ROAD CONSTRUCTION TO STAND MODERN TRAFFIC.

By J. T. Noble Anderson.

(Past President.)

INTRODUCTION:

The first factor to be considered in all road problems is the extent and class of traffic which the road will be called on to carry. Far too little has been done in the past to thoroughly and scientifically investigate this factor before deciding on the main questions of construction and location such as:

(a) Location between the established centres;
(b) Details of road section, such as depth of metal, width of formation, camber of surface;
(c) And materials of construction.

The result is that millions of pounds of public moneys have been squandered, owing to haphazard decisions. And, worse still, greater economic loss has been imposed on the community, as compared with the benefits it would have derived from a better road service, giving less loss of time and labour to every road-user.

In the older countries, where settlement is fixed, there is no excuse for haphazard methods, and latterly it has been the use in Great Britain and Western Europe to study road problems by a full and scientific set of records, called "Road Censuses," of the traffic, before embarking on any extensive road enterprise. Such censuses discriminate, not only the density of the traffic at all hours, and seasons, but also the character, whether single-horse drawn or multiple team; whether slow or fast motor; whether steel, solid rubber, or pneumatic shod, and also separately, tractors, with full details. Occasionally this has been supplemented by viagraph records of how former construction has stood up to the traffic.

In most new countries, such as this, these investigations would be largely beside the question, and would tend in some measure to actually confuse issues, and hamper progress, because the population is not yet fixed, and the chief function of the roads is to develop the districts they will serve. Here, if properly located, a good road will induce a fresh settlement
of population, make new towns, and create for itself an even greater volume of traffic than had been anticipated by its most sanguine promoters.

Under such conditions, the usual investigations are discarded, and the best thing would seem to be to rely on a limited board of business and engineering experts of proved judgment, who, by constant travel, and an intimate knowledge of the problems peculiar to the country, are best fitted to decide on how the country shall be served by roads. The intuitive action of such a board will, in the main, be found to be pretty well what a more scientific and fuller investigation, if such had been possible, would have approved.

The subject now introduced is so wide and important that the author will be pardoned for restricting himself to a very few of its aspects, and, to avoid confusion, the question of road location, and the widths of formation and metalling, as well as cross camber and gradients, though intimately affecting road construction, will be left to subsequent treatment.

MODERN TRAFFIC:

This must be taken as practically synonymous with motor traffic, and at present such traffic is entirely self-propelled by wheels, though there seems a possibility that a big traffic may spring up in self-propelled motor vehicles in which the thrust for motion is taken, not from the friction against the road surface, but, as in aeroplanes, from the air, as now used in starting aeroplanes. Some five years ago, speaking at this table, the author made the prophecy that the time is not far distant when the roads, whose functions have, during the past seventy years, been replaced by the railways, would again come into their own; and, instead of being an auxiliary to the railways—running mainly to feed the railways—that the future developments would mean far more expenditure on roads than even Telford (working before the railway era) ever dreamt of, and that, in our own Victoria, the fifty millions spent on our railways would be ultimately more than equalled by the road expenditure.

In justification of this view may be cited the facts, so far as we have got them, of the present world war. We learn that France's control of her roads for motor traffic has en-
abled her to almost equal Germany’s control of strategic railways. And as evidence of how fully she appreciates the advantage of her roads, and the terrible loss due to any neglect of them, comes the boast, that, notwithstanding the tremendous drain on her labour resources, she has kept all her highways in as good repair as ever before in times of peace—and French highways are proverbial for their excellent upkeep. In a word, France has used as efficient methods of road repair and upkeep as Great Britain has used in her wonderful railway system.

HORSE-DRAWN VERSUS MOTOR TRAFFIC: THE ECONOMIC PROBLEM:

It has been a practice in nearly all road problems, whether for construction of the road-bed or the choice of class of material for culverts, bridges, crossings, etc., to make the economic problem merely one of interest on money, and the amortisation, or sinking fund, to replace the material when its life is done. No value seems to have been set against the great loss which the public at large is put to every time a road is taken up. An example of how the public have been “put upon” in the past is one which is often quoted, viz., that old-fashioned method which was universal in Great Britain up to 30 years ago, when the loose metal sheeting was laid down in the autumn, the traffic of the road was so barricaded, that it was compelled to traverse over the rough metal until it had worn it down to bed with a solid surface. It is almost impossible to calculate the economic value of the damage done to private property of the general public, nor to estimate the value of delay and inconvenience which this method entailed. In Australasia, the public, impatient of such methods, developed the equally uneconomical practice of binding, or, as it is more appropriately called, “blinding,” with surface loam, and even vegetation, or any handy material, which would not only give some measure of adhesiveness to the loose metal, but would cloak its dangerously sharp edges, and so protect horses’ hoofs, and save vehicles from some of the rough jars. Under this system, the road could never be rigid or properly elastic, and ultimately must yield in irregular patches; the surface becoming a series of lumps, ruts, and
waterholes. Every engineer now realises the economic evils of these methods, and they have been finally abandoned. But up to now too little regard has been paid to the heavy impost of compelling the public to put up with the delay of narrowed traffic-way during reconstruction, or the economic loss of closed roads.

