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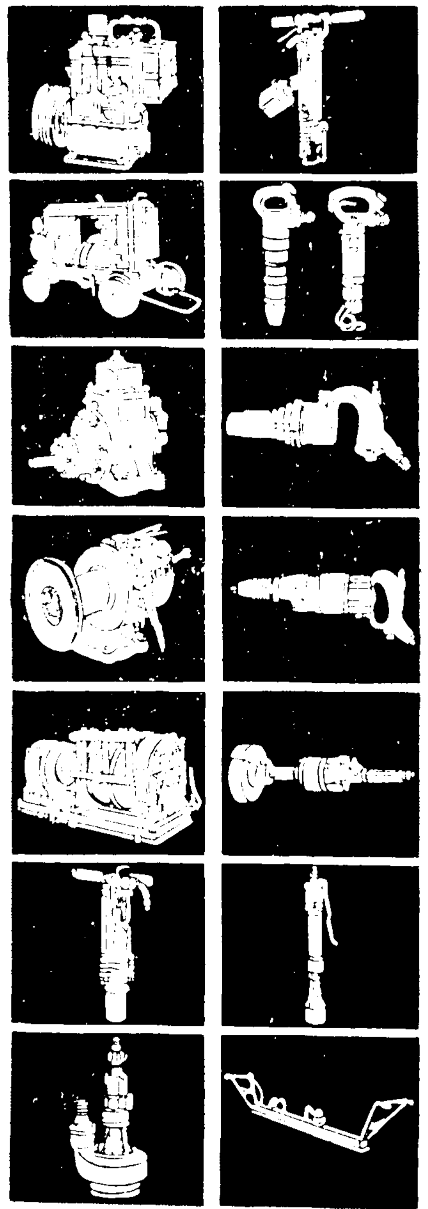

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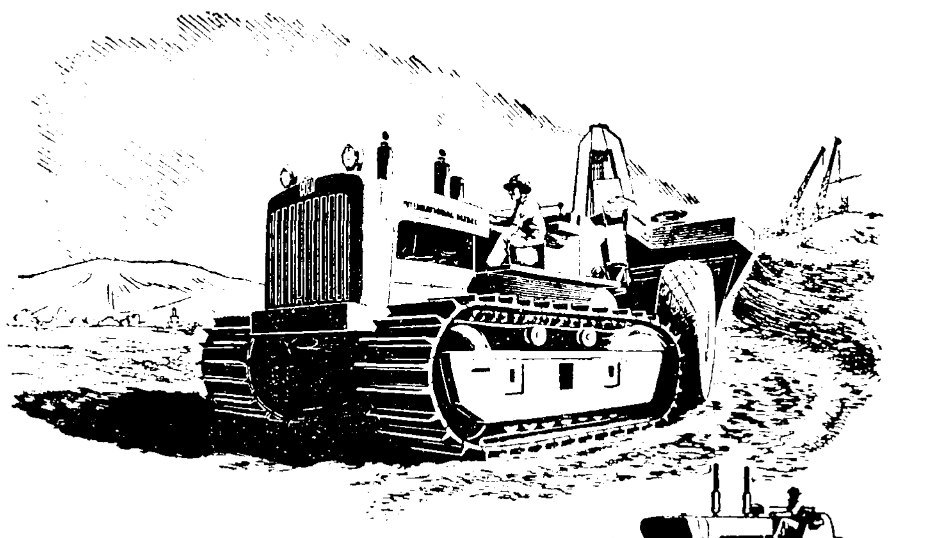

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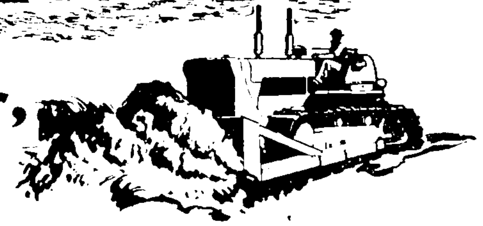

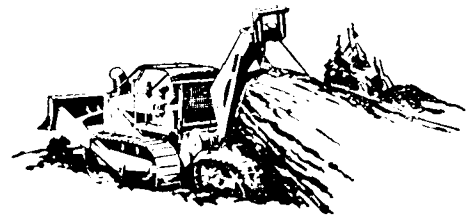

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August 1953

THE ECONOMY AND PERFORMANCE OF TRACKWAYS FOR RURAL ROADS.

(Contributed)

DEVELOPMENT of roads has to be balanced and, since each main road must be fed by its feeder roads, it is essential that the construction or improvement of the main roads must be co-ordinated with those of the feeder roads.

There is no doubt that the feeder roads in this country have suffered from neglect for centuries. Therefore, the greatest need at the moment, in the matter of roads, is to improve the rural roads. There are thousands of miles of these roads which are utterly impassable.

For a long time the bullock cart will remain as the principal means of rural transport in India. The existing earth roads or cart tracks are not the proper thing for the iron tyred bullock cart: not even the scientifically stabilised soil roads can stand up to the cutting action of the narrow iron tyre of the cart.

Then, there are the difficulties created by the excess of rain or utter dryness, dearth of suitable road building stone, conflicting demands of the bullock cart and motor traffic, and so on.

These facts afford some measure of the problem of resuscitating India's rural roads and putting their maintenance on some reasonable footing. The greatest obstacle is the lack of adequate and assured funds. Engineers, therefore, have to do the best they can with whatever funds are available. It is in this scene that the story of **Trackways** begins.

Trackways did not have to be discovered as a new thing. They suggest naturally to the road engineer by the very familiar and simple fact that it is less costly to make good the ruts in a road with more durable material than to metal the whole width frequently.

For some years immediately preceding the war, Engineers in India were quite excited about the possibilities that trackways seemed to offer. Many experiments were carried out to put "ideas" to test in the field. Evidently, it was necessary to discover specifications and technique of construction suitable for wide variations of climate and terrain: to observe and analyse the utility of trackways for various patterns of traffic, that is, slow and fast traffic mixed in varying proportions: and to study the comparative economy of trackways versus the orthodox water-bound macadam roads.

The following is a list of the experiments performed before the war:

(1)	Near Lahore ...	1923–24
(2)	Jaranwala-Sayadwala Road, Punjab ...	1934
(3)	Badli Railway Station Feeder Road in Delhi ...	1934
(4)	Creteways on the Assam Trunk Road in Assam ...	1934
(5)	Trackways in Sind ...	1937
(6)	Gohana-Sonepat Road ...	1939

At the Indian Roads Congress Session of 1941, Sir Kenneth Mitchell, the then Consulting Engineer to the Government of India (Roads), gave a review of the problem, as it then stood. It was estimated that there were about 50,000 miles of earth roads, excluding village roads, in a very bad condition requiring metalling. But the cost of initial construction and maintenance of the metalled roads was considered too heavy a burden on the country's finances. A case was therefore made out, more or less exclusively on the grounds of economy in overall costs, for trackways.

At that stage it seemed, in the light of the experimental work done till then, that the needs of the iron tyred bullock cart could be satisfied by providing trackways and that light motor traffic could be carried on cheap stabilised soil surface alongside the trackways. The economy and performance of this scheme remained to be tested as against providing a full width metalled surface carrying mixed traffic. Unfortunately, with the rapid fluctuations in cost and other difficulties during the war it became impossible to make any further progress in these investigations.

After the war, research was restarted with a view to testing the popularity of the trackways with the cartmen and reducing costs through improved layouts and designs of trackways. Engineers in India were aware of the work done on trackways in Southern Rhodesia and East Africa. But in those countries the trackways had been designed and tried mostly for light motor traffic whereas in India rural traffic consists predominently of bullock carts.

As time passed and knowledge accumulated, Engineers in this country began to incline to the view that the feasibility and economy of trackways were restricted to those cases where only one kind of traffic, namely the bullock cart, had to be catered for. It also became clear that where the bullock cart traffic became heavy, a single line of trackway ceased to be a satisfactory answer to its needs.

In recent years scepticism has been growing and it is becoming more and more obvious that, with an eye on economy, trackways cannot be adopted everywhere as a standard type of construction for rural roads in replacement of metalled roads. Nor have the experiments demonstrated that, where there is any choice, the trackways are readily used by the bullock cart.

At this stage mention may be made of the tests made on the Nagpur-Katol road in 1947. Fourteen different specifications were tried. Unfortunately, the observations made in those experiments and the conclusions derived therefrom were not encouraging. The important points that emerged are described further in the next para.

Between the tracks and on the sides, the filling of only moorum or of the natural soil is not adequate. When a cart has to pull off the track it sinks deep into this filling, which gets quickly powdered under the traffic. It is then very difficult for the cart to come up again on to the trackways. Once off the trackways the cart continues to travel on the moorum or natural soil surface and this results in the formation of deep ruts in several lines parallel to the trackways. During the rains the ruts hold water which seeps into the subgrade and softens it. The subgrade loses its supporting power and this leads to the deformation and ultimate failure of trackways. Therefore, it is inevitable, from the service point of view, that between the trackways and outside them soling and metalling should be done. But this would militate against the primary object of economy in adopting trackways.

Particularly, where the natural soil is weak, such as the black cotton soil of Central India, concrete trackways are not suitable unless they are laid on a substantial base course of boulders or metal and unless metalling is done in between and on the flanges of the trackways. Such a specification cannot compete in costs with the ordinary specification of metalling and where necessary, surface painting.

In conclusion, it has to be said that, in the light of our present knowledge about the technique, economy, and performance of trackways, it is considered that they are feasible where :

(a) traffic is predominantly of bullock carts and its volume is small ;

(b) the cost of ordinary metalling is high due to stone not being available within economic leads ;

(c) the natural soil is not spongy and weak nor the intensity of rainfall high.

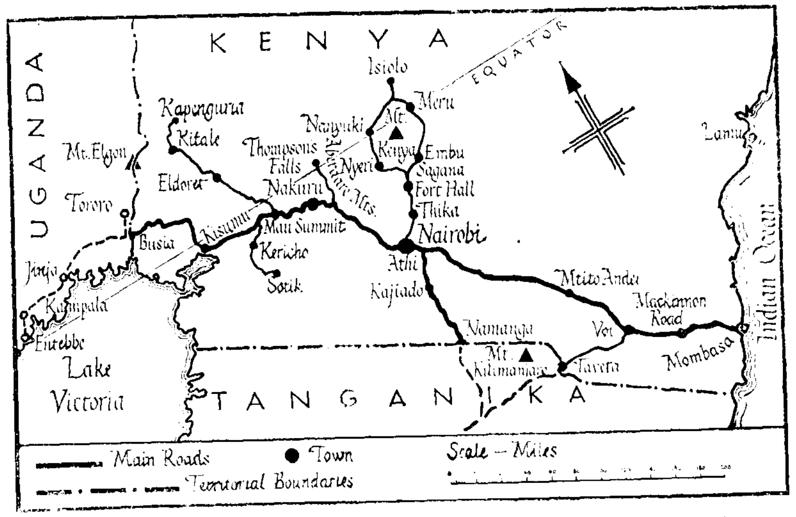
—o—

ROADS IN KENYA

(Extracted from 'Roads and Road construction' May, 1953)

KENYA'S main road system comprises two principal inter-territorial roads, two major territorial roads branching from them and several less important ones which are however classed as main roads because they are links between centres of population.

Firstly, there is the route forming a section of the "so-called" Great Trunk Road connecting Cape Town with Cairo. This leads North Eastwards for about 120 miles from the Tanganika border in the region of Mount Kilimanjaro to Nairobi, the capital of the colony, whence it continues in a North Westerly direction forming the backbone of the road system to the Uganda border at Busia. At Athi some 20 miles South of Nairobi, the other principal inter-territorial road branches from it leading Southwards to the common port of Kenya and Uganda at Mombasa.



Secondly, there are main territorital spur roads serving the tourist area around Mount Kenya and the highland farming and tea and sugar growing districts between Nairobi and Uganda.

