

The Heads of the Valleys Road

A. S. COOMBS & L. W. HINCH

The above Paper was discussed in Cardiff on 17 November, 1969, and in London on 9 December, 1969. The report covers both meetings.

Mr A. S. Coombs

The scheme was completed in 1966 but was conceived in 1945, and since then there have been six Divisional Road Engineers of the Wales and Monmouth Division of the Ministry of Transport, in whose area the road lies. I went to Wales as DRE in 1963 and was there when the first Secretary of State for Wales, with complete autonomy for roads, was appointed.

87. New roads, particularly this one, have their problems in the planning, design and construction stages, but I have also to live with this completed road and with the many day-to-day problems that arise from its use.

88. The road, even with increasing traffic flow, has now an accident rate well below that given in the Paper (in 1968 it was 0.47/million vehicle miles), which makes it much safer statistically than a motorway. This relative safety is due perhaps in no small measure to the adverse publicity which has been given to it by the press and by local authorities along its route, both individually and collectively, so that most of the drivers using it are fully aware of its hazards and drive accordingly. The real reason is I think that the road has been deliberately designed and built as a three-lane road and not just widened from a substandard two-lane road. This has been done in the past and has provoked much criticism, which in many instances has been justified.

Cardiff meeting

Mr D. Farrar, County Surveyor, Glamorgan County Council

I am concerned with the maintenance of part of this road. Under 'Carriageway' (§ 28) there are references to differences in the type of specification of the surfacing on the steeper parts of the road towards its western end, compared with the remainder. Here 100% lake asphalt was used in the surfacing. Was there a large price differential between that 100% lake asphalt and the 50/50 lake asphalt/residual bitumen mixture which was used on the remainder of the road? If there was, could the Authors say whether the extra lake asphalt which was used on the steep parts was worthwhile?*

90. The Pant Viaduct is constructed of steel beams with composite deck. There has been some cracking of the asphalt at the joints of this bridge. In general, the joints and the backs of the abutments have stood up remarkably well but there is a little trouble at the joint at the free end and water is leaking through. As all the other bridges are trouble-free, could either of the Authors give the reason for this? Is it due to the difficult ground conditions that pervade the immediate area of the Pant Viaduct or to the greater temperature susceptibility of the exposed steel in the construction of the deck? In all other cases concrete was used.

Mr R. H. Daniels, County Surveyor, Breconshire County Council

Would the Authors comment on the adequacies of the design standards for this three-lane carriageway, and whether, in view of the long delay which has occurred since the inception of the scheme and the date of completion, opportunities should not perhaps

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* This point was also raised at the London meeting by Mr K. E. Ainscow of Rendel, Palmer and Tritton.

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have been taken to have it up-dated? Would they care to comment on whether the design is adequate for a 20 year period from completion or whether, if they were doing it again, they feel some other form of design should be adopted?

92. I would also like their comments on the adequacies of the roundabout junctions, in particular those on a fairly steep gradient. Are these to the right size or could they not profitably be replaced by some form of grade-separated junction?

93. Netting has been provided in the rock cuttings to contain any rock falls. Unfortunately, if the netting is brought down to the level of the carriageway to contain the rock, it offers a temptation to the local inhabitants to do rock climbing with the assistance of the netting; if, however, the netting hangs free of the carriageway, the rocks fall on to the narrow verge and some find their way on to the carriageway.

94. I would also like to raise the question of the design of maintenance facilities, particularly for such things as drainage culverts. Some thought ought to be given at the design stage to providing access for small plant to carry out the cleansing which needs to be done periodically. Shale flows down the very fast mountain streams and this presents a maintenance problem which will increase in the future.

Mr D. P. Cartwright, Borough Engineer and Surveyor, Newport

What was the range of the cost/sq. ft of the structures from the minimum to the maximum?

96. In passing this comment I appreciate that it is easy to criticize. This was a marvellous project but I would query the retaining walls that have been erected. It seems rather a pity that some stone facing was not used as it might have improved their appearance.

Mr S. A. Vincent, formerly Agent for John Morgan on Stage 1

Much is made of the structures and I would like to pay tribute to the Resident Engineer, Mr Johnston, and his staff, who dealt with the day-to-day problems of the many different soils encountered during the excavation. The varying moisture content of sand makes it very tricky to handle, and this also applies to shale and old fine coal deposits from the mining tips on the line of the road. I feel that the Resident Engineer's and the Contractor's staffs made a very skilled technical job of the muck shifting along the full length of the road.

98. The problem of retaining the slopes and the height of the retaining walls required is not now appreciated when driving along the road. It was only at the excavation stage that the reason for some of these very high and extraordinarily thick retaining walls was apparent.

99. At the suggestion of the Architects for the bridges, Alex Gordon and Partners, rough-from-the-board formwork was tried for facing at one point. On Stage 1 about 200 sq. yd were used but when the extra cost was considered we went back to plain facing.

Mr R. Colquhoun, Messrs Brian Colquhoun and Partners

What were the factors which had to be considered in the choice of the different types of bridge construction from one location to another, and in particular, what were the deciding criteria in each case and to what extent did aesthetics influence the choice of the design?

101. Also, following an earlier question, it would be very interesting to have some more detailed indication of the unit costs based on the whole cost of the structure, including abutments but excluding approach embankments or ramps, divided by the product of the distance between the abutment faces and the width between the kerbs.