A sidelight on how much less engineers regard the convenience of the public than loss directly felt by their employers can be got by comparing the liquidated damages which they inflict (or rather propose to inflict) on road contractors for delay in the completion of their works, with similar liquidated damages for delay in completion on such other public activities as railways or waterworks, where the liquidated damages are most often assessed from regard to the delay in earning the interest the corporation has to pay on the borrowed money, added to the wages and standing charges. The inconvenience the public is put to during reconstruction is a much heavier factor, in many cases, than amortisation in determining whether the most stable possible material should be used, or less permanent material, such as wood, whether mortared reinforced concrete, or weaker class of metal, and whether a cheap type of bitumen surface should be preferred to the best asphalt.

**Bitumen versus Water Bound Surface:**

It is now regarded that, for main roads, the day of the water bound surface is passed. In all places where good bitumen surfaces have once been laid down, they have come to stay, because not only is the saving to the public in the lesser tractive effort so great, and also the luxury of abating the dust nuisance, but, wonderful to relate, the saving in the wear of the road material from its old internal friction, with water to help the abrasion, has meant a tremendous decrease in the former annual upkeep. And though, so far as the author knows, it has not been recorded, there also has been the saving to the public, in that the traffic is not impeded to the same extent by the annual autumn repair.

Consequently, in laying down new roads, it is wise, even if the present traffic will not justify a bituminous surface, to so construct the road that when such a surface is required it
may be laid on the old foundation, with the minimum of cost. And the great point must be steadily borne in mind that the real secret of road construction is the preparing in the first place of a wide, dry, and well consolidated foundation. But, having secured the necessary road-bed, the traffic requires certain essential qualities in the road surface.

SURFACE SMOOTHNESS AND RESILIENCE:

Obviously, from regard to the tractive effort, the smoother the road surface the more successful the road will be. On "a priori" consideration, it would seem that a rigid steel surface, like a planishing plate, would be the ideal. But there are other factors besides tractive effort, which make such a surface impossible; and the more rapid the traffic, as in railways, the more important it is that the surface should be resilient.

Black ice of the frozen surface of a calm lake some three or four inches deep, supplies an ideal surface, except that it fails in two important respects for ordinary road traffic. It is so smooth that side-slip cannot be avoided; and it is so soft that surface abrasion is almost as common as in water bound macadam, and, unfortunately, the abraded particles do not adhere, or when they do after a thaw adhere, spoil the surface on refreezing.

What is wanted is a material which, after abrasion, will fall back and bind again into its old place. It must have a certain adhesive quality. So far, bitumen supplies the best material, and those bitumens which are equally high in cohesive and ductile qualities have been found to stand heavy traffic best. The chief sources of abrasion are the calkins of horses' shoes, and ordinary motor traffic. Except the camber of the road profile has been made too steep, there is practically no abrasion until the material perishes in length of time by the constant compression.

To those who have had no experience of the water bound surface under motor traffic, a few words of explanation of its advantages, and how it breaks down, may not be amiss. The ideal water bound surface can be seen on an ocean beach, where there is a heavy surf. There, below the tide, and almost awash from the heavy breakers, if the sand be of a fine
and heavy consistency, the thoroughly saturated material gives an almost perfectly smooth surface. And there is no more ideal surface for racing than this—as the bare-footed urchin knows. The hard, but yet partially yielding sand, fits with so little compression to his yielding foot, that he can run with less effort than on any other surface. It is well worth the trouble to study the phenomena of the movement of the water in this sand under rapidly moving pressure, in such a beach. At first, if you press your foot hard, the sand will be seen to dry along a narrow margin round the foot, which apparently forces the water further away. And under rapid running it will be noticed that a moment after the foot is withdrawn, the sand seems dry where the foot rested; but only for a moment, because immediately after, the print is wetter than the adjoining sands. In explanation, the first pressure, compacting the fine sand, drives the water back, and gives the appearance of a dry surface. When the pressure is removed, the particles flowing back to nearly their former positions, enable the water to return, and the subsequent wet appearance of the footprints is due to a slight depression of the surface of the sand. A somewhat similar set of phenomena explain why, when a concrete aggregate is tamped, the moisture and finer particles rise to the surface.

