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The development of Gatwick Airport†

by

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and

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Discussion

Mr N. E. V. Viner-Brady (New Works Engineer, British Railways, Southern Region) said that the original conception, for which they were greatly indebted to Sir Alfred Le Maitre, had been to provide an airport at Gatwick where air was combined with rail. This was the first time that such an idea had been attempted in Britain and it had raised a number of problems on railway matters.

114. There had been much concern about the nearness of the runway to the heavily used Brighton mainline. In fact, the runways had been moved 2,000 to 3,000 ft away from the railway to minimize the danger on take-off. It had been difficult to decide whether the airport terminal should then be moved out to the runways or should remain alongside the railway. Happily it had remained alongside the railway.

115. Eight to ten stations beyond Gatwick had had to be altered and the timetable recast in order to provide a regular-interval service, the first of its kind in Britain, for passengers arriving at and departing from Gatwick. It had indeed been a most successful arrangement.

116. Many other problems had arisen as the work had proceeded. There had been the question of engineers and architects adopting railway methods when they were not used to them; their rhyme and the railways' reason had not always coincided, but the work had proceeded smoothly. Staff problems, too, had arisen, particularly in regard to the portorage, owing to the different arrangements between the men. It was difficult to decide in a combined station of this description the boundary where the airport porters should cease and the railway porters begin, and vice versa. However, through the wisdom of the Airport Commander and the understanding of the people locally, these problems had been overcome fairly quickly.

117. It had been necessary to provide an additional platform and new high-speed switches to take speeds up to 60 m.p.h. The consulting engineers and architects had made use of many railway standards, such as standard platform buildings, lighting, sanitary fittings, and design of platform roof. The railways, in turn, had had to accept many ideas that were foreign to them. The pier stretching out on to the apron was no doubt an ideal arrangement from the aircraft point of view, but when transposed over the railway track it raised a number of problems, not the least of which was the encasing of the exterior steelwork by coloured enamelled plates to match in with the general colour scheme of the airport, and although the plates were detachable such a practice raised maintenance problems.

118. One of the biggest problems of the Southern Region, with its intensified electrical service, was the discoloration that occurred to painted structures, owing to the rusting of the heavy deposit of brake dust from the cast-iron brake shoes. That was why such colours as stone and green were used.

119. The siting of the ticket office had raised many questions, one of which was that

† Proc. Instn civ. Engrs, vol. 14, p. 43 (Sept. 1959).

it was quite foreign to railway staff to work outside the limits of their station. However, after much debate it had been decided that the railway ticket office should be sited in the main terminal building, adjacent to the air companies' ticket counters, and this arrangement had proved most successful.

120. There had been little problems of design in station buildings to which they had not been accustomed, but some of the methods used had proved a great success. For instance, it had been decided that it would be more efficient to buy heat from the central boiler-house of the airport to heat the railway station, rather than to make separate arrangements. In fact, the supply of heat had been most satisfactory, except that it had not occurred to anybody during the planning period that the phasing of the demand for heat between the airport and the railway would not always coincide. It had been necessary, therefore, to make additional arrangements to heat the station premises and signal box during the off-peak periods. That was only an example of what could happen when work was rushed, but by and large, the co-operation between the two organizations had been most successful.

Air Commodore W. E. G. Mann (Ministry of Transport and Civil Aviation) said that not only had the consultants and contractors had to deal with a number of very varied problems in the construction of the airport, but they also had to cater for many precise operational and technical requirements from the aviation point of view. For example there had been thirteen different radio navigational stations. It had been necessary to lay about 25 miles of communication cables. The runway work had been complicated by the need for ducting to provide the necessary lights and the approach lighting. Much survey work had had to be carried out in connexion with navigational data and possible obstructions in the approaches, particularly since the runway had been shifted about 2,000 ft farther to the west than originally planned, at the request of the railway authorities. Local inhabitants to the west of the runway had not approved of this! It was of interest that the visual beacon on this approach had been positioned with the aid of a helicopter.

122. To illustrate the problems he described one of the aids—the instrument landing system. This system aided the pilot to make a correct approach to the runway in bad visibility and bad weather. It comprised a localizer installed beyond the end of the runway, to give the pilot guidance in azimuth, a glide path offset beside the runway to give guidance on the glide path, and marker beacons to give guidance on his distance from the threshold of the runway.

