Redevelopment of the airport at Newcastle-upon-Tyne

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Discussion of the structural design of the flexible pavement in § 28 is somewhat confusing if the design is based on the recommendations in refs 3–5, which it presumably is.

82. The total thickness of construction includes the 7 in. of bituminous surfacing and the 6 in. of dry lean concrete base. The bituminous surfacing is always used and its presence is implied when the CBR design curves are utilized.[4] Clearly 30 in. of construction consisting entirely of fill is not equivalent to 23 in. of fill with 7 in. of bituminous surfacing. The much higher stiffness of the surfacing reduces the stresses imposed on the subgrade. This fact pinpoints one of the shortcomings of the basic CBR design procedure, namely that no account is taken of the different strengths of the many materials which may be used, in general, to make up the 'depth of construction'. All design methods using CBR curves require some additional information specifying at least the depth of bituminous surfacing required. In this case for an LCN of 50, 7 in. is normally used.[4] It is thus the 6 in. of lean concrete which is additional to the basic design requirement and it replaces an equivalent thickness of fill.

83. It is stated in § 28 that the bituminous surfacing and lean concrete together are equivalent to 2 in. of additional construction. This implies that 13 in. of strong, bound material are equivalent to 2 in. of fill, which is clearly not so. It is the contribution of the lean concrete layer which needs to be assessed in order to compare the strength of the pavement with the basic LCN 50 design.

84. Calculations of vertical stress on the subgrade, which is an inverse measure of the bearing strength of the structure, were carried out using the BISTRO layered system computer program.[10] The object of the calculation was to check whether a pavement with a total thickness of 32 in. (on the fill) incorporating just the 7 in. of surfacing was equivalent to the design pavement, which incorporated 6 in. of lean concrete in a total thickness of 30 in.

85. In order to perform this calculation it was necessary to assume values of the modulus of elasticity and Poisson's ratio for the materials in each layer of the structure. The lean concrete layer is potentially very stiff, but as a result of cracking due to shrinkage and possibly tensile load induced stresses, the stiffness will decrease. The elastic constants chosen for the materials and detailed in Table 9 were chosen on the basis of research work carried out in this field summarized recently by Brown and Pell.[11] The load details are based on the curves given by Skinner and Martin[4] assuming, reasonably, that contact pressure is equal to tyre inflation pressure. It can be seen that for the values of elastic constants chosen the structures are almost equivalent in terms of the vertical stress transmitted to the subgrade. Hence the assessment of the effect of the lean concrete layer on the 'bearing strength' is not very 'conservative'. It would be of interest to know on what basis the assessment mentioned in § 28 was based.

86. It is of interest to compare the vertical stress at the top of the shale fill for the two structures. While the actual figures may not be exact because of assumptions involved in this theoretical analysis, a comparative idea of magnitudes can be obtained.

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Table 9. Details of structure

Layer no.	Modulus of elasticity, *lbf/sq. in.*	Poisson's ratio	Thickness, *in.*	Structure	Vertical stress, *lbf/sq. in.*	
					Subgrade	Sub-base
1	500 000	0·4	7	Actual structure used. Total thickness = 30 in.	6·0	22·4
2	50 000	0·25	6			
3	20 000	0·3	17			
4	7 500	0·4	—			
1	500 000	0·4	7	Basic structure for LCN 50 design + 2 in. Total thickness = 32 in.	6·1	37·0
2	20 000	0·3	25			
3	7 500	0·4	—			

Single wheel load: load 3500 lbf; contact pressure 150 lbf/sq. in.; radius of loaded area 8·6 in.

87. By incorporating the lean concrete layer, the vertical stress on the sub-base has been reduced by 40%. (A true comparison would involve calculations on a 30 in. structure rather than the 32 in. one, but this will not affect the vertical stress on the sub-base significantly.) These sub-base stresses may be regarded as allowable for materials with CBRs of 20 and 27[12] for the two structures respectively. It would be of interest to know the CBR of the shale fill and, apart from the merits of the lean concrete layer as a good working surface for subsequent paving operations, the considerations which led to its inclusion in the structure.

Mr J. F. Harbidge, Jamieson and McKay

I was particularly interested in the Paper as I have spent the last year at the University of Newcastle-upon-Tyne studying the generation and distribution of personal travel produced by Newcastle Airport.

89. Regional airports are too often disregarded in planning the total transportation system, and since even airports with modest air traffic volumes will generate appreciable amounts of road traffic, this omission is not easy to understand. The result is a lack of data generally about airports and air passengers which tends to make any sort of prediction unreliable.

90. I should like to ask the Author if he could explain in a little more detail the forecasting methods adopted. Were past trends extrapolated subject to modification according to authoritative judgements, or was account taken of the socio-economic characteristics of the catchment area population? If the latter analysis was made, then presumably it should be applicable in principle to other regional airports. The development of Teesside as a civil airport has occurred since the forecasts were made and, unless due allowance was made, presumably will have affected their accuracy.

91. Finally I am intrigued by parts of Table 2. Firstly, is it to be concluded from this table that for every departing aircraft there are two arrivals? If so where do they keep them all? Secondly, what is the basis for the estimate that the average 1980 air passenger will carry a quarter as many bags again as today's typical passenger?

Mr D. Allford, Yorke, Rosenberg and Mardall

On behalf of the Architects for the scheme, I would like to add a few notes to the Paper.