The sketch (No. 1*) shows how the larger particles are driven down by the impact, while the smaller and lighter particles are driven upwards—when they are surrounded by water. On the other hand, when the aggregate is dry, the surface friction comes into play to so great an extent that the tendency is for the larger particles, having, in proportion to mass, a lesser surface on which friction can act, if suitably shaped, will work upwards (see sketch No. 2). Generally it has been assumed that, under external forces acting impactively, the finer constituents of the aggregate work up to the surface, while the internal forces, such as occur with changes of temperature, cause the larger constituents to work up to the surface. This is, however, only partially true. A familiar example of how natural forces raise the larger rocks to the surface is seen in what are known as floaters, or rocks on the

* The sketches have not yet been supplied by the author.—[Publication Committee.]
surface resting on the clay through which they have gradually been lifted.

However, to return to what happens under stress of rapid traffic, causing a series of impacts when applied to a water bound surface. The author’s observations show that, during the wet season, the finer parts of the aggregate rise to the surface as mud, leaving the material just below the surface with too little of the adhesive binding mortar. The damage to the road is not at once observed, because the fine material lies, as a cloak, over the place it has risen from. In dry weather, it becomes a dust, and rapidly passing wheels and the suck of air under the low-bodied car, raise it to the winds, which scatter it broadcast over adjoining lawns, houses, and gardens.

All this is glibly described as “suction,” and, while it is true that the suction between the impressed shoe or tyre has primarily had something to do with the dragging of the finer ingredients out of the aggregate, that can hardly be said to be the true cause. The generally received idea that a rubber tyre acts like a sucker to lift the surface is utterly at variance with fact. The way the surface gets raised is exactly similar in the case of a self-propelled vehicle to the way it gets raised by the calcins of a horse’s shoe. Only there is this difference, that the automobile’s wheels “track” in the wheel ruts, whereas the horse’s feet pound on the less worn part of the road. The result is that, on a road where the binding has been abstracted in this way, the first thing noticed is that the bare metal shows clean in depressions along the wheel ruts. Later on this bare metal, being deficient in the finer materials which had helped to bind it together, is torn asunder by the pressure and backward thrust of the motor tyres.

To recapitulate. In the wheel ruts, rapid travel works the binding material out of the surface in the manner just described, and then the cohesion is reduced to such an extent that the driving wheels, acting on such a surface thrust, it backs out of place, and scatters the stones, in the manner technically known as ravelling.

HORSE-DRAWN VERSUS MOTOR TRAFFIC:

All these phenomena give the general public the idea that
motor traffic is much more severe on road surfaces than horse-drawn traffic. This cannot, however, be scientifically supported. What actually happens is that the damage to the road, whether by horse-drawn vehicles or by self-propelled vehicles, in all cases is proportional to the actual work imposed on the road. Thus, if 70 or 80 per cent. of all the power exerted in travel is due to road resistance, it follows that practically that amount of this power is put into the road chiefly in the waste of work due to internal friction between the particles in the road bed. When wet, these rapidly grind out a fine dust, which works through to the top, no matter what the traffic may be, whether motor or horse, and just in proportion as an efficient shock absorbent is used as a road surface, this work will be reduced; and just in proportion as the road material can be kept comparatively dry, the damage due to the internal work will also be reduced. This is best effected by the bitumen surface. It must be remembered, too, that this internal work is not confined to the surface, but goes on all through the thickness of the road-bed, though, of course, it diminishes as the thickness increases inversely as the square of the depth.

Thus the internal work at 8 inches beneath the surface, all other things being equal, will be rather less than a quarter of the internal work at 4 inches below the surface. Now, inasmuch as automobiles are, as a rule, much better sprung than other vehicles, it is evident that, at the same speed, they will not do much damage to the road, and, as they are springed to give comfortable travel at a high rate of speed, so much is gained, especially when pneumatic tyres are used, that, instead of the damage increasing as the square of the speed (it being an impactive force that acts) it is doubtful if it increases within usual speed limits in the direct proportion of the speed.

If, then, the damage only increases in the direct proportion of the speed, since the travel of the vehicle in miles increases in the same proportion, it is evident that, per ton mile travelled, the damage will remain constant. This fact, that increased speed is entitled to do more damage to the road in proportion as the speed increases, without costing any more for the actual service rendered, is a fact which the
ROADS FOR MODERN TRAFFIC.

general public will be very slow to appreciate. And yet there is really no more important factor in the economic problem of the replacement of horse-drawn traffic by automobiles than the fact that, to justify its existence, each automobile must travel three or four times as far in each unit of time, whether it be a week or a month, than a horse-drawn vehicle will travel. Obviously, then, in proportion to the service it renders to the public, each motor-car justifies three or four times the expenditure, both in first cost and in maintenance per mile on the road. Thus, if all the horse-drawn traffic were replaced by only an equal number of equivalent automobiles, the service the road would be doing to the public would be, perhaps, four times as great as it was before.

