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WEST COAST MAJOR PORT DEVELOPMENT COMMITTEE'S REPORT

AND

RECOMMENDATIONS

REGARDING

THE POSSIBILITY OF SITING A MAJOR PORT ON THE COAST

BETWEEN

MORMUGAO AND COCHIN

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GOVERNMENT OF INDIA

MINISTRY OF TRANSPORT

RESOLUTION

New Delhi, the 17th February 1948

No. 19-P (53)/47.—The Government of India are pleased to constitute an expert committee known as "The West Coast Major Port Development Committee" to carry out the following two investigations:—

1. (a) whether a deep-sea port on the stretch of coast covering Kathiawar and Cutch for the accommodation of ships of large size and tonnage at all seasons of the year is required;

(b) if so, where it should be sited, having regard to construction and maintenance costs, allied transport developments, possibilities of developing existing ports and the needs of the entire area to be served.

II. (a) whether a deep-sea port between Mormugao and Cochin for the accommodation of ships of large size and tonnage at all seasons of the year is required;

(b) if so, where it should be sited, having regard to economy of construction and maintenance of the port and allied transport developments required and having regard to the needs of the entire area; also what measures are necessary for establishing it;

(c) what improvements are necessary in communications to the existing ports; also what other measures should be taken for the development or provision of additional facilities in these ports as may be found necessary or desirable.

2. The composition of the committee will be as follows:—

Mr. Kasturbhai Lalbhai—*Chairman.*

The General Manager, B. B. & C. I. Railway, Bombay, for the former investigation, and the General Manager, M. & S. M. Railway for the latter.

Mr. S. N. Haji, Scindia Steam Navigation Co., Ltd., Bombay.

Mr. K. Mitter, Docks Manager, Calcutta Port Commissioners, Calcutta.

Mr. J. B. Murray, Chief Engineer, Calcutta Port Commissioners, Calcutta.

Commander D. Shankar, Director of Naval Engineering, Naval Headquarters (I).

Mr. V. V. Bhide, Secretary to the General Manager, B. B. & C. I. Railway, Bombay—*Secretary.*

3. The committee is requested to submit its recommendations to Government before the end of April, 1948.

S. CHAKRAVARTI, Jt. Secy.

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The Committee has already submitted its report on the siting of a Major Port on the stretch of coast covering Kathiawar and Cutch. A report is now submitted on the siting of a Major Port on the stretch of coast between Mormugao and Cochin as called for in the second term of reference.

1. **Second Term of Reference II(a).**—In this term of reference, the Committee is asked to find the answers to three questions, the first being :--

"whether a deep-sea port between Mormugao and Cochin for the accommodation of ships of large size and tonnage at all seasons of the year is required."

2. **Method of Approach.**—The Technical Members of the Committee traversed the entire distance between Mormugao and Cochin by road and inspected all likely sites. They also studied Admiralty Charts and Ordnance Maps and made preliminary contacts with the various ports, Government and State Authorities and other local representatives.

Having considered the report submitted by the Technical Members, the Committee gave an opportunity to all concerned to present their views.

3. **Features of the Coast.**—The coast-line, extending to a length of approximately 400 miles, is exposed to the severe swell of the South-West Monsoon, and to a lesser extent the swell induced by north-westerly winds. Both Mormugao and Cochin are sheltered ports, open all the year round, and between them lie a number of minor ports, all of which are closed during the South West Monsoon. Running roughly parallel to the coast lie the Western Ghats, forming a barrier to communications with the hinterland.

4. **Communications.**—Communications are poor throughout. Apart from the natural barrier formed by the Western Ghats, many wide rivers remain unbridged, and there is thus no through road along the coast. The whole of North Kanara is dependent entirely on roads, and there are few in existence. The only railway serving the coast-line is the S.I. Railway B.G. line, running northwards from Shoranur, and terminating at Mangalore in the South Kanara District. Rivers are not navigable except for very shallow draught craft, and for short distances only, from the sea.

5. **Existing Ports and Their Traffic.**—In the North Kanara District there are 16 ports, but of those only 5, *viz.* Karwar, Tadri, Kumta, Honavar and Bhatkal are ports of call for small coastal steamers. The traffic is largely country-craft borne, and consists of imports of grain, kerosene, salt, tea, sugar and oil-cakes and exports of timber, firewood, charcoal, cardamom, pepper, betel nuts and fish.

The traffic for all these ports in the year 1946-47 was 79,000 tons.

There are 14 minor ports in the two districts of South Kanara and Malabar in the Madras Presidency, the principal ones being Mangalore

and Calicut. They are all open roadsteads, large ocean going ships anchoring well out in deep water, cargo being transferred to lighters. Traffic consists mainly of import of foodgrains (mostly rice), salt, kerosene, piecegoods and metals and export of tiles, cashew nuts, coffee, betel nuts, pepper, coir, copra and timber. For the year 1946-47 the traffic for the South Kanara District was 2·5 lakhs tons and for the Malabar ports 3·3 lakhs tons (*vide* Appendix I).

6. **Traffic Statistics.**—In an investigation such as this, it is obviously necessary to know the dead weight tonnage of cargo handled, at all the ports, as statistics of values are of little use. It was not until 1946 that some of the ports maintained records of cargo tonnages handled, but these records are not complete. Such statistics must necessarily be kept commodity-wise, as well as in separate categories for foreign steamer, coastal steamer and country-craft. Unfortunately no such analysis of traffic figures is available.

7. **Hinterland.**—The hinterland of the coast we are considering might conveniently be divided into 4 sections, namely, the North Kanara District in the Bombay Presidency, the South Kanara and Malabar Districts in the Madras Presidency (including Coorg), and a large part of the State of Mysore. A survey of present and potential port traffic to and from these four areas has been made.

The potential traffic has been estimated by drawing a hinterland map of comparative distances from the existing major ports. Population, industries, roads, and railways are shown in the map, *vide* Appendices II(*a*), II(*b*), II(*c*), and II(*d*). A glance at these maps, and a study of the potential traffic figures leave no doubt that the answer to the problem is dependent on the volume of the traffic of Mysore State.

8. **Mysore Traffic.**— The total area of Mysore State is about 29,500 sq. miles and the total population is about 7·5 millions. A portion of this, however cannot be considered to be within the hinterland of a new port on the west coast. The industrialised area of Bangalore is closer to Madras, which would continue to serve the eastern part of Mysore State even if a new port were constructed on the west coast. However, an area of about 24,000 sq. miles of Mysore State, with over 5 million population falls within the hinterland of the new port, and includes the area round Bhadravati which is being industrialised rapidly due to the availability of raw materials in the form of iron-ore, limestone, etc., and th far-sighted policy of the Mysore Government in developing hydro-electric power, training personnel in industrial technique, supplementing and assisting private enterprise.

The Mysore Government officials have kindly made available complete details of present and future traffic. This traffic comprises diversions from the three ports of Bombay, Mormugao and Madras, and from other ports in the Madras Presidency, diversions from road and rail-borne traffic, and finally additional traffic due to industrial expansion. These figures have been studied and discussed in detail with the Mysore Government, and an estimate is given in Appendix III. Traffic is thus assessed at 514,000 tons in 1955 and 664,000 tons in 1961.

9. **Hydro-electric Schemes.**—Ports are essentially long term projects. It is necessary, therefore, to appreciate the possibilities of further industrialisation and the resultant port traffic. Due appreciation is possible only when it is realised that the Government of Mysore has already made available 89,000 K.W. of electric energy and will have an additional 246,000 K.W. of power available for industry in the near future.

Closely linked with these hydro-electric schemes are the several irrigation projects, to bring large areas under wet cultivation. The Lakavally Project alone will bring 200,000 acres under cultivation.

10. **The Need for a Port to Serve Mysore.**—Plans for further industrialisation are taking shape—plans necessitating the import and export of large volumes of cargo, and naturally the State feels the need for an outlet to the sea.

Bhadravati is 332 miles by rail to Mormugao, its nearest port, and this is over three times the distance to the coast by a more direct possible route. Madras is 381 miles away and involves a break-of-gauge transhipment. The proposed Chamrajnagar-Mettupalayam rail link will not assist as the Port of Cochin will still be 533 miles from Bhadravati, again with a break-of-gauge transhipment.

The transportation of 514,000 tons (1955 estimate) over an avoidable distance of 200 miles would cost trade over Rs. 60 lakhs a year. This is sufficient justification for the siting of an all-weather port with the necessary rail connection on the stretch of coast under review.

11. **Other Potential Traffic.**—The Potential traffic of the remaining areas of the hinterland is hard to assess. There are, throughout, large forest areas, sparsely populated.

The North Kanara area cannot offer port traffic of any magnitude until the Kali Nadi hydro-electric scheme (80,000 K.W.), at present scarcely more than in the planning stage, has materialised and industries have been established. Then only can the natural resources—forests and mines—be properly doveloped and port traffic assessed.

The South Kanara District is centred around the port of Mangalore, where the principal industry is tile-making. Mangalore is also a centre for the coffee curing, and cashew-nut industry. Pepper and betel nuts are exported in fair quantities. The resultant deep-draught steamer traffic, however, would always be small even if these industries were to expand considerably. The most significant feature of the Mangalore traffic is the high percentage which is country-craft borne. Although a small percentage of tiles has always been carried by steamer, it is essentially country-craft traffic. This is illustrated in the breakdown of the 1946-47 traffic, as given in Appendix IV. The traffic potential of Mangalore has been assessed by taking the average of the 1946-47 and 1947-48 figures, adding 25% for the period during which the port at present closes down, and a further 15% for natural growth and diversion from Malabar ports.

The Malabar District of the Madras Province is extensively cultivated. Large plantations of cashew-nuts, arecanuts, cocoanuts and

bananas exist, and paddy is grown. The area, however, is densely populated and has to depend to a large extent on imports of rice. The rich coffee growing districts of Coorg and Wynad have their natural outlet on the Malabar Coast. There are, again, large forest areas affording traffic potentialities.

