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7882 DISCUSSION

Planning and design of the Hong Kong Mass Transit Railway

J. T. EDWARDS

Mr Edwards

The ferries, trams, buses and minibuses in Hong Kong are privately owned and make profits. Against such a background it is understandable that the MeTRo had to be financed on a commercial basis of fares paying for both capital and running costs. This will make it unique.

53. The detailed design of underground works is much influenced by the method of construction. Although each contract has 50–100 drawings issued with the tender documents, showing the general arrangement of the required works, the contractor is responsible for the detailed design and working drawings. As detailed drawings are not prepared for the tender the conventional Bill of Quantities is not possible. A method has been developed based on fixed activities which are lump sums for discrete parts of the completed works, and variable activities covering items such as compressed air, ground treatment and different types of tunnel linings which will be ordered by the Engineer.

54. Conditions of Contract were developed from the ICE Conditions and a method of measurement devised based on the above activity concept. The INTERNET project control system is being used so that by estimating the percentage of completion of each activity each month and applying it to the activity, the value of work completed can be determined. The same input to the control system is also used to provide progress reports at intervals as required.

55. As an additional source of revenue the space over Kowloon Bay depot is being developed as a commercial venture. A concrete deck will be constructed over most of the depot on which will be built 5000 flats and communal facilities to form a miniature town of 25 000 people.

Mr P. E. Garbutt, London Transport Executive

The Author has referred in his Paper to London Transport's involvement in the planning of the Hong Kong Mass Transit system in respect of operations and layout. We in London Transport feel that we have been able to make a positive contribution to this work.

57. Essentially, in the planning of an urban passenger railway, there are three basic factors; the traffic demand, the engineering constraints and the operating requirements. The first two are usually given most attention. Despite the mumbo jumbo that sometimes surrounds it, the problem of aligning an urban railway to carry the main traffic flows is not one of great difficulty in large and concentrated cities which do not have any existing underground railway lines. The precise level of traffic that will be attracted may be difficult to estimate, but the route that one should adopt is usually clear from the

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existing main surface traffic corridors. The engineering constraints may well present severe difficulties, but at least these are acknowledged and some hard thinking is put into resolving them.

58. Unfortunately, it is the third factor, the operational requirement, which tends to be more neglected in the planning of new urban railways. In London Transport we are frequently consulted by state and city authorities overseas on the planning of new underground systems, and with the accumulated experience of over 100 years, we feel we are almost uniquely qualified to advise them. Among other things, LT can claim that its originators made almost every known mistake of layout in developing the London Underground. The lessons learnt have been applied in later lines, in particular the Victoria Line, and the Fleet Line now under construction.

59. Regrettably, London Transport often seems to be consulted when the layout of a new system has already been fixed, and there is little real opportunity to alter it. The result is that serious operational problems are created which usually stay with the system for the rest of its days. Faults of layout which cause such problems include (*a*) building lines with too many branches, or with branch junctions too close to the central area of the city, or with branches having uneven traffic loads; (*b*) building interworked lines, using the same pairs of tracks and providing through services from every branch to every other branch, rather than segregated lines with the easiest possible passenger interchange between them at transfer stations; (*c*) building circular railways, which can rarely be justified in traffic terms in the usual radially developed city, and which have inherent operating drawbacks; (*d*) developing lines without provision from the start for rolling stock maintenance and stabling depots of proper size and correctly sited for their purpose.

60. Fortunately, in the case of the Hong Kong Mass Transit Railway, London Transport was brought into the planning from the very start in 1966–67, through the persons of Sir Alec Valentine, former London Transport Chairman, and Mr Harold Hutchings, who was for many years Assistant Operating Manager of the London Underground. In the later more detailed work, further experienced London Transport personnel, both active and retired were involved in the Hong Kong project, among them Mr Anthony Bull, London Transport's Vice-Chairman, and Mr Gordon Maxwell, former Operating Manager (Railways).

61. The result of all the planning effort expended will, it is hoped, be an operationally well conceived Metro system for Hong Kong, to the planning of which London Transport has been proud to contribute.

