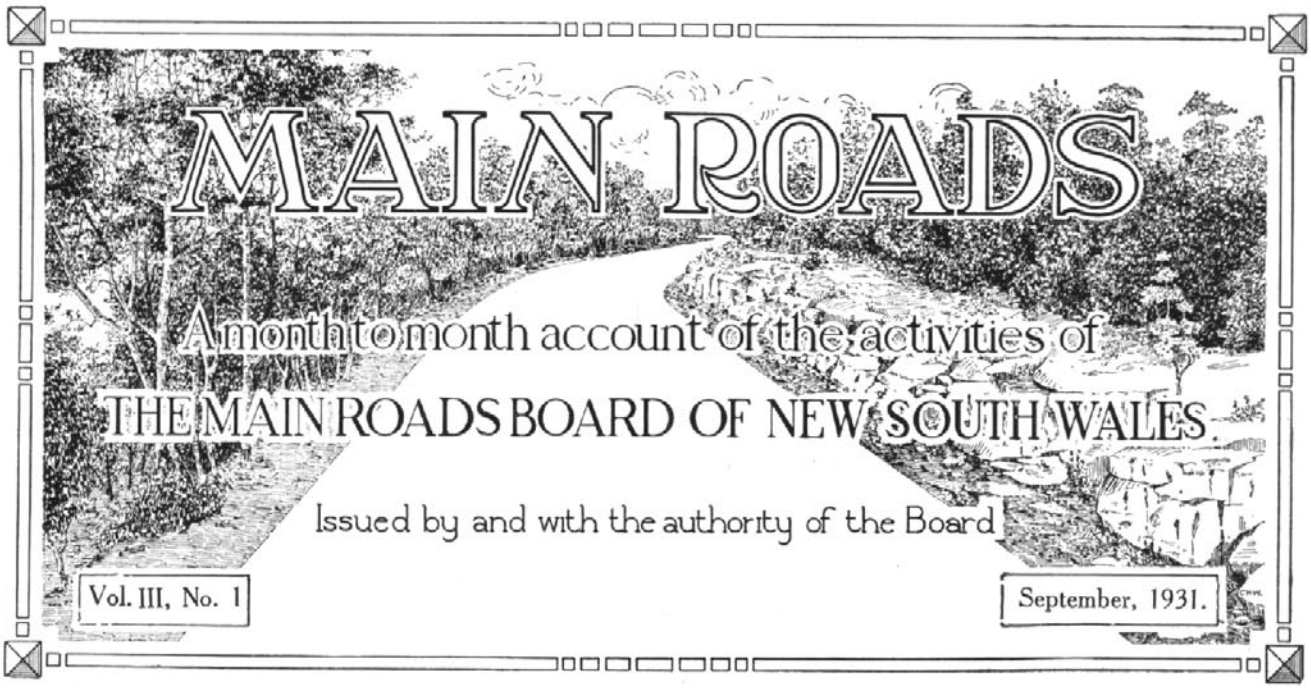


Maintenance and Minor Improvement Works for the Year 1931-32.

IN the last issue of *Main Roads*, under the heading of "Prospects for 1931-32," estimates were given of the anticipated income for the year (apart from Federal Aid Road funds, payment of which has been suspended by the Commonwealth since 1st April, 1931), and sums of £189,000 and £666,000 were set down as the amounts allocated to the maintenance and minor improvement of county of Cumberland and country main roads respectively. It is thought that some analysis of the manner in which these sums are made up will be of interest.

The broad details, so far as concern metropolitan main and secondary roads, are shown in the table opposite.

It will be seen from this that the funds available fall short of requirements for maintenance alone by £55,907, or 23 per cent., which could be met if payment of Federal Aid Road moneys were resumed, and, say, one-quarter (which is the proportion of the State motor taxation paid to the county of Cumberland Main Roads Fund) used for county of Cumberland main and secondary roads.

In the country there are three classes of main road —State highways (on which the Board pays full cost), trunk roads (on which the Board pays two-thirds of the cost and the Councils the remaining one-third) and ordinary main roads (on which the Board and the Councils share equally). Prior to 1st May, 1931, the rate of assistance on the last class of road was 30s. by the Board for each £ by the Councils, but owing to diminishing revenues this could not be sustained and was reduced to £ for £ from the date mentioned. This system of road classification and assistance has operated since 1st July, 1928 (except for the variation in respect of ordinary main roads just mentioned). A comparison of maintenance and minor improvement expenditure on State highways and main and trunk

County of Cumberland Main and Secondary Roads.

	Estimated requirements.	Allocation.	Percentage of allocation to estimated requirements.
	£	£	Per cent.
Main Roads	190,234	139,000	73
Secondary Roads	13,893	5,000*	72
Operation and maintenance of major bridges and ferries (excluding Hawkesbury River Ferry)	23,780	15,250	64
Operation, maintenance and collection of tolls, Hawkesbury River Ferry ...	15,000	15,000†	100
Remaining for later allocation...	...	14,750	.....
Totals	£242,907	£189,000	77

* Board's half share only.

† Whole cost, exclusive of any deduction on account of tolls collected. For purposes of convenience in accounting, the whole of the anticipated receipts from tolls, estimated at £13,750, have been included in the estimated revenues of the county of Cumberland Main Roads Fund, and at the end of the year any surplus or deficiency between revenue earned and expenses will be adjusted equally between the two main road funds.

*71300

roads for the last three years, together with the forecast for the present year, will therefore indicate the relative demands which each group makes on the Country Main Roads Fund. This is as follows:—

Although, as indicated above, the average cost to the Country Main Roads Fund of maintaining the main roads of the State has amounted to £860,000 for the past three years, the expenditure for 1930-31 and 1931-32 has been curtailed to £666,000 and £606,000 respectively. These amounts are, in the Board's opinion, less than the normal sum which should be devoted to the purpose and a deterioration in the condition of the road surfaces is taking place and will continue until further funds can be allocated. It is for this reason that the Board (as indicated in its fifth annual report) welcomed the amendment of the Federal Aid Roads Agreement, which is now before the Federal Parliament, permitting the use of Federal Aid Road moneys for maintenance. The annual cash requirement for the maintenance of the country main roads is, under present conditions, in the vicinity of £850,000, as compared with £606,000 which the Board is at present able to provide for this year. The difference between these two amounts is approximately three-fourths of this State's share (estimated at £340,000) of the funds that will be made available under the new agreement, which proportion is also approximately the proportion of the State motor taxation paid annually to the Country Main Roads Fund.

Country Main Roads.

	Mileage of Roads.*	1928–29.		1929–30.		1930–31.		1931–32.	
		Expenditure.	Per cent. of Total.	Expenditure.	Per cent. of Total.	Expenditure. †	Per cent. of Total.	Expenditure. ‡	Per cent. of Total.
		£		£		£		£	
State Highways	3,451	526,850	63	631,401	59	397,412	60	31,500	52
Trunk roads and ordinary main roads	2,298 7,506	311,068	37	443,460	41	269,168	40	291,000	48
	13,255	837,918	100	1,074,861	100	666,580	100	606,000	100

* The figures given apply to the position at 30th June, 1930, but the variations throughout the whole period dealt with in the table have been slight.
† Subject to finalisation and audit of accounts.
‡ Estimated.

The expenditure on State highways includes a small amount of expenditure on bridges and ferries which were previously national works, and are situated on main or trunk roads. The Board bears the full cost of maintaining these.

It will be seen that for the past three years the division of expenditure has been fairly uniformly in the proportion of three-fifths to State highways and two-fifths to main and trunk roads. In order to obtain the proper weight of relationship, however, between the classes of roads, it is necessary to take into consideration the Council's contributions to the maintenance of trunk and main roads, as follows:—

Class of Road.	Average Annual Expenditure. 1928/29-1930/31.		Percentage of Total.
	£	£	
State Highways...	.....	518,554	48·63
Main and Trunk Roads—			
Contribution by Board ...	341,232		
Contribution by Councils...	206,526	547,758	51·37
Totals ... £	.....	1,066,312	100

It will be thus seen that slightly more than one-half of the total expenditure for maintenance by both Councils and Board has been made on the trunk and ordinary main roads and slightly less than one-half on the State highways.

The departure for the present year from the subdivision of the total maintenance funds available which has applied in previous years among the three classes of road is due to the suspension of payment of Federal Aid moneys and the necessity of replacing a number of bridges in extreme need, for which the sum of £90,000 has been set aside. It will be noted, however, that this has been done at the expense of State highway maintenance, which it is hoped to adjust when the payment of Federal Aid Road moneys is resumed.

Northern Approach, Sydney Harbour Bridge.

THE demolition of the last of the buildings on the properties resumed for the new road, 100 feet wide, from the northern end of the Harbour Bridge approaches to Miller-street, at the North Sydney Post Office, is in hand, and excavation for the new roadway has been commenced. The maximum grade of the new work will be 6.80 per cent. (1 in 14.7), which is the best obtainable, and less steep than the existing routes via Mount or Blue streets. The excavation involves the removal of over 20,000 cubic yards of material, of which the greater portion is sandstone. It is anticipated that all work will be completed in time to coincide with the opening of the bridge on 19th March, 1932.

News of the Month.

Metropolitan Division.

As the result of over-stressing by heavy wheel-loads, a number of steel buckled plates in the deck of Fig Tree Bridge over the Lane Cove River, in the Municipality of Hunter's Hill, have failed, and are being replaced by new plates, measuring 4 ft. 7 in. x 5 ft. x ⅜ in., with a 3 in. buckle, obtained from Walsh Island Dockyard. The plates are being electrically welded in place under contract by Mr. A. E. Goodwin, of Lidcombe. The tar macadam pavement is being removed and replaced by the divisional maintenance branch.

Council on behalf of the Board. The old pavement was reconditioned to form a base, and surfaced with a 2-inch penetration wearing course for a length of 1,900 feet. The work has greatly improved this length of the Highway.