123. The siting of I.L.S. and particularly of the localizer was a difficult business and not a precise art. It was very sensitive to the reflexions from buildings or any electrical conductors. In fact, power or communication cables, or any of the conductors, had to be electronically symmetrical around the localizer. Ground and flight testing might take 2 months or more to prove a site and to set up the localizer in order to be sure of giving a safe and reliable service. This meant that there should be no work on the runway, no vehicles moving around, and no unusual obstructions during this testing period, which would not be there when the runway was completed.

124. It would therefore be seen that there were very difficult and conflicting phasing demands between the logical way of doing the job from the civil engineering point of view and what was required by the telecommunications engineer. In addition to all the flight testing there had often been demands for completion of some of the stations to which he had referred because of a desire to install equipment and to give the staff familiarization training.

125. Nevertheless, the consulting engineers had met all these very difficult requirements, providing roads where, from the civil engineering point of view, they had no need to provide roads until several months later, and providing buildings long before it was convenient to do so. He was full of admiration for the way the consulting engineers and the contractors had managed to deal with all these very difficult problems. He felt that the Authors must have learned many valuable lessons which might be applied when constructing other airports in the future.

Mr D. Allford (Partner, Yorke, Rosenberg, and Mardall, Architects) said that as an architect he was interested in architect-engineer co-operation. This co-operation had clearly existed in a project which, because of its speed and unusual nature—engineers and architects were not building airports every day—called for unusual methods of working, and methods which had to be developed as the work progressed. Had the engineers or the architects been specialists with fixed ideas of the way in which people should work in teams, the project would never have been completed. In fact, they had been adaptable, always keeping the end in view; for the engineers the production of the airport and, for the architects, the production of the buildings on the airport under the general co-ordination of the engineers. A great deal of work had been done after hours, even in public houses, developing methods of work. There had been no time for normal meetings, formal agenda, and formal committees.

127. This comment applied not only to the architects and engineers, but also to the Ministry of Transport and Civil Aviation, and British Railways, who had also adopted methods which normally they would not adopt.

128. An architectural point which was of interest was the use of the concrete on the airport. This had been no mere whim. The use of concrete everywhere, inside the terminal building, in the restaurant, exactly as it came from the shutter, was a symbol of the distance that architects and engineers had moved since the nineteenth century. In those days the architects had been the "art boys" on the fringe, in contrast with the engineers who were regarded as practical and rather soulless technicians. The two professions had moved together since then, and a symbol of this was to be found in this use of concrete, not only at Gatwick but in many other buildings.

129. No medals would be given to the architects for this. The use of concrete in this way was first developed by the French, particularly by Auguste Perret, who had died 2 years ago at the age of 70, and his pupil for 1 year, Le Corbusier, who refers to concrete as "*béton loyale*".

130. All the colours and all the materials had been set to this. Everything had been keyed to it.

131. The contractors with whom he had been concerned were the Turriff Construction Corporation. Their agent, Mr Fowgies, had been extremely patient under the difficult conditions created by the architects' demands for quality and the peculiar ideas that architects sometimes had. The quality of the building produced by them was extremely high.

Mr J. Lister Rodger (Resident Engineer, Frederick S. Snow and Partners) said that most of the problems facing the engineering site staff could best be covered under the headings: co-ordination, supervision, and liaison. Taking, first, liaison, the Ministry of Transport and Civil Aviation had been represented on the site by visitors from the interested sections, such as telecommunications, lands branch, lighting, airfield control, etc. Each of the technical branches had its own programme and its own priority, and all these had had to be fitted into the overall programme of the development of Gatwick. Work had been carried out on behalf of the Ministry of Transport and Civil Aviation on land owned by the British Transport Commission; work had been carried out on behalf of the British Transport Commission on buildings which were being constructed for the Ministry. The Surrey County Council had acted as agent authority for the Ministry of Transport in constructing the A23 diversion, which went through the airport, and particularly through the terminal area. The Thames Conservancy had had an overall interest in the major waterways around Gatwick. The local authority and the local inhabitants (represented by their consultative committee) had also followed the progress of the work.

