77

TRANSPORT COMMUNICATIONS

Monthly Review

Dec 1954 No. 92

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TRANSPORT-COMMUNICATIONS

MONTHLY REVIEW

DECEMBER 1954—No. 92

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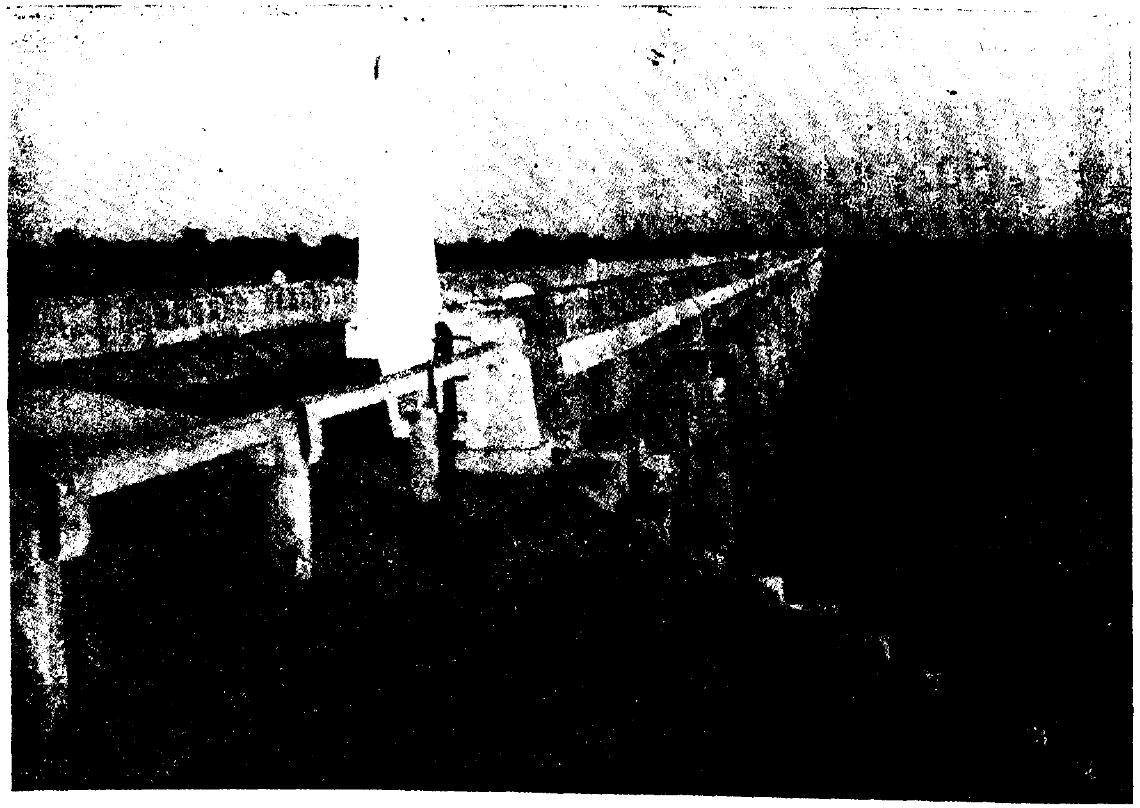
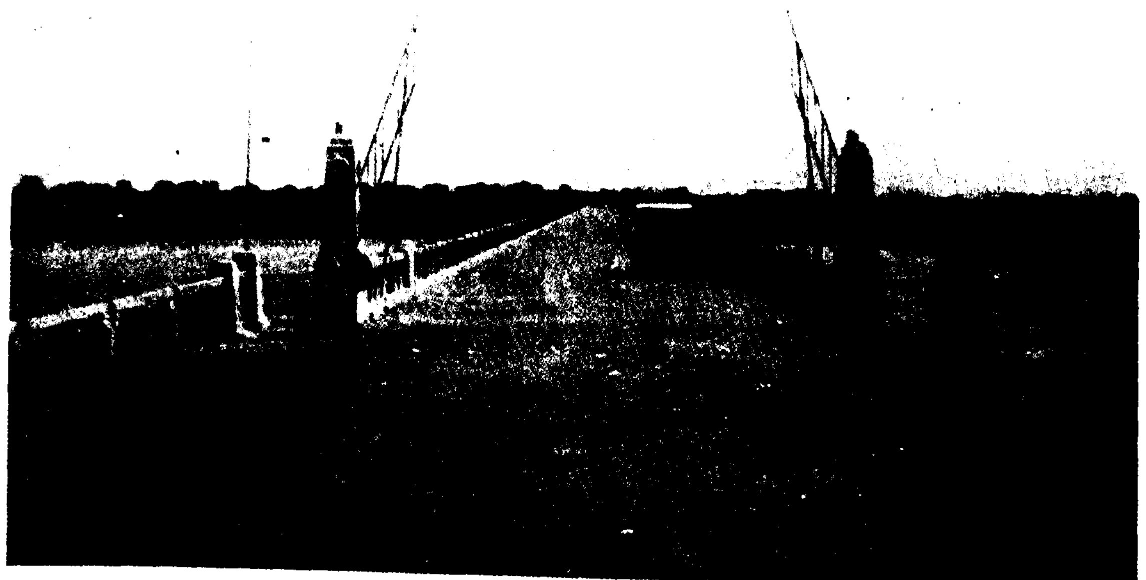


THE GANDHI BRIDGE ACROSS THE MAHANADI.



TRANSPORT-COMMUNICATIONS MONTHLY REVIEW

A REVIEW OF ROAD ENGINEERING, DEVELOPMENT & TRANSPORT

DECEMBER 1954

BRIDGING INDIA'S RIVERS

GANDHI BRIDGE ACROSS THE MAHANADI IN MADHYA PRADESH

THE new bridge across the Mahanadi on the Bombay Calcutta National Highway was thrown open to tarffic in October 1954. It is the second major bridge on this trans-peninsular link to be constructed under the National Highway Development Scheme initiated by the Government of India, the first one being across the same river further down at Hirakud, in Orissa State.

The River Mahanadi originating in the Sihawa hills in east Madhya Pradesh crosses National Highway No. 6 about 27 miles east of Raipur town. Prior to the construction of this bridge a ferry service used to operate at this crossing during floods. The arrangement was unsatisfactory. During the rains from about the 15th of June to about the 15th of November every year communication between the two sides were cut of. The construction of this bridge not only supplies an essential link in an inter-State through route, but also helps open up interior tracts and stimulate local development. It is estimated that nearly 15 lakhs of population inhabiting an area of 5,000 square miles in Madhya Pradesh and another 5,500 square miles in Orissa State will eventually benefit by having access to the railhead and market centre at

Photo 1. **Dr. K. N. Katju opening the Bridge.**

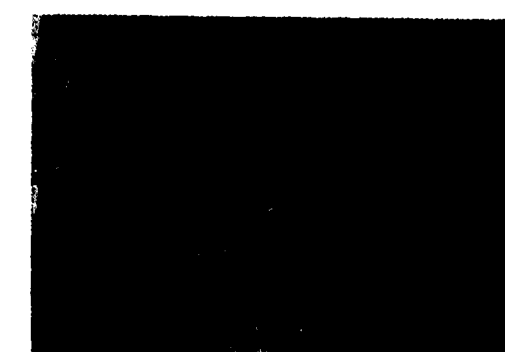
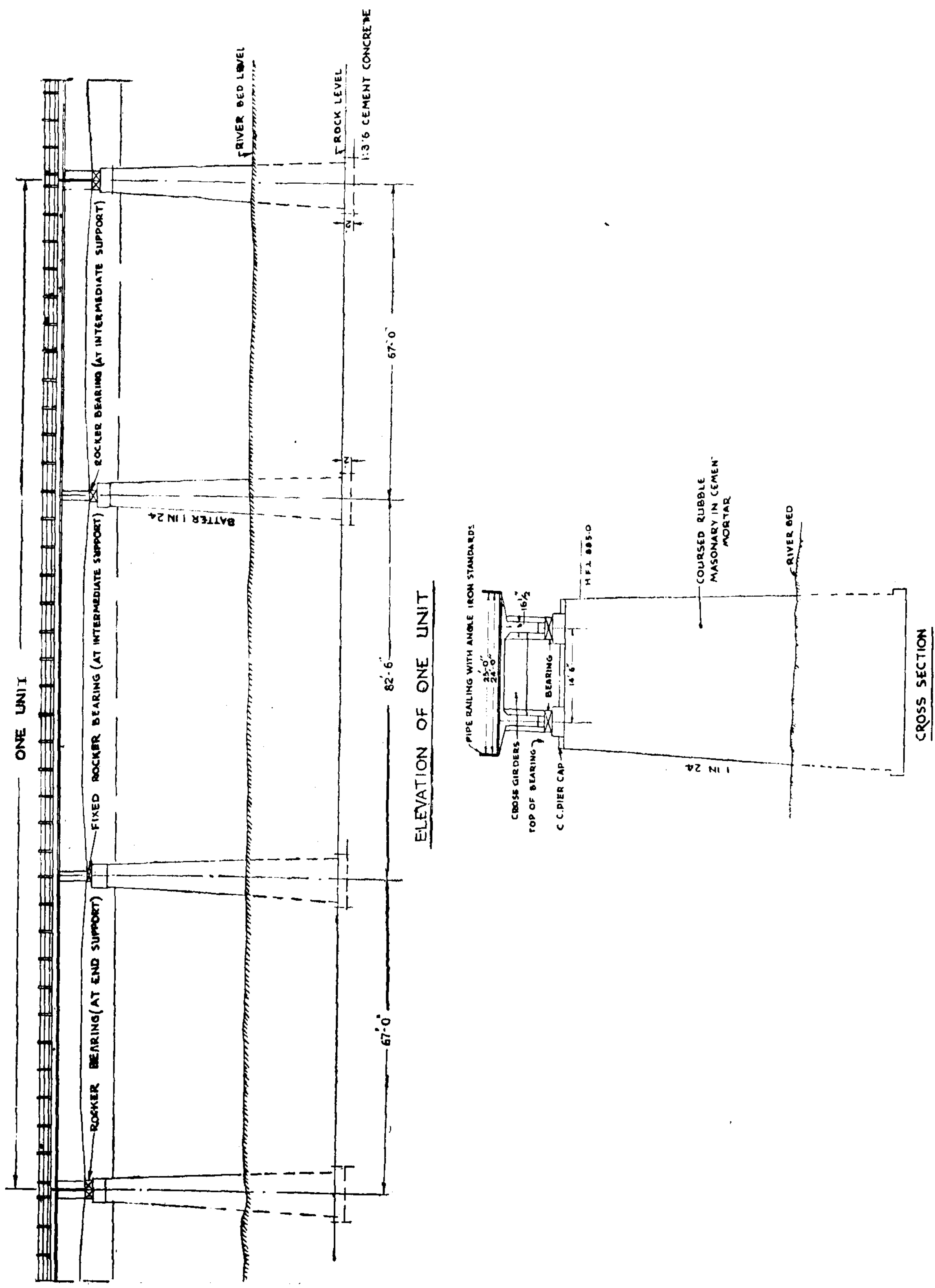


Photo 2. **Testing Bearing Capacity of soil in river bed.**



Raipur by making possible free flow of trade in rice and timber throughout the year.