Mr A. Saunders, Kleinwort Benson Ltd.

My organization and Freeman, Fox and Partners share a client in the Hong Kong Mass Transit Corporation. Our role has taken the form of providing advice on the structure of the Corporation itself in the early days, on the financial packaging, and on the cash flows which are involved in formulating a financial proposal that is acceptable to the international capital market from which funds are to be raised, and which is within the broad revenue earning power of the project.

63. We have become involved in the financial evaluation of tenders, advising on the kind of currencies, prices and terms of payment. This is significant in this case because of the heavy reliance on export credit and the fact that there is a different export credit agency for each nation, making a different financial offer.

64. We hope the confidence of the Corporation will continue in the future and that we shall continue to advise the Corporation, jointly with Wardley's, a subsidiary of the Hong Kong and Shanghai Bank, on financial aspects as they go through this very impressive and bold project.

Mr G. B. O'Rorke, PWD, Hong Kong

As a former project manager of the Shatin new town, I believe I can offer some clarification of § 8 which states that the proposed Shatin Line was dropped in 1969. Although the Shatin Line was not required by the design year of 1986, it will be needed eventually.

In 1973 a new government housing project was adopted which involved the accelerated development of new towns in Hong Kong including Shatin. As the Author has stated, earlier construction of the Shatin Line has therefore been under examination, but this has been in conjunction with improvement of the Kowloon Canton Railway which already serves Shatin. It would be useful if the Author could say something about how the mass transit railway has been planned to fit in with the Kowloon Canton Railway and other forms of transport such as buses and ferries.

66. As a further point of clarification, I would mention that the length of the system in Fig. 3 extending beyond built-up areas is, of course, to serve areas being developed at the time of the further studies.

67. Although the text only describes underground construction, Fig. 5 shows some of the system above ground. I believe that such a design is also proposed for much of the later stages, and some description of the proposed type of construction would be useful. As the Author is no doubt aware, concern has been expressed by some in Hong Kong about the possible adverse environmental effect of noise from the railway operating above ground in built-up areas, and I should be grateful for his views on this.

68. Conscious as I was of the very thorough feasibility studies described in the Paper, when I was being shown the Montreal Metro under construction in 1968, I inquired what investigations had been carried out there. Some borings were then described to me, but on saying that I was inquiring more about the basis of the decision to proceed, I was told 'Oh, Mayor Drapeau promised that if he was elected the Metro would be built'! Would the Author care to comment on the extent of the investigations and other deliberations made before the construction of the Hong Kong Mass Transit Railway started?

Mr G. J. Easton, G. Maunsell and Partners

It is the practice on the continent of Europe in many of the recently constructed rapid transit systems to provide very much more space in the stations than generally applies on, say, the London Underground system. During peak periods in London, platforms become so crowded as to appear dangerous. Has any reflexion of the continental practice been incorporated into the design of the Hong Kong system? Space underground is of course expensive and the Hong Kong system is designed for very large flows of passengers. It would be of interest to know how the balance between safety and cost has been made in this situation.

Mr J. O. Tresidder, Freeman Fox and Associates

I was very interested in what Mr Garbutt had to say about there being no need to resort to detailed planning techniques to decide on the alignment of metros. I would agree, having been involved with him in planning these types of systems. On the system of the traffic estimates, though, I disagree. I would like to endorse the Author's point where he emphasizes the importance of a sound assessment of potential traffic volume in the planning of the system.

71. The public transport planner is immediately confronted with the sheer volume of travel and the dependence of the traveller on public transport. The original surveys indicated that as an overall average, public transport accounted for over 75% of all personal trips in Hong Kong. Moreover, the amount of public transport travel was increasing at a faster rate than population growth—a feature which many operators in Britain would greatly welcome. Usage of public transport vehicles was even higher than in cities with existing underground railway systems, bearing in mind it was only a bus and tram system that existed at that time. Passengers per vehicle mile, for example, were found to amount to a figure of 14, while in London the equivalent figure, including the Tube, is less than 6. Coupled with this situation was a rapidly increasing car ownership. Although only about 7% of all households were car owners, as compared with about 40% in London, the number of vehicles per mile of road was extremely high. In fact from international statistics only Monaco and Gibraltar had more. This

combination of a large number of vehicles per mile of road with rapidly increasing vehicle registration, coupled with very high urban densities and shortage of developable land, was clearly creating a situation of extremely congested traffic conditions requiring drastic action.