Thirdly, the system connects, either directly from the inter-territorial routes, or via the territorial main roads, with a network of feeder roads covering the areas of the European and African District Councils respectively. Also linked to the system are the more sparsely trafficked roads serving the outlying desert areas used for the most part only by the police and officers of the Government administration. The disposition of the more important routes and towns can be seen from the accompanying key map.

HIGHWAY ADMINISTRATION

Since 1950 all public roads in Kenya have become the responsibility of a Road Authority. This body, representative of the interests of both Government and settlers, administers a road fund into which are paid the revenues from fuel taxes and licence duties, contributions from the general revenue of the Colony and special funds for new road construction and re-construction. **Unspent balances at the end of each year are retained in the fund and do not revert to the Government's revenue account.**

The Road Authority has under consideration legislation to codify and extend the existing highway law. This review is being related to concurrent revision of ordinances dealing with road traffic and with Local Government. Sections of the proposed local Government ordinance refer to matters affecting highways in municipalities, and feeder roads in the areas administered by European and African district councils.

The Authority's responsibilities for the main road system are, for the most part, delegated to the Colony's Public Works Department which receives an annual allocation of funds from the road-fund. These highway matters are dealt with by the road branch of that Department, the road engineer of which also acts as chief technical adviser to the Authority.

A proposal for the formation of this roads branch was on the point of being implemented in the late 1920's, but was shelved owing to the world depression, and not officially sponsored again until 1946. The branch was in fact formed during that year but was considerably expanded during the period 1949-1952. It now comprises a headquarters and field staff covering all aspects of planning, maintenance and construction.

SIGN POSTING

A system of route numbering has recently been devised. This is based on the system in use in Great Britain, i.e., a clockwise series of zones but centred on Nairobi instead of on London and Edinburgh.

Kenya has adopted a system of traffic signs based on current international standards and substantially in conformity with those in use in the Union of South Africa and other central and southern African territories. For conspicuity and to present a clear message to the many semi-literate drivers, symbols without lettering are used, the panel being of reflectorised traffic-yellow plastic on which the symbol is stencilled in black. In the case of warning signs, the symbol is not placed within the red triangle as is current in most European countries, the permitted alternative of placing the rectangular informative panel below it being used instead.

Both Nairobi and Mombasa have a number of "zebra" crossings and a few traffic control light signal installations are in use.

ENGINEERING ORGANISATION

Owing to very limited funds being available at the time, the existing alignments of most of the main roads were chosen with more regard to the avoidance of heavy earthwork than to the provision of curves of adequate radii. Also, the average speed of traffic is now such that reconstruction of new and improved alignment is often essential. Even in relatively flat country, an alignment adjoining the existing road is preferred as it enables the latter to continue to be used by traffic during construction of the new road.

Furthermore, the volume of traffic has increased on many roads to the point where the maintenance of poorly aligned roads is becoming excessively costly.

STANDARDS OF ROAD CONSTRUCTION

Present standards of layout and alignment for new construction aim at a ruling gradient of 1 : 20 but even steeper gradients are necessary in the more hilly districts. The width reserved for new roads is usually 120 feet except where earthwork requires this figure to be increased.

The usual width of formation is 32 feet and that of the carriageway 20 feet. One thousand feet is the minimum radius of curve aimed at except where the terrain is such that a lower figure is essential for economical construction. The speed standard is now either 50 or 60 m.p.h. depending on the terrain; and super-elevation is provided on all curves up to 4,000 foot radius.

The road pavement is designed for a 7,000 to 9,000 lb wheel load even though funds available at the time of construction may not permit of this being completed to bitumen standard as soon as the foundations have consolidated.

SURVEYS

Location surveys for reconnaissance and ground control of aerial surveys and in immediate advance of construction are carried out by the department's own survey parties. Until recently very little reliance could be placed on existing road maps but thanks to an aerial survey of the colony, the coverage of which has recently been largely completed, this deficiency will be remedied when all the maps prepared from the survey are available.

Aerial surveys form the first step in detailed planning for new construction and contracts are invariably let for this work although charter flights are sometimes made for initial reconnaissance.

MAINTENANCE

Prior to 1949, maintenance of roads was undertaken mostly by hand labour but this has now been largely superseded by mechanical units comprising a motor grader, trucks and a certain amount of labour, retained mainly for drainage. Each unit is allotted a net-work of roads to look after: the milage varies but a figure of about 100 is usual.

In addition to ordinary maintenance, rather larger units are in use. These are known as "gravelling" or "betterment" units and are employed on adding laterite or other surfacing material, on improving formations, drainage, sight lines, etc., and for similar minor reconstruction works on existing roads. There are five divisional areas of the Public Works Department and each division has one of these "betterment" units.

AGENCY OF EXECUTION

Except for bridging and culverting which can be satisfactorily let to contract the direct labour system has been chosen for new road construction, one reason for this being the difficulty, in the past, of ensuring competitive tendering. Where, in isolated cases, contractors are employed, the practice of letting separate contracts for bridges, earthwork, and base-courses respectively is preferred to that of letting a comprehensive contract for the whole project. A reason for this is that it may sometimes be desirable for these

various processes not to follow immediately one after another. Bitumen surfacing is done by direct labour when the base course has consolidated, and if funds permit.

Hardly any of the plant used on construction, betterment, or maintenance is obtained under hiring contracts. Instead, purchase, overhaul and replacement are effected by means of a departmental funding scheme. Thus, when an item of plant is allotted to a road job, this is charged with the appropriate hire rate to cover overhaul and eventual replacement. The amounts accruing is used to replenish the plant fund.

ENGINEERING PROBLEMS

There are probably few countries where the problem of making a sound modern road system is so difficult as it is in Kenya.

The five main reasons for this are: complete lack of really good quality roadstone; limited availability of such inferior material as does exist; former methods of road maintenance; prohibitive cost, at present, of soil stabilisers; and water supply difficulties. These very facts however make the provision of an up-to-date road system with limited funds a particular test of engineering ingenuity, even with the help of modern roadmaking plant.

The country is practically devoid of stiff clays and the soils and rocks are to a large extent volcanic in origin. The most commonly occurring soils are those known locally as "black cotton," a humus-bearing clay having extremely poor bearing power when wet; "red coffee," a silt easily handled by earthmoving equipment but of unusual properties when used as a subgrade; and "lava ash," having the appearance of cement when dry but very moisture absorbent rendering the use of compaction equipment not at all easy. For instance the best amount of water to add for the combined requirements of maximum field density and absorption is such that wheelspin is only just avoided. However, there are also considerable areas of sands and sand-clays admirable for use with soil stabilisers when these become economically available.

Generally, the "black cotton" soil does not exceed about 3 ft in depth below the surface when it is usually underlain by a limestone "brash." Under these conditions complete excavation and replacement by the limestone is often a practicable and economic proposition.

Much use is made also of laterite for surfacing. The occurrence of this decomposed ironstone rock, known locally as "murram", is fairly widespread. It is very variable in quality, however, although as a wearing surface it retains its shape reasonably well when wet, whereas road surfaces of "cotton" or "coffee" soil rapidly pothole in this condition. The "lava ash" soil forms a rather better all-weather surfacing than the two last mentioned ones, but all except the "coffee" soil corrugate badly under traffic when dry. As a general rule, materials which retain their stability well when wet suffer from this latter tendency. Less stable materials, although they corrugate less, are nearly always susceptible to the more serious fault of becoming potholed.

Most of the available roadstone consists of a fairly soft fine grained rock of which much use is made as a building stone. It is however usable as a sub-base for roads and there are a few widely scattered deposits of a rather harder aggregate known locally as "black trap" which can be used either for water-bound macadam, premixed bitumen macadam, or for surface dressing. It has been adopted in the past also for semi-grouted bitumen macadam but this method of construction is no longer favoured and full-grouted macadam is preferred.

It is often thought that, because of the paucity of good roadstone, extensive soil stabilisation is common practice in Kenya. Whilst it is true that good use has been made of controlled compaction for subgrades in new main road construction, the cost of soil cement, bitumen stabilisers or the various types of water-repellent additives is at present uneconomic. There are, however, many miles of road on which the soil would lend itself to satisfactory use of one or other of these processes.

—o—

DEFINITIONS OF HIGHWAY ENGINEERING TERMS

BY-PASS ROAD: A road to enable through traffic to avoid congested areas or other obstructions to passage.

SERVICE ROAD: A subsidiary road constructed between a road and buildings or properties facing thereon and connected only at selected points with the principal road.

A letter from Scotland reads:

"If you continue to publish jokes about Scotchmen, I will cease to borrow your Journal."

—o—

LEANING TOWER OF PISA

(Extracted from the Engineering News Record, 2nd April, 1953).

THE Leaning Tower of Pisa may be compared to a building 180 ft high whose base is at the building line and whose top leans over the sidewalk, and projects out beyond the kerb. No wonder the tourist gazes in astonishment at the bell tower which, his experience tells him, should not be standing at all.

Actually, it stands virtually intact, the only visible damage being a slight cracking in a few of the outside columns, which have been reinforced with steel bands. The nearby cathedral has undergone similar settlements, which by 1825 were so serious that part of it had to be taken down and rebuilt.

History – The construction of the Tower of Pisa was started in 1174 under the supervision of a Florentine named Bonanno. The foundation consisted of a large ring of masonry about 20 ft wide and about 60 ft in exterior diameter, bearing on the soil, it is believed, only a few feet below ground level. The soil probably consisted of a wet volcanic silt, called in some accounts fine sand and clay, and if anything had been known at the time about the bearing values of soil, the tower would never have been built. No modern building code would assign to such a soil a presumptive value of more than about ½ ton per sq. ft. whereas the actual load under the tower foundation is about 8 tons per sq. ft.

It is stated in some accounts that "many logs" were placed in the soil below the masonry. Whether these were placed as a mat or driven as piles is not known, but in any case apparently they added nothing to the support. By the time the equivalent of three stories had been erected, settlement had occurred, and the tower was tilting at an alarming rate. The cities of Florence and Pisa were not too friendly at the time, and ugly rumours of deliberate sabotage began to float around Pisa. Bonanno thought it was about time to leave the town—construction was abandoned, and the tower remained three stories high for 60 years.

By that time it had settled into the ground sufficiently to consolidate the soil, and temporarily to arrest the settlement. It was with confidence, therefore, that Giovanni de Simone decided to finish the tower. As the work progressed, an attempt was made to straighten the structure by adding additional courses of masonry on the low side. Giovanni added another story, and it is believed that the settlement and tilting increased alarmingly. In any case, the work was stopped and Giovanni disappeared.

Nothing further was done for nearly 100 years, by which time continued settlement had developed new consolidation in the soil sufficient to cause the structure again to come to apparent rest. An architect of Pisa named Tomasso, then deciding that it was safe to finish the structure, designed a narrow belfry, made other minor changes in the plans, and proceeded.

As to further settlement and tilting during construction, we know nothing except that the practice of attempting to straighten the tower by adding masonry courses on the low side was continued, until, on completion, the low side was nearly 3 ft longer than the high side.

The structure was finished in 1350, and we have every reason to believe that the settlement and the tilting, accompanied by the consolidation process, have continued over the 600 years to date. The structure is now more than 14 ft out of plumb, and while there is no record of its original elevation, it has settled about 12 ft on the low side and about 8 ft on the high side. Settlement proceeding at a slow rate over the centuries is what has saved the structure from complete collapse.

The tower may be said to be supported on a truncated cone of consolidated soil, extending from the underside of the tower down to a clay layer about 35 ft below the surface, and about 90 ft in diameter at the latter level. If this were correct, unit load on the lower clay is less than two tons per sq. ft. which such material should be capable of supporting.