Hydraulics of the River

The deep, well defined course is confined to a width of about 260 ft between low banks about 10 ft high, while in high floods it spreads to a width of nearly 8,000 ft with a deep channel 30 to 35 ft deep.

Photo 3. **Well Foundations in Progress.**

The catchment area at the site of the bridge is 3,872 square miles. The average annual rainfall of the basin is 80 to 90 inches. The calculated 100-year maximum flood discharge based on the High flood level of 885 attained in 1882 is 13,29,600 cusecs.

Site

The bridge is 400 ft downstream of the railway bridge and parallel to it. Advantage is taken of the pitched spurs of the railway bridge to guide the river into the road bridge. The total length of the bridge is 2,598 ft between centres of abutments, almost the same as that of the railway bridge.

The salient dimensions and technical details of construction of the bridge are given below.

Type: The length of 2,598 ft is made up of 12 units each of R. C. C. girders continuous over three spans of 67 ft, 82 ft 6 in., and 67 ft; thus there are 36 spans.

Foundations: The bed of the river is sandy with rock occurring at depths varying from 3½ to 19 ft below bed level. Eight of the 35 piers are resting on R.C.C. double well foundations while the rest of the piers and the two abutments are on open foundations. All pier foundations have been taken down to a minimum depth of 2 ft into good rock. Wells are 10 ft diameter on the inside with 1 ft thick steining and have been sunk 4 ft apart. The two wells have been covered by an R. C. C. well cap 40 inches thick.

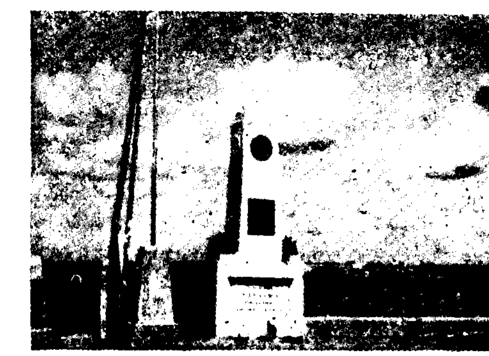


Photo 4. **The Pylon.**

Masonry: The masonry for the open foundations is of cement concrete 1 : 2 : 4 upto 1 ft above subsoil water level and of stone masonry in 1 : 6 cement mortar above the subsoil water level.

Substructure: Piers have semi-circular cut-waters and ease-waters with a batter 1 in 24. Abutments have a front batter 1/8th and side batter 1/24.

Bearings: Rocker bearings are of Meehanite having the following properties:

Tensile strength 40,000 lb per sq. inch.

Modulus of rupture 82,000 lb per sq. inch.

Compressive strength 15,000 lb per sq. inch.

These bearings have lugs fixed at the top and bottom plates and can move only in the longitudinal direction.

Loading: The bridge is designed for I. R. C. Class A two lanes or I. R. C. Class A single lane, whichever imposes the greater stress.

The Superstructure

The superstructure of the bridge consists of two R. C. C. T-beams continuous over two supports, 5 ft in depth, 16.5 in. in width, and 14 ft 6 in. centre to centre, with cross girders 3 ft deep and 9 ft 5 in. centre to centre. The $8\frac{1}{2}$ in. thick deck slab is cantilevered 4 ft 6 in. on each side of the longitudinal beams. It has thickness varying from 12 in. to 5 inches. See Fig. 1 and 2.

Roadway

Clear width of roadway is 23 feet. Parapet walls are of R. C. C.

Levels

Top of masonry with cap	R.L. 886.46
Soffit of beam	R.L. 891.63
Top of slab	897.33
Formation level over the bridge	897.50
Approach roads	$2\frac{1}{4}$ miles in length

Formation width of embankment is 36 ft in high bank.

Materials: Stone is available quite near the site.

Labour: Local labour was available for earthwork, but skilled labour had to be imported from Bombay, Orissa and Hyderabad.

Cost of the bridge-Rs 27.87 lakhs including approaches.

Cost per running foot - Rs. 850.

DEFINITIONS OF HIGHWAY ENGINEERING TERMS

SUBSIDENCE: Downward movement of the soil produced by removal or displacement of the underlying strata.

SURCHARGE: Earth supported by a retaining wall above the top level of the wall.

A SUBSTITUTE

A restaurant displayed this sign:

"Don't divorce your wife because she cannot cook. Eat here and—keep her for a pet."

ROADS PAY

Good highways don't cost, they pay. But the savings that result from good highways do not accrue to the highway department to any appreciable extent.

GERMAN ROADS

A joint visit to Germany was made by members of the Committee for Co-operative Research between the Road Research Laboratory, the Cement and Concrete Association and the Pavings Development Group. The following are the personal impressions of one of the members of the Group.

The question most often asked is how are the motor roads of Germany today? Taking the system as a whole and judged even by 1954 criteria, the standard of highway which they provide is very high.

The autobahn construction programme commenced in 1935, continuing for some five years, during which time some 2400 miles were completed, and it is against this age background that one should assess the condition. Many stretches ride as well as the day they were laid and there were very few stretches where cracking and settlement were such as to necessitate early, or extensive repair. The scarcity of cracking in general, and on many stretches the complete absence of cracks, is remarkable.

An article on 'The lessons of the German Motorways' in **Concrete Quarterly No. 20** drew attention to the importance of the subgrade, and pointed out that German engineers, like those of this country, have of recent years been aware of the great effect the subgrade has on their pavements. In the light of present knowledge and as the result of experience, the condition of some of the poorer stretches of carriageway is blamed on a lack of a full appreciation of the need to provide a subgrade of uniform bearing capacity, which is protected from the effects of weather and more particularly from water. It used to be standard practice to construct the concrete slabs on a base of sand varying in thickness and although this sand was compacted reasonably thoroughly by the standards then prevailing, it has since been realized that full compaction was not obtained. The vibration due to traffic has further compacted the granular material and some settlement affecting the slabs has occurred. This trouble is being borne in mind in connection with the new work now going on.

The problem of freezing of the subgrades is a recurring trouble on the Continent. To prevent damage to the subgrade when in a frozen condition, **local German highway engineers now have the authority to restrict the speed of traffic using a particular road until the danger is past and in an extreme case, to prohibit heavy traffic altogether**. This scheme was started in 1953, and details of the roads affected are put out over the radio. Standard road warning signs are used for the affected sections and the scheme as a whole has been considered successful.

The value of full-scale experiments is realized in Germany. One experimental road, constructed in the first half of 1952 between Sandhofen and Viernheim, has a total length of approximately $3\frac{1}{2}$ miles and was designed to investigate the influence of slab length and weight of reinforcement on performance. Twenty-three test slabs each 328 ft long and three slabs of 1,312 ft have been laid down with varying weights of reinforcement. The concrete used had an average strength after twenty-eight days of 6,500 lb per sq. in. and air entraining agents were added to the mixes. As might be expected, the riding qualities of the longer slabs are better than the shorter ones when tested by a profilometer. The standard of this work when judged from a moving vehicle was extremely high. Only three of the 328 ft long slabs have cracked so far and two of these contained the smallest amount of reinforcement. It is too early as yet to draw any firm conclusion from the performance of the very long slabs which, as would be expected, exhibit a certain crack pattern. The German authorities hope that as a result of this work it will be possible to decide the maximum lengths of slabs which it is reasonable to use and this length will be specified for future autobahn construction.

Prestressed concrete roads are also receiving some attention. The first test section laid in Germany is at Heidenheim. Three lengths, each of 365 ft, were constructed, two being stressed by the Leonhardt-Bauer system and the third by the Freyssinet method. As was to be expected, the riding qualities of the surface were excellent. The road was constructed in September of last year and so it is as yet too early to draw any conclusions from the experiment.

A few random impressions

The Germans seem to be convinced that road slabs provided with reinforcement, dowel bars and tie bars are not only superior in performance to plain slabs but economically advantageous. Very little evidence of surface damage due to frost action can be seen on German concrete roads, although they are often in exposed positions and are subjected to low temperatures in winter. For the replacement of odd bays damaged by mines or shelling during the war, it is considered desirable to use the full-scale standard machinery for the compaction and finishing of the concrete. The pre-war specification for autobahnen has been proved so generally successful that in post-war work, apart from experiments, only very minor alterations have been considered necessary. The standard of maintenance is high on German concrete roads—joint filling is carried out annually and jacking of slabs which have settled is a commonplace and very economical technique. Sawn joints have been used in some recent work and it was impressive to see how good these were, not only from the point of view of surface riding qualities but because they were so neat and unobstructive. As always, the excellence of the landscaping and alignment of the autobahn made its impact on the eye. Apart from the early straight stretches, the twin carriageways appear a part of the landscape instead of a man-made application. Fifteen or more years of growth added to the trees since construction has enhanced the general effect. The German traffic engineers of Wiesbaden seemed to be enjoying themselves in devising interesting and varying ways of denoting the pedestrian phase for traffic light controlled junctions. The cheeriest contribution to the street scene which was noticed was the sounding of a low-pitched electric horn for the duration of the phase devoted to walkers. The great increase in traffic density that has occurred in Germany since the war, said by her traffic engineers to be 200 per cent, is very noticeable. The size of some of the goods vehicles with their trailers is impressive but last year the permitted number of these trailers was reduced by law to one. The crossing of a full white line is a traffic offence in Germany.

