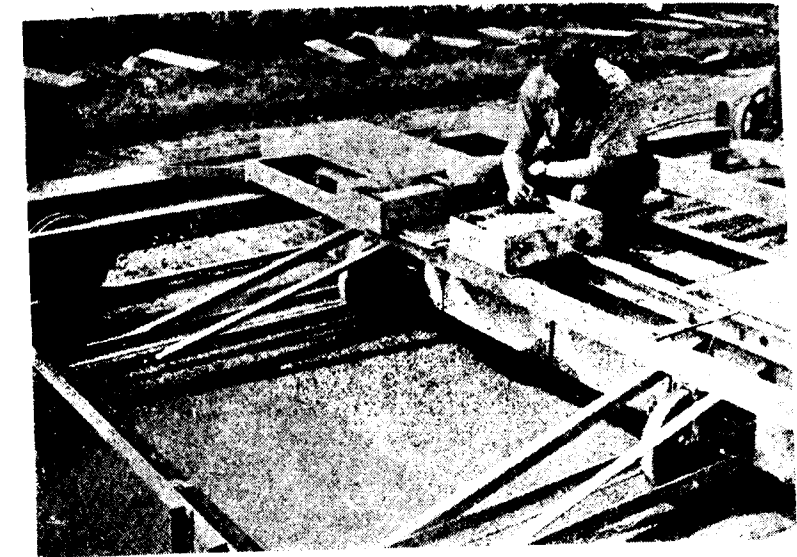
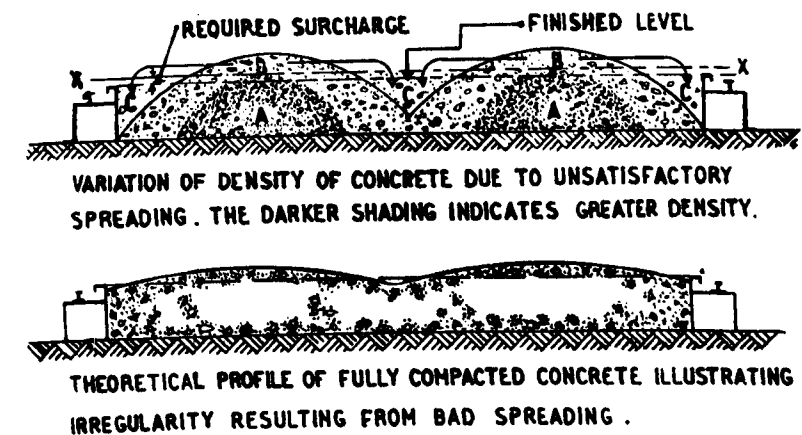


Photo. 6

Spreading: The effect of spreading concrete and the efficiency of spreading machines as affecting compaction and the riding quality of the road has been extensively investigated. When the concrete is first dumped in heaps over the subgrade and then spread by the spreading machines of the reciprocating blade type or the screw type, the size and position of the heaps

have a great influence on the surface irregularities and the compaction^{7, 12, 25} (Fig 3). The heaps should never overlap each other⁷. Smaller heaps of 1 cu. yd. each dumped in fairly evenly spaced heaps from both sides of the lane for both the top and bottom courses give a much better surface. But often dumping in heaps on both sides of the lane is not practi-



(WITH ACKNOWLEDGEMENTS TO CEMENT & CONCRETE ASSOCIATION U.K.)

Fig. 3

cable. In such cases, to allow for the precompaction in the heaps the surcharge on the side opposite to the dumping has to be about 3/8 in. more, this being achieved by slightly tilting the screeds of the spreading machine. In the spreading machine of the hopper type (Photo 9), difficulties in the free flow of concrete due to arching was one of the reasons that caused variations in the density of the spread concrete. There was, in addition, the precompaction of

the concrete caused by the load in the hopper. Attempts to eliminate this by providing hydraulically operated bottom doors were unsuccessful.

Another method to improve the surface was by moving a full hopper over the surface of the spread concrete for both top and bottom courses. This, however, results in considerable spilling of concrete over the form.

On the whole, none of the available



Photo 7.