Wingecarribee Shire Council, on behalf of the Board, is scarifying, reshaping, rolling, and adding gravel to the Hume Highway between Berrima and the Cross Roads.

The bridge over Tullian Creek, on the Prince's Highway, north of Bomaderry, is being reconditioned by the

The former high brick parapets on this bridge over the railway at Glencoe, on the Great Northern Highway south of Glen Innes, have recently been replaced by chain wire mesh fencing in order to improve visibility.

The periodical docking and overhaul of the motor ferry vessel "Frances Peat" has recently been carried out by Mort's Dock and Engineering Company, Ltd., at the company's pontoon dock ("Chapman's"), Balmain. As the vessel is only twelve months old, the work was not of an extensive character, occupying in all five working days.

Outer Metropolitan Division.

The reconditioning of the Bathurst-Ilford trunk road (No. 54) has recently been completed by the Turon Shire Council, and the surface is in excellent condition throughout. On the Bathurst-O'Connell-Oberon road (No. 256), also, the surface has been much improved. At Lee's Creek, on the latter road, south-east of Kelso, where in the past traffic has been held up at times of heavy rain, good progress is being made with the construction of a two-cell 8 feet x 3 feet reinforced concrete culvert. Contractors Fletcher and Clark have been delayed by wet weather.

The pavement on the Hume Highway through Berrima has been reconditioned by the Nattai Shire

divisional maintenance forces. It was recently necessary to place temporary supports under the girders of this bridge and restrict the loading. The existing concrete abutments are in good order, and the deck is being widened from 15 feet to 16 feet, a greater width not being obtainable except at heavy expense.

Upper Northern Division.

Ballina Municipal Council has repaired the bridge over the North Canal, on the Pacific Highway. The work included the renewal of ten girders, four corbels, four cross-bearers, portion of the decking and kerbs, and the repainting of the hand-rails.

Repairs to the three-span timber beam bridge over Straight Creek, on the Gwydir Highway, have been completed by the Nymobida Shire Council. The bridge was in very bad order, and the repairs included the renewal of five girders, six corbels, kerb and decking.

A length of 3,760 feet on the Pacific Highway, between 11 and 12 miles north of Ballina, has been reconditioned and surface treated by the Tintenbar Shire Council.

Contractors J. and V. McIlwan have completed the construction of 2 miles of water-bound macadam pavement on the Great Northern Highway, in the Shire of Tenterfield. This section connects up with the length of 2 miles recently constructed east of Old Koreelah.

Lower Northern Division.

Improvement of the Oxley Highway between Mullaley and Rocky Glen, in Coonabarabran Shire, has just been effected by the formation of 3½ miles of road in sandy country, at an average cost of £50 per mile. The work was done by two day labour gangs, each equipped with a caterpillar tractor and a scarifier grader and sharing a 6-ton tractor-drawn roller. The illustrations show the type of country dealt with and the finished formation, 24 feet wide, complete with table and catch drains. The photograph of the finished work was taken after heavy rain, and it will be noted that there is practically no rutting by traffic. With repeated grading, this formation will develop a very hard surface capable of carrying traffic in the wettest season. There are still some miles of this highway east of Coonabarabran which can be treated in this way, thus making a suitable road, without bringing any materials to the site, at only a nominal cost.

The Board is finding the cost of 20 feet of the pavement, the Council financing the balance of the work, and carrying out the construction by day labour.

Three important bridges over the Cudgegong River in Wyaldra Shire are at present under repair. The bridges at Belinafante (on the Mudgee-Gulgong trunk road (No. 55), south of Gulgong) and Guntawang (on the Gulgong-Wellington road (No. 233), west of Gulgong) were built twelve years ago, that at Yamble (further west on the latter road) being twenty years old. As a result of test borings it was found that, although the majority of the timbers were quite sound, one or two are now mere shells. These defective members are being replaced, and at the same time, Yamble bridge is being repainted.

Central Western Division.

On the Tullibigeal-Palisthan developmental road (No. 1,029) in Lachlan Shire, Contractor F. Broad has completed 4 miles 2,000 feet of new gravel road and two causeways, at an average cost of £740 per mile, and Contractor S. E. Priddis has completed 11 miles 700 feet of clearing, costing £66 per mile.

Owing to the withholding of payment of Federal Aid funds, it has been necessary to curtail the work being carried out by Messrs. Model Homes, Ltd.,

The Oxley Highway between Mullaley and Rocky Glen, in Coonabarabran Shire.

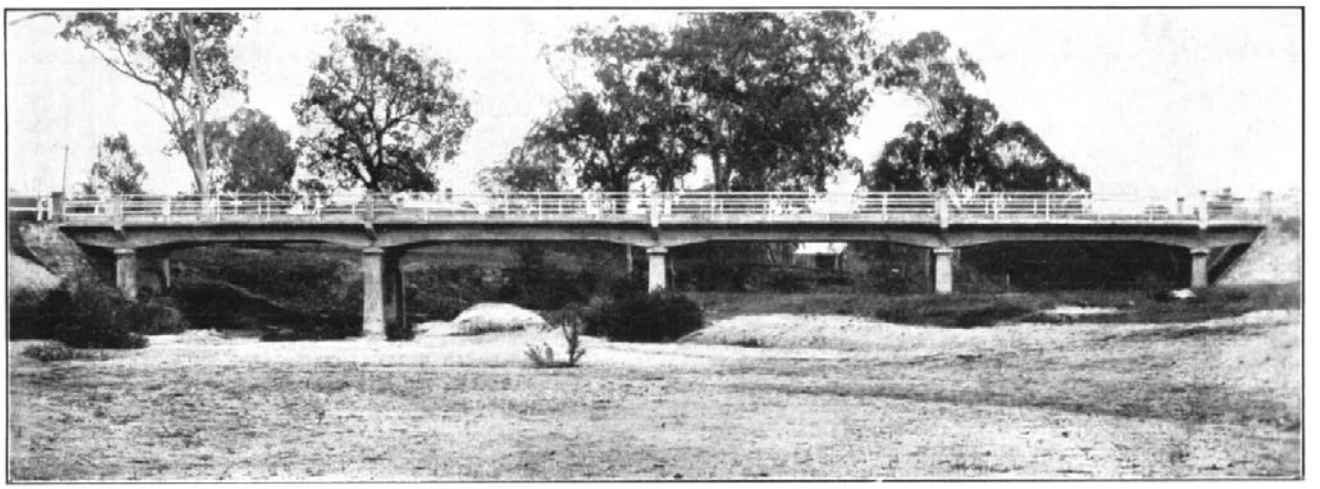
1. Typical view of track before improvement. 2. A sandy stretch, necessitating scooping excess sand to the sides before forming up the natural sand-clay beneath. 3. Finished graded and drained natural sand-clay road after heavy rain. This work cost £50 per mile.

Marius-street, Tamworth (Great Northern Highway), is 96 feet wide between kerbs, which is too wide for present traffic requirements and very costly to maintain. To reduce the area to be maintained, and to improve the appearance of the street, the Municipal Council has prepared a scheme for restricting the carriage-way to two one-way traffic lanes, each 20 feet wide, with a central garden plot between. Gaps will be left to enable vehicles to cross over from one traffic lane to the other. As a first stage in the work, the formation of the traffic lanes is now in progress. The pavement consists of a base course of soft shale, dressed with a wearing surface of hard river gravel, which will be sealed with bitumen. The garden plots will be formed later, as the Council's funds permit.

between Cowra and Holmwood, on the Mid-western Highway in Waugoola Shire. The length of tar penetration surface course under the original contract, 2 miles 40 feet, is being reduced by 2,358 feet, and gravel substituted in its place.

Southern Division.

Contractors Lane and Peters have completed approximately 4 miles of concrete pavement on the Hume Highway through Marulan, in the Shire of Mulwaree. This work has been hampered considerably by wet weather during the past few months, and 1 mile of pavement yet remains to be constructed to finish the contract.



Wylie's Creek bridge, Great Northern Highway, Shire of Tenterfield.

This bridge is one of those built in recent years to eliminate open crossings on the Highway north of Tenterfield. The superstructure is continuous, consisting of two central spans, each of 42 ft. 6 in.; two side spans, each of 37 ft. 6 in.; and two cantilevers, each of 10 ft.—a total length of 180 ft. The bridge cost £6,300, being built by the McLean Construction Company.

[Photograph by courtesy of Mr. W. K. McLean.]

Contractor De La Torre has completed the construction of 2 miles of new earth formation on the Kiah-Lower Towamba developmental road (No. 1,045), in the Shire of Imlay. This is the first section of a new road providing access to rich dairying country along the Towamba River.

The Jindabyne-Kosciusko road (No. 286), which is maintained by the Board, is in excellent order, and no difficulty has been experienced so far this year in keeping it clear of snow. The road above the hotel, however, is snow-covered and blocked to traffic.

Riverina Division.

Contractors White and Cross have constructed a length of 1 mile of gravel pavement on the Mid-western Highway near Marsden, in Bland Shire, commencing at the bridge over Bland or Yeo Yeo Creek and extending westerly. During the recent floods the road on both sides of the creek was submerged, and the new construction was under water for about two weeks, but other than the scouring of the shoulders near the bridge little damage was done.

On the Monaro Highway in Gundagai Shire a temporary crossing has been completed where the approach to Hillas Creek bridge, near Mount Adrah, was washed away. The construction of a low-level bridge on the Hume Highway over the same creek south of Gundagai is also in hand to take the place of the concrete bridge destroyed by flood waters on 11th June last.

The Board's maintenance organisation has restored the section of the Monaro Highway recently washed out by flood waters from Kyeamba Creek at Alfredtown, in Kyeamba Shire. The roadway has been reconstructed to its former level, and stone-pitched on the down-stream side of the embanked formation as a precaution against washouts in the future.