Last year Dr. Glanville said in reference to an earlier visit he had made to Germany—" It was an amazing experience to travel along these big German roads with the traffic, including large lorries and trailers, thundering along at fifty miles an hour." It is still impressive and is perhaps even more so now owing to the increase in the traffic using the roads. The fact that this speed is still possible in complete safety on roads which were almost entirely laid down at least fifteen years ago is, in itself, food for thought.

(Extracted from 'Concrete Quarterly 22' —April-June, 1954).

INSTRUCTED MIND

It is a mark of instructed mind to rest satisfied with that degree of precision which the nature of the subject admits, and not to seek exactness where only an approximation of the truth is possible and/or acceptable.

—Aristotle.

SCIENTIFIC MANAGEMENT

1. Each and every part and subdivision of an organisation should be the expression of a definite purpose in harmony with the objectives of the undertaking.

2. (a) All actions towards the accomplishment of a given aim must be directed by one person.

(b) Each person should have only one immediate superior, and must receive instruction about a particular task or operation from that person only.

(c) Each person should know clearly to whom and for what he is responsible.

3. The number of subordinates reporting to a superior is governed by limitations of the human mind.

4. To be efficient, a man should have a job which is whole and complete in itself, and within his physical and mental capacity.

5. Where responsibility is assigned to a person it must carry with it authority to implement it. Responsibility is a privilege, as well as an obligation. It carries with it the right of decision, to determine what, how, when, where and by whom the work shall be done, and to stand or fall by the results.

Insufficient delegation means :—

(a) Senior personnel spend time on detail work. As a result they have less time for work correctly appropriate to their function, training and capacity. Decisions are delayed, and ' Red Tape ' increases.

(b) Decisions are made without personal or up-to-date knowledge of facts.

(c) Initiative is stifled.

Too much delegation, brought about by delegating too far down the chain, produces the following anomalies :

(a) The person deciding may be too low in the organisation to understand its full implications.

(b) His decision may compromise the overall policy.

(c) Decisions based on uninformed judgement are frequently unsound.

6. Discipline consists of "obedience, diligence, energy, correct attitude and outward marks of respect, within the limits fixed by contract between the organisation and the employees ".

7. Wise leadership is more essential to successful operation than extensive organisation or perfect equipment.

8. Good personnel relationships imply high morale and whole-hearted, spontaneous co-operation towards a common goal. These are:

(a) Earn the respect of others.

(b) Take a personal interest in subordinates, but avoid the fatherly approach, unless it is really necessary.

(c) Give credit promptly, where credit is due; do not put it off until tomorrow.

(d) Be fair and unbiased in your judgement.

(e) Give punishment only when you are certain it is deserved.

(f) Within the limits of security, keep subordinates fully informed about what is happening, and why. Where possible, give reasons for all orders.

(g) Respect the views of others.

(Adapted from 'The Journal of the Institution of Military Engineers')

ROAD FACTORS AFFECTING THE SPEED OF TRAFFIC

TRAFFIC movement is often best measured by its speed and the speed of traffic is affected by many factors. The speed of any individual vehicle is affected by the power of its engine and by the smoothness with which it runs. It is affected by the temperament of the driver, by his physical condition, and by whether or not he is in a hurry. It is, however, apparently affected even more by the general factors, such as the nature of the surface and layout of the road and the amount and nature of other traffic. The effect on average speed of traffic of (i) horizontal and vertical curvature, (ii) the width of the road, and (iii) the amount and nature of other traffic, is given below.

The Effect of horizontal and vertical curvature of road on speed

Fig. 1 shows the results of an investigation of the effect of horizontal and vertical curvature on speed on the rural roads of Buckinghamshire U. K. It will be seen that every increase in average horizontal

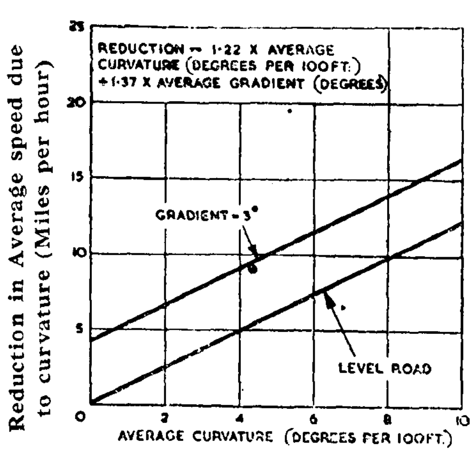


Fig. 1. The effect of road curvature on average speed.

curvature of one degree per 100 ft reduces the speed by 1.2 m. p. h. and every degree of average vertical gradient decreases speed by 1.4 m. p. h. These figures apply to rural roads with the traffic composition of Buckinghamshire. If the composition were altered, the results would be different. The results in the figure apply to the average of all traffic, private and commercial. Private cars are, however, affected more than is indicated on the figure by horizontal curvature and less than is indicated on this figure by vertical curvature. On the other hand, commercial traffic is affected less than is indicated on the figure by horizontal curvature and more by vertical curvature.

The Effect of width of road

The effect of width of road on average speed of traffic on some of the rural roads of Buckinghamshire is indicated in Fig. 2. There is a marked increase in average speed of both private and commercial traffic as the width of road increases from about 16 to about 20 ft. The increase was about 7 m.p.h. for private cars and about 6 m. p. h. for commercial vehicles.

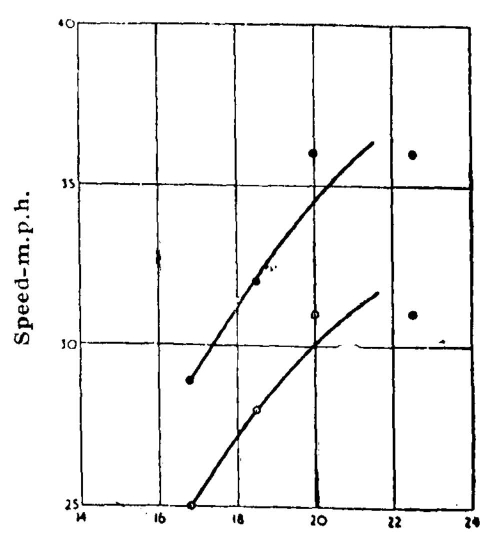


Fig. 2. The effect of width of road on speed on rural roads.

A large part of this increase in speed is undoubtedly due to the fact that the narrower roads covered by this investigation were generally more curved than the wider ones, but there can be little doubt

about the reality of the effect of width. Both width of road and curvature of road seem to affect the average speed of traffic.

The effect of amount of traffic

A laboratory investigation on the effect of the amount of traffic on its average speed on the roads of rural Buckinghamshire gave no indication of any appreciable change in the average speed due to the presence of other vehicles. This result means that the roads on which vehicle speeds were being investigated were not being used at anything approaching their maximum traffic capacity. Another investigation on the effect of amount of traffic on speed in Central London showed a very marked relationship between the two quantities. The results are shown in Fig. 3. When the amount of the traffic is small the average running speed of traffic in Central London is about 24 m. p. h. As the amount of traffic increases, the speed of traffic decreases, and this effect is very much greater on narrow than on wide roads. For example, for a road 32 ft wide, the average traffic running speed goes down from 24 m. p. h. when traffic is very light, to 19 m. p. h. when 400 vehicles are using the road every hour. It goes down to about 14 m. p. h. when 800 vehicles per hour are using the road. It will be seen that about 800 vehicles per hour can travel at an average speed of 18 m. p. h. on a 37-ft wide road, and at 23 m. p. h. along a 52-ft wide road. On a road 22 ft wide it could be extrapolated to this low speed. It is more likely, however, that the traffic would jam up and everything would come to rest.

Capacity

Fig. 3 leads naturally to the conception of the capacity of a road, that is the answer to the question, how many vehicles can drive along it per hour? The method of answering this question used by early workers on the subject was to watch groups of vehicles following one another along a road, to select groups in which the vehicles were travelling close behind one another, usually at the same speed, and to count the number of vehicles in such groups passing a given point at a given time. From the observations it was possible to calculate the number of

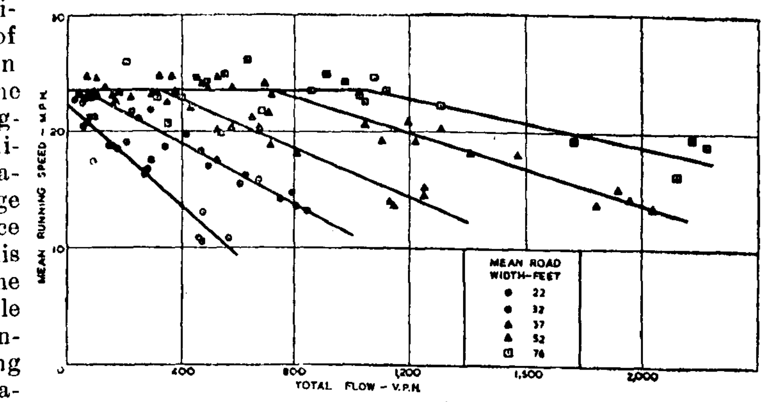


Fig. 3. Mean running speeds against total flow.

vehicles per unit time that could pass a given point in a single lane at a given speed. The most careful and accurate observations of this sort show that at speeds between about 15 m. p. h. and 60 m. p. h. about 2,500 vehicles can travel along a single lane per hour and this figure might therefore be called the theoretical traffic capacity of a single traffic lane, i.e., 2,500 vehicles per hour per lane. On this basis, a two-lane 22 ft. wide road would have a capacity of about 5,000 vehicles per hour. However, fig. 3 shows that under the conditions of traffic in Central London, it is certainly not possible to get more than about 900 vehicles per hour along a 22 ft wide road even at a very low speed or 450 vehicles per hour, per lane, less than one-fifth of the theoretical capacity. The reason for the difference is, of course, quite obvious. The theoretical capacity is calculated on the assumption that vehicles are travelling at uniform speeds in single lanes, as closely behind one another as possible. In practice, there are random fluctuations in the amounts of traffic wishing to use a road; overtaking occurs since some drivers wish to drive at faster speeds than others, some vehicles wish to stop to take up or set down passengers, and pedestrians walk across the road in front of oncoming vehicles. These conditions reduce the capacity of a single lane of road from about 2,500 to a few hundred vehicles per hour. However, road engineers and planners need to know how many vehicles a road will take under the various conditions. The difficulty is that the road will take different numbers of vehicles under the different conditions. If the road engineer is prepared for the average speed of traffic to be low, the road will take a much larger number of vehicles than if he requires the speed to be high. Before one can specify the capacity of a road, it is necessary to know something about traffic conditions on it and then decide on the minimum speed at which it is desired the traffic should travel. If it is decided that under conditions of traffic in Central London, it is desirable that the minimum running speed should be 15 m.p.h., the capacity of a 22 ft wide road is then about 300 vehicles per hour, of a 32 ft wide road 700 vehicles per hour, and of a 37 ft wide road 1,100 vehicles per hour. A table of capacities deduced in this manner is given in Table I and compared with some results of so-called 'practical' capacities, given by Normann, for uninterrupted flows on urban roads in the United States on which 20 per cent of the traffic consists of heavy lorries travelling at 35–40 m. p. h.