Unfortunately, the loading is eccentric, and tends to become more so as the lean of the tower increases. The consolidated soil beneath the tower attempts to compensate by "bridging out" farther on the weak side. However, increased consolidation involves further settlement and further tilting, and the process will continue until the centre of gravity of the tower moves beyond the danger point.

Within the tower, the Italian authorities have constructed a special room with a level floor about 30 ft above the ground. In this room they have placed a plumb line extending to the roof, an accurate level and seismographs to check on any earth movements that might be immediately disastrous. Continuous readings on these instruments show that the tower is increasing its lean at the rate of .04 in. per year. On this basis Italian engineers estimate that collapse will not occur for about 200 years. However, as it leans, its centre of gravity moves towards the low side, the rate of lean will increase, and the tower must be declared unsafe within 100 years.

—o—

THE LESSONS OF WAR AND PEACE ARE THE SAME

In Peace

"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."

Jawaharlal Nehru

"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

In War

"The more experience I have had of both peace and war, the more I appreciate its general truth. After some years in high military command, I am inclined to put forward as a parallel dictum that "War is Transportation." Certainly it is the ruling factor in military operations; and no compaign has better illustrated this than that on the North-East frontier of India and in the north of Burma."

Lord Wavell

—o—

ROADSIDE SLIPS NEAR DHARAMSALA

(Condensed from a report of the Geological Survey of India by G. Kohli)

CERTAIN lengths of roads round about Dharamsala in the mountainous Kangra district of the Punjab (1) have been known to be particularly subject to slips during the monsoon rains. Some time ago the Punjab Government requested the Geological Survey of India to investigate the causes of these slips. The investigation was carried out in April 1951. The following extracts are from the report on the subject.

TYPES OF LANDSLIDES

(1) Major slips (failures) are hillside slumps, subsidence, and mudflows, displacing sections of the road enmass during the rainy season and involving shaly marls, soil, etc.

(2) Subordinate slips involving fresh rocks are due to outward dipping joints. These are very local and do not damage the road section normally.

(3) Soil creep — Observation on steep slopes shows tree trunks curved by soil creep. See photo 1.

CAUSES OF HILLSIDE FAILURE

Examination of the region and the unstable sections clearly shows that the slips are independent of structure lines and the joint pattern. The rocks dip more or less into the hill and thus tend to stabilise it. In no case is the dip of the rocks responsible for the failure under review. The failures are due to the reduction of the coefficient of internal friction (static) caused by saturation with water of the shaly marls, soils, etc. during the monsoon. Under dry conditions the coefficient of static friction is sufficient to prevent slipping.

The decrease of the coefficient of internal friction is attributed to

(a) increase in pore-water pressure ;

(b) increase in weight per unit area ;

(c) air-filled voids getting filled with water, causing reduction in internal friction ;

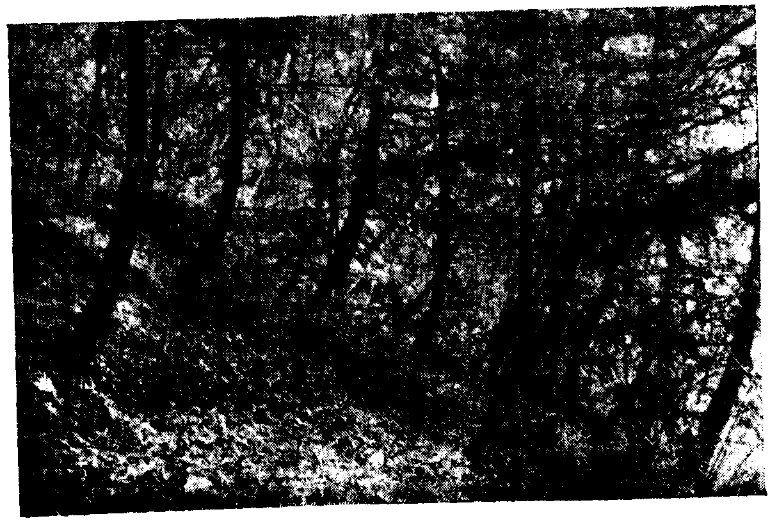
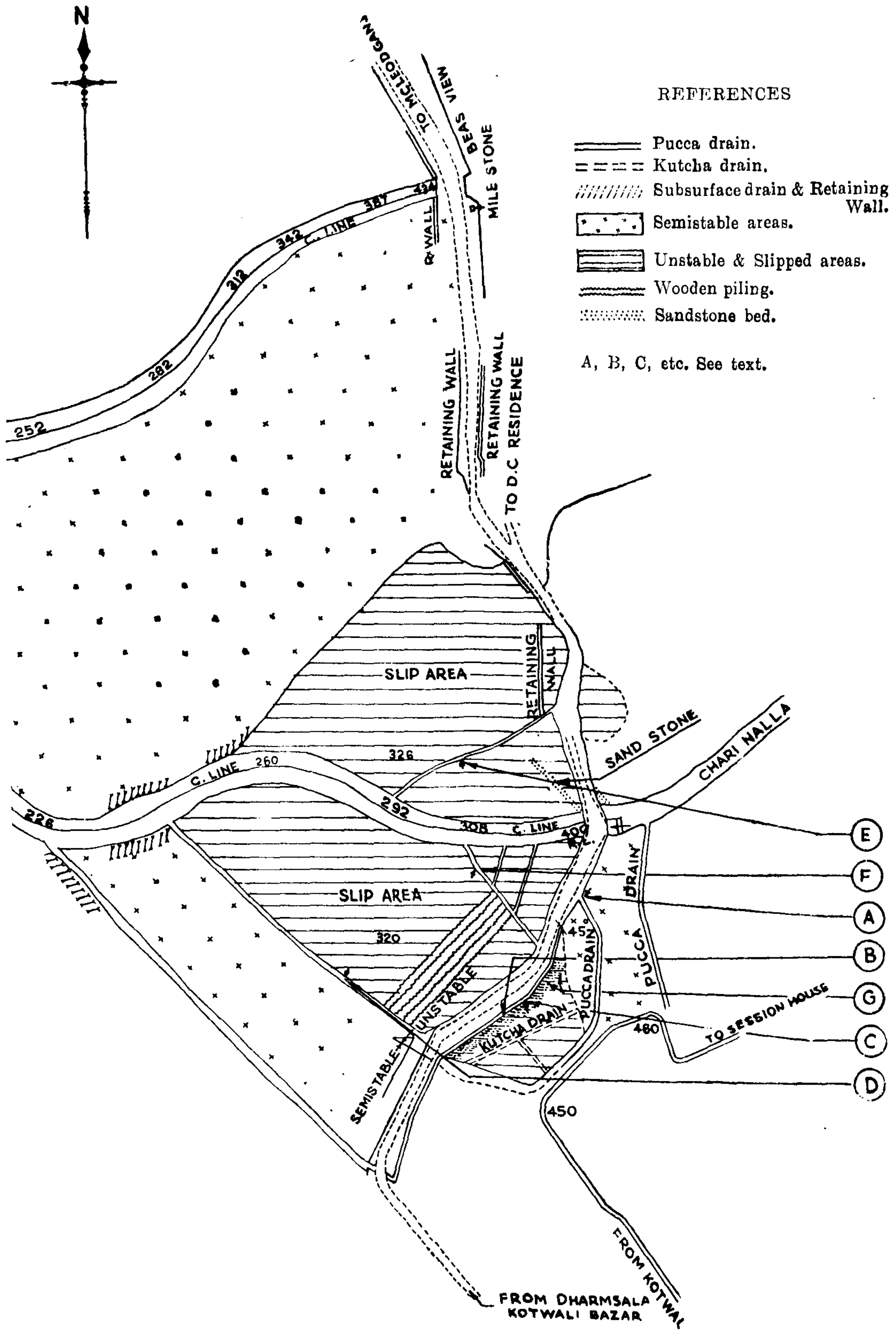


Photo: 1. Tree trunks curved by creep just above motor road near Mcleodganj.



South

North

Photo 2. Charri Nala Slip.

(d) super-saturation which destroys the structure of soil leading to actual mudflows: and

(e) soluble constituents in the marls and soils being dissolved by water.

Another contributory cause of these failures is the under-cutting of the toes of the spurs by the onrush of water, during the monsoon, in channels which are normally dry.

PREVENTION AND CONTROL OF LANDSLIDES

Terraces and flats above and well below the road section should be carefully drained.

The water content of the unstable masses should be decreased by constructing ditches, drains or drilling conduits, and by diverting surface flow around the unstable ground and draining it off as completely and rapidly as possible. Effective surface and sub-surface drainage thus appears to be the main-measure to be adopted for minimising landslips in the area under consideration.

To avoid upsetting the equilibrium of the delicately adjusted slopes, additional weight on them, such as construction of houses, etc., should be avoided; construction should be permitted only with the knowledge and approval of the engineers of the Public Works Department.

Afforestation, i.e., the growth of grasses and small plants, may help in binding the soil although that would possibly increase the water content in the soil. Large areas, however, are unlikely to be of any positive value. Additional weight and root pressure from these are likely to have a detrimental effect where the ground is unstable.

Drains should be large enough to carry away water when heavy precipitation occurs and should discharge well below the road, preferably into the nala. No diffused percolation should be allowed around areas.

Wooden piling, besides giving some support, would retard mudflow during the monsoons. Two or three sets of wooden piling with brushwood and wire, alternating in space, should be constructed below the road.

RECOMMENDATIONS FOR MILE 100/6

This section of the road slipped over 30 feet during the 1950 rainy season.

The only effective way to minimise the slips is to drain the surface water from precipitation as completely and rapidly as possible and to protect the toe of the slipped masses and spurs where they are being undercut. The construction of pucca drains and re-afforestation is suggested. (See plan and photo 2).

(A) Besides the existing catchment drains, (A) above the Charri Nala slip, other catchment drains are necessary higher up (east).

(B) Open pucca drain is required along the road in the slipped section and it should preferably discharge water below road level, beyond the unstable ground. The eastern wall of this drain could form the breast wall. The sub-surface drains should emerge through this breastwall.

Drum drains are required across the face of the slip (C): Water from these should be led into the pucca drain or discharged outside the unstable area.

Drains (D & E) already proposed and shown on the plan should suffice. A small additional drain (F) (drum) (where the concrete retaining walls end) may be constructed along the stable section as it would give the additional advantage of protecting the concrete structures, whose stability is endangered by undercutting.

Sub-surface Drainage

In order to eliminate water already present in the slipped masses and semi-stable zones and thus to increase internal friction, the following measures are suggested:

At the level of the road, perforated tubes (G) (drums) should be driven in as

(Continued on page 16)

CONSTRUCTION OF ROADS WITH ROLLED LEAN-MIX CONCRETE BASE

(Extracted from the British Constructional Engineer, June, 1953)

THE Chief Engineer's Department of the Crawley Development Corporation, U.K. was faced with the problem of providing roads for the Langley Green Neighbourhood Unit in a short time.

Since time was a vital factor and hardcore (soling) supplies were difficult, it was decided to construct the major proportion of the roads with a rolled lean-mix concrete base.

The carriageways are of widths 22 ft, 16 ft and 13 ft and the concrete is generally 8 in. deep although this depth was increased to 10 in. for roads scheduled as bus routes. The concrete was laid between steel forms set direct on the formation. It was placed in two equal layers, each being evenly spread with a surcharge of about $\frac{1}{2}$ in. to allow for compaction. Particular care was taken to avoid segregation by additional mixing by hand where necessary.

Compaction of the concrete was carrie out with a $2\frac{1}{2}$-ton roller. During the course of the work heavier rollers, up to 6 tons in weight, were tried, but they did not improve on results given by the light roller.

The concrete had an aggregate cement ratio of 14 : 1 by weight with a water-cement ratio of 0.7 which included an allowance of 0.1 for evaporation losses during the transporting and placing of the concrete during the hot summer.