There are good road connections from the Malabar coast to the hinterland, and the Madras Government is considering the construction of a highway running the entire length of Malabar and South Kanara. Irrigation schemes near the coast are being investigated which will increase the output of rice, but these will tend to reduce the import of food grains, and will thus have an adverse effect on port traffic.

Coorg lies to the north-east of the Malabar coast, and is connected to the coast by several roads. Coffee, rubber and fruit are grown, and there are extensive forests. Possibilities for hydro-electric power exist, and with better communications and a new-all-weather port on the West Coast, the development of Coorg would undoubtedly be accelerated.

12. **Justification for a New Port.**—The potential traffic of the coastal districts does not justify the construction of an all-weather deep-sea port. The bulk of this traffic is either borne by country-craft or small coastal steamer and would probably continue so, even if the facilities offered by such a port were provided.

The Mysore traffic, on the other hand, is mostly bulk cargo and would normally be carried by deep draught steamers, and discharged over a quay. A new port, therefore, can only be justified if the Mysore traffic, present and potential, is taken into consideration and it would be desirable if possible to attract the Mysore and South Kanara traffic to one point. This leads to the second question, namely, where the port should be sited.

13. **Selection of Site II (b).**—"If so, where it should be sited, having regard to economy of construction and maintenance of the port and having regard to the needs of the entire area ; also what measures are necessary for establishing it".

14. **Available Data.**—The engineering data available was both meagre and unsatisfactory, none of the possible sites having been surveyed for many years, although it was known that changes had taken place in the regime of rivers, and in the various harbours and anchorages along the coast. Practically the entire coast-line is of under-lying rock formation, and outcrops of rock appear off shore in places. With a few exceptions, borings were not available and it was not known whether large quantities of rock would have to be blasted away from under the sea to form a harbour, or in the opposite extreme, how deep foundations would have to be taken to carry the massive loads involved in dock construction.

15. **Sub-Soil Investigations and Hydrographic Surveys.**—It was decided, therefore, to request the Government of India to arrange for the collection of data which would enable the Committee to assess, with reater accuracy, the relative merits of possible sites for the new port.

As a result, hydrographic surveys have been made, and sub-soil investigations carried out, at sites which were considered likely to be selected.

Sub-soil investigations were conducted at Karwar, Bhatkal, Malpe and Mangalore.

Hydrographic surveys have been made of the Ports of Bhatkal, Malpe and Mangalore.

16. **Factors to be Considered.**—In selecting a site, many factors had to be considered such as the needs of the entire area, any existing features favouring a sheltered harbour, the availability of land for a port estate, the cost of construction and maintenance of the port, the railway distance from the hinterland and the length of new railway construction.

The railway connections will be considered in the first instance separately, the other factors being considered later on or during the treatment of the various ports.

17. **Railway Connections.**—There are several known routes by which a railway could be carried through the ghats into Mysore State. Though some of the routes were surveyed quite a number of years ago, sufficient up-to-date data was not available regarding the possible alternative routes. The Government of India were therefore requested to obtain the necessary data, and this was done through the Railway Board.

Taking Bhadravati as the centre of the area which provides the traffic for the proposed Major Port, the relative positions of the four ports of Karwar, Bhatkal, Malpe and Mangalore are given below:

	Total distance Miles	Length of new construction in miles	Cost of construction in lacks of rupees
1. Karwar-Talaguppa-Bhadravati .	152	90	431
2. Bhatkal-Talaguppa-Bhadravati .	114	52	286
3. Malpe to Bhadravati *via* Hulikal Ghat.	108	108	584
4. Mangalore to Bhadravati *via* Hulikal Ghat.	150	150	711

These routes are shown in the map [Appendix II(*d*)].

It will be seen that although the length of new construction is only 90 miles in the case of Karwar the total distances for haulage of goods from Bhadravati is 152 miles which is more than the distance from any one of the other three ports.

In the case of Bhatkal the length of new construction required is the shortest due to the proximity of the Mysore Railway terminus at Talaguppa. The distance of haulage from Bhadravati is however 114 miles and this is slightly in excess of the distance from Bhadravati to Malpe along the direct route now proposed.

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The Bhadravati-Malpe route considered runs westward starting from Bhadravati, touches Tirthahalli, crosses the Western Ghats at the Hulikal Ghat and following a south-westerly direction along the Hosangadi-Brahmawar Road reaches Malpe at mile 108. This is the shortest of the four routes considered, although in the matter of initial construction it is longer than routes (1) and (2).

The Bhadravati-Mangalore route follows the same alignment as route No. 3 between Bhadravati and Malpe and from Malpe it follows the coastal route to Mangalore, the distance between Malpe and Mangalore being 42 miles. It may be mentioned that another alternative route between Malpe and Mangalore is possible along an inland route, but this would increase the distance by 21 miles. The route considered is the shortest possible between Mangalore and Bhadravati, and both in the matter of initial construction and total haulage it is more than in the case of Malpe.

Another railway alignment connecting Mangalore with Mysore territory appears to have been under consideration some time ago. This is along the Mangalore-Hassan route, *via* Shiradi Ghat, and this has also been examined. According to this alignment even although the length of new construction required between Hassan and Mangalore is only 108 miles the total distance from Bhadravati to Mangalore is 203 miles.

Having established the source and volume of existing and potential traffic, and the possible railway conections to the hinterland, the coast line may now be examined in detail.

18. **Mormugao.**—This port, situated in Portuguese territory, is operated by the Madras and Southern Mahratta Railway. There is a good harbour with natural protection from the South West Monsoon, and an artificial break-water has been constructed to afford greater protection. There are five cargo berths, and various anchorages in the harbour. The port has handled 600,000 tons of cargo per annum, and there is scope for considerable expansion. At present, the limiting factor is the capacity of the Ghat Section of the Railway, which links up with the M. & S. M. Railway at Castle Rock. The port serves the Deccan and to a certain extent the northern portion of Mysore State, *via* Hubli Junction, 126 miles distant from Mormugao.

Although in foreign territory, Mormugao is, to all intents and purposes, an Indian Port. The bulk of the traffic passing through the port is in transit to or from India, and for such traffic customs duty is levied only by the Indian Government.

19. **Karwar.**—The port of Karwar is situated about 40 miles south of Mormugao. Karwar Bay forms a fairly extensive anchorage, with varying depths of water, up to 25 feet. Protection from the south west is afforded by Karwar Head, a rocky promontory stretching out into the sea at the southern extremity of the bay, and a number of islands give some slight protection from north-westerly winds. When the port was inspected a north-westerly wind was blowing, resulting in a swell in the harbour which would cause ships to range if tied up at berths.

Generally speaking, Karwar is very similar to Mormugao, and the construction of an all-weather port would follow the same procedure as that adopted at Goa. Berths could be constructed on the northern face of Karwar Head, where there is already a depth of 25 feet of water. As a subsequent stage of development, Baitkol Cove could be deepened and widened to form additional berths. A breakwater would be necessary on lines similar to that constructed at Mormugao.

There are a number of rocks and islands at the approaches to the harbour affording a certain amount of protection and there are several charted submerged rocks. Ashore the entire geological structure is of rock formation.

The sub-soil investigations which were carried out in Karwar Harbour indicate that it would be possible to dredge the harbour to give a depth of 30 feet at low tide. Rock was found at depths varying from 32 feet to 58 feet below zero, and above the rock there is an overlay of silt and clay. The bearing capacity of this silt is very poor, and breakwaters would have to be carried down to rock, necessitating very heavy sections.

Another important factor is the position of the mouth of the River Kalinadi. This river debouches into the northern extremity of the harbour, and from measurements of the present position of the river mouth compared to a study of old charts it would appear to be moving southwards. As silt is brought down by this river, it is possible that the construction of a deep water port in the harbour would result in a dredging problem of some magnitude.

Although Karwar has many features to commend it from the engineering point of view, the natural advantages of Karwar harbour are not superior to those of at least one other site further down the coast. Karwar cannot be recommended as the site for a new major port, the following disadvantages being evident :—

1. Its geographical position, in relation to the hinterland.
2. Its proximity to Mormugao, only 40 miles away, and which is already served by a Ghat railway.
3. The construction of the port may result in a dredging problem of some magnitude, owing to the proximity of the Kalinadi River.
4. Longer railway haul. Karwar is 44 miles further from Bhadravati than Malpe, and 38 miles further than Bhatkal.
5. The present trade of Karwar is only 4,500 tons per annum, and there is little likelihood of the port attracting new traffic.

20. **Bhatkal.**—Bhatkal is situated at the southern extremity of Bombay Province about 112 miles south of Mormugao. It is a very small port, and at present does a negligible amount of trade. The Bhatkal River, with a catchment area of only about 24 sq. miles enters the sea, and forms a sand bar, immediately east of Lighthouse Hill. Suggestions have been made, from time to time, for the construction of an all-weather port at the mouth of this river, either to the east or west

of Lighthouse Hill. The five fathom line lies over 3,000 feet out from the shore. There is no protection from the monsoon swell, and to construct a port the cost of outside works would be very heavy.

Several eminent engineers have reported on Bhatkal on behalf of the Mysore Durbar, and they have all commented on the difficulty in making such a port an economic proposition, on account of the high cost of the outside works, *i.e.*, breakwaters and approach channel, the latter probably having to be cut through rock.

Apart from the high cost, however, Bhatkal lacks the features necessary for a really first class port, as it would have no outer harbour, and could not accommodate many more vessels than the number of berths provided. It would have no elasticity and could not cater effectively for the bunching of ships, the laying up of ships inside the port, or the arrival of ships in convoy.

In spite of these drawbacks it was decided to investigate Bhatkal further in view of its very favourable geographical position, and borings and hydrographic surveys were prepared and made available to the Committee. The surveys revealed that whereas a channel could probably be made from the sea to the 5 fathom depth, without much difficulty there are numerous dangers in the approaches and a buoyed channel would be necessary for several miles to seaward of the five fathom contour. The bed of the sea between the 5 fathom contour and the shore is studded with rocks. The borings and probings revealed that, with the exception of a narrow gorge along the alignment of the river, rock levels are high. From the beach, the bed rock slopes down towards the sea with an overburden of not more than 6 feet, and at the highest point the level of the rock is one foot above low water level. The implications of this are serious. A vast quantity of rock would have to be removed from under the sea to form an entrance channel, and this would be a tremendous task. Further rock excavation would be necessary to construct the berths, but as this could be done within a cofferdam, it would not present the same difficulty.