It will be seen that there are three sets of vastly different results for the capacity of a road. For a 24-ft wide road, for example, the R.R.L. London traffic survey results gave a capacity of 400 vehicles per hour. Normann's figure is 1,200 whilst the theoretical capacity is about 5,000 vehicles per hour. Although these figures for the capacity of a road are very different they all represent actual conditions. The column — R.R.L. figures gives the capacity of roads in which traffic conditions are of the type common in Central London, with pedestrians wandering across the road whenever the opportunity offers, buses stopping and starting, occasional parked vehicles, and intersections close to one another, whereas Normann's figures give the results for uninterrupted flow in straight rural roads. The fourth column gives the capacity of a road when every driver is disciplined to travel at uniform speed behind the vehicle in front. In practice, such capacities are only realised at bottlenecks, although a capacity of 1,500 per hour per lane is quoted for American urban expressways.

TABLE I

Capacity of Uninterrupted Streets

(Vehicles per hour)

Carriageway width (feet)	R.R.L. London Traffic Survey	Normann 20 heavy lorries (35-40 m.p.h.)	Theoretical capacity deduced from R.R.L. observations
24	400	1,200	5,000
36	1,000	1,700	7,500
48	1,600	5,000	10,000
60	2,200	6,200	12,500

(Extracted from 'The Journal of Municipal Engineers'—September 7th, 1954)

—o—

ALL FOR LOVE

A married woman sued the car owner who involved her in a very serious accident from her point of view, and from the point of view of the Court also. She was originally awarded £ 500 as damages and when she told the sympathetic court that the accident made it painful for her to kiss, the damages doubled itself to £ 1,400 ! Surely, she must have had the support of expert medical men whose diagnosis of the kiss that pain could be relied upon. To those who live by kisses and divorces, an automobile accident of this nature could be a sure cause to break the material felicity. This is another reason why we should build safety into the roads.

GOOD MANAGEMENT

The secret of good management lies in spreading responsibility not in centralising it, in making men believe that they belong to a team and not a herd.

FOUNDATIONS FOR CONCRETE ROADS THEIR PREPARATION AND PROTECTION

THIS paper describes the practical measures that should be adopted by road engineers in the initial preparation and for the subsequent protection of the foundations of concrete roads.

The provision of a stable foundation for a concrete road consists of:

(1) the selection of suitable soils for embankments and materials for the road bases;

(2) the compaction of these soils and materials;

(3) the control of the moisture conditions in these soils and materials.

Each of these aspects is dealt with in turn.

Introduction

It is just as necessary to provide a stable foundation for a concrete road as for any other type of road. A stable foundation can only be achieved if the road engineer is prepared to understand what constitutes a stable foundation and to acquire a working knowledge of the basic principles of soil mechanics.

The present paper indicates briefly the conditions the engineer should aim at achieving in his foundations, and then describes in more detail the practical measures that can be adopted in various circumstances to bring these about.

Effect of foundation on design of concrete road slabs

For concrete roads Westergaard's theory enables the tensile stresses developed in a concrete slab to be calculated in terms of the strength of the foundation, expressed as a modulus of subgrade reaction measured by means of a loaded plate test on the foundation quite apart from the other factors which affect the tensile stresses developed in concrete slabs, the present view is that Westergaard's theory understimates the stresses associated with the degree of support provided by the foundation, since the theory postulates uniformity of support over the whole area of the slab, a condition which can rarely be achieved in practice. In the design of concrete road slabs it is thus necessary to take into account not only the strength of the subgrade but also the uniformity of support it affords the slab, and it follows that, to enable the most economic design of slab to be employed, the aims should be to maintain the strength of the subgrade soil at the highest value consistent with the circumstances, and to ensure that non-uniformity of support for the slab is kept to a minimum by creating soil conditions that will result in only small vertical movements after the slab has been constructed.

Factors controlling the stability of the foundation

In practice the achievement of a stable foundation for a concrete road comprises the thorough compaction of the soil where necessary and of the base material, and the control of their moisture contents, since both the strength of these materials and the extent to which uniformity of support for the slab is maintained are dependent on the state of compaction of the materials and their variation in moisture content after the road has been constructed. Some materials, for example peat, are of course of such a nature that neither compaction nor moisture control can make them into a satisfactorily stable foundation.

The provision of a stable foundation for a concrete road thus resolves itself in practice into dealing with the following three matters:

(1) the selection of suitable soils and base materials;

(2) the compaction of these soils and materials ;

(3) the control of the moisture conditions in these soils and materials.

Selection of soils and base materials

The practical problems that arise under this heading are the selection of the alignment of the road and the choice of materials for constructing embankments and bases. These requirements can be properly met only by a thorough survey of the soil conditions underlying the site of the proposed road and an exploration of sources of local materials. It may be assumed that road engineers are now generally aware of the importance of these matters in ensuring a satisfactory standard of road construction.

For a soil survey to be of real value, the soil conditions should be explored to an adequate depth and with bore-holes at sufficiently frequent intervals. The extent of the exploration depends on the particular circumstances at the site, but depths of boring should be usually from 6 to 15 ft and the spacing of borings of the order of 200 ft. Experience has shown that some form of mechanical borer, such as that developed at the Road Research Laboratory, (3, 4) is advantageous, while the earth resistivity method (1) is of value in checking on the uniformity of soil conditions between two adjacent borings.

In examining the results of a soil survey, the following points need to be noted in connection with the design of a concrete road constructed on a soil formation in cut:

(1) The uniformity of soil conditions both along the site and in depth

Lack of uniformity of soil type, particularly in the profile, can usually be taken as an indication of a poor foundation for concrete roads and should be allowed for in the design. For example, where the profile consists of successive thin layers of varying inclination and thickness of sand and clay, the foundation is particularly liable to give non-uniform support.

(2) The Presence of compressible soils

Wherever peat and highly organic clays occur extensively in the ground, considerable uneven settlements may be expected in any road constructed upon it. In certain circumstances it may be possible by a suitable adjustment of the horizontal alignment to avoid such ground, but where this is not possible measures should be taken to remove the compressible soils if this is practicable or alternatively the road must be designed to provide a satisfactory riding surface when constructed directly on the soil.

(3) The presence of a high water-table

Irrespective of the type of soil a high water-table (less than 3 ft below the soil formation level) usually results in a poor foundation condition. Where a rapid lowering of the water level can be effected, the necessary drainage measures should be taken in order to stabilize moisture conditions in the sub-grade before the concrete slabs are constructed. Should this be impossible, a lowering in the level of the water-table may do more harm than good, in which case it is preferable to make some allowance in the design of the road for the presence of the high water-table.

Where a concrete road is to be constructed on an embankment the results of the soil survey should be used :

(1) To select suitable materials for the construction of the embankment

While it is economically desirable to use soils taken from cuttings on the line of the road for the construction of embankments, where the cuttings are composed of peat or organic clays these soils should never be used, because of their high compressibility and low strength, and a survey should be made to locate the nearest source of more stable soils.

In addition, cases will sometimes arise in practice where it would be preferable to use a stable soil occurring near the site, rather than a soil from a cutting on the site, if the latter soil was liable to be troublesome under certain practical conditions.

For example, silty sands are quite amenable during dry weather but are often impossible to use for embankment construction in wet weather. In a case such as this, where the weather is likely to be predominantly wet, it would be preferable to employ a local source of soil which is less susceptible to wet weather.

Where two types of soil are available fcr constructing an embankment, the better soil should where practicable be used to form the upper part and the poorer soil the lower part of the embankment. For example, a frost-susceptible soil should usually be placed below a soil not affected by frost.

(2) To judge the condition of the soil on which the embankment is founded

The main aspect to consider under this heading is the presence of compressible strata, especially where the embankment is high. Cases may arise with high embankments where considerable settlements taking place over a period of many years may occur as a result of the presence of an unsuspected compressible layer of soil occurring at a depth of 10 to 20 ft below the surface of the ground.

Surveys of local sources are also needed to select a suitable material for constructing the base for the road. The materials generally used are well-graded gravels or artificial materials such as clinker or slag. In either case, the criterion of quality should be their ability to be compacted readily to a dense and stable mass. Where the grading of the material is poor, no amount of compaction will produce a satisfactory base, and experience has shown that the use of such materials has led frequently to structural failure of the concrete. It is also desirable to avoid the use of materials whose stability is liable to serious reduction in wet weather. For example, during wet weather, a compacted clean gravel will become unstable because of its high permeability, whereas, a compacted clayey gravel having a low permeability will remain comparatively stable. On the other hand, the clayey gravel will become very unstable if exposed in an uncompacted condition during wet weather, and in drying weather it will remain unstable for a longer time than the clean gravel.

Compaction of soils and base materials

The adequate compaction of embankment fills, placed subgrade soils and base materials is essential for the provision of a stable foundation for a concrete road, since the poor compaction any of these materials will result in uneven settlements, necessitating the employment of a stronger design of concrete slab if structural defects are to be avoided.

The process of compaction involves the increase of the bulk density of a mass of soil by the removal of air by mechanical means from between either adjoining particles or adjoining aggregations of particles of soil. The state of compaction of a soil can therefore be most logically measured in terms of its air content, and at a known moisture content this can be simply converted to a dry density with knowledge of the specific gravity of the soil particles. In the specification of the state of compaction required in embankment, subgrade and base materials, it is convenient therefore to require the attainment of a dry density, corresponding to a maximum permissible air content of the material. Dry density is a quantity simply measured in practice by such tests as the sand-replacement method (B. S. 1377 : 1948).