Aggregate used was a Thames ballast blended at the pit to give a $1\frac{1}{2}$ in. down grading with approximately 35 per cent passing a 3/16 in. sieve. It was soon established that deliveries of aggregate maintained an almost constant grading and thereafter grading checks were carried out only at weekly intervals.

The work was carried out under summer conditions and no expansion joints were formed in the lean concrete. Construction joints were formed by extending the bottom layer 2 ft beyond the top one, the upper layer being finished with a vertical face against a stop end.

After the final rolling the surface was immediately sprayed with bitumen emulsion. Any small areas which had to be left temporarily unsprayed for convenience of rolling on the following day were cured with wet sand or waterproof paper.

No traffic was allowed on the lean concrete for seven days after spraying and for a further period of seven days traffic was restricted to that absolutely necessary for the laying and rolling of the tarmacadam surfacing.

The cost of this type of construction is largely dependent on the availability of aggregate supplies. It was found on this particular contract that the cost of a lean concrete road with a tarmacadam surface was comparable with a similar surface on a hardcore base, and the ratio of cost of labour, plant and materials was found to be 10 : 18 : 72. Moreover, it has been shown by measurements carried out by the Road Research Laboratory that the riding quality of the finished road with a lean concrete base is markedly superior to that with a hardcore base.

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DOCUMENTARY FILMS ON ROAD ENGINEERING

THE Roads Organization has acquired a number of documentary films that interest road engineers. The available films are described below. Interested institutions and departments can borrow any of these films, free of charge, from the Consulting Engineer to the Government of India, Road Development, Jamnagar House, Shahjahan Road, New Delhi-2.

List of Documentary Films and Film Strips available with the Roads Organization.

Silent Films

1. **Soil Testing.**

Part I. A routine soil survey.

A map of the site is examined in the laboratory. A party travels to the site in a mobile laboratory and on arrival the site is pegged out and samples of the soil are taken out with augers. Coarse sieve analysis is followed by pretreatment of soil samples for fine sieving, hydrometric analysis and determination of liquid and plastic limits. **Running time, 18 minutes.**

Part II. Laboratory examination of soils.

The mobile laboratory returns to the Road Research Laboratory and the wet sieve analysis and pipette analysis are carried out. The organic content, specific gravity and carbonate content of the soil are measured and a sample of the soil is retained for the museum. **Running time, 18 minutes.**

2. **Soil Compaction - An Experimental Study.**

Smooth, pneumatic-tyred and sheepsfoot rollers are shown in operation in an investigation designed to study the relative effectiveness of these rollers on a brick-earth soil. **Running time, 10 minutes.**

3. **Soil-Cement Construction in Great Britain.**

Cement is spread on the levelled soil forming the perimeter track of an airfield and is mixed in with various types of agricultural machinery. The soil cement mixture is watered during mixing and is then compacted by rolling. **Running time, 10 minutes.**

4. **Road Stone Testing.**

Part I describes the tests carried out on lump rock. After preparation of the specimens, tests of resistance to abrasion, impact and crushing strength are carried out.

Part II shows the testing of aggregates in the dry and wet attrition tests and in the aggregate crushing tests **Running time, 19 minutes.**

5. **Machinery in Concrete Road Construction.**

Mixing, spreading and compacting machines are shown in the construction of the Chichester by-pass in 1939. Studies of the measurement of vibrations in concrete are also shown. **Running time, 10 minutes.**

6. **Routine Acceptance Tests for Concrete Roads.**

Cores cut from a concrete road with a core-cutter are tested for compressive strength in the laboratory. The cement content is determined by chemical analysis of the crushed cores. **Running time, 6 minutes.**

7. **Tarmacadam-From Quarry to Road.**

Stone is blasted from the quarry face and taken to the primary crusher. After crushing the stone moves on a belt to the stockpile, and is then dried, passed through secondary crushers and screened into bins.

The crude tar is refined and its viscosity is measured with the British Road Tar Association viscometer. Distillation is carried out as specified in B. S. 76-1943. The softening point after distillation is then measured by the ring and ball test.

In making the tarmacadam the aggregate is proportioned to the grading required

and after being heated passes into the mixing plant. Hot tar and small quantity of quarry fines are added in succession to the aggregate. The materials are mixed and a sample tested from binder content and grading (B. S. 598-1940.)

A thin carpet of the tarmacadam is laid with the Barber-Greene machine. **Running time, 35 minutes.**

8. **Wet Aggregate Tarmacadam.**

Satisfactory results are not obtainable with wet aggregate using the normal process, but the addition of hydrated lime enables the stone to be coated with the binder.

Laboratory tests illustrate the effects of water, limewater and caustic soda on the coating of wet stone by tar and bitumen. Mixtures are tested by immersion in water.

The final section of this film shows the method being used successfully for airfield construction using a local sand. **Running time, 35 minutes.**

9. **Boulder Dam.**

It shows the constructional details of a boulder dam in the U. S. A. The film is self-explanatory. **Running time, 40 minutes.**

10. **Trip over Pennsylvania Turnpike.**

Supplement to No. 12. **Running time, 20 minutes.**

Sound Films

11. **Horizons Unlimited.**

The film shows that the present prosperity and world position of the U. S. A. is due to its roads and can be used to demonstrate the need for improving and extending India's highways to meet the economic and cultural necessities of the country. **Running time, 35 minutes.**

12. **Pennsylvania Turnpike.**

This is an excellent documentary film about the planning and construction of a modern express highway known as the "Pennsylvania Turnpike." **Running time, 40 minutes.**

13. **Arteries of the City.**

The film classifies elements which influence the development of a city's transportation facilities, including the distribution of residential and business sections; the daily flow of people; ferry, bus and automobile traffic systems; and police regulation. **Running time, 20 minutes.**

14. **Building a Highway.**

The film skillfully demonstrates major steps in the construction of a modern two-lane highway. It also illustrates such processes as clearing, cutting, scrapping and levelling the road bed; assembling materials, mixing and dumping the concrete; and smoothing and finishing the surface. Finally the film reveals the completed highway open to traffic and emphasises the necessary skills involved in providing well built, safe highways for motor traffic. **Running time, 20 minutes.**

15. **The Mexican Story—Road for San Pablo.**

The film shows how backward the Mexican farmer was and how a highway passing right through his farm brought civilisation and progress closer to him. **Running time, 36 minutes.**

16. **Stabilized Soil for Road Making.**

The film begins with an explanation of the general idea of Soil Stabilization and follows the various stages of soil tests and the evolution of control specifications.

By the use of soil tests, it is possible so to control the technique of construction as to have strong and durable foundations. A brief treatment of the methods of soil stabilization in India and of the special technique developed in the Madras State for waterlogged conditions are shown. **Running time, 50 minutes.**

17. **Road Ahead.**

The film shows the actual operations involved in the relaying of Park Lane, London, with animated cartoons. **Running time, 40 minutes.**

Film Strips.

18. **The Story of British Roads (36 shots).**

(With teacher's commentary—Silent)

The film strip describes the growth and development of highway communications in Britain since the earliest times. Photographs and text illustrate the economic benefits of good roads. Road building in various European countries and the United States is outlined briefly towards the end of the story.

19. **Unsuitable for Motor Vehicles (40 shots).**

(With teacher's commentary—Silent)

This film strip provides a comparison between the British highways and those of Western Europe. It also explains why certain roads are dangerous to all types of road traffic and gives examples of how danger spots can be eliminated.

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(Continued from page 12)

far as possible into the unstable hillside at a slight angle to the horizontal.

The discharge from these should be led into the pucca drain along the road. The diameter of these will depend on the "tubes" available and the facilities available to drive these into the hill. It should not be less than one foot. Spacing would naturally depend on the size of the drains used. To stop the perforations from getting blocked a layer of gravel may cover the drain. Similar or larger drains could be put in where water normally oozes out. The discharge from these should be led into pucca drains, well below the affected zones.

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PEDESTRIAN SAFETY

When a pedestrian steps from the curb at a cross walk, he has started to cross the street and the right of way is his. By giving the pedestrian the breaks as well as the brakes motorists can easily cut accidental injuries and fatalities.

(Extracted from "California Highways and Public Works" January-February, 1953).

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DESIGN

Design, in the engineering sense of the word, is a process of matching requirements against available means and of recording the results of so doing in the form of drawings and written specifications to show how it is to be translated into actual practice.

COVELONG BRIDGE ACROSS THE BUCKINGHAM CANAL AND BACKWATERS (Near Madras)

FOUNDATION STONE LAID

SHRI O. V. ALAGESAN, Deputy Minister for Transport, Government of India, laid the foundation stone of a bridge on the Kelambakkam-Covelong Road on June 27th, 1953. The bridge spans the backwaters and the Buckingham Canal on the road connecting Kelambakkam and Covelong.

Shri Alagesan speaking on the occasion said that Covelong being a seaside resort would provide excellent opportunity for holiday makers. Also, there existed places of worship which should attract religious minded people.

Shri K. K. Nambiar, Chief Engineer of the Highways Department of Madras said that in undertaking new road projects there had been a tendency to postpone the construction of bridges to a later date and to complete only the roadwork in the first instance. That was so, because bridges cost a great deal of money. But, he said, it could be no satisfaction to us to have roads on which traffic was interrupted by streams during rains causing great hardship to agriculturists. The need for bridges, he declared, was even greater than that for the road itself. The development of roads in the past had left much lee-way to be made up in this matter. He said that bridging the Buckingham Canal was a simple matter but crossing the tidal section was an extremely costly proposition. After considerable investigation an estimate for Rs 1.75 lakhs had been framed and sanctioned. The design, as finalised, consisted of a high level bridge across the Buckingham Canal with a free board of 12 ft above the high water level to enable the boats to pass through. There would be three causeways with a total length of 315 ft vented with hume pipes. The roadway over the embankment and the causeway would be 18 ft wide with its surface gravelled. The embankment would be protected by revetments. The roadway over the bridge would, however, be 12 ft wide designed for one-way traffic. The work would be financed from the Central Road Fund.

ANYTHING BREAKABLE?

A woman was mailing the old family bible to a brother in a distant city.

Postal Clerk: "Does this package contain anything breakable?"

Lady: "Only the Ten Commandments."

HERE AND THERE

1. COMMITTEE TO SURVEY ENGINEERING CAPACITY

THE Government of India have appointed, in June last, a Committee consisting of three officials of the Government of India and four non-officials representing private industry, to make a preliminary assessment of the capacity lying idle in the engineering field in India, and the degree to which the production of machinery and spare parts can be rationalized.

During the last session of the Parliament, **Shri T. T. Krishnamachari,** Minister for Commerce and Industry, had announced that the Government were contemplating a survey of the country in this direction.

This Committee is expected to finish its work in three months. The Committee constitutes of the following:

Mr. S. Moolgaokar of Tatas; Mr. S. L. Kirlosker of Messrs. Kirlosker Oil Engines Ltd.; Mr. K. Gopala Iyengar, Retired Superintending Engineer, Madras Public Works Department; Mr. S. E. Golledge of Associated Chambers of Commerce; Mr. Jang Bir Singh, Industrial Adviser (Engineering), Ministry of Commerce and Industry; Mr. P. C. Kapur, Joint Director, Mechanical Engineering, Ministry of Railways; and Mr. I. N. Dar, Assistant Director of Ordnance Factories, Ministry of Defence.

2. THERMIC BORING THROUGH REINFORCED CONCRETE

IN drilling holes in reinforced concrete difficulty is always experienced in cutting through reinforcement, and in many cases the vibration and noise which accompany drilling prohibit its use. Thermic boring is a method of boring through reinforced concrete, stone or similar materials by the fusion of oxygen and iron, the temperature of which is sufficient to melt the material. In the case of concrete the silica content becomes fluid and is carried away with the products of combustion, the presence of steel actually facilitating the process and the work being carried out without noise or vibration.