72. As far as the techniques used in making the predictions of public travel are concerned, the usual process was adopted of establishing the relationship between present travel and such planning characteristics as population, vehicle ownership, employment, household type and family income, and then forecasting future demand on the basis of new values for the expected future population and levels of employment. As one might expect, this presented unusual problems in Hong Kong. It was found, for example, that land use was not clearly defined as between residential and commercial usages and in many areas was at variance with the building regulations—domestic buildings being used for business purposes and business premises being used for residential purposes. Although this situation presented problems for the mechanics of technical analysis, it is a form of land use distribution that is very helpful to public transport in that an even distribution of population and employment leads to an equal balance in traffic in either direction. It may be of interest to note the very high density of over 1000 persons/acre as compared to figures of about 250 at the maximum in London, and very high employment densities of well over 500 employees/acre. The average household was also found to contain 5·1 persons as compared with 2·6 in London.

73. These represent the 1965 level of development, and the colony was expected to increase from 3·5 million then to 6·9 million population in 1986. There were plans for vast government building programmes and expectation of rapid economic growth at an annual rate of about 7%, and so one wonders how Hong Kong managed to exist, let alone grow and develop, without a metro system long ago. There can be little doubt of the future success of the metro in attracting traffic, and I should like to menton one point in relation to this.

74. One feature to take into account was the opening of the cross harbour road tunnel in 1972. Since it was to be operated on the basis of a toll development to maximize revenue rather than to maximize traffic, this meant that the ferries could be expected to continue to operate. The great success of the tunnel and the subsequent growth shows that people are prepared to spend money on better and quicker travel. This has been especially so in Hong Kong where the volume of cross harbour traffic, both by car and by bus, has surprised many people, including at an earlier stage, the Government.

Mr G. G. Kibblewhite, Kennedy and Donkin

What is remarkable about this project is that having been for six years, as it were, looked at in every way, the route alignment is still more or less as it started. Much advice has been given over the period as to what changes could be made, but what is being built today is the original spine of the system from the depot across the harbour to Chater.

76. I would draw attention to the number of people which it is intended to move over this system. The only way this can be done is by bringing a large train in by the system and to produce a headway of about 2 min., although we hope to get less than that. It is only by this means that one can get this vast number of 90 000 people/h in one direction.

77. It is also clear that the whole system has to be designed to move these trains with minimum interruption. Mr Garbutt mentioned the operation problem. The only way in which one can get to minute headways is to minimize the time the trains spend in the stations, to give the maximum acceleration away and the maximum braking to stop, and then at the end of the system to turn them round in the minimum time. This may be the first system in the world to produce a clear 2 min. headway from the start.

78. Recently I was in Sao Paulo where they put a similar system to work, but I regret to say that due to difficulties with automatic gear they have not yet achieved a 2 min. headway. Only 15 s lost in turning a train round means that the number of people referred to in the Paper cannot be accommodated.

Mr E. G. Brentnall, Kennedy and Donkin

There are two systems of signalling control, *viz.* a fail-safe train control system, providing automatic train working, with protection against collision; and a superimposed train driving system.

80. The safety control systems depends on certain modulated frequencies of track circuits, giving train speeds of 45, 65, and 80 km/h. When a train leaves a station, the switch to start is given by a man on the train. The train then moves automatically, depending on the state of the line ahead and reaches the highest permissible speed. The control for stopping in a station is effected by the train driving system, from lineside points at which an instruction is passed to the train antenna either to coast, to brake, or possibly to accelerate, depending on the requirements of the system. If the line is occupied ahead, the track circuit frequencies reduce and the brakes are applied automatically if the train does not obey the speed restriction controls. The system is such that any train will come to a stand with at least one clear section between it and the obstruction.