Specification of State of Compaction

It is suggested the maximum air contents that should be specified are, respectively, 10 per cent for the main part of the embankment fill and 5 per cent for the top 2 ft of subgrade soil and for the base material.

It is not recommended that states of compaction should be specified in terms of a dry density that is some percentage such as 95 per cent of the maximum dry density obtained in a laboratory compaction test, since experience has shown that this method can in certain circumstances be quite impractical.

Moisture Content at which to Campact

The moisture content at which compaction should be carried out depends on the type of material. With clay soils compaction should be at the natural moisture content which they possess in the ground below the depth affected by weather conditions. Research work on this subject suggests that, if this is done, there is little likelihood of subsequent changes in moisture content which, if they occurred, would result in changes in the volume of the soil and therefore in vertical movements in the level of the soil formation. In practice, this means that when clay soils are excavated for constructing embankments the time taken between excavating them and compacting them in the embankment should be kept to a minimum. The top of the fill should at all times be maintained in a good shape during construction to prevent the ponding of rain water, and pockets of wet soil should be removed before placing the next layer. When the embankment is completed some time before the road is to be constructed, the fill should be built about 1 ft above the final formation level, in order to protect the ultimate subgrade soil from changes in moisture content due to rainfall or evaporation.

The compaction of granular soils and base materials should be carried out at a moisture content which will give the maximum dry density with the type of plant selected for the work. Although this usually implies a reduction of moisture content, which is, as a rule, the optimum moisture contents of granular soils do not usually differ significantly from the natural moisture content above the water-table and below the zone affected by weather. The change in moisture content required will therefore usually be small, unless the soil has been removed from below the water-table or has been allowed to be affected after excavation by the weather. Every effort should, of course, be made to avoid these two contingencies.

Thickness of Layer to be Compacted

One of the principal causes of the uneven settlement of foundations is the placing of layers of fill too thick to be compacted adequately. In the construction of embankments the fill should be placed in layers having a reasonably uniform thickness of about 9 in. Compaction will reduce this to a dense layer about 6 in. thick. The top 2 ft of placed subgrade soils and also base materials should be compacted in layers not exceeding 6 in. thick, which after compaction will form a dense layer about 4 in. thick. The above suggestions apply for most of the compaction machines in common use.

Compaction of Surgrade Soils in Cuttings

In the foregoing paragraphs the compaction of subgrade soils has referred to the case where they are placed as the upper part of an embankment. A different situation arises when the subgrade is in a cutting.

Clay soils occurring in cuttings are usually close to saturation so that their compaction is unnecessary; in fact, heavy compaction can be harmful since the stressing of the soil may destroy the internal structure of the soil and result in a reduction of its strength.

Granular soils, on the other hand, often occur naturally in a poor state of compaction, so that they require further compaction when they are exposed in a cutting. Sometimes this poor state of compaction may be associated with a high moisture content, and in such cases drainage measures are required before the soils can be satisfactorily compacted.

Since a high state of compaction, corresponding to an air content not exceeding 5 per cent, is required in the top 2 ft of the subgrade, the necessary compaction of granular soils in a cutting can best be obtained by excavating the soil to a depth of 2 ft below the final formation level and then replacing the soil in well-compacted layers 4 in. thick. An alternative procedure which avoids the excavation of the 2 ft of soil is to compact the soil formation with either frog-rammers or vibrating-plate machines. These machines compact granular soils satisfactorily to a depth of about 1 ft, and this is probably adequate for most lightly trafficked concrete roads.

A similar problem arises when a badly damaged slab has to be replaced in an existing concrete road. It is common experience that replaced slabs do not always remain sound as long as the average life of the original slabs, and this is probably associated with the difficulty of compacting the base and subgrade

exposed when the damaged slab is removed. Rammers of various types and vibrating-plate compactors are again the best machines for compacting in the confined area to be occupied by the slab. Particular care with the compaction is required round the edges of the area.

Backfilling of Trenches

Particular care is needed in the compaction of soils used to backfill trenches which cross the formation of the road, since the settlement of the soil in the trench after the road is constructed would be quite likely to result in a local failure of the concrete over the site of the trench.

There is no reason why satisfactory reinstatement of trenches should not be achieved if the basic principles of soil compaction are adhered to. The work should be planned so that the soil is back. filled as soon as possible after excavation; this is to reduce changes in the moisture content of the soil to a minimum. The soil should be replaced in the trench in layers about 9 in. thick and compacted with an adequate numbers of blows of a power-rammer. Rammers with a diameter of base of 12 in. should be used since they help to ensure that enough compaction is applied to each layer.

Wherever practical the trench should be reinstated before the final soil formation has been prepared, so that the soil in the trench may be backfilled to a level a few inches above the final level, and later trimmed to correct level with the rest of the formation.

Compaction plant

Generally speaking, pneumatic-tyred rollers are the most suitable machines for compacting soils in embankments; in confined areas rammers for clay soils and vibrating machines for granular soils are particularly convenient; smooth-wheeled rollers and vibrating-plate machines are satisfactory for most cases of subgrade and base compaction.

Control of soil compaction

In view of the importance of achieving a high state of compaction in the foundations underlying a concrete road it is essential to have an inspector available to control the compaction operations. His duties should be:

(1) to reject soils and base materials whose moisture contents are unduly higher or lower than called for in the specification;

(2) to ensure that the thickness of layer placed does not exceed at any point the maximum value specified;

(3) to ensure that the specified number of passes of the plant is applied to each layer, and that the compaction is carried out systematically so that no area is inadequately treated;

(4) to check the dry density against the specified dry density by one of the methods of test described in B. S. 1377 : 1948. The mean of ten separate measurements should be determined for each area treated in one operation.

The control of moisture conditions in soils and base materials

The main object of subsoil drainage as applied to roads is usually to lower the water-table level and thereby achieve an increase in the stability of the soil by a reduction in its moisture content. The increased knowledge of the properties of soils and of their behaviour in practice have shown that so far as concrete roads are concerned, the aim should rather be to maintain the soil at a constant moisture content after the road has been constructed.

The reason for the development of this different concept of the subsoil drainage of concrete roads is that a change in the moisture content of a soil, whether it be a decrease or an increase, is usually accompanied by a change in volume which results in vertical movements of the soil formation. Because of the lack of uniformity of soil properties, even within a comparatively small volume, such vertical movements can usually differ within the area of a concrete slab to an extent sufficient to produce a serious loss of uniformity of support of the slab by the soil formation. It is therefore considered that to use subsoil drainage to increase the strength of the soil at the expense of a loss of uniformity of support for the slab is unjustified in the case of concrete roads. The object should be rather to create conditions in which the soil is maintained at its highest strength consistent with no change in moisture content occurring after the road is constructed.

The whole problem of subsoil drainage as applied to concrete roads thus involves an understanding of the factors affecting the movement of moisture in soils and how to control them. In practice, the road engineer can take the following measures:

(1) control the conditions during construction so that the soil is maintained at a moisture content close to the average value it will possess during the life of the road;

(2) control the agencies by which water can enter or be removed from the subgrade.

These aspects are considered in more detail below.

Control of Moisture Conditions of soil During Construction.

The control of the moisture content of soils used to construct embankments has already been considered in the section on compaction.

In the case of subgrade soils the main problem is to protect the prepared soil formation from the action of weather during the period before the construction of the pavement. Failure to provide protection from rain is one of the commonest faults in road construction, and it is of course equally desirable to prevent undue drying of the formation.

In concrete construction it is usually impracticable to organize the work in such a way that the necessary protection can be provided by laying part of the road structure immediately after the preparation of the formation. In this connection porous granular bases such as clinker and clean gravels have the disadvantage of allowing the easy passage of rainwater to the subgrade; an impervious base such as a well-compacted clayey gravel on the other hand would provide the necessary protection, but would itself need protection.

A new technique of providing the necessary protection to either the subgrade or the base is to apply a bituminous sealing coat as soon as the formation has been prepared. Experience has shown that this method can be successfully applied to all soils. Tars with a viscosity ranging between 25 E. V. T. in winter and 35 E. V. T. in summer and cutback bitumens having a viscosity in the range 20–60 seconds at 40 C (Standard Tar Viscometer) are the most satisfactory, although rapid-breaking road emulsions are satisfactory when applied as a double dressing. Rates of spread of the order of 3 sq. yd. per gallon should be used, and the bituminous sealing coat should be blinded with ⅛-in granular material, such as gravel or clinker. The main function of the granular layer is to prevent the binder film being picked up by traffic, but where the subgrade is very weak, a well-compacted layer about 4 in. thick should be laid to provide a firm working formation on which to construct the concrete slabs.

Where the bituminous sealing of formations is adopted, it is important to obtain a good shape, in order that water may be completely shed to the side of the formation. It is also necessary to carry the surface dressing 2–3 ft beyond what will ultimately be the edges of the carriageway, in order that rain water will be carried to a point where it will not affect the soil under the bituminous seal.*

Control of the Moisture Content of the Subgrade After Construction

Assuming that effective measures have been taken during construction to protect the soil from undue changes in moisture content, the prevention of changes in the moisture content of the subgrade soil after the road has been constructed reduces to the control of all means by which water can enter or leave the subgrade.

* Full details of this process are given in 'Transport-Communications Monthly Review.' June 1954—p. 14.

An increase in the moisture content of the subgrade soil and base material can occur after the road is constructed as a result of:

(1) Entry of surface water through joints between slabs

To prevent this happening, the bituminous sealing of joints between slabs should be regularly maintained with a recognized sealing material.* Any substantial cracks that form in the concrete should be immediately sealed.

(2) Rise in the water-table level

Where there is an occasional possibility of the level of the water-table rising considerably above normal, subsoil drains should be installed as shown in Figure 1 on either side of the carriageway. On a

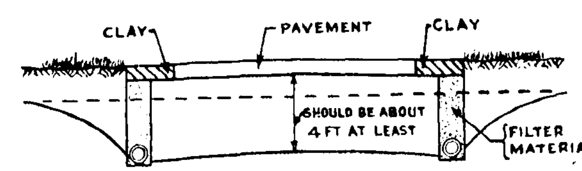


Fig. 1. Lowering the level of the water-table by the installation of drains.

dual-carriageway road an additional drain may be required under the central reservation. The use of herringbone drains in the soil formation is considered to be generally undesirable.

