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# Planning and design of the Hong Kong Mass Transit Railway

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The Paper describes the planning and design of the Hong Kong Mass Transit system from the outset in 1965 of a mass transport study to the invitation of tenders in 1975 for the construction and equipment of the railway. It does not deal with structural design or construction in any detail.

## Introduction

In February 1966 the Hong Kong Government commissioned Freeman Fox, Wilbur Smith and Associates to undertake a mass transport study, and their report was submitted in September 1967. The government commissioned further studies from Freeman Fox and Partners in 1969 and that work lasted until August 1970. The object of the further studies was to confirm the extent and detailed alignment of the whole (preferred) system, and to define an initial system to serve those areas where the traffic problem would be greatest. In May 1972 the Government decided that a mass transit railway should be constructed and, in July 1972, Freeman Fox and Partners (Far East) began the detailed design of the first two stages of the nine stages required in the preferred system.

2. However, during the period since 1972 there have been three major changes in policy: first, when the government decided to invite proposals from consortia to undertake the whole of the initial system (four stages of the preferred system); second, when they began negotiations with only the Japanese consortium, which were terminated in December 1974; and third, in January 1975, when the government reverted to the original multi-contract procedure for construction and equipment of the system as recommended in the Further Studies Report. Because of the large worldwide increase in capital costs during 1974, design was reduced to approximately the first three stages instead of the first four; this is now known as the modified initial system and the first tenders for construction were invited in April 1975. Nevertheless this will still be a route 15·6 km long costing about £400 million at 1974 prices.

## Mass transport study

3. A 1963 census showed that there were 3·7 million people in the built-up area of Hong Kong Island and Kowloon. A projection to 1986 estimated that the population would rise to 6·8 million, of whom 3·9 million would be concentrated in the urban area of 125 km², a density of about 32 000/km².

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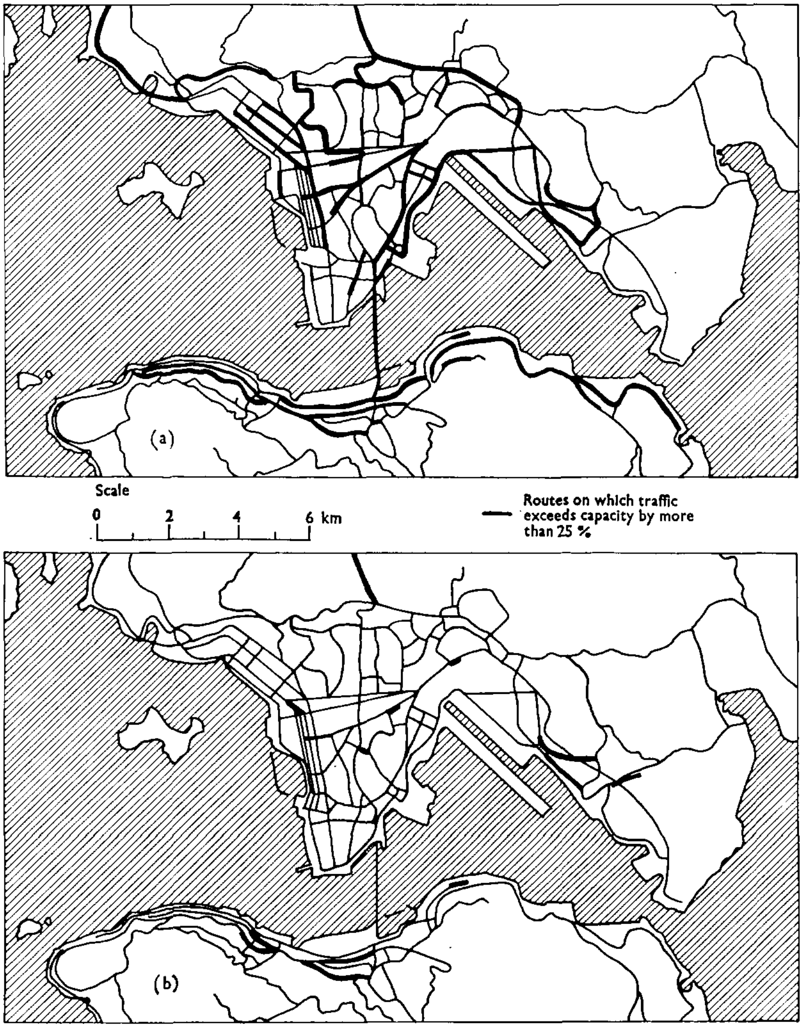


Fig. 1. Roads with capacity deficiency in 1986 (a) if the Mass Transit Railway were not built and (b) if the full system were completed (forecasts prepared in 1967)

This high density in Hong Kong was the fundamental reason why the mass transport study was able to show that it would be possible to build an extensive mass transit railway which, at the then level of costs and fares, would be commercially viable and able to repay from fares the whole capital cost by the year 2003.