81. There is overall control for the train driving system from the central control office at Kowloon and a controller can give extra instructions: for example, if he wishes the train to accelerate faster than the driving control normally allows, in the rush hours, providing, of course, that everything is safe and clear. In the depot, there is a different and simpler form of signalling. Movements will be controlled still, but by men on the spot.

82. As mentioned earlier, the train control system operates on fail-safe principles. The controls from the track circuits are picked up inductively on to the train and there mixed in with speed measurement made from all four axles of a car, with the highest reading being taken. If the speed at a point is more than 2 km/h higher than the scheduled speed, the brakes will be applied.

Mr E. H. Cuthbert, London Transport

My remarks concern questions on the design. Reference is made to design criteria, and I should be interested to know what are the minimum radii and maximum gradients on which the layout was based. I envy the designers of this line starting with a clean sheet, and being able to produce the sort of diagram shown in Fig. 6 to arrive at an optimum width of vehicle. London Transport starts a new line with many constraints. I should be interested to learn what design clearances are provided between the load and structure gauge, and how it was arrived at, whether a kinetic envelope was used in the design of stock plus some air space or if the structure gauge was reached on more traditional lines.

84. Reference is made to the submerged tube of an all-concrete design, but with steel plate used for externally waterproofing the bottom. That follows a reference to the unsatisfactory life of steel possibly through corrosion. Perhaps the Author could say a word on this section. The steel does not appear to be shown in Fig. 8. Could he describe how the whole tunnel section was waterproofed if only the bottom was steel plated?

85. Reference has been made to the track design being as quiet as the more conventional design, the design proposed being a continuously supported rail on a resilient pad. Were any other precautions taken to reduce the noise and vibration to be experienced by the passengers in the trains? In London there are noise reflecting precast concrete slabs at the side of the track, and experiments have been carried out of spraying absorbing material on the inside of the tunnel lining. Is anything of that sort proposed in Hong Kong?

86. There was no mention directly of building work and finishes in the programme. I take it that they are going on concurrently with the track work and electrical and mechanical work. I would be interested to know whether the civil engineering contracts include all finishes, or whether separate architectural contracts have to follow the

civil engineering. One of the problems in project management is to get the work flowing smoothly, and it seems there would be great advantage if civil engineering and building work finishes could all be included in one contract. Has that been attempted? Perhaps something could be said on the project management arrangements for the work.

The Chairman (Mr I. M. Campbell)

With regard to the question of noise, it was implied that this would not be a problem. Mr Cuthbert asked whether there was any coating or other special arrangement with the side walls. Is environmental pressure in Kowloon rather less vociferous than in London and Glasgow, where I am particularly concerned at the moment? Apart from noise, are there any criteria for vibration limitation in these built-up areas?

Mr J. Cartmell, Kennedy and Donkin

One thing which, rather surprisingly, has not been mentioned, is the question of safety and emergency operating procedures. A joint working party on the Hong Kong Railway has been set up by Freeman Fox and my organization to look into this aspect. We have to consider, of course, every conceivable eventuality that might arise on the railway, whether it is in the underground section or overhead section, and whether the breakdown (or what it may be) causes any one of a whole variety of effects which may not immediately be apparent to the train operator and others in the vicinity. It is very difficult in looking at these rules and regulations first to keep a clear head, and not be panicked into restrictive measures that prevent the normal running of the railway when, after all is said and done, we hope there will not be emergencies every day of the week. At the same time, we have to consider situations in the tunnel on the occasions when incidents occur. Would the Author care to say a little more about this aspect?

Mr B. Wex, Freeman Fox and Partners

It is perhaps a strange reflexion of the current pressures of professional life that I should be asking my partner, Mr Edwards, technical questions when I see him once a month at partners' meetings. Unfortunately it always seems that matters other than technical questions bedevil us at these times, so I apologise to him for raising matters which might otherwise have been discussed in private.