102. It appears that the method of constructing the open spandrel arches was such that it was essential that two carriageways approached each other from opposite banks;

they had to be joined in the centre. It is interesting to note that the two arches were constructed simultaneously and there were four falsework carriages, rather than two carriages constructing one arch at a time as is a more usual method. Was this a programme requirement or what determined this method?

Mr J. J. Liptrott, formerly DRE (Wales and Monmouth Division), Ministry of Transport

A few years before the present works were started, I was engaged on widening and improving the old Black Rock Hill. It was realized then that the road should have been put along the tramway to effect any real improvement. It would, even then, have been a two-lane substandard road and as this was before the days of the various trunk road Acts which allow 100% Government expenditure it was quite out of the question at that time.

104. On the present work I should like to comment on the standards adopted. A very even gradient of 1 in 20 has been obtained for four miles and I think this is the main feature of the job. In the Clydach Gorge there is just room for three lanes and a dual carriageway would be quite out of the question. If any further relief is needed in about 20 years' time a parallel road somewhere else will have to be considered.

Mr W. J. Ward, Borough Engineer and Surveyor, Swansea

There is no reference in the simple sketches of how the half viaduct in the Clydach Gorge is tied back to that part of the road which is on the rock shelf. It is possible that it is self-stable and that tying back is not necessary, but as there are horizontal curves in the gorge an explanation would be helpful.

106. I would also like to ask if the Authors are able to enlarge on the site investigation mentioned in §§ 22-24. I would ask if a little elaboration could be given to the way in which the site investigations were carried out and analysed. The Ministry, the Welsh Office, and no doubt the Scottish Office, have gone to a lot of trouble recently to emphasize the need for recommended procedures for site investigation, and I would like to ask the Authors whether, in the light of their experience in this scheme, more could have been done. Have there been some patent lessons in this scheme arising from site investigation which would be useful for future reference?

107. Would the closing of the railway over the Merthyr Bridge enable it to be used to cut out another right turn on the road?

108. A number of bridges have original features. As rationalization of bridge design is obviously looked for, has there arisen from this scheme some particularly economic method of construction which could be adopted elsewhere?

Mr H. G. Barnes, Sidney Green and Sons, Contractors Ltd

With most bridges of concrete construction, I think the carriageway was at one time given its own concrete slab. The asphalt was laid on the concrete slab or the concrete slab itself was used as a running surface, independently of the structural concrete.

110. In the case of the bridge over the Taff River and many other bridges constructed now, the asphalt surfacing is placed directly on the structural concrete with, of course, a waterproofing layer of mastic asphalt or a membrane between. This is much more sensible and efficient, but, particularly in large spans and perhaps more particularly when the spans are formed of precast units, the question of levels arises and it is difficult to work to close tolerances.

111. I noticed how accurate the levels had to be in the case of the long bridge over the Taff River, with a 1 in 200 longitudinal slope. Although this principle of cutting out an extra layer of concrete is right, the design should be such that there should be a regulating course deliberately put in. Surely the structural concrete can be constructed efficiently to realistic tolerances which will give a perfectly satisfactory

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structure and are within practical limits? Small variations can be adjusted with the regulating course and the surfacing can then be put on top. It seems that the tolerances allowed in bridge construction might be more realistic on bridge decks. *One day I presume that even the asphalt will be made thinner, with something like $\frac{1}{2}$ in. of epoxy resin bonded directly to the concrete, as in a recent prize-winning design for a temporary flyover.*

Mr P. Rushton, Messrs Brian Colquhoun and Partners

The footbridges were particularly good in their appearance and in the way they blended into their setting. One must make a grudging tribute to the Consultant's Architect who had the aesthetic knowledge to separate the arch from the deck in the open spandrel arch bridges.

113. I would like to ask a question on the controversial three-lane carriageway. Britain is now adopting a 12 ft lane width which will be adjusted slightly on conversion to metric. This road is, I believe, 33 ft wide, i.e. three 11 ft lanes. Should our standards for three-lane carriageways be revised? Would it be better to use a dual carriageway with four 10 ft or four 11 ft lanes or should we perhaps allow an extra width to give that extra margin of safety where three lanes are used?

114. Has there been any traffic growth on the road and consequently an indication of the extent to which the developmental requirements of the area are reflected in this growth?

115. The 1 in 16 $\frac{1}{2}$ gradient was obviously necessary on a particular part of this road. Are there any accident statistics which may indicate that 1 in 16 $\frac{1}{2}$ is too steep for an all-weather road?

116. I should like the Authors to indicate further what made them choose a composite construction for the Pant Viaduct.

117. Expansion joints have been dealt with very well indeed. They have been cut down to a minimum of one, and in some cases cut out altogether. It is a pity that it is impossible to avoid using them in every case as they are a big problem in bridge construction, and there appears to be, as yet, no satisfactory answer—the list of failures of expansion joints is quite considerable. I would like to ask what problems, if any, have arisen over the joints and what remedial methods were used, with special reference to the joints on the Pant Viaduct?

London meeting

The Chairman, Mr J. L. Paisley

There are two particular points on which I should like the Authors' views. They mentioned the significantly high level of the road, running for several miles above the 1000 ft contour. What was the provision made for dealing with ice formation on the road, e.g. the frequency of depots, and the scale of vehicular provision in the depots? Also, what is done to deal with snow clearing, which would seem to be possibly a difficult problem in the gorge, with the likelihood of drifting? On the open sections, has any use been made of snow fencing?