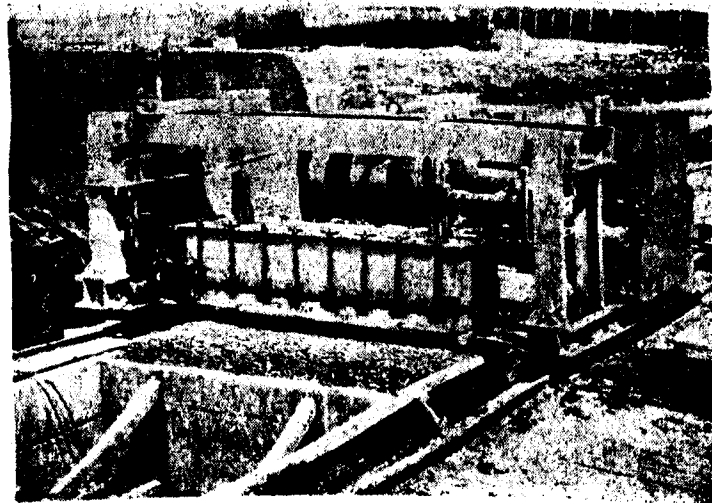


Photo. 8

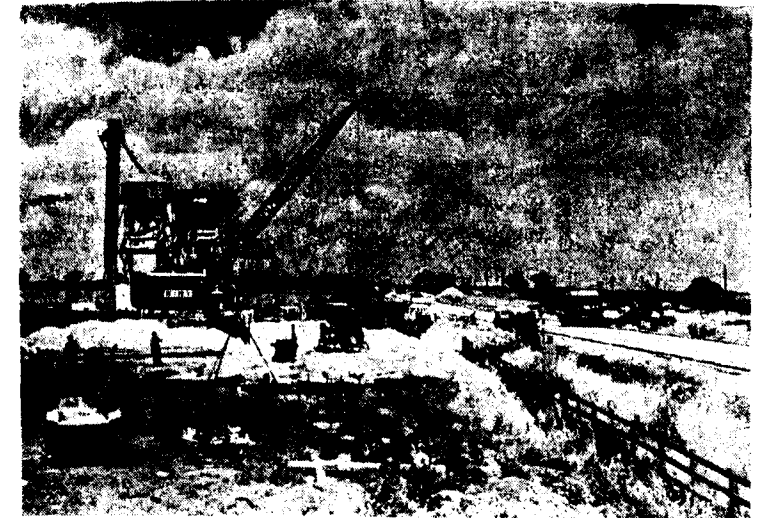


Photo. 9

type of spreading machines in England was found to be quite satisfactory ^{7, 25}.

Hand spreading for hand operated vibratory screeds as used in smaller jobs in England, should be of some interest to us, loads of 3 cubic feet and less dumped by hand barrows at the working face do not lead to much difficulty in obtaining a good riding surface ^{12, 26}. Larger loads give rise to bumps. The surcharge, which depends upon the type of mix and the vibration characteristics of the screed, has to be carefully adjusted. Use of rake for this purpose resulted in complete compaction below 5 in. depth. With a screed on the other hand, good compaction was obtained for greater depths. The screed could be a board provided with means of adjusting its height above the form with handles for pushing it along the form.

COMPACTION AND FINISHING

Compaction of power propelled or hand operated screeds had been studied from many angles. The effects of the frequency, amplitude and acceleration as also the effects of the weight of the beam, the shape of the vibrating shoe, the speed of travel and the height of

surcharge of concrete before compaction are being studied ^{27, 28}. An experimental vibrator (Photo 10) has been built up in which any of these could be changed and the effect measured in terms of the irregularity index of the surface and the degree of compaction attained in slabs with depth upto 18 in. The degree of compaction was formerly measured by cutting cores; but this was tedious and time consuming. The cores could be cut only 28 days after laying. The thin sectioning was tedious and the density determination of these sections could only yield limited information of the density of the core at certain depths. The recent development of the gamma ray absorption technique (Photo 11) on the other hand gives far quicker results since it could be put in operation a day or two after laying the concrete ^{18, 19}. It is essentially a nondestructive testing method and the density at any or many point along the depth could be known in a matter of minutes.

In the case of table vibration as employed in the manufacture of precast units, best results are obtained with high frequency and high acceleration. But, for vibration from the top surface the acceleration whether 1, 4 or 12 g

Photo. 10

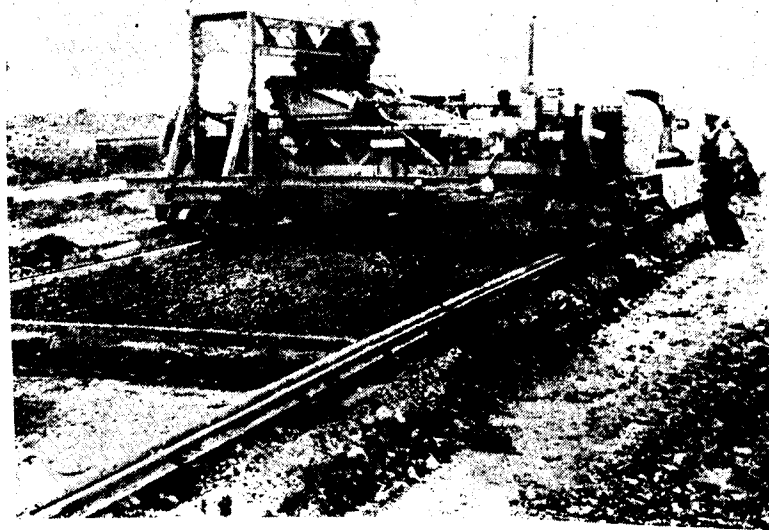
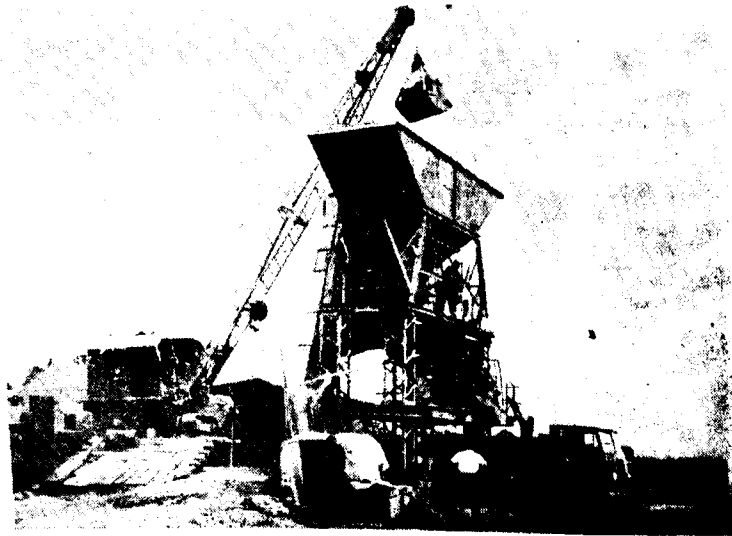


Photo 11.

does not affect compaction in the tests in which the concrete of constant workability was compacted with a constant amplitude and a constant number of vibrations per foot length²⁸. The frequency had a grater effect on the surface finish rather than the compaction. Only the amplitude had an important bearing on compaction. At

.016 in. amplitude, which is the average value of the finishing machines, the concrete was well compacted upto 6 in. At 0.64 in. amplitude good compaction upto 12 in. depth was achieved. Thus it was concluded that for the vibrating machines, low frequency of about 1500 v.p.m. with high amplitude gives the best results.

