MACADAMISED ROADWAYS.

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By James Vicars, M.E.; A.M. Inst. C.E., City Engineer and Surveyor, Adelaide.

IN this brief paper it is not proposed to recapitulate the history of road making, or to notice all the vicissitudes and changes inseparable from the progress in this art during the lapse of the past century. Though this would form a most interesting and instructive work, showing how methods have varied with altered circumstances, it would not be materially useful for present day practice. At the outset, therefore, it is intended to describe how macadamised roads are made to-day.

Neither will road location be discussed, as this important subject should be dealt with in a special paper. But it is thought that by setting out the practice adopted in Adelaide, there will be more latitude for discussion, which is often the most valuable part of a paper.

Assuming, therefore, that the site of the roadway is fixed, and that provision has been made for drainage of flood-waters, there remains the road way, carriage way, or drive way—the latter an American term, which better distinguishes between the parts of a road set apart for foot traffic and wheel traffic.

FORMATION.

The ground is first excavated or made up to the desired levels and graded to the same contour as intended for the surface: that is, the macadam is made of equal thickness throughout. Where material is costly this will not be so economical as a level formation, which reduces the depth at either side, but makes a stronger, and it is believed, better wearing road. The parallel, cross sectioned road is stronger, especially under heavy or very frequent traffic. For the curved section causes the macadam to act as an arch, reinforced by the support from the ground beneath. It is rarely that the formation is uniform in character for more than a few chains, and even then local patches may be discovered by careful observation, which are softer or harder than the general run of the formation. And the very worst element of destruction in a road is cross breaking or bending. Therefore, roads should be made of curved and parallel cross section, and of sufficient depth to sustain the prospective traffic when the top or wearing coat of metal has been worn off.

It is customary to re-instate roads in the winter, as the worn surface is then softer and binds better with the new coat. It will then be readily seen that at this period the road is weakest and most liable to destruction, if not originally made of sufficient strength. Should irregularities occur in the formation, these should be attended to. Soft patches should be excavated to a sufficient depth and made up with stronger stuff, similar to surrounding earth or sand, gravel or other similar material should be rolled in to bring surface to approximate uniformity. Likewise, outcrops of boulders should be similarly treated.

It is not necessary to hunt for irregularities with a microscope; any of sufficient importance to demand special treatment will be readily apparent to the practised eye, and are usually strongly marked after the horse roller has been over the formation a few times.

The formation should be well rolled with a horse roller weighted up to at least four tons. From six to twelve trips for each width of roller will be ample, according to weight of roller and nature of formation. A ten-ton steam roller has about same weight per inch of width of wheels as a six ton horse roller. When using horse roller on formation, employ sufficient horses to draw roller easily. With a small team the effort of the horses causes rooting up of the surface; and in turning, draw roller clear of work first, and on steep inclines only roll down hill.

Drainage Course.—When the soil is heavy clay or of a retentive nature, it will be found most economical in the long run to spread over formation a layer of ashes, sand, gravel, or other similar material, to a depth of from two to six inches. In the case of a road having a longitudinal fall exceeding one per cent., the thinner coat may be used, and only in the case of a naturally wet clay in a hollow need the depth be six inches. Any formation which retains comparatively little moisture, as sand, gravel, ordinary earth or marl, needs no such buffer and drainage course. This bottom course adds to the first cost, but will reward the expenditure in the minimising of maintenance and renewals. Macadam which remains damp wears away rapidly, and is costly to maintain. This buffer course should be rolled as described for formation.

Bottoming.—Having prepared the formation, a bottom course of metal broken to a four inch gauge should be spread to a depth of from eight to twelve inches, depending on the importance of the road. This metal should be preferably hand broken; machine broken metal of this gauge is very irregular in section, and contains too many flat or "flaky" pieces. As broken by hand, the pieces vary from two-and-a-half to four inch gauge, the bulk of the metal being large stuff. This is spread to a uniform thickness and blinded with the small chippings—say, ten to fifteen per cent., to which is added from five to ten per cent. (by bulk) of gravel, road-scrapings, clay, marl, or earthy sand, and then well rolled, dry, with a steam roller, preferably. Unless there is a large proportion of sand in blinding, it will stick to the wheels of the roller, and leave voids in bottoming vacant, and, of course, water would ruin the foundation. Any depressions in the surface during rolling operations should be made up with metal of suitable gauge. Ten trips per width of roller should be sufficient to roll in bottoming. This metal need not be of best quality, although it is preferable; good sandstone will do. Next spread a uniform coat of two-and-a-half inch metal to a depth of four to five inches, and thoroughly roll in, say thirty to forty trips per width of roller, and the surface should not be affected by cart wheel. Then road scrapings, or sandy marl equal from seven to twelve per cent. of metal, should be spread over the surface in the form of slurry, and be well rolled in as before. When this has set for from twenty-four to forty-eight hours, the latter being preferable, add from three to five per cent. metal screenings from three-quarter inch guage to dust, and roll in with about ten trips per width of steam roller. It will be found that but little watering is necessary with slurry blinding. All surplus blinding should be swept off.

