THE NEW HIGH LEVEL ROAD TO
THE KELANI VALLEY

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The New High Level Road, 21½ miles in length, has been traced and designed to provide a modern line of communication above ordinary high flood level and therefore open to traffic at all times of the year, connecting Colombo with the Kelani Valley and the main road system beyond. The road takes off from Havelock Road opposite the Spinning & Weaving Mills in a southeasterly direction to the New Municipal Bridge over the Dehiwela canal at Kirillapone, and joins the Colombo Avisawella road at the turn off to the Labugama Water Works near the 19½ mile post.

The original proposal included the construction of a new bridge over the Wellawatta Canal at the Spinning & Weaving Mills, but, owing to financial depression, this work cannot be undertaken at present.

The portion of the road between the take off and the Kirillapone bridge over the Dehiwela Canal has not been put in hand yet but the land required for the construction has been acquired and the advisability of undertaking this as a relief work for the unemployed is under consideration.

The other portions of the road as detailed in the following pages have been completed.

From Kirillapone Bridge the trace more or less follows the Kelani Valley Railway through Nuwegoda and Nawinna village areas till it joins the old Cotta—Kottawa minor road alongside which it runs for some three miles. It was
originally intended to take over and improve this minor road and absorb it into the new road but opposition from villagers to the acquisition and demolition of the buildings which would have been necessary for the required reservation was so strong, and the cost of acquisition was likely to prove so expensive, that it was decided to abandon the old road and cut an entirely new trace a short distance from it. That this decision was sound has been amply proved by results.

From Kottawa, where the new road leaves the minor road, the trace runs through numerous paddy fields to a point about half a mile from the village of Homagama where it crosses an existing minor road. This minor road has been taken over and improved and forms an approach both to the Railway Station and Rest House.

From Homagama Junction the road runs on a gently rising gradient for one and a half miles to cross the Kelani Valley railway by an overhead bridge. The site chosen for this bridge is one where the railway runs in a deep double cutting through hard cabilook or laterite necessitating very little expenditure on abutments although great care had to be taken in laying out the approaches which form a large "S" in plan.

From Homagama Railway Bridge the trace runs along somewhat uneven ground to Panaluwu Ela Bridge, crossing the old Cotta Padukka minor road near the 17th mile post. The Panaluwu Ela (or stream) is small in itself but, being affected by floods from the back-waters of the Kelani, it has been necessary to provide a bridge with a span of 30 feet.

From Colombo to Panaluwu Ela Bridge the road runs over undulating country and across paddy fields subject to only minor local flood conditions; but from this bridge to the end of the road difficult flood conditions, due to the rising of the Kelani Ganga, have had to be considered and dealt with.

About one mile beyond the Panaluwu Ela the Pusweli Oya is crossed by a bridge having a span of 120 feet and a roadbed of 18 feet. This oya (large stream) drains a considerable area of open
flat land to the south of the road and, during flood time, rises to a considerable height, and discharges a large volume of water. The Bridge is situated three quarters of the way across the valley which is approximately 2,000 feet wide and is approached by embankments 20 feet high.

Three quarters of a mile beyond the Pusweli Oya Bridge the road joins the existing Public Works Department main road from Hanwella to Padukka at Galagedera approximately one mile from Padukka. A quarter of a mile further on the road meets the Ingiriya-Hanwella road at Mipé Junction. The junctions at Galagedera and Mipé have been made triangular in form so that traffic, converging on the junctions, can disperse itself along either of the three lines of road which are separated by a raised grass plot on the centre of which a sign post has been planted.

From Mipé to Pathgama, a village half a mile from Hanwella, the existing P.W.D. road was raised in places and widened throughout its length.

At Pathgama the road turns north-eastwards through a deviation on high ground which was necessary to avoid the flooded sections of the old Kelani Valley road between the 18th and 19th mile posts, to join the old Kelani Valley road at its junction with the road to Labugama Reservoir close by the 19\(\frac{1}{4}\) mile post. Close to the turnoff to Hanwella a new road has been made running eastwards connecting Niripola and Diddeniya villages to the High Level Road. This new road is carried on a high embankment which serves the purpose of preventing flood water from the Wak Oya from flowing southwards to the new road where it crosses the same valley lower down, thus saving the expenditure which would otherwise have been necessary for the construction of a large bridge and preventing the frequent flooding of a large area of valuable land.

The Colombo Water Mains are crossed at the junction of the new road with the old Avisawella road and, in order to take the load of the new bank off these and make the pipe line freely accessible, a bridge has been built having a direct span of 17
feet and a span of 30 feet on the skew. This bridge has been blocked up so as to prevent water passing under it and over the pipes in flood time.

The old Avisawella road from the 19th mile post to the Wak Oya Bridge at the 19\(\frac{1}{2}\) mile post is low lying and has always been one of the first sections of the road to be affected by floods. To deal with this the new road has been constructed alongside it on banking from 10 to 16 feet above the old road level.

The Wak Oya—the stream which, in its higher reaches, fills Labugama Reservoir and supplies Colombo with water—is crossed by an 80 feet span bridge having a roadway 18 feet wide and is a striking contrast to the old bridge alongside it as will be seen from the photograph at the end of this paper.

