

WAVE POWER PROJECT

PRELIMINARY REPORT ON THE

USE OF TUNNELS FOR POWER TRANSMISSION

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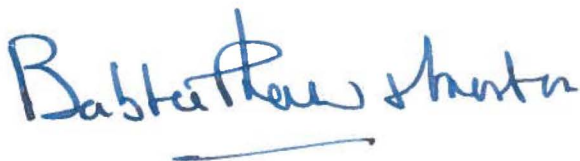
Dear Sir,

Wave Power Project
Preliminary Report on the
Use of Tunnels for Power Transmission

We have pleasure in submitting a brief report giving our preliminary views on the use of tunnels for power transmission in connection with the Wave Energy Project.

We find the whole concept of considerable interest and would be very pleased to undertake further work on the project.

Yours faithfully,



MS

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WAVE POWER PROJECT

USE OF TUNNELS FOR POWER TRANSMISSION

1. Introduction

- 1.1. A meeting was held in our Glasgow office on 27th September to discuss the problems of power transmission lines in connection with the wave power project being undertaken by the University of Edinburgh. The meeting was attended by Dr. W.H. Whittington and Mr. R. Freer who are working on the Project at Edinburgh and Messrs. N.S.M. Berry and P.G. Carter of Babbie Shaw and Morton.
- 1.2. The potential for power generation from wave action increases with the distance off shore and the initial study has suggested that a location some 15 kilometres to the west of Uist would be attractive. The transmission lines are a major problem as in the extremely hostile off shore environment they would be very difficult to maintain. The North of Scotland Hydro-Electric Board's experience with cables in these locations has been very adverse and a reliable method of transmitting the power back to shore is essential. It was agreed that Babbie Shaw and Morton should investigate and prepare a preliminary report on the possible use of tunnels for this purpose.

2. Location and Extent of Tunnels

- 2.1. In addition to providing a link from the generating location to the shore, tunnels could also be used for the link across the Minch. The general arrangement and location of the proposed tunnels is shown in Figure No. 1 appended to this report. The tunnels would be required to carry power cables with a total capacity of 2,000 megawatts and because of the distances involved it is likely that a simple rail access would be provided.

However, neither the rail access nor the actual space required for the cables would determine the diameter of the tunnel which would primarily be dependent on excavation methods, and the geological conditions, but for the purposes of this initial study a diameter of 4 metres has been assumed.

3. Geology

3.1 The method of construction and the cost of tunnelling is very much dependent on the geology. We have examined the published geological maps of the area and also a certain amount of unpublished information to which we have access and we would make the following observations:

3.1.1. Area to west of Uist The major rock type likely to be encountered would be the Lewisian gneiss although there could also be bands of Torridonian sandstone with some Mesozoic patches some distance off shore. All the rocks are extremely hard and abrasive and the drift cover to rockhead will often be negligible as the Lewisian gneiss outcrops on the seabed over much of the area. As a result it would be necessary for the tunnels to be driven below the zone of weathering, in order to minimise the possible inflow of water.

3.1.2. The Little Minch The major feature of the geology of this area is the Little Minch Fault which occurs a short distance off shore from the east coast of Uist. To the west of the fault the most likely rock would be the hard Lewisian gneiss but to the east of the fault there are Mesozoic sediments including Triassic and Jurassic sandstones and shales which are in general terms fairly weak. On Skye there could be some overlying basalts. The drift cover to rockhead over the area is unlikely to exceed 100 metres and again the tunnel will require to be relatively deep to avoid problems of weathering.

- 3.2. A very large proportion of the overall cost in evaluating the feasibility of the tunnel would be in investigating the geology. This investigation would naturally fall into the following stages:-
- 3.2.1. Pre-feasibility Study This would entail a detailed examination of all available geological information and include discussions with organisations such as The Institute of Geological Sciences and probably with contacts in various oil companies. This study would allow the selection of the most favourable route or routes and an estimate could also be prepared at this stage of the cost of the full scale feasibility study involving geophysical investigation. The total cost of this would be relatively modest involving only one or two weeks' work.
- 3.2.2. Feasibility Study This would involve carrying out geophysical traverses along the most promising routes to establish the basic geology and to help with route selection. It is difficult to put a firm cost on this but it would be of the order of £50,000 per tunnel route. It is worth noting that the Institute of Geological Sciences are actively considering further geophysical work in the area to the west of the Outer Hebrides and it may be possible to co-operate with them in this.
- 3.2.3. Full Scale Site Investigation This would involve drilling a number of boreholes to confirm the lithology and stratigraphy and to recover rock samples for testing. It would also allow detailed geological sections to be drawn up and would very substantially increase the confidence level of any estimates for the tunnel costs. On the other hand the cost of a site investigation of this nature could be as high as £1 million per tunnel route.

