LUNDY JETTY AND BEACH ROAD

By

DR. JOHN GRIMES AND JONATHAN HEARN
John Grimes Partnership, Leonards Road, Ivybridge, Devon, PL21 0RU

INTRODUCTION

Landing on Lundy has always been a precarious exercise and the need for a jetty to provide necessary safe access for both people and cargo has been long established. Although the east side of the island affords shelter from westerly and south-westerly storms, it is exposed to easterlies. To maximise jetty use, the site shown on Figure 1 was chosen, since this affords a degree of protection from south-easterly storms.

In 1987 proposals for the construction of a new jetty were well advanced. The site for this jetty was similar to the one now under construction. The jetty then proposed was to be of solid construction, made from concrete caissons (boxes) which were to be cast on the mainland, taken to the site of the jetty and sunk on a prepared bed, keyed together and filled. This jetty was to allow the 300 tonne MS Oldenburg to berth and unload at most states of the tide. The tidal range is some 8m. The jetty proposed was about 100m long. Proposals for this jetty were advanced to a considerable stage. Offshore bathymetry and seismic surveys were carried out, the latter to ascertain the depth of sediment. A vessel was purchased to transport the caissons from the mainland to Lundy. Projected costs escalated from £1 million to £2 million and the scheme was shelved.

Plate 1 records the foreshore and cliffs as they were in 1988 prior to any construction work on the Beach Road. Plate 2 shows the site in 1998 prior to the commencement of Beach Road works. The best site for the jetty presented a major engineering problem in as much that an access track, usable by tractors, had to be constructed prior to the construction of any jetty.

The jetty under construction and presently nearing completion (August 1999) (Plates 3 and 4) comprises a 90m long precast concrete deck supported on piles to form an open structure. This form of construction minimises the environmental impact the jetty would have on both the intertidal and near-shore environments. The site is a Site of Special Scientific Interest, Special Area of Conservation, and Britain's only Marine Nature Reserve.

In 1988 a track, cut both into the cliffs and constructed across the rocky foreshore, was commenced by the contractor, Devon Rock Services. Consulting Engineers & Geologists, John Grimes Partnership, were commissioned to design and supervise the rock excavation and stabilisation works. These rock cut works were completed in 1989.

ENGINEERING GEOLOGY & GEOMORPHOLOGY

a. BATHYMETRY AND NEAR SHORE SEDIMENT

Figures 2a and 2b are extracts of the bathymetric and seismic surveys. Sediment comprises largely sands and gravels. Along the line of the jetty (Figure 2b), rounded granite and slate boulders were identified at the base of the sediments. A previous sea level, possibly that immediately pre-Flandrian (10,000 years ago), is suggested by the 3m/4, isopachs (Figure 2b).

b SLATY ROCK MASS

The slaty rock mass is bisected by numerous major discontinuities along which there is potential for both planar and wedge-shaped rock slides in the sea cliff. There is abundant evidence of both historic and contemporary planar sliding and wedge sliding in the sea cliffs between Divers Beach and Landing Beach. Slaty cleavage is typically 85 to 60° / 025° to 040° (dip / direction) and is usually sufficiently undulous that sliding along the cleavage does not occur generally. The material strength of intact slate is moderately strong to strong (10 to 60 MPa).

c MARINE EROSION

A marine process, sometimes referred to as 'quarrying', is the most destructive process actively at work within the sea cliff. Within a discontinuity fissure, notch, cave etc., air is compressed by an impinging wave. The magnitude of the pressure head generated may be as much as 100 times the height of the impinging breaker. The air between the wave front and general surface on which the wave is breaking may go into solution, causing the wave to 'slam' into that surface. Air trapped in any fissures and erosion features in the surface is compressed and, where not vented, can be extremely destructive. Rock blocks are actively quarried by these transient pneumatic pressures.

A cave actively formed by such action is located at chainage 150m (Figure 1). Figure 3 shows a section along the cave as recorded in 1988. Interestingly, the entrance to the cave records a rock cill at elevation 5.5m AOD. The entrance is angular and above MHWS. Several fissures in the promontory chainage 90m to 140m (Figure 3) have been eroded along near vertical discontinuities striking north-south. Hydraulic conductivity with the sea has been reduced in this cave since the works in 1988. Much of the blast waste from those works remains on Divers Beach and Landing Beach and has now significantly replenished these two beaches (Plates 1 & 2).

