The problem of how to prevent serious damage being done to road embankments by occasional floods, has been engaging my attention for some years, and I hope that the observations I make in this brief paper, will be of interest, not only to the Engineers of the Public Works Department, but also to those engaged in Railway and Irrigation Works.

During the North East monsoon rains in particular, and especially in the low-country, many roads are rendered impassable for several days, due not so much to their being flooded, but owing to damage done by floods which are subsiding.

As a result of several observations, I have found, that more damage is done by comparative small floods of long duration, than by big floods which rush over the road and subside in a few hours. Following this result, I have watched carefully to see what really occurs to cause the serious scour, or total breach, of the road. In no instance did I find, that the road was breached on account of the weakness of the embankment, but, in every case under my observation, I noticed that a total scour of the road surface, was followed by a serious breach. I further observed, that the damage started at the outer edge of the bank, and
gradually extended towards the inner side, and also that the extent of the scour depended more on the duration of the flood than its intensity. (I should explain that I call the "inner side" of the road, the side which first comes in contact with the flood water). From this latter fact, I have come to the conclusion, that the damage is due more to thorough saturation of the road than to anything else. I have, on more than one occasion, observed a road, over which floods had gone for a period of 3 or 4 days, left practically intact till the flood water had subsided to a depth of only a few inches over the road surface; when the scour began, and in the short space of an hour, only half the road was left.

I now come to remedial measures. The best course obviously in the case of all low lying roads is to raise them above flood level, but except perhaps in a few instances, the expenditure involved in such a work would not be justified; for, as a rule, these floods do not last for more than a few days in the year and, provided the road is not damaged, traffic can pass, even though the flood water is several inches over the road surface. Unfortunately however, roads under continuous floods do get severely damaged, and when this happens in some places miles from anywhere, much time is taken in erecting temporary bridges, &c., and traffic is seriously inconvenienced. As a result of some practical experiments, I have devised a measure which so far has proved very satisfactory in preventing the initial scour of the road surface, which, as I previously observed, is the chief contributory cause of a breach in the road embankment. I submit the results of my experiments not only to P.W.D. men who have to deal with flooded roads, but also to the Engineers of the Irrigation and Railway Departments and if any of you are not satisfied that my idea is theoretically sound, I would suggest that you try an experiment on a small scale and see what results you obtain. I do not claim that my scheme is perfect, but I have always found that it prevents serious damage to road
embankments and saves thousands of rupees which would otherwise be spent in repairing such damage: The main point in my scheme is to prevent the initial scour of the road surface, which, as I have stated before, starts at the outer edge. To do this, dig a trench about 6′ wide, and to a depth of about 1/3 of the height of the bank, along the outer edge of the road platform. In the centre of this trench, at intervals of say 3 feet, drive in 1′ iron rods so that the tops of these will be level with the road surface. (The length of these iron rods will depend on the height of the bank). They should be driven to a depth of about 4 feet into solid ground. Fill in this trench with cement concrete, using ordinary road metal as the aggregate.

I need hardly point out that a concrete wall of this type requires no skilled labour, can be made in a very short time and costs little more than Re. 1 per lineal foot.

An experimental wall of this nature, on a fairly large scale, was built by me when I was stationed in Batticaloa in 1912. The design was slightly more elaborate than the one I have just described, but the main idea, viz., a narrow concrete wall or panel, which only went a few feet below the top of the embankment, and which depended for its stability on iron rods which pass through it into solid ground, was the same: I had unfortunately left Batticaloa before I could have seen what effect the floods had on this wall, but Mr. Fraser, of the Irrigation Department, in his paper on “Floods in the Batticaloa District in 1913,” which he read to this Association, made the following observations:

“Between 92nd and 94th miles of the Radulla Batticaloa road, the major portions of the road are in banking about 8 feet above ground level.”

“The flood water topped the road, scoured the bank and the road breached and was swept away for 3 mile of its length.”
"At certain points along this section of road, the road is enclosed by panels of concrete. * * * At the points where these panels were inserted, no scour occurred, and the road remained intact."

Since I took up duties in the North Central Province, I had further opportunities of carrying out my experiments and I had several of these scour prevention walls put in at places where the road was subject to periodical damage. I am pleased to say that whenever the floods went over a part of the road where there was a wall of this type the road remained intact. I might incidentally mention that the cost of repairing roads damaged by floods in the North Central Province during the last 3 years amounted to no less than Rs. 57,000.

A plan and section of a road where a concrete wall described in this paper, has been put in, is shewn in figures 1 and 2.
FLOOD DAMAGE PREVENTION OF ROAD EMBANKMENTS.

SECTION

PLAN
DISCUSSION.

5th Paper.

The CHAIRMAN: Gentlemen, the next paper is "Flood Damage Prevention of Road Embankments" by Mr. de Kretser.

Mr. de Kretser said: I do not think I will take up your time by reading the paper. It deals with some successful experiments I have tried in preventing roads being damaged by floods.