The equipment consists of three steel containers for oxygen connected by a manifold with pressure gauges from which the oxygen passes through flexible hoses to a holder into which is inserted a mild steel tube filled with a number of soft-iron wires. The size of the tube and the number of wires are determined by the size of the hole required.

The point of the tube is first heated to a red heat by an oxy-acetylene burner or some other method and oxygen is fed through it. The end of the tube then fuses and is applied to the material to be penetrated. The heat generated melts the material and the flow of slag is assisted by the molten metal. Holes can be bored horizontally or vertically up to about 15 ft to 20 ft long, but in boring vertically difficulty is experienced beyond depth of about 10 ft after which a special system for removing the slag is required.

The diameter of the hole produced can be varied by using tubes of different diameters, one of 3/8 in. producing a hole between $2\frac{1}{2}$ in. and 3 in. diameter. The speed of penetration for a horizontal hole of this size is about $1\frac{1}{2}$ minutes per foot, and six to seven feet of the tube and wires and about 23 cu. ft. of oxygen are consumed, but this depends largely upon the silica content of the material being bored. Larger holes, up to 4 in. diameter, can be produced by tubes up to 1 in. diameter. For vertical boring the consumption of the tube and wires and of oxygen is the same as with horizontal boring for a depth of about 8 ft, beyond

which it increases to about 8 ft to 10 ft of tube and 30 to 32 cu. ft. of oxygen per foot of penetration.

Although the method is for boring and not for cutting, it is possible to cut concrete by boring a series of closely spaced holes along the line of the cut required. The system has been used in this way to cut holes through reinforced concrete foundation beams 3 ft 9 in. thick immediately behind which was 1 ft $1\frac{1}{2}$ in. of brickwork. One of the holes, 1 ft 2 in. by 2 ft 2 in., required the boring of 20 holes, consuming 2970 cu. ft. of oxygen and 462 ft of $\frac{1}{2}$ in. tube packed with nine soft-iron wires; the total weight of iron and steel used was 577 lb. The work took 13 hours. Another application required the cutting of three holes, 4 ft diameter by 1 ft thick, in a reinforced concrete roof. The circles were marked-out by cutting a chase 1 in. wide by 1 in. deep with a $\frac{1}{2}$-in. tube and then boring holes about 2 in. apart around the circumference, using a steel sheet for protection.

The sheet was then removed and the portions between the holes burnt away, the slabs having previously been attached to a block and tackle. About 150 holes were bored requiring 1331 ft of $\frac{1}{2}$-in. tube and 15,400 cu. ft. of oxygen. The work was carried out by three men in 90 hours.

(Extracted from Concrete and Constructional Engineering, March, 1953).

3. ALUMINIUM PLATE GIRDERS

AN example of the use of aluminium plate girders to reduce deadweight to a minimum and to ease the difficulties of erection under the limited head-room available, is to be found in the remodelling of one of the depots of the Birmingham City Transport Department. The depot is being converted from tram to bus use, and as buses need a different parking arrangement from that of trams, in particular, greater space to manoeuvre, alternate stanchions are being removed. Supporting the roof has required the erection of large-span roof girders between the remaining stanchions. Three girders, 67 ft long, with a depth of nearly 6 ft and each weighing $2\frac{1}{2}$ tons, together with two girders of 50-ft span and a number of 23-ft span, are being installed in this depot. Aluminium members of a size of the largest of these girders are as yet unusual and the present example is a good instance of the increasing use of light alloys in structural engineering. Although there have been some notable examples of aluminium construction in recent years, it is likely that, as experience with the material increases, there will be a greater proportion of structures designed in light alloys, particularly where self-weight is an important factor, as in long-span roof girder and bridge members.

The use of aluminium for the girders at Birmingham has ensured that the dead load on the remaining stanchions is increased as little as possible, while the problems of transporting and handling such large members have been considerably reduced. These girders, are built up of plate of Noral 65-SWP alloy and of extruded angle sections of Noral* 51-SWP alloy. These two materials, are both heat-treated aluminium-magnesium-sillicon alloys of the type that is now being used for general structural work of all kinds, for they combine a resistance to atmospheric corrosion with a yield strength comparable with that of structural steel. The highest design stress accepted was **4.94** tons per square inch in the compression flange; for Noral 65-SWP plate, a typical 0.1 per cent proof stress in compression is $17\frac{1}{2}$ tons per square inch, so that a factor of safety of over $3\frac{1}{2}$ with respect to the yield point has been obtained in this case.

The web of the largest girders, is of 5/16-in. plate, 5 ft 9 in. deep, with angle stiffeners on both sides, generally at 3 ft 9 in. centres; the angles used for the stiffeners have either 5 in. by 3 in. or 4 in. by 3 in. legs. There are six splices in the web, the connections being made with

*Northern Aluminium Company.

double cover plates. The tension flange is built up from two 6-in. by 4-in. angles, the longer legs outstanding, and a 5/16-in. flange plate, 14 in. wide. The compression flange is similar except that the flange plate is 20 in. wide by 3/8 in. thick, and is stiffened along the edges by angles with equal 3-in. legs. The three splices in each flange were made by a cover plate outside the main flange plate, by angles inside the flange angles, and by cover plates on the outside of the up-standing leg of the stiffening angles along the edge of the compression flange. Hot-driven rivets of mild steel, 13/16-in. in diameter, were used throughout, the usual precaution of staggered riveting being observed during assembly to avoid local overheating of the aluminium alloy.

(Extracted from "Engineering" May 1, 1953.)

4. THE "VACUUM CONCRETE" PROCESSES

IN the "vacuum" processes for treating concrete, devised by Mr. K. P. Bilner, of Philadelphia, water in excess of that required for the hydration of the cement is extracted from the concrete immediately after it is placed. This is done generally by lining one or more faces of the shutter with a filter, which comprises wire mesh and a gauze fabric, connected to a vacuum pump. As the pump is operated the concrete is compacted by atmospheric pressure, which in some cases may be assisted by the weight of the concrete. In untreated fresh concrete the atmospheric pressure is resisted by the intergranular pressure between the pieces of aggregate and the hydrostatic interstitial pressure in the minute channels in the concrete. The action of the vacuum is to reduce the interstitial pressure and so compel the concrete to contract within the mould, thus expelling part of the water through the filter. This effect penetrates the mass of the concrete but at a diminishing speed similar in manner to the progressive increase in temperature along the length of a metal road heated at one end.

The expulsion of the water and the contraction of the concrete result in the production of a compact mass with a high cohesive strength allowing the immediate removal of shutters of elements up to 18 ft high, and also reduces the water-cement ratio and so improves the properties of the hardened concrete. The compressive strength of vacuum-treated concrete at an age of eight or nine days is, for example, equal to that of untreated concrete with the same cement content at 28 days, and the final strength is usually increased by 1200 lb to 1500 lb per square inch.

(Extracted from "Concrete and Constructional Engineering," June, 1953.)

5. ADVANTAGES OF ONE-WAY TRAFFIC OPERATION

ONE-WAY traffic operation gives so many traffic benefits at such relatively small cost that it deserves, and is receiving, increased consideration by state and municipal traffic agencies (in the U. S. A.). It results in greater carrying capacity and better average speeds on existing streets. It reduces conflicts and accidents and makes possible more efficient progression of signals. It improves driving conditions and, at the same time, gives the pedestrians a better break. Finally, because one-way operation is less expensive than new facilities, it affords the opportunity to provide traffic benefits now, rather than in the indefinite future. The inconvenience to the adjoining property owners is entirely apparent; but this is, again, a compromise that must be made to benefit the majority.

(Extracted from 'Proceedings of the Thirty-Seventh Annual Highway Conference, Michigan, March, 1952.)

6. RESEARCH VERSUS TRIAL AND ERROR

TRIAL-AND-ERROR methods are essential for engineering progress and development. Not every decision in design or production can be made the subject of research inquiries, but, on the other hand, in certain branches of engineering, applied or even fundamental research is an indispensable prerequisite of technical progress and cannot safely be replaced by guesswork, however inspired. It may be that, on the strength of research done now, future generations will be so used to the new problems that their engineering intuition will again lead to reliable progress, but at present trial and error would seem too dangerous and costly in such advanced branches. Between these extremes lies the wide industrial field, where research on one hand and trial and error on the other are both possible means of technical progress and constantly compete against each other. In this field, research has to justify itself in terms of time and money spent against practical improvement found and information gained.

As compared with trial and error, research bears an initial disadvantage; its very name seems to spell time and money spent with little certainty of practical success; it may suggest tedious work, long reports, and argument meant to impress rather than to produce remedies to be applied immediately. Trial-and-error methods are more spectacular both in failure and success; the money spent is bound to reappear in practical results, even though the only comforting thought after the event may be the well-worn "I told you so!" Yet, given that time and money spent and practical success obtained were equal with both methods, the approach by research would have the additional advantage of giving more precise knowledge about the various factors affecting the practical problem at hand.

Engineering troubles usually occur in waves, and the rational solution of one problem may help in dealing rationally with the companion problems. Moreover, past research experience often suggests possible practical solutions applicable without further investigation. In fact, competition turns to co-operation when research experience provides a fruitful basis for further trial and error.

The industrial research engineer who is conscious of having to compete with the more direct application of trial and error will always look for the shortest and cheapest approach to his problem. He will first consider whether his problem or a similar problem has already been satisfactorily investigated in the large amount of research available in literature. If not, then he will inquire whether an intended experimental investigation cannot be undertaken at little cost on existing apparatus at a research institution within reach of his firm. Only if this proves impossible will he ask for facilities to conduct research on specially built equipment. Since practical problems rarely require intricate or novel methods of investigation and the accuracy required is often not critical, a rather rough and surprisingly cheap equipment will produce good results.

(Extracted from 'The Engineer', 29th May, 1953.)

7. MULCHING ON ROADSIDES

MULCHING means an application of a surface cover of straw, hay, leaves, or other material spread to protect newly planted seeds.

Mulch plays an important part in modern roadside erosion control. It reduces soil movement and protects and encourages the establishment of grass and other ground cover.

When first used (in the U. K.) mulching was a laborious operation for special locations only. However, its use quickly spread to steep cut slopes, then to all cut slopes, and currently is finding considerable favour as an integral part of all roadside seeding. Principal benefits of mulch on roadside areas are that (1) by intercepting raindrops, it reduces their force, breaking them into droplets or spray having too little energy to seal over soil pores: (2) it conserves soil moisture by reducing evaporation: (3) it reduces movement of soil, seed, and young seedlings by water, wind, etc.; (4) it gives protection to young seedlings against sun, drying winds, and wide fluctuations in soil temperature; and (5) it slowly but eventually adds organic matter to the usually low-organic-content soils of roadsides.

(Extracted from 'Civil Engineering and Public Works Review', June, 1953).

8. NEW ROADS NEEDED IN CEYLON

THE International Bank for Reconstruction and Development stresses the need of roads in Ceylon. It says that a great many improvements are needed, some of them more of the character of long-deferred maintenance, and much remains to be done in extending the local rail and road network into more of the Dry Zone lands which are being opened up. Almost every current development project scheme, the bank report states, needs at least new minor roads, and every new factory puts heavier—sometimes very specialized—demands on roads, railways and ports.

Better transport is thus an underlying need of agriculture, industry, and indeed of all development.

(Extracted from 'World Construction,' January—February, 1953).

QUALITIES NEEDED FOR RESEARCH

In research we want men who are insistent on self-discipline, men who are meticulously curious and observant of small distinctions—with a natural call to study and an inborn spirit of enquiry, never those not suited to its continual disappointments.

Dr. Percy Dunsheath.

GOOD MANAGEMENT

" The things that really count in good management are the ones you can't put on an organization chart......the feelings and attitudes which men have within themselves about their jobs and their organization."

TECHNICAL INFORMATION

1. COMPACTION OF SOIL

(Contributed)

[In this part, information on some aspects of road engineering will be included in the form of questions and answers. This is mainly intended for young engineers working on highways.—Ed.]