Measurements of the amplitude for different commercial machines showed that the amplitude was not uniform all along the vibrating beam. In order to obtain uniform amplitude, it was found that the symmetrical placing of the units transmitting vibration and drive with respect to the centre line of the beam was important. The beam had to be rigid enough without any attachment of extension pieces. The weight of the beam and the elasticity of the support should not damp the vibration.

Screeds when freely supported tend to ride over the lumps. In the experimental vibrator, when the screed is freely supported on wire ropes, extra weights upto 1,000 lb added to the screed gave a better surface with a q value of only 47-65 in./ mile. Hence, the weightier the screed, the better it is, so long as the weight is not so great as to damp the vibration.

With hand operated screeds, with a range of frequency, and amplitude of 3,800-5,500 v.p.m. and .006 in. respectively, concrete could be compacted upto 8 in. The practice of dragging the screed along the form gave unsatisfactory compaction. The screed should be lifted and placed over the uncompacted concrete as the screed moves forward. Mechanical contrivances to lift and place the screed over the concrete are incorporated in some of the screeds.

MEASUREMENT OF RIDING QUALITY

Two types of profilometers, one, the multi-wheel profilometer and the other, the wet surface profilometer have been developed at the Road Research Laboratory. The former measures the surface irregularities of hardened concrete. In order to assess the quality of the surface while the concrete was still sufficiently plastic for improvements to

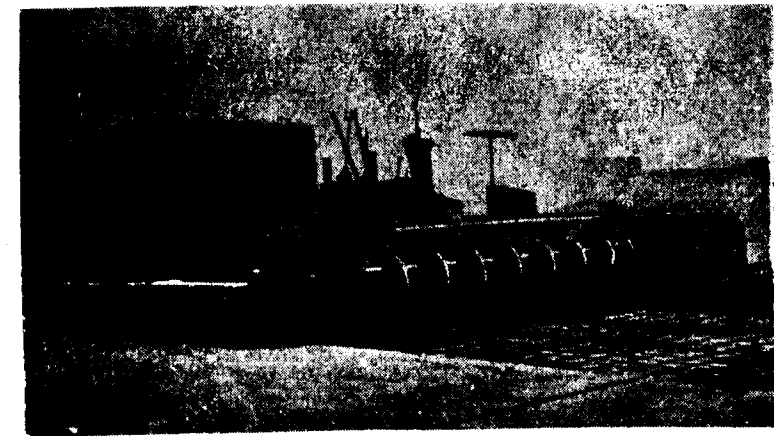


Photo. 12.

Regarding the speed of travel of the machines, experiments showed that for the normal types of machine, a speed of 1 ft-2 ft/min. gave good results.

In the case of hand operated screed the amplitude is greater at the ends than in the middle. The position of the vibrating units thus becomes important in these cases.

be made, the latter machine has been evolved recently. This is the one used during the construction of the concrete pavement (Photo 12). It consists essentially of a rigid frame having the same wheel as the finishing machine⁷. The frame carries two recording wheels in the same position relative to the chassis wheels as that occupied by the trailing edge of the vibrating beam of the finisher,

TABLE
Selection of blade to suit the aggregate together with average performance of blades and estimate cost of sawing

Type of aggregate used in the concrete	Age of concrete	Type of blade recommended (CG 7)	Depth of cut (in.)	Average life of blade at stated depth of cut	Average rate of cut (ft per hour)	Estimated total cost including cost of water supply (per ft)	Remarks
Flint gravel with natural flint sand	24-48 hr.	Steel-centred silicon carbide (CG 7)	1½	45-70 ft	30-40	10d.-1s. 3d.	To saw flint gravel concrete economically it is essential to saw as soon as possible. When sawing was delayed for 16 days, the depth of cut obtainable was reduced to about 5/8 in. with the CG 7 blade and the cost at this depth was 7d.-10d. per foot. Diamond blades will cut to at least 2 in. at all ages but the cost is very high.
Limestone with limestone dust	28 hr. 48 hr.	Wire reinforced silicon carbide	2 2	3000-4000 ft About 3000 ft	130 50	2d. 5d.-6d.	In estimating the life of blade, uniform rate of wear has been assumed.
Limestone with natural flint sand	24 hr. 48 hr. 6 months	Wire reinforced silicon carbide	2 2	About 1000 ft About 1000 ft 600 ft	135 75 40	2d. 3d. 4d. 10d.-11d.	In estimating the life of blade, uniform rate of wear has been assumed.
Granite with granite dust	24 hr. 3 days & upto 6 months	Steel-centred silicon carbide (CG 4) Diamond	2 2	90 ft 1300 ft	30 160	10d.-1s. 1d. 1s. 1d.-1s. 5d.	The CG4 blade is the most economical to use at ages upto about 48 hrs. after which the diamond blade gives the most satisfactory performance.
Granite with natural flint sand	24 hr. 3 days 5 months 17 years	Steel-centred silicon carbide (CG 4 or CG 2) Diamond Diamond	2 2 2	60-80 ft 880 ft 830 ft 700 ft	35-40 190 100 50	10d.-1s. 2d. 1s. 8d. 1s. 10d. 2s. 3d.	The CG2 or CG4 blades are the most economical to use at ages upto about 48 hrs. after which the diamond blade gives the most satisfactory performance. Figures given for cutting at 17 yrs. have been estimated from data obtained when cutting 1½ in. deep. Life of blade and speed of cutting have been assumed proportional to depth of cut.

the wheels being 2 feet 9 inches from the edges of the slab. The recording wheels are counterbalanced so that the pressure on the concrete is only just sufficient to rotate the wheels and their vertical movements are recorded on rolls of paper driven through a 60 to 1 reduction gear by a wheel running on the forms. The profilometer is generally towed by the finishing machine. With this arrangement, irregularities in form setting are not reproduced in the record and a horizontal line would indicate that the finishing machine has produced the best surface possible whilst any departure from this line would indicate an irregularity which might be corrected by further passes of the finishing machine. The irregularity is given in terms of "q" value as so many inches per mile. A "q" value of less than 60 inches per mile could be regarded as indicating a good finished surface.