Where the water-table is less than 4 ft below the formation level at the time the road is constructed, subsoil drains should be used to lower the level of the water-table before the concrete slabs are constructed, and with granular soils before the formation is finally compacted. Where this is not practical because of the low permeability of the soil it may be desirable to accept a higher level of water-table and to employ subsoil drains to prevent a rise above this accepted level.

(3) Water seeping from higher ground

Where the road is constructed on sloping ground a subsoil drain may be required to intercept water flowing towards the road from higher ground. The aim should be to keep the seepage water less than 4 ft below the formation level. Two types of intercepting drain are shown in Figure 2 and 3.

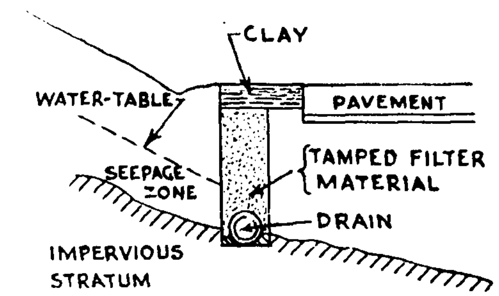


Fig. 2. Interception of shallow seepage zone.

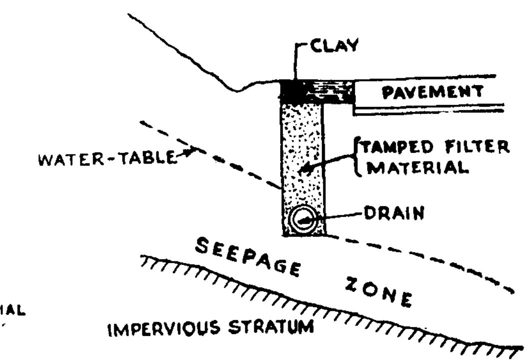


Fig. 3. Partial interception of deep seepage zone.

The filter media used to backfill subsoil drains can be any suitable naturally occurring stone with a grading designed to permit the easy percolation of water and at the same time minimize the danger of silting and thus making the drain inoperative. Full details of a satisfactory method of determining the desirable grading of the filter material are given elsewhere (7).

A decrease in the moisture content of subgrade soils and base materials under concrete roads occurs generally as a result of the transpiration of moisture by vegetation close to the road. The loss of moisture is accentuated during prolonged droughts.

This effect can be minimized in the following ways:

(1) no large trees or shrubs should be permitted within say 15 ft of the carriageway;

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* The specification for joint sealing compounds is given in B.S. 2499: 1954. See 'Transport-Communications Monthly Review October 1954'—p. 20.

EXCAVATION IN WET GROUND

The Well Point Method

CLASSICAL methods of dealing with the inflow of water into an excavation are the open sheeting and pumping technique and the deep-well method. Another way to stop the flow of water is by freezing the ground by artificial means, a somewhat expensive undertaking. All engineers will be aware of the disadvantages of open sheeting and pumping. As the water flows into the excavation it carries with it a considerable amount of the finer materials of the soil, and if pumping is carried on for long there is a danger of the collapse of the shuttering due to hollows being formed behind. Even if it is possible to convey the water to a sump in one corner of the excavation, the bottom on which men have to work is wet and often sticky. If the worst comes to the worst, a dangerous boil occurs.

Deep-well Method

The deep-well method consists of digging shafts around the outer perimeter of the area to be excavated and to a slightly lower level, and then pumping out the water as it enters. By this means the ground-water table is lowered at the actual excavation. Naturally, such a method is expensive, the extra excavation and sheeting is a cost not to be reckoned lightly.

It is from this latter method that a new method has originated. With its increasing use during the war years and since on new constructional work, the wellpoint dewatering system has rapidly gained popularity.

With the wellpoint method the water is withdrawn from the soil before it reaches the excavation. Equipment comprises the actual wellpoint through which the water is withdrawn from the soil, riser pipes which connect the small wellpoint with the main water removal pipe on the surface. This pipe, usually of 6 in. diameter, runs along the surface of the ground to the wellpoint pump, which, by creating a vacuum in the system, draws the water from the ground through the wellpoint and up the header pipe.

The wellpoint itself is approximately 3 ft long and about 3 in. in diameter, the actual dimensions depending upon the manufacturer. When placed vertically in the ground, the upper face connects to the riser pipes by a screwed coupling, and at the lower end is a special jetting head. This consists of a non-return ball valve which allows the water to pass downwards through the riser pipe and out at the jetting head. In this case the water travels in the opposite direction to when dewatering is taking place. The object is to sink the assembled riser pipe and wellpoint into the ground by means of the jetting action. A non-return ball valve is provided so as to prevent sand and other fine material being drawn into the system through the jetting orifice when dewatering is in progress.

Between the upper riser pipe connection and the jetting head is the wellpoint screen through which water is withdrawn from the ground. Basically it consists of a central steel tube, around which is a heavy brass screen separated from the inner tube by spacers which also serve as filters. An average weight for a wellpoint is around 15 lb.

Connecting the wellpoint to the surface of the ground is the riser pipe. Usually of 1½ in. diameter, the pipe is of steel or iron with threaded couplings. The riser pipe delivers ground water into a header pipe which is of light-weight steel tube of 6 in. in diameter and runs more or less horizontally. Bosses are fitted into this pipe at 30 in. intervals to allow riser pipes to connect into it. Should the riser pipes be spaced at greater intervals, bosses may be fitted into the inlets. It is essential, if time is not be wasted, to have some form of flexible coupling between the riser pipe and the header line, so that great exactitude in the jetting of the wellpoint assembly is not necessary. This is achieved by means of the swing joint. It consists of two halves, the header half and the riser half, with a shut-off valve on the header side allowing each wellpoint to be

disconnected from the system. Flexibility is obtained by using a length of rubber hose in the riser half of the coupling.

After the header line has picked up, all the riser pipe connections it is connected to the wellpoint pump, which by creating a vacuum in the system withdraws water from the ground. With a long length of header line and consequently a large number of wellpoints, and with the air contained in the ground water, a pump is required which can handle a large amount of air. It has been found by experience on work in the U. K. that a 6 in. pump of the centrifugal type with a single impellor is most suitable. Such a pump can withdraw upto 1,000 gallons per minute against a 40 ft head. Water for jetting may also be obtained from this type of pump at a pressure of up to 20 lb per sq. in.

Often in difficult ground this pressure is not high enough to jet the assembly through the ground, and if a high enough water pressure is not available from the mains, a special jetting pump must be employed.

The simplest case of wellpoint dewatering is perhaps the square or circular excavation down to a depth of about 25 feet. According to the type of ground and the amount of water expected, the wellpoint spacing is selected, conditions vary considerably and it is difficult to generalise. Assuming the water table is 10 ft below the surface, the excavation is taken out to this depth in the dry. At this elevation the header line is then laid around the periphery of the excavation and the wellpoint assemby jetted down into the ground to a certain depth below the lowest level to which excavation is to be taken out. The necessary extra depth will consist of the depth of the wellpoint, for, of course, this must be below subgrade, together with extra depth to allow for the gradual rise of the water table across the excavation. If the excavation is large in area and the distance apart of the wellpoint lines on opposite sides of the excavation is great, the extra depth may be large. The wellpoint pump is then connected into the system and the ground water withdrawn.

Such an elementary case in a static system is that once installed the wellpoints remain in place until the work is completed. In excavation for such work as a sewer the wellpoint system must be progressive ; it must move along with the excavation. Such a system can be divided into several stages which are described below :

1. The first step is to instal the wellpoint system so that the ground may be dewatered for the next day. If the trench is wide, two header pipes may be necessary on either side, otherwise one header line is set out. Valves are placed between each section, so that when dewatering is completed each section may be cut off and the wellpoints withdrawn.

2. Excavation is taken out, the sewer placed in position and concreted in place.

3. As backfilling takes place the wellpoints are withdrawn, and the header line disconnected and removed to the other end of the trench.

Where the lowest level of the excavation is more than about 25 ft below the water level, it is necessary to use a multistage system. Excavation is taken out to the water level and a wellpoint system installed; digging is continued with until excavation nears the bottom of the first set of wellpoints. The next series is installed and the excavation continued. Such a method of dewatering involves the removal of a greater amount of material, as the side of the excavation must be stepped to accommodate the header lines and pumps.

Naturally, the wellpoint system can only be installed in sandy soils or in soils where water can percolate to the withdrawal points. If clay is present, the water may be prevented from reaching the wellpoint. Should the clay be in narrow layers surrounded by permeable material, it is possible to take special steps to remove the water. This is achieved by fastening a star shaped device to the foot of the wellpoint during jetting. The resulting hole formed is larger than the wellpoint, and the annular space is then filled with sand. The sand allows water to flow from layers above the clay down to the wellpoint.

When jetting is commenced the wellpoint and riser pipe are assembled and held vertically with the jetting hose attached to the top. The supply of water either

(Continued on page 32)

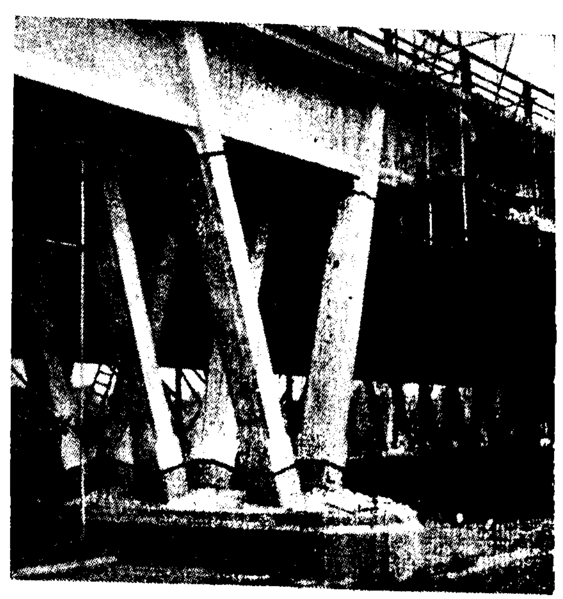
HERE AND THERE

1. BRIDGE OF UNUSUAL DESIGN ON THE OSTEND BRUSSELS MOTORWAY

Bridge Over the Dendre

● THE BRIDGE, which is a fine example of unusual design, is constructed in three spans, has a total length of 347 ft between end supports, and a width of approximately 120 ft. The width is made up of seventeen prestressed concrete beams placed at approximately 8 ft centres. The beams have a height of 6 ft throughout their length, a bottom flange 22 in. wide and $8\frac{1}{2}$ in. thick, and a top flange 5 ft wide and varying in thickness from 6 in. to $7\frac{1}{2}$ inches. The web varies in thickness from $5\frac{1}{4}$ in. to $7\frac{3}{4}$ inches. The bridge was calculated as a continuous beam resting on four supports. The intermediate supports each consist of a series of inclined struts converging in pairs to a common base to form a row of seventeen Vs across the width of the bridge. The struts are hinged top and bottom and Freyssinet flat jacks are incorporated in the bases of the inner struts.