1. What is soil compaction?

Soil in its natural state consists of (1) solid particles, (2) moisture, and (3) air entrapped in the voids. Compaction is the process by which close packing, through reduction of air voids, of soil particles is achieved by mechanical means such as rolling, ramming, or vibrating. The state of compaction of a soil is measured by its dry density (see question 4).

Compaction should be distinguished from consolidation. The latter term is used for the gradual increase in the density of a soil under the weight of the soil itself or that of a structure erected upon it.

2. Why is soil compaction important in road construction?

When an embankment is made without compacting the soil, considerable settlement occurs over a long period of time resulting in damage to the road pavement. But where the embankment is well compacted during its construction, settlement is much reduced and the road crust stays intact over a practically stable subgrade.

Also, compaction of the soil improves its shear strength and reduces its permeability, water absorption, and the tendency to settle under repeated loading.

The increased strength and resistance to deformation of the compacted subgrade enable the engineer to reduce the design thickness of the pavement for the given loading and thus considerable economy can be effected.

3. Formerly ponding the soil used to be specified as a means of compacting soil. Is this method any good?

Scientific study has revealed that ponding as a means of compaction, is efficient only in sandy soils; in clayey soils little or no compaction occurs. In the latter case water may get entrapped inside the fill and cause trouble later.

4. What is dry density of a soil?

The dry density of soil is the weight of solids in a unit volume of soil mass. For any one soil the dry density would increase with the amount of compaction because the soil grains get closer together under compaction.

Dry density is dependent on the specific gravity of the soil particles and the amount of voids.

The maximum dry density that can be obtained with any soil depends on the type of soil and generally varies from 140 lb per cubic foot for well graded gravels to 90 lb per cubic foot for heavy clays.

5. How is dry density measured?

In the laboratory the specific gravity of the soil particles and the amount of voids in a unit volume of the soil are found out. The specific gravity multiplied by the unit weight of water (62.3 lb per cubic foot) divided by one plus the amount of voids, in cubic feet, gives the dry density in pounds per cubic foot.

In the field the dry density is obtained by weighing the soil removed from an approximately cylindrical cavity in the soil and measuring volume it occupied. The following four methods of measuring the volume are in use:

(i) use of a cylindrical core-cutter;

(ii) filling the cavity with loose sand and estimating the volume occupied from the volume of the loose sand used;

(iii) filling the cavity with water contained in a rubber bag and noting the fall of water level in a graduated cylinder attached to the bag;

(iv) filling the cavity with oil and measuring the volume of oil used.

Method (i) is the quickest and is suitable only in clayey soils. Method (iii) is not accurate because of the difficulty of getting the rubber bag to fill the cavity completely.

Method (iv) is suitable only for relativley impermeable fine grained soil.

Method (ii) which is both accurate and suitable for all types of soils has been standardized. Interested readers may refer to "Standards for Testing Soils", Central Board of Irrigation Publication No. 42, for details.

6. What is optimum moisture content for compacting a soil?

The dry density of a soil that can be achieved by compacting the soil under given conditions depends on its moisture content. For any one soil there is a particular moisture content which permits **maximum dry density** to be obtained for the given amount and method of compacting. This moisture content is known as the **optimum moisture content** for the specified process of compaction.

7. Why do soils attain maximum dry density only at the optimum moisture content?

Soils are composed of varying sizes of particles. During compaction, movement of the particles is resisted by the friction between them. In the dry state of the soil this resistance is high. The addition of water acts as a lubricant. "Optimum" moisture gives maximum lubrication and enables the soil to be compacted to maximum dry density. The water is "free" and only replaces the entrapped air. Under this condition for a given compacting effort, maximum density can be obtained through particles moving freely over one another till they are most closely packed, the smaller ones occupying the voids between the larger ones.

With the addition of more water than the "optimum" the soil begins to swell. The additional water increases the film thickness round the soil particles, the soil grains are forced apart, and the density is reduced.

(To be continued).

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2. CURING OF CONCRETE PAVEMENTS

(Extracted from Civil Engineering and Public Works Review, May, 1953)

CURING is the process of maintaining a satisfactory moisture content and a favourable temperature in concrete during the period immediately following placement so that hydration of the cement may continue until the desired properties are developed to a sufficient degree to meet the requirements of service. Curing is recognised as one of the important factors in the manufacture of concrete. Even if properly designed and placed, concrete can develop its potential strength and durability only if kept under favourable temperature and moisture conditions during the period prior to be being put in service.

Moisture is necessary to the hardening process of portland cement and constitutes

the most essential factor in curing. When moisture is not present the curing process stops and no improvement in strength or quality of concrete will be obtained. Methods to assure the proper curing of concrete insofar as control of moisture is concerned may be divided into two general groups:

(1) Those which prevent or minimise the loss of water initially put into the concrete by interposing an intermediate source of water to counteract the evaporation process and thus prevent or materially reduce the withdrawal of initial mix water from the concrete. The methods frequently used are ponding: sprinkling; spraying; and applying of wet burlap, cotton mats, wet earth, sand, sawdust, hay, or straw. For many years, concrete pavements were cured almost entirely by means of a thorough and continuous application of water for periods up to 10 days after placement.

(2) Those which prevent or minimise the loss of water by the application of waterproof paper or impermeable membrane.

Frequently a curing process is used that combines these two procedures: an initial curing period during which water is applied followed by application of paper or a sealing film. Calcium chloride (not in excess of 2 lb per bag of cement) is sometimes used as an admixture for the purpose of accelerating hardening.

Hydration reactions proceed more rapidly at the higher outdoor temperatures, and the hardening of concrete is greatly retarded as the temperature approaches the freezing point of water. Temperatures below 50 deg. F are considered less favourable for the early curing period. Below 40 deg. F the curing is greatly retarded, and at freezing temperatures it is extremely unreliable. When concreting is permitted during cold weather, extra precautions should be taken such as heating the mixing water or the mixing water and aggregate and subsequent protection by applying blanketing materials (hay or straw) to maintain suitable temperatures during hardening. In addition, calcium chloride (not in excess of 2 lb per bag of cement) in flake or solution form may be added to the mix to accelerate hardening but this does not eliminate the need for protective blanketing materials. In quantities which will not adversely affect the concrete, calcium chloride will not lower the freezing point sufficiently to be of any value in protecting the concrete from freezing.

This recommended practice covers materials and methods for curing portland cement concrete pavements through the application of wet coverings, initial water spray, liquid membrane [illegible] or water proof paper and [illegible] protection of the concrete against [illegible]. The engineer shall [illegible] the following described me[illegible] coverings, waterproof pape[illegible] membrane seal coats.

Wet Coverings.

(1) *Burlap or Cotton Mats.* After the final finishing operation and as soon as it is possible to do so without [illegible] the surface, the concrete shall be covered with burlap or cotton mats. During the application the mat shall not be dragged over the concrete nor over mats already spread. This covering shall remain in place for not less than 72 hours and shall be kept wet by means of a water spray of such fineness and so applied that it will not damage the concrete surface.

(2) *Water Spray.* If cotton or burlap mats or other suitable wet coverings are not available, after the final finishing operation and immediately after the free water has disappeared the surface of the concrete shall be kept wet continuously for not less than 72 hours by means of a water spray of such fineness and so applied that the surface will not be marred.

(3) *Ponding.* After 6 hours of curing, the surface of the concrete shall be kept wet by ponding until 72 hours have elapsed since the final finishing of the concrete surface.

(4) *Wet Earth, Wet Sand or Wet Saw dust.* After not less than 6 hours of curing, the surface of the concrete shall be protected immediately by not less than one in. of thoroughly wet earth, sand or sawdust until 72 hours have elapsed

since the final finishing of the concrete surface. The earth shall be free from large lumps. If sawdust is used care must be taken that the sawdust contains no acids or other constituents harmful to the concrete.

(5) Wet Straw or Hay. After 6 hours of curing, a 6-in. layer of straw, hay or similar material shall be placed on the surface of the concrete and kept thoroughly wet until 72 hours have elapsed since the final finishing of the surface.

Waterproof Paper.

Immediately after the final finishing operation and after any surplus water that has collected on the surface has disappeared, the concrete shall be entirely covered with waterproof paper in such a manner that the surface will not be marred. The paper shall be lapped at least 18 in. and shall be placed and held in intimate contact with the surface covered. If surface checking develops in the surface before finishing is completed, the engineer may require water spraying. The paper shall remain in place for 72 hours and may be re-used so long as it provides a moisture-proof seal over the pavement.

Membrane Seal Coats.

Membrane curing compounds are of two general types, bituminous and non-bituminous. The latter are more commonly used and may be of the clear membrane type or of the white-pigmented membrane type. If the bituminous membrane is used it should be given a coat of whitewash to reduce the temperature differential between the top and interior of the slab.

Immediately after the final finishing operations and after the free water has disappeared, all exposed surfaces of the concrete shall be sealed by spraying thereon (preferably by mechanical equipment operating on the forms) the curing material as a fine mist in such manner as to provide a continuous, uniform, water-impermeable film without marring the surface. A burlap curtain or metal screen shall be provided to prevent excessive loss of the curing material by wind. Care should be taken that no non-bituminous membrane compound is permitted to enter the expansion or contraction joints.

Where bituminous curing compound is used, the coated surface of the concrete shall also be covered with a coating of whitewash in not less than 3 hours nor more than 4 hours following the application of the bituminous material, and to avoid segregation of the solids, the containers of membrane sealing compounds shall be thoroughly agitated immediately before the material is used.

Edge production of Pavement Slabs.

As soon as the forms are removed, the edges of the pavement shall be cured as provided for the surface, or the trench left by their removal shall be immediately filled with earth which shall be kept thoroughly wet until the end of the curing period.

Protection against low Temperature or Freezing.

If existing or anticipated air temperatures are such that newly placed pavement may be damaged by low temperatures or by freezing, the concrete shall be so protected as to prevent temperatures at the surface from going below 50 deg. F for periods of 7 days where normal portland cement is used, and 3 days where high early strength portland cement is used. The above requirement is intended to apply to the placing of concrete in those seasons of the year, or in such places where the possibility of freezing or continued low temperatures is to be expected. It is not intended to apply where temperatures below 40 deg. F are a rarity. In any case, however, concrete must be protected from freezing temperatures at any time during the first 72 hours where normal portland cement is used, or 24 hours where high early strength portland cement is used.

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3. BINDER QUANTITY FOR SURFACE DRESSING IN RELATION TO STONE SIZE

THIS note is intended to stress the value of assessing the variable factors in surface dressing in terms of numerical expressions. The various quotations reprinted below are taken from authoritative publications which have been circulated in the Industry for a long time. Interpreting of specifications and recommendations that affect surface dressing continues to require experience in the work to an extent which amounts to an art, but the more factual information about each item of work that can be obtained, the more definitely can the numerical recommendations be employed.

"All the surface dressing experiments have shown that good results can be obtained with all types of rock or gravel, provided that uniform rates of spread, chosen to suit the condition of the old road surface and the size of chippings, are employed for both tar and chippings.

"There has been no significant difference in the performance of the two types of gravel. The two series of sections made with 3/8 in. gravel show that a heavier rate of spread of binder is required with the more single sized (in effect bigger) chipping."

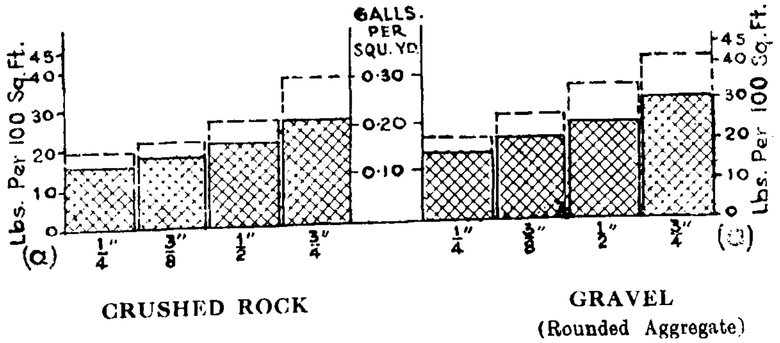
"The rate of spread of tar is the most important factor affecting the quality of a surface dressing."