The Committee has no hesitation in rejecting Bhatkal as the site for a major port, and the reasons are summarised as follows :—

1. There are no natural advantages for the construction of an all-weather port, and it is exposed to the full force of the South-West Monsoon.
2. A port constructed at Bhatkal would have no outer harbour, and would thus have no elasticity.
3. Breakwaters would have to be built out into deep water at great cost.
4. Hydrographic surveys reveal that before deep water is reached, the sea bed is studded with rock projections, which would have to be removed to form a channel and this channel would have to be bouyed and lighted.
5. Sub-soil investigations reveal the presence of rock over the entire area, and at a high level. Large quantities of rock would have to be removed from under the sea to obtain an entrance

channel. Further large quantities of rock would require to be excavated in order to construct steamer berths.

The next port proceeding down the coast is MALPE, but before examining the claims of Malpe, the remaining possible sites may be considered.

21. **Mangalore.**—This is already a minor port of some importance situated 196 miles south of Mormugao. It is the centre of the South Kanara District, and as already indicated, handled an import and export trade in 1946-47 amounting to 184,230 tons, *vide* Appendix IV.

The port is an open roadstead, and is closed from May to September during the south-west monsoon. Vessels lie at anchor about 2 miles from the harbour entrance and cargo is transferred to lighters and taken to the inner harbour.

The harbour is formed by the Gurpur River which runs in a southerly direction, parallel to the coast, and joins the Netravati River, at its mouth. The former river is separated from the sea by a narrow sandspit, several miles long, which provides complete protection from the sea. The entrance to the harbour is *via* the mouth of the Netravati, and there is a bar just outside the entrance, which varies after each monsoon, the depth over the bar varying from 7 to 9 feet.

Mangalore has not, in the past, been favoured as a possible site for a major port because of the fear that a deep water channel could not be maintained at the mouth of the Netravati River. This is probably correct, but it may be that the claims of Mangalore have been dismissed too lightly. It may be possible for example to convert the present harbour into a tidal basin, by diverting the two rivers away from the harbour, and cutting a new entrance channel through the sandspit near the northern end of the port. The rivers, particularly the Gurpur follow an unnatural course at present. The Gurpur has on more than one occasion burst through the sandspit, and it would be merely assisting nature to allow this river to run straight out to sea, north of the harbour.

The question for consideration is, could a deep water channel be dredged and maintained from the five fathom line to the inner harbour, a distance of about 1½ miles? The Port of Cochin has an entrance channel three miles long, unprotected by artificial means. Whether or not such a channel could be maintained at Cochin was a subject of controversy for years, until the channel was dredged and it was proved conclusively that its maintenance was easy and no more than a normal port dredging problem. It is well known that the mud banks of Malabar have a tranquillizing effect on the sea, and even before the new harbour was constructed at Cochin, vessels could lie outside, in safety during the monsoon. These conditions, however, do not apply at Mangalore.

It was felt by the Committee that Mangalore might offer a solution to the problem of finding an all-weather port without having to resort to artificial protection in the form of breakwaters. Consequently Mangalore was given the fullest consideration, and sub-soil investigations and surveys were put in hand.

Several borings were taken in the harbour, and on the alignment of the proposod entrance channel. Those in the harbour revealed rock at an average level of —50 L.W.O.S.T. almost ideal conditions from the point of view of dredging and construction of steamer berths. Unfortunately, however, the borings on the alignment of the proposed entrance channel were not so satisfactory. Coming in from the sea the first two borings revealed soft clay and silt but as the shore was approached sand was found in increasing depths. The boring taken on the sandspit revealed sand to —22 L.W.O.S.T., a total depth of 35 feet below ground level. It is obvious that a channel, dug through such a depth of sand, would be obliterated very quickly unless protected by some artificial means.

The sub-soil investigations therefore revealed that the chief attraction of Mangalore, namely, the possibility of constructing an all-weather port without outside protective works, did not in fact exist. They also revealed that even with protective works there is no certainty that the entrance channel could be maintained without extensive dredging. In fact there is an element of doubt as to whether it could be maintained at all.

Had the results of the investigations proved more satisfactory Mangalore would have had a good case, as the cost of constructing the port would have been very much less than elsewhere. It was on this premise that so much consideration was given to Mangalore.

Another objection to the selection of Mangalore is the lack of room for development in the vicinity of the port. There is a large sand-spit which would provide adequate room for transit sheds and railways, but a major port should have room to attract new industries, including the possibility of ship-building yards, and in this respect Mangalore is also lacking.

The Committee has therefore decided that Mangalore should not be selected as the site for the new port, and for the following reasons :—

1. Conditions at Mangalore, as revealed by the sub-soil survey, introduce an element of doubt regarding the possibility of maintaining a dredged channel open throughout the year, even at the cost of heavy dredging.
2. Distance from the hinterland. The rail distance from Mangalore to Bhadravati is 42 miles longer than from Malpe to Bhadravati, and 36 miles longer than from Bhatkal to Bhadravati.
3. Availability of land. All the land in the vicinity of the port is built-up with the exception of the sand-spit. Although this provides sufficient space for the development of the port, there is no room to attract new industries which might be expected to develop in conjunction with the growth of a major port.

22. **Other Ports.**—Other sites were visited along the coast, but none were found suitable for conversion into an all-weather port, particularly

when their geographical positions were taken into account. South of Mangalore, visits were made to Cannanore, Tellicherry and Calicut, all open roadsteads, and likely to remain as such, as they have no features to commend them. Beypore, and a few other sites, may possibly be developed for small coasters, and this will be dealt with later under "Minor Ports".

23. **Malpe.**—This is at present a small port, of little importance, in the north of Madras Province, 164 miles south of Mormugao. It is situated at the outlet of a small river which enters the sea in a northerly direction. About 1 mile off-shore there is a string of granite islands, known as St. Mary's Isles, running generally parallel to the coast.

It was apparent to the Committee that a large sheltered harbour could be obtained by running out breakwaters from the shore to St. Mary's Isles and connecting the islands together, also by breakwaters. The breakwaters would be, for the greater part, in shallow water, as most of the protection in deep water would be provided by the islands.

It is significant that although the five fathom contour line is some distance out to sea, beyond the islands, there are indications of a wide channel 25 feet deep between the two islands known as Middle Rock and North Island. Before the possibilities of Malpe could be properly assessed, however, it was essential to know the depth at which rock was likely to be encountered both in the harbour and in the approach to the harbour. As in the case of the other ports considered, sub-soil investigations were put in hand, and a new survey of the harbour was prepared.

The results of these investigations are very satisfactory. Rock is found in the harbour at an average level of —33 L.W.O.S.T., which means that the harbour could be dredged without encountering rock. It was also confirmed that there is a good entrance channel, between Middle Rock and North Island which would require little dredging, and is clear of obstructions in the form of submerged rocks.

Conditions at Malpe are therefore favourable for an all-weather port, although the cost of protection work, involving about 2 miles of breakwaters, will necessarily be high.

The advantages of Malpe are summarized as follows :—

1. The islands off-shore from the nucleus of a sheltered harbour. Although groynes would be required to link up the islands with the shore, most of the protection in deep water has already been provided by nature.
2. The sub-soil investigations reveal that the harbour could be dredged without encountering rock.
3. There is a good entrance from the sea.
4. The total area of the harbour would amount to over 400 acres, which is ample for a very large port.
5. Only a small river enters the harbour, and this could easily be diverted. There would thus be no dredging problem.

6. The geographical position is favourable in relation to the hinterland. The railway haul from Malpe to Bhadravati is 42 miles less than from Mangalore and 44 miles less than from Karwar.

7. There is extensive land available for the port estate, and to attract new industries.

8. Malpe is only 60 miles from Jog where hydro-electric power is available.

Two factors which are against Malpe are (*a*) the extra cost of new railway construction which amounts to Rs. 298 lakhs over the connection to Bhatkal, and (*b*) the tonnage of estimated traffic which will be 277,000 tons per annum less than for Mangalore. But the advantages mentioned above far outweigh these disadvantages especially when the conditions obtaining at the two other ports are taken into consideration.

The above considerations have led the Committee, without hesitation, to select Malpe as the site for the new port. An approximate estimate of the cost of construction of the first stage, amounting to Rs. 350 lakhs has been prepared, and is given in Appendix VI. This estimate provides for the construction of four deep water berths and lighter berths, the necessary groynes and breakwaters, and the provision of a dredged channel from the sea to the berths.

24. **Probable Traffic.**—The following is the estimated tonnage of import and export traffic which is likely to be attracted initially to Malpe based on the 1951-52 forecast :—

	Steamer tons.	Country craft tons.	Total tons.
(1) Traffic from Mysore	4,20,000	25,000	4,45,000
(2) Traffic from South Kanara . . .	20,000	20,000	40,000
(3) Traffic from new railway—Bhadravati to Malpe (forest produce, etc.) .	15,000	25,000	40,000
(4) Bunker coal, etc.	30,000	..	30,000
TOTAL .	4,85,000 *plus* petroleum.	70,000	5,55,000

The above figures are based on 1946-47 traffic with the exceptions of the Mysore industrial expansion which is based on the 1951 estimate. Figures have been worked out for the development of Mysore traffic up to 1961, and allowing for a normal growth of trade in the other districts and taking into account traffic trends the tonnage of imports and

exports likely to be attracted to Malpe would be as follows :—

	Steamer tons	Country craft tons	Total tons
(1) 1955	5,69,000	63,000	6,32,000
(2) 1961	7,33,000	73,000	8,06,000

The Mysore traffic figures as given above and in Appendix III were arrived at a joint meeting with the Mysore officials of the Departments of Railways and Industry. Figures obtained subsequently from M. & S. M. and S. I. Railways show that the estimate may be on the high side by nearly 70,000 tons. The original estimate was also based on the assumption that the entire quantity of high quality industrial coal (76,000 tons in 1951, 136,000 tons in 1961) would be port traffic and that the fairly heavy traffic between Mysore and Bombay would move by the rail-cum-sea route. Consultation with the Coal Commissioner, Calcutta reveals that a fair proportion of total coal required is likely to move by the all-rail route from the Central India coal fields. Similarly some portion of the Mysore-Bombay traffic is sure to move by the all-rail route on grounds of quick transit, less handling and direct delivery. It may therefore appear that the Mysore traffic has been over estimated by 100,000 tons.