Beyond this bridge the road to Labugama turns off eastwards and the approaches to this have been regraded and improved.

The new construction work ends opposite the entrance to Kaluaggala Roman Catholic Church, the old road having been regraded and improved by eliminating a dangerous blind corner between that point and the bridge.

Although the road has been designed to be above flood level, the floods to which this applies are normal ones but exceptional floods, such as occurred in 1913, will top the road. The raising of the levels to provide against maximum floods would have been a waste of money as it would have meant that the new road would have been isolated, as other sections, in the direction of Avisawella, have not been raised. It is noteworthy however that even in the exceptional floods which occurred in May, 1930 the depth of water at any point on the new road did not exceed one foot.

**Reasons for Adopting the Trace.**

The old Avisawella road, which runs through Ambatale, Kadowela and Hanwella close to the river, is subject to flooding twice a year for periods of considerable duration and this flooding caused serious interruption to traffic where the floods
were worst, i.e. between Colombo and the 19 1/4 mile post. The increase in motor car and motor lorry traffic in the years following the war accentuated the inconvenience caused by these floods and necessitated the investigation of remedial measures to deal with them. The first suggestion which, naturally, required investigation was the raising and improving of the existing road but, as this appeared likely to be very expensive and unsatisfactory, it was soon given up and investigation diverted to providing some less costly solution of the problem. The principal reasons which governed this decision were that the valley of a river, such as the Kelani, is the most unsuitable line for a road which is required to be above flood level; that the acquisition of land and buildings to provide for the required reservation width would be expensive and would necessitate the dehousing of roughly one-third of the village population along the existing road, who would have no suitable land on which to rebuild; that heavy bridging would be necessary to deal with a practically unknown volume of water flowing between the Kelani River and the lowland to the South across the existing road in flood time; and last, but not least, that traffic would continue to discharge into the congested Dematagoda and Maradana areas of Colombo necessitating heavy costs in improving roads inside Municipal limits.

The idea of improving the old Avisawella road having been abandoned the possibility of utilizing some of the other existing roads was next considered and the only possibility in this direction appeared to be the P.W.D. Road from Hanwella to Padukka and minor road from Padukka to Cotta. Whilst very little bridging would have been required to deal with floods on these roads the objections to their use were, in general, the same as in the case of the Kelani Valley Road, i.e. it would be necessary to dehouse a considerable number of villagers and traffic would continue to discharge into the congested areas of Colombo.

It was finally decided that the best method of dealing with the problem was the construction of a completely new road for most of the required length; and it may be stated incidentally here that this will invariably be found to be the most econo-
nical method of dealing with road construction under similar conditions.

The trace adopted has the advantage of reducing the cost of acquisition and the number of villagers to be dehoused to a minimum; of providing additional frontage for new buildings; and of discharging traffic into an area of Colombo where wide roads are available for distributing traffic on its arrival and no expensive programme of road widening in the city is necessary.

**Specification.**

The plans and estimates provided originally for a road having a metalled width of 16 feet (except inside Municipal limits where the width was to be 40 feet) at a cost of Rs. 2,218,000.00 but it was decided later to increase the metalled width to 20 feet to conform to the British Ministry of Transport specification for main roads and the estimate was increased to Rs. 2,650,000.00. This included certain additional works not provided for in the original estimate. It may be stated here that the additional 25% width of traffic way was obtained at an increased cost of only 11% over the cost of the narrower traffic way originally intended.

The specification which was finally adopted was as follows:—

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<thead>
<tr>
<th>Description</th>
<th>Measurement</th>
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<tbody>
<tr>
<td>Metalled width</td>
<td>20 feet</td>
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<tr>
<td>Width on Banks and between Side</td>
<td>26 feet</td>
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<tr>
<td>Drains</td>
<td>22 feet</td>
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<tr>
<td>Stone Foundations, 9&quot; thick</td>
<td>Bitumen</td>
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<tr>
<td>Surface</td>
<td>Paint</td>
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<tr>
<td>Width between Parapet of Culverts</td>
<td>26 feet</td>
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<tr>
<td>Width of Roadway of small Bridges</td>
<td>24 feet</td>
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<tr>
<td>Width of Roadway of large Bridges</td>
<td>18 feet</td>
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<tr>
<td>Land Reservation</td>
<td>66 feet</td>
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<tr>
<td>Ruling Gradient</td>
<td>1 in. 30 feet</td>
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<tr>
<td>Minimum Radius of Curves</td>
<td>150 feet</td>
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**Connecting Roads.**

It has been stated that no internal improvements would be required in Colombo and this is, strictly speaking, accurate; but in addition to the main
line provision was made for one large connecting road, namely Baseline Road South Connection estimated to cost Rs. 285,000.00. Unfortunately the financial condition of the Island has not been such as to allow of this proposal being carried out and a very useful connection has had to be given up and allowed to lapse.

This proposal originated with Sir Cecil Clementi, Colonial Secretary, when administering the Government and consisted of extending Baseline Road directly south so as to join the new road at Kirillapone. Its object was to provide direct access from the new road to the Borella area of Colombo and divide up traffic before it entered Colombo. It also had in view the opening up of a large block of excellent building land lying between Kirillapone and Narahenpitiya and developing a new suburb close to Colombo and with easy access to the Fort.

