(*Paper No. 4242.*)

"Notes on Road Construction and Maintenance."

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THE construction and maintenance of roads in a country where military operations are in progress constitutes one of the most important of an Army's needs. The construction and improvement of the roads in the United Kingdom forms a subject of increasing importance, and this Paper may be of service in connection with such undertakings, in the design and execution of which experience shows that the possibility of military considerations becoming involved should not be neglected.

ENGLISH ROADS.

The average English roads and by-roads are, as a rule, well made, and fit to carry ordinary country traffic in normal times, but they are commonly too narrow, and when subject to military traffic soon get into a bad state, and have to be relaid, when the width may also be increased with advantage. No road which may be called upon to carry military traffic should be less than 24 feet wide, and, if possible, should be 30 feet wide

FRENCH ROADS.

The roads of France, chiefly constructed under government supervision prior to hostilities, were excellent for the traffic likely to use them; they consisted of well-considered main traffic roads (*Routes nationales* or *Routes départementales*), usually roads connecting large towns; with minor traffic roads (*Chemins de grande communication*) connecting smaller towns; and lesser highways, connecting villages, completing the network of inter-communication.

The *Routes Nationales* have a width of 8 feet to 10 feet of *pavé* in the centre, pitched much in the manner of a stable yard, namely, with 6 to 9 inch square limestone or granite pitching sets, bedded in sand on a firm soil foundation. This may have on either side 6 to 10 feet of macadam of a few inches thickness, or flint gravel direct from the pit without screening; but more often the natural soil is all that constitutes this surface.

The total width varies from 24 to 30 feet. Generally, where the *pavé* forms the principal traffic way, a ditch is cut on either side of the road, about 1 yard from the trees invariably bordering the roads.

Grande Communication roads as a rule have no *pavé* centres. They are made with 9 inches of well rammed or rolled chalk as a foundation (except where chalk already exists), above is a layer of 8 inches to 12 inches of soling rock, generally thrown down without packing, over this a layer of rock seconds (4-inch cubes) commonly laid one stone thick, and finally a dressing of 2-inch macadam, 6 inches in thickness. A steam roller is commonly used on each layer. The average width of these roads is 24 feet. It is seldom that side ditches are cut, as it is the general belief that better drainage is secured by a large camber (which may be 9 to 12 inches) throwing the water to soak-pits at the sides, spaced 50 yards apart, and 2 yards from the road edge. These pits are commonly 6 feet by 6 feet by 6 feet in size.

For civilian traffic of, say, 100 tons per day, in peace time, consisting chiefly of slow carts, and light motor cars, roads made by either method proved no doubt adequate, but both construction and material—largely a friable limestone—have proved unsuitable for heavy and fast military traffic. The original good condition of the roads, with favourable weather, delayed the appreciation of this, but after the second winter of hostilities, the road surfaces having become bad, frost got into the foundations, and with further increase of traffic the roads fell into a deplorable condition. Broken springs were frequent, and breakdowns of loaded lorries, sometimes two or three together, were not uncommon. Materials, whether timber for corduroying, or soling rock, was scarce, and temporary measures had to be adopted, using fascines, brick rubble, or anything available.

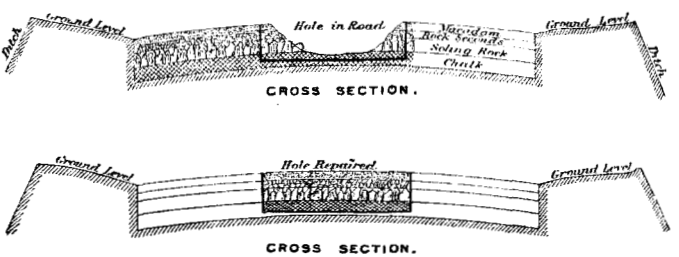
The commonly accepted view that the excessive amount of mud on the roads of France is due to the metal being forced down to the chalk, or other subsoil, which then comes to the surface as mud, is disputed by the Author. Excepting the case of *pavé* roads, and roads badly worn in holes, he is of opinion that no mud rises to the

surface by pressure from above. The true cause of mud formation is the poor quality of the material used, namely, limestone of very soft and porous nature, which, by attrition through some inches of depth, forms the mud, while destroying the surface. The character of this material is against consolidation by rolling; so that there is always some moisture between the particles, making it unsuitable as a surface dressing. Under frost this unsuitability is the more apparent, with disintegration of the stone, and loosening of the surface when a thaw follows. This material—used also in England —is less objectionable when a surface coating of tar is applied. The only other materials available in France were pit-props, whole or split, brick rubble, and a poor quality of flint gravel.

Repairing Roads.