JETTY DESIGN AND CONSTRUCTION

a CONCEPTUAL DESIGN

The jetty is shown in Figure 4. The conceptual design, prepared in liaison with both the Landmark Trust and the Master of the Oldenburg, consisted of a 90m long by 7m wide concrete deck supported off one metre diameter tubular steel piles embedded in the seabed. The outer 45m is ramped down to finish one metre above mean sea level in order for the jetty and ship deck levels to be close enough for disembarkation and unloading whilst providing vehicular access to and from the shore. The proposal has minimal environmental impact in that only the small area of seabed below the piles was disturbed and the open structure allows free movement of sediments. Conceptual design facilitated the Landmark Trust grant application.

b. DETAIL DESIGN

With the funds in place, the design process commenced. A survey of the rocky foreshore, and bathymetric and side scan sonar surveys of the sea bed were carried out. An environmental impact assessment followed, including diver surveys to identify species present on the site, and was submitted with the planning application. Wave analysis identified a 1:50yr design wave height of 7.5m. Design forces (lateral, upward and downward) were computed and structural members selected. The deck comprised 800mm deep precast concrete units similar to road bridge sections bonded together with in situ reinforced concrete to give a composite deck 1000mm deep. This was supported on double 356 x 368 steel I cross beams, in turn supported off pairs of 1000mm diameter 25mm wall thickness grade 50 steel piles at 15m centre. The piles were embedded 5m into the slate bedrock. The pile/cross head assembly was detailed to provide a fixed support portal action to resist lateral loading from wave and berthing forces. Braced steel UC fenders spanned from deck level to sea bed, a distance of some 10m. The specification for all steelwork corrosion protection was for 600µm of Alocit solvent free epoxy coating, a durable and environmentally friendly product that has the advantage of being able to be applied under water.

c DESIGN DEVELOPMENT

Tenders were issued following receipt of planning permission. The lowest tender, from Taylor Woodrow, was over budget. A period of consultation followed during which contractor proposed amendments to the construction details were developed and designed by the consultant. After this process an approximate £1.0M fixed price contract was negotiated with the contractor. The major amendments to the structure centred on the minimisation of in situ concrete work (which included intertidal work) by the substitution of 400 x 1000 deep rectangular precast concrete beams for the combined precast/in situ deck construction. Precast beams were tied together with staggered stainless steel tensioned tie bars grouted across the full width of the deck at 1m c/c. The fendering design was developed and now consists of 450 square ekki hardwood (imported from Cameroon in West Africa) faced with low friction polyethylene 40mm thick strip and mounted on rubber energy absorbing cone and arch fenders.

d CONSTRUCTION

Site mobilisation commenced in early March 1999. Exploratory boreholes were drilled from the 18m square Taylor Woodrow jack up rig 'Charlotte Louise'. These confirmed sea bed conditions assumed during the design process.

The drilling of the piles was subcontracted to the Belgian company Hydrosoils who made the five day trip from Antwerp via Lands End in the rig 'De Zeebouwer'. The uneven, rocky foreshore led to difficulties in the operation of the reverse circulation rock drill, but the piles are now successfully installed. Precast beams have been constructed at Pembroke Docks, which also serves as the collection point for all construction plant and materials which are transported to site via a tug pulled flat topped barge. This arrangement requires rigorous planning, and even during the summer months is prone to delays due to sea state. On site assemblage and construction of the deck, fixtures and fittings is ongoing. Logistical problems, (locally known as the Lundy factor!) continue to pose all involved a challenging problem. Plates 4 & 5 show the construction of the jetty during July 1999.

[Note: The jetty was substantially completed on 2 September 1999]
CONSTRUCTION OF THE BEACH ROAD.

a CONCEPT
The tidal range is shown on Figure 2a. The experience of the islanders in using the Beach Road over the past 10 years indicated that a target minimum elevation of 6.9m AOD for the track was advisable. Retaining walls, in places up to 7m high, were necessary to achieve this. At commencement of the works accessible usable space above the level of wave overtopping for the storage of materials and to provide a working space was limited. The manufacture of good quality concrete in particular was seen as potentially problematic. Additionally the cost of providing the necessary plant and material would be significantly higher than on the mainland. Essentially there was a need to reduce the plant and materials necessary for construction to an absolute minimum.

The fractured rock mass, although weak in tension is generally strong in compression. The structural thickness of reinforced concrete walls could consequently be reduced if the walls were to be frequently anchored to the rock mass. It was decided that by spraying concrete, formwork could be substantially reduced. By grouting the main bars into the rock mass and using sprayed concrete, the need for extensive base excavation into the rock and reinforced concrete base construction could be avoided.

Gunite is the name given to a sprayed, well graded sand aggregate concrete. A dry cement and aggregate mix is introduced to the spraying plant without the addition of water in the dry process. Compressed air is used to deliver the dry mix under pressure to the spraying nozzle of the equipment. Water is added at the nozzle. The gunite process is described in detail by Ryan 1973.