Tracing.

In laying down the trace reference was made to the very excellent contour maps prepared by the Survey Department of Ceylon and too much emphasis cannot be laid on the assistance which these maps gave in locating the best line to be adopted. These maps made tracing easy and it was possible to select the best line to be adopted and proceed along it with practically no preliminary investigation.

The main objects kept in view in preparing the original survey were (a) Alignment and the necessity for keeping curves as flat as possible consistent with reasonable economy in earthwork.

(b) That, whilst the quantity of earthwork should be reduced to a minimum, such reduction should not be a ruling factor. It was realized that reduction of earthwork quantities (and consequently costs) is uneconomical if, by so doing, the length of road is increased and the cost of other more expensive work expanded.

(c) That special attention should be paid to the provision of suitable building frontages on both sides of the road especially in the neighbourhood
of Colombo where the opening out of a main thoroughfare was likely to lead to the development of a new suburban area and the construction of new buildings. That this assumption was justified is proved by the rapid development on the first 5 miles of the new road, where it passes through Kirillapone, Nugegoda and Nawinna villages, and where over 100 substantial buildings have been erected since the road was opened to traffic some three years ago. It is only to be regretted that this development is being allowed to go on almost uncontrolled and that advantage has not been taken of an almost unique opportunity for town planning and the scientific laying out of feeder roads to assist development which the improved communications provided.

Construction.

The writer has been asked, in preparing this paper, to include in it certain information which was embodied in a report submitted to the Director of Public Works when the work was completed. This information covered various subjects such as calculation of quantities, methods of carrying out work, etc., and was intended mainly for the information of officers of the Public Works Department engaged on similar undertakings in the low country. Some of it is elementary but most of it has been included in this paper in the hope that it may prove useful to members and serve as a reminder of factors that might otherwise be overlooked.

Estimates.

It is usual in Ceylon to divide estimates up mile by mile but this method was not adopted in the present case. In place of it the whole work was divided up into sections of varying lengths and based mainly on physical feature such as a junction with, or crossing of, a main road or the railway. This method was found to be satisfactory as it made it possible to let out contracts of varying lengths to suit contractors' capabilities and capital and to divide supervision within more definite limits. It also meant that earthwork for filling was always obtained from the same section or
division of the work from which it was cut and thus facilitated both measurements and accounting.

The estimate was divided into four main subdivisions which covered:

(a) Construction works such as earthwork, stone work, culverts, etc.

(b) Large bridges and special culverts.

(c) General Items such as Lines, Acquisition, Plant and surveys and

(d) Supervision and Contingencies.

**Earthwork.**

The country round about Colombo consists, geologically, almost entirely of good cabook or laterite with occasional large outcrops of rock. A certain amount of brittle white disintegrated stone occurs in places but the total quantity is practically negligible. This cabook or laterite is easily worked especially in wet weather; has an angle of repose almost vertical and consolidates into a hard mass when tipped into banks and allowed to settle. It forms almost the ideal material for road construction work.

A considerable proportion of the total length of road crosses paddy fields and in calculating the quantities of spoil required for the banks an allowance of from 15% to 20% was made for penetration. This was found, in practice, to be quite inadequate especially where banks from 4 to 5 feet high predominated, the excess over the calculated quantities amounting in some cases to as much as 60%. This is reasonable when it is realized that there is an initial penetration in paddy fields of from one to two feet according to conditions at the time spoil is tipped and the nature of the paddy field soil and, as this penetration is spread over the base of the bank where it is widest, it forms a high percentage of the total volume of filling required. Investigations were carried out to see if some more reliable method of estimating could not be evolved, and, whilst there were considerable differences between extremes, it was found that a rough and ready method of fair accuracy would be to allow for an
initial penetration of 1 foot 6 inches plus one inch per foot height of bank. This allowance can be shown on the cross sections as penetration in the usual way.

It was originally intended to roll all banks before foundations were laid but this was found to be impracticable mainly due to the fact that rollers tended to sink very deep into the filling which had been tipped even one year before and in consequence suffered badly and delayed work.

In place of this new banks were constructed to designed level for the finished road plus a settlement allowance and were allowed to stand for a year. A track was then cut to the designed width of the foundation and 6 inches deep and foundations laid and rolled. When the road was finally finished it was usually found that the verges stood up some six inches above the metalled surface and had to be cut down to conform to the designed section. As the earthwork contracts had long since been closed it was not possible to make the cutting down of these edges part of the contract and additional expense had to be incurred for which no provision had been made in estimating and quantities were, in consequence, exceeded. The average quantity for this worked out at 3 cubic feet per foot run of bank and it is advisable that provision should be made for this in the earthwork quantities in future estimates. An attempt was made to avoid this additional cost by leaving the edges lower to begin with and by laying the foundation stone on top of the bank without cutting a trench for it but this was not found to be satisfactory as the foundations tended to "spread" badly when rolled due to lack of lateral support.