Top Course.—On top of this course lay another of two inch guage metal exactly similar in all respects, blind and roll as before mentioned, and keep traffic off for at least one day if possible, and the road will be the best macadam that can be made. Each course will be reduced in depth when consolidated, about one-third, except bottoming which will be reduced only about one-fifth of its bulk when spread. The bottoming gives the strength and serves to distribute the pressure over the formation surface, the dry blinding serves to fill voids and to cushion intermediate course of metal and prevent it from being crushed during rolling; the intermediate course is a waterproof coat which keeps effects of weather from foundation and bottoming, and prevents traffic displacing same when top course is worn through; the top coat is the wearing coat, which has to be periodically renewed.

Second Class.—For less important streets as in residential suburbs subject to light traffic and where merchandise is rarely carried, the intermediate course is omitted, as being unnecessarily expensive. Then the bottoming should be ten inches thick when spread.

Third Class.—For thoroughfares or right of ways, which chiefly tradesmen's carts use, a six-inch coat of metal in the loose is employed, or the bottoming is reduced to eight inches in the loose with top course as before, the latter being generally adopted. Again, where the formation consists of a hard limestone crust, or other similar stuff, the bottoming may always be omitted.

Blinding.—For important streets which are frequently watered to lay the dust, it is advisable to blind metal with sandy stuff, such as road-scrapings or sand with a fair proportion, say one to one, up to one to three, of clay or marl, or metal screenings containing dust. Clay or marl poor in sand is soluble and washes out under the action of water cart, eventually causing surface to become corduroyed. Almost any road which is watered will become corduroyed in time, especially where watered so heavily that it runs over the surface, but blinding with sand in it is difficult to dislodge when moist. All sand, however, will never bind the metal in a road, no matter how well the work is carried out. Again, it is often very inconvenient, and in the absence of kerb and gutters almost impossible to prepare blinding in form of slurry. Then it is necessary to adopt either of the following methods: After the metal is rolled dry, the blinding is spread over the surface uniformly and well watered, men at the same time sweeping the blinding about so as to produce slurry, which is swept into interstices. Then the rolling proceeds as before; much more water is necessary with this method. Or, the blinding is thrown over loose metal and rolled in dry. After being thoroughly consolidated, the water cart preceding the roller, sprinkles the surface till the blinding ceases to adhere to the wheels of the roller: then the rolling is finished as before. This latter method is generally adopted for roads where the traffic is light, such as in residential suburbs, but also requires excess of water. When the newly rolled road has stood for forty-eight hours, much of the water either evaporates or drains out of blinding, causing shrinkage When the screenings are then rolled in surface stones are jammed tight and spaces filled with grit, which produces a dry and good wearing surface. In the absence of screenings, sand for gravel should be used. The rolling, except of formation, should be done with a steam roller. These weigh from ten tons to twenty-four tons, producing a pressure of from about one-and-a-half to three tons per foot of width of rolling wheels, equal to two-and-a-half to five cwt. per inch of width; the heaviest cart or trolly load being about five cwt. per inch of tire. The lighter the roller the more often must it travel over the metal. The best rule for rolling is to allow from one-and-a-half to two-and-a-half tons miles at an average speed of one-and-a-half miles per hour, per cubic yard (equal one ton usually) for loose metal. The lower limit is for sandstone, the higher for basalt and trap rock, &c. That is, suppose the sheet of metal to be rolled measures 100 cubic yards, it will require 200 ton miles of rolling, at two ton miles' rate for quartzite. If a twelve ton roller be employed, it will travel altogether seventeen miles, equal to eleven hours work, or with an eighteen ton roller, eleven miles, equal to seven hours work. Excessive rolling is detrimental, as it wears off the angularities of the metal. In this respect a light roller is not as serviceable as one of fifteen to eighteen tons, the latter, if of the compound type is very economical. At the commencement, always travel three or four times over the crown to fix it, then go to the side and gradually work up to crown. By this method the surface will assume more of the elliptic curve, which is the best for traffic. If the crown be not started first the haunches will be rather flat and the crown unnecessarily peaked.