The bridge over the River Dendre, near Alost. (Belgium) The lower photograph shows the V-shaped supports, formed of inclined struts hinged top and bottom.



The beams werecast in situ, using metal formwork, which was moved on as work proceeded. The supports were constructed first, and then the beams were concreted, and partially prestressed on the Freyssinet system. At this stage the beams rested on the end supports and the outer struts of the intermediate Vs. The next stage involved the adjustment of the jacks to take the load on to the inner struts, after which the intermediate slabs and diaphragms between the beams were concreted. The bridge was then prestressed transversely, and lastly the longitudinal prestressing was completed and the jacks given their final adjustment.

The bridge is founded on Franki piles some 108 ft to 140 ft long.

(From 'Concrete Quarterly 22' - April - June 1954).

2. NEW METHODS OF SOIL TESTING

● A NEW METHOD of in situ testing of soil moisture and density has been developed at the University of California and has been used under the paved areas at San Francisco Airport. The higher the moisture content of the soil the greater will be the number of hydrogen atoms present and if these atoms are bombarded by high-speed neutrons emitted from a suitable radioactive source, the energy of these neutrons is considerably diminished and slow moving neutrons remain which are converted into beta and gamma-rays and counted by a Geiger counter. The extent of conversion of the neutrons depends upon the amount of hydrogen atoms present and the Geiger counts thus give a measure of the moisture content.

Density determinations are carried out by allowing gamma rays to impinge on the soil. Scattering of the rays then takes place and the denser the soil the greater the scatter. The extent of the latter is again indicated by a Geiger counter. In order to make the tests probing tubes are inserted in the soil to any required depth up to ten feet and the radio-active source and counter are lowered down the tubes on a lead wire. The tubes are of aluminium about one inch inside diameter shod with a steel point and special precautions are taken to avoid the infurious effects of exposure to radioactivity. It is claimed that the method is simple, cheap, and effective, although the initial cost of the equipment is about £ 500.

(Extracted from "Highways and Bridges," September 1st, 1954).

3. A SOIL STABILIZED RUNWAY FOR JET AIRCRAFT

● ONE OF THE LARGEST soil cement stabilization projects ever to be carried out in the U.K. is now nearing completion at Somerford Airfield, Christchurch, Hants. The project has involved the replacement of a permanent grass runway by a soil stabilized runway, 4,500 ft in length and 100 ft in width, and suitable for heavier types of jet aircraft.

Basic Problems Solved

In a project of this kind, drainage is a major factor, particularly during construction. At Somford the drainage of the runway has been effected by a 1 in 100 fall from the centre line to the edges to provide immediate run-off to perimeter drains on both sides of the runway. The perimeter drains were cut to a fall and filled with $1\frac{1}{2}$ in. gravel rejects and further implemented by 12 in. vertical drains down to 12 ft depth at 100 ft intervals. It is understood that the water table at winter level is approximately at 14 ft and since the underlying stratum is of high permeability, the dispersal of precipitated moisture is fairly rapid.

No problem has been created by the mechanical properties of the subgrade. The soil below formation level is a well-graded gravel of C.B.R. value 7 per cent. It was, however, necessary to remove the turf and top soil to a depth of 6 in. and to import gravel from a borrow pit to regain the required level. Top soil of such high organic content as exists at Somerford cannot be stabilised with cement with any degree of economy.

The airfield has been required for normal flying while construction is in progress. The runway has therefore had to be offset 2 deg. to give clearance for aircraft at the narrowest part of the airfield.

Stabilization

Soil-cement stabilization to a depth of 6 in. has been carried out at the rate of 270 sq. yds. per hour per single-pass 'train'. This time includes a final rolling. The final tar or bitumen surfacing added to the soil-cement formation has been reduced to the minimum necessary to give protection from mechanical and climatic damage.

Preliminary trials included stringent tests with Service aircraft on seven different types of surfacing. As a result, three types have been selected for long-term test. Part of the runway will be surfaced with tar and chippings, part with a 2-in. tarmacadam carpet, and part with 'Jet-crete'—a special material developed for use with jet aircraft.

(Extracted from 'Highways & Bridges'—September 29, 1954).

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4. A COMPARISON OF RAPID METHODS FOR THE DETERMINATION OF LIQUID LIMITS OF SOILS

● ENGINEERS responsible for the routine testing of large numbers of soil samples for highway construction and maintenance need rapid methods for testing. In this study, two simplified methods of determining the liquid limit of soil are compared with the standard method to indicate their reliability and accuracy. Both are "one-run" methods, that is, they require a single determination of moisture and a number of blows for groove closure to calculate the liquid limit.

The methods discussed—the chart method developed by the Washington State Department of Highways and a modification of the chart method involving use of a slide rule—have been compared for a wide range of soils found in many of the States. Both of these methods are rapid and reduce the time normally required for testing by as much as 30 to 70 per cent. They were found to have good reproductibility and to have sufficient accuracy, within limits, to be acceptable as alternate test procedures for the standard method used for the determination of the liquid limit soil constant.

(Public Roads, August 1954.)

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5. PYRAMIDS FORM FLEXIBLE RETAINING WALL

● PRECAST TETRAHEDRA with 7 ft sides and containing $1\frac{1}{2}$ yds of concrete have been used effectively to protect the toe of a road slope from the ravages of high water in a nearby creek. The pyramids were aligned in a row on $3\frac{1}{2}$ ft centres and laced together with galvanized guy strand. The cost of installation is reportedly much less than that of a retaining wall. A further advantage is gained because it is felt that since the individual blocks are free to settle if undermined, the pyramid installation will withstand much less damage than would accrue to a wall.

(From 'Engineering News Record'—Oct. 7, 1954.)

6. REINFORCED VITRIFIED BRICK PAVINGS

● IN THE FIRST TRIALS in the Netherlands with steel reinforced vitrified brick paving two test sections were laid, one in a brick yard and the other on a State Road. The bricks were laid on a compacted sand base and steel rod reinforcement was placed on small mortar blocks in the joints, so that a mesh was obtained. The joints were filled with mortar (cement, lime and sand in the proportions $1 : \frac{1}{2} : 3$) which was compacted by vibration. Loading tests indicated a good bearing capacity. The spreading of the load reduced the unit pressure on the sand base to about a tenth of the unit pressure on the surface.

(Road Abstracts)

CURRENT LITERATURE

ABSTRACTS

U. D. C. No. 693.5 ENGINEERING STATISTICS AND QUALITY CONTROL by Irwing W. Burr. McGraw-Hill Book Company—1953.

THE book is primarily written for junior as well as the senior students of engineering and physical science. A few fundamental statistical measures such as arithmetical mean, the median, the standard deviation are given. The theoretical probability curve known as the normal curve is introduced. Control charts and their use is dealt with at some length.

U. D. C. No. 691.328 : 691.71. PRESTRESSED CONCRETE by Y. Guyon. Contractors Record and Municipal Engineering, Lennox House, Norfolk Street, London, W. C. 2. Price 70s.

THE book is edited by W. M. Johns from the original French. The Author is the righthand man of Freyssinet whose name is inseperably connected with prestressing.

In his preface to the book, Freyssinet says, "It is by reason of his remarkable moral qualities that Guyon is specially qualified to undertake this first attempt at clearing a corner of the field of prestressing."

The aim of the present work is to describe the basic phenomenon of prestress and to develop their application to the problems of simply supported beams. A fairly detailed study of some particular applications which makes it possible to bring out the general principles involved is made.

The book, running into 540 pages, is divided into 3 parts, viz., Part I-General Consideration, Part II - The Elastic Design of Simply-Supported Beams, and Part III - Tests on Simply-supported Beams.

The chapter headings are:

Many worked out examples are included.

U.D.C. No. 625.7 DESIGN OF FLEXIBLE PAVEMENTS- Research report 16-B, National Academy of Sciences-National Research Council, 2101 Constitution, Washington, D.C. August 1954.

THIS publication includes research papers from six state highway departments of Texas, North Carolina, Missouri, Wyoming, Virginia, and Kansas, which contain actual experiences with pavements built in accordance with the different methods of design. These are :—

1. Triaxial Tests in Analysis of Flexible Pavements (Texas).

2. Flexible-Pavement Design as Revised for Heavy Traffic (North Carolina).

3. Flexible-Pavement Design by the Group-Index Method (Missouri).

4. Modified C.B.R. Flexible-Pavement Design (Wyoming).

5. Designing Flexible Pavements (Virginia).

6. Flexible-Pavement Design Correlated with Road Performance (Kansas).

These papers report the results of pavement performance surveys of roads built in accordance with the several methods of design and evaluate the measures as a measure of the adequacy of the methods.

The general discussions given at the end of the pamphlet bring out the important features of each of the methods and discuss the rationale of the methods.

U. D. C. No. 691.3 RECOMMENDED PRACTICE FOR SELECTING PROPORTIONS FOR CONCRETE – Journal of the American Concrete Institute, Vol. 26 September 1954.

THE proportioning of concrete, including mixes containing entrained air, is set forth in this recommended practice. Tables are provided which, along with laboratory tests on physical properties of fine and coarse aggregate, yield information rapidly for obtaining concrete proportions. Three examples are included in the design of air-entrained and non-air entrained mixes which utilize the tables. Adjustment of aggregate proportions due to moisture present in aggregates is illustrated. Laboratory tests are given in the appendix and include those on physical properties of cement and aggregate. Also included is a simple method of obtaining mix proportions for the small job.