JOINTS

Great attention is paid to the formation of joints without impairing the riding quality. Methods similar to those adopted in Germany for the formation of dowel joints are being tried in experimental roads. Experimental

tion is going on for the use of fewer joints and long slab lengths. The present recommended practice in summer is to space expansion joints at 90 ft-120 ft for plane slabs with dummy joints every 15 ft and 120 ft-180 ft for reinforced slabs with dummy joints every 30 ft-60 ft. In winter these spacings are reduced further.

Cutting of joints is increasingly being tried since this allows (a) continuous laying of long slabs without interruptions and (b) gives a better riding surface avoiding bumps. The cutting results in a neat job requiring minimum filler (Photo 13). It is, however, a more expensive method. Table opposite gives some data for the cutting of concrete with different types of aggregates with different saws.

Joints should be sawn as soon as possible in order to avoid random cracking. This also gives a longer blade life and lowers cost. The interval from the laying of concrete to sawing depends upon climatic condition. The concrete should attain sufficient strength (in practice about 1000 psi) to prevent the disruption of concrete during cutting³⁹. With the type of concrete used in

Photo. 13



Britain an interval of 20 hours in warm weather was found to be needed. In cold weather this interval may extend to 3 days and more.

PAVEMENT DESIGN

As a result of the observations on the existing concrete roads and experimental roads, certain recommendations have been made in Road Note No. 16, on slab thickness, slab length amount of reinforcement to be used, etc. These are being put to further tests. Already there is a feeling in some quarters that the amount of reinforcement 5—14 lb sq. yd. as recommended in the Road Note is high and that the amount should be reduced as in U.S.A. or Germany.

ACKNOWLEDGMENTS

The bulk of the information given in this paper was collected by the author during his training in U.K. under the Colombo Plan. All figures and photographs except Fig. 2 and 3 have their crown copy right reserved and are reproduced with the kind permission of the Director of Road Research, England.

This article is published with the kind permission of the Director, Central Road Research Institute, New Delhi.

REFERENCES

1. The application of lessons learnt in air field construction and the construction of concrete roads - J. M. Laing, J. M. Fisher and E. F. Baroadbent. Proc. of the meeting of Pavement Group (Concrete and soil cement) 30th March 1955.
2. Some aspects of current concrete road construction - D. R. Sharp. Proc. of the meeting of Pavings Development Group (Concrete and Soil Cement) 13th June 1957.
3. Recent progress in research on concrete roads and experience in their construction - A. R. Collins. Proc. of the meeting of the Pavings Development Group (Concrete and Soil Cement) 19th November, 1953.

4. An investigation of the influence of form-work unevenness on the surface irregularity of a machine finished concrete road. (A 4123, Birmingham-Wolverhampton) - RN/1697/WJOS. RHHK. Road Research Laboratory 1952 (unpublished).
5. Alignment of Road Forms - RN/ 2004/ WEIA Road Research Laboratory 1953 (unpublished).
6. A further examination of the factors affecting the riding quality of concrete roads - RHH Kirkham RN/1700/RHHK Road Research Laboratory 1952.
7. Factors affecting the riding quality of machine laid concrete roads - RHH Kirkham. Proc. Institution of Civil Engineers. Part II, 2 (3) pp 656-709 1953.
8. Foundations for concrete roads; their preparation, protection—D. J. Maclean. Mag. of Concrete Research Vol. 6 No. 16 pp 17-32 1954.
9. Further studies in the compaction of soil and the performance of compaction plant - W. A. Lewis. Road Research Technical Paper 33. H. M. S. O. 1954.
10. Concrete Roads: I Earth works, Sub-grade and bases - Published by the Cement and Concrete Association.
11. Soil Mechanics for Road Engineers - Road Research Laboratory, H. M. S. O. 1952.
12. Concrete Roads - Design and construction—Road Research Laboratory H.M.S.O. 1955.
13. Design of concrete mixes for compaction by surface vibrators R. H. H. Kirkham. Symposium on Mix design and quality control of concrete, London 1954.
14. Road Research 1957, H. M. S. O
15. The design of concrete mixes on the basis of flexura strength - P. J. F. Wright Symposium on mix design and Quality control of concrete, London 1954.
16. Entrained air concrete - P. J. F. Wright. Proc. of Civil Engineers pp. 33.-58; 1953.
17. Buoyancy meter for rapid estimation of moisture in concrete aggregates. - R.H.H Kirkham. Civil Engineering and Public Works Review. - Vol. 50. pp 579-80. 1955.
18. The measurement of the density of concrete by Gammaradiations—A. C. Whiffin. R. N. /1445/A. C. W. Road Research Laboratory 1950.
19. Density measurement of concrete slabs using gamma radiation - E. E. Smith and A. C. Whiffin. Engineer, London. Vol. 194 (5040) pp 278-81. 1952.
20. The control of concrete quality; A review of the present position—F. N. Sparkes. Symp. on mix design and quality control of concrete. London 1954.