133. In addition, a job of this nature and size which was of news interest attracted visits to the site by representatives of newspapers, broadcasting and television companies, associations and institutions, often in large numbers. All these points had a bearing on the number and type of site staff to be employed.

134. Many of the points to be made about supervision also applied to liaison. In the development of the concept, the works carried out had been very diverse. They could be covered broadly under the headings of civil engineering, building, structural, electrical, and such other contracts as demolition and tree felling. The works on the airport had covered the whole area of approximately 700 acres.

135. The access on the airport to the various sites had not always been straightforward. Works had been carried out outside the airport boundary, 4 miles to the west and 4 miles to the east of the airport. It had therefore been necessary to bear these points in mind when considering site staff.

136. Co-ordination had been emphasized by Air Commodore Mann. Eighteen direct contractors working with ninety-six nominated subcontractors had been employed on the site. In some cases a subcontractor had worked as a direct contractor; a direct contractor had worked as a nominated subcontractor; subcontractors had worked for more than one direct contractor.

137. There had also been works by the local service authorities, such as water and gas undertakings. Work by the G.P.O. had been carried out as a contract directly between the G.P.O. and the Ministry, not coming under the resident engineer's direct jurisdiction.

138. Apart from the contractors directly engaged on the airport, there had been works carried out by Surrey County Council through the terminal area and the airport work had had to be co-ordinated with that of the County Council.

139. At the peak period of construction at Gatwick an Engineer's site staff of forty had been employed. This staff had comprised engineers, an architect, surveyors, inspectors, and office staff, such as secretaries, typists, drivers, and chainmen. It had also included a number of overseas students who had been in this country to gain experience of work here.

140. The site architect had been mentioned in the list of site staff. At Gatwick there had been an example of the architect, who was appointed on the recommendation of the engineer, being represented on the site by a site architect on the engineer's staff. This had proved to be a most successful way of maintaining a liaison and co-operation on the supervisory side, and it had played a great part in the completion of the work on time.

141. The work had been carried out in 2 years, in weather which had been particularly unkind to the contractors dealing with large volumes of clay over large areas. The figures of rainfall for July–August–September in 1956, 1957, 1958, and 1959 were interesting: 7.83 in., 9.57 in., 10.47 in., and, this year, 2.46 in. Most of the clay filling had been placed in that period in 1957, with a rainfall of 9.57 in.

Mr F. W. Spencer (Senior Engineer (in charge Airport Section), Scott & Wilson Kirkpatrick & Partners) observed that the Authors had said that the location of the high-speed turn-offs was such that the majority of take-offs were likely to be in the westward direction. What proportion of take-offs were likely to occur from each direction? That would have a bearing on the type of layout adopted.

143. At first sight it had seemed that the intention had been to develop in the future a staggered parallel runway layout, but this was obviously not the case, because the railway was located in such a position that this could not be done. Taxying distances appeared likely to be excessively long, and one was tempted to conclude that the intention of the planners was to ensure that the aircraft could taxi straight up to the railway station! He thought that the terminal area would have been better located in a more central position, possibly near the control tower or somewhere between there and the east end of the runway, where the greater proportion of the take-offs was likely to occur. A spur line could have been constructed from the terminal area to the railway station, or a road access provided. That would have had the effect of providing a more balanced layout and little would have been lost in the way of passenger dispersal to the railway.

144. It also seemed to be unusual to divorce the control tower from the terminal area. Presumably there had been some overriding consideration which had compelled the planners to adopt the layout used. Could the Authors give some indication of the

special factors which had had to be taken into account? The Authors had referred to the testing programme. They had mentioned that under the bearing test, five out of eleven cracks had occurred at load classification numbers between 70 and 85. The age of the concrete was not stated, but it could be inferred that the factor of safety was nearly equal to unity.

145. The shoulders had been constructed of 14 in. of gravel, 4 in. of dry lean concrete, and 1 in. of surfacing, making 19 in. altogether. Allowing for the slight increased strength of the dry lean concrete, it might be said that the total depth was effectively equal to 21 in. If this were related to the design curves, using CBR3 as a basis, this was equivalent to a load classification number of 16 to 20, yet the Authors stated that the bearing strength of the shoulders was slightly less than half that of the runway. Would they explain the basis of their design?