90. My interest is in relation to the immersed tube tunnel and his comments upon steel. My background is primarily one of hanging steel structures, i.e. bridges, up in the air where there is plenty of oxygen and some water to assist rusting. The Author mentions the question of steel tunnels and says that he feels no satisfactory solution really has been found to the question of proofing them against corrosion. The same problem gave me some thought at the time when I was involved in the building of the Hong Kong cross harbour road tunnel, where the contractor constructed an alternative design using steel which acted virtually as an external shutter for the wall of the tunnel. Since the tunnel itself was buried under decomposed granite or backfill, it was probable that only very limited corrosion of the steel could take place, since the source of oxygen was cut off.

91. For the new tunnel one could check to make certain that sulphate reducing bacteria were not in evidence and this presents quite a strong argument that corrosion under suitable backfill would not be a problem. Furthermore, the maintenance of internal steel surfaces should not be too difficult with modern coatings. Thus it seems that a contractor might see a steel tube as an economic solution as was the case for the cross harbour tunnel.

92. What then I wonder would be the reaction to an alternative design based on an entirely steel structure, since I assume alternative designs from the contractors are permitted.

Mr K. R. Northgreaves, Freeman Fox and Partners

I have been closely associated with the project for the past five or six years. There are a number of interesting features concerning the design on which I should like to comment.

94. This will be the most heavily used railway system in the world. All aspects had to be examined afresh, and there were problems in the design of the stations, particularly with regard to the concourses. Each platform has escalators along its length, and in order to feed the escalators it is necessary to have a large concourse. It was not possible to create the concourse on one end of the station only; the design of the structure favoured a large concourse.

95. In dealing with this very large number of passengers, it was necessary to take the railway to the passengers, and not make the passengers walk to the railway. In looking at the layout of Hong Kong, one sees attractive wide thoroughfares along which it would be easy to put a railway, but sometimes they were one or two blocks away from the load centre of passengers. Consequently, it was necessary to put the railway in awkward places in order to serve the community.

96. Hong Kong is a town where a large amount of reclamation takes place in order to increase the available land area. Over the years the shoreline has extended out into the harbour, and building construction has taken place. The result is that many streets are beyond the old shoreline, and are really right out in what used to be the sea.

97. I should like finally to ask the Author what alterations he would make if he were to undertake a similar exercise again, other things being equal, and how would he tackle it?

Mr J. F. H. Tyler, Transmark

Mr Kibblewhite mentioned a point in regard to the running of intensive services. It is true that the limiting headway depends on the turn-round time at terminal stations. I should like to ask the Author whether consideration was given to making the terminals into through stations by a loop at the end of the line.

99. Secondly, there is reference to a maximum traffic capacity of 30 trains/h (2 min. headway) providing the station dwell time does not exceed 30 s. The trains will no doubt have good acceleration and braking. In these circumstances one would have expected that the minimum headway would have been nearer 90 s.

Mr Garbutt

In response to Mr Tressider I had no intention whatever of denigrating the great work of traffic estimation for new urban lines, which is a vital exercise. What I was trying to point out was that many new underground railways abroad are started without proper consideration for operating requirements, and get saddled for the remainder of their existence with operating faults.

Mr J. T. Edwards

Interesting points have been raised by speakers, many of which I do not feel competent to discuss.

102. **Mr Garbutt** referred to the work done by London Transport over the years. The lessons which they have learned from their predecessors' mistakes over many years can be applied in quite different situations. We have often met the view that while it may be all right in London, it will not work in Hong Kong. This has been harsh, because the fundamentals of working trains satisfactorily do not change because the passengers or the operators have a different colour of skin or because the climate is different. They may not be absolute physical laws, but they are well established principles and if they are not followed, trouble will occur. I am sure that he can quote examples from around the world of people who have thought they were improving for the better, but their results have not come up to expectations.

