

used, the same area may be moderately consolidated in eighteen hours. If siliceous gravel, from $\frac{3}{4}$ in. to the size of a pin's head, mixed with one-fourth part of macadam sweepings, obtained in wet weather, be used, the area may be thoroughly consolidated in nine hours. Macadam laid by the last method wears better than that laid by the second, and that laid by the second much better than that laid by the first."

Experiments conducted by Mr. W. H. Grant, superintending engineer of the New York Central Park, in the construction of his park roads demonstrates the necessity of using binding material.

Mr. Grant in these experiments followed Macadam's "no-binding" theory. The bottom layer of stone was, under a 12-ton steam roller, sufficiently consolidated to form and retain (after the compression had reached its practical limit) an even and regular surface, but it was found impracticable to solidify the top layer and reduce it to such a surface as would prevent the stones from loosening and being displaced by the action of wheels and horses' feet. No amount of rolling was sufficient to effectually bind the metal, although the rolling was persisted in until the metal was damaged by the extensive crushing action of the roller.

It is generally agreed that any description of binder which is used in conjunction with water should be used sparingly, with a view to filling the voids only, as an excessive quantity of binding material will have the effect of keeping the units of stone apart, and will be washed out in wet weather or exuded as the result of traffic pressure in damp weather, thus causing the road crust to lose its even surface.

Scarifying.—The question of the scarifying of existing road surfaces previous to partial or entire resurfacing is one concerning which road engineers entertain somewhat divergent views, but it may be stated, as a general proposition, that scarifying is only justifiable when the existing road surface or crusts consist of sufficient thickness of one grade of material to ensure that the foundation of the road shall not be disturbed by the operation. In such cases the surface may be safely scarified and cleaned by screening out the binder and small aggregate, adding such a quantity of new material as will bring the road up to the required strength when re-rolled; but if the structure of the road is at all weak, a new coating of material should be superimposed on the whole work and the edges and ends only should be picked up or scarified to ensure a satisfactory join between old and new work.

If scarifying is necessary, it will be better and more economically done by machine than hand, always assuming that the extent of the work to be so carried out justifies the employment of a machine scarifier. In works of small character hand picking or scarifying may be judged to be more economical.

Repairs.—Concerning the important detail of road maintenance, which is comprehended under the general term "repairs," much may be written. When dealing with "water-bound" roads the methods of repair adopted appear to be very largely governed by the personal predilections of individual surveyors, one section of whom rely principally on what may be termed the continual-patching methods, while others prefer the complete re-coating method. Possibly a system which includes both methods is the more to be preferred. On the one hand the patching method requires a fair amount of skill for its proper performance, and, if carefully and consistently carried out, will render a road more comfortable for traffic; but it will not entirely eliminate the necessity for

occasional re-coating, inasmuch as it is next to impossible to restore by this method the exact amount of wear to which any given road is subjected. On the other hand, it often becomes necessary, even when a road has been resurfaced, to undertake repairs to weak places or potholes which may show themselves from time to time.

It has often been a subject of conjecture as to why a recently resurfaced road should develop potholes on its upper surface, when the whole of the resurfacing material is, theoretically at all events, of similar texture or hardness, and the author has arrived at the conclusion that this may be due to the fact that, where potholes do occur, the granite or other material has been originally spread rather more thickly at those places than on the general body of the work, and in the subsequent steam rolling the material on these high places has been more damaged or weakened by crushing under the influence of the rolling, thus rendering the road weaker at the very points where, in the first instance, a slight excess of material had been inadvertently or unskilfully applied.

The principal defects connected with the repair of road surfaces may be said to be:—

- (1) Unskilful application of materials.
- (2) Application of unsuitable materials.
- (3) Inadequate amount of materials employed, resulting in the "starving" of the road.
- (4) Insufficient supply of labor and consequent neglect.
- (5) The employment of unskilled or unskilful labor.
- (6) Neglect of proper consolidation of materials even in small patching work.

It is as perfectly possible to over-metal a road as it is to jeopardize its condition by a too sparing use of material; a surface over-coated will be less likely to be strong and homogeneous in structure than one to which has been applied a sufficient but not too generous a coating. It should never be forgotten that the principal strain to which the average road is subjected is that of the frictional and attritional wear on its surface, and therefore if a just sufficient thickness of resistant material is applied to the surface the under-coating or sub-structure may be quite properly formed of a softer or cheaper material, as it has only a dead-weight load to sustain and transmit to the earth foundation, and is not subjected to the other influences above mentioned.

The suitability or adequacy of foundation, and the character of the sub-drainage of a road are other important elements which cannot be overlooked or neglected in considering the question of road maintenance or administration, as it would be of little use to look for successful results with whatever skill or care a road had been repaired if its foundation or drainage was either insufficient or unsuited to its purpose, and no hard-and-fast rules can be laid down in this connection which would be appropriate to all circumstances.

With respect to the general question of foundations to ordinary country roads, it often happens that one is not bound to observe such fixed surface levels as it would be necessary to observe in towns or places where curbs and channels are already laid; therefore, it will often be found sufficient in order to strengthen a weakly founded road to leave what foundations may already exist, and apply a coating over the same of a thickness sufficient to render the road strong enough for the work it is called on to do.

The author has also on many occasions strengthened a weak road (especially on clay sub-soil) by strengthening or buttressing the shoulders. This is done by excavating trenches of, say, 1 ft. 6 in. wide and deep on each side of