On the other hand, account was not taken of the considerable port traffic which is bound to arise from further industries following in the wake of the second stage of the Jog Hydro-electric scheme. Further, in view of recent announcements from the Centre, it is likely that considerable encouragement will be given to the development of the ship-building industry. Where would there be a more suitable place for a ship-building yard than at the new port—close to the new industrial centre of Mysore, with adjacent forests, and cheap electric power ?

Taking everything into consideration the estimate may be left unaltered.

24a. **Economic Considerations.**—The economics of a port are governed by two principal factors : (*a*) the cost of construction and maintenance, and (*b*) the revenue from traffic using the port. For (*a*) the cost of construction as given above is estimated at Rs. 350 lakhs. For (*b*) a net yield of Rs. 2 per ton of traffic is normally considered a fair yield to the port. In the case of Malpe it will perhaps be better to take an average of Rs. 1/8 per ton in view of the fact that a fair portion of the traffic consists of country craft traffic and bulk cargoes like coal. On this basis the following return on capital would be obtained, to cover interest and sinking fund charges :—

Annual Traffic	Percentage Return on Capital
5,55,000 tons (1951 Estimate)	2·4
6,32,000 tons (1955 Estimate)	2·7
8,06,000 tons (1961 Estimate)	3·4

It would appear, therefore, that a port at Malpe would develop into an economic proposition, and it must be remembered that even on the basis of the 1961 traffic the port would not be working to full capacity as it would handle up to 1 million tons of traffic annually with four deep water berths and lighter berths (1st stage).

With a large volume of the Mysore traffic travelling the entire length of the new railway, it can be expected that a railway constructed from Bhadravati to Malpe would yield a satisfactory return on capital.

Quite apart from this there is the enormous saving to the trade in transport costs. As an example the estimated port traffic to and from Mysore State is 5,14,000 tons in 1955. The cost of transport by rail is approximately 12 pies per ton mile, while the reduction in haul between Bhadravati-Mormugao and Bhadravati-Malpe is 224 miles. On these figures the saving in transport costs to the trade is no less than Rs. 72 lakhs per annum. Too much emphasis need not be laid on the self sufficiency of a new port. Viewed in the context of the material advantage to the country the siting of a new port would be justified even if the port be not self-sufficient for a few years to come.

25. **Needs of the Entire Area.**—We have throughout considered the problem from the point of view of the traffic potential, based on sanctioned projects for industrialisation. An investigation such as this, however, would be incomplete if consideration were not given to the possible effects of the hydro-electric projects in Coorg and the Madras Presidency, with their possible industrial developments in the thickly populated districts of South Kanara and Malabar. The people living in the coastal belt stretching from Karwar to Mangalore at present suffer from complete lack of facilities for movement out of their districts during the monsoon months. The siting of an all-weather port would provide a much needed facility for passengers during the monsoon months. Looked at from these points of view Malpe is a suitable choice.

26. **Recommendations.**—(1) In answer to question II(a) the Committee is of the opinion that a deep-sea port between Mormugao and Cochin for the accommodation of ships of large size and tonnage at all seasons of the year is necessary.

(2) In answer to Question II(b), the Committee is of the opinion that—

(*a*) The port should be situated at Malpe.

(*b*) A railway link should be provided from Malpe to the industrialised district of Mysore centred around Bhadravati.

(*c*) The broad gauge railway linking Madras with Mangalore should be extended to Malpe.

(*d*) The programme for improvements to existing ports, such as Madras, Cochin and Mormugao, whose traffic is likely to be affected by the construction of a port at Malpe, should be carefully scrutinised in order to avoid unnecessary expenditure.

27. **Implementation.**—It is recommended that the following investigations be made as soon as possible :—

(1) The sub-soil investigations already carried out at Malpe should be supplemented by a complete set of borings throughout the harbour.

(2) The approaches to the port should be swept, and all obstructions marked on the chart for future removal.

(3) A scheme for an adequate water supply to the port should be prepared.

(4) Detailed surveys should be made for the proposed new railway links.

The construction of an all-weather port on this coast, combined with a railway through the Western Ghats, is a big undertaking and it will be most desirable to obtain the best engineering advice for the final layout of the port and rail connections.

28. **Improvements to Existing Ports II(c).**—"What improvements are necessary in communications to the existing ports ; also what other measures should be taken for the development or provision of additional facilities in these ports as may be found necessary or desirable".

Minor ports are at present in the charge of Provincial Governments. Thus the Government of Bombay look after the minor ports in that Presidency through the Collector of Excise. Madras Government on the other hand have a Presidency Port Officer with a number of Sectional Port Officers and a small engineering staff. The trade of the Madras Minor Ports is many times that of the trade of the minor ports in the Bombay Presidency and this possibly explains the greater care exercised in following a definite line of policy in the management of the Madras Minor Ports.

North Kanara.—The Minor Ports Committee appointed by the Government of Bombay published its report in 1939 and suggested improvements at certain ports by dredging, removal of or demarcation of shoals, prevention of siltation, development of roads and communications and provision of certain facilities for landing of passengers and handling cargo. The Committee did comment on the very poor traffic passing through these minor ports justifying little or no major improvements. They did however, recommend certain improvements to some of the minor ports which in most cases have not been carried out either through lack of funds or because the Public Works Department did not consider that the trade justified the extra expenditure.

There is considerable amount of passenger traffic to and from North Kanara ports and certain facilities such as jetties, passenger sheds, and sanitary arrangements are necessary, particulary at Karwar Government's attention is drawn to the fact, that port traffic small as it is in these minor ports, would benefit considerably if some of the rivers or tidal creeks were provided with road bridges. There is a definite need for the new dangers discovered at the approaches to Bhatkal to be marked by buoys.

South Kanara and Malabar Ports.—Some of the proposals of the Madras Government regarding the improvements to the existing minor ports are :—

Malpe.—Dredging the channel and provision of more powerful coast lighting. Cost Rs. 40,000.

Coondapur.—Construction of a wharf wall and provision of coast lights. Cost Rs. 78,700.

Mangalore.—Reconstruction of south wharf and road facilities on the south reclamation. Cost Rs. 1,10,000.

Tellicherry.—Road improvements. Cost Rs. 14,000.

Calicut.—Strengthening of both piers—laying trolly lines and provision of roads and cranes. Cost Rs. 2,72,000.

The works at Mangalore and Tellicherry are reported to have been completed, and the strengthening of the piers at Calicut is progressing. The work at Malpe should be postponed.

As regards communications, the highway running the entire length of South Kanara and Malabar, proposed by the Madras Government would be of inestimable value.

Proposals have been made by the Madras Government for improvements to existing inland waterways on the west coast. These proposals visualise the utilisation of existing rivers and backwaters for very small craft, and interconnecting these waterways by means of canals. While these schemes would certainly benefit the districts concerned, by providing better communications, they have no material bearing on port traffic.

As mentioned earlier in the report, statistics have not been maintained of dead weight tonnages of cargo kept commodity-wise. It is recommended that these statistics be maintained at all minor ports in three separate categories, *viz.*, (*i*) ocean traffic, (*ii*) coastal traffic (ship-borne), and (*iii*) country craft traffic.

29. **Coastal Shipping.**—Along this coast line there are many suitable sites for the construction of small ports, or sheltered anchorages, for small coastal vessels. At present, coastal shipping practically closes down during the monsoon, on account of the lack of sheltered harbours. As the west coast is separated from the interior by the Western Ghats, the only effective means of transport, in many places, is by sea, and it is a serious deterrent to trade when this form of transport breaks down for several months every year.

It would appear that there are a number of the minor ports on the west coast which could probably be converted into all weather ports if in each case, a channel were dredged into calm water, deep enough to take small coastal steamers. The depth of the channel should be twelve feet at L.W.O.S.T. or thereabouts and if necessary ships could cross the bar taking advantage of the tides. This scheme also visualizes the construction of small jetties at which coastal steamers could tie up and

work their cargo. It would be necessary to employ a sea-going dredger probably of the trailer-suction type, as it might have to work in a slight swell, to dredge and maintain these channels. The Madras Government did, in fact, contemplate procuring a dredger for this purpose but discarded the idea when it was stated that the coastal ship of the future will be a large ship of deep draught.

Obviously the success of such a scheme would depend entirely on the policy enunciated by the Central Government which has often expressed its keen desire to build up national shipping. It would be in the fitness of things if this policy is now clearly outlined in detail with regard to overseas traffic, and coastal traffic. Whereas the main trade movements between the east and west coasts require large ships, there is considerable room for the small coaster of 1,000 to 1,500 ton capacity drawing not more than 14 feet of water. Further, there is much to commend the policy of using small ships along this coast as feeder services. Such a policy has been worked to advantage in other countries.

Not only does this system offer better facilities for the minor ports but merchants could obtain through bills of lading.

The economic indivisibility of the Indian Dominion and the Indian States, the requirements of India's rapidly increasing industries and agriculture, and the desirability of dispersal of industry and the development of import and export trade, all point to the necessity for a well-balanced and comprehensive policy controlled from the Centre.

The need for a Central Harbour Board, co-ordinating all port matters with industry, commerce, customs, railways, communications and defence, was felt at every stage of the investigations. It is strongly recommended that such a Board be formed under the auspices of the Central Government. While not necessarily controlling the day-to-day activities of the many ports in India, this Board would be responsible for the broad policy to be followed in the development of all ports, major or minor, and for the conservation of the entire coastline of India.