The contractors for the construction of a three-span concrete bridge over Burrangong Creek, in Short-street, Young, have abandoned their contract, and the work is being completed by the Board by direct labour. The portions so far completed comprise the concrete pile foundations, one pier, and parts of both abutments.

Expenditure for the Month of July, 1931.

	£	s.	d.
County of Cumberland Main Roads Fund—			
Construction of Roads and Bridges ...	1,131	11	8
Cost of Land Resumptions	3,966	3	8
Maintenance of Roads and Bridges ...	14,403	13	10
Repayment of Loans	3,885	8	1
Survey, Design, Supervision, and Administration	5,362	12	8
Miscellaneous	.....		
Total	28,749	9	11
Country Main Roads Fund—			
Construction of Roads and Bridges, including Resumptions	19,249	11	5
Maintenance of Roads and Bridges ...	57,017	7	2
Repayment of Loans	.....		
Survey, Design, Supervision, and Administration	4,089	13	2
Miscellaneous	211	3	3
Total	80,567	15	0
Federal Aid Roads Fund—			
Construction of Roads and Bridges, including Resumptions	16,523	10	9
Miscellaneous	6	10	0
Total	16,530	0	9
Developmental Roads Fund—			
Construction of Roads and Bridges ...	3,105	3	4
Survey, Design, Supervision, and Administration	84	6	9
Miscellaneous	.....		
Total	3,189	9	4
SUMMARY, ALL FUNDS.			
Construction of Roads and Bridges, including Resumptions	43,976	0	10
Maintenance of Roads and Bridges	71,421	1	0
Repayment of Loans	3,885	8	1
Survey, Design, Supervision, and Administration	9,536	11	10
Miscellaneous	217	13	3
Grand Total	129,036	15	0

Low Cost Road Construction in Namoi Shire.

By D. H. Sky, B.E., B.Sc.,

Shire Engineer.

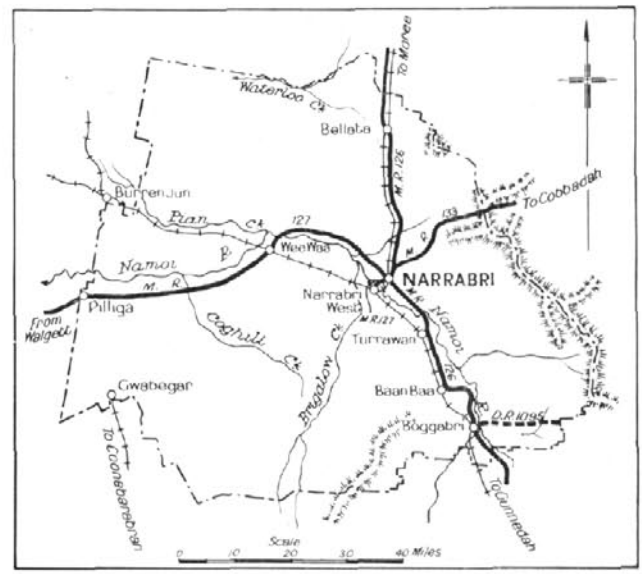
In the following articles Mr. Sky tells how, in one locality in Namoi Shire, serviceable sand-loam pavements are being constructed for less than £1,500 per mile by utilizing local materials in lieu of the gravel formerly imported from a distance and used for pavements costing approximately £2,500 per mile; and how, in a locality more favoured as regards materials, a gravel road was built for £925 per mile, largely by limiting the design to bare essentials. The first article, particularly, emphasises the outstanding characteristic of practically all recent work on country main roads, viz., the carefully considered use of low-grade, local materials to build all-weather pavements. This is in sharp contrast to the haphazard use of similar materials only a few years ago, and the mediocre results formerly obtained. In low-cost or, as is perhaps the better term, low-type work, individual initiative and ingenuity on the part of the local engineer undoubtedly contribute more to success that the set formulae represented by standard specifications: for this reason, the Board is always pleased to publish in *Main Roads* articles on work similar to the very creditable examples described below.—Editor.

Sand-loam Construction on the Narrabri–Wee Waa–Pilliga Road (No. 127).

THE Shire of Namoi embraces an area of about 3,282,000 acres, the greater portion of which, particularly to the north and west, consists of black soil plains or Pilliga scrub country; in either case, stone or gravel of any description are not available for road construction. Needless to say, these characteristics make the problem of all-weather road surfacing a difficult one here, and during the last two years special attempts have been made, happily with a good measure of success, to obtain from local materials a road surface which combines good running qualities in dry weather with an adequate degree of traffickability under wet conditions.

As an outstanding instance, the case may be cited of the main road which, commencing at Narrabri, runs via Wee Waa and Pilliga (where it crosses the shire boundary) to Walgett. This is an important road, that section from Wee Waa to Pilliga, on the south side of the Namoi River, being a vital link to the shire, as the Pilliga district is not directly served by railway. The first 11 miles from Wee Waa towards Pilliga traverse a belt of what is known as "gilgai" country, consisting of a grey-black clayey soil, covered with depressions ("gilgais"), which may be up to 30 feet in diameter, and 3-4 feet deep. In wet seasons these depressions hold water for months at a time, and as the soil when wet becomes sticky and treacherous, and with over an inch of rain will bog almost any wheeled vehicle, it can be well understood that this road enjoyed a reputation for many years as the worst main road in the north-west. After 11 miles of gilgai country, timbered with the dark and straggling brigalow scrub, the road passes into a cleaner, sandy type of country, for the most part traffickable in almost any weather without serious difficulty.

The construction of the first section (3 miles) of the impassable link west of Wee Waa was undertaken about five years ago, being financed by the Main Roads Board from Federal Aid funds. For this purpose ironstone gravel, obtained at Turrawan, 13 miles south of Narrabri, conveyed to Wee Waa, a distance of 34 miles, by rail, and then transported by road to the job, was used. By a subsequent grant, in 1928, the gravel construction was carried to a point 8 miles from Wee Waa. Owing, however, to the increasing distance of haulage of gravel from the railhead, the work was becoming unduly expensive, and in 1929 the Board, in conjunction with the council, raised the question of the possible use of more immediately local materials.

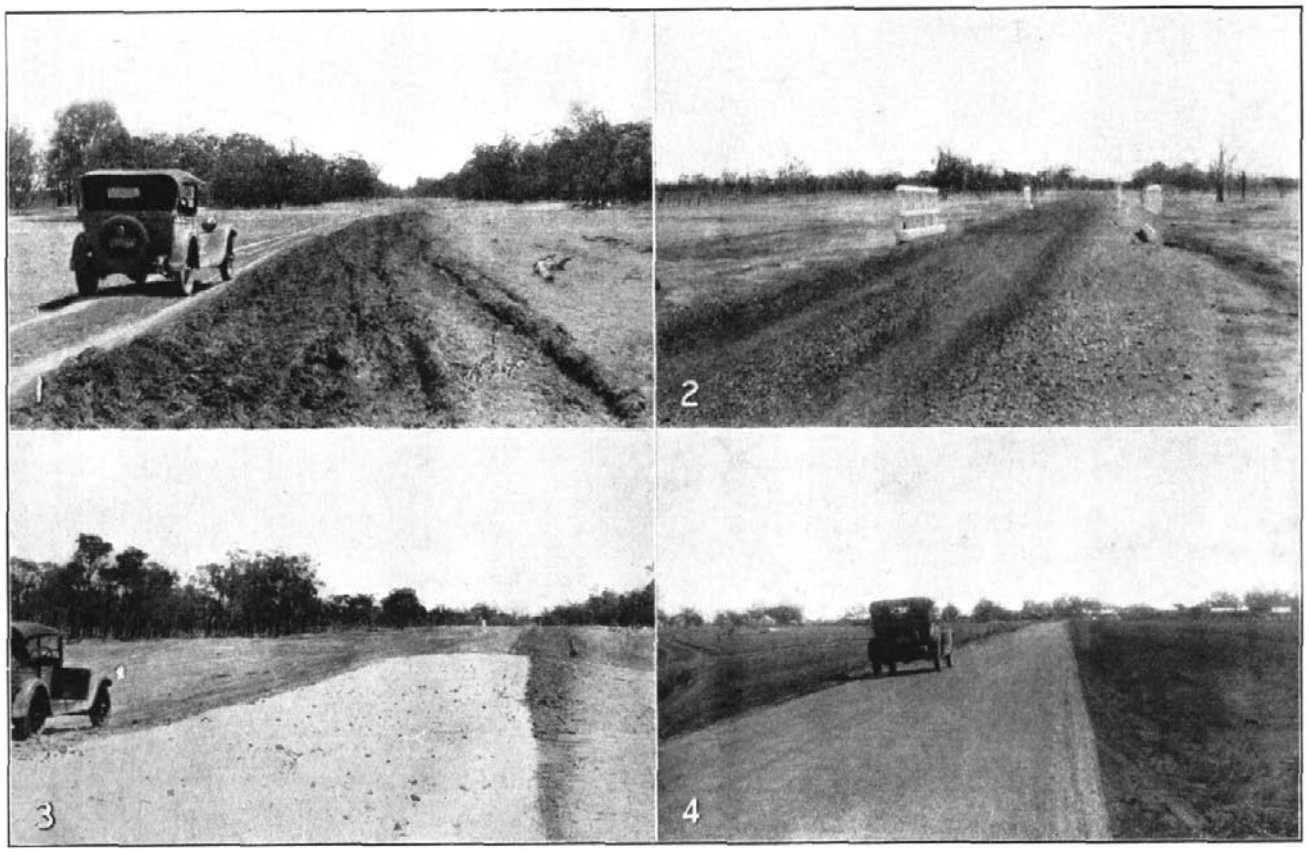


Map of Namoi Shire.