93. First, I would stress the close nature of the collaboration with Sir Frederick Snow and Partners on this project. The Architects worked with them as a design team at all levels, from the development of the Clients' brief to the completion of the buildings. On the buildings, there are a few points not covered in the Paper.

94. The terminal building was originally designed to be built in two stages with a standard busy hour rate of 350 passengers for the first stage. However, during the course of the Contract it was decided, on the basis of increased traffic, to construct the planned Stage 2 development for a standard busy hour rate of 650 passengers.

95. The Architects worked closely with the Consulting Engineers to achieve by economic cut and fill a main concourse at the same level as the access road. This gives a smooth passenger flow at concourse level with baggage and other facilities on the ground floor (apron) level. Facilities such as the restaurant, long-term waiting spaces and offices are on the floor above concourse level: cross-circulation is virtually eliminated.

96. The airport can deal comfortably with up to 500 000 passenger movements per year. If significant growth continues in the 1970s, extensions will be required.

97. The ancillary buildings are planned in a linear manner and have expansion space for future growth. They have been treated with the same external finish (white glazed tiles) as the terminal building, and this, it is believed, contributes to the overall unity of the scheme with a minimum of fuss.

98. Architecturally, my organization is strongly against the creation of monumental terminal buildings. However, the aim has been to achieve a clear and straightforward expression to the buildings, which it is hoped gives a sense of significance and reassurance to passengers.

Mr Lister Rodger

The points made by **Dr Brown** elaborating on the inadequacies of the basic CBR design procedure are widely accepted; certainly I agree with them and many other points he makes. The design system used is essentially empirical in that stress distribution is assumed to be a direct function of depth where no allowance is made for the varying strengths of layers of materials. As the theory does not take into account the effect on stress distribution arising from the use of materials with relatively high tensile strength, it was considered that the use of a high strength Marshall asphalt (which is designed to provide a strong mechanical interlock of coarse aggregate) would have a greater effect than that implied by the design curves; it was therefore not only the 6 in. of lean concrete that was additional to the basic design requirements.

100. I believe the implication of § 28 is clearly that the 7 in. of high strength asphalt on 6 in. of lean concrete are at least as effective in spreading the load as 7 in. of normal bituminous construction on 8 in. of shale fill.

101. I am indebted to Dr Brown for carrying out the calculations and supplying his results, which confirm that this assessment of strength comparison was indeed correct. Whether it is conservative or not might be shown by further calculations assuming different characteristics and thicknesses of material.

102. Since the pavement of Newcastle was designed attempts have been made to produce analytical approaches to the design of flexible pavements, the BISTRO program being an important contribution; other work has been carried out by the ex-Ministry of Public Buildings and Works and the Federal Aviation Authority, particularly directed to the solution of the problems of multiple-wheel systems of loading.

103. I welcome the contribution of **Mr Harbidge** and particularly his support of my often repeated plea that airports must be considered within the total transportation strategy of a region, not necessarily because of the road traffic which they

generate but more because of their total influence in all aspects of planning of future growth.

104. In considering the forecasting methods it is important that the purpose of such forecasts in relation to the planning of a regional airport be borne in mind. It was essential to derive the parameters within which the interrelated operational areas of the airport would be planned and designed to ensure, as far as possible, that the flow rates of aircraft and passengers were compatible and that adequate reservoirs of waiting space were provided wherever incompatibility occurred.

105. The highly sophisticated socio-economic methods often adopted for long-term forecasting are not of immediate assistance in the derivation of design criteria for the operational areas of an airport. Annual or seasonal flow rates have to be analysed to determine the particular flow characteristic in peak hours or the SBR. For example, in our recent report on Luton Airport the forecast annual traffic for 1980 had to be reconciled to give a peak hour passenger rate of 5700 and an SBR of 3700. The distribution of hourly movement rates was such that the twentieth to the fortieth hour would have rates of only $\pm 10\%$ of the thirtieth hour. This range of variation is much less than the capacity available from the planned allocation of space in the terminal area to accept, under reasonable conditions, an SBR of 3700.

106. The forecasts for Newcastle were based on extrapolated figures of passenger and aircraft movements within the several categories and types of service, e.g. London scheduled, domestic charter, etc., projected forward at different rates of growth. This was combined with earlier forecasts by airlines of future traffic potential and other planned changes of aircraft type. Hourly movements were then assessed by comparing historical data with revised scheduling procedures to derive an assessment using a decreasing ratio of peak and SBR values to annual movements. Subsequent traffic rates have confirmed the forecasts in general terms and the peak hour and standard busy rates have been accepted within the capacity of the apron and the buildings.

107. The effect of the opening of the Teesside civil airport has not been significant, but the probable increasing rate of growth of tourism from the region may result in some of the potential traffic being attracted to the Teesside airport.

108. The derivation of flow rates of passengers is necessary for planning the capacity of certain areas of the terminal building. We had found from statistical analyses at other airports that, for planning purposes, a flow rate of 2:1 in either direction covered the standard busy rate situation. The change in the assessed number of bags per passenger is derived from the forecast increase in the proportion of holiday traffic (when passengers have more luggage) compared with the business traffic.

109. The contribution from **Mr Allford** amplifying some of the points which it was impossible to cover in the Paper, is very useful and I should like to thank him for the details he gives.

References

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