Repair work consists largely in mending holes, which, whether large or small, should be effected in the same manner. *Figs. 1* show a hole previous to repair, the thick lines indicating how the hole has to be dealt with by squaring its sides, prior to mending. If the hole is of greater depth than 18 inches, by a reasonable amount, it must be filled with chalk well rammed, or soling rock hand packed to within 18 inches of the road surface. If very deep (as shown

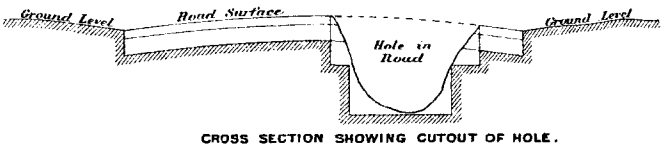
Figs. 1.



in *Fig. 2*), say, 4 feet to 6 feet, as the Author has sometimes experienced, and hard material is scarce, it is best to fill up by "pig-stying" with pit-props (*Fig. 3*) to within 18 inches of the surface, care being taken to ram soil well over each layer of props. The lower foundation being complete, will then be fit to receive the road foundation proper, consisting of soling rock, or large uneven pieces, packed on edge, base downwards, with the longest side running in direction of traffic. Wedge stones should be rammed

home in any crevices there may be, and high points appearing above the average surface of the soling rock should be broken off. Rock seconds (4 inches cube) are then placed above the soling, preferably

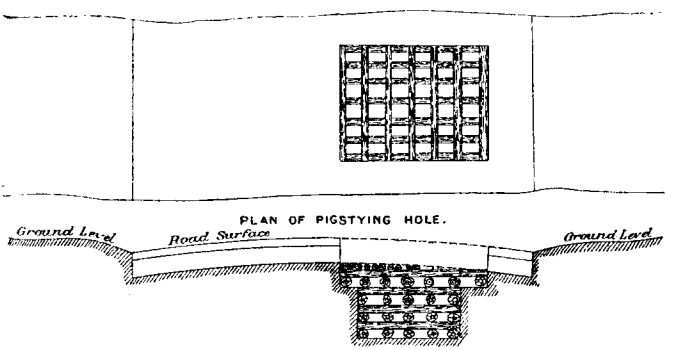
Fig. 2.



CROSS SECTION SHOWING CUTOUT OF HOLE.

hand packed, with length of stones parallel to the traffic, as for the soling. Above this there is a dressing of macadam. Each layer should, if possible, be rolled separately, if the area dealt with is

Figs. 3.



PLAN OF PIGSTYING HOLE.

SECTION OF PIGSTYING HOLE.

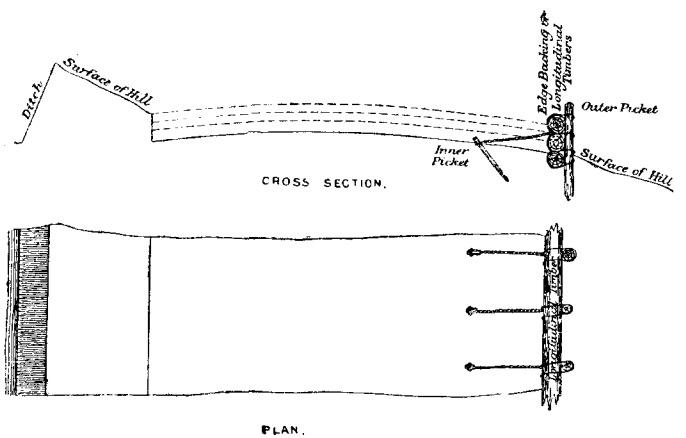
sufficiently large. Failing this, hand rammers must be used. Care should be taken that during the repairs no water be allowed to accumulate in the hole, as if it does, the work will not properly consolidate.

Road Construction.

Metalled Road.—The Author has reached the conclusion that there is but one way, as now given, of constructing a road fit to stand abnormal traffic for long. Having set out the road limits to the desired width, drainage must first be dealt with. No ditch should be nearer the road than 6 feet, the bottom being 1 foot below

road formation. Side drains from road edge to the ditch should be not more than 50 feet apart. If the road on one side cuts into a hill slope, culverts must be formed under the road leading from one ditch to the other—these, whether of stone slabs or wood, should not be less than 18 inches square. Side tilted roads draining across the surface are to be avoided. The edge of the road next the falling ground, if wanting from any cause the 6 feet margin between the road and the ditch, must be securely supported to take the pressure induced by road traffic, which has a tendency to push the edge of the road outwards, causing the road to lose its camber. The best method of securing road edges is shown in *Figs. 4*. The longitudinal timbers forming the edge backing are most suitably made of rough

Figs. 4.



round timbers, not less than 8 inches diameter, of any length. Outer pickets, not smaller than 4 inches diameter, and spaced 3 feet to 4 feet apart, securing these, must be driven below the natural surface of the ground a minimum depth of 2 feet 6 inches. Inner pickets must be placed 4 feet inside the longitudinal edging timbers, and opposite the outer pickets, driven down almost flush with the road foundation. The outer and inner pickets are then bound together with wires which may be tightened by twisting with a bar thrust between the strands. The rest of the work must also be secured by binding wires of $\frac{1}{8}$ inch diameter, fastened with iron staples. Nails must not be used, as they are apt to work loose and become a source of mischief to horses or motor traffic.