As already mentioned, no gravel or stone of any description was obtainable in the locality. At Wee Waa, however, there are extensive deposits of a hard loam, in colour a brilliant red, due to an admixture of iron oxide, and containing a fair proportion of quartz sand. This loam had been extensively used in the neighbourhood for many years, and provided a hard surface which never cut deeply or bogged, a fatal greasiness in wet weather alone limiting its usefulness. In 1929 this defect was completely overcome by the simple expedient of top-dressing the loam with a layer of clean sand 1½ inches thick, which was allowed to work in under traffic. This loam-sand combination has given really surprising results, producing a splendid running surface, either in wet or dry weather, non-slippery, and superior in some respects to gravel, as it shows practically no tendency to ravel or corrugate in dry weather. It has all the wearing qualities of gravel, and, once consolidated, requires a good deal less maintenance than the average gravel road.

A section of 5 miles of the same road, from Wee Waa towards Narrabri, is now treated with red loam and sand, and an interesting comparison can be made with the balance of the road towards Narrabri, which is surfaced with river gravel. The latter requires light treatment with a scarifier-grader about three times a year to keep it free from corrugation and potholing, notwithstanding the fact that the bulk of the dry-weather traffic follows the black soil sidetracks. The red loam-sand section had, until the recent floods to enable an experimental section of this type of surface, ¼ mile in length, to be carried out on the road west of Wee Waa.* This has been completed, and is now in process of consolidation by traffic, assisted by frequent grading. If successful, these materials will be used to complete the balance of projected construction on this road.

Many specifications for sand-clay or sand-loam roads provide for a thorough mixing of sand and loam by harrowing. This has been tried locally, but



1. The Wee Waa–Pilliga road before construction.
2. Typical ironstone gravel construction.
3. Red loam–sand road under construction, showing the sand freshly spread upon the loam, on the Wee Waa–Pilliga road.
4. A red loam–sand pavement on the Narrabri–Wee Waa road, after twelve months under traffic.

damaged some portions, carried traffic for more than twelve months without requiring any treatment whatever, and offered a surface so smooth that the traffic used the roadway at all times, the sidetracks formerly in use having disappeared.

The thickness of red loam originally laid down on this section was 3 inches, consolidated, and that of the sand topping about 1½ inches. Systematic maintenance is advisable when the sand is freshly applied, until the sand seal is thoroughly consolidated. On this stage being reached, maintenance can be practically dispensed with for a period of about two years, when a fresh coat of sand (about 1½ inches) should be applied. The loam seldom needs renewing, as it is virtually a base course, and receives very little of the actual wear.

Acting on information regarding the success of the loam-sand treatment above described, the Board last year made available a grant from Federal Aid funds has not met with the same measure of success as the process above described. For the local materials, such

*Samples of the loam and sand proposed for use in this work were tested in the Board's laboratory, with the following results—

Sand—Clean, well-graded quartz sand.

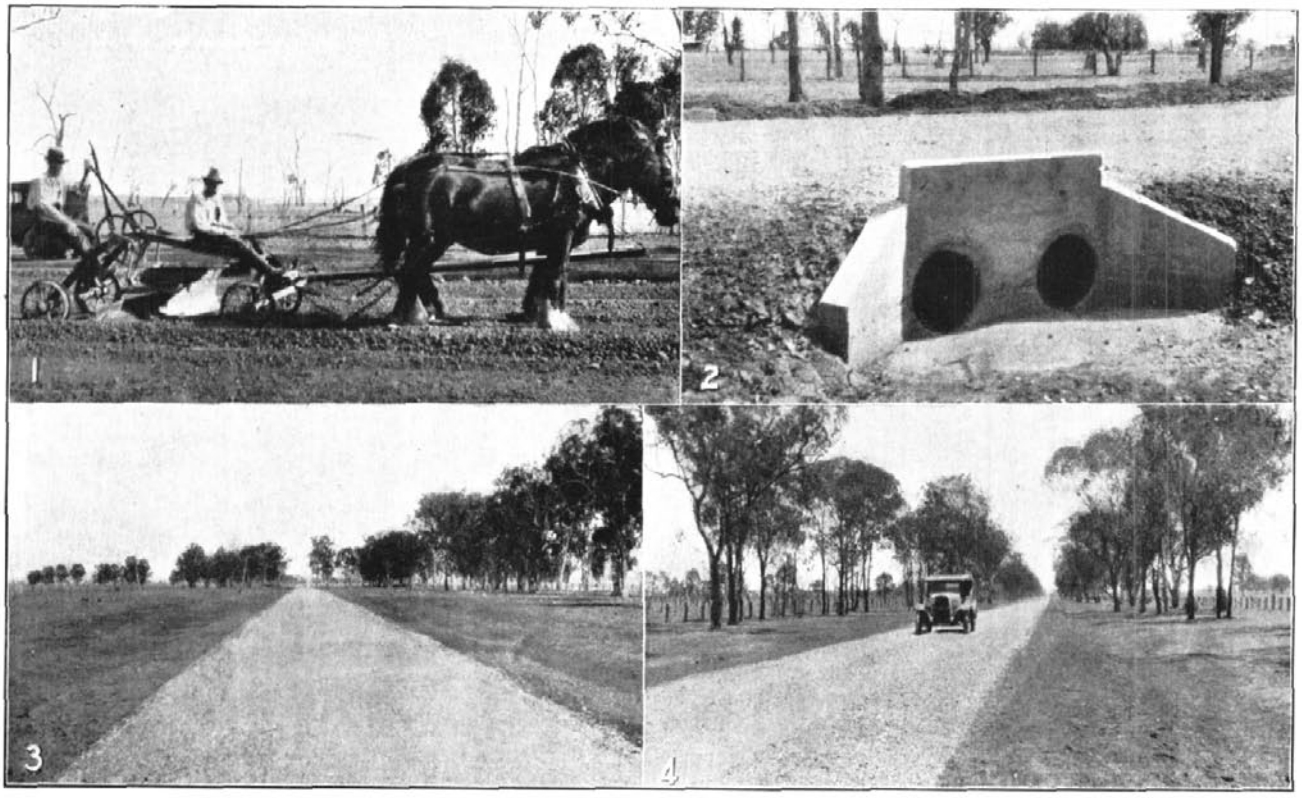
		Per cent.
Mechanical analysis.	Retained on 8 mesh sieve	1·2
,,	16 ,, ,,	9·4
,,	30 ,, ,,	41·3
,,	50 ,, ,,	42·7
,,	100 ,, ,,	5·3
Passing	100 ,, ,,	0·1

Loam—Dark red, colour due to iron oxide. Quartz sand 58 per cent.; silt and clay, 42 per cent.

Tests of Mixtures—Mixtures of the loam and sand were tested for strength in compression of consolidated specimens and shrinkage due to drying out of moistened specimens. The proportion of loam to sand giving the best results was 40 per cent. loam to 60 per cent. sand, *i.e.*, in the best mixture there was 17 per cent. silt and clay and 83 per cent. total sand.—EDITOR.

an admixture, in the writer's opinion, is not advisable. The pure loam provides an excellent base course, and the sand is considered merely as a seal, or surface skin, worked in possibly to a consolidated thickness of 1 inch, chiefly by the action of traffic. If harrowed in, the weather-proofing effect of the sand is largely lost, and nothing is gained. As the sand is usually the more expensive material, it is wise to conserve it by placing it where it has the maximum degree of usefulness, *i.e.*, on the surface.

It will be seen that the cost of the sand-loam treatment represents a very considerable saving on that of the original gravel, being only 56 per cent. of the latter. This saving, it must be admitted, has been slightly reduced in practice by the greater relative amount of grading and subsequent attention necessary to secure satisfactory consolidation of the sand-loam pavement. Rolling, in fact, particularly with a 10-12 ton roller, was found almost impracticable on account of the springy nature of the freshly-spread loam, and



1. Unemployment relief hands forming with baby grader on the Boggabri–Manilla developmental road.

2. A typical twin 18 in. diameter pipe culvert.
3 and 4. Views of the completed work.

The following figures give the cost, based on actual contract rates, of both the ironstone gravel and sand-loam types of construction, as carried out on the above road. Costs of incidental culverts and other waterways are, of course, not included.

Ironstone Gravel.

	Per 100 l.ft. £	s.	d.
Formation, Type A, total width, 84 ft.	8	0	0
Gravel pavement, 6½ in. consolidated thickness (24s. 6d. per cubic yd.) ...	39	6	5
Rolling subgrade and gravel	1	0	0
	£48	6	5

= £2,550 per mile.

Sand Loam.

	Per 100 l.f £	s.	d.
Formation, Type A, total width, 84 ft....	8	0	0
Red loam, 5 in. consolidated thickness, (12s. 6d. per cubic yd.)	15	8	9
Sand, 2 in. thickness (6s. per cubic yd.)	2	19	4
Rolling subgrade and loam	0	17	6
	£27	5	7

= £1,440 per mile.

consolidation was only secured eventually by continued grading over a period of several months. On the other hand, it may be stated that the cost of suitable loam (12s. 6d. per cubic yard) was practically a maximum in the case of the job quoted above, and there are many similar projected works in the locality for which the estimated cost of first-class loam would be as low as 4s. per cubic yard.

The test will be a thorough one, as this road carries a large amount of team traffic, hauling loads on iron tyres, chiefly of timber from the scrub, up to 10 tons in weight. However, it is believed that a 5-inch consolidated thickness of red loam, topped with 2 inches of the splendid quartz sand obtainable in large quantities in creek-beds in the scrub, will carry this traffic quite as effectively as the 6½-inch gravel pavement already constructed.

Unemployment Relief Work on the Boggabri–Manilla Developmental Road (No. 1095).

An important cross-country link in the southern portion of Namoi Shire is the road running from Boggabri easterly towards Manilla. The portion of this road within Mandowa Shire was proclaimed a developmental road several years ago, and, late in 1929, Namoi Shire was successful in having the proclamation extended to cover that portion, 18 miles in length, at the Boggabri end, within this Shire. The road serves, besides through traffic, a rich and extensive grazing and wheat-growing area centred on Boggabri, and had been previously constructed to a point about 8 miles from Boggabri, the remaining 10 miles being unformed, and mostly traversing black soil country, notoriously difficult for traffic in bad weather.