ROAD BED:

Unyielding surfaces, such as concrete, no matter how smooth, compatible with non-skid conditions, are impossible, because they ultimately break up under the shock of traffic. What is much used in America is a surface of, say, 3 inches of bitumen resting on a distributing and drying layer of one inch of clean sand, which, in turn, is supported by 4 inches of 8 to 1 concrete. Such a road is probably less suited to bear heavy traffic than one founded on a well-drained and consolidated Telford, or even macadam, formation, where, beneath the bitumen there is a thoroughly rolled bed of 10 to 12 inches of solid, hard rock, properly cubed and consolidated by thorough rolling.

Without damaging the bitumen surface by excessive compression, it can be made to bear a pressure of, say, 200 lbs. per square inch. Assume the contact of each tyre to be 5 inches by 4 inches, and the weight borne to be 4,000 lbs., then the transmission of this pressure, assuming the angle of transmission through the bitumen at 60 deg. with the vertical, would be spread over 220 inches at the bed of the 3-inch bitumen, or the pressure would be reduced to less than one-tenth. But as the transmission of pressure is uneven over the surface, these figures give rather more than twice as favourable results than those which will occur in actual practice. The viscosity of the bitumen will cause surface wavering and wear, which, with deterioration, may reduce the shock-absorbing value far below this. Consequently the designer
of the road will not be guilty of any extravagance if he provides the bed equal to carry the traffic even without the bitumen cover.

CONCLUSION:

For the present, it may be taken that roads must be provided equal to the strain which a steam-roller of 14 tons, or a motor lorry of 8 tons, will impose on them, and that the latter will travel at speeds up to 20 miles an hour.

What the future may bring it is impossible to foretell, but, while it may seem extravagant to provide main roads sufficient for something rather more severe than the present traffic, there is nothing surer than that, if the country is to go ahead and compete with modern conditions, undoubtedly the extravagance would be the policy of laying down a weaker road.

Briefly, this is the main point, that the roads must be made with wide and well-consolidated foundations, efficiently drained, that the metal must be not less than 10 inches deep after rolling; and that the road must have a sufficient bitumen surface to reduce surface friction, and to give the pressure distribution through a yielding material which is so essential.

DISCUSSION.

The President said they had listened to an interesting paper on a subject on which Mr. Anderson was recognised as an expert. It was a subject of supreme importance to those members who were road engineers. He did not know that there were many present that night who were competent to speak as specialists on traction on roads; so the discussion would necessarily be postponed until next meeting, when they hoped they would be able to get some of their road experts to attend and discuss the subject. If there was one subject more than another that required standardisation it was that of road making. If they could not speak on the matter professionally, they certainly could exercise the right of the private citizen to growl at many of the roads in the Melbourne area, particularly if they were motorists. There seemed to be
as many methods of construction as there were engineers. It was a good thing that a few years ago the Government instituted the Country Roads Board, with the object of getting standardisation. There were so many different methods of constructing roads that the ordinary citizen became a little puzzled as to the most efficient type of road to advocate. In the Dandenong road, for instance, they would find four different types of construction, each having been made under the control of a separate municipality. All that must lead to a good deal of waste. They heard of roads which required very expensive materials for construction—such as asphaltum and wood-blocking, the cost running into about 25/- per square yard, and yet they heard of roads built in a cheaper way which apparently stood the strain of motor traffic. He had one in mind—High street, Prahran—the road bed of which was laid down about five years ago. The surface was now as good as when it was first laid down. He understood that it cost about 3/6 per yard. It was built of macadam, laid under good supervision, with good material. And yet they heard of roads costing a good deal more not standing more than a year or so before they had to be patched.

Mr. J. T. N. ANDERSON asked if that road was not built on a grade, so that it would be always dry?

The PRESIDENT said in some parts it had a good grade. It had a good crown. It was constructed with a tarred surface. Each layer was laid with tar. If they could get roads like that at 3/6 per square yard, the ordinary engineer would ask, “Why all this talk about expensive roads?”

Mr. ANDERSON said that was the crux of the matter. The road was waterproof, and so laid that water would not find a lodgment beneath it.

Mr. J. A. SMITH said Mr. Anderson had given them a great deal of material for reflection in respect to the dynamics of the subject alone. They might go into the matter of principle involved therein to an almost indefinite extent.

Just one point he would refer to: Assuming that all roads here and elsewhere were constructed of bitumen,
would there not ultimately be difficulty in obtaining sufficient bitumen? Must they not in the future look to some method other than that requiring that material?

Mr. Anderson said he thought not. There were numerous sources of supply; from oil distillation, for example.