Mr A. F. Smith (Assistant County Engineer of Surrey) said that the Authors had dismissed the road works in the Paper in two short lines, merely stating that the diversion of roads had been involved. As a road engineer he would not approve of such brevity, since about £850,000 had been spent on the road and ancillary works.

147. There had been criticism of the limited length of dual-carriageways provided on the new section of the London-Brighton trunk road. He emphasized that when the Minister had asked the Surrey County Council for their suggestions about the routes for the diversion of the trunk and other roads, they had strongly recommended that a part of the London-Brighton motorway should be constructed. Unfortunately, after the public inquiry the Minister had decided against this in favour of the rather more modest diversion which existed today. It was a pity that it had been necessary to economize to that extent on the road works, but all that was past history.

148. The road contractors had been Tarmac Limited of Wolverhampton, and they had commenced work in January 1956. In spite of very adverse weather they had been able to complete the road diversions sufficiently to enable the traffic to be diverted to the new trunk road by the agreed date, 1 August, 1957.

149. CBR-tests on the clay had indicated that it would be unwise to design on a value of more than 2½%, which would require a construction thickness of not less than 28 in. of flexible pavement. Alternative tenders had been sought, one for a lean rolled concrete with a 4½-in. hot rolled asphalt surface superimposed, and the other for the Minister's traditional specification of 4,000-lb. concrete, constructed in bays with similar black top. It was interesting to note that the accepted tender for the lean rolled concrete had been £16,000 cheaper than that in the traditional specification.

150. To some extent the road works had been a large-scale experiment in this class of work. In the first instance the specification for the lean rolled concrete had been 15:1, but during the construction minor cracking had been observed and it had been concluded that, to reduce this cracking, it might be desirable to reduce the cement content. Eventually cement in the lean rolled concrete had been reduced to 5%.

151. No cracking had appeared in the leaner mix of concrete before the black top was placed in position, but more recently a crack survey had indicated that it was almost impossible to differentiate between the two types of construction. None of the cracking so far observed could be considered detrimental, and all that could be said at this stage was that 25% of cement had been saved.

152. Three bridges had been constructed. The new bridge over the River Mole had a 50-ft skew span. Eventually it had been carried out with a prestressed concrete deck. In the first instance an ordinary reinforced concrete structure had been specified, but the contractor had asked for permission to construct a prestressed deck. Permission had been given, on condition that the Council approved the design. The design had been approved and the prestressed deck was provided at exactly the same price.

153. Subways had been constructed under the new road to carry pedestrians from the station to the airport site.

Mr W. A. Lewis (Road Research Laboratory) pointed out that in § 32 the Authors

had said that from the results of various compaction tests on the soils encountered, it would be seen that any attempt to specify compaction in terms of the Proctor compaction test would have been very difficult to interpret. From this he deduced that the Authors had not much faith in the standard laboratory compaction test for controlling compaction in the field. They had used the air voids basis.

155. Many years ago the Road Research Laboratory had been the first to suggest this method to overcome the problem resulting from the presence of various soil types on a particular job, but this method had been subjected to some criticism from engineers in this country. Would the Authors comment on this point? Did they feel that the Proctor method of specification was not as good as it was claimed to be?

Mr K. J. Surridge asked for information on the cost of the L.C.N.75 runways and aprons and, if possible, a split showing the cost of excavation, the preparation of the subgrade, and the preparation of the concrete slab and the joints as a percentage of the total cost.

Mr R. P. Whiting (Senior Engineer, Scott & Wilson, Kirkpatrick & Partners) said that he had noted that the design of the concrete paving was based on the structural strength of the concrete at 6 months, and in deducing what this would be, two main assumptions had been made. The first was of the relation of the flexural strength of the concrete to the compressive strength, and the second was of the rate at which the flexural strength increased with time. On both of these two questions not much work appeared to have been done, and it was therefore most desirable to check assumptions that were made.

158. Nevertheless, it seemed that on the site the concrete had been tested only by compressive-strength tests and that no tests of flexural strength, such as beam tests, had been made. The Authors could perhaps point out that bearing tests made on the completed pavement showed that its L.C.N. was about what it was designed for, namely, 75. On the other hand, he noticed that whereas the pavement design assumed a concrete strength of 5,000 lb/sq. in. at 28 days, the histogram showed that the average strength in practice was about 6,000 lb/sq. in. The pavement might therefore be expected to be rather stronger than the design had intended. Would the Authors comment on this apparent discrepancy and its implication on the assumptions made in design?