In July, 1930, a grant of £2,500 was made available from unemployment relief funds for construction on this road, and as it was advisable to extend the construction as far as possible, a type of construction as inexpensive as possible, consistent with the requirements of traffic was adopted. The existing cleared line was, in places, only 30 feet wide, and, principally to minimise clearing, as some heavy timber was involved, the overall width of formation adopted was 40 feet. The gravel pavement was built 14 feet wide and 6 inches thick, consolidated, with 4-feet shoulders. The gravel used was a fine material of very good quality, obtainable in an extinct creek-bed which crossed the road near the western end of the job.

A peculiarity of this gravel deposit was that the old creek-bed containing it is not now marked by any visible depression of the ground surface. The deposit varied in width from 15 to 30 feet, and averaged about 4 feet in depth. It is overlaid *in situ* by several inches of loamy material. The course of this narrow belt of excellent gravel can be traced for several miles, being discoverable only by test-holes. At the western end, where the gravel bed crosses the road, the haulage was short, but at the eastern end the lead from the nearest point of the bed was slightly over a mile.

The principal object of the grant being the relief of local unemployment, the work was carried out under conditions by which all registered unemployed in the Boggabri district were systematically employed for periods of a week at a time. During the greater part of the time, thirty-five men were employed, twenty of these providing horses and drays.

As it was desired to expend the largest possible proportion of the grant on wages, the use of power plant was eliminated, with the sole exception of a 30-cwt. truck which assisted the drays for a short time on the longer haulages. The formation was carried out by No. 69 ploughs, two buck scrapers, and a number of ¼ yard scoops, and finished off by two baby-graders, all horse-drawn. The gravel was spread in two courses, each being rolled to consolidation with a horse-drawn roller ballasted to 5 tons weight. The work included four concrete pipe culverts, each with concrete headwalls, the width of culverts, between headwalls, being 25 feet.

The length of road completed was 2 miles 3,740 feet. The cost—£925 per mile—is a low figure for work of this type in the locality, particularly in view of the fact that the men engaged were obtained from all classes of unemployed, for the most part inexperienced in the type of work, and, moreover, were liable to be replaced each week by a fresh and raw contingent, just when beginning to be really useful.

U.S.A. Practice in the Use of Aggregates for Low Cost Untreated Roads.

(Extracted from a Paper by C. N. Conner, presented to the American Society for Testing Materials, Vol. 29 of Proceedings.)

Practically all roadway surfaces contain two essential elements, aggregate and binder. Among the untreated types of surfacing, gravel is most commonly used as aggregate with clay as binder.

The quality of low-cost aggregates varies from soft and friable to hard and durable when local materials are used. Gradation is governed by several factors; two of the most important are ease of maintenance and stability under traffic.

Requirements for Aggregates.

When quality is determined by means of tests, such tests are for percentage of wear and toughness, although the toughness test is not as frequently specified as the wear test. Many specifications simply call for "hard, durable" material. Nearly all specifications require that aggregates shall be clean and free from "foreign" material.

The gradation requirements for aggregate are principally affected by the purpose for which they are to be used. If the material is intended for base construction, softer aggregates and larger sizes are sometimes permitted than for wearing courses; but surfaces which are maintained by machining and dragging are usually composed of durable aggregates whose maximum size is less than 1 inch.

Sand-clay.—This mixture for best results should contain sand composed of hard, durable grains, preferably angular in shape. Silt is usually present by tolerance. The clay should be sticky and non-slaking in character. The total sand content should be 65 to 80 per cent. of the total, silt not more than 15 per cent. and clay not more than 20 per cent. Sand in sizes above No. 10 sieve is particularly desirable.

Chert.—There are no standard tests for chert, but its suitability and durability are determined by usage. A typical specification in Georgia requires that all material pass a 1½-inch screen and at least 60 per cent. be retained on a No. 10 sieve.

Shale.—There are various classes of shale but those which have given best results under traffic in West Virginia contain more than 55 per cent. of silica and more than 4 per cent. of iron oxide. The maximum

(*Continued on page* 11.)

Depreciation Rates for Road Plant.

By F. W. Symons, B.E., A.M.I.E.Aust.
Assistant Engineer.

In the June, 1931, issue of *Main Roads* was published a general statement on the plant hire rates adopted by the Board in connection with road plant,* and of the principles which had been followed in fixing them. One of the most important matters in determining these rates is that of depreciation, *i.e.*, the allowance to be made for the gradual wearing out of the plant. This allowance may be:—

(i) Spread evenly over the useful life of the plant, *i.e.*, a uniform percentage of the original capital cost is deducted each year, or

(ii) fixed at a constant percentage, but calculated on the residual value of the plant at the end of each year of its useful life, or

(iii) taken as being the equivalent of the amount which, with interest, if set aside annually, would yield a sum sufficient to replace the item at the end of its useful life, or

(iv) arrived at by independent re-valuation at the end of each financial year, the difference between successive valuations being taken as the depreciation for the year.

The first is the simplest, and perhaps the most common method, and is that adopted by the Board.

The second method is more scientific than the first, particularly when applied to items which depreciate rapidly in the earlier years of their life, or are subject to obsolescence (*e.g.*, motor vehicles for which the market value falls sharply in the first year of use), as the amount of the depreciation charge under it is greater at the beginning and tapers to a minimum towards the end (being calculated on a continually diminishing amount). It also has the advantage of evening up the combined charges made in any year for depreciation and repair, as repairs usually increase with age. As, however, it is sufficient for road building authorities to show reasonably accurate values for assets on their books, it is not thought that its more scientific basis is sufficient to make it preferable to the simplicity of the first method. The percentage for use in calculation in this case is determined from the formula:—

$$r = 100\left\{1 - \left(\frac{V_2}{V_1}\right)^{\frac{1}{n}}\right\}$$

where r = percentage;
n = number of years of useful life of the plant;
V_1 = initial value of the plant;
V_2 = scrap value of the plant at end of n years.

The third method is based on the theory that the plant item will require to be replaced at the end of its life by a similar item at the original cost. The loss in value of the item is therefore compensated by, and may be taken as equalling, the amount of money which is accumulating in a reserve fund, at a fixed rate of interest. Under this method the amount written off the original value increases slightly each year because of the interest earned on the increasing amount available for investment. It is the method usually applicable to trading concerns, *e.g.*, electric light or gas works, where the asset values shown in the balance-sheet are important, and where it is desirable that adequate provision from gross profits shall be made for the replacement of capital items. It does not differ substantially in its results from the first method, as will be seen by reference to the diagram, and in view of the assumptions involved cannot be regarded as more accurate than the first.

The fourth method is probably the best to adopt in cases where a few items only are used, but it is usually found to be too expensive, and too much subject to delay where the items are numerous or their locations scattered.

A comparison of the first three methods may best be seen by reference to typical examples:—

(1) 30 H.P. Caterpillar Tractor.—Initial cost, £750; scrap value, £90 after three years' effective life.

Depreciation.

Year.	Method (1).	Method (2).	Method (3).
	£	£	£
1	220	380	207
2	220	187·4	220
3	220	92·6	233
	£660	£660·00	£660

(2) Heavy Steam Roller (10/12 ton).—Initial cost, £1,400; scrap value, £140 after nine years' effective life.

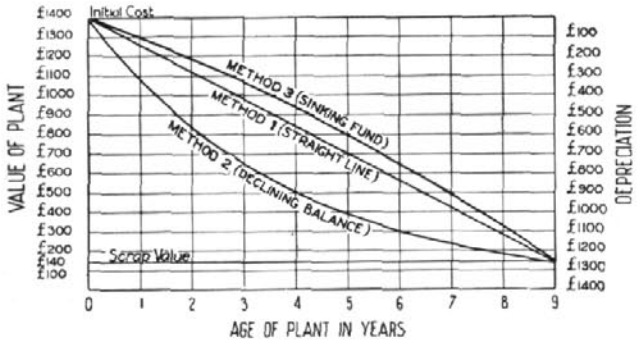
Depreciation.

Year.	Method (1).	Method (2).	Method (3).
	£	£	£
1	140	315·98	109·648
2	140	244·66	116·227
3	140	189·46	123·2005
4	140	146·68	130·5925
5	140	113·58	138·4281
6	140	87·94	146·7338
7	140	68·09	155·5379
8	140	52·73	164·87
9	140	40·88	174·7622
	£1,260	£1,260·00	£1,260·00

It will be noted that in the diagram, definite scrap values have been assumed. The scrap value of plant is, however, frequently ignored when calculating depreciation, the actual cash received from the sale of worn-out plant being treated as income when received, in those cases where the original cost has been wholly written off over a period of years. This is the Board's practice.

*See article *Plant Charges* by H. E. Roberts, *Main Roads*, June, 1931, p. 164.

The following table sets out the rates of depreciation for road plant as at present adopted by the Board. They are intended to be calculated annually on the original cost, and are based on the Board's experience to date of plant purchased by it and working a



Comparison of methods of computing plant depreciation.

normal week of from forty-four to forty-eight hours. As time proceeds, and items become worn out, it will be possible to determine even more precise rates.

Plant Depreciation Rates, 1931.