4. The heavy travel demand also clearly indicated that, if the traffic generated were carried solely on roads, then even if all those roads for which space

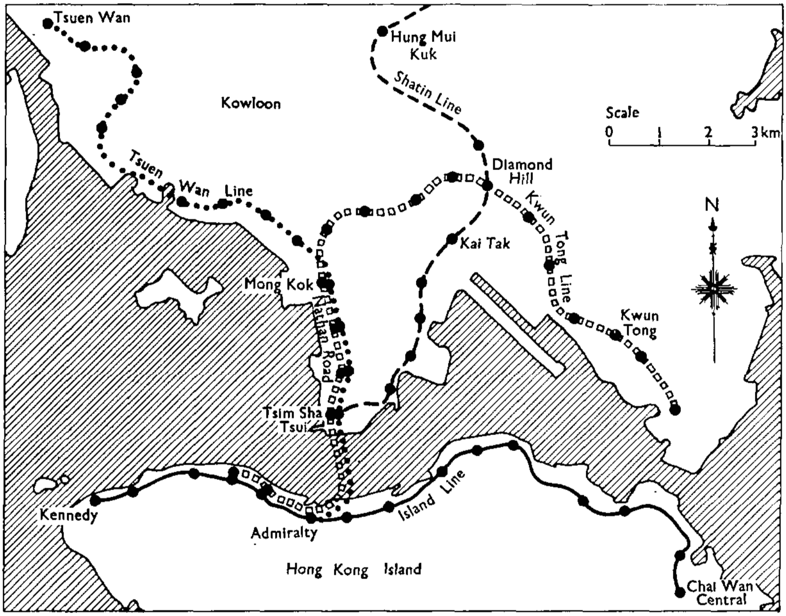


Fig. 2. Hong Kong recommended mass transit system

could be found were to be built, they would be grossly overloaded (Fig. 1). It was therefore concluded that a mass transit railway was essential in the urban areas to relieve the roads sufficiently to maintain acceptable conditions for the traffic which necessarily had to use the roads. A brief examination was made of the possibility of carrying some freight traffic on the mass transit railway but it was quickly concluded that there was no foreseeable way of providing the necessary level of passenger service if freight were carried as well. The suggestion that a railway could be used exclusively for freight at night was also shown not to be practical, as the period available would be too small to justify the additional facilities and rolling stock.

5. The study went on to identify the corridors along which the railway might be run and several alternative routes were examined. The recommended system is about 64 km long, divided into four separate lines so arranged that they could be constructed in stages (Fig. 2).

6. The four lines were:

(*a*) the Kwun Tong Line, from Western Market on Hong Kong Island, across the harbour, up Nathan Road in Kowloon, then curving eastwards to Kwun Tong and Mau Yau Tong;

(*b*) the Tsuen Wan Line, from Admiralty Station near the dockyard on the island, across the harbour, up Nathan Road and curving westwards to Tsuen Wan;

(*c*) the Island Line, running from Kennedy Town in the west to Chai Wan in the east;

(*d*) the Shatin Line, from the Tsim Sha Tsui at the extreme south end of the Kowloon peninsula, up the east side of Kowloon to a new town at Shatin.

## Mass transit further studies

7. The objective of the mass transit further studies, begun in 1969, was to define an initial system which could be developed to provide the recommended system of the mass transport study or any variation of that system which the study showed would be more suitable for the 1986 design year traffic. The routes had to be planned in sufficient detail for them to be protected against obstruction by future building, and the engineering proposals had to be established in sufficient detail for the cost to be estimated so that, together with more refined revenue studies, the financial viability could be assessed.

8. The basis of good estimates of both cost and revenue was a sound assessment of the potential traffic. The traffic assessment was updated to include allowance for changes in the population estimated from the 1966 bi-census. This was coupled with changes in the development plan for the whole colony, which included the deferment of the building of the new town at Shatin. The government therefore dropped the proposal that the line up the east side of Kowloon should extend as far as Shatin and decided to terminate the line at Diamond Hill where it crossed the line to Kwun Tong. The change in the population projections also showed that the potential traffic down the Kowloon peninsula made it unnecessary to have four tracks under Nathan Road.

9. The solution adopted was to join the lines at the north end of Nathan Road, initially by a station with tracks on two levels at Mongkok. This was later replaced during development by Prince Edward and Argyle Stations which, together with Waterloo, also require tracks on two levels. The second crossing of the harbour was made by routing the Shatin Line from Hung Hom across the southern tip of Kowloon to a point beneath the present Star Ferry terminal and thence to a station at Rumsey, adjacent to Western Market on the Island Line. The northern end of the line terminated at Diamond Hill on the Kwun Tong Line and the line was renamed East Kowloon Line.

10. These changes from the recommended system resulted in the preferred system (Fig. 3) of four lines having 48 stations and a route length of 52·6 km, to be constructed in nine stages. The first four stages formed the initial system of 20·2 km with 20 stations.

11. Some 13 major alternatives were examined. Brief reconsideration was given to such alternatives as running the Island Line further inland so that it would be wholly in bored tunnel or, at the other extreme, locating it along the water's edge and then forming a continuous circle up the east side of Kowloon, along the Kwun Tong shore and connecting across the Lei Yue Mun Gap. Such routes, running along one side of the densely built-up area would appear to be attractive from the construction point of view but, remembering that the object of the railway is to carry the maximum number of passengers, it is necessary to locate the line down the centre of the built-up areas or at least to keep the walking distance to a minimum.

12. Amongst further alternatives examined was the possibility of running the Tsuen Wan Line across the top of the Kowloon peninsula to a station at Kai Tak Airport and thence down the east side of Kowloon and across to the