U.D.C No. 624.13 SYMPOSIUM ON SURFACE AND SUB-SURFACE RECONNAISSANCE. Special Technical Publication No. 122- American Society of Testing Materials, Race Street, Philadelphia, 3, U. S. A.

TRADITIONALLY, sub-surface conditions are estimated on the basis of bore holes to a desired depth and on tests of samples extracted. This limited the direct information to specific locations at which the borings were made. Co-relations among the borings formed the basis of estimating continuity of strata. Provided these borings were close enough, haphazardous inferences could be avoided. To help a proper assessment of the soil conditions various approaches have been developed. This symposium which deals with all these contains 15 papers, of which three relate to geologic approach, two to the pedologic.

There are two Papers dealing with the application of aerial photography to soil surveying. There are eight Papers on geophysical methods dealing with both the resistibility and seismic methods. The panel discussions which are recorded in two groups bring out the limitations, advantages and disadvantages of these methods.

TROUBLES OF A TRAFFIC ENGINEER

He daily fights pressure groups, consoles taxpayers, berates selfish commercialism, argues futilely that the primary purpose of a street is to transport persons and goods, and searches vainly for parking sites within acceptable walking distance of trade areas.

SELECTED RECENT LITERATURE IN ENGINEERING JOURNALS

VII. CONCRETE

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(Continued from page 21)

from a hydrant or jetting pump is slowly turned on, and as three men hold the assembly upright, it is slowly worked down into the ground with a fourth man guiding the jetting hose. As soon as the wellpoint has sunk to the final position it is desirable to connect it straight into the header line, so that if any slight movement is required it can be carried out whilst the sand around the riser pipe is still fluid.

In extremely difficult grounds, where even the use of the star-shaped jetting device might not give satisfactory results, the standing shell technique is employed. Here a steel shell or about 1 ft diameter is jetted into the ground and then cleaned out. The wellpoint is then inserted and the space between the sides of the shell and the wellpoint filled with sand. The shell is then withdrawn, leaving a filter around the wellpoint.

(Extracted from 'Contractors Record & Municipal Engineering'—September 15, 1954.)

(Continued from page 19)

(2) the amount of foliage on roadside hedges should be controlled by regular cutting ;

(3) weeds and grass on roadside verges should be controlled to prevent them growing to full maturity ;

(4) cut-off walls impermeable to moisture should be provided on either side of the carriageway to a depth of 3-4 ft.

The article contains 14 photographs illustrating defects of concrete pavements resulting from faulty foundation.

For further details about the subject reference should be made to Road Research Road Note No. 6 & 9.

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(Extracted from 'Magazine of Concrete Research'.)

†All the references listed are available for loan to the Members of the Indian Roads Congress on request.

BUDGETS AND ADMINISTRATION REPORTS

Government of Hyderabad Budget Estimates for the year 1954-55

The following extracts have been taken from the Budget estimates of Hyderabad for 1954-55.

	(All figures are in lakhs of rupees).		
	Accounts 1952-53	Revised Estimate 1953-54	Budget Estimate 1954-55
Civil Works (Revenue)			
Rents	8.14	5.69	7.14
Receipts from Workshops	0.01	1.99	2.50
Recoveries of Expenditure	4.58	—	—
Transfer from Central Road Fund	—	13.00	30.00
Transfer from State Road Fund	—	13.28	15.78
Miscellaneous	-0.70	0.41	0.70
Deduct-Refunds	-0.10	—	—
Total	11.93	34.37	56.12
Civil Works (Expenditure)			
Original Works			
Buildings	8.50	8.30	7.29
Communications	16.19	28.03	48.25
Repairs			
Buildings	18.52	20.38	21.18
Roads	66.65	67.79	67.12
Establishment	25.56	51.13	50.49
Tools and Plant	1.74	2.91	4.45
Grants-in-aid	—	—	0.02
Suspense	- 2.10	0.26	0.26
Total	135.06	178.80	199.06
Capital Account of Civil Works outside the Revenue Account			
Roads	13.24	19.25	25.00
Buildings	16.34	24.69	19.12
Works under City Improvement Board	3.98	4.28	4.28
Development Works under Nizamsagar	2.49	3.60	3.60
Rehabilitation Works	2.44	0.94	1.00
Distribution of Establishment Charges on Pro-rata Basis	8.66	—	—
Total	47.15	52.76	53.00

Revenue from Roads

	Accounts 1952-53	Revised Estimate 1953-54	Budget Estimate 1954-55
Receipts under the Motor Vehicles Taxation Act	13.61	13.72	16.22
Sales Tax on Petrol (gross receipts)	2.06	20.00	20.00
Total	15.67	33.72	36.22

GOVERNMENT OF HYDERABAD BUDGET FOR 1954-55.

(A brief review with reference to Civil Works)

THE budget estimates of the Government of Hyderabad for 1954-55 indicate a revenue of about Rs 27.96 crores and revenue expenditure of about Rs 29.02 crores i.e. a revenue deficit of the order of Rs 1.06 crores. The revised estimate for 1953-54 show a larger deficit viz., Rs 1.52 crores, while the year 1952-53 closed with a surplus of Rs 1.42 crores. One of the budgetary measures for additional revenue is the proposal to raise Motor Vehicles Tax (which had been low in Hyderabad as compared to other States) by 20%. This is expected to fetch about Rs 2.5 lakhs per annum.

Expenditure on Civil Works for 1954-55 is estimated at Rs 199.06 lakhs, which forms about 7.1% of the total State revenue. In 1953-54 it was about Rs 178.80 lakhs (Revised Estimate) and in 1952-53 about Rs 135.06 lakhs (Accounts) which work out to 6.9% and 5.0% of the total State revenue for the corresponding years. Expenditure on Roads and Communications (Original Works and Repairs only) has been registering a steady increase Rs 82.84 lakhs in 1952-53 (Accounts), Rs 95.82 lakhs in 1953-54 (Revised Estimate) and Rs 115.37 lakhs in 1954-55 (Budget Estimate). This formed 3.1% of the total State revenue in 1952-53 and 3 7% in 1953-54, while for 1954-55 the budget provision is about 4.1%. Apart from revenue expenditure, the estimated capital outlay on roads for the current year is Rs 25 lakhs as against Rs 19.25 lakhs in 1953-54 (Revised Estimates) and Rs 13 24 lakhs in 1952-53 (Accounts).

REAL MEANINGS OF OFFICIAL TERMINOLOGY

To Implement a Programme — *Hire more people and expand the office.*

Under Consideration — *Never heard of it.*

Under Active Consideration — *We're looking in the files for it.*

We are Making a Survey — *We need more time to think of an answer.*

Will Advise in Due Course—*If we figure it out we will let you know.*

The Issue is Closed — *I'm tired of the whole affair.*

LIST OF APPROVED WORKS ON NATIONAL HIGHWAYS

S. No.	Job No.	Name of work	Amount (Rs in Lakhs)
		ORISSA	
1.	980 RS 5	Exploratory borings for the Brahmani bridge on National Highway No. 5 in Orissa.	0.06
2.	981 RS 5	Exploratory borings in connection with the construction of a bridge over the river Uharsuan on National Highway No. 5 in Orissa.	0.04
3.	982 RS 6	Soiling and metalling of road in Tangarbilla Section of National Highway No. 6 from Tangarbilla to Baitarni bridge.	0.58
4.	986 RS 6	Soiling and metalling National Highway No. 6 in Bangriposi Section in Orissa.	0.22
5.	988 RS 6	Soiling and metalling N. H. No. 6 in Baderma Ghat Section.	0.37
		VINDHYA PRADESH	
6.	983 VP 27	Black topping 12¾ miles of Mangawan-Chak Section of National Highway No. 27 (including widening the existing road from 10′to 12′).	1.53
		UTTAR PRADESH	
7.	984 UP 28	Widening miles 3/11 of Lucknow-Gorakhpur road National Highway No. 28.	4.31
8.	997 UP 25	Widening miles 4/0 to 46/4 of Lucknow-Jhansi Road, National Highway No. 25.	18.20
		MADRAS	
9.	985 MD 7	Constructing a bridge at mile 187/4 of the Madras-Bangalore Road, N. H. No. 7.	1.71
10.	990 MD 45	Construction of a bridge over the Ponniyar river in mile 104/2-5 of the Madras-Dindigul Road, National Highway No. 45.	33.32
		ANDHRA	
11.	987 AH 5	Upgrading Veerawaram Kadiam Section of N. H. No. 5 in Godawari Delta.	0.99
12.	993 AH 5	Upgrading Hukumpetla Lalacheruon Section of N. H. No. 5 in East Godawari District.	1.10

(Continued)

S. No.	Job No.	Name of work	Amount (Rs in Lakhs)
		MADHYA PRADESH	
13.	989 CP 26	Black topping miles 3¼ to 42 of Sauger-Jhansi Section of N. H. No. 26.	5.90
14.	991 CP 26	Widening and blacktopping miles 3 to 64/F6 of Sauger-Narsimhpur Section of N. H. No. 26.	11.56
15.	998 CP 7	Constructing miles 46-50 of Hinganghat-Wardha District Border Section of N. H. No. 7.	4.37
		BOMBAY	
16.	992 BM 8	Construction of four minor bridges in Karjan-Makarpura sub-section of Karjan - Baroda Section of Bombay-Ahmedabad Road, N. H. No. 8.	0.78
17.	996 BM 8	Construction of cross drainage work No. 24 in the Pirojpur Prantij section of the Bombay-Ahmedabad Road, N. H. No. 8.	0.42
		BIHAR	
18.	994 BR 31	Widening and strengthening Gulabbagh portion of G. D Road from 31st mile fifth flg. to 32nd mile 4th flg., N. H. No. 31.	0.79
19.	1004 BR 31	Widening of Kharant-Rajauli Road in the Distt. of Gaya - N. H. No. 31.	5.29
		PUNJAB	
20.	999 PB 1	Remodelling of Munshi Khava attached to Inspection Bungalow at Khanna in Ludhiana Distt. on N. H. No. 1.	0.03
		JAMMU & KASHMIR	
21.	1000 JK	Acquisition of land near village Nangam for the construction of residential and office accommodation for the staff of the Executive Engineer, South Tunnel Division.	0.03
		RAJASTHAN	
22.	1002 RJ 8	Construction of a high level arch bridge, and providing by pass at Parash in mile 13 of Rajnagar-Dewair section of N. H. No. 8.	1.62

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