Cross Section.—In deciding on the best elevation to give to crown of a road, the first thing to consider is the maximum allowable for traffic conditions; the maximum allowable for economical maintenance; and the minimum allowable for drainage purposes. An ellipse of proper proportion varies but little from a parabola for road purposes. A light trap travelling round a square bend on a thirty feet road at high speed, would about overbalance on a slope of one in ten. This gradient then for the slope of roadway may be taken as a maximum value for the tangent to the curve of the cross section at the kerb. That is, the maximum rise of crown should not exceed one in twenty, equal to one-fortieth width of road, for safety. For comfort, and wear and tear to vehicles, horses, and roadway, a flat surface is best, and as this cannot be maintained, other circumstances must control the minimum. The maximum which can be adopted without unduly impairing economy varies with circumstances, being about one in sixty of width of road where maintenance is by patching, or about one in forty of width where maintenance is by sheeting. For drainage purposes the minimum rise allowable varies with the efficiency of maintenance. In the case of new well-made roads one in 120 rise will drain water off, but where there is loose metal, or much blinding and therefore tendency to make much mud, the minimum rise should be one in eighty of the width. And as all roads which are maintained by sheeting cannot be considered as a newly made surface at the time of renewal, the minimum will fall to nearer the latter limit. Therefore, where patching is practised, the rise should not exceed one in sixty, the width of road. For roads which are sheeted the rise should not exceed one in forty width. In the latter case, however, it would only be exceptional circumstances which would call for such a rise. In countries subject to tropical rainfall, or where much snow falls, a rise of one in fifty should prove ample. For rainfalls up to fifty inches annually, the formula $\frac{S}{5} + 1$ equals rise in inches, where S equals width of road in feet gives very good results, and allows of substantial sheets being added when renewal is necessary. If this depth prove insufficient for the traffic, it will be found more economical to pave the road with other material.

METAL.

The following table fairly represents the value of the different kinds of metal used for road making:—

Porphyry, quality varies from	10 to 20
Trap	16 to 20
Basalt, Trachyte, and Quartzite	11 to 19
Diorite	13 to 17
Limestone	5 to 17
Gneiss	5 to 17
Granite	8 to 16
Sandstone	3 to 14

Porphyry, trap, basalt, and trachyte are suitable for heavy traffic; quartzite, diorite, granite come next; then limestone, and gneiss; and last sandstone. For light suburban taffic, limestone and even sandstone make very good roads, especially sandstone containing much iron. Very hard stone wears cobbly under light traffic, but the softer stone is worn down regularly. On no account, however, should metal from different quarries be mixed or spread indiscriminately together, as it is very rare to find two quarries of equal quality, and the mixture of hard and softer stone causes cobbliness and quicker wearing away of road.

Hard stones of two and two-and-a-half inch guage should be broken by machine, as invariably with hand broken metal the hardest pieces are the largest, being more difficult to break, whereas the opposite is the best for wearing qualities. It is customary to specify that this metal shall pass through two or two-and-a-half inch gauge screen, and be caught on one-inch guage.

Hand broken metal requires less blinding than machine broken metal, as the former contains all the small chippings, but both make equally good roads. The costs of first-class and second-class road, one chain long and each of forty-five feet width, in Adelaide, are as follows:—

First-class Road :—

		£	s.	d.
Excavation and removal of earth, say, 275 cubic yds., @ 1/6	=	20	13	0
Grading and rolling formation 330 square yds., @ 1d.	=	1	8	0
Bottoming twelve inches in loose = 110 cubic yds., @ 4/8 and 4d. spreading	=	27	10	0
Blinding twenty cubic yds., @ 2/3 and 3d. = 2/6 ..	=	2	10	0
Rolling 110 cubic yds., @ 2d.	=	0	18	0
Intermediate and Top Courses, each four-and-a-half inches :—				
Eighty-three cubic yds., @ 4/9 and 4d. = 5/1 ..	=	21	12	0
Blinding and screenings, 12 cubic yds., @ 4/6 and 6d. = 5/-	=	3	0	0
Rolling eighty-three yds., @ 9d.	=	3	2	0
Total cost per chain		£80	13	0

= 5/1 per square yard.

Second-class Road :—

		£	s.	d.
Excavation 220 cubic yds., @ 1/6	=	16	10	0
Grading and rolling 330 square yds., @ 1d.	=	1	8	0
Bottoming ten inches loose = ninety-two cubic yds., @ 5/-	=	23	0	0
Blinding seventeen cubic yds., @ 2/6	=	2	3	0
Rolling ninety cubic yds., @ 2d.	=	0	16	0
Top course, four-and-a-half inches loose = 42 cubic yds. @ 5/1	=	10	16	0
Blinding and screenings six cubic yds., @ 5/- ..	=	1	10	0
Rolling forty-two cubic yds., at 9d.	=	1	11	0
Total cost per chain		£57	14	0

= 3/6 per square yard.