Item.	Rate.	Item.	Rate.
	Per cent.		Per cent.
Jacks, hydraulic ...	7½	Breaker, pavement ...	20
Monkeys, pile-driving		Excavators, power ...	
Tanks, compressed air		Graders, horse-drawn ...	
Weighing machines ...		Graders, power ...	
		Graders, scarifier ...	
Boilers, steam	10	Jackhammers	
Caravans		Tanks, bitumen spraying	
Drill, pavement testing		Tripod, cradle and casing for boring plants ...	
Governors			
Grubbers		Brooms, road	25
Pumps, diving ...		Chute, stone crusher ...	
Rater, road surface ...		Conveyors, belt ...	
Rollers, road, steam ...		Discs, road	
Welding outfits ...		Elevators, belt ...	
		Hoppers	
Engines	12½	Loaders, bucket ...	
		Maintainer, road ...	
Boats	15	Mixers, concrete ...	
Boring plant, hand ...		Mixing plant, hot ...	
Boring plant, jet ...		Pavers	
Boring plant, power ...		Plates, street, tractor ...	
Compressors, air ...		Plough, disc	
Cranes		Rippers	
Lighting set		Rooters	
Pile drivers		Saw, portable, power ...	
Pumping equipment, petrol		Screens, broken stone	
Pumping unit		Tipping gear, power, hot mixer ...	
Pumps		Tractors	
Punts (lighters) ...			
Spraying machine ...		Cars, motor	33⅓
Stone crushing plant ...		Cycles, motor	
Stone handling plant ...		Ditchers	
Turntable, motor truck		Drags, road	
Watercarts		Lorries, motor ...	
Winches		Scoops, buckscraper ...	
		Scoops, tractor ...	
Backfillers	20	Spreaders, chip ...	
Bin, steel			
Boilers, bitumen ...			

U.S.A. Practice in the Use of Aggregates for Low Cost Untreated Roads.

(*Continued from page 9.*)

size of particle allowed in that State is 3 inches. Under traffic and maintenance the larger pieces are broken down to much smaller sizes.

Disintegrated Granite.—The wearing quality of this material is furnished by the silica content which is more than 60 per cent. of the total. The bonding properties are furnished by the iron and calcium content, which form over 6 per cent. of the total. The material is commonly placed on the road in sizes up to 4 and 6 inches, but is broken down in size to less than half under maintenance, traffic, or rolling.

Gravel.—Surfacing gravel is usually specified as a "hard and durable" material. Clay in excess of 20 per cent. is not usually tolerated. Ten to 15 per cent. total of clay and loam is considered better practice as binder material, but non-slaking binders such as iron oxide and limestone are preferred. In California 50 per cent. of the gravel must consist of crushed particles, because of the greater stability of crushed aggregate under traffic. Experience generally has shown that best results are obtained when the aggregate passes a 1-inch screen, and where a high percentage, 35 or more, is retained on a No. 10 sieve.

Gravel, Slag, and Stone for Traffic-bound Surfaces.—The quality requirements for gravel, slag, and stone for traffic-bound surfaces are usually high; that is, the particles must be hard and durable. As specified they are equal to those used for water-bound and penetration macadam, or highest quality gravel roads. Screenings when used are produced from hard rock. In gradation, best results are effected when all material passes a ⅞ or ¾ inch screen. Practice varies as to the lower limits. Ohio practice for the fine material permits about 10 per cent. through a No. 10 sieve; Tennessee uses all stone through a 1½-inch screen, including dust of fracture.

Stone for Macadam.—For base courses of macadam, softer aggregates are tolerated than for wearing courses. For example, in Ohio the maximum allowable percentage of wear may be as high as 10 or 12 per cent. for limestones, 15 or 20 per cent. for slag and 25 per cent. for sandstone. In such cases the gradation calls for larger size particles; all passing a 5½-inch and retained on a 2½-inch screen for the coarse stone.

The top course is usually composed of harder stone, but if a bituminous surface treatment or bituminous surface course is to cover the top course, soft stone is sometimes permitted. Usually the top course is stone having a percentage of wear of not more than 5 or 6. The gradation of the coarse stone for this surface is between a 4-inch and 2½-inch screen in Ohio and between a 2½-inch and 1¼-inch screen in Massachusetts, thus showing considerable variance in practice.

Lime Rock, Marl, and Caliche.—These materials are soft—in fact, so soft that wear tests are meaningless. They consist principally of carbonate of lime.

(*Concluded on page 16.*)

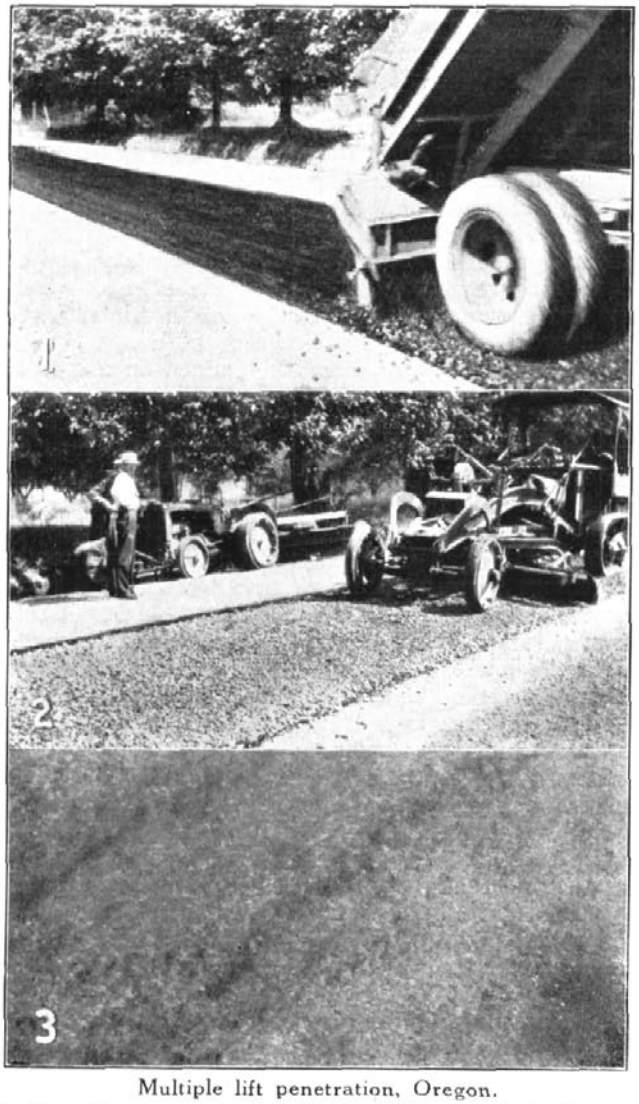
Highway Work in the United States.

By H. M. Sherrard, M.C.E., Assoc. M.Inst. C.E.

Assistant Chief Engineer.

(*Continued from page 197, August, 1931.*)

Multiple Lift Penetration, Oregon.—This is another type of asphaltic macadam with a machine-finished surface. It consists of several layers of stone, each of which is sprayed and bladed. A single layer, with surface treatment, which is the lightest surface built of this type, is constructed as follows:—



Multiple lift penetration, Oregon.

1. Spreading aggregate for the first lift upon the tack coat.
2. Blading and smoothing the first lift.
3. The finished work under traffic.

If the base is already oil-surfaced, any depressions are first filled by the penetration method and consolidated. If the base has not been previously surface-treated it is thoroughly smoothed and consolidated by blading, dragging, and watering. It is then given a "tack" coat at the rate of about 0.12 gallons per square yard.

Rock (1½ inch to ¾ inch) is then spread to a thickness of 1 inch, and smoothed by blading and dragging, any deficiencies or excesses of material being remedied by hand. It is then rolled until there are no surface irregularities of more than ¼ inch in 10 feet. Asphalt (95 per cent. asphaltic oil or 200 pen. asphalt) is then applied at the rate of 1/3rd gallon per square yard, covered with ¾ inch to ½ inch key rock, and wire-broomed and rolled.

For the double seal coat, the first application is 1/5th gallon per square yard, upon which ½ inch to ⅛ inch screenings are applied, swept, and rolled. After traffic for a week, a second application is made at the rate of 1/6th gallon per square yard, and again covered with screenings, swept, and rolled.

For a thicker course, 2½-inch rock would be used, or a succession of up to three layers of appropriately sized stone, topped with a double seal coat. The types most commonly used are that just described in detail, and a two-layer course with a first layer of 2-inch to 1½-inch stone, and a second layer of 1½-inch to ¾-inch stone. The cost is from £650 per mile for a 1½-inch top, 18 feet wide, to £1,200 per mile for a 2½-inch top, 18 feet wide.

An example consisting of a 4-inch thick stone base and a 2-inch surface course, carrying heavy tourist traffic near Mount Hood, cost £1,500 per mile. Although 3 years old, it was in excellent order. It had a rough-textured surface and had not reached the stage of requiring a reseal.

Penolithic Pavement, Warren Bros.—The only difference between this and ordinary asphalt penetration macadam is that, after spreading, the stone is well rolled and then sprayed with a non-volatile oil. For penetration, an asphalt of a harder grade than is customary is used. After penetrating, pre-oiled keystone is applied, and the procedure is then the same (*i.e.*, rolling and sealing) as for ordinary penetration work. It is claimed that oiling the stone enables thorough coating of the stone by the asphalt, and allows of the use of a harder asphalt. A somewhat similar process is in use in Germany.

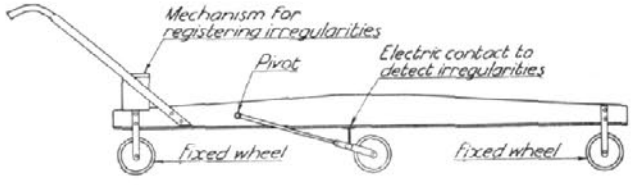
Mixed Macadam, Ontario.—This is similar to the premixed macadam constructed in New South Wales; both originate in English practice. Very little of this type has been constructed in the United States, and none was seen. The aggregate is crushed stone, graded as follows:—

Passing 2-in., retained on 1 in. screen	...	10 to 35 per cent.
,, 1 in., ,, ¼ in. ,,	...	30 to 50 ,,
,, ¼ in.	...	15 to 30 ,,
Asphalt (70 to 100 Penetration)	...	4 to 6 ,,

The proportions of the three sizes are varied to obtain maximum density. The asphalt is measured by

weight. Payment is made per ton of mixed material, and once a plant is on the job, work proceeds at the rate of about 1 mile per week.