Mr. Smith said he was not considering simply a day or a year hence, but the ultimate general condition. It would seem that bitumen could hardly be the ultimate material for road making.

Mr. D. McLean asked whether the angle of 30 deg. mentioned was the angle of the bituminous material, because he remembered the angle given in the Country Roads Board's first report was 48 degrees. Was that low angle owing to the different material?

Mr. Anderson: Yes; undoubtedly. The angle which he had referred to was the angle in respect to bitumen material.

Mr. J. N. Reeson said Mr. Anderson's paper was very interesting, and had given material for a great deal of thought. His experience in road construction had not been large; but he had worked in connection with dust prevention and the protection of the road surface; and he remembered in connection with Mr. Maybury, in England, having tried several experiments. They tried the ordinary bitumen and some distilled tars, and also the lighter tars, and they obtained some very extraordinary results. He remembered one piece of road surface that they saturated with a very light oil tar, and that tar penetrated the surface of the road and lubricated the edges of the aggregate, and in time the pieces of road metal began to grind against each other until they became spherical, and there was no binding effect at all. He thought that was the first point that was noted in showing that distilled tar, a very thick, viscous tar, was a very much better material for preventing the dust nuisance than the oil tar, which would simply absorb the dust; for, although the thick tar had, of course, no absorbing effect, it did prevent the destruction of the road surface, the light tar, while preventing the dust nuisance, was impracticable on account of its lubricating properties.
As the President had said, even after these years the principle of road making did not seem to be quite clearly understood, because they got in some cases a cheap road giving quite satisfactory results. He supposed the ideal road would be a level road without any camber in it at all. The camber was simply put there to throw the water off the metal. In this country one of the features that one noticed was the immense width of the roads, and naturally the upkeep of those roads must be a serious matter. They were faced with difficulties in many directions. They had immensely wide roads—probably a great deal too wide. Those wide roads might have been necessary in the old days when sheep and cattle were driven freely along them. He would like to thank Mr. Anderson for his most interesting paper.

Mr. J. C. LANE said that Mr. Anderson had spoken of a 20 h.p. car on an ordinary road expending about 14 h.p. in tractive effort. How much would that tractive effort be reduced on, say, the ideal road of macadam, supplemented with a tarred surface? If it were very much reduced, then there was a very great reason why motorists should contribute a little more than the owner of the ordinary vehicle towards the maintenance of good roads, as they had the effect of cutting down his expenditure so much in other directions.

Mr. J. T. N. ANDERSON said the point about the diminution in the h.p. depended on two things. The first thing was the resilience of the material. Obviously the less the material was compressed, the less the resistance would be. They got all sorts of conditions up to almost the rigidity of a railway. They got down to some 8 lb. to the ton tractive effort. They could get tractive effort almost as low as on steel with the best and hardest surface.

The two factors were a good bitumen surface, and the speed at which they travelled. The compression of the macadam, and the compression of the elastic materials might be practically the same, but the shock losses, which varied as the square of the speed, were tremendously greater in the macadam. He thought Woods estimated that there was something like five times as much loss travelling at 25 miles
an hour on macadam than in the case of traffic over the tarred surface. Of course it depended on the speed very much.

On the question of work done on the material that had the tarred surface, it would be considerably less than in the macadam. The chief part of the waste was in the shock. At 25 miles an hour there might be a saving of four-fifths—practically 3 h.p., with 11 h.p. saved.

Mr. J. A. SMITH asked what proportion of that would be turned into heat, and not into actual disruptive mechanical effects?

Mr. ANDERSON said it would require an instrument almost as sensitive as the one Mr. Smith had just shown, to determine that.

The PRESIDENT said he would ask members to show their appreciation of Mr. Anderson’s efforts in contributing so valuable a paper to the Institute.

This was done by acclamation.

The PRESIDENT announced that at the next meeting there would be a paper by Mr. Catani on “Modern Methods of Earth Excavation.”

At 10.20 p.m. the meeting closed.
ROAD CONSTRUCTION TO STAND MODERN TRAFFIC.
(Paper by J. T. Noble Anderson.)

Mr. E. F. Gilchrist (engineer to the Prahran City Council) thanked the President for the invitation to attend. He had come with the idea of listening to the discussion rather than of taking part therein.

He had read Mr. Anderson's paper with great interest. It dealt with a subject that exercised the minds of municipal engineers to a great extent at the present time. He supposed it was about eight or ten years ago that, in the old country, difficulties of motor traffic became prominent. There was a discussion about the spoiling of the roads and so forth. Since then he thought there had been about three International Road Congresses held at different European centres. Although a good deal of generalisation had been indulged in on the point, on the advent of the motor in this country, it was soon found that the ordinary dry macadam roads would not stand the test, and methods had to be resorted to, to try and overcome the dust nuisance.