21. Control in mixing and placing concrete - R. H. H. Kirkham. Paper presented to the Public Works and Municipal Services Congress, London. 1956.
22. Apparatus for the field control of workability - R. H. H. Kirkham. Civil Engineer and Public Works Review Vol. 50. No. 592 pp 1109-10.
23. The testing of concrete mixers - R. H. H. Kirkham. The Engineer. (Feb. 13th, 20th, 27 March, 6th) 1953.
24. The transport of fresh concrete in general purpose lorries - R. H. H. Kirkham and D. E. Welles. R. N. /2711 RHHK. D. E. W. Road Research Laboratory 1956. (unpublished).
25. Spreading machines for the construction of concrete roads - R. H. H. Kirkham. R. N. /2308/ RHHK, Road Research Laboratory 1954.
26. Methods of improving riding quality of concrete roads laid with hand operated vibrating finishers - R. H. H. Kirkham and M. G. White. Roads & Road Construction. Vol. 301 (359) pp 317-21. 1952.
27. The vibration of concrete slabs - R. H. H. Kirkham. Mag. Concrete Research. 1949, 3, 141-3.
28. The compaction of concrete by surface vibration; First series of experiments - R. H. H. Kirkham & A. C. Whiffin. Mag. Concrete Research. (8) pp 79-91, 1951.
29. Use of small vibrating screeds for compacting concrete R. H. H. Kirkham. Contractor's Record. Vol. 66 (15) pp 11, 12. 1955.
30. The design and construction of concrete pavements - F. N. Sparkes. Paper read at the meeting of Reinforced Concrete Association Nov, 14, 1951.
31. The structural design of concrete roads - F. N. Sparkes. Mag. of Concrete Research. Vol. 6 (17) pp 61-70. 1954.
32. Investigations into the design of concrete mixes on the basis of flexural strength - P. J. F. Wright and A. D. Mc. Cubbin. RN/2433/ PJFW. ADMC, 1955.
33. Specification for housing estate and other minor roads in concrete-Cement and Concrete Association. 1958.
34. Variations in strength of portland cement P. J. F. Wright. Mag of Concrete Research. Vol. 10 pp 123-32, 1958.
35. Statistical methods in concrete research - P. J. F. Wright. Mag. of Concrete Research. Vol. 5 No. 15 pp 139-49, 1954.
36. Quality control for road and airfield construction - J. M. Fisher, Proc. of the symposium on mix design and quality control of concrete, London 1954.
37. The application of statistics to concrete quality—F. R. Himsworth. Proc. of the symposium on mix design and quality control of concrete, London 1954.
38. Quality control of concrete - Its rational basis and economic aspects. Proc. of Institution of Civil Engineers. Part I. Vol. 2 (3). pp 311-336. 1953.
39. Sawn joints in concrete roads and airfield pavements - L. S. Blake and L. O. Southin. The Surveyor Vol. 115 pp 153-55. 1956.

PUBLICATIONS of the INDIAN ROADS CONGRESS

A limited number of copies of the following publications are available for sale:

Name of publication		Price (including postage, etc.)		Rs. nP.	
1. Vol. IX (Bound)	...	—	...	1945	10 00
2. Vol. XII-2	...	January	...	1948	3 00
3. Vol. XII-3	...	April	...	1948	3 00
4. Vol. XII-4	...	March	...	1948	3 00
5. Vol. XII-5	...	September	...	1948	3 00
6. Vol. XII (Bound)	...	—	...	1947-1948	12 00
7. Vol. XIII-1	...	December	...	1948	3 00
8. Vol. XIII-2	...	January	...	1949	3 00
9. Vol. XIII-3	...	January	...	1949	3 00
10. Vol. XIII—parts 1 & 2 (Bound)	...	—	...	1948-1949	5 50
11. Vol. XIV-1	...	September	...	1949	3 00
12. Vol. XIV-2	...	December	...	1949	3 00
13. Vol. XIV-3	...	December	...	1949	3 00
14. Vol. XIV-4	...	July	...	1950	3 00
15. Vol. XIV (Bound)	...	—	...	1949-1950	8 00
16. Vol. XV-1	...	August	...	1950	3 00
17. Vol. XV-2	...	November	...	1950	3 00
18. Vol. XV-3	...	January	...	1951	3 00
19. Vol. XV-4	...	August	...	1951	3 00
20. Vol. XV (Bound)	...	—	...	1950-1951	9 00
21. Vol. XVI-2	...	March	...	1952	3 00
22. Vol. XVI-3	...	April	...	1952	3 00
23. Vol. XVI-4	...	October	...	1952	3 00
24. Vol. XVI (Bound)	...	—	...	1951-1952	8 00
25. Vol. XVII-1	...	December	...	1952	3 00
26. Vol. XVII-2	...	January	...	1953	3 00
27. Vol. XVII-4	...	December	...	1953	3 00
28. Vol. XVII (Bound)	...	—	...	1952-1953	9 00
29. Vol. XVIII-3	...	January	...	1954	3 00
30. Vol. XVIII-4	...	March	...	1955	3 00
31. Vol. XIX-4	...	September	...	1955	3 00
32. Vol. XIX (Bound)	...	—	...	1954-1955	10 00
33. Vol. XX-1	...	October	...	1955	3 00
34. Vol. XX-3	...	December	...	1955	3 00
35. Vol. XX-4	...	January	...	1957	3 00
36. Vol. XX (Bound)	...	—	...	1955-1956	9 00
37. Vol. XXI-1	...	February	...	1957	3 00
38. Vol. XXI-2	...	March	...	1957	3 00
39. Vol. XXI-3	...	April	...	1957	3 00
40. Vol. XXI-4	...	December	...	1957	3 00
41. Vol. XXI (Bound)	...	—	...	1956-1957	10 00
42. Vol. XXII-1	...	November	...	1957	3 00
43. Vol. XXII-2	...	December	...	1957	3 00
44. Vol. XXII-3	...	December	...	1957	3 00
45. Vol. XXII-4	...	November	...	1958	3 00
46. Vol. XXIII-1	...	November	...	1958	3 00
47. Vol. XXIII-2	...	December	...	1958	3 00
48. Vol. XXIII-3	...	December	...	1958	3 00
49. Vol. XXIII-4	...	October	...	1959	3 00
50. Road Research—Bulletin No. 1	...	...	...	...	5 00
51. Road Research—Bulletin No. 2	...	...	...	...	5 00
52. Road Research—Bulletin No. 3	...	...	...	...	5 00
53. Road Research—Bulletin No. 4	...	...	...	...	5 00
54. Road Research—Bulletin No. 5	...	...	...	...	5 00
55. Proceedings of the Chief Engineers' Conference at Nagpur on the Post-war Road Development in India	...	...	...	...	2 62
56. Dimensions and Weights of Road-Design Vehicles	...	Re. 0 50	...	...	...
57. Recommended Practice for Location and Layout of Roadside Motor-Fuel Filling Stations	...	Re. 0 50	...	...	...
58. Type Designs for Furlong & Boundary Stones	...	Re. 0 50	...	...	...
59. Type Designs for Highway Milestones	...	Re. 0 50	...	...	...
60. Route-Marker Signs for National Highways	...	Re. 0 50	...	...	...
61. Standard Specifications and Code of Practice for Road Bridges, Section I—General Features of Design (1956)	...	Re. 0 75	...	...	...
62. Standard Specifications & Code of Practice for Road Bridges, Section II (1958)—Loads & Stresses	...	Rs. 2 50	...	...	...
63. I.R.C. Paper No. 167—"Design of Small Bridges and Culverts" by Goverdhan Lal.	...	Rs. 2 00	...	...	...