103. **Mr Saunders** mentioned the necessity of producing a financial package which

is acceptable in the capital money market, a situation also applying to construction insurance. I personally have known occasions where bright ideas suggest that things can surely be done better or differently merely because the project is large, only to find that the world capital money or insurance markets run on rigid guidelines and it is impossible not to go along with them. The Mass Transit Corporation had to raise this large sum of money commercially and therefore it was enormously important to prove that the money would earn its keep. Although the banks required a guarantee (in this case from the Hong Kong Government) that their loans would be repaid, nevertheless, the Corporation had to show that it was possible for the loans to be repaid from revenue before the capital was forthcoming.

104. **Mr O'Rorke** quite rightly points out that the Shatin line, which extends from Diamond Hill northwards, was not cancelled but deferred. The Kowloon–Canton Railway terminus was transferred in November 1975 to a new terminal at Hung Hom which has been designed so that the railway will eventually run beneath it, with escalator connexion. The track is planned to thread between the station piles. This East Kowloon line, which will eventually go up to Shatin and which will provide an interchange with the Kowloon–Canton Railway will, I think, not be built until after the Island and Tsuen Wan lines and will be a good few years ahead; in the meantime, the Kowloon–Canton Railway (KCR) goes past Kowloon Tong Station, and is in a shallow cutting. It is quite feasible to build a halt there, and the KCR is setting up a joint planning group with us to decide how it will be done. It will be built in conjunction with modernizing and doubling of the Kowloon–Canton track which is only single track at the moment. A couple of miles further on from Shatin is a Chinese university with 8000 students, a high proportion of whom live in this built-up area. They will be able to come down on the train, change at Kowloon Tong and come right into the city on the Metro.

105. The other point concerned the overhead sections. The line is underground to Choi Hung where it comes out through a cliff face to a section which, in the first system, runs to the station at Kwun Tong; all that length will be overhead and will be the only overhead section in the whole system. For obvious reasons the depots have to be at ground level, and therefore there is a short section at ground level on each side.

106. The important feature of the overhead section is that although the area is very densely built up, the route is down a wide dual carriageway lined with industrial buildings set well back from it on each side. Immediately behind them is a dense area of flats, creating an extremely large captive population, giving an ideal situation for building an overhead line. Rotterdam has an overhead line running close to blocks of flats, but they have had few complaints. The system has a prestressed concrete structure with the rail resiliently mounted, with solid parapets at each side to contain the noise thus reducing sound emission to reasonable levels.

107. The preliminary investigation has been dealt with by **Mr Tresidder.** A substantial part of the 1965–67 period was spent in examining the traffic and results were reviewed in the 1969–70 period. There are few places where such very close attention has been given to the potential traffic and therefore the order in which the lines should be built.

108. **Mr Easton** raised a similar point. Many systems around the world, including Munich and the RER system were examined. It is true that they have a great amount of space; whether they are economically justified is not for me to say, but a civil engineer looking at an enormous cavern built underground in poor ground conditions knows it is not a cheap structure. Hong Kong, unlike almost any other railway system, has to repay its capital cost out of 'the fare box', in the American phrase. Paris does not do that and neither does Munich. Other systems were studied and lessons were learnt, but our approach is different because Hong Kong circumstances were different. The Hong Kong residents will be just as proud of the compact stations with modern, high-quality, functional finishes.

109. I should, however, like to emphasize the point Mr Tressider made about revenue. There are 190 000 people going through the cross harbour tunnel each day.

They travel on the bus for a flat fare of $HK1, i.e. 10 p, which will take them either 4–5 miles or merely through the tunnel. The shortest and cheapest journey they can make any other way (by bus, ferry and then another bus) costs 70 cents; hence they are paying 30 cents more for the speed and convenience.

110. The minibuses which carried 1 million passengers a day in 1970 have a fixed fare set arbitrarily according to what the market will stand. That from the Ferry to Happy Valley racecourse is 50 cents most days of the week but on race days it is $HK1.50. A $HK1 minibus fare along the island (probably the most common fare) is equivalent to a ride on tram or bus for 30 cents. So, people are paying over three times for the speed and for the seat. The Metro will give only 10% of them a seat but the journey will be faster. More important, in the summer it will be in an air conditioned train which will certainly attract passengers.