The municipal engineer was annually faced with the difficulty of strengthening the present roads. The question thus came in as to whether the nature of the roads should not be fixed by road censors. He had with him a table showing an analysis of the traffic crossing the Church-street Bridge, between Richmond and Prahran. He had it taken over seven days for the complete twenty-four hours, and the results were as follows:—Single horse traffic, 299; one-horse vehicles, light, 5,967; one-horse vehicles, heavy, 5,768; two-horse vehicles light, 212; two-horse vehicles, heavy, 2,046; three-horse vehicles, 98. Motor traffic—Ordinary cycles, 1,084; motor cars, 1,579; motor waggons, 398. Grand total, 15,651. It would be seen that the motor traffic was about 21 per cent. of the whole.

The road engineer had to undergo a good deal of criticism, and also had a number of difficulties to face. He was supposed to make a road with a surface smooth enough for a motor car or cycle, and also strong enough to carry a traction engine or motor 'bus, while it also was required to give an easy foothold for a horse, and at the same time no dust must
form, and there must be a minimum of noise; also the cost of construction must be as small as possible.

Coming to the point that Mr. Anderson's paper particularly dealt with—the construction of the road to meet present-day requirements—that depended on the surface of the road. He thought they must all go in for a bitumen or asphaltic surface. They were doing a fair amount of macadam road. It was a very fair foundation. The road was strengthened with a light coat of 2½ inch metal, and then sprinkled with distilled tar, and rolled again. Then a coat of tar macadam was put down about three inches thick. The tar macadam was composed of 1½ inch metal and screenings of about 7 to 1. This was rolled down to about three inches, and then dusted with toppings.

Mr. J. A. Smith said Mr. Gilchrist had given some very interesting data as to the amount of traffic passing over a certain bridge. He had given it in terms of the number of vehicles. He would like to ask Mr. Gilchrist if he could give it in terms of tonnage per horse employed, and if possible the approximate gross tonnage. In other words, what was the proportion of weight, horse or motor, that passed over that bridge; and what proportion of that would be net. Possibly these data had not been obtained, but they would be very interesting if they had.

Mr. Gilchrist thought it could be ascertained approximately. He thought the different headings he had given could be averaged pretty well. A pretty good general idea could be formed from the table he had given as to what would be the gross tonnage.

Mr. J. S. Dethridge said Mr. Anderson had given them material for a great deal of thought, more particularly by the way he had approached the subject from the economic point of view, in pointing out the immense amount of work that was lost through a bad road.

He was in agreement as to the merits of bitumen; it was ideal in its place, but was hardly practicable except in close proximity to busy centres. Mr. Gilchrist had admitted that tar macadam was good for suburban streets. But on going further out they came upon the earth road, over which they
travelled in whatever their vehicle might be, losing, he did not know, how much work. He had no doubt Mr. Anderson could make out a much better case than most shire councils were aware for a greater expenditure in metalling the roads, on the ground of the saving in the work.

He had had a rare experience the previous week during the Goulburn floods. He had occasion to travel four miles down the road in a boat. The boat was drawing more than was convenient for the purpose, and they had to dodge the road formation; yet all along that road formation, although the floods had been there three days, bubbles were rising. He could only explain it by supposing that the road bed was so drained that for many feet down the earth was charged with air, and that this was gradually being released. Perhaps some other member had seen the same thing, and had another solution. He would like to express to Mr. Anderson his appreciation of the paper.

The President said a number of gentlemen interested in roads had been invited to be present, but had evidently been prevented by the weather from attending. He asked Mr. Anderson if he would prefer to reply to the discussion at that stage.

Mr. Anderson said he would prefer to reserve it to next meeting. Possibly there might be some further discussion.

The President said the discussion could only be postponed on a motion to that effect.

Mr. J. A. Smith moved that the discussion be adjourned to next meeting.

Mr. M. E. Kernot seconded. Carried.

A METHOD OF STRENGTHENING EXISTING IRON AND STEEL BRIDGES.
(Paper by F. K. Esling.)

As the author was not present, the discussion was postponed to next meeting.

The President announced that at next meeting a paper would be read by Mr. H. E. Grove on "Gas Holder Construction."

At 10 p.m. the meeting closed.
DISCUSSIONS.

ROAD CONSTRUCTION.

(Paper by J. T. N. Anderson.)

Mr. C. F. Lindblade said Mr. Anderson had referred to the more costly asphalt road and the cheaper bitumen road. There were many ways of looking at bitumen and asphalt. There was the asphalt which was a natural product, and the bitumen which might be a compound of residuals and distillates. Again, the author had spoken of the resiliency of the roads. Resiliency in bitumen was rather a rare attribute, especially during the hot weather. He had had some experience of it, not in the matter of road construction, but of road destruction, during the opening up of Melbourne thoroughfares for electrical reticulation.