Concessions: Most of the publications are available to Members of Indian Roads Congress on concession. Details on application.

Copies can be had from the Secretary,

INDIAN ROADS CONGRESS,
JAMNAGAR HOUSE, MANSINGH ROAD,
NEW DELHI-2.

extra profit in every trip

AVELING BARFORD

DUMPERS

7 MODELS. RANGE 1 TO 27 TONS PAYLOAD

SOLE DISTRIBUTORS

For Western, North-Western,
Central & Southern India:

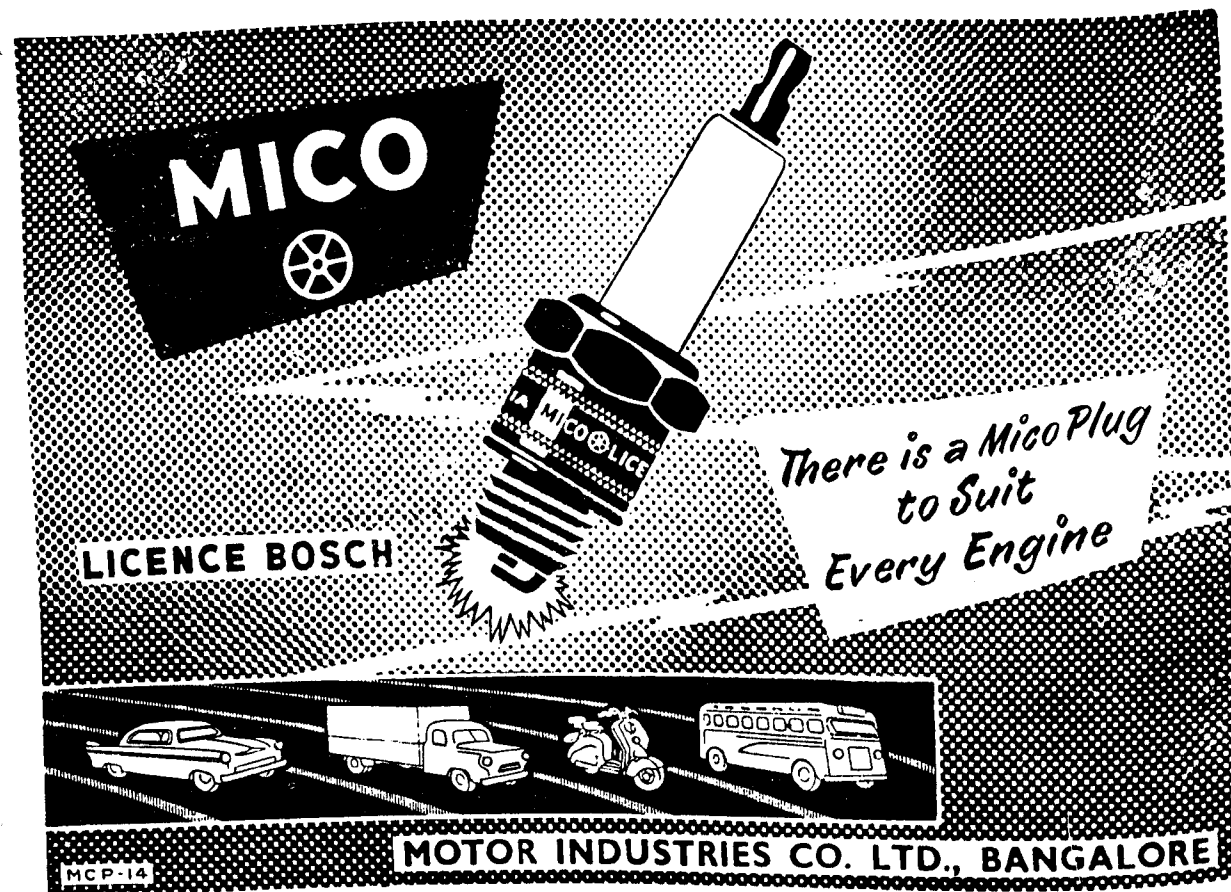
For Eastern and
North-Eastern India:

GREAVES COTTON JESSOP & CO LTD
& CO LTD
CALCUTTA

BOMBAY • NEW DELHI • MADRAS

GC/19-24 B

Please mention this journal when replying to advertisements.
vii



MICO

LICENCE BOSCH

There is a Mico Plug to Suit Every Engine

MOTOR INDUSTRIES CO. LTD., BANGALORE

MCP-14

no trouble at all ...

from
drum
to
road ...