119. With regard to traffic, the three-lane road is much castigated these days. In the early 1960s, when the construction of this road was imminent, the old road was carrying something over 4000 vehicles/day, and it is now carrying about 7000. What sort of life do the Authors anticipate for this road before it becomes significantly overloaded, not in terms of design capacities but in terms of the practical capacities they think it would carry?

Mr K. E. M. White, Christiani and Nielsen

I wish to confine my remarks to the bridges constructed by Christiani-Shand on stages 2 and 3.



Fig. 19. Bridge 2

121. In the 17½ miles of road there were 41 bridges and a number of cattle grids and culverts. The access to these bridges was difficult in view of the mountainous terrain and wetness of the Welsh climate.

122. There were numerous types of bridges; thirteen were of flat concrete slabs, with only one or two of any other kind. All the bridges required individual temporary works which were designed on site, except for the carriages and prestressing for Taf Fechan, Nant Hir and Taf Fawr, which were designed in our London office. The Sirhowy bridge, supported on Shorload, is typical of the temporary works used on these contracts.

123. Bridge 33, a flat concrete deck slab 5 ft deep in the middle, was supported on r.s.j.'s to take the heavy deadweight and span the road and stream.

124. Bridge 36 has one of the hollow concrete box decks, allowing systematic construction by carpenters, steel-fixers and concrete gang. This is a very good form of bridge.

125. Bridge 2, built on a skew, has a concrete beam and slab deck with diaphragms and a curved soffit underneath (Fig. 19). The density of steel was such that the main bars were butt welded. Where the diaphragms and the main beams intersect there is also extra hinge steel over the piers, making the fixing of the steel reinforcement very difficult. All the shutters for these skew bridges had to be worked out in detail to accommodate the angle of skew, fall in road, road camber and curved soffit, which made the bridge deck construction take longer and cost more than expected.

126. The wing wall for bridge 1 has two re-entrant angles in plan. Several changes of level in elevation required special shutters, and this was unduly complex.

127. The aqueduct was a very nice design using precast pretensioned units, post-tensioned over the piers.

128. The maximum deflexion near the centre of Taf Fechan Bridge was 11 in. and cables were stressed during the casting of the last section in cantilever (Fig. 20). Several methods of erecting the carriages were considered. Scaffold towers were

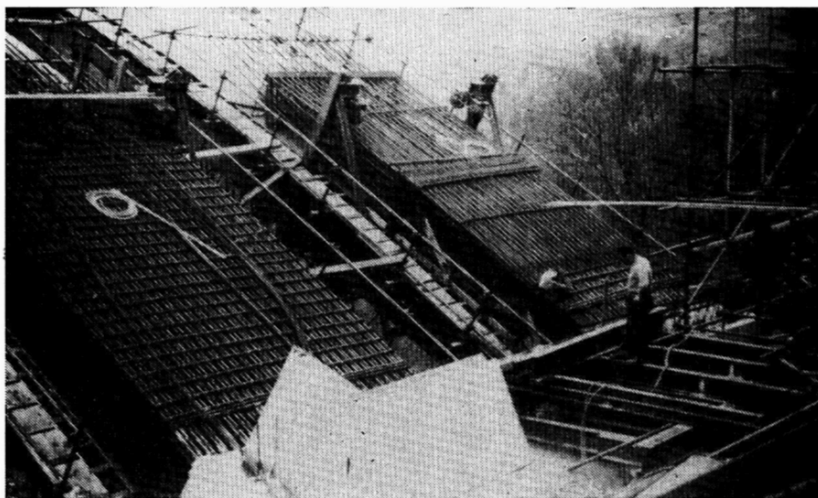


Fig. 20. Taf Fechan Bridge

eventually used to support the ends of the carriages here, and Rendhex columns were used at the middle for Nant Hir, letting the carriages cantilever out over the reservoir. The Engineers designed slender ribs, 3 ft 7 in. at the springing and 2 ft 6 in. at the crown, so that the Contractor would have as little weight as possible to support. I think the resultant heavy reinforcement was the right answer but it produced quite a problem in placing the concrete.

129. The 1 in. strands were each stressed to 6 tons, as by keeping to a constant figure there was less likelihood of human error. This system also gave a good deal of flexibility in applying exact loads to the arch ribs ensuring that the applied moments never exceeded the moments of resistance of the arch ribs.

130. Several ways of erecting Taf Fawr Bridge were considered, by means of derrick, tower crane, and crawler crane, before deciding on the NCK 605 and access roads cut into the bank. On the west side the access was very difficult and a carriage was needed to position the units.

131. One of the disadvantages of this precast form of construction is that there are a large number of starter bars to be cast into the moulds in the casting yard. We used 1 in. strands which had to be pulled from one end through to the other for stressing. When the length exceeded about 85 ft the cables had to be winched through the ducts. At Medway the Macalloy bars were similarly stressed from one end to the other over the pier, requiring the use of temporary anchorages for early movement of the carriages. At Ferrybridge there were torsion boxes over the piers containing anchorages which avoided the restraint on movement forward of the carriages.

Mr J. E. G. Palmer, Consultant, Rendel, Palmer and Tritton

My comments deal with the early days, as it is about 20 years since I was responsible for the road work of Rendel, Palmer and Tritton.