Provision in earthwork quantities, which are often apt to be overlooked, are for metal depots, scour due to rain or to flood lap on the toes of new banks; provisions for halting places for buses; and for widening out junctions. No specific data is available for estimating these as they vary considerably according to circumstances but in the case of metal depots it may be stated that the most satisfactory and economical position is usually at the junction of cuttings and fillings if no level spots are available elsewhere.
Light railway track was used throughout the work and is almost indispensable where large quantities of materials have to be handled and no made roads exist. Trolleys of 18 cubic feet capacity and rails of 16 lbs per lineal yard were used and proved satisfactory.

In constructing banks the method of working was to run out a narrow bank say 5 feet wide well ahead of the general work and then to tip in on each side. This made it possible to set the required level ahead of the main work and also gave two tipping faces. It was not often necessary to use both these tipping faces unless there was some urgency but they were always available if necessary. Rails were moved across from the centre as work of widening progressed until the full width was obtained.

Practically the whole of the earthwork was completed during the boom years when prices were high and labour expensive so that these costs are of very little use under present conditions. The average worked out at Rs. 2.49 per cube (65 cents per cubic yard) and can be divided up into two distinct sections namely, where flood banks were being constructed with long lead, and in ordinary cut and fill sections where the lead was much shorter. In the former the cost worked out at Rs. 2.64 per cube (71 cents per cubic yard) where the lead was between 2,000 and 2,500 feet average; and in the latter at Rs. 2.14 per cube (58 cents per cubic yard) where the lead averaged 600 to 700 feet. These rates included all charges such as laying and maintaining trolley lines and trimming slopes.

Foundations.

The specification provided for 9 inch sledged stone foundations laid on edge throughout with no provision for smaller stone for sealing before metal was laid. Quantities of sledged stone required were based on this figure plus 10% for voids in piling or 0.83 cubes per square of paving. Allowance was also made for opening out junctions and road crossings.

The quantities actually required worked out at 0.75 cubes per square (0.25 cubic yard per
yard sup) but this figure is apt to be misleading as the depth of paving was reduced to 6 inches in double cuttings where hard formation was available. The actual quantity used per square varied considerably due to conditions under which it was laid and rolled but a fair basis for estimation would be:

- In double cutting with good formation where only 6 inches depth is required
  - 0.55 cubes per square
  - 0.18 cubic yd. per yard sup.

- For single cutting in side long ground with full 9 inches depth
  - 0.80 cubes per square
  - 0.27 cubic yd. per yard sup.

- For banks with average well settled fillings
  - 0.90 cubes per square
  - 0.30 cubic yd. per yard sup.

- For soft banks and unstable ground
  - 1.00 cube per square
  - 0.35 cubic yd. per yard sup.

Special provision should be made where circumstances make it possible that extra stone will be required due to soft ground.

The type of foundations provided for above are "Open," i.e. the smaller voids are not filled up but left to form an intimate bond with the surface metal. This was found to be expensive in its consumption of metal and about 0.15 cubes per square (0.05 cubic yard per yard sup.) of 4 inches or 34 inches metal should be provided to be spread loosely over the foundations, before they are rolled and to act as a seal.

The method of laying was based on four operations namely the larger stones were laid on the prepared formation with flats down and tips up. It was impressed on the labourers that these stones must be laid vertical and not leaning up against their neighbours and that the longest axis should be parallel to the centre line of the road. Insistence on these three cardinal points made it possible to get a more intimate locking of stones and facilitated the next operation. After the large stones had been laid to form a very open surface, large wedging stones were driven in with 4 lbs.
hammers to tighten up the main bedding stones. Smaller wedging stones were then driven in to increase the wedging effect and finally all projecting points were knocked off with a 1 lb hammer on a long handle and allowed to lie and be crushed in when rolled. The quantity of chippings, however, did not prove to be sufficient for a proper seal and metal had to be used as well.

It is for this reason that the provision of a small supply of 4 inches or 3½ inches stone is recommended.

When the foundations had been laid a ten ton roller was passed over them till they conformed to the general designed outline of the road. As a rule there was fairly even settlement and little difficulty was experienced in obtaining the correct shape approximately except when rolling was done in wet weather. Small hollows which occurred during rolling, if they did not exceed 3 inches to 4 inches were made up with metal but where they exceeded that figure or where high spots occurred which could not be rolled down, the paving was lifted and reset. The necessity for lifting the paving did not amount to more than 5% of the total length except on a section of new banking which was rolled in wet weather and where flood levels had to be considered. This section, over 1,000 feet long, sank between one and two feet when rolled and had to be relaid.

When the paving had been thoroughly rolled and appeared to have assumed its correct shape a thin layer of metal usually 0.10 cubes per square (0.03 cubic yard per yard sup) was spread and rolled in to seal the foundations and, when fairly consolidated, was slightly roughened up to provide a bond with surface metal and the final layer of surface metal was laid. This system of operations proved successful although the estimate did not provide for sufficient metal to give a full final layer 4 inches thick.

The average cost of sledged stone piled in the quarry worked out at Rs. 6.00 per cube (Rs. 1.62 per cubic yard) and piled on the road at Rs. 10.95 per cube (Rs. 2.95 per cubic yard) the average distance of transport being about one and a half miles over unmade roads. Practically all this
work was done in 1927 to 1929 when rates were high and the costs are not a fair guide under normal conditions.