There are a variety of different machines on the market. The one used to construct the road retention structures on Lundy is the cement gun. The cement gun was developed in America by a sculptor in the early 20th century. By 1920 it was extensively used in civil engineering and building works, including marine works. In the writer's opinion, the cement gun, far more than other dry mix processes, provides a consistent, high quality concrete. Strengths of 50N/mm^2 are achievable and were achieved in the Beach Road structures. Concrete formed by this process is dense with no interconnecting voids. A low water cement ratio, around 0.35, ensures a low permeability concrete, essential for durability in a marine environment.

b DESIGN REGIME
Reinforced sprayed concrete walls are frequently anchored back into rock with steel anchors grouted some 3.0m into the rock. The anchoring was such that wall thickness of the gunite is typically no more than 250mm. The finish of the wall is rough cast and aggregate colour selected to minimise the visual impact of the road.

c ROAD CONSTRUCTION WORKS
The works were carried out with the Lundy Company themselves acting as the Main Contractor, the Island Manager, Paul Roberts, and foreshore foreman, Nick Jeffries, both undertaking key roles. Professional Gunite Services provided the necessary plant and guniting expertise. Works were substantially completed over a six month period in 1998. The wall

across Divers Beach and certain marine erosion protection works are to be carried out following completion of the jetty. Materials were transported from the mainland to Lundy by the MS Oldenburg and to the foreshore using the landing craft. Aggregates for concreting were delivered in 1 tonne bags.

Hessian and galvanised expanded metal lathing were tied to the vertical reinforcement, a minimum 40mm space being maintained between lathing and reinforcing steel. Gunite was then sprayed against the hessian covered lathing, which, once impregnated with gunite, was maintained as a permanent formwork.

The main steel and anchors securing the wall were grouted into the rock mass using a proprietary high strength ordinary Portland cement grout. The strength of anchors and reinforcement bonded into rock was verified with a 30 tonne jack or torque wrench as appropriate. Plate 5 shows the wall from the north end of the promontory to Landing Beach.

The structure across Divers Beach is constructed using slate and granite boulders won from the foreshore. Divers Beach is highly mobile and abrasion caused by sediments entrained in swash could be substantial. The masonry wall is more appropriate in this situation where a greater sacrificial depth for abrasion can be allowed.

SERVICEABILITY

The jetty and Beach Road are located in a high energy marine environment. Maximum marine erosion potential is at mean high water springs. It will continue to exploit lithological and structural geological weakness. Like all marine structures, regular inspection and maintenance will necessarily remain an important part of the strategy to maintain this foreshore facility.

REFERENCE

Ryan, T. F. 1973. Guniting. : A Handbook for Engineers Cement & Concrete Association. London.

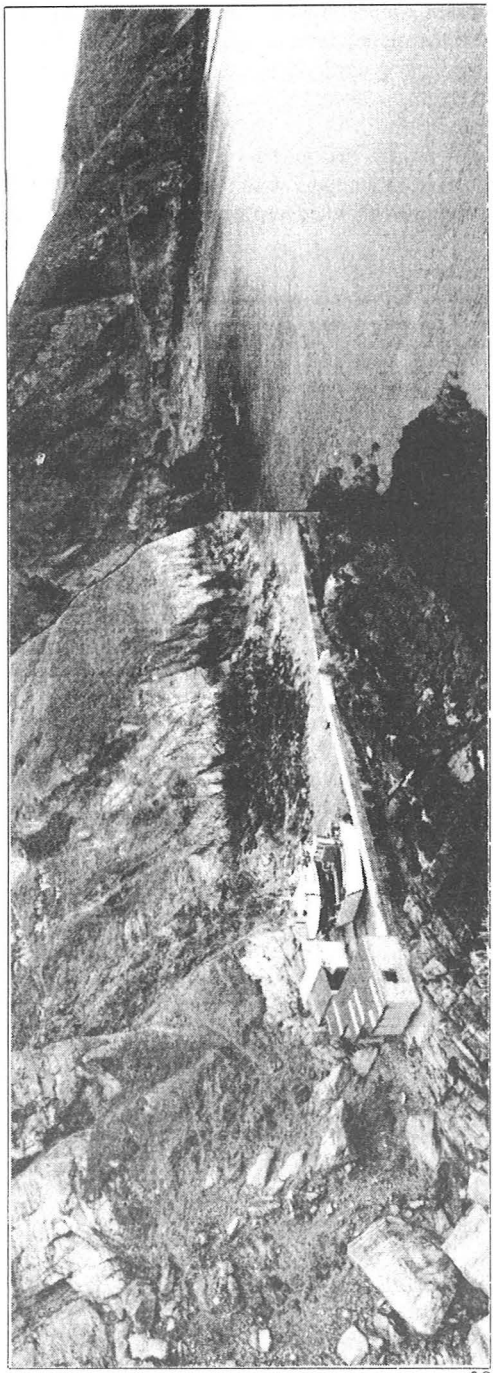

Plate 1: Divers Beach and Landing Beach 1988.