133. The original location of the job was carried out in 1945 by Mr J. A. Potts, a most experienced location engineer, whose name should be recorded. I was apprehensive when I saw his proposal to build this road along what seemed to me a somewhat treacherous mountain side. I feared that the steep hillside, especially after long periods of heavy snow, might tend to slide down on to the luckless travellers,

and called for an independent opinion from Dr Anderson, the Professor of Geology at Cardiff University. He, however, assured us that there was no need to worry. Nevertheless, I notice that Mr Hinch has decided to install protective wire netting.

134. The other important point in the early days was traffic intensity. I tried hard to persuade Mr J. F. A. Baker, then Divisional Road Engineer at Cardiff, that a dual two-lane carriageway was necessary up the Clydach Gorge, but he was adamant that his traffic forecast did not even justify three lanes. However, in the end it was agreed to build a three-lane highway but I still think that now is the time to start a survey for the next two lanes in the Clydach Gorge. Perhaps Mr Coombs would tell us what he now forecasts as the intensity of traffic in the gorge in 1980, and also in 1985.

Mr R. H. Daniels, County Surveyor, Brecon

Snow fences have been mentioned but very little trouble has been experienced on this road on the open mountain sections, as the snow seems to blow fairly clear. There is quite a problem in the gorge and on those sections which are protected from the wind but where there are accumulations of snow. Three lanes do make it very difficult to clear the snow, inasmuch as one always has to move quite a large volume to one side of the road or the other, and with the three-lane carriageway and traffic moving in two directions, this is very difficult indeed. I shall be very interested in the answer to the question concerning the siting of depots and the provision of these for a road like the A465 as compared with the very much more substantial provision made for motorways.

136. I think that the effect on industry and the social environment is not always taken into account in assessing the traffic volumes. We have found since the road has been built that quite a lot of industrial development has been attracted to the Brynmawr area. People generally do not want to live at this elevation and there is a tendency to choose the rather more pleasant parts of the valley which are now quite a short distance in journey time. I think therefore that we shall find a build-up in traffic. Do the speakers think that three-lane carriageways are generally being built in other countries? The accident record for this road is very good but I do not think that three-lane carriageways are finding much favour either in the US or on the Continent.

137. I am not sure whether the Authors are entirely satisfied with netting for controlling rockfalls. Because of the difficult nature of the ground the verge width has been very restricted, so that any rockfalls that occur come straight on to the carriageway. It is very difficult country with shattered rock, and I think some better treatment of the rock faces is necessary.

138. Much of the land alongside the road is open grazing, and the responsibility of a highway authority for fencing should be mentioned. Some sections were not previously fenced; some have been fenced as part of the Contract for construction; others remain the responsibility of private owners; but, strangely enough, it is always through the portion for which the highway authority is responsible that the sheep gain access to the road, with consequent claims!

Mr M. Springett, R. Travers Morgan and Partners

The Paper described two features of design which by recognized standards are not normally acceptable today. First the road consists of a single carriageway three-lane construction, which one is led to believe is accident prone and should be avoided. In addition vertical alignment standards are below the recognized minima as laid down by the authorities. There is a gradient of 5% over a length of about 2 miles, and one of 6% over a distance of 1 mile.

140. However, the Paper states that, although it is a single carriageway three-lane road, the accident figures indicate that the safety record is equal to motorway standards. Furthermore, experience seems to indicate that most vehicles are not severely

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restricted in speed by the long steep gradients. The conclusion appears, therefore, that it is possible to produce a purpose-built road which does not necessarily comply with current rigorous standards but which is entirely acceptable and functional.

141. With regard to the problem of defining acceptable gradients in difficult topographical conditions, it would be interesting to know how limiting gradients were determined. Were travel loss factors on steep gradients taken into account and balanced against construction costs? Also, do the Authors consider that, in the light of present stringent design standards, the authorities today would accept a new road to their standards?

Mr A. A. Osborne, G. Maunsell & Partners

Was the lane marking introduced for the overtaking of slow traffic on steep gradients, or for visibility on the curves?

143. Although the Paper gives some information on blasting I should be glad if the Authors could give more. I am interested in the maximum single charge used in blasting rock near to the adjoining road and at what minimum distance such blasting necessitated the closure of the adjoining public road. Was any advantage found in using micro-second delays to diminish complaints from the public?

Mr R. W. Bishop, W. V. Zinn and Associates

The Authors are to be congratulated on a most interesting Paper describing the construction of a road which provides a much needed link between South Wales and the Midlands.

145. A road over rugged mountainous terrain with variable geological conditions presents many problems. Unless a detailed soil survey is carried out, with boreholes at very close intervals, it is difficult to incorporate precise details of every requirement in the contract drawings, and much has to be decided as the work is progressed.

146. It would be interesting to know how much detail was provided in the contract drawings for this Contract. For instance, the road through the Clydach Gorge was excavated into steep sidelong ground with embankments on the downhill side supported in places by retaining walls. Did the contract drawings show precise details of each retaining wall or merely typical cross sections, leaving the exact lengths and heights to be decided when the ground had been opened up?

147. Again, in a mountainous country where rainfall exceeds 60 in./year, drainage is a problem. Of course, the road itself acts as a huge cut-off drain, trapping water streaming down the mountainside, and this water has to be collected and carried across the road in culverts. Was the exact location, level, and size of each culvert shown on the contract drawings or settled on site?

