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PACIFIC LOCOMOTIVE COMMITTEE REPORT
RECORD OF PACIFIC ENGINES STUDIED
EXPERIMENTS IN BRITAIN, INDIA, FRANCE, GERMANY AND AMERICA
MODIFICATIONS IN DESIGN RECOMMENDED

The Report of the Pacific Locomotive Committee instituted to implement the recommendations made by Sir John Thom in his enquiry into the Bihta accident which occurred on the East Indian Railway in July 1937, is published today.

The Report shows that from early days locomotives have been known to disturb the track by shifting it sideways with a consequent risk of derailment. In some cases the fault has been ascribed to the engine, in others to the track. Requiring many new engines, the Railway Board decided on X Class Pacifics; with the information then available, they had no reason to anticipate that the engines would have a more searching affect on the track than previous types. The engines were brought into use about 1930, thus coinciding with the introduction of retrenchment measures which retarded to some extent

track renewals. At the same time, there was some reduction in expenditure on track maintenance, but there is no conclusive evidence that this had any effect on the safety of the engines. There was, nevertheless, the combination of circumstances, in which more powerful engines which tended to put more side pressure on the rails, were introduced on track not hitherto subjected to so much pressure. The problem has not been dealt with up to the present time because little was known about it even outside India until 1934, and the research begun by the Railway Board in 1935 had not sufficiently advanced to indicate any decisive action when the Bihta accident occurred. Meanwhile, the Railway Board had made alterations to the engines from time to time which, according to the reports, had got over the trouble but which, under special circumstances, had proved to have not been entirely successful.

"In India, until the advent of the Pacific engines, as in England until now, it is true to say that lateral forces on rails have not presented an urgent problem", say the Committee and observe that whilst certain tests made in India showed that "hunting can be practically cured (without alterations to the engines) if intensive attention is paid to the track, this desirable result for these particular engines requires a standard of track maintenance financially impracticable". The recommendations are, therefore, a compromise between the two, and consist of altering the engines to reduce their hunting tendencies, and of improving track within limits which they consider financially possible.

The Committee point out that the record of safety and operation on Indian Railways is an enviable one. The 284 Pacific engines have run no less than 90,000,000 miles, and the incidence of derailment has been mainly confined

to the first five years of their service. Meanwhile the speed restrictions imposed on these engines, until improvements both in the engines and the track have been effected, are to continue.

THE PACIFIC TYPE IN INDIA

Recalling the Pacific Locomotive's history in India, the Committee says that in 1923 the Railway Board addressed all Railways in order to lay down standards of new types of locomotives which, while giving sufficient power should also have boiler fire-boxes designed to burn low grade fuel; this was important because the cost of first grade coal had risen since the War by over 50 per cent. The Pacific type which had already been extensively developed in America and in France, and which has since been widely adopted in other countries, fulfilled this requirement. A feature of the Pacific type is that the boiler's fire box is not placed in the limited space between the driving wheels but is placed behind the driving wheels, which enables it to be widened so that a large grate area, essential for the burning of low grade fuel, is obtained. This lengthening of the boiler behind the driving wheels, entailed by the adoption of the "wide fire-box", also resulted in a longer engine which, in turn, required an additional carrying axle, which differentiates it from previous types.

The Pacific Locomotive's important feature is that it is much longer than previous types, with the result, as subsequent experience has shown, that it has different riding characteristics as a vehicle on the track. It has since been discovered that, owing to its greater length, when angular movements are set

up, much more powerful side forces are imposed on the rails, which introduce a liability to cause the track to be shifted with a consequent risk of derailment. The possibility of such a riding characteristic was unknown at the time the engines were ordered. At that time, proper consideration to the suitability of the weight of axle loads for the weight of rails on Indian track was given, and the co-ordination between them according to previous experience and calculation of vertical loads on the track was correct. Subsequent testing of the stresses in the rails by electrical recording has not only proved this but shown that the rails have a margin of strength for the vertical loads imposed. The Committee remark "in the past, as elsewhere, this one function of the rail, viz., its ability to carry certain axle loads vertically, was almost the only criterion by which standards were assessed".