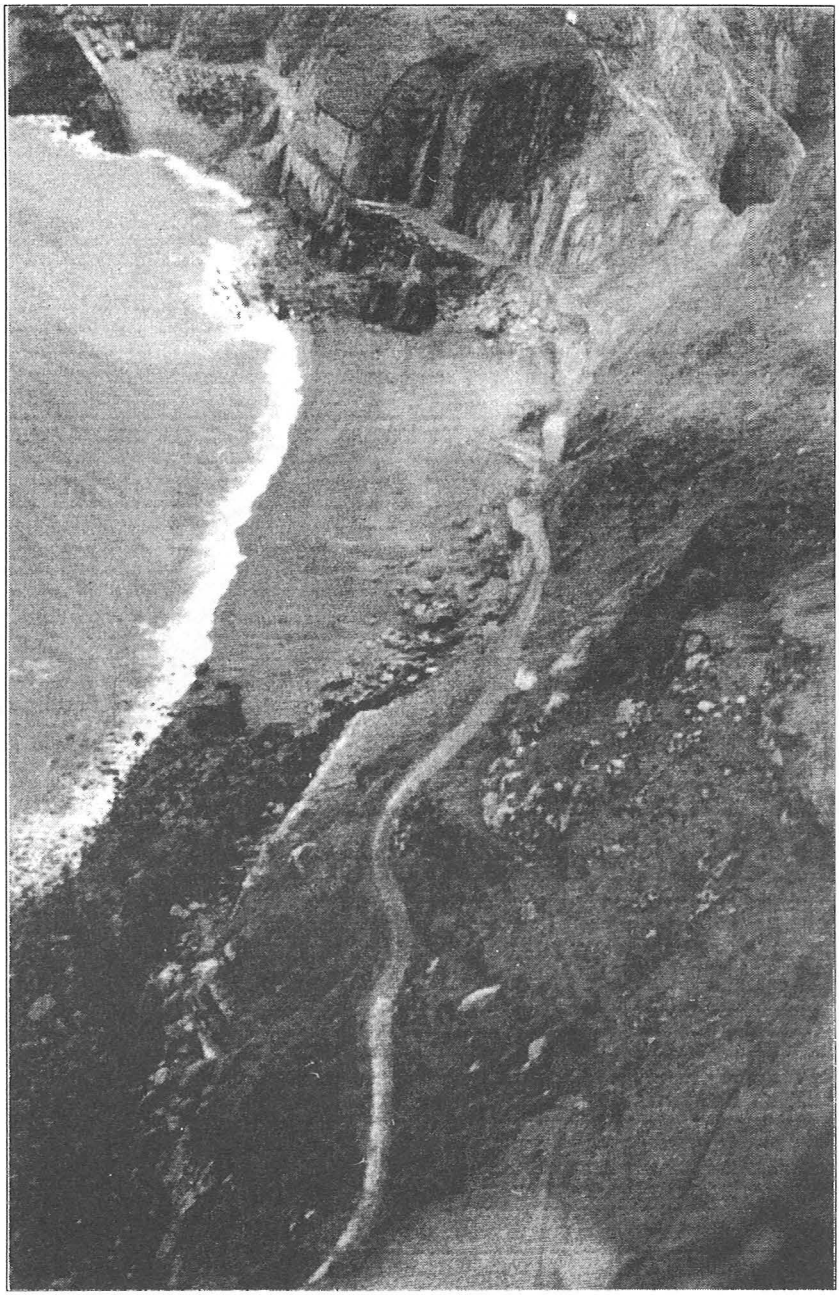

Plate 2: Divers Beach and Landing Beach 1998 prior to the start of the works.

Plate 3: The jetty under construction July 1999.