"The rate of spread of tar should be determined primarily by (a) the size and shape of the chippings, (b) the texture and hardness of the old road surface, and (c) the volume of traffic."

"The rate of spread of chippings depends on the size, shape and specific gravity of the chippings."

The diagram shows that for different sizes and shapes of chippings [condition (a) above], there are clear numerical recommendations for the rate of spread of binder. The limits of choice in each case have only to be guided by the observer's experience of conditions (b) and (c). If, however, nominal sizes of aggregate may contain (as they certainly may with existing specifications) appreciable quantities of lower nominal sizes, then the added difficulty arises of considering a variation in condition (a):

The well tried rates of spread for each of the commonly used nominal sizes take into account the duty of the tar film immediately after it has been applied. This is to stick the undersides of each chipping to the old road surface and fill the lower 50 per cent of interstices in order to bind the chippings laterally. For the quantities



For uniform nominal sizes the choice of rate of spread is influenced by factors (b) and (c) and lies within the dotted area corresponding to the known value for (a). With irregular sizes an additional variant becomes prominent because the value of (a) may be spread over more than one nominal size.

(Continued on page 29)

ABSTRACTS

625.7* "ADOPTION OF AERIAL SURVEYS FOR HIGHWAYS" by W.T. Prior: (Highway Research Abstracts, Volume 23 (5), May, 1953).

A brief history of the adoption of aerial surveys by highway engineers in the United States of America is given. The advantages of adopting aerial surveys are explained. It is shown how aerial photographs give soil information for aligning a highway and siting its structures.

The article discusses in brief the following four stages of highway alignment and the use of aerial surveys in them:

(1) Reconnaissance of a broad area to determine all feasible alternate routes from one terminal point to another.

(2) Reconnaissance of the feasible alternate routes to compare them and select the best route.

(3) Preliminary survey of a band of topography along the best route for designing the highway location on it.

(4) Location survey, namely, the actual staking on the ground of the highway alignment (centre line), grades, cross sections, structures, and rights-of-way.

Cost data of a recently completed project are included.

625.746. "SOME AIDS TO TRAFFIC FLOW". By R. A. B. Smith. (Proceedings of the Institution of Civil Engineers, Part II, Volume 2, Number 2, June, '53).

Discusses the two main objectives of traffic aids namely, (i) to maintain a smooth and safe flow of motor traffic by day and by night, and (ii) to give the other users of the road (than the motorists) a fair share in the use of the highway.

The Paper avoids reference to major schemes the essentiality of which has already been well-explored and concentrates on such aids as might well be employed even during a period of stringent economy. The reduction of traffic congestion by better siting of bus stops and by adopting alternative routes especially lit and signed, is discussed. The value of the pedestrian-operated lights, the use of lines of reflectors at the crossings, and contrasting colour at all crossings have been examined.

The faults of the existing road junctions have been pointed out and a limited form of traffic subway has been suggested.

Discusses congestion of traffic in cities and the way it can be relieved by a system of outer garages connected to a bus or tube route. The use of white lines outside towns: the design of roundabouts: left and right hand turns: the gradients of roads at entry to a main road and lay-bys and their design for various purposes.

A plea is made for the use of a "built-up area" sign rather than a speed limit sign.

Name plates and signposting have been deprecated and the use of the "halt" sign condemned.

Finally the case for by-passes is pressed especially from the standpoint of road safety and national economy.

625.81. "METHODS OF SOIL STABILIZATION AND THEIR APPLICATION TO THE CONSTRUCTION OF AIRFIELD PAVEMENTS." By D. J. Maclean, and P. J. M. Robinson. (Proceedings of the Institution of Civil Engineers, Part II, Volume 2, Number 2, June, '53).

Consideration is given to the use of stabilized soil for constructing the bases of airfields of the permanent or of the temporary military type. As shown in the Appendix, a fairly large number of airfields have already been constructed with stabilized soil, the techniques employed being usually extensions of road practice.

*Refers to Universal Decimal Classification Number.

Owing to the large increase in the wheel loads and tire pressures of modern aircraft this procedure can no longer be adopted, and, as with all other forms of base material, it is essential to design the structure of the airfield pavement in relation to the stresses imposed by the aircraft wheels and the strength of the stabilized soil and of the subgrade soil. It is shown that stabilized soil should always be regarded as forming part of a flexible pavement, and methods of determining the minimum stability it should possess in different circumstances are suggested.

The relevant properties of the materials produced by mechanical, cement, bituminous, and chemical methods of stabilization are discussed in relation of the requirements they must satisfy in airfield construction, and a description is given of full-scale trials in which the performance of soil cement for use on military airfields has been investigated.

625.745. "SOME RECENT FOUNDATION RESEARCH AND ITS APPLICATION TO DESIGN." By G. G. Meyerhof, (The Structural Engineer, June, 1953).

In the past, foundation design was essentially empirical and based largely on permissible bearing pressures or loads to avoid failure of the ground. The study of foundation behaviour in the field amplified by laboratory research has led to a more rational approach in which the results of a site exploration and soil tests form the basis of an analysis of the stability and probable movement of the proposed foundation and superstructure. The present paper is mainly concerned with recent research on foundation behaviour and indicates how the results may be applied to structural analysis.

The paper shows how the soil, the foundation and the structure can be considered as one integral unit and discusses in general terms the main aspects of this approach. Since foundations form the link between the superstructure and the soil, they have to fulfil two main inter-related functions: First, the stability of the foundation soil must be assured with an adequate margin of safety and, second, the movement of the foundation must be within limits that can be tolerated by the superstructure.

The bearing capacity of shallow and deep foundations under a central load is briefly discussed, and the effects of eccentricity and inclination of the load are indicated. The total and differential settlements of foundations are estimated in relation to the soil and foundation characteristics and the stiffness of the structure. The settlement stresses in foundation and superstructure are considered, and recent observation on brick walls and cladded building frames are analysed. The lateral movement and tilting of foundations are estimated and illustrated by the results of some loading tests on model portal frames on clay and sand.

(Continued from page 27)

recommended to prove satisfactory, the nominal size of aggregate must bear a known agreement to the actual size of chippings employed. This is the case whether chippings are angular from crushed rock, when the cube is the desirable form, or rounded from gravel.

Where, therefore, nominally single sized aggregates are used, it may be necessary, either to use more binder than the upper limit recommended or, if appreciable proportions of the bulk delivered pass the next lower screen size to the nominal one, the quantity of binder may well be less than the lower limits recommended for the nominal size. In such cases a right choice can only be made after the aggregate has been delivered and its grading determined.

(Extracted from "Road Tar" June, 1953.)

BUDGETS AND ADMINISTRATION REPORTS

1. GOVERNMENT OF MADRAS CIVIL WORKS BUDGET 1953—1954

The following extracts relating to Civil Works have been taken from the Madras Budget 1953-54

(In lakhs of rupees)

	Accounts 1951–52	Revised Estimates 1952–53	Budget Estimates 1953–54
I. Revenue (Civil Works)			
(i) Rents	9.51	9.07	9.07
(ii) Receipts from Workshops	0.86	0.82	0.72
(iii) Recoveries of Expenditure	56.42	54.00	52.00
(iv) Transfer from Central Road Fund	23.05	85.71	55.12
(v) Miscellaneous	14.99	15.86	15.40
(vi) Ferry Receipts—Highways Department	4.38	5.33	4.70
(vii) Deduct—Refunds	-1.97	-0.52	-0.36
Total :	107.24	170.27	136.65
II. Expenditure (Civil Works)			
1. Original Works	154.47	188.67	117.03
2. Repairs	390.39	344.15	315.84
3. Suspense, etc.	-34.89	46.22	6.95
4. Establishment	68.86	63.28	56.44
5. Tools & Plant	85.71	118.22	48.44
6. Grants-in-aid	98.05	129.11	57.72
Total :	762.59	889.65	602.42
III. Expenditure (Communications)			
(i) **Original Works**			
(a) Excluding Post-war Reconstruction	19.67	62.14	46.64
(b) Post-war Reconstruction Schemes included in the 5-year Plan	89.88	72.17	38.97
(ii) **Repairs**	356.25	308.29	282.20
Total :	465.80	442.60	367.81
IV. Revenue from Roads			
(i) Receipts under Motor Vehicles Acts	390.14	429.32	490.65
(ii) Sales Tax on Motor Spirit	129.00	169.86	184.86
Total	519.14	599.18	675.51

A BRIEF REVIEW OF THE MADRAS BUDGET 1953-54

(With special reference to Civil Works)

THE total revenue receipts of Madras for the year 1953-54 are estimated at Rs 65,74 71 lakhs and revenue expenditure at Rs 65,74.51 lakhs with a consequent nominal surplus of Rs 0.20 lakhs. The revised estimates for 1952-53 indicate a deficit of Rs 5,39.73 lakhs with the revenue receipts amounting to Rs 63,35.55 lakhs and expenditure to Rs 68,75.28 lakhs.

Revenue expenditure on Civil Works for 1953-54 estimated at Rs 602.42 lakhs forms 9.2 per cent of total State revenue against 14.0 per cent in the previous year 1952-53 (Revised Estimates).

Expenditure on Communications under the heads original works (including the provision under the 5-year plan) and repairs is estimated at Rs 3,67.81 lakhs in 1953-54 against Rs 4,42.60 lakhs in 1952-53 (Revised Estimates). It forms 5.6 and 7.0 per cent respectively of total revenues in the two corresponding years.

2. ADMINISTRATION REPORT OF THE MADRAS HIGHWAYS DEPARTMENT 1950-51.

The Madras Highways Department which during 1950-51 entered the fifth year of its existence as a separate department continued to execute works on all Government and District Board roads, viz., National Highways, Provincial Highways, District Roads etc., with a view to ensuring uniformity in methods, standards and quality. According to the Report the main consideration of the Department has always been to secure addition to the existing milage of roads *pari passu* with the maintenance of existing roads.

The total expenditure on Government works and District Board works during 1950-51 and the preceding year was as follows :

(Lakhs).

	1950-51			1949-50		
	Govt. Works	Distt. Board Works	Total	Govt. Works	Distt. Board Works	Total
Original Works (including Post-War Road Development)	163.21	112.86	276.07	145.34	100.97	246.31
Maintenance	387.74	134.79	522.53	337.91	129.86	467.77
TOTAL	550.95	247.65	798.60	483.25	230.83	714.08

(NOTE :—In addition to the above, the expenditure on District Board non-road works amounted to Rs 39.16 lakhs in 1950-51 against Rs 36.76 lakhs in 1949-1950).

Ninety miles of roads were cement concreted, 379 miles were black topped, 807 miles of new roads were formed and 205 bridges and culverts were constructed, besides carrying out special repairs to the extent of Rs 28.8 lakhs covering 352 works.

From an analysis of maintenance expenditure in relation to traffic intensity, it is seen that there are about 3,500 miles of roads with intensities of traffic ranging from 1,000 tons to 2,500 tons per day and about 900 miles of roads with over 2,500 tons per day, and that a very large portion of the maintenance allotment is spent on such reaches. Experience has shown that improved surfacing is desirable if traffic exceeds 500 tons per day, and quite essential if it exceeds 1,000 tons per day. In order to meet this situation and to raise the standard of service rendered by the roads, surface dressing with precoated chips was extensively done under maintenance.

Post-War Road Development Programme:

The first five-year programme of Post-War Road Development was initiated in April 1947. The bulk of the work relating to new construction and improvement of roads, bridges etc., is done under this programme. The rest of such work is done mostly under the Central Road Fund Schemes and grants-in-aid to local bodies under Ex-post-war Roads.