Stp
**BITUMEN
EMULSION**

... in one easy
application

Bitumen emulsions are efficient and economical for surface dressing, premix work and soil stabilization. They require no heating. Hence—no fire hazard ... no annoying smoke ... no heating equipment. Just open the drum and you're ready to start work. Bitumen emulsions are specially suitable for repair work, and factory and residential roads.



SHALIMAR TAR PRODUCTS (1935) LIMITED
CALCUTTA • DELHI • BOMBAY • LUCKNOW • CHANDIGARH

Agents: The Bombay Co. Private Ltd., Madras I • R.C. Abrol & Co. (Private) Ltd., New Delhi I

"I'd better give up this road transport business"
cried Surjit Singh

"Better buy ASHOK LEYLAND COMET" said his friend

MANY road transport companies are finding it increasingly difficult to maintain their organisations because of higher prices of diesel oil and tyres. Overloading is not only risky but bad for the vehicle too.

ASHOK LEYLAND COMET carries 50% more goods than any other chassis

built in India. It saves on oil and on maintenance because it carries in two trips what others do in three or more.

When you buy a chassis it always pays to buy the best even if it costs a little more.



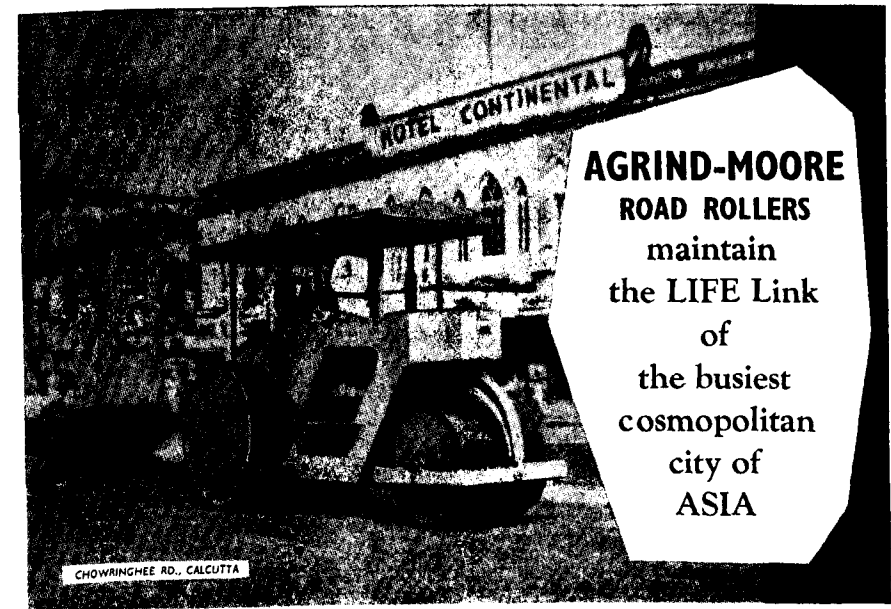
Ashok Leyland COMET

The only 7½ ton payload chassis made in India



ASHOK LEYLAND LIMITED, Ennore, Madras

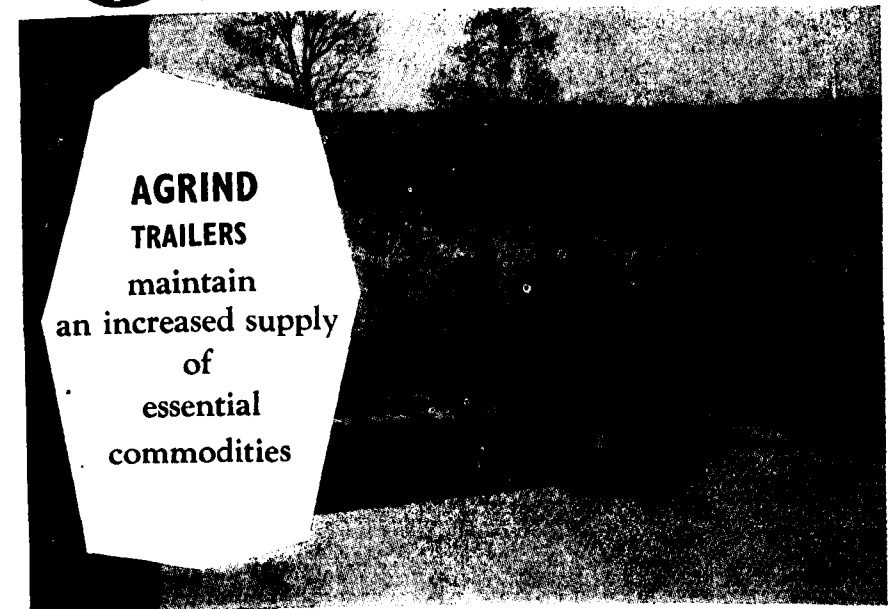
Main Dealers: Bombay State and Andhra Pradesh: Automotive Manufacturers Private Ltd., 108, Bazaar Ward Kuria, Bombay 37. • West Bengal and Bihar: Associated Indian Enterprises (Private) Ltd., 206, Lower Circular Road, Calcutta 17. • Assam, Manipur and Tripura States: Walford Transport Limited, Mankatta Road, Dibrugarh. • Uttar Pradesh: Dharam Singh Ram Singh (Motors) Private Ltd., 25, Bhopal House, Lal Bagh, Lucknow. • Delhi Himachal Pradesh, Punjab and Rajasthan: Globe Motors Private Ltd., Saradham, 1/2, Jhandewala, New Delhi. • Madras, Mysore, and Kerala: T. V. Sundaram Iyengar & Sons Private Ltd., West Veli Street, Madurai and Sundaram Motors Private Ltd., Mount Road, Madras. • Jammu and Kashmir: Jay Kay Automobiles, Residency Road, Srinagar (Kashmir). • Madhya Pradesh: Fairdeal Motors, Palasia Point, Bombay-Agra Road, Indore.