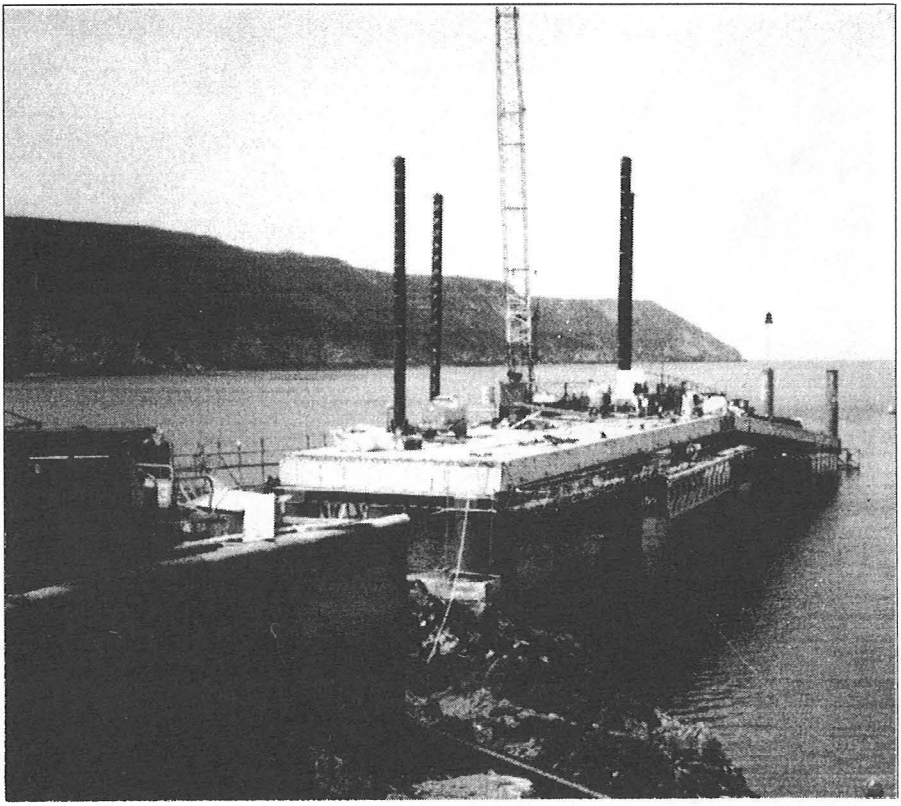

Plate 4: The jetty under construction July 1999.

Plate 5: Beach Road Chainage 150m to 300m.