30. **Conclusion.**—The Committee wishes to place on record its grateful appreciation to the Governments of Bombay, Madras and Mysore for the great help and kindness which was extended to them wherever they went. They also desire to thank all the municipal, port and other officials and the various trade representatives for their untiring help and advice and for the mass of information which they produced. The Committee also wishes to express its appreciation to the Royal Indian Navy for the surveys which they made of various ports and for the loan of craft and equipment for carrying out the sub-soil investigations, and to the Railway Board for the surveys and estimates of the cost of new railway connections.

The Committee is also indebted to Mr. M. Ramabrahmam for the expeditious and efficient manner in which he conducted the sub-soil investigations.

The thanks of the Committee are also due to Mr. V. V. Bhide who acted as Secretary for the greater part of the investigations, and to

Mr. Ramabrahmam who latterly acted as Secretary and Executive Engineer.

KASTURBHAI LALBHAI,

Chairman.

My note is attached.

W. G. W. REID,

2-7-1949

Member.

S. N. HAJI,

Member.

K. MITTER,

Member.

J. B. MURRAY,

Member.

CAPT. G. P. RANSON, R. N.

Member.

M. RAMABRAHMAM,

Secretary.

31st May, 1949.
2nd July, 1949.

NOTE

It is unfortunate that a member of the Committee who whilst I was on leave had more to do with this matter than myself, has now left the country, and I am called upon to sign a report on a proposition with which to a large degree, I have not been associated. For this reason, I have felt it necessary to consider various aspects of the question, in my own way, before supporting the conclusions of the Committee, which unlike myself, has had considerable time to deal with the whole subject.

I may be quite wrong in my assessment of the necessity for a new port. In fact, I am not prepared to say that a new port is not necessary on the West Coast of India between Mormugao and Cochin, but the economic aspect of the matter is one about which I am somewhat concerned. It may be that it is only necessary to say a port is required as a convenience and leave it at that, but if it is to be financially justified—either that or the Government of India should be prepared to shoulder a continual loss—a close examination of the justification is essential. In other words, if the projected port is to become a financial proposition as distinct from an amenity, then I feel it is vitally necessary to examine very carefully the economic grounds on which the construction of the port is to be justified.

The Committee has made a statement to the effect that the transportation of 514,000 tons (1955 estimate) over an avoidable distance of 200 miles would cost trade over Rs. 60 lakhs a year. They go on to say "This is sufficient justification for the siting of an all-weather port with the necessary rail connections on the coast under review".

With that statement I cannot agree as I do not consider that the transportation of 514,000 tons is sufficient to justify the building of a major port.

The cost of construction today requires, in my view, a very much larger volume of traffic to reduce overheads to reasonable proportions and show a profit on working, unless of course, it is accepted that the financial side of the matter is to be entirely subordinated to the trading amenities which the port will provide.

The Committee have commented on the movement of coal and, quite rightly I consider, have conceded that the movement of this commodity would not be by the rail-cum-sea route, but 100,000 tons is a considerable proportion of the traffic involved and to retain it in the traffic estimates by substituting this heavy coal demand (which with the advent of cheap electric power is unlikely to materialise in any case) by 100,000 tons of nebulous traffic may assist the economic or financial justification on paper, but it ignores, in my view, the realities of the case and is misleading.

A breakdown of the imports 1961-62 give the following figures, except that coal and coke are substituted in terms of unknown traffic :—

Imports	*Tons*
Coal and Coke	136,500
Scrap	15,000
Refractories	8,000
Pulp and Chemicals	11,600
Sulphur	9,400
Rock Phosphate	80,000
Salt	15,000
Electrodes	5,000
Cryolite	1,000
Electric goods	25,000
Textiles	5,000
Plastic etc.	3,500
Gunnies	1,000
TOTAL	316,000

The point arises here whether the movement of this material through the port would be advantageous to trade. It is unquestionable that coal will not move by the rail-cum-sea route if and when, the Railways can move it by the all-rail route and in any case movement by sea-cum-rail would lift the cost of transportation considerably above that by the all-rail route. The movement of scrap and refractories (and as a striking example 1,000 tons of gunnies, which would come from the Calcutta area) would not in my opinion move other than by all-rail route. 15,000 tons of salt expected to move from Tuticorin must pay country craft rates up to the new port, whereas Mysore normally gets most of its salt by the all-rail route from Bombay, so that the total cost of transportation would still be about the same. Actually the movement from Tuticorin is doubtful and even if it is attracted to the sea route it will probably continue to move from Bombay.

I am inclined to the view that the only traffic on which the lead would be less and therefore, provide a gain in transport cost to the Trade, would be imports from overseas. At the figure of saving of Rs. 14 a ton (used by the Committee in their Report paragraph 24) the total savings would be no more than Rs. 21 lakhs to be set against increased cost on either coal or other traffic, scrap, gunnies, etc. If to this is added the losses on exports if they should follow the rail-cum-sea route the position is

still less healthy. The exports are listed below :—

Exports.	*Tons*
Steel, pig iron and C. I. pipes	43,500
Chemical fertilisers	40,000
Paper	4,000
Sugar	8,000
Caustic Soda and bleaching powder	6,000
Electric goods	7,000
Metal products	8,000
Textiles, tobacco, etc.	10,000
Aluminium	3,000
Plastic and Rayon	2,000
Ferro Silicon	8,000
Acetic acid	500
TOTAL	140,000

The question I ask is where is this exportable surplus to go ? It must either go overseas or to other ports in the Indian Dominion.

The first I consider may be ruled out because India itself can consume everything Mysore may have to offer and why should this large volume of traffic move out of one port merely to re-enter India *via* another, over a difficult Railway system.

The disadvantages of this, as compared with all-rail transport (with only one transhipment) are :—

(*i*) Comparatively high rail freight to and from the port would be paid as the advantage accruing from the telescopic scales of rates would be lost. An additional charge of Rs. 1/11 0 per ton would also be payable in Railway terminal charges, as matters stand at present, because of four end terminals, against two by the all-rail route.

(*ii*) Goods will be handled six times, *i.e.*, loading and unloading four times on rail and twice on ships, as against only three, by the all-rail route (including the break of gauge transhipment).

(*iii*) Higher total costs of transport F.O.R. internal destinations and longer transit time. For traffic consumed in the port areas, the advantages by the all-rail route are, of course, slightly less.

In addition, unless the Government of India decree otherwise, the Railways to be affected are certain to lower their rates to attract the traffic to the all-rail routes and in view of the disadvantages enumerated

above, there is every reason to believe that the Railways will be able to compete successfully.

The argument, therefore that the cut in the lead to the coast and thereby Trade will benefit to the extent of about Rs. 72 lakhs per annum cannot be sustained, because it appears that it is based on the wholly fallacious assumption that transport of the estimated exports and imports (*vis-a-vis* the other ports) commences and ceases at the new port and that passage through the new port is inevitable. Except for imports and exports (if any) to overseas, these assumptions are incorrect.

I do not dispute that ultimately a new port may be necessary on the West Coast of India, but I cannot accept the picture as it is presented at the moment, as a justification. "Viewed in the context of the material advantage to the country the siting of a new port would be justified even if the port be not self-sufficient for a few years to come" is a statement made. It may be that this is the case, but the justification must rest on something real and the decree to which the words "a few years" in the context of the statement will influence the self-sufficiency must be taken into consideration.

It is necessary I feel to examine more closely the financial implications if the avoidence of a loss on working is a consideration to be taken into account as I believe it should be.

The Committee state that with an annual traffic of 550,000 tons (1952 estimate) the percentage return on Capital will be 2·4, rising to 3·4 when the estimated traffic of 806,000 tons is moved in 1961. It has been stated that the siting of a new port would be a material advantage to the country even if the port is not self-sufficient for a few years to come, but, on the other hand, "that a port Malpe would develop into an economic proposition" and the information given showing the return on capital indicates that this would be the case, but in my opinion, quite apart from any doubt as to the accuracy of the traffic estimates, there are several other features of the financial statement which are open to question. For purposes of what follows I am accepting the estimates of traffic given in the report *viz.*, 550,000 tons (1951) and 806,000 tons.

Capital Cost.—This has been estimated as 3·5 crores which, to my mind, is on the low side. A study of the estimates discloses for example, that no provision has been made for the purchase of dredgers, tugs, etc. The cost of 4 berths 600′×60′ quay width + 550′ frontage is given as 75 lakhs of rupees, whereas the Madras Port Trust estimate for a *single* berth of the same dimensions, without taking into account cost of rail and crane tracks etc. would be Rs. 27 lakhs. For a new wet dock 600′× 25′ complete with transit sheds, railway tracks, dredgers, etc. etc., *i.e.*, fully equipped, the Madras Port Trust have submitted detailed estimates amounting to Rs. 4·5 crores. It is very doubtful, therefore, whether in another year or two, it will be possible to build a complete new port for Rs. 3·5 crores.

I propose to assume that the new port instead of costing Rs. 3·5 crores costs actually Rs. 4·5 crores (it will probably cost much more)

and on this basis, financial liability would be as under :—

	Rs.
Capital Cost	450,00,000
Interest at 3%	13,50,000
Amortization at 0·6 %	2,70,000
TOTAL .	16,20,000
Anticipated net revenue per ton of traffic handled . .	1/8/-
Tonnage required to be handled to meet capital charges in full will be	1,080,000 tons
Estimated tonnage in 1951	550.000 tons.
At Rs. 1/8/- per ton, revenue will be	Rs. 825,000
Loss in 1951	Rs. 795,000
Estimated tonnage in 1961	806,000 tons.
Loss in 1961	Rs. 411,000
Accumulated loss between 1951 & 1961	Rs. 61 lakhs (approx.)

It is to be noted that the anticipated net revenue per ton of traffic handled is shown as Rs. 1/8/0 but the estimate of country craft in relation to deep sea traffic is high roughly 10% of the total in 1961.

The Madras country craft traffic for 1948-49 is only 4% of the total. Country craft will not bear the same rates as deep sea traffic which will mean the loading of deep sea traffic from the Port of Malpe with an inflated charge to compensate for the low rate at which country craft traffic must be handled, in order that the overall return should be Rs. 1/8/- per ton.