148. Cut slopes in rock were designed to $1\frac{1}{2}$ vertical to 1 horizontal, and embankments 1 vertical to $1\frac{1}{2}$ horizontal. It would be interesting to know who met the cost of overbreak beyond the designed slopes and the making good of slips.

Mr J. E. Barnes, Ministry of Transport

One of the burdens the engineer carries is that as soon as his job is finished and open to the public that public forgets the difficulties that have been overcome in the planning and construction of the road.

150. From the DRE office we worked closely with the Consultants on the extremely wide range of problems which emerged. About 450 property interests were involved in Stages 1 and 2, ranging from ICI to hill squatters. Both these stages were got through without a single Inquiry, but the cost was a great deal of personal care expended on individual interests and apparently minor problems. This must be the lot of the engineer in piloting future schemes, particularly in urban areas.

Mr K. E. Ainscow, Rendel, Palmer & Tritton

I feel there are one or two points which perhaps might bear further explanation. Those of us who have had to do with specifying road works would be very interested to know whether, since the road was opened to traffic, there has been any evidence of the relative worth of different types of binder used in the rolled asphalt wearing course surfacing.

152. For my own part, I am always very keen to pick up other people's experience on the use of lean concrete bases, with particular reference to reflexion cracking problems, and any measures found necessary to overcome these problems, if in fact they arose on this job. Could the Authors give some further information on this point?

153. In § 51 it is stated that 'Blasting was restricted to periods when children were attending a nearby school'. Was this at the request of the teachers or the pupils?

Mr P. R. Hart, Project Manager, M. M. Dillon Ltd, Toronto

I was particularly interested in § 11 of the Paper. Single three-lane carriageways certainly do have their critics from the road safety aspect, and it has been my experience that the accident rate increases disproportionately, at a greater rate than the increase in vehicular traffic on these facilities. I cannot, therefore, agree that a single two-lane carriageway would have undoubtedly proved to be more dangerous and would have restricted free traffic movement on the steep gradients.

155. Did the Authors investigate the construction of a two-lane facility with climbing lanes on the steep gradients, thus creating a two-lane 'up' and one-lane 'down' situation in these locations? This would result in a safer road and a saving in costs, and in the removal of the undesirable 'use at your peril' centre lane of a three-lane carriageway.

Mr A. Gordon, Alex Gordon and Partners, Architects and Planning Consultants

I would like to add my congratulations to the Authors on their Paper. It has been my privilege to work with Messrs Rendel, Palmer and Tritton since the commencement of design of the Heads of the Valleys Road almost 20 years ago. Indeed, some of the bridges were designed in the early 1950s and it is a pity that they could not have been built at that time.

157. It is to be remembered that 20 years ago honest, simple engineering structures were rarely permitted to 'stand on their own feet' and often had to be given cosmetic architectural treatments. From the commencement of our association with Rendel, Palmer and Tritton, it was our joint wish to avoid such a dishonest and unnecessary approach and to collaborate together to produce sound engineering, which was also pleasant to the eye in its own right.

158. A word on the manner in which the working arrangements developed may be of interest. In the early days the tendency was for designs to be developed to quite an advanced stage before being submitted in a formal manner to the Architects for their consideration and comment. As time went by, the consultations took place earlier and earlier in the design operation until, finally, it was not uncommon for the Engineers and Architects to talk over together the problem to be solved in a particular situation, the Engineers explaining the abutment conditions, etc., and the engineering form most suitable for the situation, while the Architects might ask whether, in the light of the environmental situation, another form might not be considered. The Engineers often undertook to investigate these alternatives, but the Architects made it a rule that they would never press for a general form for a bridge, unless the Engineers confirmed that it was sound from an engineering point of view and the most economical.

159. During the development of the designs, consultation ultimately took place

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over the drawing board and formal meetings over 'presentation drawings' in conference rooms were left far behind.

160. I have learnt a lot from my association with the Engineers and have been most grateful for the opportunity to be involved.

Mr H. G. Clapham, Ground Engineering Ltd

The Authors are to be congratulated on a clear well written Paper.

162. In the section given to site investigation it appeared that additional information to that obtained in the investigation would have been very useful both in design and construction of the works. Two particular cases mentioned were the recovery of soft shales in the vicinity of some sludge beds and the location of solution caverns at Cefn Coed bridge site.

163. With a project of this magnitude the Authors must have had considerable time to assess all the information that ideally would have been required from a site investigation and also to form their opinions on the best methods of obtaining such information. Could they give some guide lines so that the experience gained on this Contract could be made available for the planning of future investigations under similar difficult subsoil conditions?

Dr G. Davies, Department of Civil Engineering, University of Nottingham, formerly Section Engineer with Rendel, Palmer and Tritton

I write as one who was involved in the construction of Stage 2 of the Heads of the Valleys Road, and who is also a fairly frequent user of the road.

165. At the time of construction when various bits of the new road were opened to traffic, one appreciated the tremendous improvement in the ease of travel, and nowhere was this more noticeable than on Black Rock. However, as the initial advantages fade in memory, one cannot but be disappointed by the road's many shortcomings.

166. As the Paper points out, this is difficult country in which to build a good road: both the terrain and the weather are difficult. Indeed in such country suitable alternative routes are hard to come by, and any route chosen must not only satisfy the requirements of the near future but also take into account possible long-term developments. This is naturally difficult, but nevertheless of great importance in this kind of terrain. Road developments to satisfy long-term traffic demands should not be seriously prejudiced by the presence of existing routes, either in terms of capital cost or the cost in delays of what will then be a considerable volume of traffic. The open moorland does not present serious problems, as the existing road can be widened as and when required. However, the problem of improving the road for major valley crossings such as Cefn Coed is a much more difficult problem.