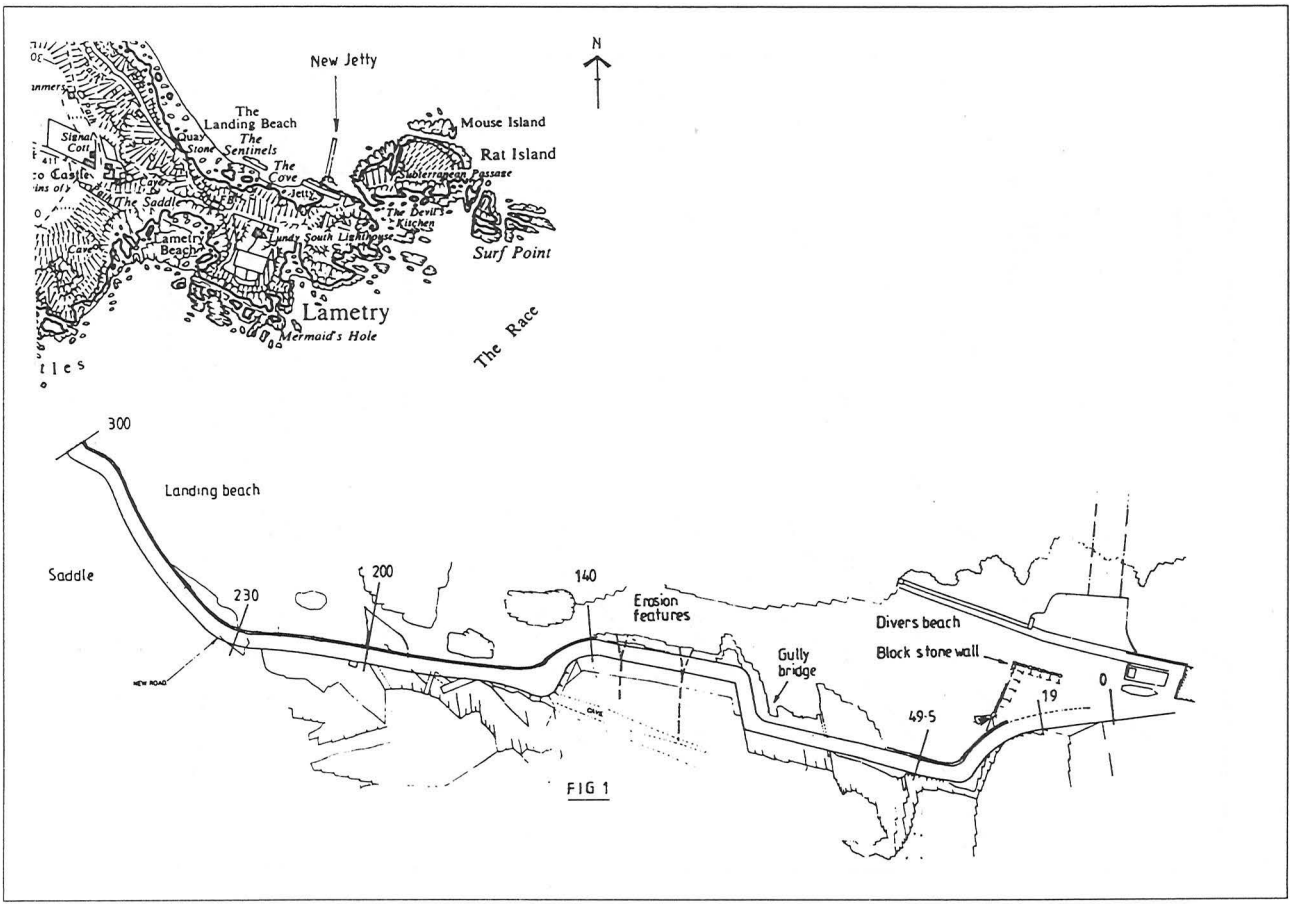

Figure 1: Setting of jetty and Beach Road.

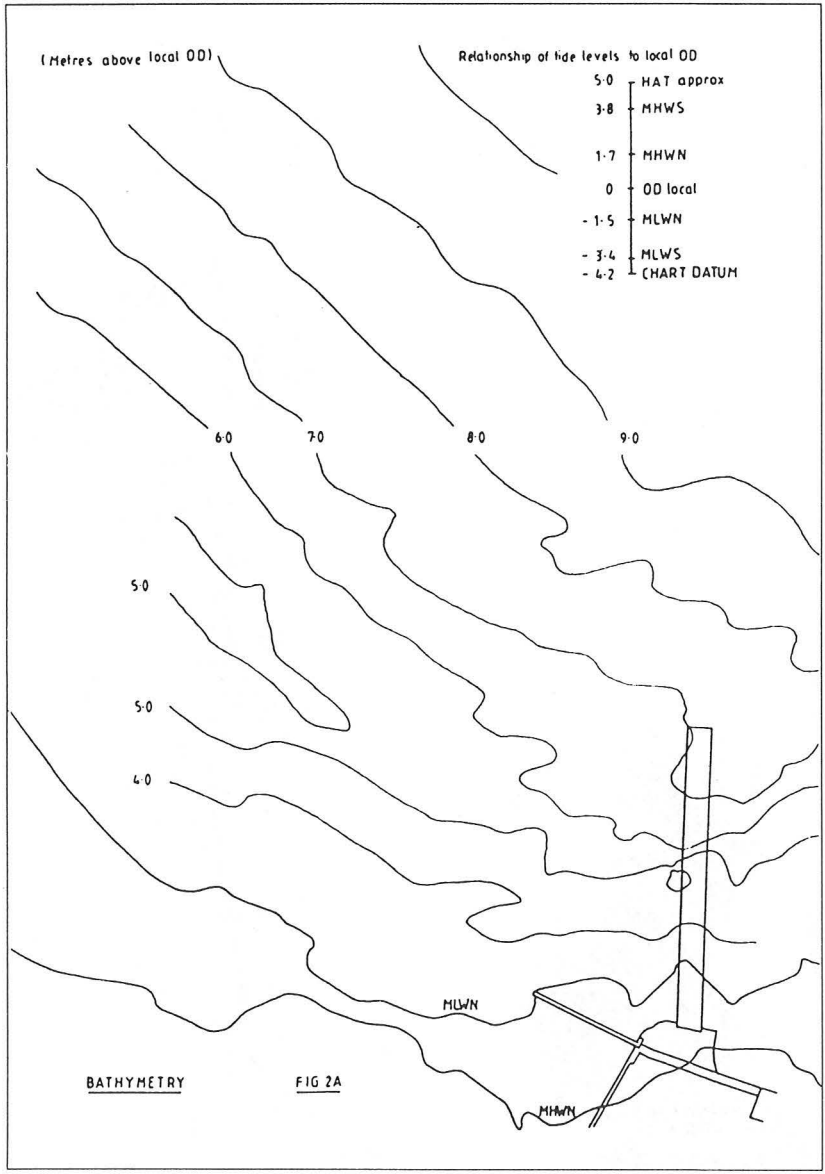

Figure 2a: Bathymetry.