AGRIND-MOORE
ROAD ROLLERS
maintain
the LIFE Link
of
the busiest
cosmopolitan
city of
ASIA



AGRIND FABRICATIONS LTD. 6, GANESH CHANDRA AVENUE-CALCUTTA 13.



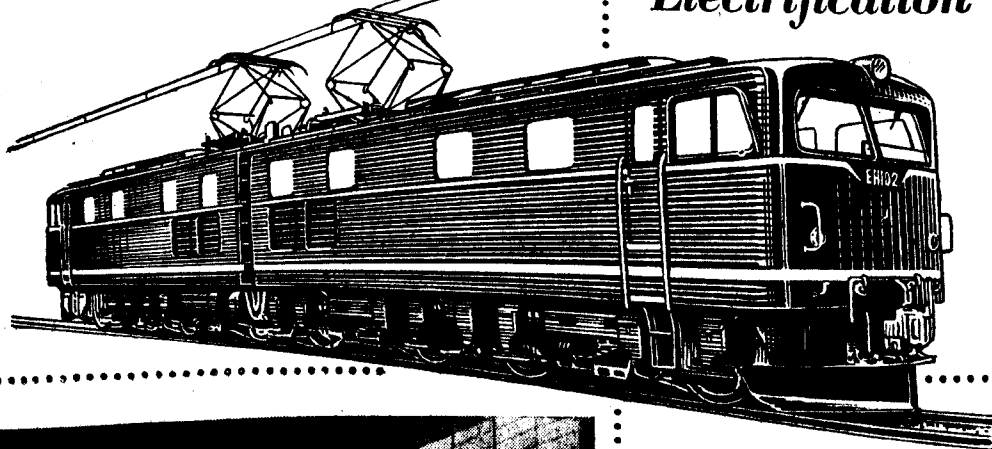
AGRIND
TRAILERS
maintain
an increased supply
of
essential
commodities

DPS/AF-8/59

Please mention this journal when replying to advertisements.

HITACHI

for
Railway
Electrification



For several decades now Hitachi Ltd., Tokyo, Japan, have been one of the leading manufacturers in the world of almost every type of rolling stock, including Electric Locomotives. They also have an established reputation as manufacturers of equipment necessary for Railway Electrification—Electric Multiple Unit Coaches, Transformers, Mercury Arc Rectifiers, Rotary Convertors, Switchgear, Power Cables, Trolley Wires, etc.



Hitachi, Ltd.

Sole Agents in India

**William Jacks
& Co. Ltd.**

(Incorporated in England.
Liability of Members Limited.)

Calcutta Bombay Madras

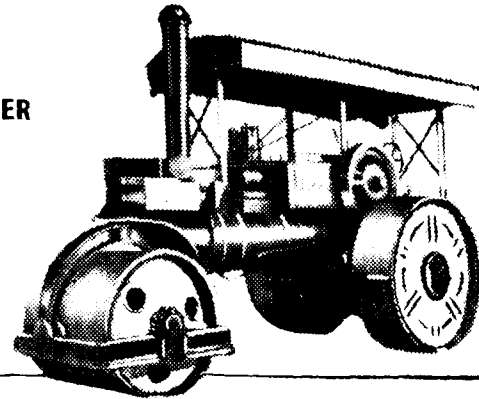
15,000 kVA Transformer for
Power Station, Japan

Please mention this journal when replying to advertisements.

THE ANSWER TO YOUR ROAD CONSTRUCTION PROBLEM

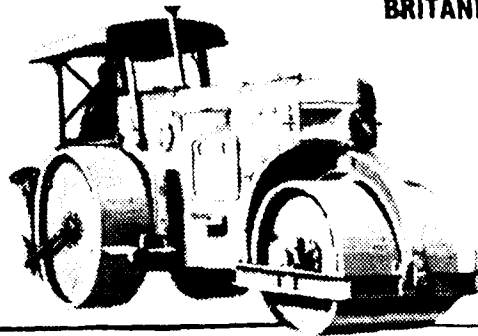
BRITANNIA - MARSHALL STEAM ROAD ROLLER

Ever popular and Efficient Road
Roller indigenously manufactured by
**THE BRITANNIA ENGINEERING
CO. LTD. TITAGHUR** to the
MARSHALL Design.



BRITANNIA-ROAD-MARSHALL DIESEL ROAD ROLLER

Reliable, Robust and Economical
Road Rollers indigenously manu-
factured by **THE BRITANNIA
ENGINEERING CO. LTD.
TITAGHUR** to the **MARSHALL
Design.**



MARSHALLS

**MARSHALL, SONS & CO.
(INDIA) LTD.**

33/1, Netaji Subhas Road, Calcutta.
Marshalls Building, Ballard Road, Bombay.
Marshalls Building, 9, Second Line Beach, Madras.
Marshall House, Hanuman Road, New Delhi.

MIEAR.