The expenditure incurred under the programme to end of 1950-51 was Rs 2.99 crores on Government Works and Rs 1.97 crores on District Board Roads, the expenditure during the year being Rs 93.94 lakhs and Rs 65.80 lakhs respectively.

Expenditure on National Highways, the financial responsibility in respect of which has been taken over by the Government of India since April 1947, amounted to Rs 88.02 lakhs up to the end of 1950-51, the expenditure during 1950-51 being Rs 53.67 lakhs.

The total amount spent from the Central Road Fund during the year under review came to Rs 22.55 lakhs of which Rs 16.66 lakhs was on Government Works, the rest being on District Board Works.

Grants-in-aid to local bodies under Ex-Post-War Reconstruction during 1950-51 (revised estimates) amounted to Rs 29.91 lakhs.

The total expenditure on all capital works, Government roads as well as District Board roads, during 1950-51 amounted Rs 276.07 lakhs against Rs 246.32 lakhs during the previous year.

Traffic Census

During the year under review traffic census was recorded for a week in all the division on all the State roads and on all the important district board and Municipal roads during the month of September and also during the peak load periods which were fixed by the Superintending Engineers (Highways). A study of traffic trends on a few roads selected at random during the years 1937-40 and 1947-51 indicates the following broad conclusions :

(i) The volume of traffic during the years 1947-51 is much more than the volume during the pre-War years.

(ii) On many roads the intensity of traffic during 1950-51 was the heaviest ever recorded.

(iii) The post-war increase in traffic is very largely due to increase in motor traffic, especially trucks.

Road Milage

Road milage in the State including roads under Highways Department, District Boards, P. W. D., and Municipal Councils as on 31st March 1951 was as below :

1.	Cement concrete roads	343
2.	Black-top surface roads	1,669
3.	Metalled roads	27,921
4.	Unmetalled roads	13,565
	TOTAL	43,498

BOOK REVIEW

"Indian Practical Civil Engineer's Handbook", by P. N. Khanna, published by the Engineers' Publishers & Advertisers, New Delhi; Price **Rs 15.**

THE book is a compilation of technical information on various Civil Engineering subjects, such as Hydraulics, Irrigation, Roads and Bridges, etc. It is mainly intended to serve as a book of reference for the young engineer engaged on construction and designing.

List of Approved Works on National Highways

S. No.	Job No.	Name of work	Estimated Cost Rs (in lakhs)	Remarks
		BOMBAY		
1.	741 BM 8	Construction of a diversion outside Navasari town on the Bombay-Ahmedabad National Highway No. 8.	2.45	
2.	742 BM 8	Constructing a diversion road in miles 69/4 to 71/1 (Bhorghat section) of the Bombay-Poona Road : National Highway No. 4.	2.03	
3.	745 BM 3	Providing asphalt carpet in miles 74 to 80 of the Bombay-Agra National Highway No. 3.	2.43	
4.	746 BM 6	Widening miles 148/6 to 192/0, 194/0 to 208/4 and 211/5 to 237/2 of the Dhulia-Edlabad-Nagpur National Highway No. 6.	0.20	
5.	747 BM 8	Construction of the Karjan-Makarpura sub-section of the Karjan-Baroda section of the Bombay-Ahmedabad National Highway No. 8.	1.90	
6.	748 BM 8	Acquisition of additional land for widening Kadodra Junction Kathor section of the Bombay-Ahmedabad N. H. No. 8.	0.92	
		HYDERABAD		
7.	743 HD 7	Survey of certain portions of National Highway No. 7	0.07	
		MADHYA BHARAT		
8.	733 MB 3	Black-topping National Highway No. 3 in Gwalior Division.	1.28	

S. No.	Job No.	Name of work	Estimated Cost Rs (in lakhs)	Remarks
9.	734 MB 3	Black-topping National Highway No. 3 in Shivpuri Division.	10.18	
10.	735 MB 3	Black-topping National Highway No. 3 in Guna Division.	12.38	
11.	736 MB 3	Black-topping National Highway No. 3 in Shajapur Division.	1.30	
12.	737 MB 3	Black-topping National Highway No. 3 in Dhar Division.	3.96	
		MADRAS		
13.	732 MD 5	Formation of the metalled road between Badampudi and Tadepalligudem in the West Godavari District, N. H. No. 5.	1.46	
14.	749 MD 5	Construction of a bye-pass at Durva on National Highway No. 5 in the West Godavari District.	0.82	
		ORISSA		
15.	740 RS 5	Black-topping with pre-coated chippings carpet on National Highway No. 5 from Chandgiri to Railway crossing near Bhubaneswar.	0.87	
		PUNJAB		
16.	744 PB 1	Construction of a high level bridge over the Beyene in mile 220 of the Grand Trunk Road, National Highway No. 1.	15.18	
		WEST BENGAL		
17.	738 BG 34	Construction of Berhampore-Raghunathganj section of National Highway No. 34.	34.10	
18.	739 BG 31	Raising the Inglis bridge spans of the Leesh bridge near Bagrakote.	0.69	

WORDS OF WISDOM

Motivation is even more important than ability, for the latter without the former is sterile.

A man of imagination without knowledge has wings but no feet.

—*Poet Hiene*

List of Books Added to the Roads Organisation Library during June, 1953.

1. **Geophysics, Vol XVII, No. 3, July 1952,** containing an article "**Geophysical Methods Adapted to Highway Engineering Problen**" by R. Woodward Moore. (Society of Exploration, Geophysicists, Wisconsin.)

2. **Detailed Procedure for Testing Bituminous Mixtures,** (Division of Highways, Materials and Research Deptt., State of California, 1951).

The Eastern Economist Ltd., 52, Queensway, New Delhi.

3. **What Goes on in the U S. S. R.—Eastern Economist Pamphlet No. 15** by Odysseus.

4. **The Welfare State** by T. W. Kent.

5. **Indian in the free World** by E. P. W. Da Costa.

6. **B. S. 1840 : 1952—Tubular Steel Columns for Street Lighting.** (British Standards Institution, 24, Victoria Street, London, S. W. 1.)

7. **The Influence of Mineral Sulphates on the Permanance of Concrete Structures—No. TSS. 16.** (Lafarge Aluminous Cement Co., Ltd., Technical Service Section, Brook Street, London, W. I.)

8. **Asphaltic Bitumen as an Adhesive—Shell Bitumen Reprint No. 6.** (Burmah-Shell Oil Storage & Distributing Co. of India, Ltd., Burmah-Shell House, Connaught Circus, New Delhi-1.)

(The Manager of Publications, Central Publications Branch, Civil Lines, Delhi.)

9. **Summary of the Work Done at the Hirakud Research Station during 1952.**

10. **Summary of Work Done at the Hydraulic Research Station, Krishnarajasagara.**

11. **Summaries of Investigations and Table of Contents of the Annual Report (1952) of the Irrigation & Power Research Institute, Punjab, Amritsar.**

12. **Note on the Duty of Irrigation Water Proposed to be Adopted for Various Groups in the Delta Area of the Mahanadi River** by M. S. Hiranandani.

13. **Hydrometeorology of the Mayurakshi Catchment** by S. K. Pramanik and K. N. Rao.

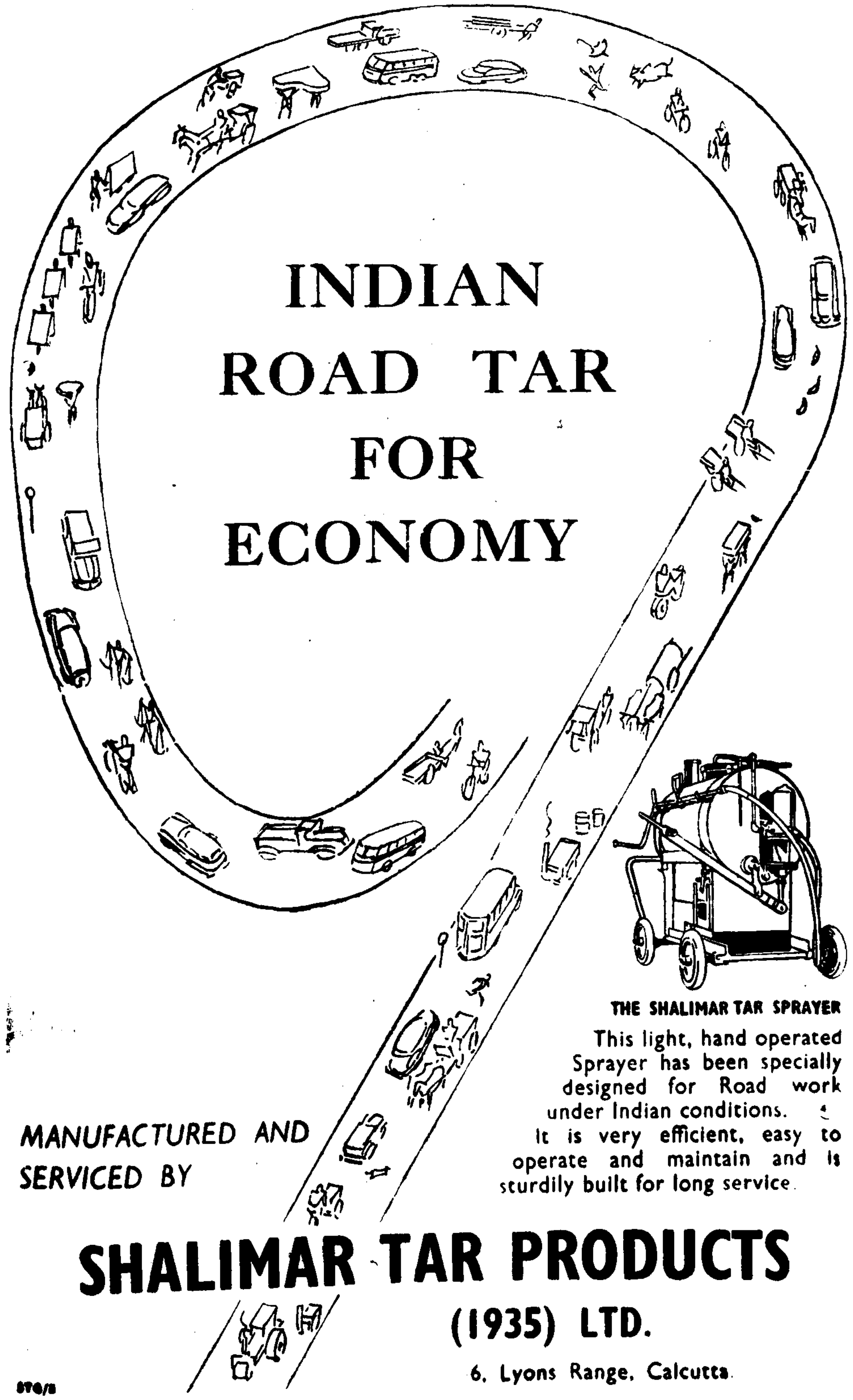
14. **Annual Report (Technical) of the Central Water and Power Research Station, Poona, 1952.**

Dhantoli Road—Two coats surface dressing work. First Coat—30 lbs. Mexphalte 80/100 6 c ft. 1/2″ to 5/8″ Chips. Second Coat—40 lbs. Mexphalte 80/100 4 c ft. 3/8″ Chips. Executed in May, 1950.

IN NAGPUR

Pach Pawli Road—5½″ Full Grout Specification:—30 c ft. 1½″ to 2″ metal 125 lb. Mexphalte 30/40 6 c ft. 3/4″ to 5/8″ chips 30 lb. Mexphalte 80/100 4 c ft. 3/8″ to 1/2″ Chips. Executed in March 1948.

BURMAH-SHELL... IN INDIA'S LIFE AND PART OF IT



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