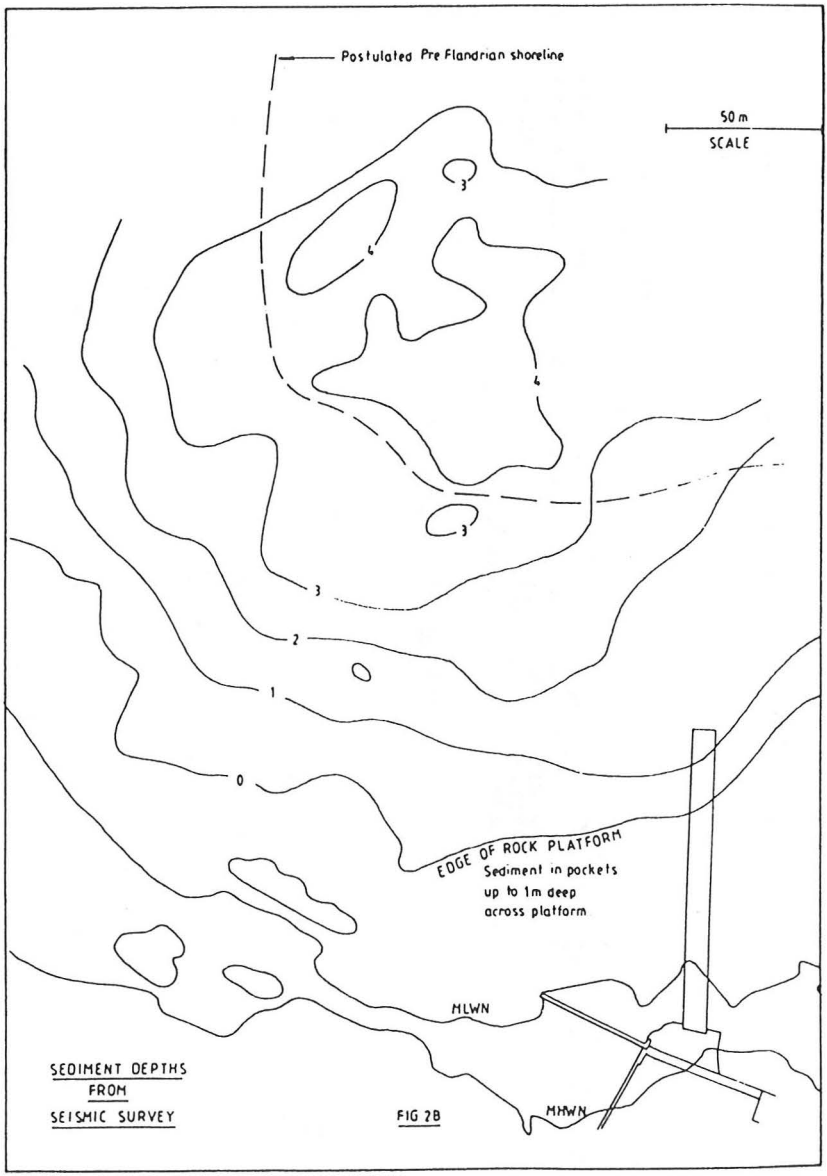

Figure 2b: Sediment Isopachs.