Mr O. P. Edge (Director, Sir Alfred McAlpine & Son Ltd) said that no contractor liked to see a photograph of one of his—apparent—failures in the Institution Proceedings. Would the Authors describe the cause of the failure and the thought which had been jointly given on how to avoid such failures in the future?

Mr P. Caldwell (Engineer and Surveyor, Dorking and Horley R.D.C.) said that the airport was in his area. The finger pointed out parallel with Horley, and contained a large area of glass. For some reason, in the middle of the night—and apparently only in the middle of the night—aircraft increased their engine revolutions to screaming pitch at that position on the finger. This was the only time of the day that any noise was heard, and it was not often heard even then, but it was very loud on those occasions because of the reflexion of the noise off the finger. If all the traffic were on the other side there would be no trouble.

161. On the whole, there seemed to be very little trouble in the district from the airport. People had their grumbles, but these had subsided considerably and everything seemed to be working very smoothly.

Mr E. L. Leeming (Resident Engineer (Trunk Roads), Stretford Borough Council) suggested that the use of dowels as a means of carrying loads across a joint between concrete slabs either on runways or on concrete roads should be discontinued.

163. Over a considerable period in his own practice in concrete road construction, he had provided for all joints to be carried on a base or foundation slab, about 2 ft 6 in.

wide and 6 to 8 in. deep (Fig. 22). That gave adequate foundation support as the wheel load passed over from one slab to the other; the base slabs were laid in advance of the main slab and separation could be ensured by the use of waterproof paper.

164. The main advantage of that construction was that the joint was virtually watertight; water could not easily penetrate and weaken the foundation of the road. He could not recollect a single case of a failure, such as a corner or other crack with that type of joint in reinforced concrete construction.

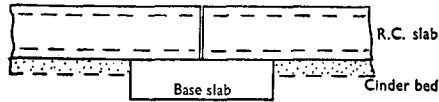


FIG. 22.

The Authors, in reply to Mr Viner-Brady's comment on the length of the finger and the distance to be walked, said that that length—880 ft—was similar to the maximum distance to be walked along the station platform at Victoria.

166. Liason with the Trade Unions had been good from the start. There had been little or no trouble with the workmen throughout, and this good record was largely due to the fact that there had been personal contact with the heads of the various sections. Interest had been excited at the start of the contract, with the result that the men had co-operated with the contractors and the Consulting Engineers. This was something which consulting engineers must do.

167. No speaker had mentioned the fact that 75% of the people going to or coming from Gatwick travelled by train; it was an airport served principally by a rail connexion to its city centre. That had been the original conception of Sir Alfred le Maitre, which the consulting engineers had attempted to implement; it appeared they had been successful.

168. Air Commodore Mann had highlighted a very important facet of airport construction in referring to the necessity of meeting the advance requirements of all the technical branches. The first lesson learned had been the old lesson about sound planning in the early stages, in which each party in the project put over to the other parties what they required. It was not enough to write letters. It was necessary that the technical men should fully understand each other. The telecommunications engineer was very different from the civil engineer and used a different phraseology. They must ensure that they understood each other, for although they were both technicians, they used different terms and put a different meaning on the same terms. A closely integrated team was required. It was not possible to build airports with committees; they could be controlled by committees but not built by them. The answer was found in responsible small committees and small working groups for a given design job.

169. Plain speaking was also essential. Mincing words would never get anywhere in a project of this nature. In this instance the consulting engineers had been honest all the time and had not deluded either themselves or the client; in the long run, the client had deluded no one, either. The engineers would have been happier had the G.P.O. work on the airport been under their control rather than the direct control of the Ministry. He realized that there were administrative and technical difficulties which had prevented this, but it would have made the work much smoother. The difficulties, however, had been overcome.

170. Mr Lister Rodger had rightly mentioned the number of visits to the site. More than a thousand engineers had visited the site during the construction, apart from visits by schools and other bodies. This was merely another aspect of the disturbances which they had suffered.