4. Construction Methods

- 4.1. Over the years a great many tunnels have been constructed under the sea. By far the most ambitious of these is the Seikan Tunnel being constructed for the Japanese Railways in the Islands of Honshu and Hokkaido where tunnels almost 50 miles long have been driven by conventional means in extremely unfavourable geological conditions. This project has been under way for the last eight years and is still not completed. On the other hand there have been many short sea outfalls driven under the sea in connection with sewage projects and the National Coal Board have, of course, driven many miles of very deep tunnels to win coal from under the sea.
- 4.2. The length of the tunnels would make the use of full face tunnelling machines very attractive as in general terms they can drive at rates more than double that which can be attained using drill and blast methods. Unfortunately, none of the present generation of machines would be capable of coping with the very hard Lewisian gneiss and the tunnels to the west of Uist would almost certainly have to be driven by drill and blast. On the other hand in the area between the Little Minch Fault and Skye the relatively low strength Mesozoic deposits would likely be suitable for machine driving.
- 4.3. We would emphasise that the rates of driving are very heavily dependent on the actual geological conditions encountered but we consider that up to 5 to 10 kilometres per annum could reasonably be attained using a machine but not much more than 2 to 3 kilometres per annum when excavation is being undertaken by drill and blast.
- 4.4. We would envisage that the bulk of the tunnels would be unlined particularly in the Lewisian gneiss although when the tunnel is in shale or faulted ground support probably using sprayed concrete would be necessary.

A very major concern in all tunnels and particularly those being driven under the sea is the question of safety and we would consider it essential that extensive probing ahead of the tunnel is carried out during the construction. A major effect of this tends to be a slowing down in the rate of construction although this is more critical in the case of machine driven tunnels.

5. Costs

5.1 We have given some consideration to both the overall cost of the project and also to the cost of the various levels of investigation. These would tend to fall into the same broad groups as those indicated for the geological investigation and can be summarised as follows:-

5.1.1. A desk study of all aspects of the tunnels including the pre-feasibility level of geological investigation. The detailed study of the various methods of driving the tunnels and the preparation of indicative costs for all the work. We estimate the overall cost of this would be about £5,000.

5.1.2 A detailed feasibility study including geophysical traverses along the most promising tunnel routes and an in-depth assessment of the construction methods and costs. The overall cost of this level of investigation would be very heavily dependent on cost of the geophysical investigation but for the entire project we consider it should be of the order of £100,000.

5.1.3. Full scale site investigation, the preparation of contract documents and the obtaining of firm tenders for the construction of the tunnels. As in the case of the two foregoing this is again heavily dependent on the cost of the site investigation but the total cost is likely to be between £1 million and £2 million.

5.1.4. The actual cost of driving the tunnels is entirely dependent on the outcome of the geological investigation but assuming the conditions are in general terms as outlined in Section 2 of this report and that there are not major "geological surprises" we estimate that the overall cost for driving a total of 45 kilometres to the west of Uist plus a further 25 kilometres of tunnel between Uist and the Island of Skye would be between £60 million and £100 million.

6. Conclusions

- 6.1. We have already mentioned several times in the foregoing text the paramount nature of the geology in determining the overall cost of the project. However, we are reasonably confident that the broad pattern of geology outlined will be correct in which case we can see no technical reason why tunnels should not be constructed to carry the power lines for the wave power project.
- 6.2. A major concern is the relatively long period of time which would be necessary to construct the tunnels to the west of Uist. On the basis of the 2 to 3 kilometres per annum figure quoted in Section 3 these tunnels would take 10 to 15 years to construct which we believe to be unacceptable. However, we are of the opinion that using techniques currently being developed these rates could possibly be bettered and this is an aspect which we would like to investigate in more depth. On the other hand the 25 kilometre tunnel across the Minch could be constructed by machine in a period of two to three years which is quite an acceptable time scale.

6.3 We consider the entire project to be a very exciting one in these days of "energy crises" and we would be very pleased to carry out a more detailed appraisal of the project.

BABTIE SHAW AND MORTON

A4010/NSMB

15 October, 1979

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JOB	WAVE POWER PROJECT	JOB No.	FIG. No.	DATE
LOCATION OF TUNNELS FOR POWER TRANSMISSION		A4012	1	Oct. 79