It may of course be argued that in time the traffic will reach the proportions which will cover the charges; but this means 140,000 wagons with an average load of about 7 tons per wagon, giving a density of 280,000 wagons to be moved over the proposed Railway per annum or approximately 770 wagons per day covering both directions.

Let me assume that industries develop round the Port and only 230,000 out of a total of 280,000 wagons will move over the Railway during the year. With a heavily graded Ghat Section, it is unlikely that an overall average of more than 30 wagons per train could be maintained over the whole length of the proposed new Railway. This would mean 21 trains per day continuously without any stoppage or interference of any kind. This figure is high and if it could not be handled it would mean doubling the track and nowhere would the traffic be available to cover the capital charges of doubling the track, since the capacity of a double line is very much greater than the traffic offered; but it might be a necessity nevertheless.

It is to be noted here that the approximate length of the Ghat Section is 31 miles against the W.I.P. Railway of only 16 miles. The timetabled capacity of the W. I. P. Railway which is limited of course by the

Ghat Section, is 21 trains a day. It is for this reason that I consider there is a distinct possibility of having to double the line between Malpe and Bhadravati, in view of the fact that the Ghat Section is twice as long, and its capacity as a single line is greatly lowered by the limited speed on the Ghat Section.

I do not claim cent per cent accuracy for these figures nor do I overlook the possibility that my conclusion be wrong. I do, however, feel that if the financial aspect of this proposition is important, then a closer investigation of these figures is called for before a final decision is taken.

W. G. M. REID.

2nd July, 1949.

APPENDICES

APPENDIX I.

Total Import and Export Traffic of South Kanara and Malabar Ports.

South Kanara Ports.	1946-47 *Tons Traffic.*
1. Baindpur	3,962
2. Coondapur	31,492
3. Hangarkotta	5,866
4. Mulki	859
5. Kasargod	3,703
6. Malpe	16,765
7. Mangalore	184,230
TOTAL	246,877

Malabar Ports.	
1. Calicut	250,025
2. Ponnani	23,778
3. Badagara	9,475
4. Tellicherry	8,753
5. Cannanore	6,691
6. Kallayi	1,221
7. Azhikal	24,445
TOTAL	324,388

GRAND TOTAL . 246,877 tons + 324,388 tons = 571,265 tons.

APPENDIX III.

Estimate of traffic from Mysore State likely to be diverted to a new Port on the West Coast in the year 1951-52.

	Tons.
1. Traffic diverted from Bombay	20,000
2. Traffic diverted from Mormugao	50,000
3. Traffic diverted from Madras Ports (50 per cent)	80,000
4. Traffic reconsigned from port areas, and likely to move by rail-cum-sea-rail routes.	50,000
5. Road-borne traffic diverted to port	5,000
6. Industrial Expansion (1951-52)	210,000
7. Traffic from Irrigation Projects	10,000
	425,000
Add 2 per cent per annum natural growth, except for items 6 and 7	20,000
TOTAL for 1951-52	445,000

Year 1955-56.

Total traffic for 1951-52	445,000
Add 2 per cent per annum for natural growth	16,000
Add for industrial expansion by 1955	53,000
TOTAL for 1955-56	514,000

Year 1961-62.

Total traffic for 1951-52	445,000
Add 2 per cent per annum except for items 6 and 7	45,000
Add for industrial expansion	174,000
TOTAL for 1961-62	664,000

APPENDIX IV.

An analysis of Import and Export Traffic dealt with at the Port of Mangalore.

Commodity	Total tons.		Country-craft tons		Coastal steamers tons.		Foreign steamers tons.	
	1946-47	1947-48	1946-47	1947-48	1946-47	1947-48	1946-47	1947-48
Supary and Betel Nuts	5,525	6,673	1,800	3,373	3,725	3,300	..	..
Bricks and Tiles	88,808	118,462	88,808	115,962	..	..	..	2,500
Cashew Kernals	8,325	2,575	1,000	275	1,025	500	6,300	1,800
Coffee	2,056	616	306	80	750	136	1,000	400
Copra	200	224	75	100	125	124	..	..
Pepper	696	950	..	..	196	300	500	650
Oil vegetable	620	583	620	583	..	..	..	..
Fish	8,790	5,827	8,790	5,827	..	..	..	..
Cardamoms	476	310	36	30	90	80	350	200
Rice paddy and grain	4,467	6,392	4,467	6,392	..	..	..	..
Coir	3,112	1,973	3,112	1,973	..	..	..	..
Grains of other sorts	5,082	6,184	2,033	2,474	3,049	3,710	..	..
Tobacco	750	838	750	838	..	..	..	..
Sundries	10,516	20,954	4,206	10,782	6,310	16,172	..	..
Firewood	30,929	29,546	30,929	29,546	..	..	..	..
Salt	9,221	4,960	9,221	4,960	..	..	..	..
Hardware	1,510	1,424	530	424	980	1,000	..	..
Timber	3,147	663	3,147	663	..	..	..	..
Cashew shell oil	..	618	..	..	..	..	..	618
TOTAL	184,230	215,772	159,830	184,282	16,250	25,322	8,150	6,168

Average of the two years : 213,874 tons per year.
Add 25 per cent for the period during which the port at present closes down.
Estimated average total traffic per year : 250,000 tons.
These figures of traffic have been furnished by the Port Officer, Mangalore (Madras Government).]

APPENDIX V.

Estimates of Port Traffic of Bhatkal, Malpe and Mangalore for the years 1955-56 and 1961-62.

	1955-56		
	Country-craft	Steamer	Total
	Tons.	Tons.	Tons.
Bhatkal.			
Mysore traffic	27,000	487,000	514,000
North Kanara	19,000	5,000	24,000
Talaguppa-Bhatkal	15,000	15,000	30,000
Coal	..	30,000	30,000
GRAND TOTAL	61,000	537,000	598,000
	1961.62		
	Tons.	Tons.	Tons.
Mysore traffic	30,000	634,000	664,000
North and South Kanara	20,000	7,000	27,000
Talaguppa-Bhatkal Railway	16,000	20,000	36,000
Coal	..	35,000	35,000
GRAND TOTAL	66,000	696,000	762,000
	1955-56		
	Tons.	Tons.	Tons.
Malpe.			
Mysore traffic	27,000	487,000	514,000
North and South Kanara	21,000	27,000	48,000
New Railway	15,000	25,000	40,000
Coal	..	30,000	30,000
GRAND TOTAL	63,000	569,000	632,000

APPENDIX V—*contd.*

Estimates of Port Traffic of Bhatkal, Malpe and Mangalore for the years 1955-56 and 1961-62—*contd.*

	1961-62		
	Country-craft Tons.	Steamer Tons.	Total Tons.
Mysore traffic	30,000	634,000	664,000
South and North Kanara	23,000	31,000	54,000
Railway	20,000	28,000	48,000
Coal	..	40,000	40,000
GRAND TOTAL	73,000	733,000	806,000

	1955-56		
Mangalore.	Tons.	Tons.	Tons.
Mysore traffic	27,000	487,000	514,000
South Kanara	240,000	50,000	290,000
Malabar traffic	15,000	20,000	35,000
Mangalore new railway	25,000	15,000	40,000
Coal	..	30,000	30,000
GRAND TOTAL	307,000	602,000	909,000

	1961-62		
	Tons.	Tons.	Tons.
Mysore traffic	30,000	634,000	664,000
South Kanara	245,000	55,000	300,000
Malabar plus Coorg 2 per cent increase over 1955.	17,000	23,000	40,000
New Railway	20,000	28,000	48,000
Coal	..	50,000	50,000
GRAND TOTAL	312,000	790,000	1,102,000

APPENDIX VI.

Proposed Major Port at Malpe.

ESTIMATE for the construction of Stage 1.

Breakwaters, entrance channel, inner harbour and four berths each 600' long and one lighter or heavy lift berth, 550 feet long.

(*A*) *Breakwaters.*

	Rs.
North Breakwater 6,600 Lin. feet @ Rs. 1,000	6,600,000
South Breakwater 5,000 Lin. feet @ Rs. 1,000	5,000,000
Between Islands 1,000 Lin. feet @ Rs. 3,000	3,000,000
	14,600,000
	Rs. 146 Lakhs.

(*B*) *Dredging.*

Outer Channel.

3000′ × 400′ × 2′ Av. = 2,400,000 Cub. ft.

Inner Harbour.

5000′ × 1000′ × 18′ Av. = 90,000,000 Cub. ft.

92,400,000 Cub. ft.

@ Rs. 15 per 1000 cub. feet. = Rs. 14 Lakhs.

(*C*) *Construction of Berths.*

4 berths each 600 feet long × 60′ quay width + 550 feet frontage for lighters or heavy lifts.

5 berths @ Rs. 15 lakhs each	Rs. 75 lakhs.
Transit sheds 4 Nos. each 400′ × 150′ 240,000 sq. ft. @ Rs. 10 per sq. ft.	Rs. 24 lakhs.
Cranes and Equipment 4 berths @ Rs. 10 lakhs each	Rs. 40 lakhs.
	Rs. 139 lakhs.

(*D*) *Moorings and Lighted Channel.*

Allow	Rs. 10 lakhs.

Summary.

	Lakhs of Rupees.
(A) BREAKWATERS	146
(B) DREDGING	14
(C) BERTHS AND EQUIPMENT	139
(D) MOORINGS, LIGHTED CHANNEL	10
	309
Add 15 per cent for engineering and contingencies	41
TOTAL	350

APPENDIX VIII.

Report on the Sub-Soil Survey at the Ports of Karwar, Bhatkal, Malpe and Mangalore conducted by Mr. RAMA-BRAHMAM, B. E., A. M. I. E., Executive Engineer.

LIST OF PLANS

REPORT ON THE SUB-SOIL SURVEY

AT THE PORTS OF

KARWAR, BHATKAL, MALPE AND MANGALORE.

INTRODUCTION

A sub-soil survey at the four ports of Karwar, Bhatkal, Malpe and Mangalore was ordered by the Government of India at the instance of the West Coast Major Port Development Committee in order to enable the latter to examine the suitability or otherwise of these ports for development into a major port. The following is a report of this survey.