The mixed material is usually spread through spreader boxes, the trucks backing up from a turntable. Two boxes are used, one on either side of the road, and one about 100 feet ahead of the other. By this means, traffic is permitted to pass continuously, which is regarded as one of the chief advantages of this method of construction. An 8-inch x 4-inch timber on the flat is often spiked along the edges to form a rigid shoulder for spreading and rolling. One 10-ton roller is used for each 150 tons of material rolled per day. The wheels of the roller are kept moistened with water or oil. After rolling, the surface must be true to ¼inch in 10 feet. Immediately after initial rolling, ¾-inch screenings are spread. After final rolling, a light seal coat of asphaltic oil or light tar is given. Sometimes the work is built in two layers; in one case two 4-inch thick layers were seen.



The "bumpometer" used for measuring the surface accuracy of pavements.

Immersion Process, Indiana.—Contractor MacConachie, of Indianapolis, has developed a process whereby broken stone is dropped into a tank containing quick-breaking emulsified asphalt, and drawn out by a conveyor with perforated buckets. While the stone is entirely covered with asphalt, the covering is a very thin one, resulting in stability of road surface and economy in cost. The emulsifying is done on the spot by a small portable plant devised by the same contractor, who is selling the mixed material at 22s. per ton, and is constructing surfaces 2 inches thick on existing gravel bases, including preparation of base, rebuilding ditches, &c., for £1,200 per mile, 18 feet wide.

In paying for work of this nature (which, as in most cases in U.S.A., is on a schedule of rates basis), the State Highway Commission allows water up to 52 per cent. to be used in the emulsion, but does not allow payment for water in excess of 25 per cent.

Asphaltic Premixed Surfacings (other than Macadam).—Advances have been made in construction, although there is little development of new types. Sheet asphalt, 1½ inches thick, laid on a binder course of asphaltic concrete, 1½ inches thick, over a base of 1 : 3 : 6 cement concrete is, perhaps, the most common type near cities; while asphaltic concrete, 2 inches thick, usually on a cement concrete base, sometimes on black base, and Kentucky rock asphalt both have fairly extended use on the more heavily trafficked routes in the eastern States. The Warren pavement also has fairly wide use. Patented cold mixtures have also a fairly extensive use. All types are used for surfacing old concrete pavements, frequently in conjunction with the construction of cement concrete edge strips. Asphaltic premixed surfaces carry the heaviest possible traffic.

Non-skid Surfaces.—Ordinary asphaltic surfaces soon become "polished" under the effect of traffic, and greasy roads resulting from light rain and the effect of oil drippings, or roads slippery with ice, are dangerous. In all asphaltic road construction in the United States to-day, and especially with surfaces of sheet asphalt, asphaltic concrete, &c., special attention is given to dealing with this condition.

In Oregon, practically all existing asphaltic premixed surfaces have been given a non-skid top. The existing surface has been lightly sprayed (say, 1/12th gallon per square yard) with 95 per cent. oil and clean 1-inch to ½-inch screenings are then spread, bladed, and rolled in. Three-quarter inch screenings are too fine for this work. This is usually followed by a second slightly heavier spraying (say, 1/6th gallon per square yard) and the light application of fine screenings, smoothing, and rolling. For fairly new surfaces, 95 per cent. oil has too great a softening effect, and a medium penetration asphalt is used. In new construction, premixed screenings are rolled in while the asphaltic concrete is still warm. The cost of the non-skid top on an existing pavement is 5d. per square yard.

In some cases a heavier coating is given by first applying 1¼-inch to 1-inch screenings, then spraying again and applying ½-inch screenings to partly fill the voids. This treatment is quite similar to a light layer of multiple lift macadam. In South Carolina, a similar result has been obtained by spraying the existing surface with kerosene at the rate of about 1/5th gallon per square yard, and then spreading and rolling the screenings.

Patented Cold Mixtures.—In one of these (Amiesite) fine graded crushed stone is dried and coated with a material such as kerosene, and then mixed with hot asphalt. It can then be shipped a long distance without setting hard. It is usually provided in two gradings, and the finer is placed in a layer on the coarser, to a total finished thickness of 2-inch or 2½-inch, *e.g.*, a 1½-inch to 2-inch layer of 1-inch stone, on which is placed a ½-inch to ¾-inch layer of ½-inch stone. Amiesite is most suitably used for small jobs where it would be uneconomical to set up a hot-mixing plant, and for patching.

Another patented process (Colprovia) consists in using a very hard asphalt, which is pulverised and then combined with a mixture of ordinary sheet asphalt aggregates and a flux. It is shipped, handled, and laid cold.

Design of Asphaltic Mixtures.—Perhaps the most important new factor bearing on the design of asphaltic mixtures is the design of machines for testing the stability of trial mixtures, or of samples taken from pavements being laid, and of samples cut from existing pavements. The displacement of the material under pressure is measured and tests show that the old method of design based on certain grading limitations is not entirely satisfactory. Such factors as the appropriate amount of filler for maximum stability can be

studied by a series of tests on the stability machine. One important deduction made from tests already carried out is that 1 per cent. variation in the amount of asphalt used has five times the effect of a change of ten in the value of the peneration of the asphalt.

Other tests have disclosed—

(1) that a stability value for sheet asphalt of at least 2,000 lb. is required for heavy traffic;
(2) that variations in ordinarily acceptable sands may result in large differences in stability values ;
(3) that ordinarily acceptable fillers may give divergent results;
(4) A small variation in the amount of filler, or asphalt content, may cause a big difference of stability.

The design of asphaltic mixtures has heretofore been largely determined by previous experience, aided by the stain test, but, using stability testing machines, the best possible mixture from available local materials may be obtained by trial and error testing. An entirely logical method of design for asphaltic mixtures, as for portland cement mixtures, has yet to be devised.

Construction Methods.—Mixtures are usually spread through spreader boxes and rolled by a 10-ton three-wheel roller, followed by a lighter tandem roller for cross-rolling and final smoothing. Mechanical spreading and raking is generally used in the western states, and is spreading rapidly throughout the United States. It gives economy and greater speed in construction and smoother riding surfaces. Machines enable normal outputs of 600 tons per day to be placed—at least twice what could be obtained by hand methods.

Waving and Corrugations.—In Oakland, California, and Honolulu, T.H., corrugations in asphalt pavements were seen undergoing removal by scarifier-grader outfits.

Cement Concrete.—Cement concrete pavements may be seen in every State of the American Union, varying from old and broken thin-edged jointless sections to heavily-constructed modern designs provided with longitudinal joint, transverse contraction joints and transverse expansion joints. Practice is far from stable. Some new pavements were seen without any joints or steel, in others the design aimed at providing against all contingencies, with consequent elaboration. Most states use thickened-edge slabs, but a number use slabs of uniform thickness. The underlying consideration is whether it is cheaper to provide against a possible form of failure, or to ignore it until it occurs.

The most valuable innovation which came under notice was the raised-edge cross-section used in Minnesota and Iowa. This discourages traffic from driving out on to the shoulders, one of the main causes of maintenance cost in hard-surfaced pavements, while at the same time it definitely encourages traffic to drive near the edge of the pavement, thus making the full width of the pavement effective for passing vehicles. A third advantage, and that originally sought for is to keep drainage on the pavement, preventing softening and scour of the shoulders and drains in friable soil.

In nearly all cases, proportioning is by weight. This is insisted on by the Bureau of Public Roads on all Federal Aid works. When it is realised that moist sand may bulk some 25 per cent., it will be seen how necessary this is. Inundation of sand has been generally discarded, as lacking the simplicity of weighing.

While various methods of curing have been tried out, *e.g.*, sprinkling with calcium chloride, spraying with asphaltic material (the Hunt process), the consensus of opinion, borne out by at least three series of tests, is that wet earth is the best curing agent. Extensive test slabs were seen at the laboratories of the Bureau of Public Roads, and the Iowa State Highway Commission. Wet earth and building paper on the slab are allowed as alternatives in California. Calcium chloride curing was seen in progress in Rhode Island. Sodium silicate is allowed as an alternative in some cases. Some New York State concrete highways have been sprayed with asphaltic emulsion after construction, to remove the glare. The effect is not lasting, but oil droppings automatically replace it in time. Silicate of soda appears to be used for hardening the surface of concrete slabs in one or two States only.

In some States, very old pavements are still in use, although they are being re-surfaced as funds permit, usually by widening with cement concrete side portions, any depressions or steep cross fall on the old slab, or necessary super-elevation, being made up with coarse-graded asphaltic concrete, and then, sometimes after applying a tack coat, surfacing with asphaltic concrete. A road undergoing this treatment near Medford, Oregon, was 5½ : 6½ : 5½ section, 16 feet wide, and, although fifteen years old, was carrying 1,500 vehicles per day. Another road nearly of about the same age and carrying the same traffic was of 4½ : 5½ : 4½ cross-section but was still not excessively rough, although considerably cracked and patched. When old slabs are surfaced with concrete, it is the practice in California to lay first a 1½-inch cushion of sand as an insulation on the old slab.

In New York State, the severe frost action in some of the higher parts restricts the life of concrete pavements to five to six years. In many cases, the old slabs have been widened with penetration side strips, and re-surfaced with re-tread. In Pennsylvania, near Gettysburg, test sections of Amiesite and of Tarvialithic (premixed tar and slag) have been placed over old slabs. Flaking of the surface is another result of frost action in both New York State and Pennsylvania. In New York State some affected surfaces had been tar-surfaced to preserve them. Tar surface treatments three years old and still in good condition were seen in Pennsylvania.

Cement-grouted pavements were constructed in the United States under the Hassam patent—similar to the Sunderland process—but none are being built now. Hassam pavements, fifteen to eighteen years old, in suburban streets in Portland, Oregon, were seen successfully carrying light traffic, although rough and cracked.