167. More critical in these terms is the Clydach Gorge and Valley, which incidentally carries the greatest volume of traffic. There are strong reasons for believing that this section should have been built as two separate carriageways probably at split levels. However, this would have given rise to steeper gradients on the upgrade carriageway if the existing route were followed, unless the traffic flow between Saleyard and the Clydach Viaduct were reversed, which is quite possible since bridges or viaducts are required at either end. However, if the route had followed the same side of the valley as the railway no such reversal would be necessary.

168. The Authors in § 11 indicate that the only factors taken into account in deciding on a three-lane single carriageway were cost and forecasted traffic density. These criteria may be generally applicable elsewhere but the very nature of the difficult terrain, the poor visibility, the steep gradients and slow heavy traffic suggest that a dual carriageway solution should have been seriously considered between Gilwern and Brynmawr. It is almost certain that were this section to be built today, it would be a dual carriageway. What in the Authors' opinion would have been the extra cost of this improvement had it been carried out during the construction of Stage 1?

169. It would be interesting to know whether the Welsh Office has any plans to improve visibility on those parts of the road where this is now poor, and also for building a dual carriageway in the Clydach Valley. As the latter project is inevitable well before the end of the century it would be interesting to hear comments on what the Authors consider to be the best solution.

170. However, having decided to build a three-lane road it is surprising that the horizontal alignment should in some areas follow the minimum sighting distance of 750 ft so slavishly, a noticeable case being from Gilwern to Saleyard, or again in utilizing the Tafarnaubach railway cut. Here one worryingly swerves from one limiting curvature to another, making overtaking quite hazardous.

171. The consequence of accepting a three-lane road with poor horizontal alignment is that for extensive lengths it is only in effect a two-lane road, with compulsory single-lane working in one direction in some areas of poor visibility, and in both directions at most T junctions. Matters appear to have been made worse in some sections by the use of open timber fences along the top of embankments, reducing visibility which would otherwise be good, this being particularly noticeable climbing from the Brynmawr roundabout. In this area some small mining spoil heaps occur between the road and the stream. Had these been removed the visibility would have been very much improved. It is to be hoped that future road projects in South Wales will not be considered in isolation but as providing the opportunity to improve the adjacent environment to mutual advantage.

172. I would be grateful if the Authors would comment on the percentage of the length of the road which is either subject to minimum sighting distance (and less), and those lengths which now have hazard traffic lines due to junctions, etc.

173. The design and detail of the bridges is noticeably sensitive, the arch bridges in particular fitting beautifully into their valleys. It is a great pity that this same sensitivity has not been applied to the rock cutting through Cefn Coed, which still looks gaunt, being bare of shrubs or any vegetation even five years after completion.

Mr Coombs and Mr Hinch

The Chairman and a number of other speakers have referred to the capacity of the road. When the road was designed traffic projections justified only a single two-lane carriageway, but because of the steep gradients it was considered that an additional overtaking lane would be worthwhile, and this has been proved in practice.

175. On the eastern part of the road there was a 20% increase in flow between 1965 and 1968, which is the national average rate of growth. By projecting the existing flow at this rate the volume would be 16 500 vehicles/day in 1980 and 18 500 vehicles/day in 1985. The three-lane layout may not, therefore, be adequate for a 20 year life but it is expected that some of the longer-distance through traffic will use other routes now under construction such as the new Midlands Road and the M4 extension, in order to reach the Swansea area.

176. Some of the roundabouts are too small and grade separation will need to be introduced in the future. Had the road been designed in the 1960s instead of the 1950s grade separation would have been provided at the more heavily loaded roundabouts and junctions.

177. The Authors consider that a single two-lane carriageway carrying the same volume of traffic as a single three-lane carriageway is likely to be more dangerous because of the greater overload and because the absence of an overtaking lane can cause bunching of vehicles with consequent excessive local overload. The third lane, with suitable markings, has made two lanes available in the uphill direction on the steeper gradients. In the Authors' opinion there is still a place for properly designed single three-lane carriageways where the predicted traffic flow is not expected to exceed the recommended capacity of the road.

178. The wisdom of adopting 12 ft wide lanes for a three-lane road, as suggested

by **Mr Rushton**, is open to question, as the width of the road would then be sufficient for four cars to travel abreast with dangerously small clearances.

179. The accident record does not show that the 1 in 16½ gradient is particularly dangerous in itself, but accidents have occurred at a T junction on this gradient due to a conflict between right turning vehicles and fast moving vehicles overtaking on the hill.

180. The Chairman and **Mr Daniels** have raised the question of winter maintenance, and **Mr Daniels** has referred to the problem of snow clearance. Snow fences have not yet been provided but the situation is being closely watched and, where justified, fences will be erected in the most effective positions. In the gorge ice is more of a problem than drifting snow, but the equipment available is adequate to cope with both ice and snow. There are winter maintenance depots with salt hoppers, patrolling Atkinsons, and Macks with high wing V-ploughs, at about 10 mile intervals, at Brynmawr, Dowlais Top and Hirwaun, and on the whole a high standard of winter maintenance is assured. The spacing of the depots compares very favourably with that on motorways where the depots are at approximately 12 mile intervals.