111. **Mr Kibblewhite** emphasized how little the routes have changed, although they have been looked at from all directions, in all possible ways and argued about endlessly. To be fair, one has to remember the geography. There are high hills a short distance from the waterfront, so there are restrained corridors, and choices are reasonably limited. Nevertheless, it is interesting that the initial work which was done has been supported in all the reviews.

112. The only other thing I would say in regard to his complaint about the hard way in which the electrical and mechanical engineers are dealt with by the civil engineer, is that it is of course the old, old story; but one should always remember that although holes may well take longer to build, they last a lot longer once you have built them!

113. The signalling system was described by **Mr Brentnall** but perhaps I might add that there are no red and green lights. The system is a great deal more sophisticated, and will be more effective.

114. **Mr Cuthbert** raised a number of interesting points on design criteria. When one starts the planning it is always a temptation to start off with the ideal. However here one had to start by stating the minimum requirement. The problem was complicated by the large number of passengers requiring the large trains which make minimum radii more difficult. The minimum radius figure adopted was 300 m, but like all hard and fast rules, there are a few exceptions. An interesting side line is that in a rather special overrun situation the minimum radius is 140 m, but this is not in an operational situation. The maximum gradient is 3% and stations are located on humps so that as a train leaves it has a down gradient, normally of that value, to help acceleration and a similar gradient leading up to stations assisting deceleration.

115. The width of the vehicle was not arrived at from Fig. 6. It was first fixed and the calculation justified the selection. It does not prove that the width of *exactly* 10 ft 6 in was right and at the same time it would be untrue to say that 10 ft 4 in or 10 ft 8 in would be hopeless.

116. The contract system whereby the contractor is given a reasonable margin of latitude for design contributes to the position that no loading gauge was specified. A kinetic envelope which would deal with the sort of train envisaged, including its suspension and all the other factors, was produced and a suitable structure gauge for the kinetic envelope was then devised.

117. As to the immersed tube, the waterproofing membrane is of bitumen and plastic. The structure is in prestressed concrete, and is not expected to leak. Steel has to be put on the bottom, because if bitumen or plastic are used there, they are bound to become damaged when the concrete is placed or when the completed unit is located on the sea bed.

118. In 1973 or 1974 when the shipbuilding depression looked like coming, Per Hall Associates did a design for an all-steel tube, because the proximity to Japan, with its enormous capability for building ships, might produce Japanese tenders for steel tubes. At that time there was as **Mr Wex** mentioned, the problem of corrosion. When the Japanese consortium put in a proposal in 1974 it was for a semi-steel tube, with sacrificial anodes, but they had not solved the problem of replacement. A detailed

investigation did not come up with any very firm answer. Tenders have been received, but they do not include an all-steel proposal.

119. The finishes to stations will be carried out concurrently with the electrical and mechanical work. The track laying is little affected by finishing. The prime contractor for each civil works contract is solely responsible for all the civil engineering and building finishes, and he is required to co-ordinate the work.

120. Anti-noise and anti-vibration measures for tracks tend to cost money. Hong Kong is a noisy place and the Chinese, with the greatest possible respect, like making a bit of noise themselves. While it would be wrong to give the impression that noise has been ignored, we are not in a position to take extreme steps to minimize it. As far as the trains and the passengers are concerned, sealed windows and air conditioning will keep out some noise and there is a solid car floor with no openings to get at equipment underneath; hence the passengers will have basically a quieter train. Normally there will also be many passengers in the train, and passengers are very good for absorbing noise.

121. As to external noise, I am afraid I cannot answer the point raised about noise levels. The Americans have done some work recently in establishing standards for underground railways but I know no-one who has really achieved what they think should be done. As mentioned earlier the overhead line is so located that noise should not present any problem.