The average cost of laying came to Rs. 3.35 per square (90 cents per yard sup.) which included all charges for rolling. It was possible latterly to reduce this to Rs. 2.75 per square (75 cents per yard sup.) of which Rs. 2.00 represented cost of laying and cents 75 cost of rolling and this would probably be a fair basis for estimating under normal conditions.

Metal.

The specification provided for a thickness of 5 inches of 2 inch metal which, it was anticipated, would consolidate to a finished depth of 4 inches and the quantities provided for in the estimates were based on this with no allowance for voids in piling or for granulating. This amounted to 0.42 cubes per square (0.11 cubic yard per yard sup.) This quantity was quite insufficient to provide 4 inches finished depth due to the fact that the foundations absorbed a considerable portion of it and the finished depth was seldom more than 21/4 inches.

A certain amount of this metal was passed through a granulator which produced approximately 35% stone one inch and over and 65% under one inch. The proportions varied considerably according to the condition of the jaws and nature of the stone. Stone under one inch was reserved for use as a filler over the bitumen surfacing but stone over one inch was used as a blinder when 2 inches metal had been partly rolled and proved useful in closing up spaces on the surface.

Metal was laid in two stages. After foundations had been rolled and formed roughly to shape a thin layer of 2 inches metal was laid and gradually rolled to correct shape. It was then slightly loosened with a pickaxe and the final surface layer laid and rolled. This final layer should normally be 4 inches thick but, as supplies of metal were insufficient, it seldom exceeded 21/2 inches. Some few weeks after metal spreading was finished the bitumen surfacing coat was laid and blinded but this method is not recommended for future work.
as it was found that the surfacing tended to break up due to the slight internal movement which is almost inevitable in new road work. A much more satisfactory method to adopt is to lay the foundations and first metal layer and allow traffic to use the road for so long as it remains in reasonable order. When the surface has reached a state of deterioration which makes it uncomfortable for traffic to use it the surface should be roughly picked up and the final metal layer laid down, consolidated, and surfaced. This method was adopted latterly and has led to a more satisfactory and permanent surface.

If this method is adopted and if provision is made for the small quantity of 4 inches or 3¼ inches stone recommended the following quantities of metal will be required for the various construction work.

For first layer metalling  \(0.15 \text{ cubes per square yard sup.}\)

For final layer metalling  \(0.35 \text{ cubes per square yard sup.}\)

For granulating for surfacing  \(0.05 \text{ cubes per square yard sup.}\)

Total  \(0.55 \text{ cubes per square yard sup.}\)

This should allow for a full finished depth of 4 inches metal.

The cost of metal supplied in the quarries averaged Rs. 9.00 per cube (Rs. 2.43 per cubic yard); and on the road, with 1¼ miles transport over unmade roads, Rs. 14.00 per cube (Rs. 3.78 per cubic yard).

The cost of spreading worked out at Rs. 4.07 per cube (Rs. 1.10 per cubic yard) including all charges for rolling, etc. The rate, latterly, fell as low as Rs. 3.40 per cube due to reduction in labour charges and this should prove to be a fair average figure for future work.

**Surfacing.**

The road has been opened for a comparatively short time and it is too soon to say definitely
which of the types of surfacing experimented with will prove the most satisfactory. It will be difficult to decide on this in any case as they were laid under varying conditions.

The types tried out were:

(a) Ordinary hot run bitumen paint.
(b) Emulsion paint.
(c) Hot Bitumen grout and Emulsion seal.
(d) Emulsion grout and hot run bitumen seal.
(e) Emulsion first coat paint and hot run bitumen seal.
(f) A small quantity of Road Board Tar.

Nos. (b), (c) and (f) definitely proved to be unsatisfactory and did not last.

No. (a) proved satisfactory but there was a tendency for it to lack adhesion and roll up under traffic.

As far as can be seen at present No. (d) seems likely to prove the most satisfactory and the method of laying may be of interest.

The road was first given a rough brushing with bass brooms to remove large grit and cattle droppings. A heavy jet of water was then played on the road from a water cart. As the water cart moved slowly forward six labourers followed it in echelon brushing as hard as possible until the road was scrubbed clean. The road at this point was thoroughly soaked and wet and whilst in this condition from $3\frac{1}{2}$ to 4 gallons of 57% emulsion were sprayed on per square (from .85 to 1 gallon per yard sup.) As soon as the emulsion had broken and become black a thick layer of $\frac{1}{4}$ inch chips was spread and the surface rolled with an eight-ton roller at once. When the roller had passed over twice or three times a layer of quarry or granulator dust was laid and again rolled. The road was then opened to traffic for one or two months, after which it was thoroughly brushed and cleaned and $\frac{1}{2}$ to 2 gallons hot run bitumen was spread with squeegees and blinded with either $\frac{1}{4}$ inch chips or coarse sand. This method proved (apparently) to be the most satisfactory as it appeared to give better adhesion to the underlying stone than straight run hot mix surfacing.
All the experiments have been stultified, somewhat, by the fact that internal movement has tended to make the surfacing break much sooner than it should and it is recommended that a longer period be allowed for this internal movement to cease before surfacing is laid.