181. **Mr Daniels** is correct in his assumption that the Authors are not entirely satisfied with the netting provided on some of the rock slopes. His use of the word 'rockfalls', however, suggests that large falls of rock are expected. In fact, the purpose of the netting is to channel the fall of small pieces of rock dislodged by frost on to the verge and the near side of the carriageway. It would have been prohibitive in cost to face a 100 ft high cutting, and grouting would have caused a high build-up of water pressure.

182. In answer to **Mr Osborne**, the double white line lane markings in the gorge were originally provided on two curves where visibility is restricted and were later extended to provide an overtaking lane in the uphill direction.

183. Traffic on the old trunk road was stopped whenever explosive charges which could cause rock to fall on the road were fired. The weight of charge depended on the type of rock, its bedding and jointing, and the distance from the public road. The minimum charge used was about 15 lb at 1-1½ lb/hole, fired by millisecond delay detonators.

184. **Mr Farrar** and **Mr Ainscow** have each asked about the use of 100% lake asphalt. The additional cost of this over 50/50 lake asphalt/bitumen binder was about 1s/sq. yd; this increased the total cost of the surfacing by about £9500 or 10%. The omission of the bitumen undoubtedly increases the resistance to skidding, but it is not possible to equate the additional cost to any savings resulting from a reduction in the number of accidents. Due to the delays to the programme caused by the severe winter of 1962/63 much of the surfacing had to be carried out in the winter, and there was a noticeable tendency for the 100% lake asphalt to skin over more quickly, making the rolling in of the precoated chippings difficult.

185. If unit costs of structures (requested by **Mr Colquhoun** and **Mr Cartwright**) are to serve any useful purpose for comparison or estimating, they must be derived on a rational basis from the total cost of the structures including their share of the preliminaries and finishing items, and be applicable to most types of structure.

186. The problem is illustrated in Fig. 21 where the two bridges at (a) and (b) perform identical functions. If the not unreasonable assumption is made that the total cost of each bridge is the same, and if the unit cost is based on the actual deck area, then the cost/sq. ft of bridge (b) is 2½ times that of bridge (a). However, a road which is to cross over the cutting in Fig. 21(c) can be built only as far as the tops of the cutting slopes on each side before the bridge is constructed. If, then, the total cost of the bridge is taken to include the cost of all works required to close the gap between the tops of the cuttings, the unit costs of the bridges at (a) and (b) can be directly compared, the effective length of the bridge in each case being as shown in (c). The total cost of the bridge should include the cost of any wedge fill, road base and surfacing within the gap.

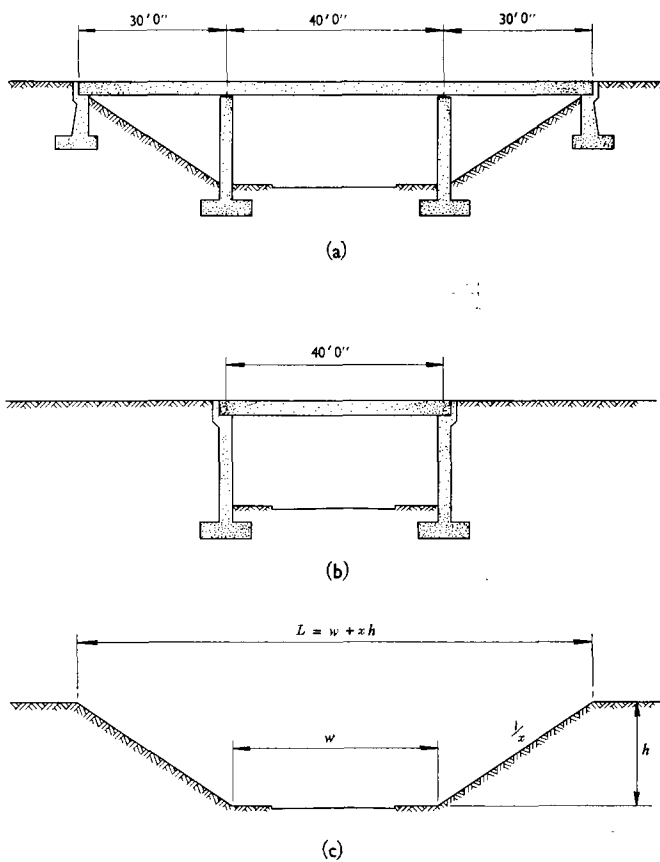


Fig. 21

Table 5. Unit costs of bridges

Bridge	Cost, £/sq. ft	Bridge	Cost, £/sq. ft
New Usk	9.2	Taf Fechan	7.4
Clydach Viaduct	2.4	Taf Fawr	7.2
Garn Lydan	5.4	Nant Ffrwd	9.1
Garn Lydan footbridge	5.0	Nant Hir	8.4
Sirhowy	5.8	Nant Melyn	6.7
Pant Viaduct	7.2	Tower Colliery footbridge	9.7

187. In comparing unit costs, however, it must be remembered that where bridges form only part of an extensive roadworks contract, overheads and profit are not always distributed uniformly over all items of work. In six tenders recently received for a major road project, the cost of the structures varied from 35% to 46% of the total cost of the works; within the normal range of unit costs of £5–£10/sq. ft the unit costs would thus vary by as much as 30s to £3/sq. ft, depending on which tender was the lowest. The unit costs of the large bridges, calculated by the method described in § 186, are given in Table 5.