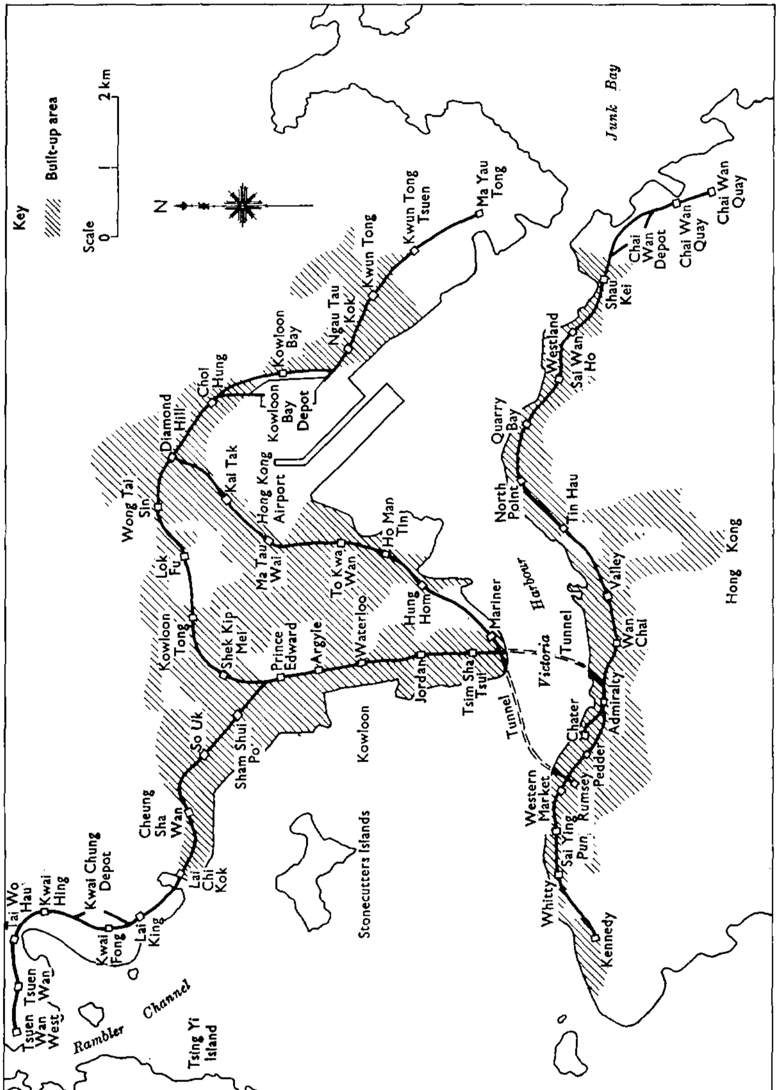


Fig. 3. Hong Kong MTR preferred system

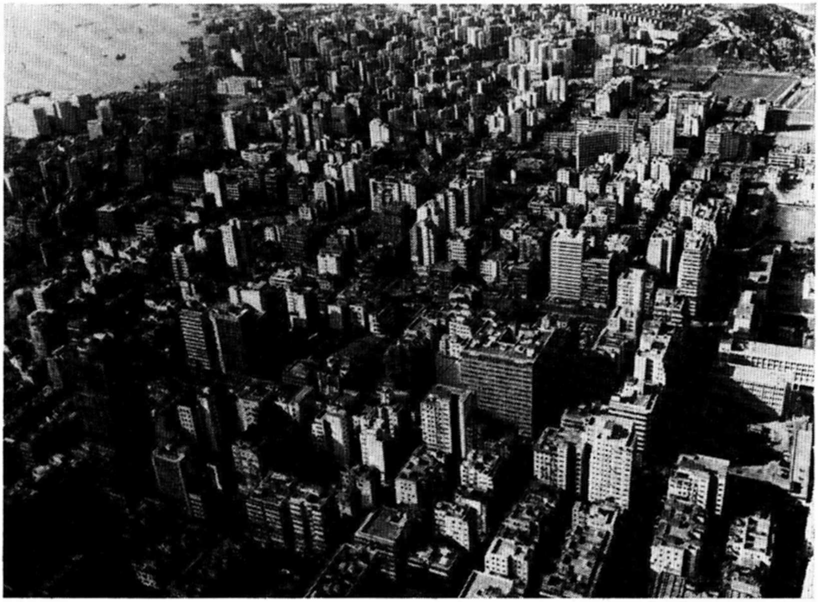

Fig. 4. Kowloon in 1975, showing density of building and difficulty of locating railway under the streets

Island. This alternative would have provided a service to the airport much earlier than the East Kowloon Line, but no practicable and satisfactory route could be located. The possibility of taking either this new line or the Shatin Line itself across the harbour from Hung Hom to Causeway Bay or Wanchai was also examined. These alternatives were ruled out because the traffic would have been considerably less than by a route to the central area of the Island. A further cross-harbour link examined was from North Point to Kwun Tong. This route, in addition to two cross-harbour routes in the central area, could not be justified and it was too far from the central area to replace one of the two routes in the central area.

13. The geometry of the railway system was based on design criteria, mainly the minimum radii for the tracks, the gradients acceptable between stations and on each side of the station, and the precise location of the stations. The line location was also affected by the topography, including the location of buildings and the form of their foundations. Most of the high rise buildings are on piled foundations and this makes a route beneath them very difficult to construct because, in most cases, the rail tunnels would not be below the level of piles. Looking at aerial photographs of Hong Kong (Fig. 4) it seems impossible to choose routes that run largely under the streets but, surprisingly, it was possible to do so. At only one point on the modified initial system has it been necessary to demolish buildings to accommodate the railway. There may be similar problems when a later stage is built but, in some cases, arrange-