The Hon'ble Mr. J. Strachan said: Mr. President and Gentlemen, I think that Mr. de Kretser is to be congratulated very much for introducing this paper, because I am quite sure that it will be discussed by other members of the Public Works Department. They will perhaps be able from experience to say what they have done. Personally I don't wish to criticise his scheme because I have seen it. It has been effective on one particular road and I believe it did save a great deal of the road. I wish, however, to mention one or two points which occurred to me in reading the paper. First of all in the paper I think Mr. de Kretser says the scour can be prevented by constructing this wall, I should like to know to what extent. He says to construct a wall to about one third the height of the embankment. I should like to know whether he has any figures to prove that it should be one third the height or whether this is the result of practice.

There is another small point which strikes me. He proposes to construct a trench six inches wide and one third the height of the
embankment. For the sake of argument, take an embankment 20 feet high, then we would need a trench 6" by 7 feet deep. This is rather impossible I think. Then an iron rod has to be driven into the ground about 4 feet. I see a discrepancy between the sketch on the blackboard and the diagram on the paper. So far as I read on the paper the iron rod is fixed into the concrete. It is quite impossible, in my opinion to drive that iron bar down through the solid ground; Then as regards the question of cost. Cost is one of those things which worries me very much. Mr. de Kretser says that in one Province the flood damages cost during the three years not less than Rs. 57,000. I am sure we will all be pleased if flood damages in that Province can be prevented by spending the small sum of a rupee per linear foot. The iron bar alone would cost about Rs. 1 a foot of wall. Then what about the cost of the wall? I don’t want to take a hostile attitude in criticizing but I wish he would put me right on cost. One other point occurs to me: on this particular road I don’t think there is a drain and the space between the metal track and the wall is very small. The roads being narrow carts get to the sides and I think they cut up the sides of the road, and possibly would damage the wall. I hope that Members of the P.W.D. and Irrigation will give their experience in matters of this sort, as such will be of very great value to road maintenance.

Mr. Browy: It would appear that given very special conditions the writer’s method of flood protection would be effective and two of these very special conditions as I understand them are:—(1) That there must be no great flow over the road. (2) That the flow must not be of long duration. He would not presume advocate the use of his method for the protection of an Irrigation tank where the height above the spill had not been designed large enough to discharge the maximum flow, nor for a railway embankment on the scale of that of the Batticaloa-Trimcomalie Light, Railway crossing, of the Mahawelli-
ganga Valley. The writer's treatment must necessarily be fairly expensive in the case of an embankment of 12 feet in height and over where the concrete curtain wall will be, at least, 4 feet in depth and will have to be of greater width than six inches. It is quite possible that a road which was regularly submerged year after year may only be very occasionally breached, but would it not be a wise precaution to examine conditions in each case of flooding in order to ascertain whether a simple and effective remedy such as the raising of an embankment or the widening of a bridge or culvert would not be economically practicable? It is obvious that for a road embankment crossing a Valley there can be only two conditions which will cause submergence:—(1) Inadequate flood accommodation; (2) Restriction of the valley lower down and less flood discharge capacity, than that provided through the road embankment. Inadequate flood accommodation can be remedied by raising the embankment or by increasing the sizes of the waterway of bridges and culverts, or by a combination of both methods. If there is restriction of the valley lower down then the trouble can be met by raising the embankment or by increasing the size of the restricted waterway downstream or by an admixture of both methods. Failing a satisfactory solution in any of these directions then the writer's method may be found useful.

The Chairman: Will any other gentlemen offer remarks. The room is full of road experts. Mr. Adams?

Mr. Adams: I am afraid Mr. Strachan has dealt with the points I proposed to deal with.

Mr. de Kretser: I should have noted in my paper that the experiments which I conducted were in places where the embankments were not more than eight feet high. I did not experiment on 20 feet high embankments. I daresay on embankments of that height it would not be successful. My paper deals with flooded roads in the Low-country, where most of the embankments are not 20 feet high.
Regarding the question of iron bars it is stated in my paper that after the trench is dug, the iron bar is then driven into the trench, after which the concrete is laid. The iron bars will be surrounded by concrete. The reason for the iron bars is merely to prevent the concrete wall toppling over, as it has no foundation. The diagram I did not draw to scale. It is more a sketch so that details could be clearly seen. The space between the road metal and the edge of the bank where the concrete wall has been laid in my experiment is about three feet. With regard to Mr. Brown's remarks I said in my paper that floods which are of short duration but great intensity do not do as much damage as floods that were not so intense but kept on for two or three days. Raising an embankment to prevent it being damaged by floods would I think be certainly the best course to adopt. It would be at the same time a costly business, especially where these floods occur occasionally and only last for a day or two in the year. Enlarging the waterways of the road at these points only will not have much effect because the surrounding country is all flooded. Making the culverts bigger would not make any difference.

The Chairman: Gentlemen, we have got to thank Mr. de Kretser for his paper. It is a very simple matter. He mentions that in 1912 a certain section of the Badulla-Batticaloa road was enclosed by panels of concrete and the flood water topped the road, but this section has not been damaged in any way. I think we owe a debt of gratitude to Mr. de Kretser for giving us a tip and we will follow it wherever we can.