188. The first part of Mr Colquhoun's contribution has been answered by Mr Gordon in § 158, but with regard to the construction of the arch ribs, four falsework carriages were used to complete the bridges as quickly as possible to improve access.

189. In reply to **Mr Ward**, the deck of the half viaduct is not tied to the rock shelf, but is supported in the manner described in § 35 and amplified by Fig. 8.

190. The site investigation, also referred to by **Mr Clapham**, was carried out by shell and auger boring, diamond drilling and shallow trial pits. More information applicable to earthworks problems can now be obtained by the visual examination of continuous cores of soil and rock than by laboratory testing of undisturbed samples taken at intervals from a shell and auger borehole, although laboratory testing is still necessary. In addition, the Authors favour a much more extensive use of deep mechanically excavated trial pits.

191. **Mr Barnes** has raised an interesting point regarding tolerances on concrete bridge decks. There appears to be no reason why bridge decks cast on centering cannot be laid to the same tolerance as a concrete road slab, but in span-by-span or cantilever construction the use of a regulating course would perhaps be justified to improve the running surface.

192. Mr Farrar and Mr Rushton have referred to the design of the Pant Viaduct. Because of poor ground conditions, composite construction was adopted to reduce the load on the foundations. The joints between the deck spans were covered with Rigidflex and the rolled asphalt surfacing was laid continuously from end to end. It appears that the movement has been greater than this method can accommodate and that it would have been better to have adhered to the original intention of cutting out a 2 ft wide strip of rolled asphalt and replacing it with rubberized mastic asphalt. The joint at the west abutment is a comb type and is not intended to be waterproof, the water being collected in a channel below and carried away in pipes through the embankment. It is possible that these pipes are blocked.

193. In reply to **Mr Bishop** full details of all retaining walls and culverts considered necessary were given on the tender drawings. The Contractor met the cost of over-break only beyond the slopes which were determined by the Engineer when the nature of the rock in each cutting was known. Payment for the making good of slips followed normal contract procedure.

194. The facing of the retaining walls with masonry advocated by Mr Cartwright would undoubtedly have improved their appearance. The cost of the facing, however, was high (£6/sq. yd), masons were in short supply and the speed of construction would have been reduced because the concrete could only have been placed in 3 ft lifts behind the facing; this would have placed severe restrictions on progress in the gorge where most of the walls occur.

195. The arrangement whereby blasting was restricted to periods when children were at school was, contrary to Mr Ainscow's suggestion, proposed by the Engineers to ensure that the children were under supervision in a known location while blasting was taking place. The children, whose powers of penetration would rival those of demonstrators at Cardiff Arms Park, would have much preferred a grandstand, or even touchline, view of the proceedings.

196. **Dr Davies** and several other contributors have commented on the alignment of the road. The alignment in many places is not in accordance with current standards, but it should be remembered that the alignment was fixed at a time when

visibility standards were much less stringent, and the limited funds available for road construction at that time made it imperative that the cost of the project should be kept within bounds. The Authors consider that, when a new road is designed, its alignment should not be based on a predetermined speed standard less than the permitted maximum, which is now 70 mile/h, but that lower speed limits should be set on those sections of the road where the desired visibility cannot be obtained. On a section of the Clydach Gorge a 50 mile/h speed limit has been introduced because of restricted visibility and a concentration of accidents. On other sections the situation is being watched and if necessary and practicable, visibility will be improved to match the speed of traffic. About 25% of the length of the road has sight distances below that specified at the time for a speed of 60 mile/h.

197. The nature of the structures and the terrain near Cefn Coed would, it is agreed, make it difficult to widen the road, but this particular length carries the lightest volume of traffic on the whole road. In 1968, 5220 pcu were recorded, which at national growth rates would not reach the capacity of a two-lane road until 1985.

198. The widening of the road in the Clydach Gorge does, however, present a much greater problem. The Authors agree with **Mr Liptrott** that a parallel road elsewhere will have to be found. The Merthyr–Abergavenny Railway was not abandoned in time for use as part of the new road in the gorge, but, in any case, the problems in converting it to a road would be infinitely greater than those obtaining further west where the line of the railway was used. An alignment to the north of the old road was, however, investigated in 1947 and this, suitably modernized, could no doubt be used.

199. It is difficult to estimate the additional cost of constructing a dual two-lane carriageway between Gilwern and Brynmawr without a considerable amount of detailed design work, but the Authors believe that, had it been built as part of the original scheme, the additional cost would certainly not have been less than £1 m.

200. With regard to the rock cutting through Cefn Coed, the Authors are not sure what **Dr Davies** has in mind. The rock is a hard quartzitic sandstone which will not weather quickly, but eventually it is thought that some vegetation will become established. The alternatives of facing the cutting slope or flattening it to receive topsoil would have increased the cost and would not, in the Authors' opinion, have been justified.

201. In answer to **Mr Springett**, it was considered that the steep gradients climbing out of the Taf valleys were preferable, in the circumstances, to the long detours which would have been necessary to maintain the ruling gradient. As road expenditure is now less restrictive than when the road was designed, the Authors are quite sure that, if the road were designed today, it would be more in line with present standards.

202. The Authors are grateful to **Mr White** for the additional information he has given in respect of a number of the bridges and assure him that the type of bridge referred to in § 125 has not been and will not be repeated.