122. The question of vibration transmitted to buildings is a much more difficult subject and organizations all round the world are spending a great deal of money on it. Measures have been taken in London and many other cities, and the improvement which can be obtained by spending quite a lot of money is very variable. In Hong Kong the Admiralty Station is a virgin site at present, adjacent to the central area, and when that station has been completed, it will undoubtedly have a large complex over it with hotels, offices, etc. in a very high rental district. The track will therefore be on a floating slab, that is a slab supported on rubber pads to minimize the transmission of vibration. This may be done at one or two other locations, but it will not be done generally. It is interesting that even on a system such as in Washington DC which is built to very high standards, they are providing a floating track slab only in sensitive areas (hospitals, government offices, computer rooms, etc.). It is very difficult to establish criteria which will be wholly acceptable to everybody without enormous cost.

123. Mr Cuthbert raised the question of programme and project management. Progress is monitored regularly by a central control consisting of the Consultants and the Corporation. It is hoped to keep such a close watch on the contracts that the terrible situation to which an underground railway is prone, where the whole is completed except for a vital bit in the middle and is thus utterly useless, will not arise. The system will detect trends of falling behind sufficiently clearly for something to be done. There is no bonus incentive scheme in the contracts, but there is a fairly high level of liquidated damages attached to specific key parts of each contract.

124. **Mr Cartmell** referred to safety. This has been at the front of our thoughts during the whole of planning. Not only has London Transport been involved, but Colonel Robertson, who was the Chief Inspecting Officer for Railways in the UK, is now consultant, keeping an overall eye on that aspect. The intention has always been that, although Hong Kong has no railway inspecting office set-up such as that in the UK, when the line is ready for service, it will be passed by Colonel Robertson as if he were inspecting it on behalf of the Department in Britain. He is also responsible for ensuring that the emergency procedures for all conceivable events have been devised and recommendations have been made to the Corporation who, of course, will be responsible for running the railway. It may be that the recommendations will not be accepted, but we shall be producing procedures which will deal with any likely emergency in relation to the equipment or the whole of the system.

125. On the immersed tube, Hong Kong is again unusual in that the railway has initially one, and later a second immersed tube crossing where a road tunnel has been

completed by that system a few years earlier, so there will be engineers and tradesmen available in Hong Kong who have experience of that unusual method. This again is one of the fortuitous circumstances in Hong Kong which gives confidence that the system will be built on time.

126. **Mr Northgreaves** made some interesting points. The whole question of station design would form a paper in itself. The design of a small station for a small line is no great problem. One puts down a platform and a way in and a way out and maybe some means of collecting fares. But the detailed design of very large stations which have to be built economically is a problem. This was examined repeatedly with the architects, London Transport and ourselves to learn the lessons of other systems throughout the world, most of which, as far as station design is concerned, have tended to grow rather haphazardly.

127. On the question of what alterations we might make the next time, all the systems which are operating throughout the world have certain common fundamental features, while many features differ. Nevertheless, although they do operate when they have been built, one is impressed by the enormous variations that people adopt and which somehow work. I suppose the answer is you never really know how much better it might have been, because you seldom have a chance of trying the same situation again.

128. **Mr Tyler** mentioned the interesting point raised earlier by Mr Brentnall, of the importance of turnround time in running a system regularly. This is a great problem in Hong Kong because many of the lines (particularly that which terminates on the island now being built) are built under streets which are only just wide enough to get two tracks and an island platform between the walls of the building and, more important, between their foundations on each side. This prevents the building of a three-track terminal station in many cases. The alternative of a loop which Mr Tyler suggested is one of the great controversial subjects in the planning of underground railways. There are systems which operate a loop turnround arrangement and the operators will tell you there is a great advantage in the driver not having to walk to the other end, nor is it necessary to change the destinations on the sides. However, the bulk of those with experience in these matters are against loops, one reason being that they have one of the worst features of a circle line: delays lost in one part of a line cannot be made up at a well-planned terminal.

129. The 30 s dwell time is the average time if a regular 2 min. service is to be maintained. This does not mean that there will not be the odd 40 s one, just as there will be 10 or 15 s ones. An average dwell time of 30 s will give a 90 s headway. Consequently the train control system is such that there must be a 90 s headway between consecutive trains if there are to be 30 trains over an hour.