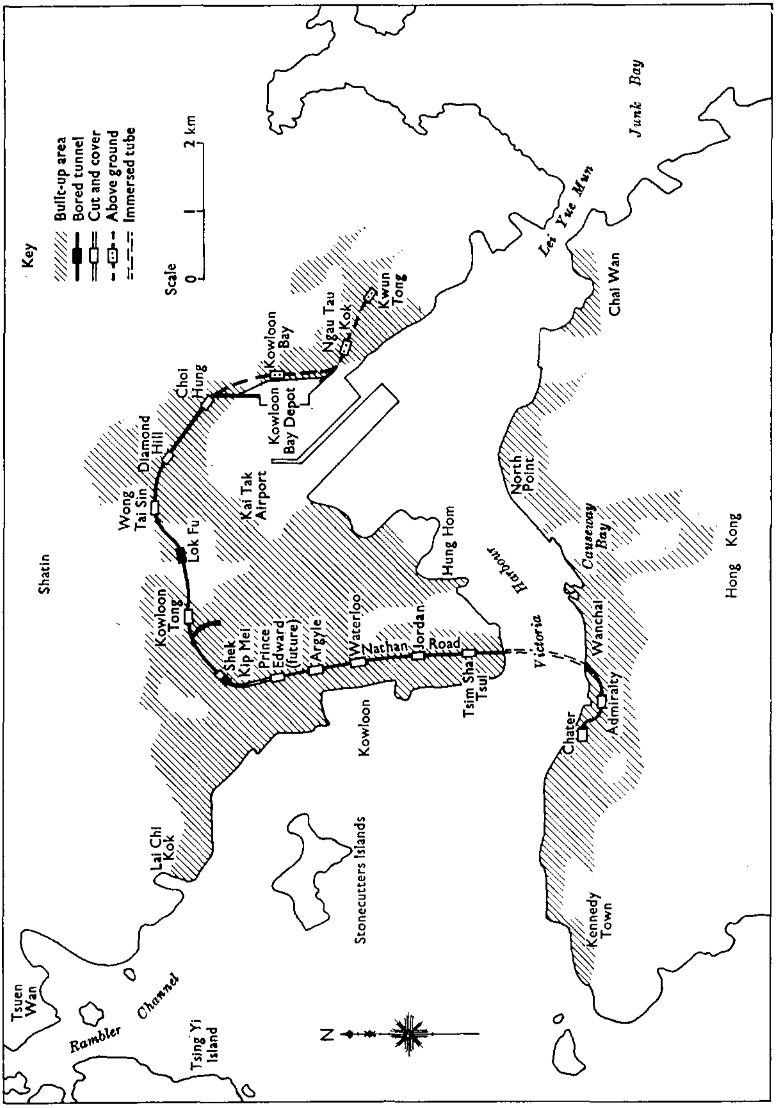


Fig. 5. Hong Kong MTR modified initial system programmed for completion in 1980

ments have been made to avoid them by making provision in the foundations of new buildings for the tracks to pass between the piles.

## Modified initial system

14. When the negotiations with the Japanese consortium ceased in January 1975 the government decided (in view of the high inflation and high interest levels) that the capital cost of the first part of the system to be constructed should be reduced to a minimum, but without in any way limiting the preferred (or full) system or lowering the standard of the service to be provided. This modified initial system (Fig. 5) involves deferring until later the following parts of the initial system:

(*a*) the Tsuen Wan branch from Prince Edward to Lai Chi Kok;
(*b*) the Island Line from Pedder to Western Market.

Both these two sections of line would have required higher percentages of the total capital cost to construct than the percentages of total revenue lost by omitting their construction.

15. As a consequence of these two omissions, Pedder Station and the line from there to Admiralty were also omitted, together with Prince Edward Station and the complicated junction work associated with it. The postponement of the line to Lai Chi Kok also enabled the lower platform levels at Argyle and Waterloo stations to be temporarily omitted. Further minor works, mainly station entrances, have been postponed.

## Train design and operation

16. It became apparent early during the mass transport study that the principal corridors were likely to have a traffic demand of the order of 60 000 passengers/h in a single direction. To be able to satisfy that demand meant providing a train capacity of the order of 90 000 passengers/h. The frequency of trains which can be operated regularly on a heavily loaded system was considered to be a maximum of 30 trains/h or a 2 min headway, which would require the average station dwell time not to exceed 30 s. As is mentioned later (§§ 24–30), the dwell time to permit the passengers to enter and alight is a controlling factor in fixing train frequency and, in turn, determines the facilities necessary to handle the passengers in the station.

17. To provide for 90 000 passengers/h with a maximum of 30 trains requires a train capacity of 3000 passengers. Carrying such large numbers in main or suburban line systems operating at ground level is fairly readily achieved, but it requires wide trains, a large proportion of standing area and a great length of train. Trains that are both wide and long, however, are expensive to put underground.

18. Because of the very high density of population in the urban area, the average journey length will be short and it is therefore not a great hardship for passengers to stand, and one to which the population of Hong Kong is already accustomed. An economic system could therefore be provided by basing the trains on the majority of passengers having to stand, and only 384 passengers out of 3000 are provided with seats.

19. Preliminary design showed that the majority of the stations would be of cut-and-cover construction and that a substantial part of the underground line stations would be in circular bored tunnel. On the assumption that these