In 1925, following the Board's reference to Railways, the Locomotive Standards Committee, formed in 1923, laid down the features of design for the new engines, and the Consulting Engineers in London were requested to get a few engines of each type constructed for trial purposes. The Committee note that the final proposals of the Locomotive Standards Committee at this time were not laid before Railways, but they also record that a member of the Consulting Engineer's staff visited India

in this connection and discussed requirements with individual Railways. It was intended at that time that only two engines of each type should be built in the first instance, but owing to the demands of Railways for new locomotives, backed by the Acworth Committee's recommendations, a total of 284 engines of the new types were eventually purchased.

At the time the Consulting Engineers advised caution in purchase until the new engines had proved themselves in service, but the Railway Board could not agree that engines of the previous types, considered obsolescent, should be purchased. It was considered essential that the wide fire-box should be adopted in the interests of economy in fuel and so large purchases were made before any trial results were known. The Committee point out that the Board had no reason to doubt that the new engines would be satisfactory, that the engines were designed as power units, and at that time it was not known that these longer engines would present problems in riding characteristics.

IMMUNITY IMPROBABLE

The Committee remark that "in view of the state of knowledge and method of testing adopted at the time, it is unlikely that adherence to the policy of waiting for trials would have assured immunity from subsequent troubles, or altered the conditions of operation which have led to this Enquiry". Actual experience of the engines showed that they were peculiarly sensitive to the condition of the track and that small track irregularities, which had little effect on previous types, were liable to set up pivoting oscillations or hunting movements.

Little, however, was known about locomotive stability even outside India until 1934. In India, the Railway Board started systematic research in 1935, and precise knowledge concerning the stability of these engines has only been revealed in the most recent investigations prior to the Committee's coming to India.

The Committee recognise the great complexity of the problem of engine stability on track, further complicated in

India in regions where black cotton soil exists, and owing to monsoon conditions; in general, there is first, the lateral play required for free running between the wheel flanges and the rails, and secondly, the inevitable wear and tear of the running parts due to dust penetration, etc., resulting in considerable lateral play being set up in the axle boxes. Neither the engines nor the track itself is completely rigid, and the result is that if, for any reason, an engine starts to swing with a turning movement from its straight path on the rails, which it is enabled to do owing to the clearances and wear, it is possible for the springy reaction from the wheel flanges pressing on the rails at one side to turn the engine to the other side with an added impetus. The pressure contact at the other side again causes a reaction to the original side and so on, backwards and forwards, a hunting movement can thus be set up which may grow to such proportions that the pressure on the rails is sufficient to move the track out of its proper alignment.

NO ABSOLUTE SOLUTION

The Committee, after consulting all the available mathematical information on the stability of vehicles on track, consider that the problem, by its complexity, is not capable of absolute solution, and that empirical measures, based on trial and error, must be adopted. They emphasize that the provision of safeguards to prevent hunting must be a compromise between the requirements of running on straight track and of running on curves, since an excess of lateral control on the straight may cause difficulties and raise high flange forces at the wheels on curves. Consideration is given to evidence from tests made in America, Germany, France, South Africa, Great Britain and India. Tests made in India, whilst criticised in some respects, are considered to have been of great value to the Committee in drawing their conclusions.

The Committee draw attention to the intensive retrenchment campaign on Indian Railways, begun in 1930, which had some repercussions on expenditure on track maintenance. As a result

of this, and of the Pope Committee's recommendations on "job analysis" of operations carried out, some reductions were made in the strength of track maintenance gangs. There was also "Some falling off in the number of miles of track and track components renewed and of betterments effected".

The Committee, however, remark that "economies made in expenditure on track have not been made by curtailment of expenditure which was really essential for the safe operation of traffic".

It is noted that the Railway on which the largest reduction in expenditure on track maintenance was made, the North Western, has had no trouble with the running of these engines. Moreover, the Indian Railway Enquiry Committee of 1937 considered further reductions were possible. The Committee remark that it has been "no part of the Railway Board's policy to deny to Administrations the necessary funds for essential maintenance".

CONFLICTING REPORTS

In dealing with the suitability of the new engines, the Committee draw attention to the conflicting reports received on their performance in service. They remark "it was this more than anything that retarded the finding of a lasting solution and which, more than once, gave an impression in the last ten years that the trouble was solved, only for it to break out again in another place or in different circumstances".

The Committee say that "the merits of the problem must be gauged by the standard of locomotive design existing at the time, and not in the light of present day experience".