As the method of treatment varied considerably it is not possible to give an average rate for surfacing carried out on the whole job but the type mentioned above worked out at approximately Rs. 4.00 per square (Rs. 1.08 per yard sup.) which included the cost of rolling and granulating metal for filling.

Culverts.

Two types of culverts were used throughout the work except in a few isolated cases namely, precast concrete pipes and masonry culverts with reinforced concrete decking.

Concrete pipes 2 foot internal diameter were standardized, one to four lines being used as required. As the road ran for a considerable distance on high land relatively few culverts were required, the number of pipe culverts averaging about 10 per mile. About half the number were required to deal with irrigation and drainage channels in paddy fields where foundations were poor but little difficulty was found in dealing with these. The usual method adopted was to excavate to the level of the bottom of the concrete foundations and then drive in 9 inches sledged stone on edge till the whole was solid, wedging stones being used to tighten up the surface. This method proved satisfactory and provided a clean bed for laying the concrete foundations. No instance of settlement or fracture occurred throughout the work. On top of this prepared bed 6 inches of cement concrete gauged 4 : 2 : 1 was laid. Where the depth between road level and the top of the pipe was less than four feet the pipes were encased in cement concrete 4 inches thick but where the depth below road level exceeded four feet no casing was used, the pipes being merely haunched in concrete up to springing level.
In fixing the number of pipes required, their position and level, the local land owner, as the one most concerned, was always consulted and the result has been that no complaints have been received. The ordinary villager has a very sound idea as to what is required to irrigate or drain his fields and the number of pipes required agreed fairly closely with the number provided for in the estimate. It was possible in a few cases to cut out culverts provided for in the plans by diverting water into enlarged side drains and carrying it to an adjoining outlet.

In the case of culverts carrying irrigation channels under the road it was usual to set the invert approximately 3 inches below the channel bed but in the case of drainage channels the invert was set 9 inches below ground level.

Practically all pipes were carried out to the toe of the bank with concrete head walls at 45 degrees to the centre line of the culvert dropped to conform to the slope of the bank. It was found that it was more economical to extend culverts to full length than to shorten the culverts and construct heavy head retaining walls. The adoption of wings at 45 degrees makes it possible to reduce the thickness of masonry as the wings act as buttresses to the retaining walls which in all cases were only one foot thick. These head walls were carried up to varying heights above bank outlines to see which was most effective. Latterly they were constructed only sufficiently high for the tops to be flush with the slope of the bank, nothing appearing above that line. This method has two advantages as it reduces the cost of construction by reducing the quantity of concrete in the head walls and also reduces the cost of maintenance as there are no exposed parapets to be maintained and whitewashed. By avoiding parapets close to the road, where they are used by the local population as a convenient resting place, periodic repairs are reduced to a minimum.

The main defect in standardizing pipe culverts in new construction work is the heavy cost of handling. The pipes have to be made in a central depot, transported to site and then handled in paddy fields. This handling is costly as each
pipe weighs approximately 600 lbs. and is difficult to deal with in paddy field mud where culvert construction is being carried out ahead of filling.

These pipe culverts varied in length the shortest being 28 feet and the longest 70 feet. The average length was about 40 feet.

The cost per lineal foot of culvert pipe laid complete worked out about Rs. 10-00 but varied somewhat according to distance the pipes had to be transported and the nature of the foundations. Head walls cost about Rs. 80-00 each including the necessary apron and drop wall.

Larger culverts were standardized at 8 feet and 10 feet span very few of the former being constructed. These consisted of masonry abutments and wings carried down to solid—usually about 6 or 8 feet below ground level—with reinforced concrete decking and stone sett paving. The decking consisted of a 14 inches concrete slab with double reinforcement of 1 inches rods at 3 inches centres and ¼ inch shear rods at 4 inches centres formed into a grid. The reinforcement was spaced 8½ inches centres giving ample strength for almost any loading. The reinforcement was carried up into the parapet walls to strengthen them and form a light longitudinal girder.

Special Culverts.

A special culvert was constructed in the Hin Ela Bank at the 25th mile post. The road is carried across the Hin Ela Valley on an embankment and it was originally intended to provide an 80 feet span bridge to deal with water from the Wak-Oya discharging down the valley in flood time. It was found on investigation that this flood discharge could be prevented by constructing a short bund higher up the Hin Ela Valley and at a narrow point where it joined the Wak Oya Basin. By constructing this bund an area of approximately 300 acres was isolated from floods except through the drainage culvert in the Hin Ela Bank and it was decided to provide this culvert with automatic flood gates. Had this not been done it would have been necessary to provide for a much larger culvert to allow ingress and egress of flood water.
and the 300 acres referred to would have continued to be subject to floods.

The culvert was eventually constructed with four openings 2 feet 6 inches wide and 4 feet high each opening having two gates, (an upper and a lower), the upper overlapping the lower. These gates were hung on gunmetal links and opened under a head of a few inches. This scheme has worked satisfactorily and has not only provided flood protection for 300 acres of land but resulted in a saving of Rs. 30,000-00 to Government and the provision of an access road over the new bund to the villages of Niripola and Diddeniya which were formerly practically isolated during the flooding of the Kelani Ganga.