Surfaces are required to be correct, usually, to ¼-inch in 10 feet, but several States, including California, require ⅛-inch in 10 feet, and some 1-16 inch in 1 foot. For measuring surface accuracy in a thorough and simple manner, a surface rater or "bumpometer" has been devised. Straight-edges, sometimes

of aluminium, are also used. For ready correction of errors, the straight edge must be used before finishing is complete. The bumpometer cannot be used until next day, when carborundum is necessary to correct defects.

The beam test is generally used as a guide in determining how soon a slab may be opened to traffic. In California, the beam is sometimes actually cast in the slab.

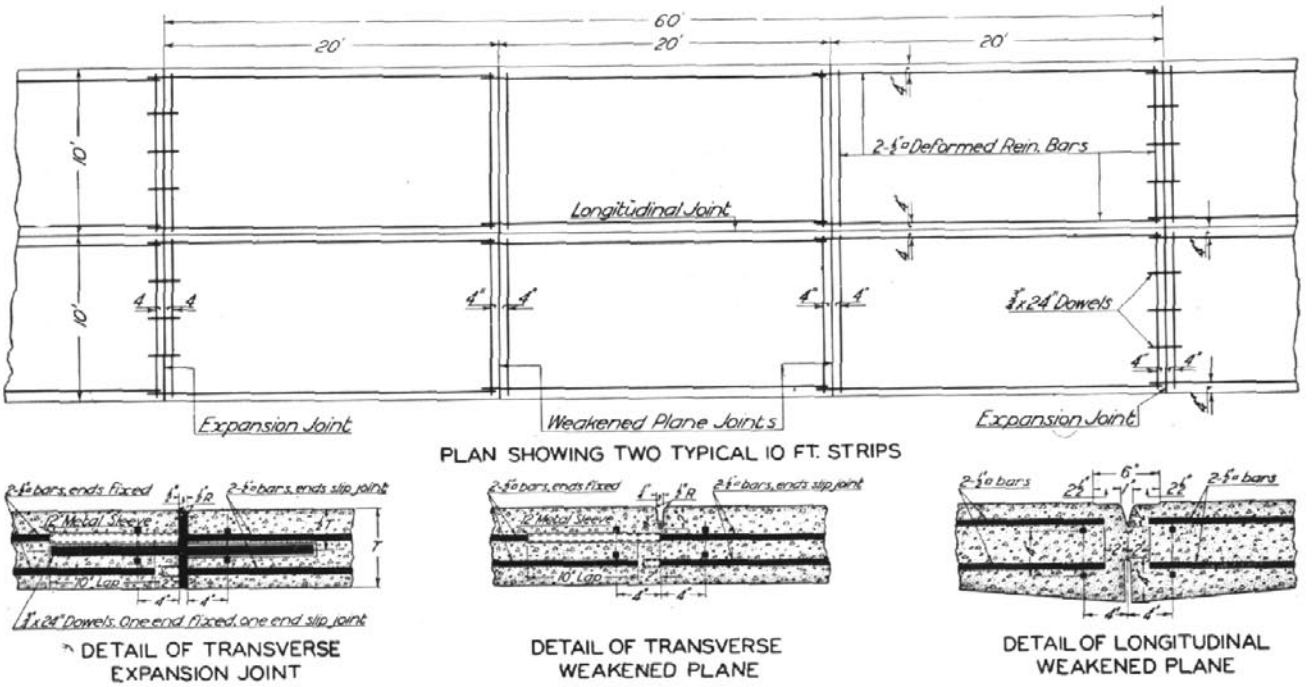
Considerable attention is paid to the accuracy of the subgrade. In most cases no sub-base is required. In California, on clay soils having a shrinkage value of more than 5 per cent., a 6-inch thick cushion is required, and for a shrinkage of 10 per cent. (*e.g.*, adobe), up to a 12-inch cushion is required.

moulds provided on the latest concrete finishing machines.

Concrete pavements are often given a "broomed finish" by lightly sweeping transversely, which reduces skidding, reduces the glare at night, and breaks any laitance.

California.—The standard California cross-section consists of a 6-inch or 7-inch slab, with 9-inch or 10-inch edges on both sides of both half slabs. Two ½-inch diameter edge bars, and dowels across the transverse expansion joints are used.

The longitudinal and transverse joints are substantially the same as described for Oregon, except that the transverse joints are filled with sponge rubber and are sealed after completion of the pavement. Free



Standard concrete pavement details, California.

Ten feet wide concrete slabs were seen in several parts of the United States. So far as could be learnt, these are no longer considered economical, considering both construction and maintenance.

Average concrete roads in U.S.A. cost from £4,500 to £5,000 per mile, for pavement only, 18 feet wide and 7 inches thick.

Oregon.—A certain weight of cement is required in each cubic yard of concrete in place. Expansion joints, ½ inch wide, are constructed 60 feet apart. The joint filler is cut off flush before the pavement is opened to traffic, but no other treatment is given. Contraction joints—two for each 60 feet of pavement—are grooves in the surface 2 inches deep and ¼ inch wide at the top, poured with 60-70 penetration asphalt.* The longitudinal joint is sometimes similar to the construction joints, but having fixed dowels, or is of the ordinary deformed type. The grooved joints can be made by forcing in a T-iron, or by forcing in special ends of dowels are inserted in metal sleeves. The pavement is opened to traffic after fourteen days, or as soon as the concrete has developed a modulus of rupture of 400 lb. per square inch.

The impression is sometimes given that all or most roads in California are of concrete. The present position is, for highways only, as follows:—

	Miles.
Earth	2,000
Crushed rock or gravel	474
Oiled rock or gravel	1,186
Cement concrete	1,800
Bituminous macadam	458
Sheet asphalt	55
Asphaltic concrete	460

South Carolina.—This State builds its pavements without a centre joint, but with transverse joints at 45 feet intervals. No reinforcement is used. On fills likely to settle, a central plane of weakness is provided, and the spacing between transverse joints is increased.

(To be continued.)

* See page 21, October, 1930.

U.S.A. Practice in the Use of Aggregates for Low Cost Untreated Roads.

(*Continued from page* 11.)

of which more than 50 per cent. is desirable. The best bases of Florida lime rock contain more than 70 per cent. of carbonate of lime. Small stones and sand are not undesirable. A small percentage of clay, less than 10 per cent., is tolerated in caliche. When power rolling and watering are used in the shaping and bonding process, Florida permits all material to pass a 3½-inch screen with not less than 30 per cent. retained on a ¾-inch screen. In some of the western States which use caliche, smaller sizes all passing a 1¼-inch or 1-inch screen are specified when the surface is to be traffic bound without watering.

Miscellaneous Materials such as stone screenings, mine chats, iron ore, topsoil, stamp sand, and others, are fragments of hard, durable material. In size they all pass a 1½-inch or 1-inch screen, and may or may not contain a high percentage of material passing a ¼-inch screen or No. 10 sieve. The fines should preferably be non-slaking in character.

Conclusions.

1. Materials which are adaptable and suitable for untreated surfaces and which can be improved later by the addition of other types of surfacing include stone, slag, gravel, lime rock, marl, caliche, chert, shale, disintegrated granite, shell, sand-clay, and volcanic cinders.

2. Non-slaking binders for untreated surfaces such as disintegrated limestone and stone screenings, are more satisfactory than clay or loam; relatively small proportions give best stability.

3. Stability of surface appears to be increased when the particles are angular in shape, but the wear of rubber tyres is increased thereby.

4. Soft aggregates can be used more economically in a base course than in a surface course, but base courses of soft aggregate give reasonable service when covered by a relatively thin surface of hard and durable aggregate.

5. Surfaces constructed or maintained by blading or by dragging should be composed of aggregates passing a 1-inch or ¾-inch screen, and the immediate surface, to a depth of ½ inch when used as a surface "mulch" should all pass a ½-inch screen.

6. Present practice shows that, in general, quality and gradation of aggregates for low-cost untreated road surfaces are determined by usage and field service rather than by standard tests in either the laboratory or field.

7. There is now a need for the development of simple standard tests for determining the suitability, proportions, gradation, and other characteristics of aggregates for untreated surfaces.

Tenders and Quotations Accepted.

The acceptance by the respective Councils of the following Tenders has been approved by the Board during the month of July, 1931:—

Work.			Name of Recommended Tenderer.	Amount of Recommended Tender.
Shire or Municipality.	Road No.	Description.		£ s. d.
Bellingen	1,134	Construction of two timber culverts with gravelled approaches.	Jenkins and Love ...	120 10 8
Bellingen	1,134	Construction of gravel pavement and timber culvert between 14¾ and 16½ miles.	Boulton and Caratti ...	144 0 0
Bellingen	1,134	Construction of gravel pavement and timber culvert between 11½ and 12½ miles.	Boulton and Caratti ...	135 0 0

The following Quotations were accepted by the Board during the month of July, 1931:—

Quotations.

No. of Quotation.	Description of Article.	Name of Successful Tenderer.	Amount of Accepted Quotation.
			£ s. d.
54	Coal—Best large steam, f.o.r. Kogarah railway station, as required, 350 tons.	B. Byrne	367 10 0
54	Coal—Best large steam, f.o.r., Ryde railway station, as required, 250 tons.	„	267 10 0
56	Bridge timber—4 in. thick, 7 in. to 10 in. wide, in 21 ft. 6 in. lengths, f.o.r. Cowra, 29,240 super ft.	Eades & Company	472 0 10
60	Blue-metal—$\frac{5}{16}$-in. gauge, f.o.r. quarry, 1,000 tons	N.S.W. Associated Blue-metal Quarries...	320 16 8
62	Blue-metal—¾-in. gauge, f.o.r. quarry, 1,000 tons	Emu and Prospect Gravel and Road-metal Company.	262 10 0

Sydney: Alfred James Kent, I.S.O., Government Printer—1931.