They conclude that the procedure adopted in dealing with the design and manufacture of these engines, as between India and England, appears to have conformed generally to accepted practice, in the supply of engines to other countries and was generally satisfactory. For the future the Committee consider the policy of trial before bulk purchase should be adhered to, "since modern research should now enable decisive

results to be obtained from a small number of units". The Committee, also visualise the possibility of India eventually designing and building her own locomotives. In this eventuality more and more responsibility will be thrown on the technical officers on Indian Railways and, with this in mind, the Committee have made certain recommendations regarding the expansion of the staff and work of the Central Standards Office.

The Committee comment on the valuable work done by the Railway Board's investigating officers attached to the Central Standards Office in experimenting since 1935 on the strength and stability of track and in determining what are the flange forces imposed laterally on the rails by the wheel flanges of a locomotive travelling at speed. The Committee refer to many cases in England and in other countries where locomotives have proved over-sensitive to track irregularities. They remark "No criticism was received from any Railway regarding the adoption of the Pacific type or of the sizes and range of the standards proposed".

RECOMMENDATIONS

The Committee's recommendations include such alterations to the engines as a particular combination of lateral control and frictional damping to resist hunting movement. They propose that more powerful springs should be introduced on the leading bogie. They note that experiments made by the Railway Board by increasing the strength of these springs had led to negative results, and this form of cure had not, therefore, been pursued. They, nevertheless, explain their firm recommendation in this connection by saying that it be coupled with the adoption of a combination of other features, not present in the Railway Board's tests, and that the latter, whilst approaching a solution of the matter did not reach the stage of leading to the definite conclusions which the Committee have been able to give. The list of engine alterations

recommended includes, in addition to extra powerful bogie control springs, the use of low and constant friction material in the bogie slides, limits of wear allowed in the bogie moving parts, thickening of the bogie wheel flanges (a complete innovation, but already visualised by the Railway Board), introduction of special high friction material in the bogie pivot bearing and in the hind truck slides for damping out oscillation (both these being in accordance with instructions already issued by the Railway Board), and stiffening of the main frames of the engine to reduce its flexibility.

They recommend that the 45 m.p.h. speed limit conditionally imposed on these engines by the Railway Board be retained until the Committee's recommendations have been carried out.

These recommendations are coupled with the remark that their "recommendations relating to improvement in the riding qualities of X Class Pacific engines cannot be implemented without a continuance of research (in India) which has been so ably commenced", and further that the apparatus designed by the Railway Board's officers should be used for this purpose.

Their recommendations include a preference for single piece type sleepers on black cotton soil and research into the improvement of foundation supports to the track on weak soil, further investigations into the best types of sleepers to give lateral stability in the track, some increase in the number of sleepers per mile on the routes where these engines are run, a minimum standard of 90 lb. F.F. rails in the track where the engines operate, to be provided within an economically practicable period, extended use of track recorders, review of maintenance gang ~~strengths~~, extension of the training of permanent-way staff and recruitment of literate gangers.

The Committee's terms of reference were framed so as ^{and} to present the problem in its widest aspect ~~to~~ obtain the maximum amount of information from their deliberations.

They were to consider the design and operation of the three main passenger classes of Pacific Locomotives, the XA, XB and XC, which are similar but which differ in size and power, and to advise on -

- (1) the suitability of the designs, as originally framed and as subsequently modified, for the type of work for which the engines were intended;
- (2) the suitability of the procedure followed in preparing and approving the designs for these engines;
- (3) the circumstances attending, and the justification for, the initial and subsequent purchase of these engines;
- (4) the conditions subject to which these engines can be used with safety, with particular reference to their suitability for the track on which they are required to run, and, conversely, the suitability of the track for these types of engines;
- (5) any modifications which would have the effect of increasing their scope without any sacrifice of safety; and
- (6) any modifications that ~~should~~ be made in the procedure hitherto followed for the trial and purchase of engines.

The Committee consisted of Colonel Mount, Chief Inspecting Officer of Railways in England as Chairman, and with members consisting of Mr. Carpmael, Chief Engineer, Great Western Railway, England; Rai Bahadur Dhawan, a former Railway Chief Engineer in India, and now Member, Federal Public Service Commission, Monsieur Leguille, Regional Chief Mechanical Engineer, French National Railways, and Mr. Stanier, Chief Mechanical Engineer, London, Midland and Scottish Railway. The Committee was assisted by Mr. Cox, Technical Assistant to Mr. Stanier, and by Mr. Bakhle, Divisional Engineer of the G.I.P. Railway, who acted as Secretary.