The Colombo Water Mains are crossed at the junction with the old Avisawella road by a skew bridge 17 feet on the square and 30 feet on the skew. This consists of two 24 inches by 7¼ inches by 90 lbs joists with cross-bearers, trough decking and sett paving. It was erected at the request of the Municipal Waterworks Engineer in order to take the extra loading due to the raising of the road off the pipe line and make it possible to obtain free access to the pipes. As the culvert or bridge is constructed in a bank which is liable to a difference in head when the Wak-Oya is in flood and the Kelani Ganga is not, it has been necessary to close up the opening by a masonry wall so as to prevent the passage of water over the pipes and possibility of scour being set up.

Bridges.

The number of bridges constructed is small due to the location of the trace and only four of 30 feet or over have been built.

The bridge over the Kelani Valley Railway has a span of 30 feet with roadway 24 feet wide and, as it was in hard cabook, very light abutments were necessary, foundations being carried down some four feet below rail level.

The Panaluwa Ela is crossed by a 30 feet span bridge with 24 feet by 7½ feet by 90 lbs. joists carrying Dorman Long trough decking with stone
sett paving. Foundations caused some trouble but were eventually bedded on cabook gravel 8 feet below bed level. Concrete abutments faced in stone with wings at 45 degrees dropped to conform to the bank outline were built.

The Pusweli Oya Bridge 120 feet span is the longest erected and consists of two Warren type girders with underslung cross bearers, lattice wind bracing, Dorman Long troughing and stone sett decking. The steel work was designed in the Public Works Head Office and was fabricated and erected by the Government Factory.

The foundations consist of cement concrete octagonal cylinders founded on rock and filled with 8:4:1 cement concrete. Some difficulty was found in sinking the wells on the eastern side due to sand blows occurring when rock was reached but this was eventually overcome and the cylinders successfully bedded on rock. As in the case of all bridges on this work cement concrete faced in stone was used in the abutments.

The Wak-Oya—the river which supplies Labugama Reservoir with water—is crossed by an 80 feet span bridge with lattice girders having cross members carried on the lower channels. The bridge has roadway width of 18 feet and is founded on concrete wells bedded on hard cabook. The work was carried out entirely by the Government Factory and was the first unit to be completed.

Lines.

A very considerable saving was made on the provision for lines in the estimate due to alteration in conditions. It was originally intended to provide for two sets of overseers quarters and thirty rooms of lines but quarters for overseers were cut out completely and the number of rooms of lines reduced to thirteen.

The first set of lines were of solid cabook masonry with tiled roofs and consisted of four rooms 12 feet by 10 feet with closed in kitchen verandah and fireplace. This type cost approximately Rs. 800—per room exclusive of fencing, well and latrine. Latterly a very much cheaper type costing, Rs. 400-00 per room was evolved consisting of
cabook masonry walls with steel framing carrying a galvanized iron roof. No kitchen accommodation or fireplace was provided but, as this type seems to please the labourer just as much as the more expensive one, its adoption seems advisable. The average cost of latrine accommodation worked out at Rs. 65.00 per seat where Dudley type portable pit latrines were erected.

A well was sunk for each set of rooms. In the later sets constructed the wells were unlined and consisted of an 8 feet circular opening sunk in cabook to an average depth of 16 feet with 2 feet curb walls in cabook masonry plastered in cement. The average cost of these worked out at Rs. 50.00.

Acquisition.

Approximately 200 acres of land had to be acquired at a total cost of Rs. 405,000.00. Of this sum Rs. 90,000.00 was paid for acquisition of some 3 acres inside Colombo limits and the total figure included payment for about fifty dwellings mostly of the wattle and daub variety but with a few more substantial structures near Colombo.

The cost per acre varied very widely having a maximum of Rs. 50,000.00 per acre and a minimum of Rs. 500.00. The increased value of land due to the construction of the road is indicated by the fact that when additional small blocks had to be acquired towards the end of the work to adjust certain defects in the boundaries cost per acre had increased by some 300%.

Approach Roads to Railway Stations.

The estimates provided for the construction of connecting roads to Nawinna, Pamipitiya, Homagama and Megoda Railway Stations but, with the exception of Homagama, all these were omitted as the cost did not seem to justify them.

Sign Boards.

The road has been sign boarded to meet modern requirements, standard Ministry of Transport indicators being used where necessary. As all
junctions and crossings have been opened out to give ample view line the number of these required has been small and very few crossings or junctions were considered sufficiently dangerous to warrant their erection.

Concrete posts with individual sign boards supported on direction arrows were adopted for all direction notices. These posts are 14 feet long 8 inches across base and 5 inches across top flats and are reinforced with spiral wound steel similar to that adopted for telegraph posts.

The system adopted is to indicate the direction to Colombo and Avisawella on practically every post, the only other indication being to the nearest town en route.

Plant.

A very large proportion of the plant used on the work was provided and paid for from the estimate but practically no tools were supplied to contractors as the contracts provided for them to supply their own. This reduced the necessity for keeping complicated tool accounts and for dealing with recoveries for lost tools.

Light Railways.