Part I of the report gives a brief description of the nature of the work and the types of observations taken.

In Part II is given a summary of the data obtained during the investigations.

Appendix 'A' gives an extract from the Note of the West Coast Major Port Development Committee giving details of data required.

Appendix 'B' gives a resume of the sequence of events and details of equipment and work done in this survey.

Appendix 'C' is a report of the properties of soils analysed.

PART I

In order to enable them to come to a decision on the question of the location of a major port between Mormugoa and Cochin on the West Coast of India, the West Coast Major Port Development Committee requested the Government of India to arrange for a sub-soil survey at the four ports of Karwar, Bhatkal, Malpe and Mangalore. An extract of the note of the Committee giving details of the data required by them is given in Appendix 'A'.

Accompanying the above note of the Committee, there were four plans prepared by them showing the locations where borings and probings were required. The locations were divided into two categories, some of them having been marked as "Essential" and the others to be taken up if time permits. The data required was (a) determination of rock levels at sites marked at the ports of Karwar, Bhatkal and Malpe, and (b) examination of soils down to a level of −35·00 L.W.O.S. at the sites marked on the plan furnished for the port of Mangalore.

The sub-soil survey conducted to collect the above data consisted of—

(*a*) Dry sample borings,

(*b*) Wash sample borings,

(*c*) Jet probings, and

(*d*) Rod probings.

(*a*) *Dry sample borings.*—These were carried out by a hand boring set and were only done on and. The soil sample was collected by a sand shell.

(*b*) *Wash sample borings.*—These were done on the sea. The soil sample was flushed out of the casing pipes by a jet of water and examined. The casing pipes were of 4" diameter while the jet pipes were 1 inch in diameter. Pressure water was supplied by fire fighting trailer pumps and just the minimum pressure sufficient to bring out the soil only was used.

(*c*) *Jet probings.*—These were put in by forcing pressure water at a maximum pressure of 200 lbs. per sq. inch through a jet which consisted of 1" diameter pipes with suitable nozzles and adapters fitted to them. These jets were driven down to refusal and the rock level was recorded from the depth of penetration.

(*d*) *Rod probings.*—These consisted of driving M.S. Rods by the fall of a drop hammer. Two equipments were used, one with rods 1" diameter and a drop hammer 80 lbs. in weight and the other with rods $1\frac{1}{4}$" diameter and a drop hammer 100 lbs. in weight. The rods were driven down to refusal and the rock level was deduced from the depth of penetration.

The type of probing adopted in each case was decided by the convenience of distribution of work between different units.

The investigation was first limited to taking probings or borings at the points marked "essential" on the plans above referred to in order to cover all the four ports in this season, but as the work progressed, certain additional locations were also examined in order to give a connected picture of the strata.

Thus, a total number of 54 probings and borings were taken as against 39 "essential" ones required at the four ports and it is considered that these give a fairly connected picture of the strata which is sufficient for our requirements. A brief outline of the factors which limited the time for carrying out the surveys, the problems which had to be tackled, the details of equipment used and the nature of the work done is given in Appendix B.

PART II

A summary of the data obtained from the sub-soil survey is given below.

The tidal conditions at the four ports are similar. The range of spring tides is about 6 feet, with slight differences. The times of occurrence of high and low waters also differ slightly at the different po ts

KARWAR (Plan No. 3).

At Karwar, there is a bay formed by a rocky headland known as the Karwar head projecting out to a distance of about 2 miles from the shore line. The bay which is to the north of this headland is well-protected by the latter from the South West Monsoon. The purpose of the present investigation is to find out the suitability of this bay for development into a major port. Rock levels were required at specified points in the bay. These were obtained by putting in jet probings at sites Nos. 1 to 4. 12 and 19 and rod probings at the rest of the sites. A total number of 19 probings were taken against 14 required as "essential".

From the nature of the soil sticking to the probing rods and the jet pipes, it was observed that the soil and sub-soil in the Karwar bay is a mixture of fine silt and clay. The penetration of probing rod was large for each blow which suggests that the bearing capacity of the soil is poor. No soil tests were done for the soil in this area.

Samples of soils were however collected from the beach by dry sample boring at the place marked 20 on the plan. The boring revealed that there is a layer of 20 feet of sand underneath which is clay. The samples of this clay and sand were analysed to determine mechanical analysis and plastic limits and the values are given in Appendix C.

An examination of the rock levels as revealed by the probings show that there is a gradual sloping down of the bed rock from the Karwar head towards north reaching down to a depth of about 55 feet below L.W.O.S. at the northern extremity of the area investigated. In the immediate vicinity of the Karwar head, there is foul ground with protruding rocks at shallow depths. This is demarcated by a conical buoy and an isolated rock projecting above High Water Mark in a line with the buoy roughly parallel to the northern face of the Karwar head. Probings taken in this line reveal no rock down to 32.00 L.W.O.S. except near the isolated rock. In the small area between this alignment and the Karwar head the rock levels are shallow and irregular while to the north of this line the rock slopes down gradually to about 53.00 L.W.O.S. at the northern-most probing.

The probing taken in the cove to the east of the Karwar head reveals rock at a depth of —27.00 L.W.O.S. In view of the fact that this cover is situated in betwen two hills and that rocks show above high water mark on the headland immediately to the west of the cove, it appears that the position of this probing might be in a valley and the area with rock at this depth is likely to be very limited.

BHATKAL (Plan No. 4)

Two rocky headlands projecting about 200 to 300 feet from a sandy beach in the form of an arc about three-fourth of a mile in between them represents the area in which the harbour is proposed at Bhatkal.

The sub-soil survey conducted to collect the above data consisted of—

(*a*) Dry sample borings,

(*b*) Wash sample borings,

(*c*) Jet probings, and

(*d*) Rod probings.

(*a*) *Dry sample borings.*—These were carried out by a hand boring set and were only done on and. The soil sample was collected by a sand shell.

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Samples of soils were however collected from the beach by dry sample boring at the place marked 20 on the plan. The boring revealed that there is a layer of 20 feet of sand underneath which is clay. The samples of this clay and sand were analysed to determine mechanical analysis and plastic limits and the values are given in Appendix C.

An examination of the rock levels as revealed by the probings show that there is a gradual sloping down of the bed rock from the Karwar head towards north reaching down to a depth of about 55 feet below L.W.O.S. at the northern extremity of the area investigated. In the immediate vicinity of the Karwar head, there is foul ground with protruding rocks at shallow depths. This is demarcated by a conical buoy and an isolated rock projecting above High Water Mark in a line with the buoy roughly parallel to the northern face of the Karwar head. Probings taken in this line reveal no rock down to 32.00 L.W.O.S. except near the isolated rock. In the small area between this alignment and the Karwar head the rock levels are shallow and irregular while to the north of this line the rock slopes down gradually to about 53.00 L.W.O.S. at the northern-most probing.

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RHATKAL (Plan No. 4)

Two rocky headlands projecting about 200 to 300 feet from a sandy beach in the form of an arc about three-fourth of a mile in between them represents the area in which the harbour is proposed at Bhatkal.

The general geological formation of the surrounding hills consists of a surface layer of hard laterite under which is a bed rock of gneiss.

The sub-soil survey reveals that generally rock levels are high except for a narrow gorge along the alignment of the river course.

A boring put in at site No. 1 revealed rock at a level of 10.00 L.W.O.S., the overburden consisting of sand and shingle. Another boring put in at site No. 6 revealed rock at plus 1.00 L.W.O.S., the overburden in this case being coarse sand.

Rock levels at the other places were ascertained by putting in rod probings. These reveal a narrow gorge in rock along the river bedin the alignment 2, 3 and 4 showing rock levels varying from —26.00 to —32.00 L.W.O.S. To the west of this on the beach, however, rock levels are higher giving values of—13.00 L.W.O.S. at probing No. 5 and —7.00 L.W.O.S. at probing No. 7.

From the beach the bed rock gradually slopes down towards the sea. As the depth of the overburden above rock level in this area is very limited (the maximum depth of penetration of probings being about 6 feet), the slope of the rock almost corresponds with the bed level of the sea in this area. The rock levels vary from plus 1.00 L.W.O.S. at site No. 6 to —33.00 L.W.O.S. at site No. 13.

MALPE (Plan No. 5)

At Malpe, there is a line of rocks known as St. Mary's Islands (Darya Bahadurgarh Islands) roughly parallel to the shore and about a mile away from it, and the investigation was intended to find out the rock levels in the sea between the shore and these Islands. While the equipment for taking probings to ascertain rock levels in the sea was being rigged up, two land borings were taken at sites Nos. 14 and 17. These reveal layers of sand and clay overlying rock which was met with at levels of —64.00 and —45.00 respectively at these two places. The soils were analysed for mechanical analysis and plastic limits and the results given in Appendix C.

The probings taken in the sea were rod probings which were driven down to refusal. The penetration in the last few feet where the overburden exceeded 10 ft. was hard revealing a high bearing capacity of the soil. The rock levels as presented by the probings in the sea reveal a fairly level stretch of rock varying from about —30.00 to —37.00 L.W.O.S. in the whole area covered except at site No. 3, where the probing rod could not be driven down below —26.00 L.W.O.S. As rock was met with at boring at site No. 14 at —64.00 L.W.O.S. four extra probings were taken around this area to get an idea of the depression. These revealed rock levels varying from —28.00 to —37.00 L.W.O.S.

From the above observations the rock statum in this area appears to consist of a general level plateau over most of the area at depths varying from —30.00 to —37.00 L.W.O.S. with a few high spots. Along the alignment of the present sandspit, there appears to be a valley in the

rock. The soil overlying rock in the sea bed is clay. Along the beach there is a layer of about 23 feet of sand overlaying this clay.

No more probings could be put in in the gap between the North and Centre (Darya Bahadurgarh) Islands as it was not possible to anchor a boat in this area. While boatmen with a knowledge of local conditions were prepared to take their boats across the gap without any difficulty they were unwilling to lay anchor in this area due to the presence of rocks which would result either in the anchors not "gripping" or alternately in their getting "locked in" in crevices in the rock masses which would necessitate their cutting off. One of these protruding rocks was visible above Low Water Mark at a distance of about 180 feet from the tip of the north island, the total width of the gap between the two islands above Low Water Mark being about 600 feet.