Having guarded against trouble with water, the road excavation may be begun. This must be taken out across the whole width to 18 inches below the finished road-surface, the bottom being curved to conform to the road camber, which may vary between 1 to 12 and 1 to 50, 1 to 25 being a fair average (*Fig. 5*).

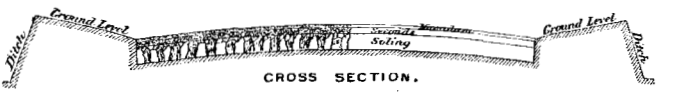
It is well to have upon the ground soling rock, seconds and macadam, in advance of excavation, to avoid delays which may

Fig. 5.

CROSS SECTION.

expose the foundation to weather influences. The surface laid bare should also be protected from disturbance by foot or barrow traffic. If mud does form, this should be taken out and replaced by ashes, or fine clinker, or by gravel. Excavation being completed the bottom is covered with a 2-inch layer of ashes, or clinker; this, though not essential, is desirable. The soling rock is then packed and rolled as already described for mending holes. Where the soling rock, when set and keyed, is rough it will be well to hand-

Fig. 6.



CROSS SECTION.

pack the rock seconds that come next, if only for one stone thick, "throwing in" to make up the desired thickness; 9 to 12 inches of soling rock is sufficient. If this is not procurable, hard block chalk will serve, though not so good. The "seconds" should be from 4 inches to 6 inches thick, as also the macadam finish (*Fig. 6*). Each layer should be rolled as completed.

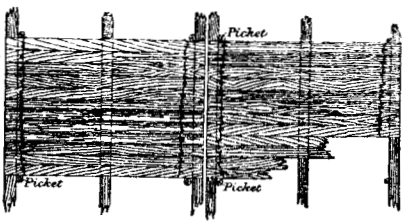
This makes a good road easily maintained, and serviceable even when the macadam is worn away.

Pit-Prop or Corduroy Roads.

Roads of this kind are possible only in a well-wooded country, and last but a short time unless well covered with metalling, without which the foundation soon becomes wet and soft, with consequent disturbance of the timbers.

To construct a good corduroy road attention must first be given to drainage and excavation carried out as for metalled roads, when "beds" to receive the longitudinal stringers should be excavated (*Figs. 7*), one on each road edge and one at the centre, with two intermediate channels, the centre channel being of width sufficient to take two timbers spaced 2 inches or 3 inches apart. The stringers may be either round or half-round pit-props, of any length, but not less than 8 inches diameter, and these serve to carry the corduroy proper. They should be well packed and rammed solid. The corduroy may also be pit-props, not less than 8 inches diameter with but little taper. They must be long enough to reach from

Figs. 7.



PLAN OF CORDUROY AND STRINGERS

CROSS SECTION OF CORDUROY ROAD

the road centre to the outside of the edge longitudinals. As each is placed the lower spaces must be filled and rammed, so that the next prop beds solid, leaving no voids.

When laid the corduroy must be secured by $\frac{1}{8}$-inch diameter wire fastened by staples to each timber. At every 15 feet it is desirable to drive pickets, to secure the timbers from shifting. On completion the corduroy should promptly be covered with a thin layer of ashes, or dry soil, followed by a layer of seconds and macadam well rolled in. If pit-props are not available, sleepers, or brushwood faggots (fascines) may be used in much the same manner as the props.

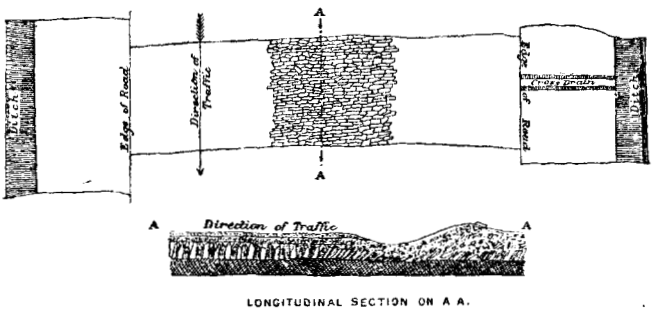
General.

Some principal faults in road construction are:—Delay in drainage arrangements until late in the work. Careless laying of soling

rock on irregularly formed bottom. Packing soling rock on edge with length of stones transverse to road, in which case the stones are liable to tilt forward in the direction of traffic with consequent disturbance of road surface (*Figs. 8*).

In evidence of the ill effects of bad methods of road making, the Author may quote a case in which drainage having been neglected

Figs. 8.



LONGITUDINAL SECTION ON A A.

—the subsoil being chalk—rock broken to 5-inch cubes was thrown down and roughly packed in places, to which rough macadam with mud was added, each layer being rolled. Upon the road being brought into use, severe weather set in, when under by no means excessive traffic the road deteriorated so quickly that heavy repairs were necessary after 4 weeks' use.

The Paper is accompanied by nine sketches, from which the Figures in the text have been prepared.