Light railway track and trolley were largely used for transport of spoil and stone and the type adopted proved admirably suited to the purpose. This consisted of 16 lbs. rails and 18 cubic feet side tipping wagons. This weight of rail is strong enough to carry a considerable load; each section is light enough to be conveniently handled by two labourers and can be bent to form curves and straightened out again without difficulty. The 18 cubic feet trucks can be handled on a slope of 1 in 30 up by two labourers with a full load and when empty can be handled on the same gradient by one man.

Split cocoanut sleepers, to which rails were fastened by dog spikes, were used at first but, as the sleepers tended to split and the dog spikes to loosen, steel sleepers were substituted. These proved much more satisfactory except in very soft ground where they tended to sink but this
was remedied by packing either split coconuts, stumps or blocks of stone under them. These sleepers are fastened to the rails by means of clips and bolts and it is necessary to keep a large supply of the latter in stock to provide for replacements as the bolts and nuts tend to rust badly, become bent and break when uncoupled.

Light rail track can be laid out to deal with almost any duty for which it is likely to be called upon by using plenty of switches and lead lines at each end and double working in between. In practice the capacity is usually controlled by the area of the cutting face and tipping point and single line working is all that is necessary. For single line working passing places should be provided at intervals of about one-eighth mile; trucks being worked in groups of from three to ten and passing places made of sufficient length to accommodate the number of trucks being worked. In providing for crossings for ordinary working it is advisable to have at least four sets of switches for every 3/4 mile of track plus a few crossovers.

It was found that one labourer can push a trolley on the level for seven trips per day with a lead of 1/4 mile; for eight trips with a lead of half mile; and nine trips for a lead of 1/2 mile. Considerable time is usually wasted in the turn round with the result that long leads are relatively cheaper than short ones.

The cost of earthworks where trolley transport is used, can be split up into six main divisions:—
(a) Cutting—This varies according to the nature of the soil being dealt with and the height of the cutting face but a fair average is four cubes per labourer per day. (b) Loading into Trucks—This is usually carried out by women and varies with the lead from cutting face to truck but a fair average with a lead of say 15 feet is one to one and a half cube per day. (c) Transport—Figures for this have already been given for work on the level but these must be varied if the lead is up hill or down hill. Provided the gradient being worked on is not more than say 1 in 100 the difference will not be great but, where the gradient uphill exceeds that additional provision must be made for what may be termed “trace labourers,” i.e.,
extra men required to assist in pushing trucks up the gradients. As cuttings are usually above the levels of fillings the necessity does not often arise and the transport figures may usually be calculated for the level. (d) Tipping and Dressing Slopes—This is a variable which depends largely on the height of the bank but for a bank with average height say 6 feet about one labourer per twenty or thirty cubes tipped should be sufficient. (e) Contingent Items—This is for labourers required to extend the truck line ahead of the tipping as work progresses and for other minor works such as clearing stones or earth off adjoining roads and is naturally a variable. Three labourers are usually required for this work one of whom should be a fitter with a reasonable amount of intelligence. The cost of this depends directly on the sectional area of the bank but for banks of six feet high and twenty-six feet crest width costs worked out between five and ten cents per cube.

Costs.

It is easy enough to give average cost per mile by dividing the total cost by the length of road but this would be most misleading as the actual cost varied widely. The average cost worked out at Rs. 105,000.00 per mile. This can be divided up into two distinct parts namely where flood areas were crossed with heavy banking and bridging; and where high land and no floods occurred and little bridging was required. The former cost approximately Rs. 215,000.00 per mile against Rs. 72,000.00 per mile for the latter despite the fact that costs of acquisition for the latter were much higher than the former. Supervision costs, apart from charges met from the votes for Personal Emoluments, only amounted to 14% of the total expenditure and contingencies to 31%.

Progress.

Preliminary investigation was begun in 1924 but it was not till September, 1925 that all the necessary plans and estimates were ready and submitted for sanction. There was, unfortunately a delay of practically one year before these were passed by the then Legislative Council although
VIEW ON NEW ROAD NEAR 13½ MILE POST.

VIEW ON NEW ROAD SHOWING WIDTH.
PUSWELI OYA BRIDGE SHOWING ROADWAY.

30 FEET SPAN BRIDGE 24 FEET ROADWAY OVER KELANI VALLEY RAILWAY.
PUSWELI OYA BRIDGE. 120 FEET SPAN.

WAK OYA BRIDGE AT 19½ MILE SHOWING OLD AND NEW BRIDGES.
votes on account made it possible to proceed slowly with a small section of the work. As soon as the estimates were passed the necessary proceedings were put in hand for the acquisition of land. This is always a slow proceeding and, although the Government Agent and Surveyor-General made every effort to push it on, it was not till well into 1928 that it was completed and land handed over to the Public Works Department. This, necessarily, prevented work being put into full swing for some time.

Sections of the road at both ends were opened to traffic in 1929 and 1930 as soon as they were ready and further sections were made available to the public as completed till the whole road was opened to through traffic on 19th March, 1932. Progress had to be slowed down in 1930 due to the financial stringency. Had this not been necessary the road would probably have been opened about the end of September, 1931.

By the courtesy of the Associated News Papers of Ceylon some photos of the new road are attached to this paper and a diagramatic map of the area is also given for the information of members. These photos show various views along the finished road and serve to illustrate the width, and freedom from sharp curves and other obstacles to fast travel.