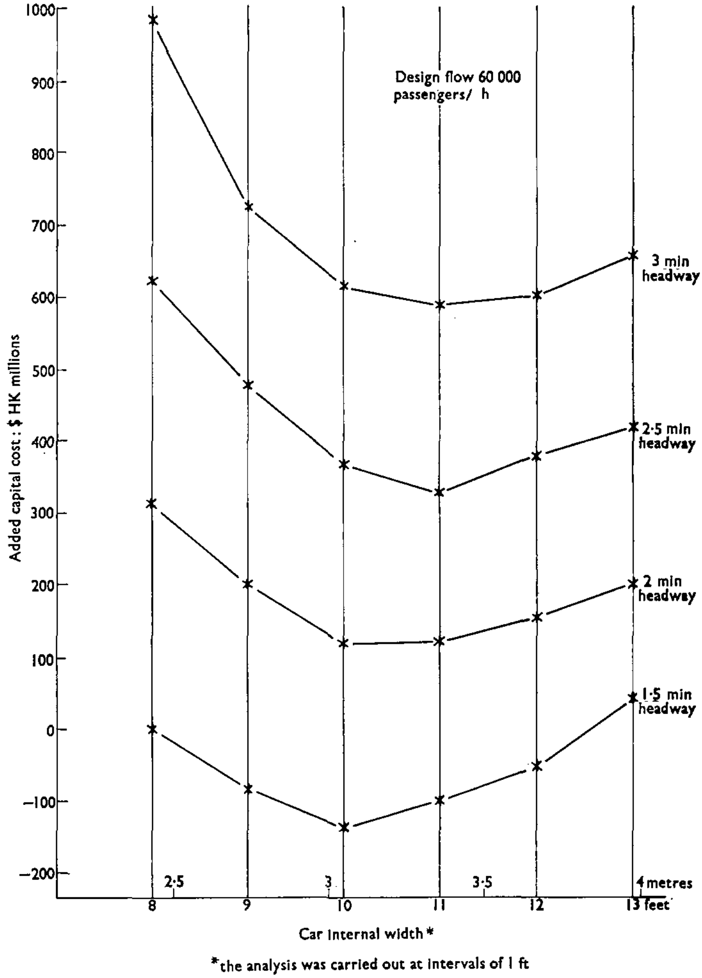


Fig. 6. Added initial capital cost against car internal width for different headways to *provide sufficient capacity to carry 60 000 passengers/h*

methods of construction could be used, costs were prepared which enabled a comparison to be made of achieving the required train floor area with relatively narrow, long trains rather than wide, short trains. The results of these calculations are shown in Fig. 6 which indicates curves of construction cost against train width.

20. The conclusion was reached that 3·05 m (10 ft 0 in.) internal width, corresponding to an overall width of 3·2 m (10 ft 6 in.) was the optimum and, at the same time, it was considered that this width was about the greatest which could be provided on a conventional 1432 mm (4 ft 8½ in.) track without

further research and development, which would not have been in accordance with the agreed design philosophy to use, wherever possible, well-tried and tested designs and components. The corresponding length of train is 182 m, made up of eight cars, each having an internal length for passengers of 22 m. In the early years trains will be of four or six cars.

21. To provide a train capacity of 3000 passengers under peak conditions, the design floor area of the train has to take about 3300 passengers. No train would ever be loaded so that all parts of each car were uniformly full of passengers. However, to make loading as uniform as possible in Hong Kong, wide open vestibules are provided between cars. In a partly filled train most passengers will be in that part of the train which stops nearest to the exit at their destination station. Some passengers joining at the last minute will be in that part of the train nearest the entry to the platform at the origin of the journey. When these two factors lead to one part of the train becoming crowded then, with the open vestibule type of train, the pressure is relieved by passengers flowing into the less densely filled part of the train. This feature is amply demonstrated in trains of this arrangement operating in Osaka and Tokyo.

22. The importance of a minimum station dwell time in achieving a high train frequency has already been mentioned. In addition, the system must be designed so that once the train has been started by the operator it is driven at the optimum speed until it has stopped at the next station. This function has traditionally been carried out by the train driver who regulates the power delivered by the motors and applies the braking of the train. To achieve uniform time between stations, with the constantly varying line conditions from one station to the next, requires great application. It is difficult for it to be done regularly by all drivers. The automatic operation system adopted requires the train operator only to start the train, having supervised loading and closed the doors. A second man is not required to control the doors or take action in an emergency, such as the driver's illness. This saving in manpower will be just as important in Hong Kong as it is already in cities like London and New York, where operating a labour intensive industry such as an underground railway is becoming increasingly difficult.

23. The trains operate on a 1500 V d.c. third rail system. This high voltage minimizes the number of sub-stations required and hence the capital cost of the system.

## Station layout and services

24. Station design on lightly loaded systems is important only so far as it affects the attractiveness of the system and hence profitability by encouraging the maximum number of passengers. This is probably the position for passenger levels of up to about 50 000 passengers/day using a station. In more heavily used stations it becomes necessary to ensure that the passenger circulation within the station is carefully designed, otherwise the number of passengers which the trains can take into or out of the station will be greater than the number of passengers which can enter or leave the station. A good layout is therefore essential for the busier stations. In Hong Kong, some stations will handle 100 000 passengers/day in the early stages and, when the full system has been developed, the number will reach 250 000/day.

25. With the usual arrangement of two tracks, stations can have either a platform on each side of the pair of tracks or a single island platform between the two tracks (busy stations on some systems have both, but this is very expensive). Surface lines and shallow lines with both tracks in single cut-and-cover tunnels can conveniently have side platforms. Such an arrangement permits the tracks to be kept parallel through the stations and, in the case of narrow streets, it has been possible in many cities to build the platforms partly under buildings at the side of the streets. If the running tracks each side of the station are in bored tunnels the tracks have to be wider apart than in cut-and-cover construction. It is then easier to widen the tracks for an island platform rather than bring them closer together for side platforms.

26. The standard station arrangement adopted during the mass transport study provided side platforms and this suited predominently cut-and-cover construction. During the further studies, the number of bored tunnel running tracks between stations was increased and, after a more detailed study of station design, the normal layout was changed to an island platform arrangement. This is also more suitable for stations carrying large numbers of passengers where movement in and out of the station is by escalator. If, as usual, the direction of the heavier traffic is opposite in the morning and evening peak hours, the same escalators serve an island platform for both the morning and evening peaks, whereas, with side platforms, it would be necessary for both platforms to have sufficient escalators to deal with peak traffic.

27. The usual arrangement in Hong Kong will be to have a ticket concourse over the platform and the running tracks. The concourse will be connected to the platform by escalators and to the street usually by 'up' escalators and 'down' stairs.