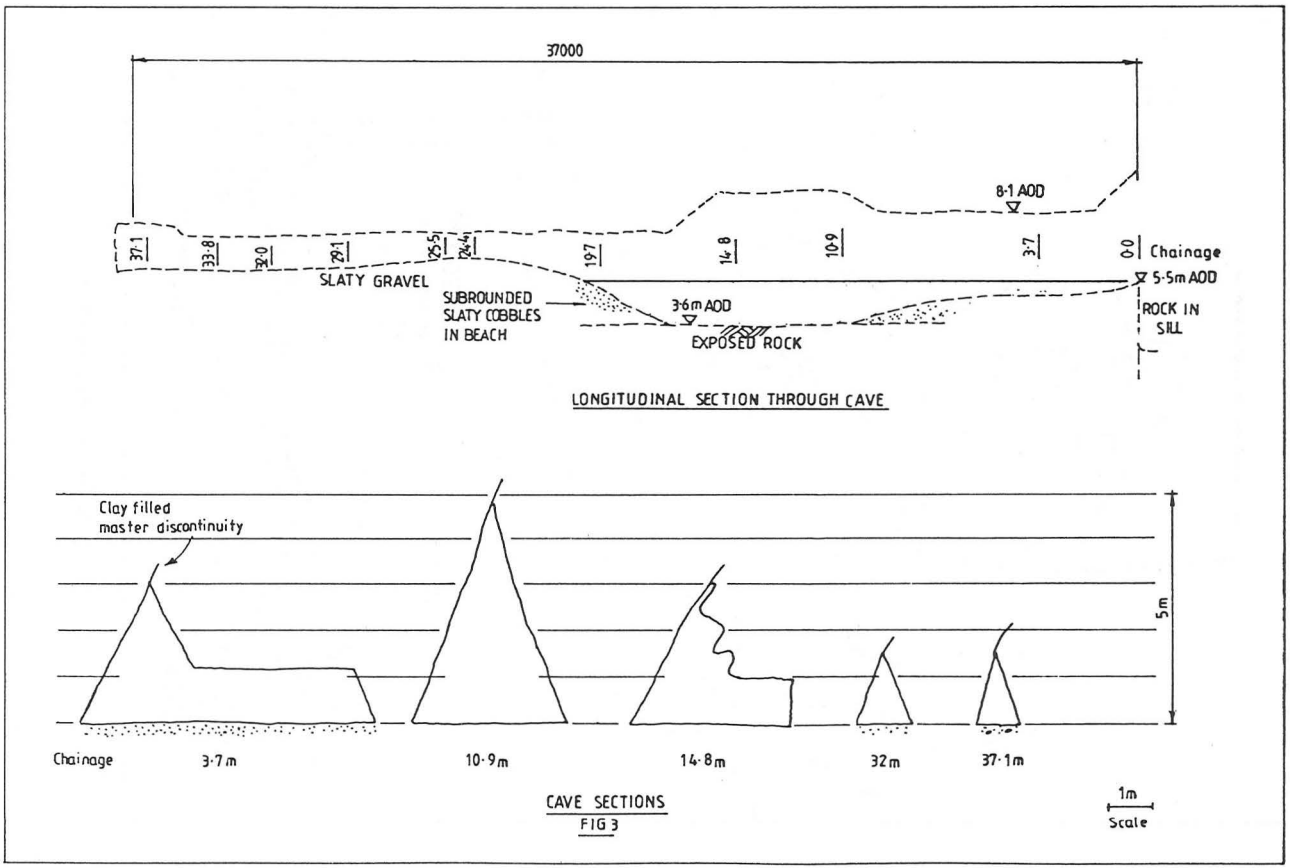

Figure 3: Cave sections.

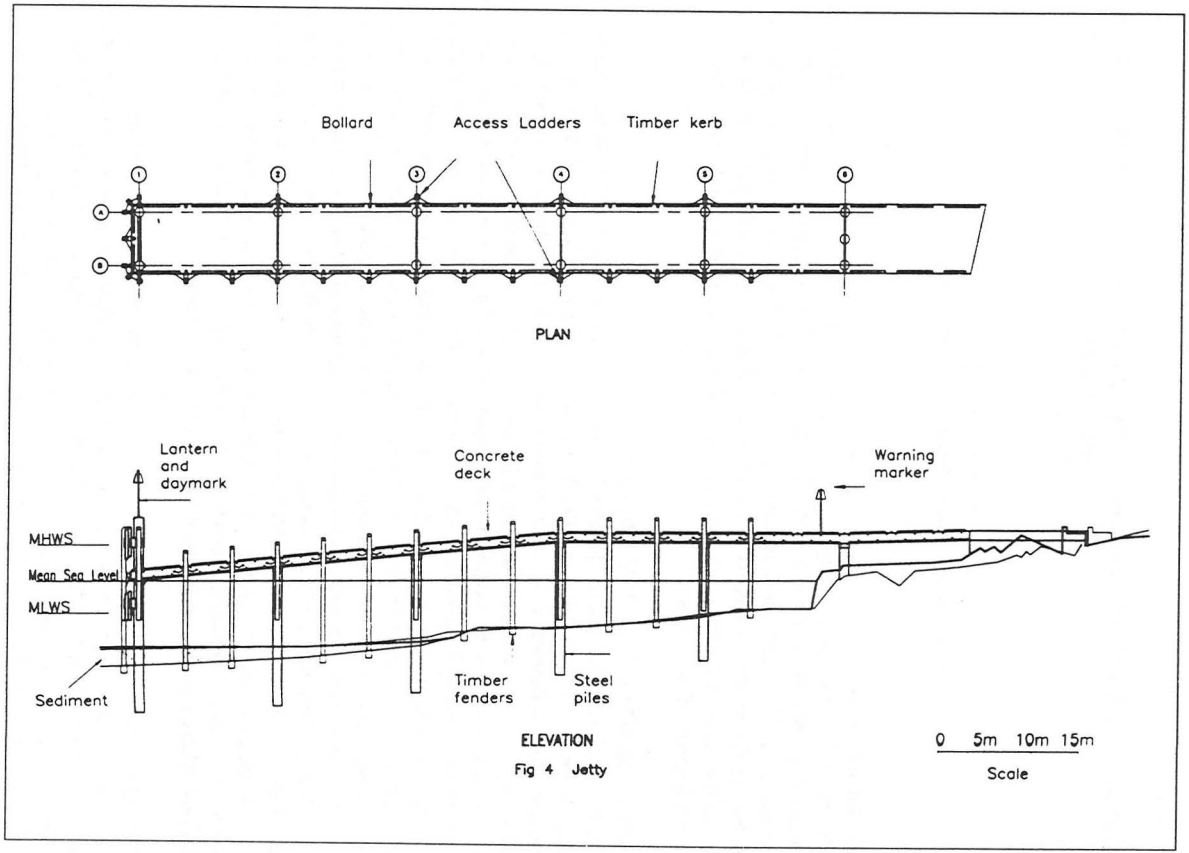

Figure 4: Jetty.