The matter of resiliency was a very illusive factor. Many of the roads were far from being resilient in the summer time. In water-bound surfaces, he thought air had a good deal to do with it. The exchange of air in a mass of bitumen was a very serious matter. It would be noticed in the city footpaths. On a hot day they would notice a heavy, oily smell, and every draught of cold air going over the surface meant a gas exchange, which had a great effect on the wearing properties of the bitumen. It also must have an effect on many of the roads, where he had noticed it, but not to the same degree. He thought Mr. Dethridge had remarked upon air interchange in the case of a submerged road. It was quite apparent in wet weather. Sometimes in “opening up” they found air passages. Through some old roads, even with good foundations, there were many breathing spaces. He thought if it were investigated it would be found that air had a great deal more to do with the disintegration of the road than the actual water.

As to the foundations of roads: For a long time, in breaking through roads, he had noticed a series of layers, and that the smaller particles were at the top. He had put it down to the “blinding;” but he noted the explanation of the author that the smaller particles had been gradually squeezed to the top.

As to the smoothness of roads, he did not profess to be able to speak authoritatively, but he thought matters with
regard to bitumen should certainly be looked into. There were
many classes of bitumen, and they were acted upon in many
ways by moisture. Many of the roads were purely experi-
ments to find out the best, and some of them tended to show
that breathing action was a factor to be reckoned with.

Mr. JAS. ALEX. SMITH said he understood Mr. Lindblade
was about to carry out some experiments as to the resiliency
of bitumen by means of the sclerometer. Might he ask if he
had any data?

Mr. C. F. LINDBLADE said he had tried some experiments
in that way, but could not give the data right off. Some of
the experiments produced somewhat elaborate data, but he
would not care to give them that night.

The PRESIDENT suggested that Mr. Lindblade might supply
them in the form of a written contribution to the discussion.

Mr. SMITH said he thought there were several gentlemen
who had specialised in road construction, who had intended
to be present. They had not attended, probably because it
was assumed there would be a rather lengthy paper that would
not give sufficient time for a complete discussion. Perhaps
Mr. Anderson might wish that the discussion should be further
adjourned, in order that those specialists might be present.

Mr. J. T. N. ANDERSON said he was in the hands of the
meeting. He was disappointed that there had been no more
questioning criticism, for he thought his paper would have
provoked a certain amount of opposition and difference of
view. Mr. Lindblade and Mr. Dethridge had agreed with the
views expressed in the paper, and had brought out more
forcibly points that he had tried to make. But he had looked
for new points being brought forward, and to some of his
points being challenged. If there was any chance of that he
thought it would be desirable to postpone the discussion, but
he left the matter in the hands of the members.

The PRESIDENT thought there could be no objection to
postponing the discussion. Perhaps the absence of aggres-
sive discussion was a sign of concurrence with the author's
views. As this discussion had been postponed previously, a resolution would be necessary to postpone it again.

Mr. JAS. ALEX. SMITH moved that the discussion be postponed. Mr. J. S. DETHRIDGE seconded. Carried.

A METHOD OF STRENGTHENING IRON AND STEEL BRIDGES.
(Paper by F. K. ESLING.)

On the motion of Mr. JAS. ALEX. SMITH, seconded by Mr. C. F. LINDBLADE, this discussion was postponed to next meeting, on account of the limited time available.

BAIRNSDALE TO ORBOST RAILWAY.
(Paper by M. E. KERNOT.)

Mr. J. T. N. ANDERSON said, on page 183, Mr. Kernot had referred to the silting up of the Tambo River, to the extent that the old bridge, which originally had a clearance of 10 feet above summer level, was now completely submerged in the sand. He would like to mention that he built the present road bridge 16 years ago. At that time, part of the hand-rail of the old bridge was just showing above the silt, so there was no doubt as to the statement. Of course, he could not say as to whether the old bridge had had a clearance of 10 feet, but when he was there the hand-rail was 2 feet 6 inches above the bed of the river. There was no doubt whatever that was an example of what was going on in a great many of the level stretches where the rivers were getting close to where they debouch to the sea.

An immense amount of valuable land was swept down from the undulating country, and no attempt was being made to protect it. It was simply so much capital lost to the nation. He believed the time would come when it would be found comparatively cheap means could be adopted to prevent that waste.
discussion or amendment or suggestion of any modification of those conditions?

The President said his intention was that they should be submitted to the Council for its opinion as to whether they should be officially recognised and recommended. They could not force them upon engineers, but if they could recommend them as being suitable conditions for contracts for the purchase of machinery, it would be of great use to engineers practising in this country.