28. When the full system has been completed, many journeys will exceed 16 km with a maximum of 30 km and, as the system has to be self-supporting for both operating and capital costs, a stage fare system has been adopted to maximize the revenue and yet attract short-journey passengers. Because of high manpower costs (which will become ever greater relative to equipment costs) a fully automatic fare collection system will be employed. The system is based on the use of magnetically coded plastic tickets which will provide for stored or single rides. Entry and exit from the ticket concourse will be controlled by automatic barriers which will normally be open but will close if the plastic ticket put into the machine is not valid. An excess fare office will be provided to deal with passengers who have travelled further than their ticket permits and for passengers whose ticket fails to operate the gate.

29. A considerable investigation has been made into the best layout for the station, especially the ticket concourse, and the location of the ticket machines and automatic gates. The arrangement that has been developed, shown on Fig. 7, was also tested by a full-scale mock up. This was necessary because the large number of passengers using the stations will require many gates, the best arrangement of which is vital to a smooth flow of passengers.

30. Rooms will be provided at one end of the concourse for the station manager and for station staff, as well as a booking office for the issue of stored ride tickets (single ride tickets will be bought from machines). At the opposite end of the hall there will be a service area for cleaners' rooms, space for batteries and air conditioning plant. The other electrical equipment rooms are located at each end of the platform. Because of the large numbers of people

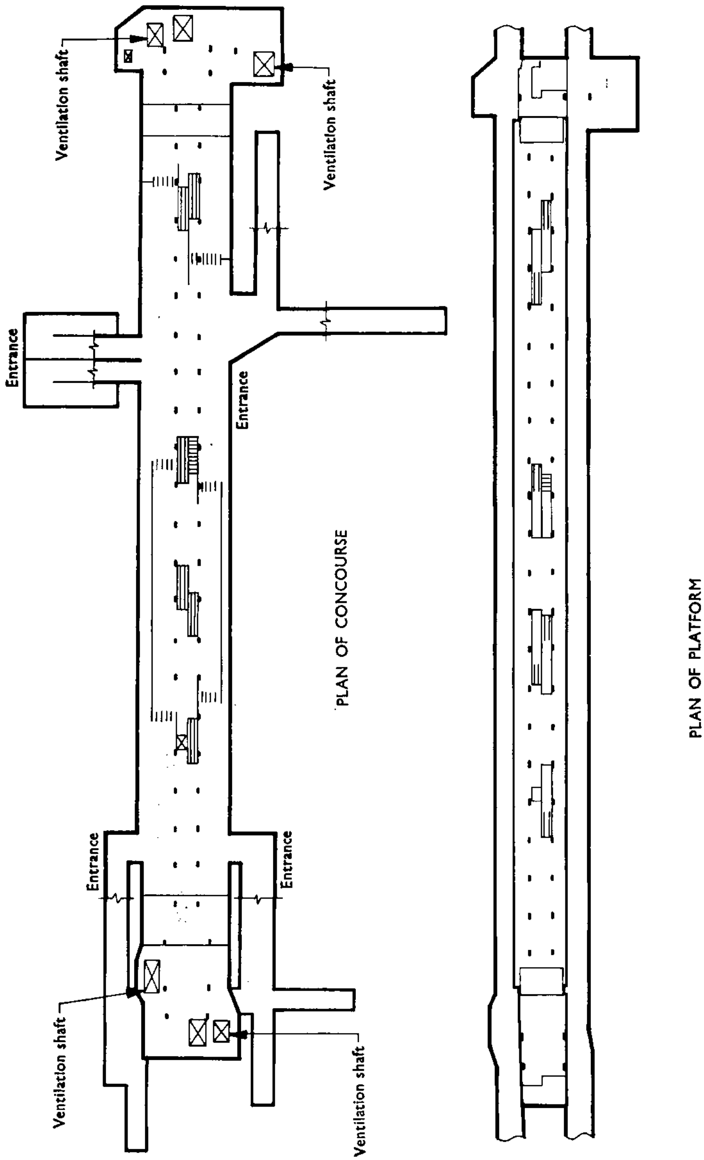


Fig. 7. Plan of typical medium-size station

to be handled at stations, and the relatively small number of station staff required for normal operation, an extensive arrangement of public address and closed circuit television equipment will be installed. Each station controller will be able to monitor conditions on his platforms and in the concourse, and the line controller in the central control room will be able to select pictures from any station which is likely to have crowd problems.

## Depots

31. An essential need for any underground railway is a depot for maintenance, overhaul and repair of the rolling stock and ancillary equipment. It is also a base from which the staff can maintain electrical and mechanical station equipment such as escalators, ticket machines and pumps, and where repairs can be carried out. Extensions or new lines added to existing systems can sometimes use existing depots, but for a new system like Hong Kong it is essential that a major depot capable of meeting all these functions should be available with construction of the first line.

32. The mass transport study located a suitable site in Kowloon Bay lying NE of the Kai Tak Airport runway. This site was reclaimed between 1969 and 1974. In addition to the maintenance depot there will be an administration block in which the main control centre is also to be located. The depot will incorporate a small training school.

33. When the Tsuen Wan branch is opened beyond Lai Chi Kok, a depot for it will be constructed on the Kwai Chung reclamation, and when the Island Line is extended westwards beyond North Point a third depot will be constructed at Chai Wan. If, as is planned, the Island Line is opened initially between Western Market and North Point, then the trains for that section will at first be serviced and maintained from the Kowloon Bay depot. Furthermore, when the East Kowloon Line is built, its trains will also have to be maintained by the Kowloon Bay depot until such a time as the line is extended beyond Diamond Hill to Shatin where provision will be made for a depot for that line.

34. Thus the Kowloon Bay depot will fulfil two changing roles. It will fully service and maintain all trains until the subsidiary depots open. Thereafter it will be used for cleaning and minor maintenance of a smaller number of trains, but it will continue to do the major overhauls and repairs for all trains.