MANGALORE (Plan No. 7)

The investigation here consisted of an examination of soils to a depth of —35.00 L.W.O.S. along the proposed alignment of the entrance channel. Four borings were taken, one a dry sample boring on land and three wash borings in the sea. Boring No. 1, taken on the sandspit reveals a layer of coarse sand from Ground Level (Plus 13.00) to —22.00 L.W.O.S. below which is clay down to —49.00. This soil between —22.00 and —49.00 was analysed and found to contain 57% of clay, 23% of silt and 20% of sand. It had an initial moisture content of 46.7%.

At the site of boring No. 2, the bed level of the sea is —19.00 L.W.O.S. From this level to —23.00 L.W.O.S. there is a layer of very soft clay and silt underneath which is a layer of a mixture of fine sand and silt down to —35.00. This mixture of fine sand and silt which was obtained direct from the casing pipe which was removed for examination, has been analysed and its properties given in Appendix C.

At the sites of borings Nos. 3 and 4, the bed levels were —25.00 and —27.00 respectively and in both cases the soil down to —35.00 consisted of soft clay and silt with very little resistance to penetration so that the boring pipes had to be suspended from above in order to prevent their very rapid descent into the ground.

A number of borings were taken at Mangalore, prior to the sub-soil survey now undertaken. A plan showing the positions of these borings and the soils encountered is enclosed (Plan No. 8).

ACKNOWLEDGMENTS

Organization of this work has been an unusual experience. Starting with no equipment, no organization to make the necessary equipment and no staff, the work had to be completed within a period of a few months. Staff was recruited, equipment was designed and made, special labour recruited and the field work completed, all within a period of three months from the date when it was known that no specialist firm was willing to take up the work. This was done by utilising the organization, equipment

and services of various departments, which was only possible because of the kind co-operation of the officers of various departments whom I had to approach in this connection. I would therefore be failing in my duty if I do not acknowledge my grateful thanks to these officers of the following departments but for whose help I would never have been able to complete this survey :—

Naval Headquarters (India).

H.M.I. Dockyard, Bombay.

The Port Department, Industries Department and the Public Works Department of the Madras Government.

Central Excise Department in the Bombay Province.

APPENDICES

APPENDIX 'A'

Extract from the Note of the West Coast Major Port Development Committee giving Details of Data required

It is requested that further data be collected on the following Ports :—

(1) Karwar,
(2) Bhatkal,
(3) Malpe,
(4) Mangalore.

1. *Karwar* (Drawing No. 1).

Trial borings or probings should be made at the points indicated on the drawing so as to ascertain the levels at which rock exists.

2. *Bhatkal* (Drawing No. 2).

Trial borings or probings should be made at the points indicated on the drawing so as to ascertain the levels at which rock exists.

3. *Malpe* (Drawing No. 3).

Trial borings or probings should be made at the points indicated on the drawing so as to ascertain the levels at which rock exists.

4. *Mangalore* (Drawing No. 4).

Trial borings should be made along the alignment of the proposed new entrance channel so as to ascertain the nature of the material which would have to be excavated. The borings should be carried down to 35 feet below low water and samples obtained of the different materials encountered.

Trial Borings :

It is most desirable that all the work at the different sites be co-ordinated and an Engineer should be placed on special duty to take charge of the investigation. This Engineer, who will work directly under the Central Government, should be authorised to place contracts with firms specialising in boring. He should maintain contact with both the Madras and Bombay Governments, and these Governments should be requested to give the officer all the necessary assistance, *i.e.* loan of craft for supporting boring plant, and also the loan of boring plant, if available.

The Executive Engineer, on the staff of the Madras Presidency Port Officer, has already commenced the taking of borings at Mangalore, and it is suggested that he would be a suitable officer to take charge of the investigation. If Government agree, therefore, the Madras Government may be asked to loan the services of the Executive Engineer to the Central Govt. for a period of about six months. The work cannot be commenced until after the monsoon, but the officer should commence now arranging for boring plant and placing contracts, if necessary, with specialist firms.

APPENDIX 'B'

The Government of India (Ministry of Transport) in their orders No. 19-P(96)/48, dated 25th October 1948 appointed a special Engineer to conduct a sub-soil survey at the four ports of Karwar, Bhatkal, Malpe and Mangalore. Work was commenced at Bombay on 29th November 1948. The first step was the calling of tenders inviting specialist firms to take up the boring work required at the four ports. Though a number of firms obtained copies of detailed specifications and drawings no tender was received on 10th January 1949, which was fixed as the last date for receipt of tenders. Attempts to induce selected specialist firms to take up the work were unsuccessful. It therefore became necessary to carry out the work departmentally.

But, for doing this, no equipment or floating craft was available except for one hand boring set which was lent by the Industries Department of the Madras Government and was being used at Mangalore for taking borings on land.

Equipment suitable for the work was not available for purchasing either in Bombay or Madras. Enquiries made at the H.M.I. Dockyard, Bombay, showed that it may be possible to utilise some of the pumps available there for jet probings and wash borings if suitable pipes, connections, nozzles and adapters were designed and made. The workshops of the H.M.I. Dockyard were in a position to make these. They were also in a position to lend one power driven floating craft for the work. Necessary permission was then obtained from the N.H.Q.(I) to carry out the work at the Dockyard. The jet pipes and connections were then made to be used in conjunction with fire fighting trailer pumps available in the Dockyard. The floating craft lent was an R.C.L. A suitable platform was erected on the side of this vessel amidships and a davit and winch were provided for handling the pipes.

In the meanwhile, one penetrometer or rod probing equipment was made at the Madras Port Department Workshops at Cocanada. Transport of this from Cocanada on the East Coast to Mangalore by rail took time. By now it was the middle of February and it was clear that unless steps were taken to carry on the work simultaneously with a number of units, it would not be possible to complete the work before the end of April, when the strong winds which precede the South West Monsoon make work impossible. One more probing set was therefore made at Mangalore. All the equipment made either at the Dockyard, Bombay, or Cocanada or Mangalore, had to be designed and made from material readily available in stock as obtaining any particular size or type of material would have involved considerable delay and might prevent the work being completed in time.

The equipment as finally assembled from these various places was suitable for—

(*a*) Dry sample borings,

(*b*) Wash borings,

(*c*) Jet probings, and

(*d*) Rod probings.

It was now necessary to have more floating craft in order to utilise these different types of equipment simultaneously and to the best advantage. Two 30-ton sea-going sailing vessels were therefore taken on hire at Mangalore. Platforms on one side were erected on these and suitable derricks were fitted up to the sailing mast in order to handle the probing equipments. Thus there were three floating units consisting of one R.C.L. which was driven by petrol engines and two sailing vessels. In spite of the best efforts of everybody concerned, the R.C.L. could not be fitted out and made ready for the work by the middle of February as expected. Work was therefore commenced with the two sailing vessels and the probing equipment. These could not be moved from the position of one probing to another unless wind was favourable and this was rarely the case at the time when it was required. Further, it was observed that lifting the anchors, moving to the new position and relaying anchors would have taken such a long time as to leave very little time for a second probing before the afternoon breeze makes the sea rough. Buoys were therefore laid out one day in advance showing the position of the probings and at the close of work each day, the tindals of the boats were instructed to move to these buoys whenever wind was favourable and lay anchor. Thus with each unit one probing could be done per day. Moving of these vessels from one port to the other involved time as they had to wait for favourable winds. It was therefore necessary to plan the work providing for any contingency of unfavourable winds which might delay the work considerably and thereby prevent the completion of all the ports in this season. It was for this reason that it was decided to limit the investigation to an examination of the sites marked "essential". As explained in the body of the report, this, however, was amplified when circumstances necessitated it in order to give a satisfactory picture of the strata. With all these steps

to speed up the work, it was just possible to complete the work by the middle of April, just a little ahead of the strong winds which precede the south west monsoon.

A complete list of the floating craft and equipment used on the work is given below. The sizes adopted were governed mostly by the necessity to adopt readily available materials.

Floating Craft.—

1. One R.C.L. driven by petrol engines.
2. Two sea-going sailing vessels—30 tons capacity.
3. One smaller sailing vessel—10 tons capacity.

Boring and Probings Equipment.—

1. One hand-boring set with 4″ dia. casing pipes.
2. Two petrol driven fire fighting trailer pumping units with hoses, couplings and other fittings complete.
3. Jet pipes 1″ diameter with nipples and nozzles.
4. One rod probing equipment with 1¼″ diameter rods and a 100 lbs. drop hammer.
5. One rod probing equipment with 1″ diameter rods and a 80 lb. drop hammer.

APPENDIX 'C'

Properties of Soils.

Name of Port	Sample No.	Boring No.	Depth at which sample is got	Mechanical Analysis					Liquid limit %	Plasticity Index	Moisture content %	Casagrande classification
				Gravel %	Sand %	Silt %	Clay %	Total fines				
Mangalore	2	1	—22 to —49	..	20	23	57	80	83	48	46.7	Medium Clay.
	3	2	—19 to —23	..	24	48	28	76	68	34	67	Clay.
	4	2	—23 to —35	..	62	38	..	38	..		..	Sand with excess silt.
Malpe	7	14	+9 to —1	..	97	2	1	3	..	..	..	Well graded sand.
	8	14	—1 to —14	..	100	..	..	..	..	..	..	Poorly graded sand.
	11	14	—26 to —64	..	74	22	4	26	46	26	27	Sand with excellent clay binder.
	12	17	+10 to —14	..	97	1	2	3	..	..	..	Well graded sand.
	13	17	—14 to —45	..	50	13	37	50	33	21	20	Sand with excess clay.
Karwar	18	20	+5.43 to—25	..	95	0.5	4.5	5	..	..	..	Well graded sand.
	19	20	—25 to —41	..	66	26	8	34	32	12	47	Sand with excess clay.

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