Mr. Kernot said as he understood it the question was as to whether those particular conditions were to be accepted or not. They were not then asking the Council to study the conditions and suggest improvements.

The President said, Yes. They might accept the set with certain modifications. The suggestion was that the whole question be remitted to the Council for report.

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DISCUSSIONS.

ROAD CONSTRUCTION TO STAND MODERN TRAFFIC.

(Paper by J. T. Noble Anderson.)

Mr. J. T. N. Anderson contributed his reply to the discussion, as follows:—

The Chairman of the Country Roads Board has verbally expressed his regret that he is unable to attend, but kindly mentioned his only criticism, i.e., that the author was in error in assuming the old pernicious method of "blinding" road surfaces with "any handy material" had "been finally abandoned." Unhappily the author must admit the accuracy of this criticism. Even one of our most important Melbourne Metropolitan Corporations still persists in this ruinous and "blind" practice and also in the "pro-machinery age" attempt to punish the road users, by compelling them to do all the work
of consolidation of large, roughly hand-broken metal, with
feet, hoofs, and rubber tyres.

With reference to the remarks on other subjects, Mr. Deth-
ridge’s narrative of the air coming out of the submerged road
is a very valuable illustration of one of the essentials of a good
road. No matter whether the material be best bitumen, tarred
macadam, or an ordinary consolidated earth road, the neces-
sary resilience is only compatible with a large proportion of
occluded air.

The under surface must be well drained so that the matrix
shall not become water-logged. Also the rolling or traffic
must not go so far as to crush the material to a compressed
inert mass. It is found with almost all asphaltic material that
sooner or later the traffic works it into that condition, and it
must be replaced by fresh, live asphaltes.

Similarly, as the author has pointed out (vide page 107),
that “Unyielding surfaces, such as concrete, no matter how
smooth, compatible with non-skid conditions, are impossible
because they ultimately break up under the shock of traffic.”

The road which Mr. Dethridge cited would have been re-
silient owing to the air-cushions which it contained. Unlike
the surrounding ploughed lands, it would not part with its air
at once, but would gradually for days keep giving up its air and
becoming saturated. After the road was so saturated, and the
flood had subsided, the road ought to have been closed to
traffic for some weeks till it had again drained out, otherwise
it would never again be quite as good as before.

Mr. Lindblade and Mr. Reeson had each touched on one of
the questions agitating the profession, namely, the best char-
acter of the bituminous agent. Where the work to be done
was sufficiently important to justify it, experiments should be
made to determine the most suitable of the materials available,
and on strict chemical and physical specification prepared to
insure the uniformity of the article supplied with what was
chosen. Otherwise little more can be done than to insist on
sufficient boiling and care to remove not only all aqueous
matter, but the more volatile hydrocarbons. For the lower
layers possibly a material almost pitch, and as free from lubri-
cating properties was needed. But for the surface pitch was
insufficiently plastic, and the aim should not be to get a cinder
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so much as a suitable surface with that binding quality which would enable it when shredded asunder to automatically rebind itself.

As to Mr. Smith's doubt as to the limitation of bituminous supplies, were such roads adopted generally.—A somewhat similar pessimistic fear had at some time or other been expressed about almost every mineral product, which to the imagination seemed to have this peculiar advantage in comparison with products of natural growth, and yet in our own time we have seen that the increase in price of those of the great natural commodities, which could be reproduced to an unlimited extent, such as timber, had been far greater than the increase in the price of the exhaustible commodities. This did not even except that most limited in proportion to the demand, commodity, iron. The truth was that the greatness of the demand was a stimulus which had brought to light fresh unexpected sources of supply, and the adoption of more economical methods of treatment, so that a larger proportion of the useful ingredient could be extracted.

As to the other speakers, the author believed he had answered them already; but with reference to the President's statement that a certain main street in Prahran had only cost 3/6 per yard, he believed that if the President would look into the matter in detail, he would find that that cost was really only a tar sheeting cost of a road which had already cost considerably more, but which had been re-made on several occasions.

There are few important main thoroughfares such as this which could be made with a solid bed and a bituminous surface for less than three times this sum if all the items, such as sub-drains, curbing and culverts were added. This statement was not made with a view to discredit the cheap and efficient work mentioned by the President, but to prevent the possibility of readers forming a wrong impression of what good roads would cost. For the rest everyone must, most heartily, endorse the President's approval of all means, such as the appointment of the Country Roads Board, calculated to improve road work and bring about that uniformity of practice which was so much needed, not only in the interests of the motorists and other road users, but of the ratepayers themselves.

Discussion closed.
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Anderson, Joshua Thomas Noble

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