## Ventilation and air conditioning

35. The underground railway will have to carry a very large number of passengers in the adverse climatic conditions of high temperature coupled with high humidity during several months in each year. It was quickly appreciated that these conditions would require a fully effective ventilation system. During the further studies a system was developed based on forced draught, with heated air being extracted in the stations and fresh air being introduced into the tunnels through shafts.

36. Initially air conditioning was to be provided only in the offices and enclosed spaces in the concourse. During later more detailed studies it was recognized that the summer heat and humidity, coupled with high traffic density, made it necessary for an effective environmental control system to be designed if attractive travelling conditions were to be normally available and casualties due to heat were not to occur under emergency conditons.

37. The system now developed provides conditioned air in the stations at both concourse and platform level. Loss of this conditioned air is minimized by providing extraction ducts beneath the platform to remove the hot air from the equipment below the floor of the trains, especially that concerned with braking, and by providing air curtains across the tracks at the entry and exit to the tunnels at each end of the station. The hot air being pushed along the tunnel in front of a train will be deflected up the outlet shaft before the next station by a vortex induced at the base of the shaft by a jet of high pressure air. After the train has passed, the jet re-establishes the vortex, and so the air being sucked behind the train is also exhausted up the outlet shaft and prevented from being carried into the station outside. Likewise, as the train leaves the station, fresh air at outside temperature is drawn down the inlet shaft immediately beyond the air curtain; it collects the heat from the tunnel and in turn is exhausted up the next shaft.

38. The air curtain and the vortex formation are the keys to the success of this system, and the design was therefore tested by the British Hydromechanics Research Association at Cranfield to prove the details. Subsequently the system for a length, including stations, was tested in the Developmental Sciences testing facility at Pasadena, California.

39. The trains will be air-conditioned, with the equipment for each car being mounted either beneath the floor or in the roof.

## Harbour crossing

40. In the full system there will be two crossings of the harbour: the first runs from the tip of Kowloon to Admiralty, and the second will be made when the East Kowloon Line is built from Kowloon to Rumsey near Western Market on the Island. The relatively high cost of any underwater crossing makes it essential that the chosen method of construction should be the cheapest possible to suit the harbour bed, which consists of soft marine deposits and granite decomposed in varying degrees overlying a very irregular level of rock head. Taking account of the gradients that would be required on each side, the topography makes a bored tunnel impossible at any reasonable level. The material, however, is suitable for excavating a trench in which to lay an immersed tube type of tunnel. As in this method the tunnel is at minimum depth, it is particularly suited to railway construction where the gradients at each side must be less than for a road tunnel.

41. As originally planned, the alignment of the tube from Kowloon to Admiralty was to be straight, with a curved section each end. However, the line, which will be 1400 m long, was changed to a single 2800 m radius curve throughout, thus permitting all the units forming the tube (except for the end two units) to be the same size and shape. This results in an appreciable economy, particularly if the units are manufactured in a temporary dry dock as is at present envisaged.

42. Immersed tube units can be constructed in four ways: all-concrete; all-steel; steel shell with a concrete lining; or composite steel and concrete. On a straight financial basis, the all-concrete version is probably the cheapest for Hong Kong, but there are cases, an example being the Hong Kong cross harbour road tunnel, where a steel-and-concrete design becomes more attractive because of the export credit terms available for steel from some countries,

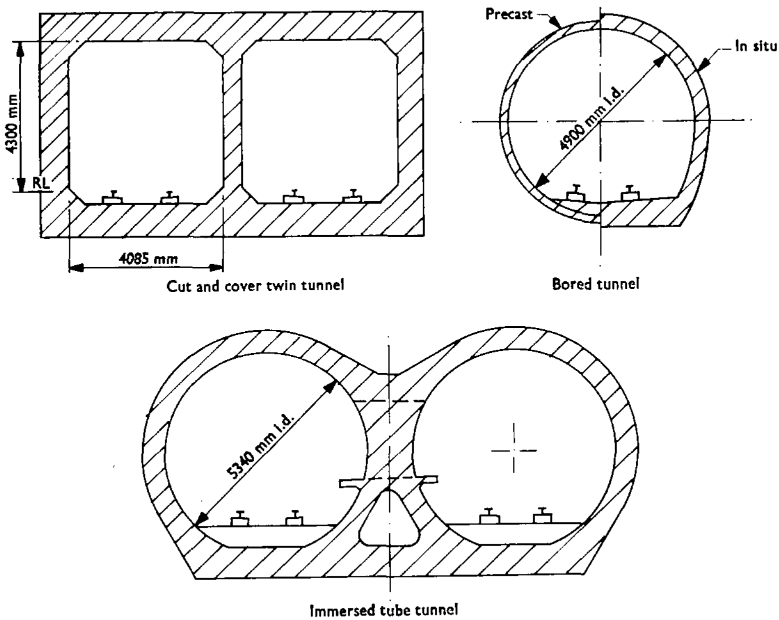


*Fig. 8. Tunnel cross-sections*

As part of the design study this argument was carried to the extreme, and an all-steel design was investigated. However, no wholly satisfactory solution could be found to the corrosion problem, bearing in mind the normally accepted criterion for an underground railway of an indefinite life. The design finally adopted as being the most economical was an all-concrete design, but with steel plate used for externally waterproofing the bottom.

43. The cross-section of the immersed tube (Fig. 8) comprises two single-track tunnels with a small bouyancy chamber between them. The cross-section of each track tunnel is larger than that of the corresponding circular bored tunnel. The additional cross-sectional area is required to ensure sufficient flow of ventilation air past a train in extreme circumstances when, because of the distance between adjacent stations, several trains could be stalled in one tunnel. The larger size also permits a walkway adjacent to each track allowing side exit from a train; if passengers have to be taken out of a train, they will be able to walk through connecting adits to a train in the adjacent tunnel.