171. The statement by Mr Spencer concerning take-offs in a westward direction was correct; in fact, 70% were in that direction. The taxiing distance was long, but the airport had been conceived as one associated with a railway and the planning had been

bound by an undertaking given at the public inquiry that no development would take place on the east side of the railway line. This had forced the runway configuration into what Mr Spencer had rightly described as an uneconomical and unusual configuration, if only the geometric pattern were considered. An airport was not only a purely geometric pattern; it was a facility for handling passengers, and it was better to keep passenger walking and handling distances short and suffer longer aircraft travelling distances, as at Gatwick. Had it not been for the railway they would have reverted to the normal offset layout.

172. The question of location of railway station and terminal building had been thoroughly investigated. Trains serving the airport did not start or terminate at Gatwick; they stopped there, but they also provided a service to the south coast. To run the trains into the middle and out again would have been impracticable, apart from being expensive. It should be remembered that the Gatwick Racecourse Station already existed.

173. The divorce of the control tower was a functional requirement; the building had to be in the centre of the geometric pattern of the two main runways to give the aerodrome controller equidistant viewing to the four ends of the two runways. This had produced problems in communications. On balance its location was desirable, because the control tower area functions were dissociated from the terminal building functions. The Authors would always prefer to have a control tower separate from the terminal building, even if it were directly alongside it.

174. Turning to the L.C.N. value of the shoulders, there had been insufficient space in the Paper to explain that they had not taken the customary number of repetitions in the design factor. It had been assumed that the shoulder pavement was designed for limited use and for failure purposes; the assumption had been that 500 passes would provide the customary deformation on which the design had been based. On the reduced number of passes, the L.C.N. was 30 and not 16. This was making use of the customary logarithmic transition.

175. Mr Smith's remarks on the road diversion works, which the Authors could not describe in the Paper, were welcome and they had hoped a Paper on this aspect of the work would be presented. The Authors would always use the air-void method for determination of soil compaction, if possible; they did not believe that the Proctor method was any use for this kind of work.

176. Mr Surridge had asked for costs; the cost per square yard of pavement (including earthworks, but excluding drainage, electrical ducts, and other associated works) was 77s. In this cost the earthworks and subgrade preparation represented 37·7%; concrete slab, including lean-mix base, membranes, etc., 48%; and joints 14·3%.

177. Mr Whiting had asked if the Authors had checked their assumptions on relation of flexural strength, cube strength, and the actual gain of strength on the job. The following tests had been made to evaluate the various relations:—

200 flexural strength tests on laboratory-prepared beams.

186 compressive tests on beam ends for equivalent cube strength.

120 compressive tests on cores cut from pavements.

52 correlation tests on beams, cylinders, and cubes.

From these it was found that the relation flexural strength/cube strength was slightly lower than estimated, and this had been compensated for by the higher average strength in cubes, giving a correct pavement strength.

178. Mr Edge had raised the question of failure of the expansion joints. These few failures were due to the non-alignment of the medium-quality hardboard topping to the chipboard joint filling after compacting and finishing machinery had passed. This had allowed bridging between the two sections of the runway. A small but significant length of joints had been cut out and replaced.

179. The Authors' present thoughts, when constructing expansion joints in a dowelled pavement, were to stop the construction with dowel bars projecting, starting the new construction 2 ft away with dowel bars also projecting and returning to concrete the

expansion joint later. They would probably put abutments in the ground in the 2-ft strip to hold that section of the runway in one location and to stop the tendency for the expansion joints to "caterpillar" up along the runway, evidence of which had been found in America.

180. Mr Leeming had queried the possible use of slabs for load transference. The Authors agreed that these were useful in certain special circumstances, but could not agree that they should generally be used in place of dowelled joints. One of the differences between a road and an airfield pavement was the number of longitudinal joints required. In a road, either these were not necessary, or only one was required along the centre. For a 150-ft-wide runway several were required (nine in the case of Gatwick). For an L.C.N. of 75 the main concrete slab, even reinforced for crack control, would require to be at least 12 in. thick. It was probable that at least 15 lb/sq. yd of reinforcement would be required. The cost of this reinforcement and the numerous base slabs would make the method very expensive. The placing of a very large number of the small base slabs under the pavement would cause considerable delay to the progress of the work.