## Construction methods

44. Several aspects of station and track layout planning are vitally affected by the construction methods used. It was therefore necessary for the investigation and selection of construction methods to be continued concurrently with the planning of the stations and lines. All stations except one and part

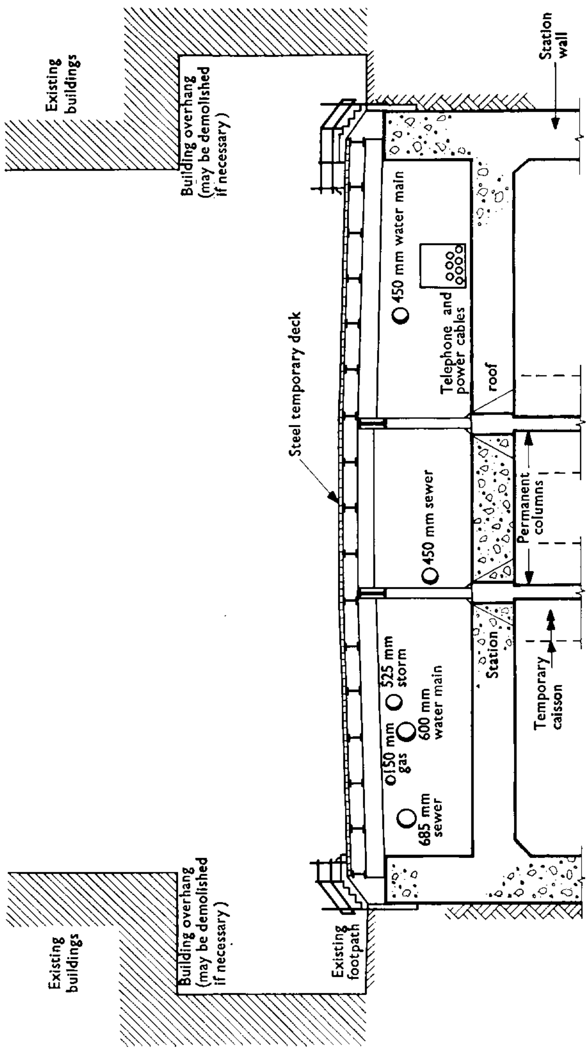


Fig. 9. Station construction under Nathan Road showing frontage line, overhang of buildings and present location of utilities; also temporary works proposed to permit building of station by cover-and-cut after construction of diaphragm walls to form the station walls

of another in the underground section are planned as cut-and-cover construction. This has the obvious merit of keeping the tracks in the stations as close as possible to ground level and thus keeping the time for passengers to get from the surface to platform level to a minimum. The saving in cost using shallow construction in stations that cater for large numbers of passengers is appreciable, not only for the construction but for items of equipment such as escalators. Generally, the level of the top of the station roof is determined by the need to pass beneath utilities which cannot be diverted.

45. The soils structure at cut-and-cover stations is usually of bedrock in the lower part, overlain by decomposed granite, fill and marine deposits. The levels of the strata often change abruptly. Many stations (Fig. 9) have to be built below narrow streets which will prohibit sheet steel piling with its requirement for additional working space, and investigations showed that the cheapest form of construction was likely to be one using diaphragm walls for the main station walls, with the reinforced concrete roof, floor and intermediate floors designed to act rigidly within the walls.

46. Investigations indicated that there would be a saving if bored tunnels were used between stations where possible. Some will be in rock and others in soft marine deposits, but most will be driven through mixed-face ground with rock, in the form of large boulders or bedrock, over part of the face. In built-up areas tunnelling not only has substantial environmental advantages over cut-and-cover in reducing noise during construction, but also provides a considerable saving in cost because it avoids the necessity to divert, or at least temporarily support the numerous utilities that exist. There is also the further advantage that it avoids prolonged dislocation of road traffic.

47. Track maintenance is difficult and time consuming on underground railways, as well as involving a considerable specialized labour force. Various methods of track construction were studied and it was concluded that the best was a concrete bed with a continuously supported rail on a resilient strip held in place by patent clips. The concrete bed can be laid in a variety of ways and the contractor will have considerable freedom in choosing the method. The resultant track system should be free from maintenance until rail relaying is required. Both maintenance and capital costs should be minimal. Not much experience of such track is yet available but the indications are that it should be no noisier than conventional sleepers laid on ballast.

## Acknowledgements

48. The Author wishes to thank the Hong Kong Mass Transit Railway Corporation for permission to publish the Paper. The opinions expressed therein are those of the Author and not necessarily of the Corporation.

49. The Hong Kong mass transport study was carried out in 1967 by Freeman Fox Wilbur Smith and Associates. The further studies were carried out by Freeman Fox and Partners in 1970.

50. The principal consulting engineers since 1972 have been Freeman Fox and Partners (Far East) who retain the following specialist advisers:

| | |
|---|---|
| Freeman Fox and Partners | Civil engineering |
| Kennedy and Donkin | Electrical and mechanical plant and operations |

| | |
|---|---|
| Design Research Unit | Architecture, passenger handling and industrial design |
| Charles Haswell and Partners | Bored tunnels |
| Per Hall Associates Ltd | Immersed tube |
| Scott Wilson Kirkpatrick and Partners (Hong Kong) | Site investigation |
| London Transport | Operations and layout |
| Freeman Fox and Associates | Traffic and fare structures |

51. The Consulting Engineers' railway safety adviser is Colonel J. R. H. Robertson who succeeded the late Colonel D. McMullen.